BULLETIN
Theia Land Data Service Center

Theia

n° 11- February 2020

CONTENT

A word
from the Scientific and Technical Directors

2019 ends with a last semester rich in events and productions that we are happy and proud to report on.

Theia's various actors, researchers and animators combined, are doing their best to disseminate the products, to promote their appropriation and to train the actors in the field. Events such as the AppSpace held in Marseille in November 2019 illustrates the richness and dynamism of the French ecosystem based on satellite data.

However, Theia's role does not stop at French borders, as demonstrates the dynamism of the GeoDEV Regional Animation Network (RAN) and of its new New Caledonian component.

More broadly, Theia product portfolio continues to grow with the automation of the production of level 3 reflectance mosaics, a snow product covering the whole of Europe from spring onwards, a mapping of irrigated areas in Catalonia and a new land cover product on Reunion Island.

These developments are based on a constantly evolving ecosystem, with new applications such as biodivMapR, infrastructures dedicated to the acquisition of high-resolution images such as DINAMIS or partnerships with companies such as Magellium. A dynamism and a strong involvement in the construction of the DataTerra Research Infrastructure that should continue in 2020. ■

NEWS

AppSpace Sud: a successful snapshot of the space ecosystem in France

This year, the AppSpace Forum, an annual symposium that brings together a community of players and users of space-based solutions, has settled in the South of France. This 3rd event entitled "Space, from observation to action in our territories" was held on 5 and 6 November 2019 at the Hôtel de la Région in Marseille, France. This event was organized within the framework of the regional partnership established between CNES and the Sud Region, but also of Theia regional animation network for the region (Sud RAN) lead by CRIGE and GeographR.

AppSpace Sud, brought together more than 160 people, scientists and professionals with different profiles, from beginners to specialists. This variety of actors allowed for rich exchanges and contributed to the success of the two days, which offered a wide variety of presentations.

More than twenty well-attended stands in the AppSpace 2019 Exhibitor Village.

More than fifty regional and national experts, professionals and specialized companies took part in the plenary sessions, thematic workshops and round table discussions. The debates and demonstrations made it possible to fully promote the operational and innovative potential of space-derived technologies. AppSpace Sud took stock of the space ecosystem in France, highlighted innovations and short- and medium-term prospects, and identified actions likely to develop the space industry and economy. ■

**Claire AJOUC, (CRIGE-PACA)
& Philippe ROSSELLO (GeographR),
Sud RAN Co-facilitators**

Find all contributions on the AppSpace 2019 website
► appspace-sud2019-crige.fr/

Sud RAN
► www.theia-land.fr/artlist/art-sud/

Applisat: federating players and promoting experience sharing

In urban or rural areas, over vast territories or on a fine scale, space applications are able to provide decision tools for policy delivery: land use planning, environmental observation, climate change monitoring, etc. However, this potential is insufficiently exploited by public users. The Satellite Applications Plan 2018-2022 supported by the MTES* and the MCTRCT** aims to enhance use of satellite application in these different topics. The website Applisat is a part of this scheme: it offers dedicated sharing space for thematic use of spatial information.

www.applisat.fr.

Designed and managed by Cerema, with the support of CNES and IGN, the applisat.fr website is intended to meet this challenge by bringing together the players and encouraging the sharing of experiences. State services and local authorities will now be able to pool their operational experiences to mobilize spatial data for monitoring public policies. Space professionals (research, design offices, industry) will be able to enhance the value of their projects and find the needs of the services listed in the Satellite Applications Plan. All will benefit from dedicated spaces to exchange and thus promote the emergence of operational space solutions.

Online resources and communities

Applisat.fr is structured around two central sections:

○ A "Resources" space to pool knowledge, access all available material (uses, services, products) as well as to provide useful training and to submit feedback;

○ A "Community" space dedicated to exchange and sharing for thematic groups of users and space actors. The leadership roles of this community are entrusted to thematic pilots from local authorities or state services.

○ Two transversal discussion areas are proposed: a "Multi-thematic thread" designed to bring out new thematic groups and an "Image acquisition" group offering user assistance. Three thematic areas are currently in place: "Agricultural wastelands", "Covering the snowpack", "Flooding". Access to all these discussion areas can be freely accessed via online registration. See you soon on Applisat.fr! ■

Amélie LOMBARD
(Cerema)
► applisat.fr

* MTES: Ministère de la Transition Écologique et Solidaire
**MCRTRC: Ministère de la Cohésion des Territoires et des Relations avec les Collectivités Territoriales.

GeoDEV: A busy 2019 year

The GeoDEV network, Theia Regional Animation in Overseas and Southern countries, has had a busy year in 2019:

In Madagascar, thanks to funding from IRD's Seed Fund, GeoDEV supported cycles of seminars and workshops in 2019 dedicated to the setting up of an Earth Observation Pole of Competence project. Organized by the Madagascar Intersectoral Committee on Remote Sensing and the IRD Representation in Madagascar, these exchanges involved some 40 Malagasy organizations involved in the use of satellite information, CIRAD and Cnes members of GeoDEV RAN, and teams from the Montpellier UMR Espace-dev and the sub-region (Reunion Island). Their aim was to draw up a roadmap for the implementation of this Pole, based on contributions and needs expressed by scientific and institutional stakeholders in Madagascar. At the beginning of 2020, this effort will lead to the production of a reference document containing the stages of a quantified development plan. Its implementation, in which Theia will be involved, will depend on obtaining funding from national and international donors.

In New Caledonia, a local network affiliated to GeoDEV RAN has been created, bringing together the community of New Caledonian users of Earth observation products. Led by the IRD New Caledonia (UMR Espace-Dev) and the company InSight, this initiative will improve the services provided to this community, both in terms of access to imagery (via DINAMIS) and the use of the cluster's products and processing chains.

In the French Guiana Plateau, exchanges continued with Suriname to finalize the PROGYSAT proposal, a project submitted to Interreg Amazonia in four application areas: Health and Environment, Forests, Urban, Renewable Energy and Pollution. In West and Central Africa, the GeoForAGRI proposal (OSFA-

Workshop on GeoDEV and Theia SEC, Toulouse, 1st October, 2019.

CO follow-up) was finalized and sent to AFD for analysis and implementation in 2020.

Finally, the ART Assessment and Foresight Workshop held in Toulouse (Cesbio) on 1st October 2019 with Theia's management team and numerous Theia SECs helped identify joint actions (mapping Theia's efforts in the South, awareness-raising actions, intervention at the ISPRS 2020 Conference, etc.) and prepare support for GeoDEV RAN's initiatives in priority areas. The slideshows and conclusion of this Workshop are available on the GeoDEV website:
► www.theia-land.art-geodev.fr/atelier-ces-art-geodev-01-10-19-cesbio-toulouse/ ■

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

A French-Indian remote sensing school in Bangalore

From October 28 to 30, 2019, an Indo-French Monsoon School on Remote Sensing was held at the Indian Institute of Science in Bangalore.

Co-organized by the Indian Institute of Science and Theia, the three days alternated theoretical presentations and practical satellite applications, particularly in the field of water, soil and vegetation. Bringing together a French-Indian audience of some 60 people, the days had the following objectives:

The sixty participants of the French-Indian School of Remote Sensing in Bangalore (India)

○ To give an overview of the Orfeo Tool Box (OTB) open source software for remote-sensing image processing and apply it to a concrete case (feature extraction, calibration, classification, segmentation, etc.).

○ To share the experience gained within Theia in terms of value-added products

○ To facilitate workshops and hands-on sessions based on Theia algorithms and generate products from royalty-free images.

○ To train and facilitate practical sessions on how to practice Disaster Rapid Mapping. ■

Nicolas BAGHDADI
(INRAE, Tetis, Theia)

New Caledonia RAN: a newcomer but an already busy agenda

Since its creation in mid-2019, GeoDEV-NC RAN, the New Caledonia Regional Animation Network (RAN) has been truly integrated into its ecosystem, with a local, regional and international influence and representation.

Indeed, initially introduced to the local geomatics community last July on the occasion of the OSS-NC seminar organized in collaboration with the French Space Agency CNES, this overseas RAN has been able to participate in numerous events since then and thus present Theia RAN and SECs networks and, more globally, Theia and Data Terra dynamics.

Between last September and November, GeoDEV-NC RAN has been represented at the following events and seminars:

○ RAN Meeting, 5th September 2019, Montpellier (France): introduction of the "newborn" to the RAN community.

