2012 Ocean Surface Topography Science Team Meeting (Venice)

CENTRE NATIONAL D'ÉTUDES SPATIALES

Jet Propulsion Laboratory
California Institute of Technology

Jason-1 Project Status

Jason 3
2014

OSTM/Jason 2
2008-Present

Jason 1
2001–Present

TOPEX/Poseidon
1992–2006

Glenn Shirtliffe
NASA/JPL Jason-1 Project Manager
Thierry Guinle
CNES Jason-1 Project Manager

Status of the Jason-1 Mission

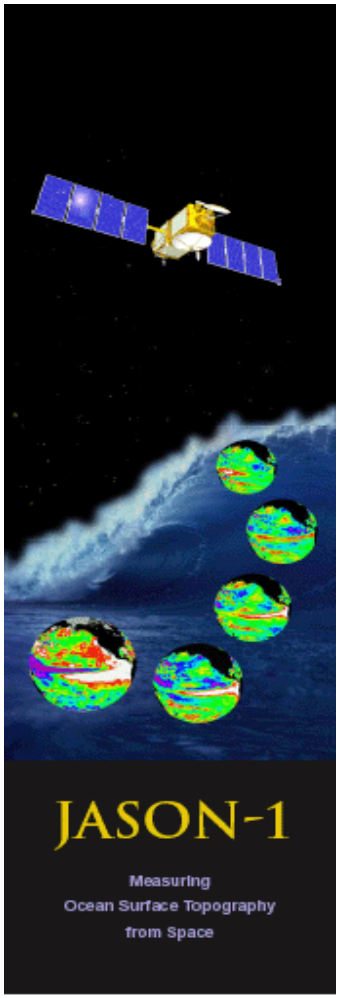
- **Jason-1 completed 50,000 orbits on 18 September 2012 !**

- **Jason-1 continues to exceed all Level-1 Science Requirements, despite:**
  - Loss of reaction wheel #1 in November 2003
  - Loss of half-satellite (PMB) in September 2005 (Tx)
  - Gyro #1 anomaly in March 2010 and switch to Gyro #3 in April 2010
  - **The loss of double reconfiguration capability in safe hold mode**
  - **The ageing of the RAM**

- **Operational Milestones:**
  - Jason-1 began its 11th year of operations in December 2011
  - Jason-1 was maneuvered into a geodetic orbit in May 2012

Jason-1 continues to make an essential contribution to ocean surface topography and to geodesy

Jason-1: Major Events Since Last OSTST (San Diego, October 2011)



Project Milestones

- Fuel depletion maneuvers, Sept. & Oct. 2011. → **success**
- Ten years in orbit, Dec. 2011 (JPL), Jan. 2012 (CNES) → **success**
- Joint Steering Group (JSG), Jan. 2012: Mission extended until 2013. → **approved**
- JSG, Apr. 2012: Transition to a geodetic mission phase → **approved**
- Five orbit change maneuvers: April & May 2012 → **approved**

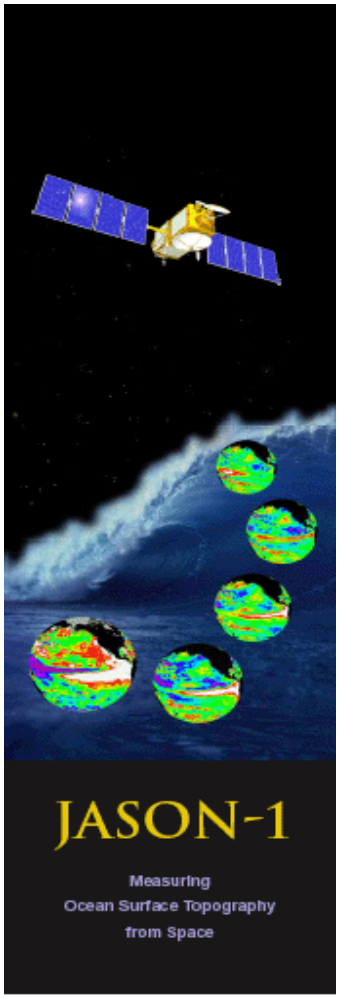
Unplanned Satellite Events

- Jan. 2012: Redundant Star Tracker #1 in HALT mode. (Recovered)

Safe Holds:

- Feb. 2012: Anomaly on Gyro#3. (SEU)
- Mar. 2012: Double EDAC error in RAM memory (SEU)
  - Led to a double reconfiguration, linked to a problem in RAM memory.
  - After extensive technical analysis, no short-term workaround was found.
  - This situation led to a decision to move to the geodetic orbit.
  - Jason-1 returned to nominal operations on 24 April 2012

Jason-1: Major Events Since Last OSTST (San Diego, October 2011)



Unplanned Payload Events

- Sept. & Oct. 2011: 5 DORIS Navigator auto-init during depletion maneuvers, mainly due do thrusters under-performances. No action needed from ground (DIODE software self recovery function)
- Feb. to June 2012: UTC leap second anomaly on the platform GPS (known anomaly) → JMR data was corrected by JPL on ground.

Major Ground Events

- E1 data communications line (CNES/JPL) :
  - Feb. 2012: around 13 hours of nominal link outage.
  - Mar. 2012 : modification of the nominal & back-up line monitoring on CNES side → automatic failover is now automated.
- Aussaguel ET : minor hardware failures, no data loss.

Current Jason-1 mission status is nominal !

Jason-1 Orbit Change Operations Summary

- On 12 April 2012, the CNES—NASA Joint Steering Group (JSG) determined that due to the state of the spacecraft after the safe hold events of early 2012, Jason-1 should immediately be moved to the planned geodetic orbit.

