Jason and our Ocean Planet

Mission Kit

National Aeronautics and Space Administration
Jet Propulsion Laboratory

CENTRE NATIONAL D'ETUDES SPATIALES

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Moving towards operational oceanography

The oceans are a fundamental element in our planet's climatic system. We should be able to monitor their conditions at all times, in the farthest reaches of our blue planet. We should be able to describe them, explain them and forecast their changes.

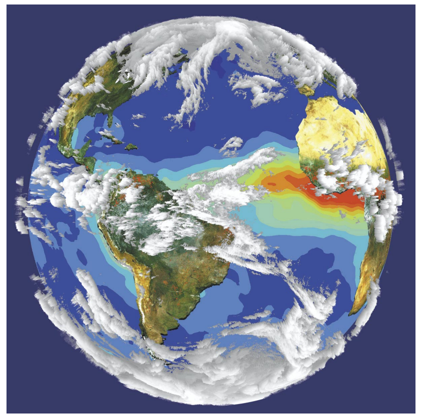
One may wonder if our planet was incorrectly named—we call it Earth, but water covers 71% of its surface and seems to be absent from the other planets in our solar system. Water covers 360 million sq. km., more than forty times the size of the United States, and oceans contain 97% of the liquid water on Earth.

This water, which is in a constant state of flux, plays a key role in climatic and environmental changes on Earth. This is because its inertia is much greater than that of the atmosphere—its mass is 500 times as great.

The Earth's climate follows the rhythm of its seasons and its Sun that heats it unequally. The oceans, atmosphere, landmasses and ice distribute this heat through the natural circulation of winds and sea currents.

The series of catastrophes we have experienced in recent years—flooding, powerful storms, climatic changes related to "El Niño" and "La Niña"—gave us a sudden wake-up call and made us notice just how deep an effect climatic changes can have on our daily life. Scientists have also needed to examine the causes, the consequences and the "predictability" of oceanic changes, because it is now accepted that the ocean has a fundamental disruptive and regulating role in the Earth's climate.

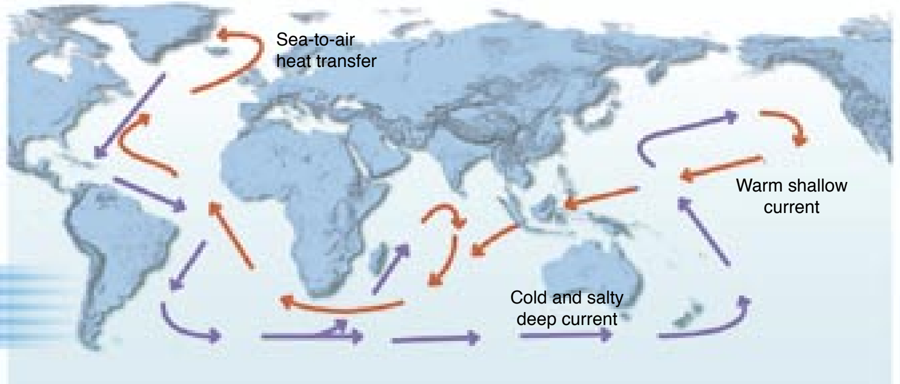
Our limited view of the ocean has become much sharper over the last thirty years. Just a few decades ago, the thought that we could have a continuous, real-time global view of



Many oceanic parameters are currently measured from space: temperature, water color, wind, waves and dynamic topography.

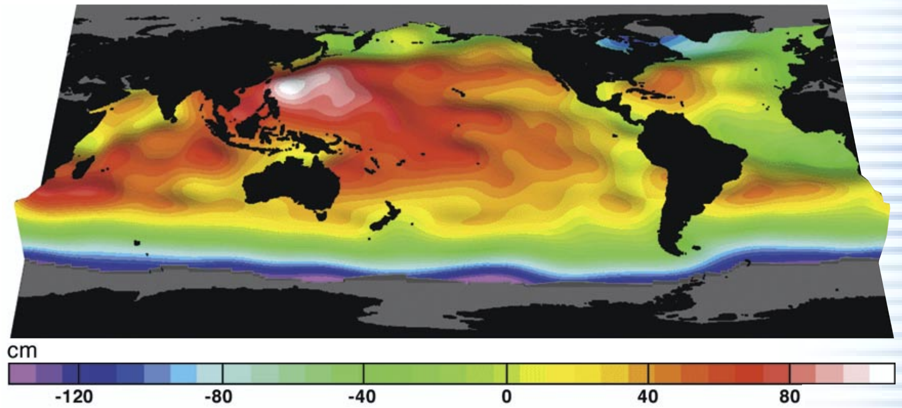
the ocean seemed unrealistic; at that time, only partial and intermittent in situ data was available. This is no longer the case, thanks to the many satellites that monitor the Earth and its oceans, flying over the entire surface of the planet in just a few days, and measuring, with unparalleled accuracy, surface temperatures, water colors, wind speed and direction, and sea surface topography.

The ocean is constantly changing: on the surface, these changes can take from a few hours to a few years; but in its deepest areas, these changes can occur over several centuries.



The Franco-American satellite TOPEX/POSEIDON was launched in 1992, as a follow-up to SEASAT (1978), GEOSAT (1985). Together with ERS-1/2 (1991, 1995), it showed the wide range of oceanographic applications that can be obtained from space. Using very powerful radar altimetry technology, the sharp eye of this satellite can detect the slightest variations in sea level with an accuracy of about 1 centimeter. Satellite altimetry has revolution-ized physical oceanography, giving access for the first time to quick, synoptic, global and regular measurements of ocean surface topography. The half-million measurements gathered by the satellite over all the Earth's oceans every 10 days have allowed scientists to regularly draw up charts of sea currents, follow their seasonal and annual variations and observe the oceanic signatures of major climatic anomalies, such as the 1997-99 El Niño/La Niña phenomenon. This has helped scientists better understand and describe the complex mechanisms and interactions among the oceans' different variability modes.

With the TOPEX/POSEIDON mission living up to expectations, satellite altimetry has become an indispensable discipline in the development of a new challenge, that of operational oceanography. This challenge has been spurred on by the success and interest generated by recent oceanic space missions and their related research. This is the case, for example, with several pioneer programs such as WOCE (World Ocean Circulation Experiment), TOGA-COARE (observing climatic anomalies in the tropical Pacific region), and more recently the CLIVAR (Climate Variability and Predictability) research program.



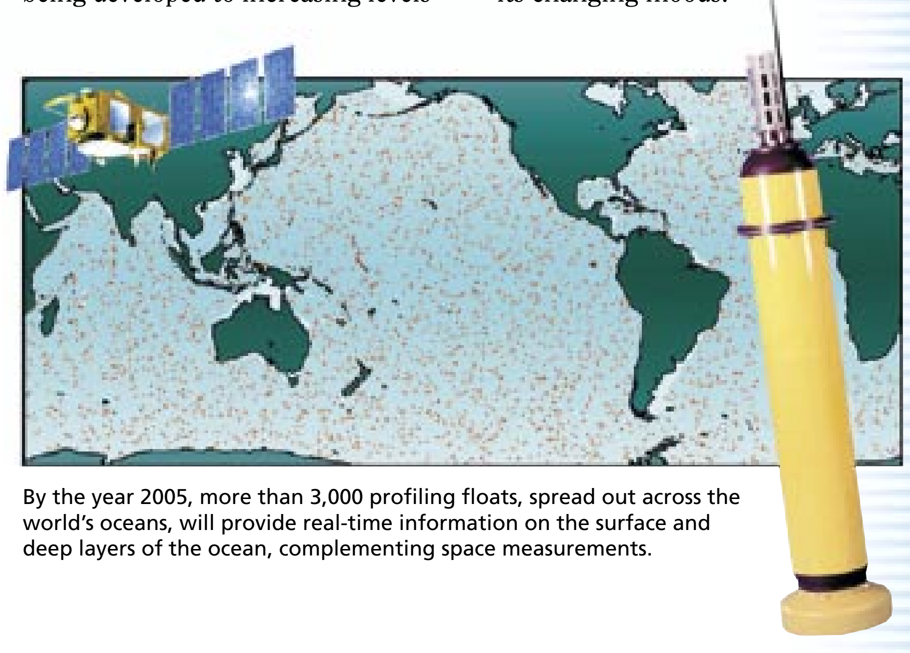
Ocean dynamic topography as seen by the TOPEX/POSEIDON altimeter.

The American satellite Seasat, launched in 1978, marked the beginning of a new era for oceanography.

Progressing from research to practical applications is always delicate, and this change is currently under way. Regional operational oceanography services have already been set up; examples are the SOPRANE system developed by SHOM in the north Atlantic and the European MFSPP project (Mediterranean Forecasting System Pilot Project). The next step is to go global, with, in particular, the international program GODAE (Global Ocean Data Assimilation Experiment), which will be operational in 2003. The MERCATOR center, the French part of the GODAE project, will provide high-resolution 3D oceanic description and forecasts on a planetary scale. Since January 2001, a preliminary operational version of MERCATOR is providing forecasts for the northern and tropical areas of the Atlantic Ocean. While satellite systems and oceanic models are being developed to increasing levels of sophistication, the global in-situ observation network will also be enhanced and maintained. This is the goal of the ARGO program, which will put more than 3,000 profiling floats across the world's oceans by the year 2005.

The success of these initiatives has shown that a large number of scientific, technical and opera-tional skills can be successfully mobilized to implement opera-tional oceanography, which is now both necessary and feasible.

Providing weather forecasts for shipping and commercial fishing fleets, forecasting major abnormal climatic events, and better managing coastal areas…
Satellite altimetry data provided by Jason-1, and a permanent in situ and satellite observation network, will help us better understand our "ocean planet" and better forecast its changing moods.



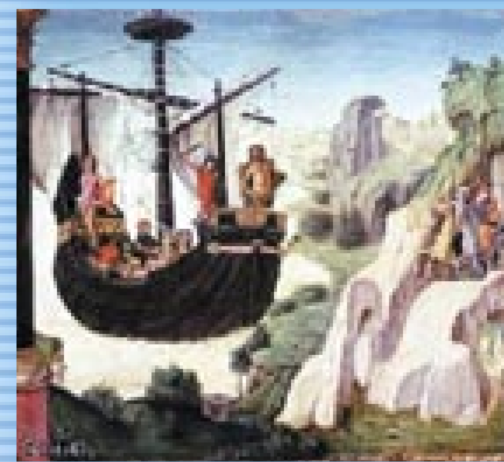
By the year 2005, more than 3,000 profiling floats, spread out across the world's oceans, will provide real-time information on the surface and deep layers of the ocean, complementing space measurements.

The Jason name

Jason is a figure in Greek mythology. Leading the famous Argonauts expedition, he went on a search for the Golden Fleece, which was guarded by a dragon in the Black Sea.

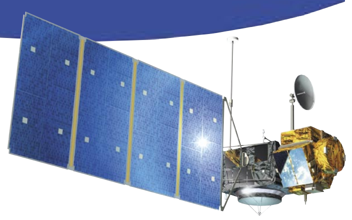
His ship, Argo, provided real-time information about sea conditions and communicated with its crew. After several years of searching, and crossing the Mediterranean from end to end, Jason finally reached his goal.

Every civilization needs myths and successful quests, and the Argonauts' expedition included both of these. This will also be the case for Jason, which will showcase the two driving components of space activity: a quest (research) and a conquest (the implementation of applications).



Jason on his ship, the Argo, searching for the Golden Fleece.

In the footsteps of TOPEX/POSEIDON



The main research objectives for the new Jason-1 altimetry mission were defined after examining feedback from the TOPEX/POSEIDON mission. The first discipline to benefit from these remarkably accurate tools is physical oceanography. But other disciplines in Earth sciences, also benefited greatly.

Launched into a 66° orbit, at an altitude of 1336 km, Jason-1 will follow the same ground tracks as its predecessor TOPEX/POSEIDON. Covering these tracks every 10 days, it will detect the slightest variations in sea level and will provide high-quality data to different research programs.

The TOPEX/POSEIDON mission, dedicated to the observation of oceanic circulation, revolutionized physical oceanography. It was launched on August 10, 1992 by an Ariane 4 rocket from Kourou, and is still functioning after 9 years of faithful service.

Mean ocean circulation

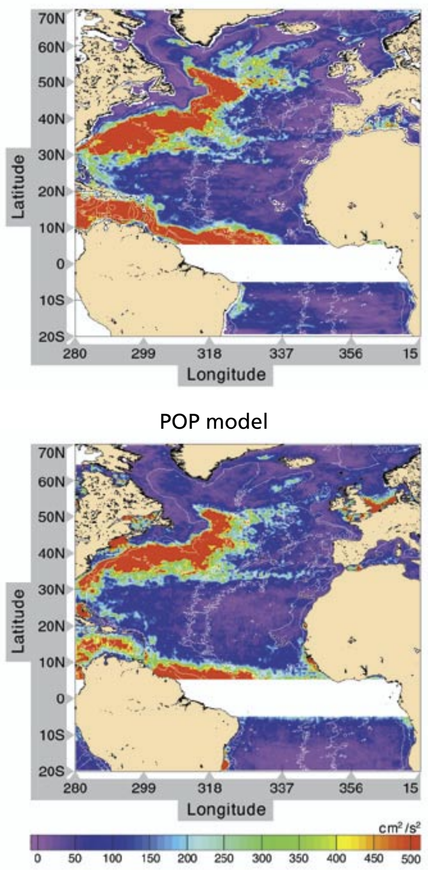
Describing average currents using altimetric measurements is essential to better understand their influence on the transient move-ments and the physical charac-teristics of these phenomena. This makes it possible to model them and develop a more precise initial state for the ocean. Jason-1's measurements, combined with the marine geoid extrapolated from current (CHAMP) and future (GRACE and GOCE) gravimetric space missions, will provide significant contributions to a better understanding of this "mean" ocean.

