Jason

Jason URLs
sealevel.jpl.nasa.gov/mission/jason-1.html
www.aviso.oceanobs.com/

Summary

Jason maps ocean surface topography. The data collected provide information on ocean surface current velocity and heights which, when combined with ocean models, can lead to a four-dimensional description of ocean circulation. Data from Jason are also extending ocean surface topography into the 21st century, providing a 5-year view of global ocean surface topography, increasing understanding of ocean circulation, improving forecasting of climate events, and measuring global sea-level change.

Key Jason Facts

Joint with France

Orbit
- Type: Circular, non-sun-synchronous
- Descending Node: N/A
- Altitude: 1336 km
- Inclination: 66°
- Period: 112.4 minutes
- Repeat Cycle: 9.9156 days

Dimensions:
- Satellite support module: 95.4 cm × 95.4 cm × 100.0 cm
- Payload module 95.4 cm × 95.4 cm × 121.8 cm
- Solar array span: Two wings with four 1.5 m × 0.8 m panels per wing; total surface of 9.8 m^2

Mass: 500 kg

Power: 2100 W

Downlink: Jason telemetry downlink is 0.7 Mbps (700 Kbps) S-Band to JPL, Wallops Island, Virginia, Poker Flats, Alaska, and Aussaguel, France

Design Life: 3-year primary mission; 2-year extended mission

Contributors: NASA, CNES

Instruments

- Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS)
- Jason Microwave Radiometer (JMR)
- Laser Retroreflector Array (LRA)
- Poseidon-2 altimeter
- Turbo Rogue Space Receiver (TRSR), a Global Positioning System (GPS) receiver

Points of Contact

- *NASA Jason Project Scientist:* Lee-Lueng Fu, NASA Jet Propulsion Laboratory/California Institute of Technology
- *CNES Jason Project Scientist:* Yves Menard, Centre National d'Etudes Spatiales (CNES) Toulouse Space Center

Other Key Personnel

- *Jason Program Scientist:* Eric Lindstrom, NASA Headquarters
- *Jason Program Executive:* Lou Schuster, NASA Headquarters
- *Jason Project Manager:* Sophie Coutin-Faye, CNES Toulouse Space Center
- *Jason Mission Operations Manager:* Mark Fujishin, NASA Jet Propulsion Laboratory/California Institute of Technology
- *Jason Mission Operations Manager:* Nathalie Malechaux, CNES Toulouse Space Center

Mission Type

Earth Observing System (EOS) Systematic Measurements

Launch

- *Date and Location:* December 7, 2001, from Vandenberg Air Force Base, California
- *Vehicle:* Delta II rocket

Relevant Science Focus Areas

(see NASA's Earth Science Program section)

- Climate Variability and Change
- Water and Energy Cycles

Related Applications

(see Applied Sciences Program section)

- Coastal Management
- Disaster Management

Jason Science Goals

- Determine general ocean circulation and understand its role in Earth's climate, particularly how ocean circulation impacts Earth's hydrological and biogeochemical cycles.
- Study the variation of ocean circulation, on time scales ranging from seasonal and annual to decadal, and how this variation impacts climate change.
- Collaborate with other global ocean-monitoring programs to produce routine models of the global ocean for scientific and operational applications.
- Study large-scale ocean tides.
- Study geophysical processes and their effects on ocean surface topography.

Jason Mission Background

To gather useful long-term information about Earth's oceans and currents, orbiting instruments must take extremely precise measurement of the topography of the ocean surface. Ocean surface topography measurements determine the height of the ocean surface relative to a hypothetical ocean surface that corresponds to mean sea level in the absence of winds, currents, and most tides—called Earth's 'geoid'. Such measurements should not be confused with bathymetry measurements, which are used to map the topography of the ocean bottom. Ocean surface topography data have significant practical applications including in the study of global climate and weather, monitoring of shoreline evolution, protection of ocean fisheries, and other operational oceanographic efforts.

