BULLETIN
Theia Land Data Center

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no 5 - December 2016

Contents

A word

from the Scientific and Technical Directors

In the four years since Theia was started, a great deal has been accomplished, and we have already developed a significant portfolio of products and services. We still have a long way to go before reaching our objectives, but the Theia team is, as always, ready to meet the challenges ahead with unwavering enthusiasm.

The Scientific Expertise Centres (CES) are continuing the development of new products corresponding to the needs of users (scientists and actors in charge of public policy), and the Theia Regional Coordination Network (ART) is ramping up to facilitate appropriation of our innovative mechanism.

The success of Theia belongs of course to our institutions and their ability to pool resources for use by all, but whether you were a stakeholder from the start or are a new user, it also belongs to you.

N.Baghdadi S.Ayoubi A.Sellé

Latest news

MMCO, a local antenna of the PACA ART

The MMCO (Orres Meteorology and Climate Centre) - a scientific and technical research centre in the Alps, at an altitude of 1700 metres - is becoming a local antenna for the Provence-Alpes-Côte d'Azur (PACA) Theia Regional Coordination Network (so called «ART»). GeographR, heading the PACA ART since 2015, will rely on MMCO to inform and support actors in the Alps in order to facilitate access to and use of satellite images. The main objective is to promote dialogue, to coordinate the community of remote sensors, and to build bridges between public and private actors, as well as to encourage participation in the Scientific Expertise Centres (CES). For further information, see http://www.mmco.fr/la-mmco/contact or write to geographr@numericable.fr

Philippe Rossello (GeographR)

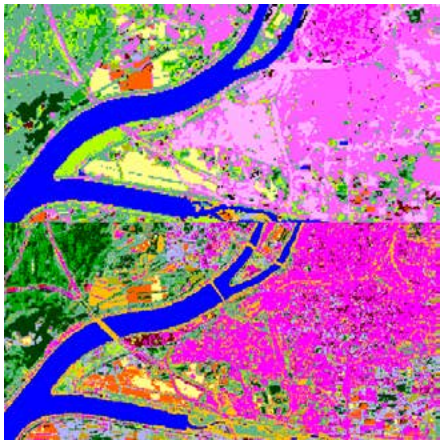
Orres Meteorology and Climate Centre © Alice Simonard

News from the Land Use Land Cover CES

In the April 2016 Theia bulletin, we explained that the final characteristics of the product would be set before the end of 2016 in consultation with the users, based on feedback received on the prototype products published.

Since the month of April 2016, the Land Cover CES (CES OSO) has continued to work on the iota² chain to prepare for the arrival of the Sentinel 2 data.

For the first version of the product, the map will be produced based on a reference year from January to December 2016 and distributed in raster form with 20 m pixels, although the product with 10 m pixels will be available on request. Vector files



Comparison between land cover maps generated using Landsat 8 data (top) and Sentinel 2 (bottom) on the Rhone, the Durance and the city of Avignon

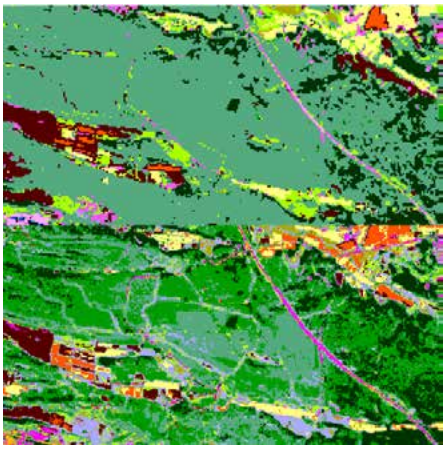
broken down by administrative region, with a minimum collection unit of 0.1 ha, will also be available to download.

The list of mapped classes will be as follows :

1. Annual summer crops
2. Annual winter crops
3. Prairies
4. Vineyards
5. Orchards and arboriculture
6. Deciduous forests
7. Conifer forests
8. Grass and natural pastures
9. Wooded heath
10. Impermeable artificial surfaces
11. Urban continuous
12. Urban discontinuous
13. Commercial and industrial areas
14. Road surfaces
15. Natural mineral surfaces
16. Beaches and dunes
17. Water
18. Glaciers and permanent snow cover

We have not yet been able to validate the breakdown of the "Impermeable artificial surfaces" class into four sub-classes because the Sentinel-2 surface reflectance data were not released until October, but we are working on this so that by early 2017 the map can include a nomenclature of 17 classes rather than only 14.

Thus, the product specifications are not frozen, allowing the product to evolve



Comparison between an area of natural vegetation with a small amount of agriculture

according to users' needs. The R&D activities are in progress and will continue for several years. The quality of the product will evolve, but continuity will be ensured through reprocessing operations. Moreover, the data used and the processing chains are "open", which allows for changes and adaptation in the case of specific requirements and user independence with regard to Theia.

Jordi Inglada (Cesbio / Cnes)

The Brittany ART in action

GIS BreTel, the organisation heading the Brittany ART, has broken down the actions it is conducting into four categories: research, innovation (economic development of the space industry in Brittany), education/training (initial and continuing), and distribution (promoting space applications to confirmed or potential users).

