BULLETIN
Theia Land Data Services Centre

n° 8 - January 2018

A word
from the Scientific and Technical Directors

The 11 partners of THEIA land data services centre have signed the terms of the second agreement for 2017-2021, which will allow our efforts to be sustained throughout this new period.

An «Earth IR System» research infrastructure is being put in place to unite the four national thematic centres, while access to very high resolution imagery is becoming a cross-functional component across the centres with the creation of the Dinamis space imagery procurement device.

This agreement establishes the objectives of providing greater support for scientific users and public stakeholders, expanding the portfolio of products and services to airborne and in situ data, and developing on-line processing services.

For the next period, 2017-2021, we should continue to encourage the scientific community to suggest new Scientific Expertise Centres (SEC). THEIA must also provide products over vast areas in order to gain recognition and exposure.

Nicolas Baghdadi   Arnaud Sellé

NEWS

Initiation of production of level 2A products from Sentinel-2B

Sentinel-2B, the twin satellite of Sentinel-2A, was launched in March 2017 by the ESA. The two satellites now work together to observe Europe and Africa every five days, and, for now, the rest of the world every 10 days.

Sentinel-2B was declared operational by the ESA at the start of October and, since 26 October, our Muscate processing centre has started processing its data at level 2A with the Maja chain developed by CNES, CESBIO and DLR.

Level 2A products provide surface reflectances data after atmospheric correction including an accurate cloud mask. As for Sentinel-2A, the data may be downloaded from the Muscate distribution workshop (theia.cnes.fr).

For more details about these products, see: cesbio.ups-tlse.fr/multitemp/?p=11550

The start of production was made possible by the installation of a new version of the Muscate production centre, which should also allow greater stability of production and, before long, some new products :

- snow cover maps, in real time

- resumption of the production of level 2A Landsat data, which can be directly superimposed on Sentinel-2 data.

Olivier Hagolle (Cesbio / Cnes)

Series of two images acquired in turn by Sentinel-2A and Sentinel-2B, in northern China (tile T49TCF) near the town of Baotou

Sentinel-2A (04/10/2017)

Sentinel-2B (19/10/2017)

2nd workshop on «Remote sensing for Studying Urban Environments»

The second workshop on Remote sensing for Studying Urban Environments (TEMU) will take place on 19 - 20 March 2018 in Strasbourg, at the Maison Inter-universitaire des Sciences de l'Homme.

This workshop aims to bring together national stakeholders working on the theme of remote sensing for studying urban environments (methods and applications), as well as people interested in these applications, in order to present the progress made in the field and to identify barriers and future requirements.
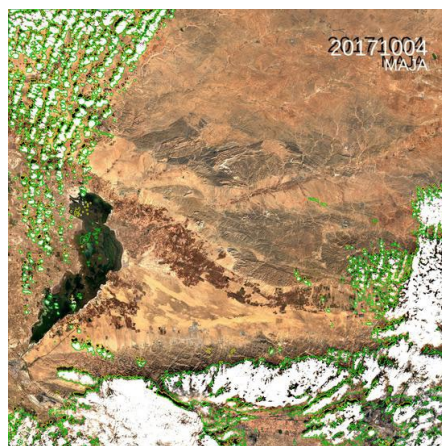
Further details about the workshop's themes and objectives, procedures for registration and for submission of abstracts (maximum one page) and practical information for attending the event can be found on the website temu2018.sciences-conf.org.

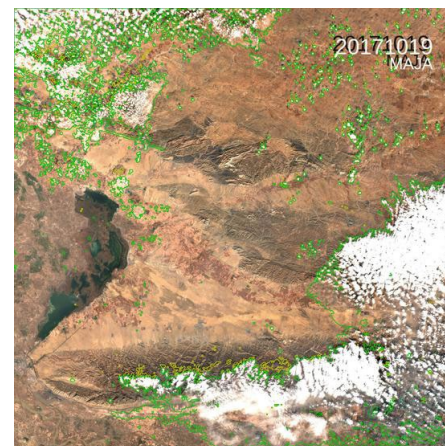**Anne Puissant (Live - Unistra) et Laure Roupioz (ICUBE - Cnes)**

THEIA regional coordination network in the Global South

The THEIA regional coordination network dedicated to Southern Partnerships, called « ART GeoDEV », continues to develop: (1) structuring of coordination instruments and tools; (2) implementation of actions to support creation or consolidation of remote sensing resources centres in Southern countries. **>>**

GEODEV

>> An ART GeoDEV Memorandum Of Understanding between CNES, IRD and CIRAD has being signed. It promotes pooling of resources and knowledge sharing within the network. The network's website is currently being created. It will provide stakeholders established in the South with informative contents and/or resources (documentary, thematic, educational, etc.) linked to remote sensing and Earth observation application. The objective will be to promote technical and scientifical partnerships, actions and programs: support the definition and implementation of joint projects, capitalise on progress made by ongoing projects, experiment new methods, disseminate Earth Observation products and tools, empower local human ressources. Proposals for relevant contents useful to these purposes may be sent to the network contact indicated below.

In parallel, in recent months, various actions have been conducted to support the design, consolidation, implementation or prospective creation of remote sensing resources centres centres with Southern Partners. Examples of this include: a foresight workshop for implementing an Earth observation resources centre, held on 11 and 12 September in Antananarivo under the aegis of Madagascar's National Research Center for the Environment (CNRE) and IRD; the coming launch of a feasibility study relating to agricultural applications in West Africa, backed by CIRAD; the signing of an agreement at the 2017 Paris Air Show between CNES and the French Development Agency, supporting space observation for development in Africa; the signing of a memorandum of understanding on space hydrology between CICOS (the International Commission of the Congo-Oubangui-Sangha Basin) and 7 public and private institutions (AFD, BRLi, CNES, CNR, IRD, IRSTEA, IOWater), submission of a collaborative project dedicated to the monitoring of the environment by satellites, in the Guianas amazonian subregion, backed by scientific stakeholders from French Guiana, Suriname and northern Brazil.

**Jean-François Faure
(Espace-Dev / IRD)**

Cerema workshop

The workshop on «The utility of satellite imagery for land management» organised by CEREMA Sud-Ouest within the framework of coordination by ART Occitanie, was held on Tuesday 7 November 2017 at the Toulouse (31) CVRH [Human Resources Development Centre].

The day session was a great success, bringing together a hundred or so participants from regional and local authorities, government departments, the private sector (research departments, SMEs, etc.), public institutes and agencies, focusing on the following themes: planning and urban design, nature in urban areas, risk management and monitoring of large land areas. Presentations endeavoured to show examples of operational applications implemented by different organisations (town planning agencies, institutes, government departments) and mature results of research in these fields. A specific review of access to satellite data and associated services (Copernicus, DINAMIS), and of the organisations coordinating the network between the scientific community and the professions (THEIA, Copernicus, CoTITA) was also on the agenda.

There is growing interest from potential users of satellite imagery for land management within regional and local authorities and government departments, on several different levels of services: from orthoimagery to vertical products in the form of thematic satellite-derived indicators.

The presentation materials from this workshop can be found on the ART Occitanie and the CoTITA sites.

Amélie Lombard (Cerema)

DL2T days

With the support of CNRS, the Detecting Changes Scientific Expertise Centre organised a two-day event on 29 and 30 November 2017 in Paris on the theme «Deep Learning - Remote Sensing - Time».

The goal of these days was to bring together:

○ «specialists» in Deep Learning of remote sensing data time series, and also medical and other specialists

○ theme specialists for Environmental Science, Earth Observation, etc.

○ remote sensing «methodologists» (computer engineers, image processors, etc.)

to discuss and exchange views about the potential and the limits of Deep Learning

for the analysis of remote sensing image series.

The idea is to link thematic requirements to barriers that are potentially blocking the implementation of deep learning approaches for temporal analysis of remote sensing image series, and hence propose avenues of research aiming to break down these barriers.

In order to provide the ideal framework for discussions, these days took the form of round tables focused on 4 questions that we consider it important to address:

○ What changes can potentially be extracted by methods of this type?

○ What is the «optimum» granularity of objects of interest (pixels vs objects)?

○ What are the methods to be adapted or developed within this context?

○ How can users become accustomed to results in the unorthodox form of neural networks, and for what potential uses?

Pierre Gançarski (Unistra)

LabOCS project

LabOCS is an experimental laboratory project about the Opendata IGN framework large-scale land use (OCS-GES) in Occitanie. The main target of LabOCS is the development of local and national uses of OCSGES, and it will be made up of three working areas: monitoring developments, possible derivations and enhancements, and services related to consumption of the product.

