# Jason-1 GDR
# Quality Assessment Report

## Cycle 137

## *24-09-2005 / 04-10-2005*

| | | |
|---|---|---|
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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**
- **TP and Jason-1 comparisons**
- **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 V7.1_04. The content of this science software version is described by N.Picot (electronic communication, October 21, 2005) [1]). The main impacts of these evolutions are described in section Impact of CMA version 7.1 for the SSH calculation (page 3).

## 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 6.57 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 4.95 cm rms.
The standard deviation of Sea Level Anomalies (SLA) relative to a 7-year mean (based on T/P data) is 10.31 cm. When using a selection to remove shallow waters (1000 m), areas of high ocean variability and high latitudes (> |50| deg) it lowers to 8.91 cm .

- Performances from crossover differences are detailed in the dedicated **section Crossover statistics**.
- Detailed CALVAL results are presented in **section 3**.

## 2.3 Missing measurements

Due to a platform incident, passes 1 to 91 are missing and pass 92 is partly missing with 11.75% of missing measurements. A wrong quaternion was used in SCAO loop on 2th October, 8:34 leading to high off-nadir values (several degrees) and therefore to altimeter lost of tracking. In consequence, pass 196 is partly missing with 94.44% of missing measurements. Missing measurements relative to a nominal ground track are plotted on **section Missing measurements**.

## 2.4 Impact of product version "b" (CMA version 7.1) for the SSH calculation

### 2.4.1 Editing procedure

The new MLE4 retracking algorithm based on a second-order altimeter echo model is more robust for large off-nadir angles (up to 0.8 degrees). For product version "a" (previous CMA version 6.3), the maximum threshold on square off-nadir angle proposed in Jason-1 User Handbook document was set to 0.16 $deg^2$. Henceforth, 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)

For 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. This is due to the ice flag which is not perfect.

### 2.4.2 Impact on mean SSH

Some evolutions have a direct impact on the SSH estimation. The global bias between version "a" and "b" of the products is 1.9 cm :

$$\overline{SSH_{CMA_{7.1}}} = \overline{SSH_{CMA_{6.3}}} - 1.9cm$$

This comes from two main components:

- A very slight effect of the MLE4 retracking and of the new instrumental tables (0.1 cm).
- The improved SSB correction is shifted in average by 2.0 cm in comparison with the previous one
$$\overline{SSB_{CMA_{7.1}}} = \overline{SSB_{CMA_{6.3}}} + 2.0cm$$

For several scientific applications (mean sea level trend, ...), it is important to take this difference in mean SSH into account until all the GDRs cycles are provided with the new ground processing version.

### 2.4.3 Impact on mean SWH and sigma0

MLE4 retracking algorithms has no impact on SWH mean value.
Impact of MLE4 retracking algorithms on sigma0_ku mean value is 0.1 dB (sigma0_ku becoming higher). Please note that the rms on 20 Hz Ku sigma0 has increased as a consequence of the MLE4 inversion scheme.

### 2.4.4 Jason-1 Radiometer wet troposphere correction

The Jason-1 Microwave Radiometer (JMR) has been recalibrated using data from repeat cycles 1-115. Version "b" GDRs contain the recalibrated JMR data and some improved algorithms to derive JMR brightness temperatures. The recalibrated JMR data remove the anomalous jumps observed in the JMR path delays on the version "a" GDRs. As a result of this recalibration a bias of approximately 0.9 cm in the JMR wet path delays exists between the version "a" GDRs from cycle 135 and the version "b" GDRs from cycle 136. This bias will then also affect mean SSH at this transition when JMR wet path delays are used to compute SSH.

A JMR replacement product that contains recalibrated JMR wet path delay measurements for cycles that are being reprocessed into version "b" GDRs (e.g. cycles $<$ 136) will be released soon. This replacement product can be used to ensure a stable sea surface height time series for precision applications such as mean sea level monitoring. In the meantime, it is preferable to use the EWCMF model wet troposphere correction.

# 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.

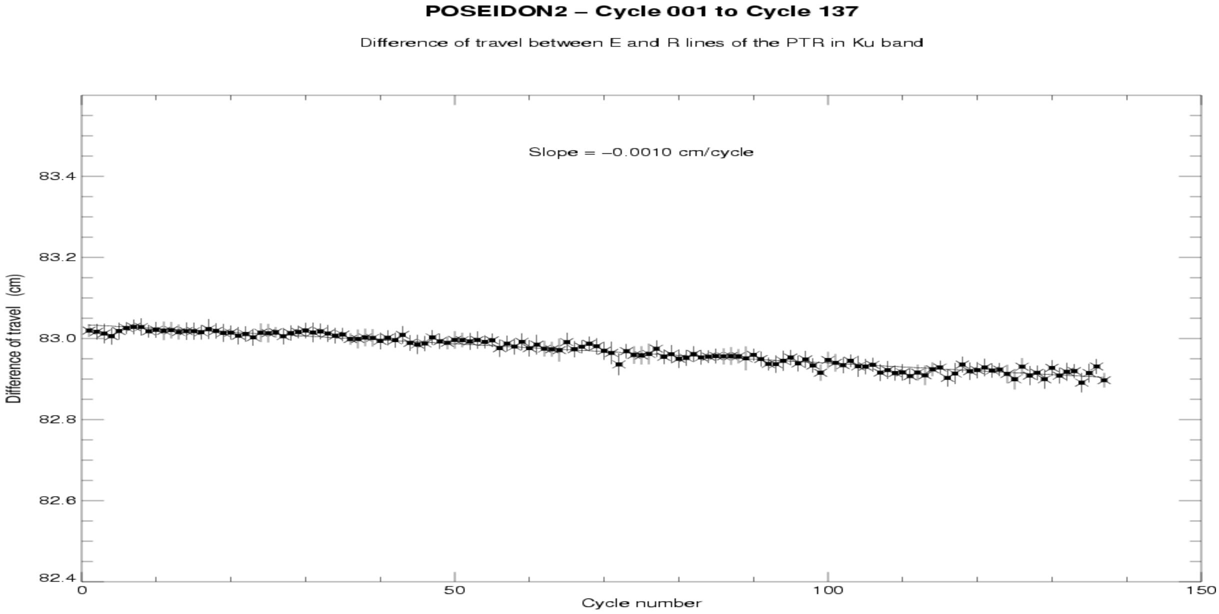
## 3.2 Poseidon-2 altimeter status

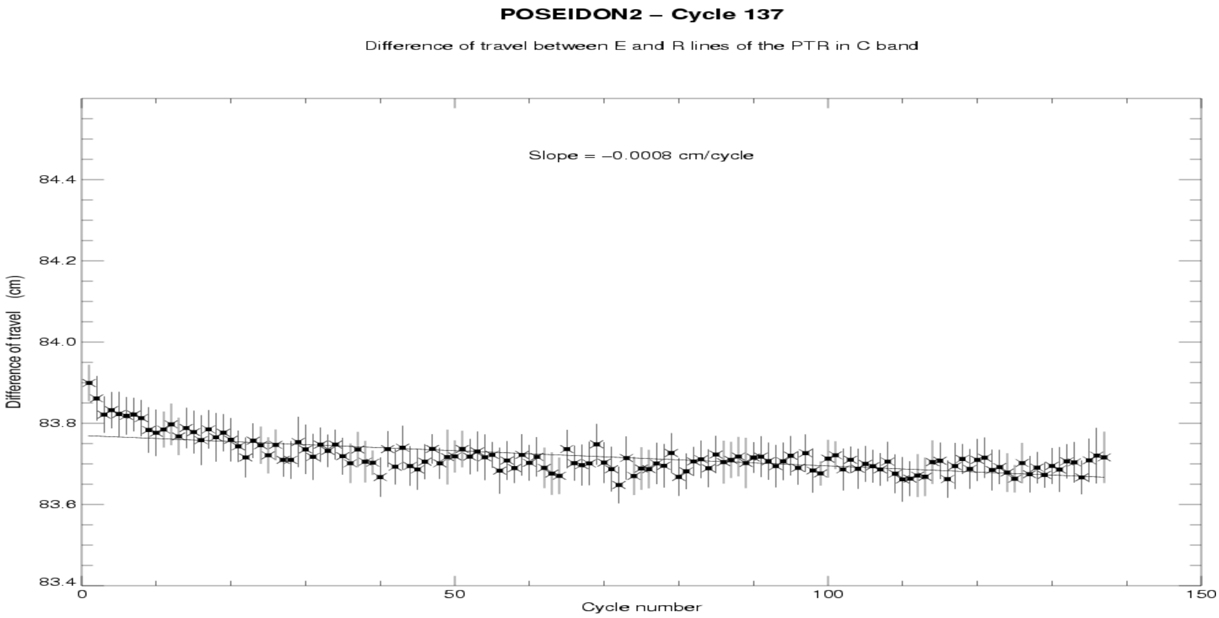
This section presents the general status of the altimeter for main instrumental variations through the Jason-1 mission. Two calibration modes are used to monitor the altimeter internal drifts and compute the altimetric parameters. They are programmed about three times per day, over land.
The CAL1 mode 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

