BULLETIN
Theia Land Data Service Centre

n° 16 - May 2022

A word
from the publication directors

2022 marks a transition for THEIA with the leaving of Nicolas Baghdadi who, thanks to his great involvement and leadership, was able to set up the consortium and develop it to its current stage, illustrated in these pages: a dynamic network, transversal to many land surface themes, at the interface between innovative research and users.

With the recruitment process now complete, we are pleased to welcome Anne Puissant, who has been involved in Theia for many years through its SECs and RANs. She will take up her full duties as Scientific Director by the end of spring. We will have time to open these pages to her to present her projects.

In 2022, there will be no shortage of challenges. Theia will have to prepare to process the data from the new missions (SWOT, Trishna), take its place in the major structuring projects, such as Terra Forma or Gaia Data, and continue its work of scientific animation and mobilisation in the territories.

This issue of THEIA Bulletin presents important new services, products and methods: on-demand calculation of MNS, thermal data for cities, measurement of tropical deforestation, estimation of hydrological reservoirs, soil properties, flow velocity and ice thickness, all of which provide answers to the major environmental challenges facing our world. Enough to give us the energy and confidence to move forward. ■

NEWS

12 May 2022: a Day Dedicated to Monitoring Irrigated Areas

Following on from the Forest and Water Quality workshops held in the autumn, the THEIA consortium is organising a day dedicated to the use of remote sensing for irrigated areas on 12 May 2022 on the campus of the Institut Agro Montpellier, France.

The issue of monitoring irrigation and water management in the agricultural context is a major environmental challenge that mobilises various stakeholders: water agencies, managers of hydro-agricultural facilities, local authorities, chambers of agriculture, cooperatives, etc., as well as the scientific community developing methods to address it. While agricultural production increasingly relies on irrigation, ongoing climate change is increasing the frequency of droughts, requiring everyone to develop methods for monitoring and optimising water consumption in agriculture. For the past ten years, France has seen many areas resort to water restrictions each year, particularly for agriculture. In 2020, a record was reached with 80 departments subject to drought orders. Remote sensing, particularly through Sentinel data, can help to build responses to this challenge. The satellite images available today offer high spatial (10 m) and temporal (5 days with S2 optical sensors and between 15 and 20 images per month with S1 radar sensors) resolutions, available in near-real time at any point on the globe.

The workshop, which is open to all (public and private), will focus on the tools and operational indicators available and useful to stakeholders in order to carry out an objective and reproducible diagnosis of their territory, and to identify relevant adaptation strategies. It will provide an opportunity for actors in the field to share their experiences and needs and to exchange with research teams working in the field.

Programme and registration:
www.theia-land.fr/irrigation2022-inscription

The workshop, designed in person, is organised around the products and communities of THEIA Irrigation and Soil Moisture at Very High Spatial Resolution SECs and in partnership with the CNES, INRAE and the Institut Agro. As such, the UMR Cesbio, Tetis, G-eau and Emmah are associated with this event, which follows on from the workshop organised in Toulouse in 2018. Like the previous thematic workshops, this initiative benefits from the financial support of the European FPCUP scheme - Framework Programme Agreement on Copernicus User Uptake - dedicated to the promotion of the use of Sentinel data. ■

Scientific Committee: Nicolas BAGHDADI & Dominique COURAULT, INRAE, Valérie DEMAREZ, CESBIO - Gilles BELAUD, G-EAU

Irrigation SEC
► www.theia-land.fr/en/ceslist/irrigation-sec/
Soil Moisture at Very High Spatial Resolution SEC
► www.theia-land.fr/en/ceslist/soil-moisture-with-very-high-spatial-resolution-sec/

22 to 24 March : First Edition of the Trishna Days

From 22 to 24 March 2022, a conference dedicated to thermal infrared imaging at high spatial and temporal resolution around the TRISHNA mission was held in Toulouse, France.

The community of the different themes (Stress of eco-systems, coastal and continental waters, urban climate monitoring, cryosphere, solid Earth, atmosphere...) was present with more than 200 participants. 140 of them were on site at the Mercure Compans-Cafarelli hotel in Toulouse, including a delegation from ISRO with the Indian PI, Dr. Bimal Bhattacharya.

Coordinating efforts and supporting data use

All current and future scientific activities were discussed, as well as the challenges that remain, with the aim of involving future users in the definition of the mission, better coordinating efforts and supporting the use of the data, both for the scientific community and for the applications that will benefit from it.

A first focus was devoted to product development and calibration/validation:

» Definition of scientific products and Trishna variables

» Requirements and constraints for the distribution of products to users

» Product development, through the writing of documents describing the algorithms

» Calibration and validation activities

The coming TRISHNA mission

Accurate monitoring of the Earth's surface water cycle is becoming extremely important in the context of climate change and population growth. It also provides valuable information for a number of practical applications: agriculture, soil and water quality assessment, irrigation and water resources management, etc. It requires surface temperature measurements at the local scale.

The latter is the objective of the Franco-Indian mission TRISHNA (Thermal infraRed Imaging Satellite for High-resolution Natural resource Assessment), led by ISRO, the Indian Space agency, and CNES, the French Space Agency. The satellite will be launched in 2025.

Surface temperature and its dynamics are accurate indicators of soil water evaporation, plant transpiration and local climate. Trishna and its frequent high-resolution measurements raise major scientific, economic and societal questions through the six themes that the mission addresses in terms of research and application development: ecosystem stress and water use, coastal and inland waters, urban climate monitoring, cryosphere, solid Earth, atmosphere

A second focus was devoted to scientific topics and associated applications:

» Ecosystem stress and water use (progress in assimilating land surface temperature or evapotranspiration into hydrological models)

» Coastal and inland waters

» Urban climate monitoring

» Cryosphere

» Solid Earth

» Atmosphere

Delegations from NASA/JPL and ESA also came to Toulouse to promote the future synergy between the TRISHNA, SBG and LSTM missions. The meeting laid the ground for a future effort to harmonise the format of the products, the content of the processing algorithms and the CAL/VAL between these three missions.

Another TRISHNA DAYS event in 2023 in India is envisaged. All informations are on ► www.trishnadays.com ■

Thierry CARLIER,
TRISHNA Project Manager CNES

Philippe GAMET,
TRISHNA Project Scientist CESBIO/CNES

Jean-Louis ROUJEAN,
TRISHNA Principal Investigator (France) CESBIO

Philippe MAISONGRANDE,
Land Program Manager CNES

Delphine LEROUX,
TRISHNA Downstream applications CNES

Bimal K. BHATTACHARYA,
TRISHNA Principal Investigator (India) ISRO

12 April 2022| GAIA Data ESR/Equipex+ Project Kick-Off

Seamless access to a continuum of interoperable distributed data and service infrastructures for cross-referencing, analysis and dissemination has become a challenge for the Earth system sciences.

Supported by the three French E-Infrastructures of the Earth system and environment domain - DATA TERRA, CLIMERI-France, PNDB - and involving 21 partners, GAIA Data aims to develop a data and services infrastructure for the observation, modelling and integrated understanding of the Earth system, biodiversity and the environment.

The project responds to the scientific challenges of multidisciplinary and multi-scale approaches to the Earth system, involving the atmosphere, oceans, continental surfaces, internal Earth, biodiversity and their interactions.

Managing the entire data cycle

The system, based on very high-speed interconnected data centres and services, will make it possible to manage the entire data cycle and seamlessly access, extract and combine multi-source data in order to develop intelligent products and uses adapted to the needs of the scientific communities.

GAIA Data kick-off meeting will take place on 12 April 2022 at the Muséum National d'Histoire Naturelle in Paris (France), in the presence of Claire Giry, Director General of Research and Innovation at the MESRI and the heads of the main partner organisations.

Save the date and stay tuned for more information on the project. ■

Sandrine Dalmar,

IRD, GAIA Data Project Manager

Three French Research Infrastructures (RIs) support the Gaia Data project:

Data Terra, its four thematic data consortia and the image acquisition mechanism, Dinamis
► www.data-terra.org

Climeri-France, National infrastructure for modelling the Earth's climate system
► climeri-france.fr

The Pôle National pour la Diversité Biologique (PNDB), a data centre serving scientists producing, managing and analysing biodiversity data
► www.pndb.fr

The project involves 21 partners: CNRS (coordination), CNES, IRD, INRAE, MNHN, IFREMER, BRGM, Sorbonne University, Météo France, IGN, CEA, IPGP, CINES, University of Grenoble-Alpes, University of Lille, University of Toulouse-III-Paul-Sabatier, University of Strasbourg, SHOM, OCA, FRB, CERFACS.

Budget: 62 million € over 8 years, including 16.16 million € of MESRI/PIA3 aid within the framework of the ANR/EQUIPEX+ programme "Equipements Structurants de la Recherche"; 560 FTEs mobilised.

The international jury of the EQUIPEX+/ESR programme has selected 50 projects for a total budget of €422 million. The GAIA project is one of the 18 projects ranked A+.

7 to 10 March 2022 | Four Days and an Award for the Critical Zone

The 6th OZCAR Research Infrastructure (RI) Days are being held from Monday 7 to Thursday 10 March 2022 in Ardèche (France). The OZCAR RI is developing the THEIA|OZCAR Information System, whose objective is to provide access to all in-situ continental surface observation data collected by French research organisations and their partners in France and abroad.

As at each of these meetings, key speakers will present the latest advances in research on the understanding of the functioning of the critical zone with, this year, a focus on the link between sediment and contaminant transport.

