BULLETIN
Theia Land Data Service Centre

Theia

CONTENT

A word
from the Scientific & Technical directors

The Covid pandemic and its restrictions on events have once again marked the first half of 2021. Theia thematic workshops planned for October 2021, with attractive programmes, are intended to open a new networking season. Theia also attended to GeoData-days, organised by Afi-geo on 15 and 16 September in Grenoble, France, to meet users.

In this difficult context, we must commend the territorial dynamics of our regional network, who keeps innovating, mobilising and offering services, training and events for the general public and extending their network. They now provide a privileged link with users –a link that is now of interest to Data Terra and its components (consortia and Dinamis) as demonstrated by the first meeting in May 2021.

The production of Theia SECs does not suffer from confinements and restrictions: surface reflectance, soil moisture, monitoring of soil artificialisation, characterisation of urban areas, health, land use mapping, monitoring of the world's glaciers, the portfolio of products and methods is constantly expanding.

Theia's news also includes the CNES's increased investment in the cluster's operations with the arrival of Thérèse Barroso, who is taking over from Arnaud Sellé as the cluster's CNES project manager and who is therefore signing this editorial. ■

NEWS

Theia thematic workshops
Two events not to be missed in the autumn

In mid-October 2021, Theia –the French consortium dedicated to Satellite Land Surface Observation– is holding two thematic workshops dedicated to highlighting a selection of operational tools developed by associated research teams for monitoring two major current environmental issues: forests and water quality. Numerous space missions are currently acquiring observations using various sensors (optical, radar, lidar), at several dates (multi-temporal data) and with multiple spatial accuracies on both issues. The two workshops are to take place in Montpellier (France) and to convene the largest audience from professionals, both private and public, and academics. Their organisation is possible thanks to the financial support of financial support of the Caroline Herschkel Framework Programme Agreement on Copernicus User Uptake– dedicated to promoting the use of Sentinel data.

The first workshop, on 11 October 2021, will be dedicated to the uses of remote-sensing for forestry: from climate change mitigation to the provision of timber resources, from recreational uses to the protection of flora and fauna. This workshop aims to present innovative and established tools and discuss their results with the community of researchers and users. The various presentations scheduled for this workshop cover a wide range of areas and fields of application. Each presentation will deliberately focus on the most successful products operational in its field.

The second, on 12 October 2021, will explore the uses of remote-sensing for monitoring water quality. The management of continental waters up to the interfaces often suffers from a lack of data on quality at global, regional, national and local levels. The workshop on 12 October will highlight the responses of remote sensing to overcome this lack of operational data. The programme will focus on the needs of users (European directive, regular operations, ecological disasters, etc.) for the various methods for measuring water quality (pollution, flows, etc.), as well as the contributions of the various different sensors available.

All presentations will be recorded and broadcasted on Theia website before the end of the year. More on Theia website: www.theia-land.fr ■

Do you know the SCO ?

Several projects carried out by Theia Scientific Expertise Cenres (SECs) and Regional Animation Network (RANs) have received the SCO label, three small letters that stand for the fight against the impacts of climate change. Founded on 17 June 2019 at the initiative of France, the Space Climate Observatory already brings together 31 space agencies and international organisations. Their objective: to use space data to produce operational tools as soon as possible.

Coastal erosion, marine submersion, collapse of biodiversity, floods, droughts... The birth of the SCO is based on the urgent need to provide decision support tools to territorial managers who must define policies to adapt to the impacts of climate change. What better input data than spatial information? In this respect, each SCO project combines satellite data with other data sets to operationalise scientific models capable of delivering relevant indicators, early warning systems or short, medium and long-term modelling.

Accelerating the development of operational and replicable tools

The SCO philosophy is based first and foremost on certified projects. They must systematically use spatial data, involve end users, become operational in a maximum of 24 months and be replicable in other places. In order to support the projects and their actors as closely as possible to the field, each SCO signatory country undertakes to set up a local branch.
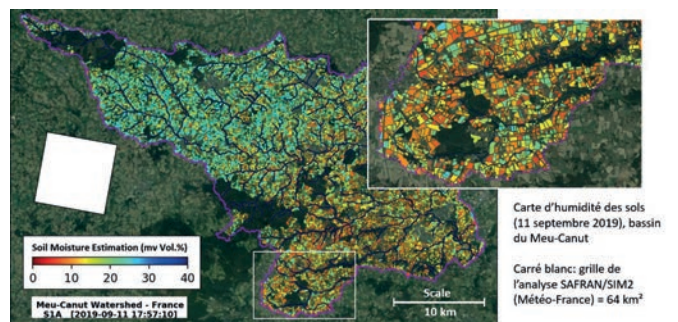
Attend SCO France quarterly meetings

Thanks to the 22 members of its Inter-Organisational Committee, SCO France is very dynamic. Its Quarterly Meetings are exchange sessions to promote synergy between partners and projects.

Each session illustrates a theme through 2 to 4 SCO projects which are as many discussion booths. Free registration on the website!

► **www.spaceclimateobservatory.org**

Carte d'humidité des sols (11 septembre 2019), bassin du Meu-Canut

Carré blanc: grille de l'analyse SAFRAN/SIM2 (Météo-France) = 64 km²

Soil Moisture Estimation (mv Vol.%)
0   10   20   30   40

Meu-Canut Watershed - France
S1A (2019-09-11 17:57:10)

Scale 10 km

Certified by SCO in 2021, the BOSCO project will deploy the approved Theia Soil Moisture satellite product at very high spatial resolution for monitoring soil water content in the Brittany region. Geosciences Rennes/THEIA Soil moisture at very high spatial resolution SEC.

Cascading certification

As the instigator of the initiative, CNES must be a driving force and an example both in the organisation of the national SCO and in the certification process. Following the calls for projects launched in 2019 and 2020, the SCO France is already supporting 37 of the 40 labelled projects. The most represented themes concern agriculture, water management, biodiversity and land use planning.

A strong rise in power

The SCO is expanding more and more each day on all continents. France, China and Mexico have already created their national SCOs, and others are in preparation. Under the status of SCO Acceleration Committees, 4 nations (Gabon, India, Morocco, Thailand) are relying on the need to develop projects presented on their territories to structure their own SCO. All or part of these "balloted" projects will be certified at the 6th International Steering Committee in July 2021. New calls for projects will be launched each year in October. ■

Karol BARTHELEMY,
► **www.spaceclimateobservatory.org**

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All SCO projects related to Theia SECs and RANs
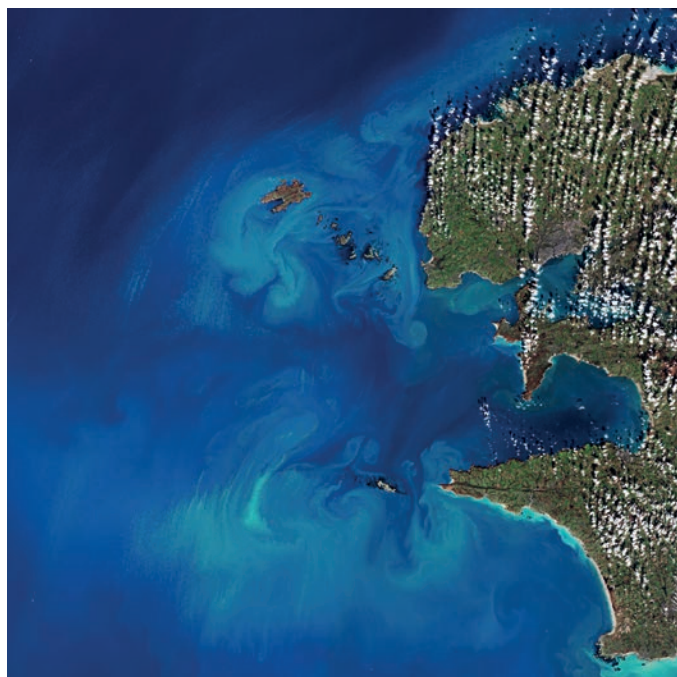► **www.theia-land.fr/en/ theia-projects-with-the-sco-label- an-ever-growing-list/**

ClimHealth project certified SCO in 2020. This Sentinel-2 image of the city of Yangon (Myanmar), processed with an NDVI vegetation index, is taken from the operational demonstrator designed to predict environments favourable to leptospirosis in Yangon. This project is based on the work of Theia Infectious Disease Risk SEC. IRD/ Contains modified Copernicus Data

«Vu de l'espace», an exhibition to discover Brittany through space imagery

This summer, the exhibition "Vu de l'Espace" (Seen from Space), displayed in the park of the Océanopolis aquarium (National Centre for Scientific Culture dedicated to the Ocean and one of the largest aquariums in France, in Brest), has invited visitors on a unique journey to Brittany through exceptional images obtained by Earth observation satellites. These magnificent snapshots, with their powerful visual impact, highlight environmental and climatic phenomena that are often invisible from Earth.

The exhibition has also featured the Breton territory, while concentrating a large amount of scientific expertise in Earth observation from space (universities, engineering schools, research institutes, industrialists, start-ups) regretfully still largely unknown to the general public.

This exhibition, designed by the GIS BreTel (Bretagne Télédétection), with the help of its partners (IMT Atlantique, University of Rennes 2, Ifremer, Ocean Data Lab, CLS), and the support of the European Space Agency (ESA), the European Network of Regions Using Space Technology (NEREUS) and Océanopolis, has been displayed through the summer and is still available on internet www.vudelespace.bzh ∎

Marie JAGAILLE
GIS BreTel, co-facilitator for Theia Bretagne RAN
► www.theia-land.fr/artlist/art-bretagne/

If you haven't had the chance to go to Brittany this summer, you can find pictures of the exhibition and more on www.vudelespace.bzh

The University of New Caledonia joins Theia local activity task-force!

