CNES MAG

SPACE ● INNOVATION ● SOCIETY

#84
May 2020

#SUPPLEMENT EN FR COVID-19

BIODIVERSITY

BUILDING RESILIENCE

cnes
CENTRE NATIONAL D'ÉTUDES SPATIALES

INSIDE

PARTNERS

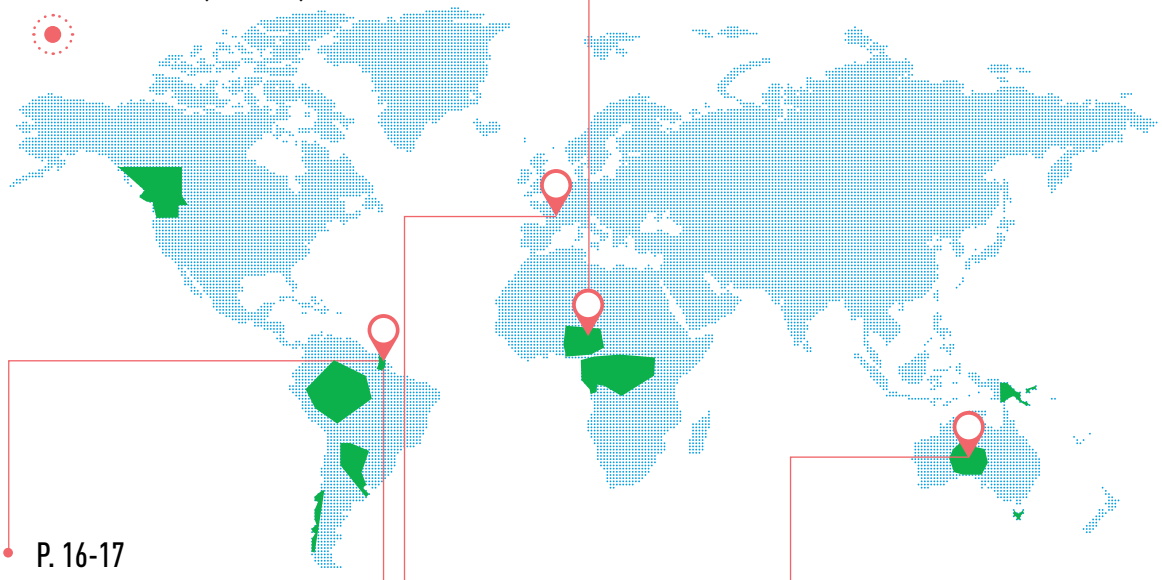
In this issue: p. 11 Department of Health (DGS) and CIRAD; p. 10-25-35 Conservatoire du littoral coastal conservancy; p. 10 AFD development agency; p. 11-15 Meteo-France; p. 18 CLS; p. 15 ADEME; p. 10-15-36 IGN; p. 23-25-34 ONF; p. 23 IPEV polar institute; p. 24 Hydreco; p. 24 Institut Pasteur, Antea, IRD, BRGM and Biotope; p. 26 Paul Sabatier University; p. 32 French natural history museum; p. 35 IFREMER and INRAE.

More content in this new issue on line at cnes.fr/cnesmag

WWW.CNES.FR

CNESfrance @CNES YouTube CNES

SPACE WATCHING OVER THE WORLD'S FORESTS



CONTRIBUTORS

LAURENCE MONNOYER-SMITH

Formerly Interministerial Delegate and Commissioner General for Sustainable Development, Laurence Monnoyer-Smith led efforts to chart the French roadmap for implementing the Agenda 2030. Since June 2019, she is the CNES President's adviser on environment and climate matters and a strong advocate of the utility of space in protecting the environment, helping CNES to lead the way as an environmentally committed government agency.

SELMA CHERCHALI

Within the Directorate of Innovation, Applications and Science (DIA), Selma Cherchali coordinates the structuring of CNES's Earth Sciences programmes inside and outside the agency. Her missions include leading the TOSCA committee, which is the link between the scientific community and CNES in this field. She is our authority on space for this issue.

THIERRY DE PRADA

An optronics engineer within the photo and video department at the Guiana Space Centre (CSG), where his job is to film and photograph Ariane, Soyuz and Vega launch campaigns, Thierry de Prada also supports the French forestry commission ONF in monitoring species and spaces inside the launch base's perimeter (see Insights, p. 34). In this issue, we see French Guiana's fauna through his eyes.

VINCENT RUFRAY

As head of the Amazon office of consulting firm Biotope, Vincent Rufray is instrumental in tailoring CNES projects to the exceptional environment of the CSG and drafts regulatory impact studies. In this capacity, he coordinates implementation of ecological offset mechanisms by nature conservation associations for CNES. In particular, he gave us the benefit of his insight into French Guiana's savannas.

CNES MAG

CNESmag, the magazine of the Centre National d'Etudes Spatiales, 2 place Maurice Quentin. 75039 Paris cedex 01. For all correspondence, write to: 18 avenue Edouard Belin. 31401 Toulouse cedex 9. Tél. : +33 (0)5 61 27 40 68. Internet: http://www.cnes.fr. This review is a member of *Communication&Entreprises*. Subscriptions: https://cnes.fr/reabonnement-cnesmag. **Publication director:** Jean-Yves Le Gall. **Editorial director:** Marie-Claude Salomé. **Editor-in-chief:** Brigitte Alonzo-Thomas. **Proofreading:** Céline Arnaud. **Editorial staff:** Brigitte Alonzo-Thomas, Karol Barthélémy, Liliane Feuillerac. **Photos and iconography:** Marie-Claire Fontebasso. **Photo editor:** Loic Octavia. **Photo credits:** p. 4 H.Piraud - F.Maligne - T.De Prada - V.Ruffray; p. 5 C.Peus; p. 6 M.Diekmann – REST; p. 7 ESA/Copernicus Sentinel data (2019-20) processed by KNMI/ESA; p. 8 (top) S.Girardot/Naturagency - (bottom) Getty Images; p. 9 CNES; p. 10 (top) Conservatoire du littoral/F.Larrey - (bottom) F.Guèrin/Naturagency; p. 11 DGS/ARS/CIRAD/CNES/ADS; p. 13 AFP/L.Hans; p. 15 AFP L.Marin; p. 16 IRD-UMR AMAP/C.Proisy; p. 17 CNES/ESA/Arianespace/CSG photo and video department; p. 19 CNES/ESA/Arianespace/CSG photo and video department/P.Baudon; p. 20 T.Montford/Naturagency; p. 21 Getty Images; p. 22 CNES/ESA/Arianespace/CSG photo and video department/P.Piron; p. 23 IPEV/I.Tucoulet; p. 24 CNES/ESA/Arianespace/CSG photo and video department; p. 25 (top) CNES/ESA/Sentinel - (bottom) CNES/ESA/Arianespace/CSG photo and video department/L.Mira; p. 26 (top) Getty Images - (bottom) CNES/N.Tronquart; p. 27 Getty Images; p. 33 I.Arnould; p. 34 T.De Prada; p. 36 Nantes 15 november 2018 - CGSatellite Jilin - 1 0.92m - IGN BDORTHO 5m & IRIS. **Illustrations:** François Foyard, Jean-Marc Pau, Robin Sarian (Idix), Thomas Hayman (cover). **Webmaster:** Sylvain Charrier, Mélanie Ramel. **Social media:** Mathilde de Vos. **English text:** Boyd Vincent. **Design and pre-press:** Citizen Press – Camille Aulas, David Corvaisier, Fabienne Laurent, Alexandra Roy. **Printing:** Ménard. ISSN 1283-9817. **Thanks to:** Jennifer Amsellem, Alice Andral, Touria Bajjouk, Brigitte Behal,Typhanie Bouju, Éric Boussarie, Selma Cherchali, Cathy Clerbaux, Philippe Collot, Christine Correcher, Carole Deniel, Danielle Destaerke, Francis Gohin, Antoine Huguet, Marie-Pierre Joseph-Alberton, Murielle Lafaye, Juliette Lambin, Anne Lifferman, Vincent Lonjoux, Véronique Mariette, Benoit Mertens, Sylvain Michel, Laurence Monnoyer-Smith, Bastien Nguyen, Didier Olivry, Camille Pinet, Milena Planells, Amélie Proust, Sandrine Richard, Tristan Rouyer, Anne Serfass-Denis, Anne Thieser, Cécile Vignolles, Hervé Yesou.

