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SPACE ● INNOVATION ● SOCIETY

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AGRICULTURE

REMOTE SENSING RAISES THE BAR

cnes
CENTRE NATIONAL D'ÉTUDES SPATIALES

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PARTNERS

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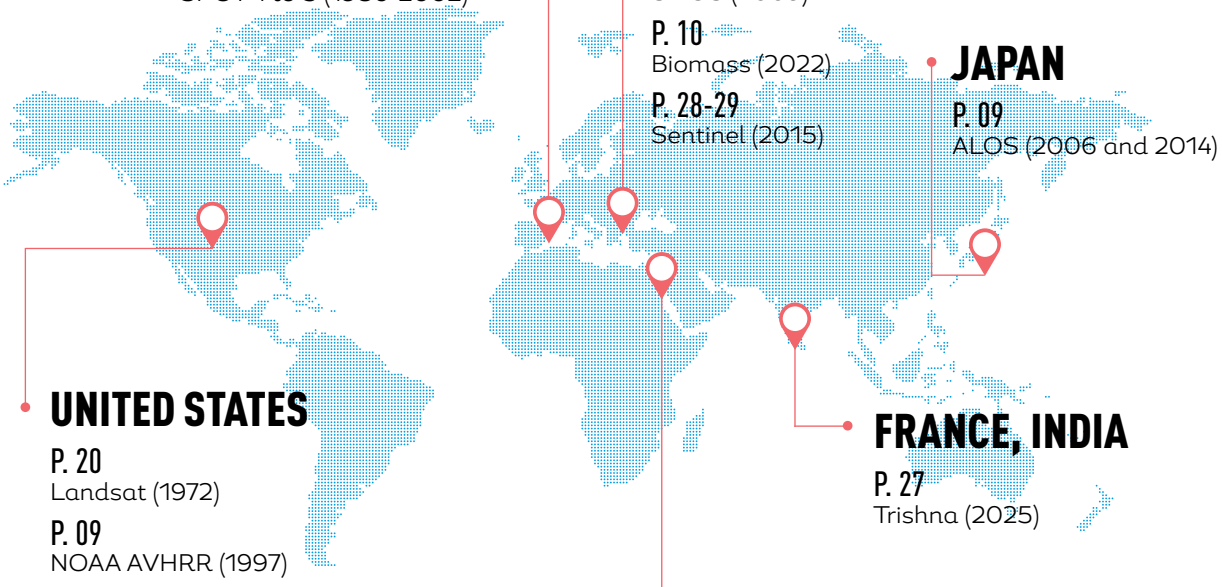
SPACE COOPERATION SERVING AGRICULTURE



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CONTRIBUTORS

PHILIPPE MAISONGRANDE

After 30 years working in research at the CESBIO biosphere research centre and then at the LEGOS space geophysics and oceanography research laboratory, Philippe Maisongrande today specializes in satellite observation of Earth's land surfaces at CNES's Directorate of Innovation, Applications and Science. In the agricultural domain, he notably coordinated drafting of the framework agreement signed recently between CNES and INRAE, the national research institute for agriculture, food and the environment. Drawing on his experience as programme manager for space missions like VENμS, SMOS and Biomass, he shed light for us on how space is aiding agriculture and on CNES's historic role in this respect.

GÉRARD DEDIEU

With qualifications in physical sciences, astronomy and space technologies, this CNES engineer has worked in many of the agency's research laboratories, particularly CESBIO. Lead scientist for the French-Israeli VENμS mission, he's now working with India on the Trishna project. Supporting cooperatives, he continues to keep farmers informed about the kinds of satellite data they can freely access. His experience from these two missions helped us to gauge just how important remote sensing is to agriculture.

THIERRY CHAPUIS

As an expert in space applications at CNES's Directorate of Innovation, Applications and Science, Thierry Chapuis promotes uptake of satellite data in the farming domain. With digital agriculture now driving strong demand for data, his role is to support stakeholders in the farming ecosystem. He revealed the latest trends in agricultural robotics and gave us access to French firms Naïo and AgreenCulture.

ÉRIC CESCHIA

As an INRAE director of research at CESBIO, Éric Ceschia has been working since 2003 on evaluating mechanisms for coping with climate change in agriculture. His work combines in-situ measurements with agro-meteorological models and remote-sensing data. He's also leading agro-ecosystem research efforts at CESBIO. He was involved in drafting the CNES-INRAE framework agreement and lifted the veil for us on several projects now underway.

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IMPRIM'VERT

The grain, the furrow and the orbit

The world's growing population, climate change and the environment are three of the challenges that face farming today. The urgency of the situation calls for a new model for which space technologies, data and services offer effective and sustainable solutions. Space systems and the global Earth-observation and geolocation services they underpin are playing a significant role in defining this new agricultural model. Earth-observation data acquired from orbit across the wavelength spectrum enable the status of crop fields, pastures and water resources to be monitored in real time all over the globe and harvests and yields to be estimated. Space is also easing agriculture's environmental footprint by aiding a more-integrated approach to managing inputs, fertilisers, phytosanitary products and water, while reducing energy consumption. All of this is being made possible by the development of agricultural robotics leveraging the European Galileo geolocation system, capable of guaranteeing positional accuracy of a few centimetres. The partnership engaged by CNES and INRAE, the national research institute for agriculture, food and the environment, which will be on view at the forthcoming Agricultural Show, is part of this dynamic. As a tool supporting a broad range of policy initiatives on climate, the environment, security, transport, agriculture and the digital divide to name a few, space and the technological advances it is driving are a great asset that will help agriculture to rise to the demographic, health, environmental and climate challenges of the 21st century.

JEAN-YVES LE GALL
CNES PRESIDENT

CNES/INRAE

Joining forces

CNES will be present alongside INRAE[1] for the first time at this year's upcoming French Agricultural Show. The two organizations further consolidated their ties with the signature on 22 July last year of a framework agreement to put their collaboration on a formal footing. Agriculture and space are indeed linked, as research is central to what both organizations do and they share the same scientific approach serving agro-ecology. They are also both working to innovate and on remote-sensing missions advancing knowledge, science and technology, such as SMOS (microwave), VEGETATION on SPOT and VENμS (optical) and tomorrow Trishna (infrared). As they seek to step up their collaboration, the two partners are ploughing new furrows to sustain farming driven by technology and climate action. Today, the focus is on water resource management, sustainable management of agro-ecosystems, biodiversity, landscapes, green corridors and digital agriculture.

1. As of 1 January 2020, INRA, the national agronomy research institute, and IRSTEA, the national research institute for environmental and agricultural sciences and technologies, have merged to form INRAE, the national research institute for agriculture, food and the environment.

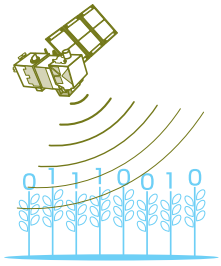
www.salon-agriculture.com

Irrigated crops viewed by the VENµS satellite in Phoenix, Arizona (United States).

DIGITAL AGRICULTURE

THE GREEN REVOLUTION SOWING SEEDS FOR THE FUTURE

Digital agriculture is already here, fuelled by remote sensing and giving farmers the keys to success through information and communication technologies (ITCs). Several layers of information from satellite data and geographic information systems (GIS) are overlaid and models are correlated to agronomic expertise to generate key recommendations, for example for field-level adjustments to nitrogen inputs or crop-sowing density. With Farmstar (see p. 34), Airbus Defence & Space was the first to 'translate' such data into useful recommendations for farmers. Today, consulting firms and cooperatives are putting decision-support software into farmers' hands, with applications they can operate from their smartphone. And freely accessible data from Europe's Copernicus programme is a boon for digital agriculture.



