WINDOW ON GMES

A GMES4REGIONS PUBLICATION

Discover what GMES can do for European regions and cities

FOCUS ON GMES BENEFITS FOR LOCAL GOVERNMENT AND FOR GROWTH AND JOBS

Institutional corner

Gerhard Stahl, Secretary General of the Committee of the Regions, explains why the alliance of GMES and regions is of mutual benefit

Henri Malosse, President of the European Economic and Social Committee, details his vision of GMES.

Portraits of GMES users

Thirteen users at local or regional level recount their experience of using GMES products and services.

The SME corner

Four successful entrepreneurs share their story, their experience as well as their advice on how to build a business around GMES services.

OPINIONS ON GMES The added-value of GMES for regional and cross-border cooperation in Europe *MyAir* services: a GMES contribution to public health **Thilo Erbertseder** Monitoring Natura2000 habitats at local, regional and European scale **Stefan Lang** GMES Urban Atlas develops urban planning applications at regional and city level **Tomas Soukup** Earth Observation services to improve waste management at local level **Daniel Drimaco** GMES services monitor ground instability for local authorities **Ren Capes** GMES snow and land ice monitoring services **Thomas Nagler** GMES services for local forest management **Mathias Schardt** Using GMES to map and monitor landslides and ground subsidence **Fausto Guzzetti** GMES services for renewable energies **Lucien Wald**

SPECIAL ISSUE

GMES4REGIONS AND LOCAL AUTHORITIES

GMES – a world of opportunities for Local and Regional Authorities

The adoption of the GMES (Global Monitoring for Environment and Security) regulation[1] marked the transition from the existence of GMES as an initiative to its consolidation as an official programme of the European Union. GMES has a robust legal foundation and is now seeking to consolidate its user base at a local level across the European Union.

The objective of this publication is to contribute to raising awareness of GMES among European Local and Regional Authorities (LRAs) as they represent the largest reservoir of potential users of GMES services. Whilst this edition of *Window on GMES* showcases the many benefits of GMES services with respect to the needs of LRAs, our ambition is also to emphasise that GMES will contribute to foster growth and employment in the EU.

When dealing with environment-related issues, regions, provinces and cities are at the forefront of policy-making and initiative-building. But due to the fact that European LRAs differ widely from one to another, a great variety of heterogeneous challenges stand to influence the design of such policies or initiatives. GMES offers solutions to efficiently address these challenges, and many of these solutions are presented in this publication.

To facilitate the uptake of GMES services at local and regional levels, it is necessary to make LRAs aware of the solutions available on the market, for providers to understand the needs of LRAs, and for LRAs already using GMES services to share their experience. This is the *raison d'être* of this issue of *Window on GMES*, dedicated to regions and lower levels of local authorities.

Through a set of portraits of users of GMES services and a range of detailed articles, this issue of *Window on GMES* will guide you through the diverse applications and services of GMES, such as urban planning, air quality, water quality, waste management, environmental monitoring, cross-border cooperation, monitoring of forest fires, road network management, and many others.

Beyond these areas of benefit, GMES also provides a unique opportunity to create synergies amongst two goals which are often considered divergent: economic growth and sustainable development. GMES represents an opportunity for LRAs to use services that have a positive impact on the local economy, the environment and, ultimately, on our quality of life.

The GMES4Regions team trusts that this immersion into the world of GMES from a regional and local perspective will generate interest, raise awareness and demonstrate that Local and Regional Authorities can successfully become active users of GMES.

Finally, we hope that the gmes4regions.eu portal will help you to connect with GMES!

The GMES4Regions Team

[1] Regulation 911/2010 on GMES and its Initial Operations, September 22nd, 2010.

GMES demystified *

GMES: GLOBAL MONITORING FOR ENVIRONMENT AND SECURITY - ONLY FOUR LETTERS ARE REQUIRED TO ENCAPSULATE THE ESSENCE OF AN IDEA, BORN ALMOST FIFTEEN YEARS AGO IN THE MINDS OF A FEW PIONEERS. THESE VISIONARIES, AWARE OF THE FUTURE CHALLENGES TO BE MET IN EUROPE IN ORDER TO PRESERVE OUR ENVIRONMENT AND GUARANTEE THE SECURITY OF ALL ITS CITIZENS, WERE ALSO MINDFUL OF THE NEED TO ACT AT THE PAN-EUROPEAN LEVEL.

NECESSITY KNOWS NO LAW. GMES gathers, in order to share it, all the countless pieces of data about our environment and Security, accumulated from all European countries and born from years of fruitful research, that have enabled our common technological developments to reach maturity.

Born from years of fruitful research

So, GMES was designed. GMES is a huge and ambitious programme for environmental monitoring, to be used by all players – both public and private – aiming to protect the environment as well as the lives of European citizens.

The "G" of "Global" encompasses both the global dimension and the diversity of the data to be taken into account.
The "M" of "Monitoring" includes the observation activities required for monitoring.
The "E" of "Environment" and the "S" of "Security" are precisely the two important fields benefiting from the GMES initiative.

The GMES programme is a joint undertaking by the European Commission, its Member States, the European Space Agency (for the Space infrastructure) and the European Environment Agency (for the *in situ* infrastructure).

GMES aims to coordinate the use of Earth Observation technologies with existing and future data collection systems.
One of its biggest challenges is to compile the vast number of very different data sets, collected from the ground, from altitude by balloons or aircraft, from the depths of the sea or the surface of the ocean, by networks of probes and sensors, as well as from Space for the observation of the Earth. These data resources are then made compatible with statistical data including, particularly, socioeconomic data gathered for the European Union, its Member States and their local and regional authorities.

The other great challenge is to be able to deliver the data and information to those decision makers, public authorities, and private companies who are assigned the task of implementing policies or responding to crisis situations and who need such information at the right time.

Enabling decision makers and users to access a myriad of information

The first GMES services have now entered into Initial Operations[1], others are being delivered in a pre-operational mode. They already enable decision makers and end users – institutional as well as those from the private sector – to access a great deal of information, such as: the occupation and condition of our soils; the quality of the water we drink and the air we breathe, as well as the nature and degree of the pollution affecting them; the direction of marine currents and level of the ocean's surface; the movement of animal populations and variations of the flora; the behaviour of airborne particles and the extent of the ozone hole; and, the monitoring of glaciers and polar ice cover. All of this is GMES.

Ensuring that operators are prepared and equipped

Such information will enable users to:

- organise city and regional planning, with management plans that are more attuned to our natural resources;
- control our agricultural production and our fish resources effectively;
- monitor the factors of pandemic disasters and their evolution more accurately, minimise the consequences of natural disasters more effectively, and even anticipate their occurrence and implement the necessary mitigation actions.

In the field, GMES services ensure that operators are better prepared and equipped to act during floods, forest fires and landslides, as well as marine pollution events and illegal dumping, and to provide more effective support for humanitarian missions responding, for example, to the impacts of earthquakes, volcanic eruptions, tsunamis and famine.

These services allow political decision makers and all of those whose mission is to be at the service of the citizen's security, to have the necessary data at their disposal during international negotiations. At the national, regional or even local levels, these data will also be most useful to enable decision makers to fulfil their obligations more efficiently, and to improve the precision of their budgetary planning.

Other GMES services will be developed based on scientific or technological evolution and the provision of necessary budgets. Services at the European level respond to the collective needs of institutional agents, and address the more specific demands of end users at the national, regional and local levels.

Help give Europe a leading role in the monitoring of our environment

GMES is an essential tool in the fight against the consequences of climate change that affect our entire planet, without exception. Eventually, GMES is also intended to give Europe a leading role in the monitoring of the global environment.

GMES is a tool of international cooperation, following the example set by meteorological services and constitutes the contribution of the European Union to the creation of a vast and worldwide system of observation systems, the Global Earth Observation System of Systems (GEOSS).

GMES4REGIONS AND LOCAL AUTHORITIES

[1] GMES Initial Operations (GIO) refers to the period 2011-2013, in which the first GMES services have become operational. The GMES Regulation provided a legal basis for the Initial Operations, and made available €107 million in EU funding.

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GMES4REGIONS AND LOCAL AUTHORITIES

Getting LRAs closer to GMES

THE ROOTS OF THE GMES4REGIONS (G4R) INITIATIVE LIE IN THE FOLLOWING PARADOX: CONSIDERING THEIR SPECIFICITIES AND ADMINISTRATIVE PREROGATIVES, EUROPEAN LOCAL AND REGIONAL AUTHORITIES (LRAs) ARE THE LARGEST RESERVOIR OF POTENTIAL USERS OF GMES SERVICES; AND YET THEY HAVE A VERY LOW AWARENESS OF GMES OR ITS BENEFITS

WITH the gmes4regions.eu portal, G4R intends to facilitate the matching of Service Providers with European LRAs and thus become a business development tool helping to enlarge the user base of GMES among LRAs. The industrial, economic and social structures that exist at regional and local levels in the European Union (EU) can strongly benefit from GMES tailor-made services, which ultimately address decision makers, technical end-users and European citizens.

The gmes4regions.eu portal: giving GMES a phone number

The objective of GMES4Regions is to raise awareness of GMES among LRAs and to foster the development of GMES services at local and regional levels. GMES4Regions develops several tools addressing LRAs, small and medium-sized enterprises (SMEs), Research and Academia:

- To bring the Supply and Demand sides closer and to foster the shift from a "Business to Clients" to a "Clients to Business" model, a "Matching Platform", inspired by web dating services and adapted to GMES is available on the web portal. To contribute to raising awareness of the benefits brought by GMES for LRAs, a MultiMedia Presentation showcases several GMES services.
- The business stakeholders are addressed through a section dedicated to Entrepreneurs and SMEs, which targets public or private organisations looking for a service provider as well as providers looking for partners to develop new products or services; and private companies looking for funding or new business development opportunities. This section provides information on the various funding opportunities available at European level for entrepreneurs and SMEs. It also offers a directory of service providers identified in the EU.
- The Research component is addressed through the creation of the GMES Academy (GA) and its objective is to facilitate the effective link between private sector, local administration and academic communities. The "GMES Academy" is established by G4R as a platform for exchange.

Finally, the gmes4regions.eu portal is one of the entry points to the GMES Regional Contact Offices (RCO).

Bringing Regions and GMES closer: the network of GMES Region al Contact Offices (RCO)

THE EUROPEAN NETWORK OF GMES REGIONAL CONTACT OFFICES EXISTS TO RAISE AWARENESS AND STRENGTHEN REGIONAL INVOLVEMENT IN GMES. A GMES REGIONAL CONTACT OFFICE (RCO) ACTS AS A FOCAL POINT IN ITS REGION TO ASSIST REGIONAL ACTORS TO USE GMES-BASED SERVICES IN THEIR DAILY LIFE: AT THE INTERFACE OF INDUSTRY (GMES SERVICES PROVIDERS), RESEARCH AND DEVELOPMENT ACTORS, REGIONAL USERS AND POLICY MAKERS.

Hosted by an independent entity and mandated by its regional authority, a RCO serves as a regional centre of GMES expertise.

The main tasks of the RCO are to:
- identify potential users of GMES services;
- raise awareness of the benefits offered by GMES and Earth Observation based services;
- seek business opportunities for local GMES actors;
- have an extensive and up to date knowledge of the GMES portfolio and new services;
- assist users in the expression of their needs or in the search of services answering their needs;
- facilitate dialogue between users and service providers;
- promote new services developed by regional actors;
- support training in the field of Earth Observation.

GMES RCO network in Europe consists of actors on the Earth Observation stage exchanging information, expertise, good practices, on GMES and satellite applications and support on market opportunities, innovation, and participating in ongoing initiatives.
The idea of setting up a European network came to life out of the aim of strengthening intra-regional and inter-regional dialogue, linking regional and local authorities, service providers, local R&D institutions and policy makers. Such a network is organised by the regions themselves.
The benefits of having an RCO in a region are manifold and arise from various possible impacts on the economy, environment and the quality of life of the citizens, but also contribute to such regional strategic objectives as boosting regional competitiveness, stimulating innovation and collaborations, and increasing the visibility of the region at a European level.
Since July 2011, six RCOs have been established in the following regions that are all members of NEREUS (www.nereus-regions.eu):

- Aquitaine - Midi Pyrénées (FR) at CETE Sud-Ouest
- Azores (PT) at SRCTE
- Basilicata (IT) at TeRN
- Bremen (D) at CEON
- East Midlands (UK) at G-STEP, University of Leicester
- Lombardia (IT) at CNR-IREA

RCOs are in preparation in another fifteen European regions (see map on left of the RCO network).

This *Window on GMES* issue presents several GMES User Portraits collected by the following RCOs:

RCO Lombardia hosted by CNR-IREA, a public research centre in remote sensing and its applications. With its versatile economic activities of Space system development, agriculture, industry, and services, Lombardy offers perfect framework conditions to promote and integrate the services of GMES. Priorities are: agro-food, climate change, health and environment, and risks and civil protection.

RCO Aquitaine - Midi Pyrénées hosted by South West CETE (service from the French Ministry in charge of the environment) has promoted GMES and satellite applications in its regions since July 2011. It works in the position between actors in charge of the environment and internationally known actors involved in satellite applications as CNES, Aerospace Valley, Astrium, CLS, Mercator, small and medium sized businesses (SMEs) and research centres (CNRS, IRD, etc.). It has organised events and actions with end-users to raise their awareness on the benefits of GMES and satellite applications, especially for maritime and land segments, key domains of competencies for Midi Pyrénées and Aquitaine regions.

RCO East Midlands - hosted by G-STEP at the University of Leicester. It aims to boost the development of GMES applications into urban planning and air quality. By promoting Space technologies within the region, the RCO assists collaboration between academics, local authorities and SMEs. Through the organisation of regional events to build awareness of GMES capabilities and follow-up workshops on various application areas (thermal mapping, solar power, land management and GIS), the RCO creates networking opportunities between users and providers and facilitates this link to develop new applications for end users.

RCO Basilicata, run by TeRN - Technological Cluster of the Basilicata "Earth Observation and Natural Hazard Technologies Consortium". Its mission is to increase the use of Space technologies for the benefit of potential users and developers of innovative applications and to help create business opportunities addressing regional needs. Activities range from monitoring/mapping of existing GMES services at regional level, supporting the transformation of research results in new applications, services and patents, to the training of potential users to foster the demand for added value products and Space applications.

Pole Mer Bretagne (aiming at becoming a RCO) – Based in one of the most 'maritime' French regions, the competitiveness cluster Pole Mer Bretagne aims to promote the emergence of innovative projects that will satisfy the demands of new markets. In this context and seeking to respond to the demand for 'safety and security' and the need for 'sustainable development', the Pole Mer Bretagne showed its intention to become an RCO. This initiative, along with the Brittany's region implication within NEREUS (Network of European Regions Using Space Technologies), will help to enhance the already existing regional GMES capabilities and skills and facilitate the development of maritime services for end users.

For more information on the Regional Contact Offices network: carrara.p@irea.cnr.it
Useful link: www.gmes4regions.eu – "Access your Regional Contact Office"

Regions and GMES – a promising alliance

by Gerhard Stahl, Secretary General of the Committee of the Regions

THE TWO EUROPEAN FLAGSHIPS – THE GLOBAL MONITORING FOR ENVIRONMENT AND SECURITY SYSTEM (GMES) AND THE GALILEO SATELLITE NAVIGATION PROGRAMME – HAVE BOTH REACHED SIGNIFICANT STAGES IN TERMS OF ECONOMIC, SOCIAL AND SECURITY DEVELOPMENT. VERY SOON, JUST LIKE MOBILE PHONES OR THE INTERNET, NAVIGATION SYSTEMS WILL BECOME AN INTEGRAL PART OF OUR LIVES. AS A TOOL FOR EMERGENCY MANAGEMENT, THE GMES IS BECOMING MORE AND MORE A TOPICAL ISSUE FOR THE WIDER PUBLIC. ONE OF ITS MAIN AIMS WILL BE TO PRODUCE DATA THAT HELP TO FORECAST BOTH NATURAL DISASTERS (STORMS, FOREST FIRES, FLOODS, TSUNAMIS) AND MAN-MADE ONES (URBAN FIRES, CHEMICAL ACCIDENTS). THESE DATA CAN THEN BE USED TO PREVENT OR MITIGATE DAMAGE CAUSED BY SUCH EVENTS. SO FAR, VALUABLE USE OF THIS INFORMATION HAS BEEN MADE IN THE AREAS OF OIL SPILL/DISCHARGE DETECTION AND MONITORING, LAND USE AND SERVICES TO FARMERS, CIVIL PROTECTION, AND ENVIRONMENT AND PUBLIC HEALTH (SUCH AS OZONE AND UV EXPOSURE MONITORING).
AS WELL AS A WIDE RANGE OF APPLICATIONS, GMES ALSO REINFORCES EUROPE'S COMPETITIVENESS IN CUTTING-EDGE TECHNOLOGY, PROMOTING INNOVATIVE BUSINESSES AND CREATING HIGHLY-SKILLED JOBS. HOWEVER, THE CHALLENGE IS TO PRODUCE CONCRETE RESULTS WHICH ALLOW CITIZENS TO SEE THE ADDED VALUE OF THESE RESOURCE-INTENSIVE NEW TECHNOLOGIES.

What this technology means for regional and local authorities and the role of the Committee of the Regions

It is clear that the development of the GMES has a very concrete territorial dimension which can be divided into two aspects.

Firstly, the inclusion of local and regional governments can, on the one hand, help in explaining the value of GMES to citizens and thereby strengthen the acceptance of these new technologies. Since regional and local authorities are strongly concerned with the everyday lives of citizens, they are best placed to communicate tailor-made information according to the needs on the ground. The Committee of the Regions (CoR) sees the GMES programme as an indispensable EU tool for providing vitally-needed data, in particular for environmental monitoring and civil security, which makes it significantly important for local and regional authorities.

"GMES is important for European regions in combating climate change and mitigating its impact"

Secondly, regional and local authorities could themselves be valuable facilitators of GMES implementation: not only do they host the ground-segment infrastructure of the Space chain, but they also promote clusters to spread knowledge on a regional scale, often in cooperation with research centres. As frontline users of new technologies and applications, they could create a favourable environment for industry-led innovation by initiating and stimulating interest in research and development. GMES would also considerably improve local and regional authorities' access to data and contribute to their harmonisation.

Citizens, heritage sites and buildings are exposed to man-made and natural disasters. In Prague, the Vltava river has caused several dramatic floods. GMES provides services to mitigate natural disasters and improve disaster management (Credits: Ricardo Liberato).

Local and regional authorities are also end-users of environmental information services. They have a particular demand for tailor-made data in order to better manage all forms of transport in towns and regions, accurately prepare for flooding, improve general crisis management, coordinate rescue operations and monitor environmental change. In combination with infrastructure and underground mapping, GMES would facilitate planning for territorial development. In this regard the system is important for European regions in combating climate change and mitigating its impact.

The CoR believes that Galileo and GMES will both become new instruments for encouraging further growth and increasing European regions' competitiveness.[1]

"GMES reinforces Europe's competitiveness in cutting-edge technology, promoting innovative businesses and creating highly-skilled jobs"

The local and regional level should also be able to benefit from GMES, and this should be taken into consideration when developing the initiative and its applications. In particular, any additional costs for local and regional authorities arising from necessary adaptations of existing databases, for example in order to harmonise data, or changes to data

[1] Cfr. CoR Opinion 96/2007

interfaces, should be offset by appropriate financial mechanisms so as to avoid the local and regional level, which is in possession of much of these data, being left to bear the costs alone.

The Committee of the Regions is the voice of Europe's local and regional authorities and is ready to assume the role of intermediary and coordinator between local and regional authorities, the European Commission and the relevant bodies of the GMES system. Coordinated action within the framework of the CoR is ever more important as these new technologies could significantly contribute to the creation of growth and jobs under the Europe 2020 strategy and, in so doing, enhance territorial cohesion. To achieve this aim the CoR provides a platform for cooperation and communication between local and regional actors and other stakeholders.

GMES and spatial technologies will not only benefit the regions directly involved in such industry (likely the "richest regions"), but potentially also other regions which will use the services and products of this industry.

Signatories of the Covenant of Mayors voluntarily commit to increasing energy efficiency and the use of renewable energy sources on their territories.

The GMES could also enhance existing local and regional cooperation networks, such as the Covenant of Mayors. This initiative is a commitment by signatory towns and cities to go beyond the objectives of EU energy policy in terms of reduction in CO_2 emissions through enhanced energy efficiency and cleaner energy production and use. Cooperation could be significantly improved by the GMES's remote sensing satellite systems. Together with land-, air- and sea-based techniques, they will provide cities with geo-spatial information in support of many different policies from civil protection to climate change. Equipped with the same quality of data, local authorities' common initiatives would be facilitated and best-practice approaches would be more easily accessible.

Political support for a common implementation of spatial technologies at regional and local level

The CoR believes that the strong political engagement of local and regional players will be one of the key elements needed for the success of GMES and spatial technologies in general. A recent example, supported by the CoR, has been the creation of the "NEREUS" network of European regions using Space technologies.

Many sectors managed by regional administrations are affected by the development of Earth Observation capacity, information and services e.g. transport and communication, land survey, agriculture, fisheries and waterways, tourism, waste disposal and logistics.

Tools for distance learning, remote medicine, remote health and remote administration are key fields of future

Gerhard Stahl, Secretary General of the Committee of the Regions, during a conference of the NEREUS - Network of European Regions Using Space Technologies (Credits: Committee of the Regions).

application in every region. Information and communications technologies play a key role in improving the quality of life of citizens and their social and economic opportunities, stimulating more efficient and personalised public services and promoting local businesses.

In furthering recent energy market liberalisation measures, the European Council has called for improved access to and use of cross-border transmission networks across Europe. Given the necessity of ensuring security of supply, the use of satellite projects to verify EU networks in real time becomes particularly relevant. The Council has also highlighted the potential for applying the technologies offered in the framework of Galileo/GMES to the intelligent management of grids in real time and developing instruments that could help prevent the loss of biodiversity, such as spatial planning and sustainable forest management. Until now, from a local and regional perspective, GMES has meant environmental monitoring rather than management of energy grids. However, local and regional authorities must not lose sight of the cutting edge of technological development and innovation.

Last but not least, in order to develop new applications and technologies for present and future Space programmes, current knowledge must be improved. Research centres and universities in Europe are able to meet this challenge of supporting industry activities in a competitive world and regional administrations should involve themselves in the education and research-support processes at all appropriate levels. For these reasons, we need an ambitious and clear EU Space policy, backed up with appropriate level of funding from the EU budget.

Concluding remarks

Satellite and Earth Observation technologies represent an important step for

the development of European regions. A strong alliance of these projects with local and regional governments would significantly improve the development of Earth Observation services and applications on the ground while at the same time fostering their implementation. Thanks to Earth Observation technologies and services, benefits such as greater security and reduced congestion for all forms of transport, improved monitoring of the environment, better prevention and management of crisis situations, and better targeted, quicker and more effective intervention can be achieved, thereby improving the everyday lives of citizens. These goals deserve coordinated action by local, regional, national and European partners, in a multi-level governance approach.

Gerhard STAHL was born in Ludwigsburg, on December 2nd, 1950. He graduated in Economics at the Technical University in Berlin, where he had his first professional post as an assistant to the chair of Public Finance. He then spent three years working as an economist at the Federal Ministry of Finance in Bonn.
He also worked in the European Parliament and on the regional level in Schleswig-Holstein at the Ministry for Economics, Transport and Research and later on as Director-General for European and International Affairs at the Ministry for European and Federal Affairs. In this role, he specialised in EU policy preparation for the Bundesrat, the German second legislative chamber, and inter-regional cooperation projects.
From 1995 to 1999, Mr Stahl was a Member of the Cabinet of European Commissioner for Regional Policy, Dr Monika Wulf-Mathies.
From 1999 to 2002, he was Deputy Head of Cabinet for Pedro Solbes, the European Commissioner for Economic and Monetary Affairs.
In September 2002, Mr Stahl was appointed Director for Consultative Work at the Committee of the Regions; he has been Secretary-General of the CoR since April 1st, 2004.
Mr Stahl is a Member of the Advisory Committee (Kuratorium) of the IFO-Research Institute in Munich and the author of several publications on economic, regional and European policy issues. He is married and has two children.

GMES: a plea for a citizen-led approach

by Henri Malosse

HENRI MALOSSE HAS BEEN ELECTED AS THE NEXT PRESIDENT OF THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE, TAKING UP HIS POST FROM APRIL 2013 ONWARDS. IN THIS ARTICLE HE PRESENTS HIS VISION OF THE GMES PROGRAMME.

My ambition as next President of European Economic and Social Committee is clear: we have to strengthen the link between Europe and its citizens. We must learn from the different messages that the citizens send us on the occasion of the various referenda and "Eurobarometers". If we want the European Union to succeed, then we must ensure that citizens feel more European and dream again about a more integrated Europe.
It is from that perspective that I want to look at the GMES programme. We need to be realistic. The programme is ambitious and costs a lot of money. The investment must be put in perspective with what it brings to citizens. So, in the end, the only question is the following: do we really need a global Earth Observation system?
Economic studies have been conducted showing that the societal benefit of GMES exceed, by up to ten times, the costs. So, in a nutshell, it is good value for public money. But these studies, as important as they are, don't convince the average citizen that investing money in such a long term project is a priority. The current context makes it all the more difficult. The crisis continues to hit the EU hard, particularly in the regions, and many needs remain unfulfilled in the short term.

Let's have a closer look at GMES. Without becoming too technical, GMES aims at providing continuous and independent information to European policy makers, to the business community and to the general public. GMES consists of three components: a satellite constellation for the collection of Earth Observation (EO) data from Space; an Earth-based observation infrastructure (ground, airborne, ship or buoy-based sensors) and a network of service providers producing and delivering EO information relevant for six different domains: Atmosphere, Climate Change, Land Monitoring, Emergency Management, Marine and Security.

"GMES has a significant impact on jobs, employment and innovation"

Today, GMES is a reality although not all of the six services are operational yet. With the implementation of the GMES Initial Operations (GIO) 2011-2013, GMES moved from research to operations. Two services are now running under an operational mode: The Land Monitoring Service for which the European Environment Agency (EEA) ensures the technical coordination; and the Emergency Management Service (EMS). The other services continue to be

financed under the EU's 7th Framework Programme (FP7), i.e. marine environment, atmosphere monitoring, climate change, and Security-related services. The six services should be fully operational by 2014.

To illustrate the benefits of GMES for the citizens let's look at one of the services. The EMS has been operational since the April 1st, 2012. In its first six months of operations, the EMS was activated nine times. Let me give one example. During the earthquake that hit the Italian Emilia region the GMES Emergency Management Service had produced new reference maps within six hours. These maps showed with great precision where the damage was, which roads could still be used and what the fastest ways were for ambulances and other emergency actors to reach damaged areas and return. These maps facilitated the work of those people helping and working on the spot considerably. If it helps to hasten relief and support operations to help people in danger, or even to save lives, there is no doubt that GMES is worth the investment. Of course, such benefit in terms of life is not reflected in the economic studies I mentioned earlier. Indeed, how much is a life worth? It is inestimable.

This map shows a delineation of building affected by the May 2012 earthquake in Emilia Romagna (Credits: European Commission).

More Europe, not less

The same reasoning holds if GMES is used for instance in the case of the monitoring of deforestation or desertification. Without monitoring, no adequate political action is possible. Therefore, monitoring tools are crucial. Besides, GMES is a good example of European countries and regions working together. At this stage, there is almost unanimity about the fact that the best way out of the crisis is not less Europe, but more Europe. Even Joseph Stiglitz, the Nobel prize winner in economics, pleads for more Europe despite his euro-scepticism.

The fact that GMES "europeanises" the many national Earth Observation and *in situ* systems is a good example of what more Europe brings. The Space component of GMES is fully in line with the Space competence that Europe has acquired since the Lisbon Treaty. GMES, as one of the flagship programmes, finally has a significant impact on jobs, employment and innovation. The Earth Observation industry is made up of distinct segments. First there is the upstream sector, which concerns Space-based and Earth-based infrastructure providers, including the building of satellites. This sector is highly innovative. This is especially true for GMES where, in contradiction to Galileo, every satellite is different. Then there is the downstream sector, which consists of services and products that can be developed thanks to the availability of continuous and accurate Earth Observation-based information. Finally, in between, we have the midstream sector represented by those operators exploiting Space-based and Earth-based systems to produce and sell data. Studies show that midstream and downstream sectors can be eight times bigger than the upstream sector. So there is a gearing effect on the investments in the upstream sector. GMES, together with Galileo, represents a very significant part of the upstream sector.

Closing the gap between Europe and its citizens

We all know that European institutions are not always good communicators. This is also true for the GMES programme which can be seen, for instance, in the very complicated articles it publishes. But, I agree that GMES is not easy to explain. Galileo, the other Space flagship, is easier: it is the European GPS system, though it is more sophisticated and more accurate than the current GPS.

Further efforts must be made to explain how GMES can eventually improve our quality of life. In that regard, the European Space Expo is a very interesting initiative as it explains what Space, and GMES in particular, means for our daily lives. When I was at the Space Expo in Toulouse I was amazed to discover that there are currently about 30,000 Space-based applications available and in use to improve our daily life. We clearly don't realise how important Space is. In Helsinki, 25,000 citizens visited the Space Expo in three days. The European Space Expo certainly contributes to bringing citizens closer to what we are doing. The fact that this Space Expo visits another 25 European cities in the next two years is, in my view, a very good example of what "good communication" is.

It will be my role, as future President of the European Economic and Social Committee to look at programmes such as GMES from a stakeholders' perspective. In this context one should not forget that the most important European stakeholder is represented by the citizens. Representing the citizens is a key role for the European Economic and Social Committee. During my Presidency my priority will be to close the gap as much as possible between the European citizens and the European institutions, to make Europeans dream again about Europe.

Henri MALOSSE President of the Employers' Group within the European Economic and Social Committee (EESC). From April 1st, 2013, he will be President of the European Economic and Social Committee. Before becoming President of the Employers Group of the EESC in 2006, Henri Malosse was President of the EESC's SOC and ECO sections, and was Co-President of the EU-Bulgaria Joint Consultative Committee. He is currently director and advisor to the Presidency of the French Assembly of Chambers of Commerce and Industry, and advisor to the President on European matters. He is the creator of the network of Euro Info Centers (with over 250 offices now and with over 600 employees) that provide information to small businesses in all parts of Europe. He is Vice-President and founding member of the European Association of SMEs, SME Union in the European Parliament. Henri Malosse graduated from the Institute of political studies in Paris, is Knight of the national Merit Order, Member of the Advisory Council of the Jean Monnet Association. He gives lessons on Europe at several European universities (Strasbourg, Paris, Moscow, Wroclaw) and has written several books including " Building Europe: The History and Future of a Europe of the People", "Europe at your door", "Europe from A to Z", "Reuniting the Greater Europe ", " Saving the European citizen".

GMES service in support of urban planning for the municipalities of North Bari, in the Puglia Region

WITHIN THE EUROPEAN SPACE AGENCY-FUNDED GSE[1] LAND PROJECT, THE ENVIRONMENTAL TERRITORIAL AGENCY OF THE TERRITORIAL PACT FOR NORTH BARI/ OFANTINO OCCUPATION, IN THE REGION OF PUGLIA (ITALY), USED CONTEXT MAPS AS SUPPORT TOOLS FOR MUNICIPALITIES TO IDENTIFY URBAN AND RURAL CONTEXTS FOR NEW URBAN PLANS.

Mauro IACOVIELLO during an Urban Planning Conference

"In 2008 the new Regional Document for the General Structure of Puglia Region required all municipalities to identify and map their urban and rural contexts, referred to as a zoning of that portion of territory located between the city and the countryside.
The context maps were obtained according to our specific requirements, using the Urban Atlas products implemented as part of the GSE Land project for the nine municipalities of the Territorial Pact for North Bari/Ofantino Occupation."

Architect Mauro IACOVIELLO
(Technical Coordinator of the Territorial Pact for North Bari/Ofantino Occupation Environmental Territorial Agency)

The context maps were integrated into the GIS[2] applications of the Territorial Pact to provide technical support for:

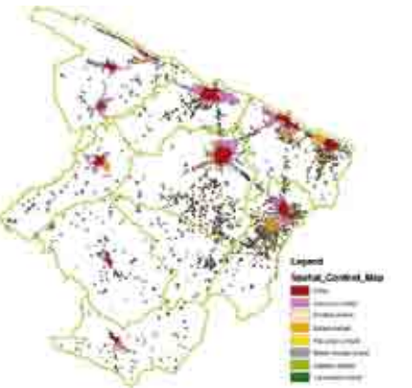
- Decision-making activities related to voluntary negotiated planning, that local administrations decided to adopt during 2004-2011: Agenda 21 programme for wide areas; (http://www.atanbo.it/agenda21.htm);
- Strategic environmental assessment of local plans and programmes.

[1] GMES Service Element.
[2] Geographical Information Service.

The Contexts Map, obtained by merging Urban Atlas classes according to thematic aggregation criteria, has the scope of providing a "**segmented land use map**" to be used as a support to territorial analysis.

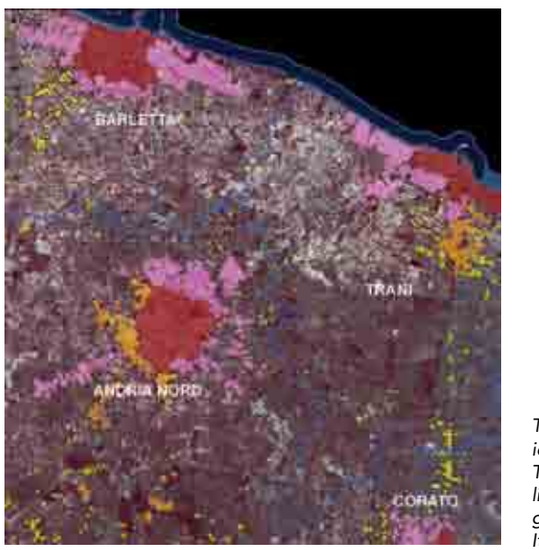
URBAN CONTEXTS
- Suburban
- Building
- Sprawl

RURAL CONTEXTS
- Peri-urban
- Multifunctional
- Borderline
- Agrarian
- Landscape



Overview of Contexts Map (2009) (Credits: Planetek Italia s.r.l.).

Urban Atlas of the Territorial Pact for North Bari/ Ofantino Occupation (2006) (Credits: Planetek Italia s.r.l.).



This GMES service delivers mapping that identifies the rural and urban contexts. The map, produced from SPOT 5 satellite data, supports the editing of the programmatic urban plan (Credits: Planetek Italia s.r.l.).

A GMES service for the timely detection of forest fires in Palermo province

THE CIVIL PROTECTION DIRECTORATE OF PALERMO PROVINCE (SICILY -ITALY) SYSTEMATICALLY USES AN ADVANCED EARLY FIRE DETECTION SYSTEM BASED ON THE RST-FIRES METHODOLOGY DEVELOPED BY THE UNIVERSITY OF BASILICATA AND CNR-IMAA. IT IS PRESENTLY DISTRIBUTED BY GEOSPAZIO-ITALIA AS PART OF ITS PROGRAMME FOR FOREST FIRE PREVENTION AND FIGHTING. THE ADDED VALUE OF SUCH A GMES SERVICE HAS BEEN DEMONSTRATED AFTER TWO YEARS OF TESTING, TUNING AND VALIDATION THROUGH THE *AVVISTA* PROJECT, FUNDED BY THE PARLERMO PROVINCE.

The Civil Protection directorate of Palermo Province. From left to right: Giuseppe BENIGNO, Head of the Technical and Organisational Office; Salvatore SERIO, The Director; and Girolamo CRIVELLO, Head of the Operations Management and Special Means office.

"One of the critical aspects of the whole fire fighting chain is timely identification of fire outbreaks. The prompt sighting and alerting of a fire, in fact, can allow for an immediate reaction of fire fighters who, intervening when fires are small, can extinguish flames in a more easy and effective way. Since 2008 Palermo Province decided to improve its fire fighting procedures by using advanced satellite technologies provided by the University of Basilicata and CNR-IMAA. Thanks to near real-time (every 15 minutes) provision of satellite-based active fires maps during the last two years, hundreds of fires were detected solely thanks to the satellite system and often identified well before traditional surveillance systems. Many hectares of forests were saved by this and, in one case, the service allowed the identification of pyromaniacs still in action!"

Salvatore SERIO

Basilicata Regional Contact Office (RCO)
More information on http://doris-net.eu/en/node/340
Contact: Carmela Cornacchia • rco_basilicata@tern.it • Tel: +39-0971-427275

An example of fast intervention: it took seven minutes to receive the anomaly from satellite, alert the airplane already overflying the area and receive confirmation of the presence of a fire outbreak. (Credits: Adnkronos, Repubblica.it August 28th, 2010).

A GMES SERVICE FOR TIMELY FOREST FIRE DETECTION

The service, based on the RST-FIRES methodology, uses 3 different satellite systems for providing fire alert maps. These are updated every 15 minutes and can be immediately visualised via a dedicated Google Earth plugin in the user's monitoring room. Specific software tools (and training for Civil Protection personnel) are provided for the identification of major or more dangerous events and to support decisions on priorities of interventions.

The unique capability of detection of very small fires also demonstrated its usefulness for controlling the timing of cleaning fires (prohibited during the hottest hours of the day) or to avoid their extension toward forested areas. In the top picture in red the SEVIRI ground resolution cell where a cleaning fire was identified on September 10th, 2010 by the RST-FIRES system, just close to a Special Protection Zone delimited by a blue line (Credits: M. Iato, Kumeta, Maganoce and Pizzo Parrino). In the bottom picture: the aircraft photo collected the day after confirming the correct detection of a cleaning fire (Credits: S. Giuseppe Jato - Palermo Province).

A fire alert map updated every 15 minutes presenting an active fire scenario. In the map, detected hot spots are reported by applying the RST-FIRES methodology to MSG/SEVIRI, NOAA/AVHRR and EOS/MODIS satellite data (Credits: University of Basilicata, CNR-IMAA, Geospazio Italia s.r.l.).

Monitoring snow to improve flood forecasting

THE CZECH REPUBLIC HAS EXPERIENCED DIFFERENT TYPES OF FLOODS IN RECENT YEARS, SUCH AS SUMMER FLOODS DUE TO THE LONG TIME PRECIPITATION (JULY 1997, AUGUST 2002), FLASH FLOODS (JULY 1998, JUNE 2009) BUT ALSO SIGNIFICANT FLOODS FROM SNOW MELT (MARCH 2000, MARCH AND APRIL 2006). A WIDE RANGE OF POSSIBLE TYPES OF FLOODS ALSO BRINGS VERY DIVERSE AND COMPLEX DEMAND ON THE INPUT DATA AND HYDROLOGICAL METHODS AND MODELS THAT ARE USED. THE CZECH HYDROMETEOROLOGICAL INSTITUTE (CHMI) REGULARLY EVALUATES QUANTITY OF SNOW AND COMPUTES PROGNOSIS OF FLOODS. INFORMATION OBTAINED FROM THE GROUND STATIONS IS NOT SUFFICIENT SO EARTH OBSERVATION SATELLITES HELP SIGNIFICANTLY AS THEY OFFER SPATIAL INFORMATION.

RNDr. Jan Daňhelka, Ph.D.
Director deputy for Hydrology - Czech Hydrometeorological Institute

"Snow cover detection methodologies under imperfect conditions (cloud occurrence) and hydrological/geographical evaluation is one of several very important tasks in operational hydrology. Such information is important for the precision of interpolation among point measurements of snow water content.
CHMI operates GIS[1] procedures for snow water content interpolation and evaluation of snow water storage in the Czech Republic. Products of snow extent identification are currently used as a base for estimation of interpolation parameters made by an experienced hydrologist.
The estimation of the Snow Water Equivalent from satellites cannot be foreseen in conditions of hilly regions. However a monitoring of snow top characteristics may contribute to an overview of regional and spatial occurrence of melting in the critical period of spring. That may in advance identify the hotspots of flood generation before it is monitored in the water gauging network."

RNDr. Jan Daňhelka, Ph.D.

FLOREO SNOW MAPPING SERVICE

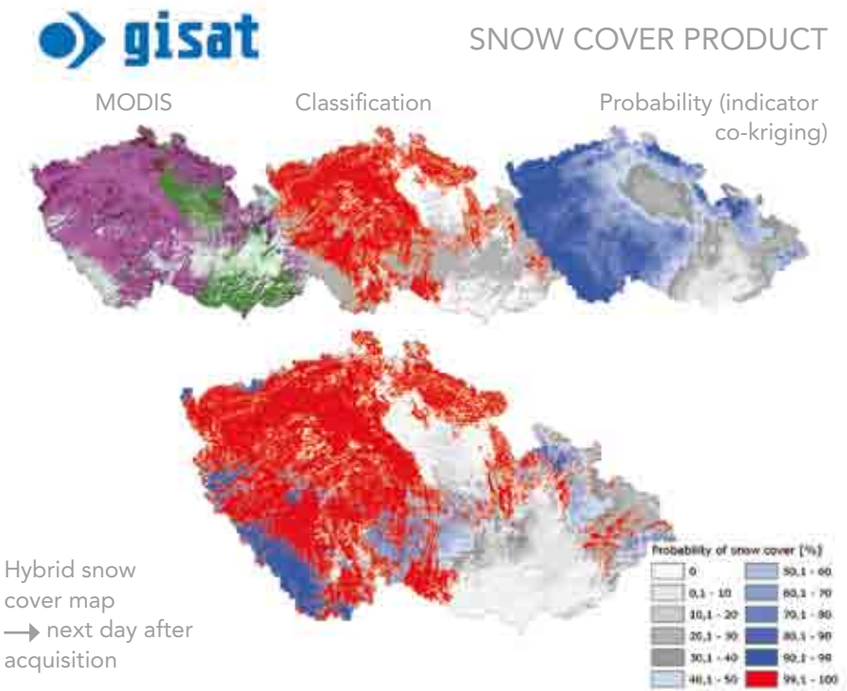
An early warning system of flood hazards was developed in the frame of the *FLOREO* project (ESA PECS). It validates the use of Earth Observation technology in synergy with *in situ* data. The development of this system was steered to support existing hydrological monitoring activities, especially snow melt and surface water runoff contributing to flooding events. GISAT has been running the service in operational mode for the past two years.

ČHMÚ

[1] Geographical Information Service.

In late June 2009 several south-bohemian rivers, including Vltava, caused flooding of several villages and cities. Prague is located in a flood-prone area and faced major flooding in 2002 (Credits: Aktron / Wikimedia Commons).

The snow cover and its changes (the changing snow-line) are monitored using several satellite systems, such as Terra MODIS imagery with spatial resolution of 250m or ENVISAT ASAR radar imagery with spatial resolution of 150m. The advantage of MODIS data is daily acquisition with full coverage of the area of interest but clouds can hide the land surface. In that case ASAR data are processed independently of the cloud cover. Additionally, probability of snow occurrence is calculated to substitute cloud cover in case of missing SAR images.



Example of snow-cover information extraction from combined Terra MODIS and in situ *data (Data: NASA, CHMI) (Credits: GISAT).*

EO-based water quality products support governmental waterway authorities with monitoring the dynamics of suspended matter

WITHIN THE GMES PROJECT *FRESHMON*, A SERVICE LINE IS PREPARED FOR WATER QUALITY MONITORING IN RIVERS AND LAKES. DR. NORBERT WINKEL, HEAD OF THE SECTION IN CHARGE OF COASTAL AREAS AT THE FEDERAL WATERWAYS ENGINEERING AND RESEARCH INSTITUTE (BAW) IN HAMBURG, USES THE NEW SATELLITE-BASED PRODUCTS TO OPTIMISE RIVER ENGINEERING IN SYNERGY WITH HYDRODYNAMIC MODELS AND *IN SITU* DATA.

Dr. Norbert WINKEL
Head of Section K3 Coastal areas
Federal Waterways Engineering and Research Institute (BAW), Hamburg

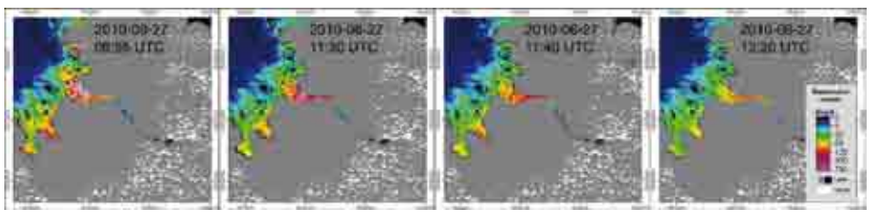
"Understanding the transport processes of suspended sediments in waterways is essential to reduce river engineering expenses such as dredging. As the federal authority BAW is responsible for the German waterways, we optimise waterway engineering for example in the estuaries of the Elbe, Weser and Ems rivers. Measurements in combination with 3D hydrodynamic modelling are a key to understanding the processes and optimising engineering works. The area-wide remote sensing products of suspended matter provided by the FRESHMON *consortium give very valuable synoptic measurements of suspended matter surface concentrations. We expect that the anticipated temporal and spatial resolution of observations with the GMES satellite fleet will significantly improve our daily work."*

Dr. Norbert WINKEL

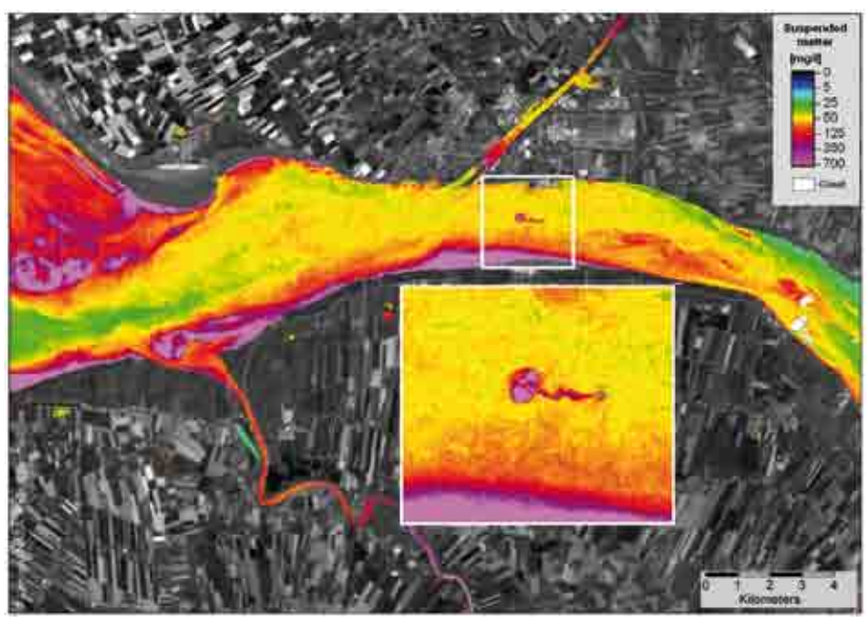
BAW
Bundesanstalt für Wasserbau
Kompetenz für die Wasserstraßen

SUSPENDED MATTER MONITORING IN RIVERS

Within *FRESHMON*, suspended matter monitoring maps of the River Elbe have been provided to the Federal Waterways Engineering and Research Institute (BAW) in Hamburg.
The products included time series of turbidity and total suspended matter concentrations in different spatial and temporal resolutions. The satellite data of MODIS, MERIS and RapidEye with a spatial resolution of 300m, 250m and 5m, respectively, have been used to detect concentration ranges from 0 to 500 mg/l of suspended matter.
With the provision of several maps per day, the tidal affected changes of total suspended matter from the river mouth to the inland part are visualised, also showing very small scale features such as plumes from power plants, the wake of ships and mixing processes in the river's course.



