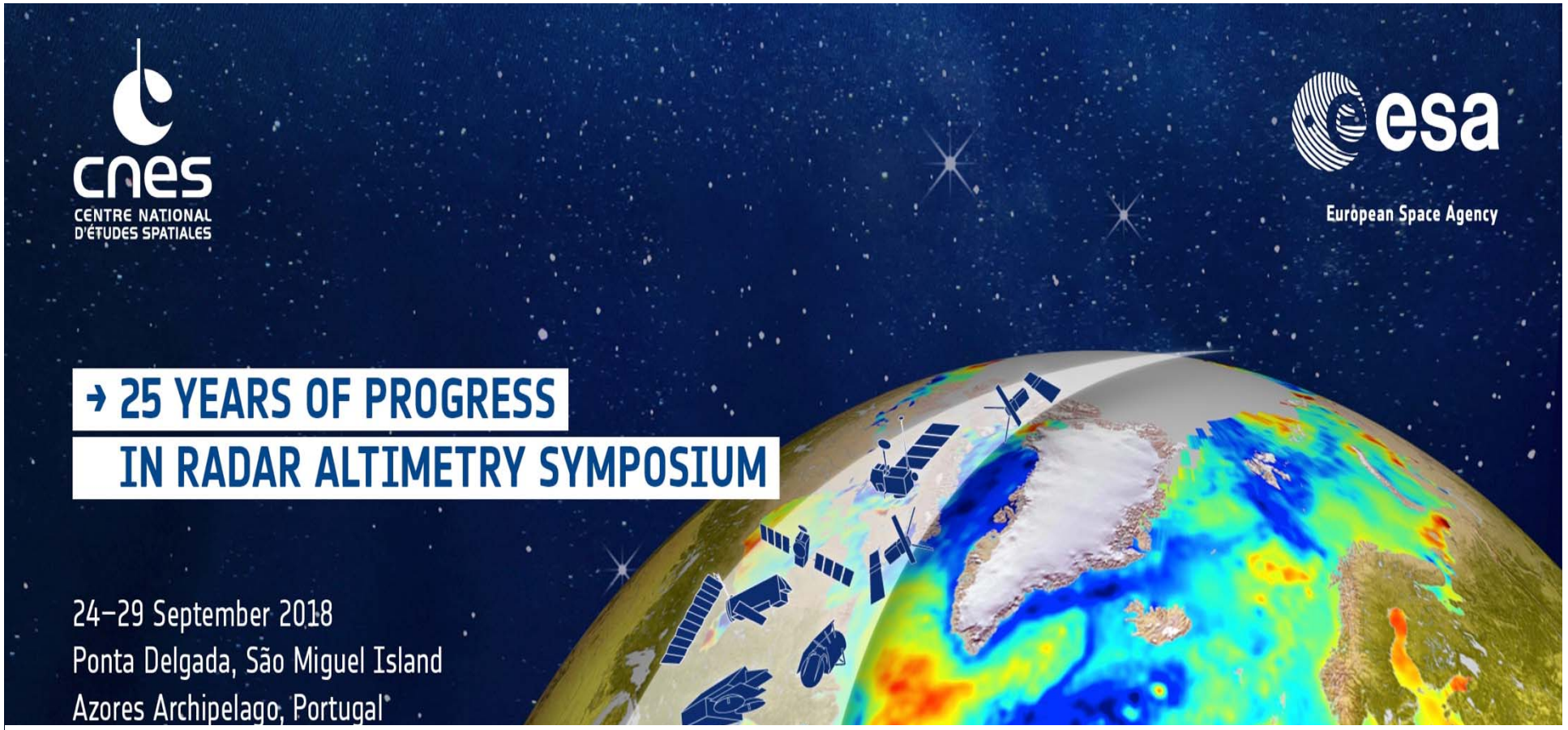
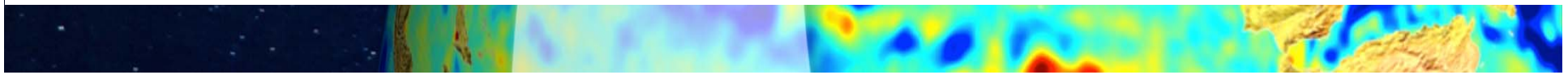


Jason-1/2/3 and SARAL GDR Status

CNES, NASA, NOAA, EUMETSAT

From all 4 MSEs

Cristina (EUM), Alejandro (NOAA), Shailen (JPL), Nicolas (CNES)



