SERVICE
ALTIMETRIE
&
LOCALISATION
PRECISE

Jason-1 GDR
Quality Assessment Report

Cycle 315

20-07-2010 / 30-07-2010

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1. Introduction. Document overview

The purpose of this document is to report the major features of the data quality from the Jason-1 mission. The document is associated with data dissemination on a cycle per cycle basis.
This document reports results from Jason-1 GDRs.

The objectives of this document are :

- To provide a data quality assessment
- To provide users with necessary information for data processing
- To report any change likely to impact data quality at any level, from instrument status to software configuration
- To present the major useful results for the current cycle

It is divided into the following topics :

- **General quality assessment and cycle overview**
- **Poseidon-2 altimeter and sensor**
- **CALVAL main results**
- **Jason-1 Long term performance monitoring**
- **Mean Sea Level (MSL)**
- **Particular investigations**

2. General quality assessment and cycle overview

2.1. Software version

This cycle has been produced with the CMA Reference Software V9.3_03. Since GDR version "c" products, DORIS TEC data are no longer computed. They are replaced by GIM model ionosphere correction. The results presented in this report have been performed with GDR products in version C.

2.2. Cycle quality and performances

Data quality for this cycle is nominal.
Analysis of crossovers and sea surface variability indicate that system performances are close to usual values that are obtained from the TOPEX/POSEIDON data. For this cycle, the crossover standard deviation is 7.43 cm rms. When using a selection to remove shallow waters (1000 m), areas of high ocean variability and high latitudes ($> |50|$ deg.) it decreases down to 6.14 cm rms.
The standard deviation of Sea Level Anomalies (SLA) relative to a 7-year mean (based on T/P data) is 10.91 cm. When using a selection to remove shallow waters (1000 m), areas of high ocean variability and high latitudes ($> |50|$ deg) it lowers to 9.86 cm .

- Performances from crossover differences are detailed in the dedicated section Crossover statistics.
- Detailed CALVAL results are presented in section 3.
- Note that since cycle 262, Jason-1 is on its new interleaved ground-track.
- Note that cycle 315 was impacted by several inclination maneuvers in order to deplete fuel starting on 2010-07-20. In consequence, cross track distance versus nominal ground track departed up to 7 km.
- Maneuver Burn (inclination maneuver, OCM4) on 2010-07-20 from 18 :58 :51 to 19 :06 :03 (pass 001).
- Maneuver Burn (inclination maneuver, OCM4) on 2010-07-20 from 21 :47 :23 to 21 :54 :48 (pass 004).
- Maneuver Burn (inclination maneuver, OCM4) on 2010-07-21 from 18 :24 :02 to 18 :31 :37 (pass 026).
- Maneuver Burn (inclination maneuver, OCM4) on 2010-07-21 from 21 :12 :35 to 21 :20 :22 (pass 029).
- Maneuver Burn (inclination maneuver, OCM4) on 2010-07-22 from 19 :41 :40 to 19 :49 :38 (pass 053).
- Maneuver Burn (inclination maneuver, OCM4) on 2010-07-22 from 22 :30 :12 to 22 :38 :23 (pass 056).
- Yaw Flip on 2010-07-25 from 03 :32 :45 to 03 :51 :48 (pass 113).
- Maneuver Burn (inclination maneuver, OCM4) on 2010-07-25 from 17 :57 :39 to 18 :06 :00 (pass 128).
- Maneuver Burn (inclination maneuver, OCM4) on 2010-07-25 from 20 :46 :11 to 20 :54 :45 (pass 131).
- Maneuver Burn (semi-major axis change, OCM4) on 2010-07-26 from 19 :13 :28 to 19 :13 :41 (pass 155).
- Maneuver Burn (semi-major axis change, OCM4) on 2010-07-26 from 22 :02 :07 to 22 :02 :19 (pass 158).
- Maneuver Burn (inclination maneuver, OCM4) on 2010-07-27 from 18 :40 :38 to 18 :49 :22 (pass 180).
- Maneuver Burn (inclination maneuver, OCM4) on 2010-07-27 from 21 :29 :10 to 21 :38 :07 (pass 183).
- Maneuver Burn (inclination maneuver, OCM4) on 2010-07-28 from 18 :05 :48 to 18 :14 :54 (pass

205).
- Maneuver Burn (inclination maneuver, OCM4) on 2010-07-28 from 20 :54 :21 to 21 :03 :38 (pass 208).

2.3. Missing measurements

Passes 127 to 131, 155 to 157, 181 and 206 to 208 are completely missing, several passes are partly missing :
- Due to POS2 incidents on 2010-07-25 covering approximatively 13h58 to 22h03, passes 127 to 131 are completely missing and passes 124 to 132 are partially missing.
- Due to a POS2 incidents on 2010-07-26/27 covering approximatively 14h41 to 00h17, passes 155 to 157 are completely missing and passes 150 to 159 are partially missing.
- Due to a POS2 incidents on 2010-07-27 covering approximatively 18h43 to 20h21, pass 181 is completely missing and passes 180 to 182 are partially missing.
- Due to a POS2 incidents on 2010-07-28 covering approximatively 18h18 to 23h10, passes 206 to 208 are completely missing and passes 205 to 210 are partially missing.

Missing measurements relative to a nominal ground track are plotted on **section Missing measurements**.

2.4. End of scientific mission for TOPEX/Poseidon

Since cycle 139, there are no results from intercalibration between Jason-1 and TOPEX/Poseidon data. During TOPEX/Poseidon cycle 481, on 9th October 2005, the pitch reaction wheel showed an anomalous behavior, followed by stalling. Despite of several attempts to restart the wheel, it continues to stop working after a short warm-up phase. In consequence the TOPEX/Poseidon satellite is currently in a sun-pointing safe mode on two-wheel control.

2.5. Impact of product version "c"

2.5.1. Editing procedure

For GDR version "c" the same editing criteria and thresholds like in GDR version "b" are used. Thus the MLE4 retracking algorithm, based on a second-order altimeter echo model and more robust for large off-nadir angles (up to 0.8 degrees), is used. For product version "a" (CMA version 6.3), the maximum threshold on square off-nadir angle proposed in Jason-1 User Handbook document was set to 0.16 deg^2. Since GDR version "b", this threshold is too restrictive and has to be set to 0.64 deg^2.

However, this editing criteria had the side effect of removing some bad measurements impacted by rain cells, sigma0 blooms or ice. With the new threshold (0.64 deg^2), these measurements are not rejected any more even though the estimated SSH is not accurate for such waveforms.
Therefore 2 new criteria have to be added to check for data quality :
- Standard deviation on Ku sigma0 $\leq$ 1 dB
- Number measurements of Ku sigma0 $\geq$ 10

The Jason-1 User Handbook suggests the following editinig criteria for the version "a" GDRs :

- -0.2 $deg^2 \leq$ square of off-nadir angle from waveforms (off_nadir_angle_ku_wvf) $\leq$ 0.16 deg^2
- sigma0_rms_ku $<$ 0.22 dB (optional criterion)

Since the version "b" GDRs these two edit criteria should be replaced by :
- -0.2 $deg^2 \leq$ square of off-nadir angle from waveforms (off_nadir_angle_ku_wvf) $\leq$ 0.64 deg^2
- and sigma0_rms_ku $\leq$ 1.0 dB
- and sig0_numval_ku $\geq$ 10

With these new criteria, the editing gives similar results for both product versions. Most of anomalous SSH measurements are rejected. Please note that some of them are still not detected, in particular close to sea ice.

2.5.2. Orbit

The orbit of GDRs "c" uses EIGEN-GL04S gravity field and ITRF2005, instead of EIGEN-CG03C and ITRF2000 for GDRs "b". The change of ITRF induces a North/South bias when comparing with GDRs "b".

2.5.3. Sea state bias

The sea state bias (SSB) model on the GDRs "c" products has been empirically derived from MLE4-retracked altimeter data (cycles 1 to 111, GDRs "b"). Users need to be aware that the SSB model on the GDRs "c" will shift the globally averaged SSH lower by 3-4 cm relative to GDRs "b" (when using SSB from the GDR "b" product).

2.5.4. Altimeter instrument correction tables

The altimeter instrument correction tables have been updated using a new version of the altimeter simulator. This allows the Jason-1 and Jason-2 altimeter correction tables to be aligned with each other. As a result, altimeter range, SWH, and sigma0 measurements reported on GDRs "c" products are slightly different than the corresponding measurements on GDRs "b", even though identical retracking algorithms (MLE4) were used to generate both products. For more details, see Jason-1 User Handbook.

2.5.5. Jason-1 Radiometer wet troposphere correction

Version "c" GDRs contain the recalibrated JMR data and some improved algorithms to derive JMR brightness temperatures. Time-variable calibration coefficients with new coefficients once per cycle were implemented. There was also a correction of the scale error.

3. Poseidon-2 altimeter and sensor

3.1. Sensor status

A detailed assessment of the Poseidon-2 sensor is made in a separate bulletin to be made available on request.

