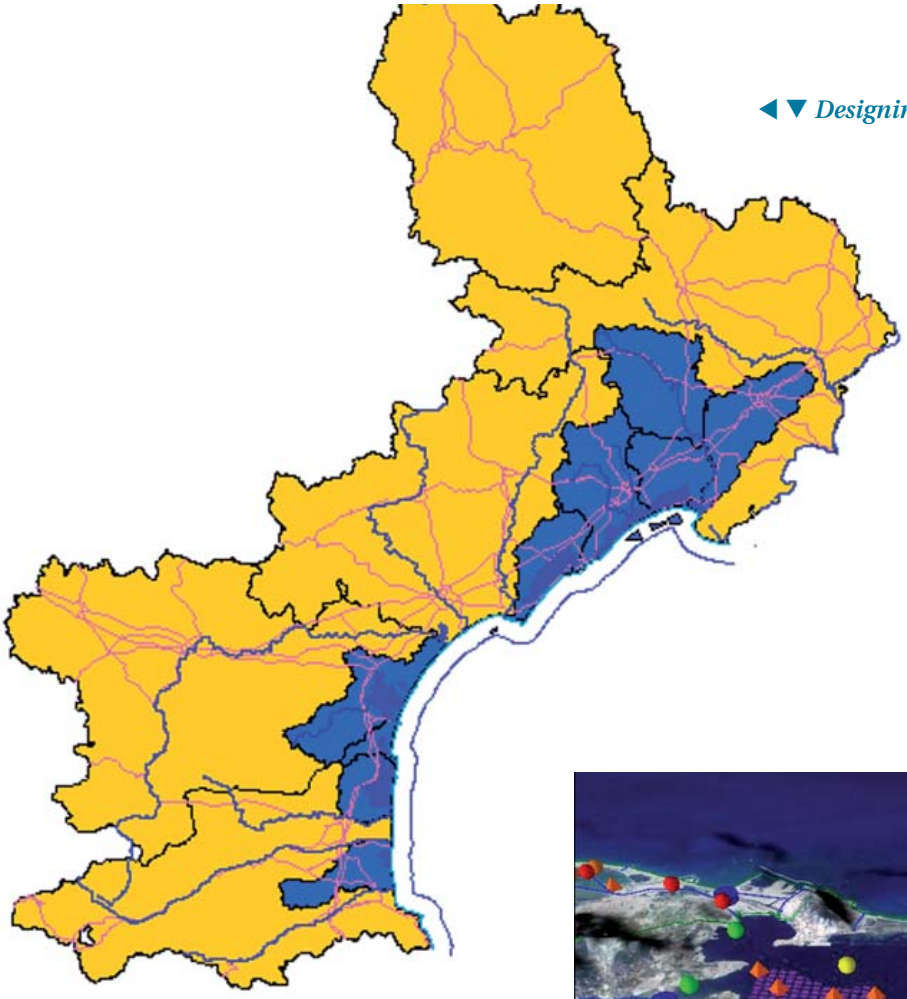
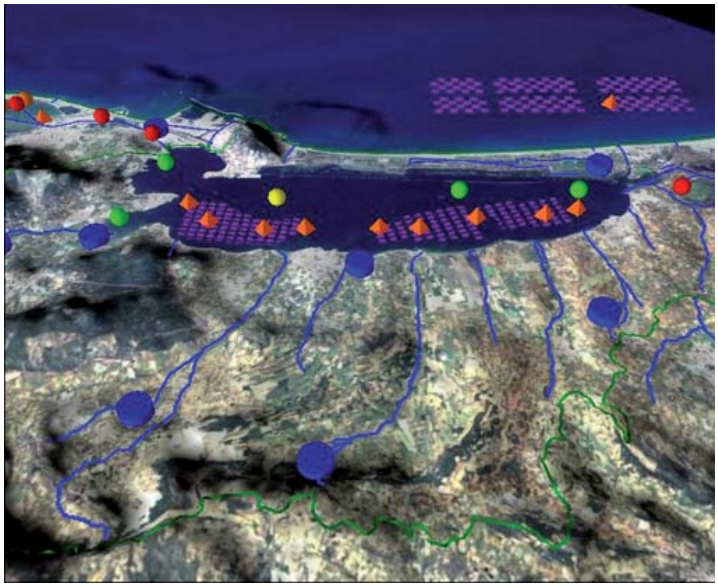


◀ ▼ *Designing management and mapping systems (AGIL and SYSCOLAG projects).*



Information systems *and observatories*

From Agropolis International thematic directory n° 9 - "Geoinformation and Earth Observation for environment and territories" (February 2010 - 68 p.)