Reprocessing Plans
2017 status remind

- **Two missions (JA3 and S3A) launched early 2016, generating a lot of activities (Calibration, Validation, …) and updates (in particular on S3A ground processing).**
- **Two missions on LRO orbits (SARAL in 2016, Jason-2 in 2017) have also required processing updates and additional validation efforts.**
- **Two new missions in 2018 (S3B, CFOSat) requiring some preparation and support.**
- **And the need to prepare (already …) SWOT and Jason-CS processing software.**
- **Currently 7 flying altimeters, with a quite homogenous processing baseline (thanks to coordination between all agencies) and overall very good data quality.**
- **Jason-1 reprocessed recently, ENVISAT as well and CryoSat about to be delivered.**

Reprocessing Plans
2017 status remind

- **Thus:**
  - ✦ Reprocessing of Jason-2 and Jason-3 is not a high priority.
  - ✦ Topex and SARAL reprocessing **will be performed in 2018.**
  - ✦ We will also prepare the GDR-E standard to be applied on Jason-2, Jason-3, and SWOT altimeters, accounting for Jason-CS/Sentinel-6 proposed updates (product format, …). To insure a seamless continuity for the reference mission data set.

TOPEX Reprocessing Plan

- Use original SDR, GDR
  - Search for missing cycles, pass data to make record as complete as possible. Both SDR and GDR are needed in retracking.
- Revisit retracking software.
  - Investigate use of separate PTR for Ku and C.
  - Validate with simulations.
- Include additional parameters on record
  - 20Hz Range at both Ku, C as available on SDR, with time tags, locations. (All corrections still at 1 Hz like Jason-1/2/3)
  - Key parameters for both original GDR and Retracked
- Regenerate some corrections, flags
  - Oscillator drift from long term fit (TBD)
  - Doppler shift and acceleration corrections (TBD from orbit or altimeter data)
  - Surface, rain, ice flags with Jason-like algorithms
- Use latest POE from GSFC (ITRF2014), new environmental corrections & geophysical fields from CNES, end-of-mission recalibrate TMR data.
- Refit SSB with all above improvements, perform CalVal analysis within the project with the support from key PIs
- Update format to Jason version E (as used for Jason-1 reprocessing)
- Deliver GDR products by mid 2018, then work on SGDR data files (including waveforms and calibration data)

Jet Propulsion Laboratory
California Institute of Technology

TOPEX Reprocessing Plan

- Retracking of TOPEX waveforms demonstrates promise for improvement to TOPEX data record.
- Some questions remains to be tackled in the next future.
- Plans is to work on TopexB data during Jason-1 tandem phase, then complete TopexB reprocessing before completing TopexA.

- Deliver GDR products by mid 2019, then work on SGDR data files (including waveforms and calibration data)

CENTRE NATIONAL D'ÉTUDES SPATIALES

Calibration and Validation of Reprocessed TOPEX Geophysical Data Records

S. D. Desai[1], P. S. Callahan[1], J.-D. Desjonquères[1], B. Haines[1], M. Talpe[1], J. K. Willis[1], G. Shirtliffe[1], N. Picot[2], T. Guinle[2], H. Roinard[3], M. Ablain[3]
[1]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, U.S.A.
[2]Centre Nationale des Etudes Spatiales, CST, DCT/PO/AL, Toulouse, France
[3]Collecte Localisation Satellites, Ramonville, France
Contact: shailen.desai@jpl.nasa.gov

2018 OSTST
Ponta Delgada, Azores
CVL_015

Abstract

We present preliminary results from the calibration and validation of reprocessed TOPEX Geophysical Data Records (GDRs). These products have been generated in 2018 through a collaborative effort between JPL and CNES. They adopt new approaches to retracking the TOPEX altimeter Ku- and C-band waveform data, the most recent ITRF2014-based precise orbit determination solutions from the Goddard Space Flight Center, a recent regeneration of the TOPEX Microwave Radiometer enhanced path delay product, sea state bias models derived from the retracked altimeter data, and the most recent GDR-E-based standards for geophysical corrections. We highlight differences between ground retracking of waveforms being performed for this reprocessed TOPEX data product and the original TOPEX GDR. The overall impact on accuracy is evaluated using comparisons with the Jason-1 GDR-E data record during the tandem period when TOPEX/POSEIDON and Jason-1 were flying approximately one minute apart.

Introduction

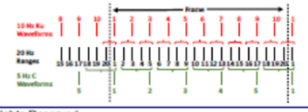
- **Joint effort between JPL and CNES to generate end-of-mission TOPEX/POSEIDON Geophysical Data Records (GDRs).**
- Ground retracking of TOPEX (side-A and side-B) and POSEIDON waveforms.
- Adopt end-of-mission calibration of TOPEX Microwave Radiometer (Brown et al., 2007) (Includes coastal path delay algorithm).
- Use ITRF2014 DORIS+SLR precise orbit determination solutions from Goddard Space Flight Center (Lemoine et al., 2017)
- Adopt current standards for geophysical corrections and models.

