

SOMMAIRE

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A word from the Scientific and Technical Directors

THEIA is continuing to work to achieve its goals of providing calibrated and validated satellite imagery and value-added products, developing innovative algorithms, participating in in-situ data structuring efforts, organising methodological and subject-related workshops and seminars to promote discussions between scientists, and also between scientists and public stakeholders.

THEIA is also actively involved in putting the «Earth IR System» research infrastructure in place, and will contribute to the success of the new Space Climate Observatory programme.

Our friend and colleague, Selma Cherchali, a member of the THEIA Executive Committee, is taking on a new role as head of the Space Climate Observatory programme. On behalf of the THEIA Executive Committee, we would like to thank her for her contributions to the creation of THEIA, and her boundless commitment to promoting the centre and its influence. We know that she will stay in touch with our Land Surfaces community.

Many thanks to everyone for your contributions.



Nicolas Baghdadi



Arnaud Sellé

NEWS

Start of Venus products distribution

The THEIA Centre has started distributing Venus level 1C (L1C) products in near real time. A few days after acquisition, the products are available on theia.cnes.fr.

Since January 2018, Venus has systematically acquired data over all of the selected sites. Occasionally some acquisitions have been missed, for various technical reasons. These acquisition failures will progressively become less frequent. Not all of the Venus sites are yet available on the THEIA site, as the production of reference images that allow multitemporal registration takes time, and depends on clear images being obtained.

The in-orbit commissioning phase of the Venus mission is not yet completed as regards image quality. This delay is due to various difficulties, the most important of which are explained in this bulletin.

These difficulties do not prevent the data being used, so CNES has decided to process and distribute the L1C images. This level corresponds to ortho-rectified images expressed in top of atmosphere reflectances. These products have version number 0.9, which means that in a few months they will be subject to reprocessing with improved performance.

The distribution of level 2 products (surface reflectances) is expected to start by the summer 2018.

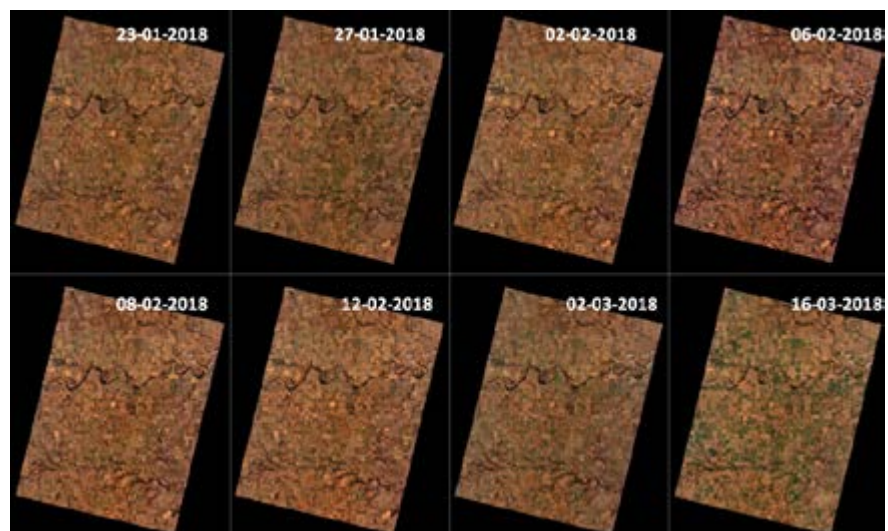
A simplified description of the format of the L1C product is available on the [Multitemp blog](#). The complete description of the format will soon be available on the [CNES site](#).

Gérard Dedieu (Cesbio / Cnes)

Workshop on Remote Sensing for Studying Urban Environments



The second workshop on Remote Sensing for Studying Urban Environments took place on 19&20 March at the University of Strasbourg. During these two days, organised with the support of CNES, THEIA - Kalideos Alsace and ZAEU, around sixty participants from the research and the socio-economic communities were gathered. Research activities and methodological developments related to several major issues for urban environments (heat islands and urban climatology, links with vegetation, extraction and the evolution of artificialized surfaces, etc.) were presented. >>



Time series of Venus images acquired in Oklahoma (USA) and processed at level 2A (with a 1st atmospheric correction test)

>> The workshop has also allowed developing some collaboration between the research and the application domains. These exchanges are essential to propose consistent and scientifically expertise for relevant studies dedicated to sustainable urban planning and management. These feed-backs will be taken into account for works in progress by the partners involved in the “Urban”, “Albedo” and the newly “Surfaces temperatures and emissivity” Scientific Expertise Centres.

Anne Puissant (LIVE / Unistra) et
Laure Roupioz (Onera / Toulouse)

Feedback from the DL2T seminar

The objective of the « Deep Learning - Remote sensing - Time », days organised by Pierre Gançarski (ICube), Dino Ienco and Christiane Weber (TETIS) under the change detection CES was to bring together:

- specialists and users of Deep Learning for analysis of data time series
- theme specialists for Environmental Science, Earth Observation, etc.
- remote sensing methodologists (computer engineers, image processors, etc.)
- companies in the field

to discuss and exchange views about the potential and the limits of Deep Learning for the analysis of remote sensing image series.

Taking place on 29 and 30 November 2017 in Paris, these days aroused great interest from various scientific communities and also from companies in the field. This meant 145 people registered, with approximately 120 people taking part on the first day, and approximately 100 people on the second day.

The organised programme alternated between themed presentations and presentations that were more focussed on methodology, to allow the different scientific communities to better understand each other and interact. Debates through



Coordination of DL2T workshops by Pierre Gançarski and Dino Ienco

round table discussions followed the presentations. They came to the conclusion that while Deep Learning techniques will be increasingly used in Earth observation, and that it would appear possible for the approaches proposed to date in the context of computer vision to be adapted to time series of satellite images, they still require further advanced scientific and technical studies and validation.

For example, there are still important questions to be answered about approaches allowing the processing of multiscale observations (the same area may be observed at different space scales) or multisensor observations (the same area may be observed through different sensors). This also applies to methods of constructing networks that are able to extract and characterise objects of interest that are extremely heterogeneous (large areas of water vs a flag over a dozen pixels for example).

Lastly, a very important point was raised about the interactivity of Deep Learning processes with experts who, in addition to good performance, would like to understand what the model is doing, and on what basis it makes its decisions.

Discussions during these days were extremely rewarding, though unfortunately too brief in terms of time and in viewing examples resulting from experiments or responding to actual problems. The final «consensus» was that it is essential to continue working together on these different aspects, in order to propose solutions that can quickly be used in the different sectors addressed by the THEIA Scientific Expertise Centres.

Pierre Gançarski (Unistra)
Dino Ienco (Tetis / Irstea)

Joint coordination of ART PACA

The THEIA regional coordination network in the Provence-Alpes-Côte d'Azur Region (ART PACA), the main aim of which is to facilitate the use of images taken from land surface observation from airborne and space platforms, has until now been headed by GeographR. It will now be entrusted to GeographR, continuing its mission, and the Regional Centre of Geographic Information in the Provence-Alpes-Côte d'Azur region (CRIGE PACA).

The aim of this partnership is to:

- develop the regional network of public and private stakeholders, users and/or producers of aerial and space data,
- create a community of users and stimulate cooperation,
- raise awareness among professionals (government departments, regional and local authorities, land managers, associations, compa-



nies, etc.) about the potential of remote sensing,,

- promote the use of satellite resources,
- reinforce users' technical and scientific skills,
- identify the needs of data users and producers,
- organise training sessions,
- propose events dedicated to remote sensing,
- encourage users to participate in the Scientific Expertise Centres (CES): feedback, validation of satellite products, methodological, technical and scientific contributions, etc.

The aim is to contribute to the improvement of knowledge, and to support the efforts of the public institutions involved in Earth observation, working towards better sustainable management of the territories in terms of anthropic and environmental aspects.

Claire Ajouc (CRIGE-PACA)
Philippe Rossello (GeographR)

PNTS Assessment and Outlooks symposium

The French Remote Sensing National Program (PNTS) held its Assessment and Outlooks symposium in Grenoble on 20 and 21 March 2018. Amongst other things, the symposium was organized around three sessions focussed on inverse problems, time series and innovative synergies.

During the 2012-2017 term, 60 projects were financed, including 3 requests for support for symposia, for a total of €784,000, with an average of 2.1 publications per project. Five themed days were also organised.

In the coming years, the program would like to support themes such as inversion and synergy of space data, uncertainties, modelling of radiation transfer, observation and 4D modelling of the Earth system, or use of geostationary sensors. It would also like to promote the application of recent techniques that are already tested in the field of big data. Don't miss the next PNTS call for projects around 30 June 2018 on the [French Remote Sensing National Program site](#).