Multi-season to multi-year variability

This oceanic variability, which especially affects major oceanic currents, has a significant effect on climatic changes. The seasonal cycle, for example, leads to an increase or decrease in sea level in each hemisphere, exceeding 15 cm in some areas; there can be significant variations from one year to the next. The recent occurrences of the "El Niño" phenomenon, especially the pronounced case in 1997-98 in the tropical Pacific, are extreme examples of these multiyear anomalies. The wave frames that cross the ocean basins over several month-long periods also carry high levels of energy that they exchange with the atmo-sphere. The TOPEX/POSEIDON mission represented a key step in observing this type of variability through the increased accuracy of its measurements and the considerable reduction in error sources. The systematic integration of Jason-1 altimetry data in oceanic models will also play a key role in the description and forecasting of these phenomena.

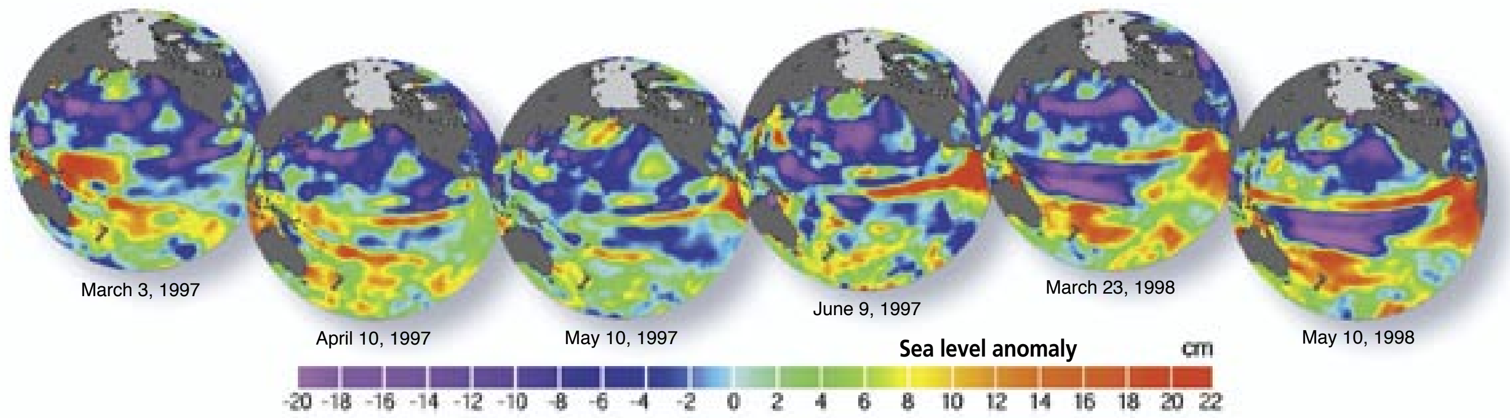
Mesoscale and coastal variability

Altimetric data is particularly useful to understand mesoscale oceanic variability. This term covers signals with weak spatial scales (a few dozen kilometers) and time scales of few months. One example of this is the very energetic eddies that form near major oceanic currents, and that



Altimetry, used to better describe and quantify the energy transported by ocean currents (here, the Gulf Stream), is an indispensable tool for adjusting and validating computerized models of oceanic circulation.

play an essential role in moving heat from low to high latitudes. Coastal zones, which represent 8% of the oceans' surface, also undergo a great deal of turbulence. These areas are especially fragile and



The El Niño phenomenon was observed in its entirety, and continually, for the first time in 1997-98 thanks to TOPEX/POSEIDON.

complex, and are subject to many different types of influence: an accumulation of organic matter and fresh water carried by rivers and streams; glacial action in high latitudes; coastal swamps; and interactions between coastal currents and deep-sea currents. Jason-1, together with the European Space Agency's ENVISAT satellite, will be excellent tools for observing and resolving this type of variability.

Changes in the mean sea level

The mean sea level is a significant indicator of global warming. TOPEX/POSEIDON measurements were used to confirm this trend, already observed with tide-gauges, which represents an average increase in sea level of 2 mm per year. Nevertheless, this extremely small variation is at the limit of what can be observed, even using a system as efficient and accurate as TOPEX/POSEIDON. Confirming these observations requires the accumulation of several years of this type of measurement. This is why it is necessary to add Jason-1 measurements to those made by TOPEX/POSEIDON.

The Jason-1 satellite, one-fourth the weight of TOPEX/POSEIDON, will follow the same ground track and will provide the same level of performance as its precursor.

Tides

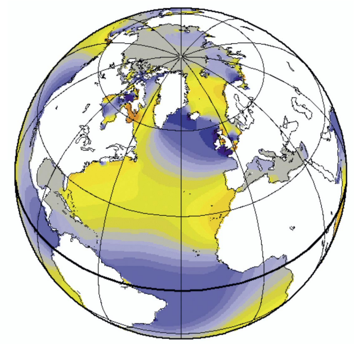
TOPEX/POSEIDON data has helped develop several models that can forecast the main diurnal and semi-diurnal components of ocean tides with an exceptional precision of approximately 2 cm. Internal waves, generated by the tides, have even been identified using estimates of tidal energy dissipation inferred from altimetry. Jason-1 will help refine these studies. In coastal regions, the combination of data from Jason-1 and ENVISAT will be particularly beneficial to help understand the long periods and tide signals with weak spatial scales.

Sea-state conditions

Altimetry will also provide estimates of wave height and wind speed, two elements which are of great scientific and operational value for marine meteorology. Several meteorological centers are already adding altimetric measurements to their operational models and will benefit from Jason-1's wind-wave measurements, which will be available less than 5 hours after being recorded by the satellite.

Other applications in geodesics, geophysics, glaciology and hydrology

Altimetric sea level measurements first represent the signal from the marine geoid, the result of the Earth's gravity on the ocean, whose amplitude is 10 to 100 times higher than that of the oceans' dynamic topography. Geophysicists also have access to a great deal of data to study bathymetry and plate tectonics with levels of precision and resolution that had never been reached before. Many other investigations in the field of earth sciences, such as research on ice, enclosed seas, great lakes, and desert regions, will also greatly profit from Jason-1's altimetric measurements.



Tide forecasting models have benefited greatly from altimetric measurement data. Tides can now be forecast with a precision of 2 cm in the middle of the ocean. (M2 component here mapped)

The satellite and its payload

Jason-1 is the first of a new mini-satellite family. Five times lighter and almost three times cheaper than TOPEX/POSEIDON, it uses the PROTEUS multi-mission platform.

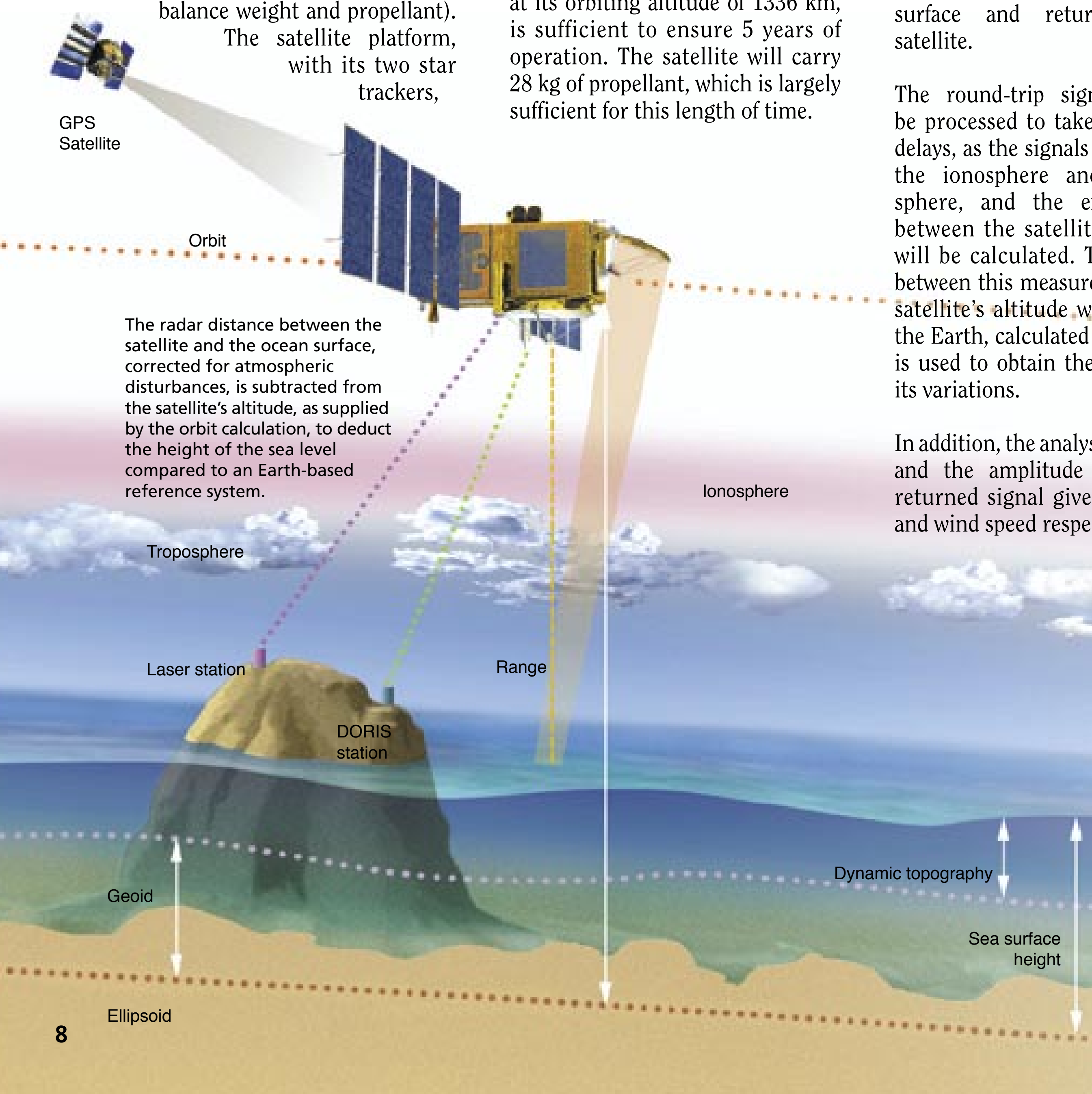
The satellite

Jason-1 is the first satellite to use the multi-mission Proteus platform, developed as part of a long-term partnership between CNES and Alcatel Space Industries.

This three-axis stabilized satellite is approximately 3.4 m high and will have a total launch mass of 490 kg (including its launch adapter, balance weight and propellant). The satellite platform, with its two star trackers, has a mass of 275 kg, and the total payload mass is 175 kg (instruments and structures).

Once the satellite is placed into orbit, it will deploy two sets of solar panels with a total surface of 9.5 m^2 that will generate 500 W of energy for the platform and payload.

While Jason-1 is designed to last for 3 years, its resistance to radiation at its orbiting altitude of 1336 km, is sufficient to ensure 5 years of operation. The satellite will carry 28 kg of propellant, which is largely sufficient for this length of time.



