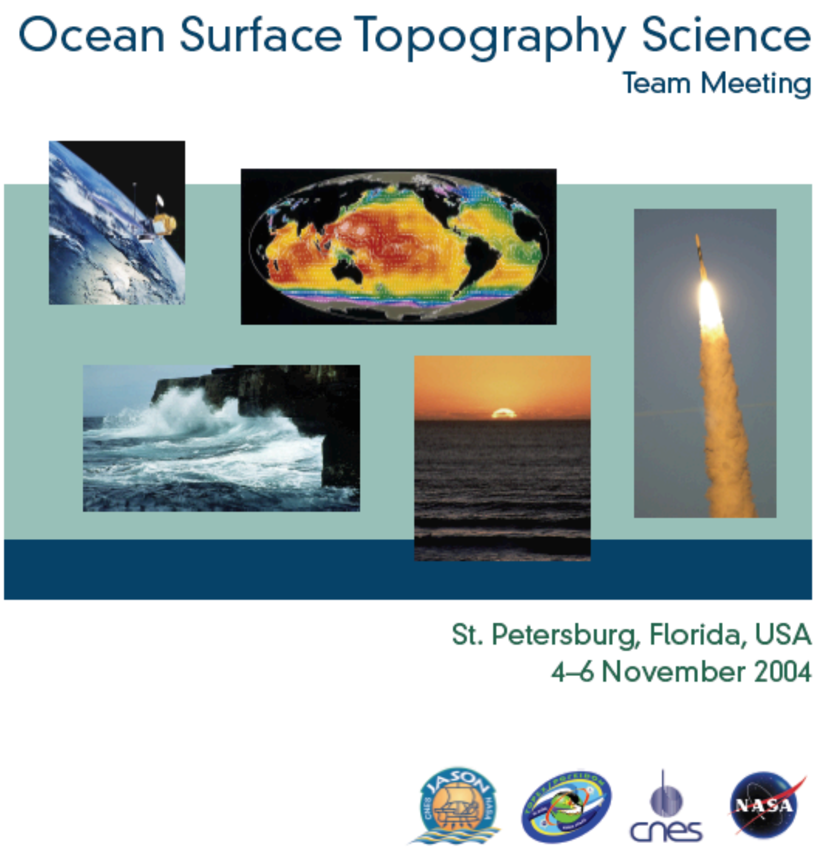
# Minutes of the Ocean Surface Topography Science Team Meeting

**November 4-6, 2004**
**St. Petersburg, Florida**

**Edited by Lee-Lueng Fu**




**JPL D-31211**

Table of Content

## 1. Introduction

The first meeting of the newly selected Ocean Surface Topography Science Team (OSTST) Meeting was held on November 4-6, 2005 at the Hilton Hotel, St. Petersburg, Florida. The primary objectives of the meeting were (1) to provide an introduction to the new team of the status of the satellite missions and data products; (2) to review and discuss technical and scientific issues in processing and applications of the mission's data products; (3) to provide a forum for the team to get familiarized with the science plans of each principal investigator.

The meeting was opened by Lee-Lueng Fu and Yves Menard by introducing the new OSTST. A total of 86 investigation teams from 10 countries were selected. The subjects of investigation and the number of teams in each subject are as follows:

- High Resolution (short to meso-scale, coastal, inland) (28)
- High resolution Operational Systems (6)
- Wide Swath Ocean Altimeter (4)
- Global Ocean, Large scale, Mean Sea Level (22)
- Tropics (8)
- CalVal (16)
- Outreach (2)

It was noted that a total of 38 (44%) teams had proposed projects with objectives of studying problems that required high-resolution ocean topography data. The approach is either through merging data from multiple satellites or through development of the Wide Swath Ocean Altimeter (WSOA). Fu pointed out that the current situation of 4 coexisting satellite altimeters (T/P, Jason, GFO, and ENVISAT) would not last for long, and that the only approved altimetry mission for the time frame beyond 2008 was OSTM/Jason2. However, the proposed WSOA on board OSTM/Jason2 will have sampling capability better than 5 coordinated conventional nadir-looking altimeters. The flight of WSOA will provide the only opportunity for getting high-resolution data in the time frame beyond 2008.

Given the high payoff of WSOA, NASA was in the process of canceling the flight of WSOA due to budgetary problems. A recommendation was drafted by a small group of OSTST members urging NASA to work with international partners to resolve the funding problems and keep WSOA on schedule for launch on OSTM/Jason2 in 2008. The draft recommendation was circulated to the entire team for comments to reach a conclusion at the end of the meeting.

Yves Menard presented a tribute to Christian Le Provost, who passed away in last February. Christian was a PI on previous T/P and Jason Science Working Teams. He was a pioneer in tidal modeling and global sea level studies using altimetry. His enthusiastic dedication to science and friendship offered to everyone will be sorely missed. The meeting was officially dedicated to the memories of Christian.

The meeting was organized into plenary sessions (Section 2) on the status of the programs and projects, poster sessions (Section 3) on the progress in research, application, education and outreach, and splinter sessions (Section 4) on special topics. The conclusions of the meeting are provided in Section 5. Meeting agenda can be found in Appendix A. A list of the titles of the poster presentations is provided in Appendix B. Included in the attached CD are slides of all the plenary and splinter presentations, poster presentations, and the information of the participants.

## 2. Plenary Session I –Program and Project Status and Issues

### 2.1 Program Overview

### NASA report

Transitions in NASA Organization

1) Earth and Space Science Enterprises merge to become the Science Mission Directorate (Al Diaz, Associate Administrator)
2) 

Research Division of Earth Science and Sun-Earth Connection Program merge to become the Earth-Sun System Division (Mary Cleave Acting Director).

Component parts remain largely unchanged for the moment.

Next research opportunities announced in “ROSES ‘05” (end of January release).

OSTST Selection and Funding

1) New OSTST selected. Excellent proposals received. Some turnover in team, but core remains solid.

2) POD taken out of the team financial structure in hopes of funding it as part of “as only NASA can” infrastructure at some point in the future. Now it resides financially in the Physical Oceanography Program.

3) Team support remains stable in out year budget projections.

OSTM/WSOA

1) 4 party discussions and agreements supporting the core mission for OSTM (Jason-2) proceeding well.
2) We are finalizing the configuration of OSTM/Jason-2. NASA has been unable to accommodate the WSOA due to significant budget shortfall ($70M)
3) Science investigations wholly dependent upon the WSOA will not be funded if its flight on OSTM is terminated.

**CNES report**

CNES Plans in Oceanography

- Contribute to scientific and operational outcome of altimetry through various cooperation scheme
  - Space component :
    - US/France : TOPEX/POSEIDON => JASON1 => JASON2/OSTM =>?
    - European programs (coop. with ESA)
      - ERS 1 & 2 => ENVISAT => ?
      - CRYOSAT (2005) : ice mission, ocean product under consideration
    - Earth reference frame : DORIS series
  - In situ : CORIOLIS,
  - Assimilation : MERCATOR/COO/ECOMF, ...
- Preparation activities for future altimetry missions/instruments :
  - AltiKa, WSOA, …
  - directional wave spectrum (SWIMSAT)
- Contribute to space measurements of other ocean physical parameters :

- salinity : SMOS, CNES contribution to ESA project
- ocean color

- Prepare for ocean applications of ORFEO (Cosmo SkyMed/Pleiades) :
  - mainly coastal applications

Status of Altimetry Missions/Activities

- TOPEX/POSEIDON :
  - more than 12 years of ocean observations
- Jason / TOPEX/POSEIDON tandem mission : success !
- ENVISAT
  - excellent synergy with Jason1, (T/P and ERS complementarity further improved)
- DORIS
  - 6 DORIS receivers simultaneously in flight : earth reference system strengthened
- AltiKa : Preliminary Design Review in July 2003
- MERCATOR
  - inter Agency structure for the implementation of an oceanographic forecasting center in Europe in the mid term
  - next step : C2O (Center for Operational Oceanography) in 2006
- Next Step : O3 = Operational Ocean Observer (phase 0 until end 2004)

OSTM/Jason2 Status (French side)

- Cooperative Framework : letter co-signed by NOAA/NASA/EUMETSAT/CNES
  - Basic mission, continuation of Jason1 (Core Mission)

    - Major new feature considered :
        - Wide Swath Ocean Altimeter (Enhanced Mission)
    - 4-party MOU is being prepared
- CNES
    - Anticipated procurement phase : 2002-2003
        - Anticipated procurement for DORIS and the Altimeter
        - Platform already funded through PROTEUS multi satellite contract with Alcatel Space
        - Preliminary WSOA accommodation study
    - Phase B/C/D has started in 2004
        - WSOA included in the baseline payload for satellite and system definition and development
- Considering the high interest of WSOA experiment, CNES will support any action in favor of maintaining the Enhanced JASON2/OSTM mission, assuming it is done :
    - at no additional cost for CNES
    - with no impact on the core mission (performance, schedule)

**2.2 TOPEX/Poseidon status**

➢ Satellite bus and instruments continue to age gracefully into 13th operational year
experienced reaction wheel failure in May 2004
remaining tape recorder removed from service in October 2004
Entering third year of Tandem Mission with Jason-1
now approaching science data objective of 3-5 year tandem mission

➢ TOPEX/Poseidon-Jason science open literature database available on-line

1,885 articles using information from TOPEX/Poseidon and Jason-1 have appeared in over 335 Journals or Publications

Searchable by author, title, keyword, abstract, & category for TP/J-related science, engineering, applications, and education research from 1990-present

➢ T/P mission operations currently approved through at least FY'05
Project was merged/funded under Jason-1 budget starting in FY'04

**2.3 Jason-1 Status**

- ❑ Joint operations continuing to proceed extremely well
    - ❑ Weekly CNES-JPL joint telecon for normal satellite uploads, and as required
    - ❑ Regular proficiency and training tests ongoing

- ❑ Instruments and ground operations systems at JPL are meeting all mission objectives

- ❑ Entering two-year extended operations phase in December 2004
  - ❑ Mission currently funded through December 2006

- ❑ Mission operations needs to continue through launch of OSTM/Jason-2 to satisfy long-term goal of contiguous ocean topography data

- ❑ As expected, relationships and lessons learned from TOPEX/Poseidon continue to be extremely important to Jason-1 mission success

### 2.4 Jason-1 and SALP System Status

Jason-1 Data Availability

- Data availability since last SWT (18 November 2003) :
  - ***Requirement = 95% of all possible over-ocean data***
  - Payload telemetry data losses due to :
    - bus 4.85% (2 SHM, 1 mass memory incident)
    - altimeter 0.12% (4 incidents, 1 TM gap)
    - Doris 1.12 s% (1 incident, Doris switch & software upload)
    - JMR 0.00%
  - Satellite (total) : ~ **6.09%**
    - ground system: ~ **0.05%** (data loss at earth terminal level)

⇒ **Total Availability ~ 93.85% since last SWT at OSDR/IGDR**

During Doris incident, data has been dated using GPS datation → more than 3 days of data were recovered

⇒ Total Availability ~ 94.7% since last SWT at GDR

Jason-1 Data Time-Tagging

- Altimeter Measurements time-tagging
  - altimeter measurements are time-tagged on-board with platform UTC time information
  - during ground processing, use of Doris/ Platform correspondence provided by Doris, to time-tag altimeter data with DORIS TAI time
  - *Requirement =* ***100 µs*** *for OSDR ,* ***10 µs*** *for IGDR*
  - **Performance :**

~ **2 µs** (bias + drift)

Jason-1 Altimeter Antenna Pointing

- Attitude maneuvers performed in order to calibrate the biases between Altimeter antenna and nadir direction. Bias values have then been introduced in the guidance commands in order to tilt slightly the satellite pointing direction and compensate for the identified biases.

- Very good pointing performance :

Typical pointing value below 0.05° *(requirement < 0.2 °)*

- Except for the STR out of the AOCS loop for long periods : a few attitude drifts up to ~ 0.25° in Dec 2002-Jan 2003, corrected by S/W patch.
  Very Low Mission impact :
- correction of attitude effects applied on the altimeter geophysical parameters in GDRs released to Users
- corrections are valid for mispointing up to 0.3°

SALP operation center

- Processing, archiving and distribution of orbitography and altimeter data for :
  - Jason-1, T/P, ENVISAT, SPOTs satellites
- Routine production of MOE and POE for all satellites
- Routine production and validation of IGDR/GDR products for Jason-1 and ENVISAT
- Routine distribution of level2 products for all missions
- Routine production and distribution of high level products

DUACS and level3 products

- SSALTO/Duacs system (Ssalto near real time multi-mission altimeter data processing system)
  - routine production using Jason-1/Topex-Poseidon/Envisat/GFO data :
    - Twice per week distribution of maps and anomalies along track
    - Including an in depth validation of input products
    - all DUACS products delivered in less than 24h.
- Added Value products :
  - Duacs offline mode (using GDR input products)
  - routine production of MSLA and SLA files will be resumed soon as part of the CalVal tools

Future plans (2005)

- Increase of the electronic dissemination :
  - ftp servers
  - LAS system
- New version of GDR products and reprocessing of past cycles

- More "easy to use" products (SLA, CORSSH, MSLA) for Jason-1, ENVISAT, T/P and GFO missions
- "Coastal" products (S-IGDR product ?)
- Duacs regional products as part of MERSEA project

### 2.5 OSTM/Jason2 Status

**NASA report**

- Core Mission is a Jason-1 copy with:
  - ⇨ New Microwave Radiometer developed under IIP program
  - ⇨ NOAA will take over Ground data system and Mission operation
  - ⇨ New Launch vehicle if Delta II is not used

- Enhanced Mission is the Core mission with the addition of the WSOA

- Core Payload development on schedule
  - Very low risk to complete task
  - ~ one year of schedule reserve
- WSOA:
  - WSOA technical activities progressing well.
  - Current schedule supports a delivery to CNES in Jan 2007.
- Launch Vehicle:
  - Delta II is the baseline
    - Does not support funding for enhanced mission
  - Exploring alternate launch vehicle options with mission partners to enable enhanced mission (WSOA)
    - Dual-Manifest partners for Delta II
    - Foreign partner supplied launch vehicle (Rockot)

**CNES Report**

CNES Jason2 Project has been approved by CNES Board of Governors on April 29th, 2004

Main contracts:

- Satellite and Altimeter contract with ALCATEL Space:
  - Contract has been approved by CNES Board of Governors on April 29th, 2004
  - Altimeter phase B in progress (since May 1st, 2004)
  - Satellite payload instruments final accommodation and mechanical analysis has started September 1st : Pre-phase B study from September to December 2004 :
  - Start of satellite phase B : scheduled January 2005, pending necessary inputs are available

- Doris contract with THALES :
  - Phase B from beginning of Nov 2003 till March 2004:
    - PDR held on March 11; Doris 2Gxx met all PDR success criteria, recommended to proceed to implementation
  - Phase C/D contract has started beginning of May 2004.

- WSOA TWTA contract with THALES:
  - Contract negotiated with THALES has been approved by CNES Contract Central Board on May 27
  - Phase C/D started beginning of June

- European Earth Terminal :
  - Ground station schedule agreed with EUMETSAT
  - Support EUMETSAT contract preparation
  - Start of development planned beginning of 2005
  -

Satellite accommodation status
  - No showstopper identified for WSOA accommodation
  - Nominal mass : 561.3 kg Maximal mass : 599 kg

Schedules and open issues

Current schedules are compatible with a Launch date in April 2008 pending Phase B start.
  - Pre-B study has started with following assumptions
    - WSOA experimental payload
    - Delta II launcher Interfaces and Launch constraints similar to Jason-1
  - If final decision would be different pre-B studies should be re-done and satellite contract renegotiated
  - Delay in satellite phase B start would induce delay in satellite launch availability date

**EUMETSAT Report**

Programmatic Status

- All EUMETSAT members (except Austria) are participating to this first EUMETSAT optional Programme
- Program fully subscribed since Council meeting in June
- MOU negotiation
  - Very significant progress made through several 4 party meeting
  - A few remaining open points on Legal Articles

  - Objective for EUMETSAT is to have MOU approved by Council next summer which mean that text has to be agreed at executive level by the end of the year.
  - CNES/EUMETSAT Agreement can not be signed as long as MOU is not.
  - Preliminary Authorisation to proceed already asked and approved for 2003 and 2004. A new ATP will again be asked for 2005.

Management and Technical Status

- Internal EUMETSAT organisation defined
- Ground Segment and Operations
  - Requirements, Architecture and Operation Concept presented by CNES and discussed in details with EUMETSAT
  - Internal EUMETSAT architecture satisfying the system requirement and making best benefit of EUM existing infrastructure under preparation for system PDR.
- European Earth Terminal
  - Final site selection done
  - Contract for infrastructure preparation will be kicked off in March 2005
- Main risk area
  - Very constrained internal budget

**NOAA Report**

NOAA Responsibilities

- Satellite Command and Control
- Near real time operational product processing and distribution
- Archive and Access

Status

- Conducted a comprehensive Internal System Requirements Review in September , 2004
- Completed testing with Jason-1 using NOAA Ground System at Wallops, VA
  - Test was successful
  - NOAA was able to track Jason-1 and receive its housekeeping telemetry
- System engineering tasks are well underway

**2.6 Jason Satellite/Ground System-Operations and Performance**

**CNES Report**

Platform incident synthesis since last SWT (November, 2003)

| Incident | Date | Cause | Mission impact |
|---|---|---|---|
| NFDRCRW1 red alarm | 2003/11/19 03h58 | Reaction Wheel #1 in failure | Mission interruption due to Safe hold mode (230 hours) |
| NFDRQTAR3 1 red alarm | 2004/02/15 00h41 | Incorrect navigation TC sequence | Mission interruption due to Safe hold mode (144 hours) |
| Stop writing TM in PLTM2 | 2004/04/03 11h37 | failure in module 3 of PLTM2 mass memory | Mission partially interrupted |

Star Tracker Status

- Dimming of the STR signal identified after launch is stabilized since December 2002
  - monitored through STR1 expertise twice per month
  - no sign of further degradation

- MAG/GYRO/ALTI ground attitude estimation filter has been developed

Will be activated only in case of STR failure.

Momentum Wheel Status

- Reaction wheel #1 is OFF since November 2003 SHM
- Satellite operations conducted using the 3 wheel attitude control mode
- No more redundancy to conduct nominal mission operations in case of a second wheel failure
  - OBSW patch was developed and tested to be able to maintain safehold mode in case of such a double failure

DORIS and Poseidon specific operations

DORIS

- DIODE Navigator incident on 12 June 2004 at 21h20
  - rejection counter threshold reached on Easter Island beacon
    - Side effect of radiations over SAA on the instrument
    - Since that time this threshold has been increased to avoid any new occurrence
  - no NAV data from 21H20 on June 12, 2004 to 2H55 on June 16 2004
- Switch from Doris2 to Doris1 on 28 June 2004 & Software V2.08 upload in Doris1 EEPROM (it was in Doris2 EEPROM since 25 November 2002),

  - DORIS2 was still operational and within mission requirements but SAA effect steadily increasing since launch
    - Recommendation from POD to make the switch

POSEIDON

- Specific operations limited to Restart when incident detected
- no change of configuration since last SWT, November 2003
  - from Launch, 2 patches uploaded following any restart to correct from CNG anomaly (had only an impact on OSDR, not on IGDR/GDR) and change in GPS time-out from 30 to 150 seconds (to improve robustness against GPS time gaps)

Jason Ground Status

- Earth terminal operations are very good and meeting requirements.

- S/C Telemetry, command and health/safety monitoring is very good
  - Staff is fully trained for routine operations and contingency procedures

- Sequencing
  - Hardware/software and team are operating well
  - All products and services are meeting requirements
    - Earth terminal scheduling
    - Generation of routine flight time-tagged sequence
    - Generation of all routine flight operations support data products

- Both control centers tasks performed automatically

CNES/JPL Operations Status

- Very good behavior for both Control Centers
  - 99.947 % of HKTMR Telemetry archived since Jan 15,2001
  - 98.153 % PLTM1 and 98.218 % PLTM2 Telemetry archived since Jan 15,2001
  - PLTM results due to 2 SHM since last SWT (Nov 2003)
  - Ground system : ROBUST

- Operations Status: GREEN
  - Since mid January all the JGS elements are performing well
  - All documentation and personnel training is complete and up to date
  - 2 SHM recovery successfully performed.
  - Doris switch successfully performed on June, 28th 2004

- CNES/JPL operational coordination is well understood and working smoothly.

- Training with JPL : completed in October 2004

**NASA Report**

JPL Operations Status

- Operations Status: GREEN
  - All JPL JGS elements are performing nominally
  - All documentation and personnel training is complete and up to date
  - Two SHM recoveries were successfully performed and well coordinated with CNES.

- CNES/JPL operational coordination is working very well.

- JPL JSEQ sequencing hardware/software and JSEQ Team is operating well
  - All products and services are meeting requirements
    - Earth terminal scheduling
    - Generation of routine flight time-tagged sequence
    - Generation of all routine flight operations support data products

- JPL Operations Staff is fully trained and recertified for routine operations and contingency procedures.

- JPL Control Center is implementing increased task automation.

JPL Mission Operations Assessment

- In the period since the last SWT Meeting in Arles, no science data has been lost due to operational anomalies or command errors.

- No science or mission data has been lost due to NASA ground system problems.

- The current NASA ground system configuration and station performance is adequate to meet mission requirements.

- Total data recovery rate exceeds 99.99% of the available science data.