Three Retracking Approaches for TOPEX Waveforms Compared to Original GDRs.

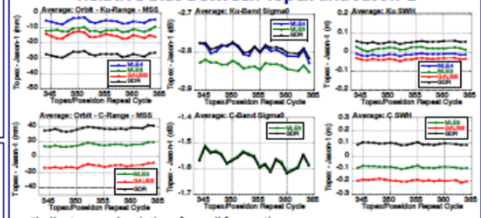
Name	Description
MLE4	• Numerical retracking: **Ku-band only.** • Estimate epoch (range), SWH, power (sigma0), and square of mispointing angle for 10 Hz waveforms. • Uses Average Point Target Response during T/P-Jason-1 tandem phase.
MLE3	• Numerical retracking: **Ku- and C-band.** • Estimate epoch (range), SWH, and power (sigma0) for 10 Hz Ku-band and 5 Hz C-band waveforms. • Uses Average Point Target Response during T/P-Jason-1 tandem phase.
GAUSS	• Gaussian retracking (E. Rodriguez, used since ~2004.): **Ku- and C-band** • Estimates epoch (range) from 10 Hz Ku-band and 5 Hz C-band waveforms, SWH, amplitude, square of mispointing angle over 1 Hz. • Uses set of Gaussians fitted to Point Target Response. • One Point Target Response per repeat cycle.
GDR	• Onboard tracking as provided on original GDR and MGDR data products. • Derived from 20 Hz **Ku- and C- band** ranges provided on Topex science data record product (without ground retracking). SWH and sigma0 from GDR.

Alignment of Waveforms in Data Frames

- Each Topex data frame reports:
  - 10 Hz Ku-band and 5 Hz C-band waveforms.
  - 20 Hz Ku- and C-band ranges and AGC.
- **Best consistency (lowest std. dev.) with Jason-1 data when first waveform in frame is aligned (i.e. "Shift"ed) to first reported 20 Hz Ku (C) range/AGC from current frame and last 1 (3) from prior frame.**
  - Time tag assigned to data is from each frame.
  - Alignment applied here to MLE4 and MLE3 only.

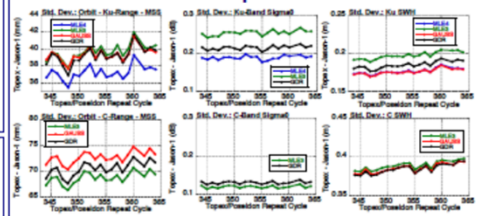


Relative Bias Between Topex and Jason-1



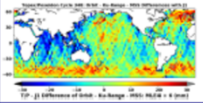
- Similar temporal variations from all four options.
- Smallest relative Ku-band range bias with MLE4 retracking (-6 mm).
- MLE4 Sigma0 intentionally "calibrated" to GDR Sigma0 at cycle 344.
  - No sigma0 generated by GAUSS retracking.
- Smallest relative Ku-band SWH bias from MLE4 retracking (-1.5 cm)

Standard Deviation of Topex – Jason-1 Differences



- MLE4 provides best consistency with Jason-1 for Ku-band range and sigma0.
  - MLE4 and GAUSS perform similarly for SWH.
- MLE3 provides best consistency with Jason-1 in C-band range and sigma0.
  - Slightly worst in C-band SWH.
- MLE3 and MLE4 benefit from waveform alignment (shift).

Relative Sea State Bias



- Relative sea state bias apparent in Topex/Jason-1 range differences.
  - Remaining dependence on wave conditions.
  - Larger than any remaining orbit error.

Conclusion

- Retracking of TOPEX waveforms demonstrates promise for improvement to TOPEX data record.
- Proper alignment of waveforms in frame with reported ranges has significant impact on Ku- and C-band ranges in particular.
  - GAUSS retracking likely to benefit from similar alignment.

SARAL GDR-E

- **GDR-E processing configuration is currently under validation on 3 cycles it include (among other …about 60 Change Requests have been included in this version):**
  - POE-F standard
  - Ice2 retracking accounting for the actual altimeter antenna aperture
  - Updated altimeter calibration scheme (CAL2 normalization, CAL1 not corrected by CAL2, updated gains values)
  - SSB based on 3D approach (SWH, wind and swell)
  - New Radiometer processing algorithm, developed by CLS in 2017 – performances are similar to Jason-2/3 methods (refer to CLS presentation)
  - Wet & Dry tropospheric correction based on 3D ECMWF fields
  - Updated geophysical correction: FES2014, GOT4.10, R. Ray internal tide model **(Shall we add a second internal tide model ?**), S. Desai pole tide with new IERS linear mean pole, 2013 MDT **(to be replaced by 2018 solution ?)**
  - Platform mispointing angles
  - Netcdf v4 product format
  - Etc …

A technical note will be circulated in the coming weeks to describe in details the evolutions.