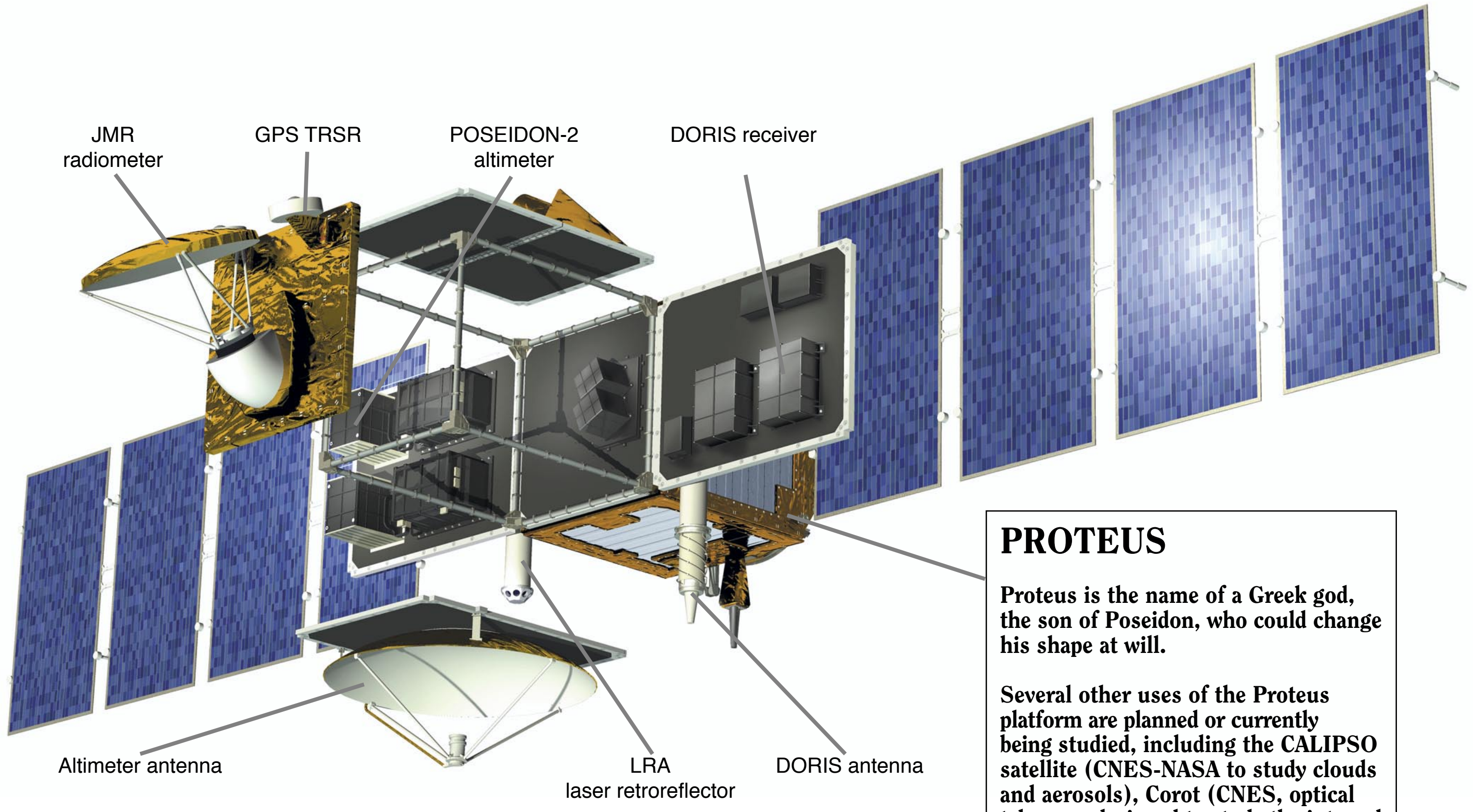
The measurement system

Jason-1 will be carrying a payload of 5 instruments. A bi-frequency altimeter called "POSEIDON- 2" and a DORIS orbitography system are provided by CNES. NASA has provided a three-frequency radiometer, a GPS location system and a laser reflector. All these instruments, with the exception of the laser reflector, are redundant.

DORIS, together with the GPS and laser reflector, make it possible to pinpoint the satellite's position, with respect to an Earth-based reference system, to within one centimeter. The altimeter is based on a radar system: radio waves sent from Jason-1 are reflected by the water surface and returned to the satellite.

The round-trip signal time will be processed to take into account delays, as the signals cross through the ionosphere and the tropo-sphere, and the exact distance between the satellite and the sea will be calculated. The difference between this measurement and the satellite's altitude with respect to the Earth, calculated from its orbit, is used to obtain the sea level and its variations.

In addition, the analysis of the shape and the amplitude of the radar returned signal gives wave-height and wind speed respectively.



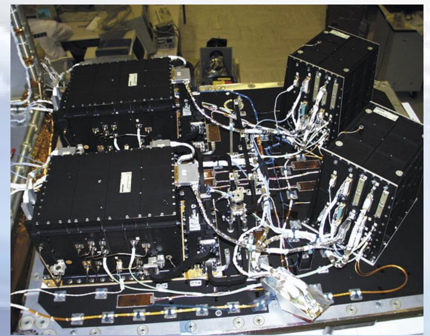
An exploded view of the satellite showing the different on-board instruments.

All the science data is stored on board the satellite in a solid-state memory. They are transmitted each time that Jason-1 is in the visibility of a ground station.

POSEIDON-2

Jason-1's radar device is the POSEIDON-2 solid-state altimeter. This was developed for CNES by Alcatel Space Industries.

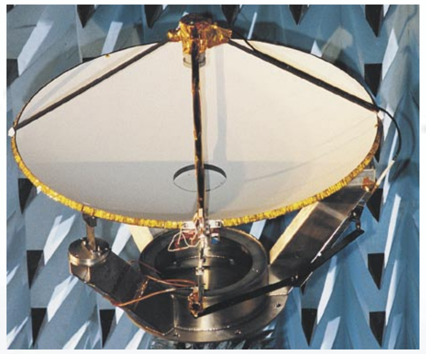
This altimeter is based on the POSEIDON-1 altimeter used in the TOPEX/POSEIDON mission. Its performance has been improved through its dual-frequency design, and it is smaller and lighter.



The two flight models of the radar altimeter on ground test benches. The performances announced were confirmed, especially the noise level of less than 2 cm at 1 Hz.

The electrical components were manufactured and tested by Alcatel Space Industries in Toulouse, and development and testing of the antenna were carried out by Alcatel Space Industries in Cannes.

Radar impulses from the 1.2 m antenna placed on the nadir face of the satellite will be sent on two



The altimeter's antenna during ground testing.

frequencies (13.6 and 5.3 GHz) in order to measure distance and make corrections for ionospheric path delay directly from the differential shift of these two frequencies in the ionosphere.

This radar is capable of measuring the distance between the satellite and the sea surface with a precision of 2 cm at 1 Hz sampling (1 measurement per second) along the satellite track.

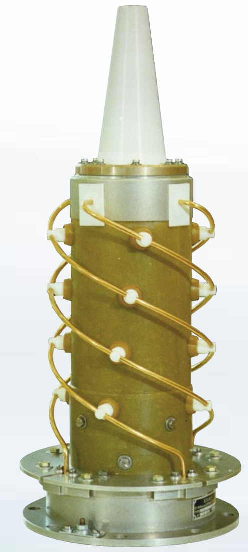
PROTEUS

Proteus is the name of a Greek god, the son of Poseidon, who could change his shape at will.

Several other uses of the Proteus platform are planned or currently being studied, including the CALIPSO satellite (CNES-NASA to study clouds and aerosols), Corot (CNES, optical telescope designed to study the internal structure of stars and to detect their planets), SMOS (ESA proposal for Earth observation), Megha-Tropiques (CNES/ISRO, study of the water cycle in the tropical atmosphere), and others.

DORIS

The success of the Jason-1 mission (just like that of TOPEX/POSEIDON) depends essentially on the ability to pinpoint the satellite's position in orbit with exceptional accuracy. This data is mainly provided by the DORIS system.



The DORIS antenna, carried by TOPEX/POSEIDON and Jason-1, is easy to recognize because of its unique shape.

Used for the first time, on an experimental basis, on the SPOT-2 satellite in 1990, the DORIS system was developed by CNES and built by THALES (formerly Dassault Electronique). Its flight-proven performance makes it the best orbitographic system currently available. It has achieved international recognition since it has been integrated into the International Earth Rotation Service.

A network of fifty beacons spread out across the Earth constantly records the satellite's location. These beacons send a dual-frequency signal as the satellite flies over them. The satellite's DORIS receiver picks up these signals and measures the Doppler effect – the shift between the frequency sent and received.

DORIS measurements carried out by Jason-1, together with measurements obtained from instruments on other satellites (SPOT 2-4 series and TOPEX/POSEIDON) make it possible to precisely locate the beacons within an international terrestrial reference system.

Doppler-shift effect measurements are sent to the ground and integrated by the DORIS Orbitography Service at the Toulouse Space Center into a complex orbitographic model which calculates the satellite's trajectory and its immediate position with respect to the Earth. The precision validated for the TOPEX/POSEIDON mission is estimated to be between 2 and 3 cm, and it is hoped that this precision will be within 1 cm for Jason-1.

The DORIS terminals and antenna are easy to transport, which ensures ease-of-use in the field, for temporary campaigns.

The DORIS receiver on Jason-1 is a miniaturized version of the receiver on ESA's ENVISAT satellite.

In addition, DORIS's performance and improved measurements have now made possible the autonomous navigation of a satellite. This involves adding a function to the DORIS receiver to calculate the precise position of the satellite in real time. This "DIODE" function, used successfully during the orbit acquisition of TOPEX/POSEIDON, then later for SPOT-3 and SPOT-4, will be implemented on Jason-1. It is hoped that it will provide positioning data within 10 cm, which makes it possible to envisage efficient use of real-time altimetry data.

Radiometer

The three-channel Jason Microwave Radiometer (JMR) is used to determine atmospheric water vapor content in the troposphere, and the correction to be applied to altimetric measure-ments for radar signal path delays in tropospheric layers.

Each of the three frequencies used is sensitive to different effects. The main 23.8 GHz frequency is very sensitive to water vapor, while the 18.7 GHz channel is used to quantify effects from wind-driven variations in the sea surface. The 34.0 GHz channel provides corrections for non-rainbearing clouds. By combining the brightness temperature measurements of each of these three frequencies, the precise amount of water vapor can be determined.

More than 50 DORIS terminals are spread around the globe, making a dense network that can tracks the satellite and help a lot in calculating its orbit with a precision of just 1-2 centimeters.

The radiometer, shown here with its antenna, is used to make precise measurements of the water vapor content of the troposphere and provide data to correct the radar altimeter measurements.

This new generation radiometer uses MMIC (Microwave Monolithic Integrated Circuit) miniaturization technologies that ensure a high level of reliability, and lower mass and power consumption. The JMR system, especially its central channel and its digital monitoring systems, are fully redundant.

GPS receiver

Jason-1's GPS receiver was provided by the Jet Propulsion Laboratory (JPL) in order to have a complementary system used to determine the satellite's exact trajectory. The Turbo Rogue Space Receiver (TRSR) can continuously and simultaneously receive dual-frequency navigation signals from 12 satellites of the GPS constellation in orbit at 20,200 km.

Using these signals, the instrument carries out and acquires phase measurements with a precision of approximately 1 mm and a pseudo-distance with a precision of approximately 10 cm.

The GPS data, combined with IGS ground-based measurements, is integrated with DORIS data into high-precision trajectography models. It is precisely this dual use of complementary geodesics systems, DORIS and GPS, which should make it possible to have measurements of the satellite's altitude precise to less than one centimeter.

Laser retroreflector

The Laser Retroreflector Array (LRA) is the target for laser tracking measurements sent from ground stations. The satellite's laser tracking measurements provide a means of calibrating altimetric measurements made by the system. The data is also used to complement other data from DORIS and GPS to provide precise trajectory calculations.

The retroreflector, placed on the nadir face of the satellite, is totally passive. It consists of nine quartz corner cubes arrayed as a truncated cone, with one cube in the center and the others arranged around the cone. The reflector provides a field of view of approximately 100 degrees. Distance measurements between the ground laser station and the satellite are precise to less than one centimeter.

The GPS receiver, which receives up to 12 GPS satellites simultaneously, works with the DORIS system to calculate the satellite's trajectography.

The Jason satellite's laser reflector is used by the ground laser stations to make additional orbitography measurements.

Industrial Partners

The "Poseidon-2" altimeter was developed and manufactured for CNES by **Alcatel Space Industries (Toulouse)**. Its antenna was developed and tested by **Alcatel Space Industries (Cannes)**.

The DORIS receiver was manufactured by **THALES** (formerly Dassault Electronique) in St Quentin-en-Yvelines, France. **C-MAC** (Argenteuil, France) provided its highly stable oscillator and its antenna was manufactured by **Chelton-Starec** (Dourdan, France). **DACTEM** (Alès, France) provided DORIS test and control benches.

The Jason Microwave Radiometer (JMR) was built by the **Jet Propulsion Laboratory (JPL)**, Pasadena, California.

The Turbo Rogue Space Receiver (TRSR) is the GPS receiver developed by the Jet Propulsion Laboratory (JPL) and manufactured by **Spectrum Astro Inc.**, Gilbert, Arizona.

The Laser Retroreflector Array (LRA) was manufactured under contract to the NASA Goddard Space Flight Centre (GSFC) by **ITE Inc.** Laurel, Maryland.

The Proteus platform (jointly developed by CNES and Alcatel Space Industries) and the Jason-1 payload module were manufactured by **Alcatel Space Industries**.

The Data Handling Unit (DHU) was manufactured by **SAAB Ericsson Space** (Goteborg, Sweden), the Star Tracker by **EMS** (Canada) and the GPS platform by **LABEN** (Italy). The gyrometers were built by **SAGEM** (Eragny, France) and the reaction wheels by **TELDIX** (Heidelberg, Germany). The telemetry and telecommand unit (TM/TC) was manufactured by **Alcatel Espazio** (Spain) and its antennas were built by **SAAB Ericsson Space**. The satellite's solar panels were built by **Astrium** (Ottobrun, Germany).