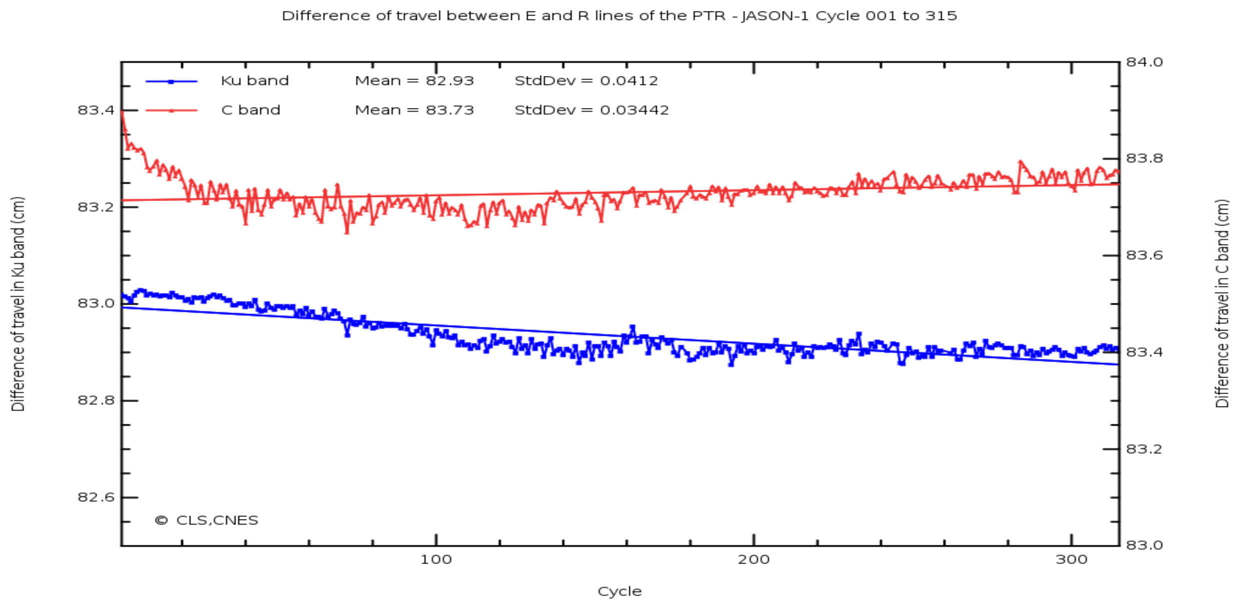
3.2. Poseidon-2 altimeter status

This section presents the general status of the altimeter for main instrumental variations through the Jason-1 mission. Two calibration modes are used to monitor the altimeter internal drifts and compute the altimetric parameters. They are programmed about three times per day, over land.
The CAL1 mode measures the Point Target Response (PTR) of the altimeter in Ku and C bands. Among the parameters extracted from the PTR are :

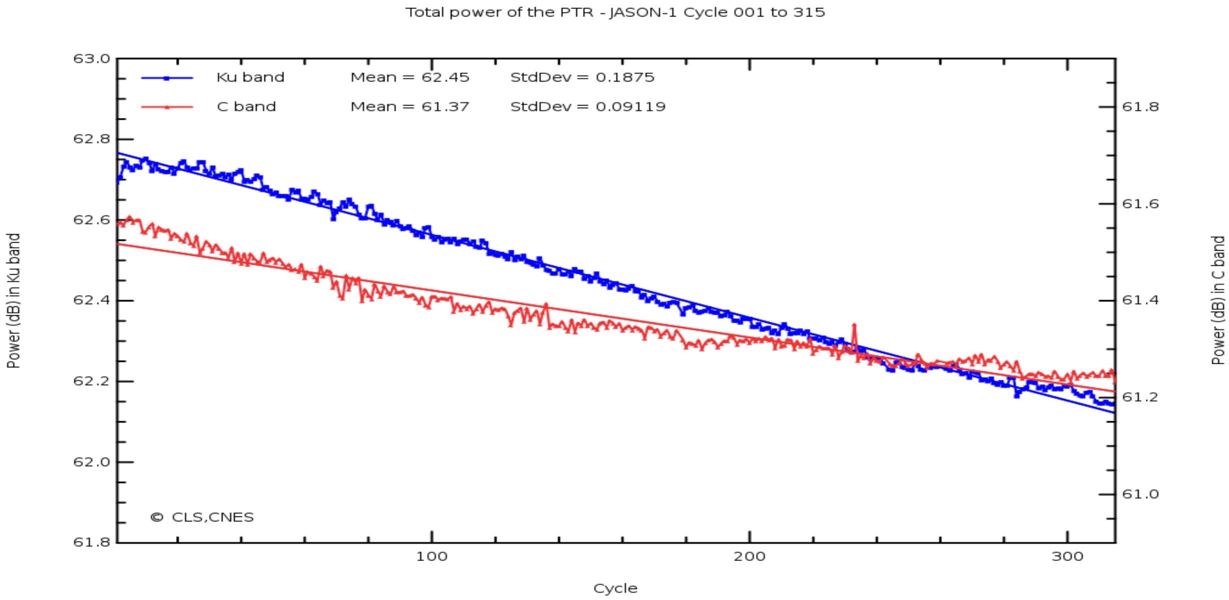
- the internal path delay
- the total power of the PTR

The evolutions of these parameters as a function of time are plotted to monitor the ageing of the altimeter. Notice that in the Jason-1 products, the range is corrected for the internal path delay and the backscatter coefficient takes into account the total power of the measured PTR.

3.2.1. Monitoring of the internal path delay



3.2.2. Monitoring of the total power in the PTR

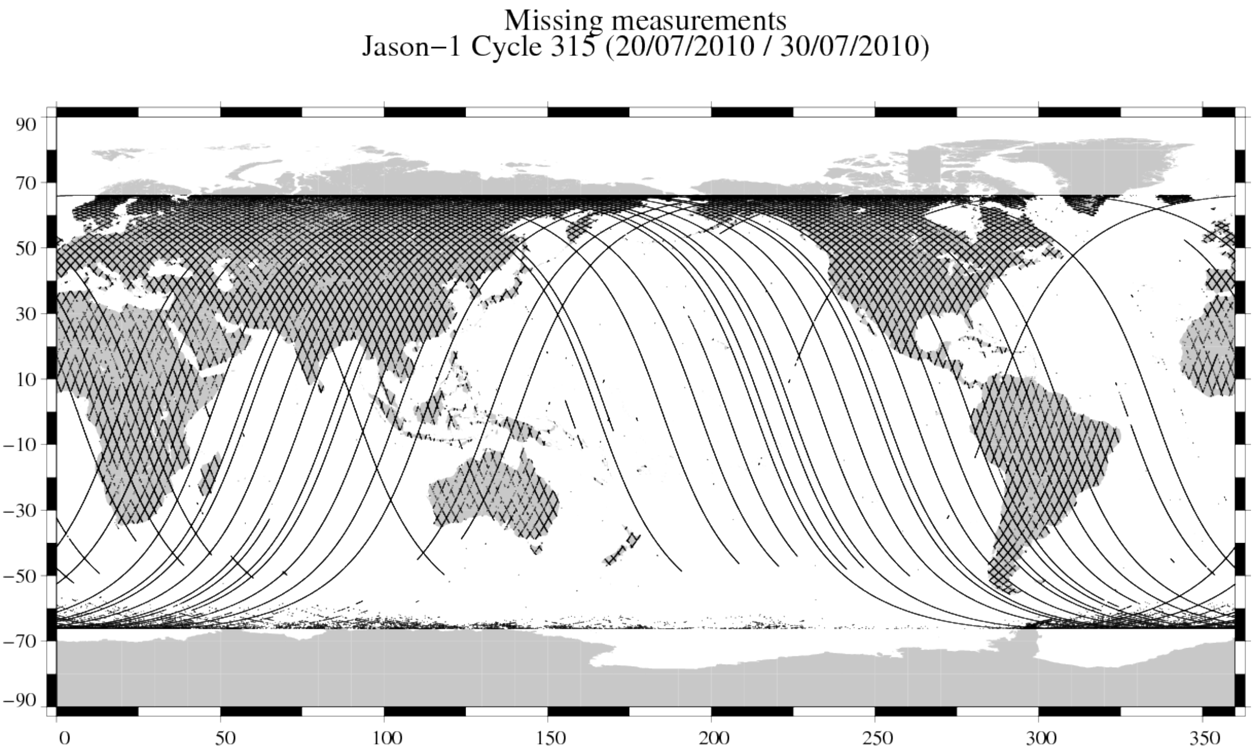


4. CALVAL main results

This section presents results that illustrate data quality during this cycle. These verification products are produced operationally so that they allow systematic monitoring of the main relevant parameters.

4.1. Missing measurements

The map below illustrates missing 1Hz measurements in the GDRs, with respect to a 1 Hz sampling of a nominal repeat track.



4.2. Edited measurements

Editing criteria are defined for the GDR product in Aviso and PODAAC User Handbook [2].
The editing criteria are defined as minimum and maximum thresholds for various parameters. Measurements are edited if at least one parameter does not lie within those thresholds. These thresholds are expected to remain constant throughout the Jason-1 mission, so that monitoring the number of edited measurements allows a survey of data quality.
In the following, only measurements over ocean are kept. This is done by applying an ocean-land mask, instead of using the altimeter state flag (alt_state_flag) or the radiometer state flag (rad_state_flag). There is no impact on global performance estimations since the more significant results are derived from analyses in open ocean areas.
The rain flag is not used for data selection.

The number and percentage of points removed by each criterion is given on the following table. Note that these statistics are obtained with measurements already edited for ice flag (12.48 % of points removed).