24%

Digital agriculture is seen as a key driver of the third green revolution. Europe, however, still has a long way to go, with less than 24% of its farmers having taken up digital technologies.

AGRICULTURE

WHAT'S IN THE WORD?

While hard to pin down exactly, agriculture defines itself above all as "the science and art developed by humans of cultivating plants and rearing livestock." Besides food, agriculture provides us with other products we need to live, such as wood, textiles and energy. This diversity is laid bare by remote sensing, which is the only way to survey large areas frequently, consistently and in detailed fashion. Whether in Brittany or Vietnam, satellites yield key indications about field sizes, soils and seasonal or long-term variations. Likewise, they highlight where arable land is being built over or how humans are affecting nature and climate, for example through deforestation in the Amazon or pastures being abandoned in the Pyrenees. Combined with other sources of information or on their own, satellite data are used to monitor croplands. Analysed alongside numerical models and weather data, they enable a broad community of stakeholders—government agencies, research scientists and farmers—to keep track of field status by measuring yields, soil moisture, carbon budgets and much more besides on a daily or weekly basis.

PRECISION AGRICULTURE

RIGHT AMOUNT, RIGHT PLACE, RIGHT TIME

Under the hammer for overusing fertilizers and pesticides, farmers have found an antidote in precision agriculture, which helps them to finely control inputs on a case-by-case basis in line with their performance objectives and actual crop status, rather than blanket-spraying and fertilizing whole fields. Overlaid on field maps, satellite imagery teases out information about leaf area index, chlorophyll content, soil moisture and more. This information can be combined with data acquired by farming machinery fitted with GPS receivers to ascertain crop health, and with the right equipment modulation of inputs can even be automated. Precision agriculture is thus driving more-targeted and more-efficient crop management as a first step towards the agro-ecological transition.

IoT

FROM HALTER TO WEATHER TERMINAL

From his upbringing in Guadeloupe as the son of a farming couple, Sébastien Luissaint knows what a hard job it is. So with his company Myditek, created in 2016, he's developing innovative solutions to make farmers' lives easier. His first application was a connected suite designed to enable herds of cattle or goats to be monitored remotely. Livestock farmers were thus able to detect any anomalies—like for example cattle straying outside their pastures or no longer moving for a long period—and keep a check on the health of their herds. His second innovation is a connected weather terminal that records a range of readings such as atmospheric pressure, temperature and humidity. And Sébastien Luissaint isn't stopping there, as Myditek intends to continue leveraging satellite data to conceive connected tools that help us to tread more lightly on the Earth and our environment. CNES is lending support through its Connect by CNES programme. After joining the Outremer Network booster at Station F, Myditek is now ramping up commercial sales of its weather terminals through markets in tropical regions like Togo. Prospects for developing the firm's business are also looking good in French Guiana, Mayotte and Réunion.

PASTURE INSURANCE

COPING WITH THE VAGARIES OF CLIMATE

Faced with a fickle climate, what's the best way to gauge decreasing pasture yield and its impact in order to compensate farmers? For the last four years, insurance companies have been using space-based surveying techniques that are proving much more reliable than human expertise. Working for agricultural insurance firm Pacifica, Airbus Defence & Space has used MODIS imagery available since 2001 to establish a pasture yield index, validated in 2015 by a committee of scientific experts overseen by the Ministry of Agriculture. Based on imagery acquired daily, this index enables variations in pasture yield to be compared each year on 31 October with a reference value[1]. Pasture insurance policyholders can then view on line how much has been lost for their area. Where applicable, the compensation procedure is then engaged automatically with no need for further valuation by the insurance firm. Sentinel-3 imagery will be supporting this operational service over the long term.

1. The reference value is the mean yield over the last five years in each of France's 36,100 municipalities.

30%

Thirty percent of farmers currently active are expected to retire in the coming years. As a result, younger and digitally savvy farmers will drive development of a more connected kind of agriculture already seen in larger farming businesses.

9 BILLION EUROS

That's how much funding France gets each year from the Common Agricultural Policy (CAP). This aid is coordinated and apportioned by ASP, the services and payments agency. Every year, its teams conduct more than 50,000 checks covering all types of aid and all regions.

51 BILLION TONNES

Better management of land, particularly pastures, would optimize carbon storage. Revegetating degraded arable land could remove up to 51 billion tonnes of carbon from the atmosphere.

SATELLITES SERVING AGRICULTURE

1972

LANDSAT
The world's first series of civil Earth-observation satellites, surveying the globe's land surfaces at a resolution of 80 metres (1984: Landsat 4, resolution 30 metres)

1986-2002

SPOT 1 TO 5
Earth remote-sensing satellites used to support the CAP. The VEGETATION instrument delivers crop yield forecast data

1997

NOAA AVHRR
Weather satellite instrument surveying crops and production crises around the globe at a resolution of 1 kilometre

2006 AND 2014

ALOS AND ALOS 2
Satellites dedicated to forest monitoring

2009

SMOS
Passive microwave radiometer measuring soil moisture for weather forecasting and crop monitoring

2015

SENTINEL
Space component of the Copernicus programme, providing free imagery at a resolution of 10 metres

2017

VENµS
Precursor of the next generation of optical Sentinel satellites

IRRIGATION
FRESHWATER UNDER CLOSE CONTROL

In the arid and semi-arid lands bordering the Mediterranean Sea, 85% to 90% of freshwater is consumed by irrigation of cereal, fruit and other crops. So every drop counts. When and how much should farmers irrigate? The SAT-IRR application has been developed to help them give plants just the right amount of water. Using satellite and weather data, SAT-IRR calculates the water budget and provides field-level irrigation recommendations tailored to the type of crop, soil and weather conditions. Users are able to access personalized data on line and modify or refine them at any time. From a broader perspective, the water budget of irrigated crops in these regions suffering from a water deficit is being monitored by a second application called SAMIR[1], which also relies on satellite data and is aimed specifically at irrigation network and catchment area managers.

1. SAtellite Monitoring of IRrigation

FORESTS
A FIGHT ON ALL FRONTS

After Brazil in 2019, the recent pictures of bushfires raging through vast tracts of eucalyptus forest in Australia have underscored the value of space-based tools. In 2009, satellite images of Windstorm Klaus in 2009 helped to establish a precise inventory of damage in the Landes region of Southwest France. But besides surveying natural disasters, remote sensing serves a range of forest management applications. In 2016, Japan's ALOS satellite was assigned to monitoring forests and an early-warning system was even developed for tropical rain forests. Europe's SMOS soil moisture surveying satellite is also able to calculate the thickness, height and heterogeneity of forest cover. The highly promising GEDI[1] lidar system developed by NASA, on the International Space Station (ISS) since last December, is set to deliver high-resolution measurements that will help scientists to better characterize the carbon cycle, biodiversity and forest habitats. And in 2022, ESA's Biomass mission will monitor global tropical forest biomass at a resolution of 200 metres. Regularly refreshed high-resolution imagery from satellites like SPOT 6/7, Sentinel and Landsat is also helping to estimate this biomass, to map tree species and track changing forest cover. Remote sensing is thus a vital complement to field surveys supporting sustainable forest management and evaluation of global forest carbon stocks.

