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## A word from the Scientific and Technical Directors

On 16 and 17 September 2014, the first seminar of the Theia Scientific Expertise Centres (centres d'expertise scientifique - CES) took place at CESBIO in Toulouse.

This seminar, which brought together around forty participants from many organisations marks the beginning of the Theia CES's. This seminar was an opportunity to take stock of the major products and services which are based on space remote sensing and evaluate the relevance of these products and services compared to what exists or what is being planned in other programmes, such as Copernicus.

The organisers of the CES's also showed their desire to play a major role in coordinating users (both scientific and public actors) at a regional level, in addition to participating in the community training efforts.

The CES's are described in detail in this edition.



Nicolas Baghdadi



Marc Leroy

## NEWS

### Theia-Geosud Seminar

The Theia Land Data Centre and Equipex Geosud are organising their first joint seminar on the theme «Space Data for the scientific community and public stakeholders», on 1 and 2 June 2015 in Montpellier.

The goal of this seminar is to present the usage potential of satellite imagery through the proposition of products and services coming from the Theia and Geosud Space Data Infrastructure. Thematic products currently in development in the Theia scientific expertise centres will also be presented. Feedback, round tables, and thematic workshops will take place over two days.

Nicolas Baghdadi - Pierre Maurel  
(Tetis / Irstea)



### Complete Spot 6/7 satellite coverage of mainland France achieved in 2014

Thanks to the Spot 6/7 satellites and the joint efforts of Airbus and IGN, a great challenge was achieved: «image» France in a year to within 1.5m resolution. This annual coverage presents possibilities for new uses, which are strongly awaited by the users, especially regionally.

CNES, IGN and Irstea, through the Equipex Geosud project, came together to share the purchase of these images from Airbus in order to make them available to all institutional users via add-on licences.

To guarantee maximum use, the acquisitions were specified by IGN, programmed by Airbus and jointly monitored to validate compliant images as soon as possible. To ensure completeness,

the conditions of acquisition were slightly loosened at the end, because the Spot 7 satellite arrived at the end of the summer.

IGN put in place a process allowing access to the coverage as soon as possible, in order to take advantage of the up-to-date information: steady orthoimagery production, creation of regional mosaics, publications on the Geoportal.

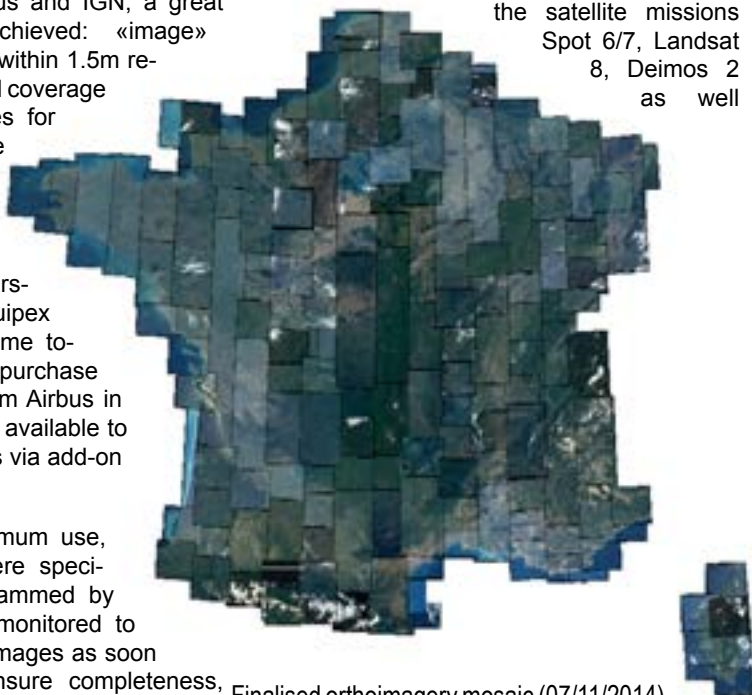
Jean Paul Sempère (IGN)

### Geosud-Theia shared satellite reception device

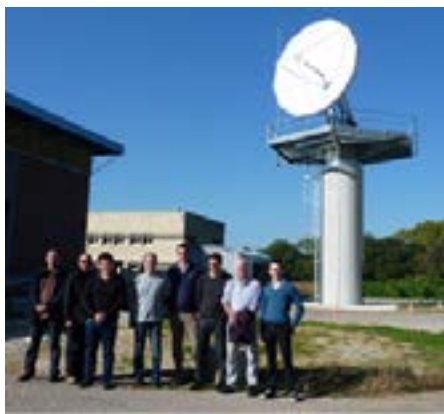
The installation of the Geosud-Theia shared satellite reception device was accelerating during the fall of 2014 with the delivery and commissioning of its main components : satellite receiving antenna and terminal. Training sessions for their handling continue until mid-December 2014 the date at which the device may be considered operational according to plan.

The receiving antenna, acquired by Irstea within the Geosud project part's funded by CPER / ERDF 2007-2013 LR, is an X-band antenna of 5.5 m diameter fixed on a hexapod that was based on a concrete and a height 8m platform.

This antenna is capable of receiving and formatting the signal from the satellite missions Spot 6/7, Landsat 8, Deimos 2 as well



Finalised orthoimagery mosaic (07/11/2014)



Satellite reception device © G. Pinget

as others, using physical adaptations (Pleiades, CBERS4, COSMO-SkyMed). A shelter located on the Irstea site houses some of the equipment, linked using fibre optics to a control and monitoring centre in an operations room temporarily set up in the current Remote Sensing Centre. The operations room will be moved to the new Geosud building currently under construction over the 2015/2016 winter.

The Spot 6/7 Terminal of the shared system was acquired by IRD in the autumn of 2014, using the Equipex Geosud budget on behalf of the Geosud and Theia Consortia, in accordance with the express requirements laid out by their managing bodies. Connected to the antenna using the Irstea computer network, the terminal can be used to place and pilot the programming of the Spot 6 and/or Spot 7 satellite, as well as to reconstruct the imagery data from the received and pre-formatted signal. The equipment is composed of a server, a Spot software suite, and a calculation centre (IBM Blade center 11 blades). Adaptable, the physical architecture of the equipment is designed to accommodate software suites from other missions (Pleiades, TerraSAR-X/TanDEM-X, PASS, then DMC2, Sentinel1/2, Landsat 8). In the operations room, there are 3 remote devices dedicated to operating the terminal and an additional device dedicated to managing the programming and interactions with Airbus Defence & Space, which all supplement the antenna piloting computer.

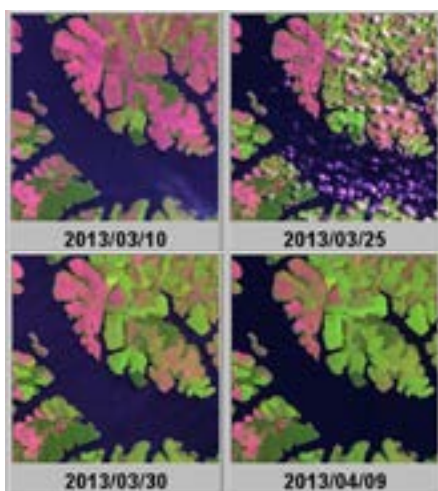
Able to plan, receive, integrate, catalogue, process and deliver Spot 6/7 image streams received in direct or indirect reception situations, as well as those of Spot 5 in virtual situations (Gerald's), the Geosud/Theia device will deliver in real time the metadata coming from these acquisitions to the global ADS catalogue and the Theia meta-catalogue. This will supply the distributed infrastructure of Theia space data, via Geosud, with product images required for the different categories of uses and users of the device.

Currently, attention is being focused on implementing the Geosud-Theia telemetry contract, which will enable the beginning of operations of the device for institutional communities. The goal is to start the 2015 acquisition campaign from the beginning of March 2015.

Jean-François Faure (IRD)

### Renewal of the Take 5 experiment with Spot 5 in the spring of 2015

After the success of the Spot 4 (Take 5) experiment (whose data were downloaded by over 600 different users), ESA and CNES have agreed to renew the Take 5 experiment with Spot 5, from April to August 2014.



Excerpt of the Spot 4 (Take 5) time series obtained over Paraguay

The **Take 5 experiment**, proposed by CESBIO, involves using the end of the operational period of the Spot 4 and Spot 5 satellites to simulate time series' provided by the ESA Sentinel 2 mission. Before definitively switching off the satellite, CNES modified the orbital altitude of Spot by a few kilometres, in order to place it on a **5-day orbital cycle**: during the experiment, Spot therefore passed above the same place every 5 days.

During the Spot 4 experiment (Take 5), 45 sites were observed every 5 days, from 31 January to 16 June 2013, **under constant camera angles**. The data was **ortho-rectified** and the **atmospheric effects were corrected** then **distributed by the Theia center** using chains developed by CNES or CESBIO.

In the case of Spot 5, ESA will be the one to choose which sites to observe, using a site proposal system which is to be sent out during November 2014.

Olivier Hagolle (Cesbio / Cnes)

### Using the annual Spot 6/7 coverage to follow land artificialisation

The goal of the «Monitoring land artificialisation using Spot 6/7 imagery» project is to map the artificialised area in France and to update it every year using the satellite imagery from Spot 6/7.

The production method under consideration is based on the following hypothesis: an anthropised object, once built, is rarely destroyed. Therefore, the anthropised objects currently present in the IGN Database (TOPO® DB) are integrated into the artificialised area. Likewise, the non-anthropised elements from the RPG (Graphical Parcel Registry) are taken into account as non-artificialised elements. Once the databases are integrated - this is called the «base canvas» (illustration 1) - the rest of the elements are compiled by an operator. This is made easier by using the pyramid image segmentation software (illustration 2) which provides an initial interpretation of the Spot 6/7 image.

The method is currently being calibrated at the IGN Space unit (illustration 3), in the French department of Hautes-Pyrénées which also houses the laboratory for the OCS-GE project.

