ER Mapper Professional

Comprehensive ER Mapper Professional Training Workbook

ER Mapper
Geospatial Imagery Solutions

www.ermapper.com

Copyright information

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Summary Contents

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About this manual

This manual is intended to get you started learning and using ER Mapper. It provides simple step-by-step lessons that give you hands-on practice using the basic features of the software, and using more advanced features as well. Please read the following important information before beginning.

- Chapter contents
- Setting up practice images
- Typographical conventions used in this document

This manual is not intended to cover all ER Mapper functionality in depth. Please refer to the *ER Mapper User Guide* and other manuals for more detailed information as needed.

Note: The hands-on exercises in this workbook require that the sample images and algorithms supplied on the ER Mapper CD-ROM be installed and accessable. Please refer to Appendix A “System setup” in this manual for more information.

Chapter contents

The chapters in this manual give you extensive hands-on experience using the ER Mapper software through a series of specially designed lessons. Most lessons have two basic sections:

- an overview of key concepts
- a series of step-by-step hands-on exercises

It is recommended that you start at the beginning and proceed through the chapters in order because the later chapters build on concepts learned in earlier ones. However, each chapter is independent of the others, so you can refer to a specific chapter at any time for a quick procedural overview or refresher course.

The emphasis of this manual is on learning and using the ER Mapper software, not on teaching remote sensing concepts and applications. For more detailed information on the principles of image processing or remote sensing for specific applications, please refer to the *ER Mapper Applications Manual*, or any of the text books available (some examples are listed in Appendix B "Reference texts" in this manual).

Setting up practice images

The exercises in this manual assume that ER Mapper is installed and licensed, and that you will use the default ER Mapper 'tutorial' directory to save sample processing algorithms and other files during the lessons. In addition, some chapters require that copies of the ER Mapper sample image files be placed into the 'tutorial' directory. For information on configuring your system for these exercises, please refer to Appendix A "System setup" in this workbook.

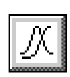
Typographical conventions

The following typographical conventions are used throughout this document:

- ER Mapper menus, button names and dialog box names are printed in boldface Helvetica type, for example:

  "Select **Print** from the **File** menu to open the **Print** dialog box."

- Where you are asked to click the mouse on an icon button in the user interface, both the button and its formal name are indicated in the text. For example:

  "Click on the **Open Transform editor**  button."

- Text to be typed in a dialog box text field is shown in boldface Courier typeface, for example: "Type **`vegetation_index`** in the text field."

1

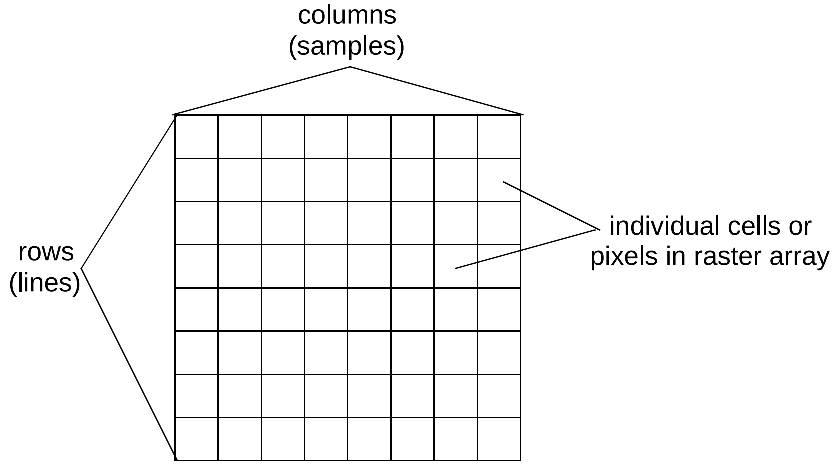
Introduction to ER Mapper

This chapter provides a brief overview of general image processing concepts, the types of data you can process, and typical ER Mapper applications in the earth sciences. It also provides an overview of how the ER Mapper software works, and advantages it provides over other image processing systems.

Image processing concepts

The term *digital image processing* refers to the use of a computer to manipulate image data stored in a digital format. The goal of image processing for earth science applications is to enhance geographic data in digital format so as to make it more meaningful to the user, extract quantitative information, and solve problems.

A digital image is stored as a two-dimensional array (or grid) of small areas called *pixels* (picture elements), and each pixel corresponds spatially to an area on the earth's surface. This array or grid structure is also called a *raster*, so image data is often referred to as raster data. The raster data is arranged in horizontal rows called *lines*, and vertical columns called *samples*. Each pixel in the image raster is represented by a *digital number* (or DN).



These image DNs can represent many different types of data depending on the data source. For satellite data such as Landsat and SPOT, the DNs represent the intensity of reflected light in the visible, infrared, or other wavelengths. For imaging radar (Synthetic Aperture Radar - SAR) data, the DNs represent the strength of a radar pulse returned to the antenna. For digital terrain models (DTMs), the DNs represent terrain elevation. No matter what the source, all these types of data can be stored in a raster format.

By applying mathematical transformations to the digital numbers, ER Mapper can enhance image data to highlight and extract very subtle information that would be impossible using traditional manual interpretation techniques. *This is why image processing has become such a powerful tool for all types of earth science applications.* The exercises in this manual provide many examples that illustrate how image processing is typically used to enhance image data and extract information.

Many image datasets have multiple *bands* (or layers) of data covering the same geographic area, each containing a different type of information. For example, a SPOT HRV-XS satellite image has three bands of data, each recording reflectance from the earth's surface in a different wavelength of light. Since each band records reflectance in a different part of the spectrum, this type of data is often called *multispectral* data. Many powerful image processing techniques have been developed to combine various bands from multispectral images to highlight specific types of earth science information such as vegetation abundance, water quality parameters, or the types of minerals present at the earth's surface.

Image processing applications

Image processing has become an important tool for a wide range of earth science mapping, analysis, and modelling applications. Following are just a few of the many applications for which image processing is commonly used:

- land use/land cover mapping and change detection
- agricultural assessment and monitoring
- coastal and marine resource management
- mineral exploration
- oil & gas exploration
- forest resource management
- urban planning and change detection
- telecommunications siting and planning
- physical oceanography
- geology and topographic mapping
- sea ice detection and mapping

Traditional image processing

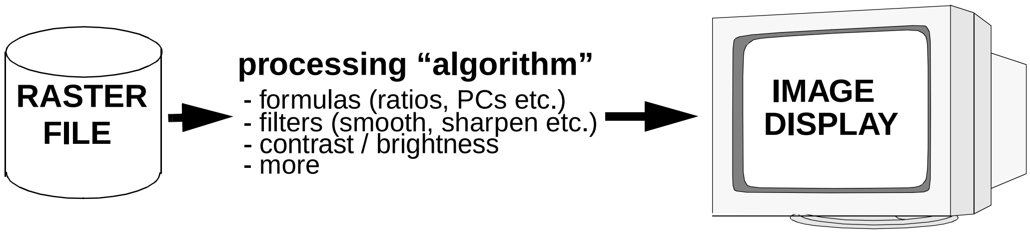
Image processing was first developed on large mainframe computers in the 1960's to process images from planetary satellites. To process an image, you specified the name of the file to process, the type of operation you wanted to perform, then waited for the system to process the data and write the results to a new image file on disk (shown in the diagram below). You then used a separate display program to view the output file and evaluate your results.

With traditional systems, the changes resulting from the image processing operation are saved in a *separate output raster file*.

With the introduction of powerful workstations in the 1980's, processing of large images could now be performed on the desktop. Surprisingly, nearly all image processing products on the market today are still designed around this "disk-to-disk" approach from the 1960's. This means that to perform a processing operation that requires several steps, you need to write an intermediate file to disk for each step. Only when the final file is created can you view your desired results. This approach can consume tremendous amounts of time and disk space, and if the result is not what you intended, you must often start all over again.

ER Mapper image processing

Recognizing the restrictions inherent in traditional image processing software, the creators of ER Mapper developed an entirely new approach. Instead of writing a file to disk for each processing step, ER Mapper lets you combine many processing operations into a single step, and render the results directly to your screen display in near real-time. (In most cases, no processed copies of your original data are written to disk unless you request to do so.) The set of processing steps you apply to your data is called an “algorithm” in ER Mapper.



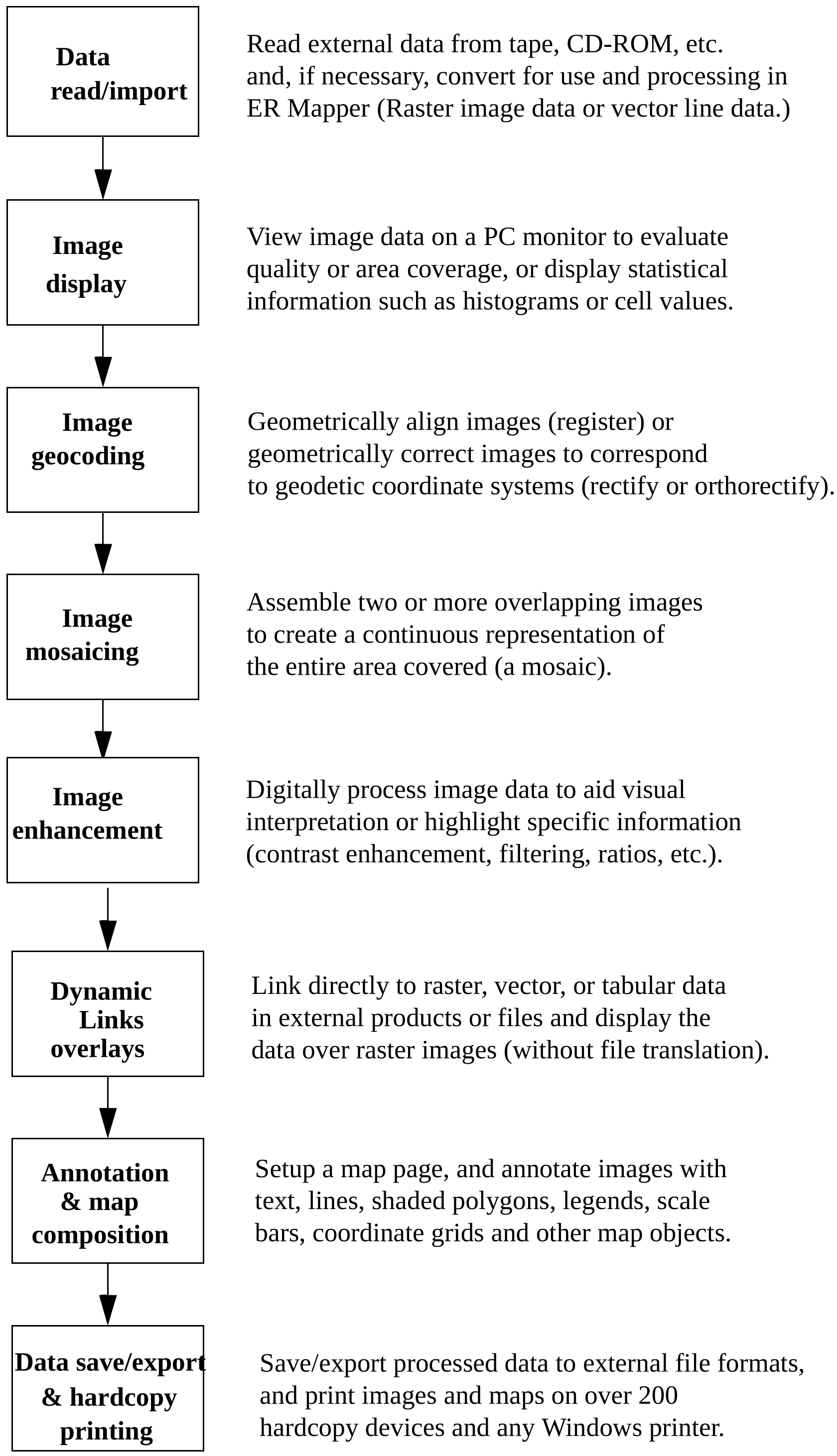
With ER Mapper, you can save only a *description of the processing steps* you wish to apply to the data (the algorithm), *not* separate processed copies of the original raster data file. By storing the processing steps separately from the actual data, image processing becomes faster, easier to learn, and more interactive. If required, you can save the processed image in a number of formats including ER Mapper Raster Dataset (.ers).

In ER Mapper, algorithms can be used for simple viewing of data, or for very complex processing and modelling operations involving many images, transformations of the data, and overlays of other types of data. Examples of common image processing operations that become much easier using algorithms include image merging (data fusion), image mosaicing, and any type of mathematical transformations such as band ratios, Principal Components, Tasseled Cap transforms, and others.

The algorithms design also allows ER Mapper to handle the next generation of very high resolution satellite imagery much more efficiently than traditional systems. These one to three meter spatial resolution datasets will have large file sizes for the area of coverage, so reducing the need to write processed copies of the data to disk is a very important consideration.

Image processing tasks

A flowchart of typical image processing tasks is summarized in the following diagram, from data import through processing to final output:



Data read/import

The first step in image processing is reading the data you want to use into ER Mapper. Typically the data might be stored on magnetic tape, CD-ROM, or other media. There are two primary types of data you may want to read into ER Mapper: raster and vector.

Raster image data is the type used as input to image processing operations. Typical sources include satellite images, digitized aerial photographs, digital terrain models (DTMs), and geophysical and seismic survey data. ER Mapper can directly read image data in the following formats:

- ER Mapper Raster Dataset (.ers)
- ER Mapper compressed image (.ecw)
- ESRI BIL and GeoSPOT (.hdr)
- Windows BMP (.bmp)
- GeoTIFF/TIFF (.tif)
- JPEG (.jpg)
- USGS Digital Ortho Quad (.doq)
- RESTEC/NASDA CEOS (.dat)

You have to import image data that is not in one of the formats listed above. When you import a raster image file (using ER Mapper's import utility programs), ER Mapper converts the data into ER Mapper Raster Dataset format by creating two files:

- a binary data file containing the raster data, in band interleaved by line (BIL) format
- a corresponding ASCII header file with a ".ers" file extension

Vector data is stored as lines, points, and polygons. Many geographic information system (GIS) products use vector data structures because it is more efficient for representing discrete spatial objects like roads (lines), sample locations (points), or political boundaries (polygons). In an image processing product, it is often helpful to overlay vector data on top of a raster image backdrop, for example overlay a network of known roads on a satellite image. When you import a vector file (using ER Mapper's import utility programs), ER Mapper converts the data and creates two files:

- an ASCII data file containing the vector data
- a corresponding ASCII header file with an ".erv" file extension

Image display

After importing the data, the next step is usually to display the image on your monitor to evaluate the data quality and geographic area of coverage. If the data is of poor quality or does not cover your area of interest, you might decide not to proceed any further and try to obtain better data.

There are several ways in which data can be viewed, including simple black and white or pseudocolor displays, and red-green-blue (RGB) or hue-saturation-intensity (HSI) color composite displays. The way in which you choose to display your raster data is called the “Color Mode” in ER Mapper.

In addition to displaying the data, you may want to view statistical information about it. Statistics are often good indicators of image quality. You may want to calculate statistics for the image, such as the mean value in each band, and view them in a tabular format. Or you may want to view statistical information in a graphical format using tools like histograms, scattergrams, and traverse profiles.

Image geocoding

Many times, raster image data is supplied in a “raw” state and contains geometric errors. Whenever accurate area, direction, and distance measurements are required, raw image data must usually be processed to remove geometric errors and/or rectify the image to a real world coordinate system.

- *Registration* is the process of geometrically aligning images to allow them to be superimposed or overlaid.
- *Rectification* is the process of geometrically correcting raster images so they correspond to real world map projections and coordinate systems (such as Latitude/Longitude or Eastings/Northings).
- *Orthorectification* is a more accurate method of rectification because it takes into account terrain and sensor (camera) calibration details. Advanced orthorectification also uses platform position information.

If your application requires that your images be registered to one another or rectified to a map projection, you will use ER Mapper’s Geocoding Wizard to do this.

Image mosaicing

A *mosaic* is an assemblage of two or more overlapping images used to create a continuous representation of the area covered by the images. ER Mapper automates the building of image mosaics because co-registered images referenced in the same processing algorithm are automatically displayed in their correct geographic positions relative to each other. This means that you can work with each image file in the mosaic as a separate entity, and you are not required to write all images to one large file on disk in order to process and enhance them.

Image enhancement

Image enhancement refers to any one of many types of image processing operations used to digitally process image data to aid visual interpretation or extract quantitative information meaningful to the user. Image enhancement is what many people commonly think of as “image processing.”

In ER Mapper, image enhancement operations are greatly simplified by the “algorithms” processing concept. Nearly all types of image enhancement operations can be applied and displayed in real time to provide truly interactive control without writing temporary files to disk.

Typical image enhancement operations include:

- *Image merging* (data fusion)–Combine images with different qualities to aid interpretation. For example, merge Landsat TM and SPOT Pan to combine TM spectral information with SPOT Pan spatial detail.
- *Colordraping*–Drape one type of data over another to create a combined display allowing analysis of two or three variables. For example, drape a satellite-derived vegetation map over an airborne magnetics image of the same area, or overlap magnetics and radiometrics images to check for correlations.
- *Contrast enhancements*–Improve image presentation by maximizing the contrast between light and dark portions (or high and low data values) in an image. Or, highlight a specific data range or spatial area in an image.
- *Filtering*–Enhance edges, smooth noise, or highlight or suppress specific linear or spatial features in images. For example, apply a gradient directional filter to highlight linear features tending north-south in an image. ER Mapper also includes Fast Fourier Transformations for filtering in frequency domain space.
- *Formula processing*–Apply mathematical operations to combine multiple bands of image data or derive specific thematic information. Examples include thresholding, differencing, ratios, Principal Components Analysis, and spatial modeling.
- *Classification*–Statistically group or cluster image data values into thematic categories or feature classes. For example, classify a Landsat satellite image to yield a thematic map of land cover types. (Raster representations of the spatial cover types can also be converted to vector polygons for export to GIS systems.)
- *Color balancing*–Balance the colors of mosiaced airphoto images to create seamless joins between them.

Dynamic Link layers

Dynamic Links are a special ER Mapper feature that let you link to data in external products or file formats, and display the data on top of raster images without the need for importing the files. Dynamic Links can link to raster, vector, or tabular (point) datasets, so you can access and integrate *all* your geographic information.

ER Mapper provides Dynamic Links to several popular products and file formats. The procedure is fully documented so you can also create your own links to any other product or format you desire.

Types of Dynamic Links include:

- *Links to GIS products*–Extract and display vector data from GIS products such as ARC/INFO. GIS links are often used to overlay vector data such as road networks, political boundaries, or land use categories.

Tip: You can display, edit, and save ARC/INFO coverage files directly in ER Mapper. See the *ER Mapper User Guide* for details.

- *Links to database products*–Extract and display tabular (point location) data from database products such Oracle. Tabular links are often used to overlay georeferenced point location symbols such as cities, well locations, or ground truth sample sites.
- *Links to external file formats*–Display specialized annotation, vector data, or other data stored in PostScript, DXF, DGN, or other standard file formats.

Map composition

You can use ER Mapper's built-in Annotation and Map Composition tools to create top quality maps combining raster, vector, and tabular data. Annotation lets you draw directly on-screen using text, line, polygon, and other annotation tools, and specify fill color, shading, line styles, user-defined symbols, and group and move objects. Vector annotation files created in ER Mapper can also be exported to external file formats for use in other products.

You can layout and compose maps comprising multiple processed images, and size and scale map output as desired. All map objects are defined as full color PostScript, and you can easily add custom map objects such as company logos or special north arrows.

Data save/export and hardcopy

Once you have completed processing your data, ER Mapper lets you translate raster and vector image data to external standard file formats or print to over 200 different hardcopy devices and any Windows printer.

You can save raster images directly to the following formats:

- ER Mapper Raster Dataset (.ers)
- ER Mapper compressed format (.ecw)
- ER Mapper Virtual dataset (.ers)

- ESRI BIL and GeoSPOT (.hdr)
- Windows BMP (.bmp)
- GeoTIFF/TIFF (.tif)
- JPEG (.jpg)
- UDF (.ers and .hdr)

  UDF (Universal Data Format) saves the image with an ER Mapper (.ers) and ESRI BIL GeoSPOT (.hdr) file. This allows it to be directly read by a number of image processing applications.

You may also want export vector annotation or vectorized thematic data to a GIS product.

The ER Mapper compressed format uses ECW (Enhanced Compressed Wavelet) compression to make the output image file size considerably smaller than the original with minimal loss in quality. The single .ecw file contains embedded georeferencing information that can be used by ER Mapper and external GIS applications.

Hardcopy printing is often the final goal of processing and annotating images, and ER Mapper provides unsurpassed hardcopy support and output to standard graphics file formats. ER Mapper also includes a built-in PostScript-compatible rendering engine, so you get PostScript-quality output (such as beautiful, smooth text) on any supported device, whether the device supports PostScript or not.

You can also easily print at exact sizes and map scales, and automatically print large images in strips for mosaicing large image displays. Supported hardcopy devices include any Windows printer, film recorders, dye sublimation printers, inkjet printers, and electrostatic plotters. Graphics file formats include PostScript, TIFF, Targa, CGM, and CMYK and RGB color separations.

ER Mapper wizards

ER Mapper has a number of useful wizards which simplify and automate much of the image processing. These are described in the ER Mapper User Guide and summarized below:

Image Display and Mosaicing Wizard

This wizard allows you to enter the file names of raster and vector images, which it then displays and/or mosaics to your requirements.

Image Compression Wizard

This wizard enables you to save an image in ECW compressed format. It provides a User Interface for you to specify a target compression ratio.

Color Balancing Wizard for Airphotos

This wizard automatically balances and clips the images in the currently active image window to produce seamless mosaics.

Change Projection/Datum/Cell Size Wizard

This wizard was designed to accommodate TIFF/TFW images that do not have Projection/Datum information. When the Projection and Datum of an image is unknown, ER Mapper defaults to RAW/RAW or WGS84/LOCAL, which may not be correct. Also, if the TFW file specifies the Cell Size to be in feet, ER Mapper will incorrectly assume it to be in meters.

This wizard modifies the ERS header file with the image with Projection, Datum, and Cell Size information you specify. It creates a new ERS header file if one does not exist. ER Mapper uses this information in preference to that included in a TFW file.

Ortho and Geocoding Wizard

This wizard geocodes images (including orthorectification) to remove distortion and set them to the correct spatial coordinates and rotation.

Gridding Wizard

This wizard generates gridded raster images from point, line or polygon data.

3-D Algorithm Wizard

This wizard creates a single surface 3D algorithm from a raster and a height image which you specify.

Contouring Wizard

This wizard adds a contour layer to a display algorithm to generate contours directly from an image or algorithm file.

Landsat TM Wizard

This wizard creates one of several standard Landsat TM algorithms. You specify the Landsat TM image, and select the type of algorithm required.

Landsat Web Publishing Wizard

This wizard gives you a choice of algorithms that it can create using the Landsat 5 or Landsat 7 image files that you specify. It also compresses the resultant images, and creates ready-to-use web pages for you to serve the images from an Image Web Server.

Common Geophysical Images Wizard

This wizard creates a selectable common type of magnetic and gravity image. You specify the image dataset to use.

Magnetics Fourier Wizard

This wizard applies a 1st Vertical Derivative or Reduce to Pole FFT formula on a single band of an image. You specify the input and output image, and select the band and FFT process to apply.

Page Setup Wizard

This wizard interactively leads you through setting up a page, including the addition of an optional vector layer.

Local Government Applications Wizard

This wizard automatically runs change detection algorithms on temporal aerial images. It also combines 1-Bit scanned mapping to aerial images, changing line colors and removing white areas to aid integration and visualization.

.tab file reader

This tool reads existing MapInfo table (.tab) files (image file only) and automatically creates ER Mapper .ers header files. This allows MapInfo users to view, mosaic and compress images with ER Mapper without needing to convert them manually.

Designing your own wizards

You can use the ER Mapper batch scripting language to design your own wizards to simplify regular tasks. You can even add an entry or button to the menu and toolbars. Refer to *Part Six - Batch Scripting and Wizards, Chapters 26,27,28* in the *Customizing ER Mapper* manual for information on the batch scripting language.

2

User interface basics

This chapter introduces the basic use of the ER Mapper graphical user interface. It gives you practice using menus, toolbars, dialog boxes, and image windows, and loading and displaying image processing algorithms.

Note: In order to complete the exercises in this manual, you will need to access the sample images and algorithms supplied with ER Mapper. If needed, ask your system manager for the location of the ER Mapper software directory at your site.

User interface components

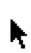
This section provides a brief introduction to the main components of ER Mapper's graphical user interface (GUI). You can perform nearly all operations by pointing and clicking with the mouse, and very little typing on the keyboard is required. The GUI is part of ER Mapper's original design, so it is well integrated and easy to learn and use.

Using mouse buttons

When using ER Mapper, use the left button on your mouse to perform operations like selecting items from menus, manipulating image windows, and drawing annotation. In this manual, all actions are performed with the left mouse button unless otherwise indicated. The following table explains terms used in this manual to describe actions you perform with the mouse.

Term	Meaning
Point	Position the mouse pointer on an item.
Click	Point to an item, then quickly push and release the left mouse button.
Right-click	Point to an item, then quickly push and release the right mouse button.
Double-click	Point to an item, then quickly click the left mouse button twice.
Drag	Point to an item. Then press and hold down the left mouse button as you move the pointer to a new location, then release the button.
Shift-click or Ctrl-click	Hold down the Shift key or Ctrl key on your keyboard, then click.
Shift-drag or Ctrl-drag	Hold down the Shift key or Ctrl key on your keyboard, then drag the mouse.

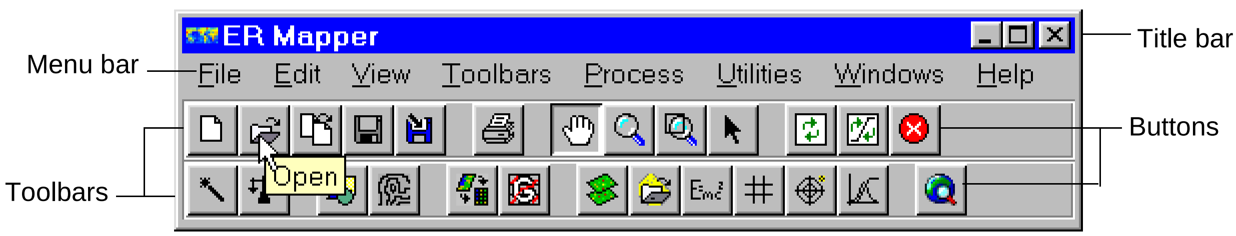
The symbol representing the mouse pointer on the screen changes shape depending on what you are pointing to and the task you are performing.

Pointer	Location on the screen	Function
	Menu bars and buttons; or inside image window	Choose menu commands and click buttons; point to the image to see data values or coordinates.
	Text fields	Type or select text, or reposition the insertion point.
	Inside the current image window	Zoom the image within the image window.
	Inside the current image window	Drag a box over an area to fill image window.

	Inside the current image window	Pan the image within the image window.
	Inside inactive image windows	Select an inactive window to become the current window.
	In image windows when annotation tools are selected	Draw annotation and map composition objects.

The ER Mapper main menu

When you start ER Mapper, the main menu appears. The main menu has two primary components–the menu bar and rows of toolbar buttons.



Menu bar	Lets you select commands used to carry out actions in ER Mapper. To select a command from the menu bar, click on the name of the menu to open it, then click the desired command name.
Toolbar buttons	Shows groups of buttons to let you carry out common tasks quickly. To choose a function from a toolbar, click on the desired button.
Tool tips	Place the cursor on any toolbar button and within a couple of seconds the function of that toolbar button is displayed in a small text window just below the cursor

Using ER Mapper toolbars

Toolbars give you quick access to many common functions, such as saving an image processing algorithm or printing a hardcopy. ER Mapper also provides optional toolbars for specific tasks and image processing applications. To hide or display various toolbars, use the **Toolbar** menu. To get short help for any toolbar function, point to the button and read the tool tips.

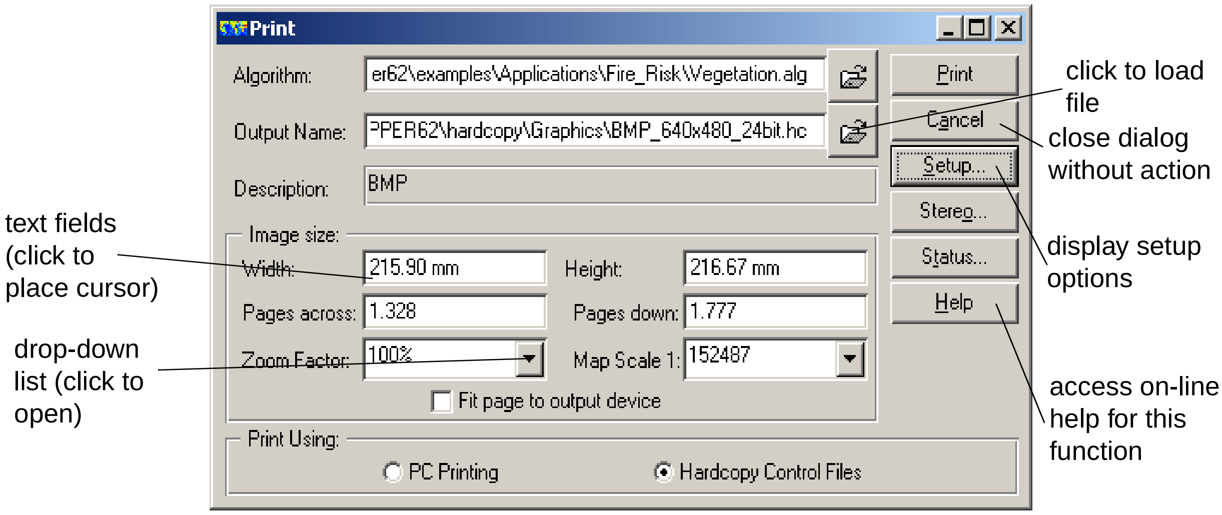
ER Mapper provides toolbars for many common tasks, and also toolbars for building processing algorithms commonly used in remote sensing applications such as forestry, geophysics, and map generation. The functions of the Standard, and Common Functions toolbars are summarized below.

Standard	Provides quick access to standard commands for opening and saving algorithms, printing, starting and stopping algorithm processing, and changing the mouse pointer. Most functions are also available from the menu bar.
Common Functions	Provides quick access to commonly used functions, such as creating general types of algorithms, viewing and editing components of an algorithm.

Using ER Mapper's scripting language, you can also create your own customized toolbars for specific tasks and functions. For more information on creating custom toolbars, see the *ER Mapper User Guide*.

Using dialog boxes

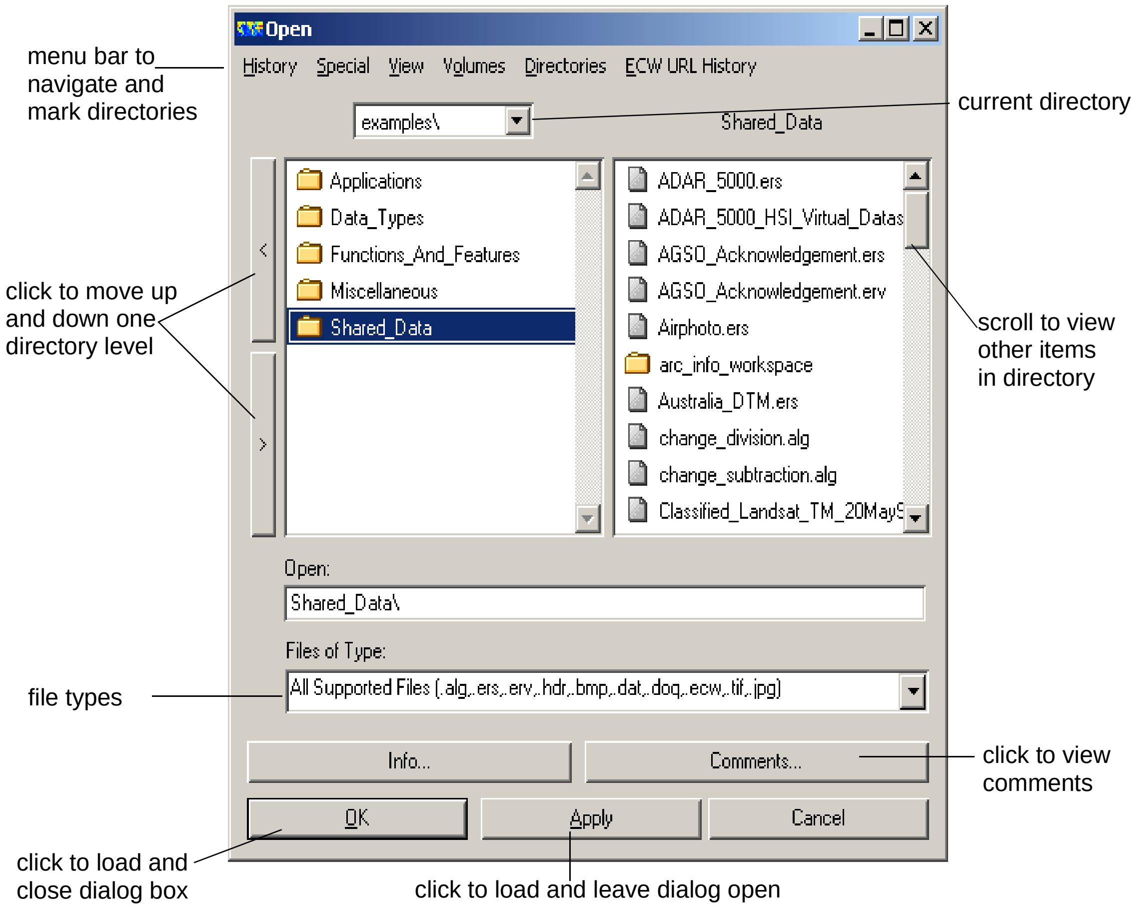
When you select menu commands or click toolbar buttons, dialog boxes often appear for you to choose options to control your image processing tasks. Some dialog boxes, such as the File Chooser, can disappear when you make your selection. Other dialogs can remain open for setting options for as long as you want to use them.



To resize a dialog box, drag one of its corners or edges to the desired size. ER Mapper automatically resizes the dialog box intelligently, so that any central display areas are enlarged, and the layout of buttons remains the same. After resizing, the dialog retains your new size for the current ER Mapper session.

Using the File Chooser dialog boxes

When you choose to open or save a dataset, algorithm, or other file, ER Mapper displays a File Chooser dialog box. The central window contains a list of directories, or files in the current directory.



To open a file or directory displayed in the scroll list window, either double-click on it, or click once to select it and click the **OK** or **Apply** button to open it.

Tip: You can see two levels of directories and/or files by widening the file chooser dialog box (drag one of the sides).

The File Chooser menus at the top have the following functions:

History menu	Use to change the File Chooser’s current directory. The menu has two parts: the upper portion lists most recently visited directories, and the lower portion lists marked directories.
Special menu	Use to change to your home directory, or to mark or unmark a directory (any directory may be marked for fast access using the History menu).
View menu	Use to sort the contents of the current directory by name, date modified, or date created.
Volumes menu	Use to access volumes or disk drives on your network.
Directories menu	Use to change to any directory defined by your preferences settings.
ECW URL History	List of the URLs of the most recently accessed image files from an Image Web Server.

Using the on-line help system

ER Mapper provides an extensive on-line help system with both simple overviews and detailed descriptions of all features and functions. There are two ways to access help:

Help menu	Lets you browse all the standard ER Mapper manuals on-line, and go between manuals and topics using hypertext links.
Help buttons	The **Help** button inside dialog boxes gives you context-sensitive help. If needed, you can navigate to view more detailed information using the hypertext links.

Typing text in text fields

To enter text for naming files or changing values in dialog boxes, ER Mapper provides text fields. When you point to a text field, the pointer shape changes to an I-beam. To enter text, click anywhere inside the text field to place the text cursor.

To select existing text, you can drag through the desired portion, or double-click on a word or numeric value to select it. Text that is selected become reverse highlighted, and any subsequent typing replaces it.

Hands-on exercises

The following hands-on exercises introduce you to the basic concepts of using menus and dialog boxes and managing image windows.

What you will learn...

After completing these exercises, you will know how to perform the following tasks in ER Mapper:

- Choose options from menus and toolbar buttons
- Display and hide toolbars
- Open an empty image window
- Open an image processing algorithm into a window
- Move and resize an image window
- Zoom and pan the image within the window
- Manipulate multiple image windows on the screen
- Close image windows

1: Using menus and toolbars

Objectives

Learn to open and make selections from menus, use toolbars, and access on-line help.

Move the ER Mapper main menu around the screen

1 Position the mouse pointer on the ER Mapper main menu title bar, then drag it to the lower-left part of the screen.

Pointing to the title bar and dragging is how you move dialog boxes and image windows around the screen.

2 Drag the main menu to the upper-right corner of the screen.

This is the recommended position for the main menu for the exercises in this tutorial.

Open a menu to display its commands, then close the menu

1 Click on the **View** menu button; a list of commands under the menu displays.

The small arrows next to **Quick Zoom** and **Statistics** indicate that they have additional commands under them.

2 Click on the **Statistics** command to display its submenu.

3 Click anywhere outside the main menu to close the open menus without making a selection.

Note: In the rest of this manual, selecting commands from menus is indicated as follows: "From the **Edit** menu, select **Preferences...**" (which means click on Edit in the menu bar, then click on the Preferences command).

Select the Print command from the menu bar

1 From the **File** menu, select **Print**.

The **Print** dialog box appears with options for printing hardcopy.

2 Click the **Cancel** button to close the dialog box.

Select the Print command from the Standard toolbar

1 On the Standard toolbar, click the **Print**  button.

The same **Print** dialog box appears again. Using toolbar buttons is often a faster way to access many commands in ER Mapper.

2 Click the **Cancel** button to close the dialog box.

Tip: Many common commands on the menu bar, such as Print, are also available on the Standard toolbar. Use whichever is fastest or most comfortable.

Display and hide a toolbar

1 From the **Toolbar** menu, select **Forestry**.

A third row of toolbar buttons appears on the main menu below the Standard and Common Functions toolbars. This toolbar has buttons for common image processing techniques used in forestry applications.

2 Point the cursor to any button on the toolbar.

A description of the button function displays in the small text field just below the cursor.

3 From the **Toolbar** menu, select **Forestry** again.

The Forestry toolbar buttons disappear from the main menu. Use the **Toolbar** menu to display or hide any toolbar. (It is recommended that you always display the Standard and Common Functions toolbars.)

2: Opening windows and algorithms

To display an image in ER Mapper, you first open an empty image window, then load and display an image processing algorithm. The algorithm references a raster data file on disk, and the processing steps ER Mapper uses to enhance and render the data on the screen display. (You will learn more about algorithms later.) You can have as many different image windows open on the screen as you need.

Objectives Learn to open image windows on your computer display, and open and run an image processing algorithm stored on disk.

Open a new empty image window

1 From the **File** menu, select **New**.

An empty image window opens in the upper left corner of the screen. The window title bar reads “Algorithm Not Yet Saved” because no processing algorithm is associated with this image window yet.

Open and display an image processing algorithm

1 From the **File** menu, select **Open...**.

The **Open** file chooser dialog box opens.

2 From the **Directories** menu, select the path ending with the text **\examples** (The portion of the path name preceding it is specific to your site.)

3 Double-click on the directory named ‘Data_Types’ to open it.

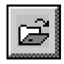
4 Double-click on the directory named ‘Landsat_TM’ to open it. (Scroll if needed to view it first.)

The list of example algorithms for processing Landsat Thematic Mapper (TM) satellite imagery displays.

5 Double-click on the algorithm named ‘RGB_321.alg.’ (Scroll down if needed to view it first.)

ER Mapper runs the algorithm and displays an enhanced Landsat TM image of San Diego, California in the image window. This algorithm displays bands 3, 2, and 1 of the Landsat image as an RGB color composite image, with band 3 in the red display channel, band 2 in the green, and band 1 in the blue. Notice also that the algorithm filename ‘RGB_321’ now appears in the title bar of the image window.

Use the toolbar to open a different processing algorithm

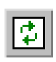
1 Click the **Open**  button on the Standard toolbar.

The **Open** file chooser dialog box appears. (This toolbar button has the same function as selecting **Open...** from the **File** menu.)

The algorithm named ‘RGB_321’ in the ‘Data_Types\Landsat_TM’ directory is already highlighted since it is currently loaded into the image window.

2 Double-click on the algorithm named ‘RGB_541.alg.’

ER Mapper runs the algorithm and displays a color composite of the same Landsat image, this time using bands 5, 4, and 1. Notice that the title bar also changes to show the filename of the new algorithm.

Note: By default, ER Mapper runs the algorithm automatically for you when you open it from disk. You can also reprocess the data at any time by clicking the **Refresh**  button.

3: Resizing windows and zooming/panning

Objectives Learn to move and resize image windows, zoom (magnify) part of an image, and pan (scroll) to other parts of an image.

Move the image window on the screen

1 Point the mouse at the image window title bar, then drag it to another part of the screen.

2 Drag the image back to the upper-left part of the screen.

Like dialog boxes, dragging images by the title bar is how you move them around the screen.

Resize the image window

1 Move the mouse pointer directly over the lower-right corner of the image window–the pointer shape changes to a double ended arrow.

2 Drag the lower-right corner to make the window about twice its original size, then release.

Dragging any side or corner of an image window lets you change the default window size as you desire.

Note: When you resize a window, ER Mapper maintains the size of the image inside the window. Empty areas on the sides are filled with a cross-hatch pattern to indicate that no data is displayed there.

Set the mouse pointer to Zoom mode

1 On the Common Functions toolbar, click the **Zoom Tool**  button.

This tells ER Mapper to use the mouse pointer for zooming when it is positioned inside an image window. Also notice that the **Zoom Tool** button becomes depressed to indicate that it is the active pointer mode.

2 Move the pointer inside the image window.

The mouse pointer displays as a magnifying glass icon.

Zoom in and out of the image with the mouse

1 Position the pointer in the center of the image, and click the left mouse button.

The image zooms in by 50%.

2 Position the pointer in the center of the image, hold down the Ctrl. key while clicking the left mouse button.

The image zooms out by 50%.

3 Position the pointer in the image, and then drag it up and down.

As you drag the pointer down the image is magnified, i.e you zoom into it. When you drag the pointer upwards, the image gets smaller, i.e you zoom out.

Set the mouse pointer to ZoomBox mode

1 On the Common Functions toolbar, click the **ZoomBox Tool**  button.

This tells ER Mapper to use the mouse pointer for creating a zoom box when it is positioned inside an image window. Also notice that the **ZoomBox Tool** button becomes depressed to indicate that it is the active pointer mode.

2 Move the pointer inside the image window.

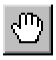
The mouse pointer displays as a magnifying glass and box icon.

Zoom in (magnify) an area of the image with the mouse

1 Position the pointer near the upper-left center of the image, then drag to the lower-right to define a box.

When you release the mouse, ER Mapper runs the algorithm again and magnifies (or “zooms in”) on the area of the image you defined with the box. Dragging a zoom box is a fast way to magnify an area of interest. (There are other zooming functions you will learn about later.

Set the mouse pointer to Hand mode

1 On the Common Functions toolbar, click the **Hand Tool**  button.

This tells ER Mapper to use the mouse pointer for panning when it is positioned inside an image window. Also notice that the **Hand Tool** button becomes depressed to indicate that it is the active pointer mode.

2 Move the pointer inside the image window.

The mouse pointer displays as a hand icon.

Pan (scroll) the image within the window with the mouse

1 Click on the image. and drag it to a new position in the image window.

The hand pointer will grab the image and move it (pan) to the new location.

Zoom back out to view the full image extents

1 From the **View** menu, select **Quick Zoom** and then select **Zoom to All Datasets**.

ER Mapper runs the algorithm again and zooms back out to display the full extents of the Landsat image data. The **Quick Zoom** submenu provides many options for zooming in or out to specific datasets, setting window geolinking, and other options you will learn more about later.

Zoom and pan using buttons for predefined options

In addition to using the mouse, ER Mapper also lets you zoom and pan using buttons to invoke predefined zoom and pan functions.

1 From the **View** menu, select **Geoposition...**.

The **Algorithm Geoposition Extents** dialog box appears.

Note: You can also click on the **Geoposition Window** button on the Algorithm window to open the **Algorithm Geoposition Extents** dialog box

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2 In the row of options at the top, click on the **Zoom** option to turn it on.

The contents of the **Algorithm Geoposition Extents** dialog change to show sets of buttons for zooming and panning the image within the window.

3 In the buttons labelled ‘Zoom,’ click the **Zoom out 50%** button.

ER Mapper runs the algorithm and zooms out to 50% of the previous display resolution.

Tip: For all icons on buttons under ‘Zoom’ and ‘Pan,’ the black square represents the current image, and the white box represents how the size or position of the image will change after the button is clicked.

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4 In the buttons labelled ‘Set Extents To,’ click **Previous**.

ER Mapper zooms out to the previous image display extents.

5 Under ‘Zoom,’ click on the **Zoom in 100%** button.

ER Mapper magnifies the images to two times (100%) of the previous display resolution (and keeps the image center point constant).

6 Under ‘Pan,’ click on the **Pan left** button.

ER Mapper pans or scrolls the image 50% to the left (the previous center point is now on the far right side of the image).

7 Under ‘Pan,’ click on the **Pan upper-right** button.

ER Mapper pans the image 50% to the upper-right (the previous center point is now on the lower-left corner of the image).

8 Experiment with other buttons under Zoom and Pan to see their effect.

9 Under ‘Set Extents To,’ click the **All Datasets** button.

ER Mapper resets the image extents to fit the entire dataset in the image window.

10 Click **Close** on the **Algorithm Geoposition Extents** dialog to close it.

4: Managing multiple image windows

Objectives Learn to open a second image window, specify overlap priority between windows, activate an image window, and close image windows.

Open a second image window

1 From the **File** menu, select **New**.

ER Mapper opens a new image window. As with all new image windows, it has no algorithm associated with it yet.

Open and display a processing algorithm in the new window

1 From the **File** menu, select **Open...**.

The **Open** file chooser dialog box appears.

2 From the **Directories** menu, select the path ending with the text **\examples**.

3 Double-click on the directory named ‘Data_Types’ to open it.

4 Double-click on the directory named ‘SPOT_Panchromatic’ to open it.

The list of example algorithms for processing SPOT Panchromatic satellite imagery displays.

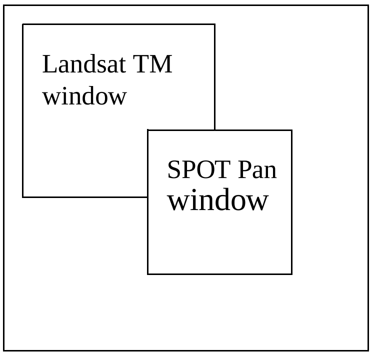
5 Double-click on the algorithm named ‘Greyscale.alg.’

ER Mapper runs the algorithm and displays a SPOT Panchromatic satellite image the San Diego (the same geographic area covered by the Landsat image in the other window). The SPOT Pan data provides greater spatial detail than the Landsat data, but has only one spectral band which is displayed in greyscale.

Move the SPOT window to overlap with the Landsat window

1 Drag the image window titled ‘Greyscale’ to the center of the screen until it partially overlaps with the Landsat ‘RGB_541’ image window.

Your windows should be similar to the following diagram:



Move one window in front of the other

1 Click on the title bar of the window with the algorithm description titled ‘RGB_541.’

The Landsat window moves in front of the SPOT window where there is overlap.

2 Click on the title bar of the window with the algorithm description ‘Greyscale.’

The SPOT window now moves in front of the Landsat window where there is overlap. Clicking on the title bar of a window or dialog box bar lets you choose which window or dialog box to display on top of others.

Select a window to be the active window

The “active” image window is the one you want to currently work with, such as zooming, loading a new processing algorithm, or editing the current algorithm.

1 Look at the title bar of the SPOT Panchromatic window and notice the three asterisks (***) on either side of the window title.

The three asterisks indicate that this is the active (or current) window of the two.

2 Move the pointer inside the image area of the window with the algorithm description titled “RGB_541.”

The pointer shape changes to a pointing hand. (This happens whenever you move from the active window to any inactive image window.)

3 Click anywhere inside the Landsat image window or on the Title Bar.

It now becomes the active window and three asterisks appear next to the title.

4 Click inside the SPOT window or on the Title Bar again to make it active.

Note: A window can be active and still be covered by another “inactive” window. To move the active window to the front, click on its title bar.

Close both image windows

1 Close one image window using the window system controls:

- Select **Close** from the window control-menu.

  The window closes and disappears from the screen.

2 Close the other image window by repeating Step 1.

The window closes and disappears from the screen. Only the ER Mapper main menu is now open.

What you learned

After completing these exercises, you know how to perform the following tasks in ER Mapper:

- Choose options from menus and toolbar buttons
- Display and hide toolbars
- Open an empty image window
- Open an image processing algorithm into a window
- Move and resize an image window
- Zoom and pan the image within the window
- Manipulate multiple image windows on the screen

3

Creating an algorithm

This chapter introduces the basic concepts involved in creating a simple image processing algorithm. You learn about the interface ER Mapper provides for creating and editing algorithms (the Algorithm window). As an application example, you learn how to create an algorithm that processes a Landsat TM satellite scene to render an image showing patterns of vegetation in the area (a "vegetation index" image).

Note: This lesson is a "quick start" for creating a simple algorithm. You learn more about the concepts and procedures covered here in later chapters.

About the algorithms concept

The goal of all image processing is to enhance your data to make it more meaningful and help you extract the type of information that interests you. To make this procedure faster and easier, Earth Resource Mapping developed a new image processing technique called "algorithms." Understanding how to use algorithms is the key to understanding how to use ER Mapper effectively.

What is an algorithm?

An algorithm is a list of processing steps or instructions ER Mapper uses to transform raw data on disk into a final, enhanced image. In this sense, algorithms let you define a “view” into your data that you can save, reload, and modify at any time.

You use ER Mapper's graphical user interface to define your list of processing steps, and you can save the steps in an algorithm file on disk. An algorithm file can store any of the following information about your processing:

- Names of image dataset(s) to be displayed
- Subsets of the image dataset(s) to be processed (zoomed areas)
- Bands in the image dataset(s) to be processed
- Brightness and contrast enhancements (Transforms)
- Filtering to be applied to the data (Filters)
- Equations and combinations of bands or images used to create the output image (Formulae)
- Color mode used to display the data (Pseudocolor, Red Green Blue, or Hue Saturation Intensity)
- Any vector images, thematic color, or map composition layers to be displayed over the raster image data
- Definition of a page size and margins (used for positioning the image on a page for creating maps and printing)

By being able to apply a set of processing steps as a single entity, the complexity often associated with digital image processing is greatly reduced. In addition, you gain tremendous savings in disk space, since you do not need to store intermediate processed copies of your original data on disk.

Building Algorithms in ER Mapper

There are two primary ways to build a processing algorithm in ER Mapper:

- Use the **Algorithm** window to add the desired types of layers, load images, and specify processing steps for each layer.
- Click a toolbar button to have ER Mapper automatically create an algorithm for you. In this case, ER Mapper adds the appropriate layers to the **Algorithm** window, prompts you to load an image, and possibly other options as well.

The majority of exercises in this manual ask you to build algorithms from scratch so you become familiar with and thoroughly understand the basic concepts. However, you will also use the automatic algorithm creation toolbar buttons from time to time to understand how they work.

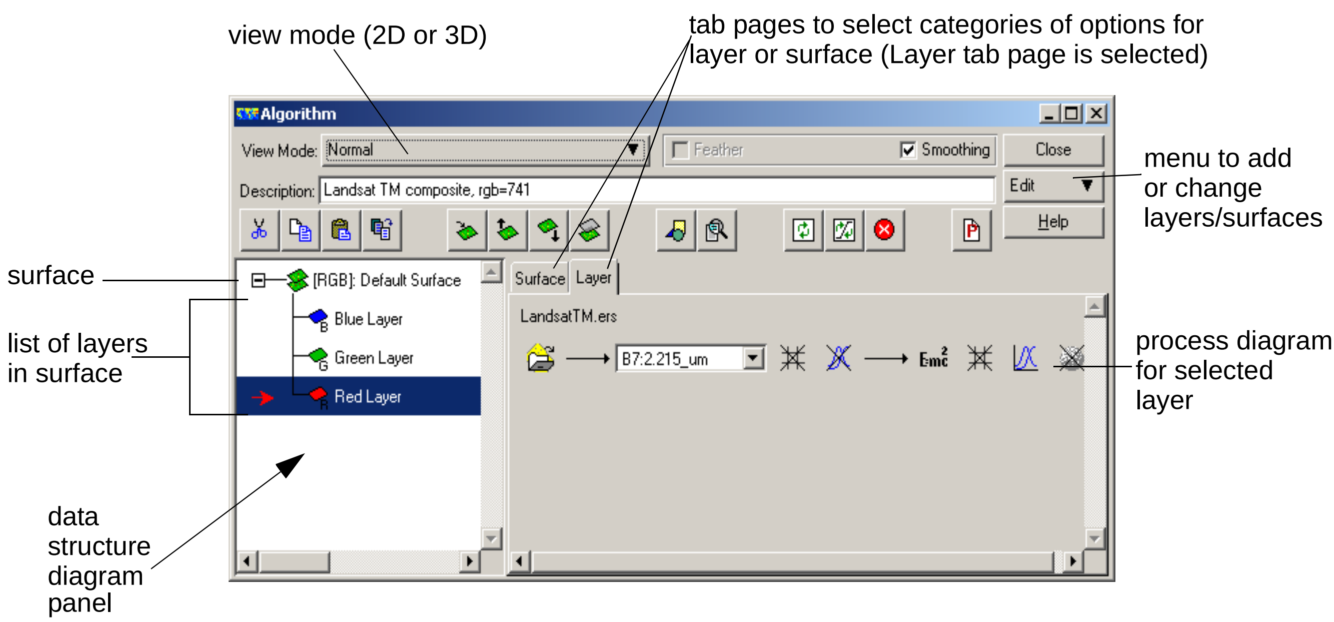
Using Algorithms as Templates

Once you have saved your processing instructions as an algorithm file, you can use the algorithm as a “template” to easily apply the same processing to different images. Any algorithm can be used as a template, but ER Mapper also provides many template algorithms for common tasks. These include common display techniques (RGB, single band greyscale, etc.), writing processed image files to disk, and saving algorithms as “virtual datasets.” Using template algorithms saves time, and you will learn more about them in later lessons.

In addition, the toolbar buttons allow you to create various types of common algorithms very quickly. You will learn more about using toolbar buttons for these tasks later.

The Algorithm window

The **Algorithm** dialog is a special dialog box that serves as your “command center” for creating and editing algorithms in ER Mapper. To open the **Algorithm** dialog, you can select **Algorithm...** from the **View** menu or click the **Edit Algorithm** toolbar button. The key components of the **Algorithm** dialog are labelled below and described in the table that follows.



Data structure diagram Shows a list of surfaces and layers contained in the current algorithm using a hierarchy or “tree” structure. Select (click on) a surface or layer change its options using the Tab pages.

Surface	A group of raster and/or vector data layers that combine to create a view or image. A single algorithm can have multiple surfaces that become independent entities when viewed in 3D mode.
Layers	Components of a surface that contain data used to construct an image. Different layer types can contain raster or vector data, and processing for each layer is controlled independently from the others.
View Mode	Sets the manner in which data is displayed as two dimensions (2D) normal or page layout, or three dimensions (3D).
Tab pages	Display categories of options for controlling the image display and processing techniques, such as Layer for options for the current layer, or Surface for options that apply to an entire surface.
Process diagram	Used to control the processing operations applied to image(s) in the currently selected layer (displayed when Layer tab is selected).

The Process Diagram

When the Layer tab is selected, the horizontal row of buttons in the right-hand panel of the **Algorithm** dialog are called the *process diagram*. They are used to define your image processing operations for the currently selected data layer. Each button in the diagram controls a specific image processing function.

As the arrows indicate, the processing stream flows from left to right. Typically, you may specify an image to be used, the bands within the image to be processed, then apply processing using formulae, filters, transforms or other options to create your desired image. ER Mapper compiles all the processing steps you specified and renders the resulting image to the screen display. The name and function of the main processing stream buttons are as follows.

Button	Function
Dataset 	Use to load an image from disk, or edit or view information or comments about an image.
Band Selection 	Use to select one or more bands in the image for use in generating an image (a drop-down list).
Formula 	Use to enter, load, or save a formula to perform image algebra and other arithmetic operations.

Button	Function
Filter	Use to add or delete one or more spatial filters. (There are both pre- and post-formula Filter buttons.)
Transform	Use to adjust image contrast and brightness. (There are both pre- and post-formula Transform buttons.)
Sunshade	Use to specify artificial illumination of the image to create shaded relief effects.

Note: A cross or “X” through the button indicates that the function is not active in the current data layer. In addition, there are other buttons for some layer types that you will learn about later in this manual.

Hands-on exercises

These exercises show you how to initially display an image, and how to build, save, and reload a simple image processing algorithm. It also shows how you can easily change the image to view it in 3D perspective.

Note: These exercises briefly introduce concepts and procedures that are explained in more detail later in this workbook.

What you will learn...

After completing these exercises, you will know how to perform the following tasks in ER Mapper:

- Load a new image and choose which bands to display
- Use the **Algorithm** dialog to define a processing algorithm
- Change the color lookup table for an image
- Add a formula to an algorithm
- Add text labels and comments to an algorithm
- Save the processing algorithm to disk
- Reload and view the saved algorithm

- Add a Height layer to view the image in 3D perspective

Before you begin... Before beginning these exercises, make sure all ER Mapper image windows are closed. Only the ER Mapper main menu should be open on the screen.

1: Loading and displaying images

Objectives Learn to open an image window and the **Algorithm** window, load an image dataset, and display the image on-screen. You will also learn to display different bands in the image, and change the lookup table ER Mapper uses to assign colors to the image.

(Part 1 shows you how to load an image from disk and display it on-screen for an initial look at the data. The image was previously imported from a magnetic tape or other media and now resides on the computer's hard disk. Details on importing data are discussed in the other ER Mapper manuals.)

Open an image window and the Algorithm window

1 From the **View** menu, select **Algorithm...**.

A new empty image window opens in the upper-left corner of the screen, and the **Algorithm** window opens in the lower-right.

Note: ER Mapper remembers where you last positioned dialog boxes on your screen. Therefore the Algorithm window could be positioned differently to what is described above.

The Layer tab is usually already selected when you first open the Algorithm dialog box. Note that the **Algorithm** window shows one Pseudocolor layer (labelled “Pseudo Layer”) in the left of the dialog, with the red arrow pointing to it meaning that is the active layer.

If you open the Algorithm window when no image windows are currently open (as in this case), ER Mapper opens an empty image window for you automatically. This shortcut saves you the step of opening a window.

Load a raster image into the Pseudocolor layer

1 In the **Algorithm** window, click the **Load Dataset**  button on the left side of the process stream diagram.

The **Raster Dataset** file chooser dialog box appears.

2 From the **Directories** menu, select the path ending with **\examples**.

The scrolling list in the center now shows a list of directories containing example images supplied with ER Mapper (such as ‘application...’ and others).

3 Double-click on the directory named ‘Shared_Data.’

A list of raster images is displayed. Note that each has a “.ers” file extension. This is the file extension associated with raster files in ER Mapper format.

4 Scroll down to view the image named ‘Landsat_TM_year_1985.ers,’ then double-click on it to load it.

The file chooser dialog box closes, and the image is loaded into the Pseudocolor layer. Note that the layer now shows the name of the image loaded (‘Landsat_TM_year_1985’), and the button left of the name is now selected (indicating that the layer is *turned on*).

ER Mapper renders the image in the image window. The image is displayed in a range of colors because the color table named **Pseudocolor** is chosen.

Note: ER Mapper remembers the last color table selected. Therefore, it might not be Pseudocolor as described above.

Also note that **Band Selection** drop-down shows the label ‘B1:0.485_um.’ This indicates that band 1 of the Landsat image is currently selected for the layer.

Select and display different bands in the Landsat image

Landsat Thematic Mapper (TM) satellite images usually contain seven spectral bands. You can choose to display any band (or a combination of bands) in a raster data layer.

1 In the **Algorithm** window, click on the **Band Selection** 

drop-down list in the process stream diagram.

A menu listing the seven different bands in the Landsat image displays.

2 Click on the band labelled **B2:0.56_um**.

The menu closes and the new band appears in the **Band Selection** list button.

ER Mapper renders band 2 of the Landsat image in the image window. (The colors look different to those for band 1 because the range of data for band 2 is different than band 1. (You will learn about data ranges and how to adjust image brightness and contrast later.)

3 From the **Band Selection** drop-down list, select the band labelled **B7:2.215_um**.

ER Mapper renders band 7 of the Landsat image in the image window.

4 From the **Band Selection** drop-down list, again select the band labelled **B1:0.485_um**.

ER Mapper renders band 1 of the Landsat image again.

Tip: The **Stop Processing** button or Esc key can be useful when you make a mistake, or when you want to take a quick look at the results without waiting for processing of the entire image to finish. Change the Color Table (on Surface Tab).

Press the **Refresh Image** button for the processing to continue.

When you are using the **Color Mode** named Pseudocolor (as you are in this example), the **Color Table** controls the set of colors ER Mapper uses to display the image.

5 In the **Algorithm** window, click on the **Surface tab** and then click on the **Color Table** drop-down list button.

A menu listing available color lookup tables appears.

6 Click on the lookup table named **green**.

ER Mapper renders the image using shades of green. Lower data values display as darker shades of green, and higher data values as lighter shades.

Note: When you change the color table, ER Mapper updates the image display automatically to apply the new set of colors.

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7 From the **ColorTable** drop-down list, select **brown_green**.

ER Mapper renders the image using shades of brown for low data values transitioning into shades of green for higher data values.

8 From the **Color Table** list, select **greyscale**.

ER Mapper renders the image using shades of grey. Lower data values display as darker grey shades, and high data values as lighter greys.

In Part 1, you have created the simplest type of algorithm: a Pseudocolor algorithm that displays a single band of data using a color lookup table to control the image coloring. You have not saved the algorithm yet because you will modify it later.

2: Processing the image

Objectives Learn to develop a simple processing algorithm using a formula to highlight vegetation in the image, and to modify the image contrast and brightness on the screen display.

Load a vegetation index formula into the layer

1 In the **Algorithm** window, click on the **Layer tab** and then click on **Edit Formula** in the process stream diagram.

The **Formula Editor** dialog box appears to let you use standard image processing formulas or create your own formulas. The menu bar at the top gives you fast access to many formulas. Note that the current formula simply reads 'INPUT1.' (You will learn more about formulas later.)

2 From the **Ratios** menu, select **Landsat TM NDVI**.

A new formula replaces the original one, and its description appears at the top. (This formula is called the Normalized Difference Vegetation Index, or NDVI. It uses information in bands 3 (red) and 4 (near infrared) of the Landsat image to highlight information on vegetation location and abundance.)

All data is initially displayed as very dark shades of grey in the greyscale lookup table because the formula processing produces a narrow range of data values (-1 to +1). You will now enhance the image to increase its contrast.

3 Click the **Close** button to close the **Formula Editor** dialog.

Adjust the image contrast

1 In the **Algorithm** window, click on the **Layer tab** and then click on the right-hand **Edit Transform Limits** button (there are two, choose the one right of the **Formula** button).

The **Transform** dialog box opens. Note that the field Actual Input Limits at the bottom shows a data range of about -1 to +0.6. This is the range of data values produced after the raw Landsat image data was processed through the NDVI formula. You need to tell ER Mapper to map the shades of gray in the lookup table to this range instead of the 0-255 default data range currently shown along the X or horizontal axis of the histogram.

2 From the **Limits** menu, select **Limits to Actual**.

The X axis data range changes to match the -0.8 to +0.6 limits of the data after the NDVI formula processing.

ER Mapper renders the image again, this time with enhanced contrast. In addition, a histogram showing the relative frequency of data values for the processed image appears in the center of the **Transform** dialog.

Areas of vegetation in the image are highlighted in light gray or white, and areas with little or no vegetation (such as water) appear very dark. You will increase the contrast between the light and dark areas even further.

3 On the **Transform** dialog, click the **Create autoclip transform** button.

Contrast between the light and dark areas further increases. The lightest shades (densely vegetated areas) are now white and darkest shades (non-vegetated areas) are black, making the patterns of vegetation easier to interpret.

4 Click the **Close** button to close the **Transform** dialog box.

Note: You will learn more about histograms, data ranges and contrast enhancements later in this manual.

3: Labelling and saving the algorithm

Objectives Learn to specify description labels, titles, and comments for an algorithm, and save the algorithm processing steps to a file on disk for later use.

Enter a description for the Pseudocolor layer

1 In the **Algorithm** window, on the left side of the data structure highlight the layer and click on the description with the Pseudo Layer.

The pointer turns into a text cursor, indicating that the area is a text field.

2 Type the text **`NDVI`** in the text field, then press the Enter or Return key on your keyboard.

This text now becomes a visual description for the layer.

Note: Layer descriptions are also used to specify labels for bands when you write an image to disk or save it as a Virtual Dataset. You will learn about this later.

Enter a description for the surface

1 In the **Algorithm** window, on the left side of the data structure highlight the surface and click on the "[Ps]: Default Surface" description.

The pointer turns into a text cursor, indicating that the area is a text field.

2 Type the text **`Surface 1`** in the text field, then press the Enter or Return key on your keyboard.

This text now becomes a visual description for the surface. Note that the "[Ps]:" prefix remains, indicating that the surface Color Mode is Pseudocolor.

Enter a description for the entire algorithm

1 In the **Algorithm** window, select the text in the **Description** text field (it currently reads 'No Description').

(To select the text, either drag through it, or triple-click to select the entire line.)

2 Type the following text, then press Enter or Return on your keyboard:

```
San Diego vegetation index
```

This text now becomes a brief description for the entire algorithm.

Save the processing steps to an algorithm file on disk

1 From the **File** menu (on the main menu), select **Save As...**.

The **Save As...** file chooser dialog box appears.

2 In the **Files of Type:** field, select 'ER Mapper Algorithm (.alg)'.

3 From the **Directories** menu, select the path ending with the text **\examples**. (The portion of the path name preceding it is specific to your site.)

4 Double-click on the directory named 'Miscellaneous' to open it.

5 Double-click on the directory named 'Tutorial' to open it.

6 In the **Save As:** text field, click to place the cursor, then type in a name for the algorithm file. Use your initials at the beginning, followed by the text 'Landsat_NDVI,' and separate each word with an underscore (_). For example, if your initials are "JC," type in the name:

```
JC_Landsat_NDVI
```

7 Click the **Apply** button to save the algorithm and leave the dialog open.

Your Landsat NDVI algorithm is now saved to an algorithm file on disk.

Add comments to the algorithm

1 Click the **Comments...** button.

A dialog box appears showing the algorithm file name with a text area for you to type comments about your algorithm. The cursor is already active in the upper-left corner.

2 Click **Cancel** on the **Save Algorithm** dialog to close it (you do not need it).

3 In the Comments dialog, type the following information about your algorithm:

```
This algorithm uses the Normalized Difference Vegetation
Index (NDVI) formula to highlight vegetation in a Landsat
TM image of San Diego. Areas with abundant vegetation
appear as lighter shades of grey.
```

4 Click the **OK** button to save your comments with the algorithm.

5 Click **Cancel** on the **Save Algorithm** dialog to close it.

(If you accidentally click **OK**, click **Cancel** when asked to overwrite the file. Otherwise your comments will not be saved with the algorithm file.)

4: Reloading and viewing the algorithm

Objectives Learn to reload and display the algorithm you just created, and to view the text file on disk that defines the algorithm processing steps.

Open a second image window

1 On the Standard toolbar (on the main menu), click on the **New** button.

ER Mapper opens a new image window (this is a shortcut for selecting **New** from the **File** menu). Drag the new window to the lower left part of the screen (so you can see all or part of the other image window).

Open the processing algorithm you created earlier

1 On the Standard toolbar, click on the **Open** button.

The **Open** file chooser appears. (This is a shortcut for selecting **Open...** from the **File** menu.)

2 From the **Directories** menu, select the path ending with the text **\examples**.

3 Double-click on the directory named ‘Miscellaneous’ to open it.

4 Double-click on the directory named ‘Tutorial’ to open it.

Your Landsat NDVI algorithm should appear in the list.

5 Click once on your algorithm name to highlight it (do not double-click).

6 Click the **Apply** button to load and process the algorithm without closing the **Open** dialog box.

ER Mapper runs the algorithm and displays the processed Landsat image in the image window. It should look identical to the other image since they both use the same algorithm and input image.

View the algorithm comments

1 On the **Open** dialog, click the **Comments...** button.

A dialog box opens showing the comments you entered for your algorithm. These comments can be very helpful to others who use or display your algorithm, and they are a good way to document the procedures you used to create it.

2 Click **Cancel** to close the comments dialog box.

5: Viewing the image in 3D perspective

Objectives Learn to create a 3D perspective view of the vegetation index image by adding a Height layer containing a digital elevation image.

About 3D perspective viewing

Up until now you have viewed your images using conventional 2D planimetric views. ER Mapper makes it very easy to view images in 3D perspective by simply adding a height (or elevation) component to your algorithm. The following is a very simple introduction to the 3D viewing features, and you will learn more about them in later chapters.

Display the vegetation image in brown and green

1 In the **Algorithm** dialog, select the **Surface** tab.

2 From the **Color Table** drop-down list, select **brown_green**.

ER Mapper redisplays the image. Areas with no or little vegetation (such as ocean) display as brown, and vegetated areas like parks and canyons are bright green.

3 In the **Algorithm** dialog, select the **Layer** tab again.

Add a Height layer to the algorithm

1 On the **Algorithm** dialog, open the **Edit** menu, select **Add Raster Layer**, then select **Height**.

A second layer named ‘Height Layer’ is added to the algorithm. Height layers are only valid in 3D view modes, so the layer is currently inactive (crossed out).

Load a digital elevation image into the Height layer

1 With the Height layer selected, click the **Load Dataset**  button in the process diagram.

The **Raster Dataset** dialog opens.

2 From the **Directories** menu (on the **Raster Dataset** dialog), select the path ending with **\examples**.

3 Open the ‘Shared_Data’ directory, then double-click on the image ‘Digital_Terrain_Model.ers’ to load it.

The digital elevation model (DEM) image is loaded into the Height layer.

Select 3D perspective View Mode to view the image in 3D

1 From the **View Mode** menu (on the **Algorithm** dialog), select **3D perspective**.

ER Mapper displays a message that the image is being processed, then displays a 3D perspective view of the image. The message “Regenerating Terrain” appears in the image window as ER Mapper performs iterations to increase the resolution (detail) in the 3D image.

The right-hand panel in the **Algorithm** dialog now has two additional tabs–**3D View** and **3D Properties**. These contain controls specifically for 3D viewing of images.

Turn off the 3D lighting option

1 In the **Algorithm** dialog, select the **3D View** tab.

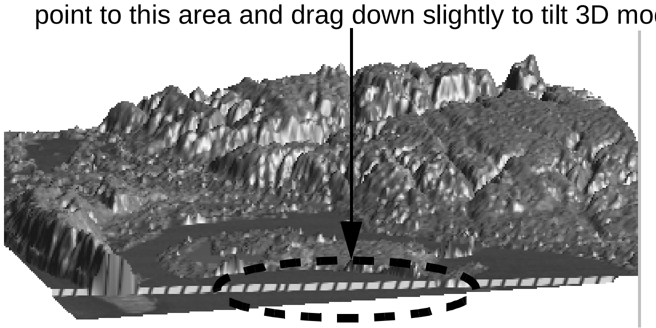
2 Turn off the **Lighting** option button.

The image redisplays without artificial lighting. (Although this is sometimes desirable, it can also obscure subtle features.)

Change the perspective viewing angle

1 Click on the **Hand Tool** button on the **Standard** toolbar, if it is not already selected.

2 Point to the lower part of the 3D image, and drag down slightly to tilt the 3D view (see following diagram).



The 3D image tilts downward, so you are now looking more from an overhead viewpoint. You can use the mouse to manipulate the viewpoint, zoom in and out, rotate the image, and other controls (discussed in detail later).

This is a simple 3D algorithm that lets you quickly see the relationship between terrain features and vegetation in the San Diego area. You can see, for example, that natural vegetation still occurs in the many of the narrow canyons and hillsides next to developed areas.

Select 2D View Mode to view the image in 2D again

1 From the **View Mode** menu in the Algorithm window, select **Normal**.

ER Mapper redisplays the image in a two-dimensional planimetric view again.

Note: This 3D exercise was a simple introduction to show how easy it can be to view data in 3D perspective in ER Mapper. You will learn more about the 3D capabilities and controls later.

Close the image and Algorithm dialog windows

1 Close the image window using the window system controls:

- Click the **Close** button in the upper-right window corner.

The window closes and disappears from the screen.

2 Click **Close** on the **Algorithm** dialog.

Only the ER Mapper main menu is now open.

What you learned...

After completing these exercises, you know how to perform the following tasks in ER Mapper:

- Load a new image and choose which bands to display
- Use the **Algorithm** dialog to define a processing algorithm
- Change the color lookup table for an image
- Add a formula to an algorithm
- Add text labels and comments to an algorithm
- Save the processing algorithm to disk
- Reload and view the saved algorithm
- Add a Height layer to view the image in 3D perspective

4

Working with data layers

This chapter introduces you to the concept of data layers in ER Mapper, and gives you practice using them. You will learn to load data into layers, turn layers on and off, specify layer priority during processing, and add, move, and delete data layers in an algorithm.

Note: This chapter focuses on the use of raster data layers for displaying and manipulating images. Use of vector layer types for displaying GIS data and annotation are covered later in this manual.

About data layers

In ER Mapper, you build your image display by creating one or more 'layers' of data in the **Algorithm** window. The various data layers combine to create a final image on your screen display or output to your hardcopy device.

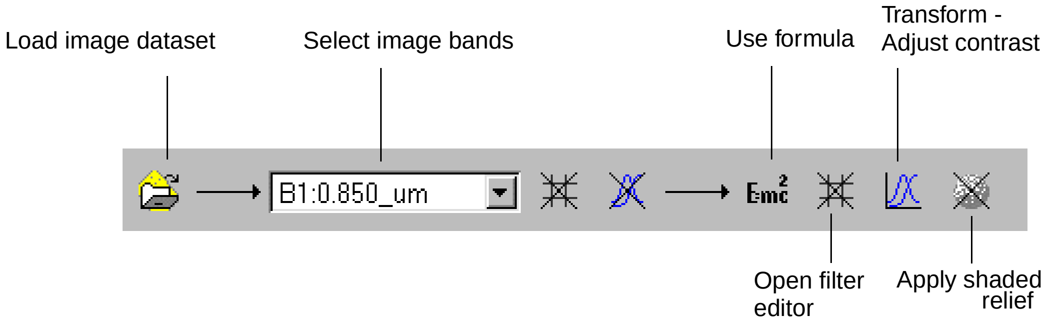
To view process stream diagram of a layer click on the Layer Tab and select the layer from the left side of the Algorithm window. Each layer in an algorithm can have different processing and use different image datasets. The simple algorithm you developed in Chapter 3 had only one layer (a Pseudocolor layer), but other types of algorithms can have several data layers. For example, an image displayed in RGB (red-green-blue) has three data layers–one for the red image component, one for the green, and one for the blue. Layers can also contain other types of data that you want to overlay on your image, such as GIS vector or tabular data, and annotation or map composition objects.

Each layer in your algorithm can be manipulated independently from the others using the process stream buttons associated with that layer. This flexibility is one of the key features in ER Mapper that makes it easy to build and fine tune complex image processing algorithms.

Typically, you build an algorithm by first defining one or more layers to display your raster image data, such as satellite images or digitized aerial photos. Then you can add additional layers to display vector data (such as a road network), tabular data (such as sample site locations), and layers to annotate your image with text, coordinate grids, and so on.

Layer controls

If you click on the layer tab, the process diagram of the current layer appears. Each layer in an algorithm has a common set of information and controls provided on the layer itself:



To turn a layer off, click on the **Turn On/Off button**  on the Algorithm window or click the right hand mouse button on the layer to display the **Short-cut Menu** and select **Turn Off**. .

About color modes

ER Mapper uses a concept called the “Color Mode” that defines the manner in which layers containing raster data are displayed. To define a particular type of image display, you choose the appropriate types of layers and the appropriate Color Mode. Color Mode is located in the Surface tab on the **Algorithm** window. Click on the Surface tab and you will see the Color Mode, the Color Table and the Transparency(%) with a slide button.

Color Mode options (in Surface Tab)

ER Mapper provides three Color Mode options in Surface Tab, and each is designed to display and manipulate raster image data in a different way. The Color Mode setting must usually correspond with the type of data layers you are using. For example, if you are working with Pseudocolor layers, your Color Mode must be set to Pseudocolor. The three Color Modes are:

Color Mode	Function
Pseudocolor	Designed to display a single layer of raster data; image colors are controlled by the current Lookup Table setting.
Red Green Blue	Designed to display raster data in Red Green Blue (RGB) color space. The image colors are built using separate layers for the red, green, and blue color planes (or color guns) of the computer display.
Hue Saturation Intensity	Designed to display raster data in Hue Saturation Intensity (HSI) color space. The image colors are built using separate layers for hue (color), saturation (color purity), and intensity (color brightness).

About data layers

ER Mapper provides several types of data layers, each designed to display a particular format of data (raster, vector, tabular), or display raster image data in a particular way. In general, there are two types of layers:

- *Raster layers* display image or pixel datasets, and the displayed image is often the result of combining two or more types of raster layers (for example, red, green, and blue)
- *Vector layers* display GIS, line, tabular (point), and map composition data, and always cover raster data underneath them where there is overlap

Raster layer types

Many of the raster layer types are only valid with a certain Color Mode setting. If the layer is not valid with the current Color Mode, ER Mapper automatically dims that layer on the Algorithm window and does not use it during processing. The types of raster layers and the valid Color Modes associated with them are listed in the table below:

Raster layer	Function	Valid Color Modes
Pseudocolor	Displays raster data, colors are controlled by the current Lookup Table	Pseudocolor
Red	Displays raster data in the display’s red color channel	Red Green Blue
Green	Displays raster data in the display’s green color channel	Red Green Blue
Blue	Displays raster data in the display’s blue color channel	Red Green Blue
Hue	Displays raster data; controls the “color” component (red, yellow, green, etc.) of the displayed image	Hue Saturation Intensity
Saturation	Displays raster data; controls the “color purity” component (pastel or pure colors) of the displayed image	Hue Saturation Intensity
Intensity	Displays raster data; controls the “brightness” component (lightness or darkness) of the displayed image	all
Height	Controls the third dimension elevation (or “z-value”) of an image viewed in 3-D perspective.	all
Class Display	Displays a raster image created with ER Mapper’s Supervised or Unsupervised Classification functions	all
Classification	Displays a solid color thematic overlay generated from raster data over other raster overlays	all

Tip: You can quickly change any raster layer in an algorithm from one type to another by using the **Layer Type** drop-down list from Edit/Change Raster Layer menu or from the Short-Cut menu which appears after clicking the right mouse button on the highlighted layer.

Vector layer types

Vector layers are used to display map annotation and data from external products or vector file formats. All vector layers are always drawn on top of any raster layers, regardless of their position among other layers in the Algorithm window. Vector layers are not affected by the Color Mode setting (those apply to raster layers only). The following are the main types of vector layers:

Vector layer type	Function
Annotation/Map Composition	Create color annotation (lines, circles, text, etc.) and map composition objects (scale bars, north arrows, etc.). Also used to display files in ER Mapper vector format (with a ".erv" file extension).
Region overlay	Define region polygons (areas of interest) for a raster image, or display existing regions and names.
ARC/INFO overlay	Display, edit, and save vector data stored in the native "coverage" format of the ARC/INFO GIS software.
Dynamic Links	Display vector or tabular data from other software products or file formats such as DXF or PostScript.

Note: There are additional types of vector layers used less frequently; these are not covered in detail in this manual. You can add any of the Vector layer types from the drop down list which appears after clicking the Edit/Add Vector layer menu.

Selecting and Modifying Data Layers

To modify a data layer, you must first select it by clicking on it. A shaded box then appears surrounding the layer to indicate that it is selected. You must first select a layer before you can load a new image dataset into it or modify it's process stream.

Note that a layer may become inactive if you change the Color Mode in the Surface Tab to an option that is not valid for that layer. When a layer becomes inactive, its text appears dimmed or "greyed out" on the **Algorithms** window. For example, if you change the Color Mode to Red Green Blue, any Pseudocolor overlays become inactive since Pseudocolor overlays are only valid with a Pseudocolor Color Mode. Inactive layers are ignored during processing (similar to being turned off).

Hands-on exercises

These exercises give you practice using and manipulating raster data layers in ER Mapper. Understanding how to work with layers is an important step in understanding how to build and use algorithms.

What you will learn...

After completing these exercises, you will know how to perform the following tasks in ER Mapper:

- Turn data layers on and off
- Load an image into one or several raster layers
- Add, delete, and move layers
- Change a raster layer from one type to another

Before you begin...

Before beginning these exercises, make sure all ER Mapper image windows are closed. Only the ER Mapper main menu should be open on the screen.

1: Turning layers on and off

Objectives

Learn to turn data layers *on* to include them in processing and *off* to exclude them from processing. Also learn how the status of layers can change if the Color Mode changes.

Open an image window and display a mosaic algorithm

1. From the **File** menu, select **Open...**.

   An image window and the **Open** file chooser dialog box appear.

2. From the **Directories** menu, select the path ending with the text **\examples**.
3. Double-click on the directory named ‘Functions_And_Features’.
4. Double-click on the directory named ‘Data_Mosaic’.
5. Double-click on the algorithm named ‘Interactive_mosaic_of_4_datasets.alg.’

ER Mapper opens and displays the algorithm.

This algorithm displays a mosaic of four separate image datasets that partially overlap with each other. Each image is loaded into its own Pseudocolor data layer, so it can be controlled independently from the other images. (You will learn more about creating mosaics of two or more images later.)

Open the Algorithm window to view the data layers

1 From the **View** menu, select **Algorithm...**.

The **Algorithm** window appears showing four Pseudocolor data layers.

2 If needed, make the **Algorithm** window taller until all four layers are clearly visible at once. (Drag the top window border upward.)

Turn overlays off to exclude them from processing

1 In the **Algorithm** window, with the Layer tab selected, click on the left side of the layer containing the image named ‘Mosaic_TM’ to select it.

A dark border surrounds the layer, indicating that it is selected.

2 Click your right mouse button on the highlighted layer and the **Short-Cut** menu will appear. Turn the ‘Mosaic_TM’ layer off by selecting the **Turn Off** option from the **Short-Cut** menu.

The layer is now turned off, so ER Mapper will ignore it during processing.

ER Mapper reprocesses the mosaic algorithm so that the data in the upper-right portion of the image window (a portion of a Landsat TM image) is not displayed. Since the layer containing the ‘Mosaic_TM’ image is turned off, its data no longer appears as part of the mosaic.

3 In the **Algorithm** window, click on the left side of the layer containing the image named ‘Mosaic_XS’ to select it.

4 Click the right mouse button on the selected layer and turn off the ‘Mosaic_XS’ data layer from the Short-Cut menu.

This time the data in the lower portion of the mosaic (a portion of a SPOT XS image) does not display since its layer is turned off.

Turn overlays on to include them in processing

1 In the **Algorithm** window, click to select the layer containing the image named ‘Mosaic_TM.’

2 Turn the ‘Mosaic_TM’ layer on again (click the right mouse button on the selected layer and select **Turn On**, from the Short-Cut menu).

The Landsat TM satellite data again displays in the upper-right portion of the image window since its layer is now turned on.

3 Click to select the layer containing the image named ‘Mosaic_XS.’

4 Turn the ‘Mosaic_XS’ layer on again.

The SPOT XS satellite image again displays in the lower portion of the mosaic.

Change the Color Mode to see how it affects layers

1 In the **Algorithm** window, from the Surface Tab select **Red Green Blue** from the **Color Mode** drop-down list.

All four Pseudocolor layers display a hatched pattern (diagonal lines), indicating that they are no longer valid with the current Color Mode.

Note: Whenever raster layers are not valid with the current **Color Mode** in the Surface Tab, they become hatched (inactive) on the **Algorithm** window. ER Mapper treats inactive layers as if they are turned off.

---

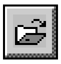
2 On the Surface Tab from the **Color Mode** drop-down list, select **Pseudocolor**.

ER Mapper reprocesses the algorithm and displays the image with all the layers active.

2: Loading data into layers

Objectives Learn to load an image into a particular layer or set of layers in an algorithm. Also understand use of the **OK**, **Apply**, **OK this layer only**, and **Apply this layer only** buttons on the **Raster Dataset** file chooser dialog box.

Open a Red Green Blue (RGB) algorithm

1 On the ER Mapper Standard toolbar, click the **Load**  button.

The **Open** file chooser appears.

2 From the **Directories** menu, select the path ending with the text **\examples**.

3 Double-click on the directory named ‘Data_Types’

4 Double-click on the directory named ‘Landsat_TM.’

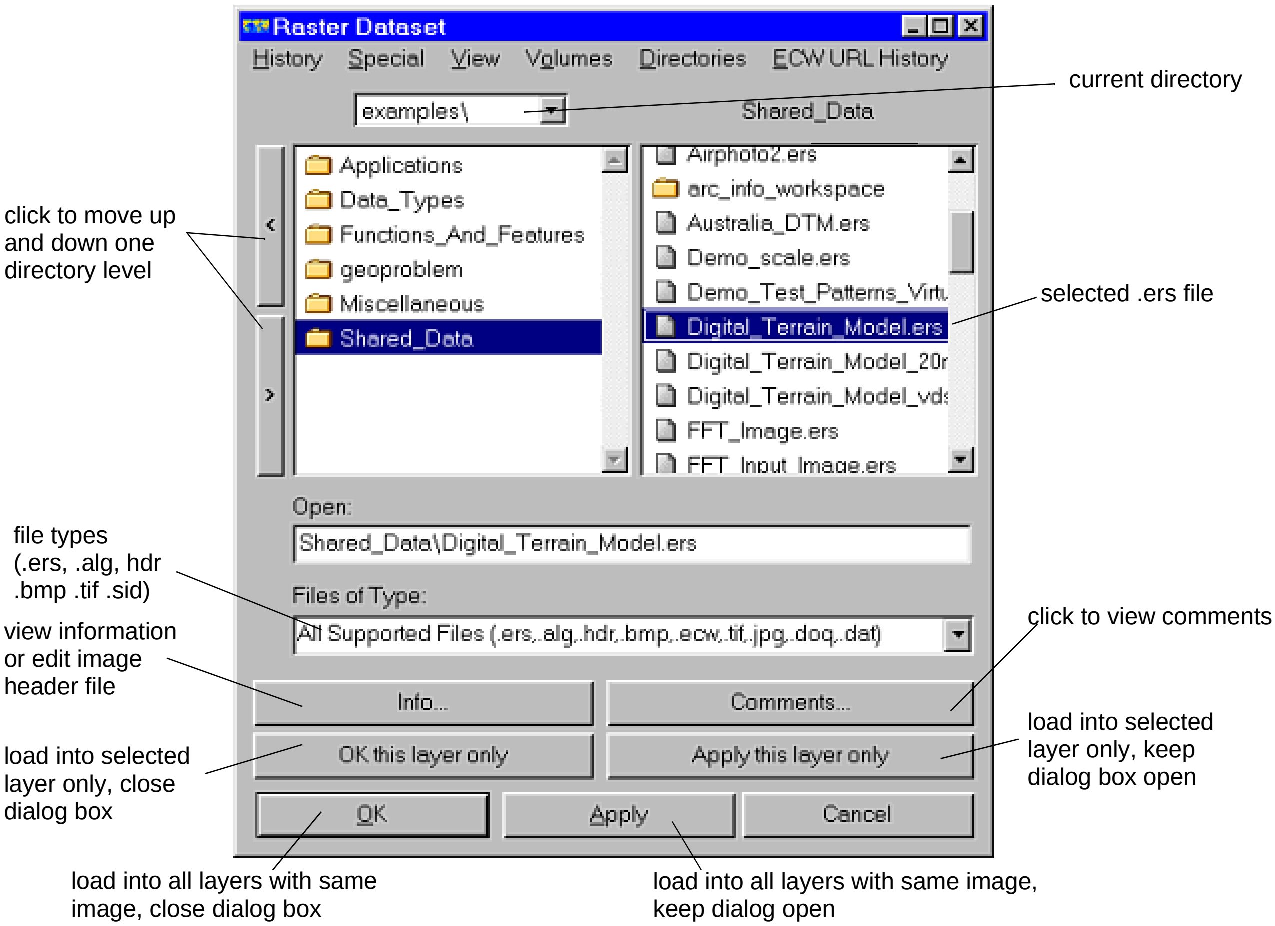
5 Double-click on the algorithm named ‘RGB_432.alg.’

This algorithm displays bands 4, 3, and 2 of a 1985 Landsat TM satellite image of central San Diego as an RGB color composite image. Water areas appear dark, and shades of red indicate vegetation.

Load a new image into all three layers

1 With the 'Layer' tab selected, click on the **Load Dataset** button in the process stream diagram.

The **Raster Dataset** file chooser appears. Note that this dialog has **OK this layer only** and **Apply this layer only** buttons in addition to the **OK** and **Apply** buttons you see on all other file chooser dialogs.



Notice that the **Raster Dataset** file chooser shows files with ".ers" extensions. You can change file types (.ers, .alg, .hdr, .bmp, .tif, .sid) from the drop down list of the button of file types. Typically you load images into raster layers for processing, but you can also load an algorithm and use it as if it were an image dataset.

Load a new image into all three layers

1 From the **Directories** menu, select the path ending with the text **\examples**.

2 Double-click on the directory named ‘Shared_Data.’

3 Click once on the image named ‘Landsat_TM_year_1991.ers.’

4 Click the **Apply** button.

ER Mapper loads the 1991 Landsat image into all three layers. Since all three layers previously contained the same image (the 1985 Landsat image), **Apply** replaced the image in all three layers at once.

Load a new image into only one layer

1 Click on the Green layer to select it.

2 In the scroll list on the **Raster Dataset** dialog, click on the image named ‘Landsat_TM_year_1985.ers’ to select it.

3 Click the **Apply this layer only** button.

ER Mapper loads the 1985 Landsat image into only the Green layer.

4 Click on the Blue layer to select it.

5 In the **Raster Dataset** dialog, click on the image named ‘Landsat_TM_year_1985.ers’ to select it.

6 Click the **Apply this layer only** button.

ER Mapper loads the 1985 Landsat image into the Blue layer.

Tip: The **OK** and **OK this layer only** buttons have the same function as the **Apply** and **Apply this layer only** buttons, but they close the dialog after performing the operation (while the others leave it open). Double-clicking on an image or algorithm name in the scroll list has the same effect as clicking **OK**.

3: Adding and changing layers

Objectives Learn to delete layers from an algorithm, add new layers, and move layers by using buttons and the mouse. Also, learn to change a raster layer from one type to another type (green to blue for example).

Open a new RGB algorithm

1 On the ER Mapper Standard toolbar, click the **Load**  button.

The **Open** file chooser appears.

2 From the **Directories** menu, select the path ending with the text **\examples**

3 Double-click on the directory named ‘Data_Types’.

4 Double-click on the directory named ‘SPOT_XS’.

5 Double-click on the algorithm named ‘SPOT_XS_rgb_321.alg’.

This algorithm displays a SPOT XS (multispectral) satellite image of San Diego as an RGB color composite of bands 3, 2 and 1. (These bands are similar to Landsat TM’s bands 4, 3 and 2 but are imaged at higher resolution.)

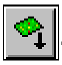
Change the order of layers using buttons

1 On the **Algorithm** window, click on the ‘Green’ layer to select it.

2 Click the **Move Up** button .

The Green layer moves up one level to the top of the layer list.

3 Click on the ‘Blue’ layer to select it.

4 Click the **Move Down** button .

The Blue layer moves to the bottom of the layer list.

Change the order of layers by dragging

1 Point to any part of the Red layer, then drag down below the Blue layer and release.

The Red layer moves down to the bottom of the layer list.

2 Drag the Green layer to move it below the Red layer.

It is often easier to move or reposition layers by dragging them rather than using the **Move Up** and **Move Down** buttons.

Note: The order of layers can be important when building image mosaic algorithms that display more than one image (it sets the display priority of images where there is overlap, those on top having the highest priority). In this case, changing the order of the layers has no effect on the image display.

Delete the Blue and Green layers

1 Click on the Blue layer to select it.

2 Click the **Cut** button to delete the Blue layer from the list.

Tip: You can also cut the layer by selecting the cut option from the Edit menu or on the computer keyboard simply press and hold the Control button and type X “Ctrl+X”.

3 Click on the Green layer to select it.

4 Click the **Cut** button to delete the Green layer from the list.

ER Mapper displays only the red component of the image (SPOT band 3 in this case) because the Blue and Green layers of the algorithm were deleted.

Restore the Green layer by adding one and loading the image

1 From the **Edit/Add Raster Layer** drop-down menu, select **Green**.

A new Green layer is added to the algorithm. The new layer has no image loaded yet (indicated by NONE), so it is turned off.

2 In the process stream diagram, click the **Load Dataset** button.

The **Raster Dataset** file chooser appears.

3 From the **Directories** menu, select the path ending with the text **\examples**.

4 Double-click on the directory named ‘Shared_Data.’

5 Click on the image named ‘SPOT_XS.ers.’ to select it, then click **OK** to load it and close the dialog.

ER Mapper loads the image into the new Green layer and turns it on. Also note that band 1 is loaded by default in the process stream diagram.

Note: If you had wanted to load this image into *only* the Green layer, you could have clicked **OK this layer only** or **Apply this layer only**.

---

6 From the **Band Selection** B1:0.485_um drop-down list, select **B2:0.645_um**.

You have now created a new Green layer that contains the same image and band as the original green layer you deleted earlier.

Restore the Blue layer by duplicating the Green layer

1 With the Green layer still selected, click the **Duplicate** button.

A second Green layer is added below the first one. The second Green layer is an exact copy of the first one, so it already has the 'SPOT_XS' image loaded.

2 Click your right mouse button on the highlighted Green layer and the **Short-Cut** menu will appear. From the **Short-Cut** menu, select **Blue**.

The Green layer changes to a Blue layer.

3 From the **Band Selection** B1:0.485_um drop-down list, select **B1:0.545_um**.

The new Blue layer is now correctly set to display band 1 of the SPOT image.

Tip: When manipulating multiple layers, duplicating an existing layer with the desired image and changing its type is usually faster than adding a new layer and loading the desired image.