○ GeoDEV RAN and SECs Workshop, 1st October 2019, Toulouse (France): first participation of the New Caledonian RAN in the annual meeting of the «mother RAN».

○ Conference on the use of Airborne Lidar by UAV, 8th October 2019: organization by the RAN of a presentation by YellowScan company to the New Caledonian geomatics

actors of the Lidar technology by UAV and possibilities offered by this technology.

○ Digital Festival Tahiti, 16th-18th October 2019, Tahiti (French Polynesia): participation in the digital Polynesian seminar, with presentation of the applications of spatial imaging, and gathering of the Polynesian geomatics community for a side event prior to the seminar for a dedicated presentation in order to introduce the concept of RAN, ART GeoDEV NC and its role and missions.

○ GEO Week, 4th-9th November 2019, Canberra (Australia): general presentation of the RAN during the international geomatics community event, gathering conferences at both ministerial and technical levels, with a special focus on the Pacific region and its island countries, their needs and skills.

○ GIS Day, 7th November 2019, Noumea (New Caledonia): participation and presentation during the annual event organized by the Geomatics Club of New Caledonia and bringing together the New Caledonian geomatics community for presentations by local institutions.

○ GIS & RS Conference, 25th-28th November 2019, Suva (Fiji): global presentation of the RAN during the annual regional conference organized by the Pacific GIS and Remote-Sensing Council (PGRSC) and aiming to bring together and represent the entire community of the South Pacific region and its various island states.

2020 also looks like being off to a good start, with some actions already underway with the New Caledonian community in the logical continuation of OSS-NC 2019. ■

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

Jean Massenet presenting the Theia consortium, Theia SECs and GeoDEV-NC RAN to the Pacific geomatics community at the GIS & SR 2019 conference in Suva, Fiji.
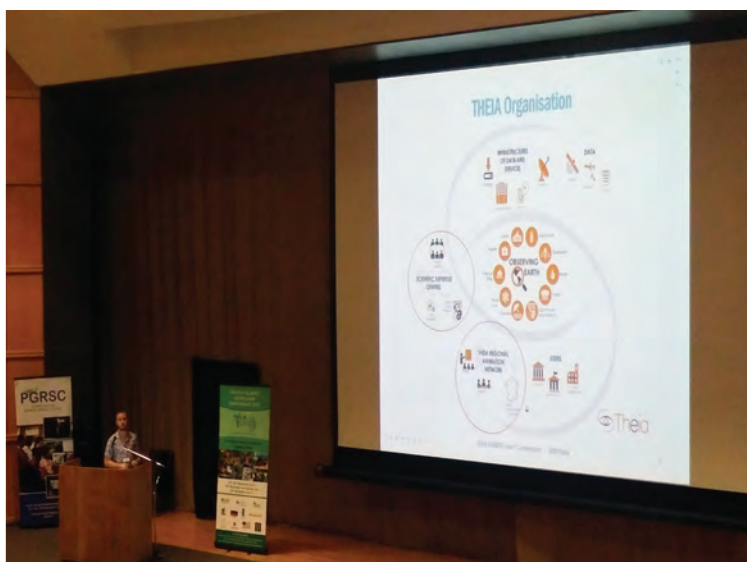
# MACLEAN: Networking Researchers in Machine Learning

The MACLEAN initiative, supported by the GDR MADICS, has the objective to supply a national forum where remote sensing and machine learning researchers as well as industries working or interested in these fields, can meet each other to exchange and debate recent advances of the national/international communities and draw short and long term collaborations.

Bringing together the machine learning community for Earth observation data

The initiative started in January 2019 and it will continue, at least, until December 2020. During its first year, we have organized several national and international meetings in order to gather the community on machine learning for EO data and support cross-fertilisation between areas.

In June 2019, we organized a national meeting, in the context of GDR MADICS Symposium, in which the CNES agency presented a tutorial about their activities on Artificial Intelligence for EO data and research teams present their ongoing work. The meeting involved around 25/30 participants coming from different institutes from all over France.

In September 2019, in the context of the European Conference on Machine Learning and Data Mining (ECML/PKDD2019), the MACLEAN initiative proposed an international workshop that attracts researchers from all around the world. During this event, we had the opportunity to host Prof. Xiao Xiang Zhu (head of the EO Data Science department at DLR, Germany) and Prof. Robert Jenssen (head of the UiT Machine Learning Group, Norway) as invited speakers. The proceedings of the workshop are available at this link: ►ceur-ws.org/Vol-2466/. As follow up of the
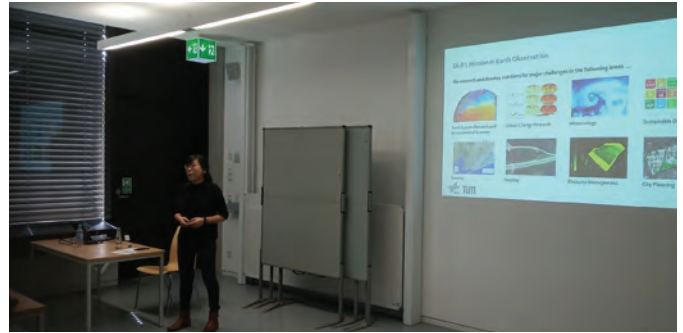
Professor Xiao Xiang Zhu, Director of the EO Data Science Department, DLR, Germany, presenting his work at the ECML.

workshop event, we will open in the next few months a special issue entitled "*Machine Learning for Earth Observation Data*" hosted by the prestigious *Machine Learning journal* (Springer).

A third event has just gathered in Paris about 40 young researchers, mainly PhD and Post-doc. It pursued the ambition to support possible connections among young researchers as well as to give them the chance to obtain feedback about their research, from an audience including senior members. ■

**Thomas CORPETTI (CNRS, LETG-Rennes COSTEL),
Dino IENCO (INRAE, UMR Tetis), Sébastien LEFÈVRE
& Minh-Tan PHAM (Univ. Bretagne-Sud)**

MACLEAN Initiative
► www.madics.fr/actions/actions-en-cours/maclean
supported by GDR MADICS
► www.madics.fr/

Mapping irrigation in Catalonia

Irrigation, nowadays, plays a significant role in agricultural production in order to meet the global food requirement. In fact, irrigated agriculture accounts now for more than 80% of water withdrawn from rivers, lakes, and groundwater aquifers and is the principal consumer of fresh water resources. A better management of irrigation policies is therefore required to deal with the high demand of food with the increase in the global population. Thus, accurate information on the irrigated area extent is essential to manage water resources or evaluate irrigation water requirements. Unfortunately, the extent and distribution of irrigated areas remain indefinite and the large-scale mapping of such property remains a challenge for modern remote sensing analysis.

Large-Scale Irrigation Mapping

Using remote sensing data (radar and optical), several efforts have been made to map irrigated areas at different scales. The data availability of the recent Sentinel-1 (radar) and Sentinel-2 (optical) constellations offers an effective tool for large-scale irrigation area mapping due to their high revisit period (5 to 6 days) and their high temporal resolution (10m).

In Catalonia, crop production is mostly linked to intensive irrigation practices. Thus, irrigation in the region is developing rapidly, as one of the central element in the modernization process. A
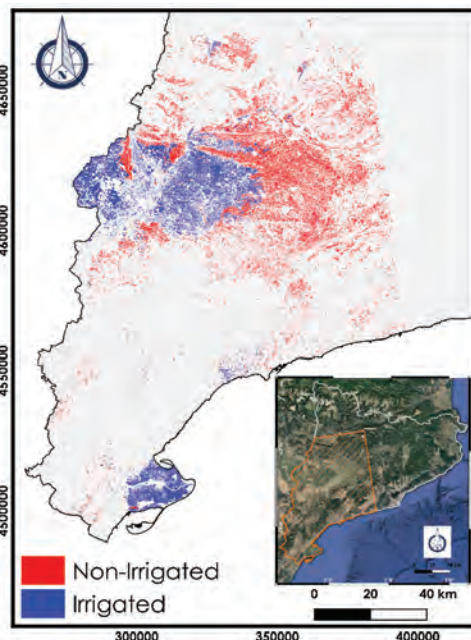
Mapping of irrigated areas (in blue) in Catalonia

third of cultivated area is irrigated representing about two thirds of the economic value of crop production.