Audrey Minghelli (LIS / Univ. Toulon)
Eric Defer (LA / CNRS, UPS) pour le
CS du PNTS

Water resources management in 2018: a global concern

A number of gatherings were organised this year about the utility of space technologies for improved water resources management in various regions of the world.

Workshop on the utility of satellite images for sustainable development

This workshop, held on 6 and 7 March 2018 at the Royal Centre for Remote Sensing (CRTS) in Rabat (Morocco) was primarily focused on the utility of space data for water resources and agriculture. One of the aims of the workshop was to gather together and encourage the work conducted by the scientific community in Morocco, and to present the first results of projects relating to the THEIA call for tenders on Sentinel-2.

The 27 presentations focussed on space programmes including Copernicus; products services offered by the international community; programmes and projects, particularly GMES for Africa; methods and techniques for processing and development of image data and case studies.

Over the 110 participants, 40% were researchers, teachers and students from 12 national and international training and research institutions, while the other 60% were users from government and operational agencies in the water and agriculture sector. 11 African countries were represented.

8th World Water Forum in Brasilia

The 8th World Water Forum was held from 18 to 23 March 2018 in Brasilia (Brazil). French stakeholders in the water sector again distinguished themselves by their active engagement, allowing significant developments with the objective of achieving Sustainable Development Goals (SDGs).

These developments must be supported in preparing and holding the High-level Political Forum (HLPF) scheduled from 9 to 20 July 2018 in New York. This «SDG COP» must be a turning point: this year, special consideration will be given to SDG6 concerning Water.

CNES took part in the Water Sciences and Information Systems event, on behalf of the partners of the space hydrology group from the SWOT downstream pre-

paratory programme. Innovative solutions for SDG6 were presented at the French stand: products derived from space technologies, use of in-situ data, value-added models (water surface levels, soil moisture) and products. This information will be integrated into Hydroweb NG, a database of space information. Developments around the Congo Basin managed by CICOS were presented by AFD and CNES in a thematic session dedicated to water resources management in trans-boundary basins.

Regional workshop on hydrological monitoring and space applications in the Congo Basin

As part of the SWOT-downstream activities setting up space hydrology pilot sites, a feedback workshop about work on the Congo Basin was organised by CICOS on 7 and 8 March 2018 in Yaoundé (Cameroon).

The workshop provided an opportunity to inform all of the participants about the uses of space technologies in hydrology. The approach used for the Congo Basin, the first pilot project, was commended: densification of the hydrometric network with space altimetry, implementation of an hydrological information system and development of downstream operational services about navigation and hydro-power potential.

The 7 French institutions in the space hydrology working group were present: AFD, IOWater, CNR, BRL, IRSTEA, IRD and CNES, as were parliamentarians from the 6 CICOS countries, representatives from the Ministries of Water and hydrological services of the 10 countries of the Congo Basin (representatives for the Senegal, Niger, Chad and Volta basins, WMO and GIZ).

The opening ceremony was presided over by Mr Ousman, representing the Ministry of Water and Energy of the Republic of Cameroon, and included speeches from the Secretary General of CICOS, the representative from CNES, and the AFD Cameroon Director.

Feedback from this workshop was extremely positive. The attendees understood the interest of space technologies and the complementary nature of in-situ data and space data. The presentations of each country and basin showed the poor condition of the in-situ network, with Gabon no

longer having any field measurements, for example. The countries have a lack of technicians for maintaining the in-situ networks. In an effort to resolve this issue, funding from donors (AFD, the World Bank) and projects (WMO) are changing, obliging the countries and regions to mobilise resources to ensure the sustainability of measures as soon as projects begin. The parliamentarians present at the workshop are also prepared to convey the message to their respective national assemblies and to ask for the financial resources required for training and maintenance of the networks.

South America Water from Space Conference

The 2nd edition of this conference took place in Santiago (Chile) from 26 to 29 March 2018, following on from the 2016 conference in Rio de Janeiro. Driven by South American and French scientists from the SWOT Science Team and SWOT-downstream, the conference was organised by the University of Concepción, with the support of space agencies (CNES, NASA) and the French Research Institute for Development (IRD). The event brought together 75 participants, representing several South American countries, the United States and France.

Experts discussed the overall context of space measurements for inland water system, and presented the future SWOT high-resolution altimetry mission and the expected deliverables in South America in the research and applications field. The first day took place in the Hall of Honour of the National Assembly. It allowed Chilean policy-makers to be aware of the issues at stake with space technologies in hydrology. The conference was then hosted at the Technological University of Chile, where local teams of researchers and students took an active part in scientific discussions and were trained on space data analysis tools (OTB open source software from CNES, SWOT simulator).

Following the success of this second edition of «SWOT» days in South America, it was agreed that this initiative would continue in the form of annual conferences, with the next one due to be held in Manaus in 2019.

Selma Cherchali (Cnes)



2017 OSO land cover map



The 2017 land cover map produced with images from the two Sentinel-2 satellites was made available on 9 April 2018 by the Land Cover Scientific Expertise Centre.

You can view it using the [display interface](#).

The raster files in GeoTIFF format are available for download:

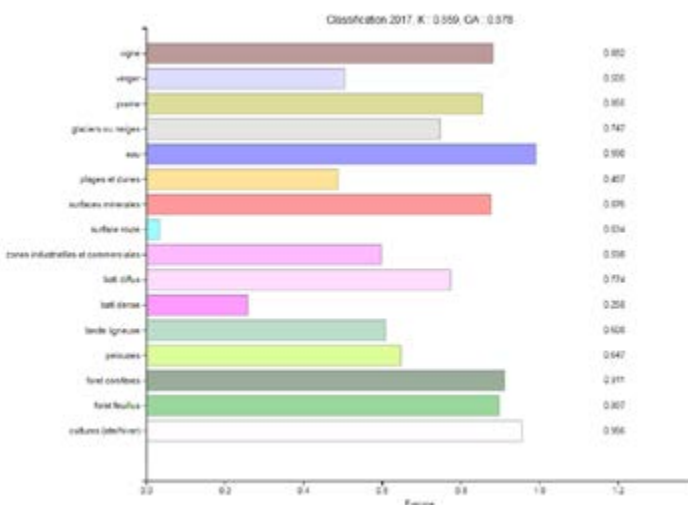
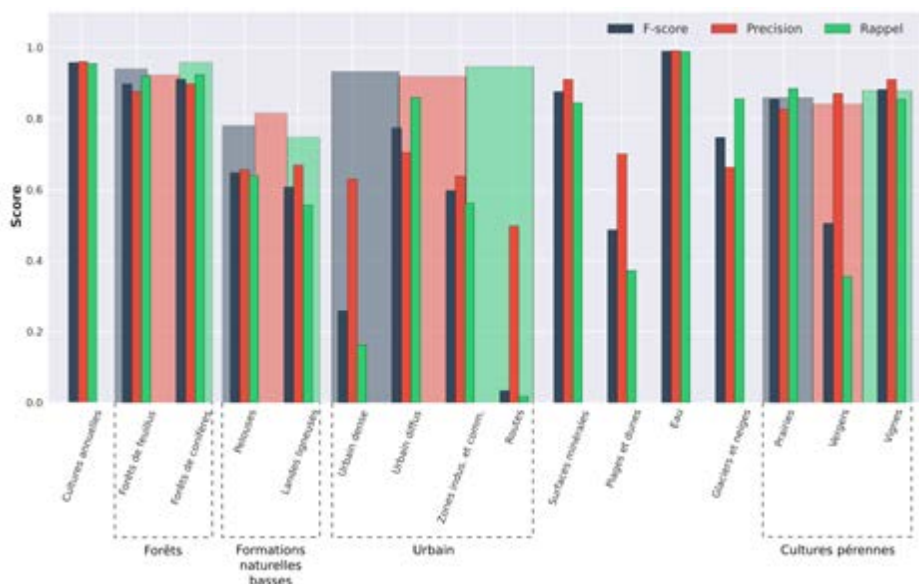
- o [land cover](#) (719 Mo), [nomenclature](#),
- o [validity map](#) (804 Mo)
- o [confidence map](#) (4.1 Go)

Vector products in Esri Shapefile format are [available](#).

The overall quality of the map is very satisfactory, although, as for previous versions, some classes are poorly recognised. The figure below shows the overall statistics measured on a different data set than the one used for training.

The proposed class groupings (forests, low natural formations, urban and perennial crops) correspond to a union of classes that are often confused with each other. This may also be observed in the confusion matrix on the following page.

The values in the boxes of the matrix correspond to a count of the validation pixels. The lines contain the true classes, and the



Nomenclature of 17 classes for the 2017 OSO Land cover map columns contain the classes obtained on the map.

