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## A word from the Scientific and Technical Directors

Theia is doing well.

Two new partners - CEREMA and ONERA - have joined the nine original founding-partner institutions. CEREMA's membership confirms that Theia is now targeting public policy-makers in addition to the scientific community, while ONERA's has brought not only airborne remote sensing data to Theia but also the research agency's scientific and technical expertise.

The scientific expert centres have been consolidated, with some of them entering a pre-operational phase next year. The regional expert centres have changed their name and are now called Theia regional coordination networks, abbreviated ART (for Animation régionale Theia).

An institutional remote sensing sector is gradually being built up. The first component, founded by six Theia partners, will be exploiting SPOT 6/7 data via the Geosud direct receiving station in Montpellier. Inter-organisation discussions will continue with the joint promotion of imagery from Pleiades, the SPOT World Heritage programme and, in the future, the Sentinel-2 satellite.



Nicolas Baghdadi



Marc Leroy

## LATEST NEWS

### Sentinel-2 launch

The long-awaited launch of ESA's first Sentinel-2 satellite took place on 22 June 2015, with the second satellite planned for the autumn of 2016. Once the constellation is complete, it will supply unprecedented optical imagery with the following four characteristics:

- Resolution : 10 to 20 m depending on the frequency band
- Coverage : all land surfaces
- Revisit frequency : each pixel will be observed every five days from a constant angle
- Spectral range : 13 bands, from 450 to 2200 nm

Dissemination of the first data should begin in late 2015, with data being both free of charge and freely accessible. The availability of these data should revolutionise the use of optical imagery, since users will be able to count on cloudless observations being available at least once per month in most cases. From early 2016, the Theia cluster will be providing users with **more advanced products** than those available at ESA i.e. data corrected for atmospheric effects (N2A) and monthly syntheses of surface reflectance (N3A).

Oliver Hagolle (Cesbio / Cnes)



Sentinel-2A's first image of north-western Italy and the south of France © ESA

### Theia CS meetings

The first Theia CS Scientific Committee meeting was held at the Maison de la Télédétection in Montpellier on 13 March 2015. There was much discussion about strategic issues for the Theia cluster concerning governance, image products, progress with the SPOT World Heritage programme (SWH), atmospheric corrections of Sentinel-2 data, the CES scientific expert centres and corresponding thematic products, the SPOT 6/7 component and the in situ and airborne data component. The committee's main recommendations are outlined below :

- The CS would like the SPOT archive concerned by the SWH programme to be extended to include imagery three years old or more rather than five years old or more as is currently the case.
- The CS would like Pleiades imagery to be made available sooner.
- The CS wholeheartedly supports the cooperation between ISIS and the SPOT 6/7 component in order to offer users a single contact point for requesting images.
- The CS recommends drawing up a call for tender for the choice of zones for which Sentinel-2 imagery will be corrected for atmospheric effects.

- The CS confirmed the usefulness of in situ data for Theia and recommends that the cluster coordinate with the SOERE and AllEnvi networks.
- The CS approves Theia's intention to encourage discussion on integrating airborne data into the Theia infrastructure.

A second Theia CS meeting was held at CESBIO in Toulouse on 13 May 2015 to analyse the maturity of CES products and their interest for the user community. CESs which are considered to be mature are :

- Land Cover : Jordi Inglada (CNES / CESBIO)
- Biophysical vegetation parameters : Frédéric Baret (INRA / EMMAH)
- Snow-covered surfaces : Simon Gascoin (CNRS / CESBIO)
- Mapping of the deterioration of forested areas using Sentinel-1 data : Thuy Le Toan (CNRS / CESBIO)

Nicolas Baghdadi (Tetis / Irstea)

### SPOT 6/7 2014 coverage and 2015 acquisition campaign

Images of metropolitan France from 2014 have been online since January 2015 and were printed on 9m x 9m plastic-covered tiles that were recently assembled on the ground at the geography festival of Saint-Dié-des-Vosges.

The 2015 campaign took place under the auspices of the new Geosud direct receiving station. The sterling efforts of consortium members made it possible to make up for the campaign's late start (early April instead of early March as initially planned).

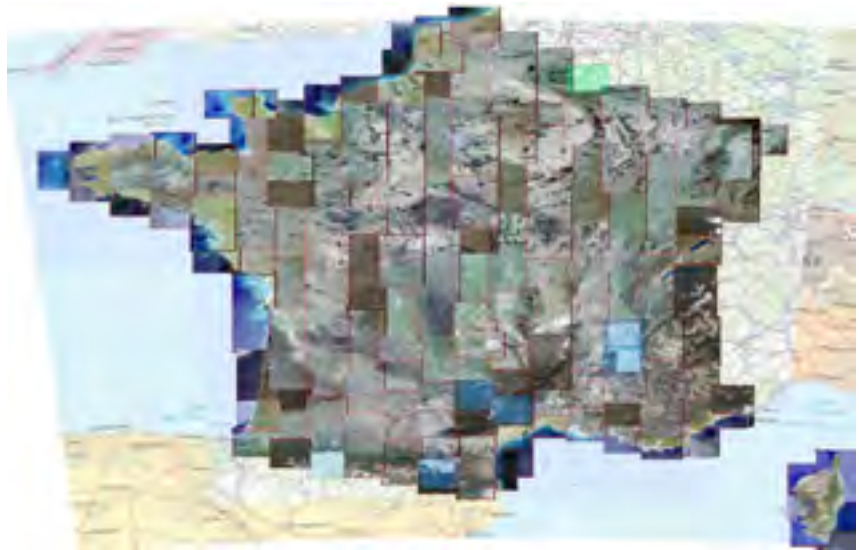
### Pleiades 2015 acquisition campaign

The 2015 campaign had four main objectives :

- Complete the coverage of French Guianese zones undertaken in 2013.
- Cover for the second consecutive year the sandy beaches along the shoreline in stereoscopic viewing mode to enable time series monitoring.
- Perform stereoscopic acquisitions for urban applications and to update the vector database.
- Perform stereoscopic acquisitions to monitor major public works (LGV high-speed train tracks).

The 2015 Pleiades campaign suffered from competition from Copernicus coverage, and only 90% of the programme will be achieved.

Jean-Paul Sempère (IGN)



2015 acquisition campaign: 230 grids out of 237 were acquired in 174 segments by 21/10/15



**Legende :**

Available images

WorldView 2011	Pleiades 2012-2013-2014
In programming	

Coverage of French Guianese zones



Pleiades coverage on 28/09/15



## Spot 5 (Take 5)

To help users become accustomed to the Sentinel-2 time series, CNES - on CESBIO's proposal and with the full backing of ESA - renewed the Take5 experiment with the SPOT 5 satellite from 8 April to 15 September 2015. At the beginning of April, SPOT 5 was lowered by 2 km to place it on an orbit with a five-day revisit frequency (i.e. SPOT 5 flies over exactly the same place once every five days). From this orbit, a time series of optical images with characteristics similar to that of the Sentinel-2 mission were acquired for 150 sites. All of them were observed from constant viewing angles every five days with a resolution of 10 m in four spectral bands.