One of the projects that GIS BreTel has launched within this framework is the Kalideos Bretagne database, aimed at assessing the offer of space-based imaging (free of charge or otherwise) in order to meet the demand for geographic information on the evolution of land and landscape cover and use and their impact on the environment in urban and rural areas, on a site forming a city-country gradient.

Among the other actions conducted, GIS BreTel and InSpace Institute held a seminar in Brest on 21 September 2016 entitled "Potential and Benefits of Space-based Applications for Territories", which was attended by around 120 people: potential and confirmed users, suppliers and students. The morning programme was an informational "conference", comprehensible for all regardless of previous knowledge in the field (inventory of geoinformation within administrations, characteristics of satellite images, acquisition platforms and data, examples of applications), and the afternoon session was dedicated to a "showroom" where the managers of territories could meet the application suppliers.

Nicolas Bellec (GIS BreTel)

"Potential and Benefits of Space-based Applications for Territories" seminar in Brest on 21 September 2016

The Midi-Pyrénées ART User Day

The Midi-Pyrénées ART had hold a user day on the 1st of December 2016 at Cesbio in Toulouse.

The event was open to remote sensing experts and novices alike, e.g. GIS specialists, technicians, managers and decision-makers. All sectors were invited to take part (research, private, public services).

Cesbio has presented the images, processing techniques and several products (Products CES) obtained at regional and national scales, from time series of Sentinel 1 and 2 decametric images.

Cerema, Onera and IGN espace has presented the equivalents at local scales, in very high spatial resolution (metric).

Other one-day events are being planned for 2017, notably on the themes of forests, agriculture - territory - environment relations, etc.

Details at hervegibrin.wixsite.com/art-midi-pyrenees.

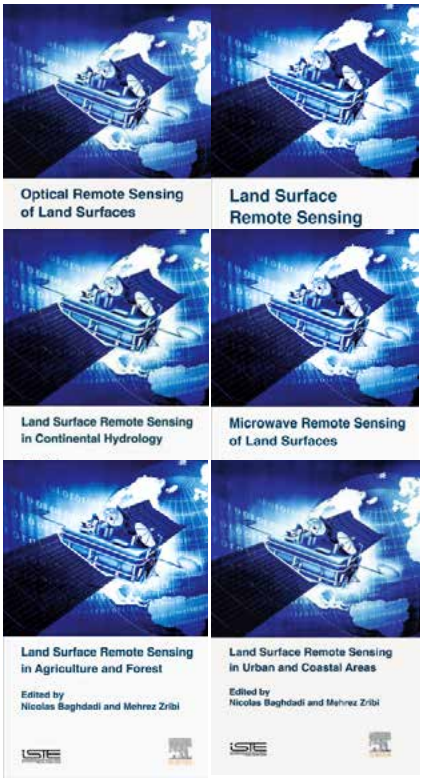
Jean-François Dejoux (Cesbio / CNRS)

New collection of books on remote sensing of continental surfaces

With the emergence of new major space missions and greater data accessibility (including in terms of cost), we expect the use of data and products of observation from space to become more widespread and even generalised, whether in new scientific fields or by new users such as managers, decision-makers, etc.

Thus, a strong need has arisen for updated educational materials on the different concepts and methods in remote sensing and its major applications, especially with regard to continental surfaces.

In order to meet this need, a new collection of books is now available, providing researchers and undergraduate - and graduate - level students, as well as decision-makers, territorial or national management departments, and actors with decision-making authority, with a resource covering, all in one place, the necessary bases of physical principles from the various space-based techniques, and the methods and illustrations of use for a large number of applications based on observation from space.



This series of books describes the physical principles of the main remote sensing techniques used for the observation of continental surfaces and methods of analysis and interpretation of the measurements and images (volumes 1 and 2). The four other volumes illustrate methods and examples of applications of remote sensing data for agriculture and forests (volume 3), continental hydrology (volume 4), urban and coastal areas (volume 5), and the environment and risks (volume 6).

This series (6 volumes, 60 chapters) is coordinated by Nicolas Baghdadi (UMR Tetis, DR Irstea) and Mehrez Zribi (Cesbio, DR CNRS) with contributions by 200 scientists of international renown in their fields. It has already been published in English by ISTE-Elsevier. The French version will come out at the end of November 2016.

These books are available for purchase at book stores or online at store.elsevier.com and amazon.fr.

Nicolas Baghdadi (Irstea)

Theia Seminar 2016

Geoinformation on Continental Surfaces for Research and Public Policy

The data and services centre Theia held its second seminar on the theme of “Geoinformation on Continental Surfaces for Research and Public Policy” on 3 and 4 October 2016 at Agropolis International in Montpellier.