The University of New Caledonia (UNC) is a multidisciplinary university present in New Caledonia since its creation in 1987 under the name of French University of the Pacific, in reference to the single entity constituted then with French Polynesia. In 1999, becoming independent from French Polynesia, it was renamed the University of New Caledonia. Today, the UNC offers New Caledonian students a range of higher education courses, up to doctorate level, from sciences to humanities and social sciences. It holds skills in geography and geomatics and also possesses unique competences in the territory in data sciences. The University is a key player in New Caledonia's research ecosystem and chairs the Consortium for Research, Higher Education and Innovation in New Caledonia (CRESICA).

Regional ambition

Regional integration is central to the UNC institutional strategy. Therefore, the UNC is actively engaged in the development of practical but strategic research and training initiatives together with partner universities in the region. UNC is already playing an important role in the designing various curricula of regional scope. First example is a series of bachelor curricula jointly developed with the University of Vanuatu to meet Vanuatu higher education priorities. Second illustration is the forthcoming opening of a joint Master's degree in sustainability science together with the University of South Pacific (USP) in Fiji. UNC also coordinates, together with USP, the Pacific Islands Universities Research Network (PIURN), which gathers 14 Universities from Pacific Island states and territories.

The University of New Caledonia joining the Theia local Regional Animation Network (RAN) thus brings additional opportunities to the RAN's initiatives. This includes additional resources and capacities to help running activities for the local community, for instance the organizing of the Annual OSS-NC seminar dedicated to Earth Observation (► Read Bulletin 14) But it also encompasses state-of-the-art scientific and technical expertise

The OSS NC 2020 seminar was held at the UNC Campus in Nouville.

supporting the work of the New Caledonian community, as well as a access to a structured regional network that contributes to serving Theia RAN's outreach to the South Pacific geomatics community. It is thus not just another co-leader who joins the RAN, but a partner that can undoubtedly enhance the capacities of the Caledonian leadership and its regional impact, and brings a complementary vision to the one originally initiated by IRD NC\ UMR EspaceDEV and INSIGHT SAS. ∎

Anne ROUAULT
Directrice de l'appui à la recherche, au rayonnement, et à l'Ecole Doctorale DARRED,
Université de la Nouvelle-Calédonie

Co-facilitator for Theia GeoDEV New-Caledonia RAN
► www.theia-land.fr/artlist/
art-geodev-nouvelle-caledonie/

Focus on the Data Terra offer for regional spatial activity

On 11 May 2021, Theia and Data Terra proposed a virtual meeting on the Data Terra research infrastructure, its four thematic consortia and DINAMIS offer for regional activity. The meeting was attended by nearly 80 participants and alternated between presentations and discussion.

The first session presented the Data Terra dynamic (Frédéric Huynh) as well as the offer of its different components: Aeris, the consortium dedicated to the study of the atmosphere (Sébastien Payan); Form@ter, the consortium dedicated to the solid Earth (Emilie Deschamps-Ostanciaux), Odatis, the consortium dedicated to the oceans (Joël Sudre), Theia, the consortium dedicated to continental surfaces (Nicolas Baghdadi) ; Theia|Ozcar information system for collecting and organising in situ data (Isabelle Braud) and, finally, the Dinamis satellite imagery access system (Jean-François Faure).

The second session explored the needs for spatial activity in the regions based on the experience and expectations of different Theia Regional Animation Networks (RANs): Bretagne RAN, represented by Marie Jagaille; Sud RAN, represented by Philippe Rossello; Occitanie RAN, represented by Myriam Cros; GeoDEV RAN, represented by Jean-François Faure; and GeoDEV New Caledonia RAN, represented by Jean Massenet.

The format of this meeting did not allow for much more than general information and initial contact. Nevertheless, it helped to improve the understanding of Data Terra and the consortia's offer by the actors using and promotin spatial at local level and to present the interest of these relays to the data users for the consortia beyond Theia. This meeting is a first step that should be followed by networking and testing. It should be noted that Theia New Caledonia RAN has already declared itself a candidate for developing Proofs of Concept with other consortia member of Data Terra, notably Odatis and Aeris.

The various presentations are now available on theia-land.fr. ■

Isabelle BIAGIOTTI (THEIA)

All the presentations (in French) are on Theia website:
► www.theia-land.fr/ offre-de-lir-data-terra-des-poles-et-de-dinamis-pour-une-animation-regionale/

Simplify the management of your territory!

One of the next events of the CRIGE Provence-Alpes-Côte d'Azur's Geodatalab will be two webinars on 7 and 9 September 2021. In the continuity of the national event AppSpace 2019, organised in Marseille, the aim of these webinars is to promote and develop the use of spatial and aerial remote sensing, to mobilise regional actors and to encourage them to work together. These webinars are aimed at all professional audiences and are part of the Theia Regional Animation Network Sud (Sud RAN), provided by the CRIGE and GeographR.

The first morning (September 7th) will be dedicated to territorial management with presentations by CNES and CEREMA, testimonies from data producers (public and private companies) and local authorities, a presentation of Data Terra. The second morning (9 September) will focus more on satellite sources and the means of taking concrete action. On the agenda: online platforms, training, innovative solutions innovative solutions, cooperation, etc.

To participate in the two webinars, a simple click is all that's required. Registration (free access) is available online:
► www.crige-paca.org/geodatalab

Philippe ROSSELLO (GeographR)
& Christine ARCHIAS (CRIGE PACA)
co-facilitators for Theia Sud RAN
► **www.theia-land.fr/artlist/art-sud/**

Discover the CRIGE Geodatalab, a new place of innovation and hybridization

The CRIGE PACA, the geographic information resource centre in Provence-Alpes-Côte d'Azur (France), has recently recently created an open and inspiring reception area with the support of partners from public sector research and the business world. The aim is to experiment with new forms and methods of working, and to design and launch projects based on geographic data.

The GeoDataLab should notably reduce the time between the emergence, incubation and implementation of a project with the technical expertise of CRIGE and its partners.

If you wish to co-produce business data or create innovative services and tools by geocollaborating, do not hesitate to contact the Geotabalab run by CRIGE PACA!

CNES strengthens its involvement in Theia

CNES, the French Spatial Agency, is a historical and central partner of the Theia consortium and is further strengthening its involvement in Theia's operations with the arrival of Thérèse Barroso. Thérèse takes over from Arnaud Sellé as CNES Theia projet manager. Arnaud takes on the role of technical director for both Theia and Dinamis.

Thérèse Barroso is in charge of managing CNES' participation in Theia. In addition to monitoring production, this mission includes opening up the consortium to downstream hydrology activities (SWOT, HYSOPE II, Hydroweb-NG, in particular. (►Read Bulletin n°13) and participating in Theia's governance bodies (Executive Board, Steering Committee, Scientific Council). She will take up her new responsibilities full-time on 1 October 2021 but has already begun to take up her duties gradually since June 2021.

Arnaud Sellé will continue as Technical Director for the Theia cluster and will be the CNES interoperability manager for its partners for DINAMIS, Theia and ForM@Ter). ■

Arnaud Sellé and Thérèse Barroso, left to right, visiting the Maison de la Télédétection, Montpellier, France, in June 2021

France launches its PNTS 2022

The French National Spatial Remote Sensing Programme (PNTS) is funded by CNES, CNRS-INSU, IGN, IRD and Météo-France. This national programme assesses scientific projects submitted in response to its annual call for tenders, and awards specific funding and certification that are taken into account by other operators or operators or resource agencies.

A programme dedicated to space observation and continental surfaces

The PNTS supports research activities related to Earth observation from space and projects to develop the thematic use of space data and derived products.

The PNTS thus supports:

- exploratory studies for future space-based instruments
- measurement physics studies, including modelling of radiative transfer in soils, vegetation, ocean or atmosphere ocean or atmosphere,
- development of new processing methods (relating to instruments already launched or in the process of being launched),
- characterisation and qualification of satellite products by comparison with exogenous data,
- a particularly original use of space observation for a thematic application.

The scientific disciplines supported by the PNTS include the study of continental surfaces, ocean physics and biogeochemistry, the atmosphere, the solid Earth, the cryosphere, and the sciences of the environment, cryosphere, and human sciences. A non-exhaustive llist of Earth observation missions of interest to the PNTS is available on the websites of CNES, ESA's EUMETSAT and COPERNICUS.

However, the use of products from space observations, obtained using proven methods, does not fall within the scope of the PNTS and should be proposed to the national programmes corresponding to the theme in question.

Cross-cutting proposals

The PNTS also supports interdisciplinary "transversal" proposals between its different communities, without excluding independent proposals. The programme also funds projects with a high potential for creativity or spin-offs, as well as projects that are in the upstream phase of international operations.

The PNTS particularly encourages the organisation of workshops workshops that allow the French scientific community to take stock and exchange experiences on unifying themes. These workshops can be thematic or by tool.

Any idea or suggestion for a workshop can be submitted through a letter of intent.

The 2022 call for proposals, opened on 2 July, closed on 15 September 2021. ■

More information on the call for proposals on the CNRS INSU website
► **programmes.insu.cnrs.fr/pnts/**

More information on the missions of interest considered CNES
► **cnes.fr/en/mission_fiches_theme**

EUMETSAT
► **www.eumetsat.int/website/home/Satellites/index.html**

ESA
► **www.esa.int/Our_Activities/Operations/ Current_and_future_missions)**

Copernicus
► **www.copernicus.eu/en/about-copernicus/ infrastructure/satellites-component.**

Discover SPOT World Heritage online

The SPOT satellites (SPOT stands for Satellites for Earth Observation in French) were designed by CNES, the French Spatial Agency, to study the planet Earth. From 1986 to 2015, the series of five satellites has been able to take images of the the planet with improved resolution with each generation of of satellites: from 20 m to 2.5 m. In order to preserve and enhance this data, the SPOT World Heritage (SWH) programme set up by CNES makes the archive of SPOT 1, 2, 3, 4 and 5 satellites available to the public free of charge.