1. Global Ecosystem Dynamics Investigation

CAP

SATELLITES FOR FARMERS

With its sixth reform planned for 2022, the Common Agricultural Policy (CAP) is set for a paradigm shift. Unsurprisingly, the new template is expected to be firmly grounded in environmental criteria such as organic farming, carbon storage and environmental certification. France's services and payments agency, ASP, which has responsibility for paying direct subsidies to farmers, will also be tasked with confirming that it's being properly applied, and for that it will be turning to satellites. In place of on-site checks, ASP will be continuously surveying fields by satellite, a method it's currently trialling with help from IGN, the national mapping, survey and forestry agency. New software methods are also being studied by payment agencies, research organizations and IT firms from 10 countries under the European NIVA[1] project. These methods have been developed in part from work conducted at the CESBIO[2] biosphere space research centre. The European Commission sees this as a way of optimizing management of funds and environmental performance and of improving the CAP, and has validated the principle of continuous checks based on analysis of satellite imagery. Such automated monitoring also aims to ease the administrative burden on farmers and help them to manage their business more efficiently.

1. New IACS Vision in Action
2. Centre d'Études spatiales de la Biosphère, overseen by CNES and INRAE

Fields around the village of Andouillé (Pays de la Loire, Northwest France) viewed by the Pleiades satellite.

LEADBEES

DIGITAL COMES TO THE AID OF BEES

Bees were officially added to the list of endangered species in 2017, which is why beekeepers are keeping a close eye on the health and potential yield of their colonies. In Tahiti, Kevin Besson has turned to space-based solutions. The young and computer-savvy beekeeper has set up sensors next to his hives to measure humidity, temperature and even yield remotely. These data are then sent to an on-line platform called LeadBees and consultable by the beekeeper in real time so he can respond quickly to alerts, like for example a parasite attack by the varroa mite. This connected, sustainable approach is taking Kevin Besson a long way from his Tahiti home, as his initiative is being backed by the Connect by CNES programme. In Paris, he has joined the Outremer Network overseas territory booster at Station F, the largest start-up incubator in Europe. Outside the circle of Tahiti's 500 beekeepers, LeadBees is already opening the national market for him.

#COMMUNITY

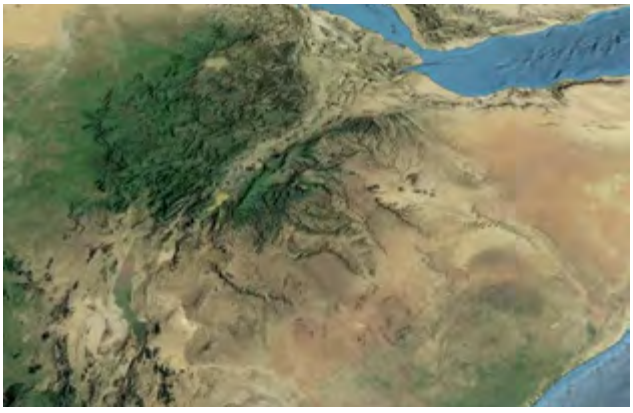
Every day, CNES engages with you on social networks and you share your thoughts and questions with us. Join the conversation!

@PAULINE_JOUZIER
Engineer specializing in digital technologies for agriculture at @agrobordeaux and special correspondent for @ChaireAgroTIC

@CNES and @Inra_France sign an agreement to step up their cooperation to adapt #agriculture to climate change
#AgTech #AgriTech #satellite

@AMBETHIOFR
The official page of The Embassy of Federal Democratic Republic of Ethiopia for France, Spain, Portugal and Vatican.

A first for Africa: Ethiopia is set to finalize a study covering 5 years of satellite observations monitoring fertile lands. #Ethiopia #agriculture #satellite



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European news and debate

The farming sector is betting on satellite data

@MIN_AGRICULTURE
Official account of the Ministry of #Agriculture and #Food.

⚡#AgriLab #satellite imagery serving #agriculture of the future via @EchosExecutives

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Q & A

PHILIPPE MAUGUIN

AT THE HELM OF INRAE, THE NATIONAL RESEARCH INSTITUTE FOR AGRICULTURE, FOOD AND THE ENVIRONMENT, Philippe Mauguin is working to forge closer ties with the world of space. His goal is to boost agronomy research and build the agriculture of the future.

WHAT COMMON HERITAGE DO CNES AND INRAE SHARE?

Philippe Mauguin: Thanks to CNES and INRAE, France is the world's number three space power and ranks second in agronomy science research. Our teams have been working together for many years to develop space missions like SPOT, SMOS, VENμS and now Trishna. We're also partners in research infrastructures and data centres like Theia, collaborating on leading-edge research topics like crop evaporation and characterization of soil properties.

WHAT ARE THE BIG CHALLENGES FACING AGRICULTURE GLOBALLY?

P. M.: The challenges are huge. We're facing the climate transition, food security risks, loss of biodiversity—including pollinators vital to agriculture—and dwindling water resources. Between now and 2050, farm production is going to be on a knife edge as the world's population continues to grow. Farming policies need to evolve around the world to make the transition to agro-ecological systems favouring natural resources rather than chemical inputs, to food-production systems that will allow us to achieve a better balance between animal and plant proteins, and to less wasteful farming and food practices.

HOW ARE RESEARCH AND SPACE HELPING TO TACKLE THESE CHALLENGES?

P. M.: We need to define how to help feed the planet in a manner that's healthy and sustainable for populations while treading lightly on ecosystems. For example, biotechnology and genetic engineering research is seeking to make plants more resistant to bio-aggressors, but sustainable solutions will elude us unless we first get to grips with the key issues and changes that lie ahead. On 1 January, INRA merged with IRSTEA, which specializes in environmental and agricultural technologies, to form INRAE, the national research institute for agriculture, food and the environment. Through the range of complementary disciplines it covers, this new structure will enhance our knowledge and provide solutions for everyone in the food value chain. Space is already a vital tool delivering continuous satellite observations that allow us to track changes and establish projections. With this in mind, INRAE has decided to step up its role in the CESBIO biosphere research centre, which is overseen by CNES, and to lend its support to research into the use of space-based technologies applied to agro-ecology.

WHAT DOES THE AGREEMENT SIGNED BY CNES AND INRA IN JULY LAST YEAR COVER?

P. M.: We're well aware of the strategic importance of space research as a tool to advance our understanding of environmental change. That's why we decided with Jean-Yves Le Gall to extend the scope of our partnership to all of the big challenges facing us, with a view to pursuing sustainable development goals. The agreement therefore targets certain priority areas of research for scientists, farmers and government agencies in France, Europe and worldwide. The first of these is soils, the thin layer of Earth's surface where we grow crops and whose carbon sequestration capacity has the potential to be a vital aid in tackling climate change. But today, soils are beset by desertification, urban spread and pollution. Efforts are underway to revegetate them and here satellites are helping us to study how they work and to monitor their health in ever finer detail. The second area is surface waters, which are a key component of life and agriculture, which consumes 75% of the planet's freshwater. By tracking the status of global

"SUSTAINABLE SOLUTIONS WILL ELUDE US UNLESS WE FIRST GET TO GRIPS WITH THE KEY ISSUES AND CHANGES THAT LIE AHEAD."

PHILIPPE MAUGUIN
CHAIRMAN & CEO OF INRAE

"SPACE IS MOST LIKELY GOING TO TAKE ITS PLACE AS A KEY TECHNOLOGY ALONGSIDE AGRONOMY AND ECOLOGY."

water reserves from space in real time, we can devise systems to manage them in integrated fashion and at local scales. And the third area is forests, which cover nearly one-third of Earth's land surfaces and play a crucial ecological role. Satellite data are a precious aid in monitoring their evolution as closely as possible, particularly how they are emitting and storing greenhouse gases. On top of all that, the agro-ecological transition demands that we gain a clearer picture of how ecosystems work at all scales. Here again, satellite data abound to help us characterize very dynamic landscape patterns. Land degradation is directly tied to the critical threats we're now seeing to biodiversity. That's why INRAE and CNES are striving to improve survey processes that rely on satellite imagery to be able to propose conservation goals to government.

WHAT KIND OF OPERATIONAL PRODUCTS DO YOU THINK ARE LACKING TODAY?