OPenIG and ART Occitanie are launching a call for interested stakeholders to pool their expectations and ideas connected to regulatory obligations (land management, land consumption, urban densification, other land developments, agriculture, risks, natural spaces, etc.) or their knowledge about OCS (production, analysis, monitoring and use).

The first workshop was held on 3 July 2017 in Carcassonne, and allowed the launch phase for LabOCS and the first communication tools to be specified. The report and contacts can be found on the OPenIG site.

Clara Levêque (OPenIG)

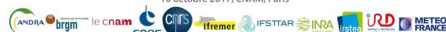Participants in the CEREMA workshop

«Land surfaces and interfaces» foresight symposium

The 4th scientific foresight symposium of the Land Surface and Interface (SIC) communities took place at CNAM in Paris from 9 to 11 October 2017.

Coordinated by CNRS, it brought together more than 250 participants from all of the French stakeholders in research into this theme, organisations and universities, to work together on the major barriers that are preventing our understanding of the main mechanisms causing the biogeo-chemical cycles, and to propose and prioritise the necessary resources. The results of this work will direct research and the resources allocated for the next five years.

The event is part of the drive to analyse the scientific and societal challenges to be taken up following COP21 and COP22, particularly the understanding of the impacts of climate change and global change in the territories. These impacts include the effects on human life and so-cieties, particularly water, soil and biodi-versity, all of which are central to the ob-jectives of sustainable development. This deep understanding of the mechanisms of change and of its impacts may bring forth solutions for remediation or limitation.

In particular, this symposium tackled questions about the organic matter cycle, the land-sea continuum, surface/atmos-phere exchanges, and the importance of the integrated approach to land surfaces including observation, experiments and modelling, in which data from space-based Earth observation play a major part.

Human societies are both participants in and victims of this change, and scientists from the SIC community therefore have a duty to conduct research and share their findings, showing society how scien-tists are taking on these challenges. The symposium was thus divided into two segments intended to complement each other, with forward-looking scientific de-bate sessions, and a forum for the gene-ral public that brought together more than 100 participants, including both scientists and the general public, particularly tea-chers.

Nicolas Arnaud (CNRS)

AppSpace Forum in Brittany

The AppSpace Forum took place on 17, 18 and 19 October with the objective of reviewing the current state of play in the space sector by bringing together the di-verse stakeholders of which it is made up. Two hundred people (researchers, institutional stakeholders, private opera-tors, land managers, students) took part in this forum, seven round tables allowed the major issues in the sectors to be dis-cussed, 14 workshops demonstrated the existing technical solutions, and around twenty stands started worthwhile discus-sions between participants.

- Raising awareness about the avai-lable data

The technical workshops helped to raise awareness about the programmes, sche-mes and platforms making data avai-lable and providing support (Copernicus, PEPS, THEIA, RUS, GéoBretagne, etc.).

- Knowing how to process these data in a meaningful way

The space applications sector has been described as an added-value chain that transforms raw data into information or a service intended for operational users. Small businesses can play this «data processor» role and be innovation dri-vers. The support systems to assist them (European funds, CNES patents, com-petitiveness clusters, boosters) were presented. In terms of skills, there are a wealth of training courses in Brittany (multidisciplinary courses, double diplo-mas) which have to continually adapt to advances and to requirements.

- Bringing together the space sector and local needs
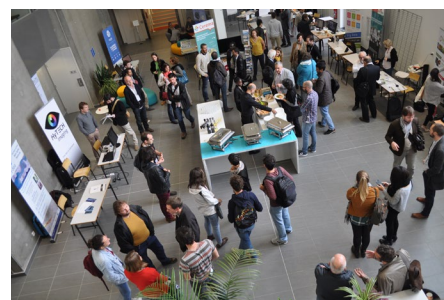
AppSpace Forum 2017 exhibitors space

The regional level has been found rele-vant for structuring the space applications sector. On the one hand, the regions can benefit from space applications for their economic development or for monitoring their territories. On the other hand, for the national and supra-national levels, the re-gions are essential local relays with the local economic fabric, and for providing feedback on best practices (NEREUS, Copernicus Relay). CNES has also rei-terated that it is at the service of the re-gions, and will make its collaboration with Brittany official at the start of 2018 by si-gning a framework agreement.

- Continuing and strengthening regio-nal coordination

Some barriers were identified over these three days: land managers have not been made sufficiently aware of space appli-cations; collaboration between public and private operators should be deve-loped and simplified; transfers between the results of research and operational stakeholders are still few and far between. The structures and projects that will help break down these barriers were presented (Kalideos, THEIA, CEREMA, SATT Ouest Valorisation, Gis BreTel, InSpace).

These three days helped to start discus-sions, review the current state of play in the space sector and hence provide greater clarity for all of the stakeholders. AppSpace was just a starting point, and the actions will continue in the region.

Marie Jagaille (IMT Atlantique)

AppSpace Forum 2017 organizers and speakers

Venµs, a scientific mission for land surfaces

During the night of 1-2 August 2017, the Venµs (Vegetation and Environment monitoring on a New Microsatellite) satellite was launched from Kourou by a European Vega rocket. This mission is the result of a collaboration between CNES and ISA (Israel Space Agency); it comprises a scientific Earth observation mission for which CNES is responsible and a technological mission (IHET: Israeli Hall Effect Thruster) for which the Israeli agency is responsible. The main objective of the scientific mission is to provide data for developing assimilation techniques within vegetation functioning models.

The first phase of the mission will last two and a half years counting from the end of in-flight commissioning, planned for the end of 2017, and will allow images to be acquired every two days with a 5.30 m resolution at nadir over approximately one hundred sites.

The second and third phases will use the IHET electric propulsion to reduce, over six months, the orbit from an altitude of 720 km down to 410 km, then to maintain the orbit at 410 km for one year, while continuing to acquire images with 3 m resolution every two days.

Venµs has on board a radiometric imager with 12 spectral bands, from blue to near infrared, with a 27 km swath at nadir. Three ortho-rectified products produced by CNES will be freely accessible through the THEIA portal: top of atmosphere reflectances (Level 1, 5 m resolution), reflectances with atmospheric correction (N2, 10 m) and temporal syntheses every 10 days (N3, 10 m). The spectral band at 620 nm is duplicated at the ends of the focal plane, allowing a slight stereoscopic effect (B/H=0.025) which can be used to assess cloud heights and hence identify them.

The choice of the selected sites following an international call for proposals was based on the quality of the proposals, the desire to observe a variety of ecosystems and, above all, constraints such as filling of on-board memory, compliance with kinematic constraints for imaging sequences or data dump capacities to the Kiruna station. These sites will be observed for two and a

The Ebro Delta (Spain) viewed by Venµs on 18 August 2017 © CNES 2017

half years from the start of 2018, every two days, at the same local time (10:30) with a constant camera angle. Five sites are in mainland France, in the Auvergne-Rhône-Alpes, Grand Est, Nouvelle Aquitaine and Occitanie regions. French scientists also manage sites in nine other countries, from Norway (Svalbard) to Madagascar.

The in-flight commissioning currently in progress is intended to test all of the equipment and perform radiometric and geometric calibration of the radiometer in order to provide users with images that comply with the specifications. The calibration methods are based on observation of desert sites, Rayleigh scattering, snow-covered sites and the Moon. Snow-covered sites, deserts and the Moon will be used throughout the mission to monitor data quality.

Preparatory work for Venµs resulted in processing algorithms that are now applied to data from other missions, such as Sentinel 2. Venµs is now fostering thoughts about the development of this European programme, particularly with regard to the observation frequency.

Gérard Dedieu (Cesbio / Cnes)

A few more tiles for Sentinel 2

We have been allowed to add 200 additional tiles in the zones where MUSCATE produces Sentinel-2 L2A products. To select the tiles. To select the tiles to be added, CNES used the following approach:

○ the 2015 call for proposals prioritised scientific applications over small areas

○ large territories favour the implementation of operational regional or national applications

○ we need to publicise our products in Europe so that our European partners help us promote global processing

○ companies interested in our products will give up if their applications can only function in France and in scattered locations

○ many European invitations to tender relate to the European territory

○ a great deal of scientific work in France concerns the western part of the Mediterranean basin

We have therefore added most of France's neighbouring countries, reached an agreement with the German space agency

(DLR) for processing Germany, and added the western perimeter of the Mediterranean basin. The map opposite shows in red the location of tiles already in production and available, which already includes our European neighbours and, in blue, the area of the Maghreb that will be added in the coming weeks.