PEFC 10-31-2690

IMPRIM'VERT

EDITORIAL

The lockdown period has seen nature reasserting its rights in many places, like the dolphins that have returned to the canals of Venice.
Looking beyond the health situation on everyone's minds right now, the COVID-19 crisis is thus prompting us to rethink our relationship with nature. The footprint we humans leave on habitats is disrupting natural ecosystems and increasing the risk of spreading zoonotic diseases.
The scientists of the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) are now calling for a concerted effort to preserve natural areas and the species that live in them.
For close on 20 years, the space community has strived to document, map and observe biodiversity. Satellites are watching over forests, measuring soil moisture, tracking habitats and hundreds of species to analyse their behaviour. New hyperspectral technologies are set to deliver deeper insights into forest and cropland biomass and the carbon sinks they represent.
Through its field centre in French Guiana, CNES is keenly aware of its role as guardian of the region's extremely rich flora and fauna. It is adopting this same attitude at the Toulouse Space Centre and stepping up to the plate through the Act4Nature initiative of the Ministry for the Ecological and Inclusive Transition.
The time for alerting is behind us; now is the time for action, and CNES is gearing up to play its part in building a new resilience for the future.

JEAN-YVES LE GALL
CNES PRESIDENT

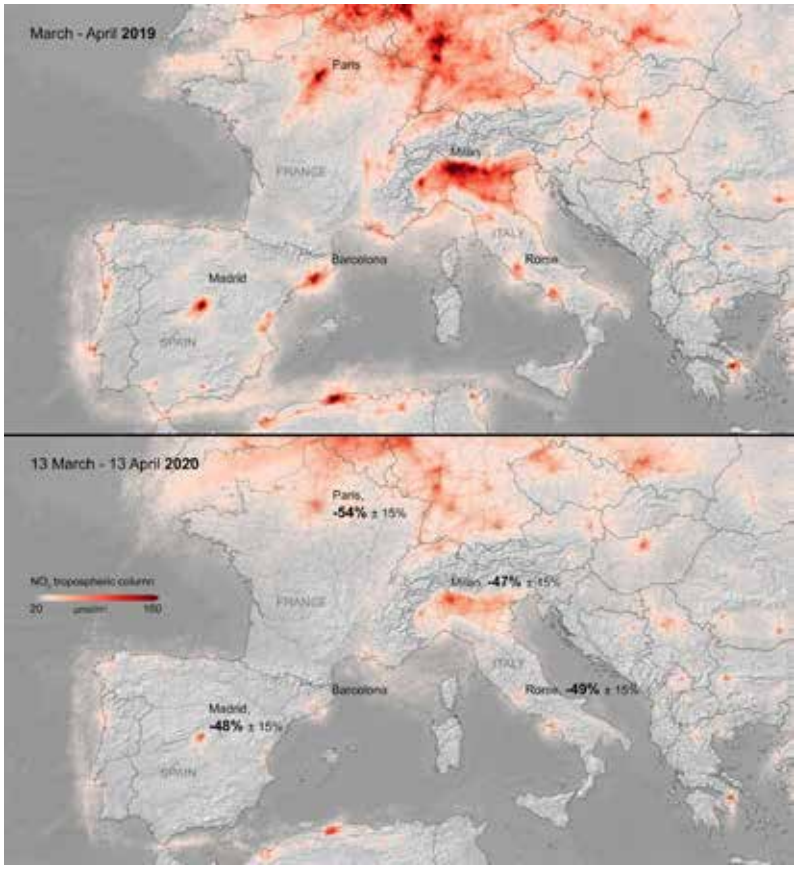
The pangolin, a harmless small mammal measuring 30 centimetres from East Asia, is suspected as the host from which humans contracted the novel coronavirus. In danger of extinction, it is increasingly the victim of illegal trafficking on a global scale.

BIODIVERSITY

State of emergency

2020 has been declared International Biodiversity Year, with all eyes on ecosystems and the dramatic decline in species.
In this context, the COVID-19 pandemic, which would seem to have been transmitted from animals to humans, raises many questions. Habitat loss and deterioration of biodiversity are prime factors in the emergence of such zoonotic diseases, as the previous SRAS (2003) and MERS (2012) outbreaks have shown before it. This year, France had signalled its call to action with the World Conservation Congress to be hosted in Marseille, and while COVID-19 has forced a change of date, biodiversity is not being forgotten and the congress will go ahead in Marseille. The Ministry for the Ecological and Inclusive Transition and IUCN[1], as co-organizers, have rescheduled it to January 2021. CNES and its partners will be there with the biodiversity dome to highlight the many ways in which space is supporting ecosystems (see Insights, p. 35).

1. International Union for Conservation of Nature.



Total nitrogen dioxide (NO_2) columns measured by the Sentinel-5P satellite for the baseline period of March-April 2019 and from 13 March to 13 April 2020, during the lockdown.

COVID-19 SEEN FROM SPACE

THE INSUFFERABLE LIGHTNESS OF AIR

If it may have felt like you were suffocating at times during the lockdown, at least the air outside is looking healthier! From the moment the restrictions came into force, the European Copernicus programme's Sentinel-5P satellite has been mapping global atmospheric concentrations of nitrogen dioxide (NO_2). Between 13 March and 13 April, it measured a drop in levels of NO_2 of around 45% in Madrid, Milan and Rome over the same period last year.
In Paris, concentrations of the gas were even 54% lower. NO_2 is emitted by road traffic and industrial facilities, but it is not the only atmospheric pollutant. In the Paris region over the same period, ground measurements however showed that concentrations of suspended particulates, also emitted by road traffic, remained high. This mystery has since been solved, as towards the end of March people were still burning wood in their fireplaces and farmers had spread fertilizers—a major source of particulates—on their fields to take advantage of the prolonged sunny weather. At the same time, the three IASI instruments developed by CNES flying on the European Metop satellites have been tracking carbon monoxide (CO), another pollutant.
Here again, a significant drop was seen over the previous two years. Scientists have noted an improvement in air quality, notably in notoriously polluted regions like the Wuhan-Beijing corridor (up to 40%) and Northern Italy (up to 20%).
As governments successively imposed the worldwide lockdown, daily maps from IASI data showed ever-lower levels of atmospheric pollution. The changes have been especially visible in countries where industry and heating still rely heavily on coal. So if we want our air to stay cleaner in the long term, does that mean we have to put the planet on pause? Obviously not. The trick is 'simply' to reduce emissions, which can be achieved by encouraging cleaner technologies and weaning ourselves off oil, gas and above all coal.

CORALS
ECOSYSTEMS IN DANGER

The continuing die-back of corals, which support a rich range of biodiversity around the world, is a serious warning sign. The changing chemistry of the world's oceans driven by climate change is a major cause, but not the only one. An initial study carried out in 2009 compiled a hyperspectral map of corals on the reefs of the Indian Ocean island of Réunion. This survey was complemented by a wider and more finely detailed study in 2015 combining Pleiades satellite and lidar data to characterize the components of the Réunion ecosystem—seaweeds, sand, living corals and sea grasses—at a resolution of 40 centimetres. Hyperspectral imagery also revealed changes in the Saint-Gilles reefs over a six-year period[1]. Scientists will now be using this imagery to probe corals in deeper waters using sensors deployed by submarine drones to gain fresh insight into global coral die-back.

1. Bajjouk et al. 2019, Ecological Indicators 96.

ECOLOGICAL CORRIDORS
SUSTAINING LINKAGES

By dispersing seeds and pollinating flowers, animals play a key role maintaining balance in biodiversity. And just as humans need roads to move around, so mammals, birds and insects need both green (land) and blue (aquatic) ecological corridors, which are vital to maintain the balance of ecosystems. But fragmentation of landscapes, break-up of habitats and division of private land are stretching these natural linkages. Restoring them is therefore a matter of urgency, and indeed mandated under the Grenelle I and II environmental laws. To safeguard the integrity of these corridors, environmental regulations require that they be incorporated at local level in territorial coherence plans (SCOT[1]) and zoning plans. By providing up-to-date territorial maps, remote sensing offers a broad palette of tools at a range of spatial, temporal and spectral resolutions. For example, data from satellites like SPOT or Pleiades can be cross-correlated to establish a national master plan or zoom in on a land parcel to identify grasslands, hedgerows, trees and shrubs that allow animals to move freely. Such data inform policy decisions with regard to action plans and efforts to promote and preserve these corridors.

1. Schémas de COhérence Territoriale.

PASTURES

NEW ANGLE ON PLANT DIVERSITY

Pastures are one element of the rural patchwork alongside fields under crop, woods and hedgerows. These grazing areas are also genuine ecosystems in their own right and their impact on the environment and on agricultural production varies according to whether they are permanent—longer than five years—or rotated with crops. Permanent pastures can be home to dozens of species of flowers, providing sustenance for a varied gallery of insects and animals. Large-scale studies have long proved unfeasible, but now that is changing with Sentinel-1 and Sentinel-2 data. For example, time-series acquired over 18 months and coupled to field surveys of 83 land parcels have enabled scientists to gauge the diversity of grassland plants over an area of approximately 40,000 sq.km with an accuracy of around 50%. These indicators are of value not only to public bodies but also to farmers looking to nurture biodiversity and ecosystem services in their pastures.

