

# CNES MAG

EN  
FR

SPACE • INNOVATION • SOCIETY

#74

November 2017

**CLIMATE**

ONE PLANET SUMMIT



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D'ÉTUDES SPATIALES



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**Mentioned in this issue:** p.8 and 21 the China National Space Administration (CNSA); p.11 and 30 Eumetsat, the European Meteorological Satellite Organization; p.11 and 21 the Indian Space Research Organization (ISRO); p.10 the CTOH centre for topographic studies of the oceans and hydrosphere at the LEGOS space geophysics and oceanography research laboratory; p.9,10,11 and 26 NASA; p.10 and 21 the Israel Space Agency (ISA); p.11 and 18 CLS (Collecte Localisation Satellites); p.26 the U.S. National Oceanic & Atmospheric Administration (NOAA); p.26 the University of Alberta in Canada; p.28-29 DLR, the German space agency, and the LSCE climate and environmental science laboratory.

**Cover:** The 400-km-wide Hurricane Matthew, the most destructive yet seen, was 200 km north-west of Miami Beach in Florida, U.S.A., when Sentinel-3A acquired this image on 7 October 2016 © Copernicus Sentinel data (2017) - ESA.



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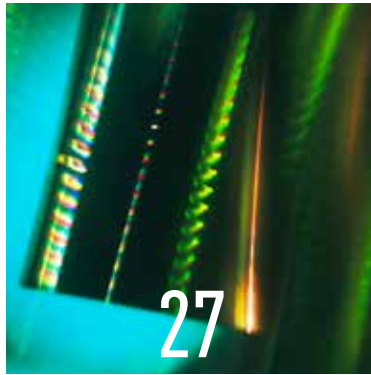
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**P. 27  
UNITED KINGDOM**

The MicroCarb mission with the UK is set to map carbon fluxes.

**P. 28-29  
GERMANY**

The MERLIN project aims to measure and record atmospheric methane fluxes.

**P. 24-25  
EUROPE**

Assuming their responsibility for issues relating to climate and its consequences, the European Union and ESA have established the Copernicus programme.

**P. 10 AND 21  
ISRAEL**

VEN $\mu$ S, a scientific demonstrator developed jointly by France and Israel, is studying how vegetation is responding to climate change.



**P. 09-10-11-26  
UNITED STATES**

The French and U.S. space agencies have been measuring variations in ocean topography since the early 1990s.

**P. 11 AND 21  
INDIA**

Climate is the central thread linking CNES and ISRO for 15 years now. An agreement to work together on the Trishna mission opens up new prospects for analysing water exchanges in ecosystems.

**P. 08 AND 21  
CHINA**

The CFOSAT satellite being developed with China will study ocean-atmosphere exchanges.



## CONTRIBUTORS



### JULIETTE LAMBIN

In charge of CNES's Earth, Environment and Climate programme, Juliette Lambin heads an expert team instrumental in informing CNES's science survey in this domain, formulating requirements for new missions, forging scientific and international partnerships and spinning off satellite data. Each member of the team contributed unique and essential information to this issue.



### PASCALE ULTRÉ-GUÉRAUD

It was with Pascale Ultré-Guéraud that we put together the first issue of the new theme-centred format of the magazine. In the run-up to COP21, climate could be the only choice as the theme for CNESMAG #65. Two years on, Pascale is now CNES's Deputy Director of Planning, International Relations and Quality, ideally placed to explain how the agency is leading the way coordinating space efforts to tackle global warming.



### FRANÇOIS FOYARD

Illustrator François Foyard sees the world through a lens all his own. He somehow always finds the hidden detail that lends a slightly zany or poetic perspective to often complex issues. While he's been working for the magazine from the outset, he still succeeds in surprising us every time. For this issue on climate, he's singled out the human factor.



### MARIE-CLAIRE FONTEBASSO

Marie-Claire Fontebasso is the photo researcher and editor who orchestrates the graphic content of each issue. Contrary to what you might think, selecting pictures and artwork to illustrate the crucial issue of climate change and get people's attention is no easy task. Avoiding the temptation of disaster photos, she's focused here on satellite imagery, which is both eye-catching and instructive.

## CNESMAG

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## EDITORIAL



2017 will go down in history as a year when hurricanes hit with unprecedented force. Harvey in Texas, Irma in Saint-Martin and Maria in the Antilles all set new records for rainfall, wind speed and destruction. At the same time, they emphasized the key role that satellites play in climate monitoring. Satellites detected the abnormally high ocean temperature—31°C instead of a more-usual 26°C—that set off the train of climatic events. Satellites provided early warning of the impending severe weather and allowed populations to be evacuated. And satellites, activated by the International Charter on Space and Major Disasters, guided emergency responders to disaster-hit areas. Because 26 of the 50 essential climate variables (ECVs) can only be observed from space, to highlight global warming, measure sea level rise of 3.2 millimetres a year or track greenhouse gas emissions. That's why CNES has made climate actions its priority, working with international partners to develop ever-more-effective tools and, above all, organizing true coordination between the world's space agencies. In this respect, the One Planet Summit initiated by President Emmanuel Macron will give us the chance to further raise awareness and create a truly global climate observatory in space. Because we only have one planet and it's worth protecting...

**JEAN-YVES LE GALL**  
CNES PRESIDENT

A satellite image of Hurricane Irma, showing a well-defined eye and a dense, swirling cloud structure over the Caribbean Sea. The surrounding ocean is dark, and some landmasses are visible on the left side of the frame.

Satellite weather picture of Hurricane Irma, which tore through the Caribbean islands of Saint-Martin and Saint-Barthélemy in the Lesser Antilles on 7 September. The 300 km/h winds were a taste of what could be to come as hurricanes become stronger but not necessarily more frequent.

## EVENTS

### Diplomacy serving climate

After the COP23 conference in Bonn in November, President Emmanuel Macron invited the signatories of the Paris Agreement to meet on 12 December at the One Planet Summit. The goal of this summit is to initiate new climate actions. On this occasion, CNES is organizing a heads of space agencies dinner with a view to promoting closer coordination and ultimately establishing a global climate observatory in space. COPUOS<sup>1</sup>, meanwhile, will be inviting climate into the debate at UNISPACE+50 in June 2018 in Vienna. The United Nations Agenda 2030 sets out 17 sustainable development goals, the 13<sup>th</sup> of which concerns climate action. CNES will be adding hydrology and the strengthening of the International Charter on Space and Major Disasters into the mix.

1. Committee on the Peaceful Uses of Outer Space (United Nations)



## ROUNDUP



### INITIATIVE EXTENDING THE DATA RECORD

**T**he European Space Agency (ESA) studies essential climate variables (ECVs) in fine detail through its Climate Change Initiative (CCI) programme, which employs a wide range of current and archive satellite data and is continually enhancing processing algorithms to improve the quality and precision of observations. All phases from data acquisition, calibration and validation through to long-term maintenance of algorithms and data storage and reprocessing are covered. Such initiatives sustain a consistent and continuous time-series of data. Fourteen ECVs were studied for a first phase decided at the ESA Ministerial Conference in 2008 and a further nine were added in 2016. Looking further ahead, these data will be made available worldwide through the Copernicus Climate Change Service (C3S).

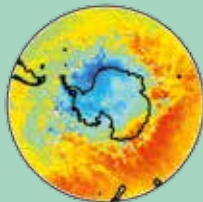
### ECVs

## DECIPHERING THE CLIMATE MACHINE

**W**e often tend to view climate change solely through the lens of global temperature or sea level, but the climate machine is in fact much more complex. It's monitored by measuring a large number of variables that characterize all elements of the Earth system, i.e., its atmosphere, oceans and land surfaces. GCOS<sup>1</sup> has identified 50 of these so-called essential climate variables (ECVs) for the purposes of long-term monitoring, measured in different places, at different dates and with different instruments. More than half of these 50 ECVs, 26 to be precise, can only be measured from space—like for example wind speed, ocean colour and snow cover—through close international coordination. Every five years, GCOS draws up a global climate status report.