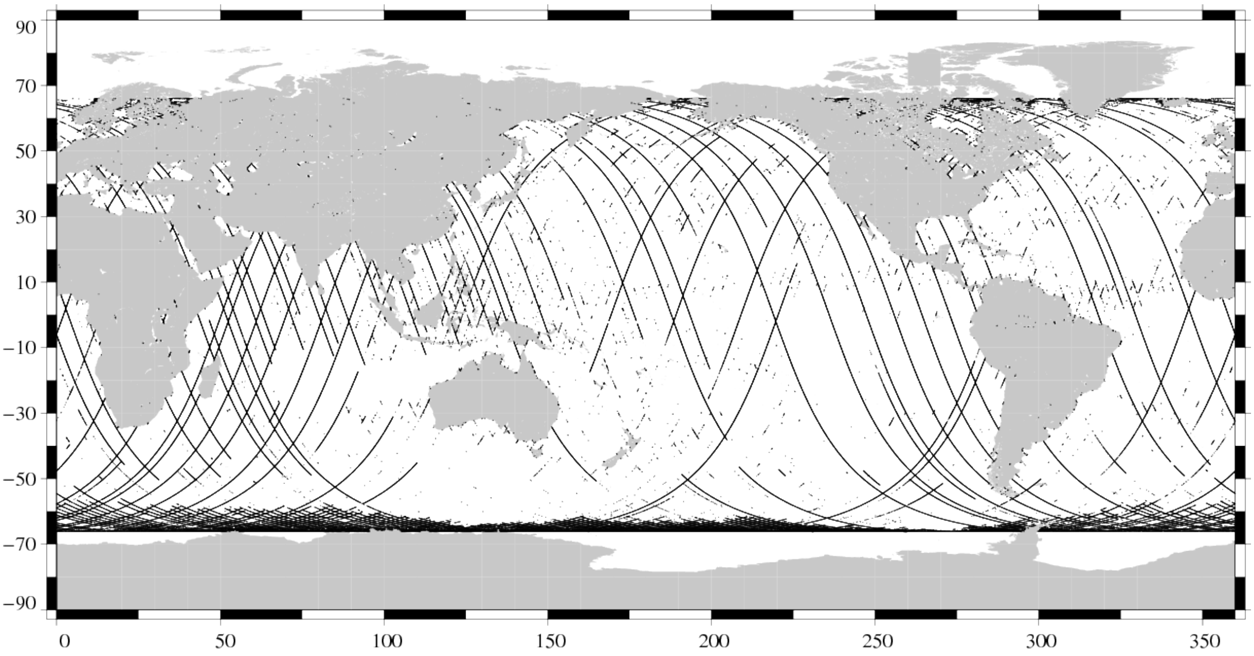
Since GDR version C, an ice flag similar to ERS ice flag is available in the products, and therefore used for the editing. It takes into account the difference between (dual frequency) radiometer and ecmwf model wet troposphere correction. It has the advantage to better detect sea ice in the Hudson Bay.

Parameters	Min threshold	Max threshold	Unit	Nb removed	% removed	% mean removed
Sea surface height	-130.000	100.000	m	38251	9.40	0.87
Sea level anomaly	-2.000	2.000	m	58820	14.46	1.07
Nb measurements of range	10.000	_	_	41698	10.25	1.22
Std. deviation of range	0.000	0.200	m	41801	10.28	1.40
Square off nadir angle	-0.200	0.640	deg^2	47291	11.63	0.58
Dry tropospheric correction	-2.500	-1.900	m	0	0.00	0.00
Combined atmospheric correction	-2.000	2.000	m	0	0.00	0.00
JMR wet tropospheric correction	-0.500	-0.001	m	1558	0.38	0.10
Ionospheric correction	-0.400	0.040	m	40192	9.88	1.20
Significant wave height	0.000	11.000	m	34597	8.51	0.65
Sea State Bias	-0.500	0.000	m	34090	8.38	0.56
Backscatter coefficient	7.000	30.000	dB	34408	8.46	0.60
Nb measurements of sigma0	10.000	_	_	41616	10.23	1.21
Std. deviation of sigma0	0.000	1.000	dB	41332	10.16	1.74
Ocean tide	-5.000	5.000	m	233	0.06	0.06
Equilibrium tide	-0.500	0.500	m	0	0.00	0.00
Earth tide	-1.000	1.000	m	0	0.00	0.00
Pole tide	-15.000	15.000	m	0	0.00	0.00
Altimeter wind speed	0.000	30.000	$m.s^{-1}$	35407	8.70	1.02
Global statistics of edited measurements by thresholds	_	_	_	77408	19.03	3.05

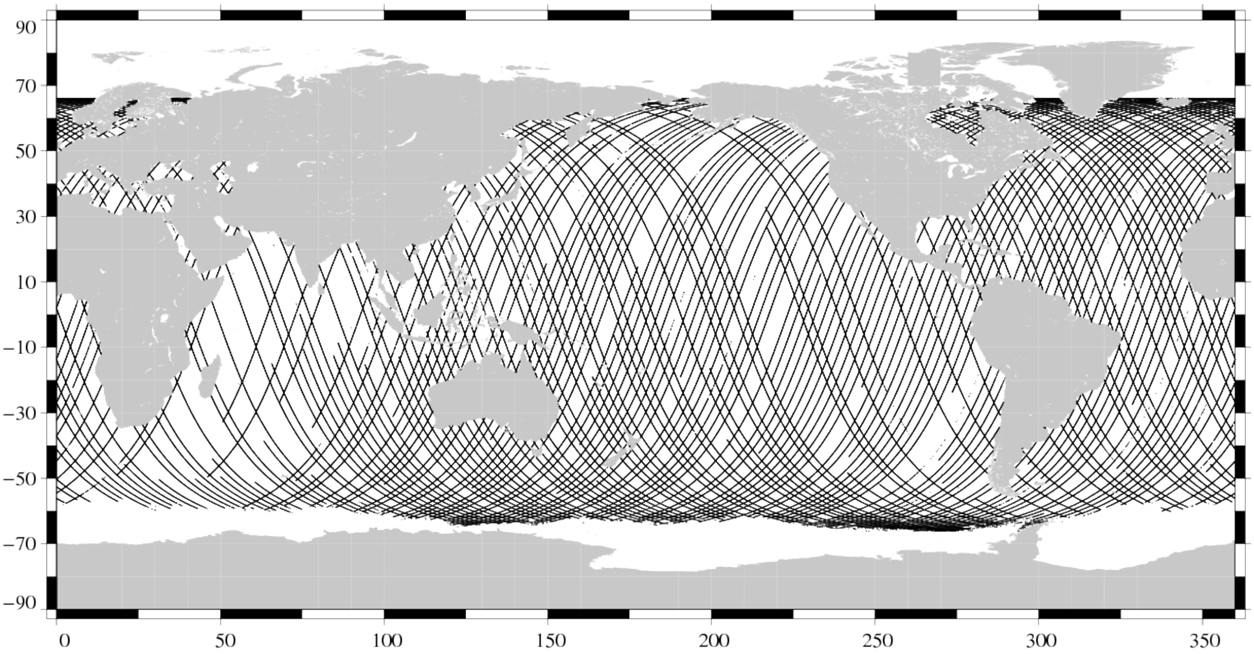
4.2.1. Figures

The following two maps are complementary : they show respectively the removed and selected measurements in the editing procedure.

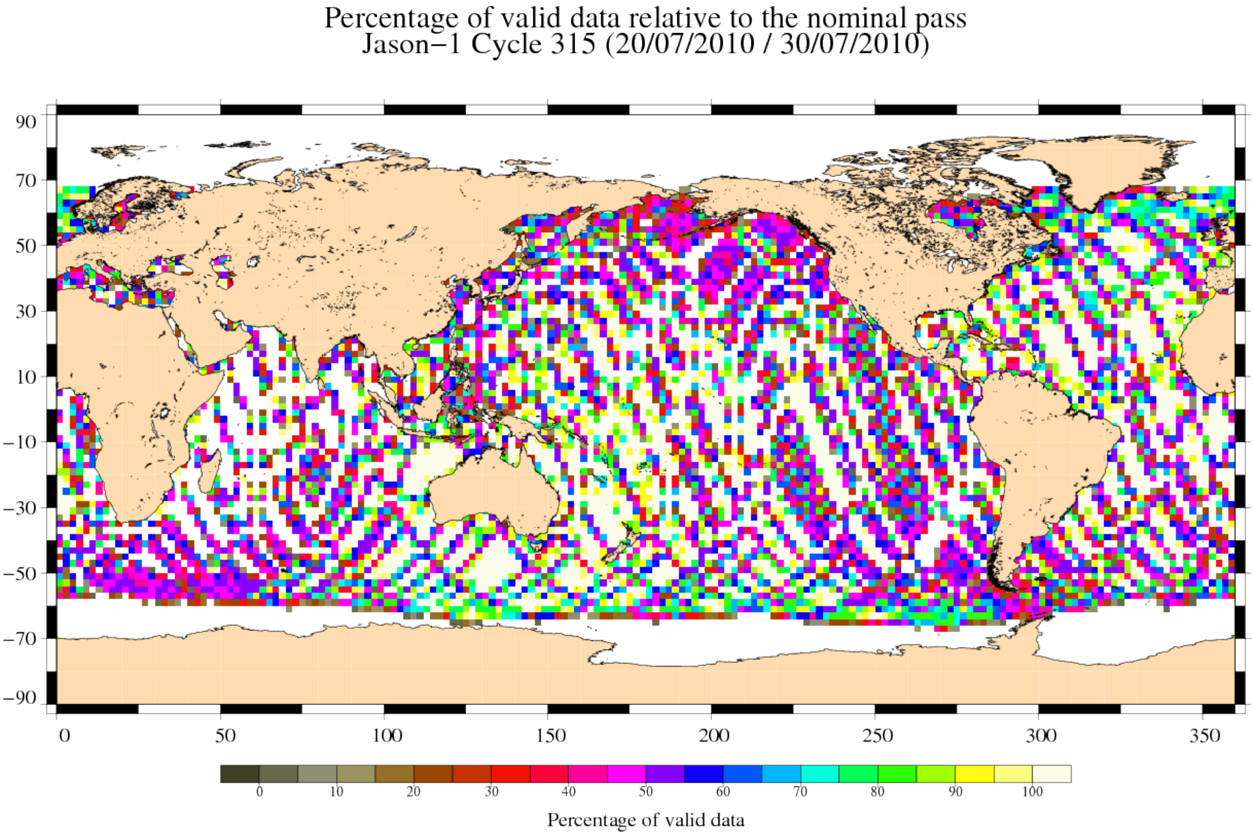
Edited measurements
Jason−1 Cycle 315 (20/07/2010 / 30/07/2010)



Valid data
Jason−1 Cycle 315 (20/07/2010 / 30/07/2010)



The next map shows the percentage of valid measurements by sample.



