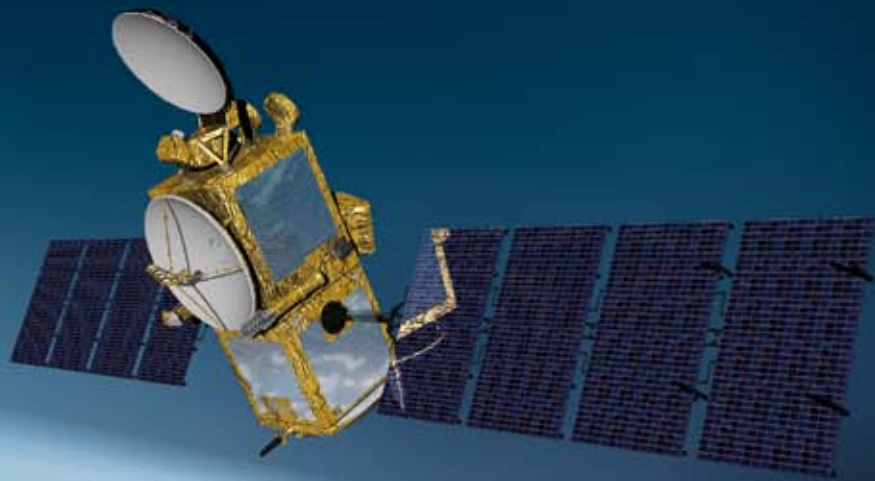


# JASON-2

GLOBAL OCEAN DATA FOR GLOBAL  
WEATHER AND CLIMATE MONITORING





# Global ocean data to meet worldwide challenges

16/01/08 - *"Big climate impact' on UK coasts"*  
(BBC Online)

March 2008 - *"Le réchauffement global stérilise les océans"*  
(Sciences et Avenir)

19/2/2008 - *"Schmelzendes Grönlandeis lässt Meeresspiegel schneller steigen"*  
(Spiegel Online)

Changes in weather, climate and the environment pose serious challenges to mankind. Meeting these challenges requires further improvements in weather forecasting, especially for mid- to long-term predictions. If there is a clearer picture of what is going to happen in the next 10 days, the next months - or even in the coming season - people and industries can prepare themselves much better for unstable weather patterns.

Meeting these challenges also implies a better understanding of global climatic factors that cause such phenomena as for example El Niño and La Niña in the Pacific Ocean, dangerous hurricanes and typhoons, and especially the potential impact rising sea levels can have on coastlines worldwide.

Seventy-one per cent of the planet's surface is covered by water and a key dimension to understanding the forces behind changing weather patterns can only be found by mapping variations in ocean surface conditions all over the world and by using the collected data to develop and run powerful models of ocean behaviour. By then combining oceanic and atmospheric models, we can provide the required accurate forecasts on both a short- and long-term basis. The coupling of oceanic and atmospheric models is needed to take the mesoscale (medium-distance) dynamics of the oceans fully into account. This becomes important for weather forecasting beyond two weeks.

The oceans are also an important part of the process of climate change and a rise in sea levels all over the world is widely recognized as potentially one of the most devastating consequences of global warming.

*"Who hasn't dreamed of one day living on a far-off island in the South Pacific? Paul Gauguin and Marlon Brando famously found their bliss among the Polynesians. But there is trouble in paradise, especially if you live on an island nation as narrow and flat as Tuvalu, where the average elevation is a mere six feet above sea level. When you live that close to the water's edge you pay very close attention to the ocean, especially if it begins to rise. And that is what's happening around Tuvalu, slowly, almost imperceptibly, the sea is rising."*

**(From the introduction to "Tuvalu: That Sinking Feeling. Global Warming, Rising Seas," PBS Frontline/World Rough Cut Series, Elizabeth Pollock, December 2005)**

Monitoring mean sea level trends is an important element in the validation of the realisation of coupled ocean-atmosphere models used in climate research. Also, worldwide data sets are required that provide a better understanding of how Earth's oceans are absorbing heat from global warming and how that in turn affects global atmosphere.

To develop these global monitoring capabilities, it is imperative that the required rich spectrum of observational ocean data is provided through an uninterrupted series of stable readings, spanning not just a month or a year but in fact multiple decades.

Due to their size, density and the dynamics of their liquid content, oceans are difficult to observe and study in detail. Before the early 1990s, when the first ocean altimetry satellite went into orbit, oceanography – the scientific study of oceans – could only make use of relatively isolated data to project the global patterns of waves and currents, surface heights, salinity and temperatures. These were based on observations from ships and buoys in which interpretations are necessarily influenced by local conditions. Moreover, a floating measurement network can never be sufficiently extensive nor capable of providing constant and accurate measurements over vast distances, although in-situ measurements are also valuable, among others as calibration points, as demonstrated by the ARGO network.

The solution to achieving comprehensive, reliable and far-reaching global data capture has already been provided - through the advent of satellite-borne ocean altimetry observations. Ocean altimetry, which uses a radar system to measure the distance between the satellite and the ocean surface, has tapped a vast mine of new information about ocean behaviour, and the scientific studies carried out during these missions have revolutionised our understanding of the ocean and its importance for weather and climate. Currently, ocean altimetry satellites measure the height of the ocean surface to within a few centimetres every 10-35 days.

