BULLETIN
Theia Land Data Service Center

n° 11- September 2019

CONTENT

A word

from the Scientific and Technical Directors

Supporting the development of high-performance products is at the very essence of Theia. The recognition obtained by the Snow product through a pan-European call for tenders and the use of the product by French national parks is therefore a legitimate reason for satisfaction. This bulletin is also proud to announce the release of a new updated set of Land Cover maps adapted to the conditions of Reunion Island; the enrichment of the Sahel cover by Theia; and the expansion of the range of Soil Moisture products.

The contributions gathered here explore other themes dear to the Theiaconsortium, such as the monitoring of new satellite missions in preparation and their ambitions as well as the computation or cooperation tools that are being developed within or outside Theia. Applications cover all areas – health, climate, drought monitoring, biomass measurement. All of them testify to the vibrant dynamism of our sector. The creation of a New Caledonia GeoDEV RAN with the holding of a seminar in July and the organization in Marseille of a national symposium on the use and development of remote sensing in the autumn illustrate the richness of Theia activities at local level. ■

News

New Caledonia: an animation dedicated to local satellite issues

Located on the Indo-Pacific axis, close to Australia and New Zealand, New Caledonia is an essential French presence in the South Pacific region. With a real awareness of the lack of spatialized information, the need for training and limited access to data in the region, the geomatics community of New Caledonia has grown in recent years, notably with the regular holding of conferences. New Caledonia is thus positioning itself as a central regional player in this field.

Seminar website www.oss.nc

In order to foster and federate the local community, a dedicated Theia regional animation network (RAN) was created last May. Co-facilitated by IRD New Caledonia and the startup INSIGHT SAS, GeoDEV-NC RAN is already at the origin of the organization of an event supported by CNES. The OSS NC seminar, dealing with Space Observation for NC End-Users, was held on July 09 and 10 in Noumea. Its stated objectives were to democratize technology and share technical knowledge around priority themes. The event and its aftermath should thus contribute to the strengthening of local skills and to French influence in the region. ■

Marc DESPINOY (IRD Nouvelle-Calédonie) & Jean MASSENET (Insight NC)

►GeoDEV New Caledonia

www.theia-land.fr/artlist/art-geodev-nouvelle-caledonie

Always more Soil Moisture products

Theia VHSR Soil Moisture SEC continues to expand, geographically and temporally, its product collection. Soil Moisture maps at plot scale and high repetitiveness (one map every six days) are now available for nine different sites.

The sites chosen illustrate above all the Mediterranean region (south of France, Spain, Lebanon, Sardinia, Morocco, Greece), but also now other European climates (Vienna in Austria, Düren in Germany, Versailles-Chartres near Paris). ■

►Soil Mosture Products

www.theia-land.fr/en/product/soil-moisture-with-very-high-spatial-resolution/

On Theia Agenda

- July, 4 >> Theia Scientific Comittee Meeting, Cesbio, Toulouse.
- July, 9 & 10 >> OSS-NC Seminar, Noumea (New-Caledonia).
- September, 5 >> Meeting of all the RANs at the Maison de la télédétection, Montpellier.
- October, 1 >> Exchange workshop between GeoDEV RAN and SECs on the needs of southern countries.
- November 5 & 6 >> National symposium on the use and development of remote sensing in space, organized by Sud RAN in Marseille.

MAJA 3.3: four major improvements

Since May 2019 a version 3.3 of the MAJA processing chain has been available from Theia. The new version brings four major improvements:

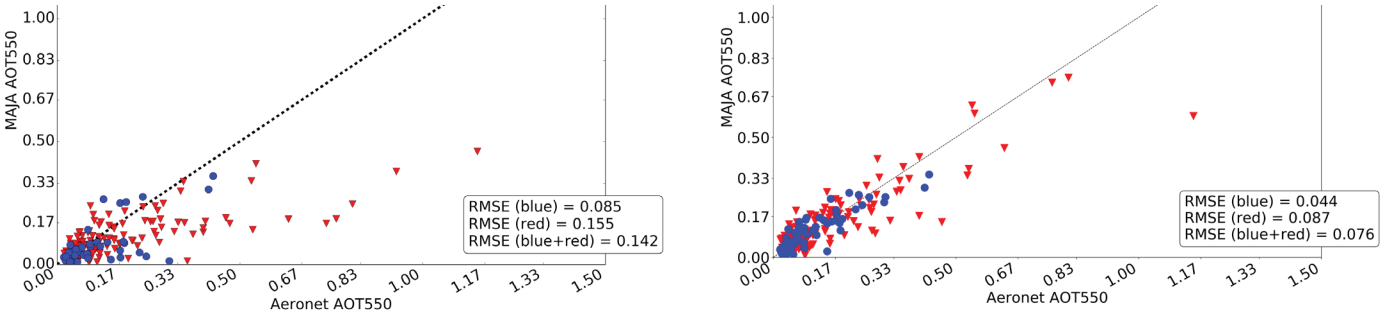
- MAJA 3.3 fixes the bug responsible for detecting clouds or cloud shadows on the edges of images;
- It fixes the various bugs that affected the CAMS option since the release of MAJA V3.0. This option uses Copernicus Atmosphere's aerosol forecasts to define the type of aerosol before recovering the optical thickness of the aerosols (AOT) from the Sentinel-2 data. We now also use CAMS AOT as a default value when it is not possible to estimate AOT using images, for example over a snowy landscape or for small areas in large cloud cover. This correction improves results when conditions are poor.
- It limits cirrus correction which tended to over-correct the impact of thick cirrus clouds, producing images with dark clouds.
- It improves cloud detection, with a better compromise between false positives and false negatives. Version 3.3 also better manages the variation in altitude of cirrus detection with band 10 (1.38 µm).

A recently published comparison (►www.mdpi.com/2072-4292/11/4/433) shows that MAJA 3.3 performs slightly better than FMask 4.0, and much better than Sen2Cor.

Version 3.3 has been integrated into MUSCATE and is in the process of being qualified, before going into production. However, CAMS changed its data format and the aerosol models, and for this reason we will not be able to use MAJA with CAMS in real time before MAJA version 4, available early 2020. ■

Olivier HAGOLLE (Cesbio)

>> Download MAJA
►logiciels.cnes.fr/en/node/57



Comparison of the validation of the aeorol optical thickness (AOT) between the MAJA 3.1 and MAJA 3.3 chain.
The blue dots correspond to a validation under good conditions while the red dots correspond to less reliable validation points.

A Digital Surface Model based on Pleiades

CNES, Theia and Form@TER plan to set up together a service to generate DSM (Digital Surface Model) for non-experts, based on pairs or stereo triplets of Pleiades images.

The DSM obtained as a GeoTIFF image with elevation values (Z) would have the following characteristics:

- Relative accuracy of 1 m 50 at altitude for a stereo pair on a slope of less than 20%.
- Planimetry accuracy on the order of 9 m at 90%.
- Spatial resolution on the ground: the MNS provided can be sampled between 0.5 and 10 m depending on usage
- User-defined map projection
- Post processing: filtering outliers. Interpolation is used to sample regularly. There are still non-measurable areas identified as no data. Their number depends mainly on the acquisition configuration.

The DSM would be accompanied by an image of radiometric value either panchromatic or resulting from the P+XS fusion.

The final product will also take into account the needs expressed by scientific and institutional users during summer 2019. ■

AppSpace 2019#Sud : Space, from observation to action

After AppSpace Bretagne and AppSpace Grand-Est, the AppSpace event is heading south! This 3rd edition, organised by CRIGE Provence-Alpes-Côte d'Azur, in cooperation with CNES, the South Region and the Theia Sud regional animation network (RAN), will bring together all the players (local authorities, the state, research laboratories, companies, associations, etc.) in order to stimulate the use and economy of space.

Appspace#Sud website: ►appspace-sud2019-crige.fr/

The satellite sector will reveal its secrets using thematic approaches in line with the needs and expectations of territorial users. These two days will be open to everyone, from beginners to experts, from the public or private sector. Exchanges (workshops, demonstrations...) will be permanent to confront different points of view and to stimulate new dynamics that will lead to innovation and to the emergence of sustainable solutions at the service of local actors. Everything will be done to decompartmentalize and bring communities closer together, to facilitate dialogue between stakeholders and participants, to enhance knowledge, data sources, practices and uses, to make technologies accessible...

