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LIST OF ACRONYMS

SEU	Single event upsets
SSH	Sea Surface Height
MSL	Mean Sea Surface
SLA	Sea Level Anomaly

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1. INTRODUCTION

This document presents the synthesis report concerning validation activities of Jason-1 GDRs under SALP contract (N° 731/CNES/00/8435/00 - CLS) supported by CNES at the CLS Space Oceanography Division. It is divided into three parts:

- CAL/VAL Jason-1 activities - Lot 6

- Jason-1 / T/P cross-calibration - Lot5 BC 3001-5-47 N° 4500006960/DSO310

- Jason-1 GDR reprocessing - lot5 BC 3001-5-50 N° 4500007045/DSO310

Since the beginning of the mission, Jason-1 data have been analysed and monitored in order to assess the quality of Jason-1 GDR products (AVISO and PODAAC User handbook, [Ref 2]) for oceanographic applications.

This report is basically concerned with long-term monitoring of main instrumental parameters statistics, system and algorithm performances. Moreover, Sea Surface Height (SSH) crossovers and along-track analyses have been also performed as well as Sea Level Variability (SLA) and Mean Seal Level (MSL) estimations.

TOPEX/Poseidon data allow us to compare the parameter behaviors and system performances. From cycle 1 to 21, both satellites are on the same ground track and are spaced out 1 minute apart. During this tandem phase, point by point differences for each parameter have been computed to assess the bias and homogeneity between Jason-1 and T/P. From cycle Jason-1 22 (Cycle T/P 365), the 15th of August 2002, a maneuver sequence was conducted over a 30 day period to move T/P to the new Tandem Mission orbit : Jason-1 is now located one half the TP/Jason-1 track spacing to the West of Jason-1. Geographical variations are then too strong to directly compare Jason-1 and T/P parameters on a point by point basis. Therefore cycle per cycle differences have been carried out to monitor Jason-1 and T/P differences, but data gaps on both satellites have been taken into account.

All Jason-1 GDRs have been produced with the same CMA version number 6. From cycle 1 to 48, GDR have been reprocessed by JPL. A great deal of effort has been made to analyze and produce a report for each cycle in a short time.

2. GDR PROCESSING STATUS

2.1. PROCESSING AND RE-PROCESSING

Jason-1 GDRs are available from cycle 1 to 65. They have been processed with the same version of the CMA ground processing software.

From cycles 1 to 48, GDRs have been reprocessed by JPL and the current cycles have been processed by SSALTO. Much effort has been devoted to analyze 60 cycles from July to November 2003, just before the Science Working Team (SWT, Arles 2003).

A report has been carried out for each cycle and is available for the GDR users. The purpose of this document is to report the major features of the data quality from the Jason-1 mission. Moreover, the document is associated with comparison results from T/P GDRs. All these cycle reports are available on AVISO web site: http://www.jason.oceanobs.com.

In addition to these reports, several meeting (CAVE) have been performed about once a month to inform the Jason-1 GDR's users about the main results and the studies in progress.

2.2. CAL/VAL STATUS

This section presents a summary of major satelite events that occurred from cycle 1 to 65. Table 1 gives a status about the number of missing passes (or partly missing) and the associated events for each cycle. Gyro calibration, Star Tracker unavailability and ground processing issues are the main events which have produced missing data.

Jason-1 Cycles	Number of Missing passes	Number of partly missing passes	Events
001	13	0	Science telemetry unavailability
002	16	0	On board Doris anomaly
003	1	1	Gyro calibration
004	2	5	Gyro calibration and Science telemetry unavailability
006	1	4	Altimeter echo data unavailability
007	2	0	Science telemetry unavailability
008	3	0	Ground processing issue
009	6	3	Poseidon-2 altimeter SEU and Gyro calibration
010	0	2	Gyro calibration
014	2	1	Ground processing issue
015	2	1	Ground processing issue
016	1	1	Ground processing issue
019	2	1	Ground processing issue
021	0	1	Star tracker unavailability
023	0	1	Ground processing issue
026	0	2	Gyro calibration
027	0	2	Gyro calibration
029	4	2	Ground processing issue
031	1	1	Ground processing issue and Star tracker unavailability
032	38	1	DORIS data unavailability and ground processing issue
035	1	2	Ground processing issue
038	0	4	Ground processing issue
039	0	1	Gyro calibration
042	8	2	Poseidon-2 altimeter SEU and ground processing issue

045	0	3	Gyro calibration
046	0	1	Poseidon-2 altimeter SEU
048	0	1	Gyro calibration
055	1	1	Ground processing issue
061	1	2	Ground processing issue
062	2	1	Ground processing issue
064	0	2	Exceptional calibrations

Table 1 : Missing pass status

Table 2 indicates the cycles which have a larger amount of removed data due to editing criteria (see in section 3.2). Most of the occurrences correspond to Star Tracker unavailability.

Jason-1 Cycles	Comments
003	Pass 1 is removed due to bad orbit quality. The burn maneuver is not correctly taken into accounts on this pass.
006	Pass 56 (in the Pacific ocean) is partly edited due to the bad quality of data. Indeed, the altimetric parameters values are out of the thresholds.
008	All the altimetric parameters are edited along 10% of pass 210 due the bad quality of all the altimetric parameters as a result of a Star Tracker incident.
010	A part of pass 087 is edited by the square of the mispointing angle criterion due to a Star Tracker incident.
021	All the altimetric parameters are edited along 15% of pass 210. This is due to the Star Tracker unavailability.
053	Small part of pass 254 is edited after checking the square of the mispointing angle criterion. Some mispointing angle values are out of threshold. This is due to a satellite maneuver on this pass.

Table 2 : Edited measurement status

2.3. CMA VERSION NUMBER 6

The updates from the CMA version number 5 used to produce the IGDR products of the verification phase to number 6 are described below:

- Define the total geocentric tide as the sum of the 3 terms (semidiurnal and diurnal ocean tide semidiurnal and diurnal loading tide + equilibrium long period ocean tide).
- Use of averaged Brightness Temperatures (TBs) instead of unaveraged ones in the computation of the JMR wet troposphere correction.
- Computation of the RMS of the 20 Hz elementary SWH
- Anomaly related to instrumental correction on the 20 Hz ranges
- Implementation of a newly adjusted non-parametric table for the Jason-1 sea-state bias (SSB)
- Implementation of calibrated JMR coefficients at level 1b and at geophysical level 2
- Correct atmospheric attenuation on sigma0 from 1-way to 2-way contribution
- Addition of a range bias to the GSFC MSS to ensure consistency with the reference atmospheric. Pressure that is used for the Jason-1 processing of the inverse barometer effect.
- Use of analyzed meteorological fields in IGDRs instead of forecast fields.
- Remove DORIS TEC and DORIS ionosphere estimates from Jason-1 IGDRs
- Take into account the MQE (Mean Quadratic Error) criterium in the altimetric compression algorithm
- Use the calibrated sigma0 in the geophysical algorithms that need sigma0 as inputs, but have the uncalibrated sigma0 in the products (Note that the biases applied to the Jason-1 sigma0 to have the consistent with the Topex sigma0 are respectively -2.26 dB in the Ku band and -0.28 dB in the C band.

- Have the ground retracking algorithm configured so that the waveform off-nadir angle estimated at the OSDR level be used as input to the IGDR processing.
- JMR TB interpolation near land (impact of about 5 mm on the Dry Troposphere correction near land i.e. closer than 50 km)
- Evolution of the L2 tide modeling in the Jason-1 software to be fully compliant with R. Ray's GOT99.2 software (maximum impact of 2-5 mm)
- Validation of the GDR products (cycles 46-48) has shown that the Qual_1Hz_Rad_Flag is always set to 7 so that it shall not be used to edit the data. Notice that the flag is correctly set in the IGDR and that it will be set correctly in future GDR cycles.

All these improvements result from the analysis of the IGDR data from the verification phase by the SWT and have been taken into account following SWT recommendations.

3. DATA COVERAGE AND EDITED MEASUREMENTS

3.1. MISSING MEASUREMENTS

Missing measurements relative to the nominal track have been monitored during the Jason-1 period. It allows detection of coverage anomalies, particularly due to altimeter problems.

3.1.1.1. Over ocean

Figure 1 shows the cycle per cycle percentage of missing measurements over ocean for Jason-1 (red curve). The mean value is about 2%. The number of missing measurements is higher than usual on cycle 32 due to the DORIS files unavailability. Ground processing issues or altimeter events (SEU) on cycles 9, 42, 46 explain a percentage slightly higher.

The blue curve shows the percentage of missing measurements on the same period for TOPEX. The figures are similar to Jason ones until cycle 26. The percentage increases from cycle 27 onwards due to TOPEX recorder anomalies. Note that Poseidon cycle figure is close to 16% due to several Poseidon-1 incidents.

3.1.1.2. Over land and ocean

Figure 2 shows the same percentage for Jason-1 and T/P over ocean and land. Jason-1 percentages are greater than TOPEX ones due to the higher number of missing measurements for Jason-1 than for TOPEX over land. The 2 maps on Figure 3 show the percentage of missing measurements for Jason-1 (top) on cycle 61 and for TOPEX (bottom) : it illustrate the high-performance difference over land between both altimeters.

Note than in most cases, processing of elementary 20 Hz data may be improved for Jason-1 to retrieve some high rate data. This will be studied in 2004.

3.2. EDITED MEASUREMENTS

3.2.1. Editing criteria definition

Editing criteria are used to select valid measurements over ocean. The editing criteria are divided into 3 parts. First, the quality criteria concern the flags which are described in section 3.2.2. Then, threshold criteria are applied on altimeter, radiometer and geophysical parameters and are described in the Table 3. Moreover, a spline criterion is applied to remove the remaining spurious data. These criteria are also defined in AVISO and PODAAC User handbook for the GDR product. For each criterion, the cycle per cycle percentage of edited measurements has been monitored. This allows detection of anomalies in the number of removed data, which could come from instrumental, geophysical or algorithmic changes.

Parameter	Min thresholds	Max thresholds
Sea surface height	-130 m	100 m
Sea level anomaly	-10 m	10.0 m
Number measurements of range	10	Not applicable
Standard deviation. deviation of range	0 m	0.2 m
Square off nadir angle	-0.2 deg²	0.16 deg²
Dry troposphere correction	-2.5 m	-1.9 m
Inverted barometer correction	-2.0 m	2.0 m
JMR wet troposphere correction	-0.5 m	-0.001 m
Ionosphere correction	-0.4 m	0.04 m
Significant wave height	0.0 m	11.0 m
Sea State Bias	-0.5 m	0.0 m
Backscatter coefficient (Ku-band)	7.0 dB	30.0 dB

Ocean tide	-5.0 m	5.0 m
Equilibrium tide	-0.5 m	0.5 m
Earth tide	-1.0 m	1.0 m
Pole tide	-15.0 m	15.0 m
Altimeter wind speed	0.0 m/s	30.0 m/s

Table 3 : Threshold criteria definition

3.2.2. Flagging quality criteria

3.2.2.1. Land flag

In order to remove data over land, the altimeter land flag is used rather than radiometer land flag. Indeed, this allows keeping more data near the coasts and then detecting potential anomalies in these areas. Furthermore, there is no impact on global performance estimations since the most significant results are derived from analyses in open ocean areas.

Figure 4 shows the cycle per cycle percentage of missing measurements edited by this criterion. No anomalous trend can be detected since launch.

3.2.2.2. Ice flag

The ice flag is used to remove the sea ice data. Figure 5 shows the cycle per cycle percentage of missing measurements edited by this criterion. No anomalous trend is detected but an annual cycle. Indeed, the maximum number of points over ice is reached during the northern Fall.

The ice flag edited measurements are plotted on Figure 6 for 1 cycle. It shows that the ice flag is not perfectly tuned especially in the northern hemisphere, for instance the Hudson Bay is divided into 2 parts.

3.2.2.3. Rain f1ag

The rain flag is not used for data selection since it is not yet tuned. It is thus recommended not to be used by users. Tuning of the flag will take place in 2004. The rain edited measurements are plotted on Figure 7 for one cycle. It shows that too many measurements are edited by this flag.

3.2.3. Threshold criteria

Instrumental parameters have also been analysed from comparison with thresholds, after having applied flagging quality criteria (land and ice flag).

3.2.3.1. Global

The percentage of measurements edited using each criterion has been monitored on a cycle per cycle basis (Figure 8). The mean percentage of edited measurements is about 3.7% : it similar to TOPEX before the problems due to tape recorder failures (see AVISO/CALVAL T/P Yearly Report 2003). An annual cycle is visible due to the seasonal sea ice coverage in the northern hemisphere.

3.2.3.2. 20-Hz measurements number

The percentage of edited measurements because of a too law number of 20-Hz measurements is represented on Figure 9. No trend neither any anomaly has been detected.

3.2.3.3. 20-Hz measurements standard deviation

Same comment as above, except for Figure 10.

3.2.3.4. Significant wave height

Same comment as above, except for Figure 11.

3.2.3.5. Backscatter coefficient

Same comment as above, except for Figure 12.

3.2.3.6. Radiometer wet troposphere correction

Same comment as above, except for Figure 13.

3.2.3.7. Dual frequency ionosphere correction

Same comment as above, except for Figure 14.

4. MONITORING OF ALTIMETER AND RADIOMETER PARAMETERS

Both mean and standard deviation of the main parameters of Jason-1 have been monitored since the beginning of the mission. Moreover, a comparison with T/P parameters has been performed: it allows monitoring of bias between the parameters of the 2 missions.

Two different methods have been used to compute the bias. During the verification phase (Jason-1 and T/P ground tracks have the same pattern), the mean of the T/P – Jason-1 differences is computed using a point by point repeat track analysis. Due to the T/P orbit change, the same method can't be applied from Jason-1 cycle 22 onwards. Thus, the T/P minus Jason-1 cycle per cycle means are obtained computing the differences between global global T/P and Jason means. Note that the same geographical areas are considered to take into account the data gaps on TP (especially in Indian Ocean due to recorders anomalies).

Only valid points, according to editing criteria, are used to analyze the behavior of these parameters.

4.1. 20 HZ MEASUREMENTS

4.1.1. 20 Hz measurements number in Ku-Band and C-Band

Figure 15 shows the cycle per cycle mean of 20-Hz measurements number in Ku-Band (top) and C-Band (bottom). The mean values are respectively 19.59 cm and 19.24 cm. No trend neither any anomaly has been detected.

4.1.2. 20 Hz measurements standard deviation in Ku-Band and C-Band

Same comment as above except for the Figure 16.

4.2. SIGNIFICANT WAVE HEIGHT

4.2.1. Ku-band SWH

The cycle mean of Ku-band SWH is plotted as a function of the cycle number on Figure 17 (top panel) for Jason-1 (red curve) and T/P (blue curve). Both curves are similar and show no anomaly. The cycle per cycle bias between the 2 parameters is plotted on the middle panel (Figure 17). The bias is quite stable about 8.8 cm, except for the Poseidon-1 which is about 15 cm (cycle 18).

The bottom panel shows the standard deviation of Ku-band SWH. Jason-1 (red curve) and TOPEX (blue curve) statistics seem very similar.

4.2.2. C-band SWH

Same comment as above except for the Figure 18.

4.3. BACKSCATTER COEFFICIENT

4.3.1. Ku-band Sigma0

The cycle per cycle mean (top panel, Figure 19) for Jason-1 (red curve) is coherent with the TOPEX mean (blue curve). In order to compare both parameters and keep a significant dynamic scale, TOPEX Ku-Sigma0 is biased by a 2.26 dB value to align TOPEX with the Jason-1 uncalibrated Sigma0.