Genesis

One of the interesting characteristics of the OSO map is that it is available before the end of the first quarter following the end of the target year. The 2017 version was meant to be the first produced by the THEIA space data infrastructure (IDS), but unfortunately this start of production was significantly delayed.

At CESBIO, Arthur Vincent and Vincent Thierion agreed to take on the workload that this production involved. Although the chain is completely automatic, the fact that it is not integrated into the THEIA IDS requires manual work to prepare the data: for example, downloading 1 year of Sentinel-2 data over mainland France always means having to juggle with limited disk space. There is also the work involved in preparing the reference data, configuring the chain, monitoring production and validating the results. All told, it can take 3 or 4 weeks. In the meantime, work improving *iota2*, methodological research, thematic experiments – a research team's normal work – all come to a standstill. Tribute should therefore be paid to the dedication shown by the OSO team at CESBIO.

We have therefore carried out this work, several times even. We first produced a map using Sentinel 2A data from January to October 2017 (everything that was available at the end of 2017 at level 2A produced by THEIA). This production used the 2016 map to have samples of summer and winter crops, as the last available RPG (Land Parcel Information System) dated from 2014.

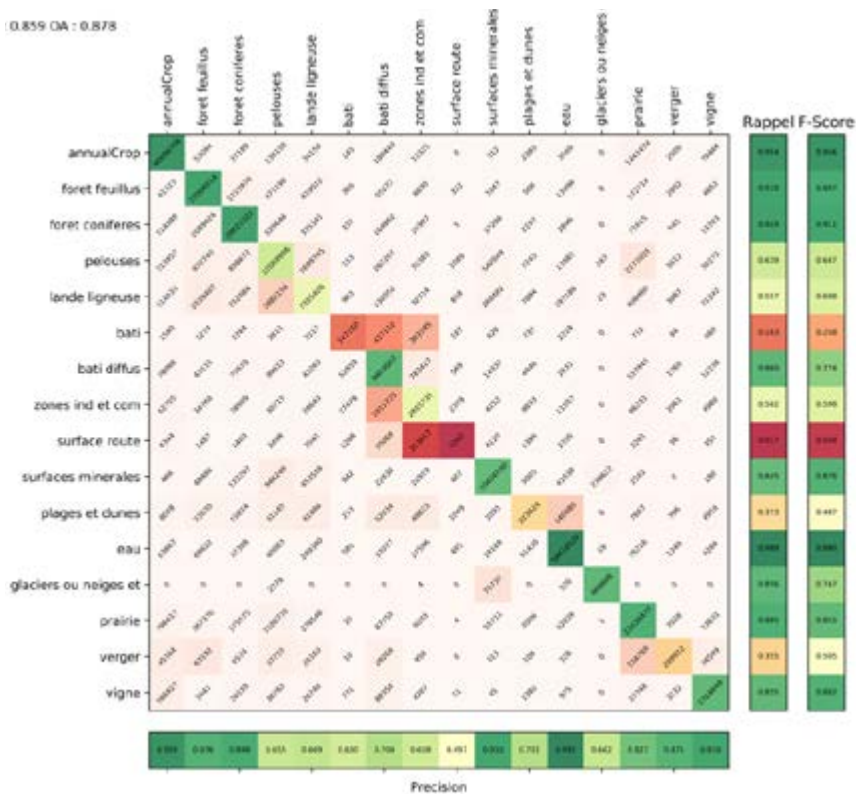
We were provided with the 2016 RPG in January 2017, when we were completing production of this map. We therefore decided to repeat the production using the 2016 RPG, and this new map was completed at the beginning of March. >>

Quality indicators (Precision, Recall and F-score) of OSO classification extracted from the comparison of 2017 OSO with independent data

>> As we still had a little time left, and THEIA was starting to make new Sentinel-2 acquisitions available, particularly images from the 2nd satellite, Sentinel-2B, we resumed production with all of this data: all of the Sentinel-2A acquisitions from January to December 2017 and all of the available Sentinel-2B data (July and September-December). Preparing this volume of data took us a very long time, and production was not completely finished at the end of March. The 2017 version was therefore distributed one week later than specified in the product specification.

Jordi Inglada (Cesbio / Cnes)

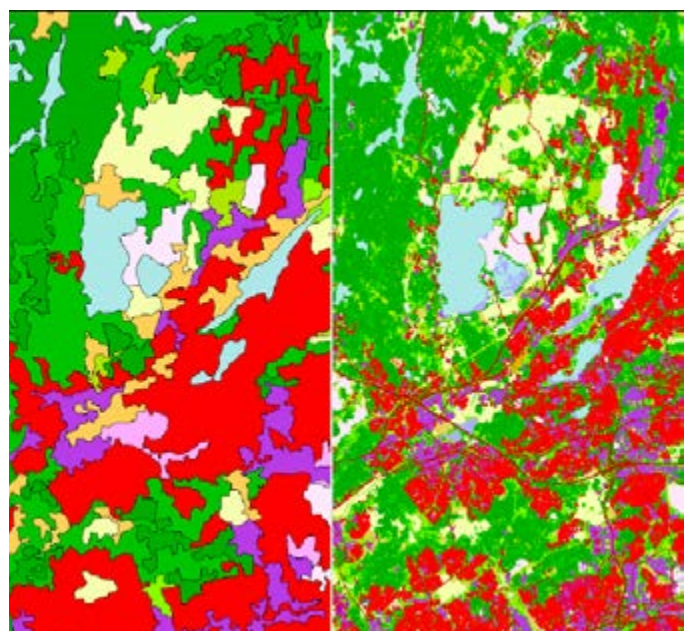
2017 OSO classification system quality measurement confusion matrix



Towards second-generation CORINE Land Cover products

Launched in 1985 at the urging of the European Union (EU) and European Environment Agency (EEA), CORINE Land Cover (CLC) is an inventory of biophysical land cover. Produced by the Member States, since 1990 it provides a regular and consistent photograph of Europe. The 2018 version is in production, for dissemination at the end of the year.

CLC is the historic product of the Copernicus (European Earth observation programme) land monitoring service; it is fully supportive of public policies. As such, it must evolve to continue to meet the challenges of preserving biodiversity and combating climate change, thanks to more precise and more frequent land cover assessments. The goals are to construct stable products that address the majority of needs for the coming decades, while



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not neglecting the continuity of the current programme. The EU wishes to call on the private sector for a production that is mainly based on automated processing of mass satellite data, while relying on the expertise and data of the Member States.

From mid-2017 onwards, EEA launched a collaborative process to elaborate the specifications of the 2nd-generation CLC products (referred to by the acronym CLC+). Drafting of the specifications was entrusted to the Action Group on Land Monitoring in Europe (EAGLE), a group of experts from the EEA's European Environment Information and Observation Network (EIONET) partnership. The specifications adopt the land cover data model, developed by this group: neutrality of format or scale, and separation of land cover and land use information. Expert and user consultations were organised to consolidate the specifications, in particular through a national survey conducted by EIONET. The key expectation expressed was the need to produce and distribute these products in compliance with the INSPIRE Directive, hence ensuring consistency with national and local works conducted.

This 2nd-generation CLC+ relies on two core products with a resolution of 1 hectare (resolution to be confirmed):

- CLC-backbone, a «skeleton» that describes the land cover components, subdivided according to persistent objects in the landscape (transport networks, etc.), classified in about ten categories.
- CLC-Core, a land cover and land use data container, dynamically updated from the Copernicus service's existing databases and data from the Member States.

Two end products will be derived from this core data: CLC-legacy which will provide continuity with the current CLC, and CLC+ which will be a refined version of CLC (higher resolution and more regular updates).

Implementation of production should begin in the summer, with the launch of a call for tenders to produce CLC-backbone 2018.

Frédérique Janvier (MTES/CGDD/SDES)

Venus : extension of the in-orbit commissioning phase

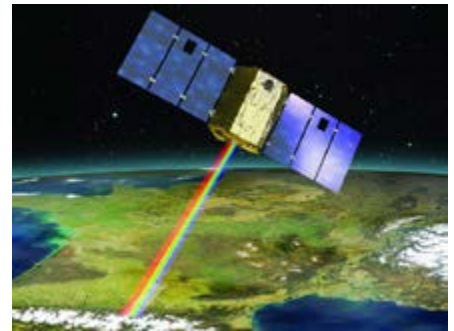
As indicated in the news, the in-orbit commissioning phase of the Venus mission is not yet completed as regards image quality (radiometry and geometry).