An information system is a scientific, technical and institutional platform that binds links within a community (companies, public institutions, research groups, territorial associations, etc.) via information. The aim is to build knowledge and to participate in coordination and negotiation between stakeholders concerned about a specific territorial or societal issue. The system, which pools structured human and material resources, organises and integrates data acquisition, processing, management, sharing and dissemination via given reproducible protocols. These functionalities are tailored to specific needs, such as knowledge building, coordination or negotiation between stakeholders.

All information systems include managerial and organizational aspects which underlie their creation, along with computer technology aspects. A system may therefore be oriented according to two standpoints, i.e. depending on the typology and nature of the information circulating between individuals, or on the system's architecture, which facilitates information exchange and storage.

The typology of information systems is broad ranging. A few that are devoted to the environment are (but this list is not exhaustive):

- technical information systems in which observation services supported by sensor networks may be classified
- organizational information services that enable some organizations to structure their information, such as environmental research observatories serving the scientific community
- information systems that are supported by informal networks in which information circulates and which can provide support for territorial projects
- information systems devoted to both monitoring and decision support, which could be called 'observatories'.

Some Agropolis teams focus research on methods concerning resource management and environmental change issues. Information systems developed in this framework should account for the complexity of the issues in terms of the diverse range of stakeholders and spatiotemporal scales. In a multi-institutional setting, the representations that stakeholders have of the same system (e.g. a territory) and their motives for subscribing to a common information sharing objective are wide ranging, and data heterogeneity is high (nature, format, scale, etc.).

Observatories represent a specific instance of information systems. They are set up to observe (monitor, analyse, understand), within a spatial area representative of a territorial entity targeted for research, socio-environmental dynamics resulting from dynamic interactions of socioeconomic and biophysical systems. These are sites for the production, exchange and sharing of information and knowledge with a long-term scope. They thus require methods specifically adapted to the management of cumulative data processes (sustainability, replication, storage, etc.) and of knowledge building processes (sharing, exchange, interaction, etc.).

This chapter highlights–through a selection of representative examples–how the teams are involved in upstream and follow-up research activities to facilitate efficient operation of information systems and observatories in many areas throughout the world: needs analysis, specification and instrumentation. It also showcases the diverse range of uses, depending on whether the focus is on knowledge production, information management and sharing or supporting decisionmaking processes. It reveals the challenges faced with respect to successfully integrating the range of different stakeholders and their views, taking the different spatial and temporal aspects of information into account, representing its complexities, managing uncertain data aspects, mobilizing and combining many different data sources, etc.

Thérèse Libourel (LIRMM),
Maud Loireau (US ESPACE)
& Michel Passouant (UMR TETIS)

Information systems *and observatories*

Main teams

BRGM, Service « Géologique Régional », Operational services « Eau » et « Aménagement et risques naturels »
(see page 49)

LGEI - Laboratoire Génie de l'Environnement Industriel et des Risques Industriels et Naturels
(see page 49)

UMR G-EAU - Water Resource Management, Actors and Uses
(see page 44)

UMR Géosciences Montpellier
(CNRS, UM2)
87 scientists, with 12 involved in the research topic
Director: Serge Lallemand,
lallem@gm.univ-montp2.fr
www.gm.univ-montp2.fr/spip/index.php

UMR HydroSciences Montpellier
(see page 18)

UMR LISAH - Laboratoire d'étude des Interactions Sol - Agrosystème – Hydrosystème
(see page 18)

UMR LIRMM - Montpellier Laboratory of Informatics, Robotics and Microelectronics
(CNRS, UM2)
155 scientists, with 9 involved in this topic
Director: Michel Robert,
michel.robert@lirmm.fr
www.lirmm.fr

UMR TETIS – Geoinformation and Earth Observation for Environment and Land Management
(see page 8)

UPR Forest Resources and Public Policies
(CIRAD)
25 scientists, with 6 involved in this topic
Director: Alain Billand,
alain.billand@cirad.fr
www.cirad.fr/en/research-operations/research-units/bsef

UPR SCA - Annual Cropping Systems
(see page 38)

US ESPACE - Expertise et SPatialisation des Connaissances en Environnement
(see page 8)

Other teams focused on this topic

UPR Dynamics of Natural Forests
(see page 44)

