The GEOSUD remote sensing data and services infrastructure

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Highlights: This paper describes the GEOSUD project which aims to implement a national data and services infrastructure in order to facilitate the use of satellite imagery by the French scientific community and public institutions. This ecosystem of innovation is part of the THEIA Land Data Centre.

Key words: *Spatial Data Infrastructure, Satellite Images, GEOSUD project, THEIA*

Background: the satellite images, a high potential clearly underexploited by the public sector

The knowledge and the understanding of territories and their dynamics, the dialogue between the actors of these territories, the definition, the implementation and the evaluation of public policies and strategies of management, imply to mobilize and to share relevant, reliable and regularly updated spatial information. Beside the reference data produced by IGN, the French national mapping agency, and the ones generated by institutional actors (State decentralized services, public institutions, local authorities), associations and private operators, satellite images allow observing in a homogeneous, repetitive and long-lasting way wide territories.

If the potential of this source of data was abundantly illustrated by numerous case studies, we have to admit that it remains little used by the public sector in charge of the management of the environment, the agriculture and the territories. Even if some domains have integrated this source of data (meteorology, oceanography, major hazards, land cover at the European scale, Common Agricultural Policy), it remains absent in most of the French operational policies and is still considered as a domain of specialists.

The reasons are known and are primarily due to the economic model of data access, the complexity of image processing, the skills required for their valuation, and the lack of dissemination of methods tailored to operational management needs. Over the last 20 years, satellite imagery has been largely seen as a sophisticated tool that was left for specialists and that the majority of public actors could not appropriate. One consequence of this weak demand is that the market was limited to companies offering services in this area.

Objectives of the GEOSUD project

In response to the context exposed above, the GEOSUD project is the result of a long-term strategic vision which aims to develop the use of satellite imagery within the scientific community and public actors involved in environmental management and territorial development. The strategy consists in removing, or at least mitigating, the various obstacles to the operational use of satellite imagery. This project is situated at the interface between "Information and Communication Sciences and Techniques" and "Environment and Society"

Initiated by the founding members of the Remote Sensing Centre in Montpellier (AgroParisTech, CIRAD, IRD and Irstea), it relies on two major funding:

- The first one, registered in the State-Languedoc-Roussillon Region Project Program (CPER) for the 2007-2013 period, includes the extension of the building of the Remote Sensing Centre and the installation of a satellite receiving antenna.
- The second one, the Equipex GEOSUD, funded under the "Investments for the Future" Programme (2011-2019), focuses on satellite imagery acquisition, the development of accessible products and services from a Web Remote Sensing Data Infrastructure, training and networking of actors. It brings together 13 partners from research, higher education, public sector, as well as the professional world of geomatics: AFIGEO, AgroParisTech, CEREMA, CINES, CIRAD, CNES, Geomatys IGN, IRD, Irstea, the Universities of Montpellier, Antilles-Guyane and Reunion. The French National Space Agency (CNES), the Ministries of Agriculture and Sustainable Development are closely involved in steering the project.

In 2012, the holders of the GEOSUD project have strongly cooperated with the CNES to create the THEIA Land Data Centre, which is described in depth in a companion paper [1].

Technical content of GEOSUD SDI

Main components

The GEOSUD project includes four main components:

- Satellite data acquisition with single multi-user licence agreement: 5 years of annual high-resolution satellite coverage of the French national territory (RapidEye, SPOT 4 and 5 images); very high-resolution images (Pleiades satellites) covering main conurbations and areas with specific issues.
- Data and computation infrastructure: data administration, broadcasting, computation capacities.
- Research and methods: upstream research on image processing methods, applied research on the structure and dynamics of ecosystems and territories
- Communities and capacities building: networking between the scientific community and public policies stakeholders; animation and training

Procedure for joining the GEOSUD community and to access its products and services

GEOSUD products and services are available to most of the French public institutions (scientific community, State Departments, government agencies, regional and local authorities, private sub-contractors, foreign partners) and small private companies for research and development.

Access to GEOSUD community and its products and services is structured in a simple two-step procedure:

- Opening a GEOSUD account (step 1) which consists of the signing by the director of the public institution of two documents (a membership charter and an act of commitment to the respect of licenses) available on line http://geosud.teledetection.fr and the designation of a contact person within the corresponding organization;
- Accessing images (step 2) that are available on the site: the authorized user chooses the type of product and the geographical area of interest. Once received the signed request, the GEOSUD team makes the images available to the user through an FTP site.

