Ocean Surface Topography Science Team Meeting

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Introduction

The 2008 Ocean Surface Topography Science Team (OSTST) meeting was held jointly in Nice, France from November 9-12, 2008, with the annual International Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS) Service (IDS) and the final Global Ocean Data Assimilation Experiment (GODAE) meetings. More than 470 participants gathered to participate in these events. This document summarizes the OSTST meeting. For more detail, a full OSTST report is available online at *sealevel.jpl.nasa.gov/OSTST2008/OSTST-nice2008.html*. Reports for the IDS and GODAE meetings are available at *www.ostst-godae-2008.com*.

The OSTST meeting assembled for the first time the new principal investigators (PIs) and co-investigators (Co-Is) selected by the Centre National D'Etudes Spatiales (CNES) and NASA in 2008. Held only a few months after the launch of the Ocean Surface Topography Mission (OSTM) on the Jason-2 satellite (hereafter referred to as Jason-2), it was mainly dedicated to the preliminary analysis of the post-launch calibration and validation results and the on-orbit mission performances. **Sophie Coutin-Faye** [CNES—*Head, Altimetry Department*] welcomed the participants in an official opening session and dedicated the meeting to the memory of **Yves Ménard** [CNES—*Co-chair, OSTST*], who passed away in October 2008 after a long and difficult fight against cancer.

Program and Mission Status

As Jason-2 was developed in collaboration between four agencies—CNES, NASA/JPL, the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT), and the National Oceanic and Atmospheric Administration (NOAA)—representatives from each of these agencies presented their respective oceanography programs.

Eric Lindstrom [NASA Headquarters (HQ)—*Physical Oceanography Program Scientist*] recalled the main events of the past year including the selection of a new Ocean Surface Topography Science Team, and the initiation of studies for the Surface Water and Ocean Topography mission (SWOT). Recommended by the recent National Research Council Earth Science Decadal Survey, SWOT is to be a high resolution wide swath altimeter for global oceanography and hydrology.

François Parisot [EUMETSAT] and **Stan Wilson** [NOAA] spoke largely about the on-going effort to secure approval for a successor to Jason-2. A Jason-3 mission, based on a recurring design from Jason-2, is the preferred solution, but some funding issues are not resolved yet. This makes the objective of launching a Jason-3 satellite by the end of 2012 (required to insure continuity in the high-accuracy altimetry time series) uncertain.

Eric Thouvenot [CNES—*Ocean Program Manager*] reported on CNES ocean observation programs and, more specifically, on altimetry missions. Currently under development: ALtiKa/Satellite with ARgos and AltiKa (SARAL) is a Ka-band altimeter to be launched [in cooperation with Indian Space Research Organization (ISRO)] in mid- to late 2010. CNES is also planning to participate in the Jason-3 program, the European Space Agency (ESA) Cryosat-2 and Sentinel-3 programs, the SWOT mission, and the Chinese Hai Yang (HY-2A) mission—Hai Yang means ocean in Chinese. CNES participation in altimetry is not limited to space systems, but also encompasses support for activities such as the Segment Sol Multimission Altimetry and Orbitography/Archiving Validation and Interpretation of Satellites Oceanographic (SSALTO/AVISO) multimission ground segment, the Mercator oceanographic forecasting center, and the DORIS contributions to Earth reference systems.

Jérôme Benveniste [ESA] presented an overview of ESA programs in ocean observation.

Hans Bonekamp [EUMETSAT] and **John Lillibridge** [NOAA] gave the first keynote presentation on the applications of near-real-time data products from ocean altimetry missions. Two series of operational products are distributed by the Jason-2 mission: near-real-time Operational Geophysical Data Record (OGDR) with 3-hour latency, and short-time-critical Interim Geophysical Data Record (IGDR) with 1-2 day latency —the time it takes for data from the satellite to make it into a product. The presenters gave numerous examples of data product applications for wind and wave monitoring and forecasting, hurricane intensity forecasting, ocean surface currents observations, ocean modeling, and data assimilation.

Current Altimetry Missions

Gérard Zaouche [CNES—*Jason-2 System Engineer*] presented the status of Jason-2, recalling the main events since launch on June 20, 2008. Jason-2 reached its final orbit on July 11, 2008, and, except for some planned calibration exercises, has been delivering data nominally since then. Jason-2 has been flying 54 seconds behind Jason-1—see illustration on page 28—,

allowing for comprehensive cross-validation of the two missions. Overall the system is performing as planned and the preliminary error budget is already within the performances requirements.