The general programme is already on-line and registration is open. Space experts will be on hand to help you design the future of your communities. Come to AppSpace and express your needs! ■

Claire Ajouc, (CRIGE-PACA)
contact@appspace-sud2019-crige.fr

ANISETTE

ANISETTE: tracking mosquitoes vectors of disease

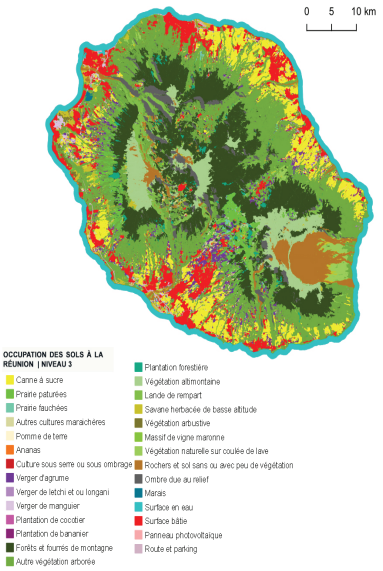
The ANISETTE project – Inter-Site Analysis: Evaluation of Remote Sensing as a predictive tool for the surveillance and control of diseases caused by mosquito – has just been launched. With CNES funding, this project aims to measure the interoperability of methods combining remote sensing and spatial modelling to predict the dynamics of mosquito vectors and associated diseases. The aim is to identify the most suitable Earth observation images to predict areas conducive to the development of different mosquito vector species – including *Aedes* (vectors of dengue fever, Rift Valley fever) and *Anopheles* (vectors of malaria). These analyses will be carried out on various geographical sites: South America (Brazil, the West Indies, French Guiana), Europe (France), the Indian Ocean (Madagascar, Reunion Island), South and South-East Asia (India, Thailand, Cambodia) and Oceania (New Caledonia).

ANISETTE is a continuation of regular and long-standing collaboration between the teams of the Institut de Recherche pour le Développement (UMR Espace Dev) and CIRAD (UMR TETIS, UMR ASTRE), within the Maison de la Télédétection in Montpellier and the "Remote-sensing, Environment, Health" group, now the Theia "Risks Associated with Infectious Diseases" Scientific Expertise Centre (SEC), and in partnership with researchers from the UMR IDEES. It brings together various French research teams working on remote sensing applied to diseases vectored by mosquitoes. ■

Annelise TRAN (Cirad)
► anisette.cirad.fr
► www.theia-land.fr/en/theme/health/ and Risks Associated with Infectious Diseases SEC
► www.theia-land.fr/en/ceslist/risks-associated-with-infectious-diseases-sec/

Reunion Island Land Cover: 2018 map

Theia Land Cover Scientific Expertise Center has just published an updated version of its land cover maps for Reunion Island initially computed in 2017. These new maps were obtained, with the Moringa chain, from a Spot 6/7 image mosaic (acquired by the Kalideos project) and a time series of Sentinel-2 and Landsat-8 images (acquired between January and December 2018). For 2018, the maps have been produced with an updated learning database, and are distributed at 3 levels of accuracy: from 4 classes for level 1 to 30 classes for level 3.



Level 3 Map offering 30 classes

These maps illustrate the effort made within the Tetis research unit to develop land cover classification methodologies based on satellite imagery adapted to the context of landscapes and agricultural systems in the South: high cloud cover, small parcels, landscape fragmentation and heterogeneity of agricultural practices, low availability of reference data.

These results are achieved through the GABiR project (Gestion Agricole des Biomasses à l'échelle de l'Ile de la Réunion) managed by CIRAD. A version computed from a mosaic of Pleiades images acquired in 2018 (replacing Spot 6/7) is currently being produced and will be available soon. ■

Stéphane DUPUY (Cirad, Tetis)

Data are available on AWARE:
► aware.cirad.fr

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

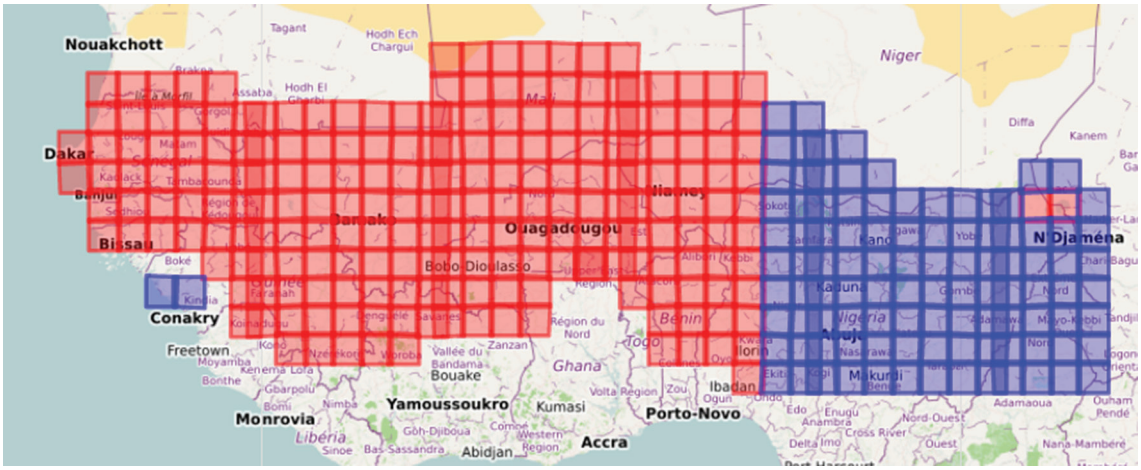
MUSCATE processes Sahel from West to East

Since November 2018 MUSCATE production center in Theia is gradually adding areas in the Sahel (► Read Bulletin n°10), starting from Senegal going eastward. Data have been processed from December 2016 onwards, which means that we still have a large amount of data to process.

In september 2019 Theia completed the processing of tiles in the UTM30 zone and in most of UTM31 area. The processing of the east of UTM31 and the whole UTM 32 tiles begun.

Feel free to take a look from time to time at the map of areas covered by MUSCATE. The blue tiles turn red as soon as we switch to near real time processing. ■

Olivier HAGOLLE (Cesbio, MUSCATE)



In red, the zones already available in real time and since the end of 2016. In blue, the zones that will soon be available.
Data can be downloaded from theia.cnes.fr

Workshop report on the French research and the research component of the 4P1000 initiative

When the French community working on the themes pursued by the 4P1000 Initiative met in Sète in November 2018, it aimed to identify and structure science fronts as well as research actions to be programmed as a priority in order to improve soil carbon storage. (► Read Bulletin n°10)

A report of the workshop «*La recherche française et le volet recherche de l'initiative 4 P1000*» has just been published and presents the results of this reflection carried out within several thematic groups.

These groups addressed the environmental, socio-economic and broader societal aspects associated with soil carbon storage at several time scales: the current situation, a transition phase and the long-term in terms of research and actions to be pursued to maintain or even increase soil carbon storage and to ensure the transition to sustainable agro-ecosystems.

The report thus focuses on farmers' perceptions and practices, the conditions for maintaining and increasing soil carbon stocks in the long term and their relationship to land use planning. It identifies research fronts in terms of evaluation and monitoring tools – including the use of remote sensing to conduct carbon assessments – as well as drivers of the transition. Finally, it seeks to highlight the co-benefits of changes to standard pratices. ■

Claire WEILL
Inra, 4P1000

>> Download the report (in French)
► 4p1000sete2018.sciencesconf.org/data/pages/Mobilisation_de_la_recherche_fr_4P1000_Sete_Rapport_1.pdf

Satellite missions

SWOT: an Innovative Mission Dedicated to Continental Hydrology

SWOT (Surface Water Ocean Topography mission) is a research mission proposed by NASA as part of the Decadal Survey of its Earth Observation program. It is also one of the high priorities of CNES further recommandations by the Scientific Program Committee following the CNES Scientific Prospective Seminar in Biarritz 2009. SWOT's main objective is to bring together the needs of the hydrological and oceanographic communities in a single satellite, with the collection of unique oceanographic and hydrographic data on a global scale including the shoreline and coastal zone. SWOT thus aims to meet the challenges and societal demand in terms of water management. The increasingly precise description of the water cycle on land allows for better climate prediction and better control of the planet's water resources (human consumption and activities such as agriculture, urbanization, hydroelectric power production, etc.). The monitoring of water resources on a global scale is a major societal challenge in which space technologies have a decisive role to play.