## 2.7 Jason instrument performance

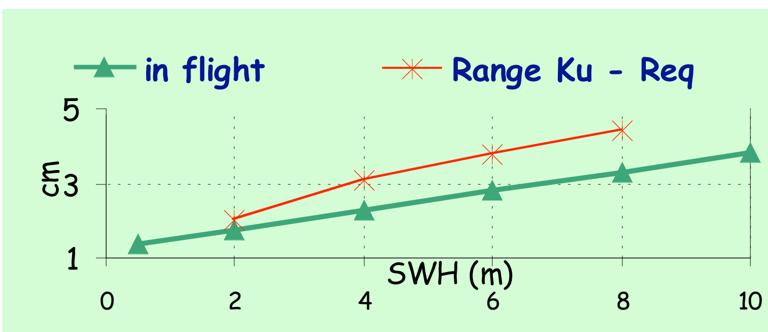
## DORIS

- DOPPLER MEASUREMENT
  - mean value for noise is 0.40-0.50 mm/s (POE residuals)
  - radiation effect on Doris2 USO frequency over SAA region has been steadily increasing since launch
    - Mission impact low at POE Level, main effect is editing of measurements over SAA

        – Considering the increasing number of edited data, decision was made to switch to DORIS1
    - Studies are in progress to elaborate an SAA Effect Model to allow processing of data over SAA, first results seem to be promising (see POD splinter)
    - Effect on DORIS1 USO frequency is smaller than Doris 2 before switching
- DORIS Time-tagging of PPS
    – used for altimeter data
    – accuracy is 1-2 microseconds as compared to on-board GPS (platform)
- Navigator (DIODE) performances (used for OSDR)
    – RMS radial 20 cm
    – RMS 3D < 1 meter (typically 50 cm)

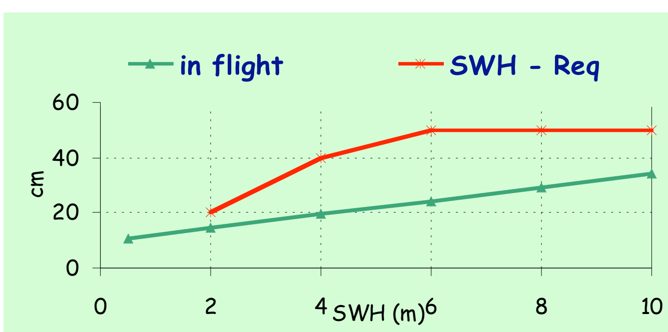
**POSEIDON2**

- 1 second Range noise in Ku band versus SWH with on board re-tracking




For SWH = 2m
    1.8 cm in real time on board
    1.6 cm after ground re-tracking
**Compliant with the system requirements**

- 1 second SWH noise in Ku band versus SWH with on board re-tracking




**Compliant with the system requirements**

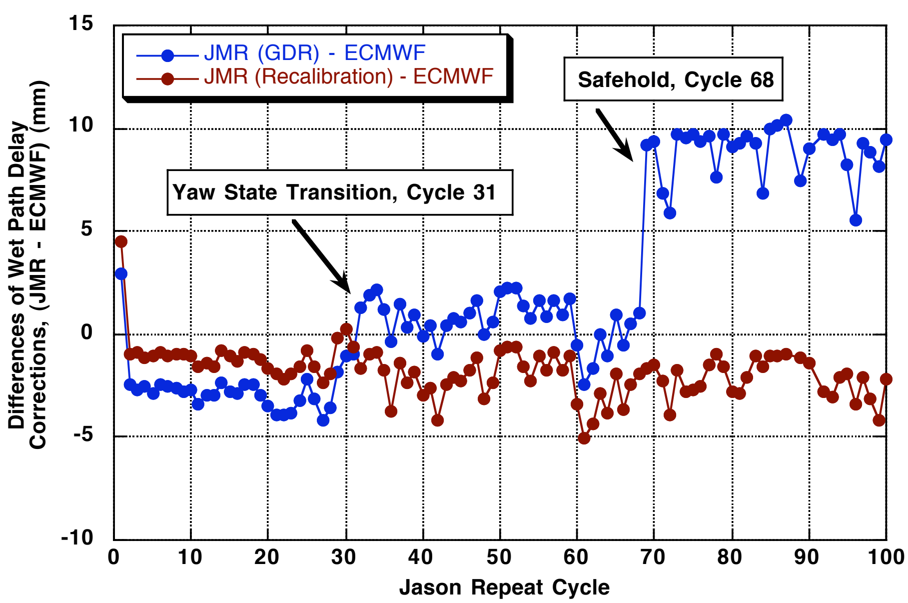
After 35 months in orbit

- Poseidon2 altimeter has an excellent behavior. (No major incident)
- The altimeter provides accurate range mesurements, significant wave height and sigma0 values over the ocean with a very good data availability.
- All the in-flight measurements are compliant with the instrument and system requirements with significant margins

**Jason Microwave Radiometer (JMR)**

- ❑ Summary:
    - ❑ Continues to operate nominally
    - ❑ No Alarms
    - ❑ No Commanding (Except for SHM recoveries)
    - ❑ No engineering anomalies since launch
    - ❑ Two science anomalies since launch
    - ❑

JMR Science Anomalies




- Two distinct offsets in the JMR measurements of wet path delay have been observed:
    - 3-4 mm drier during repeat cycle 31
        - Evidence suggests occurred near fixed to sine yaw state transition.
    - Additional 7-8 mm drier at cycle 69
        - Occurred after satellite safehold event during cycle 68.
- Evidence suggests change in hardware behavior is the cause of the two shifts, e.g. thermal shock.

- A dedicated recalibration of the JMR has been performed to remove these anomalies.
  - Antenna temperature calibration coefficients primarily adjusted to eliminate biases.
  - New calibration coefficients will be implemented in next generation of GDRs.
  - Refer to poster by S. Brown, and presentation by S. Desai during Cal/Val splinter for more details.

**Turbo Rogue Space Receiver (TRSR)**

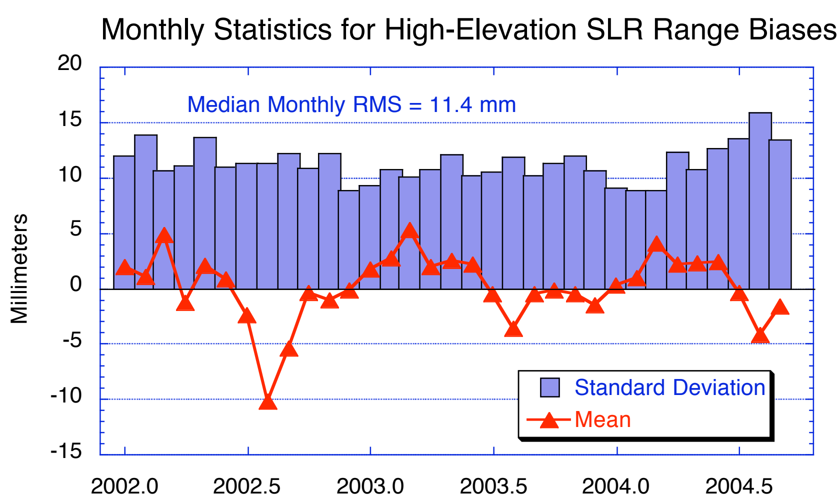
- ❑ Summary:
  - ❑ TRSR2 continues to operate nominally.
  - ❑ TRSR2 flash file system anomalies on 19-July and 16-Oct, 2004.
  - ❑ TRSR1 operation was not satisfactory and is under investigation.

TRSR Performance on Jason-1

- ❑ Tracks up to 12 GPS satellites on 2 frequencies using advanced codeless techniques
  - ❑ Temporal coverage of 85–95% (5 or more GPS tracked)

- ❑ Quality of tracking data (point-to-point scatter) is excellent
  - ❑ 20–30 cm for pseudorange (vs. 70 cm for GPSDR on T/P)
  - ❑ 6–7 mm for carrier phase

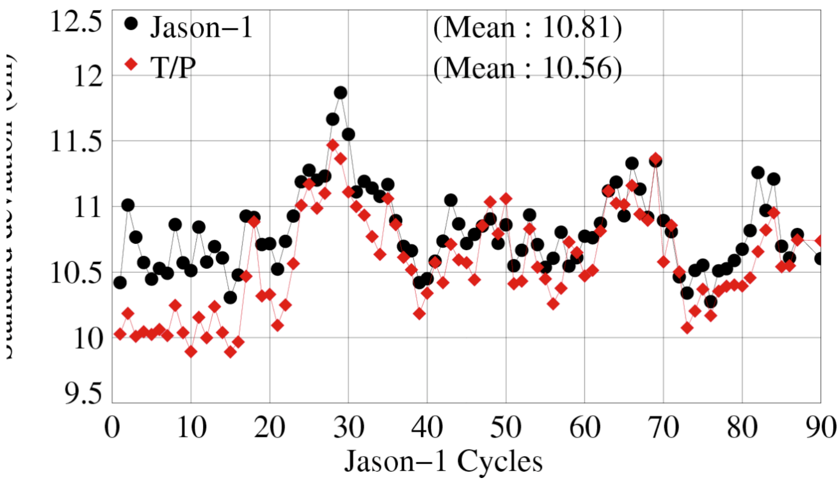
- ❑ GPS-based POD results are excellent
  - ❑ ~1 cm RMS radial accuracy for definitive solutions
    - ❑ Agreement with DORIS/SLR POD solutions is at level of 1–2 cm
    - ❑ Consistency with high-elevation laser observations is < 1.5 cm.
  - ❑ 2–3 cm RMS radial accuracy within 3 to 5 hours of real-time



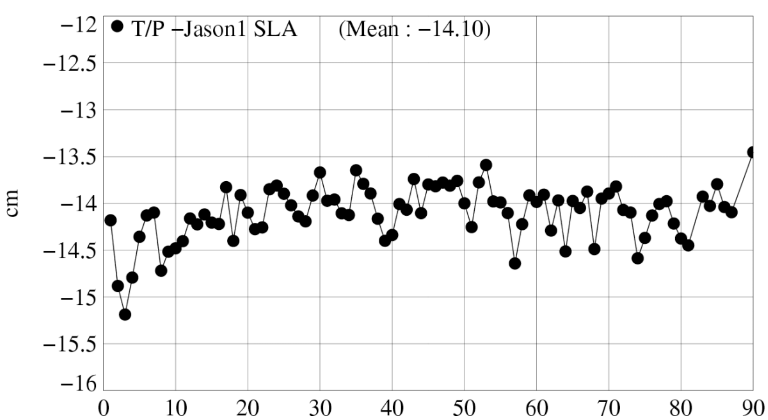
**Jason-1 Data Products and Evaluation**

- IGDR / GDR : Only one recent improvement
    - From cycle 102 onwards, for the IGDRs
    - From cycle 91 for the GDRs:
  - Upgrades concern:
    - 20 Hz data in the products

Standard deviation of Sea-Level Anomaly residuals (cm)




T/P - Jason-1 Relative bias (cm)




Status on Altimeter Bias

- A double check of many possible sources of an instrumental bias has been performed:

  - Instrument « equations » (measurement equations in the tracking mode, internal path delay computation) of the processing ground segment have been compared with the equations found in Alcatel altimeter instrument handbook

  - Numerical values of instrumental parameters used in the ground segment have been compared with Alcatel characterization values, both for the Ku and C-band

  - Antenna contribution to the TPG measurements: comparison betweenAlcatel measurements and independent CNES measurements

  - Figures linked with the satellite and antenna geometry

- SOME TINY DIFFERENCES HAVE BEEN IDENTIFIED BETWEEN GROUND SEGMENT PARAMETERS AND INSTRUMENT CHARACTERIZATION PARAMETERS EVALUATED DURING THE GROUND TESTS OF THE INSTRUMENT

- ALL THE DIFFERENCES CAN EXPLAIN AN 0.5 CM PART ONLY OF THE ALTIMETER BIAS
  - It has not been yet possible to explain the source of the decimetric altimeter bias that is estimated from global or in situ validation experiments

- Document to be issued in the coming weeks for information towards the OSTST

JMR Anomalies

- Various analyses of raw measurements from the JMR indicate that the anomalies are caused by changes in the behavior of the JMR hardware. (e.g. Cal/Val splinter presentations Brown/Tran)
- Recalibration of JMR is being performed by the JMR instrument team (e.g. Cal/Val splinter talks/posters Desai/Brown).
  - Results indicate that a single set of calibration coefficients cannot be used throughout the mission.
- Time dependence of calibration coefficients will be introduced to cope with the three distinct JMR regimes.
  - Noise diode calibration, and path loss coefficients will have the time dependence
  - Single set of coefficients applied to each regime.
- Will be implemented for next generation of GDRs.

Towards a 2-nd generation of GDR products

*Improvement of orbit performances*

- Much work has been done by the Project Team and the POD group to feed the POD discussion

- Recommendations of a POD computation configuration will be issued by the POD group
- Will be implemented in the processing ground segment
  - Possible need for a complete orbit reprocessing for a 3 year duration

- Additional Question:
  - Is it agreeable to change the orbit computation configuration (when approved by the POD group) before the whole (altimetric + radiometer + orbit) change and the start of reprocessing operations ?

*Altimeter Waveform Processing*

- Anticipated solution (refer to P. Thibaut 's presentation, Retracking Splinter Meeting):

  - Implement a higher order (order 2) altimeter echo model
  - Implement a ground retracking algorithm :
    - allowing to simultaneously retrieve the 4 parameters that can be derived from the altimeter waveforms: epoch, SWH, Sigma0 and mispointing angle
    - allowing to take into account larger mispointing angle (if this case happens)
    - refer to Thibaut et al. (2004), Amarouche et al. (2004), Zanife et al. (2004)

- The « Ground retracking/SSB » Splinter Meeting will help discussing the elements associated with ground retracking (also refer to Callahan and Rodriguez (2004) and various presentations during the meeting)

  - Development of retracking algorithm and related items in progress in the processing ground segment

*Wind and SSB*

- The Vandemark/Gourrion et al. wind algorithm has been tailored to Jason-1 data by Collard et al. (see poster session)

  - This represents an update from the previous version of the altimeter wind estimate (the present algorithm was fitted on TOPEX data)

- SSB:
  - The Retracking/SSB splinter meeting will help in making a status about the SSB estimate

  - Besides questions of re-estimating the SSB based on ground retracked data from an improved algorithm, we will have to identify if there is a need to re-generate a SSB algorithm using new wind data.

*Atmospheric fields and related items*

- 1. An investigation is ongoing to improve the atmospheric pressure (and thus, the inverted barometer correction) near the land-sea transitions

- 2. There is presently no possibility to get « global atmospheric fields » at a frequency higher than the 6-hour time sampling, on a regular basis.

- 3. The management of air tides has to be implemented in the processing ground segment in the way designed by R. Ray and R. Ponte (2003):
  - ongoing development in the processing ground segment
- 4. The inverted barometer correction will be modified to take into account the management of air tides in the 6-hour pressure fields:
  - ongoing development in the processing ground segment

- 5. Introduction of the MOG2D ocean model (Carrere and Lyard, 2003) in the processing ground segment:
  - ongoing development in the processing ground segment

- 6. The dry troposphere algorithm will be updated to consider atmospheric pressure fields with air tides better handled in them:
  - ongoing development in the processing ground segment

*Ocean tides*

- FES Case (Le Provost et al.):
  - FES2004 model for 1/2 diurnal and 1Diurnal waves
  - M4 wave from the FES model
  - S1 wave from the GOT model

- GOT case (R. Ray et al.)
  - GOT00.2 model (or any new version)
  - M4 wave from the FES model
  - S1 wave from the GOT model

- Long Period Tides
  - Static estimation maintained
  - An anomaly from the static estimation will be included in the products , after prediction of the Mf, Mm, Mtm, Msqm tides from the FES model
  -

*Mean Sea Surface(MSS), Geoid, Cross-track gradient correction*

- MSS:
  - A priori solution discussed in Arles (2003): CLS01 MSS

- Geoid:
  - A recommendation from the POD group is expected

- Cross-track gradient correction:
  - A priori solution is the correction computed by J. Dorandeu et al. (2004) (note that such a correction has been computed in a consistent way for Jason, T/P and ENVISAT)
  - Alternate solutions may of course be considered (Desai et al., Chambers et al., for instance)

*Rain Flag*

- Work has been done by G. Quartly (SOC, 2004) and J. Tournadre (IFREMER, 2004) to issue an updated version of the Jason rain flag

- An independent assessment of both solutions has been performed by N. Tran (2004) (accepted for publication in JAOT)

  - J. Tournadre ‘ solution to be preferred
  - Note that J. Tournadre has just informed us that a new version of his rain flag is available. An extra validation exercise will be performed to evaluate the new set of coefficients.

*Organisation and schedule*

- Details of the organisation and scheduling of the reprocessing operations are to under discussion

- Objective is to start producing reprocessed GDRs (2nd generation) by June 1-st, 2005

- Work is in progress to determine processing rate and rate of parallel quality checking of products

**3. Plenary Session II – Consistency in T/P and Jason Measurement Performance**

**L-L. Fu** opened the session by introducing the subject of systematic differences between T/P and Jason measurements. During the period of January-July, 2004, Jason and T/P were flying over the same ground tracks with overflight times separated by 70 seconds. The atmospheric and oceanic conditions for the two measurements are nearly identical, providing an unprecedented opportunity to compare the instrument performance of two altimetric systems. Ideally one would like to see differences dominated by random errors. Any systematic differences over finite space and time scales would potentially cause problems for matching the two measurements for making a consistent long data record for ocean circulation and climate studies.

Shown in Figure 3.1 (courtesy of D. Stammer and C. Wunsch) are the mean and root-sum-squares differences between the sea surface height measurements of T/P and Jason. There is clearly a pattern of geographically correlated orbit error differences in the map of mean difference.

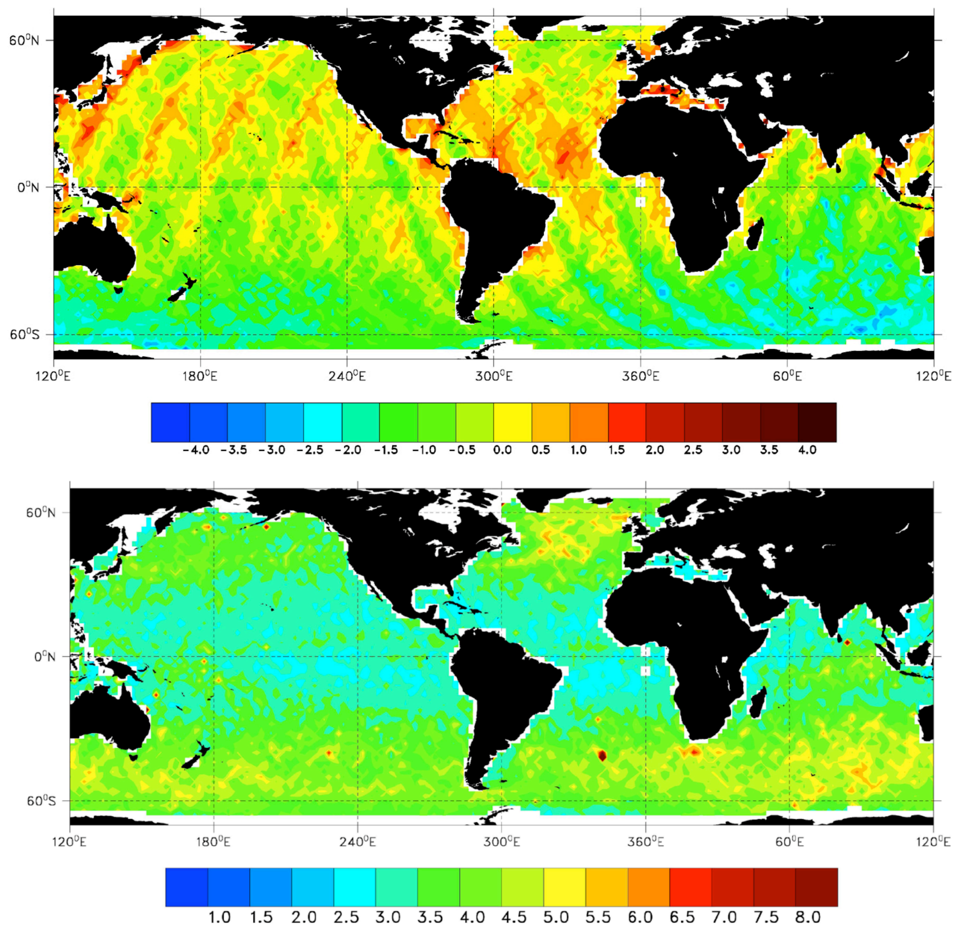



Figure 3.1 Upper panel: mean difference in SSH between Jason and T/P. Lower panel: RMS difference in SSH between Jason and T/P. (in cm)

The RMS difference shows a typical value of 3-4 cm, quite consistent with the estimated instrument errors of the two systems. However, the spatial and temporal characteristics of the differences (Figure 3.2, courtesy of D. Stammer and C. Wunsch) do suggest systematic differences in measurement errors. The tracky patterns (EOF #1 and #3) suggest orbit errors, while the apparent annual variations associated with EOF #2 suggest possible cause of wave height-related errors. Figure 3.3 displays the coherence between the differences in sea surface height (SSH) and significant wave height (SWH) between T/P and Jason, suggesting that SSH difference is correlated with SWH difference at wavelengths of 1000-10000 km.

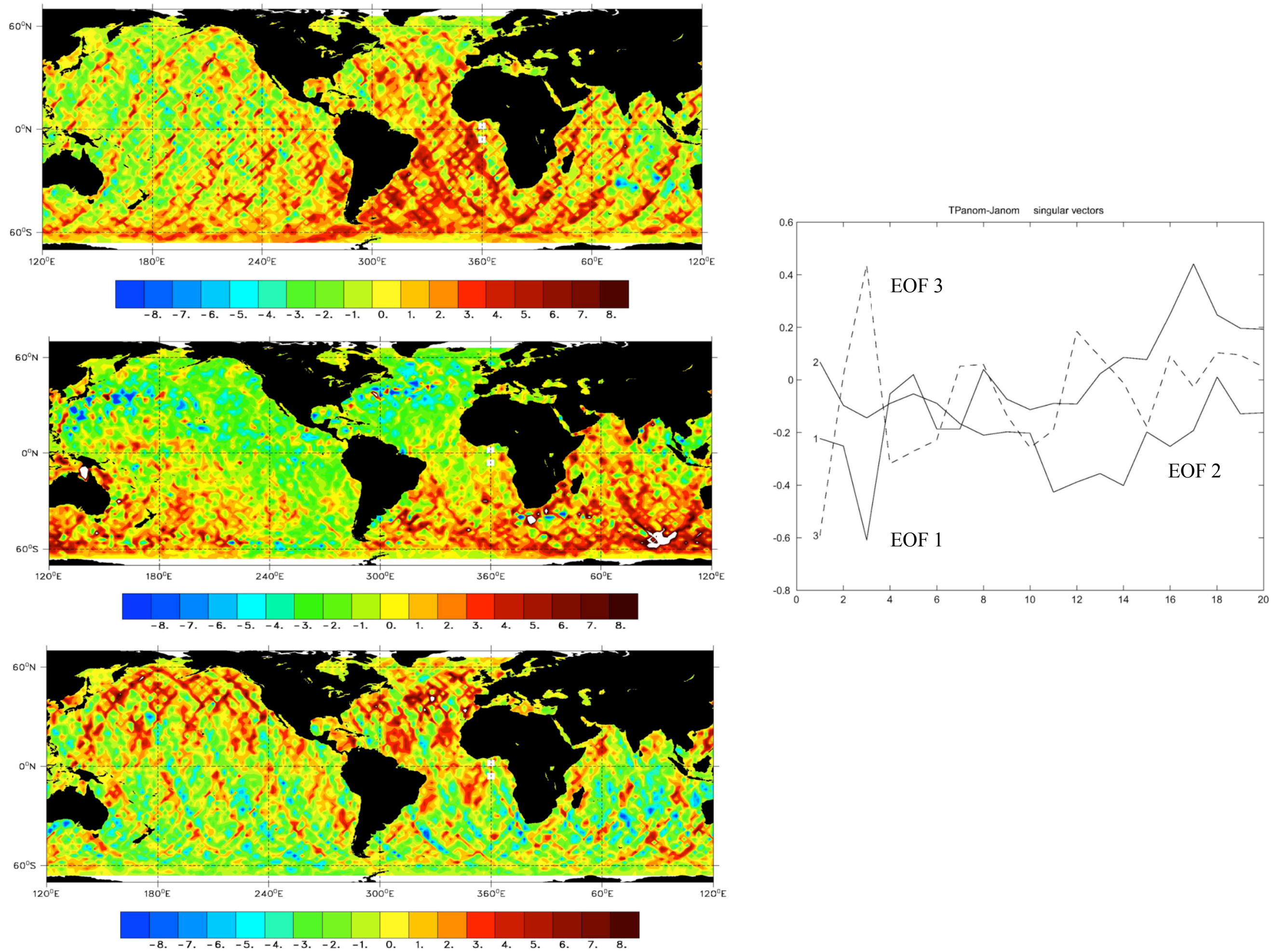



Figure 3.2 The 3 leading EOFs of the SSH difference between Jason and T/P.

