CNES MAG

EN

SPACE ● INNOVATION ● SOCIETY

#65
June 2015

CLIMATE

SPACE TAKES UP THE CHALLENGE

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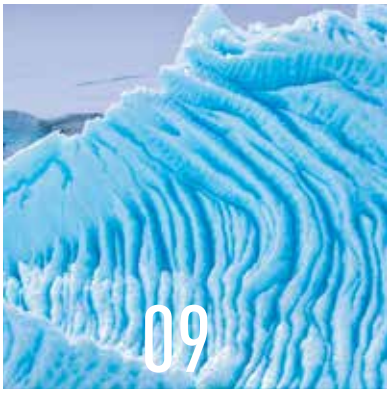
INSIDE



PARTNERS

Mentioned in this issue:
p.32 CLS (Collecte Localisation Satellites), the subsidiary of CNES, Ifremer and Ardian; p.31 Mercator Ocean, of which CNES, as a founding member, remains a key partner.

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Cover: Bora Bora in French Polynesia, viewed by the Pleiades 1A satellite on 2 May 2012.

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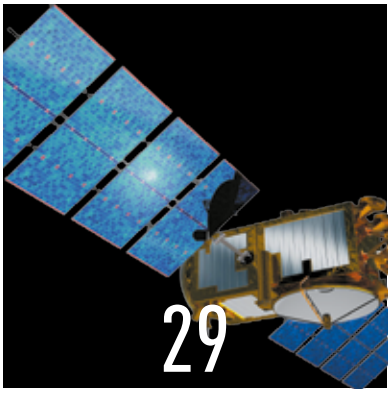


P. 23

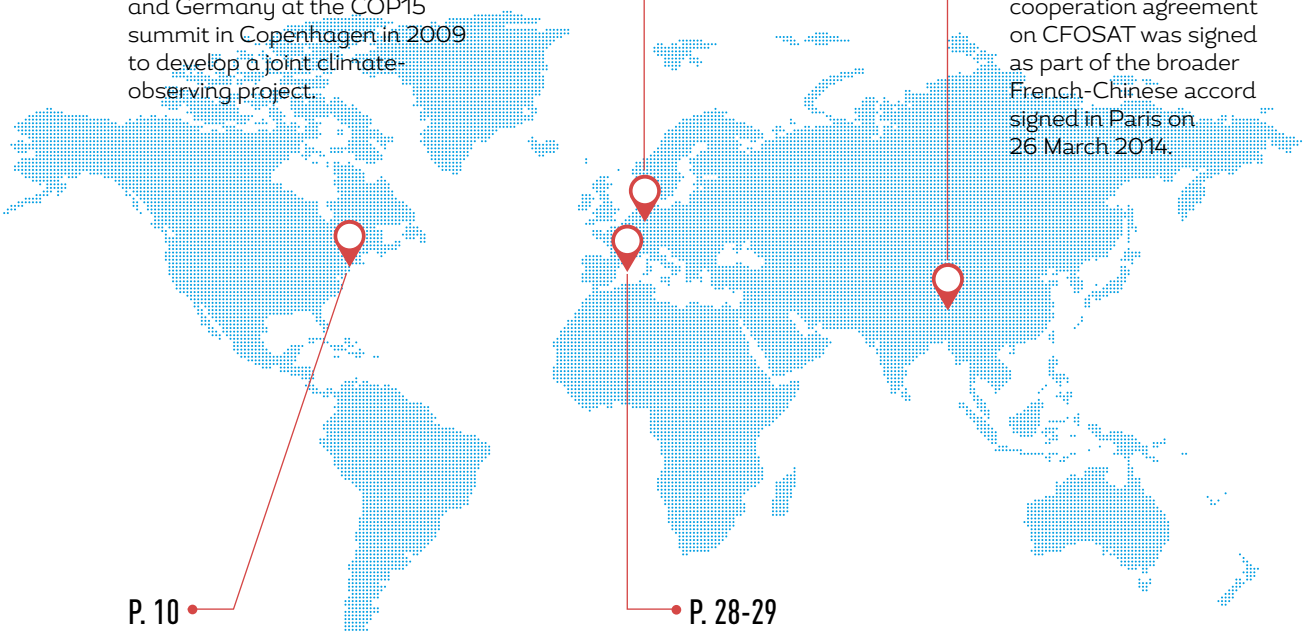
GERMANY

The MERLIN mission stems from a policy commitment by France and Germany at the COP15 summit in Copenhagen in 2009 to develop a joint climate-observing project.

P. 24

CHINA

29 January 2015 in Beijing, a formal cooperation agreement on CFOSAT was signed as part of the broader French-Chinese accord signed in Paris on 26 March 2014.



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UNITED STATES

From TOPEX/Poseidon to SWOT, satellite altimetry missions are a standout of CNES-NASA cooperation.

P. 28-29

EUROPE

Eumetsat, the European organisation for the exploitation of meteorological satellites, is tasked with developing Jason-CS in partnership with ESA to assure continuity of Jason data.

CONTRIBUTORS

DIDIER JAMET

A science journalist who has written several books on space, Didier believes that a day he learns nothing new is a day wasted. For this issue, he met–among others–the renowned climatologist Jean Jouzel, who took some time off from his busy schedule in this year devoted to climate.

LILIANE FEUILLERAC

At the helm of her own independent press agency, Liliane has the gift for writing clearly about the most complex technologies. A contributor to Cnesmag from its early days, this time she went behind the scenes with our teams to find out more about the climate projects CNES is currently pursuing.

PASCALE ULTRÉ-GUÉRARD

In charge of CNES's Earth Observation Programme, this trained geophysicist was our key contact for this issue. She mobilized her teams and network of contacts for us. Pascale represents CNES at international bodies covering the Earth, its environment and climate.

JEAN-MARC PAU

After studying graphic design and advertising, Jean-Marc Pau decided to become an illustrator and cartoonist for the press and publishing houses. His ink drawings, done with a brush and then digitally colorized, uniquely caricature politicians and artists in Le Monde, Nouvel Observateur, La Vie and Marie-Claire.

CNES MAG

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Publication director: Jean-Yves Le Gall. **Editorial director:** Marie-Claude Salomé. **Editor-in-chief:** Brigitte Alonzo-Thomas. **Feature editors:** Joëlle Brami, Liliane Feuillerac, Séverine Klein, Didier Lapierre/ Romain Desplats, Marie-Claude Siron. **Artwork and picture consultant:** Serge Delmas. **Photos:** Marie-Claire Fontebasso, Orianne Arnould. **Photo credits:** p.4 D. Jamet, L. Feuillerac, CNES/E. Grimault, Sophie Pierre; p.5 CNES/O.Pascaud; p.6 AFP Photo/STR; p.7 Atacama-DLR-2015; p7 Thinkstock; p.8 left Naturagency/Christophe Courteau; p.8 right T. Montford; p.9 Hervé Dunoyer/Naturimages; p.10 CLS/CNES/Aviso; p.11 left CNRS-LMD/D Sourgen; p.11 right CNES; p.13-p.15 Baltel/SIPA; p.16 Naturagency/Patrick Kientz; p.17 Naturagency/J-L. Klein & M-L. Hubert; p.18 CNES/E. Maligne; p.19 CNES/Distribution Airbus DS, 2012; p. 20 Nasa; p.21 CNES/E. Grimault; p.22-23 CNES/D. Ducros, p.23 bottom Coeurs de nature/Biot Tim/Sipa; p.24 Thinkstock; p.25. CNES/E. Grimault; p.26 Thales Alenia Space/J.L Bazile; p.27 CNES/P. Cocquerez; p.28-29 CNES/D. Ducros; p.33 CNES/E. Grimault; p.34 haut CNES/R. Barranco; p.34 bottom Thinkstock; p.36 Coovia. **Illustrations:** p.30-32 Jean-Marc Pau. **Webmaster:** Sylvain Charrier. **English text:** Boyd Vincent. **Design and pre-press:** Citizen Press – Camille Aulas, Stéphane Boumendil, David Corvaisier, Alexandra Roy, Aurélien Saublet. **Printing:** Ménard. ISSN 1283-9817. **Contributors:** François Bermudo, Guilhem Boyer, Selma Cherchali, Philippe Collot, Sophie Coutin-Faye, Nathalie Corcoral, Chantal Delabarre, Carole Deniel, Danièle DeStaerke, Vincent Dubourg, Jean-François Dupuis, Philippe Escudier, Anita Gonzalez, Thierry Lafon, Juliette Lambin, Denis Moura, Jean-Gabriel Parly, Sophie Perraud, Pierric Perrier, Amélie Proust, Steven Hosford, Philippe Veyre, Cecile Vignolles.