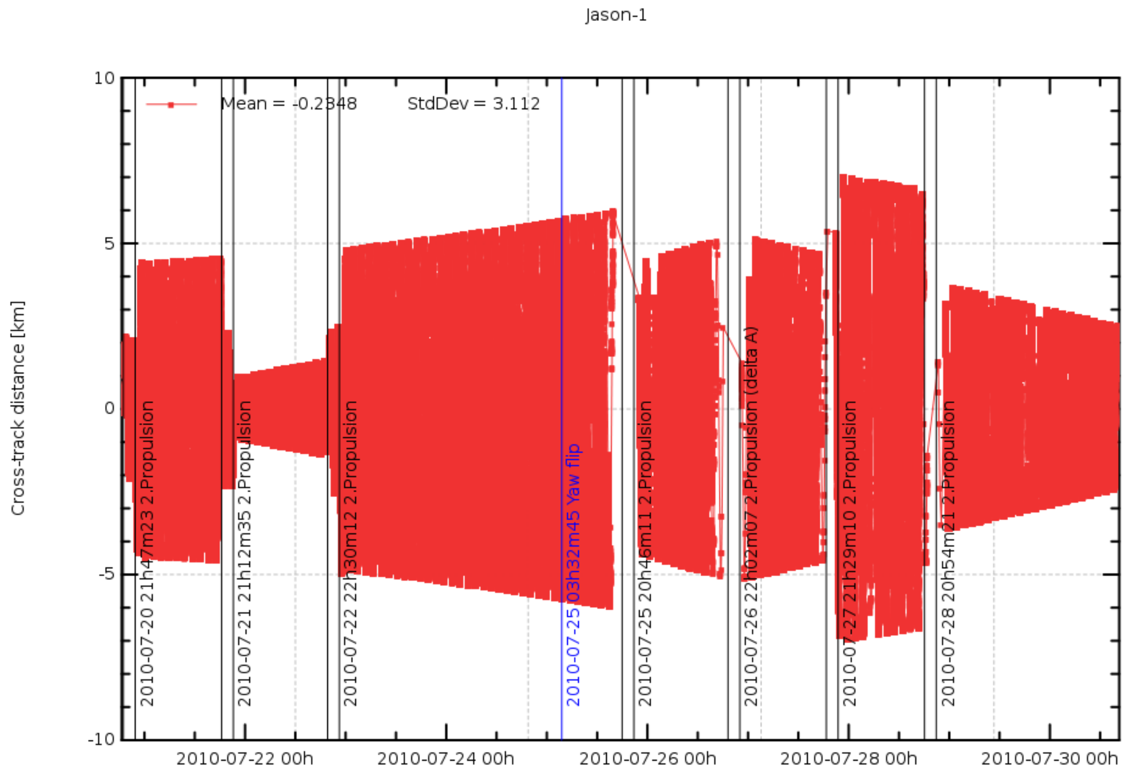
4.2.2. Comments

Wet zones appear in the plot of removed data, as it was also the case for Topex and Poseidon altimeters : measurements may be corrupted by rain. Compared with the usual maps obtained for Topex, there are less removed data in these zones and in the areas of strong sea states.

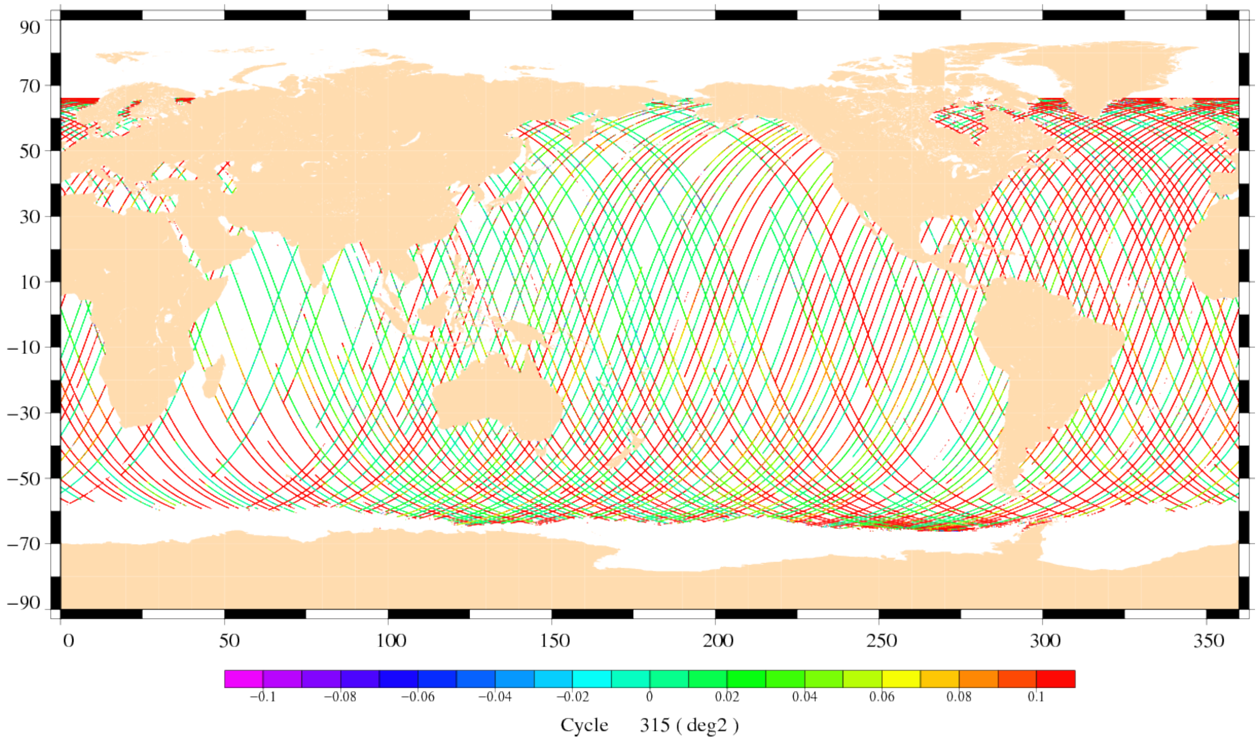
Several passes are completely edited by SLA out of thresholds (2,27,29,54,57,182,183) or SLA pass statistics out of thresholds (3,4,28,53,55,136,160). Furthermore several passes are partly edited by SLA out of threshold. This is caused by the maneuvers.
Several passes are completely (123,151,178,191,198,204,221,230,233) and several partly edited by altimeter parameters at default values. This is causes by high mispointing (to high for MLE4 algorithm).
Passes 177 and 178 are partly edited by radiometer wet troposphere correction at default value.
Several passes have altimeter quality flag set.
Several passes have orbit state flag set at 8 (orbit is extrapolated for a duration longer than 2 days or orbit is extrapolated just after a maneuver).
Note that some portions of passes in high latitudes are edited by ice flag. This is related to high mispointing (number of elementary range measurements used in computation of ice flag is zero due to high mispointing).

Note that due to the important maneuvers it is impossible to compute a complete POE for this cycle 315, the latter is an assembled MOE.

Note the cross-track distance versus nominal ground track can depart up to 7 km due to the out of plane maneuvers (see figure below).



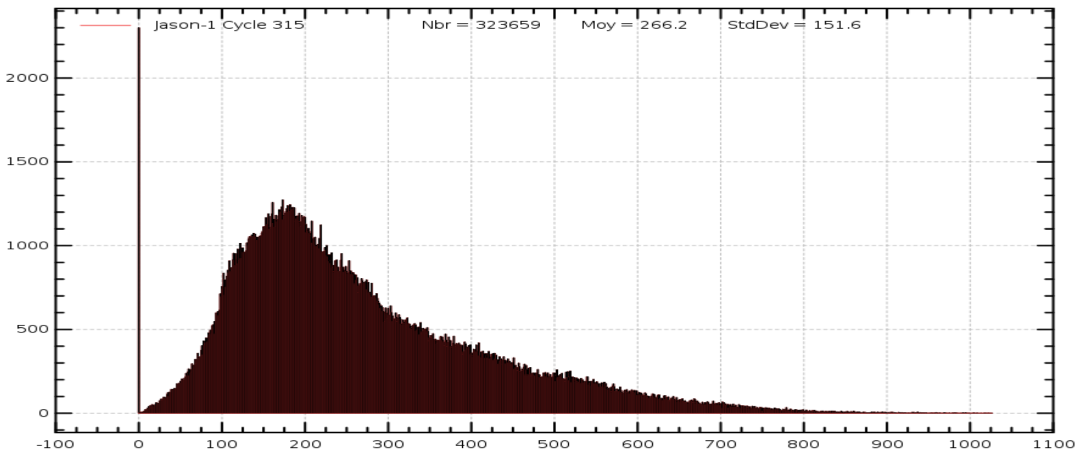
Note that due to low star tracker performances, apparent square mispointing is very high for this cycle, leading even to lost of track (see figure below).



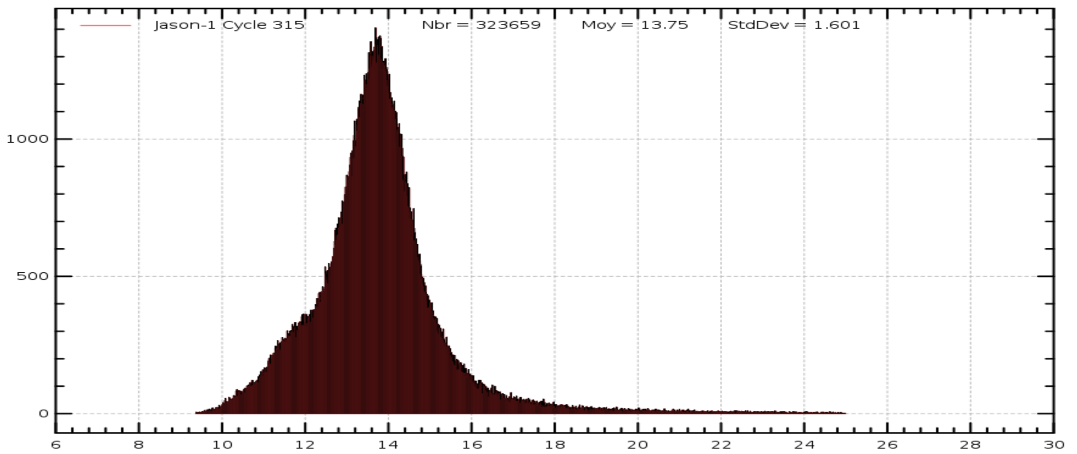
4.3. Altimeter parameters

In order to assess and to monitor altimeter parameter measurements, histograms of Jason-1 Ku-band Significant Wave Height (SWH), Backscatter coefficient (Sigma0) and RMS of altimeter range are computed for the valid data set previously defined.