An irrigation map of Catalonia has been realized by applying the Convolutional Neural Network (CNN) on the Sentinel-1 multi-temporal data for the year 2018. The classification of irrigated/non-irrigated plots has been realized over the winter and summer agricultural plots. The SIGPAC Geographical Information System for Agricultural Parcels) database has been used to define the plot limits, the land cover type and the irrigation information for training the irrigation classification model. The irrigation map of Catalonia is available via the Theia website. It is delivered in two formats (raster and vector). The Sentinel-1 time series used covers the period between September 2017 and December 2018. The precision of the obtained map reaches 94% when compared to the terrain database of the SIGPAC data. ■

**Nicolas BAGHDADI, Hassan BAZZI
& Dino IENCO (INRAE, UMR Tetis)**

Irrigation SEC
► www.theia-land.fr/en/ceslist/irrigation-sec/

Irrigation Map over Catalonia
► www.theia-land.fr/en/product/
irrigation-map-over-catalonia/

PHIDIAS, an European and transversal infrastructure project at Data Terra

The European project PHIDIAS –Prototype HPC / Data infrastructure for on-demand services– aims at the development and concrete realization of a set of interdisciplinary services and tools based on High Performance Computing (HPC). More specifically, it aims to meet the needs of Earth System Sciences to offer new services for data access and on-demand processing on large public data sets acquired by satellite Earth observation.

Follow PHIDIAS' activities: www.phidias-hpc.eu

These services will provide FAIR (Findable, Accessible, Interopable, Reusable) access to these datasets as well as value-added services on the data: from "standard" data processing (discovery, visualization, extraction...) applied to heterogeneous Big-Data datasets, to more advanced services such as Artificial Intelligence or HPC on demand. This will be made possible thanks to a large data storage capacity and a high bandwidth network across Europe.

PHIDIAS will develop and offer a catalogue allowing users to discover and access not only data, but also relevant open source software, public APIs and interactive processing ser-

vices. This catalogue will implement interoperable services for data discovery, access and processing, and will be connected to other important data repositories such as the European Data Portal, GEOSS, NextGEOSS and EOSC. PHIDIAS will also set up a common interactive web processing service for end-users based on notebook and data cube technologies.

A transversal project at Data Terra

These achievements will be built from three use cases coming from the scientific issues and partners of the Data Terra Research Infrastructure. They address issues related to access and value-added services for the atmosphere, ocean and land surface compartments of the Earth system. As far as the Theia cluster is concerned, IRD, with contributions from IRSTEA and CNES, is coordinating Work Package 5: "Big Data Earth Observations: Processing on-demand for Environmental Monitoring".

Launched in September 2019, the PHIDIAS project is supported by INEA - Innovation and Networks Executive Agency. It is coordinated by CINES. It consists of a consortium of 13 partners: CINES, CERFACS, CSC, GEOMATYS, MARIS, Néovia Innovation, SPASCIA, SYKE, Trust-IT Services, University of Liège, including three partners of the research infrastructure Data Terra: CNRS, IFREMER and IRD. ■

Jean-Christophe DESCONNETS
(IRD, Espace-Dev)

Phidias
► www.phidias-hpc.eu

DINAMIS is setting up

DINAMIS, the French National Institutional System for the Mutualized Supply of Satellite Imagery, aims to progressively centralize access to high and very high spatial resolution images to facilitate non-commercial use by the institutional, scientific and R&D communities in France. It takes over from precursor devices (ISIS, DSP Pléiades, GEOSUD, etc.) by unifying their resources: archive catalogues, reception facilities, IT infrastructures, organization.

DINAMIS will soon offer a first unified access web portal. This device is a transversal component of the Data Terra research infrastructure that feeds the data poles (Theia, Odatis, Form@ter, Aeris) for the development of downstream products and services.

An ambitious and comprehensive offer

At the end of its construction, the system will offer its users:

○ A single access point to a range of VHSR imagery for non-commercial use.

○ The meta-catalogue of all high to very high spatial resolution data available free of charge on the national territory (and beyond for certain satellite missions).

○ The possibility of custom programming new very high resolution acquisitions on the national territory or abroad. To date, two possible resolutions: 1.5 m or 50 cm . ► dinamis.teledetection.fr/

○ Supporting requests for imagery for operational access adapted to needs.

○ Additional support services that can be customized and adapted to the needs of co-financing partners (Ministries, Regions, organizations, etc.).
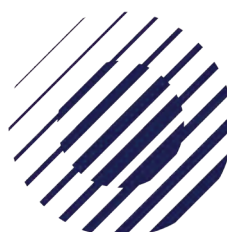

DINAMIS' mission is to meet the needs of scientific communities and territorial actors involved in the construction and mapping of spatialized indicators useful for the production of scientific knowledge or the monitoring of public policies. Several user profiles are eligible for DINAMIS:

○ Institutional users: all national or local public actors have access to all DINAMIS services.

○ Scientific users: all national scientific actors have access to all DINAMIS services. Foreign scientists, once they have signed a specific cooperation agreement with DINAMIS or are partners in research projects carried out by French scientists who are members of the system, can access DINAMIS archive images.

○ Private users: private users (1) acting as a service provider for public actors within the framework of a public order or (2) acting on their own account within the framework of innovative R&D projects in the development phase, or in the start-up phase of an operational service, can access DINAMIS archive images. ■

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

LAND COVER ON REUNION ISLAND
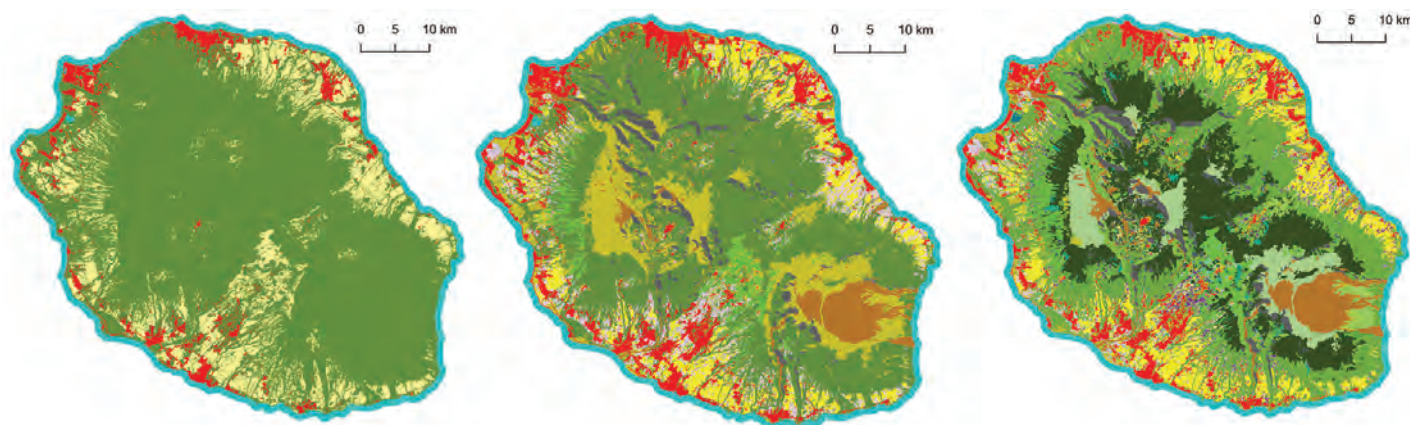
Since 2017, the Reunion land-cover map has been produced with two levels of accuracy (1.50 m with Spot 6 & 50 cm with Pleiades data). Three classifications (4, 11 and 30 classes, shown above for the year 2018) are each time available for download.

The maps produced for the periods 2016, 2017 and 2018 are freely available. The methodological report describing the treatments implemented and the results obtained is available via the following link:
► agritrop.cirad.fr/594135/1/Rapport_carto_GABIR_2017-2018_v3.pdf

A Specific Product to Map Land Cover on Reunion Island

In Reunion Island, within the framework of the GABiR project (Agricultural Management of Biomasses on the scale of Reunion Island), we needed exhaustive and up-to-date information on agricultural land use at the level of the whole territory. In this context, we decided to test the prototype Moringa chain on Reunion Island to assess whether it could meet the needs for information on land use. This tool, developed within the framework of Theia Land Cover Scientific Expertise Center (SEC), uses functions from the Orfeo Tool Box (OTB), controlled by python scripts. To function, a very high spatial resolution image (Spot6/7 or Pleiades) and a DTM, a terrain database and a time series (Sentinel-2 and Landsat-8) constitute the minimum requirement.