- Operations preparation (return to NOM mode + maneuvers) from 9—20 April → SOE validated by all operational teams and experts (V1.3) on 23 April 2012

- Beginning of operations on 23 April
  - Returned to NOMINAL mode on 24 April
  - 1st maneuver on 25 April
  - 5th maneuver the 3 May
- ~340g remained in the tank
  - Over consumption on maneuvers 4 & 5
  - Decision to suspend the maneuvers
  - Validation of current orbit as a "geodetic" one
  - Decision to stop the operations at -12 km

- Jason-1 was verified to be in a usable geodetic orbit on 4 May
  - POS2 altimeter restart on 7 May (first restart was unsuccessful on 4 May)
  - Product generation restarted on 9 May

The New Jason-1 Orbit for the Geodetic Mission (GM)

Semi major axis	**7702.437 km**
Eccentricity	**1.3 to 2.8 E-4**
Altitude at Equator	**1324.0 km**
Orbital Period	**6730s (1h 52’ 10’’)**
Inclination	**66.042°**
Cycle	**406 days**
Sub-Cycles	**3.9, 10.9, 47.5, 179.5**
Type	**12+299/410**

- JA1 orbit will be maintained within the ±1km control box at the Equator
- During underflights of JA2, the JA1 POS altimeter is set to INIT mode in order not to disrupt the JA2 reference topography mission
- GDR product generation baseline : 11-day subcycle
- Good orbit for geodetic purposes
- Non-optimal sampling WRT Jason-2

Actions & Lessons Learned

- Must monitor impacts of Jason-2 overflights every 33 days.
  - Jason-1 altimeter does not transmit when passing under Jason-2. (In INIT mode for ~3 hours)
  - Jason-2 altimeter will not transmit if passing directly over Jason-1.
- To verify science data product quality in the new orbit.
  - Prove the validity and utility of the geodetic science data to the 2013 NASA and CNES mission renewal processes.
- To define new hydrazine margins for other missions (Jason-2) based on the Jason-1 in-flight experience.

Jason-1 Orbit Change
Geodetic Mission Capabilities

- The move to a long-repeat orbit will result in a substantially improvement in resolution of the marine geoid.
- This will result in significant improvements in estimates of deep ocean topography, resolving many presently unknown seamounts and other geologic features on the ocean bottom.
- This will be a new and important contribution from Jason-1.
  - Improvements in bottom topography will be of value in ocean modeling (e.g., allowing improved representation of topographically induced mixing), in naval operations, and in solid Earth dynamics.
  - Improvements in the geoid will also increase the value of historical altimetry data, such as from GEOSAT, and be useful (at least initially) for interpretation of the planned SWOT mission.
- Removing Jason-1 from the altimetry reference orbit accomplishes the primary goal of the Jason-1 End-of-Mission decommissioning plan: that of safeguarding the 1336-km altimetry reference orbit by minimizing the collision and debris risks to that orbit.

Jason-1 Orbit Change Conclusions

- Jason-1 has left the 1336 km altimetric orbit (Last altimetry cycle #372)
- Jason-1 is now on a 1324 km geodetic orbit (First geodetic cycle #500)
- The core payload is operational
- The science mission has resumed
- The project team has decided to keep a GDR sub-cycle of 11 days (full cycle = 406 days) to avoid major upgrades in the processing centers
  - No changes to product nomenclature
  - No change in data latency (3h, 2-3 days, 30 days)
  - For more info: please attend the talk by D. Sandwell & G. Dibarboure later in the morning
- Routine OPS procedures for the geodetic mission are in place at CNES & NASA/JPL
- Decommissioning plans and procedures for the final Jason-1 end-of-mission are also in place.

The CNES and JPL Ops Teams wish Jason-1 a long and prosperous second life in the geodetic orbit !

Technical Note about the Jason-1 Geodetic Mission

A Technical Note about the Jason-1 Geodetic Mission was issued on 24 May 2012, by E. Bronner (CNES) and G. Dibarboure (CLS). *(SALP-NT-MA-16267-CNv1.0)*

This document describes the motivations for the orbit change and impacts and constraints of the new geodetic orbit. It also provides important user information and FAQs.

This Technical Note is available from:

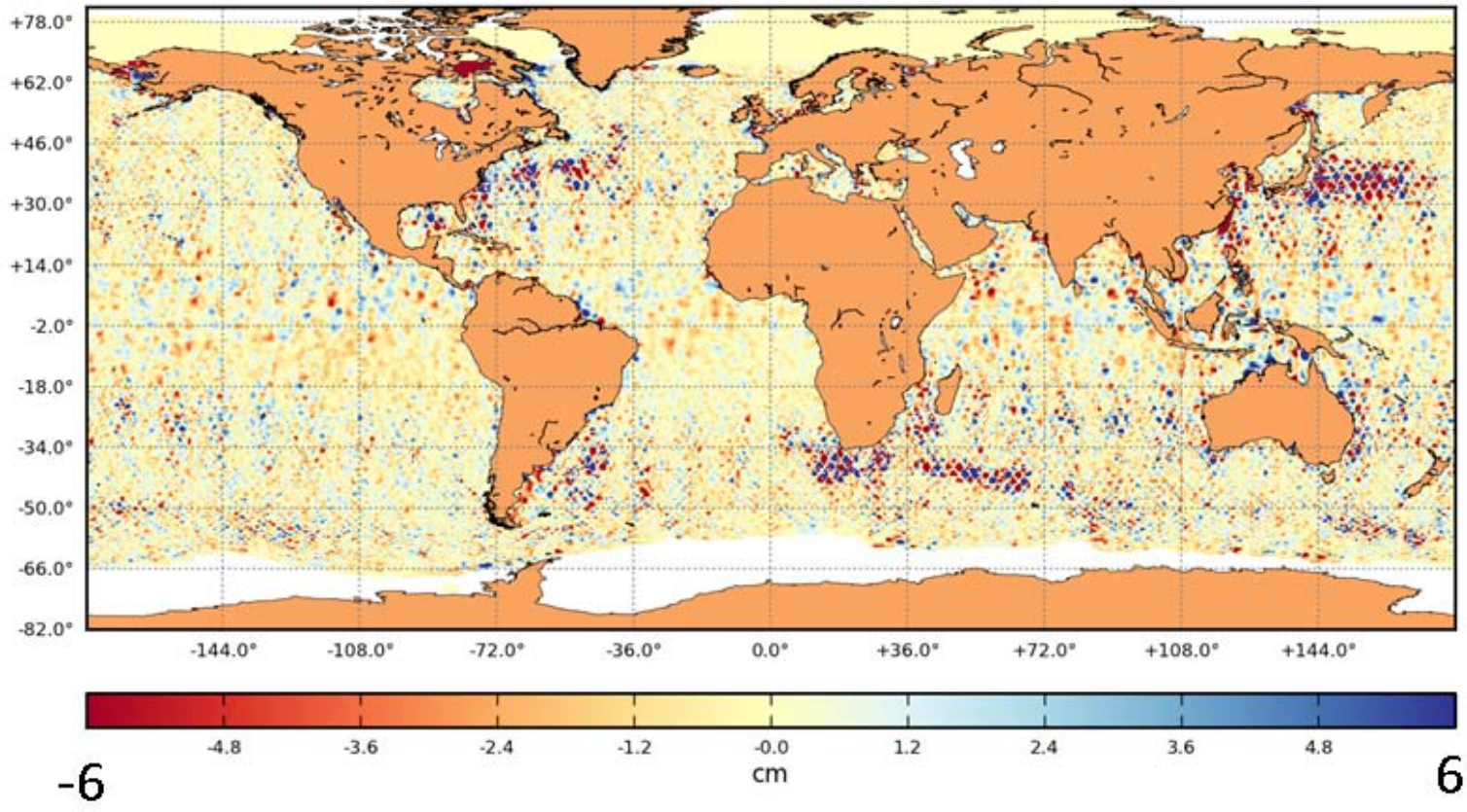
http://www.aviso.oceanobs.com/fileadmin/documents/data/duacs/Technical_Note_J1_Geodetic_Mission.pdf