The SWOT mission will measure the water levels of oceans, rivers, lakes and flooded areas using a new technical concept: interferometric altimetry. Compared to conventional altimetry, which provides point data along profiles spaced several tens / hundreds of kilometres apart, wide-swath interferometric altimetry will be able to provide centimetric precision water heights, water body slopes and widths – for rivers over 100 m wide and rivers and lakes and reservoirs over 250 m^2 – with a temporal resolution on a weekly basis. The applications of this mission are vast: flood prediction, surface water management for consumption, irrigation, river navigation, hydropower production, epidemic propagation, etc. for mesoscale circulation hydrology for oceanography.

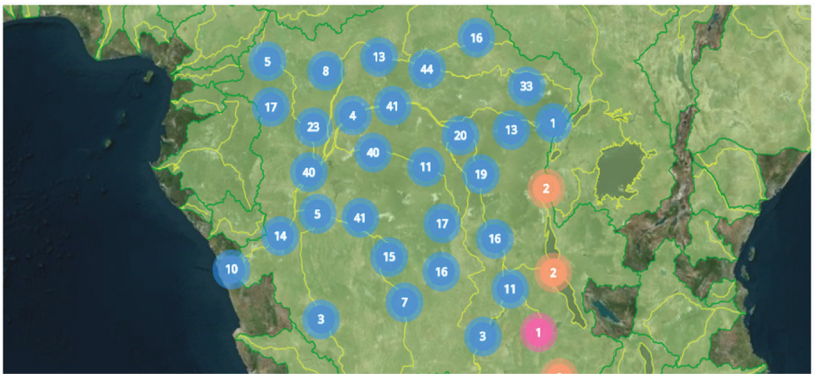
Supporting Water Stakeholders

Supported by the French Future Investment Programme (*Programme d'Investissment d'Avenir,* PIA), CNES has set up the SWOT-aval programme to prepare water stakeholders for the arrival of future SWOT data, but also to raise their awareness of the use of space (Copernicus data in particular) in hydrology. The SWOT-preparatory program monitors and supports developments in the various Theia SECs: Land Cover (IOTA2 chain on West Africa); Water Quality (OBS2CO and sediment flow estimation combined with SWOT); Water Levels (Hydroweb); Snow-Covered Surface (LIS chain); Water Surfaces with the development of the SurfWater chain based on Sentinel-1 and 2; and finally Soil Moisture with SMOS and Sentinel-1. In parallel, the SWOT-aval programme is setting up Hydroweb-NG, a spatialized water information database that will centralize access to all space-based data and products in a single access point and be integrated into Theia.

These activities are carried out in collaboration with the TOSCA, various laboratories and Theia. This coordination and promotion of French scientific excellence is a real success have been acknowledged at both European and international level: Hydroweb is now integrated into the Copernicus Global Land and Copernicus Climate Change Services programme and participates in the Climate Change Service (CCI) on lakes; snow-covered areas will be integrated into the high resolution pan-European Snow and Ice layers of the Copernicus Land Monitoring Service.

The Congo Basin Example

In order to demonstrate the interest of space to downstream stakeholders, a Working Group on Space Hydrology bringing together CNES, IRD, Irstea, AFD, IOWater, BRLi and CNR was created in 2014. The Congo Basin was chosen as a pilot region. An agreement between the seven public and private institutions was signed at COP22 in Marrakech allowing for an agreement with CICOS, the Congo River transboundary basin agency. With AFD's support this work allows CICOS to have an operational Hydrological Information System integrating Hydroweb's spatial altimetry data and



Congo Basin coverage by Hydroweb
► hydroweb.theia-land.fr/

in-situ data. Spatial altimetry has also proved to be of great interest for the development of airworthiness prediction services and for the determination of an atlas of the basin's hydropower potential.

The working group's focus is now on other African basins, such as Niger, Chad and Senegal, where altimetry and other variables of interest in hydrology (land use, water quality, water surfaces, etc.) will be highlighted, in addition to altimetry. ■

Selma CHERCHALI
(CNES, SWOT and SWOT Downstream)

TRISHNA: a Franco-Indian Mission to Monitor the Water Status of Continental Ecosystems

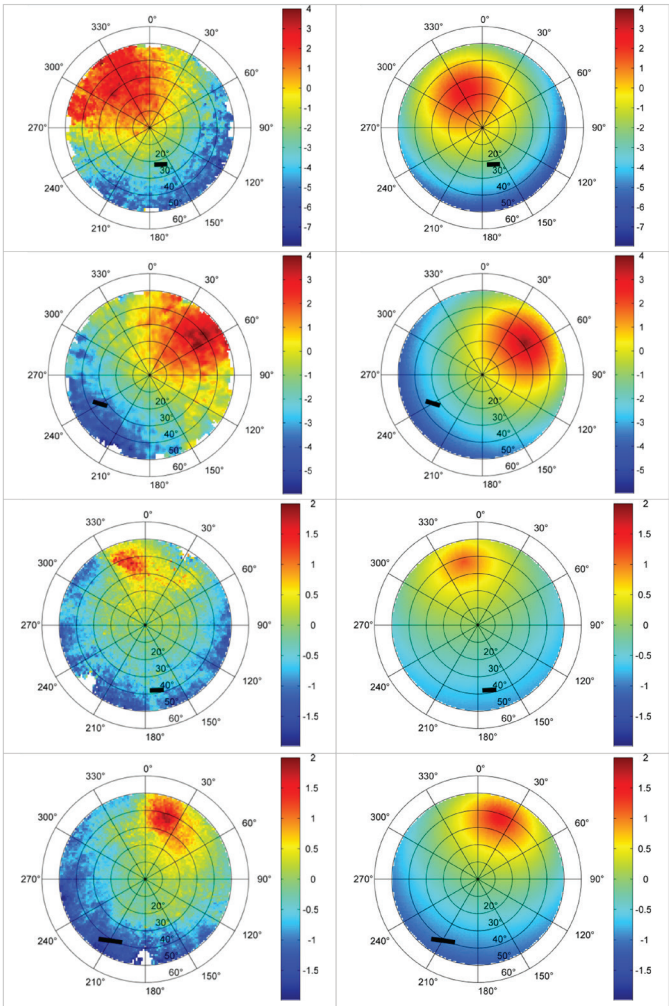
TRISHNA (Thermal infraRed Imaging Satellite for High-resolution Natural resource Assessment) is a future high-resolution space-time mission in the thermal infrared (TIR) led jointly by the French (CNES) and the Indian (ISRO) space agencies for a launch planned in 2025. The scientific objectives guiding the definition of the mission are, in order of priority, the monitoring of the water status and of the stress of continental ecosystems, the monitoring of coastal and inland waters, the urban environment, and applications to the solid Earth, the cryosphere and the atmosphere.

TRISHNA will be positioned on a polar orbit at an altitude of 761 km, providing a revisit of 3 passages over 8 days with global coverage. The time of passage around 13:00 LST allows thermal data to be acquired in the middle of the day, but also in the middle of the night. The instrument will offer 4 thermal channels (8.6 µm, 9.1 µm, 10.4 µm, 11.6 µm) and 6 optical channels (485 nm, 555 nm, 650 nm, 860 nm, 1 380 nm, 1 650 nm) with a spatial resolution between 50 m and 60 m for all channels. The required accuracy is 1k with a NeDT of 0.2K.

TRISHNA will have a large field of view of 35° to ensure global coverage, generating directional effects whose magnitude has been measured in situ up to 5°C (forests) and 10°C (vineyards, urban). In the intertropical zone and from March to October, one of the three successive observations will be contaminated by the hot spot phenomenon which consists in observing the target in the direction of illumination. Parametric models (Roujean-Lagouarde, RL), 1D (SCOPE) and 3D (DART) are being studied to best overcome angular stress based on better control of directional anisotropy in the IRT. The GWS (Global Split Window) and TES (Temperature Emissivity Separation) methods will be used to estimate the surface temperature corrected for atmospheric and emissivity effects.

A structured research system

A scientific mission group was structured into eight Franco-Indian thematic subgroups (Ecosystem stress, Coastal and Continental Waters, Urban, Cryosphere, Atmosphere, Solid Earth, Cal/Val, Product Development). The subgroups' activities are multiple and range from the consolidation of mission specifications (directional variability, characterization of the impact of atmospheric turbulence, emissivity estimation, position and width of thermal spectra) to the definition of products and their validation on in situ networks. Finally, the subgroups ensure the link with Indian partners on each of the themes, in particular through scientific exchanges and the setting up of collaborative projects.