The bias between the two corrections (Figure 19 : middle panel) is quite stable about -2.4 dB: this value is near from the -2.26dB bias which is applied in the ground processing and that was anticipated to represent the TOPEX to Jason-1 bias when computed from a small volume of data. The cycle per cycle standard deviation is monitored on cycle (Figure 19 : bottom panel). Jason-1 and T/P curves are very similar.

4.3.2. C-band Sigma0

Same as in 4.3.1 except for the C-band Sigma0 (Figure 20). The bias between TOPEX and Jason-1 is quite stable about -0.6 dB. Note that, the Jason C-Sigma0 is biased by a -0.26 dB value to align it on TOPEX in the science processing software.

4.4. DUAL-FREQUENCY IONOSPHERE CORRECTION

As in the previous analyses, the cycle per cycle mean, the mean differences with T/P and the standard deviation are plotted on Figure 21. The mean difference between T/P and Jason-1 is quite stable about -3 mm with variations lower than 2 mm. Note that a trend is observed on the mean monitoring for Jason-1 and TOPEX: it is linked with the variation of solar activity.

4.5. RADIOMETER WET TROPOSPHERE CORRECTION

Statistical monitoring analyses of the radiometer wet troposphere correction for Jason-1 and TOPEX on Figure 22 exhibit unusual variation of the JMR. Indeed the (TMR-JMR) mean differences (middle panel on Figure 22) show a 60-day signal and a 5mm jump from cycle 27 to 32.

The TMR yaw steering modes explain the 60-day signal (refer to AVISO/CALVAL T/P Annual Report 2003 for more information).

The cycle per cycle and daily differences between the radiometer and ECMWF model wet troposphere corrections for Jason and TP are plotted on Figure 23. The 5mm jump is only observed on Jason-1 (red curve) while the TOPEX curve is quite stable and exhibits only the 60-day signal due to yaw steering. Moreover, a signal linked to yaw steering modes is observed on Jason-1 differences from cycle 32 onwards (after the jump). This result tends to show that there are some unexpected effects in the JMR correction. The JMR behavior is presently under analysis at JPL both at the instrumental level (diodes) and at the science processing level.

The cycle per cycle standard deviations of the JMR and TMR radiometer wet tropospheric corrections (bottom panel on Figure 22) are very near one from the other.

5. CROSSOVER ANALYSIS

Crossover differences are systematically analysed to estimate data quality and the Sea Surface Height (SSH) performances. Furthermore, T/P crossover performances have been monitored in order to compare both performances. The main SSH calculation for Jason-1 and T/P are defined below. Note for Jason-1, all parameters are extracted from the GDR products.

$$
\begin{aligned}
& SSH = Orbit - AltimeterRange - \sum Corrections \\
& with: \\
& Orbit_{Jason-1} = POE\ CNES\ orbit \quad and \quad Orbit_{T/P} = NASA\ JGM3\ orbit \\
& and: \\
& \sum Corrections = Dry\ troposhere\ correction + \\
& \qquad + Inverse\ barometer\ correction \\
& \qquad + Radiometer\ wet\ troposhere\ correction \\
& \qquad + Dual\ frequency\ ionospheric\ correction\ (filter\ 300km)\ for\ TOPEX\ and\ Jason1, \\
& \qquad\ \ DORIS\ for\ Poseidon \\
& \qquad + Non\ Parametric\ SSB\ for\ Jason1\ and\ TOPEX, and\ BM4\ SSB\ for\ Poseidon \\
& \qquad + GOT99\ ocean\ tide\ correction\ (including\ loading\ tide) \\
& \qquad + Earth\ tide\ correction \\
& \qquad + Polar\ tide\ correction
\end{aligned}
$$

Note that for TOPEX data, a non-parametric sea state bias has been updated over TOPEX B period according to collinear method (Gaspard et al., October 2002, [Ref 3]). For Poseidon-1 data, non-parametric SSB is not yet available.

5.1. MEAN CROSSOVER DIFFERENCES

The top chart of Figure 24 allows monitoring the mean crossover differences for Jason-1 (red curve) and T/P (blue curve). The Jason-1 statistics are slightly more variable than TOPEX ones. The map of the crossover mean (bottom panel of Figure 24) from cycle 1 to 65 exhibits systematic differences between ascending and ascending passes in some areas: their amplitude is of 2-4 cm, which may be due to geographically-correlated orbit errors.

5.2. STANDARD DEVIATION OF CROSSOVER DIFFERENCES

The cycle per cycle standard deviation of crossover differences are plotted on Figure 25 (top panel) according to different crossover selection. 3 selections are applied:

- Red curve: no selection is applied. The mean value is 8.13 cm. It shows an annual signal linked to the sea ice variations in the Northern Hemisphere.
- Blue curve: shallow waters have been removed (bathy<-1000m). The previous annual signal has been removed by this selection even though it remains a signal probably due to seasonal ocean variations.
- Green curve: the last selection allows monitoring the Jason-1 system performance. Indeed, areas with shallow waters (1000 m), of high ocean variability (> 20 cm) and of high latitudes (> |50| degrees) have been removed. No anomalies have been detected; the mean value is about 6.2 cm which is a result similar to T/P.

The map of standard deviation of crossover differences over cycle 1 to 65 on Figure 24 (bottom panel) shows usual results with high variability areas linked to ocean variability.

5.3. COMPARE JASON-1 AND T/P AT CROSSOVERS

The objective is to compare Jason-1 and TOPEX performances at crossovers, which may allow detecting unusual behaviors of the systems. The following selection has been applied:

- Areas with shallow waters (1000 m), of high ocean variability (> 20 cm) and of high latitudes (> |50| degrees) have been removed.

In order, to better understand the differences between T/P and Jason-1 in the same conditions, the following has been considered:

- SSH crossovers have been interpolated with a spline tension equal to 0. Therefore the SSH is not filtered along track.
- There are data gaps on T/P from cycle 351 onwards due to recorder anomalies: some areas are then not taken into account, for instance in the Indian Ocean. Therefore, the Jason-1 crossovers corresponding with the T/P missing crossovers have also been removed on Jason-1.

The cycle per cycle standard deviation of crossover differences are plotted on Figure 26 (bottom panel) for Jason-1 (red curve) and T/P (blue curve). Both curves are very similar: however, the T/P figures are systematically slightly lower than Jason ones. Moreover, Jason-1 performances are degraded on early cycles: this is because the orbit POE has not been reprocessed on these cycles and it is known that maneuvers are poorly modeled for this cycle (this has been fully corrected from cycle 15 onwards).

In order to better understand this difference, the SSH-MSS differences have been filtered along-track (low pass filter) for both satellites. The short and long wavelength contents have been separated using a 50 km cut-off wavelength. Crossover differences are plotted:

- Crossover differences of the short wavelength signal (middle panel on Figure 26) show the impact of the different ground processing between TOPEX and Jason-1 (Zanifé et al, 2003 [Ref 6]). Jason-1 standard deviation is about 1.9 cm RMS higher than TOPEX. Note that Poseidon and Jason-1 performances (cycle 18) are the same.
- Long wavelengths (top panel on Figure 26) mainly show the impact of orbit errors on both missions (among other possible errors): let us recall that the Jason-1 POE orbit have not been reprocessed on early cycles (from cycle 8 onwards, the performances are more similar).

6. ALONG-TRACK ANALYSIS

This analysis is used to compute Sea Level Anomalies (SLA), variability and thus to estimate data quality; it is used to determine the SSH bias between Jason-1 and T/P and the trend in the Mean Sea Level (MSL).

6.1. MEAN SEA LEVEL

The cycle per cycle mean sea level is plotted on Figure 27 over T/P period on top panel. The bottom panel allows to focus on Jason-1 period. For each cycle the value is calculated averaging over 2° by 3° bins, then weighting by latitude to take into account the relative binsize. The Jason-1 SSH is biased by 14 cm (see 6.2). This result can be used to estimate the trend in the MSL as observed by T/P.

The MSL are consistent over cycles 1-25 between both satellites. Over cycles 26-60 difference between the 2 signals increase up to 0.5 cm which may be due to the JMR wet troposphere correction (see 4.5).

6.2. T/P – JASON-1 SSH BIAS

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 model wet troposphere correction to avoid undesirable effects from the JMR correction.

SSH bias with all the corrections is plotted cycle per cycle on Figure 28 (red curve). The bias is quite stable: it is about -14 cm.

Furthermore, the SSH bias has been computed applying no corrections (blue curve), then applying all corrections except for the SSB (green curve). As expected, these 2 curves are very similar: the bias is about -8 cm. This result allows us to estimate the T/P –Jason-1 SSB bias about -6 cm. Such a value has still to be discussed following the expected progress in SSB estimation in the coming years.

The SSH bias (with all corrections applied) is plotted over each hemisphere on the Figure 29. The North/South signal is quite similar from cycle 28 to 53, but the differences reach 2 cm over cycles 1-17, 22-27 with a constant sign. This is probably due to orbit calculation.

From cycle 54, the difference increases between both hemispheres, which is still under investigation.

This is confirmed by the map of the (T/P – Jason-1) SSH differences averaged over the verification phases (21 cycles) on Figure 30. These differences seem geographically correlated.

6.3. SEA LEVEL SEASONAL VARIATIONS

From Sea Level Anomalies computed relative to the Mean Sea Surface CLS 2001 (Hernandez et al, 2001), the surface-topography seasonal variations have been mapped on Figure 34 for the overall Jason-1 data set. Major oceanic signals are showed clearly by these maps: it allow us to assess the data quality for oceanographic applications.

The most important changes are observed in the equatorial band with the development of an El Niño in 2002-2003. The event peaked in the fourth quarter of 2002, and declined early in 2003. Conditions indicate an event of moderate intensity that is significantly weaker than the strong 1997-1998 El Niño (McPhaden, 2003, [Ref 5]).

6.4. ALONG-TRACK PERFORMANCES

The SLA standard deviation is plotted on Figure 31 for Jason-1 (red curve) and T/P (blue curve). It exhibits similar and good performances for both satellites. However, during the verification phase, the variability is slightly higher for Jason-1 but from cycle 26 onwards the performances are very similar. A significant signal is observed from cycle 25 and 35. It is due to the 2002-2003 “El Niño” (McPhaden, 2003, [Ref 5]).

In order to better understand the performance differences, as in the crossover analysis, short and long wavelength contents of SLA (with wavelength respectively lower than 50 km and greater than 500 km) mainly show the effect of the ground processing and the orbit quality (Figure 32). Medium and short wavelengths show a degradation of TOPEX performance after the orbit change due to the use of a MSS to compute SLA. Indeed the MSS adds errors at these wavelengths, when used away from the nominal T/P – Jason ground track.

To remove the effect of the MSS, SLA are then computed relative to dedicated mean profiles for Jason-1 and TOPEX (cycles 26-60). Consistent computation of Figure 33 proves the impact of the MSS on previous figure (Figure 33).

7. DEDICATED INVESTIGATIONS

7.1. (T/P – JASON-1) SLA DIFFERENCES

Investigations have been led to compare (SSH – MSS) differences between T/P and Jason-1 along track and to better analyze the geographical features observed. The results are presented on the following reports (click on icon).

First report shows systematic differences versus the latitude and longitude. SLA differences are computed by latitude band (360° by 1°) and by longitude band (1° by 90°) for all, ascending and descending passes:

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The SLA differences between both satellites are mapped on the second report on a cycle per cycle basis from cycle 1 to 60.

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These studies clearly showed geographical features between SLA of both satellites. These differences vary depending on the cycle and can reach 5 cm. But the (Jason-1-T/P) SLA bias is always higher on the Southern Hemisphere than in the Northern hemisphere. Moreover, the SLA bias shows a significant drift in the Southern hemisphere versus the latitude, while the bias is quite stable in the Northern hemisphere.

7.2. IMPACT OF ORBIT CALCULATION

In order to assess the POE CNES orbit quality in Jason-1 GDRs, several GSFC orbits have been tested. The following report describes the study (click on icon):

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In terms of variance, the results are very close. However, using the GSFC GPS-Laser reduced dynamic orbit instead of POE CNES reduces the crossover standard deviation by about 1 cm RMS. Geographical features are observed on SSH differences between TOPEX (NASA orbit) and Jason-1 (POE orbit). These features are reduced when the CNES orbit is used for TOPEX. Similar results are obtained with the Jason-1 GPS-Laser (reduced Dynamic) GSFC orbit instead of CNES orbit (c), with slightly lower trackiness.

7.3. HIGH-FREQUENCY CONTENT ANALYZE

A study has been carried out to analyze the high-frequency content from Jason-1 and TOPEX data. Instrumental noise analyses are usually performed from data closer to the instrument. However, it is interesting to analyze the high-frequency content of user data as the IGDR or GDR products for Jason-1 and TOPEX. The high-frequency content can be assimilated to a 1Hz pseudo noise. This one includes instrumental noise, data processing errors, correction noise, residual geophysical signals … The study is described in the following report (click on icon). Not that preliminary Jason IGDRs of the verification period (CMA version number 5) have been used.

Bruit Jason

8. CONCLUSION

Thanks to GDR repossessing performed this year (2003), 2 years of Jason-1 data (GDR) are available. The good quality of Jason-1 data has been shown in this report: main altimeter parameters have the same behaviors as T/P ones; crossover and along-track performances are very similar between both satellites; the T/P –Jason-1 SSH bias is very stable about -14 cm.

However anomalies have been detected on the JMR corrections. These are still under investigation.

Furthermore, geographical features are observed on SSH differences between TOPEX and Jason-1. The orbit calculation can partly explain these geographical differences. These features are less visible when the CNES orbit is used for TOPEX. Studies are in progress to improve Jason-1 POE orbit calculation and test the SSH performance improvement at crossovers and along-track.

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[Ref 2] Aviso and PODAAC User Handbook, April 2003: IGDR and GDR Jason User Products, SMM-MU-M5-OP-13184-CN.

[Ref 3] Gaspar, P., S. Labroue and F. Ogor, October 2002: Improving nonparametric estimates of the sea state bias in radar altimeter measurements of sea level. J. Atmos. Oceanic Technol., 19, 1690-1707.

[Ref 4] Ruf C.S., June 2002: TMR Drift - Correction to 18 GHz Brightness Temperatures, Revisited. Report to TOPEX Project.

[Ref 5] McPhaden J., April 2003: Evolution of the 2002-03 El Niño, UCLA Tropical Meteorology and Climate Newsletter, No 57.

[Ref 6] Zanifé O.Z., P.Vincent : Comparison of the Ku-band Range Noise Level and the relative Sea State Bias of the Jason-1, TOPEX and POSEIDON-1 Radar Altimeters.