Ocean topography measurements also help scientists determine important characteristics of ocean circulation. For example, the 'surface geostrophic current' is an important measurement for ocean circulation studies. Scientists are particularly interested in measuring the surface geostrophic current because it can indicate something about the density of water in the deep ocean. Scientists can combine the information on ocean surface topography with measurements of ocean density from other sources, and by doing so they can obtain a picture of the ocean circulation throughout the entire water column of the ocean.

Ocean topography measurements can also be used to measure the heat content of the ocean. Most of the heat stored in Earth's hydrosphere resides in the ocean. The top 3 m of the ocean surface contain as much heat energy as the heat energy stored by all of Earth's atmosphere. This enormous amount of heat is distributed around the world by ocean currents and has a profound influence

Jason Instruments

DORIS
Doppler Orbitography and Radiopositioning Integrated by Satellite

DORIS is a precision orbit-determination system that provides orbital positioning information. An onboard receiver accurately measures the Doppler shift on both transmitted frequencies (401.25 MHz and 2,036.25 MHz) received from an Orbit Determination Beacon (ODB) station.

JMR
Jason-1 Microwave Radiometer

JMR is a three-frequency microwave radiometer that measures total water vapor along the path viewed by the altimeter and is used for range correction. It measures brightness temperatures in the nadir column at 18.7, 23.8, and 34 GHz.

LRA
Laser Retroreflector Array

LRA is used to calibrate the other location systems on the satellite with a very high degree of precision. LRA is a totally passive reflector designed to reflect laser pulses back to their point of origin on Earth. It consists of nine suprasil quartz retroreflectors arranged to provide a near-hemispherical response.

Poseidon-2

Poseidon-2 is a dual-frequency radar altimeter that maps the topography of the sea surface and can be used for calculating ocean surface current velocity; it also measures ocean wave height and wind speed.

TRSR
Turbo Rogue Space Receiver

TRSR is a high-performance GPS receiver designed to provide tracking data for precise orbit determination of the Jason spacecraft. It measures precision GPS code phase and continuous carrier phase data from up to 12 GPS satellites.

on Earth's climate and on climate variability. Ocean topography measurements provide a means of monitoring the movement of heat energy in the oceans from space.

Jason provides global sea-surface-topography measurements and is a follow-on to the highly successful TOPEX/Poseidon mission, which was launched in 1992 and ceased operations in October 2005, after nearly 62,000 orbits. Jason assumed the orbit of TOPEX/Poseidon, which moved into a parallel orbit. While Jason and TOPEX/Poseidon were both flying in this tandem formation, the science return was doubled. The primary instrument on Jason is Poseidon-2, a solid-state altimeter. The altimeter instrument suite includes the Jason Microwave Radiometer (JMR), which at the time of launch was a technologically new instrument. JMR uses monolithic microwave integrated circuitry (MMIC) technology and weighs an order of magnitude less than the radiometer on TOPEX/Poseidon. The Precision Orbit Determination package includes the GPS receiver, TRSR, DORIS, and a Laser Retroreflector Array.

The Poseidon-2 altimeter on Jason provides high-precision measurements of sea surface topography in one dimension. It makes measurements along the track of the spacecraft—called an 'along-track measurement'. This means that the geostrophic velocity (or geostrophic current) of the ocean is also computed in one dimension. The geostrophic velocity is measured in the direction perpendicular to the ocean topography measurement and thus cuts across the track of the spacecraft—called a 'cross-track measurement'.

At each point where the ascending and descending tracks of the spacecraft intersect—called a 'crossover point'—scientists can obtain two cross-track measurements. This allows them to determine the two-dimensional velocity of the current at that point. Once they know the velocity of the current at a particular location, they can then measure the 'Reynolds stress' at the same location. Reynolds stress is an important parameter in ocean circulation studies that describes the forces imposed on the mean ocean flow by turbulent fluctuations—called 'eddies'. Reynolds stress possesses the largest share of the ocean kinetic energy and is responsible for transfer of momentum, energy, heat, salt, and other biogeochemical properties of the ocean. Accurate measurements of Reynolds stress are therefore needed to understand the dynamics of ocean general circulation.

