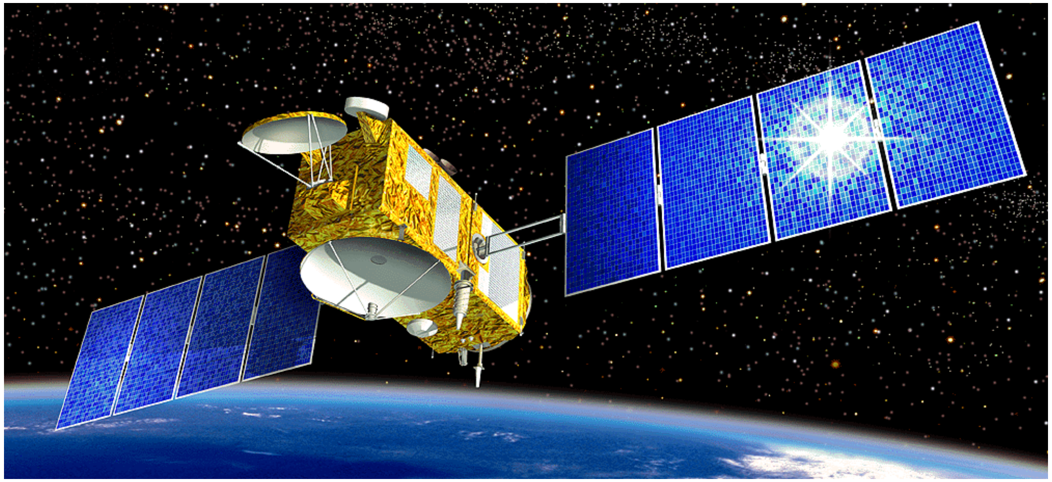
OSTM/Jason-2 Mission overview

CNES, NASA,
NOAA, EUMETSAT



OSTST meeting - Nice

Presented by G. Zaouche - CNES

Launch and Early in Orbit Phase

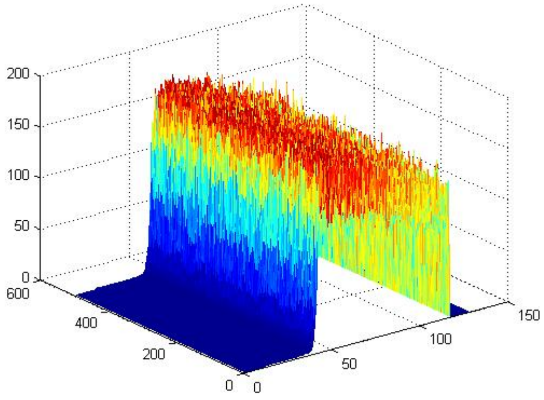
JASON-2 was launched successfully from VAFB on June 20, 2008 at 07:46:25 UTC

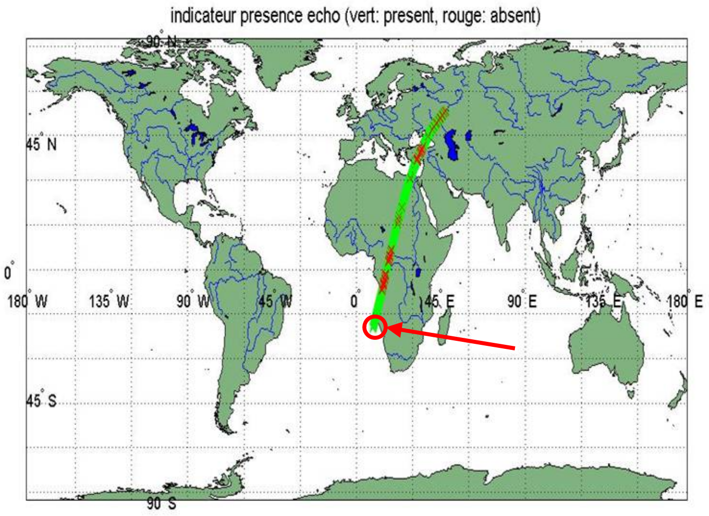
- **Separation from the launcher at 8:41:32 UTC during HBK station visibility**
- **End of LEOP (all equipment and instruments fully operational) :**
  June 22 14:00 UTC- i.e. about 2.5 days after launch

Payload instruments :

- **DORIS powered ON June 20 18:44:45 UTC**
- **POSEIDON-3, AMR, GPSP, CARMEN2, LPT powered ON June 22 between 11:00 UTC and 13:30 UTC**
- **T2L2 powered ON June 25 10:45:14 UTC**

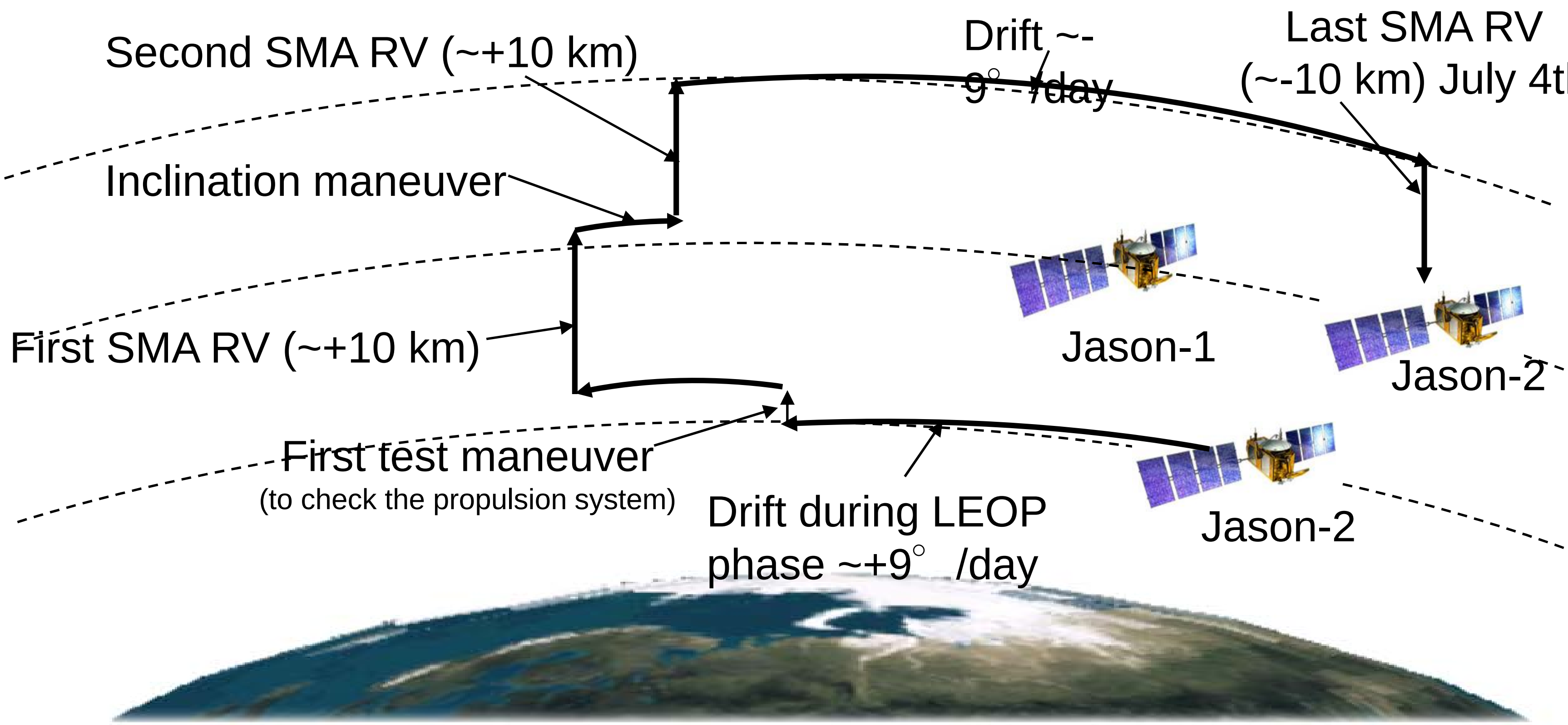
First altimeter echoes acquired and processed on June 22





Jason-2 station acquisition

- **Jason-2 final orbit characteristics :**
  - semi axis = 1336 km; inclination = 66° (same ground tracks as Jason-1)
  - Jason-2 : 54 seconds behind Jason-1 (along-track distance is around 375 km)
- **Injection orbit = 10 Km lower than the final orbit**
- **3 semi-major axis rendez-vous maneuvers (SMA) needed to reach the final orbit : 15 days from Launch**

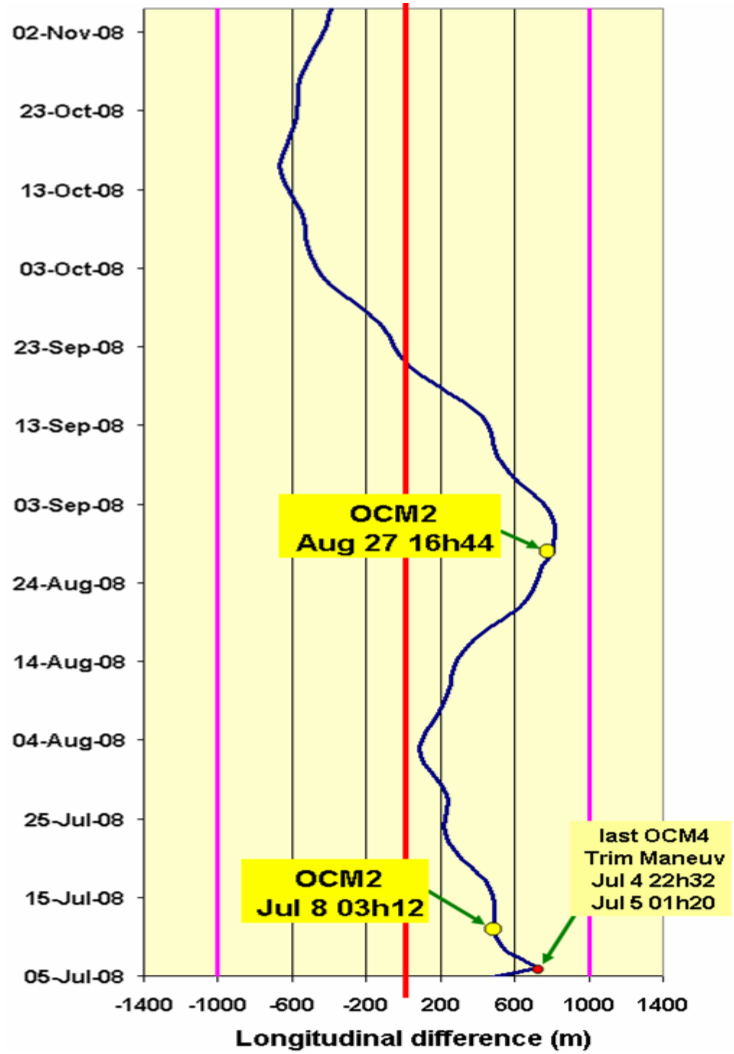


Jason-2 Station keeping

Station keeping maneuvers since July 4th

- Jason-2 ground tracks are maintained within ±1km from the reference grid

- Improvement wrt Jason-1 :
for Jason-2 station keeping, maneuvers are made with only one thrust above earth on any orbit (with 2 thrusts and on the last orbit of the 10-day cycle for Jason-1)



Conclusion :

- *For station acquisition and station keeping, all operations have been performed according to the planned strategy*

- *Total Hydrazine consumption : 3.5 kg, 24.8 kg left*

Satellite in-flight performances

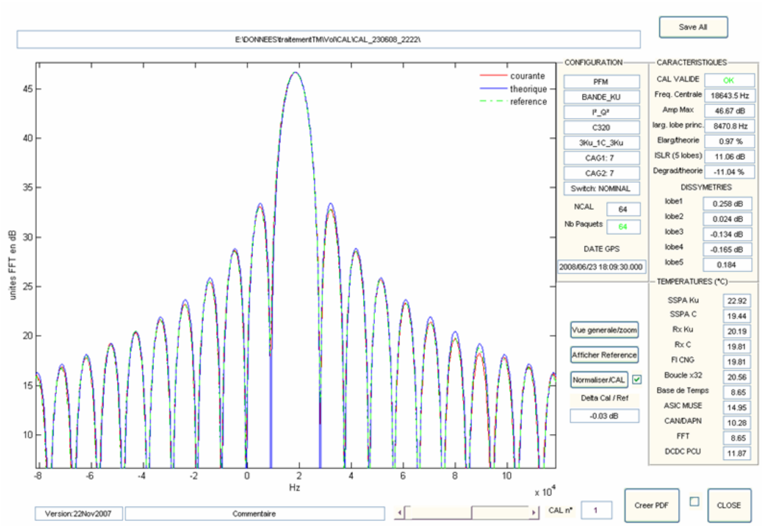
- **Thermal aspects:**
  - Active thermal control works successfully
  - All the units are inside their temperature limitation
  - Thermal behavior well predicted in terms of temperature, stability and heating power needs
  - Satellite thermal control is sized with significant margins to meet further worst case conditions
- **Mechanical aspects:**
  - Dynamic environment derived from flight data is enveloped by Spacecraft qualification
  - Good performance of the OSTM/Jason 2 SoftRide System (reduces the mechanical levels at the interface launcher : satellite)
- **Electrical aspects :**
  - Satellite power is within the estimated satellite power consumption budget.
  - Satellite consumption is within the power and energetic budget
- **Command / control , RF :**
  - On-Board Software, Mass Memory : nominal behavior
  - Jason2 Telemetry &Telecommand system is fully operational and behaves as expected
    - Good margins for TM download time and TC upload performances
- **AOCS (attitude and orbit control system) :**
  - All AOCS units work nominally, the functional behavior and performances are as expected:
  - AOCS control laws work as expected