Time series of suspended matter monitoring of the River Elbe using MODIS Terra and Aqua 250m satellite data (Credits: NASA and RapidEye for source data, EOMAP for processing).



Detecting a ship's wake using RapidEye 5m resolution satellite data (Credits: NASA and RapidEye for source data, EOMAP for processing).

GMES services help the Aquitaine region to assess coastal retreat

WITH THE AIM TO ASSESS COASTAL EROSION (A SIGNIFICANT HAZARD IN AQUITAINE, FRANCE) AND PREVENT ITS POTENTIALLY DRAMATIC IMPACTS, THE AQUITAINE REGIONAL COUNCIL IS SUPPORTING THE DEVELOPMENT OF OPERATIONAL DECISION-MAKING TOOLS. IN THIS CONTEXT, SPACE IMAGERY PROVIDED BY THE SPOT-5 AND FORMOSAT-2 SATELLITES IS USED TO DERIVE MAPS OF THE 240 KM LONG SANDY COAST OF THE REGION. THEN, COASTAL PLANNERS CAN EXPLOIT THE MAPS PRODUCED TO ANALYSE YEARLY CHANGES AND PROPOSE EVOLUTION SCENARIOS. BASED ON THIS SUCCESSFUL APPLICATION OF THE SPACE IMAGERY FOR COASTLINE SURVEY PURPOSES, TWO MONITORING SERVICES EXPLOITING SPACE OBSERVATIONS ARE CURRENTLY BEING DEVELOPED AT BORDEAUX UNIVERSITY WITH THE SUPPORT OF THE FINAL PRODUCT USERS, NAMELY THE INFOLITTORAL-1 AND DDUST SERVICES.

Cyril MALLET and collaborators during in situ *measurements on the Aquitaine coastline.*

"The protection of the littoral against marine erosion and submersion has become a crucial issue for coastal zone managers and stakeholders. Along the southwest coast of France (Aquitaine region), coastal erosion causes the sandy shore to move landward and, at several locations, chronic retreat may even modify actual urban planning and future tourism development. A regional partnership plans to anticipate littoral risks by defining a regional strategy for coastal risk management. The Aquitaine Coast Observatory (ACO) monitors and analyses the dynamics of the coastline by combining ground, airborne and Space observations. The latter presents the advantages of offering frequent and large area coverage and reduced costs when compared to similar services provided by aerial means. Thus, once every two years, we exploit high-resolution satellite imagery to derive GI[1]-formatted maps of the coastline (about 240 km long). Its changes over time are evaluated and from this analysis we establish evolution scenarios for the next decades allowing the local and regional authorities to set up coherent management strategies at local and regional scale.
This successful experience has demonstrated the usefulness of developing an operational mapping service based on Space imagery, serving the dual purpose of mapping the coastline and assessing its evolution over time[2] that are currently designing a service demonstrator applicable worldwide.
Also, we emphasised the potential of Space-based high-resolution imagery for quantifying storm impacts on coastal dunes and monitoring post-storm restoration of the dune vegetation. The innovative DDUST service intends to address both these requirements."

Cyril MALLET, Coastal Geologist Engineer, Bureau of Geological and Mining Research

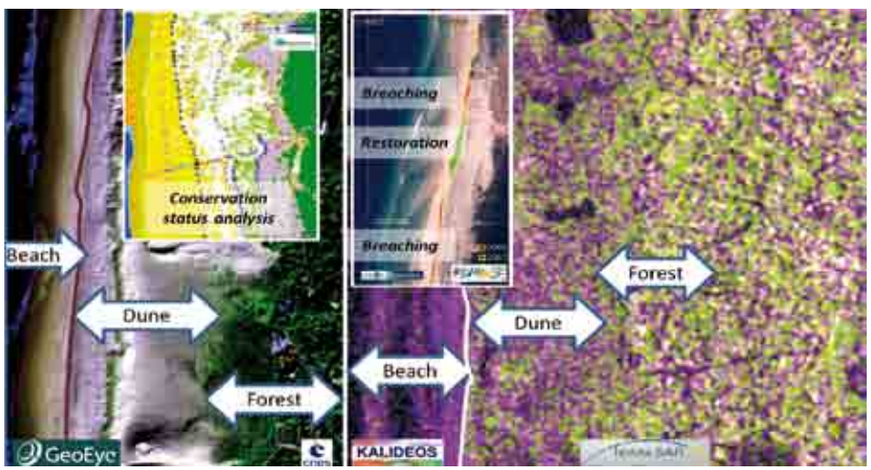
[1] Geographical Information Service.
[2] http://infolittoral.spotimage.com.

DDUST- an operational service for monitoring coastal dune erosion

DDUST is a mapping service of the dynamics of littoral dune fields based on satellite imagery. Funded by the Aquitaine Regional Council in the framework of INTERREG IV B SUDOE led by GEO-Transfert from Bordeaux University (www.geotransfert.epoc.u-bordeaux1.fr), DDUST will propose satellite-based management tools for dune monitoring and management planning. This will help assess storm impacts and post-storm beach and dune recovery. DDUST exploits the depletion of the vegetation and changes in the littoral dunes as an indicator of dune erosion, either due to long-term changes or to storms. Temporal series (annual or following events) of high and very high-resolution satellite data are processed to derive three cartographic products:

- An analysis of conservation status of the dune systems (cf. left figure below);
- The monitoring of shoreline breaching (cf. right figure below);
- And the monitoring of conservation actions aiming at stabilising dune systems.

Raster and vector GIS-compatible layers will be provided to end users. As a first step, the service will be deployed along the Aquitaine coast and the north coast of Portugal. Then, in the framework of GMES we intend to develop the DDUST service to cover all European sandy coastal areas.



Left: GeoEye satellite image. Mapping of the dune (white, light green and gray depend on the type of vegetation present), between the beach (yellow) and the forest (dark green). Crosses are ground control points used to validate the mapping. (Credits: CNES, GeoEye, OCA Geo-Transfert).
Right: Analysis of period from 2005-2007 showing changes in the western boundary of the dune showing a decline in red areas (breaching) and advances in green areas (restoration) (Credits: CNES, DLR, OCA, GEO-Transfert).

Midi-Pyrénées and Aquitaine Regional Contact Office (RCO)
More information on http://www.doris-net.eu/en/node/309
Contact: Christelle Bosc
christelle.bosc@developpement-durable.gouv.fr - Tel.: +33 (0)5.62.25.97.07

Pan-European GMES Land services offer local potential to regional environmental records offices

GROWING DEMAND FOR UP-TO-DATE, CONSISTENT AND COMPREHENSIVE DATA AT THE LOCAL LEVEL IS ENCOURAGING LOCAL ENVIRONMENTAL RECORDS CENTRES (LERCS) IN THE UK TO CONSIDER THE USE OF GMES LAND DATA AND INFORMATION SERVICES TO AVOID THE NEED FOR EXPENSIVE IN-HOUSE TECHNICAL DEVELOPMENTS AND THE MAINTENANCE OF PRODUCTION CAPACITIES.

"In Cambridgeshire we currently have very little in the way of digital habitat data, practically none in fact, but we are beginning to see a shift in focus from an interest in species data to an interest in habitat data from our partners. Local authorities are becoming aware of the need to better understand the habitats affected by developments – particularly Biodiversity Action Plan (BAP) habitats. We see Earth Observation-based habitat mapping as a good potential solution to this and with the growing availability of recent and relevant datasets through our government agency partners can see this potential solution becoming more likely."

CPERC
CAMBRIDGESHIRE & PETERBOROUGH ENVIRONMENTAL RECORDS CENTRE

John CORNELL,
Centre Manager, Cambridgeshire & Peterborough Environmental Records Centre

"The last few years has seen an increasing demand for high quality spatial habitat and land use data from the Norfolk Biodiversity Information Service (NBIS). National bodies, local authorities and ecological consultants all require this information. Coupled with this is a need for regular updates to allow monitoring of sites and habitats. At present NBIS uses aerial photographs to map habitats to Geographic Information System. This is time-consuming and we are keen to investigate the use of semi-automated analyses of Earth Observation imagery, particularly in light of future free access to European satellite imagery."

NBIS
Norfolk Biodiversity Information Service

Martin HORLOCK,
Biodiversity Information Officer, Norfolk Biodiversity Information Service

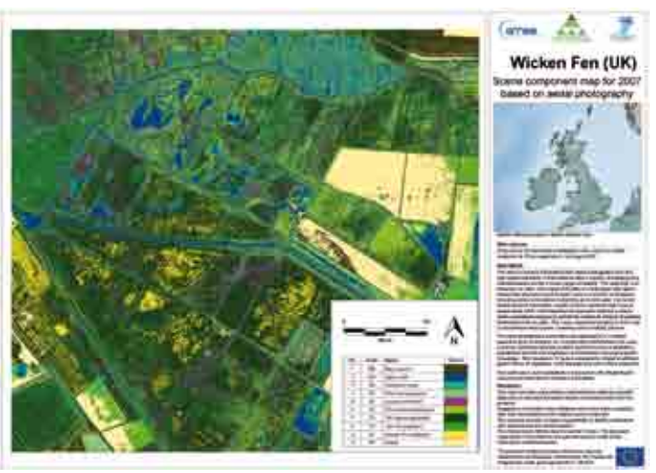
ABOUT THE LOCAL ENVIRONMENTAL RECORDS OFFICES

Local Environmental Records Centres (LERCs) have become established in the UK over the last 10 years to collect, store and make available environmental information at the municipality (local) level. They are typically not-for-profit organisations and act as the primary 'one-stop-shop' for environmental data in each county or local area. The information hosted by the LERCs addresses a wide range of topics including habitats, protected sites, species and physical aspects of the landscape.

GMES BENEFITS FOR LERCS

The individual LERCs work as a network with the UK and Ireland through the Association of LERCs (known as ALERC). Although they vary in size, set up and output, it is easy to identify commonalities between their activities. They are all required to support data users, develop relationships with groups providing data, share best practices and work within a wider landscape context. It is not uncommon for LERCs to work together on cross-county data searches or projects. In the eastern England region, six LERCs meet throughout the year to discuss general matters related to their everyday work. Overall they aim to offer the best available services and products to data users and data providers, thereby increasing both financial support and data holdings respectively.

With a growing demand for up–to-date, consistent and comprehensive data from their clients the LERCs are now considering the use of Earth Observation (EO) to deliver at least some of their requirements. The emergence of GMES Land data and information services within an operational frame will allow the LERCs to embrace EO-based products without the need for expensive in-house technical developments. The eastern England LERCs are now considering the use of EO for habitat mapping in the context of the *MS.MONINA* project.



The map above details the coverage of ten different scene components relating to different forms of vegetation, land management and surface properties (Credits: MS.MONINA).

The Tensift Hydraulic Basin Agency in Morocco relies on Remote Sensing for Integrated Water Resources Management

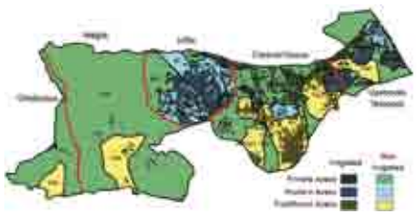
THE AGENCY IS IN CHARGE OF THE INTEGRATED WATER RESOURCES MANAGEMENT (IWRM), A CONCEPT ENCOURAGING THE PRESERVATION OF WATER RESOURCES WHILE SUPPORTING SOCIOECONOMIC DEVELOPMENT. IN THE FRAMEWORK OF THIS RESEARCH AND DEVELOPMENT STUDY, SEVERAL LOCAL SECTORAL OPERATORS AND RESEARCH ORGANISMS ORGANISATIONS (ABHT, ORMVAH, UCAM, DMN)* INVOLVED IN THE JOINT INTERNATIONAL LABORATORY TREMA AND FOREIGN INSTITUTIONS (CESBIO, IRD, GIZ, BGR, ACSAD)** WORKED TOGETHER TO IMPLEMENT A DECISION SUPPORT SYSTEM FOR IWRM.

Brahim BERJAMY during the presentation of the Master Plan for Integrated Water Resources Management of the of Haouz plain. Marrakech, 2011.

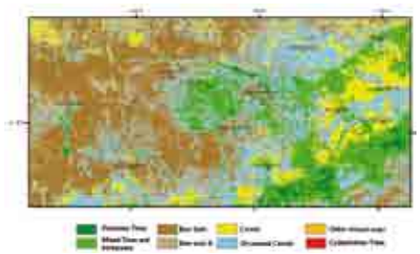
"Irrigation located mainly in the Haouz-Mejjate plain (6000 km²) accounts for about 80% of the consumptive use in the area. Moreover, the city of Marrakech requires more and more water whereas the level of the aquifer has been decreasing in the last decades (up to 2 meters/year), driven by an outbreak of groundwater pumping. Our past groundwater evaluation had always large uncertainties on groundwater discharges for irrigation because of the variation in time and space of abstractions related to fluctuating climate and land use. We decided to build an entire new tool where the water demand of plants is calculated from remote sensing and groundwater abstraction is the residue of this demand. The benefits are important. Imagery data in the GMES context gives a synoptic and continuous view of what is happening in terms of land use and irrigated areas evolution and of crop water demand with an unprecedented accuracy. In addition, our method is fully traceable, so that each stakeholder may review the modelling assumptions. Finally, we began to build middle term groundwater management scenarios taking account of the different stakeholders' visions and plans in the Haouz basin"

Brahim BERJAMY
Head of the Information Systems, Communication and Cooperation Department.
Agence de Bassin Hydraulique du Tensift, Maroc.

*: Agence de Bassin Hydraulique du Tensift, Office de Mise en Valeur Agricole du Haouz, Université Cadi Ayyad de Marrakech, Direction de la Météorologie Nationale
**: Centre d'Etudes Spatiales de la Biosphère, Institut de Recherche pour le Développement, Gesellschaft für Internationale Zusammenarbeit, Bundesantalt für Geowissenschaften und Rohstoffe, Arab Center for the Studies of Arid Zones and Dry Lands



Irrigated areas map based on the analysis of 10 years of imagery superposed to irrigation administrative areas (Credits: LMI TREMA, 2011).



Land use based on the majority class of each yearly remote sensing classification between 2001 and 2009 (Credits: LMI TREMA, 2011).

M. Berjamy is testing a multispectral radiometer with students at an irrigated area of the Haouz plain.

FROM SATELLITE IMAGERY TO AN IWRM DECISION SUPPORT SYSTEM

CESBIO derived monthly estimates of evapotranspiration from 2001 to 2009 using three main inputs: (1) Daily spatial interpolation of reference evaporation from meteorological ground stations, (2) yearly maps of land cover, (3) calculation of crop coefficients from satellite data.
An explicit model of the surface water fluxes (demand and supply of irrigation and urban areas) was implemented for fifty subareas considered homogeneous in regard to their water demand and resources. This model was linked to a groundwater model to render both spatial and temporal variations in head charges and allowing the calculation of the ground water balance. The model has been setup and validated for the whole period and undergoes a yearly actualisation. Middle term scenarios (up to 20 years) are now being studied. Some of them are demand-based (reconversion to drip irrigation, artificial recharge of the aquifer), some are supply-based (new dams, increased water transfer), and others have to do with Water Policies

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Earth Observation images help local communities to monitor lake water quality

COMUNITÀ DEL GARDA (GARDA COMMUNITY) IS AN ASSOCIATION THAT BRINGS TOGETHER THE MUNICIPALITIES AND INSTITUTIONS OF LAKE GARDA TO ENSURE PROTECTION, ENHANCEMENT AND DEVELOPMENT OF THE GARDA AREA. PARTICULAR ATTENTION IS FOCUSED ON WATER QUALITY MANAGEMENT AND TOURISM BECAUSE THE QUALITY OF THE LAKE WATER CAN HAVE A GREAT IMPACT ON TOURISM DEVELOPMENT.

Giorgio Passionelli
Head of Lake Garda Community, Lombardy Region

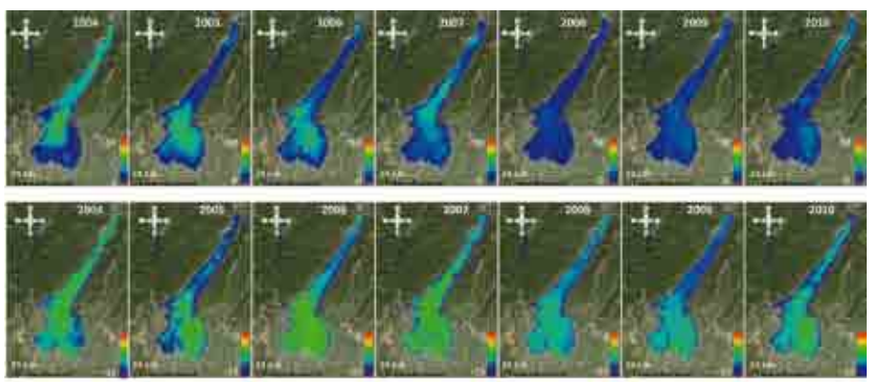
"In order to deal with this problem in the last few years Comunità del Garda has moved towards products obtained by satellite images. This solution was also a good tool for basin management plans for coping with local environmental problems. Thanks to remote sensing techniques we have access to the latest water quality information maps, such as temperature and transparency, and we are able to communicate the environmental status of the area to citizens and tourists in a clear and effective way. And all this at a sustainable costs for our institutions! An example of service derived by satellite images used by the Comunità is the map of macrophyte vegetation in Lake Garda. The use of these aquatic plants as indicators of the ecological water condition is clearly pointed out in the Water Framework Directive. Seasonal concentration maps of these indices or of other important substances, such as chlorophyll, total suspended or dissolved organic matter, are useful for improving resources planning and management."

Giorgio PASSIONELLI

Lake Garda, North-East Italy, is the largest of Italy's fresh-water lakes. Comunità del Garda is active in an area with 70 municipalities and 3 Regions: Veneto, Lombardy and Trentino Alto Adige (NUTS2) and 4 Provinces (NUTS3) (Credits: Comunità del Garda Picture).

GMES WATER QUALITY MAPS FOR LAKE MANAGEMENT

Satellite remote sensing has become a useful tool to monitor lake water quality since the late 1980s.
In the framework of the *EULAKES* (European Lakes under Environmental Stressors) project, funded by Central Europe Programme 2010-2013, multi-temporal and spatial information about the water quality status of the surface euphotic layer of water bodies was obtained through remote sensing techniques. A large data-set of MERIS (*Medium Resolution Imaging Spectrometer*) images provided by ESA (*European Spatial Agency*), was processed using bio-optical models. This allowed the retrieval of chlorophyll, total suspended matter and coloured dissolved organic matter concentration maps as well as transparency maps. Thanks to the spatial and temporal analysis, zones and years considered most vulnerable to local anthropogenic inputs and climate change effects were identified.
The results showed that the highly transparent waters of Garda Lake, (a typical feature of oligotrophic lakes) had maximum chlorophyll concentrations recorded during spring times and maximum total suspended matter concentration values located in the southern part of the eastern basin.
All products can be used inside a specific model built to support decision makers or other bodies dealing with water basin management. This model will provide a list of possible management actions to be carried out within a water quality conservation programme, as well as a list of possible scenarios considering the ongoing climate changes.



Mean annual chlorophyll concentration (mg/m3) (top row) and transparency (m-1) (bottom row) maps for Lake Garda. Each year, six images have been selected in accordance with sampling periods suggested by Water Framework Directive. These maps are produced by IREA CNR starting from MERIS images (ESA), in the context of the EULAKES project (Credits: IREA CNR).

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Academia-Industry collaboration for the development of GMES services

THE BRETAGNE TÉLÉDÉTECTION SCIENTIFIC INTEREST GROUP (BRITTANY REMOTE SENSING – WWW.BRETEL.EU), IS A CENTRE OF EXCELLENCE SPECIALISING IN SPATIAL OBSERVATION FOR MARITIME AND LAND APPLICATIONS. IT PROMOTES THE REGIONALLY SUPPORTED RADAR RECEIVING GROUND STATION PROJECT, VIGISAT (OPERATED BY CLS) AND EMPHASISES THE COLLABORATIONS BETWEEN ACADEMIC RESEARCH TEAMS AND COMPANIES TO FEDERATE A CLUSTER AROUND THE CENTRAL THEME OF REMOTE SENSING WITH A LARGE RANGE OF APPLICATIONS FOR LAND, URBAN AND OCEANS TOPICS.

Professor René GARELLO

"Exploitation of high spatial resolution satellite data is an essential part for much of the research work associated with the understanding of physical phenomena describing our environment. In Brittany, many of these physical interactions are made more complex due to land/sea interactions. As in any other regions, interactions between countryside and cities are also in constant evolution. The synergy of GMES data with other data sources allows us to better understand these phenomena, hence allowing us to make progress on understanding the consequences of climate change. As scientists, we can work towards better planning of socio-economical developments at the regional scale, preventing natural hazards and possibly also in the framework of renewable energy source implementations. This approach will have to be a model for the other regions."

René GARELLO
Professor at Telecom Bretagne, Département Image et Traitement Information
Director of Scientific Interest Group, Bretagne Télédétection (GIS BreTel)

OIL SPILLS DETECTION WITH GMES

Oil pollution is one of the maritime risks that have a significant impact on Brittany. Being able to detect, track and identify the polluters from Space, using a combination of satellite-based radar as well as *in situ* and ground (AIS – Automatic Identification System) data, is at the centre of the user oriented applications developments.
Middle term scenarios (up to 20 years) are now being studied. Some of them are demand-based (reconversion to drip irrigation, artificial recharge of the aquifer), some are supply-based (new dams, increased water transfer), and others have to do with Water Policies

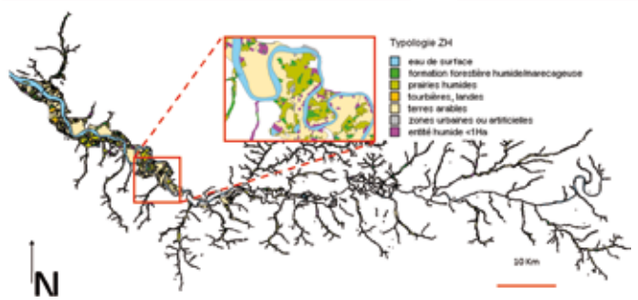
Left : Oil pollution detected by ASAR (Advanced Synthetic Aperture Radar) on-board the ENVISAT satellite. Right: The VIGISAT ground receiving station. Copyright 2011 (Credits: CLS).

GMES SERVING SUSTAINABLE ECOLOGICAL AREA MANAGEMENT

On land issues, the Regional Department for Environment, Territory Development and Housing (DREAL), public authorities, in partnership with the Regions Brittany, Midi Pyrenees, and Aquitaine must formulate a Regional Plan of Ecological Coherence (RPEC). This is a tool of town and country planning to identify ecological reservoirs and corridors (green and blue belt networks) allowing a strong permeability to the movements of wildlife species as well as their obstacles and to propose sustainable measures to protect them.

THE *VIGISAT* PROJECT

The *VIGISAT* project, supported and carried out by the GIS BreTel, is operated by the company CLS (Collecte Localisation Satellites). It focuses on studies of the properties of electromagnetic (EM) waves interacting with the surface and the resulting behaviour of the data in terms of frequency, polarisation, incidence angle, etc. Specific data processing applications associated Synthetic Aperture radar are highly supported by access to a very large number of images. The Geographic Information System (GIS) intends to bring the *VIGISAT radar* receiving ground station into the national (and international) scientific framework programmes. Indeed, most of the GIS BreTel teams are associated with works performed by the network of competence centres or the Regional Spatial Observatories of the French territory. The GIS has resulted in two papers in a NEREUS publication in the framework of the GMES initiative.



Identification of ecological reservoirs and corridors in order to provide durable/sustainable measures to protect wildlife species (Credits: Hubert-Moy, COSTEL – Université Rennes 2).

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GMES Services for better management of subsidy to farmers in EU

THE EU CAP (COMMON AGRICULTURAL POLICY), WHICH DEALS WITH ANNUAL SUBSIDIES TO EUROPEAN FARMERS, REQUIRES A COMPLETE NATIONAL/ REGIONAL GEOGRAPHIC INFORMATION SYSTEM (GIS). THIS IS USED FOR MANAGING AND CONTROLLING THE EU 27 AGRO-ENVIRONMENTS AND THE FUNDING FLOWS FROM THE EUROPEAN COMMISSION TO EACH SINGLE FARMER. A REMOTE SENSING ACQUISITION ALLOWS THE ASSESSMENT OF COMPLIANCE OF THE FARMER REQUESTS AND THE SUBSEQUENT PAYMENT OF SUBSIDIES.

Antonietta De Costanzo (on the right), and the members of OPLO team: Roberta Annoni and Paolo Ottoboni.

RegioneLombardia
Organismo Pagatore Regionale

OPLO (Lombardia Regional Agency for Subsidies in Agriculture)

"To allow mandatory subsidy controls in an objective way, EC's Directorate General for Agriculture has been managing a extensive project since 2003 based on the provision of satellite data to all EU Member States (and / or local Agencies responsible for subsidy) on pre-selected sample sites. In this framework, our Agency, in collaboration with the OPLO (Lombardia Regional Agency for Subsidies in Agriculture) and the other regional agencies of payment, annually use the remote sensing technology and Geo-Information Services (GIS) to manage subsidies. This tool presents a high benefit/cost ratio, also enabling the complete agronomic monitoring of the agro-environment. The methodology we are using has allowed us reduced the time and effort required for the identification of declared parcels, compared to traditional ground surveys. In fact we have an overview of the agronomic land use conditions for all the farms covered by the remote imagery. This Earth Observation-based service also allows us to check at any time and everywhere (web-based) the actual crops present and the farm management undertaken and thus the proper compliance with the EU CAP requirements, essential for the fast payment of subsidies to farmers."

Agea
Agenzia per le Erogazioni in Agricoltura

Antonietta DE COSTANZO
Director of the Lombardia Regional Agency for Subsidies in Agriculture (OPLO) - Regione Lombardia - Italia

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THE REMOTE SENSING CONTROLS IN AGRICULTURE

The payment Agencies created the Integrated Administrative Control System. This was typically based on Remote Sensing data (aerial and satellite), cadastral and topographic maps, annual ground surveys, terrain models, and land cover. It was aimed at maintaining, developing and controlling sustainable agronomic production.
In particular, Italy manages a complete coverage of airborne imagery (0.5 m spatial resolution) every 3 years. This is used for maintaining and updating the Italian Land Parcel Identification System- LPIS: a wall to wall land cover/use map at a reference scale of 1:10,000, with high thematic accuracy.
Satellite data provided by the European Commission's DG AGRI to AGEA, in addition to the airborne data, is annually processed through a robust procedure for providing the national/regional GIS systems with high spatial resolution remote sensing layers, for single small crop/field detection. This is overlaid on administrative boundaries, historical imagery, cadastral, morphology, climate, landscape features, risk maps, hydrologic network, forestry information, etc.
In this way, an independent and spatially distributed control of the farmers' funding request is made possible due to the multispectral capability (useful for crop identification) and the skilled experience of the interpreters. In addition, remote sensing appears to be very useful in monitoring environment parameters (e.g. soil erosion, crop conditions, presence of landscape elements, etc.), with the purpose of safeguarding the rural landscape.
In conclusion, remote sensing services, integrated in a GIS system, provide the user with a very rapid assessment for crop declaration controls, and more generally for any farming management and protection need.

Comparison of satellite images and field situation, the multispectral imagery (in this case false colour infrared) allows crops identification EU/Agea – High spatial resolution satellite image from the Quick Bird system (Credits: AGEA).

Supporting the EU Directive on the sustainable use of pesticides

AT EUROPEAN LEVEL THERE ARE MANY LEGISLATIVE INITIATIVES ENCOURAGING FARMERS TO APPLY SUSTAINABLE FARMING PRACTICES AND REDUCE THE ENVIRONMENTAL IMPACT ON AGRICULTURE.

IN PARTICULAR, THE DIRECTIVE 128/2009 EC ON *THE SUSTAINABLE USE OF PESTICIDES* INCLUDES A SERIES OF ACTIONS OF RISK REDUCTION CONNECTED TO THE IMPACT OF PESTICIDES IN THE AGRO-ECOSYSTEMS AND ON HUMANS.

THE DIRECTIVE REQUIRES MEMBER STATES TO PRODUCE NATIONAL ACTION PLANS THAT INCLUDE APPROPRIATE PESTICIDE RISK MITIGATION MEASURES TO BE APPLIED AT TERRITORIAL SCALE TO REDUCE PESTICIDE EXPOSURE AND TO PRESERVE THE QUALITY OF AQUATIC AND TERRESTRIAL ENVIRONMENTS.

Roberto Colombo, Antonio Finizio
Department of Environmental Sciences - University of Milano Bicocca, Italy

"Images from remote sensing used within Geographical information systems (GIS) are very important for our studies on the environmental impact of pesticides, as they give information concerning its spatial and temporal variability. According to the EU registration scheme, pesticide risk assessments are carried out by using laboratory acute and chronic toxicity data, and by comparing the results with Predicted Environmental Concentrations (PECs), which are calculated by means of fate and exposure models. The use of predictive models provides a tool for assessing the evolution of chemical concentrations due to changes in emission rates and land use. Predictive models are helpful in developing support an information system for managing the territory in agreement with the aims of the Directive on the sustainable use of pesticides. The challenge we face with remote sensing and GIS images is to account for the variability of the environmental parameters (i.e. land use, soil properties, climatic conditions, hydrography), that has in the past been a major problem for the site-specific application of predictive approaches."

Antonio FINIZIO

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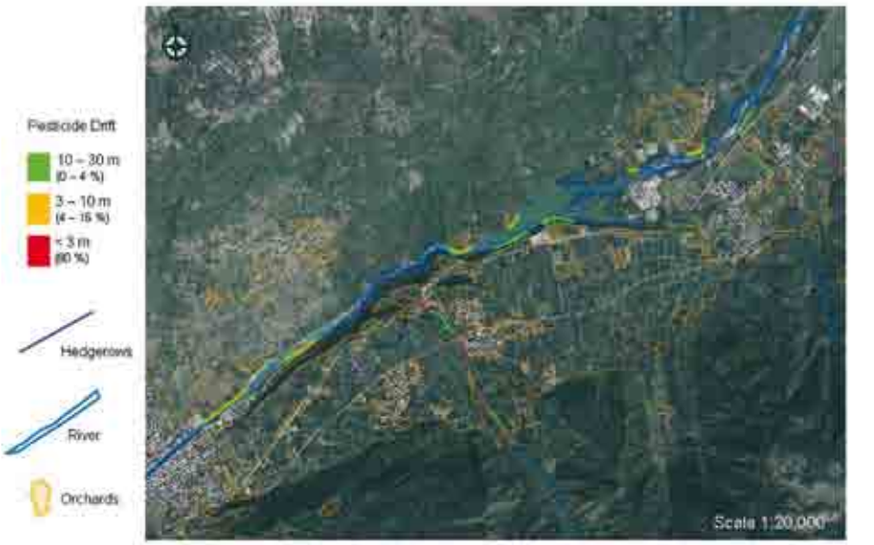
IDENTIFYING WATER BODIES POTENTIALLY EXPOSED TO PESTICIDES DRIFT USING REMOTE SENSING (RS) AND GEOGRAPHIC INFORMATION SYSTEMS (GIS)

Spray drift has been recognised as one of the main routes of pesticide entry to surface waters, leading to unwanted exposure of aquatic organisms. In the last few years, there has been much discussion on the application of risk mitigation measures (buffer zones) to reduce the contamination of water bodies through drift processes, leading to the conclusion that landscape factors should be taken into account when setting appropriate buffer zone distances.

For instance the presence of natural barriers such as hedgerows near water bodies can be an effective barrier capable of reducing drift phenomena. Furthermore, wind speed and prevalent wind direction, flow rate of water course, and size of watercourse can all be important factors influencing the magnitude of drift pesticide exposure of aquatic organisms.

The recent introduction of "*The Sustainable Use of Pesticides*" Directive has enforced the concept of pesticide risk management and of risk mitigation actions at the local scale. In this context, DOW Agroscience, dealing with products for crop protection, has recently funded a project aiming to explore the possibility of using RS technologies to develop a GIS based indicator. Starting from information on land cover and hydrographic networks such indicators could identify the presence at landscape-level of natural occurring active mitigation measures (i.e. hedgerows), or identify stretches of river most at risk of drift exposure and where to implement risk management actions.



Valtellina is an important agricultural area in Lombardia region (Italy), particularly famous for wine and fruit trees productions. For this reason this area was selected for a preliminary application of the indicator. The indicator is based on spatial features such as distance between fruit trees areas and water bodies, presence of hedgerows, buffering, and overlay analysis. An example of the obtained results is reported in the figure (Credits: BICOCCA University).

Electromagnetic sensors for investigating road infrastructures in hydrogeological hazard areas

WITHIN THE FRAMEWORK OF THE 2007-2013 BASILICATA OPERATIONAL REGIONAL PROGRAMME, IN THE CONTEXT OF THE EUROPEAN REGIONAL DEVELOPMENT FUND, THE PROVINCIAL ADMINISTRATION OF POTENZA DEVELOPED A SYSTEM TO MONITOR AREAS AFFECTED BY HYDROGEOLOGICAL HAZARD, INCLUDING PROVINCIAL ROADS. THE SYSTEM, BASED ON THE INTEGRATION OF INNOVATIVE GEOLOGICAL, GEOMORPHOLOGICAL AND GEOPHYSICAL TECHNIQUES, AND WAS IMPLEMENTED BY THE CNR-IMAA AND THE UNIVERSITY OF BASILICATA. THE PRODUCTS OF THIS SYSTEM CAN HELP THE PROVINCIAL ADMINISTRATION OF POTENZA TO DEFINE THE AMOUNT OF ACTIVITY IN AREAS, TO DEEPEN INVESTIGATION DURING SIGNIFICANT RAINFALL EVENTS AND TO PROMPTLY IMPLEMENT ACTIONS NECESSARY TO RESTORE THE TRAFFIC AND ROAD SAFETY, REDUCING TIME AND COSTS OF INTERVENTION.

Mr. Piero LACORAZZA, President of the Province of Potenza, during an inspection to verify the intervention operations on a road affected by instability phenomena.

"Landslides are the most common geomorphological hazard in Italy. Basilicata is the Italian southern region characterised by the highest density of landslides, with more than 27 landslide areas every 100 km^2. This high density is related to clay rich substrates, extreme rainfall events, deforestation, intense urbanisation, and industrialisation. Very often the landslides have affected road infrastructures causing serious damage to the road traffic and the slowdown of economic activity.
Since December 2010, the Provincial Administration of Potenza, in charge of a road network of about 2587 km, has set up a monitoring system useful for the definition of the activity state of the slopes near the provincial roads and the assessment of their degradation state. The monitoring system is based on the systematic integration of geological-geomorphological information and geophysical investigation in a GIS[1] platform.
In this context, an Electrical Resistivity Tomography (ERT) technique and mobile Ground Penetrating Radar (GPR) system, used by CNR-IMAA, proved to be very useful. In particular, ERT provides information about the geometrical characteristics of the landslide and the presence of areas with high water content. The new mobile GPR system, implemented by the CNR-IMAA, gives the possibility to perform periodical monitoring of road conditions for preventive maintenance and to rapidly obtain information about the damage of the roads to optimise planning of repair operations.

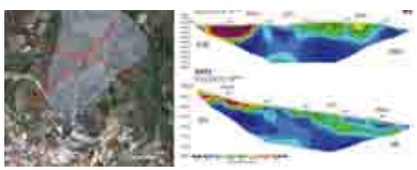
[1] Geographic Information System.

During the first 18 months of the project, many landslides have been geometrically characterised by ERT, providing important information for the planning of the interventions. Furthermore, provincial roads located in very critical areas were scanned by GPR mobile system in order to assess the road surface, base and sub-base courses."

Piero LACORAZZA
(President of Provincial Administration of Potenza)

GPR IDSRIS Hi Pave mobile system. a) antenna suspension system (to the fore); b) Digital Antenna Driver Multichannel Fast Wave; c) example of real-time data acquisition.

GPR survey carried out along the SP12 provincial road in S. Angelo le Fratte town (Basilicata region). a) location of the investigated stretch of road; b) detail of the investigated road; c) raw radargram.



ERT carried out on S. Angelo le Fratte (Basilicata region) landslide. a) Landslide with location of ERT (red lines) and GPR (blue lines) profiles. Yellow lines indicate landslide source areas; b) Transversal and longitudinal ERT.

ELECTROMAGNETIC SENSORS FOR INVESTIGATING ROAD INFRASTRUCTURES IN HYDROGEOLOGICAL HAZARD AREAS

The electromagnetic monitoring system, based on the integration of different techniques provides electrical resistivity tomograms and radargrams. These products can contain specific information about the changes of physical properties of the subsoil after the occurrence of a hydrogeological event.
Electrical resistivity tomograms were carried out in areas affected by recent activity phenomena and previously mapped by aero-photogrammetric analysis. More than 5 landslide areas were studied and information about the sizes of the movement, the depth of sliding surface and the thickness of the slide material were obtained.
Several kilometres of provincial roads were investigated by GPR mobile system obtaining information about the conditions of road surface, base and sub-base courses and highlighting the stretches of the roads for which the repair interventions are very urgent.

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Mapping the potential of roofs for the installation of solar panels using GMES

THE DEMAND FOR INCREASED RENEWABLE ENERGY GENERATION REQUIRES EFFICIENT AND EFFECTIVE TARGETING OF SUITABLE ROOFS. TO OBTAIN THE MAXIMUM BENEFIT FROM A SOLAR ARRAY ON A GIVEN ROOF, THE ROOF MUST MEET CERTAIN PARAMETRIC REQUIREMENTS. THESE INCLUDE THE GEOGRAPHIC LOCATION, PITCH, ASPECT, USABLE ROOF AREA, SHADING AND IRRADIATION. MEASUREMENT OF ALL OF THESE PARAMETERS IS PROBLEMATIC WITHOUT ACCESS TO THE ROOF; GMES CAN PROVIDE AN ACCURATE AND PROVEN SOLUTION.

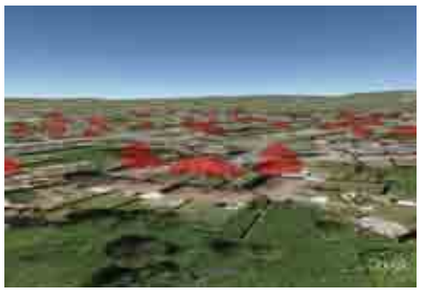
The Kier Group have used Solar Mapping data to identify suitable roofs on their housing stock.

Environment and sustainability consultants Sustain have been using Bluesky's Solar Mapping for 2 years as the basis for their work with Housing Associations and Local Authorities. Coupled with their expertise in assessing the energy saving potential of a range of renewable measures, the Solar Mapping data is proving to be a powerful and predictive tool.

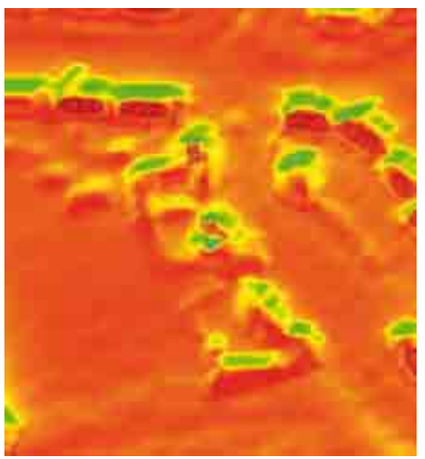
"To date, working with Bluesky, we have calculated the potential solar energy yield of nearly 15,000 properties across the UK. Using the data supplied we are able to calculate the potential yield on a roof by roof basis. This can then be amalgamated into a value for the entire stock. We then work with the individual Housing Association to offer advice on funding options and on procurement, as well as management of the installation programme."

Sustain have especially been impressed by the level of spatial accuracy that Bluesky can achieve which is vital when identifying individual properties. The high levels of accuracy can be attributed to very accurate GPS collection and state of the art airborne planning software.

Antony SCOTT
Senior Associate (GIS and Spatial Data)
Sustain



The usable area of the roof is captured as a 3D polygon. Examples are shown here over a 2D aerial photograph (Credits: Bluesky).



The Solar irradiation values are calculated using PVGIS a widely recognised and accepted metric (Credits: Bluesky).

MEASURING THE SOLAR POTENTIAL OF ROOFS

Bluesky has developed a unique method of generating solar potential maps using a range of remotely sensed datasets including aerial photography and digital terrain models. Photogrammetric techniques (the practice of determining geometric properties of objects from photographic images) are used to accurately determine the size, aspect and gradient of the roofs of individual properties from which it is possible to measure and record factors that contribute to the potential for solar power. The suitability of each roof element is then considered taking into account roof shape and other impediments such as sky lights or dormer windows, as well as potential obstructions such as neighbouring properties or trees. The results are then applied to geo-coded address locations enabling the specific buildings to be targeted.

Using Bluesky's Solar Reports in the field for commercial property.

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Take a deep breath with *Myair* Services

by Thilo Erbertseder

CONSIDERING THE ADVERSE HEALTH EFFECTS OF AIR POLLUTION, MONITORING, ASSESSING AND FORECASTING OF POLLUTANTS FROM GLOBAL TO CITY SCALE IS FUNDAMENTAL TO INCREASE OUR QUALITY OF LIFE. THE *PASODOBLE* GMES SERVICE PROJECT AIMS TO IMPROVE INFORMATION ON AIR QUALITY IN OVER 30 EUROPEAN REGIONS AND CITIES BY DEVELOPING THE *MYAIR* SERVICE PORTFOLIO.

A recent study by the European Topic Centre for Air and Climate Change attributes 492,000 premature deaths per year in Europe to the presence of fine particles in the air. This corresponds to an average reduction of life expectancy by eight months and in some areas by as much as 36 months. This is not surprising since on average we breathe 20 times a minute and the air that we breathe is the most important nutrient of the human body. Following the guidelines of the World Health Organisation (WHO) and many epidemiological studies, it is high time to face up to the fact that there is a direct relationship between human health and air pollution.

In the context of Europe's GMES (Global Monitoring of Environment and Security) programme, the *PASODOBLE* project seeks to provide information and support for regions and cities that are affected by air pollution.

Furthermore, *PASODOBLE* works towards a harmonised European framework for sustainable downstream air quality services. By developing a generic and modular service infrastructure, including ready-to-use tools, intuitive interfaces, simple data access and applied quality management, it will increase the implementation efficiency for new services in the future. In doing so, selected services can easily be implemented for new regions, cities and users. *PASODOBLE* works at local level but also at a broader scale, with, for instance, objective to move towards European harmonisation by integrating and promoting best practice tools.

Health community support

Imagine a severe air pollution episode is building up in a European region. Will the hospitals be prepared? Who will tell the doctors in the right region when to be prepared? Will the pharmacies have relief medication in stock? What can those who are vulnerable do to reduce the likely impact on their health conditions?

In collaboration with the health community, services are being developed to provide appropriate, local and timely information to enable hospitals, pharmacies and doctors to mitigate the potentially harmful effects of air pollution among vulnerable groups. Together with medical specialists, new information products have been developed and are now being used. One such product is the Aggregated Risk Index (ARI), which is based on the relative risk of the increased daily mortality and morbidity, enabling an assessment of additive effects of short-term exposure to the main air pollutants: $PM_{2.5}$[1], PM_{10}[2], SO_2[3], O_3[4] and NO_2[5]. Hence it accounts for multiple exposure impacts of chemical agents. It has been adapted for different pathologies and local prediction models of this health index have been implemented. The ARI enables the communication of health risks, using monitored and forecasted pollutant concentrations, to the health community and the general population to allow them to take proactive steps to reduce the impact on quality of life.

"Assessment of air quality against EC directives makes local air quality forecasting critical for local authorities and city bodies"

In order to improve the flow of information towards the medical community, communication platforms have been implemented to support specialists in

The *Myair* Service Portfolio

At current levels, healthcare costs associated with poor air quality in the EU27 are estimated to reach at least €189 billion/year by 2020.

By combining satellite-based data, *in situ* measurements and modelling, *PASODOBLE* is developing and demonstrating a portfolio of *Myair* Services in 4 thematic areas:

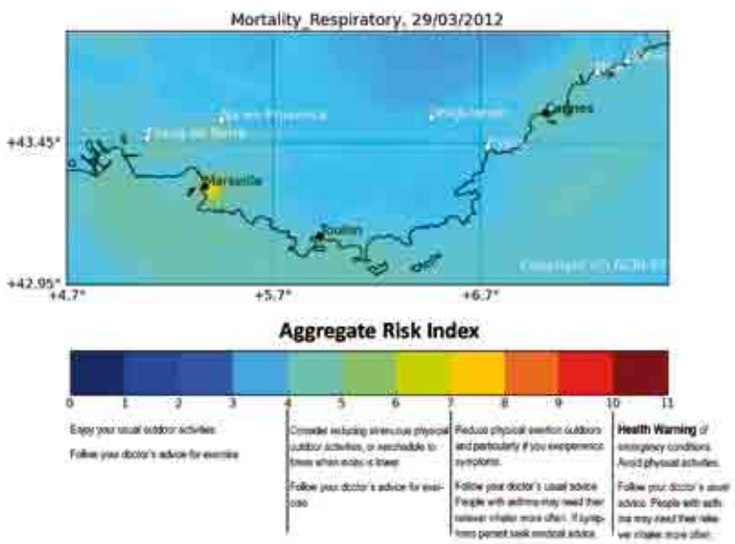
- Health community support for hospitals, pharmacies, doctors and people at risk;
- Public forecasting and assessment support for regions, cities, tourists and sporting events like the Olympic Games in London 2012;
- Compliance monitoring support on particulate matter for regional environmental agencies and governments;
- Local forecast model evaluation support for local authorities and city bodies.

Complementary to the GMES Atmosphere Service *MACC* (Monitoring Atmospheric Composition and Climate) and building on the achievements of the ESA GMES Service Element *PROMOTE*, *PASODOBLE* is developing user-driven and sustainable downstream services in more than 30 regions and cities throughout Europe (www.myair-eu.org). From 2010 to 2013 existing user requirements are being analysed to propose and implement improved service designs for new and continued air quality monitoring, assessment and forecasting services. Through close collaboration with the *MACC* project, *PASODOBLE* links global satellite and modelling capacities with specific local applications according to user needs. In close collaboration with over 50 users in 18 countries, multiple cycles of service demonstration, use and assessment versus requirements are performed.

[1] Particles of air pollutants with a diameter of 2,5 micrometers or less.
[2] Particles of air pollutants measuring 10 micrometers or less.
[3] Sulfur dioxide.
[4] Ozone.
[5] Nitrogen dioxide.