Note that the colors look slightly different to those in the original algorithm you opened at the start of this section. You need to adjust the transforms of the new Green and Blue layers.

Adjust the transforms of the Green and Blue layers

1 Select the Green layer, then click on the right-hand **Edit Transform Limits** button in its process stream diagram.

The **Transform** dialog box opens.

2 From the **Limits** menu, select **Limits to Actual**.

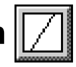
The X axis (input) data range changes to match limits of the band 2 data.

3 Click the **Move to next blue layer** B button on the **Transform** dialog.

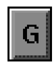
ER Mapper automatically selects the Blue layer and displays its histogram. (You will learn more about moving between histograms of layers later.)

4 From the **Limits** menu, select **Limits to Actual**.

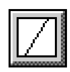
ER Mapper reprocesses the algorithm using the actual data limits as the X (input) axis limits.

5 On the **Transform** dialog, click the **Create autoclip transform**  button.

ER Mapper changes the transform line on the histogram to increase contrast of the blue data layer and redisplays the composite image automatically.

6 Click the **Move to next green layer**  button on the **Transform** dialog.

ER Mapper automatically selects the Green layer and displays its histogram.

7 Click the **Create autoclip transform**  button.

ER Mapper changes the transform line to increase contrast of the green data layer and redisplays the image.

8 Click the **Close** button on the **Transform** dialog to close it.

Close all image windows and dialog boxes

1 Close all image windows using the window system controls:

- Select **Close** from the window control-menu.

2 Click **Close** on the **Algorithm** window to close it.

Only the ER Mapper main menu should be open on the screen.

What you learned

After completing these exercises, you know how to perform the following tasks in ER Mapper:

- Turn data layers on and off
- Load an image into one or several raster layers
- Add, delete, and move layers
- Change a raster layer from one type to another

5

Viewing image data values

This chapter shows you the options ER Mapper provides for viewing image data values and coordinate locations. These include cell values, neighborhoods, signatures, traverse extraction, and scattergrams. You also learn how to measure distances between two points on an image.

About viewing data values

Viewing image data values is one of the fundamental ways to assess data quality and the particular characteristics of features in an image. Options for viewing data values and geographic locations in ER Mapper include:

Cell values	The data value associated with each cell or pixel in the image, or the data values of that cell in each band of a multi-band image.
Neighborhoods	An array of data values surrounding a pixel.
Signatures	The data values of a pixel in all bands shown in a line graph format.
Traverse extraction	A profile of data values occurring along a line or polygon drawn on the image.

Scattergrams An X-Y plot showing the relationship between data values in two bands of an image.

Histograms A plot showing the range of data values on the X axis and their relative frequency on the Y axis

Hands-on exercises

These exercises show you various ways of viewing data values, coordinate locations, and geographic distances between two points on an image.

What you will learn...

After completing these exercises, you will know how to perform the following tasks in ER Mapper:

- View image data values in text format
- View image data values in multiple bands as a signature
- View image data values in multiple bands along a profile line
- View two bands of image data values as a scattergram

Before you begin...

Before beginning these exercises, make sure all ER Mapper image windows are closed. Only the ER Mapper main menu should be open on the screen.

1: Viewing values and signatures

Objectives

Learn to view image data values in a text format, neighborhood format, and signature (line graph) format.

Open and display an RGB algorithm

1 From the **File** menu, select **Open...**.

An image window and the **Open** file chooser dialog box appear.

2 Double-click on the directory named '\examples\Data_Types\Landsat_TM' to open it.

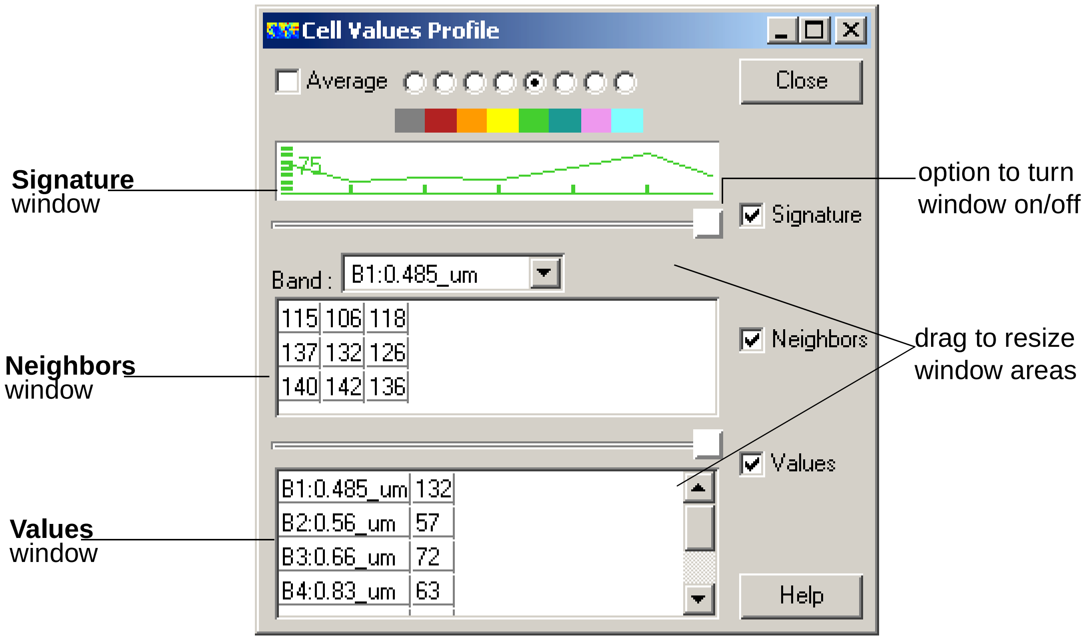
3 Double-click on the algorithm named 'RGB_741.alg.'

This algorithm displays bands 7, 4, and 1 of the San Diego Landsat image as an RGB color composite image.

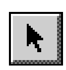
View cell values in the image for all bands

1 From the **View** menu, select **Cell Values Profile...**.

The **Cell Values Profile** dialog box appears. Drag it by its title bar next to the image window. This dialog has three display windows, any of which can be turned on or off at any time.



2 By default, the **Values** option is selected. (If this has been changed, turn on **Values** and turn off **Signature** and **Neighbors**.)

3 On the main menu, click the **Set Pointer mode**  toolbar button.

Set Pointer mode tells ER Mapper that you want to use the mouse pointer to view data values. (The other modes set the pointer for use as a zoom and pan tool.)

4 Point inside the image window, and drag the mouse pointer through the image (or just click on any pixel).

The **Cell Values Profile** dialog displays the data values in all seven bands in the Landsat image for the current cell (pixel) location in the image. The data values are updated as you drag the mouse to new locations.

(If all seven bands are not shown, simply drag the lower edge of the dialog box to make it slightly larger.)

View a neighborhood of cell values

1 In the **Cell Values Profile** dialog, turn on the **Neighbors** option.

A second window is added to the **Cell Values Profile** dialog, with a drop-down menu to select an image band.

2 Point inside the image window, and drag the mouse pointer through the image (or just click on any pixel).

A three-by-three neighborhood of cell values displays as you drag the mouse. The center pixel in the three-by-three array is the current pixel, and the surrounding eight pixels are its neighbors. This feature is useful for viewing the local variance or texture in various parts of an image.

3 From the **Band** drop-down list, select **B4:0.83_um** then drag again in the image.

The data values for band 4 of the Landsat image display in the three-by-three neighborhood.

View a signature of cell values for various features

1 In the **Cell Values Profile** dialog, turn on the **Signature** option.

A third window is added to the **Cell Values Profile** dialog, with a row of color buttons on top.

2 Make the Signature window larger by resizing the entire dialog box, or by turning off the **Neighbors** option.

3 Click on the green color button above the Signature window.

4 Point to the image window, and drag through one of the green areas on the image (natural and man-made vegetation).

The data values in all seven bands display in a line graph format (sometimes called a signature) in green. The tick marks at the bottom indicate the number of bands in the image. In this case, you are using Landsat TM data, so you see the value in each of the seven bands as an individual measurement on the graph.

5 Click on the yellow color button above the Signature field.

6 Point to the image window, and click or drag on one of the bright white areas of the image (building roofs or barren land areas).

A new signature for the bright areas appears in yellow.

7 Click on the green color button again to clear the signature.

When you click on a color button a second time, the existing signature (colored line) in the window is removed.

8 Point to the image window, and drag through a green, vegetated area again to display a new signature.

View an average signature for a feature

1 Click on the blue color button.

2 Turn on the **Average** option.

3 Point to the image window, and drag through one of the dark ocean areas surrounding the island near the bottom.

A third new signature appears in blue. Notice that the signature line gets thicker as you drag this time.

When using **Average**, the signature is an *accumulated average* of all the data values over the area where you dragged. You can add to the average signature by continuing to drag. This allows you to view the average signature over a broad feature area (instead of a single pixel at a time).

4 Click the **Close** button on the **Cell Values Profile** dialog box to close it.

2: Viewing locations and distances

Objectives Learn to view the geographic location of features in a image, and to measure the distance between two points in an image.

View geographic coordinates in the image

1 From the **View** menu, select **Cell Coordinate...**.

The **Cell Coordinates** dialog appears. Drag it next to the image window.

The upper three fields of this dialog show the location of the current pixel in image column (X) and row (Y) coordinates, and the Eastings/Northings and Latitude/Longitude coordinate systems.

2 Point to the image window, and drag the pointer through the image.

The image and geographic location of the current cell appear, and are updated as you drag the mouse.

Note: The Easting Northing and Latitude Longitude fields only display values if the image is registered to a map projection.

View distances between points in the image

The lower three fields of the **Cell Coordinate** dialog show distance between the point where you first depress the mouse button and the point where you release it. Distances are shown as Imperial distance (feet and miles), Metric distance (meters and kilometers), and Dataset distance (number of pixels in the X and Y directions).

1 Point to the image window, and click on any point in the image.

The Imperial, Metric, and Dataset distance fields are cleared to zero values.

2 Pick out two features in the image, then drag the mouse between them.

This distance between those two points is displayed when you release the mouse button. Measuring the distance between two points is called *mensuration*.

3 Click the **Close** button on the **Cell Coordinates** dialog box to close it.

3: Viewing traverse profiles

Objectives Learn to view image data values for multiple bands as a profile along a line or polygon draw through the image (called *traverse extraction*).

Set up to draw traverse profile lines

1 From the **View** menu, select **Traverse...**.

New Map Composition and **Traverse** dialog boxes appear.

2 On the **New Map Composition** dialog, be sure the **Vector File** option is selected, then click **OK**.

An **ER Mapper** warning dialog and the annotation **Tools** palette dialog appear. You will use the vector annotation tools to draw traverse lines on the image.

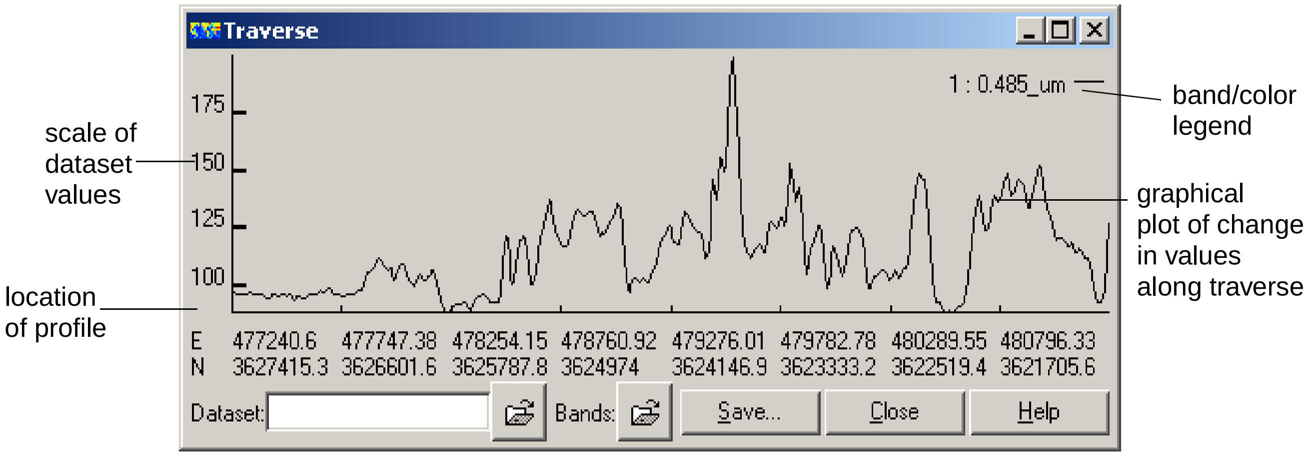
3 Click **Close** on the **ER Mapper** warning dialog to close it. (When using annotation tools for other purposes the default Fixed Page mode is not recommended, but it is fine for this exercise.)

Draw a traverse line on the image

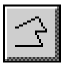
1 On the **Tools** dialog, click the **Annotation: Poly Line**  button.

2 Inside the image window, define a straight line by clicking once at the start point, click once at the end point, then double-click to end the line definition.

A profile line appears inside the **ER Mapper Traverse** dialog. This line displays the amplitude or change in the values of pixels underneath the traverse line you drew. By default, values for image dataset band 1 are shown as a black profile line.



View profiles for 3 image dataset bands

1 On the **ER Mapper Traverse** dialog, click the **Bands:**  button.

The **Traverse Band Selection** dialog appears.

2 Press the Ctrl key on your keyboard, then click on bands **1**, **4** and **7** in the list to select them.

3 Click **OK** on the **Traverse Band Selection** dialog.

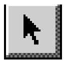
Profiles for all three bands appear in the **ER Mapper Traverse** dialog, with a legend in the upper-right indicating the line color assigned to each band. This type of display allows you to clearly see the relationship between data values in the three bands. (In this case you are viewing data values for the same bands displayed in the RGB image (7, 4 and 1), but you could also view profiles for bands not used to display the image.)

Draw a second traverse line on the image

1 Inside the image window, define a second line in a different area by again clicking once at the start point, click once at the end point, then double-click to end the line definition.

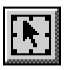
The three profile lines appears inside the **ER Mapper Traverse** dialog update to show the pixel values under the new line. You can draw as many different traverse lines on the image as you desire.

Alternate between the two traverse lines and modify them

1 On the annotation **Tools** dialog, click the **Select and Edit Points Mode**  button.

2 Inside the image window, click on the first traverse line you drew.

The line becomes selected and it's corresponding profiles again appear in the **ER Mapper Traverse** dialog. You can view the profiles for any traverse line by simply selecting it as shown here.

3 On the annotation **Tools** dialog, click the **Select and Move/Resize Mode**  button.

4 Inside the image window, click once on one of the endpoints of the currently selected traverse line (the point become reverse highlighted).

5 Point to the reverse highlighted end point, and drag it to a new location.

When you release the mouse button, the revised line appears on the image and it's corresponding profiles are updated in the **ER Mapper Traverse** dialog. You can modify the location and length of any traverse line by following these steps.

6 Revise one of your lines so it traverses across one of the dark ocean areas in the lower part of the image.

Notice the strong dip in data values in all three bands where the lines crosses the ocean. This is typical of Landsat TM data because water generally has much lower reflectance in these wavelengths of light than land areas.

7 Click Close on the **ER Mapper Traverse** dialog to close it, then click **Close** on the **Tools** dialog to close it also.

8 When asked to save the current annotation, click **No**.

Tip: If desired, you could save the current annotation layer and reload it later, and you can also save the traverse profiles to an XYZ format dataset on disk for export to other analysis software if desired. See the *ER Mapper User Guide* for more information.

4: Viewing image scattergrams

Objectives Learn to view the relationship between image data values in two bands as a two-dimensional plot called a scattergram (or scatter diagram).

A *scattergram* allows you to graphically see the correlation between the digital numbers in two image bands. Values for one band are plotted on the Y axis and the other on the X axis. These two digital numbers locate each pixel in the two-dimensional measurement space of the graph.

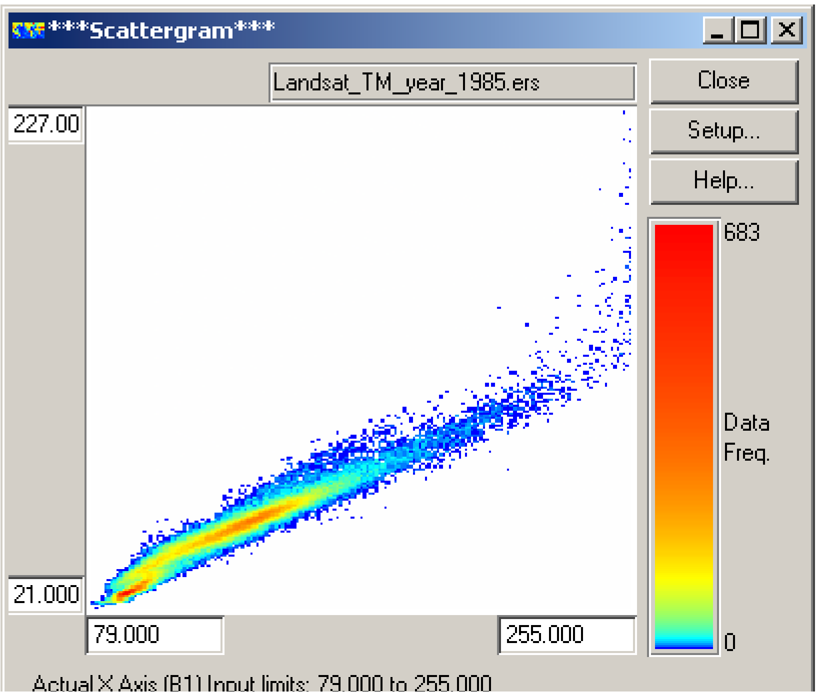
Open a Scattergram dialog box

1 From the **View** menu, select **Scattergrams...**.

The **Scattergram** dialog box and **New Map Composition** dialog boxes open.

2 Click **Cancel** on the **New Map Composition** dialog to close it. (You do not need it for this exercise.)

The **Scattergram** dialog automatically references the image in the active image window (‘Landsat_TM_year_1985’). You could choose to view scattergrams for any other image, Virtual Dataset, or algorithm as well.



By default, a new scattergram plots band 1 of the image on the X (horizontal) axis and band 2 on the Y (vertical) axis, and the cluster of points is shown using various colors inside the scattergram window. The colors represent the *accumulated* *frequency* (or “density”) of data values in both bands. Areas of the scattergram with the highest densities of points are shown in colors in the upper part of the color bar (red and yellow), and low density areas in the lower colors (blue and magenta). Typically, high density areas will be a feature comprising a large number of pixels in both bands, such as a large area of water.

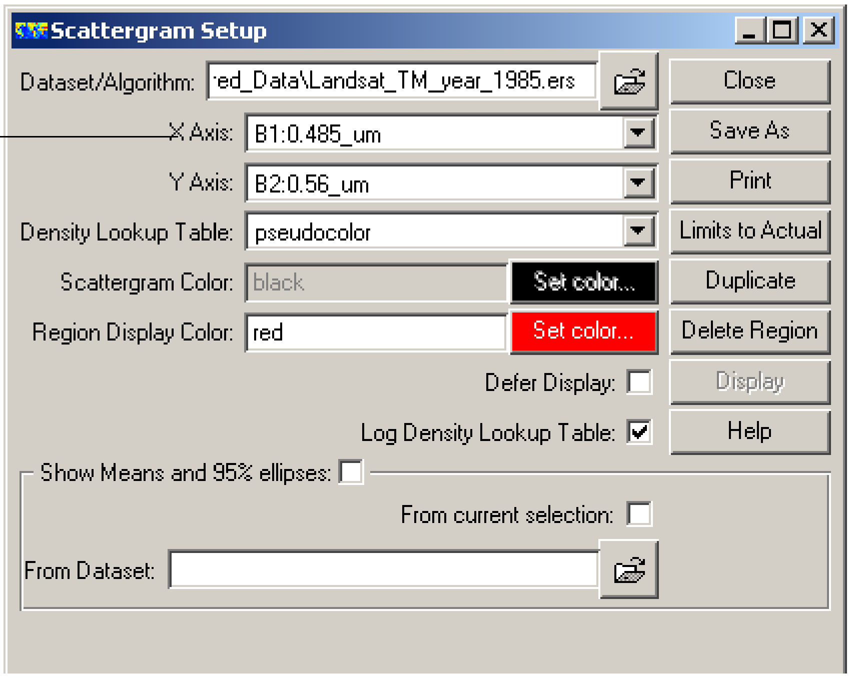
Change the image band combination

In the scattergram for bands 1 and 2, notice that the data points are tightly grouped. This indicates that there is a strong correlation between the data contained in these two bands (both visible wavelength bands), so they contain much redundant information.

1 In the **Scattergram** dialog, click the **Setup...** button.

The **Scattergram Setup** dialog opens to provide options for changing image bands, defining regions, and other functions. Move it so it does not cover the **Scattergram** dialog or image window.

select image bands for scattergram



2 Click on the drop-down list for the **Y Axis** field, and select **B4:0.83_um**.

ER Mapper redraws the scattergram, this time showing the data values from band 4 on the Y axis.

3 Click the **Limits to Actual** button to set the X and Y axis limits to the actual data ranges of bands 1 and 4.

The scattergram enlarges to fill the window. The wide spread of points shows that the data in bands 1 and 4 are weakly correlated, so they provide different types of information. (Band 4 records reflectance in near infrared wavelengths.)

Change the axis limits to "zoom in" on part of the scattergram

Notice the small, dense grouping of points in the lower-left corner of the scattergram (shown in cyan, green and red). This indicates that there is a high frequency of data points in both bands in that area.

1 Point the mouse (without depressing it) at the areas surrounding the dense grouping.

Directly above the scattergram window, ER Mapper displays the position of the mouse pointer in the scattergram and data values in both bands. The first value is the X axis (band 1) value, and the second the Y axis (band 4) value.

To focus more on this area of the scattergram, you can use the mouse to determine the approximate data limits of the dense cluster, and then reset the X and Y axis limits to "zoom in" on it.

2 In the **Setup Scattergram** dialog, turn on the **Defer Display** option. The **Display** button (greyed out before) is now active.

Defer Display tells ER Mapper to delay updating the scattergram until you finish changing the desired options (the axis limits in this case).

3 Edit the X (horizontal) axis maximum value to **120**, and press Enter or Return to validate.

4 Edit the Y (vertical) axis maximum value to **30**, and press Enter or Return.

5 Click the **Display** button.

ER Mapper redisplays the scattergram to "zoom in" on the dense cluster, so you can more clearly see the detail.

6 In the **Setup Scattergram** dialog, click the **Limits to Actual** button, then click **Display** again.

The scattergram zooms back out to the previous extents.

7 Turn off the **Defer Display** option.

8 Click **Close** on the **Scattergram** dialog to close it and the **Setup Scattergram** dialog.

Note: You will learn more about additional uses and options for scattergrams in other parts of this manual.

Close all image windows and dialog boxes

1 Close all image windows using the window system controls:

- Select **Close** from the window control-menu.

2 Click **Close** on the **Algorithm** window to close it.

Only the ER Mapper main menu should be open on the screen.

What you learned

After completing these exercises, you know how to perform the following tasks in ER Mapper:

- View image data values in text format
- View image data values in multiple bands as a signature
- View image data values in multiple bands along a profile line
- View two bands of image data values as a scattergram

6

Enhancing image contrast

This chapter explains how to modify raster image data to enhance contrast or color to improve visual interpretation. It introduces the basic concepts associated with contrast enhancement and color mapping, and gives you practice using ER Mapper's Transform options.

About contrast enhancement

Adjusting image contrast (often called "contrast stretching") is the most fundamental and often-used enhancement operation in digital image processing. The human eye is very good at interpreting spatial attributes in an image and picking out subtle features. However, the eye is poor at resolving such features when they are characterized by very subtle differences in color or brightness. Contrast enhancement techniques are useful for accentuating subtle differences in data values to improve visual interpretation.

Contrast enhancement is called a "point operation" in image processing because it applies a brightness or color transformation to each pixel in the image independent of all other pixels. By adjusting the "transform" that maps image data values to the display brightness or colors in a lookup table, you can enhance (or "stretch") the contrast or highlight specific features to make your data easier to interpret and analyze.

Two of the most common image display techniques are Pseudocolor and Red Green Blue (RGB).

Displaying images with a color lookup table

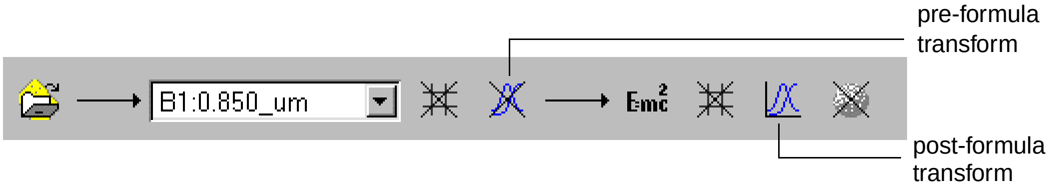
When displaying an image using a color lookup table (CLUT) (**Color Table** menu on the **Surface Tab** in the **Algorithm window**), image data values are mapped to specific colors or “slots” in a table. In this case, changing the transform tells ER Mapper to adjust the mapping between the image data values and the colors in the CLUT used to display them. For example, you can transform the data to be displayed using all the colors, or shift or compress the data to map it to a particular color or range of colors.

Displaying images in RGB

A computer screen produces colors by illuminating red, green, and blue phosphors for each pixel. When you change the transform of an RGB image display, ER Mapper controls mapping between the image data values and the brightness of the red, green, or blue phosphors of the hardware display.

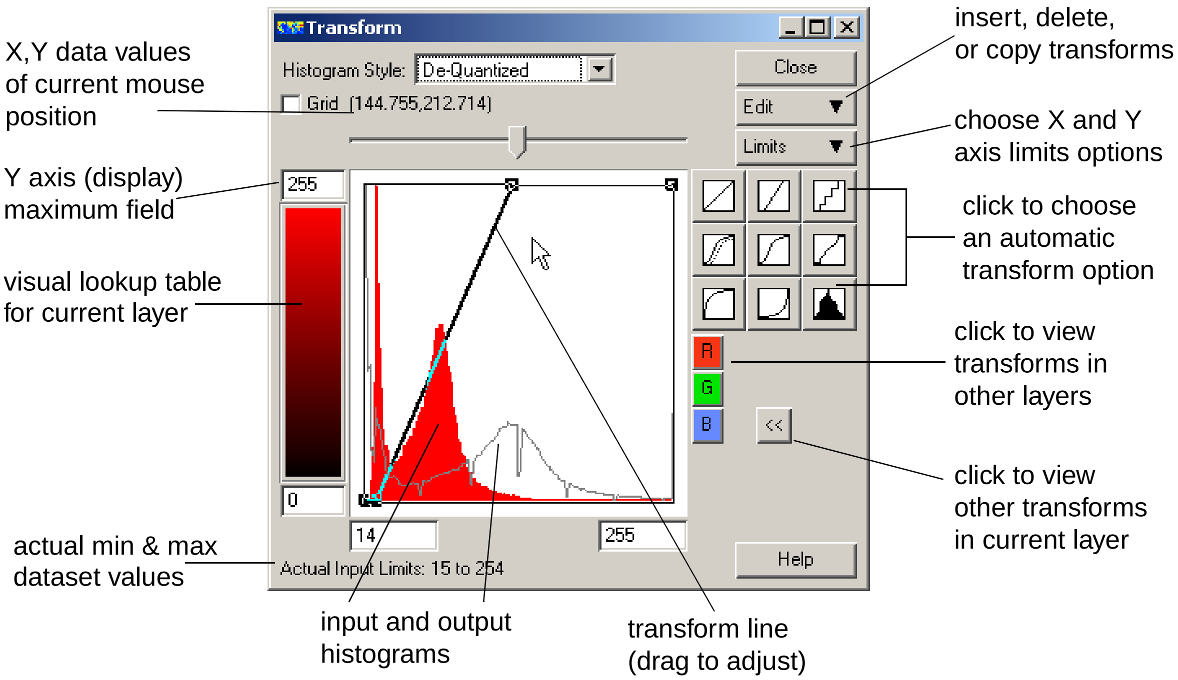
The Transform buttons

By default, most raster data layers in ER Mapper have two Transform buttons in the algorithm process stream diagram. One applies a transform *before* a formula (pre-formula), and the other applies a transform *after* a formula (post-formula). You can also insert and append additional transforms in either location to create more complex contrast enhancements.



The Transform dialog box

When you click on one of the Transform buttons in the process stream diagram or on the **Edit Transform Limits** toolbar button, ER Mapper opens the **Transform** dialog box. This dialog provides many interactive controls for enhancing contrast and modifying color mapping.



A key concept in using the **Transform** dialog is moving the *transform line*, because this is the feature that controls mapping of data values to display brightness or color. To move the line, simply drag it to a new location, or click buttons that automatically position the line for common transform techniques (such as histogram equalization).

Tip: For any algorithm, you can open the **Transform** dialog box from two places: using the **Transform** buttons in the process stream diagram on the **Algorithm** window, or using the **Edit Transform Limits** toolbar button. (Using the toolbar button lets you edit the transforms for any algorithm layers without having to open the **Algorithm** window first.)

Hands-on exercises

These exercises introduce you to the basic features of the **Transform** dialog box, and how to use them to enhance image contrast and color mapping.

What you will learn...

After completing these exercises, you will know how to perform the following tasks in ER Mapper:

- Edit the transform for a particular raster data layer
- Apply linear and piecewise linear transforms
- Edit the input (data) and output (display) ranges for a transform
- Use the automatic transform options
- Work with multiple transforms in a layer

Before you begin...

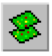
Before beginning these exercises, make sure all ER Mapper image windows are closed. Only the ER Mapper main menu should be open on the screen.

1: Viewing image histograms

Objectives

Learn to display the histogram for an image, view data values and display a coordinate grid over the histogram.

Load and display an image in greyscale

1 On the Standard toolbar, click on the **Edit Algorithm**  button.

An image window and the **Algorithm** dialog box appear.

2 In the process stream diagram on the **Algorithm** window, click on the **Load Dataset**  button.

The **Raster Dataset** file chooser dialog opens.

3 From the **Directories** menu, select the path ending with the text **\examples**.

4 Double-click on the directory named ‘Shared_Data.’

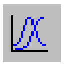
5 Double-click on the image named ‘SPOT_Pan.ers.’

ER Mapper loads the SPOT Pan image into the Pseudocolor layer and displays it.

6 On the **Surface Tab**, from the **Color Table** drop-down list, select **greyscale**.

ER Mapper redisplays the image in greyscale. This is a SPOT Panchromatic satellite image of the San Diego, California area. (The image is initially somewhat dark, and you will improve the contrast later.)

View the histogram for the SPOT Pan image

1 Click on the post-formula **Edit Transform Limits**  button in the process stream diagram.

The **Transform** dialog box opens. The histogram for the SPOT Pan image is displayed in the histogram window portion of the dialog.

A *histogram* is graphical display of the relative frequency distribution of values in an image. In this case, most of the data values occur in the lower part of the 0 to 255 data range possible for SPOT Pan images. Peaks in the histogram show where there are many pixels with similar data values, and often indicate identifiable features in an image.

View the data values inside the histogram window

1 Point the mouse to any location inside the histogram window.

The X and Y axis data values at that point are displayed in the upper-left portion of the dialog (below Histogram Style). The X location (image data range) appears on the left, and the Y location (screen brightness or LUT value) is on the right.

2 Position the pointer in the lower-right portion of the histogram window.

You see a high X value because you are at the upper end of the data range, and a low Y value because you are at the lower end of the display or lookup table range.

3 Position the pointer in the upper-left portion of the histogram window.

You see a low X value because you are at the lower end of the data range, and high Y value because you are at the upper end of the display or LUT range.

Turn on a coordinate grid

1 Turn on the **Grid** option button.

A grid appears over the histogram window with a regular spacing between grid lines and the origin in the lower-left corner. This grid can help you quickly determine a specific X-Y data location in the histogram window.

2 Turn the **Grid** option off again.

The grid disappears from the histogram window.

Close the Transform dialog and the Algorithm window

1 Click **Close** on the **Transform** dialog to close it, then click **Close** on the **Algorithm** window to close it.

2: Using linear transforms

Objectives Learn to use simple linear transform adjustments to perform lightening and darkening of images, and increase or decrease image contrast. You also learn to open the **Transform** dialog from the Common Functions toolbar.

Reopen the Transform dialog from the toolbar

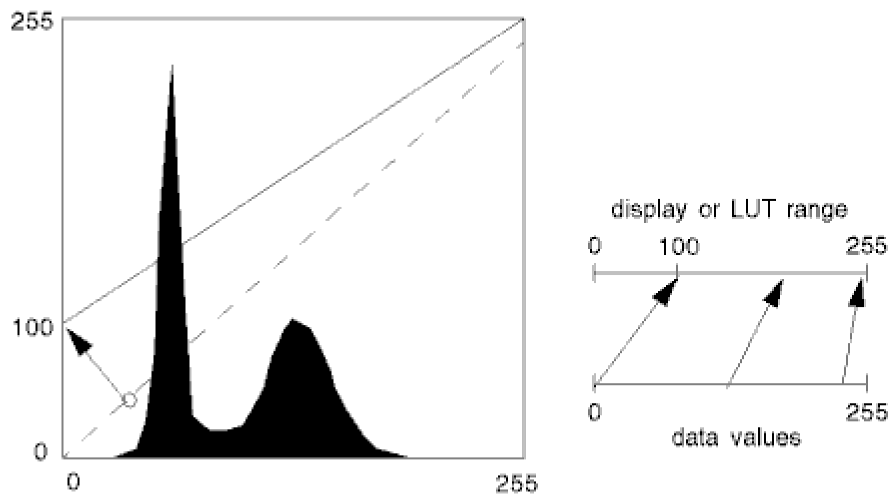
1 On the ER Mapper main menu, click the **Edit Transform Limits**  button on the Common Functions toolbar.

ER Mapper opens the **Transform** dialog box again. (This is a shortcut to access transforms for any displayed algorithm without using the **Algorithm** window.)

Apply a linear lightening effect to the image

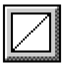
Whenever you display data in a Pseudocolor layer, the colors in the lookup table (greyscale in this case) are shown in a color bar along the Y axis. This makes it easy to see how the position of the transform line affects the way LUT colors are used to display the image.

1 As shown in the diagram below, drag the circled part of the transform line up to the left along the left-hand vertical axis.



ER Mapper applies the change and the image lightens. As shown in the right-hand diagram, you have adjusted the transform line to exclude values of about 0-100 on the display (vertical) axis, which correspond to the darker shades of grey in the greyscale lookup table. Now the entire 0-255 range of data on the X (horizontal) axis is mapped to only the lighter shades of grey in the greyscale lookup table, causing the image to appear lighter.

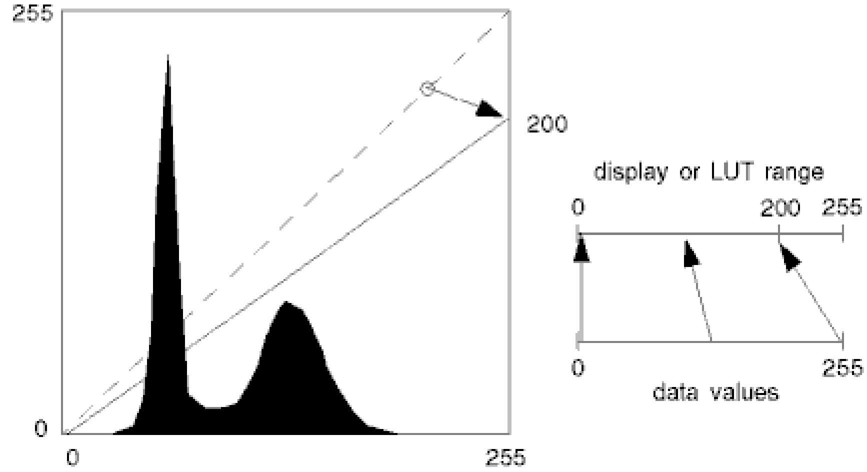
Also notice that a second unfilled histogram appears in the window. This is the *output histogram*, and it represents how your change affected the distribution of data on the display (or output) axis.

2 Click on the **Create default linear transform**  button.

ER Mapper returns the transform line to its default position and redisplays the image. (The default position is a straight linear transform, where the line's X position is equal to its Y position. This also makes the output histogram the same as the input histogram, so it is no longer visible.)

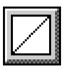
Apply a linear darkening effect to the image

1 As shown in the diagram below, drag the circled part of the transform line up to the right along the right-hand vertical axis.



ER Mapper applies the change and the image darkens. As shown in the right-hand diagram, you have adjusted the transform line to exclude values of about 200-255 on the display (vertical) axis, which correspond to the lighter shades of grey in the lookup table. Now the entire 0-255 range of data on the X (horizontal) axis is mapped to only the darker shades of grey, causing the image to appear darker.

Also notice that the linear darkening effect caused the output histogram to shift left of the input histogram (whereas the lightening effect it shifted it right).

2 Click on the **Create default linear transform**  button.

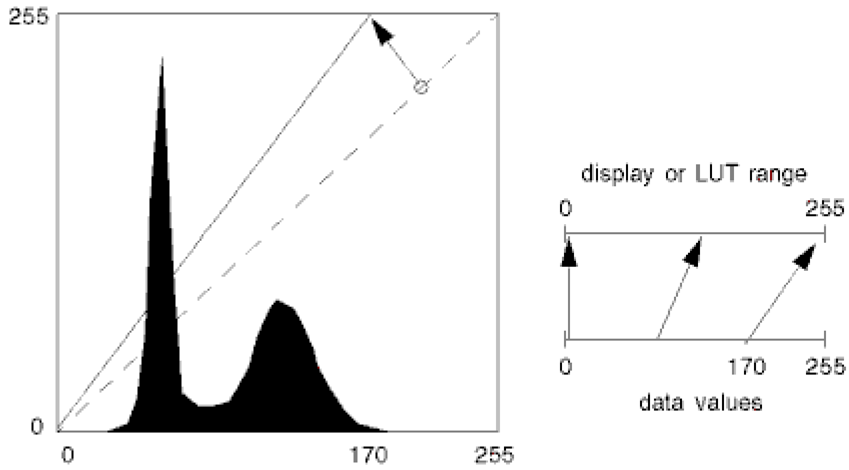
The transform line returns to its default position and the image redisplays.

Apply a linear contrast stretch to increase image contrast

1 Point to the far right-hand edge of the histogram (at the bottom of the slope).

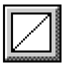
Note that X value displayed in the upper-left shows about 160-170. Even though the upper limits of the image values are close to 255, there are very few values between about 170 and 255 (as indicated by the frequency shown in the histogram).

2 As shown in the following diagram, drag the circled part of the transform line up to the left along the horizontal axis.



ER Mapper applies the change and the image contrast increases. Now the contrast between light and dark parts of the image is enhanced, making spatial features easier to visually interpret. In this case, you adjusted the transform line to map data values of about 170-255 on the horizontal axis to the lightest color in the lookup table (white), and spread the remaining data values (0-169) over the entire range of grey shades.

This mapping better utilizes the dynamic range of grey shades in the lookup table, which improves image contrast. (This effect is often called *histogram clipping* because it clips the tail off the histogram.)

3 Click the **Create default linear transform**  button.

ER Mapper returns the default transform line and redisplays the image.

3: Highlighting features

Objectives Learn to use piecewise linear transforms to create more complex contrast adjustments that highlight a specific range of values or a feature in an image.

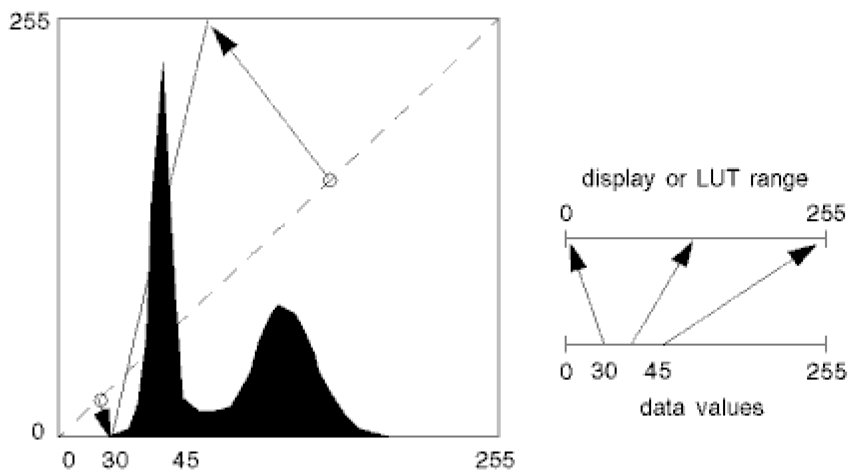
In contrast to the simple transform adjustments you used earlier, piecewise linear transforms break the transform line into several parts (or “pieces”). Each piece of the line can have a different slope (X-Y relationship), which lets you modify the mapping of that range of data differently from other pieces of the line. Piecewise linear transforms lets you create more complex types of contrast enhancements.

Adjust the transform to maximize contrast in the ocean areas

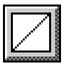
The image you are working with is a SPOT Panchromatic satellite image, which records the amount of light reflected from the earth’s surface (similar to an aerial photograph). Notice that the image histogram has two peaks that provide information about features in the image:

- One very tall, narrow peak on the left–these are primarily the *ocean areas* in the image. Ocean areas typically have low reflectance values that fall within a very narrow range (since the sea surface has little variation compared to the land).
- Another smaller, wider peak to the right–these are primarily the *land areas* in the image. Land areas typically have higher reflectance values than ocean, and the values are spread out over a much wider range (since land areas are comprised of a variety of different cover types).

1 As shown in the diagram below, drag the transform line in two different places–once down the left edge of the ocean peak in the histogram, and another up to the top in line with the right edge of the ocean peak

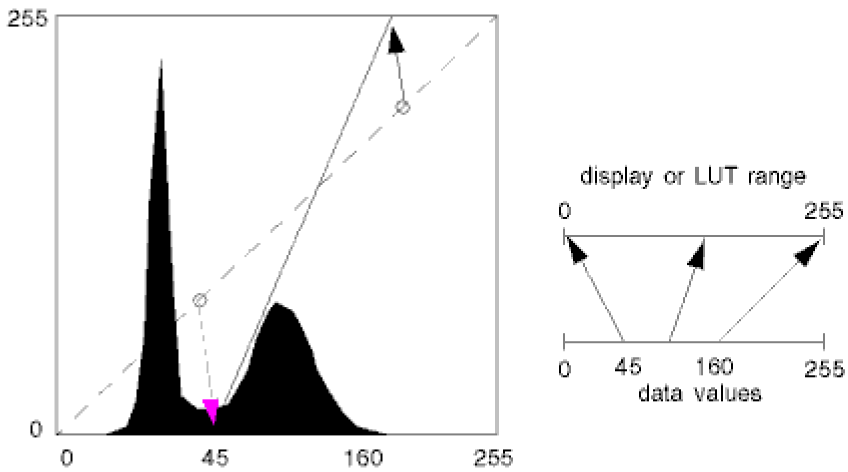


The contrast in the ocean areas is enhanced, while most land areas are displayed as white. In this case, you adjusted the transform line to map the narrow range of data values 30-45 (ocean) over the entire range of grey shades in the lookup table. Data values lower than 30 are mapped to the lowest slot in the lookup table (black) and data values over 45 (mostly land) are mapped to the highest slot (white). The subtle reflectance patterns in the ocean areas are now easier to visually interpret because the entire grey shade range is used to represent them.

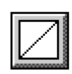
2 Click on the **Create default linear transform**  button.

Adjust the transform to maximize contrast in the land areas

1 As shown in the diagram below, drag the transform line in two different places–once down the left edge of the land peak in the histogram, and another up to the top in line with the right edge of the land peak.



The contrast in the land areas (data values between about 45 and 160) is enhanced, while the ocean areas (30-45) are displayed as pure black.

2 Click on the **Create default linear transform**  button.

4: Modifying data and display ranges

Objectives Learn to use the **Limits** menu options to specify exact ranges of data values and display values to modify image contrast and color mapping.

Use Limits to Actual to set the X axis data range

Look at the “Actual Input Limits” field on the **Transform** dialog, and note that it shows values between approximately 22 and 254. ER Mapper records the actual range of data values it finds in the image and displays the results in the Actual Input Limits field.

1 From the **Limits** menu, select **Limits to Actual**.

The data range displayed on the horizontal axis changes to match the Actual Input Limits field.

ER Mapper recomputes the histogram and applies the transform only to the actual range of data in the image.

Note that the image actually darkens slightly. Since there was no data between zero and 24, **Limits to Actual** shifted the entire histogram slightly to the left on the X axis, so the data is mapped to slightly darker shades of grey on the lookup table.

Tip: **Limits to Actual** is a very commonly used option because it allows you to work with only the actual range of data in an image. This is especially useful for images that do not use an 8-bit (0-254) data range. **Limits to Actual** is very often the first step in adjusting contrast, followed by another adjustment such as one of the automatic transform options discussed later.

Set the input limits to 99% of the histogram range

1 From the **Limits** menu, select **Input Limits to 99% Histogram**.

The data range on the horizontal axis changes to approximately 34 to 151, and the histogram itself widens to fill the X axis range.

Input Limits to 99% Histogram clips off 1% of all data values in the image, taking 0.5% from the lower end, and 0.5% from the upper end. (The results of the clipping indicates that only 1% of the image data values fall in the ranges 24-34 and 151-254.)

The image lightens quite a bit since only the range of data where the most values occur is being mapped to the grey shades. (The 0.5% of data values at the upper and lower ends are mapped to white and black respectively.)

Note: **Input Limits to 99% Histogram** works from the range of data displayed in the current histogram, which can be different than the actual image limits if you have entered your own axis limits (as discussed later).

Set exact input limits to highlight the ocean data range

The two text boxes below the histogram window let you type in new values to define the lower and upper X axis limits.

1 Inside the histogram window, point to the right side of the tall, narrow peak in the histogram.

As mentioned previously, this peak corresponds primarily to the ocean portions of the satellite scene. Note that the X value is about 50, so the ocean peak has a minimum value of about 34 and a maximum value of about 50.

2 Select the text in the X axis maximum text box (currently about 154), and enter a value of **50**.

ER Mapper applies the new X axis limits and renders the image.

Now the ocean areas are mapped to the entire range of grey shades to highlight subtle features, while the land areas (values greater than 50) are mapped to white. This is another method to map a specific range of data to the entire display range. (Earlier you adjusted the transform line to accomplish the same enhancement.)

3 On the **Algorithm** window, change the Lookup Table to **rainbow**.

The ocean areas are displayed in many colors, while the land is displayed mostly in red (the last color in that lookup table).

Set exact output limits to use specific lookup table colors

1 From the **Limits** menu, select **Limits to Actual**.

The X axis range changes to match the Actual Input Limits field.

ER Mapper recomputes the histogram and applies the transform.

2 Change the Y axis minimum value (currently zero) to **200**.

The entire image is displayed in shades of yellow, orange, and red because those colors occupy the upper slots in the rainbow lookup table.

Note: The color bar display does not change when the Y axis limits are changed because it is still desirable to see the entire range of available colors.

3 Change the Y axis minimum value to **50**, and change the Y axis maximum value to **150**.

The entire image is now displayed in shades of cyan and green because those colors occupy the middle slots in the rainbow lookup table (slots 50-150).

Tip: You can also use the Y axis limits to rescale data. For example, to rescale the range of a target image dataset to match a source image dataset, edit the Y axis transform limits for the target image to match the input limits of the source image. You can then save as a Virtual Dataset or disk file for further processing.

5: Using automatic transform options

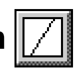
Objectives Learn to use the automatic transform options such as autoclipping, Histogram Equalization, Gaussian Equalization, level slicing, and others.

The automatic transform buttons are displayed on the right side of the **Transform** dialog box. Any time you select one of these options, ER Mapper automatically updates the image display in real time.

Reset the image display to greyscale and the default transform

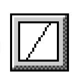
1. Change the Y axis minimum value back to **0**, and change the Y axis maximum value back to **255**.
2. On the **Algorithm** window, change the Lookup Table to **greyscale**.

Apply an autoclip transform to the data

1. On the **Transform** dialog, click the **Create autoclip transform**  button.

   ER Mapper automatically repositions the transform line, and the image updates automatically with increased contrast.

   Autoclipping clips off the “tails” of the histogram to map the more frequently occurring data values to the selected display range. By default, ER Mapper performs a 99% autoclip that clips 0.5% of the data at the high and low ends of the data range. Outlying data values on the low end of the data range are assigned zero in the display range (black in this case), and outliers on the high end are given the maximum value (usually 255, white in this case). (This is similar to the Input Limits to 99% Histogram used earlier, but the transform line is automatically adjusted rather than the data range.)

2. This time, double-click the **Create autoclip transform**  button.

   A dialog box appears to let you enter any autoclip percentage. The default is 99%.

3. Enter the value **95**, then click **OK** to close the dialog.

   The transform line is repositioned closer to vertical to clip the outlying 5% of the histogram frequency distribution (2.5% of the data values from the high and low ends). The image displays with greater contrast between light and dark areas.

Tip: For best visual results, keep your autoclip percentages greater than 90%. Values around 99% are most commonly used, but lower percentages are sometimes a good alternative for enhancing images with many outlying values.

4 Double-click the **Create autoclip transform** button again, enter the value **99**, then click **OK**.

A 99% autoclip transform is again applied an the image is updated.

Tip: The **99% Contrast enhancement** toolbar button is a fast way to perform all these operations with one click, so it is especially useful for contrast stretching images that produce narrow or negative data ranges (such as ratios, PCs, and others).

Apply a Histogram equalize transform to the data

1 On the **Transform** dialog, click the **Histogram equalize** button.

ER Mapper creates a complex piecewise linear transform line and updates the image.

Histogram equalization (also called uniform distribution stretching) automatically adjusts the transform line so that image values are assigned to display levels based on their frequency of occurrence. More display values are assigned to the most frequently occurring portion of the histogram, so the greatest contrast enhancement occurs in the data range with the most values (peaks in the histogram). Histogram equalization usually creates an image with very strong contrast between dark and light areas. In some cases, it can also saturate light and dark areas which can obscure detail.

Apply a Gaussian equalize transform to the data

1 On the Transform dialog, click the **Gaussian equalize** button.

ER Mapper creates a complex piecewise linear transform line (sometimes with slight stair steps) and updates the image.

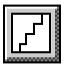
Gaussian equalization automatically adjusts the transform line so that image values are assigned as needed to make the output (display) values occur with a Gaussian distribution. (A Gaussian, or “normal” distribution, is characterized as producing a bell-shaped histogram. Notice that the output histogram has a shape close to this.)

Gaussian equalization is useful when data is skewed in such a way that features could be abnormally dark or light if stretched linearly. This technique prevents saturation of light or dark areas, and most pixels have mid-range brightness values with only a few in the extreme dark or light display regions.

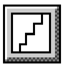
Tip: You can set the number of standard deviations used for the Gaussian equalize function by double-clicking on the button. Smaller values produce more contrast and higher values less contrast. The default is 3 standard deviations.

Apply a level slice transform to the data

Level slicing (or density slicing) divides the image into discrete colors and removes transitional colors between them. The resulting images appears to be divided into “slices,” each displayed in a specific color. This technique can be useful for looking at data in discrete intervals and colors.

1 On the **Transform** dialog, click the **Create level-slice transform**  button.

ER Mapper creates a stair-stepped transform line at regular intervals.

2 Double-click the **Create level-slice transform**  button.

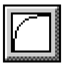
A dialog box appears to let you enter a number of steps for the transform line.

3 Enter the value **3**, then click **OK** to close the dialog.

The transform line is divided into three steps and the image is updated.

The stair-stepped transform divides the image into three shades–black for mostly ocean areas, mid-grey for middle reflectance land areas (such as vegetation), and white for high reflectance land areas (such as roads, sand, and airport runways).

Apply a Logarithmic and Exponential transforms to the data

1 On the **Transform** dialog, click the **Create default logarithmic transform**  button.

The transform line changes to a smooth curve pointing toward the upper-left corner of the histogram window, and the image becomes very light.

2 Drag the transform down line by its mid-point to flatten it slightly.

The line retains its smooth curve, and image becomes darker.

3 On the **Transform** dialog, click the **Create default exponential transform** button.

The transform line changes to a smooth curve pointing toward the lower-right corner of the histogram window, and the image becomes very dark.

4 Drag the transform up line by its mid-point to flatten it slightly.

The line retains its smooth curve, and image becomes lighter.

Tip: The Logarithmic transform type is useful for specialized enhancement purposes, such as displaying data with a large dynamic range, or to reduce apparent darkness in an image while retaining the variation in brightness. The Exponential transform is useful for processing geophysical data with a small dynamic range to increase the contrast in the displayed image.

6: Working with multiple transforms

Objectives Learn to insert, append, and delete transforms from the processing stream, and use multiple transforms.

Open the Algorithm window

1 Click the **Edit Algorithm** toolbar button.

ER Mapper opens the **Algorithm** window. You can now view the process stream diagram (which is needed for this exercise).

Apply a 99% autoclip transform to the data

1 Click the **99% Contrast enhancement** button.

ER Mapper applies a 99% autoclip transform to the image.

Insert a second transform before the current one

1 From the **Edit** menu on the Transform dialog, select **Insert new transform**.

A second transform (and button) is added to the process stream diagram on the **Algorithm** window (it is *inserted before* the previous one). Its contents, currently empty, are shown in the **Transform** dialog.

Delete the new transform from the process stream

1 From the **Edit** menu on the **Transform** dialog, select **Delete this transform**.

The current transform (the new one you inserted) is deleted from the process stream diagram.

Append a second transform after the current one

1 From the **Edit** menu, select **Append new transform**.

A second transform (and button) is added to the process stream diagram (it is *appended after* the previous one).

The histogram shows the data range (0-255) after it has been passed through the 99% autoclip transform preceding it.

Specify Gaussian equalization for the new transform

1 On the **Transform** dialog, click the **Gaussian equalize** button.

ER Mapper creates a Gaussian equalization transform line and updates the image. The resulting image is created by applying two transforms–a 99% autoclip followed by a Gaussian equalization of the autoclipped result. This is an example of enhancing an image by combining the characteristics of two different types of transforms.

Move to the previous transform and histogram

1 On the **Transform** dialog, click the **Move to previous transform in layer** button.

The contents of the **Transform** dialog box change to show the previous transform in the process stream diagram (the one applying a 99% autoclip). Also note that the corresponding transform button in the process stream diagram is now depressed.

Note that the Y axis limits are zero to 255. The transform rescales the original data range (22-254) into the 0-255 range. The rescaled range is used as the input data range for the transform following it.

2 Click the **Move to next transform in layer** button.

The contents of the **Transform** dialog change to show the next transform (the one applying a Gaussian equalization).

Note that the Actual Input Limits are zero to 255. These were created by setting 0 and 255 as the output (Y axis) data range for the previous transform.

Note: Depending on the types of raster layers in your algorithm, the **Transform** dialog may display other buttons that allow you to move between transforms in those layers (such as red, green, and blue).

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3 Click **Close** on the **Transform** dialog to close it.

7: Using automatic contrast stretching

Objectives Learn to use the button that automatically enhances image contrast. This lets you quickly view various image band combinations without needing to manually set actual limits each time.

Open an RGB algorithm

1 On the main menu, click the **Open** toolbar button.

2 From the **Directories** menu, select the path ending with the text **\examples**.

3 Double-click on the ‘Data_Types’ directory to open it.

4 In the ‘Landsat_TM’ directory, open the algorithm ‘RGB_741.alg.’

ER Mapper displays bands 7, 4 and 1 of a Landsat TM image of the San Diego, California area.

Change the band combination to RGB=321

1 Using the **Band Selection** drop-down menu (in the **Algorithm** window), change the image band in the Red layer to **B3:0.66_um**.

2 Change the image band in the Green layer to **B2:0.56_um**.

ER Mapper reprocesses the RGB algorithm with the new bands.

Notice that the image displays in reddish hues (this band combination usually creates a brown-green image when contrast stretched appropriately). This is caused by the current transforms for the Red and Green layers still being set to the data limits for the previous bands (7 and 4) rather than the new bands you selected (3 and 2).

Use the Refresh Image button to enhance the contrast

1 On the main menu, click the **99% Contrast Enhancement** button.

ER Mapper performs some internal operations, then re-runs the algorithm to display the image with an appropriate contrast stretch.

The **99% Contrast Enhancement** button is actually a batch script that performs the following sequence of operations for you: runs the algorithm once to determine the actual limits of each band, sets the input (X) axis limits to the actual data limits, runs the algorithm again to generate the new histogram, applies a 99% autoclip transform, then runs the algorithm once more to the display the image onscreen.

Tip: The **99% Contrast Enhancement** button saves you the contrast enhancement steps of setting each layer to Limits to Actual and applying an autoclip transform. Therefore it is *very* useful for initially viewing new images, and when using formulas or filters that produce data ranges outside 0-255. View different image band combinations

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2 Select **B4:0.83_um** for the Red layer, **B3:0.66_um** for the Green layer, and **B2:0.56_um** for the Blue layer.

3 Click the **99% Contrast Enhancement** button to automatically adjust the contrast and display the new band combination.

A contrast enhanced image of an RGB=432 band combination displays. Vegetation is shown in red, and urban areas in cyan and grey.

4 Select **B5:1.65_um** for the Red layer, and **B4:0.83_um** for the Green layer.

5 Click the **99% Contrast Enhancement** button.

A contrast enhanced image of an RGB=542 band combination displays. Vegetation is shown in green, and urban areas in magenta.

View a different image and bands

1 In the process stream diagram, click the **Load Dataset** button.

The **Raster Dataset** file chooser dialog box opens.

2 From the **Directories** menu, select the path ending with the text **\examples**.

3 Double-click on the ‘Data_Types” directory to open it.

4 In the ‘Ers1’ directory, double-click on the image ‘Landsat_TM.ers’ to load it into all three layers.

5 In the process stream diagram, click the post-formula **Edit Transform Limits** button for the Red layer. The histogram and transform from the previous image is still displayed.

6 Click the **99% Contrast Enhancement** button and watch the transform dialog as ER Mapper automatically adjusts it.

The transform is automatically adjusted to account for the new image limits and the RGB=542 band combination is displayed. This image is a Landsat TM image of the Netherlands coastal area in Europe.

Note: To speed this operation, ER Mapper internally runs the algorithm at low resolution, then processes the final screen image at full resolution. Therefore the input (X) axis limits in the **Transform** dialog (calculated at low resolution) may not exactly match the Actual Input Limits field (calculated from the final processing). You can manually reset the limits at this point to fine tune the contrast, but usually this is not needed.

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7 Try various band combinations such as RGB=741, RGB=321, and others, then click **99% Contrast Enhancement** to display the new composite image.

Close all image windows and dialog boxes

1 Close all image windows using the window system controls:

- Select **Close** from the window control-menu.

2 Click **Close** on the **Algorithm** window to close it.

Only the ER Mapper main menu should be open on the screen.

What you learned

After completing these exercises, you know how to perform the following tasks in ER Mapper:

- Edit the transform for a particular raster data layer
- Apply linear and piecewise linear transforms
- Edit the input (data) and output (display) ranges for a transform
- Use the automatic transform options
- Work with multiple transforms

7

Colordrape algorithms

This chapter explains how to apply shaded relief effects to an image and create "colordrape" algorithms that drape color information over intensity (brightness) information. Shading and colordraping are two of the most powerful techniques for presentation and analysis of DEM and geophysical images (e.g. magnetics, gravity, seismic horizons, etc.).

Note: This chapter describes the detailed step by step process of creating a colordrape algorithm by hand. You can also use the Geophysics Wizard (located on the Minerals and Oil & Gas toolbars) to produce colordrape images even more quickly and easily.

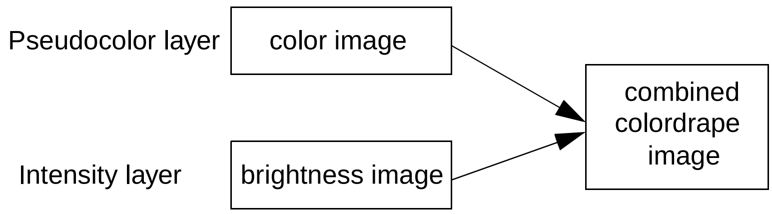
About colordraping

The term *colordraping* refers to the technique of draping one set of image data in color over another set of data that controls the color brightness or intensity. This allows you to effectively view two (or more) different types of data or methods of processing simultaneously in a *combined display.* Colordraping is usually difficult and time consuming using traditional image processing products, but ER Mapper makes it very fast and interactive by providing the special Intensity layer type.

The colordraping technique has become a very popular and powerful tool for visualization of interpreted surfaces. For example, combining seismic two-way-time images shown as both color and as structure lets you create a shaded relief image that enhances subtle faults and color-codes their placement relative to depth. From these types of images, far more useful information can be derived than from conventional visualization techniques.

The Intensity Layer Type

ER Mapper provides a special Intensity layer that is the key to the colordraping technique. When you add an Intensity layer to an algorithm, the *brightness* (or intensity) of the image colors are automatically controlled by the data loaded into the Intensity layer. Low data values in the Intensity layer produce dark colors in the image, and high data values produce bright colors.



The diagram above shows how algorithm Pseudocolor and Intensity layers are combined to create a single colordrape image. You will see for yourself how these techniques work in the following exercises.

Hands-on exercises

These exercises give you practice creating colordrape algorithms to display time surfaces as both shaded relief and color. You will also learn to drape data such as seismic amplitude over a shaded time surface to enhance analysis.

What you will learn...

After completing these exercises, you will know how to perform the following tasks in ER Mapper:

- Use Intensity layers to create shaded relief images that highlight structure
- Combine Pseudocolor and Intensity layers to create colordrape images
- Turn layers on (to process them) and off (to ignore them)
- Control the color and intensity components to modify image displays

Before you begin...

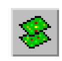
Before beginning these exercises, make sure all ER Mapper image windows are closed. Only the ER Mapper main menu should be open on the screen.

Note: Some of the following exercises repeat steps from the previous exercise to emphasize understanding of the fundamental concepts.

1: Using shading to highlight structure

Objectives Learn how to display a time image in an Intensity layer and apply sun angle shading to create shaded relief effects that highlight structure.

Open an image window and the Algorithm window

1. On the Standard toolbar, click on the **Edit Algorithm**  button.

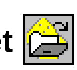
   An image window and the **Algorithm** window appear.

Change the Pseudocolor layer to an Intensity layer

1. Click your right mouse button on the pseudo layer (on the **Algorithm** window). A short-cut menu will appear. Select **Intensity** on the short-cut menu.

   The Pseudocolor layer changes to an Intensity layer. You will use this layer to create a greyscale shaded relief image.

Load the sample seismic image dataset into the Intensity layer

1. In the **Algorithm** window, click the **Load Dataset**  button on the left side of the process stream diagram.

   The **Raster Dataset** file chooser dialog box appears.

2. From the **Directories** menu, select the path ending with **\examples**.
3. Double-click on the directory named ‘Shared_Data.’

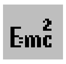
   A list of raster image datasets is displayed.

4. Scroll (if needed) to view the image named ‘Seismic3D.ers,’ then double-click on it to load it.

   The image is loaded into the Intensity layer.

Use a formula to invert the image values

Note: Note that this step is usually only done with two way time or depth data. The reason for inverting the values is to make the deeper areas to appear lower than the shallower ones.

1 In the **Algorithm** window, click on the **Edit Formula**  button in the process stream diagram.

The **Formula Editor** dialog box appears.

2 In the **Formula Editor** dialog, click to place the text cursor before the “I” in “INPUT1,” then type a minus sign (-) on your keyboard. Your formula should now look like this:

```
-INPUT1
```

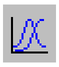
This formula tells ER Mapper to negate (invert) all values in the image.

3 On the **Formula Editor** dialog, click the **Apply changes** button.

The image appears as black initially because you need to adjust the transform to account for the new range of negative data values produced by the formula

4 Click the **Close** button to close the **Formula Editor** dialog.

Adjust the color mapping (contrast) of the image

1 In the **Algorithm** window, click on the right-hand **Edit Transform Limits**  button in the process diagram (the one after the Formula button).

The **Transform** dialog box opens showing the negative data range produced by the formula in the Actual Input Limits fields.

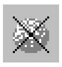
2 From the **Limits** menu (on the **Transform** dialog), select **Limits to Actual**.

The X axis data range changes to match the Actual Input Limits.

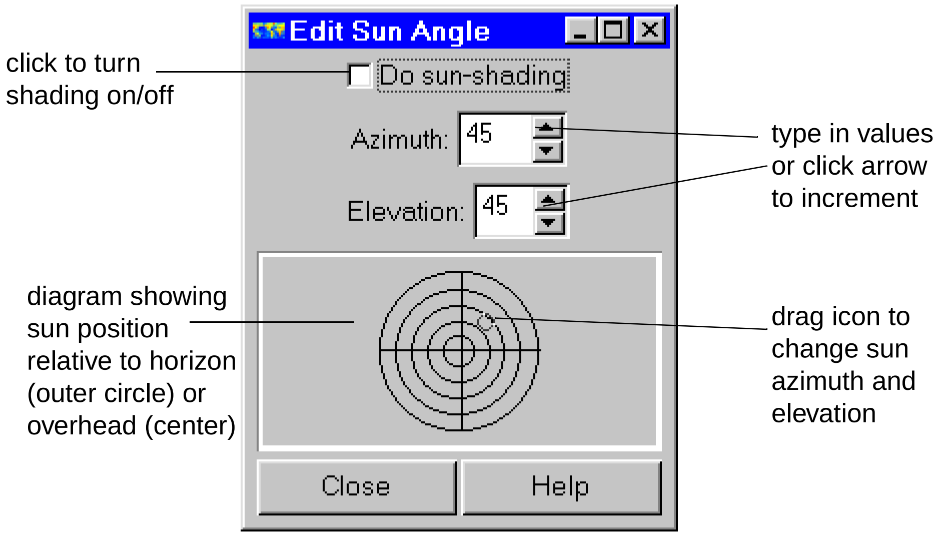
ER Mapper renders the image again, this time using the full range of grey shades to display the image. Since you inverted the data values with a formula, structural lows (larger two-way time values) are shown as dark greys transitioning into structural highs shown as lighter shades.

3 Click **Close** on the **Transform** dialog to close it.

Turn on sun shading and display the shaded relief image

1 On the **Algorithm** window, click the **Edit Realtime Sunshade**  button in the process stream.

The **Edit Sun Angle** dialog box opens to let you specify shaded relief effects for the Intensity layer.



2 Turn on the **Do sun-shading** option.

Sun Angle shading is now active for the Intensity layer, and the **Edit Realtime Sunshade** button in the process diagram changes  to indicate this.

Now the structural features of the time surface are clearly defined due to the sun angle shading. This feature allows you to apply artificial illumination from any direction to highlight very subtle structural features.

3 Make the image window about 50% larger by dragging lower-right corner of the window border.

4 Right-click anywhere on the image and select **Zoom to All Datasets** from the **Quick Zoom** menu.

ER Mapper redisplays the image to fit into the larger window size.

Change the sun azimuth

1 In the **Edit Sun Angle** dialog, drag the small sun icon (the circle) to the upper-left quadrant of the circular grid.

The shading angle of the image changes in real time to show the shading effect as if the sun were shining from the northwest.

The *azimuth* (compass direction) from which the sun shines highlights structural features normal to the sun angle. In this case, features trending in a northeast to southwest direction are now highlighted (since they are normal to the northwest sun angle).

2 Drag the sun icon to shade from different compass directions (azimuths).

Structural features normal to your new sun azimuths are highlighted.

Change the sun elevation

1 In the **Edit Sun Angle** dialog, drag the sun icon near the outer rim of the circular grid.

The image becomes darker overall and with larger areas of shadows.

The *elevation* from which the sun shines determines the length of shadows in the shaded relief image. In this case, the sun is shining from a very low sun angle (near the horizon), so you get longer shadows just as you would see right after sunrise or before sunset.

2 Drag the sun icon to the center of the circular grid.

Now the entire image has very little shadow, as if the sun is shining directly overhead during midday. This allows you to see terrain features without directional shadowing introduced by shading from a specific azimuth. (For example, you can see both sides of a fault.)

3 Experiment by dragging the sun icon until you create an image that highlights structural features of interest. (Setting the sun elevation at 45 degrees or greater is usually recommended to reduce shadowing.)

Tip: You can also adjust the sun azimuth and elevation to exact values using the adjustment arrows next to the Azimuth and Elevation fields.

4 Click **Close** on the **Edit Sun Angle** dialog to close it.

Applications of sun angle shading

ER Mapper's sun angle shading feature is a very powerful tool for rapid identification of subtle features in time surfaces. It is commonly used for many applications, including:

- identify small scale faulting
- identify subtle stratigraphic features (pinchouts, truncations, etc.)
- highlight data acquisition and/or processing artifacts

- highlight quality issues related to interpretation

2: Draping color on the image

Objectives Learn how to duplicate and modify the Intensity layer to create a Pseudocolor layer, and how to combine the two layers to create a colordrape image.

Duplicate the layer and change it to Pseudocolor

1 On the Algorithm window, select the layer that already contains the ‘Seismic3D’ image and click the **Duplicate**  button to create a copy of it.

2 Click on the new (lower) layer with your right mouse button. A short-cut menu will appear. Select **Pseudo** from the short-cut menu.

The Intensity layer changes to a Pseudocolor layer. You will use this layer to display the time surface in color over the shaded relief image.

3 Click on the **Surface** tab, then select **pseudocolor** from the **Color Table** list.

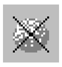
Turn off sun shading for the Pseudocolor layer

1 Click on the **Layer** tab to select it.

2 With the Pseudo layer selected, click the **Edit Realtime Sunshade**  button in the process stream.

The **Edit Sun Angle** dialog box opens. Since the layer was duplicated from the Intensity layer, sun angle shading is still turned on.

3 On the **Edit Sun Angle** dialog, turn off the **Do sun-shading** option.

Sun angle shading is now turned off, and the **Edit Realtime Sunshade** button in the process diagram has a cross through it  to indicate this.

Note: Sun angle shading is usually applied only to time surface images displayed in Intensity layers because two-way time describes structural features well. Sun shading is not normally applied to amplitude or attribute images which are generally displayed in color.

---

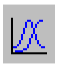
4 Click **Close** on the **Edit Sun Angle** dialog to close it.

Note that by combining the two processing techniques into one image, you can simultaneously see structure as brightness relative to depth as color. In this case blues represents structural lows, and reds structural highs.

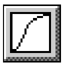
Tip: The colordrape technique you used here is one of the most important ER Mapper processing techniques used to visualize interpreted time surfaces. You should therefore practice and become comfortable with the steps used to create colordrape algorithms.

Try different color mapping transforms for the color layer

1 In the **Algorithm** window, click on the Pseudo layer to select it.

2 Click on the right-hand **Transform**  button in the process diagram (following the Formula button).

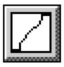
The **Transform** dialog box opens showing the current lookup table and color mapping.

3 On the **Transform** dialog, click the **Histogram equalize**  button.

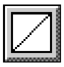
ER Mapper applies a histogram equalization transform to the data. Histogram equalization maximizes overall color contrast in the image at the expense of losing contrast in the structural highs and lows.

Note: Notice that the color mapping changes without affecting the shaded relief image in the Intensity layer. This shows how layers in an algorithm are independent of each other, and can be modified individually to affect to overall image they combine to create.

---

4 On the **Transform** dialog, click the **Gaussian equalize**  button.

ER Mapper applies a gaussian equalization contrast stretch to the data. This maximizes color contrast in the structural highs and lows, but tends to flatten out contrast in other parts of the image.

5 On the **Transform** dialog, click the **Create default linear transform**  button.

ER Mapper resets the color mapping back to a straight linear default.

6 Click **Close** on the **Transform** dialog to close it.

Display the shaded relief and color images separately

1 Turn the Pseudocolor layer off by right-clicking on the layer name and selecting **Turn Off** from the drop-down menu.

Only the structural component of the image displays since the color component of the algorithm (the Pseudocolor layer) is turned off.

2 Turn the Pseudocolor layer on again (activate the option button).

ER Mapper displays the combined colordrape image.

3 Turn the Intensity layer off by deactivating its option button.

ER Mapper displays the color image only.

By turning layers on and off, you can see them independently of each other to fine tune adjustments before adding them together again.

4 Turn the Intensity layer on again (activate its option button).

ER Mapper displays the combined colordrape image again.

3: Draping amplitude data in color

Objectives Learn how to add a second Pseudocolor layer to drape amplitude (or other data) as color over the shaded time, and how to use multiple Pseudocolor (or other layer types) in the same algorithm.

Add a second Pseudocolor layer to the algorithm

1 From the **Edit/Add Raster Layer** menu (on the **Algorithm** window), select **Pseudo**.

ER Mapper adds a new Pseudocolor layer to the algorithm. As with all new added layers, it has no image loaded yet.

Load the sample seismic image dataset into the new layer

1 In the **Algorithm** window, click the **Load Dataset**  button on the left side of the process stream diagram.

The **Raster Dataset** file chooser dialog box appears.

2 Select the image named ‘Seismic3D.ers’ from the ‘\examples\Shared_Data’ directory by double-clicking on it.

The image is loaded into the new Pseudocolor layer, so all layers contain the same image.

Tip: If you had wanted to load a different image into the second Pseudocolor layer, you would use either the **OK this layer only** or **Apply this layer only** button on the **Raster Dataset** dialog. Double-clicking on the image name is the same as clicking the **OK** button.

Change the image band for the new Pseudo layer

1 With the new (lower) Pseudo layer selected, click on the **Band Selection** drop-down list in the process diagram (it currently reads 'B1:Two Way Time_ms').

A list of two images displays. This image has two bands (or layers) of data covering the same geographic area–a two-way time band and a seismic amplitude band.

2 Click on the option labelled **B2:Amplitude** to select it as the band to be processed in that layer.

Note: When you first load an image into a layer, the first band is selected by default. You can then use the **Band Selection** drop-down list to choose any band in the image.

Label the two Pseudo layers to distinguish them

Since you now have more than one Pseudocolor layer, it is helpful to add labels to each so you can quickly distinguish between them.

1 Click in the text field on the left side of the lower Pseudo layer, and type the text **`Amplitude`**.

2 Click in the text field on the left side of the upper Pseudo layer, and type the text **`Inverted TWT`**.

Turn off the two-way time Pseudo layer

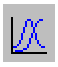
1 Turn off the Pseudo layer labelled 'Inverted TWT' by right-clicking on the layer name and selecting **Turn Off** from the drop-down menu.

The layer is now turned off and will be ignored during processing.

The data initially appears as red over the shaded time image–you need to adjust the transform (color mapping) to account for the data in the new layer.

Adjust the transform for the Amplitude color layer

1 Click on the Pseudo layer labelled 'Amplitude' to select it.

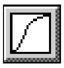
2 Click on the right-hand **Transform**  button in the process diagram.

The **Transform** dialog box opens. Notice that the actual input limits range from about -17000 to +30000.

3 From the **Limits** menu, select **Limits to Actual**.

The amplitude data now displays as various colors over the shaded time data.

Note that the histogram for the amplitude data shows that most of the data values are clustered in the center (a normal distribution). This is why the data are displayed primarily in greens and yellows since these are the middle colors in the lookup table.

4 On the **Transform** dialog, click the **Histogram equalize**  button.

Histogram equalization increases the overall color contrast in the amplitude data. Areas of high amplitudes are shown as reds, and low amplitude areas are shown in blues.

This colordrape image lets you easily associate variations in amplitude with structural features shown by the shaded two-way time surface in the Intensity layer. Using this technique, you can drape virtually any type of data in color over the shaded time surface to aid interpretation of subtle relationships.

5 Click **Close** on the **Transform** dialog to close it.

Display the two-way time data again

1 Turn on the Pseudo layer labelled ‘Inverted TWT’ by right-clicking on the layer name and selecting **Turn On** from the drop-down menu.

2 Turn off the Pseudo layer labelled ‘Amplitude.’

The two-way time data again displays in color over the shaded relief data. You can now easily display either the time or amplitude data simply by turning on the desired layer.

Note: If you have more than one layer of the same type turned on, the layer on top has display priority over layers below it. In this case, for example, you would see the two-way time data if both the ‘Inverted TWT and ‘Amplitude’ layers were turned on. (Data in lower priority layers is only displayed where they do not spatially overlap with layers of the same type above them.)

4: Saving the colordrape algorithm

Objectives Learn to save and add comments to the colordrape algorithm.

Enter a description for the algorithm

1 In the **Algorithm** window, select the text in the **Algorithm Description** text field (it currently reads 'No Description').

2 Type the following text, then press Enter or Return on your keyboard:

```
Horizon KA time and amplitude colordrape
```

This text now becomes a brief description for the entire algorithm.

Save the processing steps to an algorithm file on disk

1 From the **File** menu (on the main menu), select **Save As...**.

The **Save As** file chooser dialog box appears.

2 In the **Files of Type** field, select ER Mapper Algorithm (.alg).

3 From the **Directories** menu, select the path ending with the text **\examples**.

4 Double-click on the directory named 'Miscellaneous' to open it.

5 Double-click on the directory named 'Tutorial' to open it.

6 In the **Save As:** text field, type in a name for the algorithm file using your initials at the beginning followed by the text 'Horizon_KA_colordrape.' Separate each word with an underscore (_). For example, if your initials are "DH," type in the name:

```
DH_Horizon_KA_colordrape
```

7 Click the **Apply** button to save the algorithm and leave the dialog open.

Your pseudocolor algorithm is now saved to an algorithm file on disk.

Add comments to the algorithm

1 Click the **Comments...** button.

A dialog box opens allowing you to type comments about your algorithm.

2 Click **Cancel** on the **Save As** dialog to close it (you do not need it).

3 In the comments dialog, type the following description information:

```
This algorithm drapes time or amplitude data in color over
a shaded time surface. Sun angle shading is applied to the
```

```
time data in the Intensity layer to highlight structural
features. Two Pseudocolor layers are added to display either
time or amplitude to create a combined color/shaded relief image.
```

4 Click the **OK** button to save your comments with the algorithm and close the dialog.

Your algorithm is now commented for future users.

Tips for Colordrape Algorithms

Generally the Intensity layer of a colordrape algorithm is used to show structural features derived from two-way time data, and the color layers are used to show amplitude, azimuth, isochrons, or any other derivative or attribute images you feel are useful. To use an existing algorithm as a “template” algorithm to apply the same processing to different images, simply load new images into the Intensity and Pseudocolor layers and adjust the transforms to account for the data ranges.

One colordrape variation some researchers use is to display a dip image in Intensity instead of shading from a specific compass direction. A dip image may delineate both sides of a fault more clearly, for example. (Generation of dip images is explained in the chapter on formulas.)

Close all image windows and dialog boxes

1 Close all image windows using the window system controls:

- Select **Close** from the window control-menu.

2 Click **Close** on the **Algorithm** window to close it.

Only the ER Mapper main menu should be open on the screen.

What you learned...

After completing these exercises, you know how to perform the following tasks in ER Mapper:

- Use Intensity layers to create shaded relief images that highlight structure
- Combine Pseudocolor and Intensity layers to create colordrape images
- Turn layers on (to process them) and off (to ignore them)
- Control the color and intensity components to modify image displays

8

HSI algorithms

This chapter explains how to create algorithms that allow you to display and manipulate data in the Hue Saturation Intensity (HSI) color space. Applying an HSI enhancement is an innovative analysis technique that goes one step beyond a colordrape display, so you can visualize three variables simultaneously. This is an advanced technique most commonly used to combine multiple seismic attribute horizons in a single image.

Note: HSI is also referred to as IHS, or Intensity Hue Saturation, in some circles.

Note: Another common application of HSI processing is to improve the "look" of an RGB image (usually a satellite or airphoto image) by adjusting the image intensity or colour saturation (or both). This is described in exercise "4: Converting an RGB image to HSI" on page 143.

About the HSI Color System

In the Hue Saturation Intensity (HSI) color system, different colors are characterized by three measurable characteristics of a color:

- **Hue**–The main attribute of a color that distinguishes it from other colors in the spectrum. Hues are what you see in a rainbow, and are what we commonly think of as "color" (red, yellow, green, and so on).

- **Saturation**–The amount of a particular color or color "purity." Colors with high saturation (little grey) are said to be pure or vivid. Colors with low saturation (much grey) are pastel or dull colors. Completely desaturated colors are grey, no matter what the hue.
- **Intensity**–The relative brightness of a color. Colors with high intensity are bright, and colors with low intensity are dark.

The HSI color system is characterized as a "perceptual" color system because it provides a more intuitive means of manipulating color than the RGB (electronic) color system. ER Mapper implements the HSI color system by means of the Color Mode named Hue Saturation Intensity, and separate algorithm layer types for Hue, Saturation, and Intensity.

HSI Color Mode

To display data in HSI, you set the algorithm Color Mode to Hue Saturation Intensity, then load data into Hue, Saturation, and Intensity layers. In order to produce color, all three layers types must be used and turned on. ER Mapper provides HSI template algorithms that let you quickly load and display data using the HSI color system.

Note: Computer monitors use the RGB color system to actually display data, so ER Mapper automatically performs an internal translation of colors specified in HSI to colors specified in RGB for the monitor.

The Hue Layer

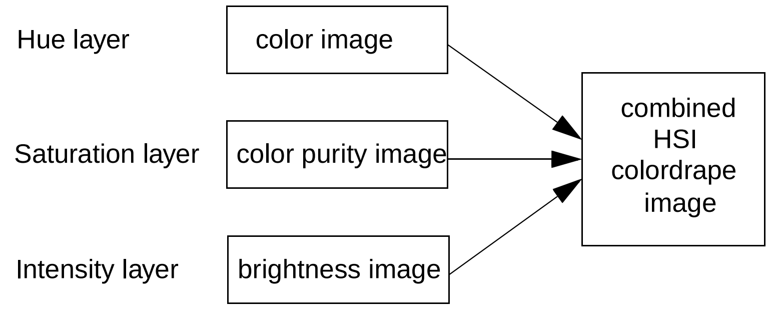
In an HSI image display, The Hue layer controls the mapping of data values to colors in the spectrum. In a typical display, the range of data values from low to high is mapped through the progression of hues: red-yellow-green-cyan-blue-magenta.

The Saturation Layer

In an HSI image display, The Saturation layer controls the mapping of data to the purity of colors in the image display (that is, the amount of grey in the colors). Low data values produce pastel or dull colors (much grey), and high data values produce pure or vivid colors (little grey).

The Intensity Layer

In an HSI image display, The Intensity layer controls the mapping of data to the brightness of colors in the image display. Low data values produce dark color, and high data values produce white color.



The diagram above shows how algorithm Hue, Saturation and Intensity layers are combined to create a single HSI colordrape image. You will see for yourself how these techniques work in the following exercises.

Hands-on exercises

These exercises give you practice creating HSI colordrape algorithms and manipulating image display in HSI color space.

What you will learn...

After completing these exercises, you will know how to perform the following tasks in ER Mapper:

- Use the algorithm Color Mode named Hue Saturation Intensity
- Combine Hue, Saturation and Intensity layers to create HSI images
- Understand the basics for interpreting data displayed in HSI
- Control the hue, saturation and intensity components to modify image displays
- Improve the appearance of an RGB image by converting it to HSI.

Before you begin...

Before beginning these exercises, make sure all ER Mapper image windows are closed. Only the ER Mapper main menu should be open on the screen.

Note: Some of the following exercises repeat steps from the previous exercises to emphasize understanding of the fundamental concepts.

1: Creating the shaded relief image

Objectives Learn how to create an HSI algorithm by opening a new image window, creating Hue, Saturation, and Intensity layers, and loading data into the H, S, and I layers. (The sample algorithm you will create displays two-way time as hues, amplitude as saturation, and shaded two-way time as intensity.)

Open an image window and the Algorithm window

1 On the Common Functions toolbar, click on the **Edit Algorithm** button.

An image window and the **Algorithm** window appear.

Change the Pseudocolor layer to an Intensity layer

1 Click your right mouse button on the Pseudo layer (on the **Algorithm** window). A short-cut menu will appear. From the short-cut menu select **Intensity**.

The Pseudocolor layer changes to an Intensity layer. You will use this layer to create a greyscale shaded relief image.

Load the sample seismic image dataset into the Intensity layer

1 In the **Algorithm** window, click the **Load Dataset** button on the left side of the process stream diagram.

The **Raster Dataset** file chooser dialog box appears.

2 From the **Directories** menu, select the path ending with **\examples**.

3 Double-click on the directory named ‘Shared_Data’.

4 Double-click on the image named ‘Seismic3D.ers’ to load it.

The image is loaded into the Intensity layer.

Use a formula to invert the image values

As before, it is often desirable to invert positive two-way time values, so larger time values are displayed as structural lows and smaller values as highs. (This is optional and may not be necessary with your images.)

1 In the **Algorithm** window, click the **Edit Formula** button in the process stream diagram.

The **Formula Editor** dialog box appears.

2 In the **Formula Editor** dialog, edit the text string “INPUT1” to add a minus sign (-) in front. Your formula should now look like this:

```
-INPUT1
```

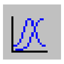
This formula tells ER Mapper to negate (invert) all values in the image.

3 On the **Formula Editor** dialog, click the **Apply changes** button.

The image appears as black initially because you need to adjust the transform to account for the new range of negative data values produced by the formula

4 Click **Close** on the **Formula Editor** dialog to close it.

Adjust the color mapping (contrast) of the image

1 In the **Algorithm** window, click on the right-hand **Edit Transform Limits**  button in the process diagram (the one after the Formula button).

The **Transform** dialog box opens showing the negative data range produced by the formula in the Actual Input Limits fields.

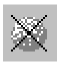
2 From the **Limits** menu (on the **Transform** dialog), select **Limits to Actual**.

The X axis data range changes to match the Actual Input Limits.

ER Mapper renders the image again, this time using the full range of grey shades to display the image.

3 Click **Close** on the **Transform** dialog to close it.

Turn on sun shading and display the shaded relief image

1 On the **Algorithm** window, click the **Edit Realtime Sunshade**  button in the process stream.

The **Edit Sun Angle** dialog box opens to let you specify shaded relief effects for the Intensity layer.

2 Turn on the **Do sun-shading** option to turn on shading.

The structural features of the time surface are clearly defined due to the sun angle shading.

3 Drag the small sun icon (the circle) around the circular grid until you find a shade angle that highlights structural features of interest. (Keep the sun elevation above 45 degrees to reduce shadowing.)

4 Click **Close** on the **Edit Sun Angle** dialog to close it.

Label the Intensity layer to identify it

1 Click in the text field on the left side of the Intensity layer, and type the text **Shaded TWT**.

(If desired, you could also add the shading angle, for example “NE shaded TWT”.)

2 Make the image window about 50% larger by dragging lower-right corner of the window border.

3 Right-click on the image and select **Zoom to All Datasets** from the Quick Zoom window.

You have now created the shaded relief image to highlight structure. Next you will add Hue and Saturation layers to drape other data in color.

2: Adding data in Hue and Saturation layers

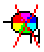
Objectives Learn how to build on your shaded relief Intensity image to create an HSI algorithm by adding Hue and Saturation layers. (The sample algorithm you will create displays two-way time as hues, amplitude as saturation, and shaded two-way time as intensity.)

Duplicate the Intensity layer and change it to Hue

1 On the Algorithm window, with the **Layer** tab selected, click the **Duplicate**  button to create a copy of the current Intensity layer that already contains the ‘Seismic3D’ image.

2 Click on the new (lower) layer with your right mouse button. A short-cut menu will appear. From the short-cut menu select **Hue**.

The Intensity layer changes to a Hue layer. You will use this layer to display the inverted two-way time data in color over the shaded relief image.

Note: Notice that the Hue layer has a red cross  over it – this indicates that the layer type in *not valid* with the current algorithm Color Mode. (In order to use Hue layers in an algorithm, you must also select the Color Mode named Hue Saturation Intensity).

Change the Color Mode to Hue Saturation Intensity

1 In the surface tab, from the **Color Mode** drop-down menu (on the **Algorithm** window), select **Hue Saturation Intensity**.

The Hue layer now becomes active because the appropriate Color Mode is now selected.

Turn off sun shading for the Hue layer

1 With the Hue layer selected, click the **Edit Realtime Sunshade**  button in the process stream.

The **Edit Sun Angle** dialog box opens. Since the layer was duplicated from the Intensity layer, sun angle shading is still turned on.

2 On the **Edit Sun Angle** dialog, turn off the **Do sun-shading** option.

Sun angle shading is now turned off for the Hue layer (shading is not normally used on color layers).

3 Click **Close** on the **Edit Sun Angle** dialog to close it.

4 Enter a label for the Hue layer by typing the text **`Inverted TWT`** in the text field on the left side.

Add a Saturation layer and load the sample image

1 From the **Edit/Add Raster Layer** menu (on the **Algorithm** window), select **Saturation**.

ER Mapper adds a new Saturation layer to the algorithm. As with all new added layers, it has no image loaded yet. You will use this layer to display the seismic amplitude data.

2 In the **Algorithm** window, click the **Load Dataset**  button on the left side of the process stream diagram.

The **Raster Dataset** file chooser dialog box appears.

3 From the **Directories** menu, select the path ending with **\examples**.

4 Double-click on the directory named ‘Shared_Data’.

5 Scroll up (if needed) to view the image named ‘Seismic3D.ers,’ then double-click on it to load it.

The image is loaded into the new Saturation layer, so all layers contain the same image.

Tip: In this case you added a new layer and loaded the image because you don't want to use the formula in the other layers. (There is no need to invert the amplitude data.) An alternative is to duplicate the Hue layer, change its type to Saturation, and reset the formula back the default "INPUT1."

Select the amplitude band and label the Saturation layer

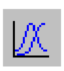
1. With the new Saturation layer selected, click on the **Band Selection** drop-down list in the process diagram, and select **B2:Amplitude**.

   This tells ER Mapper to modify the saturation of colors in the final image according to variations in the amplitude data.

   You now have an image similar to the colordrape that shows structure (shaded two-way time) and depth (color-coded two-way time). Now you need to adjust the transform of the amplitude data to make it clearly stand out against the color and shading.

2. Enter a label for the Saturation layer by typing the text **`Amplitude`** in the text field on the left side.

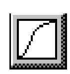
Apply a Histogram equalization to the amplitude data

1. With the Saturation layer selected, click on the right-hand **Edit Transform Limits**  button in the process diagram.

   The **Transform** dialog box opens.

2. On the **Transform** dialog, select **Limits to Actual** from the **Limits** menu.

   The complete histogram for the amplitude data appears.

3. On the **Transform** dialog, click the **Histogram equalize**  button.

   The overall contrast in the amplitude data is increased, which appears as variations in color saturation throughout the image. Notice, for example, that the V-shaped uplifted fault block in the upper-left shows high amplitudes as vivid colors and low amplitudes as greyish colors.

   You now have an image that shows three variables at once:

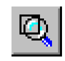
- Structure is shown as intensity (brightness) by applying sun angle shading to the two-way time data.
- Relative depth is shown as color (hues), where red indicates the troughs progressing through yellow, green, cyan, and blue to magenta for the peaks in the time surface.

- The event amplitude is shown by variations in the saturation of colors, where greyish or pastel colors indicate low amplitude progressing through to vivid or rich colors that indicate high amplitudes.

  This type of display has become a popular ER Mapper processing technique for combined analysis of two-way time and amplitude data, as well as other combinations of time and images derived from seismic images.

4 Click **Close** on the **Transform** dialog to close it.

Zoom in on upper-left portion of the image

1 On the Common Functions toolbar, click the **ZoomBox Tool**  button.

2 Inside the image window, drag a zoom box around the V-shaped structure in the upper-left portion of the image (the uplifted fault block in red and magenta).

ER Mapper zooms in on the defined area. Notice that the image takes on a slightly jagged or blocky look when you zoom in closely. (You can begin to see the limits of the seismic data resolution, or the actual pixels that comprise the image.)

3 On the **Algorithm** window, turn on the **Smoothing** option.

Notice that the image becomes noticeably smoother. The Smoothing option applies a bilinear interpolation to the image screen display. This is often useful for reducing the jagged look and helps make overall features easier to interpret.

Also notice that you can now clearly see the pattern of low and high amplitudes in the uplifted block and surrounding areas. High amplitude areas have very rich colors, and low amplitudes occur along the faults (shown by the low saturation greyish colors in those areas).

4 From the **View** menu (on the main menu), select **Quick Zoom**, then select **Zoom to All Datasets**.

ER Mapper zooms back out to the full image extents.

Tip: The **Smoothing** option is most useful when you zoom in very closely on an area of interest, and can be turned on or off as desired. It usually has little noticeable effect until you zoom in close to the pixel resolution.

3: Saving the HSI colordrape algorithm

Objectives Learn to save and add comments to the HSI colordrape algorithm.

Enter a description for the algorithm

1 Select the text in the **Algorithm Description** text field and type:

```
TWT and amplitude HSI enhancement
```

This text now becomes a brief description for the entire algorithm.

Save the algorithm to disk

1 On the Standard toolbar (on the main menu), click the **Save As** button.

The **Save As** file chooser dialog box appears. (This toolbar button is a shortcut for selecting **Save As...** from the **File** menu.)

2 In the **Files of Type:** field, select 'ER Mapper Algorithm (.alg)'.

3 Double-click on the 'examples\Miscellaneous\Tutorial' directory to open it.

4 In the **Save As:** text field, type in a name for the algorithm file using your initials at the beginning followed by the text 'Seismic_HSI_enhancement.' Separate each word with an underscore (_). For example, if your initials are "TL," type in the name:

```
TL_Seismic_HSI_enhancement
```

5 Click the **Apply** button to save the algorithm and leave the dialog open.

Your HSI algorithm is now saved to an algorithm file on disk.

Add comments to the algorithm

1 Click the **Comments...** button to add comments.

2 Click **Cancel** on the **Save As** dialog to close it (you do not need it).

3 In the comments dialog, type the following description information:

```
This algorithm displays time and amplitude data in hue
saturation intensity (HSI) color space. Sun angle shading is
applied to the time data in the Intensity layer to highlight
structure. Time is displayed as color in the Hue layer, and
event amplitude is displayed as variations in color saturation
in the Saturation layer.
```

4 Click the **OK** button to save your comments with the algorithm and close the dialog.

Your algorithm is now commented for future users.

5 Close the image window.

Tips for HSI Algorithms

Displaying data in Hue Saturation Intensity color space is one of the newer techniques in the analysis of interpreted time surfaces. It is helpful to have basic understanding of the way the HSI color system works to help you interpret data presented in this way.

Using the previous HSI image as an example, color is used to indicate absolute depth, or the structural highs and lows in the time surface. The event amplitude is not related to any specific color or hue (red, blue, etc.), but to the *saturation* of the color. For example, areas of the time surface with similar amplitudes may have completely different colors, but will have the same degree of color saturation or purity.