The original TOPEX/Poseidon science project launched in 1992 jointly by the US National Aeronautics and Space Administration (NASA) and the Centre National d'Etudes Spatiales (CNES), the French space agency, was the predecessor to the first Jason satellite (which was smaller and cheaper but had better instruments), launched on 7 December 2001. Now the next Jason satellite - Jason-2 - is ready to continue the agenda for observing and understanding the role of oceans in our global environment and delivering vital oceanographic data for meteorology, climatology and oceanography alike.



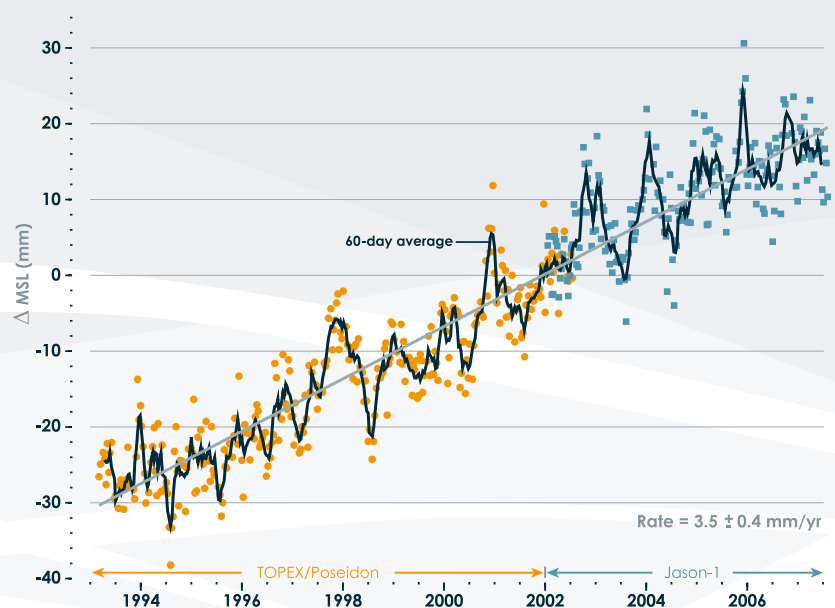
# The growing importance of satellite-based ocean altimetry



## ...for climate monitoring and oceanography

The continuous flow of altimetry data received from TOPEX/Poseidon and Jason-1 over the last 15 years has already delivered tangible benefits for weather forecasting and climate change monitoring. These data for example suggest that the mean sea level has been rising by about three millimetres a year since 1993 – about twice that estimated by tide gauges for the previous century – thus indicating a possible recent acceleration in the rate of sea level rise to be further monitored by Jason-2.

Other vital measurements that will be continued through the Jason-2 data series are the decadal (ten-year) oscillations in large ocean basins such as the Atlantic Ocean, mesoscale variability and surface wind and wave conditions. Jason-2 measurements will also contribute to the European Centre for Medium-Range Weather Forecasts (ECMWF) satellite data assimilation and improve global atmosphere and ocean forecasting.



Global mean sea level derived from TOPEX/Poseidon and Jason-1 data shows an average rise of 3.5mm a year (Source: University of Colorado, LEGOS/CNES)

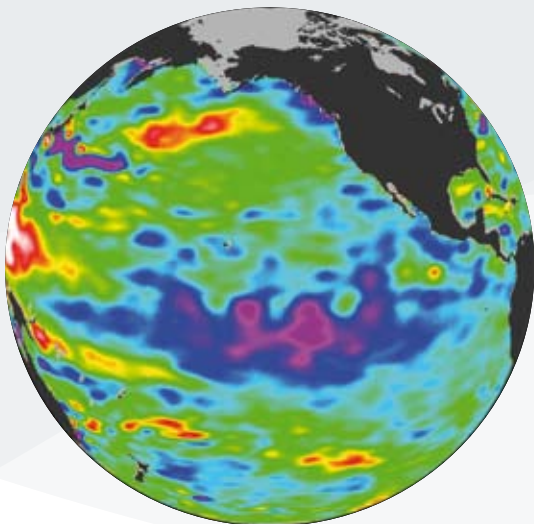
Altimetric data have also provided decade-long global observations and analyses of the El Niño and La Niña phenomena. They have made possible new discoveries about ocean circulation and its effects on climate, and provided new insights into ocean tides and internal tides, ocean circulation and turbulent ocean eddies, as well as marine gravity.

Eventually, long-term OSTM (Ocean Surface Topography Mission) data will be vital for climate modelling. To gain relevant data on, for example, the formation of ocean eddies, and to access the global 'budget' for transporting heat across the oceans, scientists need to measure mesoscale and currents variability. With this data, they can build models of climate patterns and then use them to benchmark actual observations of climate over the longer term. In this way, we can contribute to the accurate measurement of exactly what climate change will mean for mankind.

