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A word from the Scientific and Technical Directors

This first Bulletin since the confinement shows that Theia's activities have suffered little from the Covid-19 epidemic.



Scientific and regional activities have undoubtedly been disrupted, with events canceled and postponed. The events for the start of the 2020 academic year, and in particular the AppSpace, which will be held in Montpellier on September 17,

will be all the more important as we have plenty of new products to present to you.

Theia and Dinamis are now offering centralized catalogues for optimized search and download, and we invite you to discover these new tools. Theia's flagship products, such as Land Cover or Reflectance, have continued to improve during the last semester. Simon Gascoïn's Snow product in Toulouse is a direct inspiration for the FSC product now offered by Copernicus on a European scale. A promising new product developed by Antoine Rabatel in Grenoble now offers data for 240 alpine glaciers between 2000 and 2016.

This Bulletin also proposes to follow the development of the Trishna, Smos and Swot satellite missions and to imagine what new products can be developed thanks to them. Finally, it gives a voice to Theia's stakeholders: researchers, regional animators and companies that base their development on the successes of public research. ■

NEWS

Montpellier, French GeoData Capital in September 2020

Montpellier (Le Corum) will host two major events for our community in the fall of 2020: the GeoDataDays, on 15 and 16 September, and AppSpace, on 17 September. Health situation has prompted us to increase coordination between these two events, which share a large common audience.

The 2020 edition of the AppSpace event- *Space products at work for territories* - aims to bring the users of space products closer to those who create them: image producers, researchers, start-ups that help people to get started, trainers, facilitators.

The day will alternate between thematic sessions (risks, urbanisation, agro-ecology), demonstrations, concrete and interactive workshops. The event, co-organized by Theia and supported by CNES, is led by OPenIG, a structure that participates in Theia's regional activities in Occitania (► [Read p. 14](#)).



AppSpace#2020 : Space products at work for territories

Register now! The event is free for scientists, students and OpenIG members.

► www.tools.openig.org/appspace

The programming committee brings together the CNES, Theia, Dinamis, GeoSud... alongside local (Occitania Region, Montpellier metropolis) and national institutions (IGN). We look forward to seeing you there!



Register now!

► www.geodatadays.fr/inscription

After Le Havre in 2018 and Arras in 2019, the 3rd edition of GeoDataDays will be held in Occitania the two days preceding AppSpace: ecological transition, data ethics, adaptation to the crisis, etc. will be on the agenda this year. Organised around major debates, practical workshops, challenges, a fair with 50 exhibitors and moments of conviviality, GeoDataDays will mark the start of the new school year!

The GeodataDays 2020, organized by AFIGEO (and DécryptaGeo) with OPenIG, the Occitanie Region, Montpellier Méditerranée Métropole and the Ministry of Ecology, is the annual national and independent event for geodata professionals. ■

Anne FROMAGE-MARIETTE (OpenIG),
Françoise DE BLOMAC (DécryptaGéo)
& Elise LADURELLE-TIKRY (Afigeo)

Georep and its Pleiades Catalogue for New Caledonia

Pleiades 1A/1B is a space program funded by CNES and operated by Airbus Defence & Space. The public origin of the financing of these twin satellites has allowed the setting up, thanks to CNES, of a License dedicated to French institutions, known as "Authorized Institutional Users" (UIA).

As explained in a dedicated article in the *Bulletin de la Géomatique en Nouvelle-Calédonie*, this License has many advantages: in particular, the very low cost of data acquisition and the possibility for any UIA to retrieve free of charge any data already financed via the concerned License.

On INSIGHT's initiative, as the official reseller of Airbus DS' products and services within the South Pacific region and as co-facilitator of the GeoDEV-NC RAN, the Geomatics and Remote Sensing Service (SGT) of the Government of New Caledonia has set up on its territorial geographic information portal, called Georep, an application dedicated to the census of Pleiades THR data acquired in the territory under UIA License: the UIA Catalog.



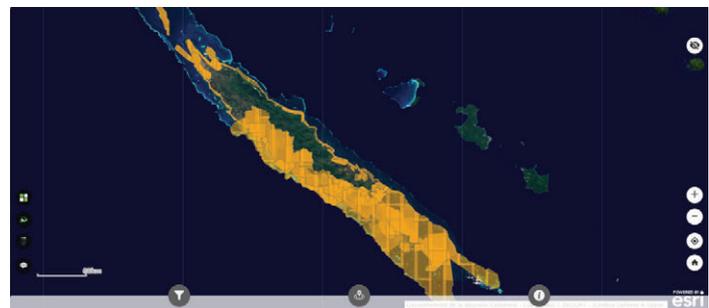
Georep website ► georep.nc

This information is fully open and thus broadcast to all New-Caledonian institutional users. For each image, the application presents the main associated metadata as well as a "quick view".

It is kept up to date by GeoDEV-NC RAN and facilitates access to such VHR data for the multiple rightsholders, while contributing both to the pooling of resources and to the optimization of public funds.

An exhaustive coverage of the territory of New Caledonia is in progress, including lagoons and reef areas; these new data will be implemented in the application upon delivery. ■

**Marc DESPINOY (IRD)
& Jean MASSENET (INSIGHT),
Facilitators of GeoDEV New Caledonia RAN**
www.theia-land.fr/artist/art-geodev-nouvelle-caledonie/



UIA Catalogue for New-Caledonia ► carto.catalogue-uia.georep.nc

The GeoDEV RAN New Resources Area

The website dedicated to Theia network for Southern Countries (GeoDEV RAN) has been expanded with a Resources Area which offers its users content related to space observation of territories and the environment in the South. Thematic resources on agriculture, forestry and land use are already open and accessible; soon materials covering biodiversity, water, health, risks and urban themes will be added to the current resources.

The Resources area, accessible by simply joining the GeoDEV network, is dynamic and collaborative.

A rich and adapted content

Further resources from Theia will be progressively added, as well as contributions from members themselves: content submission forms are already available to send and share news or documents of interest within the network.

Each Theme lists news, events or documents of interest classified into categories. It offers presentations of products derived from satellite data, links to dedicated web services, documents available for download: teaching aids, scientific publications, project sheets, slide shows, etc... The GeoDEV series of thematic GeoDEV sheets dedicated to field applications and research in progress in Southern countries will also be available in this space.

An "image catalogues & toolboxes" section", cross-cutting themes, lists a set of satellite images available on territories in the South. It leads to tools for visualization, area extraction and downloading as well as data processing (time series, classifications).



The GeoDEV team is available for any interaction with users who would like to know more. ■

**Jean-François FAURE (IRD, Espace-Dev)
GeoDEV Co-facilitator**
► www.theia-land.art-geodev.fr

“My Environment from Space”: Copernicus in Breton Schools



A group of seven engineering students from ITM Atlantic supervised by GIS BreTel (Bretagne RAN) spoke to schoolchildren on the theme “My Environment from Space”.

On the agenda: discovery of space through an interactive quiz, creation of a satellite model, discovery

of environmental issues through satellite observation.

Great enthusiasm

“This project allowed us to transmit our knowledge of space and environmental issues in a playful and interactive way, adapting it to primary school students.” “The children were very enthusi-



astic, dynamic and interested in our interventions and enjoyed making their satellite model. They were curious and asked a lot of questions,” said the engineering students.

Shortened this year with school closure, this program will be offered again next year to schools in the region.

Thanks to the engineering students Édouard d’Aviau de Ternay, Armand Douce, Louis Klein, Elsa Moudio Priso, Jean Plumail, Lucas Rakotoarivony and Hugo Si Yan Kai for their motivation throughout the project. ■

Marie JAGAILLE (Bretel)

► bretel.eu

Bretagne RAN co-facilitato

► theia-land.fr/art-kalideos-bretagne.

Interactive quiz, creation of a satellite model, and discovery of environmental issues through satellite observation.



CEREMA Broadcasts in Open Source the Satellite Image Processing Chain of Its Satellite Unit

The CEREMA Satellite Team has just published in Open Source on Github its satellite image processing chain, the result of several years of development on the themes of land use planning and risks management.