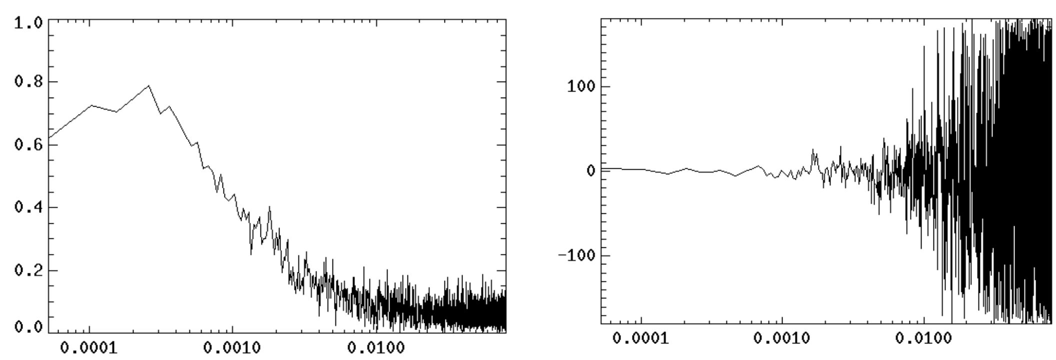


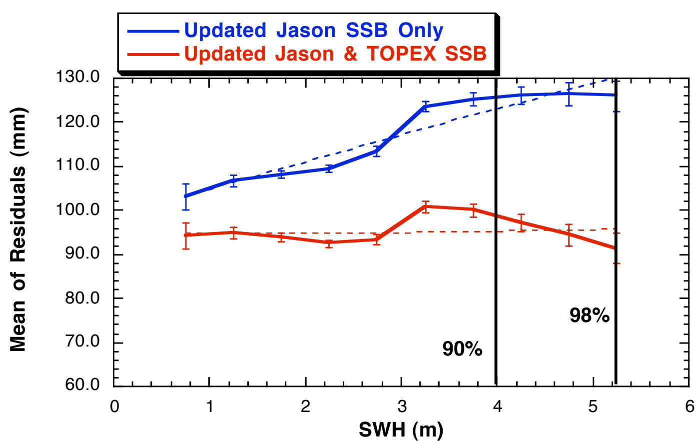

Figure 3.3 Coherence amplitude (left) and phase (right) of the SSH difference between Jason and T/P versus significant wave height. The abscissa is wavenumber in unit of cycles/km.

The following conclusions emerge:

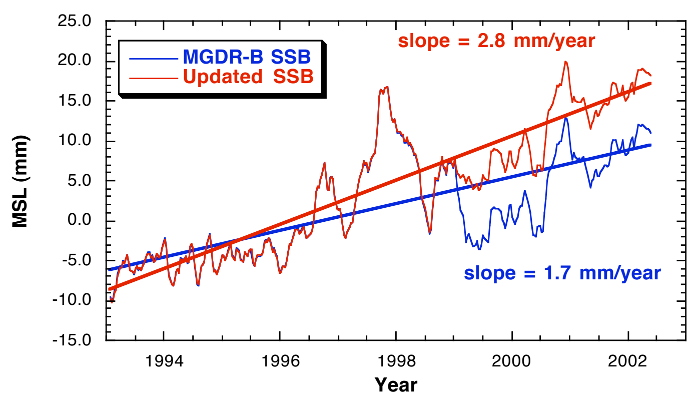
- SSH difference between T/P and Jason has a red spectrum at wavelengths larger than 500 km.
    - At the longest wavelengths (~10000 km), it is related to orbit errors (~ 3 cm).
    - At wavelengths 1000-5000 km (rms magnitude 1-1.5 cm), it is correlated with SWH, indicating differences in instrument correction algorithms (SWH effects in waveform modeling).
    - *Elimination of the SWH-dependence in the SSH difference would minimize the instrument errors in the EM bias estimation.*

**D. Chambers reported on the relative bias and sea-state effects:**

- There is a clear difference in local Jason-TOPEX_B relative bias depending on whether one uses ascending or descending passes or a combination
- Based on the comparison of SWH, we believe the problem is related to the tracking of the TOPEX_B data, and not a problem in Jason-1
- Empirical SSB models as functions of SWH and wind speed cannot fully solve the problem, although they can reduce the problem somewhat




The figure above shows that the dependence of the relative bias can be reduced by using updated SSB models.

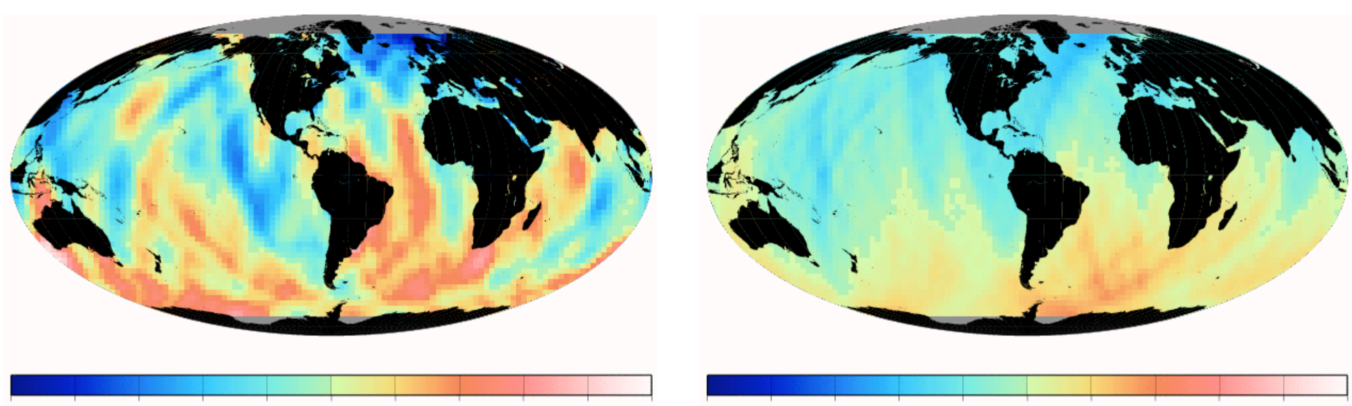


The figure above show the effects of different SSB models on the estimation of global mean sea level change.

- Until fixed, users need to carefully evaluate and link up time-series from TOPEX and Jason-1depending on application
  - » Using a single "global" bias may lead to several cm "jumps" when time-series connected, depending on location, pass

**J. Ries, P. Bonnefond, B. Haines, and S. Luthcke reported on orbit errors :**

- For purposes of cross calibration of T/P and Jason-1, the ideal (other than perfect orbits for both) is to avoid correlated errors that are different between the two
- The strategy to process Jason-1 in a manner matching T/P was reasonable
  - Assumes models and tracking systems perform the same
  - Known correlated errors in both Jason-1 and T/P orbits would, however, affect some *in situ* calibrations
  - Alternative would have been an abrupt change in both T/P and Jason-1 modeling at the outset, creating an inconsistent T/P series
- Correlated errors from dynamical model
  - Gravity (static and tides) can cause geographically correlated errors, but static gravity model (JGM-3) was unchanged
  - Solar radiation pressure model is different between the two spacecraft, so no guarantee that systematic orbit errors caused by errors in either are identical (possible source of small Z-shift)
- Correlated errors from tracking data
  - Network (ITRF2000) identical for both T/P and Jason-1
  - Unfortunately, DORIS on Jason-1 does not behave like T/P

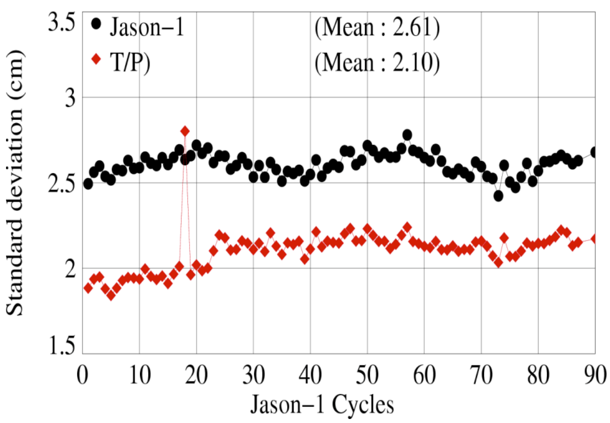



The GPS-based orbit was used as a reference to evaluate the performance of various orbit solutions. The left panel above shows the pattern of orbit errors in the current GDR (rms error estimate – 7 mm). The right panel shows the improved performance of CNES reprocess orbit with a reduced rms error of 4 mm.

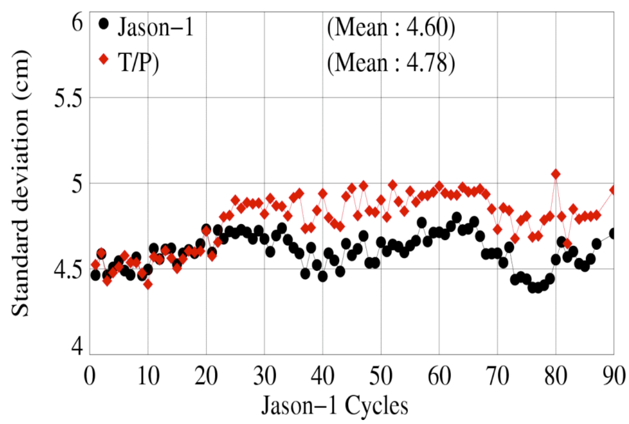
**J. Dorandeu, M. Ablain, Y. Faugère, S. Labroue, F. Mertz and P. Vincent reported on the global consistency between T/P and Jason :**

- Comparison between T/P and Jason-1 performances: differences explained by altimeter processing (HF content) and orbit errors

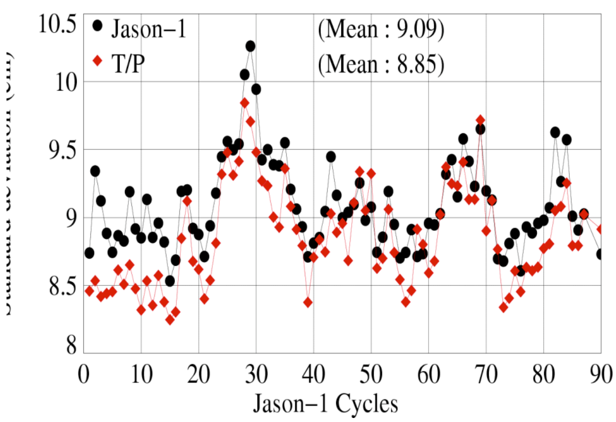
wavelength < 50 km




50 km< wavelength <500 km




wavelength > 500 km




The three figures above show the evolution of standard deviation of sea surface height at various spatial scales within a given cycle, revealing the following:

1) Impact of ground processing (the upper left panel):
TOPEX altimeter data are “smoother” (with less random noise)

2) T/P ground track change after cycle 22 (the upper right panel): causing increased MSS errors in T/P.

3) Jason-1 orbit errors in the first 20 cycles (the lower panel). Improvements from new generation orbits

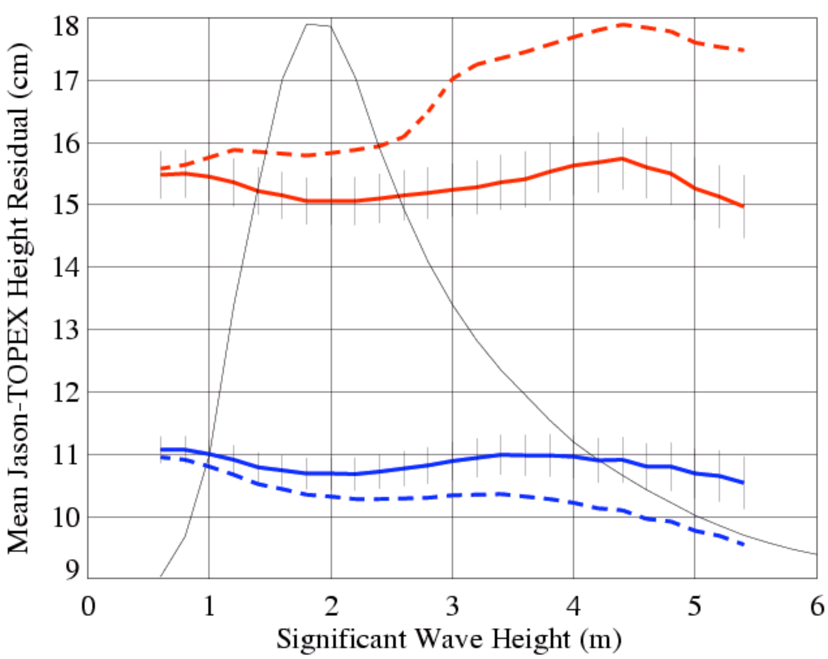
- The orbit contribution to geographically correlated differences has been shown by several groups.
  - Orbits should be as consistent as possible between T/P and Jason (standard, Earth Gravity Models, Tracking techniques?)
  - Dilemma: long term continuity / improvements
  - Removing the orbit contribution reveals other differences (Luthcke et al.): altimeter measurement and processing, SSB

- Impact of SSB estimation methods investigated in terms of geographically correlated signals. The collinear method should be preferred:
  - Better performances
  - More conservative choice, because less sensitive to
    - Ascending/descending signals
    - Ocean variability or independent North/South errors

- The strategy for Jason-1 re-processing will make choices for the future, and T/P should then be re-processed consistently.

**B.D. Beckley, N.P. Zelensky , S.B. Luthcke, R.D. Ray, and P.S. Callahan reported on Seamless Transition from T/P to Jason-1:**

Stability of Relative Bias Estimate

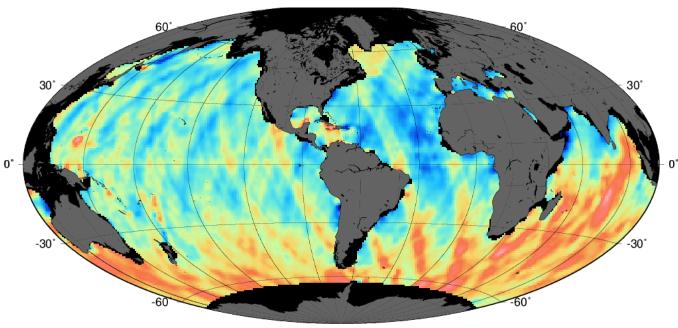


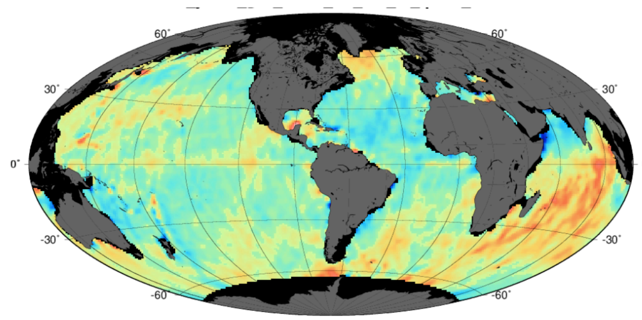

Jason project GDR – MGDR_B

Jason project GDR – TOPEX retracked with GSFC replacement orbit.

Jason with GSFC replacement orbit and dual crossover parametric SSB - TOPEX retracked with GSFC replacement orbit.

Jason with GSFC replacement orbit and crossover parametric SSB - TOPEX retracked with GSFC replacement orbit.






Improved global agreement in the TP-Jason differences:

The left panel has a mean of 152.5 mm and rms of 7.8mm. The right panel has a mean of 107.6 mm and rms of 4.7 mm.

## 4. Plenary Session III – Science

The following 4 presentations were delivered in this session. The slides can be found in the CD distributed with the report.

F. Lyard "Recent results on tides from altimetry: A tribute to Christian Le Provost"

G. Goni "Near-real time monitoring of the upper ocean from altimetry for tropical cyclone studies"

K. Kelly "The upper ocean heat budget in western boundary currents"

R. Morrow "Divergent pathways of cyclonic and anti-cyclonic ocean eddies, and their impact on ocean heat and salt transport"

## 5. Poster Session

The poster session was organized around the following topics:

A.Local and Global Calibration/Validation
B. Sea-State Bias and Re-tracking Analysis
C. Precision Orbit Determination and Geoid
D. Tides and High-Frequency Aliases
E. Multi-Satellite/Operational Applications
F. Outreach
G. Science Plans and Results
H. Consistency in Jason and TOPEX/Poseidon performance

The titles and authors of a total of XX presentations are listed in Appendix B. The abstracts of the presentations were distributed as part of the meeting handbook. Most of the posters are included in the CD distributed with the report. They can also be viewed at the following web site:

http://www.jason.oceanobs.com/html/swt/posters2004_uk.html

**6. Splinter Sessions**

**6.1 CAL/VAL** (P. Bonnefond, B. Haines and S. Nerem)

**1. Summary of Key Findings**

## 1.1. Sea-surface height biases

Jason-1 sea-surface height (SSH) bias results were presented for the Harvest (*Haines et al.*), Corsica (*Bonnefond et al.*) and Bass Strait (*Watson et al.*) calibration sites. Provided in the following table are the results from four different strategies:

- 1: fully compliant with GDR
- 2: the POE orbit (CNES) is replaced by the GPS reduced-dynamic solution (JPL)
- 3: same as 2, but using the wet troposphere correction from the ECMWF model instead of the JMR
- 4: same as 2, but using the wet troposphere correction from the local GPS data

| | **Corsica** | | | **Harvest** | | | **Bass Strait** | | |
|---|---|---|---|---|---|---|---|---|---|
| | Bias 2002.0 mm | Drift mm/yr | Mean Bias mm | Bias 2002.0 mm | Drift mm/yr | Mean Bias mm | Bias 2002.0 mm | Drift mm/yr | Mean Bias mm |
| **1** | 114 | -13 | 99 | 140 | -16 | 119 | | -8 | 144 |
| **2** | 116 | -11 | 103 | 133 | -9 | 122 | | -4 | 128 |
| **3** | 127 | -5 | 122 | 120 | 0 | 120 | | | |
| **4** | 131 | -6 | 124 | 124 | -4 | 120 | | | |

The results clearly show the impact of geographically correlated drifts in the GDR orbit (POE), as well as instabilities in the JMR path-delay measurements. After replacing the POE height measurements and JMR path-delay corrections, the drift estimates from the individual sites are not statistically distinguishable from zero. Additional monitoring and more rigorous combinations of results from the different calibration sites are needed to determine whether any residual drifts are significant. *Leuliette et al.* provided similar results using global tide gauge calibration methods (scenarios 1, 2 and 3). These points are discussed further in the following sections.

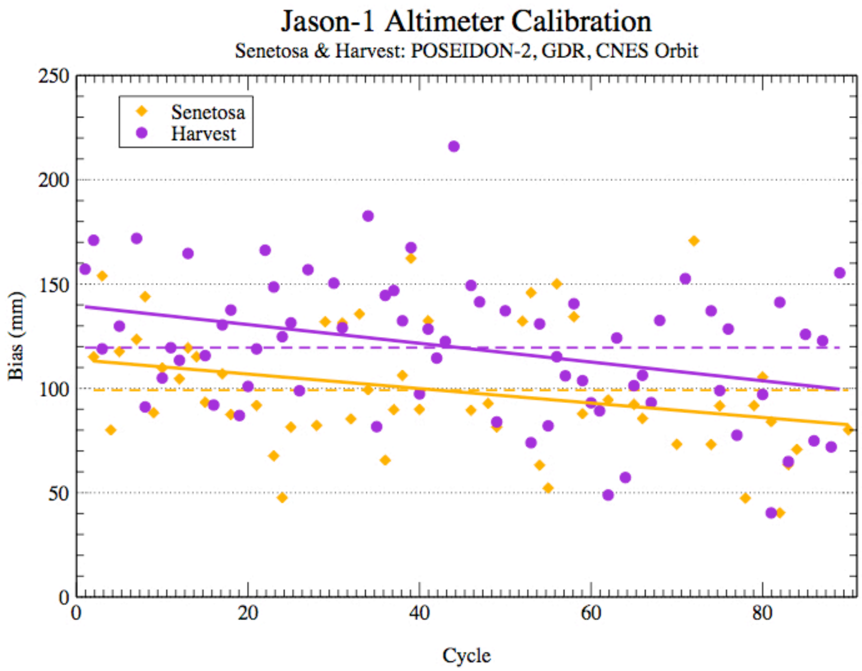
Also noteworthy are the mean (or epoch 2002.0) bias estimates, which continue to show that Jason-1 is measuring SSH short (by 10–14 cm overall) depending on the assumptions used and location of the calibration site.

*Pavlis et al.* reported preliminary results from the GAVDOS calibration site (Crete). Based on 21 recent repeat cycles, the estimated SSH bias is 145 mm, consistent with results from other sites.

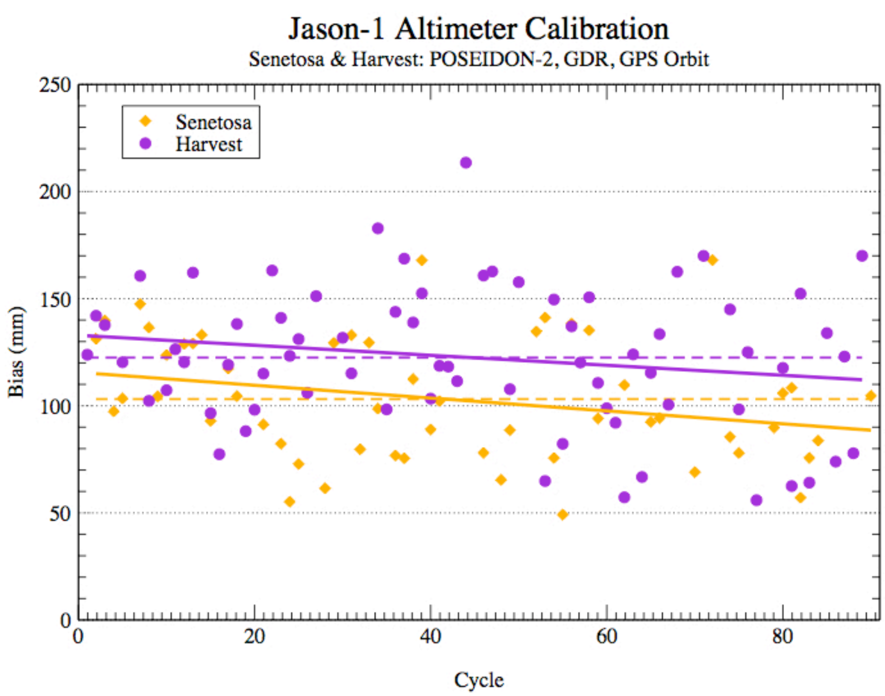
In their presentation, *Jan et al.* described a calibration method based on Mediterranean off-shore measurements (~200 km from tide gauge data) and corrections from geoid and ocean dynamic (Mog2d) models. In the vicinity of Corsica, the method gives an SSH bias of +114 mm, coherent with the mean bias of scenario 1 from the Corsica point calibration

(*Bonnefond et al*.). This method will be applied more widely in the western Mediterranean basin and also for other satellites (EnviSat, GFO).