Homogeneous objects are extracted from the very high spatial resolution image using a segmentation algorithm. This image is also used to compute textures. Each object is then classified by a supervised classification algorithm (Random Forest) using as variables the information from the time series, textures and elevation and slope information from the DTM.

Meeting users' needs

The reference database was built using existing products (DAAF land use database, Registre Parcellaire Graphique and BD Topo distributed by the IGN) but also in collaboration with partners and

users of the final maps: Syndicat du Sucre de la Réunion, DEAL, ONF, researchers from the Université de la Réunion and CIRAD (UMRs SELMET, PVBMT, HORTSYS and UPR AIDA). This database has been expanded over the course of these collaborations in order to be as exhaustive as possible and to produce maps that meet the needs of a wide range of users (► Read the focus on uses by Pascal Degenne in the framework of the GABiR project, and by Béatrice Moppert on savannas).

Despite the difficulties related to the size of the data, we tested the feasibility of producing land-use maps from a segmentation based on Pleiades images acquired by the Cnes in the framework of the Kalideos project. ■

**Stéphane DUPUY
(Cirad, Tetis)**

**Land Cover SEC
► www.theia-land.fr/en/ceslist/land-cover-sec/**

**Product Land Cover in Reunion Island
►www.theia-land.fr/product/
carte-doccupation-des-sols-a-la-reunion/**

Three Applications Within the GABiR Project

1. **Evaluation of the areas concerned by the regulatory constraints on the spreading of livestock manure on an island scale.** The classes representing cultivated plots likely to receive organic fertilization were extracted from the map. They were used as a basis for calculating the areas affected by the various constraints such as distances to watercourses, the risk of runoff on slopes, and the distance to buildings or to the drinking water catchment point. This makes it possible to construct indicators relating to the areas that can be spread on the scale of the island, on which it is possible to have multi-year monitoring thanks to the reproducible nature of the method used for land use.

2. **Influence of urban dynamics on organic fertilization at the scale of a municipality.** The land cover map was used to locate the plots not referenced in the institutional or administrative databases and likely to be concerned by organic fertilization. Fieldwork was then carried out to validate or not the plots thus identified. Projections of future constructions (in particular provided for in the Local Urban Planning Plan) were mapped and were used to estimate and map precisely the risks of loss of spreadable surfaces in the commune. (► These two applications are illustrated by the maps on the opposite page).

3. Support for the management of fodder resources, in time and space, for pastoralism. A census of herds and flocks has been carried out to estimate and map fodder requirements according to the seasons. Another work mobilized land use mapping to estimate fodder resources. Here too, the map was used to locate plots that were not available in the databases available to the project. Then, by expert appraisal and photo-interpretation, doubts were removed from the identified plots. Finally, these plots were mobilized for simulations of fodder production, transfer, storage and consumption. ■

**Pascal DEGENNE
(Cirad, Tetis)**
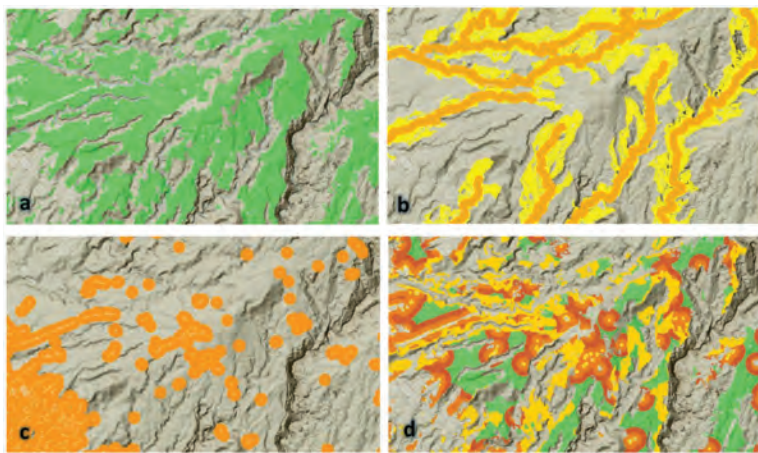
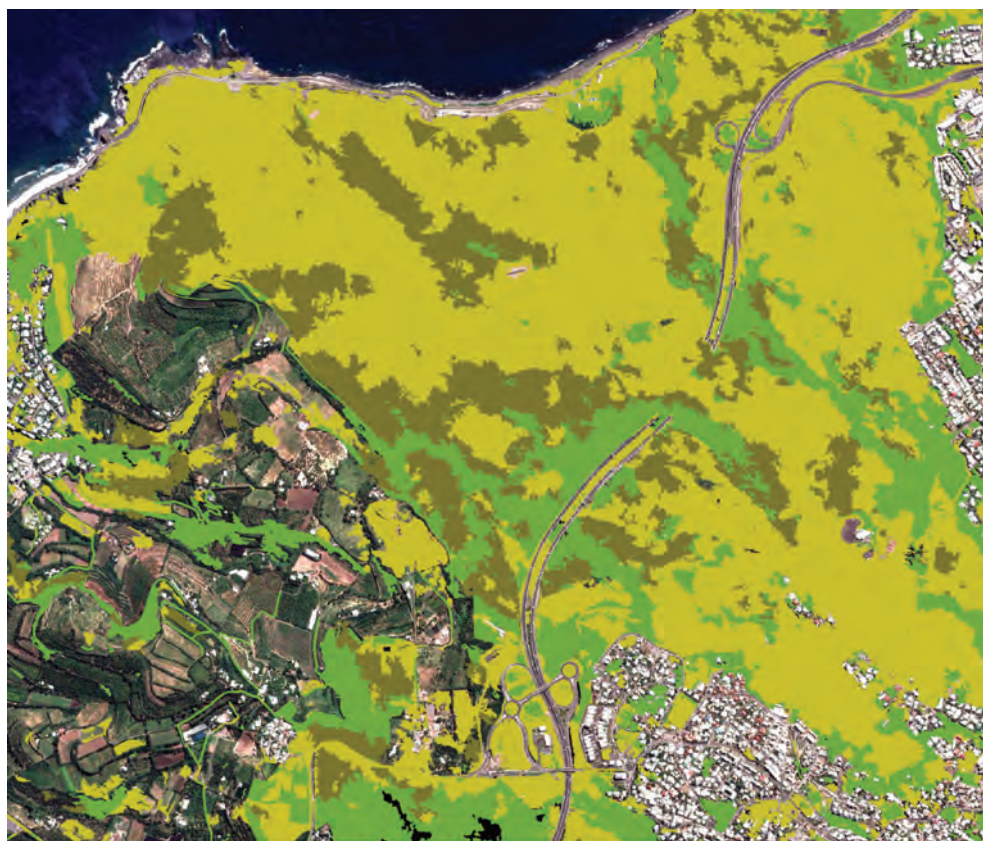**Example of mapping of regulatory constraints related to the organic fertilization of plots within the GABiR project**

(a) parcel provided to the software,

(b) 35 m strips on either side of watercourses in orange and estimated runoff risk by the software in yellow,

(c) example of distance constraint at 50m from the built-up areas,

(d) cutting out the non-applicable areas on the parcel provided and assembling them into a map. The colors indicate constraints related to different types of organic matter.

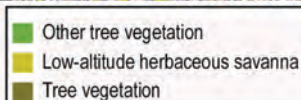This mapping uses the 2017 Reunion land cover maps.

Mapping the savannas of the Leeward Coast

The research program «Les savanes de la côte sous le vent à La Réunion» – Savannas of the Reunion Leeward Coast – is conducting an interdisciplinary and experimental approach to the knowledge and management of coastal environments. It is based on past and current work carried out for the Conservatoire du littoral in Reunion Island and proposes a historical approach to environments and landscapes in order to establish alternative practices in terms of environmental conservation and management.

A tool adapted to the study of the landscape

At the interface between the various components of this project and involving researchers from various disciplines, a mapping component aims to clarify the land use dynamics in the lower western zone and, more specifically, to reveal the expansion processes of shrub species in herbaceous environments. The land-cover map produced by Stéphane Dupuy is the best existing working base to date. Since 2018, the map has included new learning classes that make it possible to distinguish three savanna formations: herbaceous, shrubby and woody.