The catalogue offers images (60x60 km scenes) acquired from 1986 to 2015 at L1A level (radiometric equalization, without geometric correction), from 5 to 10 m in panchromatic and multispectral mode. The images are subject to the ETALAB Open 2.0 licence.

Long-lasting and readily available images

The CNES teams have worked hard to ensure that the images are permanently available in a suitable format (usable by the scientific community and meeting the criteria for permanence) and to make them accessible via a catalogue that can be interconnected with other CNES data portals.

The site already allows users to log in with their THEIA ID or to create a SWH account, without any specific conditions, and then to download images. The licence assigned to the products facilitates their use while leaving the CNES logo mention on the images.

Spot 5 satellite illustration © CNES/ill./DUCROS David, 2002

You can discover the catalogue on the SWH website.
► https://regards.cnes.fr/user/swh/

On-demand processing

The SWH team is currently working on the implementation of on-demand image processing (service planned for next year) as well as on the finalisation of the catalogue and its The SWH team is currently working on the implementation of on-demand image processing (service planned for next year) as well as on the finalisation of the catalogue and its interoperability to be easily accessible via future CNES platforms.

While waiting for the L1C levels planned for next year, CNES has developed a specific page for processing L1A images to an ortho-rectified image.
More details are available on the carto page:
► http://swh-2a-carto.fr/. ∎

Agathe MOREAU (CNES)

Already orthorectified imagery

While waiting for the implementation of the L1C on-demand service, an ortho-rectification process (Sentinel-2 type projection) without absolute registration has been implemented and is now availablewith the following link: ► swh-2a-carto.fr/

As the processing does not have an absolute reference, it is very fast (2 o 3 seconds). The final product however remains at the accuracy of the original product, which can be 400 to 500 m, or even more on older SPOT products. The location error is correctable to first order by a simple translation.

DATA TERRA, Theia, Form@ter and DINAMIS at Geodatadays

On September 15 and 16, Grenoble (France) will host the GeoDataDays 2021, the French national event dedicated to geodata organised by Afigéo - the French Association for Geographic Information - and Décryptagéo - a professional media dedicated to geoinformatics. This edition is organised around a series of highlights: major debates on strategic subjects, major themes in the forefront of the agenda, major challenges to be met together tomorrow.

It also proposes a specific section on "Space for territories", which aims to give greater visibility to space technologies and uses of space to enable the geomatics community to better appropriate technologies, data, products and services from space. This specific programme is co-organised by ConnectByCNES.

Theia will be present alongside the Form@ter consortium and DINAMIS on the stand of the French Research infrastructure Data Terra, which is sponsoring the event. This will be an opportunity for Theia and Form@ter to showcase the most mature products and tools available for continental surfaces and solid earth, respectively. It will also be an opportunity to learn more about the DINAMIS satellite image access offer. ∎

Programme and presentations
► www.geodatadays.fr/

Monitoring of Land Soil Sealing by Remote-Sensing

Monitoring land use has become increasingly important over the last decade. Regulations, political objectives, planning and development documents regularly reinforce the importance of measuring and monitoring land use and its operational implementation.

There are many avenues of research and they are part of a panorama of multiple methods and reference databases pending a forthcoming 'standardisation', starting with a shared official definition of soil sealing : identifying and finely measuring the evolution of artificialisation, but also reducing production times and facilitating reproducibility over time, among other things.

Numerous research projects, notably within the framework of Theia Urban Scientific Expertise Center (SEC), aim to develop or consolidate new methods and products that contribute to the measurement and qualification of soil sealing.

Contributing to the measurement and characterization of artificialisation

In 2007, UMR TETIS was asked by Languedoc-Roussillon regional authorities to work on this issue and to propose a regional method for mapping and quantifying artificial areas that could be generalised and reproduced over time. Based on the use of satellite images (Rapid Eye, IRS) and custom processing, this cartography required more than 25 days of processing / post-processing to cover only a part of the targeted territory.

In 2018, this work was continued and extended to the scale of the new Occitanie Region (13 departments, ~ 72,000 km²) within the framework of a "Research and Society" call for projects (Occitanie Region/ ERDF). The new methodology based on artificial intelligence and Spot 6/7 images (made available within the framework of GEOSUD / DINAMIS) has made it possible to automate the process and thus reduce the human time required for its implementation (~10 days of processing without human intervention to process the 13 departments). Figures 1 and 2 below illustrate the results of this work: automated extraction of buildings by distinguishing between residential and business use, and an intermediate product of simplified land use.
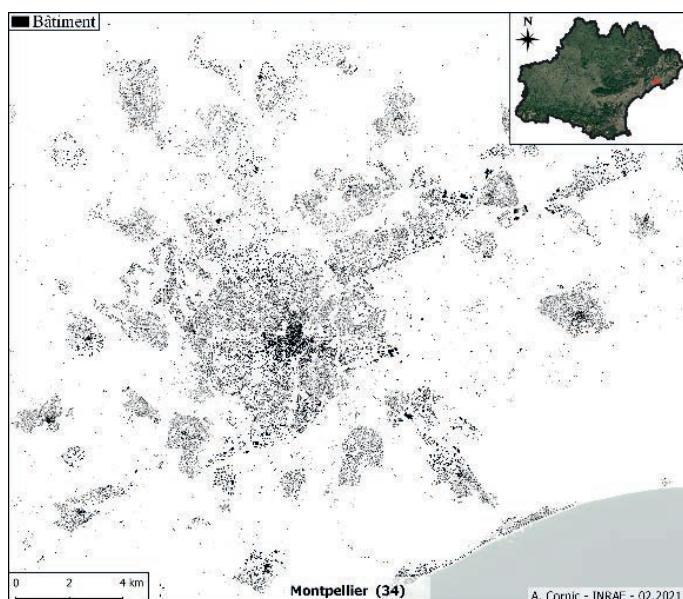
Mapping the buildings

The mapping of buildings was carried out over five consecutive years, from 2015 to 2019. It distinguishes between residential and industrial and commercial uses. This product was evaluated using two approaches:

○ a first, classical approach, based on the number of certified pixels;

○ a second, object-oriented approach, which focuses on the detected objects (contiguous pixels belonging to the same class). This approach made it possible to qualify both the geometric and planimetric accuracy of the predicted features with respect to the training set and to determine a minimum mapping unit (MMU) for the "building" class, which is of the order of 100 m².

The spatialization of these assessments also revealed a better detection of buildings in continuous urban fabric (according to the Corine Land Cover nomenclature). In peri-urban and rural areas, it seems that the trained models are less efficient, perhaps due to the very different contexts around diffuse or isolated buildings.

The intermediate land use product was refined by spatial analysis (distinction between rural and urban vegetation, for example) and structured with the addition of the IGN road network. The objective was to specify the constituent elements of soil sealing and to give users the possibility of arranging these elements according to their problems and their final definition of this phenomenon.

The methodology developed within the framework of the ArtiSols project was consolidated during 2021 within the framework of the TOSCA AIM-CEE project, and implemented on a national scale. Using the same method, the team used about 1200 Spot 6 and 7 images and the IGN BD TOPO to train an artificial neural network to map human constructions such as buildings, over the whole of metropolitan France. Once the model was trained, it could be applied to the entire Spot 6 and 7 images to generate maps. This product, called "Buildings Footprint", is
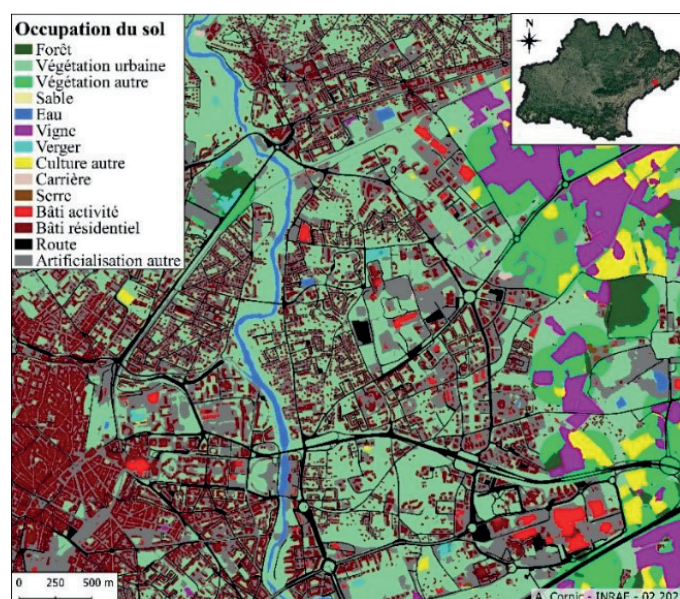