Key DORIS Facts

Heritage: SPOT-2, TOPEX/Poseidon, SPOT-3, SPOT-4, Envisat

Instrument Type: Precision Orbit Determination System

Dimensions:

- Receiver: 32 cm × 27 cm × 10 cm
- Ultra Stable Oscillator (USO): 9 cm × 7 cm × 12 cm
- USO Shielding: 33 cm × 29 cm × 10 cm
- Antenna: 37 cm height × 16 cm diameter cone

Mass:

- Receiver: 5.6 kg
- USO: 1.2 kg
- USO Shielding: 8 kg
- Antenna: 2 kg
- Total: 17 kg (Dual-string configuration)

Power: 21 W

Duty Cycle: 100%

Data Rate: 330 bps

Thermal Control: Heat transfer by conduction to mounting surface and by radiation within the instrument module

Thermal Operating Range: -10° to 50° C

FOV: 125° cone (centered on nadir)

Pointing Requirements (platform + instrument, 3σ):

- Control: 1.5°
- Knowledge: 0.2° (depending on the distance between the antenna phase center and the satellite center of mass)

Contributors: CNES (Responsible center), THALES (Instrument), SMP (Ground beacons)

Key JMR Facts

Heritage: TOPEX/Poseidon, Seasat, Nimbus-7

Instrument Type: Three-channel microwave radiometer

Scan Type: Fixed pencil-beam spatially collocated with the nadir-pointing Poseidon altimeter beam

Channel Center Frequencies: 18.7, 23.8, and 34.0 GHz

Channel Bandwidths: 200, 400, and 700 MHz

DORIS

Doppler Orbitography and Radiopositioning Integrated by Satellite

DORIS is based on the accurate measurement of the Doppler shift of radio-frequency signals transmitted from ground-based beacons and received onboard the spacecraft when it passes over. Measurements are made at two frequencies: 2.03625 GHz for precise Doppler measurement and 401.25 MHz for ionospheric correction. The 401.25 MHz measurement is also used for time tagging and auxiliary data. Approximately 60 global all-weather radio beacons are currently in operation.

The separation of the two transmitting frequencies makes it possible to reduce the ionospheric effect to around the 1 cm level. Tropospheric refraction is modeled using surface meteorological data that are directly transmitted to the satellite from the ground stations.

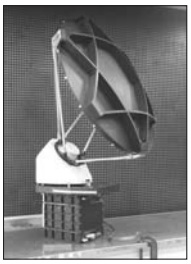
DORIS was validated by a prototype flown on the Systeme pour l'Observation de la Terre-2 (SPOT-2) satellite, launched in 1990. It provides over six-thousand measurements per day, which are used to refine data-processing methods and to improve models of Earth's gravity field. Another DORIS instrument flies on the TOPEX/Poseidon spacecraft launched in 1992. An improved DORIS instrument flew on SPOT-4 (launched in 1998) and added the ability to perform onboard orbit determination. The DORIS instrument on Jason incorporates these new capabilities. Experience with SPOT-2, SPOT-4, and TOPEX/Poseidon has shown that the instrument operates most efficiently at an altitude between 750 and 1,500 km. However, DORIS can operate at altitudes from 300 km to several thousand km.

DORIS URL

www.jason.oceanobs.com/html/doris/welcome_uk.html

JMR

Jason Microwave Radiometer



JMR provides an estimate of radar path delay due to tropospheric water vapor in a beam collocated with that of the Poseidon-2 nadir altimeter—a dual-channel (C- and Ku-band), nadir-looking radar altimeter that measures range to the ocean surface. This nadir altimeter range measurement, along with precise orbit determination (POD) of the spacecraft position relative to the Earth geoid, yields

Key JMR Facts *(cont.)*

Antenna Half-Power Beamwidth: 1.8°, 1.5°, and 0.9°

Dimensions:

Antenna: 0.79-m offset feed parabola

Envelope including reflector: 130 cm × 80 cm × 70 cm

Electronics module: 25 cm × 25 cm × 25 cm

Mass: 27 kg

Power: 31 W

DC Supply Bus: Unregulated 23–36 V

Data Rate: 1024 bps

Thermal Control: Electronics thermal control provided by spacecraft using radiative coupling. Thermal control on the JMR is achieved by radiating out to the satellite structure. The JMR box is internally mounted, with no direct exposure to space.