P. M.: Research needs more satellite data to advance knowledge and characterization across all scales. As a matter of fact, nearly 50% of French farmers are using GPS receivers to do their job and investing in new technologies. It's estimated that the global market for agricultural robotics, which makes extensive use of data from satellites and drones, will be worth close on €16 billion this year. In a world driven by big data, one of the fundamental strands of our agreement seeks to beef up digital infrastructures, notably for processing geospatial data. Another issue will be to simplify how subsidies are managed under the Common Agricultural Policy (CAP), which vary according to the type of crop or farming practices, which can be monitored by satellite.

WHAT ROLE DOES SPACE HAVE TO PLAY IN ASSURING FOOD SECURITY?

P. M.: Food security is going to be critical to our survival on this planet between 2050 and 2100. Today, it's vital that we evolve farming practices and track their impacts using satellites. At a time of tensions on all sides, with major impacts on society as a whole, we need to understand how climate, weather, crops, soil moisture, shifts in pasture lands and water resources are all interrelated. It's very hard to actually gauge all of this without recourse to space, which is most likely going to take its place as a key technology alongside agronomy and ecology. We'll need to combine these approaches and conceive solutions to help all concerned make these transitions.

Profile

2020
Chairman & CEO of INRAE

2016
Chairman & CEO of INRA

2012
Chief of staff to the Minister of Agriculture and Food

2002
Director of INAO, the French body tasked with regulating protected designations of origin

1992
Advisor to Hubert Curien, then Minister of Research and Space

SURVEYING RICE CROPS FROM SPACE

Rice is a major food crop for human populations. The question is how to grow more of it while using less water and emitting less methane. With 90% of the world's rice grown in Asia, the CESBIO biosphere research centre is working in Vietnam to set up a demonstrator of space solutions that could be transposed to other regions. Besides helping to monitor crops, satellite data are fed into models to simulate yields and methane emissions according to growing practices. And when a typhoon threatens rice fields, they are supporting early-warning systems to enable growers to harvest crops that have already reached maturity quickly.

LIFE WITH OZ

In the greenhouse or open field, Oz is the faithful companion saving market gardeners time and backache. Designed by Naïo Technologies, this small electric robot does all the weeding and clearing between rows alone, and when it has finished it sends a text to the grower, who is free to do other tasks. Soon, thanks to satellite positioning systems, it will be able to sow seeds and hoe soil without having to wait for seedlings to break ground, as it will have memorized exactly where it sowed them. Oz can be programmed to tirelessly perform a whole range of tedious tasks, making market gardening a much more attractive prospect.

30 TO 60%

Irrigation is often used in addition to rainwater to boost yields. But it's estimated that with conventional techniques, 30 to 60% of irrigation water is lost due to evaporation and is of no benefit to crops.

Living Lab

LIVING LAB IS AN APPROACH BEING ACTIVELY DEVELOPED AT INRAE, the national research institute for agriculture, food and the environment, that puts users at the centre of the innovation process. Farmers and intermediaries like cooperatives are in the loop, working with research scientists who offer their state-of-the-art expertise and methods, and with firms providing their tools. The CESBIO biosphere research centre and the E2L cooperative have pioneered uptake and consolidation of this approach applied to remote sensing, agriculture and regional development.

11 GIGATONNES

In the last 25 years, the amount of carbon stored in forest biomass around the globe has dropped by nearly 11 gigatonnes, mostly due to land being converted to other uses and to forest degradation.

79%

THE PERCENTAGE OF FARMERS USING THE INTERNET, above the average for the French population. Many of them use social media to get the latest farming news. From 2013 to 2015, the number of professional applications downloaded to smartphones rose by 110%. For example, 9 farmers out of 10 file their CAP subsidy claims on line.

720,000

In 2005, 180,000 hectares of crops were being managed in real time with precision agriculture. In 2019, this figure reached 720,000 hectares. In all, 16,000 farmers are using it today.

Sources: Ministry of Agriculture, FAO 2015 report, IGN forest inventory handbook

OBSERVING

TO FARM SMARTER

DIGITAL, PRECISE AND INTEGRATED, MODERN AGRICULTURE IS TURNING INCREASINGLY TO EARTH-OBSERVATION DATA. THROUGH PLATFORMS AND SERVICES LIKE THEIA AND NETWORKS OF START-UPS AND COOPERATIVES, SATELLITE DATA ARE TODAY TRULY BECOMING A DECISION-SUPPORT TOOL FOR FARMERS.

Land occupancy shown by the Sentinel-2 satellite in the region of Seville, Spain, where fields under crop in green contrast with arid areas.

The first-ever picture of Earth seen from space, released in the 1960s, was a long way from the field-scale maps we see today. It was a landscape view, a simple photograph taken from a unique vantage point. In the 1970s and 1980s, Landsat and then the SPOT series of satellites were the first civil optical remote-sensing systems in space, offering sufficient spatial resolution to map landscapes and their composition. But the technology was not yet sophisticated enough to combine spatial with temporal resolution.

75%

Agriculture consumes

75% of the freshwater used by humans around the globe.

TWO WORLDS CONVERGE

The first to achieve that feat was the VEGETATION instrument developed by CNES for SPOT (1998). France's first optical system enabled daily operational coverage of the globe's entire land surfaces at a resolution of one kilometre. "This leap forward in space-based observation of natural vegetation and crops is in some ways comparable to the advent of movies after photography," notes Philippe Maisongrande, head of land surface and hydrology programmes at CNES. It would be followed in later years by MODIS (NASA, resolution 250 metres) and then PROBA-V (ESA, resolution 100 metres), which further increased the precision of observations. Real convergence had to wait until the 2010s, with Sentinel-2 from Europe's Copernicus programme and VENμS (see box p. 26), offering weekly high-resolution, cloud-free multispectral imagery of

an area of interest and making it possible to map land use and land cover and to track them over time. Other remote-sensing technologies like radar complement such optical imagery, the Biomass and Trishna programmes designed to gauge biomass in forest canopies and crop water stress being good examples.

A NEW ERA

In the 21st century, old sayings and a wet finger in the air are no longer relied on before sowing, harvesting, spraying or deciding whether crops need watering or other inputs. Today, farmers are using weather forecasts combining numerical models and observations to keep track of humidity, precipitation and wind conditions in real time. Forecasts from the national weather service Meteo-France are based 90% on satellite data, and their accuracy is due largely to the IASI instrument, an ultrasensitive spectrometer conceived by CNES in 2006 and developed with Eumetsat[1]. Arguably the best sounding instrument of its kind in the world, IASI measures more than 25 different atmospheric constituents.

Another technology where farmers and space find common ground is positioning. This is one of CNES's domains of expertise, where satellite navigation and positioning systems are the bedrock. History will record that farmers were the first to use GPS. The European Galileo system—now fully operational—has further enhanced the reliability of data, enabling time, guidance and input recommendations to be accessed from any mobile device. Indeed, tractors and other farm machinery have been delivered for decades now with touchscreen tablets as standard.