The data corrected for atmospheric effects and accompanied by a cloud mask are accessible on the experiment's data server : [www.theia-land.fr/fr/produits/spot-5-take-5](http://www.theia-land.fr/fr/produits/spot-5-take-5)

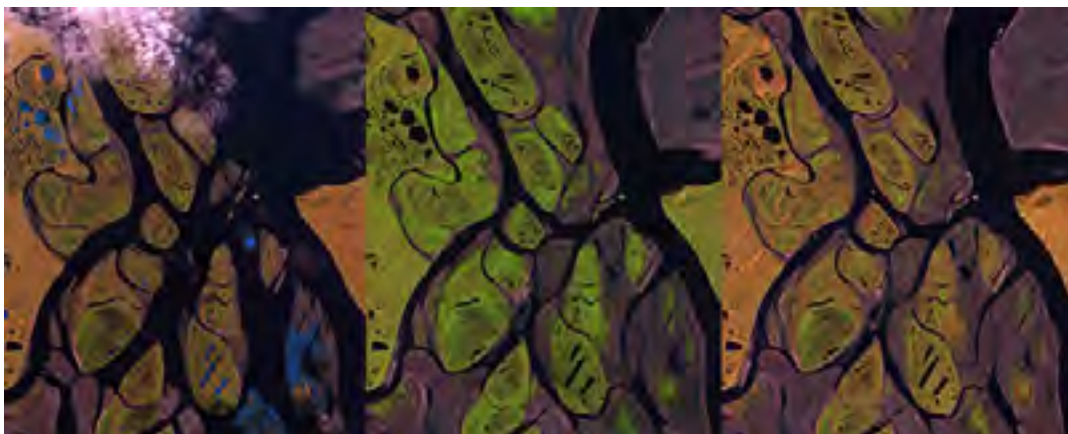
Oliver Hagolle (Cesbio / Cnes)

## Creation of the Breton ART (ART Bretagne)

The recently created ART for the Brittany region is being run by BreTel, the Breton remote sensing scientific interest group, made up of nine academic or institutional bodies conducting scientific research in various disciplines and areas of interest, such as sensors, methodologies, the Earth, shoreline and oceans. Consequently, the BreTel scientific interest group would like to represent Theia in the region through three activities.

The first, managed by **Laurence Hubert-Moy** (Costel), involves coordinating the scientific community, which will support BreTel's current activities and promote synergy with other organisations that might be interested in Theia themes.

The second activity, coordinated with the Brittany Regional Contact Office (RCO) for which BreTel is the scientific expert, concerns «discussions with regional management stakeholders» and will be managed by **Nicolas Bellec** (Telecom Bretagne). The objective is to promote satellite applications among these stakeholders and identify available services.



Extract from the time series of images acquired in August and September 2015 by SPOT 5 during the Take5 experiment. Lena Delta, Russia© CNES

Finally, **Hervé Nicolas** (Agrocampus Ouest) will supervise the training activity based on BreTel's initiative to create a multi-site and multi-disciplinary Master's degree in remote sensing and the environment. A vocational training project is also being considered to complement this initiative while targeting known and potential users.

Nicolas Bellec (GIS BreTel)

## Creation of the PACA ART (ART PACA)



Since last April, the Theia regional coordination network in Provence-Alpes-Côte d'Azur (PACA) is being run by **Philippe Rossello** (GeographR), an engineer specialised in spatial analysis and forward planning who has in particular worked at INRA's EMMAH mixed research unit.

The aim is first of all to mobilise regional stakeholders by describing in detail the Theia land surfaces centre and the potential of remote sensing through examples of applications. An initial meeting has been scheduled for March 2016 at the Arbois technology centre in Aix-en-Provence. It is being organised jointly with CRIGE-PACA - the PACA regional centre for geographic information—in order to encourage the use of satellite imagery covering landmasses, and give a regional impetus to data producers and users.

Research laboratories, companies, local and regional authorities and associations will be invited to play an active role during this first meeting and to express their needs (data acquisition, uses, technical and scientific support, training, etc).

The aim of the PACA ART is to create synergy between regional stakeholders, to make image processing techniques accessible and to create a forum for discussion and exchanges on a regional scale.

Partners outside the PACA region will also be called upon to consolidate the actions and knowledge.

Philippe Rossello (GeographR)

## AllEnvi CVT information seminar

On 14 October 2015, the information seminar on the precision farming study conducted by the AllEnvi Environment Alliance CVT (a consortium for thematic knowledge exploitation) was held on the Agropolis site in Montpellier.

The day-long seminar was intended for suppliers of farming technology and services, managers of transport facilities, academic researchers, cooperatives, distributors of agricultural machinery, the food processing industry, producers, agricultural brokers, institutions and administrations, suppliers of agricultural inputs and seed producers, insurance companies, emergency services, decentralised government departments, technology transfer accelerators, competitiveness clusters, Carnot institutes and University research groups among others.

The detailed programme is available at: [www.cvtallenvi-observationenvironnementale.fr/programme](http://www.cvtallenvi-observationenvironnementale.fr/programme) ; There were six poster presentations during the event.

These presentations were given to the participants. The report will be circulated in the next few weeks: you may register by sending a request to [contact@cvt-allenvi.fr](mailto:contact@cvt-allenvi.fr) if you wish to be kept personally informed.

François Christiaens (CVT AllEnvi)



### Harnessing satellite data for Research and Public policy

On 1 and 2 June 2015, the Theia thematic centre for land surfaces and Equipex Geosud held their first joint seminar in Montpellier on the theme of «Harnessing satellite data for Research and Public policy». The aim of the seminar was to present the potential for using satellite images via the products and services offered by the data infrastructures and services of Theia and that of its component Geosud.



The seminar proved a great success, with 150 participants for each of the two days: 57% were scientists, 18% represented institutions and 11% were manufacturers. Many organisations sent delegations, including their managers and researchers. Many government services from the Languedoc-Roussillon region (such as the DREAL, DRAAF, DDTM, and DDT) and from French ministries participated (e.g. the MESR, MEDDE and MAAF), proving the great interest and expectations of scientific communities and public stakeholders.

The seminar presented products and services currently available (including national coverage, SPOT 6/7, Pleiades, Landsat and SPOT archives from the SWH programme) or soon to come (Sentinel-2). Added value products being developed in the Theia CES scientific expert centres were presented and thematic workshops on land use, economic models, agriculture/water, and vegetation/forests were organised.

Many satellite imagery applications that were presented either as oral or poster sessions included feedback from various communities. Given the various needs for support expressed by user communities, there was a debate on the training offer for remote sensing and image processing between Marie Christine Bois (AgroParisTech) and Jean Paul Rudant (University of Paris Est Marne La Vallée).

A roundtable review of the economic model was organised by



Yves Riallant (AFIGEO). Like last year, the review and subsequent discussions were very lively. The challenge lies in sustaining the efforts already made and opening up to the private sector arrangements that were designed solely for the public sector. It appeared that the best way forward for the future would be to maintain the operation of a Data and Service Infrastructure supported by public funding, while developing an innovation ecosystem operating as a network linking players of various origins, including public stakeholders, decision-makers, private stakeholders and scientists. The question of a trade-off between data made available free of charge (which implies that public authorities will have to pay upstream) and setting prices for the actual costs, was extensively debated.



Finally, the report of the survey on uses of satellite imagery, conducted in order to better target current and potential expectations, was presented during the seminar. The 100 or so responses to the questionnaire revealed that remote sensing is widely used by the respondents and is highly diversified in terms of applications and the technicity of processing. The results revealed a persistent difference between the technical possibilities offered by remote sensing on the one hand and the actual use made of images on the other: this difference has encouraged Theia to pursue its efforts with respect to information, communication and facilitating access to processing. This is in keeping with the need to develop technical support, no doubt including the possibility of developing a private services offer.