## ...and for weather forecasting.

Data resulting from continuous sea surface measurements will help to predict the likelihood of seasonal disruption in rainfall and temperature for periods of up to nine months. By correlating observations of ocean variability collected over long periods with findings about occurrences of severe weather such as droughts, floods and even hurricane activity, meteorologists can improve seasonal forecasting, which plays an essential role in anticipating potentially hazardous weather situations. This in turn is needed to extend the early warning periods for all sorts of severe weather phenomena in order to save lives and property.

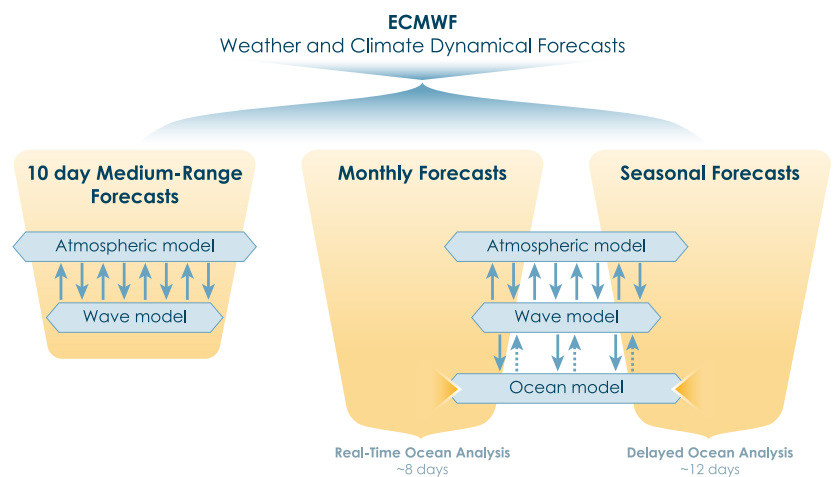
Another application of seasonal forecasting can be found in the context of a number of industries where it can quite simply support the planning of energy supplies, agriculture or water management.



Jason sea-level height anomaly data from February 2008 (Source: NASA)

Medium-term OSTM data also feed ECMWF, helping it to improve the numerical weather prediction modelling techniques that underpin its bulletins. Real-time ocean data will be analysed in eight-hour and 12-day cycles to build ocean and wave as well as atmospheric models to drive three types of forecast: medium-range, predicting the weather up to 15 days ahead, monthly (30 days ahead), and seasonal (up to 12 months ahead).

It should not be forgotten that the oceans are the home or workplace of a large number of people in the shipping and fishing industries or on offshore operations such as oil rigs. For these people, the improvement in short- to mid-term marine weather forecasts of such factors as significant wave height and wind speeds – not only in the world’s oceans but also in marine basins such as the Mediterranean and Aral seas – can be beneficial. The data will help optimize the choice of sea routes for large vessels – and will ultimately help save lives and livelihoods at sea.



Jason-2 data will contribute to the ECMWF ocean, wave and atmosphere modelling system, improving global medium range and seasonal forecasting

# From Jason-1

# to Jason-2

Satellites have limited lifetimes due, for example, to the negative effect of radiation, and this is also true for Jason-1 - even if it has exceeded its expected lifetime. The launch of Jason-2 will prevent any hiatus in the data record, and the satellite will then orbit Earth for another five years. Jason-1 and Jason-2 will work in tandem for a few months, during which the two satellites will observe the same spot of the ocean one minute apart from each other for cross checking and calibration.

The new Jason-2 mission is the continuation of the existing successful cooperation between the United States and Europe. The Jason-2 programme links two operational and two research agencies and also brings about a successful transition from the research to the operational phase:

- France's **Centre National d'Études Spatiales (CNES)** developed the satellite, the **US National Aeronautics and Space Administration (NASA)** was responsible for the launch, and they jointly developed the instruments as well as the processing software.
- **EUMETSAT** will work in close partnership with the **US National Oceanic and Atmospheric Administration (NOAA)** to secure data and near-real-time product dissemination for users groups in Europe and the United States - and in fact the world.

*The Jason-1 spacecraft launched on 07 December 2001 from Vandenberg Air Force Base (Source: NASA)*

Specifically, this means that EUMETSAT and NOAA will be responsible for making Jason-2 mission data and products available to the international scientific community via European and North American data centres, ensuring the global operational constituency dedicated to weather forecasting, climate monitoring and oceanography benefits from the observational findings. CNES will take responsibility for processing and distributing all offline products.

Through this programme, EUMETSAT will be able to address one of its top priorities - assuming a growing European role in the processing and dissemination of ocean altimetry data from satellite sources, to expand its traditional focus on supporting atmospheric weather and climate observations. Jason-2 therefore represents a crucial step forward in its ongoing commitment to examine new areas in Earth observation for its meteorological missions.