Within the framework of the Western Savannah project, it is thus possible to distinguish, on the one hand, savanna areas in relation to other modes of land use (built, cultural, other natural areas) and, on the other hand, three categories of landscape facies within the savanna areas themselves. These typologies will have to be specified through field work envisaged within the framework of the research program on the Reunion savannas. ∎

Beatrice MOPPERT
(University of Reunion Island)

Pleiades image and level-3 land-cover map for 2018
Focus on the commune of St-Paul - Cap La Houssaye
Contents informations © CNES 2018, Airbus DS distribution, all rights reserved

- Other tree vegetation
- Low-altitude herbaceous savanna
- Tree vegetation

General public exhibition & plant typology

► Carrying out a cartography entitled *"Dry plant formations of the leeward coast of Reunion Island (2018)"* as part of the *Savanna. La liberté sous le vent,* organized by the research team and the commune of Saint-Paulet and inaugurated in September 2019.

► Work on the plant typology of the savannas based on the ODS map of 2018 (field + photo-interpretation)

Remote Sensing in Forests to Improve Biodiversity-Oriented Research

An audience of more than 2,800 people from more than 96 countries. More than 1,200 research projects presented in five plenary sessions, 19 sub-plenary sessions, 172 technical sessions, 350 scientific sessions, 1,648 oral presentations, and 1,200 posters. These are some of the key numbers from the XXVth IUFRO World Congress, the largest forest research event in the world, which was held for the first time in Latin America, in Curitiba, Brazil, from September 29 to October 5, 2019.

Remote sensing as an operational solution

Within the framework of this conference in relation with topics discussed within the framework of Theia Landscape and Biodiversity Scientific Expertise Centers (SECs) a session was organized in collaboration with Petteri Vihervaara (Syke, Finland member of GOBON network) under the title: "Improving conservation targets for forest biodiversity: towards operational solutions from remote sensing technology".

Twelve presentations were selected with a poster session exhibiting more than 30 posters presenting state-of-the-art, challenges and opportunities of remote sensing and coupling modelling for forest biodiversity monitoring and system understanding as well as highlighting examples in different regions of new capabilities on coupling remote sensing, different instruments, field observation and models

Rationality of the Technical session

The preservation of biodiversity has become a major challenge for sustainable development from local, national to global levels. To address the current conservation needs and requirements, we need operational methods to assess the distribution of natural resources while integrating information on habitat condition to inform conservation planning and support the assessment of ecosystem services. Increased access to satellite imagery and new developments in data analyses can support progress towards biodiversity conservation targets by stepping up monitoring processes at various spatial and temporal scales.

Remote sensing has emerged as a fundamental data provider and method to analyze forested surfaces and monitor stressors, pressures and changes. The different presentations highlighted the variety of sensors available and the ability to develop original methods to use and combine information resulted in many forest ecology applications: the availability of image archives (Landsat), the development of new satellite constellations (Copernicus), as well as cutting-edge technologies such as imaging spectroscopy all contribute to global monitoring of forest ecosystems. Most of the cases presented and discussed highlighted the advances in LiDAR, hyper-spectral and RADAR that provide new perspectives on the possibility to accurately map phenology, species diversity, community distribution, leaf traits and biomass, contributing to filling the biodiversity data knowledge gap. All in all, remote sensing technologies coupling to modelling are leading opportunities to predict the consequences of changes in drivers at different scales and plan for more efficient mitigation measures in forested systems.
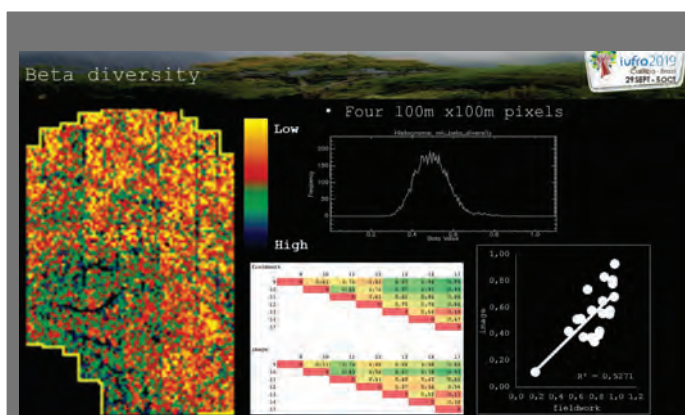
At the IUFRO Technical Session on Remote Sensing, Maria Santos of the University of Zurich (Switzerland) presented the results of a study on alpha and beta diversity mapping conducted on a gradient of moist and dry forests in India using hyperspectral imagery (Huesca et al., 2019).

The authors compared supervised approaches, such as Random Forest, with unsupervised methods similar to the one proposed in biodivMapR (►Read next page) in order to determine the optimal spatial scale of analysis, which in this case corresponds to 1 hectare.

The figure above shows the results obtained for beta diversity mapping, illustrating the composition gradients of species communities from the unsupervised approach based on the spectral variability hypothesis (Asner et al. 2017).

Future priorities

○ Among several possible paths for future research the call from UNEP WCMC, presented by William Simonson from Climate Change and Biodiversity Programme, the followings must be highlighted:

• A global, systematically-developed dataset categorizing forest areas into natural or planted forests

• Greater investment in systematic, long-term, on-the-ground monitoring of forest vertebrates and improved data sharing within the research community

• Advances in coupled models are needed to integrate field data and RS data at different scales. ∎

Sandra LUQUE
(INRAE, Tetis)
Chair of IUFRO Division 8 – Forest Environment
Co-facilitator for the Theia Landscape SEC

IUFRO - International Union
of Forest Research Organizations
► www.iufro.org/

Landscape SEC
► www.theia-land.fr/en/ceslist/landscape-sec/

Variables for biodiversity SEC
► www.theia-land.fr/en/ceslist/variables-for-biodiversity-sec/

Further reading

Margarita Huesca, Maria J. Santos, Raman Sukumar, Susan L. Ustin. 2019 Biodiversity assessment in a tropical deciduous forest in Mudumalai National Park in India using AVIRIS-NG data2019. p. 610 In *XXV IUFRO World Congress Forest Research and Cooperation for Sustainable Development.* Pesq. flor. bras., Colombo, v. 39, e201902043, Special issue, p. 1-768 2019

►pfb.cnpf.embrapa.br/pfb/index.php/pfb/article/view/2043/900

Fusion of an image of an area of the Peruvian Amazon and a β diversity mapping obtained with the application of biodivMapR.

biodivMapR: Mapping Tropical Biodiversity Through Optical Imaging

biodivMapR is a package developed in R language to produce biodiversity indicator maps from information derived from optical imaging data. The calculated diversity indicators are associated with the α and β components of biodiversity and make it possible, in particular, to map indicators of richness and abundance, such as the Shannon index, and indicators of species community distribution expressed by Bray-Curtis dissimilarity. These diversity indicators are calculated from the spatial heterogeneity of spectral information (Spectral Variation Hypothesis) and have shown good agreement with information collected in the field using forest inventories.

All codes, installation instructions and a biodivMapR tutorial are available on a dedicated web page:
► jbferet.github.io/biodivMapR/index.html

The initial method is presented in the following publication:
Féret, J.-B., Asner, G.P., 2014. Mapping tropical forest canopy diversity using high-fidelity imaging spectroscopy. *Ecol. Appl.* 24, 1289–1296. ► doi.org/10.1890/13-1824.1

Developments in the method and operation of biodivMapR are presented in the following publication:
Féret, J.-B., de Boissieu, F., 2019. biodivMapR: an R package for α- and β-diversity mapping using remotely-sensed images. *Methods Ecol. Evol.* 00:1-7. ► doi.org/10.1111/2041-210X.13310

The development of biodivMapR was made possible by the financial support of the CNES TOSCA funding program (HyperTropik and HyperBIO projects) and the French National Research Agency (BioCop project-ANR-17-CE32-0001).

biodivMapR builds on the demonstrated potential of optical imaging data to estimate biodiversity indicators in tropical forest environments. Notably, airborne hyperspectral imagery data have been used in several independent research studies and are currently being used in national ecological observatories. The availability of Sentinel-2 multispectral optical data allows the transposition of existing methods for monitoring on a regional scale to be considered. This is what biodivMapR proposes. Although initially developed for the study of tropical forests, its application to other types of environments is also possible.

