CLS MAG

N°2

Special issue on climate

King penguins raise the alarm

Tuna & climate: trends and forecast

Climate change:

myth or reality?
Satellites reveal all

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CLS, a subsidiary of the French Space Agency, ARDIAN & IFREMER, is a worldwide company and pioneer provider of monitoring and surveillance solutions for the Earth since 1986. Its mission is to deploy innovative space-based solutions to understand and protect our planet, and to manage its resources sustainably. CLS employs 700 people, at its headquarters in Toulouse (France) and in its 26 other sites around the world. The company works in six strategic areas of activity: sustainable fisheries management, environmental monitoring, maritime surveillance, fleet management, energy & mining, space & ground systems. CLS process environmental data and positions from 100,000 beacons per month (drifting buoys, animal tags, VMS beacons, LRIT tracking, etc.), ocean and inland waters observations (more than 20 instruments onboard satellites daily deliver information to CLS on the world's seas and oceans). In addition we monitor land and sea activities by satellite (nearly 10,000 radar images are processed each year by CLS). The CLS Group had a turnover close to 122 million Euros in 2017 and plans to increase it to about 136 million in 2018. The group, which has been achieving strong growth these last few years, has set ambitious goals to take advantage of the opening-up of new markets. www.cls.fr
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Editorial

How can we be sure that biodiversity really is threatened, that oceans are in tumult and that climatic events are becoming more dramatic? How can we measure and observe a phenomenon such as global warming? How can we adapt to its consequences? Only satellites can testify to this global reality and without them, it would be difficult to find solutions.

CLS was created by the French space agency, CNES, 30 years ago to operate the ARGOS location and environmental data collection system. Since then, it has increased its portfolio of tools and its expertise, currently using 15 satellite missions (more than 100 satellites) to help scientists the world over update our planet's health record. What do we see from space? We can make observations, undertake studies and come up with diagnoses. Find out more in this special issue on the CLIMATE.

Christophe Vassal,
Chairman of the CLS executive board.

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> **This measurement shows that overall our planet is warming.**
>
> *Michaël Ablain*
> Head, Performance, Mission and Climate Division, CLS

WHEN THE SEA RISES...

Michaël Ablain is an engineer who loves a challenge. He is a long-distance runner, a cross-functional manager and has been in charge of calculating mean sea level for almost 20 years.

The mean sea level has been constantly rising since 1992: +3.3 mm/ year. Indisputable data.

There are only about ten people in the world who know the accuracy of our altimetry satellites! For over 20 years, these satellites have enabled us to measure and observe the slightest movement, the smallest mood swings of our seas and oceans.

Michaël Ablain heads the Performance, Mission and Climate Division at CLS. Every month, he and his team publish the latest data on mean sea level. He is passionate about meteorology: already by the age of 12, he was carefully noting the temperature and level of rainfall in his garden. Today, Ablain "and his team" (as he insists) study the entire planet's environment.

There are about 50 employees at CLS working together to establish the key indicator of global warming: mean sea level. For over 15 years, Ablain, an engineering graduate of INSA (Institut National des Sciences Appliquées) has been coordinating the collection, processing, calibration, correction, and validation of this fundamental measurement for the international scientific community.

His job is to ensure its accuracy!
Michaël Ablain comments on the results: "*The verdict is final: the sea level has been rising constantly since 1992 at an average of 3.3 mm per year. But this is only an average. This level has increased almost 20 cm across the western edge of the tropical Pacific, with the first victim being the Kiribati Islands.*

And this level can also stagnate, sometimes even decrease, as on the eastern shore of this basin, where we've found a drop in sea level of as much as -4 cm in 20 years. Nevertheless, this measurement still shows that overall, our planet is warming. Our oceans store this heat, and like water boiling in a pan, they expand and are about to overflow. The data are indisputable!"

Michaël Ablain remembers the famous year 1998 in which France won the football World Cup but more seriously, it was the year of the largest El Niño ever recorded, prior to the one we are now experiencing.

That year his mentor, Joel Dorandeu, Head of Space Observation at CLS , noticed that the mean sea level was rising. "*At the time, no one was talking about global warming. Was it a measurement error? The controversy began.*"

Encouraged by Anny Cazenave, member of the French Academy of Sciences and oceanographer at LEGOS*, and by teams at the French Space Agency, CNES, Michaël Ablain embarked on a quest to measure the sea level with extreme precision.

This great athlete, who has made sport a way of life, likes challenges and last summer ran the Ultra Trail Race on Mont Blanc, has proven that mean sea level is a reliable indicator of climate change. The measurements are taken from satellites in orbit several hundred kilometres above the Earth, and are accurate to within 0.5 mm!

Today, using altimetry, CLS observes the sea level, currents, ice banks, rivers and even icebergs. Michaël Ablain, with his lifelong passion for meteorology, checks weather simulation models twice a day and more often when there is an extreme weather event. This hardworking engineer looks towards the future, and his goal is to understand the climate!

* Laboratoire d'Études en Géophysique et Océanographie Spatiale, CNRS

SCIENCE CALLS THE TUNE(A)

This brilliant scientist has worked for over 20 years to unravel the mysteries of tuna. His conclusion: tuna can adapt to climate change provided that we quickly limit overfishing!

More than an evolution, Patrick Lehodey is striving for a revolution in fishing practices and management.

Son of a seamstress and a shopkeeper, nothing in his background would have indicated that Patrick Lehodey should become interested in marine resources, and even less to make it his life's work. Yet the head of Marine Ecosystems Modelling at CLS has just started his third decade of research on the subject. Originally from Normandy, father of three children, and a yachtsman in his spare time, Patrick Lehodey is trying to unlock the secrets of bigeye, yellowfin, skipjack and albacore tuna. The goal of his quest is to continuously improve his model, which forecasts changes in marine populations.

What makes him different is that he has modelled, and therefore been able to understand and predict, what cannot be seen. Lehodey and his team succeeded by including a mysterious component in their model: the micronekton. Essential for aquatic life and the basis of the tuna diet, micronekton is one of the most important marine resources on which all others depend. Taking into account the precise location of micronekton it is possible to predict the movements and distributions of their predators. Scientists can therefore predict changes in the populations of tuna, turtles, seabirds and whales, which enables us to better protect them or manage fishing. He says, "*It was the missing link between what we can see from satellites by observing the colour of water, which shows the presence of phytoplankton, and what is measured at the other end of the food chain with the catches.*" Micronekton is undoubtedly the key component of the food chain – the holy grail of marine biologists for understanding population dynamics as a whole.