[www.noaa.gov](http://www.noaa.gov)



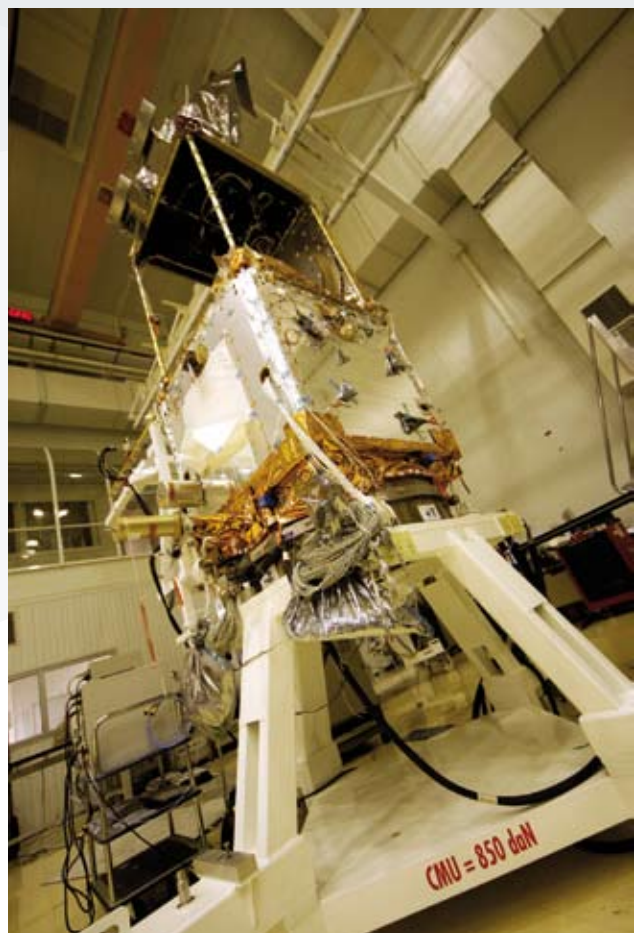
[www.nasa.gov](http://www.nasa.gov)



[www.cnes.fr](http://www.cnes.fr)



[www.eumetsat.int](http://www.eumetsat.int)



*The Jason-2 spacecraft being constructed in the cleanroom (Source: CNES/Thalès Alenia Space 2007 photo: Yoann Obrénovitch)*

# Jason-2 follow-on and the future of global climate monitoring

Through Jason-2, EUMETSAT and NOAA will gain experience in the field of operational satellite-based oceanography by assuming responsibility for the routine operation and associated Ocean Surface Topography Mission (OSTM) data processing starting in June 2008. To consolidate this experience and ensure the continuity of ocean monitoring, EUMETSAT and its partners have made proposals for continuing satellite-based altimetry for the next 15 years. There is a clear recognition of the need for a sustainable and long-term vision of satellite-based altimetry.

Continuation of the satellite-based altimetry mission is vital for global data records. If there is more than half a year's gap in the data flow, it would be more difficult to truly gauge the trend of sea level rise that is threatening to flood coastal cities all over the world and in fact whole nations in the Pacific Ocean.

Stepping up its capacity for operational altimetry through joint responsibility for the Jason-2 follow-on missions, EUMETSAT can also provide operational support and expertise to the service infrastructure of the Global Monitoring for the Environment and Security (GMES) initiative, especially the GMES Fast Track Marine Core Service (MCS), which provides a sustainable platform for observing oceanic climate variations.

EUMETSAT's important role in supporting GMES activities in Europe has been recognised in the European Space Policy document that was endorsed by the European Space Council on 22 May 2007. EUMETSAT already operates its own high-capacity data distribution system, EUMETCast. It has the potential capability to provide scientific and technical support to the European Commission on all matters related to the sustained operation of ocean observation satellites and ground segments. And the organisation will be able to provide continuity in delivering important data and services through its expanding range of satellite systems.

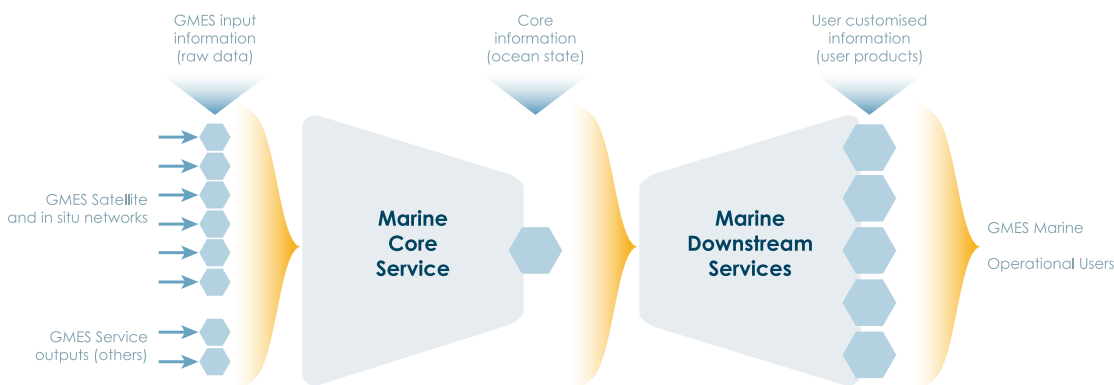
GMES itself is a key actor in the intergovernmental Group on Earth Observations (GEO), which is leading a worldwide effort to build a Global Earth Observation System of Systems (GEOSS) over the next 10 years. By continuing the work of monitoring the oceans and providing long time series of data on vital aspects of global climate change, Jason-2 and, subsequently, Jason-2 follow on will also provide data that will mesh with and enrich the planet's broadest possible climate and weather observation platform, embodied in GEO.