IT architecture of GEOSUD SDI

The design of GEOSUD SDI was led by the functional requirements described above and those relating to the interconnection between different image providers of the project including catalogs and images (i.e. the Remote Sensing Centre in Montpellier and IGN Geoportal in Paris). It has also to ensure interoperability with THEIA Land Data Centre SDI whose GEOSUD project is a major component (Figure 1), to contribute to INSPIRE Directive for data sharing at European level and to the international community of Earth Observation through the GEOSS initiative.

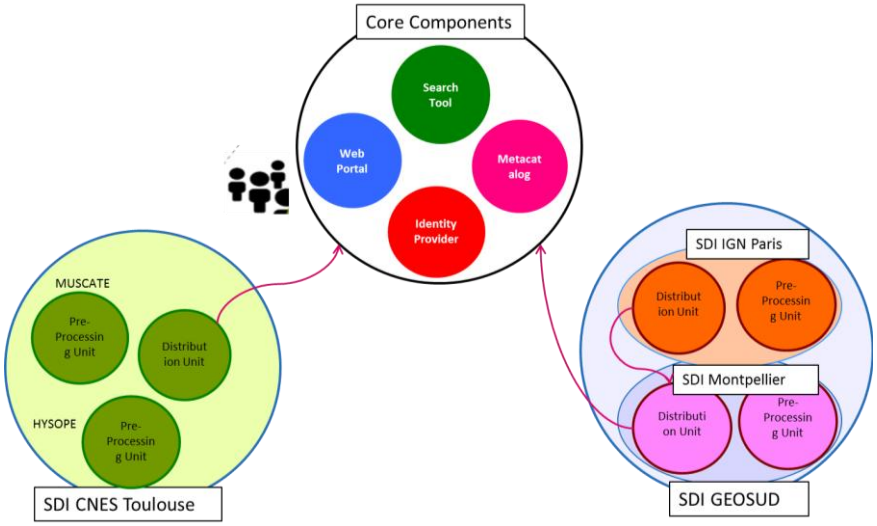

Figure 1 – GEOSUD SDI within Theia's Service & Data Infrastructure

The software component of GEOSUD SDI V1.0 addresses the needs for identifying and retrieving the images delivered by GEOSUD. Functionalities to display images at full resolution as well as for metadata consultation have been developed to accurately assess the suitability of the images for the intended use. Finally, a download function has also been added to access the selected image.

Administration functionalities are also available on the current version. They allow the harmonization and annotation of metadata, the pyramiding of images for fast display at different zoom. They also enable the management of users and their membership to GEOSUD as well as their rights regarding the use of images.

The implementation of the interoperability relies on a Web services-based infrastructure. Thus, GEOSUD SDI allows accessing images through interoperable services for image discovery, display and downloading. Image discovery services are based on the OGC CS-W standard (Catalog Service for the Web) and take into account the recommendations of the INSPIRE Directive. Moreover, this service is based on a semantic referential that enriches the description of the images in order to facilitate their selection by non-expert users [2]. The viewing and download services are implemented from OGC standard services WMS (Web Mapping Service) and WMTS (Web Mapping and Tiling Service). Finally, a single identification and authentication mechanism (SSO) is shared between GEOSUD image providers and those of THEIA Land Data Centre. It is built on the OAuth2 protocol that is widely used on the web. Using a single user account to access collections of images spread among different image providers should greatly facilitate access to these data.
The provision of high and very high resolution image collections represents a significant volume, about a hundred Terabytes. The collections of high resolution images (SPOT5, Rapid Eye) and very high-resolution images (SPOT 6-7) represent respectively a volume of about 2 Tbytes and 12 Tbytes per annual coverage.

The next version of the SDI that will be available mid-2016 will enlarge its functional range to on-line image processing capabilities. For that, several new functionalities will be developed in order to discover these processing services, to assess their compatibility with the selected images, to make available enough computing resources according to the complexity of the algorithms and the volume of data.

Satellite images portfolio

The GEOSUD web portal was opened in May 2011 with some regional image collections with a spatial resolution of 5 to 10 m (Languedoc-Roussillon 2009, Saone Basin 2009, Massif des Landes Winter 2010). A first annual coverage of the French territory (summer 2010) with Rapid Eye images (5 m) was acquired following a competitive tender pursuant to the Public Procurement Code and put online in September 2011. As a partner of the GEOSUD project, IGN then ortho-rectified these images and produced a mosaic of the whole territory in pseudo-natural colors and published it on the national Geoportal.

This first attempt proved the legal and technical feasibility and the interest of acquiring a national annual high resolution satellite coverage with a single multi-users licence. This approach was then renewed from 2011 to 2014.