Nicolas Champion (IGN)

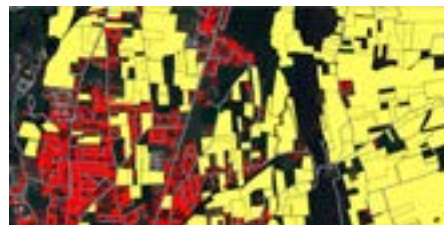


Illustration 1 : Creation of a base canvas, integrating the TOPO® DB (buildings in red and roads in grey) and the RPG (in yellow) on a Spot 6 image of the town of Aureilhan (French department 65)



Illustration 2 : Using photo-interpretation: segmenting the input image using the pyramid tool



Illustration 3 : Once the pyramid segments are labelled by an operator, the artificialised area is created

## The Theia scientific expertise centres

The scientific expertise centres (CES) of the Theia land data centre are laboratories or groups of laboratories conducting research work and developing innovative methods for satellite data concerning «land surface» issues.



CES Languedoc-Roussillon workshop, May 2014

Two categories of CES's have been defined:

- Thematic CES's: these are CES's focused on added-value products, possibly with services associated with this product. These are mono or multi-team CES's, spread over one or more regions. Example: Land use CES, Albedo CES, etc
- Regional CES's : these are CES's whose main mission is to unite and coordinate users (scientists and public stakeholders) at regional level, and to participate in community training efforts, particularly concerning added-value products developed by the thematic CES's. Regional CES's should interact well with the thematic CES's.

Many CES's have been officially presented by the organisers, and a description of their contributions to the Theia centre was noted, as shown in the different articles of this report. In addition, high level expertise is also proposed to the scientific community regarding scale changing techniques (Aggregation/Disintegration), as well as integration of satellite data into terrestrial ecosystem models (NDVI, Chlorophyll, Biomass).

## THEMATIC CES's

### Surface reflectance CES

The objective of the surface reflectance CES is to provide time series' of surface reflectance in high resolution, using data from the satellites Sentinel 2, Landsat 5, 7 and 8, Venùs, as well as the **Take5 experiment** carried out with Spot 4 or Spot 5. It supports two types of products: **level 2A and level 3A**.

The level 2A product is an instantaneous product, acquired in only one satellite pass, represented in surface reflectance after **atmospheric correction**, and including a mask which identifies clouds, shadows, snow cover and water cover. This product should be the basic product for most Sentinel 2 applications. Its quality is therefore crucial and major efforts have been made over several years at CESBIO, with the help of CNES and CNRS, to obtain a precise and robust chain. To obtain this product, the MACSS (Multitemporal Atmospheric Correction and Cloud Screening) method uses a new method based on the fact that surface reflectance varies much more slowly with time compared to atmospheric effects (both clouds and aerosols).

Operational production of the level 2A chain has already begun, in order to process **Spot 4 (Take 5) data in 2013**, or **Landsat 5,7 and 8 data** over France from May 2014. For the time being, this chain is a prototype called MACCS and developed by CESBIO and used by Theia to produce data; the operational version developed by CS-SI for CNES will soon enter production.

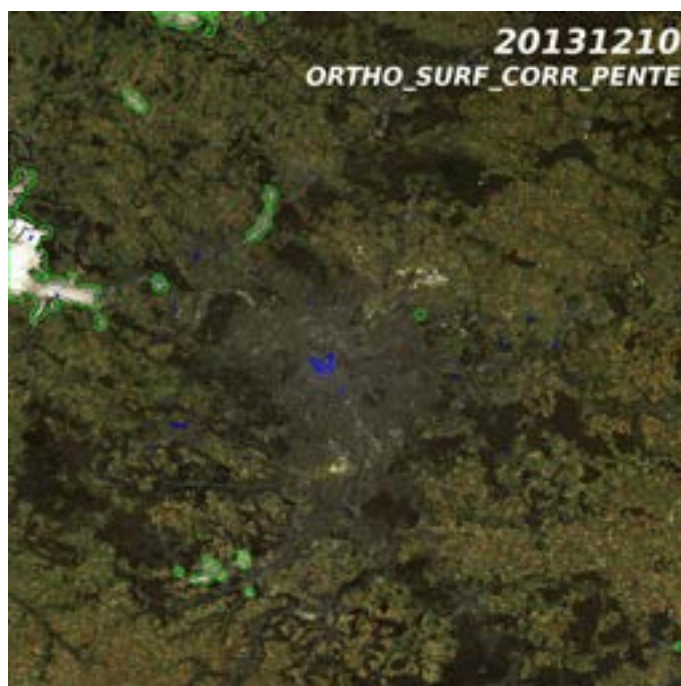
The level 3A product is currently under development, and a version for the Venùs satellite also exists. This is a monthly overview of the level 2A products, which provides a weighted average of surface reflectance for each pixel and for the dates when that pixel is not under cloud cover. The product is destined for users who wish to restrict the volume of data to be processed, or who use methods that are difficultly compatible with data absence due to cloud cover in the imagery.

For Sentinel 2, both products should be in production by Theia for a surface 10 times the size of France from 2016, using the level 1C products provided by ESA.

Discussions are currently under way with the European Union, ESA, and DLR to spread this production to the rest of the world.

Even if the development of these products is well under way, there is still some margin for improvement, and the efforts of the CES can contribute by working for example on: i) determining the type of aerosol, probably using meteorological models, which can currently predict the quantity of each type of aerosol, ii) improvements to the **cloud shadow mask** or iii) **correction of the directional effects** for the level 3A product. These efforts may involve CESBIO, LSCE, CNRM and any other laboratory which would like to join the project.

Olivier Hagolle (Cesbio / Cnes)



An example of a level 2A product, after atmospheric correction, obtained over Paris using Landsat 8. The clouds that were detected are marked in green. This data is available on the Theia centre server : <http://www.theia-land.fr>

## Albedo CES

The main objective of the Albedo CES is to contribute to calculating the energy balance on a fine scale. The surface albedo is a key variable for the water and carbon cycles. It is divided into spectral albedos, corresponding to instrumental bands, and also to large band albedos defined for standard spectral ranges (visible, near infra-red, solar). The albedo is the result of the angular integration of the reflectance on the view (to obtain the hemispherical albedo), and on the lighting (to obtain the bi-hemispherical albedo). The albedos are therefore normalised quantities which can be combined to obtain vegetation indices which can be used by the scientific community working on landscape changes.

The Albedo CES aims to fulfil user requirements with regard to space high resolution (HR) albedo, while the space low resolution (LR) is well covered by European Union and space agency projects. The input data initially taken into consideration are the Landsat and Spot 5 images with a resolution lower than 50 m. They are to be used to prototype an algorithm to calculate the albedo which is then applied to Sentinel 2 (S2) through a joint effort from the laboratories (CNRM, CESBIO, INRA) which will each have a role to play for the atmospheric correction and albedo calculations on the different scales.

### Concept methods under study

Using statistical models of the Bidirectional Reflectance Distribution Function (BRDF) is one possible approach, as it was successfully used with the wide field sensors. The latest projects are related to the PROBA-V mission, with a resolution of 300m, within the framework of the FP7/ImagineS project (see illustration) and a resolution of 1km within the framework of the Copernicus Global Land service. The BRDF from PROBA-V could therefore be used to restrict the S2 data in the future. Another possible approach, which has already been approved for HR, is to use a radiative transfer code and spectral libraries in order to create a neural network capable of simulating albedos for plot sizes that can be indexed by S2. A convergence of these approaches shall be an asset for implementing the chosen method.

The S2 albedo product will have global coverage and will be

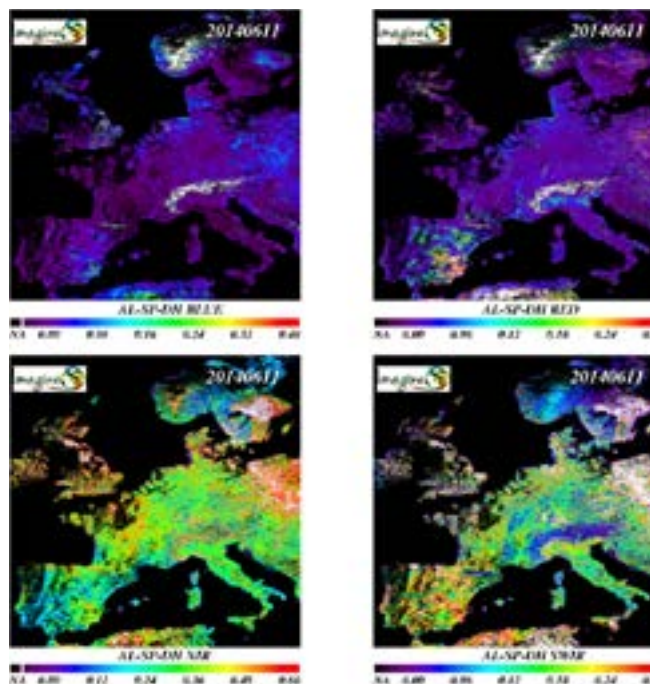


Illustration of the spectral albedos from PROBA-V at a resolution of 300m (11 June 2014)

carried out using the nominal resolution of the sensor, which is between 10m and 20m depending on whether or not the infra-red information is taken into account. The product will be updated monthly with only the S2a, and then this frequency will increase when S2b reaches orbit. The required input data for the creation of this product is all the S2 bands of the solar spectrum with a resolution no greater than 20m. The atmospheric corrections must be based on input fields provided by ECMWF (European Centre for Medium-Range Weather Forecasts) for water vapour and ozone, and in principle on MACC-II data from the atmospheric Copernicus Core Service for aerosols. The product will not be made available before the summer of 2016 because it requires an annual cycle of S2 data to qualify the method and validate the product.