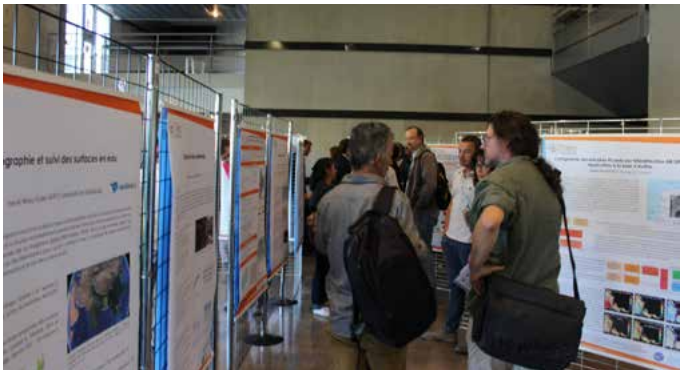
The goal of the seminar was:

- to bring together scientists, public and private actors, and non-profit organisations in order to present the goals of Theia, the progress made, and our current and upcoming actions,
- to create an event that encourages dialogue and communication between the communities,
- to present examples of applications and uses,
- to reflect on and discuss at two roundtables: (1) the success and challenges of optimised access to satellite images and value-added products and (2) the role of the private sector in the satellite image exploitation value chain.

Plenary session in the amphitheatre at Agropolis International © B.N. / IRD

The seminar was a huge success, with 315 participants over the two days. Many organisations were well-represented at the event (institutions, ministries, etc.), attesting to the strong interest and high expectations of the communities of scientists and public actors. The private sector was also present, with some twenty representatives in attendance.

Data that are now available (Spot 6/7, Pléiades, Sentinel 2, Landsat, SPOT Archives from the SWH programme, etc.) or soon to be (airborne and “in situ” data) were presented at the seminar, along with value-added products in the production, prototyping or development phase at the Theia Scientific Expertise Centres (CES) (land cover, snow cover, colours of inland waters, digital soil mapping). The future users of these products, especially land cover maps, were invited to speak about their needs and expectations.



Posters on exhibit in the grand hall at Agropolis International © B.N. / IRD

Many space-based imaging applications presented during the conferences effectively illustrated the feedback from different communities. Two series of some thirty posters exhibited throughout the seminar also presented uses of very high spatial resolution and projects by Scientific Expertise Centres. The speakers’ presentation materials and electronic files of the posters exhibited are available at the theia-land.fr website.

The roundtables sparked fruitful discussion with representatives from both the public (CNES, IGN, IRD, Occitanie region, MEEM) and private sectors (Booster Paca, Booster Nova, BRLi, SIRS, TPZ).

Immediately following the Theia seminar 2016, a training on Orfeo ToolBox (OTB) was held on 5 and 6 October 2016 at Agropolis International (Montpellier). The training, which was free of charge and open to all, was attended by 23 participants and led by the CNES (M.Grizonnet and J.Michel) with the assistance of Irstea (R.Cresson).

Nicolas Baghdadi (Irstea) et Sophie Ayoubi (Theia)

Family photo of participants in the Theia seminar 2016 © J.L./ IRD

Onera and its involvement in Theia

Onera is the French national aerospace and defence research centre. It is a multidisciplinary organisation equipped with experimentation resources unparalleled in Europe, and uses its expertise to support programme agencies and institutional and industrial actors.

Onera plays an important role in the development of observation and measurement facilities at medium and large distances, especially at centimetric and decimetric resolutions. The current techniques are multispectral and hyperspectral imaging, ultraviolet to thermal infrared and SAR (Synthetic Aperture Radar) imaging: polarimetric, interferometric, or a combination of both (PolInSAR method). In the future we will have other means at our disposal, such as airborne lidar measurements of wind fields, aerosols and gases (CH4, H2O, pollutants, etc.), 3D optical imaging through vegetation or in bad weather, and even gravimetric measurements for subsoil prospecting.

Support for satellite programmes

These developments are ultimately leading to airborne systems used by Onera for research or to support satellite programmes.

For example, since 2007, Sethi has mounted P, L and X band radar sensors on a Falcon 20 aircraft in order to provide:

- mapping day and night, in any weather;
- full polarimetry for the classification of objects or environments;
- interferometry to produce a digital terrain model or detect changes that have appeared since the reference image;
- detection of objects hidden by the canopy or in the ground.

Sysiphe, a system designed and implemented by Onera at the request of the French defence procurement agency (DGA), is the only one of its kind in Europe: it provides an image of the ground with 50 cm resolution in more than 500 spectral bands from the visible to thermal infrared. It began to be used in 2015.

LIMA, the Airborne Multisensor Imaging Laboratory, develops applications for optical technologies. It uses ground and airborne mobile measurement facilities and a processing infrastructure including databases of images and optical properties of surfaces and materials. Similar means exist for SAR imaging.

These developments also require expertise in technologies for physical image processing, extraction and digital data fusion, especially on very high resolution imaging. Onera applies these technologies for aspects of urban environment monitoring, for example.

Developing thematic applications

In addition to its primary missions, Onera has entered into partnerships to develop remote sensing applications in fields such as energy resources, transportation by rail and urban development, etc., and to promote the emergence of the civil drone industry,which not only has strong economic potential but is also an opportunity for research.