1

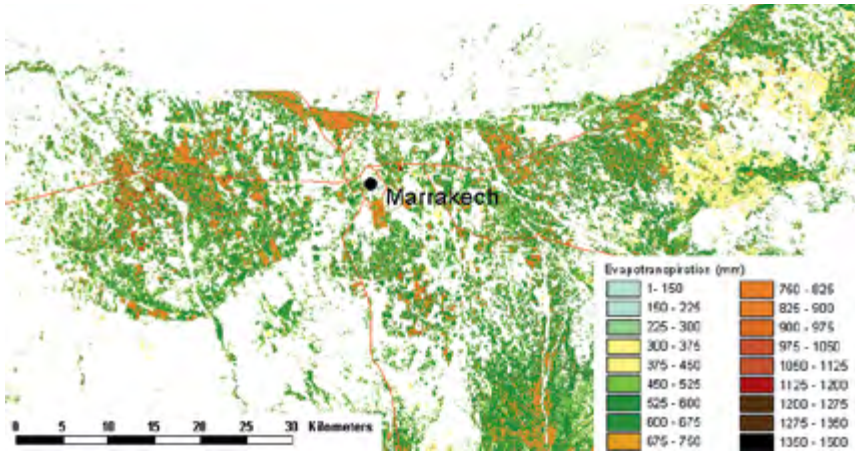
billion

In service since 2016, Europe's Galileo positioning system hit the one billion user mark last September. It is supported by no fewer than 156 models of smartphone.

WATER UNDER CLOSE WATCH

Like all economic activities, agriculture is seeking to produce more while conserving natural resources. Water is therefore being more closely monitored than ever before. While it can't actually prevent climate variations or droughts, modern remote sensing is nonetheless giving the farming sector the means to tackle the problem. When assimilated into crop models like SAMIR and SAT-IRR (see Roundup p. 11) and combined with in-situ measurements, satellite data help to make irrigation and management of water resources more efficient. Devising and disseminating such models fuelled by indicators like soil moisture and land occupancy, plant leaf area index and water stress is the challenge now being met by the Theia data centre (see p. 22-23) and the downstream programme for SWOT (CNES/NASA), another mission set to measure water levels in reservoirs and rivers from 2021 onwards.

1. EUropean organisation for the exploitation of METeorological SATellites



Cumulative evapotranspiration in the Haouz Plain, Morocco, during the winter growing season (December to May, in millimetres). White and yellow indicate areas that are not irrigated where vegetation grows very little or not at all; green and orange indicate irrigated soils (chiefly wheat, olive groves and orange groves).

THEIA
DISSEMINATING THE POWER OF DATA

The prodigious amounts of Earth-observation data generated in recent decades are not restricted to scientific research. Once processed, they are increasingly being made available to an ever broader range and number of users.

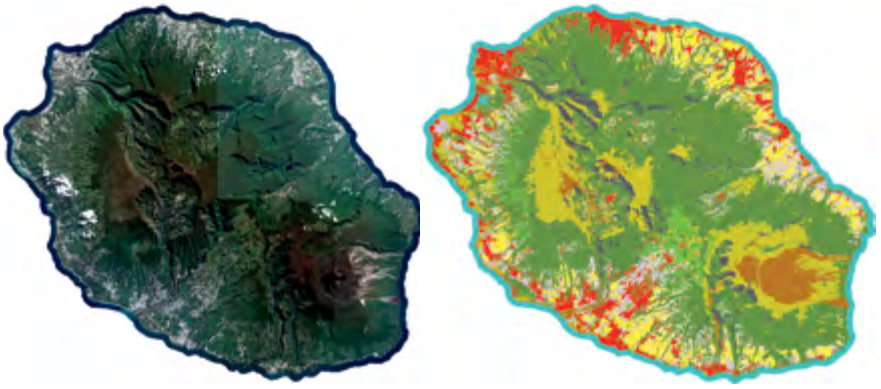
Making data available is one thing, but making them intelligible is of course even better. That's why in 2012, CNES and the national scientific research centre CNRS created a multipartite data structure called Theia in partnership with a panel of institutions, among them INRAE[1], IRD[2], IGN[3], CEA[4], ONERA[5], CEREMA[6] and AgroParisTech. This hub dedicated to land surfaces data is tasked with promoting the results of French scientific research through large-scale production of corrected imagery and a broad range of maps.

TURNKEY EXPERTISE

Theia is above all a pragmatic data centre geared towards operational applications. It offers expert and non-expert users alike a range of products and services spanning multi-scale imagery, crop and yield monitoring, and even training in how to access imagery. To this end, data are deciphered or 'translated' by algorithms and processing systems, backed by researchers at scientific expertise centres (CES) working to develop innovative data processing methods. The products disseminated via the Internet have become reliable, certified indicators. Theia is also seeking to foster ties between scientists and public stakeholders through a regional network designed to reach out to and maintain contact with users while nurturing new needs.

ONE-STOP PORTAL

The gateway to the Theia data centre is the theia-land.fr website, which guides the user towards a range of topics (agriculture, water, forests, etc.) where they can drill down to different levels. For example, users seeking information for agriculture will find value-added products covering land occupancy and high- or very-high-resolution soil moisture. Theia also delivers classified and ranked data on things like areas of interest, acqui-



Land cover map of the island of Réunion in 2018, with 11 classes derived from Pleiades imagery acquired for the Kalideos project.

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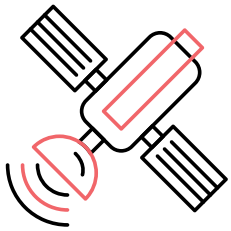
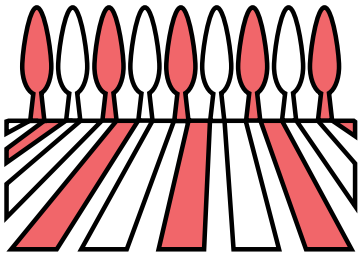
Scientific Expertise Centres (CES)

conducting research in 10 cross-cutting disciplines: agriculture, algorithms and processing, biodiversity, water, forests, coasts, snow and ice, natural hazards, health and urban.

sition periods and status. Some data are freely accessible, while others are reserved for specific kinds of user. For example, through the 'biophysical variables' menu, cooperatives or farm consortiums can view a normalized difference vegetation index (NDVI), an excellent indicator of plant health, vitality, greenness and quantity. Custom algorithms can also be developed to meet more specific needs. Theia is also a very dynamic structure driven by contributions from science experts who are constantly finding ways to exploit new data. New irrigation products are already in the pipeline and will soon be on line. And the future is looking bright with new advances expected from leading-edge optical and thermal sensing technologies and new missions (Biomass, Trishna). New platforms disseminating remote-sensing products, like PEPS for Sentinel data and Dinamis for Pleiades data, are also coming on stream with satellite data increasingly a go-to source of information in many sectors of activity.

1. National research institute for agriculture, food and the environment
2. Development research institute
3. National mapping, survey and forestry agency
4. French atomic energy and alternative energies commission
5. French national aerospace research centre
6. Hazards, environment, mobility and land planning research centre





CESBIO

FROM SIMULATION **TO INSPIRATION**

CESBIO was created 25 years ago from the merger of several research units. Dedicated to observing the biosphere, today it is encouraging uptake of space systems and inspiring future space missions.

Part of the Midi-Pyrenees Observatory (OMP), CESBIO is overseen by five scientific entities: CNES, CNRS, Paul Sabatier University in Toulouse, the IRD development research institute and INRAE, the national research institute for agriculture, food and the environment. It has succeeded in combining the talents of its contributing organizations in the pursuit of joint projects. CESBIO's specialty is observation of the biosphere, which covers the globe's land surfaces, from deserts to mountains and pastures to forests. In short, "wherever vegetation is or might be found," as Laurent Polidori, the centre's director, puts it.

PROMOTING SPACE SYSTEMS

CESBIO's priority is to encourage development and uptake of space systems and to facilitate access to Earth remote-sensing data. Satellite data are unquestionably key to advancing knowledge in such areas as forest management and the relationships between vegetation and climate. For agriculture, the centre also offers new insights into irrigation, crop monitoring, cropland management and evolving cultural practices. By making a series of adjustments, notably atmospheric corrections, it is developing products that are easy to use, based on maps and models and distributed through data centres like Theia.