Jean-Louis Roujean (CNRM / Game UMR3589)

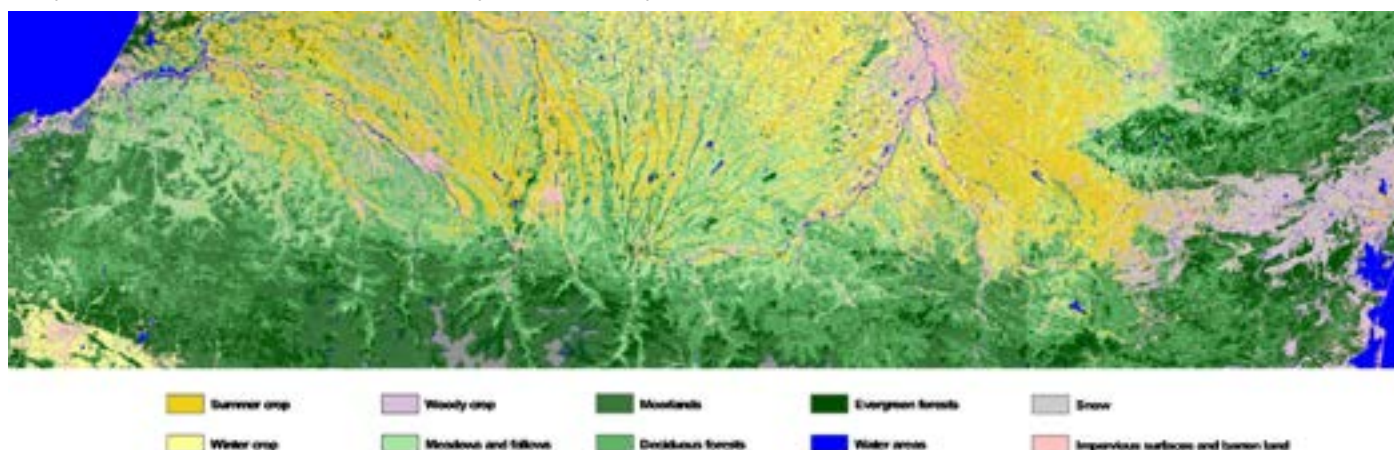
## Land cover CES

Land cover includes the (bio-)physical coverage of the above-water landmasses and the type of use (or non-use) of these surfaces by Man. The landscape mosaic is mapped by identifying the homogeneous types of environments (e.g. artificialised areas, agricultural areas, forests or moors, humid areas, etc.).

Land cover is a major issue for many research projects and for many operational applications. Consequently, it is necessary to

update this information on a regular and frequent basis.

Similarly, it is necessary to keep records in order to construct an analysis of trends and propose possible future scenarios. Satellite imagery is an essential source of information to obtain these goals. However, to obtain this information of sufficient quality within a reasonable time-frame, it is necessary to set up automatic methods which are robust and reliable, capable of efficiently exploiting available data.



Land cover map obtained using Landsat 5 and 7 time series' from 2010 produced by Theia processing chains

## An unrivalled product

The objective of the operational Land cover CES is to produce maps on a national scale with a classification of 15 to 20 categories, with a resolution between 10 m and 20 m, to be updated yearly.

The data required to generate this type of product is series' of optical multi-time images in high resolution (Sentinel 2 class), along with auxiliary reference data for the calibration of the methods and validation of the products.

The type of product described here has no equal in terms of scale in space or in time (update frequency). For example, **Cocorine Land Cover** Cover is updated much less frequently and the

Copernicus products have simplified classifications (**High Resolution Layers**) or limited geographical areas (**Urban Atlas**).

In 2015, a production chain of land cover maps in compliance with the specifications above shall be created in order to set up demonstrations on limited portions of French territory in 2016. A chain capable of producing the land cover for all of France by 2017 is under consideration. Other CES products are under development which should contribute to refining the land cover classes, for example the Artificialisation CES for urban areas or the Physiognomic Mapping of natural vegetation CES for natural settings.

Jordi Inglada (Cesbio / Cnes) - Samuel Alleaume (Tetis / Irstea) - Anne Puissant (A<sup>2</sup>S / Unistra)

## Vegetation biophysics variables CES

The main variables taken into consideration are the foliar index (GAI, Green Area Index), the fraction of photosynthetically active radiation absorbed by the green areas of the cover and the cover ratio. These variables are indicators of the state of the cover, especially the current trends, and can be integrated into the operating models of the vegetation

### Two types of products to develop

**Long global time series' with a kilometre-scale resolution.** This is obtained by using the AVHRR archive which was recently processed by E. Vermote (NASA, GSFC) which provides the LTDR surface reflectance product (version 3) over the period of 1981-2014. The algorithm is based on the GEOV2 (Geoland2/Copernicus) products which use the observations regarding Vegetation as input.

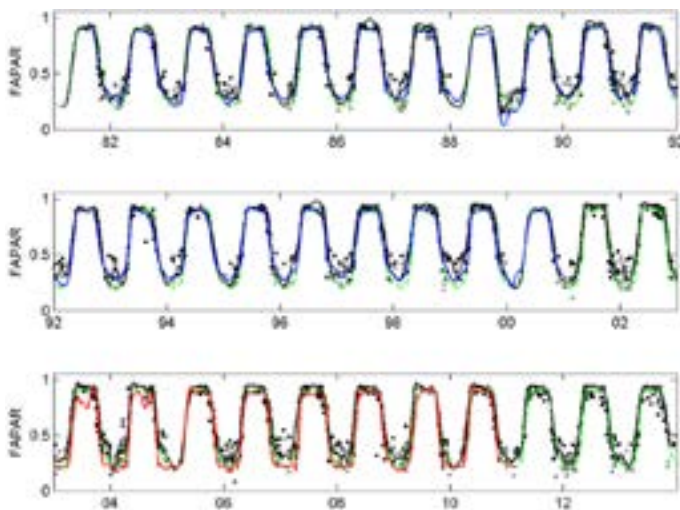


Illustration 1. Time profiles of FAPAR obtained from the AVHRR/LTDR3 version on a site where there is a deciduous forest (39.5°N, 80.5°W)

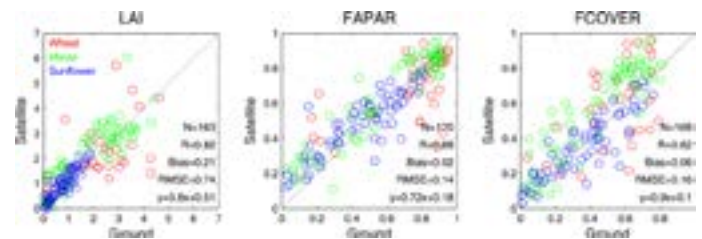


Illustration 2. Comparison between on-site measurements and Landsat 8 / Spot 4 products on the site located in south-west France.

The product will cover the entire globe, with a cadence of 10 days over the period of 1981-2014 with a resolution of 5km. It was designed to be very consistent with the GEOV2 product. It should be available during the course of 2015. This global product covers a long time frame of over 33 years and will allow for the identification of possible trends related to global changes and the study of anomalies related to the climate. (illustration 1)

**Regional decametric monitoring.** This is obtained by making use of the revisit capabilities of the decametric sensors of Landsat 8 (at a resolution of 30m) and Sentinel 2 (at a resolution of 10 to 20m). The input data required for the algorithm is the surface reflectance data (see the article by Olivier Hagolle on p.3). The surface reflectances are transformed into biophysical variables using a generic algorithm developed using simulations of radiation transfer models. The first validating results show rather good estimation performances (illustration 2). The algorithm could initially be applied to a limited number of sites, including agricultural areas (JECAM sites in particular) as well as sites used to measure carbon and water flows. Aside from the contribution to better knowledge of vegetation trends and their spatial variability, this data shall contribute to the validation of the algorithm by comparison with ground measurements. The first evaluations may be available at the end of 2016, once S2 has been in activity for a few months. This project is an extension of the FP7 ImagineS project.

Frédéric Baret (Emmah / Inra)

## Evapotranspiration CES

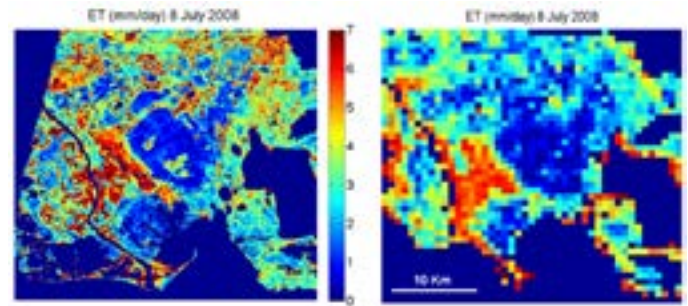
Due to increasing strain on water resources on a global scale, it is necessary to better quantify and monitor the hydric consumption of agricultural surfaces (evapotranspiration). The potential interest is a better management of supply to the scale of the irrigated areas, or a risk evaluation of hydric stress in pluvial agricultural areas. With regard to the catchment areas, the issue is a better understanding of the flows, for example the pumping from the water table, so as to better manage the resource. Finally, evapotranspiration is a critical information to comprehend the regional hydric assessment and for climate analysis.

The evapotranspiration products are only currently systematically available at low resolution and/or for time integration in the range of a week at best (e.g. MOD16 product, 1km, every 8 days); moreover their validity is questionable. Within the framework of this CES, several types of products are worth consideration, on one hand regular evapotranspiration mapping from thermal imagery at a hectometric resolution (Landsat 8, at best every 16 days) or kilometric resolution (Modis, every day), and on the other hand daily evapotranspiration mapping in high space resolution (10-30 m) using reflectance imagery (Spot, Sentinel 2, Landsat 8, etc.).

## A method based on free images

The products which use the Landsat and MODIS thermal imagery are based on energy balance models of the surface using as input the surface temperature, information regarding the vegetation such as the albedo and the foliar index, and incidental radiation. At low resolutions, this information is currently available from several data sources (Copernicus Land Monitoring Services, Modis products, LSA-SAF). The algorithms created provide evapotranspiration mapping associated with uncertainty mapping at the date of acquisition of the images. A pre-operational tool is already available which may be deployed across specific study areas by the end of 2015.

For products derived from reflectance imagery, the method under consideration is to use a model such as a simplified Soil Vegetation Atmosphere Transfer model based on the FAO-56 method, which enables the generation of evapotranspiration estimates, and where necessary estimates of the irrigation blades. In this model, the quantity of active vegetation present on the ground, which is a major factor for evapotranspiration, is supplied by time series of Sentinel 2 images (corrected for ground reflectance, 15 m). The model also requires an input of the daily meteorological data supplied by a network of stations on the ground, or an output of meteorological models (rain, temperature, humidity, wind, sunlight). It is also necessary to obtain mapping of the land cover in near real-time and regularly updated, identifying the irrigated areas. Taking into account the specific calibration and validation requirements of the types of vegetation and agricultural practices, especially with regard to irrigation (techniques, frequency, dosage), the product may be made available progressively



Mapping of daily evapotranspiration obtained using thermal imagery from the EVASPA chain over the Crau-Camargue area: Landsat 7 on the left (resolution 60m) and Modis on the right (resolution 1km). The images are centred on the dry Crau (43.5°N - 4.9°W).

scaled to the agricultural regions. Over time, a major advancement of the model is planned, which consists of periodically assimilating thermal images at high resolution provided by the previous method, or alternatively high resolution SAR images (Sentinel 1), in order to better evaluate the ground humidity.