UPR Functioning and Management of Tree-Based Planted Ecosystems
(see page 38)

UR Great Ice - Glaciers et Ressources en Eau d'Altitude - Indicateurs Climatiques et Environnementaux
(see page 44)

URP Pastoralism
(see page 38)

Geological risk studies and prevention

Géosciences Montpellier (CNRS, UM2) pools Earth scientists and a broad range of research resources in a single laboratory. Geodynamics –from the nano to the plate scale–are pivotal to the research, which is conducted using tectonic, geochemical, geochronological, geodesic and sedimentological tools. Geodynamics concern the different Earth envelopes, from the deepest to the surface, through the lithosphere, and interactions with the mantle. The team's expertise, derived from fundamental research, is utilized in studies carried out along several targeted research lines, in the fields of natural hazards (earthquakes, landslides, near-shore erosion, heavy rain storms), geological reservoirs (sedimentary architecture, fracturing, fluid transfer, mineral physics), environment and sustainable development (CO_2 sequestration, geothermal resources, subsurface hydrodynamics, water resources: stock assessment, transfer monitoring and quality). Most of these research topics require continuous or recurrent observation of physical parameters, in addition to laboratory analysis and modelling of the underlying processes. Most of the instrument-equipped Mediterranean sites monitored are located in Languedoc-Roussillon region (France).

In the laboratory, geoinformation is used to study and prevent geological hazards through, for instance, fault and landslide detection surveys. The techniques implemented include synthetic aperture radar interferometry (INSAR) and correlation of high resolution optical satellite and aerial images. The laboratory places priority on investigating hazard zones where earth movements can be measured continuously (interseismic deformations, slow landslides) or on a disaster-event basis (earthquakes, avalanches). It has a library of images on key sectors, so it is prepared to study 'before-and-after deformations' in natural disaster situations.

Géosciences Montpellier devotes research to enhancing knowledge in the internal and external dynamics of planet Earth, while also addressing societal issues through natural hazard assessment, management of mineral resources (geological fluids) and the environment.

Software engineering and information systems

The **Montpellier Laboratory of Informatics, Robotics and Microelectronics (LIRMM**, CNRS, UM2) offers a broad scope of expertise in the fields of information science and technology, communication and systems (STICS). The laboratory's research is multifaceted, i.e. theory, tools, experiments and applications, in all of its specialized scientific domains. This research is carried out in three departments: Informatics (INFO), Microelectronics (MIC) and Robotics (ROB).

Data Object Components for Complex Systems is one of the project teams in the Informatics department. This team's research involves cooperation in two fields, i.e. software engineering (components and objects) and information systems, while also being oriented towards modelling and engineering of complex systems in various application domains (chemistry, life science, environmental science, robotics).

The research is focused on the contribution of object modelling in developing highly expressive data and processing models, while also integrating the evolution concept. Because of the variety and volume of cumulated information, and beyond the problem of system continuity, scientists in these domains have to deal with the issue of information sharing and dissemination–to put it simply, relevant information must be 'served' to users. Designing mediation infrastructures is a challenge. Based on metadata and ontological concepts, the goal is to build real systems that integrate the semantics of the underlying data and processing domain. This topic concerns integration and mediation infrastructures tailored to the concerned domains. There are many mixed and distributed initial data sources. They can be located at a meta level that includes the semantic description of the domain (metadata and ontologies). These different research thrusts were developed through the involvement of LIRMM within the Geographic Information Systems, Methodologies and Applications (GDR SIGMA, CNRS) research group. ■

Environmental data sharing and dissemination infrastructures

Website for locating global environmental information based on MDweb 2.

© MDWeb - IRD

Various international conventions (Rio 1992, Aarhus 1998, etc.) and, more recently, the Infrastructure for Spatial Information in Europe (INSPIRE) European Directive have confirmed the importance of providing public access to and exchange of environmental information between different sources in support of environmental management.

This illustrates the current increase in awareness on the importance of pooling environmental knowledge and providing public access to it for decision support. In order to enhance integrated territorial management, this access could be extended from being solely focused on environmental knowledge to include technical, social and economic aspects.

In order to respect the independence of organizations and their information production, collaborative knowledge building and data distribution and processing are broad areas of debate and the focus of research in the field of information and knowledge systems. This research generates operational solutions through the development of 'building block software' tools required to create data infrastructures.