This meeting will be an opportunity to review the progress of the activities (workpackages) of the IR OZCAR and to present the new projects in response to the call for cross-cutting projects launched on 21 November 2021.

An award to honour young researchers on the critical zone

The 4th OZCAR ceremony during these days will reward a young researcher for his/her work on the critical zone, illustrating the integrated, multidisciplinary approach that the critical zone concept wants to promote. Multidisciplinarity can also extend to socio-ecological aspects. It may involve several observatories or several disciplines or both.

The award aims to encourage a young researcher (less than 8 years after thesis), first author of the article. This young researcher will be awarded, in addition to the Critical Zone Scientist of the Year award, a sum of 2000 to 3000 euros to carry out research in critical zone science. Applications will be reviewed by the winners of previous years (2019, 2020, 2021). ■

More information on the IR OZCAR
► **www.ozcar-ri.org**

OZCAR 2021 Award to Virginie Sellier for the article « Reconstructing the impact of nickel mining activities on sediment supply to the rivers and the lagoon of South Pacific Islands: lessons learnt from the Thio early mining site (New Caledonia) »
► doi.org/10.1016/j.geomorph.2020.107459

TERRA FORMA, a Smart Observatory of Territories at the Time of the Anthropocene, Is Launched

The Equipex+ TERRA FORMA project "Designing and testing a smart observatory for territories in the Anthropocene era" was officially launched on 24 January 2022 during a videoconference. The project aims to design and deploy a dense network of environmental sensors in different territories to better understand and adapt to ongoing environmental changes. These innovative sensors will be connected to data centres via wireless communication networks. Local stakeholders will be actively involved in the process.

This project is supported by the OZCAR and RZA research infrastructures (RIs). After an initial 3-4 year development phase for the sensors and communication infrastructures, all the devices will be installed on three pilot sites to refine the systems over a period of two years. At the end of the project in eight years' time, it is planned to deploy them at a dozen additional sites. The test and deployment sites will be sites of OZCAR and RZA RIs.

Defining the right tools

The kick-off seminar presented the project outline and its organisation. Two major witnesses introduced the round tables. Frédérique Aït-Touati presented the book *Terra Forma*, which gave its name to the project, as an introduction to a round table seeking to answer the question "Observing the Anthropocene: does science have the right tools? Gaël Musquet, an ethical hacker, presented his work on "the empowerment of people through new technologies", which introduced the second round table on "Observing the Anthropocene through participatory and open science".

Schematic illustration of what a TERRA FORMA observatory could be, a site combining fixed and mobile communicating sensors and communication platforms © Virginie Girard, Laurent Longuevergne, Arnaud Elger

TERRA FORMA shall be an active user the Gaia Data project (Read p.3), in which Data Terra IR is strongly involved. The implementation of the Terra Forma data acquisition and processing chain could thus constitute a use-case for Gaia Data. ■

Isabelle Braud
For more information:
►**terra-forma.cnrs.fr**

Monitoring Mangroves with Sentinel

A remote sensing platform with an application based on Sentinel images for mangrove observation is being developed at UMR Espace-dev in Montpellier (France) in close collaboration with THEIA GeoDEV RAN. This development follows on from the labelling of the project in 2020 by the Space Climate Observatory (SCO), and is accompanied by joint actions between Montpellier, Madagascar, French Guiana and New Caledonia.

Led by UMR Espace-Dev, the development of the platform is based on the GOLUM project (Global Observation of the Land-sea interface: end-User Mangrove Monitoring services), funded by the University of Montpellier and conducted in collaboration with La TeleScop. GOLUM will notably provide support in the follow-up of the development of the web platform, in the animation of its future users, and in the prospective reflection of operational services dedicated to the monitoring of mangroves.

Qualified environmental information on mangroves

This platform, connected to the Sentinel-2 image stream, will provide universal access to past and near-real-time information on spatial changes in mangroves and the monitoring of vegetation indices characterising the structure and functioning of this ecosystem. It will make it possible to produce, catalogue and disseminate sets of qualified environmental information useful to scientists as well as to national and local stakeholders in the planning, preservation and management of territories.

As part of the technical and scientific activities of the UMR ESPACE-Dev team in New Caledonia and the Pacific region (SESAME project "Surveillance de l'Etat de SAnté des Mangroves dans le pacifiquE" financed by the French Foreign Affairs Ministry through the AAP Fonds Pacifique), this prototype will be qualified and validated on this territory and will contribute to its functional enrichment in order to anchor the application in the context of the New Caledonian territory and the Pacific region. ■

Élodie Blanchard,
IRD | Espace-DEV

& Jean-François Faure,
IRD | Espace-DEV
THEIA GeoDEV RAN Facilitator

Project presentation by the SCO for Madagascar
►www.spaceclimateobservatory.org/
mangroves-madagascar

The Golum project aims to monitor mangrove sites around the world.

New Caledonia Theia GeoDEV Animation Network: Learn more about the 2022 Initiative!

The 2021 edition of the OSS-NC was a first step in terms of visibility of the THEIA community in the Pacific region, with a plenary session (►Read THEIA Bulletin n°15). This year, the objective is to consolidate the key facilitating role of the THEIA Regional Animation Network (RAN) from the Pacific and the 2022 global event aims to be the biggest one ever held in an island territory from the region! #ChallengeAccepted

All informations on the OSS-NC 2021 edition are on the website ►oss.nc

Even at an early stage, THEIA NC GeoDEV RAN has already started a first series of discussions allowing the overall dimensioning of the event and a first round of potential partners.

A whole week and a regional influence

This year, the idea is to extend the event to a full week, with a possible link it with the annual regional GIS&RS conference of the Pacific Islands. But, overall, it aims to ensure common development of the territories of the region in the field of GIS and remote sensing, also considering enhancement of collaborations within the Pacific through structuring thematic projects that will facilitate both knowledge transfer and mutualization of means. This vast program should be consolidated in the coming months and such a regional event should be held in Noumea between November and December 2022. Much more discussions with the stakeholders and details to be defined and communicated as soon as possible.

There is still the time to be identified as potential partner, support and sponsor and to share all your possible ideas and visions for the benefit of the region, that we'll be glad to take into account the best for the common good. Please do not hesitate to contact in direct THEIA NC GeoDEV RAN representatives if you are interested in the topic and would like to contribute and even to be part of the task force! ◾

Jean MASSENET, INSIGHT, Marc DESPINOY, IRD
& Anne ROUAULTUniversity of New Caledonia

Facilitators of Theia GeoDEV New Caledonia RAN
►**www.theia-land.fr/en/art/new-caledonia-geodev-ran/**

hydroweb.next: Almost Ready for SWOT

hydroweb.next is the hydrological web portal of the THEIA continental surface thematic consortium. This portal, financed initially by the SWOT-Aval downstream programme and then by THEIA, aims to facilitate access to multi-sensor and multi-source (i.e. in-situ, model, satellite) hydrological data. The objective is to centralise a maximum of hydrological data and to provide advanced functions, in particular to search, compare, extract and manipulate these data.
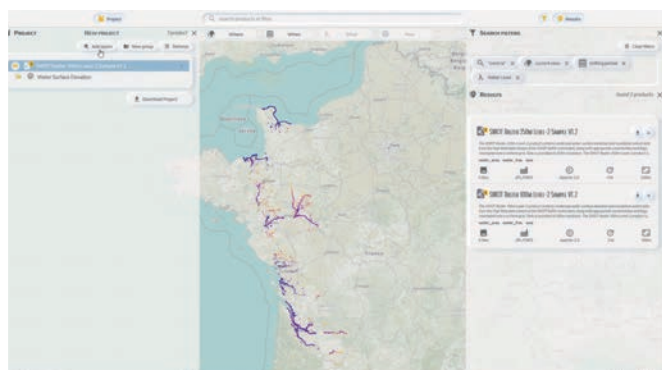
Note that hydroweb.next will be one of two portals, along with that of NASA's Jet Propulsion Laboratory (JPL), to disseminate the hydrological data of the SWOT mission, which is due to be launched next December.

Ergonomic, intuitive, built with users

The development of hydroweb.next started a little less than a year ago. Thanks to the collaboration of many users, hydroweb.next now offers an ergonomic and intuitive interface. It is already possible to search, view and download a number of data, including the simulated SWOT data.

The aim is to have the portal open to beta testers for the first time in March April 2022. This will be used to gather user feedback to further improve hydroweb.next. A wider opening is planned for mid-2022. ◾

Flavien GOUILLON & Lionel ZAWADZKI, CNES

Screenshot of the forthcoming hydroweb.next interface
To contact us and take part in its development: hydroweb-ng@cnes.fr

HYMOTEP: Producing for Hydrology, but not only

A production centre for hydrology within THEIA is being built: HYMOTEP, for HYsope II iMplementation Of TrEatments and Production.

The main objective of this centre is to realise the hydrological production plans of the THEIA continental surface data consortium. It should also, in the long term, offer a replacement solution for the Muscate production workshop, which produces the production plans for the other THEIA themes (i.e. vegetation).

HYMOTEP will allow a run-of-the-mill production of continental hydrology products (i.e. acquisition of input data, activation of scientific chains, and provision of the generated products for subsequent dissemination on the hydroweb.next portal). The centre will host products from hydrological chains such as LIS (snow). SurfWater (water surface) and Obs2Co (water quality/temperature), as well as the upstream chains necessary for these productions (S1-tiling, MAJA). The objective is to move towards continental coverage to meet the CAL/VAL needs of future missions including SWOT.