Polar graph showing the amplitude of the thermal hot spot in wide band for urban (top) and pine forest (bottom) and 2 solar positions. The measured signal (left) is compared to the simulated signal with the RL model (right). (after Duffour et al., *CSR*, 2016)

The ultimate objective is to co-construct future processing chains, to size and validate error items, and to promote the use and dissemination of data in the community. For example, an end-to-end simulator is being developed for vegetation in CNES for this purpose with the help of the "ecosystem braid" group. ■

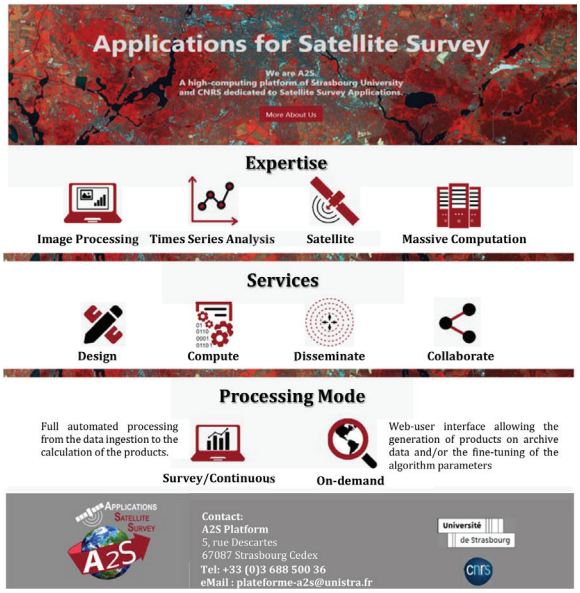
Jean-Louis ROUJEAN
(Cesbio)

A2S | A Time for Achievements

A2S is the computing platform of the University of Strasbourg and the CNRS dedicated to Satellite Monitoring Applications. A2S provides massive Earth Observation data processing services and constitutes a Spatial Data Infrastructure (SDI) for the benefit of both research and users of the Grand Est Theia Regional Animation Network. A2S is also accessible across regional borders.

This SDI, presented in detail in the December 2018 Theia Bulletin (►Read Bulletin n°10), combines its own calculation and storage capacities, specialized software – for data ingestion and pre-processing and for the creation of thematic products – as well as a team of experts in massive processing and software engineering from the various laboratories of the University of Strasbourg.

The objective pursued by the three founding laboratories of the platform (EOST, ICube and LIVE) is to enhance and develop the services of this SDI by integrating it and contributing to national and European initiatives to meet both research and end-user needs. At the national level integration is carried out through the Theia and ForM@Ter data centres, both members of the Earth System Observation RI – Data Terra. At the European level it is carried out through the ESA resource network.



Implementation in practice

Achieving this integration requires coordinating distributed resources in four ways:

- 1) the organization of the production of basic data in continuous flow (shaped satellite images and elementary derived products) and value-added geolocated information such as ARD (Analysis Ready Data),
- 2) the standardisation of these different product levels,
- 3) the organization of the distribution and cataloguing of products according to the FAIR principles (Findable, Accessible, Interoperable and Reusable), and
- 4) the implementation of interoperable dissemination tools.

In practice work has been initiated with various actors in space observation of the Earth on all or part of these different planes: role distribution, data and product formatting, metadata, cataloguing and distribution tools.

In terms of resource sharing and in order to make progress on concrete achievements, the porting of channels from the Soil Humidity at very high spatial SEC and urban resolution to the SDI A2S is in progress. In both cases, the objective is to achieve in short time a fast and recurring production of high level thematic products in several French regions. ■

A2S team
►www.a2s-earthobservation.eu

Mundi Web Services | New Opportunities for Agriculture

Mundi Web Services is a digital platform from Atos which provides better access and use of Earth observation data to create and operate innovative apps whatever the market. Combining simple, free and unlimited access to Copernicus data imagery, thematic and in-situ data, cloud and big data technologies, Mundi accelerates the time to market for innovative digital services based on Earth observation data.

Copernicus as ecosystem

The European Union Copernicus Programme relies on a family of dedicated Earth Observation missions called Sentinels. The data acquired from these missions are systematically downlinked and processed to operational user products. Copernicus data and information includes the user products from the Sentinels missions, but also value-added information generated by the Copernicus Services and data and information provided by the Copernicus in-situ component.

The Copernicus DIAS (Data and Information Access Services) consists mainly of virtual systems hosted on a cloud computing environment and providing IT services. This Cloud infrastructure makes available for processing and operations a data offer, which includes Copernicus data and information but may also include other geospatial data (e.g. EO ESA missions, National missions data, etc.). Services and applications exposure are also available on our Market Place with a global dissemination around the world.

Data Collection Mundi offers Copernicus data and information to be used right on the cloud. Of course, it covers Sentinel data and Copernicus Core Services but also Landsat-7, Landsat-8, as well as private VHR data. Data are made available through the standardized OGC interfaces. In addition, other Earth Observation data sets and more thematic data can be used on Mundi to maximize opportunities to quickly and easily develop a distinctive, reliable, and immediately monetizable service.

Tools collection Mundi provides access to two levels of tools:

- A set of free-of-charge services to reach a first level of Earth Observation Data management,
- Advanced tools provided by different partners for ensuring easier advanced data use.

It is also possible for businesses to use their own tools and software on the platform in their dedicated cloud space so that they may benefit from their industrial processes being associated with the power of the platform and the proximity of Earth observation data.

Cloud services Open Telekom Cloud provided by T-System in

Germany brings a secured, robust and performing Cloud infrastructure for European Mundi users.

- It computes with virtual computing servers.
- It has storage in block level storage capacities or in Object Storage Service that offer a highly simplified access mechanism and a high level of scalability.
- It has load balancing to distribute traffic on multiple Elastic Cloud Server (ECS).
- It provides Big Data functions.

Support Atos and its Mundi consortium can assist users in a very wide range of support activities, complementing their own skills. From technical or functional support to more thematic or business consulting, the Mundi team is designed to help users reach new opportunities.

For Companies as well as Researchers

Mundi supports many markets including agriculture, urban monitoring, the services industry (finance, insurance, retail), tourism and transport, and the environment.

Mundi integrates key elements distributed by its partners, and the creation of value-added services which rely on robust components maintained over time. Mundi supports the results of various research projects carried out by Europe, for example: EUXDAT ►www.euxdat.eu, EO4WildLife ►eo4wildlife.eu ou EO4Agri ►www.eo4agri.eu. ■

Laurent CLERGUE
Atos Integration France
mundiwebservices.com

COSPAR | Promoting Space Research

Established in 1958 by the International Council for Science (ISC), in the wake of the International Geophysical Year and the launch of the Earth's first artificial satellite, the mission of Committee on Space Research (COSPAR) is to promote international cooperation in space research, with emphasis on the exchange of results, information and opinions.

A Forum for Discussion and Cooperation

COSPAR also provides a forum for all scientists to discuss issues that may affect scientific research in space. Two to three thousand researchers from around the world attend the biennial Scientific Assembly of COSPAR. The 2018 Assembly was held in Pasadena, California (photos below). In 2020, the Assembly will be held in Sydney, Australia (►www.cospar2020.org), then in 2022 in Athens.

In off-Assembly years, COSPAR organizes a Symposium of approximatively 300 participants in countries deploying a mid-size space activity, such as Thailand (2013), Brazil (2015), South Korea (2017) or Israel (►www.cospar2019.org). The capabilities offered by small satellites are of great interest in this context. In November 2019, the Symposium will discuss the results of the Venμs microsatellite, and a training workshop titled "Principles and Practice of Nano-Satellite Engineering" will be held from November 4 to 8, 2019.



COSPAR Scientific Assembly, Pasadena, United States, 15-22 July 2018.

Training and dedicated publications

COSPAR devotes a major effort to training and capacity building (►cosparhq.cnes.fr/events/cb-workshops). On average three workshops per year are organized in developing countries, amounting to more than one thousand participants since 2001, mainly in astronomy and Earth observation. For example, a workshop entitled *"Interdisciplinary Remote Sensing, Modeling and Validation of Environmental Processes"* was held from 12 to 23 June 2017 in Kumasi, Ghana (►feer.gsfc.nasa.gov/meetings/COSPAR2017/).