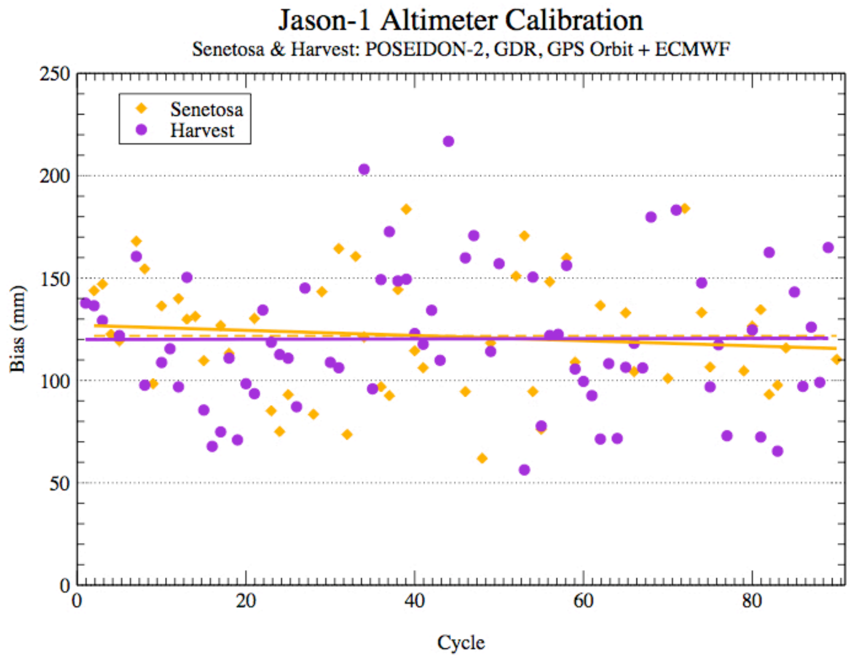
**Corsica and Harvest series, scenario 2:**



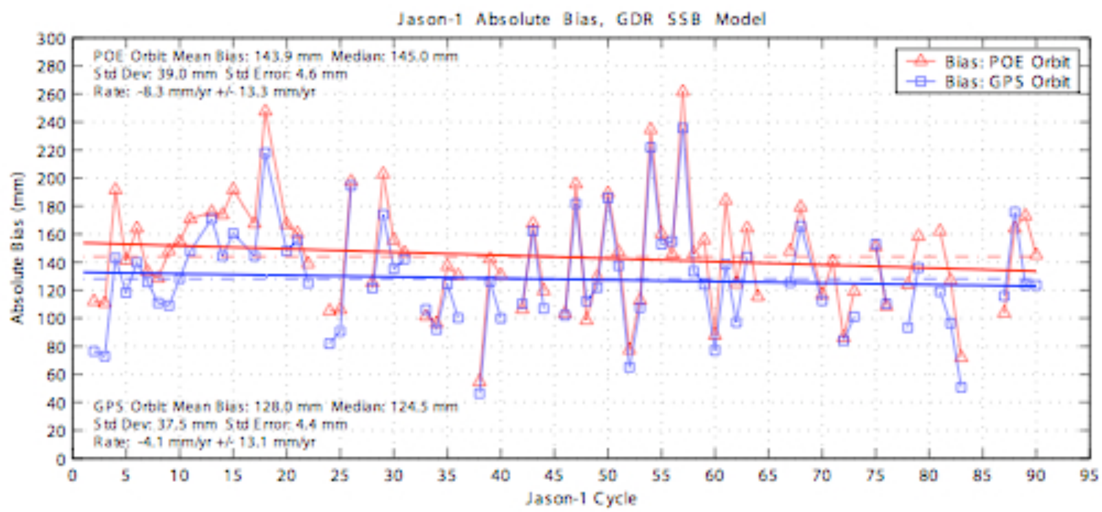

**Corsica and Harvest series, scenario 2:**

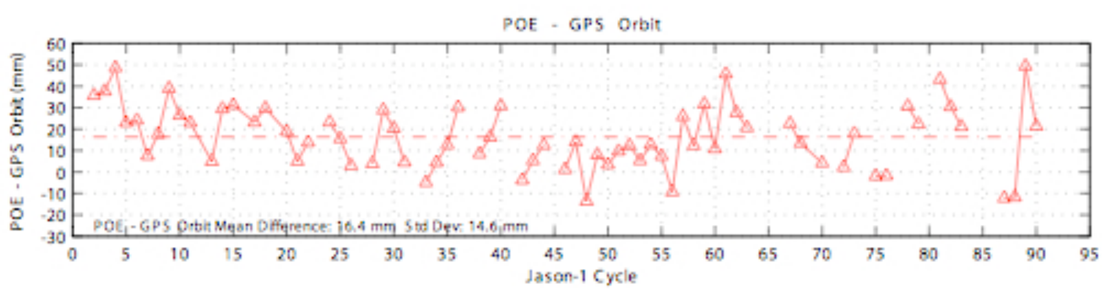


## Corsica and Harvest series, scenario 3:




## Bass Strait series, scenarios 1&2:

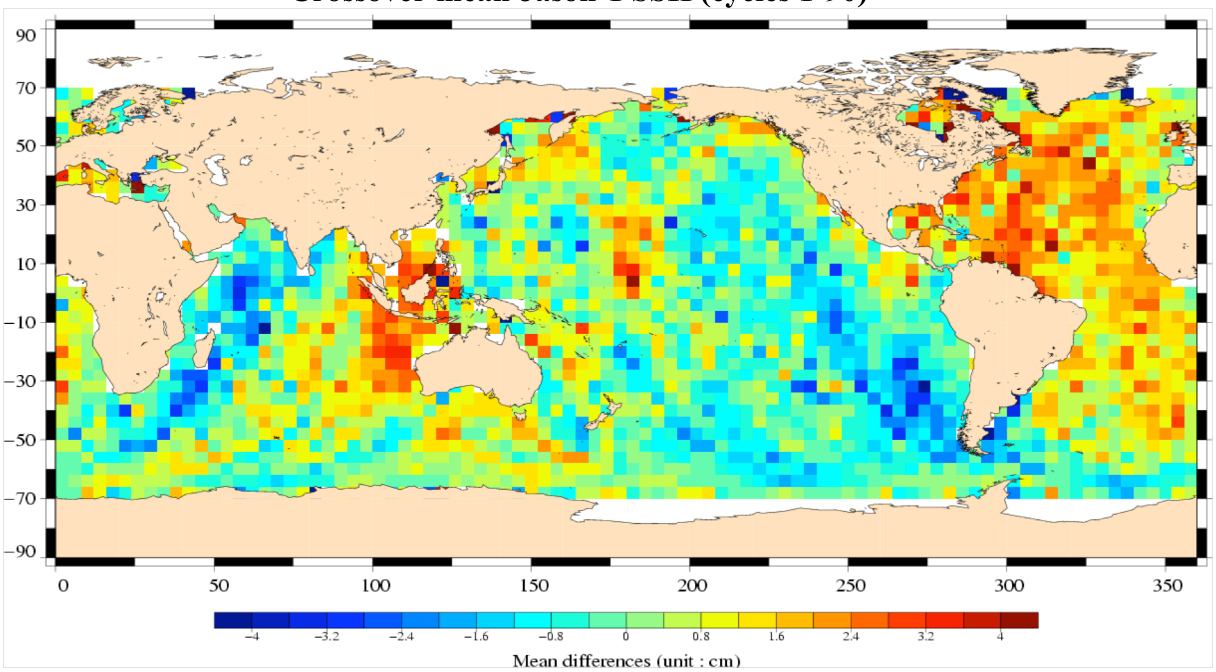


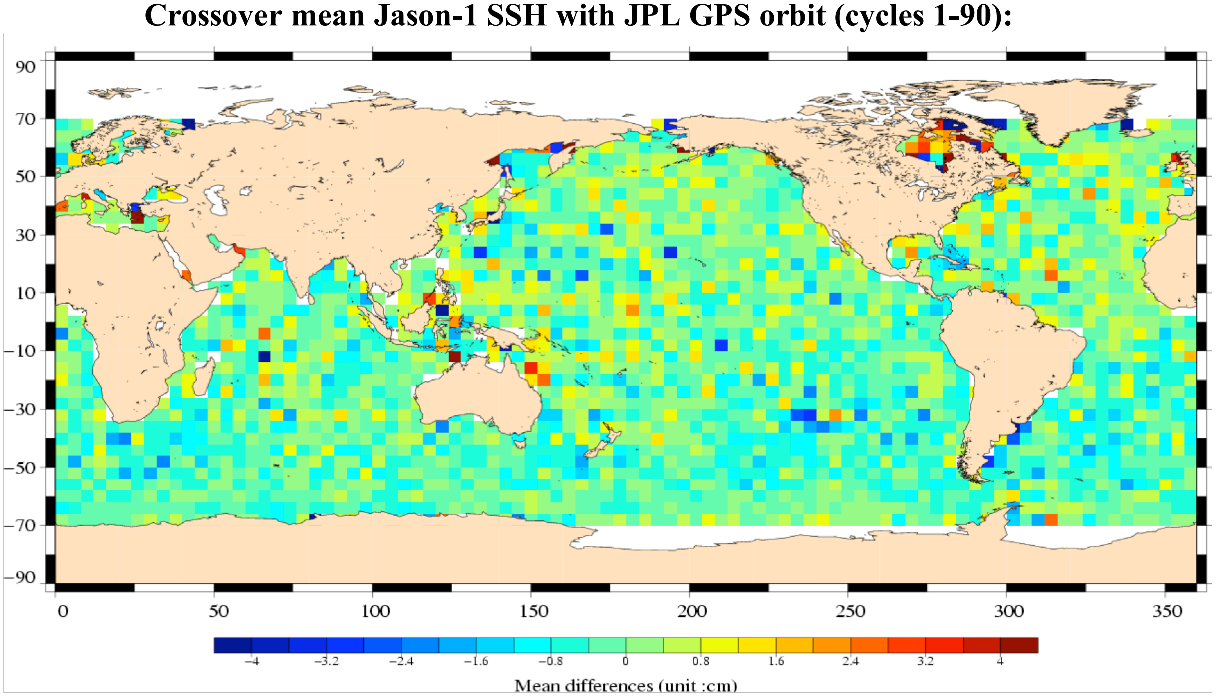
1.2. Jason-1 Orbit Error

*Ablain et al*. showed the high level of improvement in the agreement of altimeter SSH crossovers when using the GPS Reduced-Dynamic orbits (JPL) instead of the POE (CNES):

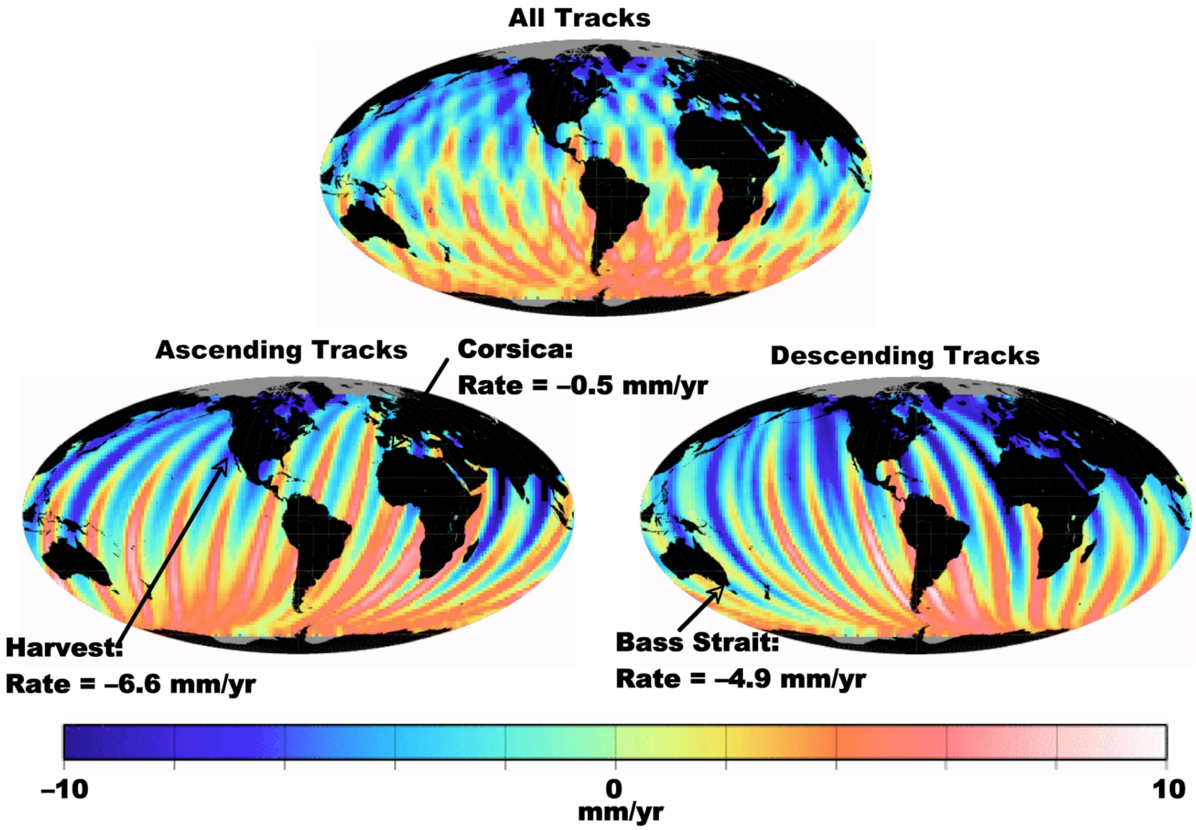
**Crossover mean Jason-1 SSH (cycles 1-90)**




**Crossover mean Jason-1 SSH with JPL GPS orbit (cycles 1-90):**



**GDR Orbit — JPL GPS: Radial Rate for Cycles 1–90**




*Haines et al*. and *Bonnefond et al*. have obtained comparable results concerning the Geographically Correlated drift of the radial orbit differences between POE (CNES) and GPS reduced-Dynamic (JPL) orbits. Results obtained at the calibration sites (scenario 1 and 2), as well as short-arc laser ranging evaluations, have shown that this drift is due principally to the POE (GDR) orbit.

This drift patterns also affects the global tide-gauge calibration method (*Leuliette et al.*), since the tide gauge distribution is not completely homogeneous.

Please refer to the report of the POE splinter for more information about this effect.

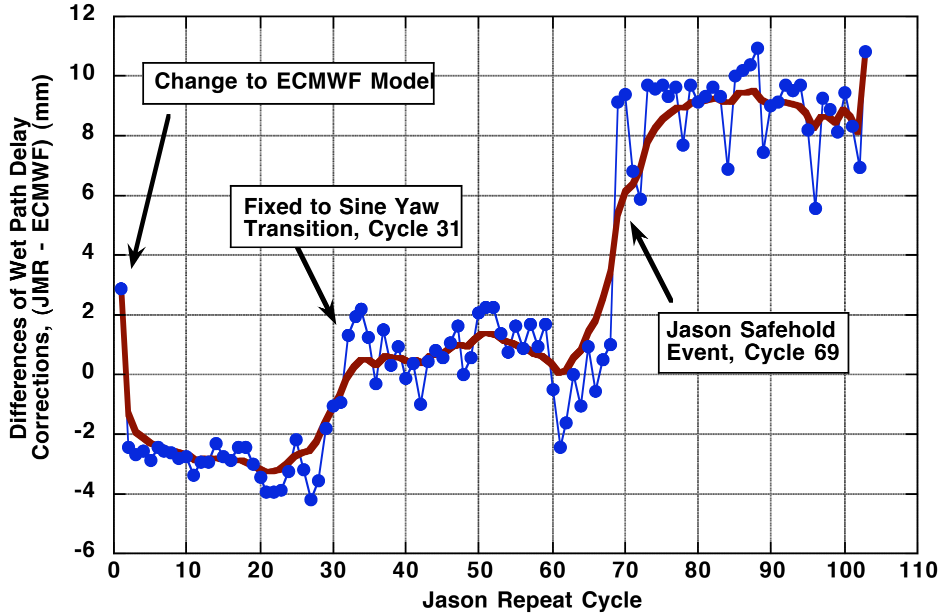
### 1.3. JMR

*Desai et al*. presented the JMR status and discussed future improvements to the GDR path-delay measurements. Comparisons of JMR to the ECMWF model show two significant shifts in JMR path delays:

- Cycle 31 Fixed to Sine yaw transition: JMR 3-4 mm drier
- Cycle 68/69 satellite safehold event: JMR 7-8 mm drier

0 Also, the yaw-state dependencies of the measurements grow after each shift, and are particularly clear after the Cycle 69 safehold. These phenomena have also been reported by *Ablain et al*. and *Leuliette et al*. Comparisons between JMR and path-delay measurements from other sources (e.g., GPS from *MacMillan et al.*) yield similar patterns, providing compelling evidence that the JMR measurements (not ECMWF model changes) are indeed the source of these systematic variations.

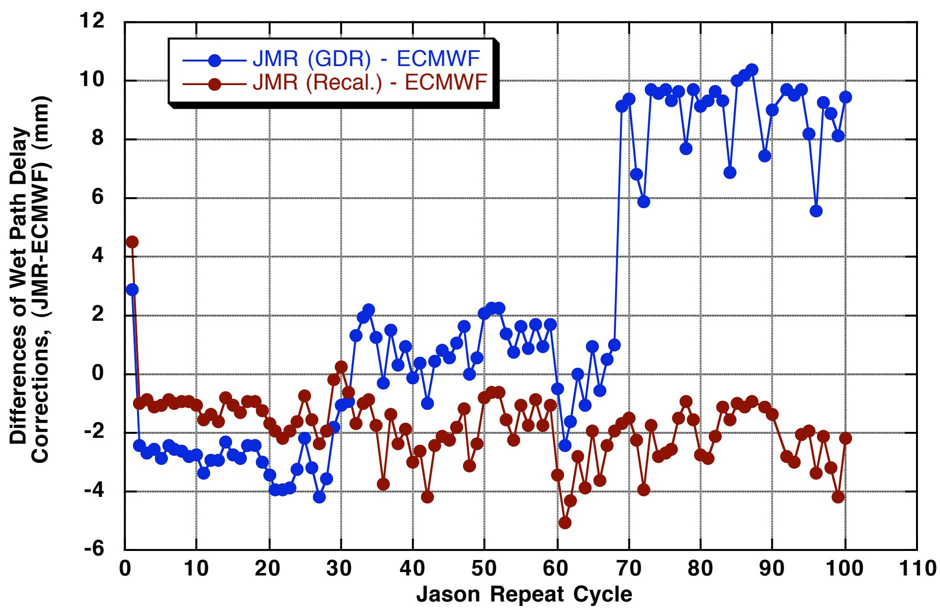
**Comparisons to ECMWF model:**




**Recalibration of JMR**

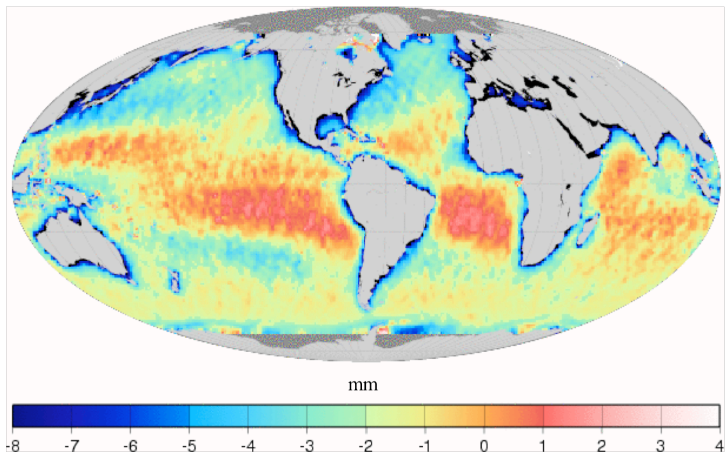
*Desai et al*. then described preliminary results of a JMR re-calibration exercise. He noted that a single set of calibration coefficients is unable to accommodate the JMR offsets. With separate coefficient sets for three regimes (Cycles 1–31; Cycles 32–68, Cycles 69+), the offsets and yaw effects are removed. Some fine tuning still to be performed before implementation in next generation GDRs:

**JMR before and after recalibration:**




One other known JMR vs TMR issue was discussed. Last year during the Arles SWT, the map showing the TMR and JMR differences (over Repeat Cycles 1–21) alerted the community to biases affecting the coastal areas. It is thus a problem for the calibration sites, for which results should differ from global comparisons. The Mediterranean Sea is globally affected by a 15-20 mm bias. It is not presently known if the JMR re-calibration exercise will substantially affect this result.