Poseidon-3 Altimeter

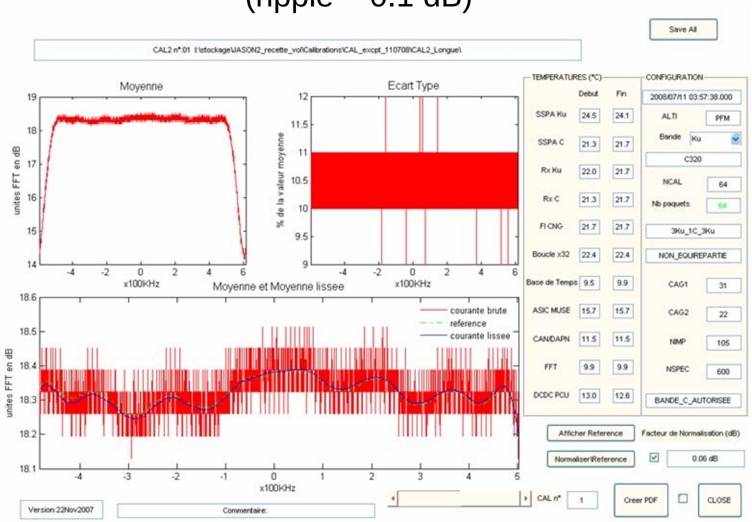
- POS-3 powered ON 22 June 2008 at 11:12:39 UTC.
  - All mode commands have been exercised
  - Engineering telemetry nominal since power-on.
  - No Flight Software errors.
  - Good temperature stability over one orbit (about 1°C)
  - All requirements are met

- In flight calibration results are in very good agreement with ground references, and no time variation has been observed

CAL1 (Ku Band)



CAL2 (Ku Band)
(ripple ~ 0.1 dB)



POS-3 Range Tracker improvements:

1. "Median Tracker algorithm " (Pos2 based on "Split Gate Tracker algorithm", well adapted to ocean surfaces but performing poorly over other surfaces, in particular for specular echoes)
   - to improve data availability on coastal zones (water/land transitions) and on continental waters (lakes)
2. Signal acquisition using real time DORIS/DIODE altitude data + usual on-board tracker :
   - to reduce the delay to get echoes after a land-water transition (2 to 3 times shorter)

(1 + 2 : Tracking mode referred as "**Median Tracker**")

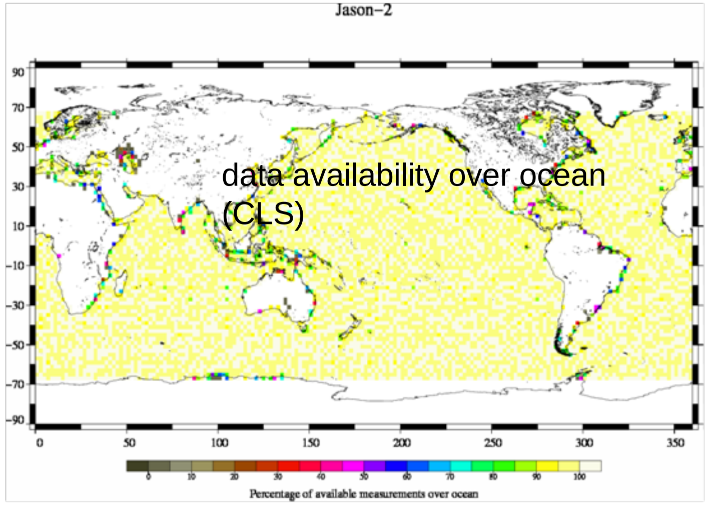
3. Open loop : Range directly computed from DIODE altitude data + Digital Elevation Model data
   - DEM data stored on-board, representative of oceans, lakes and rivers, and flat land areas (limited zones due to POS3 data storage capability)
   - to increase data availability on coastal, inland water areas, and possibly on selected land surfaces

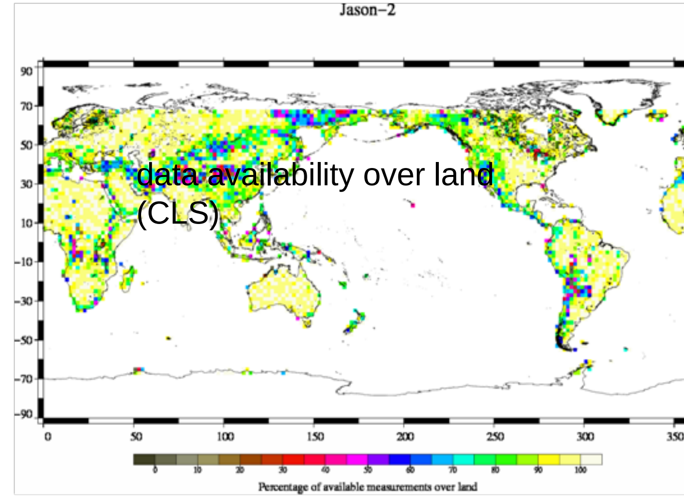
(Tracking mode referred as " **DIODE/DEM** ")

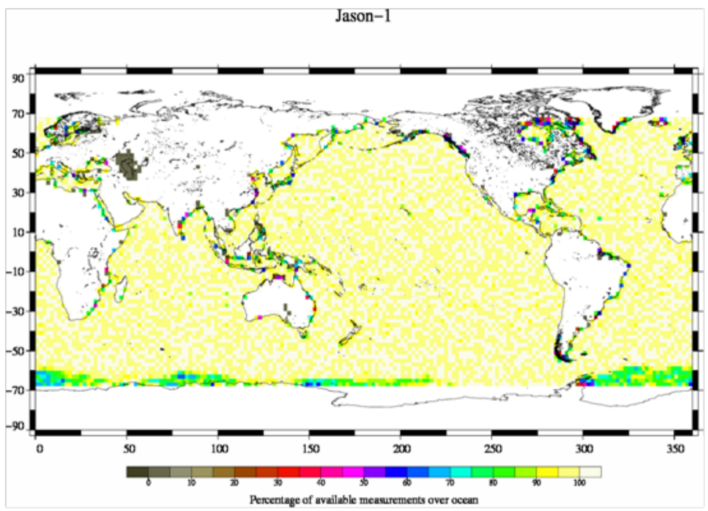
POS-3 Range Tracker evaluation

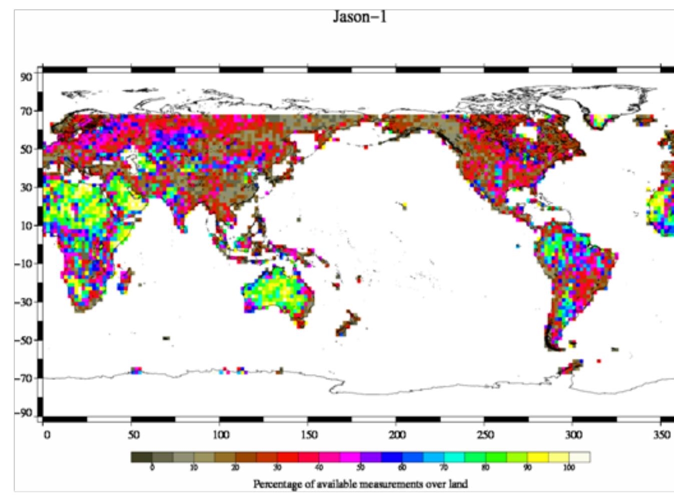
- **Median Tracker gives very good results compared to Jason-1 SGT:**
  - Robust to ice and land pollution

  -> More data available at high latitudes, over coastal zones and inland waters





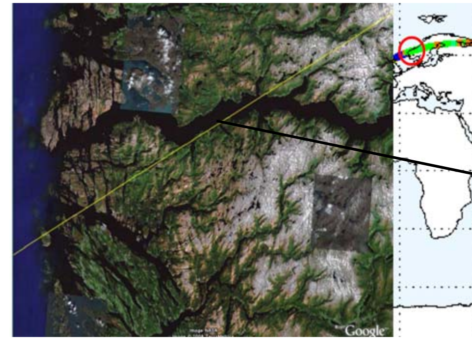


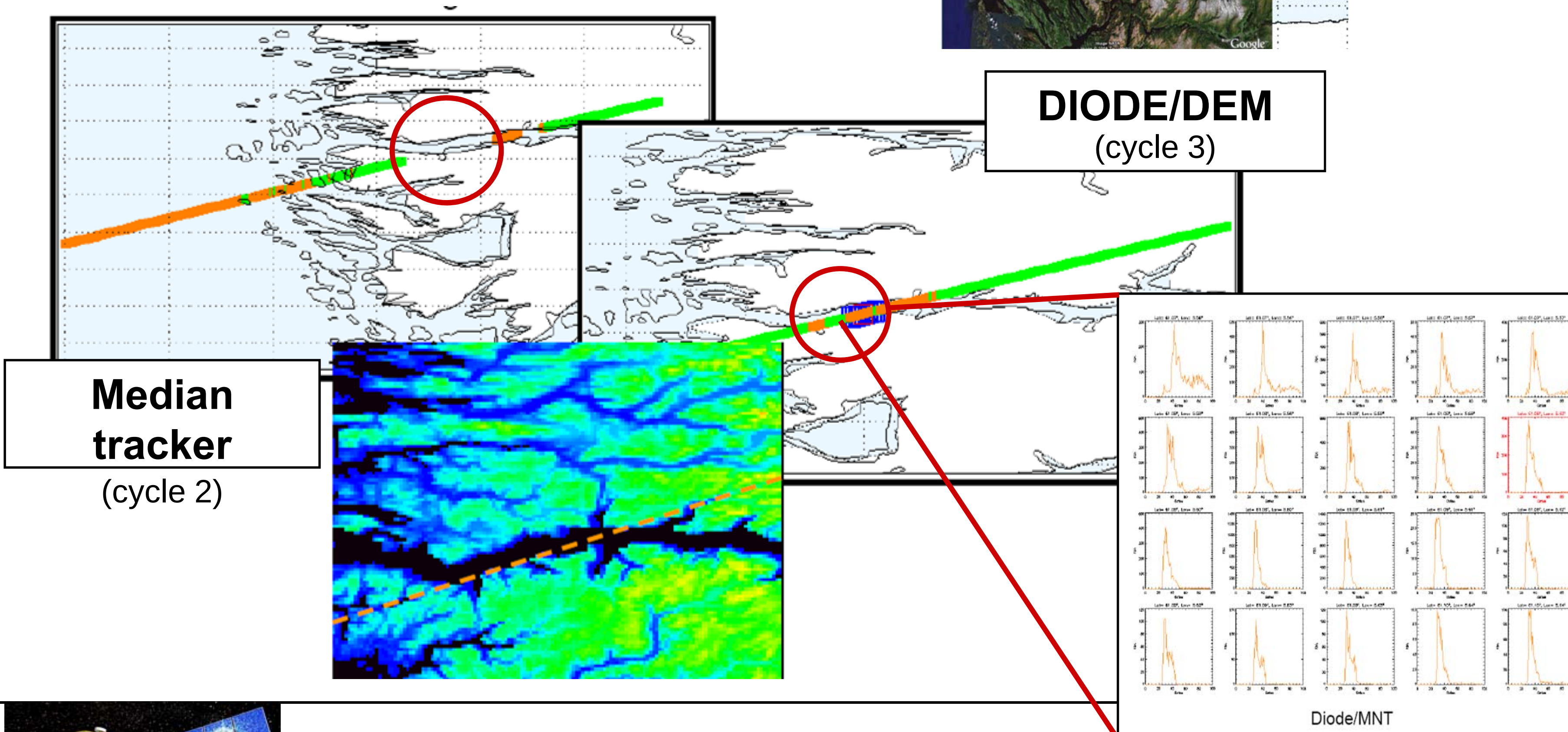


POS-3 Range Tracker evaluation

In-Flight validation of DIODE/DEM mode

Coastal zones : example in **Norway (fjords)**





Performance of DIODE/DEM vs MEDIAN mode:

- **Advantages of DEM**
  - good behavior of the DIODE/DEM mode *wrt* nominal median mode, over coastal and inland water, especially in strong relief regions (loss of data in nominal mode)
  - good (as expected) behavior of the DIODE/DEM mode for tracking water when not at nadir (but still in the altimeter footprint) - priority given to water surfaces through this slant view
- **Limitations of DEM**
  - incomplete observability of water areas (some inland water zones missing in the GMT landmask)
  - altitude precision limited over inland waters (ACE1 used to generate DEM)
  - incomplete coverage of land areas
- **Planned improvements**
  - use of a more complete landmask
  - Inland waters altitude update by using an updated version of Hydroweb / other hydrology dababases / median mode Jason-2 data
  - ACE update (ACE version2 soon available)
- After upgrade the new DEM will be uploaded on-board Pos-3 and evaluated.