Amongst all of the proposed solutions, the MDweb project is exemplary. MDweb catalogues and locates web information resources and is an essential operational tool for information pooling and sharing infrastructures. It was developed through a collaboration between several partners (IRD, LIRMM, Cemagref, CIRAD, CEPRALMAR, *Région Languedoc-Roussillon*) within the framework of research projects (ROSELT desertification observatories, data libraries of *Systèmes Côtiers et Lagunaires du Languedoc-Roussillon* [SYSCOLAG]). MDweb is an open source tool (CeCILL French royalty-free license). It is based on geographic information metadata standards (ISO 19115, CEN) for resource referencing, and on Open Geospatial Consortium communication standards. The integrated open source search engine offers multicriterion searches using spatial (cartographic interface) and thematic (thesaurus) reference bases.

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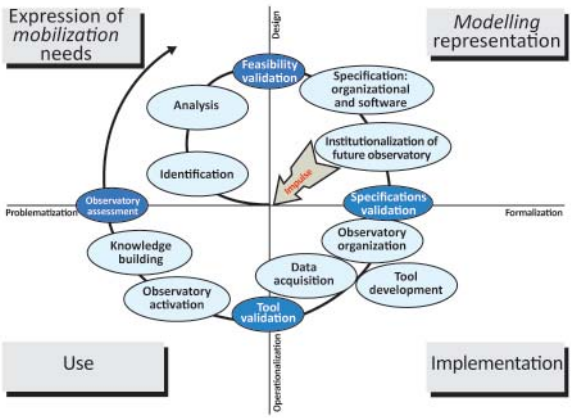
For further information: http://mdweb.codehaus.org
Online demo: http://demo20.mdweb-project.org

Methods for the design and analysis of territorial information systems

In an ever-changing rural world, sharing targeted, reliable, updated information tailored to specific issues is a key element for territorial development. This is true regardless of the aim, i.e. to gain insight into territorial dynamics, coordinate agricultural practices, characterize and manage flood hazards, control pollution or restore the ecological balance of rivers, etc.

The joint research unit (UMR) TETIS conducts research on information system concepts, formalisms, design and setup methods by implementing them using specially tailored computer tools. For instance, in collaboration with UMR G-EAU, it has developed a new participatory approach for building observatories in given territories to fulfil the needs of a collective action targeting a specific issue. Between 2005 and 2007, a test was carried out in two areas of France: Aume-Couture Basin (Charente region) where quantitative water management was the key concern to deal with, and Hien Valley (Isère region), where biodiversity and water quality were the issues. Concerned rural stakeholders' organizations were queried to establish the base of an information system. There are four steps to this iterative approach: statement of requirements, representation of viewpoints, development of the computer application and use of the resulting information system.



From Lemoisson P. *et al.*, 2008.

▲ *Spiral observatory design pattern.*

Long-term representation and capitalization of knowledge used during the development of information systems is another example of the unit's research. A case-tool, which was initially set up for the modelling and development of computer applications, was modified to focus on adding pictograms of spatial and temporal concepts used in observatories. The functions developed in this case-tool automatically enhanced the models developed during the analysis as a function of the spatial and temporal concepts introduced. Automation of model enrichment boosts the speed, traceability, quality, reliability and improves the efficiency of information system development processes.

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Complicated negotiation between three urban sellers and a rural charcoal producer (sitting) in Mali.

Role playing games used in preliminary analysis of a participatory GIS for concerted management

GIS tools have been substantially criticized for being inaccessible to citizens and mainly available for the use of public authorities. Over the last 15 years, research has been under way with the aim of designing participatory GIS that could bring together different partners (especially basic communities) for spatial decisionmaking. This concept is still relatively vague and methods for designing such systems have not been formalized.

In this new research field, CIRAD (UPR Forest Resources and Public Policies), in collaboration with the Malian forestry administration, launched companion research with the aim of building a participatory GIS with all stakeholders of the fuelwood supply subsector in Bamako. There is a very high number of stakeholders in this subsector, sometimes with antagonistic goals, with marked differences in information access. This research is based on the hypothesis that GIS, which is considered as an intermediate tool that can be used to collectively build a shared vision of the Bamako wood energy supply area, could facilitate stakeholder coordination and thus enhance forest resource management.

The selected approach is based on a role playing game and is similar to a scenario-based needs approach. It is aimed at encouraging stakeholders in the profession to describe their views on GIS, thus to express their needs, goals and the pathway that should be taken to achieve them. The game enables different stakeholders to be full-fledged protagonists of a simulated information system. They are introduced to the situation in a structured area (room) as information users, vectors and producers. The experiment highlights the efficacy of the game with respect to explaining viewpoints, analysing needs and documenting information sharing strategies. It boosts the prospects for designing information systems in relatively unstructured organizations.