Providing information on essential variables for biodiversity

By contributing to the effective monitoring of ecosystems and the operationalization of monitoring methods with the support of available Earth observation means, biodivMapR contributes to the work of the Variables for Biodiversity SEC. The Essential Variables for Biodiversity (EBVs), defined by GEO-BON, aim to document the various factors at work in the erosion of biodiversity, which is particularly marked and worrying in tropical forest environments. ■

Jean-Baptiste FÉRET
& Florian de BOISSIEU
(INRAE, Tetis)

Variables for Biodiversity SEC
► www.theia-land.fr/en/ceslist/variables-for-biodiversity-sec/

THEIA PRODUCTS & SECs

Cloudless, Automatic L3 Reflectance Syntheses

The production of monthly Sentinel-2 surface reflectance syntheses, with no clouds and virtually no apparent seams, began in 2018 within the Surface Reflectance SEC. The release of the first cloud-free mosaic for France in the fall of 2018 has enabled the method to be validated on a large scale. The integration of the WASP processing chain into the MUSCATE production center in spring 2019 marked another step forward with the automation and geographical extension of synthesis production. Theia now has a real offer of mosaics that are useful tools for observing changes in the landscape over time.

An important and now stable production zone on theia.cnes.fr.

An extended production area

Since the summer of 2019, Level 3 monthly syntheses are available for most Western European countries: Spain, Portugal, Italy, Switzerland, Belgium, Luxembourg and the Netherlands. Thanks to the partnership with the Deutsche Zentrum für Luft- und Raumfahrt (DLR), comparable data are now also available for Germany. This Theia product also covers some overseas territories such as New Caledonia, Tahiti, the Kerguelen Islands, Reunion Island, Guadeloupe or Martinique. Since October, production has been further extended to fully cover the Maghreb and the Sahel regions. Once the latter area has been integrated, supply is not expected to change geographically. All the products are available, free of charge, at Theia's distribution workshop at Cnes: theia.cnes.fr.

A synthesis made from cloudless pixels

Level 3A syntheses use, for each pixel, all available cloud-free observations over a 46-day period centered on the 15th of the month or the first of the month, depending on the geographical area. These data are derived from level 2A products obtained with the MAJA chain. This method is very sensitive to the quality of the cloud mask, which in the case of MAJA is fortunately rather good. Nevertheless, it may happen that clouds have been present on all the data acquired during the 46-day period; in this case, the data are marked as clouds in the mask provided with the data. ■

Olivier HAGOLLE
(Cnes, Cesbio)
Surface Reflectance SEC
► www.theia-land.fr/ceslist/ces-reflectance-de-surface/

Monitoring Post-Fire Vegetation Regeneration Using Satellite Imagery

Theia Fire SEC consists of Irstea, ONF, SERTIT and CERFACS teams that develop early mapping of the contours and intensity of forest fires, interface fires and vegetation damage. The aim of this SEC is to map burnt areas using satellite images accessible through Theia and to estimate fire severity levels using image processing and calibration of indices allowing damage assessment through field surveys.

The audience of the products resulting from the SEC are operational services as well as land managers involved in the management of the immediate aftermath of fires and in monitoring the evolution of burnt areas, as well as scientists for research applications.

One of the objectives of the SEC is the creation of a fire database based on satellite products. This database would initially be set up according to a semi-automated procedure that would integrate the detection, contour and severity of fires on the scale of the Prometheus zone, which includes 15 departments in the Mediterranean area that are particularly sensitive to forest fires. The first stages of this procedure are being developed in collaboration with the Irstea team of Theia Color of Continental Waters SEC.
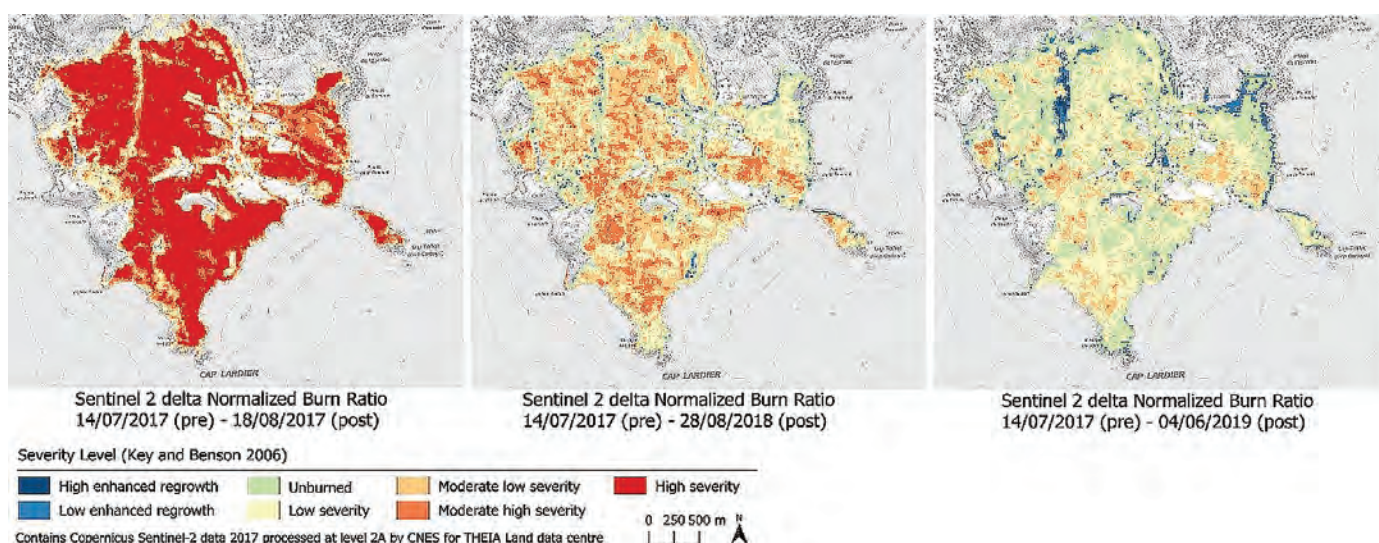
A possible application of these treatments is the post-fire monitoring of the regeneration of natural areas. On request of the Port-Cros National Park (near Toulon, France), Theia Fire SEC provided fire severity maps of the Croix-Valmer fire of July, 24, 2017. The fire notably affected Cap Lardier and Cap Taillat, both NATURA 2000 sites located in the Park's adhesion area.

Based on the evolution of the dNBR (delta Normalized Burn Ratio, Miller and Thode, 2007) over three years (2017, 2018, and 2019), these maps make it possible to highlight the areas most severely affected by the fire, to monitor the evolution of vegetation recovery, and to adapt the post-fire management of burnt areas. ■

Adeline BELLET, Marielle JAPPIOT, Fabien GUERRA,
Pierre CASTEX, Christophe BOUILLON & Éric MAILLÉ
(IRSTEA, UR RECOVER/EMR)

Fire SEC
► www.theia-land.fr/en/ceslist/fire-sec/

Sentinel 2 delta Normalized Burn Ratio
14/07/2017 (pre) - 18/08/2017 (post)

Sentinel 2 delta Normalized Burn Ratio
14/07/2017 (pre) - 28/08/2018 (post)

Sentinel 2 delta Normalized Burn Ratio
14/07/2017 (pre) - 04/06/2019 (post)

Severity Level (Key and Benson 2006)

High enhanced regrowth	Unburned	Moderate low severity	High severity
Low enhanced regrowth	Low severity	Moderate high severity	

0 250 500 m

Contains Copernicus Sentinel-2 data 2017 processed at level 2A by CNES for THEIA Land data centre

Evolution of dNBR reclassified into 7 severity classes in 2017, 2018 and 2019 at the La Croix-Valmer fire (town adjacent to the Port-Cros National Park, near Toulon, France) on 24 July 2017. The 2 classes in shades of blue correspond to zones of vegetation recovery.

An European Service Inspired by a Theia Product and Implemented by Magellium

The Pan-European High Resolution Snow & Ice Monitoring of the Copernicus Land Monitoring Service, developed and operated under EEA (European Environment Agency) delegation, produces and distributes snow cover information on land and ice cover on European lakes and rivers from high-resolution Sentinel-2 satellite data.