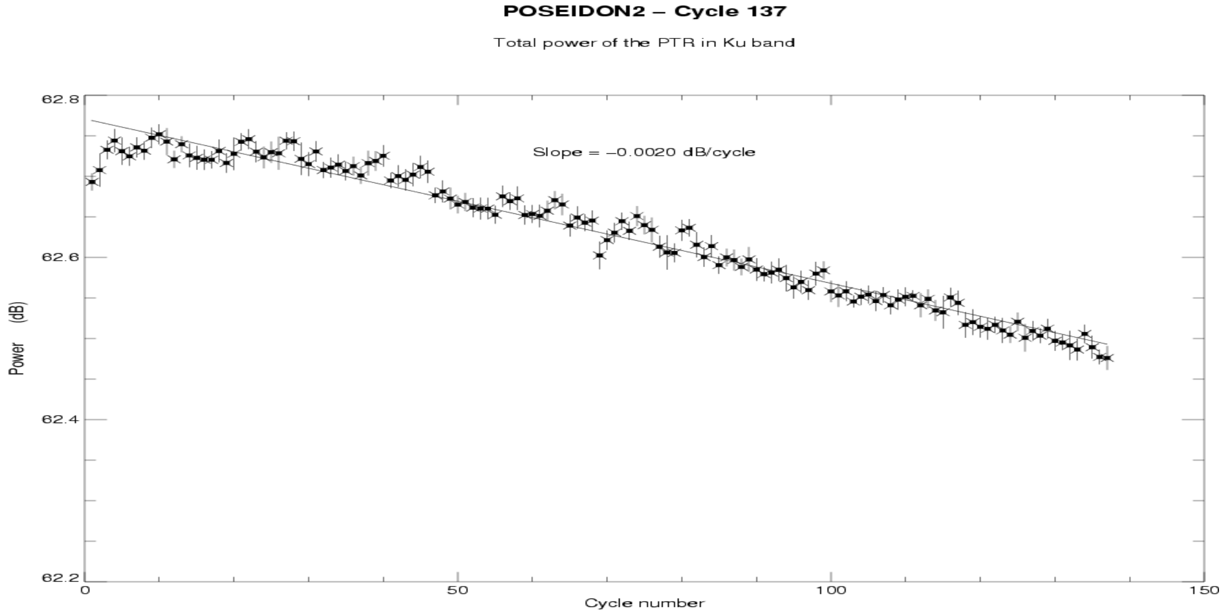
The evolutions of these parameters as a function of time are plotted to monitor the ageing of the altimeter.
Notice that in the Jason-1 products, the range is corrected for the internal path delay and the backscatter coefficient takes into account the total power of the measured PTR.

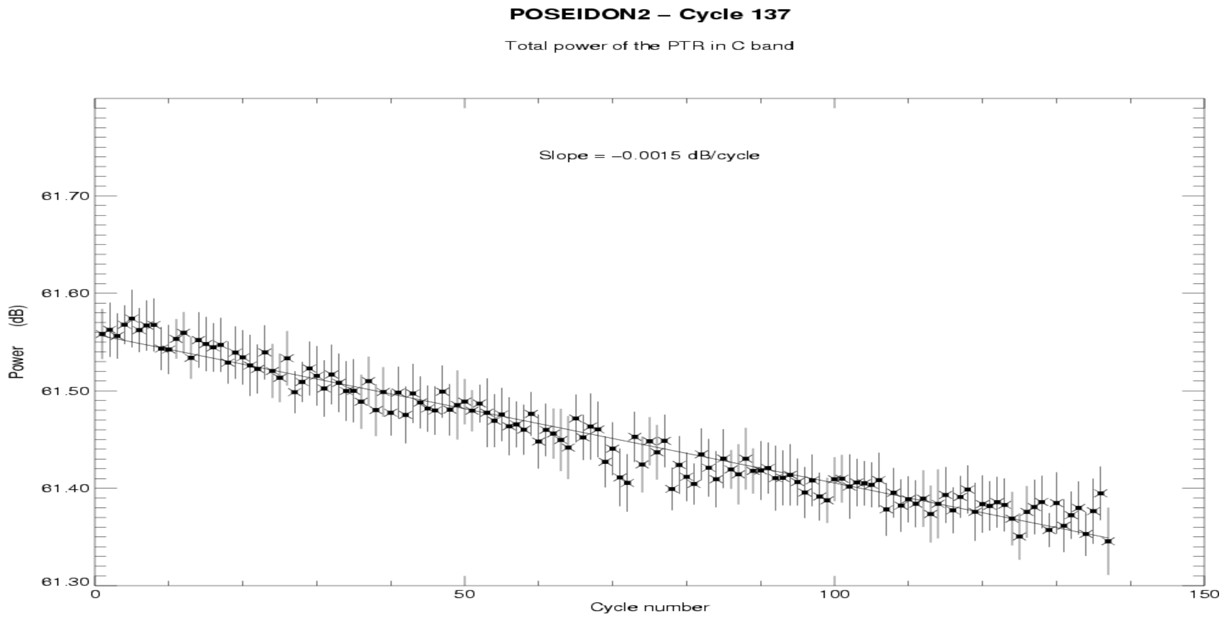
### 3.2.1 Monitoring of the internal path delay



### 3.2.2 Monitoring of the total power in the PTR



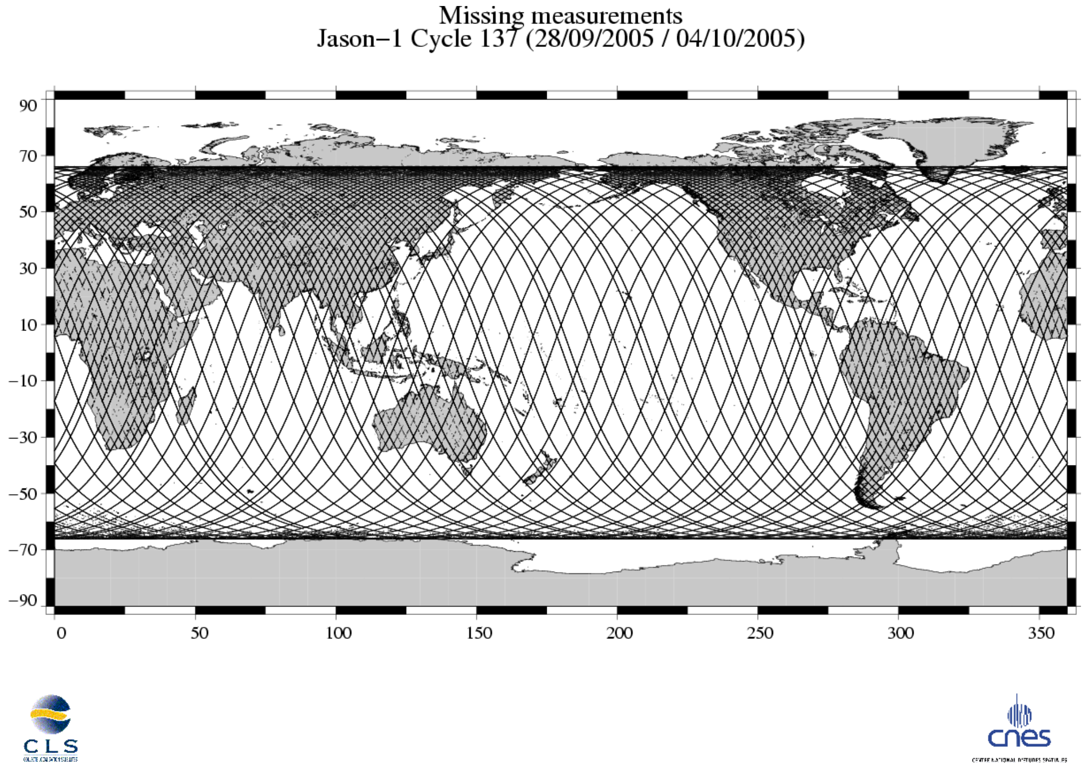



# 4 CALVAL main results

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

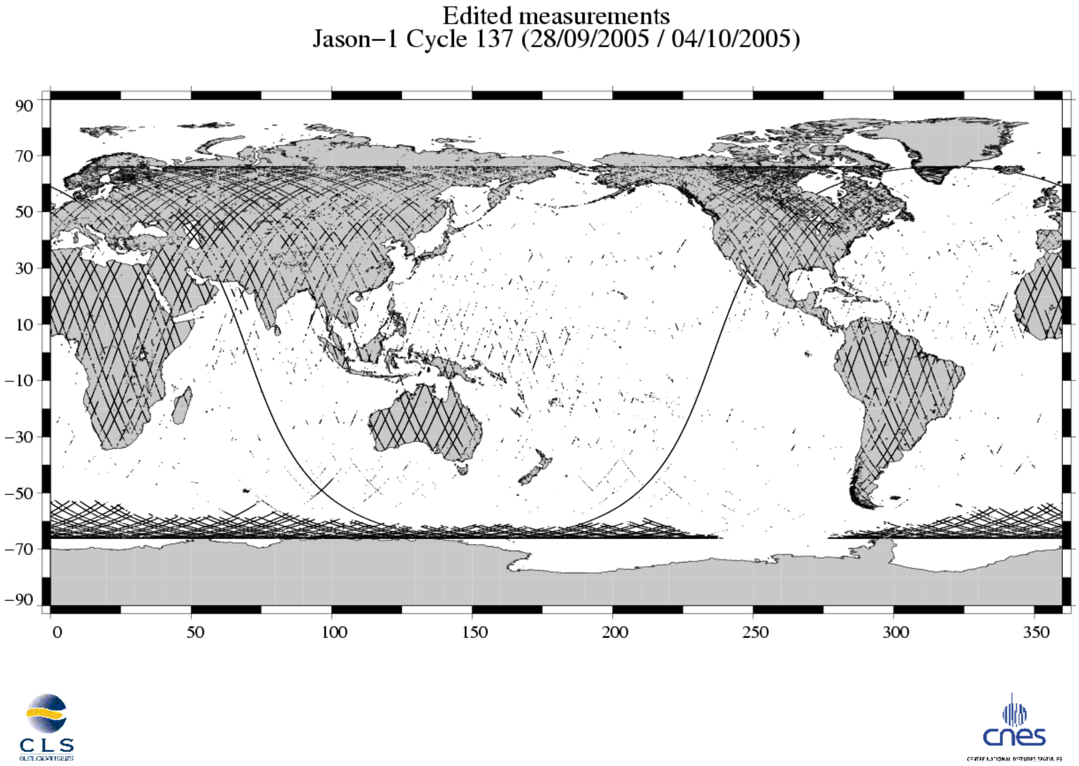
Editing criteria are defined for the GDR product in Aviso and PODAAC User Handbook [2]. The editing criteria are defined as minimum and maximum thresholds for various parameters. Measurements are edited if at least one parameter does not lie within those thresholds. These thresholds are expected to remain constant throughout the Jason-1 mission, so that monitoring the number of edited measurements allows a survey of data quality.
In the following, the altimeter state flag (alt_state_flag) is used instead of the radiometer state flag (rad_state_flag). Indeed, this allows to keep more data near the coasts and then to detect potential anomalies in these areas. Furthermore, 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 since it is not yet tuned.