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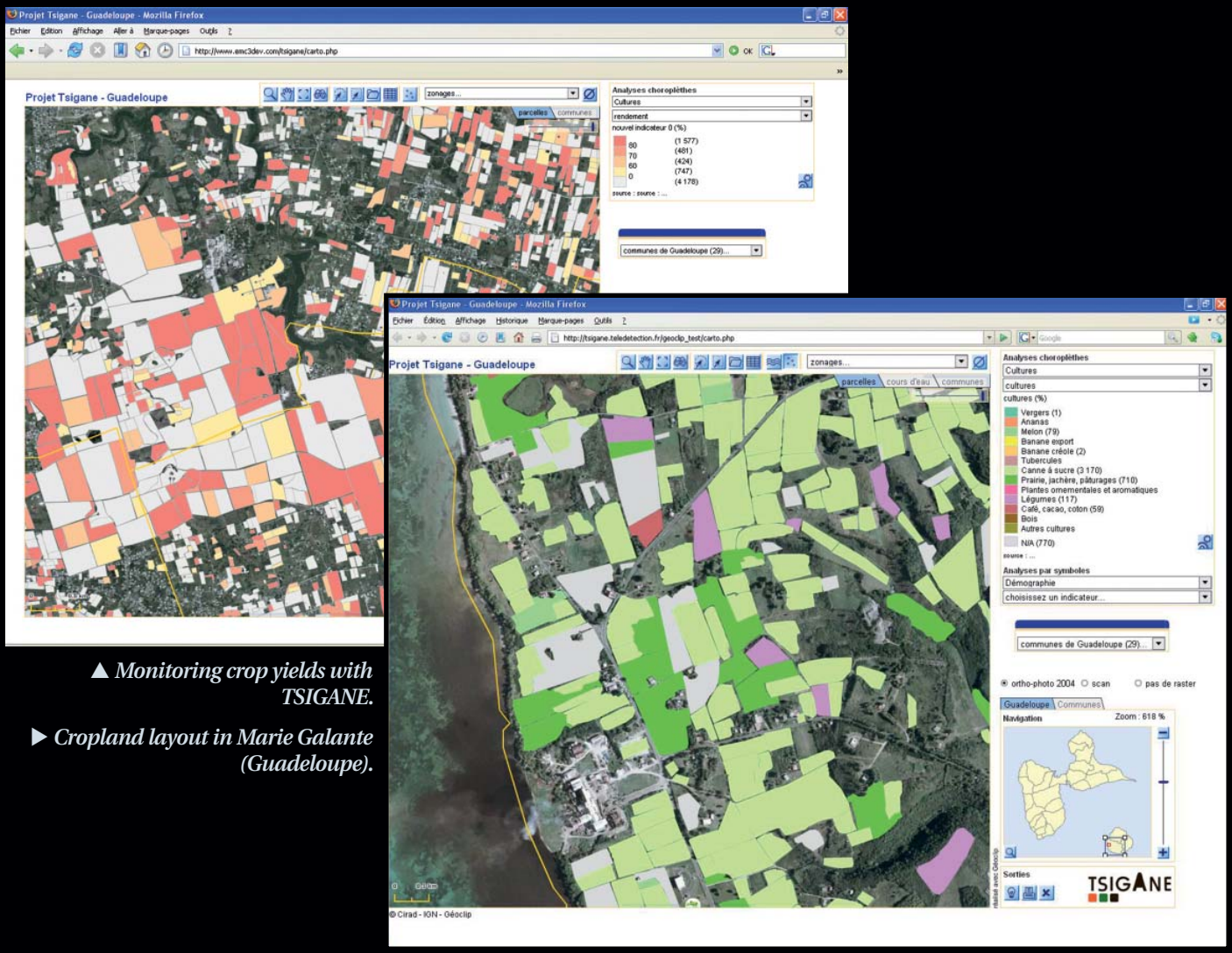

▲ *Monitoring crop yields with TSIGANE.*

▶ *Cropland layout in Marie Galante (Guadeloupe).*

TSIGANE: a geoinformation tool for commercial crop management

Agricultural production must be managed at a larger scale than individual plots in order to be cost-effective and comply with regulations. Farmers are thus faced with the problem of overcoming many constraints to optimize their production. The internal research unit (UPR) Annual Cropping Systems (CIRAD) is striving to facilitate farmers' task by developing support tools for the management of crop production on a regional scale based on geographic information:

- an information system, connected to models developed through research, containing administrative, agronomic, climatic and production data for a broad range of agricultural plots
- an online cartographic server that enables data restoration in the form of maps containing raster data (satellite images, orthophotos, etc., as well as crop growth or harvest monitoring maps), vectorial data (plots, roads, etc.) and attributary data (yield, harvest dates, area, etc.).