This Python-based processing chain is divided into three levels:

- Elementary libraries: general (file and folder processing, text and xml reading, display, mathematical calculations, etc.) and professional (for the management of image, vector and database data, etc.) based on Open Source libraries (OTB, GDAL, NumPy, OpenCV, etc.).
- Advanced processing applications, allowing complex data processing (classification, segmentation, vectorization...).
- A sequencer, allowing the parameterization of application sequences, and the supervision and distribution of calculations.

At the heart of CEREMA’s work

The chain is implemented into the work of the Cerema, particularly on the themes of urban planning or regional development, coastal monitoring or flood risk management. CartEau, a plugin for QGIS developed by Cerema for the calculation of flooded areas also relies on this chain.



The satellite images used in this context come from the Pleiades, SPOT-6/7, RapidEye or Sentinel-1 and 2 sensors.

Read all the news of the Satellite Pole on the CEREMA website. ■

Amélie LOMBARD (CEREMA)

www.cerema.fr

► github.com/CEREMA/dterso.

chaîneTraitement.

traitementImageSatelliteEtIndicateursDerives

The New Theia Catalogue: All the Collections in a Single Visualization

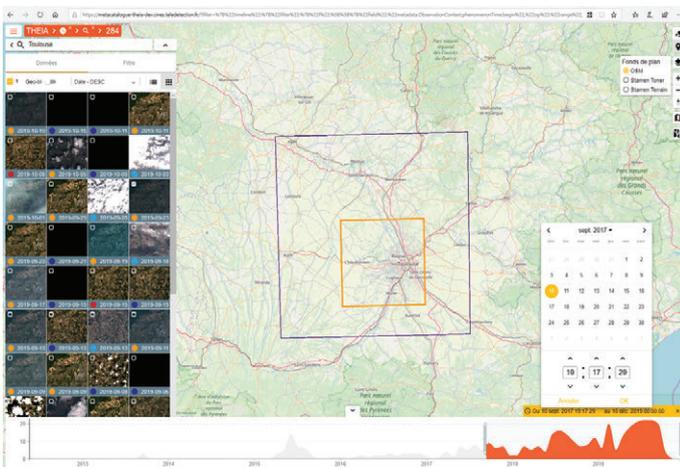
As early as 2013, Theia had put on its roadmap the implementation of a single web mapping interface allowing a centralized search and visualization of all collections. The need for an equivalent tool for the DINAMIS offer made it possible to pool resources and launch a joint development.

This new Theia catalogue, developed by Thales and Gisaïa and available since June 2020, collects therefore all existing IDSs to provide access to all Theia collections that allow it.

A fully-developed research tool

This “meta-catalogue” provides a detailed search by theme, by collection, by sensor, by geographical area, by time range and by statistical distribution.

The development was guided by the concern to make the user



A Website and Catalogue for DINAMIS

The DINAMIS - Dispositif Institutionnel National d'Approvisionnement Mutualisé en Imagerie Satellitaire in French - team is pleased to announce to its users the upcoming launch (summer 2020) of its website: www.dinamis.data-terra.org.

The site will provide users with a complete set of useful information: eligibility criteria, account creation procedures, brief descriptions of the data made available, and the steps involved in filling out THRS imagery requests via the dedicated application in particular.

Grouping together documents useful for accessing the Pleiades and Spot 6-7 imagery, the DINAMIS website fills a recurrent need and completes the Expression of Need Application. The latter will be, like the DINAMIS Unified Catalogue, directly accessible on the Home page of the site.

An advanced catalogue for an enlarged bouquet

The recently developed DINAMIS catalogue will provide access in a few clicks to the Pleiades, Spot 6-7 and RapidEye collections, previously distributed by the ISIS and GEOSUD devices. To simplify matters for users, it will also enable them to navigate, within the same interface, through the Sentinel (1 & 2) and Spot World Heritage (Spot 1 to 5) collections, which are hosted by the CNES infrastructures.

DINAMIS users will therefore be able to access a wider range of THRS and HRS data for viewing and downloading within a given territory and time range. Little by little, the Catalogue will evolve to progressively integrate within its interfaces the functionalities of the THRS Needs Expression Application.

interface ergonomic and easy to use. The device is intended to evolve in order to integrate all future collections that will be added to the Theia portfolio.

On the users' side

The original catalogues (Hydroweb, Theia.cnes, Geosud, Thisme) are still accessible and the products remain physically stored on these catalogues. But to facilitate access to the products, downloads are directly possible from the “meta-catalogue”. The user only has to enter his or her identifiers in the original product catalogue, which is easy thanks to the unique identification set up in the Theia consortium. To assist the users' first steps, a series of six video tutorials is available on Theia YouTube channel.

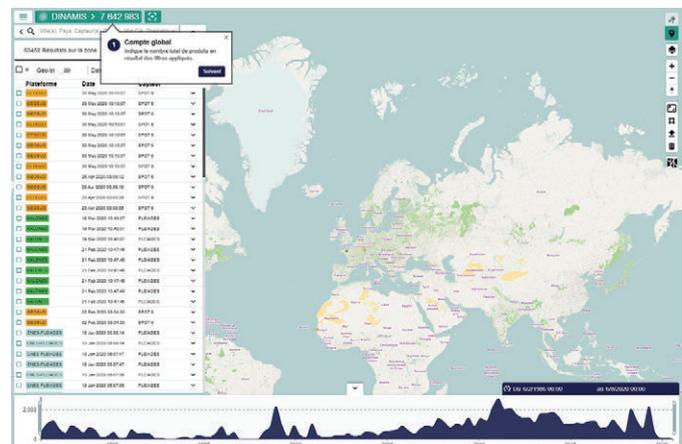
Spatial imaging products (Spot, Pléiades, etc.) are also grouped together in the unique Dinamis catalogue (► Read below). ■

Arnaud SELLÉ (CNES)
CNES Theia Project Manager
& Stéphane DEBARD (IRD)
Theia Scientific Data Mission Officer

Theia Catalogue
 ► catalogue.theia-land.fr

All the tutorials gathered in a YouTube playlist
 ► www.theia-land.fr/tuto-catalogue

Theia new catalogue provides a centralised access to SECs products as well as advanced search functions and image visualisation tools.



The new DINAMIS catalogue will offer advanced research functions for Pleiades, Spot 6-7, RapidEye, Sentinel and Spot World Heritage imagery.

The website will be equipped with a Contact Form that will allow everyone to request, according to their needs, technical support from the DINAMIS team. It will propose in a second step a Frequently Asked Questions (FAQ) section. ■

Jean-François FAURE (IRD, Espace-Dev)
DINAMIS Executive Secretary

DINAMIS website
 ► dinamis.data-terra.org

DINAMIS catalogue
 ► catalogue-dinamis.data-terra.org/

Land Cover: a Product in Continuous Improvement

The production of the land-cover map for metropolitan France has been carried out by the CNES MUSCATE operational team since the 2018 version. However, this does not mean that CESBIO, which had been running the production since the beginning of the Land Cover SEC, has stopped working for Theia. The same applies to the other partner laboratories of the Land Cover SEC. For CESBIO, we have continued to improve methods for large-scale land cover mapping and to integrate them into the iota2 processing chain.

The contributions of contextual classification

One of the important innovations is the contextual classification method developed by Dawa Derksen in the framework of his thesis. The details of the method were published in the *Remote Sensing* journal, showing that the method does as well as approaches using Deep Learning, but at a much lower cost in terms of computation (and therefore energy).

The particularity of the method is that it makes it possible to take into account the neighbourhood of a pixel in the classification procedure. In particular, this makes it possible to reduce errors in the land cover classes that are characterized by spatial heterogeneity, such as discontinuous urban fabric, orchards, etc.

Although the method is integrated into the production chain, we did not use it for the 2019 version published in March 2020. Indeed, the Land Cover SEC and Theia are committed to ensure product continuity by introducing modifications only if they improve the quality of the product and remain compatible with previous maps. Therefore we have published a prototype product in order to collect the opinions of users: a 2018 map for one third of the south of France (about 30 Sentinel-2 tiles).