This example used time in the hue layer and amplitude in the saturation layer, but you could just as easily substitute any other types of data instead. Shaded two-way time data is generally always used in the intensity layer.

The steps you followed in this exercise showed how to create an HSI algorithm from scratch, in part to illustrate the use of certain features in ER Mapper. When you learn to use ER Mapper, you can create these types of algorithms more quickly by using an existing algorithm as a template, or using a toolbar button to automatically create certain types of commonly used algorithms.

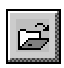
4: Converting an RGB image to HSI

Objectives Learn to improve the appearance of an image by converting it from RGB to HSI.

Certain types of image enhancements can be awkward or impossible to do by applying individual constrast stretches to the red, green, and blue channels separately. For example. if you want to brighten an RGB image, you cannot only adjust the transform for the Red layer because the image will then become more red in color. Changing the overall color saturation by adjusting the Red, Green and Blue layer transforms is even more difficult, if not impossible. On the other hand, you can independently increase the brightness and color saturation of an HSI image by merely adjusting the transforms for the Intensity and Saturation layers without affecting the color.

This exercise shows you how to use a supplied template algorithm to convert an existing RGB algorithm to HSI and then to adjust the brightness and color saturation.

Open the template algorithm

1 Click on the **Open**  button on the **Standard** toolbar.

The **Open** file chooser dialog box appears.

2 From the **Directories** menu, select the path ending with the text **\examples**.

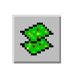
3 Double-click on the directory named ‘Miscellaneous’ to open it.

4 Double-click on the directory named ‘Templates’ to open it.

5 Double-click on the directory named ‘Common’ to open it.

6 Double click on the file named ‘RGB_to_HSI_to_RGB.alg’ to open it.

A window displaying and image will open.

7 On the Common Functions toolbar, click on the **Edit Algorithm**  button to open the Algorithm window.

Notice that the algorithm is displaying the ‘ADAR_5000.ers’ image in an Intensity, Saturation and a Hue layer. You will now replace this image with an RGB algorithm and use the ‘RGB_to_HSI_to_RGB.alg’ as template for displaying it in HSI color mode.

Load the RGB algorithm

1 In the **Algorithm** window, click on the Intensity Layer to select it.

2 Click the **Load Dataset**  button on the left side of the process stream diagram.

The **Raster Dataset** file chooser dialog box appears.

3 Select ‘ER Mapper Algorithm (.alg)’ in the **Files of Type:** box.

4 From the **Directories** menu, select the path ending with **\examples**.

5 Double-click on the directory named ‘Data_Types’.

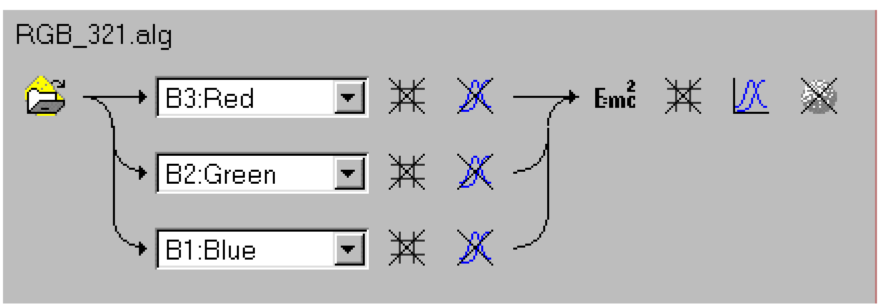
6 Double-click on the directory named ‘Landsat_TM’.

7 Double-click on the image named ‘RGB_321.alg’ to load it.

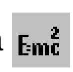
The ‘RGB_321.alg’ algorithm, consisting of a Red, Green and Blue layer is loaded into all three layers of HSI template algorithm. Notice that each layer of the template algorithm has the original Red, Green and Blue layers applied as input bands to a formula to produce the Hue, Saturation or Intensity layer

The image should currently have a grey and blue appearance because the input bands are in the wrong order for the Hue Layer formula. The formulas applied to the Intensity and Saturation layers do not require the input bands to be in a specific order.

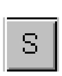
8 Select the Hue layer and change the order of the input bands to B3:Red, B2:Green and B1:Blue, as shown below:



The displayed image should become more brown and green in color.

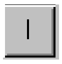
9 With the Hue Layer selected, click on the Edit Formula  button in the process diagram.

The Formula Editor dialog box will open. Notice that the formula description is “RGB to Hue”, indicating that this formula uses the three RGB input bands to create a single Hue layer. The formula has been loaded into the template algorithm from the ‘Hue.frm’ file in the ‘formula\hsi’ directory.

10 Click on the 

button on the Formula Editor dialog box.

This causes the Formula Editor dialog to display the formula for the Saturation Layer. Notice that the selection in the Algorithm window also changes to the Saturation Layer. In this case the formula description is “RGB to Saturation”. The formula has been loaded from the ‘Saturation.frm’ file in the ‘formula\hsi’ directory.

11 Click on the  button on the Formula Editor dialog box.

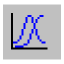
This causes the Formula Editor dialog to display the formula for the Intensity Layer. Notice that the selection in the Algorithm window also changes to the Intensity Layer. In this case the formula description is “RGB to Intensity”. The formula has been loaded from the ‘Intensity.frm’ file in the ‘formula\hsi’ directory.

12 Click on the **Close** button to close the Formula Editor.

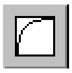
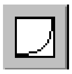
Formulas will be discussed in more detail in Chapter 10, “Using Formulas”.

Adjust the image brightness

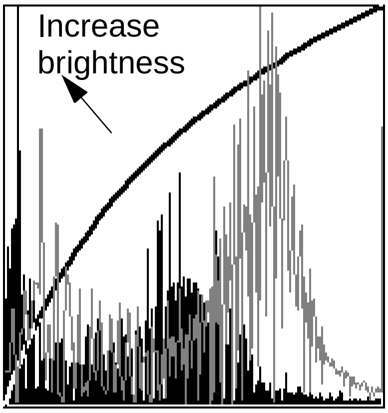
You can now adjust the brightness of the image by altering the post formula transform on the Intensity Layer.

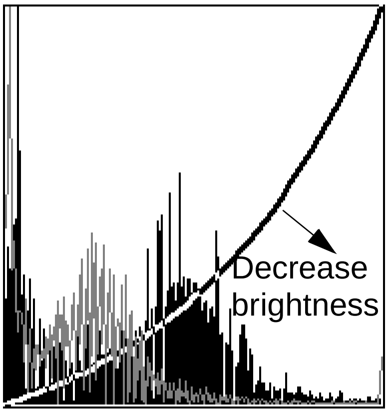
1 With the Intensity Layer selected, click on the **Edit Transform Limits**  button to the right of the **Edit Formula** button on the process diagram.

The Transform dialog will open.

2 On the Transform dialog, select the **Create default logarithmic transform**  or **Create default exponential transform**  button.

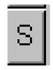
3 You can now increase or decrease the brightness of the image by dragging the transform line as shown below:



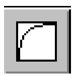
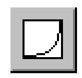


Adjust the color saturation

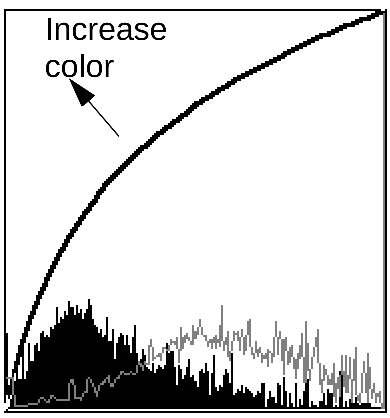
You can adjust the color saturation of the image by altering the post formula transform on the Saturation Layer.

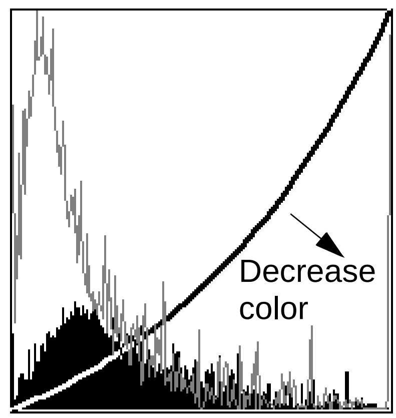
1 On the Transform dialog, select the Saturation Layer post formula transform by clicking on the  button.

If the Transform dialog was not already open, you would have selected the transform from the Sakturation Layer process diagram in the Algorithm window.

2 On the Transform dialog, select the **Create default logarithmic transform**  or **Create default exponential transform**  button.

3 You can now increase or decrease (to greyscale) the color saturation of the image by dragging the transform line as shown below:





Note: While it is possible to adjust the Hue Layer transform in the same way as the Intensity and Saturation layers, this is not usually done because it causes the colors to change making the image difficult or impossible to interpret.

Close all image windows and dialog boxes

1 Close all image windows using the window system controls:

- Select **Close** from the window control-menu.

2 Click **Close** on the **Algorithm** window to close it.

Only the ER Mapper main menu should be open on the screen.

What you learned...

After completing these exercises, you know how to perform the following tasks in ER Mapper:

- Use Intensity layers to create shaded relief images that highlight structure
- Combine Pseudocolor and Intensity layers to create colordrape images
- Turn layers on (to process them) and off (to ignore them)
- Control the color and intensity components to modify image displays
- Convert an RGB image to HSI to improve its appearance.

9

Using spatial filters

This chapter explains how to modify raster image data using spatial filtering to enhance edges, remove noise, highlight structural features, and perform other enhancements to improve visual interpretation. It introduces concepts associated with spatial filtering and gives you practice using ER Mapper's Filter options.

Note: For information on frequency domain filtering (Fourier Transforms), see the *ER Mapper User Guide*.

About spatial filtering

Spatial filtering is a common operation applied to raster image data to enhance or suppress spatial detail to improve visual interpretation. Common examples include applying filters to enhance edge detail in images, or to remove or decrease noise patterns in an image. Spatial filtering is called a "local operation" in image processing because it modifies the value of each pixel in the image according to the values of the pixels surrounding it. Filters work by removing certain spectral or spatial frequencies to enhance features in the remaining image.

Spatial frequency

A characteristic common to all types of raster data is *spatial frequency*, which defines the magnitude of changes in data values per unit distance for any particular part of an image. Areas of an image with small changes or gradual transitions in data values over a given area are termed *low frequency* areas (such as a smooth lake surface). Areas with large changes or rapid transitions are termed *high frequency* areas (such as an urban area with dense road networks). Spatial filters can be divided into three broad categories:

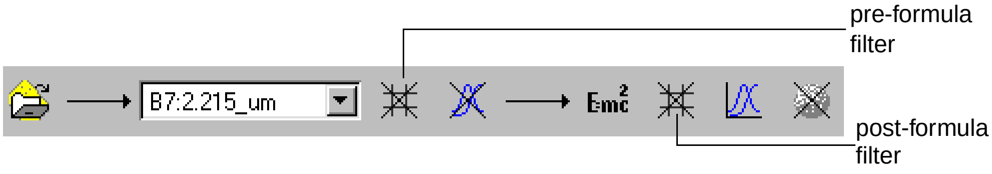
- **Low pass filters** emphasize low frequency detail to smooth out image noise or reduce spikes in the data. Since they de-emphasize detail in an image, low pass filters are sometimes called smoothing or averaging filters.
- **High pass filters** emphasize high frequency detail to enhance or sharpen linear features like roads, faults, and land/water boundaries. High pass filters are sometimes called sharpening filters because they are generally used to enhance detail without affecting low frequency portions of the image.
- **Edge detection filters** emphasize edges surrounding objects or features in an image to make them easier to analyze. Edge detection filters usually create an image with a grey background and black and white lines surrounding the edges of objects and features in the image.

How convolution kernels work

Spatial filtering is accomplished by passing a two-dimensional rectangular array (or window) containing weighting values over the image data at each pixel location. The pixel in the center of the window is evaluated according to the surrounding pixels and weighting values defined for each cell in the array, then a new output pixel value is calculated. The window then shifts over to the next pixel and performs the same operation. This process of evaluating the weighted neighboring pixel values is called two-dimensional convolution, and the filter array is often called a *convolution kernel*.

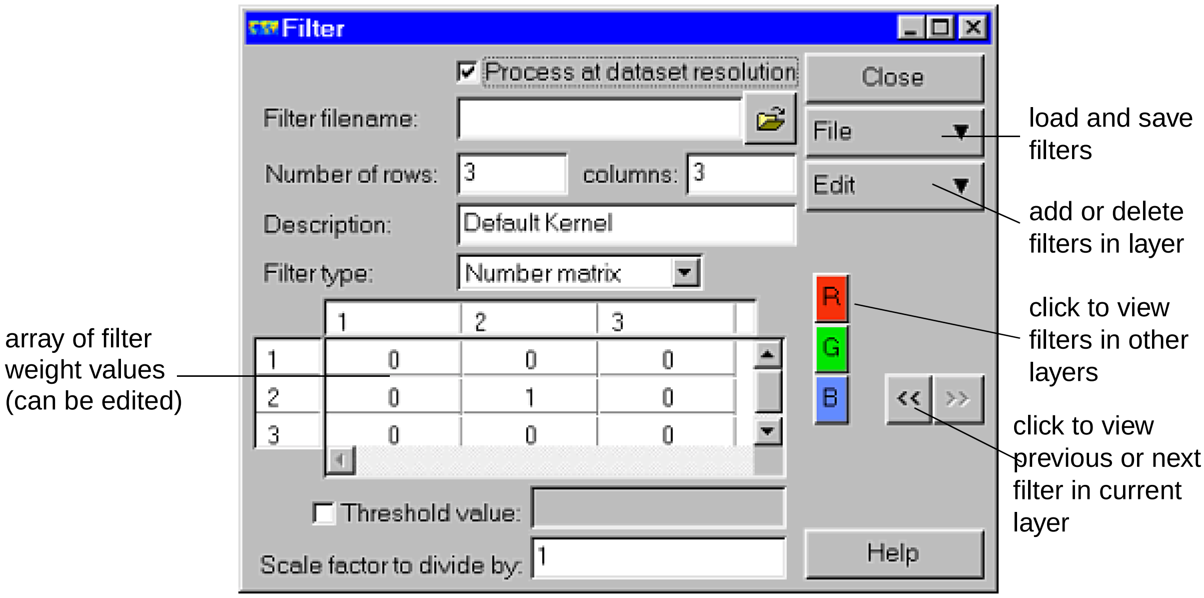
The Filter Editor buttons

By default, each raster layer in ER Mapper has two **Filter editor** buttons in the algorithm process stream. One applies a filter before a formula (pre- formula), and the other applies a filter after a formula (post-formula). You can also insert and append additional filters in either location to create more complex filtering operations.



The Filter editor dialog box

To add a filter into the process stream, or create a new filter, click on the desired **Filter** button to open the **Filter** dialog box. ER Mapper provides a wide variety of standard spatial filters, including low and high pass filters, directional edge enhancement filters, and special filters for classification smoothing and for geophysical and seismic data.



ER Mapper also lets you use filters that are written in C, and provides several C filters as examples. Using C allows you implement more complex or specialized filtering techniques that are not possible with simple convolution kernels. There is no limit to the dimensions of filters that can be defined and used in ER Mapper.

Hands-on exercises

These exercises give you practice applying filters in ER Mapper, and explain how to insert and delete filters in the process stream using the Filter buttons. You will try various types of filters to evaluate their results.

What you will learn...

After completing these exercises, you will know how to perform the following tasks in ER Mapper:

- Insert and delete filters in the process stream diagram
- Apply different types of filters to see their results
- Edit the transform to enhance the contrast of filtered images
- Use filters to generate slope and aspect images from DEMs

- Apply filters in multiple raster layers
- Use multiple filters in the process stream

Before you begin... Make sure all image ER Mapper image windows and dialog boxes are closed. Only the main ER Mapper menu should be open.

1: Adding filters to images

Objectives Learn to apply several types of standard filters to an image, and adjust the contrast of filtered data.

Open and display an existing algorithm

1 Click the **Open** button on the Standard toolbar.

An image window and the **Open** file chooser appear.

2 From the **Directories** menu, select the path ending with the text **\examples**.

3 Double-click on the directory named ‘Data_Types’.

4 In the directory ‘SPOT_Panchromatic’, load the algorithm ’Greyscale.alg’.

ER Mapper displays a SPOT Panchromatic satellite image of the San Diego, California area in greyscale.

5 Drag the image window by its lower-right corner to make it about 50% larger.

6 Right-click on the image and select **Zoom to All Datasets** from the **Quick Zoom** menu.

ER Mapper redraws the image to fill the larger window size.

Apply a low pass (smoothing) filter to the image

1 Click on the **Edit Filter (Kernel)** toolbar button on the main menu.

The **Filter** dialog box appears. This dialog allows you to load standard filters supplied with ER Mapper, and create and save your own filters.

2 From the **File** menu, select **Load...**.

The **Load filter** file chooser dialog box appears.

3 From the **Directories** menu, select the path ending with the text **\kernel**.

4 Double-click on the ‘filters_lowpass’ directory to open it.

5 Double-click on the filter ’avg3.ker’ to load it.

The filter settings are displayed in the dialog box fields. The array (or matrix) of nine weighting values defining the 3 by 3 filter appear in the central scroll window (the “filter matrix window”).

The low pass filter creates a blurring or averaging effect. In general, low pass filters work by taking the average value of all pixels in the matrix and assigning it to the center pixel, thus smoothing out jumps or spikes in the data. Low pass filters can be useful for reducing periodic “salt and pepper” noise or speckling in an image to make it easier to interpret the major features.

Tip: The filter array window contains editable fields, so you can easily experiment and create your own filters with custom weighting coefficients and parameters and save them for later use.

Delete the low pass filter from the process stream

1 From the **Edit** menu (on the **Filter** dialog), select **Delete this filter**.

The filter is deleted from the process stream and the image is rendered without the averaging filter, so it appears as it did before.

Apply a high pass (sharpening) filter to the image

1 From the **File** menu (on the **Filter** dialog), select **Load...**.

2 From the **Directories** menu, select the path ending with the text **\kernel**.

3 Double-click on the ‘filters_high_pass’ directory to open it.

4 Double-click on the filter ’Sharpen2.ker’ to load it.

ER Mapper processes the algorithm to now include your high pass filter.

The filter settings are displayed in the dialog box fields. The array of nine weighting values defining the 3 by 3 filter appear in the filter matrix window.

The Sharpen2 filter enhances high frequency detail. In general, high pass or sharpening filters tend to increase the local contrast around edge features in the image, so the image appears sharper or crisper. Features like major roads and borders between urban and vegetated areas are therefore more clearly defined.

Delete the high pass filter from the process stream

1 From the **Edit** menu (on the **Filter** dialog), select **Delete this filter**.

The image is rendered without the sharpening filter, so it appears as it did before.

Apply a directional gradient edge detection filter

1. From the **File** menu (on the **Filter** dialog), select **Load...**.
2. From the **Directories** menu, select the path ending with the text **\kernel**.
3. Double-click on the ‘filters_sunangle’ directory to open it.
4. Double-click on the filter ’North_West.ker’ to load it.

   ER Mapper processes the algorithm to now include your edge detection filter.

   The filter settings are displayed in the dialog box fields.

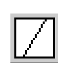
   The North_West filter is a non-linear filter designed to isolate and “raise” edge features in an image trending in a northeast to southwest direction. The data range produced by this filter is different from the previous image, so you need to adjust the transform to improve the contrast.

Adjust the contrast of the filtered image

1. Click the **Edit Transform Limits**  button on the Common Functions toolbar to open the **Transform** dialog box.

   Note the Actual Input Limits are about -500 to +500. This is the new data range created by applying the edge detection filter to the original SPOT Pan image.
2. On the **Transform** dialog, select **Limits to Actual** from the **Limits** menu.

   The X axis limits change to match the Actual Input Limits.

   The image contrast is enhanced and most pixels are assigned a mid-grey color in the greyscale lookup table.
3. Click the **Create autoclip transform**  button.

   ER Mapper redisplays the image with enhanced contrast. Edge features such as roads and land/water borders are highlighted in black and white, while features without sharp changes (such as ocean) are shown in grey.

   This filter highlights edge features in an image as if a sun were shining from the northwest (upper-left) of the image. Therefore, edge features facing northwest are highlighted in bright, while opposite (southeast) facing edge features are dark. Edge enhancement filters are often used in geological applications to highlight faults and lineaments occurring in a specific compass direction.

Note: As shown here, applying filters to your data often produces a different data range which initially creates a low contrast image. You will commonly need to adjust the transforms for each layer after applying a filter. (The first two filters you applied did not significantly change the original data range, so a contrast adjustment was not necessary in those cases.)

Apply a Northeast gradient edge detection filter

1. From the **File** menu (on the **Filter** dialog), select **Load...**.
2. From the **Directories** menu, select the path ending with the text **\kernel**.
3. Double-click on the 'filters_sunangle' directory to open it.
4. Double-click on the filter 'North_East.ker' to load it.

   This time edge features facing northeast are highlighted in white (features trending in a northwest to southeast direction). Since the data range produced by applying the North_East filter is similar to that produced by the North_West filter, you do not need to adjust the contrast.

5. Click the **Close** button on the **Filter** and **Transform** dialogs to close them.

2: Generating slope and aspect images

Objectives Learn to add filters to generate slope and aspect images from a digital elevation model (DEM) image.

Open a greyscale DEM algorithm

1. On the main menu, click the **Open**  button.
2. From the **Directories** menu (on the **Open** dialog), select the **\examples** path.
3. Open the 'Data_Types' directory, then open the 'Digital_Elevation' directory.
4. Double-click on the 'Greyscale.alg' algorithm to open it.

   ER Mapper displays a digital elevation model (DEM) image on the San Diego, California area. The image is displayed with a greyscale color table, so low elevations are dark and high elevations are light.

Load a filter to generate a slope degrees image

1 Click on the **Edit Filter (Kernel)** toolbar button on the main menu.

2 On the **Filter** dialog, click the button next to 'Filter filename.'

3 From the **Directories** menu, select the **\kernel** path.

4 Open the 'filters_DEM' directory, then double-click on the filter 'slope_degrees.ker' to load it.

The filter settings are displayed in the dialog box fields. As indicated, this 3 by 3 filter is written in C code.

5 Click the **99% Contrast enhancement** button.

After some internal calculations, ER Mapper displays an image showing steep slopes in light greys, and shallow slopes in dark greys. (The **Refresh Image with 99% clip on limits** button automatically sets the appropriate transform limits for you.)

Slope is a measure of steepness of terrain, or the rate of change in elevation in the vicinity of a given part of the topographic surface. This slope filter generates data values in degrees from the horizontal, so the slope values range from 0 (flat terrain) to 90 degrees (vertical terrain). (ER Mapper also provides a filter to calculate slopes in percent named 'slope_percent.ker.')

Note: Since few geographic areas will have very steep slopes, the output data range will usually not occupy the entire possible data range of slope values. (In the previous example, the steepest slope was 71 degrees but 90 is possible.) If you want to force the color scale to be mapped to the entire possible range of slope values, you can manually set the transform X axis limits to 0-90 for the 'slope_degrees' filter and 0-200 for 'slope' (percent) filter.

Load a different filter to generate an aspect image

1 On the **Filter** dialog, click the button next to 'Filter filename.'

2 Double-click on the filter 'aspect.ker' to load it.

The filter settings are displayed in the dialog box fields. As indicated, this 3 by 3 filter is also written in C code.

3 Click **Close** on the **Filter** dialog.

4 Click the **99% Contrast enhancement** button.

ER Mapper displays an image showing different aspects of the elevation data in various shades of grey.

Aspect is a measure of the compass direction a topographic surface faces at a given point. Aspect is computed as a horizontal angle in degrees of azimuth from due north (which is zero degrees). The aspect filter generates aspect values ranging from 0 to 360 degrees (a value of 361 degrees is also generated for a flat surface with no aspect). East-facing slopes have an aspect of 90 degrees, south facing slopes 180 degrees, and west-facing slopes 270 degrees.

Change the color table to 'azimuth'

1. On the **Algorithm** dialog, select the **Surface** tab.
2. From the 'Color Table' list, select **azimuth**.

   The image redisplays in four main colors–one for each primary compass direction. Areas facing primarily north display in black, easterly in yellow, southerly in white, and westerly in blue.

Note: 'Azimuth' is a special "wrap around" color table that has the same color (black) at the top and bottom end of the color range. This type of color table is often used to display aspect images. (To see the color set, open the **Transform** dialog.) You can use any other multiple color lookup table as well to display aspect images.

---

3. On the **Algorithm** dialog, select the **Layer** tab again to display the process diagram.

3: Adding filters to multiple layers

Objectives Learn to load a filter into several layers of data, for example to apply a filtering operation to the Red Green Blue layers of an RGB algorithm. Also learn to move between algorithm layers using buttons on the **Filter** dialog box.

Open and display an existing RGB algorithm

1. Click the **Open**  button on the Standard toolbar.

   The **Open** file chooser appears.
2. From the **Directories** menu, select the path ending with the text **\examples**.
3. Double-click on the directory named 'Data_Types'.

4 In the directory named ‘SPOT_XS,’ load the algorithm ’SPOT_XS_rgb_321.alg.’

ER Mapper displays a SPOT XS satellite image of the San Diego, California area as an RGB color composite of bands 3, 2 and 1.

Open the Algorithm window and Filter dialog box

1 Click on the **Edit Algorithm** toolbar button.

The **Algorithm** window appears. Notice that both the pre- and post-formula **Filter** buttons show a cross or “X” through the icon. This indicates that there is currently no filter loaded in the process stream.

2 On the **Algorithm** window, click on the post-formula **Edit Filter (Kernel)** button in the process stream diagram. (There are two, click on the one right of the **Formula** button.)

The **Filter** dialog appears.

Note that the **Filter** dialog has R, G and B buttons–these allow you to move between the Red, Green and Blue layers of the algorithm.

Apply a high pass filter to all three layers in the algorithm

1 In the **Filter** dialog, click on the **Move to next Red layer in surface** R button.

ER Mapper automatically selects the Red layer in the **Algorithm** window. (It may have been selected by default already.)

2 On the **Filter** dialog, click the **Filter filename** chooser button to open the **Load filter** file chooser.

3 From the **Directories** menu, select the path ending with the text **\kernel**.

4 Double-click on the ‘filters_high_pass’ directory to open it.

5 Click once on the filter ’Sharpen2.ker’ to select it (do not double-click).

6 Click the **Apply** button.

ER Mapper loads the filter into the process stream of the Red layer.

7 In the **Filter** dialog, click on the **Move to next Green layer in surface** G button.

ER Mapper automatically selects the Green layer in the **Algorithm** window.

8 In the **Load filter** file chooser, click the **Apply** button again (the Sharpen2 filter is still selected).

ER Mapper loads the filter into the process stream of the Green layer.

9 In the **Filter** dialog, click on the **Move to next Blue layer in surface** button.

ER Mapper automatically selects the Blue layer in the **Algorithm** window.

10 In the **Load filter** file chooser, click the **OK** button.

ER Mapper loads the filter into the process stream of the Blue layer, and closes the **Load filter** dialog.

11 ER Mapper processes the algorithm, which now includes your high pass sharpening filter in all three layers.

The high pass filter enhances high frequency detail to make the image appear sharper or crisper. This is the same effect you achieved earlier with a single layer of data, but this time you applied the filter to each layer of a color composite image.

4: Using multiple sequential filters

Objectives Learn how to insert and append multiple filters into the process stream to create a sequence of filters for more complex enhancements. Also learn to move between sequential filters in a layer using buttons on the **Filter** dialog box.

The following exercise assumes that the **Algorithm** window and **Filter** dialog box are still open on the screen.

Display a greyscale image

1 Click the **Open** button on the Standard toolbar.

The **Open** file chooser appears.

2 From the **Directories** menu, select the path ending with the text **\examples**.

3 Double-click on the ‘Data_Types’ directory to select it.

4 In the directory named ‘SPOT_Panchromatic’, load the algorithm ’Greyscale.alg.’

ER Mapper displays a SPOT Panchromatic satellite image of San Diego.

Add a directional edge detection filter

1 On the **Algorithm** window, click on the post-formula **Edit Filter (Kernel)**  button in the process stream diagram.

The **Filter** dialog opens.

2 On the **Filter** dialog, click the **Filter filename**  chooser button to open the **Load filter** file chooser.

3 From the **Directories** menu, select the path ending with the text **\kernel**.

4 Double-click on the ‘filters_sunangle’ directory to open it.

5 Double-click on the filter ’North_West.ker’ to load it.

Append a high pass filter after the edge detection filter

1 From the **Edit** menu (on the **Filter** dialog), select **Append new filter**.

A second filter button is added to the process stream diagram on the **Algorithm** window (it is *appended after* the first one). Its contents, currently empty, are shown in the **Filter** dialog.

2 From the **File** menu (on the **Filter** dialog), select **Load...** to open the **Load filter** file chooser.

3 From the **Directories** menu, select the path ending with the text **\kernel**.

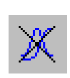
4 Double-click on the ‘filters_high_pass’ directory to open it.

5 Double-click on the filter ’Sharpen2.ker’ to load it.

The filter settings are displayed in the dialog box fields. You now have two filters loaded into the process stream.

Adjust the contrast of the filtered image

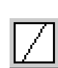
1 ER Mapper processes the algorithm and generates a histogram of the filtered data.

2 Click the **Edit Transform Limits**  button on the process diagram in the **Algorithm** window.

3 On the **Transform** dialog, select **Limits to Actual** from the **Limits** menu.

The X axis limits change to match the Actual Input Limits.

The image contrast is enhanced and most pixels are assigned a mid-grey color.

4 Click the **Create autoclip transform**  button.

ER Mapper redisplays the image with enhanced contrast. This image is the result of applying two filters–first a northwest filter to highlight northeast-southwest trending edge features, then a high pass filter to sharpen the high frequency detail around the edges. Note that you did not need to adjust the transform individually for each filter–you can adjust it once to account for the effects of *both* filters.

5 Click **Close** on the **Transform** dialog to close it.

Move between filters in the process stream

On the **Filters** dialog, note the two arrow buttons near the lower-right corner. These buttons let you easily move to view or edit the contents of any filter in the current raster data layer.

1 On the **Filters** dialog, click the **Move to previous Filter in layer** [<<] button until it becomes dimmed.

The pre-formula **Filter** button in the process stream diagram is now slightly depressed to indicate that it is being edited. Since no filter is loaded in that position, the contents of the **Filter** dialog are empty. (The button becomes dimmed when there are no more filters previous to the current one.)

Note: By default, the process stream diagram usually shows both a pre-formula and a post-formula filter button, even if no filters are being used in that layer. These buttons act as placeholders, and you cannot delete these from the process diagram.

---

2 Click the **Move to next Filter in layer** [>>] button.

The contents of next filter button are displayed in the **Filter** dialog (the North_West edge filter), and the first of the two post-formula **Filter** buttons is depressed on the **Algorithm** window.

3 Click the **Move to next Filter in layer** [>>] button again.

The contents of last filter in the process stream are displayed (the Sharpen2 filter), and the last of the two post-formula **Filter** buttons is depressed on the **Algorithm** window.

Delete the sharpening filter from the process stream

1 From the **Edit** menu (on the **Filters** dialog), select **Delete this filter**.

The high pass sharpening filter is deleted from the process stream. Notice that ER Mapper automatically moves to the previous filter in the process stream, so the contents of the **Filter** dialog now show the North_West edge filter and that button is depressed in the process stream diagram.

Close all image windows and dialog boxes

1 Close all image windows using the window system controls:

- Select **Close** from the window control-menu.

2 Click **Close** on the **Algorithm** window to close it.

Only the ER Mapper main menu should be open on the screen.

What you learned

After completing these exercises, you know how to perform the following tasks in ER Mapper:

- Insert and delete filters in the process stream diagram
- Apply different types of filters to see their results
- Edit the transform to enhance the contrast of filtered images
- Apply filters in multiple raster layers
- Use multiple filters in the process stream

10

Using Formulas

This chapter explains how to use formula processing in ER Mapper to perform mathematical operations on one or more bands of image data. You learn how to create and edit formulas, and use the standard formulas and functions provided in ER Mapper.

About formula processing

Formulas are commonly used in image processing to extract information that may reside in two or more bands (or channels) or data. Formula processing can range from simple subtraction or thresholding of data to complex “if-then-else” condition testing for raster spatial modelling and other tasks.

Formula processing is a “point operation” in image processing because it applies a mathematical function to each pixel in the image. Common uses of formulas in earth science image processing include:

- reducing the dimensionality of multi-band data (for example, Principal Components Analysis);
- extraction of thematic information from multi-band data (for example, vegetation indices or iron oxide ratios);
- merging images with different characteristics (data fusion);
- processing the same data in different ways and combining them to isolate specific features (such as edge features or seismic azimuth);
- isolating specific data ranges or geographic areas of interest using thresholding, region (polygon) masking, and other functions;

- corrections for atmospheric effects, sun angle, or vignetting on optical satellite or airborne data.

Formula processing in ER Mapper

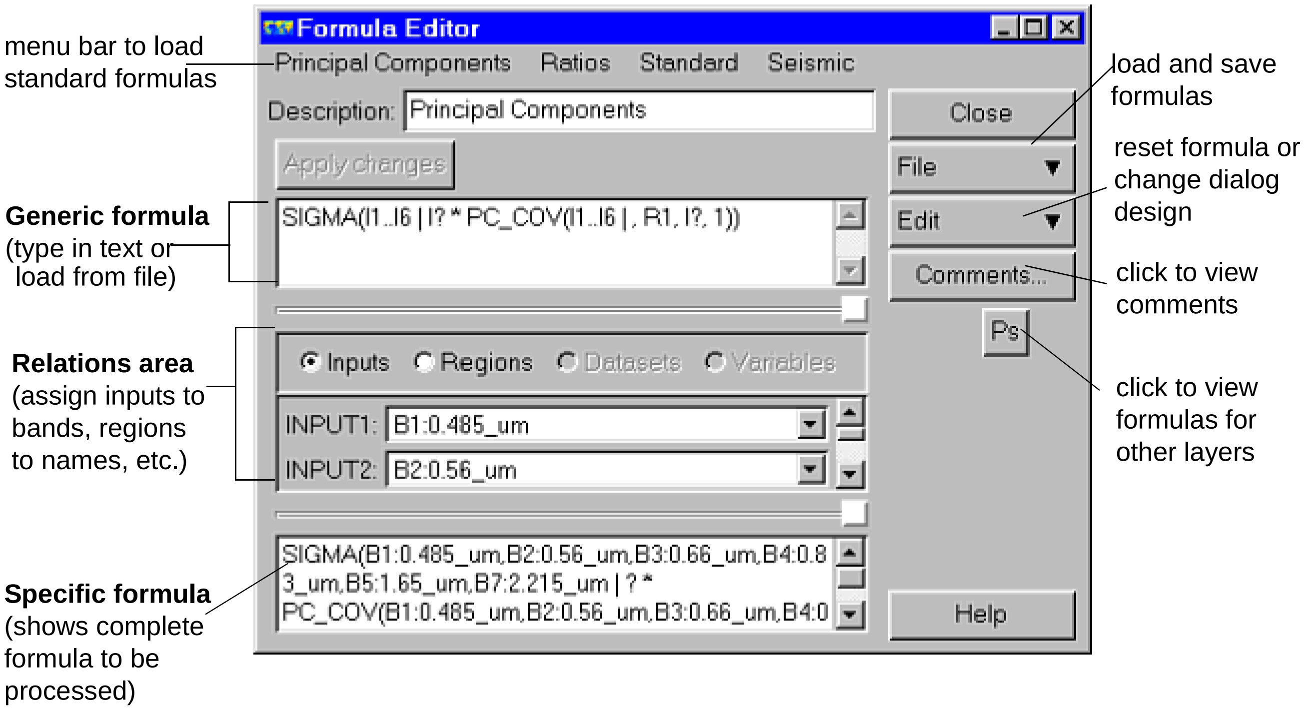
Many common types of data transformations can be implemented in ER Mapper using formula processing. These include data thresholding, data merging (or fusion), image differencing and ratioing, Principal Components Analysis, Tasseled Cap transforms, derivatives, and many others.

Since formulas are part of the algorithm processing stream, you can see the results in real time, and interactively modify the formula to quickly fine tune it. In contrast, conventional products must usually write formula processing results to a file on disk, making experimentation and fine tuning far more difficult.

ER Mapper provides a complete set of standard operators and functions you can reference in formula processing. You can also use image statistics, special functions, and functions defined with your own C user code. See the relevant sections and chapters in the *ER Mapper User Guide* for complete information.

The Formula dialog box

When you click on the Formula button in the process stream diagram or on the **Edit Formula** toolbar button, ER Mapper opens the **Formula Editor** dialog box. This dialog lets you create, edit, load, and save formulas, and it has the following components:



Tip: For any algorithm, you can open the **Formula Editor** dialog box from two places: using the **Formula** buttons in the process stream diagram on the **Algorithm** window, or using the **Edit Formula** toolbar button.

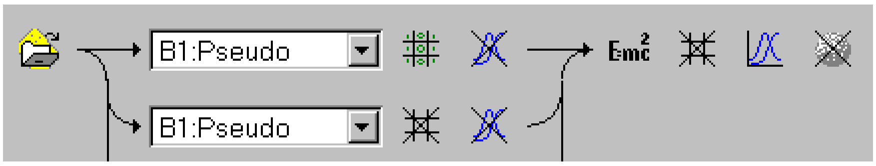
The formula relations concept

The key concept of *relations* is a very powerful feature that makes ER Mapper's formula processing very flexible and interactive. When you enter or load a generic formula, you may include one or more generic specifications that refer to any arbitrary image band, region polygon, image, or variable. You then use the Relations window to choose relations between actual image band numbers, region names, etc. and the generic specifications in the formula. The actual assignment of references to image bands, region names, and so on is then shown in the Specific formula window.

There are four types of generic specifications:

Reference	Notation in generic formula	Function
Input specifications	INPUTn, In (or lowercase)	References any band in an image.
Region specifications	REGIONn, Rn (or lowercase)	References any region polygon defined for a raster image.
Dataset specifications	DATASETn, Dn (or lowercase)	References any raster image (an actual disk file with ".ers" extension).
Variable specifications	VARIABLEn, or any text not reserved for ER Mapper functions (for example "density" or "threshold")	References any real number or value to be used as an equation variable.

Formula inputs are also shown graphically in the process stream diagram. For example, the following process stream shows that two inputs are being used in the formula, and that they are assigned to image bands 3 and 2 respectively. As indicated, each band can be modified using filters and transforms before being piped through the formula processing.



To select the specific bands to be used in a formula, you can either use the **Band Selection** drop-down list in the process stream diagram, or select bands inside the Relations window of the **Formula** dialog box.

Hands-on exercises

These exercises introduce you to the basic features of the **Formula** editing dialog box and procedures for creating and implementing simple formulas.

What you will learn...

After completing these exercises, you will know how to perform the following tasks in ER Mapper:

- Type and edit a formula, and test formula syntax
- Use generic references for inputs, variables, and regions in a formula
- Assign image bands, variables, and region names to generic references
- Save formulas to disk and enter comments
- Use formulas to process areas of interest (regions) in an image
- Use formulas to generate Principal Component images

Before you begin...

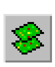
Before beginning these exercises, make sure all ER Mapper image windows are closed. Only the ER Mapper main menu should be open on the screen.

1: Entering and testing a formula

Objectives

Learn how to enter simple formulas and test formula syntax.

Load a Pseudocolor algorithm with the default formula

1. Click the **Edit Algorithm**  toolbar button.

   An image window and the **Algorithm** dialog box appear.

2. Click the **Open**  toolbar button.
3. From the **Directories** menu, select the path ending with the text **\examples**
4. Double-click on the directory named ‘Applications’.
5. Double-click on the directory named ‘Mineral_Exploration’.
6. Double-click on the algorithm named ‘Magnetics_Pseudocolor.’

The algorithm displays an image of airborne magnetics data acquired in Australia. The data represents the strength of the magnetic field on this area of the earth's surface. Using the Pseudocolor lookup table, blues correspond to lower field strengths and yellows and reds to higher field strengths.

Enter a simple formula and test for syntax errors

1 Click on the **Edit Formula** button in the process stream diagram.

The **Formula Editor** dialog box opens.

Note that the generic formula window contains the text “I1” by default, and that I1 (Input 1) is assigned to image dataset band 1 in the Relations window.

2 In the **Generic** formula window, edit the formula text to read:

```
input1 - input3
```

(This formula purposely has a syntax error to illustrate how to test for them.)

3 Click the **Apply changes** button to test the formula.

ER Mapper issues an error message warning that the formula has a syntax error. (In this case you tried to subtract an input number that was out of sequence; you must also have an “input2” before using an “input3.”

Note: The **Apply changes** button automatically tests for syntax errors in the Generic formula. You must make any corrections before continuing.

Revise the formula to subtract a value

1 In the **Generic** formula window, edit the formula text to read:

```
input1 - 100
```

(This subtracts 100 from each pixel in the image band assigned to input1.)

2 Click the **Apply changes** button to test the formula.

The formula syntax is approved, and ER Mapper translates the generic formula into a specific formula (displayed in the lower window).

Delete the formula and test the syntax

1 In the Generic formula window, edit the formula to remove all text (select the existing text and press the Backspace or Delete key on your keyboard).

2 Click the **Apply changes** button to test the formula.

ER Mapper issues an error message regarding the formula syntax.

Caution: ER Mapper considers no formula at all an error in syntax. At a minimum, the Generic formula window must always contain the text “I1” or “input1” to specify at least one input image band to be processed.

---

3 In the Generic formula window, edit the formula text to read:

```
input1
```

4 Click the **Apply changes** button to test the formula.

ER Mapper accepts the formula.

Tip: Under the **Formula Editor**’s **Edit** menu, you can select **Clear** to clear all text from the Generic formula window, or select **Default** the restore the default formula ‘INPUT1.’

2: Creating a threshold formula

Objectives Learn how to enter a simple threshold formula and use boolean “if-then-else” logic in a formula. Also learn about null image values, and how to use a variable in a formula.

Enter a simple threshold formula

1 In the Generic formula window, edit the formula text to read:

```
if input1 > 100 then input1 else null
```

This formula tells ER Mapper “if the image value is greater than 100, then process it, else assign it a value of null.” (Any image pixel assigned a value of null is excluded from further processing and does not appear in the final image.)

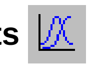
2 Click the **Apply changes** button.

The formula syntax is approved, and ER Mapper translates the generic formula into a specific formula. Notice that band 1 of the image is substituted for both occurrences of “input1” in the generic formula window.

3 ER Mapper processes the algorithm, which now includes your threshold formula.

Areas of the image with data values greater than 100 are displayed in color, while data values 0-100 display with no color (they appear black).

Process the formula and see how it affects the data range

1 Click on the post-formula **Edit Transform Limits**  button in the process stream diagram.

The **Transform** dialog box opens. Drag it to an open part of the screen.

Note that the Actual Input Data range is 101 to 255. This is expected since data values 0-100 are set to null (no value) by the formula and are thus excluded from further processing. The shape of the histogram also reflects the clipping of the data at the 100 level.

Substitute a variable for the value 100

1 In the Generic formula window, edit the formula text to substitute the word “variable1” for the value 100. Your formula should read:

```
if input1 > variable1 then input1 else null
```

Your formula now includes a variable that you can set in the **Relations** window.

2 Click the **Apply changes** button.

Two things change: the **Variables** button above the Relations window becomes active, and the value of “variable1” becomes zero in the Specific formula window.

3 Click the **Variables** button.

The **Relations** window shows that the value of “variable1” is set to zero.

4 Edit the value of “variable1” field to read **`120`** then press the Return or Enter key on your keyboard.

This time only areas with data values greater than 120 are processed.

5 Change the value of “variable1” to **`80`**, press Return or Enter to view the new threshold image.

As you can see, using references to variables in your formula (instead of actual values) can speed experimentation.

Tip: You can have several different variables in a formula, and name them nearly anything (for example *threshold*, *width*, *X*, *y*, are all valid). Be sure the names do not conflict with text strings ER Mapper uses for standard functions.

---

6 When finished, close the **Transform**, **Formula Editor**, and **Algorithm** dialog boxes by clicking **Close** on each one.

3: Creating and saving a formula

Objectives Learn how to enter a band ratio formula, change the image bands assigned to input numbers in the generic formula, and save the formula to disk for later use.

Open a template greyscale algorithm and load a new image

1 On the main menu, click the **Open** button.

2 From the **Directories** menu, select the path ending with **\examples**.

3 Double-click on the directory named ‘Miscellaneous’.

4 Double-click on the directory named ‘Templates’.

5 In the ‘Common’ directory, load the algorithm ‘Single_Band_Greyscale.alg.’

A Landsat satellite image of San Diego displays in greyscale. (You will use this algorithm as a template to display another image in greyscale.)

6 Click the **Edit Algorithm** toolbar button to open the **Algorithm** window.

7 In the process stream diagram on the **Algorithm** window, click on the **Load Dataset** button.

8 From the **Directories** menu, select the path ending with **\examples**.

9 Double-click on the directory named ‘Shared_Data’.

10 Load the image ‘LandsatTM.ers.’

Band 1 of a Landsat TM satellite image shows an area named Ebagoola in northeastern Australia displays. (You will adjust the image contrast to brighten it later.)

Enter a generic band ratio formula

1 Click on the **Edit Formula** button in the process stream diagram.

The **Formula** dialog box opens and shows the default formula “INPUT1.”

2 In the Generic formula window, edit the formula text to read:

```
input1 / input2
```

This formula tells ER Mapper to divide the image band assigned to input1 by the band assigned to input 2.

3 Click the **Apply changes** button.

When you enter a new multiple input formula, ER Mapper automatically assigns image band 1 to input 1, band 2 to input 2, and so on.

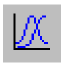
Assign image bands to create a vegetation index image

1 In the Relations window, select **B4:0.83_um** from the drop-down list next to “INPUT1,” and select **B3:0.66_um** from the “INPUT2” drop-down.

The generic reference “input1” is now assigned image band 4, and “input2” is assigned to band 3. When used with Landsat TM images, the 4/3 band ratio is a simple vegetation index formula.

The image initially appears black because of the small data range created by the band ratio formula.

Display the vegetation index image and adjust the contrast

1 Click the post-formula **Edit Transform Limits**  button in the process diagram.

Note the Actual Input Limits created by the formula (about zero to 5).

2 On the **Transform** dialog, select **Limits to Actual** from the **Limits** menu.

Your enhanced vegetation index image shows vegetated areas (higher ratio values) in light grey, and non-vegetated areas in darker shades. This band combination takes advantage of high vegetation reflectance in TM band 4 (near infrared light) and low vegetation reflectance in band 3 (red light). This is a rather barren part of Australia, so vegetation (shown as light grey shades) occurs mainly in the stream beds as shown in the image.

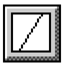
Change the bands to create a clay minerals image

1 In the Relations window, select **B5:1.65_um** for “INPUT1” and select **B7:2.215_um** for “INPUT2.”

Using the same Generic formula, you have now chosen the appropriate TM band ratio (5/7) to create a simple clay minerals image.

2 ER Mapper processes the algorithm, this time using bands 5 and 7.

3 On the **Transform** dialog, select **Limits to Actual** from the **Limits** menu.

4 On the **Transform** dialog, click the **Create autoclip transform**  button.

Your contrast enhanced clay ratio image shows clay-rich rocks (higher ratio values) in light shades of grey, and clay-poor rocks in darker shades. This band combination takes advantage of strong absorption by clay minerals in TM band 7 and high reflectance in TM band 5.

5 Close the **Transform** dialog box by clicking **Close**.

Add a description and comments for your formula

1 In the **Formula Editor** dialog, edit the “Description” text field to read:

```
Landsat TM clay minerals ratio
```

2 Click the **Comments...** button.

The **Formula comments** dialog box appears.

3 Type some comments about your formula, such as:

```
This formula is designed to process bands 5 and 7
of Landsat TM data to highlight clay-rich rocks.
It is based on strong absorption by clay minerals in
TM 7 and high reflectance in TM 5. Clay-rich rocks
produce high ratio values, clay poor rocks low values.
```

4 Click the **OK** button to save your comments and close the dialog.

Save the clay minerals ratio formula to disk

1 From the **File** menu (on the **Formula Editor**), select **Save As...**.

2 Go to the directory named ‘Miscellaneous\Tutorial’ and double click on it to open it.

3 Click to place the cursor in the **Save As:** text field, then type in a name for the formula file. Use your initials at the beginning of the file name, followed by the text ‘clay_ratio,’ and separate each word with an underscore (_). For example, if your initials are “RK,” type in the name:

```
RK_clay_ratio
```

4 Click the **OK** button to save your formula to a disk file.

Note: Since bands 5 and 7 of the image were chosen as inputs 1 and 2 when you saved the formula, they would be assigned as the default bands if you load the formula in the future. As shown, you can easily change the band assignments.

---

5 Click the **Close** button to close the **Formula Editor** dialog.

4: Creating a polygon mask formula

Objectives Learn how to use ER Mapper's "inregion" function to reference areas defined as vector polygons in an image for masking purposes

---

Note: This exercise references regions in the sample image which have already been defined using ER Mapper's vector drawing tools. More information on defining regions is contained in the chapter on Supervised Classification later in this manual and in the chapters on Supervised and Unsupervise Classification in the *ER Mapper User Guide*.

Load the SPOT Panchromatic greyscale algorithm

1. On the main menu, click the **Open** button.
2. From the **Directories** menu, select the path ending with **\examples**.
3. Double-click on the directory named 'Data_Types'.
4. In the 'Landsat_TM' directory, load the algorithm 'Greyscale.alg.'

   A Landsat TM satellite image of San Diego displays in greyscale.
5. From the **View** menu (on the main menu), select **Quick Zoom**, then select **Zoom In**.

   ER Mapper zooms in 50% on the center point of the image.

Enter a formula using the "inregion" function

1. In the Algorithms window, click the **Edit Formula** button.
2. In the Generic formula window, edit the formula text to read:

   ```
   if inregion(region1) then input1 else null
   ```

   This formula tells ER Mapper "if the area of the image is within the boundaries defined by region1, then process it, else assign it null."
3. Click the **Apply changes** button to verify the formula syntax.

   The generic formula is converted to a specific formula. Also notice that the **Regions** button above the Relation window is now active.

Assign the "region1" argument to a region name

1 Above the Relations window, click on the **Regions** button.

The contents of the Relations window change to show the REGION1 argument and its default assignment to a region named **All** (which is simply the extents of the entire image.)

2 From the REGION1 drop-down list, select **Down_Town**.

You have now selected the **Down_Town** region to be assigned to generic region1. (This region is simply a vector polygon previously drawn to define the boundaries of the San Diego downtown area in this image.)

Only the area inside the region named **Down_Town** is processed, and all other areas of the image are assigned null values (so they appear black). By using the inregion function in your formula, you have created a "mask" to process only data within a certain geographic part of the image.

Display a different region in the image

1 From the REGION1 drop-down list, select **Airport**.

You have now selected the **Airport** region to be assigned to generic region1. (Airport is a vector polygon previously drawn to define the boundaries of the San Diego Lindbergh Field airport near downtown.)

Only the area inside the region named **Airport** is processed, and all other areas of the image are assigned null values (so they appear black). By using the drop-down list, you can easily change this formula to process any region defined in an image.

5: Generating Principal Components

Objectives Learn how to use and modify a formula to interactively compute Principal Components images.

Load the Landsat TM greyscale algorithm

1 On the main menu, click the **Open**  button.

2 From the **Directories** menu, select the path ending with **\examples**.

3 Double-click on the directory named 'Data_Types'.

4 In the 'Landsat_TM' directory, load the algorithm 'Greyscale.alg.'

A Landsat satellite image of San Diego displays in greyscale. You will add a formula to this algorithm to perform Principal Components Analysis.

Load a formula to calculate Principal Component 1

1 In the Algorithm window, click the **Open Formula editor** button.

The **Formula Editor** dialog will open.

2 From the **Principal Components** menu (on the **Formula Editor** dialog), select **Landsat TM PC1**. ER Mapper loads the following formula into the Generic formula window:

```
SIGMA(I1..I6 | I? * PC_COV(I1..I6 | ,R1 I?, 1))
```

This formula tells ER Mapper to generate Principal Component 1 (PC 1) from Landsat TM bands 1-5 and 7. It uses some of the special functions and constructs ER Mapper provides, including the “SIGMA” summation construct and the “PC_COV” covariance principal component (eigenvector) value.

Principal Components Analysis is a statistical from of data compression often used to compress the information content of multiple image bands into just two or three “principal component” images. In this case, you are generating the first principal component of TM bands 1-5 and 7 (band 6 is usually not used for PC calculations because it contains thermal information).

Adjust the contrast of the PC 1 image

1 Click the post-formula **Transform** button in the process diagram.

Note that the data range create by the PC1 formula is about 40 to 520.

2 On the **Transform** dialog, select **Limits to Actual** from the **Limits** menu.

3 Click the **Create autoclip transform** button.

The image is rendered with enhanced contrast. The first principal component usually contains most of the overall scene brightness or albedo information, so it shows large scale terrain features well.

Edit the formula to calculate Principal Component 2

1 In the Generic formula window, edit the formula to change the last value from 1 to **2** as shown below:

```
SIGMA(I1..I6 | I? * PC_COV(I1..I6 | ,R1 ,I?, 1))
```

change to 2

This formula tells ER Mapper to generate Principal Component 2 (PC 2) from Landsat TM bands 1-5 and 7. (The I1..I6 part of the formula tells ER Mapper to include six inputs in the calculation which are currently assigned to bands 1, 2, 3, 4, 5, and 7.)

2 Click the **Apply changes** button to verify the formula syntax.

3 On the Standard toolbar, click the **99% Contrast enhancement** button.

ER Mapper applies a 99% clip to the data limits created by the PC 2 formula to automatically create a contrast enhanced image. The second principal component shows very different information than PC 1. Note how vegetated areas appear very dark in the PC 2 image, and ocean areas appear relatively light.

Tip: The **99% Contrast enhancement** toolbar button is especially useful for automatically contrast stretching images that produce narrow or negative data ranges (such as ratios, PCs, and others).

Edit the formula to calculate PC1 of bands 1, 4 and 7

1 In the Generic formula window, edit the formula to change values as shown below:

```
SIGMA(I1..I6 | I? * PC_COV(I1..I6 | ,R1 ,I?, 2))
```

change to 3 (I6 in both places); change to 1 (the final 2)

These changes tell ER Mapper to generate Principal Component 1 from only three image bands instead of six. (Next you will choose which three bands to use.)

2 Click the **Apply changes** button to verify the formula syntax.

3 In the Relations window, change the INPUT to image band assignments as follows:

```
INPUT1 = B1:0.485_um
INPUT2 = B4:0.83_um
INPUT3 = B7:2.215_um
```

This tells ER Mapper to use bands 1, 4 and 7 as inputs to the Principal Components formula.

4 Click the **99% Contrast enhancement** on the Standard toolbar.

The image looks similar to the PC 1 image you created earlier, but is generated using only bands 1, 4 and 7 of the Landsat TM image.

This example creates a simple greyscale image, but you can easily use the same formulas in RGB algorithms to create color composites of PC images.

Close all image windows and dialog boxes

1 Close all image windows using the window system controls:

- Select **Close** from the window control-menu.

2 Click **Close** on the **Algorithm** window to close it.

Only the ER Mapper main menu should be open on the screen.

What you learned...

After completing these exercises, you know how to perform the following tasks in ER Mapper:

- Type and edit a formula, and test formula syntax
- Use generic references for inputs, variables, and regions in a formula
- Assign image bands, variables, and region names to generic references
- Save formulas to disk and enter comments
- Use formulas to process areas of interest (regions) in an image
- Use formulas to generate Principal Component images

11

Geolinking images

This lesson explains how to use ER Mapper's geopositioning controls to display images with exact geographic extents, and use the Geolinking controls to geographically link two or more image windows. Geolinking is a powerful visualization technique that can help you analyze the same geographic area using a variety of different images or processing techniques.

About Geopositioning

In ER Mapper, the term "geopositioning" refers to specifying the position and extents of an image in geographic coordinate space. This can be useful for creating maps that cover an exact area, for example. Once an image is registered to a map projection, its display can be controlled using ER Mapper's geopositioning options. If the image is not rectified to a map projection, its extents can be controlled in terms of the row and column numbers of the image pixels.

About Geolinking

In ER Mapper, the term "geolinking" refers to linking two or more image windows in geographic coordinate space. This can be useful for viewing the same geographic area with different types of images or processing algorithms, and other applications. Once an image is registered to a map projection, it can be geographically linked with other image windows using ER Mapper's geolinking options. ER Mapper provides the following geolinking modes:

Window — Link two or more image windows to show the same geographic extents. Zooming or panning in one window triggers the same operation in other linked windows.

Screen — Link image windows to one "master" image that acts like a virtual map sheet on the screen. Linked windows display the geographic extents of their images relative to the master window.

Overview Zoom — Link image windows to one "master" overview control window. Defining a zoom box on the control window causes the other windows to zoom to the defined area.

Overview Roam — Link image windows to one "master" control window. Dragging the mouse to pan in the control window causes other windows to pan (or "roam") so their center point matches the mouse position in the control window.

The Algorithm Geoposition Extents Dialog Box

The **Algorithm Geoposition Extents** dialog box lets you precisely control the geographic extents and display resolution of images, and geographically link (geolink) two or more image windows together. The options shown in this dialog change depending on the mode selected in the row of option buttons at the top. The five modes and their functions are as follows:

Zoom — Lets you use buttons to zoom or pan the image in the window by predefined amounts, or zoom to the extents of specific images, page extents, or page contents.

Geolink — Lets you set up geolinking between two or more image windows, and set the window size and display resolution of any image window.

Extents — Lets you view or specify geographic display extents for an image using Latitude/Longitude, Eastings/Northings, or image X (column) and Y (row) values.

Center — Lets you view or specify the center point for the image display using Latitude/Longitude, Eastings/Northings, or image X (column) and Y (row) values.

Mouse info — Shows quick help for using the mouse and keyboard keys to zoom and pan.

Hands-on exercises

These exercises introduce you to many of the basic features of the **Algorithm Geoposition Extents** dialog box and how to use them to control image display extents and set up geolinking between windows.

Note: The images used in the following exercises were previously rectified to the same datum and map projection. This is a requirement when different images are to linked in Window, Screen, Overview Zoom, or Overview Pan modes.

What you will learn...

After completing these exercises, you will know how to perform the following tasks in ER Mapper:

- Display images with exact geographic extents and display resolutions
- Link image windows to show the same geographic extents
- Link image windows to a virtual map sheet window
- Control interactive image zooming and panning functions from a master window

Before you begin...

Before beginning these exercises, make sure all ER Mapper image windows are closed. Only the ER Mapper main menu should be open on the screen.

1: Geopositioning images

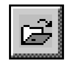
Objectives

Learn how to use the Geoposition controls to display an exact geographic area of an image, specify an image center point, and change window sizes and display resolutions.

Change the window size preference

1. Select **Preferences...** from the **Edit** menu.
2. On the **Preferences** dialog, select the **General** tab.
3. Make sure that the **Adjust window size to image aspect** option box is not checked.
4. Click on the **Close** button to invoke the change and close the Preferences dialog

Load and display a Landsat image in RGB

1 On the Standard toolbar, click on the **Open**  button.

An image window and the **Open** dialog box appear.

2 In the Files of Type: field, select 'ER Mapper Algorithm (.alg)'.

3 From the **Directories** menu, select the path ending with the text **\examples**.

4 Double-click on the directory named 'Applications'.

5 In the directory named 'Land_Information,' load the algorithm named 'Landsat_TM_23Apr85_rgb_541.alg'

This algorithm displays a Landsat TM image covering a large portion of the San Diego, California area as an RGB color composite of bands 5, 4 and 1. The image shows an area about 40 by 55 kilometers in size. The country of Mexico is located at the extreme lower part of the image.

6 Make the image window larger by dragging its lower-right corner until it fills the left half of the screen.

Note that the image does not expand to fill the enlarged window.

Open the Algorithm Geoposition Extents Dialog Box

1 From the **View** menu, select **Geoposition...**.

The **Algorithm Geoposition Extents** dialog box appears. If needed, drag the dialog to the right side of the screen.

Display an exact area by entering geographic values

1 In the upper row of option tabs on the **Algorithm Geoposition Extents** dialog, select the **Extents** option.

The contents of the dialog change to show a group of text fields for entering coordinate values.

2 Edit the value in the **Latitude** field under the **Size** column to read **`0:20`**. (ER Mapper fills out the text string to a full value of 0:20.0.0.)

3 Edit the value in the **Longitude** field under the **Size** column to read **`0:20`** also.

4 Click the **Apply** button to apply your new extents values.

ER Mapper reprocesses the algorithm with your new image extents and attempts to display an area 20 minutes of Latitude by 20 minutes of Longitude in the image window. You should notice that the size of the window remains the same, an areas not covered by the image have a cross-hatch pattern.

5 Select the **Zoom** tab, and click on the **All Datasets** button.

The ER Mapper will re-display the whole image, but the image window size will not change.

6 Once again select **Preferences** from the **Edit** menu, and click on the **General** tab.

7 Check the **Adjust window size to image aspect** option box, and click on the Preferences dialog **Close** button.

8 Edit the value in the **Latitude** field under the **Size** column to read **`0:20`**. (ER Mapper fills out the text string to a full value of 0:20.0.0.)

9 Edit the value in the **Longitude** field under the **Size** column to read **`0:20`** also.

10 Click the **Apply** button to apply your new extents values.

ER Mapper reprocesses the algorithm with your new image extents and resizes the image window to display an area 20 minutes of Latitude by 20 minutes of Longitude. The **Adjust window size to image aspect** option resizes the image window so that the required image area fits exactly.

Display an exact part of the image by entering cell values

1 Edit the contents of the four fields as listed below to display an exact portion of the image using cell X (column) and cell Y (row) values:

```
Cell X/Top Left = 800

Cell Y/Top Left = 1200

Cell X/Bottom Right = 1300

Cell Y/Bottom Right = 1800
```

2 Click the **Apply** button to apply your new values.

ER Mapper reprocesses the algorithm with your new image extents and displays an area 500 pixels (cells) wide by 400 pixels in height. The origin (upper-left corner) is at cell column (X) 800 and cell row (Y) 1200.

Center the image on an exact point

1 In the upper row of option buttons, select the **Center** option.

The contents of the dialog change to show a group of text fields for entering the center point of the image in geographic or image X and Y values.

2 Edit the value in the **Easting** field to read **`507000`** then press the Return or Enter key to validate the change. (Select all the existing text and type the new value; ER Mapper adds the “E” for you when you validate.)

3 Edit the value in the **Northing** field to read **`3609500`** then press Return or Enter to validate the change.

4 Click the **Apply** button to apply your new center point values.

ER Mapper reprocesses the algorithm and centers the image on the location you defined (the lake that was previously in the upper-right of the image). Centering can be useful for viewing the exact center point of an image, or for focusing on an exact feature of interest in an image.

Set an exact image display resolution

1 In the upper row of option buttons, select the **Geolink** option.

The contents of the dialog change to show geolink option buttons and text fields for defining window size and display resolution.

2 Edit the **Dataset cells per pixel** field to read **`1`** (the value one).

3 Click the **Apply** button to apply your new display resolution.

ER Mapper reprocesses the algorithm at a “one to one” display resolution, so that every image cell in this part of the image is represented by one pixel on the screen display. (Values greater than one cause subsampling of the image cell values, and less than one cause supersampling.)

Set an exact size for the image window

1 Edit the **Width in pixels** field to read **`400`** then press the Return or Enter key to validate the change.

2 Edit the value in the **Height in pixels** field to read **`500`** then press Return or Enter.

3 Click the **Apply** button to apply your new window size.

ER Mapper resizes the window to 400 by 500 pixels and redisplays the image.

2: Linking windows to common extents

Objectives Learn to link image windows in Geolink “Window” mode, so each linked window displays the same geographic extents.

Open an RGB algorithm

1 On the Standard toolbar, click on the **Open** button.

2 From the **Directories** menu, select the path ending with the text **\examples**.

3 Double-click on the directory named ‘Data_Types’.

4 In the ‘Landsat_TM’ directory, load the algorithm named “RGB_341.alg.’

This algorithm displays Landsat TM (30 meter resolution) image of San Diego. Bands 3, 4 and 1 are displayed as an RGB color composite, so vegetated areas appear green and urban areas are pink or grey.

Open a second window and algorithm

1 On the Standard toolbar, click the **New** button.

A second image window opens on the screen.

2 On the Standard toolbar, click on the **Open** button.

3 From the **Directories** menu, select the path ending with the text **\examples**.

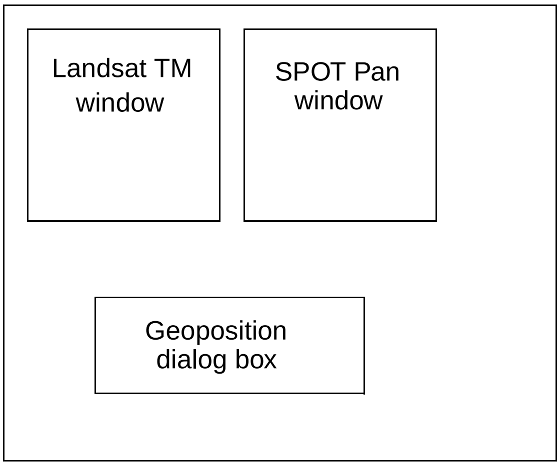
4 Double-click on the directory named ‘Data_Types’.

5 In the ‘SPOT_Panchromatic’ directory, load the algorithm named “Greyscale.alg’

This algorithm displays a SPOT Panchromatic (10 meter resolution) image of the same area of San Diego.

Resize and position the two windows

1 Resize and reposition the two windows as shown in the following diagram. (You must able to view the contents of each window clearly.)



You should now have two image windows of about the same size next to each other in the upper part of the screen, and **Geoposition** dialog below them.

Set the TM image window to Geolink Window mode

1 On the **Algorithm Geoposition Extents** dialog, select **Geolink** in the row of options at the top. (It may already be chosen.)

The contents of the dialog show ‘Geolink mode’ option buttons on the left side.

2 Click inside the Landsat TM image window to activate it (three stars *** should appear next to the title).

3 In the **Algorithm Geoposition Extents** dialog, select the **Window** option button.

4 Click the **Apply** button.

The window title indicates that it is now set to “WINDOW” geolink mode.

Set the SPOT image window to Geolink Window mode

1 Click inside the SPOT Pan image window to activate it.

2 Select the **Window** option button.

3 Click the **Apply** button.

The SPOT Pan window is now linked to the Landsat TM window since both are set to Geolink Window mode. Any changes you make to the extents of one window will be automatically duplicated in the other.

Zoom and pan in both images

1 On the main menu, click the **Zoom Tool**  button on the Common Functions toolbar.

The mouse is now set to perform zoom and pan functions in image windows.

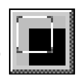
2 Click inside the Landsat TM image window to select it, and then drag the pointer down to magnify the central portion of the image.

The images in both windows automatically zoom to share the same extents.

3 Shift click inside the SPOT Pan image window to change the pointer to a hand. Drag the image to the left.

Both images pan to the right.

4 On the **Algorithm Geoposition Extents** dialog, select **Zoom** in the row of options at the top.

5 Under ‘Pan,’ click the **Pan upper-left**  button.

Both images pan 50% to the upper-left (the previous center point is now on the lower-right corner of the image).

6 Under ‘Set extents to,’ click the **Raster Datasets** button.

Both zoom out to their full extents (which are the same for both images).

3: Linking windows to the screen

Objectives Learn to link image windows in Geolink "Screen" mode, so a "master" image window becomes a virtual map sheet on the screen. The screen assumes the coordinate space of the "master" image window, and other windows display the geographic extents of their images relative to the master window.

.Set both windows to Geolink None mode

1. On the **Algorithm Geoposition Extents** dialog, select **Geolink** in the row of options at the top.

   The contents of the dialog show **Geolink mode** option buttons on the left side.

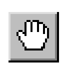
2. Click inside the Landsat TM image window to activate it.
3. In the **Algorithm Geoposition Extents** dialog, select the **None** option button.
4. Click the **Apply** button.

   The words "WINDOW:geolink" disappear from the window title, indicating that the window is no longer geolinked.

5. Click inside the SPOT Pan image window to activate it.
6. In the **Algorithm Geoposition Extents** dialog, select the **None** option button.
7. Click the **Apply** button.

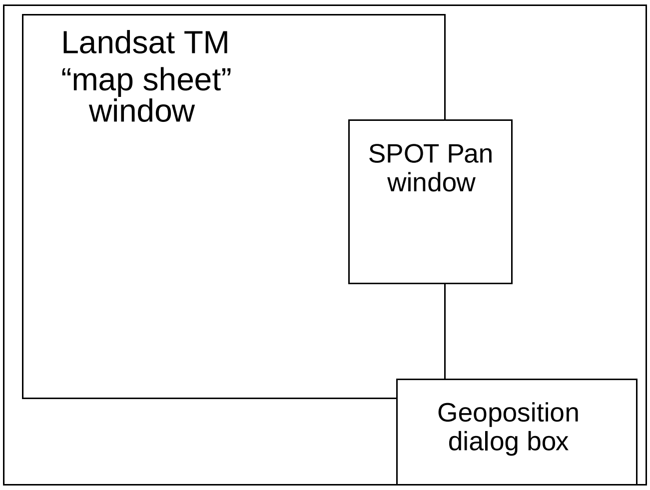
Tip: Image windows can also be geolinked and unlinked using the **View/Quick Zoom** menu on the main ER Mapper menu bar.

Resize and position the two windows

1. On the main menu, click the **Hand Tool**  toolbar button.

   The mouse is now set as a hand. (This prevents accidentally panning or zooming when you click inside a window to activate it.)

2 Resize and reposition the two windows as shown in the following diagram. (You must be able to view the contents of each window clearly.)



You should now have a smaller SPOT Pan ‘Greyscale’ window partially overlaying a larger Landsat TM ‘RGB_341’ window, and the **Algorithm Geoposition Extents** dialog in the lower-right corner.

Set the TM image window to Geolink Screen mode

1 Click inside the large Landsat TM image window to activate it.

2 In the **Algorithm Geoposition Extents** dialog, select the **Screen** option button.

3 Click the **Apply** button.

The window title indicates that it is now set to “SCREEN” geolink mode. This is the first window assigned to Screen mode, it becomes the “master” window and the entire screen assumes its coordinate space (shown clearly later).

Set the SPOT image window to Geolink Screen mode

1 Click inside the SPOT Pan image window to activate it.

2 Select the **Screen** option button.

3 Click the **Apply** button.

The SPOT Pan window is now linked to the “master” window, and it automatically redraws to show its portion of the TM master “map sheet” window.

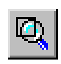
Move the SPOT Pan window over the TM master window

1 Drag the SPOT Pan window by its title bar to the lower-left portion of the larger Landsat TM window

The SPOT Pan image automatically redraws to show its new extents in the context of the Landsat “map sheet” window. By comparing the two images, you can clearly see the difference in detail provided by the higher resolution SPOT Pan data (10 meter) over the lower resolution (30 meter) Landsat TM data.

Tip: It helps to think of the larger “master” window as a paper map sheet. Any other windows moved on top of the map sheet act like a viewing port into a different image or processing technique over the same geographic area.

Zoom in on the SPOT Pan window

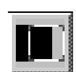
1 On the main menu, click the **ZoomBox**  toolbar button.

The mouse is again set to perform zoom functions in image windows.

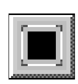
2 Inside the SPOT Pan image window, drag a zoom box to magnify part of the image.

The images in both windows automatically zoom in the same amount.

3 On the **Algorithm Geoposition Extents** dialog, select **Zoom** in the row of options at the top.

4 Under **Pan**, click the **Pan right**  button.

Both images pan 50% to the right (the previous image center point is now on the left side of the both windows).

5 Under **Zoom**, click the **Zoom out 50%**  button.

Both images zoom out 50% from their previous magnification level.

6 Experiment by moving or resizing the SPOT Pan window to view the SPOT Pan data over corresponding areas of the Landsat TM data.

Close one window and unlink the other

1 Close the SPOT Pan window using the window system controls:

- Select **Close** from the window control-menu.

2 From the **View** menu (on the main menu bar), select **Quick Zoom**, then select **Set Geolink to None**.

4: Using Overview Zoom mode

Objectives Learn to link image windows in Geolink "Overview Zoom" mode, so you can define an area of interest on an overview window, and other linked windows automatically zoom to the defined area.

Open an RGB algorithm

1 Click the **Open** toolbar button.

2 From the **Directories** menu, select the path ending with the text **\examples**.

3 Double-click on the directory named 'Applications'.

4 In the 'Land_Information' directory, load the algorithm named 'Landsat_TM_23Apr85_rgb_541.alg.'

This algorithm displays the Landsat TM image of the San Diego, California area you used earlier in this chapter.

Open a second window with the Landsat algorithm

1 Click the **New** toolbar button.

A second image window opens. Drag it to the upper-right part of the screen.

2 Click on the **Open** button.

3 From the **Directories** menu, select the path ending with the text **\examples**.

4 Double-click on the directory named 'Applications'.

5 In the 'Land_Information' directory, load the algorithm named 'Landsat_TM_23Apr85_rgb_541.alg.'

This is the same Landsat algorithm already loaded in the other window. Drag the second window to the right of the first one.

Tip: The **Copy Window** toolbar button lets you quickly create a copy of the current window and algorithm. This can be very helpful if you want to modify the processing technique and compare it to the original, or for geolinking as in this example.

Open a third window and SPOT Pan algorithm

1 On the Standard toolbar, click the **New** button.

A third image window opens. Drag it to the lower-right part of the screen.

2 Click on the **Open** button.

3 From the **Directories** menu, select the path ending with the text **\examples**.

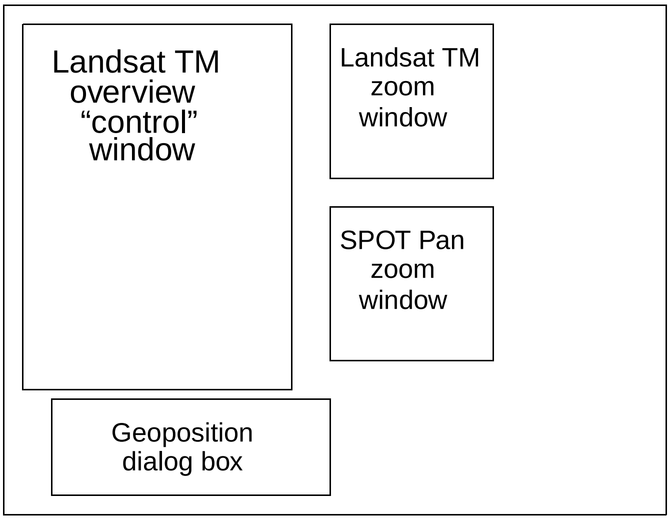
4 Double-click on the directory named ‘Applications’.

5 In the ‘Land_Information’ directory, load the algorithm named ‘SPOT_Pan.alg.’

This algorithm displays a SPOT Panchromatic (10 meter resolution) image of the same area of San Diego as the two Landsat TM windows.

Resize and position the two windows

1 Resize and reposition the three windows as shown in the following diagram. Make the Landsat window on the left larger and taller, and move the other two windows to its right (without resizing them).



You should now have the two smaller image windows next to the larger window, and **Geoposition** dialog below them. The two smaller windows will be used as “zoom” windows to examine areas in more detail.

Set the large Landsat TM window to Overview Zoom mode

1 On the **Algorithm Geoposition Extents** dialog, select **Geolink** in the row of options at the top.

2 Click inside the larger Landsat TM image window on the left side to activate it (three stars *** should appear next to the title).

3 In the **Algorithm Geoposition Extents** dialog, select the **Overview Zoom** option button.

4 Click the **Apply** button.

The window title indicates that it is now set to “OVERVIEW ZOOM” mode.

Note: When one window is set to **Overview Zoom** mode, any other image windows containing images in the same map projection are automatically linked to become “zoom” windows for that window. (Windows containing images in different projections are not affected.)

Define an area of interest on the large TM window

1 On the main menu, click the **ZoomBox Tool**  button on the Common Functions toolbar.

The mouse is set to perform zoom functions in image windows.

2 Inside the large TM window image window on the left, drag a box to define an area of interest anywhere in the image.

Both of the smaller windows automatically zoom to show the same area you defined with the box. The larger window remains unchanged because it is the master control window.

3 Drag to define other areas of interest in the master TM image window.

Both of the smaller “zoom” windows automatically zoom to magnify the area of interest. You can clearly see the difference in spatial resolution between the Landsat TM (30m) and SPOT Pan (10m) images in their respective zoom windows.

Tip: **Overview Zoom** allows you quickly pick an area on an overview window and examine it in more detail in the zoom windows. This is an especially effective analysis technique when using different types, dates, or resolutions of imagery in the zoom windows. You can open as many zoom windows as you need.

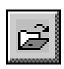
5: Using Overview Roam mode

Objectives Learn to link image windows in Geolink “Overview Roam” mode, so you can drag the mouse to pan in an overview window, and other windows pan or “roam” so their center point matches the current mouse position the overview window.

Unlink the master Landsat TM window

1. Click inside the larger Landsat TM window on the left to activate it.
2. From the **View** menu (on the main menu bar), select **Quick Zoom**, then select **Geolink None**. (You could also choose the **None** option on the **Algorithm Geoposition Extents** dialog **Geolink** tab and click **Apply** to unlink the window.)

Load the Landsat TM algorithm into the SPOT Pan window

1. Click inside the image window containing the greyscale SPOT Panchromatic image to activate it.
2. Click on the **Open**  button.
3. From the **Directories** menu, select the path ending with the text **\examples**.
4. Double-click on the directory named ‘Applications’.
5. In the ‘Land_Information’ directory, load the algorithm named ‘Landsat_TM_23Apr85_rgb_541.alg.’

   You now have the same algorithm loaded into all three windows.

Set different display resolutions for the two zoom windows

1. Click inside the smaller Landsat window on the upper-right to activate it.
2. Edit the **Dataset cells per pixel** field to read **`1`** (the value one).
3. Click the **Apply** button to apply your new display resolution.

   ER Mapper reprocesses the algorithm at a “one-to-one” display resolution.
4. Click inside the smaller Landsat window on the lower-right to activate it.
5. Edit the **Dataset cells per pixel** field to read **`0.33`**.
6. Click the **Apply** button to apply your new display resolution.

   ER Mapper reprocesses the algorithm at a higher display resolution, so the image is magnified three times greater than the image in the one-to-one resolution window above it.

Set the large Landsat TM window to Overview Roam mode

1 Click inside the larger Landsat TM window on the left side to activate it.

2 In the **Algorithm Geoposition Extents** dialog, select the **Overview Roam** option button.

3 Click the **Apply** button.

The window title indicates that it is now set to "OVERVIEW ROAM" mode.

Note: As with Overview Zoom, when one window is set to Overview Roam mode, any other image windows containing images in the same map projection are automatically linked to the master Overview Roam window.

Point to an area in the large TM window and press the mouse

1 On the main menu, click the **Hand Tool**  button on the Common Functions toolbar.

The mouse is set to perform pan functions in image windows.

2 Inside the large TM master window, point to any feature of interest and depress the mouse button.

Both of the smaller windows automatically pan so that their center point is the same as the area you are pointing to in the master window. This allows you to "roam" through the overview image to easily view any area in detail. The master window remains unchanged because it is the control window. Notice that crosshairs appear over the master window to indicate the current mouse pointer location.

Drag slowly through the large TM window to pan

1 Inside the large TM master window, drag the mouse slowly from one part of the image to another.

As you drag, the smaller windows interactively pan so that their center point is the same as the current pointer position in the master window.

2 Click or drag to define other features of interest in the master window, such as lakes, urban areas, and so on.

Both of the smaller windows automatically roam to center on your feature of interest. By setting up your two smaller windows at different magnifications, you can see different levels of detail in your feature area.

Tip: **Overview Roam** is an effective visualization technique for quickly analyzing many features in an image using different resolutions and/or types of imagery in the roam windows. You can open as many roam windows as you need.

Close all image windows and the Algorithm Geoposition Extents window

1 Close all image windows using the window system controls:

- Select **Close** from the window control-menu.

2 Click **Close** on the **Algorithm Geoposition Extents** dialog to close it.

Only the ER Mapper main menu is now open.

What you learned...

After completing these exercises, you know how to perform the following tasks in ER Mapper:

- Display images with exact geographic extents and display resolutions
- Link image windows to show the same geographic extents
- Link image windows to a virtual map sheet window
- Control interactive image zooming and panning functions from a master window

12

Writing images to disk

This chapter explains how to send the processing results of an algorithm to a raster output file on disk instead of to the computer display.

About Writing Images to Disk

Up until this point you have not needed to write image files to disk since you have been doing all processing interactively directly to the display (using ER Mapper algorithms). In general, processing your data interactively to the display is preferred since it is faster, easier, and takes full advantage ER Mapper's flexibility and the processing power of your computer. However, there are times when you may want to save your processing results to a separate raster image file on disk.

For example, if you are using very complex, compute-intensive algorithms, you may want to write a processed copy of the data to disk at some point so it does not need to be recomputed. Saving your processing as a dataset or image file can also be useful if you want to use the processed image in another software application.

To have ER Mapper send the output from an algorithm to a disk file, set up your algorithm with the appropriate layers and processing, then select **Save As...** from the **File** menu or click the **Save As**  toolbar button.

Raster layers in the **Algorithm** window can be combined when output, or they can be output to separate bands in the output image file. The layers in the **Algorithm** window are processed as follows:

- Non-Classification raster layers with no layer description or the same layer description are combined upon output.
- Non-Classification raster layers with unique layer descriptions are written as a separate band in the output image.
- All Classification raster layers are processed into a single band in the output image.

Hands-on exercises

This exercise demonstrates the procedure for sending algorithm output to a file on disk rather than to the display.

What you will learn... After completing these exercises, you will know how to perform the following tasks in ER Mapper:

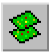
- Create an algorithm to send output to an image
- Specify output parameters and write the image to disk
- View information about the output image filet

Before you begin... Before beginning these exercises, make sure all ER Mapper image windows are closed. Only the ER Mapper main menu should be open on the screen.

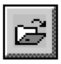
1: Writing an image to disk

Objectives Learn how to send algorithm processing output to a raster image dataset on disk. In this case, you will write three bands of a Landsat image subset to disk.

Load a Pseudocolor algorithm

1 On the Standard toolbar, click the **Edit Algorithm**  button.

An image window and the **Algorithm** dialog box appear.

2 On the Standard toolbar, click on the **Open**  button.

3 From the **Directories** menu, select the path ending with the text **\examples**.

4 Double-click on the 'Data_Types' directory to open it.

5 In the ‘Landsat_TM’ directory, load the algorithm ‘Greyscale.alg.’

The algorithm displays band 1 of a Landsat TM image of San Diego as a greyscale image. You will zoom in to define a smaller portion of the image, and choose three of the seven images bands to write to disk.

Zoom in to define a subset of the image

1 Click the **ZoomBox Tool** toolbar button to set the mouse for use as a zoom tool.

2 Position the mouse pointer in the upper-left corner of the image, then drag a zoom box to enclose the bay with the large island on its right side. (This should be about one-tenth of the image area.)

Create layers for two other output image bands

1 In the **Algorithm** window, click the **Duplicate** button twice.

Two additional Pseudocolor layers are added, and each already contains the ‘Landsat_TM_year_1985’ image since they are duplicates.

Select bands 1, 4 and 7 and label the layers

1 Click on the first Pseudocolor layer to select it.

This layer already has image band 1 selected.

2 Click in the layer’s description text field with your left mouse button.The cursor will be placed in the text field. Type the text label **`TM band 1`** then press Enter or Return to validate.

3 Click on the middle Pseudocolor layer to select it.

4 From the **Band Selection** drop-down list (in the process diagram), select **B4:0.83_um**.

5 Click in the layer’s description text field with your left mouse button.The cursor will be placed in the text field. Type the description label **`TM band 4`** for the middle layer, then press Enter or Return.

6 Click on the lowest Pseudocolor layer to select it.

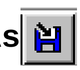
7 From the **Band Selection** drop-down list, select **B7:2.215_um**.

8 Click in the layer’s description text field with your left mouse button.The cursor will be placed in the text field. Type the description label **`TM band 7`** then press Enter or Return.

You have now created an algorithm that selects three bands from the original image (bands 1, 4, and 7) to be written to the new image on disk. By zooming in, you have defined a subsection of the image. The layer descriptions you specified will become the labels for each band in the output image.

Note: The order of layers in the algorithm determines the order of bands in the output image (the first layer becomes the first image band). In this case the layer labelled 'TM band 1' will become band 1 in the output image, 'TM band 4' will become band 2, and 'TM band 7' will become band 3.

Specify a filename for the output image

1 On the Standard toolbar, click the **Save As**  button.

The **Save As** dialog box appears. This dialog lets you specify a path and name for your output disk file, and the type of file to be saved.

You can save the output image in any of the following formats:

- ER Mapper Algorithm
- ER Mapper Raster Dataset (.ers)
- ER Mapper Virtual Dataset (.ers)
- ESRI BIL and GeoSPOT (.hdr)
- Windows BMP (.bmp)
- GeoTIFF/TIFF (.tif)
- JPEG (.jpg)
- UDF (Universal Data Format)

The format in which you save the image depends on what you are going to do with it. If you intend opening the image in another application, use the format best suited to that application. If you intend using the image in ER Mapper then you should save it in ER Mapper Raster Dataset format. The Universal Data Format (UDF) allows you to use the image in ER Mapper and in other applications that use the ESRI BIL and GeoSPOT formats.

Note: If the image is very large, you may want to save it in ECW compressed format. You can do this by selecting **Save as Compressed image...** from the **File** menu.

In this exercise, we will save the image in ER Mapper Raster Dataset format.

2 On the **Save As** dialog, select 'ER Mapper Raster Dataset (.ers) in the **Files of Type:** field.

3 From the **Directories** menu, select the path ending with the text **\examples**.

4 Double-click on the directory named 'Miscellaneous' to open it.

5 Double-click on the directory named 'Tutorial' to open it.

6 In the **Save As:** text field, type in a name for the disk file. Use your initials at the beginning, followed by the text '147_TM_subset,' and separate each word with an underscore (_). For example, if your initials are "DH," type in the name:

```
DH_147_TM_subset
```

7 Click **OK** to close the file chooser dialog and open the **Save As ER Mapper Dataset** dialog.

Choose options for the output image

The other fields on the **Save As ER Mapper Dataset** dialog are:

Data Type is the data format for the new output image. For example, if your algorithm processing produces floating point data using a formula, choose one of the Real options to write output image dataset values as real numbers.

Null Value specifies the value that is assigned to null cells. This is usually 0.

Width and **Height** specify the width and height of the new output image in pixels. You can enter any size and ER Mapper automatically subsamples or supersamples the original image data to fill the requested dimensions.

Pixel Width X and **Pixel Width Y** specify the magnification in terms of the are of the image bounded by a pixel.

If image had been setup for a page, the **Output What** box would have allowed you to select either **Current View** or **Entire Page**. The **Current View** saves only the part of the image currently being displayed in the image window, while the **Entire Page** saves the whole page containing the image. Since the image being saved has not had a page setup, only the **Current View** can be saved.

1 Click the **Defaults** button.

ER Mapper automatically fills in appropriate values in the **Cells Across** and **Down** fields by examining the extents of the area you zoomed on, and figuring the corresponding numbers of actual image pixels to be output.

Tip: To write one output image pixel for each input image pixel, use the **Defaults** button to set the output cells across and down to the correct values. Changing these values causes ER Mapper to supersample or subsample to the original data during output.

---

2 Select the **Delete output transforms** option.

Note: When writing images to disk, you should usually delete the output transforms for each raster layer to maintain the native data range of the input image. Otherwise, the output data may be scaled or clipped according to the current transform. (You can, however, use a transform to rescale the data if desired.)

Write the output disk file

1 Click **OK** on the **Save As ER Mapper Dataset** dialog.

ER Mapper asks you to confirm the path and name of the output file.

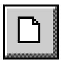
2 Click **Yes** on the output path dialog to proceed.

ER Mapper opens a dialog box to show the progress of the write to disk operation, and presents a confirmation dialog when the process is complete.

3 Click **OK** on the confirmation dialog to close it.

4 Click **Close** on the **Save As ER Mapper Dataset** dialog to close it.

Display the new image

1 Click the **New**  button on the Standard toolbar, then drag the new window below the first one.

2 On the **Algorithm** window, click on the **Load Dataset**  button in the process diagram.

3 From the **Directories** menu, select the path ending with the text **\examples**.

4 In the 'Miscellaneous\Tutorial' directory, load your new image (it will have a '.ers' file extension).

ER Mapper displays band 1 of your new image.

5 Open the **Band Selection** drop-down list to see the three bands in your output image.

Notice that the band labels are the same as the layer descriptions you entered previously.

View information on the new image

1 On the **Algorithm** window, click on the **Load Dataset** button.

2 On the **Raster Dataset** file chooser, click the **Info...** button.

Information on your new image displays, including the number of bands (3), dimensions, and file size. The new image also has the same datum and map projection information as the original image.

3 Click **Cancel** to close the **Dataset Information** dialog.

4 Click **Cancel** to close the **Raster Dataset** file chooser dialog.

Tip: This exercise showed you how to create an algorithm designed write an image to disk, but ER Mapper also provides several predefined "template" algorithms to make this easier. These algorithms are located in the 'examples\Miscellaneous\Templates' directories, and all you need to do is load in the desired image dataset and follow the general procedure described previously.

Close all image windows and dialog boxes

1 Close all image windows using the window system controls:

- Select **Close** from the window control-menu.

2 Click **Close** on the **Algorithm** window to close it.

Only the ER Mapper main menu should be open on the screen.

What you learned

After completing these exercises, you know how to perform the following tasks in ER Mapper:

- Create an algorithm to send output to a raster image dataset on disk
- Specify output image parameters and write the image to disk
- View information about the output image

13

Virtual datasets

This chapter explains how to create and use a special type of algorithm called a Virtual Dataset. Virtual datasets are an innovative ER Mapper feature that allow you to work with data in an intermediate processed state without actually needing to write the results to a file on disk.

About virtual datasets

A Virtual Dataset ("VDS" for short) is a special type of algorithm that can be used as if it were a file on disk, except that the data is computed on demand so it takes no additional disk space. Virtual Datasets are an extension of the algorithms concept, so you can carry out processing on a raw image, then save the results as a "virtual" dataset for use as input for another algorithm. By saving processing results in a Virtual Dataset, you can define "views" into your data that can be used in subsequent processing as if they were real images on disk.

Virtual Datasets offer many advantages:

- *Reduced data complexity*–layers that process combinations of bands can become a single band of data in the virtual dataset.
- *Reduced disk storage*–virtual datasets are computed on demand, so no extra disk storage is needed.
- *Virtual image mosaics*–two or more adjacent images can be merged and processed as if they were a single image.
- *New types of data*–image datasets with different characteristics can be merged to create hybrid virtual datasets.

All of these types of operations can be saved as Virtual Datasets, thereby making the processing techniques used to create them transparent to the user.

Hands-on exercises

These exercises give you practice creating Virtual Datasets and understanding how to use them in subsequent image processing algorithms.

What you will learn...

After completing these exercises, you will know how to perform the following tasks in ER Mapper:

- Prepare an algorithm to be saved as a Virtual Dataset
- Save and load a Virtual Dataset
- Compute a Tasseled Cap formula transform on an image, and save the resulting images in a “virtual” Tasseled Cap dataset
- Create a mosaic of three separate images, and save the algorithm as “virtual” image mosaic
- Create a virtual dataset referencing images of different resolutions, and use it to merge the two images

Before you begin...

Before beginning these exercises, make sure all ER Mapper image windows are closed. Only the ER Mapper main menu should be open on the screen.

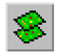
1: Creating a Tasseled Cap VDS

Objectives

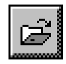
Learn to create an algorithm that generates three “Tasseled Cap” images, then save the algorithm as a Virtual Dataset for later use. This example shows how Virtual Datasets can be used to reduce the complexity of manipulating image data and make it easier to use.

About the Tasseled Cap transformation: The three Tasseled Cap formulas used in this example are designed to transform the original Landsat TM data into three separate images representing the scene brightness, vegetation greeness, and surface moisture (wetness). The Tasseled Cap (TC) transformation provides useful information for agricultural applications because it allows the separation of barren (bright) soils from vegetated and wet soils.

Open a Tasseled Cap algorithm

1 Click the **Edit Algorithm**  toolbar button.

An image window and the **Algorithm** window appear.

2 On the Standard toolbar, click on the **Open**  button to open the file chooser dialog.

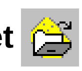
3 From the **Directories** menu, select the path ending with the text **\examples**.

4 Double-click on the 'Data_Types' directory to open it.

5 In the directory 'Landsat_TM,' load the algorithm named 'Tasselled_Cap_Transforms.alg.'

This algorithm generates the three Tasseled Cap transformation images, each in its own Pseudocolor layer. The dataset is a Landsat TM image of the San Diego, California area. The Brightness image is initially displayed because its layer is turned on and the Wetness and Greeness layers are turned off.

Load a different TM image into the algorithm

1 In the **Algorithm** window, click the **Load Dataset**  button in the process stream diagram.

The **Raster Dataset** file chooser opens.

2 From the **Directories** menu, select the path ending with the text **\examples**

3 Double-click on the 'Data_Types' directory to open it.

4 Double-click on the directory 'Ers1' to open it.

5 Double-click on the image 'Landsat_TM.ers' to load it into all three layers.

This dataset is Landsat TM image of the Netherlands that shows an area of coastal plains under various levels of cultivation.

View the different Tasselled Cap images

1 Turn the 'Brightness' layer off (by selecting **Turn Off** from the **Short-Cut** menu which appears after clicking the right mouse button on the 'Brightness' layer), and turn the 'Greeness' layer on (by selecting **Turn On** from the **Short-Cut** menu).

The Greeness image is displayed showing the location and relative abundance of vegetation (light shades are vigorous vegetation). This is similar to the vegetation index images you generated in earlier exercises.

2 Turn the 'Greeness' layer off, and turn the 'Wetness' layer on.

The displayed Wetness image is an indicator of surface moisture, so ocean areas are shown as light grey shades, and areas lacking moisture are shown as dark shades (barren land, beaches, and airport runways).

View the formulas used to create the TC images

1. Turn all three layers on.
2. Click on the 'Brightness' layer to select it.
3. Click the **Edit Formula** button in the process diagram to open the **Formula Editor** dialog.

   The formula used to generate the Tasselled Cap Brightness image displays. As indicated, this image is generated by multiplying bands 1-5 and 7 by weighted coefficients. (For best results in any particular area of the world, these coefficients should be adjusted for local conditions. However, the standard coefficients generally provide good indicators of the three parameters in most cases.)