Jason-1 GM into DUACS products

(Map of 3 vs 2 satellite impact on Sea Level Anomaly)

J2/C2 - J2/C2/J1G

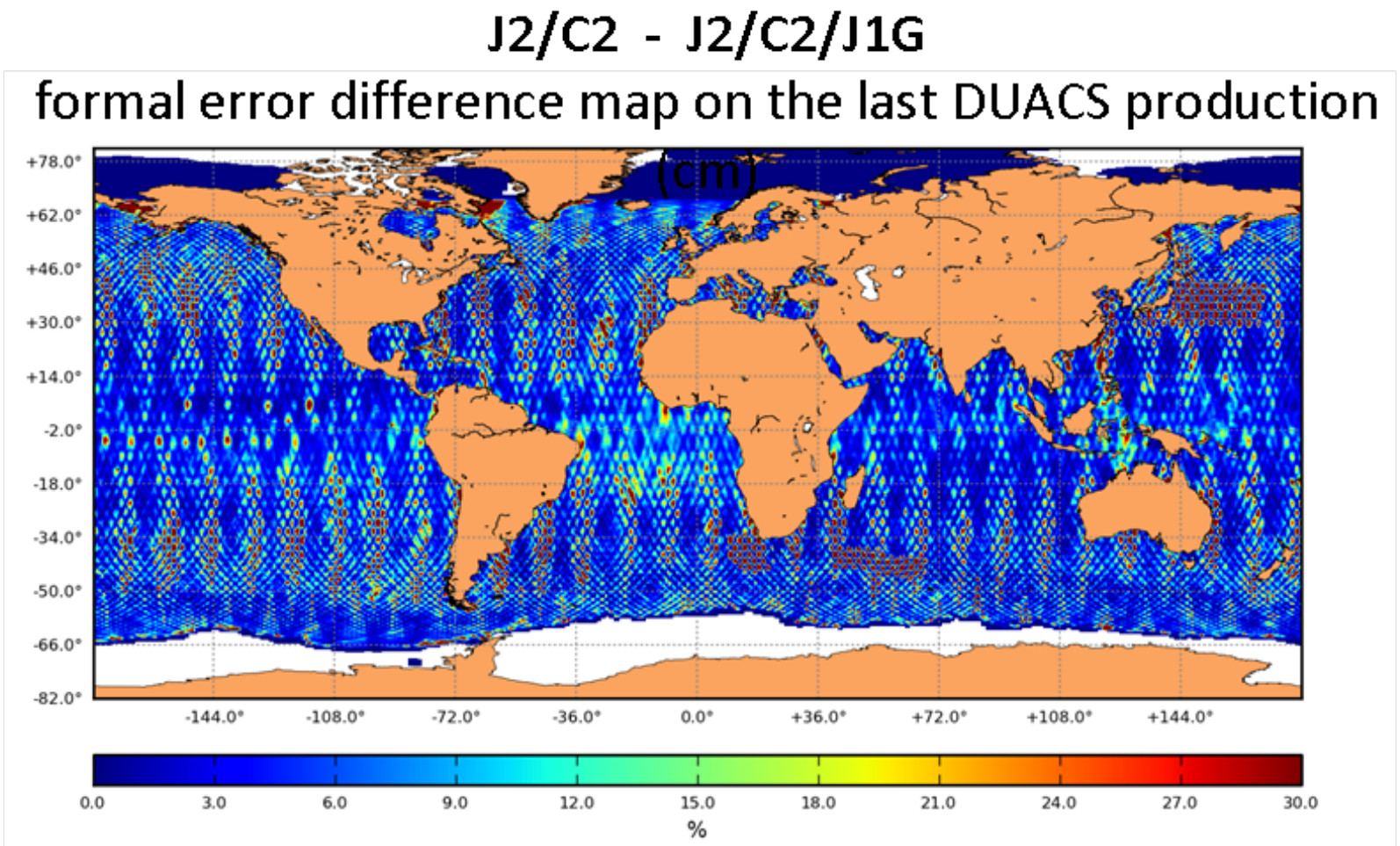
SLA map on the last DUACS production (cm)