INSPIRING SIMULATIONS

CESBIO is also helping to set science goals for future space missions. "When conceiving a new mission, you never start from a blank page," says Laurent Polidori. The centre's simulations are well suited to targeted areas of research like evapotranspiration or surface mechanisms, and often form the foundation for the science programme of space missions. The SMOS and VENμS missions (now in orbit) and, in the years ahead Biomass and Trishna, are good examples. Sometimes, work conducted by CESBIO even feeds directly into future mission concepts. The development of the Dart 3D software package is another of its flagship achievements. Employing an innovative method based on tracking light rays, this landscape simulation software provides information of unprecedented precision about plant cover. It is capable of revealing everything that a satellite 'sees' above forest cover, i.e., humidity, mist and illumination conditions at any time of day. Using satellite imagery and additional research data, it can draw up a map of France showing detail down to field scale, a product that will be most valuable to public stakeholders in charge of farming policy like agricultural boards.

With bases in Toulouse and Auch in Southwest France, the centre is also developing scientific activities abroad in Morocco, Tunisia, Lebanon, India and Vietnam. It is pur-

4

Space missions

(SMOS, Biomass, VENμS and Trishna) for which all science work is being coordinated by research scientists from CESBIO. They are of course also working on many other missions.

Rice is the main crop in the Ebro Delta in Spain, where one-third of the country's production is grown. This delta is one of the sites of interest being surveyed by the VENμS satellite every two days for two and a half years.

suing long-term observations in two areas. In the field of agro-ecology, the Sud-Ouest project in the Occitanie region is focusing on the evolution of agro-systems and mountain ecosystems, as well as studying the carbon budget over long time series. The SudMed project, meanwhile, covering the Mediterranean seaboard, is using remote-sensing data to study the water cycle at catchment area scale (see Roundup, p 11, SAMIR and SAT-IRR).

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Staff at CESBIO,
comprising research scientists, engineers, PhD postgrads and clerical workers. Most of these personnel are seconded by their overseeing bodies, thus pooling their human resources.

VENµS

SURVEYING VEGETATION

Launched in August 2017, the French-Israeli VENµS mission acquires imagery of 187 sites around the globe every two days at a resolution of five metres. This unique combination of high spatial and temporal resolution gives scientists the ability to advance knowledge of the biosphere, crop monitoring and development of tools for managing natural resources. VENµS is designed to demonstrate new services and space missions serving agriculture, the environment and climate actions.

LAB'OT
CUSTOM-DESIGNED MONITORING

Lab'OT is a place where satellite data come to life. This CNES infrastructure lends its support to users for processing and interpretation of Earth-observation data, offering a range of readily usable products each tailored to a specific need.

Through its Lab'OT[1] Earth-observation applications laboratory, CNES is demystifying satellite imagery and making it available to government departments, local authorities, private firms and research stakeholders, whom it supports during demonstration phases. Because when faced with a specific or intractable problem, all users are the same: they need solutions. Space is such a solution, but not one they're yet comfortable using. Formed two years ago, Lab'OT analyses users' requests to ascertain whether satellite imagery could meet their need. Where necessary, it does a search for available data and provides an actual demonstra-

tion of their use, i.e., how to understand the imagery, interpret and correlate it with other data and, ultimately, solve all or part of the original problem. This learning process is geared towards a co-construction approach underpinned by algorithms and artificial intelligence that seeks to leverage a knowledge base of images of areas of interest, status reports, forecasts and other kinds of field expertise. And today's increasingly sophisticated Earth-observation missions offer a panel of products to address the multiplication of cases being fuelled in particular by climate change.

COHERENT LAND-USE POLICY

An emblematic illustration of this comes from a programme being pursued in the Aude department of Southwest France in the wake of the catastrophic flooding of October 2018. The floods took a dramatic human toll and left a trail of destruction estimated to have cost more than €200 million. The mainly rural area that was hardest hit is reliant on winegrowing for its livelihood. IGN maps pre-dating the disaster were used as the baseline onto which Pleiades data acquired after the floods were overlaid to establish an inventory of vine damage. Such information is valuable to public bodies like the territorial and maritime directorate (DDTM[2]) and the Ministry of Agriculture to help deal with compensation claims. But the time has also come to restore the vineyards, a process now taking on a new significance because they can't be replanted as they were before to avoid making the mistakes of the past. This is also where satellite imagery comes in, revealing weak spots and informing more-solid replanting approaches. The maps delivered by Lab'OT indicate replanting priorities and changes to be planned, thereby helping a vital plank of the hard-hit department's economy to recover.

ANTICIPATING THE SCO

The way Lab'OT works is also of interest to projects now being set in train through the Space Climate Observatory (SCO). Indeed, the Aude post-flood observatory is in many ways a precursor for the SCO, which is guided by the same co-construction approach based on pooling satellite data, combining them with other regional and local data and analysing them to better gauge the impacts of climate change.
The goal is to prepare territories for the future and to help them spur local coping initiatives. The SCO brings together scientists for their knowledge of climate phenomena, technical organizations and land management agencies for their ability to address concrete and human issues, and public bodies in charge of planning and recommendations.

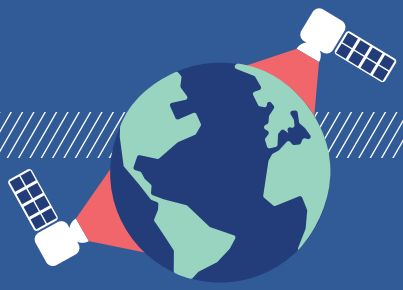
1. Laboratoire d'applications d'Observation de la Terre
2. Direction Départementale des Territoires et de la Mer

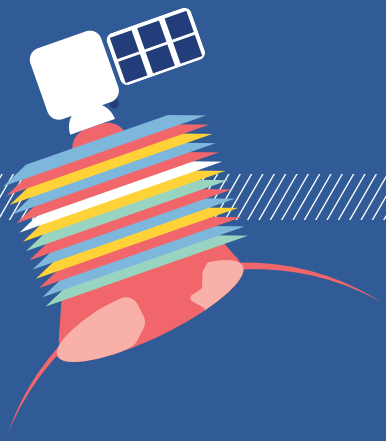
HARE TRISHNA

IN SUMMER, THE DIFFERENCE IN TEMPERATURE BETWEEN AN IRRIGATED MAIZE FIELD AND BARE SOIL CAN REACH 15°C, BUT THIS ISN'T SOMETHING SEEN BY CONVENTIONAL OPTICAL SENSORS. To study crop water requirements more closely and be able to calculate water budgets, the Trishna satellite set to launch in 2025 will carry an Indian optical sensor and a French thermal infrared sensor. Providing global coverage every three days at a resolution of 60 metres, its combined acquisitions will help to manage irrigation water more efficiently and give early warning in the event of extreme drought conditions. When plants aren't getting enough water, their leaves gradually turn yellow and their temperature rises almost instantaneously. By measuring this surface temperature, thermal sensors can detect water stress up to two weeks before leaves start to turn yellow.

Centre-pivot irrigated crops in Olton, Texas (United States) viewed by the Pleiades satellite.

SURVEY





UNIQUE

REPEAT IMAGERY AND **HIGH RESOLUTION**

Each Sentinel-2 satellite acquires imagery of the globe's land surfaces within a ground swath of 290 kilometres at a resolution[1] of 10 to 60 metres. Two satellites are thus all that's needed to cover all land surfaces every five days. Such a unique revisit rate at this resolution is crucial to track plant growth and land cover, as it generally enables at least one usable cloud-free image of any point on the globe to be acquired every month.