Figure 1. Residential and business buildings Reference

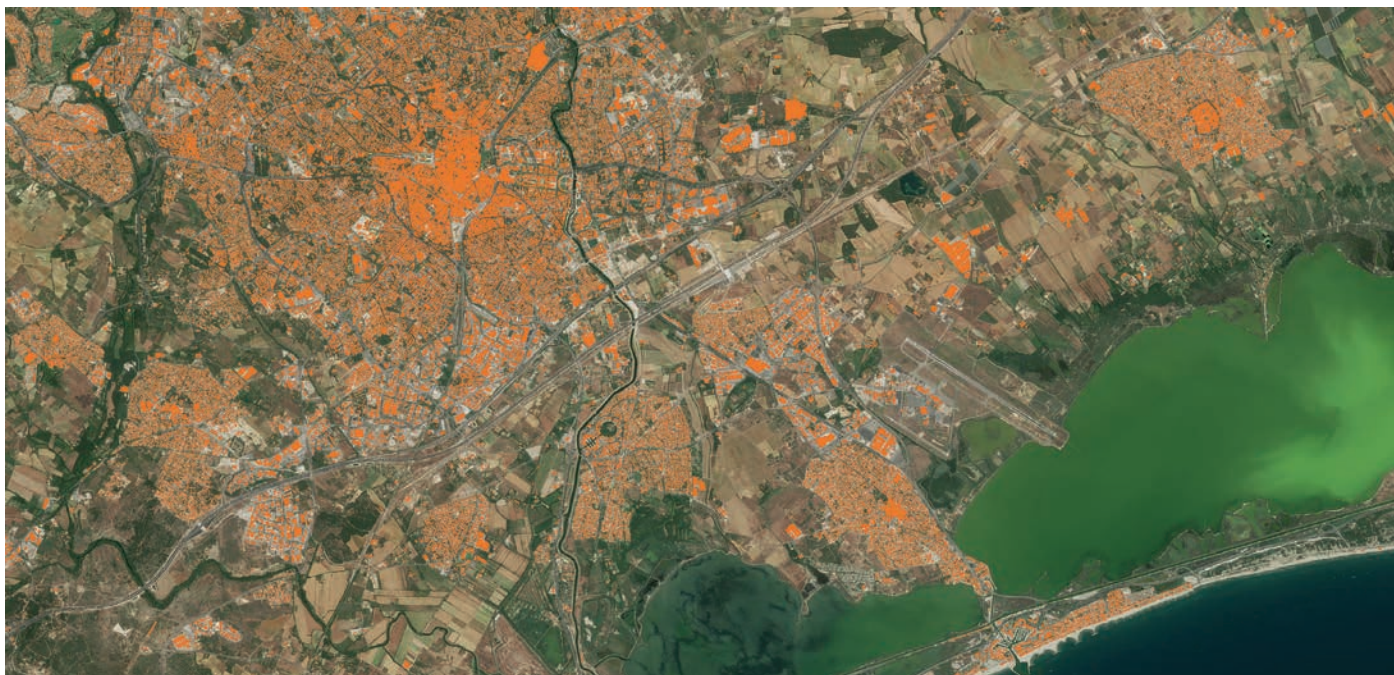**Figure 2. Simplified Land Use**

Figure 3: Building footprint for Montpellier and its region.
Data available on thisme.cines.teledetection.fr/search?collection=BuildingsFootprint&_view=map.

currently distributed by Theia Urban SEC, under an ETALAB2 licence (Figure 3, above). More information on the method and the tools used is given on the product presentation sheet: www.theia-land.fr/product/empreinte-au-sol-des-batiments

In its future work, the team plans to extend the product to French overseas territories and departments and to improve the performance of its method. Indeed, the limitations of current supervised learning methods lie mainly in the quality of the data: it is necessary to have ground truth data that is synchronised as well as possible with the satellite images. The INRAE team is addressing this problem, in particular through research and development collaborations with the IGN.

Complementing land use products and databases

The research presented here contributes to improving knowledge of artificial areas. It demonstrates the value and relevance of satellite imagery for rapidly producing information at a lower cost (automated processing, low demand on human resources, compromise between swath and accuracy, availability of DINAMIS system for making annual coverage), with high frequency (annual). This information is also qualified in order to support users. These methods and products explore new avenues of production and raise research questions about the exhaustiveness and qualification of results. Provided that their limitations are taken into account, they are already complementary to reference land use products and databases.

Éric BARBE, Rémi CRESSON & Kenji OSÉ
INRAE TetiS

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

FOTOTEX: An Unsupervised Method for Urban Areas

The French UMR Espace-dev has just published an article entitled "Fast Unsupervised Multi-Scale Characterization of Urban Landscapes Based on Earth Observation Data" in the journal Remote Sensing, presenting the use of an algorithm dedicated to the study of urban areas by remote sensing based on texture information.

Three nested scales

With FOTOTEX, this paper introduces a unique, fast and unsupervised method to characterize urban areas at three nested scales: macro-scale (urban footprint), meso-scale ("neighbourhoods") and micro-scale (urban objects). FOTOTEX combines Fourier's Transform and Principal Component Analysis to convert the spatial signal (patterns in the image) into a frequency signal (number of times the pattern is repeated in a defined area). ► Figure 1
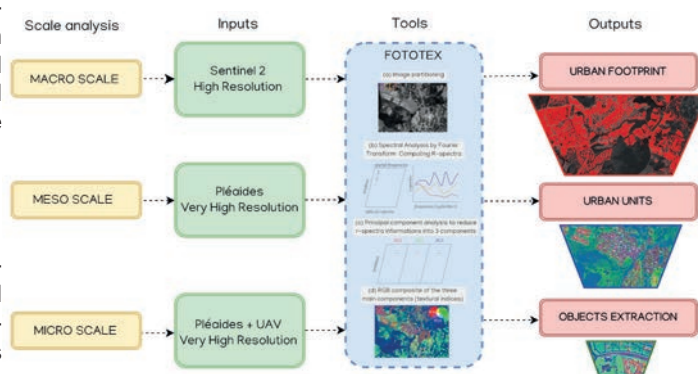

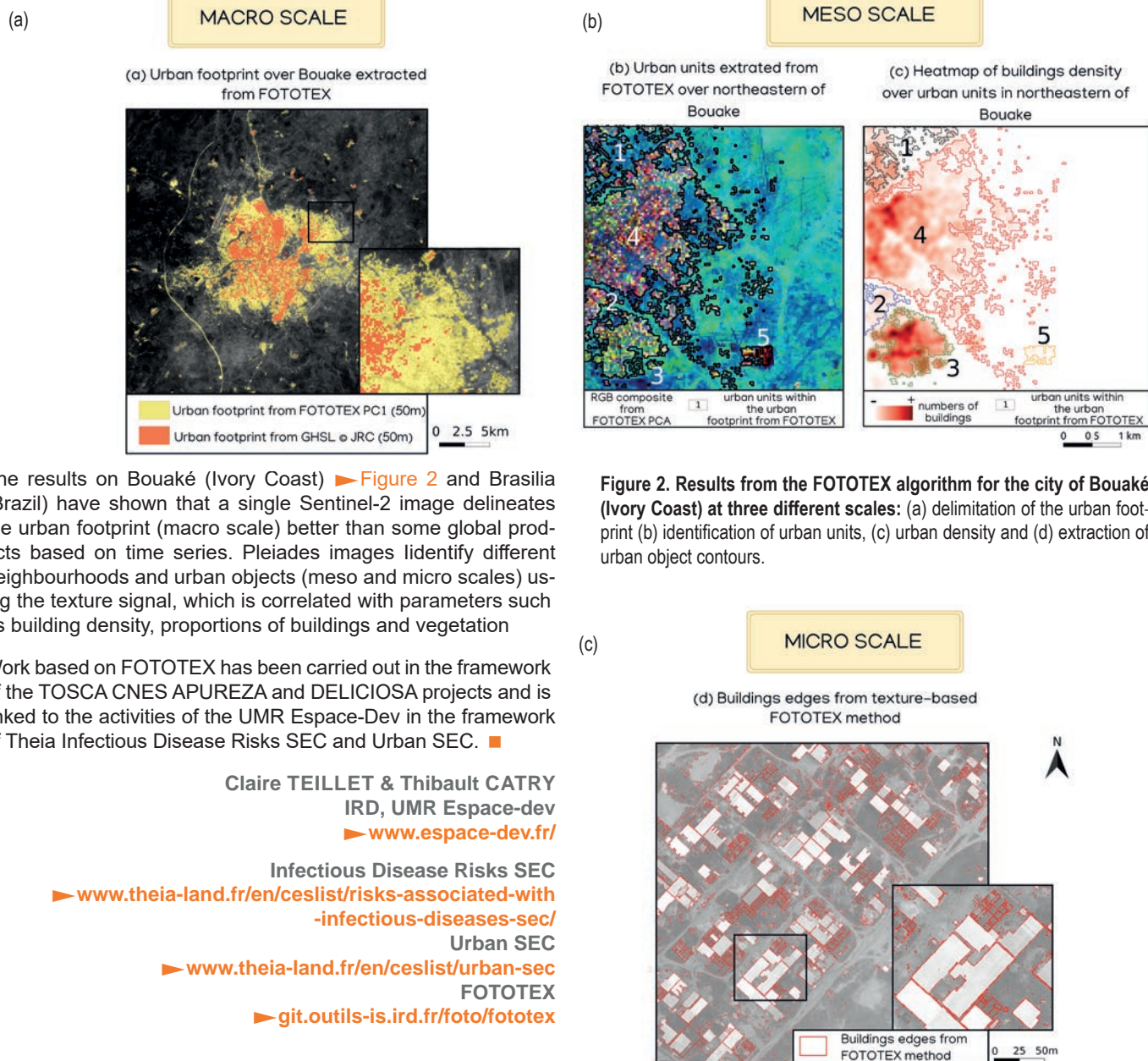Figure 1. The Fototex method enables the characterization of urban areas at three nested scales.

The results on Bouaké (Ivory Coast) ►Figure 2 and Brasilia (Brazil) have shown that a single Sentinel-2 image delineates the urban footprint (macro scale) better than some global products based on time series. Pleiades images Iidentify different neighbourhoods and urban objects (meso and micro scales) using the texture signal, which is correlated with parameters such as building density, proportions of buildings and vegetation

Work based on FOTOTEX has been carried out in the framework of the TOSCA CNES APUREZA and DELICIOSA projects and is linked to the activities of the UMR Espace-Dev in the framework of Theia Infectious Disease Risks SEC and Urban SEC. ■

Claire TEILLET & Thibault CATRY
IRD, UMR Espace-dev
►**www.espace-dev.fr/**

Infectious Disease Risks SEC
►**www.theia-land.fr/en/ceslist/risks-associated-with**
-infectious-diseases-sec/
Urban SEC
►**www.theia-land.fr/en/ceslist/urban-sec**
FOTOTEX
►**git.outils-is.ird.fr/foto/fototex**

Figure 2. **Results from the FOTOTEX algorithm for the city of Bouaké (Ivory Coast) at three different scales:** (a) delimitation of the urban footprint (b) identification of urban units, (c) urban density and (d) extraction of urban object contours.