Olivier Hagolle (Cesbio / Cnes)
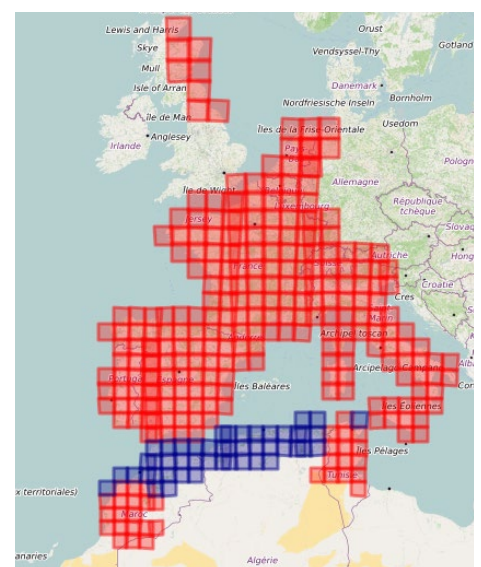

Map locating tiles processed by THEIA

On-line processing service for HR and VHR optical images

Currently, the Geosud (IDSv1) space data infrastructure provides services for standardised access to more than 8000 high resolution (HR) and very high resolution (VHR) space images. In 2017, a final production phase related to the development of an on-line, on-request processing services platform (IDSv2). The purpose of this platform is to facilitate HR and VHR image analysis activities for Geosud members by making it possible to:

○ avoid at least the stage of downloading the image, or even of downloading the result,

○ partially hide the complexity of the process, from selection of the image to execution of processing, by offering assistance during selection of images and during configuration of processing before execution,

○ optimise the processing execution time by making use of the HPC@LR computing cluster and the work undertaken previously on optimising processing of the OTB library (Rémi Cresson, et Gabriel Hautreux). A generic framework for the development of geospatial processing pipelines on clusters. IEEE Geoscience and Remote Sensing Letters, 2016, vol. 13, no 11, p. 1706-1710).

This supplement to IDSv1 Geosud initially aims to provide a set of utility and thematic processing operations developed with OTB, R and Python, amongst others. As regards execution of processing operations, the platform is based on the implementation of a WPS (Web Processing Service) standard processing server and the HPC@LR regional computing cluster. Developed based on the Zoo-project open source tool and the ElasticSearch open source search engine, they allow a fully standardised environment to be implemented that is responsible for searching for images and processing operations, their configuration and execution to the HPC computing resource.
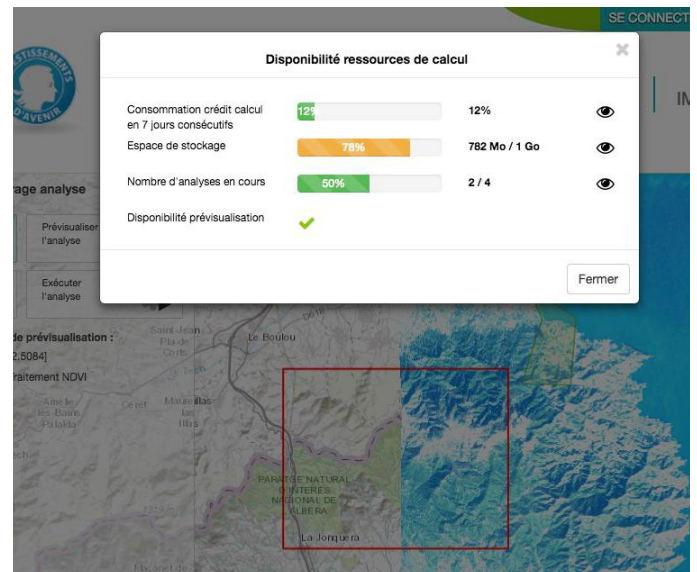
Geosud portal Analysis Module: (pre)view page for the result of an analysis. The dialogue box gives the status of the computation and storage resources for a given user.

From the user's viewpoint, an Analysis module is added to the Geosud web portal. It makes available a catalogue of processing operations. It is designed to support the user as they find a processing operation, images compatible with the selected operation, its configuration and then execution. Support by an HPC computing resource allows us to provide an almost real-time preview of the results of a processing operation. The user can therefore, by trial and error, adjust the configuration of their processing operation before executing it on an entire scene. Lastly, the log of analyses conducted as well as the resulting data can be reused for other analyses. Members have a storage space that allows them to keep their results and replay them (keeping the previously used configuration).
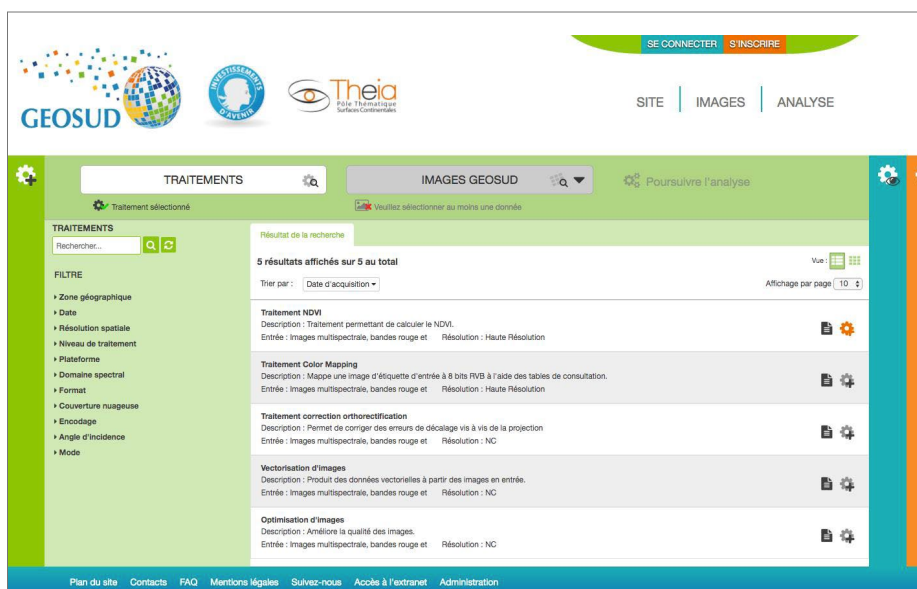
The on-line, on-request processing services platform will be accessible at the start of 2018 at the following address: ids. equipex-geosud.fr/web/guest/idsv2_analyse

**J.C. Desconnets (Espace-Dev / IRD),
Rémi Cresson (Tetis / Irstea),
Kenji Ose (Tetis / Irstea),
Pierre Malard (Espace-Dev / IRD)**

Geosud portal Analysis Module: search page for existing processing operations

Prospects

The chosen architecture, in particular through the standardisation of the web processing services (WPS) and data access services (WCS, WFS), allows us to consider implementing processing chains that can request processing operations hosted by other data infrastructures. The same applies for data held on other national infrastructures. It will also be possible to envisage the prospect of being able to combine in situ data with satellite data to be integrated in the execution of more elaborate processing chains (simulation models, calibration/validation of mapping resulting from automatic processing chains).

An application to investigate differences between SPOT coverages

The Geosud space data infrastructure is known for the distribution of SPOT and Pleiades products. The access to these products in a form that can be viewed directly, called streams, may be less known. For example, the display of most of the Pleiades and SPOT images on the project relies on the streaming service. Once the yearly coverage of the French territory with SPOT data, is completed, images are stitched together in order to setup a stream, gathering all the images.

Anyone can rely on this service to view the data within a desktop application, or a web application. As an illustration, IGN has setup a webapp to visually compare SPOT coverages through years.

On top of the comparative photo-interpretation tool, a database has been setup to store the location of the observed changes. The collected information can be downloaded for further processing in a dedicated use.

This service provides a number of facilities. Users are asked for a user name ; it helps to manage the actions of people accessing the app at the same time. For the time being, the expected input is a simple character string. A tiling scheme of the area of interest is used to make sure that the whole area has been investigated. The location and type of Land use change are gathered and made available to all.

To speed up the search for changes, a set of people can take part in a work session on a given area of interest. Once changes have been highlighted, it is possible, for one, to browse those locations again, in order to check the reports, or to select a set of changes that are relevant for a targeted use. The selected changes are then made available in a file named after the user name.