**Geographical patterns of the JMR bias (T/P - Jason-1)**



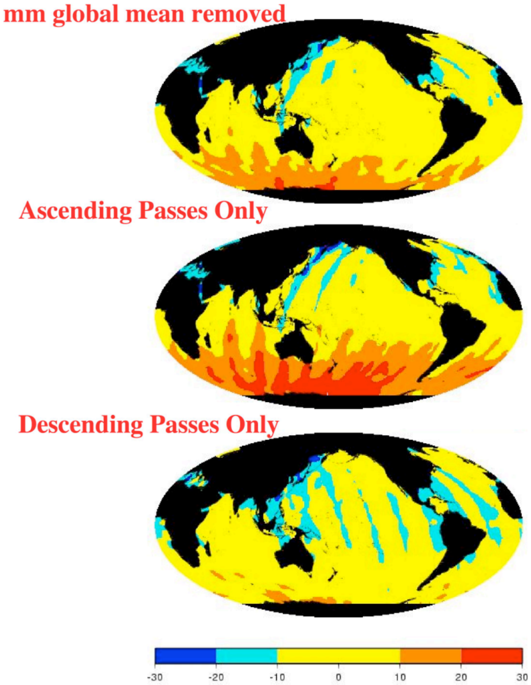

Consistency between T/P and Jason-1

*Chambers et al*. reported on the various sources of inconsistencies between the relative T/P and Jason-1 sea-surface height (SSH) bias during the cal/val (formation flight) phase. Their study emphasizes identifying the sources (T/P or Jason-1) of the various systematic errors:

**Maps of Jason-1 relative bias:**

**J-T, 150 mm global mean removed**

- Analysis based on data during cal/val phase (Feb. - Aug., 2002)
  - » Jason GDRs
  - » TOPEX B MGDRs w/ new SSB model [Chambers et al., *JGR*, 2003].
- Means of along-track SSH differences [Chambers et al., *Marine Geodesy*, 2003]
  - » Mapped to 1° grid with a 700 km Gaussian weighting function
- Significant regional departures from global mean in Southern Hemisphere of 1-2 cm
  - » Ascending pass only calculation shows departures > 3 cm
  - » Descending pass only much different



**SSB**

Use of the new SSB models for TOPEX_B reduced the problem slightly:

- Suggests problem in TOPEX_B data
- TOPEX_B SSB model still not adequate
- Still does not explain differences in ascending/descending passes

Pattern correlated with SSB pattern:

- Is there a difference in SSB between ascending/descending passes?
- No, only differences between Jason-1 and TOPEX_B models

**SWH**

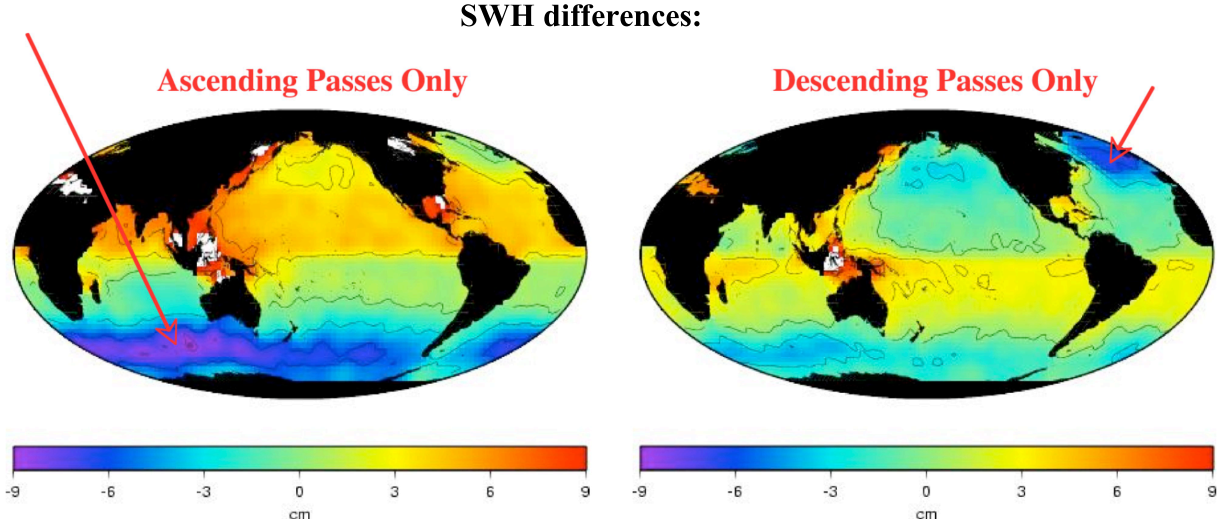
Different Ascending/Descending patterns in mean of SWH differences

- Larger difference in ascending passes, Southern Ocean
- Does not affect SSH through SSB (2.5% of 10 cm = 2.5 mm)

Note the relatively large differences when the satellite motion is from ice sheets to ocean (indicated by arrows)

- Could there be a problem in the tracking of the ocean data for one of the altimeters for some period after tracking ice?

**SWH differences:**



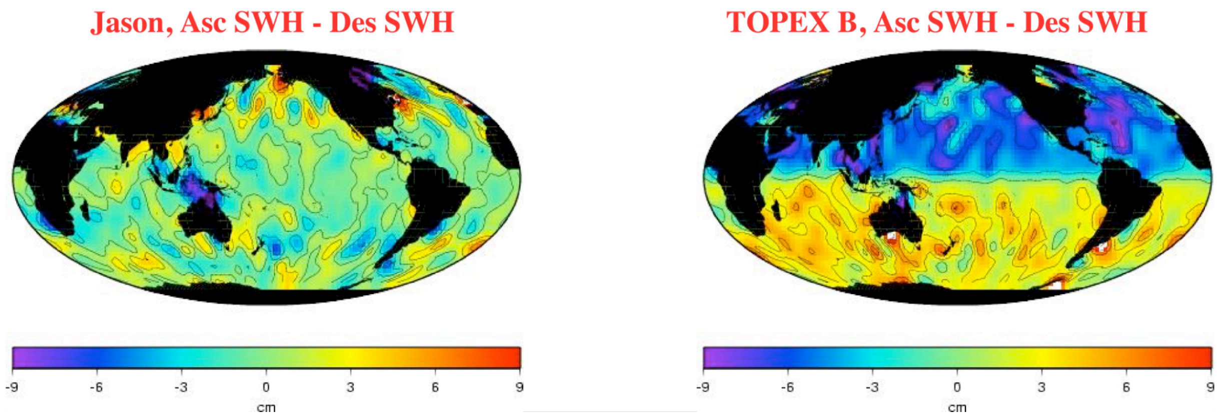

Looking at ascending-descending differences in sea level anomalies gives us no clue.

- Large, real ocean variability betweens times of passes obscures signal
- No obvious difference between TOPEX_B and Jason when examined this way

Looking at ascending-descending differences in SWH does.

- Tracker problems will affect both SWH and SSH

**Jason-1 and TOPEX (Alt-B) SWH, ascending – descending tracks:**

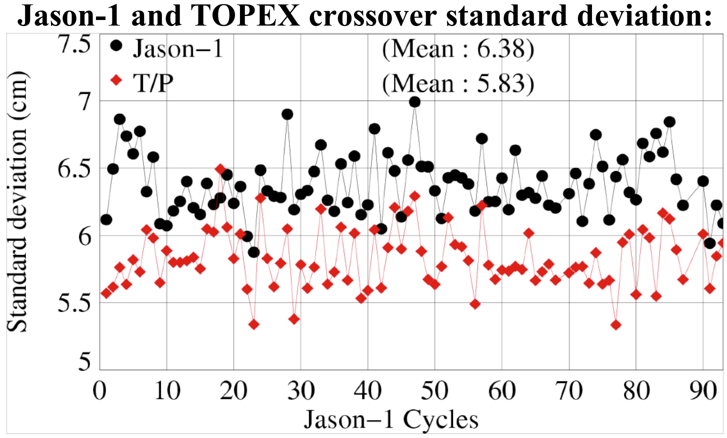



**Conclusions**

- There is a clear difference in local Jason-TOPEX_B relative bias depending on whether one uses ascending or descending passes or a combination
- Based on the comparison of SWH, we believe the problem is related to the tracking of the TOPEX_B data, and not a problem in Jason-1
- Empirical SSB models as functions of SWH and wind speed cannot fully solve the problem, although they can reduce the problem somewhat
- Need to re-track TOPEX_B data
- Preliminary re-tracking corrections available on GCP still have ascending/descending patterns
- Until this is done, users need to carefully evaluate and link up time-series from TOPEX and Jason-1depending on application
- Using a single "global" bias may lead to several cm "jumps" when time-series connected, depending on location, pass
- "Jumps" differ significantly (> 2 cm in some areas) depending on SSB model applied

*Ablain et al*. made an important report on the Jason-1 data quality assessment and on the cross calibration of Jason-1 and T/P. Concerning the difference between the T/P and Jason-1 standard deviation of the crossovers, the authors noted that the short wavelength content of the Jason-1 SSH is higher than for T/P, thus explaining most of the differences:

**Jason-1 and TOPEX crossover standard deviation:**



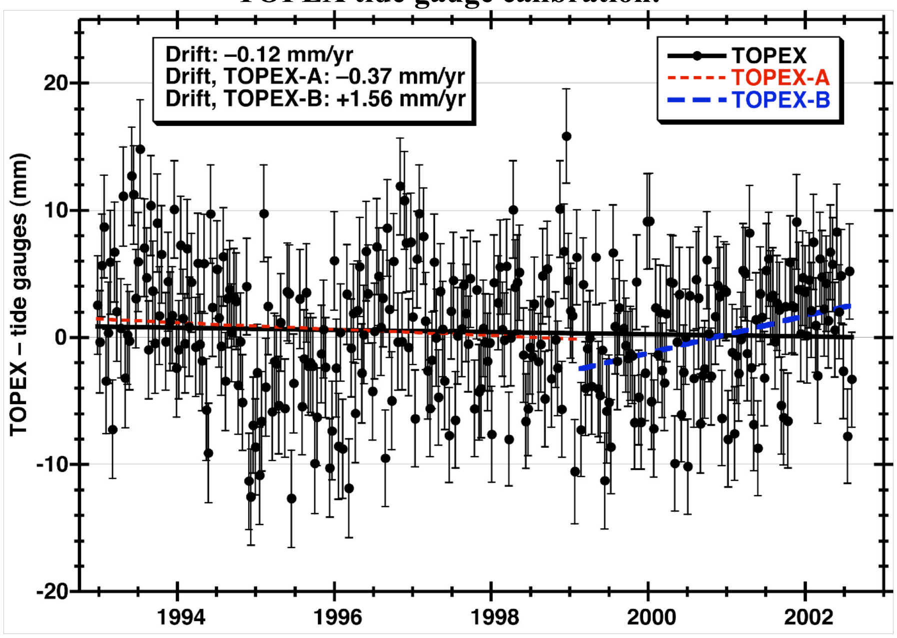
The conclusions of *Ablain et al*. were:
Good quality and general performances of Jason-1 data:

- Altimeter parameters consistent with T/P
- Similar performances with T/P :
- Jason-1 crossover RMS = 6.3 cm
- T/P crossover RMS= 5.8 cm

Main discrepancies between Jason-1 and T/P :

- JMR changes impact the long term monitoring of the mean sea level.
- Large hemispheric SSH differences are mainly explained by the orbit.
- Others differences might explain geographical patterns: SSB model, ground processing

**TOPEX tide gauge calibration:**




In *Leuliette et al*., authors have identified a drift of the T/P side B altimeter bias (~+1.6 mm/yr) using the tide gauge calibration method. This shows that inconsistencies can exist not only between Jason-1 and T/P but also between the two parts of the T/P mission.

Two other talks have analyzed the differences between T/P and Jason-1:
*J. Tournadre* has developed a new rain flag:

- Very good stability of f relation and rms for Topex and Jason
- Very good agreement of rain flagging for both satellite (no difference between the tandem and interlace missions)
- No significant between rain flagging using cycle cycle relations and mean relations
- Up to 10 % of data flagged in the Warm Pool
- Rain products determination of freezing level and rain rate
- Good agreement between Topex and Jason
- Prepare for fusion of rain products from Topex, Jason and Envisat

*G. Han* has presented T/P-Jason Comparison over the Scotian Shelf and Slope. Results of his study suggest:

- T/P-Jason comparison suggests errors of 3 cm rms in sea level and 7 cm/s in geostrophic current anomalies.
- Typical correlation coefficients are 0.9 for sea level and 0.7 for currents, different from zero at the 5% significance level.
- The mean differences for current magnitude or vorticity of the WCRs are not different from zero at the 5% significance level.

**Conclusions and recommendations**

Before the reprocessing of Jason-1 and T/P products the main problems identified during this splinter have to be solved and solutions must be validated through the CALVAL process. This concerns:

- The geographically correlated orbit errors (constant and time-varying parts)
- The JMR: the steps link to events and the geographically correlated patterns.
- The inconsistencies between Jason-1 and T/P: SSB?, tracker?, T/P orbit?

**Talks**

All the presentations can be found at:
http://www.obs-azur.fr/cerga/gmc/calval/alt/SWT_STPE_2004

1. **Some guidelines to prepare the plenary session: Consistency in T/P and Jason performance**
   P. Bonnefond, B. Haines and S. Nerem
2. **Recent Results from the Harvest Experiment**
   B. Haines, G. Born and S. Gill
3. **Recent Results from the Corsica Calibration site**
   P. Bonnefond, P. Exertier, O. Laurain, Y. Ménard, F. Boldo, E. Jeansou and G. Jan
4. **Recent results from Bass Strait and other sites in the Australian region**
   Neil White, Chris Watson, Richard Coleman and John Church
5. **JASON-1 Altimeter Calibration Results from the GAVDOS Project**
   E. C. Pavlis and the GAVDOS TEAM
6. **Jason-1 Radar Altimeter bias from in situ regional calibration method**
   G. Jan, M. Faillot, Y. Ménard, P. Bonnefond, F. Lyard and E. Jeansou
7. **Global Statistical Quality Assessment of Jason-1 data Jason-1 / TOPEX/Poseidon Cross-Calibration**
   M. Ablain, J. Dorandeu, F. Mertz, Y. Faugère, N. Picot, and P. Vincent
8. **Status of the JMR**
   S. Desai, C. Ruf, S. Keihm and S. Brown
9. **Jason Tide Gauge Calibration Results**
   E. Leuliette, R. S. Nerem and G. T. Mitchum
10. **Ascending/Descending Patterns in Relative Bias Maps: Is it Jason-1 or TOPEX?**
    D. Chambers and T. Urban

**11. Jason-1 Rain flag performance evaluation after 2 years of operations and Jason Rain products**

J. Tournadre

**12. T/P-Jason comparison and evaluation over the Scotian Shelf and Slope**

G. Han

## 6.2 POD/Geoid (J.-P. Berthias, J. Ries)

### INTRODUCTION

The main objectives of POD/Geoid activities were to (1) arrive at an assessment of the accuracy, as well as any systematic errors, in the orbits placed on the Jason-1 GDRs, (2) evaluate the improvements in the orbits that can obtained with more modern models and the GPS tracking, and select an improved set of standards, and (3) evaluate available GRACE geoid models for adoption for the GDR reprocessing.

### POD

Prior to launch, it was decided to start the production of the Jason-1 GDR orbits using the same set of models as for TOPEX/Poseidon (T/P). The objective was to minimize systematic differences between T/P and Jason-1orbits during the validation and cross-calibration phase, and in particular, to try to avoid differences in geographically correlated errors (GCEs) that would be induced by differences in the gravity model used. That strategy assumed that models and tracking systems would perform the same on T/P and Jason-1. In addition, at that time, no new model had demonstrated any significant improvement over the T/P standards (the GRACE gravity models were not yet available), and the use of GPS data in combination with the other data types was still to be validated.

However, recent comparisons between the T/P and Jason-1 mean sea surface height (SSH) observations have shown significant geographically correlated differences (Figure 1a; see also CalVal report). These differences are significantly reduced when more accurate orbits, such as the JPL GPS reduced-dynamics orbits, are substituted for the GDR orbits (Figure 1b). The JPL GPS orbits have tended to perform the best in all the tests, so they are used here as a reference for comparison with the other orbits.

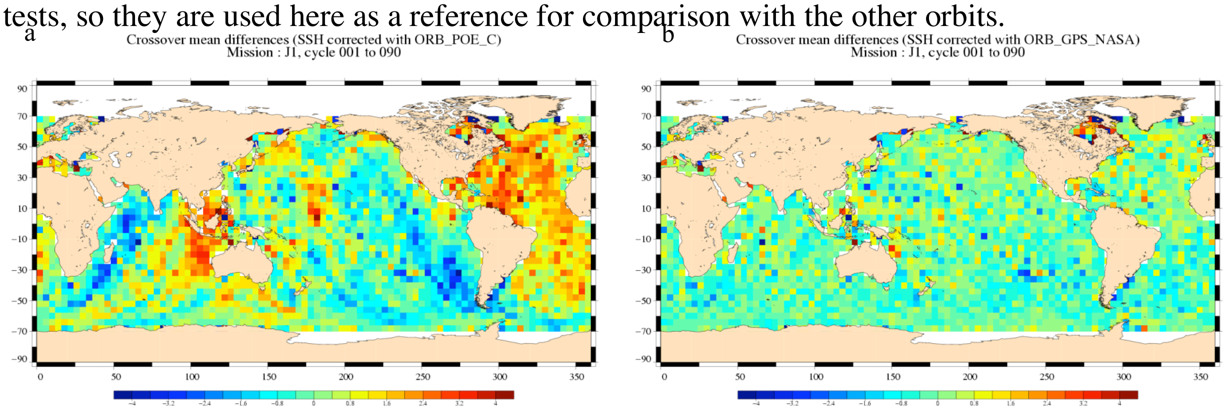



**Figure 1**. Comparison of T/P and Jason-1 mean SSH at crossovers using the GDR orbits (**a**) and the JPL GPS reduced-dynamics orbits for Jason-1 (**b**) (courtesy J. Dorandeu)

These geographically correlated differences are visible in the direct orbit comparisons between the GDR orbits and the GPS orbits (Figure 2). Part of the signal in this figure is due to the gravity model (the GDR orbits used the JGM-3 gravity field while the JPL GPS orbits are based upon the GRACE GGM01S model), part of it is orbit error in both solutions (the orbit error of the GPS orbit is estimated around 1 cm RMS compared to 2-2.5 cm for the SLR/DORIS orbit), part of it is likely due to the South Atlantic Anomaly (SAA) effect on the Jason-1 DORIS tracking. This SAA effect is what differentiates Jason-1 most significantly from T/P. It may be the reason why the use of similar models and tracking data for both satellites failed to prevent the appearance of geographically correlated differences between the two missions.

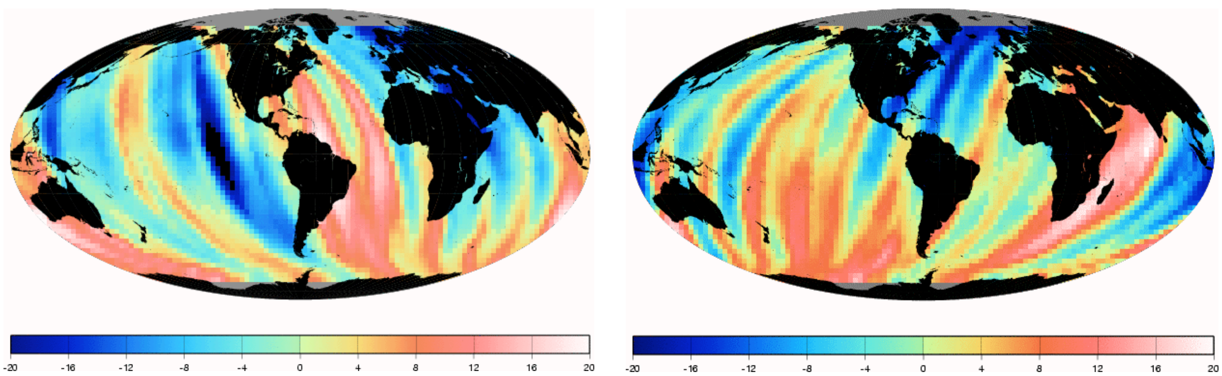



**Figure 2** Radial comparison of GDR orbits (based on JGM3) and JPL GPS reduced dynamics orbits (based on GGM01S) in millimeters (descending tracks left, ascending tracks right) (courtesy B. Haines)

J. M. Lemoine demonstrated with his model for the frequency effect onboard Jason-1 that the SAA effect mostly contributes an orbit Z-shift and a geographically correlated difference that resembles the effect of an order-1 gravity term. However, this probably does not explain everything. At this sub-cm level, many other factors can contribute. Plots of the time derivative of the geographically correlated orbit differences produced by B. Haines and P. Bonnefond show strong geographical signals, with unexplained patterns. There is clearly more work to be done to explain all of these effects.

In the mean time, there is clear evidence that the introduction of GPS data and GRACE gravity model in the Jason-1orbit computation process significantly improves the orbit precision and eliminates many of the problems seen in the GDR orbits. Depending on the processing method, particularly the level of 'reduced-dynamics' employed with the GPS tracking, an orbit accuracy for Jason-1 at the 1-cm level can be demonstrated. This is illustrated on Figure 3; from top left to bottom left it shows the improvement brought by GPS data, and from bottom left to bottom right it shows the improvement due to the gravity model.

New standards have thus been derived to take advantage of these improvements. These new Jason-1 standards are based upon the IERS conventions (2003) described in IERS Technical Note 32 (http://www.iers.org/iers/publications/tn/tn32). Most of the models selected from the IERS conventions represent an improved knowledge in the field; however, in practice, they have a very limited impact on the orbit as the difference is compensated by empirical accelerations at the orbital period. The ITRF conventions are complemented by:

- the choice of a second generation GRACE gravity model which remains to be chosen,
- the choice of a recent tide model between FES2002 and FES2004,
- a model (still to be decided) for annual variations in gravity compatible with ocean and atmosphere tides (with the possible adoption of an atmosphere tide model based on pressure field data)
- a model (still to be decided) for geocenter motion

In addition, the reference frame is set by the adoption of coordinates and velocities for a core DORIS POD network (derived from ITRF2000), and by the adoption of a set of reference orbits and clocks for the GPS constellation (to be chosen between the JPL and the IGS combination solutions).

To finalize the selection of the standards it was decided to:

- compare the newly available GRACE gravity models to select the one which leads to minimum differences between dynamical and reduced dynamic solutions
- evaluate the use of the FES2004 tide model
- investigate the sensitivity of the orbit to annual terms in gravity and the consistency between models

The last remaining issue concerns the relative data weights to be used. As explained above, the SAA effect on DORIS degrades orbit solutions. However, the robustness of the operational processing requires a balance between all three data types: the GDR orbit must offer a quality level as independent as possible of the operating status of one or the other of the instruments. Improved methods to handle the SAA thus will be further investigated.

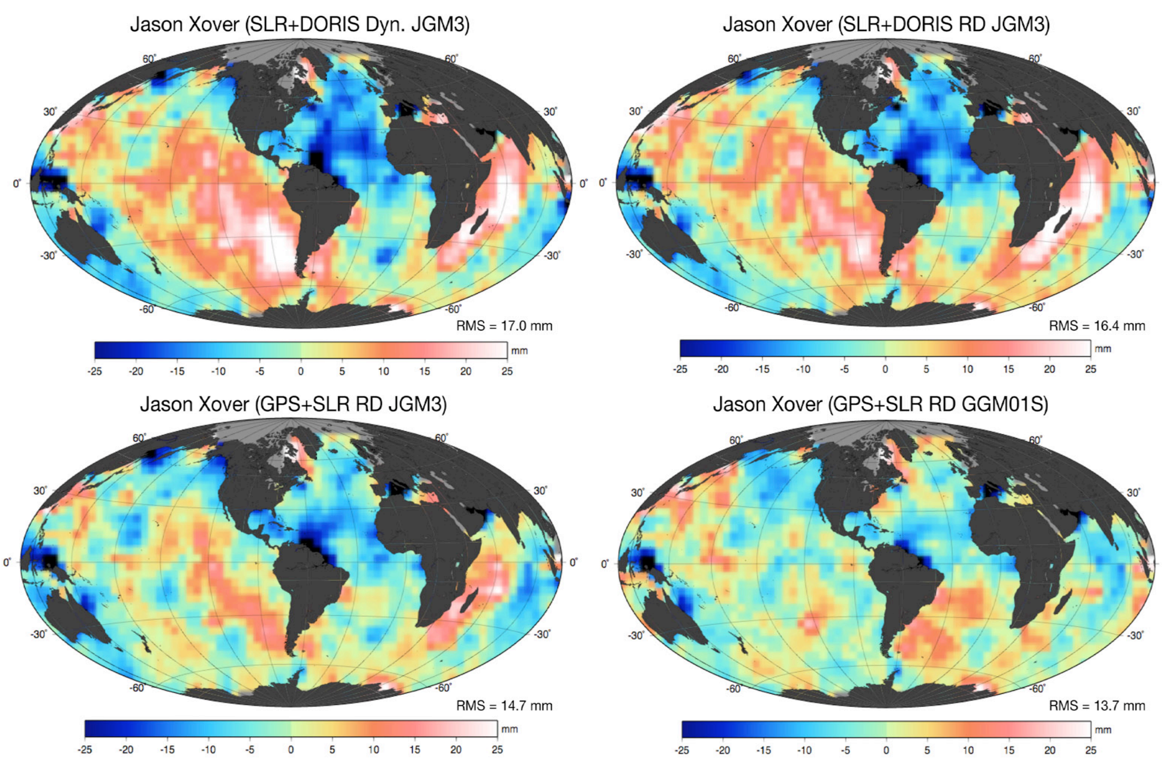


**Figure 3**. Mean altimeter crossover residual maps for Jason-1 for various combinations of tracking data types and gravity models (courtesy S. Luthcke).