COSPAR's scientific publications, including Advances in Space Research, host special articles and issues, many of which have been devoted to Earth observation. A newsletter, Space Research Today, is distributed free of charge every four months to the approximately 10,000 Associates participating in COSPAR activities (including 1,800 in Commission A, which covers Earth sciences).

At a strategic seminar held in Carnon, France, in December 2018, COSPAR adopted guidelines in favor of greater involvement of early and mid-career scientists, with a strong emphasis on parity and diversity. An improved website (►www.cosparhq.cnes.fr) will soon come on-line, and a new electronic newsletter will be distributed to Associates and all those who request it. ■

Jean-Louis FELLOUS,
COSPAR Executive Director
www.cosparhq.cnes.fr

46 national academic institutions and 13 international scientific organizations

46 national academic institutions and 13 international scientific organizations are members of COSPAR. The Council, composed of Member representatives, meets every two years, at General Assemblies, and elects a Bureau, currently chaired by Professor Lennard Fisk (University of Michigan, USA).

Based in France, the COSPAR Secretariat employs three people. Since 2017, the Secretariat has been based in Montpellier on the premises of the Maison de la Télédétection. The Secretariat coordinates the activities of COSPAR's eight Scientific Commissions and eleven Technical Panels, oversees relations between COSPAR and the national organizers of its Assemblies and Symposia, and supports the capacity building activities, publications and prospective scientific studies commissioned by COSPAR, such as the report "*Observation and Integrated Earth-system Science: a Roadmap for 2016-2025*".

French National Parks Track Snow Cover with Theia

The formulation of the 2018 Satellite Application Plan (SAP) by the French Ministry of Ecological Transition and Solidarity (MTES) and the Ministry of Territorial Cohesion and Relations with Territorial Communities (MCTRCT) has enabled many service needs to be expressed (► Read Bulletin n°10).

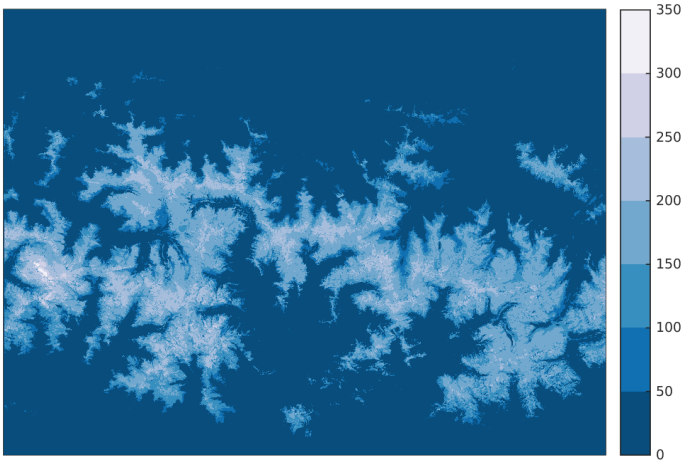
The measurement of snow cover is one of the 20 needs identified (► www.geoinformations.developpement-durable.gouv.fr/plan-d-applications-satellitaires-2018-r1016.html) – a demand steered by the Vanoise National Park. In addition to monitoring glacier retreat, the Vanoise National Park as well as the Ecrins National Park use satellite imagery as part of the Sentinel Alpine Pasture programme which aims to determine the evolution of mountain pastures in relation to climate change (date of snowmelt and availability of grass).

Other national parks, in particular Mercantour Park, are also interested in this issue, particularly for the monitoring of certain animals, like the mountain hare and the ptarmigan. Measuring the extent of snow cover and its retreat makes it possible to monitor these species and anticipate their movements.

The advantage of the Theia snow product

In the overall perspective of implementing 2018 SAP, the MTES Geographic Information Mission (MIG) has established relationships with Theia and identified an existing product that addresses this snow cover issue. Maps are produced from Sentinel-2 images with a 5-days frequency and a 20 m resolution. The legend is: snow, no snow, clouds. Maps are available four days after the capture. They are free and accessible on Theia's website (► www.theia-land.fr/en/product/snow/). The results obtained are very good even if there are still two difficulties, namely distinguishing snow from clouds and detecting snow in dense forests.

In order to promote the reuse of this application, which is already operational, the Vanoise National Park, with the support of the MIG, organised a meeting with interested users, the CNES and the Theia consortium. This exchange session was held on 23 March in Chambéry at the Vanoise National Park. In addition to the Vanoise Park, the Mercantour National Park, the Pyrenees National Park, several DDTs (15, 62, 74) and the Syndicat mixte d'aménagement de la vallée de la Durance (SMAVD) have also expressed their needs.



Map of the snow coverage in the Pyrenees during a hydrological year (1 September 2016 to 31 August 2017) produced by synthesis of Theia snow-covered surface products.

Theia Snow Product can be used to create synthetic snow duration maps and to simplify the use of Theia data for actors in the field..
► osr-cesbio.ups-tlse.fr/echangeswww/majadata/simon/snowMaps.html

Identifying uses and needs

The participants discovered the pooled opportunities of the tool developed by Theia and shared their own practices and expectations. Several uses were presented: better knowledge of water resources in a massif, snow-covered trails at a given date, regular monitoring of snow cover in ski resorts, flood risks.

Participants listed expectations: snow duration maps, measurement of snow-covered areas, estimation of water stocks (planned), high frequency snow removal dates, snow-cultivation dynamics, climate change indicators, supply only of the snow mask, delivery format (raster or vector?), tile assembly (WMS flow), several download options, user training.

The participants also agreed to complete an inventory of uses and needs, and to open it up to other potentially interested actors: basin agencies, other national parks, DDT in mountain ranges, SHAPI, etc.

MIG will also provide stakeholders with a shared space to gather user needs (document prepared by the Vanoise National Park available at: ► lite.framacalc.org/iu7tFICwqr), documents (presentations, guides) and a discussion tool (forum). ■

Claire LAGAYE
Parc national de la Vanoise
claire.lagaye@vanoise-parcnational.fr

José DEVERS
MTES – MIG
applications-satellitaires@developpement-durable.gouv.fr

Simon GASCOIN
Cesbio, Snow-covered Surface SEC
simon.gascoin@cesbio.cnes.fr

Snow in the Wicklow Mountains of Ireland near Dublin on February 02, 2019 by Sentinel-2.

Measuring Snow Cover: a Challenge Met and Recognized

What is the history and specificity of the Snow Product available on Theia?

Simon GASCOIN: The operational production of the Theia Snow Product started at the end of 2017. Before that, we generated many products on Cesbio's calculation servers, and then there was a first production phase on a batch of Sentinel-2 images by MUSCATE at CNES to test the processing line under operational production conditions.

For the most part, the algorithm and product were defined in 2015 from SPOT-4 Take 5 series on the Pyrenees and Atlas. Little has changed since then, but the parameters have been adjusted. Theia Snow Product mainly benefits from improvements in the level 2A treatment chain upstream.

There is no equivalent product to date. The USGS distributes maps of snow-covered areas from Landsat data, but this is not a continuous production and, most importantly, these maps do not offer the repetitiveness of Sentinel-2. Our map reports the presence or absence of snow and not the snow fraction per pixel. In my opinion this product is easier for users to adopt, even if the snow fraction is more informative theoriticaly.

This product is the result of teamwork: at CNES, Manuel Grizonnet, Cesbio, Olivier Hagolle and Simon Gascoin, Magellium, Germain Salgues. Manuel has changed departments and will be replaced by Aurore Dupuis at CNES. But we must also mention the whole MUSCATE team, without forgetting Arnaud Sellé and Nicolas Bagdhadi for the coordination of Theia, as well as Sophie Ayoubi and Isabelle Biagiotti for communication!

You have just participated in a European call for tenders that includes a "Snow" dimension. How did the existing Theia Snow Product contribute to the success of the proposal?

Simon GASCOIN : We had worked with the company Magellium in the development of the treatment chain. It was natural to continue to work with them to respond to a European call for tenders to map in real time the snow- and ice- covered areas with Sentinel-2 on a European scale on behalf of the European Environment Agency under the Copernicus programme.

Thanks to Theia we had a clear demonstration that our system was operational on a large scale. The development of the Theia product has also pushed us to maintain the code and its documentation as the level 2A data evolves. At a Theia meeting someone asked me if I had done an evaluation of the Theia snow product with in situ measurements. At first I was not convinced of the interest of this comparison because I preferred to validate visually or with other higher resolution remote sensing images. But this question prompted me to make a comparison with data from Météo-France stations. In addition to its scientific interest, I think that this work has paid off because it was an explicit request from the call for tenders, and we have therefore been able to show very encouraging results in this respect.