Ambitious production objectives for the coming year

The development of HYMOTEP began in October 2021. It is now able to generate products from MAJA and the LIS chain and soon SurfWater on a day-to-day basis in well-defined areas. The goal is to have day-to-day on all the chains mentioned in the summer of 2022, with active supervision by the operators of the production activities and consolidated metrics on the availability of HYMOTEP. ◾

Feel free to contact usand learn more:
hydroweb-ng@cnes.fr

Flavien GOUILLON, CNES

Modelling Cattle Movements for Disease Prevention

Florent Rumiano's thesis, entitled: The combined use of remote sensing and spatial modelling for animal movement: Application to the study of wildlife/livestock contacts and the risk of pathogen transmission in Southern Africa, was defended on 6 December 2021 at the Maison de la Télédétection, Montpellier, France. This thesis is part of the research activities carried out by the ASTRE and TETIS units within Theia Risks associated with infectious diseases SEC, and was funded by the MUSE i-site within the framework of the "TEIédétection et Modélisation sPatiale de la mObilité animale" (TEMPO) project.

Modelling movements and interactions

The aim of this thesis work was to:

1) characterise at landscape scale the environmental variables influencing the movements of two target animal species, a wild ungulate species (buffalo - *Syncerus caffer caffer*) and a domestic ungulate species (cattle- *Bos taurus* & *Bos indicus*) in three interface areas located in Southern Africa: Hwange, Gonarezhou and North Kruger National Parks;

2) to simulate the movements of the two focal animal species, at the individual and herdscales, in relation to their respective environments;

3) to determine the nature, frequency and location of contacts between the two focal animal species in order to better understand the risks of pathogen transmission.

The methodological approach, combining remote sensing, telemetry and spatial modelling, highlighted strong spatial and temporal variability in water availability in the three interface areas. The developed spatialized mechanistic movement models, based on the principle of collective movement of self-propelled individuals, showed a positive and significant correlation between observations/simulations of movements and the use of space by herds of the two focal animal species. The overall accuracy of the spatial movement models has been increased by taking into account the vegetation cover in addition to the surface water, thus allowing the frequency and spatial location of observed inter-species contacts to be reproduced, despite a fluctuation in accuracy depending on the interface areas considered.

Reproducible results

This exploratory and multidisciplinary work demonstrates the possibility of developing simple mechanistic models, requiring few parameters, to generically simulate the movements and contacts of animal species in direct relation to their respective environments. Furthermore, the mechanistic models developed in this thesis can integrate heterogeneous spatial data while being scalable and modular, allowing dynamic observations and simulations at different spatio-temporal scales in various ecological contexts with a variety of animal species.

THEIA Risks associated with infectious diseases SEC provides the results of this work, namely the environmental data used as input to the models (the surface water maps and the landcover maps), produced from a series of Sentinel-2 images (already available), as well as the contact maps and source codes (soon available). ■

Florent RUMIANO & Annelise TRAN,
CIRAD, TETIS

Link to the video of the thesis defense
►tempo.cirad.fr/actualites
/soutenance-de-these-florent-rumiano
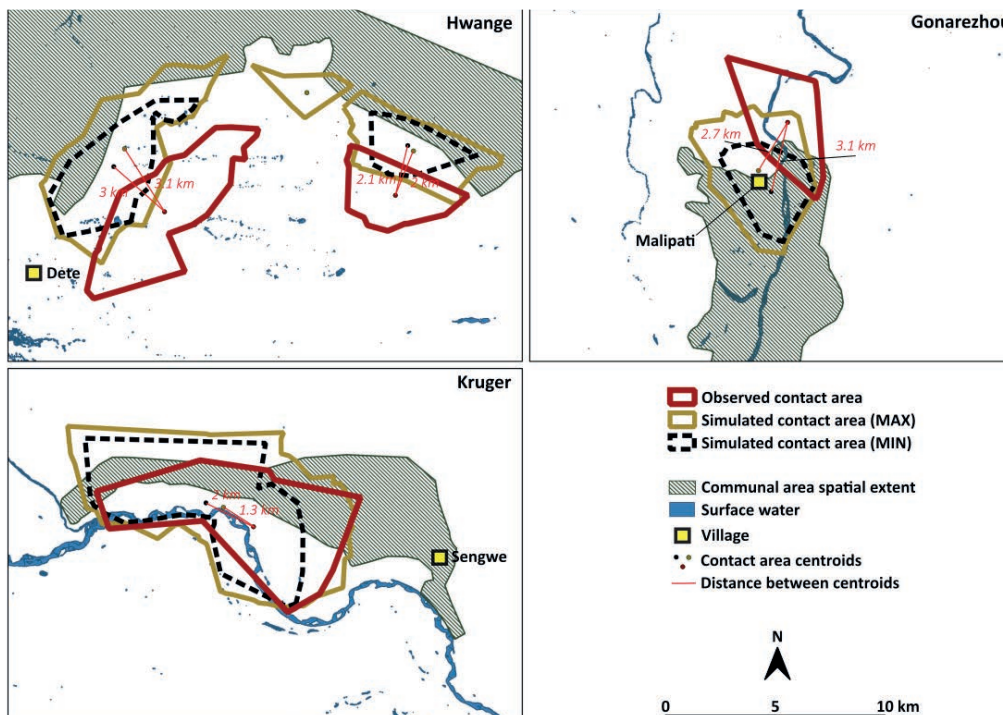Risks associated with infectious diseases SEC
► www.theia-land.fr/en/ceslist/
risks-associated-with-infectious-diseases-sec/
Land use data for parks
►www.theia-land.fr/product/
occupation-du-sol-de-parcs-nationaux-au-zimbabwe/
Data on the evolution of water surfaces in parks
►www.theia-land.fr/product/
surfaces-en-eau-de-parcs-nationals-in-zimbabwe/

Observed contact area
Simulated contact area (MAX)
Simulated contact area (MIN)

Communal area spatial extent
Surface water
Village
Contact area centroids
Distance between centroids

Land use, vegetation and water availability data are used to model animal movements and predict the potential transmission of pathogens.

PRODUCTS & SECs

A Service to Generate Digital Surface Models (DSM) from Pléiades Stereoscopic Images

Pleiades images can be acquired in stereoscopic (pairs of images) and tri-stereoscopic (triplet of images) modes. This acquisition mode allows the Earth's surface to be covered at a resolution of 0.70 m with slightly different viewing angles and from the same orbit, which makes it possible to quickly obtain a homogeneous product. The photogrammetric processing of the image pairs and/or triplets allows for the matching of images and the reconstruction of their depth, enabling the generation of very high-resolution topographic models of the ground surface.

An online service accessible to non-experts

Since September 2021, the Solid Earth Centre (ForM@Ter), in collaboration with THEIA Consortium and the DINAMIS mechanism, released the DSM-OPT (Digital Surface Models from OPTical stereoscopic very-high resolution imagery) on-demand processing service.

This service allows the calculation of Digital Surface Models from Pléiades stereo/tri-stereo images, either by uploading the images from a computer or directly from the DINAMIS institutional catalogue. The DSM-OPT service was developed by EOST with the contribution of IGN/Matis and IPGP. It is deployed on the A2S computing infrastructure hosted at the University of Strasbourg / Mésocentre. The service has been set up with the support of ESA, CNES and CNRS/INSU.

The service is aimed at communities that are not experts, with the possibility of launching the calculation with predefined parameters, and also at expert communities that can act on the parameterisation. It is based on the MicMac photogrammetric library (IGN/Matis) and ad-hoc developments from the EOST and IPGP laboratories. The service allows the filtering of the calculated elevation grid, the alignment and co-registration of the elevation grid on a reference altitude grid (to allow multi-date comparisons), the generation of true ortho-images and an ortho-mosaic and the export of the products in point clouds or grids. The prod-

Figure 2. Example of a digital urban surface model generated for the city of Strasbourg (Grand-Est) in the framework of THEIA Urban SEC activities (© A. Puissant & A. Stumpf, LIVE/THEIA)

ucts are made available under a CC-BY-NC license excluding any commercial exploitation.

Developments are on-going to extend the service's capability to process Spot6/7 and Pléiades-Néo images, and to distribute the user's Digital Surface Models free of charge via a dedicated catalogue from mid-2022.

Two examples of how the service is used to 1) monitor the dynamics of volcanic eruptions (Figure 1) and 2) create urban digital surface models (Figure 2) are presented below.

The service is accessible to authorised users and members of the Data Terra Research Infrastructure from the page dedicated to the on-demand calculation services on the ForM@Ter portal. To access the service, it is necessary to be authenticated. ∎

Jean-Philippe Malet and David Michéa, EOS,
Emilie Ostanciaux and Elisabeth Pointal, ForM@Ter,
Catherine Proy, CNES

DSM-OPT Service
► https://en.poleterresolide.fr/services-en/mns.