PEFC 10-31-2690

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EDITORIAL

Welcome to the new-format *Cnesmag*, CNES's quarterly magazine, which is now more dynamic, more readable and more attractive, reflecting what we do as an agency. In an ever-changing world, with the arrival of new players in the emerging countries and on the web, CNES is constantly adapting to the evolving geopolitics of its sector, the new paradigm in satellites and the problem of climate change.
Our satellites and our instruments enable us to study the oceans and freshwater systems, meteorology and carbon dioxide, methane and other gases and their impact on the greenhouse effect. These issues will be the central theme of our pavilion at the 51st Paris Air Show in June and will also be the focus of our attention later in the year, when Paris hosts the COP21 international climate conference. Yet more opportunities for CNES to demonstrate its policy of success through innovation!

JEAN-YVES LE GALL
CNES PRESIDENT

CLIMATE EXTREMES

When climate becomes a threat

Severe weather like the torrential rains in Chile in March and climate events like receding glaciers and rising sea level are just some of the many manifestations of our warming climate. In the space of just two decades, satellite data have brought vital new insights into such phenomena. CNES and its partners are constantly demonstrating the utility of space solutions in assessing the causes and consequences of the profound changes we can expect to see in the future.

NATURAL DISASTERS

TOWARDS A UNIVERSAL CHARTER

The 2012 Special Report of the Intergovernmental Panel on Climate Change (IPCC) on extreme weather and climate events leaves no room for doubt: as a result of changes to Earth's climate, natural disasters are going to get more frequent and more intense. The International Charter on Space and Major Disasters, co-founded by CNES and the European Space Agency (ESA) in 2000, was conceived with a view to delivering useful data quickly to signatory nations in the event of a disaster. Today, the charter is evolving and expanding its coverage. Nations to have benefitted from it most recently are Australia, Malawi, Chile (see photo left), Colombia and Pakistan. The charter's rotating presidency has also been held over the last 18 months by new members China, Germany and South Korea. The current chair is the Indian Space Research Organization (ISRO), which took over in mid-April. On average, the charter is activated 50 times a year.

315

The number of times the International Charter on Space and Major Disasters was activated in response to extreme weather events (cyclones, floods, etc.) between 2000 and 2014.

ATMOSPHERE

A CLEARER VISION FOR CLIMATE FORECASTING

What impact do aerosols—particles in suspension in the air—and clouds have on climate change? Do they fuel warming or, on the contrary, cool the atmosphere through a parasol effect? This uncertainty is one of the main limits of models currently used to predict shifts in our climate. To better understand the impacts of all of these particles on climate change, CNES launched the Parasol satellite in 2004 and then the Calipso satellite in 2006, in partnership with NASA. These trailblazing satellites have shown the value of space missions as the only way to obtain global coverage, paving the way for new-generation instruments set to be placed into orbit in the years ahead, like 3MI and EarthCARE.

WORLD WATER FORUM

SCIENCE TO INCREASE RESILIENCE

North of Botswana.

The latest World Water Forum, held from 12-17 April in South Korea, reminded us just how fundamental water is to development. For food security, energy and health, the threats to water posed by climate change are endangering populations' vital needs. Through a Partnership for Water of which CNES is a member, French stakeholders are advocating a stronger focus on water resources in negotiations at the upcoming COP21 global climate summit in Paris next December.

ALARMING FORECASTS

The latest IPCC report confirms that reducing the vulnerability of water sources in a changing climate is now urgent: with rainfall declining by 10% to 30% in mid-latitude nations and water-related natural disasters (both flooding and droughts) on the increase, alarm bells are ringing everywhere. Last March, UN experts underlined that unless we find ways to manage world water resources sustainably, the planet could be facing a global water deficit of 40% by 2030—an unprecedented situation that could be the first dramatic manifestation of climate change.

Amazon forest.

BIOMASS

FOREST-SURVEYING SATELLITE GETS GREEN LIGHT

From 2020, Biomass will be embarking on its mission to map forests across the globe and measure how much carbon they store. Data from the satellite will also serve to build a 3D-picture of forests. Supported by CNES, teams in France are gearing up to exploit these observations that are expected to shed new light on the carbon cycle and how it affects climate. The European Biomass mission got the go-ahead from ESA member states on 18 February.

COMING TO TERMS WITH

1988

Creation of the Intergovernmental Panel on Climate Change (IPCC)

1992

Earth Summit in Rio de Janeiro, where the UN Framework Convention on Climate Change (UNFCCC) is adopted

CRYOSPHERE

SATELLITE REMOTE SENSING IS THE SNOW QUEEN

With 200,000 glaciers and two polar ice caps holding a large proportion of the globe's freshwater reserves, ice is a key component of Earth's biosphere that scientists call the 'cryosphere'. Both an indicator and actor of climate change, the cryosphere is today the subject of keen scientific debate. One question now being asked is: What is the exact role of ice melt in rising sea level? In these often hostile and remote icy regions, gathering in-situ data can prove especially challenging, so satellite remote sensing is set to play a key role in providing answers.

Iceberg in Antarctica.

2°C

The UN Framework Convention on Climate Change (UNFCCC) has set the target of capping the global increase in temperature at 2°C between now and 2100. This follows on from the 4th IPCC report, which sets the goal of a 50% reduction in anthropogenic greenhouse gas emissions by 2050.

5 MILLION SQ.KM

In 2014, Arctic sea ice extent reached a record seasonal low of just 5 million square kilometres. Its long decline is due to the effects of climate change that are being keenly felt in the polar regions, where warming is almost twice as fast as the global average.

–5°C

Global warming could weaken the Gulf Stream, the warm current partly responsible for Western Europe's mild climate, leading to a 5°C drop in temperatures in Northern Europe and on the East coast of the United States.

CLIMATE CHANGE

1997

Start of negotiations on the Kyoto Protocol, which aims to reduce greenhouse gases by 5% against 1990 levels

2005

Kyoto Protocol comes into force

2007

4th report of the IPCC, which also receives the Nobel Peace Prize

2008

European Council adopts energy-climate package

2012

Special Report of the IPCC on extreme weather and climate events

OCEANOGRAPHY

REMOTE-SENSING INSTRUMENTS KEEP GETTING BETTER

Planet Earth is something of a misnomer. With 71% of its surface covered in water, a feature that makes it unique in the solar system, it should really be called planet Ocean. And to better understand climate change, we need to look closely at ocean dynamics. Oceans store vast amounts of heat, which they redistribute around the planet. Heated by the Sun in the Tropics, warm water is transferred by ocean currents to more temperate coasts where it cools, releasing heat into the atmosphere in the process. Now colder and therefore more dense, it sinks to the sea floor and flows back towards the equator in a cycle that takes more than 1,000 years to complete.

RISING SEA LEVEL UNDER CLOSE SCRUTINY

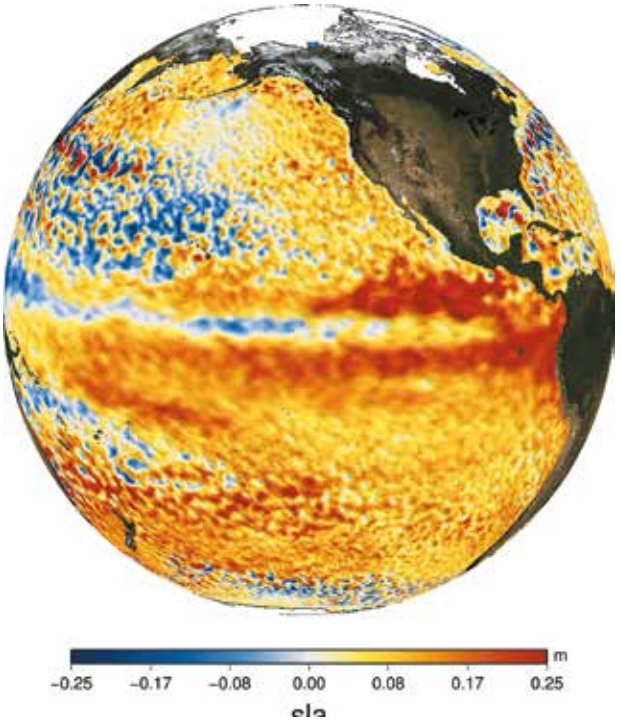
This ocean 'conveyor belt'—or thermohaline circulation to use its more scientific name—obviously plays a key role in maintaining climate balances, which is why scientists are keen to observe the phenomenon from space to obtain the wider picture. After the TOPEX/Poseidon satellite altimetry mission launched in 1992 in partnership with NASA, CNES initiated the particularly prolific Jason series of ocean-observing space missions, the third of which is to be orbited this summer (see Special Report on Jason 3 in Cnesmag n° 64). With this continuous time-series of satellite data stretching back to 1992, oceanographers and climatologists now know for certain that the mean sea level is rising three millimetres on average every year. Two factors are to blame: the increased amount of heat stored in the oceans and the influx of freshwater from continental glaciers receding in the face of rising temperatures.