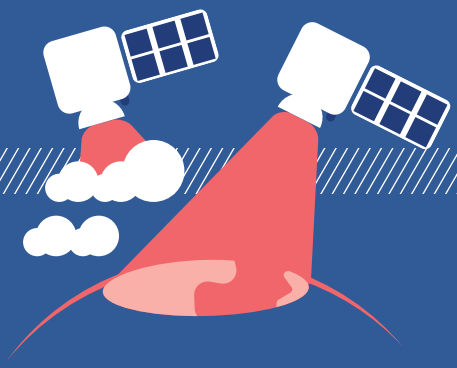
1. Smallest discernible feature

SPECTRAL SIGNATURE

13 SPECTRAL BANDS **COVERED**

Chlorophyll absorbs red light but reflects it in the near-infrared. Sentinel-2's imaging instrument closely analyses this portion of the spectral front in five bands to quantify vegetation and assess its vigour. On the other hand, bands in the short-wave infrared are responsive to soil and plant moisture, but less sensitive to the atmosphere. Sentinel-2 uses 13 spectral bands in all, three of which are dedicated to atmospheric corrections.

A FAITHFUL AND RELIABLE ALLY, THE SENTINEL-2 MISSION HAS BEEN SURVEYING FIELDS EVERY FIVE DAYS SINCE 2016, SUPPORTING PLANT AND CROP MONITORING OF UNPRECEDENTED QUALITY WITH ITS FREE AND REGULARLY REFRESHED DATA—A REVOLUTION.



COMPLEMENTARITY

SENTINEL INSTRUMENTS **REPORT FOR DUTY**

Optical remote sensing generates images close to what we see with our eyes and therefore fairly easy to interpret when skies are clear. Radar, meanwhile, can "see through" clouds to reveal other features like plant geometry. For example, an image from Sentinel-1's radar instrument can complement a Sentinel-2 image with too much cloud cover. Conversely, Sentinel-2 can check that plant cover in an area of interest won't obstruct Sentinel-1's radar signal for sensing soil moisture.

FREE ACCESS

FREE RESOURCES

The Sentinel satellites have been developed for the European Union's Copernicus programme and their data are available free of charge as a public service. Space agencies have pulled out all the stops to facilitate access to Sentinel data and derived products, which at the most basic level are corrected for atmospheric effects. In France, CNES has developed an extremely effective distribution hub in the form of the PEPS Sentinel Product Exploitation Platform, as well as the Theia data centre for more advanced products.

SYLVAIN HYPOLITE

Research and development manager for the Agro d'Oc cooperative

"Farmers need new tools..."

"There's a fantastic diversity of farming operations today," says Sylvain Hypolite, who has moved diagonally across France from his native northeast to Toulouse in the southwest to become an agronomic engineer. **Born into a farming family, it's in his blood, and he joined the Agro d'Oc cooperative in 2012.** Drawing on the dynamic of 54 CETA[1] groups of farmers, Agro d'Oc has 1,100 members across the southwest region, 18% of whom are organic farmers, a record in France. "Farmers remain fully independent, but they join Agro d'Oc so they can get training, stay informed and run their farms as a business," says the engineer.

As well as offering tools and advice, the cooperative supports bold projects that encourage best practices. One example is Naturally Popcorn, an initiative in the Gers department that pays maize producers per tonne of carbon stored in the soil thanks to the use of soil conservation techniques (see Spinoff, p. 36). Satellites are an indirect way of seeing how much carbon is trapped in the ground. "**With the help of CESBIO, CNES's biosphere research unit, we're building space tools into our projects, especially since the arrival of Sentinel-2**," explains Sylvain. "A Gers farmer and IT developer did some training at CESBIO, then designed our Préci d'Oc application, which generates maps derived from Sentinel-2 imagery." With Préci d'Oc, each member can visualize how their crops are developing and adjust seed and fertiliser inputs within a field according to their own agronomic rules. "**They've occasionally expressed concerns about being 'watched' by satellites, but it's the farmers who are asking for these kinds of services**. Society wants them to maintain or even increase yields while reducing inputs. For this reason, they need new tools and satellite imagery, so they can gain deeper insight into their fields and crops," he concludes.

1. Centres d'études techniques agricoles

TIDIANE OUATTARA

Space sciences expert at the African Union Commission (AUC)

"In Africa, we need to feed over a billion people..."

He wanted to study medicine, but was advised to apply to the University of Abidjan, Cote d'Ivoire, where he did a master's degree in physical geography, followed by a PhD in satellite remote sensing in Canada. **It was for the Canadian federal government that Tidiane Ouattara first exercised his talents in geospatial data applied to the environment**. He was later invited back to Africa by the AUC to head up its space programme. "The AUC is an intergovernmental organization that represents Africa's 55 countries," he says. "Its priority is to conduct experiments together to help build a more integrated, prosperous and peaceful Africa. Because a large part of the population lives by farming, our first area of focus is doing what we can to ensure crops give a better yield. **We use Earth-observation imagery to locate arable land, much of which is exhausted, and also encourage countries to diversify the crops they grow, with varieties that are more suitable and profitable, depending on the soil**. We also need to better understand and reduce the impacts of climate change on farming. Sometimes floods completely devastate arable land, or crops are plagued by desert locusts, not to mention the spread of diseases." **Faced with these challenges, the AUC has signed a partnership agreement with the European Commission to allow the 122 African institutions taking part in the GMES and Africa programme to use Copernicus imagery to monitor floods, wetlands and forest fires**. Ahead of the 2020 Africa-France Summit, which takes place in Bordeaux in June, Tidiane Ouattara believes in the ties between the two nations: "In Africa, where we need to feed over a billion people, half of the countries use French as a common language. We're logically hoping that France will share its space expertise, so that Africans can use it to innovate and boost our agricultural productivity."

CLÉMENT BARON

Chief Technology Officer for AgreenCulture

"CNES's spin-off policy is what paved the way for me..."

Clément Baron is CTO at AgreenCulture (see Insights, p. 34). His success story boils down to three chapters. The first begins at the SupAero engineering school in Toulouse, where he studied telecommunications and navigation, driven by his passion for technology. **After graduating in 2010, he joined CNES. What prompted his decision? "The challenge, the diversity and the technology, which will always be the case!" says Clément**. In charge of the architecture of ground segment stations at the agency's Launch Vehicles Directorate (DLA), he worked on innovative projects, including a trajectory tracking radar and various antennas. With seven years of expertise, he could have continued his career here. **In 2016, he won the French aeronautical and astronautical association (3AF) youth prize and was still driven by the call of technology and the need to innovate**. As luck would have it, Christophe Aubé, a graduate of the ENAC civil aviation school, had laid the foundations for a start-up focusing on agricultural robotics. To expand the team, Christophe and his associate Emmanuel Goua de Baix were looking for an expert in guidance systems for these robots, a subject Clément knew well. A chance meeting between old friends marked the start of the third chapter. To join AgreenCulture and its development projects, Clément Baron approached CNES about a possible technology spin-off. In its policies and procedures, the agency encourages staff who want to take entrepreneurial risks. The project also needs to be commercially viable. Once approved, the project moved to the ESA Business Incubation Centre (BIC) Sud France. The result: in three years, the AgreenCulture team has expanded from 3 to 28 people—a total success for Clément Baron, who is "pursuing his love for technology, while also taking on another form of responsibility as part of a team: what we sell isn't just a product, it's also the guarantee of safety and dependability." **Its inventiveness won the start-up a Galileo Masters prize in 2018 and also the 2018 Robot of the Year award**.

Jacques Arnould,
science historian
and theologian,
CNES ethics officer.

ETHICS CORNER

JACQUES **ARNOULD**

ROOTS IN THE SKY

At the dawn of the space era, the first observation satellites soon began serving as 'eyes in the sky' for agriculture. Today, they can do a lot more besides, but only a more united humanity will be able to solve the global challenge of food shortage.