A collaboration with Cesbio

The snow component of the service is the result of a collaboration between Cesbio and Magellium. It is based on the expertise of the Theia Snow collection, which already provides the snow surface using Sentinel-2 observations. The algorithm used in European Service builds upon the one used to generate Theia snow products, to further compute the snow cover fraction per pixel.
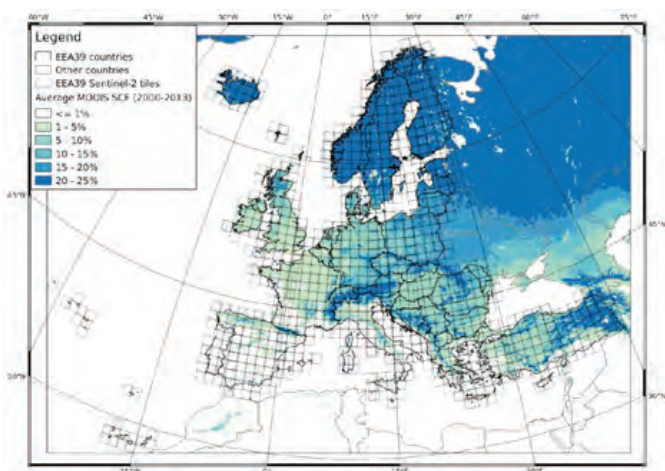
Magellium, in partnership with the Polish space agency ASTRI POLSKA, has been awarded by EEA the contract for the implementation, operation and promotion of the Copernicus High Resolution Snow & Ice service. Cesbio and ASTRI POLSKA are in charge of the algorithms and the scientific validation of the products. Météo France supports Cesbio in the validation of snow products.

Magellium was able to meet the major requirement of the service: to generate and distribute the data within 3 hours of the

Snow and Ice Detection on European lakes and rivers.
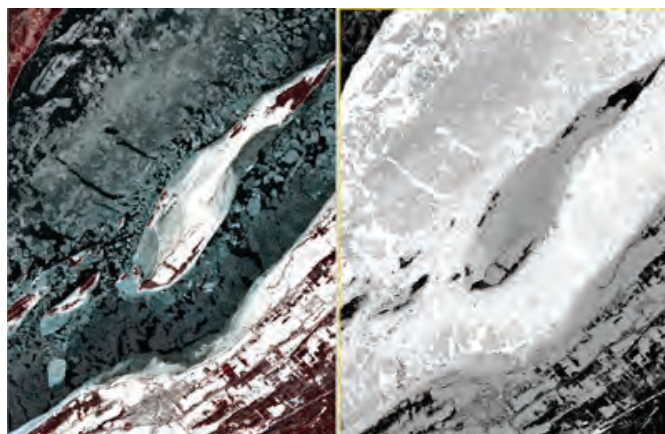
Sentinel-2 L1C data broadcast on the Copernicus Hub. The company also faced the challenge, for the first time, of integrating a Copernicus service component on a European DIAS (Data and Information Access Services) platform, which allows centralized access to Copernicus data.

It is the first Copernicus service implemented by Magellium, a service and engineering SME specializing in geoinformation, image processing and Earth Observation from Space. Its 150 employees are divided between two production sites in Toulouse (head office) and Courbevoie. Magellium mainly operates in the Space, Defence and Environment sectors. In particular, Magellium has created links and collaborations with CNES, IGN, DGA (French Armament Procurement Agency), Thalès Airbus Defense & Space, ESA, EUMETSAT and now EEA. Magellium provides services in the fields of image processing, cartography and geographic information systems (GIS), geomatics and navigation applications, robotics, scientific processing, ground segments and applications of observation satellites.

The Copernicus High Resolution Snow & Ice service service is accessible to all, via the Copernicus portal land.copernicus.eu/ Operational in June 2020. ■

Michael ABLAIN
Magellium
►www.magellium.com/fr/

NETWORKS

TEMPO: A French Observatories Network Dedicated to Phenology

TEMPO is a French national network of observatories dedicated to the phenology of the entire living reign (plant and animal species, both exploited and wild). Phenology is the study of the seasonal rhythms of living organisms determined by seasonal variations in climate. The major scientific question that TEMPO seeks to answer is how climate change impacts the seasonal rhythms of living organisms and what the consequences will be in terms of system productivity but also in terms of survival, population dynamics and distribution. TEMPO currently brings together 9 thematic observatories (forest, vine, fruit trees, field crops, meadows, arthropods, fish, reptiles, mushrooms) and a Citizen Observatory composed of two participatory science programs:

www6.inra.fr/soere-tempo

the Seasons and Phenoclim Observatory. TEMPO has about 95 partners from several horizons (research units, associations, technical institutes, public institutions...).

Thanks to the support of Allenvi, INRA, INEE-CNRS and OSU OREME, TEMPO carries out several actions:

○ The development of a data portal connecting several national databases containing phenology data (Observatoire des Saisons, GnpIS INRA, Phenoclim INRA,...). This portal, a prototype of which is already available here, should provide access to all data concerning the phenology of all species (animal, plant, fungi) observed in France.

○ The description of protocols and rating scales for the phenology of different taxonomic groups that have never before been described (e.g. plant pathogenic fungi). Training and intercalibration of observers are carried out by the network or by each observatory.

○ Actions for the recovery of old data that have already made it possible to introduce into the database more than 80,000 phenological observations of several species (peach, walnut, maize) since 1930.

○ The development of climate services based on the simulation of the phenological stages of several species on the scale of France. ■

Isabelle CHUINE (CEFE)
& Iñaki GARCIA DE CORTAZAR-ATAURI (INRAE)
SOERE TEMPO Coordinators
► www6.inra.fr/soere-tempo

Brittany Runs Its Own Regional Copernicus Program

Copernicus Regional is the regional approach program aiming to promote the use of data from the European Copernicus program and other Earth observation data. It intends to simplify access to these data through a single access point, to offer assistance, mutual aid and networking for the use of these data and to initiate and support the co-construction of regional applications and services using satellite data.

Accessible and referenced products

15 satellite products are available on the platform and referenced in the GeoBrittany GeoCatalogue. In addition to the Sentinel images made available at the beginning of the year, new products are now referenced (Theia Land Cover, Copernicus Land, Urban Footprint of the German Space Agency, etc.). In addition, a new tool for visualizing Brittany from space, from 2015 to today, has been developed and is currently being tested.

The main advantage of the platform is to provide users with a first single access point to view images and products and to access resources (product descriptions, methodologies, basic notions of remote sensing). Nevertheless, initial feedback shows that most products are accessible for viewing only and that the products do not necessarily meet local needs.

Developing, accompanying and creating a community

Different priorities have been identified. In terms of development, it is necessary to improve the ergonomics of the Copernicus Regional platform and to integrate the time dimension. Users must be able to perform simple processing to query spatial data at different scales. Training sessions and workshops will be proposed to improve user autonomy. Finally, the sustainability of the system requires that we continue to support the communities of users and experts and encourage exchanges between the two. The platform must also continue to be supplied with new regional products that respond to the problems and challenges of the territories. Supporting the co-construction of these regional products with users and experts will be central to guaranteeing this result.

To this end, the 2020 program is defined as follows:

○ Pedagogical projects involving students at different levels (on the platform's functionalities, for interventions with school audiences)

○ Workshops for expert and end-user training on different themes (e.g. coastal; forest management; urban, etc.)

○ Break down the Copernicus Regional platform into thematic platforms

○ Articulate with the satellite community (the national level is relevant for sharing use cases, methods, etc.).