APPENDIX A : FIGURES

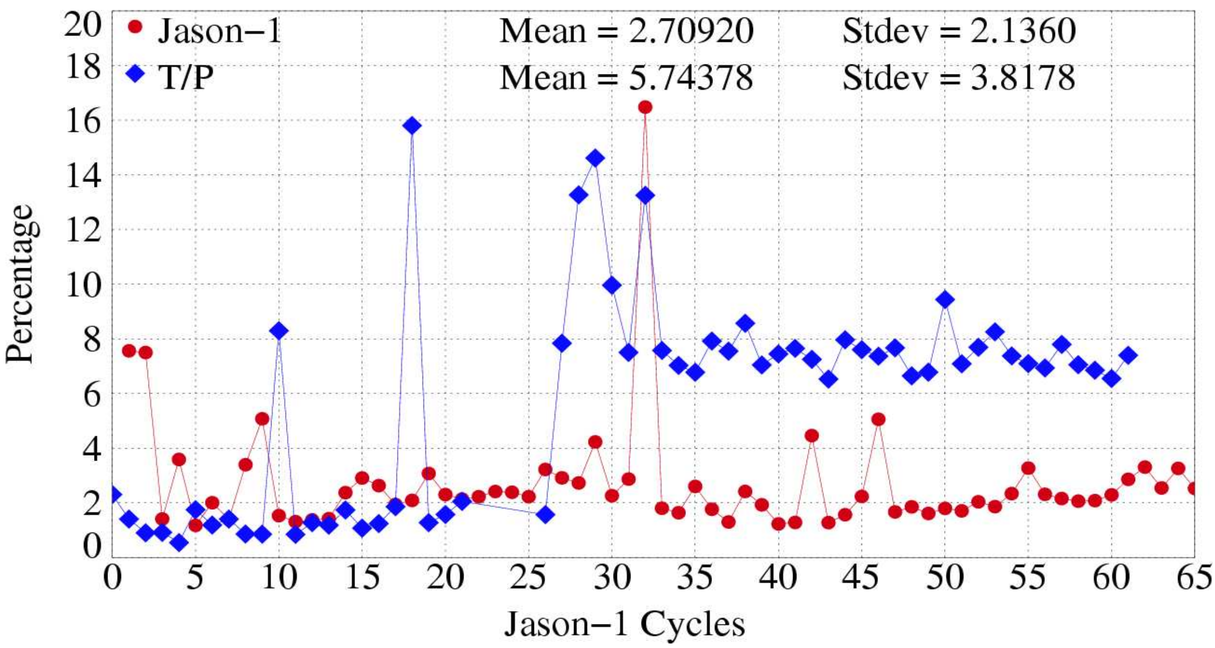


Figure 1 : Cycle per cycle percentage of missing measurements over ocean for J1 and T/P

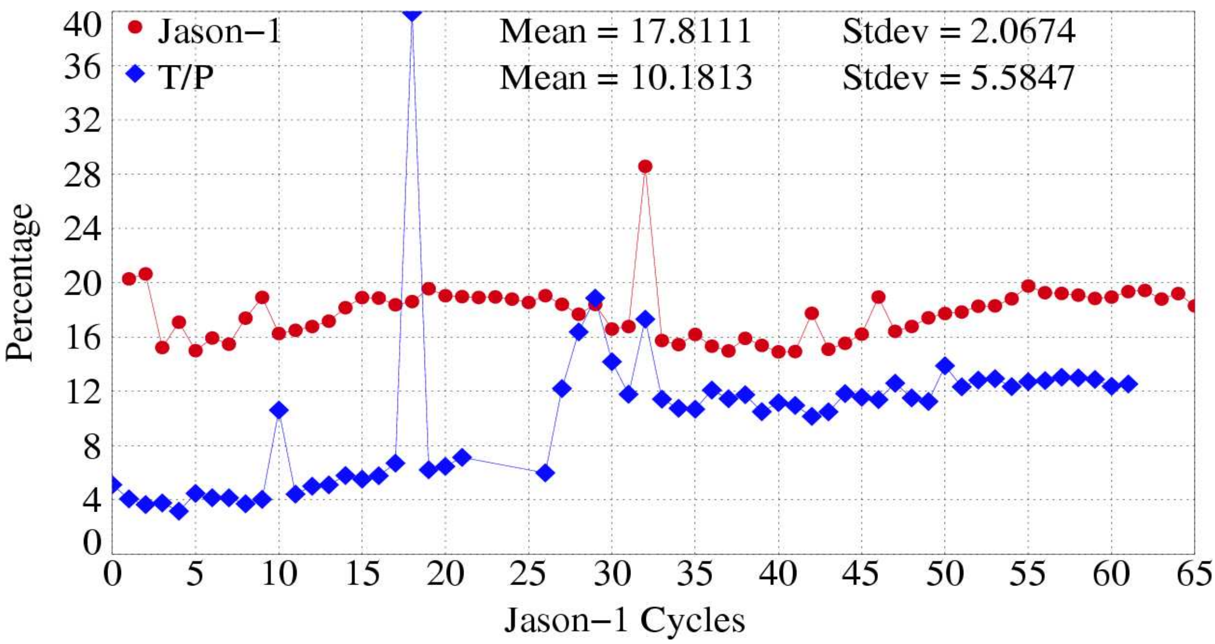


Figure 2 : Percentage of missing measurements over ocean and land for J1 and T/P

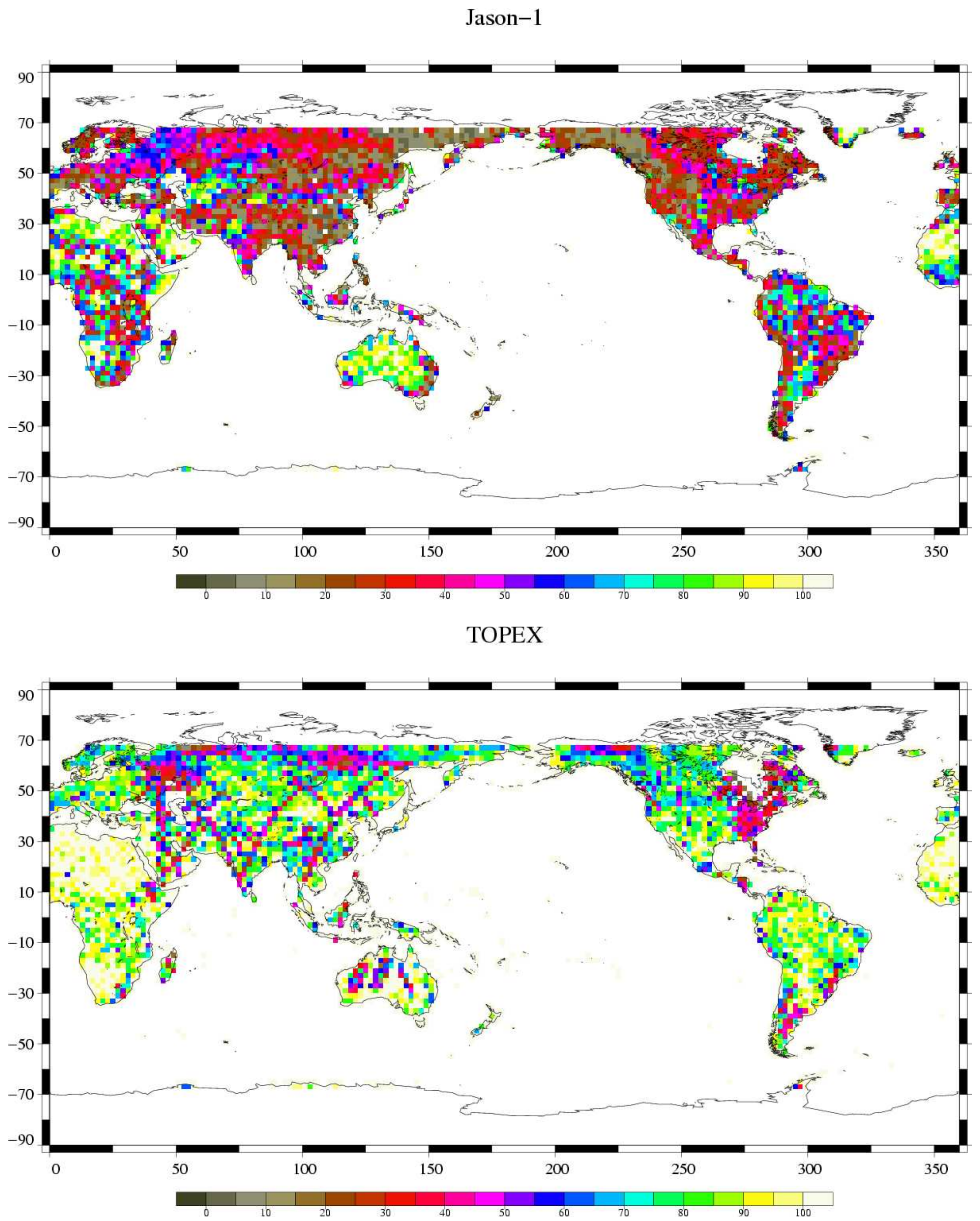


Figure 3 : Map of percentage of missing measurement over land for Jason-1 on cycle 61 (top) and for TOPEX on cycle 404 (bottom)

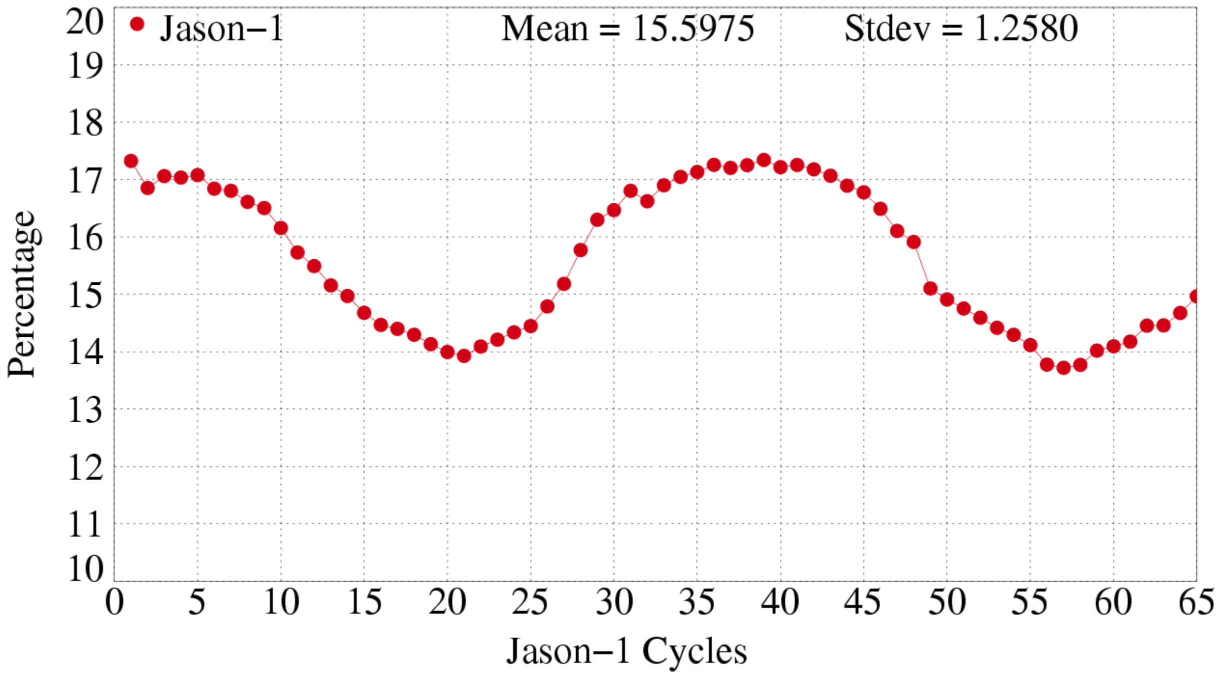


Figure 4 : Cycle per cycle percentage of edited measurements by land flag criterion

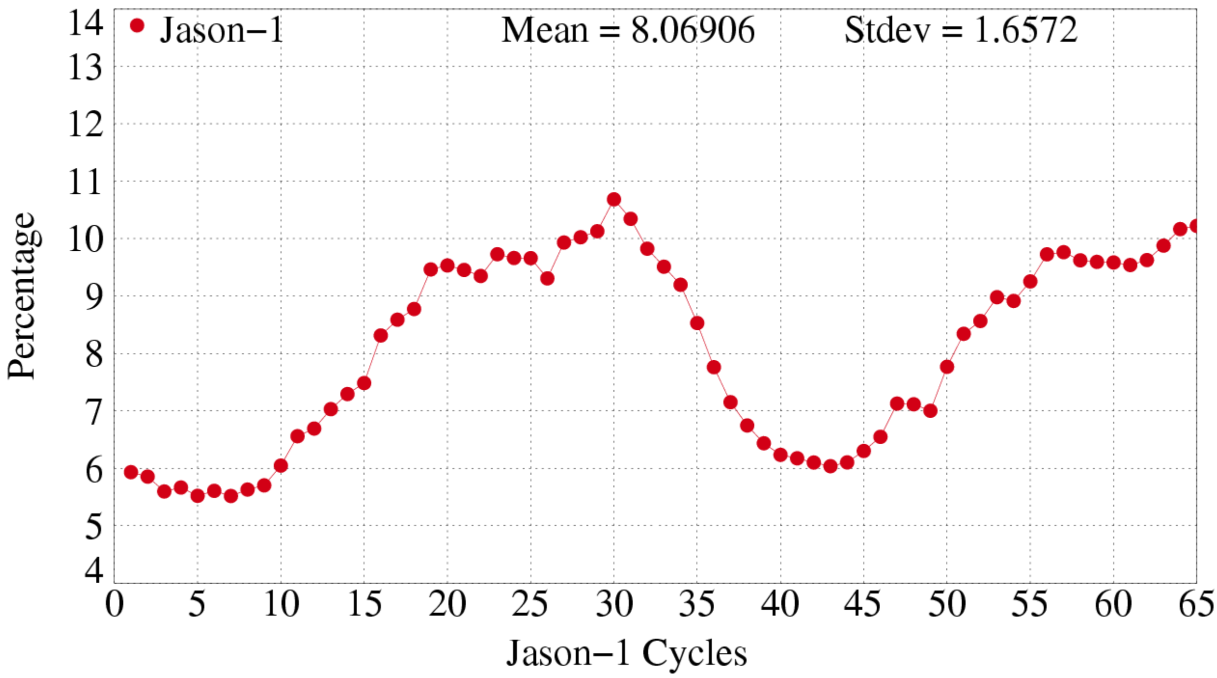


Figure 5 : Cycle per cycle percentage of edited measurements by ice flag criterion