3.8 KM

The average depth of the oceans covering more than two-thirds of Earth's surface.

ORGANIZING SPACE OCEANOGRAPHY

Besides this ability to measure the mean sea level, the most emblematic symbol of how satellite remote sensing is contributing to the study of climate change, a new field of space oceanography is establishing itself with each new mission. Today, satellites are measuring not only sea-surface temperatures and plankton by observing ocean colour, but also salinity with SMOS and soon waves with CFOSAT.



In May 2015, the telltale signs of an impending El Niño, when water piles up and propagates westward due to surface warming, can be seen in the Pacific.

STRATOSPHERE

BALLOONS TO FLY CLIMAT AND H_2O

The gondola is hoisted into position.

Satellites are not CNES's sole focus of activity. For more than 30 years, it has been sending balloons into the stratosphere to study Earth's climate. The next flight campaign is set for 12 August to 30 September with CLIMAT (Combinaison de Lasers et d'Instrument de Mesure *in situ* en Atmosphère Terrestre), carrying a suite of instruments designed to study atmosphere-climate interactions. The H_2O balloon gondola is also expected to be on the flight with instruments to measure stratospheric water vapour content.

60%

Unless current consumption trends change, in 2030 the world will only be able to provide 60% of the water that humanity needs to survive.

HEALTH

SATELLITES SURVEY INFECTIOUS DISEASES

By 2025, more than 4 billion people will be directly exposed to the threat of infectious diseases. Climate change is a contributing factor in their onset, as it can influence the reproduction and spread of disease-bearing vectors. CNES and its partners have developed a method called tele-epidemiology that consists in analysing relationships between climate, the environment and health, using satellite data to highlight how climate change increases the risk of infectious diseases emerging and spreading. Working with health authorities in affected nations, they have conceived risk-prediction tools like for example frequently refreshed maps of water bodies where certain disease-bearing mosquitoes are likely to breed, thus making it possible to take preventive action while they are still at the larval stage. The method patented by CNES is currently undergoing trials for Rift Valley fever in Senegal and malaria in urban (Dakar) and rural areas (Burkina Faso). It is also being adapted for dengue fever in the Caribbean (Martinique) and French Guiana.

MALARIA SPREADING OR IN RETREAT?

For the Paluclim study on malaria-bearing mosquitoes in Burkina Faso, the impact of two global warming scenarios has been tested to gauge the region's vulnerability to the disease. The good news is that the mean temperature is expected to increase to such an extent that by the end of the century mosquitoes will no longer be able to breed there. The bad news is that as climate change is global, it could turn hitherto malaria-free regions into a new paradise for mosquitoes. However, the mechanisms by which malaria is transmitted are complex and climate factors alone are not the only explanation for its onset.

#COMMUNITY

Every day, CNES engages with you on social networks and you share your thoughts and questions with us. Below is a selection of messages that caught our attention. Join the conversation!

@ FLORENCE PORCEL

Author, actress and presenter.

In the Arctic, the oldest pack ice is melting http://www.slate.fr/monde/83743/arctique-glace-la-plus-vieille-fond-emporte-reste-banquise-avec-elle Remember: this is the only planet we've got.

@ CHRIS HADFIELD

Canadian Astronaut, back on Earth after living aboard ISS as Commander of Expedition 35.

Perspective - the Aral Sea was our 4th largest lake, now gone due to bad policy, visible from space.

NON-PROFIT ASSOCIATION PAPILLON

2 march

We have the cutting-edge tools to observe and preserve our quality of life, more than to usher in the civilization to go with it.

KIDS TO YOUR MOBILES!

Snapchat is the social network very much in vogue with teenagers. Not to be left behind, CNES is giving young snapchatters the chance to follow two female polar bears, Diamant and Bettilia, during this year dedicated to climate. All they have to do is add cnesfr to their Snapchat friends list from mid-June to receive regular 'snaps' so they can track the bears by satellite.
The new feature will be launched at the Paris Air Show.

FACELIFT FOR CNES.FR

Intuitive usability, contemporary design, responsive technology for mobile devices – the new version of cnes.fr goes live in mid-June. Focused on CNES's activities as an agency, the website is supplemented by a blog with all the latest space news and a separate youth website, where younger space enthusiasts can satisfy their curiosity!

Corporate website: cnes.fr
Blog: blog.cnes.fr
Youth website: jeunes.cnes.fr

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VIDEO

[+]

WWW.CNES.FR

Watch the video featuring Jean Jouzel on CNES's website

Q & A

JEAN JOUZEL

CLIMATOLOGIST JEAN JOUZEL IS VICE CHAIR OF THE IPCC and the author of over 250 scientific publications. Six months ahead of the global climate summit in Paris, he gives us his assessment of how space is helping to understand the processes driving global warming.

Q & A

WHAT'S AT STAKE AT THE PARIS CLIMATE SUMMIT IN DECEMBER?

Jean Jouzel: Every year, the Conference of the Parties (COP) brings together the nations that have signed up to the UN Framework Convention on Climate Change (UNFCCC). This year will be the 21st such meeting, the two most emblematic having been Kyoto in 1997 and Copenhagen in 2009. Copenhagen set a target of capping long-term global warming at 2°C above pre-industrial temperatures. That marked a decisive step, but we now need to translate this commitment into actions. To reach this target, the conference in Paris aims to secure a specific agreement on reducing greenhouse gas emissions after 2020.

HOW BIG A CUT IN EMISSIONS IS NEEDED TO MEET THE 2°C TARGET?

J. J.: We need to start by breaking the emissions spiral by 2020 and then reduce our greenhouse gas emissions by at least a factor of two, ideally three, between 2020 and 2050 to achieve carbon neutrality—i.e. zero net carbon emissions—by the end of the century. The best way to view the problem is to look at our energy requirements, which currently are met largely by burning fossil fuels. To reach the long-term 2°C target, we need to keep nearly 80% of fossil fuel reserves obtainable with current technologies and costs in the ground. We mustn't use more than 20% of these easily accessible reserves. Seen in that light, it's obvious that we need to completely rethink our current development model.

WHAT ROLE WILL THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (IPCC) BE PLAYING AT THE CONFERENCE?

J. J.: The IPCC's mission is to provide a diagnosis and scientific elements on how the climate system works, the impacts of disruptions to this system and possible solutions to inform policymakers' decisions.

AND WHAT WILL YOUR ROLE BE?

J. J.: I will be on the French delegation's team of science experts, as I have been every year since 2000. However, I will also be involved in the run-up to the event in Paris, as Laurent Fabius has also asked me to sit on the conference steering committee he is chairing.

HOW HAVE SATELLITES HELPED TO ADVANCE OUR UNDERSTANDING OF CLIMATE CHANGE?

J. J.: Satellite data have truly revolutionized how we see the climate system. The most striking example is sea level, which is currently rising at a rate of three millimetres a year. Satellite measurements at the polar ice caps and on temperate glaciers have shown that roughly half of this rise is due to ice melt. Just under another half results from expansion of the warming ocean, which stores 93% of excess heat. The remaining proportion comes from extracted groundwater, which obviously ends up in the sea. It's not huge, but it accounts for 13% of sea level rise all the same. Satellite data enable us to precisely calculate these different contributions. Without them, we just wouldn't have that kind of precision, especially when determining regional characteristics. It's the kind of thing we didn't even dare dream about 30 years ago!

DO YOU THINK SATELLITES COULD PROVE GEOSTRATEGICALLY IMPORTANT IN THE RUN-UP TO A GLOBAL CLIMATE SUMMIT?

J. J.: For the purpose of climate negotiations, there's obviously value—without going as far as looking at a country's oil imports—in being able to determine greenhouse gas emissions in a specific region or sector of the economy. Satellite data have the potential to accomplish this really important task.

"IT WOULD HAVE BEEN EASIER TO KEEP TO THE 2°C TARGET IF WE'D STARTED MASSIVELY DEVELOPING RENEWABLE ENERGIES NOT NOW BUT 15 YEARS AGO."

JEAN JOUZEL

CLIMATOLOGIST AND RESEARCH DIRECTOR AT CEA, THE FRENCH ATOMIC ENERGY AND ALTERNATIVE ENERGIES COMMISSION, SPECIALIZING IN PALEOCLIMATOLOGY.

"SATELLITE DATA HAVE TRULY REVOLUTIONIZED HOW WE SEE THE CLIMATE SYSTEM. THE MOST STRIKING EXAMPLE IS SEA LEVEL."

AND WHAT NEW SPACE TOOLS ARE YOU DREAMING OF TODAY?

