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A Decade of Success in Earth Observation Research and Innovation

Research and Innovation

EUROPEAN COMMISSION

Directorate-General for Research and Innovation
Directorate I – Climate Action and Resource Efficiency
Unit I.4 – Climate Action and Earth Observations

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2015 Directorate-General for Research and Innovation

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Luxembourg: Publications Office of the European Union, 2015

Print	ISBN 978-92-79-51988-8	doi:10.2777/766585	KI-01-15-721-EN-C
PDF	ISBN 978-92-79-51987-1	doi:10.2777/906	KI-01-15-721-EN-N

Printed in Belgium.

FOREWORD

At a time when we are facing major threats to our environment, many studies agree in predicting increasingly severe consequences as a result of climate change, decreasing stocks of natural capital and resources and intensifying environmental pollution. These environmental challenges are complex, interrelated, cross-border in nature and inter-dependent at the global scale. Therefore, they can only be addressed by a global approach, based on comprehensive and timely information derived from Earth observations.

Earth observation data and information are vital to allow governments, society and the private sector to take informed decisions about climate, energy, food security, natural hazards, health and other societal challenges. The domain of Earth observation is characterised worldwide by the high diversity of organisations responsible for managing a plethora of different observing systems (whether space, land, marine, airborne or community-based) and data infrastructures. Coordination is therefore essential to avoid duplication of efforts and reduce observational gaps.

International collaboration in Earth observation is therefore a necessary condition to help addressing many of our global societal challenges. Recognising this, the European Commission together with 27 EU Member States are active members of the Group on Earth Observations (GEO). Since 2005, GEO has provided a global voluntary framework where governments and participating organisations can coordinate their strategies and investments in the field of Earth observation while promoting full and open access to data and information through the Global Earth Observation System of Systems (GEOSS).

In January 2014, government ministers and other heads of delegations from the GEO partnership resolved to renew the GEO mandate for a further decade. The next ten years will be crucial in terms of evolving a more robust and use-oriented GEOSS and forging new strategic partnerships. By harnessing not only Earth observation data but also socio-economic information, GEO will support the implementation of the Post-2015 agenda for sustainable development as well as other global frameworks and international agreements.

In order to contribute to this global venture, the European Union has made significant investments in the domain of Earth observation through the European research and innovation framework programmes. These efforts have significantly advanced the implementation of GEOSS and reinforce the research component of the EU Copernicus flagship programme on Earth observation. Over the last ten years, over € 250 million have been invested in research and innovation projects underpinning various societal challenges such as disaster resilience, ecosystem and biodiversity conservation or water management. These research activities have been pivotal to better understand and predict the Earth as a system, to inform policy decisions and to promote cross-border and multidisciplinary scientific partnerships.

This European contribution to GEOSS is very much in line with the three main pillars of my strategic agenda for EU Research and Innovation: 'Open science', 'Open innovation', 'Open to the world'. In particular, sharing Earth observation data on an open basis contributes to 'Open Science'; co-developing new Earth observation applications and exploring new digital markets for Earth observation contribute to 'Open Innovation'; cooperation with our international partners in the GEOSS context contributes to be 'Opened to the World'.

This booklet provides a snapshot of typical EU-funded projects which illustrate European research and innovation excellence in Earth observation and Earth sciences. It also showcases the potential of international collaboration in science for diplomacy.

Carlos Moedas,
European Commissioner for Research, Science and Innovation

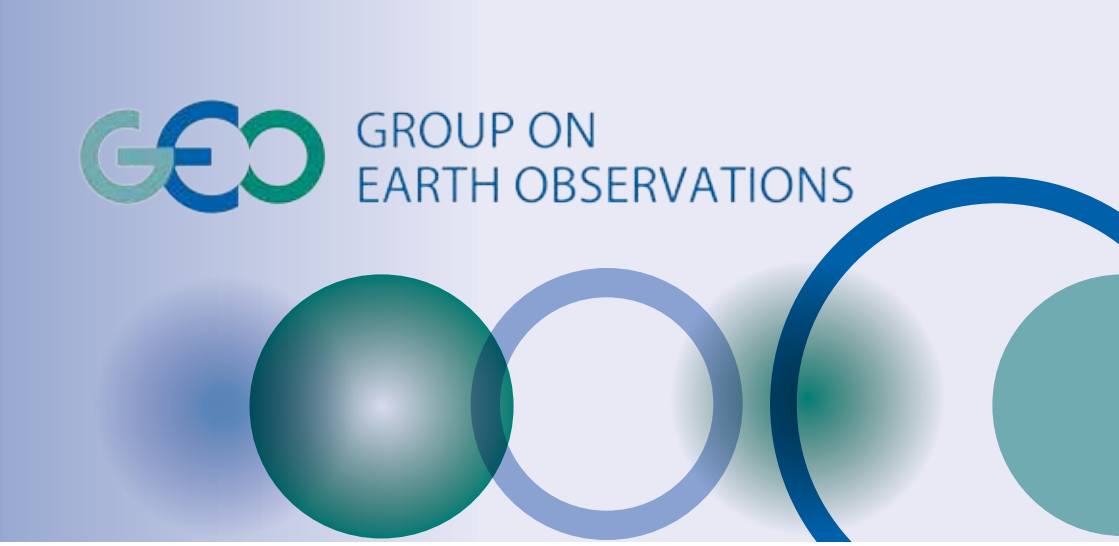
INTRODUCTION

Measuring the Earth: Building a Global Earth Observation System of Systems (GEOSS)

The Earth's atmosphere, oceans and landscapes are changing rapidly, with human activities being a major driver. Monitoring and modelling these changes are critical because they allow governments, society and the private sector to make informed decisions about climate, energy, food security, natural hazards, health and other societal challenges. To be effective, these responses must be grounded in comprehensive and timely information. More importantly, decision makers, managers and experts must have access to the information they need, when they need it and in a format which can be easily utilised.

Today, vital information is being gathered by land, sea, air and space-based Earth observation systems. The current process of collecting, storing, analysing and distributing this information however remains fragmented, incomplete or even redundant.

To address this challenge, the intergovernmental **Group on Earth Observations (GEO)** has provided a voluntary framework since 2005 where 98 governments, the European Commission and 87 international organisations develop new projects and coordinate their strategies and investments in the field of Earth observation. **The vision of GEO is to realise a future wherein decisions and actions for the benefit of humankind are informed by coordinated, comprehensive and sustained Earth observations and information.** GEO's main objective is to develop and implement the **Global Earth Observation System of Systems (GEOSS)**. The GEOSS aims to deliver a coordinated, comprehensive and sustained information system to enable and facilitate global monitoring, insight and foresight into the state of the planet, facilitating access to Earth observation data and information by decision-makers, business, scientists and citizens. Millions of resources can already be openly and freely accessed without restrictions. These can be used to tackle a number of issues of societal concern such as protecting citizens from natural hazards, supporting sustainable agriculture or improving the management



of energy resources. Data and information collected through environmental "Citizens' Observatories" platforms will also be available through the GEOSS, offering the means to empower societies, allowing citizens to play an active role in community decision-making and planning in partnership with governments and local authorities. Crucial to this success has been the implementation of the **Discovery and Access Broker (DAB)**, as the cornerstone of the GEOSS infrastructure. The DAB provides harmonised access to a heterogeneous plethora of data and services from different disciplines and communities.

In January 2014, in Geneva (Switzerland), Ministers and other heads of delegations from the GEO Member governments and the European Commission resolved to renew the GEO mandate for a further ten years, triggering the process for developing a new strategic plan for GEOSS to be endorsed by the end of 2015. In this second decade (2016-2025) **GEO will reinforce its role as a unique initiative occupying a strategic, upstream coordination position in the EO international community**. It will provide a flexible and agile forum for governments, researchers and the private sector, improve the link between scientific understanding and policy-making and foster new economic opportunities. GEO will also develop new approaches to effectively engage with United Nations institutions, Multilateral Environmental Agreements, Multilateral Development Banks, and additional Participating Organizations.

GEO and Open Earth Observation Data

The GEO adopted its full and open **GEOSS Data Sharing Principles** back in 2005. Since then, GEO has been instrumental in advocating full and open access to Earth observation data worldwide. These principles are the basis for expanding data reuse through the GEOSS, promoting broad open data across all the GEO societal challenges and encouraging governments and organisations with an Earth observation mandate to adopt, as far as possible, open access policies for the data they own. The GEO Data Sharing Action Plan, adopted in 2010, also included the new concept of the **GEOSS Data-CORE (Data Collection of Open Resources for Everyone)**, which is the subset of GEOSS data, information and products complying with the principles of full, open and unrestricted access at no more than the cost of reproduction and distribution.

Since 2010, **more than one hundred million individual resources have been made available through the GEOSS as GEOSS Data-CORE**, becoming a key success story of the GEO and making the GEOSS distinctive from any other web-based infrastructure. The increasing, worldwide trend towards full and open sharing of Earth observation data is recognised in the revised version of Data Sharing Principles adopted for the second decade of GEO, which encourages members and participating organisations **to share their data and products through the GEOSS as Open Data by default**.

GEOSS Societal Benefit Areas

GEOSS is simultaneously addressing a number of societal challenges of critical importance to decision makers and citizens in general. In 2005, nine areas where benefits could be delivered to society were identified:

- **Agriculture:** Supporting sustainable agriculture and combating desertification.
- **Biodiversity:** Understanding, monitoring and conserving biodiversity.
- **Climate:** Understanding, assessing, predicting, mitigating, and adapting to climate variability and change.
- **Disasters:** Reducing loss of life and property from natural and human-induced disasters.
- **Ecosystems:** Improving the management and protection of terrestrial, coastal and marine resources.
- **Energy:** Improving management of energy resources.
- **Health:** Understanding environmental factors affecting human health and well-being.
- **Water:** Improving water-resource management through better understanding of the water cycle.
- **Weather:** Improving weather information, forecasting and warning.