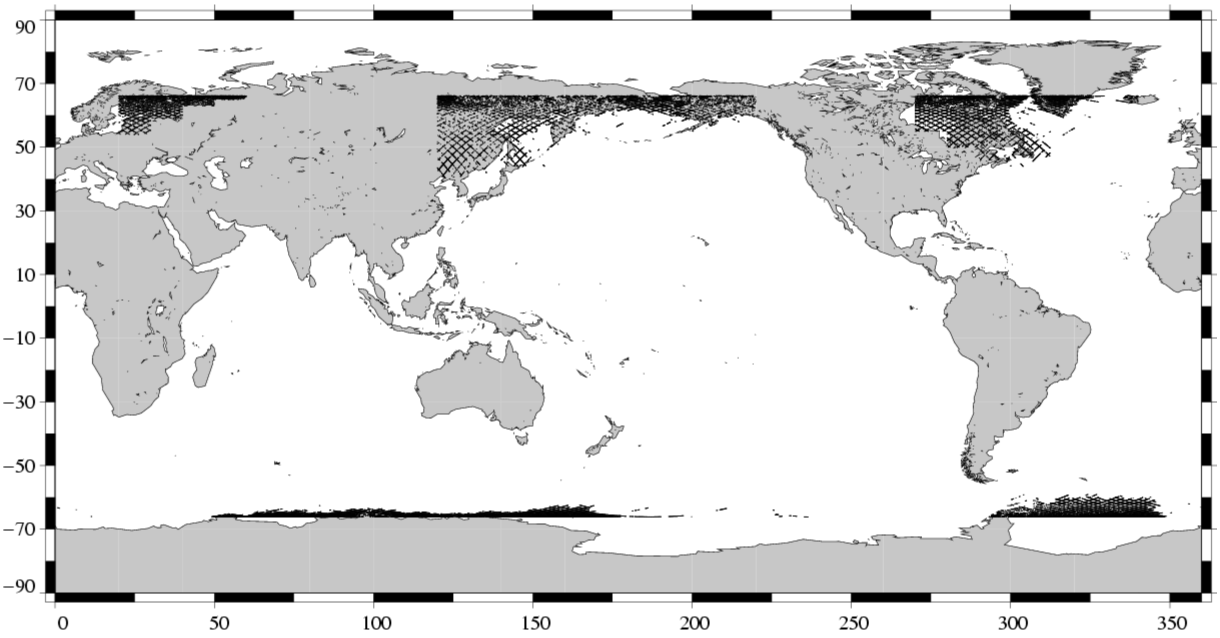


Figure 6 : Map of edited measurements by ice flag criterion on cycle 65

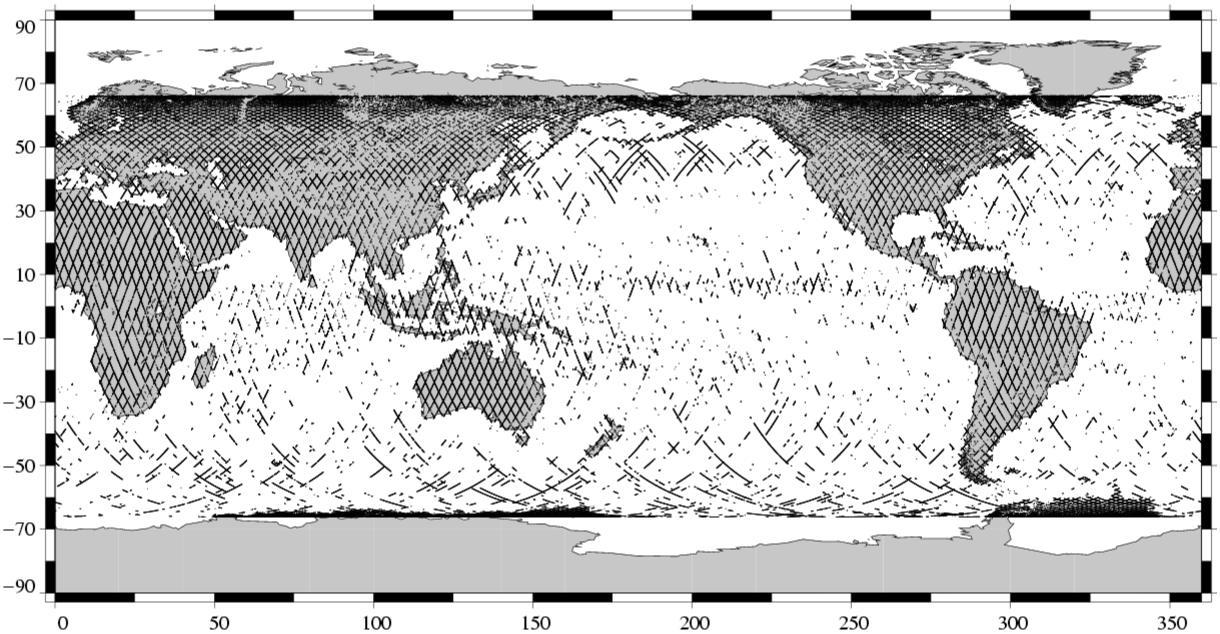


Figure 7 : Map of edited measurements by rain flag criterion

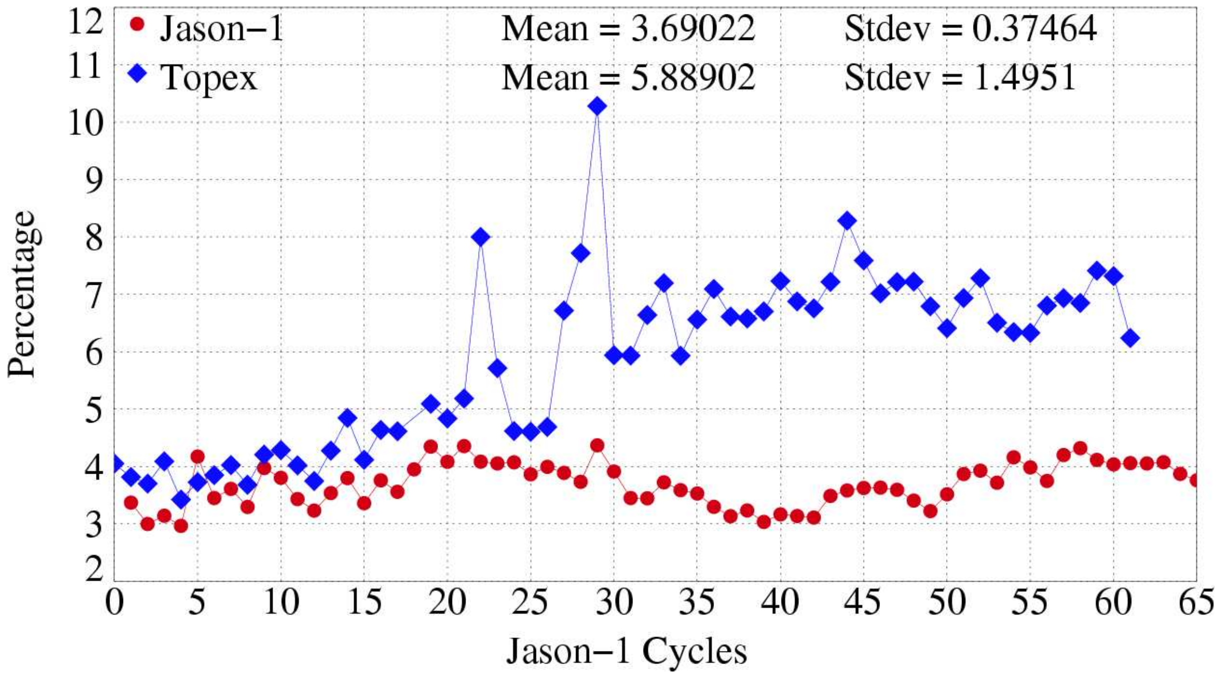


Figure 8 : Cycle per cycle percentage of edited measurements by threshold criteria

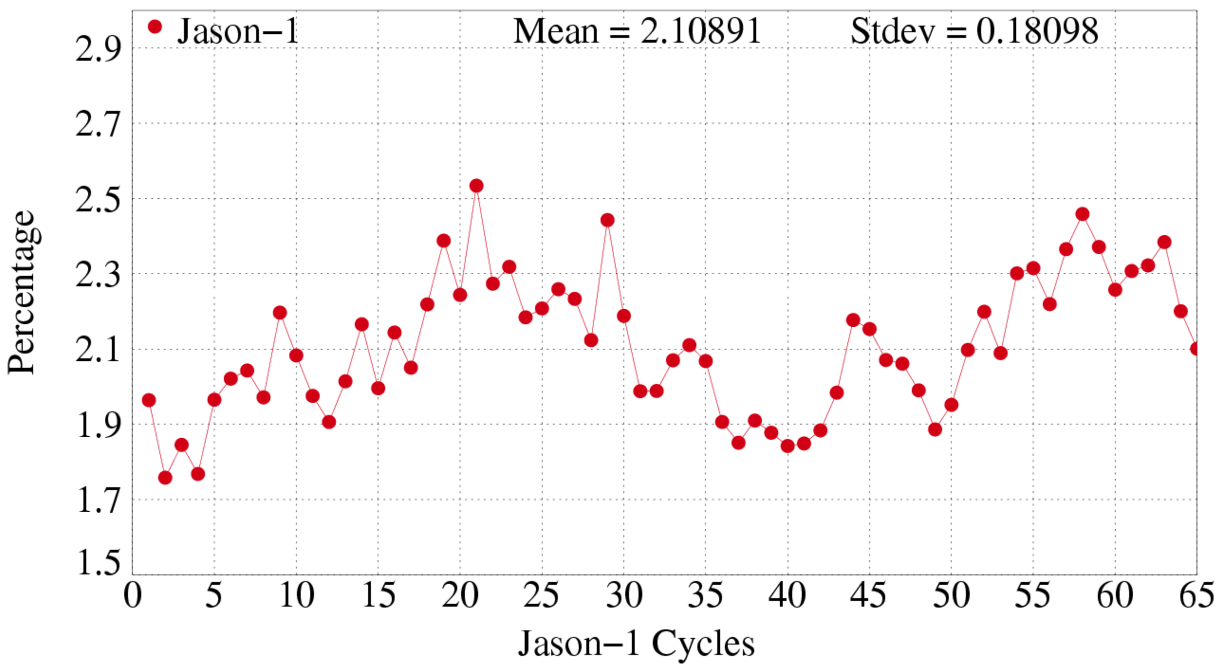


Figure 9 : Cycle per cycle percentage of edited measurements by 20-Hz measurements number criterion

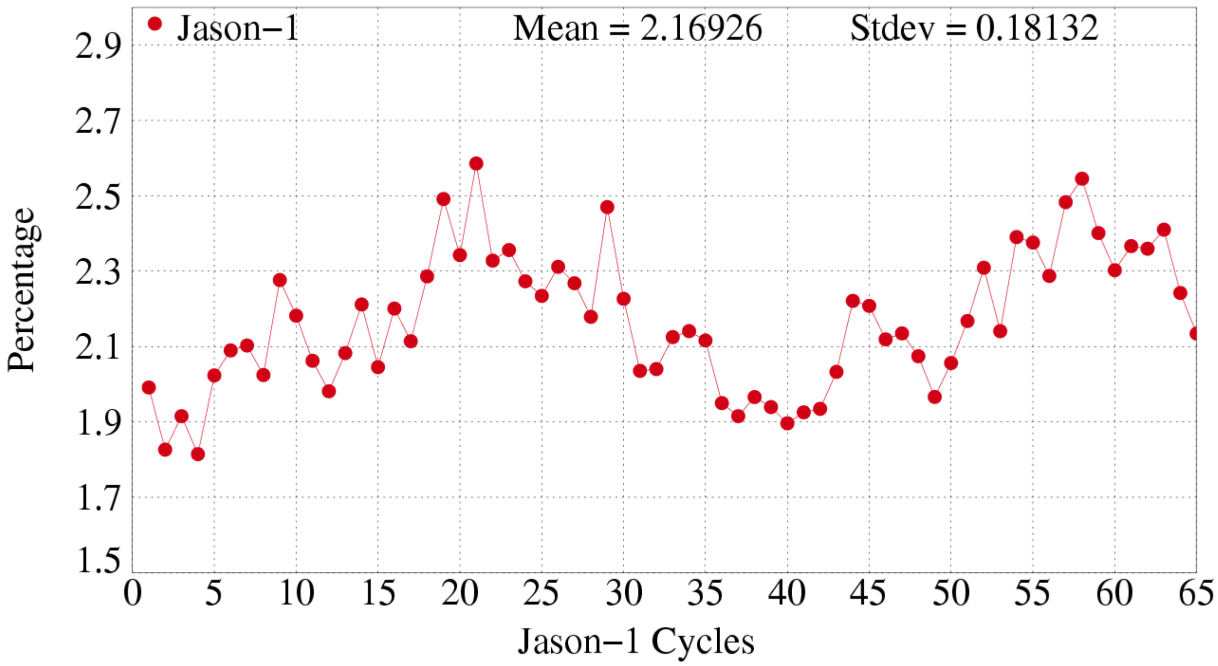


Figure 10 : Cycle per cycle percentage of edited measurements by 20-Hz measurements standard deviation criterion

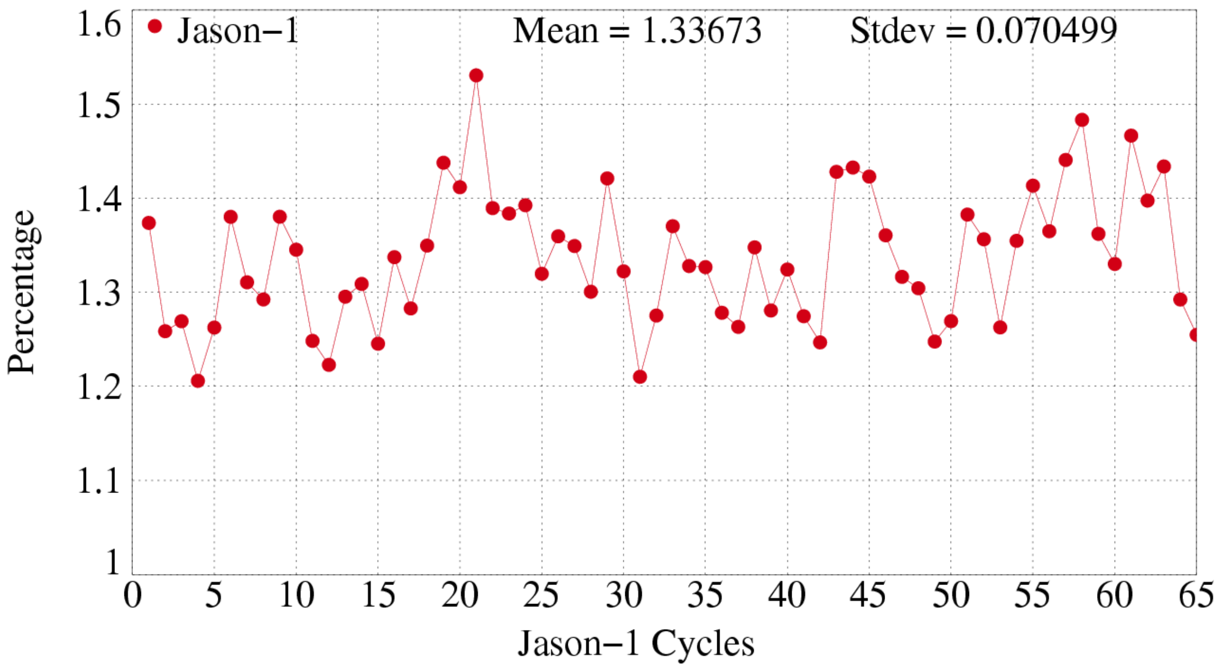


Figure 11 : Cycle per cycle percentage of edited measurements by SWH criterion

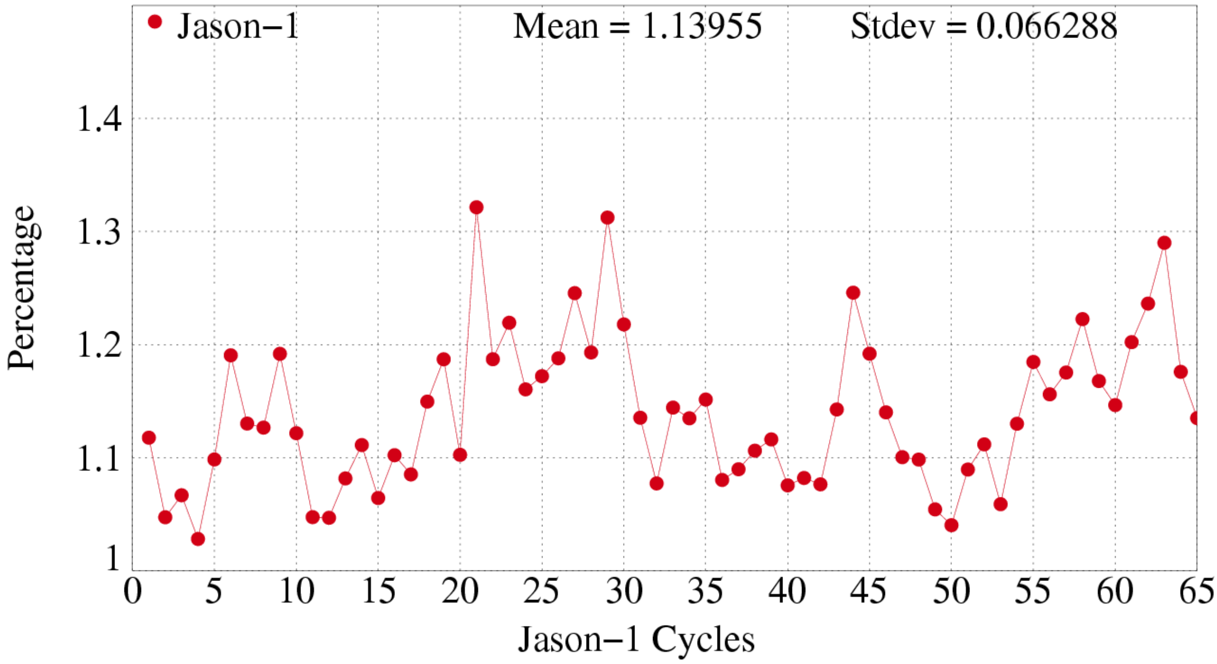


Figure 12 : Cycle per cycle percentage of edited measurements by Sigma0 criterion