In May 2015, the image collections acquired by GEOSUD and made available through its Web portal are presented in Table 1.

Satellites	**Spatial resolution**	**Area**	**Period**
Pleiades	0,5 m	Urban areas and areas with high issues (France including overseas territories, southern countries)	From 2012 to 2015
SPOT 6-7	1,5 m	Whole French territories	2014
SPOT 5	5 m	Whole French territories, some areas abroad	2011/2012, 2013
SPOT 5	5 m	France	2005
Rapid Eye	5 m	Whole French territories, some areas abroad	2010, 2011
CosmoSkyMed TerraSar X	Up to 1 m	Several areas in France and abroad	From 2013 to 2015

Table 1: Major GEOSUD image collections available in May 2015

Towards satellite direct receiving capabilities

To anticipate the end of the funding of satellite images on GEOSUD budget from 2016, a satellite direct receiving station (DRS) has been installed in Montpellier in 2014 and 2015 by mobilizing several regional and national funding sources. The GEOSUD DRS is currently composed of (1) an antenna of 5.5 meters in diameter (Zodiac Data Systems) attached to an hexapod based on a platform of 8 meters in height and (2) a multi-mission terminal (Airbus Defence and Space) able to receive and process SPOT 6 -7 telemetry, and potentially, Pleiades and TerraSAR-X.

The choice of the first terminal of the SRD GEOSUD has been SPOT 6-7 because these satellites offer an excellent compromise between high spatial resolution, ability to cover large areas and agility for custom programming of new images. They are also very complementary of Pleiades, Sentinel 2 and Landsat 8 satellites whose images will also be made available by the THEIA Land Data Centre.

Finally, six members of THEIA Land Data Centre have decided to pool their resources in a consortium for a public contract of SPOT 6-7 telemetry with Airbus Defence and Space for a period of 5 years (2015-2019).

There are plans to expand the consortium to new partners and to acquire additional volumes of telemetry depending on users needs and the availability of extra financial resources.

These direct receiving capabilities through GEOSUD DRS will be expanded in the next coming years with additional types of images that will be chosen to complete the ones already accessible via THEIA.

User and uses

The dynamic of the number of GEOSUD members is shown in Figure 2 (temporal dynamic) and Figure 3 (geographic distribution). End of May 2015, 335 public bodies have joined the project, distributed between research (85), State departments and agencies at different levels from national to local (124), local authorities and territorial institutions (85) and 40 various actors (urban planning agencies, high schools, recognized associations of public utility ...). It can be outlined that these public actors can temporarily provide GEOSUD images to private sub-contractors, in the strict framework of non commercial activities. Under given conditions, small private companies may also access these resources for research and development purposes.

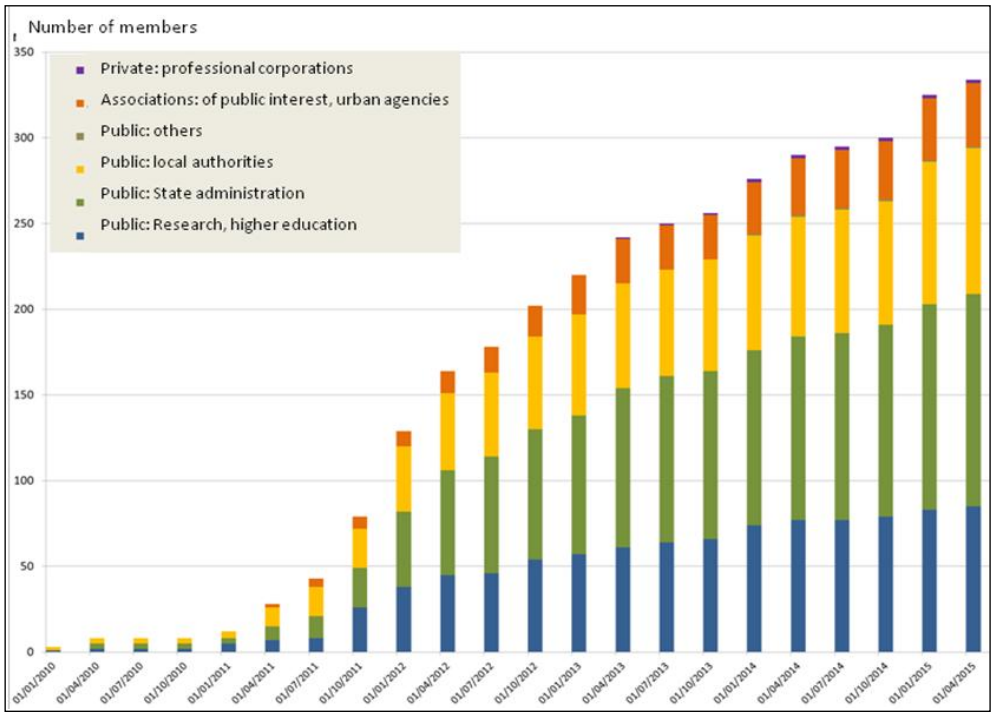

Figure 2: Dynamics of GEOSUD public members (335 in May 2015)