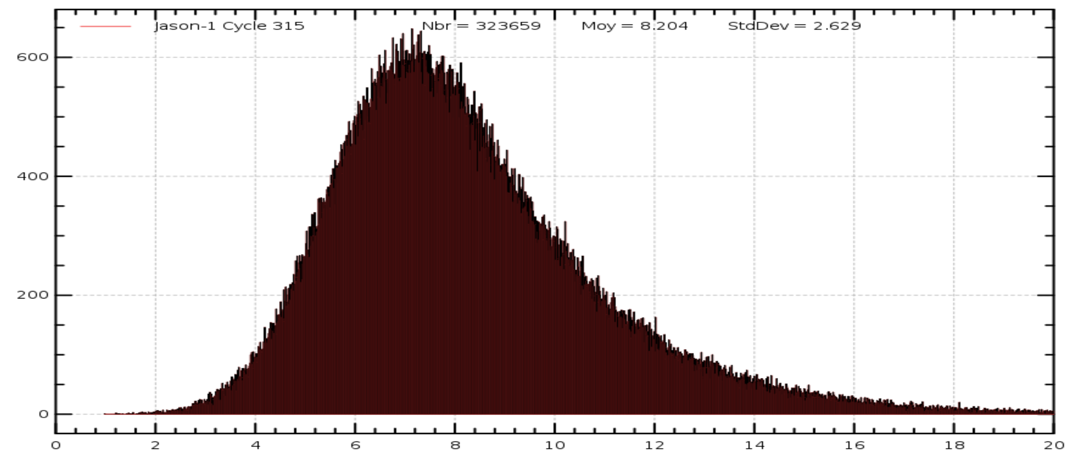
Ku-band Significant Wave Height (unit:cm)



Ku-band Backscatter Coefficient (unit:dB)



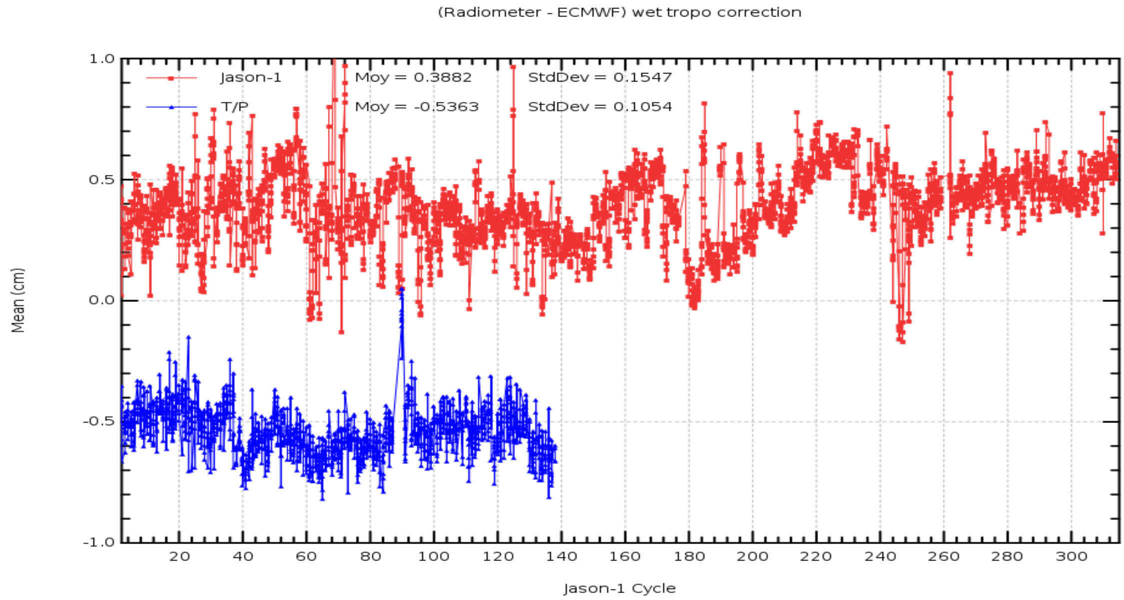
RMS of Ku-band range (unit:cm)



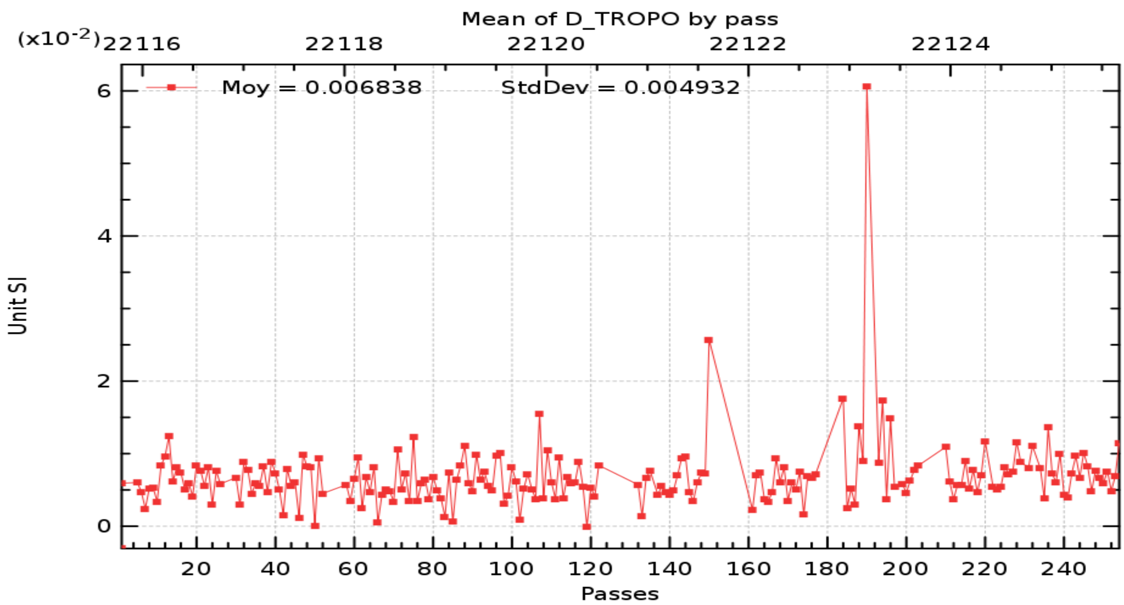
4.4. Radiometer parameters

Daily mean of (Radiometer - ECMWF) wet troposphere corrections is plotted below for Jason-1 and T/P. Note that the TMR correction has been corrected for the drift (Sharroo R. et al., 2004 [4]). Moreover the 60-day signal due to TOPEX yaw maneuvers has been partially removed. Since 9th october 2005 scientific mission of TOPEX has stopped.
JMR wet troposphere correction in GDR version "a" used to show a 60-day signal due to Jason-1 yaw maneuvers, as well as jumps. These anomalies were corrected in the GDR version "b" and "c". Nevertheless this long term monitoring still exhibited abnormal variations :

- The 60-day signals due to Jason-1 yaw maneuvers is sometimes still visible.
- After safehold modes (e.g. cycle 243/244), JMR shows thermal instabilities, leading to oscillations in JMR-ECMWF wet troposphere correction differences.

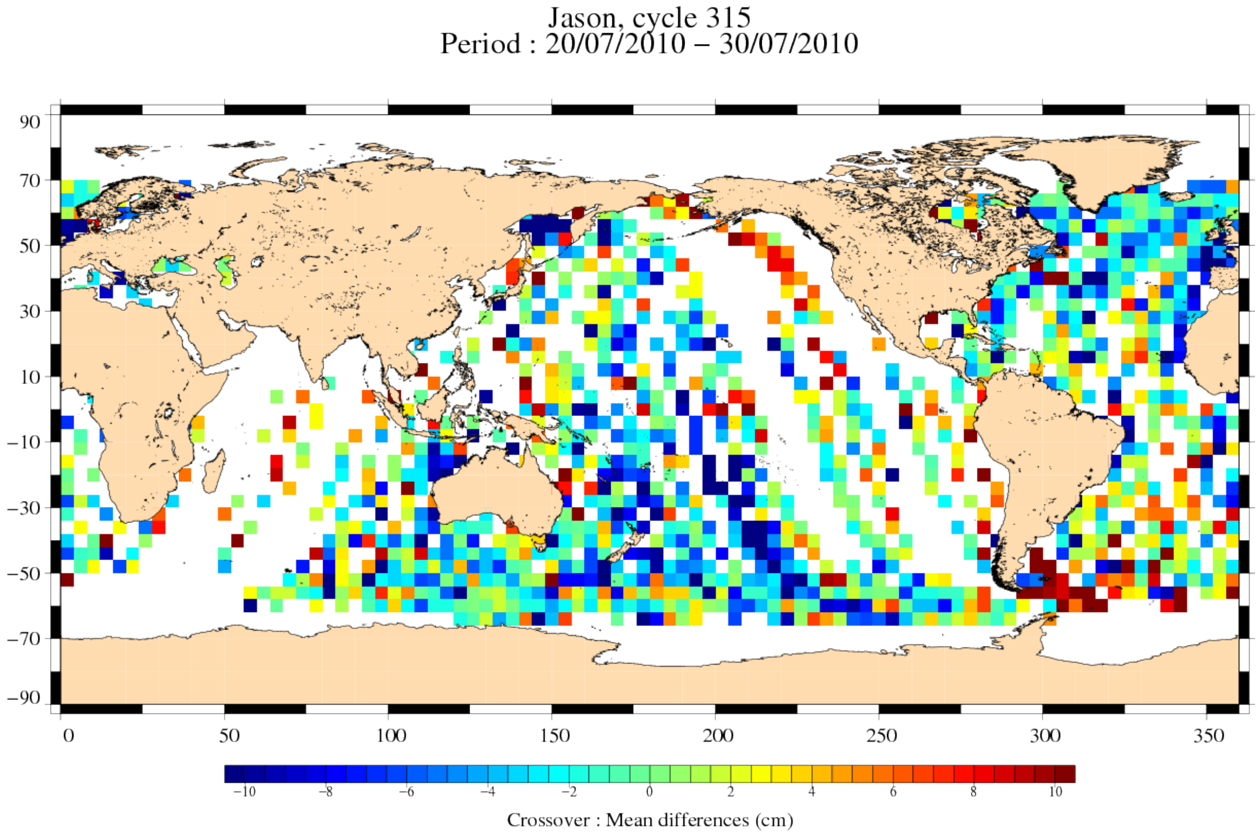


The figure below shows the mean of wet troposphere correction (radiometer - ECMWF) difference by pass.