This delay is due to various difficulties, the most important of which relate to:

1. The absolute calibrations of spectral bands B1 (415 nm) and B2 (440 nm), both of which are in the blue spectrum, are less precise than the calibration of the other spectral bands. This problem is preventing B1 and B2 being used for aerosol optical depth (AOD) inversion or for water colour applications.
2. The accuracy of satellite attitude determination is currently worse than expected. Because the different bands are not acquired simultaneously, this mainly has an impact on the precision of band to-band registration. For some sites with heavy cloud cover or uniform landscape, this issue also af-

fects multi-temporal registration.

Characterization of radiometric and geometric performance is still ongoing. Efforts are also being made to improve preprocessing algorithms.



Satellite Venus en orbite ©Cnes

As soon as significant progress has been made, all of the data acquired since January 2018 will be reprocessed with the new parameters and algorithms.

The Venus page on the [Theia web site](#) will keep you informed about progress made.

G rard Dedieu (Cesbio / Cnes)

Opening up CBERS-4 images freely available to download from Amazon (AWS)

CBERS (China-Brazil Earth Resources Satellite) satellites are the result of a cooperation agreement between the Brazilian and Chinese space agencies (INPE and CAST, respectively), launched in 1988. Since then, five satellites have been launched: CBERS 1/2 / 2B / 3/4.

The mission generates images of the Earth with similar characteristics to the USGS Landsat and the ESA Sentinel-2 missions. In 2004, INPE announced that all of the CBERS-2 images would be freely available for the public. This was the first time that this distribution model was used for medium-resolution satellite imagery. This model is now used for all of the CBERS satellites.

Since January 2018, Amazon has been involved in the development of the system used to save, process and distribute the image data from CBERS-4 thanks to a grant of Earth AWS Cloud Credits for Research.

Only CBERS-4 MUX archive data are currently available for the general public. Eventually archive images from CBERS 1/2/3 and the future CBERS-4B and Amaz nia-1 satellites will be available for download from the Amazon cloud in 2019.

The technical characteristics of CBERS-4 MUX are given below:

Camera*	Data
Spectral bands	B05 (Blue): 0,45 - 0,52 μm B06 (Green): 0,52 - 0,59 μm B07 (Red): 0,63 - 0,69 μm B08 (Infrared): 0,77 - 0 89 μm
Swath	120 km
Resolution	20 m
Raw data rate	68 Mbit / s

* Regular Panchromatic Multispectral Camera (MUX)

J r me Lev  (Irstea)

Downloading of CBERS-4 images

The Canadian site [Remote Pixel](#) offers direct access to these images without logging in and without an Amazon account (figure 1).

You will be redirected to a page with multiple dates. Identify the scene by the closest date and download the image with the best visibility conditions (figure 2).

The CBERS-4 images hosted on the cloud will be processed online and delivered with the colour composition indicated by the user. You can select the True Color 7-6-5 and False Color 8-7-6 composition (figure 3).

Then press the Download button and wait for processing of the image. It takes around thirty seconds to generate a 60 MB file.



Figure 1



Figure 2



Figure 3

Joint portal for THEIA-OZCAR in-situ data

The objective of integrating in-situ data into the THEIA data centre is to have a single portal for land surface observation data for users which will allow transparent access to data whatever site (data centre) they are hosted on. This portal does not store data that is already archived, but instead links to data suppliers' databases and makes them visible in a standardised way, according to international interoperability criteria.

The Grenoble Observatory for Sciences of the Universe (OSUG), was commissioned by the partners of the THEIA centre to build the in-situ component, in coordination with the existing portal for remote sensing data. A project team was put in place in July 2017. It is made up of 4 permanent members of staff and an employee on a temporary contract, recruited in October 2018 for 2 years.

OZCAR RI certified observatories offer a wide range of types of measurement

Implementation of the THEIA in-situ Information System (IS) started out shared with the OZCAR (Critical Zone Observatories: Research and Applications) Research Infrastructure (RI). This RI groups together the certified observatories documenting the critical zone on the long term. In 2017, the project team visited all of these observatories and data centres that host them, in order to compile their space needs/expectations with regard to the THEIA-OZCAR IS. The level of development of the 22 observatories' Information Systems varies considerably, from RDBMS1 through to lists of files placed on an ftp server.

It has been pointed out that the variable is the point of interest. All of the variables measured by the 22 observatories certified by OZCAR were listed, and matched with the GCMD² Earth Science hierarchical vocabulary. The listing identified almost 300 in-si-

tu variables measured by the OZCAR observatories, of which half are chemical measurements. An observatory can measure between 3 and 150 variables, with a median of 36. Each variable was documented by links to published thesauri (AGRO-VOC, EARTH Thesaurus, GACS Core Beta 3.1, NAL Thesaurus, UNESCO Thesaurus, LC Subject Headings, AnaEE).

Architecture of the OZCAR/THEIA IS

In order to always stay up to date, a continuous information flow is organised (figure 1). The data stays with the suppliers, who push them to the THEIA - OZCAR IS using an extraction script. This script meets the specifications of the THEIA - OZCAR pivot format. The pivot format specifies all of the metadata required for various functions: responding to requests formulated by users, respecting interoperability standards (INSPIRE, ISO 19115, etc.), declaring DOIs (Figure 1).

Next steps to be taken:

- The pivot format (obligatory, recommended and optional metadata) is being defined in collaboration with the in-situ data centres, Geosud and Dinamis.
- The data suppliers must write the extraction script for their metadata. Support may be provided by the THEIA-OZCAR team.

The aim is to have a THEIA-OZCAR portal prototype in situ at the end of 2018.

1. RDBMS: Relational Database Management System

2. GCMD: Global Change Master Directory. This hierarchical vocabulary is regularly updated by its community (cf <https://earthdata.nasa.gov>)

Sylvie Galle (Insu / IRD), I. Braud (Irstea), P. Juen (CNRS), V. Chaffard (IRD), C. Cousot (CNRS-INSU).

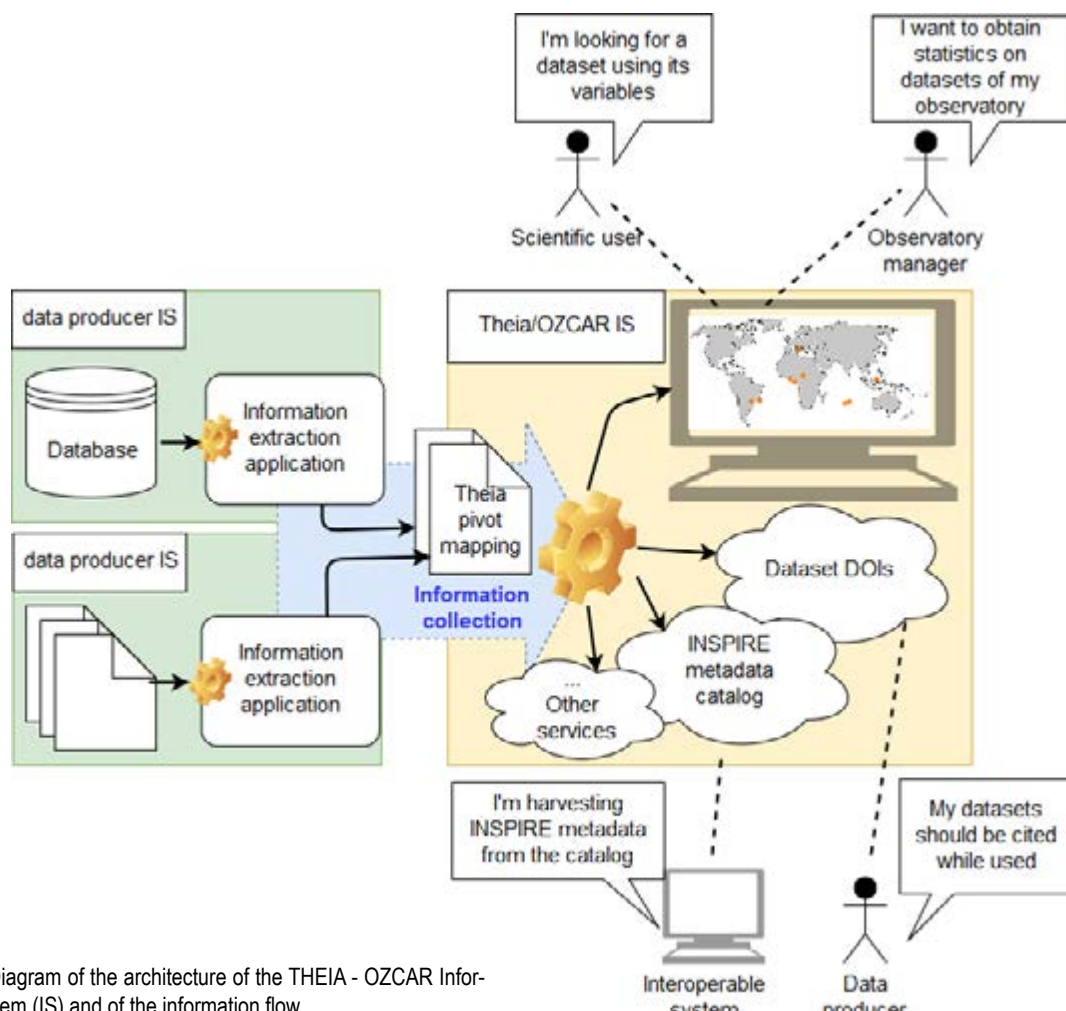


Figure 1 : Diagram of the architecture of the THEIA - OZCAR Information System (IS) and of the information flow

The new SMOS-IC product: soil moisture and L-VOD vegetation index

SMOS-IC is a new SMOS product developed mainly within the framework of the CNES Earth Environment and Climate (TEC) programme. It includes a soil moisture (SM) product and an L-band Vegetation Optical Depth (L-VOD) product. SMOS-IC complements the official ESA level 2 (L2) and CATDS level 3 (L3) SMOS products.