10

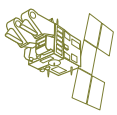
To better identify disparities in biodiversity, the international scientific community has determined a series of objective indicators or essential biodiversity variables (EBVs), along the same lines as essential climate variables (ECVs). Spanning genetic composition to the structure of an entire ecosystem, 22 EVBs have been defined, of which 10 can only be studied using space-based remote-sensing technologies.

4 + 1

The Data Terra research infrastructure provides value-added data for scientists and public stakeholders observing biodiversity and predicting how it is likely to evolve. Until recently, it comprised four data centres, two of them dedicated to biodiversity: ODATIS for ocean and coastal monitoring, and THEIA for land surfaces. A fifth network, called Ecoscope, has now been added to supply data on ecosystems.

SPACE SERVING BIODIVERSITY

2002

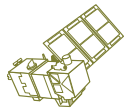


SPOT 5
Mapping of natural and semi-natural habitats, forest cover and the water cycle.

2009

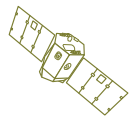
SMOS
Measurement of soil moisture and ocean salinity.

2014



SENTINEL-2
Monitoring of status of natural habitats and plant cover, measurement of biophysical variables (leaf area index, biomass).

2017



VENμS
Vegetation monitoring, study of biodiversity.

2022

BIOMASS
Observation of forest status and evolution, measurement of biomass, fight against deforestation.

Called the 'spatula' on account of its shape, this part of the spit is a topographic succession of sediments, sand and stones that clearly stands out from space.

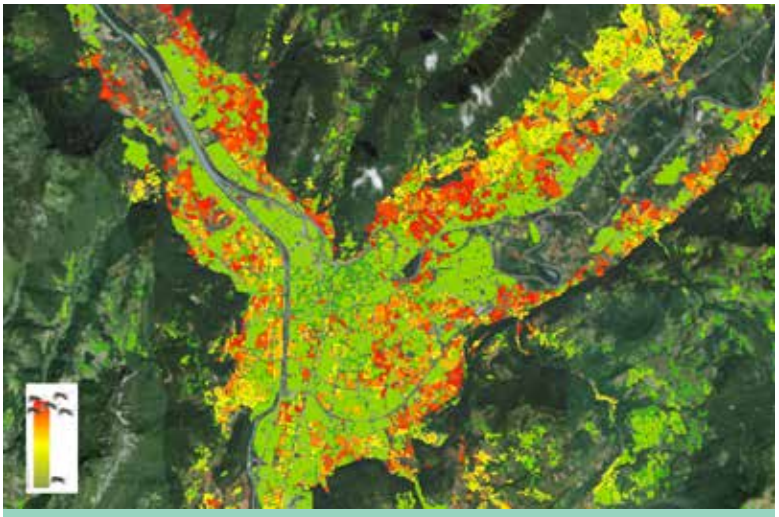
SILLON DE TALBERT
NATURE RECLAIMING ITS RIGHTS

The Sillon de Talbert is a coastal spit lying on Brittany's north coast within the municipality of Pleubian. Reshaped with each tide, this unique geomorphological feature, consisting of three kilometres of sand and pebbles built up after the last ice age, is a popular tourist attraction. It broke away from the coast during the 2018 storm. The 10-metre breach opened by that storm is today 60 metres wide. As the owner of the site, the Conservatoire du Littoral, the French coastal conservancy, has long monitored it with satellite and aerial imagery, as well as through field surveys. But should the surviving platform be reconnected to the coastline at all costs? From a science perspective, the question merits consideration, as over time shorelines change and attempting to fill the breach would prove fruitless. Above all, small islands of tranquillity have appeared in this haven of biodiversity, encouraging species like tern, oyster catcher and seagull to breed. A long-term observation strategy is therefore recommended for this natural area, supported by satellite and aerial data and the long record of time-series complemented by in-situ data. Satellite data will also enable close monitoring of erosion and other shifts of the emblematic coastline.

OSFACO
TROPICAL FORESTS UNDER CLOSE WATCH

Forests are a pillar of biodiversity vital to the survival of numerous animal and plant species. Unchecked logging and clearing can therefore have disastrous effects. For example, forest cover in Africa has declined by 20% in the last ten years. Preserving our forests is a global concern, but it is also hard to achieve. Efforts to ensure their sustainable stewardship are now coming into sharp focus, as they are being made complicated by cross-border issues where forests overlap several nations. Remote sensing is an objective source of data and the only way to gauge and keep track of forest health, but in certain African nations uptake is being stymied by lack of access to data and qualified personnel to exploit them. It was to overcome these obstacles that the OSFACO space observatory came into being, led by the French development agency AFD and executed by IGN FI, IRD, IGN and CNES. The observatory is fuelled by data from SPOT 6 and SPOT 7. Archive imagery from SPOT 1 through SPOT 5 and freely accessible Landsat and Sentinel imagery have also been supplied to eight nations[1] requesting it in Central and West Africa. Training and support for projects are helping to consolidate this emerging local expertise.

1. Guinea, Ivory Coast, Benin, Cameroon, Central African Republic (CAR), Gabon, Congo, Democratic Republic of the Congo (DRC)



Map of tiger mosquito density in the Grenoble region. High-density areas are in red, low-density areas in green.

+ 70%

Invasive exotic species have increased by about 70% since 1970 as a result of climate change and a tenfold increase in trade.

EPIDEMIOLOGY

SATELLITES TRACK THE TIGER MOSQUITO

Another health threat looms in the form of *Aedes albopictus*, the tiger mosquito that now has 57 departments in mainland France on red alert. Since it first arrived between 2004 and 2006, the mosquito has brought with it dengue fever, chikungunya, zika and other 'arboviruses' after previously infesting the overseas island territory of Réunion from Asia. The French Department of Health (DGS) has made efforts to combat this invasive insect a priority. CNES, with which the department signed a framework agreement in 2016, is providing it with expertise in tele-epidemiology. The agency has developed a mapping tool to help predict the density of tiger mosquitoes in real time. High- and very-high-resolution imagery has enhanced the model developed to track the mosquito's spread for Réunion. The Sentinel-2, SPOT 6/7 and Pleiades satellites supply imagery to derive regularly updated land-cover maps and vegetation indexes, while the model adds daily rainfall and temperature data from the national weather service Meteo-France. All of this information has driven development of a tool called Arbocarto, today operational at three pilot sites in Bordeaux, Grenoble and Montpellier. Supervised by CIRAD, the centre for international cooperation in agronomic research through development, the experiment could be extended nationwide. And while Arbocarto cannot be transposed as is, it could still be pressed into service to track *Aedes aegypti*, the yellow fever mosquito proliferating in the French West Indies.

1992

A contraction of 'biology' and 'diversity', the term biodiversity was first coined by scientist Walter Rosen. In 1992, 168 nations at the Earth Summit in Rio de Janeiro signed the first international Convention on Biological Diversity (CBD) and the sustainable use of its components.

#COMMUNITY

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

@THOM_ASTRO

European and Frenchman, spacecraft pilot, currently between space missions

Today we celebrate the 50th Earth Day, lest we forget the challenges that await us after COVID (biodiversity, plastics, climate, etc.). While physically apart today, we must act together tomorrow for a brighter future! #EarthDay50

@RIZTWITT

Planet Web: tools, utopia and myths... and Men #humanism #web

Turtle tweets with the #argos system. It's the future! Combining environmental and social data for a better world @TortugaLasi #digitalhumanities #biodiversity @CLS_Group @CNES

@VPWPRESS

By VPW, publisher of SIGMAG and SIGTV.FR #SIG #géomatique #cartographie #géographie #SIGMAG @SIGTV #SIGMAG_Campus #SIGMAG_Junior

#GéoDataDays soon set to offer a five-day weather forecast-type map showing tiger mosquito-related risks for a specific geographic area? CNES has tested the model in Montpellier, Grenoble and Bordeaux with CIRAD, the regional health agency ARS and EID... An extension is planned this year.

@IFREMER_FR

French institute of marine research and exploration. Understanding, explaining and sharing the oceans

#Sargassum, the brown seaweed washing up on the beaches of France's West Indian islands. @CLS_Group, a subsidiary of @CNES & @Ifremer_fr, has developed a detection and prediction system supporting weekly bulletins from @meteofrance.