4. Click the **Move to next Pseudocolor layer** button on the **Formula Editor** dialog to display the formula used to generate the 'Wetness' image.
5. Click the **Move to next Pseudocolor layer** button again to display the formula used to generate the 'Greeness' image.

   When you save the algorithm as a Virtual Dataset, ER Mapper will perform these three sets of calculations automatically.

6. Click **Close** on the **Formula Editor** dialog to close it.

Note: Before saving an algorithm as a Virtual Dataset, *make sure all algorithm layers are turned on*. Layers that are turned off cannot be used in the Virtual Dataset.

Save the algorithm as a Virtual Dataset

1. From the **File** menu, select **Save As...**.

   The **Save As** dialog box appears.

2. In the **Files of Type:** field, select 'ER Mapper Virtual Dataset (.ers).
3. From the **Directories** menu, select the path ending with the text **\examples**.
4. Double-click on the directory named 'Miscellaneous' to open it.
5. Double-click on the directory named 'Tutorial' to open it.

6 In the **Save As:** text field, type in a name for the Virtual Dataset file. Use your initials at the beginning, followed by the text 'Tasseled_Cap_VDS,' and separate each word with an underscore (_). For example, if your initials are "DB," type in the name:

```
DB_Tasseled_Cap_VDS
```

7 Click **OK** to save the Virtual Dataset and close the file chooser dialog.

Delete the transforms from all three algorithm layers

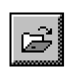
1 Click **Yes** in the ER Mapper query about deleting output transforms dialog.

This will make sure that the original data ranges created by the Tasselled Cap formulas are not rescaled in any way using a transform when the images are saved as a Virtual Dataset. (In this algorithm, each layer had a contrast stretch applied to enhance visual presentation.)

The Virtual Dataset is actually saved as a small ASCII text file on disk that describes the processing and image dataset in each layer (very similar to an algorithm). Because of this, it consumes almost no additional disk space.

Tip: It is often helpful to append the text "VDS" on the end of the name you assign to a Virtual Dataset. This helps you easily determine that the image is *virtual*, and not an actual dataset file on disk.

Open a template RGB algorithm to display your Virtual Dataset

1 On the Standard toolbar, click on the Open  button to open the file chooser dialog.

2 From the **Directories** menu, select the path ending with the text **\examples**.

3 Double-click on the 'Miscellaneous' directory and then on the 'Templates' directory.

4 In the directory 'Common,' load the algorithm named 'RGB.alg.'

The template RGB algorithm with an airphoto image displays.

Load and display the Virtual Dataset

1 On the **Algorithm** window, click on the **Load Dataset**  button in the process diagram.

2 From the **Directories** menu, select the path ending with the text **\examples**.

3 In the 'Miscellaneous\Tutorial' directory, load your Tasselled Cap Virtual Dataset image (it will have a '.ers' file extension).

4 In the process diagram, select the following bands for each layer: Blue = B1: Wetness, Green = B2:Greenness, and Red = B3:Brightness.

ER Mapper computes the Tasseled Cap calculations from the original TM data on disk.

5 Open the **Band Selection** drop-down list in the process stream to see the three bands in your Virtual Dataset.

Note this Virtual Dataset has three bands: Brightness, Greeness, and Wetness. By saving the Tasseled Cap algorithm as a Virtual Dataset, you have reduced the complexity of the data, and no longer need to use the Tasseled Cap formulas in future algorithms to generate these images.

Adjust the transforms for the RGB layers to increase contrast

1 Click on the post-formula **Edit Transform Limits** button.

2 From the **Limits** menu, select **Limits to Actual**.

ER Mapper sets the X axis (input) limits to match the data range created by the Tasseled Cap Brightness formula.

3 Click the **Move to next Green layer** G button, and select **Limits to Actual** from the **Limits** menu for the Green layer.

4 Click the **Move to next Blue layer** B button, and select **Limits to Actual** from the **Limits** menu for the Blue layer.

5 For each layer, click the **Create autoclip transform** button. (Move between them using the R, G and B buttons.)

The resulting RGB color composite image shows information about the various states of cultivated fields in the image. Bright areas (sand, barren land) appear in red, crops under cultivation appear in green or cyan, fallow fields appear brownish, and water areas are bright blue. This is a traditional way of displaying the three Tasseled Cap images as an RGB color composite, and is especially useful for assessing the cultivated states of agricultural areas.

6 Click **Close** to close the **Transform** dialog box.

View information on the Virtual Dataset

1 On the Algorithm window, click on the **Load Dataset** button.

2. On the **Raster Dataset** file chooser, click the **Info...** button.

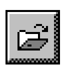
   The **Dataset Information** dialog indicates that the image dataset is Virtual. Since it is not actually an image on disk, it cannot be edited using the dataset header editor.

3. Click **Cancel** to close the **Dataset Information** dialog.
4. Click **Cancel** to close the **Raster Dataset** file chooser dialog.

2: Creating a Virtual Mosaic

Objectives Learn how to save a mosaic of three images as a “virtual” mosaic that can used as if it were a single image.

Open an RGB algorithm that displays three adjacent images

1. Click the **Open**  toolbar button.
2. From the **Directories** menu, select the path ending with the text **\examples**.
3. Double-click on the ‘Applications’ directory to open it.
4. Double-click on the ‘Airphoto’ directory to open it.
5. In the directory ‘3_Balancing’, load the algorithm named ‘ADAR_mosaic.alg.’

   This algorithm displays an RGB color composite of three separate ADAR 5000 scenes covering a portion of the Del Mar, California area near San Diego. (This data is from the ADAR multispectral scanner system acquired by aircraft.)

6. Expand the image window by 50% downward to make it taller.
7. Right-click on the image and select **Zoom to All Datasets** from the **Quick Zoom** menu.
8. Scroll through the layers in the layer list on the **Algorithm** window.

   Notice that there are nine layers in the algorithm because each of the images is displayed in its own set of RGB layers. Also, each layer has a description that indicates the band of image data loaded into it.

Save the algorithm as a Virtual Dataset

1. From the **File** menu, select **Save As...**.

   The **Save Algorithm** dialog box appears.

2. In the **Files of Type:** field, select ‘ER Mapper Virtual Dataset (.ers)’.

3 From the **Directories** menu, select the path ending with the text **\examples**.

4 Double-click on the directory named ‘Miscellaneous’ to open it.

5 Double-click on the directory named ‘Tutorial’ to open it.

6 In the **Save As:** text field, type in a name using your initials followed by the text ‘image_mosaic_VDS,’ and separate each word with an underscore (_). For example, if your initials are "SN," type in the name:

```
SN_image_mosaic_VDS
```

7 Click **OK** to save the Virtual Dataset and close the file chooser dialog.

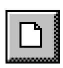
8 Click **No** in the query dialog to remove output transforms.

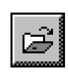
The Virtual Dataset is actually saved as a small ASCII text file on disk that describes the processing and image dataset in each layer (very similar to an algorithm). Because of this, it consumes almost no additional disk space

---

Note: In this case, you did not delete the transform from each layer before saving the algorithm as Virtual Dataset. The contrast enhancement is desirable in this case because it serves to balance the brightness between the three images and makes seam lines less apparent.

Open a template algorithm to display your Virtual Dataset

1 Click the **New**  button on the Standard toolbar, then drag the new window below the first one.

2 On the Standard toolbar, click on the **Open**  button to open the file chooser dialog.

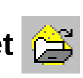
3 From the **Directories** menu, select the path ending with the text **\examples**.

4 Double-click on the ‘Miscellaneous’ directory and then on the ‘Templates’ directory.

5 In the directory ‘Common,’ load the algorithm named ‘RGB.alg.’

The template RGB algorithm with an airphoto image displays.

Load the Virtual Dataset into the RGB algorithm

1 On the **Algorithm** window, click on the **Load Dataset**  button in the process diagram.

2 From the **Directories** menu, select the path ending with the text **\examples**.

3 In the ‘Miscellaneous\Tutorial’ directory, load your new image mosaic Virtual Dataset image (it will have a ‘.ers’ file extension).

The three images are displayed as if they were one, but the data is actually being computed from the three original ADAR images on disk.

4 Open the **Band Selection** drop-down list in the process stream to see the three bands in your Virtual Dataset.

The “virtual” band 1 references the band 1 data from each of the three original ADAR image files, and so on for virtual bands 2 and 3. You can now manipulate the three images as if they are a single image, for example to contrast stretch them, apply filters, and so on.

Note: In the original algorithm (open in the other window for reference), each of the Red layers displayed band 1 of their image. Since each Red layer had the same layer description (B1:0.850_um), ER Mapper merged them into a single “virtual” band with that label when the algorithm was saved as a Virtual Dataset. Any layers in an algorithm with the same layer description will be referenced as a single layer in a Virtual Dataset.

Close both image windows

1 Close both image windows using the window system controls:

- Select **Close** from the window control-menu.

3: Creating a multiple image VDS

Objectives Learn how to save and reference multiple images as single Virtual Dataset. In this case, you will save SPOT XS and SPOT Panchromatic satellite images in a VDS, and use it in a processing algorithm to merge the two images.

Open a window and template greyscale algorithm

1 Click the **Open** toolbar button.

A new image window and the **Open** file chooser appear.

2 From the **Directories** menu, select the path ending with the text **\examples**.

3 Double-click on the ‘Miscellaneous’ directory and then on the ‘Templates’ directory.

4 In the directory ‘Common,’ load the algorithm named ‘Single_Band_Greyscale.alg.’

Load the SPOT XS image

1 On the **Algorithm** window, click on the **Load Dataset** button in the process diagram.

2 From the **Directories** menu, select the path ending with the text **\examples**.

3 In the ‘Shared_Data’ directory, load the file ‘SPOT_XS.ers.’

This image is band 1 of a SPOT XS multispectral satellite image. (The contrast of the image is not relevant at this point so there is no need to adjust it.)

4 Open the **Band Selection** drop-down list in the process stream.

Note that the SPOT XS image has three spectral bands.

Delete the transform from the Pseudocolor layer

1 Click on the post-formula **Edit Transform Limits** button.

2 From the **Edit** menu on the Transform dialog, select **Delete this transform**.

ER Mapper deletes the post-formula transform from the layer. (Since you will be performing computations on the Virtual Dataset later, you should delete the transform to prevent the original data from being rescaled.)

3 Click **Close** on the **Transform** dialog to close it.

Duplicate the Pseudocolor layer three times

1 On the Algorithm window, click the **Duplicate** button three times to create three copies of the original layer.

2 If needed, make the layer list window slightly larger until you can view all four layers together at once.

Select bands and enter labels for the lowest three layers

1 Click on the first (top) layer to select it.

2 Enter the layer description **SPOT XS1** for the first layer. (It should already have band 1 chosen by default.)

3 Select the second layer, choose **B2:0.645_um** from the **Band Selection** drop-down list, and enter the layer description **SPOT XS2**.

4 Select the third layer, choose **B3:0.84_um** in **Band Selection** drop-down list, and enter the layer description **SPOT XS3**.

You should now have image bands 1, 2 and 3 loaded in the first, second and third algorithm layers respectively, and each layer should be labelled accordingly.

Load the SPOT Pan image into the fourth layer

1 Click on the fourth (lowest) layer to select it.

2 In the process diagram, click the **Load Dataset**  button to open the **Raster Dataset** chooser dialog.

3 From the **Directories** menu, select the path ending with the text **\examples**.

4 Double-click on the ‘Shared_Data’ directory to open it.

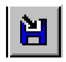
5 Click once on the image ‘SPOT_Pan.ers’ to select it, then click the **OK this layer only** button.

ER Mapper loads the image into only the current Pseudocolor layer of the algorithm. (If you had used **OK** or **Apply**, the image would be loaded into all four layers which is not what you want in this case.)

6 Enter the description **SPOT Pan** for the fourth layer.

You have now prepared an algorithm for use in saving a Virtual Dataset that will have four bands. Virtual bands 1, 2 and 3 will reference bands 1-3 in a SPOT XS image, and band 4 will reference a separate SPOT Pan image. (The first layer in your algorithm becomes band 1 in the Virtual Dataset.)

Save the algorithm as a Virtual Dataset

1 Click the **Save As**  toolbar button.

The **Save As** dialog box appears.

2 In the **Files of Type:** field, select 'ER Mapper Virtual Dataset (.ers)'.

3 From the **Directories** menu, select the path ending with the text **examples**.

4 Double-click on the directory named 'Miscellaneous' to open it.

5 Double-click on the directory named 'Tutorial' to open it.

6 In the **Save As:** text field, enter your initials followed by the text 'SPOT_XS_and_Pan_VDS,' and separate each word with an underscore (_). For example, if your initials are "JM," type in the name:

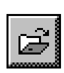
```
JM_SPOT_XS_and_Pan_VDS
```

7 Click **OK** to save the Virtual Dataset, and then Yes to deleting output transforms.

The two images are saved in a single Virtual Dataset, so they can now be referenced as if they are a single image on disk.

Tip: At this point, you may also want to save the layers you set up as a normal algorithm file (using **File/Save As**) so that you can use as a template for creating other SPOT XS and Pan Virtual Datasets in the future. This saves you the trouble of building and labelling the layers again.

Open a template RGB algorithm to process your Virtual Dataset

1 Click on the **Open**  toolbar button.

2 From the **Directories** menu, select the path ending with the text **\examples**.

3 Double-click on the 'Miscellaneous' directory and then on the 'Templates' directory.

4 In the directory 'Common,' load the algorithm named 'RGB.alg.'

Load the SPOT XS and Pan Virtual Dataset

1 On the **Algorithm** window, click the **Load Dataset**  button in the process diagram.

2 From the **Directories** menu, select the path ending with the text **\examples**.

3 In the 'Miscellaneous\Tutorial' directory, load your SPOT XS and Pan Virtual Dataset image (it will have a '.ers' file extension). Double-click on the image name or use the **OK** or **Apply** buttons to load the image into all three layers at once.

4 Click the **Band Selection** button in the process stream diagram.

Notice that your Virtual Dataset has four bands. Bands 1-3 reference the bands in the SPOT XS image, and band 4 references the SPOT Pan image.

Enter a formula in the Red layer to merge the images

1 Click on the Red layer to select it.

2 Click on the **Edit Formula** button in the process stream diagram to open the **Formula Editor** dialog box.

3 In the Generic formula window, edit the formula text to read:

```
input1 * input2 / 255
```

This formula tells ER Mapper to multiply the image band assigned to input1 by the band assigned to input 2, and then divide the result by 255.

4 Click the **Apply changes** button to validate the formula.

5 In the Relations window, select **B3:SPOT_XS3** for "INPUT1" and select **B4:SPOT_Pan** for "INPUT2."

This simple formula will merge band 3 of the SPOT XS image with the SPOT Pan image to create a merged image with the color of the SPOT XS multispectral image and the high resolution of the SPOT Pan image.

Enter similar formulas in the Green and Blue layers

1 Click the **Move to next Green layer** button.

2 Enter the same Generic formula (**`input1 * input2 / 255`**) and click the **Apply changes** button to validate it.

3 In the relations window, select **B2:SPOT_XS2** for "INPUT1" and select **B4:SPOT_Pan** for "INPUT2."

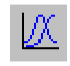
4 Click the **Move to next Blue layer** button.

5 Enter the same Generic formula (**`input1 * input2 / 255`**) and click the **Apply changes** button to validate it.

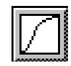
6 In the relations window, select **B1:SPOT_XS1** for "INPUT1" and select **B4:SPOT_Pan** for "INPUT2."

7 Click **Close** on the **Formula Editor** dialog to close it.

Adjust the transforms for the RGB layers to increase contrast

1 Click on the post-formula **Edit Transform Limits**  button.

2 For each layer in the algorithm, select **Limits to Actual** from the **Limits** menu.

3 For each layer in the algorithm, click the **Histogram Equalize**  button.

ER Mapper displays the final contrast stretched image, which is a merge of the SPOT XS multispectral image (20 meter resolution) and the SPOT Pan image (10 meter resolution).

This example shows how using Virtual Datasets lets you perform mathematical operations between two or more separate images *without* having to resample them to a common resolution and write them into a single image first. Multiple-image Virtual Datasets can help simplify processing techniques for many applications, including change detection, image merging, and more.

ER Mapper provides predefined algorithms you can use as templates to create common types of Virtual Datasets. These algorithms are stored in the '\examples\Miscellaneous\Templates\Virtual_Datasets' directory.

Tip: Occasionally you find it useful to edit a Virtual Dataset, for example change a formula, filter or other element. To do this, open the VDS back into it's original algorithm using **File/Open from Virtual Dataset**. Then edit the algorithm as needed, and resave to a VDS using **File/Save As Virtual Dataset**.

4: Creating a haze adjusted VDS

Objectives

Learn how to perform a simple, first-order adjustment for haze and atmospheric scattering on a Landsat image, and save the adjusted image as a Virtual Dataset. This is a good example of creating a VDS that performs a pre-processing step, so it can be used as input to subsequent algorithms.

About haze correction and histogram adjustments

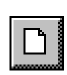
The shorter (visible) wavelength bands of optical satellite images such as Landsat TM and SPOT XS are affected by haze and atmospheric scattering, which tend to add brightness to the image in those bands. A result is that visible wavelength bands usually have much higher minimum values that do not occupy the lower end of the possible dynamic range of 0-255. When performing quantitative analysis of the data, it is usually desirable to first perform a “haze correction” adjustment to the brightness range in all bands.

When performing change detection between two images, this same type of correction should be performed on both images to normalize their brightness levels into a common range so they can be accurately compared. (Differences in the sun elevation, atmospheric conditions and other factors during the image acquisitions the two images cause them to have different ranges of values in each band.)

One simple way to do a haze correction is the *histogram adjustment* technique. This method assumes that the difference between the minimum possible value (zero) and the actual minimum value in each band is the contribution of atmospheric scattering. By subtracting the actual minimum value from each band, the histograms are shifted left so that zero values appear in the data, which somewhat minimizes the effects of atmospheric scattering. (See a reference remote sensing text for a more complete description and other more sophisticated and accurate atmospheric correction techniques.)

Note: See the section “Additional tips for Virtual Datasets” at the end of this chapter for more information on using a VDS for change detection.

Open a new window and load a Landsat TM image

1 On the main menu, click the **New**  button.

2 On the **Algorithm** dialog, click the **Load Dataset**  button in the process diagram.

3 From the **Directories** menu, select the **\examples** path.

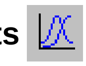
4 Open the ‘Shared_Data’ directory, then double-click on the image ‘Landsat_TM_year_1991.ers’ to load it.

5 Band of a 1991 Landsat TM image of San Diego displays.

6 Click the **Surface** tab, then select **greyscale** from ‘Color Table’ list.

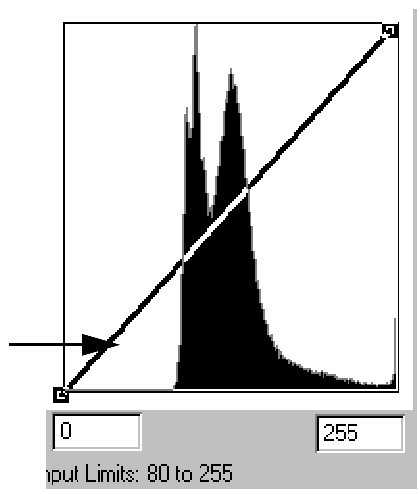
7 Click the **Layer** tab again.

View and analyze the band 1 histogram

1 On the **Algorithm** dialog, click the post-formula **Edit Transform Limits**  button in the process diagram.

2 In the **Transform** dialog, examine the band 1 (visible blue) histogram. Notice the actual input limits are 80-255, so no values occur on the lower end of the possible 0-255 dynamic range. This gap between zero and the actual minimum value is considered to be the approximate contribution of atmospheric scattering to the signal received by the satellite sensor.

approximation of brightness added to band 1 values by scattering in the atmosphere



View histograms and minimum values for other bands

1 Choose **B2:0.56_um** from the **Band Selection** list in the process diagram.

2 The histogram for TM band 2 (visible green) appears. Notice that its minimum value (about 27) is less than band 1, but still offset from zero.

3 Choose **B3:0.66_um** from the **Band Selection** list.

4 The histogram for TM band 3 (visible red) appears, and its minimum value is 22.

5 Choose **B4:0.83_um** from the **Band Selection** list.

6 The histogram for TM band 4 (near infrared) appears, and its minimum value is closer to zero (about 11).

7 Atmospheric scattering in the visible wavelengths increases brightness in TM bands 1, 2 and 3. TM 1 (blue) is most affected because it senses the shortest wavelengths. (This is effect also noticeable in the blue band of natural color airphotos.) In contrast, the pixel values of the longer wavelength bands (near and mid-IR bands 4, 5 and 7) are reduced by absorption so their minimum values are at or near zero. In general, the shorter the wavelength band, the greater the offset from a pixel value of zero.

8 Choose **B1:0.485_um** from the **Band Selection** list.

9 By subtracting the minimum value from each band, you can perform a first-order correction for the effects of atmospheric scattering.

Add a formula to automatically subtract the minimum value

One way to subtract the minimum value from all pixels in an image band is to use a formula such as **`input1 - 40`** (which subtracts 40 from each pixel value). However, this requires that you manually determine the minimum value, and type in the number, which will be different for each band. Here you will use a formula that simplifies this by subtracting the minimum value automatically.

1 Click the **Edit Formula** button in the process diagram to open the **Formula Editor** dialog.

2 Edit the formula text to read:

```
input1 - RMIN(,R1,I1)
```

This formula tells ER Mapper to take the minimum value for band 1 and subtract it from all pixels in the image. (‘RMIN’ is the region minimum function that gets the minimum value of the image from statistics stored in the ‘.ers’ file. The ‘R1’ and ‘I1’ designations refer to a region and a band.)

3 Click the **Apply changes** button to verify the formula syntax.

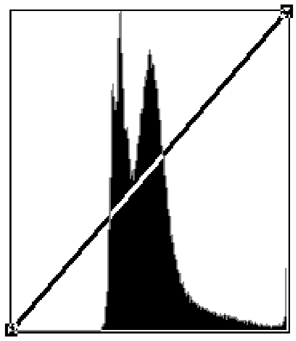
4 Click the **Inputs** button (above the Relations window), and select **B1:0.485_um** from the ‘INPUT1’ list (if it is not already selected).

5 Click the **Regions** button (above the Relations window), and select **All** from the ‘REGION1’ list (if it is not already selected).

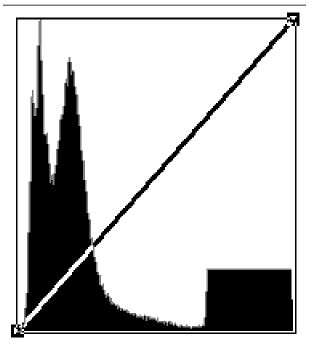
6 These settings tell the RMIN function to use the minimum value from band 1 calculated from statistics for the entire image (the ‘All’ region).

7 In the **Transform** dialog, notice that the band 1 histogram has shifted left to the origin, and the actual input limits are now 0-175. By subtracting the minimum value (80) from all pixels, you shift the histogram left so zero

values now occur in the image data. This minimizes the effects of atmospheric scattering.



original histogram (min = 80)



adjusted histogram (min = 0)

Note: Before you can use this formula, you must have calculated statistics for your image, otherwise you will receive an error message. You can do this using **Process / Calculate Statistics**. It is recommended that you use a subsample setting of 1 so statistics are calculated from every pixel in the image (to ensure the true minimum value is recorded in the statistics).

---

8 Click **Close** on the **Formula Editor** dialog.

Delete the transform and label the layer

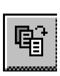
1 From the **Edit** menu (on the **Transform** dialog), select **Delete this transform**.

2 ER Mapper deletes the post-formula transform from the layer. (This ensures that the new histogram adjusted data range will be saved with the Virtual Dataset.)

3 Click **Close** on the **Transform** dialog.

4 Change the label of the 'Pseudo Layer' to **`TM1 histo adjusted`** and press Enter or Return.

Duplicate the layer five times

1 On the **Algorithm** dialog, click the **Duplicate**  button five times to create five copies of the original layer.

You now have five additional layers to perform the same histogram adjustment processing on Landsat bands 2-5 and 7. (You will skip TM band 6 since it is often not used.) Since they were copied from the first one, they already contain the adjustment formula and have the transform deleted.

Change the band and label for the copied layers

1 Select the second layer, choose **B2:0.56_um** from the **Band Selection** list in the process diagram, then change the label to **`TM2 histo adjusted`**.

2 Select the third layer, choose **B3:0.66_um** from the **Band Selection** list, then change the label to **`TM3 histo adjusted`**.

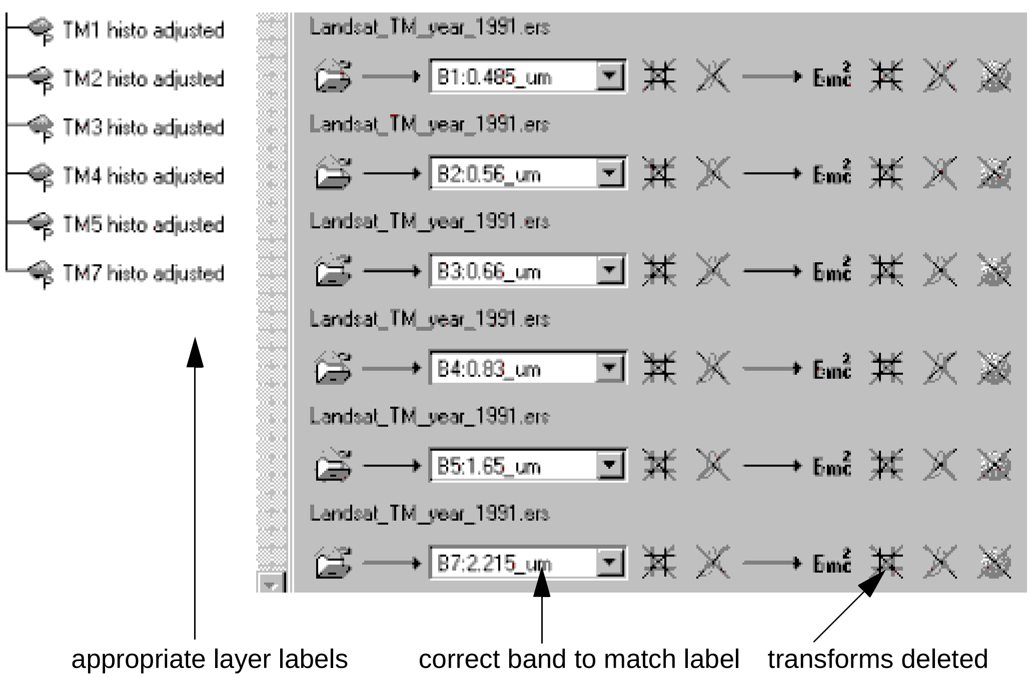
3 Select the fourth layer, choose **B4:0.83_um** from the **Band Selection** list, then change the label to **`TM4 histo adjusted`**.

4 Select the fifth layer, choose **B5:1.65_um** from the **Band Selection** list, then change the label to **`TM5 histo adjusted`**.

5 Select the sixth layer, choose **B7:2.215_um** from the **Band Selection** list, then change the label to **`TM7 histo adjusted`**.

6 Click the '[Ps]:Surface 1' icon in the layer list to show process diagrams for all six layers (if needed, make the **Algorithm** dialog taller to see all six.)

Your algorithm should look like this:



Save the algorithm as a Virtual Dataset

1 On the main menu, click the **Save As**  button.

2 In the **Files of Type:** field, select 'ER Mapper Virtual Dataset (.ers)'.

3 From the **Directories** menu, select the **\examples** path.

4 Open the 'Miscellaneous' directory.

5 Open the ‘Tutorial’ directory.

6 In the **Save As:** text field, enter your initials followed by the text **`TM_hist_adjust_VDS`** and separate each word with an underscore (_).

7 Click **OK** to save the Virtual Dataset, and **Yes** to removing the output transforms.

8 Bands 1-5 and 7 of the Landsat image have a histogram adjustment performed and are saved in a Virtual Dataset.

Open a new window and load the VDS

1 Select **New** from the **File** menu to open a new, empty image window.

2 Drag it below the first one.

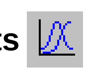
3 On the **Algorithm** dialog, click the **Load Dataset**  button in the process diagram.

4 From the **Directories** menu, select the **\examples** path.

5 Open the ‘Miscellaneous\Tutorial’ directory, then double-click on your ‘TM_hist_adjust_VDS.ers’ image to load and display it.

6 Click the **Surface** tab, select **greyscale** from the ‘Color Table’ list, then click the **Layer** tab again.

View the haze corrected band 1 histogram

1 On the **Algorithm** dialog, click the post-formula **Edit Transform Limits**  button in the process diagram.

2 In the **Transform** dialog, notice the band 1 histogram is shifted left to the origin and the band 1 minimum value is zero (in ‘Actual Input Limits’).

3 Select different bands to see their histograms and minimum values.

All bands should now have minimum values of zero, so they have had a first-order adjustment for the effects of atmospheric scattering. (A minimum value of zero may not always appear due to subsampling the data to the image window size, however the operation is still being performed correctly.)

Tip: You can use your histogram adjustment algorithm as a template to quickly apply the same processing to any other Landsat TM image. Just calculate stats for the TM image, load it into the algorithm, make sure the correct bands are selected, and save as a VDS.

Close the image windows and Algorithm dialog

1 Close both image windows using the window system controls:

- Click the **Close** button in the upper-right window corner.

2 Click **Close** on the **Algorithm** dialog.

Only the ER Mapper main menu should be open on the screen.

What you learned...

After completing these exercises, you know how to perform the following tasks in ER Mapper:

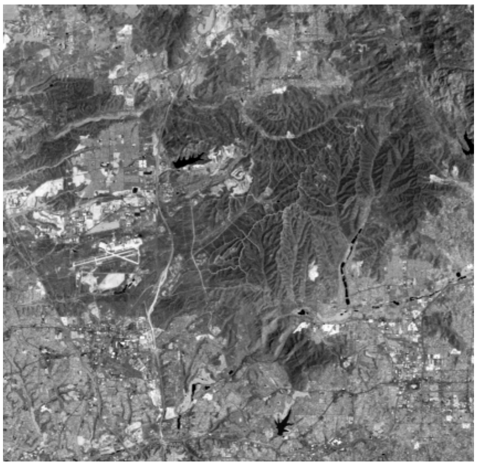
- Prepare an algorithm to be saved as a Virtual Dataset
- Compute a Tasseled Cap formula transform on an image, and save the resulting images in a “virtual” Tasseled Cap dataset
- Create a mosaic of three images, and save the algorithm as “virtual” image mosaic
- Create a Virtual Dataset referencing two images with different spatial resolutions, and use it to merge the two images
- Create a Virtual Dataset that performs a simple haze correction, so it can be used as input for subsequent quantitative or change detection processing

14

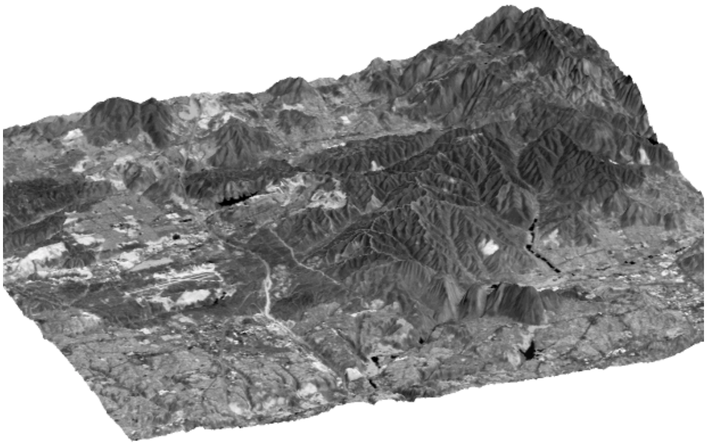
3-D perspective viewing

This chapter explains how to view and manipulate images in 3D perspective to gain a better understanding of terrain features, relationships, and other aspects of your data. ER Mapper lets you quickly change between 2D and 3D views of your data, stack multiple surfaces in a single view, set transparency between surfaces, and many other features.

About perspective viewing



Two-dimensional (planimetric) view



Three-dimensional perspective view

Viewing images in three-dimensional perspective is a valuable tool that helps increase understanding of features and relationships in images. Many types of earth science images can be integrated to create 3D scenes that show features and anomalies much more clearly than traditional two dimensional views. To create a 3D view, you simply add a Height layer to your 2D algorithm that contains an elevation image (such as a digital terrain model), then change the View Mode to 3D perspective or 3D flythrough.

ER Mapper's 3D viewing capabilities are extensive and easy to use, including:

- view any image in 3D, and quickly switch between 2D and 3D views
- use static 3D perspective or real-time "flythrough" modes
- stack multiple surfaces in a single view
- set transparency between surfaces to view underlying features
- incorporate vector data in 3D, such as roads or cultural data
- generate top quality, high resolution 3D hardcopy prints

Hands-on exercises

These exercises give you practice setting up algorithms for 3D viewing, and manipulating the images using the viewing and display controls in ER Mapper's 3D perspective viewer.

What you will learn...

After completing these exercises, you will know how to perform these tasks in ER Mapper:

- Prepare an algorithm for 3D viewing by adding a Height layer
- Change the viewpoint, zoom level, and other 3D view parameters
- Use the 3D Flythrough viewing mode
- Stack multiple surfaces in a 3D view and set surface offset and transparency
- Merge separate algorithms into surfaces in a single algorithm

Before you begin...

Before beginning these exercises, make sure all ER Mapper image windows are closed. Only the ER Mapper main menu should be open on the screen.

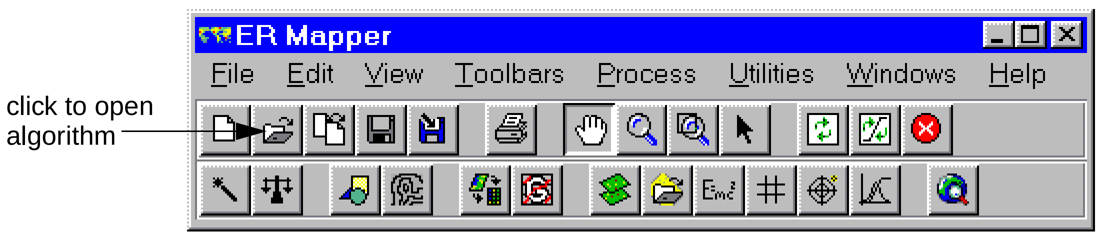
1: 3D viewing basics

Objective

Learn to prepare an algorithm for 3D viewing by adding a Height layer that contains the desired elevation data. Also learn to use 3D perspective view mode, and control the viewpoint and display parameters of the 3D scene.

Open a Landsat TM RGB algorithm

1 On the main menu, click the **Open** button.



An image window and the **Open** dialog appear.

2 From the **Directories** menu (on the **Open** dialog), select the **\examples** path.

3 Double-click on the ‘Applications’ directory to open it.

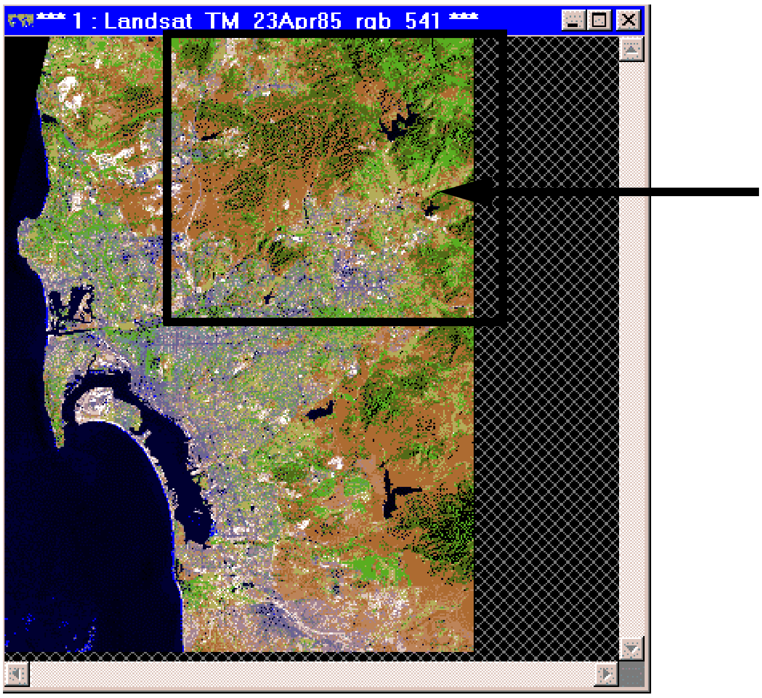
4 Open the ‘Land_Information’ directory, then double-click on the algorithm ‘Landsat_TM_23Apr85_rgb_541.alg’ to open it.

This algorithm displays a Landsat TM satellite image of a large area of San Diego, California. Bands 5, 4 and 1 are displayed in RGB so vegetation appears in various shades of green and brown.

Zoom in to the upper-right portion of the image

1 Click the **ZoomBox Tool**  button on the main menu.

2 Drag a zoom box in the image to zoom in on the upper-right portion of the image indicated below.



This is the area you will display in 3D perspective. (You can select a subset of an area to display in 3D simply by zooming in on it.)

Add a Height layer and load the DTM image

1 On the main menu, select **Algorithm** from the **View** menu.

2 From the **Edit** menu (on the **Algorithm** dialog), select **Add Raster Layer**, then **Height**.

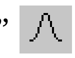
ER Mapper adds a new, empty Height layer to the algorithm. The layer is crossed out because you are currently viewing the image in 2D view mode.

3 With the 'Height Layer' selected, click the **Load Dataset**  button in the process diagram.

4 From the **Directories** menu (on the **Raster Dataset** dialog), select the **\examples** path.

5 Open the 'Shared_Data' directory, then double-click on the image 'Digital_Terrain_Model_20m.ers' to load it.

This is a digital terrain model (DTM) image of the northern San Diego area with a 20-meter grid resolution (or posting). The image values are in meters above sea level. This is the image you will use to add a height component to the algorithm to enable the Landsat image to be viewed in 3D perspective.

Note: In the **Algorithm** dialog, notice that the Height layer has a “Histogram only”  post-formula transform. This is automatically inserted for new Height layers because it forces use of the entire range of values in the DTM and prevents the data from being rescaled. (Using a transform will skew the data, for example a 99% autoclip on a Height layer will usually create flat spots in the highs and lows of the 3D image. If you duplicate an existing layer and change it to Height, delete the transform to use the full range of data for the elevation component.

Select 3D Perspective mode to view the image in 3D

1 From the ‘View Mode’ menu (on the **Algorithm** dialog), select **3D Perspective**.

ER Mapper displays a message that the image is being processed, then displays a 3D perspective view of the Landsat image in color. The message “Regenerating Terrain” appears in the image window as ER Mapper performs iterations to increase the resolution (detail) in the 3D image.

The perspective view provides clear definition of the topography of the area, which can add valuable information to aid interpretation of satellite and other types of images.

Tip: If your algorithm does not contain a Height layer, ER Mapper automatically uses an Intensity layer (if one is present) as a Height layer when you switch to **3D Perspective** view mode.

Turn off the Lighting (artificial illumination) option

1 In the **Algorithm** dialog, select the **3D View** tab.

The **3D View** tab page provides draw mode, terrain detail, lighting, and other options.

2 Turn off the **Lighting** option.

The image redraws without illumination from a light source.

Tip: When displaying images that contain natural shadows (such as airphotos or optical satellite images like Landsat), the 3D image appears more natural when the Lighting option is turned off. (Lighting is discussed more later.)

Tilt the image forward or backward

1 Point to lower edge of the 3D image and drag slightly downward.

The image moves into a more overhead perspective, and regenerates detail when you release the mouse button.

2 Point to lower edge of the image and drag slightly upward.

The image moves into a flatter, side view perspective. Dragging the image up or down tilts the 3D model forward or backward (rotates it around its X axis).

Tip: If you accidently change the 3D view too much, click the **3D View** tab in the **Algorithm** dialog, then click the **Reset View** button. This resets the the image to a standard default view.

Rotate the image around its center point

1 Point to lower edge of the image and drag slightly to the right.

The image rotates to the right around its center point.

2 Point to lower edge of the image and drag slightly left.

The image rotates to the left around its center point. Dragging the image left or right lets you view it from a side angle (rotate around the Z axis).

Zoom the image in and out

1 Drag the image window corner to make it 50% larger.

The 3D view remains the same size within the window.

2 Point to the center of the image. Then press right mouse button and drag slightly upward.

As you drag, ER Mapper zooms out so the image redraws at a smaller size.

3 Point to the image center again, press right mouse button and drag slightly downward.

ER Mapper zooms in so the image redraws at a larger size.

Right-dragging up or left reduces the image (zooms out); right-dragging down or right magnifies the image (zooms in).

4 Right-drag to set the zoom extents for the image so it fills as much of the window as possible.

Rotate the image side to side

1 Point to the center of the image. First depress the left mouse button, then the right button (hold down both), then drag slightly to the right.

ER Mapper rotates the image to the right.

2 Point to the image center again, depress the left then the right mouse buttons, and drag slightly to the left.

The image rotates left. Pressing the left *then* the right mouse buttons and dragging left or right is how you rotate the image side to side (around its Y axis).

Pan (scroll) the image within the window

1 Point to the center of the image. First depress the right mouse button, then the left button (hold down both), then drag slightly upward.

ER Mapper pans (or scrolls) the image upward without changing the perspective.

2 Point to the image center again, depress the right then the left mouse buttons, and drag around inside the window.

The image repositions as you drag. Panning in 3D is useful when want to reposition the image in the window without changing the zoom factor or viewing perspective.

Summary of 3D movement procedures

- To tilt the image backward or forward, press left mouse button and drag toward the top of the image window (to tilt backward) or bottom (to tilt forward).
- To tilt the image side to side, press left mouse button followed by right mouse button and drag to the left (to tilt left) or right.
- To the zoom the image in or out, press right mouse button and drag toward the bottom of the image window (to zoom in) or top (to zoom out).
- To rotate the image around it center axis, press left mouse button and drag the left or right side of the image (or bounding box) toward the edge of the image window.
- To move (or pan) the entire image within the window (without changing size or perspective), press right mouse button followed by left mouse button and drag to the desired location in the image window.

Increase the vertical exaggeration of the image

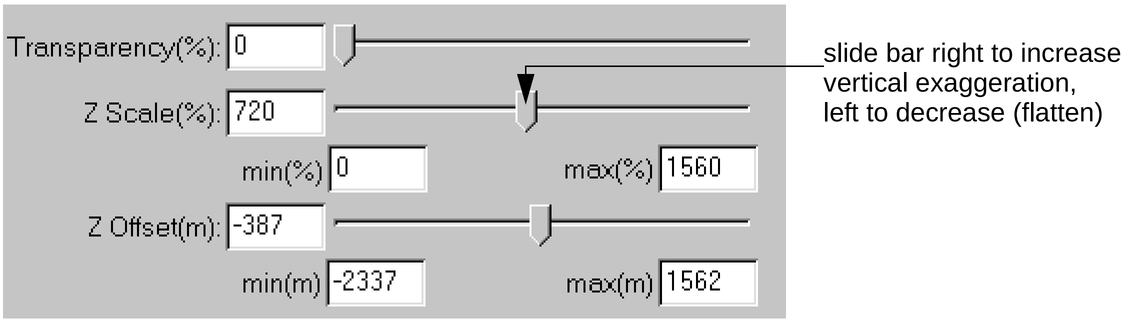
1 With the **3D View** tab selected (in the **Algorithm** dialog), click the **Reset View** button.

The 3D image perspective is reset to the initial default size and viewpoint.

2 In the **Algorithm** dialog, select the **Surface** tab.

The **Surface** tab contains controls that apply to the entire surface (such as Color Mode), and also controls for 3D perspective views.

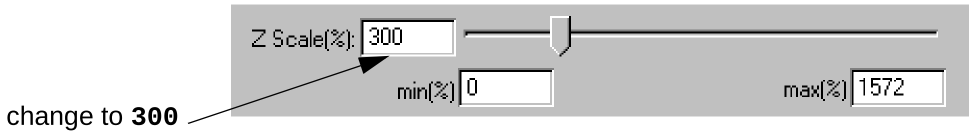
3 Move the **Z scale** slider bar right to about it mid-point.



The image redisplays with increased vertical exaggeration, so high and low elevations in the image become more apparent.

4 Try different vertical exaggerations by moving the **Z scale** slider bar left or right.

5 Change the value in the **Zscale** field to **`300`**, then press Enter/Return.



The 3D image redraws at 3 times normal vertical exaggeration.

Note: ER Mapper interprets height values to be in the same units as X and Y distances. For example, if your X and Y distances are measured in meters (as in this case) and you set **Z scale(%)** to 100, a DTM value of 10 is interpreted as 10 meters (so elevation is true to geographic scale). However, much greater vertical exaggeration is often needed to clearly bring out subtle topographic details in low relief areas such as this part of San Diego.

Apply different rendering modes for the 3D image

1 Select the **3D View** tab in the **Algorithm** dialog.

The 3D View tab page provides draw mode, terrain detail, lighting, and other options. These settings affect the entire 3D image (which can contain multiple surfaces as you will see later).

2 From the **Draw Mode** drop-down list, select **WireFrame**.

ER Mapper redisplays the image as a mesh connected grid lines. Wireframe is the fastest rendering mode, so the image regenerates quickly.

3 For **Draw Mode**, select **Textured**.

ER Mapper redisplays the image in blocks using a texture algorithm. (If your computer's graphics adapter has built-in hardware texturing, ER Mapper uses this capability to render the image quickly. If it does not, this mode requires the most calculations and may take some time for large images.)

4 For **Draw Mode**, select **Smooth Shaded** again.

ER Mapper redisplays the image with a smooth, solid fill.

Use the Lighting and Bounding Box options

1 Turn on the **Lighting** option.

The image redraws with artificial illumination from a light source, so it has a "shiny" quality to it.

2 Turn the **Lights** option off again.

The image redraws without shading effects from a light source. (Lighting is recommended when displaying geophysical or digital terrain images in color layers because they have no natural shadowing.)

Tip: You can control the amount of shininess and the material qualities used for the **Lights** option by selecting the **3D Properties** tab.

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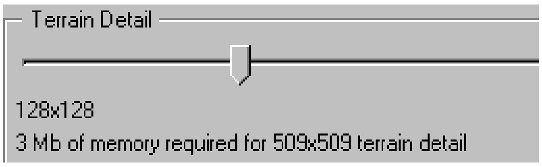
3 Turn on the **Bounding Box** option.

The image redraws with a bounding box surrounding it. The box shows the extents of the image in the X, Y and Z (vertical) directions.

4 Turn off the **Bounding Box** option.

Adjust the amount of Terrain Detail

1. Move the **Terrain Detail** slider to the right until it reads “3 Mb of memory required for 509 x 509 terrain detail” under the slider bar.



The image redraws with increased detail in the terrain.

2. Move the **Terrain Detail** slider all the way to the left.

The image redisplays with the lowest detail (128 x 128).

Terrain Detail refers to the resolution, or amount of detail, at which the image will be rendered. As you increase the detail, the rendering time, number of regeneration iterations, and amount of system memory needed also increase. It is recommended that you start at low detail settings, then slowly increase the detail to get a more accurate, high resolution image. This setting can also be important when printing 3D images to hardcopy, where you may want to use higher settings to get more detailed images.

Save the 3D algorithm

1. Adjust the viewpoint of the image to a pleasing position.
2. In the **Algorithm** dialog, change the **Description** field text to:

```
San Diego Landsat RGB=541 in 3D perspective
```

3. On the main menu, click the blue **Save As**  button.
4. In the Files of Type: field (on the **Save As** dialog), select ‘ER Mapper Algorithm (.alg)’.
5. From the **Directories** menu, select the **\examples** path.
6. Open the ‘Miscellaneous’ and then the ‘Tutorial’ directory.
7. In the **Save As:** text field, enter your initials followed by the text **`Digital_terrain_3D`** and separate each word with an underscore (_).
8. Click **OK** to save the algorithm.

Your 3D perspective algorithm is now saved to an algorithm file on disk. The next time you open it, the image automatically displays in 3D with the same viewpoint and rendering parameters.

2: 3D flythrough basics

Objective Learn to view an image in 3D Flythrough mode, and control the viewpoint and flight parameters.

In 3D Flythrough mode, it is as though the ground is stationary and you move around it, exploring the terrain. You depress the mouse button to begin your flight through the image, and the area where you position the mouse cursor controls the direction and speed of your flight.

Open a standard 3D view algorithm

1 On the main menu, click the **Open**  button.

2 From the **Directories** menu (on the **Open** dialog), select the **\examples** path.

3 Double_click on the ‘Functions_And_Features’ directory to open it, then open the ‘3D’ directory.

4 Double-click on the algorithm ‘Landsat_over_DTM.alg’ to open it.

This algorithm displays smaller Landsat TM satellite image of San Diego in 3D perspective (with Lights on).

Select 3D Flythrough mode to move through the image in 3D

1 From the ‘View Mode’ menu (on the **Algorithm** dialog), select **3D Flythrough**.

The image re-renders from a side view.

Fly through at different directions and speeds

To fly through the image, depress the left mouse button and point to an area of the image window to control the direction and speed of the flight. As you fly through the image, the terrain will appear to move in the opposite direction of your motion.

1 Point to the lower center of the image window and depress the left mouse button.

You fly backward away from the image, and the detail regenerates when you release the mouse.

2 Point to the upper center of the image and depress the left button.

You fly forward toward the image.

3 Point to the right center of the image and depress the left button.

You fly toward the right side of the image.

4 Point to the left center and depress the left button.

You fly back toward the left side of the image.

5 Point to the lower-right corner of the window and depress the left button.

You fly backward *and* to the right away from the image.

6 Point slightly above the center point of the window and depress the left button.

You fly forward slowly into the image.

Tip: To fly slowly, point near the window center. To fly faster, point further out toward the window edges.

Change the viewing altitude

1 Point to the center of the image, depress the right mouse button and drag slightly upward.

Your altitude increases, so you look more down on the 3D image.

2 With the right button depressed, drag slightly downward.

Right-dragging up or down lets you change viewing altitude.

Tip: With a little practice, you can become very good at precisely controlling your flight path and altitude. If you become lost while flying around, click the **Reset View** button to return to the default viewpoint again.

Summary of 3D Flythrough controls

- To fly forward or backward, press the left mouse button in the top half of the image window (to fly backward) or bottom half (to fly forward).
- To fly left or right, press the left mouse button in the left half of the image window (to fly left) or right half (to fly right).
- To the change viewing altitude, press the right mouse button and drag up or down.
- To control the speed of flight, point close to the center of the window for slow speed, and further out toward the window edges for progressively faster speeds.

Note: In 3D Flythrough mode, you can also add “fog” to the image display by selecting the **3D Properties** tab. Fog is only available in 3D Flythrough mode.

Add Fog to your 3D flythrough view

The fog options are set on the **3D Properties** tab in the **Algorithm** dialog.

1 In the algorithm dialog select the **3D Properties** tab. This tab will be active only when you are in the 3D Flythrough mode

2 Set the color of the fog. Click on **Fog Color** and use the normal ER Mapper **Color Chooser** to select the color.

3 Select a fog type:

Default	Creates a blanket of fog which covers the entire window.
Linear	Creates fog conditions that increase gradually with distance. The fog is thicker in the background than in the foreground.
Exponential	Increases fog tenfold with distance.

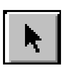
4 Set the **Fog Density**.

5 Select the **Fog** checkbox to turn the fog on.

The image is displayed with the selected fog.

3: Point profiling in 3D

You can use a 3D cursor to roam the 3D image and read the coordinates corresponding to points on a surface.

1 In the main ER Mapper toolbar click on the **Pointer Tool** button. 

2 Point the cursor over the image and press the mouse button. Move the cursor around.

The cursor will become a 3D cross hair, shaped to the terrain, and moving over the terrain as you move the cursor. One leg of the crosshair has an arrow which points to grid north for registered images. With multiple surfaces there is a vertical line through the center of the cursor so you can line up features on different surfaces.

Note: The image must finish regenerating completely before the 3D cursor will appear.

3 Make sure the Height layer is the current layer in the Algorithm dialog.

4 From the ER Mapper main View menu, select Cell Coordinate.... As you point and click your cursor over the image read the value of the Height layer in the **Terrain Height** display.

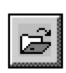
5 To change the color of the 3D cursor, select the 3D View Tab In the **Algorithm** dialog and click the **3D Cursor** button.

4: Viewing multiple surfaces in 3D

Objective Learn to view two or more surfaces in 3D perspective, and control the offset, transparency, and other parameters of the view.

Up until now, you have created algorithms that contained only one surface. In a sense, you can think of each surface as a separate image, or a separate view of your data. Since you use an algorithm to create a certain type of image, you can copy or merge different types of algorithms as separate surfaces in a single algorithm and stack the images in a single 3D view. Stacking multiple surfaces into a single 3D view lets you quickly see relationships between images in 3D.

Open a DTM 3D color algorithm

1 On the main menu, click the **Open**  button.

2 From the **Directories** menu (on the **Open** dialog), select the **\examples** path.

3 Double_click on the ‘Functions_And_Features’ directory to open it, then open the ‘3d’ directory.

4 Double-click on the algorithm ‘Digital_Terrain_Map_Colordrape.alg’ to open it.

This algorithm displays a DTM of the San Diego downtown area. The same image is used in both the Height and Pseudo layers, so the DTM data is shown as relief and also color coded (reds are high elevations, blues are lows).

Tip: You can use any type of data in the Height layer of an algorithm. For example, a vegetation index image would create high elevations in the 3D image where vegetation was most abundant.

Open a Landsat 3D algorithm as a second surface

You can easily add a surface to an existing algorithm by opening another algorithm into it as a separate surface (transfer its layers to the current algorithm).

1 On the main menu, select **Open into New Surface** from the **File** menu.

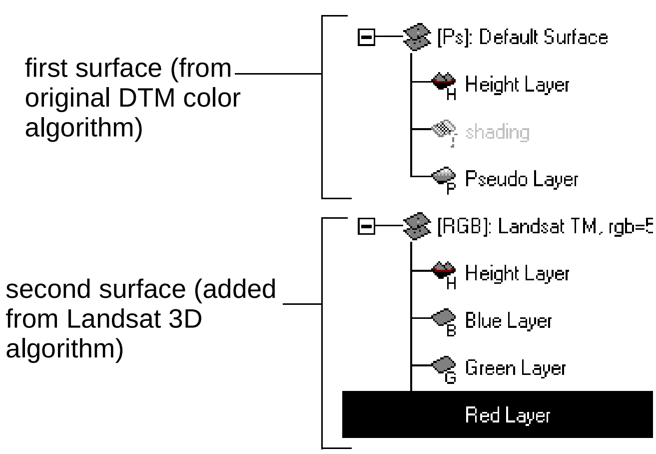
The **Open into New Surface** dialog opens.

2 From the **Directories** menu, select the **\examples** path.

3 Open the 'Functions_And_Features' directory, then open the '3D' directory.

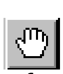
4 Double-click on the algorithm 'Landsat_over_DTM.alg' to open it.

ER Mapper loads the algorithm into a second surface and renders the image underneath the 3D color DTM image. The new algorithm shows Landsat TM bands 5, 4 and 1 in RGB. Your algorithm now has two surfaces:



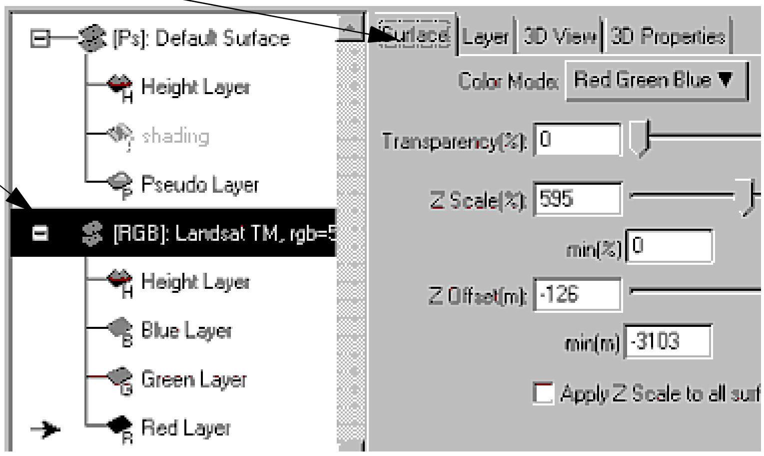
Notice that the two surfaces have different color modes (indicated in the surface name–[Ps] for Pseudocolor and [RGB] for Red Green Blue). Each surface can have its own color mode, color table or other settings independent of others.

Change the Z Offset to shift the surface in 3D space

1 Click the **Hand Tool**  button (if needed), then tilt the 3D image up slightly to view it more from the front side (so that the gap between surfaces is more apparent).

2 On the **Algorithm** dialog, select the lower Landsat surface ([RGB:Landsat TM]) icon in the data structure diagram, then select the **Surface** tab.

select surface, click **Surface** tab



3 Move the **Z Offset** slider all the way to the right.

The Landsat image created by the lower surface slides up above the DTM image.

4 Move the **Z Offset** slider to the far left.

The Landsat image slides below the color DTM image again. To move a surface relative to other surfaces in an algorithm, select the surface in the data structure diagram, then move the **Z Offset** slider. (You could also select the top surface and move up or down it relative to the lower surface's image if desired.)

Change the transparency of the top surface

1 Tilt the 3D image downward slightly until the top surface mostly covers the one below.

2 Select the top surface '[Ps]:Default Surface' in the data structure diagram.

3 Move the **Transparency** slider right to its midpoint.

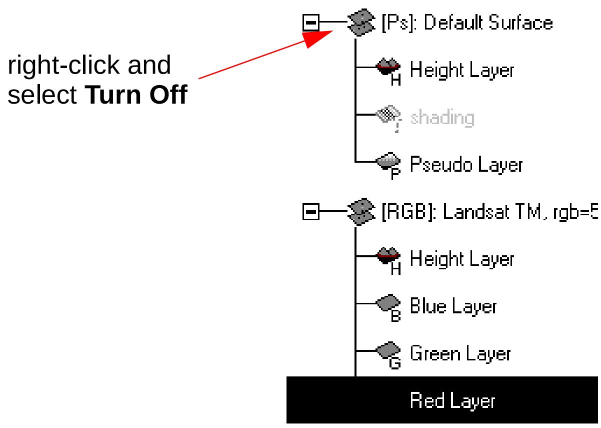
The color DTM image becomes semi-transparent, so some of the color of the Landsat image below shows through.

The **Transparency** setting ranges from 0-100 to specify how the image is "blended" with other surfaces in the image window. Zero displays the full image, 50 creates 50% transparency, and 100 makes the image invisible. Each surface can have it own transparency setting independent of others.

4 Move the **Transparency** slider to the far left to make the image fully visible.

Turn individual surfaces on and off

1 Right-click on the icon for the top surface, and select **Turn Off**.:



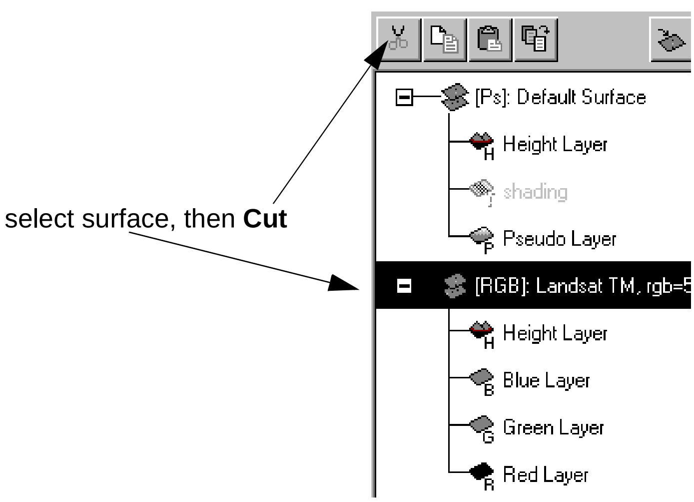
ER Mapper renders only the lower surface (the Landsat image).

2 Turn the top surface on again.

Both surfaces are again rendered.

Delete the lower surface from the algorithm

1 Select the lower surface in the data structure diagram, then click the **Cut** button (above the diagram) to delete it.



ER Mapper renders only the color DTM image.

Open a second image window and algorithm

1 On the main menu, click the **New** button.

Drag the new window down below the first one.

2 On the main menu, click the **Open** button.

3 From the **Directories** menu, select the **\examples** path.

4 Open the ‘Functions_And_Features’ directory, then open the ‘3d’ directory.

5 Double-click on the algorithm ‘Landsat_over_DTM.alg’ to open it.

This is the same algorithm as that you used earlier.

Copy and paste the surface into the first algorithm

1 Select the surface icon in the Landsat 3D algorithm, then click the **Copy** button (above the data structure diagram).

The surface and its layers are copied into the clipboard.

2 Activate the color DTM 3D image window.

3 Click the **Paste** button.

The surface and its layers are pasted into the DTM algorithm as a second surface.

(In this case the **Z Offset** settings are such that the lower levels of the DTM image are hidden by the Landsat data.)

Tip: To add surfaces to an existing algorithm, you can choose **Open into New Surface** from the **File** menu, or copy and paste surfaces between image windows. You can also copy and paste layers or surfaces within the same algorithm and modify them as desired, or a new empty surface and load images and specify processing as needed (using **Add New Surface** or on the **Algorithm** dialog).

Close both image windows and the Algorithm dialog

1 Close both image windows using the window system controls:

- Click the **Close** button in the upper-right window corner.

2 Click **Close** on the **Algorithm** dialog.

Only the ER Mapper main menu should be open on the screen.

What you learned...

After completing these exercises, you know how to perform the following tasks in ER Mapper:

- Prepare an algorithm for 3D viewing by adding a Height layer
- Change the viewpoint, zoom level, and other 3D view parameters
- Use the 3D Flythrough viewing mode
- Stack multiple surfaces in a 3D view and set surface offset and transparency
- Merge separate algorithms into surfaces in a single algorithm

General information on 3D viewing and printing

Notes about 3D rendering speed

ER Mapper can render very large image files quickly in 3D due to it's progressive rendering technology (i.e., starting with a low resolution view and progressively increasing detail with subsequent processing iterations). However, large files can take much longer to render, especially at higher Terrain Detail settings and using Textured draw mode. The speed at which the image renders in 3D is proportional to the processing speed of your computer and the 3D capabilities of your graphics display card.

ER Mapper's 3D viewer features are designed take full advantage of the latest 3D graphics hardware rendering technologies. If your graphics card has 3D acceleration, images will render much faster when using ER Mapper's 3D view modes. Be sure to turn on 3D acceleration if your graphics card supports it.

Height layer data area of coverage

If the image in your Height layer covers only part of the area of the color layers, there will be no relief in those areas of the color image (they will be flat). If the Height image covers a larger area than the color image, the height data outside the extents of the color image is not used in the 3D image.

Printing 3D images

ER Mapper has the ability to print very crisp, high resolution 3D images that are much better than can usually be viewed on a screen display. To print a 3D image, simply choose **File/Print** or click the **Print** button while the image is displayed in the active window. Higher Terrain Detail settings produce more detail in your output print and is usually desirable when printing very large images to get the full detail possible in the data. However, high Terrain Detail settings are sometimes not necessary and do increase the print time significantly.

When to use Lights option

For perspective views of geophysical data (such as magnetics or radiometrics) and digital terrain data, best results are obtained using Lights turned on. This is because these images have no inherent shadows, so artificial lighting enhances detail. Satellite images or airphotos look best with Lights off because these images have natural shadows inherent in the data.

Annotation of 3D images

You cannot draw annotation directly on an image in **3D Perspective** or **3D Flythrough** modes. Here are two options:

- Save the 3D view as an algorithm, then display the 3D image as an embedded algorithm map object on another image using the map composition feature.
- Print the 3D image to an ER Mapper file, then display the resulting 3-band image in an RGB algorithm. For 'Output Name' on the **Print** dialog, select 'ER_Mapper.hc' in the '\hardcopy\Graphics' directory. Once displayed in an RGB algorithm, you can then draw on the image but cannot change the perspective view.

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Composing maps

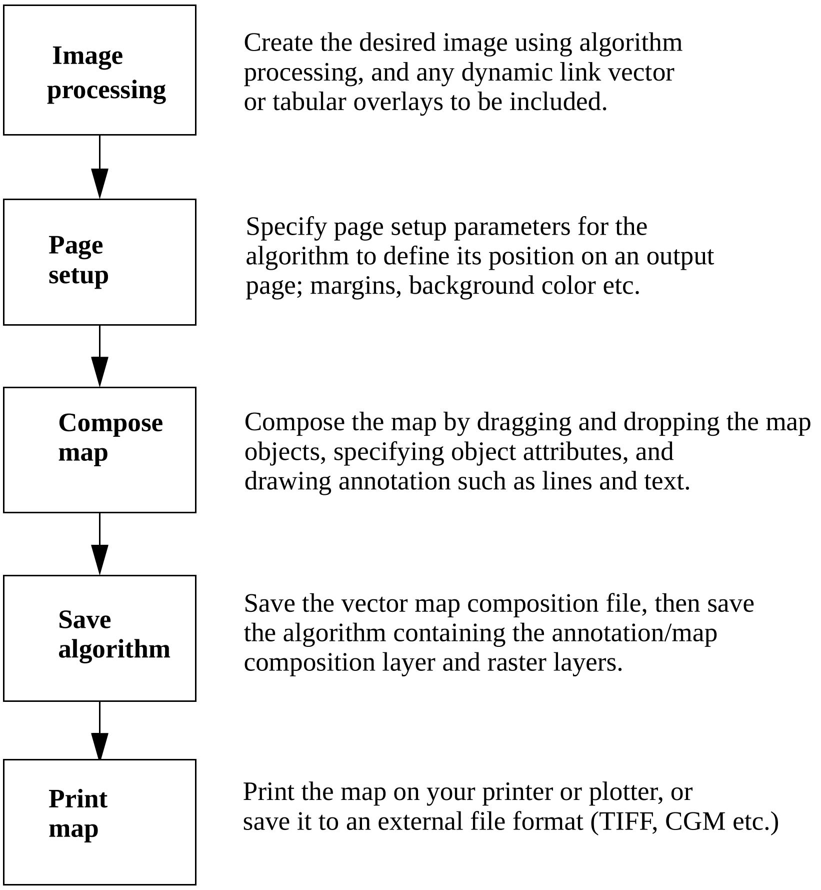
This chapter explains how to use ER Mapper's Page Setup and Map Composition tools to create top quality cartographic image maps. You will learn about setting up a page size and extents for your map, how to add map objects such as coordinate grids, scale bars, north arrows, and considerations for printing to hardcopy devices.

About map composition

ER Mapper provides a complete set of map composition tools that let you easily transform images into top quality image maps. Your maps can include common map objects such as coordinate grids, scale bars, classification legends, north arrows, and more. You can use the annotation tools to draw lines, text, shaded polygons, and other vector objects. Your maps can also include other layers to add vector data from GIS systems, tabular data, or other external data.

ER Mapper's map composition also has an open design and is user-extendable customizable. You can add your own Postscript map objects to ER Mapper's map object library, such as company logos or north arrows, include external files and text, and many other types of data. You can also modify the default attributes of map objects and save them under your own unique names for later use.

The following diagram shows the general procedure for creating and printing a map in ER Mapper:



Hands-on exercises

These exercises give you practice setting up an algorithm to create a map, defining Page Setup parameters, and composing the map by adding map objects and other annotation.

What you will learn...

After completing these exercises, you will know how to perform these tasks in ER Mapper:

- Define Page Setup parameters for an algorithm
- Display GIS vector data over a raster backdrop image
- Add an Annotation/Map Composition layer to an algorithm
- Draw annotation objects (lines, text, polygons, etc.) on your map

- Place map objects (grids, scale bars, etc.) on your map
- Specify color and other attributes for annotation and map objects

Before you begin... Before beginning these exercises, make sure all ER Mapper image windows are closed. Only the ER Mapper main menu should be open on the screen.

1: Setting up the page

Objectives Learn to use ER Mapper's Page Setup options to define the position of an image on an output page, and specify other options such as scaling parameters and background color.

ER Mapper provides you with two ways of setting up a page. You can either use the **Page Setup** dialog box or the **Page Setup Wizard**. Both methods achieve the same results, but the Page Setup Wizard leads you sequentially through the required parameters. Both methods are described.

Display a Landsat/SPOT IHS merge algorithm

1. Click on the **Open** toolbar button.

   An image window and the **Open** dialog box appear.

2. From the **Directories** menu, select the path ending with the text **\examples**.
3. Double_click on the 'Functions_And_Features' directory to open it.
4. In the 'Data_Fusion' directory, open the algorithm named 'Landsat_TM_and_SPOT_Pan_IHS_merge.alg.'

   This algorithm displays bands 3, 2 and 1 of a Landsat TM image merged with a high resolution SPOT Pan image as an RGB "natural color" composite. The image covers the San Diego, California area. This is the image you will use as the basis for your map.

Tip: ER Mapper performs the IHS (Intensity-Hue-Saturation) merge technique interactively, so you can easily "fine tune" the image saturation or intensity in real-time using the post-formula transforms for those algorithm layers. (This technique is also known as HSI.)

Open the Page Setup dialog box

If you would rather use the Page Setup Wizard, go directly to “Open the Page Setup wizard” on page 251.

1 From the **File** menu, select **Page Setup...**.

The **Page Setup** dialog box opens. This dialog provides controls for you to position your image on an output page, specify map scaling, background color and more.

The white area shows the size of the output print area in red (the “page extents”), and the size and position of the image on the page in blue (the “contents extents”).

Specify how the page or map can be scaled

The **Constraints** drop-down list lets you specify how map objects are scaled relative to the output page. For any map, there are three constraints that will affect how your map looks.

These are:

- Page size for your final map
- Scale of the main imagery in your map
- Border size between the main imagery in your map and the edges of the page

It follows that if you wish to specify any two of these, then the third value will be automatically updated by ER Mapper to ensure it fits. For example, if you use a 8.5"x11" page size, and have settled on a 1:100,000 image scale, then there can be only one size of borders that will match these requirements.

So, in ER Mapper's page setup, you specify which of the three constraints are to be autovaried (that is, calculated automatically) by ER Mapper. You control the other two constraints.

- If you know the output page size, and the scale you wish to print, select **Auto Vary:Borders**.
- If you know the scale you wish to print, and the size of the borders you wish to have, select **Auto Vary:Page**.
- If you know the border size you want to have, and the output page size, select **Auto Vary:Scale**.

Typically you need to decide which parameters are most important for your map: a fixed page size, fixed borders, or a fixed map scale.

1 From the **Constraints** drop-down list, select **Auto Vary:Borders**.

This tells ER Mapper that it can automatically change the size of page margins to accommodate any changes in map scale or page size. You will use this setting to create a 1:100,000 scale map on a US Letter size (8.5 x 11 inches) page. (Other **Constraints** options will automatically change page size or map scale if other parameters are changed.)

Snap Shot the current algorithm extents

1 Click the **Snap Shot** button.

ER Mapper updates the values in the **Contents Extents** fields. For example if you had zoomed in or out in your algorithm, **Snap Shot** updates the contents extents to match the current display extents of your algorithm.

Tip: You should typically use **Snap Shot** even if you have not zoomed or panned the image to make sure the page contents extents match the current extents of the algorithm.

Specify the output page size

1 From the **Size** drop-down list, select **US Letter**.

ER Mapper enters the corresponding values in the **Page Width** and **Height** fields, and updates the new margin sizes.

Also notice that the shape of the page extents (in red) matches the proportions of a US Letter size page. The contents extents (in blue) are positioned in the upper-left part of the page by default.

Specify the output map scale

1 In the **Scale - 1:** text field, enter the value **`100000`** then press Enter or Return to validate.

ER Mapper sets the page contents (the physical size of the image on the page) to print at 1:100,000 map scale and updates the relative size of the contents on the US Letter size page proportionally.

Position the contents on the page

1 Click the **Horz Center** button.

ER Mapper centers the page contents horizontally on the page.

2 Click the **Vert Center** button.

ER Mapper centers the page contents vertically on the page. The image is now set to print in the exact center of the output page.

3 In the **Border** area of the dialog, edit the value in **Top:** field to read **`50`**, then press Enter or Return to validate.

ER Mapper shifts the page contents upward slightly on the page. You can adjust the **Border** values to position your image as desired when creating your map.

Set the background color to white

1 Select the text in the **Background Color** field, type **`white`**, and press Enter or Return to validate.

ER Mapper sets the page background color to white (the areas of the page surrounding the page contents). If you will be printing on a device that has a white background, it is often helpful to set the background color to white while you are composing the map to get a better idea of the final output. (You can use the **Set Color** button as well to choose any arbitrary background color.)

Save the algorithm with the Page Setup parameters

1 Click **OK** on the **Page Setup** dialog to save your settings and close it.

2 From the **File** menu, select **Save As...** to save the algorithm under your own name.

3 Select **ER Mapper Algorithm (.alg)** for the **Files of Type:** field.

4 From the **Directories** menu, select the path ending with the text **\examples**.

5 Double-click on the directory 'Miscellaneous' to open it.

6 Double-click on the directory 'Tutorial' to open it.

7 In the **Save As:** text field, type a name using your initials at the beginning, followed by the text 'San_Diego_map.' Separate each word with an underscore (_). For example, if your initials are "JR," type in the name:

```
JR_San_Diego_map
```

8 Click **OK** to save the algorithm, which now includes your Page Setup parameters.

Open the Page Setup wizard

This is an alternative method of setting up the page. If you have already set up the page using the **Page Setup** dialog box, as described above, you can go directly to "2: Defining annotation objects" on page 255.

1 From the **File** menu, select **Page Setup Wizard...**.

2 Select the **Algorithm displayed in current image window** option on the wizard ’Introduction’ page, and click on the **Next>** button.

3 On the **‘**Use a template’ page, select **Define new values with this wizard** and click on the **Next >** button.

Set the background color to white

1 Select the text in the **Background Color** field, type **`white`**.

ER Mapper sets the page background color to white (the areas of the page surrounding the page contents). If you will be printing on a device that has a white background, it is often helpful to set the background color to white while you are composing the map to get a better idea of the final output. (You can use the **Set Color** button as well to choose any arbitrary background color.)

2 Set the units to **Metric (mm)** and click on the **Next >** button.

Set the contents extents

1 Select **Snapshot from current zoom,** and click on the **Next >** button.

ER Mapper updates the contents extents to match the current display extents of your algorithm.

Tip: You should typically use **Snapshot** even if you have not zoomed or panned the image to make sure the page contents extents match the current extents of the algorithm.

Set autovary parameter

The **Set autovary parameter** wizard page lets you specify how map objects are scaled relative to the output page.

For any map, there are three constraints that will affect how your map looks.

These are:

- Page size for your final map
- Scale of the main imagery in your map
- Border size between the main imagery in your map and the edges of the page

It follows that if you wish to specify any two of these, then the third value will be automatically updated by ER Mapper to ensure it fits. For example, if you use a 8.5"x11" page size, and have settled on a 1:100,000 image scale, then there can be only one size of borders that will match these requirements.

So, in ER Mapper's page setup, you specify which of the three constraints are to be calculated automatically by ER Mapper. You control the other two constraints.

- If you know the scale you wish to print, and the size of the borders you wish to have, select **Set scale and borders (page size varies)**.
- If you know the output page size, and the scale you wish to print, select **Set scale and page size (borders vary)**.
- If you know the border size you want to have, and the output page size, select **Set borders and page size (scale varies)**.

Typically you need to decide which parameters are most important for your map: a fixed page size, fixed borders, or a fixed map scale.

1 Select **Set scale and page size (borders vary)**, and click on the **Next >** button.

This tells ER Mapper that it can automatically change the size of page margins to accommodate any changes in map scale or page size. You will use this setting to create a 1:100,000 scale map on a US Letter size (8.5 x 11 inches) page. (Other options will automatically change page size or map scale if other parameters are changed.)

Specify the output page size

1 Select **Choose from standard portrait sizes**, and click on the **Next >** button.

2 From the **Size** drop-down list, select **US Letter**, and click on the **Next >** button

Position the contents on the page

1 Select **Center Horizontally**.

ER Mapper centers the page contents horizontally on the page.

2 Select **Center Vertically**, and click on the **Next >** button.

ER Mapper centers the page contents vertically on the page. The image is now set to print in the exact center of the output page.

Specify the output map scale

1 Select **Type in the scale**, and click on the **Next >** button.

2 In the **Scale - 1:** text field, enter the value **`100000`** and click on the **Next >** button.

ER Mapper sets the page contents (the physical size of the image on the page) to print at 1:100,000 map scale and updates the relative size of the contents on the US Letter size page proportionally.

Add a vector layer to overlay a road network file

1 Select **Add a vector layer**.

2 Click on the **Vector File: Load Dataset**  button.

The **Select File** dialog box opens to let you load a vector format file.

3 From the **Directories** menu, select the path ending with the text **\examples**.

4 Double-click on the ‘Shared_Data’ directory to open it.

Notice that filenames displayed have ‘.erv’ file extension. This indicates that these files are in ER Mapper vector format (in contrast with raster files that have a ‘.ers’ file extension).

5 Scroll to view the file ‘San_Diego_roads.erv’ then double-click on it to load it into the vector layer.

ER Mapper adds a new layer labelled ‘Annotation Layer’ to the algorithm.

Save the algorithm with the Page Setup parameters

1 Select **Save algorithm to disk**.

2 Click on the **Save as: Load Dataset**  button.

3 From the **Directories** menu, select the path ending with the text **\examples**.

4 Double-click on the directory ‘Miscellaneous’ to open it.

5 Double-click on the directory ‘Tutorial’ to open it.

6 In the **Save As:** text field, type a name using your initials at the beginning, followed by the text ‘San_Diego_map.’ Separate each word with an underscore (_). For example, if your initials are “JR,” type in the name:

```
JR_San_Diego_map
```

7 Click **OK** to save the algorithm, which now includes your Page Setup parameters.

8 Click on the **Finish** button to close the Page Setup Wizard.

2: Defining annotation objects

Objectives Learn to use ER Mapper's Annotation tools to display vector data from GIS systems, and draw annotation objects such as lines, polygons, and text. Also learn to zoom the image in or out to the page extents or page contents.

Open the Geoposition dialog box

1. Set the **View Mode** in the Algorithm dialog to **Page Layout**.

   The image window displays the whole page with the image in **Page Layout** mode. If you select the **Normal View Mode**, it only displays the image.

2. From the **View** menu, select **Geoposition...**.

   The **Algorithm Geoposition Extents** dialog box opens. Move it to the lower-right portion of the screen.

3. Select the **Zoom** tab to display buttons for zooming and panning.

Zoom to the Page Extents and Page Contents

1. On the **Geoposition** dialog, click the **Page Extents** button.

   The image zooms out to the proportional extents of the page defined for the algorithm, and the image (the page contents) appears on a white background. Notice that there is some empty area on the right side (the stippled white pattern) because the US Letter page is taller than it is wide.

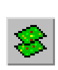
2. Expand the image window size to make it about twice as tall and 50% wider (so the shape approximately matches the shape of the white page extents area).

   You will use this display later for placing map objects on the page.

3. On the **Geoposition** dialog, click the **Page Contents** button.

   The image zooms in to the extents of the page contents (the extents of the image itself). You will first draw some annotation on the image in this display mode.

Add a vector layer to overlay a road network file

1. Click the **Edit Algorithm**  toolbar button to open the **Algorithm** window.

Note: If you used the Page Setup Wizard to set up the page, as described above, you have already added the vector layer. Therefore you can go directly to step 7.

---

2 On the **Algorithm** window, click on the **Edit/Add Vector Layer** button to display its list, then select **Annotation/Map Composition**.

ER Mapper adds a new layer labelled ‘Annotation Layer’ to the algorithm. Note that this layer has only three buttons in the process stream since it is designed to display and edit vector data, not perform image processing on raster images.

3 In the **Algorithm** window, click on the **Load Dataset** button in it’s process diagram.

The **Load Annotation** dialog box opens to let you load a vector format file.

4 From the **Directories** menu, select the path ending with the text **\examples**.

5 Double-click on the ‘Shared_Data’ directory to open it.

Notice that filenames displayed have ‘.erv’ file extension. This indicates that these files are in ER Mapper vector format (in contrast with raster files that have a ‘.ers’ file extension).

6 Scroll to view the file ‘San_Diego_roads.erv’ then double-click on it to load it into the vector layer.

7 In the **Algorithm** window, click the **Edit Layer Color** button in the process diagram of the annotation layer.

8 Pick a light blue color, then click **OK** to close the color chooser.

ER Mapper draws the vector file of roads as a blue overlay.

9 Change the layer description of the vector layer from ‘Annotation Layer’ to ‘Downtown roads’ and press Enter or Return.

This is a simple example of displaying vector data from an external system in ER Mapper. (This image of roads was imported and translated into an ER Mapper format vector file using the menu command **Utilities/Import Vector and GIS Formats**.) ER Mapper also has direct links to many common vector GIS formats.

Tip: To edit the vectors (roads in this case), you could click on the **Open Annotation editor** button in the layer’s process diagram. (Use of these tools is described in the next section.)

Add a second vector layer for map annotation

1 From the **Edit** menu (on the main menu), select **Annotate Vector Layer...**.

The **Open Map Composition** dialog box opens and indicates that the algorithm already has a vector layer (displaying the roads image). You could choose to edit this layer, or add a new annotation layer.

2 In the **Open Map Composition** dialog, click the **New** button.

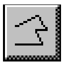
The New Map Composition dialog opens to let you choose which type of vector annotation you want to create or work with.

3 Click the **Vector File** option under ‘Mode,’ then click **OK** on the **New Map Composition** dialog to close it.

ER Mapper opens the **Tools** palette dialog box containing your vector annotation and map composition tools. Also notice that a second vector layer titled ‘Annotation Layer’ has been added to the layer list in the **Algorithm** window. This is the layer you will use to add your own annotation and map composition items to the image.

4 Click **Close** on the **Algorithm** window (you will not need it for the remainder of this exercise).

Draw two polylines on the image

1 On the **Tools** dialog, click on the **Polyline**  button.

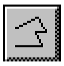
2 Point to a linear feature inside the image (such as a road). Then draw a line to trace the feature by clicking once at each point, then double-clicking to end the line.

A blue line appears on your image to highlight the linear feature. (The default line color of blue comes from the annotation layer color.) Note that markers appear on the line at each node to indicate that the line is “selected.”

3 Point to another linear feature inside the image and draw a second line by clicking once at each point, then double-clicking to end the line.

A second blue line appears, and it is now selected.

Modify the attributes of the polylines

1 On the **Tools** dialog, *double-click* on the **Polyline**  button.

The **Line Style** dialog box opens to let you choose attributes for your polylines.

2 Click the **Set Color** button, choose a bright red color, then click **OK** to close the **Color Chooser** dialog.

The line color on your image changes to red.

3 Choose **2.0** from the **Width** drop-down list to increase the line width.

4 Click on a dashed line style under **Line Pattern** to select a line style.

The attributes for your selected polyline change interactively.

5 On the **Tools** dialog, click on the **Select/Edit Points Mode** button, then click on the first (blue) polyline on the image to select it.

Notice that the contents of the **Line Style** dialog change to show the attributes of the currently selected line (a color of blue and so on).

6 Click **Close** on the **Line Style** dialog.

7 Draw a third polyline on the image (it is selected when you finish).

8 In the **Tools** dialog, click the **Delete Object** button.

The polyline object disappears from the image. Selecting an object and clicking **Delete Object** is how you delete any annotation object.

Tip: To create smooth, rounded curves from polylines made of straight line segments, you can apply a spline function to the line by turning on the **Curved** attribute after first drawing it. This is especially helpful when tracing roads and other smoothly varying linear features.

Draw a shaded polygon around the island

1 On the **Tools** dialog, click on the **Polygon** button.

2 Point to the large island in the lower part of the image. Then draw a polygon around the island by clicking once at each point, then double-clicking to close the polygon.

The polygon object appears surrounding the island, and it is selected by default. (If your polygon is not selected, select it now.) Now you will change its color and specify a shade pattern to fill it.

3 On the **Tools** dialog, double-click on the **Polygon** button.

The **Line Style** dialog box opens to let your set polygon attributes.

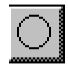
4 Click the **Set Color** button, choose a bright yellow color, then click **OK** to close the **Color Chooser** dialog.

5 Under **Fill Pattern**, click on one of the diagonal line fill patterns.

The pattern you choose appears in the **Current Fill** window on the dialog. The polygon becomes yellow and is filled with a diagonal shade pattern.

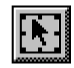
6 Click **Close** on the **Line Style** dialog.

Draw a shaded oval and move and resize it

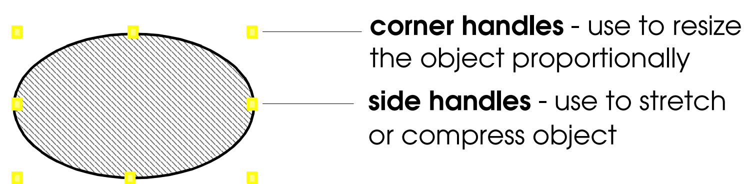
1 On the **Tools** dialog, click on the **Oval**  button.

2 Point anywhere inside the image, drag an oval shape and release.

A shaded yellow oval appears. By default, the oval is selected (blue handles appear at the four corners that define the oval extents).

3 On the **Tools** dialog, click the **Select and Move/Resize Mode**  button.

Select and Move/Resize Mode lets you move and/or resize the selected object. Notice that the oval's selection handles change–now there are eight handles colored yellow.



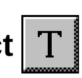
4 Point inside the oval, and drag it to a new location.

By dragging the object (not by a handle), you can move it on the image.

5 Point to one of the rectangle's corner handles and drag it to increase the rectangle size proportionally.

6 Point to one of the rectangle's side handles and drag it to stretch or compress the oval.

Draw, modify and position text strings

1 On the **Tools** dialog, click the **Text Object**  button.

The **Text Style** dialog box opens.

2 Click in the dark area near the lower-left part of the image (ocean).

A small box with four selection handles appears–this is where your text will appear on the image.

3 In the **Text Style** dialog, click in the **Text** field at the bottom to position the cursor, then type **`Pacific Ocean`**. Press Return or Enter to validate.

The text appears on the image as you type.

4 In the **Text Style** dialog box, select the following text attributes:

Size: 14.0

Color: choose any bright color

Font: Helvetica-Bold

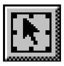
Notice that the text object automatically updates as you change the attributes.

5 Click in the dark ocean area on the lower-right of the image.

6 In the **Text Style** dialog, click in the **Text** field to position the cursor, then type **`San Diego Bay`**. Press Return or Enter to validate.

7 From the **Angle (deg)** drop-down list, select **315.0**.

The “San Diego Bay” text rotates 315 degrees counter-clockwise, so it now points down toward the lower right.

8 On the **Tools** dialog, click the **Select and Move/Resize Mode**  button.

9 Point to the text block, and drag it to an appropriate position inside the dark bay area on lower-right of the image.

You have now learned to draw and modify simple annotation objects such as lines, polygons, and text. Next you will add map objects to your page.

Tip: Text drawn as annotation can be set to always print at an exact point size (the **Fixed Text** option), or to scale up or down with the page when it is printed (the **Page Relative** option).

3: Defining map objects

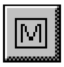
Objectives Learn to use ER Mapper’s Map Composition tools to place and modify map objects such as scale bars, coordinate grids, north arrows, and others.

Zoom to the Page Extents to view the entire map page

1 On the **Geoposition** dialog, click the **Page Extents** button.

The image zooms out to the extents of the page defined for the algorithm, and the annotation objects are redrawn at their proportional size. You can now add map composition objects to your page.

2 Click **Close** on the **Algorithm Geoposition Extents** dialog to close it.

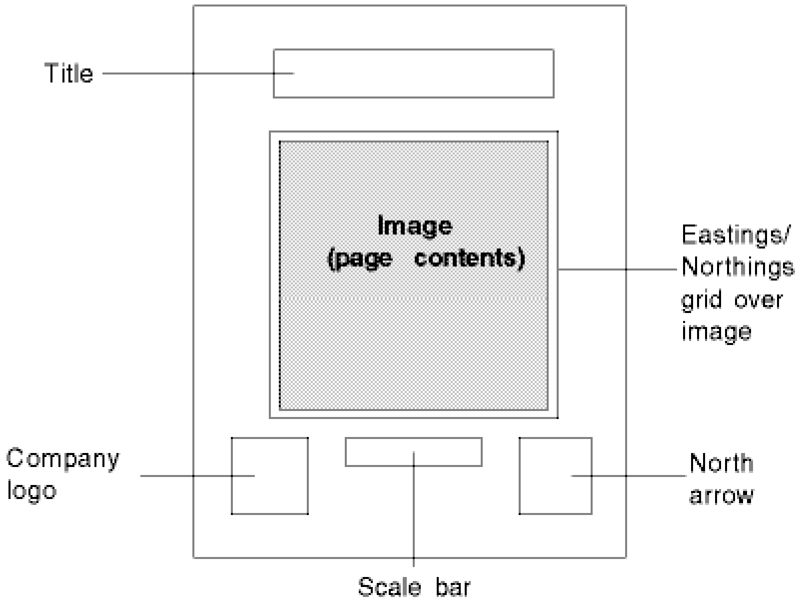
3 On the **Tools** dialog, click on the **Map Rectangle**  button.

The **Map Object Select** and **Map Object Attributes** dialog boxes open on the right side of the screen.

These dialog boxes let you drag and drop map objects onto the page in your image window, and specify attributes for the objects.

Layout the types and positions of map objects

Before creating your map, it is a good idea to determine which types of map objects you want to use, and their relative sizes and positions on the page. In this exercise, you will create simple map with the following objects:



You will define these objects on the page in two ways:

- draw a bounding box and drag-and-drop the object into it; or
- drag-and-drop the object onto the page and resize the bounding box afterward

Use the diagram above as a guide for the size and position of bounding boxes for map objects you are asked to create in the next sections.

Add a scale bar centered below the image

1 Point to the area below the image on the page, and drag a short, wide bounding box centered below it (refer to the previous diagram for the size and position).

When you release the mouse, the box is selected and handles appear at the corners. This box will define the extents of your scale bar object on the page. (The box appears in the color you chose for the vector layer earlier.)

2 In the **Map Object Select** dialog, select **Scale Bar** from the **Category** drop-down list.

A list of icons representing various types of scale bar map objects appears. The name of the object is shown in the status line at the bottom of the dialog when you point to it.

3 Point to the icon titled **Scale_Bar/Tick**, drag it into the bounding box you defined in the image window, and release.

The scale bar object is "dropped" into the bounding box and it draws a few seconds later. The extents of your bounding box are now indicated by the yellow selection handles. The default attributes for the scale bar appear in the **Map Object Attributes** dialog box.

4 On the **Map Object Attributes** dialog, change the following attributes for your scale bar:

Start Scale at Zero: Yes

Number of Divisions: 4 (press Enter or Return afterward)

Show Scale: No

Left Align Scale Bar: No

Notice that the scale bar object automatically updates as you change the attributes. Turning off the left alignment centers the scale bar within your box.

Add a compass north arrow on the lower-right

1 In the **Map Object Select** dialog, select **North Arrow** from the **Category** drop-down list.

A list of icons representing various types of north arrows appears.

2 Point to the compass north arrow (**North_Arrow/Compass**), and drag it to a position just right of your scale bar.

The north arrow object drops onto the page and draws a few seconds later at a default size. If desired, make the arrow smaller by dragging the lower-right handle to resize the bounding box.

Tip: ER Mapper's north arrows are "smart" and will always point to north on a rectified image.

Add a company logo on the lower-left

1 In the **Map Object Select** dialog, select **Logo** from the **Category** drop-down list.

A list of icons showing some sample company logos appears.

2 Point to the **ER Mapper** logo icon, and drag it into a position left of the scale bar.

The logo object drops onto the page.

Tip: You can add your own company logos as Postscript files and access them from the standard Logos category used here.

Add a main title above the image

1 Drag a bounding box centered at the top of the image window (leave some space below it, refer to the previous diagram for the size and position).

2 In the **Map Object Select dialog,** select **Title** from the **Category** drop-down list**.**

3 Point to the icon titled **Title/Outline**, drag it into the bounding box you defined above the image.

4 On the **Map Object Attributes** dialog, change the following text and attributes for your title:

Title: San Diego Image Map (press Enter or Return afterward)

Font Color: red

The title object automatically updates as you change the attributes.

Define an Eastings/Northings grid over the image

1 In the **Map Object Select** dialog, select **Grid** from the **Category** drop-down list.

2 Point to the **Grid/EN** icon, drag it onto the image.

The grid map object draws with a default position and attributes on the page.

3 On the **Map Object Attributes** dialog, click the **Fit Grid** button.

ER Mapper resizes and positions the grid to fit exactly to the extents of the image on the page. (If desired, you could resize and position it manually.)

4 On the **Map Object Attributes** dialog, turn on the **Fast Preview** option.

Fast Preview tells ER Mapper *not* to update the object interactively as you change the attributes. (Since the grid is a complex object, you will change all the desired attributes first, then refresh the object all at once to save time.)

5 On the **Map Object Attributes** dialog, change the following attributes for your grid (use defaults for all others):

Grid Style: Full Grid

Grid Spacing X: 2,500 meters (2.5 km)

Grid Spacing Y: 2,500 meters (2.5 km)

Top labels orientation: Horizontal Right

6 On the **Map Object Attributes** dialog, turn off the **Fast Preview** option.

The grid map object is rendered using the attributes you defined.

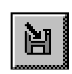
Adjust the size or position of any object

If desired, you can easily resize or position any map object by moving or resizing the bounding box that contains it.

1 In the **Tools** palette dialog, click the **Select and Move/Resize Mode**  button.

2 Click on any map object to select it (the handles will appear), and drag the bounding box to reposition it or change the size by dragging a handle.

Save the annotation/map composition file to disk

1 On the **Tools** palette dialog, click the **Save As**  button.

The **Map Composition Save As** dialog box opens.

2 Select **Vector File** for the **Save As** option and click on the File Chooser  button to open the **Save Map Composition File** dialog.

3 From the **Directories** menu, select the path ending with the text **\examples**.

4 Double-click on the directory named ‘Miscellaneous’ to open it.

5 Double-click on the directory named ‘Tutorial’ to open it.

6 In the **Save As:** text field, enter a name using your initials at the beginning, followed by the text ‘map_composition.’ Separate each word with an underscore (_). For example, if your initials are "KG," type in the name:

```
KG_map_composition
```

7 Click **OK** to save the annotation file to disk.

The annotation file contains all the objects you defined–the vector lines, text and polygons you drew on the image, as well as the map composition objects, their attributes, and position and size on the page.