Services are being developed in close collaboration with the health community to provide appropriate, local and timely information to enable hospitals, pharmacies and doctors to mitigate the potentially harmful effects of air pollution among vulnerable groups (Credits: Shutterstock).

the South of France, Greece and the Netherlands in close collaboration with hospitals, pharmacies and emergency networks. In the Provence Alpes Côte d'Azur region in the southeast of France, for example, the combination of intense road traffic and the strong hot season of the Mediterranean climate produces poor air quality, which is known to be one of the worst in Europe. The recognised effects of air pollution on public health include increased risk of hospital admissions and mortality by respiratory or cardiovascular diseases. The combination of these pollution-related health risks with the vulnerability of the elderly and children leads to serious health concerns. To facilitate interactions with the health community and to enable the validation of the ARI, a child cohort study has been integrated in the communicative platform.



To mitigate the potentially harmful effects of air pollution among vulnerable groups, specific services per pathology and age class are provided. The figure shows the forecast of the aggregate risk index for Provence, Alps and Cotes d'Azur on March 29, 2012 tailored for people with respiratory diseases taking into account the risk of mortality (Credits: ACRI-ST).

These services, developed in close collaboration with the Centre Hospitalier Universitaire de Nice and the Papageorgiou Hospital in Thessaloniki, facilitate an increased uptake by the health community, which is currently fostered by dissemination activities of the European Medical Association and its regional associates. In addition, this service area has begun to provide other intuitive information products like discomfort analyses and forecasts for several cities. These developments are fundamental to enable sensitive groups to take precautionary measures and action and therefore to reduce healthcare costs.

Public information and assessment support

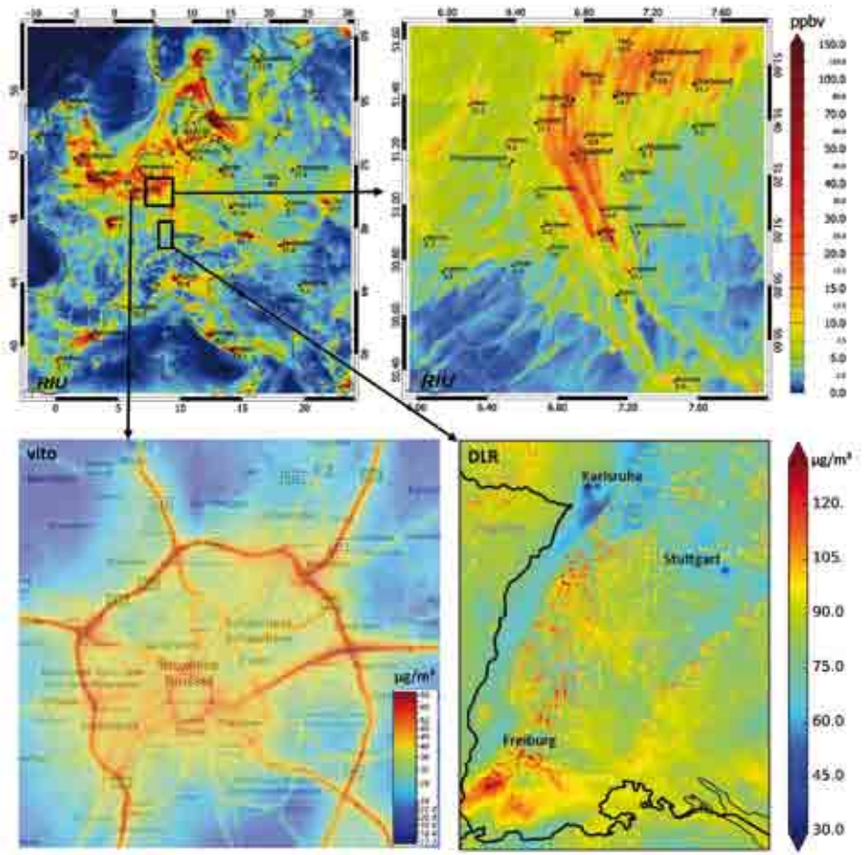
The 2008 Olympic Games in Beijing demonstrated how air pollution can impact on large sporting events and the regional economy. In Europe, legislation demands that the public is informed about air pollution levels. Therefore the service on air quality forecasting and assessment support aims at providing state-of-the-art services at a high spatial resolution. The information services are developed together with stakeholders and are also provided to the public via public bodies and their websites or other dissemination channels. This service area has already developed thematically integrated sub services combining information on air quality, pollen concentration, UV radiation and meteorology. It has been contributing to developments in physical, chemical and biological weather forecasting and turning it into intuitive information. Natural allergen information and integrated allergenic indices for Europe are being delivered. A daily bulletin for London on air quality, temperature, pollen and UV has been published at schools, libraries and leisure centres, etc.

"The World Health Organisation estimates that by reducing illness caused by airborne particulate matter the EU could save up to €29 billion/year"

The developments within for novel air quality services further comprise harbour management support in Antwerp, dynamic road traffic management in the Netherlands, forecasting services for the Olympic Games in London in 2012 with the Health Protection Agency, and improvement of tourism information and navigation systems in the Black Forest by including environmental parameters. Imagine families with children, a cyclist or a hiker planning a day trip. Wouldn't it be perfect to guide them to where the air is cleanest? Planning of outdoor activities can now be optimised by taking into account exposure to air pollution.
The regional services were able to demonstrate the need for high resolution modelling in addition to that undertaken at European scales by the project. An air quality assessment study on human exposure for Brussels shows that in 2005 more than 342,000 citizens were exposed to annual mean nitrogen dioxide concentrations exceeding the European threshold of 40µg/m compared to none when large scale modelling is applied. To capture the strong concentration gradients of NO_2, high spatial and temporal resolution air quality modelling combined with state-of-the-art satellite and observation is needed to accurately estimate human exposure NO_2 is an atmospheric pollutant with adverse health effects that is regulated by the European Air Quality Directive.

Compliance Monitoring Support

Mankind recognised the impact of air pollution early. Even in ancient Rome



Selection of air quality services covering different scales (clockwise, starting top left): Forecast of the daily NO2 maximum for Central Europe (5x5 km) for April 12th, 2012. Same forecast at high resolution (1x1 km) for a densely populated and industrialised are in North Rhine Westphalia. Ozone forecast (2x2 km) in complex orography for the Black Forest, a mountainous tourism region in Germany. Yearly NO2 assessment for Brussels at street level showing that more than 342,000 citizens were exposed to annual mean nitrogen dioxide concentrations exceeding the European threshold of 40µg/m³ in 2005 (Credits: DLR/RIU/VITO).

the Senate approved a law, which prohibited polluting the air. Today, the EU Directive 2008/50/EC on Ambient Air and Clean Air For Europe (CAFÉ) is the legislation that stipulates the need to reduce pollution levels to minimise harmful effects on human health. The directive lays down requirements for compliance monitoring of regulatory pollutants and reporting of exceedances of their respective thresholds.

Imagine a severe exceedance of concentrations of particulate matter (fine particles in the air) is detected by a regional environmental agency. How will they know and verify its source? Is it from local emissions? Advected[6] mineral dust? Neighbouring polluted areas? How do they know the exact spatial extent? What do they report to the European Commission?

[6] Advection is defined as the transfer of a property of the atmosphere, such as heat, cold, or humidity, by the horizontal movement of an air mass

"Satellite-based air quality assessments support the EC's goal of countering reduced life expectancy due to particulate matter in the air"

The service for compliance monitoring support for particulate matter is collaborating with agencies with air quality directive compliance duties with the aim of facilitating their reporting. The first achievements of include the provision of services for the explanation of exceedances whether they are caused by local emissions or advected dust. This service has been introducing satellite data, complementary to ground-based data, to better cover the spatial extent of pollution and has demonstrated positive results in particular for quantifying mineral dust loadings and PM2.5 levels. Work towards source attribution and specification is ongoing. Prototype demonstrations are currently being conducted in North Rhine-Westphalia (Germany), the Canary Islands (Spain), the Netherlands, Emilia Romagna and Lombardy (both in Italy).

A local forecast model evaluation service and toolbox has been developed to support local authorities and city bodies.

Forecasting Evaluation Support

80-90% of urban populations are exposed to particulate matter levels exceeding air quality guidelines of the World Health Organisation (WHO). Assessment of air quality against EC directives makes local air quality forecasting critical for local authorities and city bodies. To facilitate their daily work and to enable an easy in-depth validation, a local forecast model evaluation support service and toolbox has been developed. It sets standard criteria and protocols for performance evaluation, works towards standardised interfaces and aims at supporting accountability/apportionment studies. The service is currently being tested with seven local city authorities and is available from for other users. The evaluation of model output utilises and satellite data and considers evaluation methodologies and guidance of the Forum for Air Quality Modelling in Europe FAIRMODE.

Imagine a city that wants to set up an air quality forecasting and public information system to improve quality of life for their citizens. Will they know how to proceed to get an effective and efficient solution that delivers the best objective measures and values in their specific environmental conditions? This service will support and facilitate the decision-making process.

Harmonisation and sustainability

Not only is developing dedicated services, but also a sustainable generic and modular service infrastructure. Given the large number of local and regional services that are already available, contributes to regional harmonisation regarding INSPIRE (infrastructure for spatial information in Europe) directive compliance, interoperability, quality management and data access.

The first steps towards a consistent European framework for local and

regional air quality services have been made, namely harmonised interfaces and access to input data from Space, measurements, boundary conditions and emissions, simplified nesting approaches, state-of-the-art web interfaces to users including a catalogue compliant with relevant metadata standards and a metadata creation service. A special effort has been undertaken to link the and service components into stable processing chains in terms of consequent nesting approaches using the European air quality forecasting ensemble for boundary conditions. Procedures for business planning and market development are followed up in order to prepare self-supportive and sustainable services.

Quality, interoperability and fitness for purpose

As works towards a European framework and infrastructure for local and regional air quality data and services, the harmonisation of metadata and data specifications is strongly pursued. The objectives are to foster interoperability and traceability of air quality services within and also with other Global Earth Observation System of Systems (GEOSS) -related initiatives, mainly by working on the compliance with INSPIRE metadata implementing rules, INSPIRE data specifications, and internationally agreed data quality frameworks and standards. Therefore, has been registered as an official INSPIRE Spatial Data Interest Community (SDIC) to officially contribute to the drafting process of the implementing rules, recommend appropriate metadata and provide feedback on data specifications with a focus on air quality services. A critical analysis of the current implementation of INSPIRE metadata and their compliance with international references in data quality strategy, namely the GEO-CEOS (Group of Earth Observation – Committee on Earth Observations Satellites) Quality Assurance framework for Earth Observation (QA4EO), standard procedures of the Quality Management Framework of the World Meteorological Organisation (WMO-QMFT), and relevant ISO standards (a legal INSPIRE requirement) is performed. In this framework an air quality service metadata editor is being developed and implemented that is adapted to the INSPIRE metadata editor and augmented with specific requirements of the air quality community. Therefore the compatibility with the atmospheric services provided by is ensured.

Intuitive online tools enable easy information on regional and local air pollutant levels including decision-support, alerting services and validation graphs.

User interface, decision support and air quality management

An online user interface is being developed offering modular tools to access and analyse the data of the air quality services. It comprises a catalogue, a state-of-the-art visualisation tool, automatic online validation, a decision-support system, an air quality management tool optimised for the use with tablet PCs and modules for calculating human exposure as well as data fusion products. To maximise the usability and interoperability the following are implemented: web coverage, web feature and web map services compliant with the Open GIS Consortium (OGC) standards as well as Google Earth and export functionalities for data and metadata. The user interface, the decision-support tool and the air quality management system can be accessed via **www.myair.eu.**

Relevance for Europe

The project is important for Europe since air quality is a trans-national problem with local sources. The project combines local action and work towards European harmonisation, by building a decentralised modular technical infrastructure for air quality services with respect to interoperability, quality assurance, validation and INSPIRE compliance. This will increase the implementation efficiency for new services in new regions in the future. The project will therefore help to increase the competitiveness for European service providers.

The project collaborates with the European Environment Agency, the European Space Agency, the FAIRMODE forum for modelling of air quality in Europe and the (Monitoring Atmospheric Composition and Climate), (Generic European Sustainable Information Space for environment) and projects. Furthermore it considers and contributes to INSPIRE (Infrastructure for Spatial Information in the European Community), SEIS (Shared Environmental Information System) and CAFÉ (Clean Air For Europe).

Impact and conclusion

By raising awareness, reducing health costs and decreasing morbidity, will contribute to improving quality of life and sustainability of welfare. European citizens will benefit from the services since they provide solutions that will mitigate the harm from air pollution by directly reaching residents who are most vulnerable, allowing them to change their behaviour or to be given necessary medical treatment to reduce the impact of air pollution. This will, in the long term, reduce morbidity and mortality.

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Monitoring of soil moisture for irrigation water management in Catalonia

by Antonio Reppucci*

WATER MANAGEMENT FOR IRRIGATION IS AN ESSENTIAL ACTIVITY IN GENERAL BUT ESPECIALLY IN AREAS WHERE WATER IS SCARCE AND IN HIGHLY AGRICULTURAL AREAS. BY DEFINITION, WATER MANAGEMENT REPRESENTS THE USE OF THE APPROPRIATE QUANTITY OF WATER AT THE PROPER TIME AND IT IS USUALLY PURSUED BY COMBINING MEASUREMENTS OF SOIL MOISTURE WITH AN OPTIMISED IRRIGATION PLAN. WHILE THE SECOND ELEMENT IS EASY TO DESIGN IF WATER IS AVAILABLE, HAVING DETAILED SPATIAL INFORMATION ON SOIL MOISTURE IS STILL A CHALLENGE. *IN SITU* MEASUREMENT USING PROBES IS COSTLY AND DOES NOT ALLOW A DENSE ENOUGH SAMPLING OF THE SPATIAL BEHAVIOUR OF A WHOLE REGION. IN THIS CONTEXT, MICROWAVE (RADAR) REMOTE SENSING DATA FROM ACTIVE SENSORS ON EARTH OBSERVATION (EO) SATELLITES HAVE DEMONSTRATED THEIR POTENTIAL TO MEASURE SOIL MOISTURE QUANTITATIVELY ON BARE AND SHORT-VEGETATED SURFACES. THANKS TO THEIR ABILITY TO OPERATE IN ALL WEATHER CONDITIONS AND WIDE COVERAGE, DATA FROM SYNTHETIC APERTURE RADAR (SAR) OFFER THE OPPORTUNITY TO MONITOR LARGE AREAS WITH HIGH SPATIAL RESOLUTION. THE ADVANCED SAR ON THE EUROPEAN SPACE AGENCY'S (ESA) ENVISAT SATELLITE AND OTHER FOLLOW-UP GMES MISSIONS WILL HELP COMMUNITIES THAT SUFFER WATER SCARCITY TO IMPROVE THE MANAGEMENT OF WATER RESOURCES THROUGH THE CONTINUOUS MONITORING OF SOIL MOISTURE FOR MULTIPLE APPLICATIONS. THIS ARTICLE WILL FOCUS ON SOIL MOISTURE MONITORING WITH EO DATA FOR IRRIGATION WATER MANAGEMENT.

Many activities rely on the ability to measuring soil moisture over relatively large areas: crop yield expectation, flood forecast, prediction of local meteorological events, erosion and slope failure forecasting, water reservoir management, etc. Sectors such as agriculture, biological and environmental monitoring, local meteorology, geology and hydrology demand reliable soil moisture information to properly carry out their activities.

Before the development of remote sensing / Earth Observation (EO) techniques, soil moisture was mainly measured by means of ground surveys using specially designed sensors. However, the use of *in situ* point measurements might not be appropriate to represent the spatial and temporal behaviour of soil moisture. It can also be costly in terms of deployment and maintenance, hence reducing the range of applications that can benefit from such important geophysical information.

EO data have been demonstrated to be a useful source of information. The choice of the type of sensor depends on the application. In the case of water management for irrigation, the most suitable types of instruments record microwave (Radar) radiation and are presented by Synthetic Aperture Radars (SARs), which give high spatial resolution, large area coverage and night/day/all weather acquisition capabilities.

The results presented hereafter have been achieved in the framework of the *AGORA* project, partially funded by the regional government of Catalonia, which aims to study the benefits of assimilating EO data into a hydrological model for water predictions. One of the objectives of this project is to study the viability of producing maps of surface soil moisture for the Catalonia area. During its two-year duration, the partners involved in the project have worked on different issues concerning the operational retrieval of soil moisture information using SAR images.

The soil moisture maps generated from SAR data can be used by governmental agencies that manage water distribution or by the every farmer to schedule the irrigation of their fields in a more efficient way. The information contained in these maps could be an input for intelligent irrigation algorithms in the field of smart agriculture.

How Earth Observation data can help monitoring soil moisture

Scientific investigation on the analysis of soil moisture using satellite sensors has a long history: it began with the availability of the first satellite images. Research has been done using different sensors, spanning different parts of the measured electromagnetic spectrum, leading to several methodologies to estimate soil moisture content. All the algorithms developed are based on the inversion of models, of analytical or empirical nature, that relate variables measurable by satellite sensors to near-surface soil moisture. Depending on the sensor employed to image the Earth's surface, different spatial and temporal resolutions can be achieved, thus the selection of the appropriate sensor will

Improving Water Management

The monitoring of soil moisture variability is of utmost importance, especially in areas where water resources are scarce. Soil moisture is important as a prime parameter for the surface hydrological cycle. Water storage in soil, either in the surface layer or in deeper levels, affects not only the vapour transpiration, but also the heat storage capability of the soil, its thermal conductivity, and the partitioning of energy between latent and sensible heat fluxes. In addition, surface layer volumetric soil moisture direct evaporation determines the possibility of surface run-off after rainfalls.

The degree of soil moisture is an important factor to move towards sustainable agriculture, it affects, for instance, the run-off of water and fertilisers.

* This work was conducted together with Erwan Motte and Xavier Banqué from Starlab.

be related to the type of monitoring that is being pursued.

"Soil Moisture maps can be used by governmental agencies managing water distribution or by farmers"

Optical sensors are remote sensing instruments that can acquire data in several bands of the optical and near infrared part of the spectrum. The variable that is possible to measure with this type of instrument is the spectral reflectance, i.e. the ratio of reflected energy to incident energy as a function of wavelength. This quantity can be directly related to surface soil moisture, although soil reflectance is influenced also by other variables, such as soil roughness, texture and plant cover, which can lead to a wide variation in the measurements for a constant value of soil moisture. A more robust methodology makes use of combined information from the optical and infrared part of the spectrum. A major drawback of optical instruments is the impact of atmospheric conditions and the need for the sun as a source of illumination.

Microwave sensors acquire measurements in the frequency range from 0.3GHz to 300GHZ (i.e. a wavelength that spans from 1m to 1mm). There are two main types of such instruments: passive and active. Passive microwave sensors or radiometers measure the radiation emitted by the Earth's surface in the field of view of the instrument. Active microwave sensors or radars send out pulses of electromagnetic radiation and measure the amount that is backscattered in the direction of the sensor. Over land, the emitted radiation is mainly dependent on soil temperature and its dielectric properties, the latter being directly influenced by soil moisture. Although radiometers do not require solar illumination and the atmosphere has a small impact on the measured signal, the resolution of such instruments is in the order of several kilometres making them useful only for studies on the global scale, and therefore not suitable for irrigation water management applications.

The backscatter data recorded by microwave radars (Scatterometer, SAR) are also sensitive to changes in soil moisture among other parameters. Having their own source of illumination, such sensors can acquire data at night and day and in presence of cloud coverage. Scatterometers, with a spatial resolution of several kilometres, have been used with success for studies on the global scale, while SARs, with a spatial resolution that can be as small as a few meters, is suitable for studies on the local scale.

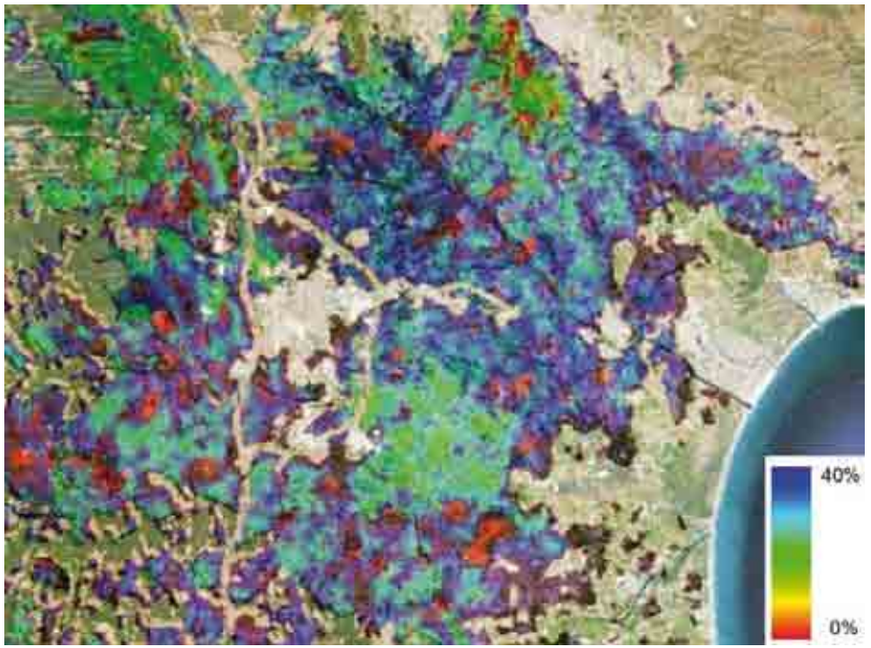
The methodologies developed for the estimation of soil moisture from active microwave sensors are based on the following idea: the microwave radiation backscattered from sparsely vegetated surfaces is related to dielectric [1] properties of the illuminated area, surface characteristics (roughness, topographic conditions) and instrument characteristics. The soil's dielectric constant is highly dependent on soil moisture; typical dielectric constant of dry soil is around three while the one of water is eighty. Theoretical models (e.g. small perturbation model, geometric optics model) are able to represent the backscattering variations due to changes in soil moisture content, surface roughness and vegetation attenuation. However, from an operational point of view, these models cannot be employed due to the restrictive assumptions made when building them. Therefore, empirical models may be more useful and robust to estimate soil moisture operationally from SAR data.

[1] A dielectric material is a substance that is a poor conductor of electricity, but an efficient supporter of electrostatic fields.

The area used for the calibration of the algorithm, which extends for about 20 km x 20 km, is located in the North-East of Catalonia (Alt Empordà); red dots represent the field sampled during the surveys (Credits: Google Earth).

The approach chosen for the measurement of soil moisture in the Mediterranean area of Catalonia is based on the calibration of a semi-empirical algorithm [1]. The calibration attempts to optimise the model to take into account the specificities of the vegetation cover in the area of interest. The soil moisture retrieval method is a two-step process. First the conversion of the measured backscattered signal to dielectric constant is accomplished. This is done using a semi-empirically derived relationship between the measured backscattered signal and the dielectric constant.

In a second step, the conversion from dielectric constant to soil moisture is performed. For this purpose a dielectric mixing model is used. The employed algorithm was originally developed and validated over an area located in central Europe where the main vegetation types were fields planted with cereals, grassland, root crops or covered by bare soil. As soil and vegetation characteristics vary when moving between different regions, a calibration of the algorithm was needed to take into account the vegetation type specific of the area of study. For this purpose a series of ground campaigns were planned in the framework of the project. Ground data were also used to validate the developed algorithm.



Soil moisture map generated from an image taken with the ASAR sensor on ESA's satellite ENVISAT acquired on September 3rd, 2011 over the area of study. Values are given according to the volume percentage of water (Credits: Starlab).

The area selected for the soil moisture survey is located at the most north-eastern corner of the Iberian Peninsula. Its natural boundaries are the Pyrenees, the Mediterranean Sea, and the plains of the Empordà that joins it with the Baix Empordà and the area of Alta Garrotxa. The landscape consists of a great alluvial plain furrowed by the Muga and the Fluvià rivers. The campaigns were carried out on 24 fields distributed throughout an area of about 20 km x 20 km.
The most common crops present in Catalonia (wheat, oat, alfalfa, ray-grass, root crops, olive groves) were chosen as a reference. Soil and plant samples were taken by triplicate at each site.
The EO-based soil moisture measurements relate to the first few centimetres of the ground (about 5 cm using the C-band SAR data from ESA satellites).

In Fig. 2, an example of a soil moisture map generated using an image acquired by the ESA satellite ENVISAT with the ASAR sensor is shown.

The results have been compared to ground measurements acquired during several *in situ* campaigns, showing that SAR data are able to estimate surface soil moisture with a root mean square error that can vary between 5% and 10% (volumetric units), depending on the type of vegetation cover. Once the algorithm has been calibrated for the area of interest, maps of soil moisture with a resolution of 150 m x 150 m can be produced with a repetition time of some days, depending on the latitude. When the planned GMES Sentinel constellation is operational, the frequency of data acquisition will be between one and three days over Europe and Canada.

Soil moisture maps generated from SAR data can be used to monitor the evolution of soil moisture conditions at a regional scale with high spatial resolution. This is particularly interesting for an application such as water management for irrigation where the knowledge of the fine scale distribution of the soil water content would allow detecting sensitive areas precisely. Moreover, such a product could bring improvements in the accuracy of numerical model forecasting, through assimilation.

The results obtained in the first phase of the project have paved the way to study the development of an innovative forecasting model based on computational intelligence techniques and the retrieval of soil moisture from Earth Observation, *in situ* measurements, and weather prediction data, which will provide forecasting irrigation assessments to the final service users.

Conclusions

The results of this study have confirmed that retrieval of soil moisture using C-band SAR data is feasible over surfaces with sparse vegetation and having highlighted the importance of correctly accounting for the local vegetation type and characteristics. High spatial resolution maps of surface soil moisture could be of great interest to monitor droughts and to control vegetation growth especially in areas that suffer from water scarcity.
To further improve the results and the robustness of the approach employed, the potential of combining SAR measurements with a limited number of *in situ* measurements is being studied. This could allow a dynamic calibration of the retrieval algorithm in real-time to continuously produce more and more accurate results. The outputs from such a combined approach could be of great interest for many applications where continuous knowledge of soil moisture is a key parameter.

Reference

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Antonio REPPUCCI received his Laurea degree (five-year legal course of study) in Nautical Sciences at the Università degli Studi di Napoli 'Parthenope', in Naples, Italy, in 2004. From September 2004 to April 2005 he worked as a post-graduate research assistant at the Remote Sensing Research Laboratory of the University of Naples 'Parthenophe'. In May 2005 he joined the Remote Sensing Technology Institute (IMF) at the German Aerospace Center (DLR) as a PhD student. Since September 2008 he has been working at Starlab as a researcher in the field of Earth Observation.

MS.MONINA – Monitoring *NATURA 2000* Habitats of European Community Interest at the local, regional and continental scales

by Stefan Lang, Geoff Smith and Jeroen Vanden Borre

A MULTI-SCALE MAPPING SERVICE EXPLOITS THE POTENTIAL OF GMES FOR THE MONITORING OF EUROPEAN PROTECTED HABITATS AND SPECIES AT THE LOCAL, REGIONAL AND CONTINENTAL SCALES.

Biodiversity, as the 'diversity of life', i.e. the variety and variability among living organisms and habitats, is key to the integrity of any given ecosystem, but it has been under ever increasing pressure since the advent and spread of humanity to all parts of the globe. This period of human expansion is know as the Holocene Extinction and has seen ongoing biodiversity reductions, primarily through habitat destruction and degradation. The UN Convention on Biological Diversity (CBD), signed at the 1992 Earth Summit in Rio de Janeiro, was the first legally binding agreement in international law to recognise the conservation of biodiversity as a concern common to all mankind. The CBD covers all species and genetic resources, sets out a philosophy of sustainable use of this finite resource and ensures that, whilst ecosystems can and must be used for the benefit of humans, the long-term decline of biodiversity will not be allowed to continue unchecked. *NATURA 2000*, the European response to the challenges of the CBD, is one of the success stories among pan-European initiatives, and one of the world's most effective legal instruments concerning biodiversity and nature conservation (cf. Natura 2000 box).

Biodiversity loss and man-made activities are connected. NATURA 2000 is the largest network of protected areas in the world and the EU is committed to the protection of biodiversity, and to halting biodiversity loss within the EU by 2020. (Credits: Chris Harshaw).

Observing and managing natural habitats

NATURA 2000 has established a network of protected / designated sites across Europe and its territorial waters which require detailed monitoring of their habitat types and condition and standardised reporting every six years by Member States.

The reports from the sites, provided by local and regional authorities, are combined for assessment at the European scale, enabling the EU to keep track of the efficacy of the Habitats and Birds Directives and adjust policy where necessary. The variation in the types of sites present in the network, their constituent habitats and their varied management and monitoring practices means that the integration of the reported information at the EU level can be quite challenging. For these reasons, an objective, operational, transferable and economically priced monitoring solution is required, which can be applied consistently across Europe. This solution should ideally build on integrated approaches and incorporate recent technological achievements particularly in geographic information science and Earth Observation (EO).

"An objective, operational, transferable and economically-priced Earth Observation-based monitoring solution is required, which can be applied consistently across Europe"

Within the European Commission's Seventh Framework Programme, as part of theme dedicated to 'Space', a Global Monitoring for Environment and Security (GMES) project has been funded to address these monitoring needs. The 'Multi-scale Service for Monitoring *NATURA 2000* Habitats of European Community Interest (*MS. MONINA*) project is designed to develop new EO–based services for the cost-effective collection of information

at different scales across the *NATURA 2000* network and beyond.
The *MS.MONINA* partners (see Project box) represent a broad spectrum of local and regional users, service providers and research institutions with relevant backgrounds in experimental habitat mapping, the development and implementation of operational monitoring systems and experience in site, state and EU-based reporting. The *MS.MONINA* design applies integrated mapping approaches from the local to regional to European levels and addresses the reporting, monitoring and management needs of stakeholders at three scales: the individual local site, the Member State, and the EU. The 'multi-scale' concept of the project addresses not only the hierarchical implementation scheme of *NATURA 2000*, but also reflects the notion of hierarchically organised ecological systems.

As has been demonstrated in earlier initiatives and current activity, the demands of Member State or EU level monitoring require much more than just compiling data from the respective lower levels: Member State reports need to provide an extended view on the status of biodiversity on their entire territory, not just within the protected sites. Similarly, EU level monitoring needs to take into account the great natural variability between Europe's biogeographical regions to provide meaningful conclusions for policy. To bridge the gap from site level monitoring to information relevant to Member States or EU levels, advanced up-scaling methods will be employed which see the individual sites in a wider landscape and biogeographical context. Additional tools and information, such as potential habitat modelling techniques and the use of generic interpretation support layers, will improve the approach. These tools will be combined with advanced analysis of satellite data at different spatial resolutions, again mimicking the ecological processes that occur at different scales in the environment, to give the final results within a State Image Analyser Tool. The Member State and EU level activity will focus on key habitats within four biogeographical regions (Atlantic, Continental, Alpine and Mediterranean). It will also look both within and outside the protected sites to give an indication of the efficacy of legislation.

"*MS.MONINA* also addresses the reporting, monitoring and management needs of individual sites"

The added value of Earth Observation

At the local site level, remote sensing and image analysis is becoming a powerful and versatile tool to meet the monitoring needs of *NATURA 2000*, with clear advantages over traditional, field-based methods. Recent advances in image acquisition technology along with increasing spatial and spectral resolution (e.g. the WorldView II satellite system with 0.5 m resolution and 8 spectral bands) have broadened the scope and detail of what can be measured remotely. Hyperspectral imaging offers detailed spectral information for the identification of certain plant species and the characterisation of vegetation condition. Laser scanning technologies record the three-dimensional structure of vegetation, giving information on canopy height and density, and allowing consequent subdivision of woody vegetation types. Advances in image analysis (such as segmentation and object-based approaches) have further enhanced the potential for applying this technology to the subtle and complex habitat distributions within protected sites. Remote sensing delivers a spatially exhaustive and consistent view of the Earth's surface over larger areas giving full-coverage measurements of quantitative data at high sampling densities. It is also non-intrusive for areas sensitive to disturbance, or inaccessible for other reasons. By contrast, fieldwork can only deliver similar information through exhaustive point sampling and subsequent spatial interpolation.

The remote sensing technology also brings the potential for frequently repeated measurements, and faster information extraction processes allow for more frequent map and product updates, thereby resulting in more intensive monitoring. Unlike in most large-scale fieldwork campaigns, where a mapping typology is usually necessarily defined in advance, the data acquisition process of remote sensing does not require any *a priori* interpretation. This allows for more flexibility of information extraction, while at the same time promoting improved documenting and repeatability of the applied analyses. For some areas the existence of image archives dating back several years or even decades may also enable a retrospective evaluation of changes that have occurred to date.

"At local level, remote sensing and image analysis offer clear advantages over traditional field-based methods"

The project has selected a range of representative sites within the biogeographical regions used at the MS and EU level to develop and demonstrate patch level monitoring.

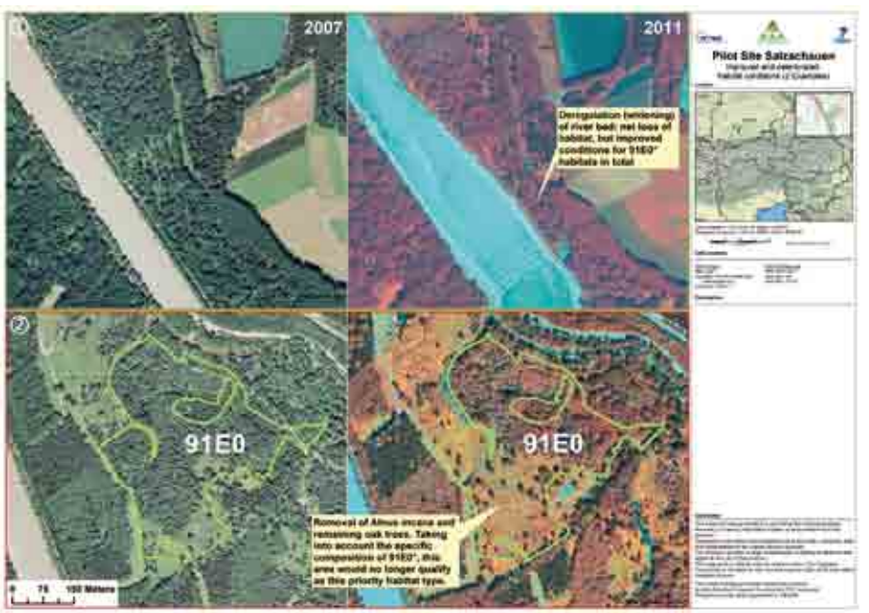

Figure 1: Example products from the pilot site at Salzachauen, Austria with 'zoom' to critical changes in habitat conditions (Credits: PLUS/Z_GIS; orthophoto: Federal state of Salzburg; habitat delineation: Revital; figure composition: T. Strasser).

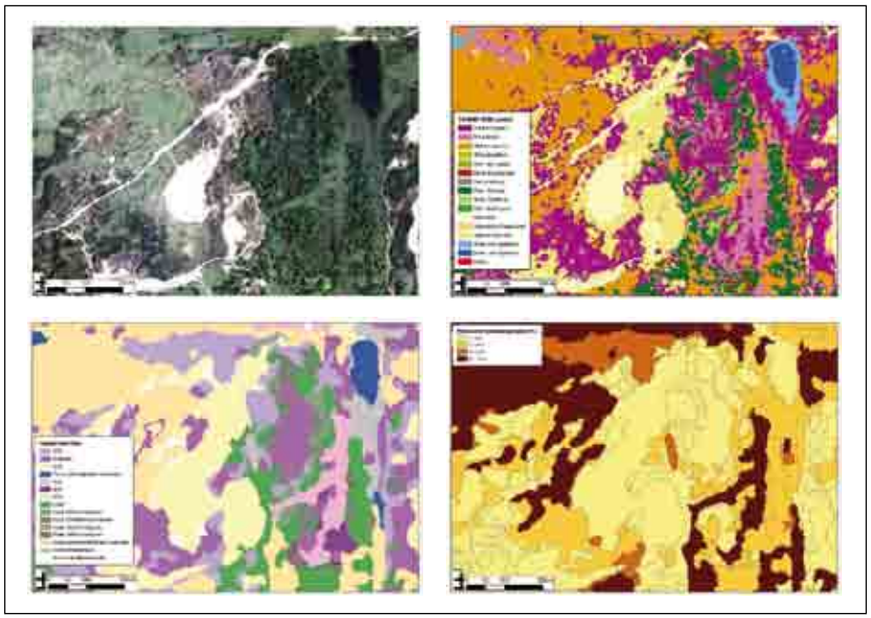

Figure 2: Examples from Kalmthoutse Heide, June 2nd, 2007. Higher left map: True-colour mosaic of AHS-160 image for study area. Higher right map: Vegetation cover map. Lower left map: Habitat map. Lower right map: Cover of Purple moorgrass Molinia caerulea (in percentage classes) per habitat patch (Credits: HABISTAT project; VITO – INBO – UA – BELSPO).

Figure 1 gives two landscape change examples from the *NATURA 2000* site "Salzachauen" in Austria, an important area of riparian forest habitat dominated by alder and ash with other wetland habitats in the Alpine zone. In the first change, the river has been widened with a subsequent loss of habitat and in the second the habitat composition has been changed by the removal of certain tree species resulting in a change of habitat type that will require re-mapping. These types of habitat changes, in terms of both extent and composition, need to be monitored as part of the *NATURA 2000* regulations.

In the Atlantic zone, De Zoom–Kalmthoutse Heide is a cross-border nature reserve along the Belgian-Dutch border giving a good example of the types of sites where consistent pan-European monitoring approaches would be helpful to both local and regional users. The Kalmthoutse Heide is a varied and complex site with many pools, heathland, inland dunes and forests. The management of the area is also complex with several national and local authorities, nature conservation NGOs as well as large and small private owners responsible for the area.

Figure 2 a-d shows the types of products that can be developed for a site. These products, produced as part of the *Habistat* project, demonstrate the implementation of tools to derive vegetation patches, habitat patches and indicators from remote sensing data. These types of products and services are developed and tested at a varied set of sites across Europe to assess the transferability of the approach.

Involving the Users

The work that *MS.MONINA* draws together, and the developments during the project, will result in a rich set of analysis tools and example implementations that are starting to be appreciated within the end user community. To further support technology sharing and exploitation of the results the project is developing a tool repository or body of knowledge (BoK) to capture what has been done and provide a simple and flexible interface for those looking for a solution to a monitoring requirement. The BoK takes the form of a web application where project partners can post their tools and results and where users can search the tools by means of a range of key attributes such as output products and input data prerequisites. The BoK is continuously extended in response to user requirements and feedback during the project and could gain additional functionality such as the on-line validation of a user's input datasets and the provision of some of the tools as 'software as a service' over the Internet.

The project has a dedicated user engagement programme which supports the focused development of the monitoring tools and other activities at the three spatial scales. The project includes users from the selected test sites as project partners so that they are fully integrated into the development process. This facilitates the uptake of the project's outputs by the broad and multi-level user community associated with the *NATURA 2000* network and ensure cost effectiveness in the exploitation of the results. So far this work has questioned a broad range of users both inside and outside the project and is already beginning to produce some key messages in response to monitoring requirements at different

NATURA 2000

NATURA 2000 is a EU-wide network of designated 'sites of community interest', each of which representing high value natural conservation areas rich in biodiversity. It was established under the Habitats Directive (Council Directive 92/43/EC), which designates Special Areas of Conservation (SACs) and complements the earlier Birds Directive (original Council Directive 79/409/EEC, now codified directive 2009/147/EC), which designates Special Protection Areas (SPAs). Both Directives together constitute a flagship policy for the EU, which will hopefully be held up in future as an example of how to achieve conservation goals over large biogeographical regions. The network of SACs and SPAs currently covers over 25,000 sites, representing around 17.6 % of the total terrestrial area of the EU. *NATURA 2000* sites are home to many of Europe's rarest and most threatened habitats and species. The sites range from specific locations to national parks covering thousands of hectares.

Targets for the network are tough, with a planned 100 per cent increase by 2020 in the number of habitat assessments showing an improved conservation status (COM (2011) 244 final of the European Commission). Reaching these ambitious goals will require extensive knowledge based on systematic and continued data collection; however, many Member States are still lacking the ability to provide such information in a regular and routine fashion.

Project details

Duration: 36 months. Partners: Coordinator - Paris-Lodron-Universität Salzburg, Centre for Geoinformatics Z_GIS (AT), IRSTEA (FR), Flemish Institute for Technological Research (BE), National Observatory of Athens / Institute for Space Applications and Remote Sensing (GR), EURAC Research - Institute for Applied Remote Sensing (IT), Rheinische Friedrich-Wilhelms-Universität (DE), Instytut Geodezji i Kartografii (PL), Berlin Institute of Technology (DE), University of Málaga, European Topic Centre for Spatial Information and Analysis (ES), EFTAS Fernerkundung Technologietransfer GmbH (DE), eoVision GmbH (AT), Specto Natura Ltd. (UK), Luftbild Umwelt Planung GmbH (DE), Research Institute for Nature and Forest (BE), Regional Conservatory for Natural Areas Languedoc – Roussillon (FR), State Agency for Agriculture, Environment and Rural Areas of the State of Schleswig-Holstein (DE), Goulandris Natural History Museum (GR).

A service for the Research Institute for Nature and Forest (INBO), in Flanders, Belgium

The Research Institute for Nature and Forest (INBO) is a scientific institute of the Flemish Government in Belgium. It is responsible for the monitoring of the state of nature in Flanders, including the reporting to the EU. Flanders is one of the most densely populated regions in Europe, resulting in high anthropogenic pressures on the environment, and high fragmentation of the remaining natural areas. The distribution of its *NATURA 2000* habitats and other biotopes of high biodiversity value has been mapped in the field in great detail over the past 12 years, but information on habitat quality ('structures & functions') is still largely lacking. Moreover, such maps are rapidly outdated, and updating using field campaigns is no longer evident, due to the high costs.

INBO expects *MS.MONINA* to put in place a service that will enable regular updating of habitat maps, hence allowing more reliable trend assessments of habitat areas and ranges. Furthermore the service should provide a better view on habitat quality in selected *NATURA 2000* sites (including areas with difficult accessibility such as military zones), and identify likely causes of further deterioration. Such information will greatly facilitate the process of policy evaluation at the Flemish level, and habitat status reporting towards the European Commission.

scales and the current technical bottlenecks. These messages are important to *MS.MONINA*, GMES and the wider environmental sector and continue to be analysed during the project.

A particular message received from users is the availability of EO data in a suitable format for integration into their existing business systems. *MS.MONINA* has noted this through the previous activity of partners and has therefore adopted both direct data purchases and engagement with the GMES Space Component Data Access (GSCDA) or Data Warehouse to deliver the project's requirements. The GMES Data Warehouse is an important new opportunity for users of EO-based services as it offers both generic acquisitions to support detailed habitat mapping across Europe and targeted acquisitions to address the specific requirements of *MS.MONINA*.

Final Remarks

MS.MONINA develops and promotes the services, tools and interfaces shown here that are found to provide significant added value for local and regional stakeholders, Member States and European institutions. By providing essential (and currently often missing) spatially explicit information, the project strengthens the strategic role of *NATURA 2000* to support Europe's environmental commitments. Beyond EU territory, it also has a global impact by contributing to the implementation and verification of the Community environmental policies, national regulations and international conventions.

Ultimately, the project strives to install EO technology as a key element in the monitoring routines for sites and landscapes that harbour threatened habitats in Europe and beyond.

Stefan LANG is Deputy Director of the Centre for Geoinformatics (Z_GIS) at Salzburg University and active in the fields of advanced geo-spatial image analysis, EO-based monitoring and spatial indicator development. Within GMES, Z_GIS focuses on the design, optimisation, and user validation of service concepts in both environment and security related application domains.

Geoff SMITH is an Earth Observation consultant with experience of land cover and habitat mapping at site and national levels. Specto Natura Limited is involved in a number of projects to develop and promote the use of EO and GMES products and services in the land domain.

Jeroen VANDEN BORRE is a biologist with experience in evolutionary ecology, vegetation mapping, and nature and forest management planning. At the Belgium Research Institute for Nature and Forest, he is involved in setting up a monitoring scheme for NATURA 2000 habitats in Flanders, in which he is responsible for outlining and evaluating the potential contribution of remote sensing in this field.

From Space to species: Solutions for biodiversity monitoring

by By Palma Blonda, Richard Lucas and João Pradinho Honrado – on behalf of *BIO_SOS* consortium

ACROSS A RANGE OF SCALES, NATURA 2000 SITES WHICH HAVE BEEN DESIGNATED FOR PROTECTING BIODIVERSITY AND ECOSYSTEMS ARE STILL THREATENED BY HUMAN ACTIVITIES, SUCH AS LOGGING, MINING, POACHING, AGRICULTURAL INTENSIFICATION, CONTAMINATION, INFRASTRUCTURE DEVELOPMENT FOR TOURISM AND SPILLAGE OF WASTES. WHILST SUCH EVENTS AND PROCESSES MAY OCCUR WITHIN THE BOUNDARY OF PROTECTED SITES, OFTEN THEY TAKE PLACE IN THE SURROUNDING LANDSCAPE AND PARTICULARLY WHERE URBAN AREAS AGRICULTURE OR TOURISTIC SITES ARE IN CLOSE PROXIMITY. THE CUMULATIVE EFFECT OF SUCH ACTIVITIES THROUGH TIME CAN EVENTUALLY LEAD TO HABITAT LOSS, DEGRADATION AND FRAGMENTATION. IN THE PAST, SUCH CHANGES HAVE RARELY BEEN MONITORED EFFECTIVELY OR ROUTINELY.

The recent provision of very high spatial resolution (< 4 m) remotely sensed data and automatic classification techniques has provided a unique opportunity for periodic and automated mapping of land surfaces and habitats and their changes over time. Whilst such monitoring may be undertaken externally, this capability will benefit local and regional authorities by providing timely information on pressures and impacts, allowing them to take appropriate action. The data and techniques will also contribute to national and international reporting requirements.

What was the need from end users?

In the European Union (EU), the Habitats Directive (92/43/EEC) and the Birds Directive (79/409/EEC) oblige Member States to report on the conservation status of species and habitats of European importance every six years and trends in status during the intervening period. However, as reported by the European Topic Centre on Biodiversity, data on species and especially habitats are collected in different ways, are unavailable, or are insufficient in their spatial coverage. For these reasons, the development of a uniform observation system that can be easily used by all Member States for reporting obligations and defining management strategies (either strategic or operational) is very important. This is particularly the case in Mediterranean countries, which typically lack long-term baseline data for assessing changes and evaluating biodiversity indicator trends. This is because there are few volunteer groups for observing biodiversity on the ground and the staff of nature protection agencies is relatively small and often not well equipped for the tasks they have to do.

"Innovative planning activity at a local level must try to modify a static municipal planning system into a dynamic planning system"

User requirements are varied but common requirements are as follows:

- Long-term baseline data (e.g., thematic maps at 1:5,000 scale or finer) of land covers types and habitats as well as new automatic, standardised, rapid and cost-effective monitoring techniques. These are needed to meet commitments, define management policies and assess the impacts of existing policy;
- A means of reducing costs, mainly related to in-field campaigns;
- Methods for assessing the significance of measured land cover changes and evaluating trends;
- Modelling techniques for evaluating the combined impact that different drivers affecting soils and/or vegetation may have on biodiversity over time.