J. J.: It would be great if satellites yet to be invented could reduce the uncertainties in our models. The main uncertainty today concerns clouds. We don't know if they are heating or cooling the climate system. It would be fantastic if satellites, thanks to their global coverage, could give us new insights into how clouds, aerosols and radiation interact, and tell us more about how the physical and chemical make-up of clouds evolves as they warm. I know there are projects in the pipeline, even if it's a tough challenge. The other aspect is our knowledge of the atmosphere's composition. Several satellite projects are looking to determine regional greenhouse gas emissions, but what we need is continuous observations. Lastly, satellites still have a lot to teach us about the consequences of global warming on agriculture, forests, permafrost and more.

IN THIS CONTEXT, HOW DO YOU SEE CNES'S ROLE?

J. J.: CNES provides satellite solutions. Each of the climate missions to which it has contributed has brought us net benefits. I also note a real sense of emulation in the research laboratories it has worked with to conceive and build remote-sensing instruments, even if today their research scientists are perhaps not quite so close to CNES as they once were. But it's a good working relationship, as the whole scientific community gets behind space projects that generate a wealth of results, publications and ultimately satisfaction.

DO YOU THINK HUMANKIND IS CAPABLE OF REACHING THE GOAL OF LIMITING LONG-TERM GLOBAL WARMING TO 2°C?

J. J.: We face a big challenge, and it would be a lot easier if we'd really started acquiring data 20 years ago. Back then, scientists were already saying what they are now: that we need to rapidly reduce greenhouse gas emissions to stabilize global warming. We said the same thing again 10 years ago. The Kyoto Protocol was a success in a sense, since it was put in place less than 10 years after the IPCC was formed. So it's not as if nothing's been done, but there was too much foot dragging in the first 10 years of this century. Greenhouse gas emissions have never increased more quickly than since the year 2000! It would have been easier to keep to the 2°C target if we'd started massively developing renewable energies not now but 15 years ago. But the political vision wasn't there. Coming back to satellites, they could greatly assist negotiations by measuring CO_2 precisely enough to allow us to finely distinguish sources of emissions. I believe we'll get there in a few years' time and I know that new projects are underway.

Profile

2012
Vetlesen Prize, equivalent to the Nobel Prize in the field of geophysics and geology
2007
IPCC is awarded the Nobel Peace Prize while he is Vice Chair
2002
CNRS Gold Medal, France's highest scientific distinction

CNES subsidiary CLS has fitted 900 polar bears with Argos transmitters to track their movements on the North Pole pack ice. As the bears' territory shrinks as a result of ice melt, prey is proving hard to come by. One female swam non-stop for nine days to find food, losing 22% of her body weight and her cub in the process. Data being gathered on how the species is responding to a changing environment are helping scientists to select potential habitats and sanctuarize them for polar bears.

King penguins could soon be extinct as a result of warming waters in the Antarctic Ocean. This penguin tracked using Argos transmitters was found to be swimming ever further offshore to fish. Data retrieved via satellite showed that its favoured feeding grounds were coming into conflict with industrial fishing vessels. Tracking of king penguins is delivering concrete information for defining plans to manage marine territories in a way that preserves ecosystems.

PATENTS

90 satellite imagery patents have been filed by CNES. Such innovations play an important supporting role in understanding phenomena like global warming.

30 seconds to 2 minutes

IS THE TIME INTERVAL SEPARATING THE SIX FRENCH, US and Japanese satellites in the A-Train constellation studying Earth's radiation balance and clouds, the chief source of uncertainty in climate projections. OCO-2, GCOM-W1, Aqua, Calipso, CloudSat and Aura form the A-Train. Parasol exited the constellation on 18 December 2013 after 9 years of loyal service.

GLOBE

1,025 primary and secondary school pupils are involved in Calisph'AIR, the educational project accompanying the Calipso satellite dedicated to studying the role of clouds and aerosols in climate change. More broadly, Calisph'AIR is a French contribution to the GLOBE international educational programme to observe the environment, for which 635,313 measurements are performed every month by pupils at 28,234 schools in 114 countries.

1,316

FLIGHT DAYS WERE ACCUMULATED by the flotilla of 19 stratospheric balloons for the Concordiasi international atmosphere-observing programme studying ozone dynamics and chemistry in Antarctica in 2010. The Strateole 2 project plans in 2018 to fly 50 such balloons at altitudes of 18-20 km over the equator.

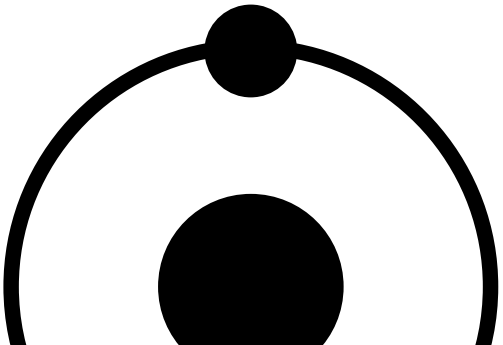
70 cm

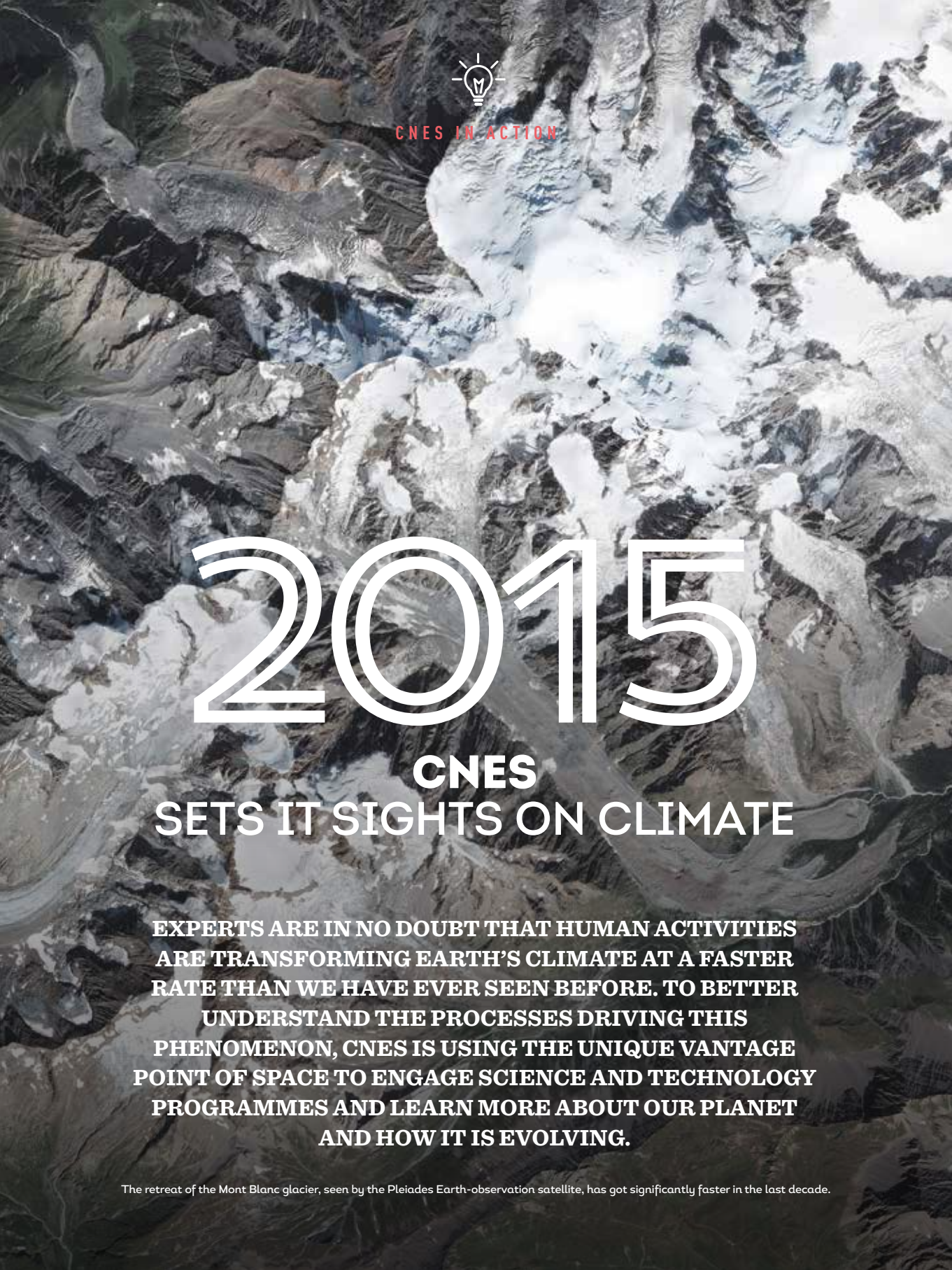
IS THE RESOLUTION OF THE PLEIADES SATELLITES

observing and mapping Earth's surface every day from their 694-km orbit. Pleiades imagery is a valuable aid in organizing relief efforts and supporting post-disaster reconstruction.

