

A word from the Scientific Director

With the creation of the THEIA Land Data Centre, the partner entities hope to promote satellite data and to meet the national scientific community's needs in terms of data, products, methods and training for Earth observation from space.

THEIA's goal is to unite the national community in a concerted effort to address major scientific and societal issues: the environment, agriculture, global changes, biodiversity and risks, etc. Success in this endeavour will depend in large part on the contributions from all of the scientific and public players.

Many projects are already contributing to THEIA, such as Kalideos, Spot World Heritage and GEOSUD... In this first issue, GEOSUD is in the spotlight.

We wish THEIA every success!

Nicolas Baghdadi, IRSTEA

A word from the Technical Director:

From the start, THEIA's Management and Data Processing Centre (CGTD) was designed to be a federation of different data centres geographically distributed throughout France (Montpellier, Toulouse, Paris, etc.). One of the goals in setting up the CGTD was to establish connections between the stakeholders in these data centres, in order to unify them and to pool the services provided for users. Down the road, this setup will allow the CGTD to benefit from other national contributions than those identified today. The proposed model paves the way for THEIA's CGTD to join a wider network – at European level.

Marc Leroy, CNES

News / Headline

A Remote Sensing seminar (INRA Bordeaux, June 2013) was held within the framework of the prospective study requested by the Environment Science Director (INRA) with regard to the development of operational services for agriculture and forests (~80 participants).

Pleiades news

The two Pleiades satellites 1a and 1b, used for mapping purposes, were launched in December 2011 and December 2012. They are operated by Spot Image; CNES and IGN act as the relays with French scientists and institutional partners and ensure the interface with the operator. The Pleiades images (70 cm resolution) are complementary to higher-resolution aerial photographs, thanks to the agility of the satellites and the frequency of their passes. This will allow IGN's reference data to be updated more quickly, the fastest-changing urban areas to be redefined more frequently, and high-stake areas to be photographed on demand. It will therefore also be possible to develop new applications, such as urban density, coast line and flooding tracking. To learn more, attend the Pleiades Days being held in Toulouse from 1 to 3 April 2014. See, also, the Pleiades images access system:

(<http://professionnels.ign.fr/satellites-pleiades>)

Magali Stoll, IGN

GEOSUD reception platform

Based on a component of the Languedoc-Roussillon State-Region Project Contract by the same name, EQUIPEX GEOSUD is planning to set up a direct satellite reception platform serving French institutional communities that use space imagery. This public infrastructure, to be implemented in 2014 at the Remote Sensing Centre in Montpellier, is designed to produce regular coverage for all of mainland France and to offer agile reception capacity that can be activated on demand. It will serve scientific applications, and more broadly, players in territorial management, as well as enable reception of data acquired in the Maghreb through international scientific partnerships. It will provide users with high to very high-resolution images (SPOT 6-7, initially) and be supported by processing chains offering added-value products and services.

Jean-François Faure, IRD

News / Headline

The THEIA Users and Science Committee met for the first time on 19 September 2013 in Montpellier. The discussion focused in particular on the needs of the national scientific community and public players in terms of data from the Sentinel 1-2-3 satellites covering land surfaces. These needs were assessed at the national Copernicus workshop attended by the various geosphere communities, held at CNES on 18 November 2013.

THEIA interfaces with PEPS

PEPS (Sentinel Product Exploitation Platform) is a private cloud-based platform offering innovative services for accessing data from Sentinel missions that meet Big Data requirements. By redistributing Sentinel data to data centres such as THEIA and offering storage capacity and remote processing capabilities, PEPS is the link between the European infrastructure and services at the regional and local level.

Ensuring special access to Sentinel data in France is essential, both to help implement and monitor environmental policies, and to promote industrial development and company competitiveness by creating growth and jobs.

Hervé Jeanjean, CNES

ESA Ground Segments

THEIA is involved in the European Space Agency's Collaborative Ground Segments programme, which consists of initiatives by each Member State to supplement the basic Copernicus services offered by the European Union. THEIA's "Land Surface" Collaborative Ground Segment comprises:

- The provision of daily Sentinel data corrected for atmospheric effects, and cloudless monthly averages, over a surface area 10 times the size of France;
- Added-value products, such as land use maps, for example;
- Setting up user support services.

Selma Cherchali, CNES

Overview of the THEIA Centre

The THEIA Land Data Centre is a national inter-agency scientific and technical organisation dedicated to helping meet the needs of the national scientific community and public actors in terms of data, products, methods and training relating to land surface observation particularly from space. THEIA was created at the end of 2012 by nine French public institutions involved in Earth observation and environmental sciences: CEA (Atomic Energy Commission), CIRAD (Agricultural Research Centre for International Development), CNES (French Space Agency), IGN (National Geographic Institute), INRA (National Institute for Agricultural Research), CNRS (National Centre for Scientific Research), IRD (Institute of Research for Development), IRSTEA (National Research Institute of Science and Technology for Environment and Agriculture) and Météo France (national weather forecasting service).

The Centre's objectives

- To create a common system capable of producing added-value space data (on local to global scales) for "land surfaces" and providing services based on user needs,
- To promote the sharing of experience and pooling of methods,
- To showcase national achievements at European and international level.

Organisation

THEIA's programmatic, scientific and technical organisational structure comprises:

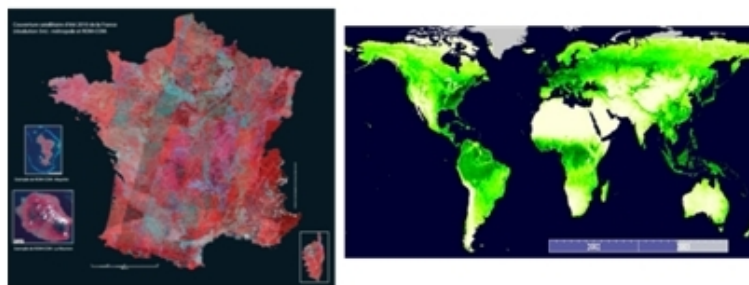
- A Steering Committee: Bernard Dreyfus (Chairman, IRD), Pierrick Givone (IRSTEA), Jean-François Soussana (INRA), Richard Bonneville (CNES), Philippe Campagne (IGN), Pierre Fabre (CIRAD), Nicolas Arnaud (CNRS), Valérie Moulin (CEA), Philippe Bougeault (Météo-France);
- A Management and Data Processing Centre (CGTD)
- spread between several players;
- An Executive Committee composed of Nicolas Baghdadi (Scientific Director, IRSTEA), Marc Leroy (CGTD Technical Director, CNES), Selma Cherchali (CNES), Jean-François Faure (IRD), Pierre Maurel (Equipex GEOSUD, IRSTEA), Magali Stoll (IGN);
- A network of Scientific Expertise Centres (CES) in the various regions of mainland France and the French overseas territories;
- A Users and Science Committee (CSU).