For all of these algorithms, on each pixel, 2-parameter inversion (SM & L-VOD) of the direct model (L MEB) relies on a series of SMOS observations made over an angular range that varies according to the position of the pixel in the field of view, and for horizontal and vertical polarisations. The L2 and L3 products are based on a relatively complex approach taking into consideration a detailed description of the footprint of SMOS at a resolution of 4 km x 4 km that varies depending on the observation angle. On the heterogeneous pixels, the inversion is performed on the dominant fraction: either low vegetation & bare ground or forest and water bodies. On the non-dominant fraction, auxiliary information is used to simulate the brightness temperature; in particular soil moisture (SM) and the foliar index to estimate the effect of vegetation (VOD) on forests. It is helpful to use various auxiliary data to better constrain the inversion. However, this auxiliary data contains errors that can propagate into the inversion algorithm and lead to noise and biases in the products.

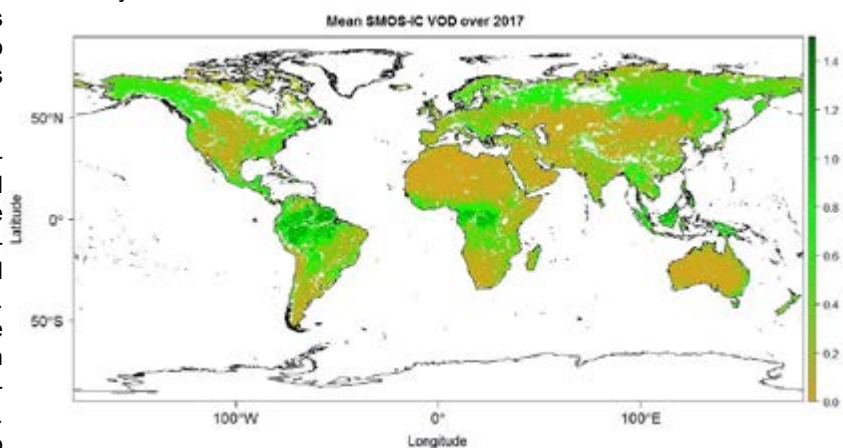
The SMOS-IC inversion algorithm, which corresponds to an original inversion approach proposed for the SMOS mission, aims at making minimal use of auxiliary data by using (i) the multi-angular signature and bipolarisation of SMOS observations and (ii) the relatively slow seasonal variation of L-VOD. SMOS-IC is hence much simpler and does not take into consideration the corrections associated with characterisation of the antenna pattern and pixel heterogeneity that varies with the observation angle. SMOS-IC considers pixels as homogeneous to avoid possible uncertainties and errors linked to the

data sets used to characterize the pixel heterogeneity. As with the L3 product, SMOS-IC provides global SM and L-VOD data in the EASE-Grid 2 and NetCDF format with a ~25 km cylindrical projection. SMOS-IC SM (2010-2017) is distributed as a scientific product by CATDS.

Despite its simplicity, SMOS-IC has proven to be extremely effective for in-progress inter-comparisons of SM products based on SMOS (IC, L2, L3), SMAP, CCI, ASCAT. As a result of its performance and its independence from auxiliary data, the SMOS-IC product is increasingly used in applications. The main applications in progress are based on the L-VOD index and relate to monitoring of vegetation biomass and the carbon balance at the continental and global scales in connection with the impact of droughts or large-scale reforestation programmes, the vegetation water content cycle, and large-scale forest mortality episodes.

Link to SMOS-IC SM product : ftp://ext-catds-cecsm:catds2010@ftp.ifremer.fr/Land_products/L3_SMOS_IC_Soil_Moisture

J-P Wigneron, A. Mialon, A. Al-Yaari, Y. Kerr (ISPA, INRA Bordeaux et CESBIO Toulouse)



Global map of L-VOD vegetation index correlated with vegetation biomass (A. Al-Yaari, 2018)

From the Pleiades stereo to regional indicators, DSM contributions

With the aim of addressing the challenges of urban land monitoring and assessing land-use planning public policies, CEREMA has developed a tool offering thematic monitoring indicators. This tool is based on the analysis of Pleiades satellite images, Digital Surface Models (DSM), combined with exogenous learning databases (BD TOPO, RPG, etc.).

The image classification is built on a simple nomenclature corresponding to urban challenges such as use of space, urban density, flooding issues, preservation of biodiversity or urban climatology. The final products are activity indicators, in a vector format, that are easy to integrate into a GIS. Ultimately, the challenge is to offer off-the-shelf products, for establishing and monitoring land-use planning public policies, for design offices and elected representatives.

The process is part of an industrialisation approach. As such, questions regarding data reproducibility and qualification are particularly important. The highly automated method minimises the subjectivity related to the operator. Drafting procedures and documents for monitoring quality help to achieve a good level of reproducibility.

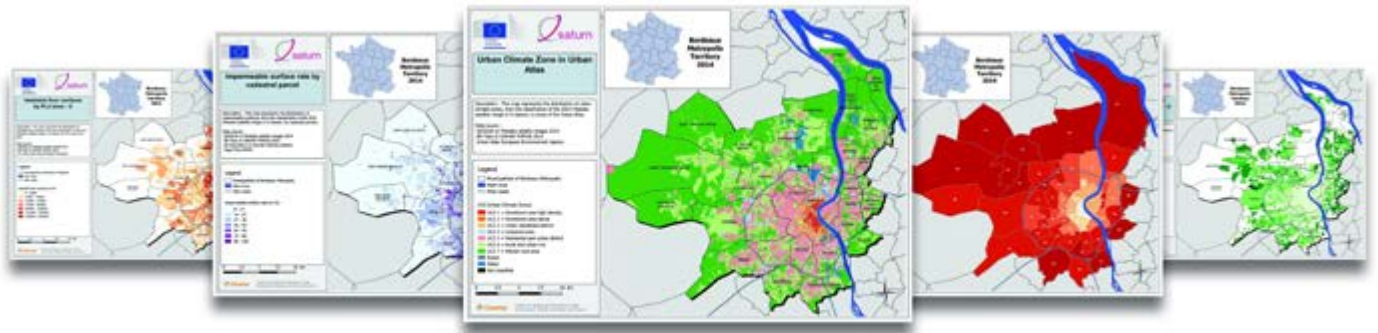
We noted that the DSM made a significant contribution to the quality of the final result of the classification process (a gain of up to 10%), and also that the configuration of the pair of stereo images used to produce this DSM affected the quality of the DSM obtained as an output.

A study was therefore launched at the end of 2017 (scheduled to end in 2019) in collaboration between CEREMA (responsible for developing the classification process) and IGN Espace (responsible for geometrical alignment of images for institutional stakeholders, and DSM producer), with the support of CNES for the supply of images.

Previous collaborations between IGN Espace and CEREMA have already allowed the definition of a compromise between acceptable acquisition angles, an acquisition period to be complied with and an acceptable probability of the image being obtained.

The characteristics of the pairs of stereo images studied are the date and the acquisition angles (incidence of images and B/H of the pair) and the position of the sun (size of cast shadows).

Difficulties are often noted correlating images in shadow, resulting in defects on the DSM. These DSM defects, reflected in noise around some buildings, will adversely affect the measurement of



Set of regional indicators: CEREMA production. DSM: IGN Espace production

>> slight dynamic changes in the construction. Furthermore, we also know that tri-stereo provides assured added value. Lastly, we can intuitively conclude that seasonality will have an effect on the results but this has not yet been quantified.

Acquisition of around ten stereo pairs, spread out regularly over a year, has been scheduled for an area of one hundred square kilometres located in the city of Bordeaux. One pair will be supplemented with a third picture to assess the utility of tri-stereo. The data

collected will be jointly analysed by IGN Espace and CEREMA.