Launch and first operations

On August 10, 1992, France used an Ariane 4 rocket to put the TOPEX/POSEIDON satellite into orbit, as part of a Franco-American satellite altimetry mission. This time, the partners have exchanged roles and NASA will be handling the launch of the Jason-1 satellite.

Jason-1 will be placed into a 66-degree inclined orbit around the Earth at an altitude of 1,336 km. The satellite will be launched from the Vandenberg Air Force Base (VAB) in California, and will be placed in orbit by an American Delta II rocket built by Boeing.

The Delta II launch vehicle (7920-10) will be equipped with a recently developed Dual Payload Attach Fitting system (DPAF) that will allow the launcher to carry two satellites at the same time. Jason-1 will be launched with TIMED, a NASA-Applied Physics Laboratory satellite, which will study the mesosphere and lower thermosphere, little-known regions of the atmosphere at an altitude of 60-180 km.

Jason-1, physically attached to the top of the support structure, will be the first payload separated from the rocket. Once Jason-1 is deployed, the Delta rocket will maneuver to change orbit, and, after the DPAF support structure has separated, TIMED will be placed in its own orbit.

Before the launch, Jason-1, its ground support equipment and control consoles will be sent by plane from Alcatel Space Industries in Cannes to the Vandenberg Air Force Base. Launch preparation will last 7 weeks and will be carried out first in the facilities of Spaceport Systems International (SSI), then on the Delta launch pad at the Space Launch Complex-2W, (SLC-2W).

Liftoff will occur after a countdown of approximately ten hours. In order for Jason-1 to be placed in the same orbit, slightly offset from TOPEX/POSEIDON, the launch window will be approximately 20 minutes with two possible launch slots (between –10' and -1', and +1' and +10').

After a flight of approximately one hour, Jason-1 will be placed into orbit about 10 km below its definitive orbit. A sequence of maneuvers will then raise its altitude so that is ahead of or behind TOPEX/POSEIDON by 1 to 10 minutes.

Each satellite will carry out measurements on a specific point on the Earth's surface one to 10 minutes apart. The formation flight of the two satellites, which will last approximately 6 months, will be used to cross-calibrate the two altimetric systems, to calibrate the radiometer and to validate the measurements made by Jason-1.

After this calibration and verification period has been completed, following the recommen-dations of the Jason-1 scientific group, TOPEX/POSEIDON should be moved to an orbit whose ground track will be slightly different from that of Jason-1 until the end of its life span. It will supplement Jason-1's spatio-temporal sampling to help in the observation of small-scale phenomena.

The Vandenberg launch site.

Separation and orbit acquisition

Lift off of a Boeing Delta II rocket.

The Delta II launch vehicle

Manufactured by Boeing, and launched from either Cape Canaveral in Florida or the Vandenberg Air Force Base in California, the Delta II rocket is a flexible launch vehicle that can be adapted to the needs of different missions. Delta II, with two stages, can launch up to 5.8 tons into low Earth orbit. With three stages, the launch vehicle can put 2 tons into geostationary transfer orbit and launch interplanetary probes, such as those sent to Mars.

The two-stage version of the launch vehicle has a diameter of 2.4 m and is composed of a central core stage with a Rocket Dyne RS-27A liquid propellant (kerosene and oxygen) engine, and to which up to 9 solid fuel GEM boosters can be added. The upper stage uses an Aerojet AJ10-118K engine with the same propellant. The eventual third-stage is powered by a Thiokol Star-48A engine.

The Delta II rocket used for the Jason-1 mission is the 7920-10 two-stage version, with nine boosters. With its 10-foot payload enclosure, it will stand 40 meters tall, and its mass at launch will be 230 tons.

The Delta launch vehicle is derived from the Thor Intermediate-Range Ballistic Missiles (IRBM) from the 1960s. More than thirty different versions preceded the present-day Delta II, whose first launch took place in 1990. Altogether, through its different versions, more than 280 Deltas have been launched. All of its missions since 1997 have been successful.

Ground segment and data processing

Each satellite has its own ground control system, the infrastructure on Earth in charge of controlling its orbit, collecting and processing data from its instruments, and distributing these data to users.

Satellite command and control

The Jason-1 Control Ground System includes:

- a Jason Command Control Center (JCCC) located in Toulouse.

This center monitors the satellite during the whole mission lifetime. Satellite control and operations are executed from this center until the end of the Jason assessment phase. After completion of this phase, preparation of the operation plan, navigation functions, platform configuration changes as well as performance and trend analysis are still this center's responsibility while routine operations including satellite activities scheduling, command plan preparation, command transmission and telemetry acquisition and routing are transferred to the NASA POCC.

- a Project Operation Control Center located in Pasadena (POCC).

During the assessment phase, the POCC has the role of routing telemetry from the US Earth terminals towards JCCC. It also ensures the monitoring and control of the satellite in parallel with JCCC, and monitors the instruments under US responsability.

This center takes over from JCCC at the end of the assessment phase and controls the satellite and the associated instruments for the remainder of the mission.

- an Earth Terminal Network

The control center and the operation center rely (for command transmission and data acquisition) upon a ground terminal network of two or three earth terminals suitably located to allow the required orbit coverage compliant with the data latency requirement. The planned configu-ration is to have one earth terminal located in Poker Flat, Alaska and the second one in Aussaguel (France). A third earth terminal is available at Wallops (USA) for backup.

CNES and JPL controllers keep a close watch on the satellite at all times.

The Earth Terminal Network performs satellite telemetry capture, its recording and distribution to the control centers and to the mission centers. The earth terminals also perform the uplink commanding to the satellite.

Mission control

With the prospect of two major altimetry missions, Jason-1 (CNES/NASA) and ENVISAT (ESA), CNES has implemented a new generation of ground control. SSALTO (Segment Sol multi-missions d'ALTimetrie, Orbitographie et localisation precise; Multi-mission Altimetry Orbitography and Precise Positioning Ground Control), located at the Toulouse Space Center, will function as ground control for the DORIS system and the Poseidon altimeters.

Before SSALTO was deployed in November 2000, a dedicated CNES center controlled the DORIS instruments on the SPOT and TOPEX/Poseidon satellites, and the POSEIDON-1 radar on TOPEX/POSEIDON. It also handled data processing for these instruments.

SSALTO provides a common ground control for altimetry and precise positioning missions (DORIS-SPOT, TOPEX/POSEIDON, Jason-1, ENVISAT). SSALTO also provides altimetry expertise for third-party missions (such as ERS-2).

This new ground control system can simultaneously monitor and control different instruments of the DORIS and Poseidon families, as well as the DORIS ground beacon network, and data processing for the DORIS altimetry and orbitography payloads on all the satellites. It also provides user support for all the products of these missions.

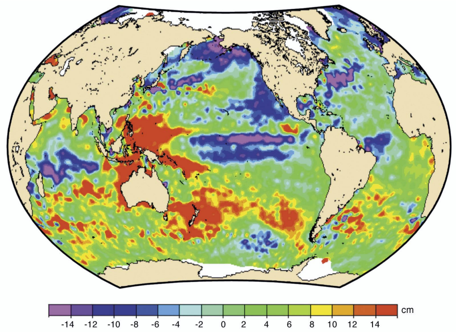
The CNES has support from its subsidiary CLS for SSALTO ground control operations. Symmetrically, the JMR and TRSR instruments under NASA responsability are monitored and controlled by the Jason Science Data System (JSDS).

The science data processing center

Users of space oceanography measurement data expect the data processing and production center to provide them with geophysical data that can be immediately used, or that can be utilized in conjunction with in-situ data or digital models.

Once it is received on the ground, raw data from Jason-1—and data received from TOPEX/POSEIDON—must be pre-processed before being distributed. After the altimetry radar echoes are analyzed, three main geophysical parameters are produced:
- the distance between the satellite and the surface of the sea,
- the average wave height,
- the wind speed.

These parameters are then corrected to take into account instrumental biases.
Environmental and geophysical corrections are also provided so that the users have all in hand to process and correct the data. Météo-France participates in this process by providing meteorological and atmospheric data which is essential for these corrections. While these radar altimetry data are being processed, the satellite's precise orbit is calculated from the



A sea level anomaly map produced as part of the DUACS (CNES/CLS) project – one of the many altimetric products now available in near-real time for scientific and operational applications.

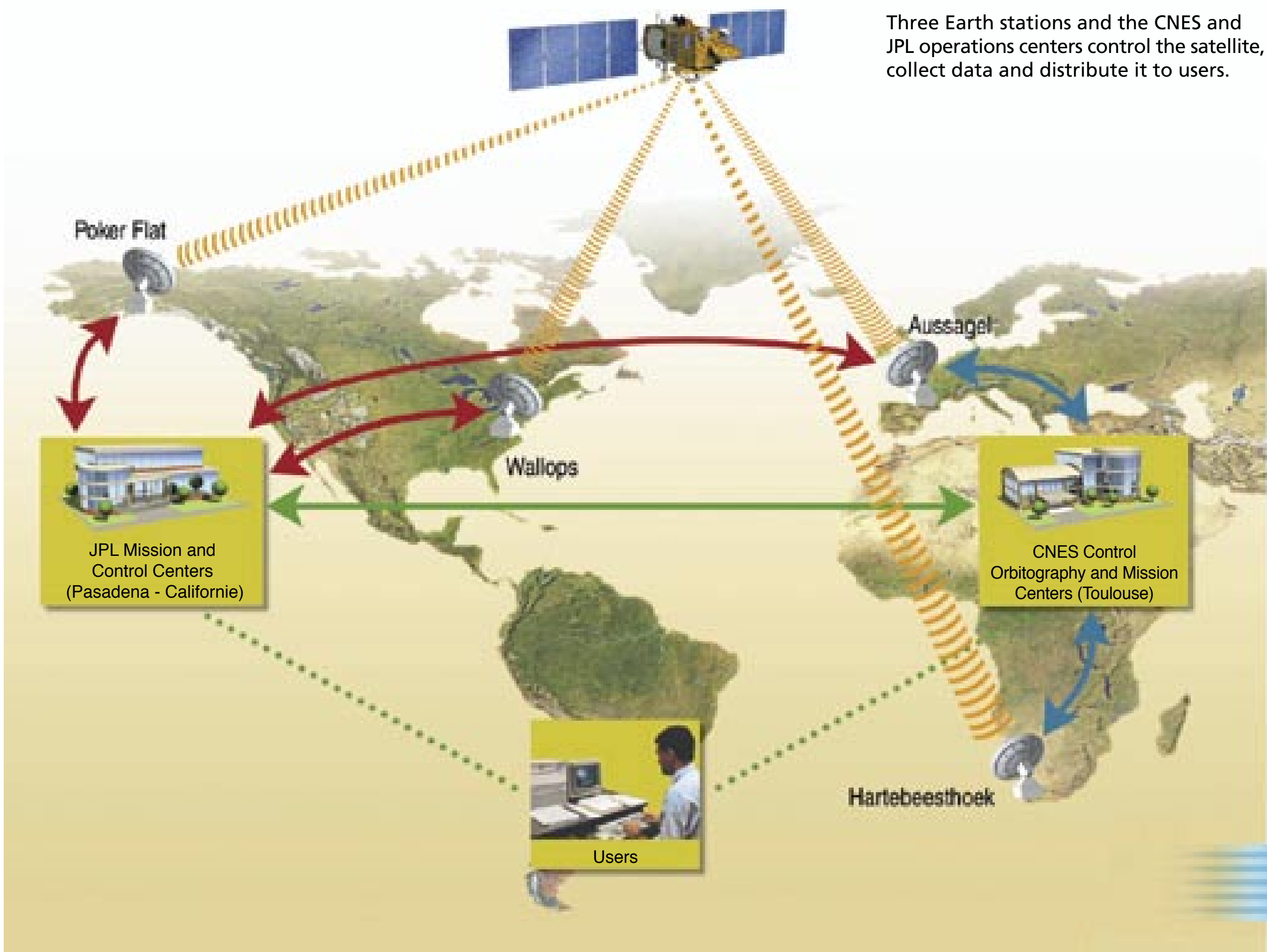
different measurements available (DORIS, GPS and Laser) and a complex model of the satellite's trajectory.

For CNES, Jason-1 science data processing is handled by the Centre Multimission Altimétrique (CMA, Altimetric Multimission Center, part of SSALTO) for altimetric data and the Service d'Orbitographie Mission (Mission Orbitography Service, also part of SSALTO) for precise orbitography data. CMA then combines these data to create geophysical products from the mission.

A version of CMA developed by CNES will operate at NASA-JPL to handle data processing from the Jason-1 mission and to provide data to the American Physical Oceanography Distributed Active Archive Center (PODAAC).

The CMA center in Toulouse also validates data, based on its large experience developed during the TOPEX/POSEIDON mission. It handles the simultaneous processing of data from Jason-1 and ENVISAT.

SSALTO will continue enhancing oceanographic data received from the CMA. Its role is to validate the physical content of the data from each mission in greater detail, and to create coherent multi-satellite products from it. The final goal is to obtain long time series of measurements that can be used to detect multi-year signals and to monitor the Ocean over a long period.