The members of the CSU were chosen in accordance with various criteria: geographic representation, thematic representation, institutional representation, representation with expertise on various product ranges, and participation in national research programmes. The members of the CSU are as follows:

1. Nicolas Baghdadi, (Montpellier) : Irstea, THEIA
2. Marc Leroy (Toulouse) : CNES, THEIA
3. Agnès Bégué (Montpellier) : Cirad, Agriculture
4. Yves Brunet (Bordeaux) : INRA, Agriculture
5. Dominique Courault (Avignon) : INRA, Agriculture
6. Gérard Dedieu (Toulouse) : CNES, Agriculture
7. Agnès Ducharme (Paris) : INSU, Hydrology
8. Laurent Durieux (Montpellier) : IRD, France's scientific needs outside the mainland territory
9. Olivier Hagolle (Toulouse) : CNES, , Muscate + PI Take5 line manager
10. Laurence Hubert-Moy (Rennes) : Université de Rennes, Biodiversity
11. Clément Mallet (Paris) : IGN, Forest/Urban
12. Nadège Martiny (Dijon) : Université de Bourgogne, Climatology
13. Anne Mayere (Toulouse) : Université P. Sabatier, SHS
14. Philippe Peylin (Paris) : CEA, Climate
15. Jean-Louis Roujean (Toulouse) : Météo France, Climate
16. Vincent Thierion (Grenoble) : Irstea, Snow
17. Jean-Pierre Wigneron (Bordeaux) : INRA, Ground/Agriculture/Forest
18. Hervé Yesou (Strasbourg) : ENSPS (National School of Higher Education in Physics, Strasbourg), Territories/Risks/Hydrology
19. Vincent Thierion (Grenoble) : Irstea, Biodiversity

Resources and Products

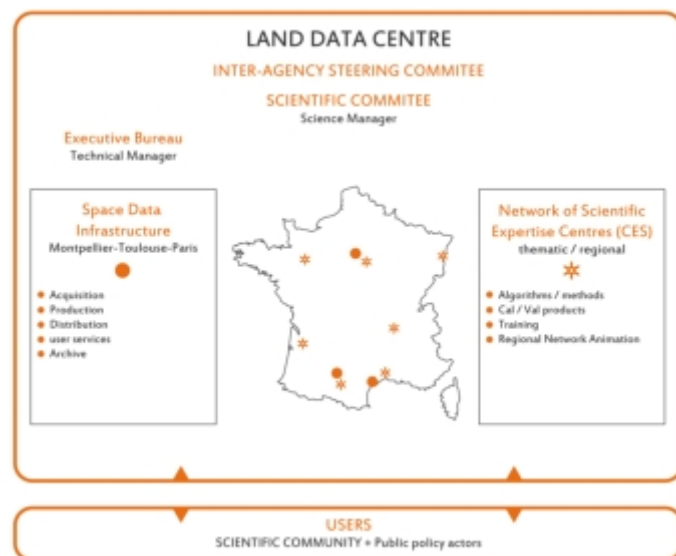
The THEIA Centre's resources are those of its partners and projects, such as GEOSUD, Kalideos, POSTEL, SPOT World Heritage, Institutional Pleiades Programme, etc. The products provided by THEIA are annual coverage of the national territory in satellite images, surface reflectance time series, biophysical variables (biomass, water levels, surface humidity), data pre-processing and viewing tools, processing methods and algorithms, and methodological guides for thematic applications.



Challenges and Prospects

The THEIA infrastructure will help improve the scientific community's knowledge and support the development of research-derived applications useful to public policies, in order to promote sustainable management of the territories in every aspect – anthropic, ecological and agricultural. This involves many challenges:

- Playing a key role in addressing the major scientific and societal issues: environment, agriculture, climate hazards / global change, biodiversity, fires, pollution/contamination, etc.
- Providing quality-controlled multi-date and multi-resolution space data that cover large territories over long periods.
- Offering a consultation platform in order to develop national strategies collaboratively (Sentinel, Pleiades, SPOT, etc.).
- Taking part in European and international initiatives: Copernicus, Horizon 2020, GEO-GLAM, JECAM, etc.



EQUIPEX GEOSUD project

Goals and organisation

Funded through the Investment Programme for the Future (allocation of €11.5 M for the 2011-2019 period) and the Languedoc-Roussillon State-Region Project Contract (allocation of €7.2 M for the 2007-2013 period), the EQUIPEX GEOSUD project is aimed at developing a satellite data infrastructure providing French public players with free access to annually updated satellite images of the national territory (mainland France, overseas regions and communities), and to various services such as access to data and software, image searches and viewing, calculation capabilities, method development and transfer, training, user networking, etc. EQUIPEX GEOSUD is made up of a group of 14 institutional partners, representing research, higher education, public management of the environment and territories, as well as private players from the ICT and Environment sector: AgroParisTech, CETE Sud-Ouest, CINES, CIRAD, CNRS, IGN, IRD, IRSTEA, Université de Montpellier, Université Antilles-Guyane and Université de la Réunion, as well as AFIGEO and Geomatys (private players and associations). Major players in the field such as CNES, the Ministry of Agriculture, and the Ministry of Ecology and Sustainable Development, etc. are also associated with the project. EQUIPEX GEOSUD constitutes one of the major components of the THEIA Data Centre: involvement in the Management and Data Processing Centre (CGTD) and in the Executive Committee and Scientific Expertise Centre (CES) made up of partners from the Montpellier centre.

GEOSUD: a system in operation since 2011

The procedure for accessing the system is simple and structured into two main steps:

- Opening a GEOSUD account (step 1): the “public player” entity signs a Membership Agreement and License Compliance Commitment and designates a correspondent within its structure. Private players, service providers or research partners can have access to images within the scope of joint projects with public players: in this case, a contractual service provider agreement or research partnership commitment must be signed between the two players.
- “Conventional” satellite image requests (step 2) are processed on the web interface: The member-user selects the geographic area and desired products; on receipt of their signed and scanned request, via email, the images are made available via an FTP site.

Additional services are provided for members:

- “Special image” requests can be submitted via the GEOSUD system: “on request” acquisitions (VHRS Pleiades imagery, Radar imagery, southern-hemisphere imagery, etc.); shared-purchase acquisitions, etc. A form is available on the GEOSUD website.
- Access to proprietary software can be requested by sending a form that is available on the website. ENVI licences are currently available (2 ENVI, 2ENVI+IDL, 2 “Feature Extraction” module) and made available to members free of charge, for periods of 1 to 4 weeks. The provision of e-cognition licences is currently being considered. (<http://www.geosud.teledetection.fr/>)

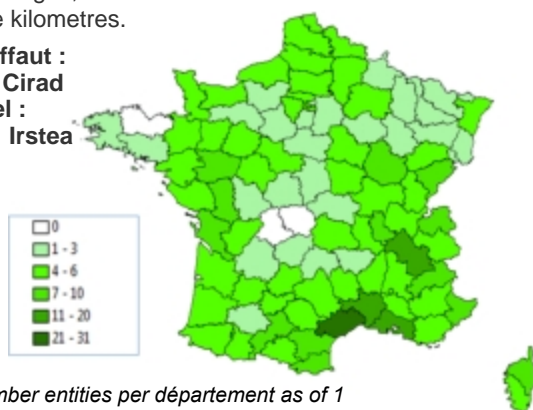
Products and users

As of 1 October 2013, 255 entities had joined the GEOSUD system, including 65 research and higher education structures, some one hundred government services (DDT(M), DRAAF, DREAL, and other public establishments), some sixty local authorities (General or Regional Councils, mixed trade unions, public establishments, etc.), some thirty public or legally-recognised public interest organisations, and urban development agencies. Of the 255 member entities, twelve are public players from overseas regions and communities (ROM-COM).