4.5. Crossover statistics

SSH crossover statistics are computed from the valid data set. They are used to estimate the data quality and to monitor the system performances.
After data editing and using the standard Jason-1 algorithms, the crossover standard deviation is about 6.14 cm rms, when using a selection to remove shallow waters (1000 m), areas of high ocean variability and high latitudes ($> |50|$ deg.).
The map of the mean differences at crossovers (4 by 4 degrees by bins) is plotted below.

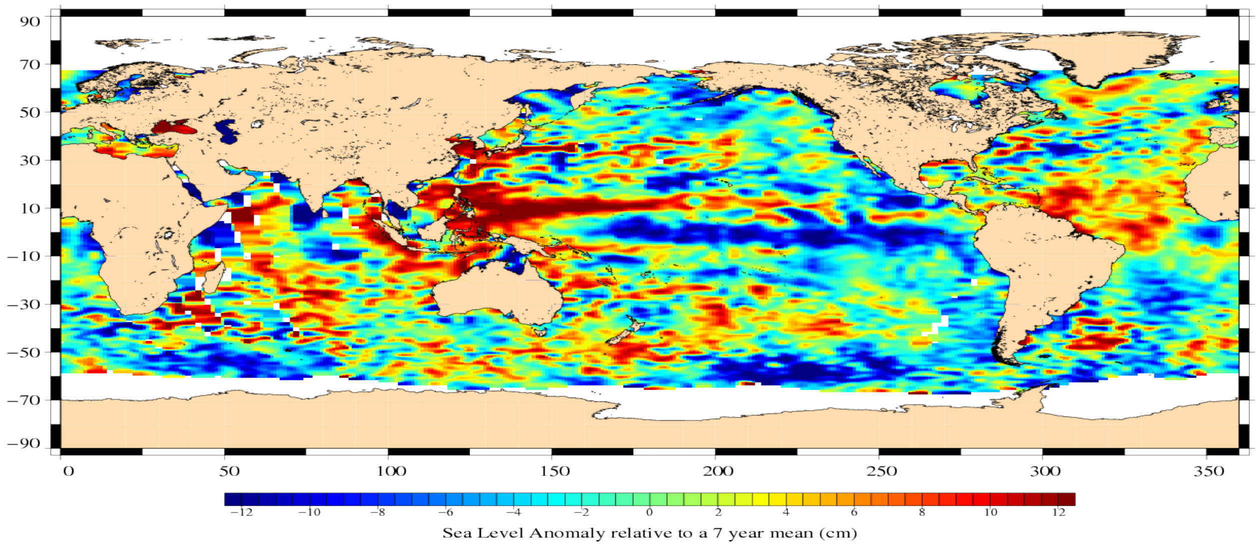


4.6. SSH variability

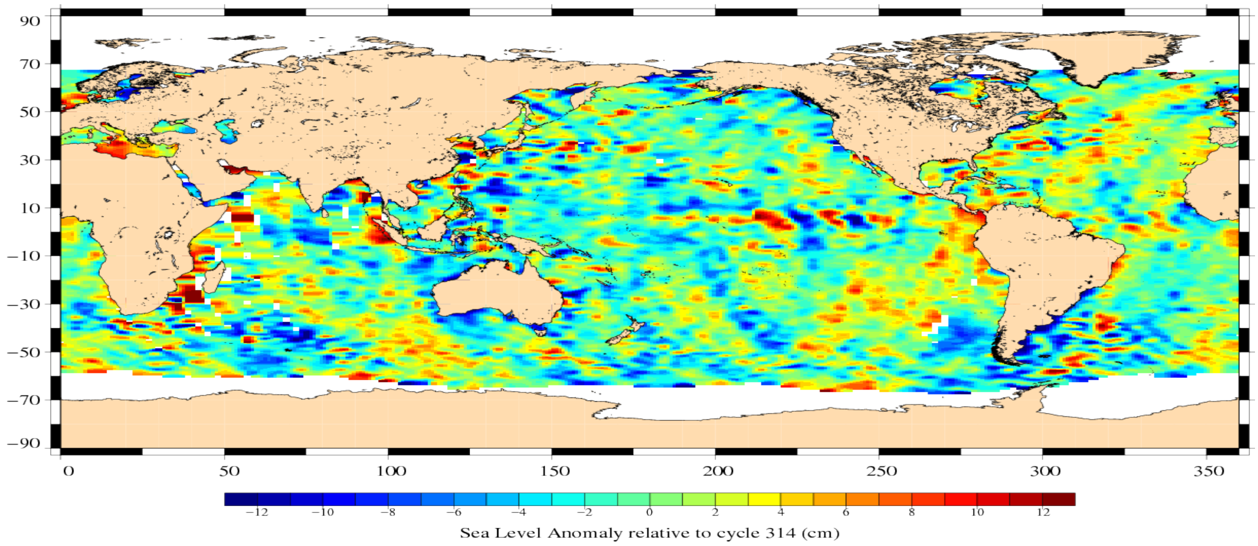
4.6.1. Jason-1 Sea Level Anomalies

Repeat-track analysis is routinely used to compute Sea Level Anomalies (SLA) relative to the previous cycle and relative to a mean profile. SLA relative to a 7-year mean (based on TOPEX/Poseidon data) shows general oceanic features in good agreement with what is observed with TOPEX/Poseidon.
The SSH differences relative to the previous cycle 314 are plotted on the bottom figure. The differences seem homogeneous and do not exhibit any particular trackiness pattern, showing the good quality of the orbit calculation in the Jason-1 GDRs.