At this stage, available investigation areas are pre-set with a tiling scheme corresponding to districts scale. A few urban areas have also been pre-set; it's mainly on those areas, that one will find the first datasets available for download.
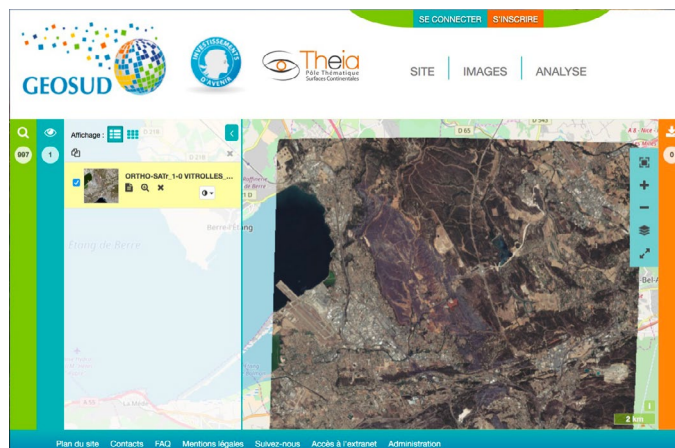

Stream visible on the IDS Geosud website

The application relies on image streams. That means that one can make use of SPOT imagery as well as the one of Pleiades, when available, or some aerial imagery.

While keen interest has been observed in the production of indicators dealing with land use changes, on yearly bases, the use of annual streams is not the only option provided by the application. The list of available streams makes it possible to compare images on a time period suited for the update of a scheme for territorial coherence (SCoT) or the update of a local urban planning scheme (PLU). On this last topic, an experiment has been conducted on Toulouse area, together with the Urban Planning and Development Agency (AUAT). The selected time period was 2013-2016.

The Geosud project team is here to help in the procurement of access to the available image streams and in the evaluation of the application described here; for example by defining a tiling scheme suited to the investigation over areas of choice: images-satellites@ign.fr

Eric Breton (IGN)
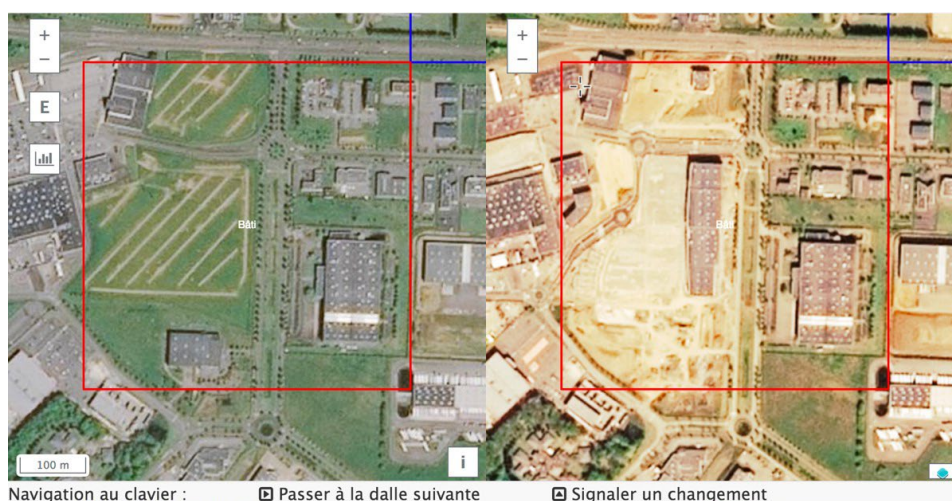
Exemple of change observed between 2016 and 2017

Long-term archiving of digital data

The archiving service provided by the National Computing Center for Higher Education (CINES) is designed to meet three main objectives in the medium term (e.g. several years after the end of the scientific project) and the long term:

1. Preserving the document: ensuring that the document is always present on the storage medium and that it maintains its integrity.

2. Making it accessible and legible: being able to find the document on the storage medium and being able to read it (i.e. open the file(s) despite obsolescence of reader software and/or file formats) >>

>> 3. Maintain its intelligibility: ensure that the document remains understandable by its potential users over time.

Long-term archiving of satellite images is essential for Equipex Geosud because of their high production cost and the need to make use of them again over time (studies on environmental changes observed over several decades, etc.).

These sizeable images are produced according to procedures specific to each satellite, distributed in varying formats, and require metadata dedicated to Earth observation. As part of this archiving project at CINES, two service levels have been considered:

○ full archiving in the long term for the raw images,

○ retention with a more limited duration for some reprocessed images.

These high-added-value processing operations have generated a non-compliance with the standards of the field and force their unprocessed equivalents to be included.

Joint discussions between THEIA and CINES have just been initiated about data obtained by in situ observation and associated with these satellite images. Watch this space in a future THEIA bulletin.

Marion Massol (Cines)

Is there a risk of the storage medium deteriorating? Will the reader still exist in a number of years?

Is the file sufficiently well described to remain understandable over the years?

When I need a document, will I be able to find the software used to create it? Will it be possible to run it on my operating system?

Descriptive metadata - Authenticity
Medium - Hardware environment
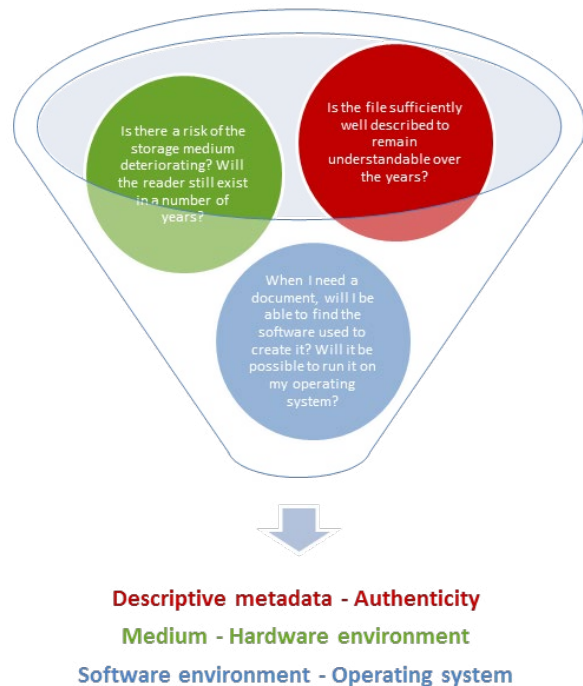**Software environment - Operating system**

Figure 1 : Questions that are asked when we wish to reuse preserved data in the medium/long term, independent of any archiving process

GeFolki

GeFolki (Geoscience Extended FlOw Lucas-Kanade Iterative) is an algorithm that estimates deformations between two remote sensing images. It was developed at ONERA by adapting a fast and robust optical flow algorithm (eFolki). GeFolki is now distributed as open source (github.com/aplyer/gefolki) under the GPL license, in Matlab and Python versions.


GeFolki is intended for fine co-registration of images: it calculates a deformation field in each pixel. The algorithm is positioned after an «initialisation step», obtained either by a minimalist approach, resampling the images with the same orientation and pixel size, or by georeferencing. At the end of this step, there are often co-registration biases, because the useful auxiliary data (orbits, sensors, relief) are not precise enough. It is here that GeFolki comes into play: the algorithm calculates all of the residual distortions between the two images in order to improve the precision of the superposition. Knowing the deformation map, the slave image has then to be resampled.

At present, this method has demonstrated a major benefit for at least three applications:

○ in interferometry, without auxiliary data, with different modes or resolutions (TerraSAR-X SpotLight and StripMap; airborne)

○ when two airborne sensors with different focal lengths and distortion are used: for example to co-register VNIR and SWIR, hyperspectral and optical data.

○ to co-register data from mixed sensors: Lidar and radar, or radar and high-resolution optical, etc.

We encourage anyone who is interested in using the algorithm to contact us us if they are having problems, and, if using it as part of a scientific publication, to cite one of the reference articles mentioned in the GeFolki installation documentation.