8 Click Close on the **Map Object Attributes**, **Map Object Select**, and **Tools** dialogs to close them.

Save the algorithm to update the changes

1 On the main menu, click the **Save** toolbar button.

2 When asked to confirm the overwrite, click **OK**.

Your algorithm can now be printed using the **Print**  toolbar button or by selecting **Print** from the **File** menu.

Note: It is important to remember to save your algorithm after defining map objects. Otherwise the annotation file will not be part of the algorithm when you attempt to print it later.

Additional features of Map Composition

The preceding simple example covered only the basics of using ER Mapper's Map Composition, and following are some additional features. Refer to the chapter on creating maps in the *ER Mapper User Guide* for complete information.

- If you drag an object into a bounding box that already contains an object, the old object is replaced by the new one. This is an easy way to try several north arrows, for example.
- Objects that are dragged and dropped to replace a current object automatically inherit any common attributes from the previous object. For example, if you have a red north arrow in a bounding box and then drag in a scale bar object, the scale bar automatically inherits the red color (since both objects have the "Color" attribute in common).
- You can modify the default attributes of map objects and save them under your own names (using **Save As** on the **Map Object Attributes** dialog).
- You can draw other image processing algorithms you've created as map objects on the page (using the **Category: Algorithm** on the **Map Object Select** dialog).
- You can plot objects from external files like TIFF, EPS, or Targa (using the **Category: Image** on the **Map Object Select** dialog)
- You can import text directly from ASCII text files and plot it on your map page (using the **Category: Text** on the **Map Object Select** dialog)

Page Relative and Map Unit Relative map objects

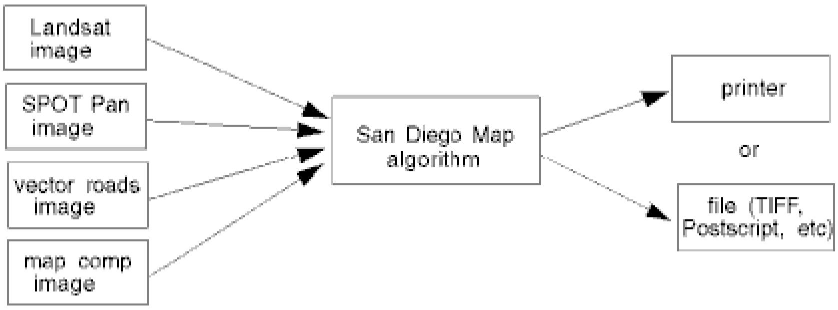
The vector map objects you defined in this exercise have their position and size specified relative to the page, rather than to map units (such as Latitude Longitude). This allows you to create standard map sheets with objects that remain in a fixed size and position on the page, regardless of how the page is scaled or the extents of the images used in the page contents are changed.

You can also specify the position of map objects in geographic coordinate units. The position of each object is tied to a particular geographic location and map sheet size.

To specify a map object as map unit relative, turn off the **Page Relative** option on the **Map Object Attribute** dialog box. The page relative attribute can be assigned either before or after the object is dragged-and-dropped onto the page. See the *ER Mapper User Guide* for more information.

Printing your map

When you want to print your final map algorithm (using **File/Print** or the **Print**  button), ER Mapper asks for the name of the algorithm. When the print operation begins, ER Mapper automatically locates, processes and renders all the images used in the algorithm into one final print image. In this case, your map algorithm uses four images–a Landsat raster image, a SPOT raster image, a vector roads image, and a vector map annotation image (which you created).



Since the map algorithm is made of several layers (and images), you can easily change it. For example, to print the image without the road network overlay, simply turn off that layer in the algorithm, resave it, and print it.

Close all image windows and dialog boxes

1 Close all image windows using the window system controls:

- Select **Close** from the window control-menu.

2 Click **Close** on the **Algorithm** window to close it.

Only the ER Mapper main menu should be open on the screen.

What you learned...

After completing these exercises, you know how to perform the following tasks in ER Mapper:

- Define Page Setup parameters for an algorithm
- Display GIS vector data over a raster backdrop image
- Add an Annotation/Map Composition layer to an algorithm
- Draw annotation objects (lines, polygons, etc.) on your map
- Place map objects (grids, scale bars, etc.) on your map
- Specify color an other attributes for annotation and map objects

16

Thematic raster overlays

This chapter explains how you can create raster overlays in ER Mapper to display thematic data as solid or translucent colors over backdrop images. You will learn to use formulas, Classification layers, and other features. You can use these simple examples as the basis for developing more complex raster spatial modelling applications in ER Mapper.

About thematic overlays

ER Mapper's algorithm processing approach allows you to interactively extract or derive data from multiple image bands (or from multiple images) and display the result in color over another image used as a backdrop. This type of display is commonly used to highlight areas meeting certain criteria in the context of a backdrop image used to show an overall view of an area. You can also define regions on scattergrams and highlight those pixels in color on an image.

The data for the color overlay can be derived interactively from a single image, or from multiple images when virtual datasets are used. For example, you could derive a sensitivity index based on slope and aspect from a DEM image and vegetation cover/type from a Landsat image, and display the result in color over a SPOT Panchromatic greyscale image used as backdrop. Any of the parameters can then be adjusted to modify the criteria and display the updated image.

Hands-on exercises

These exercises give you practice using Classification and other raster layer types to display color overlays of thematic data. The thematic data can be extracted from one or more raster images using formulas, filters, and other means.

What you will learn...

After completing these exercises, you will know how to perform these tasks in ER Mapper:

- Display raster thematic data in solid color over images
- Display raster thematic data in translucent color over images
- Use formulas to define criteria for displaying thematic color overlays
- Define a region of data values in a scattergram and highlight them on the image
- Display the three type of classes in three surface

Before you begin...

Before beginning these exercises, make sure all ER Mapper image windows are closed. Only the ER Mapper main menu should be open on the screen.

1: Simple threshold overlays

Objectives

Learn to add a Classification layer to an algorithm to display a feature defined by a threshold in one band of an image, or data derived from multiple bands such as a band ratio. In this case, you will derive thematic information on water and vegetation areas in a Landsat TM image and highlight them as color overlays.

Display a Landsat TM RGB algorithm

1. On the Standard toolbar, click on the **Open** button.

   An image window and the **Open Algorithm** dialog box appear.

2. From the **Directories** menu, select the path ending with the text **\examples**.
3. Double_click on the ‘Data_Types’ directory to open it.
4. In the directory named ‘Landsat_TM,’ load the algorithm named ‘RGB_321.alg.’

   This algorithm displays an RGB color composite of bands 3, 2 and 1 of a Landsat TM image covering a portion of the San Diego, California metropolitan area. The dark areas in the lower portion are ocean.

5 Click on the **Edit Algorithm** button to open the **Algorithm** window.

Add a Classification layer and load the Landsat image

1 On the **Algorithm** window, select **Classification** from the **Edit/Add Raster Layer** menu.

A Classification layer is added to the layer list.

2 Click the **Load Dataset** button in the process stream diagram for the new layer to open the file chooser dialog.

3 From the **Directories** menu, select the path ending with the text **\examples**.

4 In the directory named 'Shared_Data', load the image named 'Landsat_TM_year_1985.ers'.

This is the same image loaded in the RGB layers of the algorithm. You will use a formula to define a threshold one band of the image and display the result as a color overlay.

5 Turn off the classification layer by right-clicking on it and selecting **Turn Off.**

The classification currently covers the image with an all white layer. Turn it off for the moment to make the image visible.

Determine the threshold value for ocean areas

Next you will use traverse extraction to determine a data threshold between land and ocean areas of the image using band 5 of the Landsat data. You will use this information to highlight the ocean areas in color using the Classification layer.

1 From the **View** menu, select **Traverse...**.

New Map Composition and **Traverse** dialog boxes appear.

2 On the **New Map Composition** dialog, be sure the **Vector File** option is selected, then click **OK**.

An **ER Mapper** warning dialog and the annotation **Tools** palette dialog appear. You will use the vector annotation tools to draw traverse lines on the image.

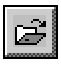
3 Click **Close** on the **ER Mapper** warning dialog to close it. (When using annotation tools for other purposes the default Fixed Page mode is not recommended, but it is fine for this exercise.)

4 On the **Tools** dialog, click the **Annotation: Poly Line** button.

5 As shown in the following diagram, define a traverse line starting from the dark ocean area at the bottom and extending through to the land areas

beyond. (Click once at the start point, click once at the end point, then double-click to end the line definition.)

A profile line for band 1 appears inside the **ER Mapper Traverse** dialog.

6 On the **ER Mapper Traverse** dialog, click the **Bands:**  button.

7 On the **Traverse Band Selection** dialog, press the Ctrl key on your keyboard, then click on **B5:1.65_um** in the list to select it.

8 Click **OK** on the **Traverse Band Selection** dialog.

A single profile for band 5 appears. Notice that the value in band 5 dips to less than 20 in all areas of ocean, and jumps up to greater than 20 in land areas. TM band 5 records middle infrared reflectance, which is typically very low in water areas due to strong absorption of infrared light. You will use this value of 20 as the threshold in your formula to highlight ocean areas.

Tip: You could also use the **Cell Values Profile** feature under the **View** menu to determine this threshold.

---

9 Click Close on the **ER Mapper Traverse** dialog to close it, then click **Close** on the **Tools** dialog to close it also.

10 When asked to save the current annotation, click **No**.

Define a formula to mask water from land

1 Turn on the Classification layer by right-clicking on it and selecting **Turn On**.

2 With the Classification layer selected, click the **Edit Formula** button in the process stream to open the **Formula** dialog box.

3 In the **Generic** formula window, edit the formula text to read:

```
if input1 < 20 then 1 else null
```

This formula tells ER Mapper "if the image data values in the selected band are less than 20, then set the value to 1, else set it to null." Any pixels with a value less than 20 are considered water, and 20 or greater are considered land.

4 Click the **Apply changes** button to validate the formula.

5 In the Relations window, select **B5:1.65_um** from the INPUT1 drop-down list.

The threshold formula now references band 5 of the Landsat image.

6 Click **Close** on the **Formula Editor** dialog to close it.

Choose an overlay color and name and display the image

1 In the process diagram, click the **Edit Layer Color** button.

2 Choose a blue color, then click **OK** to close the **Color Chooser** dialog.

3 In the Classification layer's text description field (on its left side), type the description text **`water areas`** and press Enter or Return.

The areas of ocean in the image are highlighted in a blue mask (areas where band 5 values meet the criteria of being less than 20). Other areas that do not meet that criteria are assigned the value null by the formula, so the color composite image created by the RGB layers "shows through" the blue mask in those areas.

Note: You may add additional Classification layers to display overlays in other colors meeting other criteria. Classification layers on top of the layer list take display priority over others below them. For example, if two Classification layers would cover overlapping areas, the color of the layer on top covers the color in the layer below it where the two overlap. The color of the lower layer is only visible where there is no overlap. (Classification layers always cover other raster layer types, regardless of their position among the other layer types.)

2: Translucent color overlays

Objectives

Learn to use Intensity layers along with Red, Green, Blue, or Pseudocolor layers to create translucent color overlays that allow features underneath to show through the color (as opposed to the solid color overlays you used earlier).

The concepts here are very similar to using Classification layers, but the color overlays can be translucent instead of opaque. This technique is based on the concept of colordraping (covered in another chapter) except that you are only showing color in areas that meet a certain criteria.

Display the SPOT Panchromatic greyscale algorithm in a new (second) surface

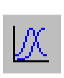
1. Click the right mouse button on the first surface.

   A short-cut menu appears

2. On the Short-cut menu select the Turn Off option and turn off the first surface
3. On the main window, select **Open into New Surface** from the **File** menu.
4. The **Raster Datase**t dialog box appears.
5. From the **Directories** menu, select the path ending with the text **\examples**.
6. Double_click on the 'Data_Types' directory to open it.
7. In the directory named 'SPOT_Panchromatic,' load the algorithm named 'Greyscale.alg.'

   This algorithm displays a high resolution SPOT Panchromatic satellite image of the San Diego area as a greyscale image.

Contrast stretch the SPOT Pan image

1. On the **Algorithm** window, click the post-formula **Edit Transform Limits**  button.
2. On the **Transform** dialog, click the **Gaussian Equalize**  button.

   ER Mapper applies a Gaussian equalize contrast stretch to the data, so more detail appears in darker areas and the image appears lighter overall.

3. Click **Close** on the **Transform** dialog to close it.

Change the Pseudocolor layer to Intensity

1 Click the right mouse button on the Pseudo Layer.

A short-cut menu appears

2 On the Short-cut menu select **Intensity**

The Pseudocolor layer changes to an Intensity layer. You will use this layer to create a greyscale backdrop image for your translucent color overlays.

The image does not change because displaying data in an Intensity layer by itself looks exactly the same as displaying the image in Pseudocolor with a greyscale lookup table.

Change the Color Mode to Red Green Blue

1 Click on the Surface tab

The setting of the second surface appears

2 From the **Color Mode** drop-down list, select **Red Green Blue**.

You will be adding a Green layer next, so you will need to use Red Green Blue color mode to make it active (since Green layers are not valid with Pseudocolor color mode).

Add a Green layer and load the same Landsat image

1 On the **Algorithm** window, select **Green** from the **Edit/Add Raster Layer** menu.

A Green layer is added to the layer list.

2 Click the Layer tab on the Algorithm window

The process stream diagram of the layer appears

3 Click the **Load Dataset**  button in the process stream diagram for the new layer to open the file chooser dialog.

4 From the **Directories** menu, select the path ending with the text **\examples**

5 In the directory named ‘Shared_Data’, load the image named ‘Landsat_TM_year_1985.ers.’

6 In the Green layer’s text description field, type the description text **`green vegetation`** and press Enter or Return.

Define a formula to highlight vigorous green vegetation

1 With the Green layer selected, click the **Edit Formula** button in the process stream to open the **Formula** dialog box.

2 From the **Ratios** menu, select **Landsat TM NDVI**.

ER Mapper loads the Normalized Difference Vegetation Index (NDVI) formula for Landsat TM data into the Generic formula window.

3 In the Generic formula window, edit the formula text to read:

```
if (i1 - i2)/(i1 + i2) > threshold then 1 else null
```

This formula tells ER Mapper "if the data values generated by the NDVI formula are greater than a variable named 'threshold,' then set the value to 1, else set it to null." You can now set the value to be used for the 'threshold' variable.

4 Click the **Apply changes** button to validate the formula.

5 Above the Relations window, click the **Variables** button.

The value currently assigned to the variable named 'threshold' (zero) displays in the Relations window.

6 Edit the value in the 'threshold' text field to read **`0.4`** and press Return or Enter.

Display the image with the translucent color overlay

The areas with NDVI values exceeding 0.4 are highlighted in a translucent green color. Areas with high NDVI values are generally parks, golf courses, or other areas with irrigated grass or other vigorous vegetation.

Notice that the surface features show through the colored areas, so you still see underlying structure. This type of display technique can be valuable for highlighting features in color and still be able to analyze areas of interest underneath them. It is sometimes less distracting or more visually pleasing to identify features using translucent color than by using solid colors.

Tip: When using this technique, dark features underlying colored areas will not be as visible as brighter features. You may want to adjust the transform of the Intensity image to increase the brightness and visibility of these features.

Decrease the NDVI threshold variable in the formula

1 In the Formula Editor dialog, edit the value in the 'threshold' text field to read **`0.3`** and press Return or Enter.

The areas with NDVI values exceeding 0.3 are highlighted this time, so more fringe areas and areas with less vigorous natural scrub vegetation are also displayed in green. Although this example is simple, it gives you an idea of how using variables can help you interactively test and develop raster spatial modelling applications.

2. Try other threshold values between zero and 0.5 if desired.
3. Click **Close** on the **Formula Editor** dialog to close it.

3: Slope and aspect overlays

Objectives

Learn to create overlays that highlight specific ranges of slope and aspect in a digital terrain model (DTM). Also learn to use filters to generate slope and aspect images.

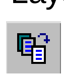
Load a DTM image into a new (third) surface

1. Click the right mouse button on the second surface.

   A short-cut menu appears
2. On the Short-cut menu select the Turn Off option and turn off the second surface
3. On the Algorithm window, click on the **Add New Surface**  button and add a new surface.
4. Click on the + sign of the new surface.
5. An inactive Pseudo Layer appears.
6. Click on the inactive Pseudo Layer.
7. Click the **Load Dataset**  button in the process stream diagram for the new layer to open the file chooser dialog.
8. From the **Directories** menu, select the path ending with the text **\examples**
9. In the 'Shared_Data**'** directory double click the file named 'Digital_Terrain_Model.ers' and load the DTM image into the Pseudo Layer.

   ER Mapper displays the DTM image of San Diego.

Create a colordrape image

1. Duplicate the Pseudo Layer of the 'Digital_Terrain_Model.ers' image by clicking the Duplicate  button on the Algorithm window.

2 Click your right mouse button on the duplicated Pseudo Layer.

3 The short-cut menu appears.

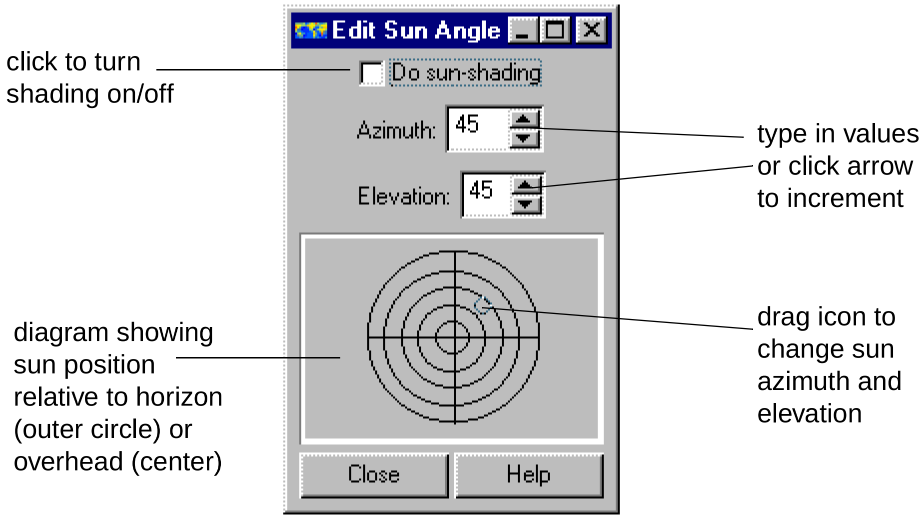
4 Select **Intensity** on the short-cut menu to change the Pseudo Layer to Intensity.

The Pseudocolor layer changes to an Intensity layer. You will use this layer to create a colordrape image.

5 Highlight the Intensity Layer.

6 On the **Algorithm** window, click the **Edit Realtime Sunshade** button in the process stream.

The **Edit Sun Angle** dialog box opens to let you specify shaded relief effects for the Intensity layer.



7 Turn on the **Do sun-shading** option.

ER Mapper displays the colordrape image of the 'Digital_Terrain_Model.ers' San Diego DTM image.

Sun Angle shading is now active for the Intensity layer, and the **Edit Realtime Sunshade** button in the process diagram changes to indicate this.

Add a Classification layer and load the DTM image

1 On the **Algorithm** window, select **Classification** from the **Edit/Add Raster Layer** menu.

A Classification layer is added to the layer list.

2 Click the **Load Dataset** button in the process stream diagram for the new layer to open the file chooser dialog.

3 From the **Directories** menu, select the path ending with the text **\examples**.

4 In the directory named ‘Shared_data’, load the image named ‘Digital_Terrain_Model.ers’ by clicking the **OK this layer only** button on the Raster Dataset file chooser dialog.

This is the same image loaded in the Pseudocolor and Intensity layers of the algorithm. Next you will load a filter to calculate slope from the San Diego DTM data, and then use a formula to display a specific range of slopes as a color overlay.

Load a filter to calculate slope in degrees

1 With the Classification layer selected, click on the pre-formula **Edit Filter (Kernel)** button in the process stream diagram. (The **pre-formula filter** button is on the left side of the Formula button.)

2 From the **File** menu (on the **Filter** dialog), select **Load...**.

The **Load filter** file chooser dialog box appears.

3 From the **Directories** menu, select the path ending with the text **\kernel**.

4 Double-click on the ‘filters_DEM’ directory to open it.

5 Double-click on the filter ’slope_degrees.ker’ to load it.

The filter settings are displayed in the dialog box fields. As indicated, this 3 by 3 filter is written in C code, not using a weighted convolution array.

Slope is a measure of steepness of terrain, or the change in the vertical component of the DTM data. This slope filter generates data values in degrees from the horizontal, so the slope values range from 0 (flat terrain) to 90 degrees (vertical terrain). (ER Mapper also provides a filter to calculate slopes in percent.)

6 Click **Close** on the **Filter** dialog to close it.

Since your slope calculation is generated with a pre-formula filter, you can now use a formula to isolate a specific range of slopes for your thematic overlay.

Enter a formula to show slopes more than 30 degrees

1 Click the **Open Formula editor** button in the process stream to open the **Formula** dialog box.

2 In the **Generic** formula window, edit the formula text to read:

```
if i1 > slope then 1 else null
```

This formula tells ER Mapper "if the data values calculated by the slope filter are more than a variable named 'slope,' then set the value to 1, else set it to null."

3 Click the **Apply changes** button to validate the formula.

4 Above the Relations window, click the **Variables** button.

5 Edit the value in the 'slope' text field to read `30` and press Return or Enter.

6 Click **Close** on the **Formula Editor** dialog to close it.

Specify a layer color and name and display the image

1 In the process diagram, click the **Edit Layer Color** button.

2 Choose a yellow color, then click **OK** to close the **Color Chooser** dialog.

3 In the Classification layer's text description field (on its left side), type the description text `slopes > 30 degrees` and press Enter or Return.

The surrounding areas of the San Diego with slopes more than 30 degrees are highlighted in yellow. (These are the steepest areas of terrain such as scarps.) Note that this image is 15 m resolution, so estimates of slope are generalized.

4 If desired, try different values between zero and 90 for your 'slope' variable in the formula to highlight different slope ranges.

Add a Classification layer to show south facing aspects

1 With the Classification layer selected, click the **Duplicate** button on the **Algorithm** window.

A copy of the first Classification layer is added to the layer list.

2 Click the **Edit Layer Color** button, choose a red color, then click **OK** to close the color chooser.

3 Change the layer description text to read `SE-SW aspects`.

Load a filter to calculate aspect

1 With the Classification layer selected, click on the pre-formula **Edit Filter (Kernel)** button on the left side of the process stream diagram.

2 From the **File** menu (on the **Filter** dialog), select **Load...**.

The **Load filter** file chooser dialog box appears.

3 From the **Directories** menu, select the path ending with the text **\kernel**.

4 Double-click on the 'filters_DEM' directory to open it.

5 Double-click on the filter 'aspect.ker' to load it.

The filter settings are displayed in the dialog box fields. As indicated, this 3 by 3 filter is also written in C code.

Aspect is a measure of the compass direction a surface slope faces. This aspect filter generates data values in degrees clockwise from north, so aspect values range from 0 to 360 degrees (a value of 361 degrees is also generated for a flat surface with no aspect). East-facing slopes have an aspect of 90 degrees, south facing slopes 180 degrees, and west-facing slopes 270 degrees. (*Aspect* is similar to the term *azimuth* but refers directly to the orientation of slopes.)

6 Click **Close** on the **Filter** dialog to close it.

Enter a formula to show southeast to southwest facing slopes

1 Click the **Edit Formula** button in the process stream to open the **Formula** dialog box.

2 In the **Generic** formula window, edit the formula text to read:

```
if i1 > aspect1 and i1 < aspect2 then 1 else null
```

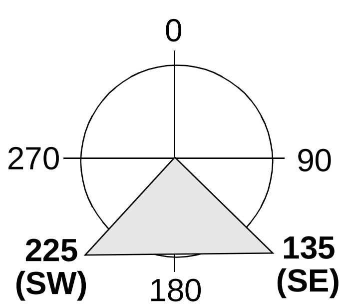
This formula tells ER Mapper "if the data values calculated by the aspect filter are greater than a variable named 'aspect1' and less than a variable named 'aspect2,' then set the value to 1, else set it to null."

3 Click the **Apply changes** button to validate the formula.

4 Above the Relations window, click the **Variables** button.

5 Edit the value in the 'aspect1' text field to read **135** and press Return or Enter, and edit the 'aspect2' value to read **225** and press Return or Enter.

The values 135 and 225 correspond to southeast and southwest on the zero to 360 aspect scale, so the formula displays any slopes facing between those two compass directions.



6 Click **Close** on the **Formula Editor** dialog to close it.

7 Turn off the other Classification layer displaying the slopes.

The algorithm now includes your color aspect overlay.

The surrounding areas of the San Diego with southeast to southwest facing slopes are highlighted in red. As you can see, these types of overlays and formulas provide very powerful and flexible tools for spatial modelling applications.

8 If desired, try different threshold values between zero and 360 for the ‘aspect’ variables in the formula to highlight different aspect ranges.

4: Displaying algorithms on multi-surfaces and applying transparency

Objective Learn to use the transparency option and apply it on different surfaces

1 Click your right mouse button on the first surface

The short-cut menu appears

2 On the short-cut menu select the **Turn On** option and turn on the first surface.

3 Click your right mouse button on the second surface

The short-cut menu appears

4 On the short-cut menu select the **Turn On** option and turn on the second surface.

5 Click your right mouse button on the third surface

The short-cut menu appears

6 On the short-cut menu select the **Turn On** option and turn on the third surface.

Note: All the three surfaces are turned on.

---

7 Select the first surface and click on the surface tab

The settings in the first surface appear

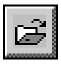
8 Adjust the transparency to 50% for the first surface

The image in the first surface with 50% transparency is displayed on the image of the second surface. Adjust the **Transparency(%)** and see the affect of the transparency on first and second surfaces.

5: Scattergram region overlays

Objectives Learn to define a cluster of data values in a scattergram to highlight those pixels in a color overlay on a corresponding image window.

Open a Landsat TM RGB algorithm

1 Click on the **Open**  toolbar button.

2 From the **Directories** menu, select the path ending with the text **\examples.**

3 In the 'Data_Types' directory named 'Landsat_TM', load the algorithm named 'RGB_321.alg.'

This algorithm displays bands 3, 2 and 1 of an Landsat TM satellite image of the San Diego area as a color composite image.

View a scattergram of the image data

1 From the **View** menu, select **Scattergrams...**.

The **Scattergram** dialog box and **New Map Composition** dialog boxes open.

(If the algorithm page setup mode is 'fixed page,' you may see a third dialog warning about annotation in this mode. If so, click **Close** to close it.)

2 Click **Cancel** on the **New Map Composition** dialog to close it (you do not need it for this exercise).

The **Scattergram** dialog automatically references the image in the active image window ('Landsat_TM_year_1985'). By default, the band 1 data values are shown on the X axis, and band 2 values on the Y axis.

Revise the scattergram bands and limits

1 In the **Scattergram** dialog, click the **Setup...** button.

The **Scattergram Setup** dialog opens.

2 From the **Y Axis** drop-down list, select **B5:1.65_um**.

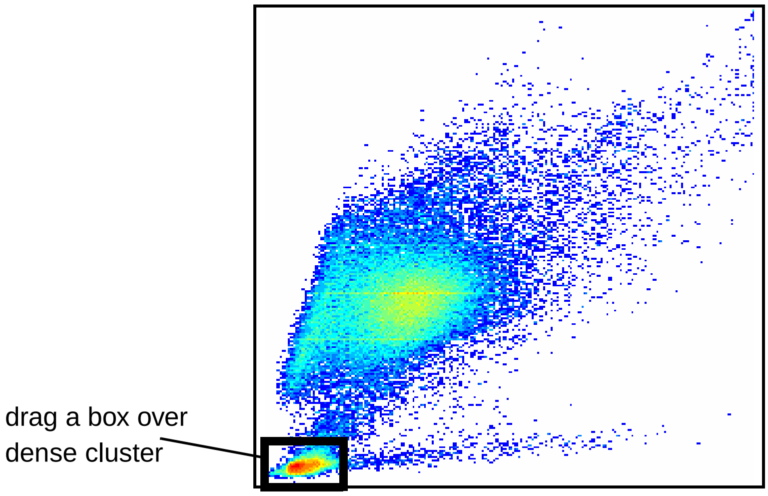
3 Click the **Limits to Actual** button to set the X and Y axis limits to the actual limits of the band 1 and 2 data ranges.

The scattergram is redisplayed to fill the window. TM bands 1 and 5 are not strongly correlated, as indicated by the wide dispersion of points.

Draw a region box on the scattergram to highlight ocean

Notice that the scattergram shows a dense cluster of data values near the axis origins in the lower-left corner–these represent the ocean areas on the image. Ocean areas typically have lower reflectance than land areas, and there is a dense cluster here because this image contains significant areas of ocean.

1 In the **Scattergram** dialog, point to the dense cluster and drag to define a small box around it.



When you release the mouse, ER Mapper runs the algorithm again and then draws a solid color over pixels in the image window whose data values fall within the box limits you defined on the scattergram. By default, the overlay is drawn in red.

Also notice in the **Algorithm** window that ER Mapper has added a Classification layer to the algorithm titled 'Scatter region.' It added this automatically and entered a formula to define the data limits you specified by dragging the box.

Refine the region box on the scattergram

Notice that the small box on the **Scattergram** dialog is selected (it has "handles" at the four corners). You can move or resize the box using the mouse.

1 In the **Scattergram Setup** dialog, turn on the **Defer Display** option.

This tells ER Mapper to delay updating the scattergram until you finish changing the desired options (moving or resizing the region box in this case).

2 On the **Scattergram** dialog, resize your region box by dragging a handle, or move the box by pointing inside it and dragging to a new location.

3 After revising the box, click the **Display** button in the **Scattergram Setup** dialog.

ER Mapper redraws the box and updates the color overlay on the image to reflect the new pixels falling within the box's data limits.

4 Change the box location or size to highlight other clusters of pixels in the scattergram, then click **Display** to highlight them on the image window.

Delete the scattergram region

1 With the region box selected, click **Delete Region** on the **Scattergram Setup** dialog.

ER Mapper deletes the region box from the scattergram, and deletes the Classification layer from the algorithm.

Close the scattergram dialogs

1 Turn off the **Defer Display** option.

2 Click **Cancel** on the **Scattergram Setup** dialog to close it, then click **Cancel** to close the **Scattergram** dialog.

3 When asked whether to delete the scattergram layers from the current algorithm, click **Yes**.

Close all image windows and dialog boxes

1 Close all image windows using the window system controls:

- Select **Close** from the window control-menu.

2 Click **Close** on the **Algorithm** window to close it.

Only the ER Mapper main menu should be open on the screen.

What you learned...

After completing these exercises, you know how to perform the following tasks in ER Mapper:

- Display raster thematic data in solid color over images
- Display raster thematic data in translucent color over images
- Use formulas to define criteria for displaying thematic color overlays
- Display algorithms on multi-surfaces and applying transparency on upper surface/s
- Define a region of data values in a scattergram and highlight them on the image

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Creating image mosaics

This chapter explains how to create algorithms to display and process two or more separate image datasets as a mosaic. You will learn how ER Mapper approaches the concept of mosaicing and how to build an image mosaic algorithm.

ER Mapper 6.0 introduced the **Image Display and Mosaicing Wizard** and the **Color Balancing Wizard for Airphotos** which simplified image mosaicing to a large extent. The exercises in this chapter show you how to mosaic and balance images manually and by using the wizards. The manual exercises are included to give you background knowledge and can be skipped over.

About creating mosaics

In the context of remote sensing, a mosaic is an assemblage of two or more adjacent or overlapping images to create a continuous representation of the area covered by the images. You might, for example, create a mosaic of several overlapping satellite scenes or aerial photos to cover a larger geographic area. The process of creating image mosaics is very simple in ER Mapper once the images are rectified to the same coordinate space. Any number of co-registered images used in the same processing algorithm are automatically displayed in their correct geographic positions relative to each other.

Image requirements for creating mosaics

In order for ER Mapper to create a mosaic, each of the images must have the following in common:

- they must be registered to the same geographic datum
- they must be registered to the same map projection
- they must be rotated the same amount from north (if rotation is used).

You will learn how to rectify images to datums and map projections later.

ER Mapper mosaic capabilities

Other than having a common datum and map projection, you can create mosaics that contain very different types of data. An image mosaic can be built with datasets that have:

- different numbers of bands (i.e., seven for Landsat TM versus three for SPOT XS)
- different data formats (i.e., byte format versus floating point format)
- different resolutions or cell sizes (i.e., 30 meter versus 10 meter).

Image display priority

By changing the order of the algorithm layers containing the separate image datasets, you can control dataset display priority (that is, which images appear on top of others in the event of overlap). Images loaded into the uppermost layer of any type always appear on top of any other images in layers below where overlap occurs between them.

Images loaded into the lowest layer of any type always have the lowest display priority and will only be visible in areas where there is no overlap from datasets in layers above them. For example, if you are mosaicing a high resolution image with one of lower resolution, you can display the entire extents of the high resolution image by putting its layer(s) on top in the algorithm layer list.

Note: Layer priority only applies to raster layers; vector layers always appear on top of raster layers regardless of their position in the algorithm layer list.

Hands-on exercises

These exercises show you how to create greyscale and RGB image mosaic algorithms, and how to use histogram matching and feathering to help balance image contrast and blend seam lines between images.

What you will learn...

After completing these exercises, you will know how to perform the following tasks in ER Mapper:

- Create an image mosaic by building an algorithm containing two or more sets of layers of the same type
- Specify different processing for each image in the mosaic
- Specify image priority for the mosaic (which images appear on top of others in the event of overlap)
- Use histogram matching and feathering to minimize seams in mosaics

Before you begin...

Before beginning these exercises, make sure all ER Mapper image windows are closed. Only the ER Mapper main menu should be open on the screen.

1: Creating a greyscale image mosaic

Objectives

Learn how display several overlapping images in different Pseudo layers to create an image mosaic, and learn to specify image priority in areas of overlap.

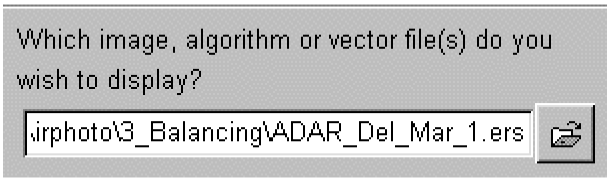
Note: The sample images used in the following exercise were previously rectified to the same map projection, so they can be displayed together in a mosaic.

Select files to display and mosaic

1 On the **Common Functions** toolbar, click the **Image Display and Mosaicing Wizard** button.

The **Select files to display and mosaic** page of the Image Display and Mosaicing Wizard opens

2 Click the **Load Image** button.



The **Select File** dialog opens.

3 From the **Directories** menu (on the **Select File** dialog), select the **\examples** path.

4 Double_click on the ‘Applications’ directory to open it.

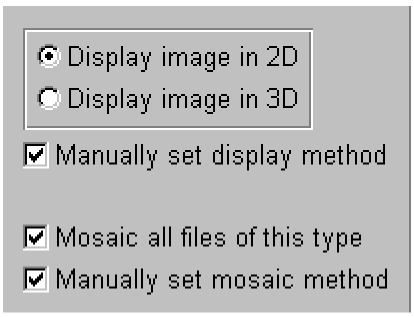
5 Double_click on the ‘Airphoto’ directory.

6 Open the ‘3_Balancing’ directory.

7 Double-click on the image dataset ‘ADAR_Del_Mar_1.ers’ to select it.

This dataset is a high resolution image covering a portion of Del Mar, California near San Diego. This dataset is a multispectral image acquired by the ADAR 5000 system mounted on an aircraft. The data values represent reflectance of light in three different wavelengths (similar to a multispectral satellite image).

8 Select the following options on the wizard page:



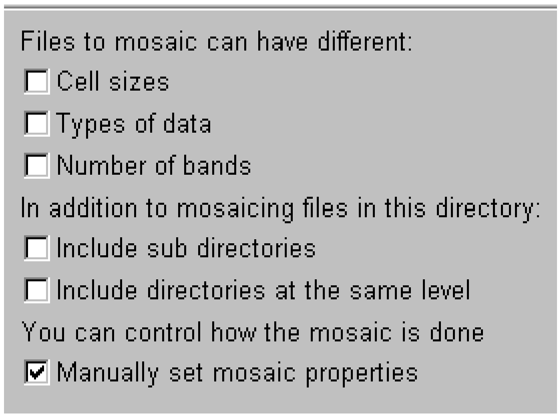
Display image in 2D	Image will be displayed in a 2D mode.
Manually set display method	Enables you to set how the image is to be displayed. If you do not select this option, the wizard will set the display method.
Mosaic all files of this type	The wizard will search for files of the same type and automatically mosaic them.
Manually set mosaic method	Enables you to set how the images are to be mosaiced. If you do not select this option, the wizard will set the mosaicing

9 Click on the **Next>** button to go to the next wizard page.

Select file types to mosaic

This page allows you to specify the characteristics and location of image files that the wizard must search for to mosaic with the image already selected.

1 Select the **Manually set mosaic properties** option. Do not select the other options on the page.



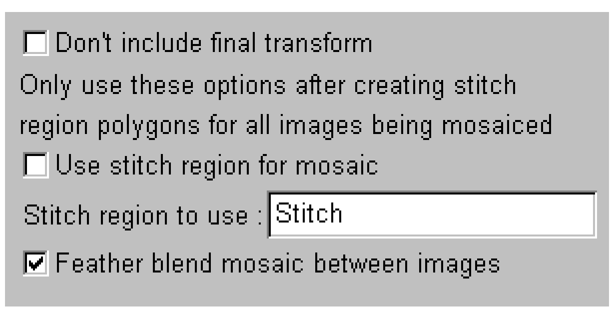
The images to be mosaiced all have the same cell sizes, data types and number of bands. They are also in the same directory.

2 Click on the **Next>** button to go to the next wizard page.

Select mosaic properties

This page allows you to specify properties of the mosaiced image.

1 Select the **Feather blend mosaic between images** options. Do not select the other two options.



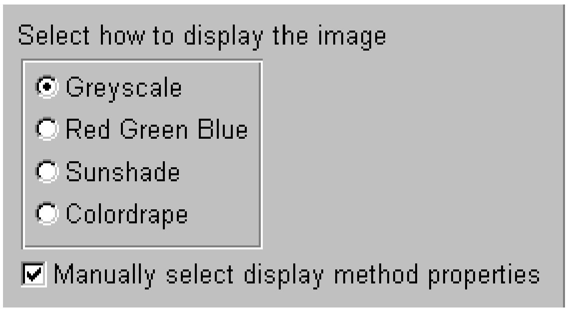
To simplify the exercise, we will not be defining and using stitch regions.

2 Click on the **Next>** button to go to the next wizard page.

Select display method

This page allows you to specify how you want the mosaiced image to be displayed.

1 Select the **Greyscale** display option and **Manually select display method** properties.



2 Click on the **Next>** button to go to the next wizard page.

Select display band

This page allows you to select the image band to display as a greyscale.

1 Select band B1 from the drop-down menu.

2 Click on the **Next>** button to go to the next wizard page.

Mosaic and display the images

The wizard searches the current directory and mosaics and displays the following images:

- ADAR_Del_Mar_1.ers
- ADAR_Del_Mar_2.ers
- ADAR_Del_Mar_3.ers

1 For the moment, leave the **Image wizard has finished** page open.

2 Drag the lower border of the image window downward about 50%.

3 Right-click in the image window, select **Quick Zoom,** then **Zoom to All Datasets**.

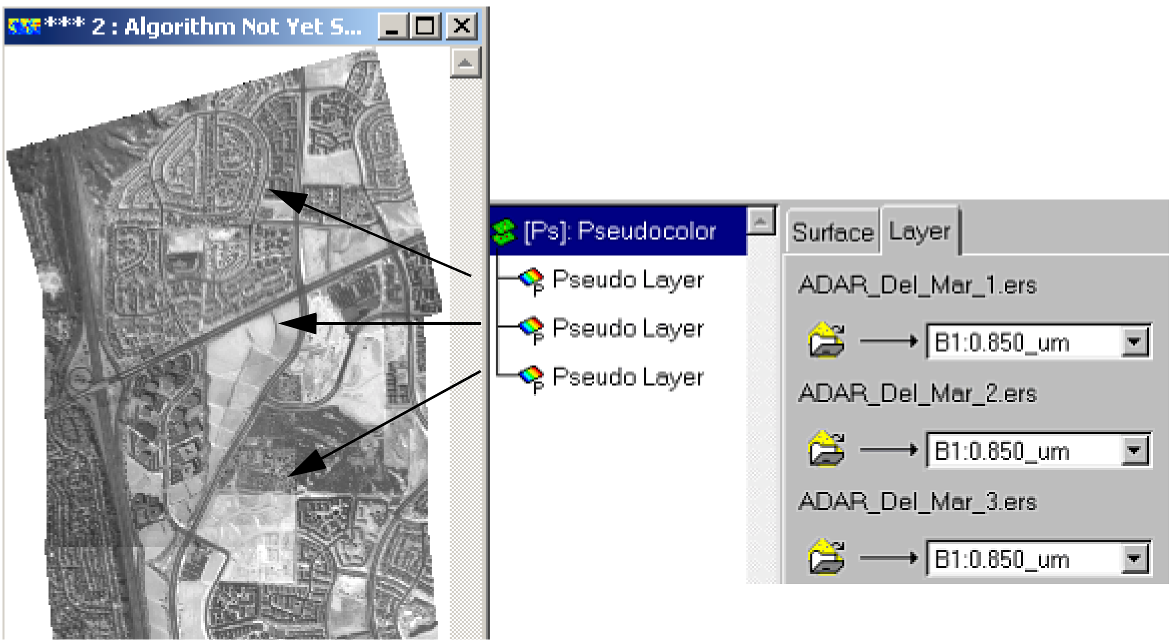
ER Mapper zooms out to show the full extents of all three ADAR images.

Since this image mosaic is taller than it is wide, increasing the window's width would have created a large unfilled area on the right side. This is an example of shaping the window to best fit a particular image display.

4 On the main menu, click the **Edit Algorithm** button.

The **Algorithm** dialog box opens.

You now have a algorithm that displays band 1 of each dataset as a greyscale image mosaic.



5 If necessary, use the **Move Up** and **Move Down** buttons to arrange the layers so that they are as shown in the diagram above.

Turn the center image on and off

1 Right-click on the middle ‘Pseudo Layer’ and select **Turn Off**.

Only the top and bottom images display (since the center image is turned off).

2 Right-click on the middle ‘Pseudo Layer’ and select **Turn On**.

The center image redisplays in its appropriate geographic position again. Any images in a mosaic can be displayed or not displayed by turning their layers on or off.

Zoom in to the geographic extents of any image dataset

1 Widen the image window

2 Select the top ‘Pseudo Layer’ (‘ADAR_Del_Mar_1’) in the algorithm.

3 Right-click in the image window, select **Quick Zoom,** then **Zoom to Current Dataset**.

ER Mapper zooms in to the full extents of the 'ADAR_Del_Mar_1' dataset (but also displays part of the lower dataset that occupies the same extents).

Zoom to Current Dataset lets you instantly zoom in or out to the extents of any raster image dataset(s) in the currently selected layer, so it is very useful for mosaic algorithms.

2: Creating an RGB image mosaic

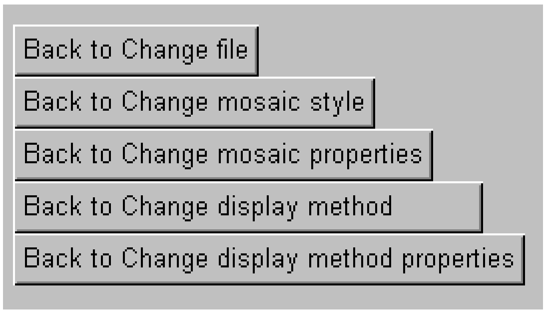
Objectives Learn how display several overlapping images in different sets of red, green, and blue raster layers to create an RGB image mosaic.

We use the Image Display and Mosaicing wizard to re-display the existing greyscale mosaiced image as an RGB image.

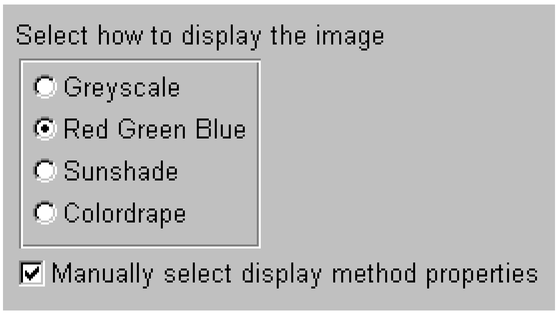
The final page of the wizard should still be open from the previous exercise.

Change the image display method

1 Select the **Back to Change display method** button from the still open **Image Wizard has finished** wizard page.



2 On the **Select display method** page, select the **Red Green Blue** option.



3 Click on the **Next>** button to go to the next wizard page.

4 Select **RGB 123** as the Red Green Blue display mode type.

This option allocates band 1 to Red. band 2 to Green and Band 3 to Blue.

5 Click on the **Next>** button to mosaic and display the images, and to go to the final wizard page.

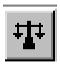
The wizard will now display the mosaiced image in RGB mode.

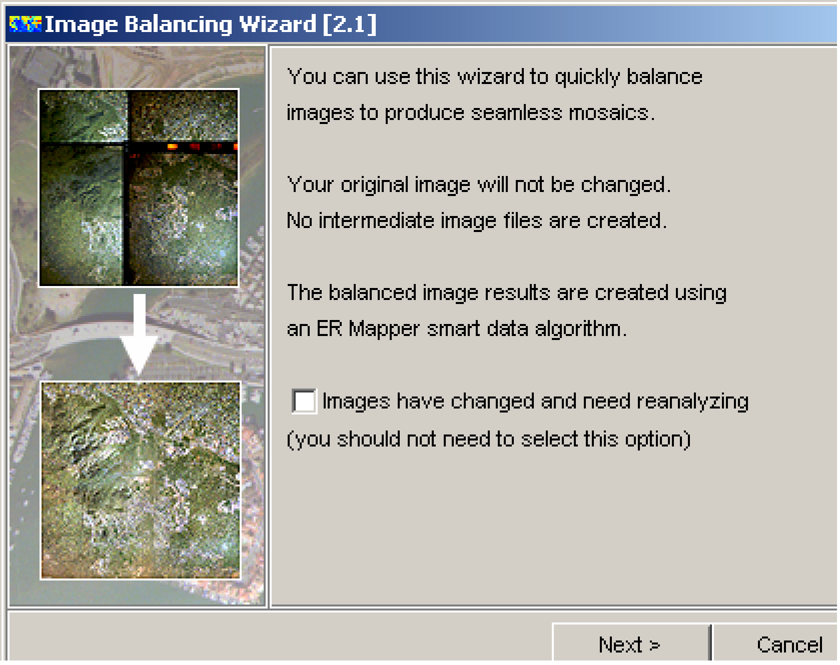
6 Click on the wizard **Finish** button to exit the wizard. Do not close the image window yet.

3: Color balancing the mosaic

Objectives Learn how to use the Color Balancing Wizard for Airphotos to color balance mosaiced images so that they interface seamlessly with one another.

Open the Image Balancing Wizard for Airphotos

1 Click on the **Image Balancing Wizard for Airphotos**  button on the **Common Functions** toolbar to open the wizard.



The wizard processes the currently active image window which you left open after the previous exercise

2 Click on the **Next>** button to go to the next wizard page.

Analyze images for balancing

The wizard requires the images to be analyzed before it can do the balancing. The analysis information is stored in the image dataset header files. If the images have not yet been analyzed, the wizard will now do so.

1 Click on the **Next>** button for the wizard to analyze the images.

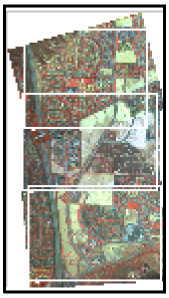
The wizard will calculate the statistics for the three ADAR images and write the information into their respective header files.

2 Click on the **Next>** button to go to the next wizard page.

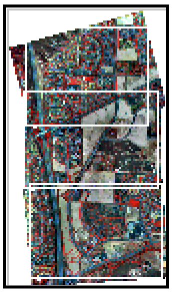
Select how to balance the images

In addition to color balancing, you also have a number of options for clipping the image. These are described below:

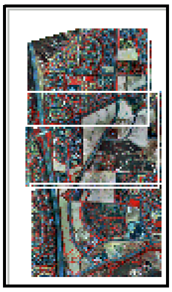
Original Remove any color balancing and display the unbalanced images.
The white boxes in the diagram show the extents of the individual images with their edges removed.



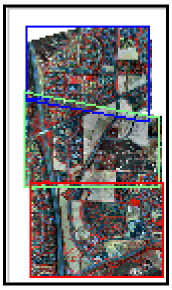
Balanced Display the balanced images but do not clip edges.

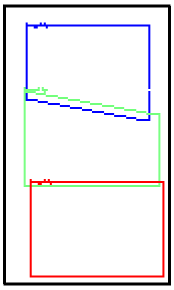


Balanced with no black/ white edges Display the balanced images and remove the black or white edges.
It is preferable not to select this option when balancing images that have very dark water, near the edges of the image. The color balancing wizard for airphotos may select too much of the image as dark edges to be removed.
Note: Some images are supplied with their black edges already removed, in which case it is not necessary to select this option.

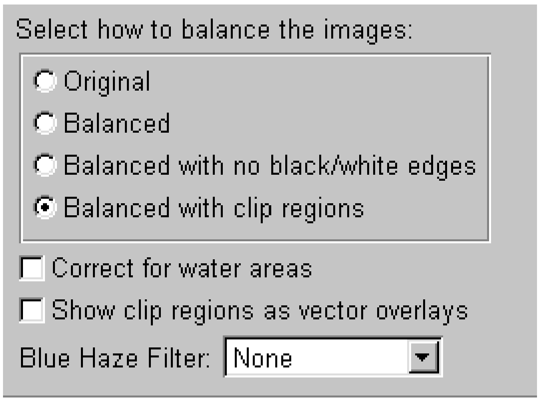


Balanced with clip regions	When mosaicing images, compute clip regions to hide the edges between images. Clip regions are areas of overlap that are trimmed off to create a seamless join. The wizard re-computes the clip regions every time you run it. By default, the wizard turns feathering ON for when balancing with clip regions, and OFF in all other cases.
Correct for water areas.	If your image has large areas with low contrast, such as water, they could be discolored by the balancing process. Select this option to prevent this happening.
Show clip regions as a vector overlay	Create a vector layer which outlines the clip regions.





1 Select the **Balanced with clip regions** option.



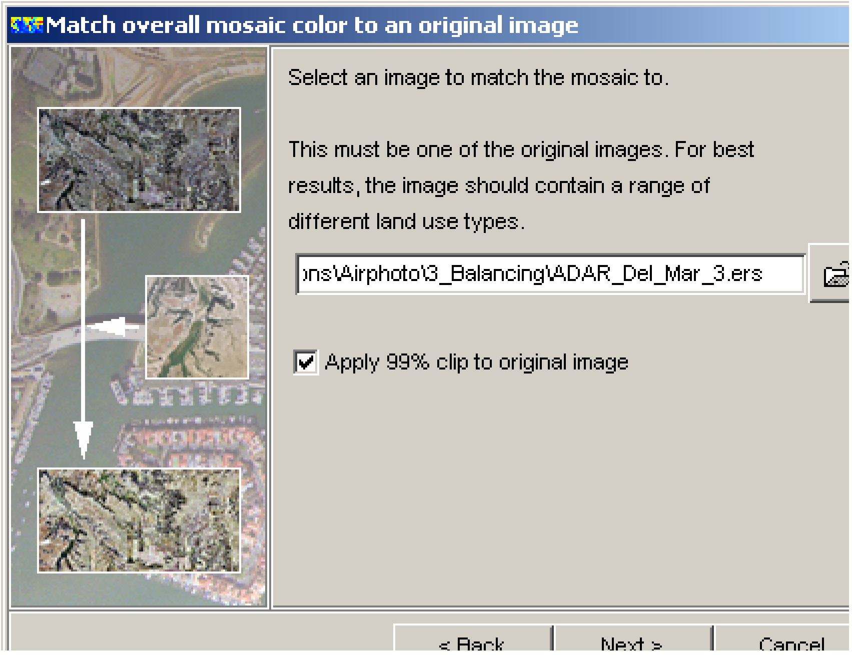
2 Click on the **Next>** button for the wizard to balance the images and go to the Color matching page.

The wizard will balance and clip the image. It will then display it in the image display window as the temp-balance algorithm.

Color matching the image

You can choose whether you want the wizard to match the colors to the whole mosaiced image or to one of the images that are art of the mosaic. Alternatively you can skip the color matching altogether. For this exercise we will match the color to the ‘ADAR_Del_Mar_3.ers’ image.

1 Select the **Match colors to individual file** option, and then click on the **Next** button.



2 Use the file chooser button to select the image to which the colors are being matched. In this case we will select ‘ADAR_Dek_Mar_3.ers’.

3 Select the **Apply 99% clip** option to improve the contrast and click on the **Next** button.

Caution: Do not select the **Apply 99% clip** option if you are going to compress the image. You will not be able to reverse it when the image is decompressed.

The wizard will display the status of the color matching. This can take some time to finish. It will then display the final balanced and matched image in temporary algorithm.

4 Click on the **Finish** button to exit the Color Balancing Wizard for Airphotos.

Close the image window and Algorithm dialog

1 On the main menu, select **Close** from the **File** menu to close the image window.

2 Click **Close** on the **Algorithm** dialog.

Only the ER Mapper main menu should be open on the screen.

What you learned

After completing these exercises, you know how to perform the following tasks in ER Mapper:

- Create an image mosaic using the Image Display and Mosaicing Wizard
- Use the Color Balancing Wizard for Airphotos to balance the mosaiced images.

4: Creating a greyscale image mosaic manually

The rest of the exercises in this chapter involve using manual methods for mosaicing images instead of using the wizards. We do recommend that you use the wizards where possible. These exercises have been included for background information, and you can skip over them if you so desire.

Objectives

Learn how display several overlapping images in different Pseudo layers to create an image mosaic, and learn to specify image priority in areas of overlap.

Note: The sample images used in the following exercise were previously rectified to the same map projection, so they can be displayed together in a mosaic.

Open a new image window and the Algorithm dialog

1 On the main menu, click the **Edit Algorithm**  button.

An image window and the **Algorithm** dialog box open.

2 Click the **Surface** tab (in the **Algorithm** dialog), and select **greyscale** from the 'Color Table' list.

3 Click the **Layer** tab again to display the process diagram.

Load a dataset into the Pseudo layer

1 In the **Algorithm** dialog, click the **Load Dataset** button in the process diagram.

The **Raster Dataset** dialog opens–move it below the image window (so the image window and **Algorithm** dialogs are visible).

2 From the **Directories** menu (on the **Raster Dataset** dialog), select the **\examples** path.

3 Double_click on the ‘Applications’ directory to open it.

4 Double_click on the ‘Airphoto’ directory.

5 Open the ‘3_Balancing’ directory.

6 Click ***once*** on the dataset ‘ADAR_Del_Mar_1.ers’ to select it, then click the **Apply** button.

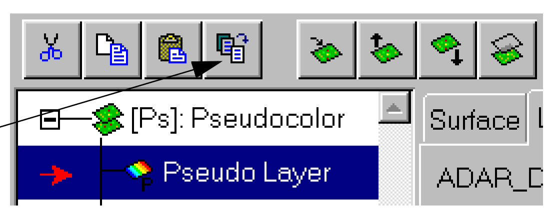
ER Mapper loads the dataset into the Pseudo layer and leaves the **Raster Dataset** dialog open (you will use it later load additional datasets).

This dataset is a high resolution image covering a portion of Del Mar, California near San Diego. This dataset is a multispectral image acquired by the ADAR 5000 system mounted on an aircraft. The data values represent reflectance of light in three different wavelengths (similar to a multispectral satellite image). Band 1 of the three band dataset is displayed by default.

Create a mosaic by adding a second adjacent dataset

1 In the **Algorithm** dialog, click the **Duplicate** button.

Duplicate button



A copy of the Pseudo layer is added to the layer list.

2 In the **Raster Dataset** dialog, click once on the dataset ‘ADAR_Del_Mar_2.ers’ to select it, then click the **Apply this layer only** button.

ER Mapper loads the dataset into *only* the selected Pseudo layer and leaves the **Raster Dataset** dialog open.

Note: Since the two Pseudo layers initially contained the same dataset, **Apply** or **OK** would have loaded the 'Del_Mar_2' dataset into *both* layers. When duplicating layers, use **Apply this layer only** to load into *only* the selected layer.

A portion of the second image displays below the first one.

Zoom out to view the extents of both images

1. Right-click in the image window, select **Quick Zoom,** then **Zoom to All Datasets**.

   ER Mapper zooms out to show the full extents of both ADAR images.

Tip: When building image mosaics, **Zoom to All Raster Datasets** lets you zoom out to view the full extents of *all* images comprising the mosaic. To zoom to the extents of specific dataset in a mosaic, select the dataset's layer then use **Zoom to Current Dataset**.

Add a third dataset to the mosaic

1. In the **Algorithm** dialog, click the **Duplicate**  button.

   A copy of the second Pseudo layer is added to the layer list.

2. In the **Raster Dataset** dialog, click once on the dataset 'ADAR_Del_Mar_3.ers' to select it, then click the **OK this layer only** button.

   ER Mapper loads the dataset into only the third Pseudo layer and closes the **Raster Dataset** dialog.

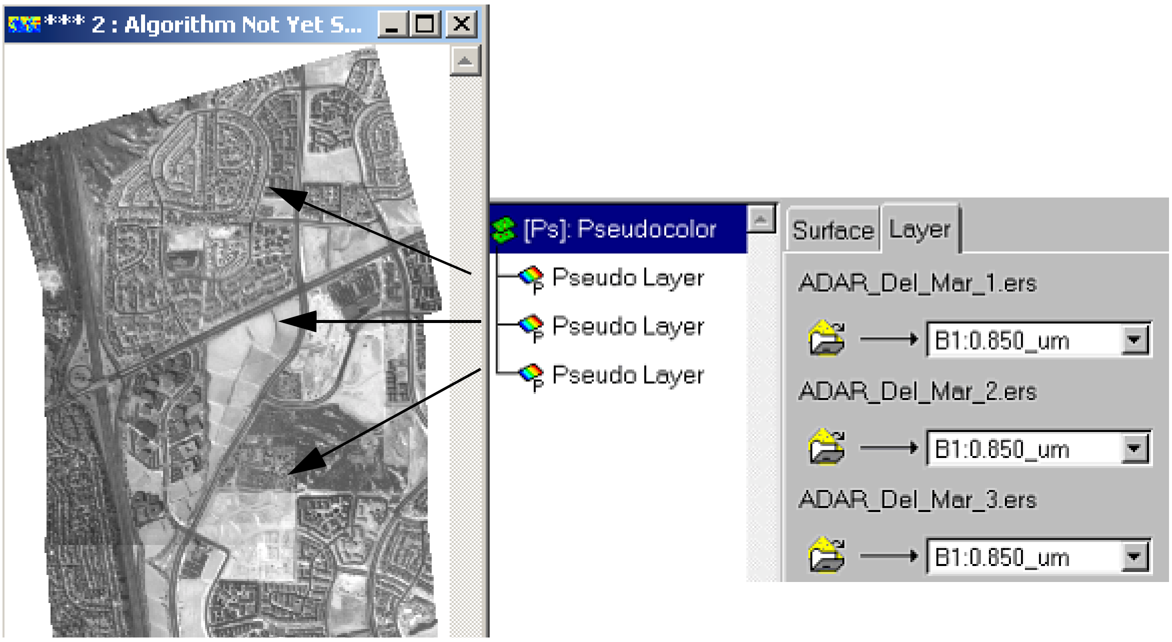
Tip: As shown here, if you plan to load multiple datasets into an algorithm, it is often easier to leave the **Raster Dataset** dialog open until you are finished. This saves the time of opening the file chooser each time.

---

3. Drag the lower border of the image window downward about 50% so the image mosaic fits into the window.

   Since this image mosaic is taller than it is wide, increasing the window's width would create a large unfilled area on the right side. This is an example of shaping the window to best fit a particular image display.

You now have a algorithm that displays band 1 of each dataset as a greyscale image mosaic.



Turn the center image on and off

1 Right-click on the middle 'Pseudo Layer' and select **Turn Off**.

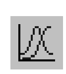
Only the top and bottom images display (since the center image is turned off).

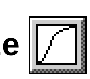
2 Right-click on the middle 'Pseudo Layer' and select **Turn On**.

The center image redisplays in its appropriate geographic position again. Any images in a mosaic can be displayed or not displayed by turning their layers on or off.

Brighten the center image to enhance the seam lines

1 Select the middle 'Pseudo Layer' containing the 'ADAR_Del_Mar_2' dataset.

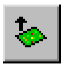
2 Click the post-formula **Edit Transform Limits**  button in the process diagram.

3 On the **Transform** dialog, click the **Histogram equalize**  button.

The center image in the mosaic displays with more contrast between light and dark areas than the top and bottom images, and the seam lines become clearly visible. (This is helpful for understanding image display priority in the next section.)

4 Click **Close** on the **Transform** dialog.

Change the display priority of the center image

1 Select the middle ‘Pseudo Layer’ (‘ADAR_Del_Mar_2’), then click the **Move Up**  button.

The layer containing the ‘ADAR_Del_Mar_2’ dataset moves up, so it is now the top layer (and has display priority over datasets in layers below it).

The center image ‘ADAR_Del_Mar_2’ displays on top of the other two datasets where overlap occurs.

2 Point to the top ‘Pseudo Layer’ (‘ADAR_Del_Mar_2’), and drag it to the bottom of the layer list.

The layer containing the ‘ADAR_Del_Mar_2’ dataset now has the lowest display priority.

The center image ‘ADAR_Del_Mar_2’ displays underneath the other two datasets where overlap occurs.

Note: When displaying two or more images in a mosaic algorithm, the image in the top layer in the **Algorithm** dialog appears on top of the others when the algorithm is processed. The image in the lowest layer has the lowest priority and will only be visible in areas where there is no overlap from other datasets in layers above it. By adjusting to order of layers, you can set which datasets appear on top of others in areas where they overlap.

Zoom in to the geographic extents of any image dataset

1 Select the top ‘Pseudo Layer’ (‘ADAR_Del_Mar_1’) in the algorithm.

2 Right-click in the image window, select **Quick Zoom,** then **Zoom to Current Dataset**.

ER Mapper zooms in to the full extents of the ‘ADAR_Del_Mar_1’ dataset (but also displays part of the lower dataset that occupies the same extents).

Zoom to Current Dataset lets you instantly zoom in or out to the extents of any raster image dataset(s) in the currently selected layer, so it is very useful for mosaic algorithms.

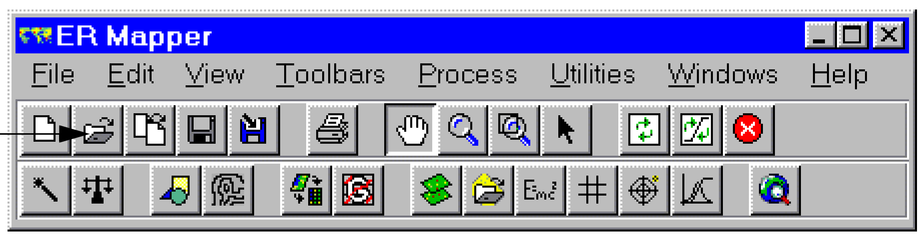
5: Creating an RGB image mosaic manually

Objectives Learn how display several overlapping images in different sets of red, green, and blue raster layers to create an RGB image mosaic.

When creating a mosaic algorithm in Red Green Blue (RGB) Color Mode, the order of layers becomes slightly more complex but still works the same way as the single Pseudo layers you used earlier. In this case, the RGB layers act together as a set, so you normally want to keep them grouped together in the layer list in the **Algorithm** dialog.

Load the template RGB algorithm

1 On the main menu, click the **Open**  button.



2 From the **Directories** menu, select the **\examples** path.

3 Open the ‘Miscellaneous’ directory.

4 Open the ‘Templates’ directory, then open the ‘Common’ directory.

5 Double-click on the algorithm ’RGB.alg’ to open it.

This algorithm is a template for displaying datasets in Red Green Blue (RGB) Color Mode. The existing dataset is an airphoto of San Diego.

Load an ADAR image into the RGB layers

1 In the **Algorithm** dialog, click the **Load Dataset**  button in the process diagram.

2 From the **Directories** menu (on the **Raster Dataset** dialog), select the **\examples** path.

3 Double_click on the ‘Applications’ directory to open it.

4 Double_click on the ‘Airphoto’ directory.

5 Open the ‘3_Balancing’ directory, then double-click on the dataset ‘ADAR_Del_Mar_1.ers’ to load it.

ER Mapper loads the ‘ADAR_Del_Mar_1’ dataset into all three layers. (Since all three initially contained the same airphoto dataset, double-clicking, **OK** or **Apply** loads the new dataset into all three automatically.) By default, band 1 is loaded into the Red layer, band 2 in the Green, and band 3 in the Blue.

This ADAR dataset is the same image you displayed earlier, but is now displayed as an RGB false color composite. Dataset band 1 (near infrared reflectance) is displayed in the red layer, band 2 (red reflectance) in the green channel, and band 1 (green reflectance) in blue. Vegetation appears red, buildings appear blue or green, and barren ground appears white.

Add a second group of new RGB layers

1 Select the ‘Red Layer’ in the layer list.

2 From the **Edit** menu (on the **Algorithm** dialog), select **Add Raster Layer**, then **Blue**.

ER Mapper adds a new Blue layer below the Red layer. (Since no dataset is loaded, the layer is turned off.)

3 From the **Edit** menu, select **Add Raster Layer**, then **Green**.

4 From the **Edit** menu, select **Add Raster Layer**, then **Red**.

Now you have a second set of RGB layers you can use to add a second image to your RGB mosaic algorithm.

Load an adjacent ADAR dataset into the new RGB layers

1 With new Red (lowest) layer selected, click the **Load Dataset** button in the process diagram.

2 From the **Directories** menu (on the **Raster Dataset** dialog), select the **\examples\Application\Airphoto** path.

3 Open the ‘3_Balancing’ directory, then double-click on the dataset ‘ADAR_Del_Mar_2.ers’ to load it.

The ‘ADAR_Del_Mar_2’ dataset is loaded into all three new RGB layers. (If a set of RGB layers has no dataset, they are treated the same as a set that has the same dataset when loading data.)

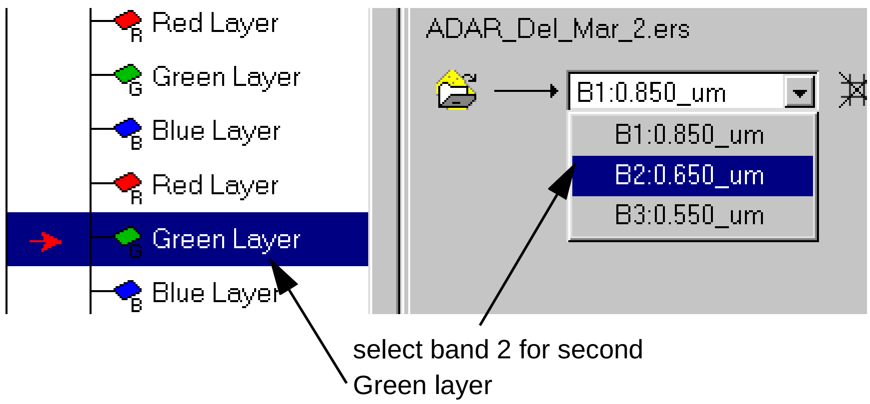
4 Turn on the new Green and Blue layers by right-clicking them and selecting **Turn On**.

When loading a dataset into a new set of RGB layers that do not already have one, only the selected layer (Red in this case) is turned on by default. You must turn the other layers on as shown here.

Select bands for the new Green and Blue layers

All three of the new RGB layers contain band 1 of the dataset since that band is always chosen by default when loading a new dataset into an empty layer.

1 Select the Green layer containing the 'ADAR_Del_Mar_2' dataset, then select **B2:0.650_um** from the **Band Selection** list in the process diagram.



2 Click on the Blue layer containing the 'ADAR_Del_Mar_2' dataset, then select **B3:0.550_um** from the **Band Selection** list.

You now have two groups of Red, Green, and Blue layers. Each group contains a different dataset but the same assignments of band numbers to layer types (i.e., band 1 is loaded into both Red layers, band 2 in both Green, and so on.)

3 Right-click in the image window, select **Quick Zoom,** then **Zoom to All Datasets**.

ER Mapper zooms out to display the full extents of both images in the RGB mosaic. You could continue this process to add additional RGB layers for other datasets in your color composite mosaic algorithm.

Creating multiple sets of RGB layers

There are several alternative ways to add additional sets of RGB layers to an algorithm. Three of these alternatives are:

- Add a new Blue layer (**Edit/Add Raster Layer/Blue**), load the new dataset into it, then duplicate it twice and change the duplicate layers to Green and Red layers.
- Ctrl-click three RGB layers containing the same dataset to select them, click **Copy** , then click **Paste** . This creates a new set of RGB layers within the same surface that contain the original dataset, so you can then load the new one.
- Use **File/Add into Current Surface** to add the layers from an existing RGB algorithm into the selected surface of the current algorithm.

6: Using histogram matching

Objectives Learn how to use ER Mapper's histogram matching feature to help balance contrast between multiple images in a mosaic.

Histogram matching is the process of automatically modifying the transform line(s) for one or more datasets to force their output histograms to match the output histogram of a reference dataset. This is a standard technique used to balance brightness across a mosaic of datasets to help minimize seams and make them appear to be one continuous image.

Look at the RGB mosaic you created in part 2 and notice the color difference between the two images. This is due to the slightly different range and distribution of data values in the two datasets. You will use histogram matching to alter the transforms of the layers containing the 'ADAR_Del_Mar_1' dataset to match the output histograms of the layers containing the 'ADAR_Del_Mar_2' dataset.

Open the Transform dialog box

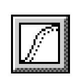
1 Select the lowest Red layer in the algorithm (for 'ADAR_Del_Mar_2').

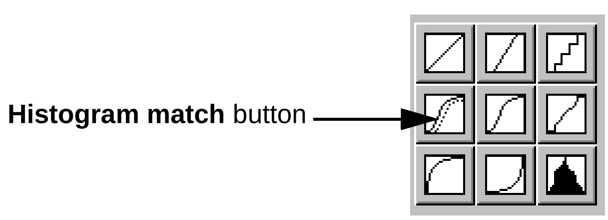
2 Click the post-formula **Edit Transform Limits**  button in the process diagram.

The histogram for the Red layer of the 'ADAR_Del_Mar_2' dataset is displayed.

If needed, move the **Transform** dialog so it does not overlap with the **Algorithm** dialog or image window.

Histogram match the Red layers

1 In the **Transform** dialog, click the **Histogram match**  button.



A dialog appears explaining the effects of the histogram match function and asking you to confirm that you want to proceed.

2 Click **Yes** to proceed with the histogram match operation.

3 Click the **Move to next red layer** button on the **Transform** dialog.

The next Red layer (for band 1 of 'ADAR_Del_Mar_1') is selected and its histogram is displayed. Notice that it has a complex piecewise transform line–this was automatically created by ER Mapper to make the output histogram match the output histogram of the Red layer of the 'ADAR_Del_Mar_2' dataset.

Histogram match the Green layers

1 In the **Algorithm** dialog, select the Green layer for 'ADAR_Del_Mar_2' dataset (the lower of the two Green layers).

Its histogram appears in the **Transform** dialog.

2 In the **Transform** dialog, click the **Histogram match** button.

The transform line for the other Green layer is modified to match the output histogram for the current Green layer. Notice the shape of the output histogram (same as the input or solid green histogram in this case since the default linear transform line is used).

3 Click the **Move to next green layer** button on the **Transform** dialog.

The Green layer for 'ADAR_Del_Mar_1' is selected. Notice the shape of the output histogram (the outline histogram) approximately matches the shape of the output histogram in the other Green layer. This is what histogram matching tries to accomplish.

Histogram match the Blue layers

1 In the **Algorithm** dialog, select the Blue layer for 'ADAR_Del_Mar_2' dataset (the lower of the two Blue layers).

Its histogram appears in the **Transform** dialog.

2 In the **Transform** dialog, click the **Histogram match** button.

The transform line for the other Blue layer is modified to make its output histogram match the output histogram of the current Blue layer.

3 Click the **Move to next blue layer** button on the **Transform** dialog.

The histogram for the 'ADAR_Del_Mar_1' layer and its modified transform line are displayed.

The brightness differences between the two datasets are minimized and they appear much closer in color and contrast. This same technique can be used to histogram match many different images to a reference image. In this case, ‘ADAR_Del_Mar_2’ was the reference image, and the transforms of the ‘ADAR_Del_Mar_1’ layers were histogram matched to it.

4 Click **Close** on the **Transform** dialog.

You can apply other contrast stretching options such as autoclipping or Histogram Equalization to your reference layers first, and then use histogram matching to modify the other layers to match them. This is likely to be desirable in most cases. (In this case the default linear transform was used for the reference layers to simplify explanation.)

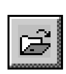
Note: Histogram matching affects all layers contained in the same surface. For example, if you have six sets of RGB layers, the other five Red layers will be matched to the reference Red layer. Histogram matching does not affect layers in other surfaces in an algorithm.

7: Using mosaic seam feathering

Objectives Learn how to use ER Mapper’s mosaic feathering feature to help blend areas of overlap to smooth seam lines between images in a mosaic.

Feathering is the process of blending the data values in areas where two datasets overlap so they gradually transition (or “feather”) from one to the other. Feathering can help to reduce the visual effect of seams between two or more images and helps them appear to be one continuous image. Feathering is an option on the **Algorithm** dialog. It is only available when you have more than one of the same layer type in your algorithm (which is necessary to create an image mosaic).

Load the mosaic of four datasets algorithm

1 On the main menu, click the **Open**  button.

2 From the **Directories** menu, select the **\examples** path.

3 Open the ‘Functions_And_Features’ directory, then open the ‘Data_Mosaic’ directory.

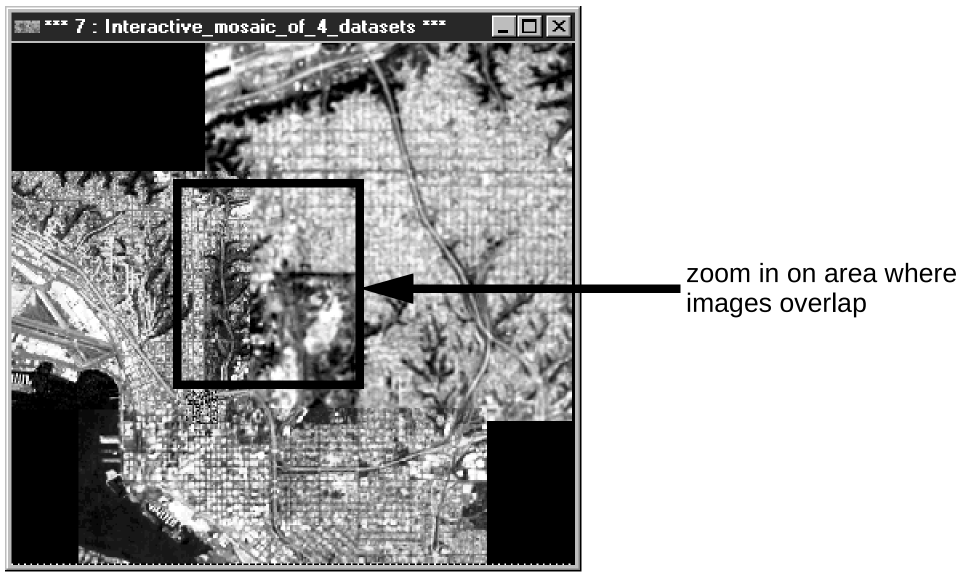
4 Double-click on the algorithm ‘Interactive_mosaic_of_4_datasets.alg.’

This algorithm is a greyscale mosaic of four datasets with different spatial resolutions–a Landsat TM image, a SPOT XS image, and SPOT Pan image, and a digitized aerial photograph.

Zoom in on a seam line between two datasets

1 Click the **ZoomBox Tool** button on the main menu.

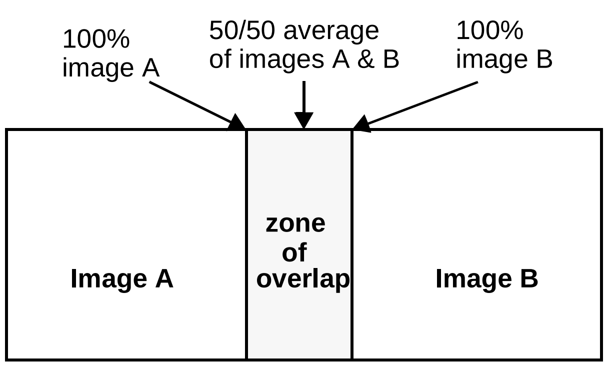
2 Drag a zoom box in the image to zoom in on the vertical seam between the Landsat and SPOT XS images in the mosaic (see below):



You should clearly see the seam line and difference in spatial resolution between the two images (the SPOT XS image on the left has higher resolution).

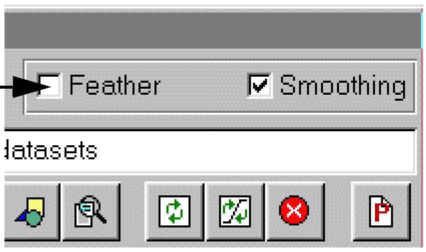
Turn on the mosaic feathering option

Feathering works by blending, or averaging, the data values between two images in the zone where they overlap:

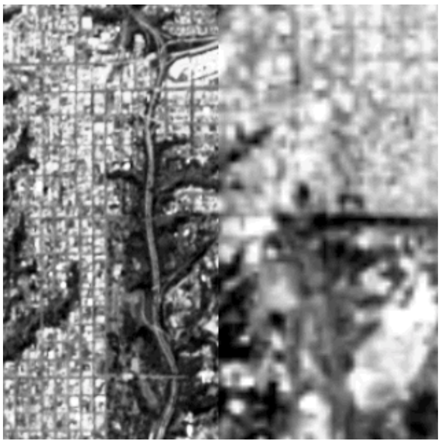


1 On the **Algorithm** dialog, turn on the **Feather** option.

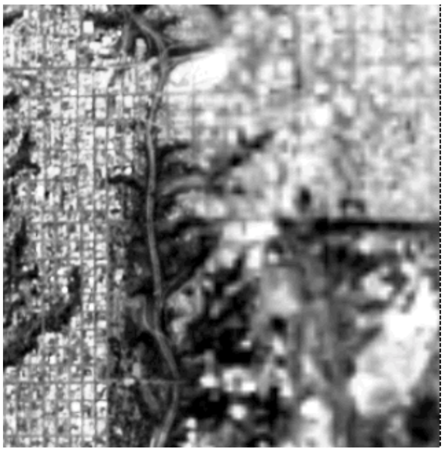
turn on Feather option



The seam line between the two images is blended to create a smooth transition between them. Feathering works by progressively blending the data values in the two datasets in the area where overlap occurs. Since the feathering computations occur in a left to right direction, it works best on vertical seams such as in this case.



feathering off



feathering on

Feathering can also be effective to hide small misalignments between features on adjacent images. (However gross misalignments will create a blurred look, and you should consider rectifying one or both images again to improve this.)

Close the image window and Algorithm dialog

1 On the main menu, select **Close** from the **File** menu to close the image window.

2 Click **Close** on the **Algorithm** dialog.

Only the ER Mapper main menu should be open on the screen.

What you learned

After completing these exercises, you know how to perform the following tasks in ER Mapper:

- Create an image mosaic by building an algorithm containing two or more sets of layers of the same type
- Specify different processing for each image in the mosaic
- Specify image priority for the mosaic (which images appear on top of others in the event of overlap)
- Use histogram matching and feathering to minimize seams in mosaics.

18

Unsupervised classification

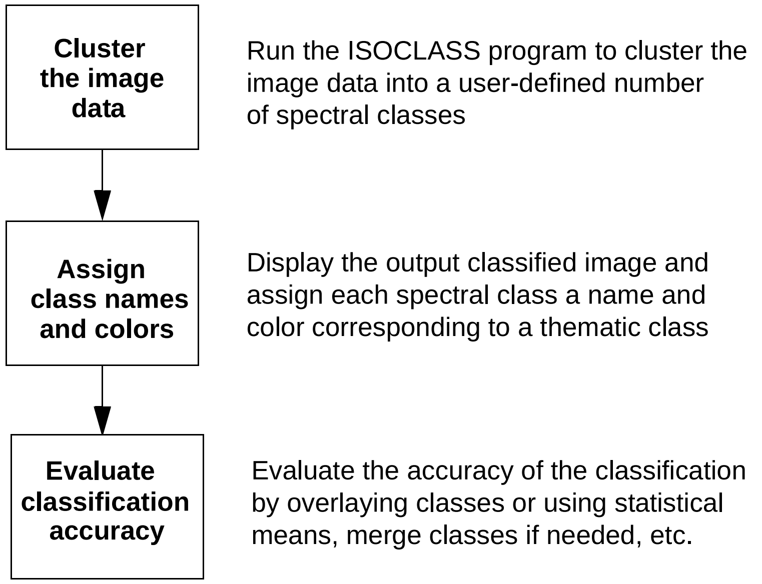
This chapter explains how use ER Mapper's ISOCLASS unsupervised classification feature to group multispectral image data into thematic information classes. You will learn to define clustering parameters, perform an unsupervised classification, and assign feature categories and colors to the classes.

About unsupervised classification

Unsupervised classification is one of two methods used to transform multispectral image data into thematic information classes (supervised classification being the other). This procedure typically assumes that imagery of a specific geographic area are gathered in multiple regions of the electromagnetic spectrum, for example Landsat TM or SPOT XS multispectral satellite imagery. (Classification can also be effective for other types of imagery. Please refer to an appropriate reference text for complete information on classification.)

With *unsupervised* classification, the classification program searches for natural groupings or clusters of the spectral properties of pixels, and assigns each pixel to a class based on initial clustering parameters you define. Typically, you ask ER Mapper to group the image data into a specific number of spectral classes and give it parameters for when classes are to be split or merged as it searches for groupings in the image data. After the classification is completed, you assign each "spectral" class to a thematic information or feature class (such as water, urban, etc.) and a color for the class display. ER Mapper uses the ISOCLASS algorithm to perform clustering of the image data during an unsupervised classification. For information on how the ISOCLASS program works, refer to Chapter 24, “Supervised and Unsupervised Classification” in the *ER Mapper User Guide*.

A typical procedure for performing an unsupervised classification is as follows:



Hands-on exercises

These exercises give you practice using ER Mapper’s ISOCLASS Unsupervised Classification feature.

What you will learn...

After completing these exercises, you will know how to perform the following tasks in ER Mapper:

- Specify clustering parameters and perform an unsupervised classification
- Assign colors and feature class names to the classified image
- Display a classified image using a Class Display layer
- Compare a classified image to a reference image

Before you begin...

Before beginning these exercises, make sure all ER Mapper image windows are closed. Only the ER Mapper main menu should be open on the screen.

1: Clustering the image data

Objectives Learn how to use ER Mapper's ISOCLASS unsupervised classification feature to group or cluster multispectral image data into several spectral classes in an output image.

Display the Landsat image to be classified

1 Click the **Open** button.

An image window and the **Open** file chooser appear.

2 From the **Directories** menu, select the **\examples** path.

3 Open the 'Data_Types' directory, then open the 'Landsat_TM' directory.

4 Double-click on the algorithm 'RGB_741.alg' to open it.

This displays bands 7, 4 and 1 of the Landsat TM image on which you will perform the unsupervised classification. (It is not necessary to display the image you want to classify, but you will use it for comparison later.)

Open the Unsupervised Classification dialog box

1 From the **Process** menu, select **Classification**, then select **ISOCLASS Unsupervised Classification**.

The **Unsupervised Classification** dialog box opens. This dialog lets you specify the input raster image and bands to be used, the output image name, starting classes to be used, and parameters for clustering the image data.

Specify the input image and bands to be used

1 Click the 'Input Dataset' chooser button.

2 From the **Directories** menu, select the **\examples** path.

3 Open the 'Shared_Data' directory, then double-click on the image 'Landsat_TM_year_1985.ers' to load it.

4 Click the 'Bands to use' chooser button.

The **Band Selection** dialog box appears to let you choose which bands in the image to use for the clustering operation.

5 Drag through all seven bands listed to select them, then Ctrl-click on the band labelled **6:11.45_um** to *deselect* it.

Bands 1-5 and 7 should now be selected. (Since Landsat TM band 6 contains data in the thermal wavelengths, it is often not included in classifications.)

6 Click **OK** to close the **Band Selection** dialog.

Bands 1-5 and 7 now appear in the 'Bands to use' field.

Specify a name for the output classified image

1 Click the 'Output Dataset'  chooser button.

2 From the **Directories** menu, select the **\examples** path.

3 Open the 'Miscellaneous' directory.

4 Open the 'Tutorial' directory.

5 In the **Save As** field, type your initials followed by the text **`10_class_ISOCLASS`** and separate each word with an underscore (_).

6 Click **OK** to validate the filename.

Specify the ISOCLASS clustering parameters

1 In the 'Maximum number of classes field,' enter the value **`10`** and press Return or Enter.

This tells ER Mapper to cluster the image data into a maximum of 10 spectral classes. (Note that this example is simplified, and you would typically choose a larger number of classes.)

All other default values on the dialog are appropriate for this simple exercise. ER Mapper will use bands 1-5 and 7 in the image, and will generate one starting class automatically (you could also use classes from another classified image to start with if desired). The clustering will finish when a maximum of 10 classes are created (although fewer are possible) and 98% of the clusters remain unchanged.

Perform the unsupervised classification

1 Click **OK** on the **Unsupervised Classification** dialog to start the clustering process.

The **Processing Status** dialog box appears to show the progress. ER Mapper runs through several iterations to cluster the image data into classes, and splits and merges classes as specified by the parameters you entered.

When the 98% unchanged parameter has been reached, the classification finishes with 10 classes. ER Mapper then generates multivariate statistics for each class.

2 When the dialog appears indicating successful completion, click **OK**.

3 Click **Cancel** on the **Unsupervised Classification** dialog to close both.

The output of the classification is a single band image. Each pixel in the image has a value ranging from 1 to 10 (the number of classes that were generated). Next you will display the output image and assign class colors and names.

Note: If statistics have not already been generated for your input raster image, they will be generated first when you start the classification (which may take a few minutes depending on the image size).

2: Assigning colors and class names

Objectives Learn how to view a classified image in a Classification Display layer, and assign colors and feature names to class numbers.

Open a template algorithm to display a classified image

1 On the main menu, click the **New** button.

An new image window appears-drag it below the other window.

2 Click the **Open** button.

3 From the **Directories** menu, select the **\examples** path.

4 Open the 'Miscellaneous' directory.

5 Open the 'Templates' directory, then open the 'Common' directory.

6 Double-click on the algorithm 'Classified_data.alg' to open it.

A classified image of San Diego displays. This is a template algorithm you will use to display the classified image you generated.

Load the classified image you created

1 Click the **Edit Algorithm** button.

On the **Algorithm** dialog, notice that this algorithm has one layer of the type 'Class Display.' The Class Display layer is designed to display images created with ER Mapper's classification functions.

2 Click the **Load Dataset** button in the process diagram.

3 From the **Directories** menu, select the **\examples** path.

4 Open the ‘Miscellaneous’ directory.

5 Open the ‘Tutorial’ directory, then double-click on your ‘10_class_ISOCLASS’ image to load it.

The image initially displays in various shades of grey by default. Next you will create a color scheme for the classified image.

6 Click **Close** on the **Algorithm** dialog.

Auto-generate a color scheme for the classes

1 From the **Edit** menu, select **Edit Class/Region Color and Name...**.

The **Edit Class/Region Detail** dialog box opens. This dialog lists each class in the image by number, and provides text fields for assigning names and a button to choose colors.

2 Enlarge the dialog until all 10 classes can be viewed at once.

3 Click the **Auto-gen colors...** button.

The **Auto-generate colors** dialog box opens. This dialog lets you automatically generate a color scheme for the classified image that simulates the colors of an RGB image display. By default, an RGB=321 band combination is chosen, but you will change it to an RGB=741 band combination.

4 Change the ‘Red Band’ value to **7**, and the ‘Green Band’ value to **4**.

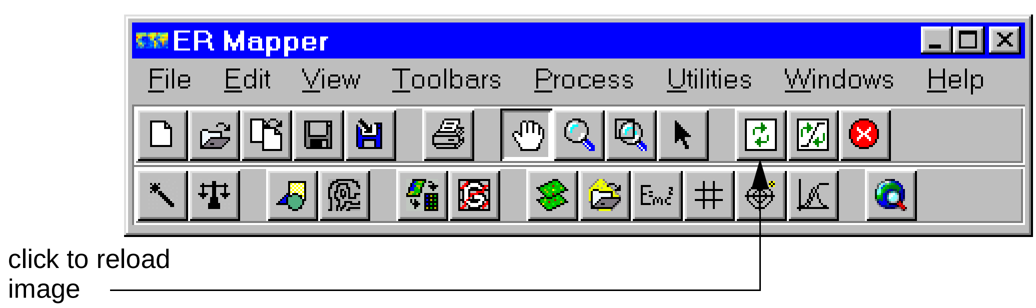
5 Click the **Auto-gen** button.

The new color assignments for each class appear in the **Set color...** buttons next to the class number in the **Edit Class/Region Details** dialog.

6 Click **Save** on the **Edit Class/Region Details** dialog, and when asked to overwrite the file click **Yes**.

The new color scheme for the classified image is now stored in the image header (‘.ers’) file.

7 Reload the image by clicking the **Refresh Image** button on the **Standard** toolbar.



Note that the class color assignments make the image appear similar to the RGB=741 image in the other window. You can use the **Auto-gen colors** option to simulate the color scheme of any typical RGB band combination.

8 Click **Close** on the **Auto-generate colors** dialog.

Note: In order to display changes to the color scheme, you must save the changes and then reload the image (to re-read the updated header file with the new colors). The fastest way to reload the image is to click the **Refresh Image** button on the **Standard** toolbar.

Close the Landsat TM RGB image window

1 Close the 'RGB_741' image window using the window system controls:

- Click the **Close** button in the upper-right window corner.

2 Move the 'Classified_data' image window to the upper-left on the screen.

Find the class representing ocean and color it blue

1 From the **View** menu, select **Cell Values Profile**.

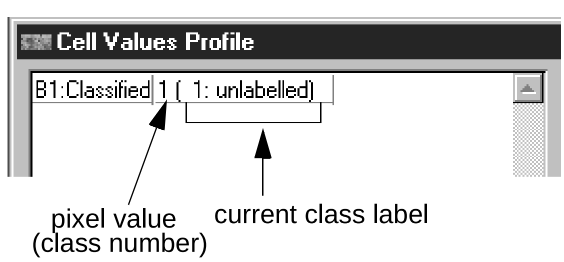
The **Cell Values Profile** dialog box appears. This will help you determine the class number of pixels in various areas of the classified image.

2 Turn on only the **Values** option.

3 On the main menu, click the **Pointer Tool** button.

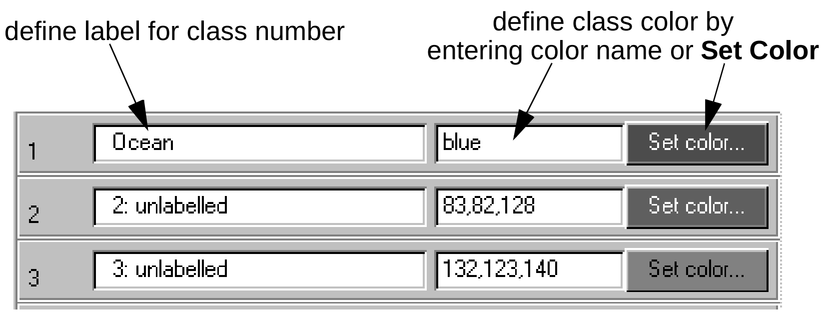
4 Drag the mouse through the dark areas near the bottom of the classified image, and note the values appearing in the **Cell Values Profile** dialog.

These are ocean areas that were generally grouped into class 1.



5 In the **Name** field for class 1 (on the **Edit Class/Region Details** dialog), change the text '1: unlabelled' to `Ocean/water`.

6 Click the **Set color...** button for class 1, choose blue, then click **OK**.



As shown above, you can also set the class color by entering a color name and clicking Enter or Return.

7 Click **Save** on the **Edit Class/Region Details** dialog, and when asked to overwrite the file click **Yes**.

8 Reload the image by clicking the **Refresh Image** button on the **Standard** toolbar.

The pixels assigned to class 1 (which you interpreted as ocean) are colored blue.

Assign names and colors to the other nine classes

1 Assign names and colors as desired to the other nine classes in the image using the previous steps 4 through 6 (use the guide on the next page).

Generally you should use the **Cell Values Profile** dialog to determine the class number of a specific feature type on the image, and then fill in a name for the class and choose the desired color. This requires some subjective interpretation, and you should pan and zoom on different areas as needed.

Another way to do this is to pick a bright color for a class, save it, then see which areas are highlighted. This may help determine what feature class name to assign in the context of the other classes.

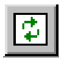
Tip: To zoom using the mouse, remember to set the mouse to **Zoom Tool** to zoom, and back again to **Pointer Tool** to view cell values.

As a shortcut, the following class assignments are generally correct for this image (colors are purely subjective choices, choose any you prefer):

Class	Name	Color
1	Ocean/water	blue
2	Beach/sandy soils	tan
3	Urban/industrial	magenta
4	Natural vegetation	dark green
5	Residential 1	red
6	Residential 2	pink
7	Mixed vegetation	light green
8	Parks/golf courses	green
9	Asphalt/tarmac	brown
10	Cement/barren land	white

Tip: The current color values (numbers) are RGB values that represent a specific color. You can quickly change them to the colors above by typing the color name and pressing Return or Enter (without using the **Set Color** button).

2 When finished, click **Save** on **Edit Class/Region Details**, then **Yes** to overwrite the file.

3 Reload the image by clicking the **Refresh Image**  button on the **Standard** toolbar.

4 Click **Close** on the **Cell Values Profile** dialog.

5 Click **Close** on the **Edit Class/Region Details** dialog.

3: Overlaying classification results

Objectives Learn how to display a Classified image using transparency over a reference image, and to use a formula and Classification layer to display individual classes.