Three Earth stations and the CNES and JPL operations centers control the satellite, collect data and distribute it to users.

AVISO/PODAAC user services

Since the TOPEX/POSEIDON satellite was launched, user support for this project has been handled, on the French side, by AVISO (Archivage, Validation et Interprétation des données des Satellites Oceanographiques; Archiving, Validating and Interpreting Oceanographic Satellite data), and by PODAAC on the US side. More than 500 users receive monthly CD-Roms containing satellite data.

AVISO distributes Jason-1 mission data and products operationally, either through Earth-based networks, satellite uplinks, or, more classically, on physical media.

AVISO is also involved in the distribution of multi-satellite products produced after data are processed by the CMA (Altimetric Multimission Center, part of the SSALTO). In a more general manner, its role is to promote oceanic altimetry activities to the scientific community, operational services, decision-makers and the general public.

Just as the CMA has an American counterpart at NASA-JPL, which is directly derived from the center developed by the CNES, AVISO has an American counterpart as well: PODAAC (Physical Oceanography Distributed Active Archive Center). This center handles the same distribution functions for Jason-1 from JPL in California. The PODAAC center also distributes data from other space oceanography measurements, such as wind vector and sea surface temperature.

Since early 1999, AVISO and PODAAC have offered a catalogue of products over the Internet that allow any user to access basic and more detailed altimetric products, or to formulate specific requests through a simple ordering service.

Providing very close support and follow-up for its users, AVISO and PODAAC's goal is to offer even more efficient service for the Jason-1 mission and its operational products.

The millimeter per year Challenge

Performance goals for Jason-1 are very demanding. They can only be met if instruments are precisely calibrated and monitored constantly to ensure that the system operates correctly. This is the objective of the Jason-1 CALVAL (Calibration-Validation) program.

Performance standards for Jason-1 were specified at an early stage, following error assessment of the TOPEX/POSEIDON data. The goal was to ensure that the Jason-1 measurement system was at least as precise as its predecessor.

In order to detect sea level variations in the range of one centimeter, errors in the measurement of distance (provided by radar) and satellite altitude (provided by trajectory calculations) must be of comparable orders. Another objective, important for long-term monitoring of mean sea level, is that after calibration the drift of the altimetric system should be known to within a range of 1 mm per year.

The Harvest oil rig, off the California coast, has been used by NASA since 1992 to verify and calibrate TOPEX/POSEIDON altimetric measurements as compared to in situ sea level measurements. This system will also be used for Jason-1.

To verify this performance while the satellite is in orbit, the CALVAL (Calibration/Validation) program was developed, using the expertise of project teams, processing centers and partner scientific teams.

CALVAL's activity will begin following flight acceptance, when the satellite has reached its operational orbit, approximately one month after launch. For approximately six months, Jason-1 and TOPEX/POSEIDON will fly "in formation" on the same orbit, separated by just a few minutes. This will allow ultra-precise cross-calibration of measurements to be made from the two systems.

The observation of low amplitude oceanic phenomena, such as changes in the mean sea level of about 2 mm per year, requires precise control of the stability of altimetric systems.

The evaluation of the performance of an altimetry system depends on an estimation of errors that may occur; some of these come from the instruments themselves, and others from environmental conditions affecting the measurement.

The instruments' operation will be monitored by internal calibration data. In addition, ground verification sites will be used to obtain in-situ measurements that can be directly compared to data obtained by the satellite. Operations will concern all components of the altimetry system and will be used to evaluate the quality of measurements from the altimeter, the JMR radiometer and the Doris and GPS positioning systems.

Validation of the Jason-1 system will be assisted by a worldwide network of some thirty tide-gauges collocated by Doris and GPS measurements, along with several sites located along the satellite's ground track.

These dedicated sites are not only equiped with tide-gauges to measure local sea level, but also have complementary instruments (GPS, laser, radiometers, etc.) to validate the other geophysical parameters used together with altimetric measurements.

The main CNES calibration site, used since 1996 for the TOPEX/POSEIDON mission, is located in Corsica, on Cape Senetosa, near Ajaccio. A second site, on the same satellite's ground track, will also be used. This is on the Italian island of Capraia, located between Corsica and the Italian peninsula.

The main NASA calibration site uses an offshore oil platform, Harvest, located off the California coast. This experiment, begun in 1992 just before the launch of TOPEX/POSEIDON, has since been providing essential measurements to monitor and record the system's bias and drift.

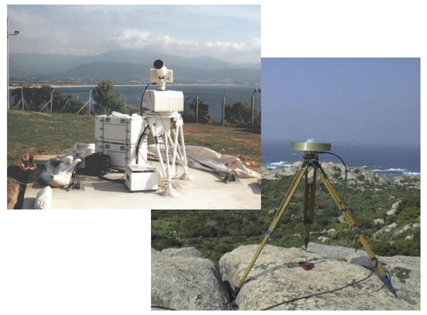
Additional sites are planned in the Gulf of Mexico and the Mediterranean (Ibiza, Crete). They will also be used by other altimeter missions, such as ENVISAT.

In addition to on-site calibration experiments, CNES and NASA data processing centers will carry out global evaluations of Jason-1 data. They will verify the consistency of geophysical products using highly efficient statistical analyses.

Significant efforts, involving the CNES Mission Orbitography Service, as well as other orbitography experts from the Jason science team, will work on precise orbit validation, one of the key elements of the Jason-1 mission.

Many validation experiments will be carried out by the Jason-1 science team as part of the CALVAL program. More than thirty scientific teams have offered to participate in the validation activities. Météo-France will also participate in this Jason 'wind-wave' data validation program by comparing estimates provided by meteorological models.

The CALVAL program will ensure that Jason-1 measurements are scientifically and technologically reliable, not only during the intense verification period during the first 6 to 8 months, but throughout all the mission.



CNES, together with CERGA and IGN, have set up sea level and geodetic stations at Senetosa in Corsica to verify and calibrate Jason-1 altimetric measurements.
The ultramobile laser station developped by OCA, CNES, IGN and INSU will support this campaign.

Jason and climate forecasting

Eusuring the continuity of high precision altimetry missions, like Jason-1, is essential to monitor the ocean changes and understand better their impact on the climate.

In meteorology centres around the world, such as Météo-France's facilities in Toulouse, super-computers crunch numbers 24 hours a day. Most of the time, short-range weather forecasting is the highest priority. But, in off-peak periods, these computers calculate models developed by scientists working on longer-term forecasts, who are trying to better understand the interactions between atmospheric and oceanic phenomena.

Weather modeling is a sort of digital laboratory where scientists juggle with millions of numbers and initial physical hypotheses to get as close as possible to reality. These numbers represent different parameters spread out over time (air pressure, temperatures, wind speed and direction, sea currents, etc.). Calculations are complex, but when the computers hand down their verdict, the results can lead to many new investigations and a great deal of progress.

Within the Centre National de Recherches Météorologiques à Météo-France, is the Groupe de Météorologie à Grande Echelle et du Climat (Group for Large Scale Meteorology and Climate). Its goal is to come to a global under-standing of climatic variations on our planet. CERFACS[1] and IPSL[2] participate in this joint project to model the atmosphere and the Ocean as a couple (that is, to understand how these two systems operate together) in order to provide, at an experimental level, reliable seasonal forecasts. Other research groups around the world (ECMWF, FNOC…) pursue the same objective.

Altimetry data will be essential in helping establish the initial state of the ocean and its evolution as precisely as possible. Topographic ocean data will be incorporated with all the other available data (from buoys, boats, etc.) in oceanic models so the data will be "assimilated".

This assimilation will lead to a description of oceanic currents, temperatures and salinity for all the oceans of the world, and this will be done with a level of precision that has never before been obtained. Naturally, refining this system will require a great deal of effort, which is being shared by the many different national organizations interested in oceanography who work together as part of the project called MERCATOR. The same effort is made at an international level, for instance in the GODAE programme.

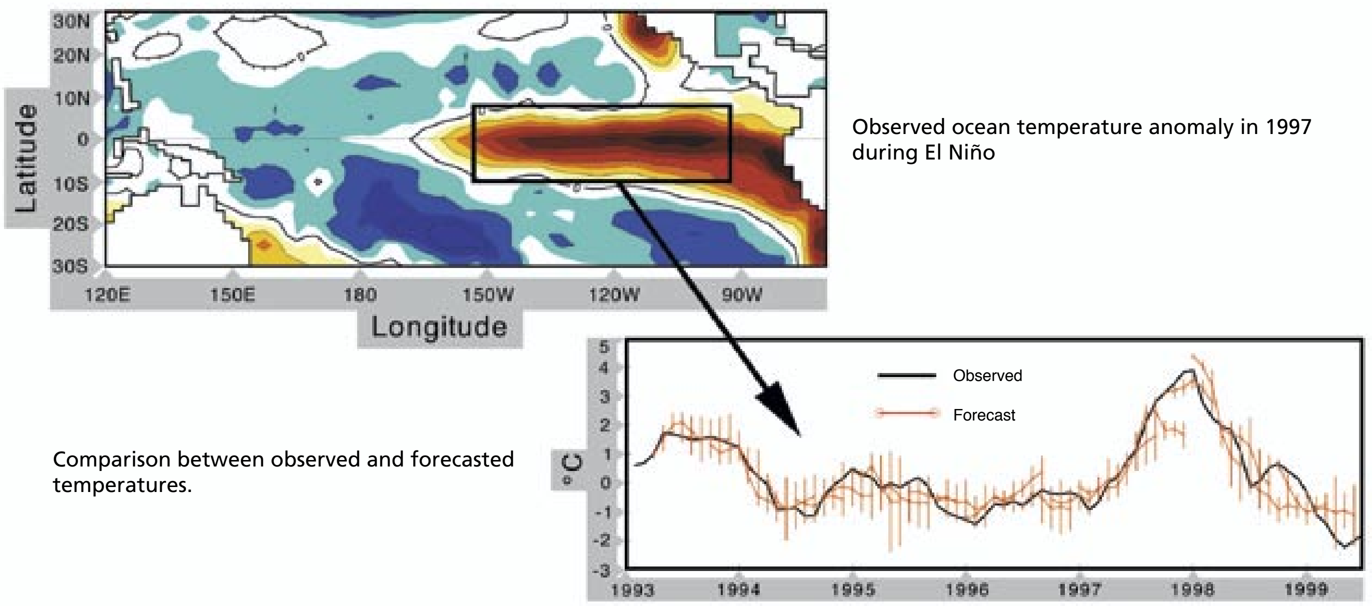
It is essential that high precision altimetry missions be carried out to maintain and follow-up long-term oceanic projects. Among the reasons for this are the following:

- Global warming, observed since the beginning of the XX^{e} century through temperature measurements on the surface, has led to an increase in sea level of approximately ten to twenty centimeters. Altimetric measurements can confirm this rate of increase and will be used to monitor future changes.

- The "El Niño" phenomenon (and its "La Niña" counterpart), which occurs in the Pacific, is a special case. Since the beginning of the 1980s, new observations and developments in weather modeling have helped us better understand this regional phenomenon that can have global influences. Scientists now understand the importance of the Pacific basin and the tropical oceans and how they affect the climate of the entire Earth. More detailed observation from space, using satellite altimetry, will help scientists better understand the mechanisms behind these kinds of phenomena.

Even though signs of climatic variability are weaker in other parts of the planet, and more difficult to detect, scientists are putting a great deal of hope in the assimilation of altimetric data in oceanic models to further increase our understanding of the climate and improve its predictability.