Onera is making serious efforts to bring this opportunity to fruition by overcoming hurdles in terms of the miniaturisation of sensors and on-board systems, drone dependability, legal and operational constraints with regard to implementation, decision-making autonomy and cooperation between vectors. Onera has planned scientific and technical coordination in this emerging field for the Theia community.

Since joining, Onera has increased its participation in the thematic CESs: digital soil mapping, land artificialisation-urbanisation, forest biomass, etc.

Finally, interoperability with the data and services infrastructure has been established, in the aim of providing access to the original airborne data acquired by Onera facilities. This aspect could also be developed through a system of mutual management of requests from Theia during airborne measurement campaigns organised by Onera.

Bernard Rosier (Onera)

Sysiphe imagers in a Dornier-228 ©DGA

CORINE Land Cover: 30 years of European cooperation

CORINE Land Cover (CLC) is the only free, open data source that provides a full photograph of France's land cover (mainland and overseas departments [DOM]) at regular frequencies. As such, it is a benchmark tool.

Launched in 1985 by the European Union to support its environmental policy, CLC is the result of collaboration between the European Environment Agency (EEA) in charge of its implementation, the countries of the European Union and cooperating countries.

Since its last update started in 2013, CLC has been a component of the land monitoring service within Copernicus (www.copernicus.eu), the EU programme for the establishment of a European capacity for Earth observation. It thus ensures the entire basic data acquisition chain from the satellite images to distribution of the products.

After the first edition for the year 1990, spanning 28 countries, CLC now covers 39 countries. Since the year 2000, it is updated every six years. For France, its overseas departments (DOM) have been included in the project since 2006. CLC now covers 604,000 km² of French territory.

The CLC project is also evolving under the leadership of the EEA. For the 2012 edition, in addition to the CLC databases, new high resolution layers of land cover are available through automatic mapping of satellite images. These layers significantly enhance the information available in CLC on major themes such as forests, land waterproofing, prairies, wet areas and water surfaces. For the next campaign, a new product on green linear elements (hedges, aligned rows of trees in rural areas, etc.) will also be available.

Finally, CLC will soon benefit from the arrival of the new Sentinel 2 satellites, whose deployment in orbit began in 2015. These two satellites allow the territory to be covered with greater frequency, and will help make data available more quickly for future editions

CLC, a custom-made production

As the French representative of the EEA's partnership network, the observation and statistics service (SOeS) is the project owner of CLC for the national territory.

Production of the 2012 edition is the fruit of a partnership between SOeS, IGN and SIRS, under the responsibility of EEA, which ensures overall management and the final validation.

The CLC is produced at a scale of 1/100,000, and the minimum surface area of mapped units is 25 ha for status databases (year in question) in mainland France, 10 ha in the overseas departments (DOM) and 5 ha for change databases (mainland and DOM). The minimum width of objects to be mapped is 100 m on the mainland and 50 m in the overseas departments (DOM). The nomenclature is made up of 44 stations on the mainland and 50 in the DOMs. There are currently four editions for mainland France (1990, 2000, 2006, 2012) and three for the DOMs (2000, 2006, 2012).

In order to meet the quality requirements, CLC production relies on a precise development and monitoring protocol. Headed by a project manager, the production was conducted by a team of experienced photograph interpreters, a production and quality assurance manager, and a quality control and delivery manager. Regular intermediate deliveries allowed the SOeS and IGN to make a daily assessment of the quality and consistency of the work by SIRS. This made it possible to quickly identify and process any divergence or need for technical and methodological details.

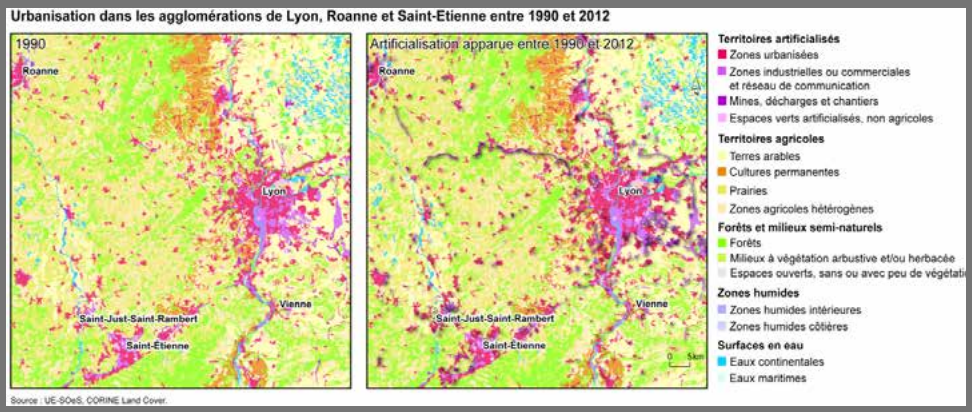
The territories under study were broken down into sub-sectors based on the image scenes/dates, following a specific order so as to optimise the rate of progress and facilitate the junction between sub-sectors. Each section is assigned to an operator who covers his/her entire zone using tools and a dedicated production interface to digitise and codify the land cover changes in accordance with a specific protocol. Prior custom training was provided by IGN on the method, image selection, and the validation protocol.