These tools are designed for:

- farmers wishing to more efficiently manage the growth of their crops on a plot level
- extension services to tailor their technical advice
- industrial stakeholders to enhance production system operation (supply, volumes to process, optimal dates for technical interventions, etc.)
- institutions so that they will have a more accurate idea of the production capacities per commodity channel and be able to calculate the amount of assistance needed (price guarantees, natural disasters, etc.)
- research organizations.

These tools are now integrated into a modular system that can be implemented by a broad range of users thanks to new information and communication technologies.

TSIGANE is an online information platform that combines different components specifically designed for:

- management of climatic information
- management and dissemination of agricultural data on a per-plot basis (GIS and web mapping)
- harvest forecasting
- crop growth simulation
- satellite image based mapping for harvest monitoring.

Other research-generated components could potentially be integrated into this scalable platform.

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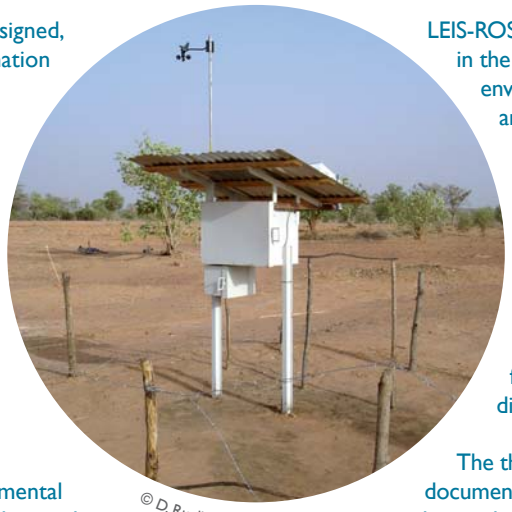
For further information on the TSIGANE platform (Online technology and geographic information systems for crop management): http://tsigane.teledetection.fr

ROSELT/OSS: an information system for monitoring desertification in sub-Saharan Africa

The service unit ESPACE (IRD) has designed, developed and implemented an information system (IS) within the framework of the Convention to Combat Desertification and the Long Term Ecological Monitoring Observatories Network of the Sahara and Sahel Observatory (ROSELT/OSS). This all-encompassing IS–from the collection of biophysical and socioeconomic data on specific territories (methodological guides) to the sharing and dissemination of generated information (MDweb), as well as integrated and spatial data processing–enables joint analysis of territorial dynamics. This local environmental information system (LEIS-ROSELT) is the product of a collective initiative, with substantial involvement of research institutions responsible for observatories in member countries of the network (Institute of Arid Regions, Tunisia; University of Alexandria, Egypt; *Centre de Suivi Écologique*, Senegal; 'ROSELT team' associated with the Ministry of Environment, Niger).

MDweb–an online environmental information cataloguing and search tool–is used for inventorying, describing and accessing information produced by all of the observatories.



© D. Ruelland

LEIS-ROSELT combines GIS and generic models in the ArcGIS platform for the assessment of environmental vulnerability utilizing minimal data and calculating synthetic spatial indices of land degradation risks. The temporal results are comparable between observatories. The models are tailored to dry areas where there are marked nature/society interactions, with high spatial and temporal variability and where resources are simultaneously or successively tapped for various end uses. By changing the input parameters, long-term forecast maps may be produced to facilitate discussions with resource managers.

The thematic guides are open-ended scientific documents that are shared within the network. They are designed to enable users to gradually organize the streamlined monitoring system by topic (nature/societies), thus ensuring the synchronous and diachronous approach of ROSELT. The recommended sampling data collection and processing methods can be implemented to develop specific indicators for each topic and indicators adapted to the interdisciplinary spatial approach applied in the LEIS.