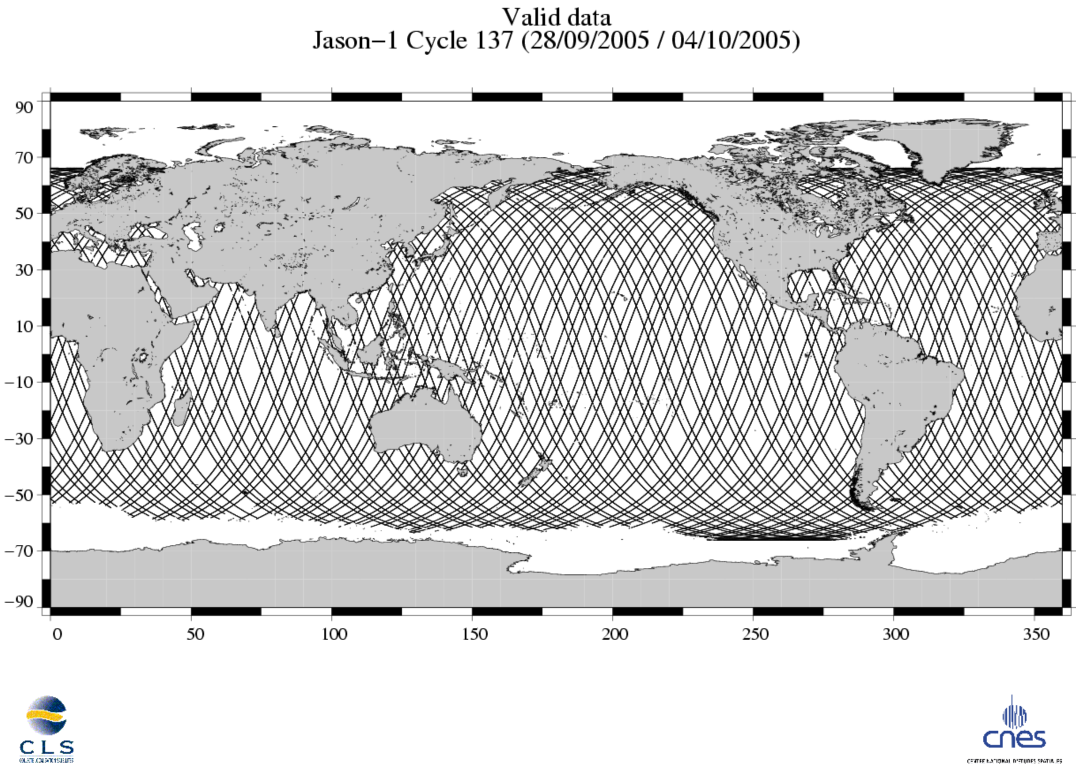
The number and percentage of points removed by each criterion is given on the following table. Note that these statistics are obtained with measurements already edited for altimeter land flag (14.31 % of points removed) and ice flag (10.16 % of points removed).

| Parameters | Min threshold | Max threshold | Unit | Nb removed | % removed | % mean removed |
|---|---|---|---|---|---|---|
| Sea surface height | -130.000 | 100.000 | $m$ | 5959 | 1.79 | 1.66 |
| Sea level anomaly | -10.000 | 10.000 | $m$ | 11407 | 3.43 | 2.25 |
| Nb measurements of range | 10.000 | _ | _ | 7390 | 2.22 | 2.08 |
| Std. deviation of range | 0.000 | 0.200 | $m$ | 7708 | 2.32 | 2.13 |
| Square off nadir angle | -0.200 | 0.640 | $deg^2$ | 3427 | 1.03 | 1.75 |
| Dry tropospheric correction | -2.500 | -1.900 | $m$ | 0 | 0.00 | 0.007 |
| Combined atmospheric correction | -2.000 | 2.000 | $m$ | 6 | 0.00 | 0.005 |
| JMR wet tropospheric correction | -0.500 | -0.001 | $m$ | 5412 | 1.63 | 0.20 |
| Ionospheric correction | -0.400 | 0.040 | $m$ | 6609 | 1.99 | 1.85 |
| Significant wave height | 0.000 | 11.000 | $m$ | 3953 | 1.19 | 1.32 |
| Sea State Bias | -0.500 | 0.000 | $m$ | 3326 | 1.00 | 1.35 |
| Backscatter coefficient | 7.000 | 30.000 | $dB$ | 4219 | 1.27 | 1.13 |
| Nb measurements of sigma0 | 10.000 | _ | _ | 7341 | 2.21 | _ |
| Std. deviation of sigma0 | 0.000 | 1.000 | $dB$ | 7579 | 2.28 | _ |
| Ocean tide | -5.000 | 5.000 | $m$ | 1967 | 0.59 | 0.85 |
| 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 | 1.61 |
| Altimeter wind speed | 0.000 | 30.000 | $m.s^{-1}$ | 4341 | 1.30 | 3.70 |
| Global statistics of edited measurements by thresholds | _ | _ | _ | 18774 | 5.64 | 3.70 |