*A set of five operational systems providing real-time ocean forecasts. (Source: MERSEA)*

Through the evolving sequence of OSTM and related missions, Jason-2 and its follow-on will help provide the best possible scientific climate and weather data to enable governments and their constituencies to address tomorrow's strategic decisions about the economy, the environment and sustainable development.

*A European Marine "core" service clearly defined by the EC GMES Implementation Group (Source: Ryder P. 2007 GMES Fast Track Marine Core Strategic Implementation Plan)*



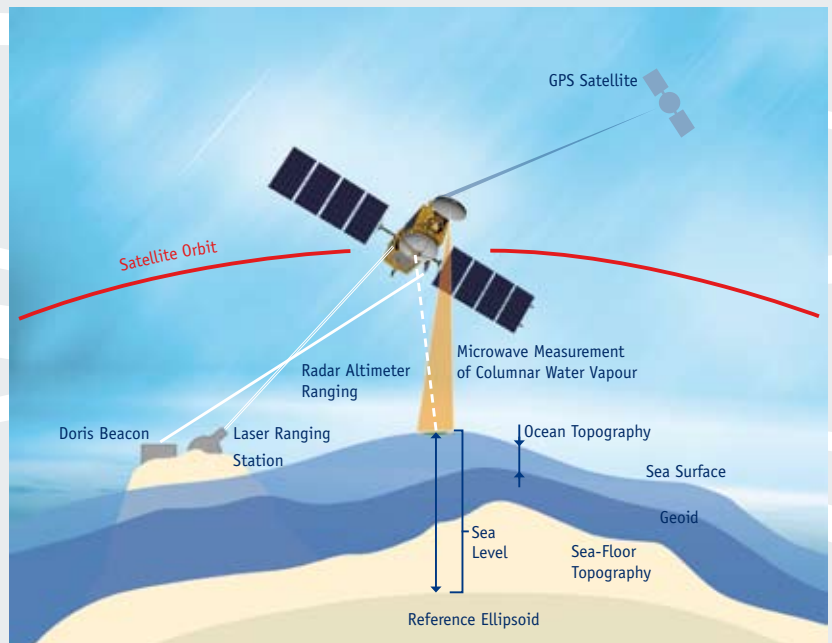
# How Jason-2 works

Despite what is commonly thought, the ocean surface is not an unchanging flat plane. In reality, it mirrors the hills and valleys of the ocean floor and shows 'bumps' of anything up to 100 meters in height. Scientists have managed to measure what they take to be the mean sea level – the “reference surface” – as a benchmark against which to compare the rise in global sea levels. Since the Earth also rotates on an axis, this, combined with the impact of radiation from the sun, tides, whirlpools and wind-driven ocean currents, generates an extremely mobile ocean surface – or dynamic surface topography.

The main purpose of the Jason series of satellite-borne radar altimetry missions is to take distance measurements by bouncing a radio wave signal from the satellite to the ocean surface. These radio waves measure the global variations in dynamic surface levels and send the results back to mission control. These topographic data are then analysed to determine average sea surface height phenomena to extremely accurate distances of just a few millimetres.

There are two key steps in ensuring accurate altimetric measurements aboard a satellite. First, the exact location of the satellite has to be indicated each time an ocean measurement is taken similarly to a GPS system. This gives the exact location of the satellite above the Earth to within two centimetres.

Second, the on-board altimeter is used to measure the distance from the satellite to the water surface by measuring the time it takes for a radio signal to travel down and back. A complex set of corrections then has to be made automatically to correct the influence of the electrons in the ionosphere (derived from dual frequency altimeter measurements) and the dry air - from the European Centre for Medium-Range Weather Forecasts (ECMWF) models - or water vapour (derived from radiometer measurements) in the atmosphere. Each Jason altimeter can make measurements on the surface to an accuracy of three centimetres. There are two altimeters on board each satellite to ensure backup in case of problems.



## Instruments on board Jason-2

On Jason-2, the on-board instruments used to make these altimetry readings are provided by CNES and NASA. EUMETSAT and NOAA provide Earth terminals and part of the ground network and are also responsible for near-real-time product processing, archiving, and product distribution. NASA will also deliver the launcher and launch services, while CNES will be in charge of overall system integration.

The basic equipment platform (or “bus”) is known as the *Plateforme Reconfigurable pour l’Observation, les Télécommunications Et les Usages Scientifiques (PROTEUS)* and is provided by CNES. The payload module includes the altimeters and the Doppler Orbitography and Radio-positioning Integrated by Satellite (DORIS) receiver from CNES, while the radiometer, GPS Receiver, and laser retroreflector array are from NASA.