Reference

Teillet, C.; Pillot, B.; Catry, T.; Demagistri, L.; Lyszczarz, D.; Lang, M.; Couteron, P.; Barbier, N.; Adou Kouassi, A.; Gunther, Q. ; et al. Fast Unsupervised Multi-Scale Characterization of Urban Landscapes Based on Earth Observation Data. *Remote Sens.* 2021,13, 2398. doi.org/10.3390/rs13122398.

RedGems: monitoring infectious diseases from space

Re-emergent Diseases, Global Environment Monitoring from Space, or RedGems, was born at MEDIAS-France (GIP) about 20 years ago under the vision of Yves M. Tourre (MEDIAS-France) and Dr. Antonio Güell, Murielle Lafaye and Cécile Vignolles from the French space agency, CNES.

RedGems was to promote the new concept of "tele-epidemiology" which was then in full implementation at CNES. The basic concept was to integrate climatic and environmental variability/changes by using remote sensing techniques and tools, and to link the real-time observations with the necessary conditions for the appearance of infectious diseases. This multi-disciplinary conceptual approach led to a patent application developed by CNES in 2009 entitled "Method and devices for establishing from space, representative areas under risks of infectious diseases transmissible by air, water or vectors".

Based on co-construction with local and international health actors, the ultimate aim is to provide to the users at large critical information from spatial tools/products/indicators in order to monitor the emergence and evolution of infectious diseases (primarily) such as Rift Valley Fever, Malaria or Dengue among others. Many of these studies are already well known to Theia users, as they were developed within the framework of the Infectious Disease Risk SEC.

The Early warning systems (EWS)

Today, RedGems is an overall tool contributing to the implementation of the Early Warning Systems (EWS) for epidemics and pandemics, such as COVID-19. (See box on next page). It is to provide researchers, stakeholders and users with important sources of information and relevant historical research at glob-

al and local scales, thus playing a central role in the interaction within the multi-disciplinary community. The site currently receives an average of 50 visits per day for a total of 165,774 visits in 2020 (January-October). It offers as expected multidisciplinary content, combining public health (30%), climate and environment (20%), spatial tools (15%) and multiple projects (35%). Some dataset is downloaded in csv (Excel) format for further processing by users.

The current ambition of RedGEMS is to improve its visibility and to better respond to the needs and expectations of its users who should soon be consulted. Part of this strategy will be based on active cooperation and strengthened links with Theia and its "Risks Associated with Infectious Diseases SEC, some

of whose products meet RedGEMS' priorities. Another axis is to better publicise innovative work carried out by the RedGEMS community, as started with the article published in the journal Geospatial Health on COVID-19 and space-based tools (read box below). ■

Yves TOURRÉ
MEDIAS-France
RedGEMS
►www.redgems.org/
Risks Associated with Infectious Disease SEC.
►www.theia-land.fr/en/ceslist/
risks-associated-with-infectious-diseases-sec/

Space-based products for a real-time monitoring of COVID-19

Various studies have linked COVID-19 diffusion to atmospheric chemical variations and air pollution. Concentrations of nitrogen dioxide (NO_2) and fine particles (PM10 and PM2.5) may be responsible for the overexpression of angiotensin-II converting enzyme (ACE-2) in human respiratory cells. ACE-2 acts as a receptor, andplays a key rôle in capturing SARS-CoV-2, infects the individual, and thus contributes to the disease diffusion.

Spatial data for gaseous and solid components may therefore become crucial data for spatio-temporal monitoring of the disease. Providing health information systems with proxies

of air and chemical pollution in the boundary layer of the atmosphere, based on data from space agencies - CNES, ESA, NASA, JAXA, ASI, CSA, INPE, among others. It would allow decision-makers involved in public health to monitor the risks of COVID-19 in real time.

A good example is the linkages and the dynamics between the evolution of NO_2 concentration and COVID cases in northern Italy. Imagery of the monthly average NO2 concentration levels (µmole/m2) in the tropospheric column, can be measured by the Copernicus Sentinel-5P satellite before, during and after the confinement period in the Padana plain. Also since the confinement started in March 2020, the decrease in NO2 levels (from less transport and industrial activities) and consequently in COVID cases later (public health sources), is particularly visible during the April-May 2020 mapping from space. https://www.esa.int/ESA_Multimedia/Videos/2020/03/Coronavirus_nitrogen_dioxide_emissions_drop_over_Italy

The evolution of NO2 concentration in northern Italy.
Imagery of the monthly average NO2 concentration levels (µmole/m2) in the tropospheric column, measured by the Copernicus Sentinel-5P satellite before, during and after the containment period on the Padana plain. As the containment started in March 2020, the decrease in NO2 levels is particularly visible in the April-May 2020 maps. (see figure opposite from the European Union, Copernicus Sentinel-5P, July 2020)
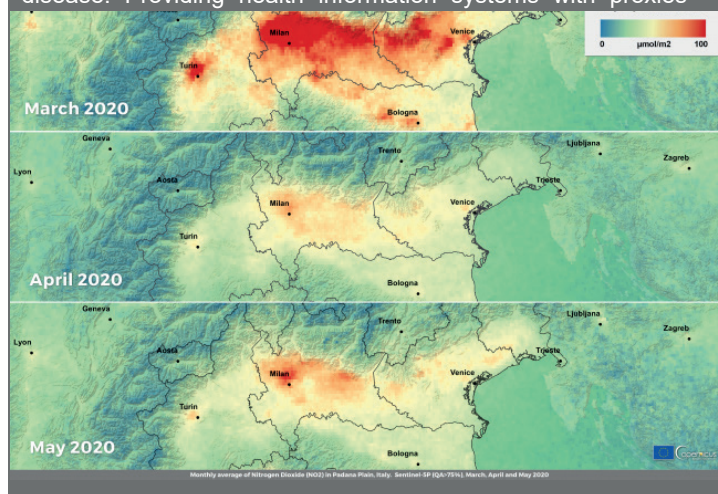
Land-Cover: Mapping Three Watersheds in Haiti

As part of the project "Territoires Productifs Résilients en Haïti" (TPR, i.e. Resilient Productive Territories in Haïti)), the CIRAD team at UMR TETIS produced land-cover maps using the IOTA2 and Moringa processing chains. The aim was to compare the results, and make recommendations to the National Center for Geospatial Information (CNIGS) of the Republic of Haiti, with the objective of a regular map production throughout the entire country. The study was carried out on a demonstrative area corresponding to 3 watersheds in the Nippes Department. The produced maps are now available on Theia as part of the work carried out by the Land Use Committee (►see also p.13).

An exemplary database

IInitially, the CIRAD assisted the CNIGS in building a reference database of approximately 1 600 polygons. This database is based on the combination of field surveys and photo-interpretation by experts. The nomenclature presents 3 levels of precision:

○ a detailed level (named "level 2"), comprising 12 classes corresponding to the types of land-cover that can potential-

ly be distinguished on Pleiades images and that are useful for the TPR project;

References

Lelong C., Dupuy S. 2021. Guide technique. Constitution d'une base de données de référence dédiée à l'apprentissage et la validation des classifications d'images satellites : la vérité-terrain. Montpellier : CIRAD-ES-UMR TETIS, 16 p. http://agritrop.cirad.fr/597844

Dupuy S., Lelong C., Gaetano R. 2021. Rapport méthodologique : Cartographie de l'occupation du sol sur le site des NIPPES à Haïti. Montpellier : CIRAD-ES-UMR TETIS, 45 p. http://agritrop.cirad.fr/597938

Gaetano R., Lelong C., Dupuy S. 2021. Rapport méthodologique : Inter-comparaison des produits de cartographie de l'occupation du sol avec les chaines Iota2 et Moringa : cas d'étude de la région des Nippes en Haïti. Montpellier : CIRAD, 31 p. http://agritrop.cirad.fr/597991

○ a less detailed level (named "Level 1"), comprising 8 classes, intended to produce a classification with the Iota2 chain, which does not use VHSR images;

○ a coarse level (named "Level 0"), comprising 7 classes only, and grouping together all the ligneous covers whether cultivated or not, because the discrimination of these different types of cover (included at level 1) is too difficult at 10m/pix.

To carry out this study, the team also benefited from data distributed by the CNES:

○ Very high spatial resolution data (Pleiades and Spot6/7) acquired as part of the "Recovery Observatory (RO) in Haiti" programme

○ Copernicus Sentinel-2 level 2A data distributed by the THEIA data hub (surface reflectance corrected for atmospheric effects and provided with a cloud and shadow mask).