Jason-1 GM into DUACS products

2 sat vs 3 sat impact on formal mapping errors:

➔ Jason-1 geodetic data provides added value, particularty significant in red areas



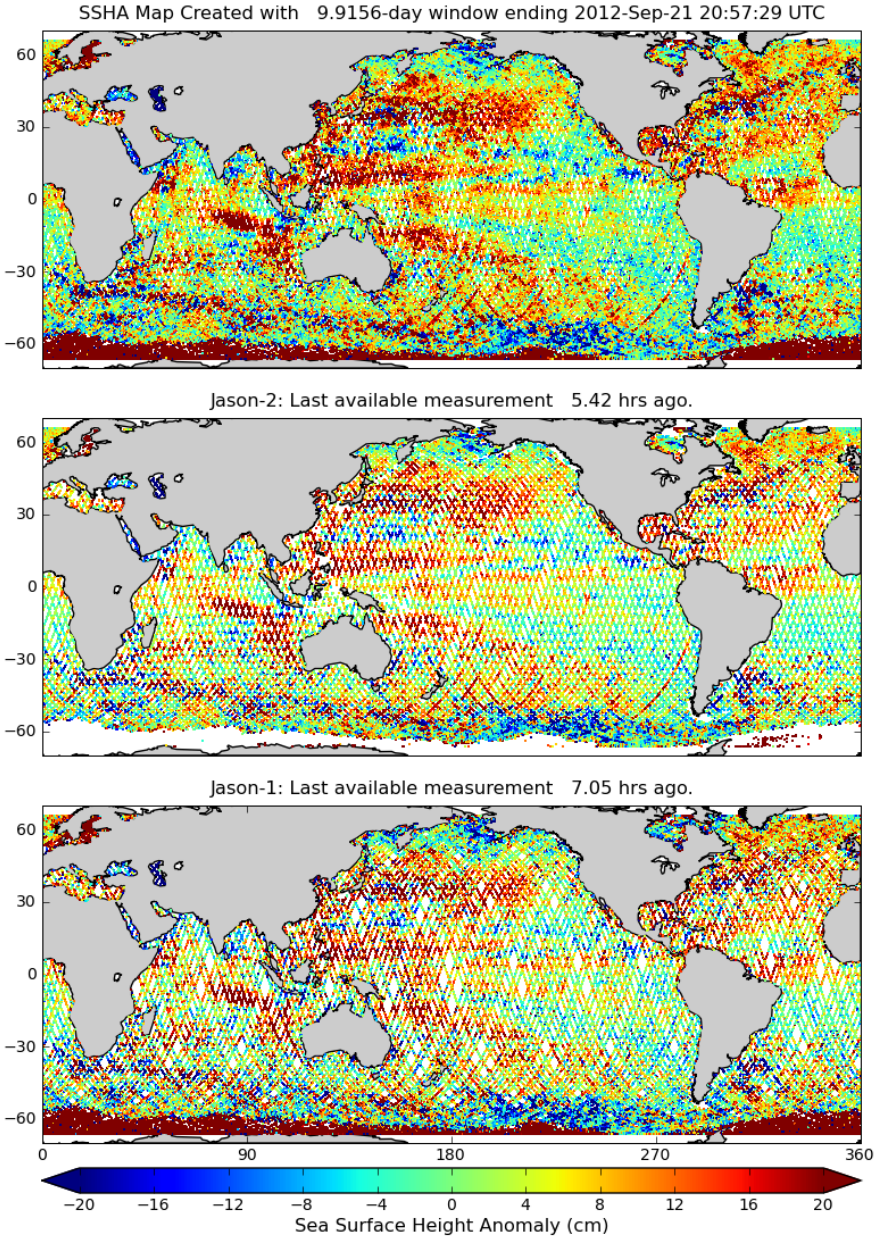
Near-Real-Time Data Products

JPL has continued development of a NRT SSHA product that combines the OSTM/Jason-2 and Jason-1 NRT SSHA data.

TOP: Combined JA1 + JA2 10-Day NRT SSHA

MIDDLE: JA2 NRT SSHA

BOTTOM: JA1 NRT SSHA (in geodetic orbit)