Open the Landsat TM 321 algorithm into a new surface

1 From the **View** menu, select **Algorithm** to open the **Algorithm** dialog.

2 From the **File** menu (on the main menu), select **Open into New Surface**.

3 From the **Directories** menu, select the **\examples** path.

4 Open the ‘Data_Types’ directory, then open the ‘Landsat_TM’ directory.

5 Double-click on the algorithm ‘RGB_321.alg’ to open it.

An algorithm (and it layers) are added as a second surface in the current algorithm. (This displays the Landsat TM image in “natural color, “ or RGB=321.)

Set transparency for the classified image

1 Select the top surface ‘[RGB]:Default Surface’ in the algorithm.

Since the classified image is on top of the RGB image, you must set transparency for it to see the RGB image underneath.

2 Click the **Surface** tab.

3 Set the ‘Transparency’ slider to its mid-point.

The two images are blended so colors from both are visible.

4 Adjust the ‘Transparency’ slider to various settings.

By shifting the transparency back and forth to different levels, you can quickly see how the natural color image underneath corresponds to the classes and colors of your classified image. This can be an effective way to compare the results of your classification to a reference image.

Add a Classification layer to the Landsat image surface

1 Click the **Layer** tab in the **Algorithm** dialog to display the process diagram.

2 Right-click on the top surface ‘[RGB]:Default Surface,’ and select **Turn Off**.

The classified image’s surface is off, so it will not be displayed.

3 Select the lower surface ‘[RGB]:Landsat TM’ in the algorithm.

4 On the **Algorithm** dialog, open the **Edit** menu, select **Add Raster Layer**, then **Classification**.

A Classification layer is added to the algorithm layer list.

5 Click the **Load Dataset** button in the process diagram.

6 From the **Directories** menu, select the **\examples** path.

7 Open the “Miscellaneous” directory.

8 Open the ‘tutorial’ directory, then double-click on your ‘10_class_ISOCLASS.ers’ image to load it.

9 In the process diagram, click the **Edit Layer Color** button.

10 Choose a yellow color, then click **OK** on the **Color** chooser dialog.

Add a formula to display pixels in individual classes

1 On the **Algorithm** dialog, click the **Edit Formula** button in the process diagram.

2 In the Generic formula window, edit the formula text to read:

```
if input1=1 then 1 else null
```

This formula tells ER Mapper “if pixels have a value of 1 (class 1) in the image, assign them a value of 1 for display, else assign them a value of null.”

3 Click the **Apply changes** button to validate the formula.

The ocean areas (class 1) display in yellow over the backdrop RGB image.

Display other classes over the backdrop image

1 In the Generic formula window, edit the formula text to read:

```
if input1=4 then 1 else null
```

This will display class 4 in yellow.

2 Click the **Apply changes** button to validate the formula.

The natural vegetation areas (class 4) display in yellow over the backdrop RGB image. This is another way to help identify the feature class represented by a particular cluster (class number), or assess the accuracy of a classification.

3 (Optional.) If desired, edit the formula to display any other class number by changing **`input1=x`** to a value 1-10. Choose any color desired.

Close the image window and Algorithm dialog

1 Close the image window using the window system controls:

- Select **Close** from the window control-menu.

2 Click **Close** on the **Algorithm** dialog.

Only the ER Mapper main menu should be open on the screen.

What you learned...

After completing these exercises, you know how to perform the following tasks in ER Mapper:

- Specify clustering parameters and perform an unsupervised classification
- Assign colors and feature class names to the classified image
- Display a classified image using a Class Display layer
- Compare a classified image to a reference image

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Supervised classification

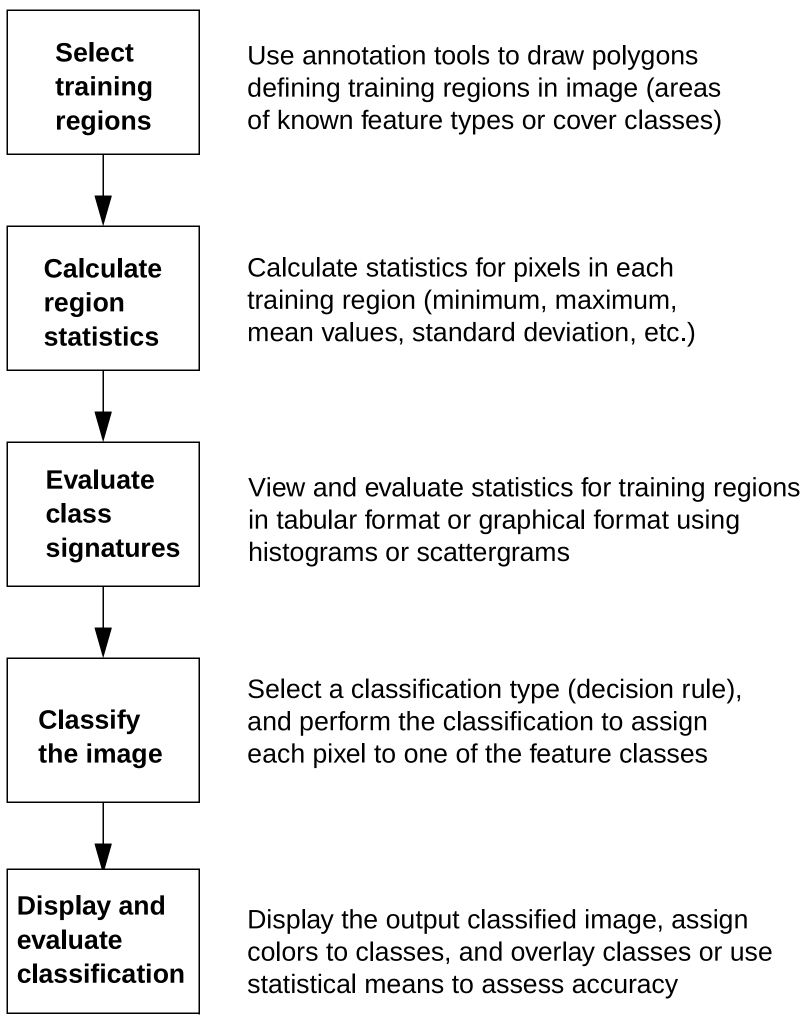
This chapter explains how to use ER Mapper's supervised classification features to transform multispectral image data into user-defined thematic information classes. You will learn to choose define training regions, perform a supervised classification, and assign colors to the classes.

About supervised classification

Supervised classification is one of two methods used to transform multispectral image data into thematic information classes (unsupervised classification being the other). This procedure typically assumes that imagery of a specific geographic are gathered in multiple regions of the electromagnetic spectrum, for example Landsat TM or SPOT XS multispectral satellite imagery. (Classification can also be effective for other types of imagery. Please refer to an appropriate reference text for complete information on classification.)

In supervised classification, the identity and location of feature classes or cover types (urban, water, wetland, etc.) are known beforehand through field work, analysis of aerial photographs, or other means. You typically identify specific areas on the multispectral imagery that represent the desired known feature types, and use the spectral characteristics of these known areas to "train" the classification program to assign each pixel in the image to one of these classes. Multivariate statistical parameters such as means, standard deviations, and correlation matrices are calculated for each training region, and each pixel is evaluated and assigned to the class to which it has the most likelihood of being a member (according to rules of the classification method chosen).

A simplified procedure for performing a supervised classification is as follows:



Hands-on exercises

These exercises give you practice defining training regions and using ER Mapper's Supervised Classification features to perform a classification.

What you will learn...

After completing these exercises, you will know how to perform these tasks in ER Mapper:

- Draw polygons to define training regions for a supervised classification
- View statistics, histograms, and scattergrams for each training region
- Perform a supervised classification
- Display a classified image using a Class Display layer type

Before you begin...

Before beginning these exercises, make sure all ER Mapper image windows are closed. Only the ER Mapper main menu should be open on the screen.

1: Defining training regions

Objectives

Learn to use ER Mapper's vector annotation tools to define training regions (polygons) representing feature or land cover classes in an image.

About regions: Regions are vector polygons that define an area of interest in an image. Regions can be used to process or display parts of an image separately from others, mask out parts of an image for mosaicing, define training sites as you will do here, and other purposes. The definition of each region is stored in the header file for the raster image.

Create a practice image

1. Click the **Edit Algorithm** toolbar button.

   An image window and the **Algorithm** window appear.

2. On the **Algorithm** window, click the **Load Dataset** button in the process stream diagram to open the file chooser. The **Raster Dataset** dialog box which is the file chooser appears.
3. From the **Directories** menu, select the path ending with the text **\examples**
4. In the directory 'Shared_Data', load the image named 'Landsat_MSS_notwarped.ers.'

5 MSS band 1 (MSS1) will be loaded into the Pseudo Layer.

If the image is very dark, do not do anything about it at this stage.

6 On the Algorithm window click the duplicate button  three times and duplicate the Pseudo Layer with MSS1 three times. You have now 4 Pseudo Layers with MSS1 band.

7 Use the process stream diagram **Band Chooser** for each layer on the **Algorithm** window to load MSS1 (B1:0.55_um) in the first Pseudo Layer, MSS2 (B2:0.65_um) in the second Pseudo Layer, MSS3 (B3:0.75_um) in the third Pseudo Layer and MSS4 (B4:0.95_um) in the fourth Pseudo Layer.

8 By turning off three layers at a time, display each band individually.

9 Edit the band descriptions and type in for band 1 (B1:0.55_um), for band 2 (B2:0.65_um), for band 3 (B3:0.75_um) and for band 4 (B4:0.95_um).

10 Turn on all the four layers.

11 From the File menu on the main menu select **Save As...**. Select **ER Mapper Raster Dataset (.ers**) as the file type and save it in the examples\Miscellaneous\Tutorial directory as ‘Landsat_practice.ers’.

Tip: To maintain the original dynamic range of the image, select the delete transforms option when saving it.

Load the practice image and display it as a RGB composite

1 On the **Algorithm** window, click the **Load Dataset**  button in the process stream diagram to open the file chooser.

2 From the **Directories** menu, select the path ending with the text **\examples**.

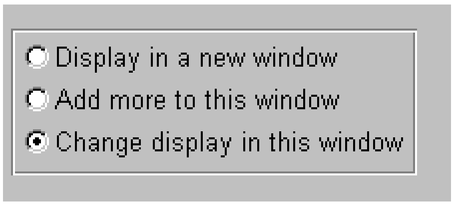
3 Open the ‘Miscellaneous’ directory.

4 In the directory ‘tutorial,’ double-click on the image named ‘Landsat_practice.ers’.

5 On the main menu click on the **Image Display and Mosaicing Wizard**  button.

The **Image Display and Mosaicing Wizard** dialog box opens.

6. Select **Change display in this window**, and click on the **Next>** button.



7. Select **Red Green Blue**, and click on the **Next>** button.

   A status window will display the progress as the ‘Landsat_practice’ image is displayed as RGB composite.

8. Click on the **Finish** button to close the Image Wizard.
9. Drag the image window by the lower-right corner to make it about 50% larger.
10. Right-click on the image and select **Zoom to All Datasets** from the **Quick Zoom** menu.

    ER Mapper will redraw the image to fit into the enlarged window.

    You will next draw polygons to define several feature classes in the image.

Add a vector layer for region definition to your algorithm

1. From the **Edit** menu, select **Edit/Create Regions...**.

   The **New Map Composition** dialog box opens.

2. In the **New Map Composition** dialog, notice that the **Raster Region** option is selected.

Note: The **Raster Region** option tells ER Mapper that the annotation layer will be used to create regions for a raster image (for use in training site selection in this case).

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3. Click **OK** on the **New Map Composition** dialog box.
4. ER Mapper opens the **Tools** palette dialog box containing your vector annotation tools. Also notice that a new vector layer titled ‘Region Layer’ has been added to the layer list in the **Algorithm** window.
5. From the **File** menu (on the main menu), select **Save As...** to save the algorithm under your own name with the new page extents information.
6. In the **Files of Type:** field, select ’ER Mapper Algorithm (.alg)’.
7. From the **Directories** menu, select the path ending with the text **\examples**.
8. Double-click on the directory ‘Miscellaneous’ to select it.

9 Double-click on the directory 'Tutorial' to open it.

10 In the **Save As:** text field, type a name using your initials at the beginning, followed by the text 'land_use_regions.' Separate each word with an underscore (_). For example, if your initials are "KA," type in the name:

```
KA_land_use_regions
```

11 Click **OK** or **Save** to save the algorithm, which now includes your Page Setup parameters.

12 Click **Close** on the **Algorithm** window to close it.

Open the Geoposition dialog box

1 From the **View** menu, select **Geoposition...**.

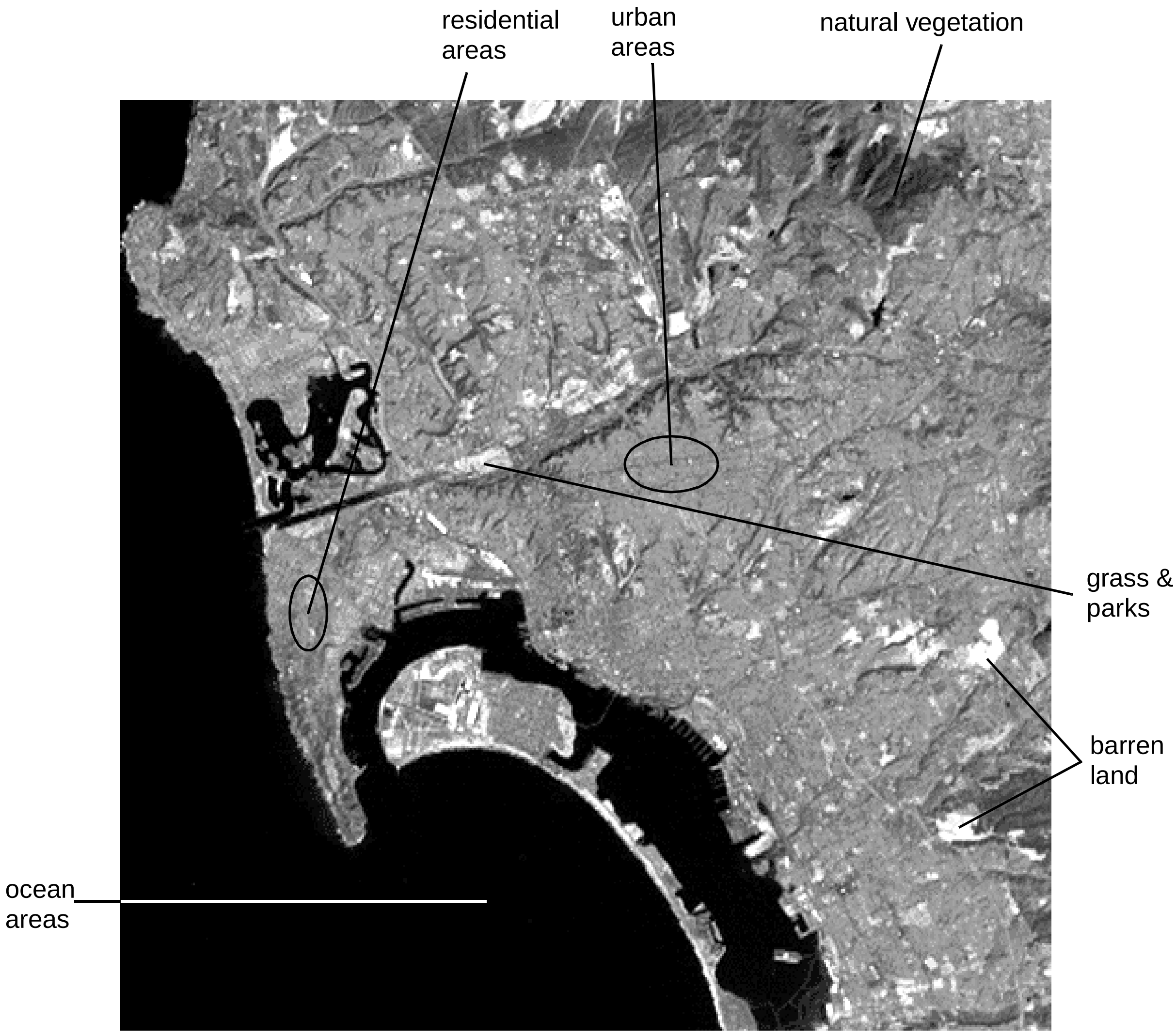
The **Algorithm Geoposition Extents** dialog box opens. Move it to the right side of the screen.

2 Select the **Zoom** option to display buttons for zooming and panning.

You will use these options to help zoom in and out of areas as you define your training region polygons.

Define training regions on the image

1 Use the following diagram as a guide to help locate training regions in the image. You are asked to define these regions in the next steps.



Define a region to represent ocean areas

1 On the **Tools** palette dialog, click the **ZoomBox Tool** button.

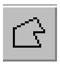
2 Zoom in on the lower-left quarter of the image.

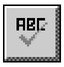
The large portion of dark blue area is ocean in this scene.

3 On the **Tools** palette dialog, click on the **Polygon** button.

4 Point to an area of ocean and draw a polygon by clicking once at each point, then double-clicking to close the polygon. (Make your polygon fairly large to get a good sample.)

The polygon is selected by default when you close it. Since it is selected, you can now add a color and text attribute to give the polygon a name.

5 On the **Tools** dialog, double-click the **Polygon**  button to open the **Line Style** dialog box.

6 On the **Tools** dialog, click the **Display/Edit Object Attributes**  button to open the **Map Composition Attribute** dialog box

Position the **Line Style** and **Map Composition Attribute** dialogs in a convenient position on the screen. You will leave these dialogs open while you define regions so you can assign a color and name to each region as you go. (The colors you assign becomes the default class colors in the output classified image.)

7 In the **Line Style** dialog, click the **Set Color** button, choose a blue color, and click **OK** to close the color chooser.

8 In the **Map Composition Attribute** dialog, enter the text **`Ocean`** in the text field at the bottom, then click the **Apply** button.

The text “Ocean” is now defined as a the name or text attribute of the polygon.

You have now defined a training region representing ocean areas in the image. When you calculate statistics for this image later, the statistics for pixels inside this region will be used as a “signature” to classify other areas of ocean in the image.

Define a region to represent natural vegetation

1 On the **Geoposition** dialog, click **All Datasets** to zoom back out.

2 On the **Tools** palette dialog, click the **ZoomBox Tool**  button.

3 Zoom in on the upper-right quarter of the image.

The dark brown areas at the top of the image are natural vegetation.

4 Click on the **Polygon**  button.

5 Draw a polygon to define a large area of natural vegetation (click once at each point, then double-click to close the polygon).

The polygon becomes selected when you close it.

6 In the **Line Style** dialog, click **Set Color**, choose a dark green color, and click **OK** to close the color chooser.

7 In the **Map Composition Attribute** dialog, enter the text **`Natural vegetation`** in the text field at the bottom, then click the **Apply** button.

You have now defined a training region representing natural vegetation.

Define a region to represent grass and park areas

1. On the **Geoposition** dialog, click **All Datasets** to zoom back out.
2. On the **Tools** palette dialog, click the **ZoomBox Tool** button.
3. Zoom in on one of the small, bright red areas (there is one in the river valley running east to west). Zoom in far enough so the bright red area fills most of the image window.

   These are parks, golf courses, or other irrigated artificial vegetation.

4. Click on the **Polygon** button and digitize a polygon around the border of the bright red park area.
5. In the **Line Style** dialog, click **Set Color**, choose a bright green color, and click **OK** to close the color chooser.
6. In the **Object Attribute** dialog, enter the text **`Grass and parks`** in the text field at the bottom, then click the **Apply** button.

   You have now defined a training region representing grass and park areas.

Define a region to represent urban areas

1. On the **Geoposition** dialog, click **All Datasets** to zoom back out.
2. On the **Tools** palette dialog, click the **ZoomBox Tool** button.
3. Zoom in on the grey areas near the center of the image.

   These are developed urban areas.

4. Click on the **Polygon** button and digitize a polygon around the border of the grey urban area (do not include red vegetated areas on the edges).
5. In the **Line Style** dialog, click **Set Color**, choose a grey color, and click **OK** to close the color chooser.
6. In the **Map Composition Attribute** dialog, enter the text **`Urban areas`** in the text field at the bottom, then click the **Apply** button.

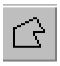
   You have now defined a training region representing urban areas.

Define a region to represent residential areas

1. On the **Geoposition** dialog, click **All Datasets** to zoom back out.
2. On the **Tools** palette dialog, click the **ZoomBox Tool** button.

3 Zoom in on one of the pink area in the northern part of the peninsula as shown in the previous diagram.

This area is primarily residential housing, so it has both buildings (houses) and vegetated areas (grass and trees).

4 Click on the **Polygon**  button and digitize a polygon around the pink areas described.

5 In the **Line Style** dialog, click **Set Color**, choose a pink color, and click **OK** to close the color chooser.

6 In the **Map Composition Attribute** dialog, enter the text **`Residential areas`** in the text field at the bottom, then click the **Apply** button.

Define a region to represent barren land areas

1 On the **Geoposition** dialog, click **All Datasets** to zoom back out.

2 On the **Tools** palette dialog, click the **ZoomBox Tool**  button.

3 Zoom in on the lower-right quarter of the image.

There are several areas of barren land here that appear white on the image (since they have high reflectance in all three MSS bands).

4 Click on the **Polygon**  button and digitize a polygon around the border of one of the barren white areas (do not include other areas on the edges).

5 In the **Line Style** dialog, click **Set Color**, choose a light brown color, and click **OK** to close the color chooser.

6 In the **Map Composition Attribute** dialog, enter the text **`Barren land/cement`** in the text field at the bottom, then click the **Apply** button.

You have now defined training regions representing ocean, natural vegetation, grass/parks, urban and residential areas, and barren land areas.

Tip: To define multiple polygons to be used as a single statistical region, assign all the polygons the same text attribute name. ER Mapper combines statistics for any regions with the same name automatically.

Save the regions to the Landsat MSS practice image

1 On the **Tools** palette dialog, click the **Save As**  button.

The **Map Composition Save As** chooser dialog appears.

2 From the **Directories** menu, select the path ending with the text **\examples**.

3 Double-click on the directory ‘Miscellaneous’ to open it.

4 Double-click on the directory ‘Tutorial’ to open it.

5 Click on the image named ‘Landsat_practice’ to select it, then click **OK**.

6 When asked to confirm the overwrite, click **OK** to proceed. After the next dialog indicates all your new regions were added, click **Close** to close it.

The regions definitions and names are saved to the header file of the ‘Landsat_practice’ image. You can now calculate statistics for the pixels in each region.

7 Click **Close** on the **Tools** palette and **Geoposition** dialogs to close them.

Calculate statistics for the new regions

1 From the **Process** menu, select the **Calculate Statistics**.

The **Calculate Statistics** dialog box appears.

The ‘Landsat_practice’ image should be chosen by default because it is the image used in the current algorithm. (If it is not chosen, load it from the ‘tutorial’ directory).

2 Set the **Subsampling Interval** to **1**.

3 Select the **Force Recalculate stats** option (to calculate statistics again in case they have previously been calculated).

4 Click **OK** to start the statistics calculation.

5 When the calculation is finished, click **OK** in the dialog indicating successful completion, then close the other statistics dialogs with **Close** or **Cancel**.

2: View training statistics

Objectives Learn to view statistics for training regions in tabular format, view histograms of data values in the training class regions, and view class means and 95% probability ellipses over a scattergram.

View tabular statistics for the training regions

1 From the **View** menu, select the **Statistics**, then select **Show Statistics**.

The **Statistics Report** dialog box appears. The ‘Landsat_practice’ image should be selected by default. You can choose to view statistics for selected regions or bands in the image, or for all regions and bands.

2 Click **OK** to display statistics for the all the regions you defined.

The display image Statistics dialog opens showing statistics for all your regions in all four Landsat MSS image bands.

3 Scroll through the list to view statistics for your training regions (make the dialog larger if needed).

(The last region listed named ‘All’ is the entire image. This region is present in every image header file.)

4 When finished viewing statistics, click **Cancel** on the **Statistics Report** dialog to close both dialogs.

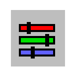
Add a Classification layer and load the Landsat image

1 Click the **Edit Algorithm**  toolbar button to open the **Algorithm** window.

2 Click on the ‘Region Layer’ layer to select it, then click **Delete** to delete the layer. (You no longer need it for this exercise.)

3 From the **Edit/Add Raster Layer** menu, select **Classification**.

A Classification layer is added to the algorithm layer list.

4 In the process diagram, click the **Edit Layer Color**  button.

5 Choose a bright yellow color, then click **OK** to close the color chooser.

6 In the process diagram, click the **Load Dataset**  button.

7 From the **Directories** menu, select the path ending with the text **\examples**

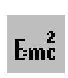
8 Double-click on the ‘Miscellaneous’ directory to open it.

9 Double-click on the ‘Tutorial’ directory to open it.

10 Double-click on the image ‘Landsat_practice’ to load it.

You can now use the Classification layer to display a training region in yellow on the image and show its histogram in any band.

Enter a formula to display a region

1 Click the **Edit Formula**  button in the process diagram to open the **Formula Editor** dialog.

2 In the Generic formula window, edit the formula text to read:

```
if inregion(region1) then input1 else null
```

This formula tells ER Mapper to process and display the data inside the region chosen as region 1 in yellow on the image.

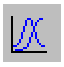
3 Click the **Apply changes** button.

Notice that the **Inputs** and **Regions** buttons above the Relations window are now active. Image band 1 is assigned to generic input1 by default.

4 Click the **Regions** button, select **Grass/Parks** from the drop-down list next to 'REGION1.'

Your **Grass/Parks** region is displayed in yellow over the RGB image.

View the histograms for the Grass/Parks region

1 Click on the post-formula **Edit Transform Limits**  button to open the **Transform** dialog box. Move it so it does not overlap with the image window or Formula dialog.

2 From the **Limits** menu, select **Limits to Actual**.

The histogram for the pixels in band 1 of the training region 'Grass/Parks' appears in the histogram window.

3 In the **Formula** dialog, click the **Inputs** button, then select **B3:0.75_um** from the 'INPUT1' drop-down list.

4 From the **Limits** menu, select **Limits to Actual**.

Note: Since the data range is different for each band and region, you need to use **Limits to Actual** each time you change the band or region. Otherwise the new histogram may not fully display due to the limits set for the previous one.

The histogram for the pixels in band 3 of the training region 'Grass/Parks' appears in the histogram window. By changing the assignments in the Relations window, you can view a histogram for any band and region combination in the image. The histogram provides important information about the distribution and range of data values in your training regions.

5 If desired, view histograms for other region and/or band combinations using the steps listed previously.

6 When finished, click **Close** on the **Formula Editor** dialog, and **Close** on the **Algorithm** window.

View a scattergram for the MSS image

1 From the **View** menu, select **Scattergrams...**.

The **Scattergram** dialog box and **New Map Composition** dialog boxes open. Notice that the **New Map Composition** dialog already has **Raster Regions** selected and the name of your image entered.

2 Click **OK** on the **New Map Composition** dialog.

The annotation **Tools** dialog opens and the **Scattergram** dialog automatically references the image in the active image window (‘Landsat_practice’). Notice also that your region polygons are shown on the image in their assigned color.

Set the scattergram bands and limits

1 In the **Scattergram** dialog, click the **Setup...** button.

2 In the **Scattergram Setup** dialog, select band 2 for the **X Axis** field, and band 4 for the **Y Axis** field.

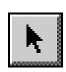
3 Click the **Limits to Actual** button to set the X and Y axis limits to the actual data ranges of bands 2 and 4.

The scattergram for image bands 2 (red light) and 4 (near infrared light) is redisplayed to fill the window. The wide dispersion of points in the scattergram indicates that the information in these two bands is not strongly correlated.

Display mean and probability ellipses for training regions

1 In the **Scattergram Setup** dialog, turn on the **From current selection** option.

This tells ER Mapper that you want to display the mean value and 95% probability ellipse for the currently selected region polygons in the image.

2 On the **Tools** dialog, click the **Select and Edit Points Mode**  button.

3 In the image, select the grey polygon defining your ‘urban’ class training region (click on a line segment).

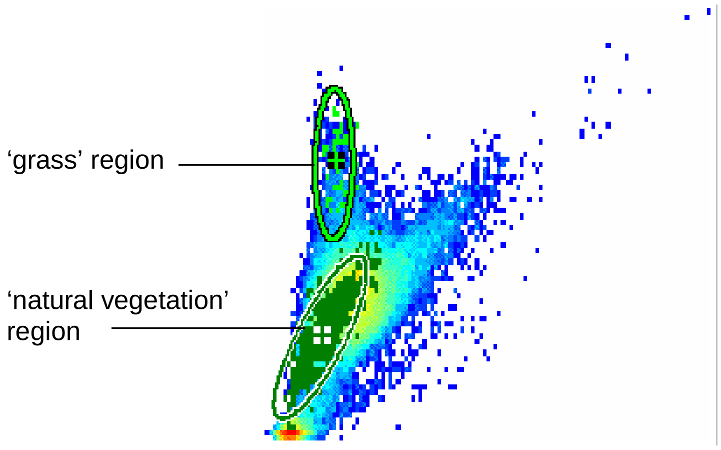
A grey ellipse appears over the scattergram showing the 95% probability threshold and mean value (the ellipse center point) for the ‘urban’ class in bands 2 and 4. (The ellipse extents represent the probability that an unknown pixel is a member of that class at the 95% confidence level.)

4 In the image, select the green polygon defining your ‘grass’ class training region.

A green ellipse appears on the scattergram. As indicated, green vegetation shows a strong response in MSS band 4 (near infrared), but low response in band 2.

5 Hold down the Shift key, then click on the dark green ‘natural vegetation’ polygon in the image.

Ellipses for both the ‘grass’ and ‘natural vegetation’ regions appear on the scattergram, so you can easily compare them. Comparing region means and ellipses in an excellent way to evaluate the separability of your class signatures.



Tip: To select multiple polygons, hold down the Shift key while clicking.

Close the scattergram dialogs

1 Click **Close** on the annotation **Tools** dialog to close it.

2 Click **Cancel** on the **Scattergram Setup** dialog to close it, then click **Cancel** to close the **Scattergram** dialog.

3: Classifying the image

Objectives Learn how to use the training region statistics to perform a supervised classification on the entire image that assigns each pixel to one of the six feature classes you defined.

Open the Supervised Classification dialog box

1 From the **Process** menu, select **Classification**, then select **Supervised Classification**.

The **Supervised Classification** dialog box opens. The ‘Landsat_practice’ image is already chosen as the default input image.The dialog also lets you choose which bands of the image to use for the classification, and the type of classification (or decision rule) to use.

2 Click the **Output Dataset** chooser button.

3 From the **Directories** menu, select the path ending with the text **\examples**.

4 Double-click on the ‘Miscellaneous’ directory to open it.

5 Double-click on the ‘Tutorial’ directory to open it.

6 In the **Save As** field, type a name using your initials at the beginning followed by the text ‘max_like_class,’ and separate each word with an underscore (_). For example, if your initials are “KA,” type in the name:

```
KA_max_like_class
```

7 Click **OK** or **Save** to validate the name and close the file chooser dialog.

Setup the classification type and parameters

1 Click the **Classification Type** drop-down to see the list.

ER Mapper provides Maximum Likelihood Enhanced, Minimum Distance, Minimum Distance with a standard deviation, Parallelopiped, and Mahalanobis classifiers.

2 From the **Classification Type/Maximum Likelihood Enhanced** menu, select **Maximum Likelihood Standard**.

3 Click the **Setup** button.

The **Supervised Classification Setup** dialog box opens. This dialog allows you to setup the options used for the classification, including which training regions to use (from this or other images), assigning class probabilities, and other options. By default, the five regions in your practice image are displayed.

4 Click the **Close** button to close the **Supervised Classification Setup** dialog box.

Classify the image

1 Click the **OK** button to start the classification.

2 When asked to confirm the successful completion, click **OK**. Then click **Close** and **Cancel** on the other two dialogs to close them.

The output of the classification is a single band image. Each pixel in the image is has a value ranging from 1 to 6 (the number of training regions you specified).

Open a second window and template algorithm

1 Click the **New** toolbar button.

An image window appears.

2 Drag the new window down below the one displaying the Landsat image.

3 Click the **Open** toolbar button.

4 From the **Directories** menu, select the path ending with the text **\examples**.

5 In the directory ‘Miscellaneous\Templates\Common’, load the algorithm named ‘Classified_data.alg.’

A classified image of San Diego displays. This is a template algorithm you will use to display your classified image.

Load the classified image you created earlier

1 Click the **Edit Algorithm** toolbar button.

Notice that this algorithm has one layer of the type Class Display. The Class Display layer is designed to display images created with ER Mapper’s classification functions.

2 In the process diagram, click the **Load Dataset** button.

3 From the **Directories** menu, select the path ending with the text **\examples**.

4 Double-click on the ‘Miscellaneous’ directory to open it.

5 In the directory ‘Tutorial,’ double-click on the image ‘max_like_class’ you created earlier to load it.

Each pixel in the original Landsat image is assigned to one of the six training classes you defined earlier. The class colors are those you defined for the training region polygons.

6 From the **Edit** menu (on the main menu), select **Edit Class/Region Color and Name**.

The Edit Class/Region Details dialog opens showing the name and color assigned to each class. If desired, you could change them here.

7 Click Cancel on the **Edit Class/Region Details** dialog to close it.

Close all image windows and dialog boxes

1 Click **Close** on the **Algorithm** window to close it.

2 Close all image windows using the window system controls:

- Select **Close** from the window control-menu.

3 Click **Close** on the **Algorithm** window to close it.

Only the ER Mapper main menu should be open on the screen.

4: Generating Confusion Matrices

Objectives Learn how to use the ER Mapper Confusion Matrix facility to test the accuracy of the Supervised Classification, using the original training regions as a reference.

Overview

The ER Mapper Confusion Matrix facility tests a classified image against a reference dataset, and then generates the following types of matrices:

- Row counts
- User's accuracy
- Producer's accuracy

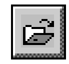
It also displays the Overall accuracy and the Kappa statistics.

All of these can give a good indication of the classification accuracy. For more information on these matrices refer to Chapter 24, "Supervised and Unsupervised Classification" in the *ER Mapper User Guide*.

Obviously, the reference data is crucial in creating the matrices. One method of obtaining this reference data is to establish sample "ground truth" points on the image, and then to physically go to where the points are located in the field to verify the actual class to which they belong. The information from these points can then be collated into an ASCII XYZ text file in which each line represents a single sample point. The information for each point includes the X and Y coordinates of the location of the point, and the number and label of the class to which the point belongs. This file can be imported as an ER Mapper vector dataset via the **Utilities / Import Vector and GISformats / ASCII Points with Attributes** menu option. You can then enter this vector file as the reference dataset to generate confusion matrices. This reference should be very accurate because the sample points been physically verified in the field. The accuracy of the confusion matrices depends on the number of sample points and how they are distributed over the classes.

Another source of reference data is the actual training regions that were used to classify the image under test. This will provide you with a very good indication of how accurate the classification was, and the effectiveness of the training regions. The ER Mapper Confusion Matrix facility accepts only classified images or vector images with points and attributes as reference datasets. Training regions are neither of these, so it is necessary to create a classified image that includes only the areas within the training regions. This exercise describes how this is done.

Load and display the practice image

1 On the ER Mapper **Standard Toolbar**, click the **Open**  button to open the file chooser.

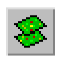
2 From the **Directories** menu, select the path ending with the text **\examples**.

3 Open the ‘Miscellaneous’ directory.

4 In the directory ‘tutorial,’ double-click on the image named ‘Landsat_practice.ers’.

The original Landsat MSS practice image will be displayed with Bands 1, 2 and 3 in Blue, Green and Red bands respectively.

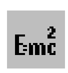
5 If necessary, you can click on the **99% Contrast Enhancement** button  to make the image visible.

6 Click the **Edit Algorithm**  toolbar button to open the **Algorithm** window.

Add a formula to each layer

We will add a formula to each layer that excludes those parts of the image that do not fall within the training regions that were previously added to this image.

1 On the **Algorithm** window, click on the Red layer to highlight it.

2 Click the **Edit Formula**  button in the process diagram to open the **Formula Editor** dialog.

3 In the Generic formula window, edit the formula text to read:

```
if inregion(region1) or inregion(region2) or
inregion(region3) or inregion(region4) or
inregion(region5) or inregion(region6) then INPUT1 else
null
```

This formula tells ER Mapper to process and display the image data inside the regions. Areas that fall outside the regions are not displayed.

4 Click the **Apply changes** button.

Notice that the **Inputs** and **Regions** buttons above the Relations window are now active. Image band 3 is assigned to generic INPUT1 by default.

5 Click the **Regions** button, select different Region names from the drop-down list next to ‘REGION1’, ‘REGION2’ etc.

The formula will cause ER Mapper to display in the Red layer only the parts of Band 3 that fall within the regions.

6 On the Formula Editor dialog, click on the Green layer G button to edit the formula in the Green Layer.

7 In the Generic formula window, edit the formula text to read:

```
if inregion(region1) or inregion(region2) or
inregion(region3) or inregion(region4) or
inregion(region5) or inregion(region6) then INPUT1 else
null
```

This formula tells ER Mapper to process and display the image data inside the regions.

8 Click the **Apply changes** button.

Notice that the **Inputs** and **Regions** buttons above the Relations window are now active. Image band 2 is assigned to generic INPUT1 by default.

9 Click the **Regions** button, select a different Region names from the drop-down list next to ‘REGION1’, ‘REGION2’ etc.

The formula will cause ER Mapper to display in the Green layer only the parts of Band 2 that fall within the regions.

10 On Formula Editor dialog, click on the Blue layer B button to edit the formula in the Green Layer.

11 In the Generic formula window, edit the formula text to read:

```
if inregion(region1) or inregion(region2) or
inregion(region3) or inregion(region4) or
inregion(region5) or inregion(region6) then INPUT1 else
null
```

This formula tells ER Mapper to process and display the image data inside the regions.

12 Click the **Apply changes** button.

Notice that the **Inputs** and **Regions** buttons above the Relations window are now active. Image band 1 is assigned to generic INPUT1 by default.

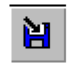
13 Click the **Regions** button, select a different Region names from the drop-down list next to ‘REGION1’, ‘REGION2’ etc.

The formula will cause ER Mapper to display in the Blue layer only the parts of Band 2 that fall within the regions.

14 Close the **Formula Editor** by clicking on the **Close** button.

Save as a Virtual Dataset

We now save the algorithm as a virtual dataset, so that it can be used to create a classified image.

1 On the **Standard** toolbar, click on the **Save As**  button.

2 In the **Files of Type:** field, select 'ER Mapper Virtual Dataset (.ers)'.

3 From the **Directories** menu, select the path ending with the text **\examples**.

4 Double-click on the directory 'Miscellaneous' to select it.

5 Double-click on the directory 'Tutorial' to open it.

6 In the **Save As:** text field, type a name using your initials at the beginning, followed by the text 'land_use_region_vds.' Separate each word with an underscore (_). For example, if your initials are "KA," type in the name:

`KA_land_use_regions_vds`

7 Click **OK** or **Save** to save the virtual dataset.

8 Answer **Yes** to the "Delete final transforms for virtual dataset?" query.

Add the Region layer to the virtual dataset

We now need to add the region layer from the 'Landsat_practice.ers' dataset to the newly created virtual dataset.

1 On the **Algorithm** window, select **Edit / Add Vector Layer / Region Layer**.

This will add a new Region Layer to the algorithm.

2 In the Region layer process diagram, click the **Load Dataset**  button.

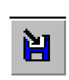
3 From the **Directories** menu, select the path ending with the text **\examples**.

4 Double-click on the 'Miscellaneous' directory to open it.

5 In the directory 'Tutorial,' double-click on the image 'Landsat_practice' to load it.

The Regions will now be displayed over the image. The areas of the image displayed should be bounded by the Region polygons.

6 In the process diagram, click the **Annotate Vector Layer**  button to open the **Tools** dialog.

7 On the Tools dialog, click on the Save As  button.

This will open the **Map Composition Save As** dialog.

8 In the **Save As** box, select **Raster Region**.

9 Click on the file chooser button in the **Save To File:** field.

10 From the **Directories** menu, select the path ending with the text **\examples**.

11 Double-click on the directory ‘Miscellaneous’ to select it.

12 Double-click on the directory ‘Tutorial’ to open it.

13 Select the name of the virtual dataset you created; e.g. ‘KA_land_use_regions_vds’ and click **OK**.

14 Click **OK** on the **Map Composition Save As** dialog to save the region layer to the Virtual Dataset.

15 Answer **Yes** to overwriting the file.

The ER Mapper Message Window will indicate that it is adding new regions to the virtual dataset.

Close all image windows and dialog boxes

1 Click **Close** on the Message Window to close it

2 Click **Close** on the Tools dialog to close it.

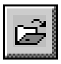
3 Click **Close** on the **Algorithm** window to close it.

4 Close all image windows using the window system controls:

Open the Supervised Classification dialog box

1 From the **Process** menu, select **Classification**, then select **Supervised Classification**.

The **Supervised Classification** dialog box opens.

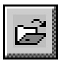
2 Click the **Input Dataset**  chooser button.

3 From the **Directories** menu, select the path ending with the text **\examples**.

4 Double-click on the ‘Miscellaneous’ directory to open it.

5 Double-click on the ‘Tutorial’ directory to open it.

6 Double-click on the name of the virtual dataset you created; e.g. ‘KA_land_use_regions_vds’.

7 Click the **Output Dataset**  chooser button.

8 From the **Directories** menu, select the path ending with the text **\examples**.

9 Double-click on the ‘Miscellaneous’ directory to open it.

10 Double-click on the ‘Tutorial’ directory to open it.

11 In the **Save As** field, type a name using your initials at the beginning followed by the text ‘land_use_regions_vds_class,’ and separate each word with an underscore (_). For example, if your initials are “KA”, type in the name:

`KA_land_use_regions_vds_class`

12 Click **OK** or **Save** to validate the name and close the file chooser dialog.

13 Click the **Classification Type** drop-down to see the list.

14 From the **Classification Type/Maximum Likelihood Enhanced** menu, select **Maximum Likelihood Standard**.

15 Click the **OK** button to start the classification.

16 When asked to confirm the successful completion, click **OK**. Then click **Close** and **Cancel** on the other two dialogs to close them.

The output of the classification is a single band image of the training regions. Each pixel in the image has a value ranging from 1 to 6 (the number of training regions you specified).

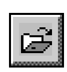
Generate Confusion Matrices

Here we will use the newly classified image as a reference to test the previously classified image Every cell in the reference image becomes a sample point to test the classified image.

1 In the ER Mapper **View** menu, highlight **Statistics**, and then click on **Confusion Matrix...** to select it.

The **Confusion Matrix Setup** dialog box will open.

2 In the **Matrix Type:** field, select ‘Row Counts’

3 Click on the **Reference Dataset** file chooser  button.

4 From the **Directories** menu, select the path ending with the text **\examples**.

5 Double-click on the ‘Miscellaneous’ directory to open it.

6 Double-click on the ‘Tutorial’ directory to open it.

7 Double-click on the name of the classified dataset you created; e.g. ‘KA_land_use_regions_vds_class’.

8 Click on the **Classified Dataset** file chooser  button.

9 From the **Directories** menu, select the path ending with the text **\examples**.

10 Double-click on the ‘Miscellaneous’ directory to open it.

11 Double-click on the ‘Tutorial’ directory to open it.

12 Double-click on the name of the classified dataset you originally created; e.g. 'KA_max_like_class'.

13 Click **OK** to generate the matrix.

The **Confusion Matrix Display** window will display a matrix where the rows show how the image under test has classified the areas within the regions, and the columns show how the reference dataset has classified the same areas.

Depending on how your PC is set up, the display might not be easy to see. You can save it as a text file to view with a text editor.

14 Click on the **Print/Save...** button to open the **Print** dialog.

15 On the **Print** dialog, select **File** as the **Destination**, and **Report** for the **Format**.

16 Click on the file chooser button and select a suitable file name for the text file.

17 Click **OK** to save the text file.

18 Open the text file in a text editor. You may have to do some editing to make it clearer.

An example matrix display (after editing) is shown below:

```
Raw Count Confusion matrix for:
      Reference Dataset  - KA_land_use_regions_vds_class.ers
      Classified Dataset - KA_max_like_class.ers

Overall Accuracy: 99.287% from 20618 observations

Kappa statistic: 0.966

------------------------------------------------------------------------------------
Classified File\Reference File
------------------------------------------------------------------------------------
```

	Barren land	Residential areas	Urban areas	Grass and parks	Natural vegetation	Ocean
Barren land/cement	77	0	0	0	0	0
Residential areas	0	453	8	0	15	0
Urban areas	0	13	426	0	0	0
Grass and parks	0	0	0	83	0	0
Natural vegetation	0	13	1	0	1186	45
Ocean	0	0	0	0	52	18246

From the above, we can see that the reference dataset provided 20,618 sample points (cells). Of these 99.287% were classified correctly in the classified image. The Kappa statistic of 0.966 indicates that the classification is 96.6% better than that expected if we had randomly assigned a class to each image pixel in the classified image.

The 'Barren land' classification appears to be accurate because, of the 77 points on the training regions, all were classified correctly in the classified image. The training region for 'Natural vegetation' was somewhat larger, providing 1253 sample points. Of these, the classified image classified 15 as 'Residential areas' and 52 as 'Ocean'.

19 On the **Confusion Matrix Setup** dialog box select **User's Accuracy** as the **Matrix Type**, and click **OK**.

The **Confusion Matrix Display** window will display a matrix showing the User's Accuracy in classification. This is the percentage of sample points that the classified image predicts to be in particular class with which the reference data concurs.

Depending on how your PC is set up, the display might not be easy to see. You can save it as a text file to view with a text editor.

20 Click on the **Print/Save...** button to open the **Print** dialog.

21 On the **Print** dialog, select **File** as the **Destination**, and **Report** for the **Format**.

22 Click on the file chooser button and select a suitable file name for the text file.

23 Click **OK** to save the text file.

24 Open the text file in a text editor. You may have to do some editing to make it clearer.

An example matrix display (after editing) is shown below:

```
Raw Count Confusion matrix for:
      Reference Dataset  - KA_land_use_regions_vds_class.ers
      Classified Dataset - KA_max_like_class.ers

Overall Accuracy: 99.287% from 20618 observations

Kappa statistic: 0.966

------------------------------------------------------------------------------------
Classified File\Reference File
```

	Barren land	Residential areas	Urban areas	Grass and parks	Natural vegetation	Ocean
Barren land/cement	100.0%	0.000%	0.000%	0.000%	0.000%	0.000%
Residential areas	0.000%	95.168%	1.681%	0.000%	3.151%	0.000%
Urban areas	0.000%	2.961%	97.039%	0.000%	0.000%	0.000%
Grass and parks	0.000%	0.000%	0.000%	100.000%	0.000%	0.000%
Natural vegetation	0.000%	1.044%	0.080%	0.000%	95.261%	3.614%
Ocean	0.000%	0.000%	0.000%	0.000%	0.284%	99.716%

From the above, we can see that 'Barren land' had 100% User's accuracy value, indicating that all the sample points were classified correctly.

25 On the **Confusion Matrix Setup** dialog box select **Producer's Accuracy** as the **Matrix Type**, and click **OK**.

The **Confusion Matrix Display** window will display a matrix showing the Producer's Accuracy in classification. This is the percentage of sample points in a particular class in the reference data, that were correct in the classified image.

Depending on how your PC is set up, the display might not be easy to see. You can save it as a text file to view with a text editor.

26 Click on the **Print/Save...** button to open the **Print** dialog.

27 On the **Print** dialog, select **File** as the **Destination**, and **Report** for the **Format**.

28 Click on the file chooser button and select a suitable file name for the text file.

29 Click **OK** to save the text file.

30 Open the text file in a text editor. You may have to do some editing to make it clearer.

An example matrix display (after editing) is shown below:

```
Raw Count Confusion matrix for:
      Reference Dataset  - KA_land_use_regions_vds_class.ers
      Classified Dataset - KA_max_like_class.ers

Overall Accuracy: 99.287% from 20618 observations

Kappa statistic: 0.966

--------------------------------------------------------------------------------
Classified File\Reference File
```

	Barren land	Residential areas	Urban areas	Grass and parks	Natural vegetation	Ocean
Barren land/cement	100.0%	0.000%	0.000%	0.000%	0.000%	0.000%
Residential areas	0.000%	94.572%	1.839%	0.000%	1.197%	0.000%
Urban areas	0.000%	2.714%	97.931%	0.000%	0.000%	0.000%
Grass and parks	0.000%	0.000%	0.000%	100.000%	0.000%	0.000%
Natural vegetation	0.000%	2.714%	0.230%	0.000%	94.653%	0.246%
Ocean	0.000%	0.000%	0.000%	0.000%	4.150%	99.754%

From the above, we can see that ‘Ocean’ had 99.754% Producer’s accuracy value, indicating that not all the sample points in the reference were classified correctly.

Close all windows and dialog boxes

1. Click **Cancel** on the Confusion Matrix display window to close it.
2. Click **Cancel** on the Confusion Matrix Setup dialog to close it.

What you learned...

After completing these exercises, you know how to perform the following tasks in ER Mapper:

- Draw polygons to define training regions for a supervised classification
- View statistics, histograms, and scattergrams for each training region
- Perform a supervised classification
- Display a classified image using a Class Display layer type
- Prepare Training Regions to be used as the reference to generate Confusion Matrices
- Generate and display Confusion Matrices to determine the classification accuracy.

20

Change Detection

This chapter discusses change detection techniques that can be applied to new road development, urban development, crop and forest monitoring, land degradation and any application that requires change detection.

About monitoring landuse

With the availability of multi-temporal images, be they Airborne, Satellite or Airphotos, monitoring landuse using image processing becomes viable. The application of change detection techniques on multi-temporal images is also easy, reliable and effective. By applying change detection techniques on multi-temporal images changes in land cover can be monitored and determined. It also enables organisations to maintain the integrity of the data that they manage. Multi-temporal imagery can be processed to highlight changes in pixel spectral response between image dates. Such information can be used in the decision making process, or used to monitor changes over time as an aid to updating information databases.

Change detection techniques are used to highlight new road development, urban development, crop and forest monitoring, land degradation and any application that requires change detection.

Reliable result

To obtain reliable results from processing multi-temporal imagery using change detection methods, the imagery of different dates should be rectified to the same co-ordinate system. (This is covered in the chapter on image rectification). The more accurate the image rectification is, the better and more reliable your result will be. The second important factor is the compatibility of the dynamic range of the imagery of the different dates. Since multi-temporal images are taken at different dates, the atmospheric effects will be different on the images. Hence atmospheric correction is necessary. A simple way to rectify the atmospheric problem is to apply dark pixel correction to the temporal images prior to carrying out change detection on the multi-temporal images.

Standardising atmospheric effects using Dark Pixel Correction

The aim of standardising atmospheric effects using dark pixel correction is to reduce atmospheric effects on imagery and normalise scenes for comparison. Dark Pixel Correction technique involves subtracting the pixel value of the darkest pixel over water from all pixel values in the same image. This is a quick and easy technique and assumes that the atmosphere has affected each pixel in the dataset equally. This cannot always be assumed, and care should be taken.

The standardising atmospheric effects using dark pixel correction technique is made easier by opening up two windows, one with each dataset, and geolinking them so that, at all times, they show the same ground area. It is best to select an area of the image where pixel values are relatively uniform such as a waterbody. By using the Cell Values Profile window, you can determine corresponding pixel responses in each dataset, and build up a table that will allow you to work out if one dataset exhibits brighter or darker responses on average. You should sample at least 20 pixels across the entire image in order to establish an appropriate pattern. If, on average, the pixels in image A are brighter or darker than image B by a constant amount, then you can standardise the images by altering the formula of one image to read Input1 + (or) - (some constant value). You will need to save this as a new dataset in order to carry out any further processing.

Hands-on exercises

These exercises give you practice using formula to carryout change detection on multi-temporal images. The multi-temporal images used are TM images of SanDiego taken in 1985 and 1991. The datasets are in the '\examples\Shared_Data' directory and the dataset names are 'Landsat_TM_year_1985.ers and Landsat_TM_year_1991.ers'. Both datasets have been rectified..

What you will learn...

After completing these exercises, you will know how to perform these tasks in ER Mapper:

- Eliminate seasonal and atmospheric effects
- Create Virtual Dataset containing of multi-temporal images
- Red Green difference change detection method
- Image Differencing change detection method
- Band Ratioing change detection method
- Principal Components Analysis change detection method

Before you begin... Before beginning these exercises, make sure all ER Mapper image windows are closed. Only the ER Mapper main menu should be open on the screen.

1:Eliminating seasonal and atmospheric effects

Objectives Learn to reduce the difference in the atmospheric effects on the two temporal images using dark pixel correction technique.

Open an image window and the Algorithm window to load Landsat_TM_year_1985 image

Before you begin... Before beginning this exercise, make sure all ER Mapper image windows are closed. Only the ER Mapper main menu should be open on the screen.

1 On the Standard toolbar, click on the **View Algorithm for Image Window** button.

An image window and the **Algorithm** window appear.

2 Click on the **Layer tab** to view the settings for the layer.

3 On the **Algorithm** window, click the **Load Dataset** button on the left side of the process stream diagram.

The **Raster Dataset** file chooser dialog box appears.

4 From the **Directories** menu, select the path ending with **\examples**.

The scrolling list in the center now shows a list of directories containing example images supplied with ER Mapper (such as ‘application...’ and others).

5 Double-click on the directory named ‘Shared_Data.’

A list of raster images is displayed. Note that each has a ".ers" file extension. This is the file extension associated with raster files in ER Mapper format.

6 Scroll down to view the image named 'Landsat_TM_year_1985.ers,' then double-click on it to load it.

The file chooser dialog box closes, and the image is loaded into the Pseudocolor layer. Note that the layer now shows the name of the image loaded ('Landsat_TM_year_1985'), and the button left of the name is now selected (indicating that the layer is *turned on*).

ER Mapper renders the image in the image window. The image (band one) is displayed in a range of colors because the color table named **Pseudocolor** is chosen.

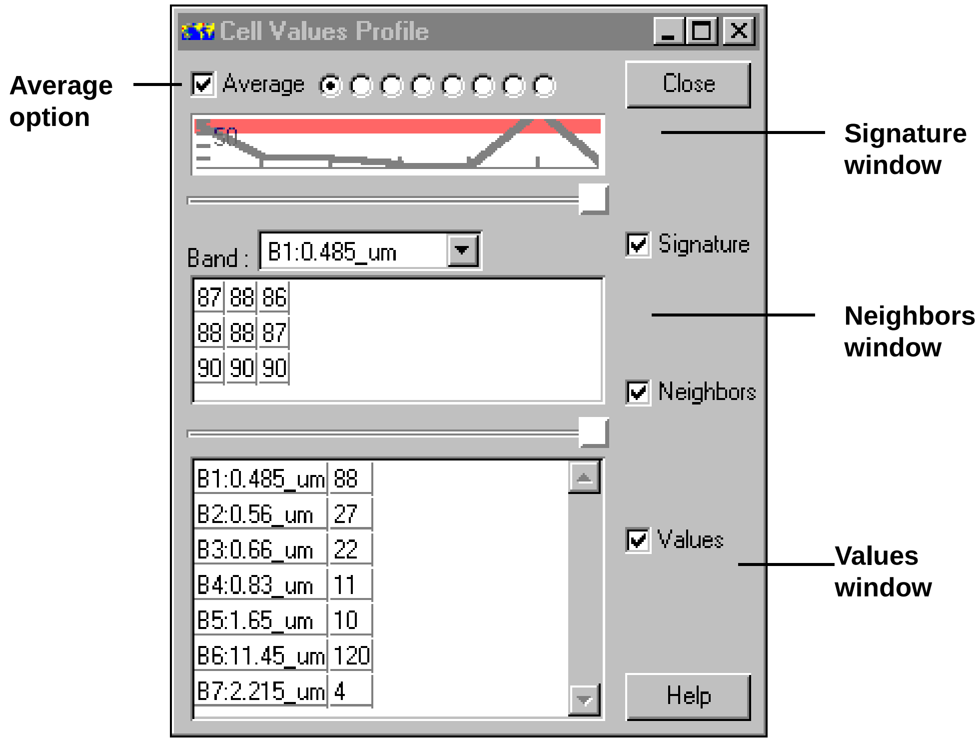
7 On the **Algorithm** window click on the surface tab. By default the **Color Mode** is in Pseudocolor. If not, change it to Pseudocolor mode. From the **Color Table** drop down list choose 'greyscale'.

8 Click **99% Contrast Enhancement**  button to display the band 1 of the dataset.

View lowest cell values in the image for all bands of Landsat_TM_year_1985 dataset

1 From the **View** menu, select **Cell Values Profile...**.

2 The **Cell Values Profile** dialog box appears. Drag it by its title bar next to the image window. This dialog has three display windows, any of which can be turned on or off at any time



3 By default, the **Values** option is selected. (If this has been changed, turn on **Values** and turn off **Signature** and **Neighbors**.)

4 Select the Average option on the **Cell Values Profile** dialog box

5 On the main menu, click the **Pointer Tool** toolbar button.

Set Pointer mode tells ER Mapper that you want to use the mouse pointer to view data values. (The other mode, Zoom mode, sets the pointer for use as a zoom and pan tool.)

6 Point inside the image window, and drag the mouse pointer through the water area around the island at the bottom part of the image.

The **Cell Values Profile** dialog displays the average data values of water in all seven bands in the Landsat image for the all the cells (pixel) locations that you dragged your cursor along. The average data values are updated as you drag the mouse to new locations.

7 Note down the average cell values of water for all 7 bands.

Open an image window and the Algorithm window to load Landsat_TM_year_1991 image

1 On the Standard toolbar, click on the **New** button.

A new image window appears.

2 The existing **Algorithm** window becomes a new **Algorithm** window for the new window. If you have closed the **Algorithm** window, on the Standard toolbar, click on the **Edit Algorithm** button.

3 The **Algorithm** window appears.

4 Click on the Layer Tab to view the settings for the layer.

5 On the **Algorithm** window, click the **Load Dataset** button on the left side of the process stream diagram.

The **Raster Dataset** file chooser dialog box appears.

6 Select the path ending with /examples/Shared_Data'.

7 Double-click on the dataset named 'Landsat_TM_year_1991.ers' to load the dataset.

Band one of the dataset is loaded into the Pseudocolor layer.

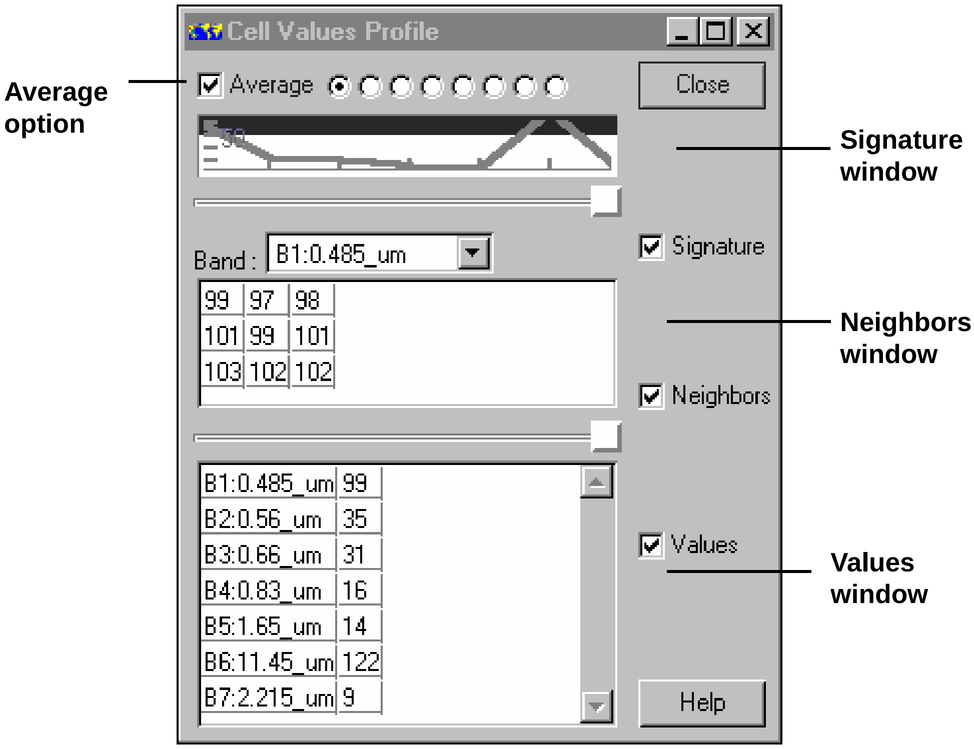
8 On the **Algorithm** window click on the surface tab. By default the **Color Mode** is in Pseudocolor. If not, change it to Pseudocolor mode. From the **Color Table** drop down list choose 'greyscale'.

9 Click **99% Contrast Enhancement** button to display the band 1 of the dataset.

View lowest cell values in the image for all bands of Landsat_TM_year_1991 dataset

1 From the **View** menu, select **Cell Values Profile....**

2 The **Cell Values Profile** dialog box appears. Drag it by its title bar next to the image window. This dialog has three display windows, any of which can be turned on or off at any time.



3 By default, the **Values** option is selected. (If this has been changed, turn on **Values** and turn off **Signature** and **Neighbors**.)

4 Select **Average** on the **Cell Values Profile** dialog box

5 On the main menu, click the **Pointer Tool** toolbar button.

Set Pointer mode tells ER Mapper that you want to use the mouse pointer to view data values. (The other mode, Zoom mode, sets the pointer for use as a zoom and pan tool.)

6 Point inside the image window, and drag the mouse pointer through the same water area around the island at the bottom part of the image as you did for the 'Landsat_TM_year_1985.ers' image.

The **Cell Values Profile** dialog displays the average data values of water in all seven bands in the Landsat image for all the cells (pixel) locations that you dragged your cursor over. The average data values are updated as you drag the mouse to new locations.

7 Note down the average cell values of water for all 7 bands.

8 Check the differences in the average cells values of water for corresponding bands 1 to 7 of the two temporal images. (You will notice that 'Landsat_TM_year_1991.ers' dataset has values higher than those in 'Landsat_TM_year_1985.ers' dataset: The differences are approximately **11 (99-88**) for **Band 1**, **8 (35-27)** for **Band 2**, **9 (31-22**) for **Band 3**, **5 (16-11)** for **Band4**, **2 (122-120)** for **Band 6** and **5 (9-4)** for **Band 7**.

Reducing the differences in the atmospheric effects between the two temporal images

1 On the Algorithm window for the 'Landsat_TM_year_1991.ers' dataset, make sure band 1 is displayed. Click on the **Edit Formula** button in the process stream diagram.

The **Formula Editor** dialog box opens.

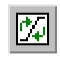
Note that the generic formula window contains the text "**INPUT1**" by default, and that INPUT1 is assigned to dataset band 1 in the Relations window.

2 In the **Generic** formula window, edit the formula text to read:

```
INPUT1 - 11
```

Note: You are subtracting 11 from the DN value of each pixel of band 1of the ‘Landsat_TM_year_1991.ers’ dataset so as to reduce the difference in the atmospheric effects between band 1 of the ‘Landsat_TM_year_1985.ers’ and ‘Landsat_TM_year_1991.ers’ datasets.

3 Click the **Apply changes** button on the **Formula Editor** dialog box.

4 Click **99% Contrast Enhancement**  button to display band 1 of the dataset adjusted for atmospheric effects.

5 Click your left hand mouse button on the **Pseudo Layer**. A text field will appear. In the text field change the band description to **B1-1991.**

Correcting atmospheric effects for bands (2-7)

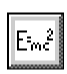
1 On the **Algorithm** window click on the **Duplicate** button  and duplicate band 1 of the dataset.

2 Turn off the first **Pseudo Layer**.

3 Click on the second **Pseudo Layer** and make it the active layer.

4 On the **Algorithm** window from the band selection 

, select band 2 of the ‘Landsat_TM_year_1991.ers’ dataset for the second **Pseudo Layer.**

5 Click on the **Edit Formula**  button in the process stream diagram.

The **Formula Editor** dialog box opens.

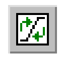
6 In the **Generic** formula window, edit the formula text to read:

```
INPUT1 - 8
```

Note: You are subtracting 8 from the DN value of each pixel of band 2 of the ‘Landsat_TM_year_1991.ers’ dataset so as to reduce the difference in the atmospheric effects between band 2 of the ‘Landsat_TM_year_1985.ers’ and ‘Landsat_TM_year_1991.ers’ datasets.

7 Click the **Apply changes** button on the **Formula Editor** dialog box.

Note: On the **Formula Editor** dialog box check the relationship window (middle part of the Formula Editor dialog box) and see that band 2 of the dataset is selected before clicking on the **Apply changes** button.

8 Click **99% Contrast Enhancement**  button to display band 2 of the dataset adjusted for atmospheric effects.

9 Click your left hand mouse button on the Pseudo Layer. A text field will appear. In the text field change the band description to **B2-1991.**

10 Repeat the process for all the other bands (3-7) with the formula for band 3 (INPUT1 - 9), for band 4 (INPUT1 - 5),for band 5 (INPUT1 - 4),for band 6 (INPUT1 - 2) and for band 7 (INPUT1 - 5).

11 Edit the band description for each band. Change the description for **band 3** to **(B3-1991)**, for **band 4** to **(B4-1991**), for **band 5** to **(B5-1991)**, for **band 6** to **(B6-1991)** and for **band 7** to **(B7-1991)**.

12 Turn on all the 7 pseudocolor layers of 'Landsat_TM_year_1991.ers' which have been adjusted for the atmospheric effects to match the atmospheric effects of 'Landsat_TM_year_1985.ers' dataset.

13 Delete the transform from each of the 7 layers.

Note: Deleting the transform from each of the layers maintains the dynamic range of the atmospheric adjusted data value of the 7 bands without scaling or clipping.

14 On the **Standard** toolbar, click the **Save As**  button.

The **Save As...** dialog box appears. This dialog lets you specify a path and name for your output disk file, and options for creating the new dataset.

15 On the **Save As ...** dialog, select the path ending with the text **/examples/ Miscellaneous/Tutorial**.

16 In the **Save As:** text field, type in a name for the disk file. Use your initials at the beginning, followed by the text 'Atmospheric_adjusted_TM_1991' and separate each word with an underscore (_). For example, if your initials are "DH," type in the name:

```
DH_Atmospheric_adjusted_TM_1991
```

17 Click **OK** or **Save** to close the file chooser dialog.

Your name appears as the Output Dataset name with a '.ers' extension.

Note: It is necessary to save the atmospheric affect adjusted data as a dataset for further processing. If you save the dataset as **Virtual Dataset** you will not be able to access the adjusted cell values.

2:Creating Virtual Dataset of the two temporal imagery

Objectives

Learn to create a Virtual dataset of two rectified temporal images.

Before you begin...

Before beginning this exercise, make sure all ER Mapper image windows are closed. Only the ER Mapper main menu should be open on the screen.

Loading the first dataset

1 On the **Standard** toolbar, click on the **Edit Algorithm** button.

An image window and the **Algorithm** window appear.

2 Click on the Layer Tab to view the settings for the layer.

3 On the **Algorithm** window, click the **Load Dataset** button on the left side of the process stream diagram.

The **Raster Dataset** file chooser dialog box appears.

4 Select the path ending with **/examples/Shared_Data**.

5 Double-click on the dataset named 'Landsat_TM_year_1985.ers' to load the dataset.

Band one of the dataset is loaded into the Pseudocolor layer.

6 On the **Algorithm** window click on the Surface Tab. By default the **Color Mode** is Pseudocolor. If not, change it to Pseudocolor mode. From the **Color Table** drop down list choose greyscale color.

7 Click **99% Contrast Enhancement** button to display the band 1 of the dataset.

8 Click your left mouse button on the Pseudo Layer. A text field will appear. In the text field change the band description to B1-1985

9 On the **Algorithm** window click on the **Duplicate** button and duplicate band 1 of the dataset.

10 Turn off the first **Pseudo Layer**.

11 Click on the second **Pseudo Layer** and make it the active layer.

12 On the **Algorithm** window from the band selector B2:0.56_um, select band 2 of the 'Landsat_TM_year_1991.ers' dataset for the second pseudo layer.

13 Click **99% Contrast Enhancement** button to enhance and display the band 2 of the dataset.

14 Click your left mouse button on the **Pseudo Layer**. A text field will appear. In the text field change the band description to **B2-1985**

15 Repeat the process for all other bands (3-7): duplicate the last band, turn off the second-last Pseudo Layer, activate the last Pseudo Layer, change the last Pseudo Layer to band 3,4,5,6 or 7 of the dataset from the band selector on the **Algorithm** window, enhance and display it with 99% Contrast Enhancement button and change the band description to **B3-1985, B4-1985, B5-1985, B6-1985** and **B7-1985**.

Loading the second dataset with the atmospheric effects adjusted

1 On the **Algorithm** window click on the **Duplicate** button and duplicate band 7 of the 'Landsat_TM_year_1985.ers' dataset.

2 Turn off the second last Pseudo Layer which is band 7 of the 'Landsat_TM_year_1985.ers' dataset..

3 Click on the last Pseudo Layer which is the duplicated layer of the band 7 of the 'Landsat_TM_year_1985.ers' dataset and make it the active layer.

4 Click the **Load Dataset** button in the process stream diagram for the last layer to open the file chooser dialog.

5 Select the path ending with the text 'examples/Miscellaneous/Tutorial,' and load the dataset named 'Atmospheric_adjusted_TM_1991.ers'

6 On the **Raster Dataset** file chooser click on **OK this layer only** button.

Note: By clicking the **OK this layer only** button, you load the 'Atmospheric_adjusted_TM_1991.ers' into the last Pseudo Layer only. If you click the **OK** button you load the 'Atmospheric_adjusted_TM_1991.ers' into all the Pseudo Layers which you do not want to do in this particular instance.

Band one of the 'Atmospheric_adjusted_TM_1991.ers' dataset is loaded into the last Pseudo layer (eight Pseudo Layer).

7 Click the **99% Contrast Enhancement** button to display band 1 (B1-1991) of the 'Atmospheric_adjusted_TM_1991.ers' dataset.

8 Click on the Pseudo Layer. A text field will appear. In the text field change the band description to **B1-1991**

9 On the **Algorithm** window click on the **Duplicate** button and duplicate band 1 of the 'Atmospheric_adjusted_TM_1991.ers' dataset.

10 Turn off the eight Pseudo Layer.

11 Click on the ninth Pseudo Layer and make it the active layer.

12 On the **Algorithm** window from the band selector , select band 2 of the 'Atmospheric_adjusted_TM_1991.ers' dataset for the ninth Pseudo Layer

13 Click the **99% Contrast Enhancement** button to display the band 2 of the 'Atmospheric_adjusted_TM_1991.ers' dataset.

14 Click your left hand mouse button on the Pseudo Layer. A text field will appear. In the text field change the band description to **B2-1991**

15 Repeat the process for all other bands (3-7) of the 'Atmospheric_adjusted_TM_1991.ers' dataset, duplicating the last band, turning off the second-last Pseudo Layer, activate the last Pseudo Layer, change the last Pseudo Layer to band 3,4,5,6 or 7 of the 'Atmospheric_adjusted_TM_1991.ers' dataset from the band selector on the **Algorithm** window, display it with 99% Contrast Enhancement button and change the band description to **B3-1991, B4-1991, B5-1991, B6-1991** and **B7-1991**.

16 Turn on all the 14 Pseudo Layers of 'Landsat_TM_year_1985.ers' and 'Atmospheric_adjusted_TM_1991.ers' which have been adjusted for the atmospheric affect to match the atmospheric affect of 'Landsat_TM_year_1985.ers' dataset.

17 Delete the transform of all the 14 layers

Note: Deleting the transform from each of the layers maintains the dynamic range of the data value of the 14 bands without scaling or clipping.

18 On the Standard toolbar, click the **Save As** button.

The **Save As ...** dialog box appears. This dialog lets you specify a path and name for your output disk file, and options for creating the new dataset.

19 On the **Save As** dialog, select the path ending with the text '**/examples/Miscellaneous/tutorial**'.

20 In the **Save As:** text field, type in a name for the disk file. Use your initials at the beginning, followed by the text 'TM_1985_Atm_Adj_TM_1991_VDS' and separate each word with an underscore (_). For example, if your initials are 'DH' type in the name:

`DH_TM_1985_Atm_Adj_TM_1991_VDS`

21 Click **OK** or **Save** to close the file chooser dialog.

Your name appears as the **Output Dataset** name with a '.ers' extension.

Note: You have saved the 'Landsat_TM_year_1985.ers' and 'Atmospheric_adjusted_TM_1991.ers' datasets as a Virtual Dataset and you are ready to perform the change detection between the TM imagery of the two dates (1985 & 1991).

3:Change Detection

(1) Red Green difference change detection method

Objectives

Learn a simple change detection method displaying compatible bands of imagery of different dates in Red and Green color layers in RGB color mode.

Before you begin...

Before beginning this exercise, make sure all ER Mapper image windows are closed. Only the ER Mapper main menu should be open on the screen.

The production of a red/green difference image is a widely used technique, and is particularly useful for interactive viewing of change areas. This technique involves displaying simultaneously one dataset in green and one dataset in red. The resultant combined image contains mainly shades of yellow (indicating the same response between dates), but areas which have changed appear as green or red. Red areas tend to have more contrast than green areas, therefore it is suggested that the most current image uses the red layer if increases in pixel brightness are of importance and vice versa. A viewing scale of 1:20 000 or larger is ideal for panning across the image to delineate areas of interest. This technique is most effective where the magnitude of the areas to be found is anticipated to be quite large, such as cleared fields or changes in crop growth.

1 On the Standard toolbar, click on the **Edit Algorithm** button.

An image window and the **Algorithm** window appear.

2 Click on the Layer Tab to view the settings for the layer.

3 On the **Algorithm** window, click the **Load Dataset** button on the left side of the process stream diagram.

The **Raster Dataset** file chooser dialog box appears.

4 From the **Directories** menu, select the path ending with '**/examples/Miscellaneous/tutorial**'.

5 Double-click on the dataset named 'TM_1985_Atm_Adj_TM_1991_VDS.ers' to load the dataset.

Band one (B1-1985) of the dataset is loaded into the Pseudocolor layer.

6 On the **Algorithm** window click on the Surface Tab. By default the **Color Mode** is Pseudocolor. Change it to 'Red Green Blue' color mode.

7 The Pseudo Layer is now with a red cross because it is incompatible with the 'Red Green Blue' color mode. Click your right mouse button on the Pseudo Layer. The short-cut menu appears. Choose 'Red' from the short-cut menu and change the Pseudo Layer.

8 On the **Algorithm** window click on the **Duplicate** button and duplicate band 1 **(B1-1985)** of the 'TM_1985_Atm_Adj_TM_1991_VDS.ers' dataset.

9 Click your right mouse button on the duplicated Red layer. The short-cut menu appears. From the short-cut menu change the layer color to 'Green'.

10 On the **Algorithm** window from the band selector B8:B1-1991, select the eight band of the 'TM_1985_Atm_Adj_TM_1991_VDS.ers' dataset which is band 1 of the 'Atmospheric_adjusted_TM_1991.ers' dataset .

11 Click **99% Contrast Enhancement** button to display band 1 (**B1-1985**) of the **'**Landsat_TM_year_1985.ers' in the Red layer and band 1 (**B1-1991**) of the **'**Atmospheric_adjusted_TM_1991.ers' dataset in the Green layer.

12 You will notice that all the areas that have been changed in band 1 of TM_1991 imagery are highlighted in green and changed areas in band 1 of TM_1985 imagery are shown in red. Areas with no change are displayed in yellow.

13 On the **Algorithm** window click on the **Copy Window and Algorithm** button and duplicate both the image window and the Algorithm.

14 Change the bands to band 2 (**B2-1985**) for the Red layer and band 2 (**B2-1991**) for the Green layer.

15 Click **99% Contrast Enhancement** button to display the band 2 **(B2-1985**) of the 'Landsat_TM_year_1985.ers' in the Red layer and band 2 **(B2-1991**) of the 'Atmospheric_adjusted_TM_1991.ers' dataset in the Green layer.

16 Repeat the process and display Red Green change detection images of band 1-5&7 between **'**Landsat_TM_year_1985.ers' and 'Atmospheric_adjusted_TM_1991.ers' datasets. Compare the Red Green change detection images of the corresponding 1-5&7 bands of the imagery of the two dates.

Note: Due to slightly longer wavelength of band 7 (2.215_um) compared to band 1 (0.485_um), band 7 has better penetration into clouds and thus producing thinner clouds in the band 7 change detection image. Thermal Infrared (TIR) band (11.45_um) (TM6) measures composite temperature of each pixel of the target area and provides different spectral reflectance information than wavelengths in VIS, NIR & SWIR. Hence TM6 is excluded in the exercise. The different reflection of different surface materials at different wavelengths should be taken into consideration when interpreting the change detection images.

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(2) Image Differencing change detection method

Objectives

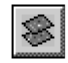
Learn a simple change detection method of subtracting compatible bands of imagery of different dates and displaying the result as a greyscale or pseducolor image.

Before you begin...

Before beginning this exercise, make sure all ER Mapper image windows are closed. Only the ER Mapper main menu should be open on the screen.

Image differencing is perhaps the most simple of all change detection methods. It is based upon the principle that by subtracting the pixel responses in one image from the corresponding pixel responses in another image, any negative value in the output image represents an increase or decrease in pixel response depending on the order of subtraction. For example, if the response from the latest image was subtracted from the response from the older image then all negative values in the output image would indicate an increase in pixel brightness.

All increases in scene brightness would cause negative pixel values in the output image but this is not to say that all negative values indicate significantly `changed' pixels. The histogram of the resultant dataset needs to be manipulated to isolate areas of increase or decrease that are significant.

1 On the Standard toolbar, click on the **Edit Algorithm**  button.

An image window and the **Algorithm** window appear.

2 Click on the Layer Tab to view the settings for the layer.

3 On the **Algorithm** window, click the **Load Dataset** button  on the left side of the process stream diagram.

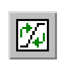
The **Raster Dataset** file chooser dialog box appears.

4 From the **Directories** menu, select the path ending with '**/examples/Miscellaneous/tutorial**' to open it.

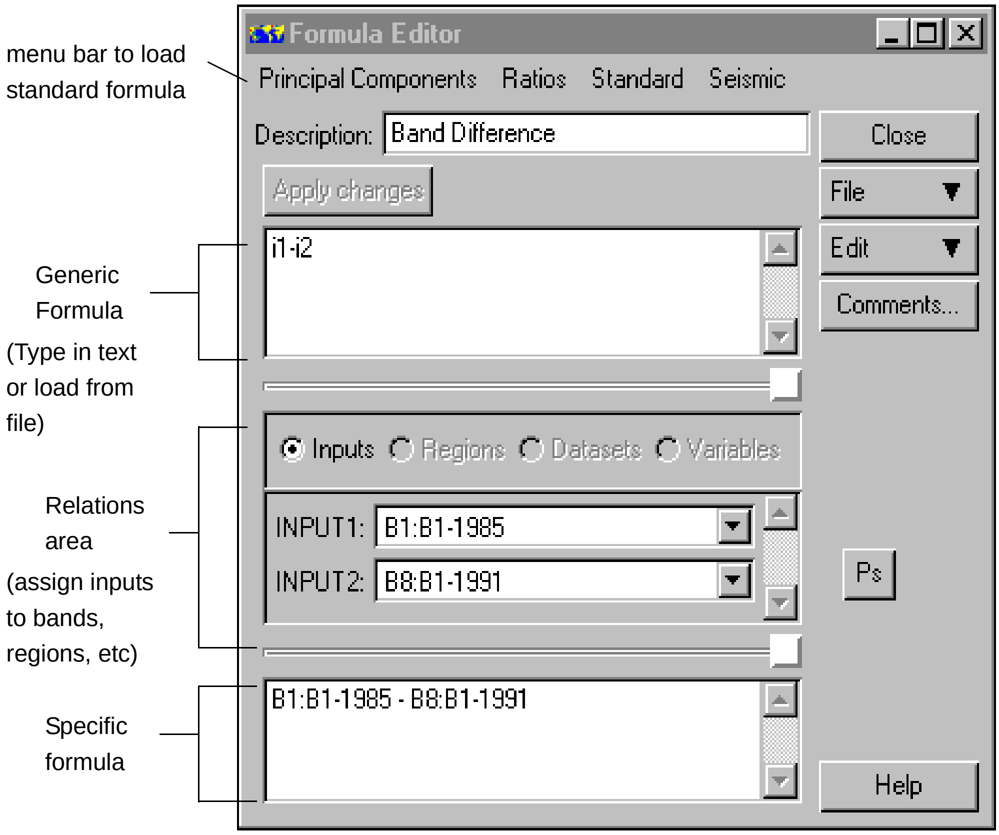
5 Double-click on the dataset named 'TM_1985_Atm_Adj_TM_1991_VDS.ers' to load the dataset.

Band 1 (B1-1985) of the dataset is loaded into the Pseudocolor layer.

6 On the **Algorithm** window click on the Surface Tab. By default the **Color Mode** is Pseudocolor. If not, change it to Pseudocolor mode. From the **Color Table** drop down list choose 'greyscale'.

7 Click **99% Contrast Enhancement**  button to display the band 1 (B1-1985) of the dataset.

8 On the **Algorithm** window click on the **Edit Formula** button . The **Formula Editor** dialog box appears.

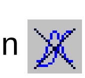


9 In the **Generic** formula area type in (i1 - i2) and click on Apply changes button on the **Formula Editor** dialog box.

10 In the **Relations** area for INPUT 1 select **B1:B1-1985** which is the band 1 (B1-1985) of the 'Landsat_TM_year_1985.ers' dataset and for INPUT 2 select **B8:B1-1991** which is the band 1(B1-1991) of the **'**Atmospheric_adjusted_TM_1991.ers' dataset .

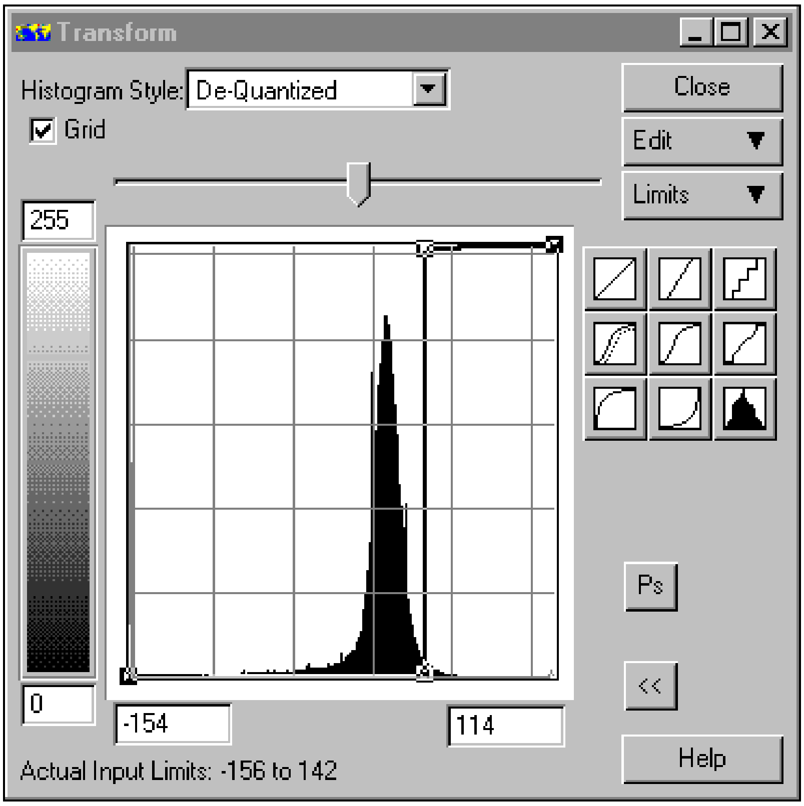
11 Click the **99% Contrast Enhancement**  button to display the band differenced image of **(B1:B1-1985) - (B8:B1-1991)** which is the band differenced image of band 1 of 'Landsat_TM_year_1985.ers' and band 1 of 'Atmospheric_adjusted_TM_1991.ers'.

12 You will notice that the changed areas between the imagery of the two dates are highlighted, with positive values shown as bright areas and negative values shown as dark areas. The areas that haven't changed are displayed as middle greyscale areas.

13 On the **Algorithm** window click on the **Edit Transform Limits** button  .

14 The **Transform** dialog box appears.

15 On the Transform dialog box adjust thelower limit of X-axis transform as the change threshold to approximately 30 (the actual input limits range from -156 to 142).



Note: The DN value 30 is the threshold of the changed areas of the positive values of the dynamic range of the change detection image. **Threshold** values will depend on the type of application and imagery used and the dynamic range of the band differenced change detection image.

Note: The areas of greatest change are found in the two ends - low and high DN - of the transform. Only changes in the high end of DN in the transform are defined in the above excercise.

Note: Only the changed areas of the high DN values are highlighted.

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16 Change the color from greyscale to pseudocolor from the **Color Table** dropdown list on the Surface Tab and view the changed areas in pseudocolor. The changed areas are now shown in red.

Save the band differenced change detection image as a Virtual Dataset

1 Save the change detection image (Transform with threshold ~30) as a Virtual Dataset

2 On the Standard toolbar, click the **Save As** button.

3 From the Files of Type drop down list select **ER Mapper Virtual Dataset(.ers)**.

4 Select the path ending with the text '/examples/Miscellaneous/tutorial'.

5 In the **Save As :** text field, type in a name for the disk file. Use your initials at the beginning, followed by the text 'B1_difference_clipped_VDS' and separate each word with an underscore (_). For example, if your initials are 'DH' type in the name:

```
DH_B1_difference_clipped_VDS
```

6 Click **OK** to close the file chooser dialog.

Your name appears as the Output Dataset name with a '.ers' extension.

Calculate the statistics of the changed area

1 On the main menu click the **Process** menu and from the dropdown list select **Calculate Statistics**. The **Calculate Statistics** dialog box appears.

2 On the **Calculate Statistics** dialog box load the 'B1_difference_clipped_VDS.ers' dataset from the 'tutorial' directory.

3 You can choose the default **Subsampling Interval** as 4 which will calculate statistics quickly taking every fourth value or you can take subsampling interval of 1 for more accurate statistics calculation.

Note: Do not select **Force Recalculate stats:** since it is the first time you calculate the statistics of this dataset.

---

4 Click the **OK** button on the **Calculate Statistics** dialog box to start calculating the statistics of the dataset.

5 After it has successfully calculated the staististics of the dataset, from the **View** menu on the main menu, select the **Statistics** option from the dropdown list and choose **Show Statisitcs**.. (View --> Statistics --> Show Statistics..)

6 The **Statistics Report** dialog box appears.

7 Load the **B1_difference_clipped_VDS.ers** dataset from the **'tutorial'** directory and click **OK** button to view the statistics of the changed areas.

Note: Notice the Null Cells number and Non-Null Cells numbers. The Non-Null Cells numbers are for the changed areas. You can calculate the area extent or percent covered for the changed areas.

Note: You have performed change detection for the higher end of the transform (high DN values from the (**(band 1 of Landsat_TM_year_1985) - (band 1 of Atmospheric_adjusted_TM_1991)**) band differenced image). For changes in the lower end of the transform (low DN values) to be highlighted, repeat the procedure mentioned above but use the formula (**(band 1 of Atmospheric_adjusted_TM_1991) - (band 1 of Landsat_TM_year_1985)**).

Tip: To highlight the lower end of the transform of the (**(band 1 of Landsat_TM_year_1985) - (band 1 of Atmospheric_adjusted_TM_1991)**) band differenced image, click the Edit Formula button on the Algorithm window. The Formula Editor dialog box appears. Insert minus sign **(-)** in front of the formula. Apply changes and display the image. The transform is now inverted and previous lowest DN is now the highest DN. Apply a threshold to the inverted transform and define the changed areas of the inverted image - differenced change detection image. Save that as a Virtual Dataset

---

Note: After you have saved the two Virtual Dataset for the changes detected in the high and low ends of the transform of the image - differenced change detection image, use the Raster Cells to Vector Polygons option from the Process menu on the main menu window and convert them to vector format. Display a greyscale band 1 image of the **Landsat_TM_year_1985.ers** and overlay ontop of it the two vector layers of the changed areas detected for high and low ends of the transform of the image - differenced change detection image. Assign each vector layer a different color.

---

(3) Image ratioing change detection method

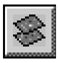
Objectives

Learn the image ratioing change detection method of dividing corresponding bands of imagery of different dates and display it as a greyscale or pseducolor image

Before you begin...

Before beginning this exercise, make sure all ER Mapper image windows are closed. Only the ER Mapper main menu should be open on the screen.

The technique of image ratioing involves dividing the spectral response value of a pixel in one image with the spectral value of the corresponding pixel in another image. This is done in order to suppress similarities between bands. The nature of band ratioing is that every pixel that has the same spectral response between input bands will have a value of 1 in the output image; deviations from 1 indicate progressively different initial spectral values. Areas of greatest change are found in the tails of the resultant histogram. Production of a change image involves thresholding the image histogram to suppress those areas where little or no change has occurred.

1 On the Standard toolbar, click on the **Edit Algorithm**  button.

An image window and the **Algorithm** window appear.

2 Click on the **Layer tab** to view the settings for the layer.

3 On the **Algorithm** window, click the **Load Dataset** button  on the left side of the process stream diagram.

The **Raster Dataset** file chooser dialog box appears.

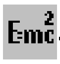
4 From the **Directories** menu, select the path ending with '/examples/Miscellaneous/Tutorial'.

5 Double-click on the dataset named 'TM_1985_Atm_Adj_TM_1991_VDS.ers' to load the dataset.

Band one (B1-1985) of the dataset is loaded into the Pseudocolor layer.

6 On the **Algorithm** window click on the surface tab. By default the **Color Mode** is Pseudocolor. If not, change it to Pseudocolor mode. From the **Color Table** drop down list choose 'greyscale'.

7 Click **99% Contrast Enhancement**  button to display the band 1 (B1-1985) of the dataset.

8 On the **Algorithm** window click on the **Edit Formula** button . The **Formula Editor** dialog box appears.

9 In the Generic formula area type in (i1 / i2) and click on **Apply changes** button on the **Formula Editor** dialog box.

10 In the **Relations** area for INPUT 1select **B1:B1-1985** which is the band 1 (B1-1985) of the 'Landsat_TM_year_1985.ers' dataset, and for INPUT 2 select **B8:B1-1991** which is the band 1(B1-1991) of the 'Atmospheric_adjusted_TM_1991.ers' dataset .

11 Click the **99% Contrast Enhancement** button to display the band ratio image of **(B1:B1-1985) / (B8:B1-1991)** which is the band ratio of band 1 of 'Landsat_TM_year_1985.ers' and band 1 of 'Atmospheric_adjusted_TM_1991.ers'.

12 You will notice that the changed areas between the imagery of the two dates are highlighted, with high values shown as bright areas and low values shown as dark areas.The areas without changes will be displayed as middle greyscale areas (The dynamic range of a band ratioed image is usually small and falls in the range of 0 to 10. That small dynamic range is scaled to 255 grey levels).

13 On the **Algorithm** window click on the **Edit Transform Limits** button .

14 The **Transform** dialog box appears.

15 On the Transform dialog box adjust thelower limit of X-axis transform as the change threshold to approximately 1.26 (the actual input limits range from 0.361 to 2.327)

Note: Only the changed areas of the high DN values are highlighted.

16 Change the color from greyscale to pseudocolor using the **Color Table** on the **Surface Tab** and view the changed areas in pseudocolor. The changed areas are now shown in red.

Save the band ratioed change detection image as a Virtual Dataset

1 Save the changed areas highlighted in the band differenced image (Transform with threshold approximately at 1.26) as a Virtual Dataset.

2 On the Standard toolbar, click the **Save As** button.

The **Save As ...** dialog box appears. This dialog lets you specify a path and name for your output disk file, and options for creating the new dataset.

3 On the **Save As ...**dialog box select the path ending with the text 'examples/ Miscellaneous/Tutorial'.

4 In the **Save As:** text field, type in a name for the disk file. Use your initials at the beginning, followed by the text 'B1_ratio_clipped_VDS.ers' and separate each word with an underscore (_). For example, if your initials are 'DH' type in the name:

```
DH_B1_ratio_clipped_VDS
```

5 Click **OK** to close the file chooser dialog.

Your name appears as the Output Dataset name with a '.ers' extension.

Calculate the statistics of the changed area

1 On the main menu click the **Process** menu and from the drop-down list select **Calculate Statistics**. The **Calculate Statistics** dialog box appears.

2 On the **Calculate Statistics** dialog box load the 'B1_ratio_clipped_VDS.ers' dataset from the 'tutorial' directory.

3 You can choose the default **Subsampling Interval** as 4 which will calculate statistics quickly taking every fourth value or you can take subsampling interval of 1 for more accurate statistics calculation.

Note: Do not select **Force Recalculate stats:** since it is the first time you calculate the statistics of this dataset.

---

4 Click the **OK** button on the **Calculate Statistics** dialog box to strart calculate the statistics of the dataset.

5 After ER Mapper has successfully calculated the statistics of the dataset, from the **View**, select the **Statistics** option from the drop-down list and choose **Show Statistics**.

6 The **Statistics Report** dialog box appears.

7 Load the 'B1_ratio_clipped_VDS.ers' dataset from the 'tutorial' directory and click OK button to view the statistics of the changed areas.

Note: Notice the Null Cells number and Non-Null Cells numbers. The Non-Null Cells numbers are for the changed areas. You can calculate the area extent or percent covered for the changed areas.

Note: You have performed change detection for the higher end of the transform (high DN values from the **((band 1 of Landsat_TM_year_1985) / (band 1 of Atmospheric_adjusted_TM_1991)**) band ratioed image). For changes in the lower end of the transform (low DN values) to be highlighted, repeat the procedure mentioned above but use the formula (**(band 1 of Atmospheric_adjusted_TM_1991) / (band 1 of Landsat_TM_year_1985)**).

Tip: To highlight the lower end of the transform of the (**(band 1 of Landsat_TM_year_1985) / (band 1 of Atmospheric_adjusted_TM_1991)**) band ratioed image, click the **Edit Formula** button on the **Algorithm** window. The **Formula Editor** dialog box appears. Insert a minus sign **(-)** in front of the formula. Apply changes and display the image. The transform is now inverted and previous lowest DN is now the highest DN. Apply a threshold to the inverted transform and define the changed areas of the inverted image - band ratioed change detection image. Save the result as a Virtual Dataset.

Note: After you have saved the two Virtual Dataset for the changes detected in the high and low ends of the transform of the band ratioed change detection image, use the **Raster Cells to Vector Polygons** option from the **Process** menu on the main menu window and convert them to vector format. Display a greyscale band 1 image of the **Landsat_TM_year_1985.ers** and overlay on top of it the two vector layers of the changed areas detected for high and low ends of the transform of the band ratioed change detection image. Assign each vector layer a different color.