Figures 1, 2 and 3 show respectively an aerial view, the map produced with the classical method and the map produced with the contextual method, over a small area. Table 1 opposite gives the validation statistics for the complete area of the 30 tiles. The contextual version contains less noise while keeping a precise definition of the shape of the objects. There is also a gain in terms of precision for all classes. However, these statistics must be interpreted with care, as they do not allow for local errors that could be important from a cartographic point of view. For this reason, the opinion of Theia Land Cover product users is very important.

Table 1 Accuracy comparison between the classical Land Cover and the contextual methods

Method	Classical	Contextual	Diff.
Global precision (%)	78,8	85,4	6,6
Dense urban	10,5	15	4,5
Diffused urban	57,3	76,5	19,2
Ind. and Comm. Zones	54,3	65,7	11,4
Roads	46,7	64,3	17,6
Canola	92,5	95,2	2,7
Straw cereals	85	90,1	5,1
Protein crops	53,3	71,3	18
Soy	80	90,1	10,1
Sunflower	91,7	95,3	3,6
Corn	90,4	94,1	3,7
Rice	96,9	98	1,1
Tubers/roots	57,9	73,1	15,2
Prairies	52,4	66,9	14,5
Vergers	36,4	62,5	26,1
Vineyards	73,3	90,7	17,4
Hardwood forests	79,1	86,3	7,2
Coniferous forests	87,7	92,8	5,1
Lawns	66,3	72,8	6,5
Landes	37,3	57,2	19,9
Mineral surfaces	84	88,1	4,1
Dunes and beaches	24,3	66,2	41,9
Glaciers and snow	74,9	84,4	9,5
Water	98,6	98,8	0,2

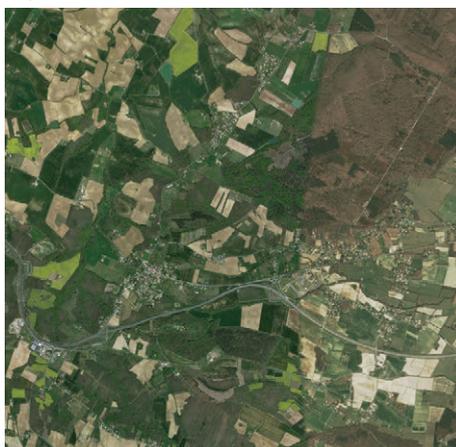
The first feedback is quite favourable, but it shows that there are still some adjustments to be made before going operational. We are always open to comments and suggestions.

iota-2

We have also worked hard to improve the iota2 processing chain. Indeed, this free software developed at CESBIO is both a research platform and a production chain. As such, it is used by research laboratories and industry for mapping activities quite different from Land Cover.

We have therefore made iota2 evolve to make it easy for other Land Cover SEC laboratories to contribute, but also to make the

1) aerial view



2) classical land cover map



3) contextual method map



References

Derksen, D.; Inglada, J.; Michel, J. Geometry Aware Evaluation of Handcrafted Superpixel-Based Features and Convolutional Neural Networks for Land Cover Mapping Using Satellite Imagery. *Remote Sens.* 2020, 12, 513.

chain useful to other SECs where the objective is cartographic production (Variables for Biodiversity SEC, Irrigation SEC, etc.). For this work, the TOSCA programme of the CNES funds the PARCELLE project, which federates the laboratories carrying these SECs. The objective is to identify the specific needs of these SECs and to develop iota2 accordingly.

The processing chain has been made easier to install and use, its documentation has been enriched and the contribution of code by users has been facilitated. In parallel with the PARCELLE project, other software optimization work was carried out. All these evolutions are not directly visible, but they make

it possible to propose a toolbox to build production chains for Theia's SECs. ■

Jordi INGLADA (CNES, CESBIO)

Land Cover SEC

► www.theia-land.fr/en/ceslist/land-cover-sec/

Product Land Cover in Metropolitan France

► www.theia-land.fr/en/product/land-cover-map/

Iota2 processing chain

► framagit.org/iota2-project/iota2

A New Theia Product to Assess the Evolution of Glaciers

Glaciers represent a major economic and societal issue (water resources, hazards, sea level change), the importance of which is being reinforced in the current context of rapid change in climate forcing, land surface states and anthropogenic pressure.

Measuring the glacier equilibrium-line altitude

The glacier equilibrium line represents the place on the glacier where the surface mass balance is zero. It thus delineates, upstream, the accumulation zone (where the mass balance is positive) and, downstream, the ablation zone (where the mass balance is negative). From one year to the next, depending on climatic conditions, the altitude of the equilibrium line varies. Measuring its altitude each year and documenting its temporal variability therefore gives us information on climatic conditions and their evolution.

Traditionally and mainly due to the difficulty of access and the topographical complexity of glacial environments, glaciological data are derived from in situ measurements and are accessible on a very limited number of glaciers. Thus, in situ measurements of the equilibrium-line altitude are carried out on an extremely small number of glaciers: around 40 glaciers have continuous measurements over more than 40 years (i.e. 0.016% of the total number of glaciers on Earth). Recent studies have shown the interest of high spatial resolution optical satellite remote sensing images to regionalize the measurement of this variable (e.g. Rabatel et al., 2005, 2012, 2013, 2016, 2017).

The proposed product consists of the elevation of the annual glacier equilibrium line, measured at the end of the ablation period for all glaciers on a regional scale using optical spatial remote sensing.

The characteristics of the product are the following:

- Satellite data sources: Sentinel-2, Landsat-5/8, ASTER, SPOT-6/7
- Frequency of publication: Annual
- Coverage: European Alps

A product without equivalent

The product Annual Glacier Equilibrium-Line Altitude has no equivalent in Europe (Copernicus) or the United-States (NSIDC). One of its strengths is that it relies on both in situ observations and remote sensing. Finally, giving access to such a product is in line with the monitoring strategy established internationally by the Global Terrestrial Network for Glaciers (GTN-G) and the Global Cryosphere Watch (GCW, WMO).

From a scientific perspective, the product fills a gap in glacier information both nationally and internationally. In terms of applications, it provides elements for a better characterization of the recent evolution of glaciers and the associated impacts (water resources, sea level) useful for land management.

240 glaciers in the European Alps

The product Annual Glacier Equilibrium-Line Altitude is available for a set of 240 glaciers in the European Alps over the period 2000-2016. The satellite data processing chain set up in the framework of Lucas Davaze's PhD (2019, Univ. Grenoble Alpes) has been published (cf. Davaze et al. 2020, Supp. Mat.). Current considerations include the possibility of minimising human intervention in the production of the product and the production of the data.

Antoine RABATEL

Université Grenoble Alpes | IGE

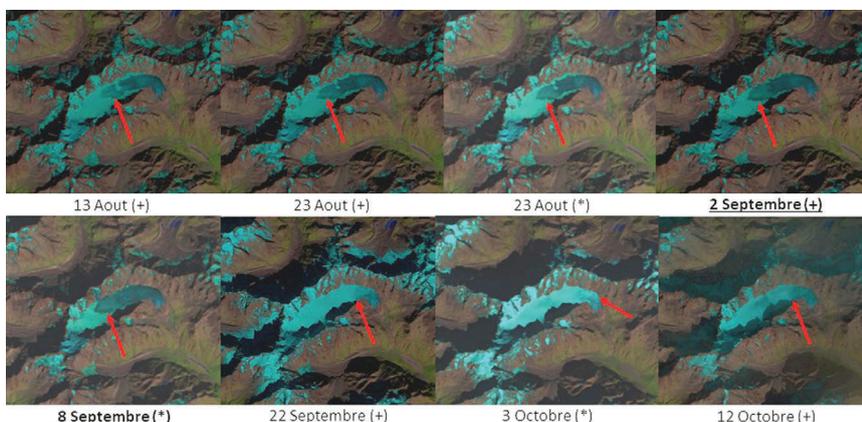
Glaciers SEC

► www.theia-land.fr/en/ceslist/glaciers-sec/

Annual Glacier

Equilibrium-Line Altitude

► www.theia-land.fr/en/product/annual-glacier-equilibrium-line-altitude/



Evolution of the snow line on the Glacier Blanc (Écrins massif, France) during the 2016 summer season. The maximum altitude reached in 2016 between September 2 and 8 gives a comparison point to assess the health of the glacier compared to other years. The images presented were acquired by Landsat-8 (*) and Sentinel-2 (+) satellites.