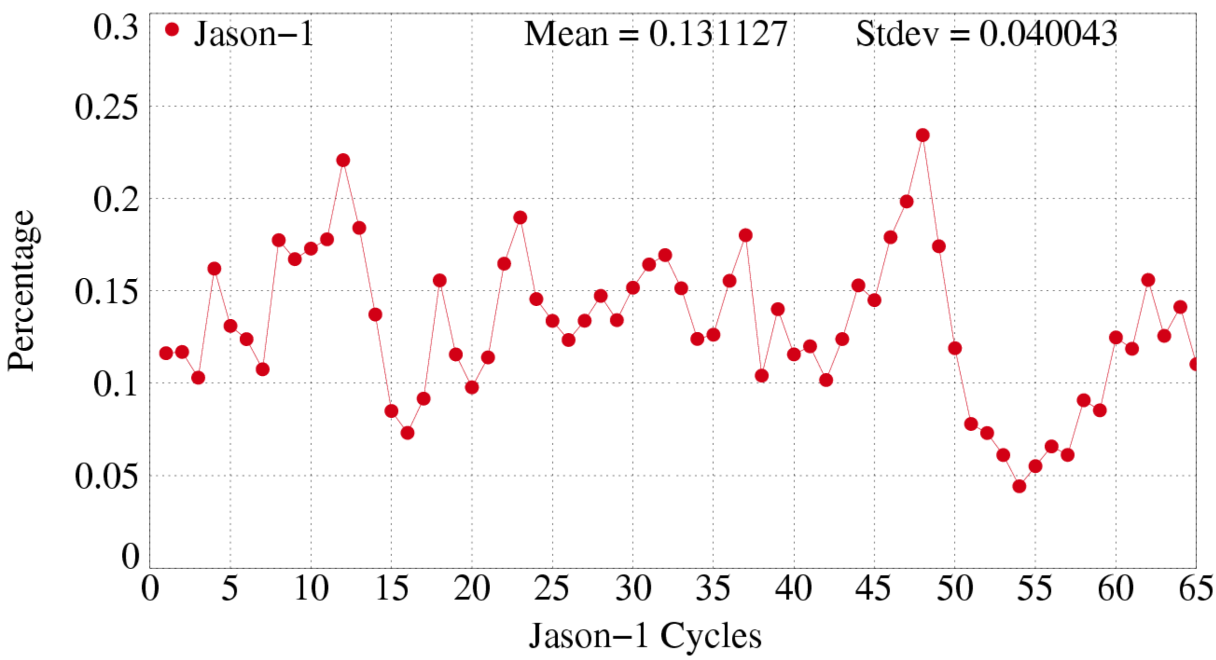


Figure 13 : Cycle per cycle percentage of edited measurements by radiometer wet troposphere criterion

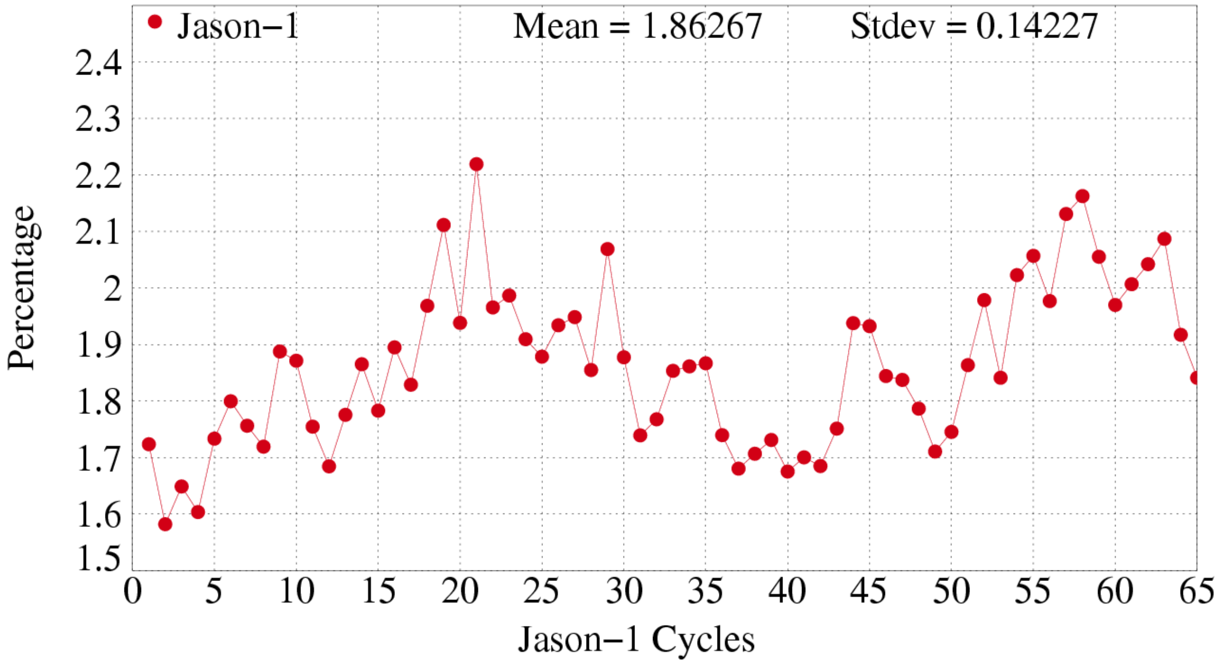


Figure 14 : Cycle per cycle percentage of edited measurements by dual frequency ionosphere criterion

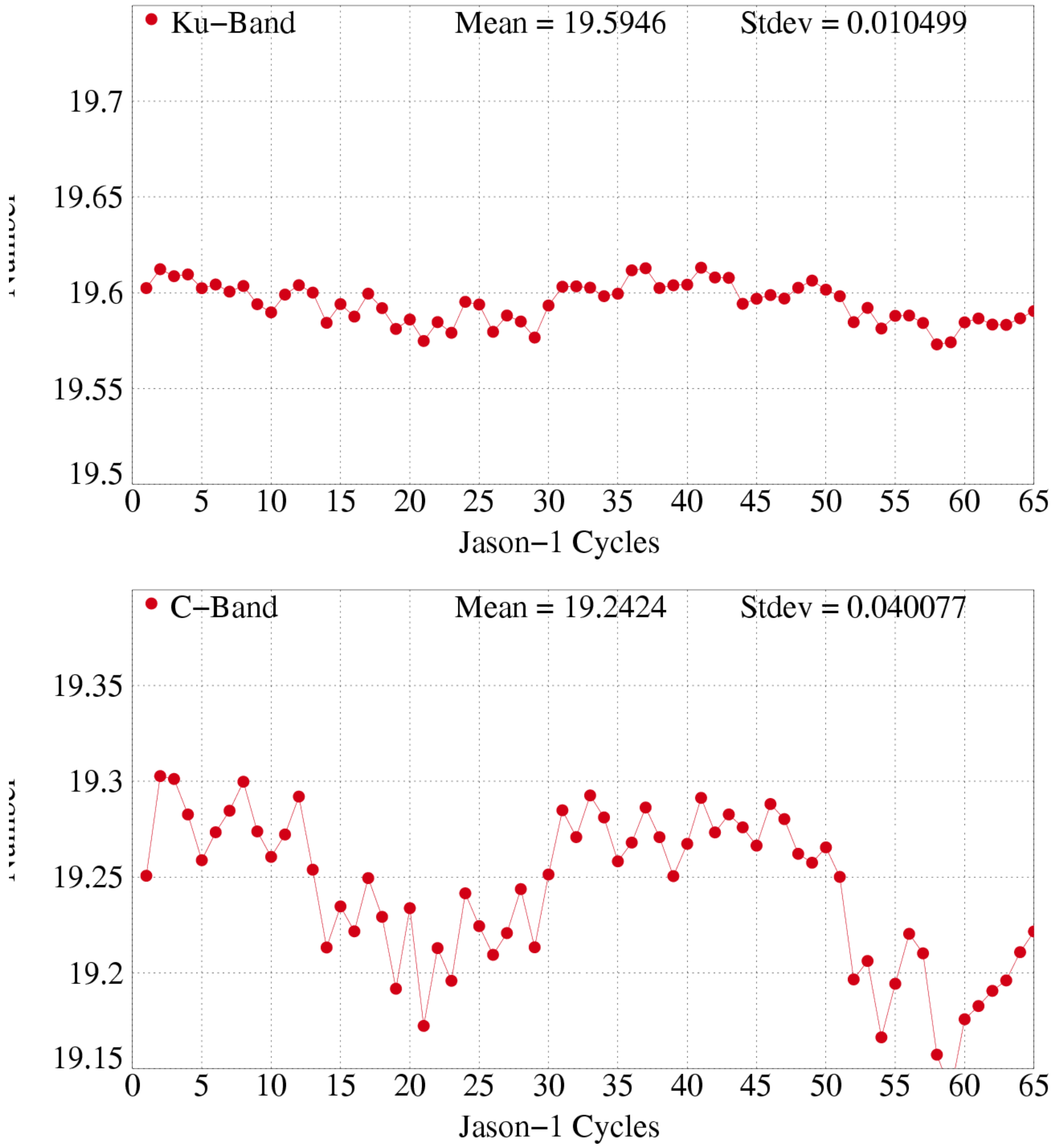


Figure 15 : Cycle per cycle mean of 20-Hz measurements number in Ku-Band (top) and C-Band (bottom)

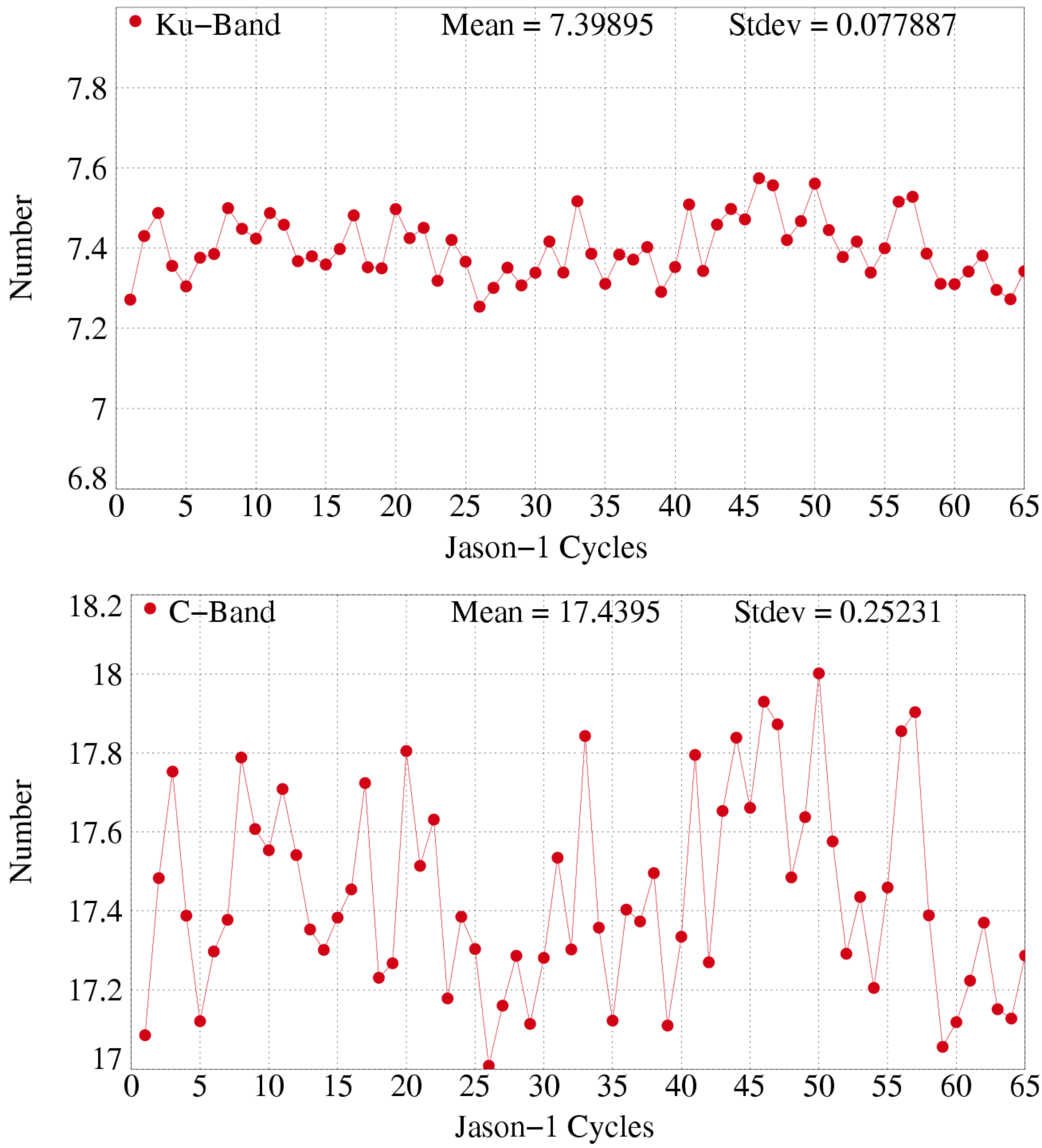


Figure 16 : Cycle per cycle mean of 20-Hz measurements standard deviation in Ku-Band (top) and C-Band (bottom)