1. Global Climate Observing System


2017



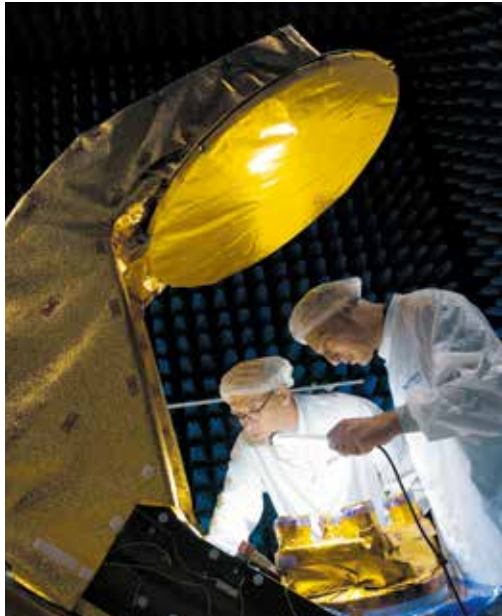
# 0.1°C

*Tiny changes such as a decrease in stratospheric ozone levels of 1% in 10 years or a rise in mean global temperature of 0.1°C per decade can impact all ECVs.*

## CFOSAT WIND AND WAVES

 Our planet's climate is governed by ocean-atmosphere interactions, so it's vital to gain a good understanding of the phenomena occurring at the ocean surface, which is where wind and waves combine to drive exchanges of heat, oxygen and carbon. The China National Space Administration (CNSA) and CNES have been working together since 2006 and are now set to launch CFOSAT<sup>1</sup> next year. This satellite will characterize these climate processes as never before, using CNES's SWIM radar instrument to observe waves and CNSA's SCAT instrument to measure winds. CFOSAT data will enable more reliable forecasting of sea state.

1. China-France Oceanography SATellite



## ATMOSPHERE GASES UNDER CLOSE WATCH

 No fewer than 32 of the world's space agencies sit on CEOS<sup>1</sup>, an international coordination body. All of them have developed space-based Earth-observation programmes. In June this year in Paris, its Atmospheric Composition Virtual Constellation (AC-VC) began work on a white paper aimed at defining an international roadmap for a global, sustainable and precise system for measuring greenhouse gases (carbon and methane). This roadmap is intended to set out the key characteristics of a global organization for observing carbon from space and to anticipate requirements generated by measuring gas composition and fluxes. It will also encompass other elements such as existing projects and validation procedures for achieving a consistent, optimal design and observation combinations for a global system.

1. Committee on Earth Observation Satellites

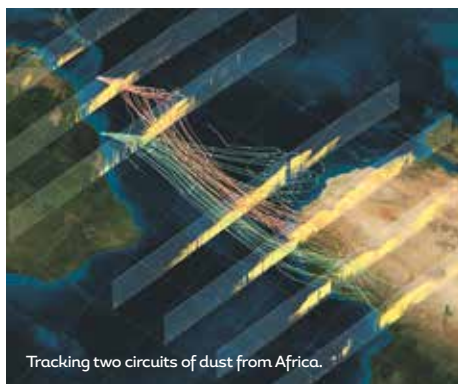




## ROUNDUP

### CALIPSO

## 10 YEARS IN THE CLOUDS



Tracking two circuits of dust from Africa.

The Calipso mission celebrated 10 years in operation in style last year on both sides of the Atlantic. Launched in 2006, the French-U.S. Calipso is part of the international A-Train of Earth-observing satellites whose data are to be found in the latest reports from the IPCC<sup>1</sup> and

GCOS<sup>2</sup>. These satellites have given us new insights into the role of clouds and aerosols in the climate machine, and their impact on Earth's radiation budget. Recently, they've also helped to study the yearly cycle of phytoplankton in the polar regions. In light of Calipso's exceptional results, CNES and NASA have decided to extend its mission to 2020 to continue the time-series of data and overlap with future lidar missions, particularly ESA's Aeolus and EarthCare. Since 2015, the two agencies have been working on MESCAL<sup>3</sup>, a new joint mission using a space-based lidar instrument to observe clouds and aerosols even more closely.

1. Intergovernmental Panel on Climate Change  
2. Global Climate Observing System  
3. Monitoring the Evolving State of Clouds, Aerosol, ocean, by Lidar

# 3.29 MM

Estimated yearly rise in mean sea level monitored continuously since 1993 by the TOPEX/Poseidon and Jason series of satellites. The SARAL, Envisat, ERS-1 and 2 missions have confirmed this figure.

# 40%

It's a tall order, but European nations are pursuing the goal of cutting greenhouse gas emissions by 40% between now and 2030. Looking further ahead, they recommend a total reduction of 50% by 2050 and full carbon neutrality by 2100.

# X 4

According to a recent study by scientists at the U.S. National Center for Atmospheric Research (NCAR) and the Chinese Science Academy (CSA), ocean warming was four times faster from 1992 to 2015 than from 1960 to 1991, and the deeper layers of the oceans are also getting warmer.

## WORKING TOGETHER TO MONITOR CLIMATE

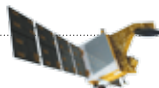
2014



### SENTINELS

- Earth-observing satellites of the Copernicus programme
- 10 dedicated satellites launched between 2014 and 2029
- ESA-Eumetsat partnership

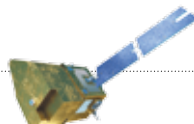
2018



### CFOSAT

- Satellite dedicated to observing wind and waves
- Launch planned in 2018
- France-China partnership (with CNSA)

2020



### MICROCARB

- Satellite designed to map carbon sources and sinks
- Launch planned in 2020
- France-United Kingdom partnership (with UKSA)

2021



### SWOT

- Satellite to map the topography of oceans and surface waters (lakes and rivers) and measure river discharges
- Launch planned in 2021
- France-United States-United Kingdom partnership

2021



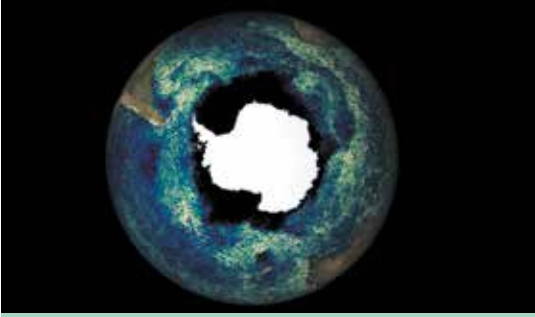
### MERLIN

- Satellite to precisely measure atmospheric methane concentrations
- Launch planned in 2021
- France-Germany partnership (with DLR)



## ROUNDUP

Altimetry data showing the Antarctic Circumpolar Current. It transports 150 million cubic metres of water per second, 150 times more than all of the world's rivers put together.



### AVISO+ A DATA GOLD MINE

**A**VISO is the digital altimetry repository of record. The portal morphed in 1998 out of CNES's SALP<sup>1</sup> altimetry and precise positioning department and subsequently joined forces with the CTOH centre for topographic studies of the oceans and hydrosphere at the LEGOS space geophysics and oceanography research laboratory. NASA followed suit with its own PO-DAAC<sup>2</sup> data archive. The AVISO portal was upgraded to AVISO+ in 2014, when it was extended to cover oceans, coasts, hydrology and ice. Its catalogue is a treasure trove for climate research, offering products from CNES, the CNRS national scientific research centre and CTOH. AVISO+ data come from Jason-3, Sentinel-3, SARAL and CryoSat, and in the future SWOT, CFOSAT and Jason-CS/Sentinel-6. AVISO+ is an open and intuitive portal providing archive data, publications, news, a guide and tools to a diverse range of scientific, institutional and private users.

1. Service d'Altimétrie et de Localisation Précise  
2. Physical Oceanography – Distributed Active Archive Centers

# 5,000

*AVISO+ is today the portal of choice for the international oceanography and altimetry communities, with more than 5,000 user groups subscribed.*

### VEN $\mu$ S FOCUS ON VEGETATION

**○**n the night of 1-2 August, Paris and Tel Aviv watched as the VEN $\mu$ S<sup>1</sup> microsatellite soared skywards. Tipping the scales at just 250 kilograms, VEN $\mu$ S is the first-ever research satellite dedicated to monitoring vegetation around the globe, and the first in a series that will include MERLIN (see Timeline p. 28-29) and MicroCarb. VEN $\mu$ S is observing 110 sites of interest on several continents every two days to gauge carbon fluxes and track how vegetation and water resources—key climate change indicators—are being managed. The first images acquired by CNES between 17 and 19 August offered exceptional resolution that will give scientists fresh insights into the impact of droughts on crops, the retreat or growth of forests, ice melt in the polar circle and drying up of rivers. VEN $\mu$ S also provided CNES and the Israel Space Agency (ISA) the first opportunity to work together on a joint project.