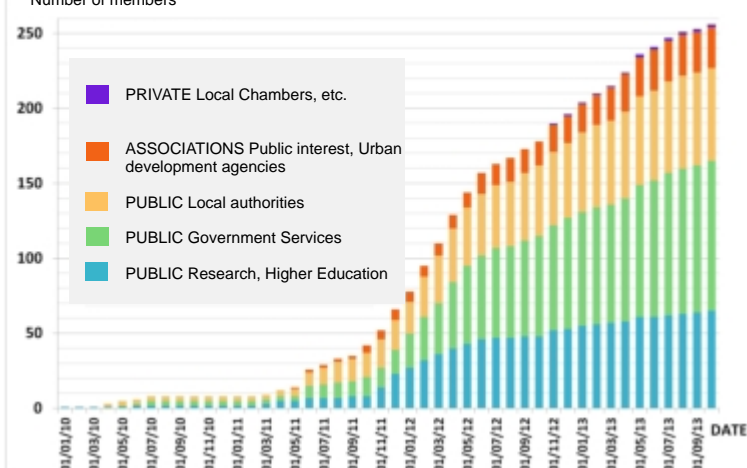
The geographic distribution of the public entities involved in GEOSUD ensures good coverage of the national territory. Another aim of the GEOSUD project is to create a network interconnecting the scientific community and the community of management players, in the aim of enhancing imagery.

As of 31 October 2013, the system had received more than 440 requests for images, for a total surface area of more than 11.3 million square kilometres.

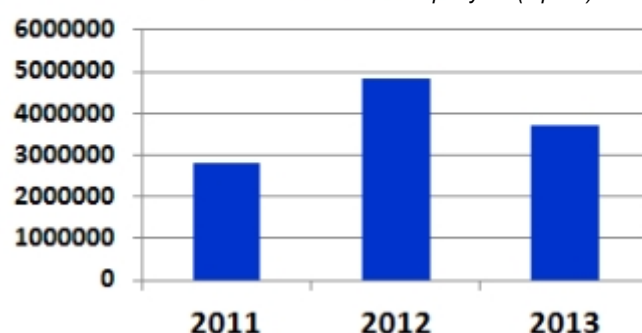
Isabelle Chaffaut :
UMR TETIS, Cirad
Pierre Maurel :
UMR TETIS, Irstea



Change in number of GEOSUD members per entity type – October 2013
Number of members



Total surface area downloaded per year (sq.km.)



EQUIPEX GEOSUD project (cont'd)

Lessons learned from the Deux-Sèvres DDT

Pursuant to the "Nitrates Directive" (1991), the French National Programme of Actions in Vulnerable Areas (updated in 2013) imposes measures to combat nitrate pollution in vulnerable territories. Thus, the Deux-Sèvres Departmental Territories Directorate (DDT 79) would like to ensure that the "Intermediate Nitrate-Trapping Crops" (CIPAN) are effectively implemented during the autumn period; these crops trap a portion of the residual nitrogen in the ground and prevent it from passing into the rivers and ground water.

DDT 79 thus has to ensure regulatory monitoring of 450,000 hectares of crops within the 6000 sq.km of the Deux-Sèvres département. In order to optimise field monitoring through targeted inspections only on patches of land presenting vegetation anomalies, DDT 79 has joined forces with UMR TETIS, within the framework of GEOSUD, to develop a satellite imagery-based method of evaluating the density of vegetation in farmland patches and the associated risk of nitrate leaching.

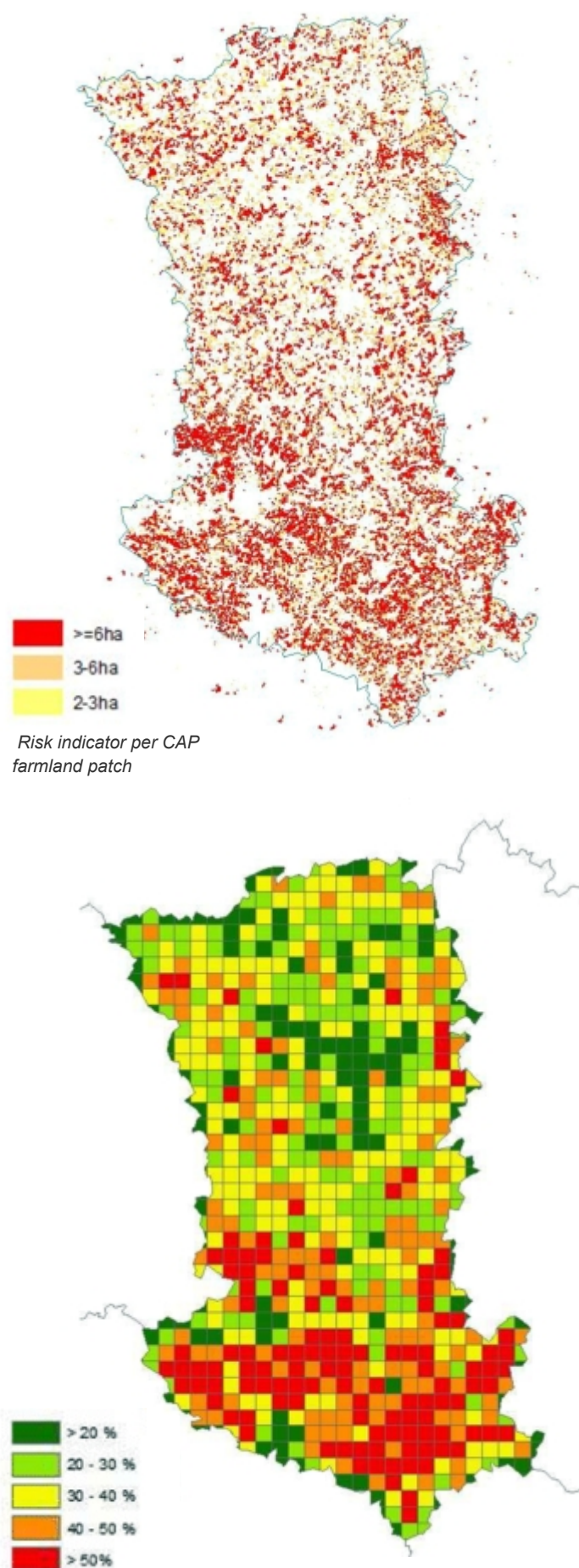
The method selected as the most accurate and operational combines the mapping of surface conditions with quantification of a leaching risk indicator for each farmland patch. The "risk" formalism consists in cross-analysing the hazard and vulnerability values: the hazard value represents the potential leaching pressure, and the vulnerability is the extent of the impact if the hazard occurs. The study is based on two types of data: high-quality satellite images (multispectral at 20 m, cloudiness below 10%) acquired from mid-October to mid-November, and the graphic parcel registry (RPG) with outlines of the farmland patches and crop information from the past year.

The surface conditions are mapped using supervised classification of the image based on a "ground-truth image" sample produced using photo-interpretation by the DDT teams, drawing on the expertise of players in the field with regard to crop-growing practices. By superimposing the RPG vector layer onto the image, on the screen, the expert identifies a sample of homogeneous areas representing the four classes of surface condition (bare ground; dry vegetation; active non-covering vegetation; active covering vegetation). One half of the ground truth image serves as a learning sample for the supervised classification; the other half is used as a test sample to determine the quality of the result. After classification of each farmland patch, the surface area of each surface condition class is calculated in order to determine the class breakdown and dominant class.