The goal is for the new standards and new strategies to be adopted in time to start the production of operational orbits on June 1, 2005. In parallel, T/P models will be synchronized with the Jason-1 models, so that both Jason-1 and T/P reprocessing can be performed after June 2005. After this reprocessing, a dramatic improvement in the consistency of T/P and Jason-1 POD is expected, as illustrated in Figure 4.

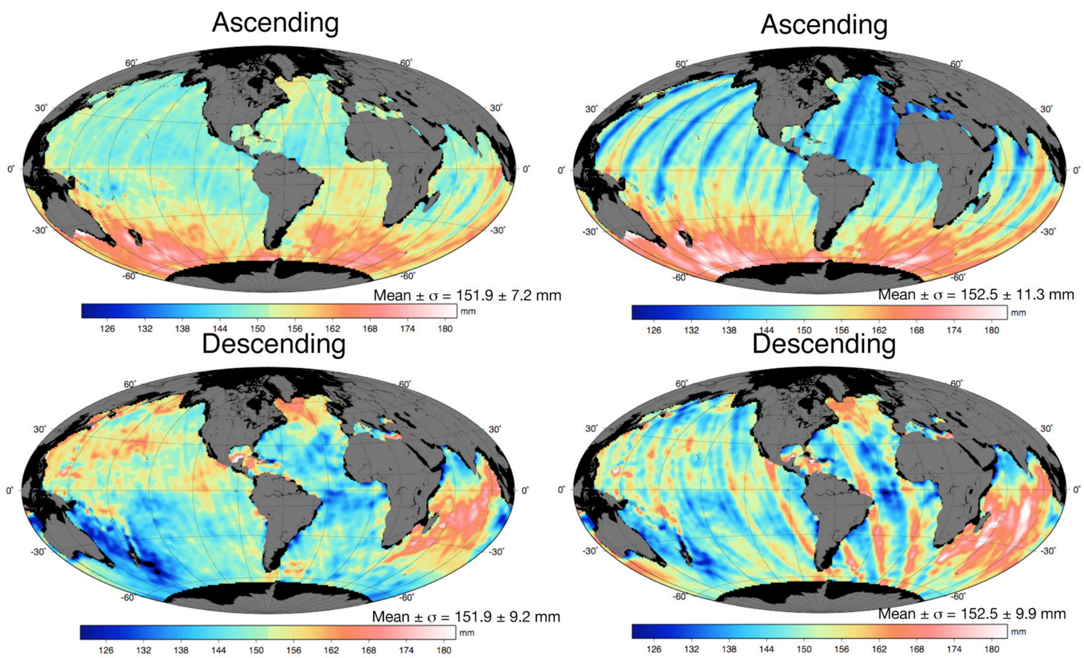



**Figure 4**. Jason-1 minus T/P mean SSH for various combinations after updating both the Jason-1 and T/P orbits to better models and processing (left) and before (right) (courtesy S. Luthcke).

## GEOID

The GRACE satellites, launched on March 17, 2002, have now collected more than 20 months of data. The preliminary GRACE gravity model GGM01S showed a dramatic improvement in the accuracy of the marine geoid, up to a factor of 10-50 or more at wavelengths of 300 km or longer, and additional improvement has been accomplished with the 'second generation' GRACE models, as shown in Figure 5 and Table 1. At this point, the circulation tests shown in Table 1 may have reached the limit of the accuracy of the long-term hydrography, and further improvements may be difficult to detect this way.

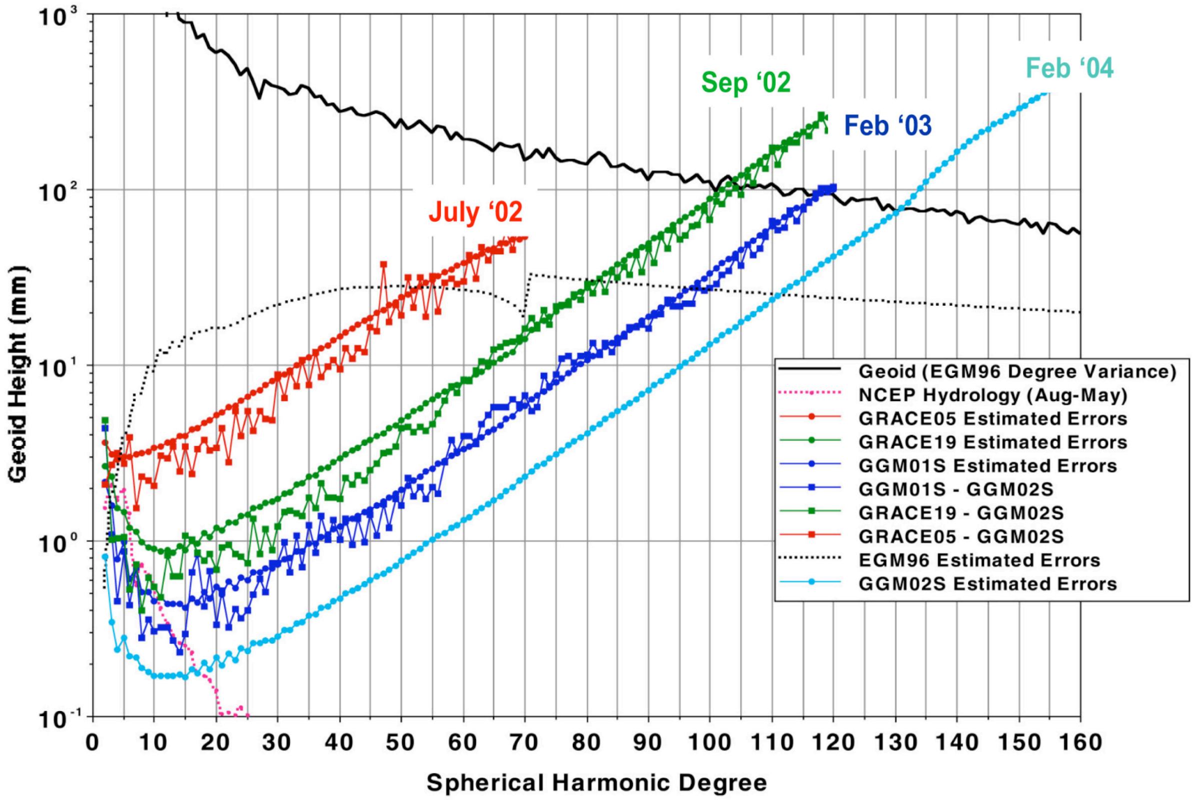



**Figure 5**. Progress in the GRACE gravity models. The consistency of the error estimates with actual errors (as determined by comparing older solutions to the most accurate current model GGM02S) gives confidence that the error estimation technique is not overly optimistic.

| Geoid Model | Zonal Correlation | Meridional Correlation |
|---|---|---|
| EGM96 | 0.43 | 0.37 |
| GGM01S | 0.93 | 0.44 |
| GGM02S | 0.94 | 0.57 |
| GGM02C | 0.93 | 0.57 |
| EIGEN-GRACE02S | 0.93 | 0.57 |
| EIGEN-CG01C | 0.93 | 0.56 |

**Table 1**. Correlation between zonal and meridional circulation (to degree/order 120) based on mean sea surface CSRMSS98 minus various geoid models and the long-term dynamic ocean topography map determined from the World Ocean Atlas 2001 (WOA01) data relative to 4000 m. GGM01S, GGM02S and EIGEN-GRACE02S use only GRACE data; GGM02C and EIGEN-CG01C also incorporate surface information.

Currently, two GRACE-based geoid models are available that can be used to degree and order 360. EIGEN-CG01C combines GRACE (to degree/order 100) with surface information (gravimetry and altimetry) to extend the solution to degree/order 360 using a special band-limited combination_method. GGM02C combines the improved GRACE information with surface information by constraining to EGM96 using the TEG4 covariance (to degree/order 200), which results in a solution that can be seamlessly extended to degree/order 360 using EGM96 above degree/order 200. Figure 6 illustrates the dramatic improvement from GGM01C to GGM02C. However, current models still exhibit some undesirable artifacts in the marine geoid. These can be expected to be improved when 'third generation' models are available in Spring '05. These models will incorporate improved Level-1B data, updated background models and processing methods that should reduce the broad-scale north-south oriented error patterns seen in Figure 6.

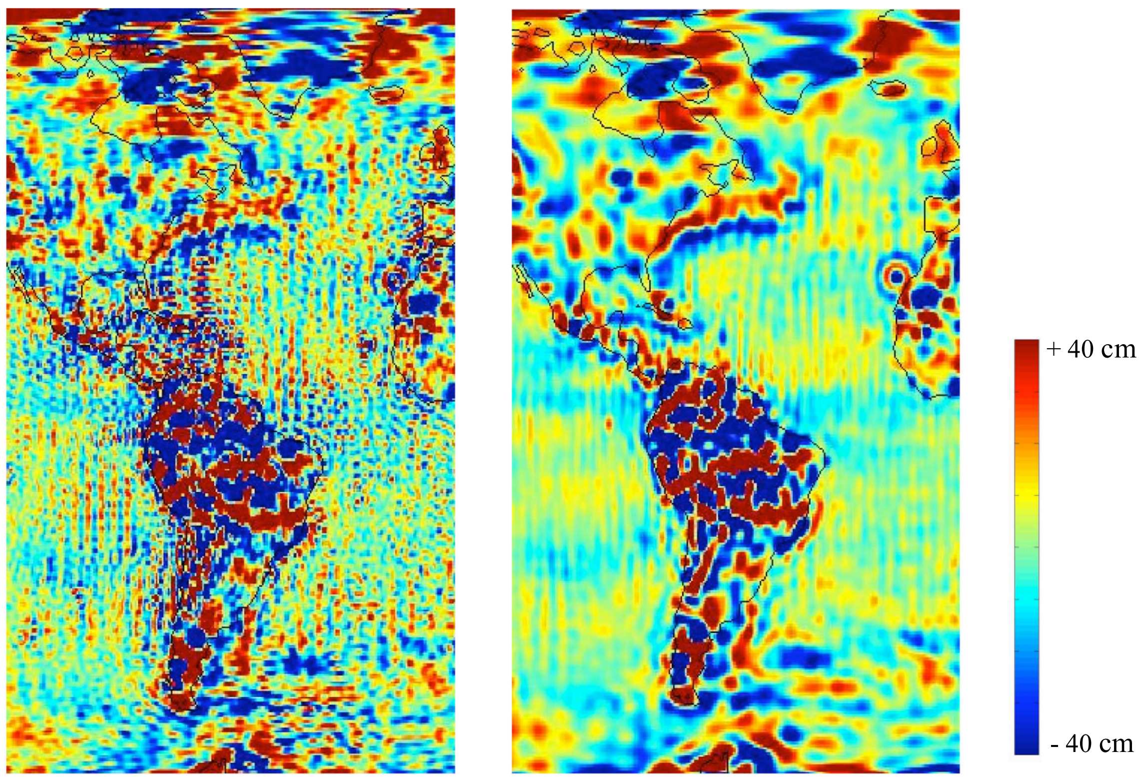



**Figure 6**. Progress in GRACE geoid models. GGM01C and GGM02C are compared to EGM96 to degree/order 200 (models are the same above 200). The improvement in the marine geoid is clear, but some error patterns over the oceans remain.

**6.3 Multisatellite/Operational Altimetry** (G. Jacobs, P-Y. Le Traon, C. Birkett)

The meeting was held Friday November 5, 2004 from 1:30 pm to 5:30 pm. Fourteen presentations (see agenda) were given and the following issues were addressed:

- Contribution of existing multiple altimeter missions including results from the T/P-Jason-1 tandem mission. Requirements for future long-term high resolution altimeter systems.
- Issues/Challenges for Coastal/Nearshore and Inland applications.
- Applications: where are we, what do we need, where are the challenges ? Outreach issues.

Main outcomes of the splinter meeting are summarized below:

- Very promising results have been obtained on the use of the tandem mission alone or in combination with ERS/ENVISAT/GFO. These studies should now be extended to a longer time series. As an optimised two satellite configuration, the tandem mission provides an excellent contribution for mesoscale studies. It is essential, however, to continue operating T/P as long as possible to fully realize the potential of the tandem mission.
- Presentations have shown the unique opportunity of the four satellite configuration to demonstrate what we will gain with high resolution altimetry both for science and operational applications. This gives now very good grounds to advocate for future long-term high resolution altimetry systems. The different studies show, in particular, that we do need WSOA on board Jason-2.
- There is an important impact of GRACE (then GOCE) on scientific and operational applications of altimetry. Future studies should be conducted to improve the Mean Dynamic Topography (MDT) models and to test their impact on science and operational applications. This is an important topic that probably should be systematically addressed in a specific OST Science Team splinter meeting.
- There is somewhat of a shift between the work of the OST Science Team in other splinters and in the splinter on multi-satellite/operational applications. Altimeter products for science and applications now mainly rely on multiple altimeter missions. It is, however, difficult to relate the multiple altimeter product quality to the assessment of T/P or Jason-1 only data sets. Work in the other splinters should probably be extended to other missions (e.g. consistency between missions, POD, etc), i.e. moving from a T/P or Jason-1 SWT to a truly Ocean Surface Topography SWT. POD splinter should also discuss the accuracy of IGDR orbits.

- There is a good progress in the development of the use of altimeter data for coastal and inland studies. In particular, several operational applications for lakes and rivers are now in place. Improvements are needed to develop further the use of altimeter data (e.g. H.F. barotropic and tidal corrections for coastal regions). Note that previous problems with the Jason-1 IGDR/GDR data, where certain lake/river data was being rejected by the ground processing teams, are now expected to be corrected from October, 2004 onwards.

- There is a very good development of operational applications (not all were reported here). Applications use either directly altimetry or more and more data assimilation systems (this is the integrated approach that GODAE has been promoting for many years). Requirements are mainly to ensure long-term high resolution altimetry. This is a very critical issue for the future of applications (and altimetry). Outreach on applications is essential and should be done in close relationship with NASA and CNES outreach teams.

### 6.4 Sea-state Bias/Waveform Retracking (P. Vincent and P. Callahan)

The « Ground retracking/Sea-State Bias » splinter meeting was held on November, 5-th, 2004. It was co-chaired by P. Callahan and P. Vincent.

The meeting addressed the following two objectives:

1. Define and recommend ground retracking improvements of Jason-1 and TOPEX altimeter waveforms.

2. Better understand the significant differences between apparent TOPEX and Jason-1 SSB.

The desired final result was recommendations for a strategy to generate corrected TOPEX and Jason-1 data from which the bias between them can be set to 1 cm or better (with no wave height dependence).

The first part of the meeting was focused on ground waveform retracking. The discussion was based on the following series of presentations:

1. *Approximating the PTR by a sum of gaussian functions - Impact on retracking*, by O. Zanife, P. Vincent, P. Thibaut and L. Amarouche

2. *The role of the instrumental correction tables in the Jason-1 altimeter processing*, by P. Thibaut, O. Zanife, N. Steunou and P. Vincent

3. *The MLE-4 retracking algorithm*, by P. Thibault, O. Zanife and P. Vincent

4. *Retracking of Jason-1 data*, by P. Callahan and E. Rodriguez

5. *Evaluation of Jason-1 skewness*, by P. Thibaut, L. Amarouche, O. Zanife and P. Vincent.

6. *Correlation between SSH and SWH errors in tracking and retracking algorithms, examples from Monte Carlo simulations and ERS-1 and Geosat retracking*, by W. Smith and D. Sandwell

The presentations that are listed above mainly result from an intensive CNES/CLS-JPL joint work that has been continued since the Arles 2003 Science Working Team meeting. Several Marine Geodesy papers (refer to dedicated volumes on Jason-1 CALVAL results) have been published on the subject. They have provided the basic elements for the presentations and the discussion. As a consequence, details of the respective CNES/CLS and JPL ground retracking algorithms are now well documented and understood by each team (and can be found in the peer-reviewed literature that is available to all scientists).

The first two recommendations from the discussion are:

- an 0.1 skewness coefficient can be recommended for future work and upgrade of the algorithm to be used by the processing ground segment (such a coefficient was already identified and used by JPL, and then re-estimated by CNES/CLS). An 0.1 value brings a clear improvement to the quality of retrieved parameters with respect to the previous assumption of a null skewness coefficient ;

- either a high order development of the PTR (Point Target Response) in terms of Gaussian functions or the use of equivalent instrumental correction tables are to be taken into account; a partial demonstration of this equivalence was presented by O. Zanife. The approach must be consolidated by end of 2004, so that the processing ground segment can implement the recommendation before starting the production of an upgraded second generation GDR product *(CNES/CLS action)*

Results from the CNES/CLS and JPL algorithm comparison exercise show that the CNES/CLS and JPL ground retracking approaches are on a converging path. Indeed, the analyses conducted by each team about the SWH and attitude dependencies of retracked geophysical parameters (mainly, the epoch/range) are leading to results that are near one another. Nevertheless, some questions are still to be better answered. These are:

- How to solve for and/or smooth the mispointing angle? What is the impact of the quality of the mispointing angle retrieval on the quality of the other geophysical parameters? *(CNES/CLS and JPL action)*

- How to interpret scatter plots of differences between (CNES and JPL) ranges as a function of 20 Hz or 1 Hz values of the square of the mispointing angle? Indeed, the spectral content of the 1 Hz square of the mispointing angle is essentially a noise (about a zero mean value): Then, scatter plots of any other retracked parameter as a function of the mispointing angle may be misleading.

- More generally, as was discussed by W. Smith in his presentation that addressed ground retracking of ERS and GFO data, a deeper analysis of the correlation between solved-for parameters is an important issue that retracking teams have to perform. *Such an action will have to be taken by CNES/CLS, JPL and NOAA (W. Smith).*

The above 3 items will have to be addressed in the coming weeks and months, a main objective being to provide the Jason-1 Project with a recommendation about the rate (1 Hz or 20 Hz) at which variables such as SWH (Significant Wave Height) and mispointing shall be estimated from retracking.

It may be noted that, if the JPL and CNES/CLS algorithm comparison analysis ends up with a complete match of the 2 approaches (as it may be expected from the progress in the comparison exercise), it then appears that:

- On the one hand, the new retracking algorithm will definitely clean up the data,

- On the other hand, the Jason SSB may not go down to the level of TOPEX (not to say that TOPEX is the truth anymore)

This leaves a question about the SSB as compared to the physical EMB effect that is assumed to be independent of instrument and processing.

To complete the ongoing CNES/CLS and JPL comparison of algorithms and approaches, it has been recommended to continue the work based on:

- The cycles that have already been exercised (also updating the correction of SGDR parameters with the updated look up tables, for sake of consistency) ;

- A simulated data set of POSEIDON-2 waveforms (*to be generated by CNES/CLS)* and to be used jointly by any team involved in the retracking studies.

A full working plan will be iterated among the CNES/CLS, JPL and NOAA (W. Smith) teams by end of December 2004 to organize the next steps of the retracking studies.

The second part of the meeting was focused on sea-state bias. The discussion was based on the following series of presentations:

1. *New wind speed algorithm for Jason-1*, by F. Collard and S. Labroue

2. *Cal/Val Overview: Comments on differences in ascending/descending SWH for TOPEX and the effect on TOPEX Sea State Bias*, by D. Chambers and T. Urban

3. *Use of a global wave model to correct altimeter sea level estimates: Model sensitivity to wind forcing fields*, by H. Feng, D. Vandemark, B. Chapron and B. Beckley

4. *Hybrid sea state bias models*, by R. Scharroo and J. Lillibridge

5. *Results on TOPEX and Jason-1 sea state bias with the non-parametric technique*, by S. Labroue et al.

An update of the Vandemark/Gourrion altimeter wind speed algorithm has been generated: The new algorithm was based on Jason-1 altimeter data, whereas the initial algorithm used TOPEX data prior to the Jason-1 launch. The newly adjusted Jason-1 wind speed algorithm improves the statistics when comparing Jason-1 altimeter winds to QuikScat and buoy wind speeds. There is a better low wind dependence with significant wave height and less high wind saturation. The global bias is reduced to 0.12 m/s and the global accuracy to 1.53 m/s for the validation with the buoys. It can also be noted that this kind of algorithm (which takes into account the wave effect in the wind retrieval) improves the accuracy compared to the algorithms expressed with sigma0 only.

Ascending/Descending SWH and sea-state bias algorithms were discussed by D. Chambers. It came that 2 criteria are certainly to be considered jointly. These are:

- The reduction of variance in some withheld data set: Crossovers or along-track sea level anomalies. This of course assumes that reducing the variance means removing the signal related to sea state, not other error sources
- The objective to get a TOPEX to Jason-1 relative bias that does not contain any sea state dependence, in order to determine a single global bias to link Jason-1 to TOPEX

From D. Chambers' analysis, it appears that:

- New non parametric sea-state bias models shift bias significantly, both globally and regionally;
- The local variations are larger than with the current GDR model;
- The different patterns in ascending/descending passes are unchanged.

Then, D. Chambers suggested not to changing from current Jason-1 model: this conclusion is valid when considering the present Jason-1 data set. It can be discussed anew (see next section) if new algorithms are used to ground retrack the Jason-1 waveforms and to derive wind speed.

R. Scharroo et al. developed a hybrid method for the direct estimation of SSB from sea height residuals with an extended parametric fitting process and a successive smoothing of the remaining residuals. It essentially produces a non-parametric model in a form of a smooth grid in a two dimensional space determined by SWH and sigma0. The hybrid method allows a much higher resolution than the parametric method, without the disadvantage of the direct method's limited sigma0/SWH range. The use of sea height residuals as input data allows estimation of a realistic SSB model with only a few months of data. As a result, it appears that although SSB models for different altimeters have much in common, there are also marked differences. One of the main results is that all altimeters that have been considered (ERS-2, GFO –after ground retracking-, POSEIDON-1, POSEIDON-2/Jason-1, ENVISAT RA2) roughly display the same type of SWH/Sigma0 dependence, whereas the TOPEX altimeters appear different from the others. The SSB percentages in SWH differ widely; also, the dependence in backscatter is variable, with a general tendency to flatten SSB at higher winds and waves.