Habitat maps, which are at the base of biodiversity indicators extraction, can be obtained by interpreting land cover maps of sufficient detail, with these often generated with EO-derived products and ancillary data. The *BIO_SOS* classification system has adopted the Food and Agriculture (FAO) Land Cover Classification System (LCCS) scheme and taxonomy for class identification because of its more generic approach. The scheme is also more suitable than CORINE as the land cover categories can be more readily translated to habitat categories, which better describe (semi)-natural systems (Tomaselli et al. 2012). Once mapped, a key component is to translate the land cover classes to habitat categories, as these are often needed for conservation efforts.
The use of General Habitat Categories (GHCs) was highlighted as a means of consistently and efficiently defining habitats in the previous *BioHab* and *Ebone* projects (Bunce et al., 2008, 2011). GHCs were proposed as they provided an exhaustive typology of habitat types that can be found in any terrestrial landscape around the globe, from natural ecosystems to urban areas, and from sparsely vegetated areas to multi-layered tropical forests (Bunce et al. 2011). GHCs also hold a close relation to other habitat classifications and particularly the Habitats Directive Annex I classification, which is of central importance for international reporting and Natura 2000 management (Bunce et al. 2012). Finally, as they describe landscapes in terms of habitat mosaics, the GHC mapping and recording methodology was also effective in describing and predicting the distribution of species and biodiversity, thereby contributing to the assessment of international sets of indicators while at the same time supporting the local management of endangered species and priority habitats.

Once generated, these maps can be updated over time to detect change, thereby supporting management options (either strategic or operational) and reporting of obligations under the Habitat Directive for management of Natura 2000 sites.

Figure 1. BIO_SOS *Consortium: field visit of the Dutch site. The article is dedicated to the great scientist and friend to* BIO_SOS *colleagues, Professor Maria Petrou, who is pictured above during an early visit to the* BIO_SOS *site in the Netherlands but was lost to cancer in October 2012 (Credits: Sander Mucher, Alterra).*

USER TESTIMONIES

Modelling techniques for providing scientific evidence as the basis of conservation policies and sustainable planning activities are required by end users, such as Regional Planning authorities.

"When regional authorities elaborate and approve a plan for a protected area, a buffer zone needs to be defined around the protected area where rules different from the ones to be adopted within the site have to be identified, discussed and approved. So far, we do not have any scientific evidence of the impact of different levels of protection rules (policies) within the areas and generally we use an a priori buffer area ranging from 100 m. to 5 km. When we enter into negotiation with local authorities and local people, we need to support our decisions with scientific evidence of the impacts that such rules may have on the areas and the importance of the buffer zone with restriction rules. For this reason we are interested in GMES products resulting from the BIO_SOS project. In addition, innovative planning activity at a local level must try to modify a static municipal planning system into a dynamic planning system. So we need indicators that can provide dynamic monitoring of the different planning processes and an evaluation of the effectiveness of the policies implemented."

Prof. Angela BARBANENTE,
Member of Regional Council for Environmental Quality,
and Protected areas, Regione Puglia-Italy.

Clive HURFORD from the Countryside Council for Wales (CCW) has been working with the BIO_SOS project on the development of the methods for mapping land cover types and habitat procedures, with particular focus on Cors Fochno in Wales.
"CCW is investing in new technologies for monitoring protected sites, and particularly across the NATURA 2000 network in Wales. All of our sites are experiencing changes, with causes ranging from habitat succession, human disturbances and natural events such as flooding, and we need to quantify and understand the impacts of these changes. We also need to monitor how our management actions are affecting the extent and condition of the threatened NATURA 2000 habitats and their associated species, not only within our reserve network but also in surrounding areas. The BIO_SOS project at the Cors Fochno test site in Wales has given us an insight into how Earth Observation data can be used to support our field monitoring and this has motivated us to acquire very high spatial resolution satellite and supporting image data collected by Unmanned Airborne Systems (UAS) at other NATURA 2000 sites. Given the rapidity of the changes that can occur over quite large areas, we need to use remote data more proactively in our monitoring to help deliver our obligations for national and international reporting. BIO_SOS has been instrumental in informing our approach to this monitoring."

In this framework, the *BIO_SOS* project is providing local and regional authorities the following services.

- Very detailed land cover/use maps, based on the integrated analysis of (as a minimum) two high or mainly very high spatial resolution satellite images acquired in two different seasons corresponding to the peak of vegetation flush and the period before or after;
- General Habitat Categories (GHCs) and Annex 1 Habitat maps derived from land cover/use maps, based on a set of expert knowledge rules and ancillary data[1]. The set of rules can also be applied to pre-existing validated land cover/use maps or to historical satellite images;
- Land cover/use and habitat change maps obtained by comparing maps from different years.

In addition, the project is also providing:

- Biodiversity indicators from remotely sensed data;
- Biodiversity indicator trends for biodiversity pressure scenarios through indicators evolution over time.

As an example, the *BIO_SOS* project in Wales has been focusing primarily on the NATURA 2000 site of Cors Fochno, which contains the Annex I habitats of an active and modified raised bog in an estuarine environment, which also includes saltmarshes and sand dune complexes.
For this site, a time-series of very high spatial resolution Worldview-2 data has been obtained covering the period prior to the spring flush of vegetation (in March), the peak flush (July) and the senescent period (November). From these

[1] In digital image processing, data from sources other than remote sensing, used to assist in analysis and classification or to populate metadata (source: www.esri.com).

BIO_SOS in a nutshell (www.biosos.eu)

BIO_SOS *has made progress towards developing an operational system for effective and timely monitoring of NATURA 2000 sites and their surroundings.* Based on the expert knowledge of botanists, ecologists and end local site managers, *BIO_SOS* is developing a classification system that is able to integrate remotely sensed data from a satellite sensor and ground reference data. Land cover / use and habitat classes are described by the experts in terms of their temporal characteristics and / or spatial relationships and this information is used in the classification. For example broadleaved and coniferous forests, are discriminated based on seasonal differences in reflectance as a function of leaf cover and type whilst sand dunes may be separated from other bare areas because of their close proximity or adjacency to the coast line. Once land cover classes and habitats are described through a semantic language, any site can theoretically be mapped and subsequently monitored over time. Where it is difficult to provide expert rules for describing classes of interest, specific ground data can be collected but this is only necessary in specific *attentive (homogenous)* areas identified by remote sensed data segmentation, with these resulting in a reduced requirement for *in situ* campaigns (e.g., vegetation inventory). *BIO_SOS* is also focusing on the development of a modelling framework for pressure analysis and threat assessment in different protected areas (Mairota et al., 2012, Harini at al. 2012) with the aim to evaluate their impacts on habitats.

Figure 2. Classification of General Habitat Categories (GHCs), Cors Fochno (UK0014791 SCI/SPA), Wales generated using time-series of Worldview-2 data from Aberystwyth University. The classification within the active and modified raised bog (centre) is at 2 m spatial resolution and reflects the complexity of plant species that comprise the bog surface (Credits: Aberystwyth University).

data, as well as others at European sites, we have been able to develop the use of the FAO LCCS for land cover classification. The method uses a combination of spectral and contextual rules that follow the LCCS scheme and can ultimately be applied at any location regardless the satellite data used. Through *BIO_SOS*, we have then developed methods for translating the LCCS land cover categories in Wales to a habitat category, using the framework of the GHCs. We then describe these habitats in more detail, particularly where these are complex as in the case of the active bog. The maps of habitats generated (Figure 2) are providing the most detailed for the NATURA 2000 site and surrounds. Furthermore, additional image acquisitions are being obtained to establish approaches for the detection of change, including where these impact on the long-term conservation status of the site.

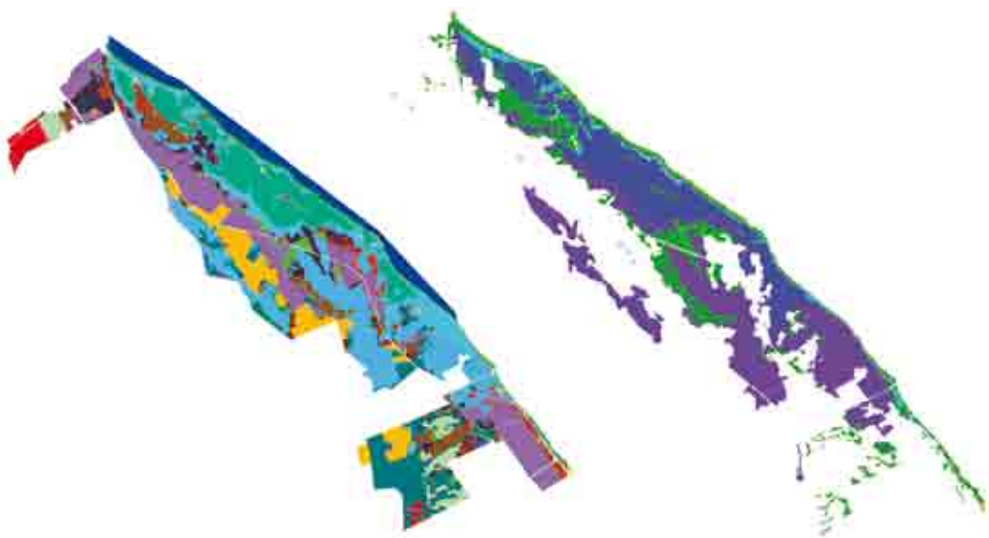

Figure 3. Habitat maps for Le Cesine site (IT9150032 SCI/SPA): Left map: General Habitat Categories (GHC) Cesine site. The colours correspond to different habitats in the GHC taxonomy. Yellow represents cultivated areas with olive grove; Light blue corresponds to Herbaceous Wetland Emergent Hydrophytes; dark blue is the sea. Right map: Annex 1 habitats. The colours represent Annex I habitats, e.g light blue corresponds to coastal lagoons (Credits: CNR-ISSIA).

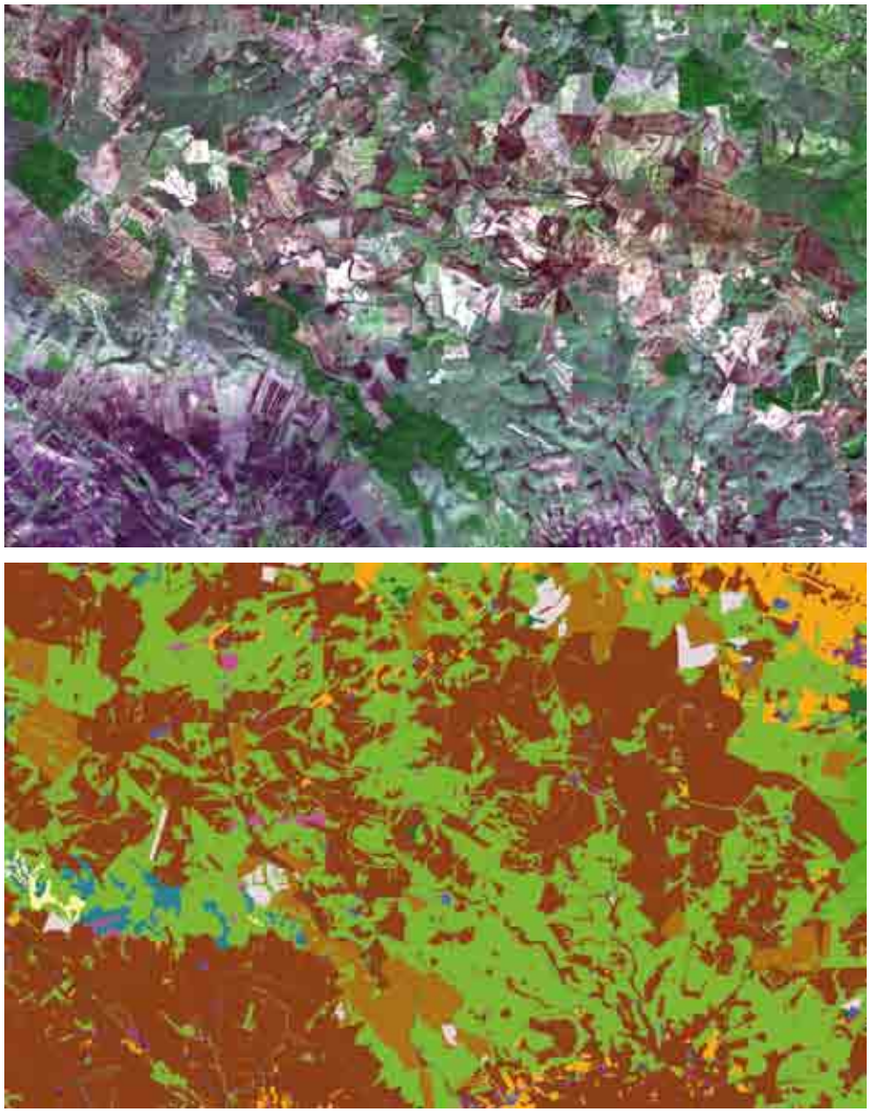

Figure 4. Murgia Alta Natura 2000 site (IT9120007 SCI/SPA). Original Worldview2 image and GHC map. In this site Grassland ecosystems were considered as focal habitat types. Substantial losses of this ecosystem have occurred between 1990 and 2000 mainly due to EU incentives promoting durum wheat production, contemporaneous to the enforcement of the 92/43/EEC Directive (Mairota et. al 2012) The colours in the low map represent different GHCs. Some examples: light green corresponds to Herbaceous Leafy Hemicryptophytes, brown colour represents Phanerophytes Evergreen Coniferous Trees, very dark green is for Broadleaved Deciduous Trees. (Credits: CNR-ISSIA).

In the Mediterranean, our studies have focused on generating GHC and Annex 1 habitat maps for NATURA 2000 sites at Le Cesine (Figure 3) and Murgia Alta in Italy. Additional study areas are located in Portugal, Greece and the

Netherlands. To demonstrate more general use, the methods are also being developed in two highly biodiverse tropical countries, Brazil and India.

"The use of General Habitat Categories (GHCs) supports the local management of endangered species and priority habitats"

GMES products for Biodiversity monitoring (examples from different sites including land cover and GHC habitats)

In this framework, very high resolution Earth Observation data are very useful for biodiversity inventories and monitoring for adaptive management on a regional and local scale since they can provide/extract information similar to field samplings, thereby reducing the need for extensive, expensive and time intensive field surveys, as well as decreasing the time interval between updates. These data thus provide the opportunity for more rapid and effective management responses to changes and threats (Nagendra et al., 2012).

The expert knowledge classification approach adopted by *BIO_SOS* strongly involves end users, including those from the scientific community (e.g., botanist, ecologists) and local managers. The method allows the description of a specific habitat to be generalised such that these can be automatically identified when different sites and conditions are encountered. Consequently, the products proposed by *BIO_SOS*, such as habitat maps and biodiversity indicators, will be more familiar to the End Users since they are built on their expertise and can be improved as they further engage with the process.

BIO_SOS will strongly support reporting for the Convention of Biological Diversity (CBD), the European Biodiversity Strategy and the Habitat Directive by making the information directly compatible and so will become central to the whole process of managing biodiversity in Europe. By integrating *in situ* data with reliable global land observations based on Earth Observation, *BIO_SOS* will allow us to unravel certain patterns and processes that were formerly not well understood. This information can then be used to adjust or fine-tune existing conservation objectives, especially in the Mediterranean areas. Moreover, *BIO_SOS* proposes an ecological modelling system that can offer an important tool to monitor changes in the distribution and status of ecosystems within and along the borders of protected areas.

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Palma BLONDA. As a researcher at CNR since 1984, she is a specialist in digital image processing with computing techniques applied to segmentation, classification, change detection, data fusion. She has participated to several national and international projects supported by Italian Space Agency (ASI), European Space Agency (ESA) and European Commission. She was the technical coordinator of CNR_ISSIA activity in LEWIS (Landslide Early Warning System) and FP7-*FIRESENSE* project. She is the *BIO_SOS* coordinator.

João PRADINHO HONRADO is a member of the University of Porto Faculty of Sciences and senior researcher at CIBIO, where he leads the Biodiversity & Conservation Ecology (BIOCON) group. His research focuses on vegetation and landscape ecology, and on biodiversity monitoring based on improved modelling frameworks. He has recently coordinated or participated in several projects on biodiversity and habitat monitoring and conservation. Currently he also coordinates the national project *EcoSensing*, aimed at developing improved approaches to the design of monitoring networks for species and habitats in changing rural landscapes. He is involved in the *BIO_SOS* project as coordinator of work package 4 (on-site data collection).

Prof. Richard LUCAS heads the Earth Observation and Ecosystem Dynamics Group within the Institute of Geography and Earth Sciences, Aberystwyth University. His research focuses on understanding the response of terrestrial ecosystems to human-induced and natural events and processes through the integration of remote sensing data from a diverse set of ground, airborne and Space borne sensors. Whilst his work in *BIO_SOS* has focused on sites in Europe, he has also been involved in a wide range of research activities relating to the characterisation, mapping and monitoring of tropical and subtropical rainforests, wooded savannas and mangroves in conjunction with organisations in Australia, Japan and the United States.

Improved information of forest structure and damages

by Mathias Schardt and Klaus Granica

FORESTS PLAY A KEY ROLE IN THE EUROPEAN ECONOMY AND ENVIRONMENT. THIS ROLE INCORPORATES ECOLOGICAL AS WELL AS ECONOMIC FUNCTIONS WHICH CAN BE AFFECTED BY THE OCCURRENCE OF INSECT INFESTATIONS, FOREST FIRE, HEAVY SNOWFALL OR WINDFALL EVENTS. LOCAL OR REGIONAL AUTHORITIES (LRAs) THUS REQUIRE DETAILED INFORMATION ON THE DEGRADATION STATUS OF THEIR FORESTS TO BE ABLE TO TAKE APPROPRIATE MEASURES TO ENSURE SUSTAINABLE FOREST MANAGEMENT. IN THE *EUFODOS PROJECT*, STATE-OF-THE-ART SATELLITE AND LASER SCANNING TECHNOLOGIES ARE USED TO PROVIDE FOREST AUTHORITIES WITH COST-EFFECTIVE, TIMELY AND COMPREHENSIVE INFORMATION ON FOREST STRUCTURE AND DAMAGE.

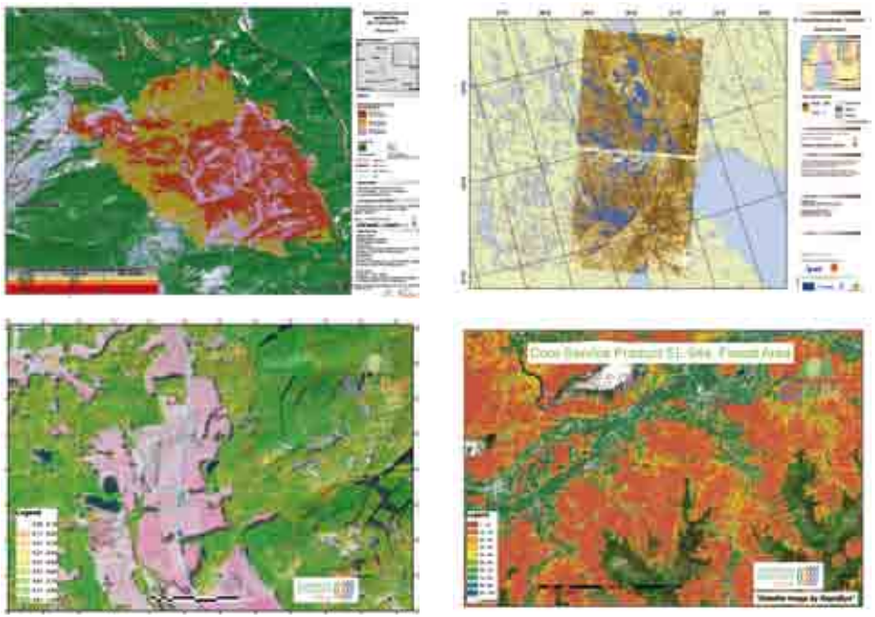
The purpose of GMES is to deliver information that meets the user's needs. The **Forest Services** being developed within *EUFODOS* – Improved Information of Forest Structure and Damages – include the assessment of forest damage and the measurement of functional parameters for commercial and protective forests. These monitoring services are urgently required by regional forest authorities and are being developed by a consortium of research organisations, commercial service providers and users from Austria, Bulgaria, Finland, Germany, Italy and Poland. Although the main focus in *EUFODOS* is on regional services, it is also the intention to put results at the disposal of national and international authorities. This will support their various reporting obligations of forest policies as imposed by several forest policy frameworks e.g. the Ministerial Conference on the Protection of Forests in Europe (MCPFE), UNECE/FAO Forest Resource Assessment, ICP Forests and ICP Integrated Monitoring or the Alpine Convention.

European forests are exposed to many threats, be they natural (forest damage from storm, heavy snowfall, forest fire or insect outbreaks) or man-made. The assessment of damage becomes crucial in forest management activities (Credits: ReSAC).

European forests are exposed to many threats, be they natural (forest damage from storm, heavy snowfall, forest fire or insect outbreaks) or man-made. The assessment of damage becomes crucial in forest management activities (Credits: ReSAC).

Use of Earth Observation Data

The use of Space and airborne sensor platforms allows data acquisition at very short time intervals and in a cost effective way. For instance, a first assessment of windfall damage can be delivered to users in the form of geo-referenced damage maps based on satellite data, in a much quicker and more cost effective way than conventional assessment methods requiring helicopter flights or field trips. From remote sensing-based services, fast and reliable information for effective damage assessment and sustainable forest management at local and regional scale can be offered to several user groups and can be used in a wide range of applications.



Higher left map - Reporting obligations require the revision of forest maps and inventories, the compilation of regular reports and annual statistics (e.g. changes in forested area) or the establishment of forest damage information systems; the image shows forest areas damaged from forest fire (Credits: RESAC);

Higher right map - Sustainable management of commercial forests: an efficient wood procurement planning process is a crucial prerequisite to any sustainable exploitation of commercial forests; image showing a map with stem volume numbers (squared shapes) derived from satellite imagery (Credits: VTT);

Lower left map - Sustainable management of protective forests: The targeted management of protective forests is vital to maintain and enhance their function. They contribute to the protection of settlements and infrastructure from the consequences of natural hazards; The map shows the distribution of crown coverage classes derived from LIDAR – in 10% steps - superimposed on a false colour infrared aerial photograph (Credits: Joanneum Research);

Lower right map: Earth Observation data from GMES services allows user to obtain maps providing a detailed view of the tree species distribution in an area of interest; image showing tree species distribution layer – in 10% steps - superimposed on a RapidEye satellite image (Credits: Joanneum Research);

Collaboration with existing GMES Services

Another important aspect in the development of Forest Services is the use and integration of existing information such as the GMES Service products into the processing chain. To achieve this goal, efficient methodologies for using GMES

Service products have been elaborated within the consortium and implemented in each of the test cases. It has been proved that the availability of the GMES Services improves the generation of *EUFODOS* Service products, mainly with respect to costs and resource efficiency.

Technical Realisation

A key goal of *EUFODOS* is the development of operational toolboxes which are to be distributed within the consortium and applied by the service providers in each service case. The first prototypes were produced and presented during a software training session in September 2011. At the beginning of 2012 the completed operational toolboxes were then distributed to the service providers.

Subsequently in each test case, the adaption, integration and testing of the processing lines has been completed, eventually resulting in demonstration products delivered to the users. The demonstration products have been assessed and validated by the users in training sessions and during field trips, with the users reporting their findings in a user utility assessment report. The first phase of *EUFODOS* was finalised after 18 months during a midterm workshop in June 2012 with positive feedback from the users that can now be used as guidance enabling the service providers to optimise and accomplish the roll-out tasks in Phase 2.

The *EUFODOS* User Community

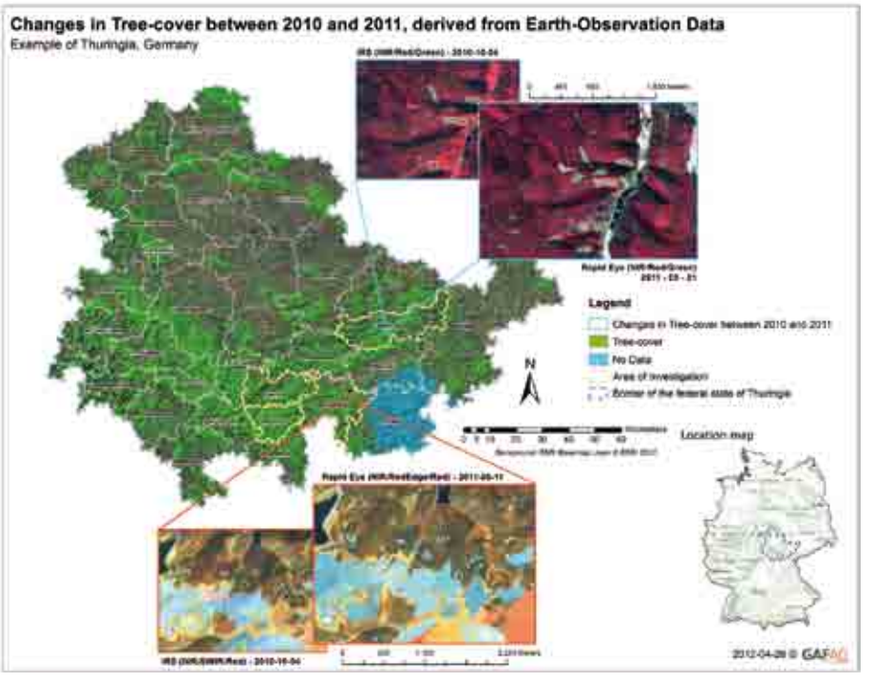
EUFODOS involves an extensive user community well connected to other related GMES User Groups. This organisation facilitates the roll-out of the services and the uptake of the services by users. It also enables the consortium to address new potential users and therefore raise awareness of the services. For this purpose a User Executive Board was set up at the start of the project and its members stay in permanent contact. Seven Newsletters have been published by the User Executive Board secretary and have been disseminated to the *EUFODOS* users and service providers as well as to further interested persons and potential users.
These newsletters can be downloaded from the www.eufodos.info.

"Local authorities require detailed information on the degradation status of their forests"

Another aspect of *EUFODOS* is dealing with research related issues focusing on the assessment of the potential of new sensor data. The investigations concentrate on RapidEye optical images, SAR data or the processing of digital surface models derived from aerial photogrammetry. This task will give the users an important outlook on the technical capacities and augmented use of forthcoming systems.

Sustainability of Services

A key element of Forest Service is its sustainability or continuation beyond the project life time. To guarantee a sustainable use of the developed services, it is envisaged that the number of European users is increased. The results of the dissemination will be incorporated into a report on economic viability.



For forest management authorities, it is important to get data allowing them to fulfil their task. One important input is the knowledge of where forest changes occur. This information can be derived in a fast and cost-effective way by using satellite imagery; this map shows an example of changes in tree cover between 2010 and 2011 for the State of Thuringia/Germany (Credits: GAF AG).

Achievements

In the first phase the framework for the Forest Service development was installed. The various elements constituting this framework are (1) the identification of the frame conditions for *EUFODOS* Service operations, (2) the coordination with other GMES Services and existing systems, and (3) the production and standardisation of production chains. Regarding the definition of user requirements, an intensive working process between the service providers and the users was initiated. The outcome builds up the basis for the successful implementation of the different service cases in the selected test sites. A continuous monitoring and feedback loop between service providers and users has proved its worth in guaranteeing a successful development of services and products.

Conclusion and Outlook

The *EUFODOS* project has successfully produced the first demonstration products for each of the scenarios such as storms, forest fires, heavy snowfall or insect outbreak. All technical software packages have been finalised and integrated into the respective toolboxes to be applied in the case of storm damage or insect infestations. Some other Forest Services were additionally installed, such as the detection of change from heavy snow fall or forest

fire damage. Other applications encompass tools for the derivation of forest parameters from LIDAR data or the derivation of forest parameters related to commercial forests. These products are needed to support forest management tasks in protective forests or the commercial exploitation of wood, and also for their integration into Forest Geographic information system. These products have been successfully evaluated by the Service Providers and the User Executive Board. Their findings have been reported and are integrated into the planning of the roll-out phase for the next 18 months.

The preliminary results show that *EUFODOS* is on a successful path to accomplish its goals to develop efficient and powerful Forest Services. All services and products have been selected in accordance with regional users of the selected countries. Users will receive a great benefit from these products and can use them in cases of emergency as well as for planning purposes. It is intended to harmonise these forest services for use in other EU countries too, to give the regional users the opportunity to obtain information quickly on the extent of damages caused by forest degradation.

Prof. Dr. Mathias SCHARDT has a background in Forest Science, and received his diploma degree in 1984 at the Albert-Ludwigs-University of Freiburg. He finished his Ph.D. in 1990 on «The Applicability of Thematic Mapper Data to the Classification of Tree Species and Natural Age Classes" and his Habilitation thesis in the field of «Landscape planning, particularly Remote Sensing and Geoinformatics» both at the Technical University of Berlin. He is Head of the department of Remote Sensing and Geo-information, JOANNEUM RESEARCH, and since 2002 he has held a Professorship at the Technical University of Graz at the Institute of Geodesy, Dept. of Photogrammetry and Remote Sensing.

Klaus GRANICA is senior scientist and project manager at Joanneum Research, department of Remote Sensing and Geo-information and has twenty years of experience in remote sensing. He has a degree in Geography and History from the Karl-Franzens University in Graz. He is mainly working in the fields of environmental monitoring, disaster management and forest mapping, and also has experience in aerial photo interpretation. He managed several projects and was project manager for Joanneum in the DG XII *SEMEFOR* project and coordinates the *EUFODOS* FP7 project (www.EUFODOS.info).

UrbanAtlas+: Exploring GMES Urban Atlas data potential for urban planning applications at regional and city level

by Tomas Soukup

AS THE GMES (GLOBAL MONITORING FOR ENVIRONMENT AND SECURITY) PROGRAMME BECOMES AN OPERATIONAL SOURCE OF SPATIALLY EXPLICIT LAND USE AND LAND COVER DATA ACROSS EUROPE, IT IS TIME TO TURN THE DATA INTO STANDARD INFORMATION AND EXPLORE THE DATA'S POTENTIAL FOR PROVIDING USERS WITH HANDY TOOLS TO SUPPORT SPATIAL PLANNING FROM LOCAL AND REGIONAL TO EUROPEAN SCALE. URBAN AREAS IN EUROPE, ACCOMMODATING MORE THAN THREE QUARTERS OF THE POPULATION, HAVE GROWN RAPIDLY IN RECENT DECADES. BOTH CITY CENTRES AND THE WIDER SURROUNDINGS HAVE BEEN TRANSFORMED, WHILE DECISION MAKERS INVOLVED IN URBAN PLANNING FROM THE LOCAL LEVEL UP TO THE EU LEVEL NEED ACCURATE DATA ENABLING THEM TO MONITOR AND INTERPRET THESE CHANGES. THE URBANATLAS+ PROJECT, SUPPORTED BY THE EUROPEAN SPACE AGENCY (ESA), CONTRIBUTES IN THIS EFFORT IN THE URBAN AND REGIONAL PLANNING DOMAIN.

Context

An understanding of the implications of changes in land cover and land use is a fundamental part of planning for sustainable development. In Europe, 75% of the population currently lives in cities and 80% is expected to do so by the year 2020 (European Environment Agency, 2006; 2009), therefore up-to-date and comparable information on land cover and land use are crucial to cope with emerging issues such as urban sprawl, urban green areas decline or sustainable urban development in general. At the same time, the GMES programme is in its Initial Operational (GIO) phase, with many of its services already pre-operational. One of the most appealing examples in land monitoring domain is the recent Urban Atlas mapping done during 2009-2011, providing harmonised Earth Observation (EO)-based land use and land cover data for urbanised areas at a pan-European level (see box 1). The resulting Urban Atlas spatial data, together with Eurostat's Urban Audit statistical data counterpart (see box 2), represent

GMES services can help decision makers designing long-term urban planning strategies to mitigate the impact of urban sprawl on the environment. Aerial view of Mosta and its region nearby the southern coast of Malta (Credits: JonasS / Wikimedia commons).

unique sources of reliable and inter-comparable pan-European urban and regional planning data with a high potential to serve European, national and even regional/local user needs.

"Urban Planners need accurate data enabling them to monitor and interpret land cover changes"

Aim

The *UrbanAtlas+* project carried out by GISAT and supported by the European Space Agency (ESA) aims to further explore this potential in order to turn data into standard information and provide user-friendly tools to explore, describe, compare and explain urban related land cover and land use changes, and thus support spatial planning from local and regional to European scale. It builds on previous experiences and achievements within the ESA GMES Service Element (GSE) projects (GSE Land[1], GSE GUS) as well as on the recent GMES spatial planning supporting activities undertaken around the *Geoland2* project (G2 Core Information Services – Spatial Planning). In cooperation with regional and local users in the Czech Republic (see box 3), the *UrbanAtlas+* project aims to progress in this area by means of service demonstration with the help of a user-friendly data exploration platform focused on:

- Urban growth dynamics monitoring and assessment;
- Socio-economic data integration.

[1] Čtyřoký J.and Pochmann M., "Urban Atlas helps urban planners in Prague" (2009): Proceedings Towards Environment, a Shared Environmental Information System for Europe, March 25-27th, 2009, Prague.

The Urban Atlas

The Urban Atlas is part of the implementation of the Global Monitoring of Environment and Security (GMES) land monitoring service, financed by the European Commission with the support from the European Regional Development Fund (ERDF) and produced in collaboration with the Member States and the European Space industry. The Urban Atlas covers all EU capitals and a large sample of large and medium-sized cities in the form of Large Urban Zones (LUZs) - administrative unit-based areas covered also by Eurostat's Urban Audit. Earth Observation based data collection provides information for more than 300 cities in the EU for the reference year 2006. Future editions of the Urban Atlas are planned in 3-5 year intervals, to complement the Urban Audit exercise, starting with the Urban Atlas update planned under the GMES Initial Operations phase for 2012. More on GMES Urban Atlas activity and resulting data can be found via the European Environment Agency (EEA) at http://www.eea.europa.eu/data-and-maps/data/urban-atlas.

Service specification

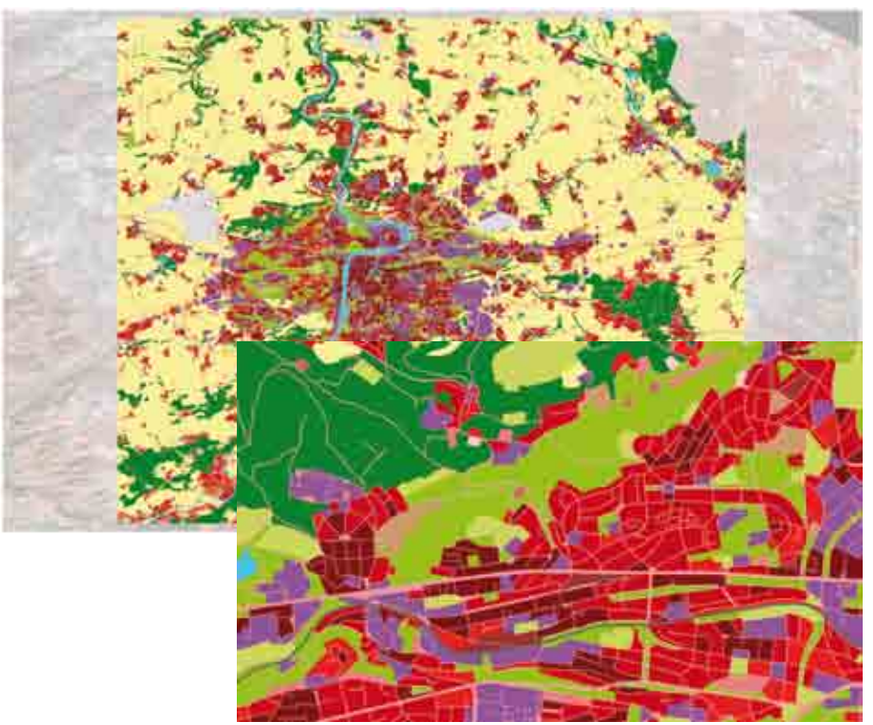
The service content addresses specific information needs, mainly at municipal and regional level, driven by the definition, implementation and monitoring of regional and local spatial planning instruments. The primary users of the service offered within the *UrbanAtlas+* project are spatial planning and environmental departments within regional governments and municipal authorities. In addition to this, the services seek links to the specific information needs at national as well as European levels. Thematically, the service is focused on spatial characteristics of urbanised areas: urban morphology and urban forms, urban sprawl, urban density, development of green urban areas and changes in urban structure, but it also addresses its economical, ecological and social consequences (population change, quality of life, economic competitiveness, biodiversity) linking physical land cover / land use information and statistical data.

"Urban Atlas has a high potential to serve regional and local user needs"

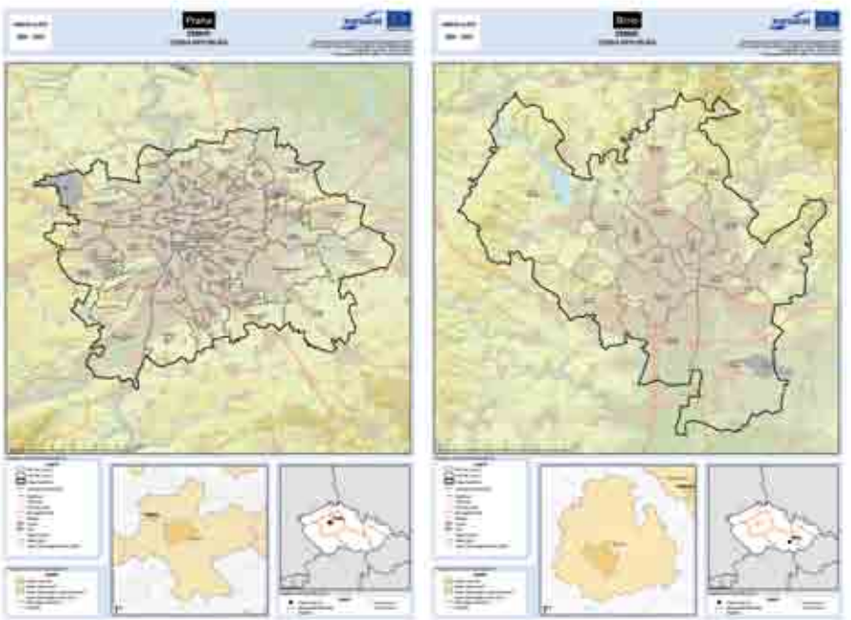
Data

Urban Atlas and Urban Audit (accompanied with local statistics) represent the main datasets for both *UrbanAtlas+* service demonstrators. Nevertheless, as there is still no time dimension currently available in Urban Atlas data, multi-temporal datasets for demonstration purposes were created using GSE[2] Land project results as well as Urban Atlas semi-automatic update/downdate data within the *UrbanAtlas+* project for five selected cities using object-oriented (OBIA) classification approaches.

[2] GMES Service Element.



Urban Atlas data example – Prague, Czech Republic (Credits: European Commission).



Urban Audit – Large urban zones (LUZ) and administrative sub-division examples - Prague (left) and Brno (right) (Credits: ESTAT).

Implementation

In order to achieve the level of flexibility and usefulness required by users, the service specification went beyond the traditional concept of data provision. It is based on an interactive web-based approach, where both spatial and socio-economical statistical data are delivered in an organised way, together with tools, in a fast and flexible environment. This allows data to be easily viewed and analysed in user-predefined themes (indicator views), as well as being further explored interactively. The web tool, based strictly on Open Source frameworks, integrates main standard presentation modes - maps, tables and graphs in an interlinked manner i.e. user-defined changes in/*via* one presentation mode are instantly reflected in all others. Finally, users can decide to export standard information data and products via softcopy (data, metadata, table) or online generation of hardcopies (PDF, maps, images).

The Urban Audit Initiative

The Urban Audit initiative of the Directorate General for Regional Policy regularly provides urban statistics for cities and surrounding administrative districts across the EU. It is co-financed by the European Commission and managed in close consultation with EUROSTAT and the national statistical institutes in EU Member States. More on the Urban Audit activities can be found at http://www.urbanaudit.org.

Based on the user requirements and also considering available data limitations, the following standard web tool tabs/themes have been specified and then implemented:

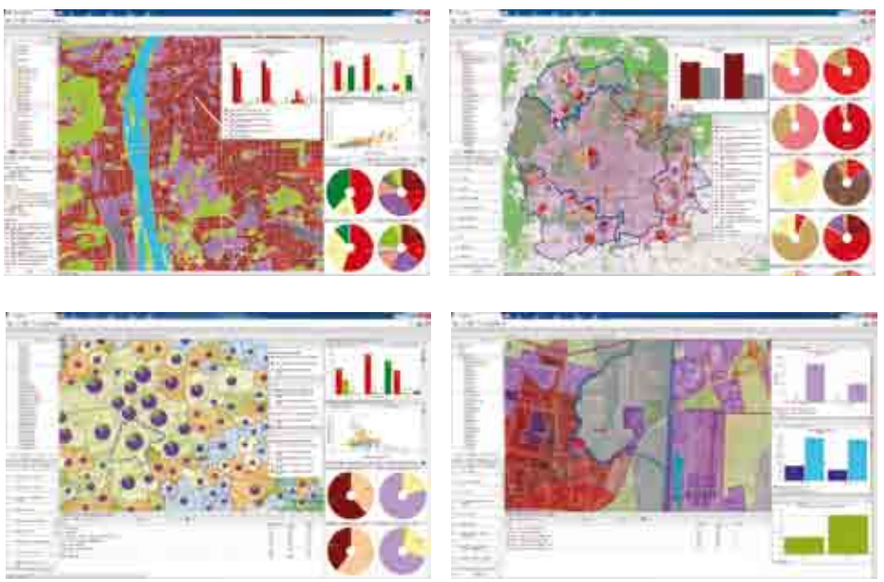
- Indicator 1: Urban growth
- Indicator 2: Growth of residential areas
- Indicator 3: Growth of industrial areas
- Indicator 4: Urban growth and population development
- Indicator 5: Productivity of land consumption
- Indicator 6: Urban sprawl intensity
- Indicator 7: Land cover replaced by built-up area
- Indicator 8: Land use
- Indicator 9: Loss of natural areas
- Indicator 10: Structural indicators

Results

Both demonstrators:

(1) *urban growth dynamics* monitoring and assessment providing insight into the land consumption and formation processes involved;

(2) *socio-economic data integration* supporting integration of Urban Atlas data with conventional statistics in general and testing the standard Urban Audit set of indicators in particular; are provided in one common environment in the form of customisable predefined tabs, easily shared between different users. Local and regional users especially appreciate this easy-to-use and collaborative concept.



Higher left image: Flexible urban structure data exploration at detailed level.
Higher right image: Consumption and structure of the land cover/ land use changes.
Lower left image: Comparison of spatial and statistical data using scatterogrames.
Lower right image: Comparison of spatial and statistical data focused on flooding and conservation zones (Credits for all images: GISAT).

The *Urban Atlas+* project

This project runs under the ESA Czech incentive scheme and although serving primarily urban and the regional planning user community in the Czech Republic, it also reflects the context of national and European directives. Therefore results can support spatial planning authorities in general across Europe in their efforts to fulfil a broad range of monitoring and reporting obligations. The Czech organisations included in the *UrbanAtlas+* project are the following:

- City Development Authority Prague (URM / MHMP);
- Regional Authority of the Pilsen Region (RAPR);
- Regional Authority of the Moravia-Silesia Region (RAMSR);
- Regional Authority of the South Moravia Region (RASMR);
- Czech Environmental Information Agency (CENIA).

The *UrbanAtlas+* project contributes to the acceptance of overall Urban Atlas based services and their application Europe-wide. The current version of the web-tool demonstrator (public part) can be seen at http://uaplus.gisat.cz

The results clearly demonstrate advantages of spatial data such as the Urban Atlas compared with traditional statistical data due to/for:

- Flexible spatial units;
- Insight into processes (consumptions, formations);
- Comparability in time and space;
- Spatial indicators on urban morphology and urban forms;
- Land use modelling;
- Spatial allocation or distribution of statistical variables.

Despite the scale limitation of European Urban Atlas products, results showed clear advantages to support planning in sub-urban commuter belts, where, despite being the area with the most dynamic development, limited support information is currently available for urban planners since it is the area out of the city extent and thus out of the city planners' responsibility. Nevertheless, these areas have in fact a huge influence on the city itself, so up-to-date data are needed to plan, implement and monitor appropriate policy measures. Besides this, comparison of city status and development indicators between individual regions or cities within the Czech Republic or abroad was also highly appreciated as it was not possible previously due to general incomparability of regional/urban planning documentation.

"The Urban Atlas helps urban planners and decision makers understand the economical, ecological and social consequences or urban changes"

On the other hand, the *UrbanAtlas+* project also clearly shows that certain basic characteristics are essential for the analytical power of the Urban Atlas data. However some last minute changes in the GMES Urban Atlas specification (comparing to original ESA GSE-based specifications) did not fully support its potential uses. The main example of such changes is the over-simplification of non-urban classes, which substantially reduces the analytical power of the dataset when it comes to the changing flows assessment. Nevertheless, these issues can, and hopefully will, be improved during upcoming Urban Atlas data updates.

The overall aim of the *UrbanAtlas+* project – to demonstrate the potential EO-derived Urban Atlas products and strengthen its acceptance in the urban/regional planning user community in the Czech Republic- has been achieved. Therefore there is a good chance that current and future European GMES investments in EO infrastructure, as well as investments into the new GMES land monitoring services such as the Urban Atlas, will find the users and be fully used in the original target domain of the Urban Atlas service – spatial planning – not only at the European scale, but also at the municipal and regional levels.

Tomas SOUKUP is senior project manager at GISAT s.r.o., Prague, Czech Republic. He received his MSc. in Geodesy, Cartography and GIS/RS at the Czech Technical University in Prague in 1991. He is a senior consultant in RS and GIS and land monitoring, experienced in spatial data integration, digital processing of satellite imagery and spatial data processing and analysis within the GIS environment. Since the mid 90's, he has been involved in multiple land monitoring activities and projects including GMES related ones such as ESA *SAGE*, ESA *GSELAND*, ESA *RESPOND*, FTSP *Sealing*, FP7 *geoland2* and FP7 *SAFER*. *Tomas has collaborated with the European Environment Agency at various levels since 1998 (PTL/LC, ETC/TE, ETC LUSI, ETC SIA) and he is also a member of the central CORINE Land Cover implementation team.*

New land use data to monitor evolution of land use

by Jana Hoymann

LAND USE DATASETS ARE ESSENTIAL FOR ADDRESSING SPATIAL PLANNING OR ENVIRONMENTAL ISSUES, ESPECIALLY AT LOCAL LEVEL. RECENTLY NEW DATASETS FOR EUROPE AND ESPECIALLY FOR GERMANY HAVE BECOME AVAILABLE. THE OBJECTIVE IS TO EVALUATE THESE DATASETS IN THEIR APPLICABILITY WITHIN LAND USE CHANGE MODELS. THE RESULTS SHOW PROGRESS WITH RESPECT TO SPATIAL AND THEMATIC RESOLUTION, ALTHOUGH FURTHER EFFORT IS NECESSARY.