Elise Koeniguer (Onera)
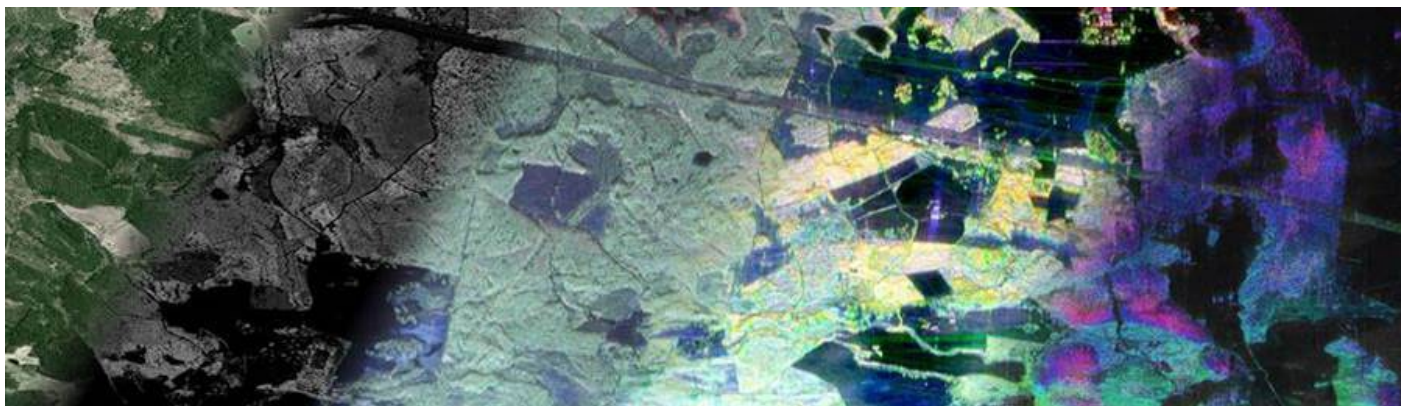
Composition obtained after co-registration by GeFolki of multisource data on the Remningstorp site (Sweden). From left to right: High-resolution optical image, high-resolution Lidar DEM, L-band polarimetric radar image, P-band polarimetric radar image, P-band multi-pass interferogram.
The optical and Lidar images are from SLU (Swedish University of Agricultural Sciences). The radar images are from the ONERA SETHI sensor and are delivered by ESA (BIOSAR3 airborne campaign)

Center for the Study of the Biosphere from Space

Having played an important role in the founding of THEIA, the Center for the Study of the Biosphere from Space (CES-BIO) is involved in various ways: it takes part in THEIA steering committees (Science and Users Council), the regional coordination network (ART) in Occitanie and many Scientific Expertise Centres (SEC).

The surface reflectance SEC was the first to start up. With support from CNES, CESBIO developed an operational chain, MAJA, to supply time series of high-resolution images without atmospheric effects. MAJA produced the data from the SPOT (Take5) and Landsat experiments from 2013 onwards, and has processed data from Sentinel 2 since 2015. The data produced are used by many other more thematic Scientific Expertise Centres, for example :

○ CESBIO developed the algorithms and the chain of the OSO (Land Cover) SEC, to produce the map of France in 2016 with Sentinel 2 ;

○ CESBIO and CNES developed the let-it-snow processing chain which allows the snow mask to be extracted from level 2A products supplied by THEIA (products indicating the presence or absence of snow every five days if there is no cloud) ;

○ CESBIO is involved with EMMAH and CNRM in the Albedo SEC, which aims to produce high-resolution (20 m) ten-day summaries of albedo by the combined use of Sentinel 2 and Landsat 8 data. CESBIO is responsible for in situ measurements of albedo on agricultural parcels for validation of the products and analysis of temporal dynamics.

CESBIO also uses microwave satellites within the framework of the ground humidity and forest Scientific Expertise Centres.

Laurent Polidori (Cesbio)

France land cover classification, from Landsat 8 to Sentinel-2.
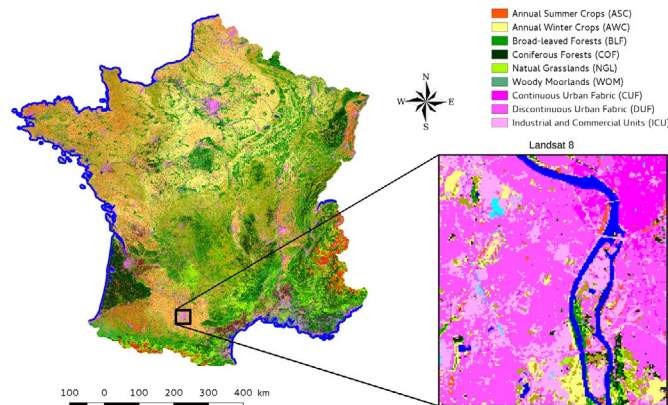
2016 land cover map produced by the Land Cover SEC

Irrigated surfaces Scientific Expertise Centre

The research work conducted as part of the CLIMATOR project (Brisson and Levrault, 2010) predicts, for certain regions of France, increasing scarcity of water resources in summer, with an increase in droughts as predicted by the IPCC climate scenarios.

In France, irrigation is used by approximately 73,600 farms (10% of French farms), covering approximately 1.6 million irrigated hectares (Loubier et al., 2013). Almost 40% of this area is grouped together in the Southwest region, which is regularly subject to summer drought. Maize is one of the key crops related to irrigation. The crop is of tropical origin and, in temperate zones, reaches its peak need for water in summer, during the driest periods, which results in the need to make use of irrigation.

To deal with droughts, which risk becoming more numerous, optimising management of water resources in the territories to address water's different uses is becoming urgent. This management requires precise and up-to-date knowledge of land use, particularly of irrigated areas.

It is in this context, and in order to address those challenges, that CESBIO has involved itself in various research programmes relating to management of irrigation water at the territory scale, and offers a «Mapping irrigated surfaces» Scientific Expertise Centre (SEC) with the aim of developing and validating methods for mapping irrigable and irrigated areas based on high spatial and temporal resolution satellite images. The Sentinel 1 and 2 high spatial resolution (10 to 20 m) images recently made available, free to access, for any part of the globe, repeating on a three-day basis, allow new opportunities for monitoring surfaces, particularly for non-scientific users.

The product offered by this SEC takes the form of a map of annual to multi-annual irrigated surfaces, intended for chambers of agriculture, water supply agencies and watershed managers. Maps of irrigated crops (maize and soy) have been produced in Southwest France within the framework of two projects (Maiseo and Simult'Eau), which have given promising results (see figure below). However, the method must be extended to other crops and other territories in order to be validated. The next crops to be studied are irrigated wheat in France and also North African countries such as Morocco.

Valérie Demarez (Cesbio / UPS)
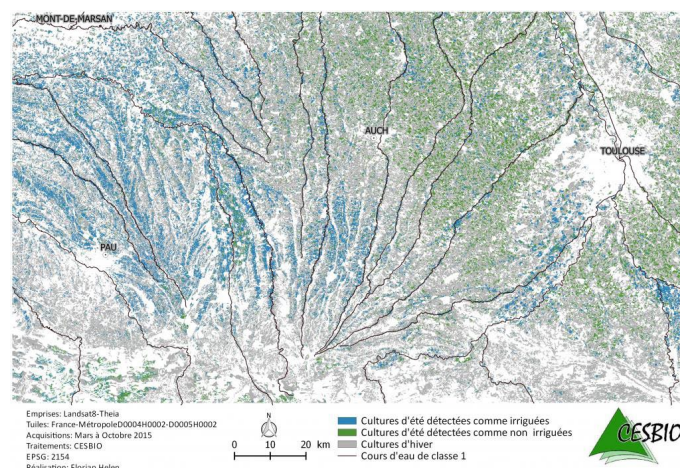
Map of irrigated crops, work carried out by F. Helen, F. Baup, C. Marais-Sicre and V. Demarez

Fire Scientific Expertise Centre : how to map the severity levels of forest fires

As part of the THEIA Centre, the new Fire Scientific Expertise Centre started this summer. The goal is to map burned areas based on satellite images accessible in Geosud and to estimate the severity levels of the fires based on image processing and calibration based on field surveys.

While waiting for the first results of analyses of fires from the 2017 season, an initial approach was to work on the Rognac fire on 10 August 2016, as multiple sources of satellite images were available, and field surveys of the damage had already been carried out. In particular, it was possible to compare multiple resolution levels in the wildland–urban interfaces.

Focus on damage in the wildland–urban interfaces

The aim of this initial approach is to test the possibility of mapping severity levels in the wildland–urban interfaces based on different sources of satellite images, and to show that there is a relationship between these severity levels and the levels of damage, observed by field surveys, to constructions and surrounding vegetation which are closely interlinked in interface areas.