The main technical issue on this latest edition was the diversity of available sources. For the first editions, there was a limited selection of images (only one Landsat image cover at 30 m for 1990 that spanned more than 5 years). For this latest edition, two satellite covers and the ORTHO® database were available, along with various exogenous databases.

Example: monitoring anthropisation

Loss of farmland, destruction of natural spaces and soil erosion are all phenomena linked to anthropisation. The multiple land cover data that exist on the territory are essential tools for analysing these sometimes irreversible phenomena.

CLC can also be incorporated into multi-theme studies, particularly by comparing them with other databases, for the analysis of complex interactions. These databases paired with other data are used, for example, to monitor protected areas, to study the fragmentation of natural areas, or to study the risks of soil erosion.



However, the possible uses are limited due to the methodological choices made in CLC. Changes or land cover in extensions of a surface area limited to less than 5 ha are not reiterated in CLC. Thus, elements with a small surface area such as hamlets or dispersed habitat are only partly accounted for in the artificialisation rate derived from this source. This is also the case for small wet areas such as ponds and marshes. This source therefore cannot be used for large-scale local studies.

The difficulty is choosing the right temporal reference (year and season) between these sources, in order to ensure a consistent database as close as possible to the reference year (2012). As a result, catalogues of appropriate images have to be generated and the exploitation of the different sources needs to be ranked.

Another complexity is image resolution. At present, we are used to having very high resolution optical sources (infra-metric). For historical reasons, CLC is produced using medium resolution images (20 and 30 mm). Superimposing these data onto precise media can reveal inconsistencies in setting or interpretation. This is why it is important to understand the aims of the project, especially its methodological characteristics.

Commercialising CLC ?

CLC is used in a number of fields such as land use, environment and landscapes. For the latest edition published in 2015, one of the first tasks was for SOeS to set up services providing open access to data via downloading, online consultation and web services.

A first statistical analysis at the national scale was produced to determine the main trends in the land cover changes. This analysis, focused on monitoring urbanisation, was the subject of a publication[1].

A battery of indicators and cross analyses has also been updated. The SOeS also generates communication media such as regional atlases[2], bookmarks, and posters on a specific theme (e.g. the progression of urbanisation). A number of projects are still underway, including a study on anthropic pressure in areas where the stakes in terms of biodiversity are high.

Konrad Rolland (SIRS) & Frédérique Janvier (MEEM/CGDD/SOeS)

1 - Land cover in France: more moderate growth of artificialisation between 2006 and 2012 - Review of No. 219 - December 2015
2 - www.statistiques.developpement-durable.gouv.fr

Automatic production of a land cover map of all of France based on very high spatial resolution (VHSR) satellite images

The automatic production chain developed at Cesbio within the scope of the Land Cover Scientific Expertise Centre (CES OSO), is now based primarily on the use of Sentinel 2 data (high resolution, high revisit frequency) for the first production of a land cover map in 2017. The revisit capacity of these satellites allows for temporal analysis of the signal on a given territory, which facilitates access to the type of crops (summer, winter) in rural environments or the type of vegetation in a forest environment. Sentinel 1 data are now also integrated in the chain. For further details, see the previous Theia bulletin.

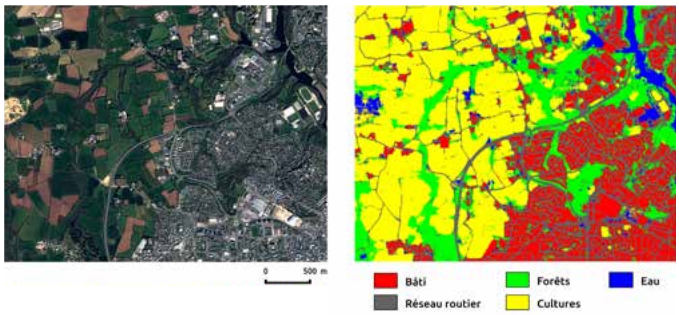
Complementarity between THR multi-spectral Spot 6/7 and Sentinel 2 time series

On the other hand, the spatial resolution of this land cover map (10 m) seems limited for describing plots and the urban environment with precision, due to lack of texture. The information contained in the VHSR images is one means of compensating for these limitations.

In addition to improving the processing chain developed by Cesbio, other tasks are underway at IGN as part of a thesis undertaken in November 2015. The aim is to provide an annual land cover map of all of France produced using VHSR images through the Theia portal. The images in question come from Spot 6 and 7 acquisitions, at a post-fusion resolution of 1.5 m on 4 spectral bands (RGB-IR) in addition to the panchromatic band. The VHSR data provide only a small number of images (1-3) for a given area in one year.