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For further information on the ROSELT/OSS network: www.oss-online.org
For further information on MDweb: www.mdweb-project.org

▲ *Meteorological recording device, HydroSciences Montpellier/G-EAU research site in Koumbaka catchment (Mali).*

Mediterranean environmental observatories

Systematic observation of the natural environment and its use by humans is essential for studying global changes and natural hazards. Observatories are collaborative structures supported by research units that define the features to be observed, implement the observation techniques and design the information systems. Autonomous flexible structures governed by all stakeholders through *ad hoc* committees ensure their sustainability and missions. These units are the main observatory developers and users. The observation products are sometimes also useful for other stakeholders (territorial communities, public and private partners). Many observatories are associated with these other stakeholders, or even developed in collaboration with them. This is a long-term approach (spanning more than 10 years).

The Mediterranean region is both a victim and witness of hazards and global changes. This area is marked by serious land instability, where water can be considered as both a hazard (extremely heavy rainfall, flooding) and a rare and hard to utilize resource, as well as a biodiversity hotspot. Several regional observatories are devoted to the observation of Mediterranean natural and man-made environments:

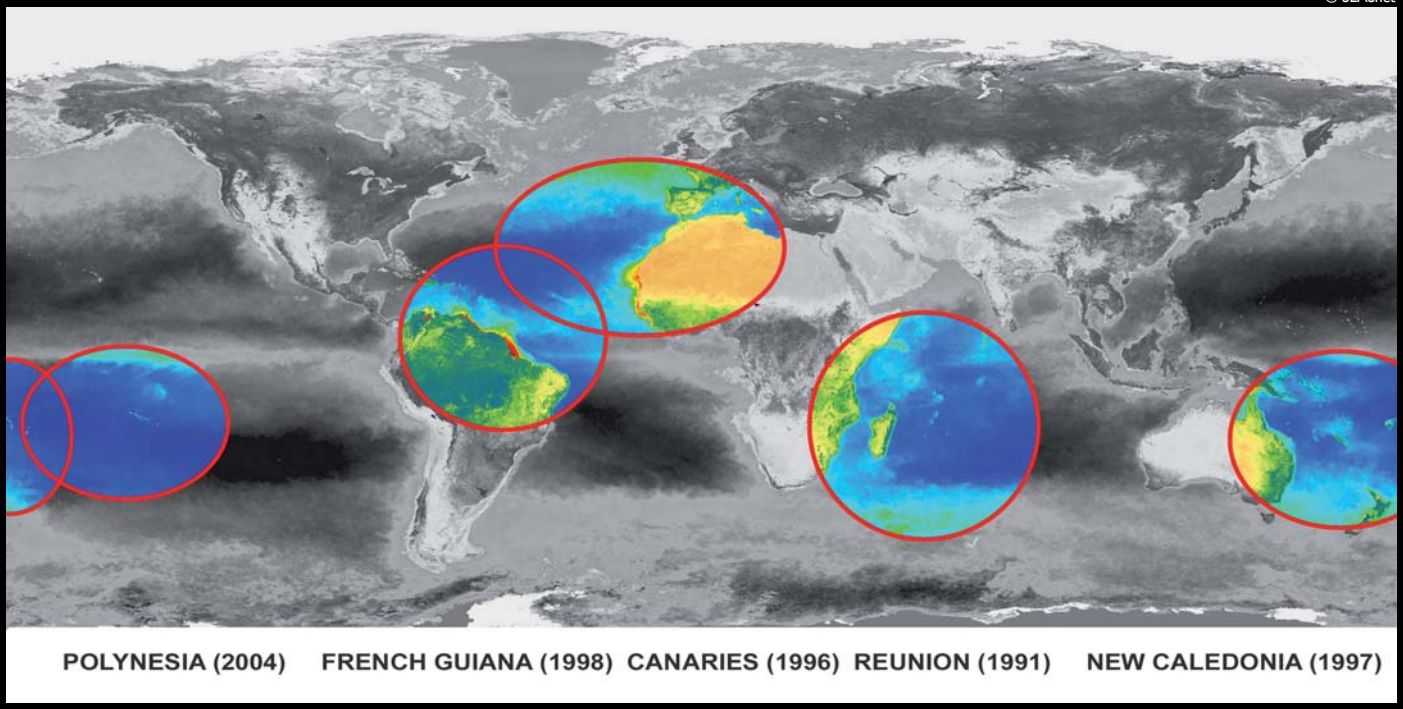
■ The *Observatoire Méditerranéen de l'Environnement Rural et de l'Eau* (LISAH, *HydroSciences Montpellier,* etc.) focuses on Mediterranean cultivated systems that can be studied for many reasons: the hydrological setting, i.e. at the interface of arid and temperate environments, while being subjected to a broad range of hydrological processes (severe drought, extreme flooding, etc.); the social and human setting in which, after thousands of years of human activities, major changes are taking place as a result of rapid population growth.