What is the future of the Snow Product?

Simon GASCOIN: Many users need to condense the information provided by snow maps and are bothered by clouds in their analyses. In addition, Theia Snow Product is only available on the date of the satellite's passage. We would therefore like to offer an on-demand service that allows us to obtain a map of the snow cover duration per pixel of 20 m for a user-defined period regardless of the satellite's passage date.

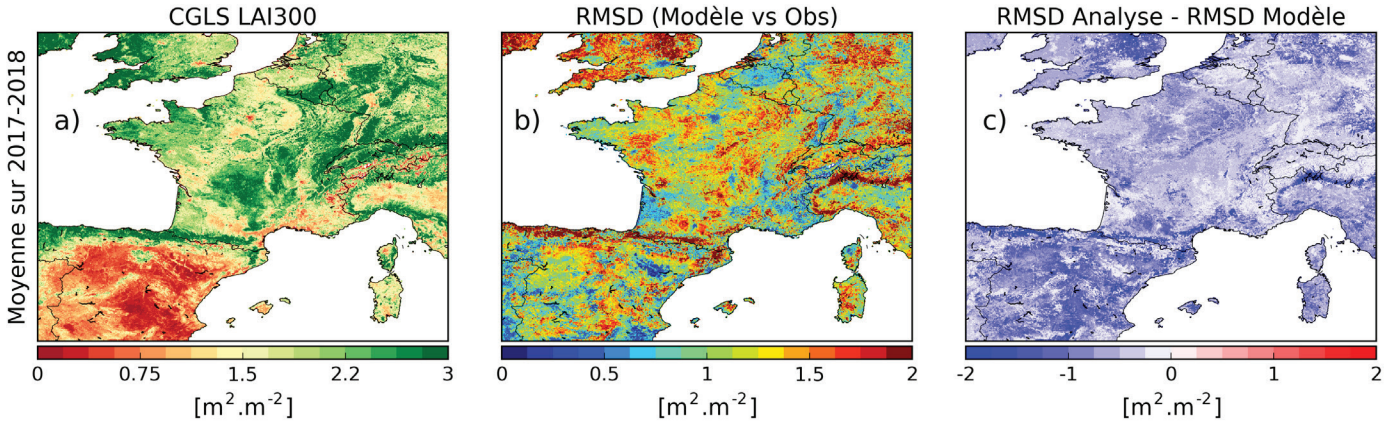
This service would solve these two obstacles and thus broaden the user community. A demonstrator is available here:
►labo.obs-mip.fr/multitemp/?p=14620. ■

Interview with Simon GASCOIN
Snow-covered surface SEC
www.theia-land.fr/en/ceslist/snow-covered-surface-sec

Towards the Assimilation of High Spatial Resolution Satellite Data on Land Surfaces

In the context of climate change, extreme phenomena and particularly drought are becoming more and more frequent in France. Drought detection and monitoring involves many soil-plant system variables, such as soil water content and vegetation Leaf Area Index (LAI).

The Soil-Biosphere-Atmosphere Interaction Model (SBAI) dedicated to continental surfaces, developed by the Centre National de Recherches Météorologiques (CNRM), is capable of reconstructing these variables at various spatial scales, from the local to the global scale. Integrated into Météo-France's SURFEX modelling platform, this model simulates the main processes related to water balance. A land data assimilation system (LDAS-Monde) allows the integration of different satellite products in order to constrain the ISBA model. For example, LDAS-World allows the dynamic assimilation of IPM satellite observations in ISBA and, thus, a reduction in uncertainties on simulated variables. These LAI observations are now available worldwide in near-real time, repeatedly over time, at 1 km or 300 m resolution («global land» service from Copernicus).



The importance of assimilation

LDAS-World has been implemented for different spatial scales, from global scale at 0.25° resolution to regional scale at 1 km resolution. The figure below describes the impact of the assimilation of LAI at 300 m resolution on the LAI simulated by ISBA on the domain covered by AROME-France, the fine-mesh numerical weather forecast model operated in operation by Météo France. This atmospheric model has a spatial resolution of 1.3 km. In the figures below, the data are aggregated at 2.5 km. On the left are the LAI observations averaged over two years, 2017 and 2018. In the centre, the mean square error (RMSD) between the ISBA model (without assimilation) and the observations is presented. Finally, on the right we show the difference between the RMSD for the analysis with assimilation and the RMSD for the ISBA model alone. The latter is entirely dominated by negative values (in blue) showing that data assimilation produces a LAI closer to observations than the ISBA model alone.

Assimilation makes it possible to include missing geographic information in the model, to reduce the cascade of uncertainties affecting simulations and to compensate for the absence of certain processes in the model. ■

Clément ALBERGEL, Bertrand BONAN & Jean-Christophe CALVET
(Centre National de Recherches Météorologiques, Meteo France, CNRS)
Contact: clement.albergel@meteo.fr

Above-Ground Forest Biomass: the Challenge of Multi-Sensor Data Fusion

LiDAR data from the GLAS/ICESAT mission have been used at many sites in recent years by Tetis to develop forest Above-Ground Biomass (AGB) maps. As these data are not very dense, it was necessary to use them in addition to other data sources: radar and optical remote sensing data (L-band satellite radar of the ALOS/PALSAR sensor and MODIS sensor), environmental data sets (rainfall, temperature, slope, etc.).

The approach used is based on the regression-kriging technique of remote sensing data and environmental variables (rainfall, temperature, slope, etc.).

The methodology follows four main steps:

- (1) Establishing a Random Forest model linking in situ biomass estimates with parameters derived from spatial and climate data;
- (2) Applying the model established (step 1) to derive a preliminary biomass map;
- (3) Estimating the best linear regression between metrics (variables) derived from GLAS/ICESat lidar waveforms (footprint of about 60 m in diameter) and in-situ biomass data (Forest Above Ground Biomass – AGB),

- (4) Improving the accuracy of the biomass map obtained previously (step 2) by adding the kriged residue (AGB GLAS – step 2 map) to it.

Biomass maps on Guyana (1 km x 1 km), Madagascar (250 m x 250 m) and Gabon (50 m x 50 m) were produced with a root-mean-square error (RMSE) between 50 and 70 Mg/ha.

These maps have great potential given their accuracy compared to the two global AGB maps established by Avitabile and Baccini. Indeed, the comparison between these two global maps and the AGB in situ data on our sites shows that the two former global maps included significant errors (RMSE between 135 and 168 Mg/ha).

Towards even greater accuracy

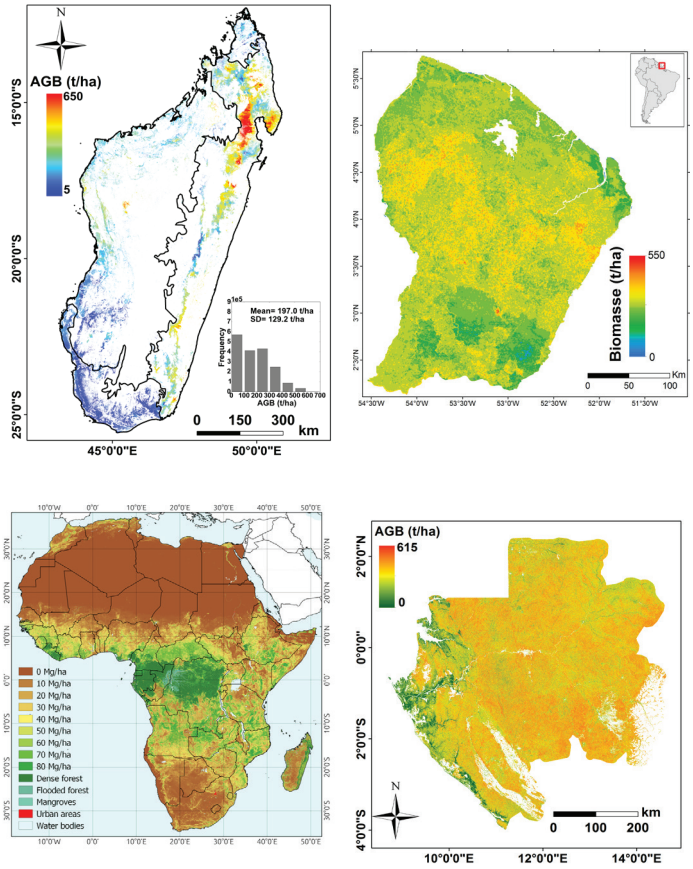
The arrival of new lidar data (mainly GEDI) with a higher point density will allow us to offer biomass products with better accuracy and finer spatial resolutions (a few hundred meters). These new data may be used in addition to L-band radar data (ALOS/PALSAR) or P-band radar data (Biomass mission).