...combined with a DTM

This mapping also used a Digital Terrain Model (DTM), produced by IGN-FI from a LiDAR acquisition in 2014, with a height resolution of 20 cm and a spatial resolution of 1.5 m. Slopes were derived from this DTM and included in the classification process. ■

Camille LELONG, Stéphane DUPUY & Raffaele GAETANO
Cirad TETIS

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

2020 Land Cover Map produced using Iota² in Haiti. Zooms over the three watersheds
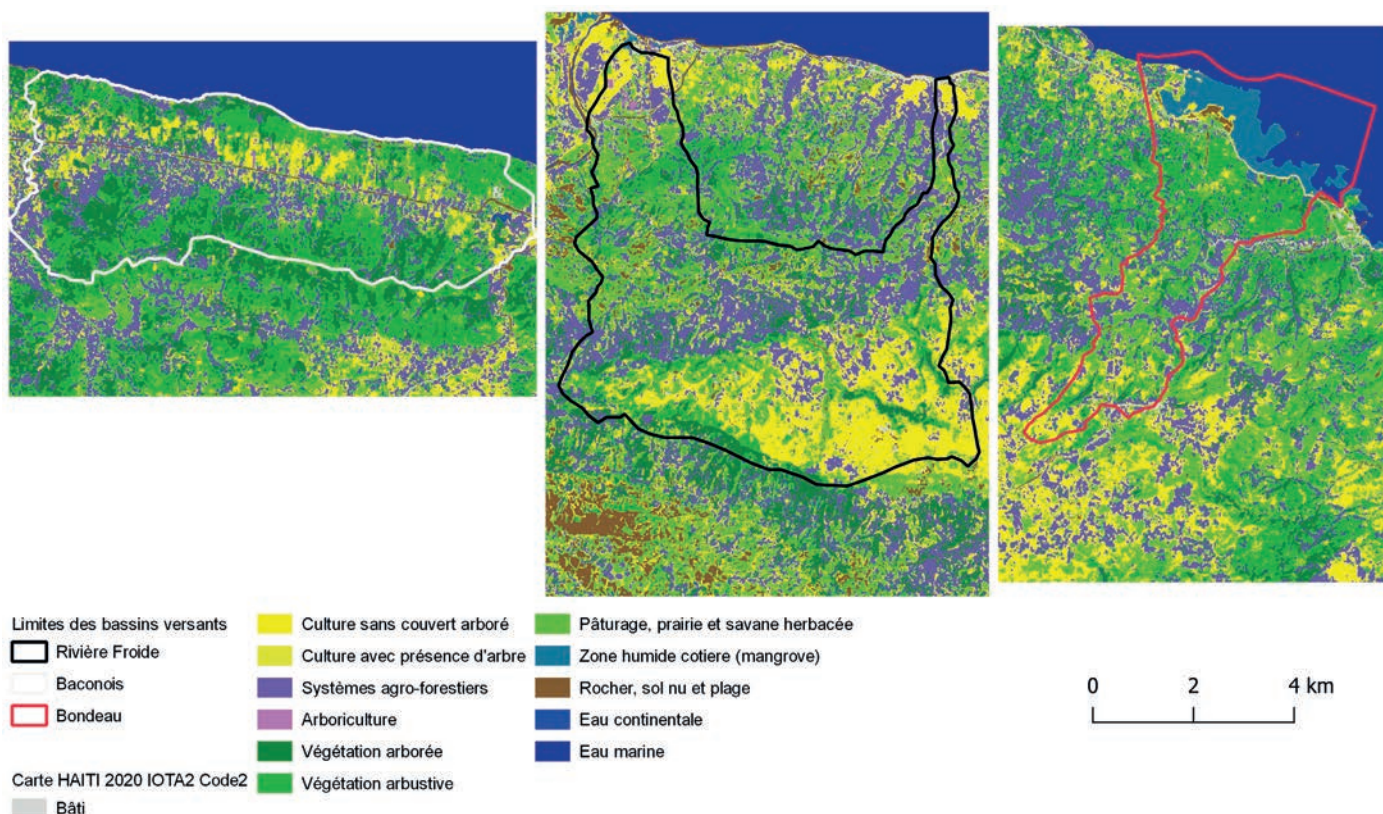
MONITORING 700,000 KM² OF THE WORLD'S GLACIERS

The 700,000 km² of glaciers on Earth (excluding the Greenland and Antarctic ice caps) are shrinking rapidly, altering regional hydrology, raising global sea level and elevating natural hazards. Yet owing to the scarcity of constrained mass loss observations, glacier evolution is known only partially, as a geographic and temporal patchwork.

In a study recently published in *Nature* using previously largely untapped satellite archives, an international team led by LEGOS glaciologists and associated with Theia Glaciers SEC has mapped the elevation changes of all the world's glaciers at high spatial and temporal resolution, revealing their accelerated and contrasting mass losses between 2000 and 2019. These data are now available in two ways on Theia: as a 1°x1° tile visualization or as a global bulk download.

Reference

Hugonnet, R., McNabb, R., Berthier, E., Menounos, B., Nuth, C., Girod, L., Farinotti, D., Huss, M., Dussaillant, I., Brun, F., and Kääb, A.: Accelerated global glacier mass loss in the early twenty-first century, *Nature*, 2021.
DOI : 10.1038/s41586-021-03436-z

The validation of this new dataset was carried out using data from the ICESat and Ice-bridge missions, but also thanks to high-resolution elevation difference maps deduced, among others, from Pleiades and SPOT6-7 images obtained in the framework of the DINAMIS programme. The whole project has been funded for almost 10 years by French space agency CNES through its TOSCA programme.

Monitoring Glaciers and their evolution by region

The product Rate of Glaciers Elevation Changes from 2000 to 2019 allows researchers to estimate glacier mass change during 2000–2019: at world scale, glaciers lost a mass of 267 ± 16 gigatonnes per year, equivalent to 21 ± 3 per cent of the observed sea-level rise. The product identifies and documents as well a mass loss acceleration of 48 ± 16 gigatonnes per year per decade, explaining 6 to 19 per cent of the observed acceleration of sea-level rise. Particularly, thinning rates of glaciers outside ice sheet peripheries doubled over the past two decades. Glaciers currently lose more mass, and at similar or larger acceleration rates, than the Greenland or Antarctic ice sheets taken separately.
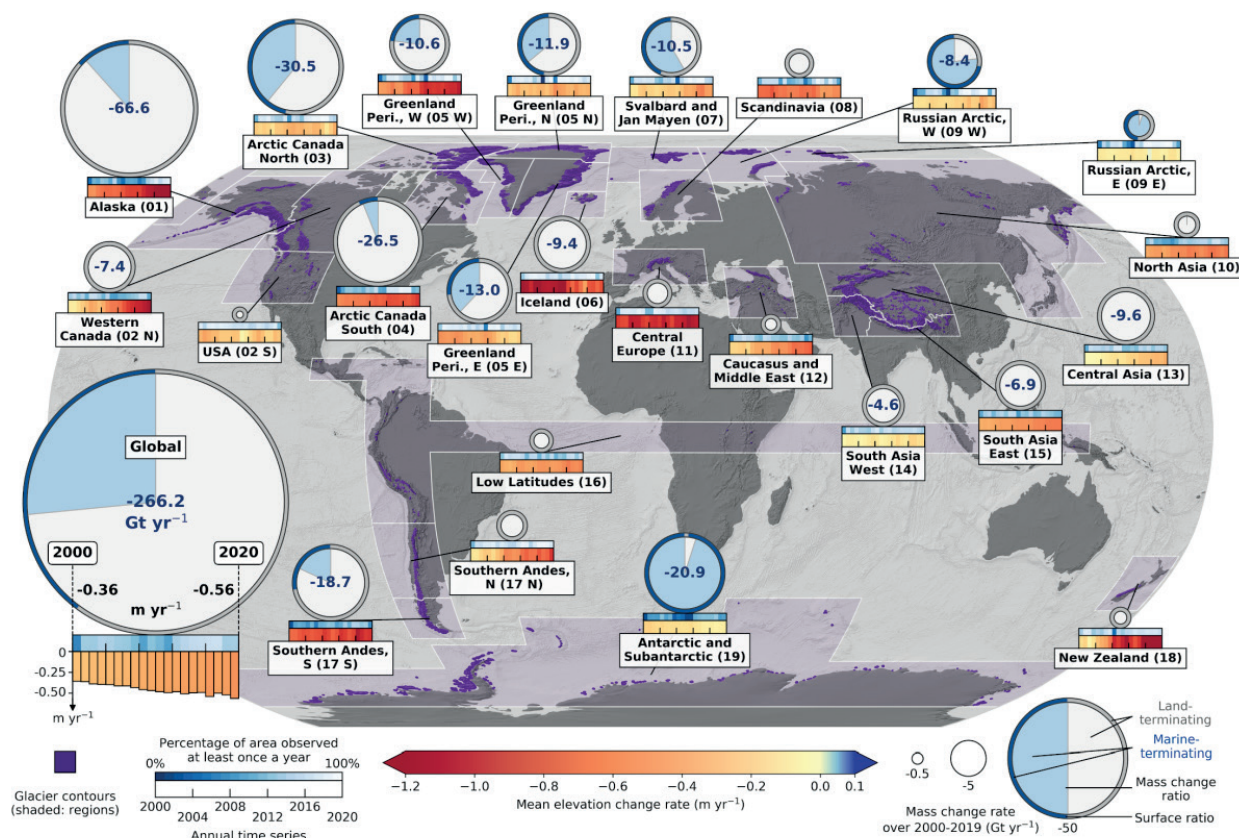
Figure 1. Mass losses of major ice regions between January 2000 and December 2019. The coloured friezes illustrate the temporal evolution for each region. The colour in circles distinguishes the relative contribution of glaciers terminating in the sea or on the continent. Source: Hugonnet et al, *Nature,* 2021

Based on these new estimates, we document contrasting glacier fluctuations that agree with the decadal variability in precipitation and temperature. These include a North Atlantic anomaly of decelerated mass loss, a strongly accelerated loss from north-western American glaciers, and the apparent end of the Karakoram anomaly of mass gain.

These highly resolved estimates should advance the understanding of drivers that govern the distribution of glacier change, and to extend our capacity to predict these changes at all scales. Predictions robustly benchmarked against observations are critically needed to design adaptive policies for the local- and regional-scale management of water resources and cryospheric risks, as well as for the global-scale mitigation of sea-level rise. ∎

Romain Hugonnnet
& Étienne Berthier,
LEGOS, Glacier SEC co-facilitator

Rate of Glacier Elevation Change
► www.theia-land.fr/en/product/
rate-of-glacier-elevation-changes-from-2000-to-2019

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

ExtractEO, Water Surface Observatory Applied to Lake Fitri

ExtractEO is a software developed by ICube-SERTIT, implementing automated end-to-end chains on satellite data. ExtractEO is able to process different satellites and has several chains implemented, from water and fire extraction to cloud detection. The objective of ExtractEO is to work both in a time series context and in a large study area (large spatial and temporal windows).