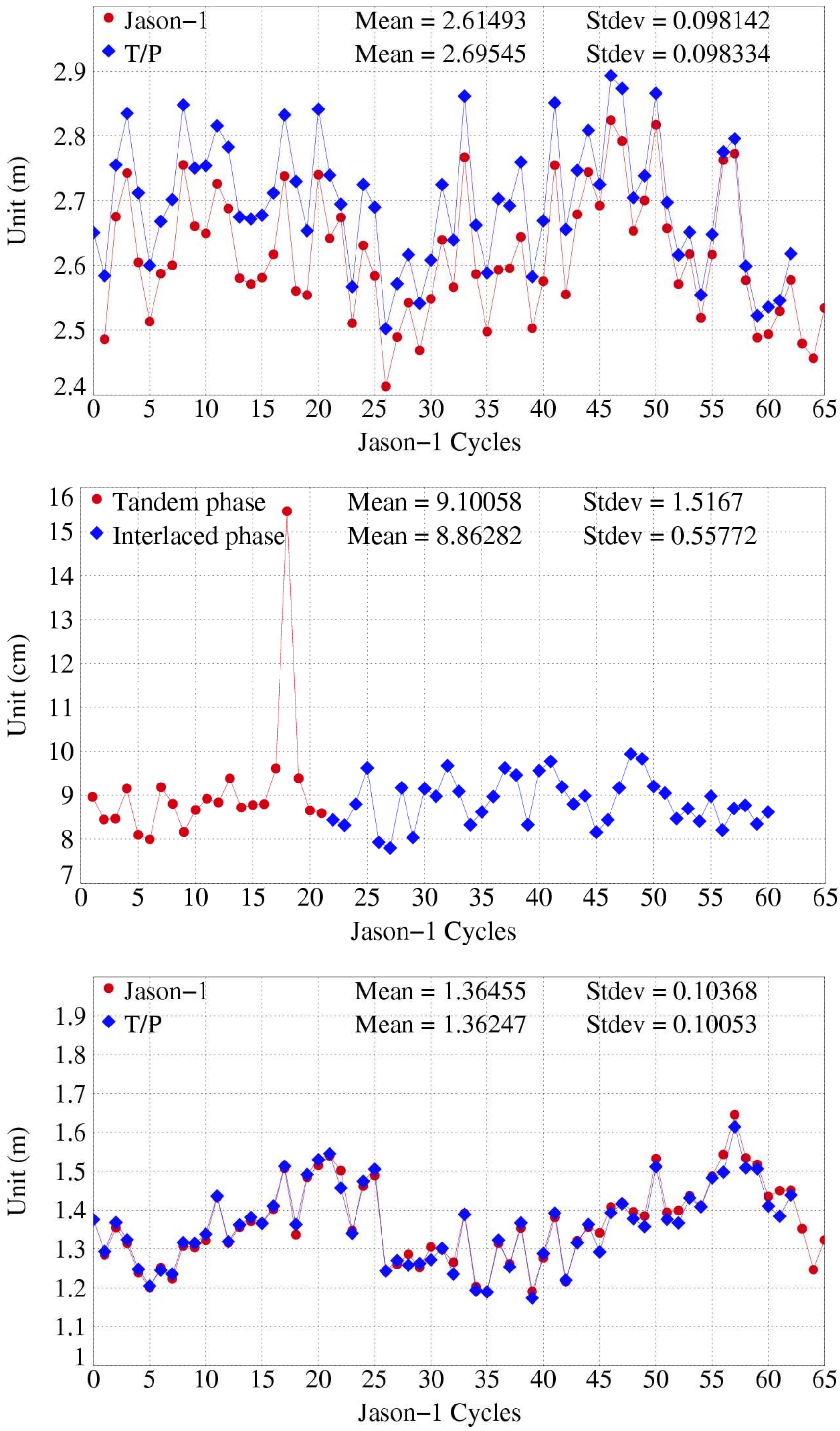


Figure 17 : Cycle per cycle mean (top), T/P – Jason mean differences (middle), and standard deviation (bottom) of Ku-band SWH

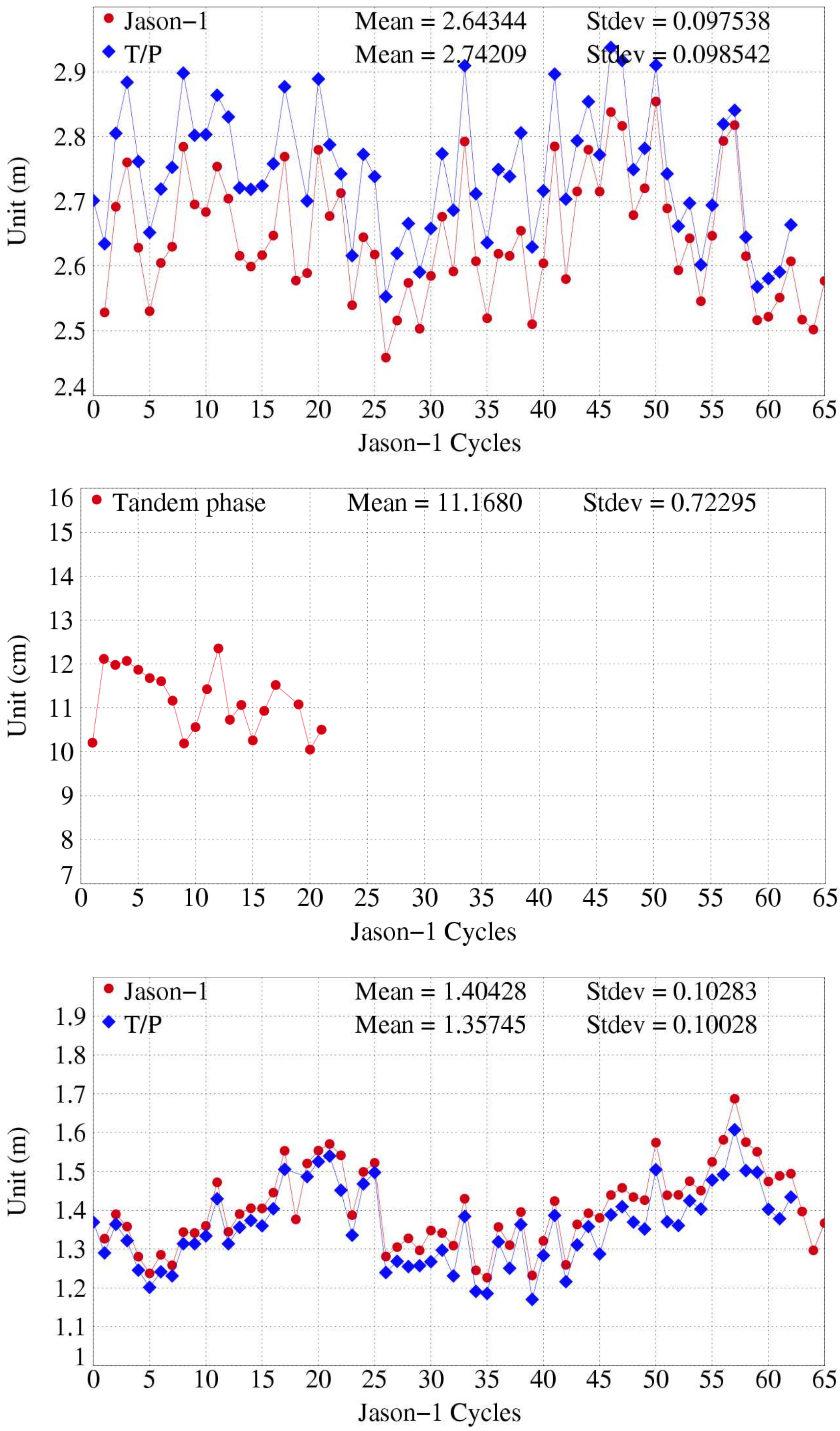


Figure 18 : Cycle per cycle mean (top), T/P – Jason mean differences (middle), and standard deviation (bottom) of C-band SWH

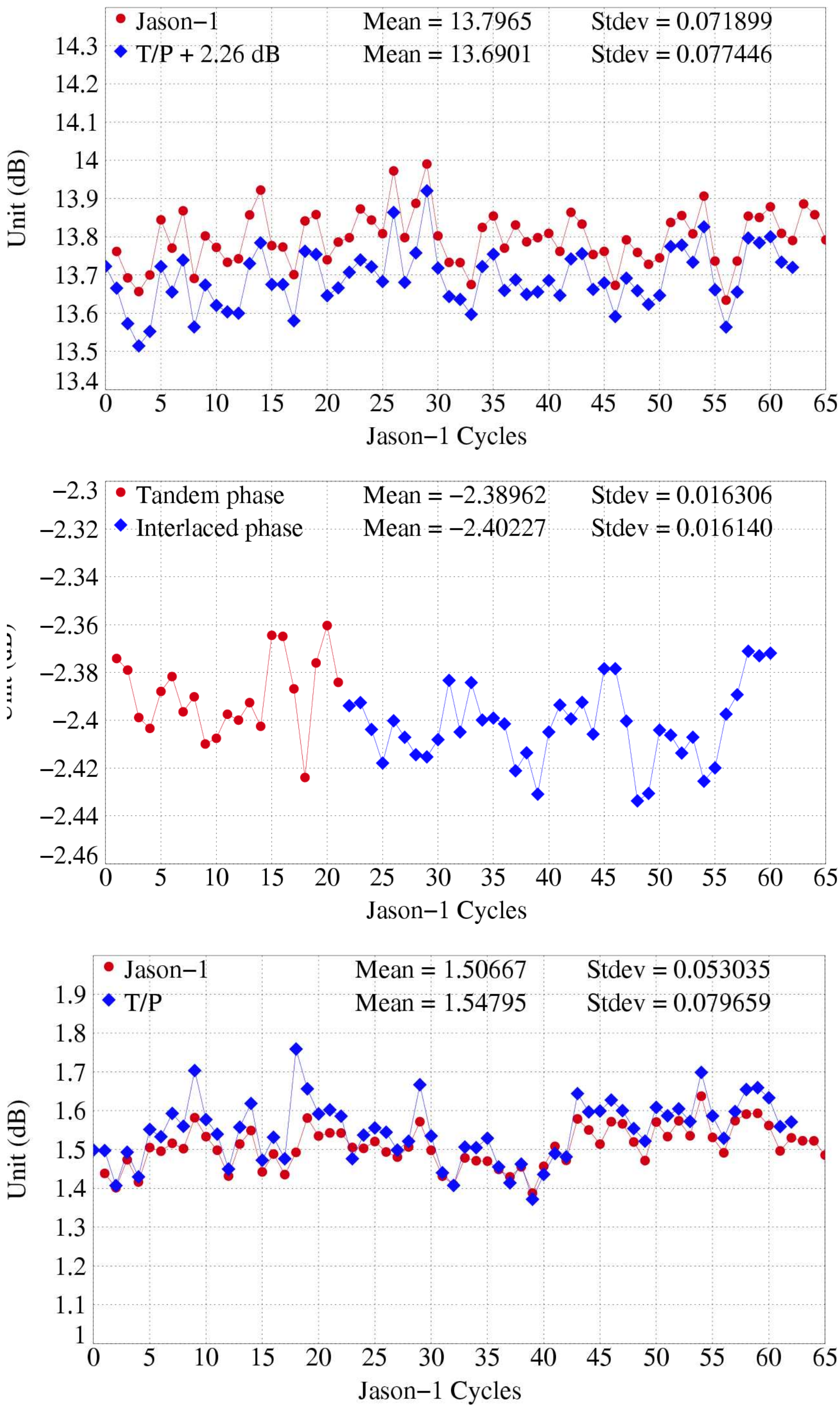


Figure 19 : Cycle per cycle mean (top), T/P – Jason mean differences (middle), and standard deviation (bottom) of Ku-band Sigma0

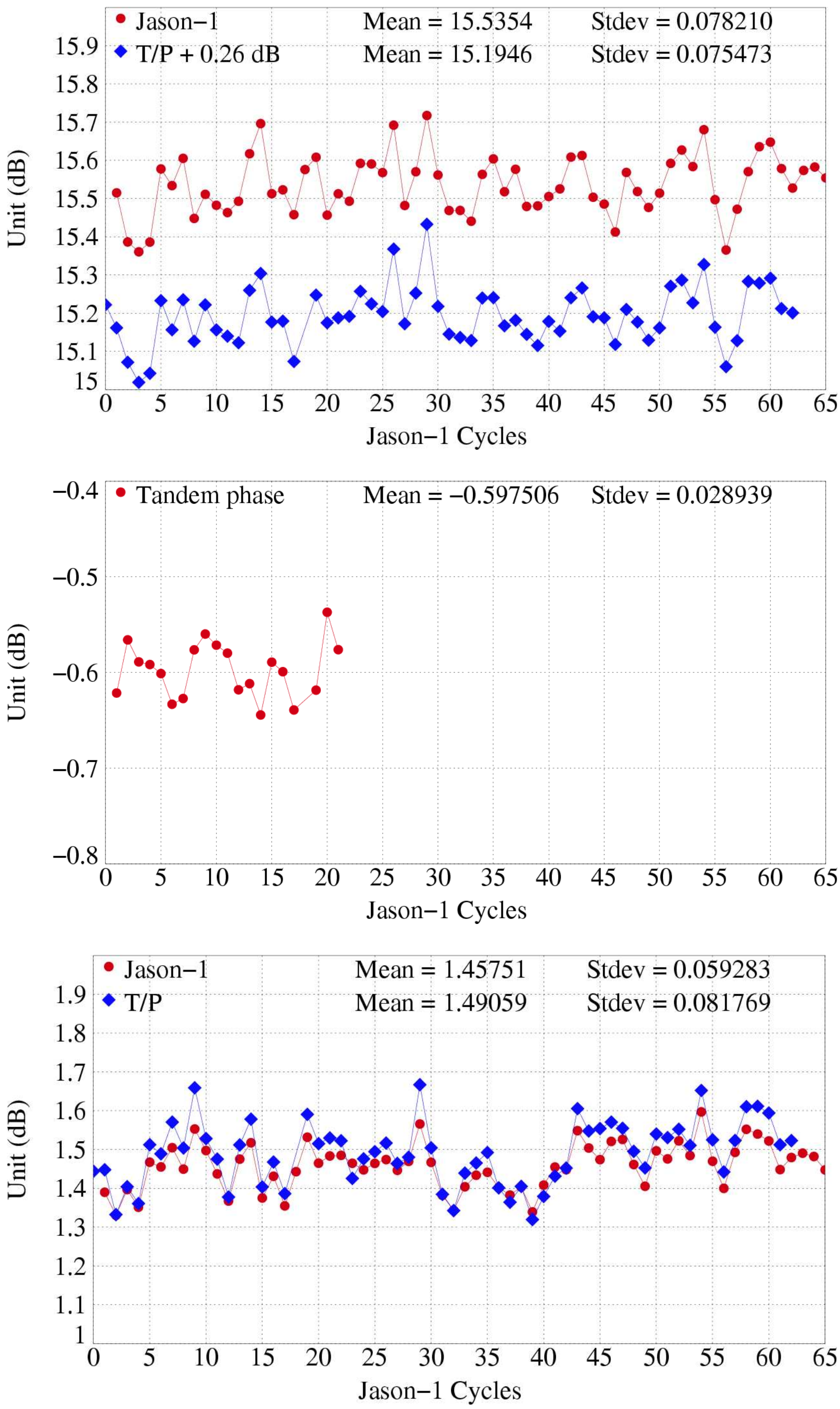


Figure 20 : Cycle per cycle mean (top), T/P – Jason mean differences (middle), and standard deviation (bottom) of C-band Sigma0