1. Vegetation and Environment monitoring on a New Micro-Satellite.



Irrigated crops seen by the VEN $\mu$ S satellite on 17 August 2017 near Phoenix, Arizona (U.S.A).



## TRISHNA FROM FOREST TO CITY

**W**ith TOPEX/Poseidon, CNES and NASA transformed the field of altimetry. But CNES isn't resting on its laurels and continues to innovate. And because indicators on evapotranspiration are still missing from the puzzle, the agency has now signed an agreement with the Indian Space Research Organization (ISRO) to collaborate on the Trishna mission, which aims to quantify ecosystem water transfers and thus provide new insights to inform management of water resources and green areas. Trishna's high spatial resolution and revisit rate will enable close monitoring of spatial and temporal changes. It will also gauge the importance of urban heat islands, the man-made microclimates that are another key driver of global warming.

## HYDRONES FLOOD RESPONSE

**H**ow do you track a flood and gauge the risks to populations or plan emergency response when all conventional methods have been exhausted? The answer is with an unmanned aerial vehicle (UAV) or drone. HyDrones, a service from CLS<sup>1</sup>, offers miniaturized altimetry technology with a fully autonomous instrument weighing just 500 grams, capable of flying on any kind of aerial platform that can be piloted from the ground. The innovative instruments developed by CNES's subsidiary can collect data on water height, bathymetry and flood extent with centimetre precision, combined with a tailored processing system for delivery to water planning teams in real time.

1. Collecte Localisation Satellites.

## IASI THE WEATHER FORECASTERS' CHAMPION



**I**t's initial vocation was to measure air temperature and humidity to improve weather forecasts. Today, the IASI interferometer is considered the best infrared sounding instrument in its class. Designed jointly by CNES and Eumetsat<sup>1</sup>, it has made a major contribution to monitoring climate and studying the composition of our atmosphere, through its ability to detect and measure more than 25 key components. The first two instruments are flying on the European MetOp satellites, in orbit since 2006 and 2012, and a third is set to launch in 2018. After more than 10 years in operation, this mission has yielded an impressive science return and many benefits for society. So CNES and Eumetsat are now developing an enhanced IASI New Generation instrument (IASI-NG) to assure data continuity and deliver even better performance. It will be a core element of the three satellites in the future MetOp-SG-A series scheduled to launch in 2021, 2028 and 2035.

1. European organisation for the exploitation of METeorological SATellites (30 European member states)



## #COMMUNITY

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




**@ESA\_EO**  
Earth observation @ESA, keeping an eye on #Earth from #space. News: <http://www.esa.int/eo> - Data: <http://earth.esa.int/> Often tweeting about #FutureEO

**.@CNES President @jy\_legall: Cooperation is essential to "Invent the Future of Space" together: [twitter.com/CNES/status/881439578548084736](https://twitter.com/CNES/status/881439578548084736) ... - @ESA @CopernicusEU**

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← ↔ \* ...




**@CNES**  
News from CNES

**#Proxima @Thom\_astro: "Earth 🌍 is a spacecraft with limited resources and a crew: all of you." [bit.ly/2qb9D46](https://bit.ly/2qb9D46)**

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← ↔ \* ...




**@JY\_LEGALL**  
President of @CNES, Chair of @ESA Council and President of @IAFastro

**Since December 2011, the #Pléiades satellites have acquired more than 2 million images: space serving the planet #Climat #COP23 🌍🌍**


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← ↔ \* ...



**@THOM\_ASTRO**  
ESA Euro-French spacecraft pilot, back from 6-month ISS mission

**So much snow in this picture it looks like cream! Let's tackle climate change to protect the balances of nature**




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← ↔ \* ...



**@\_JCBALES**  
#Entrepreneur | #Positive #digital #acceleration | #digitaltransformation #TransfoNum | @ToulouseBS | #JamaisSansElles | #marathon

**#BrandcastFR17 On stage, T. #Pesquet Pesquet We see how fragile the planet is from space > no plan B to save 🌍**

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← ↔ \* ...



Q & A

# NICOLAS HULOT

MINISTER OF STATE, MINISTER FOR THE ECOLOGICAL AND INCLUSIVE TRANSITION, and a tireless environmental campaigner, talks about the global challenge of tackling climate change and the key role space has to play.



## Q & A

### WHAT DO YOU SEE AS THE MAIN CLIMATE-CHANGE CHALLENGES IN THE DECADES AHEAD?

**Nicolas Hulot:** We must obviously start by applying the terms of the Paris Agreement. Since the COP21 conference, France has acted through this agreement as the guardian of our universal responsibility to tackle climate change. We are cultivating this heritage, for example with the Climate Plan I presented on 6 July at the request of President Macron. This plan is founded on ambition and solidarity, which are closely tied together, and aims to mobilize all of government and more broadly all French citizens to speed the energy and climate transition. That ambition is reflected in the new targets we're setting ourselves for the years and decades ahead. For example, the fourfold reduction in our greenhouse gas emissions planned until now plainly isn't ambitious enough to meet the targets of the Paris Agreement. We now need to be aiming for complete carbon neutrality by 2050. That's going to take a strong commitment, but I believe it's perfectly reachable if we get to work now.

### WHAT ROLE CAN FRANCE PLAY GIVEN THE GLOBAL SCALE OF THESE CHALLENGES?

**N. H.:** Moving on from COP21, France must continue to raise awareness and lead by example on the world stage. Our efforts are recognized and oblige us to



**NICOLAS HULOT**  
MINISTER FOR THE ECOLOGICAL  
AND INCLUSIVE TRANSITION

**“TO MEET THE TARGETS OF THE PARIS AGREEMENT, WE NEED TO BE AIMING FOR COMPLETE CARBON NEUTRALITY BY 2050.”**

tirelessly pursue the task of affirming the importance of the Paris Agreement. France is looking not only to spur the international scientific community but also all initiatives from the world of business and NGOs to tackle climate change and devise coping strategies. That's the sense of President Macron's call to "make our planet great again". France is also working to further climate diplomacy with its European and international partners. Our Ministry for Europe and Foreign Affairs attaches special importance to assisting developing nations. We're duty bound to show solidarity

towards those bearing the brunt of climate change, and for that reason France is going to be devoting €5 billion a year in 2020 to climate, with €1 billion for these victims of climate disasters.

### IN THIS CONTEXT, HOW DO YOU VIEW THE PARIS CLIMATE SUMMIT?

**N. H.:** The summit will be opening two years to the day after the adoption of the Paris Agreement, which gives this global gathering a symbolic dimension, but above all we must seek to engage new climate actions, particularly on the clearly crucial issue of funding. We will be looking to identify projects that can be funded and are achieving meaningful results. To that end, besides the many heads of state who will be there to reaffirm their commitment to the process, we will be bringing project proponents and financial stakeholders together to forge ties and thus channel funding without delay into green, climate-friendly projects. We will also be reaffirming our solidarity with the populations most at risk on the front line of climate change.

### HOW DO YOU EXPECT THE SPACE SECTOR TO AID CLIMATE RESEARCH?

**N. H.:** Without satellites, we wouldn't have been able to appreciate the climate threat. The picture they give us from the vantage point of space has changed everything, both for weather forecasting and for



## Q & A

**“I’M COUNTING ON CNES TO SHOW OUR RESOLUTE SUPPORT FOR EARTH OBSERVATION AT ALL EUROPEAN AND INTERNATIONAL BODIES, AND FOR DEVELOPING THESE SPACE ASSETS TO KEEP TRACK OF THE PARIS AGREEMENT.”**

tracking and studying climate change. Combined with in-situ data, space remote sensing allows us to study the Earth system as a whole. The space sector is helping to highlight the major upheavals our planet is undergoing, like rising sea level measured by the Jason satellites, ocean temperature and ice melt by CryoSat, deforestation by Sentinel-2 and the Pleiades satellites, and global warming through meteorological programmes. I believe the European Copernicus programme’s Climate Change service merits special attention for giving citizens access to objective, validated data on climate change, including on such vital topics as sea level. I also expect the space sector to assist in monitoring implementation of the Paris Agreement, by measuring anthropogenic greenhouse gas emissions and observing reforestation, for which the signatory nations have made commitments. In that regard, I hope the future Copernicus constellation of satellites with Sentinel-7 be tracking anthropogenic carbon and providing effective monitoring of all carbon emissions. We must also continue sharing data with our international partners. The poorest nations

need these data to understand the mechanisms at work and to ready for the impacts of a changing climate, for example through cyclone alerts. It hardly seems believable that in the 21<sup>st</sup> century there are still places with no means of warning populations properly in the event of an impending climate disaster. So we need to step up our efforts in that direction.