GEO coordinates a multitude of complex and interrelated issues simultaneously. A cross-cutting approach avoids unnecessary duplication, encourages synergies between systems and ensures substantial economic, societal and environmental benefits. Many efforts are therefore oriented towards addressing **interoperability, standardisation and data management** issues, advocating research and development by engaging with the Earth observation **science and technology** communities and **building capacities** to facilitate the use and exploitation of Earth observation, especially by developing countries.

Capacity Building within GEO

The GEO vision aims to strengthen the capability of all countries to use Earth observation data and products, which is especially relevant to developing countries having fewer monitoring infrastructures, investments or capacities to produce and process Earth observation data. GEO has been able to mobilise resources for regional capacity building networks in a number of developing countries, notably in Africa, Asia, the Balkans, the Black Sea catchment area and in South America. Typical actions included the identification of relevant stakeholders, building networks and providing training and e-training for local users. One example of these activities is the **AfriGEOSS** initiative, launched in 2013, which aims at enhancing Africa's participation in GEO, federating their efforts to bridge the digital divide on this continent and build a knowledge-based economy using GEO networks and the GEOSS.

In the 2014 Geneva Declaration, Ministers and participants assembled reconfirmed GEO's guiding principles of collaboration in leveraging national, regional and global investments, in developing and coordinating strategies to achieve full and open access to Earth observations data and information to support timely and knowledge-based decision-making. They then explicitly resolved to **strengthen engagement with developing countries**, as well as foster regional cooperation which is essential to achieve these goals by 2025.

Europe in GEO

The European Union (EU) is a driving force within GEO. The European Commission, together with 27 EU Member States, are contributing actively to this global initiative. This has resulted in strengthened transnational collaboration in Earth observation activities within the EU.

The **EU Research and Innovation programmes** have been pivotal to building the GEOSS. More than €200 Mio were invested over the period 2007-2013 through more than 50 collaborative projects funded within the Environment Theme of the Seventh Framework Programme for Research. These projects have contributed to all Societal Benefit Areas as well as to those cross-cutting activities underpinning the GEOSS. The following section incorporates a selection of these projects which illustrate the European contribution to this global endeavour.

The current EU Research and Innovation Framework Programme, **Horizon 2020**, refers to GEO as a multilateral initiative where international cooperation may be developed. In this context, the Horizon 2020 Specific Programme includes an activity on "Developing comprehensive and sustained global environmental observation and information systems", with more than € 60 Mio devoted to research activities in 2014 and 2015.

A major European contribution to GEOSS is the **Copernicus programme**, which entered into operations in 2014. Copernicus provides a crucial framework a strong and visible European role within this global initiative. Direct actions carried out by the **Joint Research Centre** are also making a key contribution to building the GEOSS.

Openly accessible Earth observation data and information obtained through GEOSS can **inform EU policies** in the domains of environment, research, space, climate, energy and sustainable development, while providing **opportunities for European businesses** to develop value-added services. Furthermore, GEO is in a unique position to increase **Europe's standing in the international Earth observation arena**, facilitating the development of strategic partnerships to jointly address global challenges.

AGRICAB

Helping Africa manage its agriculture and woodlands

To ensure food and energy security for today's growing populations, governments increasingly turn to Earth observation. Remotely-sensed data can provide valuable information on crops, livestock, woodlands and fires. Innovative, EU-funded research partnerships helped reinforce African capacities in this area.

The AGRICAB project had three key objectives: ensuring the continued, free and open provision of Earth observation (EO) data and software tools; developing real-life applications to support national policy in a set of focus countries around Africa around Africa; and stimulating uptake of Earth observation techniques at large.

Achievements in each area have significantly contributed to the Group on Earth Observations (GEO), its Global Earth Observation System of Systems (GEOSS), which seeks to integrate existing and planned observation systems for the benefit of society, and the African GEO initiative AfriGEOSS.

Reinforcing capacity, sharing knowledge, building partnerships

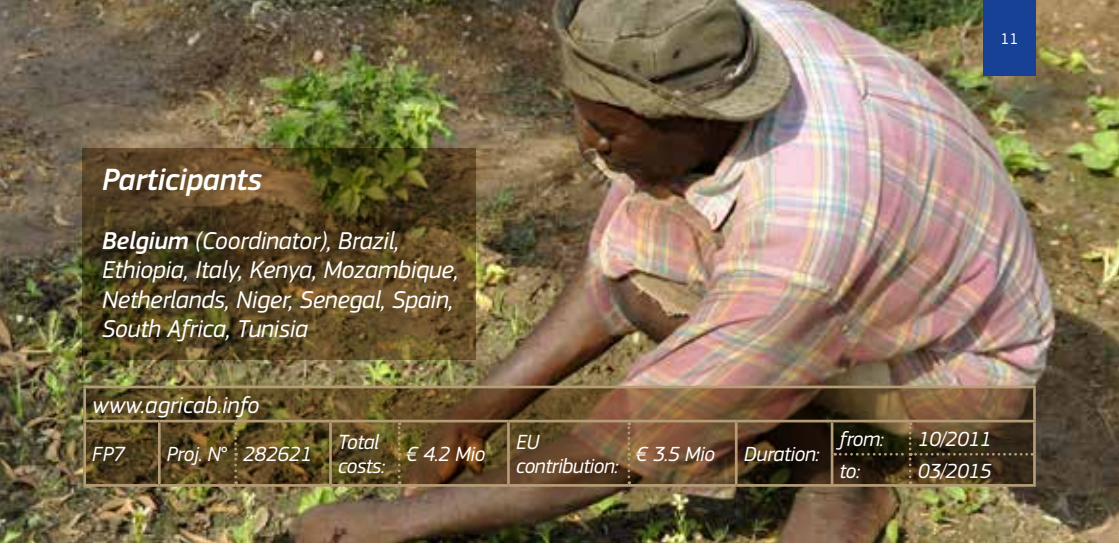
While African countries are already using Earth observation data to support their agriculture and forestry sectors, there is a risk that new technologies – or even updates to previous systems – pass them by. "When Earth observation technologies are updated, for instance with the advent of new sensors or services, we need to make sure that Africa can continue to make sensible, integrated use of the collected data," explains project coordinator Tim Jacobs of VITO NV in Belgium.

In the 3.5 years of AGRICAB, reinforcement of existing capacities involved an impressive 47 training workshops for African scientists and officials, with a total duration of 372 days. Training addressed a variety of topics: collecting and analysis of satellite data using free software, taking models to an operational level, comparing satellite and ground-based data and more.

The results are already visible, even at institutional level. In Senegal, for example, the Ministry of Agriculture set up a new unit within its statistics department and entered a new partnership with local project partner CSE (Centre de Suivi Ecologique) to carry forward the improved methods and knowledge.

Observing fields and forests

The applications integrated Earth observation data, ground measurements and local statistics in a variety of software tools. Extensive consultation with national experts



Participants

Belgium *(Coordinator), Brazil, Ethiopia, Italy, Kenya, Mozambique, Netherlands, Niger, Senegal, Spain, South Africa, Tunisia*

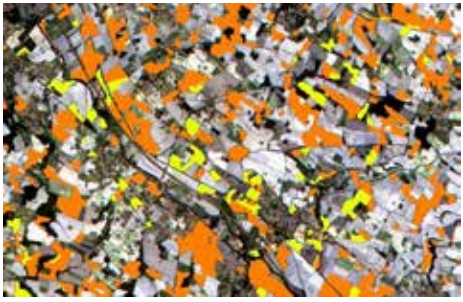
www.agricab.info

FP7	*Proj. N°*	*282621*	*Total costs:*	*€ 4.2 Mio*	*EU contribution:*	*€ 3.5 Mio*	*Duration:*	*from:*	*10/2011*
								to:	*03/2015*

and stakeholders, beyond the project consortium, and building on existing, multi-disciplinary networks and cooperation mechanisms, were further success factors.

"For rain-fed crop production in Kenya, Mozambique and Senegal, we were trying to improve the modelling of crops to forecast yields, to provide an early warning when harvests could be at risk, often by comparing with past seasons, and to estimate acreage covered by the main crops," explains Jacobs. "This of course required a partner with local knowledge, but also several consultations with the agriculture ministries."

In northern Africa, the team helped monitor the water balance between available groundwater and irrigation, tying into a pre-existing initiative involving Tunisia, Algeria and Libya.



For Niger, Senegal and Kenya, AGRICAB supported PhD studies developing better estimates of biomass production for forage, improving Earth observation indicators used in farmers' insurance against livestock mortality, and modelling livestock under various climate change scenarios.

In South Africa, the team studied the cover and structure of trees in the savannah, using new processing techniques and extensive ground validation, leading to several publications and a new map of forest cover at hectare scale. Datasets were also developed to characterise the dynamics of fires, including the impact of human activities.

Unlike some other programmes in the same domain, AGRICAB addressed the national level, and invested in innovative bilateral partnerships to ensure an in-depth exchange of knowledge.

While the project finished in March 2015, the research and partnerships are continuing through a range of projects. Many of the partners are planning to re-join forces in a new Horizon 2020 project on Africa and food security. "We are stronger together," says Jacobs.

CEOP-AEGIS

Better precipitation forecasting for half the world's population

A drought on the Tibetan Plateau could be a drought for nearly half the world's population — some 40%, to be precise. Too much water is also a daunting prospect, as floods in this area frequently affect vast communities, claiming lives and destroying livelihoods. An EU-funded project has advanced the forecasting of precipitation on the roof of the world.

The Ceop-Aegis project has developed mathematical models to analyse the water balance and predict river flows on the world's highest and largest plateau. These models, which combine ground-based measurements and satellite data, can notably be used to forecast droughts and floods. They are also of considerable interest for research into the effects of climate change, to which this area is particularly susceptible.

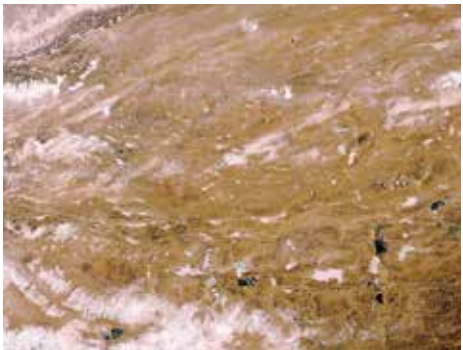
"In the watersheds we are talking about, there are 2.5 billion people — a large part of mankind," says Massimo Menenti, who coordinated the project on behalf of the University of Strasbourg, France.