Performance of DIODE/DEM vs MEDIAN mode - Summary

Ocean	=	Same performance
Coastal	+	better performance for regions with strong relief
Lakes	≠ +	differences at the border of lakes / better performance for lakes in strong relief
Lands	- -	less valid measurements

Current mode for Jason-2 : Median Tracker

- will be kept until the updated DEM is available.
- final altimeter mode will be selected after new DEM evaluation

DORIS

- DORIS receiver powered ON 20 June 2008 at 18:44:45 UTC.
- Engineering telemetry nominal since power-on.

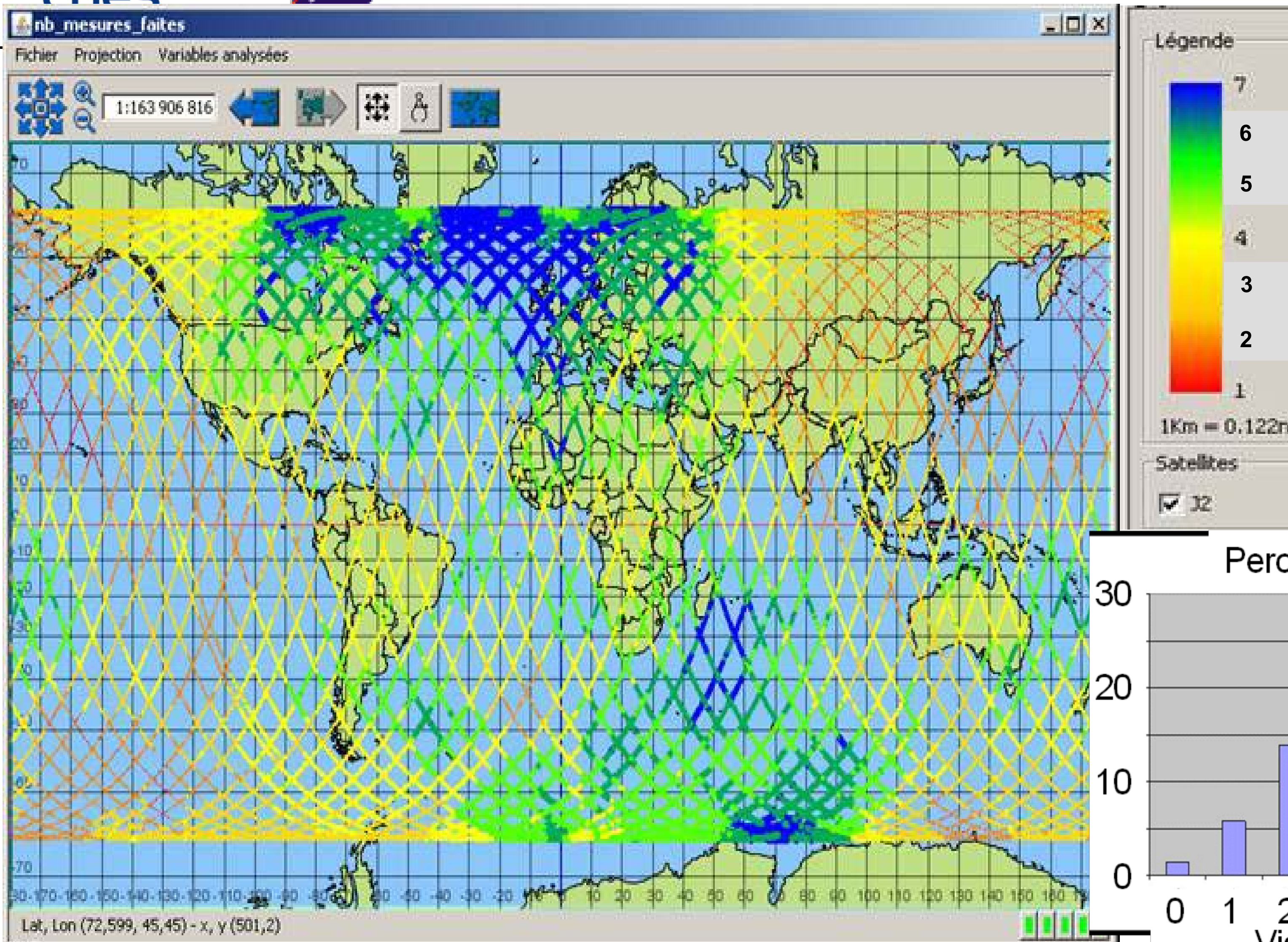
DORIS Jason-2 improvements :

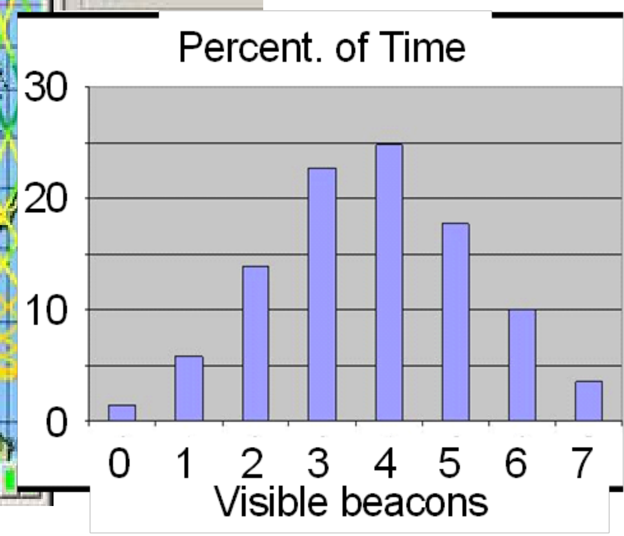
- **7 Dual frequency channels**
  - capacity to track up to 7 beacons simultaneously
    - Increases data quantity
    - Makes available low elevation measurements
    - Improves passes distribution

- **Hardened USO**
  - Frequency stability trough SAA
    - better quality of MOE
    - Jason 2 useful for beacons location

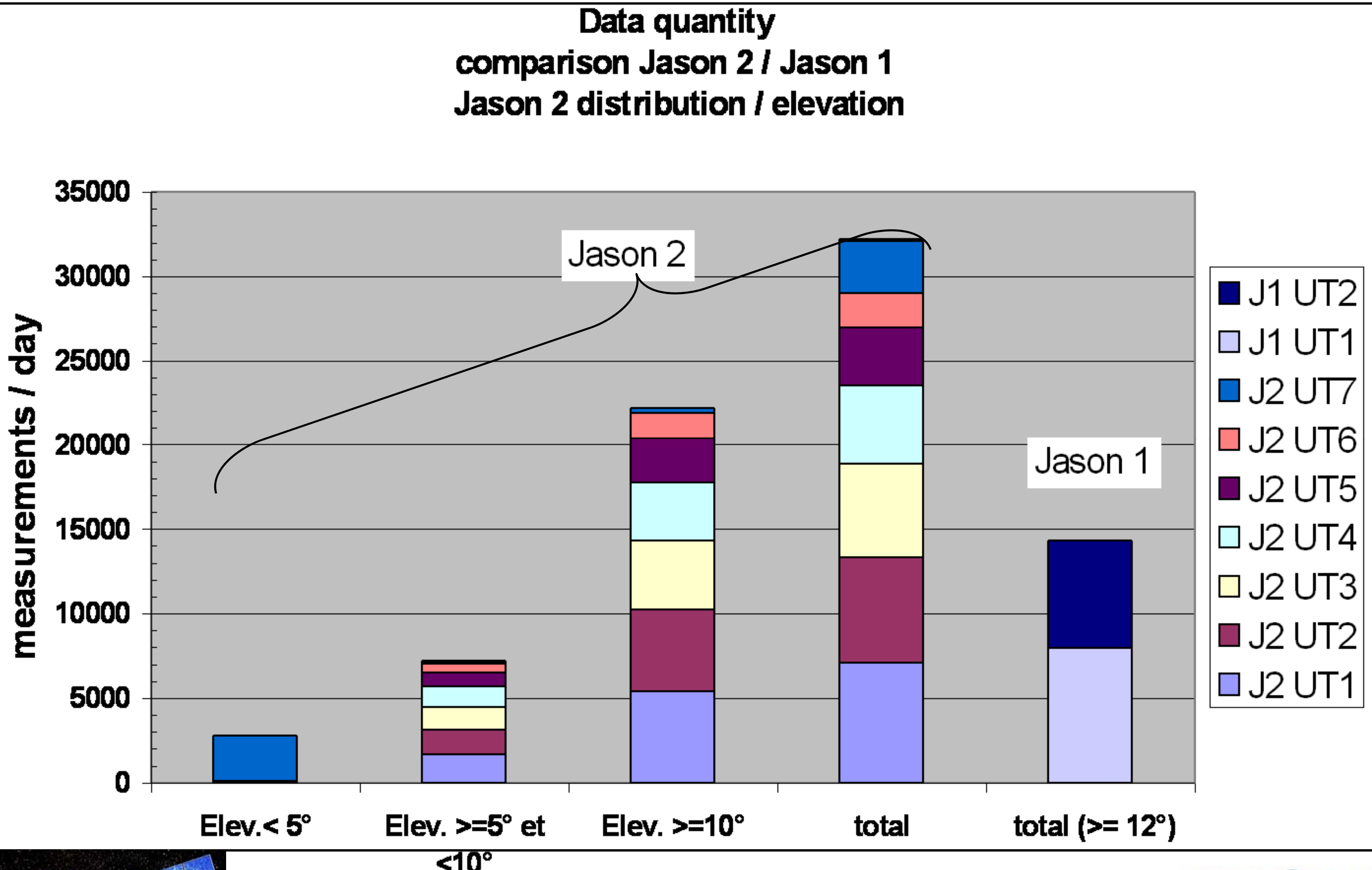
- **New DIODE Navigation software**
  - No more numerical limitation thanks to ERC32 processor
  - improved accuracy better quality of NRT products (OGDR)