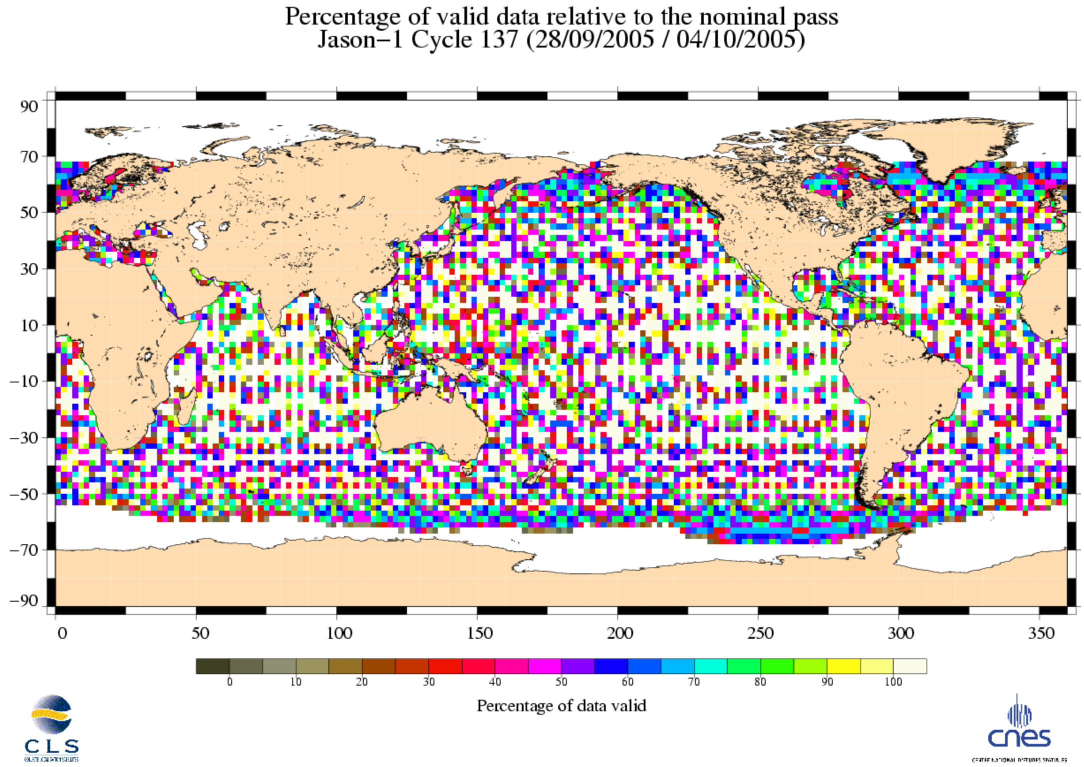
### 4.2.1 Figures

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



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

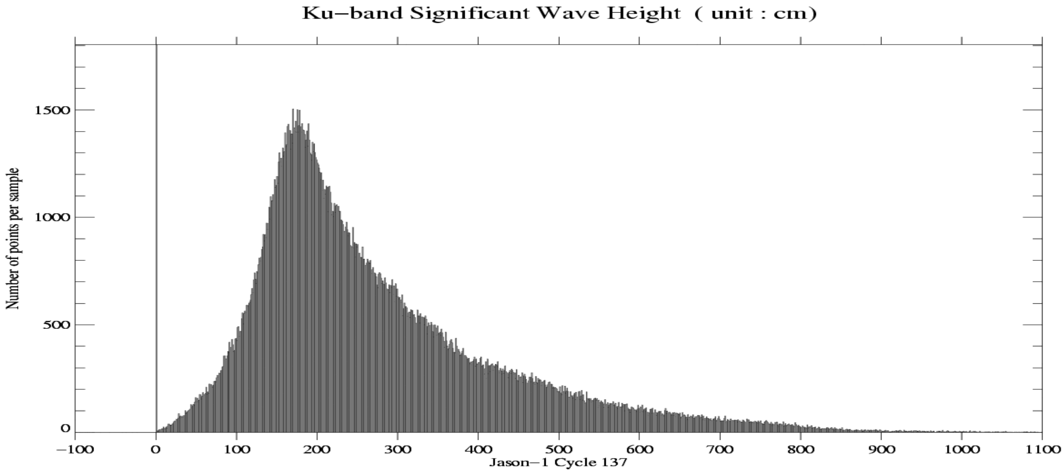



### 4.2.2 Comments

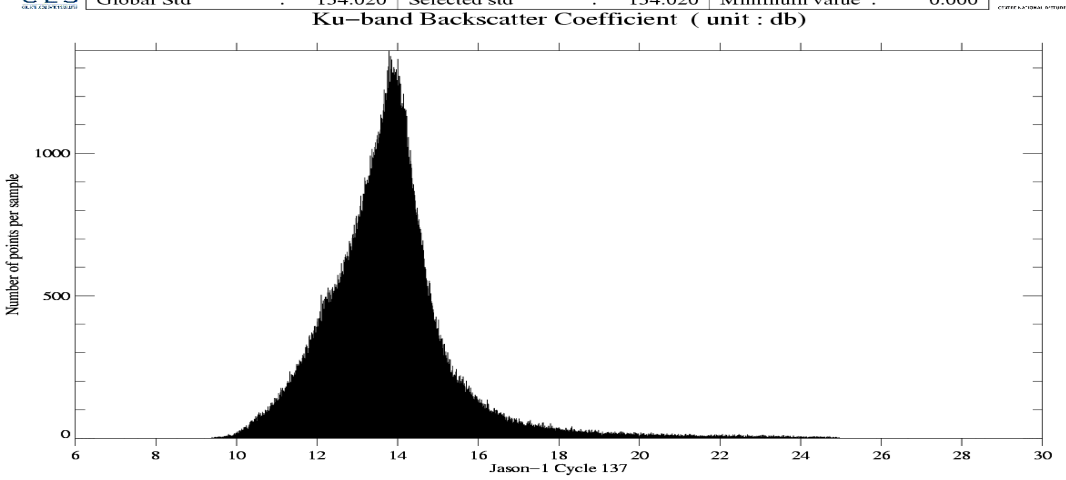
Passes 92, 93 and partly 94 are edited by radiometer wet tropospheric correction. These values are set to default values, since the radiometer was later switched on than the other instruments (after the platform incident). Notice that mispointing values are sligthly higher than usual, but generally within the threshold criteria.
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.

## 4.3 Altimeter parameters

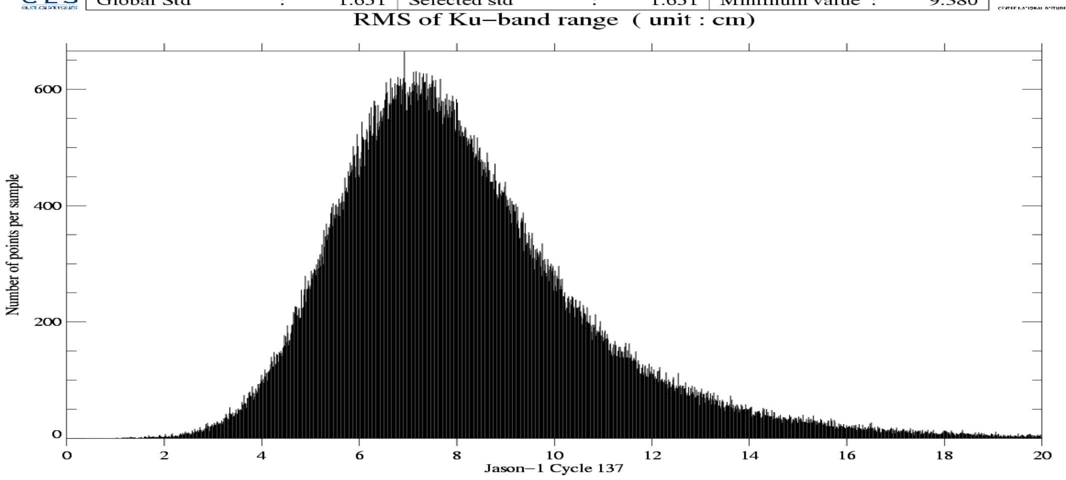
In order to assess and to monitor altimeter parameter measurements, histograms of Jason-1 Ku-band Significant Wave Height (SWH), Backscatter coefficient (Sigma0) and RMS of altimeter range are computed for the valid data set previously defined.




| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Global nb of points | : | 313845 | Sel. nb of points | : | 313845 | Sample interval | : | 1.000 |
| Global mean | : | 271.895 | Selected mean | : | 271.895 | Maximum value | : | 1099.900 |
| Global Std | : | 154.020 | Selected std | : | 154.020 | Minimum value | : | 0.000 |



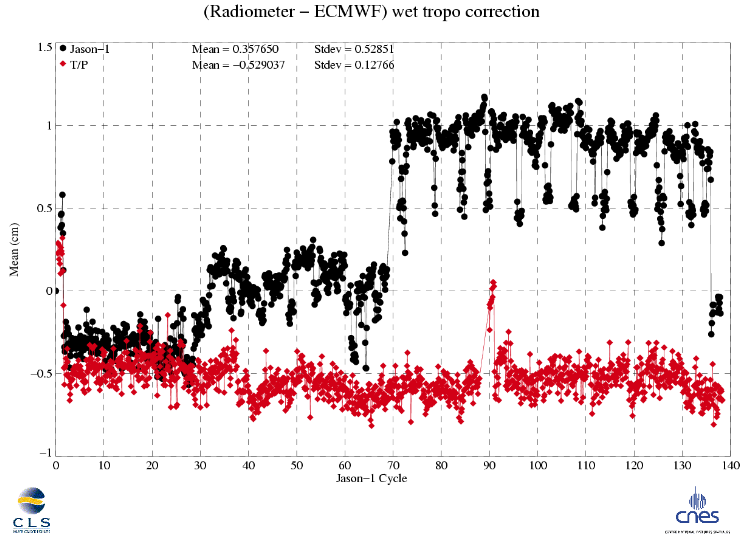

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Global nb of points | : | 313845 | Sel. nb of points | : | 313845 | Sample interval | : | 0.010 |
| Global mean | : | 13.785 | Selected mean | : | 13.785 | Maximum value | : | 24.960 |
| Global Std | : | 1.651 | Selected std | : | 1.651 | Minimum value | : | 9.380 |




| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Global nb of points | : | 313845 | Sel. nb of points | : | 313845 | Sample interval | : | 0.010 |
| Global mean | : | 8.085 | Selected mean | : | 8.085 | Maximum value | : | 19.990 |
| Global Std | : | 2.541 | Selected std | : | 2.541 | Minimum value | : | 1.020 |

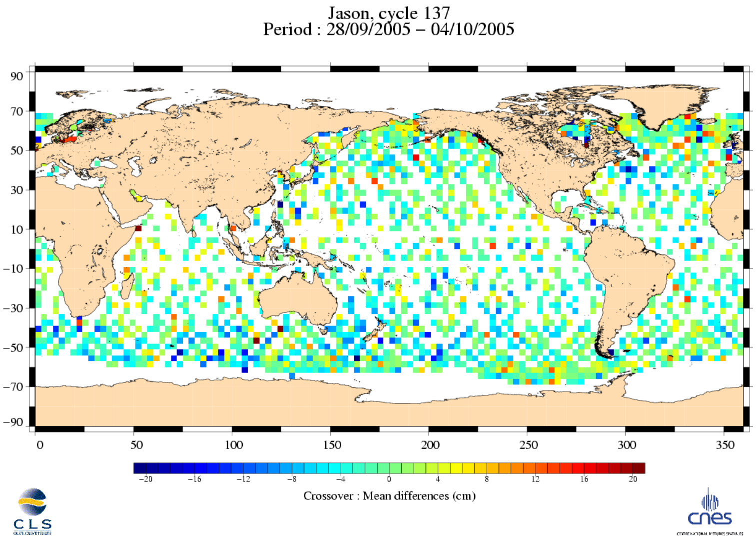
## 4.4 Radiometer parameters

Daily mean of (Radiometer - ECMWF) wet troposphere corrections is plotted below for Jason-1 and T/P. The signals observed on this figure are explained on the section TP and Jason-1 Radiometer wet troposphere correction comparisons, page 24.




## 4.5 Crossover statistics

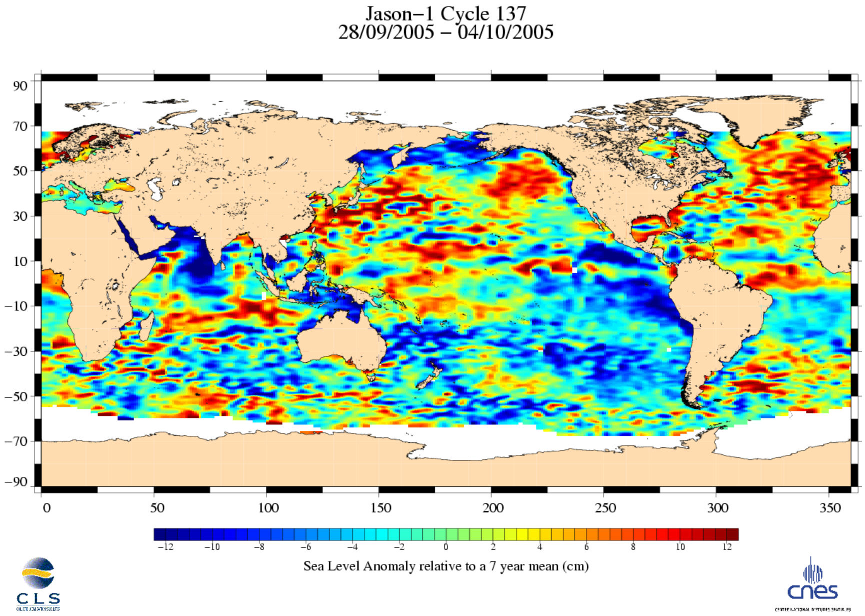
SSH crossover statistics are computed from the valid data set. They are used to estimate the data quality and to monitor the system performances.
After data editing and using the standard Jason-1 algorithms, the crossover standard deviation is about 4.95 cm rms, when using a selection to remove shallow 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.