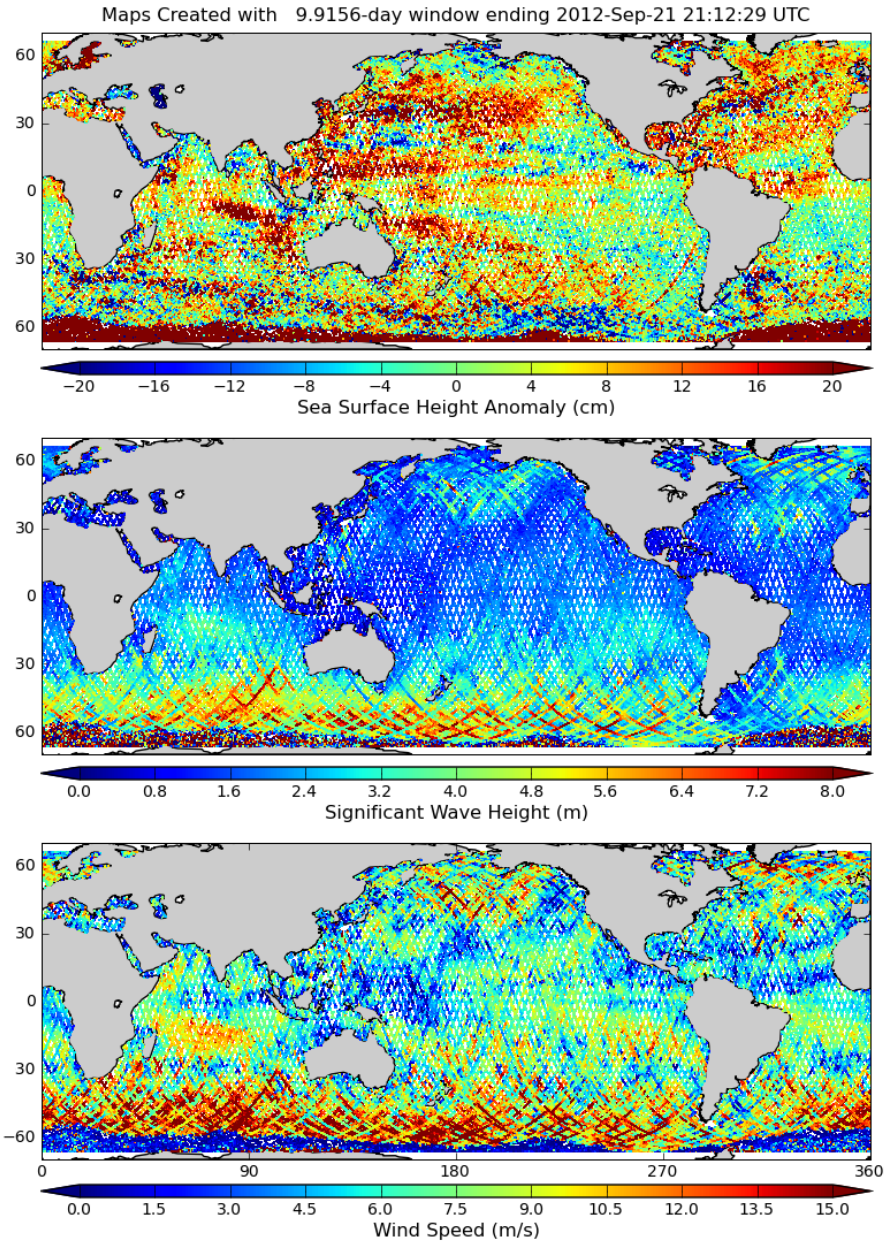
Near-Real-Time Data Products

JPL has developed a NRT SSHA / Wave / Wind product that combines the OSTM/Jason-2 and Jason-1 NRT data.

TOP: Combined JA1+JA2 10-Day NRT SSHA

MIDDLE: Combined JA1+JA2 10-Day Sig. Wave Height

BOTTOM: Combined JA1+JA2 10-Day Wind Speed



Jason-1 Backup Slides

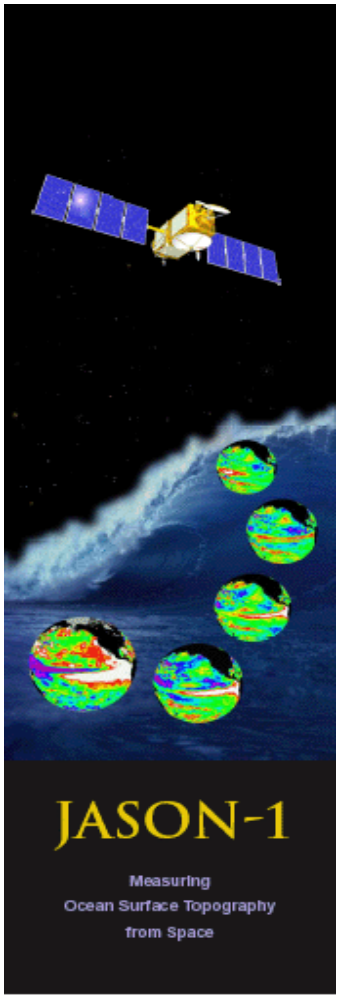
Jason-1 Orbit Change Operations Summary

Maneuver Details

Maneuver Number and Date	Predicted				Realized			Estimated		
	1st Thrust	2nd Thrust	Δa	Mass budget	1st Thrust	2nd Thrust	Δa	Mass cons.	Mass in the tank	Gr used for Δ1 m/s
1st 25 Apr.	592s -1.8 m/s	598s -1.8 m/s	- 7.6 km	798gr	592s ~ 1m/s	598s ~ 1.3m/s	~5 km	798gr	3.38kg	340 gr
2nd 26 Apr.	595s -1.1m/s	599s 1.1 m/s	- 4.9 km	935gr	360s ~ 0.4m/s	599s ~ 1.1m/s	~ 3,3km Δe +	866gr	2.48kg	562 gr
3rd 29 Apr.	599s -1.1 m/s	413s -0.8 m/s	- 4.9 km	654gr	274s ~ 0.4m/s	355 s ~ 0.6m/s	~ 2 km Δe ++	736gr	1.75kg	751 gr
4th 1 May	268 s -0.5 m/s	268 s -0.5 m/s	-2.1 km Δe --	342 gr	222s ~ 0.4m/s	268s ~ 0.4m/s	~ 1,3 km Δe -	1065gr	680 gr	1479 gr
5th 2 May	208 s -0.4m/s		-0.8 km Δe --	129 gr	73s ~ 0.1m/s		~ 0.2 km e near target	340 gr	340 gr	3400 gr

Needed for eccentricity correction

Jason-1 Instrument Status



- ***CNES provided two payload instruments for the Jason-1 mission:***
  - Altimeter (POSEIDON2)
  - Doppler Radio-Positioning (DORIS)
- ***NASA/JPL provided three payload instruments for the Jason-1 mission:***
  - Microwave Radiometer (JMR)
  - Laser Retroreflector Array (LRA)
  - Turbo Rogue Space Receiver (TRSR)