Deep learning to match the ramping up of land cover generation methods

From a methodological perspective, “deep learning” algorithms (convolutional neuron networks) are adopted in this thesis and implemented for several reasons. First, the performance of these and other methods in classification tasks is unequalled since 2012. The second reason, which relates to the first, is that these methods are reputed to be highly robust because of their generalisation potential (aptitude to recognise new data). This feature makes this family of algorithms an excellent choice for our large-scale land cover VHSR context. It is also interesting to note that once trained, the upper layers of the network have behaviours close to textural and spectral attributes. Training algorithms such as these requires a very large set of learning data in order to give them this generalisation capacity. This issue is partly resolved thanks to the topographical databases at our disposal (IGN Topo database, IGN Forest database, RPG) along with the product provided by Cesbio’s iota² chain.



Land cover in the area around Brest using deep learning

Preliminary results

Thus far, the experiments have concerned few classes and a limited study area, as the aim was to become more familiar with these approaches, define the scale of the problem, and list the operational hurdles involved with using neuron networks.

The test area (50 km²) covers the city of Tarbes (65). The classes considered are: urban environment, crops, forest and water. The networks used at this point are simple (with few layers). Limiting the number of classes and layers reduces calculation times and over-learning (poor generalisation capacity, i.e., classifying new areas when the learning set is too small compared to the size of the classifier).

The initial results are quite promising, considering that no processing was done before or after the algorithm. We are able to attain a correct classification rate above 85% for networks with the lowest performance. Also to be considered is the fact that increasing the number of classes makes training more difficult, and precautions will need to be taken (especially increasing the set of learning data to enrich the network, making it easier to distinguish between classes) in order to extend the land cover generation process.

Tristan Postadjian, Arnaud Le Bris, Clément Mallet (Univ. Paris-Est, LASTIG MATIS, IGN, ENSG)

Monitoring snow cover at ski resorts with Sentinel 2

Within the scope of the Theia thematic centre, the Snow-covered Surface CES is preparing to distribute snow cover maps established using Sentinel 2 images for the start of 2017. While the method used to detect the snowpack is based on well-proven concepts, the spatial and temporal resolution of the snow cover maps will be completely unprecedented. Until now, snow cover maps were generally produced using Modis observations at 500 m of resolution, which allows hydroclimatic studies to be done at regional-type scales. Nivologists did not make much use of Landsat data due to their low repeatability. Deployment of the Sentinel 2 mission (overall cover at 20 m of resolution every 5 days) opens up new possibilities for snow cover monitoring.

Snow cover map dated 10 July 2015 and trail map for the summer skiing area at Les Deux Alpes

Sentinel 2A is already operational but only with its twin sister Sentinel 2B will 5-day repeatability be attained. Luckily, with the Take 5 mission, we have enough to keep us busy until the Sentinel 2B launch. It happens that one of the sites in the Take 5 experiment ("France-Ecrins" tile) covers the sector containing the Alpe d'Huez and Les Deux Alpes ski resorts. As alpine skiing aficionados probably know, the Deux Alpes resort is equipped for summer skiing while the Alpe d'Huez resort is not.

So we ran this series of Spot 5 Take 5 images through our "Let-it-snow" chain to extract the areas under snow cover in the sector covering the two resorts from 11 April to 8 September 2015. We then interpolated some of the data hidden by clouds by applying the following rules :

- if a pixel hidden by a cloud was under snow cover on the previous image and under snow cover on the next image, then it is marked as a pixel under snow cover.
- if a pixel hidden by a cloud was not under snow cover on the previous image and not under snow cover on the next image, then it is marked as a pixel not under snow cover.

This allows us to fill in some but not all of the pixels hidden by clouds. We are working on a more sophisticated method for filling in gaps due to clouds. Finally, we simply laid the snow masks onto an image of the relief, and superimposed the trail maps of these two resorts.

We can verify that the summer skiing area at Les Deux Alpes is indeed under snow cover in the summer! The boundary of the snow cover exactly follows the blue run called "Signal" at the lower limit of the ski area. The satellite does not, however, tell us whether it is natural snow...

Simon Gascoin (Cesbio / Cnes)

A spatialised indicator to estimate and monitor the risk of malaria transmission

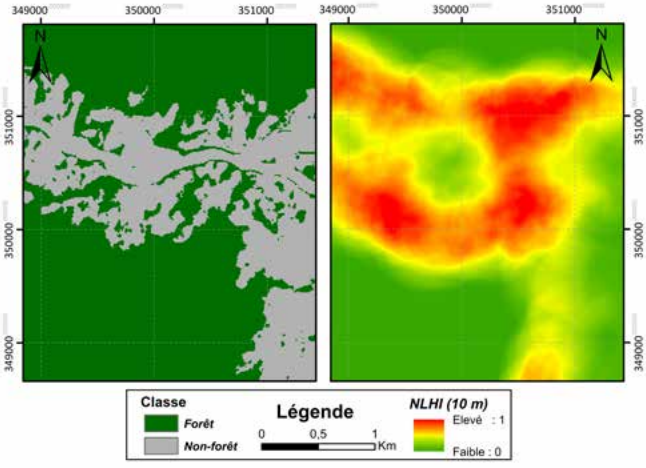
The Risks of Infectious Diseases CES is tasked with producing, based on remote sensing data, spatialised indicators entered into the construction of maps of hazards and risks associated with various health issues, such as malaria.