The description of the levels of damage on the ground is in five levels :

- 0 : no damage;
- 1 : damage to surrounding vegetation;
- 2 : damage to outbuildings;
- 3 : damage to the outside of the house;
- 4 : damage to the inside of the house;
- 5 : total destruction.

A total of 36 dwellings was described, of which nine were damaged (levels 3 to 5), and 27 were undamaged or slightly damaged (levels 0 to 2).

Three sources of satellite images available as part of the THEIA Centre were used and compared (Fig 1).

Different indices were calculated within a 50 m buffer around the dwellings affected by the 2016 Rognac fire: NDVI (Normalized difference vegetation index) and dNDVI (differencing NDVI) with the Near-Infrared (NIR) and Red bands for Pleiades, SPOT and Sentinel 2 (Tucker 1979).

GNDVI (Green Normalized Difference Vegetation Index) and dGNDVI (differencing GNDVI) (Gitelson and Merzlyak, 1998)
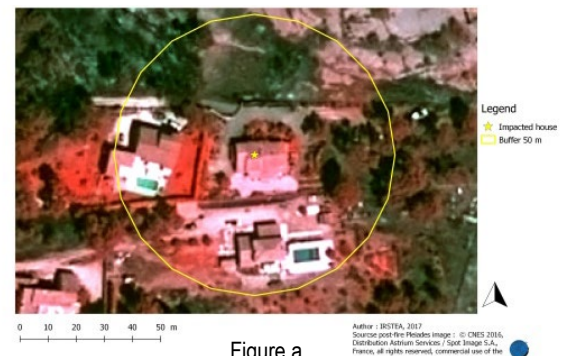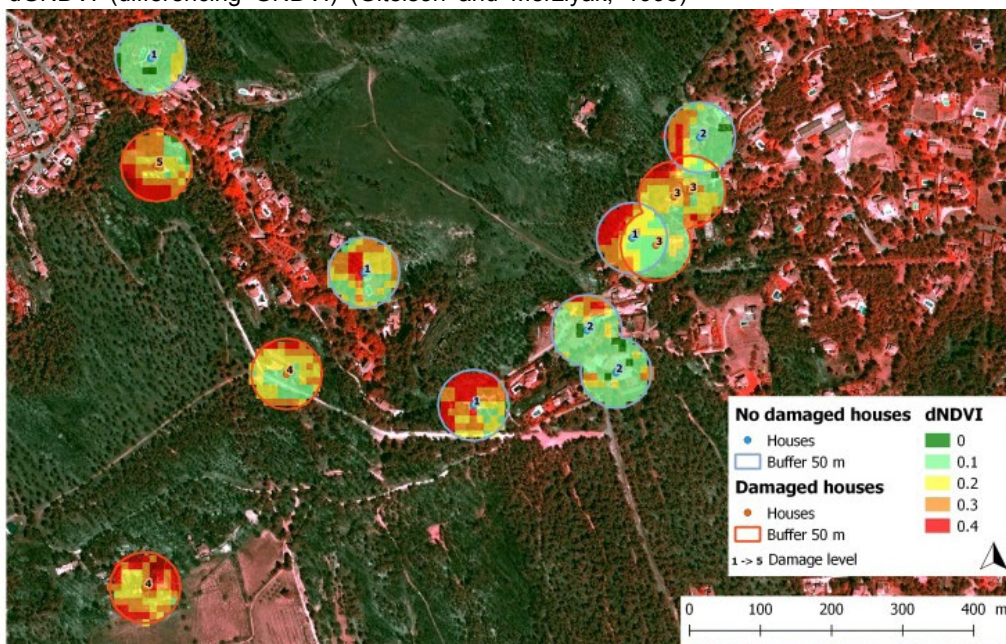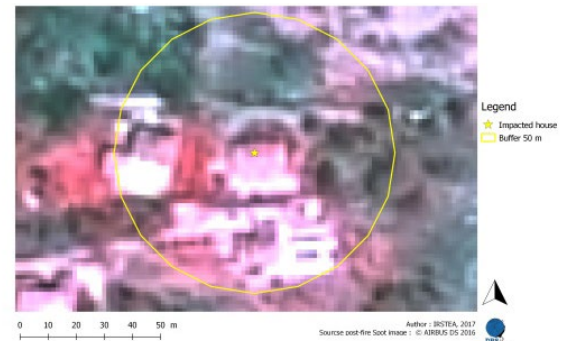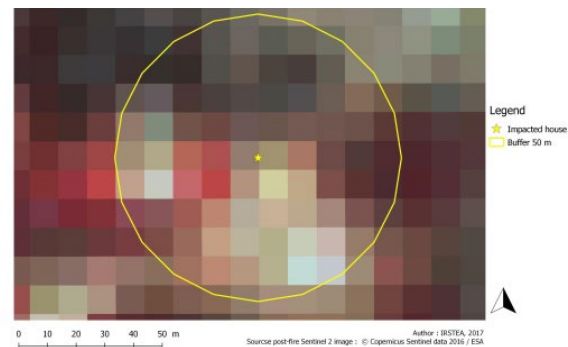

Figure a

Figure b

Figure c

Figure 1. 50 m buffer around a dwelling. (a) Pleiades image «contains information © CNES 2016, Distribution Astrium Services / Spot Image S.A., France, all rights reserved. Commercial use is prohibited.» / (b) SPOT 6/7 image © Airbus DS / (c) Sentinel 2 image «2016 Sentinel 2 Copernicus data processed at level 2A by CNES for the THEIA data centre.»

were calculated with the NIR and Green bands.

Figure 2 shows the map of fire severity in the wildland–urban interfaces based on Sentinel 2 data.**>>**

Figure 2. dNDVI 5 severity classes (from green to red) based on Sentinel 2 data «2016 Sentinel 2 Copernicus data processed at level 2A by CNES for the THEIA data centre. Mapped on SPOT 6/7 © Airbus DS

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>> A comparison of the average values of the GNDVI and NDVI indices for the three satellites in the 50 m buffer shows differences between the damaged constructions and the undamaged or slightly damaged constructions (Fig 3) and damaged/undamaged distinctions that differ depending on the resolution of the satellites.
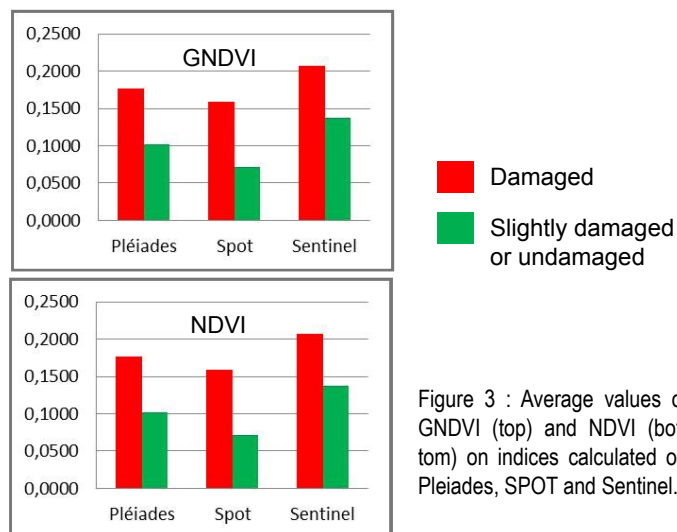

Figure 3 : Average values of GNDVI (top) and NDVI (bottom) on indices calculated on Pleiades, SPOT and Sentinel.

Prospects

This is a first study to map the severity of fires at interfaces.

There are very few studies about the use of Sentinel data in connection with forest fires. Some authors have recently demonstrated its use to estimate damage after fires (Fernández-Manso 2016; Navarro 2017), but there are no references for fires in wildland–urban interfaces.

On initial examination, it would appear that Sentinel data allow levels of damages at interfaces to be differentiated, and that the ease of access to these data allows before-after comparisons to be made (to be linked to the Change detection SEC).

These data can be used in connection with higher-resolution data, allowing a more detailed spatial analysis of the organisation of the environment of the construction, particularly with regard to ornamental vegetation.

Marielle Jappiot, Adeline Bellet, Christophe Bouillon, Fabien Guerra, Jessica Hedan, Eric Maillé, Denis Morge (UR Recover / EMR / Irstea)

Record dry conditions in 2017: local observations and regional assessment by remote sensing

With just 41 mm accumulated rainfall between 15 June and 15 October, the summer of 2017 is proving to be the driest for more than 40 years.