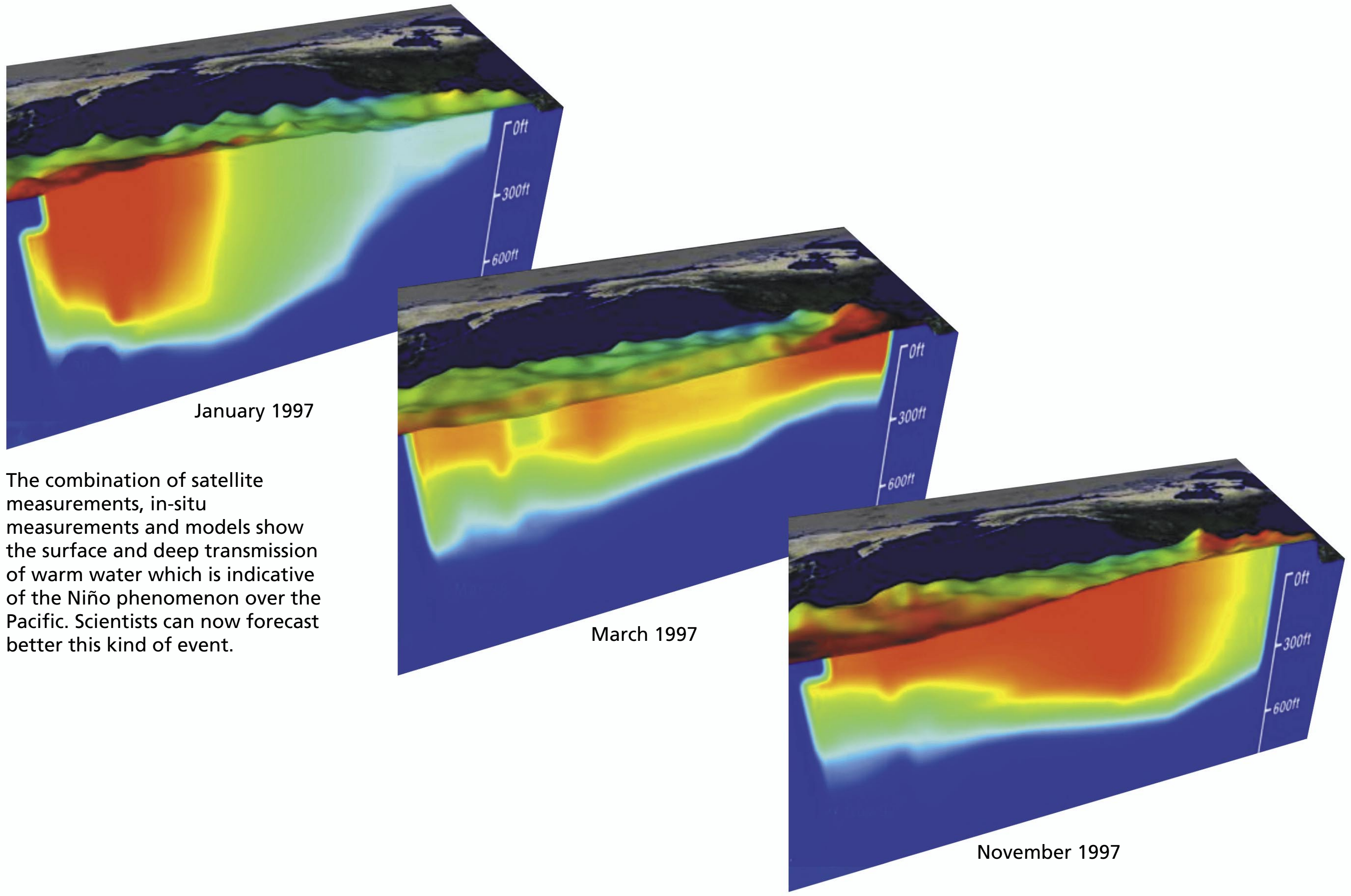
[1] *Centre Europeen de Recherche et de Formation Avancee en Calcul Scientifique (European Center for Research and Advanced Training in Scientific Calculation).*
[2] *Institut Pierre Simon Laplace.*



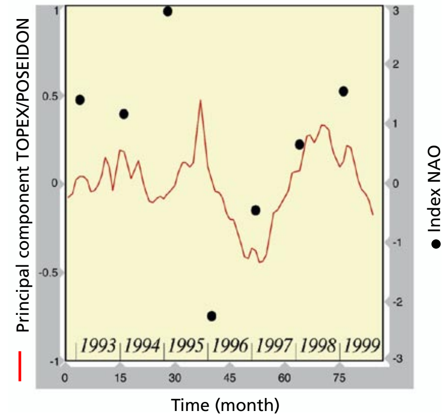
Observed ocean temperature anomaly in 1997 during El Niño

Comparison between observed and forecasted temperatures.

The association of oceanic models and atmospheric models will allow scientists, in the years to come, to make reliable climactic forecasts on a seasonal basis, as for example forecasting El Niño events.



The combination of satellite measurements, in-situ measurements and models show the surface and deep transmission of warm water which is indicative of the Niño phenomenon over the Pacific. Scientists can now forecast better this kind of event.



The increase in the level of the Tropical Atlantic Ocean, which occured between winter 1996 and winter 1997, as observed by TOPEX/POSEIDON (red curve), corresponds to the increase in the North Atlantic oscillation index (the difference in atmospheric pressure between the Azores and Iceland) (dots). Its shows that there is a dynamic coupling between the ocean and the atmosphere. The NAO signal, and other multi-year oscillations in the Pacific or Antartic, create strong changes in the climate. Long term altimetric series are very useful to understand the related ocean-atmosphere mechanisms.

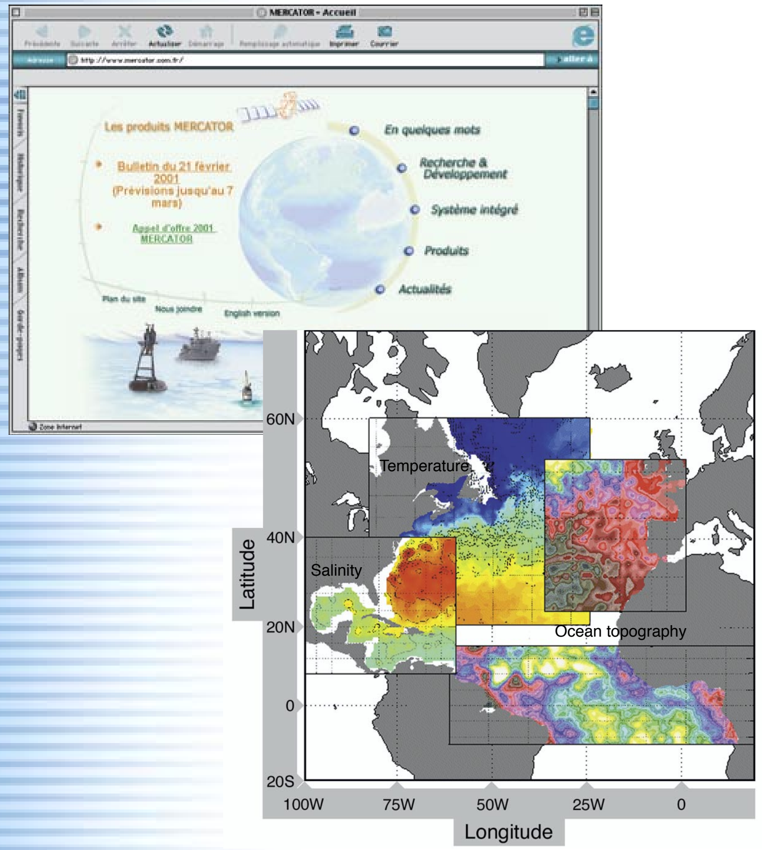
One of the first on-line service: MERCATOR

Seeing that operational oceanography has the potential to meet their respective needs, six French organizations set up a common program in 1997. The objective of this program, MERCATOR, a partnership between CNES, CNRS, IFREMER, IRD (formerly ORSTOM), Météo-France and SHOM, is to operationally implement global oceanic models, at high resolutions, for research purposes, and to develop a variety of applications for marine environments.

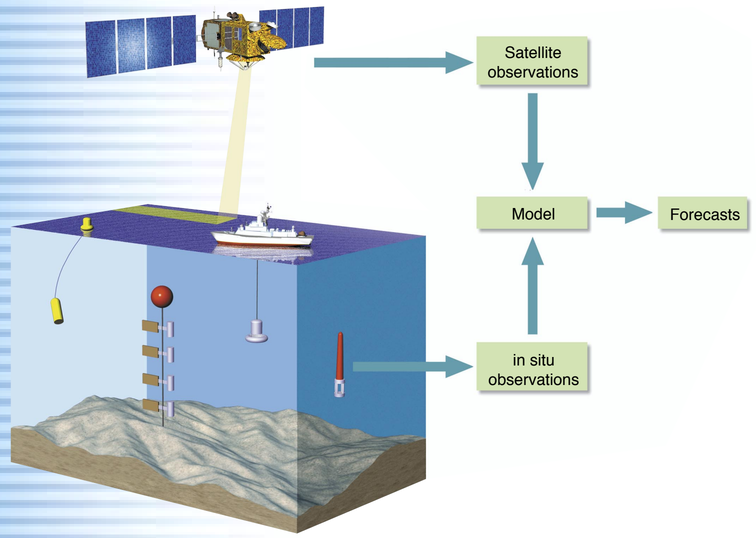
MERCATOR has three main goals: modeling, acquisition of spatial and in situ observations, and assimilation of these data in ocean models. The system depends heavily on the existence and continued availability of altimetric data, but also on other satellite observation systems and in situ networks, leading to close coordination with the various projects planned. International collaborations have been set up, such as those with researchers from the European Center for Medium Range Weather Forecasting (ECMWF) and the UK Met Office.

An initial MERCATOR prototype, functioning since January 2001, is creating real-time products for the North Atlantic. For a given date, a diagnosis of the oceanic situation and a forecast over several days will be provided. Users of these data, such as the French Navy, will use these products in pilot applications. These products will eventually play a key role in seasonal climatic forecasting systems and operational systems for coastal oceanography.

MERCATOR is the French contribution to GODAE (Global Ocean Data Assimilation Experiment). This international experiment, begun in 1997, is designed to demonstrate the feasibility of operational oceanography, using systems to assimilate spatial and in situ data in oceanic models. MERCATOR and all the other forecasting centers around the world (United States, Japan, Australia, etc.) will share their forecasting models and provide their partners with their results during the intensive three-year period of GODAE activity, from 2003 to 2005. Operational oceanography will then progressively be accepted at the same level as meteorology is today.



The Mercator system, operating since January 17, 2001, produces every week a 3D analysis and a two-week forecast of the sea state in the form of current, dynamic topography, salinity and temperature maps. Mercator is the first link in the international operational oceanographic experiment GODAE planned for 2003-2005.



The Mercator system uses satellite measurements (especially altimetric data), in-situ measurements and a high-resolution model (to a few kilometers) to describe the physical sea state.

Jason serving seafarers...

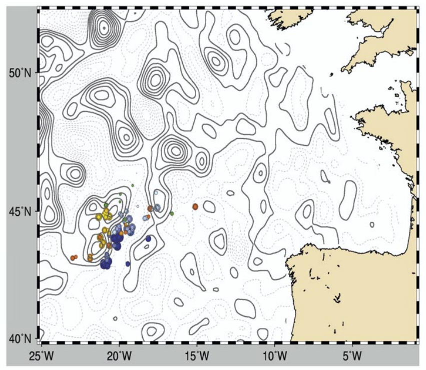
Many marine activities will benefit from the monitoring and forecasting of ocean dynamic state as derived from altimetric satellite missions.

Every week, several science and processing centers around the world, including the oceanographic department of CLS, a subsidiary of CNES, and the Service Hydrographique et Océanographique de la Marine (SHOM; French Navy's Hydrographic and Oceanographic Department), produce dynamic topography charts of the sea, which are very useful for all those who work at sea.

Computers will have processed at length the altimetric data (TOPEX/POSEIDON, then Jason-1, ERS then ENVISAT) to extract pertinent data on current positions and intensity, the presence and scales of eddies and thermal fronts.

Fishing

The fishing industry is one of the main users of altimetric products, even though the first applications of this data to commercial fishing only date back to 1998. Schools of fish can often be found in areas with an abundance of plankton, and that this plankton is often present in areas of thermal fronts and strong currents. Altimetric charts can provide important information regarding links between the marine environment, as seen on the charts, and the rate of fish reproduction and their life cycle. In addition to assisting commercial fishing, these altimetric products can help better manage variations in fishing resources according to fishing campaigns. Jason-1 also has applications useful for managing fishing quotas and "intelligent fishing".



The correlation between albacore tuna catches (indicated by colored dots) and sea level anomalies deducted from altimetric measurements shows that the catches are made at the edges of warm whirlpools (positive sea level anomalies). This type of study is especially useful to better understand the way different species of fish live and better manage fishing resources according to fishing efforts.

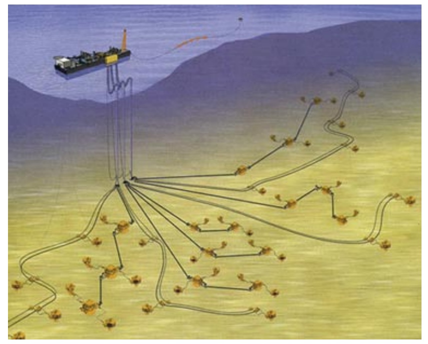
The fishing industry is a promising market for altimetric products. After an initial demonstration phase, more detailed products will be available including altimetric data and measurements of sea temperature and color by satellite, before three-dimensional modeled products are developed. CLS is one of the leading companies in this field.

Offshore Petroleum

The offshore petroleum industry is also interested in altimetric products because petrol companies are going further from the coast and into deep water. The technology used in these cases is to have wellheads installed on the sea bottom. Oil is brought to the surface through flexible umbilicals to barges anchored above the site, and tankers then remove the oil from these barges.

Knowing the currents at a depth of several hundred, or even 1000 meters can be very useful for this type of operation. Platforms such as those in the Gulf of Mexico have suffered severe damage in the past from very active whirlpools.

Precise surveillance of currents and sea states, which will be available in products derived from Jason-1 and ENVISAT data, is extremely valuable to better manage pumping operations and to better design platforms.



The increasing depth of oil drilling requires a better knowledge – and more reliable forecasts - of sea currents.