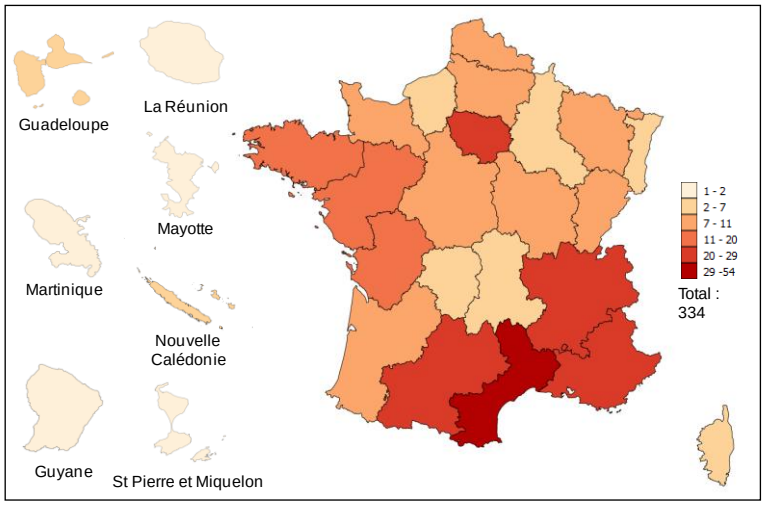

Figure 3: Geographical distribution of GEOSUD members at the department level (May 2015)

Since the project began in 2011, 830 requests of images have been processed (311 from the scientific community, 311 by the government, 117 by local authorities and 100 by other members) for a total of about 6700 images.

The Rapid Eye 2010 national coverage, after 12 months of broadcasting, was valued by a factor of 6.7. The SPOT 6-7 2014 national coverage has already been valued by a factor 9 after 5 months of broadcasting and 122 requests (more than 5 million sq km2 have been downloaded for a national territory of 550 000 sq km2).

Some examples of applications

The fields of application most frequently mentioned by the users are land-use dynamics, forests, agriculture and biodiversity.

A first example of application deals with the spatialized monitoring and quantification of nitrogen pollution pressures in western France to assess their impact on ground water quality. The November-December time period, with heavy rainfall and low vegetation cover is a critical period for nitrogen leaching. Installing interseasonal catch crops to ensure nitrogen fixation during the rainy autumn season is a major action contributing to the European Nitrogen Directive.
Satellite images are used since 2012 by several governmental institutions to quantify interseasonal crop density indicators, taking into account the dynamics of land use and agricultural practice. These data enable the public servants of the Ministry of Agriculture to better spot the areas with no catch crop cover and to priorise site inspections. Results contribute to assess the impact of sound agricultural practice on water quality, to orientate public policies and to develop stakeholders' awareness on the role and relevance of these practices.

Another example is the use of GEOSUD images for monitoring and controlling every year forest clearcutting. A whole package of products and services has already been developed and is currently used in an operational way by several regional services of the Ministry of Agriculture.

This package includes: images freely available; an algorithm for clearcutting detection implemented as a QGIS plugin (And in 2016 also in the form of an online processing web service); a user manual prepared by the experts of this application; a training kit (pedagogical material and 2 days training session); technical assistance to the users. An online forum for sharing experiences among users and experts will be added by mid-2016.

Economic model in the context of THEIA

The ambition of GEOSUD is to boost the development of remote sensing by contributing, within the broader framework of THEIA Land Data Centre, to create an ecosystem favorable to innovation. Besides access to the technological platform, this ecosystem is betting a virtuous articulation between public institutions, research teams (organized nationally in THEIA' Centres of Scientific Expertise), higher education as well as private players, to develop products and value-added services derived for all or part from remote sensing imagery.

New business models around this ecosystem under development at the national level must be implemented within the next two years. The ideal solution would be to obtain sufficient funding from major public institutions which benefit from this ecosystem to provide to the end users a free access to the products and services of the platform. Otherwise it will be necessary to invent other models capable to charge to end users a part of the operating costs of the THEIA / GEOSUD platform.

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GEOSUD Web site
http://www.geosud.teledetection.fr/