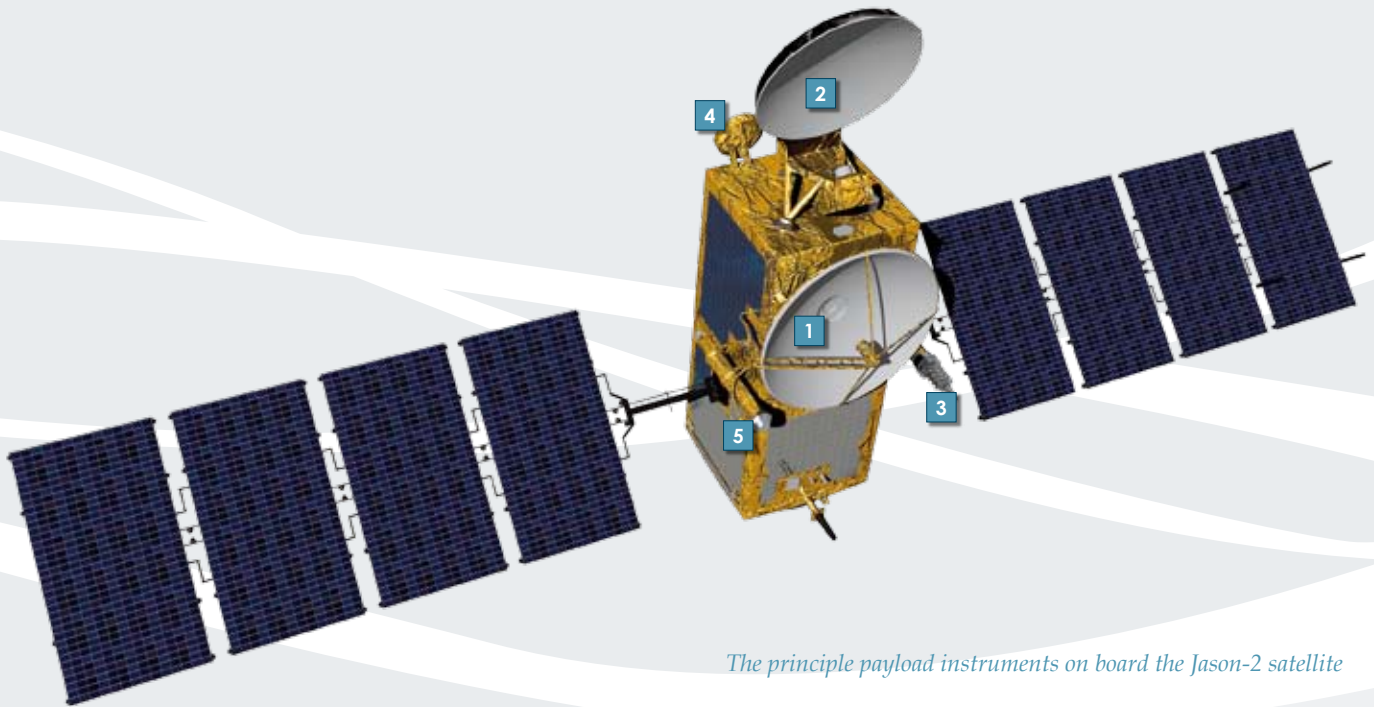
In other words, Jason-2 carries a payload of five principal instruments. They are fully redundant, ensuring a seamless flow of data should an incident affect one of the these five instruments. In this way, there is a guaranteed flow of measurements for at least five years.

The altimeter:

- **Poseidon-3** (supplied by CNES) is the mission’s main instrument, derived from the Poseidon-2 altimeter on Jason-1. It is a compact, low-power, low-mass instrument offering a high degree of reliability. Poseidon-3 is a radar altimeter that emits pulses at two frequencies (13.6 and 5.3 GHz, the second frequency used to determine electron content in the atmosphere) and analyzes the return signal reflected by the surface. The signal round-trip time is estimated very precisely to calculate the range. Poseidon-3 will be coupled with DORIS/Diode in order to improve measurements over coastal areas, inland waters and ice.

The radiometer:

- The **Advanced Microwave Radiometer (AMR)**, supplied by NASA, measures radiation from the Earth’s surface at three frequencies (18, 21 and 37 GHz). These different measurements are combined to determine atmospheric water vapour and liquid water content. Once the water content is known, it is possible to determine the correction to be applied for radar signal path delays.



The principle payload instruments on board the Jason-2 satellite

The three location systems combine to measure the satellite's position in orbit with great precision:

- **Doppler Orbitography and Radio-positioning Integrated by Satellite (DORIS)**, supplied by CNES, uses a ground network of 60 orbitography beacons around the globe, which send signals in two frequencies to a receiver on the satellite. The relative motion of the satellite generates a shift in the signal's frequency (called the Doppler shift) that is measured to derive the satellite's velocity. These data are then assimilated in orbit determination models to keep permanent track of the satellite's precise position (to within a few centimetres) in its orbit.
- The NASA-supplied **Global Positioning System Payload (GPSP)** uses the Global Positioning System (GPS) to determine the satellite's position by triangulation in the same way that GPS fixes are obtained on Earth. At least three GPS satellites determine the mobile's position at a given instant. Positional data are then integrated into an orbit determination model to continuously track the satellite's trajectory.
- The **Laser Retroreflector Array (LRA)**, supplied by NASA, is an array of mirrors that provide a target for laser-tracking measurements from the ground. By analysing the round-trip time of the laser beam, we can locate where the satellite is in its orbit.