For the region under study, a CIPAN anomaly probability table is established based on the expertise and field inspections from past years: this table indicates the probability of anomaly occurring in the farmland patch according to its surface condition and dominant crop. Thus, the anomaly probability is determined for each farmland patch, which, cross-analysed with the intensity (at-risk areas) and vulnerability (proximity to vulnerable masses of water), provides a risk indicator. The intensity of the risk for each farmland patch is mapped (graded colour scale) and an indicator threshold is applied to identify the high-risk areas for which priority field testing is required. This mapping process can also be done on a regional scale to identify the territories most vulnerable to the risk of autumn nitrate leaching.

The method was developed and applied with satisfactory results during the autumn of 2012, and was repeated and validated in 2013 in Deux-Sèvres and Charente.

Nicolas Cornuault and Franck Groneau,
Departmental Territories Directorate (DDT79)



EQUIPEX GEOSUD project (cont'd)

Lessons learned from the MAAF

The Sub-Directorate for Forests and Woodlands (SDFB), in association with the decentralised departments of the Ministry of Agriculture, Agri-Food and Forest Affairs (MAAF), is in charge of ensuring sustainable forest management by implementing a number of governing powers. In particular, for certain types of cutting operations in forests without management documents, administrative authorisation is required. Moreover, for clearcutting above a certain threshold (defined for each French département), the owners are required to ensure renewal of the forest stands.

Thanks to new possibilities with the free annual coverage provided through GEOSUD, the SDFB and DRAAFs of Rhône-Alpes and Burgundy called on UMR TETIS to help them develop and implement a method based on the detection of changes using satellite images acquired during the summer, to assist with the monitoring and inspection of clearcutting operations. The needs expressed by the MAAF services were to detect clearcuts between two consecutive years, over a minimum surface area of 1 hectare with planimetric accuracy of 5 to 10 m and omission (undetected cuts) and commission (erroneous detection) rates below 10% of the surface area.

Tests were also conducted on two forestry ecoregions (in the Morvan-Autunois and the Massif Central-Beaujolais) with high-resolution optical satellite imagery acquired between 2005 and 2012. Annual mosaics, normalised from a radiometric point of view, were created, after geometric correction of the images to reconstruct them within a known reference base, and then converting data into ToA (Top of Atmosphere) reflectance to correct the date and sighting angle effects. An NDVI (Normalized Difference Vegetation Index) was then calculated on these mosaics. By highlighting the spectral signature characteristic of active vegetation, the vegetation index allows the density of vegetation cover to be defined. Significant changes can be detected by observing differences in the NDVIs recorded between different years, such as a patch going from wooded cover one year to bare ground or little vegetation the following year. These results were further processed, through NDVI deviation thresholding, in order to identify only "recent" cuts. Finally, in post-processing, the detected surface areas were "smoothed" to highlight only areas larger than 1 hectare. Ultimately, the extraction quality of clearcuts was evaluated using a confusion matrix generated during the classification phase.





The method of detecting clearcuts by comparing differences in NDVIs between two diachronic images has been shown to be operational and applicable to various sets of satellite data, for "annual" cut monitoring (recent cuts). However, it does have certain limits, first with regard to the image acquisition constraints (dates not necessarily homogeneous), and second with regard to the relatively short time the ground remains "bare", since forest regeneration is implemented quickly after a cut, making it difficult to detect older cuts.

2005 image
Authorisations approved or not



2007 image
Evaluation of clearcuts



	Authorised and deforested
	Not authorised and not deforested
	Not authorised and deforested
	Authorised and not deforested

The Management and Data Processing Centre (CGTD)

The THEIA Space Data Infrastructure

Based on the notion of creating a unified database system, the THEIA data infrastructure architecture offers access to images held by different data centres that are geographically spread out. Each data centre is autonomous and responsible for the pre-processing, storage, archiving and distribution of its own data. The images distributed can range from raw (unrectified) products to orthorectified images.

After their pre-processing, the data are archived and prepared for publication. This last step involves annotation operations to associate each image with a geographic location, and its thematic content. This way data can be searched through a user-oriented approach. This annotation is possible thanks to the definition of a common vocabulary which is formalised and stored in a thesaurus.

At the level of the THEIA federation, interoperability between partners is ensured thanks to the definition and use of a metadata model and the common vocabulary.

These components, referred to as shared services are: the communication web portal, the user identification server, the metacatalogue or unified catalogue, and the search tool. The diagram shows the connections and interactions between these different components and the data centres.

The web portal is the special access point for target users. The identification server (IDP) is the key component of the THEIA infrastructure authentication system. It stores the identifiers of all THEIA users, enabling a "Single Sign On" authentication service. Once identified, the user can seamlessly access any source of data for which they have authorisation. However, access permits are managed and stored by each data centre. This way, their governance of the data is maintained.

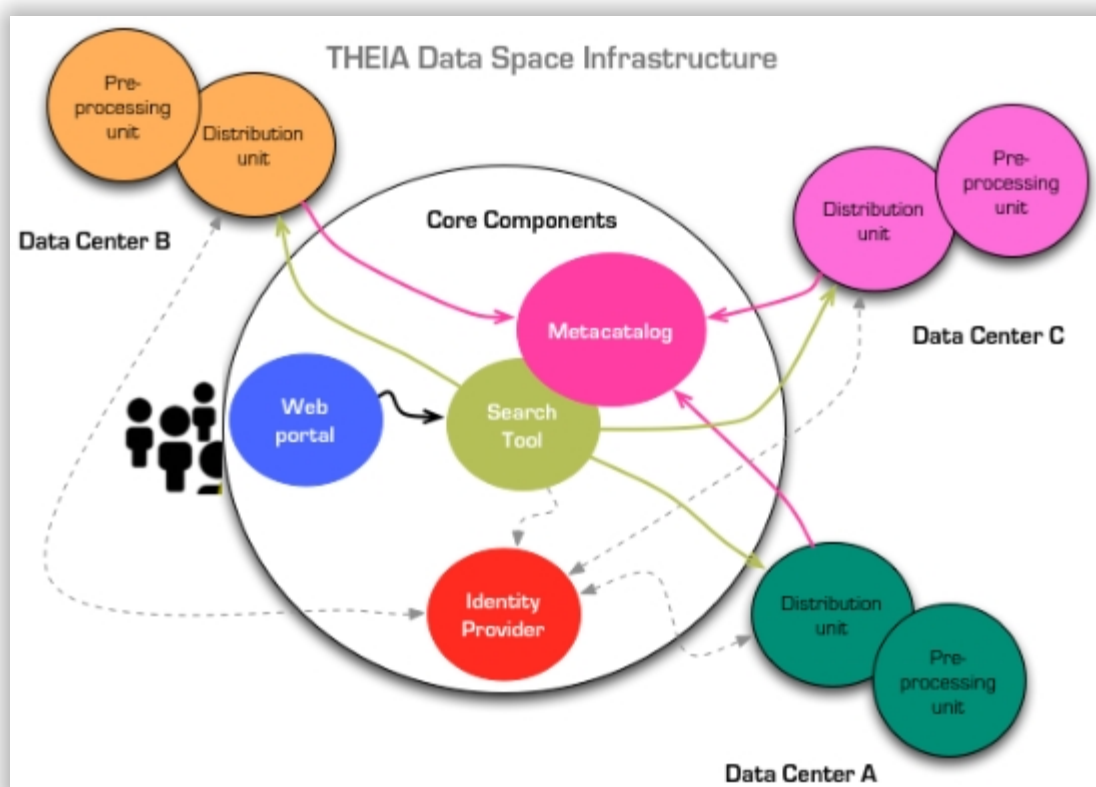
The metacatalogue (or unified catalogue) enables the search service for all products delivered by the infrastructure. This service complies with the "Open Search" specification for Earth

observation, used by most of the main infrastructures in the field. To ensure interoperability, metadata can also be distributed in ISO 19115 format, as per the requirements of the European Directive INSPIRE. The metacatalogue compiles the various data centres' catalogues in order to provide an aggregate index of all of the data. The metadata are harmonised using conversion operations based on the metadata model and the common vocabulary in the THEIA thesaurus.