Research was also carried out at CESBIO to develop a biomass map of Africa (50 m x 50 m resolution). The approach is based on the Bayesian inversion of a continental mosaic of L-band SAR data from the ALOS PALSAR instrument (HH and HV polarizations).

Above-ground biomass is estimated at up to 85 tons/ha in savannah and open forest environments. Dense forests, flooded forests, mangroves, urbanized areas and water surfaces are masked by the ESA CCI Land Cover product. ■

Nicolas BAGHDADI
(Irstea, Tetis)

Biomass Products
► www.theia-land.fr/en/products/



Madagascar, Gabon, Guyana, Africa - concrete results of above-ground forest biomass assessment based on LiDAR data.

L-VOD Index
Monitoring the Functioning and Biomass of Vegetation

Passive or active microwave (radar) measurements are highly sensitive to the effects of soil moisture, vegetation water content and also surface roughness, vegetation structure and other more secondary parameters (soil texture, temperature, etc.).

The radiation emitted (passive) or reflected (active) by the ground, more or less intensely depending on its humidity (SM), is attenuated by the vegetation cover before being measured by satellite sensors. The Vegetal Optical Depth (VOD) index is used to characterize this effect of microwave radiation attenuation by vegetation. In the passive domain, VOD is linearly related to the vegetation water content (Vegetation Water Content – VWC).

Many recent studies have used the VOD index to monitor vegetation functioning. VOD is thus gradually taking a growing place in the literature alongside vegetation indices derived from optical measurements (NDVI, EVI, etc.). The longer the wavelength and the lower the frequency (~20 cm at 1.4 GHz; ~5 cm at 6 GHz; ~3 cm at 10 GHz, corresponding to the L-, C- and -X bands), the better the radiation passes through the vegetation and the more attenuation effect (and therefore the VOD) decreases. L-band measurements (SMOS, SMAP for passive, PALSAR for active) are therefore better suited to soil moisture monitoring. They also saturate less quickly in vegetation monitoring over dense canopies.

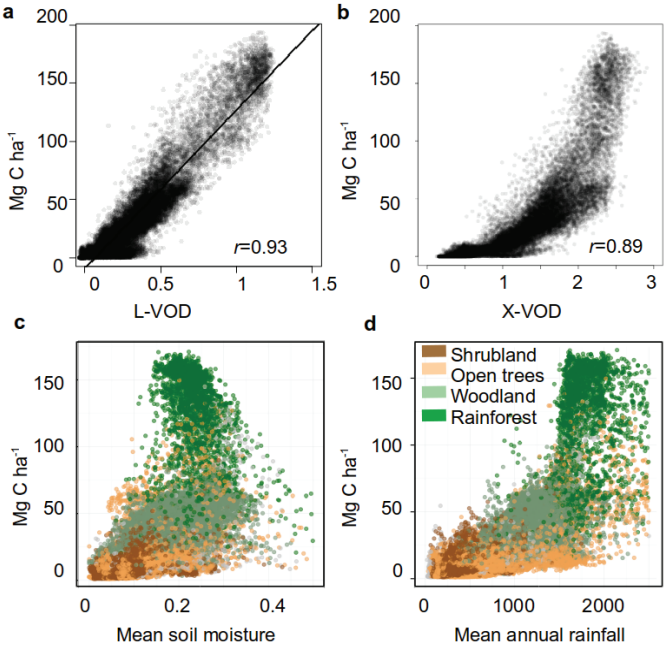


Figure 1. Relation between AGC (Above-Ground Carbon) et (a) L-VOD et (b) X-VOD on the African continent.

AGC is derived from the biomass map of Saatchi et al., *PNAS*, 2011
Brandt and al., *Nature Ecology and Evolution*, 2018
© M. Brandt – Copenhaguen University

A variety of applications

Vegetation Water Content varies on a diurnal scale, and this variation is a function of the hydrological functioning of the vegetation and the conditions of plant water stress. This property has recently been used for global mapping of ecosystem isohydricity properties (Konings and Gentine, 2016). VOD also makes it possible to monitor seasonal variations in the water content of vegetation. Thus the L-VOD (i.e. VOD in L-band; SMOS-IC version) resulting from SMOS measurements has made it possible to reveal a specific and unknown behaviour of the functioning of dry tropical forests (Tian et al., *Nature EE*, 2018). These forests accumulate water at the end of the wet period and are "inflated" with a water reserve during the dry season which supports foliar development a few weeks before the rainy season (phenomenon of "pre-rain green-up"). The study thus revealed a temporal decoupling of about 6 months between foliar phenology and water content in the immense Miombo tropical forest (Figure 1).

The VWC depends on the dry biomass (Bs, kg/m^2) and the moisture content (Mg, %) of the canopy. Over long periods of time, the moisture content of vegetation varies little on a large scale. The annual average VOD is thus well related to the dry biomass of vegetation. This property has been used in several recent studies using X-VOD (i.e. high-frequency VOD in X-band) to characterize and decouple climate/anthropic impacts on positive (greening) or negative (browning and deforestation) trends in vegetation at continental scales (Liu et al., *NEE*, 2015; Brandt et al., *NEE*, 2017).

Monitoring above-ground biomass

Very recent studies have used the new SMOS-IC L-VOD product in the monitoring of above-ground biomass (AGC) at continental scale. L-VOD is approximately linearly linked to biomass from global reference maps (Baccini, Saatchi). Unlike X-VOD, no saturation is discerned with L-VOD up to biomass levels of about 400 t/ha (~200t/ha in terms of carbon stocks; Figure 2).

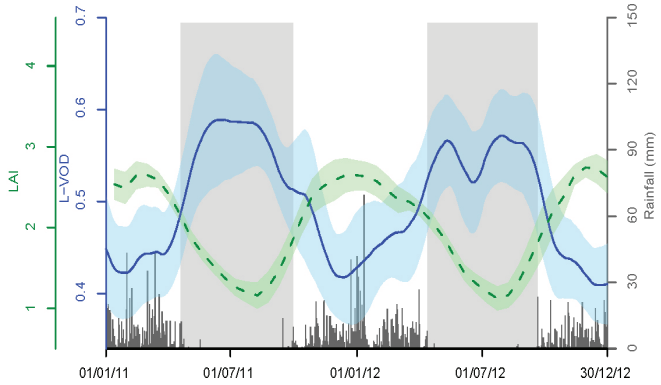


Figure 2. Seasonal variations in plant water content, foliar phenology and rainfall in the Miombo dry tropical forest in Africa.

The dry period is greyed out.
Tian et al, *Nature Ecology and Evolution*, 2017
© F. Tian - University of Copenhagen

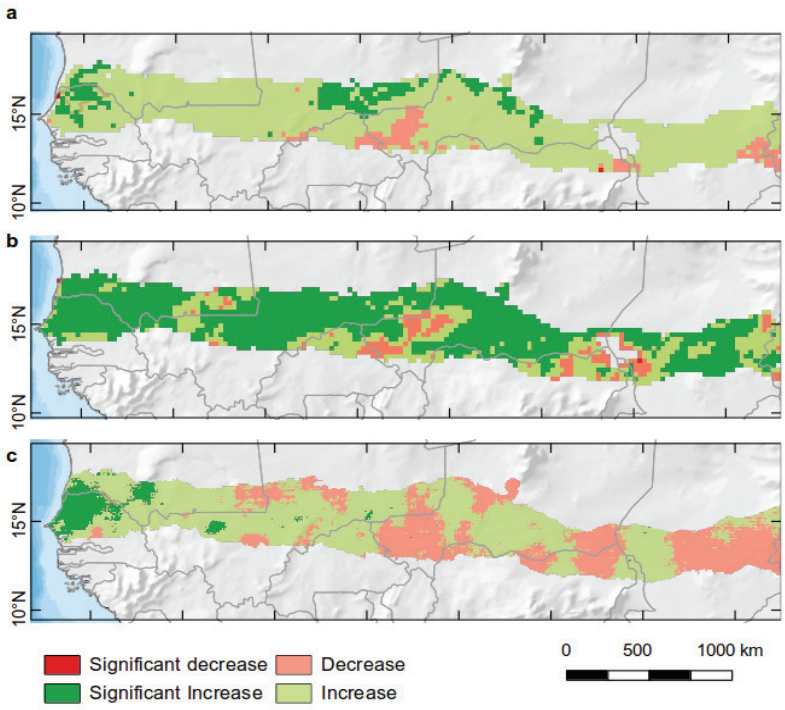


Figure 3: Trends in the X-VOD index and precipitation (1992-2012) over the western Sahel.