Thanks to this breakthrough, Patrick Lehodey and his team now use this model to predict the impact of fishing, pollution and climate change on marine populations. He sounds the alarm: Our marine resources and in particular tuna could adapt to global warming, but only if we return to reasonable levels of fishing. Today, some stocks such as bigeye tuna in the Pacific are down to 20% of their original biomass because of overfishing. This overfishing, added to the effects of global warming, will sound their death knell in the coming decades, and make those whose lives depend on fishing into economic refugees. We must act now! If we apply IPCC's most pessimistic scenarios to the tuna model, the tuna stocks will experience increasing pressure over the next twenty years. It is essential to act now. The first solution is to strictly control catches and eliminate illegal fishing.

There are ways of doing this. CLS has been developing effective solutions for the last twenty years. These new tools combine space observations, numerical models, positioning systems and real-time data collection.

CLS is working with many governments to implement reasonable fisheries management, fight illegal fishing and create sustainable fisheries. More than an evolution, Patrick Lehodey is striving, along with other CLS teams, for a revolution in fishing practices in the hope that our planet will not lose its biodiversity and thus continue to provide valuable resources for a long time to come.

> **"The future of tuna populations depends on strictly supervising catches and stopping illegal fishing.**
>
> *Patrick Lehodey*
> Head of Marine Ecosystems at CLS

TUNA & CLIMATE: TRENDS AND FORECAST

Today, marine resources are too often depleted (due to overfishing and illegal, unreported, and unregulated fishing) and are also victims of human activity (pollution). These stocks will only be able to adapt to global warming if we return to sustainable fishing levels. Today, scientists have found that stocks of certain species such as bigeye tuna in the Pacific have been reduced to less than 20% of their original biomass as a result of fishing pressure. This pressure, added to the effects of global warming, might lead to their stock collapse. The reasonable threshold established by scientists is around 40%. According to recent simulations, the peak pressure that major tuna stocks will experience, from the combined effects of fishing and climate change, should occur by mid-century. For nearly 30 years, CLS has been working for the sustainable management of marine resources using satellite observation. More recently, CLS has begun modelling marine ecosystems. What do these CLS modellers predict for the future? Which nations will be the winners and which the losers? Find out more below.

Starting in 2060, albacore tuna stock should rise again – provided that there are still tuna left to spawn…

PREDICTION: THE CRUX OF THE MATTER

The forecasting model developed by CLS' Marine Ecosystems Department simulates marine population dynamics for species such as tuna, in time and in space. This forecast is based on physical and biogeochemical conditions in the ocean, as well as fishing, pollution and global warming data. The model can predict the population distribution at different stages of life (larvae, juveniles, immature and adult fish).

TUNA & CLIMATE: RECENT DATA

Albacore is a species found in the three oceans and the Mediterranean. It is sold canned, fresh or frozen. To predict the impact of global warming on this species (also called white tuna), CLS scientists introduced scenarios from the IPCC in their model to predict changes in tuna populations. Patrick Lehodey and Inna Senina, CLS' two experts on marine resources, used IPCC's most pessimistic scenario (A2).

This scenario assumes that the rise in our emissions of greenhouse gases will remain constant over the coming decades.
Lehodey shared the first results with us: "*We expect a continuous decline in the stock until 2060 in the Pacific. Albacore in the South Pacific will be directly affected by warming waters, as conditions degrade in their current spawning areas in the Coral Sea and the subequatorial region. The warming of the surface water will increase stratification and reduce the ascent of nutrients needed for photosynthesis, which is the basis of the food chain. As a result, larval survival rates will decrease. The model also predicts that a new favourable site for spawning and larval survival will develop in the north Tasman Sea from 2060. The stock should then rise again, but only if we strictly control fishing to keep the spawning stock at a high level.*"

Marine resources will have to be controlled in order to adapt to these new conditions. The future of tuna and our natural and economic resources depends on it.

The stock of Albacore tuna, which is sold canned, fresh and frozen, is likely to decline until 2060 in the Pacific: this is the CLS forecast based on the most pessimistic IPCC scenario.
© Istock

TUNA HEADING NORTH

For several years now, Atlantic bluefin tuna have been migrating further and further north in the summer. The species is benefiting from warmer ocean waters and probably also from the larger habitat of its prey, for example the Atlantic mackerel.

"Bluefin tuna is a species that migrates seasonally to feed in waters at high latitudes that are particularly rich in the summer months. Bluefin tuna have been found off the coast of Iceland, and it is likely that this tendency to migrate further north is related to a warmer climate, but we also have to take into account decadal variability," says Inna Senina, researcher at the Department of marine ecosystem modelling at CLS. Given this new distribution, Norwegian fishermen have obtained an exploratory fishing quota and they hope to find bluefin tuna back in their waters. The species disappeared from Norway's coastal area more than 30 years ago.

TUNA AND TRENDS

Based on its data and forecast models of marine population dynamics, CLS expects that populations such as albacore tuna or bigeye tuna will tend to extend their summer migrations towards the North Atlantic. As part of the European research project Atlantos, an operational version of CLS's model applied to albacore tuna will be implemented to monitor these changes.

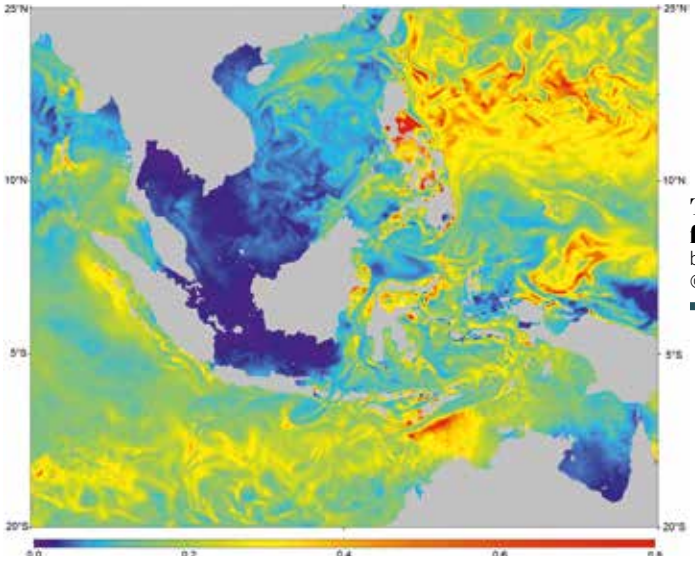
EXPLORING THE IMPACT OF CLIMATE CHANGE ON TUNA