Figure 1. Example of a numerical surface model generated on the Soufrière de Saint-Vincent volcano (West Indies) during the April 2021 volcanic crisis, and calculation of accumulated tephra volumes (© R. Grandin, IPGP/ForM@Ter)
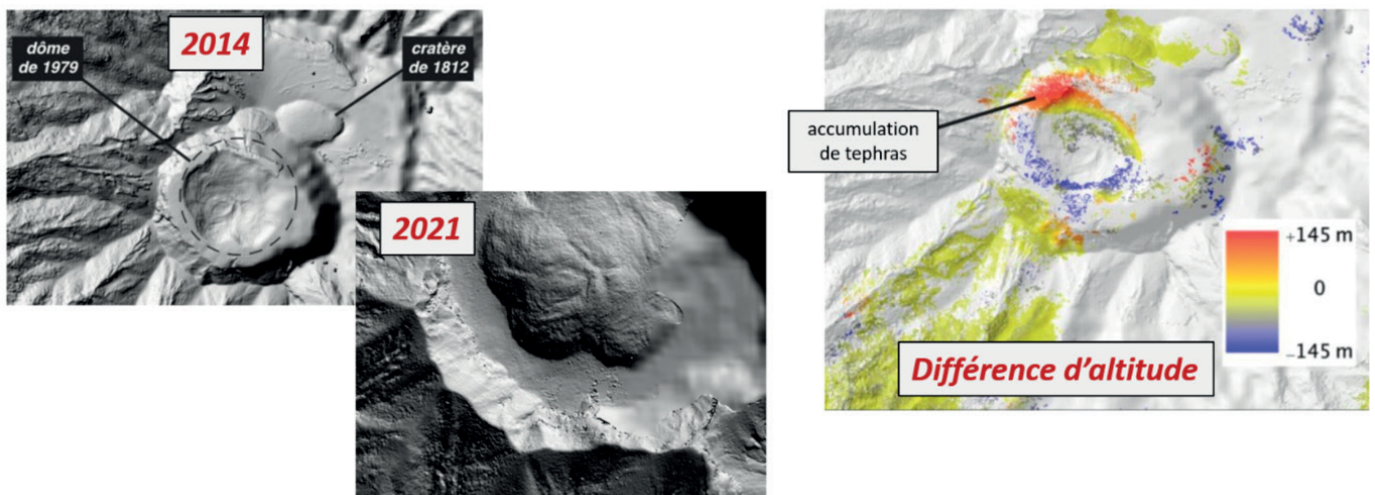
THERMOCITY: Spaceborne Thermal Data for Urban Studies

THERMOCITY is a project labelled by the Space Climate Observatory (SCO). Launched in 2020 for two years, the project is led by CNES in collaboration with ONERA, CSTB and Météo-France. It considers the study of the thermal behaviour of cities using satellite data in the context of climate change and global warming. The final objective is to provide tools for decision-makers with indicators to support urban planning.

Spaceborne thermal data are fundamental in THERMOCITY, but two case studies can be distinguished: thermography in summer and in winter. The first helps mapping the Surface Urban Heat Islands (SUHIs) while the second allows the location of poorly insulated buildings and provides an energy performance index at the urban block level or at the city level. Other data derived from spaceborne sensors can be used to refine the diagnosis, generally from the reflective domain at higher spatial resolutions, such as the land use, the 3D structure or the albedo among others. Five French cities were chosen to constitute our study areas: Marseille, Montpellier, Paris, Strasbourg and Toulouse.

Providing sufficient resolution

Around ten ASTER and ECOSTRESS (NASA) Land Surface Temperature (LST) products were retrieved for each study area, consequently around fifty images over the period 2003-2020 were obtained (images available on the THEIA website). These products are generated operationally but they do not generally take into account specific characteristics of urban environments, which can decrease the accuracy of the retrieved LST. The objective was therefore to improve the existing products by working on:

» A better consideration of the atmospheric conditions of the studied urban area to improve the performance of the atmospheric correction. Thus, for ECOSTRESS, an atmospheric correction was carried out using atmospheric profiles Météo-France produced;

» Taking into account the spectral variability of artificial materials within the Temperature and Emissivity Separation (TES) algorithm. A TES method adapted to urban environments was used to process ASTER and ECOSTRESS data;

» Improving the spatial resolution of surface temperature mapping with a disaggregation method. This method is based on a linear empirical relationship between a vegetation index and LST. The proposed method sharpened the ASTER LST images from 90m to 30m.

Beforehand, CNES carried out an extensive georeferencing work. The data were re-aligned on Sentinel-2 images, an essential step to limit errors when merging and comparing the different spectral bands and products.

For more details on the different processings that were applied, technical reports are available on the THEIA LST/LSE SEC page. The products are LST maps at 30 m, 70 m and 90 m spatial resolutions. A SUHI map analysis was also performed.

» For ECOSTRESS only: atmospheric correction using the COMANCHE radiative transfer software developed at ONERA [1].

» Application of the urban TES. This algorithm involves the classification of pixels to separate artificial and natural surfaces. For this purpose, the Imperviousness density product of COPERNICUS was used. More details in [2].

» For ASTER only: disaggregation of the LST products generated in the previous step with the daytime ATPRK method and the nighttime AATPRK method (when the necessary data were available) with the NDVI. More details in [3,4].

» Generation of a quality indicator called QA (Quality Assessment) for each image. It evaluates the impact of the 3D structure, the influence of the mixed pixels due to the spatial resolution and the physical consistency of the retrieved parameters. It is not an error propagation calculation but a quality indicator allowing users to filter pixels as needed.

» Generation of SUHI map from the generated LST products using a rural reference area to highlight thermal contrasts.

Innovative methodologies

The methods used in this project were validated in previous studies described in the different publications mentioned in the references:

» The LST maps are visually and quantitatively in agreement with the NASA LST products. Nevertheless, built-up areas and bare soils show a higher LST, which is in line with the expected behaviour of these surfaces whose emissivity is often overestimated in a classical TES algorithm

» The ASTER LSTs at 30 m show an increased visual quality with values close to the values at 90 m while revealing more contrast, allowing a finer scale analysis. No quantitative assessment could be made due to no available ground truth.
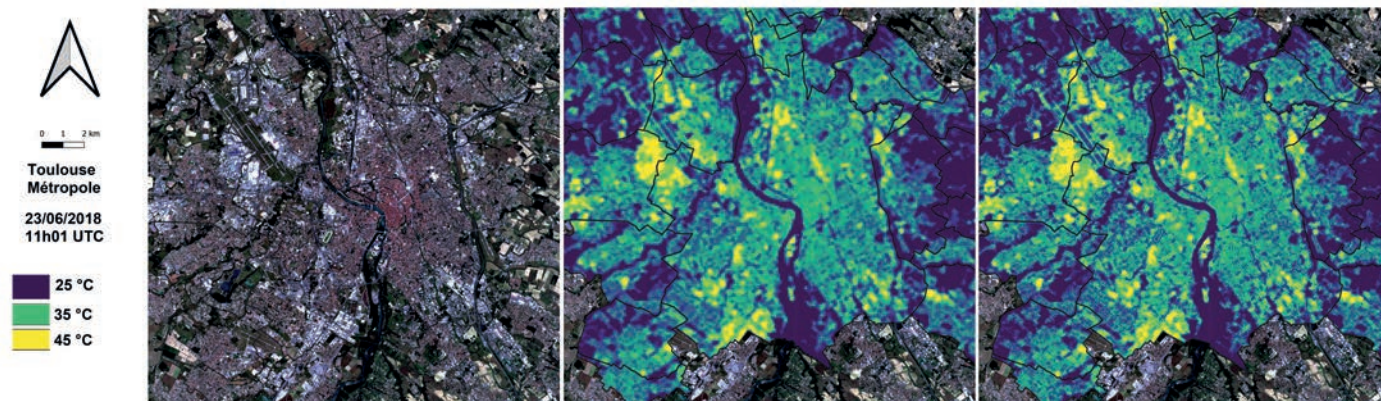
Légende : vue Sentinel-2 (gauche), LST à 90 m de résolution spatiale (milieu), LST désaggrégée à 30 m de résolution spatiale (droite)

Figure 1. The city of Toulouse in optical view by Sentinel-2 (left), surface temperature (ASTER, 90m, centre), and super-resolved surface temperature (ASTER, 30m, right). One of the challenges of the THERMOCITY project is to provide the best possible surface temperature products. To do this, CNES and ONERA have made significant improvements to the original products by refining geolocation, temperature determination and increasing the spatial resolution by a factor of 3 for ASTER data.

Légende : vue Sentinel-2 (gauche), LST à 90 m de résolution spatiale (milieu), LST désaggrégée à 30 m de résolution spatiale (droite)
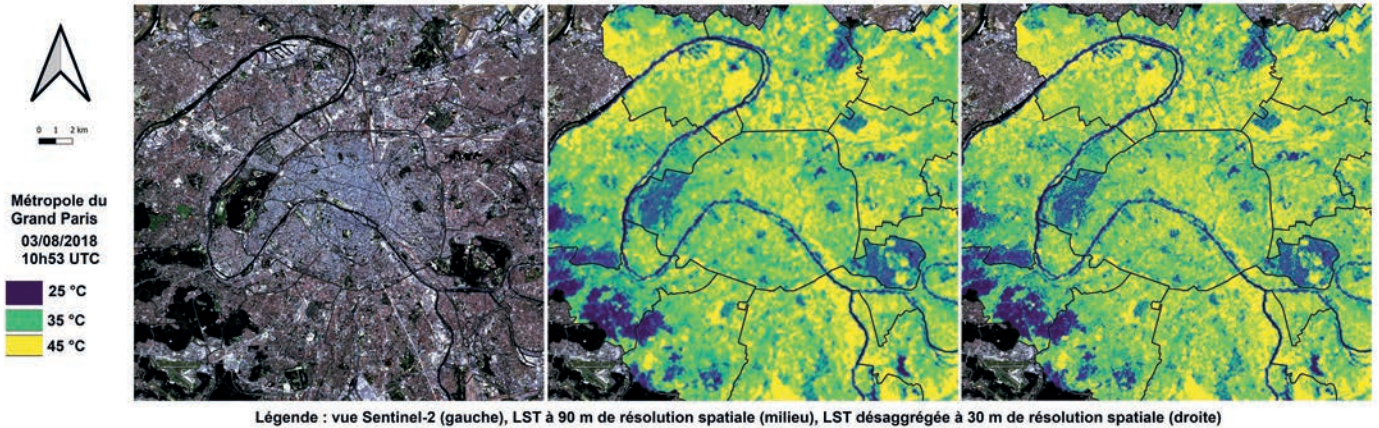
Figure 2. Paris agglomeration in optical view by Sentinel-2 (left), surface temperature (ASTER, 90m, centre), and super-resolved surface temperature (ASTER, 30m, right).