"Meltwater from snow and glaciers constitutes the largest part of these populations' water supply," Menenti explains. Accelerated melting of glaciers or snow, disrupted precipitation patterns, and changes affecting the monsoon rains on which the entire area relies could have profound implications.

Modelling the way of water

The sheer size of the area to be covered was one of the project's main challenges, and the complexity of its hydrological processes was another, Menenti notes. "We are talking about 2.4 million square kilometres, including all the headwaters of the large rivers streaming down the plateau — the Yellow River, the Yangtze, the Ganges, the Indus and so on," he adds.

The project developed applications to secure data for every variable affecting the water balance, such as precipitation, snow cover, and evaporation. "All these data streams were then fed into a hydrological modelling system to calculate the water balance for



Participants

France *(Coordinator), China, Germany, India, Italy, Japan, Netherlands, Spain*

www.ceop-aegis.net									
FP7	Proj. N°	212921	Total costs:	€ 4.5 Mio	EU contribution:	€ 3.5 Mio	Duration:	from:	05/2008
								to:	04/2013

areas of 5x5 km along with the river flows in the entire region," Menenti explains. The data was also used in an atmospheric model linking surface conditions with weather and precipitation forecasts.

The underlying time-series data is generated by ground-based measurements and monitoring, but also by satellites used for Earth observation. It provides a comprehensive picture that can be analysed to detect indications of a drought or an impending flood. A website providing information on emerging droughts has already been set up, Menenti reports, and the development of a similar system for floods is in progress.

High mountains, high stakes

The Tibetan or Himalayan Plateau is often referred to as the "Third Pole", in reference to its many glaciers, snowy peaks and frozen expanses. It is a gigantic reservoir of water, but highly exposed to climate change, Menenti notes. Many countries depend on this water, and global warming could jeopardise the stability of their supply.

The plateau and the watersheds extend across several borders, and therefore trans boundary cooperation and data flows are needed to study it comprehensively. Research institutions from India and China were involved in Ceop-Aegis, along with partners from Europe and Japan.

The modelling system they jointly developed has helped to advance understanding of the river flows in the region. It has also helped to demonstrate the feasibility and usefulness of this combination of ground-based measurement and monitoring from space, contributing valuable insights for the construction of the Global Earth Observation System of Systems (GEOSS), Menenti reports.

Ceop-Aegis ended in April 2013, having delivered sophisticated modelling tools and methodology, comprehensive data sets, and inspiration for nearly 200 students who produced their Master's and PhD theses in the framework of the project, Menenti notes.

"Thanks to the large number of people that are continuing to work on this subject, the results of the project will not be lost," he concludes. His role in the project earned him an "Etoiles de l'Europe" (Stars of Europe) award in December 2013, a prize presented by the French Ministry of Higher Education and Research to coordinators of particularly successful EU-funded research projects led from France.

CITI-SENSE

Helping clean city air through local initiatives

Although Europe's air quality has improved over the last 25 years, pollution is still prominent - particularly in cities. Cleaning the air is more difficult than before, as most people can no longer smell or see the pollution. However, the EU-funded research project CITI-SENSE is harnessing novel technologies to detect contaminated air and share the data in real-time, making this information available through the Global Earth Observation System of Systems (GEOSS).

The goal of the CITI-SENSE project is to give citizens the tools to 'sense' their environment through new devices, such as smartphones, raising awareness of areas where pollution exists. The project could allow people to assess progress and take action to improve the situation, effectively displaying the positive impact a healthy environment has on the quality of life.

Alena Bartonova is senior scientist at NILU - Norwegian Institute for Air Research and project coordinator of CITI-SENSE. According to Bartonova, the project is inspiring people to relate to their natural environment in a systematic and scientifically defendable way. "It will motivate us all to become active stewards for a good environment," she says. "We have initiated a dialogue between the technical, scientific and social aspects of environmental information, production, and use."

Empowering local communities

A key aspect of CITI-SENSE is the development of 'citizen's observatories' used to empower local people to contribute to environmental governance. This will give them and other project stakeholders like schools, Non-Governmental Organisations (NGOs) and local authorities a forum to exchange results as well as to discuss and receive additional information on related issues.

The project team is working with businesses involved in technology in order to cover the development of sensors for air quality, platforms for sensor deployment, communication solutions between the sensors and other systems, as well as data collection tools related to smartphones. The CITI-SENSE team has already developed a number of prototypes that use monitoring and information technologies, data interpretation and information content. Moreover, the researchers are developing methods on how to support the engagement

Participants

***Norway** (Coordinator), Australia, Austria, Belgium, Czech Republic, Korea (Republic of), Netherlands, Israel, Italy, Serbia, Slovenia, Spain, United Kingdom*

http://www.citi-sense.eu/

FP7	*Proj. N°*	*308524*	*Total costs:*	*€ 12.8 Mio*	*EU contribution:*	*€ 9 Mio*	*Duration:*	*from:*	*10/2012*
								to:	*09/2016*

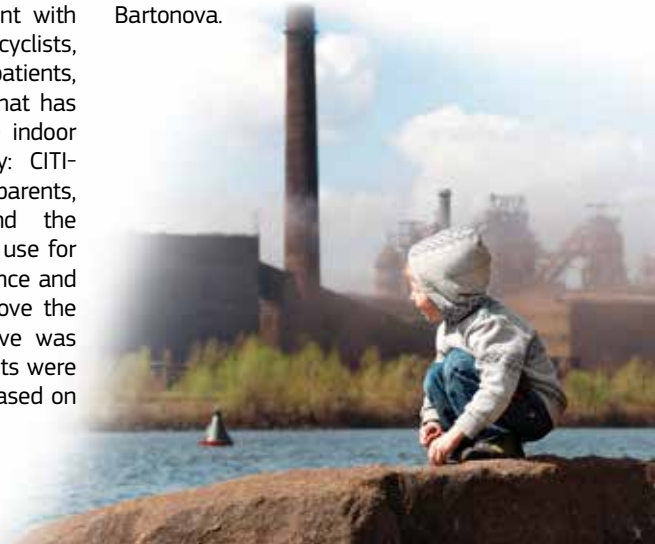
and participation of local users with the help of these technologies.

Different needs, different solutions

There are nine cities taking part in the CITI-SENSE project: Barcelona (Spain), Belgrade (Serbia), Edinburgh (UK), Haifa (Israel), Ljubljana (Slovenia), Oslo (Norway), Vienna (Austria), Ostrava-Bartovice (Czech Republic) and Vitoria-Gasteiz (Spain). Bartonova points out that "each location has different needs, which requires the development and testing of somewhat different technologies and approaches."

In many participating cities, the CITI-SENSE team builds on previous engagement with selected stakeholder communities: bicyclists, members of groups representing patients, NGOs and city planners. One area that has generated a strong response is the indoor environment at schools in Norway: CITI-SENSE researchers gave students, parents, cleaning personnel, teachers, and the school administration information to use for decision making on school maintenance and occupant behaviour that could improve the indoor environment. Another initiative was carried out in Barcelona, where cyclists were provided with data about pollution based on the city's measurements, which helped them choose alternative routes with cleaner air.

Bartonova says "the project is a unique combination of science, technology and citizens' actions." "For citizens, we are seeking ways to enable their efficient participation in local governance. For authorities, we are finding new and effective ways to provide them with information for their decision-making and new ways to communicate with citizens. And for science, we are defining new ways to process environmental data which could enable the global community to provide relevant and high quality information about our common environment," concludes Bartonova.



EGIDA

GEOSS: Global connections

GEOSS is not just a system of systems, it is also a community of communities — a global ecosystem of groups and entities that provide or use Earth observation data. An EU-funded project has smoothed the path for new members joining this growing alliance, notably by developing guidance for future contributors and setting up a stakeholder network.

The aim of the Egida project was to promote the Global Earth Observation System of Systems (GEOSS) by encouraging more stakeholders and user groups to become involved. Activities focused primarily on countries that had recently joined the EU, as well as on less affluent countries in other parts of the world.

In addition to organising networking and dissemination activities, the partners produced a methodology enabling new data contributors to re-engineer their data infrastructures for smooth integration. The project ended in December 2012, having established a network of science and technology stakeholders that continues to support the development of GEOSS, along with a legacy of dialogue and guidance that is helping to extend the reach of the global system of systems.

Technology, and more

GEOSS makes Earth observation data from sources around the world available to user communities everywhere. However, truly global coverage can only be reached if a maximum of data providers around the world are involved.

Launched in 2010, Egida set itself the task to engage with stakeholders, potential contributors and prospective users in new EU Member States and developing countries. "Technology is important, but it is only half of the solution. You also have to manage the governance and the social aspects," says project coordinator Stefano Nativi of Italy's National Research Council (Consiglio Nazionale delle Ricerche).

All together now

GEOSS enables countries that may not have advanced Earth observation infrastructure in place to benefit from information for their

Participants

Italy *(Coordinator), Austria, Denmark, France, Germany, Norway, Slovenia, Spain, Sweden, United Kingdom*

http://www.egida-project.eu/									
FP7	Proj. N°	265124	Total costs:	€ 1.6 Mio	EU contribution:	€ 1 Mio	Duration:	from:	09/2010
								to:	12/2012

territory, Nativi explains. "You can't take sound decisions, for example in the face of global change, if you don't have data or measurements. So one of the goals was to provide everybody, including countries that aren't rich, with data that can help them take more informed decisions," he notes.

"Our other main goal was to produce and disseminate methodology supporting the development of infrastructure that will underpin the sharing of data and services," says Nativi. "GEOSS has been doing this at the global level. Egida developed methodology to replicate the approach at national and regional level."

Such guidance is needed, notably, to ensure that the various contributors and stakeholders in a given area are all on the same page. "A country may have a variety of data systems, run and managed by different agencies or universities, for instance, dealing with many types of data. A way to establish a common cyber-infrastructure that integrates all these systems and data streams was needed."