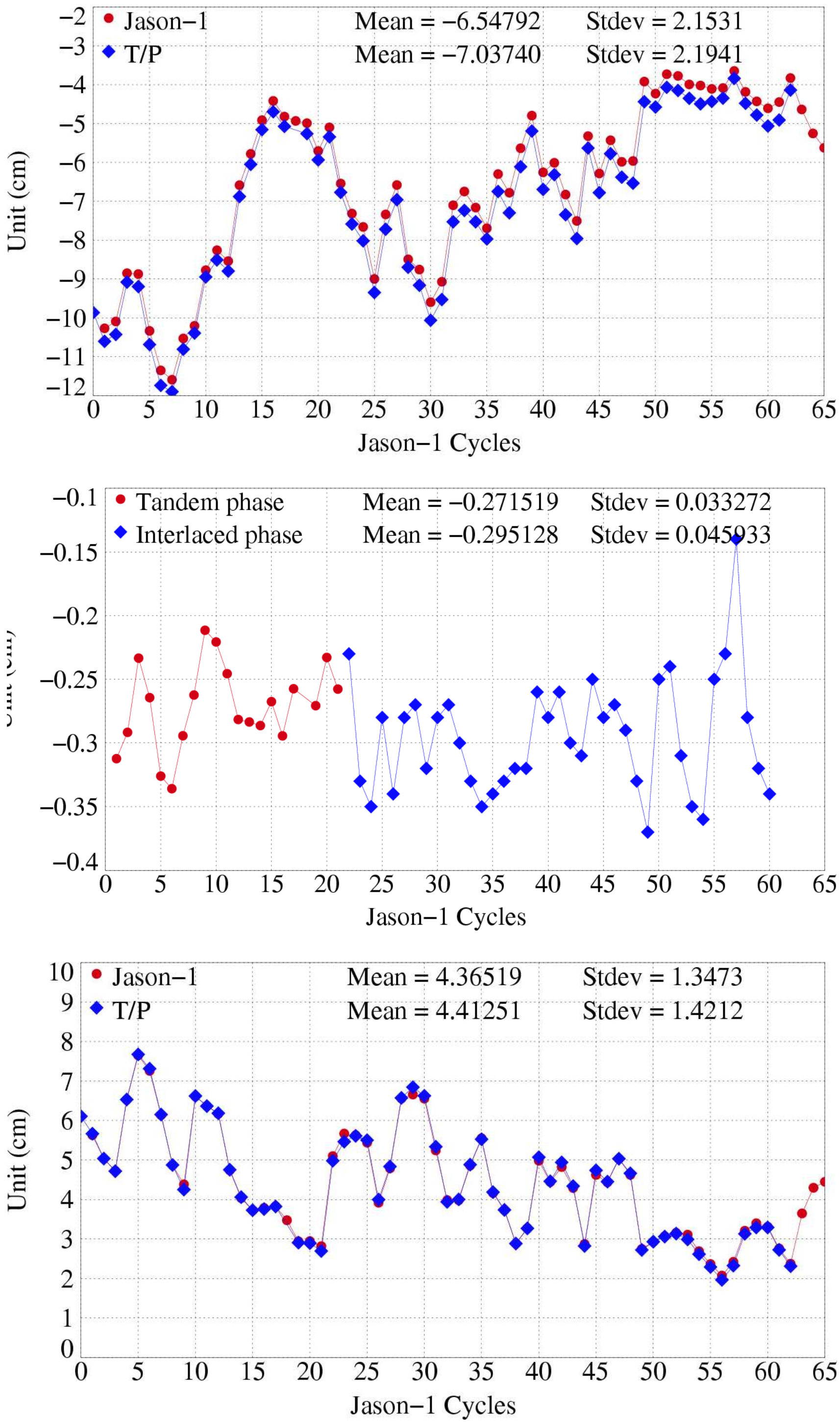


Figure 21 : Cycle per cycle mean (top), T/P – Jason mean differences (middle), and standard deviation (bottom) of dual frequency ionosphere correction

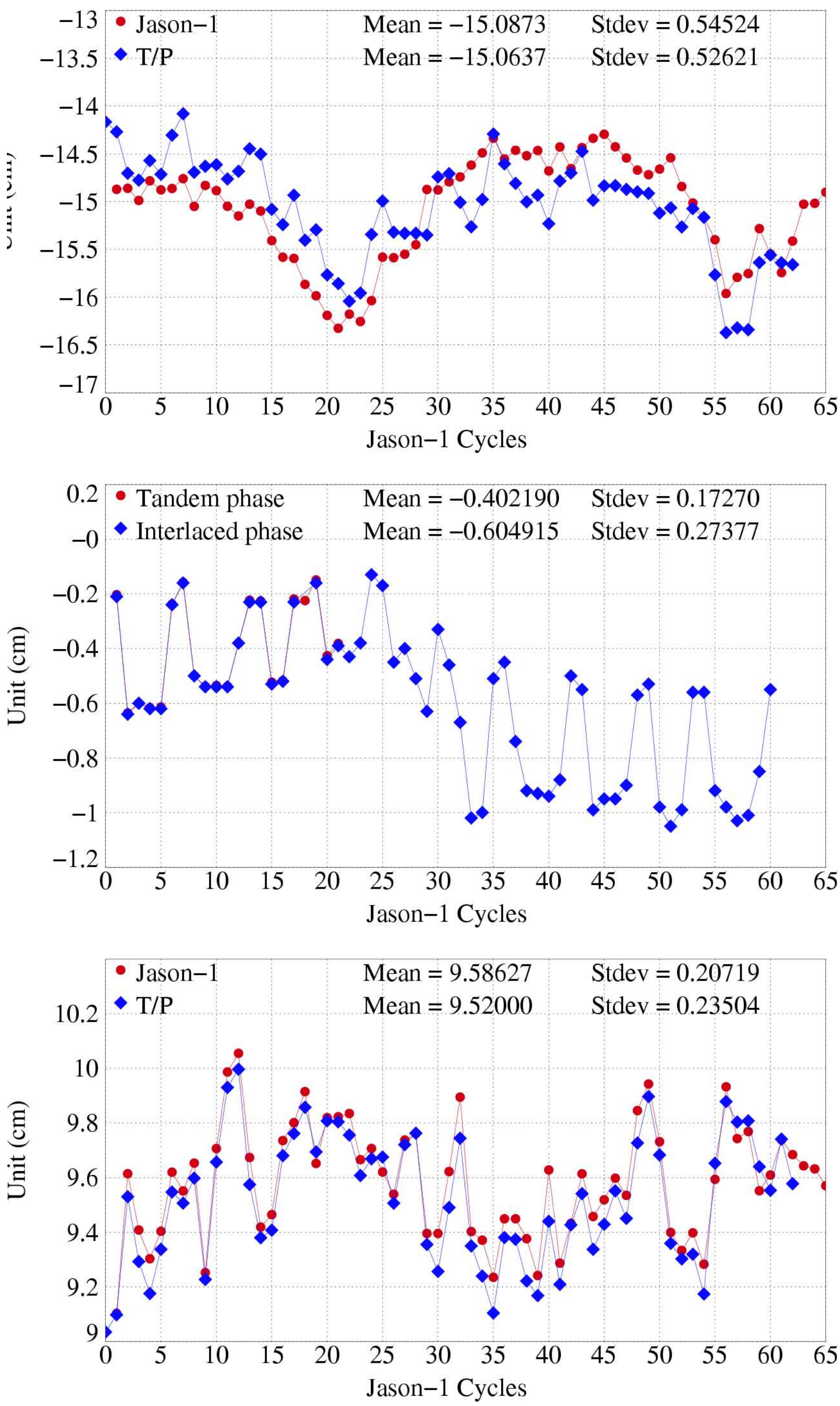


Figure 22 : Cycle per cycle mean (top), T/P – Jason mean differences (middle), and standard deviation (bottom) of radiometer wet troposphere correction

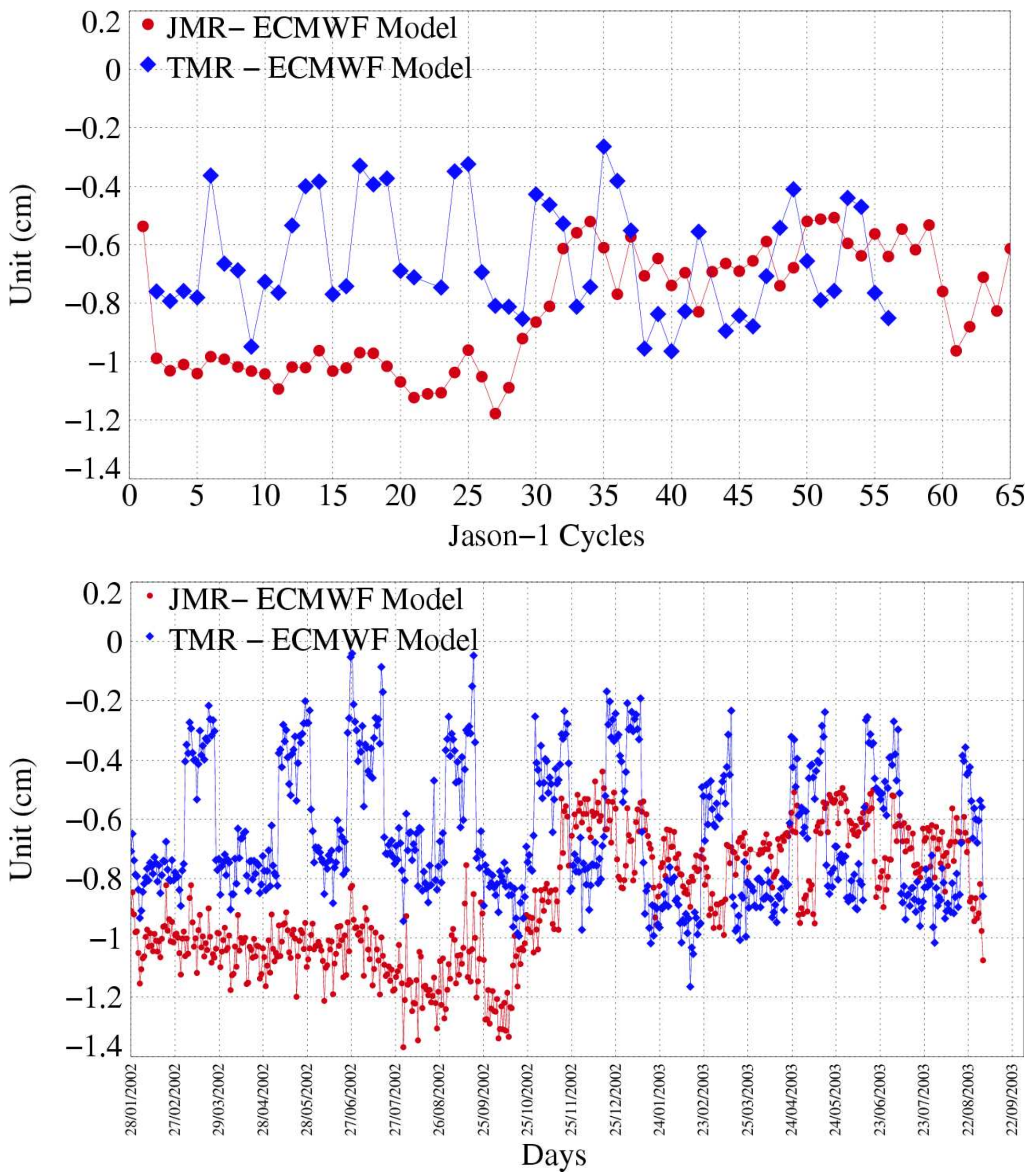


Figure 23 : Cycle per cycle mean (top) and daily mean (bottom) of radiometer and ECMWF model wet troposphere correction differences for Jason-1 and T/P

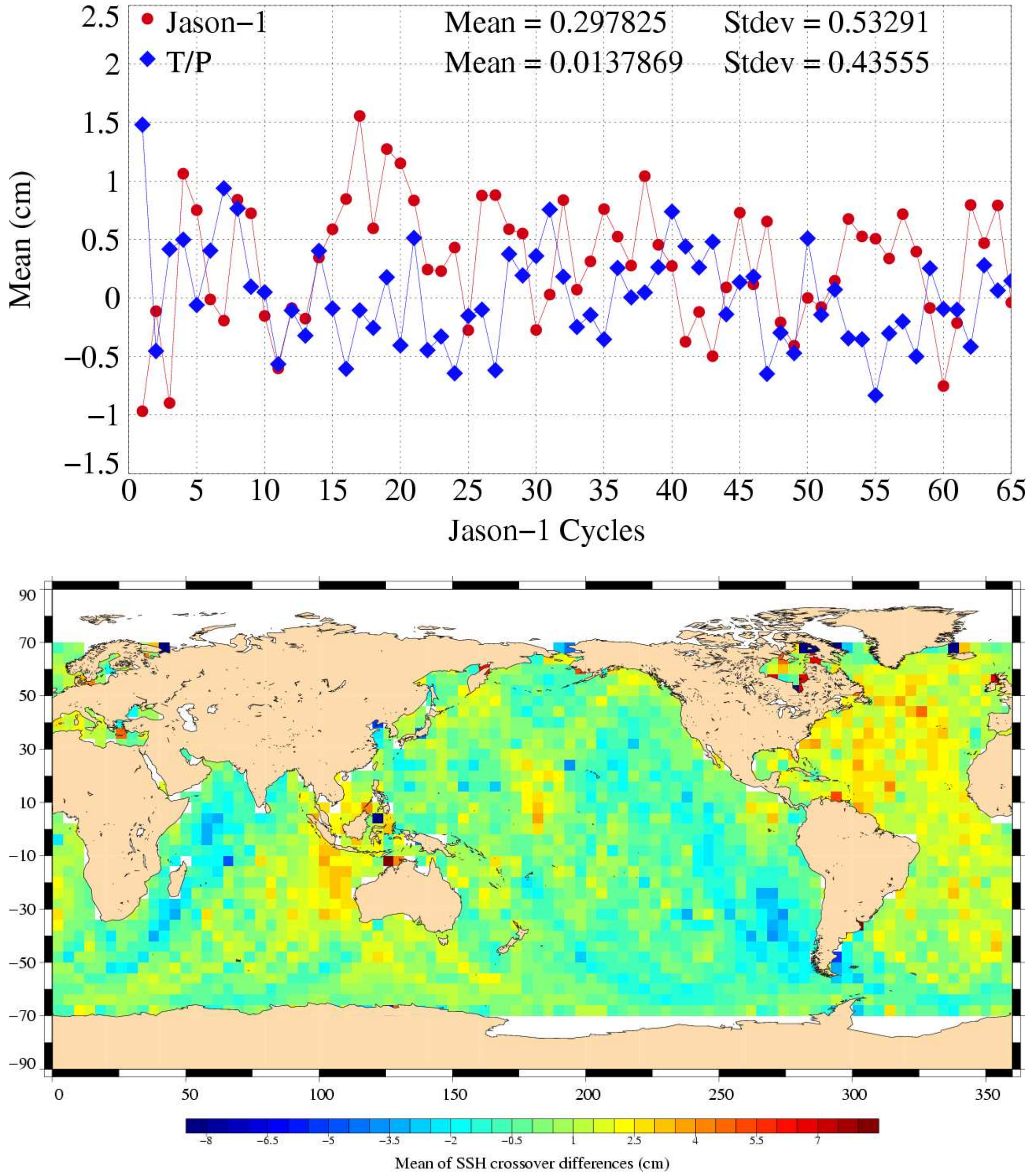
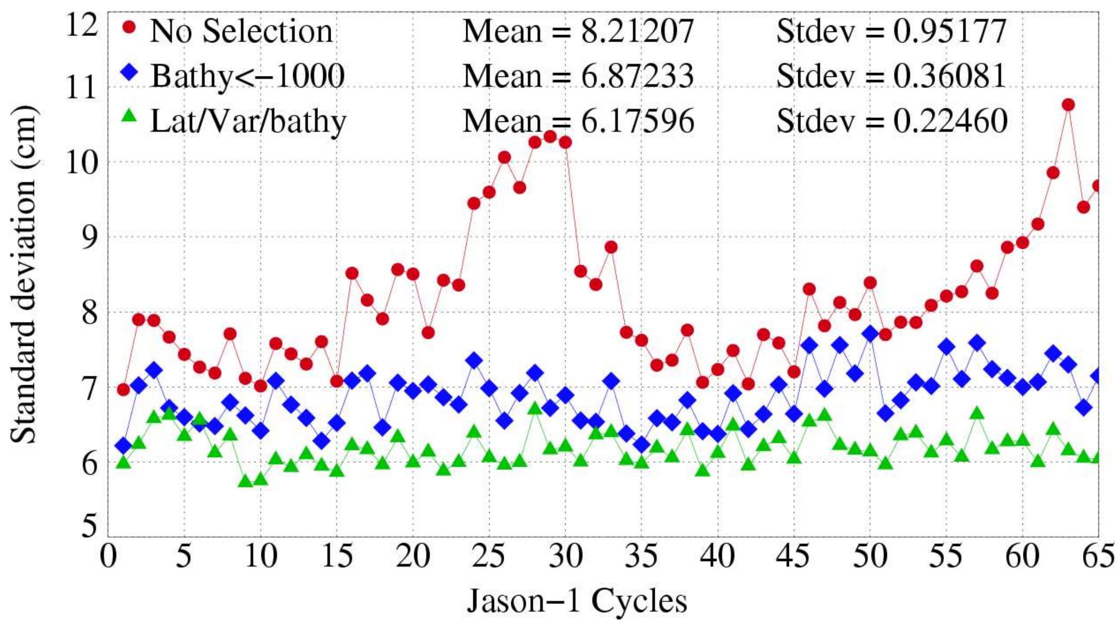