» The SUHI (Surface Urban Heat Island) maps highlighted the lack of procedure to define a reference area that is representative of the rural environment. More investigation is needed to refine the selection procedure for a generalized SUHI calculation. Despite this, the generated maps show interesting thermal behaviours with overheating of the urban area at certain dates or thermal anomalies.

» Despite the corrections, geometric problems remain with some ECOSTRESS data that could not be completely corrected and are visible on the generated products. This confirms the need for precise geometric corrections before applying further processing.

Data to be used by users

We have now entered the second phase of THERMOCITY: using the generated datasets. In order to do so, a workshop was held with the users of the metropolises to define the studies to be carried out and the expected outputs. Three main works emerged: the first on urban land use, its evolution and its effect on the urban climate, the second on the extraction and characterisation of thermal anomalies in the city and, finally, the third on the study of the urban heat island effect and the associated mitigation solutions.

On this last point, the skills of the other actors in the project will be crucial. For example, Météo-France, the French Weather Forecast Agency, will be able to simulate the effect on the urban climate of a revegetation policy at the scale of a metropolis, while the CSTB will provide its expertise at building level.

In line with the SCO spirit promoting open-access, all the data produced within the framework of the project and the associated study reports will be made public by the end of the year. THERMOCITY data is already available on THEIA. ∎

Aurélie Michel, Laure Roupioz, Xavier Briottet, ONERA

Vincent Lonjou, CNES

Surface Temperature and Emissivity SEC
► https://www.theia-land.fr/en/ceslist/surface-temperature-and-emissivity-sec/

Thermocity data
► www.theia-land.fr/en/product/thermocity-en/

More links
► www.spaceclimateobservatory.org/fr/thermocity-toulouse
► asterweb.jpl.nasa.gov
► ecostress.jpl.nasa.gov

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[4] Carlos Granero-Belinchon; Aurelie Michel; Jean-Pierre Lagouarde; Jose A. Sobrino; Xavier Briottet. Night Thermal Unmixing for the Study of Microscale Surface Urban Heat Islands with TRISHNA-Like Data. *Remote Sensing* 2019, 11, 1449 .

TropiSCO: Monitoring Forest Cover Loss in Dense Forests

The objective of the TropiSCO project is to provide maps for monitoring forest cover loss in tropical dense forests using Sentinel-1 satellite images, starting in 2018 and continuing. The maps will be publicly accessible via a webGIS platform and provided at a temporal resolution of one week, a pixel size of 10 meters, and a smaller detection size of 0.1 hectare (corresponding to ten Sentinel-1 pixels). The added value of this detection system compared to other existing systems lies both in the fine spatial resolution and, above all, in the short detection time for forest cover loss, whatever the weather conditions, which is essential in the tropics for rapid interventions in the field.

A project bringing together many players

The TropiSCO project, accredited by the Space Climate Observatory in 2021, is being conducted by GlobEO in close collaboration with CNES and CESBIO. The project is divided into two phases A and B. The three objectives of phase A, which will end in April 2022, are the collection of user requirements, an analysis of the system architecture and the costs associated with each technical solution studied, and a demonstration of the concept in seven countries with the creation, by the company Someware, of a dedicated webGIS. The demonstration is made in Guyana, Suriname, Guyana, Gabon, Vietnam, Laos and Cambodia. The main objective of phase B will be to extend the method to all dense tropical forests.

Products adapted to user needs

At present, user needs have been collected via a questionnaire from 25 institutions and are being analysed. They provide us with valuable information to produce the most relevant mapping products possible. In parallel, the architecture of the production system is being studied at CNES, in order to design a technical solution adapted to the ambition of this project.

Figure 2. Logging area in Suriname. The first cuttings are often associated with the creation of forest roads, followed by selective cuttings. Background image: Google Earth.
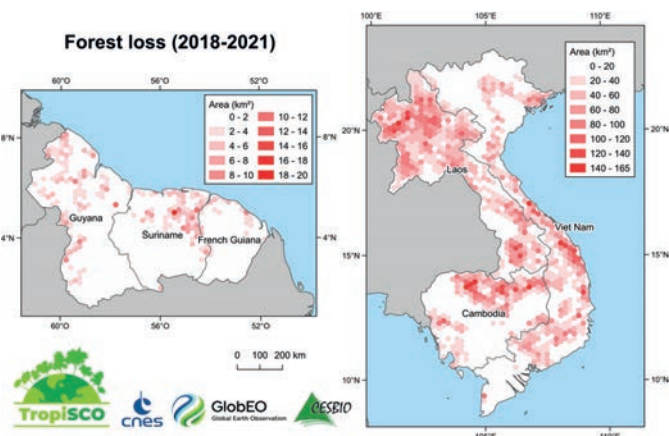
Figure 1. Synthetic maps of logging activities from January 2018 to December 2021 in Suriname and Guyana, with a weekly temporal resolution and a pixel size of ten meters, obtained with Sentinel-1 satellite images.
The figure was made with the help of Simon Gascoin and Maylis Duffau.

The products generated by the TropiSCO project consist mainly of maps of forest cover losses at high spatial and temporal resolution, and also of synthetic maps highlighting areas of significant activity, as well as monthly and annual statistics by territory (provinces, countries, etc.).

Examples of synthetic products are shown in Figure 1. The red shading indicates the area of cut forest within each 460 km2 hexagon. Examples include gold mining in Suriname on the border with Guyana, as well as the cutting of tree plantations in central Vietnam and the conversion of natural forests to tree plantations in northern Laos. The contrast between northern Laos and Vietnam can also be seen, illustrating that forest exploitation and management is highly dependent on national strategy. More than 70,000 Sentinel-1 images were processed with CNES computing resources to produce maps of Vietnam, Laos and Cambodia, covering 1,230,000 km². For these three countries, the errors of omission and commission were estimated at 10% and 0.9% respectively, according to an adapted validation protocol (Mermoz et al., 2021). Figure 2 shows an example of a detection map over Suriname from 2018 to 2021. The colour gradations from yellow to red show the progressive evolution of forest roads over time. Selective logging (yellow to red dots) is visible between the roads.

This work was presented on 11 October 2021 at the THEIA workshop on the uses of remote sensing for forestry, and on 20 January 2022 at the third Quarterly Meeting of the SCO France. By the end of phase A, the TropiSCO team will be working on the complete automation of the processing chain and on the production of forest loss maps for Gabon. The webGIS will be open and accessible to all in April 2022. ■

Stéphane Mermoz,
GlobEO, CESBIO

►www.spaceclimateobservatory.org/fr/tropisco-amazonia
►www.spaceclimateobservatory.org/tropisco-southeast-asia

Video presentation of the TropiSCO project during THEIA workshop "The uses of remote sensing for forestry", on 11 October 2021 in Montpellier (France)
►www.youtube.com/watch?v=M7AwJEd2lQc
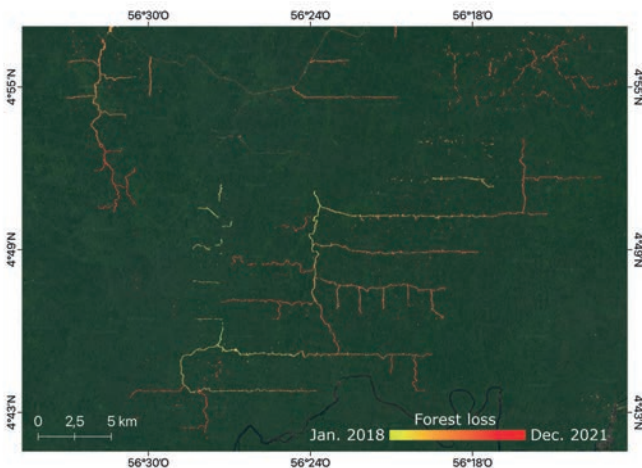
Reference

Mermoz Stéphane and al. (2021). Continuous Detection of Forest Loss in Vietnam, Laos, and Cambodia Using Sentinel-1 Data. *Remote Sensing*, 13(23), 4877.
doi.org/10.3390/rs13234877

Detecting Water under Altimeter Tracks to Improve the Estimation of Surface Water Storage in Wetlands

The amount of surface water stored in lakes, rivers and flood-plains plays an essential role in the hydrological, biogeochemical and carbon cycles. This hydrological reservoir has recently been recognised as a key climate variable. However, at present, the quantities of water contained in the surface hydrological reservoir and their temporal evolution remain poorly known on a regional scale, and, a fortiori, on a global scale.