Jason-2 will also carry three new "passenger" instruments:

- France supplies the **Environment Characterization and Modelisation-2 (Carmen-2)** instrument, which will study radiation in the satellite environment.
- **Time Transfer by Laser Link (T2L2)**, also from France, will use a laser link for high accuracy comparison and synchronization of remote ground clocks.
- Japan supplies the **Light Particle Telescope (LPT)**, also to study radiation in the satellite environment.

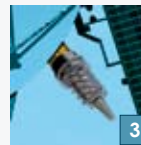
As well as providing specific scientific information, these instruments should also enhance data quality and accuracy for the mission as a whole.



Poseidon-3 dual frequency altimeter



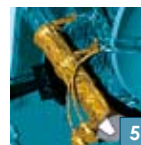
Advanced Microwave Radiometer (AMR)



Doppler Orbitography and Radio-positioning Integrated by Satellite (DORIS)

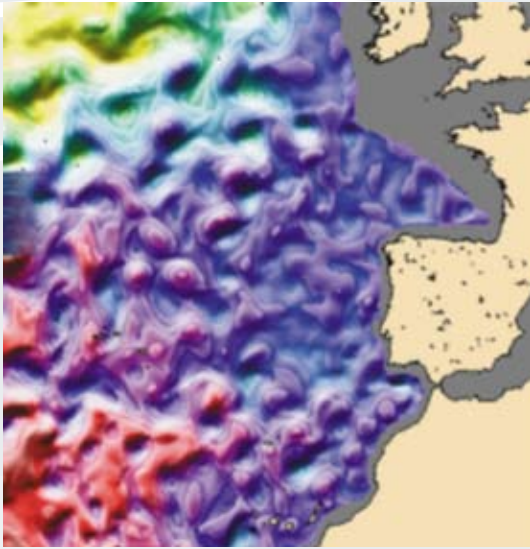


Global Positioning System Payload (GPSP)

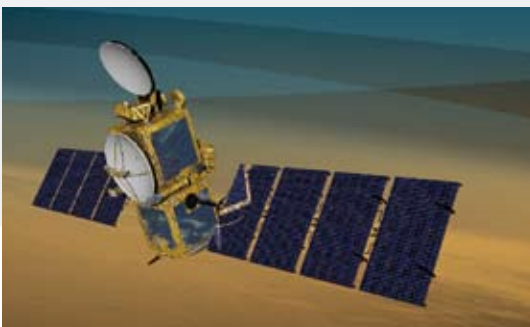


Laser Retroreflector Array (LRA)

# Jason-2 applications and products



Dynamic Sea Surface Topography. Mesoscale eddies in the north-east Atlantic (Source: Shom/CLS)



## Jason-2 - a snapshot

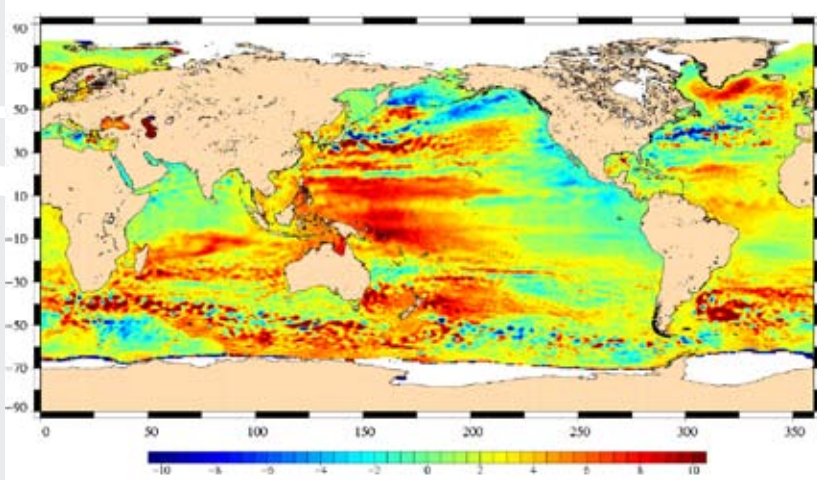
Orbit: Circular, non-sun-synchronous, 66° inclination
Altitude: 1,336 kilometres
Global data coverage between 66°N and 66°S latitude
10-day repeat of ground track (±1-km accuracy)
Coverage of 95% of ice-free oceans every 10 days
Communication: via the Ground Network Tracking Stations at Poker Flats, Alaska, and Wallops Island, Virginia, as well as the European Earth Terminal located in Usingen, Germany
Structure: 3 metres high, 500 kilos at launch, 580 watts of power
Three-axis stabilisation and nadir pointing is maintained by reaction wheels and magnetic torque rods
Hydrazine propellant system provides orbital maintenance
Designed lifetime of about five years

Providing a transition to operational altimetry, the joint Jason-2 Ocean Surface Topography Mission (OSTM) will make available a total of three global products for the user community. One of these products is delivered to users in near real-time (NRT: less than three hours), while the others are “offline”, meaning they are delivered a few days or weeks later. In terms of content, they all cover the same key ocean parameters and use the same basic format, but differ according to the auxiliary data they include (for example about orbits, meteo files, calibrations, etc.) and the level of accuracy. The NRT products will be supported by EUMETSAT and NOAA, which will provide a helpdesk; NOAA and CNES will support the offline products and also provide a helpdesk.