■ The *Observatoire Hydro-Météorologique méditerranéen Cévennes-Vivarais* is striving to boost knowledge and prediction capacities on hydrometeorological hazards associated with intense rain storms and flash floods by pooling the expertise of researchers in various fields. This observatory is managed by the *Laboratoire d'étude des Transferts en Hydrologie et Environnement* (Grenoble) in collaboration with many other laboratoires (*Géosciences Montpellier, HydroSciences Montpellier,* ESPACE, EMA).

■ The *Observatoire de Recherche Méditerranéen de l'Environnement* (OSU-OREME) monitors the natural environment while mobilizing researchers from various complementary disciplines to assess the impact of global climate change and natural hazards on Mediterranean environments. *Géosciences Montpellier, HydroSciences Montpellier,* CEFE, ISEM, ECOLAG and CBAE are the main developers and users.

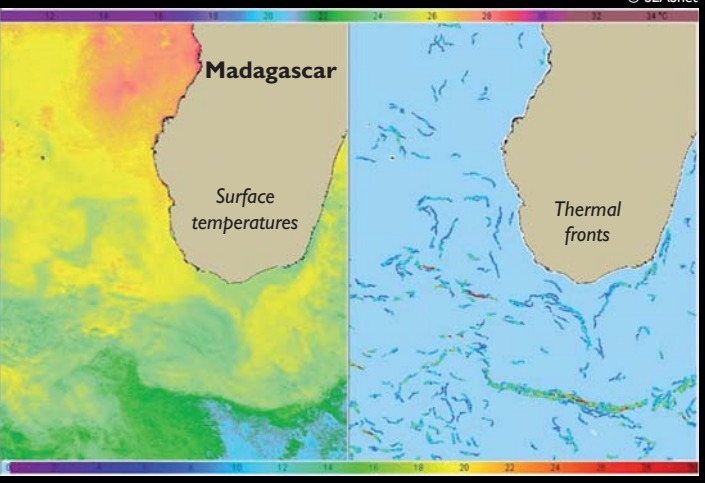
Contact: Nicolas Arnaud, nicolas.arnaud@gm.univ-montp2.fr

▲ *Photo: Barrier beach between Palavas and Frontignan (France): view of gale cones.*



▲ *SEASnet sites and footprints.*

SEASnet: a network of environmental observatories to support sustainable development



▲ *Examples of surface water data acquired in the vicinity of Madagascar. Temperatures on the left and thermal fronts (temperature gradients) on the right.*

Based on the successful experience of the *Surveillance de l'Environnement Assistée par Satellites* (SEAS) network, which was launched more than 15 years ago in the Indian Ocean region, the service unit ESPACE (IRD) has installed several environmental satellite receiving stations with wide field-of-view antennas and is using the received images in its own research programmes as well as partnership research programmes.

Receiving stations of IRD and its local partners (University of Las Palmas, Polynesian Fisheries Service) are set up throughout the intertropical region (Réunion, Canary Islands, New Caledonia, French Guiana, Tahiti). They belong to SEASnet and operate as environmental observatories. They continuously generate scientifically validated spatial thematic products (water surface temperatures and turbidity, vegetation conditions, etc.) that are available online.

There are many application fields (fisheries, coastal areas, turbidity in the Amazon River, etc.) concerning terrestrial, coastal and even pelagic oceanic areas. Over the last decade, this scientifically high value-added observatory activity has been carried out in partnership with space agencies (ESA, CNES, NASA). It is aimed at contributing to spatial environment monitoring initiatives on regional, European and international levels, including the *Observatoire National sur les Effets du Réchauffement Climatique* (ONERC), the African Monitoring of the Environment for Sustainable Development (AMESD) programme, etc.

This concept of a network with geographically dispersed expertise differs from regular centralized usage with single satellite data acquisition and global processing sites. Conversely, by allowing each station to build a regional borderless advanced technology area, SEASnet is complying closely with the recommendations outlined in the Rio Declaration. In 2006, a high resolution SPOT and ENVISAT satellite receiving station was set up in Cayenne on the basis of SEASnet concepts. A similar project is also under way in Réunion.

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For further information: www.seasnet.org and www.gobiernodecanarias.org

▲ *Wide field-of-view antenna for environmental satellite imagery reception.*