### **WHAT ROLE MUST A GOVERNMENT AGENCY LIKE CNES FULFIL?**

**N. H.:** With the MicroCarb satellite backed by my ministry, CNES is directly involved in advancing our understanding of natural carbon sources and sinks. More broadly, I’m counting on CNES to show our resolute support for Earth observation at all European and international bodies, and for developing these space assets to keep track of the Paris Agreement. I also see CNES as a key enabler of innovation supporting research in the field of space. CNES provides its expertise to translate stakeholders’ wishes into actual remote-sensing measurements, and then to make the transition to applications and services that are the end purpose of space programmes.

### **FROM A MORE PERSONAL STANDPOINT, HAS SPACE HELPED YOU TO FORGE CONVICTIONS ABOUT THE NEED TO PROTECT OUR PLANET?**

**N. H.:** The space adventure has obviously influenced my beliefs in that respect, as have my journeys around the globe.

### *Profile*

#### **1990**

Creates the Fondation Ushuaïa, later renamed the Fondation pour la Nature et l’Homme (FNH).

#### **2007**

Asks presidential election candidates to sign his ‘Ecology Pact’.

#### **2012**

Appointed special envoy for the protection of the planet by President François Hollande and tours the globe to lay the groundwork for COP21.

#### **2017**

Minister of State, Minister for the Ecological and Inclusive Transition in the government formed by President Emmanuel Macron.



## IN PICTURES



## BALLOON RELEASE

*CNES has a long record of success with superpressure balloons, which provide an excellent platform for studying climate phenomena through their ability to collect data from regions that cannot otherwise be reached. The international Strateole 2 campaign, involving French, U.S. and Italian research laboratories, is set to fly a flotilla of these large balloons that will stay aloft for three months at an altitude of 20 kilometres along the equator. The goal is to investigate the stratosphere's dynamics and stratosphere-troposphere exchange processes. Three campaigns in 2018, 2020 and 2023 will fly 5, then 20 and then 20 more balloons from the Seychelles with a view to improving real-time weather forecasting.*





IN PICTURES

VIDEO



All aboard at  
Francazal



## AERIAL SURVEYING

*The three 'sniffer' aircraft in the SAFIRE<sup>1</sup> fleet fly missions in the lower, middle and upper troposphere for investigations in the fields of cloud microphysics, atmospheric chemistry and radiation. Carrying a broad range of instruments and external sensors, they offer a unique platform for studying the climate system. SAFIRE is a joint services unit overseen by CNES, national weather service Meteo-France and CNRS-INSU, formed in 2005. It is working to develop synergies between member nations to give research scientists a wider choice of tools. Acquiring the capability to operate unmanned aerial systems (UAS) carrying payloads of more than five kilograms is another of its strategic goals.*

*1. Service des Avions Français Instrumentés pour la Recherche en Environnement*



## IN FIGURES

# El Niño

Most of the time, trade winds push surface waters across the Pacific towards Australia and the Philippines, piling up warm water in the Western Pacific. But when these trade winds slacken or disappear altogether, the pool of warm water flows eastwards—the sign that an El Niño episode is underway. This anomaly of the ocean/atmosphere system was responsible for 22,000 deaths in 1997-1998. That El Niño was also the first such event closely monitored by satellite, with TOPEX/Poseidon detecting the first tell-tale signs very early on, revealing a bulge of warm water working its way across the ocean, 20 to 30 centimetres higher than the mean level. Since that episode, El Niño has returned regularly every three to seven years. Luckily, scientists have been able to develop reliable ocean-atmosphere models, thanks largely to satellite altimetry data, and measures to protect populations are put in place six to nine months ahead. In March 2016, when El Niño hit Peru, the country had been on alert since the previous summer. El Niño isn't the only large-scale ocean anomaly: its cousin La Niña brings a reverse pattern with abnormally cold Pacific surface waters, but its impacts are smaller. The Jason, SARAL/AltiKa and Sentinel-3 altimetry missions are keeping a constant eye on these climatic events.

# 40

**PROJECTS CONDUCTED IN 2016 BY THE SAFIRE FLEET OF AIRCRAFT (see In Pictures p. 17), which devoted 20% of its flight hours to space. Data acquired by SAFIRE yield some 22 scientific papers every year.**

# 2%

**INTERNATIONAL SHIPPING TRAFFIC GENERATES TWO PERCENT OF TOTAL GREENHOUSE GAS EMISSIONS, AND EVERY LITTLE BIT COUNTS.** CLS uses satellite altimetry data to detect ocean eddies, calculate current velocities and determine the best route for ships, enabling them to operate more efficiently and reduce their emissions.

# HYDROWEB

**0.65%... the percentage of surface waters seems like a drop in the total on Earth, but it nevertheless has an important impact on life on the planet, domestic usage and climate variability.** The Hydroweb project being pursued by the LEGOS space geophysics and oceanography research laboratory through the THEIA data hub is building up a database of water levels in 80 major lakes at 300 measuring points. Combined with other measurements and hydrology models, these satellite altimetry data will help to gain new insights into the water cycle and to quantify water resources.

# Cities

**Urban spread is a factor fuelling global warming.** CNES's environmental-monitoring subsidiary CLS recently acquired French firm SIRS, thus adding new optical mapping products to its portfolio designed to support cities' climate actions.





CNES IN ACTION

# GEARING UP FOR CLIMATE

**SATELLITE DATA DELIVER CRUCIAL INSIGHTS INTO CLIMATE. WITH 40 YEARS OF SUCCESSFUL EARTH-OBSERVING MISSIONS TO ITS CREDIT, CNES IS A LEADER IN THIS FIELD. BUT THE FRENCH SPACE AGENCY ALSO KNOWS THAT CLIMATE ACTIONS ARE A GLOBAL CHALLENGE THAT NO ONE NATION CAN FACE ALONE, WHICH IS WHY IT'S FEDERATING EFFORTS BY ALL CONCERNED IN PURSUIT OF COMMON GOALS.**

Deforestation in the state of Sarawak, eastern Malaysia, on the island of Borneo, home of the world's most ancient forest. Global deforestation accounts for 20% of all greenhouse gas emissions.



## CNES IN ACTION



After the failure of the Kyoto Protocol in 1997, it has taken a long time—too long, no doubt—to reach a true consensus on tackling climate change. The Paris Agreement, a historic and universal milestone that has set the target of keeping the rise in mean global temperature well below 2°C, has been ratified by no fewer than 195 nations. On 4 August, the United States announced its withdrawal from the agreement, casting a shadow over the international community, and only the future will tell whether this was just a passing cloud or a full-blown storm.

### A UNIQUE GLOBAL APPROACH

The COP 21 conference marked a turning point for climate actions and space, underlining the technological and scientific advances of recent decades and the global approach to observing climate change. Combined with in-situ data, satellite observations are vitally important in this respect. “To study, understand and analyse climate phenomena, we need a tool to observe them continuously, uniformly and in real time. And only satellites can do that,” says Juliette Lambin, in charge of Earth-observation programmes at CNES.

For 40 years, CNES’s expertise has enabled multiple Earth-observation missions and





## CNES IN ACTION

### COP21

## FEDERATING FOR ACTION

**In December 2015, the COP21 conference spotlighted France's dynamic space policy, with CNES organizing exhibitions, scientific gatherings and public events.** At the same time, the agency announced the development of MERLIN and MicroCarb, two satellites designed to monitor greenhouse gas emissions. As a leader in climate monitoring, CNES has worked hard to federate nations around space projects. In particular, it has sought to give emerging



nations the opportunity to rub shoulders with major space powers. "Certain nations just

*don't have the resources to acquire satellites, but they're exposed to the same climate disasters as the big powers, if not even more so. COP21 gave them the chance to meet experts and glimpse solutions,"* says Pascale Ultré-Guérard, CNES's Deputy Director of Planning, International Relations and Quality (DPI). Drawing on its extensive expertise, the agency is acting as an ambassador for space solutions supporting climate research and a mediator in pooling efforts.

developed domains of excellence supporting climate research. Meteorology is one such domain, and here the IASI sounding interferometer has been instrumental in improving the accuracy of weather forecasts (see Roundup p.11). IASI was the first sounder to acquire extremely accurate vertical profiles of the atmosphere, building up long time-series of data that today are crucial for scientists studying global warming. While observing hurricanes, storms and floods can't stop their impact, improved forecasting is nevertheless informing public policies to better prepare for severe weather events and protect populations. TOPEX/Poseidon and then the Jason series have ushered in the era of operational oceanography, revealing ocean temperature anomalies fuelled by extreme climatic episodes like El Niño and La Niña (see In Figures p.18). To sustain the great results obtained, the satellite altimetry field is now being taken forward at European level through the Copernicus programme and its Sentinel-3 and



### Creation of the

**Intergovernmental Panel on Climate Change (IPCC). The IPCC's mission is to assess the science related to climate change, chart the impacts of climate perturbations and propose possible solutions to inform policy decisions.**

Sentinel-6 satellites and CMEMS<sup>1</sup> services. Satellite altimetry has also helped to prove the existence of certain climate perturbations. For example, the IPCC<sup>2</sup> has pointed to the rise in mean sea level recorded by TOPEX/Poseidon and the Jason satellites as evidence that climate change is happening.