SARAL GDR-E

SARAL GDR-E standard – implementation status

GDR-E implementation for SARAL mission started in 2018

Tentative schedule :

- 3 cycles processed and almost validated by CAL/VAL
  - ✓ **Cycle 7 (10-10-2013 - 14-11-2013)** :
    Cycle on nominal ground track, during HOT COUNT saturation and after, no mispointing.
  - ✓ **Cycle 17 (25-09-2014 - 30-10-2014)** :
    Cycle with mispointing and SHM on the period
    2 processes: one with LUTs and platform mispointing, one with LUTs and no mispointing
  - ➢ **Cycle 31 (28-01-2016 - 03-03-2016)** :
    Cycle post SHM on drifting orbit for a global check, no mispointing

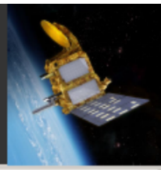
- **If CALVAL OK**, the year 2015 will be reprocessed for SSB computation; will use orbits with POE-F standard

- Implementation for routine processing at CNES, EUMETSAT and ISRO

- Full re-processing (2013-2019) planned in 2019

OSTM - OSTST -

SARAL/AltiKa performance assessment: from meso-scale to climate



G.Jettou[1], M.Rousseau[1], E.Cadier[1], N. Queruel[2], N. Picot[2]
Contact: equipe-calval-al@cls.fr
1. CLS, Toulouse, France
2. CNES, Toulouse, France

➢ SARAL/AltiKa is a joint CNES/ISRO mission which was successfully launched on February, 25 th ,2013. During September 2014, several mispointing events occurred, attributed to variations of the reaction wheel's friction. The reaction wheel eventually failed, resulting in SARAL/AltiKa going into safe-hold mode (SHM) from October 6 th to 9 th. Since then, the satellite has been experiencing occasional mispointing events. On July 4 , 2016, a last maneuver was performed to raise the spacecraft's altitude by 1 km, and leave him flying free of station keeping maneuvers: The mission entered a new phase called SARAL-DP (drifting phase).
➢ After it has been moved to its drifting orbit, no impact on mission performances was noticed. SARAL/AltiKa remains a very accurate altimetric mission which performances are summarized here.
➢ The first altimeter full dataset reprocessing is foreseen next year with several algorithm improvements. A sample of the evolutions are listed below with an overview of the expected impacts.

Main performance metrics

Data availability

➢ Since the beginning of the mission, data availability over ocean is excellent with more than 99.6 % of available data, SHM period included (99.2 % on Jason-2).
➢ The editing rate is steady over time and shows a large seasonal signal, due to annual growth and retreat of sea ice extent.

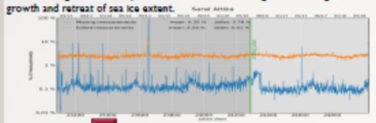


Fig1 Percentage of missing data : GDR cycle 1 to 119

Crossovers

➢ Typical standard deviation of SSH differences at crossovers is 5.3 cm for GDR data (5 cm on Jason-2 and Jason-3).
➢ Mean difference between ascending and descending tracks is slightly negative around -0.4 cm.
➢ Spatial distribution of mean SSH differences shows no geographically correlated patches with differences remaining below 2 cm (Fig2 right).
➢ Crossovers analysis demonstrates the excellent performances of SARAL/AltiKa.
➢ The change of orbit has no impact whatsoever on data quality(Fig2 left).

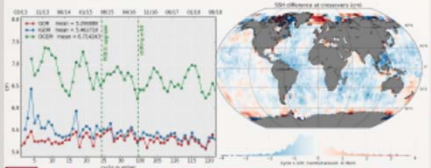


Fig2 Performance at crossovers : [left] monitoring of standard deviation of SSH differences and [right] map of mean SSH differences

Comparison to other missions

To account for the uneven distribution of crossover points, we estimate weighted statistics of crossovers differences where the weights applied are based on the crossovers density. This allows to better compare two missions that do not share the same ground track. Equivalent results are obtained for the SARAL/and both reference missions using their wet tropospheric correction (Fig 3).

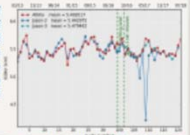


Fig3 Standard deviation of SSH crossovers differences for Jason-2/Jason-3 and AltiKa

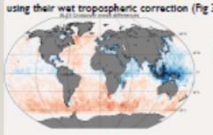


Fig4 ALJ3 crossover mean differences using wet tropospheric models

In terms of geographical patterns, good consistency is observed (Fig4) with the reference mission J3, with slight differences in small waves areas (Indonesia) and in the Atlantic where orbital features remain under investigations.