The search tool is a mapping application which provides data search, viewing and downloading functions. The user interface is 100% web-based. The search function operates using either a mapping query or a faceted semantic search. The THEIA infrastructure currently includes two data centres: the CNES data centre in Toulouse and the GEOSUD data centre in Montpellier, which in turn is connected to the Geoportail data centre in Paris. These two data centres are connected via a super high-speed RENATER network.

A new data centre can be created, on the condition that it publishes its data and metadata using standardised web services. To join the shared services of the THEIA infrastructure, the new member will refer to the THEIA technical specifications which set out the interoperability framework in terms of authentication and publication of metadata and data.

Jean-Christophe Desconnets, IRD
J  rome Gasperi, CNES



The Management and Data Processing Centre (cont'd)

Geoportail

Géoportail® hosts the IGN's reference data, as well as the data of various partners. This infrastructure offers data services complying with open standards. The main services are downloading, distribution of image streams and geocoding. Special care was taken in setting up the services provided for by the INSPIRE directive. The websites associated with Géoportail® allow access to and viewing of most of the available data flows.

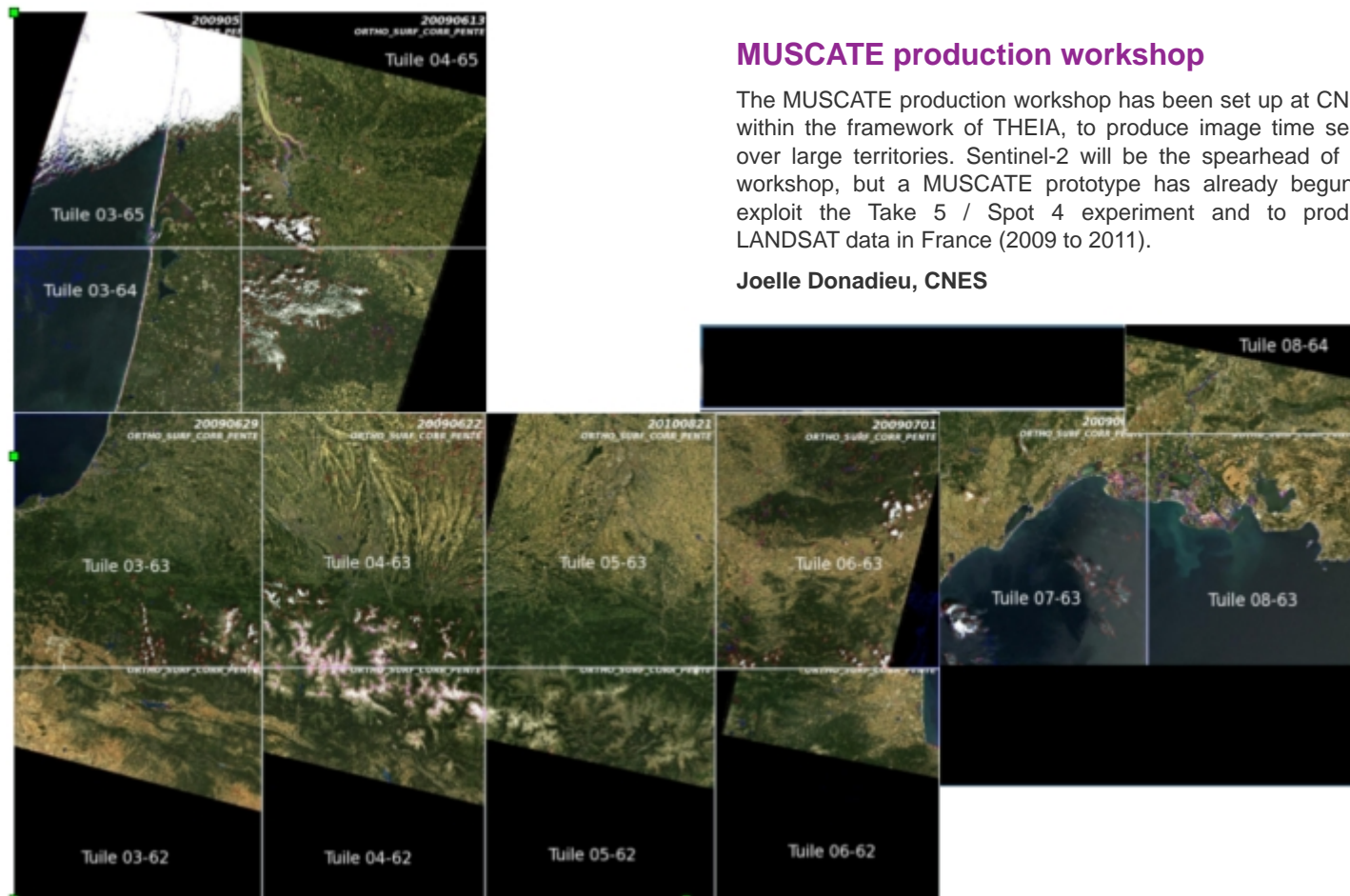
IGN offers free access to these services and reference baselines, for research and education activities and public service missions; one condition is that the activities conducted must not be industrial or commercial in nature. The eligible data and the practical information for accessing these data are set out

on the IGN website for professionals:

<http://professionnels.ign.fr>.

Providing this special access is part of the THEIA centre's mission: to facilitate access to data useful to scientists. IGN, a founding partner in the centre, is working to expand the range of products and services offered to this community of users. For example, images from Earth observation satellites are beginning to be distributed, and image processing services are being implemented, with the support of the GEOSUD equipment of excellence programme.

Eric Breton, IGN



MUSCATE production workshop

The MUSCATE production workshop has been set up at CNES, within the framework of THEIA, to produce image time series over large territories. Sentinel-2 will be the spearhead of this workshop, but a MUSCATE prototype has already begun to exploit the Take 5 / Spot 4 experiment and to produce LANDSAT data in France (2009 to 2011).