### A LASTING INTERNATIONAL PARTNERSHIP

Climate change knows no borders. Although uncertainties remain in some regions where data coverage is sparse, the warming trend is global. So no one nation or even Europe can act alone. At the Mexico Summit in September 2015, the world's heads of space agencies acknowledged the importance of international cooperation and the contribution of satellites in observing climate change. International partnerships are another area where CNES excels and the spirit of cooperation is a common thread running through all of its programmes. Climate is a federating issue that is constantly nurturing new partnerships. Megha-

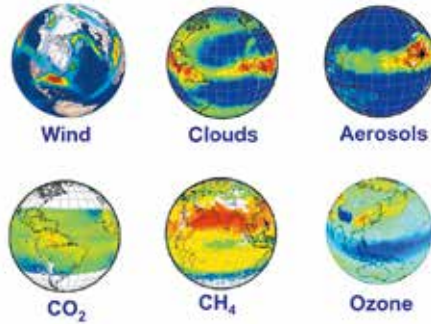
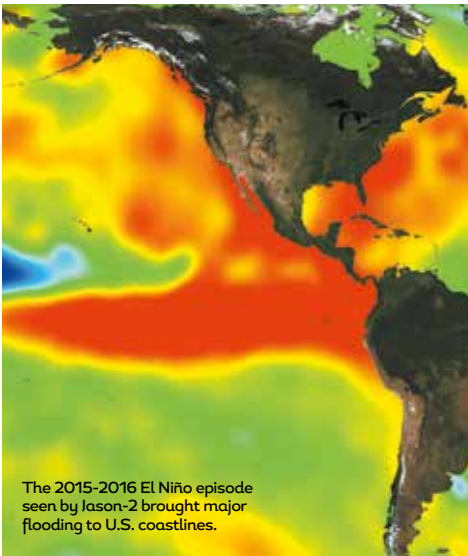


## CNES IN ACTION

Tropiques, a project developed with the Indian Space Research Organization (ISRO) that is helping India to characterize monsoon phenomena, is a good example. The CFOSAT programme with China is set to probe the impact of winds and waves on climate. And the French-Israeli VEN $\mu$ S scientific demonstrator is monitoring how vegetation is responding to a changing climate. COP21 and COP22 provided a forum for discussions with Morocco, India and Japan to establish new partnerships on data processing and innovative projects. In 2015 alone, CNES signed 12 international agreements.

While the French space agency is always ready to share its expertise, it is also playing a driving role in key international and European organizations. It was one of the founders of the European Space Agency (ESA), to which it remains the leading contributor of funding, and it has a seat on numerous bodies like CEOS (see Roundup p.08) and is an active player in major European programmes like Copernicus (see p.24) and international initiatives like GLOBE (see p.26).

1. Copernicus Marine Environment Monitoring Service
2. Intergovernmental Panel on Climate Change



IASI is studying 30 essential climate variables (ECVs) and atmospheric components. This is a sample of the six most representative of them.

## DATA CENTRES SERVING A GLOBAL APPROACH

*With each space mission, the record of satellite data continues to grow. CNES is creating specific tools and devising team approaches to compare and contrast these data and mine their full value.*

**T**he satellites operated by CNES, ESA and the European Union's Copernicus programme are generating huge volumes of data at an increasingly fast rate. Such data can now be compared with in-situ measurements from balloons, weather stations and oceanography vessels. To this end, CNES has set up platforms to enable easier access to this vast catalogue of information.

### DATA AND SERVICE CENTRES

Historically, production, validation, archiving, distribution and spin-off of Earth-observation data have always been organized on a per-mission or per-campaign basis. Once recorded, centralized, merged and inter-calibrated, these data are extremely valuable, many of them enabling long time-series to be compiled. This kind of holistic approach is vital

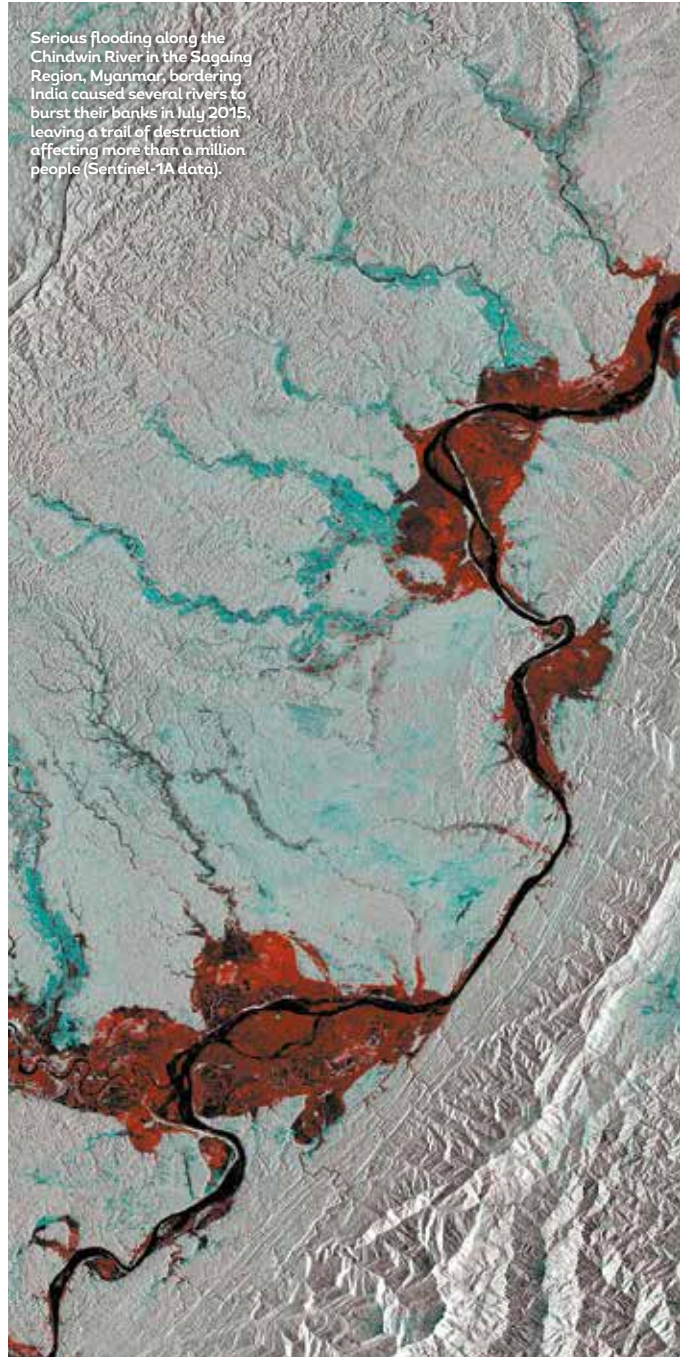


## CNES IN ACTION

to understanding climate phenomena, which is why CNES has partnered with institutional research organizations to establish four thematic data and service centres. These national centres are integral to efforts in Europe to pool Earth-observation data. They receive data from networks all over the world and are actively involved in international working groups in this area.

### NATIONAL RESEARCH INFRASTRUCTURE

To understand how the Earth system works, we need to view it as a unique system of interacting parts. For example, the carbon cycle takes in the atmosphere and the top layers of land and oceans. We might need information about the biosphere or Earth's interior when working at very long time-scales. The same applies to the water cycle. So we need to be able to compare data from the four thematic data centres. This is the task assigned to the Earth System research infrastructure project backed by the Ministry of Higher Education, Research and Innovation, being carried forward by CNES and the national scientific research centre CNRS with a long list of partners.