Surface Reflectance: Completing the Offer, Improving Validation

Complete coverage for surface reflectance products

Theia Surface Reflectance SEC keeps consolidating its portfolio of high-resolution surface reflectance time series at the time of the satellite pass (level 2A), as well as monthly syntheses (level 3A). All these products use data from the European Sentinel-2 satellite. With the provision of products for New Caledonia (May 2020) and Madagascar (March 2020), the geographical coverage that the SEC had set itself with its partners is now complete.

Are thus available for all areas: L2A products offering surface reflectances with a good cloud mask, produced with the MAJA

chain, and L3A products providing monthly syntheses of surface reflectances for cloud-free observations, produced with the WASP chain.

Improved validation on vegetation cover

The validation and improvement of the level 2A product remains a strong requirement of the SEC. The installation in July 2020 of a validation station on the Lamothe farm in Lamasquère near Toulouse (France) will contribute to achieving these objectives. The ground measurements carried out with a photometer on this agricultural area will contribute to the estimation of the optical properties of the atmosphere and surface, and in particular to study the blurring brought by the atmosphere. This station will complement the observations carried out by CNES at the two sites of Crau (France) and Gobabeb (Namibia) to assess the performance of Maja over vegetated canopies and, above all, over heterogeneous areas. ■



L2A product availability in June 2020.

Olivier HAGOLLE (CNES, Cesbio)
Surface Reflectance SEC

► www.theia-land.fr/en/ceslist/surface-reflectance-sec/

Further reading on Cesbio Blog

► labo.obs-mip.fr/multitemp/soon-a-new-device-for-measuring-bi-directional-reflectance-at-lamasquere-south-of-france/

Copernicus Delivers High-Resolution Snow Products Over Europe, Inspired by a Theia Product

The Copernicus Land Monitoring Service (CLMS) is pleased to announce the release of a new range of High Resolution Snow & Ice (HR-S&I) products. They provide snow and ice information in near-real time (NRT) over Europe at 20m x 20m resolution from the Sentinel-2 constellation observations.

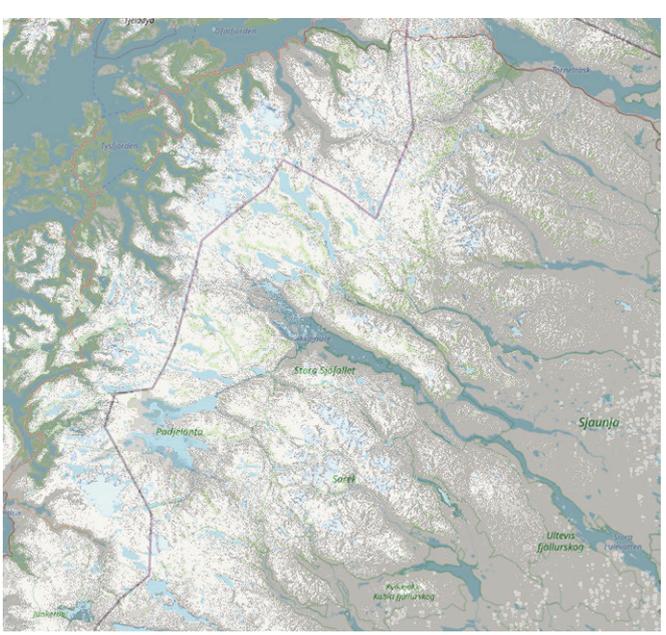
These new offer was developed and operated under EEA (European Environment Agency) delegation, in partnership with Magellium, Astri Polska, Cesbio and Météo-France. Magellium lead the project and developed the NRT system production on the WEKEO DIAS, ice products on lakes and rivers were devel-

oped by the Polish company Astri Polska, while snow products result from the collaboration between Cesbio, Météo-France and Magellium. (► About the project genesis, read Michaël Ablain's contribution in Theia Bulletin n°12)

Fractional Snow Cover (FSC) in near-real time

The FSC product is derived from the already established snow cover information proposed in the Theia Snow collection. Cesbio took a step further in the algorithm to give the percentage of snow on each pixel. FSC is delivered within three hours after the publication of Sentinel-2 L1C products by ESA, according to the 5-day revisit period. Operational production is now on-going under the supervision of Magellium and ASTRI POLSKA.

To introduce Users to these new products an user meeting will be held by videoconference on 15 & 16 of October 2020. Registration is possible as of now on the CLMS website. ■



Florence MARTI
& Michaël ABLAIN (Magellium)
www.magellium.com/fr/

HR-S&I products are accessible to all and can be downloaded at
 ► cryo.land.copernicus.eu/finder/.

More information on the CLMS portal
 ► land.copernicus.eu/

The FSC product documents the percentage of snow per pixel in near real time. Here, for Norway, 16 June 2020

Towards Systematic Monitoring of the CAP by Remote Sensing

For more than 15 years, satellite or drone data have been commonly used in agriculture. They already contribute to the monitoring of CAP (Common Agricultural Policy) declarations by European farmers, the intra-plot modulation of inputs (fertilizers, pesticides), the fine guidance of agricultural tools (precision sowing, etc.), irrigation management, yield forecast, etc. In the framework of the future CAP (2021-2026), however, the use of remote sensing should become systematic.

Modern and homogeneous tools

Thus the European project Sentinels for Common Agricultural Policy - SEN4CAP (esa-sen4cap.org/) set up by ESA in direct collaboration with DG Agri (and on request), DG Grow and DG JRC, but also in close collaboration with the CAP Payment Service Agencies (for example via the H2020 NIVA project ([Read Box](#))), has made it possible to develop an integrated processing chain that provides the European and national CAP authorities with data relevant to its management. This tool integrates algorithms from the MAJA and Iota2 processing chains, which respectively enable Sentinel images atmospheric corrections to be made and land use maps to be produced.

The SEN4CAP processing chain, which is currently being tested in six European Union countries, will thus make it possible to automate the monitoring of agricultural practices, the establishment of reports and the verification of CAP declarations (known as MRV for Monitoring, Reporting, Verification). These new tools should help modernize, homogenize between member states and simplify the CAP after 2020. They should also make it possible to accelerate the payments of subsidies to the farmers.

Documenting agri-environmental indicators

That said, the use of remote sensing in the next CAP will probably not be limited to the MRV. In the framework of the H2020 NIVA project, and at the request of the DGs Agri, Climate and Environment, methods for calculating agri-environmental indicators based on the use of Sentinel data will be tested in several countries via a collaboration between the ASP, the IGN and three INRAe laboratories (CESBIO, DYNAFOR, LBAE).

Of the twelve indicators proposed by these laboratories, three have been considered as priorities: C budget, biodiversity and nitrate leaching risk. The algorithms used to calculate these

agri-environmental indicators for large areas will soon be integrated as a module in the SEN4CAP processing chain. Also, for each indicator between two and three calculation methods of increasing complexity (TIER) have been proposed. The simplest methods, but also the least precise (TIER 1), could be implemented in an operational way by all the member states using only data from the Land Parcel Identification System (LPIS), which provides information on the contour of the plots and the type of the crops, and Sentinel data, which provide information on the presence or absence of cover crops or catch crops.