Taking into account the required data depending on the methods under consideration, the evapotranspiration CES depends on the reflectance, albedo, land cover, irrigated surfaces and ground humidity CES's. A future high resolution thermal mission (project Thirsty) will also be very interesting with a view to improving the various products.

Vincent Simonneaux, Gilles Boulet (Cesbio / IRD)  
Dominique Courault, Albert Oliosio (Emmah - UAPV / Inra)

## Irrigated surfaces CES

Knowledge of irrigated surfaces is an essential element for water managers on the scale of a catchment area. Indeed, irrigated surfaces can consume up to 80% of the usable water resources. In France, the volume of irrigated surfaces went from 500,000 ha in 1970 to 1,576,000 ha in 2000 (General agricultural census, 2000), and then stabilised, representing 5.8% of the Usable Agricultural Land (Surface Agricole Utile - SAU) in 2010. An estimated 60% of all irrigated surfaces are located in the south-western quarter of France. The managers do not have a tool at their disposal which enables them to know the irrigated surfaces with accuracy. Having maps of irrigated surfaces at the beginning, during and at the end of the irrigation cycle could enable them to better manage the water demand, which has become a crucial issue especially during periods of severe drought, which happen currently once every 5 years in the Midi-Pyrénées region.

Distinguishing between irrigated agriculture and rain-fed agriculture is a challenge. For example, the recent land cover product from Meris (CCI LandCover) is able to identify the major irrigated regions (the Nile delta, the Indus basin, etc.) but we have noted that many irrigated areas such as the Lerma basin in Mexico, the south-west of France or the Tensift in Morocco are not detected.



Example of the importance of thermal imagery. On the left, a Landsat coloured composition (TM 3, 4, 7) of the Haouz plain (Morocco), in the centre the NDVI and to the right the corresponding thermal image. Compared to the coloured composition and the NDVI, the temperature accentuates the contrast between the irrigated areas (darker, therefore colder), and the rain-fed areas (lighter, therefore warmer).

## High spatial resolution maps

We propose to develop methods enabling the creation of maps of irrigated/non-irrigated surfaces in high spatial resolution (decametric resolution) on a bi-monthly basis (or even every 10 days). The issue is to be able to develop methods both simple and robust which are valid for different areas and applicable in practice. The approach is original because it combines the information taken from multi-wavelength images with high spatial and time resolution, which are or will very soon be available for free, worldwide: Landsat 8, Sentinel 1 and Sentinel 2. The combined usage of optical vegetation indices (NDVI), ground humidity by radar imagery and surface temperatures by thermal imagery, along with using simplified SVAT models (Soil-Vegetation-Atmosphere), should result in an innovative product which fulfils the requirements of water managers.

Spot 4 images were acquired in 2013 during the Spot 4 (Take 5) campaign over south-west France, the Tensift basin in Morocco, and the irrigated plain of Kairouan in Tunisia. In 2015, a new acquisition campaign of Spot 5 images is planned for these sites. Validation data is also available for these areas, along with the data from Landsat. We propose, therefore, to evaluate the methods created with the help of this unique set of data. The applicability of these methods could then be tested when the data from Sentinel 1 and 2 is fully available. For this work, we need level 2A products.

The supplied products could also be used to evaluate the average and low resolution land cover maps supplied by FAO (FAO GMIA), Goethe University (Mirca 2000), NASA (Modis) and ESA (CCI LandCover).

Valérie Demarez (Cesbio / UPS)  
Michel Le Page, Vincent Simonneaux (Cesbio / IRD)  
Vincent Rivalland (Cesbio / CNRS)  
Mehrez Zribi (Cesbio / IRD)

## Digital soil mapping CES

The objective of the «Digital soil mapping» CES is to group the efforts of the French research laboratories which are currently developing digital mapping methods of the durable properties of the soil. These properties are required to aid decision-making and spatial modelling of continental surfaces for activities for which the soil plays a vital role (agronomy, environment and ecology). The precise definition of objectives relies on specifications defined on a global scale within the framework of the international «GlobalSoilMap» project. Therefore, the issue is to estimate, for the nodes of a 100 m grid, a set of properties of the soil of vital importance (grain size distribution for 3 fractions, pH, Organic Carbon, depth, Apparent Density, Usable Reserves), across six depth intervals (0-5, 5-15, 15-30, 30-60, 60-100 and 100-200 cm) and with a quantified indication of the degree of uncertainty of the estimates produced (estimates delivered with a 90% confidence interval).

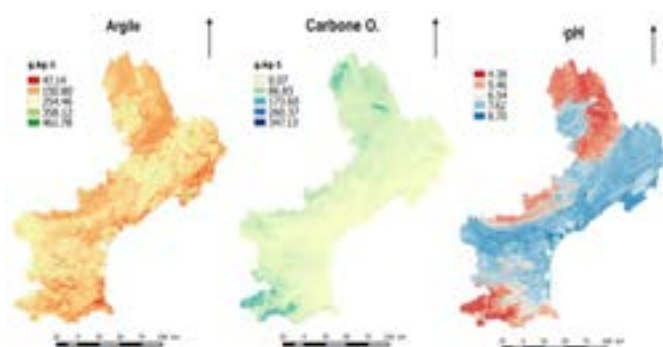
The general approach relies on using models from data mining (e.g.: Random Forest, SVM, etc.) and/or geostatistical models (Kriging, Kriging regression, etc.) using covariables from soil for which the space-rating is readily available. These covariables are either related to possible factors in the formation of the soil (climate, relief, bedrock), or factors which are strongly influenced by the nature of the soil (vegetation, land cover). The models thus created are calibrated using a ground truth data meaning one-off sites, or delimited areas of soil where the properties of the soil are measured. Depending on the level of practical operability reached by research in digital soil mapping, two development stages are planned.

**Stage 1** : usage of the covariant sources of the soil which are readily available on a national scale (release of climate models,

DET and assimilated, land cover imagery, digital images of geological maps) in conjunction with older soil analysis already available in current databases. For this stage, a methodological guide as well as development procedures may be produced by 2016.

**Stage 2** : usage of the remote sensing data to increase the characterisation density of the properties of the soil (and thus the performance of the models) in association with the aforementioned covariables. The remote sensing images in question are Vis-SWIR and LWIR hyperspectral and multi-spectral images, as well as aerial gamma radiometry images. Current laboratory research should lead to operational production at the same time as the availability of new satellite data in 2018, especially hyperspectral data (ENMAP).

Philippe Lagacherie (Lisah / Inra)

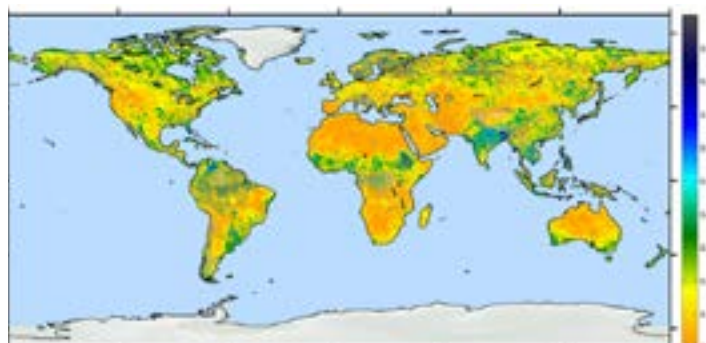


Three examples of digital mapping of soil properties in the Languedoc-Roussillon region (depth interval 5-15 cm). (according to Vaysse and Lagacherie, 2014, Geoderma Regional)

## Ground humidity CES

The soil water content is a very important variable for many applications, from hydrology to weather forecast or climate monitoring. The quantity of superficial humidity in the ground determines the exchanges of water and energy between the ground and the atmosphere of our planet. Knowing the superficial humidity is crucial to monitor the distribution and changes of our water reserves. This knowledge will help us evaluate all terrestrial components of the water cycle and therefore better manage this resource.

In order to attain this objective, SMOS uses a very innovative concept: interferometry (1.4 GHz). The sensor captures angular signatures of emission of the surfaces through all weather with the four Stokes parameters, this twice per day (at around 6:00 and 18:00 solar time). These brightness temperature signatures



Composite superficial humidity map for the period from 27 to 28 July 2013 obtained by Smos. Level 3 CATDS chain. Credit: CESBIO CATDS (CNES Ifremer)

can be inverted in order to measure the superficial humidity with an average resolution of 43 km, maximum every 3 days. In addition, these multi-angular acquisitions grant access to water content of the vegetation, or to the freeze/thaw characteristics of the ground. After treatment, we can use this information to estimate the water contained in the root zone and, using this, a dryness index (operational products). Other products exist (surface percentage of free water, flood risks, etc.) which are currently undergoing validation or implementation, for example the disintegrated moisture fields (resolution 1 km).

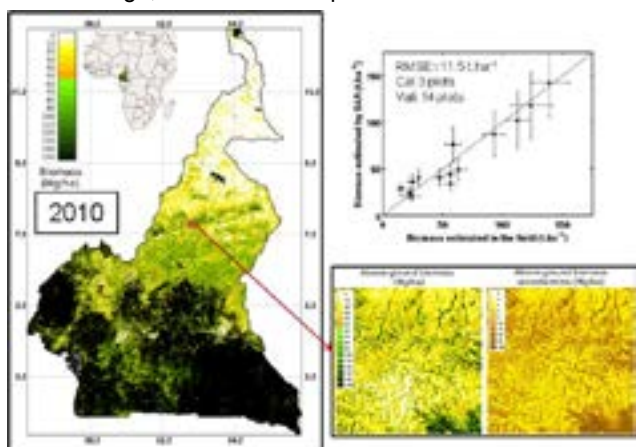
### A platform available to all

Currently, these products are developed and tested at CESBIO on the research platform (humidity expertise science centre - CES-SM) of the CATDS (Smos Data Downstream Centre - CNES-Ifremer). This platform is open to anyone wishing to test new products. Once prototyped, validated and authorised by the Piloting Committee, these products are implemented operationally at the CATDS production centre in Brest (Ifremer). The Theia thematic centre will provide the users with a direct link to this database. The data currently available are in NetCDF format, as well as in an EASE-grid-2 grid with sampling at 25 km. Daily data is available, along with composites over 3 or 10 days as well as monthly summaries. The main data points, apart from the multi-angular brightness temperatures, are the superficial moisture fields, dielectric constant fields and vegetation opacity fields. During the implementation period, there is humidity in the root zone, dryness indices and 1 km moisture fields on certain Modis tiles. In development, there are disintegrated 100 m humidity fields over some areas, flood risk indicators, free water fraction maps, etc.