(a) X-VOD P90-P30, (= 90 percentile deviation minus 30 percentile), related to herbaceous biomass.
(b) X-VOD P30, connected to woody biomass.
(c) precipitation trend.
Significant trends (P < 0.05) are shown in dark.
Brandt et al, *Communications Biology* (2019)
© M. Brandt - University of Copenhagen

By applying L-VOD / AGC spatial calibration and space-time substitution, Brandt et al (2018) highlighted the impact of droughts on negative carbon stock trends in arid regions of Africa. This study is being extended to all tropics (Fan et al., *Nature Plants*, 2019), boreal forests and globally.

These studies are part of INRA's collaborations with national laboratories, the University of Copenhagen, NASA and many other international partners (Universities of Oklahoma, Boston, Munich, etc.). Thus, many other studies based on the SMOS-IC L-VOD have been published or are underway in the monitoring of deforestation in the Amazon, the greening effect in the Sahel (Figure 3), the asymmetric response of the NPP to positive/negative climate change, major afforestation programmes in China, etc. ■

Jean-Pierre WIGNERON (Inra ISPA Bordeaux)
M. BRANDT (Prof., University of Copenhagen),
R. FENSHOLT (University of Copenhagen)
& Philippe CIAIS (LSCE, Paris)

>> All references are available from the author or on ResearchGate
www.researchgate.net/project/SMOS-IC-2

« Organizing the scientific community to face the technical challenge of exploiting data and disseminating its own research results.

Interview with Rémi CRESSON

Research engineer
UMR Tetis
www.umr-tetis.fr

Contributing to
VHSR Soil Moisture SEC
► www.theia-land.fr/en/ceslist/soil-moisture-with-very-high-spatial-resolution-sec/

Urban SEC
► www.theia-land.fr/en/ceslist/urban-sec

You are a specialist in geospatial image processing. How are you involved in Theia?

Rémi CRESSON: I am a research engineer at UMR Tetis (Irstea, soon to be Inrae) and a specialist in image processing. I am interested in approaches that extract information from geospatial images (particularly optical and radar imagery). I also monitor scientific and technological developments and provide technical support to the researchers in my laboratory.

I am also involved in open-source projects (such as the Orfeo ToolBox and Zoo-Project projects), an orientation that seems to me to be essential as an engineer in a public research organization. These projects constitute a valuable and indispensable technological platform for scientists and academics.

I typically work on high performance computing, large scale geospatial data analysis and machine learning. The data I use most of the time come from Spot 6/7, Sentinel-1 and Sentinel-2, but I have to use also all kinds of public auxiliary data.

I already contribute to various Theia Scientific Expertise Centres (SECs) – Soil Moisture with Very High Spatial Resolution SEC as well as Urban SEC, in particular. I hope to contribute to other SECs in the near future.

What motivates you to get involved in a network like Theia?

Rémi CRESSON : My raw material is essentially made up of satellite images! Today, all the images I am working on are provided by the Theia consortium: Spot 6/7 data are available free of charge for public actors *via* Geosud; Sentinel-2 reflectance data provided by the Cesbio and CNES teams have become a reliable reference data that can be mobilized by people who in the past would never have done so for lack of expertise or resources.

In addition, Theia SECs offer a tremendous opportunity for scientists. They bring together experts according to thematic research, encourage them to work together, but also increase the visibility of their work. Theia attaches great importance to the valorization of research work, and we see solid products emanating from SECs. In the field of remote-sensing. I think that this is the first time an organization succeeds at such valorization on a national scale in France.

What are the future challenges for research and for Theia today?

Rémi CRESSON: Today, we are facing a technological revolution. On one hand, there is an increasing amount of geospatial data: continuous flow and publicly available satellite images (e.g. Sentinel-1 and Sentinel-2); open in situ data; crowdsourcing data, etc. At the same time, we are seeing the emergence of new techniques and architectures (for computing, storage, etc.) to exploit all this mass of information.

The challenge for research is to adapt to this paradigm shift. The organization of resources seems to me to be a central point that only an entity like Theia, with its national scale, can make effective. If the scientific community advances in a dispersed order, I think it will sooner or later have difficulties facing the technical challenge of exploiting data and disseminating its own research results. »

« Processing massive data stream of satellite imagery for end-users and transfering the results of research laboratory in a relevant and useable form

Interview with Anne Puissant

Professor in Geography and Geomatics at the University of Strasbourg and affiliated with the «Image, Ville, Environnement» research team.

Facilitator of Urban SEC
► www.theia-land.fr/ceslist/ces-urbain

Co-facilitator of Grand-Est RAN
► www.theia-land.fr/artlist/art-kalideos-grand-est/

Co-director of the A2S plateform - Application for Satellite Survey
► www.a2s-earthobservation.eu

You are the facilitator of Theia Urban Scientific Expertise Center as well as a central stakeholder in Theia Grand-Est regional animation network (Kalideos-Alsace). What motivates your strong involvement in Theia?

Anne PUISSANT: Through my research activities and my involvement in training as head of a Master's degree dedicated to the exploitation of digital geographical data (Master's degree in "Observation de la Terre et Géomatique" from the University of Strasbourg), I have always tried to develop research with an operational vocation, i.e. which meets end-users' needs.

Strong links to training facilitate interactions with entities which may not have thought to exploit multisource data – of which satellite imagery is only a part – with their applications. These training and research exchanges also enable the developement of links with local stakeholders, particularly through former students once they become professionals, and ensure scientific monitoring in the field.

Thus, as part of my applied research activities in the fields of land use and urban planning, I was already participating in the regional information network CIGAL (Coopération pour l'Information Géographique en Alsace – now the GeoGrandEst network). Through this very active network research activities were thus presented to local stakeholders. So it was only natural that when Theia regional animation network (RAN) was created I joined the Geo Grand-Est RAN. This structure offers the possibility to formalize this local animation, which was previously carried out without any framework, in close collaboration with all the partners of the GeoGrandEst network.

How does this involvement relate to your research work?

Anne PUISSANT: In addition to my training activities, I have been working for many years with laboratories that focus on urban issues (social sciences) and/or research laboratories specializing in new technologies (engineering and computer sciences).

The creation of Theia was an opportunity to bring together all the laboratories interested in these two fields. The Urban Scientific Expertise Center (SEC) provides an opportunity to discuss research developments related to land cover/use changes and issues in a context of climate changes: urban sprawl, loss of agricultural land, loss of biodiversity, urban heat island, etc. The SEC facilitation allows us to develop research which answer end-users needs, including design of value-added products derived from satellite imagery.

What is the main challenge you see for the future?

Anne PUISSANT: With the easier availability of Sentinel constellation images and image archives (Landsat, SPOT, etc.) and the Open Data movement, tomorrow's challenge is twofold: process for end-users massive streams of satellite imagery and transfer results of research laboratories in a relevant and useable form to various services (urban management and planning, decision-making, etc.). It is in this context that the research laboratories of the University of Strasbourg propose a new platform dedicated to the massive processing of satellite imagery (A2S Platform) (►Read p. 6).

»

Theia Bulletin

Publication directors: N. Baghdadi (Irstea) - A. Sellé (Cnes)

Conception - realisation: I. Biagiotti (Theia)

Contributors to the issue: C. Albergel, N. Baghdadi ,B. Bonan, M. Brandt, J.-C. Calvet, S. Cherchali, P. Ciais, L. Clergue, R. Cresson, J. Devers, S. Dupuy, J.-L. Fellous, R. Fensholt, S. Gasoin, M. Despinoy, O. Hagolle, C. Lagaye J. Massenet, A. Puissant, A. Tran, C. Weill, J.-P. Wigneron

Follow us
► www.theia-land.fr | ► @PoleTheia | ► linkedin.com/company/pole-theia