To predict the impact of global warming on tuna, CLS scientists ran simulations of climate change with and without fishing pressure to identify the separate effects of each. Simulations were done on the four main exploited Pacific tuna species: skipjack, yellowfin, bigeye and South Pacific albacore using IPCC scenarios of greenhouse gases release for the coming Century. With the "business as usual" scenario, one of the worst defined by IPCC, the forecasts point to a decline in the western Pacific Ocean and/or distribution shifts towards the eastern Pacific for skipjack, yellowfin and bigeye tuna. For skipjack and yellowfin, this decrease is compensated for by an increase in the central-eastern Pacific, where productivity is projected to remain relatively high. For South Pacific albacore tuna, the projected change is different: current spawning grounds are predicted to shrink, but a new one could emerge in the north Tasman Sea from 2060. Yet the scenario for bigeye tuna is the most alarming: even if they stay in the eastern Pacific, all simulations up to now point to a continuous decline.

Climate Change vs Fishing effort

These forecasts are based on environmental changes without fishing impact. When adding fishing and related mortality by simply considering the projection of the current fishing effort, the simulations showed that fishing would remain the major determinant of tuna stocks, at least during the first half of the Century, leading to a strong decline in the western equatorial Pacific. However various sources of uncertainty remain, especially due to the coarse resolution of the model, that are currently explored.

Nevertheless, a first conclusion from these studies is that though tuna stocks may be able adapt to global warming, the additional pressure due to climate change needs to be included now in the management of this valuable resource.



Tuna distribution forecast
by CLS' SEAPODYM model
© CLS

CLS has delivered SEAPODYM, its model for marine population dynamics, to Indonesia. CLS works routinely alongside local organisations for the protection of marine resources.
©CLS

The mean sea level has been constantly rising since 1992: +3.3 mm/year.

THE OCEAN: KEY TO OUR CLIMATE

Although the climate has now become a hot topic, a key player seems to have been left out: the Ocean! Yet it is the planet's main carbon pump and has the largest capacity for storing heat. Understanding climate mechanisms primarily means understanding the ocean. But how can we learn more about this immense maritime territory? Over the last 30 years, observation systems for the ocean have made giant leaps. The development of satellites for space oceanography and collection of environmental data has been the driving force behind this revolution. From the start, CLS was a pioneer in the field, and receives, processes, and qualifies these satellite data for the entire international community. As world leader in altimetry and the exclusive operator of the ARGOS system for location and collection of environmental data, CLS works daily with experts in climatology. Today, they provide us with their perspective and give us an update on the planet's health.

OUR LEADING INTERVIEW

CLS MAG recently met with Anny Cazenave, member of the Academy of Science and of the Intergovernmental Panel on Climate Change. Anny Cazenave is a renowned researcher on climate change and routinely uses CLS's mean sea level indicator. She tells us just how important it is and emphasises the leading international position* of CLS in establishing this key indicator of global warming.

WHY IS IT IMPORTANT TO DETERMINE MEAN SEA LEVEL?

Mean sea level is one of the best indicators of global warming. Certainly much better than mean global temperatures.
Today, because of greenhouse gas emissions generated by human activities, our planet has an energy disequilibrium. It is accumulating heat and 93% of this excess heat is stored in the oceans. The remaining heat is causing the ice caps to melt and is heating the atmosphere.
Sea level is related to ocean warming and ice cap melting, and are therefore a key indicator of global warming.
This is because heat that accumulates in the oceans dilates the water, resulting in higher sea level. Melting mountain glaciers and the loss of ice mass in Greenland and Antarctica are another cause of the current rise in sea level. But the higher levels are far from uniform. Specific zones have seen levels rise four times faster than the overall average. This is the case for instance in the western tropical Pacific Ocean. Certain coastal regions are therefore worse hit than others by the phenomenon.

HOW DO YOU USE THIS INDICATOR?

At LEGOS**, we are trying to understand the regional and global causes of changes in sea level. Our research has shown that the mean overall rise in sea level over the past 20 years is caused for about 35% by ocean warming, 45% by melting of continental ice, and 10% by pumping water from underground sources, since this water ultimately ends up in the ocean. The remaining 10% is not accounted for at this time, but is most probably related to uncertainties in measurements. To establish a very clear picture, we need data that are as accurate as possible. ■■■

> **“The processing and qualification of data on mean sea level done by CLS is fundamental.**

* Portrait Michaël ABLAIN, when the see rises… page 4
** Laboratoire d'Études en Géophysique et Océanographie Spatiale, CNRS

More information on http://aviso.altimetry.fr/fr/ or scan this QR code

Benoît Meyssignac, Doctor of Science at LEGOS**

CLS has been working extensively these past few years on precise calculations of sea levelsbased on space altimetry data from several satellites.
Today, CLS provides us with highly accurate "sea level" products
The "sea level" indicator calculated by CLS is increasingly reliable and more and more accurate. It is no doubt one of the best products available today.

WHY IS THIS INDICATOR CRUCIAL FOR MANAGING THE CLIMATE?

Mean sea level is rising, as we said. It is a key indicator of current global warming. The time-series of sea level measurements taken by CLS are also used to validate the climate models developed to simulate future changes.

WHAT IS YOUR FORECAST FOR FUTURE SEA LEVEL?

If we continue to emit greenhouse gases at the same rates as today, climate models predict a rise in mean sea level of 50 cm to 1 m by the year 2100 (compared to level in the year 2000). Based on the optimistic scenario of a reduction in greenhouse gas emissions aimed at maintaining warming below 2 degrees, mean sea level will still increase by 40 cm on average (also versus year 2000 level). As is now the case, the increase will differ significantly according to the regions, including an expected increase of about 30% in the tropics. The extent of the impact on coastal regions will depend on the amount of greenhouse gases emitted by humans in the coming years.

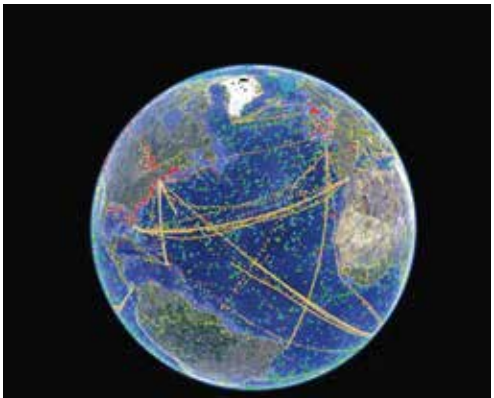
IS GLOBAL WARMING A NATURAL PHENOMENA?