3.27

mm/year is the rate at which mean sea level is rising. This figure derived with data from the Jason ocean-observing satellites conceived by CNES has been validated by the Intergovernmental Panel on Climate Change (IPCC), officially confirming and recognizing France's position at the forefront of satellite altimetry.





2015

CNES SETS IT SIGHTS ON CLIMATE

EXPERTS ARE IN NO DOUBT THAT HUMAN ACTIVITIES ARE TRANSFORMING EARTH'S CLIMATE AT A FASTER RATE THAN WE HAVE EVER SEEN BEFORE. TO BETTER UNDERSTAND THE PROCESSES DRIVING THIS PHENOMENON, CNES IS USING THE UNIQUE VANTAGE POINT OF SPACE TO ENGAGE SCIENCE AND TECHNOLOGY PROGRAMMES AND LEARN MORE ABOUT OUR PLANET AND HOW IT IS EVOLVING.

The retreat of the Mont Blanc glacier, seen by the Pleiades Earth-observation satellite, has got significantly faster in the last decade.

Climate research scientists today have a wealth of data to work with from the space programmes initiated by CNES, the French space agency. Overseen by the Ministry of Education, Higher Education and Research, the agency organizes a science seminar every 4 to 5 years to identify future missions and experiments designed to serve the needs and priorities of the national scientific community. Each project is subjected to close scrutiny for its utility, feasibility and cost before being submitted to CNES's Science Programmes Committee (CPS), which then makes its selection. The Jason 3, CFOSAT, SWOT, IASI-NG and MERLIN projects detailed on the following pages were selected through this same process.

26 ESSENTIAL CLIMATE VARIABLES

CNES also builds the recommendations of the Global Climate Observing System (GCOS) into its climate change project specifications. This international body created in 1982 has identified 50 essential climate variables (ECVs) that lend themselves, technically and economically, to systematic observation. Space missions are not always the best way to observe these variables. In all, out of the 50 ECVs identified by GCOS, 26 are currently measurable from space. But for a mission's utility to climate research to be recognized, it must fulfil a series of conditions, also defined by GCOS, for example concerning sensor calibration or data continuity.

A unique picture of Typhoon Maysak taken on 31 March 2015 by Samantha Cristoforetti from the ISS

26

The number of climate variables,

out of 50 in total, that lend themselves readily to observation from space, according to the criteria of the Global Climate Observing System (GCOS).

2,000

The number of research scientists

using data collected by the ICARE atmosphere data hub set up and coordinated by CNES.

DATA HUBS FOR RESEARCH SCIENTISTS

Space-based observations must also be complemented and validated by in-situ measurements, and then interpreted and fed into models to make sense of them. To this end, they need to be disseminated to scientists from several fields in an easily useable form. This is where the data hubs being implemented by CNES come into play. These science data centres offer research scientists expert assistance in refining their processing algorithms and devising data visualization tools, which can then be used by other scientists. These same scientists are also keen to work with data from different missions, which is why the data hubs each focus on a specific domain: atmosphere (ICARE + Ether), land surfaces (Theia), oceans

and solid Earth (Form@ter). The atmosphere data hub already has more than 2,000 users around the world.

VIRTUAL CONSTELLATION ARCHITECT

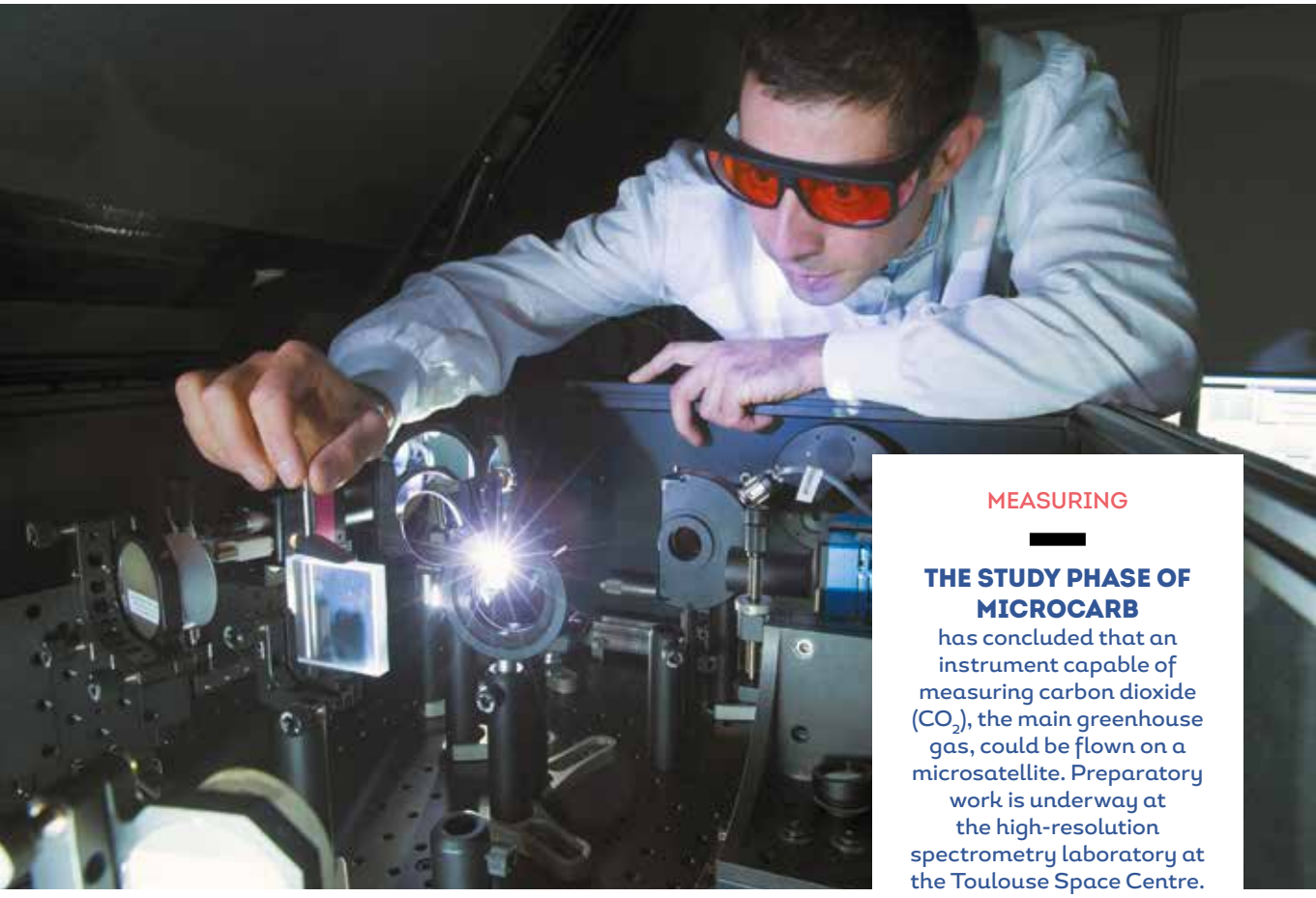
CNES's engineers often use the term 'system vision' to describe the ability to take in all aspects of space remote sensing. Climate research has taken this approach a step further to conceive a 'system of systems', a good example being the satellite altimetry missions that have proved so valuable in measuring rising sea level. Through the partnerships engaged with NASA and ESA in this domain from the early days, CNES found itself ideally placed to coordinate development of specifications designed to get instrument measuring standards to converge. These standards can now be used by other space agencies. With its altimetry expertise and its long heritage of multilateral cooperation, CNES is the architect of this system of systems so crucial to enhancing our understanding of the oceans, now and in the future. It is thus naturally leading the virtual constellation dedicated to measuring sea level for CEOS, the Committee on Earth Observation Satellites.

VIDÉO

[+]

WWW.CNES.FR

CEOS : the Committee on Earth Observation Satellites.



MEASURING

THE STUDY PHASE OF MICROCARB has concluded that an instrument capable of measuring carbon dioxide (CO_2), the main greenhouse gas, could be flown on a microsatellite. Preparatory work is underway at the high-resolution spectrometry laboratory at the Toulouse Space Centre.

SWOT is the result of a cooperation agreement between CNES and NASA to study surface water and oceanography.

SWOT **SURVEYING** EARTH'S SURFACE WATER AND OCEANS

By 2020, SWOT will be casting a close eye on the world's oceans and surface waters to gauge their potential and interactions.

There are still grey areas in hydrology, as satellite data on the globe's surface waters remain scarce, but the SWOT satellite (Surface Water & Ocean Topography) is set to plug these gaps in our knowledge. This joint French-U.S. CNES/NASA mission will measure spatial and temporal variations in surface water heights of rivers, lakes, streams and flood zones. Closer study of these reserves is now urgent to avert adding to the imbalance between populations' needs and available natural supplies of freshwater.