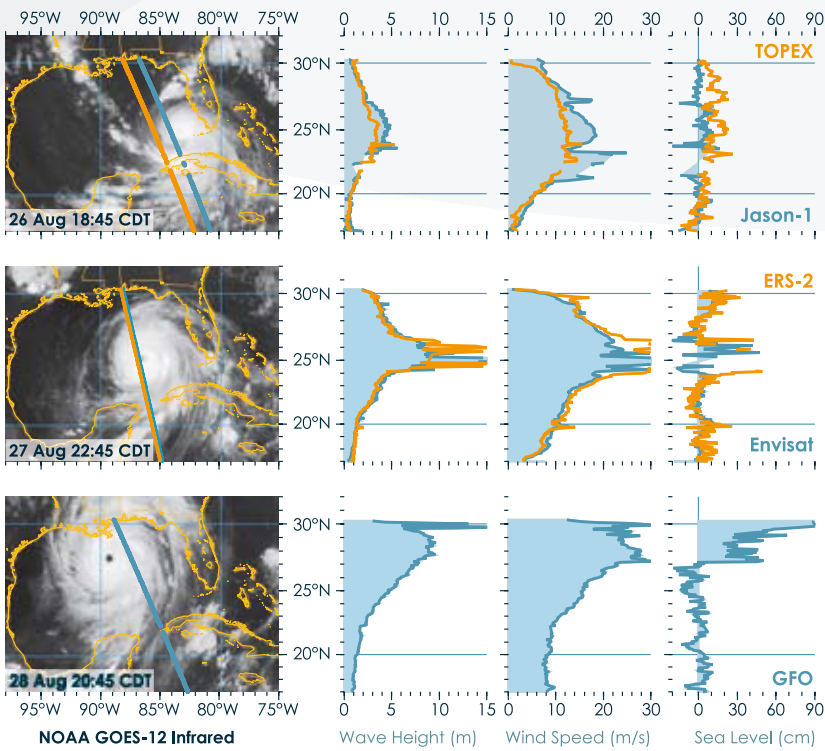
**Operational Geophysical Data Record (OGDR)** is a new operational product specially developed for the Jason-2 mission. It provides NRT data on surface wind speed and wave features, and a first estimate of sea surface height based on the data computed by the on-board DORIS system. The primary purpose is to feed data to meteorological organisations carrying out Nowcasting and operational wave forecasting. It will be especially useful for ECMWF numerical weather prediction, including atmosphere and ocean forecasting. But it will also make data on sea surface height anomalies available for ocean users. OGDR will be processed at the EUMETSAT and NOAA ground centres and disseminated over the EUMETCast satellite broadcasting system as well as via data networks and the Global Telecommunication System network. Key user organisations include ECMWF, Météo-France, NOAA, the Met Office (UK), Met.No (the Norwegian Meteorological Institute) and Mercator Ocean.

**Interim Geophysical Data Record (IGDR)** provides sea surface data which is produced within 1-1.5 days of being recorded. This record includes analysed data on sea surface height, absolute dynamic topography and ocean geostrophic velocities for medium-range weather forecasting, seasonal forecasting and ocean weather applications. Key user communities include ECMWF, NASA’s Global Modeling and Assimilation Office, NOAA’s Atlantic Oceanographic and Meteorological Laboratory, the EU’s Marine Environment and Security for the European Area (MERSEA) integrated project, the Danish Meteorological Institute and Dutch clients for storm surge modelling.

**Geophysical Data Record (GDR)** provides fully-validated data produced within 60 days of the events being recorded and covers sea surface height, principally for climate monitoring and climate modelling. The main users are geophysical and operational oceanography climate researchers working for the Global Sea Level Observing System and the International Panel for Climate Change Assessment Report on rising sea levels.



Mean sea level monitoring is used to establish the effects of global warming. This map of sea level variation trends since 1992 from TOPEX/Poseidon and Jason-1 data shows that global and regional trends can differ noticeably: while in certain ocean regions the sea level has risen by up to 20 millimetres a year, in others it has fallen (Source: CNES/CLS/LEGOS)



NOAA GOES-12 infrared images (left) and wind speed, wave height and sea level anomalies as observed by different altimetry satellites during Hurricane Katrina (Source: NOAA/Altimetrics LLC)





## Member States



## Cooperating States



EUMETSAT also has established cooperation agreements with the National Meteorological Services of Canada, China, India, Japan, Korea, Russia and USA.

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