DORIS coverage





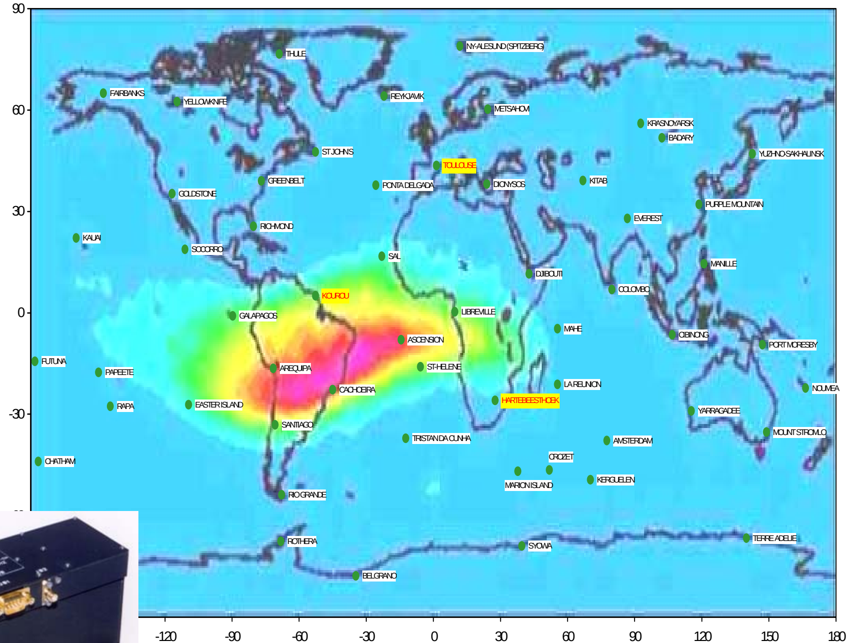
DORIS performances

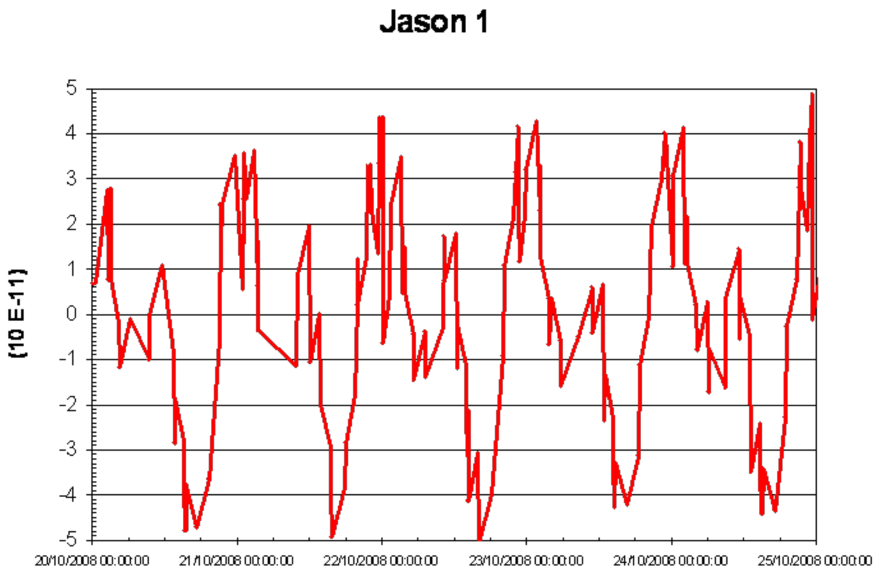


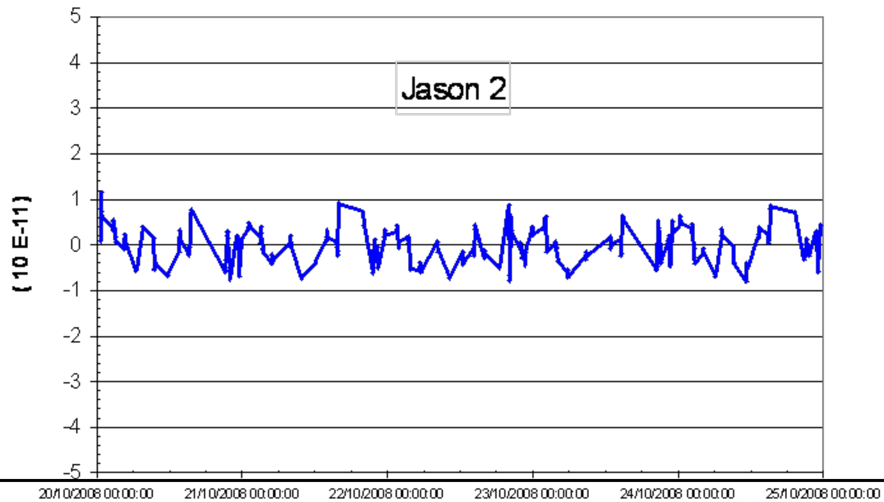
DORIS performances

The DORIS USO has been successfully hardened against radiation :

Comparison of Jason-1 and Jason-2 USO frequency variations when crossing SAA

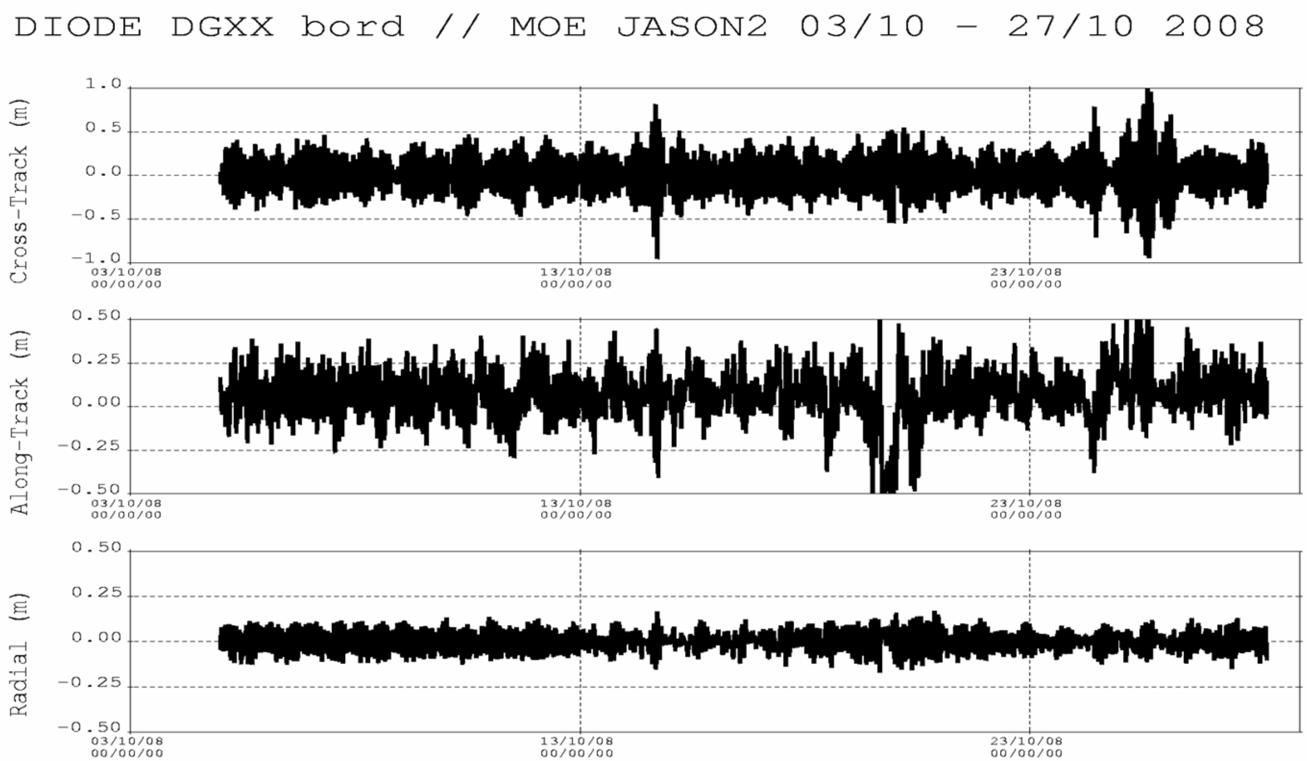






DORIS Navigator Performance

DORIS navigator accuracy has been dramatically improved wrt Jason-1.
Current performance (= OGDR orbit performance) :



STATISTICS

RMS = 0.217 m
MAX = 1.034 m

RMS = 0.136 m
MAX = 0.615 m

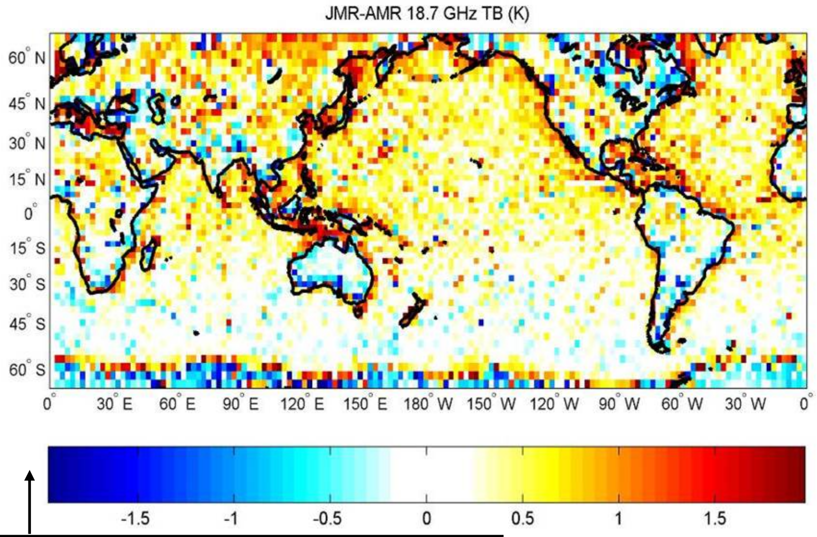
RMS = 0.055 m
MAX = 0.171 m

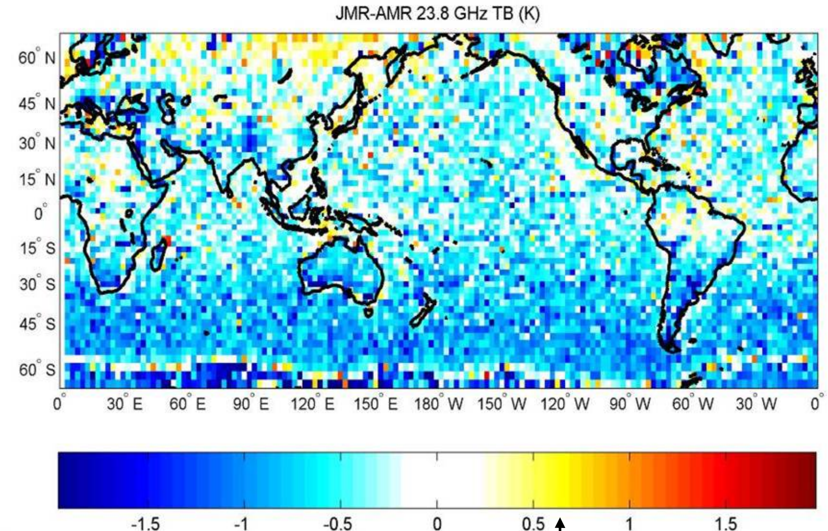
Advanced Microwave Radiometer (AMR)

- AMR-H (Primary Side) powered ON 22 June 2008 at 11:38:05 UTC.
  - **AMR operational mode command processed at 11:40:02 UTC.**
  - **CTA (S/C Thermal control) operating nominally.**
- Engineering telemetry nominal since power-on.
  - **Performance-critical receiver and noise source temperatures stable to 0.6°C peak to peak (better than 0.2°C p-p in sine yaw mode).**
- Receiver gain and reference load counts nominal on-orbit
- Noise Diode ratios stable to much better than 0.1 % over first 60 days
- Most variation is due to temperature change which is accounted for in the calibration
- No significant detectable drift in AMR cold reference TBs over first 60 days
- All channels within 0.5 K of target value based on initial AMR calibration
- The AMR thermal performance is trending as expected and compares well with pre-launch predictions
- Thermal control is fully meeting requirements