To answer that question, Benoit Meyssignac, Doctor of Science at LEGOS uses the sea surface height data calculated and qualified by CLS.**

He compares variations in sea level to estimate the energy disequilibrium of the planet caused by the climate change. In his report, Benoit Meyssignac, a specialist in climate studies, shows that this energy disequilibrium has resulted in excess heat being accumulated by the Earth over the last few decades, and that it is due mostly to human activity and not to natural climate variability.

A WARNING TO SCEPTICS

According to scientists, many islands will have disappeared between now and the end of the century, leading to the exodus of their populations.
To those who still doubt the accuracy of measurements of mean sea level, CLS engineers reply calmly that there is no longer any doubt whatsoever.
Since 1992, the mean level of the seas has risen…
On average this level has risen by 3.3 mm/year and the figure is accurate to within half a millimetre.



CLS processes, calibrates and distributes the data of more than 6000 oceanographic beacons to the international scientific community.
© CLS

ARGO, THE PLANETARY THERMOMETER

The ocean can store 1000 times more heat than the atmosphere. The network of underwater ARGO floats measures the temperature and salinity of the oceans from the surface down to a depth of 2000 meters. This unique network of 3880 autonomous beacons is used to measure thermal expansion due to global warming of the Ocean. An indispensable complement to satellite observation data, it unfortunately does not sufficiently take into account marginal seas or ice areas today. CLS processes the data of 75% of the ARGO fleet and transmits them to climatologists around the world. Some floats already measure the chemical composition of our oceans (dissolved oxygen, CO2, pH, chlorophyll, nitrogen) to better characterise the acidification of our waters. In addition, instruments capable of descending into the deepest parts of the ocean and of bringing back accurate measurements of temperature and salinity at depths of up to 6000 meters, are currently being developed. The aim is to improve our understanding of ocean currents, which in turn will increase knowledge of the Earth's climate.

BIODIVERSITY... HIGH STAKES FOR HUMANITY

From now until 2050, polar bear populations will diminish by three quarters due to global warming. Since 1981, 900 bears have been tracked with Argos at CLS.

Global warming in the Arctic means that ice fields are forming later and later in the year. Polar bears linger for longer on the coastlines. Their hunger pushes them to venture increasingly into Inuit villages, rummaging through dustbins, ravaging landfill sites, prowling around houses in search of food. As this phenomenon grows more frequent, the Inuit believe the species is not at risk. It's easy to jump to this kind of conclusion if you don't study a species in its entirety, if you don't have perspective. This is where CLS and satellites come into play. The study of highly migratory species or animal populations living in extreme environments can in fact only be done from space. In 1978, CNES, NASA and NOAA created the ARGOS satellite location and environmental data collection system. Data from the system is acquired, processed and shared by CLS with the international scientific community. Each month, the company tracks over 8,000 animals. More than 100,000 have been monitored since the 1980s. Here is an overview of the impact of climate change on biodiversity, as seen from space.

George Durner,
USGS Alaska Science Center
© Photos and results

https://www.facebook.com/trackwithargos

BEARS ON BORROWED TIME

900 bears have been observed from space, with over the equivalent of 300 years of tracking data by CLS.

The conclusion is that since the '90s, the polar bear's hunting habitats have been altered, reduced and spread out considerably. To find food, the bear must travel further afield. In the 90s, he travelled a few hundred kilometers, but today a polar bear can cover over 1,000 km in a single week of hunting, costing him considerable energy expenditure. The distribution of female bears' dens has also changed. Since the quality of snow has deteriorated, the dens do not last as long. All this data led to the polar bear, *ursus maritimus*, being classified as an endangered species in 2008. Despite this measure, scientists forecast that between now and 2050, the population of the polar bear will diminish by three quarters, dropping from 25,000 individuals to 5,000.

LEATHERBACK TURTLES: EXODUS

Already at risk from man (through occupation of nesting beaches and fishing), turtles are now threatened by rising sea temperatures.

This parameter determines their habitat zone (26-30 °C). We know this thanks to Argos data collected from females equipped with Argos transmitters. With rising temperatures forecast for our oceans, Pacific leatherback turtles will move away from the equator. But will they survive the exodus?

With ARGOS data and population dynamics models, scientists have proved that leatherback turtles are likely to leave their traditional habitat. Will they survive this exodus?

A TRANSMITTER SMALLER THAN ONE EURO CENT COIN

Birds are bio-indicators of climate change. They have been observed to migrate and lay eggs earlier than in the past, as their migration corridors, feeding and reproduction patterns alter. These discoveries are made possible by satellite tracking. With advances in miniaturisation, very small birds will soon be equipped with the smallest ARGOS solar transmitter. Lighter than a one euro cent coin (2.3g), it will enable biologists to study over 1,000 new species. This technological advance will enhance our understanding of the impact of global warming on biodiversity.

© Ben Parkhurst

ARGOS FORUM

Discover the full accounts of these victims of climate change with our ARGOS FORUM
www.argos-system.org
or flash our CLS-CLIMATE QR Code.

PHENOMENAL EVOLUTION

In Australia, climate change has generated increasingly severe drought phenomena.

From agriculture to urban consumption, water supply is becoming more difficult. Some species react better than others. The banded stilts are one of the species that should easily adapt to the new conditions. With ARGOS satellite tracking, scientists have discovered that these birds fly hundreds of kilometres at night to reach areas of the country which have just been flooded, where they hurry to build nests and reproduce. These birds are even capable of feeling the rain and undertaking incredible journeys! One specimen travelled 2,000 km in two days to find a freshly flooded salt lake! Stilts are practical to the extreme. During long drought periods, they hang about in the marshy areas near the waterfront and wait for favourable conditions before breeding. But one mystery persists : how can stilts sense the arrival of rains from several thousands of kilometres away?....to be continued!

BIOLOGISTS OF SOUTHERN LATITUDES

Based in Chizé, in the Deux-Sèvres region of eastern France, their real field of investigation is thousands of kilometers away from mainland France. In the French Southern and Antarctic territories, made up of the Crozet and Kerguelen islands and Adélie Land, these far-flung researchers are studying unique regional biodiversity. First of all we find Henri Weimerskirch, director of the 'marine predators' team from CEBC/CNRS and a specialist on albatross, next Christophe Guinet, the elephant seal expert and Charles-André BOST, alias Charly, the king penguin man. Between the three of them, they track almost 400 animals via the ARGOS system. Together, they've discovered the 'positive' or negative effects of global warming on the three populations endemic to these southern territories.