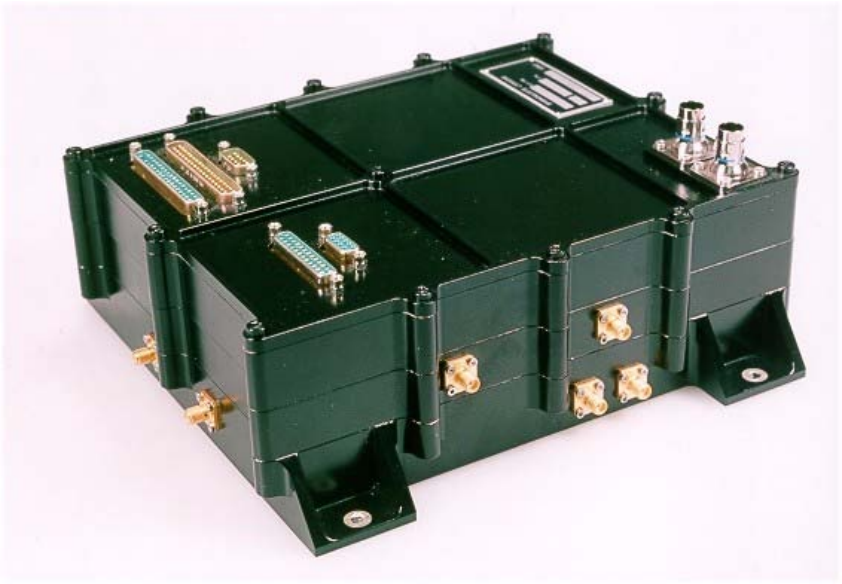
DORIS Status

DORIS

Switched from DORIS #2 to DORIS #1 on 28 June 2004 after USO instability was observed.

DORIS #2 is now redundant

DORIS #1 availability since last OSTST is >> 99%



DORIS IS FUNCTIONING NOMINALLY

Jason-1 DORIS Performance

- DOPPLER MEASUREMENT
  - Mean value for noise is **0.39-0.42 mm/s** (POE residuals) (**Stable**)
  - Still a "radiation USO effect" for "SAA Beacons"
    - Since Cycle 262, the SAA Effect Model for the DORIS Chain#1 has been updated to take into account the Jason-1 orbit change
    - **This model will be adapted for the geodetic orbit.**
- DORIS Time-tagging of PPS performances (**Stable**)
  - Used for altimeter data
    - *Requirement = **100 μs** for OSDR , **10 μs** for IGDR*
    - **Accuracy is ~2 microseconds** compared to on-board platform GPS
- Navigator (DIODE) performance are beta-prime dependent: (**Stable**)
  - daily radial RMS: **10 to 20 cm**
  - daily 3D-RMS: **40 to 70 cm**

POSEIDON-2 Status

POSEIDON-2

Chain #1 was turned on 10 December 2001.
Chain #2 is redundant and has never been used.

POSEIDON2 performance is nominal and stable for range and power.

POSEIDON2 availability since last OSTST is >> **99%**

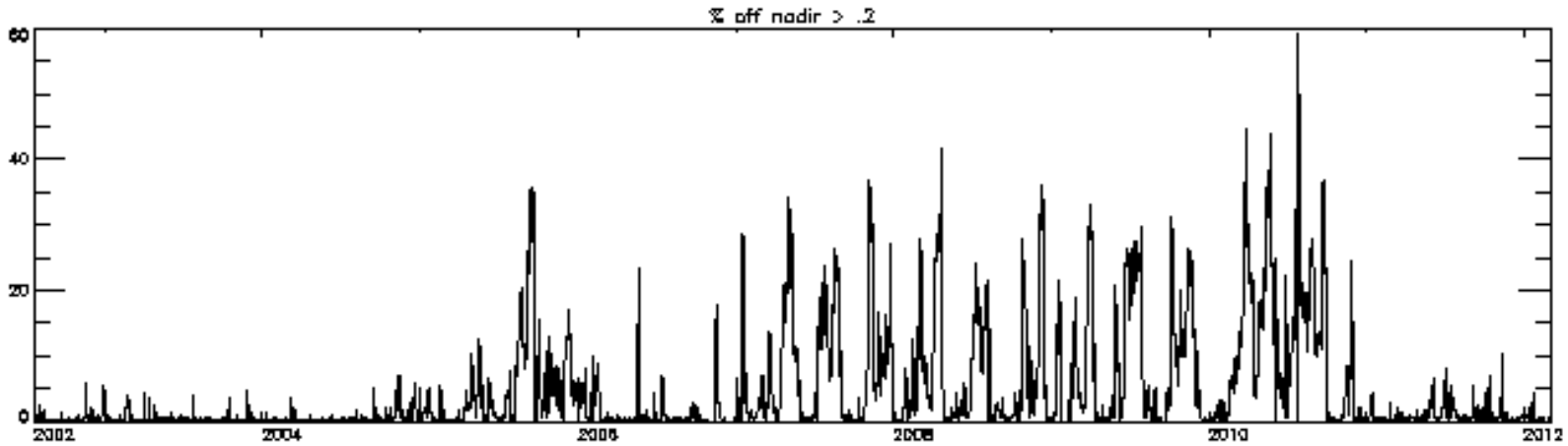
POSEIDON2-1 ALTIMETER IS FUNCTIONING NOMINALLY

New geodetic orbit required modification of the Pulse Repetition Frequency (PRF). The accuracy of this parameter has been improved in subsequent ground processing, impacting the range bias by -3.2 mm.

POS2 Altimeter Antenna Pointing Performance

Typical value : below 0.07° *(requirement < 0.2 °)*

Significant improvement off OFF NADIR performance after end 2010 implemented actions: still very good



OFF Nadir

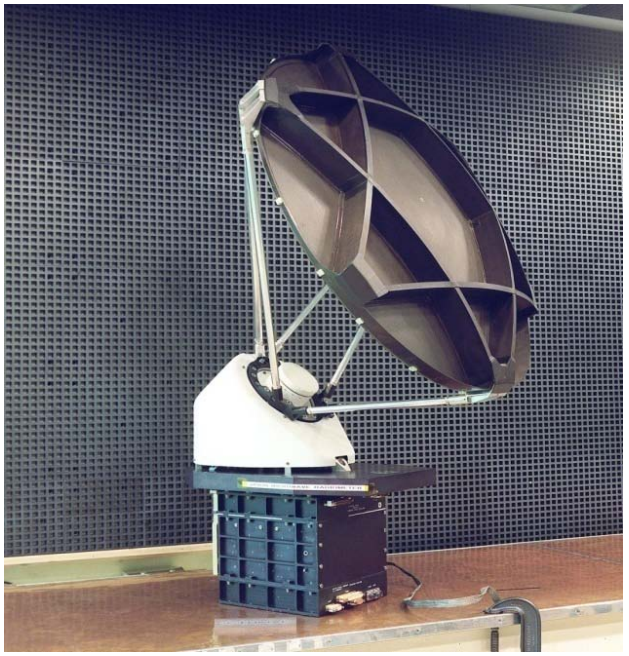
% of the points per day with dispointing > 0.2°