Q & A

ÉLISABETH BORNE

THE MINISTER FOR THE ECOLOGICAL AND INCLUSIVE TRANSITION reviews the progress made preserving biodiversity in France and around the globe and emphasizes the key role that space is playing.

FROM THE CREATION OF THE AFB BIODIVERSITY AGENCY TO THAT OF THE OFB BIODIVERSITY OFFICE ON 1 JANUARY THIS YEAR, FRANCE IS CLEARLY PAYING CLOSE ATTENTION TO BIODIVERSITY. WHAT ARE THE NEW OFFICE'S MISSIONS?

E.B.: Biodiversity is in a critical condition. It is the intention of the French biodiversity office OFB to step up our efforts to preserve it. With the reservoirs of land and marine biodiversity in its possession conferred by the world's second largest maritime domain and its overseas territories, France has an exceptional natural heritage.
In merging our biodiversity agency AFB and our national hunting and wildlife commission ONCFS, we are giving ourselves a tool geared to restore land and marine biodiversity, manage water and fauna sustainably and preserve habitats. OFB is the sole agency tasked with executing the national biodiversity strategy, adding coherence and clarity to government policies and aligning them to the specific needs of territories. It is also responsible for policing and enforcing environmental regulations. Moreover, we have beefed up its inspectors' powers to identify offenders more effectively and punish them more severely.

HOW IS THE NEW OFFICE OPERATING IN FRANCE'S REGIONS AND OVERSEAS TERRITORIES?

E.B.: AFB and ONCFS had already built a solid local base. OFB has structured teams and defined a hierarchy and teams' responsibilities. National directorates and delegations are in charge of setting policy and strategy, while regional delegations coordinate and apply actions and department-level and local delegations are tasked with executing them.
The office's purview also covers nine marine nature parks, the Agoa marine mammals sanctuary and 26 nature reserves. In the overseas territories, it will be supporting efforts to tackle invasive exotic species, create new protected areas and preserve endangered coral reefs.

WHAT PROGRESS IN PRESERVING BIODIVERSITY HAVE ACTIONS UNDERTAKEN IN RECENT YEARS ALREADY ENABLED?

E.B.: In 2018, the Biodiversity Plan outlined our national strategic priorities, with the ambition of achieving zero net biodiversity loss and a strong commitment to "zero net land take". This plan advocates extending the network of marine and land protected areas.
On 7 November 2019, I officially announced the creation of the National Forest Park, the first and only national park of its kind, after a ten-year consultation process involving all local stakeholders.
This 11th national park covers 241,000 hectares in the Bourgogne-Franche-Comté/ Grand Est regions and will help to promote and preserve deciduous plain forests.
We have also succeeded in getting the 673,000 square kilometres of our French Southern and Antarctic Lands listed as a UNESCO World Heritage Site, making it the largest listed area in the world.

WHAT PRIORITY AREAS DOES FRANCE INTEND TO FOCUS ITS ACTIONS ON?

E.B.: We depend for our survival on the climate system and on sustaining rich biodiversity, as the current crisis unfortunately has put into stark perspective. We must learn the lessons from this crisis to support the recovery of our economies and societies. I want our ambition to accomplish the energy and environmental transition to step up a gear. In terms of biodiversity, that supposes we stick to our course of establishing protected natural areas covering 30% of our national territory, with strong protection for 10%, and reducing land take and limiting pollution, notably from plastic.
For example, by 2021 the natural habitats at the summit of Mont Blanc will be protected areas and four new regional nature parks will be created before the end of 2022. The Glorioso Islands, which are home to numerous endangered species on the Red List of the International Union for the Conservation Nature (IUCN), will be made a national nature reserve.

ÉLISABETH BORNE

MINISTER FOR THE ECOLOGICAL AND INCLUSIVE TRANSITION

"PRESERVING BIODIVERSITY CALLS FOR NEW INSIGHTS INTO ECOSYSTEMS FROM NEW DATA PROCESSED AND DISSEMINATED TO THE RESEARCH COMMUNITY AND PRIVATE SECTOR."

WHAT PLACE DO SPACE ASSETS OCCUPY TODAY IN THE ARSENAL TO TACKLE DECLINING BIODIVERSITY?

E.B.: A vital one! Space-based instruments are enabling finely detailed analysis of the status of habitats and monitoring of biodiversity, notably the impacts of climate change. They are also helping to clamp down on overfishing and to geolocate, track and study endangered species. The satellite applications plan for 2018-2022 intends in particular to map natural habitats and protect them from land take, to characterize shipping traffic and measure its impacts on flora and fauna, and to improve tracking of marine animals like turtle, gannet and small cetaceans like dolphin. Preserving forests in the face of multiple threats such as water stress, fires and human-induced deforestation is also a priority. The combination of radar, lidar and optical technologies is now making it possible to monitor and precisely map their health and biomass, notably with data from the Copernicus programme's Sentinel satellites.

MORE BROADLY SPEAKING, WHAT ROLE DO YOU SEE A GOVERNMENT AGENCY LIKE CNES PLAYING TO PRESERVE BIODIVERSITY?

E.B.: For the government, CNES is operating cutting-edge technologies to boost knowledge and research. This kind of knowledge is fundamental, as I firmly believe in action being supported by science. Preserving biodiversity precisely calls for new insights into ecosystems from new data processed and disseminated to the research community and the private sector. In forming the Space Climate Observatory (SCO) with other government agencies overseen by my ministry, like the environment and energy agency ADEME, the national weather service Meteo France and the national mapping, survey and forestry agency IGN, CNES is federating expertise around projects focused specifically on biodiversity and water management. It is working closely with my ministry's departments within the Commissariat General for Sustainable Development to give our public policies the right tools and the benefit of the space industry's expertise.

WHAT NEW PROSPECTS DO SPACE ASSETS OFFER?

E.B.: All of these R&D efforts are culminating in programmes like SWOT, CFOSat and Biomass. As a result, more relevant actions will be able to be engaged in the future to safeguard biodiversity, protect the environment and tackle climate change. Over time, these missions will interface with other drone-based or aerial platforms, as we need this kind of complementarity. Integrating multisource, multiresolution and multidate imagery will bring a deeper understanding of natural environments.

Profile

2019
Minister for the Ecological and Inclusive Transition

2017
Minister of Transport within the Ministry of State for the Ecological and Inclusive Transition

2015
CEO of RATP, the Paris public transport operator

2013
Prefect of the region of Poitou-Charentes

MANGROVES MOVE TO THE TIDAL BEAT

Tropical mangrove forests are rooted in a mud substrate regularly flooded by saltwater with the tides. These markers of littoral dynamics recede, adapt and then regenerate, offering a vital haven for coastal biodiversity. Fuelled by the vast amounts of silt coming from the mouth of the Amazon, the amplitude of erosion and accretion phenomena along French Guiana's shorelines is exceptional. The ebb and flow is clearly revealed in optical and radar remote-sensing imagery, helping us to better understand the physical mechanisms at play in mangroves around the globe.

SHELTER FOR SAVANNAS

The 260 sq.km of grassy expanses in the thick of the Amazon forest that form French Guiana's wet, dry, tree and shrub savannas may only cover 0.3% of the territory, but they harbour a unique biodiversity of orchids, big cats, amphibians, birds and more. Some species can now almost only be seen inside the perimeter of the Guiana Space Centre, which spans 640 sq.km and preserves the coastal strip in its original wild state, safe from human constructions and hunting. Led by nature conservation associations in partnership with CNES, the European LIFE+ programme is applying urgent measures to protect the savannas from invasive plants like the paper-bark tea tree.

BARELY 3,500

That's the number of Siberian crane and Oriental stork—both endangered species—that winter only on China's Lake Poyang. Thousands have disappeared from the shrinking monsoon lake as it has dried up, leading to a huge loss of biodiversity. Climate is not the only culprit, intensive sand dredging and damming of the Yangtze River also playing a role. The Dragon[1] programme, which has been monitoring the lake for more than 15 years, supplies long time-series of high-resolution and altimetry data from the Sentinel-1, Sentinel-2 and Sentinel-3 satellites. Its aim is to gain deeper insight into the complex dynamics at work and to restore biodiversity. The SWOT mission set to launch in 2022 could further refine observations of this jewel in the crown of global biodiversity.

1. Programme established in 2004 by ESA and MOST, the Chinese Ministry of Science and Technology. Monitoring is performed by ICube-Sertit in Strasbourg.