The benefits of altimetric backscattering

Satellite remote sensing is an essential tool for monitoring the surface hydrological reservoir. Before the launch of the Franco-American (CNES-NASA) Surface Water and Ocean Topography (SWOT) mission in 2022, which will map, for the first time, the water levels of continental hydrosystems using the low-incidence SAR interferometry technique, several techniques can already be used to estimate the temporal evolution of the water quantities contained in the surface reservoir. To do this, it is necessary to estimate both the extent and the level of the water bodies. Satellite imagery, optical, radar (SAR), or passive microwave, can be used to monitor temporal variations in the extent of wetland flooding. Satellite, radar or lidar altimetry provides time series of water level over lakes, rivers and flooded areas. For lakes and rivers, automatic or semi-automatic techniques have been developed to update the water level time series with each altimetry mission. On the other hand, on floodplains, which are often temporary, the rare altimetric water level time series are created manually. Given the extent of these areas, where there are many intersections with altimeter tracks, it is fanciful to think of creating dense networks of virtual altimeter stations without resorting to methods of identifying the water beneath the satellite tracks. As a result, the estimation of surface water quantities in these environments is approximate.

Few studies have demonstrated a link between the water status of continental surfaces and altimeter backscatter. A recent study has shown that it is possible to use temporal variations in altimeter backscatter to identify the presence of water below the track. This study was conducted in the central Congo basin, a large floodplain in the tropics with key wetlands under forest (Figure 1). In this region, an analysis of the annual cycle of Ku-band (~13.6 GHz) backscatter measured by the ENVISAT (2002-2010 on its nominal orbit) and Jason-2 (2008-2016 on its nominal orbit) altimetry missions using an unsupervised classification technique (k-means) made it possible to distinguish between
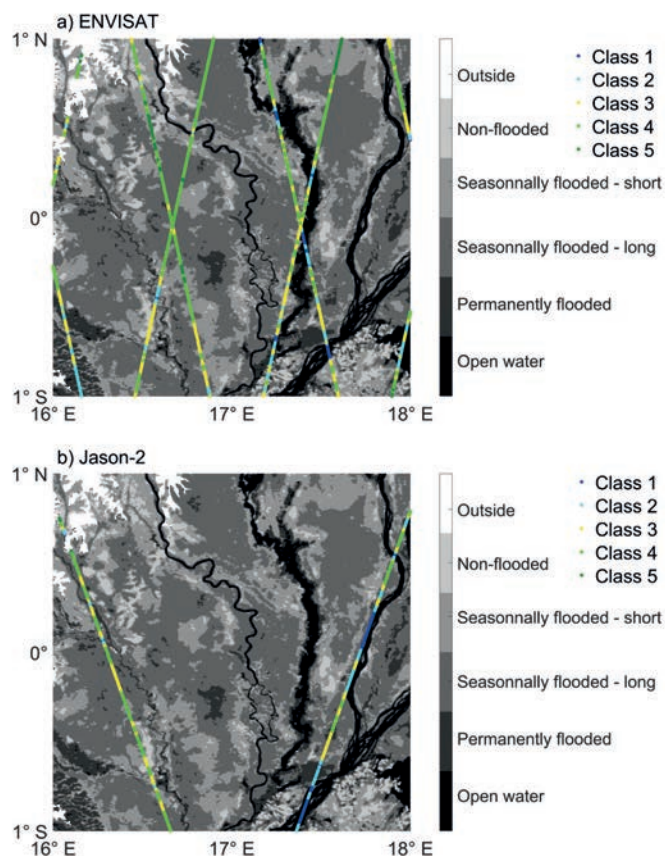

Figure 2: Results of the ENVISAT annual backscatter cycle classification using the k-means algorithm. The classes represented by dark blue, blue and yellow dots correspond to the water areas of the land use map (rivers, permanent and seasonal flooded areas).

water classes and vegetation classes (Figure 2). The results were compared to a land cover map produced from PALSAR L-band SAR images and Enhanced Vegetation Index (EVI) maps derived from MODIS multispectral reflectances. The correct detection of the classes corresponding to water areas (open water, permanent and seasonal flooding) is above 90%.

A network of virtual stations

For the classes identified as water, water level time series were created over the central Congo basin. Criteria were taken into account to create the network of virtual height stations. They are related to the minimum and maximum dimensions of the virtual stations (i.e. the number of measurement points per pass of the altimeter on which the water level is estimated) and the minimum distance between two virtual stations located on the same track. It was thus possible to build several hundred virtual altimeter stations in the Congo Central Basin (358 and 250 for ENVISAT and Jason-2) both on the river and in the flood plains. Comparisons were made with manually constructed altimeter time series made available by the Hydroweb database (hydroweb.theia-land.fr/) on rivers and lakes. In the vast majority of cases, a very good agreement (correlation > 0.95 and root mean square deviation of less than or equal to 0.25 m) was obtained.
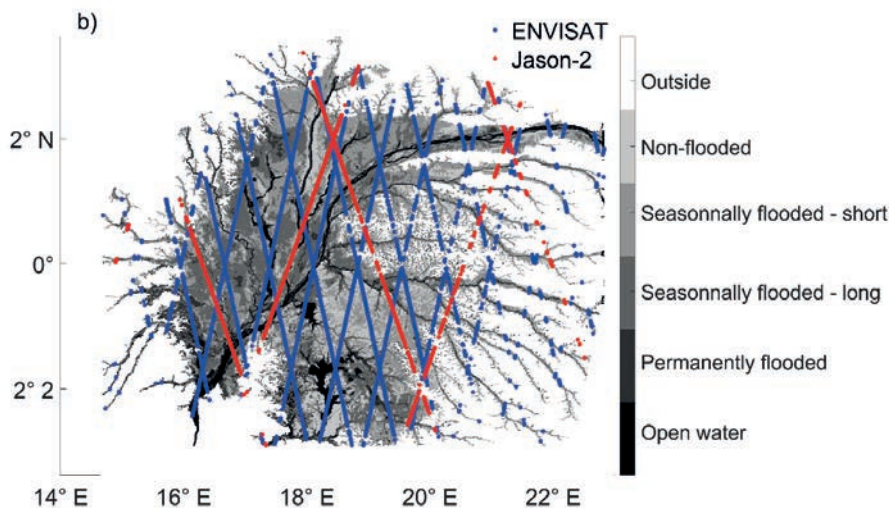

Figure 1 : The Central Cuvette of Congo in Equatorial Africa. Altimeter tracks (ENVISAT, Jason-2) are superimposed on the land use map of the region.
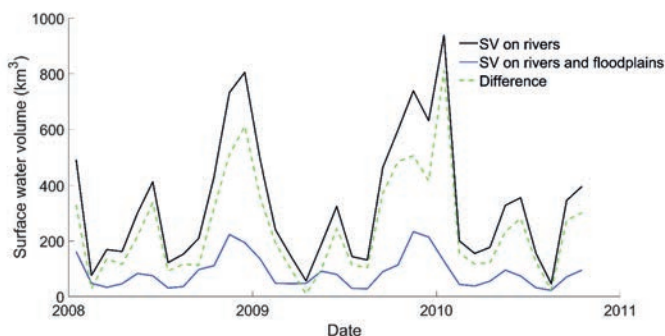
Figure 3. Measurement of the altimetric water level of the rivers and the whole central basin of Congo.

In order to estimate the impact of the densification of the network of virtual elevation stations on the surface water stocks deduced from the combination of imagery flood extent and elevation water level information, water level maps were produced using either the elevation water levels over the rivers flowing in the central basin or those obtained over the whole basin. The associated surface water volume variations were calculated in both cases (Figure 3). As the water level variations on the wetlands are smaller than those in the rivers, surface water volumes four times smaller were observed when taking into account the variations on the floodplains. This shows the importance of integrating floodplain water level variations for hydrological balances. ■

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Julie BETBEDER & Valéry GOND, CIRAD
Régis BELLOT, IGN
Nicolas BAGHDADI, INRAE, UMR TETIS
José DARROZES & Luc BOURREL, GET,
Frédérique SEYLER, ESPACE-DEV, IRD

Surface Water Volumes of Floodplains SEC
►**www.theia-land.fr/en/ceslist/water-volumes-sec**

Digital Soil Mapping: Educational Resources and Property Maps

Theia Digital Soil Mapping Scientific Expertise Center main action is pursuing methodological work in collaboration with its members to evaluate existing products and improve future Products. Nevertheless, at the beginning of 2022, various recent achievements are available to users.

Partnering for the dissemination of soil property maps

Two types of map products are available or in the process of being made available at national and/or regional scales:

» **Soil property maps** following the specifications of the GlobalSoilMap project. This product is already distributed for the former Languedoc Roussillon region by the Theia regional facilitator for Occitanie, OPenIG.

Examples of soil properties mapping using GlobalSoilMap format for what used to be the French Languedoc-Roussillon region.

GlobalSoilMap maps at the national scale have also been produced and are being disseminated by the INRAE Infosol Unit. Other regional GlobalSoilMap products are expected in the near future.

» **Soil Available Water Capacity Map.** This functional property of the soil, crucial for many decisions, has benefited from a specific effort at both national and regional scales.

On the national scale, a map is distributed by the Infosol unit. At the scale of the former Languedoc Roussillon region, a map of the soil's useful reservoir (and associated uncertainty) is distributed by OPenIG.

Educational resources

In addition to producing data, Theia Digital Soil Mapping SEC has also set itself the objective of disseminating the methods and tools used to produce soil property maps.