Thermal Operating Range: 10° to 35° C

Radiometric Resolution: < 0.25 K

Absolute Calibration Accuracy: ±1K

System Noise Temperature: < 650 K

Contributors: NASA JPL (responsible center, instrument design), TRW (receiver units)

Key LRA Facts

Heritage: TOPEX/Poseidon

Function: Laser-tracking targets

Wavelengths: 532 nm (primary), 1064 nm (secondary)

Configuration: 9 corner cubes: 1 nadir looking, 8 arrayed azimuthally in truncated cone

FOV: 110º w/1.5 arcsec dihedral angle per cube

Dimensions: Each cube is 163-mm diameter × 66-mm height

Mass: 0. 8 kg

Duty Cycle: 100%

Thermal Operating Range: -65º to 95º C

Contributors: NASA (responsible center), ITE Inc. (instrument)

ocean height. To meet ocean-height-accuracy requirements, however, the radar altimeter range measurements must be corrected for path delay due to ionosphere, dry air in the atmosphere, and tropospheric water vapor.

An estimate of integrated free-electron content using the difference in time of flight between the two nadir radar frequencies provides the ionosphere-delay correction. The dry atmosphere delay can be estimated from widely available global surface barometric pressure data. The delay due to water vapor is determined using measurements from the three-channel microwave radiometer. The apparent increase in path length due to water vapor typically ranges from 5–10 cm in cold dry air, to 30–50 cm under warm, humid conditions.

The JMR instrument measures single polarization, radiometric brightness temperature in three channels optimized for downward looking water-vapor retrieval over the ocean. These include a 23.8-GHz channel, the primary water-vapor sensor, an 18.7-GHz channel to estimate ocean-surface contributions to the observed brightness temperature, and a 34.0-GHz channel to estimate cloud liquid. An antenna-pattern correction is applied to the resulting measurements to correct for brightness-temperature contributions from outside the main beam, and a retrieval algorithm using empirically derived coefficients yields the wet-path-delay estimate for altimeter range correction. The overall error budget allocation for the JMR water-vapor correction is 1.2 cm.

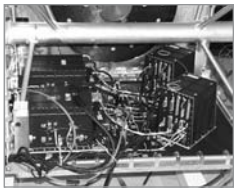
The Jet Propulsion Laboratory, in Pasadena, California, has overall responsibility for JMR management, system design, electronics development, integration and test, and calibration. The MMIC receiver modules were developed by TRW, Inc. in Redondo Beach, California. The JMR includes, as part of its heritage, radiometers flown aboard the Nimbus-7, Seasat, and TOPEX/Poseidon spacecraft.

JMR URL

sealevel.jpl.nasa.gov/technology/instrument-radiometer.html

LRA

Laser Retroreflector Array



The LRA is one of three location systems on board Jason—the three systems are used together to measure the satellite's position on orbit. The ability to determine a satellite's precise position on orbit is critical in interpreting altimetry data used for measuring ocean surface topography.

The LRA is used to calibrate the other Jason location systems and to verify the altimeter's height measurements. The LRA is an array of mirrors onboard the satellite that provides a target for laser-tracking measurements from ground stations. By analyzing the round-trip time of the laser beam, it is possible to determine precisely where the satellite is on its orbit. The laser-tracking data

Key Poseidon-2 Facts

Heritage: Poseidon-1 radar altimeter (TOPEX/Poseidon)

Instrument Type: Dual-frequency radar Altimeter (Ku-band and C-band)

Scan Type: Fixed nadir-pointing beam

Transmitted Pulse Width: 105 s

Pulse Repetition Frequency: 2100 Hz (1800 Hz for Ku-band and 300 Hz for C-band)

Maximum Radio-Frequency Output

Power to Antenna: 38.5 dBm (Ku-band); 44 dBm (C-band)