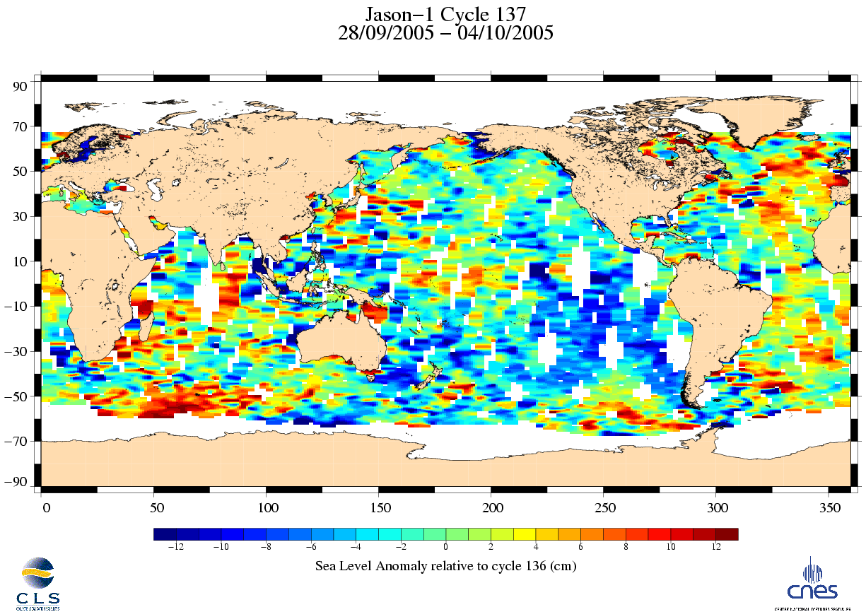


## 4.6 SSH variability

### 4.6.1 Jason-1 Sea Level Anomalies

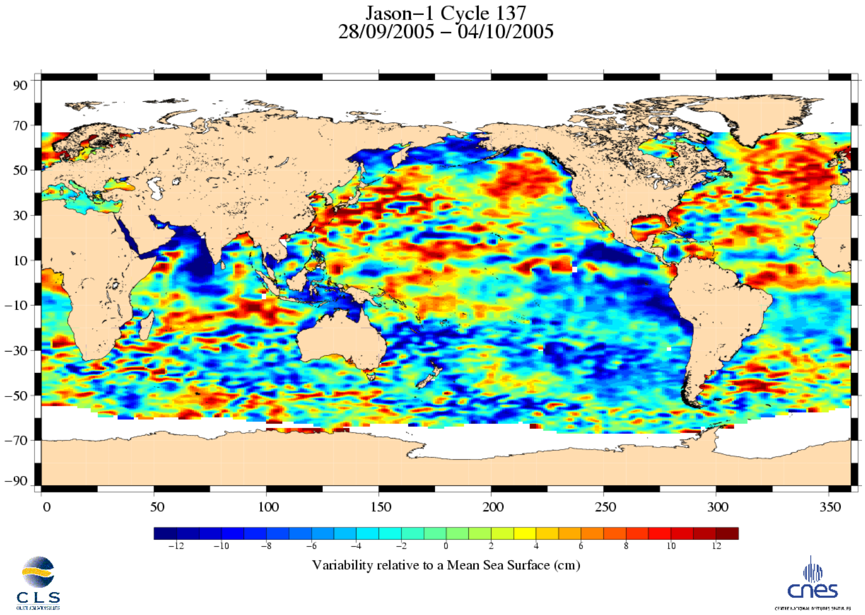
Repeat-track analysis is routinely used to compute Sea Level Anomalies (SLA) relative to the previous cycle and relative to a mean profile. SLA relative to a 7-year mean (based on TOPEX/Poseidon data) shows general oceanic features in good agreement with what is observed with TOPEX/Poseidon.
The SSH differences relative to the previous cycle 136 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.

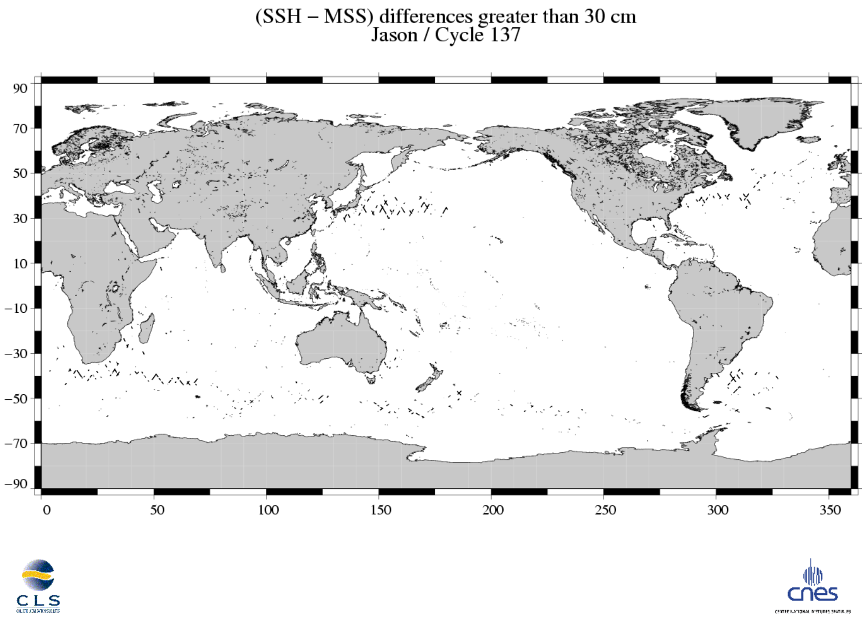


### 4.6.2 Comparison to a Mean Sea Surface

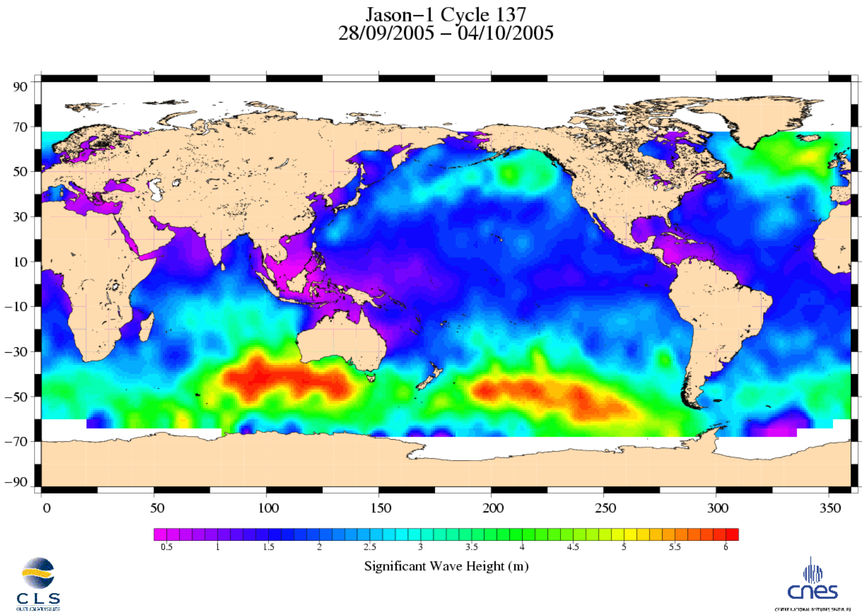
The following two maps respectively show the map of Jason-1 SLA relative to the MSS and differences higher than a 30 cm threshold (after centering the data). The latter figure shows that apart from isolated measurements that should be removed after refining the editing thresholds, higher differences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