Platform behavior

Altitude loss during drifting orbit

Thanks to a particularly weak solar activity, the altitude of SARAL/AltiKa has decreased by less than 200m in 2 years of unmaintained orbit. The slowly decaying altitude is way under the predicted estimations which maintains the good mesoscale sampling capability of the mission.

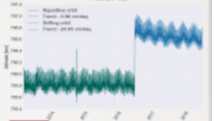


Fig5 Altitude evolution (km)

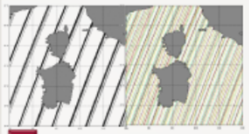


Fig6 [left] Repetitive orbit ground track [right] Drifting orbit ground track

Drifting orbit ground track

SARAL/Altika's orbit change provides a larger data coverage (Fig6) which opens up new opportunities for Mean Sea Surface sampling , inland water level studies

Mispointing events

Due to the loss of the reaction wheel, mispointing events occur randomly. These events are carefully monitored and waveform derived pointing is routinely compared to platform information provided by ISRO (Fig7). The currently observed mispointing levels are stable and do not impact data quality except the editing of punctual track portions.

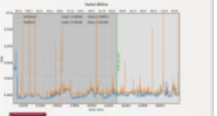


Fig7 Platform stability (from waveform mispointing estimate and ISRO information)

GDR-E : Coming up next

Upgraded/New fields	Expected impact
Orbit GDR-E standard MSS_CNES_CLS15	Homogeneous time series
MWR derived fields (brightness temperatures, atmospheric attenuation, wet tropospheric correction, ice flag, etc)	Mesoscale Coastal areas Short scales error reduction (crossovers)
Look Up Tables	Wave and mispointing dependent effects on all retracked parameters
Ocean Tide FES_2014B	Number of SLA valid data increase
Platform mispointing, Mean wave period.	Mesoscale Short scales error reduction (crossovers)

Tab1 A Sample of the various evolutions and expected impacts

So far, a preliminary analysis over a test dataset has been run and shows very encouraging results (Fig8-Fig9-Fig10). These improvements are mainly due to a better understanding of instrumental features included in the processing.
A more complete analysis will be distributed in a dedicated report jointly with the data, at the end of the reprocessing and validation process.

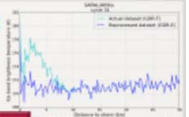


Fig8 Ka-Brightness temperature with respect to shore distance

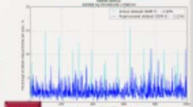


Fig9 Percentage of edited measurements

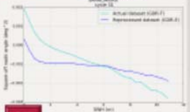


Fig10 Mispointing with respect to waves

Conclusions and perspectives

➢ The SARAL/AltiKa mission is now in the middle of its sixth year and has been on a drifting orbit for more than two years .
➢ Mission performance remains excellent, compared to Jason-2, Jason-3 and Sentinel-3, from fine scale ocean dynamics to long-term stability.
➢ SARAL/AltiKa data undergo a complete Cal/Val process: instrumental parameters, products status and mission performance metrics are routinely checked by Cal/Val teams.
➢ Several updates have been implemented and are currently run over a test dataset with very encouraging results. The complete reprocessing (GDR-E) is planned for 2019.

OSTST Meeting, Azores 2018

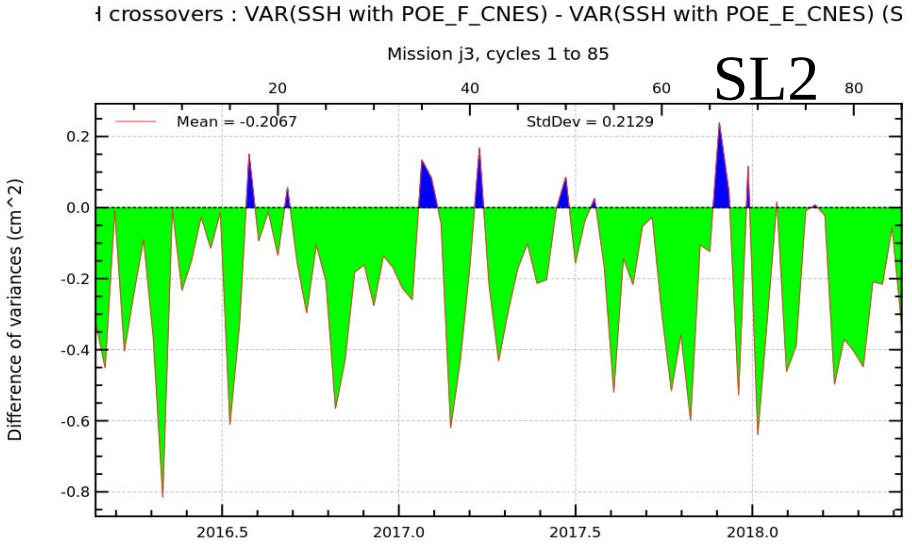
Jason-2 and Jason-3 Mission Product Status