**Theia-Geosud seminar organisation team**  
N.Baghdadi, P.Maurel, M.Leroy, S.Ayoubi, C.Tailleferie  
C.Martignac et E. Bappel





## Collective strategic analysis on environmental observation technologies for agriculture and natural hazards

France's Environment Alliance, AllEnvi, federates public research efforts in order to programme and coordinate French scientific strategy on environmental issues. Its mission is to meet the major scientific challenges concerning food, water, the climate and the environmental quality of French regions.

Created in 2013 with financial backing from the FNV fund to support knowledge exploitation under the French PIA future investment programme, the AllEnvi thematic knowledge exploitation consortium, CVT, is tasked with economic intelligence. The AllEnvi CVT initiates and undertakes studies to analyse the background for research and the economic context in areas that AllEnvi works in so as to identify strategic guidelines for research by AllEnvi members. The long term aim of these AllEnvi CVT studies is to add value to research results and transfer them within five to ten years. The AllEnvi CVT- a team of six specialised people supported by thematic and professional experts among AllEnvi's membership - draws on specific skills and tools which enable the team to undertake original studies combining research and innovation, technology, societal changes and markets. These studies are intended for public research stakeholders, their knowledge exploitation and transfer structures, as well as to private research stakeholders to encourage the setting up of partnership projects.

For a year now, a team of AllEnvi experts has been studying environmental observation technologies for agriculture and natural hazards. The specific context for the study is that of the Copernicus programmes (€3.7 billion between now and 2030; impact studies evoke the creation of 50,000 jobs in Europe) which give players other than research scientists access to Earth observation data supplied in particular by the Sentinel satellites and UAVs which enable dynamic investigation of environments; another facet concerns the fact that an increasing number of countries have gained access to space and are developing and/or integrating technologies related to environmental observation.

### Challenges

The challenge for AllEnvi is to stimulate partnerships between the public and private sectors and orient cooperation towards segments with a major potential for innovation.

The challenge for researchers is to promote proficiency in Earth observation technologies, which is essential for scientific research and the development of services. Technology transfers should make it possible to sustain and develop the skills and know-how required to address natural hazards and agricultural issues.

### Methodology

The successive steps of a study consist in :

1. Studying target markets by linking market surveys, interviews with industrial stakeholders and academic experts and by facilitating work groups made up of scientists and sector-specific experts. For this particular study, the focus was on precision farming and insurance markets among others ;
2. identifying and analysing research laboratories and industrial stakeholders, their skills and technology on the basis of bibliometric studies and/or patents ;



3. Summarising this information so as to produce a benchmark in terms of industrial partnerships and research and development themes.

For the study devoted to Earth observation technologies for agriculture and natural hazards, the technological fields involved are those of sensors and corresponding methods, data processing and help in interpreting data.

### Workshops

The AllEnvi CVT studies in particular offer the opportunity of comparing the needs of socio-economic players (manufacturers, public authorities, etc.) and the lines of research undertaken by AllEnvi members. During a workshop on 3 April 2015, the AllEnvi CVT brought together 20 people (with as many researchers as economic players) around the use of observation technologies to address natural hazards.

Starting with a description of a twofold context of natural hazards on the one hand and Earth observation on the other, a debate was held on the observation sector with a focus on the prevention and management of natural hazards: far from constituting a homogeneous field, it appears that the value chain has been broken down into innumerable sectors each with specific needs. It was nonetheless possible to identify some generic needs, whether related to water or the monitoring of infrastructures; in the field of insurance, a more refined analysis will be necessary, but the market is still sluggish with respect to observation data in general and satellite data in particular.

French research - ranked among the top three in Europe along with Germany and Italy, and in the top five worldwide behind China and the United States - is in a good position for both major themes such as geosciences, meteorological and atmospheric science, and promising themes such as water resources and physical geography.

Another workshop was organised on 9 September on precision farming. The gains and costs related to the moderation of farming inputs were identified and obstacles to the identification of satellite solutions discussed. This developing market will continue to expand rapidly and the needs of stakeholders have already been discerned as the interpretation of measurements for specific applications and improvement of models. These needs have been expressed as technical parameters.

François Christiaens (CVT AllEnvi)

## National data clusters are evolving

The national data clusters for geosciences provide a set of services and information based on in situ or space observations acquired by satellites or other spaceborne means. They are primarily intended for the French scientific community, but may also serve other users (international scientific communities, public policy makers, the private sector, education and training, etc.).

In 2014, a think tank mandated by CNES and the CNRS drew up a new roadmap for the national data clusters.

This development is mainly motivated by the following :

- scientific considerations : the geosciences are based on increasingly integrated approaches to the Earth system and its compartments, requiring multi-source and multi-variable information; new observation systems already in place or in the offing will meet the needs for observation continuity, in particular for environmental monitoring ;
- technical considerations : the huge increase in volume and the wide range of observations require the redefinition of the corresponding means for processing, accessing and archiving these data and for providing and sharing expertise ;
- institutional considerations : programmatic rationales and governance have evolved in France (with inter-establishment approaches and alliances), in Europe (the Copernicus programme and EU research infrastructures, in addition to joint development strategies set up by ESA or EUMETSAT) and internationally (coordination by GEO or the WMO, etc.).

Furthermore, it is necessary to maximise the use of institutional observation infrastructures and derived information and to push back the boundary beyond that of experts working on data in the realm of measurement physics to reach new users also working on data.

The proposals resulting from this think tank include :

- organisational elements, including :
  - the definition of a European strategy for national

data clusters, taking into account what the French systems can contribute to Europe and vice versa ;

- the creation of four national data clusters for the atmosphere, oceans, land surfaces and solid Earth, built on existing resources and integrating the data acquired from spaceborne instruments and in situ observations coherently. The Theia Land Data Centre is the national data cluster for land surfaces ;
- simpler and clearer governance and executive functions for the data clusters, as well as inter-cluster coordination to address interface issues and pool functions and developments ;
- creation of a transfer rationale from data clusters to national or European operational services while ensuring that transfers do not degrade the quality for research purposes ;
- clarification of the role of private structures, whether as regards their contribution to data cluster activities or as users of the data clusters' information and services ;
- adding value to data cluster information for training and by circulating it to the general public, while taking into account new information and communication technologies ;
- technical aspects, and in particular the :
  - importance of simplifying access to data, in compliance with standards (particularly European standards), principles and usage ;
  - introduction of a national approach to archiving data taking into account the short, medium and long term (future sustainability);
  - use of new Big Data-related technologies such as the cloud and semantic web which will make it possible to pool data processing and archiving systems, and to decentralise activation of certain functions by users.

The plan is for these proposals to be implemented in the medium term (typically before 2018) following the ongoing definition phase.

Alain Podaire (Mercator / Cnes)



Conceptual diagram showing four data centres each with its own focus (the atmosphere, ocean, land surfaces and solid Earth) © CNES

## Aeris Atmosphere Cluster

The Aeris atmosphere data and services cluster was created on 16 December 2014. It has a fully operational management team including the managers of its four data and service centres. It gathers and manages all atmospheric data (in situ observations, campaigns, satellite data, model outputs with the exception of the GCM). The main challenge when the cluster was created was to raise its profile both nationally and within Europe. It is supported by the following organisations: CNRS, CNES, Météo-France, Lille 1 University, the Nord Pas de Calais region, Paul Sabatier University, French atomic energy agency CEA, the Pierre and Marie Curie University (TBC), Ecole Polytechnique, the IGN and IRD.