Spatial information on land use and its changes is essential for many spatial planning and environmental issues. The monitoring of land use changes is - for example - an important component of the German Sustainable Development report. But forecasting can also help authorities with decisions on, for example, infrastructure planning or adaptation to climate change. The application of spatial information in land use change models allows for an *ex ante* evaluation of certain policy decisions. Such analysis is part of the on-going *CC-LandStraD* project (see box). It analyses land management strategies that contribute to the adaptation to and mitigation of climate change in Germany. The impacts of land management strategies are analysed with land use change models that require high spatial resolution information. The project cooperates with federal, regional and local authorities in Germany to ensure that relevant measures are analysed and that the results are useful for users. In recent years several spatially explicit land use datasets were developed. They may be suitable for the German federal monitoring of land use changes as well as land use change modelling, which is an important instrument to evaluate the effect of measures on the land use pattern:

- Corine Land Cover 2006;
- GMES Urban Atlas 2006;
- DLM-DE 2009.

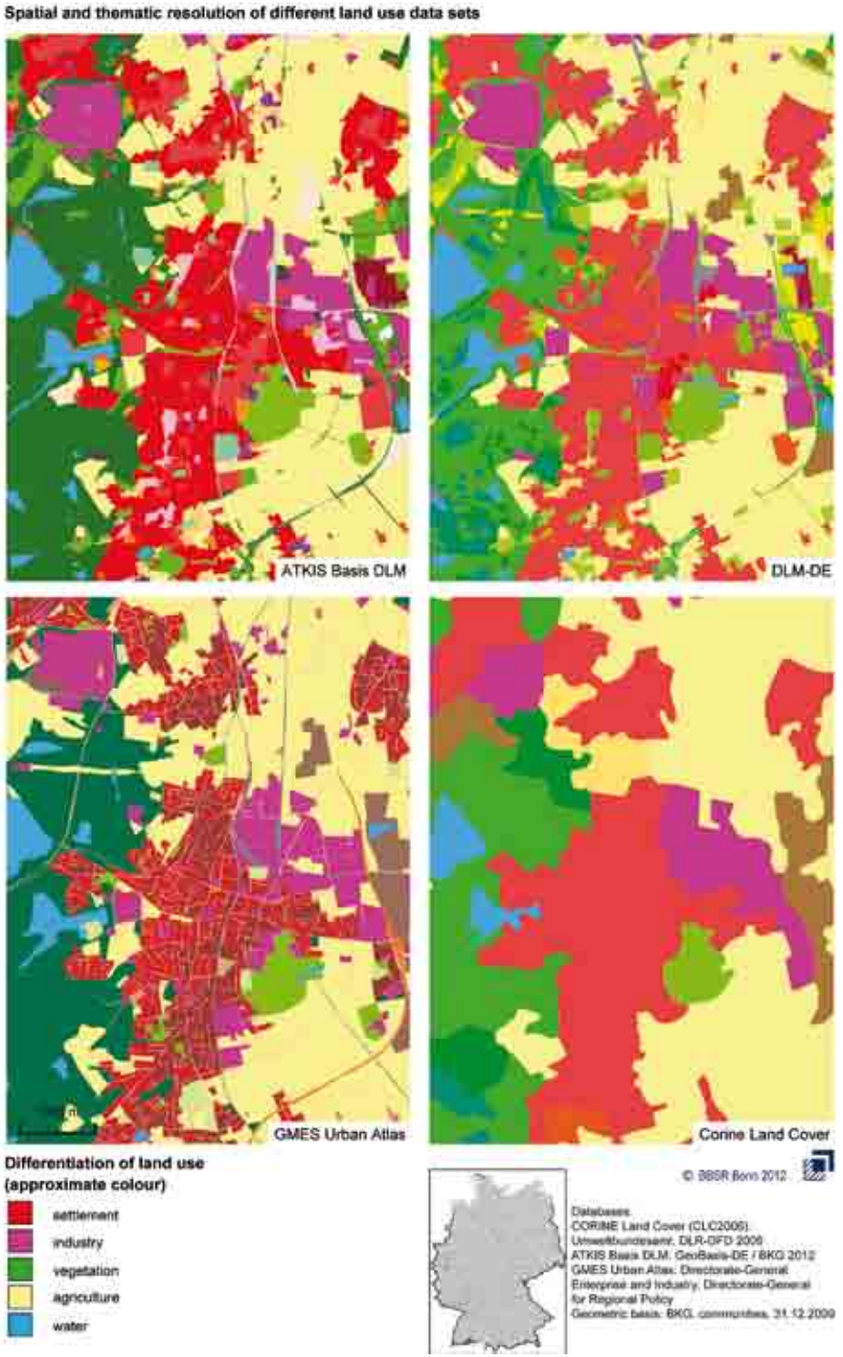
The first and second datasets are part of the GMES Mapping Service "Land Cover and Land Use Monitoring", now referred to as GIO-Land, while the third is a German dataset. Here we will compare and contrast the available datasets and discuss their applicability for land use change modelling.

Datasets

Several land use datasets are available for Germany. They differ in terms of thematic, spatial and temporal resolution. The next image provides an overview of various datasets.

Corine Land Cover

Corine Land Cover (CLC) is a Europe-wide harmonised land use dataset. It is available for three different years (1990, 2000 and 2006) and covers all relevant land use types like urban areas,



The highest thematic resolution is given by the ATKIS Basis DLM. The Urban Atlas also includes transport areas (Credits: BBSR).

agriculture, natural areas and forest as well as water. This dataset was used in several European and regional cross border studies to analyse changes in land use and land cover. At European scale CLC was for example used for the analysis of landscape fragmentation, the development of green infrastructure and the assessment of suburbanisation (EEA 2006a, EEA 2006b, EEA 2011a, EEA 2011b). CLC was also used in several scenario studies for the analysis of future land use developments (EEA 2007, Hoymann 2010, Lavalle et al 2011).

GMES Urban Atlas

The Urban Atlas (UA) can be used as a supplement to the CLC. It covers large urban zones (LUZs) with more than 100,000 inhabitants across Europe. In Germany 35 LUZs cover about 28.5% of the total territory of the country. This dataset has a higher spatial resolution than CLC and for artificial surfaces it also has a higher thematic resolution, thus differentiating more urban land use types.

Digital Landscape Model for Germany

The Digital Landscape Model for Germany (DLM-DE) was developed by the Federal Agency for Cartography and Geodesy (BKG). The DLM-DE is based on the ATKIS-Basis DLM, the Authoritative Topographic-Cartographic Information System for Germany. Instead of the more than 190 feature types of the ATKIS database, the DLM-DE uses the CLC classification scheme. Therefore, a semantic transformation of the feature types was conducted (Arnold 2009). The database is further updated with the interpretation of satellite images. This processing approach will be used for the future update of CLC in Germany.

Combination of DLM-DE and Urban Atlas

For the following analysis an additional dataset has been developed to combine the advantages of several datasets. DLM-DE and UA have a spatial resolution of at least 1 ha. Both datasets show a better differentiation of the land use categories than CLC. Moreover, compared to Urban Atlas-data, non-artificial surfaces are depicted with more thematic detail in the DLM-DE while the Urban Atlas allows a better description of artificial surfaces.

Figure 2: The artificial surfaces in the 35 German regions covered by the Urban Atlas. No spatial dataset monitors the artificial surfaces completely (Credits: BBSR).

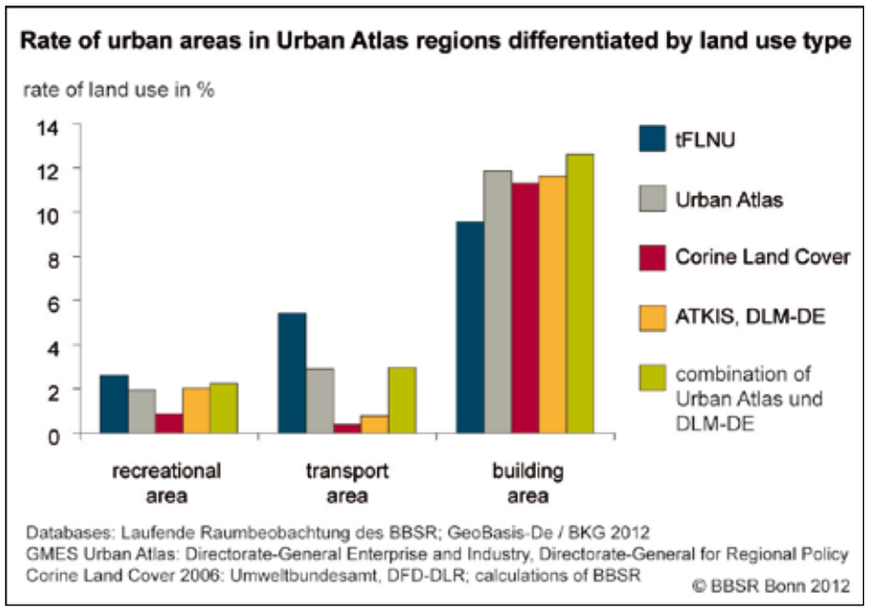


Figure 3: The artificial surfaces in the 35 regions covered by Urban Atlas differentiated by database and land use type. Urban green and transport areas are significantly underestimated (Credits: BBSR).

Comparison of land use datasets

This section compares the thematic and spatial resolution of the datasets. Since artificial surfaces have a high political relevance, these areas are analysed in more detail. Figure 2 shows the sum of all artificial surfaces (CLC Level 1) for the 35 regions that are covered by the UA. For reference purposes the figure also includes housing and transport areas of the official statistical database for the monitoring of land use changes in Germany (Flächennutzung nach Art der tatsächlichen Nutzung - tFLNU).
CLC and DLM-DE show a significant lower amount of artificial surfaces than the statistical database tFLNU. The result for the UA shows an approximation to the tFLNU, but the best approach is reached by the combined dataset of DLM-DE and UA. While CLC represents only 67% of the housing and transport area of tFLNU, the DLM-DE represents 76%, the UA 88% and the combined dataset 95%.

Meinel et al (2007) showed that within CLC2000 where there are smaller and more fragmented municipalities the underestimation of artificial surfaces was greater due to the minimum mapping unit of 25 ha. The UA represents an almost full survey for municipalities of more than 100,000 inhabitants. In the combined dataset of DLM-DE and UA artificial surfaces in smaller municipalities are also well represented.

Figure 3 distinguishes land use types belonging to artificial surfaces. Urban green areas are poorly mapped in the CLC - due to the minimum mapping unit which leads to removal of smaller pieces of land by generalisation. The share of urban green areas in comparison to the total cadastral area is only about 1% in CLC while the statistical tFLNU lists about 3%. Transportation areas are also underrepresented in CLC and the DLM-DE. They have a share of below 1% and those of DLM-DE of about 1% while tFLNU lists about 5%. The reasons will be discussed in the next section.

Challenges

Main reasons for the differences described above lie in the variety of data sources, mapping approaches and scales, as further explained below. These criteria are also very important for the selection of a land use dataset suitable for the upcoming modelling task.

- **Linear elements:** Most spatial datasets do not represent linear elements like roads, railroads and waterways adequately. Progress has been achieved with the UA data where linear elements are mapped due to higher spatial resolution and the use of secondary data. These are also the reasons for better representation of transport areas in the UA and the combined dataset in Figure 3;
- **Thematic classification:** The comparison revealed that in some cases the objects are classified differently. For example, buildings in parks are assigned to different land use types in CLC and UA also squares / plazas are assigned to transport, industrial or urban area in the different datasets. This reduces comparability;
- **Minimum mapping unit:** A high spatial and thematic resolution is important to *ex ante* analyse measures that will lead to land use changes. In contrast to CLC the UA and the DLM-DE show large improvements concerning the minimum mapping unit and the scale. This results in a better spatial representation, especially of artificial surfaces. The advantage is even greater in combination with a higher thematic resolution;
- **Temporal resolution:** Time series data are important to analyse past changes and to understand the change process for calibration of the land use change model. Up to now only CLC provides a time series. In the future, DLM-DE-data will be used as a base for the CLC-update. This actually leads to a break in the comparability of the datasets over time. UA and DLM-DE do not have time series data yet, but they can be expected.

	Corine Land Cover	*Urban Atlas*	*DLM-DE*	*tFLNU*
Translation of land use types into nomenclature of another land use dataset	No, not directly	Yes, with CLC	Yes, with ATKIS Basis DLM and CLC 2009	No, not directly
Time series available	Yes	Is planned	Is planned	Yes
Temporal consistency with other land use datasets	With Areas by type of actual use 2000 until 2006	With CLC 2006 and Areas by type of actual use 2006	Is planned with CLC	With CLC 2000 and 2006
Complete spatial coverage of Germany	Yes	No, 35 regions covered	Yes	No, administrative units
Thematic resolution in urban areas	Low	Very high	Low	Low
Spatial resolution in urban areas	Low	High	High	No

Table 1: Evaluation of different land use types by relevant criteria (Credits: BBSR).

It can be shown that all analysed datasets have both advantages and disadvantages. Table 1 gives an overview of the datasets characteristics.

Land use change modelling

Land use and land cover change are influenced by a large number of natural and social processes. Land use change models must understand and reflect these complex processes and interactions. They can be used to simulate natural succession processes, suburbanisation processes or to evaluate planning decisions.

There exist several land use change models, which differ in spatial extent, model theory, modelling approach or temporal resolution. A summarised overview is for example given in Stillwell et al (2007) or Hoymann (2010). One of them, a land use change model which is used within the research project *CC-LandStraD* (see project box) is introduced in the next section.

The Land Use Scanner

The analysis of measures for climate change mitigation and adaptation with regard to land use is done with a spatially explicit land use simulation model, the "Land Use Scanner". It is an operational, GIS-based land use change model, which uses an optimisation approach to balance demand for and supply of land on a grid level. All land use types can be modelled (Hilferink et al 2000). Figure 4 shows the principal models.

The demand for the different land use types is provided externally by sectoral models on the level of counties or federal states, which the Land Use Scanner distributes these demands. Suitability maps, which represent the supply of land, are developed from current land use, physical constraints like slope or soil types, distance relations and planning regulations.

The Land Use Scanner has been applied in several case studies already, for example in the Netherlands and the Elbe River Basin to analyse the effect of land use changes on the water cycle (Dekkers et al 2007, Hoymann 2010). In other studies flood risk assessment was the focus (Verburg et al 2012; Leeuwen et al 2012) or the *ex ante* evaluation of planning decisions (Koomen et al 2011; Jacobs et al 2011; Koomen et al 2008).

Choosing a land use dataset

As shown, up to now no dataset fulfils all requested criteria (Table 1). Thus, it is a matter of weighing up which dataset is chosen for the modelling task. Within *CC-LandStraD* the spatial and thematic resolution is particularly important. Therefore, the combined dataset of DLM-DE and UA will be used for the simulation of future land use changes.

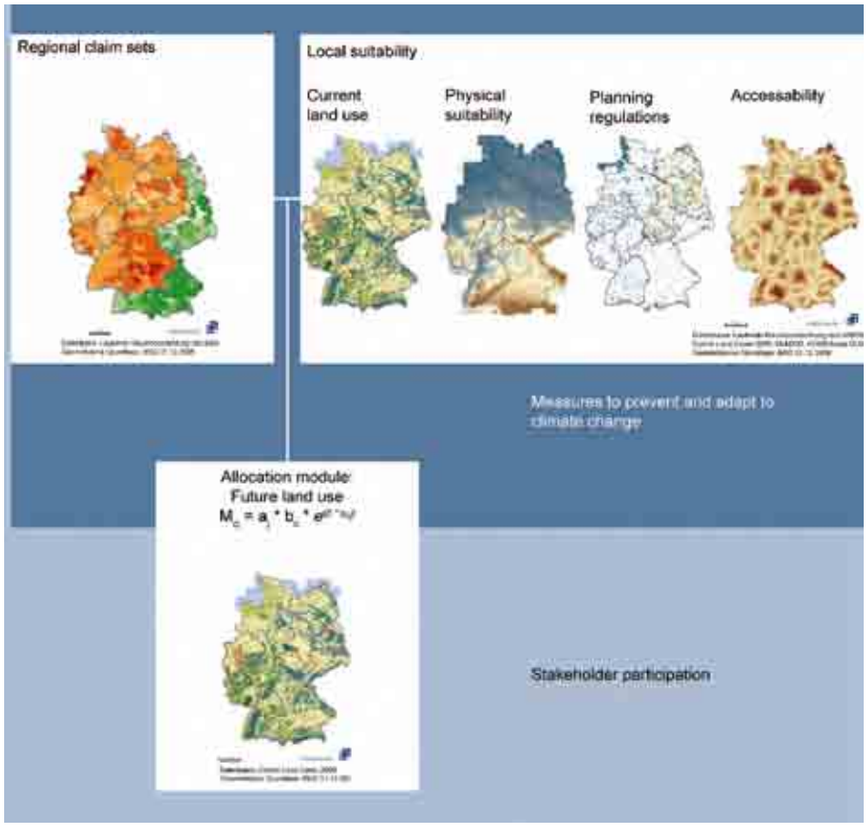


Figure 4: The Land Use Scanner is a GIS-based land use change model, which uses an optimisation approach to balance demand for and supply of land on grid level (Credits: BBSR).

DLM-DE is applied as a background database. The UA data is overlaid for the available regions but only for the artificial surfaces. The reason is that UA only has a better thematic resolution on artificial surfaces but not on agricultural, natural and forest areas. For the latter land use types the DLM-DE is preferred.

Conclusion

The development of new and up to date spatial land use data is a reaction to longstanding demands. Nevertheless, challenges remain. For most datasets, time series information is yet to become available, however, an update of the UA is planned for 2012. Furthermore, it would be helpful if the data could be more comparable. Due to the use of secondary data some progress has been achieved, but further harmonisation is desirable to be able to use the specific advantages of the datasets in a combined way.

The selection of a suitable land use dataset is crucial for the planned analysis of land management strategies in *CC-LandStraD* because reliable simulation results are only achievable with detailed information about the current situation. Within *CC-LandStraD* the combined dataset of DLM-DE and UA is used. After applying the Land Use Scanner model to Germany, the first results about suitable land use measures for climate change mitigation and adaptation are expected in 2013. They will be provided to and discussed with our stakeholders – regional and local authorities in Germany.

The *CC-LandStraD* project

Interdependencies between land use and climate change are complex and require the analysis of all land use sectors. The question of how land use in Germany can contribute to mitigating climate change is the central topic of the interdisciplinary joint project "*CC-LandStraD* – Interdependencies between land use and climate change – Strategies for a sustainable land use management in Germany". The project is funded by the Federal Ministry of Education and Research within the research programme "Sustainable land management". In applying the scenario approach, different cross-sectoral land use management strategies are developed. In a second step, the strategies are analysed regarding their efficiency and conflict potential in reaching the climate protection goals. Finally, recommendations for stakeholders are derived.

Dr. Jana HOYMANN holds a Ph.D. in Environmental and Land Economics from Technische Universität Berlin. She is currently a scientist at the German Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR) where she is responsible for the *CC-LandStraD* project. Past roles included work as a scientist in the GLOWA-Elbe project at TU Berlin. She has wide expertise in analysing land use changes in connection with climate change research by land use change modelling, especially of urban areas in Germany and Europe.

PanGeo: monitoring ground instability for local authorities

by Ren Capes

GEOHAZARDS ARE COSTLY, CAN BE DANGEROUS AND AFFECT US ALL. YET INFORMATION ON GEOHAZARDS IS EITHER NOT AVAILABLE OR VERY DIFFICULT TO ACCESS. A REASON FOR THIS HAS BEEN THE IMPRACTICALITY OF MEASURING THE GROUND INSTABILITY ASSOCIATED WITH MANY INSIDIOUS GEOHAZARDS THAT ARE OFTEN HIDDEN AND IMPERCEPTIBLE UNTIL IT'S TOO LATE AND THE DAMAGE HAS BEEN DONE. RECENT ADVANCES IN SATELLITE TECHNOLOGY, HOWEVER, NOW ALLOW THE WIDE AREA MAPPING OF EARTH SURFACE MOVEMENTS TO AN UNPRECEDENTED RESOLUTION, MEANING THAT MOTION HISTORIES DATING BACK TO 1991 CAN BE COMPUTED, SAY, FOR THE WHOLE OF LONDON IN ONE, ALBEIT HIGHLY SPECIALISED, PROCESS. THE *PANGEO* PROJECT IS BASED ON THIS NEW TYPE OF SATELLITE-DERIVED DATA. MOTION-MAPS FOR THE 52 LARGEST TOWNS OF THE EU ARE BEING ANALYSED AND INTERPRETED BY EXPERTS AT NATIONAL GEOLOGICAL SURVEYS, AND THEN MADE AVAILABLE IN A STANDARDISED FASHION VIA AN ONLINE VIEWING PORTAL. ALL *PANGEO* PRODUCTS ARE ENTIRELY FREE TO USE, EVEN FOR COMMERCIAL GAIN. THIS ARTICLE GIVES A LITTLE MORE BACKGROUND TO THE WORLD OF GEOHAZARDS AND DESCRIBES HOW THE *PANGEO* SERVICE CAN HELP FILL A VITAL GAP IN OUR KNOWLEDGE.

Mapping Geohazards

Geohazards are natural or man-made phenomena that make the ground unstable, and ground instability in the built environment can be dangerous and costly. Geohazards can fall into two broad categories; those that are sudden, obvious, wide-area, and sometimes catastrophic, causing significant loss of life and damage to property. Such geohazards include earthquakes, volcanoes and landslides and are generally quite easy to map, at least after they've happened – you can see where they are. But then there are geohazards that are more insidious in nature, slower, often invisible underground and below buildings, generally of less risk to life (although there are many exceptions), but still accounting for billions of euros of damage and costs to the economy each year. For example, the building damage caused by the cyclic shrinking and swelling of clay-soils in the English southeast, now exacerbated by climate change, costs the UK insurance sector an estimated €7 billion a year (British Geology Survey, 2001). That is just in one part of the UK for one type of geohazard. If one extrapolates the potential for damage from all the other towns built on clay soils across Europe, together with towns and structures built over old mines, water aquifers, on peaty soils, or reclaimed land, on fault zones, landslide-prone areas, on old sediments, and so on, one can begin to see that the overall costs of geohazards on our society are probably very high indeed.

Effects of typical urban geohazard (Credits: Paul Anderson 2010).

Not the normal route for the 49! (Credits: Mira66 2012).

> **"The service is aimed at helping Government Local Authority planners and regulators who are concerned with managing development control and risk"**

Given this state of affairs one would expect maps of all types of geohazards, showing what and where they are, to be readily available, especially to those that need them, like civil protection agencies considering strategies of preparedness, or to regulators and controllers of planning and development who need to ensure safety when granting permission to build. However, maps of geohazards are generally not available. If they are, they tend to be localised (e.g. a specific landslide), only about one type of hazard (e.g. an earthquake map of Europe), or confidential and only accessible to a few (e.g. insurance sector's claims' history databases). There is no general access to geohazard information. There is no standardisation in geohazard mapping.

The reasons for this general lack of availability are varied, but a key impediment has been the traditional impracticality, or *impossibility*, of mapping unstable ground over any kind of large area. For many years scientists have inferred susceptibility-to-geohazards by interpreting geological maps, but the actual detection and measurement of ground instability could only be performed on a piece-meal, reactive, or very localised manner.

To date, no one knows the extent of geohazards across our towns in any systematic way. No one could tell you how much the coal mining legacy might cost the European economy, or how many people are affected by local changes to the water table. The vital *hazard* component is missing from many emergency *risk* maps. In short, although geohazards affect us all, there is very little *accessible* information available.

Mapping ground instability from Space

In recent years, astonishing advances in satellite technology have been made. Using European radar satellites, high spatial and temporal resolution measurements are now routinely made of the 'motion' of the Earth's surface over time. This motion is directly related to ground instability and geohazards. For the first time, whole towns can be mapped in one process. These maps reveal the relative displacements to millimetre precision of millions of surface features which serendipitously reflect the radar signal back to the satellite (e.g. curb stones, sides of buildings, pylons). Motion histories can be computed from

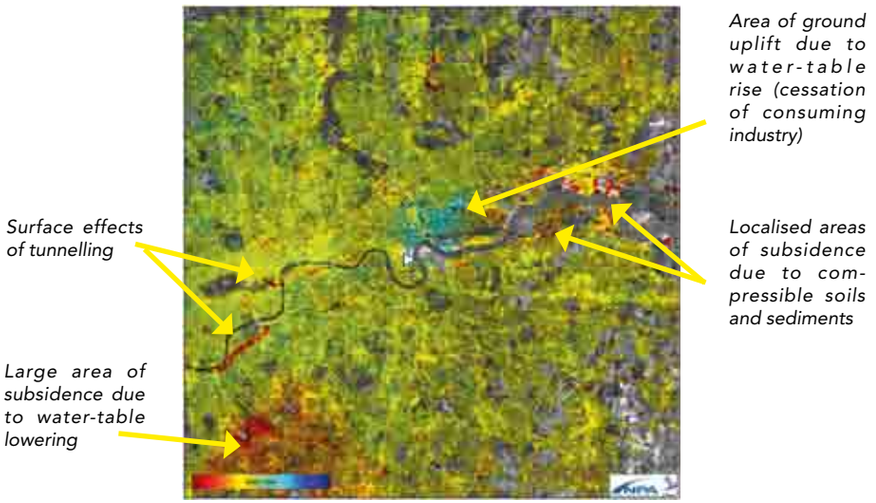


Figure 1: Average annual velocity map of London (Credits: FNPA 2000).

when the European Space Agency's ERS-1 satellite first started building an archive of radar images in 1991. The archives continuance is assured by the EU's forthcoming *Sentinel 1* radar satellite mission due for launch in 2013. The example image below shows a map of the average movement of London over a 10 year period. The red colours indicate movement *away* from the satellite and blue colours movement *towards* the satellite. Green and yellow colours represent stability. Various geohazard features can be observed.

The *PanGeo* Service

The map above is the result of a revolutionary technique called *Persistent Scatterer Interferometry*, or PSI. These kinds of data are forming the basis of a new service called *PanGeo* that is providing standardised information about geohazards for 52 of the EU's largest towns, equalling around 13% of the population. The service is entirely free and comprises an online viewing tool showing where geohazards, by type, are located in each town. Each geohazard location is dynamically linked to text providing an expert interpretation compiled by the country's national Geological Survey. The geohazard location maps and interpretations are both downloadable as stand alone files to be used in the user's own Geographic Information (or other mapping) System. The Figure 2 shows how Geological Surveys make the products.

Figure 2: Making PanGeo products (Credits: PanGeo project consortium 2011).

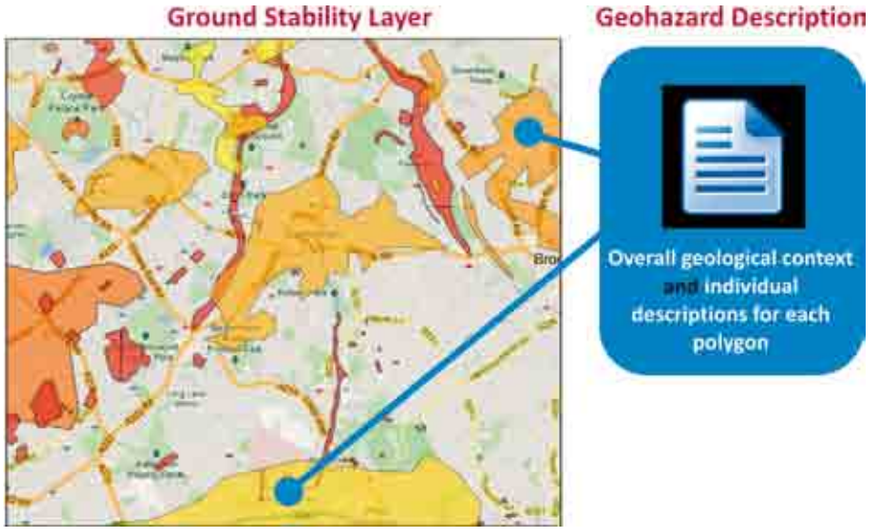


Figure 3: Representations of the PanGeo Ground Stability Layer and Geohazard Description (Credits: PanGeo project consortium 2011).

The process depicted above results in two main products compiled by the national Geological Surveys, a *Ground Stability Layer* and a corresponding *Geohazard Description* document – one each per town. The Ground Stability Layer shows areas of geohazard in six classes (which sub-divide into 20 in interpretation). The Geohazard Description contains a geological overview for the whole town, and then individual interpretations for each geohazard area. Clicking on a geohazard area will automatically open its interpretation.

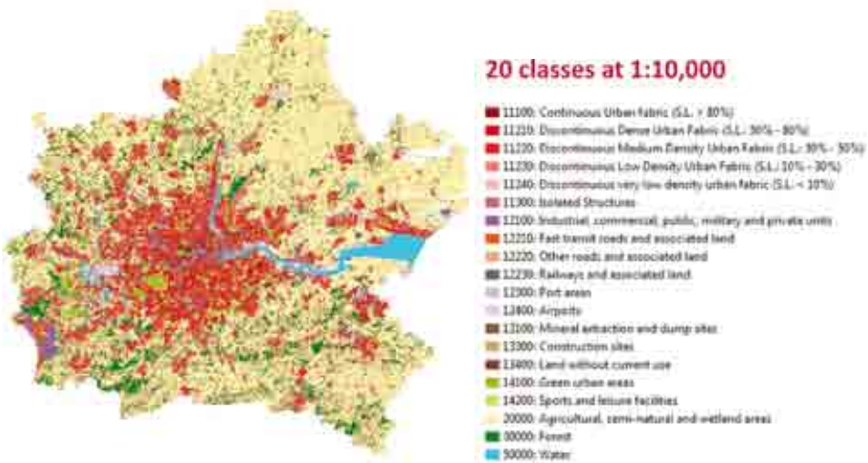


Figure 4: The EC's Urban Atlas landcover data for the London Larger Urban Zone (Credits: EEA 2012).

The *PanGeo* service includes integrations with land cover data and population statistics to provide statistical measures of geohazard-exposure. The EC's *Urban Atlas*, produced as part of the GMES Land Service, and available via the European Environment Agency (EEA), is a collection of 20-class, 1:10,000-scale, landcover maps for all 305 EU towns with populations over 100,000. See Figure 4.

Coinciding *Urban Atlas* data with the geohazard areas provides useful data on the types of buildings and structures and land cover types influenced by the hazard. By integrating population statistics available from the EEA, statistics are also given on the populations living and working on a particular land cover, that are affected by a particular geohazard type.

Access

Access to the information in *PanGeo* has been designed to be simple and intuitive, and to be useful to both the non-specialist and expert alike. Upon visiting the *PanGeo* website, the user clicks on a 'Coverage Map' link to see a familiar Google map of all the towns included in the service. Those marked green are complete, with red waiting to be done.

The user is given the choice of seeing the data either in the *OneGeology* Portal or via the familiar Google Earth interface (see Figure 6). Levels of transparency can be applied to allow visibility of all data layers. Statistics can be viewed, or products can be downloaded directly. Users can input their own post-code to see what geohazards might affect their area.

Figure 5: Access to PanGeo products (Credits: PanGeo project consortium 2011).

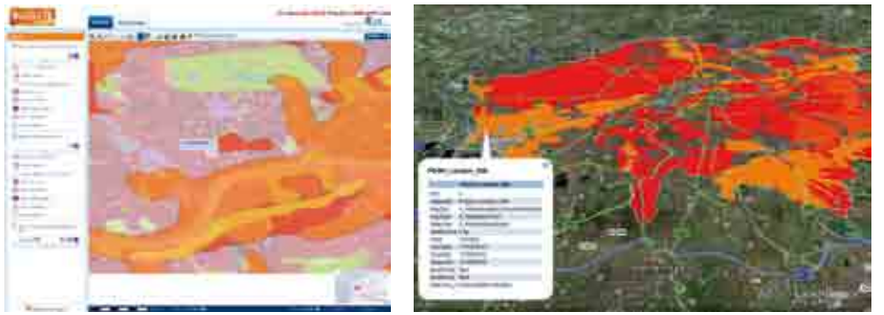


Figure 6: Visualising PanGeo products; either through the OneGeology Portal, or Google Earth (Credits: PanGeo project consortium 2011).

Target users of the *PanGeo* service

PanGeo is targeted at six key user groups:

- Government Local Authority planners and regulators who are concerned with managing development control and risk;
- Civil Protection Agencies who use *preparedness* data to aid disaster mitigation;
- National Geological Surveys and Geoscience Institutes who collect and disseminate geohazard data for public benefit;
- Policy-makers concerned with assessing and comparing pan-European geological risk;
- The public, for general empowerment;
- Commercial markets in insurance and environmental reporting.

Costs

The cost for a new town to be included within the *PanGeo* service is approximately €40,000. That includes the special PSI processing of the satellite radar data, interpretation by the local national geological survey,

About the *PanGeo* Project

PanGeo is a GMES project of the FP7 Space Programme. The project was conceived and proposed by Ren Capes of Fugro NPA Ltd, UK, who is now the project Coordinator. *PanGeo* comprises 37 partners in two teams: a *Core Team* of 13 partners including FNPA, the British Geological Survey, Landmark Information Group, TNO, SIRS, Institute of Geomatics, BRGM, EuroGeoSurveys, European Federation of Geologists, AB Consulting, Tele-Rilevamento Europa, Gamma Remote Sensing and Altamira Information. Finally, there is a *National Geological Survey Team* of 27 experts representing all 27 EU Member States.

For more information,
visit www.PanGeoproject.eu

PanGeo Town Listing

Country	Town 1	Town 2
Austria	Saltzburg	Vienna
Belgium	Brussels	Liege
Bulgaria	Sofia	Varna
Cyprus	Lefkosia	N/A
Czech Republic	Prague	Ostrava
Denmark	Copenhagen	Aalborg
Estonia	Tallinn	Tartu
Finland	Helsinki	Turku
France	Lyon	Toulouse
Germany	Berlin	Hannover
Greece	Athens	Larissa
Hungary	Budapest	Miskolc
Ireland	Cork	Dublin
Italy	Palermo	Rome
Latvia	Riga	Liepaja
Lithuania	Vilnius	Kaunas
Luxembourg	Luxembourg	N/A
Malta	Valetta	Gozo
Netherlands	Amsterdam	Rotterdam
Poland	Warsaw	Nowy Sacz
Portugal	Lisbon	Faro
Romania	Bucurest	Cluj-Napoca
Slovakia	Kosice	Presov
Slovenia	Ljubljana	Maribor
Spain	Zaragoza	Murcia
Sweden	Stockholm	Göteborg
UK	Stoke	London

The 52 towns being processed in PanGeo

compilation of the Ground Stability Layer and Geohazard Description, and finally, formatting the products in such a way that the *PanGeo* portal can harvest them from the Geological Surveys' servers in real time.

The 52 towns currently included

The following list shows the 52 towns currently included within the *PanGeo* service. Note that Cyprus and Luxembourg only have one town each as these countries only have one Urban Atlas dataset available as the threshold for inclusion in the Urban Atlas is a minimum population of 100,000. In most cases the towns chosen are simply the two largest in the country. The final decision has been made by the country's Geological Survey.

Ren CAPES has 18 year experience in satellite remote sensing, specialising in application development, project management and SAR interferometry. In 1995, Ren initiated the world's first commercial InSAR processing chain, going on to build what is acknowledged globally as one of the most successful InSAR processing capabilities. He was Chair of the earthquake panel that contributed to the *CEOS Disaster Management Support Group* – predecessor to GMES and the Charter. Ren instigated and led the ESA GMES Service Element project *Terrafirma* project from 2002 to 2009 (developing geohazard applications), and, besides involvement with several other ESA and EC projects, is currently Coordinator of the *PanGeo* FP7 Collaborative Project (involving 37 partners, including all EU27 national geological surveys).

Using GMES to map and monitor landslides and ground subsidence

by Fausto Guzzetti, Alessandro Cesare Mondini and Michele Manunta

LANDSLIDES AND SUBSIDENCE ARE WIDESPREAD AND FREQUENT IN EUROPE WHERE, EVERY YEAR, THEY CAUSE CASUALTIES AND EXTENSIVE ENVIRONMENTAL DAMAGES, WHICH OFTEN RESULT IN CONSIDERABLE COSTS. MASS MOVEMENTS ARE CAUSED BY A VARIETY OF METEOROLOGICAL, CLIMATIC AND GEOPHYSICAL TRIGGERS AND BY VARIOUS HUMAN ACTIVITIES. IMPROVED ABILITIES TO DETECT, MAP, MONITOR AND FORECAST MASS MOVEMENTS ARE IMPORTANT TO REDUCE THE CASUALTIES AND TO MITIGATE THE ECONOMIC AND ENVIRONMENTAL COSTS OF LANDSLIDES AND SUBSIDENCE.

DORIS is an advanced GMES service for the detection, mapping, monitoring and forecasting of ground deformation (primarily landslides and ground subsidence) that exploits European satellite technology already in use, and combines it with ground-based information and innovative modelling tools. Given the diversity of landslides and ground subsidence phenomena in Europe, *DORIS* is being evaluated in six study areas, with test sites in Italy, Hungary, Poland, Spain and Switzerland. The locations were selected to cover a range of physiographical and environmental settings, and represent the majority of types of ground deformations for which the service will be used. The test sites were also selected considering different societal, political and organisational conditions. This guarantees the widespread applicability of the *DORIS* service in Europe and elsewhere.

The sensors on modern Earth Observation (EO) satellites sensors can image large areas with unprecedented spatial detail, temporal revisit and potentially global coverage capability. The integration of multiple EO datasets and technologies with surface and sub-surface information provides new opportunities to advance our understanding of mass movements. Since the occurrences of these dangerous phenomena are complex and can vary widely, *DORIS* adopts a unique dual approach that combines Space-borne data and technology with ground-based data through innovative computer modelling tools. The approach is proving beneficial to the construction of a complete

Many European major cities are exposed to Geohazards. GMES data can be used before a geohazard occurs (monitoring and risk-assessment) or afterwards, notably to support the action of Civil Protections during the post-disaster management phase (Credits: Vikingenergy).

and detailed picture of the factors contributing to each ground deformation event.

"Mapping and monitoring ground movements help mitigate economic and environmental costs of ground-movements"

Mapping event landslides

DORIS exploits very high spatial resolution optical satellite images and innovative processing techniques to detect and map landslides caused by specific triggers, such as intense or prolonged rainfall events. To detect and map the landslides, the project adopts techniques based on the analysis of single images taken shortly after an event, and techniques that exploit pre- and post-event images jointly.

For example, on the October 25th, 2011, a high-intensity storm hit the Liguria coast of northern Italy with cumulated rainfall measurements exceeding 540 mm in 6 hours. The event caused numerous shallow landslides and debris flows, surface erosion, and flooding in an area exceeding 1000 km^2. The death toll was severe, with eleven casualties. Damage to agriculture and the environment was also severe. Immediately after the event, *DORIS* prepared an accurate map showing the extent of the areas affected by landslides and floods. This is important information for evaluating the amount of damage and to establish levels of residual risk. To prepare the map, on October 28th the acquisition of very high spatial resolution satellite images was commissioned for an area of 210 km^2 most affected by the rainfall event. On October 31st, the WorldView-II satellite acquired panchromatic and multispectral stereoscopic images of the area. The imagery was available on the same day. Using image classification techniques supervised by trained geomorphologists, landslides and flooded areas were detected semi-automatically on the satellite images, and an accurate map of the event was prepared. **Figure 1** shows a portion of the mapping obtained for Borghetto di Vara, a town that suffered massive inundation and widespread landsliding.

Figure 1 - Landslide and flooding map for Borghetto di Vara, Italy, where the impact of the high intensity storm of the October 25th, 2011, was most severe. The area suffered massive flooding and widespread mass movements. Mapping obtained by processing very high spatial resolution satellite images taken on October 28th, 2011.

DORIS has dealt with other events from around the globe. From the 5th to the 10th of August 2009, typhoon Morakot crossed the island of Taiwan bringing record-breaking rainfall. In some places, the accumulated amount of rainfall exceeded 2880 mm in 100 hours. The very high intensity precipitation triggered thousands of shallow landslides and debris flows, and caused inundations and massive mobilisation and deposition of sediments. The fatalities caused by landslides and inundations were at least 650 and the economic damage was severe. In the aftermath of the event,

Landslides pose serious threats to citizens living in areas prone to ground movements (Credits: Pflatsch).

DORIS prepared an event landslide inventory map showing the location and type of the landslides triggered by the typhoon. For this purpose, *DORIS* adopted an innovative image classification technique that exploits different measures of changes between pre- and post-event multispectral satellite images. **Figure 2** portrays an example of the mapping obtained processing images taken by the Formosat II satellite on July 3rd, 2007 and on November 5th, 2009 in an area where shallow landslides were particularly abundant.

"Monitoring is particularly important when the deformations affect urban areas, critical infrastructures, or the cultural heritage"

DORIS is advancing the current capabilities of detecting and mapping landslides in different physiographical and climatic environments. The results will be beneficial for civil protection and environmental authorities interested in knowing the extent of a landslide event and in assessing the impact of ground deformations shortly after an event.

Monitoring ground deformations

Where slow moving landslides are present, or where the ground is subsiding in response to human activities (e.g., mining, underground excavations, water or gas withdrawal), it is important to monitor the spatial distribution and the temporal pattern of the ground deformations. Monitoring is particularly important when the deformations affect urban areas, critical infrastructures, or the cultural heritage. Nowadays, accurate monitoring of ground deformations caused by landslides and land subsidence phenomena can be performed by effectively exploiting images captured by Synthetic Aperture Radar (SAR) sensors onboard multiple satellite platforms.

"Some of the end users are civil protection and local environment authorities"

DORIS exploits DInSAR techniques to monitor the long-term behaviour of the Ivancich landslide, in the Assisi municipality in Umbria, Italy. The Ivancich landslide is a deep-seated mass movement of the slide type that affects a residential area characterised by one- to

Figure 2 - Landslide map for an area in central Taiwan where landslides caused by typhoon Morakot in August 2009 were abundant. Mapping obtained processing optical satellite images taken before and after the event.

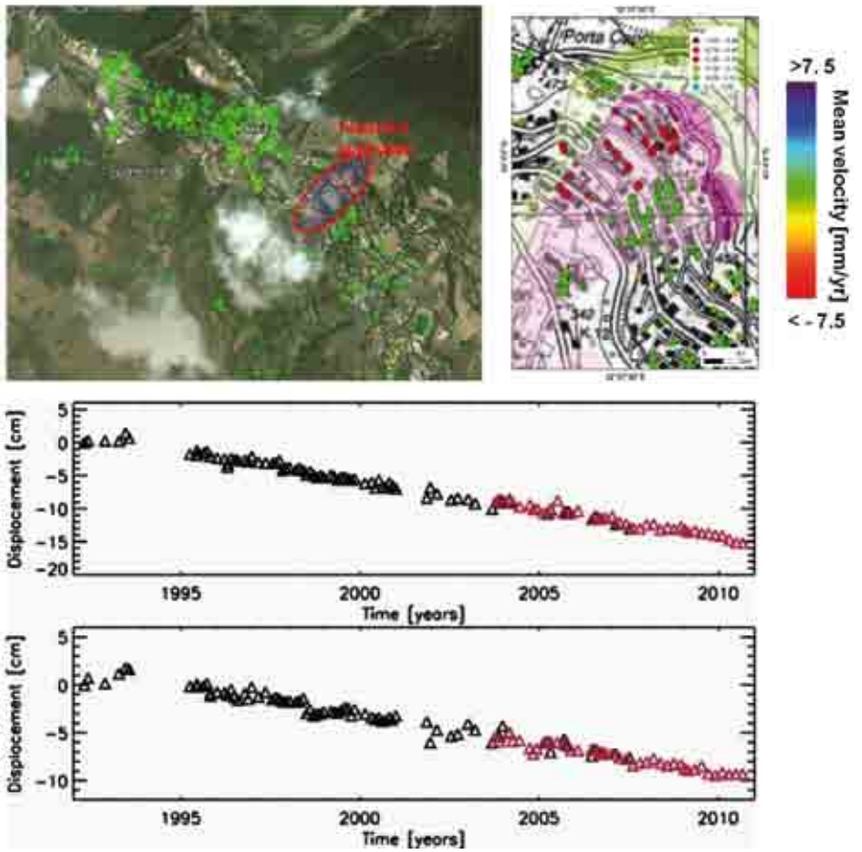


Figure 3 - Map showing the deformation velocity in a landslide area in the Ivancich area, Assisi, Italy, in the 18.5-year period from April 1992 to September 2010 and graphs reporting the temporal evolution of the ground displacements reaching a maximum value of about 15 cm during the analysed time interval. This map was obtained by processing 116 C-band images collected by the ERS-1/2 (black) and ENVISAT (red) satellites.

three-story private buildings constructed mainly between 1960 and 1970. The landslide also affects the Assisi hospital and a Franciscan convent. C-band SAR data, collected by the European Remote Sensing (ERS-1/2) satellites in the period April 1992 – July 2007, and by the ASAR sensor on board the ENVISAT satellite in the period October 2003 – September 2010, were used to obtain maps showing the total ground deformation and the average rate of deformation in the 18,5-year observation period. Processing of the satellite radar images produced a time series of deformation with an unprecedented temporal coverage for individual points ("targets") located inside and outside the landslide area i.e., in unstable and stable terrains. This information was used to single out sections of the mass movement that moved at different velocities during the investigated period. The information was also exploited to attempt a correlation between the time series of deformation and the local rainfall history recorded by a rain gauge. Results revealed the lack of an immediate effect of the rainfall on the landslide, and confirmed the existence of a complex temporal interaction between the precipitation and the mass movement. This is important information for deciding on remedial works to mitigate the risk posed by the Ivancich landslide. **Figure 3** portrays a map showing the deformation velocity in the landslide area in the 18,5-year period from April 1992 to September 2010 and graphs reporting the temporal evolution of the ground displacements reaching a maximum value of about 15 cm during the analysed time interval.

DORIS takes full advantage of the modern X-band SAR sensors on board the TerraSAR-X satellite and the Cosmo-SkyMed constellation of four satellites. The short revisiting time of the new SAR sensors and their improved ground resolution offer the unique opportunity to remotely investigate ground deformations characterised by average velocity rates of up to tens of centimetres per year. These are relatively fast-moving phenomena that cannot be monitored using C-band SAR sensors. In addition, compared to the old generation of C-band sensors, the new X-band systems significantly improve the density of "targets" on the ground where accurate deformation measurements are obtained. This facilitates the geological interpretation of the ground deformations.