Yann Kerr (Cesbio / Cnes)

## Forest biomass and changes in forest cover CES

The biomass product is a mapping of the aerial biomass estimations (Above Ground Biomass AGB, in tonnes per hectare) of the vegetation formations, in majority ligneous, which can be found in each resolution cell. The biomass product derived from remote sensing is obtained from radar data. The current product, derived from L-band radar data (Alos/Palsar and Alos 2), is limited to 150 tonnes/ha. The method which uses Alos/Palsar, developed at CESBIO, has been applied to several areas (Cameroon, southern Africa, Vietnam, France) and will be tested with the data from Alos 2. While we wait for the P band SAR from the Biomass mission which will provide the biomass estimates up to 500 tonnes/ha in 2020, the current product covers the low biomass forests, the plantations and tree-filled savannah, which were up until now disregarded in the carbon assessment. The scientific stakes are therefore very high when evaluating the role of forests as both a well and a source of carbon. The economic stakes are also high, with the development of a world carbon market.



Map of the tree-filled savannah biomass of Cameroon in 2010 (aerial biomass range: 0-150 tonnes/ha). Bottom right: detail of an area with the dimensions 10 km x 10 km, biomass maps and biomass uncertainties. Top right: Validation results.

## Two types of sensors for two types of methods

The forest cover product is obtained using two types of sensors: 1) using the Palsar or Alos 2 data by segmenting the biomass maps using a predefined threshold according to the definition of a forest as set out by each country. The change that occurs over time provides information about deforestation, forest degradation and forest regrowth; 2) from the dense time series' from Sentinel 1 over the critical deforestation and forest damage areas, using an algorithm which detects changes. The precise mapping of these changes is used to meet the needs of REDD (Reduced Emissions through Deforestation and Degradation), a United Nations programme which requires countries to compensate for the carbon emissions for which they are responsible.

For the biomass product, the resolution is 25m at the different levels (region/country/world) and 20m for deforestation and forest damage 'hot spot' sites. Optimally, the biomass product is to be renewed annually and the changes in forest cover product twice per year.

The Alos/Palsar data at 25 m on a global scale is available with one renewal per year for 2007, 2008, 2009, 2010. For Alos 2, launched in May 2014, data acquired within the framework of the 'Kyoto and Carbon initiatives' programme by Jaxa will be available from 2015. The time series of the Sentinel 1 data at a resolution of 10 m over 'hotspot' zones is also necessary for the product. The main auxiliary data includes the DEM at 30 m from the SRTM in 2015, and the land cover maps available in various programmes.

The methods using Alos/Palsar which have already been validated will be available in 2015. The method using Alos 2 and Sentinel 1 will probably be available at the end of 2015, after validation. Once validated and published, mapping results will also be made available. The development of methods is carried out in conjunction with the following programmes: Global Forest Observation Initiatives (GFOI), REDD+, UNREDD, Kyoto and Carbon Initiatives (Jaxa), GlobBiomass (ESA).

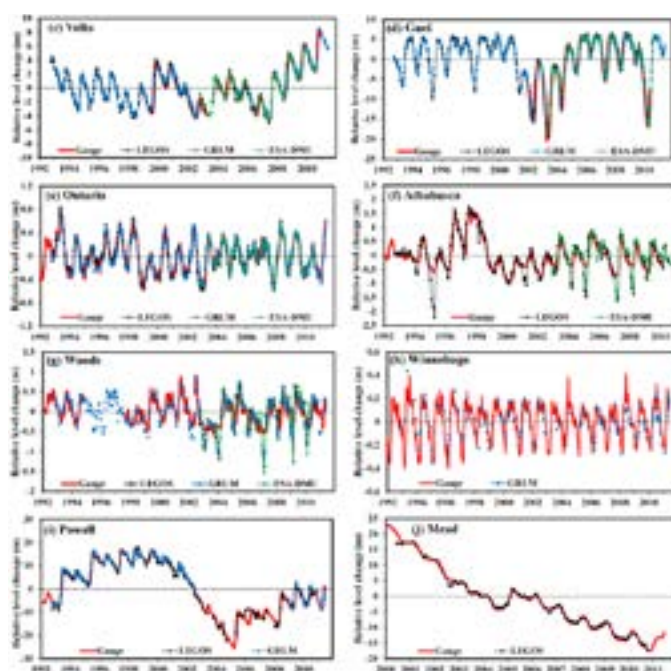
Thuy Le Toan, Stéphane Mermoz, Alexandre Bouvet (Cesbio)

## Water levels of lakes and rivers CES

The Hydroweb service ([www.legos.obs-mip.fr/soa/hydrologie/HydroWEB](http://www.legos.obs-mip.fr/soa/hydrologie/HydroWEB)) was developed at Legos in 2003 in order to provide the scientific community with continuous and long-term time series' for the levels of large lakes and reservoirs, as well as rivers, calculated using altimetry satellites. This database has been gradually expanded with new products, both with regard to the diversity of the objects being monitored (today, around 230 lakes and 20 large rivers are present in the database) and the nature of the products: in particular, aside from water levels, the spreading and variations in volume of around a hundred large lakes are also a part of the portfolio of available products.

While the number of users of this database was quite small ten years ago, over the past three or four years we have observed a surge in the user base due to an increased interest in this technique from scientists, who still make up the majority of the users of these products.

However, it became readily apparent that the mode of operation of the Hydroweb database, as well as its supply of new products and the wait period for updates of the time series', which were becoming obsolete, were all obstacles which prevented its generalised use, especially in the eyes of institutions and private stakeholders who required a more operational use of this type of database.



Comparing the time series of 8 large lakes between different databases. Depending on the size of the lakes, the margin of error is between 2-3 cm and a few tens of cm..



## A modernised database, in real time and automated

Taking advantage of the emergence of the Theia land data centre, Legos, with the consent and coordination of CNES, specified the fundamental changes required for the Hydroweb database in order to modernise it and make it compatible with the requirements of real time and automated use in the form of an industrial process.

At the beginning of 2015, the transformation of the Hydroweb database shall be made a reality as it will be housed by Theia and operated by a manufacturer with the support of CNES and Legos.

The product provided shall be made up of a subgroup of around a hundred large lakes and some large rivers, for which the variations in water levels shall be calculated automatically and in near real time. The frequency of updates will only depend on the revisit time of the satellites used, from 10 to 35 days depending on the satellite, and which could be brought down to 2-3 days for the large lakes which are passed over multiple times during one orbit cycle.

For the rest of the database, operations will continue in the so-

called research mode, meaning that updates will occur once or twice per year, the idea being that, once the service is in place, the as many lakes and rivers as possible are to be transferred to operational, especially when the satellites Jason 3 and Sentinel 3 are in orbit. All continents shall be concerned by this, the short-term objective (for 2015) being to submit this service as a database which is both operational and interoperable with other services proposed by Theia to the Copernicus programme to monitor continental waters. The satellites currently in use to calculate the Hydroweb projects are Jason 2 and Saral/AltiKa; in the near future there will be Jason 3 and Sentinel 3, in the medium term, Jason CS, and in the longer term, Swot. To calculate the water areas and variations in lake volume, the products shall be processed using a combination of satellite altimetry and classification of the areas under water using satellite imagery.

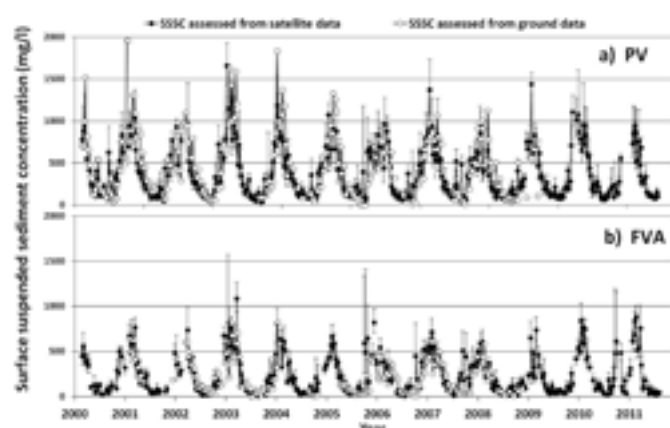
Legos will maintain near permanent quality control through comparisons of the data with on-site data and a validation campaign on the ground, along with research and development activity which will be aimed at increasing the list of products broadcast using new space sensors.

Jean-François Cretaux (Legos / Observatoire Midi Pyrénées)

## Colours of the continental waters CES

The study of continental surface waters is doubly important because it represents the largest part of the hydric resource available to our society and the quality of this water enables us to trace numerous processes at work within these catchment areas (erosion, changes in the land cover, pollution, climate change).

The idea is to develop the following products: «concentration of suspended matter» and «concentration of chlorophyll-a» for the surface water of rivers, lakes and estuaries. The product shall be adapted to the satellite platform (spectral and radiometry resolution) and shall benefit from prior works by integrating radiometric hyperspectral measurements (inherent optical properties of water which are apparent), characterisation techniques for the river waters, bio-optical modelling and analysis of low resolution time series' of images from Modis/Meris. It will be delivered in the form of regular data, similar as to what a hydrological station supplies, or in the form of 2D maps. The possible applications range from estimating the erosion or silting process of waterways to eutrophication of the body of water.



Concentration of suspended matter on the surface of the Rio Madeira river (Brazil) estimated by satellite (black dots) and measured on site every 10 days (white dots) by the HYBAM Observation Service at the hydrological stations of the Brazil Water Agency: Porto Velho (graph A) and Fazenda Porto Alegre (graph B).

## The final users already interested

A pre-operational demonstrator was developed with the Brazilian Water Agency thanks to collaboration with IRD (UMR, GET) and the HYBAM Observation Service. An internet portal ([ana.gov.br/hidrosat](http://ana.gov.br/hidrosat)) gives access to the monitoring of the concentration in specific substances of the rivers and the eutrophication processes of lakes via satellite for several catchment areas in the country. Modis images are used as input and an automatic processing chain was developed. Not only does this demonstrator show which kind of product to develop for the Theia centre, it also shows the interest of the final users, such as the Water Agency, for these kinds of thematic products.