Egida produced guidance explaining how to develop such a common cyber-infrastructure in line with the GEOSS principles. The partners then implemented a number of use cases to test and refine this methodology. A pilot application in Slovenia, for instance, involved the development of a so-called Special Data Infrastructure — a system of systems, built from scratch — for monitoring data on chemical pollution.

Another use case reached across the entire territory of the EU, for the development of a pan-European system monitoring air quality for health. Two further trials focused on the Mediterranean region, with one aiming to boost the involvement of countries along the southern coast, and another integrating data streams from networks tracking chemical pollution. In addition, the Spanish project partners applied the methodology to set up a coordinating body for their country's involvement in GEOSS, Nativi adds.

The methodology is a guideline, but is not intended as a one-size-fits-all solution, Nativi notes. Every capacity-building programme faces challenges of its own, he concludes, and every one must start by adapting it to the local context. Destination GEOSS can be reached via a number of routes.

ENERGEO

Energy mix models make a case for more ambitious renewable targets

Using sensors on board platforms such as satellites and advanced modelling systems, EU-funded researchers have quantified the impact of future energy use on the environment. Their headline conclusion? That we can go further than the EU goal of increasing renewable energy's contribution to global supply to 80% by 2050.

The production, transport and consumption of energy all put considerable pressure on the environment. If we were to make changes to our energy mix, for example by relying more on biomass, solar or wind energy, what would the impact be? Would it impact air pollution or human health? What about ecosystems, fresh water systems or the biosphere? The EnerGEO project designed and built a system to evaluate this.

The team started by linking environmental observation systems already under the umbrella of the Global Earth Observation System of Systems (GEOSS) with new energy models developed during the project.

Linking systems and semantics

One of the major challenges for EnerGEO was to connect a variety of observation systems, each focused on a very specific environmental question, with a large array of energy resources that have widely different impacts on the environment.

Finding a way for experts from very different specialisations to work together went some way towards solving this, explains EnerGEO coordinator Martijn Schaap of the Nederlandse Organisatie voor Toegepast Natuurwetenschappelijk Onderzoek (TNO) in the Netherlands: "People came from different backgrounds, which meant they were not talking the same language. We had to connect certain parts and understand how we could use each other's expertise."

By linking observation data and energy models, it is possible, for example, to have an idea of how much biomass is available, and then to estimate how much could be harvested. This, in turn, indicates how much energy could be produced from biomass.

EnerGEO also worked with data on air pollution trends and the presence of pollutants such as carbon monoxide and nitrogen dioxide.

Participants

Netherlands *(Coordinator), Austria, France, Germany, Poland, Pakistan*

http://www.energeo-project.eu/									
FP7	Proj. N°	226364	Total costs:	€ 7.9 Mio	EU contribution:	€ 6.1 Mio	Duration:	from:	11/2009
								to:	10/2013

Energy scenarios

Once the data had been connected to the team's models, the whole system was applied to four scenarios:

- 'Baseline' – current EU policies on limiting CO_2 remain as they are;
- 'Open Europe' – solar energy is imported to Europe from North Africa, the share of energy provided by biomass is high and nuclear energy is phased out;
- 'Island Europe' – no electricity is imported from outside of Europe, renewable energy use is equal to or higher than that in the 'Open Europe' scenario and nuclear energy use continues;
- 'Maximum Renewable Energy' – renewable energy penetration is close to 100%.

Testing these scenarios showed that the potential of wind, solar and biomass energy would make it possible to increase the share of energy from renewable sources by more than is currently targeted. "The targets can be more ambitious than the EU 80% target," confirms Schaap.

Impact on air quality – a victim of today's high fossil fuel use – was another project focus; the findings make the case for a rigorous climate policy to control air pollution, says Schaap: "If you have a stringent climate policy, it will have a significant impact on air quality. But if you focus on air quality, you won't necessarily meet climate change goals."

The third key finding was confirmation that earth observation data can indeed be used to create spatial maps illustrating renewable energy potential. These would be useful for engineering consultants looking for the optimal location for new infrastructure, such as solar panels.

Many of the EnerGEO project partners are now working with the new modelling systems while continuing to develop them. Although no follow-up project is currently planned, Schaap would be keen to expand the EnerGEO system geographically and to other energy sources, such as geothermal and tidal energy, and to expand beyond electricity production. He also has further scenarios in mind for testing, including the impact of higher electric vehicle usage on electricity demand and consequent shifts in environmental impacts.

ENVIROGRIDS

Shedding light on the Black Sea environment with accessible, actionable data

An EU-funded project that built the first hydrological model of the Black Sea region has played a key role in expanding the use of Earth observation data, putting crucial environmental information at the fingertips of scientists and policymakers globally.

The enviroGRIDS project, which brought together 30 teams from 14 countries, resulted in the first comprehensive environmental analysis of the entire Black Sea area, covering factors such as land use, water quantity and quality, demographics and the impact of climate change.

This Earth observation data – collated, analysed and disseminated via grid computing – is enormously important to the societies and economies of the Black Sea catchment area, a region covering 2.2 million square kilometres and home to more than 180 million people. But the methods and tools developed in the project, as well as the information itself, are no less significant to scientists around the world as they attempt to establish a global overview of our changing environment.

The enviroGRIDS project is one of numerous activities supporting developments in the Global Earth Observation System of Systems (GEOSS), which connects the producers of environmental data and decision-support tools with end users, from policymakers and conservationists to farmers and businesses. Established by the Group on Earth Observations, a voluntary partnership of 98 countries, the European Commission and participating organisations, GEOSS' aim is to establish a global public infrastructure that generates comprehensive, near-real-time environmental information and analyses to tackle global issues such as pollution, agriculture and climate change.

"In enviroGRIDS, we worked on the implementation of GEOSS principles in the Black Sea region, and directly contributed to both Armenia and Georgia becoming members," explains Anthony Lehmann, the enviroGRIDS coordinator at the University of Geneva. "We trained numerous researchers on developing GEOSS data sets and models, pushed forward new concepts about data sharing, and made the information accessible through simple web services and tools, allowing users to distribute, analyse and visualise crucial data on the past, present and future states of the region."

Participants

Switzerland *(Coordinator), Austria, Belgium, Bulgaria, Czech Republic, France, Georgia, Hungary, Italy, Romania, Russia, Spain, Turkey, Ukraine*

http://www.envirogrids.net/									
FP7	Proj. N°	226740	Total costs:	€ 8.1 Mio	EU contribution:	€ 6.3 Mio	Duration:	from:	04/2009
								to:	03/2013

A helping hand for policymaking

This work included exploring different scenarios for the future of the Black Sea catchment area by developing spatial predictions of climate, land use and demographic changes. The predictions, in turn, were incorporated into policy briefs aimed at encouraging policymakers in the region to tackle impending issues, not least the long-running challenge of water pollution from agricultural fertilisers, a problem known as eutrophication. In this regard, the project team has worked closely with organisations such as the Black Sea Commission and the International Commission for the Protection of the Danube River.

"The hope is that this information will encourage cooperation among governments to tackle environmental challenges facing the Black Sea area, but it's a long-term process and it is often a struggle to bridge the gap between science and policymaking," Lehmann acknowledges.

Bridging that gap, however, is precisely one of the main goals of GEOSS, not least by making scientific data accessible and readily applicable to real-world issues.

EnviroGRIDS is one of five founding EU projects behind the follow-up IASON project, which has established a permanent network of scientific and non-scientific institutions, stakeholders and private enterprises across the Mediterranean and the Black Sea. It is also one of six projects behind the EOPOWER initiative, which aims to create conditions for sustainable economic development through the increased use of Earth observation products and services for environmental applications.

"In their two-year timeframe, these projects have incorporated a lot of material, tools and methodologies from enviroGRIDS," Lehmann explains. "By making this scientific data accessible in new ways, we are generating actionable information that can be used to address real-world problems.

EO2HEAVEN

Putting health risk on a map

Asthmatics already know that certain weather conditions can leave them short of breath. If sufferers of this and other diseases had access to an alert system warning of environmental conditions that could put them at risk, lives might be saved. The EO2HEAVEN project has done the groundwork for such a system.

Making a link between environmental conditions and health is not new, but previous data contained gaps, explains EO2HEAVEN project coordinator Kym Watson of Germany's Fraunhofer Institute of Optronics, System Technologies and Image Exploitation.

For example, while health workers may use simple environmental data such as temperature to assess health risk, they rarely use geospatial (location) data and do not look at maps to visualise risk, Watson explains.

The project put health and environmental data together – no simple task since they come in different formats – to create maps showing the correlation between time and health events in three locations:

- Dresden, Germany: temperature, particulate matter and ozone levels – cardiovascular disease;
- Durban, South Africa: air pollution – asthma;
- Uganda: various environmental factors – cholera outbreaks.

The problem with privacy

While Germany may have the most advanced data collection infrastructure, creating a health risk map for the city of Dresden posed its own problems – in particular accessing medical data protected by strict privacy laws. But Watson suggested health staff with data access could themselves use the EO2HEAVEN system to visualise impending risk.

By the project end in May 2013, the team had created a system to produce maps showing air pollution and risk, displaying at the same time cardiovascular incidences. Everything has been passed on to the region's Spatial Data Infrastructure, which is using the system to assess risk incidences.

In Durban the team's early warning system, based on air quality, is today being used by the Department of Pollution Control and Risk Management of the eThekwini municipality. It provides early warning of likely respiratory problems. An unexpected benefit has been the highlighting of gaps in local air quality data collection. It is now also being used to

Participants

Germany *(Coordinator), European Commission - Joint Research Center, France, Netherlands, South Africa, Spain, Uganda, United Kingdom*

http://www.eo2heaven.org/

FP7	*Proj. N°*	*244100*	*Total costs:*	*€ 8.6 Mio*	*EU contribution:*	*€ 6.3 Mio*	*Duration:*	*from:*	*02/2010*
								to:	*05/2013*

identify where new measurement stations are needed – four are in place already.