For a test site located near Zermatt, Switzerland, where ground deformations caused by different geological phenomena exist, *DORIS* is collecting and analysing data captured by different SAR sensors, including images obtained by the ENVISAT and the TerraSAR-X satellites. In addition, the Gamma Portable Radar Interferometer (GPRI), an innovative ground-based radar system, is used to take repeated images of the test site. **Figure 4** shows mean deformation velocity maps performed by processing

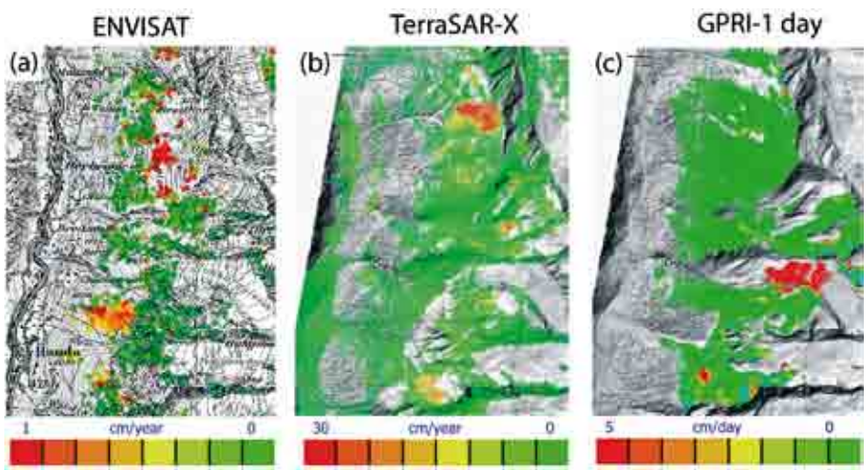


Figure 4 - Mean deformation velocity maps for an area near Zermatt, Switzerland, performed by processing data captured by (a) the ENVISAT satellite, (b) the TerraSAR-X satellite, and (c) the ground based Gamma Portable Radar Interferometer. Inspection of the maps reveals the significant increase in the number of coherent "targets" with the reduction of the sensor revisiting time (35 days for ENVISAT, 11 days for TerraSAR-X, one day for the Gamma Portable Radar Interferometer) (Credits: Tazio Strozzi, Gamma Remote Sensing AG).

data captured by different radar sensors. Inspection of the maps reveals the significant increase in the number of coherent "targets" with the reduction of the sensor revisiting time (35 days for ENVISAT, 11 days for TerraSAR-X, one day for the Gamma Portable Radar Interferometer).
DORIS exploits multi-sensor DInSAR techniques to construct very-long or high-frequency time series of ground deformations for selected test sites in Europe. This information proves to be useful to determine the kinematic behaviour of geological and geomorphological phenomena with ground deformations controlled by meteorological and climatic triggers.

Fausto GUZZETTI has a Master's degree in Geology and a PhD in Geography, and has more than 25 years of experience in landslide mapping, landslide susceptibility and hazard modelling and zonation, and landslide risk evaluation. Fausto Guzzetti was principal researcher of the ASI *MORFEO* project of the Italian Space Agency for the exploitation of remote sensing data and technology to mitigate landslide risk, and he is the principal researcher of the EU *DORIS* project for the design of a downstream service for the detection, mapping, monitoring and forecasting of ground deformations.

Michele MANUNTA has a Master's degree in Electronic Engineering and a PhD in Informatics and Electronic Engineering, and has more than 10 years of experience in high-resolution SAR interferometry data processing, geological applications, and SAR/GIS data integration. Michele Manunta has collaborated in various national and international projects for the exploitation of satellite technology, including the ASI *MORFEO* project. In *DORIS*, he is responsible for the project satellite acquisition and procurement programme.

Alessandro Cesare MONDINI has a Master's degree in Physics, is completing his PhD in Earth Sciences, and has more than 10 years of experience in remote sensing applications, including land surface temperature analysis, snow cover mapping and modelling, and landslide recognition and mapping. Alessandro Mondini has collaborated in the ASI *MORFEO* project, and he is the principal researcher of a bilateral project between the Italian National Research Council and the Taiwanese National Science Council for the exploitation of optical and SAR satellite data for the rapid mapping of event landslides.

GMES is an opportunity for regional and cross-border Territorial cooperation in europe

by the *Window on GMES* staff writers

THE *WINDOW ON GMES* TEAM HAD DISCUSSIONS WITH DR. WOLFGANG STEINBORN (GERMAN AEROSPACE CENTER – DLR) TO UNDERSTAND HOW GMES CAN BENEFIT CROSS-BORDER TERRITORIAL COOPERATION BETWEEN EUROPEAN LOCAL AND REGIONAL AUTHORITIES.

Everybody knows that "*grass is always greener on the other side*" and, when discussing GMES, local authorities in European Members States often say "*we have better geo-data*". However, this argument ignores the situation of border areas and cross-border activities. In most cases these areas are at an economic disadvantage. Cross-border territorial cooperation between neighbouring regions is high on the European political agenda, encouraged by the Cohesion Policy and manifested by the regulation concerning European Groupings of Territorial Cooperation (EGTC). This regulation, which is currently under consideration for enforcement, gives the EGTC a legal status with certain autonomy from national legislation of their respective Member States. In addition to this, besides the Committee of Regions and the Euro-Institute, a number of associations and networks are also dealing with cooperation issues between European regions.

Projects in the regional planning and cohesion context generally criticise the poor availability of suitable geo-information. An example is the ESPON FOCI study, which states the following in its final report: "*existing databases for urban research on cities across Europe are inadequate. Eurostat and DG REGIO are advocating the need for more territorially detailed data, but much depends on the support from Member States. The Urban Audit has proved very useful in this respect, and other initiatives supporting the provision of local data are emerging*"[1] The same study also states the following: "*However, in its current state, and even more so for the recent 2004 round than for the previous one, holes in the data abound and often with a very strong national boundary effect, making the use of the data difficult, or even impossible*"[2]. The emerging data mentioned in the ESPON FOCI study is a reference to the GMES European Urban Atlas, which provides pan-European comparable land use and land cover data for Large Urban Zones (LUZ) with more than 100,000 inhabitants.

According to Dr. Steinborn, there is a great opportunity for GMES to improve the situation of thematic geo-data-bases

[1] ESPON, Future orientations for Cities – final report, December 2010.
[2] ESPON, Future orientations for Cities – Interim Report, April 2009.

The number of cross-border commuters is increasing, thus affecting transport infrastructures as well as, for instance, long-term urban planning activities. Earth Observation provides data allowing the development of coordinated policies between cross-border areas (Credits: David Monniaux).

at the regional scale. At regional and local levels in particular, where potential applications of GMES are most abundant, the only solutions available to the users are Geographic Information Systems (GIS). Francesco Pisani stated the following in a March 2012 Unosat press release: "*The more GIS is understood and adopted, the more our work as experts in satellite analysis will be useful and relevant*".

There are several case studies of GIS use in cross-border areas around Germany and the perspectives for GMES. The case of Germany is particularly interesting since it has the largest number of neighbouring countries in Europe: 9 (France, Austria and Hungary have 8, Poland has 7). This entails a great deal of cross-border cooperation, which, when it comes to territorial and spatial management, is mostly done at the regional level.

Planning and information needs at cross-border regional levels

Progressing European unification has led to the current absence of border controls. This freedom to live and work in other EU Member States has driven people all across Europe to earn their income across borders, while continuing to reside in their home country. Mobility has indeed become a crucial issue in the European Union. This has led to enormous daily commuting in European border regions (e.g. Geneva region, Upper Rhine, "*CENTROPE*" of Vienna-Bratislava-Brno, Euregio Rhine-Meuse). The region around Luxembourg, which is part of the *Grande Région* of Wallonia, Lorraine, Saar, Rhineland-Palatinate and Luxembourg, is the cross-border region with the highest labour flow worldwide with almost 200,000 (out of the half million Europe-wide) daily commuters. However, a recent study has demonstrated that the administration and infrastructure situation has not kept pace with this aspect of European reality.

"Potential applications of GMES are most abundant at regional and local levels"

To ensure correct governance of territorial and infrastructure planning, disaster prevention or environmental protection, good geo-information (GI) is essential. This has been known since the inception of GIS in the 1970s. Mapping, the name by which geo-information was referred to in the past, has always been in the domain of national and even provincial governments. Hence the importance of initiatives such as the *INSPIRE* Directive (Infrastructure for Spatial Information in the European Community)[3], which in the era of globalisation, seeks to overcome existing interoperability problems. The *Grande Région*, which represents a 'little Europe' model area with the participation of regions from four EU founding countries, has a long pre-*INSPIRE* record of data harmonisation and application efforts as well as established cross-border administrative relationships in spatial planning, disaster prevention and management, and cultural and touristic affairs.

The *GMES Land Monitoring Service* encountered unexpected difficulties when exploring the usefulness of existing geo-data for a uniform land-cover/land-use mapping of the four-nation Saar-Mosel river basin, the area chosen as a test bed to develop services for the integrated reporting required under the Water Framework Directive and the Flood Directive[4]. The data had to be procured from many heterogeneous sources and under varying licencing conditions. Similar experiences occurred in other cross-border regions throughout Europe.

Cross-border best practices in geo-data treatment

In many border regions across Europe there are attempts under way to both harmonise existing and create new consistent geo-information content to support the increasing territorial cooperation between countries. Elements such as forests, water bodies, roads and even buildings occupy areas on both sides of a border, and their mapping will have to comply with the *INSPIRE* Directive[5]. The following is a brief overview of activities in Germany's neighbouring countries.

Germany – the Netherlands

Cooperation between mapping and cadastre agencies of the Land of North Rhine-Westphalia and the Netherlands has a long tradition. Activities focus on issues such as improving reaction times to natural disasters like floods and fires. Inconsistent map projections are overcome by transformation software to display both data sets equally and according to international standards. A joint geo-data infrastructure has been put in place, which would also allow seamless mosaicking of aerial and spatial imagery in the future. A number of application sectors have already been addressed through the INTERREG-IV project "*Cross-border geo-data infrastructure*" (http://www.x-border-gdi.org).

Germany – Czech Republic – Poland

Saxony is one of the most innovative and best organised of the new *Bundeslaender* in terms of geo-information. It borders the neighbouring regions of Silesia in Poland and Bohemia in the Czech Republic. This position has led to intense cooperation, especially across one of the oldest existing borderlines in Europe, which falls between Saxony and Bohemia (agreed in 1459). In a recently completed project[6], supported by the INTERREG-IV initiative, topographic data from both sides of the border were geometrically and semantically harmonised so that they can be used for diverse cross-border applications. In a small part of the area, the touristic Saxon-Bohemian National Park of the Elbe Sandstone Mountains, satellite remote sensing had already been employed in a precursor project for joint thematic maps and a terrain model.

[3] The GMES *HUMBOLDT*-Project quotes the necessary investment to harmonise all European geo-data to be 25 Billion €.

[4] European Union Directives 2000/60/EC and 2007/60/EC.

[5] European Union Directive 2007/2/EC and on-going specification of data listed in three annexes.

[6] Transboundary homogenisation of reference geo-data between the Free State of Saxony and the Czech Republic", Institute for ecological spatial development (IÖR), Dresden 2011, in German (http://www.geodat.ioer.info).

Cross-border impacts make it more important to improve coordination of disaster management and response capacities (Credits: SAFER and SERTIT).

Cooperation with Poland is not yet so advanced, although a framework agreement has been signed within which geo-data can be exchanged and projects conceived. Former joint projects include one in which *CORINE Land Cover* (CLC) data were tested to assess potential damage and help agricultural and environmental restoration in the aftermath of the Odra flooding in 1997. However, according to a German summary workshop on *CLC2000*, expectations of geometric resolution had not been met at that time.
Encouraged by the European umbrella organisation EUROGI and in support of these activities, the interdisciplinary geo-information associations (of private and public geo-information service providers, research and topical associations) from their respective countries (DDGI in Germany, CAGI in the Czech Republic and PASI in Poland) have agreed on having a trilateral exchange of best practices and cooperation in projects.

Germany – Austria – Switzerland

These three countries meet at Lake Constance where they have worked together in the International Lake Constance Conference (which includes Liechtenstein) since 1972. The *HUMBOLDT* GMES project triggered intensive efforts of geo-data harmonisation around the lake; one of the nine application scenarios focussed on water risks and took this region as a model case. It was necessary for existing data on roads, railways and water bodies to be interoperable, for which close cooperation between the mapping agencies and other actors involved in flood management was necessary[7]. The efforts have continued even after the termination of *HUMBOLDT* and the participants continue to provide their joint pool of geo-data for best practice application, and for which they even offer awards.

Special case: Grande Région

With the entry into force of the *INSPIRE* directive, and the compulsory requirement it establishes for Member States to create the metadata included in annex-II (terrain models, orthophotos, land-cover, geology) and annex-III (habitats, energy resources, atmospheric conditions, demography, land use, among others), the opportunities to use GMES increase considerably. Whereas all other cited cross-border harmonisation initiatives have so far restricted themselves to annex I (reference data), the *Grande Région* (GR) is more ambitious and plans to include thematic geo-data (covering annexes II and III) in its four-nation geo-data portal. The "GIS-GR" was decided upon by the 11th *Grande* Région political summit of 2009 and is currently under construction, coordinated by the geo-information agency of the German state of Rhineland-Palatinate. The bilingual statement (French-German) declares that for the main purpose of territorial development, the aim is: "*to create a GIS involving a Grande Région Internet Geoportal that enables to consolidate and harmonise all the existing data in the various partners and the existing data at European level covering the* Grande Région. *Finally, geographic data will be made available to the general public*"[8].

The 11th *Grande Région* political summit implementation plan lists the *ensemble of relevant GMES data*, be it soil sealing, forest, Urban Atlas, water or agricultural (mostly from the Geoland project), for inclusion in the GIS. For instance, the GMES Urban Atlas has given priority to conurbations of the *Grande* Région, and has mapped land-cover/land-use of the year 2006 at a scale of better than 1:10,000 in 21 classes, suitable for local mapping. The 10 large urban zones (LUZ) covered (three in Belgium, four in Germany, two in France and one in Luxembourg) correspond to about 20% of the whole *Grande Région*.

Uses of the Urban Atlas for today's challenges, such as curbing land take by holistic spatial and infrastructural planning, preparing for disasters and new energy concepts, have been discussed with municipal representatives of the *Grande* Région. However, structural political barriers to the use of GMES have surfaced during these talks. As much as urban administrations appreciated having large-scale consistent geo-information (i.e. taken at the same point in time and obeying the same data model and formats) from beyond their narrow city limits, there was little support from the surrounding regional authorities to engage in cross-border talks on these aspects. This dilemma was most evident in the case of the Grand Duchy of Luxembourg. The age of globalisation increasingly requires a new way of thinking in categories of larger spatial contexts beyond the confines of a border. The European EGTC legislation is a first step in that direction, but it is essential for national governments to follow.

An exceptional success story to this limitation in territorial competence is the *Sillon Lorrain* (furrow of Lorraine), where four cities (Thionville, Metz, Nancy and Epinal) have committed themselves to becoming the first *pôle* métropolitain according to a new French law of 2010. The purpose of this law is, similarly to the EGTC legislation, to foster sustainable spatial development and attractiveness of regions across territorial units (départements) and even national borders. In this particular case, the balancing of the already existing French West-East axis (TGV Est Paris-Strasbourg) by an enforced North-South axis is at stake. The measures considered include both improved rail connection reaching Luxembourg to cope with the overflowing daily traffic congestion, and connecting the waterways of Moselle and Saône to prepare for the expected growth in goods transport. Representatives of the region have

The Saar-Mosel River Basin is a good example of cross-border coordination between regions using GMES data.

[7] http://www.esdi-HUMBOLDT.eu/files/hs_eriska_user_report_diss_version_110405.pdf).

[8] 11th Summit of the Grande Région: Common Declaration – annexes, 2009 The GR is by size (65000 km²) and population (11 million)- comparable to Bavaria, Germany's largest state.

expressed an interest in using GMES data for these endeavours.

GMES is not only a provider of geo-information services, but an important element towards innovative territorial thinking in Europe in two ways: more holistic cooperation of politicians at all levels in a region, and the emancipation of thematic geo-information from the, until now, dominant reference geo-data. The latter is the most important aspect since there has recently been some dissatisfaction, voiced by hydrologists and soil administrators, with the way *INSPIRE* annex II and III data are specified in the manner of mapping agencies. The International Commission for the Protection of Mosel and Saar (IKSMS/CIPMS) has corroborated the advantage of using GMES by stating that *"the land-cover maps provided by GSE Land to the IKSMS/CIPMS are harmonised across the country borders. They are thematically better than any other available map information today. Thus these digital datasets can be used for a multitude of further environmentally relevant planning and management activities"*.

Conclusions and outlook

The expectations of the topical geo-information user communities in Europe are nowadays high with respect to the interoperability of not only geodetic or reference data (*INSPIRE* annex I) but also of thematic data (*INSPIRE* annexes II and III). Since this turns out to be an even greater challenge, there is room for additional pan-European geo-information content generation as in GMES, to fill gaps and provide standards on which to calibrate traditional data. A positive sign of this is that the number of topical user gatherings at which GMES is presented and discussed, is growing. A recent strategy forum on "Chances and potential of Earth Observation for public administration" organised by the German Ministry of the Interior and DLR in 2011, received a strong participation from regional authorities (almost 20% out of 160 participants in the event).

As far as Germany is concerned, two recent developments in German policy will boost the need for more thematic geo-data:

The "transformation of the German energy system" (known as the "Energiewende") refers to the move towards the age of renewables and energy efficiency. The German government decided that the country's energy supply should be generated primarily from renewables by 2050. This requires the energy supply system to be fundamentally restructured, confronting Germany with economic and technological challenges. Restructuring implies a transition from centralised towards decentralised supply, which in turn entails more regionalised and localised approvals needing an informed decision basis. Based on a recommendation of the German Science Council from 2009 regarding the research data infrastructure for the social, behavioural, and economic sciences, the German Data Forum (RatSWD) established an interdisciplinary "Geocoding Data" working group. By the end of 2011 the working group had produced a decision-oriented report with practical suggestions for the development and use of geo-data. In this report, the experts repeatedly stress the need for more detailed spatially referenced statistical data in a suggested grid spacing of 100 metres (which other European countries already have). This will produce an additional thrust for the generation and updating of thematic geo-data. The potential contribution of the GMES Urban Atlas towards higher resolution spatial data was presented to the international network SCORUS (Standing Committee of Regional and Urban Statistics) at its annual meeting in 2010.

The cases described illustrate the growing weight of regional and local use of thematic geo-data, which must be taken into account by the on-going research and development on Earth Observation, including GMES. Perspectives and limits of urban remote sensing for applications such as renewable energy sourcing, disaster prevention, security of mass events, soil sealing and transport management, microclimate improvement, spatial planning and land-use typologies and 3D visualisation, are reviewed in "*Remote Sensing in Urban Spaces – Earth Observation on its way to planning practice*" published by DLR in 2010 (in German).

The vast majority of local and regional geo-information users are not experts in Space technology and will not search for input data in GMES or other Space-related portals. On the contrary, they stick to geo-data sources they are familiar with, which in most cases are the national and provincial (Lander in Germany) geo-data portals. Data they do not come across through these portals do not exist for them and their providers miss a chance of broader use. The best strategy to enlarge regional and local use of GMES is therefore to offer it through established channels and geo-data infrastructures and in formats that are ready for overlay with other data. Projects that aim towards such kind of "intuitive access" are under way in Germany. Professional geo-information associations like EUROGI and its member organisations in European countries are ready to spread best practice experiences within the geo-information community.

ABOUT WOLFGANG STEINBORN

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SubCoast: Preparing services for monitoring changes in land elevation in flood-prone coastal lowlands

by David Hamersley and Rob van der Krogt

COASTAL LOWLAND AREAS ARE WIDELY RECOGNISED AS VULNERABLE LOCATIONS EXPOSED TO EXTREME EVENTS, WHICH CAN POTENTIALLY HAVE A LARGE RANGE OF SOCIAL, ECONOMIC AND ENVIRONMENTAL IMPACTS. CLIMATE CHANGE IS ONE OF THE PRINCIPAL CHALLENGES FACING THE WORLD, NOW AND INTO THE FUTURE. SCIENTIFIC STUDIES OF CLIMATE CHANGE, SUPPORTED BY ADVANCEMENTS IN SPACE-BASED TECHNOLOGIES, HAVE GREATLY IMPROVED OUR UNDERSTANDING OF THE NATURAL ENVIRONMENT AND THE COMPLEX INTERACTIONS THAT EXIST BETWEEN HUMAN POPULATIONS AND VULNERABLE AREAS SUCH AS COASTAL REGIONS. THE VULNERABILITY OF COASTAL REGIONS TAKES ON TWO ASPECTS: THE DIVERSE IMPACTS FROM THE SEA AND ANTHROPOGENIC IMPACTS RESULTING FROM INCREASED LAND USE. SUBSIDENCE IS A HAZARD THAT CONNECTS BOTH OF THESE ISSUES AND IS THE FOCUS OF THE *SUBCOAST* PROJECT.

Subsidence and Associated Hazards

Ground subsidence has many causes that can be divided into two broad categories; shallow due to, for example, peat oxidation, compaction and groundwater extraction and deep due to, for example, tectonic phenomena and effects of mining and extraction activities (gas, salt). Although subsidence can be a direct hazard (e.g. landslides, sinkholes), more commonly it is the associated hazards that are exacerbated by subsidence, which are a greater threat to human populations and livelihoods. Subsidence is generally under acknowledged as a geohazard, indeed subsidence movement is generally too slow for human perception and effects are often invisible, at least before structural damage appears. This makes subsidence an insidious threat, which may proceed undetected for decades, having a significant cumulative effect on both the primary and associated hazards.

> "*SubCoast* is designed to allow identification of regions and structures that need to be monitored"

In coastal lowland areas the most obvious hazards exacerbated by land subsidence are those associated with water. Recent climatic trends have shown changes in the distribution and intensity of precipitation events. At the same time, global sea level has reached an annual average rise of approximately 3 mm during the last two decades (Bally, 2012), although regional differences exist (mean sea level has fallen in some locations). Combining this information with measurements of downward changes in land elevation would allow easier identification of Local and Regional Authorities (LRAs) exposed to increasing flood risk, thus allowing them to design mitigation plans. Existing mitigation measures such as flood defences can also be monitored to determine their efficacy over time. Infrastructure failures due to reduced budget allocation or ground subsidence beneath flood defences usually carry large costs and increasing risks if left unchecked. The *SubCoast* service is designed to identify regions and structures in need of attention. Other collateral data such as variations in groundwater tables and water balances could also be used in conjunction with *SubCoast* core products to highlight hazards posed by increased exposure to flooding, water shortages and the social and economic implications that might arise.

Risk has various definitions and connotations but is commonly associated with the potential (or probability) for a hazard to be realised as an event resulting in a loss (ISDR, 2009). This loss may relate to human life, infrastructure, the environment or a multitude of other factors. Subsidence is a hazard in its own right, but other processes leading to changes in land elevation and that alter the landscape, as well as the way the various processes interact with each other can compound the situation. For example, subsidence can increase the possibility (frequency or magnitude) of flooding events in certain areas (so-called 'risk zones'; see figure 1).

User Communities of the *SubCoast* services

SubCoast aims to provide data on changes in land elevation at a number of different scales: local, regional, national and European. User communities with a potential interest in *SubCoast* services are those principally interested in monitoring risks which may threaten human life or put infrastructures at risk. Users of the *SubCoast* services include stakeholders dealing with issues pertaining to hazard management, monitoring and policy development (e.g. water boards, infrastructure departments of ministries, provinces, regions and municipalities throughout European coastal regions, as well as authorities at European scale such as the European Environment Agency).

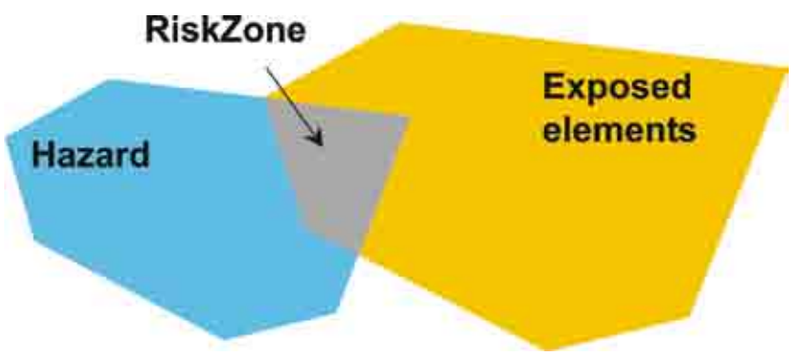

Figure 1. Concept of 'risk zones', based on INSPIRE: «Natural risk zones» where natural hazards areas intersect with highly populated areas and / or areas of particular environmental / cultural / economic value (indicated as 'exposed elements') (INSPIRE, 2007; http://inspire-forum.jrc.ec.europa.eu/pg/pages/view/1768) (Credits: TNO).

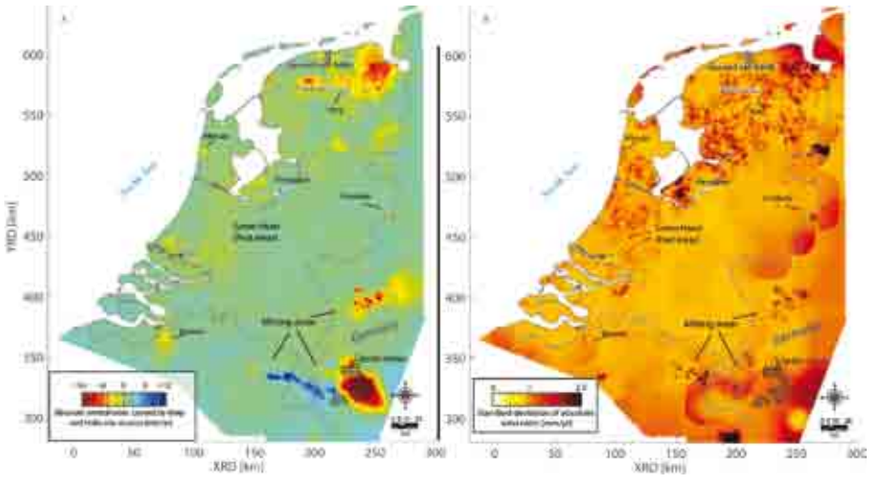

Figure 2. Absolute wide scale subsidence maps of the Netherlands, showing estimated rates of elevation change in mm/year, and the connected estimated standard deviation of these values (Credits: Hanssen, 2012).

Development of a Land Elevation Change Map or a 'Dynamic Digital Elevation Model'

Providing land elevation change data in coastal lowland areas is the principal ambition of the *SubCoast* project. Elevation change rates need to be connected reliably to a regional or national common reference point or geodetic datum. With regard to flood risk management, this is required to enable the determination of land elevations relative to sea level, including the changes in both levels over time (i.e. land subsidence and sea level rise). The *SubCoast* project therefore has defined the production of a so-called "Dynamic DEM (Digital Elevation Model)" to show variations in ground elevation for a location, as a function of time. In this instance the DEM is defined as a digital terrain model which excludes building cover, showing the ground elevation, connected accurately to a regional or national datum. In many regions or countries DEMs are available from either optical or radar measurements (optical or SAR stereoscopy, SAR interferometry); sometimes more information is also available from levelling, GPS, or other measurement campaigns. The additional value of a *Dynamic* DEM is to express the *rate of change* of elevation of terrains. Connected to a local or regional DEM it creates the possibility to estimate future terrain elevation. However, despite the fact that a Dynamic DEM expresses quite simple and explicit parameters (elevation change rates/ absolute elevation), there are substantial technical issues to be solved. At this stage of the *SubCoast* project, the most advanced result with regard to the development of a Dynamic DEM is the so called "absolute wide scale subsidence map" of the Netherlands (Hanssen, 2012). Figure 2 is an illustration of this product, showing estimated vertical rates of changes in elevation. The second map shows the estimated uncertainties associated with the dynamic DEM as an illustration of the required quality characteristics. Methods and solutions for Local and Regional Authorities are still to be fine-tuned.

Service Delivery

Methods of delivery of *SubCoast* services are still subject to discussion with potential users. However, it is anticipated to develop a web-based geo-portal as the most effective means of data viewing and access. The geo-portal will provide relevant data, information and maps depicting absolute ground level at different times on local, regional, national, and pan-European scales. This geo-portal will be the first stage potentially of a more comprehensive service in the future, covering much wider areas, larger time scales, with more developed models and scenarios. At this preliminary stage the service will build on limited datasets and information within the pilot areas.

Pilot Studies at regional level

Four pilot studies have been devised to develop the *SubCoast* service. These pilots include the Rhine Meuse Delta in the Netherlands, the Southern part of the coast of Emilia-Romagna region in Italy, and a part of the Baltic area that was subdivided into 3 countries: Denmark, Poland and Lithuania. The fourth pilot is comprised of a parallel 'European integration' of services.

The four pilot study sites are distributed across several countries in Europe, and therefore have a variety of factors influencing their vulnerability to hazards even though they all have coastlines.

Baltic pilot: Pilot studies performed in the Baltic using PSI have yielded results showing general terrain stability. However, the study of past and present

Persistent Scatterer Interferometry

The main data for producing the Dynamic DEM is derived from a satellite-based technique called Persistent Scatterer Interferometry (PSI). PSI uses multi-temporal stacks of radar data to measure millimetric changes over time in the distance between the satellite and radar-reflecting ground features. PSI thus measures 'terrain motion' and has several advantages such as high precision and wide-area coverage. It is also non-invasive (see figure 3). PSI is constrained however, by land cover characteristics (vegetated areas do not reflect back to the satellite with sufficient coherence for the technique to work), the measurement being a single dimension 'line-of-sight' from the satellite, and availability of satellite data in archive. This latter constraint will be significantly eased by the successful (and enduring) operation of the European Commission's forthcoming Sentinel 1a and b satellites carrying a SAR instrument, the first of which is due for launch during 2013.

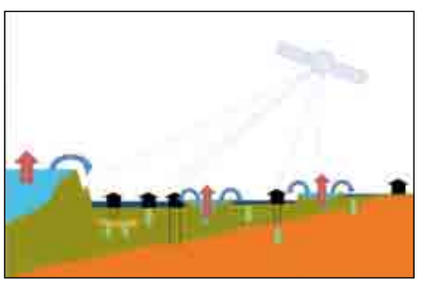

Figure 3 PSI data is gathered by satellite synthetic aperture radar (SAR) systems to determine ground motion in the vertical plane, e.g. for the purpose of flood risk management in coastal areas and river plains. Fixed ground-based objects such as buildings and infrastructure provide an ideal source of backscattered signal (Credits: TNO).

orthophotos have revealed substantial advance and retreat of the coastlines due to the accumulation and erosion of shoreline sediments, which in some regions have already led to the destruction of some buildings. More crucially, the erosion of natural defences, such as sand dunes, has been shown to represent an imminent threat.

Rhine-Meuse pilot: The Dutch pilot offers a unique case where changes in land elevation play a significant role in the management of flood risk and security of water resources. The region of the Waterboard Delfland is characterised by soft sediments And the natural process of peat oxidation causes a consistent rate of subsidence. Groundwater levels are continuously adjusted to account for corresponding reductions in ground level. Unfortunately, adjustment of groundwater levels also increases the amount of subsidence, contributing to a positive feedback loop, hence resulting in a continuous natural/man-made subsidence cycle. Human impacts on the groundwater levels may affect different aquifers at different depths. To obtain a better understanding of causal relations, PSI processing over the period 1992-2000 was performed to separate ground level measurement points from those of buildings. Since buildings in this location are often founded on deep sand layers, they are not sensitive to shallow aquifers. Comparing the results of subsidence rates of buildings and deformation of the ground demonstrates the significance of the topsoil layer in the process.

Italian Southern Emilia-Romagna pilot: This study focuses on a low lying coastal region at the base of the Apennine foothills. Natural subsidence, together with the effects of groundwater pumping from shallow depths in Southern Emilia Romagna, has resulted in subsidence and in erosion of the coastline, lower efficiency of the waterworks and a significant increase in the risk of flooding. PSI results were validated and integrated with satellite navigation positioning data and a database of historical levelling data. The aim was to extend conventional PSI-processing from a line-of-sight displacement estimate to full 3D.

European Integration pilot: Efforts towards a pan-European integration have required confrontation of various issues including: determination of user needs, assessment of data availability based upon cross-cutting technologies, identification of an initial development site, development of methodologies for high and lower data availability scenarios, and trial and validation of methodologies.

Conclusions

The reduction in land elevation is a real yet often imperceptible hazard in coastal lowland areas that over time can have detrimental and cumulative impacts on a coastal community's infrastructure and economic capabilities, for example through an increase of flood risks. The forthcoming improvement in the availability of data promised by the Sentinel 1 mission will significantly enhance the potential of Dynamic DEMs, especially if longer time series of data are acquired. *Terrafirma*, *SubCoast* and related research provide important first steps for the development of more comprehensive monitoring services, consisting of a complete chain of data collecting, processing, interpretation, modelling, and the release of this information through interactive portals, for integrated services for risk management.

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Rob VAN DER KROGT, educated in Spatial Planning and Policy Management (MSc), has 17 years of experience in managing projects related to (spatial) policy development, infrastructure (ports, roads, railways), geo-information, water management and climate adaptation in the Netherlands and Europe. He has been affiliated with DHV Consultancy and Engineering, Deltares and TNO/Geological Survey of the Netherlands. For TNO he is now fully involved as project coordinator for EU-projects, such as FP7-Space project '*SubCoast*' that builds services from Earth Observation for monitoring and forecasting subsidence hazards in coastal lowland areas, and the *'EGDIScope'* FP7-Infrastructures project, preparing a European Geological Data Infrastructure. The latter project is an important pillar for the common international strategy of 27 European Geological Surveys.

GMES services for renewable energies provide support to Local and Regional Authorities

by Claire Thomas and Lucien Wald

THE EUROPEAN UNION (EU) HAS COMMITTED TO PROVIDING 20 % OF EUROPE'S ENERGY FROM RENEWABLE SOURCES BY 2020. THE DEVELOPMENT AND ACCEPTANCE OF RENEWABLE ENERGIES IN EUROPEAN LOCAL AND REGIONAL AUTHORITIES (LRAs) ARE CURRENTLY LIMITED BY A LACK OF KNOWLEDGE OF THE RESOURCES THEMSELVES AND OF THEIR VARIABILITY IN SPACE AND TIME. THE EUROPEAN UNION HAS MADE GREAT EFFORTS TO PROMOTE TOOLS FOR THE MAPPING OF RENEWABLE RESOURCES AND TO FAVOUR THE DEVELOPMENT OF SERVICES IN LINE WITH THE EXPECTATIONS OF EXPERTS AND LRAs. THE *ENDORSE* PROJECT IS A REALISATION OF THIS OBJECTIVE OF THE EU. TEN SERVICES EXPLOIT EARTH OBSERVATION DATA IN FIVE ENERGY DOMAINS (WIND, SUN, ELECTRICITY LOAD BALANCING, BIOMASS AND DAYLIGHTING) WITH THE AIM TO PROVIDE SOLUTIONS AT A REGIONAL SCALE. THESE SERVICES ARE PRECURSORS AND SHOULD STIMULATE THE DEVELOPMENT OF SIMILAR SERVICES IN OTHER REGIONS.

The demand for energy is increasing in the European Union (EU). An increasing exploitation of renewable energies is one of the options currently adopted to meet this demand. Renewable energies - exploiting sun, river, sea, wind, geothermal, and biomass - have been known for many years and are currently exploited to some degree in the EU. What is required now is a large increase of the production of energy from these renewable sources in a paradigm shift for the industry. Dealing with a much larger share of renewable energy production is a crucial challenge, which is receiving a lot of attention from researchers, engineers and other stakeholders.

Wind and solar energy are currently the two renewable resources with most development. As these sources, are volatile – being subject to weather conditions – and often organised as distributed generation units, their effective exploitation requires careful analysis in terms of power system planning and operations. To reduce operational uncertainty and maximise return on investment, resource evaluation and monitoring tools are essential for the management of energy production. They can significantly contribute to reducing the cost of planning and deploying renewable energy plants and to the integration of these variable energy sources into the overall energy system. The percentage share of renewable energies is increasing and so is the demand for electricity. Network managers require accurate forecasts to balance generation and consumption in real-time, or to manage large-scale storage in water pumping facilities and, soon, in large-scale electrochemical batteries. Facility operation managers are also using real-time assessments to detect potential breakdowns by comparing expected and produced power outputs. Tools already available on the market for accurate evaluation and forecasting of resources are costly. For wind farms or solar plants, at least one full year's analysis of meteorological measurements should be performed. This necessitates to purchase *ad-hoc* instruments and to ensure operation as well as maintenance. Furthermore, a dedicated analysis of the measurements, including quality-check, is required. The optimisation of these costs is all the more important as they are incurred a year before decision on investment is made. Airborne photographic and terrestrial surveys are the current means for assessing local biofuel potential of a forest. These surveys are expensive, often of limited extent, and can therefore not be carried out very regularly. As a consequence, yearly changes in biomass are not detected.

About the *ENDORSE* project

ENDORSE is a three-year project co-funded by the European Commission running until 2013. It aims to help regions by developing services to increase knowledge and understanding of their various renewable energy resources as well as improving management of electricity load.

The *ENDORSE* project aims to provide user-driven development of new services in the renewable energies field by exploiting existing GMES services and other Earth Observation data and models. It deals with regional services by promoting energy use from sun, wind, and biomass and also addresses electricity grid management at local level. *ENDORSE* meets the needs of:

- expert companies delivering resource data and forecasts, tailored to specific needs in renewable energies;
- industrial end-users (engineering consultancies, energy producers, investors, plant managers, maintenance services and electricity grid managers);
- public authorities and other organisations supporting policy making, incentives and permit delivery at national, regional or local levels, as well as European policy makers in charge of supporting the implementation of EU policies.

"There is a strong demand from the renewable energy community for an integrated service"

ENDORSE is developing ten services in collaboration with regional users. These services are listed below (three are detailed later in this article):

- "Local Solar Atlas Generation" aims to produce local atlases for decision-support in solar energy policy planning and private investment. An atlas has been produced for Provence, France;
- "Design CSPS" provides a design for Concentrating Solar Power Systems and *a priori* analyses of their performances. A demonstration is made for Sicily, Italy;
- "Irradiance Forecasts" produces short-term forecasts for electricity production of a solar plant located in Andalusia, Spain;

- "TMY" produces highly spatially-resolved Typical Meteorological Year (TMY) data sets for the design and performance assessment of complex solar energy-based systems for electricity production. It is tested in Provence, France;
- "CSP-GIS" produces a Web-based GIS (Geographical Information System) for concentrating solar power systems. The demonstration area is Morocco;
- "Certification of Sustainable Bioenergy Use" aims at certifying the sustainable production of bioenergy products that are imported in the European Union;
- "Lighting energy savings" computes the possible annual savings in energy that would result from the control of blinds and artificial lights by incoming daylight in buildings. A demonstration site in Nantes, France, shows a benefit for building design and retrofit, energy regulation policy planning, and private investment.

The Wind Energy Service

The development of an on-shore wind farm requires an accurate assessment of its Annual Energy Output, even at an early stage, for decision making, investment assessments, and the correct sizing of the plant. Such an assessment is made by engineering companies using numerical models whose inputs are taken from the planned wind power system, and geographical and meteorological information related to the site. Data describing the wind power system are directly communicated by the wind-farm developer and can thus be easily collected. However, information relating to meteorology and wind potential, such as surface orography, surface roughness, and local wind climate is more difficult to collect and to analyse. All these data are scattered across many sources of different quality. As a consequence, the data for the first steps of a project evaluation are very challenging to collect and process.

Various stakeholders are facing this challenge: local policy administrations working for energy planning and investment, public authorities and banks in charge of evaluation of premises, and finally the developers of wind farms themselves.

Therefore, there is a strong demand from the renewable energy community for an integrated service that would offer first-line resource assessment estimation. The *ENDORSE* service entitled "generation of Annual Energy Output (AEO) for decision-support of wind energy policy planning and private investment" meets this demand. It provides estimates of wind resource for a wind farm with the capability of combining various data required in the decision-making process.

The Belgian company 3E is developing this service. One of the main innovations is to use the powerful daily numerical weather prediction models to obtain maps of the wind at surface and in vertical profile. The second innovation is the enhancement of these maps both in the horizontal and in the vertical directions, leading to the respective resolutions of 200 m and 20 m. The enhancement is performed by a model whose inputs are the orography and the aerodynamic roughness length derived from a map of land cover. Finally, these maps of intensity (Figure "W1") and profiles of wind are combined with the specifications of the wind power system to produce the Annual Energy Output. Before presenting the service to users, 3E has validated its results against measurements made in a few wind farms. The relative average error and standard deviation are 1% and 6%.

The user perspective

The prime-user of this service is EDF-Luminus, the second largest player on the Belgian energy market, with a total production capacity of about 2 000 MW. 12% of the production capacity of EDF-Luminus is derived from renewable energy sources in Belgium.

EDF-Luminus was surprised that the Wind Service only requires wind speed data over the last 10 years, instead of the usual 20 to 30 years required by banks and investors. 3E advocated that recent research results show a continuous slight decrease of the mean wind speed over this area, therefore the last 10 years are more representative of the current situation than a longer period.

EDF-Luminus was then informed that it would take about a day to get the results. In fact, only a few minutes were necessary to deliver results. The user expected a maximum 10% deviation between the results obtained by the Wind Service and those resulting from previous *in situ* measurements. Finally, the deviation was limited to 6%, hence matching the expectations of EDF-Luminus.

The first version of the service was only available for a single wind turbine. The influence of other wind turbines on the wind flow ("wake" influence) was not yet taken into account. This was a requirement expressed by EDF-Luminus and it is currently being added in the service.

The user expressed its interest in several options such as an increased number of ground stations for calibration by importing mast measurement data to perform the Annual Energy Outputs (AEO) calculation, or the possibility to use real production data in the calculation either to allow comparison or to use in the case of wind farm extension.

The first version has not yet included the option to choose between a co-ordinates system or to locate a point on an aerial picture or on a map.

User testimony: *"The current outcomes of the service are in line with the expectations. The overall achievements are suitable."*

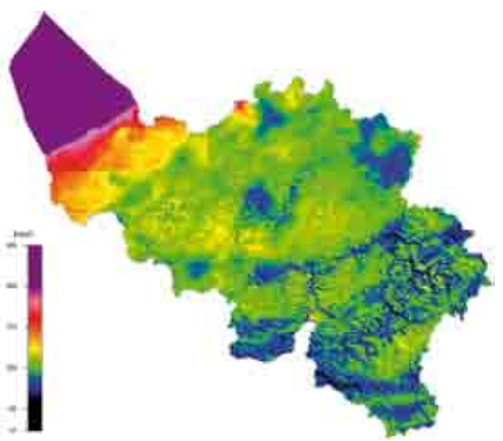


Figure "W1": Map of wind power density (W/m²) at 100 m above ground level (Credits: 3E).

The key benefit of this service is the automation of the whole process. Currently, operators spend many days handling data, but by using the numerical weather prediction (NWP) outputs and the fusion with other geographical information, the process is much more automated and is completed in less than one hour instead of several days.

"The benefit of these services in the daily life of the users has been proven"

Service for an increase stability and reliability in electricity supply with a large fraction of solar energy

An increasing amount of electricity is now produced by photovoltaic (PV) power systems. Rapid changes in solar radiation induced by changes in cloud cover lead to fluctuations of the power produced by these PV systems. Such fluctuations have adverse effects on the stability of the grid and quality of delivery in electricity (frequency, voltage). The impacts of these effects increase with the increasing proportion of PV power in the total production, Therefore grid operators want to foresee how a larger fraction of solar power will impact the grid. The grid operators need to know how solar power could be integrated in the load forecast and the scheduling of conventional power plant operation for efficient grid management. An accurate knowledge on the behaviour of solar power at utility level is a prerequisite for the development of energy services and load balancing.

The Ulm University in Germany has developed a service called "load balancing within electricity distribution grids enabling high penetration of photovoltaic power systems". It aims at providing forecast of power produced by an ensemble of individual PV systems, thus helping the electricity grid managers to balance the load over the grids to maintain the quality of the provision of electricity to customers. Such a forecast has been done so far only with virtual grid models.

Figure "E1" is an image resulting from the processing of data acquired by a very high spatial resolution satellite. It depicts roofs in a district and individual PV systems pertaining to a low voltage sub-network. A model of electricity yield is made for each of these PV systems. Thus a map of production potential is obtained. This map is an input to the method for forecasting the production of the sub-network. The other inputs are the forecasts for temperature and wind from numerical weather prediction models and for solar radiation derived from another *ENDORSE* service. The forecast of each sub-network offers supplementary information that can be integrated into the grid management operation centre. The capacity to represent and forecast fluctuations at the scale of the sub-network is an essential asset of this service.

Figure E1: Processed satellite image of a district on the periphery of Ulm, Germany. It is composed of 133 houses 17 with PV installations with a total of 221 kWp, a transformer of 630 kVA and an area of 0.2 km² (Credits: Ulm University).

The major benefits of the service are the improved efficiency of grid planning and grid management processes. A better knowledge of the solar power forecast at local scale induces a decrease in error of load forecast and, consequently, an improvement in the planning accuracy and in the predictability of grid operation. As investments are necessary to adapt the grid to increase the number of solar systems, this service brings additional knowledge and leads to a safer return on investment.

The user perspective

SWU Netze GmbH is the prime-user of this service. This company is a German utility owned by the towns of Ulm and Neu-Ulm. SWU is active in the energy and transport sector and has about 100 employees. It is responsible for the operation of the local electricity, gas and water grids. By 2020, SWU intends to rely only on renewable energy sources to cover 100% of the electricity demand for private households. SWU owns and operates several renewable energy systems. The production of each individual PV system is added to the low-voltage grid. SWU faces the challenge of balancing this variable production to ensure the quality of electricity supply.

SWU was satisfied that the irradiance, the ambient temperature and the wind speed were considered within the model. Later in the course of the *ENDORSE* project, SWU will also be given the option to input meteorological parameters.

User testimony: *"This new product in the research framework brings great improvement. None of the previous systems is actually comparable."*

Service for biomass of forested areas

The biomass of forested areas is currently used for energy and material purposes; an increase in its use for energy is expected in order to substitute fossil fuels. In addition, the cultivation of short rotation forests as a biofuel resource will get more attention in the coming years.

Forests are managed by public agencies or private owners who design the policies and strategies for forest exploitation and management. Airborne photographic and terrestrial surveys are the main means for assessing the biomass potential of the forest at regional scale. These surveys are expensive, they only cover limited areas and cannot be carried out frequently enough to be able to follow rapid changes in biomass. This means that important changes in the forest are missed, resulting in incomplete monitoring and less efficient management.

A reliable and automatic method for forested areas growth estimation therefore becomes more and more attractive especially when large areas are investigated. The DLR, the German Aerospace Center, has developed a new method for estimating biomass potential based on numerical models, remote sensing images, meteorological and forestry data. The service produces regular assessments of annual increases of above ground biomass in the format of GIS-compatible layers giving biomass in tons per hectare, at a 1 km of spatial resolution and on a yearly basis (Figure "B1"). The service will support sustainable, economic and ecological development of a region in respect to timber and energy production.

The dynamic carbon cycle model BETHY (Biosphere Energy Transfer HYdrology) is used in the service developed by DLR. Efforts are put into the pre-processing of the data from the different sources to ensure the provision of high quality inputs to the model. These data have different space and time properties; merging techniques are used to produce harmonised data sets. Ground campaigns produce data of high accuracy and thus are used as reference information to quantify the performance of the model outputs.