The conclusions of this study will help to fine-tune the specifications for scheduling stereo image pairs with a view to DSM production. It will also help with assessing the impact of the acquisition season on the quality of DSMs, classifications and final indicators.

Dominique Hébrard (Cerema)
Isabelle Léonardi (IGN Espace)

Integration of satellite observations into land surface models for monitoring variables of the critical zone

Land surface modelling may be improved through the dynamic integration of observations. Observations from spatial remote sensing have the advantage of being available on a global scale (at higher spatial resolution) and repeatedly over time. Many observations from spatial remote sensing, in connection with the hydrological cycle and vegetation are already available. Combining land surface modelling with these satellite observations helps to access parameters that are not directly observed. Data assimilation is the digital method that allows these significant volumes of data to be integrated into the models representing land surfaces in a manner that is consistent with their representation of the processes.

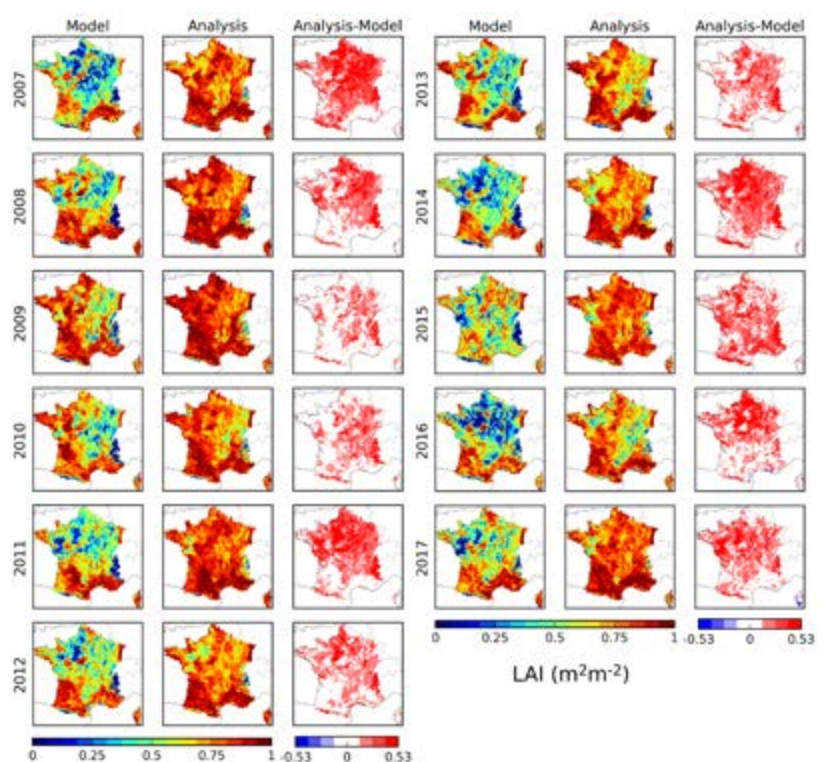
The French National Centre for Meteorological Research (CNRM) has developed data assimilation systems that are suited to land surfaces in the SURFEX (SURface Externalisée) modelling platform. The aim is to constrain the ISBA (Interaction-Soil-Biosphere-Atmosphere) surface model using satellite observations such as surface soil moisture and leaf area index (LAI). These sequential data assimilation systems have been successfully implemented in a chain monitoring carbon and water flows on a global scale. The reanalysis from LDAS builds on synergies between the various satellite products and helps to improve the representation of surface variables by ISBA. There is a LDAS-France version, which assimilates the LAI and superficial ground humidity products from the European Copernicus Global Land service with a spatial resolution of 8km x 8km. The illustration opposite represents correlation maps for the LAI between (i) the model and the observations, (ii) the analysis and the observations, (iii) the difference in correlation between the analysis and the model (from left to right, respectively) for each year between 2007 and 2017.

Correlation maps for the LAI variable between (i) the model and the observations, (ii) the analysis and the observations, (iii) the difference in correlation between the analysis and the model (from left to right, respectively) for each year between 2007 and 2017..

The difference maps (analysis-model) are dominated by positive values (warm colours), with the LAI having been assimilated, it is reasonable to find better scores in the analysis. The average correlations vary between 0.46 (in 2016) and 0.67 (in 2009) for the model and between 0.71 (in 2016) and 0.83 (in 2009) for the analysis.

The LDAS systems have been assessed and validated using satellite observations (evapotranspiration, gross primary production, etc.) and independent in-situ measurements (ground humidity, river flow rates, water and energy flows, agricultural yield, etc.). They are now sufficiently developed to act as decision support tools in applications such as monitoring edaphic and agricultural drought. They represent surface conditions more accurately and may also be used to initialise forecast systems.

Clément Albergel, Jean-Christophe Calvet
(CNRM / Météo France)



Creation of ART Kalideos-Alpes

The THEIA and Kalideos regional coordination network (ART) officially created for the Alps in January 2018 is jointly supported by the Kalideos-Alpes consortium and by the OURANOS-AuRA platform of the Envirhônalp Scientific Interest Group. Collaboration between Kalideos-Alpes and OURANOS-AuRA began in 2017.

The priority areas for ART Kalideos-Alpes encompass :

- the regional mountain climate and adapting to climate change (public policies, tourism, land use planning, agriculture, silviculture)
- research into snow, its extent and the properties of seasonal snow cover
- research into glaciers, monitoring of mass balance for some glaciers as well as quantification of surface run-off speed
- monitoring of alpine vegetation through maps of vegetation indices, amongst other things
- monitoring of known instabilities, detection of new instabilities and monitoring of avalanche deposits
- snow hydrology

The satellite observations of interest are the high and very high resolution optical (Pleiades, SPOT 6 7, Sentinel-2) and radar (Sentinel-1, ALOS-2, TerraSAR-X) observations.

The objective of ART Kalideos-Alpes is to promote the use of research data, and to distribute it to the academic community and regional stakeholders. This involves setting up multidisciplinary networks helping to bring about collaborations (responses to calls for tenders, working groups, sharing of tools, etc.). Events such as science/society workshops will be regularly organised. These will bring together researchers from various backgrounds and operational stakeholders to share the results and data from the research related to regional issues. These discussions are expected to encourage the development of research subjects arising from the partnership between operational stakeholders and researchers or through interdisciplinarity. The first workshop of this type took place on 19 October 2017 on the Saint Martin



Participants de la journée science / société sur les données satellites et leurs usages en montagne © Dominique Lecorps(CNRM)

d'Hères campus, on the topic of: «satellite data and its uses in mountains», welcoming almost 70 participants. The day opened up a space for discussion between researchers (approximately 2/3 of the participants) and public and private stakeholders of mountain areas (approximately 1/3 of the participants), around several key questions :

- (a) conducting a review of scientific developments, the limits and obstacles on new applications or their operational porting,
- (b) identifying areas of research to be developed within a partnership bringing together researchers and regional stakeholders,
- (c) promoting stakeholders' expression of need in terms of satellite data and discovering its potential uses..

All presentations from the day are available from the [Ouranos platform](#).

ART Kalideos-Alpes is strengthening the efforts for pooling resources and multidisciplinary discussions across the region, already initiated with the provision of academic data on the [Ouranos AuRA platform](#) and satellite data of interest for the priority areas (high and very high resolution optical and radar: Pleiades, SPOT 6-7, ALOS-2, TerraSAR-X on the [Dotcloud platform of the Kalideos system](#), Sentinel-2 and Sentinel-1 on the dedicated distribution platforms).

F. Karbou (CNRM), C. Lutoff (Laboratoire PACTE),
M. De Gouville (GIS Envirhônalp)

THEIA regional coordination network in the Global South

In 2017, ART GeoDEV initiated support actions which are still continuing in the Caribbean area (Haiti), the Amazon (French Guiana, Brazil), the Indian Ocean region (Madagascar), Central Africa (Gabon), and North Africa (Morocco, Tunisia). Projects initiated have involved training initiatives for THEIA tools, the proposal and submission of application projects, coordination of communities in the area around priority applications, and support for sizing skills centre projects backed by national authorities.

At the start of this year, a new project was started in West Africa in the field of satellite-assisted agricultural applications: GeoForAgri – Feasibility study, funded by AFD, backed by CIRAD with IRD and CNES. The current activities involve conducting surveys on needs and practices, with regard to spatial information for the agricultural sector, with a wider range of stakeholders in the field (public and private sectors) in Senegal and Ivory Coast, in order to design the future Project's operational borders with the partners. In this case, as with the majority of projects brought

under the GeoDEV banner, the IRD, CIRAD or CNES teams involved have worked together to formulate and propose common or shared action plans, making use of the Centre's expertise internationally.