Stopping cholera in its tracks

Uganda presented challenges of a different scale, with no measurement stations and very limited health data. The focus was also different – instead of a system to warn of risk for people with specific vulnerabilities, the team worked on a map to visualise how cholera is likely to spread.

Rain, moist soil and warm water temperatures create the perfect conditions for cholera bacteria, and the team found that the disease tends to spread between villages connected by road.

Once the first case is detected, authorities need to react within a week to prevent a serious outbreak. They can warn the population and provide clean water, launch an immunisation campaign and/or prepare medical staff, reducing the outbreak's scope in time and area.

Incidences are recorded on a piece of paper that could take five days to reach authorities. But the same process could take a matter of seconds using the EO2HEAVEN smartphone app. A prototype is up and running, while the app must simply be integrated into Uganda's health system for it to revolutionise cholera reporting.

The EO2HEAVEN team has also been working closely with the World Health Organisation (WHO) and the US' National Oceanic and Atmospheric Administration (NOAA), building on EO2HEAVEN experience and knowledge, to create an early warning system for Uganda and other countries where cholera is a problem.

Geospatial data from space

Environmental data from satellites can supplement data traditionally collated by ground stations or may even be the only possibility, especially in developing countries.

Although weather conditions meant satellites weren't always practical for this project, Earth observation has great potential in this area, says Watson. For example, it can be used to gauge large-scale environmental factors, such as rainfall over a large area.

EO2HEAVEN's work on Earth observations led the team to contribute to the work of the Group on Earth Observations (GEO) on health – it is working with the health community to improve the flow of environmental data.

EOPOWER

Capitalising on the power of Earth Observation for economic development

EOPOWER, an EU-funded project that seeks to bring Earth observation products into wider use among environmental decision-makers, is raising awareness of Earth observation's uses while building capacity. Strengthening the role of Earth observation in environmental policy will contribute to sustainable economic development globally. Partners have published an online catalogue and pledged to keep up the awareness-raising after the project ends.

The increased use of Earth observation products for a variety of environmental applications has the potential to not only save money, but to save lives. Using data from satellite systems and other Earth observation infrastructure can help decision-makers understand the most effective measures to mitigate natural disasters.

According to the partners behind the EOPOWER project, responses to everything from crop modeling to forest management, and from climate change to water management, could be improved by using Earth observation. The purpose of the project is to create the conditions for sustainable economic development by increasing the use of Earth observation products and services in environmental applications. The added value of Earth observation in risk assessment and simulation models, forecasting and early warning, monitoring, damage assessment, and prevention and planning is undeniable.

Earth observation involves the monitoring and/or study of an area, object or phenomenon, it includes using data collected by satellites but also in-situ observations on land, sea and in the air. It provides indispensable data to support informed decision making at local, national, regional and global level to reduce disaster risks, improve adaptation to climate change, better prepare for unavoidable losses and damage, and deliver on the promise of sustainable development. Earth observation products range from simple Earth observation tools to complex satellite systems.

Building capacity for development

Raising awareness about the potential of Earth observation is crucial. Marketing comprises both promotion of its benefits and capacity building.

As an EU-funded Coordination and Support Action project, EOPOWER's core activity is the marketing and promotion of Earth observation products in areas of the world

Participants

Switzerland *(Coordinator), Czech Republic, France, Greece, Italy, Mexico, Morocco, Netherlands, Poland, Serbia, South Africa, Turkey*

http://www.eopower.eu/									
FP7	Proj. N°	603500	Total costs:	€ 1.2 Mio	EU contribution:	€ 1 Mio	Duration:	from:	06/2013
								to:	05/2015

where their use can be better exploited. The project targets eight regions – Southern Africa, French-speaking Africa, the Czech Republic and Slovakia, Poland and Ukraine, Turkey and Turkish-speaking countries, the Balkan region, the Black Sea region and Latin America and the Caribbean. The project team organised activities in each location: workshops, roadshows, the translation of material, and interaction with schools for various events. The team also facilitated collaboration between institutions.

EOPOWER builds on a number of previous projects that have promoted Earth observation in various ways. The most notable of these is GEONetCab, which produced global and regional marketing studies, success story texts, marketing toolkits and valuable feedback from promotion activities and quick-win projects.

"EOPOWER didn't start from scratch. This allowed the project and partners to benefit fully from the results and experience of several earlier EU/FP7 projects," says Nicolas Ray, EOPOWER project coordinator from the University of Geneva. "For example, we have built on the previous GeoNetCab capacity building portal and developed the Earth Observation Capacity Building Portal (GeoCaB - www.geocab.org), which gives access to a catalogue of hundreds of capacity building resources on Earth observation. GeoCaB is now the official GEO (Group on Earth Observations) portal for accessing capacity building material, and it greatly facilitates the discovery and use of such material."

Among the project's other outputs is a dedicated platform for the Black Sea catchment to extract hydrological data sets and models by country and river watershed. The project also helped move forward Georgia and Armenia's applications to become GEO members.

Says Ray: "Many activities in the project push for open access to data, tools and information related to Earth observation. Previous studies have shown that benefits from the availability and sharing of public sector information can vastly outweigh the costs, notably through the creation of new market opportunities for the private sector."

Partners have pledged to continue many of the activities carried out in the project, promoting Earth observation services as part of their work. The Earth Observation Capacity Building Portal will also continue to be updated and further developed.

EU BON

Combining citizen and satellite biodiversity data

From the individual birdwatcher to the most ground breaking satellites – a team of EU-funded researchers is integrating observation data on nature and the environment to give a fuller picture than ever before of biodiversity in Europe.

"Information on life on Earth is crucial to addressing global and local challenges, from environmental pressures and societal needs, to ecology and biodiversity research questions," says Christoph Häuser coordinator of the EU BON project and deputy director general of Berlin's *Museum für Naturkunde*.

While existing data are vast and dispersed, information is not always easy to locate, accessible or understandable. And gaps remain: many areas have not been monitored, or not over any length of time. In other cases, less 'popular' flora and fauna have been neglected.

EU BON is an attempt to overcome these problems at European level and to contribute to the Group on Earth Observations' (GEO) global initiative with the same aims – GEO BON.

Elsewhere, information exists, but is not available to the general public. "Of 20 data providers investigated by EU BON, only one third was freely inaccessible to the general public, whereas two thirds were available with various restrictions.". This was a surprise to Häuser, who would like to see a political will to share information. Environmental services are, after all, a huge opportunity for governments, he makes clear.

Comparing like with like

The very different ways in which data are recorded are also a barrier to integration. Häuser gives the example of botanists in Central Europe where they divide a map into squares and record the occurrences of a particular plant for each square. The exact locations of the plants within the square are not noted. Elsewhere in Europe, botanists work differently, sometimes marking exact locations.

These gaps and lack of comparability are not only a barrier for scientists, but, in the case of biodiversity, for those dealing directly with natural resources (for example agriculture, fisheries, nature conservation), and for decision-makers charged with protecting biodiversity or shaping environmental policies. Both groups require data in a digestible format, as well as more standardised data analysis.

Participants

***Germany** (Coordinator), Belgium, Brazil, Bulgaria, Denmark, Estonia, Finland, France, Greece, Israel, Italy, Norway, Philippines, Slovakia, Spain, Sweden, Switzerland, United Kingdom*

http://www.eubon.eu/									
FP7	*Proj. N°*	*308454*	*Total costs:*	*€ 11.6 Mio*	*EU contribution:*	*€ 10 Mio*	*Duration:*	*from:*	*12/2012*
								to:	*05/2017*

From sketchpad to space satellite

EU BON is building the technologies to integrate available data, which fall into three main categories:

- Classical observation data, including from individual plant or bird enthusiasts, as well as from specimens preserved in collections. Europe has a very rich history here, explains Häuser. But information may not be digitised, and first convincing ordinary citizens to contribute data and then finding a way for them to do this may require a separate project of its own, he concedes.

- Spatial data on specific – often protected – areas marked for monitoring. While rich, the data only covers a limited area.

- Satellite data, on vegetation cover or other biological properties, for example. While satellites and sensors provide extensive coverage at increasingly high resolution, they also have weaknesses – in recording most animal life, for example, or monitoring what happens in soil or under water. There is also no historical satellite data with which to compare today's observations.

All of these data types will be integrated in a European biodiversity portal, providing users with a more complete overview and customised access to their subject, also showing historical trends or comparisons with other geographical regions. "I'm pretty confident about delivering an innovative technical solution to integrating these systems," says Häuser.

Another goal is to make the information scalable, even down to community level, and to provide open and free access. Those providing the data should however be properly accredited for their efforts – clear rules and guidelines are needed according to Häuser.

The biggest achievement to date has been getting the network together, says the EU BON coordinator. And he's not just referring to the 31 official partners from 18 countries, but also the 30 or so associated partners – "the number is growing daily". This has already provided the team with an "outstanding grasp of the biodiversity data landscape" and provided the basis for the next stages.

EUROGEOSS

EUROGEOSS – Untangling the science Web

People can now access millions of scientific data resources about our planet thanks to the EUROGEOSS project. EUROGEOSS ('European approach to the global Earth observation system of systems'), backed under the Environment Theme of the EU's Seventh Framework Programme (FP7) to the tune of EUR 6.1 million, has developed an innovative way to search thousands of Earth observation catalogues. This has increased the number of datasets and products publicly available for scientific research, from a few hundred in 2011, to more than 28 million in 2012.

The uniqueness of this novel application, what the consortium calls the EUROGEOSS broker, is that it is a software middleman that makes all this possible. It bridges the multitude of complex standards used by scientists.

Much more than just discovery

Previously independent information catalogues and systems can now be connected to each other. The scientific resources they contain are also made available to a much wider audience. A family of multiple components is responsible for this deceptively simple solution, enabling the discovery of datasets and their transformation into a common geographical reference system and timeframe. The result is the ability to access and use data in scientific models running on the Internet,

Participants

France (Coordinator), Austria, European Commission - Joint Research Center, Germany, Italy, Portugal, Slovenia, Spain, United Kingdom, United Nations Environment Programme, United States

http:// www.eurogeoss.eu/									
FP7	Proj. N°	226487	Total costs:	€ 8 Mio	EU contribution:	€ 6 Mio	Duration:	from:	05/2009
								to:	04/2012

and to publish the resulting information through Web services and social networks.