The key benefit of this service is a more frequent assessment of the increase of the forest biomass. The provision of

The user perspective

The Eberswalde Forestry Competence Centre in Germany was the first user to test the service. Its challenge is to find new strategies for managing forests in the face of climate change on the local, national and international levels. The Eberswalde Forestry Competence Centre evaluated the results over a test area in the forest of Brandenburg, in the north-east of Germany. The user asked for a few improvements, in particular concerning the accuracy in the output maps and an increase in the spatial resolution up to 300 m.

User testimony: *"Preliminary results are fairly satisfying. The service could be an efficient tool for public consultation, and should help forest managers to comply with environmental policies. The estimation for growth of forest stands using terrestrial methods is a heavy workload. There is a high potential in saving time and money from the use of remote sensing products."*

harmonised GIS-ready information enables it to reach a larger audience, such as private agencies or public authorities. Finally, the forest biomass potential is delivered with a higher temporal and spatial resolution compared to conventional processes.

Conclusion

ENDORSE has worked with local users to develop ten services for the renewable energy sector. The benefit of these services in the daily life of the users has been proven. Though it is outside the exact scope of *ENDORSE*, work is on-going with these users to create operational services. *ENDORSE* has also demonstrated that the exploitation of GMES services and Earth Observation data and models is an efficient means of providing solutions at regional scale in five energy domains (wind, sun, electricity load balancing, biomass and daylighting). These *ENDORSE* services are demonstration precursors and should stimulate the development of similar services in other regions. The last step of the *ENDORSE* project in 2013 is to identify other users for the developed services and promote such development.

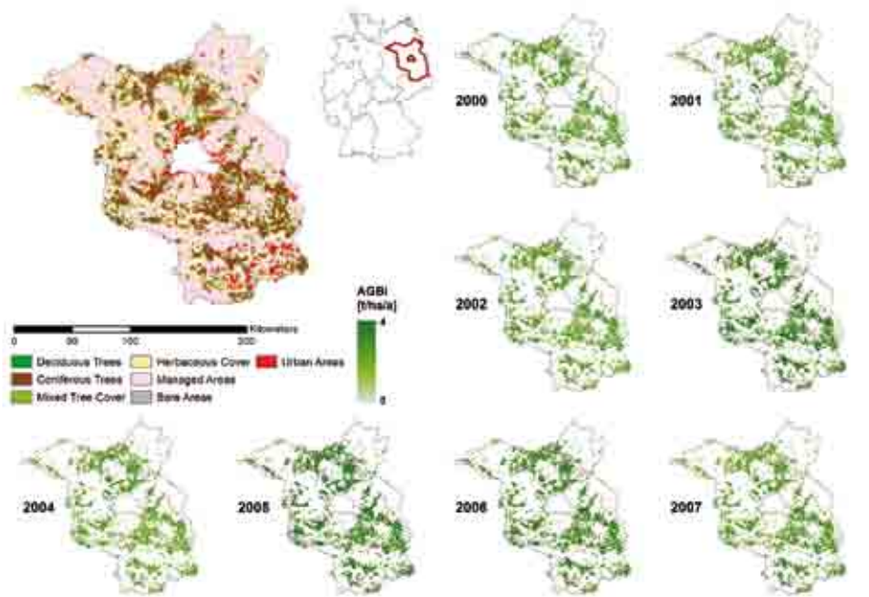


Figure "B1": Above Ground Biomass increase (AGBi) for Brandenburg's forests in tonnes per hectare over a number of years (2000 – 2007) on a 1 km² resolution, with land cover map (Global Land Cover 2000, copyright European Union 2010) describing forests (deciduous, coniferous, mixed) and non-forest cover (herbaceous cover, managed areas, bare areas, urban areas) (Credits: DLR).

Claire Thomas is a graduate of the University Louis Pasteur (Strasbourg, France) where she studied Electronics, Image and Cybernetics in 2002. After a 6 month internship at the National Severe Storm Laboratory, Oklahoma, USA, she joined the research centre Observation, Modélisation et Décision (OMD) of Mines ParisTech, Sophia Antipolis, France in 2003 to begin her PhD thesis in the domain of Image Pan-sharpening. The subject was the enhancement of the spatial resolution of the multispectral satellite images using higher spatial resolution panchromatic data. She then joined a research centre specialised in geography and image processing in Rennes, France, for an 18 month post-doctoral position working on the assimilation of data for the detection and tracking of severe storms on Meteosat infrared images. Since April 2009 she has been employed by Transvalor S.A., Sophia Antipolis, France. This company is in charge of the valorisation and the promotion of the research outcomes of Mines ParisTech. She is working in the commercialisation of the solar radiation information derived from the Meteosat images. In addition, Transvalor is also involved in the *ENDORSE* European project, for which she is the leader of a work package for the dissemination of the *ENDORSE* results.

Lucien Wald graduated in Theoretical Physics at University of Aix-Marseille II and University of Paris UPMC, France, in 1976-1977. He obtained a Ph.D. degree in 1980 at University of Paris UPMC on infrared remote sensing of the ocean. He joined MINES ParisTech in Sophia Antipolis in 1980. He obtained the Doctorat d'Etat ès Sciences degree in 1985 on the applications of remote sensing to oceanography. He has been a Professor at MINES ParisTech since 1991. He focused his own research in applied mathematics, data fusion, and meteorology and solar radiation. He obtained the Autometrics Award in 1998 and the Erdas Award in 2001 for articles on data fusion. His career in information technologies was rewarded in 1996 by the famous French Blondel Medal. He contributed to the development of the series of the Heliosat methods for assessing solar radiation from satellite images. He set up a team for operating these methods daily and producing the series of the HelioClim databases. He was the promoter of the SoDa Service, a Web-based collaborative system for professionals offering access to dozens of databases and applications in solar energy provided by several institutes and companies worldwide. He has collaborated with many European projects and he leads *ENDORSE*.

Local, regional and governmental authorities are supported with Earth Observation-based water quality products for implementing EU directives

by Thomas Heege and Karin Schenk*

FRESHMON IS AN EU COLLABORATIVE GMES PROJECT SET UP TO PROVIDE HIGH RESOLUTION FRESHWATER MONITORING AND SERVICES USING EARTH OBSERVATION DATA. THE MAIN OBJECTIVE IS TO CREATE CONTINUOUS AND WELL ACCEPTED SERVICES FOR INLAND WATER MONITORING IN RIVERS AND LAKES AT EUROPEAN LEVEL. IN THE FIRST PHASES OF THE PROJECT HARMONISATION OF DATA FORMATS WAS ACHIEVED, VALIDATION STANDARDS AND QUALITY CONTROL WERE DEFINED AND THE FIRST PROVISION OF WATER QUALITY SERVICES WAS DELIVERED TO THE END USERS.

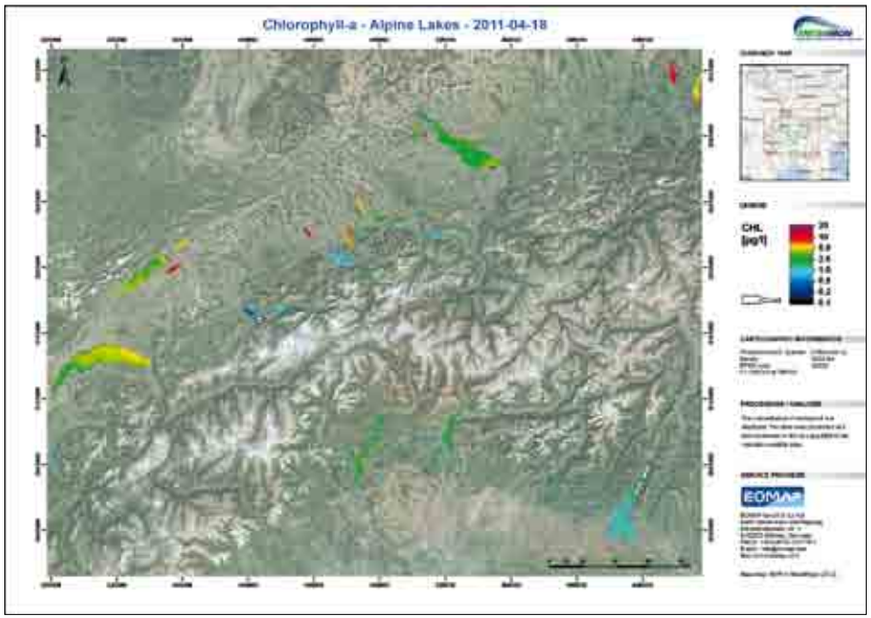
Inland aquatic systems are under significant pressure from agriculture, economical development and climate change. The European Commission Directorate General for the Environment emphasises that "*water is life*" on its website and underlines the meaning of water as a "*precondition for human, animal and plant life as well as an indispensable resource for the economy*"[1]. European directives, like the Water Framework Directive (WFD), require the status of aquatic ecosystems to be sustained or improved, which entails environmental reporting obligations to the European Commission, where each Member State shall regularly report on the environmental state of its aquatic ecosystems.

Monitoring requirements

Activities impacting aquatic ecosystems are subject to monitoring requirements. National monitoring programmes are required to establish a coherent and comprehensive overview on the water status within each river basin and lake catchment area. Hence, frequent high resolution water quality map products are required. The WFD requests the determination of water quality as the range of deviation from the 'pristine status' associated with 'type-specific reference' conditions.

[1] http://ec.europa.eu/environment/water/index_en.htm.

* This article has been written in collaboration with Kerstin Stelzer (Brockmann Consult), Timo Pyhälahti and Sampsa Koponen (SYKE).



Map product of chlorophyll concentration in the Alpine Lakes using the 300m resolution Medium Resolution Imaging Spectrometer MERIS (Credits: ESA for MERIS imagery, FRESHMON *for processing).*

"GMES products are powerful tools to help public authorities in the management of waterways"

Any variation of the assessed parameters could either be an important early warning or a desirable development. In any case, this needs to be documented. Earth Observation (EO) products can improve the capability of harmonised monitoring of water constituents at the catchment scale to indicate the direct impacts on water quality and changes

FRESHMON- a GMES project

Earth Observation-based water quality services support local, regional, national and European authorities responsible for inland water quality in rivers and lakes. The new service-line for the continuous provision of EO-based products, integrated with *in situ* and hydrodynamic modelling components, for water quality monitoring is developed within the *FRESHMON* project.
Five partners in four European countries represent the core consortium: EOMAP GmbH & Co.KG and Brockmann Consult GmbH (Germany), the Finnish Environment Institute SYKE (Finland), Water Insight BV (Netherlands) and the Swiss Federal Institute of Aquatic Science and Technology EAWAG (Switzerland).

within aquatic ecosystems. These products are supporting river authorities in the management of their waterways (cf. User Portrait p.24-25).

"GMES water quality services support local and authorities responsible for inland water quality in rivers and lakes"

FRESHMON key users

The users of the GMES products developed by *FRESHMON* are local, regional, national and state-wide authorities mandated for coordinating and conducting the implementation of the Water Framework Directive (WFD) and other related directives.

Additional users are national and international private entities, who are dealing with water quality and related issues.

By providing high spatial resolution geo-information on water quality parameters a wide group of user needs are addressed. Current end-users are the Zurich Water Supply, the State Institute for the Environment, Measurements and Nature Conservation of Baden-Wuerttemberg, the German Federal Institute of Hydrology (BfG) and the Federal Waterways Engineering and Research Institute (BAW) in Germany, the research institute Deltares in the Netherlands, the Freshwater Centre and Marine Research Centre of the Finnish Environment Institute (SYKE) and the JVP/VET Combo consortium in Finland, and the Tartu Observatory in Estonia.

Contribution to European water policy implementation

The main objective is to create continuous and well accepted services for inland water monitoring at the European

Suspended matter content in rivers is regularly monitored by harbour and river authorities, due to its significant economic and ecological impact to the waterways (Rotterdam harbour).

Water Framework Directive (WFD)

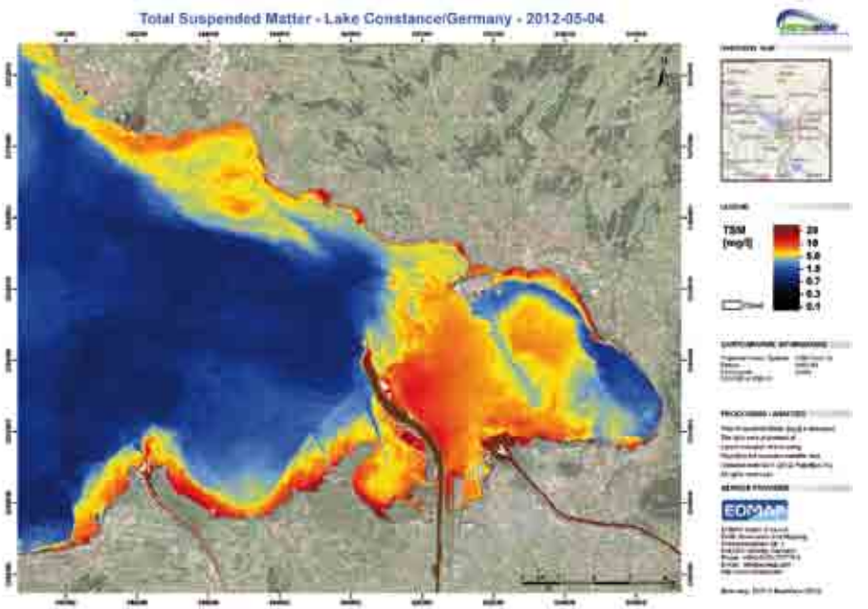
"The Water Framework Directive creates a legal framework for the protection and restoration of clean waters across the European Union. The Directive provides common principles, approaches and requirements for water management in the European Union; it also leaves broad leeway for Member State individual approaches. The Directive addresses EU surface waters, including coastal waters, as well as groundwater. By 2015, Member States are to achieve "good water status", a term that incorporates both chemical parameters (i.e. low pollution levels) as well as ecological ones (healthy ecosystems). Under the Directive, water management is based on River Basins. EU Member States set up river basin districts and designate the administrative unit for each district." (http://waterwiki.net/index.php/European_Union_Water_Framework_Directive) Features to be monitored for the classification of the ecological status are biological elements like the composition, abundance and biomass of phytoplankton, measured e.g. with the concentration of chlorophyll-*a* (Chl-*a*). Hydromorphological elements, like lake depth variations, or chemical and physio-chemical elements, like thermal conditions, are supporting the biological elements for the classification.

FRESHMON Product and Service Portfolio

The *FRESHMON* Portfolio currently comprises

- Water quality products:
  - Total suspended matter related to the total scattering of the particles in the water column in [mg/l];
  - Turbidity, closely related to the concentration of total suspended matter in Nephelometric Turbidity Unit [NTU];
  - Chlorophyll a (Chl-a) as a measure of phytoplankton [µg/l];
  - Yellow substances comprising all colored dissolved organic matter in [1/m].
- Water depth mapping from 0m to 25m in clear waters

Referring to user needs the product range may be extended with:
- Algae bloom indicators
- Submerged macrophyte coverage or sea floor composition
- Secchi depth
- Sea surface temperature



Map product of Total Suspended Matter at Lake Constance using RapidEye satellite data with 5m resolution (Credits: RapidEye for imagery, FRESHMON *for processing).*

level, through methodological research aimed at improving and harmonising different EO-based methodologies for retrieving water constituents and water depth. A transparent, *INSPIRE* (Infrastructure for Spatial Information in the European Community) -compliant product line and validation as well as quality management standard with end-users is developed. Standardised data transfer portals and efficient EO data integration of the user's work flows are established. The integration of coupled hydrodynamic modelling and transport components with *in situ* and EO measurements is performed to improve assessment of spatial and temporal processes in lakes and rivers. *FRESHMON* aims at providing customisation, confidence and acceptance of EO products for end-users. In the next project phases the focus lies on the dissemination of information about the project, its objectives, approaches, the service network and the end-users, and also the establishment of a European business network of inland water service providers and end-users.

European Union policies

The requirements of several EU Conservation directives are relevant to *FRESHMON*:

- Water Framework Directive (*2000/60/EC*);
- Bathing Water Directives (*76/160/EEC*) & (*2006/7/EC*);
- Marine Strategy Framework Directive (*2008/56/EC*);
- Urban Waste Water Treatment Directives (*91/271/EEC*) & (*98/15/EC*)
- Nitrates Directive (*91/676/EEC*);
- Natura 2000 Directive (*92/43/EWG*) & (*79/409/EWG*).

The success of the *FRESHMON* services will rely on product quality and on the availability of reasonably priced products with adequate spatial and temporal detail. Satellite imagery and related products shall be used for multiple purposes, and related products shall serve many different users in order to offer competitive prices.
This requires a high acceptance of products and an optimal dissemination of the services, both Europe-wide and globally.

Dr. Thomas HEEGE, Managing Director of EOMAP GmbH & Co.KG, has more than 15 years experience in aquatic remote sensing and technical consultancy. Prior to founding the EOMAP GmbH & Co.KG, he worked as a scientist and project manager at the German Aerospace Center DLR and the Technische Universität München. As a remote sensing expert with experience of various projects in Asia, Australia and Europe he is familiar with implementing users specific and complex needs into practical solutions. EOMAP is the coordinator of the *FRESHMON* project.

Karin SCHENK studied Geography in Tuebingen, Germany, with a focus on soil science, remote sensing and GIS. After her diploma thesis on studying sediments in Yemen, she worked for a remote sensing company in Munich, Germany, on several projects such as the IACS (Integrated Administration and Control System). Since September 2011 she has been working for the *FRESHMON* project at EOMAP GmbH & Co.KG.

A monitoring services to improve waste management at local level

by Daniela Drimaco

A WASTE MAPPING AND MONITORING SERVICE TO IMPROVE WASTE MANAGEMENT PRACTICES AND TO DETECT ILLEGAL LANDFILLS USING SATELLITE EARTH OBSERVATION (EO) DATA IS USED BY THE ENVIRONMENTAL PROTECTION AGENCY OF THE PUGLIA REGION IN ITALY AND BY CONVERSANO, A SMALL TOWN LOCATED IN THE SAME REGION.
WORLDWIDE, INCREASING WASTE LEVELS ARE BECOMING EXTREMELY COMPLEX TO DEAL WITH AND WASTE MANAGEMENT IS ONE OF THE MOST CRITICAL ENVIRONMENTAL CONCERNS THAT MODERN SOCIETY IS FACING. RECENT INTERNATIONAL AND NATIONAL REGULATIONS ARE INDEED TRYING TO ESTABLISH SUSTAINABLE SYSTEMS THAT PREVENT OR REDUCE THE ADVERSE EFFECTS OF WASTE PROCESSING OR DISPOSAL ON THE ENVIRONMENT.
THESE ALL-EMBRACING CHARACTERISTICS MAKE SPACE-BASED EARTH OBSERVATION A KEY TOOL FOR THE MONITORING AND MANAGEMENT OF A WIDE VARIETY OF ISSUES RELATED TO WASTE MANAGEMENT.
THE *WASTEMON* PROJECT PROVIDED KEY SUPPORT FOR SOME WASTE MANAGEMENT PRACTICES USING SPACE-BORNE REMOTE SENSING IMAGES. CLOSE COOPERATION WITH THE FINAL USERS ALLOWED THE PARTNERS OF THE *WASTEMON* PROJECT TO CLEARLY GATHER THEIR NEEDS AND TO BETTER SUPPORT THEM IN THE PROVISION OF *AD HOC* PRODUCTS, WHICH CAN BE INTEGRATED INTO THEIR WORKING SYSTEMS.

Waste Monitoring and Management in Europe

According to the European Union Waste Framework Directive (European Directive 2006/12/EC), waste is defined as "*any substance or object the holder discards, intends to discard or is required to discard*".
Waste may be broadly classified in three ways:

1. Hazardous waste that usually meets one or more of these four characteristics: ignitability, corrosivity, reactivity, or toxicity;
2. Non-hazardous waste;
3. Inert waste.

Previous differences in the terminology used for waste classification led to calls for a standardised classification for waste. In this sense, the EU has generated a single catalogue that meets the needs of classifying and defining all waste. The final version of *The European Waste Catalogue* came into force on January 1st, 2002 with the European Commission Decision 2001/118/EC (as amended by 2001/119/EC).
Waste can be disposed of in a number of ways, including landfill, incineration, recycling, mechanical biological treatment (anaerobic digestion and/or composting), pyrolysis and plasma arc gasification.
The management of non-hazardous residential and institutional waste in urban areas, including collection, disposal and planning aspects, usually falls on the shoulder of local government authorities.

At national level, EU legislation (through Council Directive 75/442/EEC on waste) requires each Member State to draw up one or more waste management plans in compliance with relevant EU directives, which are implemented by regional or local authorities. Each individual Member State has the duty to apply the principles of these directives when implementing a national waste management system.
EU Member States are also required by law to identify all waste disposal sites, undertake a risk assessment and then prioritise them for remediation if necessary.

"The management of non-hazardous residential and institutional waste in urban areas, including collection usually is the responsibility of local government authorities."

Waste management in Italy

The "Ronchi" decree (Waste Management Act 22/77), published in February 1997 and the subsequent revisions of this Act, regulated the management of waste in Italy at the national level, forbidding uncontrolled landfills and stipulating that every region must have a waste management plan. Despite the EU directive of 1999, which limited the use of landfills, this practice remains the main method of waste disposal in Italy. Moreover, a high level of illegal landfill sites resulted in numerous convictions by the European Court of Justice (ECJ) in 2007. The landfill problem is particularly evident in southern Italy, which has the largest number of illegal landfills.
In Puglia, a region in the south of Italy, the waste management plan intends to fight the abandonment, discharge and uncontrolled disposal of waste. The

European Local and Regional Authorities are often responsible for waste management. Beyond the visual pollution it represents, illegal waste disposal also affects local eco-systems (Credits: Carla Antonini).

current practices for waste monitoring in the region include:

- Inspection and monitoring activities that are carried out by provincial departments with local responsibilities;
- A regional waste register that is in its implementation phase;
- Implementation of a database for illegal landfill;
- In this European and national scenario, Planetek Italia s.r.l., ERA-Maptec Ltd. and EBA Engineering Consultants are involved in the *Wastemon* project, funded by the European Space Agency.

The *Wastemon* project

The project offers waste mapping and monitoring services aimed at improving the environment, protecting human health and increasing efficiency in waste management across Europe and Canada. The services are based upon the use of remote sensing satellites coupled with the expertise of scientists.

Wastemon service offering

Wastemon is based mainly upon very high-resolution applications, hyperspectral and thermal satellite imagery, and to a lesser extent on differential interferometric synthetic aperture radar (InSAR). These technologies are applied to filter

The case of ARPA Puglia

ARPA Puglia, the local technical body of Puglia Region in charge of the monitoring of landfill and contaminated sites, is the Italian user that benefits from *Wastemon*'s results as a support tool to be compliant with European, Italian and regional directives.
ARPA Puglia expressed its interest and willingness to use innovative Earth Observation (EO)-based technology for landfill monitoring, by expecting to integrate the *Wastemon* products in their current waste monitoring systems. In particular, the user aimed to apply the project's results to adopt a monitoring and prevention strategy for illegal landfilling at the level of the municipality. The interest of the user was focused on the monitoring of buried or near-surface illegal landfills, surface landfills, tyre waste and illegal industrial waste disposal.
The specific products required by ARPA Puglia are briefly described in the table below.

Services	Product requirements
Buried or near-surface waste	Location and extent of dumps of waste with clay or sandstone topsoil
Surface waste	Location, extent and description of surface waste (mostly industrial dumps)
Surface waste	Location and extent of potential illegal dumps of tyres

Table 1 Specific products required by ARPA Puglia

areas with potential buried and surface waste as well as monitoring active landfill sites.
Following analysis of user requirements and business opportunities for EO data in waste management, the following four services are offered:

- Service 1A – Detection of sites with potential buried waste
- Service 1B – Support for *in situ* investigations and monitoring of sites known to have buried waste
- Service 2 – Detection of sites with potential surface waste
- Service 3 – Mapping active landfills

Planetek Italia has implemented some of the aforesaid services by developing products for a municipality located 30 km south-east of Bari in Puglia Region (South Italy).
The extent of the test area is about 130 km^2. Urban areas account for about 10%, while most of the rest of the territory is covered by orchards, olive groves and arable land. As in most of southern Italy, this area is frequently affected by the phenomena of illegal waste disposal frequently located in the countryside.
The steps of the service chain implemented by the *Wastemon* project and tested in Puglia are described below.

- **Step 1 Ordering product**
  ARPA Puglia and the local Urban Planning Office of the Apulian municipality placed the request to detect potential illegal waste sites in the mentioned area, located in the southern part of Puglia region.
  Planetek, responsible for Italy, ensured that the request could be fulfilled after verification of the necessary data (availability of Very High Resolution data and ancillary data over the test site).

- **Step 2 Feasibility analysis**
  After the verification of the availability of the necessary input data, a feasibility analysis of the requirements expressed by ARPA Puglia was carried out.

- **Step 3 Input data collection**
  The WorldView-2 VHR images taken in April 2011, which included multispectral and panchromatic bands, were selected. The user provided the updated land-use map issued in July 2011, as ancillary[1] data useful during the next step, and an orthophoto[2] taken in 2006.

- **Step 4 EO data processing and Step 5 Data integration**
  Steps 4, 5 and 6 represent the core component of the service chain. As a first step, the WorldView-2 image was geometrically corrected in the reference system requested by ARPA Puglia (UTM33 WGS84). Then, the corrected image was submitted for segmentation process in an eCogniton[3] software environment in order to produce a set of spectrally homogeneous objects. Following this, an object-based classification was performed on the basis of the spectral response of the sample area waste sites. The result was a preliminary land-cover map that identified potential illegal waste sites. The land-cover information and the road-network was used to filter out such preliminary results, building a sort of probability map based on selective criteria such as distance from the road network of less than 100m; distance from existing landfills, etc. The co-occurrence of the parameters related to the previous criteria makes the probability of finding illegal sites very high and allows the confirmation of the waste sites mapped from the preliminary EO data processing (done in step 4).

- **Step 6 Product validation**
  This step was implemented and tested to ensure an appropriate spatial and thematic accuracy of the EO output data. A first validation check was performed by on-screen qualitative analysis on the basis of the

[1] Data from sources other than remote sensing, used to assist in analysis and classification or to populate metadata.

[2] Aerial photograph geometrically corrected ("orthorectified") such that the scale is uniform: the photo has the same lack of distortion as a map.

[3] eCognition is an original object-based image analysis software for geo-spatial solutions for any environment, data type, or specialised application.

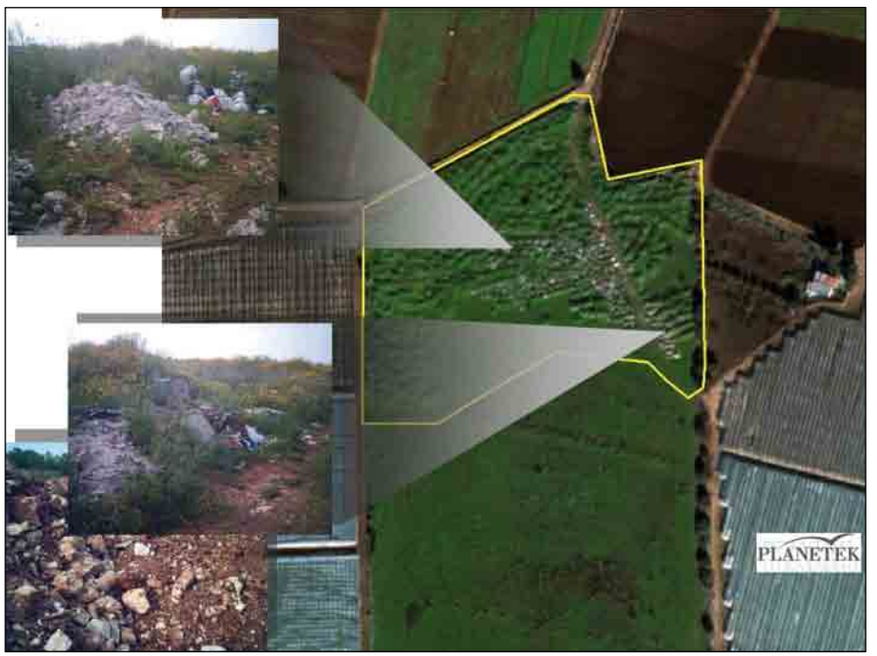
Subset of test site showing the output of automatic processing in red and the final delineation of an illegal waste site in yellow. The World-View2 image also allows identifying the tracks of the illegal transport of material to the site (Credits: Planetek Italia s.r.l.).

Very-High-Resolution image available over the area of interest (WorldView-2 image and ortophoto). Then a field-survey was performed in order to assess the plausibility of the output result. Figure 2, which shows images taken during the field survey, confirms the occurrence of illegal waste sites. Over 10 potential illegal waste sites were mapped in the area of interest, and a sample of 5 sites were selected to be visited physically. The field survey confirmed the occurrence of illegal waste sites in 4 of these therefore resulting in an accuracy of 80%.

"The Urban Planning Office of the Municipality considered that the product is an effective way to optimise the traditional monitoring activity"

Example of surface waste map produced for an Apulian site (Credits: Planetek Italia s.r.l.).

- **Step 7 Product formatting and delivery**
  The map of the potential waste sites was delivered following a template of ArcGIS digital layout (Figure 3). The results are projected in the reference system requested by the final user. The waste site map is delivered with a technical report describing the characterisation of the area under analysis with reference to the particular critical events affecting the site.



Illegal waste areas confirmed in situ *after being detected using EO data (Credits: Planetek Italia s.r.l.).*

User feedback and *Wastemon* services benefits

The Italian end-user organisations involved in the *Wastemon* project are in charge of environmental monitoring both at regional scale (ARPA Puglia) and at local scale (Apulian Municipality, Urban Planning Office).

At the end of the testing activity, the resulting products have been delivered directly to the local user, the Urban Planning Office of the Apulian Municipality in order to collect the first impression on the quality of the output. The user showed great interest in the results, deemed it useful source of support for their current cartography updating and to complete the understanding of their local land evolution. The satellite-derived product has been evaluated as an effective way to optimise the traditional monitoring activity and a complementary instrument to face the even more frequent phenomena of illegal exploitation of land resources.
As a matter of fact, after the delivery of the waste map, the Apulian Urban Planning Office started with a field campaign aimed to check the reliability of the information provided to proceed with legal actions in case of confirmation. The field checks have been performed by the police authority in charge of environmental monitoring. As a result, the information detected by remote sensing has been confirmed and some legal actions have been placed for the confiscation of those plots of land where a waste site was detected.
The success case in Puglia, is testified not only by the legal measures taken by the local authorities but also by the great echo of the news published by the local newspapers, highlighting the importance of the information extracted from satellite data analysis for the local authority and the real possibility to be fully integrated into their land monitoring activity.

The final results have been evaluated as a very useful tool to take operative and strict decisions in a faster, more accurate and economic way. Moreover, the perfect integration of the final products into the user's working systems, allowed the customer to further appreciate the results and to better understand the potential of Earth Observation data.

Daniela DRIMACO received the degree in Telecommunication Engineering in 2005 from the Federico II University of Naples, Italy. From July 2006 to February 2007 she started an on-the-job training period in Planetek Italia s.r.l., Bari, Italy through which she did an internship at ESRIN centre, European Space Agency, Frascati, Italy focused on Earth Observation and WebGIS technologies exploitation for environmental monitoring and management applications. From March 2007 up to now she works in Planetek Italia s.r.l. as Business Development Manager R&D supporting the technical and economical project proposal and following the main Earth Observation R&D activities carried out by European Commission, European Space Agency, Italian Space Agency, national and local institutes.

CryoLand – GMES Snow and Land Ice Monitoring Service

by Thomas Nagler

IN THE *CRYOLAND* PROJECT, A FULLY INTEGRATED AND USER RELEVANT SNOW AND LAND ICE SERVICE IS DEVELOPED AND TESTED, BUILDING UPON EARTH OBSERVATION DATA INCLUDING THE SO TO BE LAUNCHED GMES SENTINEL SATELLITE FAMILY. FULLY VALIDATED SNOW AND LAND ICE PRODUCTS COVERING LOCAL TO CONTINENTAL SCALES ARE DELIVERED IN NEAR REAL TIME TO USERS OPERATING IN VARIOUS APPLICATION FIELDS. *CRYOLAND* HAS THE POTENTIAL TO FULLY COVER THE CRYOSPHERE COMPONENT OF THE GMES LAND SERVICE.

There are only a few environmental topics which are more urgent to study than the sustained supply of fresh water. As climate change adds more uncertainty to the availability and distribution of fresh water, understanding the huge water resources which are contained within snow and glaciers are vital factors in planning for the future. The possible depletion of water from glaciers- and snow-covered environments may have a big impact for human consumption, agriculture, hydropower generation and other uses, not to mention its role for ecosystems and biological diversity.

The *CryoLand* Project (2011-2015), supported by the EU Seventh Framework Programme (FP7), develops and implements integrated and comprehensive products for monitoring and subsequent management of snow and ice resources. The project builds on Earth Observation satellite data and *in situ* measurements for generating and delivering a portfolio of products to customers operating in various application fields. The products of *CryoLand* include the extent of seasonal snow cover, maps of melting snow area, statistical snow information tuned to match drainage basins, glacier outlines, snow / ice maps on glaciers, and lake / river ice extent.

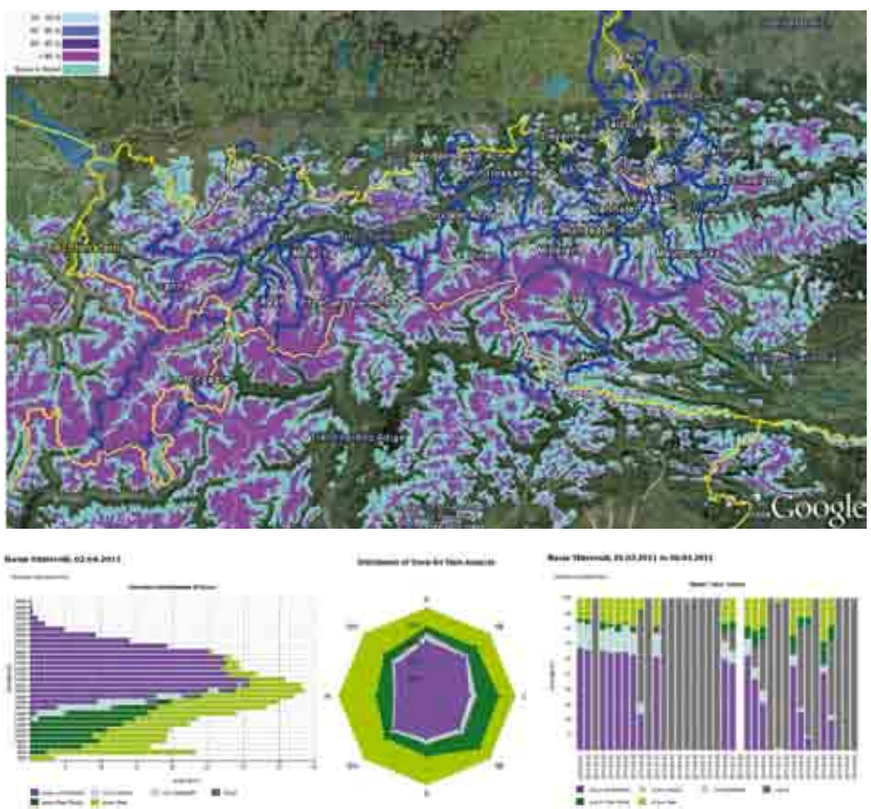
Snow and ice are characterised by high temporal and spatial variability. The seasonal snow cover responds to short term weather conditions, but seasonal and inter-annual variations are also of great importance for hydrology and climate monitoring. Given this variability, cross-referencing and superimposing broad-ranging temporal and spatial data is important for managing the water amount coming from melting snow packs, and for assessing the impact of climate change.

"*CryoLand* creates a self-sustained service to support better management of snow and ice resources"

Satellites are excellent tools for monitoring glaciers and seasonal snow cover and their physical properties, delivering accurate observations which are not only relevant for climate change research – but also for the socio-economic well-being of large communities. As a value-added Service, *CryoLand* will receive Earth Observation data inputs directly from the GMES Space Component and from third party satellite missions. From this data, *CryoLand* develops, implements and validates a standardised and sustainable service on snow, glacier and lake/river ice monitoring. This addresses diverse stakeholders from hydropower generation and water management, traffic security and guidance (roads, railways, and rivers), geotechnical and construction companies, the tourism industry, ecology and agricultural management.

Geo-spatial snow and ice products

CryoLand creates a self-sustained service to support the better management of snow and ice resources for activities in different application fields. The requirements of snow and ice products for the different applications were collected in several user workshops held in 2011, with more than 60 participating organisations operating in a wide range of application fields, including water management and flood forecasting, meteorology, hydro power generation, ecology and agriculture. The production of snow and ice products builds upon methods and processing lines developed by scientists and technicians of the project partners and optimised within *CryoLand* to match the needs of the various users. The product specifications

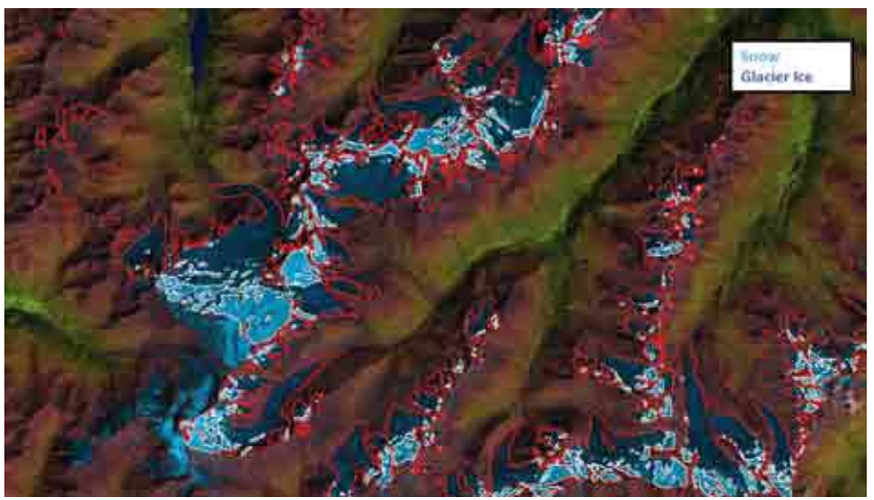


Fractional Snow Map for the Alps, April 2nd, 2011, based on MODIS satellite data. Blue lines delineate drainage basins specified by regional hydrological services in Austria. For the basins statistical snow information is calculated on demand, an example of snow area / elevation curve and snow extent for aspect classes is given for drainage basin Mittersill, Alps (Credits: ENVEO).

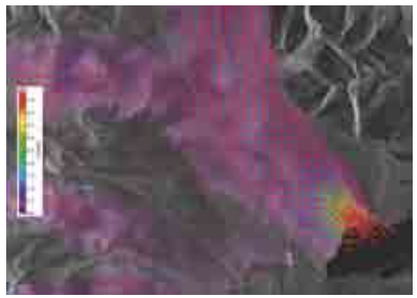
and priorities for implementation were consolidated jointly with users in a User Coordination Meeting, held in Stockholm in May 2012.

"*CryoLand* products match the needs of a large range of users, from local authorities to the tourism industry"

Snow products with highest priority for implementation in the *CryoLand* Service are snow extent, snow water equivalent (presently available at low spatial resolution), and snow melt areas. Follow-up products include snow wetness, surface temperature and spectral albedo maps. The snow extent products cover regional to continental scales, use high spatial resolution optical satellite data (e.g. ASTER, Landsat TM/ETM+, SPOT, in near future also Sentinel-2) and medium resolution optical sensors (e.g. MODIS, in near future also Sentinel-3). Improvements for snow mapping in different environments are achieved by integrating accurate land cover data from the GMES Land Monitoring Service into the fractional snow cover retrieval algorithms. Beside the regional snow products, the project team works towards a fully validated Pan-European Snow Extent product. For snow melt runoff modelling, up-to-date information on the extent of melting snow is important. Synthetic Aperture Radar (SAR) images are used as input to an automated method for mapping snow melt areas. Due to its high temporal and spatial variability, seasonal snow is monitored on a daily basis and requires well defined and optimised data flows from the satellite data providers to the *CryoLand* processing centre to enable timely delivery of the products to users. *CryoLand*'s glacier products are based on high spatial resolution, multi-spectral optical and SAR data. The guidelines for generating glacier products and the product format follows international standards of the Global Land Ice Measurement from Space (GLIMS) programme. The primary product is glacier outlines (boundaries), followed up by maps of snow and ice areas, ice velocities, and maps of glacial lakes.



Glacier boundaries (red lines) and late summer snow / ice extent, Ötztal Alps, August 31st, 2009. Snow areas (cyan), Ice areas (dark blue), based on Landsat-5 TM (R-G-B: TM Band 5-4-3) - (Credits: ENVEO).



Ice velocity field from multi-temporal TerraSAR-X data using image cross-correlation, Breidamerkurjokull, Iceland (Credits: ENVEO).

The glacier outline (defining the total glacier area) is basic information which is also required to derive other glacier products from satellite images. The processing line uses multi-spectral, optical satellite images from high spatial resolution sensors (SPOT-5, IKONOS, Landsat ETM+, ASTER, etc.). Time sequences of snow and ice area extent on glaciers during the melting period, supplied by the project, are key information for computing the melt water contribution and estimating glacier mass balance. At the end of summer, the ratio of snow to ice area extent is a proxy for the annual mass balance of a glacier, which is an essential climate variable. Ice motion data are needed to determine and predict a glacier's dynamic response to climate change. Repeat pass SAR images enable the mapping of ice motion at high accuracy by means of differential processing techniques.
Primary lake and river ice products include ice extent and concentration, and snow cover on lake ice, derived from optical satellite data. Ice cover on lakes and rivers is also obtained from SAR data. Additionally, users are interested in snow depth and snow water equivalent on lake ice; algorithms based on passive microwave data at low spatial resolution are in development. For water and ice surface temperature products prototype algorithms are available. An important task of *CryoLand* is to fully validate the production lines and products, to provide estimates on the performance and uncertainty of the services. Depending on the nature of the product, validation and performance assessments are carried out using very high spatial resolution satellite data made available through the GMES Data Warehouse mechanism or *in situ* measurements available at partners or users premises.

Time series of lake ice extent of Lake Peispi, Estonia, from optical satellite data (Credits: Finish Environment Institute / SYKE).

Map of melting snow (red colour) of Eastern Alps, June 9th, 2006, from ENVISAT ASAR Image Mode data, superimposed to ASAR amplitude image (Credits: ENVEO).

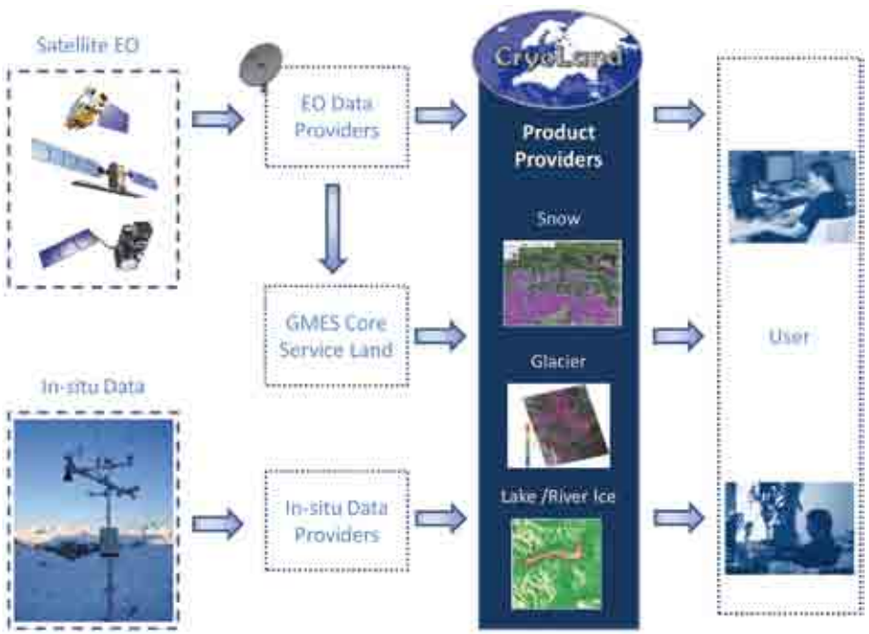
Well developed data flow

The design, development and implementation of the network of snow and ice services has been conceived with a high level of interoperability, compliant with INSPIRE and GEOSS, as well as with the Land Monitoring Service, the GMES Space Component Data Access System, and the required *in situ* and reference data access. Due to fast temporal changes of the snow and ice parameters, fully automatic processing lines and well developed data flow lines are needed for timely provision of up-to-date products. *CryoLand* Services are provided by different service providers, each with high level expertise in the snow and ice remote sensing domain. The designed service system enables the standardised provisioning of online services which can be consumed by different clients for an easy and direct integration of *CryoLand* functions and products into the user's Geographic Information System (GIS), modelling tools and decision support environments. Through full end-to-end tests and verification of products and services in pre-operational environments, rigorous procedures and protocols for validation and qualification are ensured.

"Users are interested in snow depth and snow water equivalent on lake ice"

The *CryoLand* Service System

The products themselves are important, but so is ensuring their timely and efficient delivery. The project's system architecture ensures that its products are made available to users through modern and efficient mechanisms for information distribution and data access with well-defined interfaces. The design of the *CryoLand* Service System follows the recommendations provided by GIGAS (GEOSS, INSPIRE and GMES an Action in Support), and applies the Open Geo-spatial Consortium Reference Model of Open Distributed Processing. Interfaces are established and implemented to allow direct integration of *CryoLand* products into GIS systems, modelling tools and decision-support environments. Additionally, the system enables the provision of information for targeted areas and for times specified directly by the user, without the download of large files containing only small amounts of relevant information. The tools for processing and information extraction on demand, e.g. the calculation of the snow extent within a drainage basin, are optimised in cooperation with users. Far from being a fixed service, *CryoLand* will be improved and augmented as time goes on, to adapt the user requirements at the partner institutions as needed.



Data flow of CryoLand Services.

CryoLand in a nutshell Project Web Site: http://www.CryoLand.eu	
Project partners	
ENVEO IT GmbH (Project Coordinator), Innsbruck, AT	Norwegian Computing Centre, Oslo, NO
EOX IT Services GmbH, Vienna, AT	Northern Research Institute AS, Tromsø, NO
Finnish Environmental Institute, Helsinki, FI	National Meteorological Administration, Bucharest, RO
Finnish Meteorological Institute, Sodankylä, FI	Gamma Remote Sensing AG, Gümligen, CH
Kongsberg Satellite Services AS, Tromsø, NO	Swedish Meteorological and Hydrological Institute, SE

Thomas NAGLER is Managing Director of ENVEO. Thomas received the M.Sc. degree in Meteorology and Geophysics and the Ph.D. degree from the Faculty of Natural Sciences, University of Innsbruck, Austria, in 1991 and 1996, respectively. From 1991 to 2004, he was a Research Scientist with the Institute of Meteorology and Geophysics, University of Innsbruck. In 2001, he became Cofounder and Managing Director of ENVEO - Environmental Earth Observation IT GmbH, Innsbruck. His main research activities include microwave signatures and inversion methods for snow and ice parameter retrieval, satellite applications for cryospheric research and hydrology, natural hazards monitoring and the assimilation of remote-sensing products in geophysical-process models. Thomas was project and work package leader of ESA, FP6-EC, and national research projects, and is the Coordinator of the GMES *CryoLand* Project. He has coordinated and/or participated in several scientific expeditions to Alps, Patagonia, and Antarctica and was involved in international field campaigns in preparation for new satellite systems.