Atmospheric research mainly concerns atmospheric dynamics, meteorology and atmospheric chemistry. It includes studies that focus more on climate change. This community is quite well structured in frequently large laboratories that are themselves players or stakeholders in community structures such as the Universe Science observatories and federations. Its two thematic expert centres, ICARE and ETHER, were created several years ago. Among others, campaign data are managed by the Midi-Pyrenees Observatory's SEDOO data service and the IPSL's ClimServ service which comes under the IPSL's ESPRI project. Sixty percent of the observation services certified in the 1990s are linked to international networks. The data are most often processed in the laboratories, then transmitted and integrated into international databases in addition to their national website. This organisation has federated a significant number of engineers, technicians, administrative staff and researchers, often with various complementary professional backgrounds and skills.



The creation of the atmosphere data and services cluster has consolidated this system. It is built around four data centres or services which are defined as having collective data management facilities for ICARE, IPSL-ESPRI's ETHER and ClimServ, the OMP's SEDOO and finally, SATMOS - the satellite observation data meteorological processing and archiving service run by Météo-France. The cluster also includes laboratories, laboratory networks (SOORE) and expert centres that are indispensable components of a data cluster for developing algorithms and prototyping.

Consequently, all the missions of a data cluster are fulfilled, with a single entry point, compliance with standards (this homogenisation of practices will be a gradual process and one of the cluster's main challenges) and value being added to all data, whether in situ, campaign, satellite or modelling data.



In order to achieve these aims, one important development with respect to existing facilities will be to have effective governance, i.e. more than mere coordination. In addition to a steering committee whose standing members are organisations and institutions contributing human and financial resources to the cluster, the cluster will be run by a management team made up of four people: N. Papineau (Director), A. Lifermann (space project manager), B. Legras (science project manager) and F. André (technical manager). The team will also include a CNES project head to monitor CNES activities, supported by an executive office responsible for decision-making. In addition to the people mentioned above, the executive team will include the technical managers of the four data and service centres: C. Boone (IPSL-ESPRI), D. Boulanger (OMP-SED OO), J. Descloitres (ICARE mixed service unit) and D. Levailant (SATMOS-CMS). To help the cluster define its data strategy, it has a Science Council chaired by B. Legras and made up of scientists with insight into user needs and capable of defining strategic priorities. The members (approximately ten) are chosen according to their expertise in atmospheric and climate science.



To conclude, the atmosphere data and services cluster is already being implemented. In addition to pursuing the activities of the four centres, it coordinates multi-centre actions and develops mutual tools. This satisfies the first priority of raising the cluster's profile within France and Europe, whether through the ACTRIS-ERI project under ESFRI or through the Copernicus project for atmosphere or climate services. We are not forgetting forthcoming space missions such as EarthCare, Sentinel and evermore multi-satellite products. Please do not hesitate to contact the cluster's management for further information.

Nicolas Papineau (IPSL)





To meet the challenges of the 21st century, it is essential to investigate the “Earth System”, the physical environment from its core to the confines of the atmosphere, along with interactions and feedback between it and the living environment. Such research is supported by observation, experimentation and modelling. Our knowledge is expanding thanks in particular to the analysis of satellite data. To fully exploit this unprecedented input, the data must be processed, archived and disseminated. This is why four national clusters are being set up, each addressing one of the four major components of the Earth system - solid Earth, oceans, land surfaces and the atmosphere. Benefitting from the legacy, culture and approach of each field, these clusters are currently at different stages of maturity and development.

The solid Earth science cluster is currently under construction. The first brick has been laid with ForM@Ter (URL [poletterresolide.fr](http://poletterresolide.fr)) in conjunction with the national research infrastructure RESIF and the European Plate Observing System, EPOS. It is based on existing data dissemination structures. ForM@Ter is tasked with facilitating access to data and the use of products to investigate the Earth’s shape and movements. It is designed for the solid Earth scientific community and other scientists investigating the Earth system and needing its products for their own objectives. At first it will focus on ground movements using optical imagery, radar interferometry data, GNSS observations and information on velocity and calculation tools.

Michel Diament (IPGP / Paris-Diderot University)

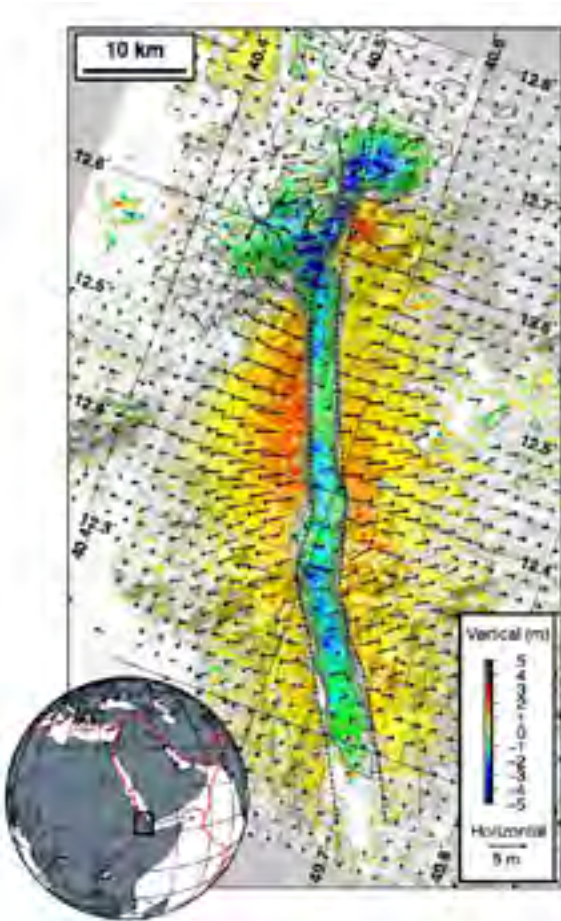
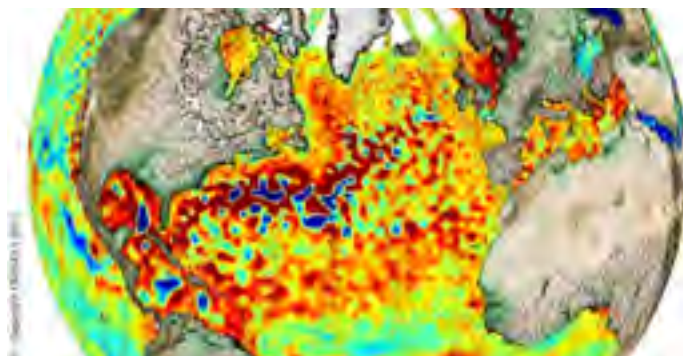


Illustration of deformation in Ethiopia obtained from InSAR analysis correlated with optical imagery © R.Grandin

### Ocean Cluster

The Ocean cluster’s general objective is to promote and facilitate the use of observations made either in or at the ocean’s interface with other environments, whether using in situ or remote sensing resources (radar, airborne or spaceborne equipment). The Ocean cluster will help describe, quantify and understand the ocean as a whole, especially ocean dynamics, changes in its physical and chemical properties, bio-geo-chemical cycles and the workings of marine ecosystems. It will also address coastal topics such as estuaries and lagoons that bear witness to morpho-dynamic changes to the shoreline, sea level, pollution, eutrophication and changes in coastal ecosystems.