Bridging the data model gap

The value of the EUROGEOSS broker is significant. A case in point is how it relates to Natura 2000, the largest network of protected areas in the world with nearly 26 000 sites covering alost 18% of the EU. Natural phenomena, such as forest fires, as well as man-made pressures threaten these areas.

Overall, 60 000 hectares of protected areas went up in smoke in forest fires in Spain, Italy and Portugal in 2010 alone. When such events take place, it is important to identify areas that have similar ecosystems to the ones damaged and which may contain endangered species in need of additional protection.

To do so requires running a simulation with key data, including a mean drought index, percentage of forest cover, temperature, rainfall and elevation. Finding these data across multiple databases for any part of Europe used to be a challenge. The EUROGEOSS broker now makes it much simpler and faster not only to find the data, but also to run the model on the Web and get results without having to download data or modelling tools. This means that you can run these simulations anytime, anywhere, even in areas with slow Internet connections.

Through the broker it is also possible to mine social networks and find observations made by the public that are relevant to the protected areas, as well as to consult the list of endangered species managed by the International Union for Conservation of Nature (IUCN). This is end-to-end service for science, policy and citizens.

The EUROGEOSS broker is developed by the National Research Council of Italy, which has committed to maintaining it for the next three years, and the Joint Research Centre (JRC) -the European Commission's in-house science service.

FUTUREVOLC

Increasing our understanding of volcanic eruptions

EU-funded FUTUREVOLC project is improving the monitoring and understanding of magma movements at Icelandic volcanoes.

Volcanic eruptions are notoriously difficult to predict. With increased seismic activity at Iceland's Bárðarbunga volcano, and lava flowing at nearby Holuhraun, experts are carefully monitoring and analysing large amounts of data being collected from the area.

Learning from experience

Many Icelandic volcanoes are ice-covered, a factor that often contributes to explosive, ash-rich eruptions similar to Eyjafjallajökull in April 2010. Eyjafjallajökull spewed large ash clouds across northern Europe, leading airlines to make costly flight cancellations and disrupting travel for some 10 million people. Financial damage is estimated at up to €3.9 billion.

But this time there is a difference. In response to Eyjafjallajökull's eruption, the EU has been funding research to provide more accurate and timely warnings. The approaches being pioneered by such projects aim is to give civil protection authorities, and economically important commercial groups such as airlines, more time to react effectively – helping to protect lives and reduce damage to Europe's economy.

One example is FUTUREVOLC. Since October 2012, when FUTUREVOLC started, the researchers have added volcanic gas detectors, infrasound sensors, high resolution cameras, seismometers and sensors to detect ground movements across the most active regions of Iceland to complement the existing network. Many of these additional sensors are part of mobile networks, allowing them to be deployed at active sites as needed and to support the permanent network.

New monitors, such as the seismometers, can detect minute movements (seismic tremors), a possible indication of the movement of magma up towards the Earth's surface or of flooding caused by the extrusion of magma under the ice. These floods are a significant threat to local inhabitants and infrastructure.

Additional GPS instruments and satellite data can help detect minute changes. At Bárðarbunga these have been used to estimate the volume of magma intruded into the Earth's crust at up to 10 km below the surface.

Participants

Iceland *(Coordinator), France, Germany, Ireland, Italy, Netherlands, Norway, Sweden, Switzerland, United Kingdom*

http://futurevolc.hi.is/									
FP7	Proj. N°	308377	Total costs:	€ 7.9 Mio	EU contribution:	€ 6 Mio	Duration:	from:	10/2012
								to:	03/2016

Improving forecasting from the ground

The project is also focused on monitoring eruptions once they reach the surface – measuring dangerous gases and lava flow rates, for example. This information can indicate whether volcanic activity is likely to evolve into an eruption similar to that of 2010.

In July the team added three ground-based infrared cameras to Iceland's network to detect silicate particles in volcanic ash. The project has also tested a plane-mounted sensor that was able to detect ash collected from one of Iceland's volcanoes and dropped from the air over France's Bay of Biscay. The sensor, which uses multispectral cameras to distinguish silicate from ice particles, detected the ash from 60 kilometres away. If Bárðarbunga does erupt, the team could deploy the same sensor to monitor any release of ash.

When combined with meteorological data and advanced modelling techniques, FUTUREVOLC's results will help to improve ash dispersal forecasting, said project coordinator Freysteinn Sigmundsson of the University of Iceland.

FUTUREVOLC's research will feed into the Group on Earth Observations (GEO), part of Europe's contribution to a global effort to improve forecasts on volcanic activity.

GEOCARBON

Capturing the world's carbon observation data

Think carbon data. Are you picturing a placid stream of harmonised figures from the four corners of the Earth? Not so. At the moment, information from different sources can be hard to compare, and the coverage is patchy. Efforts to channel the available information into a global system of systems are under way. An EU-funded project has contributed to this drive.

GeoCarbon was a European project with a global reach, engaging with partners around the world to develop building blocks for a carbon observing system designed to span our planet. "It was an EU contribution to the construction of GEOSS, the Global Earth Observation System of Systems," says Antonio Bombelli of the Euro-Mediterranean Center on Climate Change in Italy, who managed the project.

By the time GeoCarbon ended in December 2014, it had helped to lay the foundations of the future system. It notably provided an aggregated set of global carbon data along with upgraded mathematical software for the assimilation of this data. These and other modelling tools are used annually to document the previous year's balance of carbon flows in the so-called "global carbon budget", among other applications.

The project also strengthened ties with data contributors in the EU and beyond, developed specifications for the future system of systems, analysed socio-economic aspects of its implementation, and helped to set up an observing system for the Amazon to translate the theory into practice.

At the coalface

Faced with the reality of climate change, society needs better information about greenhouse gas emissions and the mechanisms involved in global warming. Detailed carbon data will also help researchers to learn more about the phenomenon and help policymakers to monitor the effectiveness and implementation of emission limits and offsetting schemes, Bombelli notes.

The proposed global carbon observing system would not only channel earth observation data, which is collected using methods as varied as manual measurement, airborne sensor readings and satellite imagery. It would also make it possible to visualise this data and inject it into the powerful mathematical models known as carbon cycle data assimilation systems — providing users with the bigger picture, as Bombelli explains.

Participants

Italy *(Coordinator), Austria, Belgium, Brazil, Cameroon, France, Germany, Netherlands, Norway, Switzerland, United Kingdom*

http://www.geocarbon.net/									
FP7	Proj. N°	283080	Total costs:	€ 8.7 Mio	EU contribution:	€ 6.7 Mio	Duration:	from:	10/2012
								to:	12/2014

GeoCarbon demonstrated the feasibility and the power of such an approach in a case study focusing on the Amazon. The partners helped to build an observing system for the entire region by combining data streams from various well-established local networks.

Sink or source?

The emphasis on the Amazon rainforest area was, of course, no coincidence. "This area is often described as the lung of the planet," Bombelli explains. "It functions as a carbon sink, a reservoir that absorbs CO_2." A second case study focused on tropical Africa.

Half the excess CO_2 from human activity is absorbed by such carbon sinks, which mitigates the impact of rising emissions, he explains. "But, in a changing climate, we don't know how these sinks will evolve," he adds. "Soaring temperatures, rising CO_2 levels and changing rainfall patterns could affect them. The Amazon, for instance, might turn into a carbon source."

If this were to happen, he adds, global warming could accelerate dramatically. Decisive action is needed, and the situation must be monitored closely. Given this imperative, is building a global observing system an expense or an investment? A GeoCarbon study has looked into this question, concluding that the system would free up far more resources than it would absorb.

Real data for a reality check

Earth observation infrastructure is rare in some parts of the world. Aggregated information about carbon flows and budgets therefore includes a lot of data derived by mathematical models, Bombelli notes. As part of its drive to reduce data uncertainty, GeoCarbon advocated a shift towards figures from actual observations wherever possible.

The project created momentum, adds Bombelli, which the partners hope to sustain by launching an internationally funded follow-on project. "We need to provide more and better information to policymakers," he concludes. "Climate change does not wait for us, nor does it wait for policy decisions."

GEOWOW

GEOSS: Now with more wow

The Global Earth Observation System of Systems (GEOSS) is providing access to streams of data from around the world, but this is just one of its objectives. Enabling users to benefit from these data and derived information is another. An EU-funded project has advanced the technology, using the example of data on water, oceans and the weather (WOW).

The GEOWOW project aimed to ensure that GEOSS information on inland waters, ocean ecosystems and the weather is easy to find, access and use. "A lot of data were already available when our project started," says coordinator Joost van Bemmelen of the European Space Agency. "But users often didn't know how to access them, or put them to good use. Our objective was to help users locate and exploit the data they need."

Much of the project's work to enhance interoperability focused on the Discovery and Access Broker (DAB), the part of the GEOSS Common Infrastructure that provides the interface between the sources contributing data to the system of systems and the communities that use these data. GEOWOW notably enhanced the DAB by boosting its search capabilities and the ranking of results.

In addition, GEOWOW produced modules that enable users to make the most of GEOSS data. These include generic components and tools designed for specific user communities. "Making data accessible is not just a matter of enabling users to download them," says Van Bemmelen. "It also involves giving users the possibility to use data remotely, and giving them ways to extract the information they need."

Tapping the world's torrents...

Earth observation is a complex information environment, where input is produced by technologies as diverse as wind gauges, buoys and satellites, potentially recorded using incompatible data structures and formats, and managed by many different entities. The users of this disparate material are also quite varied, frequently using terminology specific to their community. As one of many contributions to greater interoperability, GEOWOW identified discrepancies and adapted the DAB's search capabilities to facilitate the dialogue.