HENRI WEIMERSKIRCH

has proved that accelerating winds, a secondary effect of global warming, cause the albatross to expend less energy during its fishing expeditions. Larger birds are more resistant. The winds have also redistributed their feeding zones. These new, unexploited zones are less dangerous for the albatross. Indeed, industrial fishing lines equipped with fishhooks are a great threat to the species when they have to feed in fishing zones.

CHRISTOPHE GUINET

has discovered that global warming shifts the elephant seal's feeding zones to deeper waters. These mammals therefore spend more time and energy in diving for food. Consequently, the females build up less reserve, and give birth to offspring that are less equipped to face life's challenges. They also wean them in worse conditions. As a result, mortality rates could reach 70 to 90 % in unfavourable oceanic and climatic conditions.

CHARLES-ANDRÉ BOST

has placed nearly 200 Argos transmitters on king penguins, and his conclusion is clear. Using data collected from the Argos satellites, scientists have established predictive models which show that if man continues using fossil fuels as he does today, king penguins will have disappeared from the north of their distribution area (Crozet and Marion islands) by 2100. This disappearance would be a dramatic loss for the biodiversity of these regions. It would also entail the loss of a link in the food chain, with a still unknown impact on the Southern Ocean.

All these studies and results allow us to evaluate the expected effects of climate change on the mythical populations around the South Pole.

On Crozet, Kerguelen and Terre Adélie, CEBC/CNRS researchers study regional biodiversity thanks to Argos and CLS.

Top left to right:
Christophe Guinet
Charles-André Bost
Henri Weimerskirch

LIMITING OUR CARBON FOOTPRINT

A global reduction of 40% to 70% by 2050 is essential. The ultimate objective is to approach zero emissions by the end of the century. Here again, satellites, which are already operational, will continue to play a key role. CLS uses satellites to monitor our carbon footprint in maritime areas. How? By optimising all human activity on our seas and oceans: maritime routing, support for green energy, protection of mangrove forests, and tax incentives to reduce the production of waste.

Maritime routing solutions developed by CLS enable operators to save up to 40 tonnes of fuel oil on a trans-Pacfiic sea route ©Istock

LIMITING CO2 EMISSIONS AT SEA

International maritime traffic is responsible for 2% of the total emissions of greenhouse gases. Nowadays, every percentage of savings counts. Using real-time altimetry data, CLS detects eddies, calculates the speed of currents and determines the most favourable route. Thanks to CLS, ships optimise their performance and fleet managers save fuel. All these things help enormously, considering that the energy that pollutes least and causes least damage is energy that is not used!

PROTECTING MANGROVE FORESTS

Mangrove forests not only act as carbon sinks but also provide a bulwark against the impacts of climate change (hurricanes, tsunamis, etc.). With rising water levels, they also help combat soil salinisation. In Indonesia, CLS has delivered INDESO: a satellite-based operational oceanography centre capable of receiving high-resolution satellite optical images. This information enables Indonesia to map its mangrove forests and monitor their state of health day after day.

Mangroves act as a carbon sink and a barrier against tsunamis. From space we can observe them, map their extent, monitor their state of health and better protect them. ©Istock

THROW AWAY LESS: IT'S GOOD FOR THE PLANET AND GOOD FOR YOUR WALLET

We all know that to reduce our production of CO2, it is essential to produce less waste.

What's less well known is that CLS, through its subsidiary NOVACOM SERVICE, has developed a solution for the comprehensive tracing of household waste. Rubbish containers are fitted with electronic chips. Trucks with a direct receiving antenna collect the following types of data emitted by the chip: position, address, volume, and possibly the weight. At this stage, there are two benefits: the first is modulated billing, based on the weight of waste produced. This type of billing encourages users to recycle more if they want to pay less. Secondly, it also reduces fuel consumption and the CO2 produced. By keeping the tonnes/kilometre ratio under control, it becomes possible to redesign the circuits and reduce the number of trips. Trucks are driven less and more waste is recycled.

Mapping the production of waste from each household by satellite: a solution to help local authorities introduce measures to encourage selective sorting.
©Istock

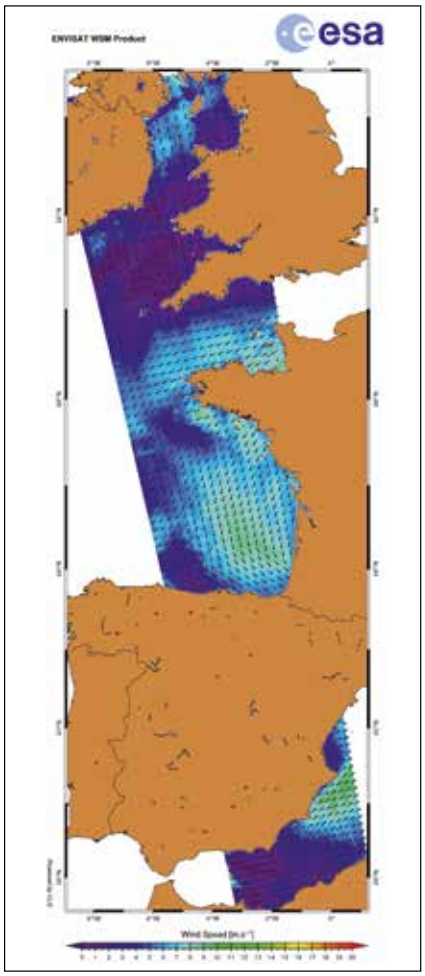
VIGISAT is a station for direct reception and analysis of satellite images, operated by CLS.
With CLS's expertise in satellite radar imagery, VIGISAT proposes high quality ocean observation and monitoring services.

OPTIMIZE GREEN ENERGIES

Satellite radar data acquired by the VIGISAT receiving station based in Brest enable CLS imagery experts to calculate wind fields. Vincent Kerbaol, Director of Radar Applications at CLS, explains: "*The use of radar images is very important for study of the wind at sea. At CLS, we measure invisible parameters: wind direction and strength, all at very high resolution. This enables the industrial sector to judge the potential of a site as an energy resource, to establish their offshore wind farms at the best locations and to make the best possible design decisions for the equipment (blades, masts, etc.). For such substantial investments, the issue of maintenance is crucial.*"

On the other side of the Atlantic, knowing the precise position of large dynamic current structures (eddies and loop currents) helps ensure the safety of men and equipment during work (installation or maintenance) on offshore installations in the Gulf of Mexico. Such services are part of an approach to support green energy initiatives.