This is currently done through a website ►philippelagacherie. wixsite.com/cartograph-e, which objective is to provide users with the fundamental knowledge of Soil Mapping by Statistical Modelling and to provide the main information concerning the use of products such as soil property maps.
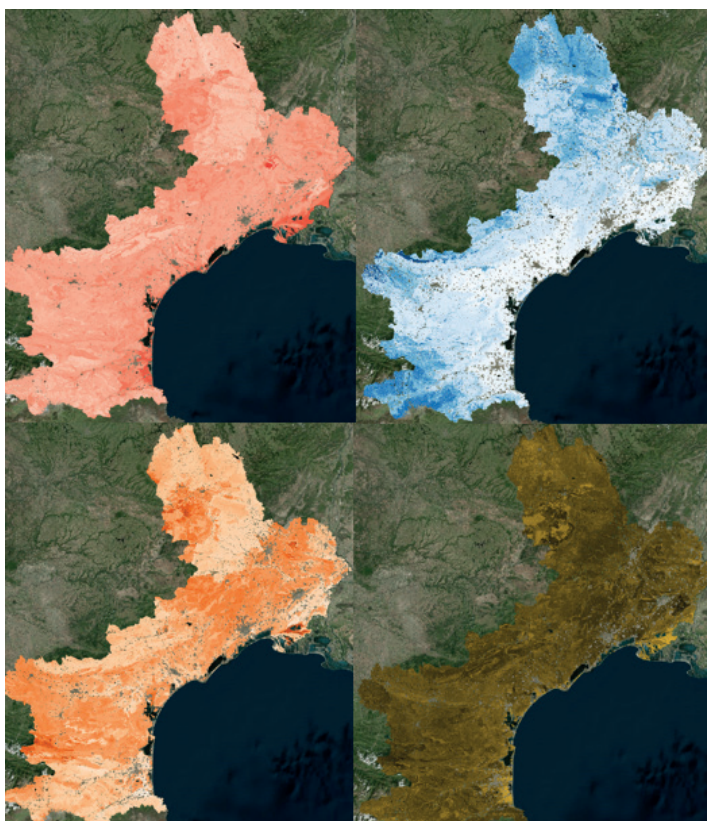
From the beginning of 2022, Anne Richer de Forges (Infosol Orléans) will take over from Philippe Lagacherie for the facilitation of Theia Digital Soil Mapping SEC. ■

Philippe LAGACHERIE,
INRAE, UMR LISAH
& Tom BRUNELLE,
OPenIG

Digital Soil Mapping SEC
►**www.theia-land.fr/en/ceslist/digital-soil-mapping-sec**
Soil properties maps
(requires an OPenIG account)
►**ckan.openig.org/dataset/digital-soil-maps -soil-property-maps-in-languedoc-roussillon**
Maps of the useful soil reservoir
►**ckan.openig.org/dataset/cartes-numeriques-du -useful-soil-reservoir-in-languedoc-roussillon**

Flow Velocity and Ice Thickness: An Unprecedented Combination of Indicators for all the Earth's Glaciers

Within the framework of the Glaciers Scientific Expertise Center of the French Land Data Consortium THEIA, glaciologists from the Institut des Géosciences de l'Environnement in Grenoble (France) - Université Grenoble Alpes, CNRS, IRD, Grenoble-INP, with the support of CNES - and Dartmouth College (USA) are publishing two new products covering all of the world's glaciers. The first product is the mapping of glacier flow velocities on a global scale (Figure 1), and the second is the distribution of ice thicknesses in these glaciers (Figure 2).
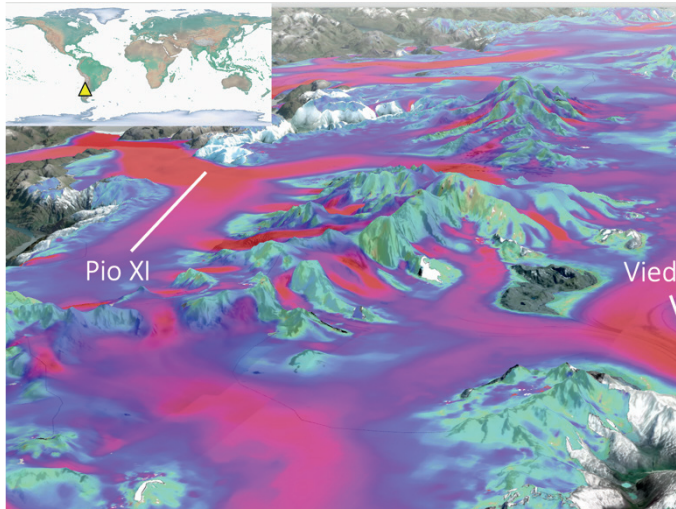
Figure 1: Map of glacier flow velocities flowing from the southern Patagonian ice field (2017-2018).
Similar data are available for all major ice regions on Earth.

The mapping of glacier flow velocities was first established from satellite images covering the period 2017-2018, mainly from the Sentinel-1 and -2 (Copernicus, ESA) and Landsat (USGS, NASA) programmes. By combining these new observations with field data, an unprecedented estimate of the ice thicknesses contained in each of the Earth's glaciers was then made. More than four million hours of intensive computing on the servers of the University of Grenoble Alpes were required to process these data.
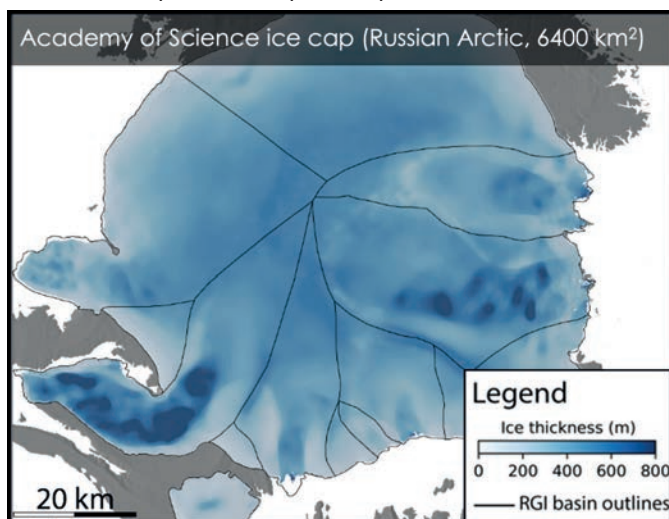

Figure 2: Ice thickness distribution map of the 'Academy of Science' cap on Komsomolets Island in the Russian Arctic.
Similar data are available for all major ice regions on Earth.

Predicting the evolution of glaciers, water resources, sea levels…

These results, due to their exhaustive spatial coverage and their resolution (50 m), constitute a paradigm shift that makes it possible to revise estimates of future glacier evolution and associated impacts, particularly with regard to water resources and future sea level evolution.

In the article published in Nature Geoscience in February 2022 [https://doi.org/10.1038/s41561-021-00885-z], the researchers estimate that water resources stored in glaciers are, on a global scale, up to 20% lower than in previous estimates, with significant regional variability, which would considerably increase the pressure on water availability in certain regions. For example, in the tropical Andes, where glaciers contribute to the drinking water supply of more than 4 million people, the situation is most alarming, with estimates of glacier volumes revised downwards to around 23%. On the contrary, in the Himalayas, in the Indus and Chenab river basins, where more than 6.5 million people live, water stocks of glacial origin are estimated to be more than 30% higher than in previous studies.

These results open up new perspectives for better predicting the future contribution of glaciers to sea level rise, as well as for better understanding the size of drinking water reservoirs in the catchment areas. Beyond a better understanding of glacier evolution in a context of climate change, these new observations will also allow glaciologists to better understand the physics of glacier flow and to improve the models that represent glacier evolution in future projections.

These data are made available to the community via THEIA Glaciers SEC and can be viewed and downloaded via the THEIA layer and map interface. The Sedoo offers the possibility to download the whole dataset or regional data. An interactive 3D visualisation is also available on IGE website. ■

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Université Grenoble Alpes, CNRS, IRD | IGE

Mathieu Morlighem,
Dartmouth College, Hanover, États-Unis

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

Glacier Surface Flow Velocity
► www.theia-land.fr/en/product/glacier-surface-flow-velocity-2017-2018/

Glacier Ice Thickness Distribution, 2017-2018
► www.theia-land.fr/en/product/glacier-ice-thickness-distribution

Visualisation and map layers download
► maps.theia-land.fr

Interactive 3D-Visualization
► ige-vis.univ-grenoble-alpes.fr/glaciers/index.html

Reference

Millan, R., Mouginot, J., Rabatel, A., & Morlighem, M. Ice velocity and thickness of the world's glaciers. *Nature Geoscience*, (2022)
doi: 10.1038/s41561-021-00885-z.

PRIVATE EXPERTISE

THEIA Snow Data in the Flight Plan

SINTEGRA is a firm of Chartered Surveyors specialising in Topography and Aerial Mapping and 3D modelling based in Meylan near Grenoble. SINTEGRA works on LIDAR and photo data acquisition throughout France and also abroad (Wallonia, Antilles, Laos, Madagascar, etc.). The company has an aerial service equipped to carry out topographic measurement campaigns using LiDAR technology on complex objects. LIDAR is the name of a measurement technique. It is used to calculate and estimate distances using laser light.

The command of these technologies allows SINTEGRA to participate, for example, in the key 3D mapping project launched by the IGN for the whole of mainland France and the French overseas territories. Our 2021 mandate was to carry out a 10 point per m2 survey to map 25,000 km² in the Alps: from Lyon to Nice, and Corsica.

Specialist in the treatment of mountainous areas

SINTEGRA also works with SNOWsat, providing digital terrain models that are integrated into the on-board groomer control system. These DEMs are used to guide the machines by providing precise knowledge of the mountain terrain in order to optimise the preparation of ski runs by estimating the volumes of snow to be worked.