### Thematic data

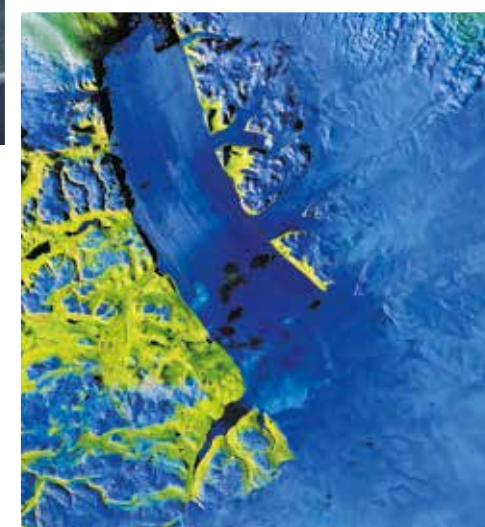
centres: AERIS (atmosphere),  
ODATIS (oceanography),  
THEIA (land surfaces) and  
FORM@TERRE (solid Earth).



## CNES IN ACTION



The rate of ice melt on Petermann Glacier has accelerated in recent years. Scientists believe that if Petermann collapses completely, sea level would rise by about 30 centimetres (Sentinel-2A, August 2017).



# COPERNICUS A HOME-GROWN FLEET AND A COMMON GOAL

*Assuming their responsibility for issues relating to climate and its consequences, the European Union and ESA have established the Copernicus programme. Today, the programme has far exceeded its initial goals.*



initiated in 2012, Copernicus is the European Union's flagship Earth-observation programme. It was created with the aim of streamlining satellite and in-situ data

and enabling cross-comparisons to support a forward-looking vision, notably with respect to climate change<sup>1</sup>. Today, Copernicus is harvesting a wealth of data from satellites like the SPOT, Jason and Pleiades series. But to round out its 'stock in trade', it is progressively rolling out its own fleet of Sentinel



**Since** its inception, the Charter has been activated 556 times and 75% of activations are triggered by hydro-meteorological events.

satellites, of which six have entered service since 2014. Each Sentinel carries instruments tailored to its specific mission: surveying Earth's land surfaces, ocean colour and atmospheric chemistry, or acquiring altimetry data. Ultimately, the fleet will replace older Earth-observing missions when the time comes.

### OPEN DATA ACCESS

The Copernicus infrastructure does more than just receive and store these data. More importantly, the programme seeks to extract





## CNES IN ACTION

### VIDEO



Satellites saving lives

information from them for its six thematic service areas: Land, Marine, Atmosphere, Climate Change, Emergency and Security. Besides serving experts, government users and policymakers, the original feature of the Copernicus catalogue is that it's also open to citizens and businesses free of charge. Visitors to the home page of the website (<http://www.copernicus.eu>) are guided by six icons, one for each service. New applications and innovative downstream services developed by start-ups are also set to spawn a 'Copernicus economy'. Examples of such initiatives already abound, like Weather4D, a smartphone application designed by Toulouse-based start-up ATP4Nav that provides weather information for the general public and navigation and weather-routing services for professionals, and WaveCERT, an application developed by Scottish SME Stevenson Astrosat to monitor and measure potential wave and tidal energy anywhere in the world. 2020 will mark the end of the programme's first budgetary period and funding for Copernicus will now have to be defended in the European Union's plans for 2021-2027. The next ESA Ministerial Conference at the end of 2019 will be proposing new satellites to complement the Sentinel series and meet users' evolving needs. These two milestones are set to be defining moments for the European programme's future.

1. Besides climate, Copernicus also covers security and environment aspects.

### DISASTER RESPONSE



## SOLUTIONS FROM SPACE

**Harvey, Irma, Maria... the International Charter on Space and Major Disasters was activated several times in September. The idea of using Earth-observation satellites for decision support and disaster response was first floated in 1999, and CNES, ESA and the Canadian Space Agency (CSA) founded the charter one year later. Since then, 13 other space agencies have signed up. Whatever the nature of the disaster, the charter is activated by its authorized users.**

**The 16 member agencies then deliver imagery of the disaster zone free of charge and as quickly as possible to civil protection teams and government agencies in the affected nation. For the recent severe weather events in September, more than 20 satellites were in action, among them the Pleiades-1A and Pleiades-1B 'twins' activated by CNES.**



CNES IN ACTION

# GLOBE

## PREPARING FUTURE GENERATIONS

*Curbing climate change is a challenge our children will also have to face. CNES is naturally drawn towards outreach and education, and so it's working to engage youngsters.*

**I**n 2004, climate was already becoming a pressing issue. Sitting on the launch pad, the Calipso atmospheric research mission was a federating force, and CNES created Calisph'Air, the mission's outreach offshoot, in its wake. The programme also ties in perfectly with the aims of the GLOBE educational initiative conceived 10 years earlier by NASA and NOAA<sup>1</sup>. GLOBE is a project through which pupils, teachers and scientists work together to observe and collect environmental data. Every year, in spring and in autumn, some 1,000 pupils and their teachers conduct local measuring campaigns and feed their results into the GLOBE database. These measurements are then compared with satellite data and used in school projects. The GLOBE programme has today built up a 22-year record of global data, constituting a real treasure trove for classes.

### IN THE TRACKS OF POLAR BEARS

Besides GLOBE, CNES is also engaged in other programmes designed to get young generations interested in climate science. Argonautica and its ArgoNimaux wildlife tracking project are examples. "Youngsters care a lot about what happens to wildlife. The changes animals are having to cope with in their habitats and their feeding strategies, and the disappearance of certain species all focus their attention on climate issues," says Danielle Destaecke, in charge of youth education at CNES. Animals are fitted with Argos transmitters and then

**130,000**

**Since 2004,** the Calisph'Air programme has reached out to some 50 schools every year. Between 130,000 and 150,000 junior high school pupils are estimated to have taken part since its inception.

tracked in real time by satellite, and their movements correlated with other data from satellites like the Jason series. The favourite of youngsters everywhere is the polar bear. ArgoNimaux classes are invited to 'adopt' a bear and follow its movements, conducting their investigations like scientists to ascertain how it's coping with a changing environment. The project is being partnered by the University of Alberta in Canada, which fits the bears with transmitters and studies them. CNES is also starting a hydrology project called ArgoHydro associated with the mission of the future SWOT satellite.

1. National Oceanic and Atmospheric Administration





MATERIALS

# CARBON LOOKOUT

**NEVER HAS THE NEED FOR RELIABLE, GLOBAL DATA ON CARBON FLUXES** been stronger than it is today. The MicroCarb satellite, scheduled to launch in 2020, plans to meet this need by mapping global fluxes of carbon, the principal greenhouse gas. To be precise, it will quantify and locate the main sinks of carbon around the globe—in oceans and forests—as well as sources of emissions, and track them over time. Flying on a spacecraft bus from CNES's Myriade series, the compact instrument will employ a novel sensing technique based on analysing the solar spectrum backscattered by Earth's surface and emitted through the atmosphere. MicroCarb will have a spectrometer capable of measuring levels of carbon very precisely and an imager to detect clouds, which can otherwise skew measurements.



## TIMELINE



### STATUS CHECK **METHANE,** SECOND IN LINE

*What is it? Less abundant than carbon in the atmosphere, it nevertheless packs 28 times more calorific power. Where does it come from? It's produced naturally by wetlands (swamps) and termites. A lot is also generated by human activities, chiefly intensive farming, cattle rearing and open-air waste tips. What are its effects? Increased concentrations of methane in recent years pose questions about its chemical transformations and possible new sources. It only persists in the atmosphere for 10 years, compared to 100 years for carbon, so there is scope for action.*