These forecasts are provided by Horizon Marine, the U.S. subsidiary of the CLS Group. The company monitors the most threatening eddies to protect men and facilities. These are indispensable solutions, because on the high seas there is only one instrument capable of doing the job, the satellite.



Satellite radar images processed by CLS provide high resolution wind strength and direction information.
©CLS/ESA

Satellite radar images enable us to "see" the invisible – the wind – and to support the offshore wind turbine sector.
©Istock

EXTREME EVENTS MANAGED FROM SPACE

Often in the news, extreme climate situations are sadly becoming more frequent. How are we to deal with violent meteorological phenomena, cataclysmic earthquakes and migration of climate refugees? By using CLS's world-wide operational satellite solutions for early warning of hurricanes or for managing emergency aid vehicles. A closer look at these operations.

CLIMATE REFUGEES

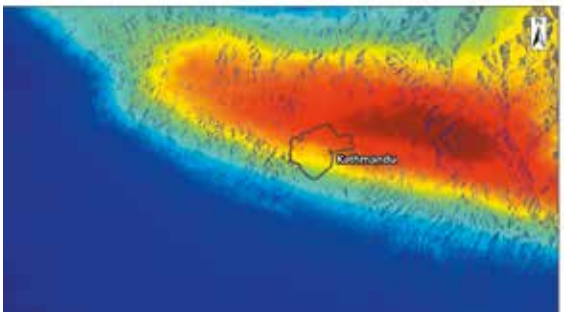
Typhoons, cyclones, tsunamis, mere words we Westerners hear while for others they are a violent reality that is difficult to resist. Organisations such as the UNHCR (United Nations High Commission for Refugees) or the Red Cross are in the front line and need the most efficient way of deploying emergency resources.

NOVACOM SERVICES, a subsidiary of CLS equips more than 1500 humanitarian vehicles in the world. ©UN

NOVACOM SERVICES, a CLS subsidiary, geolocates the vehicles of organisations working in the front line to save lives. Christophe VASSAL, Chief Executif Officer of CLS, head quarter of NOVACOM SERVICES explains: «The trust which these organisations have placed in NOVACOM SERVICES enables close cooperation in the field through the Humanav Next project that is consolidating and legitimising our involvement in the humanitarian world.»
By helping the victims of these disasters through its solutions, CLS and its subsidiary are indispensable players wherever extreme climate situations occur.

EARTHQUAKES

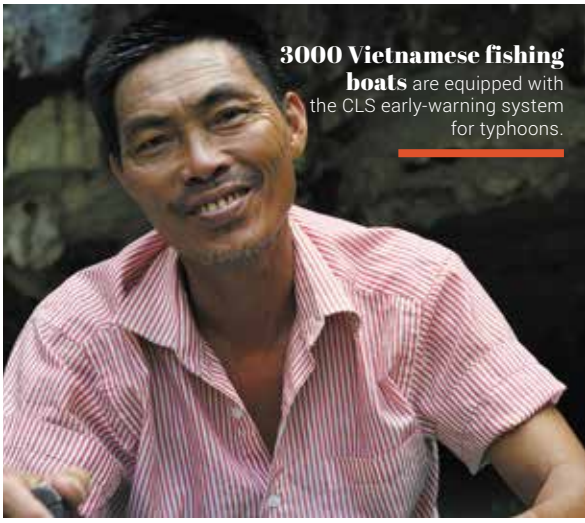
Tectonic plates are being subjected to phenomenal pressures. Earthquakes created by these shifting plates are thus occurring more frequently. Altamira information, a CLS subsidiary, offers a solution for providing terrain maps and expertise in interpreting radar satellite data for the zones concerned. By measuring ground movements and highlighting differences before and after events, Altamira facilitates the work of rescue teams while indicating which zones are likely to suffer aftershocks, thus providing backup for relief workers in the field during climate catastrophes.



Ground-movement map generated by ALTAMIRA INFORMATION following the earthquakes which occurred in Nepal last April.

TYPHOONS

In 2006, the typhoon Chanchu proved devastating when it killed many fishermen. The Vietnamese then decided to equip themselves with a CLS solution: Movimar. This advanced technology has coupled a fishery surveillance system with another for sending early warnings of typhoons by satellite. Three surveillance centres in Vietnam keep watch over the boats and their environment. When they receive a warning the crews can then move away before the storm hits them.



3000 Vietnamese fishing boats are equipped with the CLS early-warning system for typhoons.

THE FRESH WATER CHALLENGE

SATELLITE MANAGEMENT WILL BECOME ESSENTIAL

According to the IPCC report, "*The proportion of the world population facing water shortages or affected by major flooding will increase with the level of global warming in the 21st century.*" The scarcity of fresh water resources will be most strongly felt in countries in the Southern hemisphere, whereas countries in the Northern hemisphere are expected to experience more regular and devastating episodes of flooding.

CLS, a world leader in altimetry, is putting its 30 years' experience of ocean monitoring at the service of sustainable management of water resources.

HOW CAN WE COPE WITH THESE NEW CONDITIONS?

CLS and satellites can provide solutions for managing water resources, water stress or extreme weather events. The Toulouse-based company is willing and able to combine different types of satellite, in-situ or numerical modelling data. These solutions should prove indispensable for the comprehensive and fair management of water resources.

They will make it possible to predict and monitor river networks, and to control the state of resources at a regional level. With satellite tools, the authorities will be in a position to monitor the intrusion of saltwater into estuaries, providing vital ammunition in the fight against salinisation of coastal farmland. Stéphanie Limouzin, director of space oceanography at CLS, tells us more: "*We've been preparing satellite solutions for sustainable management of our global water resources for several years. With satellites and CLS expertise in altimetry (measuring the surface height of water), we are monitoring the surface level of great rivers like the Amazon, the Congo or the Maroni. During a flood, we are able to monitor water levels in order to anticipate the flooding of infrastructures further downstream. Our solutions enable global, remote monitoring of freshwater reservoirs: surface areas, levels and volumes.*

Powerful technology means this monitoring concerns both reservoirs located on the surface and the impact of the exploitation of groundwater reserves and aquifers. Through our subsidiaries ALTAMIRA INFORMATION and TRE, based respectively in Barcelona and Milan, our satellites measure movements on the ground to the nearest millimetre. This essential information tells us about underground circuits and allows us to monitor the subsidence of deltas."