The Puéchabon experimental site in Hérault (OSU OREME's Mediterranean forest OS) has recorded variables since 1998 demonstrating the impact of climate variations on the functioning of the holm oak ecosystem. The trees' water stress is monitored by measuring the tension of the sap in the wood (water potential).

2017 beat the double record of the most intense drought (absolute minimum water potential of -5 MPa compared with an average of -3.4 MPa) and the most severe drought in cumulative intensity over the summer season (water potential integral over the summer or WSI of -335 MPa days compared with an average of -168 MPa days). The cumulative index of the VARI (Visible Atmospherically Resistant Index) calculated based on MODIS images over the 2001-2017 period is strongly correlated with the inter-annual variability in WSI on the Puéchabon experimental site. The regional analysis of the year in which there occurred the minimum cumulative summer VARI seen over the 2001-2017 period illustrates how exceptional the 2017 drought was, as well as its consequences for the occurrence of large fires over the summer (Map: OSU OREME 2017 'Fire' observation task, Sentinel 2 images).

By combining long-term local observations and regional observation by remote sensing, OSU OREME's Mediterranean forest OS allows operational monitoring of the condition of Mediterranean forest ecosystems and the disturbances to them.

Jean-Marc Ourcival, Florent Mouillot, Jean-Marc Limousin (Cefe / CNRS)
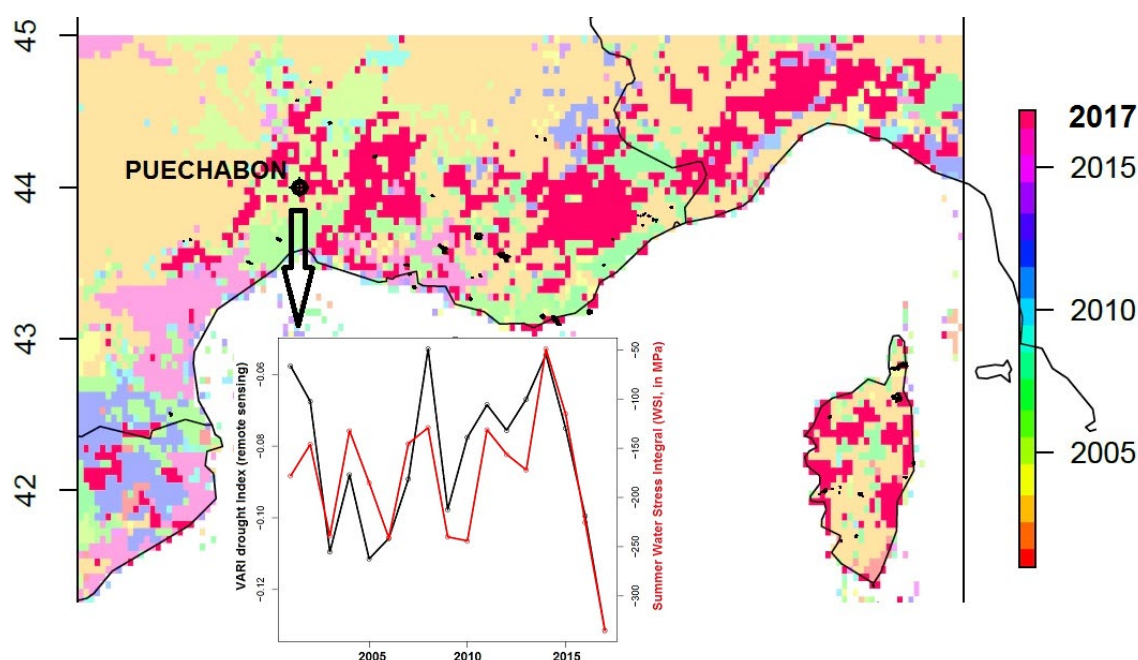
Regional map identifying the year of the lowest cumulative summer VARI over the 2001-2017 period (2017 in red), and the outlines of fires >30ha in black. The annual variation in VARI and WSI on the Puéchabon site is shown in the box.

SWOT: a «GPS carpet / Drone / LiDAR» campaign in the valley of the Lower Seine

A measurement campaign took place in June 2017 in the valley of the Lower Seine, using different techniques as preparation for future validation of SWOT data.

The SWOT mission

The SWOT (Surface Water and Ocean Topography) mission, the result of cooperation between France and the United States (CNES/NASA, with the involvement of CSA and UKSA), will allow water levels (and their spatial and temporal variation) of oceans, rivers, lakes and coastal and estuarine areas to be measured using a new technical concept: interferometric altimetry. The new capabilities and performance provided by the SWOT mission demonstrate the need to make progress and innovate in science, to conduct specific methodological development (new processing methods, adaptation of existing methods, etc.), in close collaboration with scientists and operational users. Integrated into complex information systems, data from the SWOT mission will allow the quality of oceanic forecasts, weather and climate forecasts, and hydrological diagnoses, which have recognised economic value, to be maintained and improved. These analyses will only be possible if we prove the quality of the SWOT measurements. This mission therefore requires the development of Calibration and Validation (Cal/Val) resources that are suited to the extremely high measurement precision that is expected. In 2021, after the launch, SWOT performances must be calibrated and validated using inputs from other space missions, the available in-situ data, and also dedicated resources deployed onsite during satellite passes in order to have contemporaneous measurements. It must be possible to deploy these resources in remote locations (the Amazon rainforest, Africa, India, etc.) in order to have facts on the ground on sites without instruments, so they must be light.

In-situ CalVal

Of the various resources envisaged for validating SWOT continental water level measurements, the most promising are water level information deduced from GPS measurements on a specific buoy and/or airborne and/or drone-based LiDAR data. Within this framework, CNES has called upon its partners (IRD, INSU, CNRS, CLS, etc.) to develop resources that would be implemented during the Cal/Val phase in orbit in 2021. These resources were developed on the Seine estuary between Rouen and Honfleur on 22 and 23 June 2017 in order to validate behaviours of the different vectors.

The Seine estuary between Rouen and Honfleur was chosen as the experiment site because one of the scientists associated with the SWOT mission (B. Laignel from the University of Rouen) has extensive knowledge of the local hydrology, and has the necessary technical resources. Data from existing tide gauges are available along the entire river, to provide independent information, as well as a set of resources simulating the SWOT measurement on this section of the Seine.

The HyDrones system

It is common knowledge that existing LiDAR scanner type instruments do not allow a precise measurement of the water surface. It is in precisely this specific field that CLS has developed its expertise over many years, through work measuring the ocean surface. With regard to LiDAR measurements by drone, the onboard remote sensing technology on the HyDrones payload allows measurements equivalent to those offered by satellite altimetry, and provides a continuous time series of water surface level data on hydrological systems. The solution HyDrones is based on the synergy between a flying drone, which is flexible and quick to deploy, and an innovative autonomous payload dedicated to measurements of hydrological objects. The different HyDrones remote sensing instruments were therefore developed for real-time monitoring of all of the physical parameters of the water, starting with the water surface level, bathymetry (dependent on water quality, as it cannot be too turbid) and the area of the bed of a hydrological system. In short, the objective of the HyDrones solution is to provide a complete service, from measurement acquisition to the summary of relevant information for the clients, based on CLS's expertise in processing of oceanic data.

Payloads

In addition to the remote sensing technology suited to the physical parameter measured, the HyDrones instruments are fitted with sensors allowing absolute position information to be provided, through a GPS receiver, and also the attitude (particularly pointing and acceleration due to the angles taken by the drone during its pass) of the payload to be taken into account when taking measurements and the associated calculations. This flexible solution, which is able to adapt to the specific needs of the users, was also designed to offer an affordable solution compared with existing measurement resources for monitoring waterways.

In terms of payload, the objective of HyDrones is economical production with advanced technology. The measurements made by the instruments therefore have a precision of less than 10 cm for the measurement of the water surface level.   >>

Figure 1 : Prototype of HyDrones #MK1.1 light altimeter. In the background: «CalNa-Geo» GPS carpet

>>

At present, the HyDrones instruments also have several distinguishing markers compared with other types of payload that exist on the market:

- HyDrones offers continuous measurement on hydrological objects.

- The HyDrones payloads are so compact (sides of 12-15 cm) and light (800-900 g) that they can be fitted onboard any type of drone. They are also completely independent of the native drone (they do not use the drone's GPS or battery).

- HyDrones instruments have significant autonomy of 3-4 hrs.