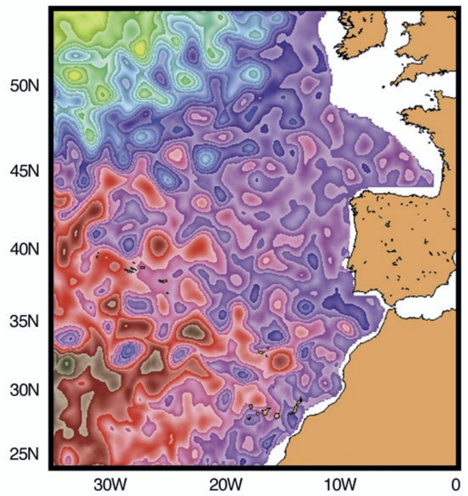
All petroleum prospecting zones in deep water are concerned, especially those off the coast of Europe (Norway, Irish Sea, etc.) but also those in the Gulf of Guinea and off the coast of Indonesia.

Navigation

The French Navy has been using altimetric data regularly and operationally since 1998, and the US Navy has developed a similar operational system. Each Wednesday, French navy ships at sea receive a chart of the northeast Atlantic, developed from oceanic models that include measurements from TOPEX/POSEIDON and ERS. This system, "the Systeme Operationnel d'Analyse et de Previsions" (SOAP; Operational Analysis and Forecasting System), was developed and implemented by the Toulouse branch of the Service Hydrographique et Oceanographique de la Marine (SHOM).

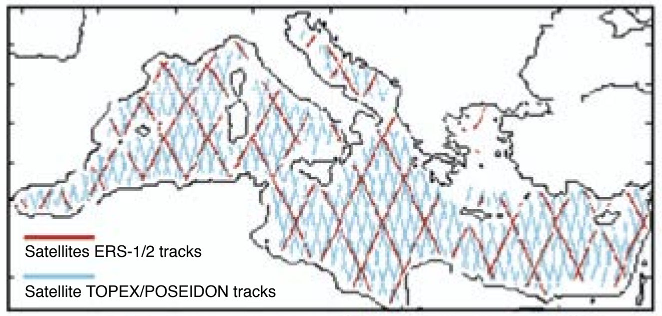
SHOM has a dual mission: to support naval forces, and to provide a public service. The public service mission consists in ensuring safe navigation, creating sea charts and developing documentation for navigation, such as tide tables. As part of the Navy's environmental support mission, SHOM provides the Navy with more specific forecasting and analysis data concerning the sea environment. Water masses, temperatures, currents, eddies and the position of fronts in the open sea are essential information to help both surface and underwater navigation.

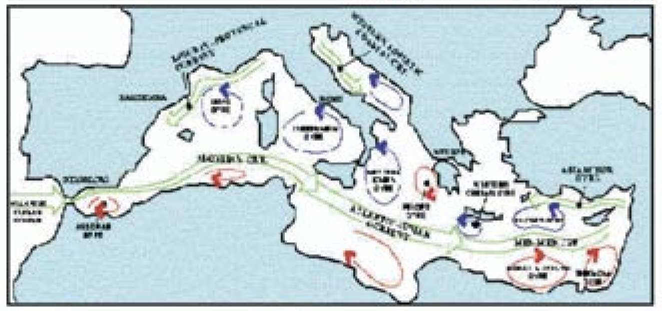
SOAP's oceanic forecasts, which may extend as much as 14 days, are developed from models that integrate satellite altimetry data (from TOPEX/POSEIDON/Jason, ERS/Envisat, etc.), water surface temperature data (from NOAA satellites), wind force data (from weather satellites), and in situ



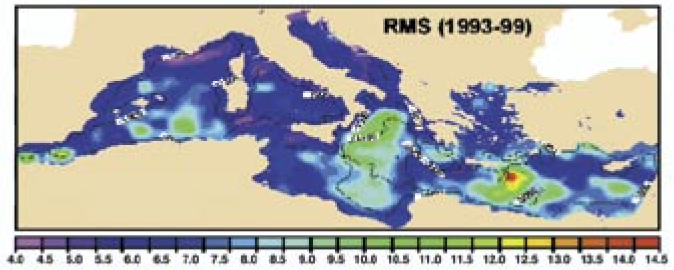
The dynamic topography data provided by altimetric satellites, used, for example, in the French Navy's SOAP oceanic forecasting model, is essential to predict changes in the ocean's small eddies.

measurements. In the near future, other data sources will be used, and the scope of this project will be extended to the north Atlantic and the Mediterranean. Performance will also be improved as more efficient models are developed as part of the pluri-organization project MERCATOR, in which SHOM is an active participant.





As with TOPEX/POSEIDON and ERS, the combination of ENVISAT and Jason-1 measurements will allow scientists to detect and monitor small-scale eddies phenomena present in the Mediterranean. It is used by the European pilot project MFSPP (Mediterranean Forecasting System Pilot Project) provide analyses and forecasts of physical and biogeochemical parameters of the Mediterranean.



Sea level variability (cm).

Coastal Surveillance

Another field of activity where altimetric data is useful is that concerning coastal areas where there are many problems related to risk prevention and coastal development. The altimetric products currently available need to be merged to observe coastal areas with a better resolution, and to observe small scale and short term features present in the regions such as coastal tides and currents. In the near future, the rapid progress expected in terms of high-resolution modeling and the production of adequate data sets should make it possible for a significant level of support to be provided.

Anticipating Storm Surges

A positive storm surge is an abnormal increase in sea level caused by low pressure or high winds blowing from the sea toward land. An opposite phenomenon also exists: it is called a negative surge. When a hurricane or a depression approaches a coast, these two phenomena combine. In some areas with certain geographic characteristics, such at the heads of bays or gulfs, this accumulation of water can be amplified.

The increase in sea level can sometimes reach several meters (6 meters when hurricane Hugo reached the East coast of the United States in 1989 and 1.5 meters on the French Atlantic coast during the storm of December 27, 1999). Storm surge effects can be especially destructive on the shoreline where most populations and activities are concentrated.

Negative storm surges which occur in high pressure situations have fewer safety risks but can nevertheless be a problem for the operation of large ports.

Météo-France and other meteorological offices around the world have developed oceanic modeling systems to forecast storm surges and prevent eventual risks.

Information is provided to local authorities to assist them in decision making. Jason-1 and ENVISAT altimetric data will help verify storm surge forecasts, and, integrated in real time into meteorological models, even improve them.

Forecasting Drift

Drift results from the combined actions of wind, tide currents and oceanic circulation, on an object lost at sea. Drift forecasting requires special oceanic models, used in conjunction with tide and wind forecasts, coupled with models describing the behavior and changes of the drifting objects. These complex tools are used operationally by Météo-France, in collaboration with Cedre (CEntre de Documentation, de Recherche et d'Experimentation sur les pollutions accidentelles des eaux; Center for Documentation, Research and Experimentation on Accidental Water Pollution) for sea pollution, together with sea authorities and CROSS (Centres Regionaux Operationnels de Surveillance et de Sauvetage; Regional Operational Centers for Surveillance and Rescue) during search and rescue operations.

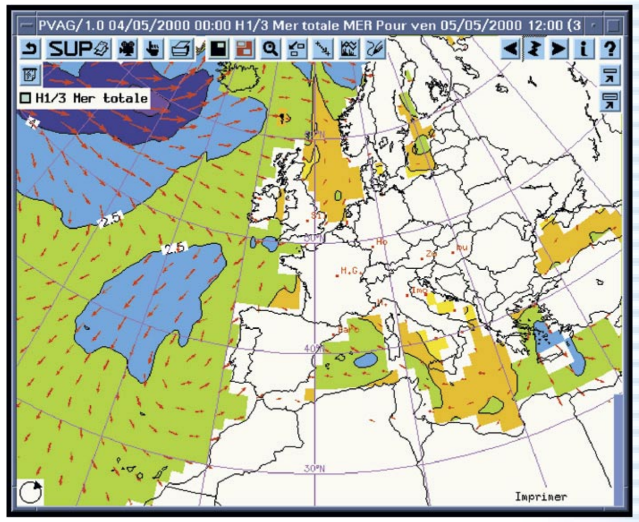
Since the assimilation of Jason-1 data will improve oceanic models, forecasts for high sea drift will be more efficient. Forecasting drift near the coasts, which is essential when any pollution occurs in the sea, will also benefit.

Marine Meteorology

Satellite altimetry provides real-time oceanic observations of the sea-state (wind, waves…) to meteo-rologists, and these data can help them develop forecasts. These data, as well as that produced by diffusiometers, are currently provided by the ERS-2 satellite. Météo-France uses these data each day in VAG, its sea state forecasting model. The European Center for Medium-Term Weather Forecasting (ECMWF) does the same with the wave model WAM.

WAM and VAG simulates the evolution of different wave sets and swells, which are superimposed, and forecasts the sea state on all parts of the Earth, with a higher level of precision for Europe. Météo-France provides sailors with regular forecasts and special weather updates when weather conditions deteriorate.

The ERS-2 observation mission (launched in 1995 with a life span of 3 to 5 years) will be continued by ENVISAT and Jason-1, and these satellites will provide data with a delay of 3 to 5 hours. Thus, Jason-1 will offer a potential for progress in all areas of marine forecasting: forecasting of sea state, but also storm surges and drift.



Wave height and wind speed data, less than 3 hours old, will be provided by Jason-1 and used in operational sea state models to improve forecasts.

The ENVISAT satellite will carry a payload of several instruments including an altimeter that will be used for a mission complementary to that of Jason-1.

ENVISAT, the Fellow Traveler

The European Space Agency's ENVISAT mission is ambitious and innovative. This polar platform for observing the Earth will study the Earth's surfaces, atmosphere, oceans, and ice caps for a period of five years.

This very large satellite (more than 10 m high and with a mass of 8 tons) will carry no fewer than ten instruments, including an altimeter (RA-2; Radar Altimeter 2) and CNES's DORIS positioning system. The dual-frequency radar altimeter, derived from that used on ERS-2, has been designed to carry out measurements on all types of surfaces. It will map the oceans, sea ice, polar ice caps and most of the planet's landmasses.

Data acquired by ENVISAT will then be used to support global climatic research. It will help better monitor environmental changes and contribute to the development of operational and commercial applications.

While Jason-1's orbital cycle is 10 days, ENVISAT - like ERS - has a 35-day cycle. Its altimeter "sweeps" the oceans much more densely. It can detect oceanic phenomena on a much smaller scale than Jason-1. This difference makes the two missions highly complementary.

Backed by the world's scientific community

During a scientific symposium at Venice, in 1980, results from the Seasat satellite, the second altimetric satellite launched by the Americans, were presented. The participants then had the opportunity to realize the extraordinary potential of altimetry for studying the oceans. So much progress has been made since then!

In 1987, when CNES and NASA issued the announcement of opportunity to select researchers who would provide support for the TOPEX/POSEIDON mission during its development and operation stages, the response was overwhelming. More than 40 teams, containing over a hundred scientists of all nationalities, were selected on the basis of their research proposals.

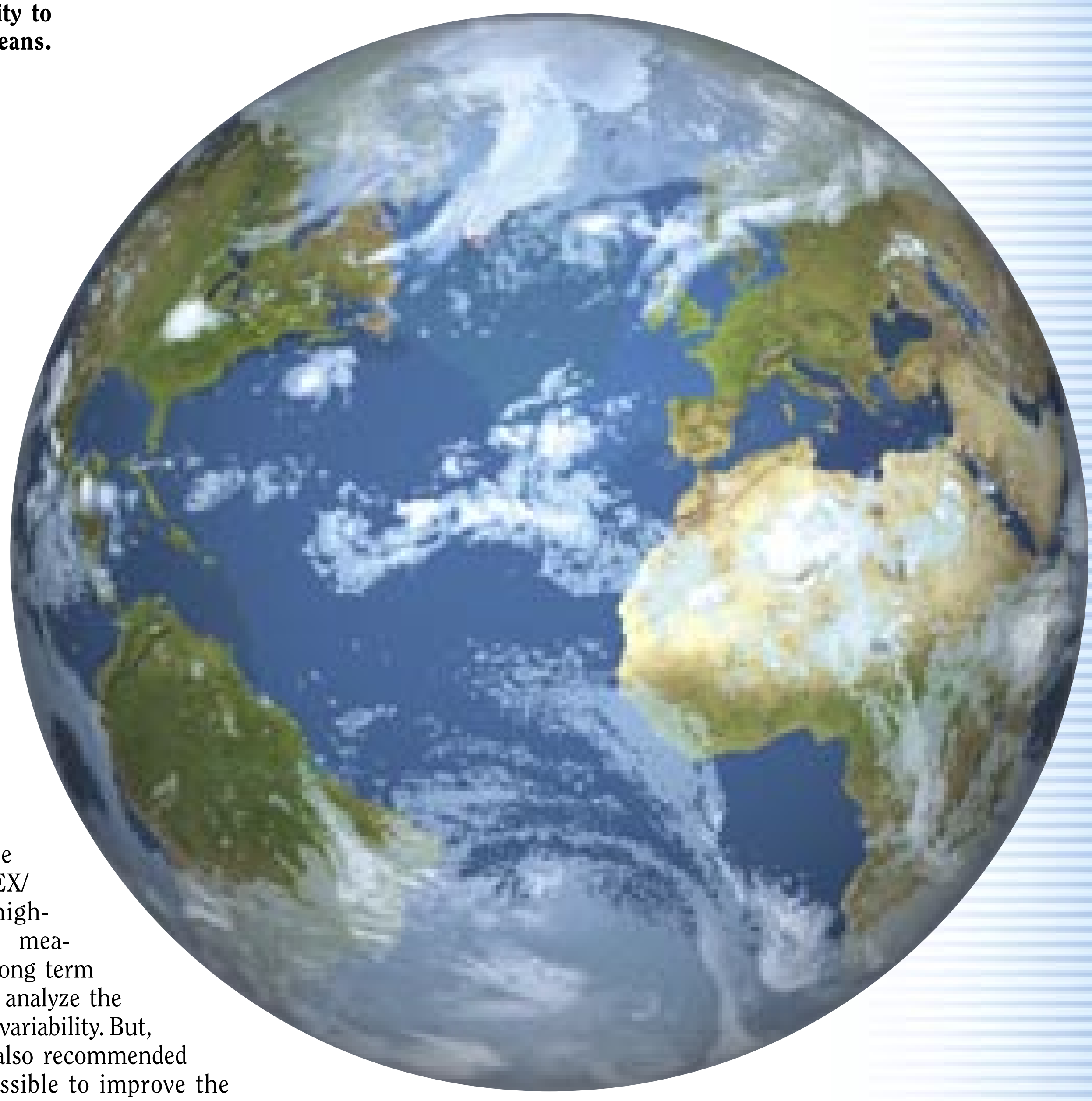
Through exchanges with technical teams, these scientists helped develop the specifications for the geophysical and instrumental performance of the system. Once the satellite was launched, they were involved in quality control of measurements, in upgrading the data-processing algorithms and in the scientific enhancement of data. As early as 1993, they recommended that NASA and CNES begin working on a successor to TOPEX/POSEIDON to ensure that these measurements be continually available.