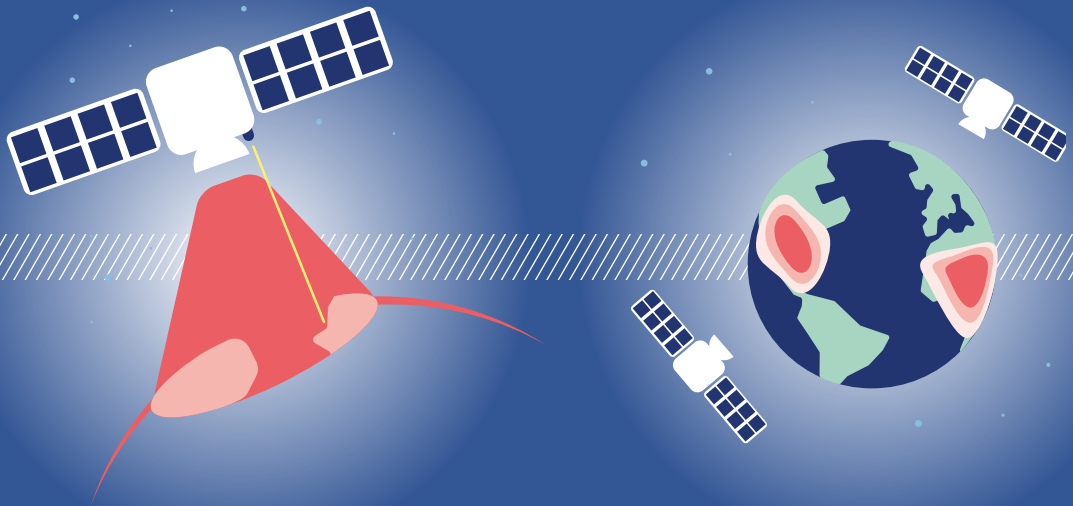
### ACTION **A FRENCH-GERMAN** PROGRAMME

*In 2009, after COP15, France and Germany signalled their intention to work together on climate actions. Both have cutting-edge scientific communities, led by the LSCE climate and environmental science laboratory in France and the Max Planck Institute in Germany. They also have renowned expertise in lidar technologies. As the mechanisms driving global methane emissions and transformation are still poorly understood, the two space agencies have decided to conceive a dedicated mission now in development. Called MERLIN, it will operate at the same time as MicroCarb, which will measure atmospheric concentrations of carbon.*



## TIMELINE

WHILE CARBON MAY BE THE MAIN GAS FUELLING GLOBAL WARMING, METHANE COMES SECOND. BUT WHERE DOES IT COME FROM? TO FIND OUT, MERLIN, AN INNOVATIVE MISSION CONCEIVED JOINTLY BY CNES AND THE GERMAN SPACE AGENCY DLR, IS SET TO TRACK SOURCES OF METHANE EMISSIONS STARTING IN 2021.



### REACTION

## TECHNOLOGICAL INNOVATIONS

*The scientific community has great expectations for MERLIN, and so do CNES and DLR. The two agencies are taking on some big technological challenges, and the mission is set to score a number of firsts. The instrument will be supplied by Germany and MERLIN will be the first-ever orbital lidar system, its laser measuring methane concentration at two carefully chosen wavelengths, day and night. The lidar will be flown on one of the first spacecraft buses from the new Myriade Evolution microsatellite series.*

### PROJECTION

## WHAT NEXT?

*The mission is planned to launch in 2021 and last three years. CNES and DLR will be responsible for processing data and delivering them to the scientific community. MERLIN's space-based measurements will be unique in their precision and resolution, enabling scientists to better quantify, locate and track methane emissions around the globe. They will complement measurements acquired by missions like IASI, IASI-NG and soon the Copernicus programme's Sentinel-5P satellite, yielding precious information to refine our planet's carbon budget.*



HORIZONS

# CATHY CLERBAUX

Research director at CNRS (LATMOS/IPSL, Pierre et Marie Curie University).

“Back then, the data we needed for studying atmospheric composition came from America. Now, they’re asking for ours!”



Cathy Clerbaux has played a key role in the success of the IASI series of instruments, designed by CNES and flown on the MetOp weather satellites, launched by Eumetsat. IASI (Infrared Atmospheric Sounding Interferometer) is the only instrument able to simultaneously measure more than 20 atmospheric components, twice daily, at any point on the globe and in real time. **With her team at the LATMOS atmosphere, environment and space observation laboratory, Cathy Clerbaux has demonstrated the potential of infrared sounders** for monitoring peaks in pollution, large-scale biomass fires, volcanic ash plumes (which aircraft need to avoid), ammonia emissions (from

intensive agriculture) and the hole in the ozone layer. However, she originally planned a career in fundamental research. **She completed her PhD in spectroscopy in 1993, but found her research too disconnected from real-world concerns** and didn't like being unable to explain it to others. So, she moved to applied spectroscopy, focusing on the chemical composition of the atmosphere, and obtained a postdoc grant from CNES to support preparations for the IASI mission. “Who’d have thought I’d spend half my life on it? It was 13 years from when I started work on IASI to the launch of the first MetOp satellite. There’s been a real shift in that time. Back then,

the data we needed for monitoring atmospheric composition came from America. Now, they’re asking for ours! **After 25 years, I love working with the CNES teams as much as ever.** It’s a flexible relationship, based on trust,” she says. Cathy Clerbaux splits her time between Paris and Brussels, where she lectures on atmospheric change and climate at the Université Libre de Bruxelles. IASI has so improved forecasting that some weather services say it’s the best meteorological sounder ever developed. Cathy Clerbaux sits on CNES’s Science Programmes Committee as an expert in atmospheric sciences.



HORIZONS

# GILLES BOEUF

Former president of France's natural history museum, lecturer at Pierre et Marie Curie University, Paris, and chairman of the scientific board of the French agency for biodiversity.

“Satellite observations are extraordinarily valuable.”



In 2015, the ocean's key role in mitigating global warming was recognized for the first time with the Paris Agreement, signed by 197 countries. **Gilles Boeuf was part of this revolution.** Now lecturing in marine biology at Pierre et Marie Curie University, he was president of France's natural history museum for seven years and previously spent 20 years at IFREMER, the French institute of marine research and exploration, and two years as scientific adviser to the French environment ministry during preparations for COP21. Outgoing and enthusiastic, he recalls: “From the meeting of over 2,000 scientists in Paris in July 2015 to the Paris Air Show, we hammered home the

message that the ocean is the primary regulator of global climate. It does this because it's living, but today it's sick! The climate is changing, and this is not only affecting the oceans, with rising sea temperature and sea level and acidification, but also the impact of human activities on the oceans is also changing the climate. Overfishing, for example, reduces their ability to absorb carbon.” Since Paris, Donald Trump's election has dampened the enthusiasm of some, but **Gilles Boeuf would rather point to the progress achieved.** “The IPCC has made the oceans a central concern and is producing a special report on this issue. The major private-sector

companies have agreed to review the energy cost of international shipping. And more marine protected areas are being created. To improve our understanding as the basis for action, satellite observations are extraordinarily valuable for measuring ocean colour, the dissemination of species and the destruction of coastal areas.” He adds, “**While we're responding to climate issues, we also need to focus on the six other ecological scourges**—the loss of biodiversity, agricultural overproduction, water wastage, overexploitation of resources, deforestation and pollution!”



HORIZONS

# SOPHIE COUTIN-FAYE

Head of Altimetry and Argos at CNES.

“In 1992, with TOPEX/Poseidon, we saw more in 10 days than a century of shipborne measurements could yield.”



Life is not without a sense of irony. For Sophie Coutin-Faye, becoming an engineer was “everything I didn’t want to do”. Driven by a love of learning, she simply wanted to “go as far as possible”. And after graduating from the Arts et Métiers engineering school, that meant the IPGP global physics institute in Paris. After completing her **PhD, she started her career in a project to measure Earth’s magnetic field.** Here she crossed paths with Claude Allègre, then the IPGP’s Director, who was keen to bring in space-based geophysics and geodesy tools and methods. Her first involvement with space came when she joined CNES. “I was lucky enough to be introduced to

space via the *DORIS* system. Its performance is still hailed today. It was an exciting project.” And there was more to come. **With TOPEX/Poseidon, then Jason, she was instrumental in the advent and development of satellite altimetry.** “In 1992, with TOPEX/Poseidon, we saw more in 10 days than a century of shipborne measurements could yield. While there are things we don’t yet understand about ocean circulation, we’re pleased to have helped to observe El Niño events (see *In Figures*, p.18) and the continuous rise of sea level.” **Sophie Coutin-Faye is a great believer in knowledge sharing:** “Users should benefit from our expertise—supporting them is really important to

me”. She also appreciates the sense of team cohesion, which transcends borders. The French-US partnership was tricky at the start, but has proved to be richly rewarding. On either side of the Atlantic, the science and project teams have worked closely together. And the adventure continues with SWOT. As for Sophie Coutin-Faye, engineer despite herself, she’s spent the last 25 years on planes, working on different continents and sharing her time between altimetry and the Argos system—another great contributor to climate research. She’s never regretted the path her life has taken: “All I’ve ever wanted is to serve science!”