3rd

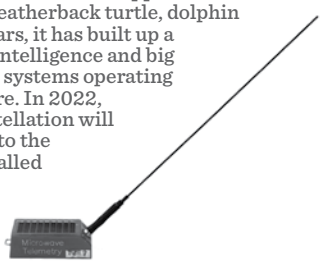
CORONAVIRUSES are the cause of deadly epidemics. The 21st century has already seen three outbreaks. In 2003, SRAS-CoV[1] was the first of these respiratory viruses to infect humans. In 2012 and 2013, MERS-CoV[2] spread like wildfire through the Middle East. The particularly contagious and aggressive SARS-CoV-2, responsible for the ongoing COVID-19 pandemic, is therefore the third coronavirus epidemic we have faced.

1. Severe Acute Respiratory Syndrome.
2. Middle East Respiratory Syndrome.

150,000

In 1979, the first Argos transmitter was used to tag a humpback whale. Today, small birds like the cuckoo are tagged with miniature transmitters tipping the scales at no more than two grams. There are 150,000 land and marine animals and birds currently carrying such sensors. Every month, CLS[1] tracks 8,000 animals in support of efforts to preserve endangered species like bear, leatherback turtle, dolphin and basking shark. In the space of 40 years, it has built up a priceless record of data. Now, artificial intelligence and big data technologies are turbocharging the systems operating alongside all of the transmitters out there. In 2022, the 25 nanosatellites in the Kineis constellation will carry aloft new Argos payloads tailored to the Internet of Things (IOT), offering unrivalled revisit capability to take the pulse of observed species every 12 minutes.

1. Collecte Localisation Satellites, a subsidiary of CNES.



Illegal fishing

More than 30 fishing vessel monitoring centres around the world use remote-sensing satellites, numerical modelling and geolocation systems to collect data in real time. And their catch is often good. In the Galapagos Islands, a boat was detected fishing illegally in a protected area many miles offshore. When inspectors boarded the offending boat, they found several tonnes of fish in its hold, including 80 shark fins for the clandestine market. Illegal shark fishing proves very lucrative for poachers but is an environmental crime.

In September 2015, two jaguars were captured inside the perimeter of the CSG. The two males were tagged with a GPS/satellite collar that has enabled scientists to learn more about this species' behaviour, biology, territory and habitat.

BIODIVERSITY

ON SPACE'S WATCH

BIODIVERSITY IS IN DECLINE EVERYWHERE WE LOOK AND PRESERVING IT IS A CRITICAL CONCERN. CNES IS GETTING RIGHT BEHIND THIS EFFORT, LENDING ITS EXPERTISE TO EARTH-OBSERVATION MISSIONS WHILE TAKING CARE TO PROTECT THE ECOLOGICAL HERITAGE OF ITS FIELD CENTRES.

French Guiana's primary forest.

The decline in biodiversity is neither new nor inevitable. It continues to be driven by the climate change spiral fuelled by anthropogenic activities, even though successive measures have attempted to stem it. As far back as 1971, the international Ramsar Convention sought to address the loss and degradation of wetlands and waterfowl habitats. We know that habitat loss is ultimately a death warrant for species. In 1992, at the Earth Summit in Rio de Janeiro, 168 nations recognized the conservation of biological diversity as "a common concern of humankind". In Europe, the Habitats and Birds directives ratified by France in 1994 led to the creation of Natura 2000 zones. Global efforts gained momentum in 2010 with the proclamation of International Biodiversity Year, while in Nagoya, Japan, the Aichi Targets mapped out a strategy for 2011-2020. The next World Conservation Congress in Marseille and the COP 15 conference in China will write the next chapters.

1

million

According to a UN report, out of 8 million species of animals and plants, between 500,000 and 1 million could already be in danger of extinction.

GLOBAL CONCERN

The ambition of the 20 Aichi Targets is "to live in harmony with nature". But the wolf is at the door. The breakdown in biodiversity that has long been creeping up on us is now clear for all to see. "With the decline in biodiversity, a sixth mass extinction is looming on the horizon; at least that is the clear verdict of a number of studies," admits Laurence Monnoyer-Smith, Climate and Environment Adviser to the CNES President. To put it plainly, humankind is destroying at an unprecedented rate not only the biodiversity we know, but also the biodiversity we are yet to discover. The French biodiversity office OFB, created on 1 January 2020, signals the government's intention

to tackle this threat. Overseen by the Ministry for the Ecological and Inclusive Transition and the Ministry of Agriculture and Food, OFB is the result of the merger of AFB, the French biodiversity agency, and ONCFS, the national hunting and wildlife commission, and is staffed by specialists in aquatic, land and marine habitats. Its mission is to coordinate public initiatives to preserve and restore biodiversity, which it does through a variety of initiatives on water, ecological linkages and land planning (see Q&A p. 13-15) supported by its regional branches. Alongside these efforts, international bodies like IPBES[1] are playing a similar expert role for ecosystems to that of the IPCC[2] for climate. Since its inception in 2012 under the aegis of the United Nations, IPBES has brought together specialists across disciplines from around the globe to assist governments and build the biodiversity capacities of emerging nations.

SHARING OBSERVATIONS

Remote sensing is among the disciplines that lend themselves best to providing a broad picture of natural habitats and their conservation status. Earth observation is one of CNES's domains of excellence, and the agency offers a wide range of key radar and optical technologies and new sensors operating at high- and very-high-resolution. Today's satellites employ the very best modern technologies to deliver easily accessible, harmonized, shared and interoperable data in near-real time. It is also setting up numerous platforms for scientists and policymakers to access these data. All over the world, satellite imagery is supporting a plethora of programmes to monitor water quality, tackle land take and fragmentation of natural areas, manage soils sustainably, track deforestation, keep a check on invasive plant species and curb atmospheric and light pollution to name a few. With the SPOT series (1986), the Pleiades system (2012) and the Sentinel satellites of the European Copernicus programme, CNES is working to restore biodiversity. In 2022, it will be extending these efforts with the Biomass satellite for ESA's Living Planet programme to study the world's tropical biomass.

More than one billion animals perished in the wildfires that raged in Australia in 2019. 20% of the country's forests burned, one-fifth of their total area.

SUSTAINABLE DEVELOPMENT GOALS

STRUCTURING SUSTAINABILITY

The UN Agenda 2030 provides guidelines for nations to transition to a sustainable development model. Its 232 indicators will track progress over the next decade. Two of the agenda's 17 Sustainable Development Goals (SDGs) cover biodiversity.
SDG 14 promotes the conservation and sustainable use of marine and coastal ecosystems.
Its targets are to combat illegal, unreported and unregulated fishing and overfishing, strengthen the resilience of ecosystems and reduce ocean acidification.
SDG 15 is geared towards achieving sustainable management of forest and mountain ecosystems and recommends national plans to preserve them.

1. Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services.
2. Intergovernmental Panel on Climate Change

Once a month, a guide from the French forestry commission ONF takes visitors on a tour along the boardwalks winding through the heart of French Guiana's savannas.

ACT4NATURE
CNES NAILS ITS COLOURS TO THE MAST

As the owner of the Guiana Space Centre (CSG), CNES is the guardian of an ecological heritage unmatched anywhere in the world, 90% of it primary forest. The Act4nature initiative launched in December 2019 offers the opportunity to ramp up environmental commitments across the agency's field centres.

Certification to the ISO 14001 environmental management standard is not mandatory, but CNES decided to seek it for all of the agency's activities as far back as 2006. In February this year, it shifted its efforts into higher gear by joining the Act4nature programme initiated by the Ministry for the Ecological and Inclusive Transition. In so doing, CNES is blazing a trail as the first government agency to sign up to this process that aims to boost action plans in favour of biodiversity.

TRANSLATING WORDS INTO ACTION

The Act4nature label lays down a set of common principles through which signatories commit to measure their impacts on

biodiversity, curb them when they are negative or optimize them when they are positive, and establish a biodiversity stewardship plan for each of their facilities. CNES intends to go one step further in French Guiana with its 2010-2020 plan in partnership with ONF, the French forestry commission, and in Toulouse with its strategy to tackle urban biodiversity loss. The agency is also raising awareness of its personnel through Biodiversity Days and Environment Days, discovery trails at the CSG and the biodiversity trail at the Toulouse Space Centre (CST).

A second strand of Act4nature to which CNES is also set to sign up encourages 'individual' commitments. Any extension at the agency's field centres is today subjected to close scrutiny. For example, the new Ariane 6 launch pad in French Guiana was examined in every detail to ensure that ecosystems will get maximum protection. To leave nothing to chance, CNES also inserts clauses in the contracts of subcontractors working at the base that oblige them to exert the same degree of vigilance. And if a waiver has to be sought, it systematically puts in place a mechanism to offset any negative effects (see box p. 25).

500,000

Of the 5.9 million known species on Earth, 500,000 no longer have a natural habitat to ensure their long-term survival unless it is restored in time.