In 2018, since the GeoDEV Agreement was signed in March, IRD, CNES and CIRAD, founding members of the ART, decided to open up the discussions more widely within the Centre between teams working in the Global South and would like to bring promotion, communication, coordination or transfer actions into the ART. The GeoDEV website project, which suffered a delay in setting up in 2017, is the unified instrument that has been identified for facilitating these approaches and bringing them to fruition. The generic content of the site, which is under development, will be released to the managers of the Centre's concerned Laboratories, so that they can propose and insert content relating to their own activities in the Global South. Do not hesitate to express your views to the dedicated WebContacts: veronique.rousseau@ird.fr, sophie.ayoubi@teledetection.fr and jean-francois.faure@ird.fr.

Jean-François Faure (IRD)

Glacier Equilibrium Line Altitude Scientific Expertise Centre

Glaciers constitute a major economic and societal challenge (water resources, contingencies, change in sea level) the significance of which is heightened in the current context of rapidly changing climate forcing, surface conditions and anthropic pressure.

Due to access difficulties and the topographic complexity of glacial environments, glaciological field measurements are taken on a very limited number of glaciers. For example, only around forty of the world's glaciers have continuous measurements of their annual surface mass balance over more than 40 years, i.e. 0.016% of the total number of glaciers on Earth.

In this context, remote sensing offers tremendous potential for monitoring the evolution of glaciers on a global scale. The objective of the new «Glacier Equilibrium Line Altitude» Scientific Expertise Centre set up by the Institute for Geosciences and Environmental Research (Univ. Grenoble Alpes, CNRS, IRD, Grenoble INP) is to measure, using optical satellite images, the altitude of the glacier snow line at the end of the ablation period when it can be considered representative of the equilibrium line altitude (ELA). This ELA marks the boundary of the accumulation zone (where the mass balance is positive) and the ablation zone (where the mass balance is negative). The equilibrium line altitude may vary depending on the weather conditions for the year.



Equilibrium line for the year 2015 on the Glacier Blanc in the Massif des Ecrins, France. Sentinel-2 image from 29 August 2015 (©ESA).

Knowing its altitude every year and documenting its temporal variability provides us with a direct indication of the glacier mass balance.

The processing chain (data retrieval, filtering of cloudy images, topographical corrections, band ratio, calculating gradients to extract the altitude value from the equilibrium line, statistical processing over the time series) for high spatial resolution optical images (of the Sentinel-2, Landsat 8, ASTER type) and archive images (Landsat, World Heritage) is in the validation phase. Data obtained on glaciers in the French Alps for the period 1985 2018 should be made available some time in 2019.

Antoine Rabatel (Université Grenoble Alpes)

Surface water volumes Scientific Expertise Centre

Surface water plays a major role in global hydrological and biogeochemical cycles, exerts powerful feedback on the Earth's climate, and is highly important for human activities in terms of water resources, irrigation, or for watershed management. Despite its importance, its extent, but more importantly the volume it represents, and its temporal variations are still poorly understood.

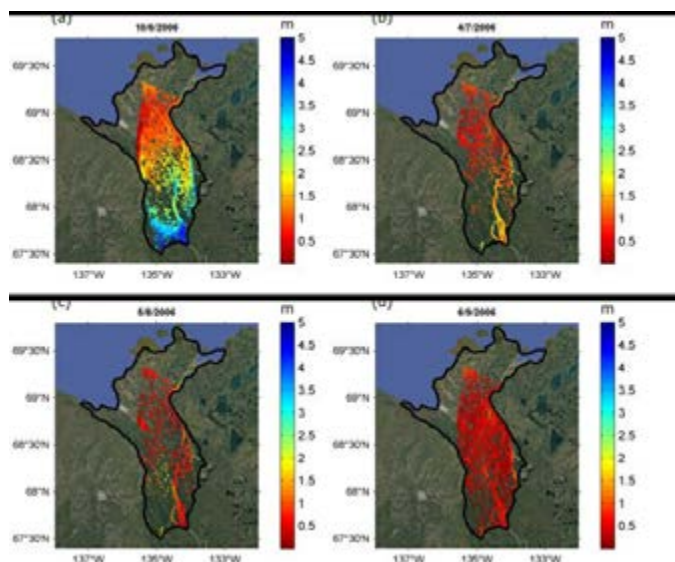
The «Surface water volumes» (SWV) Scientific Expertise Centre (CES) brings together researchers and engineers from six laboratories (CESBIO, EPOC, ESA Purpan, ESPACE-DEV, LEGOS, LERMA) around the classification of surface water quantities in major river basins and their changes over time. Its objective is to define methodologies for merging flooding extents, supplied by satellite imagery, with water levels from radar altimetry, which help with mapping the extent of flooded areas.

The CES aims to produce water level maps using summaries, over an 8-day period, of the best reflectances from the MODIS sensor. In order to improve the likelihood of clouds being absent in the study zones, summaries from Terra, since 2000, and AQUA, since 2002, are used. Three different methods for detecting floods, based on the thresholding of various spectral indices, have been implemented. To reduce the number of mixed pixels, containing both free water and a different type of land cover, 500m spatial resolution spectral bands were resampled to 250m. Comparisons will be made with flooding extent results based on the use of 100m spatial resolution passive microwaves such as GIEMS-D3 or SMOS Water Fraction (SWAF) in its high spatial resolution version. They will help to assess flooded surface areas beneath forest canopies, undetected by results from reflectance measurements. Water level maps are obtained by interpolation of water level time series calculated with intersections of altimetric tracks and watercourses or virtual altimeter stations on previously determined flooded surface areas. The interpolation technique used so far has been weighting that is inversely proportional to the distance to the nearest virtual stations. New

techniques are currently being tested, taking into account the primary flow direction obtained from a digital terrain model (DTM). These methods will be applied in various major river basins and major drainage areas such as the Amazon, the Mekong, the Inner Niger Delta, the Mackenzie Delta and the Aral Sea Basin. The subsequent results will be made available by [Hydroweb](#).

In parallel, there will be a discussion on the limitations to be overcome in order to extend use of altimetry to the study of flooded areas. Currently the main limitation lies in defining virtual station networks. For each altimetric mission, several thousand of them must be defined in order to densely cover a major river basin such as the Amazon. Studies are under way within the framework of the SWV CES to try to automatically detect water areas under the altimetric track, based on altimetric radar echo parameters.

Frédéric Frappart (Legos / Observatoire Midi-Pyrénées)



Temporal evolution of surface water levels in the MacKenzie Delta over the course of summer 2006 (Normandin et al., 2018).

Remote sensing and food security in the Global South

Following the 2008 global crisis and the subsequent food riots, the agricultural issue is back at the forefront of the international stage. The FP7 Sigma project (Stimulating Innovation for Global Monitoring of Agriculture and its Impact on the Environment; 2013-17) in support of GEOGLAM (GEO-Global Agriculture Monitoring), and the various TOSCA projects financed by CNES are all examples of the international community's support for applied research in this field.

Within this framework, CIRAD has been able to develop methods and products around the classification of agricultural systems in the Global South and their dynamics :

- The stratification of territories into agricultural landscapes; this stratification is based only on temporal, spectral and textural attributes of time series of MODIS images, and implicitly takes environmental factors and land use into account (example in Figure 1).
- Detection of the initial stages of vegetation; the start of the season estimated by analysing MODIS time series has been shown to be a good indicator of the planting date of cereal crops in Burkina Faso, and to improve yield simulations performed with a crop model (Figure 2).
- Analysis of vegetation patterns (NDVI); an original approach has been proposed to identify and produce a map of the key determining factors in crop-growing patterns in the Sahel region of Africa, either climate-related or human-induced, highlighting vulnerable areas in terms of production capacity decline.
- • Mapping of cultivated areas: on the local scale, CIRAD has conducted activities within the framework of the JECAM network (Joint Experiment of Crop Assessment and Monitoring) on 6 sites: 4 small-scale farming sites in Africa (Burkina Faso, Madagascar, Senegal, Kenya) and 2 intensive

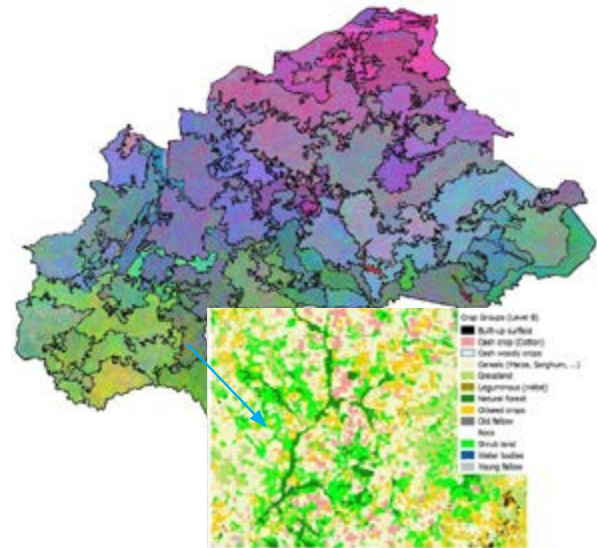


Figure 1. Agricultural landscapes of Burkina Faso obtained by segmentation of the time series of MODIS images (on a coloured background for Principal Components), and detailed look at the agricultural land use obtained by object-oriented classification from a Sentinel-2 time series and a VHSR SPOT 6 image.

farming sites in Brazil, with specific constraints related to the landscape, growing seasons, cloud cover, as well as access to training data. CIRAD has developed expertise in mapping small-scale family farming areas (according to 5 nomenclature levels, from the cultivated area to the cropping practices) based on an approach combining object-oriented analysis and Random Forest, using spectral information from High Spatial Resolution (HRS) time series (Sentinel-2, Landsat 8) together with a Very High Spatial Resolution (VHRS) image (SPOT 6/7 or Pleiades). This chain is in the process of being integrated into iota2 (Figure 1).