According to the World Health Organization, around 214 million cases of malaria were declared in 2015, including 438,000 deaths. Given the decline in malaria recorded over the last fifteen years, it is plausible that the disease could be completely eradicated by 2030 as part of the United Nations Sustainable Development Goals.

Within this framework, an indicator called Normalized Landscape-based Hazard Index (NLHI) has been developed (Li et al., Remote Sensing, 8(4), 2016). NLHI quantifies and spatialises the increase in the risk of human-vector contact as a result of the surface area and structure of deforested areas in the Amazon, thereby playing an important role in estimating the risk of transmission.

The NLHI is a robust indicator based on a simple characterisation of the land cover (Forest vs. Non-forest), which allows it to be produced automatically and regularly. Production will be based on products from other CESs, such as the Land Cover CES, and the implementation of high-performance generic processing chains associated with the data and service infrastructure Geosud. This is a significant step towards routine production of maps of the risk of malaria transmission, which will ideally include characteristics of vectors and humans, on populational and individual scales.

Nadine Dessay, Zhichao Li et Emmanuel Roux (Espace DEV/ IRD)



Normalized Landscape-based Hazard Index on malaria in the region of Camopi (French Guiana) calculated using a Forest – Non-forest land cover map. This map was produced based on a multispectral Spot 5 image acquired on 17/10/2009 with spatial resolution of 10 m

Monitoring continental surfaces by satellite altimetry

A technology initially developed for the determination of marine geoid undulations and monitoring dynamic ocean topography, satellite altimetry has demonstrated strong potential in the study of the polar ice caps and continental surfaces.

The Centre of Topography of the Oceans and the Hydrosphere (CTOH) is a French observation service for the National Institute for Earth Sciences and Astronomy (INSU) and the French Institute for Development Research (IRD). Based at the Laboratory of Studies in Spatial Geophysics and Oceanography (LEGOS), at the Midi-Pyrénées Observatory (OMP), the CTOH is specialised in the processing and distribution of radar satellite altimetry data. Motivated by the importance of better understanding the water cycle on the continents, the CTOH offers new tools and products for specialists in earth observation from space who want to develop new applications in the field of space hydrology, water cycle modellers looking for data to validate or force hydrologic and hydrodynamic models, and hydrologists working on the scale of a catchment area who would like additional sources of data to use with the measurements they rely on traditionally.

The CTOH provides these various users with expertise in the physics of altimetric measurement in a continental context, software for the simulation and processing of altimetric measurements and new space hydrology products.

The CTOH is very involved in the scientific definition and calibration phases for new missions using nadir or LRM (Low Resolution Mode) altimetry or wide-swath altimetry, which will be tested for the first time on the Surface Water and Ocean Topography (SWOT) mission. It is also involved in efforts to improve the quality of data from past altimetry missions in order to obtain long times series of data that are as uniform as possible in terms of the processing applied to the observations. The CTOH has developed corrections for altimetric measurements specific to continental surfaces and has reprocessed all of the radar echoes from the European Space Agency's (ESA) ERS-2 mission with adapted algorithms for monitoring continental surfaces and polar ice caps. The resulting product has characteristics similar to the latest version of data from Envisat, a satellite travelling in the same orbit as its predecessor ERS 2 (Figure 1).

The team has also developed an altimeter radar echo (or waveform) simulator. In complex and highly irregular environments such as continental surfaces, electromagnetic modelling offers a clearer understanding and helps correct some of the errors that can interfere with the reconstruction of water levels based on altimeter measurements. The team also distributes MAPS

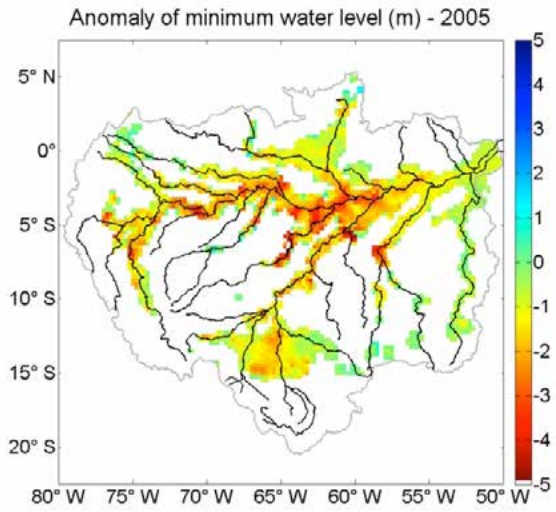


Fig. 2 : Differences, in metres, between minimum surface water levels in 2005 and the average minimum of this level for the period from 2003 to 2007, obtained by combining the extension of flooded surface areas determined using satellite images and the water levels given by satellite altimetry.

(Multi-mission Altimetry Processing Software), a software program developed with a team from the EPOC (Oceanic and Continental Environments and Paleoenvironments) research laboratory, which is used to derive water level temporal variations in continental hydrosystems using altimeter measurements.