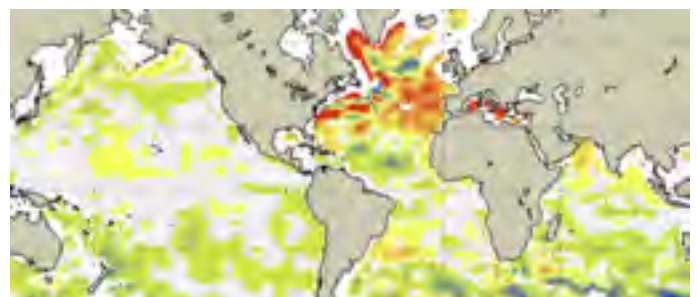


The Ocean cluster will unite two approaches to ocean circulation under the same thematic focus. The sea level anomaly derived from AVISO altimetry (above) shows variations in surface current, while ARGO floats are used to plot three-dimensional temperature and salinity fields (opposite) which provide information on the evolution of water masses and vertical structure of currents. By bringing both data sets together within the Ocean cluster, users are offered all the variables describing the properties of water masses and their circulation.

Partner data centres have been identified and the cluster is tending towards final constitution of the governance structure. As soon as the teams have been defined, they will begin operating. The goal is to remove obstacles related to time, space and discipline by implementing methods that will promote interoperability between data sets. The inventories completed will be used to define the major data groups for which common vocabulary and standards will be established. The implementation of such basic guidelines will enable us to manage databases spread throughout France. A particular effort will be made to develop tools for accessing data sets in order to encourage the combined use of different kinds of observations (in situ or satellite data, for example) or different sources (such as deep sea or coastal networks).

Alongside this background activity to make available national data sets and access to international databases, the cluster will develop thematic focuses gathering data, information and products on subjects of interest to the community. The first themes will focus on sea level, ocean circulation and water masses, the water cycle, the carbon cycle, the impact of climate change on coastal ecosystems, habitats and the shoreline.

Fabienne Gaillard (LPO / Ifremer)





## SPOT 6/7 component

In the last Theia bulletin of December 2014, we told you about the Geosud direct receiving station on the IRSTEA site in Montpellier, run with the IRD. This station consists of a receiving antenna, an initial terminal for receiving data from SPOT 6/7 satellites and an operations room for managing the station and programming image acquisitions with Airbus Defence & Space (ADS). This component of the Theia data and services infrastructure made huge progress in 2015.

### Telemetry contract and expression of needs

Six organisations - CIRAD, CNES, CNRS, IGN, IRD and IRSTEA - decided to join forces within a consortium managed by IRSTEA in order to purchase a given volume of SPOT 6/7 telemetry from ADS over a five-year period, the goal being to exploit these data in order to construct and disseminate images and derived products. The contract and consortium agreement were signed on 18 June at the Paris Air Show in the presence of Ségolène Royal, Minister of the Environment. The contract is based on a telemetry credit system which can be used to pay either for programmed acquisitions inside or outside the Geosud station's receiving footprint or for archived SPOT 6/7 images already available in the ADS catalogue. The 600 credits for the basic contract may be extended by additional batches of 50 credits on condition that the corresponding budgets are available. The consortium remains open to new partnerships.

Once the contract had been signed, we were able to begin preparing the SPOT 6/7 and Pleiades programming requests made by users during an initial survey of needs in the spring of 2015 then subsequently expressed one at a time using an [online form](#). The IGN took care of requests from public stakeholders and the 2015 national coverage, while CNES handled those from the scientific community for Pleiades images under the ISIS programme. The *Maison de la Télédétection* in Montpellier managed requests from the scientific community for SPOT 6/7 imagery.

This work required the participation of several people for preparing the programming requests, the planning group for summarising the requests and making trade-offs, the two operators from the Geosud station's operational staff for programming acquisitions and manufacturing products in collaboration with the ADS programming department and IGN Espace personnel for acquisition of the annual 2015 coverage. It was often necessary to discuss requests with users in order to better grasp their needs and then find suitable solutions or even reduce the volumes requested in order to better manage expenditure of credits. For this first year, draft developments using Excel as well as structured management of request files (Excel forms, KML files) and e-mails facilitated the handling of requests.

### On the whole, the provisional review of the 2015 campaign is very positive

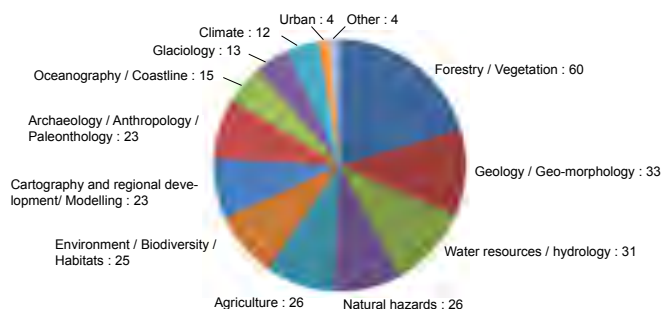
Acquisition of the 238 grid cells for the 2015 national coverage (mainland France and Corsica) was finally completed on 2 November after twice relaxing the angular constraints. This task was managed by IGN, ADS and the Geosud receiving station operational staff on the basis of specifications drawn up by the IGN. The acquired segments were orthorectified by IGN Espace as they became available in order to make the national mosaic accessible before the end of 2015, as was the case for the 2014 coverage. The single orthorectified segments will be available on the Geosud v1 IDS (data and services infrastructure) in early 2016. Further acquisitions of French overseas regions and communities will be made in late 2015 to early 2016.

New, more precise planimetric and altimetric reference systems, produced by IGN in partnership with ADS, were integrated into the SPOT 6/7 terminal during the autumn.

By 15 November 2015, over 220 user-specific acquisition requests had been received and processed, of which 205 were for SPOT 6/7 images. The latter requests were mostly (93%) from the scientific community, while the others (7%) were from public stakeholders. Over 2/3 of these requests were satisfied by purchasing SPOT 6/7 images from the ADS archives, the rest by dedicated programming. Two thirds of these requests concerned areas outside the Geosud direct receiving station's footprint.

The scientific requests for ad hoc SPOT 6/7 images (whether programmed or from archives) submitted for the 2015 campaign may be broken down as follows between the three thematic clusters.

	Total number of ad hoc SPOT 6/7 requests in 2015	Number of requests not followed through	Total estimated credits	Average number of credits per request already delivered by 15/11/2015
Theia	131	16	192.8	2.7
Form@ter	44	5	96.7	5.9
Océan	13	4	8.5	1.5
Total	188	25	298	3.4



Breakdown of requests by type of application

In support of the consortium's pooling of efforts, 30 or so of the 2015 requests were satisfied with Geosud national coverage imagery (2010 to 2015), saving 50 to 65 credits compared to dedicated programming acquisitions in 2015.

Furthermore, maximum advantage is being taken of the consortium's status through the "all public stakeholders" licence for the reuse of national coverage. For example, 1,809 images from the 2014 coverage and 4,700 tiles from its 8-bit mosaic have already been downloaded by 196 different users via the Geosud portal and the IGN Geoportal, which represents a gain factor of 12 for imagery and 20 for the 8-bit mosaic.

Finally, analysis of the 2015 requests for national coverage imagery from 2010 to 2013 shows that there is continued interest in these data sets for applications aiming to measure changes over a period of several years.

The next quarter will be devoted to putting products from the 2015 campaign on line in the new version of the Geosud IDS and the 2015 national coverage products on the IGN's Geoportal. We shall then be able to kick off the 2016 campaign while working this time in close cooperation with the ForM@Ter and Ocean clusters to quickly create a unified national system providing access to SPOT 6/7 and Pleiades imagery.

Pierre Maurel (Tetis / Irstea)

## Spot World Heritage

Spot 1 – 5 is a CNES programme, the last satellite of which has now ended its commercial exploitation. A new phase is beginning for this programme, called Spot World Heritage, whose overall goal is to make those images deemed to be of interest available to the public.