Glenn Shirtliffe [JPL—*Jason-1 Project Manager*] presented the status of the Jason-1 mission. Now in its 7th year, NASA and CNES have approved extended operations for Jason-1 up to 2011. The satellite continues to perform very well, and the data production is within requirements both in terms of availability and latency and with regards to the error budget. However, most of the redundancies have already been lost, so the system is now quite vulnerable. Jason-1 will move to an interleaved orbit at the end of the Jason-2 calibration and validation (cal/val) phase [as was done for TOPEX/Poseidon (T/P)]. Two remaining open points remain regarding the desired duration of the cal/val *formation flying phase* and the relative phasing between the two satellites once in interleaved orbits. The OSTST assembly will decide these two remaining points during the meeting.

Phil Callahan [JPL] presented the status of TOPEX/Poseidon reprocessing activities. JPL performs this task with the help of CNES in order to provide a full data set of the T/P mission compatible with the latest standards used by Jason-1 and Jason-2. This includes getting new orbits [from Goddard Space Flight Center (GSFC)] and correction fields consistent with the Jason products, and also performing a retracking of the entire series of waveforms, correcting for instrument variations. The latter is a challenging task as T/P data processing did not include retracking, and the Jason retracking algorithm is not suited for T/P waveforms.

Science Keynotes

Anny Cazenave [CNES/Laboratoire d'Etudes en Géophysique et Océanographie Spatiales (LEGOS)] focused on the value of sea level measurements for climate change studies. Altimetry is a key tool in monitoring global sea level rise, and is complemented by *in situ* and gravity field measurements [e.g., from the Gravity Recovery and Climate Experiment (GRACE) mission] to differentiate between the different sources of sea level rise— i.e., steric effect versus melting of ice sheets.

Ted Strub [Oregon State University] presented a panorama of coastal altimetry, a fairly recent field that developed as a result of improvements and on-going efforts to get high quality altimeter data closer to the coastline. He focused on the work presented at the Second Coastal Altimetry Workshop held in Pisa, Italy, the week before the OSTST meeting.

Charon Birkett [University of Maryland] presented the growing use of altimetry data for land hydrology (i.e., to study rivers and lakes). Although altimeters were not designed to target inland waters, in areas where the data are available, they prove to be useful, thanks to their capability of covering remote areas.

Two groups of students from two junior high schools in France (Amiens and Nice) presented work they performed as part of a science class project on altimetry. The presentations were remarkably well delivered. OSTST participants were quite impressed with the talks given by the teenagers.

Splinter Sessions

The bulk of the meeting was devoted to splinter sessions on the following topics:

Precise Orbit Determination (POD) and Geoid

Chairs: **John Ries** [University of Texas], **Jean-Paul Berthias** [CNES]

The geodetic standards for POD were upgraded for the Jason mission to be consistent with Jason-2. While the orbit error is approaching 1 cm, the temporal variability of the Earth's gravity field must be considered in the POD process. The POD performance of Jason-2 was assessed and a slight improvement over the Jason-1 performance was observed.

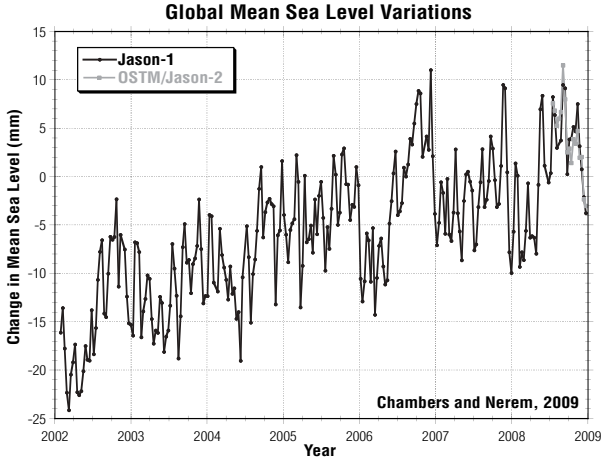
Local and Global Calibration/Validation (Cal/Val)

Chairs: **Pascal Bonnefond** [Observatoire de la Côte d'Azur], **Bruce Haines** [JPL], with help from **Nicolas Picot** [CNES], **Shailen Desai** [JPL], **Steve Nerem** [University of Colorado]

The primary goals of this session were to evaluate the accuracy of the Jason-2 measurements and their consistency with Jason-1 and T/P. The cal/val group was also charged with making recommendations on the length of the Jason-1/Jason-2 cal/val tandem mission as well as the relative phasing of the interleaved orbits of Jason-1 and Jason-2 after the completion of the cal/val tandem mission.