Jason−1 Cycle 315
20/07/2010 – 30/07/2010

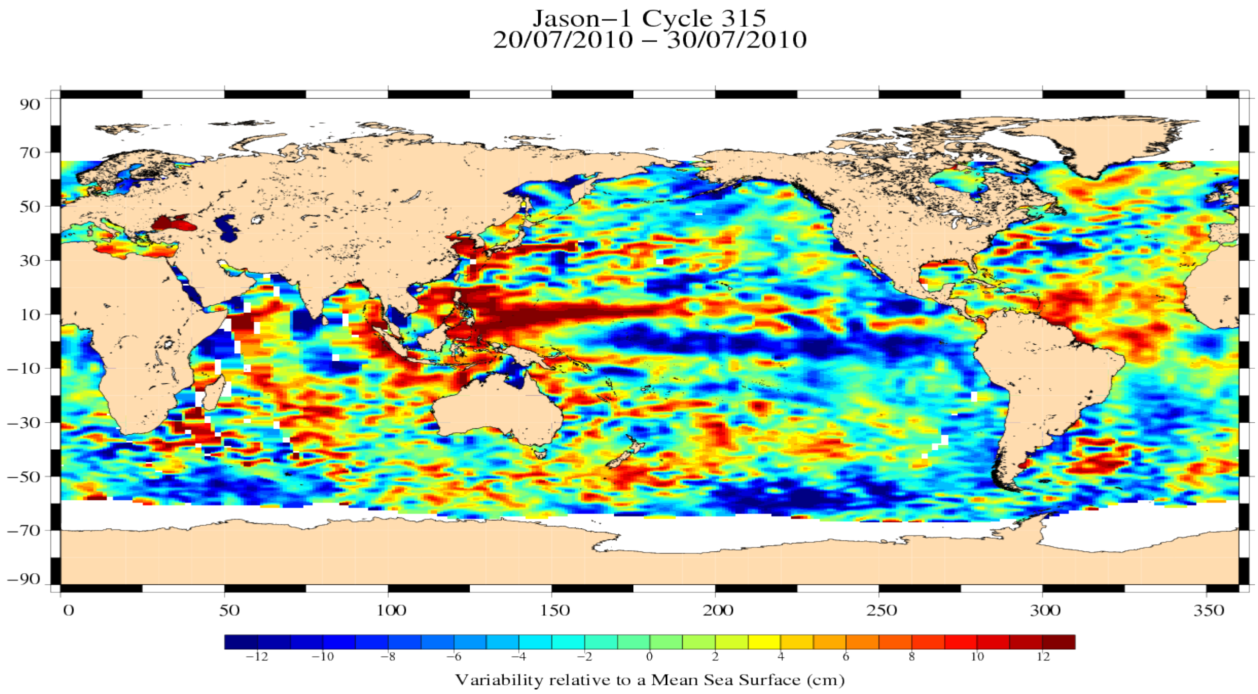


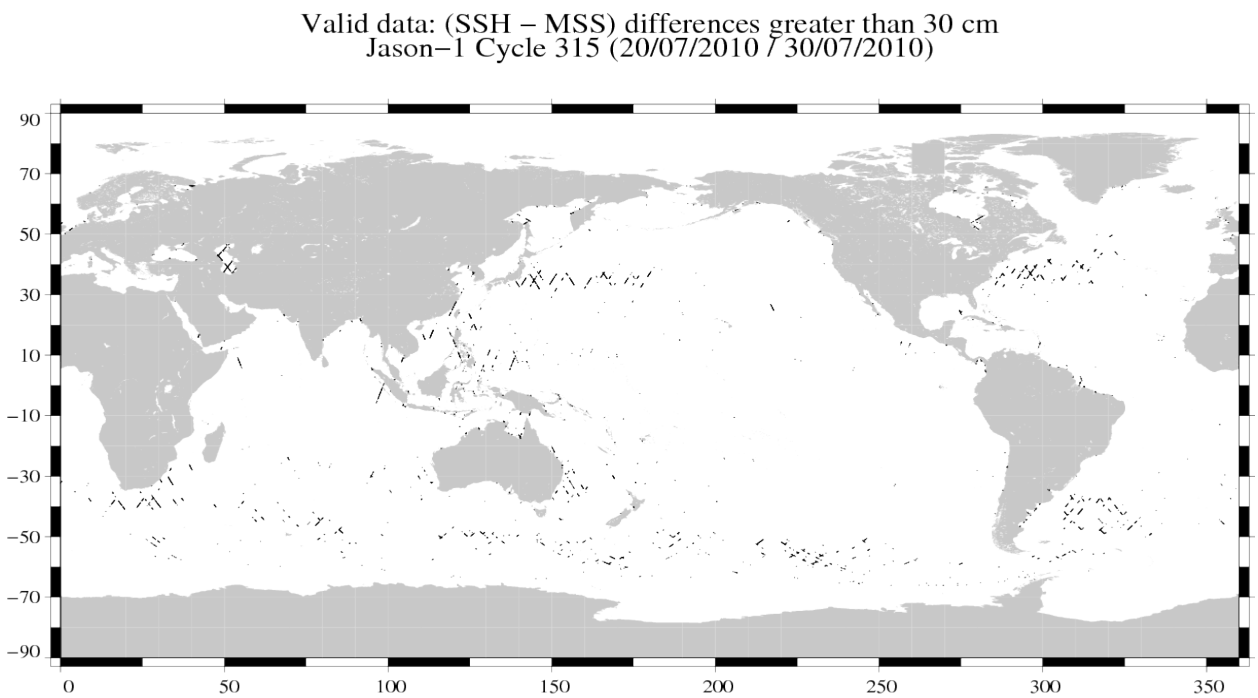
Jason−1 Cycle 315
20/07/2010 – 30/07/2010



4.6.2. Comparison to a Mean Sea Surface

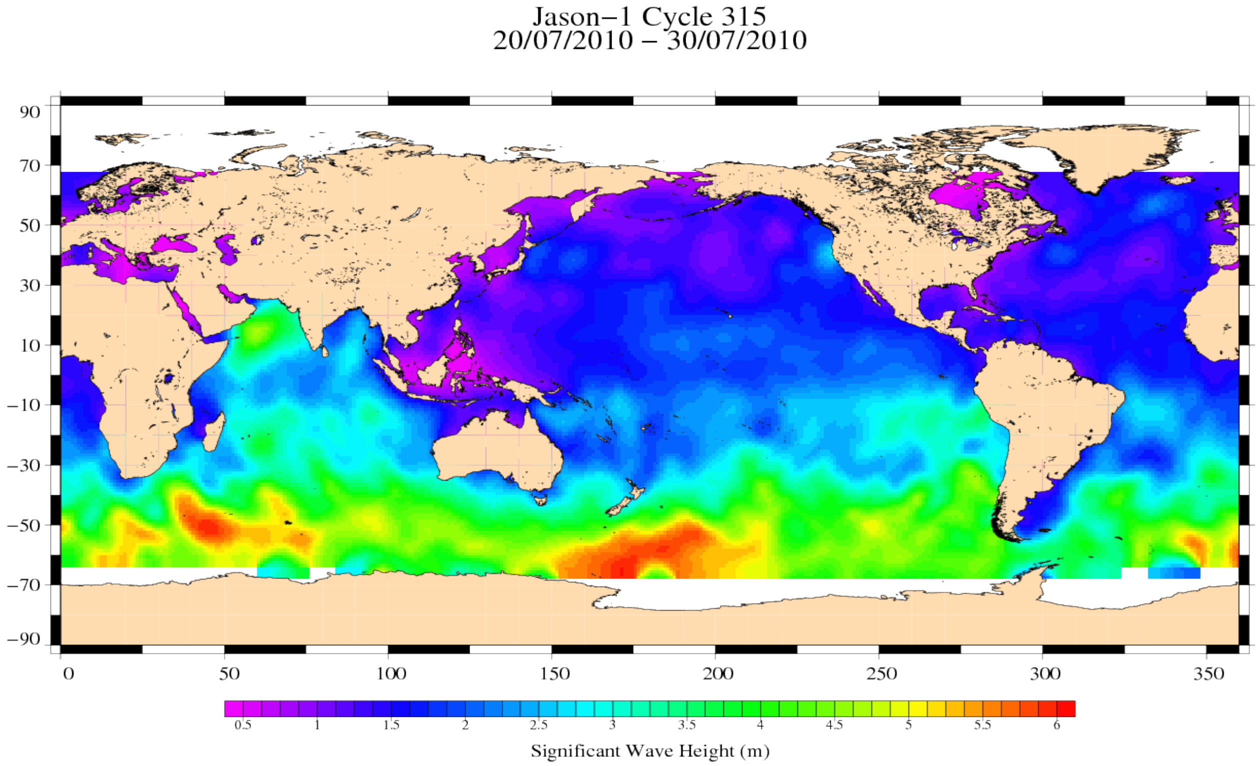
The following two maps respectively show the map of Jason-1 SLA relative to the MSS and differences higher than a 30 cm threshold (after centering the data). The latter figure shows that apart from isolated measurements that should be removed after refining the editing thresholds, higher differences are located in high ocean variability areas, as expected.

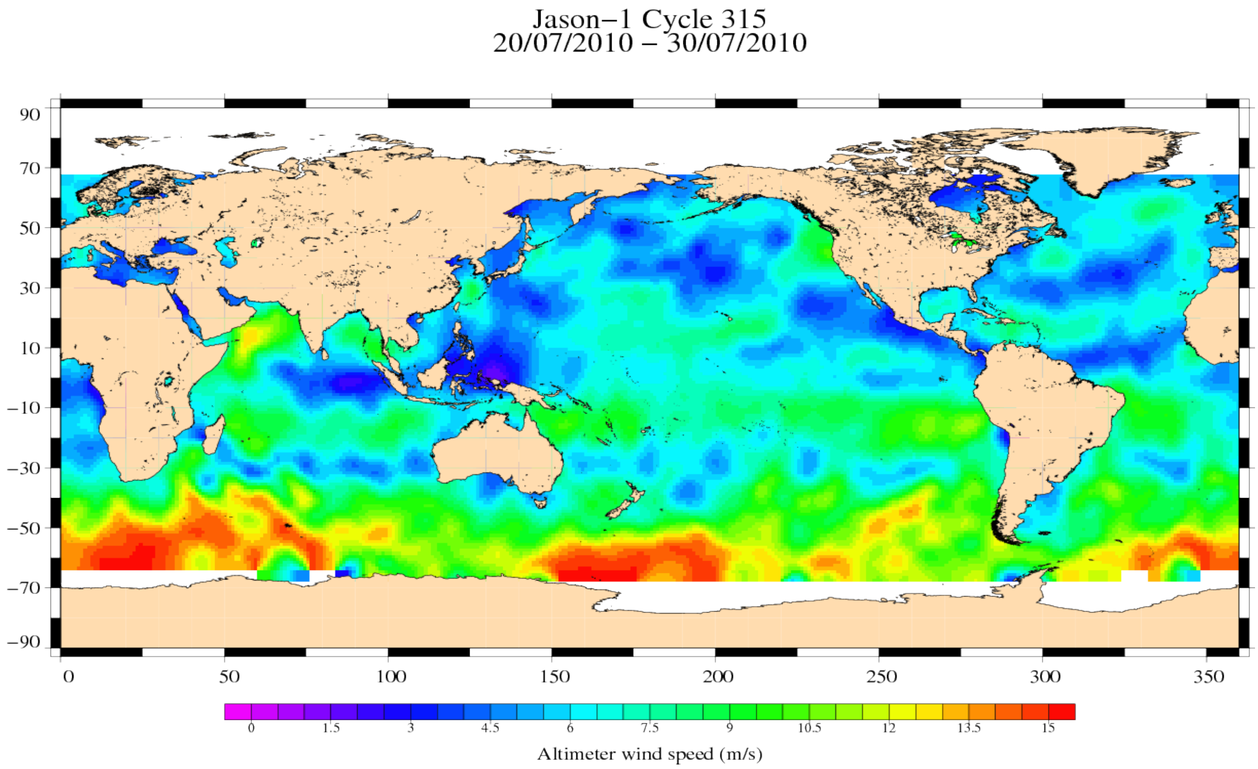




4.7. Wind and wave maps

These two figures show wind and wave estimations derived from 10 days of altimeter measurements.