Transmission Frequency: 13.575 GHz (Ku-band), 5.3 GHz (C-band)

Dimensions:

Radio Frequency Unit (RFU): 42.2 cm × 24.6 cm × 24.5 cm

Power Control (PC) Unit: 26.8 cm × 20.5 cm × 24.9 cm

Mass: 52 kg (dual-frequency, dual configuration with one antenna)

Power: 66 W

DC Supply Bus: Unregulated 21–32 V

Duty Cycle: 100%

Data Rate: 22.5 kbps (including waveform data and onboard estimated parameters)

Thermal Control: Heat transfer by conduction to mounting surface and by radiation within the instrument module

Thermal Operating Range: -5° to 35° C

Pointing Requirements (platform + instrument, 3σ):

Control (Satellite): 0.33°

Knowledge: < 0.1°

Contributors: CNES (responsible center), Alcatel Space Industries (prime contractor)

are analyzed to calculate the satellite's altitude to within a few mm; however, because there are a small number (10–15) of ground stations and the laser beams are sensitive to weather conditions, it is not possible to track the satellite continuously using the LRA alone. That is why other location systems are needed on board the satellite.

Jason's LRA consists of nine quartz corner-cube reflectors arrayed on a circular structure on the satellite's nadir side (facing Earth). A corner-cube reflector is a special type of mirror that always reflects an incoming light beam back in the direction from which it came. The retroreflectors are optimized for a wavelength of 532 nm (green), providing a field of view of about 100°.

The LRA was manufactured by ITE, Inc., for NASA Goddard Space Flight Center.

LRA URL

sealevel.jpl.nasa.gov/technology/instrument-lra.html

Poseidon-2

Poseidon-2 is a nadir-looking radar altimeter that maps the topography of the sea surface. The shape and strength of the radar-return pulse also provide measurements of ocean-wave height and wind speed, respectively. Through the mapping of sea surface topography, Poseidon-2 provides information on the ocean surface current velocity which, when combined with ocean models, can lead to a four-dimensional description of ocean circulation. The heat and biogeochemical fluxes carried by ocean currents hold the key to understanding the ocean's role in global changes in climate and biogeochemical cycles. Secondary research contributions include the study of the variations in sea level in response to global warming/cooling and hydrological balance, the study of marine geophysical processes (such as crustal deformation) from the sea surface topography, and the monitoring of global sea state from the wave-height and wind-speed measurement.

Poseidon-2 was designed by Alcatel Space Industries (ASPI) for CNES Toulouse Space Center, and is essentially an improved version of the Poseidon-1 altimeter that flies on TOPEX/Poseidon (see TOPEX/Poseidon description). Poseidon-2 improves on Poseidon-1 by adding a second frequency at 5.3 GHz, changing to digital technology, and using a new more powerful rad-hard microprocessor. It makes these improvements while keeping the same compact mass and size as its predecessor.

Poseidon-2 URL

www.aviso.oceanobs.com/html/missions/jason/instruments/poseidon2_uk.html

Key TRSR Facts

Heritage: Blackjack GPS receiver (Shuttle Radar Topography Mission)

Instrument Type: GPS Receiver and Antenna

Dimensions:
- Receiver: 18 cm × 18 cm × 11 cm
- Antenna: 10.5-cm height × 30-cm diameter

Mass:
- Receiver: 2.5 kg
- Antenna: 0.855 kg
- Total: 6.5 kg (Dual-string configuration)

Power: 14W @ 28 V

Duty Cycle: 100%

Data Rate: 800 bps

Thermal Control: Heat transfer by conduction to mounting surface and by radiation within the instrument module

Thermal Operating Range: -10° to 50° C

Pointing Requirements:
- Control: 5°
- Knowledge: 5°

Contributors: NASA JPL (responsible center); Spectrum Astro (instrument)

TRSR

Turbo Rogue Space Receiver

The ability to determine Jason's precise position in orbit is critical to interpreting its altimetry data. The TRSR is one of three location-determination systems onboard Jason that are used to measure the satellite's position. The TRSR uses the Global Positioning System (GPS) constellation of navigation satellites for this purpose.