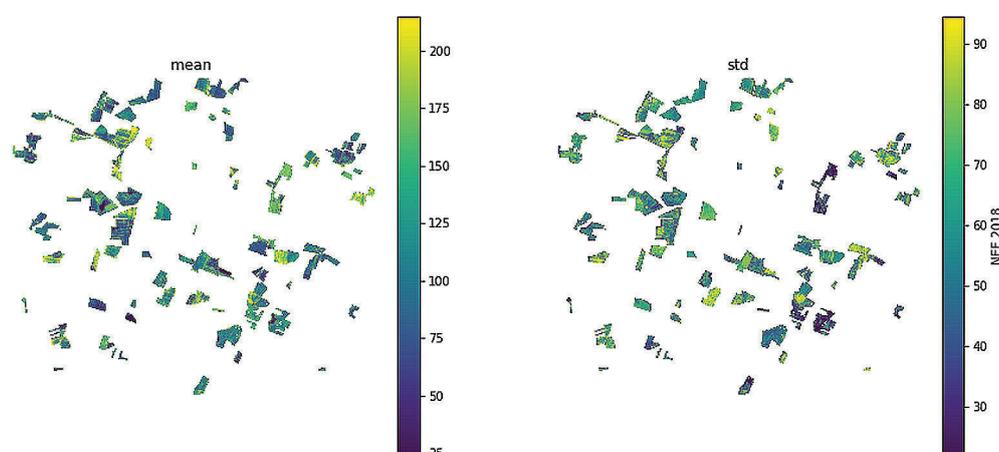
The TIER 2 and 3 methods, which are more precise but more complex to implement, will require the use of additional data (climate, information on practices provided by farmers, etc.) and/or agronomic models.

Diagnosis at the plot level

These new tools for monitoring and calculating agri-environmental indicators could be very useful to farmers. In fact, all the data produced and made available to them free of charge should enable them to establish agronomic diagnostics on a plot-by-plot basis and thus to improve their practices (input modulation, improvement of soil fertility, etc.) and their net margins. These new applications will also most certainly help to promote agro-ecological transition, in particular by providing financial support for agro-ecological practices (e.g. cover crops) via the second pillar of the CAP. In the near future, the Copernicus Land Surface High Resolution (10m) service will offer two new services for mapping and monitoring the development of crops and practices throughout Europe: the Phenology HR service (end 2020, produced with the SEN4CAP processing chain), and the CropLand HR service (in 2021). These services will produce for each plot in Europe the information needed to calculate agri-environmental diagnostics.

In addition to these data, information provided by farmers or collected automatically by machines, such as fertiliser inputs or plant health treatments, would allow the calculation of very precise environmental performance indicators at plot- or farm- level. Connecting satellite data flows with data from farmers in order to establish precise agri-environmental indicators is therefore a societal issue and this is one of the challenges that the European NIVA project has set itself.

Éric CESCHIA (INRAE, CESBIO)



Mapping of net CO₂ fluxes (left) and associated uncertainties (right) on wheat plots carried out with the TIER-3 method (SAFY-CO2 model) over southwestern France using Sentinel-2 and Venüs data. This method allows to calculate biomass productions, yields, CO₂ fluxes and C balances at 10m resolution. The high spatial and temporal resolution allows to quantify the impact of intra- and inter-parcelar heterogeneities in vegetation development as well as their uncertainty. Illustrations authored by Taeken Wijmer et Gérard Dedieu (CESBIO).

Box 1 NIVA- A H2020 Project

European Union countries are responsible for the administration and control of the payments to farmers in their countries under a principle known as 'shared management'. The main component of the payment management system is the Integrated Administration and Control System (IACS). The H2020 NIVA (New IACS Vision in Action) project aims to provide a set of digital solutions, electronic tools and best practices for the electronic governance of the CAP and launches an innovation

ecosystem to support the development of IACS that will facilitate data and information flows.

NIVA aims to modernise IACS by making efficient use of digital solutions (including remote sensing) and electronic tools, creating reliable methodologies and harmonised data sets for monitoring agricultural performance, while reducing the administrative burden for farmers, paying agencies and other stakeholders.

PRIVATE EXPERTISE

VisioTerra: Democracy by Satellite

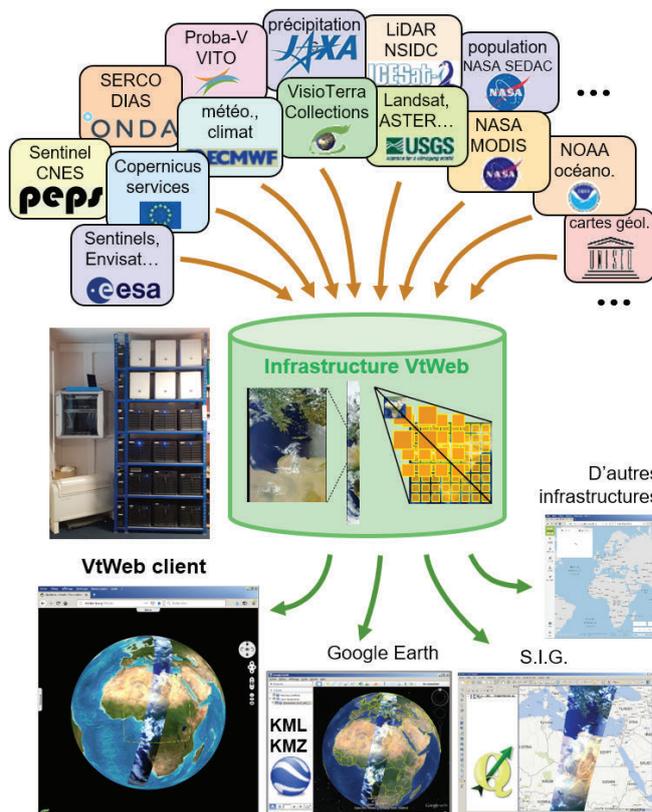
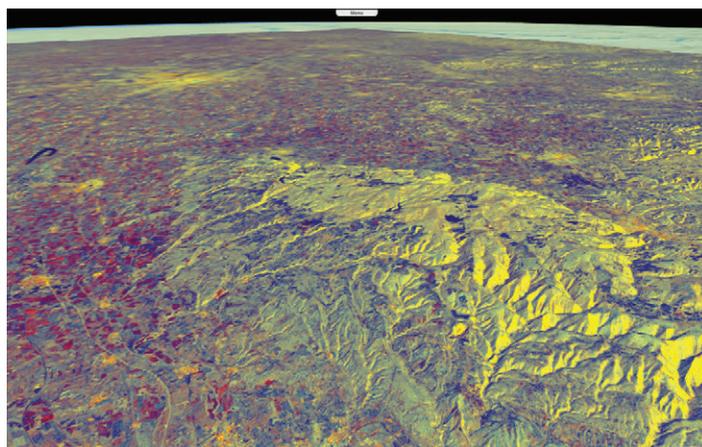
Created in May 2004, VisioTerra is a company specialized in scientific consulting in Earth observation. Its services include expertise, training and communication in remote sensing, the provision of geoservices, the development of software tools based on virtual globes, the editing of scientific documentation, quality control for the evaluation of Earth observation instruments and products, the specification and prototyping of new products and instruments, audit missions and the generation of cartographic products for GIS. Located on the campus of Paris-Est Marne-la-Vallée, VisioTerra collaborates with the University Gustave Eiffel, the ENSG, the University Paris Diderot, the Cité des Sciences, etc. through demonstrations and training of students.

The world just one click away

Since its creation, VisioTerra has been campaigning and doing everything possible to make the multitude of free data available on the Web easily accessible: Earth observation data, meteorological, climatic, biogeophysical and socio-economic data. The VtWeb platform (see figure opposite) implements the Data Processing Relay concept, enabling users to interactively control the processing of terabytes of data using the petabytes of disks and the fibre optic link provided free of charge.

Digital ecology

Sophisticated treatments are performed on the fly according to parameters interactively adjusted by the user. The servers process only the required parts and at the desired scale. These processes can be complex such as the following average of 5 Sentinel-1 radar scenes acquired between 8 May and 25 June 2020, corrected for thermal noise, calibrated in g0, orthorectified by SRTM and using a normalized polarization difference index. Any browser will display it in 2D or 3D.