A number of case studies enabled the GEOWOW partners to test their approach and upgrades in practice. One of these,

Participants

European Space Agency *(Coordinator), European Commission-Joint Research Centre, Brazil, France, Germany, Italy, Japan, United Kingdom*

http://www.geowow.eu/

FP7	*Proj. N°*	*282915*	*Total costs:*	*€ 9.2 Mio*	*EU contribution:*	*€ 6.4 Mio*	*Duration:*	*from: 09/2011 to: 08/2014*

known as the River Discharge Modelling and Validation Showcase, combined data from two organisations involved in the project: the European Centre for Medium-Range Weather Forecasts and the Global Runoff Data Centre.

"This application enables users of the GEOSS portal to access both observed and predicted river discharge data," Van Bemmelen explains. "We developed tools allowing users to visualise and compare the two types of data, for example to assess the accuracy of results produced by mathematical models."

...of water and weather data

GEOWOW also advanced developments in support of the United Nation's Global Ocean Observing System (GOOS). This use case was more particularly taken forward by the Intergovernmental Oceanographic Commission of UNESCO, which was a partner in the project and acts as the host agency for the GOOS.

The project improved use of various ecosystem Essential Ocean Variables reflecting the state of the oceans. It then developed visualisation tools combining these data streams with other sources of marine data, emphasising key aspects, and providing easy access to these datasets, Van Bemmelen reports. The indicators and data generated as part of this particular case study were made available in the decision support web portal OneSharedOcean.org, also built by GEOWOW.

Further project activity was dedicated to promoting free and open data, i.e. data that are not subject to access restrictions. This work centred on the GEOSS Data Collection of Open Resources for Everyone (GEOSS Data-CORE). "We tried to make a maximum of open data resources available to the users," Van Bemmelen reports.

GEOWOW ended in August 2014, having completed its mission to advance interoperability in GEOSS, Van Bemmelen reports. Its achievements are feeding into a new research effort, he adds: the Ecopotential project has set out to make Earth observation and monitoring data exploitable for ecosystem modelling and services.

GMOS

A global approach to effective mercury reduction strategies

EU-funded scientists are pioneering the development of a coordinated, global mercury observation system. It will help policy makers and researchers from around the world to monitor the presence of mercury in ecosystems and food chains and assess the effectiveness of emission reduction measures.

Launched in November 2010, the EU-funded Global Mercury Observation System (GMOS) distributes global monitoring data that can be used to measure mercury concentrations in sensitive ecosystems and the food chain. The data can be used to assess the effectiveness of efforts to reduce mercury concentrations and fluxes entering aquatic and terrestrial ecosystems.

Several countries had no provisions for monitoring mercury prior to GMOS. "The GMOS community is carrying out an impressive programme of capacity building in cooperation with UNEP (United Nations Environment Programme) and GEF (Global Environment Facility) in order to assist nations in developing their own monitoring system," explains project coordinator Nicola Pirrone, Director of the CNR Institute of Atmospheric Pollution Research in Italy.

"We established global monitoring systems for measuring mercury concentrations in ambient air at over 40 rural locations worldwide at different latitudes. From these systems, data will be gathered to analyse emission reduction measures and their effectiveness."

Getting a global picture

This project will fill an important monitoring gap and give scientists a truly global picture of current mercury pollution levels. Mercury is a naturally occurring element found in atmospheric, water and soil ecosystems. It originates in the Earth's crust and cannot be created or destroyed. However, natural and human activities can redistribute mercury with potentially hazardous health effects.

To properly monitor risks to the environment and human health, scientists and policy makers must coordinate both their research and legislative efforts. National and

Participants

Italy *(Coordinator), Argentina, Belgium, Cape Verde, China, Denmark, France, Germany, Latvia, Norway, Russia, Sweden, Slovenia, Suriname, South Africa, United Kingdom*

www.gmos.eu/

FP7	*Proj. N°*	*265113*	*Total costs:*	*€ 9.2 Mio*	*EU contribution:*	*€ 6.9 Mio*	*Duration:*	*from:*	*11/2010*
								to:	*10/2015*

regional monitoring networks on their own are not enough; coordinated global mercury monitoring is needed in order to make global assessments. Prior to the GMOS project, there were no monitoring sites in the tropics or in the southern hemisphere.

"Establishing monitoring sites in these areas now means that scientists will be able to compare hemispheric levels for the first time," says Pirrone. "The project will also help implement the Minamata Convention, approved by over 100 nations in November 2013 in Kumamoto, Japan, which among other things requires nations to assess the effectiveness of the measures implemented to reduce the emissions.

"The EU – as well as the European scientific community – played a key role in preparing the Minamata Convention, and GMOS is the only global monitoring system capable of supporting its implementation."

Tracking changes in real time

The project has also been building up existing monitoring sites to better integrate the global monitoring community, while a task force has been created to validate and unify policy assessment tools. GMOS is also a key project of the Group on Earth Observation (GEO), contributing to develop the Global Earth Observation System of Systems (GEOSS), which links together observing systems from around the world and encourages the development of new systems.

The GMOS database, which conserves historical data, is now continuously updated with data from the expanded monitoring network. Updated emissions data have been developed to track changes related to regulations, energy production and manufacturing output. As new data become available, model predictions are checked against observations in order to fine-tune model capabilities.

"We are confident that GMOS will continue, enabling the European scientific community to continue and reinforce its leadership by developing advanced monitoring technologies such as sensors based on nanostructured materials, which will allow all nations to develop and manage national monitoring systems at an affordable cost," says Pirrone. "Cost remains a limiting factor for most countries, especially in the developing world."

IMPACTMIN

New tools to manage mining's impact

ImpactMin project team developed new methods and tools for monitoring the environmental impact of mining using remote sensing.

Open pit mine

In 2011, Europe produced 1.6 billion metric tonnes of minerals, making it the world's 3rd largest producer, behind Asia and North America. Mining has been practiced in Europe since the Romans in the 1st century AD and it is still an integral part of the European economy in employment and resource exports. While the volume of production has been declining since the 1990s, the industry still employs around 350,000 people.

Mining has often been associated with a range of potential negative environmental effects such as chemical exposure, soil erosion and post-mine clean-up. In response to this, the European Union-funded project ImpactMin developed state-of-the-art tools and practices for monitoring and managing mining activities throughout Europe, based on four case-study sites in Russia, Sweden, Bosnia and Herzegovina, and Romania. With an emphasis on innovation and efficiency, ImpactMin team focused on the use of remote sensing technologies, which uses sensors, on-board satellites, small aircrafts or even Unmanned Aerial Vehicles (UAVs) to gather information about the Earth's surface or atmosphere.

The environmental impact of mining, which the ImpactMin researchers demonstrated in four sites across the EU, varies and depends upon the type of mining that is taking place. Results from the Mostar Valley demonstration site in Bosnia and Herzegovina indicated that there were increased concentrations of sulphate and hydroxide minerals in the vicinity of the mine, which were damaging the surrounding vegetation by contaminating the water. Remote sensing also helped locate expanding clays such as montmorillonite which can swell by up to 200% when wet and can then cause landslides.

At the Karabash test site in the Chelyabinsk region of Russia, where mining has been practiced for over 3,000 years, the ImpactMin team was able to identify substantial changes in soil conditions and vegetation stress levels in relation to the distance to the mine. The main impact-zone was up to 15km away from the mine, with evidence of acid precipitation and particles of toxic lead, zinc and arsenic. Such discoveries can be made with conventional field measurements, but the use of remote sensing technologies makes the process quicker and less expensive.

Participants

Hungary *(Coordinator), Belgium, Bosnia and Herzegovina, Croatia, Germany, Netherlands, Romania, Russian Federation, Sweden, Ukraine, United Kingdom*

http://www.impactmin.eu/									
FP7	Proj. N°	244166	Total costs:	€ 3.4 Mio	EU contribution:	€ 2.7 Mio	Duration:	from:	01/2010
								to:	12/2012

Unlike previous forms of mine monitoring, such as in-situ field measurements of chemical analysis and vegetation sampling, the ImpactMin researchers' new methods could enable entire areas to be examined at once and at a relatively low price. "The scale of the impact can be very high which means that we cannot go to every single point to take field measurements. That is where satellite imagery is handy," says ImpactMin project coordinator Peter Gyuris, from Geonardo Environmental Technologies Ltd. in Hungary.

The use of Unmanned Aerial Vehicles (UAVs) and small aircrafts was not entirely without difficulties, since safety and privacy concerns by local authorities occasionally meant that some methods could not be used in certain areas. "Over the course of the project, the research team was able to demonstrate the capability of these technologies to monitor the mining impact," explains Gyuris. "The difficulties we encountered were more logistical rather than technological, so now that we are aware of them we can talk to legislators to ensure that such issues are resolved in the future," he adds.

Another result of the project was the development of an online e-training platform. "The idea behind that was to disseminate the information about what we were doing. We targeted professionals in the mining industry, specialists in the remote sensing domain and, increasingly, university students," says Gyuris.

ImpactMin has been an important base for subsequent European funded mining projects, such as EURARE, Minerals4EU and I2MINE, which are targeting how to better use unexploited mining resources in Europe.

MEDINA

Equipping North Africa to map and protect our shared sea

A data sharing portal to facilitate marine ecosystem monitoring in North Africa, a spin-off satellite mapping start-up and continued cooperation between researchers in the region – these are some of the key results from an EU-funded project likely to have a long-lasting impact.

Urban growth and intense maritime activities have led to a decline in marine biodiversity and the degradation of natural areas along the Mediterranean coast. The three-year EU-funded MEDINA project increased the involvement of North African countries in developing solutions to what is a shared ecosystem.

A holistic view of the Mediterranean

"The main goal of this project was to increase the capacity of countries in North Africa to use data in a cost-effective and efficient manner in order to better manage their marine environments and identify ecosystems at risk from climate change," explains project coordinator Roberto Pastres from the Ca' Foscari University of Venice, Italy. "This was achieved by making better use of freely available satellite data and combining it with mathematical modelling and site-specific data, gathered by working closely with local partners in the region."

Limited resources for fieldwork and political instability in some North African countries obliged the team to use remote sensing data from satellites as much as possible. "All indicators produced were then summarised in maps and uploaded for free viewing on the MEDINA geoportal (www.medinageoportal.eu)," says Pastres. "With this innovation, we showed how North African countries can cost-effectively increase their capacity for environmental monitoring."