We will evaluate the new satellite platforms, especially the ones in high resolution. This work shall first be carried out on data sets which come from measurements on site, from models and from existing satellites (Modis, Landsat 8) in order to simulate the next satellite configurations (Sentinels 2 and



Modis satellite imagery above the Rio Madeira in Brazil. The colour of the river is due to the presence of particle and dissolved substances which impact the absorption and diffusion properties of light.

3). The inversion algorithms and image processing methods will then be tested on the images from the new satellites when they are available for several test sites in France and in the South. This work shall benefit from the operational methods of radiometric and atmospheric correction developed for Theia.

In France, different laboratories specialised in hydrology and sediment transport have shown interest in using time series' of products concentration of suspended matter of bodies of water on their sites. The products proposed by CES are not considered as yet in the Copernicus Land Service and are therefore considered to be original applications.

Jean-Michel Martinez (UMR GET / IRD)

## Snow-covered surface CES

Snow plays an essential role in the hydro-meteorological processes in mountainous regions. In particular, the melting dynamics controls the replenishment of water sources and the flow of the rivers which supply the regions downstream. The snowmelt is often used to produce hydroelectricity and to irrigate crops. To model the stock of snow in mountainous regions, the main difficulty is the heavy spatial variability between physiographic and meteorological conditions with regard to in situ observations.

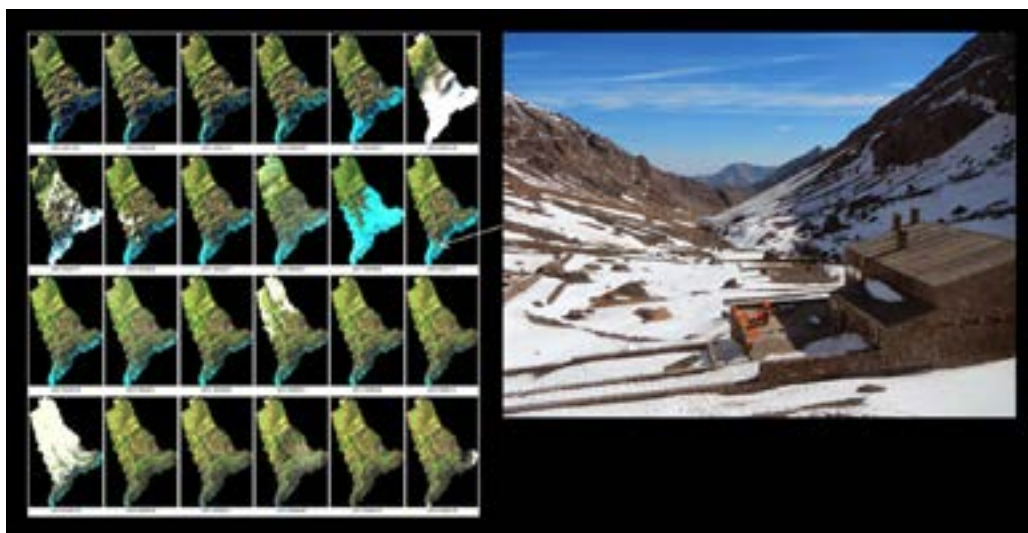
Today, the spatial sensors do not allow for proper measurement of the amount of snow or its equivalent in water in mountainous regions. The variable which may be obtained using remote sensing is the snow-covered surface. For this, current algorithms are based on optical multi-spectral data, but the products which are generated either suffer from insufficient spatial resolution with regard to the jagged relief of the mountains, or from an acquisition frequency which is too low to correctly understand the dynamics of the melt. The data from Sentinel 2 will provide the unique pos-

sibility to go beyond this compromise and therefore to improve our knowledge of the water resources in mountainous regions.

### Coverage of the most anthropised European peaks

The product that we propose is a filter coded by pixels which are 20 m, with a frequency of every 10 days: (1) presence of snow, (2) absence of snow, (3) cloud cover, (4) presence of snow after interpolation, (5) absence of snow after interpolation. The objective is to finalise a parsimonious algorithm which is capable of processing large amounts of data in order to eventually cover the most anthropised European mountain ranges. The product will use the surface reflectances (i.e. after atmospheric correction as well as gradient effects) calculated from observations from both Sentinel 2 satellites. On a larger scale (e.g. northern hemisphere), the medium resolution products (Sentinel 3) are sufficient and are currently under development in the project GlobSnow-2.

The method will be tested with the Spot 4 (Take 5) and Landsat 8 data and in the best case available by the end of 2015.



Simon Gascoin  
(Cesbio / CNRS)

Left: example of Sentinel 2-type time series imagery (Spot 4 (Take 5)) of a semi-arid catchment area in the High Atlas mountains of Morocco (Rheraya 225 km<sup>2</sup>, altitude between 1084 and 4167 m).

Right: photo taken from the Toubkal mountain refuge in that catchment area. The spatial resolution and repetitiveness of Sentinel 2 are required to capture temporal (such as the fleeting event at the beginning of April) and spatial variability of snow cover (depending on exposition, gradient, etc.).

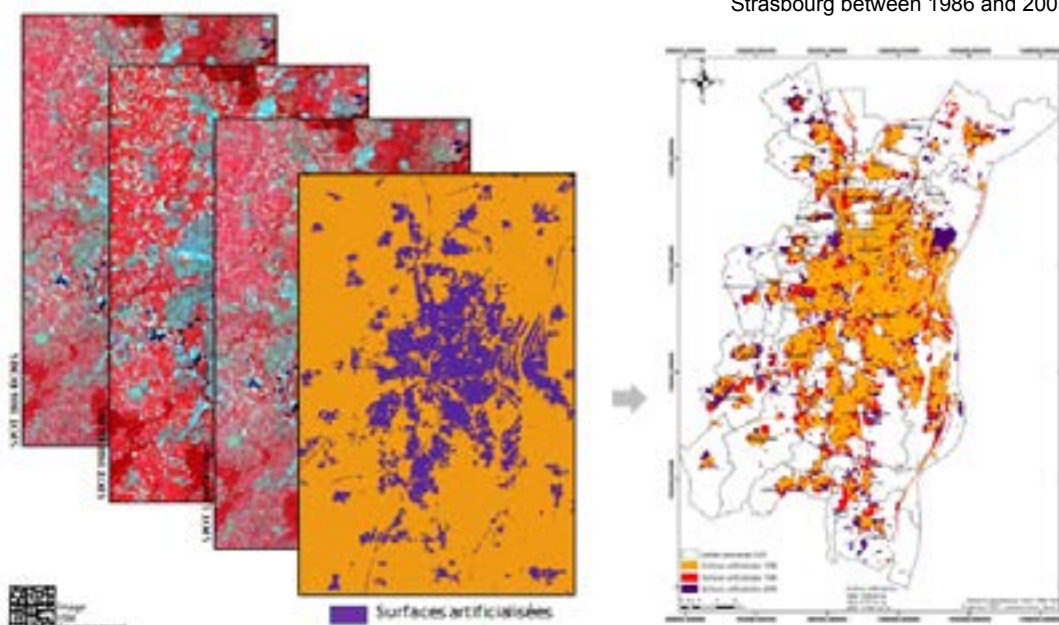
## Urbanisation / Artificialisation CES

The worldwide demographic explosion comes with a rampant artificialisation which in turn provokes a geometric expansion of urban areas. Since 2008, for the first time in human history, more than half the population lived in urban areas. In 2050, an estimated 70% of the world's population will be urban. This artificialisation of the land will weigh heavily on the natural resources on a large scale with strain on available land, the environment and biodiversity.

To address this challenge, monitoring artificialisation and characterising urban changes have become vital in many operational applications. These applications require access to information that is updated regularly enough to cope with needs. The objectives of the Urbanisation-artificialisation CES is

(i) to develop the usage of tools, methods and remote sensing data with regard to this issue, and (ii) to accentuate and qualify this information and encourage its use among the community.

Evolution of artificialised surfaces around the Urban Community of Strasbourg between 1986 and 2005.



In this context, the aims are :

- to produce, on a national scale and at a resolution of 10 to 20 m, several reference products (artificialised surface mapping with their degree of artificialisation, mapping of the types of changes) with an annual or even bi-annual update frequency depending on the product. To attain these objectives, the Sentinel 2-type high temporal frequency optical images, as well as publicly available data will be used to calibrate the methods and validate the products. The operational transfer of the methods proposed in this CES, especially their large-scale production schedule, will depend on partnerships which are currently being developed with institutions which deal with such matters (IGN).
- to create indicators which promote these reference pro-

ducts as useful for public territorial policies.

- to develop qualification methods for the reference products and indicators.
- to define the best conditions in which the user can understand this information.

This CES supplements other thematic CES's (Changes CES / Physiognomic mapping of natural vegetation CES for rural areas) and it will make it possible to narrow down the propositions of other CES's such as the Land cover CES. The products proposed are different from those proposed by Copernicus (e.g. HR Layer Imperviousness) by their better spatial resolution and their higher potential update frequency.

Anne Puissant (A<sup>2</sup>S / Unistra) - Eric Barbe (Tetis / Irstea)

## Risks associated with infectious diseases CES

These past decades have been marked by the emergence of numerous human and animal infectious diseases, which has had a major impact on public and veterinary health, especially vector-borne diseases: this is the case of human diseases such as dengue fever or the chikungunya virus, and zoonotic diseases such as the Rift Valley fever and the West Nile virus. On the other hand, some pathogenic agents that are not vector-borne can cause epidemics (e.g. meningitis epidemics in Africa).