AMR TB Comparisons with JMR

- **Initial AMR calibration put TB in close agreement with JMR**

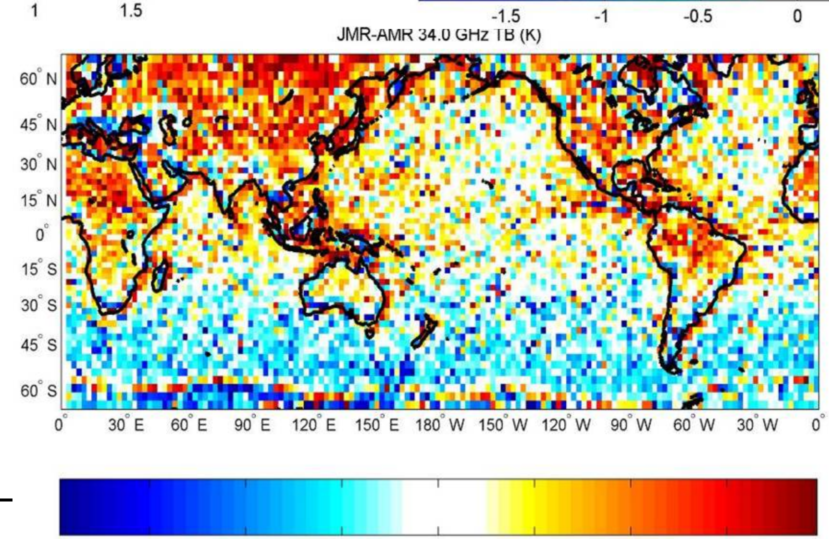




18.7 GHz JMR-AMR

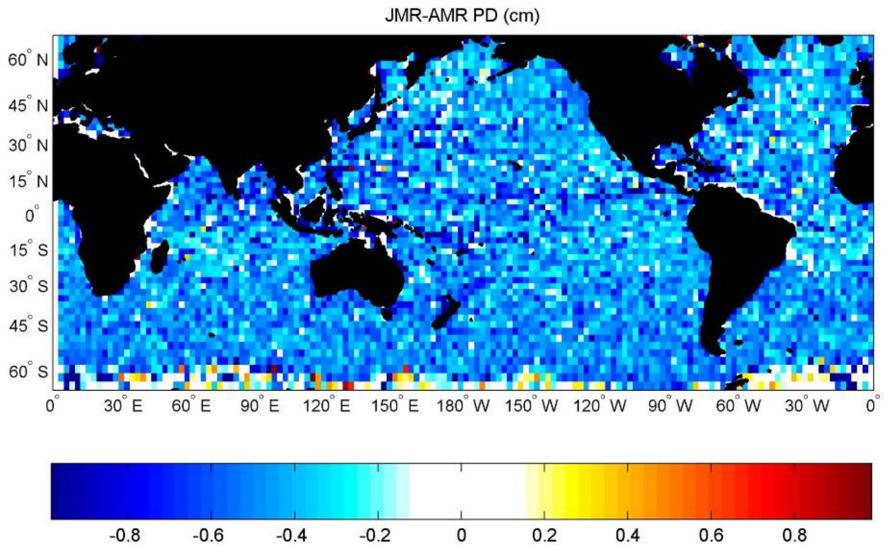
23.8 GHz JMR-AMR

34.0 GHz JMR-AMR

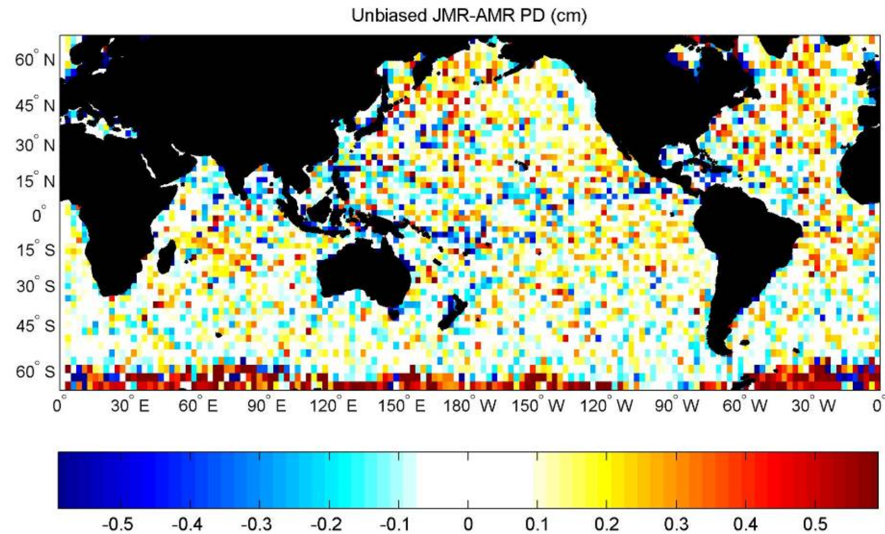


AMR PD Comparisons with JMR

- Path Delay bias between JMR and AMR is 4.5 mm (AMR wetter)
- Geographically correlated errors between JMR and AMR appear to be much less than 5 mm



JMR GDR-C - AMR v0 PD (cm)



JMR GDR-C -AMR PD w/ Bias Removed (cm)

AMR - Summary

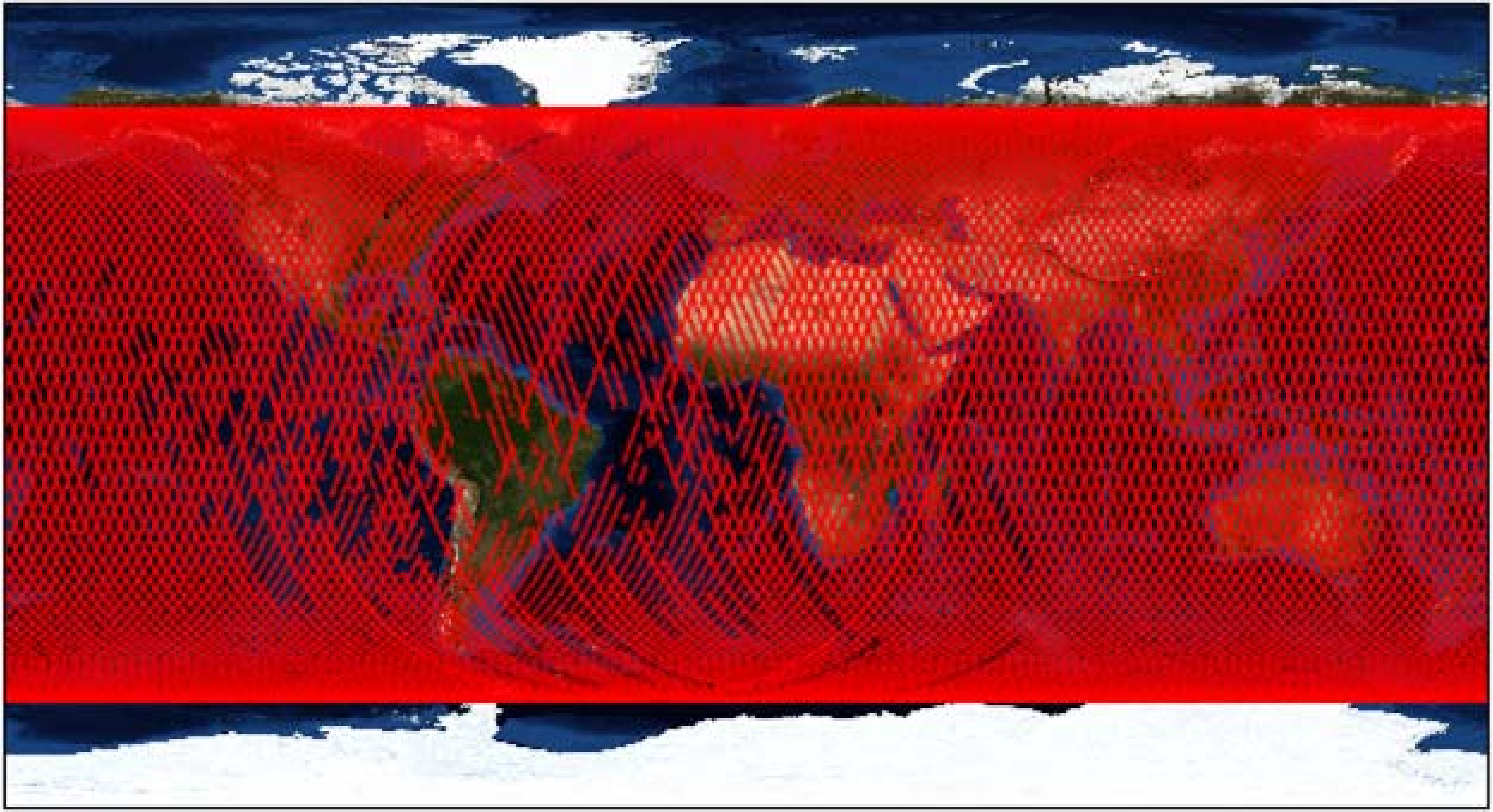
- **AMR-H (Primary Side) continues to perform excellently**
  - All analyses to date indicate that AMR is significantly exceeding its performance specifications
- **AMR Active thermal control minimizes thermal variations compared to JMR**
  - Benefit to both short term and long term instrument stability

GPSP

Engineering Assessment

- GPSP-A (primary) powered ON 22 June 2008 at 11:40:47 UTC.
- GPSP-A is healthy with all engineering parameters within operational limits
- Two periods of 1 Hz engineering data confirmed the receiver is operating as expected
- Heightened radiation sensitivity: GPSP-A is experiencing frequent (but small 1-2 minutes) loss of lock events in the South Atlantic Anomaly (SAA) causing multiple data gaps
  - Events result in a reset if a GPSP navigation solution has not been computed for 10 minutes (Very few software induced reset like Jason)
  - Most likely cause is a piece-part radiation sensitive component as GPSP is not built with radiation-hardened parts (know pre-launch risk)

GPSP - Data Locations



Points on map indicate locations where 4 or more GPS satellites are being tracked for the dates, Aug 10-19, 2008

GPSP POD Status

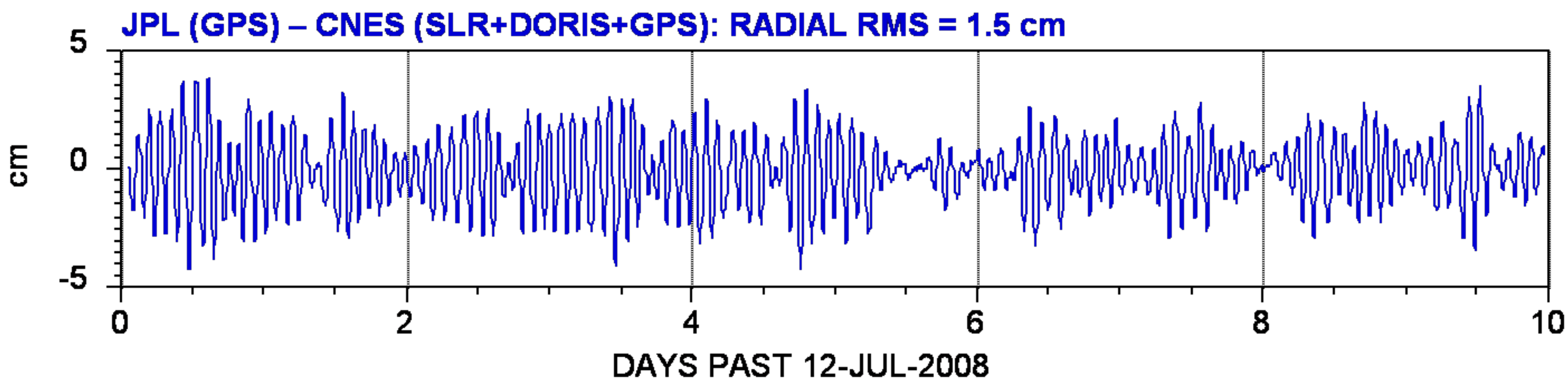
- **Tracking 8+ GPS satellites simultaneously (capped at 12)**

- **Temporal coverage of 95% over since start of Cycle 1**
  - Even with gaps over SAA, Similar temporal coverage to Jason-1
- **POD coverage of 100% should be attained**

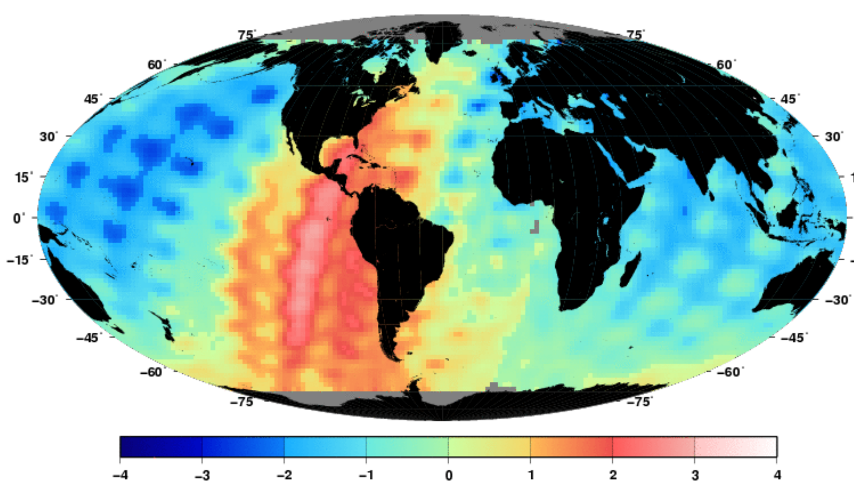
- **Quality of tracking data (point-to-point) is excellent**

- **Early GPS-based POD results are excellent**
  - 3-mm radial RMS overlap (daily solutions)
  - 12–21 mm radial RMS agreement with independent CNES solutions (Cycle 1)
  - 22 mm radial RMS agreement with GSFC SLR only solution (Cycle 1)
  - Near real-time POD process activated (analysis underway).