VtWeb Platform ► visioterra.fr/?VtWeb

From producers to consumers

In addition to its numerous projects with ESA, VisioTerra develops geoservices for end users. For example, the FLEGT Watch application automatically detects deforestation in 8 countries in Central and West Africa. More than 180 areas (national parks, forest concessions, classified forests...) are permanently monitored, representing more than 45 million hectares.

Each time one of the Sentinel-1 satellites passes over an area to be monitored, the detection algorithm analyses the signal and can publish an event. This is transmitted to the observer community, which evaluates its relevance and may decide to organize a field mission. The FLEGT Watch App allows in-situ observations to be collected and shared with the community. A mission report can be automatically generated. ■

Serge RIAZANOFF (VisioTerra)

► visioterra.fr

« Hyperlinks » allow one to share this view in :

2D ► visioterra.org/VtWeb/hyperlook/a34f037f0f5e42aca78806cf318c3348

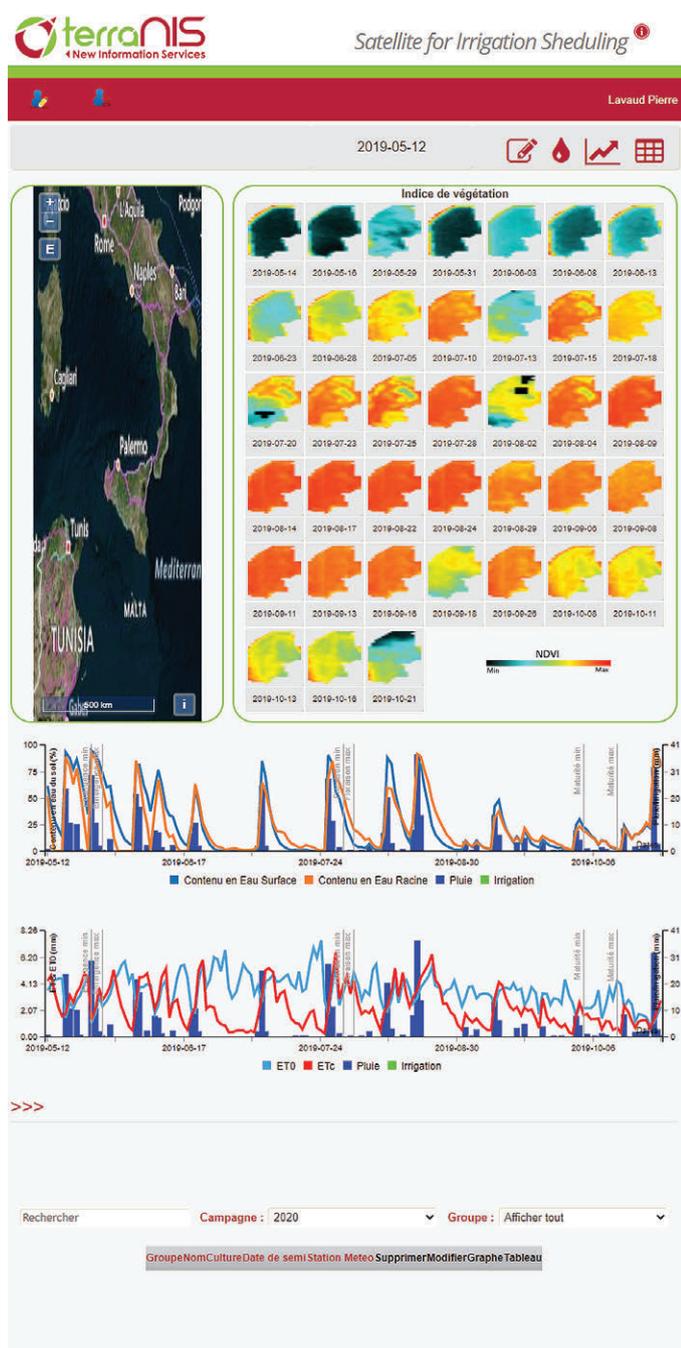
3D ► visioterra.org/VtWeb/hyperlook/7642b4bea24d47a99149878d3b276e46

Sat'Irr: The Result of a Fruitful Partnership Between a Research Institute and a Company

The Institute of Research for Development (IRD), the Cadi Ayyad University of Marrakesh (UCA) and the company TerraNIS signed a technology transfer contract in March 2019 concerning the Sat'Irr (Satellite for Irrigation Scheduling) application.

This tool is developed in the framework of a French-Moroccan collaboration within LMI TREMA - Laboratoire Mixte International de Télédétection et Ressources en Eau en Méditerranée semi-Aride (Joint International Laboratory for Remote Sensing and Water Resources in the Semi-Arid Mediterranean). It uses Earth observation images, meteorological data (observation and forecasting) and in-situ data (e.g. the soil characteristics of the agricultural parcel) to estimate the amount of water available to the plant in the soil. In case of drought, the application indicates to the farmer when and how much water to bring. This tool has been tested on several experimental sites in the South-West of France and in the Marrakesh region, Morocco.

Sat'Irr, an application for plot-scale irrigation



Building a partnership

TerraNIS is a company based in Toulouse (France) and specialized in the design, development and marketing of geoinformation services using satellite imagery in the fields of agriculture, environment and land use planning. The development of innovative decision support tools for the optimization of natural resources and agro-ecology is a major development axis of the company. To implement this strategy, TerraNIS favours the creation of partnerships and the management of R&D projects.

It is within this dynamic that TerraNIS wanted to benefit from the transfer of Sat'Irr. The company's objective was to optimize R&D investments by accessing to a technology that had already been developed and validated, while benefiting from strong scientific expertise in this field. Concerning the laboratory, the objective was to enhance the value of the research results and know-how acquired through operational use of the tool developed.

The actual transfer took place in three stages:

1. Theoretical and practical training on the operation of Sat'Irr. The aim was to enable TerraNIS teams, made up of agronomists, remote sensing specialists and computer scientists, to improve their skills on the subject and on the tools used.
2. A deployment of the solution in the TerraNIS work environment in order to install a first instance on a server hosted within the company.
3. The definition of a roadmap shared between Cesbio and TerraNIS in order to define the evolutions envisaged and the actions to be implemented. This last step seemed essential in order to guarantee the success of this transfer in the medium and long term.

Development and industrialisation

Following this first stage, new projects have been set up both within Cesbio and TerraNIS. Although the objectives differ, with scientific issues on the one hand and commercial issues on the other, close collaboration between the actors seems essential to guarantee the sustainability of the cooperation. Thus, the laboratory focuses mainly on the improvements to be made, in particular through better detection of water stress by thermal imaging and detection of irrigation by radar imaging. For its part, TerraNIS focuses on the industrialization of tools and the development of new functionalities in order to meet the specific needs of users. In parallel with these technical activities, TerraNIS is building the commercial offer by developing the marketing aspect. TerraNIS aims to market the tool from 2021 after a season of pre-operational tests in 2020.

The success of this technology transfer was made possible thanks to the proximity between the Cesbio laboratory and the company TerraNIS. This collaboration is a real opportunity to acquire, share and develop complementary tools, know-how and skills from Research and Industry. ■

Guillaume RIEU (TerraNIS)
www.terranis.fr

Evapotranspiration SEC
<https://www.theia-land.fr/en/ceslist/evapotranspiration-sec/>

SATELLITE MISSIONS

TRISHNA: A Mission of High Scientific Value

The first meeting of the TRISHNA (Thermal infraRed Imaging Satellite for High-resolution Natural resource Assessment) Mission Group (MG) was held at CNES on 22 June 2020. It brought together nearly 60 researchers in Earth sciences, from many organizations including Cerema, CNRS, CNES, ESA, INRAE, IRD, OFB, Onera, Météo France, Ifremer, and several French and foreign universities.