About 25 million Spot data have been acquired in 30 years, between 1986 and 2015 :

- About 7 million archived in CNES Toulouse.
- About 13 million archived in direct receiving stations worldwide, which are currently being transferred to CNES Toulouse.
- About 5 million archived in direct receiving stations worldwide, which are not believed to be easily transferable to Toulouse (format compatibility, data losses, ...).

The data archived in Toulouse or in stations cannot be exploited directly, they must be first converted to raw or orthorectified images. The overall goal of SWH is to make the data available to the public in an appropriate image format.

### SWH Principles

SWH is a CNES programme considered as a contribution by CNES to national inter-institutional thematic data centers such as Theia for “Land” and Form@ter for “Solid Earth”.

SWH has been announced by France at the GEO Plenary, in January 2014 at Geneva. The announcement included a commitment to start processing a first batch of 100 000 images to orthorectified level, and make the images available freely to the public for non commercial use.

At the same time a call to interested international institutions was made to contribute to the programme by processing large batches of images hosted by receiving stations worldwide. At present IRD has shown interest and could process data in their stations of Guyana, La Réunion, and in the GEOSUD station of Montpellier. Discussions are currently taking place with SANSA, the South African space agency, which would process the images hosted by their station. Some interest was also shown by other direct reception stations (eg. in Australia).

### SWH Production status

CNES has so far organised the processing of 200 000 images, with the collaboration of ADS. The share of work is as follows :

- CNES specifies the areas to be processed
- ADS produces the data from the Gerald level archived in Toulouse up to level 1A (radiometrically corrected images)
- CNES produces the images up to level 1C (orthorectified)
- CNES distributes the data on the THEIA web site

The images entering the CNES – ADS agreement were specified as follows :

- Multispectral images only from Spot 1 to Spot 5
- At least 5 years old
- Archived in Toulouse only
- If possible, when an area is specified, the whole time series is processed, with a specified maximum cloud cover of 50%.
- Distribution for non-commercial use only.

Distribution of the first SWH images started on June 23, 2015. At present about 30 000 images of France from Spot 2, 4 and 5 are available on the Theia Web site.

The areas for the rest of the 200 000 images have been specified with the help of the national science community, and in the framework of international programmes such as the Global Forest Observing Initiative or the CEOS Working Group on Disasters for example. The areas covered are displayed in the Figures below ; they cover a little part of Europe (France & Denmark), parts of Tunisia, Morocco, and Central Africa, Turkey, Central America and a few other sites elsewhere.

At present, the 200 000 images have been processed up to level 1A ; the processing at level 1C is progressing. We hope to have the 200 000 images available in the second semester of 2016.

Marc Leroy and Steven Hosford (Cnes)



America areas covered by the two first 200 000 images of the Spot World Heritage programme.



Africa and Europe areas covered by the two first 200 000 images of the Spot World Heritage programme.



Asia and Oceania areas covered by the two first 200 000 images of the Spot World Heritage programme.



## PEPS, the Sentinel Products Exploitation Platform

In the continuity of Sentinel missions contributing to Europe's Copernicus programme, CNES - representing France - signed an agreement with ESA to set up a French "mirror site" known as PEPS (Sentinel products exploitation platform).



PEPS will not only be a national relay for the dissemination of data from recurring satellites A and B of Sentinel-1, -2 and -3, but will in the longer term be able to "host" users' own data processing.

PEPS is thus contributing to further the objectives of Copernicus, especially the initiation and monitoring of environmental and security policies while meeting the need for data access locally, nationally and even internationally.

PEPS offers institutional, scientific and even business users such as SMEs/SMIs innovative services for accessing data from the Sentinel missions in order to promote the industrial development and competitiveness of companies further down the Earth observation value chain.

On the basis of expectations expressed by users, CNES - using its own resources - has designed and implemented PEPS using the expertise of its state-of-the-art computing centre.

In the long term, this innovative platform will develop into an integrated European system coordinated at a European level and involving cloud companies.

The Theia community will benefit from PEPS directly to access the whole data archive, particularly through the CNES MUSCATE processing facility which will directly access Sentinel-2 data hosted by PEPS to perform the atmospheric correction processing (level 2A) and monthly syntheses (level 3A) in areas selected by the Theia community. These new products will be circulated by the Theia cluster, which has dedicated capacity in the PEPS infrastructure that can be gradually expanded.



PEPS Exploitation room © CNES/Frédéric MALIGNÉ, 2015

### PEPS makes Sentinel-1A, and soon Sentinel-2A, products available to users

PEPS is now operational and offers users access to the whole time archive of Sentinel-1A products. These five-metre resolution radar images of landmasses and oceans in all weathers, night and day, are today used by a growing community (there are currently 250 registered user accounts). Three hours after an acquisition, the Near Real Time products are available on PEPS.



PEPS team © CNES/Frédéric MALIGNÉ, 2015

You can conduct searches, display and download products through a user-friendly interface.

In the very near future, PEPS will also distribute Sentinel-2A products and thus directly supply the MUSCATE processing line in order to generate Sentinel-2 products corrected for atmospheric and cloud effects for Theia. The next version of PEPS will be able to perform on-line processing. After that, more complex processing will be carried out on the CNES computing centre's high performance infrastructure.

Mireille Paulin (Cnes)

### High Performance Storage System (HPSS)

A 1.7 m x 1.2 m cabinet hosts 7PB of data, the sum of all the Sentinel-1, -2 and -3 data processed or to be processed up to 2017. Two petabytes of data are stored on hard disk but this storage capacity can be extended to 20 PB.

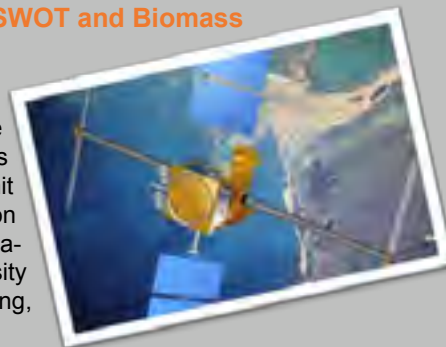


In order to optimise resources, this storage system will gradually evolve in keeping with needs but will rapidly be made available for Theia's storage needs.

## INVESTIGATING THE WATER AND CARBON CYCLES

### Two missions dedicated to research into the water and carbon cycles : SWOT and Biomass

Scientists are currently seeking to assess the consequences of global warming and investigate potential mitigation or adaptation solutions. There is also a move to reduce the environmental impact of intensive production systems and conceive new, innovative and sustainable systems that guarantee food safety. We are seeking new approaches in order to manage different environments in an eco-friendly way, the goal being to limit the risks of pollution or degradation (water quality, soil pollution and erosion, emission of greenhouse gases, dispersion of pesticides etc.). The general aim is to improve management of resources (continental water, land use, landscaping, promoting biodiversity etc.) and mitigate disasters such as flooding, fire, storms and drought.



The water and carbon cycles are a major focus of research efforts because they are central to the evolution of (1) a fundamental resource whose presence or absence directly determines the satisfaction of human needs and farming production conditions; (2) global climate change. Carbon is a key component in this issue, yet its budget and dynamics within the Earth's biosphere (carbon pools and fluxes) remain largely unknown.

### SWOT and the water cycle

The dynamics of continental water regulate not only the functioning of terrestrial, aquatic and coastal ecosystems but also the economic activities of human society (including irrigation, industries, energy and transport). They are greatly influenced by global change: firstly by human activities then, in the medium and long term, by climate change. Monitoring the dynamics of continental water is a major scientific challenge to research on the hydrological functioning of basins and river systems, research on the global water cycle and climate and finally, research on the relationship between hydrology and ecosystems. In the longer term, the operational challenge will lie in managing water resources.