---

(4) Principal Component Analysis change detection method

Objectives

Learn the **Principal Component Analysis** change detection method by applying Principal Component Analysis on 6 bands of the images of the two dates (excluding band 6 which is Thermal Infrared (TIR) band):

- subtracting or ratioing the Principal Component 1 of **Landsat_TM_year_1985.ers** and Principal Component 1 of the **Atmospheric_adjusted_TM_1991.ers** and
- display the Principal Component Analysis change detection images as greyscale or pseducolor images

Before you begin...

Before beginning this exercise, make sure all ER Mapper image windows are closed. Only the ER Mapper main menu should be open on the screen.

Principal Components Analysis (PCA) is a technique employed in image processing to reduce the correlation between bands of data and enhance features that are unique to each band. A characteristic of PCA is that information common to all input bands (high correlation between bands) is mapped to the first Principal Component (PC) whilst subsequent PCs account for progressively less of the total scene variance. The advantage of PCA principle is that you will obtain all common information of the six bands applied in the PCA, in the Principal Component 1. After accumulating all information common to the six bands in PC1 for both the multi-temporal imagery you perform either the band differencing or band ratioing change detection methods using the two PC1 of the multi-temporal imagery. The areas of greatest change are found in the tails of the image histogram. Though information common to the bands applied in the PCA of the multi-temporal imagery is used, precautions should be taken in applying Principal Component Analysis change detection method.

Calculate the statistics of the dataset

Note: In performing Principal Component Analysis, the dataset’s statistics should be calculated first.

1. On the main menu, click on the **Process** menu and select **Calculate Statistics.**

   The **Calculate Statistics** dialog box appears.

2. Load the ‘TM_1985_Atm_Adj_TM_1991_VDS.ers’ dataset from the ‘tutorial’ directory.
3. You can choose the default **Subsampling Interval** as 4 which will calculate statistics quickly taking every fourth value or you can take subsampling interval of 1 for more accurate statistics calculation.

Note: Do not select **Force Recalculate stats:** since it is the first time you calculate the statistics of this dataset.

4. Click the **OK** button on the **Calculate Statistics** dialog box to start calculating the statistics of the dataset.
5. After ER Mapper has successfully calculated the statistics of the dataset a small status window will appear and the message ‘Calculate Statistics finished successfully’ will be displayed.

Load the dataset

1 On the Standard toolbar, click on the **Edit Algorithm** button.

An image window and the **Algorithm** window appear.

2 Click on the **Layer tab** to view the settings for the layer.

3 On the **Algorithm** window, click the **Load Dataset** button on the left of the process stream diagram.

The **Raster Dataset** file chooser dialog box appears.

4 Select the path ending with 'examples/Miscellaneous/tutorial'.

5 Double-click on the dataset named 'TM_1985_Atm_Adj_TM_1991_VDS.ers' to load the dataset.

Band one (B1-1985) of the dataset is loaded into the Pseudocolor layer.

6 On the **Algorithm** window click on the Surface Tab. By default the **Color Mode** is in Pseudocolor. If not, change it to Pseudocolor mode. From the **Color Table** drop-down list choose 'greyscale'.

7 Click **99% Contrast Enhancement** button to display the band 1 (B1-1985) of the dataset.

8 On the **Algorithm** window click on the **Edit Formula** button. The **Formula Editor** dialog box appears.

9 On the **Formula Editor** dialog box, from the **Principal Components** menu select the **PC1 generic**.

10 In the Generic Formula area the **Principal Componet Analysis** formula will be loaded for you. The PC1 generic formula is **(SIGMA(I1-I7|I? * PC_COV(,R1,I?,1)**)

11 Change the formula to **(SIGMA(I1-I6|I? * PC_COV(,R1,I?,1))**

Note: You have changed the formula to calculate PC1 from 6 bands instead of from 7 bands.

---

12 In the relations area on the Formula Editor dialog box , select (B1-1985) to (B5-1985) and (B7-1985) which are band 1 to 5 and band 7 of the 'Landsat_TM_year_1985.ers' dataset.

Note: Band 6 is in the Thermal Infrared (TIR) electromagnetic spectrum region and is not used.

---

13 Click the **99% Contrast Enhancement** button to display the PC1 of ‘Landsat_TM_year_1985.ers’.

14 Click your left mouse button on the Pseudo Layer. A text field will appear. In the text field change the band description to **`PC1-1985`**

15 On the **Algorithm** window click on the **Duplicate** button and duplicate the **PC1-1985** layer of the ‘Landsat_TM_year_1985.ers’.

16 Turn off the first **PC1-1985** Pseudo Layer.

17 Click on the duplicated Pseudo Layer and make it the active layer

18 On the **Algorithm** window click on the **Edit Formula** button. The **Formula Editor** dialog box appears.

19 On the **Formula Editor** dialog box, click on the **Principal Components** menu and select **PC1 generic**.

20 In the Generic Formula area the Principal Componet Analysis formula will be loaded for you. The PC1 generic is **(SIGMA(I1-I7|I? * PC_COV(,R1,I?,1)**)

21 Change the formula to **(SIGMA(I1-I6|I? * PC_COV(,R1,I?,1)**)

Note: You have changed the formula to calculate PC1 from 6 bands instead of from 7 bands.

---

22 In the Relations area on the **Formula Editor** dialog box, select (B1-1991) to (B5-1991) and (B7-1991) which are band 1 to 5 and band 7 of the ‘Atmospheric_adjusted_TM_year_1991.ers’ dataset. In the ‘TM_1985_Atm_Adj_TM_1991_VDS.ers’ dataset they are (B8:B1-1991) to (B12:B5-1991) and (B14:B7-1991).

Note: Band 6 is in TIR electromagnetic spectrum region and is not used.

---

23 Click **99% Contrast Enhancement** button to display the PC1 of ‘Atmospheric_adjusted_TM_year_1991.ers’ dataset.

24 Click your left mouse button on the Pseudo Layer. A text field will appear. In the text field change the band description to **`PC1-1991`**

25 Turn on the first Pseudo Layer (PC1-1985).

26 Delete the transforms of both Pseudo Layers.

Save the PC1-1985 and the PC1-1991 images as a Virtual Dataset

1 On the Standard toolbar, click the **Save As** button.

The **Save As ...** dialog box appears. This dialog lets you specify a path and name for your output disk file, and options for creating the new dataset.

2 On the **Save As** dialog, select the path ending with the text 'examples/ Miscellaneous/Tutorial'.

3 In the **Save As :** text field, type in a name for the disk file. Use your initials at the beginning, followed by the text 'PC1_1985_PC1_1991_VDS.ers' and separate each word with an underscore (_). For example, if your initials are 'DH' type in the name:

`DH_PC1_1985_PC1_1991_VDS`

4 Click **OK** or **Save** to close the file chooser dialog.

Your name appears as the **Output Dataset** name with a '.ers' extension.

Apply band differencing change detection method to the PC1 of the multi-temporal images

1 Follow the procedure of the band differencing change detection method and perform change detection on the 'PC1_1985_PC1_1991_VDS.ers' dataset.

Apply band ratioing change detection method to the PC1 of the multi-temporal images

1 Follow the procedure of the band ratioing change detection method and perform change detection on the **PC1_1985_PC1_1991_VDS.ers** dataset.

Note: Compare the images and statistics of the threshold applied change detection images of Band Differencing, Band Ratioing and Principal Component Analysis change detection methods. You will notice that the Principal Component Analysis change detection method detects the greatest change. In comparing the change detection images of different methods it is best to Geolink the windows and compare them. Care should be taken in applying different change detection methods and accuracy should be assessed.

Close all image windows and dialog boxes

1 Close all image windows using the window system controls:

- For Windows, select **Close** from the window control-menu.

- For Unix systems, select **Close** or **Quit** from the window control menu in the upper-left corner (for systems with both options, select **Quit**).

2 Click **Close** on the **Algorithm** window to close it.

Only the ER Mapper main menu should be open on the screen.

What you learned...

After completing these exercises, you know how to perform the following tasks in ER Mapper:

- Reduce atmospheric effects on images
- Create Virtual Dataset of multi-temporal images
- Perform Red Green Difference change detection method
- Perform Band Differencing change detection method
- Perform Band Ratioing change detection method
- Perform Principal Component Analysis change detection method

21

Raster to vector conversion

This chapter introduces you to the concept of raster to vector conversion and gives you practice using ER Mapper's raster to vector conversion features.

About raster to vector conversion

Raster to vector conversion, sometimes called vectorization, allows you to convert data from a raster data structure to a vector data structure. For example, features or thematic classes defined by processing a satellite image can be converted to polylines and polygons, and then imported directly into a vector-based GIS product or used for further processing of raster data. Raster to vector conversion is an especially valuable feature for extracting timely information from satellite images to quickly update vector-based information stored in GIS products.

In raster to vector conversion, ER Mapper analyzes the boundaries of the features you specify in a raster image, then traces polylines or closed polygons around the features. Typically you first need to perform some type of image processing to extract the features you are interested in, such as classification or thresholding to mask or highlight a particular feature. After vectorizing the features of interest, the output polylines or polygons can be saved to an ER Mapper format vector file, regions in a raster file, an ARC/INFO GIS coverage, or exported to other vector formats such as DXF.

Hands-on exercises

These exercises give you practice creating algorithms to highlight a feature in a raster image, and then converting the feature to a vector representation. In this case, you will create vector polygons from classes in a previously classified image, and generate a binary land/water image and create a vector representation of the coastline.

What you will learn...

After completing these exercises, you will know how to perform these tasks in ER Mapper:

- Apply smoothing to a classified image to remove isolated pixels
- Extract classes from a classified image and convert them to vector polygons
- Process a satellite image to create a binary land/water image
- Vectorize the binary image to extract polylines tracing the coastline

Before you begin...

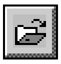
Before beginning these exercises, make sure all ER Mapper image windows are closed. Only the ER Mapper main menu should be open on the screen.

1: Vectorizing a feature class

Objectives

Learn to prepare an algorithm displaying a classified image to extract and vectorize a feature class of interest, and perform the raster to vector conversion.

Display a classified Landsat image

1. Click on the **Open**  toolbar button.

   An image window and the **Algorithm** dialog box appear.

2. From the **Directories** menu, select the path ending with the text **\examples**.
3. Double_click on the ‘Functions_And_Features’ directory to open it.
4. In the directory ‘Classification,’ open the algorithm ‘ISOCLASS_Landsat_TM_year_1985.alg.’

ER Mapper runs an algorithm displaying a classified image of the San Diego, California area. This image was previously generated from a 1985 Landsat TM image of same area using ER Mapper’s **ISOCLASS Unsupervised Classification** feature. There are 10 feature classes in this image representing water, vegetation, barren land areas, and other feature classes.

Zoom in on the park area near the image center

1. Slightly to the right of the image center there is a nearly rectangular area containing mostly vegetation (shades of green and light green). This area is San Diego’s Balboa Park. Click the **ZoomBox Mode** toolbar button and drag a zoom box surrounding the green areas defining the park borders.

   Your zoomed image should show mostly green and light green pixels (vegetation) with possibly some magenta pixels (urban areas) along the outer borders. You will create a vector representation of the vegetation areas.

Apply a median filter to generalize the classification

Notice that the classification contains many small, isolated groups of pixels within the larger single color areas. It is generally a good idea to incorporate these isolated pixels into the larger feature classes before performing a raster to vector conversion. That way, you vectorize only the major features in the image and minimize the number of very small polygons that will be created.

1. In the process diagram, click the pre-formula **Edit Filter (Kernel)** button. (Be sure to choose the button left of the **Formula** button.)
2. On the **Filter** dialog, click the **Filter filename** chooser button.
3. From the **Directories** menu, select the path ending with the text **\kernel**.
4. In the directory ‘filters_ranking,’ load the filter ‘median_5x5.ker.’

   This is a 5 by 5 filter that assigns the center pixel the median values of all pixels in the 5 by 5 window. This and other filters such as ‘majority.ker’ are commonly used to generalize classified images.
5. ER Mapper runs the algorithm with the median smoothing filter.

   Notice that most of the smaller, isolated pixels or clusters are merged into the surrounding dominant feature classes, giving the image smoother look.
6. Click **Close** on the **Filter** dialog to close it.

Enter a formula to aggregate the two vegetation classes

Notice that there are two vegetation classes in this part of the image represented in green and light green (the light green areas are a golf course and darker green are other vegetation types). For this exercise, you will aggregate these into one common class representing all vegetation before vectorizing them. (You could also vectorize each into its own polygons if desired.)

1 Click the **Edit Formula**  button in the process stream diagram.

2 In the Generic formula window, edit the formula text to read:

```
if input1=3 or input1=5 then 5 else input1
```

This formula tells ER Mapper “if pixels have a value of 3 (class 3) or 5 (class 5) in the image, assign them both a value of 5, else do not change them.”

3 Click the **Apply changes** button to validate the formula.

ER Mapper runs the algorithm and aggregates the two classes.

Both vegetation classes are assigned the same value (5), so they both appear in the light green color. This light green area is portion of the image you will convert to a vector representation.

4 Click **Close** to close the **Formula Editor** dialog.

Save the algorithm as a Virtual Dataset

To run the raster to vector conversion, you need to save the algorithm as a Virtual Dataset (VDS). The VDS will contain all your processing, including the zoomed area, the smoothing filter, and the class aggregation formula.

1 From the **File** menu, select **Save as...**.

2 Select **ER Mapper Virtual Dataset (.ers)** for the **Files of Type:** field.

3 From the **Directories** menu, select the path ending with the text **\examples**.

4 Double-click on the directory named ‘Miscellaneous’ to open it.

5 Double-click on the directory named ‘Tutorial’ to open it.

6 In the **Save As:** text field, type a name using your initials at the beginning, followed by the text ‘raster_classes_VDS,’ and separate each word with an underscore (_). For example, if your initials are "CJ," type in the name:

```
CJ_raster_classes_VDS
```

7 Click **OK** to save the Virtual Dataset.

8 Click on the **Yes** button on the **Delete output transforms...** dialog box.

Convert the raster cells to vector polygons

1 From the **Process** menu, select **Raster Cells to Vector Polygons...**.

The **Raster to Vector Conversion** dialog box opens. This dialog contains options to vectorize specific bands or cells values in an image, to create polygons, polylines, or filled polygons, and to smooth (interpolate) vectors.

2 Click the **Input Raster Dataset** chooser button.

3 From the **Directories** menu, select the path ending with the text **\examples** Then open the 'Miscellaneous\Tutorial' directory and load the 'raster_classes_VDS.ers' image you just created.

4 Turn on the **Fill Polygons** option (to create polygons instead of polylines)

Tip: To smooth rugged edges of the polygons turn on **Smooth** option.

---

5 Click the **Output Vector Dataset** chooser button.

6 From the **Directories** menu, select the path ending with the text **\examples**. Then open the 'Miscellaneous\Tutorial' directory and type a name in the **Save As:** text field as follows, then click **OK** to close the chooser. For example, if your initials are "JT," type in the name:

`JT_vegetation_polygons`

7 Edit the value in the **Cell Value** field to read **5** then press Enter or Return.

This tells ER Mapper to vectorize all pixels (cells) with the value 5 in the Virtual Dataset (the vegetation areas from the classification). By default, ER Mapper will create vector polygons.

8 Click **OK** to start the raster to vector conversion.

ER Mapper displays a status dialog indicating the progress, then displays a confirmation dialog when the conversion is complete.

9 Click **OK** to close the confirmation dialog, then click **Close** and **Cancel** to close the other two raster to vector dialogs.

You have now created a vector file containing polygons representing the areas of vegetation on the classified image.

Display the vector polygons over the classified image

1 In the Algorithm window, select **Annotation/Map Composition** from the **Edit/Add Vector Layer** menu.

A new annotation layer is added to the algorithm.

2 Click the **Edit Layer Color**  button in the process stream diagram to choose a color for displaying the vectors.

3 Select a red color, and click **OK** to close the **Color Chooser**.

4 Click the **Load Dataset**  button in the process steam diagram.

5 From the **Directories** menu, select the path ending with the text **\examples**.

6 In the directory 'Miscellaneous\Tutorial,' double-click on the 'vegetation_polygons.erv' image you created to load it.

ER Mapper first processes the raster data, then draws the vector polygons in red. Notice that the vectors closely follow the outlines of the green areas on the image.

Display the vector polygons alone

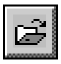
1 Turn off the Class Display layer containing the ISOCLASS image.

ER Mapper draws the vector polygons in red over an empty (black) backdrop image so your can see them more clearly. As you can see, vectorizing raster data in this way can save hours or days of digitizing feature outlines by hand, so it is especially valuable for updating vector information for use in GIS products.

2: Vectorizing a binary image

Objectives Learn to prepare an algorithm that creates a binary image (land and water in this case), and perform the raster to vector conversion to extract a polyline defining the coastline.

Display a greyscale Landsat algorithm

1 Click the **Open**  toolbar button.

2 From the **Directories** menu, select the path ending with the text **\examples**.

3 Double_click on the 'Data_Types' directory to open it.

4 In the directory 'Landsat_TM,' open the algorithm 'Greyscale.alg.'

ER Mapper runs an algorithm displaying band 1 of a Landsat TM satellite image of the San Diego, California area. This image contains a significant area of ocean in the lower portion, and artificial recreational bay in the upper-left (Mission Bay). You will create a binary image to separate the land from the water, then vectorize the image to trace the coastline.

Enter a formula to mask land from water

Binary images are often created in earth science image processing to mask or isolate major features from each other. Land/water binary images are especially common because analysts are often only interested in working with one of the two features, and wish to mask out the other. A simple way to do this, when possible, is to define a data threshold to separate one feature from the other.

1 Click the **Edit Formula**  button in the process stream diagram.

2 In the Generic formula window, edit the formula text to read:

```
if input1 < 20 then 1 else 2
```

This formula tells ER Mapper “if pixels in the band selected for input1 have a value less than 20, assign them a value of 1, else assign all other a value of 2.” After this formula each pixel in the image will be reassigned a data value of 1 or 2 (a binary image).

3 Click the **Apply changes** button to validate the formula.

4 In the Relations window, click on the ‘INPUT1’ drop-down list and select **B5:1.65_um**.

Now your formula uses a threshold of 20 in band 5 (mid infrared) to separate land from water. Infrared bands are useful for separating land from water because water absorbs nearly all incident infrared radiation.

Note: The threshold value of 20 for this image was determined in an earlier exercise using ER Mapper’s **Traverse Extraction** feature. This value would typically be different for each image.

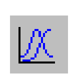
Initially the image appears black because the Transform limits need to be adjusted.

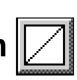
5 Click **Close** to close the **Formula Editor** dialog.

Adjust the Color Table and Transform for the binary image

1 From the **Color Table** drop-down list, select **unique**.

‘Unique’ is a special lookup table with widely different colors in slots next to each other (so it is good for emphasizing small differences in data values).

2 Click the post-formula **Edit Transform Limits**  button to open the **Transform** dialog box.

3 On the **Transform** dialog, click the **Create default linear transform**  button to reset the transform line.

4 From the **Limits** menu, select **Limits to Actual**.

The image is displayed in two colors–grey for the water areas (a value of 1) and red for the land areas (a value of 2). The land and water are generally well separated from each other.

Save the binary algorithm as a Virtual Dataset

1 Click **Close** to close the **Transform** dialog.

2 From the **File** menu, select **Save as...**.

3 Select **ER Mapper Virtual Dataset (.ers)** for the **Files of Type:** field.

4 From the **Directories** menu, select the path ending with the text **\examples**.

5 Double-click on the directory named ‘Miscellaneous’ to open it.

6 Double-click on the directory named ‘Tutorial’ to open it.

7 In the **Save As:** text field, type a name using your initials at the beginning, followed by the text ‘binary_image_VDS,’ and separate each word with an underscore (_). For example, if your initials are “BP,” type in the name:

```
BP_binary_image_VDS
```

8 Click **OK** to save the Virtual Dataset.

9 Answer **Yes** to the **Delete output transforms for virtual dataset** query.

You adjusted the transform so the binary image could be displayed onscreen. Before vectorizing the binary image, you need to delete the transform so the 1-2 data range is not transformed to 0-255.

Convert the raster cells to vector polylines

1 From the **Process** menu, select **Raster Cells to Vector Polygons...**.

The **Raster to Vector Conversion** dialog box opens.

2 Click the **Input Raster Dataset** chooser button.

3 From the **Directories** menu, select the path ending with the text **\examples**. Then open the ‘Tutorial’ directory and load the ‘binary_image_VDS.ers’ image you just created.

4 Click the **Output Vector Dataset** chooser button.

5 From the **Directories** menu, select the path ending with the text **\examples**. Then open the ‘Miscellaneous\Tutorial’ directory and type a name in the **Save As:** text field as follows, then click **OK** to close the chooser. For example, if your initials are “MJ,” type in the name:

`MJ_vector_coastline`

6 Edit the value in the **Cell Value** field to read **1** then press Enter or Return.

This tells ER Mapper to vectorize all pixels (cells) with the value 1 in the Virtual Dataset (the water areas in the image).

7 Turn on the **Polylines** option (to create polylines instead of polygons).

8 Click **OK** to start the raster to vector conversion.

ER Mapper displays a status dialog indicating the progress, then displays a confirmation dialog when the conversion is complete.

9 Click **OK** to close the confirmation dialog, then click **Close** and **Cancel** to close the other two raster to vector dialogs.

You have now created a vector file containing polylines representing the coastline (land/water boundary) in the Landsat TM image.

Display the vector polylines over the Landsat image

1 Click the **Open** toolbar button.

2 From the **Directories** menu, select the path ending with the text **\examples**.

3 Double_click on the ‘Data_Types’ directory to open it.

4 In the directory ‘Landsat_TM,’ open the algorithm ‘Greyscale.alg.’

This is the same Landsat TM image you used to create the binary VDS.

5 In the Algorithm window, select **Annotation/Map Composition** from the **Edit/Add Vector Layer** menu.

A new annotation layer is added to the algorithm.

6 Click the **Edit Layer Color** button in the process stream diagram to choose a color for displaying the vectors.

7 Select a yellow color, and click **OK** to close the **Color Chooser**.

8 Click the **Load Dataset** button in the process stream diagram.

9 From the **Directories** menu, select the path ending with the text **\examples**.

10 In the directory ‘\Miscellaneous\Tutorial,’ double-click on the ‘vector_coastline.erv’ image you created to load it.

ER Mapper first processes the raster data, then draws the vector polylines in yellow. Notice that the vectors closely follow the land/water boundary in the image.

Close all image windows and dialog boxes

1 Close all image windows using the window system controls:

- Select **Close** from the window control-menu.

2 Click **Close** on the **Algorithm** window to close it.

Only the ER Mapper main menu should be open on the screen.

What you learned...

After completing these exercises, you know how to perform the following tasks in ER Mapper:

- Apply smoothing to a classified image to remove isolated pixels
- Extract classes from a classified image and convert them to vector polygons
- Process a satellite image to create a binary land/water image
- Vectorize the binary image to extract polylines tracing the coastline

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Vector and tabular data

This chapter explains how to use ER Mapper to add overlays of vector and tabular data from external products and sources.

About vector data and Dynamic Links

In addition to drawing your own annotation using ER Mapper's drawing tools, you can also display vector data imported from other applications, and link directly to data in external formats without translation. These functions can be useful for overlaying geological interpretations stored in vector format, or linking to and displaying tabular data (such as well locations) or vector data (such as lease boundaries) in external formats.

Vector data can come from GIS products or external file formats such as DXF or Postscript. Typical uses for vector Dynamic Links include displaying subsurface geological structure interpretations, surface geology, or cultural data such as lease boundaries or road networks.

Tabular data can come from database products or tabular data files. ER Mapper can display tabular (point) data as colored circles of varying sizes. This capability is useful for applications such as plotting the locations of wells, drill sites, sample sites, and so on.

Hands-on exercises

These exercises introduce you to the basic features for displaying vector and tabular data in ER Mapper.

Note: These exercises use a satellite image as the reference raster image for overlaying vector and tabular data, but the same concepts apply to using seismic or other geophysical data.

What you will learn...

After completing these exercises, you will know how to perform the following tasks in ER Mapper:

- Add annotation layers to display and edit vector data stored in ER Mapper format.
- Add Tabular Data layers to display data stored in tabular format
- Add layers to display data stored in an external vector GIS format

Before you begin...

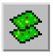
Before beginning these exercises, make sure all ER Mapper image windows are closed. Only the ER Mapper main menu should be open on the screen.

1: Overlaying vector data

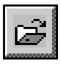
Objectives

Learn to add a layer to an algorithm to display vector data imported from an external format. In this case you will overlay vectors for a road network previously imported using ER Mapper's vector import utilities.

Load a greyscale satellite image algorithm

1 Click the **Edit Algorithm**  toolbar button.

An image window and the **Algorithm** dialog box appear.

2 Click the **Open**  toolbar button.

3 From the **Directories** menu, select the path ending with the text **\examples\Data_Types**.

4 Double-click on the directory named 'SPOT_Panchromatic'.

5 Double-click on the algorithm named 'Greyscale.alg.'

The algorithm displays a satellite image of the San Diego, California area in the US from the SPOT satellite system. The image is 10 meter resolution, so it provides good detail and is often used for base mapping applications.

Add an Annotation layer and load a vector roads image

1 On the **Algorithm** window, select **Annotation/Map Composition** from the **Edit/Add Vector Layer** menu.

An Annotation layer is added to the algorithm layer list.

2 Click the **Load Dataset** button in the process stream diagram for the new layer to open the file chooser dialog.

3 From the **Directories** menu, select the path ending with the text **\examples**.

4 In the directory named ‘Shared_Data’, load the file named ‘San_Diego_roads.erv.’

This is a vector image of roads in the greater San Diego area. It was previously imported from a Digital Line Graph (DLG) file format using the ER Mapper import utilities that converted it to an ER Mapper format vector file (with an “.erv” file extension).

5 In the process diagram, click the **Edit Layer Color** button.

6 Choose a red color, then click **OK** to close the **Color Chooser** dialog.

ER Mapper runs the algorithm again and displays the vector road network as a red overlay. If desired, you can edit the vectors to add, delete or modify them. (Use of the annotation tools is covered in the chapter on Map Composition.)

7 In the Annotation layer’s text description field, type the new description text `San Diego roads` and press Enter or Return.

2: Overlaying tabular data

Objectives Learn to add a layer to an algorithm to display point data stored in a tabular format. (The examples used here are fire station locations, but they could just as easily be well locations on an interpreted time surface.)

Turn off the vector roads layer

1 In the **Algorithm** window, turn off the vector ‘San Diego roads’ layer by right-clicking on the layer name and selecting **Turn Off**.

(This will make it easier to see the tabular data where there is overlap.)

Add a Tabular Data layer and load sample data

1 From the **Edit/Add Vector Layer** menu (on the **Algorithm** window), select **Tabular Data**, then select **Table of data shown as Outline Circles**.

A Table of Data layer is added to the algorithm layer list.

2 With the Table of Data layer selected, click the **Load Dataset** button in the process diagram.

3 From the **Directories** menu, select the path ending with the text **\examples**.

4 In the directory named ‘Data_Types\Spot_Panchromatic’, load the file named ‘San_Diego_Fire_Stations.tbl.’

This is a tabular dataset containing the locations of fire fighting stations in the greater San Diego area.

5 In the process diagram, click the **Edit Layer Color** button.

6 Choose a cyan (light blue) color, then click **OK** to close the **Color Chooser** dialog.

ER Mapper runs the algorithm again and displays the location of each fire station as a cyan circle. (To display the circles, ER Mapper is accessing data in an external file with an Easting and Northing value for each location and other information.)

7 In the Annotation layer’s text description field, type the new description text `fire stations` and press Enter or Return.

3: Overlaying GIS vector data

Objectives Learn to add a layer to an algorithm to display vector data stored in an external GIS product format (ARC/INFO in this case). In this case, you will display a network of roads stored in an ARC/INFO format coverage file.

Turn off the Tabular Data layer

1 In the **Algorithm** window, turn off the tabular ‘fire stations’ layer by right-clicking on the layer name and selecting **Turn Off**.

(This will make it easier to see the GIS data where there is overlap.)

Add an ARC/INFO layer

1 From the **Edit/Add Vector Layer** menu (on the **Algorithm** window), select **ARC/INFO Coverage**.

An ARC/INFO layer is added to the algorithm layer list.

2 With the ARC/INFO layer selected, click the **Dynamic Link Chooser** button in the process diagram.

The **ARC/INFO Chooser** dialog box opens to let you choose the coverage you want to link. (Note that the button is different from the **Load Dataset** button because you are not loading an ER Mapper format raster or vector file, but linking directly to a file that is not in ER Mapper format.)

3 On the **ARC/INFO Chooser** dialog, click the **Workspace** button.

The **ARC/INFO Workspaces** dialog opens to let you specify the location of the ARC/INFO coverage files on your system.

4 From the **Directories** menu, select the path ending with the text **examples\Shared_Data**.

5 Click once on the directory named ‘arc_info_workspace’ to select it, then click the **Select** button.

The **ARC/INFO Chooser** dialog now shows the selected workspace, and the Coverage drop-down list shows the available GIS vector coverages.

Choose a coverage, line width and line color

1 On the **ARC/INFO Chooser** dialog, select **lajollards** from the **Coverage** drop-down list.

This coverage file contains the road network for the La Jolla area of San Diego (covering the northern portion of this SPOT satellite image).

2 Select **1.0** from the **Line Width** drop-down list.

3 Click **OK** on the **ARC/INFO Chooser** dialog to close it.

ER Mapper runs the algorithm again and displays a large area network of roads in the La Jolla area. This data was accessed directly from an ARC/INFO coverage file, so no file translation was needed to display it. (You can also edit ARC/INFO coverages and save them back to coverage format.)

4 Click the **Edit Layer Color** button in the ARC/INFO layer’s process diagram.

5 Choose a yellow color, then click **OK** to close the **Color Chooser** dialog.

IER Mapper runs the algorithm again and displays the network in yellow.

6 n the Annotation layer’s text description field, type the new description text **`La Jolla roads`** and press Enter or Return.

Turn on all three color layers

1 Turn on all three of the color layers by right-clicking on their names and selecting **Turn On**.

Note: Vector layers always appear on top of any raster layers in an algorithm, regardless of their position in the layer list. Relative to each other, the uppermost vector or tabular layer has display priority where there is spatial overlap with other vector or tabular layers.

---

2 Click on the ‘fire stations’ layer to select it, then click the **Move Up** button .

The ‘fire stations’ tabular layer moves above the other two vector layers, so it now has the highest display priority.

The circles representing fire station now appear on top of the vector roads overlays.

Close all image windows and dialog boxes

1 Close all image windows using the window system controls:

- Select **Close** from the window control-menu.

2 Click **Close** on the **Algorithm** window to close it.

Only the ER Mapper main menu should be open on the screen.

What you learned...

After completing these exercises, you know how to perform the following tasks in ER Mapper:

- Add annotation layers to display and edit vector data stored in ER Mapper format.
- Add Tabular Data layers to display data stored in tabular format
- Add a layer to display data stored in an external vector GIS format

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Gridding

The ER Mapper Gridding Wizard uses irregularly spaced data to create a gridded raster image. It does this by laying a regularly spaced grid over the whole area and calculating a value for each cell in the grid. The accuracy of these calculations depends on the method used and the density and spacing of the input data.

The ER Mapper Gridding Wizard extracts regularly gridded raster files from a combination of any or all of the following types of data.

- Random line data
- Contour data, with faults, streamlines, ridgelines, and breaklines
- Random point data
- Regular line data
- Regularly gridded raster file

The output data is a raster (.ers) file with single or multiple bands containing regularly spaced grids.

ER Mapper supports two gridding techniques:

- Triangulation
- Minimum Curvature Under Tension

These are described in Chapter 38, “Gridding”, in the ER Mapper User Guide.

Creating a gridded raster image

You can use the ER Mapper Gridding Wizard to generate a single or multiband raster image file from one or more input data sources. The input sources can be any of the following formats:

- Generic ASCII XYZ
- DXF
- USGS contour format (DLG-3)
- Any raster formats directly readable by ER Mapper (including .ers)
- ER Mapper .erv format

Hands-on exercise

These exercises give you practice in using the Gridding Wizard to create a gridded raster image.

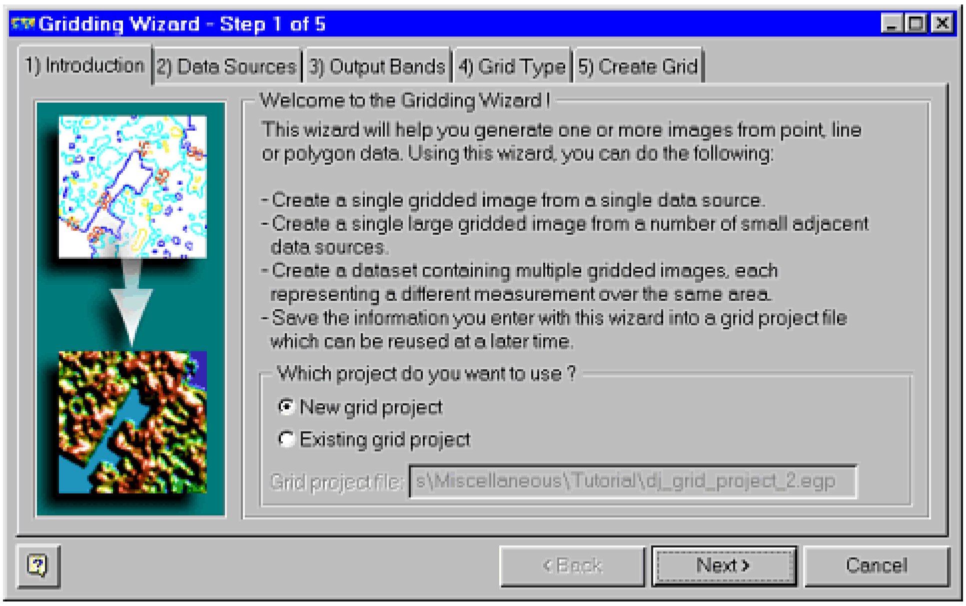
Before you begin... Before beginning these exercises, make sure all ER Mapper image windows are closed. Only the ER Mapper main menu should be open on the screen.

1: Create a gridded image from text files

Open the Gridding Wizard

1 Click the **Gridding Wizard** button on the Common Functions toolbar. 

The Gridding Wizard dialog opens with the **1)Introduction** tab selected.



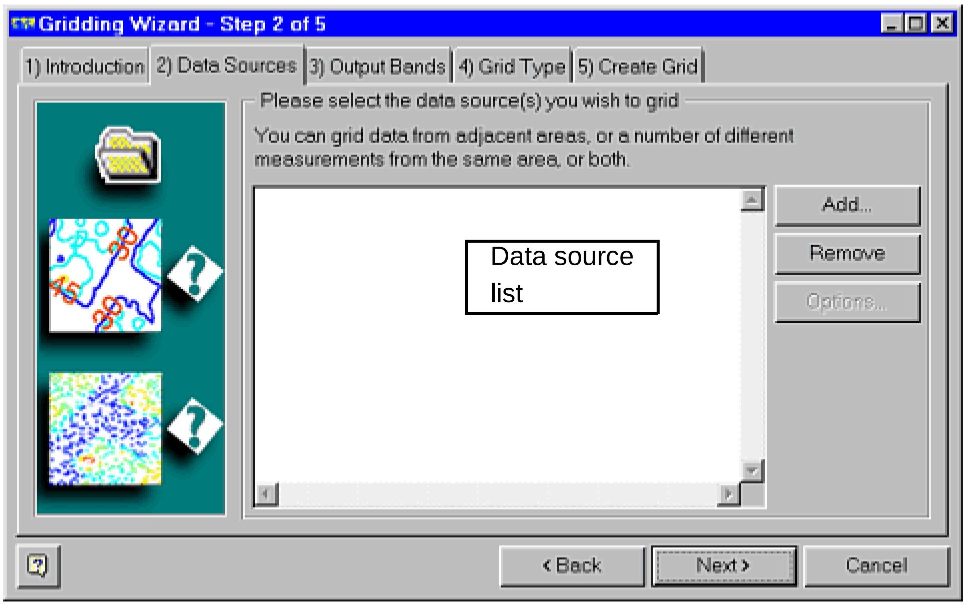
2 Select the **New grid project** option.

Notice that the **Grid project file:** field is grayed out. This is because you are creating a new project file. Therefore, you do not have to specify an existing one.

3 Click on the **Next>** button or select the **2) Data Sources** tab.

Both actions will take you to the next step by opening the Data Sources tab

Select the input data source.



This tab allows you to enter one or more data sources for gridding. The data sources can be from the same or adjacent areas. For this example we are going to choose a number of text files as data sources.

The list of data sources should be empty because we have not yet entered any.

1 Click on the **Add...** button to enter a data source.

A file chooser dialog should open.

2 In the chooser dialog **Files of Type** field, select **AsciiXYZtext(.txt)**.

3 From the **Directories** menu, select the path ending with the text **\examples**

4 Double-click on the directory named ‘Functions_And_Features’ and then on the ‘Gridding’ directory.

The directory has four text files, supplied with the permission of the Geological Survey of Western Australia, that list geochemical sample readings at locations specified by Easting/Northing coordinates. An extract from the ‘Peak_Hill_Al203.txt’ file listing aluminum oxide sample readings is shown below

#Easting	Northing	Al203
679346	7186699	11
675848	7182842	10.4
675882	7180203	7.22
680312	7182703	8.76

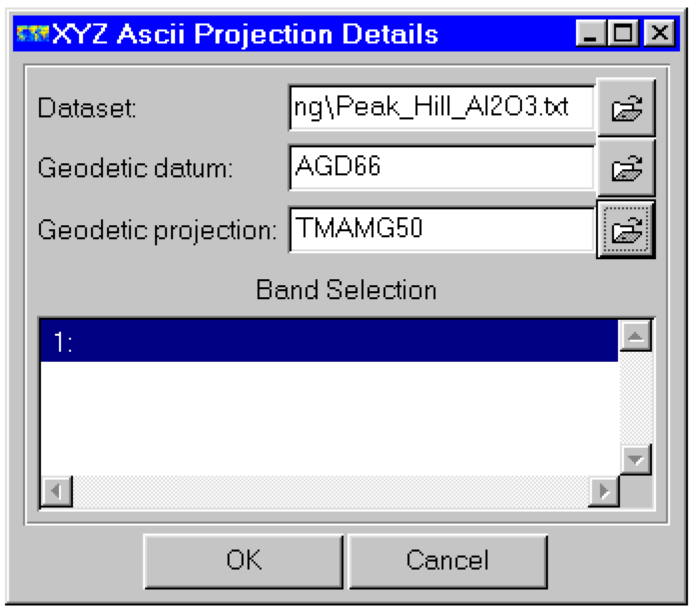
The information contained in the file is known as ASCIIXYZ data. The X Y components are the Easting/Northern coordinates of the locations, and the Z component is the aluminum oxide reading at each of the X Y locations.

The other three files are ‘Peak_Hill_CaO.txt’, ‘Peak_Hill_Fe203.txt’ and ‘Peak_Hill_MgO.txt’ which list traces of calcium oxide, copper oxide and magnesium oxide respectively.

In this exercise we will use the Gridding Wizard to create a gridded raster image with separate bands each showing overall concentrations of aluminum oxide, calcium oxide, copper oxide and magnesium oxide.

5 Click on the file named ‘Peak_Hill_Al203.txt, and then click **Apply**.

The Ascii Projection Details dialog box should open.



6 Check that the projection details are as shown above and then click on the **OK** button to return to the data source chooser.

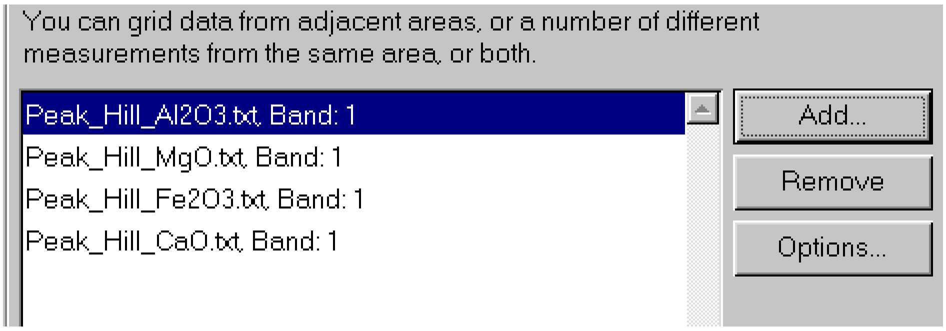
If the projection details are not as shown above, use the file chooser buttons  on the **Geodetic datum** and **Geodetic projection** fields to select ‘AGD66’ for the datum, and ‘TMAMG50’ from the ‘tranmerc’ projection list. Set **Coordinates** to ‘Easting/Northing’.

7 Repeat steps 5 and 6 to add the following files to the data source list:

- Peak_Hill_CaO.txt
- Peak_Hill_Fe203.txt
- Peak_Hill_MgO.txt

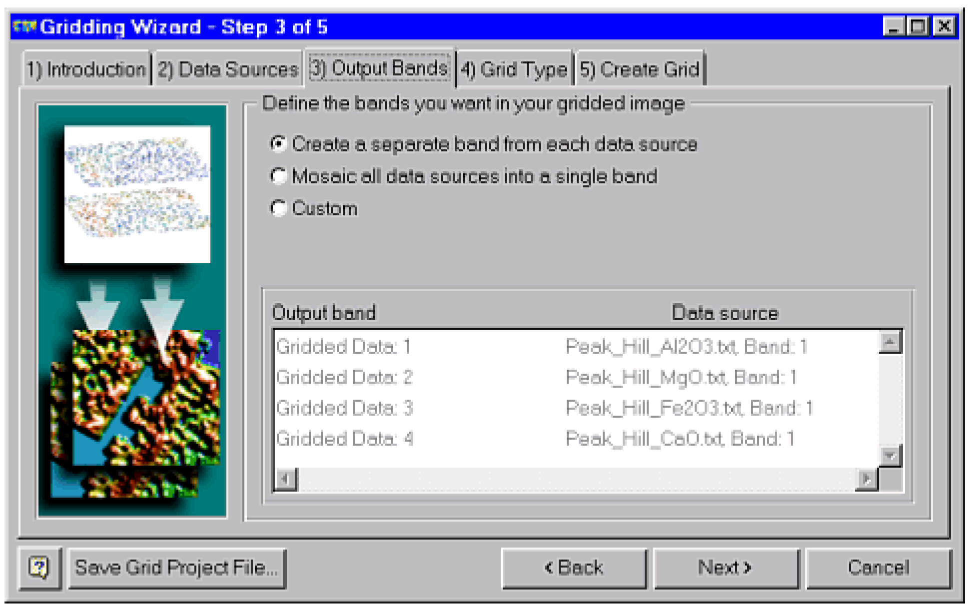
Click **OK** instead of **Apply** after selecting the last file.

The file names will appear in the source list box.



8 Click on the **Next>** button to go to the **3) Output Bands** tab.

Define the output bands



The output gridded raster image can have one or more bands of information. The “Output Bands’ tab allows you to specify how the input sources are to be mapped to these output bands. There are three main options:

Create a separate band from each data source	Each input source is allocated to a separate band. This creates an output gridded image with multiple bands as thematic overlays.

Mosaic all data sources into a single band	All the input sources are allocated, i.e. mosaiced, into a single band. This creates a single band output gridded image.
Custom	Enables the toolbar buttons for you to customize the output. You can specify the number of output bands and their descriptions, and then allocate individual or combinations of input sources to the output bands.

1 Select the default option **Create a separate band from each data source.**

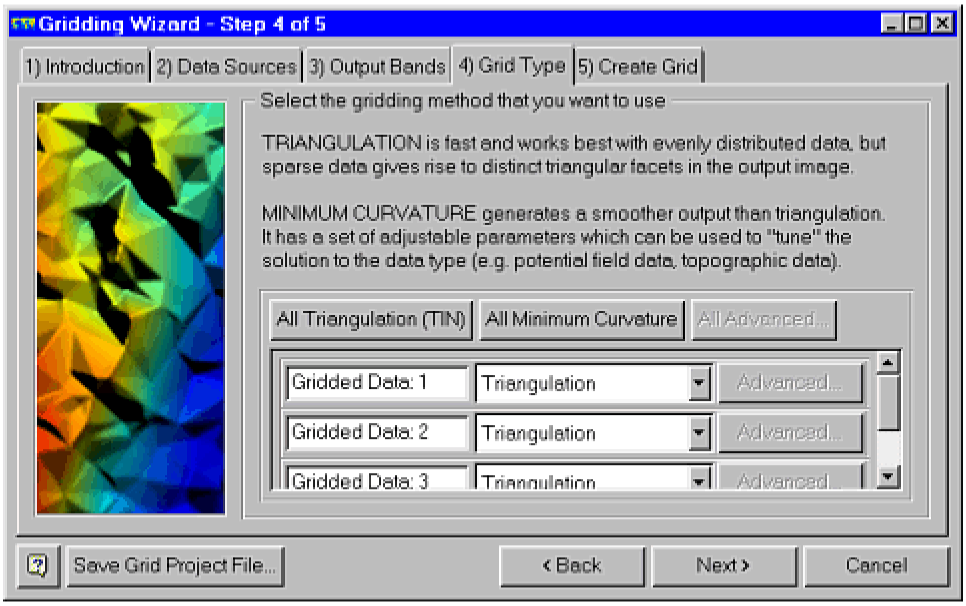
The list box will show:

Output band	**Data source**
Gridded Data:1	Peak_Hill.Al203.txt, Band:1
Gridded Data:2	Peak_Hill.MgO.txt, Band:1
Gridded Data:3	Peak_Hill_Fe203.txt, Band:1
Gridded Data:4	Peak_Hill.CaO.txt, Band:1

You will not be able to edit the entries in the list box.

2 Click on the **Next>** button to go to the **4) Grid Type** tab.

Select the gridding method



There are two gridding methods available, viz. Triangulation and Minimum Curvature. Triangulation is simpler and works best with evenly distributed data. Minimum Curvature has a number of parameters which you can adjust to suit the input data.

The ‘Grid Type’ tab allows you to set the gridding method for the output bands collectively or individually.

We will set all the bands to Triangulation.

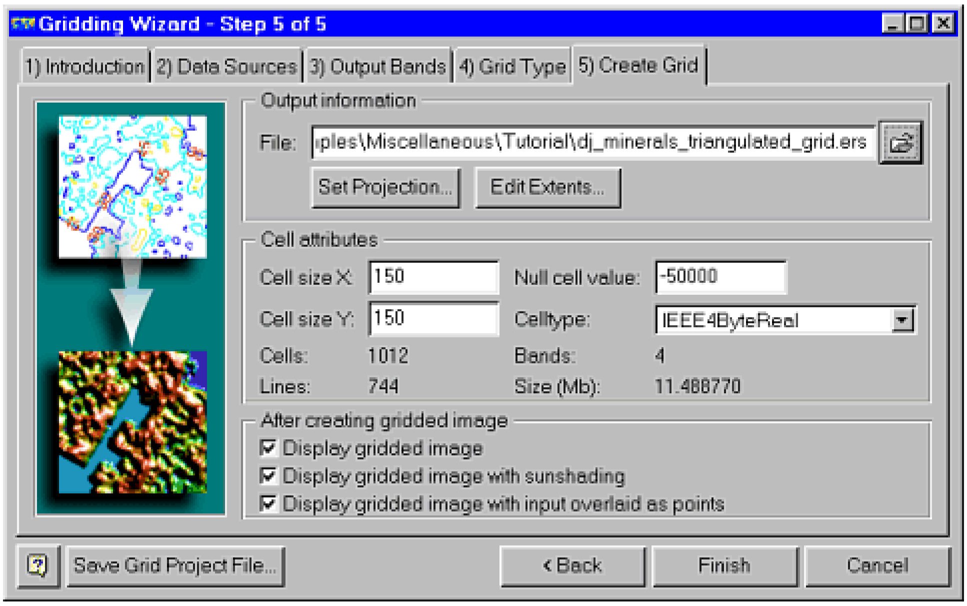
1 Click on the **All Triangulation (TIN)** button to set the gridding method to Triangulation.

   You could also have selected **Triangulation** from the drop-down list next to each band description.

   Notice that the **Advanced...** buttons are grayed out. This is because you do not have to set any further parameters for Triangulation.

2 Click on the **Next>** button to go to the **5) Create Grid** tab.

Create the gridded image



The **Create Grid** tab allows you to specify the file name and define the Extents, Projection and Cell attributes of the output gridded file. You can also select how you want the gridded image to be displayed.

1 Click on the File Chooser  button to open the **Gridding Wizard Output File** chooser dialog box.

2 From the **Directories** menu, select the path ending with the text **\examples**

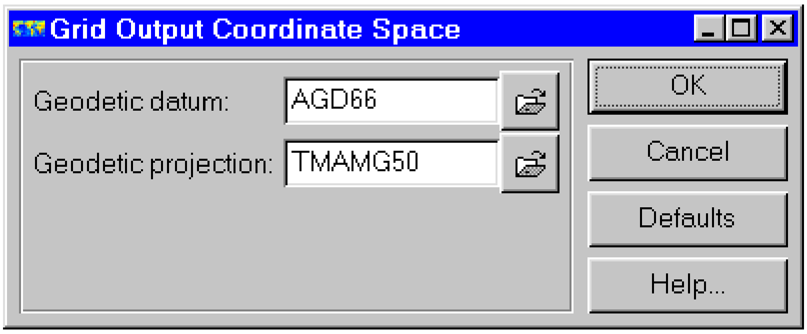
3 Double-click on the directory named ‘Miscellaneous’.

4 Double-click on the directory named ‘Tutorial.’

5 Enter ‘minerals_triangulated_grid_*<your initials>*’ in the chooser **Save as:** field, and click on the **OK** button.

The name with its path and a ‘.ers’ extension will be inserted in the **File:** field of the ‘Create Grid’ tab. When you create the gridded image it will be saved to that file name.

6 Click on the **Set Projection...** button to open the **Grid Output Coordinate Space** dialog.

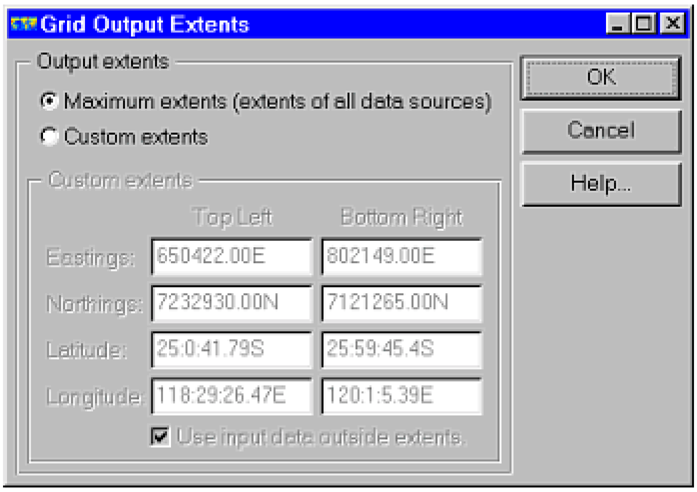


This dialog allows you to select a Geodetic datum, Geodetic projection and Coordinate type for the output gridded image. For this example we will use default values.

7 Click on the **Defaults** button to select the default values.

8 Click on the **OK** button to return to the Gridding Wizard.

9 Click on the **Edit Extents...** button to open the **Grid Output Extents** dialog box.



This dialog box allows you to specify the area to be included (extents) in the output gridded image. If you select the **Maximum extents** option, the output image will include the full extents of all the data sources. If you select the **Custom extents** option, you can then enter the top left and bottom right coordinates of the gridded image in the units you specified in the **Grid Output Coordinate Space** dialog. Generally this is in Eastings/Northings Longitude/Latitude or meters. This enables you to limit the extents of the gridded image to an area of interest.

10 Select the **Maximum extents** option.

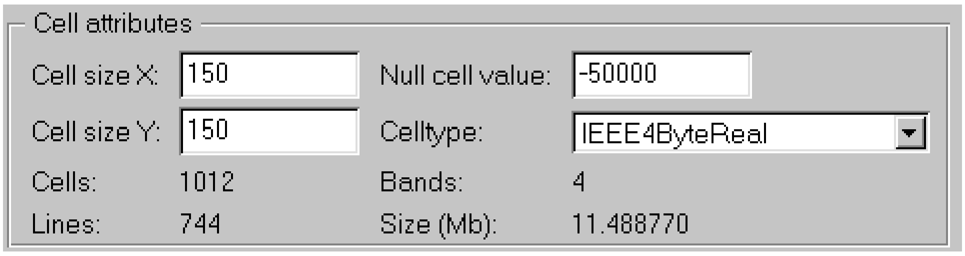
11 Click on the **OK** button to return to the Gridding Wizard.

12 Check that the number of cells and lines in the **Cell attributes** box show reasonable values.

13 If the size of the output file is larger than 12 Mb, increase the Cell size X: and Cell Size Y: values until the size is less than 12Mb.

Note: In practice you would probably not do this because it decreases the resolution of the output gridded image. It is done here to save time and conserve disk space.

Cell size values of 150 should result in the file size shown below



14 Select the following display option:

- Display gridded image with input overlaid as points

You could also have selected the following options but, for the purpose of this exercise, we will just select the one:

- Display gridded image
- Display gridded image with sunshading

15 Select the **Save Grid Project File** button the open the chooser dialog.

All the grid data sources and settings you entered are stored in a project file which you can save and re-use.

16 From the **Directories** menu, select the path ending with the text **\examples**

17 Double-click on the directory named ‘Miscellaneous’.

18 Double-click on the directory named ‘Tutorial.’

19 Enter ‘grid_project_1_*<your initials>*’ in the chooser **Save as:** field, and click on the **OK** button.

The project file is saved to the file name with a ‘.egp’ extension.

20 Click on the **Finish** button to generate the gridded image and close the Gridding Wizard

A Status dialog will indicate the progress of the gridding. On completion, ER Mapper will display an image window displaying the following algorithm;

- The gridded image in a pseudo layer and a grid datasource points vector layer.

21 Click on the **Close** button to close the **Status** dialog.

View an algorithm with the gridded image

1 Click on the image window title bar to make it active.

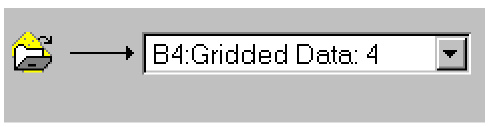
2 Open the Algorithm dialog by clicking on the **Edit Algorithm** button on the **Common Functions** toolbar.

The algorithm has a surface with Pseudo and a Grid Datasource Points vector layer.

3 Select the Pseudo layer

This layer contains band **B1 Gridded Data:1** of the raster image you created. This displays the overall traces of aluminum oxide gridded from the 'Peak_Hill_Al203.txt' data source

4 Select bands B2 to B4.



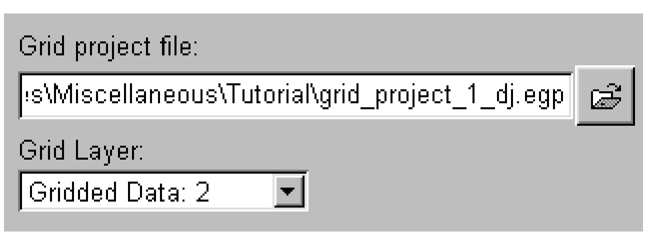
The image window will display the gridded trace of mineral associated with the band.

5 Select the Grid Datasource Points layer.

Notice that this layer is a Dynamic Link to the Project File you created. It shows point locations for the layer 1 (aluminum oxide) sample readings.

6 Click on the **Dynamic Link Chooser** button in the layer process diagram to open the **Display grid datasource** points dialog box.

7 Select 'Gridded Data:2' from the **Grid Layer** drop-down list, and click on the **Finish** button to exit the dialog.



The image window will now show the point locations for the layer 2 (calcium oxide) sample readings.1

Close all image windows and dialog boxes

1 Close all image windows using the window system controls:

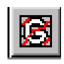
- Select **Close** from the window control-menu.

  Only the ER Mapper main menu should be open on the screen.

2: Create a gridded image using Minimum Curvature

In this exercise, we will create the same gridded image as we did previously. Instead of using Triangulation for all the bands we will now use Minimum Curvature for two of them. We will also gave the bands more meaningful names.

Open the Gridding Wizard

1 Click on the **Gridding Wizard**  button on the **Common Functions** toolbar.

The Gridding Wizard dialog opens with the **1)Introduction** tab selected.

2 Select the **Existing grid project** option.

3 Select your previously saved ‘grid_project_1_<*your initials*>.egp’ project file from the ‘\examples\Miscellaneous\Tutorial’ directory.

4 Click on the Gridding Wizard **Next>** button or select the **2) Data Sources** tab.

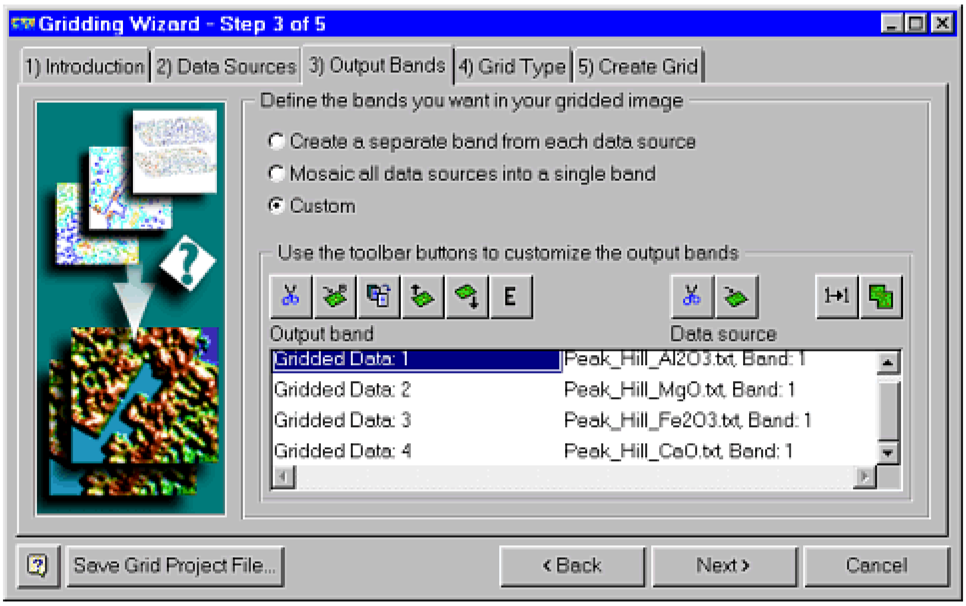
Both actions will take you to the next step by opening the ‘Data Sources’ tab

5 The list of data sources should show the four ‘Peak_Hill’ text files you selected in the previous exercise.

Leave the data sources unchanged.

6 Click on the **Next>** button to go to the **3) Output Bands** tab.

Define the output bands

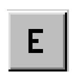


1 Select the option **Custom.**

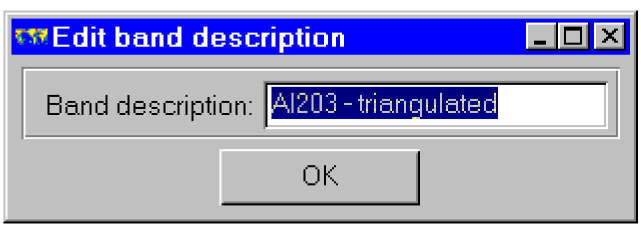
This should already be the default selection because we are using an existing Project File. The toolbar buttons will now be visible.

We want to give the output bands more meaningful names.

2 Select the 'Gridded Data:1' entry under **Output band**.

3 Click on the **Edit output band description**  button.

The Edit band description dialog will open.



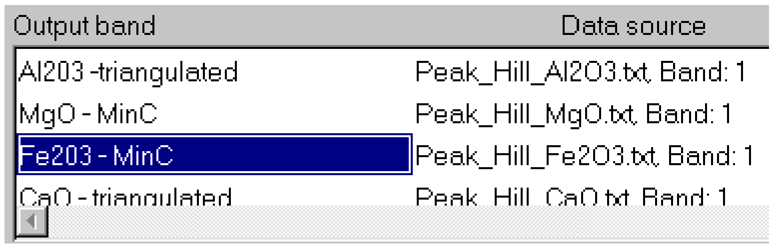
4 In the **Band description** field, enter the text "Al203 - triangulated". Make sure that the 'Peak_Hill_Al203.txt' data source is allocated to this output band. If not, change the name accordingly.

5 Click on the **OK** button to return to the Gridding Wizard.

The Output band name will have changed to "Al203 - triangulated".

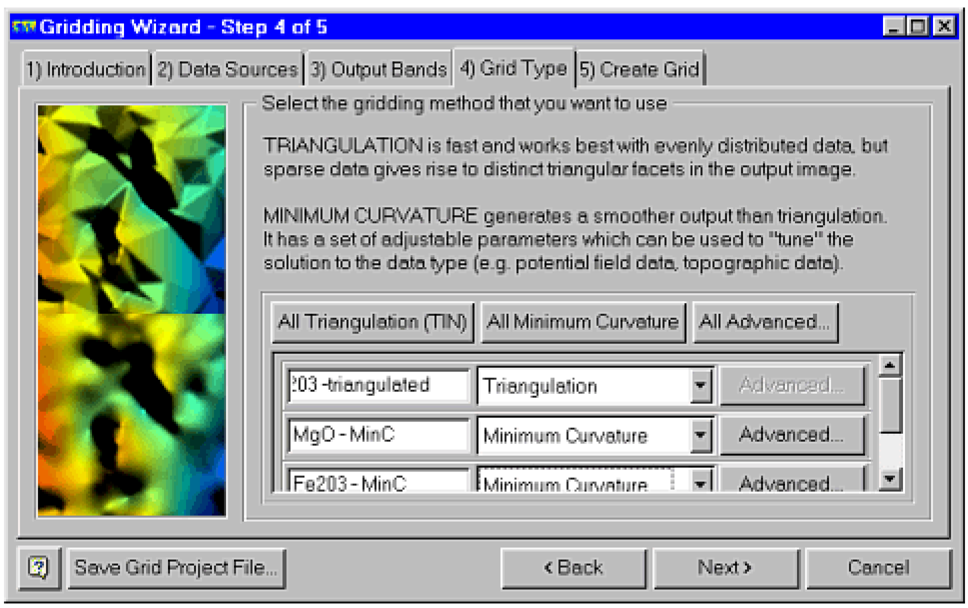
6 Repeat the previous two steps and rename the other bands, "CaO - triangulated", "Fe203 - MinC" and "MgO - MinC".

You should now have the following entries in the list:



7 Click on the **Next>** button to go to the **4) Grid Type** tab.

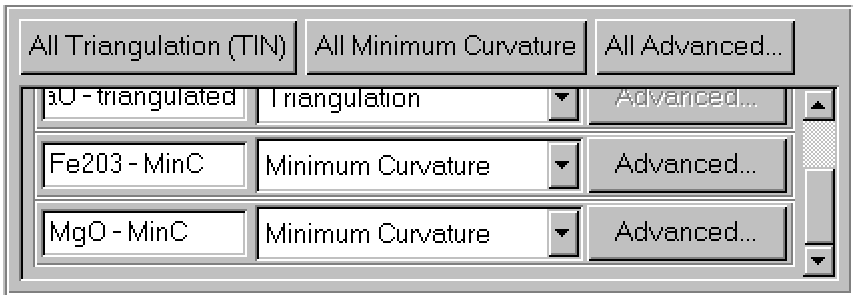
Select the gridding method



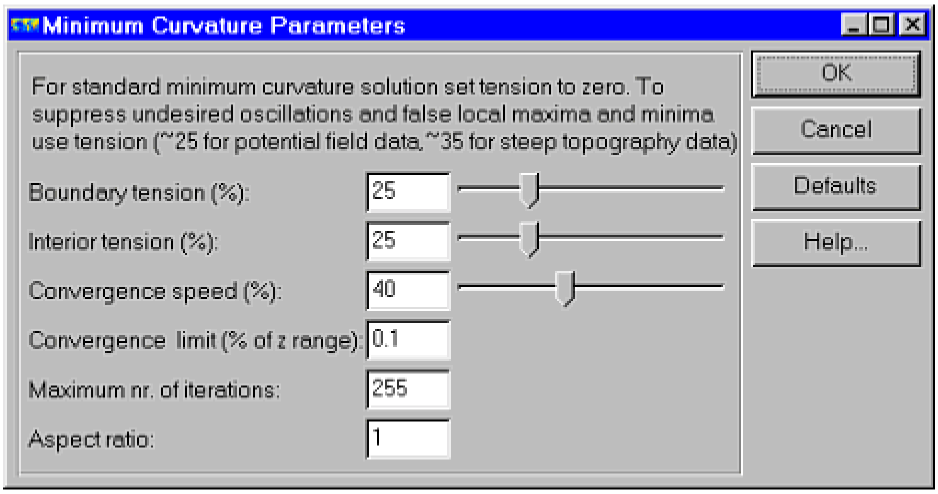
We will set two bands to Triangulation, and the others to Minimum Curvature.

1 Select **Triangulation** from the drop-down list next to ‘Al203 - triangulated’ and ‘CaO - triangulated’.

2 Select **Minimum Curvature** from the drop-down list next to ‘Fe203 - MinC’ and ‘MgO - MinC’.



3 Click on the **Advanced...** button next to the ‘Fe203 - MinC’ entry to open the **Minimum Curvature Parameters** dialog.



4 Use the sliders to set the **Boundary tension(%)** and **Interior tension(%)** to 25.

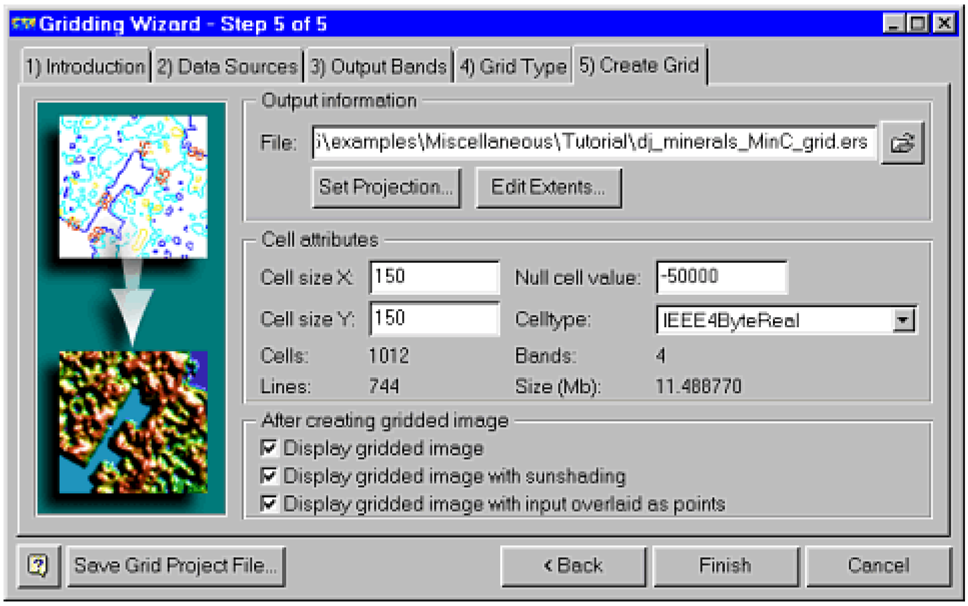
Note: Leave the other settings at their default values. It is advisable not to change them unless you have a good reason for doing so and you know what you are doing. See “Gridding methods” on page 582 of the ER Mapper User Guide for more information on these parameters.

This will create the ‘Fe203 - MinC’ band with Minimum Curvature under tension, and the ‘MgO - MinC’ band with Minimum Curvature.

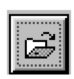
5 Click on the **OK** button to close the dialog and return to the Gridding Wizard.

6 Click on the **Next>** button to go to the **5) Create Grid** tab.

Create the gridded image



The ‘Create Grid’ tab allows you to specify the file name and define the Extents, Projection and Cell attributes of the output gridded file. You can also select how you want the gridded image displayed.

1 Click on the File Chooser  button to open the **Gridding Wizard Output File** chooser dialog box.

2 From the **Directories** menu, select the path ending with the text **\examples**

3 Double-click on the directory named ‘Miscellaneous’ and then select the ‘Tutorial’ directory.

4 Enter ‘minerals_MinC_grid_*<your initials>*’ in the chooser **Save as:** field, and click on the **OK** button.

The name with its path and a ‘.ers’ extension will be inserted in the **File:** field of the ‘Create Grid’ tab. When you create the gridded image it will be saved to that file name.

5 Select all the display options:

- Display gridded image
- Display gridded image with sunshading
- Display gridded image with input overlaid as points

The image will be displayed in three separate image windows.

6 Select the **Save Grid Project File...** button to open the chooser dialog.

All the grid data sources and settings you entered are stored in a project file which you can save and re-use.

7 From the **Directories** menu, select the path ending with the text **\examples**

8 Double-click on the directory named ‘Tutorial.’

9 Enter ‘grid_project_2_*<your initials>*’ in the chooser **Save as:** field, and click on the **OK** button.

The project file is saved to the file name with a ‘.egp’ extension.

10 Click on the **Finish** button to generate the gridded image and close the Gridding Wizard

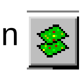
A status dialog will indicate the progress of the gridding.

On completion, ER Mapper will display three image windows displaying the following algorithms;

- The gridded image in a pseudo layer
- The gridded image in a pseudo layer and an intensity layer with sunshading on.
- The gridded image in a pseudo layer and a grid datasource points vector layer.;

View an algorithm with the gridded image

1 Click on the ‘pseudo layer’ image window title bar to make it active.

2 Open the Algorithm dialog by clicking on the **Edit Algorithm** button  on the Common Functions toolbar.

The algorithm has a surface with Pseudo layer.

3 Select the Pseudo layer

This layer contains band **B1:Al203 - triangulated** of the raster image you created. This displays the overall traces of aluminum oxide gridded from the ‘Peak_Hill_Al203.txt’ data source.

4 Select the B3:Fe203 - MinC band from the drop -down list.

The image window will now display the overall iron oxide traces gridded from the ‘Peak_Hill_Fe302.txt’ data source using the Minimum Curvature method.

Close all image windows and dialog boxes

1 Close all image windows using the window system controls:

- Select **Close** from the window control-menu.

  Only the ER Mapper main menu should be open on the screen.

What you learned...

After completing these exercises, you know how to perform the following task in ER Mapper:

- Use the Gridding Wizard to create a multi-band gridded image from text files.
- Select some of the output bands to use Triangulated gridding, and others to use Minimum Curvature and Minimum Curvature under tension.

24

Contours

The ‘Contours’ dynamic link analyses raster data and draws contours from the values. For example, you may wish to generate contours from digital terrain data, or magnetics or seismic data. You can view the contours on screen in 2D and print them. You can also save them as a separate vector file if you want to view them in 3D or export the file to another application.

ER Mapper contouring has the following features:

- images, algorithms and virtual images can be contoured
- you need only select the data source (image) and the band, and ER Mapper will automatically create the contours
- you can let ER Mapper set the parameters or you can specify them yourself
- you can see contour start value and interval, contour labels and contour color, line style and line width
- you can add contours to the entire image or to a part of an image.

Adding and setting up a contours layer

Contours are added to an algorithm using a Contours dynamic link layer. Any number of Contours dynamic link layers can be included in an algorithm.

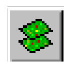
Hands-on exercise

These exercises give you practice contouring a magnetics image (images, algorithms and virtual datasets can be contoured)

Before you begin... Before beginning these exercises, make sure all ER Mapper image windows are closed. Only the ER Mapper main menu should be open on the screen.

1: Draw Contours on an image

Open an image window and the Algorithm window

1. Click the **Edit Algorithm** button  on the **Common Functions** toolbar.

   An image window and the **Algorithm** dialog open.

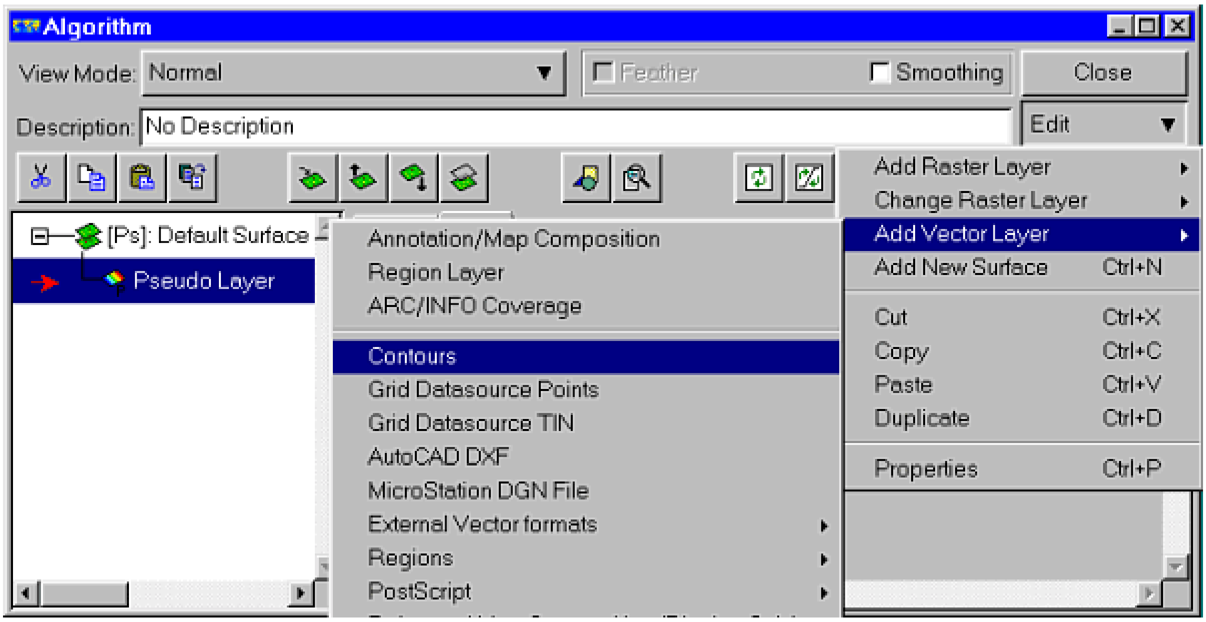
2. On the **Algorithm** window, click the **Load Dataset** button  on the left side of the process stream diagram.

   The **Raster Dataset** file chooser dialog box appears.

3. From the **Directories** menu, select the path ending with **\examples**.
4. Double-click on the directory '**Shared_Data**' to open it.
5. Double-click on the image named '**Newcastle_Magnetics.ers**' to load it.

   The image is loaded into the Pseudocolor layer.

6 From the **Edit** menu in the Algorithm dialog, select the **Add Vector Layer** submenu and click on **Contours**.

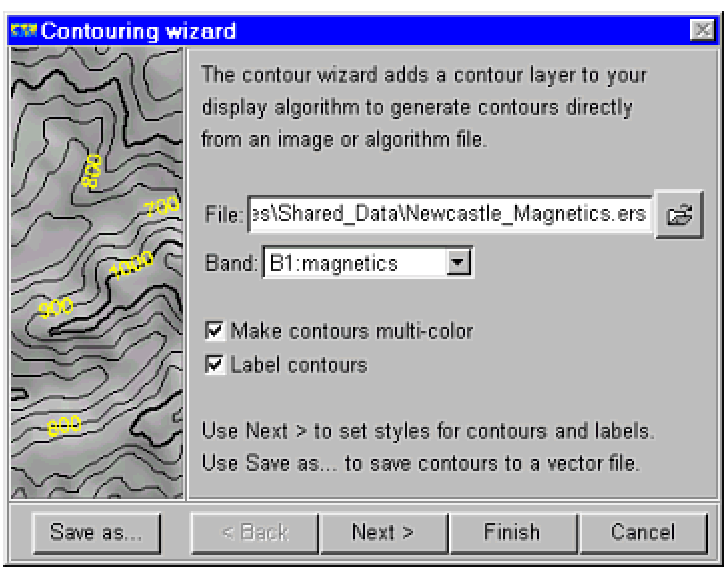


7 A Contours layer is added to the data structure diagram in the left panel of the Algorithm dialog.

To start the Contouring Wizard

1 In the Algorithm dialog, click the Chooser button. 

The Contouring Wizard dialog opens.



2 In the **File:** field on the Contouring Wizard dialog select ‘**Newcastle_Magnetics.ers**’ file in the ‘\examples\Shared_Data’ directory

---

Note: Virtual datasets and algorithms can also be contoured.

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3 Choose the band to contour. (Newcastle_Magnetics.ers has only one band)

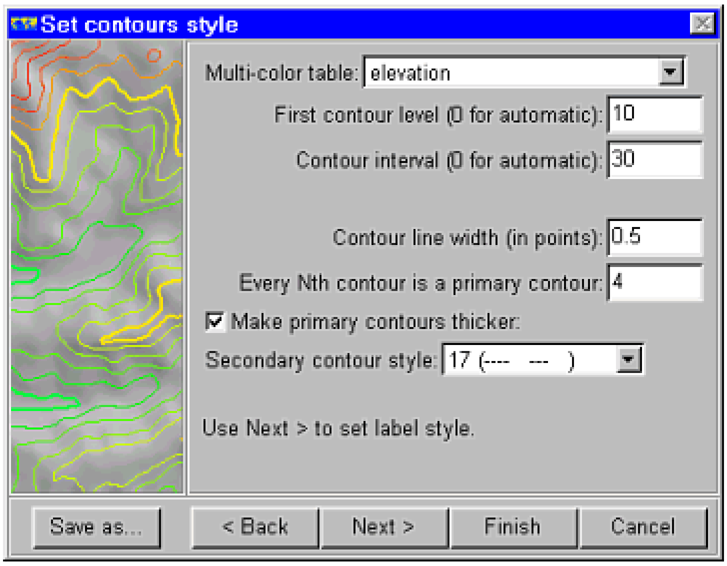
Band:	Choose the image band to contour. Band 1 is chosen by default.

4 Select the **Make contours multi-color** and **Label contours** options.

Make contours multi-color	Select this option for the contour lines to have colors from a specified color table. Otherwise they will have a single color.
Label contours	Select this option if you want the contour lines to be labelled.

5 Click on the **Next >** button to go to the **Set contours style** wizard page.

Set contours style.



1 Select **elevation** from the drop-down list in the **Multi-color table** field.

2 Enter 10 for the **First contour level**, 30 for the **Contour interval**, and a **Contour line width** of 0.5 points.

3 Enter 4 for **Every Nth contour is a primary contour.**

4 Select the **Make primary contours thicker** option.

5 Select **Secondary contour style** number 17 from the list.

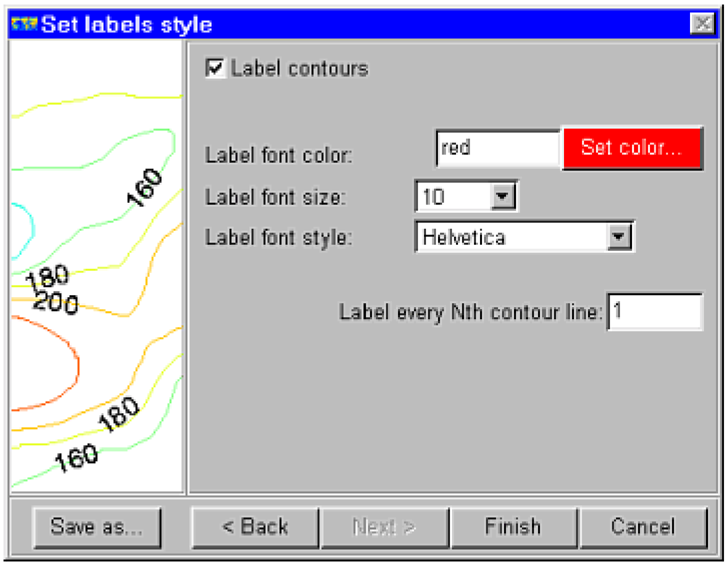
Every fourth contour line will be solid and thicker than the other lines, which will be dotted.

Note: If you leave the options as they are the default options will be used.

First contour level	The value at which the first contour is drawn. If you leave the value as 0, ER Mapper will automatically choose a value.
Contour interval	The distance between contours. If you leave the value as 0 the step between contours will be automatically chosen by ER Mapper.
Contour line width	Specify the width of the contour lines in points. The default is 0.5 points.
Every Nth contour is a primary contour	The contour lines at the specified interval will be primary contours which you can specify to be thicker. Leave at the default value of 0 or 1 for no primary contours.
Make primary contours thicker	Select this option for primary contour lines to be thicker than the width specified in the **Contour line width** field. This option has no effect if there are no primary contours; i.e you entered 0 or 1 in the **Every Nth contour is a primary contour** field.
Secondary contour style	Select the line style for secondary contours from the list. Please note that you will only have secondary contours if you elected to have primary contours. Therefore ER Mapper will not use the secondary contour style if you entered a 0 or 1 in the **Every Nth contour is a primary contour** field.

6 Click **Next** to go to the **Set labels style** wizard page.

Set labels style



1. Select the **Label contours** option.,

   The Label contours option should already be checked because you selected it in the first page of the wizard.

2. Leave the **Label font color**, **Label font size** and **Label font style** to the default values of red, 10 and Helvetica respectively.

3. Set **Label every Nth contour line:** to 2 so that every second line is labelled.

4. Click on **Finish** to exit the Contouring Wizard.

   ER Mapper will redraw the image with contour lines.

Note: You could also have used the **Save as...** button in the Contouring Wizard to save the contours as an ER Mapper Vector Dataset (.erv) file. This is only necessary if you want to use the contours in some other applications. The ER Mapper **Contours** layer will re-draw the contours every time you run the algorithm.

Close all image windows and dialog boxes

1 Close all image windows using the window system controls:

- Select **Close** from the window control-menu.

2 Click **Close** on the **Algorithm** window to close it.

Only the ER Mapper main menu should be open on the screen.

What you learned...

After completing these exercises, you know how to perform the following task in ER Mapper:

- Use the ER Mapper Contouring Wizard to define and draw contours on an image.

25

Creating Lookup Tables

This chapter explains how to create lookup tables that will transform digital values of raster images to colors in pseudocolor layers.

About Lookup Tables

The lookup table files are text files, each holding an array of 256 lines of four entries each. The first entry is the pixel lookup value and runs from 0 to 255 down the array. The other three entries are the Red, Green and Blue values in the 0-65535 range (16 bit) that will be used to display that pixel value.

A variety of lookup tables is supplied with ER Mapper. In addition, you can create your own tables tailored to your needs.

Color Lookup Table files are held in the ‘lut’ directory. Add any new lookup tables in this directory so that they will appear in the **Color Table** menu in ER Mapper's Algorithm dialog box.

To select a Lookup Table

1 In the Algorithm dialog box, select the **Surface** tab.

2 Select ‘Pseudocolor' from the **Color Mode** drop-down list.

3 Select the desired Lookup Table from the Lookup Table drop down list.

To create a new linear Color Lookup Table

To include the lookup table in the lookup table menu, make sure the file is in the ‘lut’ directory and has a `.lut' extension.

If your color lookup table is to consist of a linear gradation from one color to another, you can use the `makelut' utility supplied with ER Mapper to help you generate it. `makelut' creates a Color Lookup Table which adjusts one specified value to another, and outputs the Color Lookup Table to the `makelut' standard output path.

To generate a Color Lookup Table:

1 PC - Bring up a command prompt window.

2 Type in the CLUT utility command at the \bin\win32> prompt:

makelut -n "CLUT_name" iR iG iB nR nG nB > ERMAPPER\lut\CLUT_filename.lut

Where:

-n "CLUT_name" is the name of lookup table that will be mentioned in the CLUT_filename.lut file.

iR iG iB are the Red Green Blue values of initial lookup table

nR nG nB are the Red Green Blue values of new lookup table

ERMAPPER\lut is the ER Mapper Color Lookup Table directory. The created CLUT_filename.lut lookup table file will be stored in that directory.

CLUT_filename is the file name of color lookup table and will be displayed (without the .lut extension) in the Color Table drop-down list on the Algorithm window.

The pixel lookup values are specified in the range 0-255 in the first column, and the `makelut' utility correctly generates the RGB values in the 0-65535 range (16 bit) in the 2nd, 3rd and 4th columns.

Tip: To find out the values of the colors in the lookup table, load the CLUT_filename.lut file into any Text Editor. The CLUT_filename.lut file will display all the variations of Red Green Blue and the corresponding unit values.

Hands-on exercises

These exercises teach you to create 2-color and multi-color lookup tables.

What you will learn... After completing these exercises, you will know how to perform the following tasks in ER Mapper:

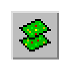
- Create 2-color and multi-color lookup tables
- Select combinations of Red Green Blue values of any color you would like to use in the color lookup table that you are going to create
- Create a combination of colors and grey scale lookup table
- Apply the created lookup tables to the raster images

Before you begin... Before beginning these exercises, make sure all ER Mapper image windows are closed. Only the ER Mapper main menu should be open on the screen.

1: Creating a 2-color lookup table

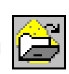
Objectives Learn to create a 2-color lookup table and use it to display a raster image

Display an image in Pesudocolor mode

1 On the Standard toolbar, click on the **Edit Algorithm**  button.

An image window and the **Algorithm** window appear.

2 Click on the **Layer tab** to view the settings for the layer.

3 On the **Algorithm** window, click the **Load Dataset** button  on the left side of the process stream diagram.

The **Raster Dataset** file chooser dialog box appears.

4 From the **Directories** menu, select the path ending with **\ examples**.

5 Double-click on the directory ‘Shared_Data’ to open it.

6 Double-click on the image named ‘Landsat_TM_year_1985.ers’ to load it.

Band one of the image is loaded into the Pseudocolor layer.

7 On the **Algorithm** window click on the surface tab. By default the **Color Mode** is in Pseudocolor. If not, change it to Pseudocolor mode. From the **Color Table** drop down list choose ‘pseudocolor’.

The image window displays band 1 of the image with the ‘pseudocolor’ lookup table.

Finding the combination of Red Green Blue values for a particular color

1 On the main menu click on the File menu and from the drop-down list select **Page Setup...**

2 **Page Setup** dialog box appears.

3 On the **Page Setup** dialog box select **Set Color...** button.

4 **Color** dialog box appears.

5 From the **Basic colors:** choose bright blue color and note down the values Red = 0, Green = 0 and Blue =255.

6 From the **Basic colors:** choose bright red color and note down the values Red = 255, Green = 0 and Blue =0.

Creating a blue_red color lookup table

1 Bring up a MS-DOS Prompt window. At the \bin\win32> prompt type in the following

makelut -n “blue->red" 0 0 255 255 0 0> C:\ERMAPPER\lut\blue_red.lut

---

Note: The following procedure assumes that C:\ERMAPPER is where ER Mapper is installed. Change the command to suit your environment.

---

makelut	command to make lookup table
-n	switch to include the name “blue->red” in the blue_red.lut file
“blue->Red”	Name of the lookup table appears in the blue_red.lut file
0 0 255	Red, Green, Blue values of Blue color
255 0 0	Red, Green, Blue values of Red color

>	create the blue_red.lut file in the defined directory
C:\ERMAPPER\lut\blue_red.lut	The defined directory path and the file name to be saved

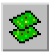
2 The blue_red.lut lookup table file is created and is saved in the C:\ERMAPPER\lut directory.

Display an image using your blue_red.lut color lookup table.

1 Exit from ER Mapper and restart it again.

Note: To enable the ER Mapper to recognize the created lookup table file you have created, it is necessary to exit from ER Mapper and restart it.

---

2 On the Standard toolbar, click on the **Edit Algorithm**  button.

An image window and the **Algorithm** window appear.

3 Click on the **Layer tab** to view the settings for the layer.

4 On the **Algorithm** window, click the **Load Dataset** button  on the left side of the process stream diagram.

The **Raster Dataset** file chooser dialog box appears.

5 From the **Directories** menu, select the path ending with **\ examples**.

6 Double-click on the directory ‘Shared_Data’ to open it.

7 Double-click on the image named ‘Landsat_TM_year_1985.ers’ to load it.

Band one of the image is loaded into the Pseudocolor layer.

8 On the **Algorithm** window click on the surface tab. By default the **Color Mode** is in Pseudocolor. If not, change it to Pseudocolor mode.

9 From the **Color Table** drop down list choose ‘blue_red’ - the color lookup table you have created.

The image window displays band 1 of the image with the blue_red color lookup table you have created.

2: Creating a multi-color lookup table

Finding the combination of Red Green Blue values for five colors

1. Display an raster image in Pseudocolor mode.
2. On the main menu click on the File menu and from the drop-down list select **Page Setup...**
3. **Page Setup** dialog box appears.
4. On the **Page Setup** dialog box select **Set Color...** button.
5. **Color** dialog box appears.
6. From the **Basic colors:** choose black color and note down the values Red = 0, Green = 0 and Blue =0.
7. From the **Basic colors:** choose bright blue color and note down the values Red = 0, Green = 0 and Blue =255.
8. From the **Basic colors:** choose bright green color and note down the values Red = 0, Green = 255 and Blue =0.
9. From the **Basic colors:** choose bright red color and note down the values Red = 255, Green = 0 and Blue =0.
10. From the **Basic colors:** choose white color and note down the values Red = 255, Green = 255 and Blue =255.

Creating a Black_blue_green_red_White color lookup table

1. Bring up a MS-DOS Prompt window. At the \bin\win32> prompt type in the following and press enter.

   makelut -n "Black->Blue->Green->Red->White" 0 0 0 0 0 255 0 255 0 255 0 0 255 255 255 > C:\ERMAPPER\lut\blk_blu_gr_rd_wht.lut

Note: The following procedure assumes that C:\ERMAPPER is where ER Mapper is installed. Change the command to suit your environment.

makelut	**command to make lookup table**
-n	switch to include the name “Black->Blue->Green->Red->White” in the red_blue.lut file
“Black->Blue->Green->Red->White”	Name of the lookup table appears in the blk_blu_gr_rd_wht.lut file
0 0 0	Red, Green, Blue values of Black color
0 0 255	Red, Green, Blue values of Blue color
0 255 0	Red, Green, Blue values of Green color
255 0 0	Red, Green, Blue values of Red color
255 255 255	Red, Green, Blue values of White color
>	create the blk_blu_gr_rd_wht.lut file in the defined directory
C:\ERMAPPER\lut \blk_blu_gr_rd_wht.lut	The defined directory path and the file name to be saved

2 The blk_blu_gr_rd_wht.lut lookup table file is created and is saved in the C:\ERMAPPER\lut directory.

Note: Bring up a Text Editor and open the blk_blu_gr_rd_wht.lut file. Check how the color changes gradually from Black to Blue to Green to Red to White from the pixel lookup value (the first column) 0 to 64 to 128 to 192 to 255 down the array.

Display an image using your blk_blu_gr_rd_wht.lut color lookup table.

1 Exit from ER Mapper and restart it again.

Note: To enable the ER Mapper to recognize the created lookup table file you have created it is necessary to exit from ER Mapper and restart it.

---

2 On the Standard toolbar, click on the **Edit Algorithm** button.

An image window and the **Algorithm** window appear.

3 Click on the **Layer tab** to view the settings for the layer.

4 On the **Algorithm** window, click the **Load Dataset** button on the left side of the process stream diagram.

The **Raster Dataset** file chooser dialog box appears.

5 From the **Directories** menu, select the path ending with **\ examples**.

6 Double-click on the directory 'Shared_Data' to open it.

7 Double-click on the image named 'Landsat_TM_year_1985.ers' to load it.

Band one of the image is loaded into the Pseudocolor layer.

8 On the **Algorithm** window click on the surface tab. By default the **Color Mode** is in Pseudocolor. If not, change it to Pseudocolor mode.

9 From the **Color Table** drop down list choose 'blk_blu_gr_rd_wht' - the color lookup table you have created.

The image window displays band 1 of the image with the blk_blu_gr_rd_wht color lookup table you have created.

Note: View the blk_blu_gr_rd_wht color lookup table from the vertical color scale bar in the transform window.

3: Creating a combination of multi-color and greyscale lookup table

Creating a Greyscale color lookup table

1 Bring up an MS-DOS Prompt window. At the \bin\win32> prompt type in the following and press enter.

makelut -n "Black->White" 0 0 0 255 255 255 > C:\ERMAPPER\lut_black_white.lut

---

Note: The following procedure assumes that C:\ERMAPPER is where ER Mapper is installed. Change the command to suit your environment.

---

makelut	command to make lookup table
-n	switch to include the name “Black->White” in the black_white.lut file
“Black->White”	Name of the lookup table appears in the black_white.lut file
0 0 0	Red, Green, Blue values of Black color
255 255 255	Red, Green, Blue values of White color
>	create the black_white.lut file in the defined directory
C:\ERMAPPER\lut\black_white.lut	The defined directory path and the file name to be saved

2 The black_white.lut lookup table file is created and is saved in the C:\ERMAPPER\lut directory.

3 Bring up a Text Editor and open the black_white.lut file. Check how the color changes gradually from Black to White from the pixel lookup value (the first column) 0 to 255 down the array.

4 Edit the first 20 pixel values (0-19 of the first column) to 0 0 65535 (Blue) and the last 20 pixel values (236 to 255 of the first column) to 65535 65535 0 (Yellow).

5 Save the file as blue_grey_yellow.lut.

Display an image using your blue_grey_yellow.lut color lookup table

1 Exit from ER Mapper and restart it again.

Note: To enable the ER Mapper to recognize the created lookup table file you have created it is necessary to exit from ER Mapper and restart it.

---

2 On the Standard toolbar, click on the **Edit Algorithm**  button.

An image window and the **Algorithm** window appear.

3 Click on the **Layer tab** to view the settings for the layer.

4 On the **Algorithm** window, click the **Load Dataset** button on the left side of the process stream diagram.

The **Raster Dataset** file chooser dialog box appears.

5 From the **Directories** menu, select the path ending with **\ examples**.

6 Double-click on the directory 'Shared_Data' to open it.

7 Double-click on the image named 'Landsat_TM_year_1985.ers' to load it.

Band one of the image is loaded into the Pseudocolor layer.

8 Select Thematic Mapper band 5 (TM5) from the band selection drop-down list on the Algorithm window.

Note: DN value of water in TM5 is less than 20. You are going to display the water region in TM5 in blue color using your blue_grey_yellow.lut lookup table.

---

9 In the **Algorithm** window click on the surface tab. By default the **Color Mode** is in Pseudocolor. If not, change it to Pseudocolor mode.

10 From the **Color Table** drop down list choose 'blue_grey_yellow' - the color lookup table you have created.

The image window displays band 1 of the image with the blue_grey_yellow color lookup table you have created.

Note: View the blue_grey_yellow color lookup table from the vertical color scale bar in the transform window.

---

11 Click the **99% Contrast Enhancement** button.

The water region is displayed as blue with some areas displayed as black. It is because the transformation has been clipped to 99%.