Because of the smooth operation of Jason-2 and its early successful engineering check-out, sufficient overlap data with Jason-1 were available for the evaluation. The cal/val group was confident that the mission's performance has met the science requirements.

There was a proposal made to initiate the orbit maneuver sequence as soon as possible after the end of Cycle 20 (~January 26, 2009), but not before. This ensures a minimum of six months from beginning of Cycle 1 (July 12, 2008), and is also responsive to needs of the operational oceanographic community. The phasing of the interleaved orbits was also discussed, but the recommendation was deferred to the closing plenary discussion.



Global mean sea level variations from Jason-1 and OSTM/Jason-2 showing the consistency in measurements between the two missions.

Instrument Processing

Chairs: **Phil Callahan**, **Juliette Lambin** [CNES], **Shannon Brown** [JPL]

This session was the forum for varied topics from on-board features of the Poseidon-3 altimeter to ground processing of the instrument data, Jason Microwave Radiometer for wet tropospheric corrections, altimeter raw data for additional processing, etc.

Education/Outreach

Chairs: **Vinca Rosmorduc** [Collecte Localisation Satellites (CLS)], **Margaret Srinivasan** [JPL]

This session focused on educational activities, and the importance of the website as outreach medium. The goals of the ocean altimetry outreach effort incorporated into this session included:

- Increasing public awareness of NASA/CNES satellite oceanography missions;
- featuring operational and research applications (altimeter and multi-sensor);
- promoting societal benefits;
- providing oceanography content for formal and informal education; and
- promoting ocean and climate literacy.

Operational Applications, Wind/Waves, Coastal/Inland and associated Cal/Val Studies

Chairs: **Charon Birkett**, **Hans Bonekamp**, **Emilie Bronner** [CNES]

This session covered a wide range of topics, including the application of the Jason-2 Near-Real-Time data products. Other topics included wind/waves, coastal processes, inland water storage, sea-ice/snow, hurricane forecasting, wave modeling, storm surge monitoring, water resources monitoring, big wave monitoring (e.g., surfing), and aspects of natural hazard monitoring in terms of long-term droughts and flood observation.

Closing Plenary Discussion

Several important topics were discussed in the closing plenary session.

1. The quality of the Operational Geophysical Data Record (OGDR)

The results presented in the meeting indicated that the quality of the OGDR has met the mission's requirements. OSTST recommended that OGDR is ready for dissemination to public users for operational applications.

2. The need for a seamless transition between the different versions of Jason-1 GDR (Geophysical Data Record) products

Following previous OSTST recommendations, CNES and JPL implemented a new version of GDRs (GDR-C) in June 2008. However, shortly after this production started the programmers detected an anomaly in the use of some of the time-varying gravity field parameters for orbit determination. Therefore, project teams took the initiative to process the data into a GDR-C′ version. The occurrence of three different versions (GDR-B, GDR-C, and GDR-C′) in a short amount of time led to some confusion for users. CNES and JPL recalled that the GDR-C′ standard is produced using the best algorithm available today. Reprocessing of all the Jason-1 data archive in GDR-C′ is on-going and will provide a fully consistent data set. In addition, the standards used for GDR-C′ are also used for Jason-2 processing, and some effort is made to provide reprocessed TOPEX/Poseidon data with consistent standards.

3. The remaining duration for Jason-1/Jason-2 cross-calibration phase

The debate was mostly fueled by two opposite views. As

global intercomparisons between Jason-1 and Jason-2 showed that the consistency between the two missions was very good, some people were advocating for a shorter duration than the six months initially planned. However, other scientists were concerned that the continuity of the long-term record (i.e., sea level rise) and our ability to identify and monitor any relative drift might be compromised should the cross-calibration phase be shortened. The group decided to require that the cross-calibration phase be extended for 20 full cycles, and let the project teams choose a convenient time for switching Jason-1 to an interleaved orbit no sooner than January 26, and preferably no later than February 15.