CHARTING THE FUTURE

Because we are not going to halt the decline in biodiversity overnight, future generations need to be informed and prepared. Education is precisely a part of the roadmap the government has charted for CNES. Working with schools, the agency is striving to build understanding of the planet's wider climatic and biological balances. Argonimaux, one of the strands of the Argonautica educational programme, brings satellites into primary and secondary school classrooms. For example, classes are currently tracking the movements of king penguins. From tagging penguins with an Argos transmitter to exploitation of acquired data, CNES guides them step by step in their meticulous investigations. We also take on the role of instructors, helping teachers to perceive the potential of remote sensing. For three years now, our specialists have been leading workshops and practical exercises for life and Earth sciences and physics teachers.

KING PENGUIN STEALS THE SHOW

Under the Argonautica programme, several classes are investigating the king penguin. Pupils watched their screens as Julie, a vet from the Institut Polaire, tagged penguins with transmitters on Île de la Possession in the Crozet Islands. They also did classwork to learn more about this protected species.

CSG
ZEROING IN ON BIODIVERSITY

When it arrived in French Guiana in 1965, CNES chose a location best suited to its launch activities. In becoming the owner of the new site, it also took on the responsibility for the exceptional biodiversity that it never tires of discovering and preserving.

The Guianese red brocket: France's national hunting and wildlife commission ONCFS, in partnership with the Natural History Museum, is set to undertake a study of deer inside the perimeter of the launch base, notably the endemic red brocket.

With 90% of its primary forest preserved, its dry and wet savannas, mangroves, mudflats and rocky islets, the Guiana Space Centre (CSG) forms an ecological continuum between the ocean and tropical forest that harbours an exceptional diversity of flora and fauna covering the complete spectrum of Guianese ecosystems. When it first came to these almost virgin lands, CNES knew full well that its industrial operations brought with them a high degree of potential risk and pollution. It therefore undertook from the outset to control the impacts of the explosive cocktail of propellants, alumina, carbon monoxide/dioxide and hydrogen chloride at the base.

STRINGENT REGULATORY REGIME

"Certain areas of the Kourou site are protected ZNIEFF[1] areas that CNES is careful to preserve," says Sandrine Richard, an environmental engineer at the CSG. The base also falls under France's stringent ICPE environmental protection regulations. Every time an extension is planned, it carries out preliminary studies to limit the impacts of launch operations on the environment. The good news is that analyses show these impacts are confined to a radius of less than one kilometre around each launch site.

100

A survey plan comprises some 100 measurement points or 600 samples.

CNES regularly acquires readings with support from specialist environmental partners like Hydreco for aquatic habitats, the LHE environmental health laboratory at the Institut Pasteur for chemical fallout, Antea for monitoring of industrial emissions, the IRD development research institute for gauging launch site impacts, the French geological survey BRGM for soils and ground displacements and Biotope for the impact of construction sites on fauna and flora. It also monitors forests with ONF, the French forestry commission, and recently renewed its agreement with OFB/ONCFS, the national hunting and wildlife commission, to safeguard

large mammals like puma and jaguar, extending it to include deer.

REASSURING STATE OF NATURE

There are 33 species of stingless Melipona bees in French Guiana. Water and environment consulting firm NBC uses them as 'sentinels', as the presence of all 33 species in immediate proximity to the launch pad confirms that the quality of the air is good. The CSG is also home to some remarkable species of flowers, including rare orchids and grasses (Poaceae) for which it has launched a research programme. The range of habitats attracts a rich variety of fauna: whether in plain sight or hidden from view, besides the Guiana spider monkey (or red-faced spider monkey) all large mammal species have been recorded in this haven of biodiversity. And as hunting is prohibited, they have every opportunity to thrive.

PLANS REGULARLY REVISITED

The CSG is guided by its 2010-2020 environmental management plan, which is currently under review. While the base is not administratively speaking a 'nature reserve', the management plan nevertheless takes its cue from this methodology. Drawn up by ONF, the plan has evolved to encompass the new ELA4 launch complex for Ariane 6 (see box). For these new facilities, CNES is adopting the ERC method—for *éviter* (avoid) *réduire* (reduce) *compenser* (offset) in French, an obligation given more weight by the 2016 Biodiversity statute. This method puts the natural environment at the centre of the initial project design. Where applicable, the project proponent undertakes to offset any environmental damage caused.

Thanks to the CSG's Environment department, pale-throated sloths reintroduced to the base are now breeding safe from poachers.

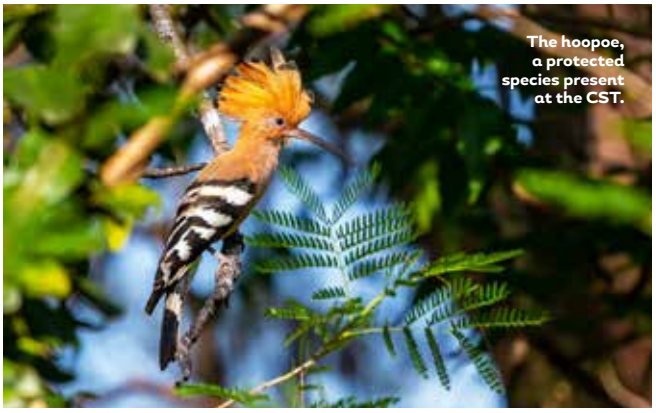
ELA4

A LAND DEAL BENEFITING BIODIVERSITY

To launch Ariane 6, CNES is building a new pad called ELA4. The initial blueprint sought to locate the pad 500 metres north-east of where it is now, which would have impacted 51 remarkable plant species. The revised project will affect only three protected species. The agency has therefore proposed a land offset deal that will benefit biodiversity, handing over to the Conservatoire du Littoral coastal conservancy 617 hectares—including 165 hectares of dry savanna—around the Montagne des Pères and 719 hectares—including 48 hectares of dry savanna—in the Wayabo sector, both of them in ZNIEFF areas of special interest. It is also undertaking to combat invasive plant species. Lastly, it has started studies to lay the groundwork for action plans to protect orchids and rare plants, as well as the bearded tachuri and the butter frog (or lesser foam frog), an emblematic bird and amphibian of the CSG.

1. Natural area of ecological interest, fauna and flora.

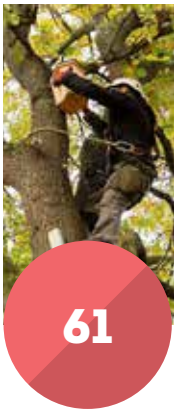
CST BIODIVERSITY **REGAINING GROUND**



The hoopoe, a protected species present at the CST.

The Toulouse Space Centre (CST) spans 56 hectares in the middle of an urban area. While the centre generates little pollution, over the years it has added buildings and gradually consumed space. CNES and its personnel are now reversing this trend.

Today, built-over surfaces and grass equitably share space at the agency's field centre. "Safeguarding biodiversity is a long-haul effort," explains Anne Serfass-Denis, an environmental specialist at the CST. With this aim in mind, an inventory conducted in 2017 by an engineer intern highlighted the rich variety of flora and fauna at the centre. Another survey in 2019 revealed the presence of protected species like orchids, as well as unwanted visitors like the African clawed frog, which is harmful for other aquatic species.



61

In 2018, 61 nest boxes

were put up around the CST. The boxes and their location are aimed at specific species like blue, long-tailed and marsh tit, wagtail and wren. Boxes have even been put up to try to attract the swallows that have deserted the Toulouse region.

MULTI-YEAR ACTION PLAN WELCOMED

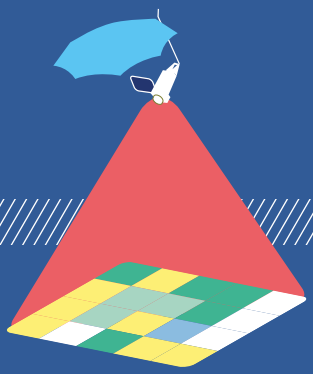
Under a partnership signed in 2018 with Paul Sabatier University, students doing their master's degree in biodiversity, ecology and evolution came up with a multi-year action plan. The result was 38 indicators measured and catalogued. Among the actions undertaken, the most visible has been the provision of nest boxes for tits, flycatchers, wagtails, hoopoes and pipistrelle bats. Going one step further, the CST then decided to adopt a more targeted approach to maintaining its green spaces. Pastures, for instance, are a paradise for biodiversity (see Roundup p. 10), so its 28 hectares of grass areas are mown less often and cutting heights tailored to life cycles, notably of insects. Some areas are even left to grow 'wild' and touched as little as possible. As the enthusiastic response to the agency's Biodiversity Day in February 2019 and its Environment Days showed, this pro-active policy is strongly supported by personnel, who feel empowered and regularly propose new initiatives. In all, 13 information panels have been put up around the site, some with stickers suggesting ideas to be tried at home. While the return on investment will only be seen with time, the return of species recolonizing environments previously kept in close check will be seen much sooner, to the delight of all concerned.