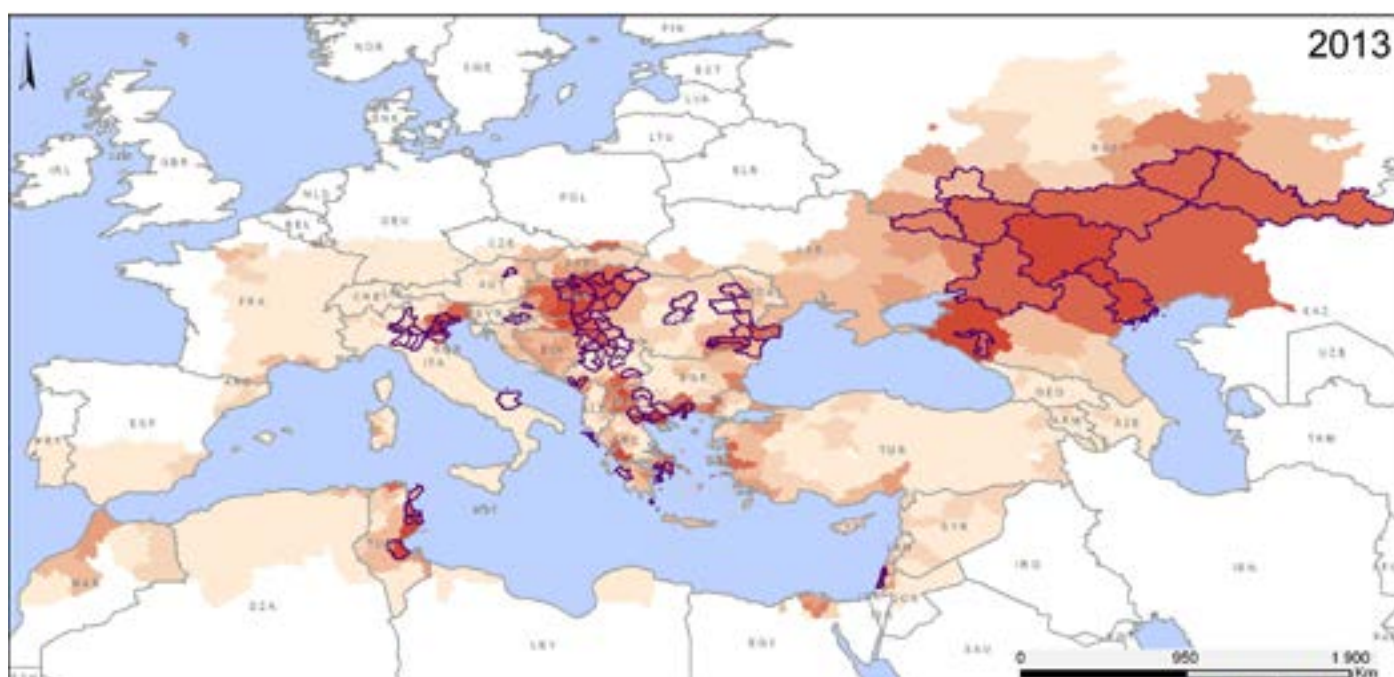
Remote sensing has the potential to characterise the environmental conditions which are favourable to the presence of a pathogen in a given area or the presence of the required vectors: the teams working on the «Risks of infectious diseases» CES have therefore developed different methods and models to better understand the link between the presence or abundance of vectors and the risk of infection on the one hand, and the environmental and meteorological indications which can be derived from remote sensing on the other hand. Some research results have ended in the development of operational mapping methods of epidemiological risks for different infectious diseases, both vector-based and not vector-based, from remote sensing data, in particular for West Nile fever, Rift Valley fever, malaria, the pre-

sence of *Aedes albopictus* or *Aedes aegypti* mosquitoes, which are vectors of the dengue and chikungunya viruses, and the risk of triggering meningitis epidemics in west Africa.

### Mapping epidemiological risks

The proposed products are risk maps, defined in terms of probability of the occurrence of a case or the presence of vectors, for the various infectious diseases mentioned above, different study areas (Europe, Africa, South America and Asia) and different spatial scales (from local to continental), which correspond to the research results of the proposing teams, along with update frequencies which can be variable as needed (weekly, monthly or yearly map generation). The remote sensing data used include, in particular, very high, high, and medium spatial resolution optical imagery (Pleiades, Spot 5, Modis). These maps are intended to contribute to spreading information about epidemiological risks linked to infectious diseases, especially with regard to public health and veterinary actors, and on a more general scale with regard to the holistic environment/health approaches that use remote sensing.

Annelise Tran (Cirad) - Emmanuel Roux (IRD)  
Nadège Martiny (CRC Université de Bourgogne)  
Jean-Pierre Lacaux (Observatoire Midi-Pyrénées)  
Cécile Vignolles (Cnes)



Mapping of the risk zones for West Nile fever in Europe and the Mediterranean (in red: high risk; pink: low risk) as predicted using environmental variables for 2013, and localisation of the cases of West Nile fever actually reported in 2013 (districts in purple)

## High frequency change detection CES

The objective of the High frequency change detection CES is to produce a systematic inventory of changes on a national scale. To this end, it aims to propose incremental methods for the generation of change maps (the «where?») which can be (post-) processed thematically (the «what?») to manage natural risks, environmental monitoring (observatories) or territorial development.

This objective and the methodological and thematic research that is derived from it are shared with other thematic CES's such as the Land cover CES, or the Urbanisation / Artificialisation CES.

The idea is to combine the flow of information from the Sentinel (S1 and S2) with exogenous data (Database, WEB, etc.). The

resolution and update frequency will therefore be identical to that of these satellites.

### Delivery schedule

Following the theoretical studies on the incremental algorithmic methods adapted to the high frequency, volume and heterogeneous nature of the data based on current work by the laboratories involved: Markov models, decision tree forests, collaborative clustering, active learning, learning through conceptual derivatives, a software and hardware architecture for the implementation (in production) of the processing chain should be proposed in 2016, a prototype produced in 2018, and a production across the whole country starting in 2020. The whole project should be available in Open Source.

Pierre Gançarski (Icube / Unistra)

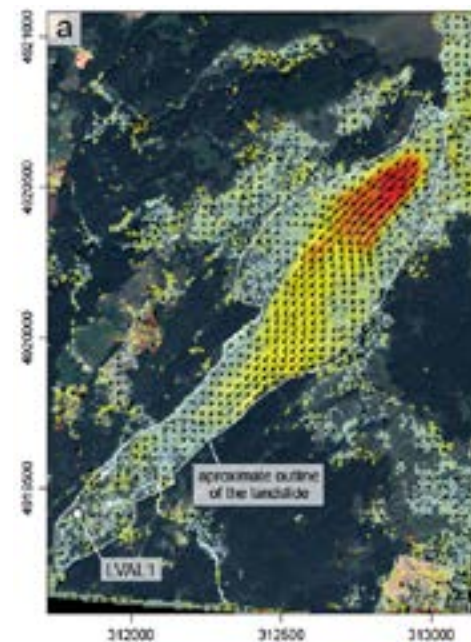
## Crustal deformation CES

The continental surfaces are affected by ground movements which are of varying magnitude and kinematics which contribute to the evolution of the shape of the earth and the creation of natural hazards. Satellite imagery is a vital source of information for quantifying these deformation fields and better understanding the physical mechanisms. The high temporal frequency of the Sentinel imagery and complementarity of the radar (S1) and optical (S2) acquisitions now make it possible for us to follow the process over a wide dynamic spectrum, from a few centimetres to several metres per year, with a high level of responsiveness for mapping the deformations after catastrophic events.

### Risk prevention and resource management

The Deformation CES is primarily focused on high frequency monitoring of superficial movements (landslides, sinkholes, glaciers, geothermal and mining operations) by combining radar and optical imagery as well as reference measurements on the ground to calibrate the methods and validate products. The aim is to produce maps and time series' of the movement speed on high-stakes territories (mountains, coastline, high-density demographics) in a short time frame (at least as quickly as the image data is acquired). From an application point of view, the challenge is to provide a reference product for risk prevention and management of resources and infrastructures/buildings. The type of product that is proposed here has no equal on the temporal scale that is envisioned.

Several processing models (S2 optical imagery correlation;

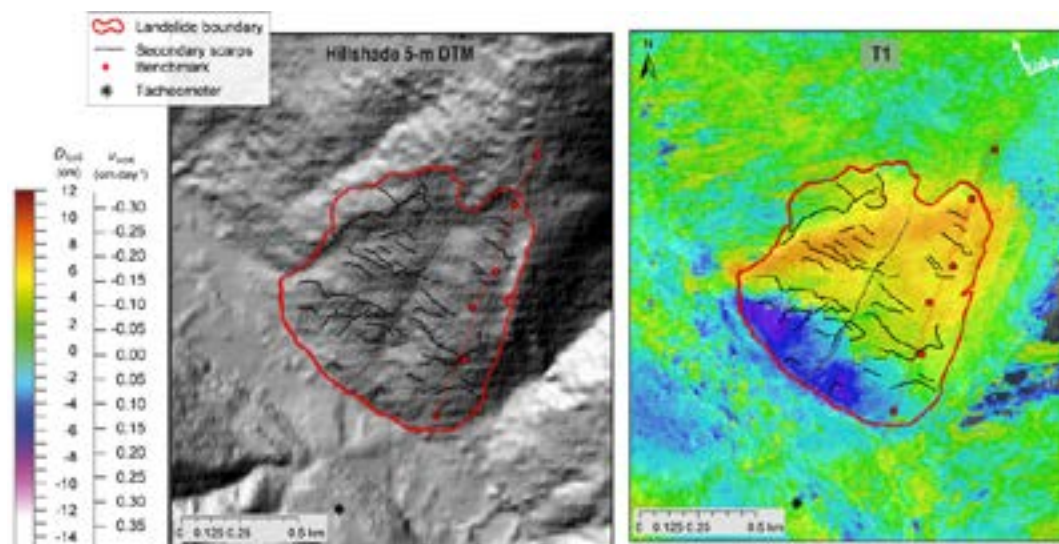


Horizontal movement of a landslide in La Valette (south-east of the Alps) between August and October 2012 by correlation of Pleiades images

SBAS-InSAR and PS-InSAR S1 differential interferometry) will be successively integrated into a processing chain optimised with the Sentinel data flow. Demonstrations will take place by 2016 for observatories, where reference data will be available. With this in mind, from 2014, a network of co-localised radar reflector corners with permanent GNSS measurements has been set up in the Alps and in the Rhine Graben. The processing methods implemented for the Theia Deformation variable will take part in the developments planned within the framework of the Form@Ter centre, including other research laboratories (Brest University, Lyon University, Joseph Fourier University).

Theia Deformation variable will take part in the developments planned within the framework of the Form@Ter centre, including other research laboratories (Brest University, Lyon University, Joseph Fourier University).

Bernard Allenbach  
(A<sup>2</sup>S - Unistra / Sertit)  
Jean-Philippe Malet  
(A<sup>2</sup>S - Unistra / Eost)  
Cécile Doubre  
(A<sup>2</sup>S - Unistra / Eost)



Deformation rate of the landslide in La Clapière (south-east of the Alps) between May and August 2007 by differential interferometry of Alos images (L band).