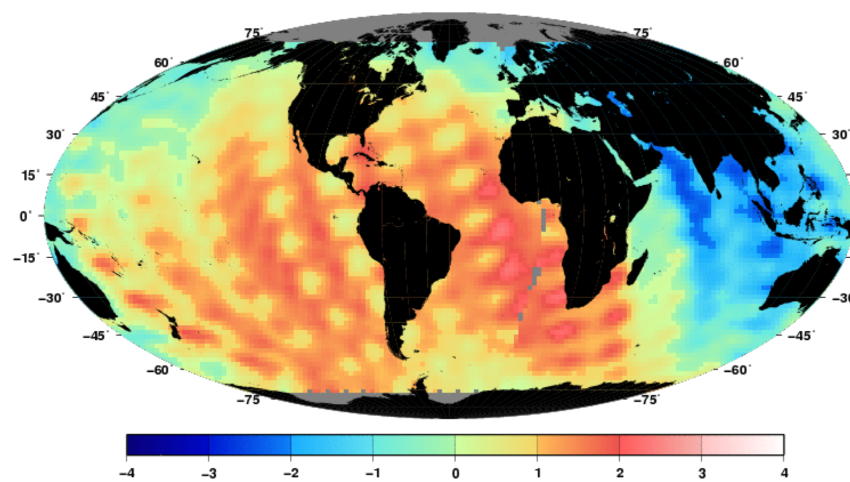
GPSP Radial Orbit Differences:
1.5 cm Agreement with CNES Solution



Cycle 1 JPL – CNES (Asc. RMS = 1.2 cm)



Cycle 1 JPL – CNES (Des. RMS = 1.2 cm)



SLR / LRA

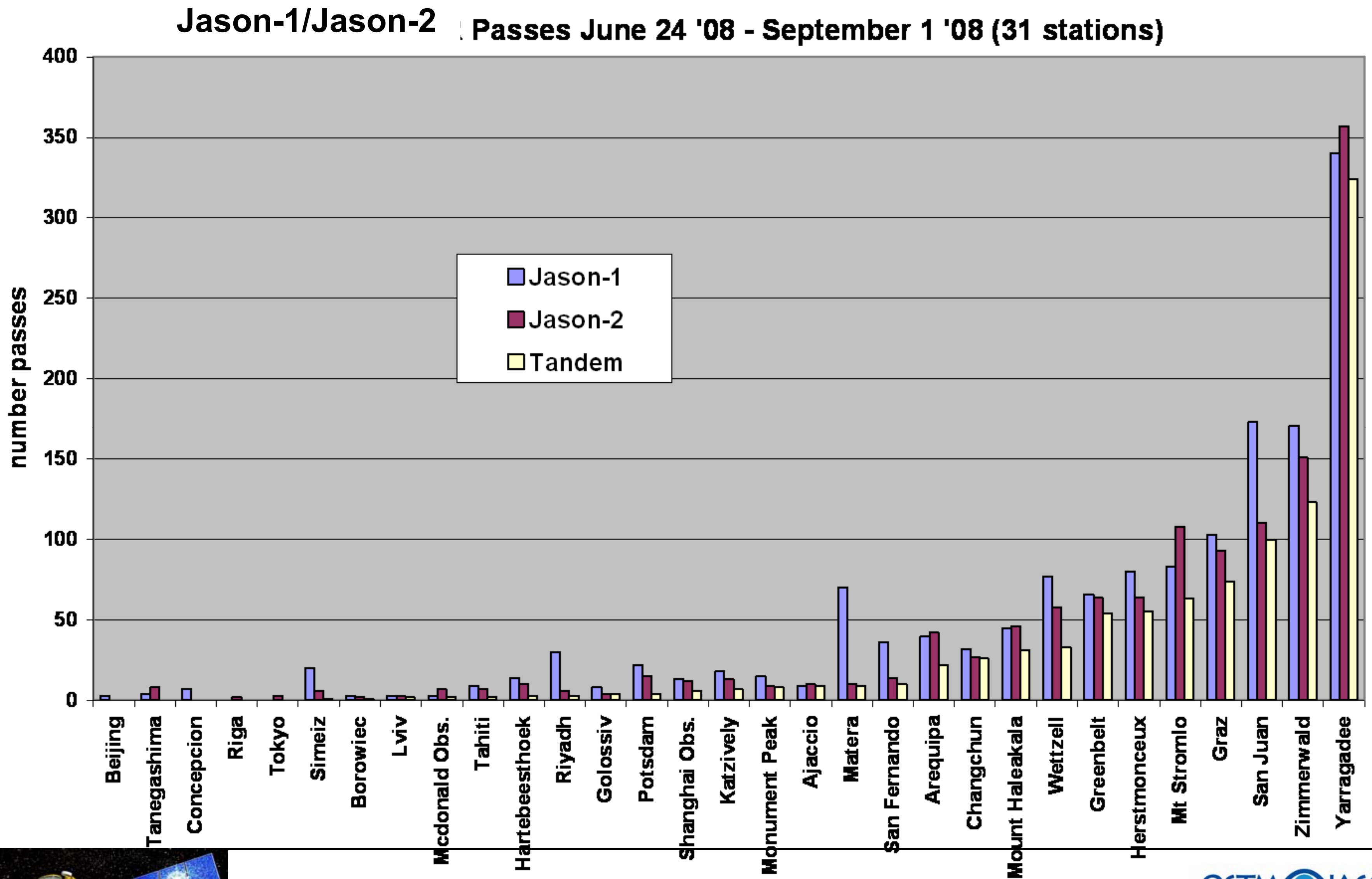
• SLR (Satellite Laser Ranging) Tracking of Jason-2 has been nominal.

• LRA Returns are the same power as Jason-1.

• Stations report no problems, and Many stations are tracking Jason-1 & Jason-2 in tandem mode (interleaving observations between the spacecraft during the same orbital pass).

• The Top stations for Tandem SLR tracking of Jason-1/Jason-2 (24 June to September 1, 2008) are Yarragadee, *Australia* (324 passes), Zimmerwald, *Switzerland* (123 passes), San Juan, *Argentina* (100 passes), Graz, *Austria* (74 passes), Mt Stromlo, *Australia* (63 passes) Herstmonceux, *U.K.* (55 passes) and Greenbelt, *U.S.A*. (54 passes)

SLR / LRA


Jason-1/Jason-2 Passes June 24 '08 - September 1 '08 (31 stations)
number passes
400
350
300
250
200
150
100
50
0
Jason-1
Jason-2
Tandem
Beijing
Tanegashima
Concepcion
Riga
Tokyo
Simeiz
Borowiec
Lviv
Mcdonald Obs.
Tahiti
Hartebeesthoek
Riyadh
Golossiv
Potsdam
Shanghai Obs.
Katzively
Monument Peak
Ajaccio
Matera
San Fernando
Arequipa
Changchun
Mount Haleakala
Wettzell
Greenbelt
Herstmonceux
Mt Stromlo
Graz
San Juan
Zimmerwald
Yarragadee

PASSENGERS STATUS
T2L2

CNES – CENTRE NATIONAL D'ÉTUDES SPATIALES · NASA · EUMETSAT · NOAA

T2L2 : Time Transfer by Laser Link

– Instrument is fully operational since Jun. 30 and is working properly (**powered ON 25 June 2008 at 10:45:14 UTC)**

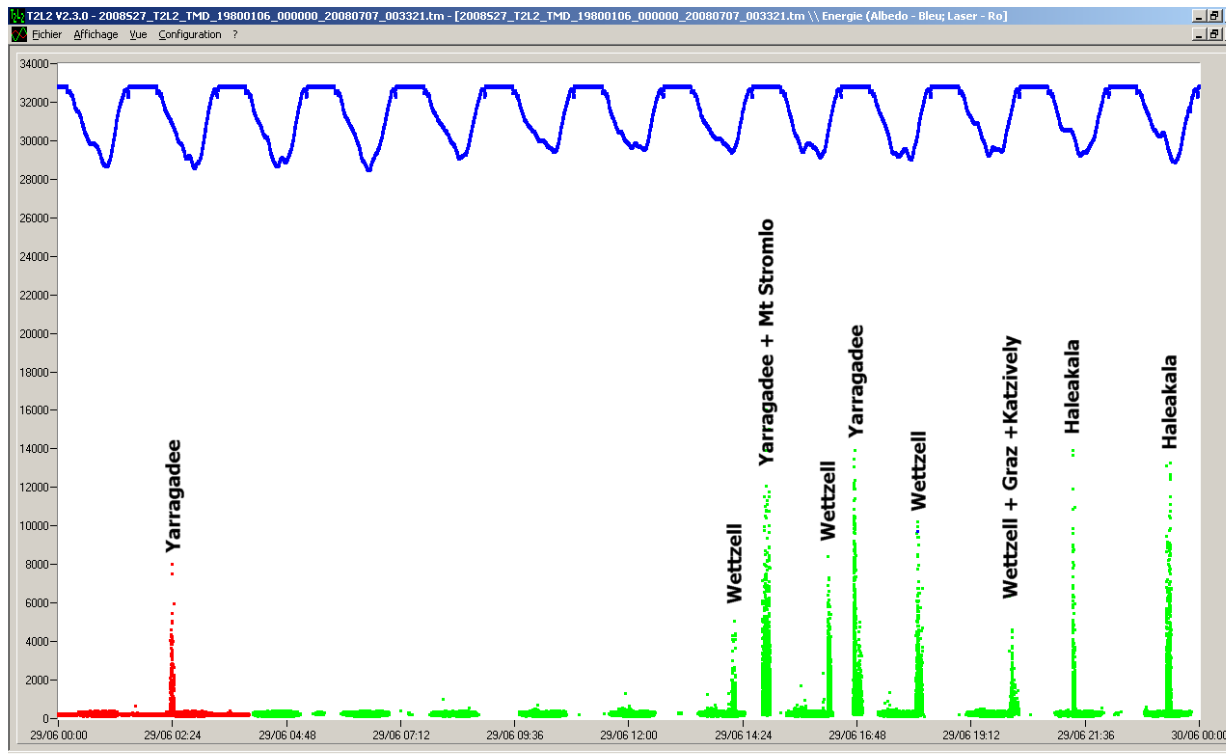
– In flight measurements are compliant with the instrument and system requirements

– **SLR** : Active participation to T2L2

– Science Mission Center is operational
  - Reconstitution of triplets is working properly
  - Waiting for first Time Transfer : expected next months

– Ground to Space time transfer computation
  - First Ground to Space time transfer (w/o any correction) : RMS < 1 ns

– DORIS frequency restitution : see dedicated presentation in IDS symposium



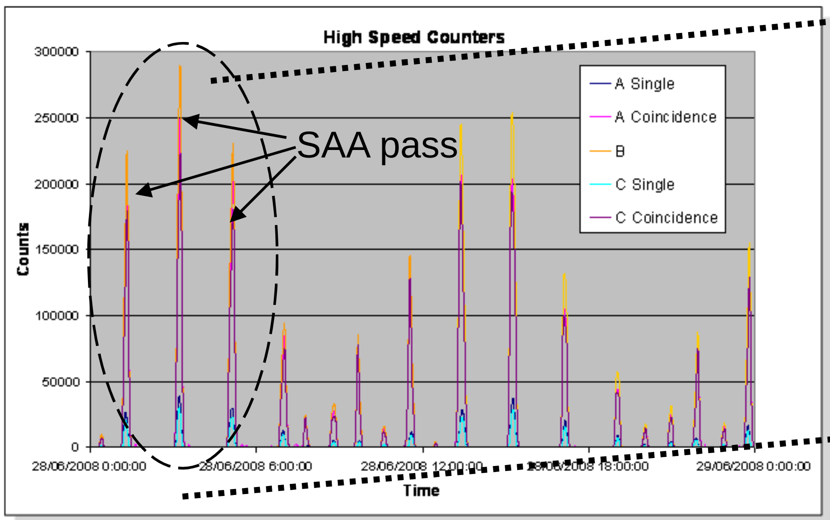
OSTM JASON-2

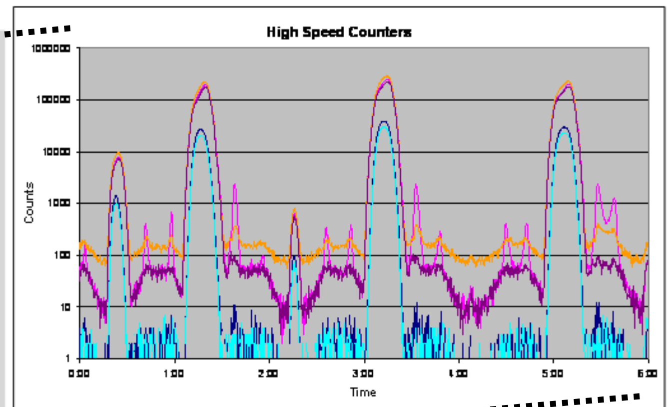
PASSENGERS STATUS CARMEN-2

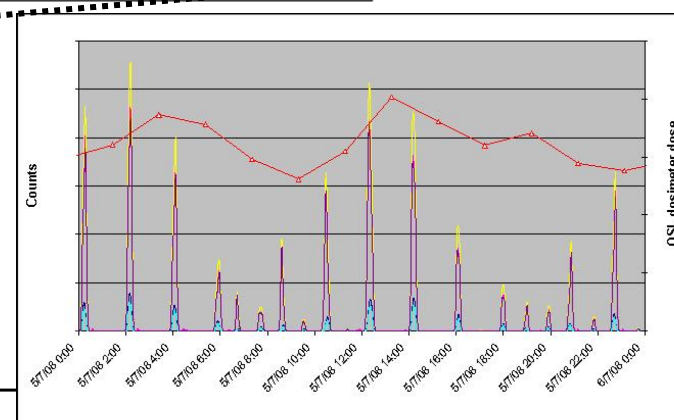
- **CARMEN- 2 :** to study the influence of space radiation on advanced components.