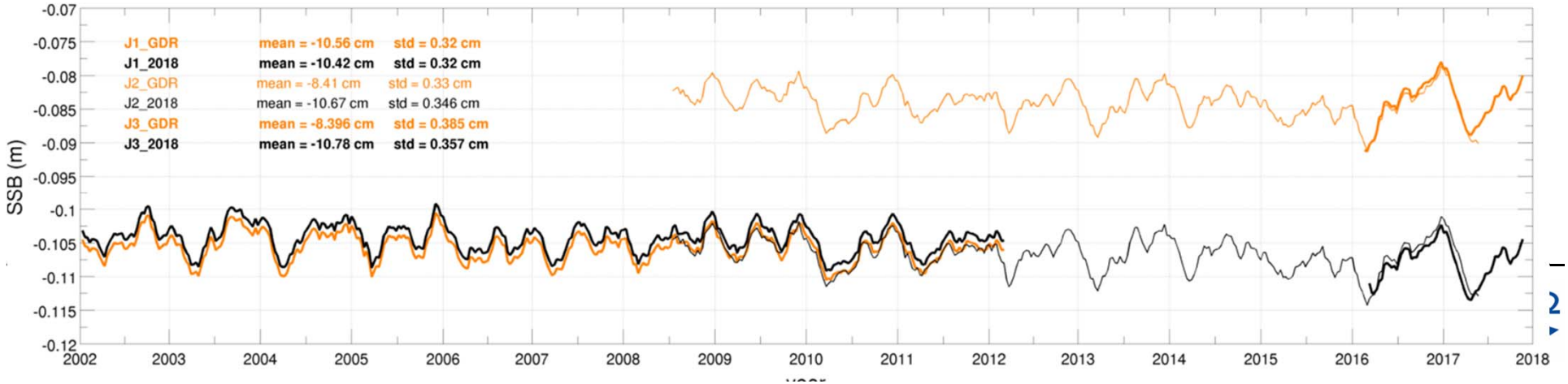
- **Jason-2 GDR_D** since March 2013.
  - Processing baseline described in the User Handbooks (available for example on https://www.aviso.altimetry.fr/fileadmin/documents/data/tools/hdbk_j3.pdf)

- **Jason-3 using the same GDR-D standard** :
  - JA3 also available as prototype products (PEACHI)

JASON GDR-E/F STANDARD

- Jason-2/3 will inherit from the evolutions implemented on SARAL
- Ongoing discussion with Jason-CS team to insure a seamless continuity for the reference mission data set.
- Evolutions will be finalized in 2019, POE-F being already available, accounting for the new SSB approach to stabilize the inter mission bias





BACKUP SLIDES

JA1 GDR Reprocessing Status

- **Jason-1 GDR_E** : reprocessing completed end April 2016

De : Desai, Shailen D (335A) <shailen.d.desai@jpl.nasa.gov> Date : lun. 09/05/2016 17:25
À : ostst; ostst-users
Cc :
Objet : Jason-1 Version E GDR Release Notice

Dear OSTST,

We are pleased to announce that reprocessing of all Jason-1 data, as version "E", is now complete and available for download. This release includes reprocessed data from primary, tandem, and geodetic mission phases, which spans 2002-2013 and includes repeat cycles 1-373, 500-537.