It contributes to the development of new space hydrology products, such as monthly maps of the water level in various major river basins, obtained by combining the extension of flooded surface areas determined using satellite images and the water levels given by satellite altimetry (Figure 2). These data sets are a unique source of information that can be used to measure interannual variations in the amount of water at the surface. They also prefigure the data that will be provided by the future SWOT mission, a joint development by CNES and NASA that should be launched around 2020.

All of this information and more can be found on the continental surfaces pages of the CTOH website http://ctoh.legos.obs-mip.fr.

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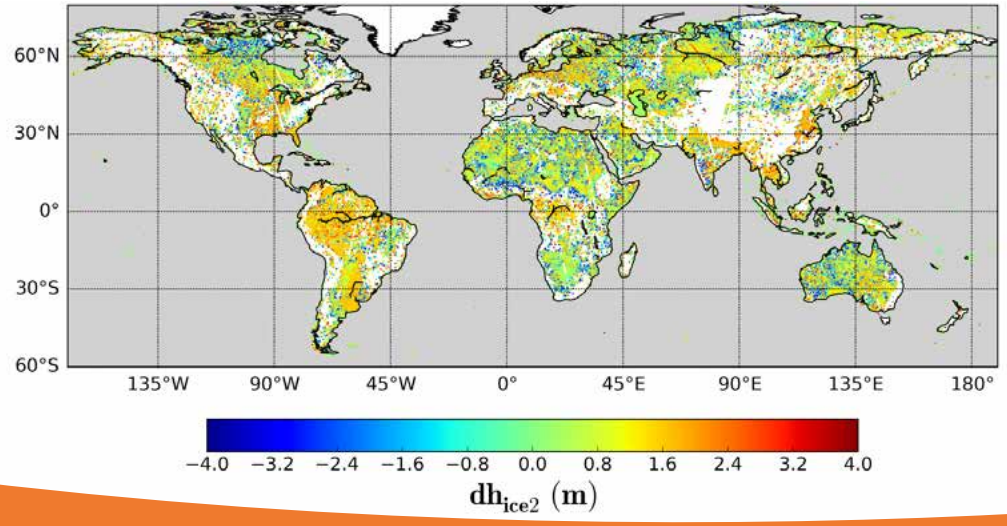

Fig. 1 : Average difference in water levels measured by ERS 2 (reprocessing by CTOH) and Envisat (v2.1) during the tandem period (June 2002-July 2003) when the two satellites were travelling in the same orbit, separated by a half-hour interval.

Environmental observation technologies for agriculture and natural risks

The AllEnvi Thematic Commercialisation Consortium (CVT) published a collective strategic analysis (ASCo) on environmental observation technologies for agriculture and natural risks. Nicolas Baghdadi (Theia) and Pierre Maurel (Geosud) were members of the ASCo steering committee. This study identified market opportunities up to 2020-2025 and correlated them with research areas in order to prepare for the transfer of technologies and skills in step with the development of new associated services in remote sensing.

Satellites and drones: Two distinct sector-specific studies

The study on satellites presents the value chain for the Earth observation market and the markets pertaining to dedicated satellites, including a focus on microsatellites. It shows the sale of space data and related services to be an economic sector characterised by both upheaval and growth; with regard to value-added services, AllEnvi offers a number of advantages such as complementarity with existing free public systems, the level of excellence, and the strength of the network of research laboratories.

The study on drones offers an analysis of the economic market, its actors and their tactics. Especially in agricultural contexts and applications relating to natural risks, the many advantages of using drones far outweigh their drawbacks. The study also presents foreseeable technical advances in drone technology.

Agricultural applications

Digital technology is beginning to be used in agriculture; the levers and hurdles relating to the adoption of remote sensing technologies are examined in this context. The main needs for remote sensing in agriculture are analysed. Precision agriculture appears to be the most fertile sector for developing partnerships and technology transfers, not only because it seems to be economically solid, but also because the scientific research, often interdisciplinary, conducted by AllEnvi on topics such as ground humidity, water cycles, etc. is concretely translated through regional projects, placed in real contexts in the field and international in scope.

Remote sensing for natural risks

Economic and social pressure from natural catastrophes continues to grow. These technologies are involved at every step of risk management and the authorities, because of their legitimacy, are the most obvious users. There is no specific market for natural risks. Public and private actors share the same economic approaches in terms of incorporating remote sensing into risk management. Of the various private sectors, the insurance industry would not be the most profitable in terms of commercialising know-how gained through environmental observation data from satellites. This is less true in the case of data acquired by drones. The surveillance of infrastructures and work sites is, however, more fertile territory. Through its involvement in many international projects and its significant experience in public-private collaboration, AllEnvi is positioned as a key player in this field.

Finally, AllEnvi's strengths and weaknesses in environmental observation for agriculture and natural risks were considered with regard to opportunities and threats. This approach helped identify innovation areas that have a better chance of success, according to commercialisation approaches.

If you would like to receive this study, please send us a request by email at contact@cvt-allenvi.fr

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Bulletin Theia

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