Improvement since 2010

Jason-1 Microwave Radiometer (JMR)

Presentation contributors:

- Shannon Brown, JPL
- Shailen Desai, JPL



Summary:

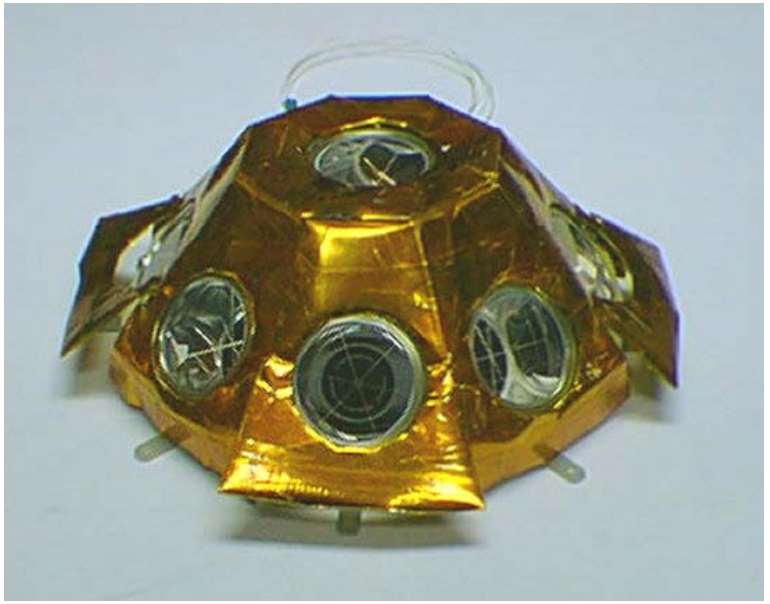
- JMR continues to operate nominally
- No Alarms
- No Commanding
- No engineering anomalies since launch
- Three confirmed science anomalies:
  - Cycle 31 and 68 anomalies was corrected in Version B GDRs
  - Cycle 136 anomaly was corrected in Version C GDRs
  - Replacement products available for Cycle 242 and Cycle 285 anomaly. Cycle 285 anomaly corrected on current GDRs.
  - Post 2012 SHM recalibration was required prior to the processing of future GDR products.

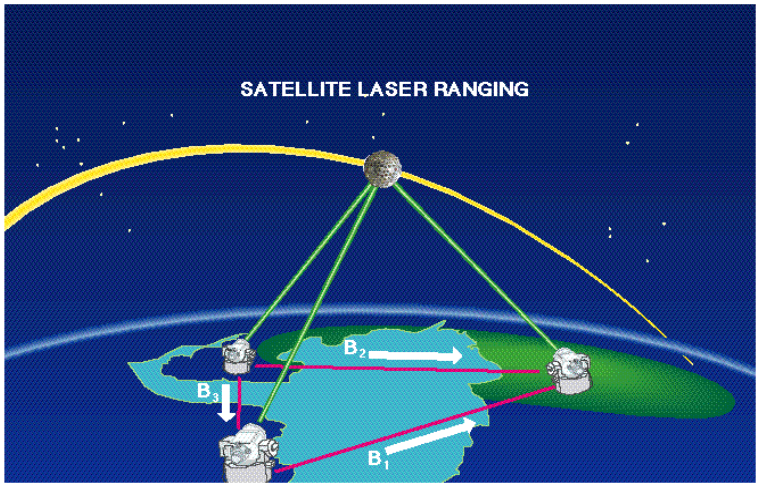
Laser Retroreflector Array (LRA)

Summary:

- The LRA continues to provide returns adequate for tracking.
- SLR Tracking of Jason-1 has been nominal. (Tracking maintained during extended SHM in 2012.)
- LRA Returns are the same power as Jason-2.
- The top five stations for Jason-1 tracking are:

  Yarragadee *(Australia)*
  Zimmerwald *(Switzerland)*
  Changchun *(China)*
  Mt. Stromlo *(Australia)*
  Herstmonceux *(U.K.)*

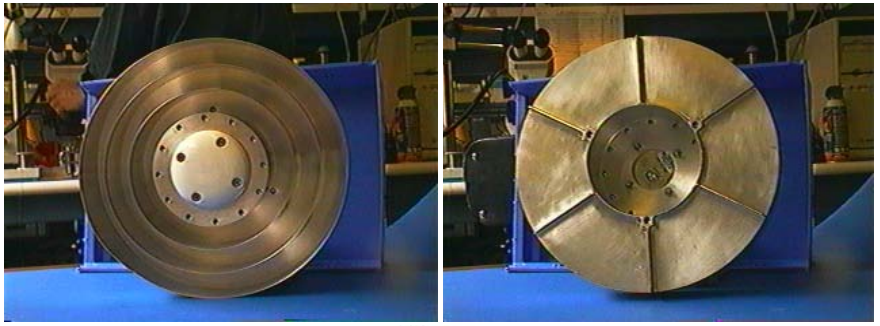




Turbo Rogue Space Receiver (TRSR)

Presentation contributors:

- Walton Williamson, JPL
- Angie Dorsey, JPL
- Tim Munson, JPL
- Glenn Shirtliffe, JPL



Science contributors:

- Bruce Haines, JPL
- Shailen Desai, JPL
- Willy Bertiger, JPL

Summary:

- TRSR1 (redundant receiver) experienced a critical failure during a software upload in September 2006 and will remain powered off.
- TRSR2 (primary receiver) experienced a critical failure during nominal operations in April 2009 and will also remain powered off.
- The TRSR instruments are NOT critical to mission success.
- **All Level 1 science and POD requirements can be met using DORIS and SLR.**