The portal is compatible with and accessible through the Global Earth Observation System of Systems (GEOSS) of the Group on Earth Observations (GEO), which links together observing systems from around the world and encourages the development of new systems to address global challenges.

Demonstrating the benefits of satellite mapping

Case studies were carried out in Morocco, Algeria, Egypt, Libya and Tunisia. In Morocco a lagoon ecosystem was closely monitored, while across the border in Algeria, environmental data was applied to identify sites suited to fish farming in line

Participants

Italy *(Coordinator), Algeria, Belgium, Egypt, France, Gabon, Morocco, Spain, Switzerland, United Kingdom*

www.medinaproject.eu

FP7	*Proj. N°*	*282977*	*Total costs:*	*€ 4 Mio*	*EU contribution:*	*€ 3.5 Mio*	*Duration:*	*from:*	*10/2011*
								to:	*12/2014*

with government objectives. Water quality in the Delta lakes of Egypt was monitored to provide valuable information to the local fishing industry.

"In the Gulf of Gabès in Tunisia, we developed a model for estimating the presence of the seagrass *Posidonia oceanica*," explains Pastres. These seagrass meadows – a key spawning ground for marine organisms – have been damaged due to intense fishing activities. MEDINA provided a preliminary estimation of lost ecosystem services in order to address the issue of potential restoration, and the model has subsequently been applied to the whole North African coastline.

"In Libya, basic information concerning ecosystem status is lacking, so we carried out an exploratory analysis based on satellite data," says Pastres. This analysis sought to identify areas where certain physical parameters are homogeneous, which is a key step towards developing ecosystem-based management. Ongoing conflict in the country meant that fieldwork was not possible.

"Through these case studies, we showed how shared data benefits everyone," says Pastres. "Another satisfying aspect of this project has been the development of close relationships with our partners in North Africa. Since completion of the project [in December 2014], we have kept in touch; I will be visiting the Morocco case study site in a few months, and my institution will shortly be hosting an Algerian researcher for a year."

The effectiveness of processing satellite data to produce ecosystem mapping also led to the creation of a spin-off company, which Pastres founded together with French project partners. The business applies satellite data to sustainable aquaculture management, and is currently focusing on mussel, sea bass and prawn farming. Satellite mapping applications will also contribute to studies of the impact of climate change on coastal habitats, helping to identify risks posed by human activities such as tourism and fishing.

SWITCH-ON

Saving water through effective and open knowledge sharing

Freely accessible online tools to enable sustainable and efficient water resource management are being developed by the EU-funded SWITCH-ON project. The initiative is currently building a web portal to host innovations such as a virtual water-science laboratory, product marketing point and meeting place.

Environmental information tools are in high demand but not always available or accessible. This is due in part to a wide dispersion of potentially useful material and a lack of information on how to actually apply available tools at an acceptable cost.

SWITCH-ON, which began in November 2013, is promoting the use of open data tools to support sustainable water use. Open data is the idea that certain information should be freely available to everyone without restrictions.

By exploiting the untapped potential of open data, the project team believes it is possible to improve water information provision, leading to more efficient environmental services and better handling of environmental problems, including those induced by climate and environmental change.

"This portal will be the first one-stop shop where you can find different kinds of water-information and users in one place," explains project coordinator Berit Arheimer, head of hydrological research at the Swedish Meteorological and Hydrological Institute (SMHI). "It will lead to more efficient water management tools, which can be used to create jobs that contribute towards a more sustainable and safe society."

The innovation will also help to foster new business opportunities and growth by facilitating the development of new products and services based on the principles of information sharing. SMEs and service providers are expected to be able to access new markets, increase their competences and achieve more efficient production as a result of collaborating within SWITCH-ON.

A one-stop-shop

"We are currently developing the portal at www.water-switch-on.eu," says Arheimer. "This will contain 14 new products to aid operational water management, all based on open data. We have had stakeholder workshops to get feedback on the products so far, and to judge market potential." To ensure successful implementation, each

Participants

Sweden *(Coordinator), Australia, Germany, Greece, Italy, Netherlands, United Kingdom*

http://www.water-switch-on.eu/									
FP7	*Proj. N°*	*603587*	*Total costs:*	*€ 7.8 Mio*	*EU contribution:*	*€ 6 Mio*	*Duration:*	*from:*	*11/2013*
								to:	*10/2017*

product involves a detailed business plan and close cooperation with appointed end-users.

The virtual water-science laboratory is one tool currently under development. Dedicated software and modelling tools will enable scientists to contrast water-related processes in different environments, and help them understand complex processes in a more holistic way.

"The first scientific journal paper on using the Virtual Lab is currently under revision, while six new scientific experiments are now under way," adds Arheimer. Potential end-users include environmental consultancies, agriculture, hydropower companies, insurance companies and governmental authorities.

The portal will also run an open virtual product market, with products and services for water managers. A virtual meeting place where visitors can have a dialogue on product development and marketing is also being constructed. "We want to build bridges between policy-makers, water managers, product developers and researchers with this one-stop shop," explains Arheimer.

While focused on water, it is hoped that the project will inspire the sharing of environmental and societal knowledge in other domains, by demonstrating that openness and collaboration can lead to innovation. The latest information and presentation technologies, such as web-based visualisation tools and mobile phone apps, will be used to disseminate the project's findings to end-users in a quick and efficient manner.

SWITCH-ON also contributes to the intergovernmental Group on Earth Observations (GEO), which will act as an international platform to leverage the project's results and amplify its impact on a global scale.

WESENSEIT

Putting the citizen at the centre of flood prevention

Social media has broken down barriers between information providers and consumers. An EU-funded project is seeking to capitalise on this by enabling citizens to monitor and report on their own environment, and thus become the first line of defence against flooding.

Recent events in England, central Europe and elsewhere have once again underlined the human and economic costs of flooding. The number of people who will be affected is predicted to double over the next 70 years, with annual damages increasing from EUR 7.7bn to EUR 15bn. Europe's ability to mitigate and adapt to the effects of climate change is therefore one of the challenges of our time.

The EU-funded WeSenseIt project aims at strengthening Europe's response to water management and to directly engage with citizens and communities on the front line.

A citizen's observatory

When it comes to floods, citizens have often been thought of as mere consumers of information; potential threat warnings would trickle down from authorities to those living in areas at risk. But couldn't citizens and communities be given a more active role and become part of the solution to better water management?

This is why WeSenseIt is developing the concept of a citizen-based water observatory, where communities form part of a two-way information chain. The advent of mobile phones and social media means that citizens can be fully active in capturing, evaluating and communicating valuable information on water levels, creating cost efficiencies and acting as early warning systems for over-stretched local authorities.

"There are so many rivers that it would be impossible to monitor them all with sensors," explains project coordinator Fabio Ciravegna from the University of Sheffield in the UK. *"Not all necessary information can be captured with sensors. Moreover, cost is a major issue: often the cost of the communication infrastructure to transmit data dwarves the cost of the sensors themselves."*

Citizens can help by taking measurements using new apps currently being developed by the project and sending information and images by phone.

Participants

United Kingdom (Coordinator), France, Italy, Netherlands, Poland, Spain, Switzerland

http://wesenseit.eu/

FP7	Proj. N° 308429	Total costs: € 7 Mio	EU contribution: € 5.5 Mio	Duration:	from: 10/2012 to: 09/2016

They can also help by reading existing sensors and sending authorities the data via mobile apps. The collected data will be made available through the GEOSS.

New technologies and approaches to water management are being tested and validated in three EU countries: the UK, the Netherlands and Italy. *"For example, we are developing mobile apps so that flood wardens in the UK can walk along river banks, and take tagged pictures if think there is something of concern,"* says Prof Ciravegna. *"We have already received hundreds of pictures from Doncaster."*

In Italy, an evaluation involving some 500 volunteers simulating a flood in the city of Vicenza was completed at the end of March 2014. The project has also been asked to provide assistance in supporting the city of Vicenza during the evacuation of some 50 000 people, in order to allow an unexploded World War Two bomb to be diffused.

Sensing business opportunities

WeSenseIt also has a strong focus on creating new economic opportunities, which is why eight small to medium-sized enterprises (SMEs) are involved. One company is already commercialising a tool developed during the summer 2013.

The tool, which carries out large scale social media analysis to help emergency responders during large scale floods, found an application in monitoring large city wide events in England. Events involving over 600,000 citizens were monitored with excellent results, reflecting the breadth of potential applications of this kind.

Overall, the citizen observatory concept will provide solid infrastructure within which SMEs can create and test applications and services at low cost, in a project setting that will give them high visibility. Businesses stand to benefit hugely from being able to apply developed technology to such an important issue.

"The long term impact of this project will be the development of a new way of understanding the environment; that it is something shared by us all," says Prof Ciravegna. *"The real lesson here is that it is not just about monitoring emergencies, when everyone wants to help; monitoring and measuring on a daily basis enables preparation, prevention and understanding. I think, with this project, we are getting there."*

European Commission

Investing in European success
A Decade of Success in Earth Observation Research and Innovation

Luxembourg: Publications Office of the European Union

2015 - 45 pp. - 14,8 x 21,0 cm

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KI-01-15-721-EN-N

Earth observation data and information are vital to allow decision-makers and society in general to take informed decisions about climate, energy, food security, natural hazards, health and other societal challenges. These challenges are complex, interrelated, cross-border in nature and inter-dependent at the global scale and therefore coordination is essential to avoid duplication of efforts and reduce observational gaps. The European Commission together with 27 EU Member States are active members of the Group on Earth Observations (GEO), which provides a global voluntary framework where governments and participating organisations can coordinate their strategies and investments in the field of Earth observation while promoting full and open access to data and information through the Global Earth Observation System of Systems (GEOSS).

This booklet provides a snapshot of EU-funded projects which illustrate how European research and innovation contribute to this global initiative, showcasing the potential of international collaboration in science for diplomacy.

Project Information

Publications Office

ISBN 978-92-79-51987-1