3D IMAGER

The innovations that SWOT will bring start with its K_a-band radar interferometer (KaRIn), to which CNES has contributed, supplied by the Jet Propulsion Laboratory (JPL) in Pasadena and based on a new concept that breaks

with traditional satellite altimetry technologies. With its two antennas perched at the end of a 10-metre boom, KaRIn will afford continuous coverage of a 120-kilometre wide swath to acquire reliable measurements of lakes, rivers and reservoirs across the globe. Meanwhile, its 3D imager will cover the entire globe at very high resolution in just 11 days. All of these data will help the scientific community to shed new light on the global dynamics of water and interactions with coastal areas and estuaries.

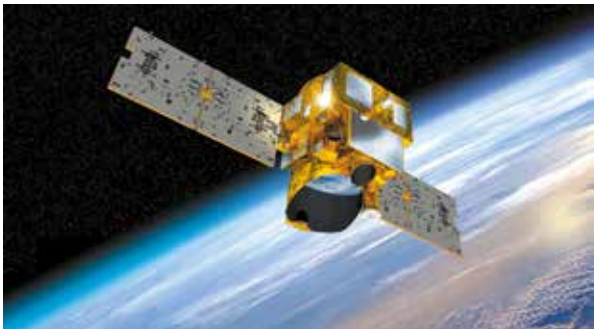
WORKING AS A TEAM

SWOT is planned to launch in 2020. The mission is receiving funding from France's PIA future investment programme and CNES is closely involved, supplying the spacecraft bus, DORIS instruments, K_u-band altimeter, KaRIn's radio frequency unit (RFU) and the ground control segment. SWOT data will be exploited at a processing centre built by CNES. This new joint effort with NASA extends the longstanding cooperation between the two agencies on TOPEX/Poseidon and the Jason series. *"The SWOT programme is working like an integrated programme team with daily videoconference contacts,"* says Thierry Lafon, SWOT project leader at CNES. Every six months, science teams, oceanographers and hydrologists get together at a seminar. CNES has also launched a preparatory programme for future SWOT data users to nurture development of applications.

Mont Cenis lake, Vanoise national park, French Alps.

MERLIN
METHANE UNDER SURVEILLANCE

Methane contributes significantly to global warming. The French-German MERLIN programme is set to track its variations day and night.



Both members of the European Space Agency (ESA), CNES and DLR[1] also work together on bilateral projects. The latest of these is MERLIN[2], which will focus on observing the impacts of methane, a powerful greenhouse gas partly responsible for global warming. The mission is set to monitor sources and sinks of the gas to derive models for calculating fluxes. In line with their respective governments' commitment to implementing the Copenhagen Accord, the two agencies are combining their expertise in pursuit of this goal.

HIGH-PERFORMANCE LIDAR AND SATELLITE

While data on methane are sorely lacking over regions of the globe like the Arctic and South America, MERLIN's observations are expected to enable scientists to test certain hypotheses. To this end, DLR has designed a high-performance lidar that will hunt for traces of methane in all seasons, including the polar night. With funding from France's PIA future investment programme, CNES will supply the satellite and ground segment. Currently in the definition phase, MERLIN is scheduled to launch in 2019.

1. Deutschen Zentrum für Luft- und Raumfahrt (DLR)
2. MEthane Remote sensing LIdar missioN

CFOSAT
WIND, WAVES AND CLIMATE

The result of a unique collaboration between France and China, the CFOSAT mission is focused on observing the surface of the oceans to deliver new insights into our changing climate.

CNES's partnership with the China National Space Administration (CNSA) is a first. Now an established player in space, China is turning its attention to new applications designed to support efforts to curb global warming. And France and Europe are working with it. CFOSAT, scheduled to enter operational service in 2018, is a joint mission through which the French and Chinese space agencies are set to cast their eye together on sea state, collecting and processing data via ground receiving stations and mission centres in both nations.

WEATHER FORECASTING

The CFOSAT satellite's French SWIM radar instrument will survey waves while its Chinese SCAT instrument will measure winds, a logical division of tasks, since waves are generated by wind energy. Such joint observations are the missing piece in the satellite data puzzle eagerly awaited by climate research scientists to enhance our understanding of atmosphere-ocean interactions. The highly innovative technology employed for the SWIM radar supplied by CNES is also expected to deliver unprecedented performance for measuring wave spectra. The satellite, supplied by CNSA, will serve as a demonstrator for future missions that could deliver a continuous stream of data for weather forecasting systems.

CLOSE COOPERATION

SWIM and SCAT's tasks are clearly defined, as are CNES and CNSA's responsibilities. This is the first time that French and Chinese teams have worked in unison in this way. "*Our cultural, individual and technical approaches are different. For a programme as complex as this, we had to build a climate of trust and find points of convergence*," explains Patrick Castillan, CFOSAT project leader at CNES. The result has exceeded expectations, with thermal, mechanical, electrical and radiofrequency tests confirming the good understanding between the two teams. Now in the final straight, their exemplary cooperation is bringing both engineering and human benefits.

CNES engineers integrate the electrical model of the SWIM instrument.

CARBON FOOTPRINT
CNES SHOWS THE WAY

Watching water consumption, printing on both sides of paper and encouraging eco-friendly modes of transport are just some of the efforts the agency is engaging to reduce its environmental footprint.

CNES is required to assure compliance with France's Grenelle environmental law. In 2011, it performed a full check of greenhouse gas emissions at all of its field centres. It could have stopped there, but that isn't how the agency sees things. A proactive attitude is ingrained in its culture and applies equally well to large-scale projects and routine everyday tasks.

The agency is rethinking its systems with a view to reducing its environmental footprint, which means cutting greenhouse gas emissions. In Paris, Toulouse and Kourou, it is looking to curb energy wastage, adapting and modernizing facilities, upgrading heating, cooling and lighting systems, installing photovoltaic solar panels and bringing water consumption under control. All of these efforts have already delivered quantifiable savings. For example, electricity consumption was reduced from 50,336 MWh in 2010 to 45,861 MWh in 2013, while gas consumption dropped from 57,652 MWh to 51,600 MWh.

CNES's daily work routines and practices are also becoming more virtuous. All documents are printed on both sides of paper to save forests and preserve vital carbon sinks. Transport plans encourage eco-friendly modes of transport, while bicycle changing rooms and garages motivate personnel to leave their cars at home. Increased use of videoconferencing also limits the need to travel. In the final analysis, all of these small steps add up to a smaller carbon footprint. Future initiatives based on voluntary carbon offsetting will further boost CNES's efforts.

The instrument undergoes electromagnetic compatibility testing in an anechoic chamber.the SWIM instrument.

IASI-NG
A WORTHY SUCCESSOR

Ten years after the launch of the IASI interferometer, a new-generation instrument is being readied to scale new heights of performance for meteorological observations.

In 2006, the scientific community discovered the remarkable results achieved with the first IASI instrument, which delivered temperature and humidity profiles derived from infrared spectra of the atmosphere. Now, the new-generation IASI-NG, a core element of the European EPS-SG[1], programme, is set to improve observations for operational weather forecasting and atmospheric chemistry from 2020 through to 2040.

25%

Expected gain
in accuracy from IASI-NG for atmospheric temperature profiles.

2021

The date
IASI-NG is scheduled to deliver its first results.

Climatologists are also eagerly awaiting IASI-NG to help them study several gases in Earth's atmosphere. By analysing the impact of these gases on the greenhouse effect, it will support long-term monitoring of climate change. IASI-NG marks a major technological step forward over its predecessor, as it will be the first such instrument based on the innovative principle of the Mertz interferometer to fly in space. The historic mission partners behind this world first are CNES, which is supplying the instrument, and Eumetsat, which will operate it.

ECONOMIES OF SCALE

The two key areas where the new interferometer really shines are its radiometric noise and spectral resolution, affording a twofold increase in performance and a significant expected improvement in characterization of the atmosphere. CNES will deliver IASI-NG to Eumetsat in 2019 for launch on a MetOp-SG satellite scheduled in 2021. To achieve economies of scale, three flight models will be built in succession but their launch will be phased up to 2035. With this follow-on instrument, climatologists can look forward to a treasure trove of data stretching from 2006 right through to 2040.