Initially, a light altimeter based on LiDAR technology new-generation, called HyDrones #MK1.1, was developed to measure the water surface level. This prototype is presented in Figure 1, as well as the «CalNaGeo» GPS carpet used during the Seine experiment. This payload, onboard a tethered drone within the framework of this deployment for CNES, has the aim of following the boat to be able to compare its performance with those of the GPS carpet mentioned above. The drone flies in the wake of the boat, just in front of the GPS carpet (approximately 30 m behind the boat, depending on the wake), at an altitude of 30 m. Two people on the boat (a remote pilot and an operator) control the drone. The deployment constraints for this drone are rain and winds of more than 40-50 km/h. The drone has an automatic pilot: the pilot is present on the boat in case of specific events (bridges, electric cables, Seveso zones, etc.).

Figure 2 : HyDrones #MK2 prototype dedicated to bathymetry

Similarly, the HyDrones #MK2 instrument prototype allowing access to bathymetric measurements (in a known frame of reference) was developed and used during this experiment. This instrument has been specified on the basis of the instrument dedicated to water surface height, with a remote sensing sensor specific to bathymetric measurements (Figure 2).

For more information, you can contact the team : hydrones@cls.fr

G. Valladeau (CLS) for the HyDrones team (J-C Poisson, P. Prandi, O. Lauret) & B.Laignel (Université de Rouen)

Nanosatellites at university

The Montpellier-Nîmes University Space Center (CSU) is the University of Montpellier's technological platform dedicated to the engineering of nanosatellites (satellites weighing less than 10 kg). Close collaboration between CSU Montpellier-Nîmes and a network of institutional partners (CNES, ESA, the Languedoc-Roussillon Occitanie Region, etc.) and industrial partners through the Van Allen Foundation enables it to combine implementation of new technologies, training of student trainees and research collaborations.

Following the launch of two CubeSats (cube-shaped satellite measuring 10x10x10 cm3 and weighing approximately 1 kg), Robusta-1A in 2012 and Robusta-1B in June 2017, CSU Montpellier-Nîmes became a pioneer and then a major player in the field of nanosatellites in France.

Robusta-1B is currently in orbit 510 km from Earth. Its two-year mission is to measure the in-flight deterioration of parameters from operational amplifiers subjected to space radiation. Following recent solar flares, very promising results are being analysed.

Three other CubeSats are being developed for 2018 and 2019: two 1U, MTCube and Celesta, and one 3U, Méditerranée.

- MTCube, developed for ESA in collaboration with LIRMM, will measure the error rate on different types of memory in space.

- Celesta, the result of a partnership with CERN, will compare radiation environments in Low Earth Orbit and in the CERN CHARM accelerator using the CERN RadMon radiation monitor. This project was selected to be part of the ESA Education Office's «Fly Your Satellite!» programme, which supports the six best European teams.

- Méditerranée was developed in partnership with CNES and with substantial support from the Van Allen Foundation. It

will be capable of orientating itself towards a precise spot on Earth to collect environmental data for Météo France to improve forecasting of Cévenol episodes.

Christine Julien (CSU Montpellier - Nîmes)
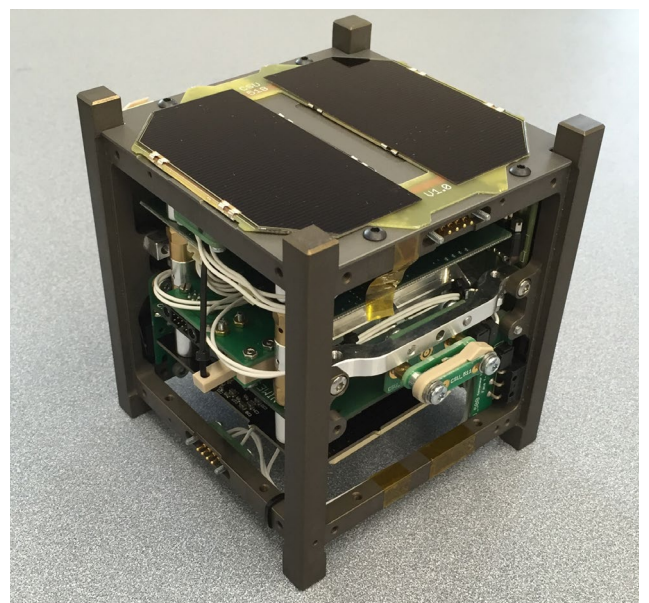
Celesta nanosatellite

RUS: a new service for users of Copernicus data

The Research and User Service (RUS) builds on the Copernicus User Uptake project put in place by the European Commission (EC). Its aim is to acquaint users with processing and use of Sentinel data, and is structured around three major objectives :

- Promoting the use of Copernicus data,
- Making it easy to handle tools in the Copernicus ecosystem,
- Encouraging the emergence of scientific and industrial projects making use of Copernicus data.

The Service offers centralised support for users (researchers, scientists, SMEs, government agencies or general public) to allow handling of large volumes of data generated by the Copernicus missions, and to stimulate the use and development of new algorithms and services.

The RUS project supplies cloud working environments in PaaS (Platform as a Service) mode, and the tools required to promote access, analysis, use and processing of Copernicus data. In parallel, the project also has the aim of providing training and support services to users in both technical and thematic fields.

The Research and User Service is free and can be accessed at: rus-copernicus.eu

It is financed by the EC, overseen by ESA, and performed by CSSI and its partners: Serco SPA, Noveltis, Along-Track, and CS Romania.

Eric Guzzonato & Brice Mora (C-S / RUS Copernicus)
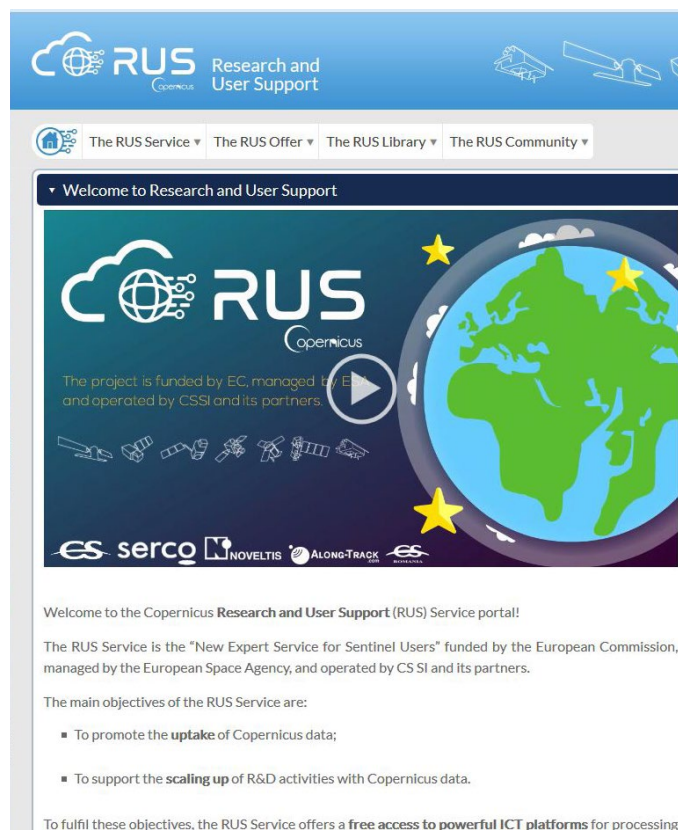
RUS web interface

A Copernicus Academy at the Maison de la Télédétection

In 2016, the European Commission published a report providing the foundation for a serious European strategy for the use and enhancement of Copernicus products and services (€5.6 billion invested between 2008 and 2020).

In this context, two types of institution were approved at the end of 2016:

- Copernicus Relays, which are national or regional structures or institutions in the space field, have the tasks of broadcasting information, coordinating actions and promoting events related to the programme.
- The Copernicus Academy Network is made up of Copernicus Academies, which are teaching structures or institutions. Their task is to develop classes and sessions with the aim of training the new generations.

AgroParisTech, a member of UMR TETIS, was awarded the Copernicus Academy label. The existing training and its position within the UMR (joint research unit) and the Maison de la Télédétection (Remote Sensing Centre) in Montpellier were considered assets.

An initial action plan, not financed by the EU, is being worked on in 2017 thanks to contributions by the scientists concerned who are involved in the sessions. In 2018, the team will be mobilised to seek funding allowing new training courses based around Copernicus to be developed.

Pierre-Yves Vion (Tetis / AgroParisTech)