Joelle Donadieu, CNES

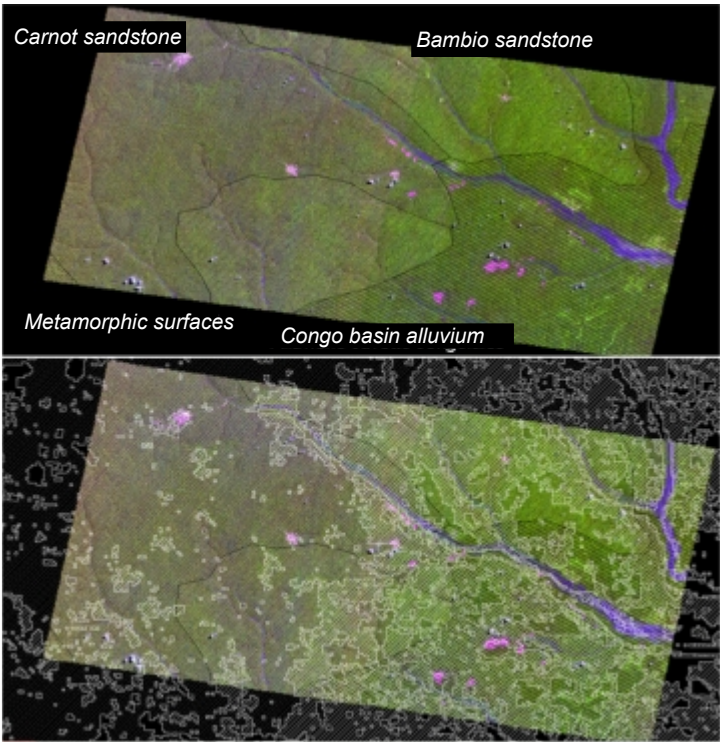
Example of production of LANDSAT data by a prototype of MUSCATE developed and operated by CESBIO over southern France

User Feedback and Expertise Centres

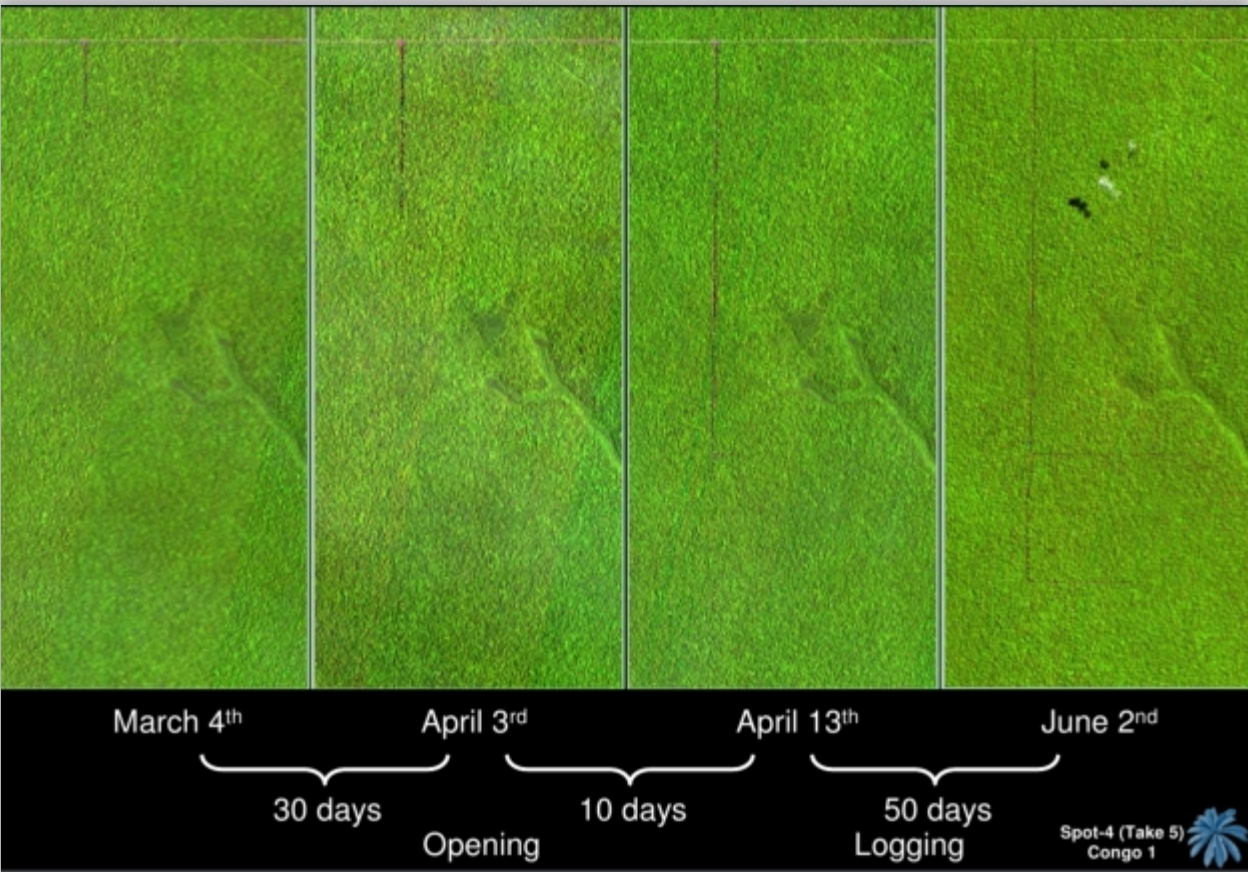
User Feedback: SPOT 4 Take 5 data

Valéry Gond, a researcher at CIRAD, studies tropical forests in northern Congo and uses image time series to separate evergreen-type forests from deciduous-type forests. Based on analysis of ten years of MODIS vegetation index at 500m resolution, we reconstructed synthetic annual temporal profiles reflecting the phenology of the forest formations under study, allowing us to differentiate between these two types of forest. These variations in foliar phenology seem to be partly linked to the geology of the land. The site chosen for the SPOT4 (Take-5) experiment is located at the transition between these two areas. Six very clear images were acquired between February and June 2013, which is exceptional in this very cloudy area. Compared to MODIS-based analysis, these data will enable much more precise analysis of the temporal profiles of photosynthetic activity, in order to better understand how these different forests operate. This set of high-temporal-frequency data also allows us to evaluate possible ways of monitoring human activity in tropical rain forests. The images reveal the opening of the canopy by a logging company, which illustrates how Sentinel-2 can be used to identify and assess human impact in the most remote places on Earth.

Valéry Gond, Cirad



Evergreen forests (<30% deciduous) Semi forests (<40% deciduous)



Left to right, SPOT4 (Take5) images from 4 March, 3 and 13 April and 2 June. Starting from the forest track at the top of the extract, a forest track opens toward the south on 4 March and continues southward until 13 April. At the date, the track turns eastward to set up logging operations in the forest stands. On 2 June, the infrastructures are complete and logging begins.