1. Eumetsat Polar System Second Generation

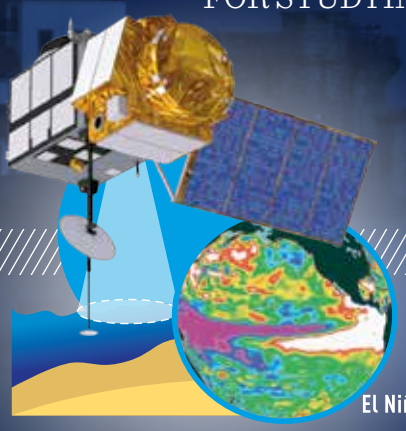
NEW-GENERATION BALLOON

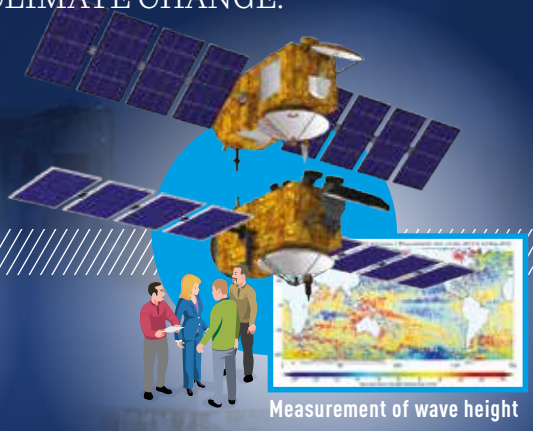
INSTRUMENTED BALLOONS USED FOR CLIMATE-OBSERVATION CAMPAIGNS are evolving. The oldest of them, zero-pressure stratospheric balloons, were made with polyethylene, a plastic suited to short missions and heavy payloads. The new generation is stronger and more eco-friendly. Pressure balloons for the Strateole 2 campaigns planned in 2018 and 2019 will thus be made of polyethylene terephtalate, a material capable of keeping gondolas aloft at a constant altitude for three months. A prototype Aeroclipper[1] balloon made of a fabric coated with polyurethane will also be developed next year to withstand winds and peer inside the eye of storms—a world first for CNES.

1. A small semi-stationary tethered blimp

JASON

PRECISE SATELLITE ALTIMETRY MEASUREMENTS DESCRIBE THE OCEAN FLUXES UNDERLYING THE ENERGY EXCHANGES THAT DRIVE OUR CLIMATE. AFFORDING GLOBAL COVERAGE AND A CONTINUOUS TIME-SERIES OF OCEAN DATA, THE JASON SERIES IS AN INVALUABLE TOOL FOR STUDYING CLIMATE CHANGE.





1992-2005

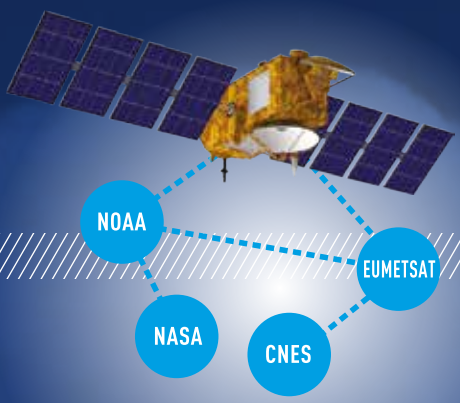
TOPEX/POSEIDON
THE PRECURSOR

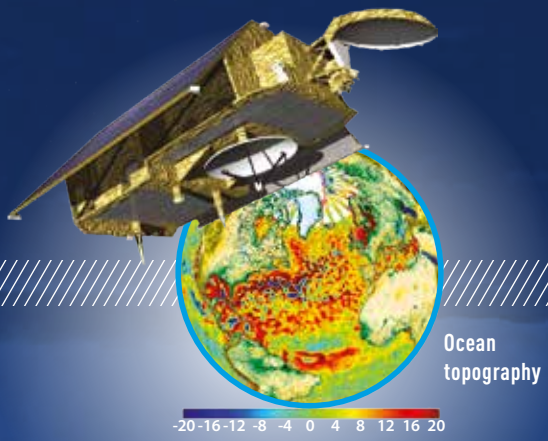
In 1992, CNES and NASA initiated TOPEX/Poseidon, an ambitious and innovative satellite altimetry programme designed to measure annual variations in mean sea level with centimetre accuracy. Successfully avoiding the traps posed by eddies and by wind and pressure variations, it pulled off the challenge and impressed the scientific community. It was the first satellite to get to the bottom of El Niño episodes. From this point on, satellite altimetry became a vital tool for climatologists.

2001-2013 AND 2008

JASON 1 AND JASON 2
THE SUCCESSORS

Jason 1 and Jason 2 succeeded TOPEX/Poseidon, measuring sea-surface height and surface wind speed in real time. Both satellites were built around Proteus, a small, light and radiation-hardened spacecraft bus conceived by CNES and Thales for their ocean-observing orbit. At the same time, CNES and NASA set up a science team to accompany the project from its development phase.





SECOND HALF OF 2015

JASON 3

OPERATIONAL OCEANOGRAPHY COMES OF AGE

Jason 3 shares the same orbit, instruments and measurement accuracy as its predecessors. Where it innovates is in the close international cooperation between operational agencies, space agencies, industry and users working together to set a new standard in terms of data quality and scientific and operational applications. Jason 3 will extend the uninterrupted time-series of data that goes back 23 years.

2021

JASON-CS/SENTINEL-6

JOINS COPERNICUS

Jason-CS/Sentinel-6, scheduled to launch in 2021, is part of Europe's Copernicus Earth-observation programme. This mission will be built around a new spacecraft bus derived from CryoSat and an enhanced Poseidon-4 altimeter. Operating in the same orbit, the satellite will pursue the mission of its predecessors. The new-generation SWOT radar mission will acquire surface water and ocean topography data to complement those acquired by the Jason satellites (see p. 22-23).

PIERRE BAHUREL

Managing Director of Mercator Ocean.

"Turning satellite data into something directly usable by a fisherman, research scientist or decision-maker..."

In November 2014, the European Union tasked Mercator Ocean with implementing and operating its ocean monitoring and forecasting service. At the helm of this Toulouse-based company is a visionary captain: **Pierre Bahurel, pioneer and promoter of French operational oceanography.** As a child, he wanted to be a mapmaker. As a student, he took a year out to work on a diving support vessel. Back at university, he chose oceanography. His career began in 1994, just as the recently launched TOPEX/Poseidon mission was opening up new horizons in this field. Pierre Bahurel turned his attention to a key technological challenge, combining satellite remote sensing with the power of computer modelling to test the concept of ocean forecasting. **In 1998, he produced the first operational ocean forecast bulletin for the French Navy.** Three years later, he helped establish France's first ocean analysis and forecasting centre. Mercator Ocean soon set the standard in ocean forecasting. But Pierre Bahurel was already looking further ahead: "*I was determined to give it the international identity, reach and recognition it deserves*," he says. His determination was commended by his peers and **he was chosen in 2007 to coordinate a European consortium of 60 partners in 28 countries that would lay the groundwork for Europe's future ocean data service.** Mercator Ocean, which today employs 60 people, is the flagship of this service. Its figurehead is still the same captain, proud to have kept France as its home port. The European Union's decision is a "*huge reward for French oceanography*," he says. A touch idealist, he's now looking beyond operational utility: "*Turning satellite data into something directly usable by a fisherman, research scientist or decision-maker—that's our mission. But by sharing this understanding of the marine environment, we're also making people more aware of the oceans and their role in the climate system*," he concludes.

FRANÇOIS PARISOT

Jason-2 Mission Manager at Eumetsat.

"Following in Jason's footsteps"

For almost two decades, François Parisot's career path has closely followed that of the Jason oceanography mission. At CNES, he was one of the linchpins of the Jason-1 programme. ***"I've always loved oceanography and believed in its vital role in climate monitoring,"*** he says. In 2003, François Parisot left France to join Eumetsat[1] in Germany, where he helped develop applications for the Jason programme. At the time, the intergovernmental organization and weather satellite operator was seeking to extend its scope of action. After changes to its remit, it moved into operational monitoring of the climate system and climate change.

As Altimetry Manager at Eumetsat, François Parisot contributed his expertise and stepped up to the challenge: "*Jason-2 offered key capabilities for ocean and climate observation, particularly wind, wave and current measurements and monitoring of sea level rise*," he adds. "*We developed a whole range of custom products, from very-short-term datasets to extremely precise monitoring over longer timescales.* ***This flexibility combined with high-quality products ensured Jason's success*** *with the user community, which has thousands of members.*"

Despite these achievements, space altimetry isn't all smooth sailing. "*Feedback has consistently confirmed the excellence of Jason products and the absolute need to pursue this type of observation*," concludes François Parisot. "*It's also one of the most successful space partnerships between Europe and the United States.* ***However, public funding is crucial during the operational phase, but securing it isn't getting any easier!"*** The Jason-3 mission has the support of the European Commission, which is funding operations through the Copernicus programme.

1. Intergovernmental organization with 30 member countries.

TRU'O'ONG CÔNG CHOR'I

Vietnamese fisherman.

"The Movimar system has revolutionized the way we fish."