Lake Fitri, located in the semi-arid zone of Chad within the Sahelian band, is a flat-bottomed lake with high intra- and inter-annual variability. This characteristic is linked to the variability of the West African monsoon, which is reflected in Lake Fitri by large fluctuations in the surface area of open water and the depth of the lake, on all time scales (from one season to several millennia). In recent decades, since the droughts of the 1970s-1990s, open water and wetland areas have doubled and stabilised since
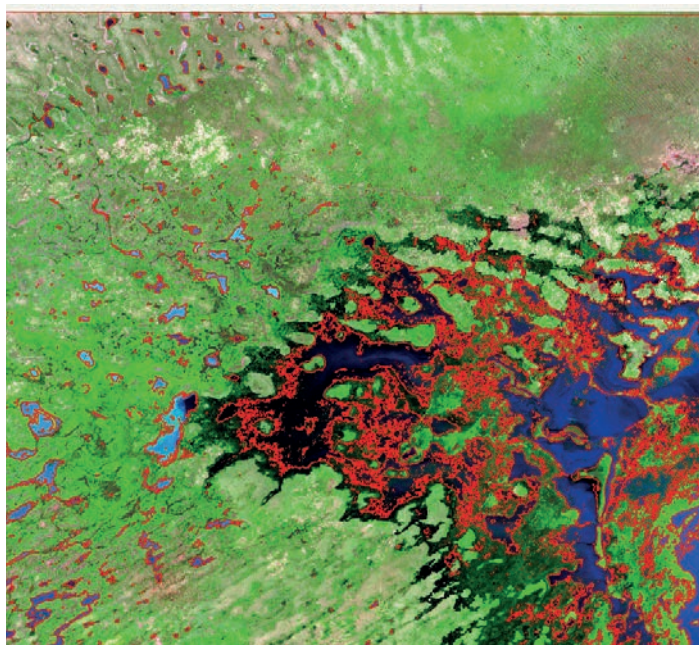

Figure 1. Water surfaces of Lake Fitri, displayed with a red border and detected from the Sentinel-2 image acquired on 22 September 2020, displayed here in the background and with a mid-infrared/near-infrared/red colour composition to highlight the water surfaces.

Figure 2. Monitoring chart of the water surfaces of Lake Fitri over the period January 2017 - February 2021. Surfaces are expressed in km².

are automatically derived from each Sentinel-2 observation. The 246 Sentinel-2 images are selected and downloaded by Extract-EO directly from the CREODIAS platform. Water surfaces are detected using a multilayer perceptron (neural network) algorithm and integrating the Global Surface Water database (Pekel et al., 2016) for sampling.

Understanding lake dynamics

A chart monitoring the lake's water surfaces over time is produced from the surfaces calculated for each usable date (no clouds over the lake). The variations in the lake's surface area are impressive, with a minimum surface area of 194 km² and a maximum surface area of 1249 km² over the period observed. Furthermore, the dynamics of the water surfaces are similar for the years 2017, 2018 and 2019. In 2020, the rise in water level is significant since the maximum area observed this year is twice the maximum area observed in the three previous years.

Occurrence products are also derived from the lake masks: annual occurrence and overall occurrence over the 4-year observation period. These maps are very useful for understanding the inter and intra-annual dynamics of the lake.
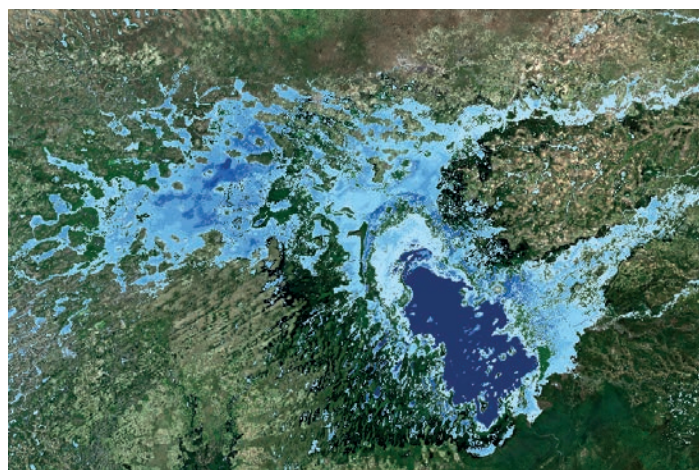
iThe results as a whole offer very rich information for the study and management of this lake. A combination with altimetry data is being carried out by LEGOS to derive hypsometric curves and extract volume variations. Such regular monitoring of the flooding of Lake Fitri, in addition to rainfall, would provide an excellent indicator of climate trends in this poorly studied region, but also of resource stresses due to population growth. To this end, a TOSCA project has been submitted, involving PRODIG, LEGOS, EOST, SERTIT and CEREGE.
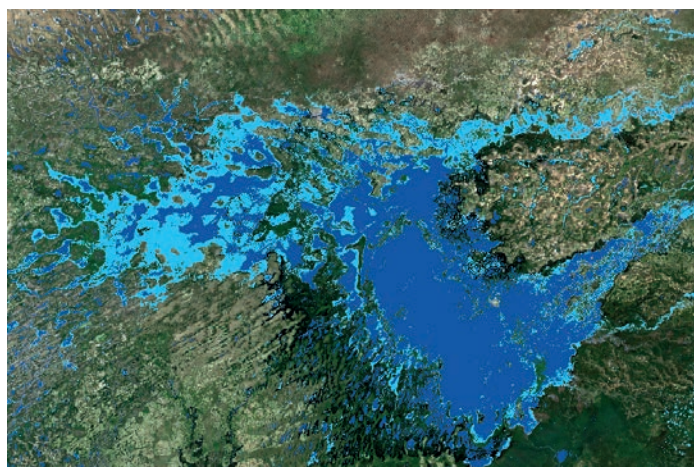
It is a success for ExtractEO which enables the automatic derivation of water and cloud masks of very good quality on a time series (Sentinel-2 but also Sentinel-1), to compute the surfaces to build a tracking curve and, finally, to compile occurrence products. ∎

Jérôme MAXANT, Thomas LEDAUPHIN & Hervé YESOU
Cube-SERTIT
► sertit.unistra.fr

Christine RAIMOND
CNRS - PRODIG
► www.prodig.cnrs.fr

Mapping and Monitoring of Water Bodies SEC
► www.theia-land.fr/en/ceslist/
mapping-and-monitoring-of-water-bodies-sec/

Figure 4. **Lake Fitri's maximum extent observed over the three years 2017-2018-2019** in dark blue, and additional water surfaces observed in 2020; in the background the Sentinel-2 image acquired on 22 September 2020 in natural colours

Figure 3. Map of 2020 occurrence with a blue gradient indicating the frequency of presence of water in the year, dark blue corresponding to permanent water; in the background the Sentinel-2 image acquired on 22 September 2020 in natural colours.

References

Jean-Francois Pekel, Andrew Cottam, Noel Gorelick, Alan S. Belward, High-resolution mapping of global surface water and its long-term changes. Nature 540, 418-422 (2016). doi:10.1038/nature20584

Yalikun T., Raimond C., Nagorngar, Zakinet D., Schuster M., Sylvestre F., 2019 : Variabilités des crues et des paysages du lac Fitri depuis les grandes sécheresses des années 1970-1990.

PlanetObserver : Maximise your Projects with Powerful Geospatial Data

Founded in 1989, PlanetObserver is a French SME based in Clermont-Ferrand whose activities are all related to remote sensing and Earth observation. The company positions itself as an expert in high value-added geospatial data that maximise the visual and technological performance of clients' projects and solutions. Since its inception, all products have been developed in-house, drawing on a high level of know-how in geospatial data processing and 30 years of technological expertise and innovation.

Expertise and innovation in geospatial data

PlanetObserver develops and markets imagery and elevation products with global coverage. As an authorised distributor of Airbus DS for Europe, the company also offers a wide portfolio of very high resolution imagery and elevation data.

In the field of imagery, PlanetObserver's know-how covers the assembly of thousands of satellite images, their colorimetric processing and the creation of seamless, georeferenced and ortho-rectified mosaics. The end-result is PlanetSAT Global basemap with 10-meter resolution, which provides an unparalleled visual experience for users. Updated every year with fresh Sentinel-2 data, this PlanetObserver flagship product is notably integrated in Airbus OneAtlas Basemap offer and in IGN Geoportal. It is also used as a background map by Thales, Boeing and Hensoldt Avionics in their flight simulation solutions as well as in Betria Interactive's IFE (Inflight Entertainment) solution.

The company's expertise has been extended to elevation data processing. PlanetObserver produces PlanetDEM global elevation data from open source data that is aggregated and corrected to provide optimal quality. ESA and CNES have notably used this data for the orthorectification of Sentinel-2 satellite images of the Copernicus programme. CONNECT by CNES is now supporting PlanetObserver in its R&D project in the field of elevation data.

The experience and skills of the technical team guarantee a very high level of quality in the processing of satellite imagery and elevation data. All products are available as plug-and-play data, easy to integrate into any solution. The work is carried out by a multidisciplinary team including PhDs in Environmental Geography and Remote Sensing, Masters in Geology and Computer Science and Computer Graphics Technicians.