As Yuri Gagarin and Neil Armstrong's shadows grow longer, humanity seems to be hesitating. Should we rekindle the flame of those first pioneers, pick up space exploration where it left off, almost half a century ago, and go back to the Moon while squaring up to the long voyage to Mars? Or would it be better to focus our efforts on and invest our resources in terrestrial affairs, safeguarding Earth and helping earthlings to live better lives? This isn't the place for a debate which, in my view, will never find a more valid response than that inspired by shared reason and, more prosaically, the observation that we walk on two legs and think with two brains. But what if being human meant keeping our feet on the ground and our heads in the stars?

The 50-year heritage of space technology has clearly shown that the faithful who worshipped Ashvattha, the cosmic tree of Indian mythology, were right after all. A rather odd tree, since it grows upside down: "Its branches downward, its roots upward, from on high may its rays descend as far as us". When you recall that the trees of our own forests sometimes have an underground 'foliage' as developed as their aerial canopy, this fantastic image conveys a singular vision of existence: nothing that is, Ashvattha would teach us, can exist or survive without roots in the sky. Sap and breath, water and fire, life and death are not only drawn from Earth's maternal depths; they're also the gifts of the sky.

KEYS FOR THE FUTURE OF FARMING

In the same way, space gives to those on Earth much more than a celestial vantage point or 'overview effect', to coin a term now common in space parlance. It inspires, sustains and supports the growing awareness of a global and collective responsibility, not least the challenge to feed humans, all humans. Our satellites must not only help us improve the performance of our cultural technologies and protect our farmlands—they must also help us improve the way we share what we produce and reduce waste. Farming now has its roots in the sky.

PROOF BY EXAMPLE

Robotics serving agriculture

Toulouse-based start-up AgreenCulture designs some 'weighty' assistants for farmers: its 500-kilogram robots are packed with advanced technologies to make farming smarter. Fully autonomous, these monster farmbots have built-in artificial intelligence to analyse their environment. Positioning technology with centimetre-level precision using navigation satellite signals controls the robot's movements during each phase of the crop cycle, from sowing to fertilization and mechanical weed control. AgreenCulture has developed an innovative, low-cost location system that guarantees the integrity of the vehicle's position. This is a key factor for autonomous systems, to prevent them wandering off the field due to error. The use of Galileo signals has further improved performance. Its inventiveness won the start-up a Galileo Masters prize in 2018 (see the interview with Clément Baron in Horizons on p. 32).

MUST READ

ALL ABOUT ROBOTICS IN AGRICULTURE

Dr John Billingsley is a professor of mechatronic engineering in Australia. In this rigorously researched book, he reviews the key advances in the use of robots in agriculture. Chapters cover developments in location and guidance systems, GPS technologies, machine vision and navigation, communication and control technologies. The second part discusses how these technologies can be deployed to save labour and improve precision, speed and efficiency in farming operations, not forgetting the use of robotics in the livestock sector.

Robotics and Automation for Improving Agriculture,
Published by Burleigh Dodds Science Publishing.

LEARN MORE: INFO@BDSPUBLISHING.COM

GOOD TO KNOW

FARMSTAR
TIME TO SIGN UP

Airbus Defence & Space is leading the way with its pioneering Farmstar decision-support app. Initial research was conducted with CNES in 1996. Building on this work and in partnership with the Arvalis Institut du Végétal and the Terres Inovia institute, Airbus designed the first crop management support tool. Released in 2002, Farmstar uses satellite and multisource imagery from drones and aircraft. This is coupled with weather data and agronomic models to generate recommendation maps, which can be viewed on a tractor's display console. Subscribers are sent three to six maps a year, depending on their crops (maize, rape, wheat, barley, etc.). In 2020, Airbus plans to roll out the tool internationally.

FIRA

AGRICULTURAL ROBOTICS FORUM

For four years, Toulouse–famous as the city of aerospace pioneers–has been hosting trailblazers in another segment: agricultural robotics. On 10 and 11 December 2019, the International Forum of Agricultural Robotics (FIRA) showcased, albeit in an urban setting, what the farmers of tomorrow can look forward to: easier working conditions, improved profitability and higher-quality produce. If they needed convincing, participants only had to walk through the exhibition hall and watch the demonstrations of these new robots and assistants of every shape and size, from pocket format to monster machines, some of them already operating on farms today. This annual gathering was initiated by Gaëtan Séverac, co-founder of start-up Naïo Technologies (see In Pictures, p. 17). The forum's objective is to develop and promote agricultural robotics internationally. The programme included roundtable discussions and talks by some of the world's most prominent experts. Topics included technology as well as use cases and some of the issues ahead, not least safety, which was the subject of a scientific workshop organized by non-profit organization RobAgri. With its packed and varied programme, the forum is above all pragmatic, fostering dialogue and sharing of experience, especially through the business meetings space.

DIARY

22 FEBRUARY – 1 MARCH 2020
Paris International Agricultural Show
Porte de Versailles exhibition centre, Paris

4–6 JUNE 2020
Africa-France Summit
Theme: sustainable cities and regions
Bordeaux

8–12 NOVEMBER 2020
Paris International Agribusiness Show (SIMA)
Paris-Nord Villepinte exhibition centre -
simaonline.com

They came, they were impressed

FIRA's impact reaches far beyond Toulouse. The talks in English and French were also posted and widely viewed on YouTube, not surprising given the forum's focus on technology. Its appeal is increasingly international, with 42 countries represented at this year's event. Impressions? "All very interesting", "a great place for networking" and some "really great projects". FIRA now wants to go even further and attract more land users: farmers, market gardeners and cattle breeders. In November this year, FIRA will be at the Paris International Agribusiness Show (SIMA), a new showcase of the agriculture of the future, where it will be keen to meet them.

NATAÏS: POPCORN AND CARBON HAND IN HAND

In total harmony with the surrounding countryside at its base in the Gers department of Southwest France, Nataïs is consolidating its green credentials as it encourages popping corn growers to adopt sustainable and eco-friendly farming practices. This innovative approach relies notably on satellite data.

Agro-ecology is the watchword for Nataïs. Since its inception, the firm has been supporting its growers through initiatives like the use of capacitive soil moisture probes to optimize water use for more than 7,000 hectares of crops in France. Taking this commitment a step further, it's now inviting its 260 partner growers to sign up to the Naturally Popcorn approach founded on three pillars: regenerative growing, high-quality production and the region's economic development. To consolidate the first of these, Nataïs is working to perfect a measuring tool capable of calculating tonnes of carbon stored in soil. This PSPC[1] competitiveness project being pursued with several partners[2] aims to promote carbon capture and storage in their fields.

EFFORTS SHOWING RESULTS

Here's how: in the autumn, after harvesting, growers plant legumes between the rows of corn, and in summer, after harvesting their wheat crop, they plant sorghum. These cover crops continue to produce biomass and thus capture carbon durably. When sowing time arrives, they are turned under to preserve organic matter in the soil. Nataïs and its partners have validated a reliable and objective numerical model to measure how much carbon is retrieved in this way. The tool currently in development will correlate daily data from Sentinel-1 and Sentinel-2 with survey data from crop fields. Farmers signed up to this innovative approach will receive a bonus indexed to the amount of carbon stored in their field. Trials for the pilot project are already underway and there's every reason to envisage extending it to other types of crop.

1. Projets Structurants Pour la Compétitivité
2. INRAE, CESBIO, Agro D'OC and STMS

From the outset, some 40% of popping corn growers went along with Nataïs' approach. The firm is hoping to get as many growers on board as it can over the next five years. The bonus it pays varies from €60 to €80 € per tonne of carbon fixed in soil.