In 2006, Tru'o'ong Công Chor'i was captain of a fishing vessel in the South China Sea when he and his crew were caught in Typhoon Chanchu. Many of them did not survive. Nine years later, **he was again caught at sea when Typhoon Maysak struck in April 2015**. He had 35 hands on board, but this time they avoided tragedy. Equipped by the Vietnamese government with Movimar, a high-tech solution combining fisheries monitoring with a satellite-based storm warning system, fishing vessels are now alerted to the dangers of tropical cyclones. In Vietnam, CLS[1] has supplied more than 3,000 fishing boats with LEO satellite-based transmitters and Marlin terminals. The company has also set up three fisheries monitoring centres. ***"I can clearly remember the first storm warning we received on the system,"*** says Tru'o'ong Công Chor'i. *"It was 3 April and the alert was issued by one of the shore-based centres."* The crew set a course away from the approaching low-pressure system. The alert continued for three days. On 6 April, the typhoon finally tracked away from the area and they headed back to their usual fishing grounds.

Today, one thing is clear: these typhoons are causing increasing levels of devastation in Asia. They are much more intense than the storms observed a century ago. Rising ocean surface temperatures and dramatic changes in atmospheric circulation patterns seem to be the main factors driving this worsening trend.

"Before Movimar, there was no other warning system for fishermen at sea," he concludes. ***"Today, we get daily weather bulletins as well as alerts if there's any immediate danger.*** *The system has revolutionized the way we fish. We feel much more confident and it's taken a lot of the worry out of our job."* While the impact of human activities on the environment can be catastrophic, the impact of technology on our quality of life can equally be beneficial.

1. CLS (Collecte Localisation Satellites), a subsidiary of CNES, IFREMER and investment company Ardian, has been operating satellite systems and delivering value-added products and services since 1986.

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

ETHICS CORNER

JACQUES **ARNOULD**

THE FROG AND THE BUTTERFLY

In two centuries, humankind has climbed to a higher vantage point, using balloons, planes and rockets. This in turn has changed how we see our planet, its weather systems and climate.

It's all a question of scale. Looking at the world from a frog's perspective, our horizon will never go beyond predicting the immediate weather. A halo around the Moon, the wind picking up or changing direction, a chill in the air or a swallow skimming the grass, and instinctively we're wondering what the weather will be in the next few hours. With the development of weather science, its observation and communication networks and its prediction models, our horizon has been pushed a few days further forward, enabling us to save lives and crops and protect the works of art our hands have achieved. But we're still on a frog-like scale. From high above our heads, the seasons change and the years pass in a never-ending procession. Or as wise people of ages past have often wondered: "Is there ever anything new under the Sun?"

AFTER US, THE DELUGE!

When humans took on the wings of a butterfly, then the wings of an eagle, when they pushed beyond the limits of the atmosphere using satellites, they not only improved their weather forecasting, they also discovered that, low and behold, Earth's climate was losing its eternal immutability. Yes, there is something new under the Sun—from temperatures to sea levels, polar ice caps to biomass, everything seems to be changing. At the risk of sounding ominous, has no one pointed out that a butterfly beating its wings can cause a tidal wave? On a butterfly-like scale, humanity's horizon now extends to the entire planet and decades into the future. And what we're seeing looks frightening, catastrophic even.

Should we listen to the admirers of Madame de Pompadour, who cling to their frog-like perspective and drown their sorrows by repeating her now-famous mantra "After us, the deluge…"? Rather, I believe it's time to take a serious look at the future of humanity and our world. We already have the means to measure the impact of our deeds on the present and transpose them into the future. So what's stopping us from changing course, so far as we're willing and able, and starting to reverse some of the worrying statistics about the health of our beautiful and venerable planet? A lack of determination or boldness? Remember the butterfly, which also goes through several transformations in the course of its lifecycle. What if humanity is on the verge of such a metamorphosis?

BOOK

CLIMATE CHANGE AND SATELLITES

As France prepares to host the COP21 climate conference, Sud(s) Concepts has republished its magazine-style book Changement Climatique & Satellites (2007). In this 176-page updated edition, the original authors have revisited their copy and others have joined them, with a new chapter on the impact of climate change on society. CNES is pleased to be associated with the new edition produced by Thales Alenia Space.

EXHIBITION

CULTURE CENTRE

As part of a science outreach partnership between CNES and cultural venues in Toulouse, Rangueil community centre is putting on an exhibition from 2 to 19 June on climate change and polar animals, with an information point and video screenings.

INNOVATION

C3 CLIMATE CHALLENGE

We're looking for new ideas to take on the climate challenge! In a novel approach, C3 is open to innovative project ideas from citizens and professionals, start-ups and larger organizations—anyone can get involved. Launched by various partners, including CNES, the Meteo-France national weather service and the survey and mapping agency IGN, C3 is sponsored by France's General Secretariat for the Modernization of Public Action and the Ministry of Ecology, Sustainable Development and Energy.

+ **WWW.C3CHALLENGE.COM**

TECHNOLOGY

ACTINSPACE, ACT 2

The second ActinSpace event was held on 20 and 21 May. Teams had just 24 hours to solve climate-related and other problems set by CNES and ESA, using space technologies.

ETHICS

A BLUE PEARL

Viewed from space, Earth is a blue pearl of singular beauty. It is subject to all kinds of changes, which we are learning to measure and predict. What if space could teach us how to work together to secure our planet's future and our own? After *La seconde chance d'Icare – Pour une éthique de l'espace* (2001) and *Le rire d'Icare – Le risque et l'aventure spatiale* (2013), Jacques Arnould continues his reflections with a new book entitled *Une perle bleue. L'espace, la Terre et le changement climatique*. Published by Cerf (2015).

CNES's pavilion at the 2015 Paris Air Show.

COP21

PART 1, PARIS AIR SHOW

For CNES, the Paris Air Show (15–21 June) marks the start of a major operation leading up to the COP21 international climate conference. As in previous years, CNES is organizing a large-scale 'space for climate' installation. Under a huge dome representing our planet, space-based solutions to climate change are presented in a highly original manner, with immersive staging, giant screen and interactive exhibits.

PART 2, AUTUMN EVENTS

CNES will be pursuing this effort at France's national science week (7–11 October) with the ClimaTrain. From 6 October, the ClimaTrain will carry the message to people in cities up and down the country, from enthusiasts to the simply curious. A section of the train will show how space is helping to better understand climate. Also in the autumn, the CNES climate dome will be back in Paris to support preparations for COP 21. It will also be part of the operation at the Grand Palais (4–11 December) alongside a host of organizations and industry partners proposing solutions to cope with climate change.

DIARY

15–21 JUNE
Paris Air Show
Paris-Le Bourget airport

7–10 JULY
Science conference on climate change
UNESCO (Paris)

22 JULY AT THE EARLIEST
Launch of Jason-3 oceanography satellite

6 SEPTEMBER – 11 OCTOBER
French national science week (ClimaTrain)

25 SEPTEMBER
European Researchers' Night
Brest, Montpellier, Toulouse

13–16 OCTOBER
Pollutec show on low-carbon solutions
Paris – Porte de Versailles

17–19 NOVEMBER
Symposium on water and energy cycles in the tropics
Paris – Maison des Océans

CAR SHARING GETS CLEVER WITH COOVIA

Coovia is a smartphone app that combines GPS positioning with car sharing. CNES helped the start-up to develop its product through ESA BIC Sud France.

At 8 in the morning it's gridlock on the ring road in Bordeaux, Paris and Toulouse. *"It's bad for your health and bad for the climate! Automobile pollution really is an environmental curse,"* affirms David Larcher, the creator of Coovia[1]. It's also bad for the economy: *"the yearly cost of driving to and from work amounts to a month's wages,"* he points out.

The simple concept dreamed up by David Larcher involves using private vehicles to extend public transport. *"There's always a free seat in a car somewhere,"* he explains. *"Our app tracks them and creates a synergy between public transport databases and social network platforms."*

The innovative feature of this app is its reliance on space. *"Coovia users are geo-located by GPS to optimize the system's responsiveness and flexibility,"* explains Larcher. Since last January they can also change or even cancel trip requests.

Supported by ESA's Business Incubation Centre (BIC) Sud France, Coovia germinated on the fertile ground of Toulouse, the cradle of the space industry. ESA's first business incubation centre in France, ESA BIC Sud France is run by the Aerospace Valley competitiveness cluster in association with CNES and the Pégase competitiveness cluster. Today, the Coovia app is operating in Rennes, Nantes, Paris and Bordeaux. It is expected to turn its first profit next year.

+ HTTP://WWW.COOVIA.FR

1. David Larcher won the Open Data Toulouse Métropole 2012 Grand Prize for Coovia

VIDEO

[+]

WWW.CNES.FR

Our reporter test drives the app in Toulouse

8,500

The number of people using the Coovia network in Toulouse. 800 trips are logged every day.

16%

That's how much the number of vehicles on the road could be reduced by two people sharing every car (source: CGDD, the office of the French commissioner general for sustainable development).