The TRSR concurrently tracks the radio signals transmitted by up to 12 GPS satellites. The receiver measures the phase of the GPS carrier signals with better than 1-mm precision and measures the pseudo-range between Jason and each GPS spacecraft being tracked with better than 10-cm precision. (Pseudo-range is a measurement of the transit time of the signal between satellites. The measurement contains timing errors, which can later be corrected to recover the true range.) The TRSR's measurements determine the satellite's position in near-real time to better than 20 m and its clock to better than 100 nsec. There are two complete and independent TRSR systems onboard Jason.

To achieve the orbit accuracy goals, detailed knowledge of the Jason spacecraft and its behavior need to be known so the forces acting on the spacecraft can be modeled. In ground processing, the TRSR's GPS observables will enable determination of the Jason orbit height with an accuracy of 1–2 cm.

TRSR measurements of variations in Jason's orbital motion in relation to Earth's center will improve our overall knowledge of Earth's gravity field. NASA's Jet Propulsion Laboratory, at the California Institute of Technology, designed and tested the TRSR hardware, software, and ground-support. Spetrum Astro. Inc fabricated the TRSR flight unit.

TRSR URL

sealevel.jpl.nasa.gov/technology/instrument-gps.html

Jason References

Carayon, G., N. Steunou, J.-L. Courriere, and P. Thibaut, 2003: Poseidon-2 radar altimeter design and results of in-flight performances. *Marine Geodesy*, **26**, 159–165.

Chelton, D. B., J. C. Ries, B. J. Haines, L-L. Fu, and P. S. Callahan, 2001: Satellite altimetry, in L-L. Fu and A. Cazenave, eds., *Satellite Altimetry and Earth Sciences*, Academic Press, San Diego, 1–131.

Fu, L-L., and D. Chelton, 2001: Large scale ocean circulation, in L-L. Fu and A. Cazenave, eds., *Satellite Altimetry and Earth Sciences*, Academic Press, San Diego, 133–169.

Ménard, Y., L-L. Fu, P. Escudier, F. Parisot, J. Perbos, P. Vincent, S. Desai, B. Haines, and G. Kunstmann, 2003: The Jason-1 mission. *Marine Geodesy*, **26**, 131–146.

Perbos, J, P. Escudier, F. Parisot, G. Zaouche, P. Vincent, Y. Menard, F. Manon, G. Kunstmann, D. Royer, and L.-L. Fu, 2003: Jason-1: Assessment of the system performance. *Marine Geodesy*, **26**, 147–157.

Vincent, P., S. D. Desai, J. Dorandeau, M. Ablain, B. Soussi, P. S. Callahan, and B. J. Haines, 2003: Jason-1 geophysical performance evaluation. *Marine Geodesy*, **26**, 167–186.

Jason Data Products

Additional information can be found at: podaac.jpl.nasa.gov

Product Name or Grouping	Processing Level	Coverage	Spatial/Temporal Characteristics
DORIS, JMR, LRA, Poseidon-2, TRSR *Data Set Start Date: January 15, 2002*			
Operational Sensor Data Record (DORIS, JMR, Poseidon-2)	2	Global	66° N – 66° S latitude/every 10 days
Interim Geophysical Data Record (DORIS, JMR, LRA, Poseidon-2)	2	Global	66° N – 66° S latitude/every 10 days
Geophysical Data Record (GDR)	2	Global	66° N – 66° S latitude/every 10 days
Near-Real-Time Sea Surface Height Anomaly (DORIS, JMR, LRA, Poseidon-2, TRSR)	2	Global	66° N – 66° S latitude/every 10 days
Sea Surface Height Anomaly (SSHA) (DORIS, JMR, LRA, Poseidon-2, TRSR)	2	Global	66° N – 66° S latitude/every 10 days
Gridded Sea Surface Height Anomaly (DORIS, JMR, LRA, Poseidon-2, TRSR)	2	Global	66° N – 66° S latitude/every 10 days

Jason Data Products