It is known that wave height and backscatter both show trends as a function of time. Wave heights appear to drop over time, but backscatter show trends either way. This results in trends in SSB and hence sea level that may not be real. The different trends in SSB between TOPEX A and TOPEX B poses challenges on the estimation of sea-level change to better than 0.2 mm/yr.

S. Labroue performed a comparative analysis of the present methods used to estimate a sea-state bias model. The major conclusions are:

- The collinear method gives better results for the variance reduction globally and also spatially.
- The direct method seems to be more correlated to oceanic variability and is more sensitive to systematic geographically correlated signals whereas the SSH differences are more likely to reduce or cancel these signals.
- The direct method seems to remove an error that is known to be due to orbit error whereas the collinear SSB does not remove it.

As a conclusion, it is recommended that a SSB model fitted from collinear differences be used.

In the frame of the coming Jason-1 GDR reprocessing activities, the following question has to be addressed: Is a new fit of a non parametric SSB model based on improved ground retracked data and on the new altimeter wind data required? *(Action CNES/CLS).* If this is the case, an action will then have to be taken to derive a sea-state bias model from a subset of upgraded Jason-1 data, test it, and introduce it in the GDR products.

As far as differences between TOPEX and Jason-1 SSB are concerned:

- It is confirmed that the difference is about 1.5% SWH for waves ranging from 2 m to 8 m (when correcting the standard GDR products for updated post-launch instrumental corrections)
- Zanife et al (2003) have shown that the 1.5% SWH difference cannot be attributed to ground retracking effects, so that it is needed to come back to other onboard aspects of the altimeter instruments (tracking systems, other?)

- As also shown by the independent hybrid method developed by R. Scharroo et al., the magnitude of Jason-1 SSB is in agreement with the one obtained on GFO, ENVISAT, Poseidon-1 and ERS-2 (significantly different from TOPEX).

Feng at al. presented an original approach to derive an SSB correction based on the use of a global wave model to correct altimeter sea level estimates, with a special focus on the model sensitivity to wind forcing fields. Indeed, both observations and theory have indicated that wave height and wind are not the most direct SSB drivers. Rather, the long wave orbital velocity and short scale wave slope variances most likely drive the SSB and its variability. Then, potential means for sea state bias model refinement are thus to obtain more reliable wind measurements and higher order ocean wave parameters through a wave model. Feng et al. have studied outputs from a global ocean wave model (WaveWatch 3) forced by several (four) different wind fields. The main conclusion of the work is that wind fields having higher spatial resolution (due to the incorporation of scatterometer or radiometer winds) are needed for the wave model to pick up variations in the wind sea energy and in higher order SSB related wave spectral moments.

### 6.5 Tides and High-Frequency Aliasing (R. Ponte, F. Lyard)

The splinter session was intended as an open forum on issues regarding tidal and non-tidal sea level variability at frequencies poorly sampled by TOPEX/Poseidon and Jason-1 altimeters and on ways to improve the "de-aliasing" of the altimeter data. Five talks were presented on a variety of topics related to both tidal and non-tidal sea level variability and respective altimeter data corrections.

The session started with a presentation by T. Letellier (LEGOS) on the new FES2004 tide solution. The major difference between FES2004 and FES2002 consists in the use of output from MOG2D —the barotropic model developed at LEGOS for the estimation of non-tidal sea level variability— to remove atmospherically-forced signals from the data used in the assimilation procedure. Modest improvements in the quality of the new tide solution were reported for coastal and high latitude regions. FES2004 was recommended to replace FES2002 in future altimeter data releases, including the data reprocessing scheduled for completion in 2005. Letellier also reported on experiments with a new model error covariance obtained by combining information available from previous tide models. Initial tests of such new parameterization of model errors indicate substantial improvements in the tide solution, as judged from comparisons with ground truth tide gauge data, but full assessment of the new procedure is still on-going.

An update on the new version of the Oregon State University tide model (TPXO.7) was presented by G. Egbert. Apart from providing a global tide model that retains the highest resolution in coastal areas and that assimilates all available altimeter and high latitude tide gauge data, Egbert mentioned the present efforts to include an inverse model for the internal tides. Such model will permit improved studies of tidal energy fluxes and should also provide an internal tide correction to be added to the barotropic tide corrections currently applied to sea level measurements. Egbert also emphasized the importance of having multi-satellite altimeter missions to achieve higher resolution and reduced errors in coastal tide models and to resolve relatively short-scale processes associated with generation and propagation of internal tides near topography.

From both Egbert and Letellier talks and some of the ensuing discussions, it seems that present efforts to improve tide solutions in the deep ocean are only marginally successful, as the errors in tide solutions are approaching the noise levels in the data. Large improvements are still expected, however, in coastal and high latitude tides and the need to revisit issues related to the quality of altimeter tide corrections in some of these regions was stressed.

The topic of atmospherically-induced ocean tide variability was discussed by F. Lyard (LEGOS), with focus on the $S_1$ and $S_2$ components. His analyses of multi-year surface atmospheric pressure time series highlighted the substantial seasonal and interannual variability of the $S_1$ and $S_2$ barometric air tides and the corresponding ocean tides. Lyard stressed the need to treat $S_1$ and $S_2$ variability consistently in several data corrections involving pressure fields, pointing out the value of using barometric air tides defined for periods overlapping the altimeter data. The discussion that followed revisited the issue of what climatologic air tide effects should be treated as part of the ocean tide correction vs. atmospheric loading corrections, as well as the issue of possible effects of wind stress on $S_1$ and $S_2$, but the impact of such issues on the quality of the data processing procedures is expected to be weak.

Still on the topic of atmospherically-driven signals, R. Ponte (AER) examined the potential effects of precipitation and evaporation on high frequency sea level variability, in comparison to those of atmospheric pressure. Based on results from a barotropic model forced by realistic 6-hourly fields of precipitation and evaporation, Ponte concluded that, at sub-monthly periods, the dynamic response to such forcing is weaker than that to pressure forcing except in the tropical regions. Neglecting such effects on sea level variability should lead to induced errors smaller than 1 cm (rms). It was noted, however, that including freshwater forcing in the barotropic model currently being considered for the non-tidal high frequency correction should be easy to implement. Coastal effects from river runoff were not included in Ponte's study.

The session concluded with J. Dorandeu (CLS) providing an update on two topics that have been the subject of extensive discussion and planning in previous years. First, regarding the changes outlined by Ponte and Ray (2002, Geophys. Res. Letts., vol. 29, no. 24, 2153, doi:10.1029/2002GL016340) to deal consistently with air tides and related ocean tides in data processing, Dorandeu reported on several variance reduction tests that indicate the newly proposed procedures lead to general improvement of the quality of the data. One remaining issue relates to the particular $S_1$ tide solution to be used, which needs to be provided as part of the tide correction. Second, on the implementation at CLS of the non-tidal high frequency correction based on MOG2D, tests of the intended operational correction confirmed positive results of earlier modeling efforts. Ground segment processing steps are in place to provide the high frequency correction in an operational mode for Jason-1. A similar correction will be made available for the whole T/P period. The inclusion of the new high frequency correction together with consistent inverted barometer and tide corrections is planned for the reprocessing of the data currently in preparation and represents the culmination of several years of modeling and data analysis efforts by many science team members.

One final issue raised by Dorandeu's presentation was the apparent problem with the inverted barometer correction currently available on the Jason-1 GDRs. The presence of noise in the atmospheric pressure fields near coasts, particularly near high topography, was noted. Possible issues with conversion between different horizontal grids or between surface and sea level pressure values were mentioned. People directly involved with data processing were urged to clarify the nature of the problem and provide the necessary fix, to avoid an extra degrading factor in data quality.

**6.6 Outreach** (V. Rosmorduc, M. Srinivasan, A. Richardson)

The outreach splinter session was held on Thursday afternoon. A project outreach update and five presentations were given, with some discussions in between.

Outreach is a vehicle for explaining altimetry data; what they are, and what they enable; to ensure that the data and information are used, and to attract attention to the technique and its usefulness in everyday life. With the future of altimetry in discussion today, outreach is more necessary than ever. Since users need a long-term and continuous dataset, this need must be advertised to ensure continuity of altimetry missions and information products. It is important that people understand the role of altimetry in conjunction with other instruments in providing information about our oceans and climate to stimulate interest in ocean science and the environment. This understanding ensures that scientists, marine operators and educators are able to use the data and information if appropriate to their work.

Outreach has many possible audiences, e.g., the general public, potential and current users, scientists, decision-makers, college students and professors, children, and teachers. These last ones are the link to formal education, Teachers and professors: need outreach to be aware of what material exists.

Users are no longer only altimetry experts but may come from other science and marine operation backgrounds, With this broader audience comes the need for more and more "basic" information. Thus we see the mechanisms by which users are provided information approaching "general public" outreach. The Link between users and outreach is not just a one way street, i.e, just outreach professionals informing users. User feedback provides information that may become outreach "stories" – for example new research results, new applications, etc –help to make applications and science results known and also help to enhance available outreach documentation. Users need to promote their work, and detailing the "what for" is an important issue for outreach and education. Outreach, user information, and education are thus enriching each other with material, information, ideas, and contacts.

Outreach operations during 2004 included:

- Geonauts CD ROM (OCA/CERGA/CNES) produced and distributed by NASA in 2004
- JPL board game re-printed
- Aviso Newsletter #10 published
- Presentations of the basics of altimetry: Ready-made presentations with ideas on communicating altimetry, adaptable to different audiences, available to science team members
- 3D images and animations from altimetry data:
    - Geoid
    - Mean Dynamic Topography
    - Variability
    - El Niño…
- Educational activities : LILA (Lycée International de Los Angeles), Argonautica
- Media activities
- Aviso website
    - Aviso Newsletter #10 online
    - New posters online
    - Updated list of products
    - Updated link page
    - Wave heights, wind speed, dynamic topography in the Live Access Server
    - Continued activities include: the Image of the Month, El Niño bulletin, maps, News, "Lively data"…
- Joint web site
    - Yellow Pages – http://www.aviso.oceanobs.com/yp/
        - ROSES tracks oil pollution and toxic algae blooms
        - Mesoscale Circulation in the California Current
        - Northern fur seal and Stellar sea lion research
        - Near Real Time Monitoring of Global Lakes and Reservoirs
- JPL 'Sea Level' website
    - Junior oceanographer web pages
    - Web-based, searchable literature database
    - "Societal benefits" slide set
    - Latest Jason-1 data every two weeks
    - El Niño Watch

One of the major (and traditional) questions addressed was to know how to increase science team participation in outreach. We think team members should consider outreach participation as a responsibility. Since it is not fully the case currently, or since team members don't always have time to devote to outreach, participation in actual outreach is not as substantial as we would wish, and has remained rather constant during the past twelve years. Several proposals were issued to improve this situation:

- Have an outreach update in plenary session. Outreach is part of the Project and, as R. Stewart said "Outreach funded by projects is essential, since no one else will tell our story!". This would enable OST/ST members to have a better view of what is done in the outreach field, even if they don't wish to or can't attend the outreach splinter session. It would give outreach more visibility, and more weight in the team members' eyes.
- Establish closer collaboration with the science team to better highlight the science results, with web pages dedicated to those. User Services could serve as a liaison, since they are more easily aware of what's going on with the altimetry data.
- Establish more links on project web pages to scientists pages...
- Develop a way to reward outreach efforts e.g. "outreach citation index" (!)

Attendees agreed that interactive data visualization tools have clearly a role to play in outreach & education. Such tools can be a good way of letting kids use real science data, get them nearer to science/scientists, and of improving data availability for non-specialists at the same time. The Bilko Unesco programme, presented by G. Quartly, is in this respect an interesting initiative, devoted to distance learning in coastal and marine remote sensing, with an emphasis in reaching developing countries. The University of Colorado Long-Term Sea Level Change web site, presented by E. Leuliette is a more dedicated tool, but has some interactive data visualization aspects, too, that seems to encounter some interest, in both the scientific community and the general public. Some other projects are either working (e.g. POETS for PODAAC, Live Access Server for AVISO) or will be in the next year. We strongly recommend their development wherever it is possible.

Outreach & education operation feedback is also a continuing concern. T/P and Jason-1 projects have been producing outreach material now for twelve years. R. Stewart gave us his point of view over "twelve years of ocean topography outreach: experiences and lessons learned", emphasizing the idea that websites are the best media nowadays, and that work should focus on them. But, on the whole, few surveys are ever returned and feedback in general is lacking. Suggestions in that respect are:

- Invite 'outreach users' to present during OST/ST meetings, so as to better show the impact of outreach, e.g.:
  - Children and/or teachers participating in Argonautica
  - Journalists
  - Others?

  But that needs funding… Would the Project, on either or both sides, be willing to do so?

On the other side, some projects are clearly successful. The Argonautica project participation has been increasing since its creation. Thus JPL is working on getting it started in the US. A. Richardson gave us the preliminary plans for 2005-2008 for such a start. It is to be noted, however, that:

- Translation in English of all available material (especially the web site) is needed
- Scientists' participation is ALSO needed, in several aspects (material validation, classroom presentations of your activities, or even mentoring classroom…)

- The Argonautica 2004-2005 operation which began on November 8, is centered around the Vendée Globe around the world alone sailing race, with drifting buoys and some animals equipped with Argos beacons; tracking of those, plus altimetry and model maps will be delivered to the classrooms, so students can work to understand the whys and hows of the animals' routes.

The last discussion question, about ocean topography outreach with respect to other ocean-related project outreach, aroused several interesting suggestions, including some during the plenary session:

- Try to build an "ocean outreach society" with other oceanography-related outreach groups.
- Participate in / organize ocean outreach session during science meetings. An attempt had been made for an ocean outreach session during the joint EGS/AGU/EGU in Nice in 2003. It ended up merged in a general geophysics outreach session, due to fewer than 12 presentations. However, all in all, it has enabled us to meet new people involved in ocean outreach. In particular, having an "outreach" item in the list of ocean sessions may have attracted scientists involved in outreach that would not think to have a look in an 'Educational Symposium' or 'Education and Human Resources' topic. Such a session could be reproduced, either (or both?) during EGU and AGU meetings. It requires sponsorship by actual members and/or section heads.
- Ask OST/ST member that participate in other missions' science teams to give us the outreach contact names. It would be interesting to have at least one such person presenting during OST/ST outreach session each year.
- Submit our websites to ocean specialized search engines and portals.

Some relations already exist with other altimetry missions (even if they aren't much involved in outreach – yet), and with operational oceanography projects (Mercator) and programs (Godae).

Outreach operations planned for 2005 are:

- Soon, an Aviso 2005 calendar
- Solidify partnerships for Argonautica activities ; need to translate the website in English
- More presentations:
    - Target children ages 5-12
    - "SALP" presentation in English
- Updates of the "Jason-1, an ocean odyssey" movie and "A bird's eye view of the ocean" CD Rom
- Aviso web site
    - Image of the Month, El Niño bulletin, News, "Lively data" cont'd
    - Refurbishing of the website?
    - 3D interactive interface
    - More interactive data retrieval and use tools
- JPL 'Sea Level' web site
    - Quarterly updates of Literature Database

  - Monthly features
  - More Societal Benefits
- More Yellow Pages
- Aviso Newsletter #11 and/or OSTST science plan

## 7. Conclusions

**High-resolution altimetry and the Tandem Mission**

A major outcome of the meeting was the recognition of the enormous progress made in using data from multiple satellites for achieving high resolution not possible with a single conventional nadir-looking altimeter. In particular, the Tandem Mission of T/P and Jason provide the first simultaneous parallel along-track observations which allow high-resolution estimate of the along-track geostrophic velocity. This new capability leads to the first high-resolution global field of velocity and Reynolds stress. Because of the optimal inclination of T/P and Jason, the Tandem Mission data are also uniquely suited for improving the models of coastal ocean tides which have scales too small to be resolved by either T/P or Jason by itself. With two years' worth of the Tandem Mission data, tide modelers are beginning to tackle the coastal problems. However, it is recognized that more data are required for separating some of the constituents with close aliased frequencies such as the M2 and S2 tides. Extension of the Tandem Mission for at least another year is critical to these objectives.

**Recommendation on WSOA**

The needs for high-resolution data have underscored the bleak situation of not having multiple altimeters in the future. The team recognizes that the proposed experiment of WSOA onboard OSTM/Jason2 is the only feasible and practical approach to high-resolution ocean topography in the near future. The team unanimously passed a resolution to forward a recommendation to the leadership of the 4 partners of OSTM/Jason2 to urge the continuation of the development of WSOA for a timely flight with OSTM/Jason2. This recommendation is attached at the end of the section.

**A New Science Plan**

A new science plan will be produced by the OSTST to summarize the investigation plans of the newly formed team. The model of the previous plan as a special publication of the AVISO Newsletter series is adopted. The document is to be completed before the next team meeting.

**GDR Reprocessing**

The second generation of the Jason GDR is scheduled for production beginning in June, 2005. A major goal of the reprocessing effort is to minimize the systematic errors which were extensively discussed during the meeting. Some improvements in the processing efficiency are also planned.

**Recommendation from the OSTST on WSOA**

The TOPEX/Poseidon Mission was praised by Walter Munk of the Scripps Institution of Oceanography as the most successful ocean experiment of all times. This is because for the first time, the large-scale physical state of the ocean has been observed globally for understanding the ocean circulation and its effects on climate. Despite this success, the most energetic component of ocean circulation at the mesoscale (circa 100 km) is not fully resolved by the mission based on a single nadir-looking altimeter. With the serendipitous situation of four satellite altimeters (TOPEX/Poseidon, Jason, Geosat-Follow-On, and ENVISAT) flying simultaneously over the past several years, the science community has discovered a wealth of new opportunities for research and practical applications from the increased resolution offered by the multiple-satellite observations. Examples of the new discoveries include the global velocity field of oceanic jets and eddies, the details of coastal tides, the global distribution of internal tides, the heat potential for improving hurricane forecast, and fluctuating levels of lakes and rivers in remote areas of the world. Among the eighty-six investigations recently selected by NASA and CNES for the Ocean Surface Topography Science Team (OSTST), thirty-eight of them (44%) are addressing mesoscale processes using data merged from multiple satellites. Many of the practical applications of the high-resolution data (e.g., ENSO and hurricane forecasts, pollution monitoring, marine safety, ship routing, etc.) have become essential to operational agencies (e.g., NOAA) as well as new international programs such as CLIVAR (Climate Variability) and GMES (Global Monitoring for Environment and Security) in Europe.

The benefits of high-resolution altimetry were documented by the High-resolution Ocean Topography Science Working Group convened by NASA in 2001, as well as by the European group, GAMBLE (Global Altimeter Measurements By Leading Europeans) in 2003. The flight of the Wide-Swath Ocean Altimeter (WSOA) on the Ocean Surface Topography Mission (OSTM) was recommended by both groups for demonstration of mapping high-resolution ocean topography by a single spacecraft. The sampling capability of WSOA is better than that of five coordinated conventional altimeters, which are required for mapping the mesoscale variability. The current situation of four simultaneous altimetric satellites will not continue for long. Without the WSOA, the capability of resolving the important mesoscales will not be possible in the foreseeable future.

During the recent OSTST Meeting at St. Petersburg, Florida, on November 4-6, 2004, a resolution was passed by the team to urge NASA and CNES to consider the following:

The flight of WSOA on OSTM is the most effective approach to high-resolution ocean altimetry by a single spacecraft. There is not another foreseen opportunity to test and demonstrate this new technology in conjunction with a well understood instrument.

The demonstration of WSOA on OSTM is critically timely for establishing the standard for future operational altimetry to be taken over by operational agencies. The Integrated Program Office has expressed interest in the technology to address Pre-Planned Product

Improvements ($P^3I$) that are not obtainable by present technology.

Without WSOA, critically important information for understanding ocean circulation and climate as well as practical applications with well-demonstrated societal benefits will be lost.

NASA and CNES, in partnership with NOAA and UMETSAT, should continue the current development of WSOA as an experimental payload of OSTM for a timely launch in 2008.

## Appendix A

**Ocean Surface Topography Science Team Meeting**
**November 4-6, 2004**
**St. Petersburg, Florida, USA**

**Agenda**

**Thursday, November 4**

7:30 Registration/Continental Breakfast

| | |
|---|---|
| 8:30 Welcome and meeting overview | L-L Fu, Y. Menard |
| 8:45 NASA program status | E. Lindstrom |
| 9:00 CNES program status | E. Thouvenot |
| 9:15 TOPEX/Poseidon, Jason and SALP status | M. Fujishin, N. Picot |
| 9:45 OSTM/Jason-2 project status | S. Kaki, G. Zaouche, F. Parisot, W. Bannoura |

10:15 Break

| | |
|---|---|
| 10:30 Jason satellite/ground system operations and performance | G. Zaouche, G. Shirtliffe |
| 10:50 Jason instrument performance | G. Carayon, G. Zaouche, G. Shirtliffe |
| 11:30 Jason data products and evaluation | P. Vincent, S. Desai |
| 12:00 Splinter meeting introductions | Splinter Chairs |

12:30 Lunch

1:30 Poster Session

3:30 Break

4:00 Splinter Sessions

| | |
|---|---|
| Tides/high-frequency aliasing | R. Ponte, F. Lyard |
| Outreach | V. Rosmorduc, M. Srinivasan, A. Richardson |

6:00 Adjourn

6:30 Reception
7:30 Dinner

**Friday, November 5**

8:00 Continental breakfast

8:30 Splinter Sessions

| | |
|---|---|
| Calibration/validation | P. Bonnefond, B. Haines, S. Nerem |
| POD/geoid | J-P. Berthias, J. Ries |

10:30 Break

11:00 Splinter Sessions (continue)

Calibration/validation
POD/geoid

12:30 Lunch

1:30 Splinter Sessions:

| | |
|---|---|
| Sea-state bias/waveform retracking | P. Vincent, P. Callahan |
| Multi-satellite/operational altimetry | G. Jacobs, P-Y. Le Traon, C. Birkett |

3:30 Break

4:00 Splinter Sessions (continue):

Sea-state bias/waveform retracking
Multi-satellite/operational altimetry

5:30 Adjourn

**Saturday, November 6**

8:00 Continental Breakfast

8:30 Plenary Sessions:

Consistency in T/P and Jason performance (P. Vincent, B. Haines)

| | | |
|---|---|---|
| | Systematic Errors and Ocean Circulation Studies | L.–L Fu |
| 13. | Sea State and Relative Bias Issues | D. Chambers |
| 14. | Orbit Errors | J. Ries/P. Bonnefond |
| 15. | Global T/P and Jason-1 Consistency | J. Dorandeu |
| 16. | Towards a Seamless Transition from T/P to Jason-1 | B. Beckley |
| 17. | Summary of New Results/Issues from Splinters | P. Vincent/B. Haines |
| | Discussion | |

10:00 Break

10:30 Science Talks

F. Lyard "Recent results on tides from altimetry: A tribute to Christian Le Provost"

G. Goni "Near-real time monitoring of the upper ocean from altimetry for tropical cyclone studies"

K. Kelly "The upper ocean heat budget in western boundary currents"

R. Morrow "Divergent pathways of cyclonic and anti-cyclonic ocean eddies, and their impact on ocean heat and salt transport"

12:30 Lunch

1:30 Splinter meeting summaries

3:30 Conclusions

4:00 Adjourn

## <u>Outreach Splinter Session</u>
## <u>Thursday, November 4th, 4–6 pm</u>

4:00 pm
Ocean surface topography outreach activities in 2004
Outreach Team

4:15 pm
Aviso user service: At the crossroad between user information, outreach, and education
V. Rosmorduc

4:30 pm
UNESCO-Bilko: A tool for education and altimetric data visualization
G. Quartly

4:45 pm
Discussion:

- Science Team involvement: What can we do to increase Science Team participation in outreach?
- New interactive data visualization tools (GIS, LAS, POETS...): What role is there for them in outreach & education?