An innovative company serving various sectors

PlanetObserver geospatial data enriches many commercial and military applications. From web-mapping to 2D and 3D visualisation and simulation solutions, moving maps applications, GIS tools to cartographic and audiovisual production. PlanetObserver's know-how, combining technicality and aesthetics, is recognised by major players in the sector in France and internationally, such as Airbus DS, Boeing, CNES, Dassault Aviation, ESA, Eastview Geospatial, IGN, L3Harris, Sogitec and Thales.

Member of Aerospace Valley and the French Tech network, PlanetObserver is connected to the space and geographic data ecosystem. Meet us at different events such as the ESA Industry Space Days or the upcoming GeoDataDays 2021 in Grenoble (►Read p.6). ■

Marie-Pierre BOUTIN
PlanetObserver
► **planetobserver.com**

PlanetSAT Global imagery basemap with 10-meter resolution
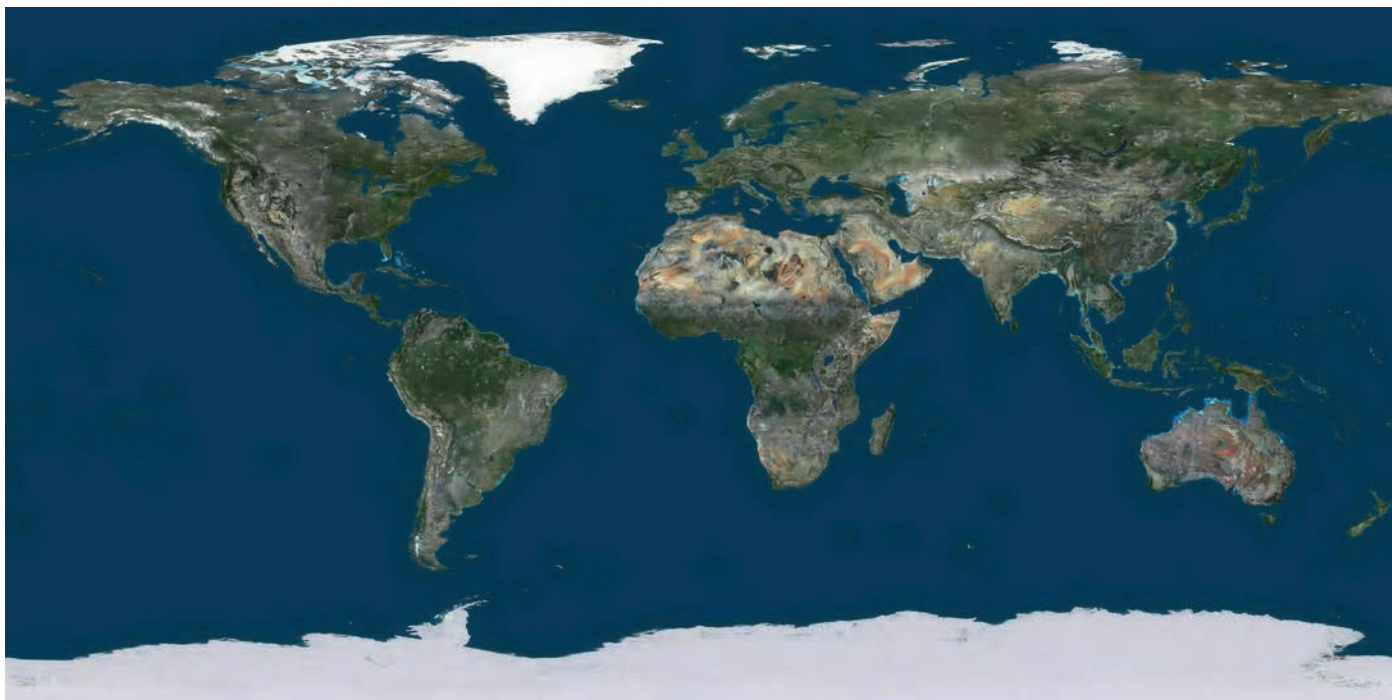
« Contributing to the development of our partners in the South in the fields of applicative Earth Observation, based on the resources offered by Theia

Who are you and what is your role within Theia? How and why did you get involved? Since when?

Jean-François Faure: I am a Research Engineer at the IRD within the UMR Espace-dev and I am as well a member of Theia Executive Board, representing the IRD. In 2016 I proposed to the Steering Committee to support a regional animation network (RAN) dedicated to scientific and technical cooperation with southern countries: the GeoDEV network, which I have been facilitating since its creation with colleagues from IRD, CIRAD and CNES.

Finally, I also act as a correspondent for the French initiative offer for a pooled supply in satellite imagery, DINAMIS, of which I am the Executive Secretary and which is a transverse component of IR Data Terra.

I have been involved in the Theia consortium for a long time: as early as 2011, through my involvement in the founding project EQUIPEX GEOSUD (Montpellier), I took part in the numerous meetings that prepared the reactivation of the Pôle Thématique Surface Continentales (PTSC). It was during one of these meetings that I suggested naming it 'Theia', which is a Titanid from Greek mythology, daughter of the union of Ouranos, the Sky, and Gaia, the Earth.

How do your activities as coordinator of the GeoDEV RAN and as a researcher in Earth Observation fit together?

Jean-François Faure: The aim of the GeoDEV RAN is to contribute to the development of our partners in the South in the fields of applicative Earth Observation, based on the resources offered by Theia. This objective is directly linked to one of the units within my UMR - the unit for the valorisation and transfer of tools, methods and knowledge, which I manage with my colleague Benoît Mertens.

Within the framework of the application research projects that I have the opportunity to lead or contribute to, accompanying the appropriation, collaboration and co-production of research results with our partners constitutes a very important dimension,

Interview with Jean-François Faure

IRD Research Ingenior at Espace-dev
IRD Representative in Theia Executive Comittee
DINAMIS Executive Secretary

GeoDEV RAN Facilitator

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generating specific components or axes. For example, a training, usage and feedback programme for the platform has been programmed and should take place in the first half of 2022 as part of a project submitted to the Space Climate Observatory (CNES) devoted to the monitoring of mangrove forests using Sentinel 2 imagery via an e-platform of online services. We have high expectations for this type of action, which allows us to integrate societal concerns into our own work for committed, involved and open science in line with the general policy that the IRD promotes. This approach is also in line with the founding principles of Theia, which are based on the sharing and pooling of remote sensing data and resources.

What are the needs in the South today? In your opinion, what are Theia's greatest achievements in this field and the major challenges for the consortium in the future?

Jean-François Faure: The partners in the South are unanimous about the need for training. Without taking the place of the competent entities in this field, we are trying to address this issue in GeoDEV in close collaboration with the different parts of the Theia consortium. Summer schools are offered. We regularly work on information sheets and teaching aids, and organise collaborative workshops dedicated to discovering Earth Observation, expressing our partners' needs in terms of imagery and indicators from satellite imagery, and co-constructing priority application projects in conjunction with Theia. Beyond these recurring needs, it appears that the very concept of an Earth Observation Competence Centre has an intrinsic value that attracts strong interest from many partners in the South who wish to set up similar structures.

In terms of scientific challenges and issues, applications that allow the measurement and monitoring of the impacts of climate change on human environments constitute an emerging request for several years now. This is one of the reasons why the GeoDEV partners are calling for projects to set up a consortium inspired by Theia..

»

« Providing key information for environmental studies to document changes and trends

Interview with Silvia VALERO

Senior lecturer at Paul-Sabatier University, Toulouse.

Facilitator for Theia Land Cover SEC

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

Who are you and what is your role in the Theia consortium? How and why did you get involved in Theia?

Silvia Valero: I am a senior lecturer in Computer Science at the University Paul Sabatier - IUT'A, Toulouse. My research activity within the CESBIO laboratory focuses on the fields of image processing and machine learning. I joined the Theia team in January 2021, replacing Jordi Inglada as main facilitator for the Land Cover SEC, best known for its OSO product: an annual, 10-meters resolution, automatically-produced land cover map for Metropolitan France using Sentinel-2A and Sentinel-2B data.

My involvement stems from the Sen2Agri and SenSAgri projects, which focused on the development of new methodologies for large-scale crop mapping on a European scale. My motivation for this commitment is to contribute to fostering between research organisations and users to improve the existing OSO product. It is very important for me to participate in bringing together the French community (research organisations and users) to address major scientific and societal issues. One of my main activities is the development of new machine learning methodologies for the exploitation of remote sensing data. The Land Cover product available on Theia is mainly produced by the classification of time series of optical satellite images. The synergy is clear!

What do you consider the current priorities in terms of land use mapping?

Silvia Valero: A revolution in remote sensing applications is underway in this new era of artificial intelligence and "big data". The integration of human knowledge into machine learning for land cover mapping is a very promising area of research. In this context, Theia Land Cover SEC provides an opportunity to discuss research developments and to collect knowledge from state actors and users.

The users have already raised several expectations. For example, the need for more frequent (ideally seasonal) land cover maps with adaptive land use legends. Thus, users are still in need of maps with higher spatial resolution in order to map green linear features, for example. In terms of nomenclature, the mapping of some land cover classes is unfortunately still difficult (such as areas of natural vegetation like wasteland, lawns, etc.). Users also stressed the need to map land cover from previous years (without Sentinel data) for the study of historical land cover evolution. This product could provide key information for environmental studies to document changes and trends. Unfortunately, mapping past years is very difficult due to the lack of data (satellite with high temporal resolution and reference data

In your opinion, what are the best achievements of Theia and the major challenges for the future?

Silvia Valero: As far as I am concerned, the best achievement seems to be the availability of data and products for the different users. In this sense, Theia has enabled exchanges and communication. In the immediate future, the large volume of data represents an important challenge, both in terms of ensuring that Theia has the necessary IT structure and in terms of supporting users in dealing with the large amount of data available. What information is essential? How to respond to new user demands? How to exploit the different data modalities? Another difficult but necessary task for Theia is to match the different products (and other European products) and to ensure that the data is available to the users.

»