User Feedback: Kalideos data

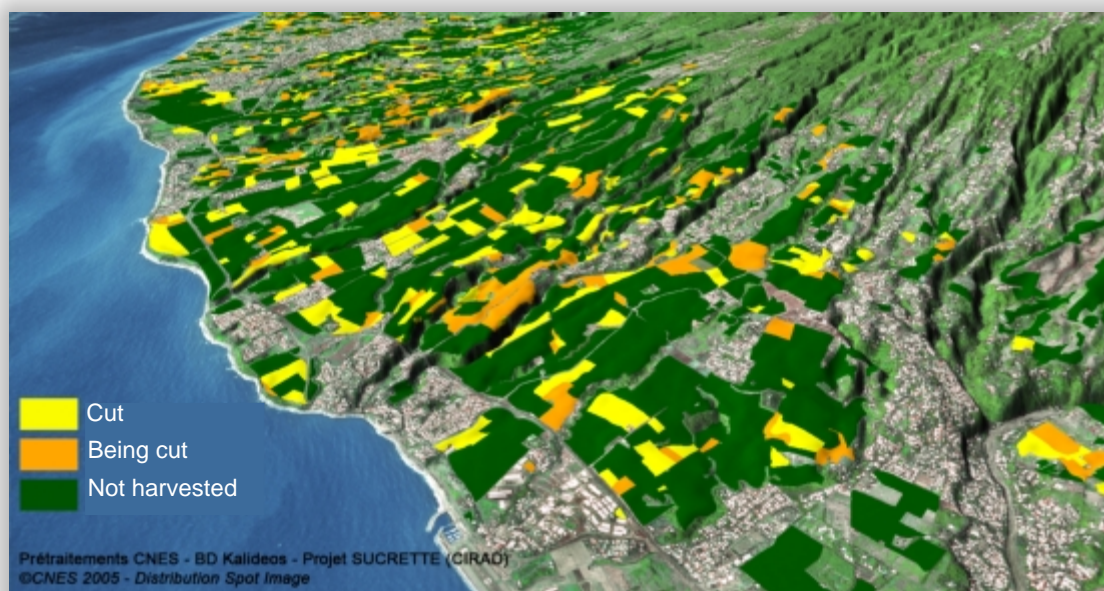
For the past ten years, CIRAD has been developing remote sensing research applied to aiding decision-making for sugar cane production. Initiated in Reunion and Guadeloupe, in collaboration with CNES, SPOT Image, and sugar cane growers and manufacturers, this research led to the development of prototypes of remote sensing products which help the sugar cane industry optimise production.

For reliability and reproducibility purposes, and out of the need to have comparable images, this methodological research was done using inter-calibrated Top of Canopy (ToC) products delivered by the CNES Kalideos programme. Relieved of the long and fastidious post-processing tasks, the researchers were able to concentrate their work on translating the radiometric information contained in the SPOT 4 and 5 images into agronomic indicators. Thus, the Kalideos images were used to

develop mapping products (different growth rates, yield forecasting, progress in sugar cane harvest) providing information that would not otherwise be available to decision-makers in an agricultural context in which production is distributed between several thousand planters.

After being distributed to potential users for several years, these products are now being made available in production versions, which can be distributed quickly after acquisition, at a low cost, as they are obtained using easy-to-produce Top of Atmosphere images. Their reliability is validated through comparison with the reference products obtained from the Kalideos Top of Canopy images.

Pierre Todoroff and Agnès Bégué, Cirad



INRA Scientific Expertise Centre

The INRA remote sensing system is aimed at developing applications for agriculture, forests and landscape and territory management. The researchers concerned are mainly from the Environment and Agronomics (EA) and Ecology of Forests, Prairies and Aquatic Environments (EFPA) Departments, with a coordinated network of specialists and remote sensors. The main capabilities in terms of scientific expertise in remote sensing are located at 4 centres, with some overlap in the thematic scope of their activities: Avignon (agriculture, landscape, global), Bordeaux (forest, landscape, global), Montpellier (ground) and Toulouse (agroecology). Research involving specific remote sensing developments is also being done at the centres in Nancy (forest carbon & water cycle, forest health), Orleans (ground classification), Ile-de-France and Rennes, etc. Within the framework of setting up the THEIA centre and in consultation with the other research organisations, a prospective study requested by the Environment Science Director with regard to the development of operational services for agriculture and forests is underway.

Nathalie Bréda and Jean Pierre Wigneron, INRA

CESBIO Scientific Expertise Centre

This centre is involved in several tasks for THEIA:

- preparing processing methods and processing line prototypes. One of these prototypes is used to produce surface reflectance with SPOT4 (Take5) and soon with LANDSAT 8 and Sentinel-2. For this same project, a monthly surface reflectance synthesis product is currently being developed;
- validating products provided by THEIA, such as cloud masks, atmospheric corrections, surface reflectances and biophysical variables;
- defining methods for using these data, implementing them in pilot projects, providing the related feedback, making applications available in open source libraries (OTB) and possibly developing operational lines, for the production of land use maps, for example.

CESBIO is also involved in the SMOS project (algorithm search, prototyping, validation, valuation).

Olivier Hagolle and Yann Kerr, CESBIO

Estimation of yields and water required for crops based on high-resolution spectral satellite images

The aim of the thesis that Martin Claverie defended at CESBIO in January 2012 was to show the utility of high spatial and temporal resolution satellite data in monitoring agro-ecosystems, particularly summer crops. The subject of this work was chosen in preparation for the Sentinel-2 programme, the goal of which is to provide images of the entire planet with 10 m spatial resolution and repeatability of 5 days. The research done for this thesis showed the importance of having images with both high spatial and high temporal resolution (FORMOSAT). Regular temporal monitoring (at least 2 images per month) enables more accurate estimation of the biophysical variables characteristic of crops, such as the GAI (Green Area Index) or the FAPAR (Fraction of Absorbed Photosynthetically Active Radiation). This knowledge is necessary in order to model crop behaviour more accurately. Knowing the temporal dynamic of these variables made it possible to coordinate and spatially define a simple agrometeorology model developed at CESBIO (SAFY). This model serves to estimate the crop yields based on meteorological data and the GAI estimated using remote sensing. The yields estimated with combined use of the remote sensing data and the agrometeorology model were compared with the AGRESTE statistics (ministerial agricultural statistics) for the Haute-Garonne. The results led to very good estimates (Figure 1).

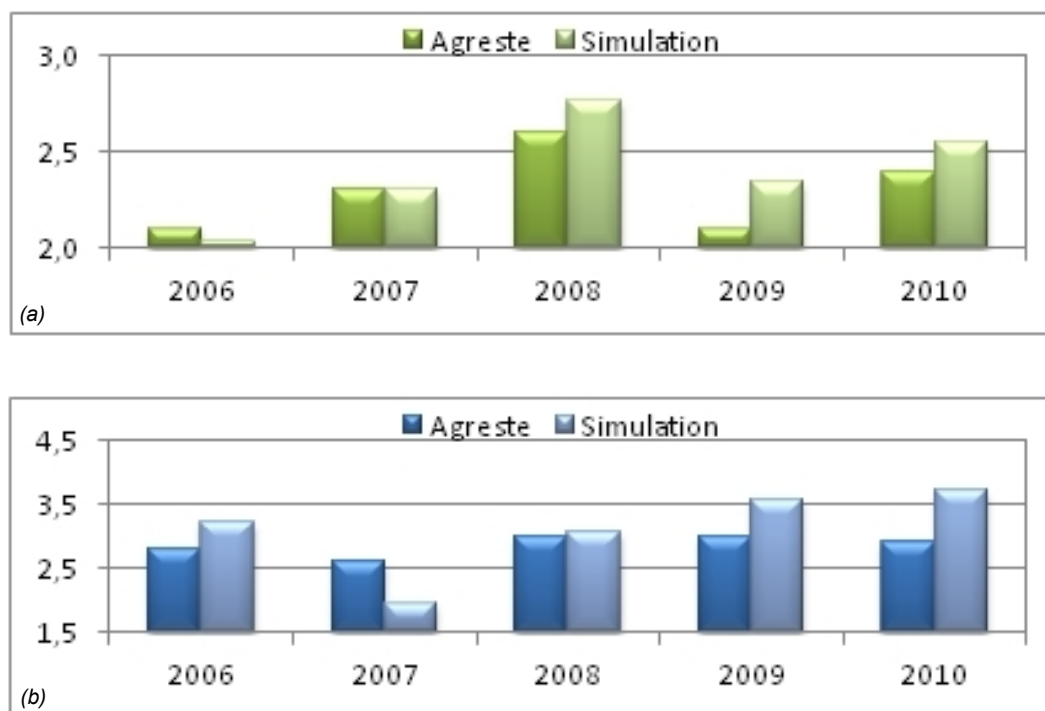
This work is now being continued within the framework of Marjorie Battude's thesis (MAISEO project, 2013-2017). The partners associated with this project are the Compagnie d'Aménagement des Coteaux de Gascogne (CACG, Gascony Hillside Development Company), the water management entity for the drainage basins of South-West France, MétéoFrance and CESBIO. One of the aims of this project is to provide innovative and operational methods of estimating crop water requirements, in near real-time, on the scale of a catchment area – i.e., for this study, the Neste River Basin.