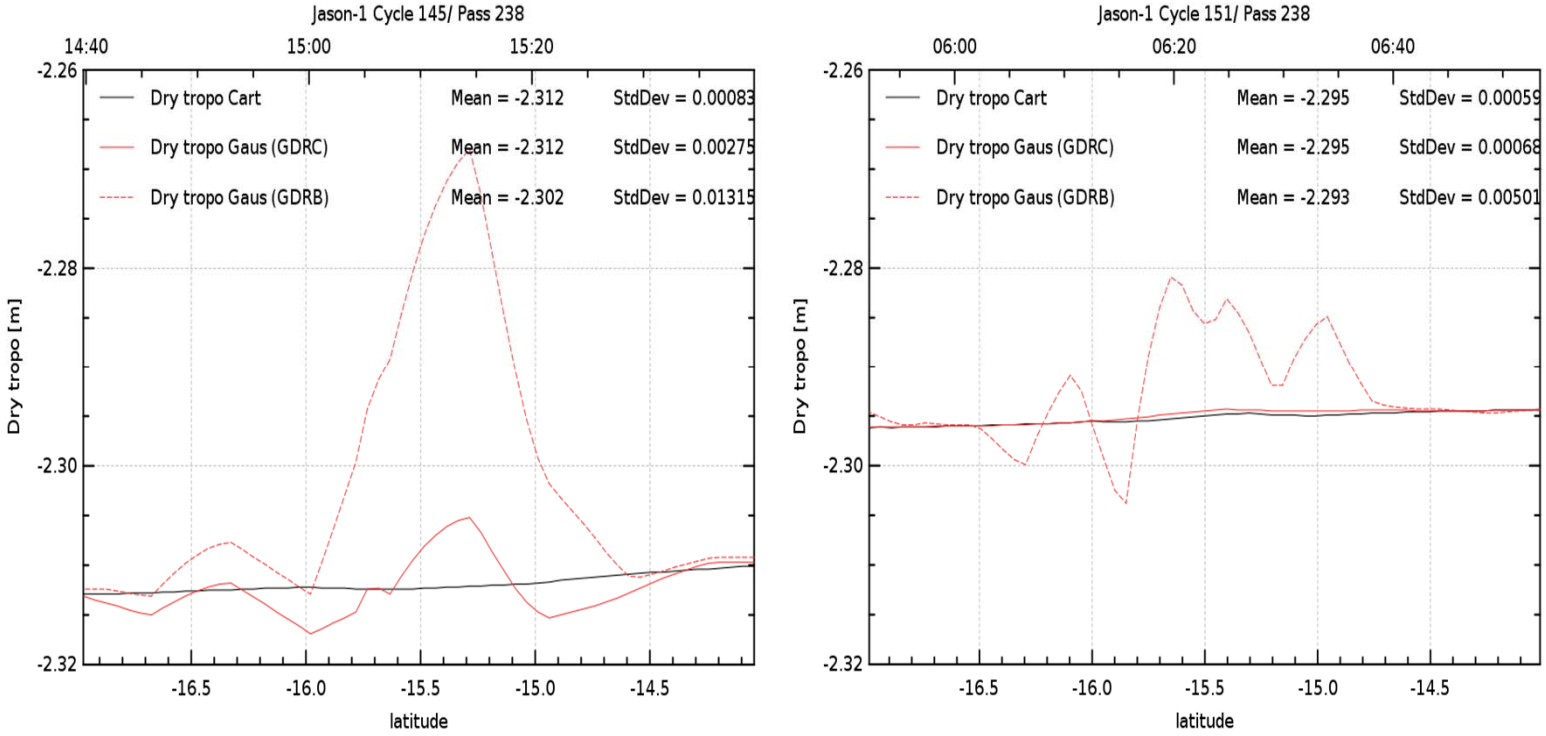
This new release takes into account user and cal/val feedback from last year's beta release.
Products from this updated release have creation dates ("history" parameter on products) of January 2016 and later.
Products from the last year's beta release have creation dates in 2015, and should be discarded.

The reprocessed data are now available as version "E" GDR data products at the AVISO and PODAAC ftp sites as follows:
ftp://avisoftp.cnes.fr/AVISO/pub/jason-1/
ftp://podaac.jpl.nasa.gov/allData/jason1/L2/

  - One anomaly on the dry tropospheric (see next slides)
  - Validation report will be issued by end 2016