  - a spectrometer to measure e- dedicated and p+ energy spectrum
  - an Experiment Module (dosimeters and components under test, such as memories, linear and opto-electronic devices, power MOSFETs, …)

– **Instrument is performing well since launch (powered ON 22 June 2008 13:27:08 UTC)**





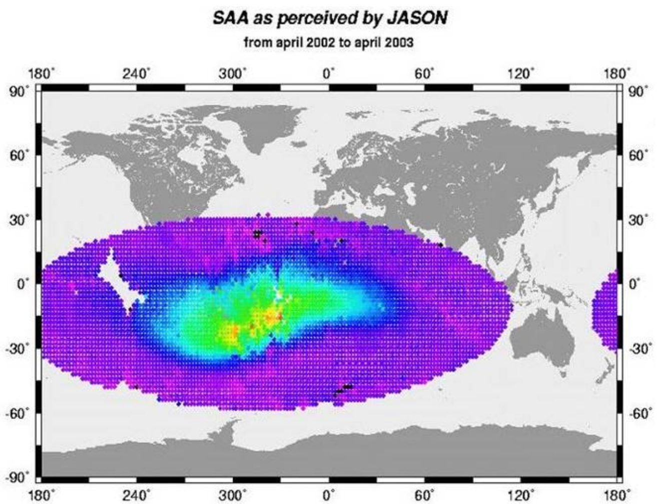


– **Dosimeters : Good agreement with the expected dose and the space environment**

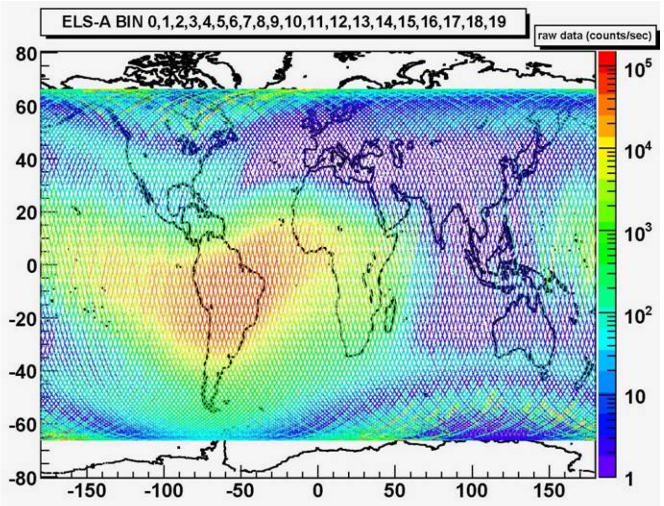
PASSENGERS STATUS LPT

- **LPT : Light Particle Telescope**
  - To measure radiation environment around the Jason-2 S/C : Electrons, protons, 4He particles, in 4 energy channels
  - Instrument is performing well since launch (powered ON 22 June 2008 at 13:30:26 UTC)

APS-B proton raw counts from BIN 10 and 11, which correspond to protons with energies higher than 75MeV (<u>DORIS sensitive range</u>).

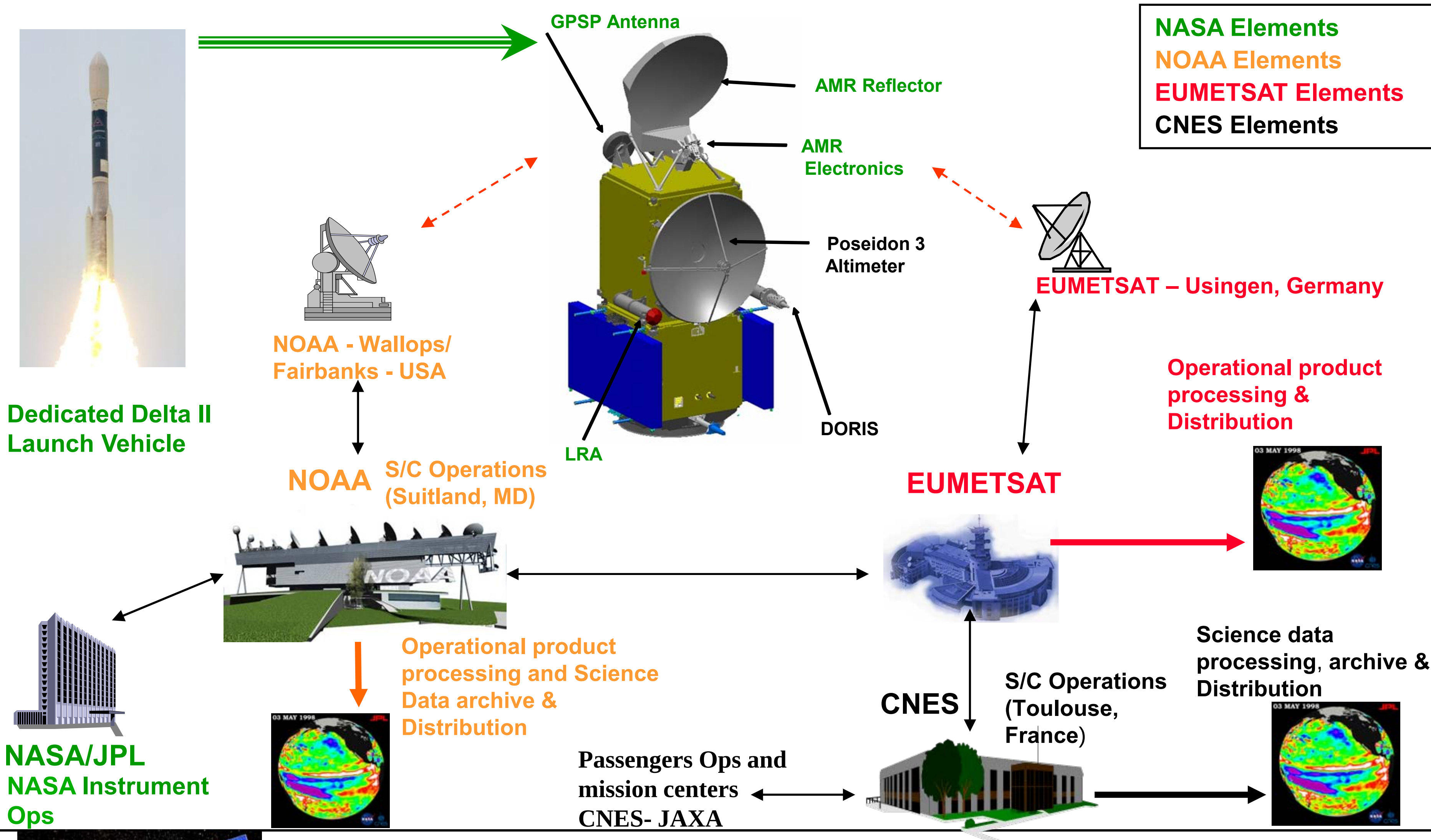


ELS-A data sample : 30keV - 1.3MeV electrons **(not calibrated)**

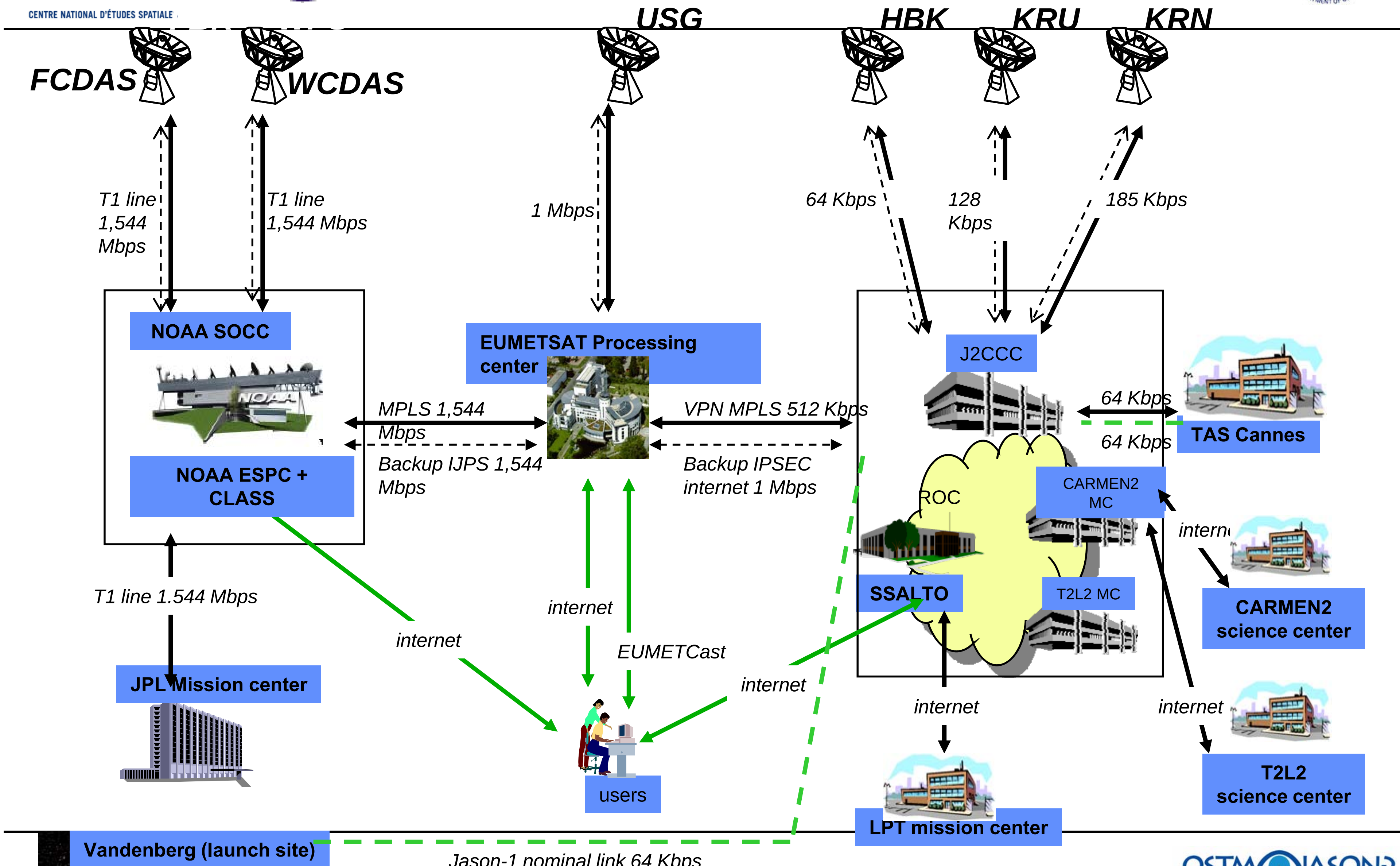


The South Atlantic Anomaly (SAA), the Inner radiation belt and the Outer radiation belt can be seen clearly

System Elements



J2GS Data Communication Network



Ground & Operations performances

- **Analysis from Launch date to Nov 8, 2008 (end of cycle 12)**
  - **Number of passes Usingen (USG), Wallops and Fairbanks (CDAS) : 1692 passes**
    - Usingen : 880 passes
    - CDAs : 812 passes shared between Wallops : 425 passes and Fairbanks : 387 passes
  - **TC to satellite**
    - Routine mode : nb TC /day = about 110 TC
    - DEM upload : about 20000 TC - can be made over 10 to 11 passes for one POS instrument
  - **TM volumes**
    - Housekeeping TM : 2 GBytes Scientific TM : 60 GBytes Passengers TM : 6 GBytes
  - **Products generation**
    - EUM : Aug-Sept-Oct : 100% OGDR successful for PLTM1 acquired at USG
    - NOAA : Aug-Sept : 100% - Oct : 99.9% OGDR successful for PLTM1 acquired at CDAs (2 OGDR recovered from CNES)
    - CNES : Aug-Sept-Oct : 100% IGDR successful
  - **Products archiving and distribution to PIs**
    - EUM and NOAA : 100 % OGDR products archived, about 272 GBytes, all disseminated via EUMETCast and via NOAA Distribution services to registered PIs
    - CNES and NOAA : 100% IGDR products archived, about 4400 GBytes, all disseminated via CNES AVISO and NOAA Distribution services to registered PIs
  - **Satellite Operations --> Handover**
    - CNES Active control center : from launch until Oct 29, 2008
    - Handover : Oct 29, 2008
    - NOAA Active control center : from Oct 29, 2008

Products

- **All O/I/GDR products have the same format and very close scientific content.**
- **One OGDR product correspond to 3 files : Native, Reduced, BUFR**
- **One I/GDR product correspond to 3 files : Native, Reduced, Sensor**