HYPERSPECTRAL

THE EARTH'S SURFACE REFLECTS LIGHT FROM THE SUN SELECTIVELY ACCORDING TO ITS WAVELENGTH. To analyse this property, called reflectance, hyperspectral imagery breaks light down into 200 spectral bands, whereas our eyes—and conventional imagery—only use three: red, green and blue. The wealth of information this yields is useful for measuring biochemical vegetation parameters such as chlorophyll, water content and dry matter, thus enabling the health of crops and forests to be monitored. It can also reveal the 3D structure of coastal environments by measuring the type of seafloor, water composition and sea surface height. Drawing on ten years of hyperspectral imaging R&D, CNES is working on ESA's CHIME[1] project and pursuing a preliminary project in collaboration with Singapore.

1. Copernicus Hyperspectral Imaging Mission for the Environment

FOREST



THREE CHALLENGES...

... TO UNDERSTAND FORESTS

Biomass is an essential climate variable (ECV) indicating the amount of carbon stored per hectare. Chiefly composed of water and carbon, forests are the main producers of biomass, in proportion to the rich diversity of life they harbour; and the higher a forest's biomass, the greater its biodiversity. From 2022, the European Biomass satellite will be setting out to meet three key challenges: to measure tropical forest biomass, to map forest structures in 3D and to detect and quantify changes underway in forests.

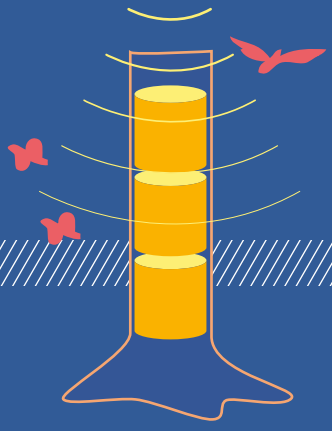
A UNIQUE RADAR...

... TO SEE THROUGH THE CANOPY

Observing the tropics, where cloud cover is frequent, calls for a special kind of technology called synthetic aperture radar (SAR) that can 'see' through clouds but is currently unable to pierce the canopy of dense forests. To reach the tree trunks where most of a forest's biomass is to be found, the Biomass satellite's radar will operate at a low frequency (435 MHz). This first-of-a-kind radar will penetrate 40 metres from the tree tops down to the floor below, shedding new light on how forests are changing in response to both climate-driven and anthropogenic factors.

TIMELINE

HOME TO 80% OF BIODIVERSITY ON EARTH, TROPICAL FORESTS ARE BEING RIDDLED BY DEFORESTATION. THE EUROPEAN BIOMASS SATELLITE IS SET TO INVESTIGATE THE ROLE THESE LUNGS OF THE PLANET PLAY IN THE CLIMATE, CARBON AND LIFE CYCLES.



SAR TOMOGRAPHY...

... TO MAP BIOMASS

Not content with being the first to estimate forest biomass, the Biomass satellite employs another pioneering technology called SAR tomography. Using advanced radar signal processing techniques, it will 'slice' forests to view their strata in 3D from the tree tops to the floor, the aim being to figure out exactly where they store biomass. The first 18 months of the satellite's mission will be devoted to building a global tomographic picture, after which it will generate a new global map of biomass every seven months—a first.

IN-SITU MEASUREMENTS...

... TO CALIBRATE THE INSTRUMENT

Fifteen French research laboratories—including CESBIO, the biosphere space research component of CNES—and a number of leading world research bodies are working on this ESA mission. Since 2009, field surveys in several countries are serving to calibrate the instrument and optimize data exploitation. To understand how varying seasonal biophysical parameters affect the radar signal, the TropiScat2 experiment is acquiring continuous radar measurements from a 65-metre-high tower at the Paracou site in French Guiana.

DIDIER HERVÉ

Director of the Haut Béarn Heritage Institute (IPHB)

"There's nothing better than the teeth of our livestock for maintaining the countryside..."

Like any species, humans can make the most of their environment in a way that benefits both. In the Haut-Béarn region of Southwest France—which is grazing country and 95% is common land—the local people know this well. **Born and bred in Haut-Béarn, agricultural engineer Didier Hervé set up the IPHB Institute with his friend Jean Lassalle in 1994:** "We don't need to protect our natural ecosystem; it's in great shape," he explains. "But we want to manage it intelligently so we can combine farming and tourism effectively. Founded on a charter drawn up by the people living in the valleys, IPHB acts as a facilitator for local development in such areas as mixed farming, forestry, water resources and the environment." Given that 65% of Haut-Béarn is given over to grazing, **IPHB in partnership with the CESBIO biosphere research centre is using Sentinel-2 satellite imagery to develop a diagnostic tool specially adapted to mountain pastures.** The idea is to keep closer track of changes in summer pasture and the results of transhumance, the seasonal movement of livestock between summer and winter pastures. Talking to this countryman, it's clear that **wild and domesticated nature interact in a virtuous and productive circle.** "The pastureland is an extension of the valley farms, which benefits local diversity. Sheep graze on the softer grass. Cows eat what the sheep leave. Horses go for the tougher plants. And goats eat almost anything, so they really clear out the landscape." A well-grazed summer pasture can be home to over 200 plant species rich in the essential trace elements animals need. "Without the teeth of ruminants, the mountain hazelnuts so sought after by wild boar would be suffocated by vegetation limited to 20 or so invasive species, and the young galliforme birds living on the tiny insects found in the grassland would disappear," concludes Didier Hervé. "From bears and Pyrenean desmans to golden eagles and bearded vultures, all these species are a positive indicator of our practices and use of the land—and they bring such joy for local people and visitors alike."

AURÉLIE DEHOUCK

President of i-Sea

"Natural environments are closely tied to national and European policy—and that means maps!"

Phenology is the study of periodic life-cycle changes in plants, and it's more a research discipline than a commercial service. Yet it's the core business of i-Sea, an SME with a team of four researchers, who've been developing their project at the Bordeaux oceanography laboratory's technology spin-off unit. "We're a pure product of the innovation process," says Aurélie Dehouck. **"We were initially nurtured by the ESA Business Incubation Centre (BIC) network and have benefited from CNES's unfailing support every step of the way."** Their products are designed to monitor water, biodiversity and the coastline. They meet the regulatory requirements of public- and private-sector players involved in the environment, from conducting the necessary preliminary environmental impact studies as part of any marine project to keeping regular track of the status of protected areas, such as sites in the Natura 2000 network. "Mapping is the first step," explains Dehouck. "To map vegetation and natural habitats—as marine parks ask us to do, for example—**we apply supervised classification algorithms to very-high-resolution satellite data, mainly from Pleiades and SPOT,** across three or four seasonal dates. On the protection side, biodiversity managers may request this type of observation more frequently than the regulatory six years." i-Sea's services are also enabling other customers to tackle problems. In Arcachon Bay, "the SIBA interborough union asked us to produce a map of spartina populations to help them organize efforts to control this plant, as one species of it, *spartina anglica*, or common cordgrass, is colonizing the coastline at a rapid rate," says Dehouck, who points out that **"space also has the benefit of 40 years of data, which enables us to retrace the changes that have brought certain environments or habitats to where they are today."**

VINCENT HULIN

Expertise Director at the French Natural History Museum

"Centralizing knowledge so it can be more readily accessed and used..."

Scientific data underpin much of what we know today, and it's vitally important for effectively reducing our environmental footprint. Vincent Hulin is a forestry engineer who grew up alongside a non-profit environmental education association. For him, joining the Natural History Museum was an obvious choice so he could be part of the "best possible interface between the worlds of research and business, between accumulated knowledge and the needs of society". **Responsible for maintaining the national natural heritage inventory, the museum produces and collects as much data as it can in order to create value from it and share it.** "In 2019, the IPBES report (see CNES in Action, p. 20) offers a dramatic assessment of the world's biodiversity and raises many questions about human development and our ability to maintain our societies and how they operate," says Vincent Hulin. **"We have to take action now, protect species and find ways to reduce the impacts of the pressure we're putting on biodiversity."** This is where expertise is so crucial. The museum provides data, methods and tools to the French government and other stakeholders for species at risk and ecosystem management. **If it doesn't have the data, as is currently the case for micro-organisms overseas, it organizes field expeditions.** Here, scientists and non-profits conduct on-site observations using standardized protocols to gather usable and comparable data. For now, the museum uses space solutions to identify the need for these expeditions and plan them. But the Expertise Director also has other expectations going forward. They include space-based tools that would enable "real-time tracking of land surfaces and indicators such as carbon exchange, helping us understand how they're changing over time, in line with scientific protocols".