○ Continue to exchange with other Theia RANs (RAN meetings, AppSpace), Copernicus Relay and Academy. ■

Marie JAGAILLE
(Bretel)

Copernicus Bretagne
► geobretagne.fr/mviewer/
?config=/apps/teledetection/config.xml

Co-facilitator of Theia Brittany RAN
► www.theia-land.fr/artlist/art-kalideos-bretagne/
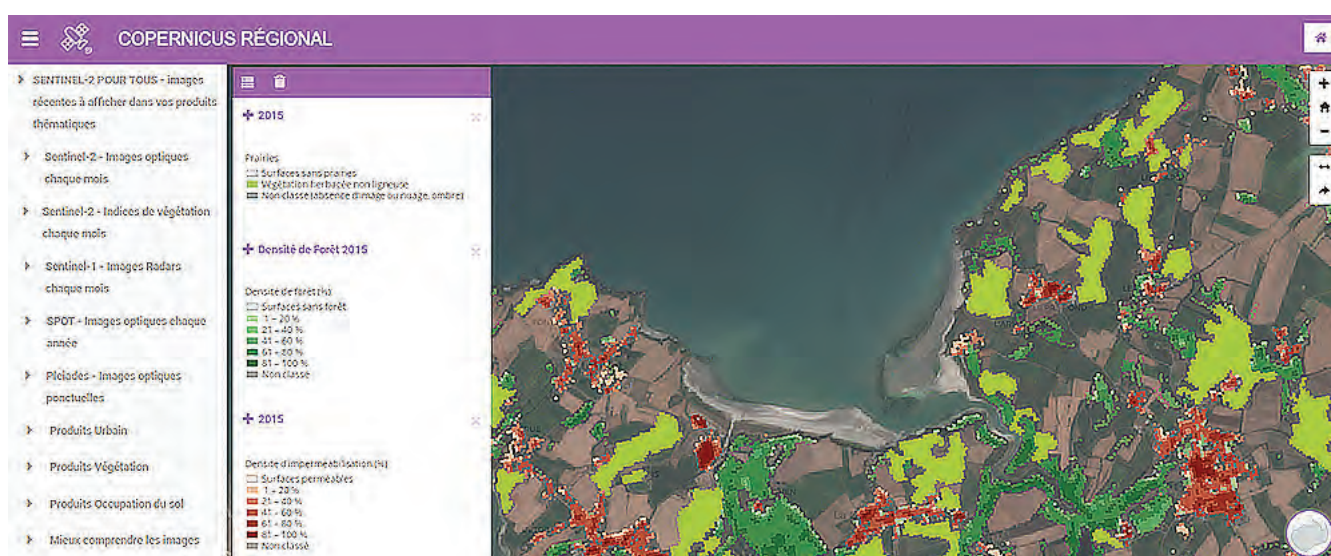
« # Making Satellite Research, Products and Applications More Visible.

When and why did you get involved with Theia? What motivates you to get involved in a network like Theia?

Jean-Pierre WIGNERON: I was involved in several committees whose work led to the creation of the Theia consortium, in particular the PTSC (Thematic Cluster on Continental Surfaces). At the Aquitaine level, I co-animated the AST Télédétection network (Transversal Scientific Action) of the OASU (Aquitaine Observatory of Sciences of the Universe) which aimed to create the first remote sensing network in the region. This network then provided a basis for the Theia Regional Animation Network (RAN) when it was set up. I also co-animated the remote-sensing network within INRA for many years.

Therefore, I naturally continued these different activities within the cluster when it was created. Theia plays an important role in making the work carried out in France on remote sensing visible to the supervisory authorities and ministries. Theia also provides real scientific animation and highlights the results obtained in the laboratories.

**Interview with
Jean-Pierre WIGNERON**

**Research director, INRAE
MOST team, Bordeaux, France**
www.umr-tetis.fr

Co-facilitator of Theia Surface Soil Moisture SEC
► www.theia-land.fr/en/ceslist/soil-moisture-sec/

Co-facilitator of Theia VOD SEC
► www.theia-land.fr/en/ceslist/vegetation-optical-depth-sec/

the robustness of a valid approach from the plot scale to a continental or global scale (from a soybean plot to tropical forests with almost the same data processing algorithm!). These different results validate the potential of passive microwave data to measure canopy biomass and soil moisture, and thus to propose a development of these products in Theia. Why? Firstly, to offer an increased visibility to this work, to use the sounding board of Theia to make it known and to develop its use in applications. This is what we are doing with experts on the water and carbon cycle (P. Ciais, A. Ducharne, J. Chave etc. and many others internationally).

Moreover, one of the current challenges of remote-sensing is to succeed in combining Earth observation data in monitoring the functioning of the cover. For example, for forest monitoring, it is particularly interesting to combine information on soil moisture and surface temperature for monitoring water stress, biomass, LAI to monitor photosynthetic activity and phenology, etc. Most applications today rely on the combination of space-based observations. Theia, by promoting exchanges and collaborations within the community, is helping to make this possible.

What are the challenges today for the future of satellite in France and for Theia?

Jean-Pierre WIGNERON: From what I observe in France today, there is quite strong support for the development of new sensors and new products. We now need to succeed in obtaining equivalent support for the development of applications based on these products in order to valorise them within major research institutes, such as INRAE or CNRS. Indeed, the purpose of remote sensing is not to produce a series of images or products, but to support applications on the water and carbon cycle, the functioning of ecosystems, etc. Tn many cases, remote sensing is an indispensable tool on scientific fronts that cannot be tackled effectively without the contribution of space observations. For me, Theia therefore has an important "political" role in raising awareness of this challenge among the supervisory authorities and research institutions, by highlighting and showing the value of the applications developed.

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

Jean-Pierre WIGNERON: My personal research and my scientific activities within Theia are very intertwined. I take part in Theia Surface Soil Moisture SEC and the brand new Theia Vegetation Optical Depth (VOD) SEC that I initiated and whose work is very close to my personal research. In both cases, the aim is to show the contribution of microwave data in the monitoring of the water and carbon cycle through soil moisture and biomass variables. The work launched in the VOD SEC, for example, is based on the results of various experimental campaigns that I was able to carry out at INRA in Avignon in the inversion of VOD on plots of soybean, wheat or corn almost 30 years ago. Thus, it is almost the same model (L-MEB for L-band Microwave Emission of the Biosphere) developed and calibrated on these agricultural fields that is now used in algorithms of the SMOS mission, showing

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Together, Simplifying the Spatial

How are you involved in the co-facilitation of Theia Occitanie RAN?

Amélie Lombard: Cerema's satellite pole is involved in various missions to promote the use of spatial data by government services, local authorities and their operators: network animation and training, development of image processing methodologies, data expertise, comparison of uses and evaluation in the form of thematic indicators. Always with a view to proposing reproducible, stable and sustainable solutions in the field of public policies supported by the French Ministry for Ecology: land use planning, environment, risk management, adaptation to climate change, etc.

As such, the role of the Regional Animation Networks (RANs), which aim to link research work with regional business users of remote-sensing data, is completely in line with our missions. So I took over this role of co-facilitator of ART Occitania when I joined Cerema in 2016.

How do you see your role as a mediator between research and users?

Amélie Lombard: Theia allows us to follow the progress of research work on themes of interest to public policy, both on innovative treatment methods and on the products that come out of them. This technology watch helps us to meet the needs of operational planning departments and to propose integrated approaches.

Several of our actions aim to transmit information to potential users of satellite imagery in Occitanie or on a national scale: thematic days on the "Contribution of satellite imagery for land use planning" in Toulouse; "Awareness of spatial data" training courses given throughout France to government departments, and contributions to Theia Newsletters.

The term "user" is sometimes employed for different profiles; our target audience are public policy-makers. Beyond the question

Interview with Amélie LOMBARD

Project manager, in charge of satellite applications, Pôle observation des territoires et applications satellitaires, Cerema, Toulouse.

Co-facilitator of Theia Occitanie RAN
► www.theia-land.fr/artlist/art-occitanie/

of the economic model of the data, a user will find it easier to get involved in space and remote-sensing in general, if the efficiency of the tool has already been demonstrated on its business issues. Sharing operational feedback is essential: the national Applisat portal, which we are implementing for the Ministry, is heading in this direction. (► Read the announcement of the opening of Applisat, p.2.)

What challenges does Theia face today?

Amélie Lombard: For "professional" users, Theia's essential contribution is to provide thematic data such as Soil Occupation (OSO) or Snow products. These high value-added layers are easily usable by GIS technicians, who are the natural conduits for the applicative uses of data in departments. However, these data are sometimes subject to misinterpretation: OSO is, for example, wrongly used to monitor artificialization, whereas its vocation is to meet the monitoring needs of natural, agricultural and forest areas in rural areas. The external qualification of products in relation to an application on a concrete business issue and support for use in general should not be neglected.

In a context of making OpenData images and data accessible and of the deployment of automatic processing methods for large volumes of data (Artificial Intelligence), users need all the more support. A neophyte must be guided in accessing image data and may resort to photo-interpretation, which is satisfactory for certain themes. Thematic products can complete this information if they are well chosen or even approved in terms of use. On-demand services correspond more to an advanced profile wishing to generate predefined thematic products, especially for a temporal follow-up more in line with its needs.

The simplification of the spatial landscape, of the devices and tools and even of the associated vocabulary is a challenge that we, spatial actors, must take up together.