In addition to this core group of researchers, hundreds of other researchers use the freely distributed data of the mission. Currently, more than 500 international research teams work with TOPEX/POSEIDON data. This partnership between these scientific and technical teams was so rewarding for the TOPEX/POSEIDON mission that CNES and NASA decided to maintain it for the Jason-1 mission and made a new announcement of opportunity in 1997.

This led to the selection, in 1998, of a new Jason-1 scientific group composed of 68 teams from around the world (including more than 200 researchers).

The knowledge acquired by TOPEX/POSEIDON has led to more de-tailed discussions of the many scien-tific results obtained, during the scientific group's meetings (approximately one per year), but also on potential improvements to the system.
The main goal has been to continue making TOPEX/POSEIDON class high-precision altimetric measurements over the long term to better sample and analyze the wide range of oceanic variability. But, the scientific group also recommended doing everything possible to improve the system's performance. This effort was undertaken, especially through the development of even more efficient geophysical models and more adequate means of controlling the quality of the measurements.

Once again, the calibration measurements and validation of the new Jason-1 system will require a great deal of involvement from the scientists working on this project. During the verification phase, teams belonging to the scientific group will be the first to receive Jason-1 measurements to make exhaustive analyses before providing the data to their colleagues around the world. There is no doubt that the many results obtained from these measurements will help further our knowledge of the ocean even more.



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French players among the Argonauts

In recent years, many French laboratories, organizations and companies have become involved in the use and analysis of satellite altimetry data and the definition and development of new altimetric missions.

This sector has led to the creation, in Toulouse, of a Space Oceanography Group which organizes local resources in this field, from the development of on board instruments and their software to the scientific analysis of measurements and the distribution of specific products. In addition to CNES, prime contractor in charge of space projects and systems, the other partners involved are:

- *Collecte Localisation Satellites (CLS)*, center for processing and analysis of spatial oceanographic data and the enhancement of altimetry applications,
- *Météo-France*, which uses altimetry for diagnostic studies of sea states and forecasts for marine meteorology and coastal dynamics,
- *The French Navy's Hydrographic and Oceanographic Department (SHOM)* which has developed a system dedicated to oceanic analysis and forecasting for the north Atlantic,
- *The Laboratory for Geophysical and Spatial Oceanographic Studies (LEGOS)*, CNRS/CNES/UPS, a laboratory doing research in oceanography, geophysics and glaciology, which works in many areas such as oceanic dynamics, mean sea level, tides, ice, NAO, El Niño… The Center for Ocean Topography (CTO) is also part of LEGOS.
- *The European Center for Research and Advanced Training in Scientific Computation (CERFACS)*, which works with Météo-France Research group (CNRM) to create advanced models that couple oceanic and atmospheric data to develop seasonal climatic forecasting systems.

The French scientific community involved in space altimetry projects is especially active and includes technicians, engineers and scientists from many disciplines.

In addition to these different organizations in the Midi Pyrénées region of France, other industrial partners are involved: *Alcatel Space Industries*, which designed and manufactured the POSEIDON altimeter and the PROTEUS platform, and the many computer service suppliers involved in the development of ground control and data analysis software. *The Cité de l'Espace* exhibition complex has also helped promote space activities to the general public.

On a national level, *Thomson Detexis*, *CEPE* and *Starec* were involved in the manufacture of the DORIS system, and many researchers from the *National Center for Scientific Research*, *Universities, Observatories, the Institute of Research for Development, the Museum of Natural History, IFREMER and National Geographic Institute (IGN)* are involved in the Jason-1 scientific group. Some of these are:

- *The Dynamic Oceanography and Climatology Laboratory (LODYC)*, at Paris VI University, which uses altimetric data to study oceanic processes and modeling,
- *The Laboratory for Geophysical and Industrial Fluid Flows (LEGI)*, in Grenoble, whose scientists work on the assimilation of altimetric data into oceanic circulation models,
- *The Laboratory for Physical Oceanography*, part of the Museum of Natural History in Paris, involved in the study of Antarctic circumpolar current dynamics,
- *The Laboratory for Ocean Physics (LPO)*, part of the IFREMER center in Brest, which uses both in situ and altimetric data to study oceanic variability,
- *The Department of Space Oceanography*, also part of IFREMER, is involved in processing and valorizing satellite data, and does research using altimetric data to study sea states and their effect on radar signal physics,
- *The Institute of Research for Development (IRD)* has several teams, based in Nouméa, Toulouse, Paris, Montpellier and Brest, who use altimetric data to carry out geophysical and oceanographic studies in tropical areas,
- *The National Geographic Institute* provides expertise in the field of terrestrial reference systems,
- A team from *the Center for Terrestrial and Planetary Environmental Studies*, in Velizy, is working on improving knowledge of the highest layers of the atmosphere and their effect on the propagation of radar signals,
- A *CERGA* team from the Côte d'Azur Observatory is involved in verifying and validating altimetric measurements and tracking altimetry satellites by laser, as part of geodesic activities carried out by *the Research Group in Satellite Geodesy (GRGS)* which itself is involved in the development and improvement of gravity field measurements for better modeling.

In addition to these French scientific teams, many scientists from the United Kingdom, Germany, the Netherlands, Denmark, Spain and Italy provide their expertise to the Jason scientific group, in complement to the many American, Australian, Japanese and Chilean scientists contributing to this project.

Since many years, french and american project teams works hand in hand to make successful TOPEX/POSEIDON and Jason-1 missions.

French - US space cooperation

Since its creation in 1962, CNES has maintained an important program of cooperation with the main American space organizations.

This cooperation, mainly carried out with NASA, covers the following areas: observation of the Earth and its environment (TOPEX/POSEIDON, Jason and CALIPSO missions), space science, exploration of the solar system (especially Mars), astronomy, astrophysics, microgravity science and manned space flights, and data collection.

Observation of the Earth

In addition to the TOPEX/POSEIDON and Jason-1 programs, in late 1998 NASA and CNES decided to continue cooperating in this area with the Franco-American CALIPSO mission (formerly ESSP3-CENA mission). This mission, scheduled to be launched in 2004, will study clouds and aerosols and their impact on the Earth's radiation balance. CNES will provide a PROTEUS platform and infrared imaging instruments. To continue after Jason-1, in 2005 the Jason-2 mission, should be realized, for a launch, within a partner ship between CNES, NASA, EUMETSAT and NOAA.

Space Science

Franco-American cooperation in this area occurs through programs of the European Space Agency and as part of bilateral relations between CNES and NASA.
The major bilateral program for the coming years involves cooperation in the exploration of Mars. CNES, together with its American partners, is examining the possibilities of a partnership that will lead to the return of Martian soil samples at the first possible opportunity. The two Agencies are currently negotiating a Memorandum of Understanding defining the key aspects of this cooperation. An orbiter and netlanders provided by CNES will be the centerpiece of the mission planned for 2007, and the two organizations are studying the use of an ARIANE 5 rocket to carry them. CNES and NASA are also considering carrying out a series of small missions to Mars together.

This is the most recent development in a collaboration that has seen many French scientific instruments launched on missions carried out in conjunction with NASA: a large-scale holographic network for the FUSE (Far Ultra Violet Spectroscopic Explorer) satellite, a relay for data collected by the Mars Global Surveyor, a gravimetric experiment as part of the NEAR (Near Earth Asteroid Rendezvous) mission, and experiments in aerosol collection and pyrolysis from Saturn's moon Titan, as part of the Cassini Huyghens mission.

Sciences in Microgravity and Manned Space Flights

In October 1995, ministers of the ESA member countries decided to develop a European program to participate in the International Space Station. France is the second leading contributor to this program, which essentially involves the supply, by Europe, of a European laboratory, and automated transfer vehicles (ATV) launched by ARIANE. These ATVs will be used for logistical flights to the International Space Station.

French and American scientists have jointly developed several projects in areas such as life sciences and physics in microgravity. The Ramses, Kinelit, Biorack and Echographe experiments, developed in France, were launched on the space shuttle to study plant biology, cardiovascular regulation and electrophoresis. In April 2000, the "Kinelit and Development" experiments flew onboard the NEUROLAB mission. The STS-93 mission, which involved the French astronaut Michel Tognini in July 1999, also carried the French ICMS (Integrated Cardiovascular Monitoring System) experiment.
As for the French astronaut Philippe Perrin, he will be making his first spaceflight on the American Shuttle in March 2002 (STS-111).

Data Collection

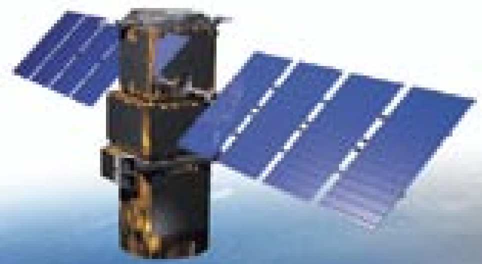
CNES and NOAA (National Oceanic and Atmospheric Administration) have long cooperated, operating the Argos and Cospas-Sarsat operational data collection systems.

Argos is an environmental data collection system, which has been operational since 1978; the payloads developed by CNES were launched on NOAA's polar meteorology satellites.

France and the United States have worked together since 1982 on an alert and rescue program called Cospas-Sarsat. NOAA has launched search and rescue payloads, supplied by France, on 4 satellites. Since the beginning of this program, thousands of lives have been saved.

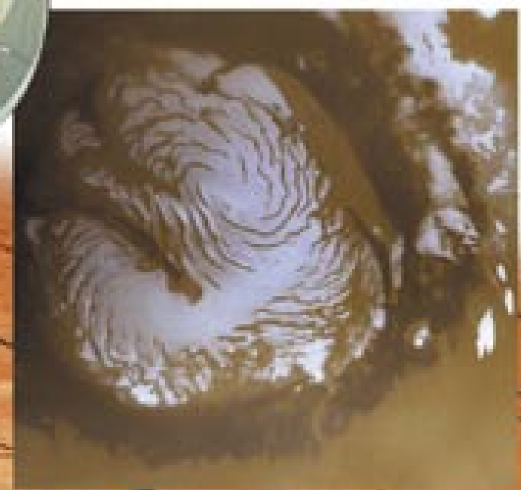
The ATV "en route" for the ISS

The french astronaut Philippe Perrin



CALIPSO satellite

The Mars Premier sonde



The Mars north pole ice cap

The cospas-sarsat system

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Centre National d'Etudes Spatiales

CNES is France's national space agency, tasked with developing France's space activities since 1961. Its mission is to help shape France's space policy and to implement space programmes, working in partnership with industry, research organizations and the defence establishment.

CNES is involved in a wide range of activities, including Earth Observation, Telecommunications, Sciences of the Universe and Human Spaceflight Missions. Since 1972, it has been delegated as prime contractor of the Ariane space programme by the European Space Agency (ESA).

For further information, visit the CNES website at:
http://www.cnes.fr - www.cnes-tv.net
or: http://www-aviso.cnes.fr

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Five strategic enterprises comprise NASA's primary mission areas: Space Science, Earth Science, Biological and Physical Research, Human exploration and Development of Space, and Aerospace Technology.

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