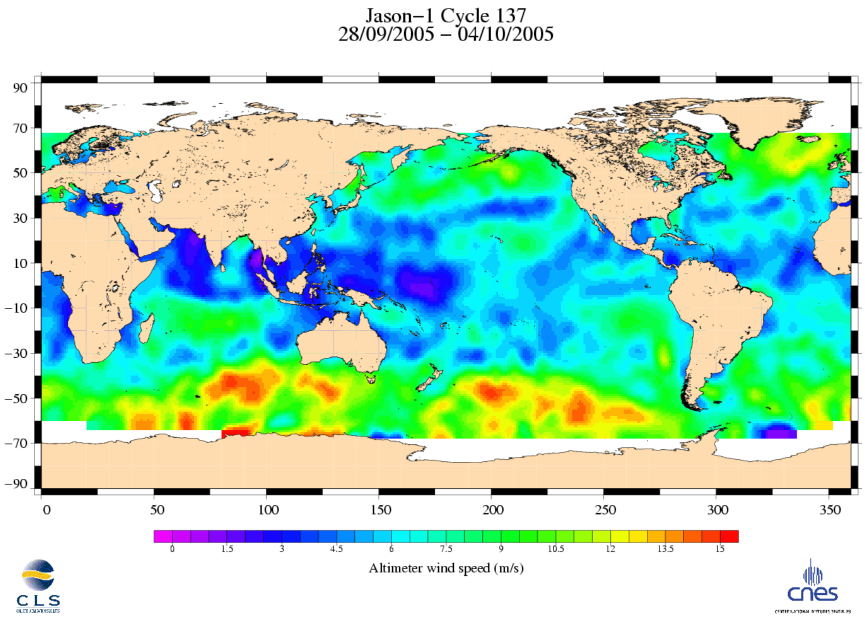


## 4.7 Wind and wave maps

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



# 5 Jason-1 long term performance monitoring

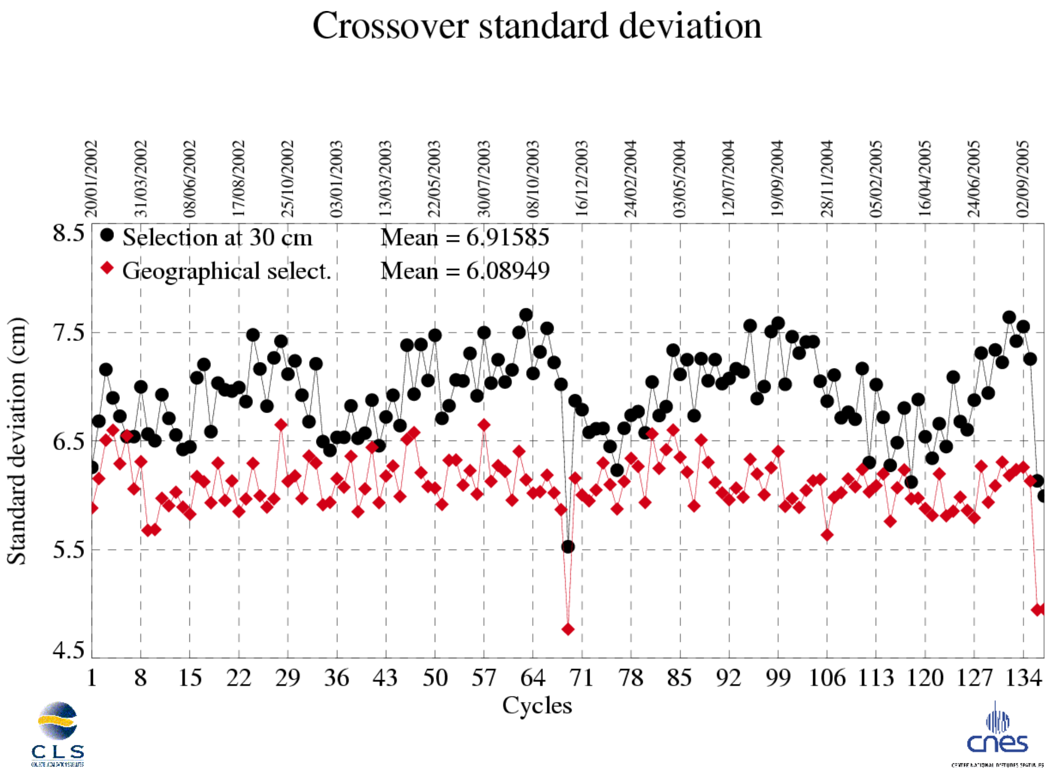
Statistics of SSH variability are computed after crossover and repeat-track analyses. This allows to estimate how Jason-1 data fulfill the mission objectives in terms of performances.

## 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:

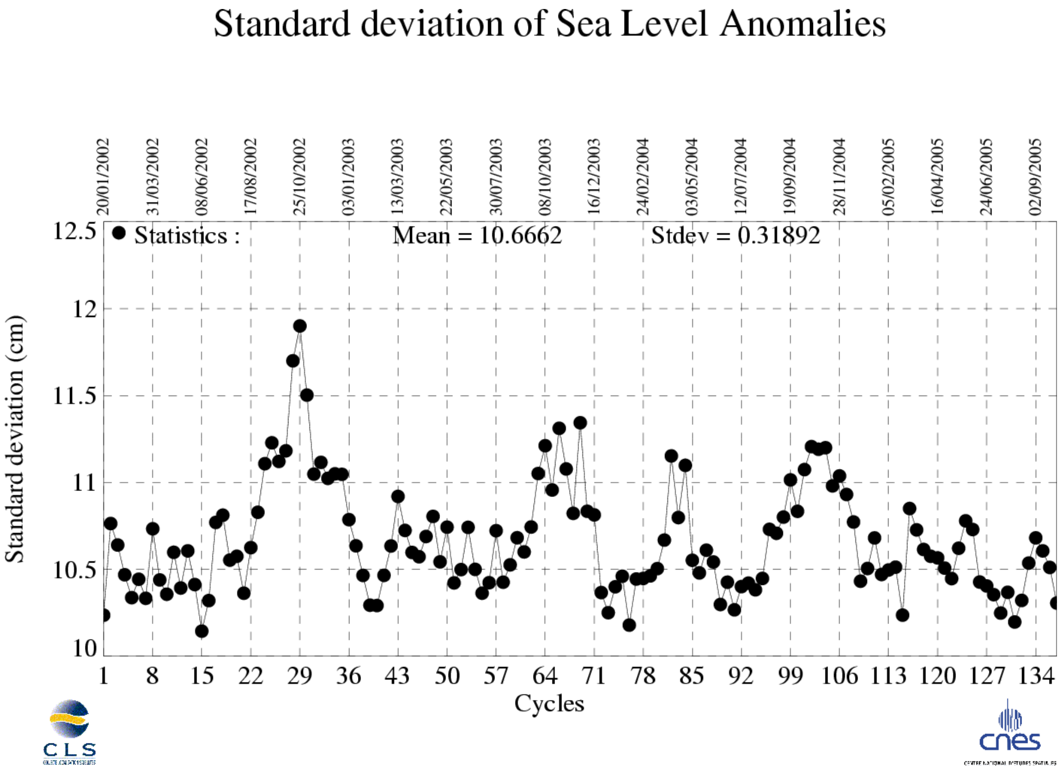
- Selecting crossover differences lower than 30 cm to avoid contamination by remaining spurious data.
- Removing shallow waters (1000 m), areas of high ocean variability and high latitudes (> |50| deg.) to avoid ice coverage effects.

From cycle 136 onwards, GDRs have been processed with CMA version 7.1. Perfomances are better for these cycles due to these evolutions: new retracking, new orbit, new atmospheric corrections, new tidal model, ...



## 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.



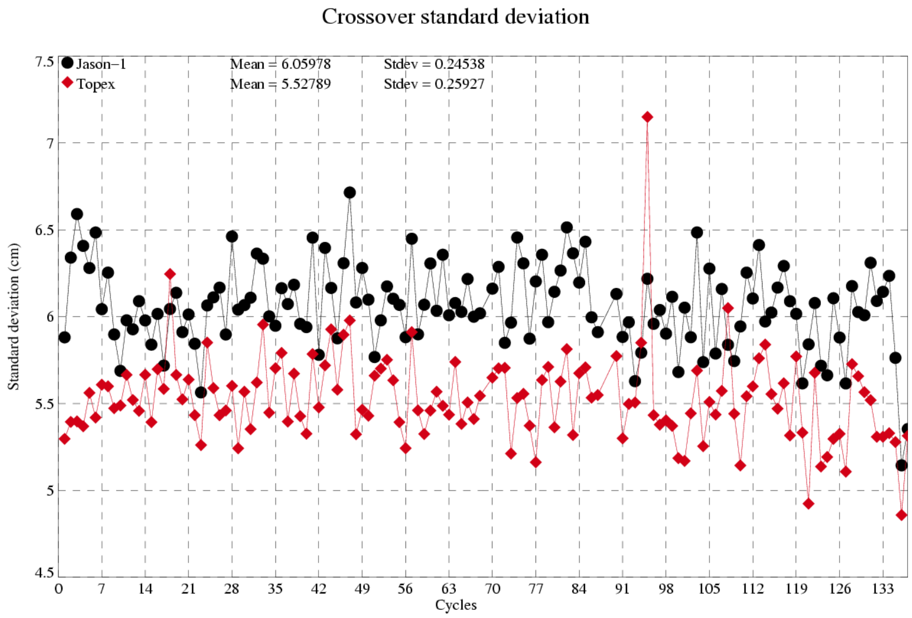
# 6 TP and Jason-1 comparisons

In order to compare TOPEX with Jason-1 SSH estimations, TOPEX data from M-GDRs have been updated so that all the geophysical corrections are the same as Jason-1. The TOPEX-B non-parametric sea state bias has been applied. This bias has been computed with the same method as TOPEX-A non-parametric sea state bias (Gaspar et al., 2002 [3]).
Note that cycle 1 for Jason-1 corresponds with cycle 344 for TOPEX.
Statistics are not relevant for cycle 69 as a result of Jason-1 mission interruption due to safe hold mode.

## 6.1 Performance comparisons

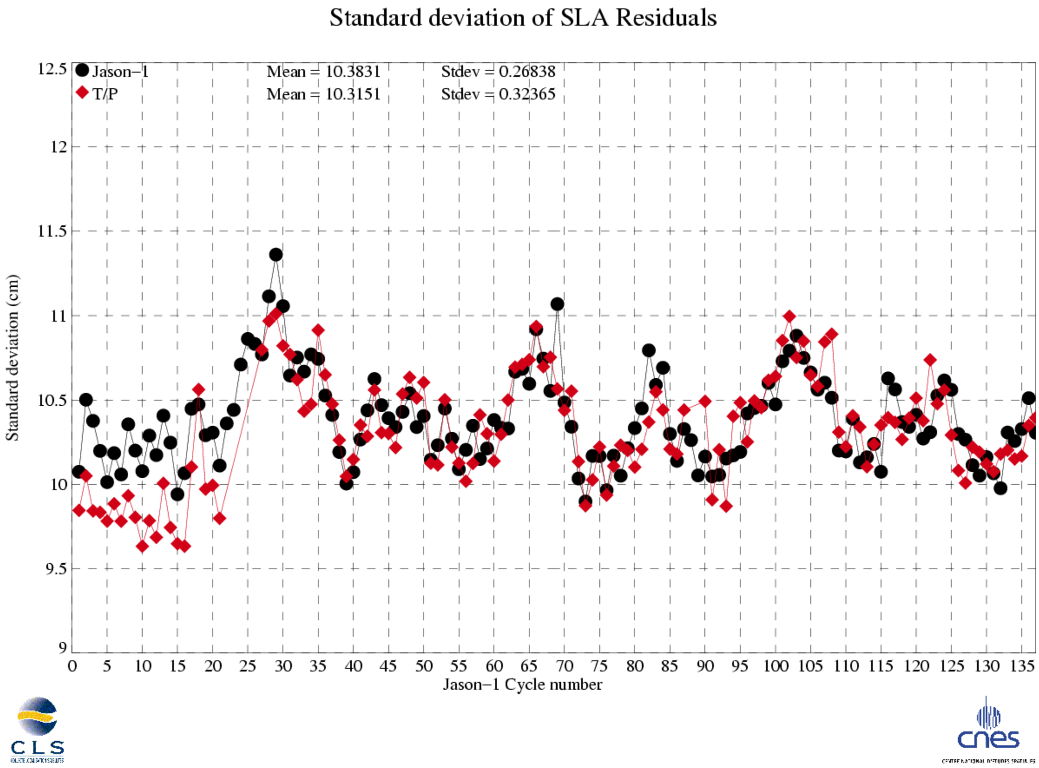
### 6.1.1 Crossover performances

10-day crossovers are computed on a 1 cycle basis both for TOPEX and Jason-1. In order to estimate the system performances, crossovers are selected according to several criteria: shallow waters (1000m), areas of high ocean variability (> 20 cm), and high latitudes (> |50| deg.) are excluded.
Futhermore, because of tape recorder problems, TOPEX measurements are missing over large geographical areas (essentially over the Indian ocean). These areas are then excluded from the selection for the two satellites.
The long term statistics are reported below. The slightly higher standard deviation for Jason-1 might be explained by residual orbit errors and larger high frequency content due to different altimeter processing (Zanife et al., 2003 [5]).
Notice the particular high value for T/P at cycle 95 (T/P cycle 438). This is probably due to a pitch wheel event linked to the T/P safehold mode occurred on cycle T/P 430.
Jason-1 performances are better from cycle 136 thanks to CMA version 7.1.