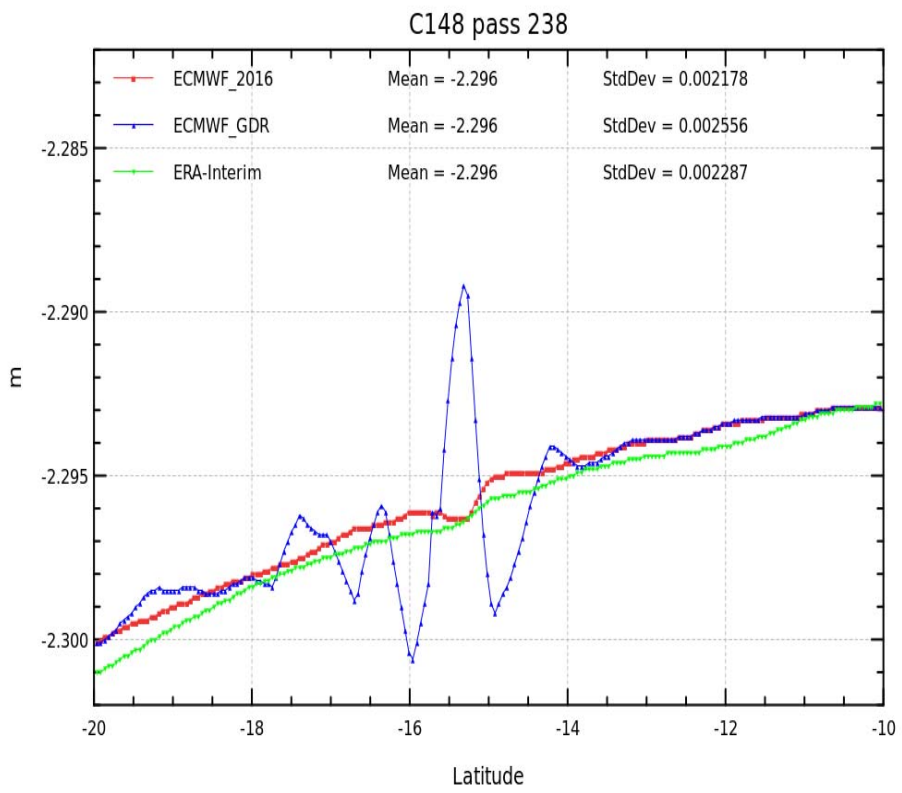
JA1 GDR Reprocessing Status – Dry Tropo

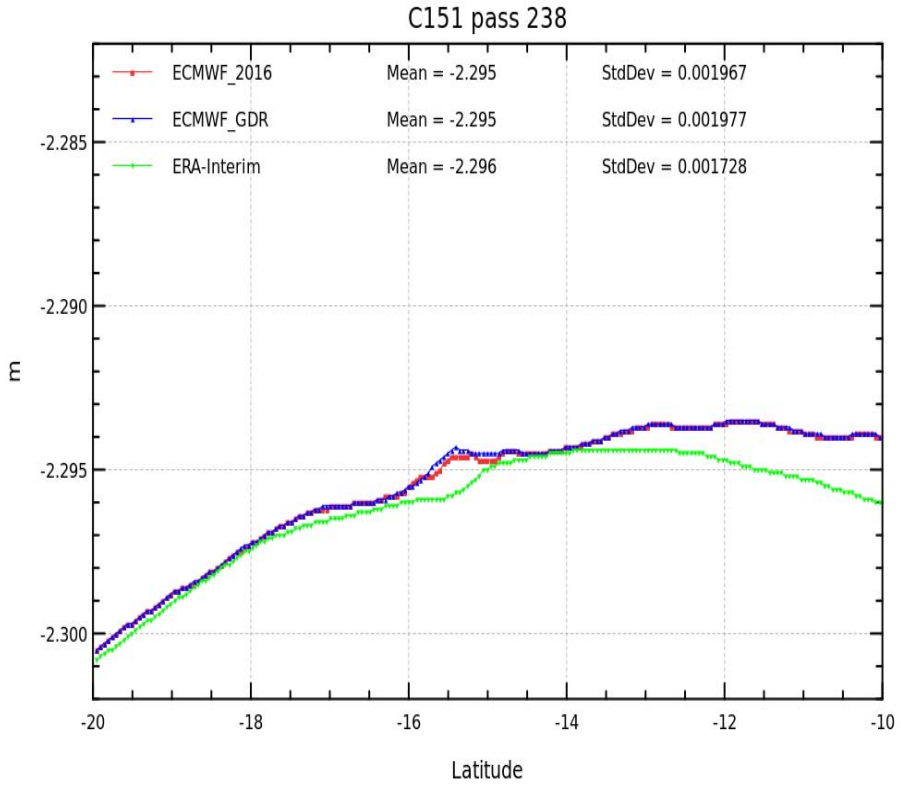
- Oscillations in dry troposphere correction **were clearly visible in Jason-1 GDR-B** data when approaching coasts. The amplitude of these oscillations were more important before the change of ECMWF grids model on 2006-02-01 (corresponds to cycle 150)
- These oscillations were reduced but still visible before cycle 150 (and they disappeared after cycle 150) in GDR-C data thanks to the use of reprocessed ECMWF **(update 'Met Script' no modifications of the ECMWF fields)** data between 2002-01 and 2007-03-07)
- As dry troposphere correction were copied from GDR-C in GDR-E, **this phenomenon is also visible in GDR-E**



JA1 GDR Reprocessing Status – Dry Tropo

The use of the sea pressure fields over ocean allows to correct these oscillations (red curve)





JA1 GDR Reprocessing Status – Dry Tropo

➢ Oscillations that were visible on ECMWF minus ERA-Interim difference near coasts before cycle 150 (light blue) are no more visible when sea pressure fields are use over ocean

➢ We propose to patch Jason-1 GDR-E netCDF with a recomputed dry troposphere correction solution.

➢ We propose to compute dry troposphere correction with:

- ✓ the surface pressure ECMWF fields over land
- ✓ the sea pressure ECMWF fields over ocean