An ambitious roadmap

The TRISHNA mission is a cooperation between the French (CNES) and Indian (ISRO) space agencies. (Read Bulletin n°11) It is designed to measure at least three times a week the thermal infrared signal of the surface-atmosphere system over the entire globe, at a resolution of 57m for the continents and the coastal ocean, and a resolution of 1,000m for the rest of the ocean surfaces. The scientific objectives that guided the mission specifications are the monitoring of the water status of continental ecosystems and the monitoring of coastal and continental waters. In addition to these design driver themes, other



TRISHNA artist's view. Copyright CNES/ISRO/ADS

► labo.obs-mip.fr/multitemp/trishna/

► www.cesbio.cnrs.fr/la-recherche/activites/missions-spatiales/trishna/

equally interesting themes are the study of Urban Environments, Cryosphere, Atmosphere and Solid Earth.

On March 5, the CNES Council of Scientific Programs (CPS) confirmed TRISHNA's high priority as a precursor to Copernicus Land Surface Temperature Monitoring (LSTM), thus endorsing the conclusions of the last Scientific Prospective Seminar based on the recommendations of the Continental Surfaces scientific community. Based on this advice from the CPS, the CNES Board of Directors, scheduled for the following day, decided on the official start of the industrial phases leading to the launch of the satellite planned for 2024 on an Indian launch vehicle.

In this context, the TRISHNA MG met to draw up the roadmap for the mission's preparatory programme between now and launch. After reviewing the scientific and programmatic news of the project, the group's researchers reviewed the scientific issues related to each theme. Some themes such as urban and hydrology fields were also zoomed in on their downstream application dimensions. In addition to this theme, the transversal groups in charge of product development, calibration and validation presented their progress in understanding the main topics related to the physics of TRISHNA thermal measurements: temperature/emissivity separation, taking into account atmospheric and directional effects, and the high-frequency dynamics of surface temperatures.

Theia's commitment

The arrival of TRISHNA in the programmatic landscape will certainly encourage the rise of Theia Temperature & Emissivity SEC, which, in the same way as the Surface Reflectance SEC, could be useful for many thematic SECs such as evapotranspiration, urban, cryosphere, and useful for their support to the downstream sector, *via* the network of Theia Regional Animations (RANs). ■

**Philippe MAISONGRANDE (CNES, Program Manager),
Jean-Louis ROUJEAN (PI), Philippe GAMET (Product
Manager), Corinne SALCEDO (System Manager)
& Thierry CARLIER (Project Manager)**

Surface temperature and emissivity SEC

► www.theia-land.fr/en/ceslist/surface-temperature-and-emissivity-sec/

Towards a Second Generation SMOS With Improved Resolution

The SMOS mission (European Space Agency - ESA, and French Space Agency - CNES), as well as the subsequent NASA Aquarius and SMAP missions, have demonstrated the value of L-band passive radiometry (1.4 GHz, 21 cm) for measuring soil moisture and ocean surface salinity, the primary applications of these missions. SMOS provides the longest time series of L-band measurements (since 2009) and it plays a central role in the Soil Moisture and Sea Surface Salinity programmes of the ESA Climate Change Initiative (CCI) and contribute to the CCI Biomass.

Since the launch of SMOS, other research and operational applications have emerged. SMOS soil moisture is operationally assimilated at the European Centre for Medium-Range Weather Forecasts. SMOS data are also used to monitor the thickness of sea ice (thin) or to monitor the freeze-thaw cycle at high latitudes, which affect the methane emission. However, the resolution of

SMOS and SMAP (~ 40 km) is a limiting factor for several applications, particularly in agriculture or hydrology, as well as for the study of mesoscale phenomena in the ocean or the monitoring of processes in coastal regions such as ice caps melting and river plumes. Those works, have been recently documented in an ESA study on the continuity of L-band observations that concludes that many applications can make significant progress if measurements were available at a native spatial resolution of 10 km or less. This is the goal of the SMOS-HR (High Resolution) mission: ensuring the continuity of L-band observations with a resolution increased by at least a factor of 4 compared to SMAP/SMOS. ■

**Nemesio RODRIGUEZ-FERNANDEZ, Yann KERR,
Éric ANTERRIEU & François CABOT (Cesbio)**

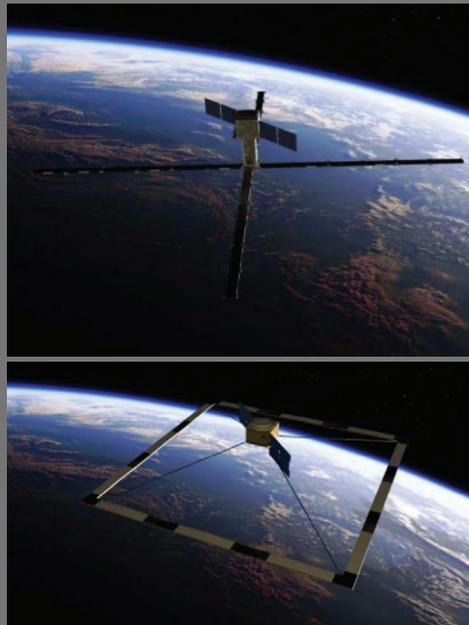
► www.cesbio.cnrs.fr/

The SMOS-HR mission

The SMOS-HR concept is a connected interferometer with baselines up to 17 m to provide a spatial resolution of the order of 10 km. Approximately 230 antennas will be placed along a large structure using a patented method to reduce aliasing.

During the Phase 0 study at CNES finalized in 2019, two structures were studied by Airbus Defence and Space and CESBIO: a 12-meter square and a 12-meter four-armed cross (see figure). Deployment mechanisms were found for both structures, which are otherwise equivalent in terms of image reconstruction capabilities. The cross configuration was chosen because it involves less risk.

SMOS-HR will observe the entire globe in less than 3 days with a sensitivity at least equivalent to SMOS/SMAP. SMOS-HR



will allow L-band brightness temperature measurements to be made in polarimetric and multi-angle incidence modes. It will be equipped with an advanced radio interference filtering system that will take advantage of the experience of SMAP and ULID (Unconnected L-band Interferometry Demonstrator) nanosatellites.

The SMOS-HR mission project complemented with antennas placed in ULID-type nano-satellites around it, to further increase the resolution, has just been accepted by CNES to move into Phase A.

Artist's view of cross (above) and square (below) SMOS-HR. Courtesy images of Airbus Defence and Space.

Ready for Hydroweb-NG?

The SWOT (Surface Water Ocean Topography) space mission aims to measure with great precision the level of oceans and continental waters (rivers over 100m wide; lakes, reservoirs and other water surfaces over (250x250)m². Result of a NASA/CNES cooperation, in partnership with the Canadian Space Agency (CSA) and the British Space Agency (UKSA), SWOT will be launched in February 2022.

This new mission will open the doors to new scientific perspectives, not only in oceanography but also and above all in continental hydrology. The SWOT mission should be seen as the precursor and as a scientific demonstrator, of a series of operational satellites which will contribute, alongside the Copernicus Sentinels in particular, to the development of a new sector of activity.

A national system to access and combine hydrological products

The innovative nature of this mission, combined with the economic and strategic stakes involved in water resource management, led the French government to approve the inclusion of SWOT in the Future Investment Plan (known as PIA in French) in order to position French industry in this promising sector.

To meet the PIA commitments, CNES has set up a support program, the SWOT downstream program, aimed at developing and distributing operationally products adapted to user needs (i.e. with added value) and integrated within existing or future services, but also at preparing water stakeholders to use of these new data from space.

Through Hydroweb-NG, the objective is to set up a national system of hydrological products with the following objectives:

- the distribution of SWOT HR (hydrological products),
- the operational development of level 3 (multi-satellite water level heights) and level 4 (including exogenous models and in-situ data) products for hydrology,
- archiving, distribution and user services, including the creation of a spatialized water database.

This is intended, in the long term, to be the portal for accessing the spatial data on water and hydrology. Hydroweb-NG is

intended for a large public (scientific, institutional, private) with first layers of information such as: DTM / DSM, water heights, water surfaces, precipitation, soil moisture, snow, water quality and temperature, groundwater stock variations and land use.