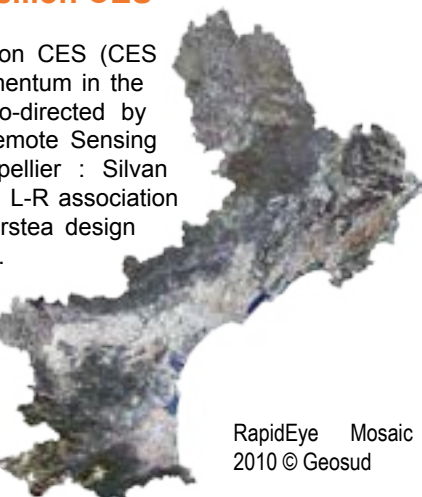
## REGIONAL CES's

### Languedoc-Roussillon CES

The Languedoc-Roussillon CES (CES LR) started gaining momentum in the spring of 2014. It is co-directed by two players from the Remote Sensing Centre (MTD) in Montpellier : Silvan Coste, leader of the SIG L-R association and Samuel Alleaume, Irstea design engineer from UMR Tetis.

The regional CES was founded in a very favourable geographical and historical context.

The Languedoc-Roussillon region has many advantages for creating an ecosystem which is suitable for the development of the use of satellite imagery. The MTD is an organization that just celebrated its 20th anniversary and which includes teams from different centres and institutes to create an applied research hub in remote sensing and geographical information. The region is equipped with many research laboratories in the fields of the environment, agriculture and territorial administration.



RapidEye Mosaic  
2010 © Geosud

Within the framework of the regional strategy of European specialisation, the Languedoc-Roussillon region defined the innovation domain «Data acquisition - processing and viewing digital data» as a priority moving towards 2020. Furthermore, the CES LR can count on the unique experience and network of the SIG L-R association, which is the oldest regional geographical information platform in France.

The first CES LR workshop took place on 14 May 2014 as part of the Geosud seminar. It put forward the need for support and information surrounding satellite imagery and the products which are derived from it. In parallel, the regional CES will also be able to contribute to developing and creating new products which are directly linked to needs expressed on a regional scale. A product such as the artificialised area created in 2009 could find a future in the CES LR. The next meeting will be organised on 12 December 2014 at Irstea in Montpellier, following a tour of a Geosud receiving antenna.



CES LR workshop, May 2014

Samuel Alleaume (Tetis / Irstea) - Silvan Coste (SIG L-R)

### Midi-Pyrénées CES

Many thematics that are dealt with by the thematic CES's depend on an existing device in the Midi-Pyrénées region: the south-west OSR (Observatoire Spatial Régional - Regional Space Observatory) ([www.cesbio.ups-tlse.fr/fr/osr.html](http://www.cesbio.ups-tlse.fr/fr/osr.html)). It is a device used to collect and analyse data using different terrain observation services (flow measurements, etc.) and remote sensing (Kalideos, etc.), the objective of which is to calibrate and validate the regional products in remote sensing of continental surfaces.

The OSR has also developed an organisational activity since 2006. In 2013, the Spot 4 (Take 5) acquisition campaign fuelled several projects which were presented in Toulouse in a seminar, which brought together nearly 80 participants, and which could be considered as an «early launch» of the Midi-Pyrénées CES ([www.cesbio.ups-tlse.fr/multitemp/?p=494](http://www.cesbio.ups-tlse.fr/multitemp/?p=494)).

In parallel, the local institutional players are becoming increasingly interested in the potential of satellite imagery, even though we haven't seen a real switch to operational use of this technology.

#### Coordination

Cerema and Cesbio volunteered to coordinate the Midi-Pyrénées regional CES, but the door is open to anyone with good will.

Cerema is a public establishment under the responsibility of MEDDE and METL. Its mission is to help institutional services in their territorial development tasks in a technical capacity. Specifically, its «satellite applications» centre helps institutional services to integrate space technologies when carrying out public policy. Cerema will therefore be the link between the CES and end users: civil service and local communities.

Cesbio will be responsible for coordinating with the laboratories, or about certain thematics (water, agriculture, etc.), especially through the activities created by OSR and the dynamics linked to creating a 'PYGAR' Workshop Zone with over a dozen regional laboratories (Insu, Inee, Inra, etc.).

#### Study subjects

The objective of the Midi-Pyrénées CES is to promote satellite acquisition campaigns, thematic operational CES's, and to look for synergies between the different players (sharing of on-site data, results, etc.) on the relevant thematics in the Midi-Pyrénées region: agriculture, forest, mountains, land cover, prairies, snow, hydrology, etc.

Coordination of the Midi-Pyrénées CES will begin simply in 2015 and will ramp up in 2016 with a training component and support for users. Its launch will take place during the first quarter of 2015, at the same time as the kick-off for Spot 5 (Take 5) action in the Midi-Pyrénées region and the launching of Sentinel 2A and Sentinel 1B.

Awareness campaigns have been planned through existing organisations: regional work group regarding land cover, Pyrenees Climate Change Observatory (OPCC - Observatoire Pyrénéen du Changement Climatique), Mixed Technological Units (UMT - Unités Mixtes Technologiques), etc. Depending on requirements, specific events will be organised for targeted subject matters (agriculture, water, land cover).

Jean-François Dejoux (Cesbio / CNRS)

Olivier Hagolle (Cesbio / Cnes)

Jacques Bouffier, Dominique Hebrard (Cerema)



Influence of the Spot 4 (Take 5) campaign (February to June 2013) in the Midi-Pyrénées region.

## Aquitaine CES

Setting up an organisation that brings together the Aquitaine region's main strengths in remote sensing had already been initiated through the OASU (Observatoire Aquitain des Sciences de l'Univers - Aquitaine Observatory of the Sciences of the Universe) thanks to the ASTT (Action Scientifique Transverse Télé-détection - Remote Sensing Transversal Scientific Action) as early as 2010. ASTT organised and brought readability to this remote sensing network during the 2010-2014 period, which means that the Aquitaine region is one of the major regional centres on the national scale. The work of the Aquitaine CES is focused on the major issues of the impact of human activities and/or climate change on the biosphere, and in particular on:

- the evolution of biodiversity, water quality monitoring (Bay of Arcachon, Gironde estuary), erosion monitoring (Aquitaine coastline);
- monitoring the productivity and state of health of the forest cover (Landes forest) and agriculture (vineyards, large-scale farming) with respect to extreme events or climate trends over the long term (storms, heat waves, dieback);



Vineyard planting practices: finished (left), 1 row out of 2 (right). Image courtesy of Pleiades «Entre deux mers» from 15/04/2014 / Corresponding views on the ground!

## Alsace CES

The objective of the A<sup>2</sup>S programme - Alsace Aval Sentinel - which is a regional initiative organised by Sertit for the University of Strasbourg, is to develop a regional multidisciplinary research centre focused on exploiting the massive stream of Earth Observation images and setting up an added-value production centre which specifically uses the data from the Sentinel constellation.

The A<sup>2</sup>S programme includes three components which take the form of projects: a research and training component, a production component focusing on both the tools and their use, and an economic development component based on the exploitation of the data provided by the Earth observation images.

The Alsace regional CES (label still to be validated) is at the heart of the research and training of the A<sup>2</sup>S programme. This consists in a voluntary gathering of scientific partners within the framework of national coordination of Theia. This gathering is made up of the research laboratories, observatories and engineering schools of the University of Strasbourg, specialised in the fields of remote sensing, imagery, geodesy and engineering, exploiting satellite imagery for the analysis of many thematic domains in Environmental sciences and Earth sciences.

The research teams participating in the programme are members of Icube (Laboratory of the engineering, computing and imaging sciences, UMR 7357) with the following teams in particular: BFO (Theoretical biocomputing, data mining, and stochastic optimisation), MIV (Models, Images and Vision) and Trio (Remote sensing, Radiometry and optical imagery), at the Live (Laboratory Image City Environment, UMR 7362) at the Eost (School and observatory of the Sciences of the Earth, UMS 830). The programme also includes the TPS engineering school (Telecom Physics Strasbourg) and Engees (National School for Water and

These activities can rely on many resources in terms of methods and study subjects in the Aquitaine region workshop site, which is where services get demonstrated (Cnes/Kalideos label, site Spot4 (Take 5), etc.). The whole length of the spectrum (optical, thermal infra-red, active/passive microwaves) and all the techniques (multi-spectral and hyperspectral remote sensing, multiple acquisitions (stereo mode, etc.)) are covered across a large range of spatial resolution: Very High Resolution (Pleiades, Geoeye, etc.), High Resolution (Spot, Rapideye, etc.), Medium Resolution (Spot/Vegetation, Modis, Meris, Palsar, Radarsat 2, etc.) and Low Resolution (Smos, Smap, etc.), with an update frequency going from a day to a year depending on the system.

The Aquitaine CES maintains a healthy relationship with the Aeronautics, Space and Embedded Systems Centre (Aerospace Valley), and also works closely with many socio-economic and industrial players in the Aquitaine region. Specifically, the GIP Littoral, the GIP ATGeRi (with the PIGMA platform since 2008), SIBA, Cete, BRGM, IGN (including the forest inventory), the Department of Forest Health (DSF) from the French Ministry in charge of the forest, the wood-cutting trade, the Earthlab Aquitaine project by Telespazio, i-SEA, etc., are very active in exploiting geographical information and contribute alongside the Aquitaine CES to the coherent description of the area and its changes (coastline, catchment areas, agricultural areas, forests, urban areas, etc.) on a strategic and operational level.

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Environmental Engineering in Strasbourg). The HPC (High Performance Computing) hub from the IT Department of the University of Strasbourg is also associated with this project, joining the University Calculation Centre in the production component. The applicability aspect, piloted by Sertit (Service Régional de Traitement d'Image et de Télé-détection - Regional Services for the Processing of Imagery and Remote Sensing), is backed by the different laboratories on site (Live, Eost, Engees), through proposal of and/or participation in several product CES's (Deformation, Urbanisation, Changes, Water surface, Land cover).

The training aspect, within the University of Strasbourg, relies on the OTG (Observation de la Terre et Géomatique- Observation of the Earth and Geomatics) and Iriv (Imagerie, Robotique et Ingénierie pour le Vivant - Imagery, Robotics and Engineering for Living Things) Masters' degrees, as well as on ad-hoc teaching from professionals and public operators, or thematic schools (Image Mining Summer Schools).

Within the framework of the A<sup>2</sup>S programme, the objective is to develop the research and training component by formalising it through national and international research instruments

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