DAILY SCIENCE
DÉCOUVREZ LA SCIENCE, LA RECHERCHE ET L'INNOVATION "MADE IN BELGIUM"

Oceans are monitored globally, as well as millimetre by millimetre

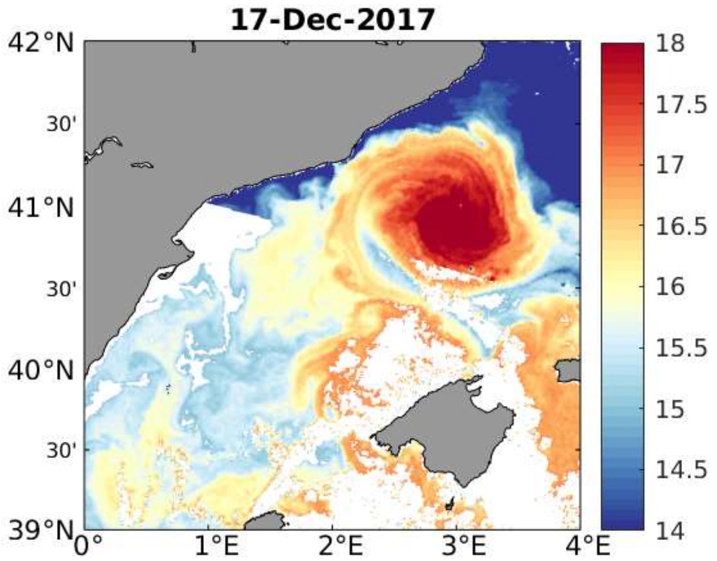
By Christian Du Brulle

The colour of our oceans, sea levels, wind, temperatures and exchanges with the atmosphere – to name but a few of the elements monitored from space that keep researchers informed about Earth's state of health and the extent of the gigantic phenomena taking place on the blue planet.

Dr Aida Alvera-Azcárate, a member of the GHER (GeoHydrodynamics and Environment Research) research group from the University of Liège (ULiège), focuses her observations on the temperature and colours of our oceans, which allows her to track the evolution taking place here.

Torrid eddies off the Balearic Islands

"I have just finished a collaboration on the vast eddies that form in the Mediterranean – in the Balearic Sea," she explains. "Satellite data has allowed us to study two of these recent events, which occurred over a particularly long time. They lasted between two and four months."



Remote identification of an eddy and temperature anomaly off the Balearic Islands detected by Sentinel-3 © Dr Alvera-Azcárate

By isolating certain water masses, these phenomena have an impact on both oceanic general circulation and ecosystems. The findings of this study reveal that these eddies have also led to an increase in temperature of around 2.5 degrees. “Considering the ocean as a whole, we could almost refer to these eddies as heat waves,” explains the oceanologist.

An early spring in the North Sea

Closer to home, the early arrival of spring has been detected in the North Sea. Another study, which is part of the STEREO programme financed by Belspo, the Belgian Federal Science Policy, has enabled the researcher to identify another effect of global warming.

Based on more than twenty years’ worth of data related to chlorophyll in the sea, the oceanologist was able to prove that spring blooms are occurring increasingly earlier in the year. “There’s a difference of about one month between 1998 and 2020”, she explains.

The ULiège scientist owes these research findings to the use of satellite data. She regularly makes use of data from the European satellites Sentinel 3 and Sentinel 6, which are managed by EUMETSAT within the framework of the European Copernicus programme.

“Sentinel 3 is equipped with a series of instruments that provide data on our oceans’ altimetry, colours, chlorophyll content and the quantity of sediments, as well as temperatures,” explains Dr Alvera-Azcárate. “Sentinel 6, which goes by the name of Michael Freilich, has taken over the provision of altimetry data, which first began with the Jason satellites. And the data it delivers is extremely precise."

The instruments and data need constant fine-tuning

Although the instruments in space gather vast amounts of data, the data delivered needs to correspond as closely as possible to scientists’ needs. This is one reason why Aida Alvera-Azcárate is also concerned with how to improve the quality of satellite data. “One example of this is trying to eliminate specific disturbances, such as the shadows on the sea caused by clouds. These can cause the data provided by the satellites to be misinterpreted,” she explains.

This is a very tricky problem to solve because it is often difficult to tell cloud shadows and non-shaded areas apart. Shadows caused by clouds have similar spectral characteristics to water pixels.

In Brussels, Professor Véronique Dehant from the Royal Observatory of Belgium highlights another challenge related to improving spatial instruments: their localisation accuracy. “When we talk about the rise in sea levels, we are talking about altimetry,” explains the head of the Observatory’s Reference Systems and Planetology directorate.

Improving localisation accuracy of satellites

“As far as altimetry satellites are concerned, their performance cannot be improved unless we reconsider the techniques that the satellites use to determine their own location.

It goes without saying that if we want to determine the average sea level to the nearest millimetre, we also need to improve the accuracy of the reference coordinates to at least the same degree. Indeed, this is recommended in the United Nations resolution A/RES/69/266.

"If we want to achieve this goal, we need to change our methods. And this means testing a new technology. This is what we have set out to do with the Genesis mission, the aim of which is to improve and standardise the temporal and spatial references on Earth down to a tenth of a millimetre," explains the expert mathematician.

Breaking our reliance on terrestrial reference coordinates

What does this entail? Well, we need to 'co-locate' all spatial geodetic measurements in a single satellite – in other words, the Global Navigation Satellite System (GPS/GNSS), Laser Satellite Ranging (SLR), Very Large Baseline Interferometry (VLBI) and Doppler Orbitography and Integrated Radio Positioning by Satellite (DORIS).

"Let's imagine that we want to determine average sea levels and their evolution. We would use an altimetry satellite, such as Jason," explains Véronique Dehant.

"We would measure the level of the sea in relation to this satellite. This means, of course, that we need to know the position of the satellite with exactly the same degree of precision. We can do this using a GNSS. However, this technology doesn't allow us to determine the satellite's position with 100% accuracy. A GNSS measurement enables something to be positioned in relation to GPS or Galileo satellites, which are themselves positioned using observations conducted on Earth – on a planet that is continually changing shape. In other words, we are never able to determine a 100% accurate position in space."

From planet Mars to planet Earth: a new application for LaRa (lander radioscience)

"The only way of determining positions in space is by using VLBI (very long baseline interferometry). This technique measures positions on Earth in relation to quasars, which are objects that are so far away in the universe that they display virtually no movement at all. In other words, we can consider them to be a kind of fixed beacon in the sky. Quasars allow us to position ourselves more accurately on Earth," she explains.

To be able to use this concept, however, we need further technology. Satellites need to be fitted with a special instrument, which is where the expertise of the Belgian scientists comes into play.

The LaRa device, developed at the Royal Observatory of Belgium for studying Mars, is able to be adapted to this kind of task. All that is left to do now is build it and test it in orbit. This represents the core mission of the Genesis project, supported by Véronique Dehant and her co-worker at the Observatory, Dr Ozgür Karatekin. A Belgian manufacturer involved in the LaRa project (Antwerp Space) has the exact capabilities required to build the instrument.

All that remains to be done now is for this ambitious scientific mission to get the go-ahead so that it can achieve its extremely specialised primary goal. As a by-product, the project will also deliver a new space tool that should be suitable for fitting on board all second-generation European Galileo (positioning) satellites further down the line. Will the ultra-precise measurement of the Earth's surface using elements from outer space be the new Belgian specialism? It certainly looks that way!