## ETHICS CORNER



JACQUES ARNOULD

# OF HUMOURS AND MEN

*For 60 years, space has offered humanity a unique view of Earth—and an often-worrying diagnosis of its health. But it's down to us to counter the global threats and changes, while respecting every human being.*

**F**or lack of humour, the cabbages have died of thirst in our gardens.” Gone are the days when 15<sup>th</sup>-century Norman poet Olivier Basselin could use the same word ‘humeur’ to mean moisture in the soil, liquids in the body and temperaments of the soul. This usage first gained credence in the rich philosophy of antiquity, from the Hippocratic treatise *Airs, Waters and Places*, written in the 5<sup>th</sup> century BC, to the later works of Galen in the 2<sup>nd</sup> century AD and, more generally, the conception of the world defended by Aristotle. The key idea was simple: humans and the cosmos reflect each other in a relationship of resemblance, one a microcosm, the other a macrocosm. Between them, the only difference is one of scale. Of course, modern science has given this philosophical view a hard time, while not refuting Jean-Jacques Rousseau when he explained how the “climates, seasons, colours, darkness, light, elements, food, noise, silence, motion, rest, all act on our machine and on our soul.”

### A QUESTION OF SCALE

We now know that the changes revealed by the study of our planet’s climate aren’t simply sudden changes of mood, or humour, but indicators

of global shifts in space and time. And it worries us. We’re developing better ways to observe, monitor and understand, in an attempt to counter the changes, or at least adapt to them. Space technologies are unique in their powers of observation, not least their ability to give us the ‘big picture’. And indeed, we must learn to think and act globally, despite the barriers of our social and cultural differences and our national and economic interests. Humanity is still learning how to think like a macrocosm, itself dependent on an even larger macrocosm. Yet we mustn’t overlook the microcosm end of the scale. Climate change will affect the mood, or humour, of each human—and indeed is already doing so in places. We are reminded of the words of Carl Sagan as he reflected on an image of Earth taken by the Voyager probe: “Look again at that dot. That’s here. That’s home. That’s us. On it, everyone you love, everyone you know, everyone you ever heard of, every human being who ever was, lived out their lives.” On that “pale blue dot” we see the greatness and smallness of our humanity, which we must never forget.



## TUESDAY SPACE TALKS All about Copernicus



On the third Tuesday of each month, CNES, in partnership with the Science Bar, welcomes members of the public to the Tuesday space talks, from 7:30 to 9:30 p.m. at a Paris bar. Each session starts with a talk on a particular space-related theme and includes a Q&A session hosted by a journalist, when the speakers take questions from the floor. A pianist provides musical interludes. The Tuesday talks are a chance to chat with

experts from CNES and other scientific bodies on a wide variety of topics. The 11 April session will focus on Copernicus, Europe's ambitious Earth-observation programme. CNES's own Véronique Mariette will be explaining how Copernicus is set to play such a crucial role in monitoring climate change.

MORE INFORMATION: [CNES.FR](http://CNES.FR)

## SYMPOSIUM THE CLIMATE NEEDS SPACE

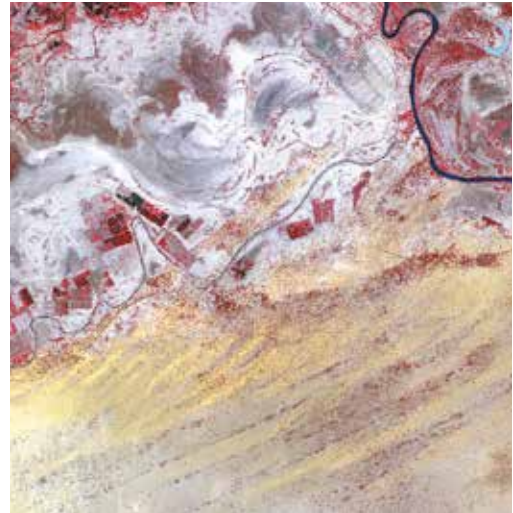


In October, the French Air and Space Academy held a symposium at the Meteo-France conference centre in Toulouse on the theme of "The climate needs space". It was attended by over 100 people, who unanimously recognized the crucial role of space systems for measuring the key parameters of climate change. Participants stressed the need for closer synergy between scientists and engineers to specify instruments as

optimally as possible, combine multiple types of space and non-space data and conceive the systems of tomorrow, factoring in the innovative approaches of NewSpace. They also agreed that international cooperation is vital for coordinating the activities of the various agencies, improving the inter-calibration of sensors and moving towards a Space Climate Observatory (SCO), which will be on the agenda of the meeting of the world's heads of space agencies before the One Planet Summit.

## TERR'IMAGE

# EDUCATION IN HIGH RESOLUTION



Since the launch of the Pleiades satellites, CNES's Education and Youth department has made very-high-resolution imagery available to schools through Terr'Image. This classroom project includes a free tool that makes it easy for pupils to work with satellite data. Staff training is provided nationally through initiatives such as the 'Espace Education' summer school, held every other year to promote space in the classroom and help hundreds of teachers prepare lesson plans. Ahead of the COP21 conference, CNES produced a climate pack for teachers, with ready-to-use worksheets and case examples. By working on such varied topics as environmental management, coastline change, biodiversity, hazard management and land planning, pupils gain valuable insight into the risks and challenges associated with climate change.



## INSIGHTS



### MAPATHON

# PRACTICAL HUMANITARIAN EXERCISE

On 12 October, CNES's Toulouse Space Centre hosted a fun and practical exercise. Staff took part in two two-hour sessions based on a humanitarian crisis situation in the aftermath of a natural disaster. Using Pleiades satellite imagery, they compiled detailed maps of Madagascar—one of the countries most exposed to the vagaries of the climate. Each year in the rainy season, the island is battered by violent cyclones, with dramatic humanitarian and economic consequences. This time, 150,000 people had been displaced, many in difficult

conditions. Participants identified features on the satellite images, such as houses, roads and points of interest, and added them to an OpenStreetMap database to create a more detailed map of the affected areas than previously available. Once validated, it will be used operationally by French Humanitarian Firefighters (PHF), an NGO supporting the local civil protection services since 2005. A highly original awareness exercise, with hands-on use of space information.



## DIARY

**18-23 MARCH**  
8<sup>th</sup> World Water  
Forum  
*Brasilia, Brazil*

**6-8 APRIL**  
International Climate  
Show 2018  
*Geneva, Switzerland*

**11 APRIL**  
Tuesday space talk  
on Copernicus  
*Paris, France*

# 800

That's the number of pupils involved in CNES classroom projects who attend special events every year to talk about the climate and the environment. Outreach in schools is a great way to engage future generations. In the summer term, pupils from across France will attend events organized with scientists to present their projects. These include the Météo Espace day (Caliph'Air and Globe France projects) at CNES in Toulouse on 17 May 2018, the Argonautica symposium in La Rochelle, 23 to 25 May, and the ArgoNimaux day at CNES in Toulouse in partnership with the Toulouse museum on 7 June (also World Oceans Day).



## SPINOFF

# DATA PERSONALIZED WEATHER FORECASTING

*CNES was among the first to put its faith in a start-up on the recent winning America's Cup team. Algorithms developed by EXWEXs helped Emirates Team New Zealand to forecast winds with unprecedented accuracy. It all began with CNES's PEPS platform.*



On 26 June in Bermuda, the Kiwi team carried off the 35<sup>th</sup> America's Cup, a success in which CNES was involved from the very early stages through its PEPS Sentinel Product

Exploitation Platform. Opened in 2015, PEPS offers open and free access to data from these Earth-observing satellites with a view to spurring their uptake.

A call for ideas was then launched<sup>1</sup>, CNES enabling direct access to Sentinel data without having to download them, as well as free processing and storage capacity and technical support. Christophe Messenger, the founder of EXWEXs (Extreme Weather Expertises), grasped the opportunity to propose his firm's already tried-and-tested weather data processing system, which was selected.

Combined with the PEPS platform, the firm's algorithms are now set to be applied to all Sentinel data. "We're really proud of this victory! Our system is capable of supplying weather forecasts updated every hour, including wind variability, integrated with the system on the boat. Satellite products are the only source of high-resolution data to enable forecasts to start from a precise current weather picture." For the launch base in Kourou, this ability to forecast weather conditions in fine detail could prove a crucial aid.

1. An initiative set to be repeated on a larger scale in 2018. Watch out for details.

EN

3

million products available on PEPS, amounting to 13 terabytes of data every day.

2,500

users of PEPS, with 100 new subscribers signing up every month.