The project will involve providing the water management entity with tools enabling it to anticipate and better manage the demand for irrigation water for the dominant crop in this catchment area, which is corn. The agrometeorological model will be adapted using the remote sensing data acquired in 2013, during the SPOT4-Take5 campaign.

This campaign provided a single set of satellite data available for all of South-West France (including the Neste River catchment area), with monitoring once or twice a month throughout the irrigation period. A diagnosis of ground use and the irrigated surface areas within the catchment area will be done at the beginning of the irrigation period, and the inclusion of these data will be evaluated for the crop water requirement forecast and near real-time irrigation water management.

<http://www.cesbio.ups-tlse.fr/multitemp/?p=4>

Gérard Dedieu and Valérie Demarez CESBIO



Comparison of yields (t/ha) simulated by the agrometeorological model adapted to high temporal resolution satellite data and the statistics provided by AGRESTE (2006 to 2010). (a) for sunflowers, (b) for soy.

Scientific Issue

Albedo estimation

Albedo is an Essential Climate Variable (ECV) in the Earth's energy budget, varying between 0 and 1. It quantifies the fraction of solar radiation (between 0.3 μm and 3 μm) that is reflected back by the Earth's surface, and the fraction absorbed by the Earth, with differing values depending on the ground condition (i.e., bare, vegetation cover, snow).

Climatic factors (rain, wind, temperature, etc.) have a significant influence. The albedo of bare ground depends on the surface humidity, which can reduce the albedo by half compared to dry ground. The effects of humidity vary by a matter of hours or days, and can be observed from space. Albedo on melting snow changes quickly, and the variations are even greater, i.e., the initial albedo for fresh snow is around 0.85 in the visible, whereas on wet, dark ground it can be as low as 0.1. Albedo for vegetation, on the other hand, varies from one season to another. Its range includes value intervals in the visible as well as in the near infrared, which are used to establish a Normalized Difference Vegetation Index (NDVI).

The physical measurement includes calibration, atmospheric "decontamination" and angular correction processing, which enable albedo measurement within around 3% accuracy, i.e. about ten W/m^2 in terms of radiative forcing. The areas of uncertainty concern the presence of residual clouds and aerosols. Moreover, in relief areas, topography also needs to be taken into account. Conventionally, albedo values are generated for the solar noon, as the daily average, and in the visible and near- and mid-infrared spectrums.

For Europe, the recent flagship programmes have used polar-orbit observation systems (PARASOL, SPOT/VEGETATION and ENVISAT/MERIS) or geostationary-orbit observation systems (MSG/SEVIRI). These systems offer the high revisit capabilities required to generate "albedo products". However, the pixel resolutions are moderate, varying between 300 m and 6 km. MERIS is the only sensor that offers high-resolution multispectral imagery: it is a precursor for the Sentinel 3 programme, which will include albedo measurement for the Copernicus ImagineS project.

The HYDRA (HyMeX Data Transformer) initiative undertaken by THEIA's CNES CGTD provides a service for the HyMeX (Hydrological cycle in Mediterranean Experiment) community, by preparing the Land-SAF MSG/SEVIRI albedo products, projected onto the HyMeX target area at 0.05° resolution.

<http://www.landsaf.meteo.pt>

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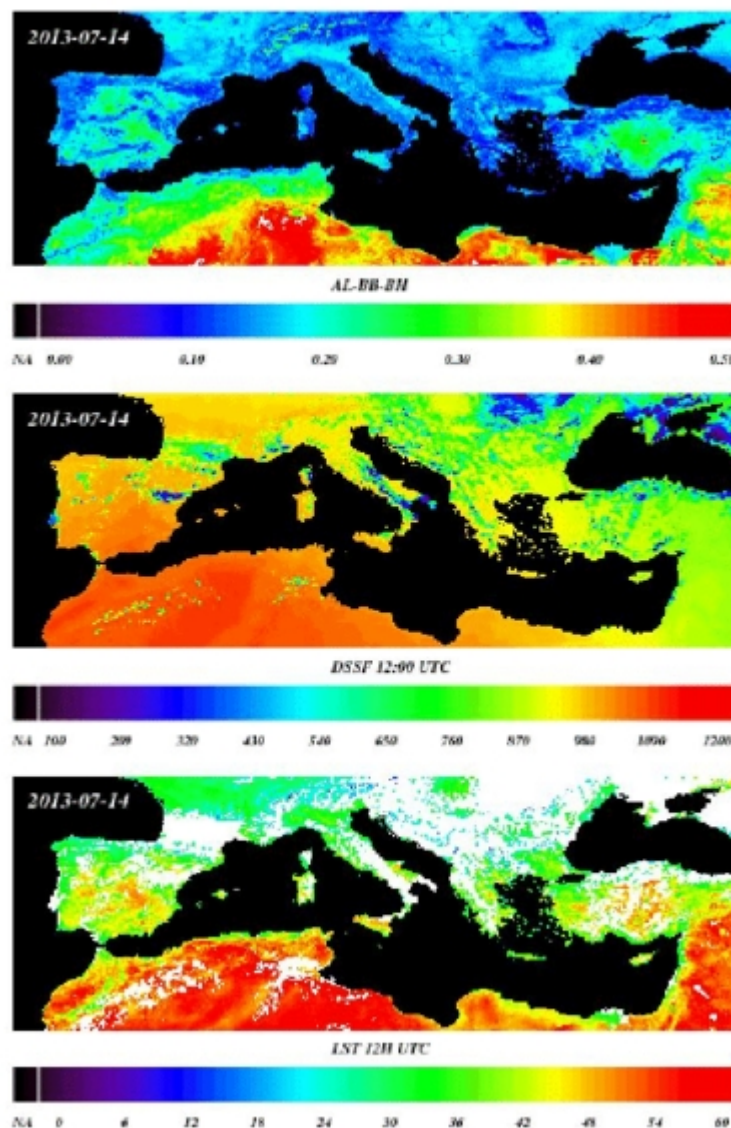


Illustration of the daily solar albedo for 14 July 2013, estimated according to MSG/SEVIRI observations.