Specialised in the treatment of mountainous areas, SINTEGRA regularly has to deal with laser reception problems due to the presence of snow on the ground. The reflection of the laser on the snow distorts the topographic surveys and the production of digital terrain models ordered by clients. The best way to avoid these problems is still to plan flights and surveys according to the presence of snow.

This is where the use of THEIA Snow data comes in. Available in near-real time and integrated into a GIS, it can easily be superimposed on the fleet's flight plans. It enables the type of surveys possible to be anticipated and flight plans to be specified according to the presence of snow. They thus play a full part in the SINTEGRA decision-making and acquisition planning process, particularly in the off-seasons when the presence of snow can vary greatly depending on the location. ■

Camille GUILLOUD,
SINTEGRA
► www.sintegra.fr/

Example of a SINTEGRA flight plan using Theia data to identify the presence of snow (light blue) in Savoie (France), over Aix-les-Bains lake, and the start of the Maurienne and Tarentaise valleys near to Alberville.

THEIA map layers for snow

THEIA Snow product indicates the presence or absence of snow per pixel. It is available in different forms: single date data, annual summaries, and map layers corresponding to the snow cover observation data of the last twenty days.

These WMTS layers can be viewed directly or downloaded from maps.theia-land.fr. They can then be used directly in GIS software such as QGiS.

Thanks to a recent development of the maps.theia-land.fr server, the map layer distinguishes in dark blue snow whose last visualization by satellite without clouds goes back to more than fifteen days, and for which we have no new data, from snowfalls of the presence of snow observed by satellite during the last fifteen days (cyan blue). ■

Snow cover layer for the central Pyrenees on **27 January 2022,** downloadable from maps.theia-land.fr

Dark blue = Snowfall between 27 and 16 days
Cyan blue = Snow between 7 and 15 days
White = Clouds on all acquisitions of less than 20 days
Transparent = No data or no snow or clouds
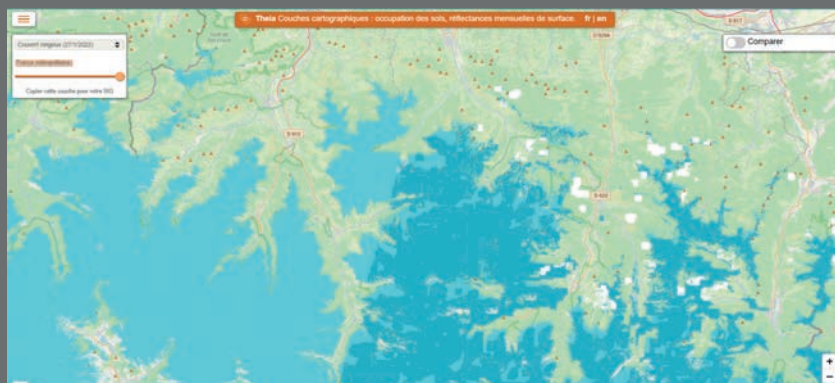
THEIA SPEAKS UP

« Using satellite imagery to establish a link between the environment, the habitats that are favourable to these species, and the human and animal populations at risk

Interview with Annelise TRAN

Researcher, Cirad, Tetis

Facilitator for THEIA Risks Associated with Infectious Diseases SEC

► www.theia-land.fr/en/ceslist/ risks-associated-with-infectious-diseases-sec

What motivates your involvement in THEIA as facilitator of the Risks Associated with Infectious Diseases SEC?

Annelise TRAN: Until recently, the number of teams in France working on remote sensing and health was very small, even though the subject has grown in importance over the last fifteen years. Participating in THEIA, which covers a wide range of topics, first of all allowed us to give visibility to our research work. Furthermore, the work of THEIA Risks Associated with Infectious Diseases SEC has resulted in operational tools and methods that THEIA makes it possible to transfer to users - which is very motivating. Today, THEIA offers a single portal where users can find all the information on remote sensing applications for land surfaces, which makes it possible to link different themes. This is particularly interesting for the health theme, for which we need land use products, water data, urban data and biodiversity data. The links between all these themes or research dynamics are visible on THEIA. For me, it is one of THEIA's great achievements to link these works, these products and these teams

How does this involvement fit in with your research work on the use of remote sensing for health?

Annelise TRAN: In the context of vector-borne or zoonotic infectious diseases, which involve vector or reservoir species in the transmission cycle, the aim is to use satellite imagery to establish the link between the environment, the habitats that are favourable to these species and the human and animal populations at risk. To document these fairly indirect links between images and health, we need Earth observation data that can describe the habitat of these vectors or reservoirs, with appropriate spatial and temporal resolutions. The remote sensing offer today is becoming interesting with both very high spatial resolution and significant temporal repeatability. We can thus play with these different types of images to obtain relevant information. What is still missing are more models capable of establishing these successive links.

In THEIA Risks Associated with Infectious Diseases SEC, we propose both products derived from remote sensing - land use, variations in water surfaces, for example - and processing chains and models that make it possible to make these successive connections: land use maps, coupled with meteorological data, make it possible to map the risk of abundance of disease vectors, such as mosquitoes. Another example is the work carried out as part of the TEMPO project on animal mobility: maps of water surfaces and land use are used to simulate the movements of domestic and wild ungulates, making it possible to map the areas of contact between these species and the risk of transmit-

ting diseases such as foot-and-mouth disease (► Read p. 6).

As a CIRAD researcher, how do you approach the issues of transfer and cooperation with the South?

Annelise TRAN: At CIRAD and IRD, research is organised in partnership with developing countries. At CIRAD, it is through platforms in partnership (DP), i.e. regional networks supporting research and teaching activities. I have just spent six years in the One Health Indian Ocean DP, which brings together all the human and veterinary health stakeholders in the region. The mechanism allows research to be conducted in consultation with the stakeholders, in order to best meet their needs, which in turn encourages the appropriation of tools. For its part, the IRD has international joint laboratories - such as the international joint laboratory (LMI) Sentinela on infectious diseases in Brazil - which organise cooperative research and the transfer of methods and results. In the field of health, perhaps more than elsewhere, the question of transfer is not only from North to South as one might think. The research carried out by THEIA Risks Associated with Infectious Diseases SEC teams over the years on mosquito-borne diseases was initially born of the needs of the countries of the South and has enabled the development of operational tools. But finally, with the arrival of the tiger mosquito in France, the transfer of methods and tools is now being made to the regional health agencies in the North!

What do you see as the key challenges for Theia in the future?

Annelise TRAN: I think training is a key challenge for THEIA. THEIA has already made the products from different themes very visible and has accustomed users to remote sensing. Many health actors are now convinced of the value of satellite images for taking the environment into account during studies on infectious diseases. However, much remains to be done to make users autonomous in the use of remote sensing products and methods. Theia, in its role as a link between researchers and users, must contribute to this.

Another challenge is to include the characterisation, monitoring and modelling of the impact of climate change in THEIA's themes. In health as in other sectors, strong impacts are expected. Earth observation data and models will be needed to better understand the relationships between climate, environment and health and thus help anticipate the future health impact of global changes, including climate change. This is another key challenge to be met.

»

« What motivates my interest in THEIA, but also in the very idea of data consortia, are the ever-changing activities and the associated challenges.

Interview with Arnaud SELLÉ

CNES-Partner Interoperability Manager for DINAMIS, Theia & ForM@Ter

Technical Director of the Theia consortium

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

Arnaud SELLÉ: The THEIA Continental Surfaces consortium was created 10 years ago out of a desire to pool means and expertise, on the initiative of French public research bodies, with the aim of promoting scientific research by networking researchers, facilitating the use of remote sensing data from space and responding to the societal expectations of public players. Since its creation, the consortium has demonstrated its usefulness thanks to the large number of themes covered by its Scientific Expertise Centres and the diversity of products made available in Open Data.

CNES is one of the consortium's major partners. During my activity as project manager from 2016 to 2021, and then as technical director, I was able to participate in implementing a significant expansion of the product portfolio and coordinate activities between CNES and its partners. One of the biggest successes, from my point of view, is the adoption by the European Environment Agency of THEIA's Snow Cover product. The fact that the Let It Snow (LIS) algorithm has proven its robustness through its operational implementation in the pole has been a key factor for this success.

In your opinion, what are the main challenges for THEIA in the future?

Arnaud SELLÉ: What motivates my interest in THEIA, but also in the very idea of data consortia, are the ever-changing activities and the associated challenges. The setting-up of new infrastructures, supported by funding obtained at the Data Terra level, through the GAIA Data project (►Read p.3) will make it possible to add new collections to the THEIA portfolio, in particular those based on RADAR Sentinel-1 products, and also to increase the geographical coverage of the consortium.

Similarly, the arrival of Anne Puissant as the consortium's Scientific Director (►Read her interview in Bulletin n°12) and the upcoming appointment of a deputy director, which follows that of a new CNES project manager (►Read Bulletin n°15), will certainly provide an opportunity to take up new challenges, such as the integration of data from new source space missions (SWOT, Trishna, CO3D, Biomass, etc.) or pooling with other consortia within Data Terra the framework.THEIA must consolidate its national and regional reputation and interface better with the economic players in the downstream sector by clarifying its relations with them. In particular, THEIA should not be considered as a competitor of private companies, but as a supplier of "Analysis Ready Data" in the framework of a public service mission.

Finally, the data hubs in the frame of the Data Terra research infrastructure should be the right framework to undertake an effort to Europeanise the consortium's activities: in particular, by seeking to integrate or complete the structuring projects of the European Union and the European Space Agency (ESA) in order to meet the challenges of the European data strategy. »