Less than 0.1% of all the water on Earth is accessible for human consumption in rivers, reservoirs or lakes.

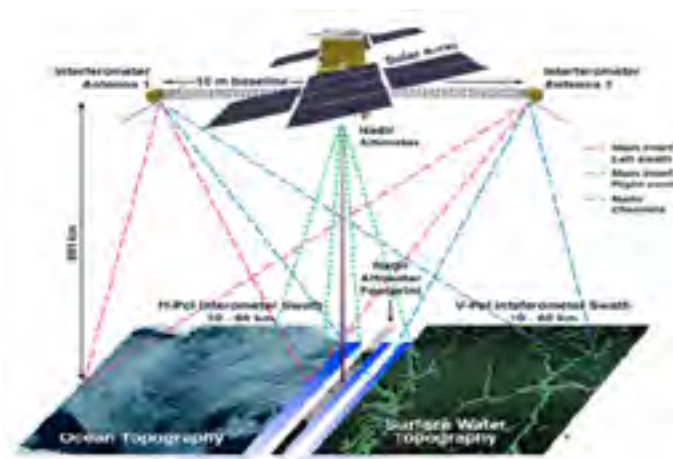
There are over 300 million lakes covering over 0.001 km<sup>2</sup>. There are only about ten lakes with a surface area between 10,000 km<sup>2</sup> and 100,000 km<sup>2</sup>. It is not these big lakes but the small ones which make the biggest contribution to the overall variation in lake water volume.

#### An ambitious and innovative mission

The SWOT mission's goal is to offer unprecedented observations for studying the dynamics of continental water, namely the water level of rivers, lakes and wetlands. Based on the legacy of nadir radar altimetry, the KaRIn Ka-band satellite interferometer should measure the level of continental water within a 100-km wide swath (with a nadir blind spot 20 km wide) at a resolution of 100 m and with a precision within 10 cm (and around 1 cm over the oceans). It will also quantify gradients with a precision exceeding 1 cm per kilometre. SWOT should provide information on the variation over time of the amount of water stored in surface water systems and flow dynamics.

Coupled with precise geoid models from GOCE and accurate digital terrain models, SWOT data should radically improve hydrodynamic river models in order to estimate flow rates. The methods used for these estimations need to be tried, tested and improved in order to fully prove their worth.

SWOT will provide a global inventory of all continental water surfaces over 250 m × 250 m (lakes, wetlands and reservoirs) and



SWOT mission operating principle

rivers at least 100 m wide (the ultimate objective being 50 m). SWOT will measure the variations in water stocks and river flow rates on a monthly, seasonal and annual scale. The mission will also characterise ocean circulation at mesoscale and sub-mesoscale with a spatial resolution of some 15 km.

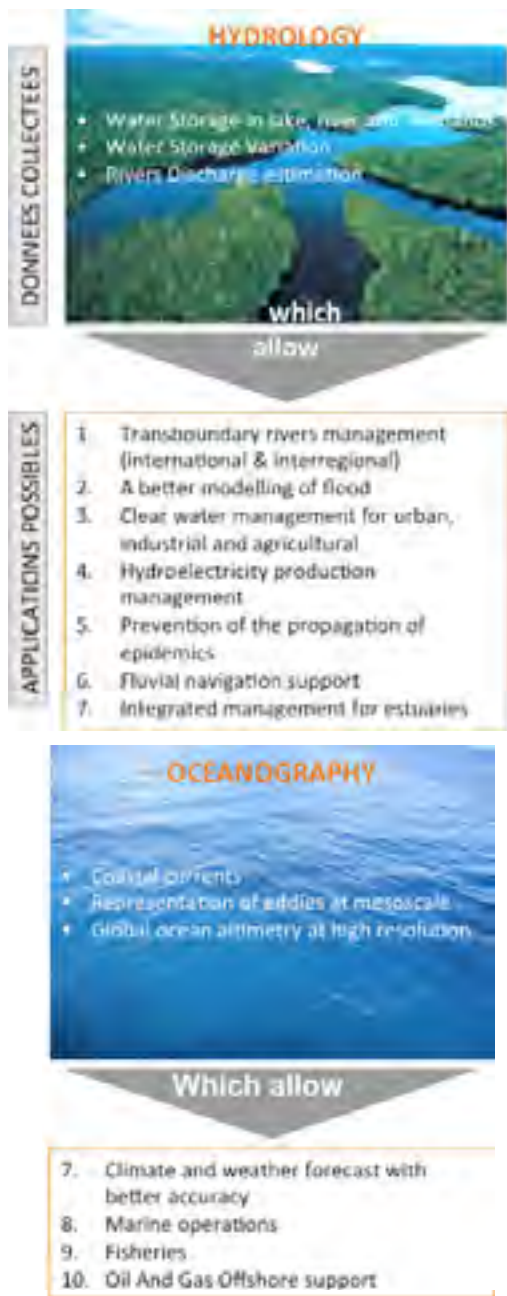
SWOT will enable hydrologists and river hydraulics engineers to take a further step forward in the use of satellite data to study river dynamics from local up to global scales. Nationally, it requires close collaboration between specialists in spaceborne radar techniques and river hydrodynamics engineers, with coordination between this twofold community. The highly innovative character of this wide-swath altimetry mission implies major efforts in terms of developing algorithms to support the community in order to create completely new hydrology products.

The SWOT mission is of particular interest to the oceanography community for studying processes with a high resolution. This will give rise to interactions between the "hydrology" and "oceanography" communities in coastal regions and when estimating exportation of freshwater from rivers to the sea.

#### Application challenges

SWOT has received French funding via the PIA future investment programme due to its potential in terms of future applications. A preparatory programme known as "SWOT Aval"





## Biomass: the first mission to measure the biosphere

Our knowledge of carbon fluxes between the atmosphere and the biosphere remains sketchy because any estimations on the continental part of the carbon cycle are uncertain at best. To better understand this essential component of the carbon cycle, it is vital to accurately evaluate the stock of carbon found on land and explore its dynamics on a global scale using the same methodology.

This is the main objective of the Biomass mission chosen for ESA's Earth Explorer programme and given the go-ahead to proceed to phase A following the User consultation meeting of January 2009 in Lisbon.

### Assessing carbon dioxide sources and sinks

The carbon cycle has been greatly impacted by human activities which, in the majority of cases, depend for their energy on the exploitation of fossil fuels. While the concentrations of different greenhouse gases and their evolution over the last century are well known, very little is known about carbon stocks in the form of terrestrial and oceanic biomass. Similarly, the sources and sinks of these greenhouse gases—and especially CO<sub>2</sub>—are very difficult to locate and quantify. The lack of accuracy in evaluating stocks, sources and sinks obviously makes it difficult to accurately forecast future concentrations of these greenhouse gases and thus climate change.

Behind this assessment of CO<sub>2</sub> sources and sinks lie major economic and political stakes, particularly in the context of carbon taxes. It is vital for Europe to have its own means of evaluation in order to have reliable and independent information to be used as input for the negotiations that will surely come.

The United Nations REDD initiative to reduce emissions from deforestation and forest degradation, appended to the framework convention on climate change, is a major economic challenge for the years to come. The stakes are particularly high for countries in tropical regions with vast forested areas.