The *PIGMA* platform: sharing geographical information in Aquitaine

THE SHARING OF GEOGRAPHIC INFORMATION IS THE INNOVATION PROPOSED BY PIGMA (PLATFORM FOR SHARED GEOGRAPHICAL INFORMATION IN AQUITAINE) FOR A KEY REGIONAL ISSUE: HELPING PUBLIC DECISION-MAKING IN THE FIELD OF SPATIAL PLANNING. IMPLEMENTED IN 2008 AND ORGANISED BY THE GIP ATGERI (PUBLIC INTEREST GROUP ON SPATIAL PLANNING AND RISK MANAGEMENT), PIGMA AIMS TO CREATE A FRAMEWORK FOR DECOMPARTMENTALISING GEOGRAPHICAL INFORMATION AND MAKING IT ACCESSIBLE TO ALL STAKEHOLDERS OF THE PUBLIC SPHERE.

The foundations of *PIGMA*: exchanging and sharing geographical information

Geographical information such as aerial photography, satellite data, maps, digital data files etc. have become indispensable for spatial planning. Since 2008 state agencies, local authorities, public and parastatal institutions, educational and research institutions of the Aquitaine Region (France) as well as the voluntary sector, can access a large collection of spatial data thanks to the *PIGMA* platform.

The *PIGMA* platform, is in line with the INSPIRE Directive, which aims to promote the production and exchange of geographical data on the European scale. *PIGMA* has therefore two main objectives:

- data: to establish a common reference and a market for exchange of geographical data at the regional level;
- services: to support users that wish to develop and use geographical information.

PIGMA's members have at their disposal the geographical information of the network and share their own data, thus constituting a participatory database or virtual library of geographical data.

Each member must sign a "partnership agreement for the provision of digital data" which governs the provision of information acquired by *PIGMA* and their use; the agreement specifies in particular the ownership and licensing of exchanged data rights which may not be commercially exploited.

As of July 1st, 2012, *PIGMA* federated 361 members and 1691 data layers. *PIGMA* is co-financed by European Regional Development Fund (ERDF) funds (45%) and the Regional Council of Aquitaine (25%). The remaining 30% is funded by the GIP ATGeRi. *PIGMA* offers real benefits to its users; the most obvious one is the saving of public money through free access to geographic reference datasets.

This one-stop service allows the combined use of diverse information to improve the understanding of the territory, which was previously impossible, thus constituting a real decision-making tool.

Home-page of the PIGMA *portal.*

A strategic decision making tool for the Aquitaine region: the www.*PIGMA*.org portal

The www.*PIGMA*.org portal aims to facilitate access to spatial data for *PIGMA*'s partners. The portal allows partners to securely access all the services proposed by *PIGMA*. Five services are now available: the Editorial Site, the Data Catalogue, the Data Extractor, the Viewer and access to Data Streams. Since the second version of the portal, all access rights are managed centrally and the five services interact with each other.

The regional portal is compliant with all standards to enable the greatest interoperability with *PIGMA* partners' tools, platforms in neighbouring regions (where they exist) and national tools etc.

The Viewer: a reading of the territory

The *PIGMA* viewer offers a common entry point to a combined data set acquired by *PIGMA*: SCAN25® (map 1:25 000), BD TOPO® (relief), BD ADDRESS® (geo-located addresses) and BD ORTHO® (aerial photos). The aerial photography coverage for the entire Aquitaine territory was acuired by the French National Geographical Institute (IGN). Its 40 cm spatial resolution makes it possible to distinguish road markings.

Since early 2011, IGN has used *PIGMA* to distribute some of its products (mainly those specific to its public service missions). *PIGMA* has become IGN's regional partner for the dissemination of these products and data to its members.

GMES services soon available on *PIGMA*

Within the frame of the APSAT project (Public action, satellite technology and sustainable development), co-funded by the EU under the Interreg IVB SUDOE programme and in which the Regional Council of Aquitaine is involved as partner, three innovative GMES downstream services are being developed.
One of them focuses on the estimation of forest volume and biomass, and the other two on near shore bathymetry and the monitoring of dune erosion.

By June 2013, the results of these projects will be cataloged and searchable in *PIGMA*.

PIGMA training

PIGMA delivers training workshops to teach its members how to use the platform.
As far as the data catalogue is concerned, these workshops focus on key questions such as how to read a data sheet, how to identify which partner has which data in a specific area, and how to download data.

Regarding the viewer, the training allows the *PIGMA* members to test the tool, its various functionalities (navigation, search, layers, printing), use constraints (Internet speed, browser), and the main repositories available for consultation.

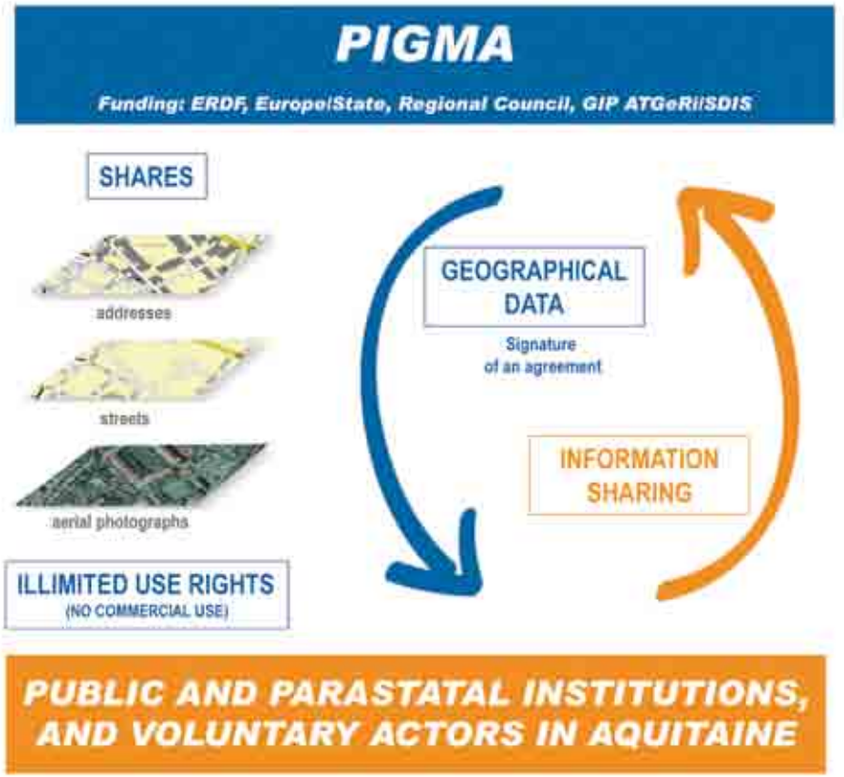
In addition, the viewer provides access to data provided by partners, such as:
- environmental areas;
- risk areas;
- classified sites, historical monuments;
- the route of the high speed train line;
- land register, land use;
- solar farms;
- aerial or underground networks (water, electricity, optic fiber...);
- etc.

Without being a GIS tool, the Viewer first meets the mapping needs of communities that do not have the necessary resources to develop their own tools. The Viewer allows for layering data on the same geographical area. In addition to data visualisation, it allows data combination to perform multi-criteria or multi-themed analyses.

The data catalogue: continuing to expand

Each signatory to the *PIGMA* agreement undertakes to continue to supply the data catalogue with new information, to update information already present and enrich it where possible. As of June 1st, 2012, 1377 data layers were catalogued. The catalogue allows the user to search by geographical area or theme with keywords with an intuitive search function to assist the user in their choice. Data are accompanied by a descriptive data sheet, in a standardised form according to the requirements of the European INSPIRE directive.

The second version of the platform included the Editorial Site, the Extractor and the Stream Exchanger in addition to the services already available. The Editorial Site, allows users to disseminate information on specific topics, technologies, practices at the national or European level, while users can download data *via* the extractor or the Stream Exchanger.



Functioning of the PIGMA *platform.*

PIGMA is therefore an evolving tool, regularly enriched as new partners join the network and as current partners share new data.

Assisting partners

PIGMA's team assists its members in several ways. In the frame of projects aimed at producing or using geographical data, *PIGMA* can provide support to write project specifications, identify and choose a contractor, monitor developments or the production of data. Above all, *PIGMA*'s objective is to ensure the best possible consideration of regional needs in the development and implementation of tools using spatial data.

PIGMA also assists its partners in cataloguing their data and encourages them to do so. *PIGMA* also helps them in the difficult but essential task of creating a knowledge base of information available in Aquitaine.

In particular, *PIGMA*'s team accompanies some partners in the standardisation of their data or in posting them on the portal.

This support is provided through the organisation of events held twice a year at the regional level and more locally,

PIGMA *regional event.*

in each department (equivalent to UK counties) of the Region. There are also training courses focusing on the different tools offered by the portal.

Gr@ce: a regional tool for geo-referencing and automated referencing of electronic communications

Gr@ce is an online tool dedicated to the management of telecommunications infrastructures (mapping, update, forum, etc.) supported by the Regional Council of Aquitaine. It is also available as a mobile tool through the use of a tablet to facilitate the collection, mapping and updating of data on the field even without web connection.

Working groups focusing on major topics of interest

The *PIGMA* team organises working groups, bringing together the different stakeholders interested in some major topics interesting the Aquitaine Region. These Working Groups are also meant to foster exchanges about members' needs and experiences or discussions about initiatives launched in other regions and at national or European level. Currently, six working groups meet three to four times a year on the following topics:

- Coastal management
- Land use on a large scale
- The socio-economic sector
- Telecommunication networks
- Open data
- Planning

Such working groups have led to the implementation of joint projects like the development of a socio-economic demonstrator, the deployment of tools for telecommunication networks (Gr@ce – cf. box) or the undertaking of a study on land use along the entire Aquitaine coastline.

An information relay in the region

GIP ATGeRi participates in several working groups taking place at the national level on the implementation of the INSPIRE Directive and developments of tools dedicated to spatial data infrastructures (SDI). It also participates in the national working group on Land Use and is actively involved in the Regional Platforms working group of AFIGEO (French Association for Geographical Information).

The objectives of these participations are manifold:

- to keep up with the implementation of INSPIRE and developments of tools related to SDI;
- to disseminate Aquitaine needs at the national level;
- to get information and best practices down from the national level to the regional level;
- to interact with other regional platforms.

Thus, *PIGMA* serves as a regional relay of information, both from an ascending and descending point of view.

For more information

www.*PIGMA*.org – www.*PIGMA*.com – contact@gipatgeri.fr

The mission of GIP ATGeRi (Public Interest Group on Spatial Planning and Risk Management) is to develop decision-making tools to help regional public players in their missions of prevention, forecasting, environmental protection, risk management and sustainable development.

In that frame, GIP ATGeRI provides access to spatial data, user training and assistance for the development of new products (software and database), consulting and engineering services in the area of GIS, and contributions to the dissemination of information in its field of expertise.

GIP ATGeRi was officially established in October 2005 and involves:

- the French State;
- the Regional Council of Aquitaine;
- several departmental fire and rescue services;
- the regional association for the defence of forests against fire (ARDFCI);
- the National Forestry Office (ONF).

Historically, the expertise of GIP ATGeRi started to develop well before its creation, around the key issue of forest fire risk, with the implementation of a shared cartography between the relevant stakeholders in 1996.

Sensing long-term environmental change through regional monitoring: the Long Term Ecosystem Research Network (LTER)

by Alessandro Campanaro, Alessandro Oggioni Alessandra Pugnetti*

THE VERY OBJECTIVE OF LTER IS THE ECOLOGICAL RESEARCH AND THE MONITORING OF VARIOUS ECOSYSTEM TYPES SPANNING BROAD RANGES OF ENVIRONMENTAL CONDITIONS AND HUMAN DOMINATION OF THE LANDSCAPE. IN THAT REGARD, LTER CAN SUPPORT THE FURTHER DEVELOPMENT AND IMPLEMENTATION OF GMES BY ACTING AS A VALIDATION NETWORK BUT ALSO *IN SITU* DATA PROVIDER FOR GMES PRODUCTS. LTER MONITORING ACTIVITIES ARE LED IN COORDINATION WITH LOCAL DECISION MAKERS AND TECHNICAL ENTITIES INVOLVED IN ENVIRONMENTAL MONITORING. THE DATA COLLECTED LOCALLY IN THE FRAME OF LTER ACTIVITIES CAN IN RETURN BENEFIT LOCAL END-USERS BY CONTRIBUTING TO FURTHER ENHANCE GMES SERVICES.

The LTER vision promotes collaborative initiatives with local decision makers

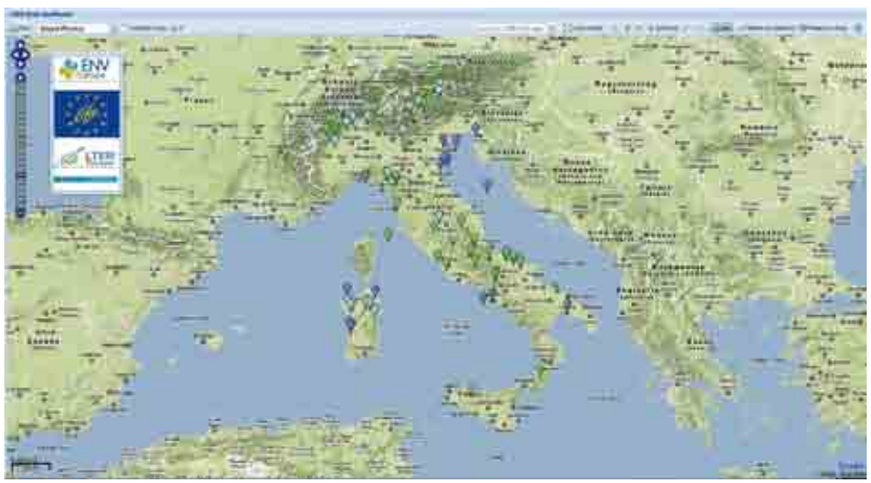
The essence of LTER is the collection of an extensive Space-time variety of data, therefore the network is an excellent starting point to support environmental protection and management initiatives. Successful results have been reached at local level by implementing specific monitoring-forecasting systems as well as Decision Supporting Systems (DSS) to help developing and implementing of environmental planning strategies.
A strong effort to promote a more fruitful cooperation between science and policy, not only at local level but also at national and international level, is the main challenge of the LTER network. A first step in this sense has been provided by the *EnvEurope* Life+ Project (cf. box). By building SEIS (Shared Environmental Information System) and supporting the implementation of GMES, the "Environmental Policy and Governance" Life+ priority area strengthens the knowledge base for policy making and implementation. The *EnvEurope* Life+ project, which was selected under this priority area, promotes the participation of representatives of selected LTER sites located in different European countries. The national LTER Italy network is part of this project through the participation of several national sites.
LTER Italy (www.lteritalia.it) comprises 20 sites, which include freshwater, marine and terrestrial environments representing the main ecosystem typologies of the country. This is completed with two international sites (Himalayan Lakes and Antarctic). All sites have been selected according to LTER-International criteria. Many Italian institutions participate to LTER-Italy, notably through site management and network coordination: the National Research Council, the National Forest Service, Universities, the Zoological Station of Napoli and Regional Environmental Agencies.

"The collection of an extensive Space-time variety of data is an excellent starting point to support environmental protection and management initiatives"

LTER-Italy sites are potential providers of *in situ* data for GMES services. This article presents three examples from terrestrial, lacustrine and marine habitats. The LTER North-Western Adriatic Sea site already provides data for the GMES Marine Service through its involvement in *MyOcean* and *MyWaves* projects. In the two other sites, Lake Garda and North-Western Alps, the existing automatically recorded medium-to-long term field data provides the opportunity for comparison with remote sensing data. This spatially extensive remote sensing data may be useful to spatially interpolate point data taken in the field.

A joint coastal oceanographic observatory network in the Adriatic Sea (LTER-Italy site: North-Western Adriatic Sea)

Fixed measuring stations and oceanographic buoys are fundamental to understand and manage the marine environment. This is particularly important in dynamic coastal areas, given the delicate balance between



The geoportal, which presents the Italian sites involved in the LTER network. Green markers: terrestrial sites; light blue markers: freshwater sites; blue markers: marine sites (Credits: LTER Italia).

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Mariangela Ravaioli, National Research Council of Italy - Institute of Marine Sciences.

The LTER network

The Long-Term Ecosystem Research-network (LTER) is a network of sites where a series of ecological data is gathered over several decades, at regional, national and continental scales. LTER sites consist of various reference ecosystems, research and monitoring facilities that form part of a global network. The long-term ecological research gives a scientific background for the study and interpretation of global environment modifications caused by human activities (e.g. the increase in the rate of supply of organic matter in an ecosystem –eutrophication- or introduction of alien species). It can also be used for identifying trends, planning solutions and assessing the success of environmental management projects.
The research network can also deal with the socio-economic effects of the modification of the natural environment, which can result in misleading interpretations. LTER benefits from a solid interdisciplinary approach to the study of environmental problems, which in recent years has involved the socio-ecological aspects.
Following the start of the first LTER programme in the USA in the 1980s, a number of national LTER networks have been established. These have been at the global and European level, giving rise to LTER-International and LTER-Europe.
The European LTER networks are associated with a number of relevant initiatives or programmes at European (e.g. Natura*2000*, GMES and SEIS - Shared Environmental Information System) or international level.

environmental and socio-economic factors. At European level, technological progress now makes it possible to automatically measure many sea state variables, particularly applicable to water quality monitoring (for swimming, public health, food safety and environmental protection) and for the understanding of environmental change. Measuring physiochemical and biological sea states through automatic data gathering systems is the new frontier of modern oceanography; to this purpose the use of a joint observatory is crucial. These instruments are able to provide real-time monitoring with high temporal resolution sampling for:

- The principal parameters describing the physiochemical and biological conditions of a marine environment, such as: temperature, salinity, current speed and direction, pH, oxygen saturation, chlorophyll, transparency and backscattering;
- Meteorological parameters near the surface, where the dynamics of energy exchange between atmosphere and the sea represent a noteworthy source of criticality for numerical forecasting.

"LTER-Italy sites are potential providers of *in situ* data for GMES services"

In Italy various research institutes, gathered in the National Operational Oceanography Group (GNOO), are responsible for the upkeep and management of the instrumentation used on buoys. There are six principal long-standing stations dedicated to observing the sea's status in the Northern Adriatic Sea (Figure 2): the Gulf of Trieste near the Miramare reserve where the MAMBO (run by the Trieste Institute of Oceanography and Experimental Geophysics OGS) and Paloma (run by CNR-ISMAR in Trieste) buoys are moored; the Gulf of Venice with the Acqua Alta Oceanographic Tower (run by CNR-ISMAR in Venice); and sites S1 south of the Po Delta and E1 off Rimini (both run by CNR-ISMAR in Bologna); the Telesenigallia mast (run by CNR-ISMAR in Ancona) at the southern limit of the North-Adriatic Sea.

The *MyOcean and MyWave* GMES projects use the data supplied by the platforms and buoys listed below to validate forecast models:

- The MAMBO buoy is moored to a 20 m seabed in the Gulf of Trieste by the edge of the Miramare marine park. It collects and transmits real-time meteorological and marine data: temperature and salinity are recorded continuously. The buoy is an ideal laboratory for using advanced instrumentation to measure marine currents or monitor dissolved carbon dioxide concentration;
- The Paloma mast is located 12 km offshore in the Gulf of Trieste, at a depth of 25 m. It records data of sea temperature, wind speed and direction, air temperature, relative humidity, precipitation, solar radiation, and air pressure. The data acquisition and elaboration occurs every 5 minutes and transmission is in near real-time (every 3 hours);
- The Acqua Alta research tower was installed in January 1970 and is located 15 km from the city of Venice. A broadband wireless communication system between the tower and the operating institute allows real time data availability. Measurements routinely acquired with periodic samplings relate to biology, chemistry and physical oceanography. Autonomous instruments cover atmospheric (wind, air and water temperature, atmospheric pressure, humidity, precipitation) and hydrological parameters (waves, currents along the column with ADCP, temperature at surface and bottom, salinity, turbidity, oxygen, chlorophyll-a and sea level) with a series of meteorological stations and oceanographic instruments. A direct view of the sea's condition around the tower is available continuously thanks to three high-resolution webcams installed on the roof. Two underwater webcams are installed at -3 m and -12 m to observe biological populations and to monitor potentially critical phenomena such as jellyfish swarms etc.;
- The S1 buoy is located at 7,5 km to the southeast of the Po di Goro mouth in the Po Delta. It is moored at a depth of 22,5 m in a coastal area dominated by the sea-river energy exchange, which is sensitive even to the smallest variations in any given environmental component. The site is optimal for studying climate variability in the upper Adriatic, the role of the seabed in local dystrophic[1] and sedimentation

Map of the buoys and fixed platforms in the NW Adriatic Sea (Credits: CNR-ISMAR).

[1] Distrophic refers to basins with brown coloured waters, which results from high concentrations of humic substances and organic acids suspended in the water.

ENVEUROPE (LIFE+ PROJECT ENV/IT/000399)

EnvEurope began and is being developed within the LTER-Europe network, which represents more than 400 sites across Europe and the Near East. The project contributes to the integration and coordination of long-term ecosystem research and monitoring initiatives in Europe. It focuses on understanding the current status of ecosystems and how they are changing, and is characterised by a broad-scale and cross-domain approach (terrestrial, freshwater and marine ecosystems), combining the efforts of over 65 LTER sites in 11 countries.
EnvEurope was conceived and organised to play a role in the conceptual and operational context of SEIS, promoted by the European Commission. The permanent long-term site network on which the *EnvEurope* project focuses will represent a valuable system for *in situ* validation of satellite data, thus also supporting the implementation of the GMES programme. *EnvEurope* will supply ecological data and information on the status and long-term trends of terrestrial, freshwater and marine ecosystems at the European level, based on field data gathered at different scales. It will thus contribute to bridging the gap between science and policy and improve scientific support to the EU's environmental policy and conservation plans. The National Research Council of Italy, through the Institute of Marine Sciences, coordinates the project, which runs from 2010 to 2013.

processes and sediment re-suspension in pro-delta areas;
- The E1 buoy is located 5.5 km north of the city of Rimini. It is moored at a depth of 10.5 m and is representative for a wide stretch of the coast between Rimini and Ancona. Its monitoring is mainly used for forecasting hypoxic[2] and anoxic[3] episodes that in the past have often characterised this part of the coast;
- **The TeleSenigallia** mast, which is two kilometres offshore of the city of Senigallia, at the bottom depth of 10.5 m, provides meteorological data (wind speed and direction and air temperature) and oceanographic data (sea temperature, current speed and direction and sea level) and near real-time data transmission at present (manual data recovery via GSM every 2-7 days).

The buoys acquire meteorological and oceanographic data. As far as the atmosphere is concerned, they measure temperature, pressure, wind speed and direction, relative humidity and net radiation. For oceanography they measure current direction and intensity, temperature, salinity, oxygen saturation, pH, turbidity and fluorescence.

All these buoys and platforms are supported by the governments of the regions involved (Friuli-Venezia Giulia, Veneto, Emilia-Romagna and Marche) and by their respective environmental agencies.

[2] Hypoxia is a phenomenon that occurs in aquatic environments as dissolved oxygen becomes so reduced in concentration that it endangers aquatic organisms living in the system.

[3] Anoxic events or anoxic events occur when the oceans become completely depleted of oxygen

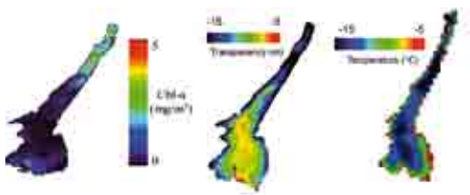
"The *in situ* long time series of data acquired in the Northern Adriatic Sea have, for instance, led to the development of a decision support system helping local authorities in the management of events affecting ecosystem integrity"

In situ long time series of data acquired in the Northern Adriatic Sea have been fundamental for the development of applied research initiatives involving regional and local policy authorities, environmental protection agencies and socio-economic actors.
One example is an observation and 3-D forecasting system and a decision support system aiming to help local authorities in the management of hypoxic and anoxic events. This system, with special focus on the Rimini coastal area, is based on an early-warning system, which predicts spatial and temporal evolution of the marine oxygen concentration, thus supporting the administrative and socio-economic actors (Municipality of Rimini, Emilia-Romagna Region, Agency for protection and environment of the Emilia-Romagna Region - ARPA) in adopting short-term and long-term strategies to reduce the impacts that these marine risks can have on tourism, fishing and the environment. Widely speaking, implementations and progresses in the field of oceanographic and meteorological predictions are supported by long-term intense cooperation with national and regional environmental protection agencies (ISPRA– the National Institute for Environmental Protection and Research-, ARPA– the Regional Agency for Prevention and Environment of Emilia-Romagna- and National Civil Protection) and groups (GNOO -Gruppo Nazionale di Oceanografia Operativa- supported by the Italian Environment Ministry). The data from buoys, included both in the setting-up and validation phases of the forecasting models, assure the high quality level of the meteo-oceanographic Adriatic Sea previsions.

Combining *in situ* and satellite data for lake management (LTER-Italy site: Lake Garda)

Lake Garda is one of the most important touristic areas in Italy, but also a very valuable one as far as hydrological resources are concerned. Together with the other Italian Subalpine lakes (Maggiore, Lugano, Como and Iseo), it plays a central role in the overall water balance of the Po River Valley, representing together more than 20% of the entire basin of the Po River.
The possibility to monitor these lacustrine ecosystems permanently, through Space-based services and *in situ* observations, can provide many answers about the impact of human and natural modifications, biodiversity loss, global warming and the increasing occurrence of natural hazards.

Lake Garda, the largest in Italy, is surrounded by mountains and represents a major environmental as well as an important tourism area. Monitoring activities help protecting the ecological status of the area despite the multiple leisure activities (Credits: Fabio Alessandro Locati).



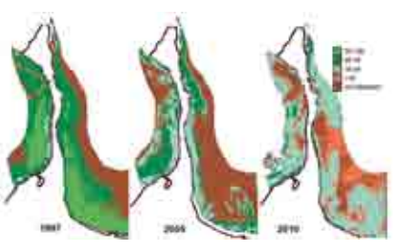
Maps of surface chlorophyll-a concentration, transparency and water temperature in Lake Garda (Credits: CNR-IREA).

Studies on Lake Garda with remote sensing techniques, made at the CNR's (Italian National Research Council) Eugenio Zilioli Experimental Station, started in the early 1990s. These studies were consolidated after 1996 with the participation in the *Satellite Remote Sensing for Lake Monitoring (SALMON)* FP4 project. In 2000 the station was established as a permanent point of reference for the collection of *in situ* measurements, in support of remote sensing. This station collected specific parameters for the validation and analysis of satellite images of the entire basin of Lake Garda.

"Permanent monitoring of lacustrine ecosystems provides answers about the impact of human and natural modifications, biodiversity loss, etc."

Through the integration of *in situ* measurements and the regular acquisition of satellite images, two types of distribution maps are produced. The first provides water quality parameters (such as chlorophyll, total suspended solids, yellow substances and transparency) on a monthly or bimonthly basis, using MERIS ESA satellite images. The second is produced using a sensor mounted on the NASA satellite AQUA MODIS 11A, which returns maps of the temperature of the lake.

Only on one occasion were specific *in situ* measurements acquired for the production of thematic maps, relating to the distribution of aquatic macrophytes[4]. These observations give meaningful information for lakeshore management and are useful for the evaluation of the long-term evolution of macrophyte populations.
All these activities, following the GMES philosophy of integration of Earth Observation with *in situ* data, allow the provision of constant monitoring services and infrastructure not only for Lake Garda but also for the entire subalpine lakes district. The main end-users benefiting from this are the local agencies and communities in charge of monitoring and assessing the status of the lake. An example of this use can be the Centro di Rilevamento Ambientale of the Municipality of Sirmione (Garda Lake), which used remote sensing images of the lake to monitor water quality and obtain the 'blue flag' certification by the Foundation for Environmental Education (FEE).



Developments in areas colonised by submerged macrophytes in the shoreline of the Sirmione peninsula (the percentages of coverage in the legend). Data purchased by hyperspectral sensors mounted on aircrafts (Credits: CNR-IREA).

[4] A macroscopic plant, commonly used to describe aquatic plant, that is large enough to be visible to the naked eye.

Monitoring the alpine environment using satellite and *in situ* data (LTER-Italy site: North-Western Alps)

The Alps represent one of the most sensitive terrestrial ecosystems in Europe, due to natural and human factors. The Alpine Convention states that the Alpine environment is under imminent threat and demands comprehensive countermeasures. The planning and success of every preventative measure strictly depends on the availability of knowledge and information about the state and evolution of the ecological conditions of the Alpine environment. In particular, the maintenance of long-term observations is essential when dealing with such a sensitive ecosystem. The synergies between conventional terrestrial investigations and satellite remote sensing represent an ideal and cost efficient tool for this purpose. Satellite images can synoptically record wide areas, and remote sensing may provide repeated observations of the same areas, which allows detailed long-term monitoring .
The LTER-Italy network includes several high elevation sites in the north-western Alps, which represent the main high altitude environments of this area falling within the Piemonte and Valle d'Aosta regions. They include six research sites located along an altitudinal gradient, ranging from 2100 m to 3100 m Above Sea Level (ASL), where soils are seasonally snow covered. Vegetation cover ranges from larch and spruce stands to alpine grasslands, and overlying soils at various degrees of evolution. One of these six sites belongs to the *GLORIA* (*GLobal Observation Research Initiative in Alpine Environments*) network while another, at a higher elevation (3100 m ASL), is a permanent area for monitoring permafrost and the active soil layer. The main organisation managing both sites is the Regional Agency for Environmental Protection of the Valle d'Aosta region (ARPA Valle d'Aosta).

The Angelo Mosso mountain research station (2901 m ASL - Monte Rosa Massif, Italy) (Credits: Università degli Studi di Torino-NatRisk-LNSA).

"The information collected contributes to the monitoring of avalanche risk and the construction and maintenance of ski slopes in the Monterosa Ski Resort"

The Istituto Scientifico Angelo Mosso (Mosso) research site, close to the Monte Rosa Massif (Alagna Valsesia – Gressoney La Trinité municipalities), belongs to the University of Torino. It is located at a high altitude (2901 m ASL) and hosts the NatRisk-LNSA research centre (www.natrisk.org). Climatic data has been collected there since 1926 thanks to the close presence of a monitoring station belonging to the *Regii Osservatori Meteorologici e Geofisici del Monte Rosa*. An automatic weather station has been in operation since 2005, managed by the Italian army. The automatic weather station has specific sensors for the measurement of temperature at the snow/soil interface and at 10 cm depth. The information collected contributes to the monitoring of avalanche risk and the construction and maintenance of ski slopes in the

Monterosa Ski Resort, where the Mosso research site is located. Moreover, thanks to specific agreements with local governments, the Mosso Institute hosts specific educational and communication activities addressed to local schools and the general public. Among these activities the International Programme for Mountains (IPROMO) organised by the FAO-Mountain Partnership Secretariat and the Turin University-NatRisk, is particularly relevant.

Final remarks

Environmental managers are recognising that a successful environmental management strategy depends on an integrated approach to the maintenance of ecosystem structure and functioning, and that this will optimise the ecosystem services for the benefit of humans and nature. The key question is whether there is sufficient ecological knowledge to provide the necessary information about ecosystem structure, function and response to disturbance. Within this context, the synergies among long-term *in situ* observations (LTER networks), technological innovations, remote sensing (GMES) and ecological modelling are crucial in order to improve our understanding of the environment and our attempts to properly manage and protect it. The activities described, from the three LTER-Italy sites, are examples of *in situ* assessment of the usability and applicability of remote sensing products for long-term ecosystem monitoring.

Alessandro CAMPANARO (biologist, PhD in Animal Biology) is a PostDoc at the University of Rome "La Sapienza" (IT) in agreement with the National Centre for Forest Biodiversity "Bosco Fontana" of Verona (IT). His main research interest focuses on the ecology and monitoring of saproxylic insects. He is involved in the LTER-Italy network since 2009 and in the Life+ Project *EnvEurope* for the "Network design" action.

Alessandro OGGIONI (natural scientist, PhD in Ecology) is a PostDoc at the National Research Council of Italy. His main research interest focuses on GIS, Data Management and phytoplankton and aquatic plants ecology in lacustrine. He is involved LTER-Italy network since 2010 and in the Life+ Project *EnvEurope* for the action about Data Management and Infrastructure development.

Alessandra PUGNETTI (biologist, PhD in Environmental Sciences) is a scientist at the National Research Council of Italy. Her main research interest focuses on phytoplankton ecology in lacustrine, transitional and marine environments. She is involved in the coordination of the LTER-Italy network since 2004 and she is the Coordinator of the Life+ Project "EnvEurope".

Interview

GMES IS NOT ONLY BRINGING VALUABLE PRODUCTS AND SERVICES TO VARIOUS LEVELS OF LOCAL GOVERNMENT; IT IS ALSO A CORNERSTONE OF THE EUROPE 2020 STRATEGY AS THE PROGRAMME WILL FOSTER GROWTH AND JOBS IN THE EUROPEAN ECONOMIC AREA. THE INNOVATIVE DIMENSION TO THE FORMULATION OF GMES SERVICES IMPLIES THAT ENTREPRENEURSHIP WILL PLAY A MAJOR ROLE IN THEIR DEVELOPMENT. TO ILLUSTRATE THE POTENTIAL BUSINESS DEVELOPMENT POTENTIAL OF GMES, *WINDOW ON GMES* HAS SOLICITED THE CEOs AND FOUNDERS OF FOUR SUCCESSFUL SMES TO SHARE THEIR STORY, THEIR EXPERIENCE AS WELL AS THEIR ADVICE.

Can you tell our readers when you created your company and what the trigger was?

Jan Kolar: I created GISAT in October 1990. The main direct driver was my professional interest in satellite remote sensing – the discipline to which I had devoted more than ten years of university research. However, the company could only become reality thanks to revolutionary changes in our society making private business possible.

Giovanni Sylos-Labini: Planetek Italia was founded in 1994. At this time in Italy, all players in Earth Observation were technology-oriented companies and a true application-oriented company was missing from the market place.

Giulio Ruffini: When I founded Starlab I thought that there was room for goal oriented scientific people wanting to make a difference outside classical academia. The science and technology were evolving rapidly, and the cycle from idea to product/service was accelerating. Since we wanted to create an interdisciplinary environment, we focused on Earth Observation and Applied Neuroscience as our target development fields. The nexus is technological: data processing and Maxwell's equations.

Christian Hoffmann: I founded GeoVille in 1998 as a one-person company. At the time I was convinced of the added value of satellite remote sensing for activities related to land management and, so far, I have not been proven wrong.

The creation of a company must build on a sound business plan. Would you advise a young entrepreneur to elaborate his business plan on his own or to get support from third parties (e.g. specialised consultancy)?

CH: The ingredients for success are a sound and realistic business plan, a unique selling proposition, an excellent accounting company and enough cash to survive year one.

JK: My recommendation is to have your own idea and also necessary the understanding of business activities in your chosen sector. Consultancy services are useful

in relation togeneral commercial activity, however their business plan should focus on a specific type of service, production or application.

GSL: It is not always obvious how to define the right competencies to support a start-up company in this field. My suggestion is that partners of the new company should have technical skills as well as good financial and management capabilities. As far as fundraising activities are concerned, some professional advice could be useful.

GR: The most important thing is to identify a viable market, where what you develop has value and where people are willing to pay for it. Unavoidably, there are always unknowns, so the next most important thing is cash: as they say in the trade … "cash is more important than your mother". Of course, having a business plan is very important, one with realistic (if optimistic) assumptions, but plans are made to be broken.

Have you applied to external funding sources? If yes, what were they? Did you know that in addition to grants for R&D activities the EU also offers several funding mechanisms to support the creation of companies such as venture capital, risk capital, loans and loan guarantees?

GSL: In Planetek Italia history we have used several types of fund raising activities, from bank loans, venture capital and the company sale. Up to now all equity oriented operations have been unsuccessful. This situation can be explained by two facts: first in this sector it can be difficult to generate large amount of cash-flow. Second, potential shareholders often have difficulty to appreciate the enormous amount of intangible assets generated by our company.

CH: I personally own 25% of the company. The remaining 75% is held by investors who made the up-front investment of one million Schilling (approx. 75,000 Euro) – at that time it was a lot of cash! They believed in the idea and have received each calendar year a fair return on their initial investment..

JK: My case is rather extraordinary one in several aspects. I started my business at home in dining room with the first version of a personal computer. For several reasons I decided to harmonise the pace of my company development with my personal financial sources. I preferred to avoid the burden of loans. Our country in that time went through revolutionary changes and the long journey to membership of the EU was yet to start.

GR: Yes, we have been recipients of EU grants. I am aware of other sources and I have only a vague notion that venture capital, risk capital and loan guarantees are also available, but I am sceptical about their practical value. Maybe I should learn more!

What were the most important barriers to entry that you have faced?

GR: In the case of EO services, the main barrier is that the technology is not understood by potential customers, thus making the typical consultancy dialogue needed for business very hard to initiate. Data availability and data continuity (i.e., Envisat) are further bottlenecks. We have developed several services around ENVISAT, and now due to the failure we can no longer provide them. This is a real European blunder.

GSL: In 1995, when we founded Planetek Italia, the main technological entry barriers associated with data processing in EO were decreasing; this was one of the reasons why we thought that the business was likely to be profitable. More standard difficulties included: red tape, funding, and the fact that we are located in Southern Italy, needless to say that it increases the distance between the company and a lot of potential customers.

JK: In the beginning of the 90's satellite remote sensing was still a relatively new technology for integration into business in operational way. Finding customers for products-based on satellite imagery was much more difficult than it is today.

CH: As a start-up with no track record it was very hard to convince customers to sign a contract.

Your respective companies have participated in several projects funded, or co-funded, by the EC. Can you tell our readers how these projects have contributed to the development of your companies and in what particular ways?

CH: It is fair to say that GeoVille was involved in all major EC or ESA projects related to land monitoring. The benefits of our involvement in such projects are multiple, including networking, business opportunities, research and development activities. However, we aim that such projects do not account for more than one third of our overall turnover.

JK: European projects were of great importance for Gisat during its first years. In that period, three-quarters of Gisat's turnover resulted from European projects. It was due, to some extent, to the capabilities of satellite images twenty years ago being more suited for continental and regional applications and it was also due to the unpreparedness, let's say non existence, of a domestic EO market.

GSL: In my view two main aspects are relevant: The partnering with other companies, mainly foreign ones, and the opportunity to fully test new products in new markets. In this respect I believe that, among several others, the *Geoland* project was a good example of these benefits. Today, thanks to the *Geoland* experience, we have generated about 20 new products under the registered trade mark PRECISO.

GR: For us EU grants have been the key to develop new technologies. They have helped us to develop our technology programmes in a way we couldn't have done otherwise, given the aversion to risk of other funding sources.

What matters for GMES4Regions is the uptake of GMES services at local and regional levels. According to you, what are, today, the most important factors limiting the development of EO/GI services among Local and Regional Authorities?

GSL: In the EO/GI sector, it is often not easy for the final user to appreciate the added value of our services to their mission. In that regard, the contrast with other Space-based services, e.g. positioning, is striking. The users understand very easily the benefits of positioning even though they do not have a detailed knowledge of the technology. Furthermore, some prejudices still survive as to the effectiveness and potential drawbacks of Earth Observation, due to earlier application development periods when EO did not deliver against expectations. EU-funded GMES Projects have allowed Planetek Italia to foster our mentoring and training effort toward our user community. It notably resulted in the adoption of a more user-oriented approach in application and service design derived from the industrial design, that's also historically a strong point of Italian industry.

GR: At the moment, the lack of a budget is the key limiting factor given the financial situation! More generally, the critical issue is to talk to the right people in such agencies so real, solvable problems can be identified and offers created.

CH: The financial crisis is certainly playing its role in slowing the uptake of GMES at local level. Despite the situation starting to improve, many potential end-users do not yet have a clear understanding of the benefits they could obtain from using EO-based services. In that regard, we as Service Providers have a role to play in raising awareness of GMES at local level, after all this is part of our business.

JK: Despite a gradually improving situation, many of EO services are not accepted as suitable for operational implementation by potential local and / or national users. There are several reasons of that. Firstly, EO services include processes and techniques so different from the traditional ones that there is a lack of general willingness to undergo the change within a user's business. Secondly, some EO services need to improve their reliability in terms of both information quality and timing. Finally, in some cases, such as emergency and security services, modifications of legal frameworks are necessary in order to facilitate operational use of a service

Does your company mainly provide services to local users or have you succeeded in "exporting" your activity in other European Member States or even beyond the EU?

JK: Today, Gisat provides substantial part of its service products outside our country. The valuable experiences gained through our involvement in European EO-based projects like *Corine Land Cover* or *MARS* have become important knowhow. Today, it allows us to provide high quality services to a growing number of domestic users and to react with flexibility to various requirements of clients inside and outside EU.

GSL: Planetek Italia is heavily engaged in "export" activities, within Europe. As a matter of fact, five years ago we established Planetek Hellas in Greece. Outside of Europe, we have recently won an international tender for the Morocco SDI (Spatial Data Infrastructure). On the medium term, we are seeking European partners to capitalise upon our great experience in the design and development of the INSPIRE Geoportal, which is to be delivered in his final version to the Joint Research Centre (JRC).

CH: GeoVille is highly internationalised, with a fully owned subsidiary in Luxembourg and project references in four continents. About 80 percent of our business is outside Austria.

GR: We work mostly within Spain.

Today's students are the future of GMES. Over time, as your companies grew, have you endeavored to develop interactions with European Universities training students in GMES-related themes?

CH: The connection to universities is essential. Unfortunately, remote sensing and business thinking are underrepresented in many university curricula.

JK: Definitely. Perhaps, I have been in better position in this respect as I give lectures in remote sensing and GIS in universities in Praha. It allows me to integrate information about GMES and other initiatives into my lectures and also to share my experiences on the practical use of EO-based services with my students. Some of my former students have become EO professionals in Gisat.

GSL: We already have several connections with national universities. For example, I'm a visiting professor, for more than a decade now, in Venice at IUAV. Our sister company in Greece successfully shares experiences with local universities, and training is one of our first priorities.

GR: Yes, we have. However, the mentality in our universities is a bit backward in this sense. The crucial role of companies in society is not sufficiently appreciated (but I suspect this will change).

As successful entrepreneurs, what advice would you give to a young entrepreneur ambitioning to start a company from scratch in the EO/GI service sector?

GSL: My first suggestion is to start from user needs and not from technology, the second is to look at business fundamentals, third to find a mentor, preferably from the industry.

GR: To think of the technical part as the easiest piece of the puzzle. The critical element is to ask yourself if you have identified a real business opportunity? Do you have a list of clients' names and addresses? Make sure you have an answer, or a plan to explore such questions rather fast.

JK: Try to understand the technology. Make your business firmly rely on your knowledge of EO methods of data acquisition and processing. This will allow you to assess what is possible and the risk associated to the services you intend to provide to meet the needs and demands of your clients. To start with, you must decide what kind of specific services you can best provide and focus your effort on them.

CH: Our business starts with customised services, but equally important are access to customers and cash. Convince somebody to invest in your company! If you achieve it, chances are high that you succeed.

The European Union finances GMES Services. It calls for a free and open data policy. Can you explain to our readers how GMES data will help your company to develop services for new domains of applications or for new customers?

JK: The data is the necessary basic "material" for providing any information service. Limited access to data means limited service in terms of information content, richness and, obviously, availability over time. Moreover, the data cost fuels the cost of a service. The improvement of existing services to make them more attractive for users would be impossible or, at least, slower without GMES data. This also applies to the development of promising new EO applications such as snow water content determination for spring flood prediction or mapping of polluted soil and vegetation.

GSL: Data is the building block of EO, and transforming data into information is the main mission of our companies. A free and open data policy is an obvious booster for our capabilities in generating new services and products, with the promise that this will be sustainable, i.e. with a commitment for long term generation of consistent dataset.

CH: Limited access to the most fundamental ingredient of our business limits major business opportunities to those owning the data. In other words, free and open access will multiply services, opportunities and revenues.

GR: Well, depending on the data needed, there are ways – sometimes awkward – to have access to free data from ESA, and also from NASA and others. GMES can help you develop new services, establish your R&D network and partly finance your R&D.

In a nutshell…

Jan KOLAR established Gisat in 1990. It was the first privately run remote sensing and geo-information service company in the Czech Republic. Its office is located in Prague. Since its inception GISAT has been working in the geomatics field with a specific focus on the advanced technology of remote sensing and GIS.
For more information: http://www.gisat.cz/content/en

GISAT (CZ) – key figures	1991	2000	2010
Number of Employees	1	7	15
Turnover (k€)	25	550	1,000

Giovanni Sylos-Labini, founder and CEO of Planetek Italia S.r.l., a leading Geographical Information Services (GIS) and Earth Observation consultancy company, which focuses on land management information. Pioneered in 1994, Planetek steadily expanded within the Italian GIS market place by incorporating the latest techniques, coupled with a proficient team of high-level professionals.
For more information: http://www.planetek.it/eng

Planetek (IT) – key figures	1995	2001	2010
Number of Employees	4	20	48
Turnover (k€)	100	1,500	4,600

GeoVille Information Systems is a private sector enterprise located in Innsbruck, Austria and was founded by Dr. Christian Hoffmann in 1998. GeoVille Environmental Services Luxembourg was founded as a subsidiary in 2007. GeoVille customers stem from private industry sectors, public organisations and research institutes. GeoVille is dedicated to providing a wide range of value-added services for remotely sensed data and GIS applications.
For more information: http://www.geoville.com

GeoVille (AT)	1998	2001	2011
Number of Employees	1	4	28
Turnover (k€)	140	450	3,200

Giulio Ruffini founded Starlab in 2000. The company is based in Barcelona, Spain. Starlab's mission is to transform science into technologies with a profound positive impact on society. Our main areas of work lie in the Space and Neuroscience sectors. We provide technical solutions, products and services for governments, industry and downstream markets.
For more information: http://starlab.es

Starlab (ES) – key figures	2000	2012
Number of Employees	4	30
Turnover (k€)	100	2,000

Downstream Observatory organised by Regions active in Space - Network
DORIS_Net

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- University of Leicester (ULEIC), UK
- Centre d'Études Techniques du Sud-Ouest (CETE), France
- Capital High Tech (CHT), France
- Secretaria Regional da Ciência Tecnologia e Equipamentos (SRCTE), Portugal
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- Paris Lodron University, Austria
- GISAT, Czech Republic
- Specto Natura, England

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