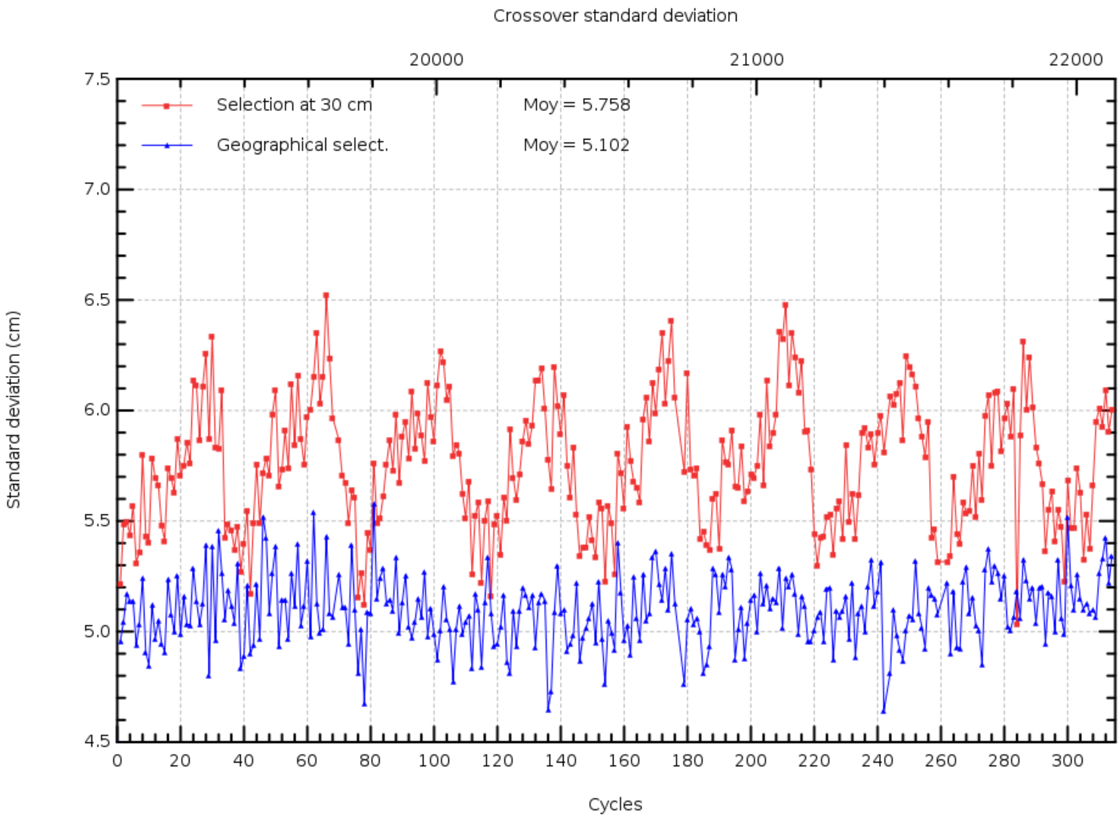
5. Jason-1 long term performance monitoring

Statistics of SSH variability are computed after crossover and repeat-track analyses. This allows to estimate how Jason-1 data fulfill the mission objectives in terms of performances.

5.1. Standard deviation of the differences at crossovers

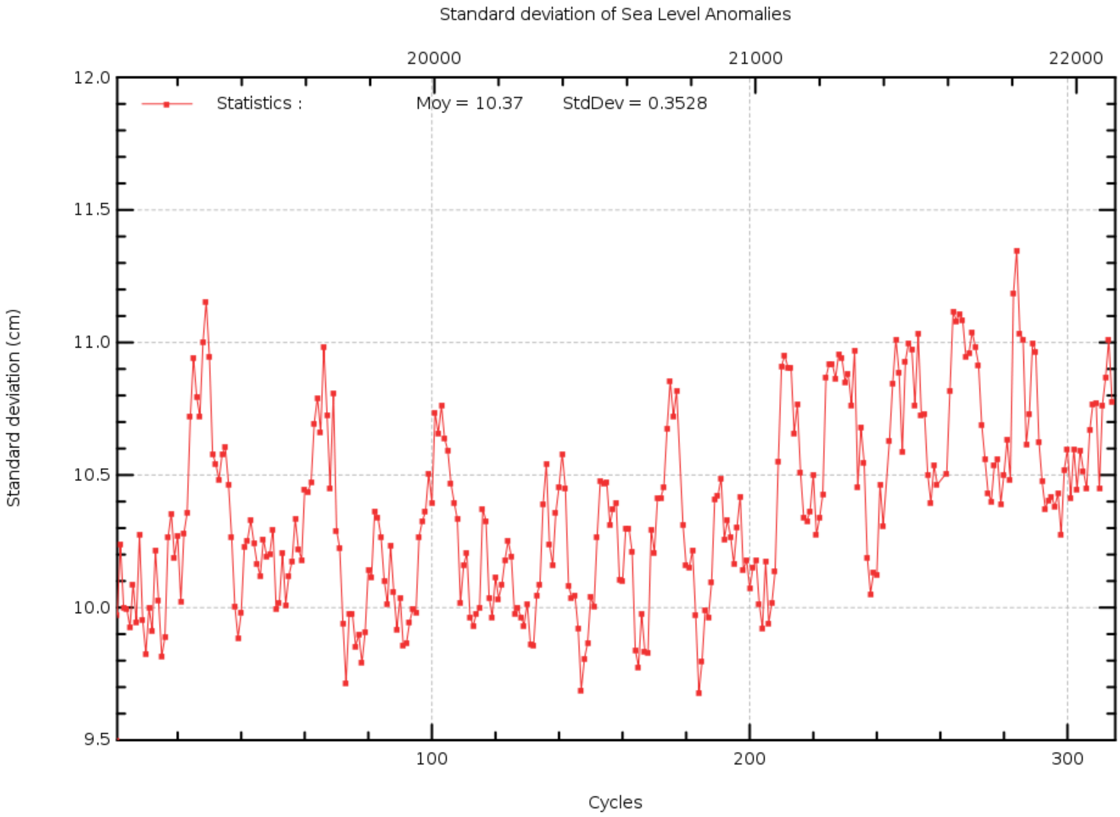
This parameter is plotted as a function of time in a one cycle per cycle basis in the figure below. It is computed after data editing and using 2 additional selection criteria :

– Selecting crossover differences lower than 30 cm to avoid contamination by remaining spurious data.
– Removing shallow waters (1000 m), areas of high ocean variability and high latitudes (> |50| deg.) to avoid ice coverage effects.



5.2. RMS of Sea Level Anomaly

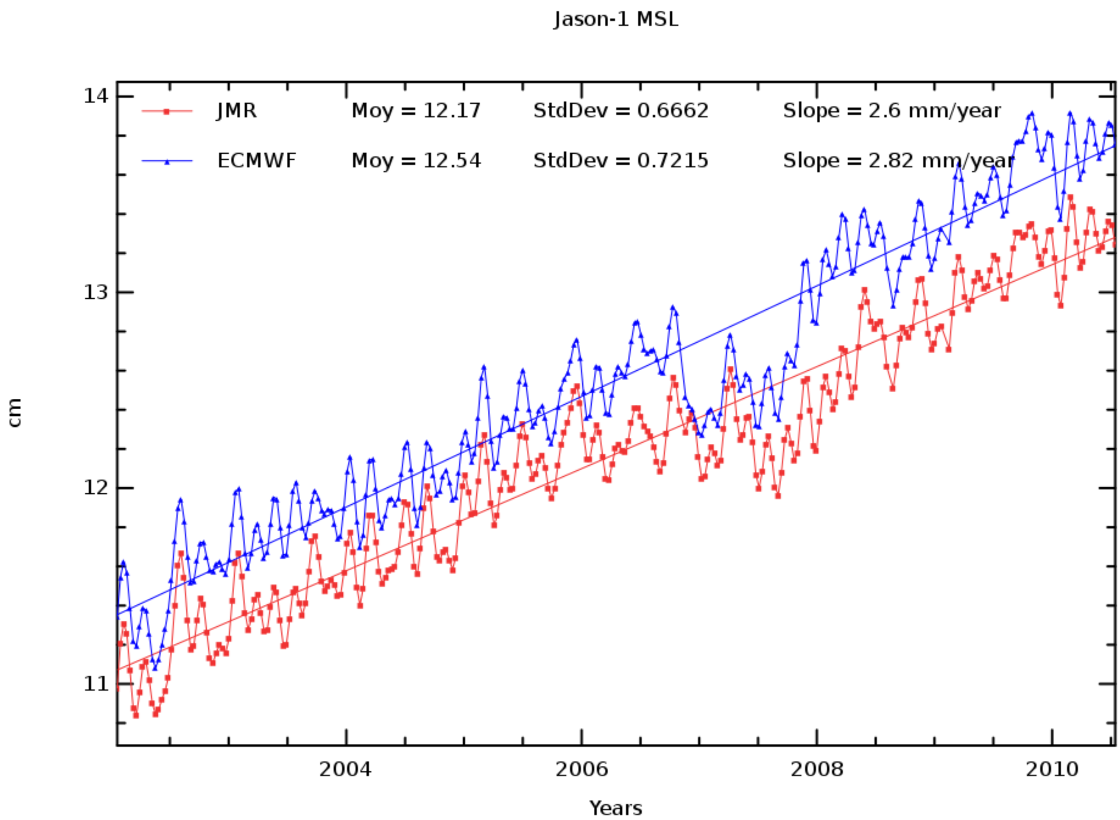
Sea Level Anomalies relative to a mean profile are computed using repeat-track analysis for each Jason-1 cycle. To monitor Jason-1 performances and ocean signals, the cycle per cycle standard deviation of the SLA is plotted as a function of time.



6. Mean Sea Level estimations (MSL)

6.1. Jason-1 MSL

MSL estimations are performed in a cycle basis averaging Sea Level Anomalies relative to a mean profile. The value for each cycle is calculated from averaging over 2 by 3 degree bins, then weighting by latitude to take into account the relative geographical area represented by the bin. Results plotted on the following figure are obtained after annual, semi-annual and 60-day signals reduction. MSL estimations are computed with JMR or ECMWF wet troposphere correction so as to compare both solutions. Indeed wet troposphere correction is a main source of error for the MSL calculation. From now on, the whole time series are available in version C. Users are strongly advised to refer to the estimated MSL provided on the AVISO website (http ://www.aviso.oceanobs.com/msl). Details of the way MSL trends are computed are described in [7]. The mean difference of almost 4 mm between both MSL comes from the mean difference of both wet troposphere corrections, which is also close to 4 mm.



Références

[1] Picot N., October 21, 2005 : New Jason-1 operational production chain. *Electronic communication.*

[2] Aviso and PoDaac User Handbook, October 2008 : IGDR and GDR Jason-1 Products, *SMM-MU-M5-OP-13184-CN.*

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