Deforestation also has a major impact on emission of the greenhouse gases responsible for the ongoing global warming situation. Thus, 17% of global carbon dioxide emissions are the result of deforestation and land use changes.

What is more, deforestation—with the transformation of tropical forests into cropland or pastures—impacts the carbon cycle by reducing evapotranspiration and therefore air moisture, changing the regional climate.

(downstream SWOT) has been instigated by CNES to pave the way for SWOT data usage. The application challenges identified to date obviously underlie the scientific efforts being made since the mission was first conceived.

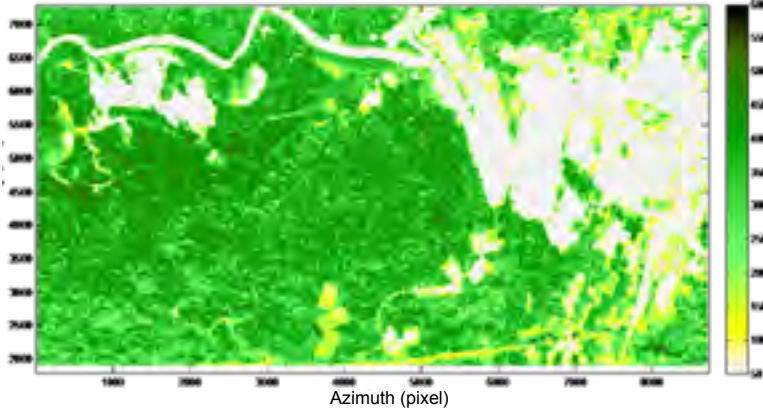
Beyond SWOT's scientific contribution to a clearer understanding of the water cycle, and despite the fact that SWOT is above all a science satellite using a new, untested technology, it offers a huge potential for the development of new applications and services with major economic and social impacts.

CNES has received public and PIA funds to set up the SWOT Aval support programme to create products tailored to user needs within current or future services. It also aims to prepare water stakeholders so they can fully benefit from these new satellite data.

The national momentum created will continue to develop as new projects are conceived and the community opens up to other components and laboratories. Indeed, the new Science Team (ST) for 2016-2019 was selected in September 2015 following an evaluation of projects by a joint expert panel including NASA representatives. There are several important milestones in 2016, particularly as the project moves on to phases C and D.



Biomass map obtained by inversion power layer 30m (t.ha<sup>-1</sup>)



First tropical forest validated biomass map (D. Ho Tong Minh et al., 2011)

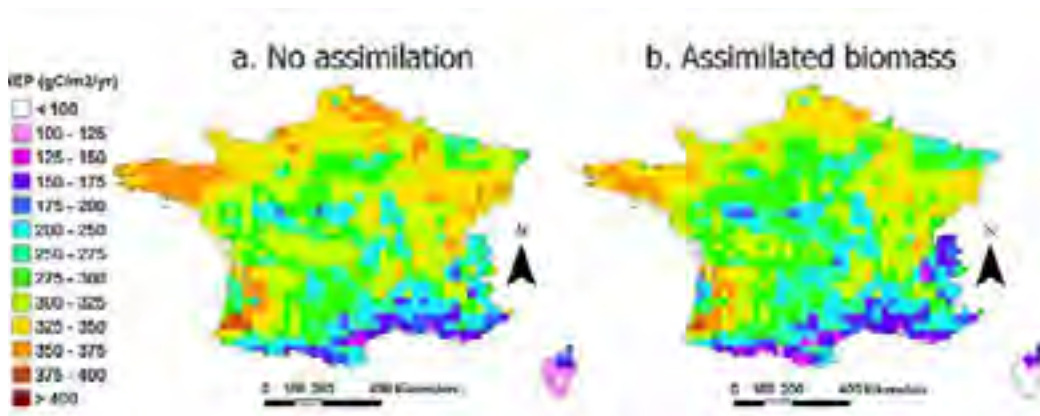
Only Earth observation satellites can monitor forests and forest biomass on a global scale and it is vital that they are used to respond to this challenge. High-resolution sensors such as those on Pleiades are needed to detect forest degradation, while frequent revisit satellites such as Sentinel-1 and -2 are needed to monitor the progress of deforestation over time.

### Biomass scheduled for around 2021

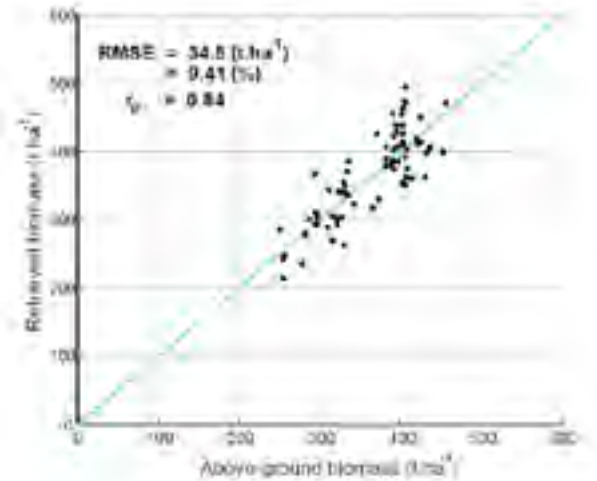
The Biomass satellite is designed to map biomass and the height of forests in order to estimate the quantity of carbon stored there and monitor variations. This is a critical objective in order to clarify the role of forests in the carbon cycle, their interactions with the climate and their economic impact worldwide.

The Biomass mission was initiated by the CESBIO biosphere research centre (Principal Investigator, Thuy LeToan). It is scheduled for launch in 2021.

Biomass is the seventh mission in ESA's Earth Explorer programme. It was approved by ESA member states on 18 February 2015 through the agency's Earth Observation Programme Board (PB-EO). The mission will fly a low-frequency P-band synthetic aperture radar with a wavelength of 70 cm. It will offer a spatial resolution of 50 to 100 metres and a revisit frequency of 17 days or so. This type of instrument has never before been flown in space, and the innovative techniques such as radar tomography that were developed to sound the 3D structure of vegetation in order to measure biomass and height, represent a huge technology leap.



Example of preparatory work : assimilation of Biomass products in the LSCE's ORCHIDEE model to calculate carbon sources and sinks



An unattainable degree of measurement accuracy

### CNES committed to Biomass

At CNES's scientific foresight seminar in March 2009, the CPS science programmes committee recommended that CNES lend its full support to the Biomass project.

Supported by CNES since 2009, numerous French teams have been involved up to phase B1 (preliminary definition) and continue to ready for the exploitation of these new observations to improve our knowledge of the Earth's carbon cycle and its impact on the climate.

CNES's support and contributions include :

- Measurement campaigns (TropiSAR, TropiScat, AfriSAR, AfriScat): CESBIO, EDB, ONERA, INRA, CIRAD
- Development of algorithms (L2): CESBIO, ONERA, IETR, Amap, OTIG, EDB, I.Fresnel, TETIS and, in phase 0, INRA, IRD-Espace, LMTG, BRGM and LATMOS
- Concepts for exploiting biomass/carbon fluxes (L3,L4): LSCE, EDB, CESBIO

The community continues to expand and prepare for this crucial challenge around 2021, for what is at stake is our very understanding of climate change !

Selma Cherchali (Cnes)

D. Ho Tong Minh, T. Le Toan, F. Rocca, S. Tebaldini, M. M. d'Alessandro, and L. Villard, "Relating P-band SAR tomography to tropical forest biomass", IEEE Transactions on Geoscience and Remote Sensing, Vol. 52, No. 2, pp. 967-979, Feb. 2014

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