Jason-1 Product Generation and Dissemination Performance

Product	Mission requirement	Effective performance
OSDR latency (JSDS only)	*Production duration :* *- 75% within 3 hours* *- 95% within 5 hours*	Availability measured at CNES level : - **92.5 %** in less than 3 hours - **97.2%** in less than 5 hours
IGDR latency	*Production duration : 3 to 5 days*	At user level : - **97.13 %** in less than 3 days - **99.29 %** in less than 5 days - 100 % over 5 days
GDR latency (POE processing dependant)	*Delivery Requirement : 30 days*	***Within requirements*** *except during exceptional maneuvers period*

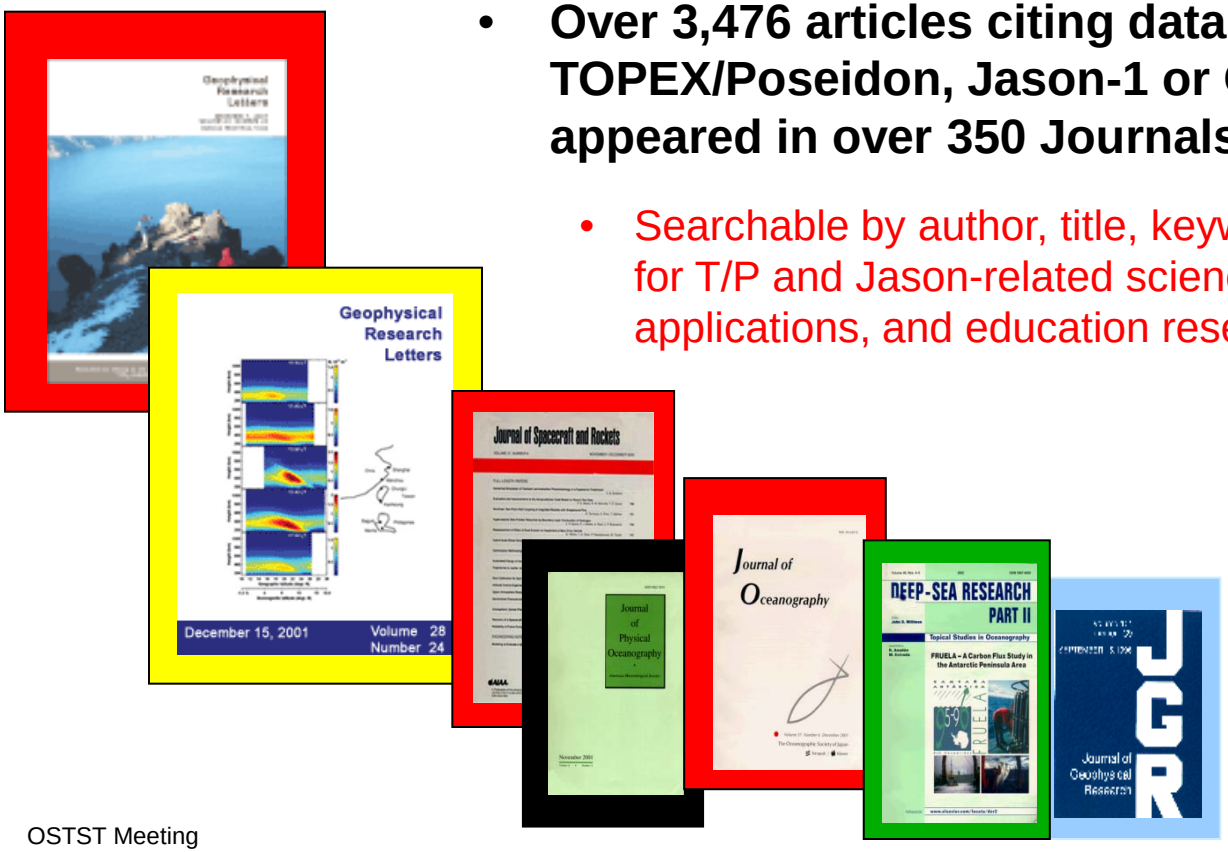
Jason-1 Payload Summary

Payload Instrument [Data Return Rating]	Current Status	Estimated Lifetime Remaining
Poseidon-2 [>> 99%]	**Both prime and redundant sides are nominal.**	**> 3 years.**
DORIS [>> 99%]	**DORIS-1 unstable, (but still provides redundancy.)**	**> 3 years.**
	DORIS-2 nominal.	
TRSR [LOST]	**TRSR1 lost. (Sept-06)**	**No remaining life.** Not mission critical. Not required for POD.
	TRSR2 lost. (Apr-09)	
LRA [100%]	**Nominal, no degradation.**	**No lifetime limitation.**
JMR [100%]	**Both prime and redundant sides are nominal.**	**> 3 years.**

TOPEX/Poseidon, Jason-1 and OSTM/ Jason-2 Science/Outreach Success

T/P, Jason-1, and OSTM/Jason-2 open literature database is available on-line:

http://sealevel-lit.jpl.nasa.gov/science/search-form.cfm



- **Over 3,476 articles citing data utilization from TOPEX/Poseidon, Jason-1 or OSTM/Jason-2 have appeared in over 350 Journals or Publications**
  - Searchable by author, title, keyword, abstract, & category for T/P and Jason-related science, engineering, applications, and education research from 1990-present

TOPEX/Poseidon, Jason-1, OSTM/Jason-2, Jason-3, and SWOT: Onward and Upward!

- **Efforts are underway to reprocess the entire TOPEX/Poseidon dataset to GDR-C standards in NetCDF data formats.**
- OSTST input will be critical to ensure that a continuous validated data record is available.
- Scientists, NASA, and CNES must continue joint efforts to demonstrate the applications and value of ocean science to the public.
- Societal benefits will define NASA/CNES strategy for long-term ocean climate observing systems.