CLS and its subsidiary ALTAMIRA INFORMATION, have been mapping and delimiting flood zones of the Adour river in Dax, using their expertise in satellites and radar imaging.
© CLS / ALTAMIRA INFORMATION / DAX

TECHNOLOGY AND CLIMATE NEWS

Global warming: we can only hope to understand and combat this new phenomenon and its consequences through technological innovation and the development of high tech solutions. CLS is working hard to save the climate. Day after day, CLS devotes its innovation, research and development to making environmental monitoring as accurate as possible. CLS has been pursuing these goals for 30 years, from recommendations to international agencies on how to improve the capabilities of satellites, to innovative new systems for processing satellite data and the development of new, more robust, better adapted and more powerful transmitters. The daily challenges taken up by this Toulouse-based company are reflected in the progress achieved and the solutions engineers have invented to combat global warming despite budgetary and technical constraints. Here are some of the ambitious technological projects CLS has undertaken.

This tiny component 7x7mm will make it possible to extend scientific research conducted through Argos satellites to include very small species of animals. © CLS

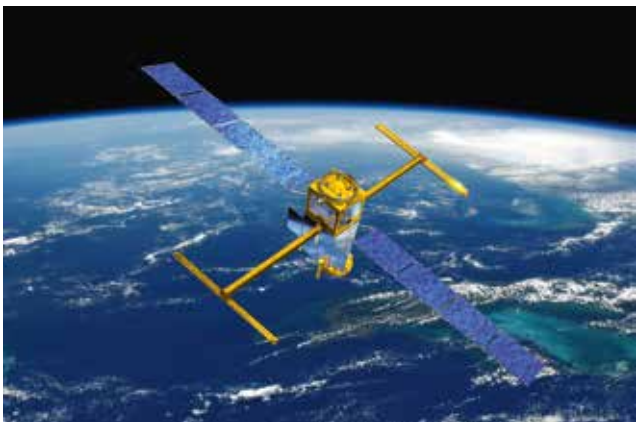
MINIATURISATION

A warmer climate will no doubt affect biodiversity (see Biodiversity, High stakes for humanity, page 10). This is why it is crucial to develop ever-more powerful transmitters, capable of being used to track the greatest possible number of species. Against this background, CLS developed a new ARGOS modem to combine miniaturisation with all the latest technological advances in the ARGOS system for location and environmental data collection. The advantages are low power consumption, low cost and efficient transmission. It weighs less than 1 gram and measures only 7x7mm. «This tiny component will make it possible to extend scientific research via Argos satellites to include very small species of animals,» says Clément Tricot, an engineer at CLS. It will replace a transmitter weighing 160g and the size of a packet of cigarettes. A technology without precedent which, for its first application, will be integrated in a transmitter for monitoring marine animals.

SWOT: A SMALL REVOLUTION IN THE SPACE SECTOR

The main objective of the Swot satellite (Surface Water Ocean Topography), planned for 2020, is to meet the need for hydrological and oceanographic data. This mission will provide accurate measurements of water levels in rivers, lakes and flooded areas as well as improving observation of coastal regions. The collection and processing of these satellite data will enable CLS to distribute accurate and qualified information on available water stocks. This information is indispensable considering that the planet could face a total deficit of drinking water of 40% by 2030. Interferometric altimetry is itself a small revolution in the field of satellite oceanography, providing very high resolution images down to a few hundred metres. SWOT will thus collect data at the global scale. This is an important advance for areas where it was previously only possible to collect data periodically, or for inaccessible areas. Practical applications can thus be deployed on a large scale including, among others, the topography of coastal areas by imaging/interferometry, the measurement of water levels in major rivers by radar altimetry, etc.

The SWOT satellite will provide accurate measurements of water levels in rivers, lakes and flooded areas as well as improving observation of coastal regions.



The SWOT satellite, planned for 2020, is expected to revolutionize hydrology. CLS is already working on techniques for processing, qualifying and exploiting the data it will provide. © CNES

CLS has developed satellite-linked super drones to detect harmful emissions.

SATELLITE-LINKED DRONES ARE CLIMATE CHANGE SENTINELS

CLS tailors these new technologies for environmental monitoring.

UNDERWATER DRONES

Brice ROBERT, satellite location and data collection engineer at CLS, describes the usefulness of these new technologies: "*For years now, we've been using underwater drones known as gliders. They assess the quantity of CO_2, plankton and hydrocarbons in seawater. We can also measure the effects of global warming, the acidification of oceans and pollution in specific areas of the world.*"

Mauricio Fragoso, oceanographer at CLS, adds: "*Guided from our headquarters in Rio, our underwater drones can stay at sea for months to perform numerous dives for missions that were impossible before. We cooperate with international research bodies using these drones, which measure data that are then collected by satellites. These state-of-the-art instruments provide valuable information on the marine environment, including wave height, wind speed, current intensity, ocean surface and depth temperatures. All these data can be fed into climate models.*"

UAVS FOR ATMOSPHERIC SCIENCE

There are already regulations to limit greenhouse gases at sea. CLS is developing innovative solutions to support authorities wanting to ensure compliance with these regulations. In order to reduce pollutants harmful to the climate and health in the North Sea, the Baltic Sea and off the US coasts (in these cases mostly nitrogen oxide and sulphur oxide), the International Maritime Organization (IMO) set standards dictating that from 1 January 2015, the maximum limit of sulphur contained in authorized marine fuel is to be divided by ten. How can we check that shipping complies with these regulations far from the shore?

Pierre Debuscherre, satellite location and data collection engineer at CLS and Jean-Jacques Valette, space systems engineer at CLS, offer a solution for coastal applications. Satellite-linked (super)drones are able to check pollution emanating from ships located by satellite. The use of polluting fuel can thus be detected remotely and in real time, offering competent authorities the means of enforcing the standards.

French West Indies beach invaded by Sargassum seaweed. CLS maps the seaweed ahead of time so it can be collected before reaching the shore.

SARGASSUM SEAWEED AHEAD!

Brown Sargassum seaweed has been amassing on the Caribbean and South American shoreline.
As it decomposes, it emits hydrogen sulphide gas, harmful to humans in high doses, and a foul smell similar to that of a rotten egg. To combat this problem, CNES has given CLS the task of implementing an operational satellite surveillance system.
The latter is based on multi-satellite detection using radar and optical instruments, in addition to a drift model.
Radar technology is a key advantage in this area because it is unaffected by cloud cover and can operate both day and night.
CLS scientists such as Romain Husson have pinpointed the signature of Sargassum seaweed in radar images.
Today, CLS maps the seaweed offshore. This information is crucial for supporting collection operations and for other players affected. The phenomenon could well be related to global warming because it is likely that the rise in water temperature is one of the factors accounting for the seaweed's proliferation.