  - OGDR = IGDR but the following :
    - File duration correspond to fly-by
    - No “S-OGDR”
    - Orbit is computed using Doris Navigator
    - Meteorological fields are predicted
    - Pole Tide, Altimeter and radiometer calibration latest available values
    - Dynamic Atmospheric correction (derived from Mog2D) is not available
    - GIM ionospheric correction (derived from JPL maps) is not available
    - Platform derived off-nadir angle is not available

  - IGDR = GDR but the following :
    - File duration is a pass (half orbit)
    - Orbit is computed using MOE ephemeris
    - Pole Tide, Altimeter and radiometer calibration latest available values
    - Dynamic Atmospheric correction (derived from Mog2D) is less accurate

Products characteristics

Major characteristics of the product	*OGDR (NRT)*	*IGDR (OFL)*	*GDR (OFL)*
Content	Not fully validated geophysical level 2 product	Not fully validated geophysical level 2 product	fully validated geophysical level 2 product
Alt. ground retracking	Applied	Applied	Applied
Orbit information source	Better than 10 cm DORIS Navigator	2.5 cm preliminary orbit	1.5 cm Precise orbit
Structure	segment	pass	pass
Packaging	segment	day	cycle
Ground Processing mode	systematic	systematic	systematic
Data latency /availability	3 hours / 75% 5 hours / 95%	<1.5 calendar days / 95%	60 days / 95%
Format / Ground Processing centers	Native and BUFR / NOAA and EUMETSAT	Native / CNES	Native / CNES
Ground Archiving centers	NOAA and CNES and EUMETSAT	NOAA and CNES	NOAA and CNES
Dissemination centers	NOAA and EUMETSAT	NOAA and CNES	NOAA and CNES
Dissemination mode	Systematic Electronic & Satellite	Systematic Electronic	Systematic Electronic - Media

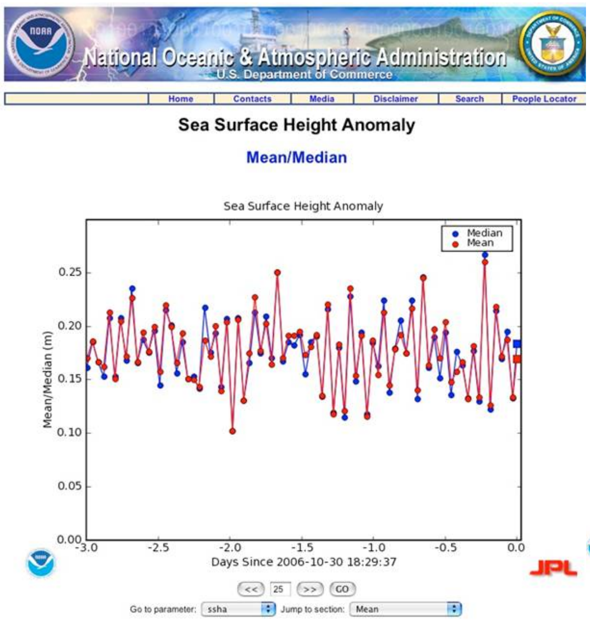
OSTM Products files

Product:	OGDR	IGDR	GDR
Latency:	3-5 Hours	< 1.5 Days	~ 60 Days
1-Hz*	OGDR-BUFR		
1-Hz	OGDR-SSHA	IGDR-SSHA	GDR-SSHA
20-Hz	OGDR	IGDR	GDR
Waveforms		S-IGDR	S-GDR

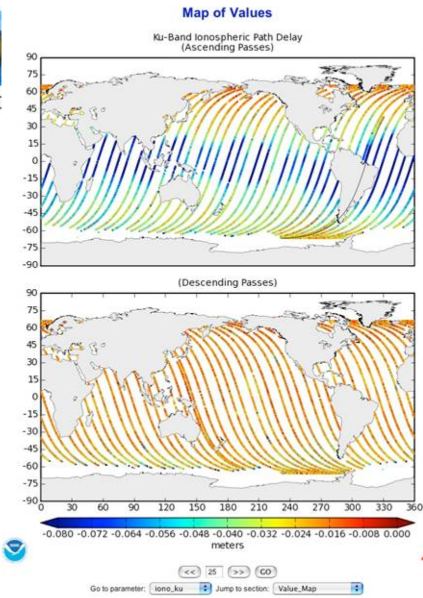
* Compressed BUFR format; all other products in native netCDF format

NRT Products Quality Assessment System

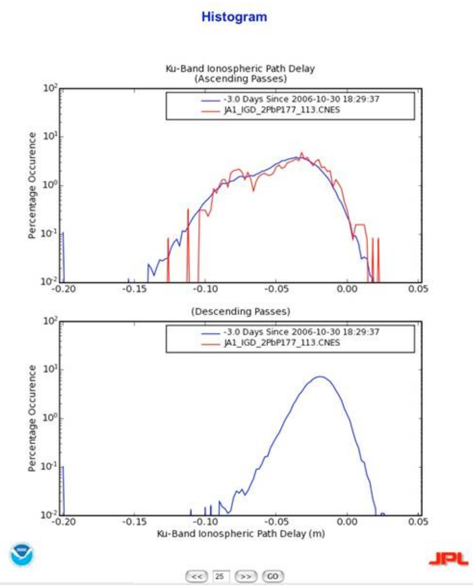
- Quality Assessment System Developed by JPL under NOAA Contract has been installed & tested at NOAA and at EUMETSAT
- Running on Jason-2 OGDR



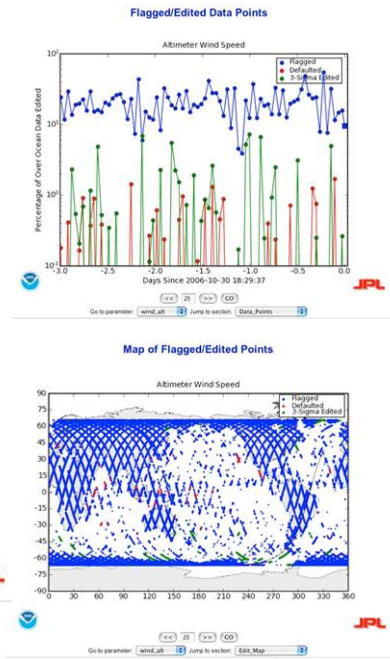
Time Series (SSH)



Asc/Des Maps (Iono)



Histograms (Iono)



Editing Time Series & Map (Wind)

Products distribution

- **OGDR products :**
  - made **by CNES** from power on of POS3 altimeter (June 22, 2008)
  - distribution to Jason-2 MSE on routine basis from June 22, 2008
  - made **by EUM and NOAA** after installation of the “assessment” version : July 2008
  - distribution to Pi’s on routine basis **by EUM and NOAA** : August 4, 2008
    No failure/interruption until now
  - new issue according to 1st CALVAL (Sep 12) meeting will be ready by end November 2008
  - delivery of the “operational” version to EUM and NOAA : November 26, 2008
  - installation of the “operational” version at EUM and NOAA : December 2-15, 2008
  - OGDR distribution **by EUM and NOAA** to USERS according to OSTST decision

- **IGDR products :**
  - made **by CNES** in the few days after Launch (June 26, 2008)
  - distribution to Jason-2 MSE on routine basis from June 26, 2008
  - distribution to Pis on routine basis **by CNES and NOAA** from August 22, 2008
  - new issue according to first Jason-2 MSE comments will ready by end November 2008
  - decision for IGDR distribution to USERS according to next OSTST (June ’09) decision

- **GDR products :**
  - First issue planned with software version expected by end November 2008
  - decision for GDR distribution to USERS according to next OSTST (June ’09) decision

- **Nota : 1st PISTACH (coast and inland water) demonstrative product has been produced on Nov 7, 2008**

System Requirements and Performances

- **Data availability :**

  Requirement : 95% of all possible over-ocean data during any 12 months period

  – unavailability allocation:
    - - Contribution of Poseidon 3 1.0%
    - - Contribution of the radiometer 0.5%
    - - Contribution of the orbit determination 0.5%
    - - Other satellite elements 2%
    - - Contribution of the ground system 1.0%

  Data products unavailability due to :
    - ***from Jul 12 (Jason-2 cycle 1) until Nov 8 (end of cycle 12)***
    - bus : 0% altimeter : 0% Doris : 0% AMR : 0%
      – NB : data gaps coming from POD sensors (Doris, GPSP and laser) does not appear on this chart due to their functional complementarity

⇒ **Total satellite 0% < 4% req**

- ground system : 0.45% over 12 cycles (July12 --> Nov 8)
  – Loss of data due to failure over some passes on USG combined to automatic operations
  – unavailability since end of August (6 last cycles) : 0.02%

⇒ **Total ground 0.45% < 1% req**

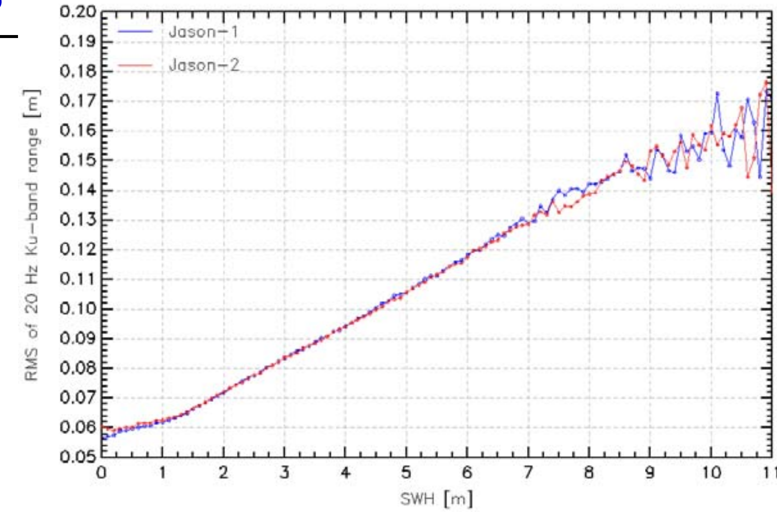
Total : 0.45% (< 5% requirement)

System Requirements and Performances

- **Data products latency :**
  - Latency is defined as the time from raw data acquisition by the payload instruments until availability by user
  - OGDR (near real time data) : requirement = 75 % available to users in 3 hours max, and 95% in 5 hours
  - S-IGDR/IGDR : requirement = 1 to 1.5 days maximum
  - S-GDR/GDR : requirement = 60 days
- **OGDR data latency**
  - EUM Stats are:
    - August: 94.5% in less than 3 hours from sensing, 96.8% in less than 5 hours (station outages)
    - September: 98.6% in less than 3 hours from sensing, 100% in less than 5 hours;
    - October: 99.4% in less than 3 hours from sensing, 99.7% in less than 5 hours (100% was in more than 9 hours);
  - NOAA Stats are:
    - August: 88.8% in less than 3 hours from sensing, 91.2% in less than 5 hours (14 needed to be reprocessed due to bad calibration file);
    - September: 98.2% in less than 3 hours from sensing, 100% in less than 5 hours;
    - October: 96.1% in less than 3 hours from sensing, 98.74% in less than 5 hours (100% in less than than 14 hours)
- **IGDR data latency**
  - current performance evaluated at SSALTO level : first results are about ~ 1.5 day

Requirements are already met in the verification phase

System Requirements and Performances



Jason-2 data products error :

- **The first preliminary results based on "(Jason-2 - Jason-1) IGDR" comparison are very promising.**

- **Some <u>preliminary</u> figures :**

		Requirements
– RMS Orbit (radial component) **DIODE** (vs MOE) :	OGDR : 5 to 6 cm	10 cm
– RMS Orbit (radial component) **MOE** (vs POE) :	IGDR : <2.5 cm	2.5 cm
– Altimeter noise (from RMS from 20Hz Ku range) :	1.61 cm	1.7 cm
– Wet troposphere (J2-J1)RMS results :	0.1 to 0.8 cm	1.2 cm
– Total RSS sea surface height (J2-J1)RMS results :	IGDR : 3.9 cm	3.9 cm
– Significant wave height (J2-J1)RMS results :	IGDR : 0.12 to 0.24 m	0.4 m
– Wind speed (J2-J1)RMS results :	IGDR : 0.2 to 0.8 m/s	1.5 m/s

- **OSTST splinter meetings will address these topics and provide the elements to refine the error budget results**

Conclusion

- **Launch: 20 June 2008**
- **LEOP and Assessment Phases nominal**

- **JASON-2 satellite has an excellent behavior**
- **All satellite and system performances requirements are fulfilled with large margins**
- **Successfully completed all mission reviews**
  - **In flight Acceptance Review Sept ‘08**
  - **Satellite Operations Handover Review Oct ‘08**

- **Verification Phase in progress to allow Products distribution**

.... A 4 partner project ... a very exciting adventure !!!!!!

Thanks to all the teams (CNES, EUM, NASA, NOAA)