It is expected that, in the long run, the various products developed will supply the early warning system of the AGRHYMET Regional Centre (Niamey, Niger) which covers the 17 CILSS/ECOWAS countries. Every year, from May onwards, monthly bulletins are published to inform decision-makers on the development of the agro-pastoral and hydrological situation for the region. With the Sigma project, this system has been improved by including the SARRA-O spatial crop model which uses rainfall estimates based on satellite data and meteorological data to simulate yield forecasts for cereal crops, and has been operational since 2016. Maps of the cultivated area and the zoning of agricultural systems (where to run the model, for which crop, with which planting date?) are spatial information that could drive the SARRA-O crop model, and therefore the warning system for food security in West African countries.

A. Bégué, L. Leroux, C. Baron, D. Lo Seen, B. Bellon, V. Lebourgeois, R. Gaetano, C. Midingoyi, S. Dupuy (Cirad) S. Traoré (AGRHYMET)

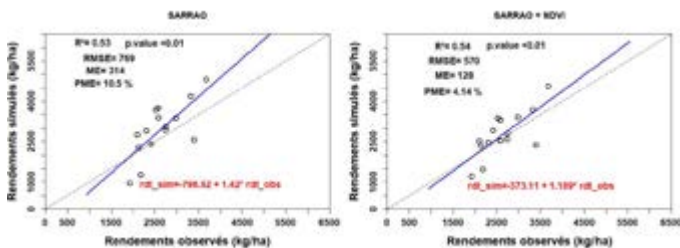


Figure 2. Comparison of sorghum yields observed in rural areas (5 villages in South-West Burkina and 3 years 2014-2016) and simulated yields with SARRA-O, without (left) and with (right) assimilation of planting dates estimated by phenometric analysis of MODIS time series

Participatory workshop, «Environmental research: how is data used by the agricultural sector?»

The National Alliance for Environmental Research's thematic valorisation consortium (CVT AllEnvi) organised this workshop on 8 February 2018 in Paris at the National Institute of Geographic and Forest Information (IGN). This workshop was an opportunity to present the results of an exploratory study into the needs of socio-economic stakeholders from the agricultural sector in terms of environmental research data. This work aims to provide

useful information for positioning public research institutions in the current context, affected in particular by the implementation of the INSPIRE European directive which has established that access to public environmental research data must be free of charge. This work is based on 38 interviews with officials from agricultural development and consultancy companies, startups, cooperatives and organisations, as well as AllEnvi researchers: BRGM, CNES, IGN, INRA, IRSTEA, Météo-France and MNHN. The workshop discussions, which brought together 16 participants from various backgrounds, helped supplement the results.



Various hurdles have hindered the effective use of data, both for research and for the agricultural sector. Although at present data from environmental research is seldom directly applied in the agricultural sector, the context now seems favourable. The agricultural sector's current digital transition, combined with agricultural

policies encouraging greater consideration for the environment, would appear to be favourable ground for the use of environmental data by the sector. Given the multitude of distribution channels and provision policies that differ from one organisation to another, it now seems necessary for research to clarify the offer and adopt an economic model that will help offset the distribution costs whilst being consistent with the current regulations requiring data to be free of charge and with the expectations of socio-economic stakeholders regarding technical, functional and thematic aspects.

Socio-economic stakeholders emphasise the need to acquire data that first of all corresponds to the important technical agricultural conditions: reliability, continuity, legibility, resolution, interoperability, frequent updating, low cost and, in particular, freedom to use the data (for commercial purposes). The matters of cost and freedom of use raise the important question of the economic model which is still to be defined, although on the research side there are already a range of service proposals using data: units attached to institutes (e.g. InfoSol, AgroClim at INRA), collaborative projects (e.g. THEIA centre, AnaEE RI), partnerships with technical institutes (e.g. MétéoFrance and ARVALIS) and the emergence of startups within research laboratories (e.g. ELL startup at CESBIO). On the operational side, stakeholders from the agricultural sector have expectations in terms of visibility of data produced, training and direct interactions with research

through the development of contact hubs, specific meetings and interface professions.

Thematically, needs appear mainly in relation to soils (nature, microbiology, C-storage capacity, transfer of water) and the reduction of crop-protection products (propagation of weeds, leaching of crop-protection products, improvement of treatments). Needs are also expressed regarding water (monitoring of stocks in terms of quantity and quality, usable reserves, and transfer of pesticides) and the climate (details on radiation and wind, and forecasts relating to climate change). Only a few references were made to biodiversity data during interviews but biodiversity is intrinsically present in each item: soil, water, etc. In addition, this type of data could find a market as part of the implementation of 2021 - 2027 CAP where the States will have to implement the monetisation of agricultural environmental services, which may rely on a tool based on data. Generally speaking, it should be noted that the thematic needs for environmental data coincide with current agricultural policies such as the "Ecophyto" French national plan or the "4 per 1000" international initiative launched at COP 21.

The socio-economic stakeholders and researchers involved in the discussion have expressed a wish that AllEnvi be involved in developing the interactions between research and the agricultural sector, and promoting the structuring of policies for making data available. This role is yet to be defined alongside that of collaborative infrastructures.

The presentation materials from this workshop and the study report are available upon request by emailing contact@cvt-allenvi.fr

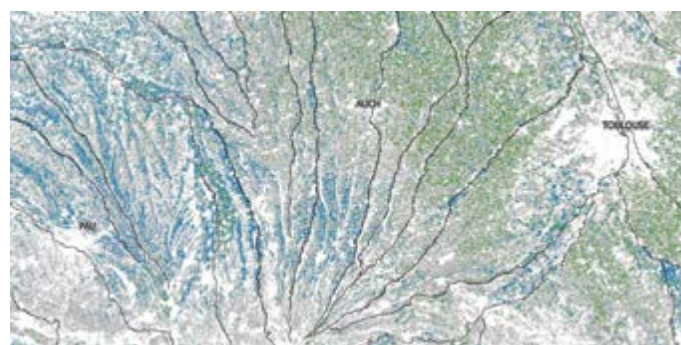
Sabine Riou (CVT AllEnvi) – Yves Brunet (INRA)

Utility of space observations in the farming industry

On 7 February 2018, a meeting was organized at the French Academy of Agriculture, addressing «The utility of space observations in the farming industry». This meeting, which was organized by Academy members Agnès Ducharne (CNRS) and Yves Brunet (INRA), was structured around three briefings focused respectively on the mapping and classification of agricultural systems (Agnès Bégué, CIRAD), the estimate of carbon stocks in the Earth's biosphere (Jérôme Chave, CNRS) and the utility of space data for agricultural water management (Jean-Pierre Lagouarde, INRA). During the discussion with the floor, involving Selma Cherchali (CNES) and Nicolas Baghdadi (IRSTEA), a wide range of topics were addressed covering, in particular, monitoring plant diseases, monitoring land cover, international cooperation, and conditions for accessing remote sensing data. This last point was an opportunity to make the audience aware of the THEIA centre and its role in the use of remote sensing, both by research and by agricultural stakeholders and public authorities. The event was well received by the audience, with a high turn-out despite the snowfall in the Île-de-France region that day.

Find more information, along with a full video of the meeting, at academie-agriculture.fr

Agnès Ducharne (CNRS) - Yves Brunet (INRA)



Map of irrigated (blue) and unirrigated (green) summer crops, from March to October 2015, based on Landsat 8 - THEIA images. Production: Florian Helen (CESBIO). Presented by Agnès Bégué (CIRAD).

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