12 On the **Algorithm** window click the **Edit Transform Limits** button.

13 The **Transform** window appears.

14 On the **Transform** window, on the X axis type in the first value 0 instead of 4 as displayed (which was clipped) and press enter.

15 The image is displayed with the water region as blue and without black areas.

Close all image windows and dialog boxes

1 Close all image windows using the window system controls:

- Select **Close** from the window control-menu.

2 Click **Close** on the **Algorithm** window to close it.

Only the ER Mapper main menu should be open on the screen.

What you learned

After completing these exercises, you know how to perform the following tasks in ER Mapper:

- Create 2-color and multi-color lookup tables
- Create a combination of multi-color and greyscale lookup table
- Apply the created color lookup tables to images.

26

Image geocoding

This chapter explains how to use ER Mapper to geometrically correct raw image data and rectify it to real world coordinate systems and map projections.

Note: The exercises in this chapter require the 'Landsat_practice.ers" image file to be in 'examples\Miscellaneous\Tutorial' directory. This file was also used Chapter 19, "Supervised classification".

About image geocoding

Whenever accurate area, direction and distance measurements are required, raw image data must usually be processed to remove geometric errors and rectify the image to a real world coordinate system. With satellite imagery, for example, these errors are introduced by factors such as roll, pitch and yaw of the satellite platform and curvature of the earth. In order to overlay or mosaic two images in ER Mapper, the images must be in the same coordinate system. The common coordinate system can be "raw" (uncorrected), or a real world map projection system.

A *ground control point* (GCP) is a point on the earth's surface where both *image coordinates* (measured in rows and columns) and *map coordinates* (measured in degrees of latitude and longitude, meters, or feet) can be identified. *Rectification* is the process of using GCPs to transform the geometry of an image so that each pixel corresponds to a position in a real world coordinate system (such as Latitude/ Longitude or Eastings/Northings). This process is sometimes called "warping" or "rubbersheeting" because the image data are stretched or compressed as needed to align with a real world map grid or coordinate system.

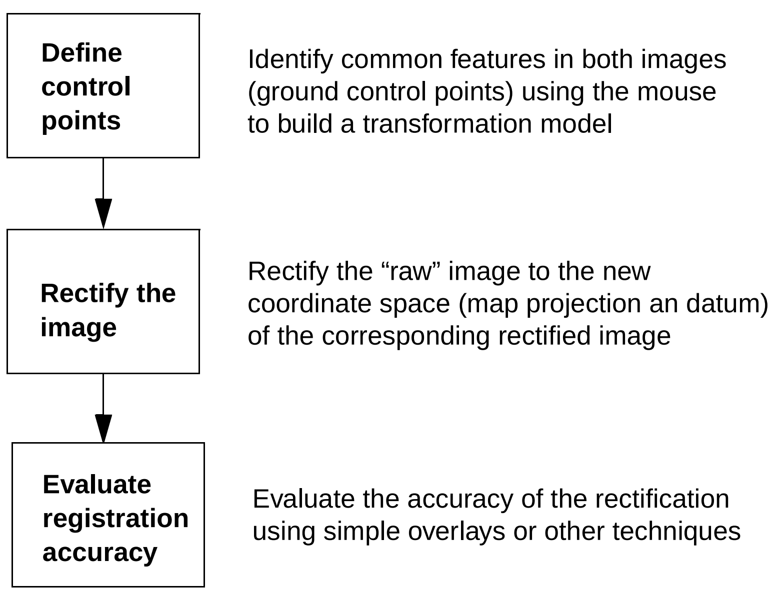
Orthorectification is a more accurate form of rectification because its takes into account sensor (camera) and platform (aircraft) characteristics. It is specifically recommended for airphotos. Orthorectification is covered separately in Chapter 26, “Image orthorectification”.

Registration is simply aligning two images so they can be overlaid or superimposed for comparison. In this case, the images do not have to be rectified to a map projection (they can both be in a “raw” coordinate system).

ER Mapper’s Rectification utilities are commonly used to perform four different types of operations:

- **Image to map rectification**–using polynomial (control point) or linear geocoding to rectify an image to a datum and map projection using GCPs.
- **Image to image rectification**–using polynomial (control point) or linear geocoding to rectify one image to another using GCPs.
- **Map to map transformation**–transforming a rectified image from one datum/map projection to another.
- **Image rotation**–rotating an image any number of degrees.

In this exercise, you will use the Geocoding Wizard to perform an image-to-image rectification. A typical procedure for performing an image-to-image rectification is as follows:



Hands-on exercises

These exercises give you practice using ER Mapper's Geocoding Wizard.

What you will learn...

After completing these exercises, you will know how to perform the following tasks in ER Mapper:

- Choose common ground control points (GCPs) between two images
- Use options to modify the GCP display and edit GCPs
- Rectify a "raw" image to the chosen datum and map projection
- Evaluate registration accuracy using a simple image overlay method

Before you begin...

Before beginning these exercises, make sure all ER Mapper image windows are closed. Only the ER Mapper main menu should be open on the screen.

Note: It is *very important* to adhere to the following procedures exactly as written. Choosing GCPs can be a fairly complex procedure, and you will learn the basics best by following these exact steps the first time.

1: Choosing ground control points

Objectives

Learn how to use ER Mapper's Geocoding Wizard to identify common features in the two images, edit the points, and modify the GCP display.

Create the FROM algorithm (the "raw" image)

Before performing an image-to-image rectification, you must first create an algorithm that displays the "raw" image you want to rectify.

1. Click the **Image Display and Mosaicing Wizard** toolbar button.

   An Image Wizard dialog box appears.

2. In the Image Wizard **Select files to display** window, click the file chooser button in the **File to display:** field to open the file chooser.

3. In the directory 'examples\Miscellaneous\Tutorial', double-click on the image named 'Landsat_practice.ers'.

Note: You should have created the "Landsat_practice.ers" image in the ‘examples\Miscellaneous\Tutorial’ directory in an earlier exercise. If you have not done so, you can create it now by copying files ‘Landsat_MSS_notwarped’ and Landsat_MSS_notwarped.ers’ from the ‘examples\Shared_Data\’ directory and renaming them to ‘Landsat_practice’ and ‘Landsat_practice.ers’ respectively.

4 Select **Display image in 2D** and **Manually set display method**, and click on the **Next >** button.

5 In the **Select display method** window, select **Red Green Blue**.

6 Check the **Manually select display method properties** box.

7 Click on the **Next >** button.

8 In the display mode properties box **Type:** field, select RGB 321 from the list.

9 Click on the **Next >** button.

10 The RGB composite with MSS1 (Blue), MSS2 (Green) and MSS3 (Red) is displayed.

11 Click on the **Finish** button to close the Image Wizard.

12 Click the **Save As**  toolbar button.

13 In the **Files of Type:** field, select ‘ER Mapper Algorithm (.alg)’.

14 From the **Directories** menu, select the path ending with **\examples**.

15 Open the ‘Miscellaneous\Tutorial’ directory, and save the algorithm with the name ‘Landsat_FROM_algorithm’ (use your initials at the beginning).

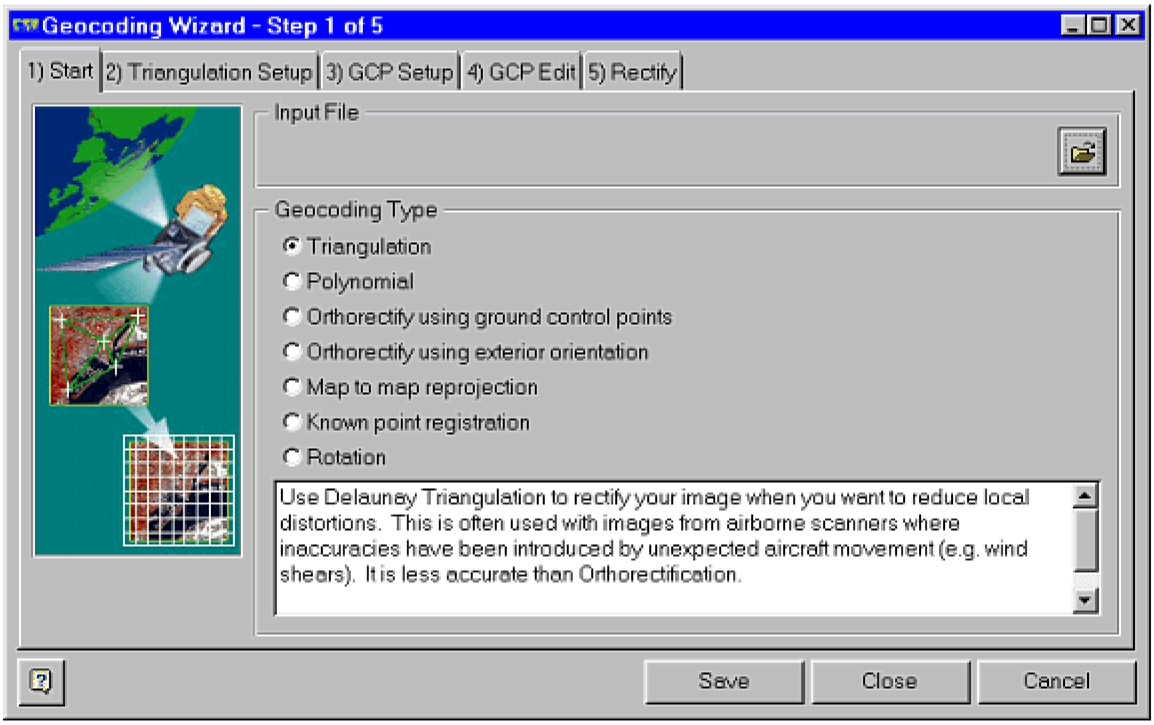
16 Close the image window using the window system controls:

- Select **Close** from the window control-menu.

Remove existing Ground Control Points from the practice image

1 From the **Process** menu (on the main menu), select **Geocoding Wizard**.

The Geocoding Wizard dialog box will open with the **Start** tab selected.



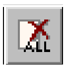
2 Click the **Load Algorithm or Dataset**  button in the **Input file:** field to open the file chooser.

3 From the **Directories** menu, select the path ending with the text **\examples**.

4 In the directory ‘Miscellaneous\Tutorial,’ double-click on your previously saved algorithm, ‘Landsat_FROM_algorithm’.

5 Select **Polynomial** in the **Geocoding Type** box.

6 Select the **GCP Edit** tab.

7 Click the **Delete all GCPs**  button and, when asked to confirm the delete, click **Yes**.

8 Click on the **Save** button to save the changes to the practice image. If asked to confirm saving GCPs to disk click **Yes**.

Set the Polynomial Order

1 Select the Geocoding Wizard **Polynomial Setup** tab.

2 Select **Linear** in the Polynomial Order box.

Specify an image-to-image rectification and algorithm name

1 Select the Geocoding Wizard **GCP Setup** tab.

The **GCP Setup** tab lets you specify the name of a geocoded reference image.

2 In the **GCP Picking Method** box, select **Geocoded image, vectors or algorithm** option.

This tells ER Mapper you plan to pick corresponding points between two images on the screen (an "image-to-image" rectification).

3 Click the **Load Corrected Algorithm or Dataset** button.

4 From the **Directories** menu on the file chooser dialog, select the path ending with the text **\examples**.

5 Double-click on the 'Data_Types' directory to open it.

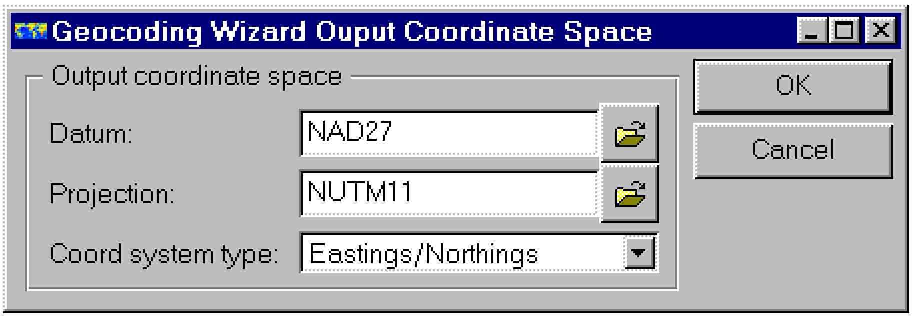
6 Double-click on the 'Landsat_MSS' directory to open it, then double-click on the algorithm 'RGB_321.alg' to load it.

This algorithm will be used to display the 'CORRECTED' image, which is the already rectified image containing coordinate information.

Setup parameters for the image rectification

The **To geodetic datum**, **To geodetic projection** and **To Coordinates**, fields in the Output Coordinate Space box show the datum, projection and coordinate type for the output rectified file you will create. These parameters are included automatically from the 'CORRECTED' (rectified) Landsat image.

1 Click on the Change... button to open the **Geocoding Wizard Output Coordinate Space** dialog.



2 Click on the **Projection** chooser button.

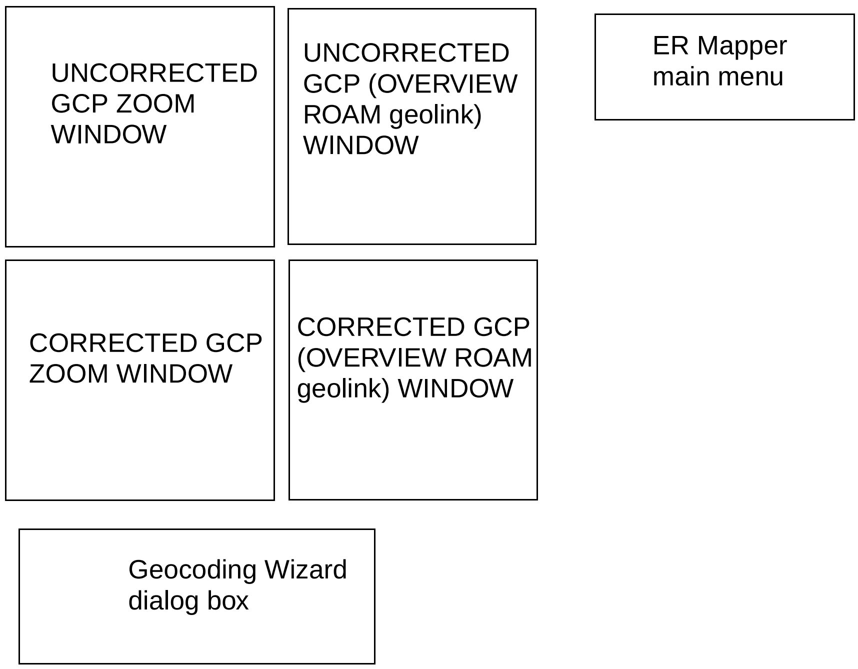
The **Projection Chooser** dialog opens showing available map projections (ER Mapper includes over 700 projections and you can add your own as well).

3 Click **Cancel** on the **Projection Chooser** dialog to close it.

4 Click **Cancel** on the **Geocoding Wizard Output Coordinate Space** dialog to close it.

5 Select the Geocoding Wizard **GCP Edit** tab.

ER Mapper opens several image windows and dialog boxes. You should see a screen setup similar to this one:



Note: If your system does not position the windows automatically, rearrange them as shown above before proceeding.

Setup the image windows to pick the first four GCPs

When you first begin picking GCPs, your “raw” (unrectified) image contains no ground control points. You will begin by picking the first four control points using the CORRECTED and UNCORRECTED image windows. Once you have picked the first four GCPs, you can use the CORRECTED windows to quickly pick the remaining GCPs.

1 On the main menu, click the **Edit Algorithm**  button to open the **Algorithm** window.

2 Click inside the ’CORRECTED GCP ZOOM’ window to activate it.

3 In the **Algorithm** window, turn off the **Smoothing** option.

4 Click your right mouse button inside the 'CORRECTED GCP ZOOM' window, and select **Zoom to All Datasets** from the **Quick Zoom** menu.

The 'CORRECTED GCP ZOOM' window zooms out to the full image extents.

5 Click inside the 'UNCORRECTED GCP ZOOM' image window to activate it.

6 In the **Algorithm** window, turn off the **Smoothing** option.

7 Click your right mouse button inside the 'UNCORRECTED GCP ZOOM' window, and select **Zoom to All Datasets** from the **Quick Zoom** menu.

The 'UNCORRECTED GCP ZOOM' window zooms out to the full image extents. You are now ready to pick your first GCP.

8 Click **Close** on the **Algorithm** window to close it.

Note: It is a good idea to turn off the **Smoothing** option on algorithms where you will pick ground control points. This makes it easier to see the locations of individual image pixels when you zoom in closely to areas.

Pick a GCP in the upper-left part of both images

Note: Make sure the main ER Mapper menu is not hidden by the image windows–move it slightly if needed so you can easily access the toolbars.

---

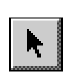
1 On the main menu, click the **ZoomBox Tool**  toolbar button.

2 Point to the 'UNCORRECTED GCP ZOOM' image window, and zoom in on a small area in the upper-left part of the image with well defined features (drag a zoom box).

3 Move the pointer over the 'CORRECTED GCP ZOOM' image window (notice the pointer is a  icon), and click once to activate the window.

4 In the 'CORRECTED GCP ZOOM' image window, drag a box to zoom in on the same geographic area you have displayed in the 'UNCORRECTED' window.

You have now zoomed to a common area in both images to pick a GCP.

5 On the main menu, click the **Pointer Tool**  toolbar button.

6 In the 'CORRECTED GCP ZOOM' window (which is active), click on a clearly identifiable feature in the image, such as a sharp boundary between red vegetation and white barren land.

ER Mapper marks the control point with green cross hairs, and the geographic location of that point appears in the Easting and Northing fields on the Geocoding Wizard **GCP Edit** dialog. (This dialog has many options you will learn more about later.)

7 Click once inside the 'UNCORRECTED GCP ZOOM' window to activate it.

8 Click on exactly the same geographic feature in the 'UNCORRECTED GCP ZOOM' window. (It is important to be as accurate as possible).

ER Mapper marks the control point with cross hairs, and the image pixel location of that point in the raw image appears in the Cell X and Cell Y fields on the **GCP Edit** dialog. The location of each point is marked with a white "X" in each image with the number "1." You have now picked the first GCP.

Pick a second GCP in the lower-left of both images

1 On the Geocoding Wizard **GCP Edit** tab, select **Auto zoom**.

The ZOOM windows will now automatically zoom into the point selected in the corresponding OVERVIEW ROAM windows.

2 On the Geocoding Wizard **Edit GCP** dialog, click the **Add new GCP**  button.

3 Click on a well defined feature in the 'UNCORRECTED GCP (OVERVIEW ROAM geolink)' window to select it.

The 'UNCORRECTED GCP ZOOM' window will zoom ito the selected point

4 Click once in the 'CORRECTED GCP (OVERVIEW ROAM geolink)' window to activate it, then click on the same feature to select it as a GCP.

The 'CORRECTED GCP ZOOM' window will zoom ito the selected point

5 Use the two ZOOM windows to adjust the positions of the GCP.

You have now picked a second GCP in the image.

Pick two more GCPs in the upper- and lower-right

1 Following the steps from the previous section, pick a GCP near the upper-right and lower-right corners of the images.

Tip: When picking the first four GCPs, it is best to pick them in the four corners of the image (if this is possible). This will make the **Calculate from point** function you will use next as accurate as possible. (In this case there was ocean in the lower-left, so you picked a point in the closest area possible.)

Pick additional GCPs using the Corrected GCP Overview window

Once you have picked the first four GCPs, notice that ER Mapper now displays values in the 'RMS' field on the **GCP Edit** dialog. The Root Mean Square (RMS) error is a measurement of the accuracy of the GCP in this image expressed in the image's pixel size. (An RMS of 1.00 would be 80 meter positional error in the case of the Landsat MSS data used here.) If you have done an accurate job selecting the first four GCPs, the RMS should be one or less.

When an RMS can be calculated, ER Mapper can now use the coefficients generated from the first four points to "predict" the location of 'UNCORRECTED' (raw) points when you pick additional points in the 'CORRECTED' (rectified) image. This feature makes selection of the remaining points much faster and easier, and you will use it next.

1 On the main menu, click the **Set Pointer mode** button (if needed).

2 If needed, activate the 'CORRECTED GCP (OVERVIEW ROAM geolink)' window by clicking in it.

3 On the Geocoding Wizard **Edit GCP** dialog, click the **Add GCP** button.

4 In the 'CORRECTED GCP (OVERVIEW ROAM geolink)' window, click on a well defined feature near the center of the image.

   ER Mapper marks the control point with cross hairs, and enters the geographic location of GCP #5 in the TO Easting and Northing fields. The 'CORRECTED GCP ZOOM' window zooms into the point for you to adjust its position.

5 In the Geocoding Wizard **GCP Edit** dialog, click the **Calculate from point** button.

   ER Mapper automatically enters values in Cell X and Cell Y fields–this is the "predicted" location of GCP #5 in the FROM image.

   Notice that the new GCP #5 has an RMS error of zero. Since it's location is computed from the existing points, it adds no new information to the rectification model (and is therefore not yet a true GCP). Next you need to "fine tune" the location of the point in the ZOOM windows to make it a true GCP.

6 Click once in one of the ZOOM windows to activate it, then click on the GCP in the image. Adjust its position if necessary.

   ER Mapper repositions GCP #5 to the new position, and calculates an RMS value to display in the Geocoding Wizard **GCP Edit** dialog box.

   You have now picked a fifth GCP using the "predict FROM points" technique.

Tip: You can keep clicking in the UNCORRECTED AND CORRECTED ZOOM windows as many times as needed to refine the GCP location.

Pick several other points spread throughout the images

1. Using the procedure in steps 2-6 above, pick several other GCPs well spread throughout the image (pick at least 10).

Tip: If the default magnification level in the ZOOM windows is too great or small for your taste, activate each window and use the **Zoom In** or **Zoom Out** options in the Quick Zoom menu to change the zoom factor by a fixed amount in both windows. That zoom factor is retained for subsequent points. (If you make a mistake, you can select **Previous Zoom** to fix it.)

Try some other features on the Geocoding Wizard GCP Edit dialog

1. In the Geocoding Wizard **GCP Edit** dialog, click on any GCP number under the ‘Name’ column.

   ER Mapper moves the crosshairs to highlight that point in all the ‘OVERVIEW ROAM’ and ‘ZOOM’ windows.

2. Turn off the **Auto Zoom** option at the bottom.
3. Click on any GCP number under the ‘Name’ column.

   ER Mapper moves the crosshairs to highlight that point in the ‘OVERVIEW ROAM’ windows, but not the ‘ZOOM’ windows.

4. Click on the **Zoom to current GCP**  button.

   ER Mapper zooms into the selected GCP in the “ZOOM’ windows.

5. Select the number text for a GCP under the ‘Name’ column, and type a short name.

   You can give GCPs text labels as well as numbers to help identify them.

6. Click on the text ‘On’ in the second column for any GCP.

   The text changes to ‘Off’ and all the RMS errors are recomputed without including that GCP. (This is an easy way to see how the positional error of any GCP influences the RMS of the others. For example, turning off a GCP with a large RMS often reduces the RMS of the others.) This can be important when choosing which GCPs will be used for the final image rectification.

7 Turn off other GCPs to see the effect, but turn all on again when finished.

8 Click on the text ‘Edit’ in the third column for any GCP.

The text changes to ‘No’ and the “X” and number marking it in the image turns green. This effectively “locks” a GCP so it cannot be edited (that is, clicking in the image windows do not redefine it’s position). This is useful when you have several very good GCPs and you to lock them to avoid accidentally changing them.

9 Turn on the **Errors** option.

The magnitude and direction of the calculated positional error are shown graphically by a line for each GCP on the image. (If you have very small RMS errors you may not see the error line, even if you increase the line length by a factor of 10 using the **x10** option.)

10 Turn on the **Grid** option.

A polynomial grid displays over all three image windows. This grid is a simple “preview” of the way in which the FROM (raw) image pixels will be reprojected onto the new coordinate grid of the TO image. (This grid is only an approximation, in reality the lines would be curved.)

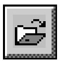
11 Click **Save** on the **Geocoding Wizard** dialog. If asked confirm saving the GCPs to disk, click **Yes**.

2: Perform the image rectification

Objectives Learn how to use the ground control points you selected to rectify the image to the selected datum and map projection.

Specify output (rectified) image file

1 Select the Geocoding Wizard **Rectify** tab.

2 Click the file chooser  button in the Output Info box.

3 From the **Directories** menu, select the path ending with **\examples**.

4 Double-click on the ‘Miscellaneous\Tutorial’ directory to open it.

5 Enter the filename ‘Landsat_MSS_rectified’ (start with your initials), then click **OK**.

6 In the **Resampling:** in the Cell Attributes box select ‘Nearest Neighbour’.

The Cell Attributes box also lets you resample the output image to a different cell size (Output Cell width and height), and specify a null cell value.

7 Select **Display rectified image** to display the image after it is rectified.

Create the output rectified image on disk

1 Click on the **Save file and start rectification** button.

ER Mapper opens a status dialog to indicate the progress of the rectification.

2 When the operation finishes, click **OK** of the successful completion dialog.

3 Click on the **Close** button to exit the Geocoding Wizard.

You have now rectified the uncorrected Landsat MSS image to correspond to the 1927 North American Datum (NAD27) and UTM zone 11 (NUTM11) map projection.

Close all image windows and dialog boxes

1 Click on the Geocoding Wizard **Close** button.

2 Close all image windows using the window system controls:

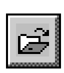
- For Windows, select **Close** from the window control-menu.
- For Unix systems, press right mouse button on the window title bar, and select **Close** or **Quit** (for systems with both options, select **Quit**).

3 Click **Close** on the **Algorithm** window to close it.

3: Evaluating image registration

Objectives Learn a simple way to visually evaluate the registration of two images using an overlay technique. In this case, you will evaluate the registration of the raw image you rectified and the rectified MSS image supplied with ER Mapper.

Load an existing RGB algorithm

1 Click the **Open**  toolbar button.

2 From the **Directories** menu, select the path ending with the text **\examples**

3 Double-click on the ‘Data_Types’ directory to open it.

4 In the directory ‘Landsat_MSS,’ load the algorithm named ‘RGB_321.alg.’

This algorithm displays the rectified Landsat MSS image of San Diego provided with ER Mapper as an RGB image. You will use only the Red and Green layers for the comparison with your rectified image.

5 On the main menu, click the **Edit Algorithm**  button to open the **Algorithm** window.

Load your rectified image into the Green layer

1 In the **Algorithm** window, click on the Blue layer to select it.

2 Click the **Cut** button to delete the Blue layer.

3 Click on the Green layer to select it.

4 Click the **Load Dataset** button in the algorithm process diagram.

5 From the **Directories** menu, select the path ending with **\examples**.

6 Double-click on the ‘Miscellaneous’ directory to open it.

7 Double-click on the ‘Tutorial’ directory to open it.

8 Click once on the image ‘Landsat_MSS_rectified.ers’ to select it, then click **OK this layer only** button to load it into the Green layer. (The Red layer should still have the ‘Landsat_MSS_27Aug91’ image.)

9 Select **B3:0.75_um** from the Green layer’s **Band Selection** drop-down list.

(Band 3 is also loaded in the Red layer for the other image for direct comparison.)

Display the two images to evaluate registration

1 Click the **99% Contrast Enhancement** toolbar button.

This image combines two different images–one in the Red layer and one in the Green layer. If your images are well aligned the image appears yellow. If you see areas that are dominantly red or green, this indicates poor registration.

2 On the **Algorithm** window, turn off the **Smoothing** option.

3 On the main menu, click the **ZoomBox tool** toolbar button.

4 Drag a zoom box over a very small area of the image that contains land and water.

Errors in registration appear as either red or green pixels because this is where the two image do not align perfectly. This is a very simple way to evaluate the registration of two images. If the RMS errors of your GCPs were generally less than one, you should not see more that one pixel offsets or registration errors.

Close all image windows and dialog boxes

1 Close all image windows using the window system controls:

- Select **Close** from the window control-menu.

2 Click **Close** on the **Algorithm** window to close it.

Only the ER Mapper main menu should be open on the screen.

What you learned...

After completing these exercises, you know how to perform the following tasks in ER Mapper:

- Choose common ground control points (GCPs) between two images
- Use options to modify the GCP display and edit GCPs
- Rectify a “raw” image to the chosen datum and map projection
- Evaluate registration accuracy using a simple image overlay method

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Image orthorectification

This chapter explains how to use the ER Mapper Geocoding Wizard to geometrically correct raw image data and orthorectify it to real world coordinate systems and map projections.

About orthorectification

Orthorectification corrects local and global distortions in an image by adjusting for camera characteristics, platform positions and terrain details.

The camera characteristics, derived from a camera calibration report, are stored in a camera file for use by the Geocoding Wizard.

The terrain details are supplied in the form of a DEM. If the terrain is relatively flat, you can use an average height value.

In the case of Advanced Orthorectification, the platform position is determined by exterior orientation values that describe the exact position of the aircraft at the time the image was taken, and how this relates to the image. The following parameters are specified:

Attitude omega The tilt angle (roll) of the aircraft; i.e. the rotation about the X axis (direction of travel).

Attitude phi The swing angle (pitch) of the aircraft; i.e the rotation about the Y axis.

Attitude kappa The azimuth angle (yaw)of the aircraft; i.e the rotation about the Z axis.

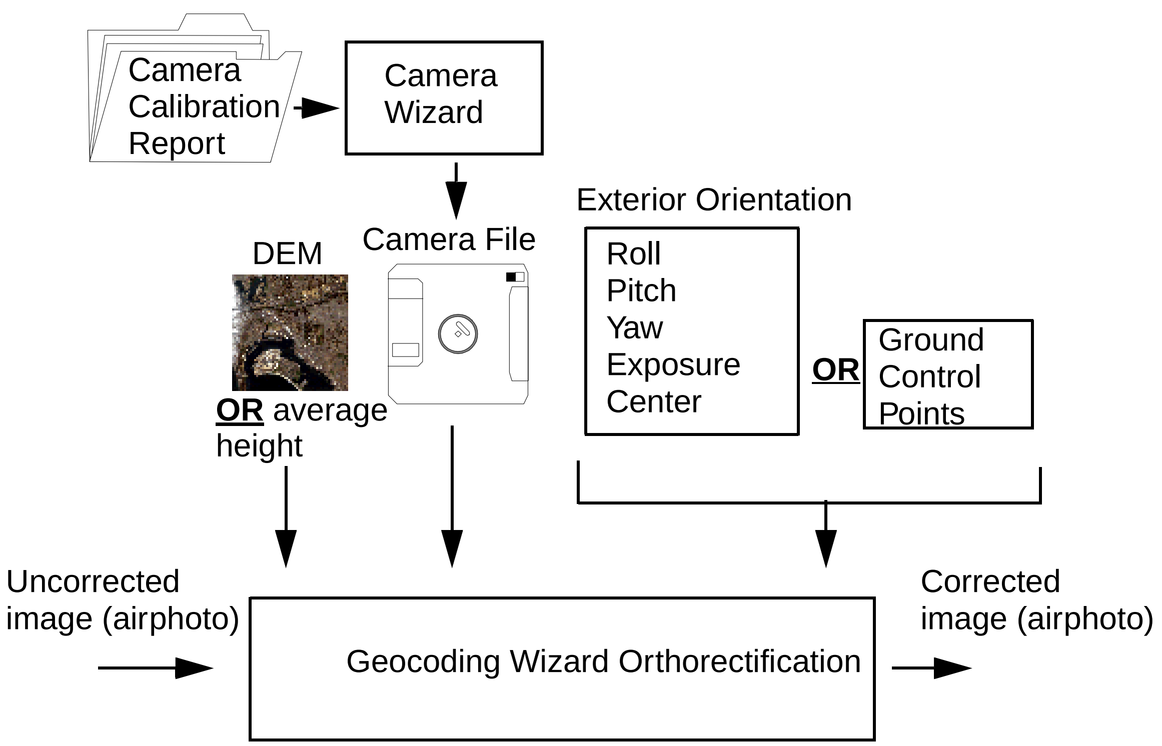
Exposure center XYZ The co-ordinates of the exposure center of the image.

If the exterior orientation parameters are not known, you have to specify about 4 to 6 GCPs for the Gridding Wizard to compute them.

To use Orthorectification you must have the following information available:

- Camera file containing camera calibration information
- DEM file (You can enter an average height if the terrain is relatively flat)
- Exterior orientation (Only for Advanced Orthorectification. Otherwise you must select GCPs)
- GCPs referenced by their XYZ coordinates.

The diagram below illustrates the required inputs for orthorectification.



Hands-on exercises

These exercises give you practice using ER Mapper's Geocoding Wizard to orthorectify an image.

What you will learn...

After completing these exercises, you will know how to perform the following tasks in ER Mapper:

- Use the Geocoding Wizard to orthorectify an airphoto
- Use the Camera Wizard to create a Camera File from a calibration report
- Locate fiducial marks on an airphoto
- Pick suitable Ground Control Points (GCPs)

Before you begin...

Before beginning these exercises, make sure all ER Mapper image windows are closed. Only the ER Mapper main menu should be open on the screen.

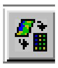
In these exercises you will use the Geocoding Wizard to orthorectify an airphoto image of San Diego taken in 1997. The example images are used with permission from Aerial Fotobank.

1: Orthorectify an airphoto using GCPs

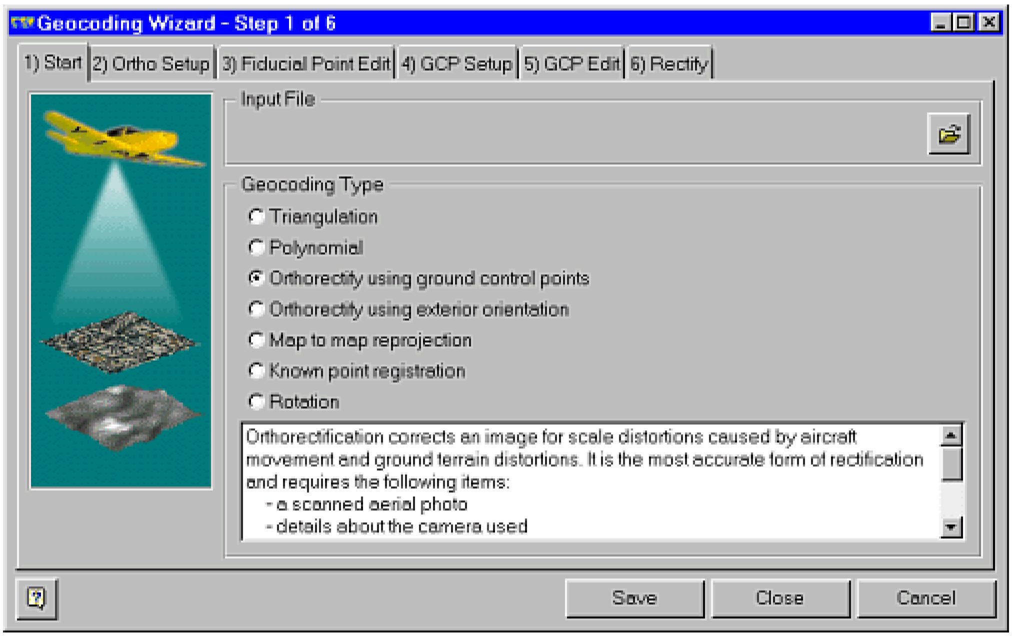
Objectives

Learn how to use ER Mapper's Geocoding Wizard to orthorectify an airphoto.
Use the Camera Wizard to create a Camera File with given calibration parameters.
Select Ground Control Points

Open the Geocoding Wizard

1 Click on the **Ortho and Geocoding Wizard**  button in the **Common Functions** toolbar.

The Geocoding Wizard will open with the **1) Start** tab selected.



2 Click the **Load Algorithm or Dataset**  button in the **Input file:** field to open the file chooser.

3 From the **Directories** menu, select the path ending with the text **\examples**.

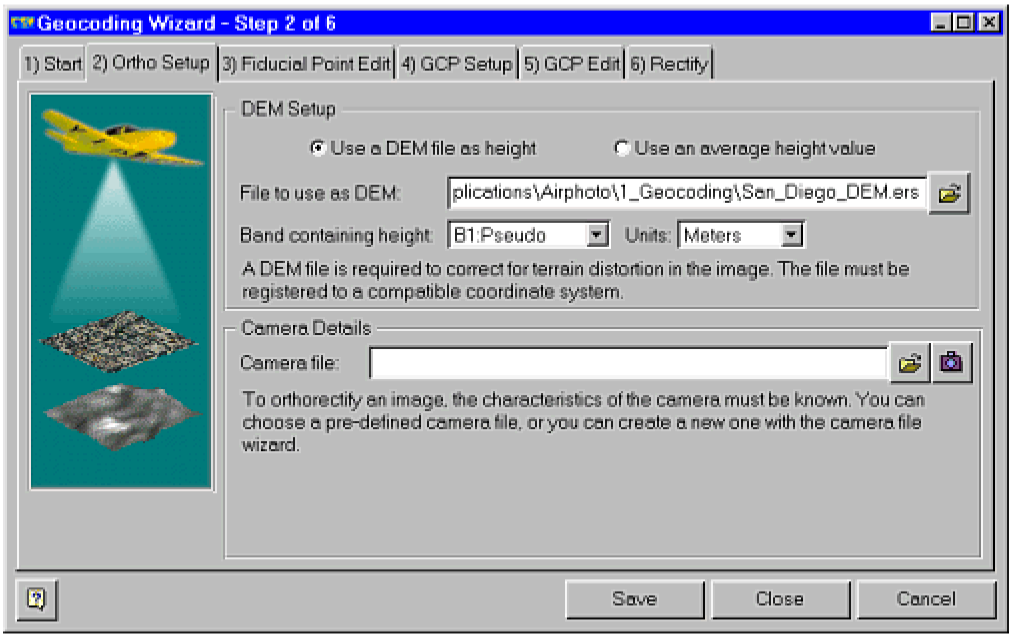
4 Select the directory ‘Applications\,Airphoto\1_Geocoding’ and then double-click on ‘San_Diego_Airphoto_34_not_rectified.ers’ to select it.

5 Select the Geocoding Wizard **Orthorectify using ground control points** option.

In this example, you do not have exterior orientation parameters which provide information on the position of the platform or aircraft. Instead, you will pick GCPs so that the wizard can compute the exterior orientation parameters. If these parameters were available, you would have chosen the **Orthorectify using exterior orientation** option.

6 Select the **2) Ortho Setup** tab.

Enter terrain and camera details

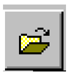


This tab allows you to enter the terrain details in the form of a DEM or as an average height value. Obviously, using a DEM would produce a more accurate result. However, if the terrain is relatively flat, you can enter an average value. In this example you will enter the name of a DEM file.

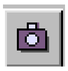
You supply the camera details to the Geocoding Wizard in the form of a camera file. If the applicable camera file does not exist, you can use the Camera Wizard to create one.

1 Select the **Use a DEM file as height** option in the **DEM Setup** box.

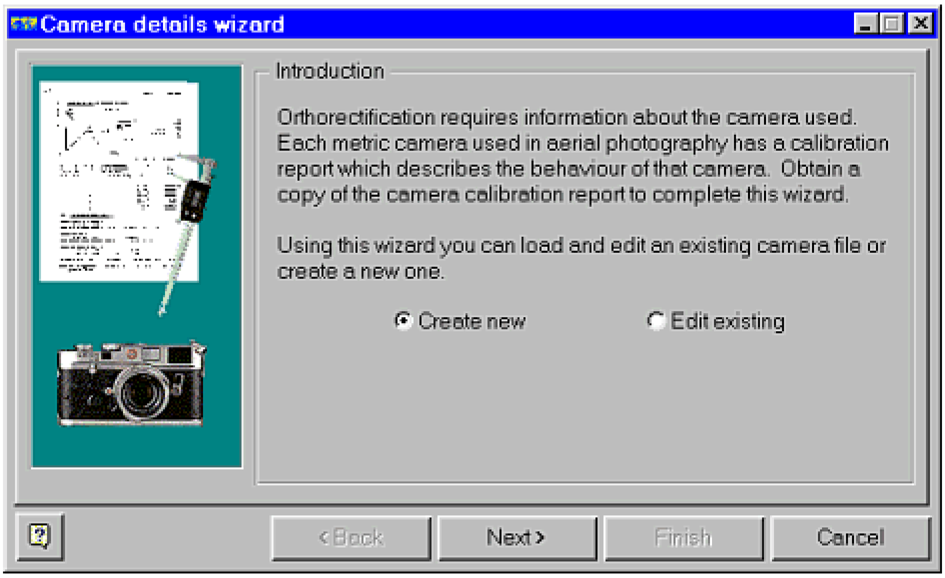
Notice that the DEM Setup box changes according to the option that you choose. Because you selected the **Use a DEM file as height** option, the DEM Setup box displays a file and a band chooser for you to select the DEM file and the required data band.

2 Click on the **Load input DEM File**  button to open the file chooser.

3 Select the file ‘San_Diego_DEM.ers’ from the ‘examples\Applications\,Airphoto\1_Geocoding’ directory and click on the OK button to return to the Geocoding Wizard.

4 Click on the **Camera Wizard**  button to open the Camera Wizard dialog.

Create a Camera file

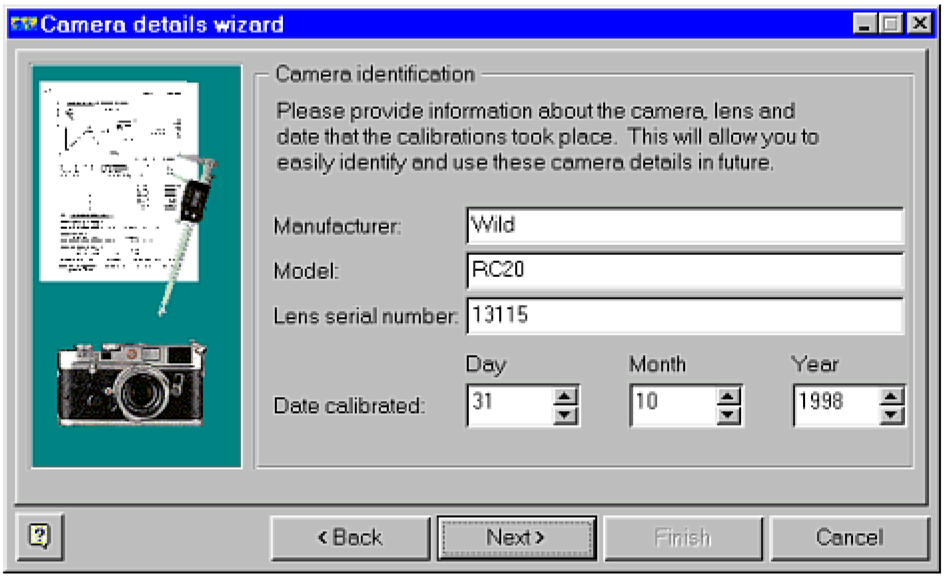


The Camera Wizard creates a Camera file for the Geocoding Wizard to use. It does this by providing a number of dialog boxes for you enter camera calibration information. You normally get this information from a camera calibration report. If you do not have a valid calibration report for the camera that was used to take the image, you can use a generic report for that camera model. This could result in a some inaccuracies.

1 Click on the **Create new** option to create a new Camera File.

You could edit an existing Camera File, in which case the wizard provides you with the **Camera file:** field and chooser to enter the name of the existing file.

2 Click on the **Next>** button to go to the Camera identification page.



The information you enter here is not used by the Geocoding Wizard. Therefore it can be omitted. It is, however, a good idea to include it because it is a means of identifying the camera and the calibration report in the future.

3 Enter the following information in the applicable fields:

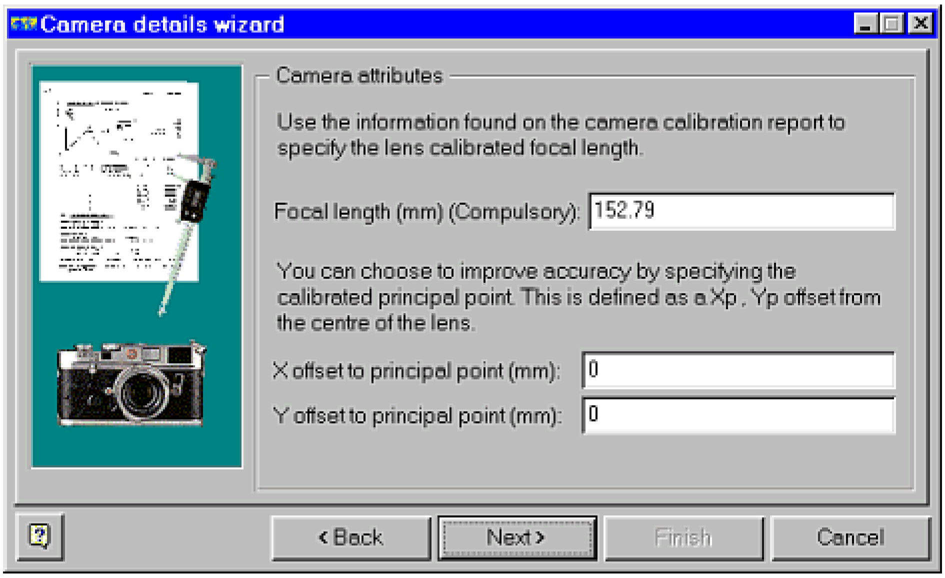
Manufacturer: Wild

Model: RC20

Lens serial number: 13115

Date calibrated: Day: 31 Month:10 Year: 1998

4 Click on the **Next>** button to go to the 'Camera attributes' page.



Use this page to enter information on the focal length of the camera lens. The Camera Wizard uses this information, so it must be entered. In addition, you can enter information on the position of the Principal Point relative to the lens center as a measure of lens distortion. Any distortion in the lens would cause the principal point to be offset from the lens center.

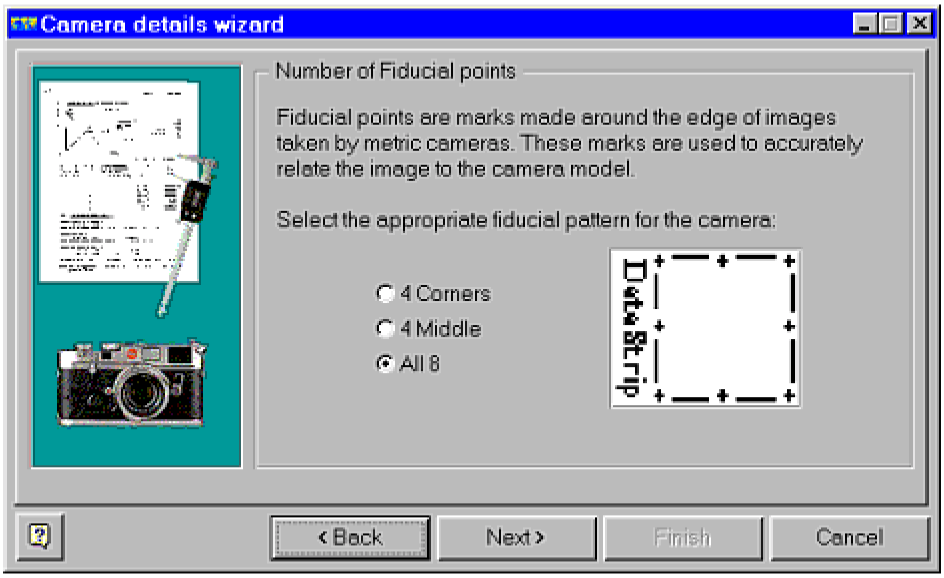
5 Enter the following information in the applicable fields:

Focal length: 152.793

X offset to principal point: 0

Y offset to principal point: 0

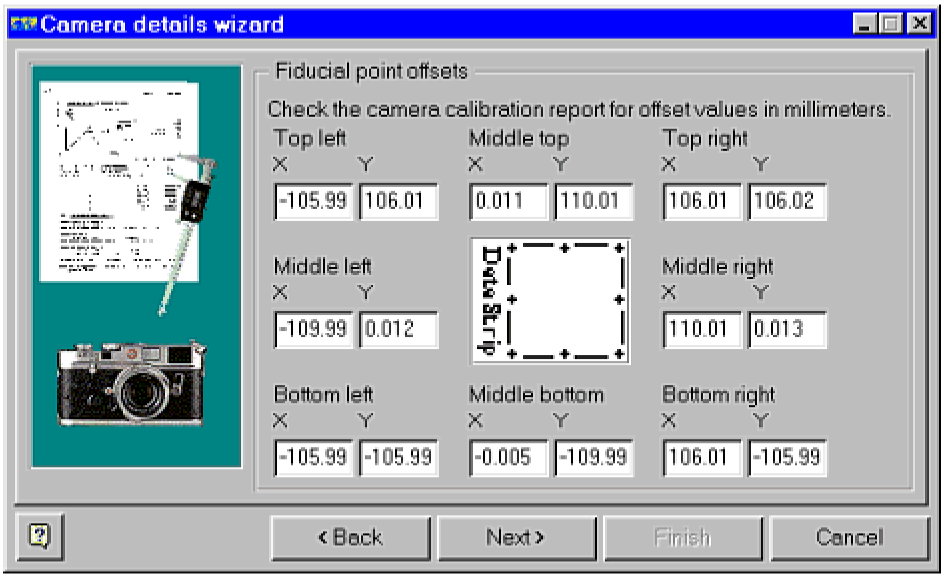
6 Click on the **Next>** button to go to the 'Number of Fiducial points' page



Aerial photography cameras insert Fiducial marks around the edges of the airphoto images. The Geocoding Wizard uses the positions of these marks to relate the image to the camera model. Different cameras insert these marks in different places on the image. Use this page to specify where the camera has placed the Fiducial marks. If you specify four Fiducial marks where the camera has, in fact, inserted eight, the Geocoding Wizard will only take into consideration the four you specified.

7 Select the **All 8** option; indicating that the Fiducial points are on the four corners and the middle of edges of the image.

8 Click on the **Next>** button to got to the 'Fiducial point offsets' page.

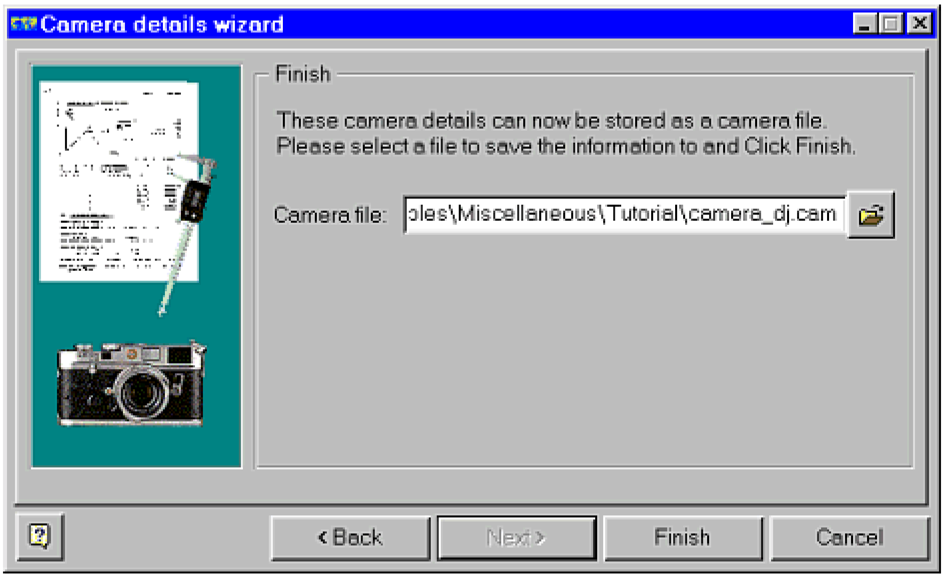


This page enables you to specify the positions of the fiducial points relative to the principal point.

9 Enter the following values in the applicable fields:

Top left	X:-105.99 Y:106.01
Middle top	X: 0.011 Y: 110.01
Top right	X:106.01 Y:106.02
Middle left	X:-109.99 Y: 0.012
Middle right	X:110.01 Y: 0.013
Bottom left	X:-105.99 Y:-105.99
Middle bottom	X: -0.005 Y: -109.99
Bottom right	X:106.0l Y:-105.99

10 Click on the **Next>** button to go to the ‘Finish’ page.



11 Click the **Save**  button in the **Camera file:** field to open the file chooser to select a directory and file name to which to save the new camera file.

12 From the **Directories** menu, select the path ending with the text **\examples**.

13 Select the directory ‘Miscellaneous\Tutorial,’ and then enter ‘camera_*<your initials>*’ in the **Save as:** field.

14 Click on the **OK** button to return to the Camera Wizard.

The file name and directory you entered should now be displayed in the **Camera file:** field.

15 Click on the **Finish** button to return to the Geocoding Wizard.

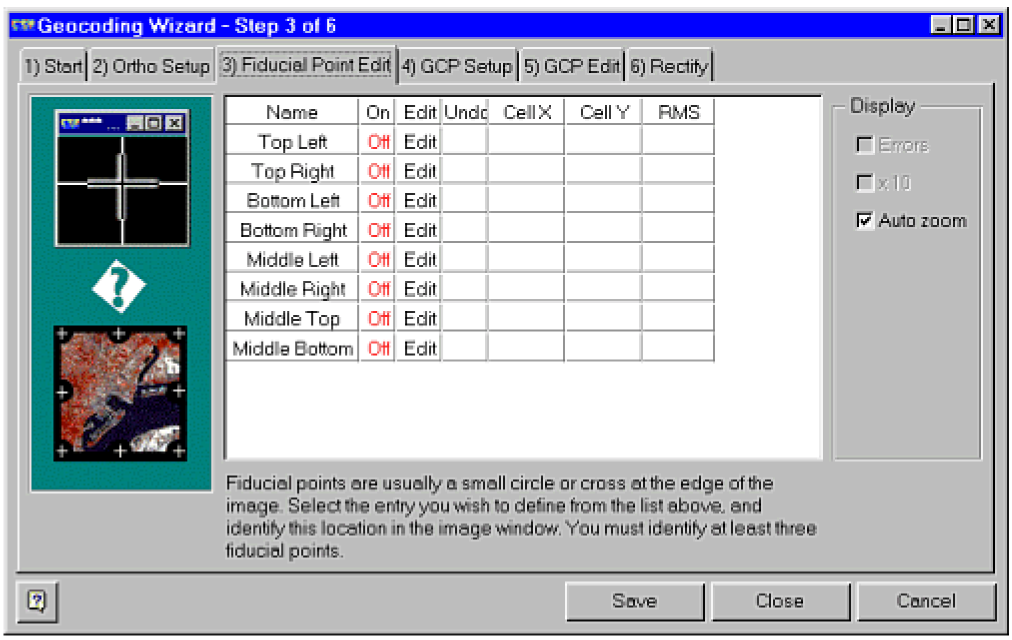
16 Click the **Load Camera File** button in the Geocoding Wizard **Camera file:** field to open the file chooser.

17 From the **Directories** menu, select the path ending with the text **\examples**.

18 Select the directory 'Miscellaneous\Tutorial,' and then double-click on the 'camera_*<your initials>*' file you saved.

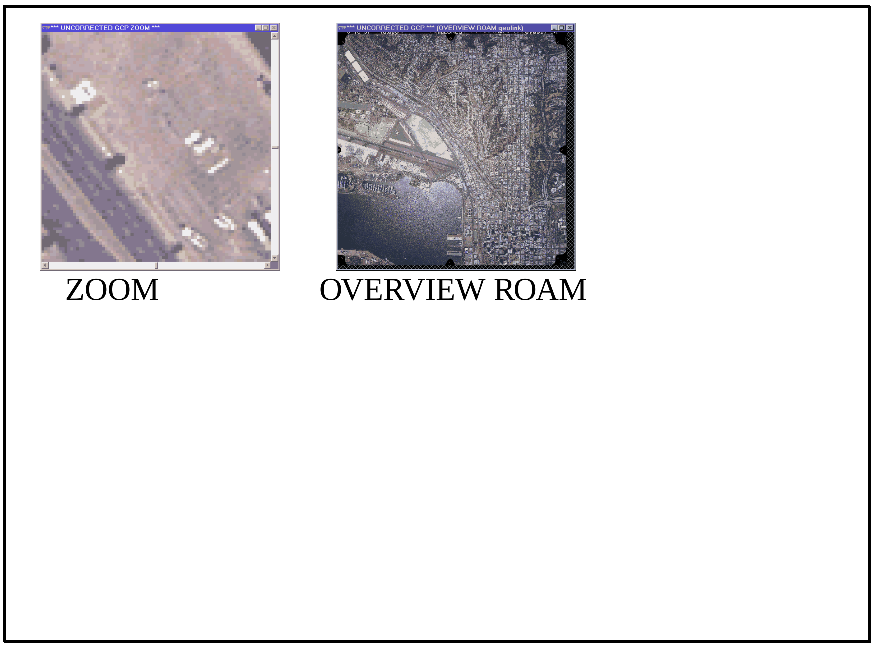
19 Click on the **3) Fiducial Point Edit** tab.

Edit the fiducial points

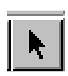


This wizard page enables you to enter the locations of the fiducial points on the image into ER Mapper.

ER mapper opens two image windows one in OVERVIEW ROAM mode, and the other in ZOOM mode.



1 Select the **Auto zoom** option. This causes the ZOOM window to automatically zoom to the selected fiducial mark.

2 Select the **Pointer Tool**  on the **Standard** toolbar.

3 On the table, select ‘Top Left’ in the ‘Name’ column.

4 In the OVERVIEW ROAM window, click on the Fiducial mark on the top left corner of the image.

The image in the ZOOM window will automatically zoom to the selected fiducial mark. Use this to adjust the position of the cursor to the center of the red circle.

5 On the table, select ‘Top Right’ in the ‘Name’ column.

6 In the OVERVIEW ROAM window, click on the Fiducial mark on the top right corner of the image.

The image in the ZOOM window will automatically zoom to the selected fiducial mark. Use this to adjust the position of the cursor to the center of the red circle.

7 On the table, select ‘Bottom Left’ in the ‘Name’ column.

8 In the OVERVIEW ROAM window, click on the Fiducial mark on the bottom left corner of the image.

The image in the ZOOM window will automatically zoom to the selected fiducial mark. Use this to adjust the position of the cursor to the center of the red circle.

9 On the table, select ‘Bottom Right’ in the ‘Name’ column.

10 In the OVERVIEW ROAM window, click on the Fiducial mark on the bottom right corner of the image.

The image in the ZOOM window will automatically zoom to the selected fiducial mark. Use this to adjust the position of the cursor to the center of the red circle.

11 On the table, select ‘Middle Left’ in the ‘Name’ column.

12 In the OVERVIEW ROAM window, click on the Fiducial mark on the middle of the left side of the image.

The image in the ZOOM window will automatically zoom to the selected fiducial mark. Use this to adjust the position of the cursor to the center of the red circle.

13 On the table, select ‘Middle Right’ in the ‘Name’ column.

14 In the OVERVIEW ROAM window, click on the Fiducial mark on the middle of the right side of the image.

The image in the ZOOM window will automatically zoom to the selected fiducial mark. Use this to adjust the position of the cursor to the center of the red circle.

15 On the table, select ‘Middle Top’ in the ‘Name’ column.

16 In the OVERVIEW ROAM window, click on the Fiducial mark on the middle of the top the image.

The image in the ZOOM window will automatically zoom to the selected fiducial mark. Use this to adjust the position of the cursor to the center of the red circle.

17 On the table, select ‘Middle Bottom’ in the ‘Name’ column.

18 In the OVERVIEW ROAM window, click on the Fiducial mark on the middle of the bottom of the image.

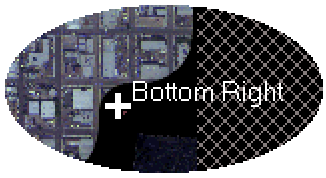
The image in the ZOOM window will automatically zoom to the selected fiducial mark. Use this to adjust the position of the cursor to the center of the red circle.

After selecting the fiducial markers, the table on the **Fiducial Point Edit** tab should be similar to what is shown below.

Name	On	Edit	Undc	Cell X	Cell Y	RMS
Top Left	On	Edit	Undc	211.13	322.41	0.23
Top Right	On	Edit	Undc	5221.11	322.26	0.13
Bottom Left	On	Edit	Undc	202.80	5333.18	0.31
Bottom Right	On	Edit	Undc	5213.25	5333.81	0.26
Middle Left	On	Edit	Undc	112.59	2827.72	0.15
Middle Right	On	Edit	Undc	5311.96	2827.56	0.34
Middle Top	On	Edit	Undc	2716.12	227.64	0.20
Middle Bottom	On	Edit	Undc	2707.95	5428.11	0.13

The RMS column should show values of less than 1.00.

The image window should now have all the fiducial points labelled.

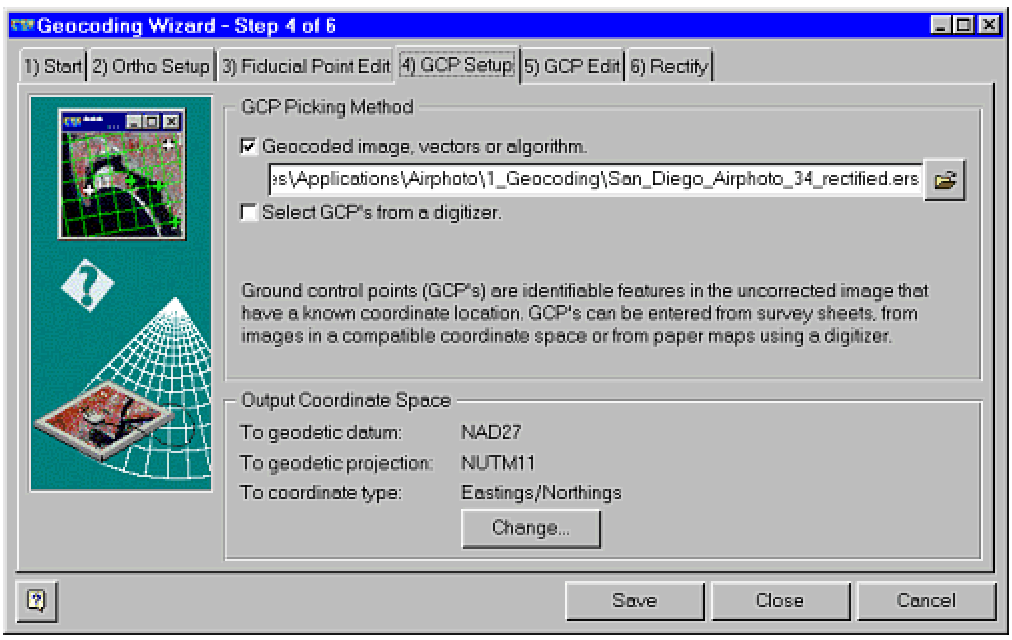


19 If necessary, select the **Errors** option, and adjust the position of the selections in the direction of the indicated errors.

The x10 option enlarges the error markers for a more accurate indication.

20 Click on the **4) GCP Setup** tab.

Setup Ground Control Points



The **GCP Setup** tab lets you specify the way that you want to choose control points. Control points may be entered manually, chosen from a reference image, chosen from a digitizing tablet, or chosen using a combination of these three methods.

In this exercise, you will use a previously orthorectified reference image to locate GCPs.

1 In the **GCP Picking Method** box, select **Geocoded image, vectors or algorithm** option.

This tells ER Mapper you plan to pick corresponding points between two images on the screen.

2 Click the **Load Corrected Algorithm or Dataset**  file chooser button.

3 Choose ‘ER Mapper Raster Dataset (.ers)’ in the **Files of Type:** field.

4 From the **Directories** menu on the file chooser dialog, select the path ending with the text **\examples**.

5 Double_click on the ‘Applications’ directory to open it.

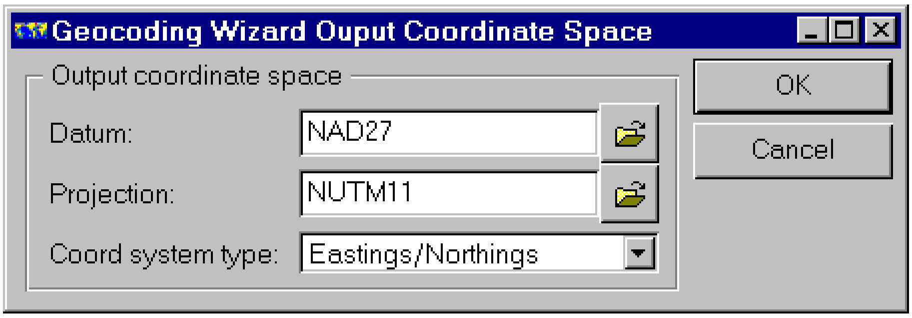
6 Double-click on the ‘Airphoto\1_Geocoding’ directory to open it, then double-click on ‘San_Diego_Airphoto_34_rectified.ers’ to load it.

This is the already rectified image containing coordinate information.

Setup parameters for the image rectification

The **To geodetic datum**, **To geodetic projection** and **To Coordinates**, fields in the Output Coordinate Space box show the datum, projection and coordinate type for the output rectified file you will create. These parameters are included automatically from the ‘CORRECTED’ (rectified) airphoto image.

7 Click on the **Change...** button to open the **Geocoding Wizard Output Coordinate Space** dialog.

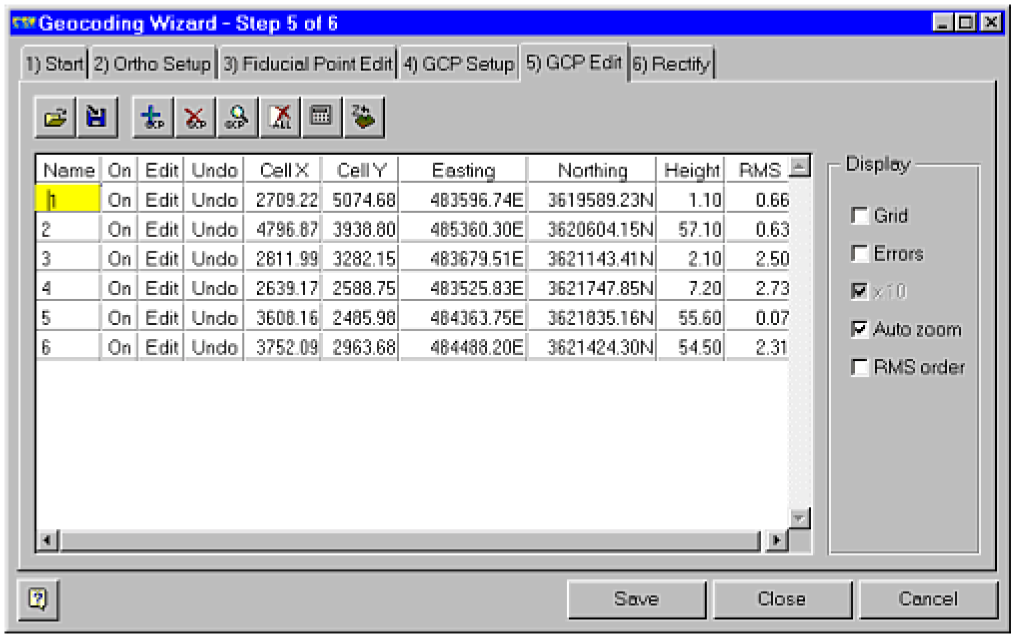


8 If necessary, change the settings to what is displayed above.

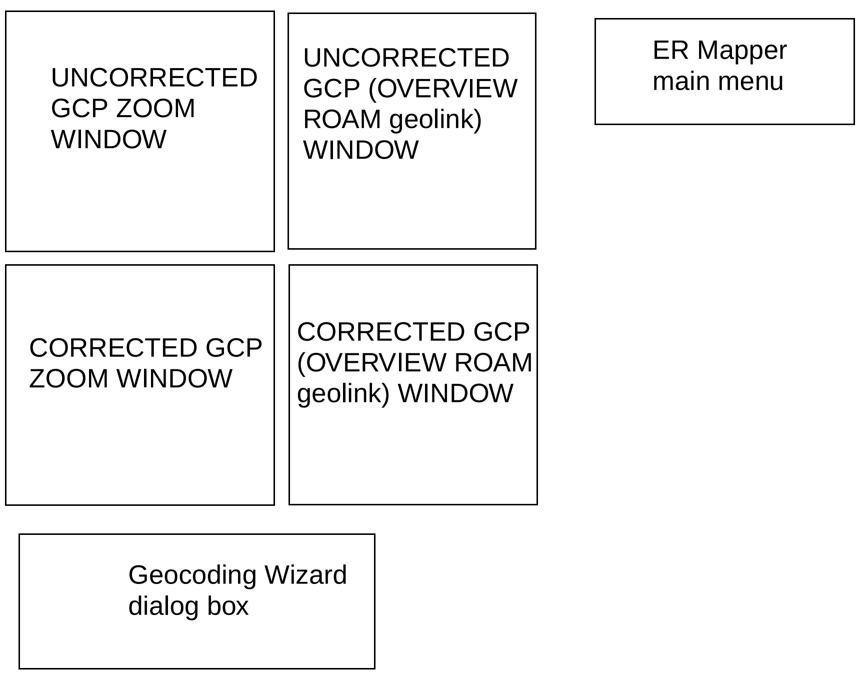
9 Click **OK** on the **Geocoding Wizard Output Coordinate Space** dialog to close it.

10 Select the Geocoding Wizard **5) GCP Edit** tab.

Edit Ground Control Points



ER Mapper opens several image windows and dialog boxes. You should see a screen setup similar to this one:



Note: If your system does not position the windows automatically, rearrange them as shown above before proceeding.

Pick a GCP in the upper-left part of both images

Note: Make sure the main ER Mapper menu is not hidden by the image windows–move it slightly if needed so you can easily access the toolbars.

1 On the Geocoding Wizard **GCP Edit** tab, select **Auto zoom**.

The ZOOM windows will now automatically zoom into the point selected in the corresponding OVERVIEW ROAM windows.

2 Click on a well defined feature in the ‘UNCORRECTED GCP (OVERVIEW ROAM geolink)’ window to select it.

The ‘UNCORRECTED GCP ZOOM’ window will zoom ito the selected point

3 Click once in the ‘CORRECTED GCP (OVERVIEW ROAM geolink)’ window to activate it, then click on the same feature to select it as a GCP.

The ‘CORRECTED GCP ZOOM’ window will zoom ito the selected point

4 Use the two ZOOM windows to adjust the positions of the GCP.

You have now picked a GCP in the image.

Pick a second GCP in the lower-left of both images

5 On the Geocoding Wizard **Edit GCP** dialog, click the **Add new GCP** 

button.

6 Click on a well defined feature in the ‘UNCORRECTED GCP (OVERVIEW ROAM geolink)’ window to select it.

The ‘UNCORRECTED GCP ZOOM’ window will zoom into the selected point

7 Click once in the ‘CORRECTED GCP (OVERVIEW ROAM geolink)’ window to activate it, then click on the same feature to select it as a GCP.

The ‘CORRECTED GCP ZOOM’ window will zoom ito the selected point

8 Use the two ZOOM windows to adjust the positions of the GCP.

You have now picked a second GCP in the image.

9 Following the above steps, pick another four GCPs near the upper-right, lower-right and middle of the images.

The more GCPs you pick the lower the possibility of errors. For orthorectification you need at least six.

Try some other features on the Geocoding Wizard GCP Edit dialog

1 In the Geocoding Wizard **GCP Edit** dialog, click on any GCP number under the ‘Name’ column.

ER Mapper moves the crosshairs to highlight that point in all the ‘OVERVIEW ROAM’ and ‘ZOOM’ windows.

2 Turn off the **Auto Zoom** option at the bottom.

3 Click on any GCP number under the ‘Name’ column.

ER Mapper moves the crosshairs to highlight that point in the ‘OVERVIEW ROAM’ windows, but not the ‘ZOOM’ windows.

4 Click on the **Zoom to current GCP** 

button.

ER Mapper zooms into the selected GCP in the “ZOOM’ windows.

5 Select the number text for a GCP under the ‘Name’ column, and type a short name.

You can give GCPs text labels as well as numbers to help identify them.

6 Click on the text ‘On’ in the second column for any GCP.

The text changes to ‘Off’ and all the RMS errors are recomputed without including that GCP. (This is an easy way to see how the positional error of any GCP influences the RMS of the others. For example, turning off a GCP with a large RMS often reduces the RMS of the others.) This can be important when choosing which GCPs will be used for the final image rectification.

7 Turn off other GCPs to see the effect, but turn all on again when finished.

8 Click on the text ‘Edit’ in the third column for any GCP.

The text changes to ‘No’ and the “X” and number marking it in the image turns green. This effectively “locks” a GCP so it cannot be edited (that is, clicking in the image windows do not redefine it’s position). This is useful when you have several very good GCPs and you to lock them to avoid accidentally changing them.

9 Turn on the **Errors** option.

The magnitude and direction of the calculated positional error are shown graphically by a line for each GCP on the image. (If you have very small RMS errors you may not see the error line, even if you increase the line length by a factor of 10 using the **x10** option.)

10 Turn on the **Grid** option.

A polynomial grid displays over all three image windows. This grid is a simple “preview” of the way in which the FROM (raw) image pixels will be reprojected onto the new coordinate grid of the TO image. (This grid is only an approximation, in reality the lines would be curved.)

11 Click the **Add new GCP** button and select a point on the CORRECTED image.

12 Click on the **Calculate uncorrected point** button. The wizard will automatically position the corresponding GCP on the UNCORRECTED image. Use the ZOOM windows to adjust the GCP position.

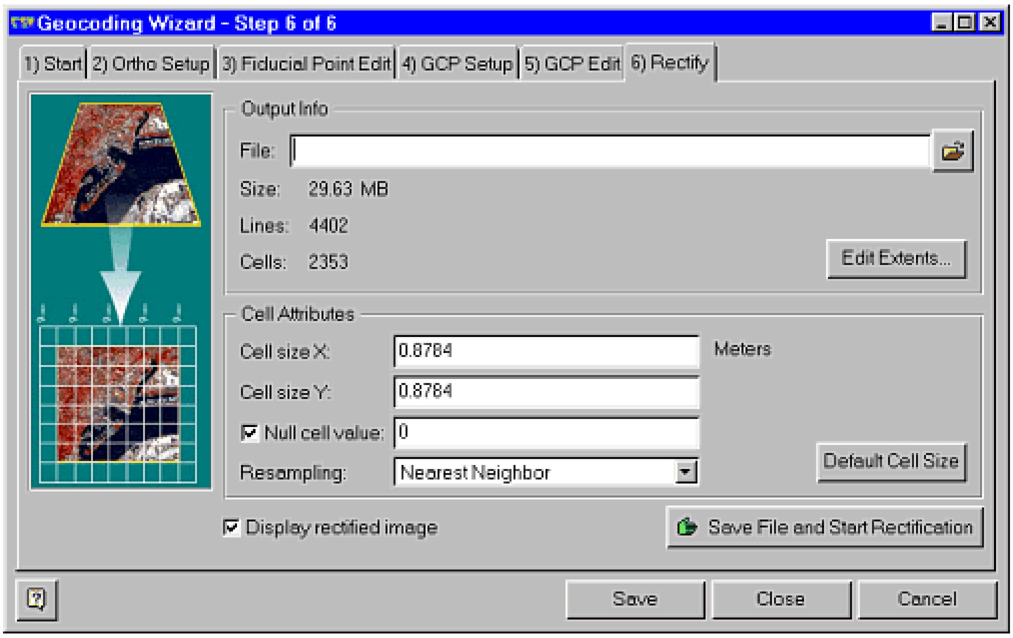
This facility is available once you have positioned four points.

13 Click **Save** on the **Geocoding Wizard** dialog. When asked confirm saving the GCPs to disk, click **Yes**.

This will save the geocoding information into the header file of the UNCORRECTED image.

14 Select the Geocoding Wizard **6) Rectify** tab.

Rectify the image



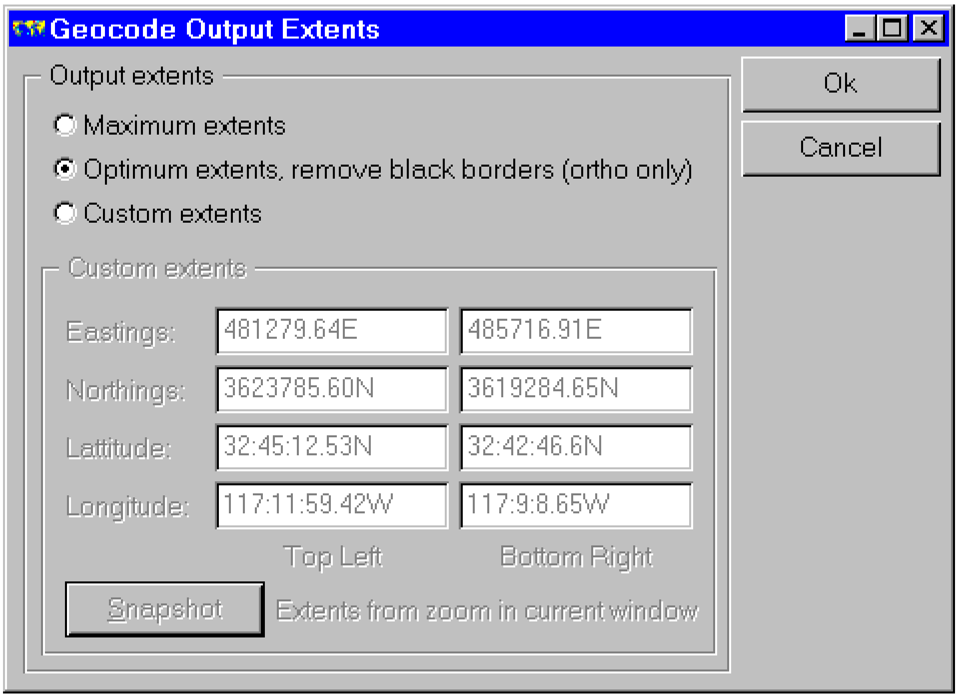
1 Click the file chooser button in the **Output Info** box.

2 From the **Directories** menu, select the path ending with **\examples**.

3 Double-click on the ‘Miscellaneous\Tutorial’ directory to open it.

4 Enter the filename ‘Airphoto_orthorectified’ (start with your initials), then click **OK**.

5 Click on the **Edit Extents...** button to open the **Geocode Output Extents** dialog box.



This dialog allows you to specify how much of the orthorectified image you want to save. You have three main options:

Maximum extents: Saves the whole image including any portion not visible in the currently active image window.

Optimum extents: Automatically calculates the extents of airphotos to exclude the black edges around them.

Custom extents: Allows you to specify the top left and bottom right coordinates of the area to be included. If you click on the **Snapshot** button ER Mapper will automatically select the extents of the visible part of the image in the currently active image window.

6 Select the **Optimum extents** button to remove the black edges.

7 Click on the OK button to return to the Geocoding Wizard.

8 In the **Resampling:** in the Cell Attributes box select ‘Nearest Neighbour’.

The Cell Attributes box also lets you resample the output image to a different cell size (Output Cell width and height), and specify a null cell value.

9 Click on the Save button to save the orthorectification parameters in the ‘San_Diego_Airphoto_34 _not_rectified.ers’ header file.

You will use this in the next exercise.

10 Select **Display rectified image** to display the image after it is rectified.

11 Click on the **Save file and start rectification** button.

ER Mapper opens a status dialog to indicate the progress of the rectification.

12 When the operation finishes, click **OK** of the successful completion dialog.

13 Click on the **Close** button to exit the Geocoding Wizard.

You have now rectified the uncorrected airphoto image to correspond to the 1927 North American Datum (NAD27) and UTM zone 11 (NUTM11) map projection.

14 Do not close the image window with the orthorectified image

Evaluate the image orthorectification

1 On the main menu, click the **Edit Algorithm** button to open the **Algorithm** window.

2 The Algorithm window shows the Red, Green and Blue layers of the orthorectified image ‘*<your Initials>*_Airphoto_orthorectified’

3 In the **Algorithm** window, click on the Blue layer to select it.

4 Click the **Load Dataset** button in the algorithm process diagram.

5 From the **Directories** menu, select the path ending with **\examples**.

6 Double-click on the ‘Applications’ directory to open it.

7 Double-click on the ‘Airphoto’ and then on ‘1_Geocoding’ directory to open it.

8 Click once on the image ‘San_Diego_Airphoto_34 _rectified.ers’ to select it, then click **OK this layer only** button to load it into the Blue layer. (The Red and Green layers should still have the ‘*<your Initials>*_Airphoto_orthorectified’ image.)

9 Select **B3:Blue** from the Blue layer’s **Band Selection** drop-down list.

Display the two images to evaluate registration

1 Click the **99% Contrast Enhancement** toolbar button.

This image combines two different images–one in the Red and Green layers and one in the Blue layer. If your images are well aligned the image appears normal. If you see areas that are dominantly yellow or blue, this indicates poor registration.

2 On the **Algorithm** window, turn off the **Smoothing** option.

3 On the main menu, click the **ZoomBox tool** toolbar button.

4 Drag a zoom box over a very small area of the image that contains land and water.

Errors in registration appear as either blue or yellow pixels because this is where the two images do not align perfectly. This is a very simple way to evaluate the registration of two images. If the RMS errors of your GCPs were generally less than one, you should not see more that one pixel offsets or registration errors.

Close all windows

1 Close all image windows using the window system controls:

- Select **Close** from the window control-menu.

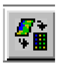
2 Click **Close** on the **Algorithm** window to close it.

2: Orthorectify an airphoto using Exterior Orientation

Objectives Learn how to use ER Mapper's Geocoding Wizard to orthorectify an airphoto using Exterior Orientation parameters

In this exercise you will orthorectify the same image as in the previous exercise. This time, instead of using Ground Control Points, you will enter Exterior Orientation parameters which have been obtained from a photogrammetry, aerial triangulation or geoposition system external to ER Mapper. In the previous exercise you saved orthorectification parameters in the 'San_Diego_Airphoto_34_not_rectified.ers' file. This means that you will not have to re-enter them in this exercise.

Open the Geocoding Wizard

1 Click on the **Ortho and Geocoding Wizard**  button in the **Common Functions** toolbar.

The Geocoding Wizard will open with the **1) Start** tab selected.

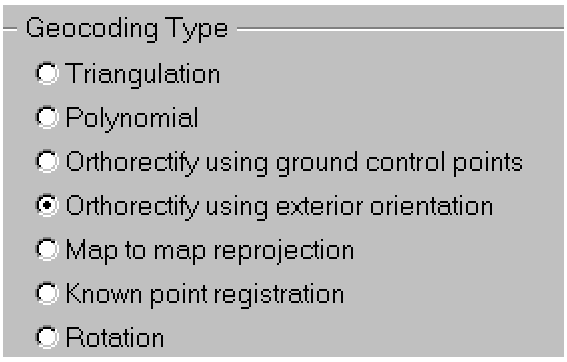
2 Click the **Load Algorithm or Dataset**  button in the **Input file:** field to open the file chooser.

3 From the **Directories** menu, select the path ending with the text **\examples**.

4 Select the directory 'Applications\,Airphoto\1_Geocoding' and then double-click on 'San_Diego_Airphoto_34_not_rectified.ers' to select it.

This is the same file as that you used in the previous exercise.

5 Select the Geocoding Wizard **Orthorectify using exterior orientation** option.



In this example, you enter exterior orientation parameters which provide information on the position of the platform or aircraft.

6 Select the **2) Ortho Setup** tab.

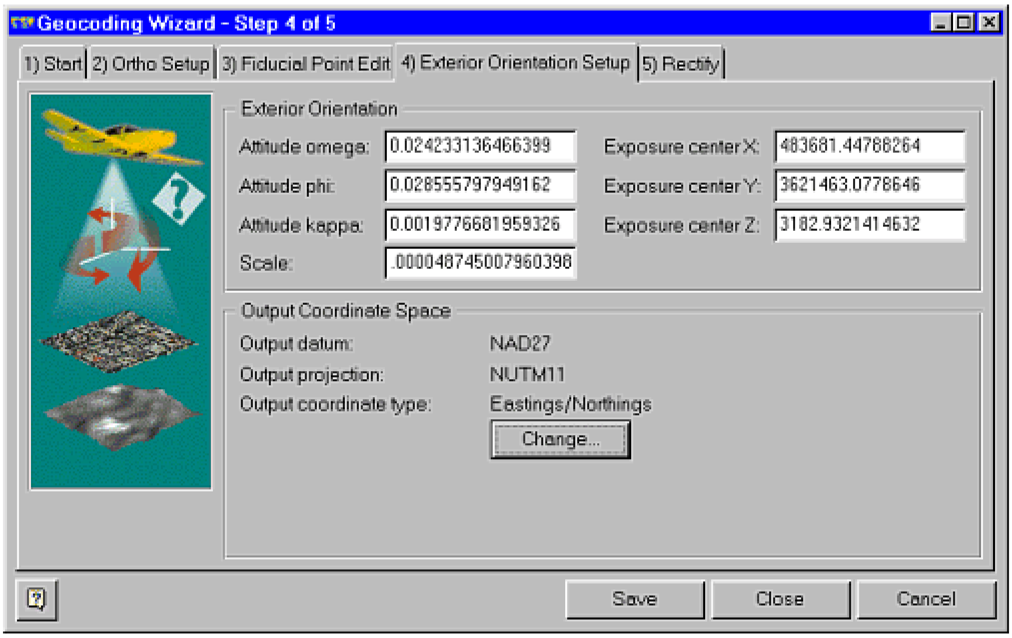
The fields in the Ortho Setup page should contain the information that you entered in the previous exercise because it was saved to the header file of the image being orthorectified.

7 Click on the **3) Fiducial Point Edit** tab.

The fields in the Fiducial Point Edit page should also contain the information you entered in the previous exercise.

8 Click on the **4) Exterior Orientation Setup** tab.

Enter Exterior Orientation parameters



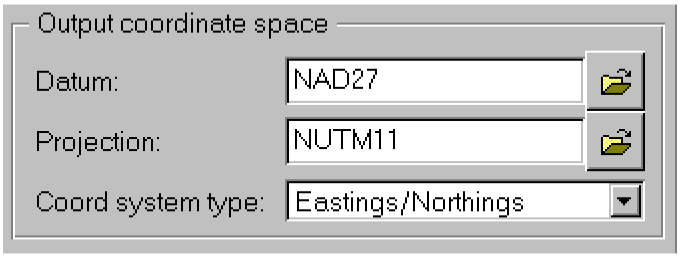
Exterior Orientation parameters contain information on the position of the platform or aircraft at the time the image was taken. You would have to obtain this data from a system external to ER Mapper. If these parameters are not available then you would use Ground Control Points as in the previous exercise.

1 Enter the information in the relevant fields as shown in the table below:

Field name	**Description**	**Enter value**
Attitude omega	The tilt angle (roll) of the aircraft; i.e. the rotation about the X axis (direction of travel).	0.024233136466399
Attitude phi	The swing angle (pitch) of the aircraft; i.e the rotation about the Y axis.	0.028555797949162
Attitude kappa	The azimuth angle (yaw)of the aircraft; i.e the rotation about the Z axis.	0.0019776681959326
Exposure center X	The X co-ordinate of the exposure center of the image.	483681.44788264
Exposure center Y	The Y co-ordinate of the exposure center of the image.	3621463.0778646
Exposure center Z	The Z co-ordinate of the exposure center of the image.	3182.9321414632
Scale	The scale of the image expressed as a decimal value.	0.000048745007960398

2 Click on the **Change...** button to open the **Geocoding Wizard Output Coordinate Space** dialog.

3 Enter the **Datum**, **Projection** and **Coord system type** as shown below



Tip: NUTM11 is a UTM projection type.

4 Click on the **5) Rectify** tab.

Rectify the image

1 Click the file chooser  button in the **Output Info** box.

2 From the **Directories** menu, select the path ending with **\examples**.

3 Double-click on the ‘Miscellaneous\Tutorial’ directory to open it.

4 Enter the filename ‘Airphoto_orthorectified_advanced’ (start with your initials), then click **OK**.

5 Click on the **Edit Extents...** button to open the **Geocode Output Extents** dialog box.

This dialog allows you to specify how much of the orthorectified image you want to save. You have three main options:

Maximum extents: Saves the whole image including any portion not visible in the currently active image window.

Optimum extents: Automatically calculates the extents of airphotos to exclude the black edges around them.

Custom extents: Allows you to specify the top left and bottom right coordinates of the area to be included. If you click on the **Snapshot** button ER Mapper will automatically select the extents of the visible part of the image in the currently active image window.

6 Select the **Optimum extents** button to remove the black edges.

7 Click on the OK button to return to the Geocoding Wizard.

8 In the **Resampling:** in the Cell Attributes box select ‘Nearest Neighbour’.

The Cell Attributes box also lets you resample the output image to a different cell size (Output Cell width and height), and specify a null cell value.

9 Click on the Save button to save the orthorectification parameters in the ‘San_Diego_Airphoto_34 _not_rectified.ers’ header file.

10 Select **Display rectified image** to display the image after it is rectified.

11 Click on the **Save file and start rectification** button.

ER Mapper opens a status dialog to indicate the progress of the rectification.

12 When the operation finishes, click **OK** on the successful completion dialog.

13 Click on the **Close** button to exit the Geocoding Wizard.

You have now rectified the uncorrected airphoto image to correspond to the 1927 North American Datum (NAD27) and UTM zone 11 (NUTM11) map projection.

14 Do not close the image window with the orthorectified image

Evaluate the image orthorectification

1 On the main menu, click the **Edit Algorithm** button to open the **Algorithm** window.

2 The Algorithm window shows the Red, Green and Blue layers of the orthorectified image '*<your Initials>*_Airphoto_orthorectified_advanced'

3 In the **Algorithm** window, click on the Blue layer to select it.

4 Click the **Load Dataset** button in the algorithm process diagram.

5 From the **Directories** menu, select the path ending with **\examples**.

6 Double-click on the 'Applications' directory to open it.

7 Double-click on the 'Airphoto' and then on '1_Geocoding' directory to open it.

8 Click once on the image 'San_Diego_Airphoto_34 _rectified.ers' to select it, then click **OK this layer only** button to load it into the Blue layer. (The Red and Green layers should still have the '*<your Initials>*_Airphoto_orthorectified_advanced' image.)

9 Select **B3:Blue** from the Blue layer's **Band Selection** drop-down list.

Display the two images to evaluate registration

1 Click the **99% Contrast Enhancement** toolbar button.

This image combines two different images–one in the Red and Green layers and one in the Blue layer. If your images are well aligned the image appears normal. If you see areas that are dominantly yellow or blue, this indicates poor registration.

2 On the **Algorithm** window, turn off the **Smoothing** option.

3 On the main menu, click the **ZoomBox tool** toolbar button.

4 Drag a zoom box over a very small area of the image that contains land and water.

Errors in registration appear as either blue or yellow pixels because this is where the two images do not align perfectly. This is a very simple way to evaluate the registration of two images. If the RMS errors of your GCPs were generally less than one, you should not see more that one pixel offsets or registration errors.

Close all windows

1 Close all image windows using the window system controls:

- Select **Close** from the window control-menu.

2 Click **Close** on the **Algorithm** window to close it.

Only the ER Mapper main menu should be open on the screen.

What you learned...

After completing these exercises, you know how to perform the following tasks in ER Mapper:

- Use the Camera Wizard to create a Camera File
- Select fiducial markers on an airphoto image
- Use options to modify the GCP display and edit GCPs
- Enter Exterior Orientation parameters for advanced orthorectification.
- Use the Geocoding Wizard to orthorectify a “raw” airphoto image to the chosen datum and map projection.

A

System setup

This appendix describes the alternate steps needed to set up your system for students to perform the hands-on exercises in this manual. There are two tasks:

- Installation of sample “tutorial” image and algorithm files
- Copying files for supervised classification and rectification exercises

In order to carry out the following instructions, you should have some basic knowledge of copying files and setting file permissions (if needed).

1: Installation of example images and algorithms

All of the hands-on exercises in this workbook require you to access sample images and algorithms supplied on the ER Mapper CD-ROM. The “Full” installation option installs ER Mapper with all the example directories and files. If you want to conserve hard drive space, you can select the “Typical” option which installs only the directories and files required to do the hands-on exercises. The “Compact” option does not install any of the required files or directories and thus precludes you from doing the hands-on exercises.

See the Installation Manual for more information.

It is preferable to select either the “Typical” or “Full” installation option to ensure that the correct files and directories are installed. If you choose the “Custom” installation option, you must select at least the following example directories for installation.

Application Examples	Airphoto
	Mineral_Exploration
	Oil_and_Gas_Exploration
	World_Topography
	Land_Information
Data Type Examples	Digital_Elevation
	Ers1
	Landsat_MSS
	Landsat_TM
	SPOT_Panchromatic
	SPOT_xs
Functions and Features Examples	3D
	Classification
	Data_Fusion
	Data_Mosaic
	Geocoding
	Gridding
Miscellaneous	Templates
	Test Patterns

2: Copying files to the ‘tutorial’ directory

The exercises for Supervised Classification and Image Rectification require a copy of the image “Landsat_MSS_notwarped” under the name “Landsat_practice” in ER Mapper’s ‘tutorial’ directory. (The ‘tutorial’ directory is created automatically during the ER Mapper installation.) Follow these steps to create a copy of the header file and data file.

Note: You must have **read and write** access to the practice image. Set the file permissions appropriately if needed.

Copying files for Windows installations

1 Use Windows Explorer to copy and rename the following files in the ‘examples\Shared_Data’ directory to the ‘examples\Miscellaneous\Tutorial’ directory as indicated:

Shared_Data\Landsat_MSS_notwarped.ers *copy to* **Miscellaneous\Tutorial\Landsat_practice.ers**

Shared_Data\Landsat_MSS_notwarped *copy to* **Miscellaneous\Tutorial\Landsat_practice**

B

Reference texts

This appendix provides references to a range of excellent image processing and remote sensing textbooks. These books will be very helpful to those new to image processing, or those who want to learn more about image processing techniques for specific earth science applications. Also refer to the *ER Mapper Applications Manual* for examples and information about image processing for many earth science applications.

Avery, E. A., and G. L. Berlin. 1992. *Fundamentals of Remote Sensing and Airphoto Interpretation*, Macmillan Publishing Company, New York, N.Y, USA.

Cracknell, A. P., and L. W. B. Hayes. 1993. *Introduction to Remote Sensing*, Taylor & Francis Ltd, London, England.

Green, W. B. 1989. *Digital Image Processing: A Systems Approach*, Van Nostrand Reinhold, New York, N.Y., USA.

Jensen, J. R. 1995. *Introductory Digital Image Processing: A Remote Sensing Perspective*, Prentice-Hall, Engelwood Cliffs, N.J, USA.

Lillesand, T. M., and R. W. Kiefer. 1991. *Remote Sensing and Image Interpretation*, John Wiley and Sons, Inc. New York, N.Y, USA.

Rees, W. G. 1990. *Physical Principles of Remote Sensing*, Topics in Remote Sensing, vol 1. Cambridge University Press, Cambridge, England.

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