5:00 pm
Argonautica in the U.S.: Planning for 2005-2008
A. Richardson

5:15 pm
Educating an informed citizenry: What should every student know about the oceans?
R. Stewart

5:30 pm
The University of Colorado Long-Term Sea Level Change Web Site
E. Leuliette

5:45 pm
Discussion:

- 12 Years of ocean topography outreach: Experiences and lessons learned
- Outreach & education operation feedback: What is useful, what is not, what must be/should be developed?
- Ocean topography outreach with respect to other ocean-related project outreach: Creating links, sharing knowledge and material

6:00 pm
Adjourn

**Calibration/Validation Splinter**
**Chairs: P. Bonnefond, B. Haines and S. Nerem**
**FRIDAY, NOVEMBER 5, 08h00 - 12h30**

***08h30 - 10h30***
15 min for each speech including questions (5 min)

- 08h30 Introduction

18. **Some guidelines to prepare the plenary session: Consistency in T/P and Jason performance**
    P. Bonnefond, B. Haines and S. Nerem

- 08h40

19. **Recent Results from the Harvest Experiment**
    B. Haines, G. Born and S. Gill

- 08h55

20. **Recent Results from the Corsica Calibration site**
    P. Bonnefond, P. Exertier, O. Laurain, Y. Ménard, F. Boldo, E. Jeansou and G. Jan

- 09h10

21. **Recent results from Bass Strait and other sites in the Australian**
22. **region**
    Neil White, Chris Watson, Richard Coleman and John Church

- 09h25

23. **JASON-1 Altimeter Calibration Results from the GAVDOS Project**
    E. C. Pavlis and the GAVDOS TEAM

- 09h40

24. **Jason-1 Radar Altimeter bias from in situ regional calibration method**
    G. Jan, M. Faillot, Y. Ménard, P. Bonnefond, F. Lyard and E. Jeansou

- 09h55

25. **Global Statistical Quality Assessment of Jason-1 data Jason-1 / TOPEX/Poseidon Cross-Calibration**
    M. Ablain, J. Dorandeu, F. Mertz, Y. Faugère, N. Picot, and P. Vincent

- 10h10

26. **Status of the JMR**
    S. Desai, C. Ruf, S. Keihm and S. Brown

- 10h25 open discussion

***10h30 - 11h00 Break***

***11h00 - 12h30 Splinter session resume***
15 min for each speech including questions (5 min)

- 11h00

**27. Jason Tide Gauge Calibration Results**
E. Leuliette, R. S. Nerem and G. T. Mitchum

- 11h15

**28. Ascending/Descending Patterns in Relative Bias Maps: Is it Jason-1 or TOPEX?**
D. Chambers and T. Urban

- 11h30

**29. Jason-1 Rain flag performance evaluation after 2 years of operations and Jason Rain products**
J. Tournadre

- 11h45

**30. T/P-Jason comparison and evaluation over the Scotian Shelf and Slope**
Guoqi Han

- 12h00 General discussion / inputs for the plenary session

***12h30 Adjourn***

## POD/Geoid Splinter Session
## Friday, November 5, 8:30-12:30 am
## Chairs: Jean-Paul Berthias / John Ries

The areas of discussion will include:

- Performance of Jason-1 orbit determination and TOPEX/Jason-1 consistency
- Standards for future Jason-1 orbit processing (and Jason-1 orbit reprocessing)
- Recent orbit improvements and progress towards 1-cm goal
- Evaluations of new gravity models for geoid and POD applications

| | | |
|---|---|---|
| 8h30 | Introduction | Berthias/Ries |
| | Jason-1 POD status and performance | F. Mercier |
| | Recent results using GPS, SLR, DORIS processing at CNES | F. Mercier |
| | Jason-1 POD evaluation | J. Ries |
| | Jason-1 orbit error and TOPEX/Jason-1 consistency | J. Dorandeu |
| | Jason-1 POD using GPS, SLR, DORIS and altimeter data | S. Luthcke |
| | Jason-1 POD: GPS and the 1-cm solution | B. Haines |
| | New gravity models for Jason-1 orbit computation | R. Biancale |
| | Sensitivity of DORIS-SLR Jason-1 orbits to gravity models | M. Feissel |
| 10h30 | Break | |
| 11h00 | Remaining POD results and discussion of standards | |
| | Assessment of the ITRF2000 accuracy for the DORIS tracking network | P. Willis |
| | DORIS SAA modeling issues | J.-M. Lemoine |
| | Quick assessment of the new DORIS receiver | P. Willis |
| | Discussion of standards | All |
| 11h45 | Review of new gravity models and applications to geoid modeling | |
| | GRACE mission status and current results | J. Ries |
| | Geoid and altimeter data assimilation : oceanographic assessment of CHAMP and GRACE products in the tropical Pacific ocean | F. Castruccio |
| 12h15 | POD/Geoid issues and plans discussion | |
| 12h30 | Lunch | |

*Presentations should be kept short (10 minutes) to allow time for questions and discussion*

**Sea State Bias and Waveform Retracking Splinter Session**
**Friday, November 5, 1:30 - 5:30 pm**

## Agenda

Issues being addressed during the session will include:

1. Progress in ground retracking of Jason-1 and TOPEX altimeter waveforms.

2. Understanding the significant differences between apparent TOPEX and Jason-1 SSB.

3. Recommending a strategy for producing corrected TOPEX and Jason-1 data from which the bias between them can be set to 1 cm or better.

1:30 Introduction and Review of Objectives P. Vincent, P. Callahan

1:40 Approximating the PTR by a sum of gaussian functions - Impact on retracking - O. Zanife et al.

1:55 The role of the instrumental correction tables in the Jason-1 altimeter processing - P. Thibaut et al.

2:10 The MLE-4 retracking algorithm - P. Thibault et al.

2:30 Retracking Jason-1 data - P. Callahan and E. Rodriguez

2:50 Evaluation of Jason-1 skewness - P. Thibaut et al.

3:05 Correlation between SSH and SWH errors in tracking and retracking algorithms, examples from Monte Carlo simulations and ERS-1 and Geosat retracking - W. Smith and D. Sandwell

3:20 Summarize main retracking results for later discussion

**3:30 BREAK**

3:50 Poster Overview: New wind speed algorithm for Jason-1 - F. Collard and S. Labroue

3:55 Cal/Val Overview: Comments on differences in ascending/descending SWH for TOPEX and the effect on TOPEX Sea State Bias - D. Chambers and T. Urban

4:05 Use of a global wave model to correct altimeter sea level estimates: Model sensitivity to wind forcing fields - H. Feng, D. Vandemark, B. Chapron and B. Beckley

4:15 Hybrid sea state bias models and their impact of SSB models on sea level change studies - R. Scharroo and J. Lillibridge

4:25 Results on TOPEX and Jason-1 sea state bias with the non-parametric technique - S. Labroue et al.

**4:35 Discussion and formulation of recommendations**

5:30 Adjourn

**Multisatellite/Operational Applications Splinter Session**
**Friday November 5, 2004**
**1h30 -5h30**

1. **Contribution of existing multiple altimeter missions including results from the T/P-Jason-1 tandem mission. Requirements for future long-term high resolution altimeter systems.**

1:30 N. A. Maximenko, P. P. Niiler, B. Cornuelle, Y. Y. Kim, and W. T. Liu. The dynamics of ocean surface circulation studied using altimeter, Lagrangian drifter and wind data.

1:45 P.Y. Le Traon, A. Pascual, G. Larnicol : Use of Jason-1, T/P, ENVISAT and GFO for mesoscale studies. What do you learn from four altimeters ?

2:00 D. Stammer and J. Theiss. Velocity statistics inferred from the TOPEX/POSEIDON-JASON Tandem Mission Data.

2:15 P. De Mey, B. Mourre : Impact of forthcoming altimeters and in situ measurements in shelf seas via ensemble modelling.

2. **Issues/Challenges for Coastal/Nearshore and Inland applications**

2:30 T. Strub. Coastal ocean operational observing systems. What are the issues for altimetry?

2:45 C.M. Birkett , B. Beckley, B. Doorn, C. Reynolds. Near-real Time Monitoring of Global Lakes and Reservoirs.

3. **Applications : where are we, what do we need, where are the challenges ? Outreach issues.**

3:00 M. Srinivasan and V. Rosmorduc. An eye on OSTST research; Highlighting the societal benefits.

3:15 M. Bell and N. Smith : Outcomes of the GODAE symposium.

Break

4:00 E. Dombrowsky and P. Bahurel. MERCATOR and its applications.

4:15 H. Hurlburt, J. Shriver, O. Smedstad, E. Chassignet, and D-S Ko. Application of Satellite Altimetry to Eddy-resolving Global Ocean Prediction.

4:30 G. Jacobs, J. Leclere and D. Fox: Impact of satellite observations on acoustic propagation transmission loss errors.

4:45 F. Bonjean. Status of Ocean Surface Current Analyses Real-time (OSCAR) and on the OSCAR-2 follow-on project.

5:00 D. Matthews, B. Emery, and D. Baldwin. Near Real time Surface Current Mapping off California with Radiometry and Altimetry.

5 :15 J.M. Lefèvre, C. Skandrani, T. Ludjet, P. Queffeulou. Operational assimilation of Altimeter Wind/Wave data.

5:30 Discussion/Concluding remarks/Recommendations to the project.

**Appendix B. Titles of the Poster Presentations** *(See accompanying CD for posters)*

**A. Local and Global Calibration/Validation**

1) Towards a Seamless Transition from TOPEX/Poseidon to Jason (Beckley D.)
2) Absolute Calibration of Jason-1 and TOPEX/Poseidon Altimeters in Corsica (Bonnefond P.)
3) Multi-Mission Crossover Analysis (Bosch W.)
4) A New Approach in Determining Relative Sea Level Change: Interferometric Point Target Analysis of Synthetic Aperture, Radar Data From the Los Angeles Basin (Brooks B.)
5) Recalibration of the Jason Microwave Radiometer (Brown S.)
6) Global Statistical Quality Assessment of Jason-1 data, Jason-1 / TOPEX/Poseidon Cross-Calibration (Dorandeu J.)
7) Long term stability of ERS2 and TOPEX microwave radiometer in-flight calibration (Eymard L.)
8) Monitoring Jason-1 and TOPEX/POSEIDON from an Offshore Platform: An Update From the Harvest Experiment (Haines B.)
9) Jason-1 Radar Altimeter bias from in-situ ocean measurement (Jan G.)
10) Long term monitoring of the ENVISAT RA-2 drift with the GLOSS/CLIVAR "fast" sea level data tide gauge network (Lefevre F.)
11) A New Backscatter Histogram Method to Define, An Ice/Rain Flag For Dual-Frequency Altimeters (Lillibridge J.)
12) Albicocca project: status of the experimental (Lyard F.)
13) The Jason Microwave Radiometer Side Lobe Correction (Obligis E.)
14) Dual-Frequency Altimetry: What have we learnt from Envisat RA-2's S-band? (Quartly G.)
15) Calibration/validation of an altimeter wave period model and application to Topex/Poseidon and Jason-1 altimeters. (Quilfen Y.)
16) Monitoring Drift and Other Errors in Altimetric Wave Height Measurements: Topex, Jason, GFO, ERS-2 (Ray R.)
17) Altimeter calibration using a ruggedized GPS-buoy (Schone T.)
18) Bottom-mounted Tide Gauges for Radar Altimetry Monitoring (Shone T.)
19) Progress in Altimeter Calibration Using the Global Tide Gauge Network (Sedwick K.)
20) High standard tide gauge network for scientific studies (Testut L)
21) Jason Rain flag performance evaluation after 2 years of operations and Jason Rain products (Tournadre J.)
22) Absolute calibration of Jason-1 and Envisat Ku-band Sigma0 (Tran N.)
23) Comparison of the two Jason-1 rain flags (Tran N.)
24) Instrumental monitoring of Jason-1 microwave radiometer (Tran N.)
25) Continuing Cal/Val of Jason-1 and TOPEX: Detailed Differences in Relative Bias (Urban T.)
26) TOPEX/Poseidon and Jason-1 Altimeters: Absolute Calibration in Bass Strait, Australia (Watson C.)

**B. Sea-State Bias and Re-tracking Analysis**

1) Retracking of Jason-1 Data (Callahan P.)

2) NEW WIND SPEED ALGORITHM FOR JASON-1 (Collard F)
3) Use of a global wave model to correct altimeter sea level estimates: model sensitivity to wind forcing fields (Feng H.)
4) RESULTS ON TOPEX AND JASON 1 SEA STATE BIAS WITH THE NON PARAMETRIC TECHNIQUE (Labroue S.)
5) Hybrid Sea-State Bias Models and Their Impact on Sea-Level Change Studies Scharroo R.)
6) Correlation between SSH and SWH errors in tracking and retracking algorithms: examples from Monte Carlo simulations, and ERS-1 and Geosat retracking (Smith W.)
7) Estimation of the Skewness coefficient in Jason-1 altimeter data Jason-1 altimeter ground processing look-up correction tables (Thibaut P.)
8) Jason-1 altimeter ground processing look-up correction tables (Thibaut P.)
9) Comparison between MLE3 and MLE4 retracking algorithms (Thibaut P.)
10) Approximating the PTR by a sum of Gaussian functions - Impact on retracking Precision Orbit Determination and Geoid (Zanife O.)

**C. Precision Orbit Determination and Geoid**

1) GPS-Based Precise Orbit Determination: Jason-1 Status and Prospects for 5 mm on OSTM (Bertiger W.)
2) Coastal Sea Surface Topography from Altimetry -, Gravity -, and Tide Gauge Data (COSSTAGT) (Bosch W.)
3) Geoid and altimeter data assimilation : oceanographic assessment of CHAMP and GRACE products in the tropical Pacific ocean (Castruccio F.)
4) GRACE Products for Oceanography (Chambers D.)
5) Evaluation of the Geosat Follow-On Precise Orbit Ephemeris (Lemoine F.)
6) Improvement of the TOPEX and Jason Orbit Time Series: Precision Orbit Determination, Calibration, Validation and Improvement Through the Combined Reduction and Analysis of GPS, SLR, DORIS and Altimeter Data (Luthcke S.)
7) Evaluation of Jason1 Doris/Laser/GPS orbits Doris rapid orbit improvements (Mercier F.)
8) Preliminary results on the sensitivity to radiations of the back-up DORIS/Jason oscillator (Willis P.)
9) Assessment of the ITRF2000 accuracy for the DORIS tracking network and implication for the Jason Precise Orbit Determination (Willis P.)

**D. Tides and High-Frequency Aliases**

1) The new global tidal solution: FES2004 (Letellier T.)
2) Coastal Ocean Tide Modeling (Shum CK.)

**E. Multi-Satellite/Operational Applications**

1) Near-real Time Monitoring of Global Lakes and Reservoirs (Birkett CM.)
2) River Dynamics, Lake-level Variability, and Near-Real Time Reservoir Monitoring (Birkett CM.)
3) OSCAR-2: Ocean Surface Current Analyses Real-time follow-on project (Bonjean F.)
4) Operational Applications of Satellite Altimetry in Real-Time Forecasting of the U.S. West Coastal Ocean (Chao Y.)

5) Application of Altimeter Observations to Tropical Climate Modeling and Prediction (Chen D.)
6) SSALTO/DUACS Global and regional operational altimeter products (Dibarboure G.)
7) Mapping the California Current with Satellite Altimetry and Radiometry (Emery B.)
8) MRI Multivariate Ocean Variational Estimation (MOVE) System. (Fujii Y.)
9) Application of operational satellite altimetry observations for shelf and coastal seas (Hoeyer J.)
10) Small-scale and short-term variability in sea surface height and effective data error (Kaplan A.)
11) Operational Assimilation of Altimeter Wind/Wave Data (Lefevre J.)
12) The Dynamics of Oean Surface Circulation Studied Using Altimeter, Lagrangian Drifter and Wind Data (Maximenko N.)
13) Altimetry at the Centre de Topographie des OcŽans et de lÕHydrosph□re (Morrow R.)
14) Mesoscale Mapping Capabilities of Multi satellite Altimeter Missions: First Results with Real Data in the Mediterranean Sea (Pascual A.)
15) DRAKKAR: Realistic ice-ocean models to support space oceanography (Penduff T.)
16) An eye on OSTST research; Highlighting the societal benefits (Srinivasan M.)
17) The Yellow Pages directory of satellite altimetry applications; An update (Srinivasan M.)
18) Velocity statistics inferred from the TOPEX/POSEIDON-JASON Tandem Mission Data. (Stammer D.)
19) Coastal Ocean Operational Observing/Modeling Systems: Altimetrys Place in the Mix of Observations? (Strub P.)

**F. Outreach**

1) UNESCO-Bilko: A Tool for Education and Altimetric Data Visualization (Byfield V.)
2) The University of Colorado Long-Term Sea Level Change Web Site (Leuliette E.)
3) Argonautica in the U.S.: Planning for 2005-2008 (Richardson A.)
4) Aviso user service, at the crossroad between user information, outreach and education (Rosmorduc V.)
5) Aviso Altimetry Products: select your choice! (Rosmorduc V.)
6) Educating an Informed Citizenry: What Should Every Student Know About the Oceans? (Stewart R.)
7) Flower pots keep satellites in check (Watson C.)

**G. Science Plans and Results**

1) Using satellite data to understand upper ocean processes in mid to high latitudes (Ayoub N.)
2) Ensemble Reduced Order Kalman Filter for Data Assimilation (Ballabrera J.)
3) Application of Altimetry Measurements to Observational and Modeling Studies of the Low-Frequency Upper Ocean Mass and Heat Circulation to Studies of Tropical Ocean Variability (Busalacchi A.)

4) Seasonal variations of the mixed layer and heat storage in the Southern Ocean based on recent hydrographic observations. (Busdraghi F.)
5) Sea level rise in recent decades and the warming of the oceans (Carton J.)
6) Estimates of the Regional Distribution of Sea-Level Rise over the 1950 to 2000 Period (Church J.)
7) Data Assimilation in Regional and Shelf Seas (DARSS) (De Mey P.)
8) Exploiting JASON to Separate Mass Specific and Baroclinic Sea Level Changes in the North Atlantic Ocean (Esselborn S.)
9) Vertical land motion and low-frequency sea level variability along the south-european coasts from altimetry and tide gauge stations (Fenoglio Marc L.)
10) Determination of annual mass variations in the Mediterranean Sea through altimetry missions and GRACE (Garcia D.)
11) Land Hydrology from Satellite Altimetry : Lakes, Rivers and Wetlands (Gennero M.)
12) Statistical Analysis of Ocean Dynamics using Ocean Model Output and Satellite Altimeter Data (Glazman R.)
13) Near-real time monitoring of the upper ocean from altimetry for tropical cyclone studies (Goni G.)
14) Comparison of the 1997-97 and 2001-02 El Ni–os - Model and Data Assimilation Results (Hackert E.)
15) An Observing System Simulation Study for an Optimal Moored Instrument Array in the Tropical Indian Ocean (Hackert E.)
16) Reconstruction of Global Mean Sea Level Variations Using Altimeter and Tide Gauge Data: A Sensitivity Analysis (Jakub T.)
17) The Upper Ocean Heat Budget in Western Boundary Currents (Kelly K.)
18) Altimetric Derived Estimates of the North Atlantic Upper Ocean Heat Budget: Consequences for Climate Prediction and Ocean Modeling (Kelly K.)
19) Global Mean Sea Level Variation Estimated with Altimeter Data and Tide Gauge Data (Kuragano T.)
20) Decadal variations of wind and currents of the Indian Ocean inferred from satellite observations and ECCO assimilation (Lee T.)
21) Thermosteric sea level over the past 50 years; inference on eustatic sea level rise. (Lombard A.)
22) A Numerical Study of the Coastal Circulation in the Southwestern Atlantic. (Matano R.)
23) Divergent pathways of cyclonic and anti-cyclonic ocean eddies (Morrow R.)
24) Impact of Improved Thermocline Simulations on Sea Level Variability (Murtugudde R.)
25) Importance of JASON-TP data to improve the coupled ocean-atmosphere modeling of El-Nino (Perigaud C.)
26) Sea level variability from surface loading effects neglected involume-conserving models (Ponte R.)
27) Estimating Eddy-Induced Heat Transport by Combining Satellite Altimetry, Argo, and TMI Measurements (Qiu B.)
28) Combining Altimetry and Radiometry for Atmospheric Studies (Quartly G.)

29) MUSICAL (Multi-Sensors Information: ocean Color and Altimetry) (Radenac M.)
30) Comparison of sequential and variational reduced-order data assimilation methods in the tropical Pacific ocean (Robert C.)
31) Argo and Jason in the South Pacific: Interannual-to-decadal variability in water mass properties and circulation. (Roemmich D.)
32) Improving seasonal climate prediction using ocean information through variational data assimilation (Rogel P.)
33) Circulation Variability Along Pacific Ocean Eastern Boundaries: Low, Mid and High Latitudes (Strub P.)
34) Theory of the free and forced planetary wave response in presence of mean flow and variable topography in a continuously stratified ocean: toward a physically-based quantitative interpretation of satellite altimeter SSH and microwave SST data (Tailleux R.)
35) Causes of Sea Level Variations in the Southern Ocean: Analyses of Sea Level and a Barotropic Model. (Vivier F.)
36) Southern Ocean heat storage variability and climatic implications: investigation plans and preliminary results. (Vivier F.)
37) Estimates of the global oceanic heat budget from assimilation models on interannual to decadal time scales (Willis J.)
38) Identification of sea level changes using GRACE, TOPEX and JASON-1 data (Wouters B.)
39) Tidal Energy Available for Mixing at the Hawaiian Ridge: Constraints from Altimetry and Numerical Models (Zaron E.)
40) A Parameterization-oriented Approach to Inferring Subsurface Entrainment Temperature from Altimeter Data: The Impact on Interannual Variability in a Coupled Model (Zhang R.)

**H. Consistency in Jason and TOPEX/Poseidon performance**

1) Global Statistical Quality Assessment of Jason-1 data Jason-1 / TOPEX/Poseidon Cross-Calibration (Dorandeu J.)
2) Sensitivity of DORIS-SLR Topex/Poseidon and Jason 1 orbital references to gravity field models (Feissel-Vernier M.)
3) TOPEX/Poseidon-Jason comparison over the Scotian Shelf and Slope (Han G.)