4. Phasing between Jason-1 and Jason-2 once on interleaved orbit

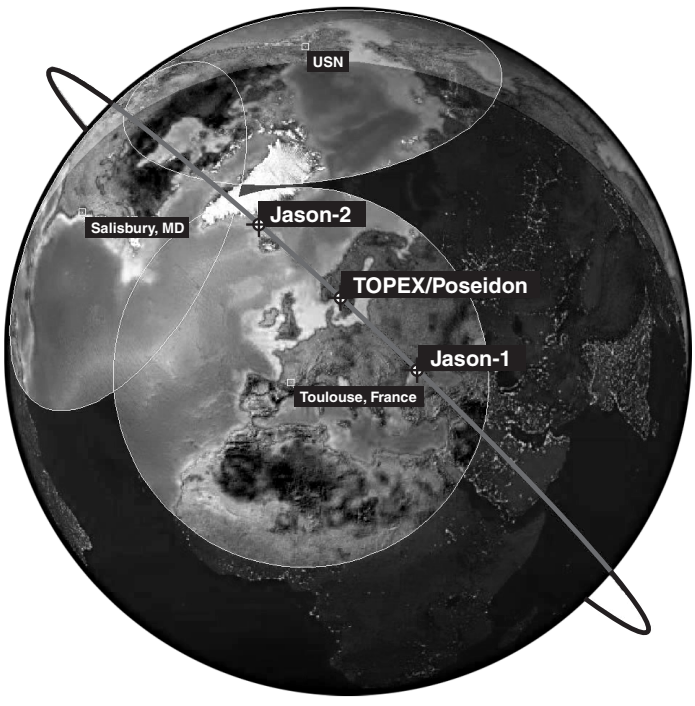
There was a proposal to place Jason-1 further apart in orbit from Jason-2 than the distance between TOPEX/Poseidon and Jason-1. The proposed phasing would mean that adjacent ground tracks for Jason-1 and Jason-2 occur five days apart, allowing for better sampling at short time scales. This appeared to be the optimal sampling for operational applications, although other options in the phasing might have been marginally better for other applications.

5. Recommendations for future altimetry missions

Raymond Zaharia [CNES], on behalf of *Club des Argonautes*, expressed two recommendations to be considered by the OSTST. In the light of the recent and successful launch of Jason-2, and the current programmatic uncertainties regarding follow-on programs, the OSTST decided to fully endorse the following two statements:

- **The four-agency Project Team should be commended for the accomplishments it has made**, especially during the rather short development period between 2004 and 2008. Overall, the decision process for Jason-2 took approximately 7 years; the first proposal for Jason-2 was issued in a CNES scientific prospective workshop in coordination with NASA, NOAA, and EUMETSAT representatives in March 1998. Meeting all the requirements, including a four-year delivery time, was only achievable with a recurrent spacecraft.

- Considering the recommendations of the *Purple Book* published 16 years ago by members of the first TOPEX/Poseidon Science Working Team, and considering the extraordinary way in which this vision has been implemented—thanks to the talents of our colleagues from the respective project teams—we now have a 16-year high-accuracy time series. **Whatever the brilliant future of multiple altimetry missions such as Sentinel-3, Jason-CS, or ALtiKa/SARAL, the reference altimetry mission would experience an irrecoverable loss with the present threat of postponement or cancellation to Jason-3**. ■



NASA's ocean surface topography *family portrait* shows the Ocean Surface Topography Mission (OSTM)/Jason-2 and its grandfather missions, Jason-1—launched in 2001—and Topex/Poseidon—launched in 1992. Scientists took advantage of the still healthy propulsion system on the Jason-1 satellite to put it into the same orbit as OSTM/Jason-2—about five days behind the newer satellite launched in June 2008. Jason-1 flies over the same region of the ocean that OSTM/Jason-2 flew over five days earlier, giving detailed measurements needed to map rapidly-changing surface currents and eddies. This tandem mission is different from that of Jason-1 and Topex/Poseidon; Topex/Poseidon traveled slightly farther ahead of Jason-1 than Jason-2, with its ground tracks midway between those of Jason-1. Topex/Poseidon and Jason-1 collected data simultaneously until Topex/Poseidon ceased operation in 2006. For more information and to view this image in color please visit: *sealevel.jpl.nasa.gov/newsroom/features/200902-1.html.*