SECTORS OF EXCELLENCE

COP21 has already achieved one objective - highlighting the day-to-day work undertaken by the space sector on climate change issues. CLS is now a leading player in this field and has decided to emerge from its usual low profile. For the last 30 years, our teams of researchers and engineers have been processing altimetery data following space missions, to be used for the benefit of international projects, such as the European programme Copernicus. CLS's range of services provides a set of detailed data about the oceans. This data is used by international organisations for various applications: forecasting climate changes, monitoring accidental pollution, managing fish resources, ensuring responsible development on coasts, supporting off-shore energy-production operations, etc. Here is an overview of CLS's fields of excellence.

An unrivalled database
CLS operates 40 satellite systems which carry almost 80 instruments used on a daily basis for environmental surveillance, the sustainable management of marine resources and maritime safety.

CLS EXPERT IN DETERMINING SEA-LEVEL

CLS has been acquiring, processing, validating and qualifying altimetry data (sea surface height) since the first TOPEX-POSEIDON altimetry mission. As such, the company has already exploited oceanographic satellite data from JASON-1&2, ERS-1&2, SARAL, HY-2A, ENVISAT, CRYOSAT-2, SENTINEL-3A&B, Jason-3 and SWOT satellites in the not too distant future.

CLS's expertise is recognized in major European projects: MERSEA, MY OCEAN, CLIMATE CHANGE INITIATIVE and MARINE SERVICE (COPERNICUS).

Our know-how is unique;
we provide crucial information with unrivalled accuracy.

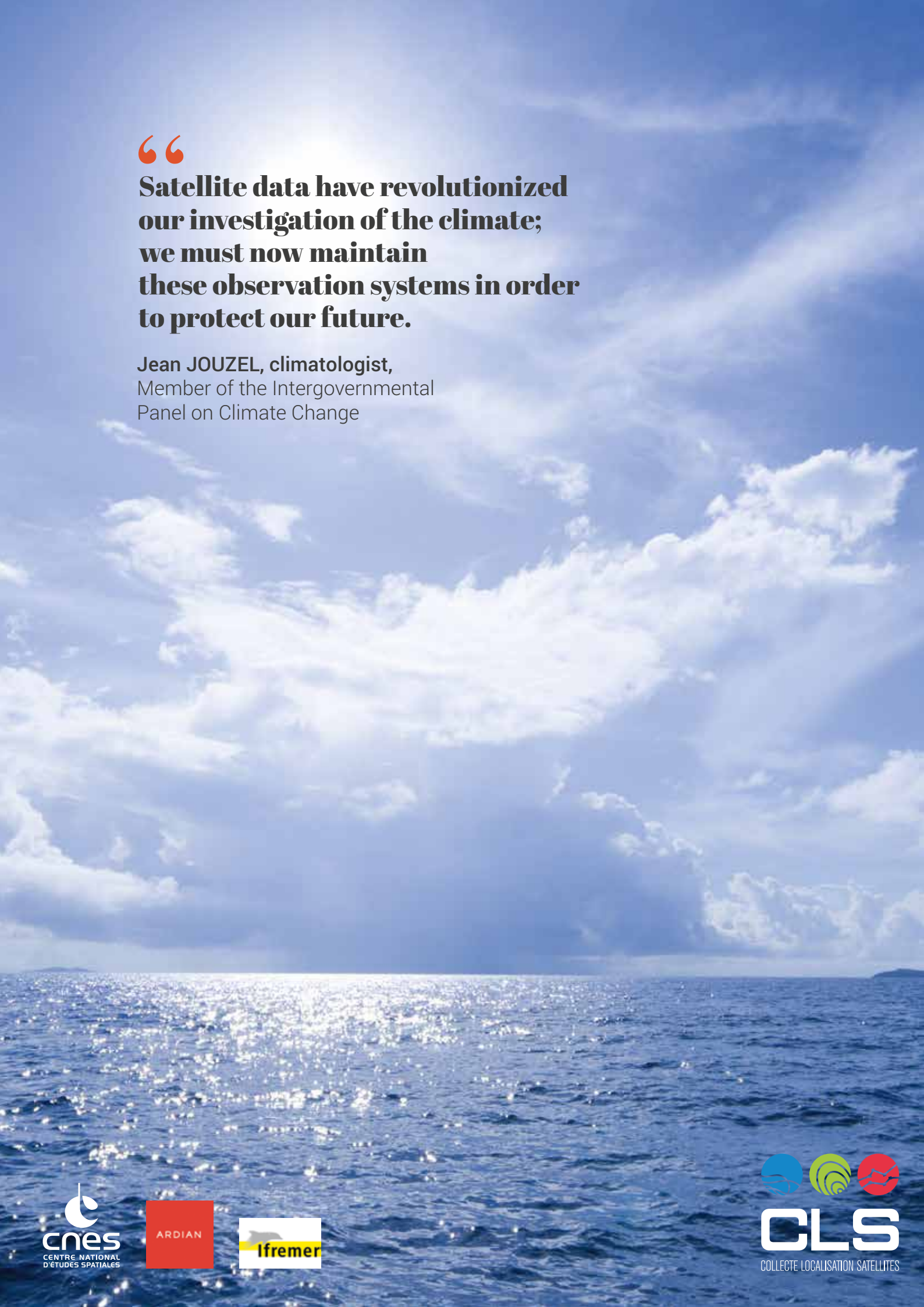
CLS Data Center
© CLS

30 YEARS OF SATELLITE–BASED DATA COLLECTION

As the exclusive operator of the ARGOS location and environmental data collection system, CLS provides data to scientists (biologists, oceanographers, climatologists) around the world to help them study and protect the planet. The data from thousands of CLS transmitters - fitted on animals, oceanographic buoys, and submarine floats - has provided vital information about the state of the planet's health. CLS's data-processing centre delivers its bulletins to the whole world around the clock, 365 days a year.

CLS Operations Centre
© Jean-Yves Valentin/CLS

Ground network
CLS operates a network of Argos ground stations. The most recent antenna installed by CLS is on Easter Island.
© Laure BOUTEMY/CLS



Satellite data have revolutionized our investigation of the climate; we must now maintain these observation systems in order to protect our future.

Jean JOUZEL, climatologist,
Member of the Intergovernmental Panel on Climate Change

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