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

ETHICS CORNER

JACQUES **ARNOULD**

ONLY ONE EARTH

During this time of lockdown, many of us have struggled with a lack of diversity in our relationships, activities and environment. But we have also learned how local actions can have a positive impact on a more global scale.

After graduating from the National Institute of Agronomy in Paris, René Dubos began his career peering down a microscope and studying test tubes. With Alexander Fleming, he revealed some of the secrets of bacterial life, developed the first antibiotics and helped advance 20th-century medicine.
With age, he also gained a higher perspective and began to be concerned about the fate of his fellow citizens in America's industrial cities, going on to become one of the leading advocates of the environmental movement. With Barbara Ward, he drafted the preparatory report ahead of the first United Nations Conference on the Human Environment in Stockholm in 1972. The text was entitled *Only one Earth*.

CHOOSING TO BE HUMAN

The current crisis and all the disruption it has caused would seem to prove Dubos right, not just as a scientist but also as the humanist he aspired to be. It was he who first came up with the "think globally, act locally" slogan that has since become the banner of sustainable development. While we endure the constraints of lockdown, the scarcity of our relationships, the restriction of our environment and the monotony of our days, each of us by this local action—or indeed inaction—is enabling the effects of this deadly virus to be better managed globally. Our (in)action is also having an unintentional but nonetheless genuinely positive effect on the quality of our environment, especially the atmosphere and water.
This proves the point that the vast array of technologies today giving us a global understanding of our planet, its riches and weaknesses—I'm thinking in particular of satellite Earth imaging—are useless if we do not believe that the coordinated actions of each and every one of us can have an impact on a worldwide scale.
Faced with a pandemic, we have chosen to be human—another of Dubos's favourite expressions—by reducing the scale and the richness of our existences. So why not do the same for the threats to our planet's biodiversity? It is a difficult balance to strike, because love for the Earth does not preclude but rather demands the respect in space and time of everyone who inhabits it, with their intelligence, their enthusiasm and their freedom, in this incredible diversity that will never cease to enthral us—because each living being on this planet really does have only one Earth.

THINGS TO DO

45 discovery trails in French Guiana

Calling all hikers and explorers. With the 2019 *Guide Guyane* to hand, you can follow in author Philippe Boré's footsteps as he takes you round 45 out-of-the-way trails. As you walk and work through the guide, you'll also discover some of the country's incredible wildlife.

Learn more: download the guide (in French) at randoguyane.com.

FEDERATION IN-HOUSE TROPHY

Winner is marine plastic tracker

CNES is the prime mover behind the FEDERATION[1] initiative. Launched at the Paris Air Show in June 2017, it's built around sharing of space-related knowledge and expertise. To provide stimulus for its teams, CNES launched a FEDERATION in-house trophy in 2018. The challenge is to envision the infrastructure that in 2030 could address the issue of the sustainable development of space. This year's trophy went to the '*Mappy du Plastique*' entry (observation of marine and coastal plastic waste) devised by Sylvain Michel. Tying together different types of data and expertise, including maps and models, the project would make it possible to monitor marine and coastal plastic pollution, estimate its concentration in the water, track how it moves and changes over time and compile maps. All we need now is a backer!

1. FEDERATION is supported by 3AF, Planète Sciences, OuiShare and Electrolab

PROFILE

THIERRY DE PRADA, WILDLIFE PHOTOGRAPHER

Since childhood, Thierry de Prada has lived in a world of images. Aged 11, he set up a mini-studio with enlarger in the garage of the family home. Today, he's just as passionate about photography. At CNES, he worked in the image quality department on SPOT, Helios and Pleiades imagery before applying for a position at the Guiana Space Centre (CSG). At the base's photo and video department, he's in charge of photographing and filming the Ariane, Soyuz and Vega launch campaigns as well as working with the French forestry commission to monitor species and spaces. As if that's not enough, he spends his free time capturing images of the local biodiversity. He knows exactly where to set up his infrared camera to film ocelots, agoutis, peccaries, pumas, monkeys and monitor lizards. And he knows how to turn a simple shot into a piece of art. While he doesn't cheat—no filters—he finds just the right technique for conveying the majesty of an ant on a blade of grass or the glance of a toucan. And while the living world is a source of inspiration, Thierry de Prada is also interested in urban exploration, or urbex, the discipline of giving industrial ruins the status of art. He's also visually documenting the dismantling of the Diamant rocket assembly bay.

VIEW THIERRY DE PRADA'S WORK AT:
THIERRYDEPRADA.MYPORTFOLIO.COM

BIODIVERSITY DOME

EVERYONE'S INVITED!

For the first time in its history, the next World Conservation Congress will be open to the public at the Parc Chanot convention and exhibition centre in Marseille.

The International Union for Conservation of Nature (IUCN) has devised Nature Generation Areas for the event. The idea is to turn visitors into movers ready to take action to promote biodiversity. CNES will be on hand in the Biodiversity Dome, working with five other public-sector agencies[1]. In this 150-sq.m. 'half planet', visitors of all ages will be able to appreciate how space is contributing to our understanding of biodiversity and efforts to protect and restore it. They'll also see how Earth observation can help research and how synergies between the six partners are benefiting our ecosystems. The space inside the dome is modular, and so is the programme. Screenings, informal debates, conferences, workshops, games and talks by one or more speakers are all part of the fun and varied line-up for novices, enthusiasts and the simply curious, young and old.

1. Conservatoire du Littoral (the French coastal conservancy), IFREMER (the French institute of marine research and exploration), INRAE (the national research institute for agriculture, food and environment), the IRD development research institute and the French Natural History Museum.

DIARY

7–15 JANUARY 2021
World Conservation Congress
Parc Chanot convention and exhibition centre, Marseille, France

COMPETITION

Kids for biodiversity

With *'Les enfants pour la biodiversité'* (Kids for biodiversity), French children's publishers Éditions Milan is this year running a competition midway between media literacy education and eco-citizenship for fifth-grade classes in mainland France and overseas. And CNES is getting involved. Experts from our Youth & Education department have been talking to pupils about the importance of preserving biodiversity and tackling climate change. They've been focusing especially on how satellites are tracking different species of animals tagged with Argos transmitters. In all, 400 classes have conducted a survey of their local ecosystem and designed a campaign poster to promote the need to protect biodiversity. Milan Presse has devoted a special issue of its *1jour 1actu* magazine to the competition entries, with 45,000 copies on sale in time for the prizegiving ceremony.

LA TELESCOP TRACKS NIGHT LIGHT POLLUTION

Artificial light in urban areas negatively impacts nocturnal biodiversity. To tackle this threat, the city of Nantes is rethinking its street lighting system with technical support from La TeleScop, a cooperative start-up specializing in remote sensing.

In 2018, three young engineers and researchers, Bastien Nguyen Duy-Bardakji, Claire Dupaquier and Julie Chaurand, combined their expertise in remote sensing, mapping and environmental science to form La TeleScop[1], which since end 2019 has been supported by the BIC-3M incubators and AxLR technology transfer booster. "Our aim was clearly to spark wider uptake of satellite imagery," says Bastien Nguyen Duy-Bardakji. For this, the cooperative start-up uses very-high-resolution satellite imagery to generate turnkey maps and operational services. The city of Nantes' project, looking to reconcile urban needs with the safeguarding of biodiversity, was therefore a perfect fit for the company's expertise.

RANKING SOURCES OF LIGHT POLLUTION

To meet the city's requirements, La TeleScop turned to very-high-resolution night-sky satellite imagery, generating brightness maps from archive satellite radiance data (Jilin-1, November 2018), orthophotos from IGN, the national survey, mapping and forestry agency, and the IRIS census basemap supplied by INSEE, the national statistics office. It was thus able to rank the impact of light pollution district by district, vital information to aid replanning of its street lighting.

This biodiversity and environment focus is now something La TeleScop intends to develop. In partnership with CNES, it has put together a new proposed proof of concept underlining the role of satellite imagery in assuring compliance with brush-clearing rules to prevent fires in the Montpellier area.

1. In 2019, La TeleScop was awarded the first space prize for new cooperative and employee-owned companies; in 2020, it won the Montpellier - Occitanie 1st prize for firms developing solutions for the social and inclusive economy.

In 2013,
the government issued a first order requiring 'unnecessary' street lighting to be switched off. Since then, 62% of urban areas in France have adopted measures to comply with this order.