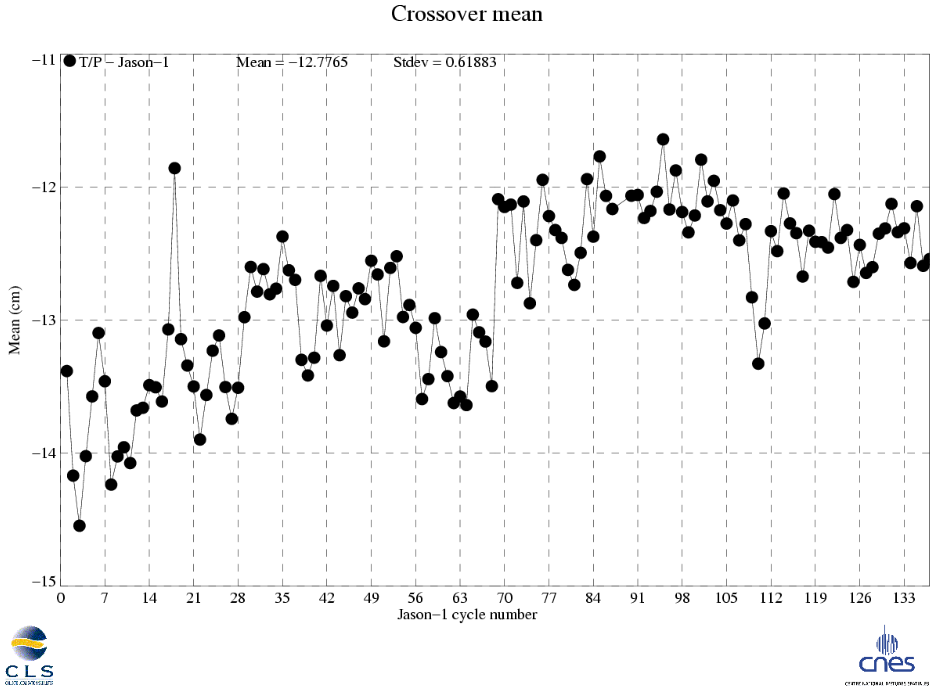
### 6.1.2 Along-track performances

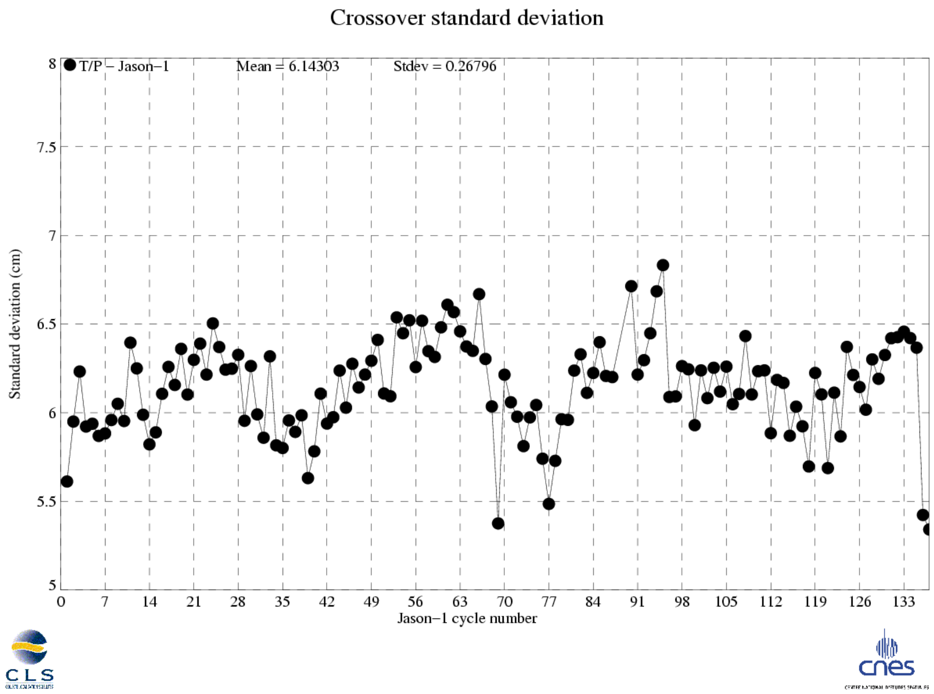
Sea Level Anomaly (SLA) statistics are computed from repeat-track analysis. The plot below gives the standard deviation of the SLA for each cycle over the whole data set (shallow waters are excluded).
It is not possible to compute the TOPEX SLA through Jason-1 cycles 22-25 (corresponding with TOPEX cycles 365-368) because T/P is not on a repeat cycle orbit. During this period the satellite is moved to the Tandem Mission orbit on the new ground track spacing to the West of Jason-1.
A degradation of TOPEX performance is observed after the orbit change due to the use of a MSS to compute SLA : indeed the MSS adds errors when used outside the nominal T/P - Jason ground track (Dorandeu et al., 2004 [6]).



## 6.2 TP – Jason-1 crossovers

The following two figures show the mean and the standard deviation of (TP – Jason-1) 10-day SSH crossovers. The statistics are computed removing shallow waters (1000 m).
Two jumps have been detected respectively around cycle 30 and 69 on the crossover mean curve. This is linked to the still unexplained variations of the Jason-1 Radiometer wet troposphere correction in these periods (see section TP and Jason-1 Radiometer wet troposphere correction comparisons, page 24 for more information).



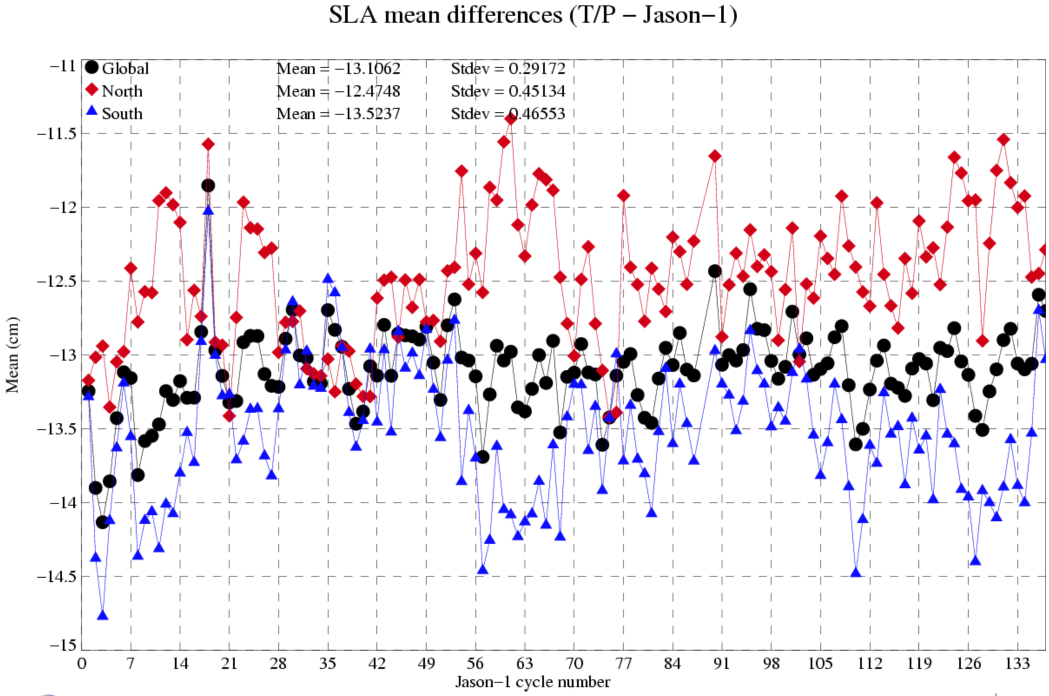



## 6.3 Colocated comparisons

Crossover points with time lags ($< 1h$) are only located at high latitudes and are very few. They cannot be used to cross-calibrate altimeter and radiometer parameters.
A colocation procedure is used to get homogeneous datasets on both missions. Differences are then averaged on a one cycle basis. This provides a large amount of data and a global coverage.