The first developments of Hydroweb-NG will start at the end of 2020. ■

Flavien GOUILLON (CNES)
Hydroweb-NG Project Manager

SWOT products for continental hydrology and oceanography

Hydroweb-NG is part of the specific context of distribution and user services of the SWOT-downstream program in continental hydrology. It proposes to create a "spatialised water database" with priority on the high resolution (HR) data of the SWOT mission for which Hydroweb-NG is the only French access point. Hydroweb-NG is thus a service data infrastructure of Theia, which will allow an easy access to a set of hydrological products (multi-sensors satellite, in-situ data, numerical model) as well as all the data of sensors useful for the theme.

For its functional part, Hydroweb-NG is equipped with a meta-catalogue that aggregates all geolocalised data such as single-date or averaged measurements, satellite data with both "mission" products (e.g. SWOT) and value-added products, in-situ data, image data, and vector data. Based on this meta-catalogue, Hydroweb-NG offers a series of services to the user: visualization, combination and retrieval of data from the system. It also offers "sandbox-type" development services and tools to the users, with access to the system's products on the CNES computing centre resources (computation, storage).

Hydroweb-NG also runs a production centre for implementing processing chains that can be activated systematically (routine workflow or reprocessing mode) or on demand, with a production objective of global coverage in the long term. Lastly, Hydroweb-NG benefits from an hypervision system to ensure the operability and exploitation of the system.



Transfer, a crucial issue for gaining user confidence, essential to respond collectively to societal challenges of the future.

When and why did you get involved in Theia? Where does your involvement in a structure like Theia come from?

Valérie DEMAREZ: My involvement in Theia stems from the Maïseo project in which I took part from 2012 to 2017 in collaboration with the Compagnie d'Aménagement des Coteaux de Gascogne (www.pole-eau.com/Les-Projets/Projets-innovation-finanSEC/MAISEO). While participating in this project, I discovered that water managers in France had no knowledge of the irrigated areas on their territory. My objective in this project was therefore to demonstrate that high spatial and temporal resolution (HSTR) remote sensing images could be used to detect irrigated crops over large areas (6,500 km² for the Neste catchment area).

At that time, I was also participating in the Joint Technological Water Unit (www6.toulouse.inrae.fr/agir/L-Unit/R-D-Partners-R-D/UMT-EAU) in collaboration with the INRA of Auzeville and the Single Water Management Organisations (OUG) of the Tarn-Aval and Adour-Amont basins. This UMT made it possible to highlight the needs of the OUGs which overlapped with those of the CACG, i.e. the need for methods and tools to quantify the areas and volumes irrigated on their territories.

The emergence of these needs, which are relatively recent in France, answers to the increasingly frequent recourse to water restrictions. In 2019, for example, 88 *départements* issued water restriction orders! The scarcity of water resource will worsen as a result of global warming and demographic pressure, in France as in many other countries that are already in situations of extreme emergency such as India, Africa or Australia. This need to provide concrete responses to the challenges of water resource management leads me to propose the Irrigation SEC (Scientific Expertise Center).

How is the link between your work as a researcher and the actions carried out within Theia?

Valérie DEMAREZ: The Theia consortium allows us to define a formal framework within which we organise exchanges between scientists and users (managers, farmers) that help us to develop our objectives and methods. For example, the Irrigation SEC



Interview with
Valérie DEMAREZ

Lecturer and researcher at the University Paul Sabatier (Cesbio laboratory, Toulouse III)

Facilitator of Theia Irrigation SEC

www.theia-land.fr/en/ceslist/irrigation-sec/

focused initially on the evaluation of irrigated areas, but following these exchanges, the researchers proposed to extend the objective of this SEC to the estimation of needs and water consumption of crops. The Irrigation SEC led me to collaborate with researchers from other laboratories who are developing complementary methods and who share a common objective: to develop robust methods that can be deployed on any territory or country. This is a major challenge that requires the pooling of ideas and methods, which is facilitated by the Irrigation SEC.

I think it is important to remember that the Theia cluster also provides access to pre-processed satellite products with high-added value. The availability of pre-processed data enables researchers to focus on their research rather than on image pre-processing. This is a major step forward for the work of researchers and an aid to the dissemination of their methods.

In your opinion, what are the main challenges Theia is facing today?

Valérie DEMAREZ: One of the obstacles to the development of our methods is the poor availability of the in-situ data necessary to validate our approaches. Researchers spend a lot of time and energy collecting these data themselves or establishing conventions to retrieve them. In France, some databases would be very useful to researchers but are inaccessible for confidentiality reasons. Access to data as well as their level of quality varies from country to country. Researchers facing these difficulties are struggling. The Theia consortium could facilitate access to in-situ data collected by proprietary organisations.

The use of satellite images is growing considerably thanks to recent space missions and the existence of data provision structures such as Theia. However, a link is often missing to ensure the transfer of methods and tools developed in laboratories to scientific and non-scientific users. In my opinion, the Theia consortium has a major role to play here. Transfer is a crucial issue for gaining the confidence of users, whose support and commitment are essential to collectively respond to the societal challenges of the future.



Animation and mediation as key tools for the dissemination of the uses of space

You are the director of OPenIG, which actively participates in the animation of Theia Occitanie Regional Animation Network (RAN). What motivates your organisation's involvement in Theia?

Anne FROMAGE-MARIETTE: OPenIG is an association set under the French law of 1901, which carries the regional geographic information platform in French Occitanie. Two thirds of our members are from local authorities and metropolitan bodies. The rest consists of research organisations, private organisations (start-ups or large companies), natural parks, associations and even individuals. These very varied members share an interest in geographical information in the broadest sense. They expect help in accessing data (from classic IGN data to satellite data), but also the expertise of both OPenIG's six employees and the other members of the association. These exchanges take place within working groups that can focus as much on monitoring thematic solutions as on technical support. It is particularly during the monitoring phases that awareness of satellite solutions and research advances is possible. OPenIG is fortunate to be housed at the Maison de la télédétection in Montpellier and to be surrounded by a very rich ecosystem of researchers, PhD students, post-docs and engineers making it possible to easily build this bridge.

The OPenIG 2019-2023 associative project is organised around six main axes. Two of them - project support as well as training and awareness-raising for members - are particularly compatible with the activities of the Occitanie RAN. A partnership with the CNES gives us additional means to reinforce our participation in this activity in 2020 and 2021. One of the highlights of this commitment will be the organisation of AppSpace 2020 - *Space products at the service of territories* - on 17 September at the Corum in Montpellier (► Read p.1).



Interview with
Anne FROMAGE-MARIETTE

Director of OpenIG,
► www.openig.org/

a structure co-facilitating Theia
Occitanie RAN

► www.theia-land.fr/artist/art-occitanie/

A recurring question for local and regional authorities is to understand what to expect from satellite research and companies. How does OPenIG define its role of mediation between these actors?

Anne FROMAGE-MARIETTE: These three poles cover a wide range of actors and needs. In large communities, one may have a specialist in satellite products; in others, none. OPenIG works first of all to disseminate knowledge. Our website highlights the products that we think are the most relevant and easy to implement; it will soon offer support (tutorials, selection criteria, etc.) and will highlight concrete examples of implementation. In return, OPenIG transmits needs and field experiences to national data producers and researchers. Our data infrastructure can also disseminate test products so that members can give positive or negative feedback. It also highlights the work of researchers to make them known and to generate more precise needs and desires. OPenIG has contributed

to the production of several theses whose results are currently operational.

What do you see as the stakes of satellite technology today and the role of Theia in this context?

Anne Fromage-Mariette: Animation and mediation are key tools for the diffusion of space uses, but they often lack human and financial means. Unfortunately, there are not so many people in France who are aware of what is done in Theia SECs. Theia Land Cover product, for example, can meet certain needs at a reduced cost (in addition to those covered by land occupations from aerial photos) but it remains necessary to assist the average GIS specialist in the use of this type of product. Moreover, many local authorities' needs are still not covered by accessible products. Major developments are still needed.



Theia Bulletin

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