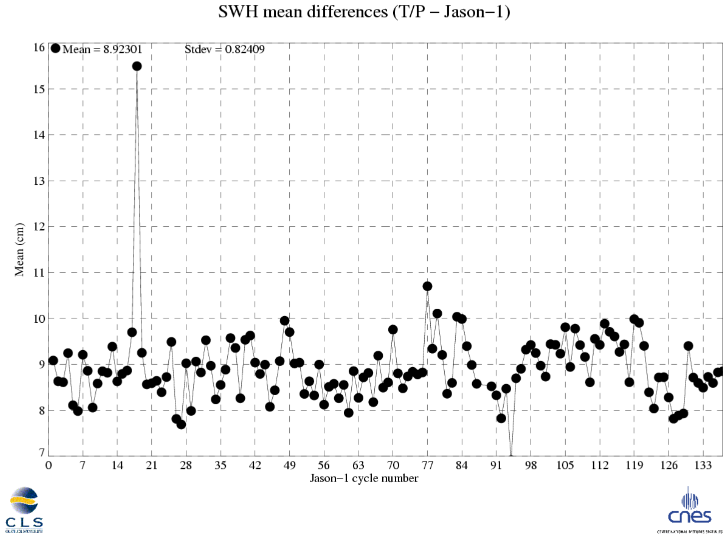
### 6.3.1 TP – Jason-1 SSH differences

The cycle per cycle SSH bias between T/P and Jason-1 has been computed over each hemisphere and globally (figure below). In order to compute the SSH bias (T/P -Jason-1), the same corrections have been used to calculate the Jason-1 and T/P SSH. The radiometer wet troposphere correction has been replaced by the ECMWF wet troposphere correction which prevents from JMR correction impact.
The overall bias is quite stable about -13 cm, but significative differences up to 2 cm are observed at hemispheric scales. The implementation in the orbit calculation of a new geoid model for Jason-1 (version CMA 7.1) and T/P orbits will allow us to reduce these effects.
Jason-1 GDRs are processed with CMA version 7.1 with the latest GRACE gravity model (EIGEN-CG03C) from cycle 136 onwards. The hemispheric differences seem reduced.



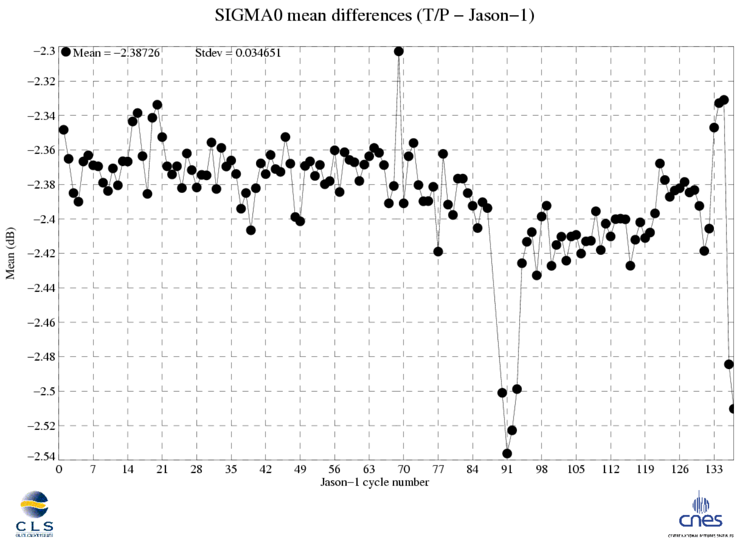
### 6.3.2 TP – Jason-1 Ku SWH differences

The cycle per cycle mean differences of Ku-band SWH between T/P and Jason-1 is plotted as a function of the cycle number on the following figure. It shows that the bias is quite stable around 8.8 cm except for the Poseidon-1 which is about 15 cm.




### 6.3.3 TP – Jason-1 Ku SIGMA0 differences

The following parameter is the Ku-Band Sigma0. The same statistics as for SWH are plotted on the below figure. The bias between the two parameters is quite stable around -2.4 dB. This value is near from the a priori -2.26 dB bias which is applied in the ground processing.
Notice that the absolute bias is higher than usual from cycle 90 to 93 (TOPEX cycle 433 to 436) by 0.1 dB: this is due to the TOPEX Sigma0 which has been problably impacted by a pitch wheel event. The jump observed from cycle 136 onwards is due to the change of CMA version. The sigma0 is slightly biased (0.1 dB) in CMA version 7.1.

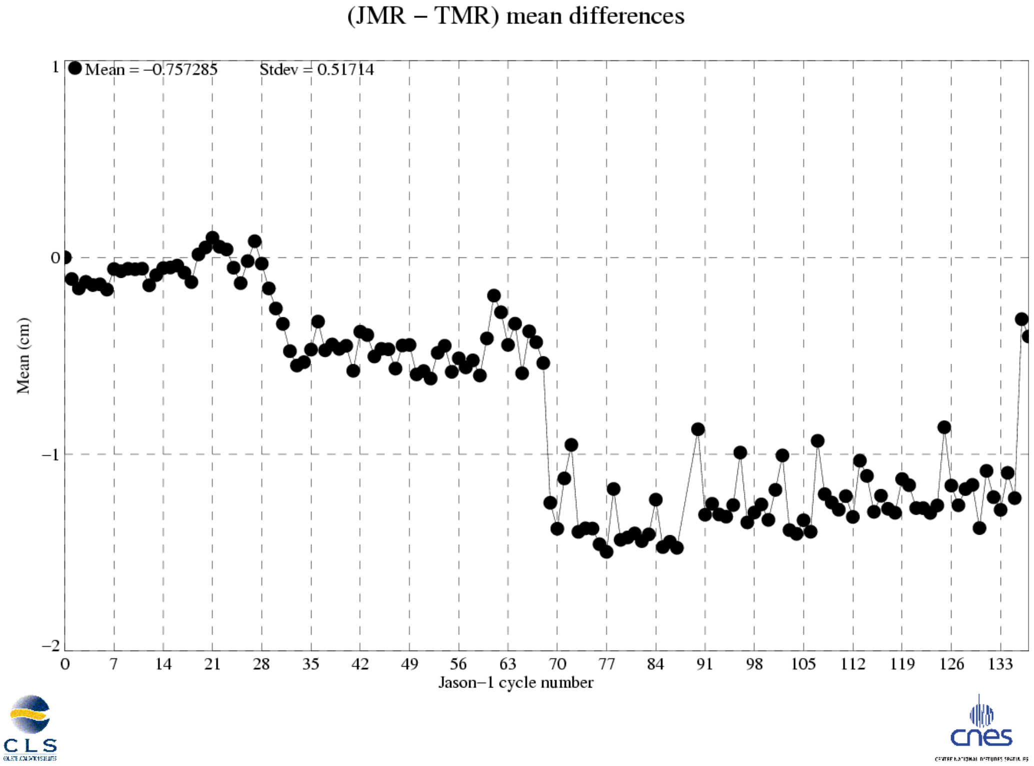


### 6.3.4 TP and Jason-1 Radiometer wet troposphere correction comparisons

The cycle per cycle mean differences between JMR and TMR wet tropospheric corrections are plotted on the following figure. 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. This long term monitoring exhibits the following abnormal variations:

- A 60-day signals is observed due to Jason-1 yaw maneuvers
- A significant decrease of about 4 mm is observed from cycle 27 to 32.
- A jump of about 9 mm is observed at cycle 69. This jump occurs after the safehold mode on this cycle.

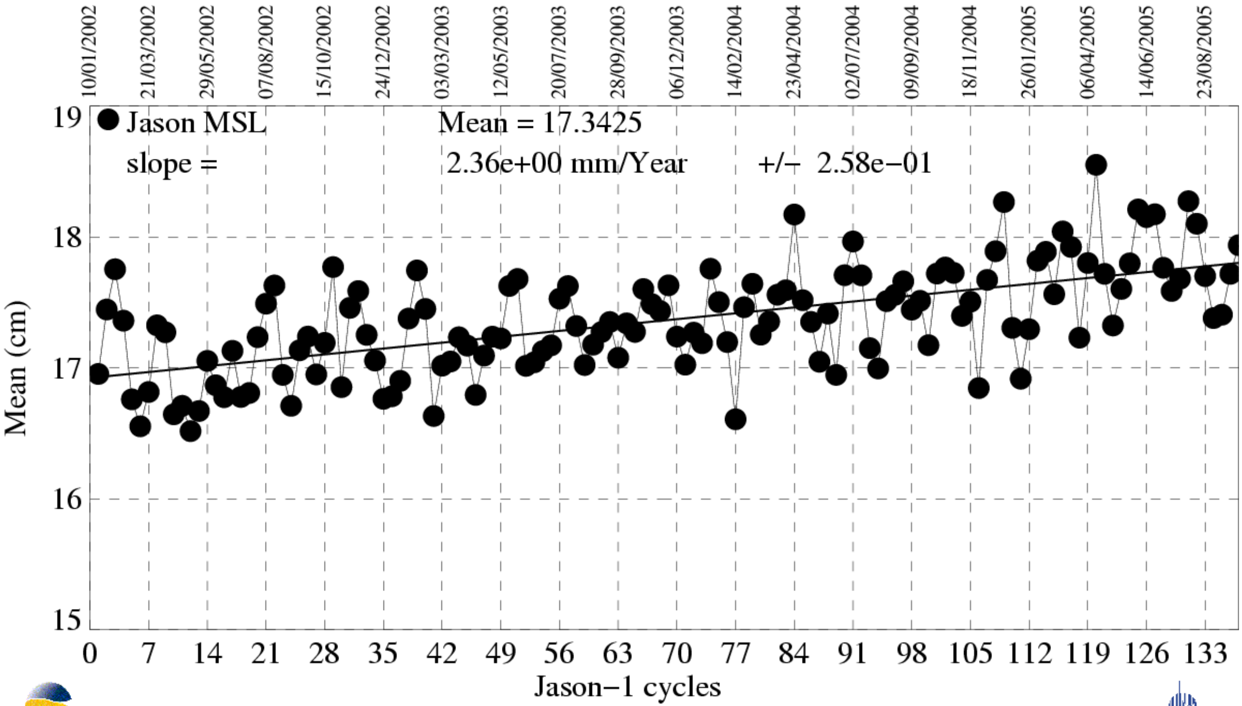
These jumps have been corrected in CMA version 7.1. This explains the jump observed from cycle 136 onwards.



# 7 Mean Sea Level estimations (MSL)

## 7.1 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 is obtained after annual, semi-annual and 60-day signals reduction. Moreover the JMR correction has been replaced by the ECMWF model wet troposphere correction in order to remove the effect of the JMR slopes.



# 8 Particular investigations

No particular investigations have been performed on this cycle.

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[6] J. Dorandeu, M. Ablain, Y. Faugere, F. Mertz & B. Soussi, 2004: Jason-1 global statistical evaluation and performance assessment. Calibration and cross-calibration results. *Marine GEODESY,***27,** 345-372.