Figure 24 : Cycle per cycle mean crossovers (top) and map of Jason-1 mean crossovers from cycle 1 to 65 (bottom)



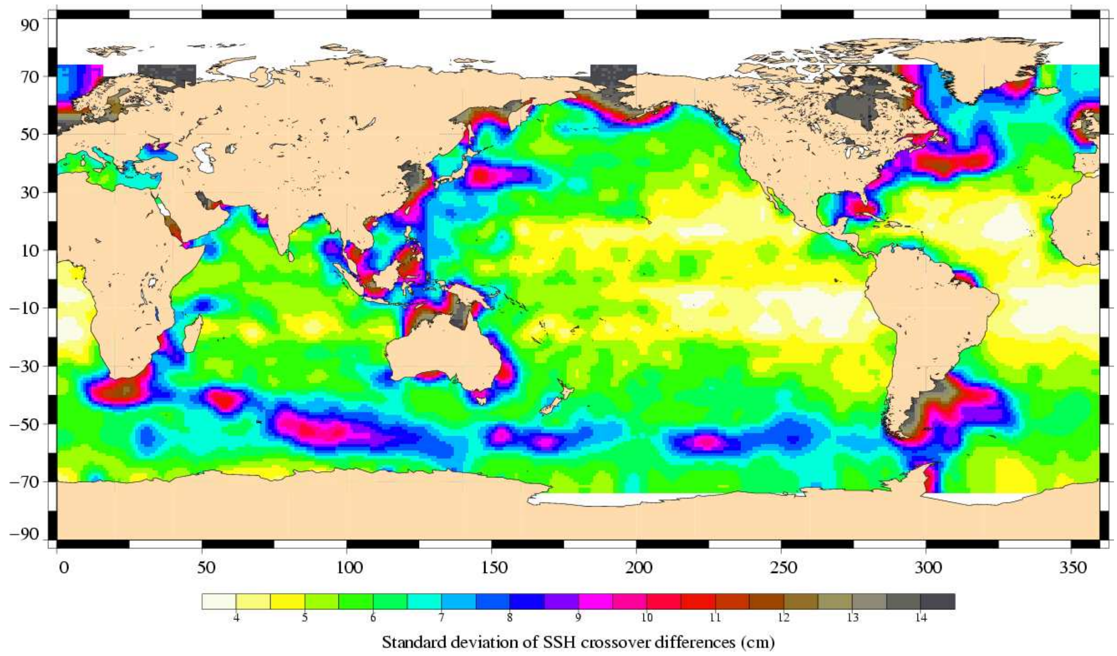


Figure 25 : Cycle per cycle standard deviation crossovers with different selections (top) and map of Jason-1 standard deviation crossovers

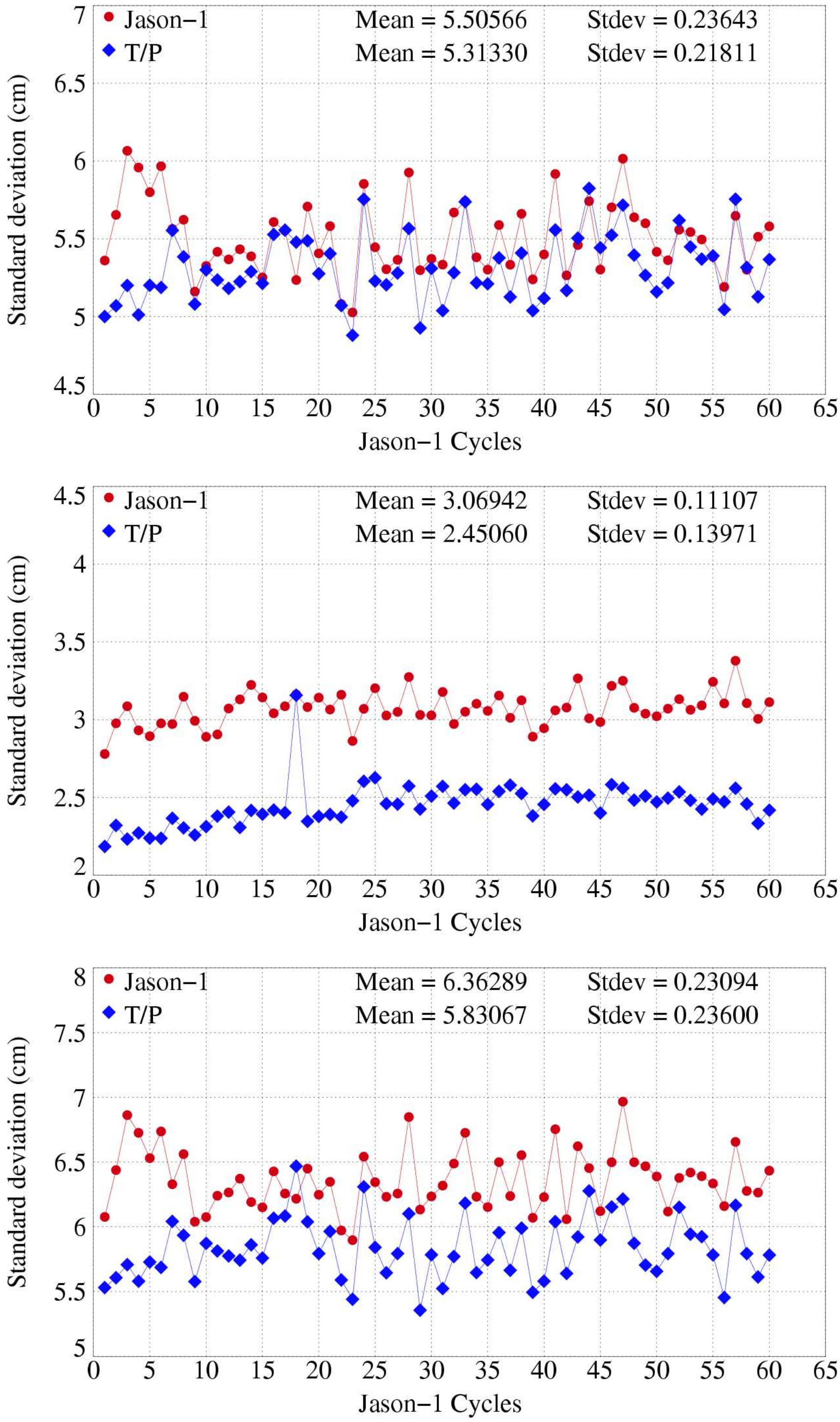


Figure 26 : Cycle per cycle standard deviation crossovers for long wavelength content (top), short wavelength content (middle) and total content (bottom)

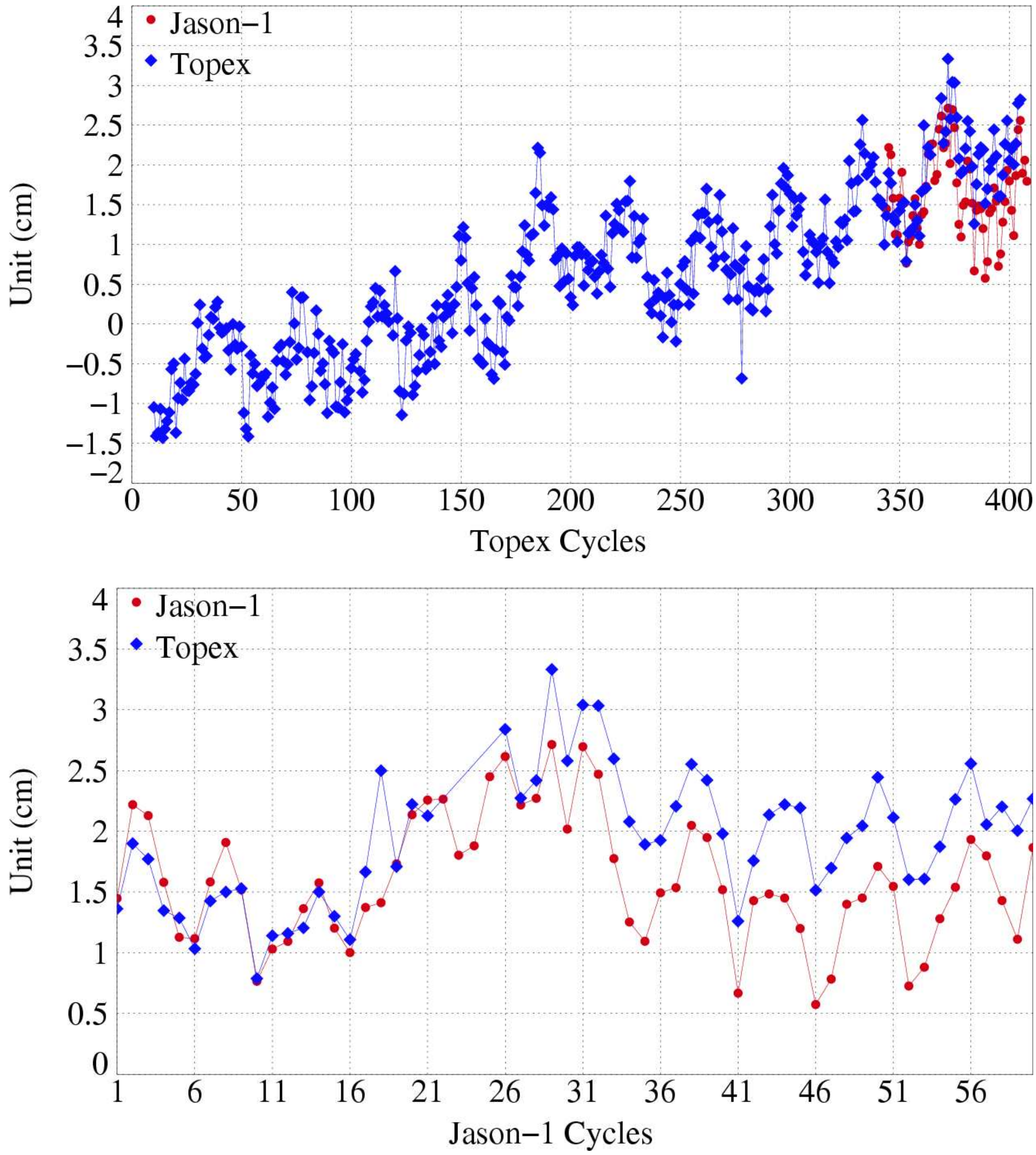


Figure 27 : Cycle per cycle mean sea level on T/P period (top) and on (Jason-1) period

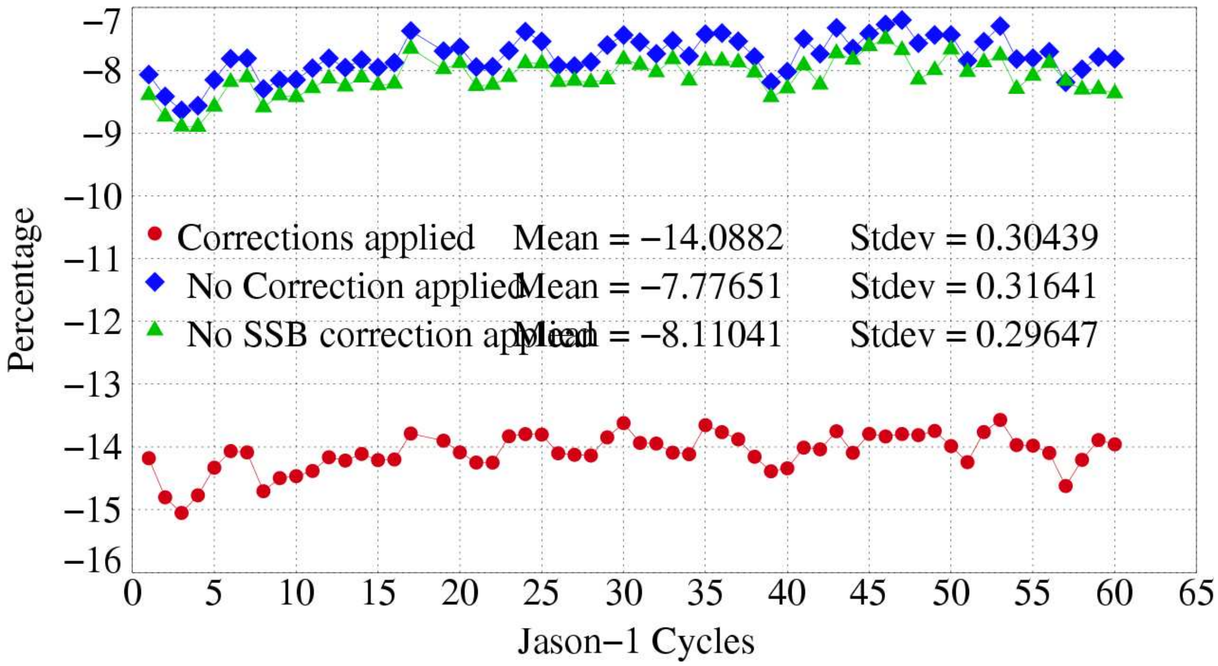


Figure 28 : Cycle per cycle mean of (T/P – Jason-1) SSH differences

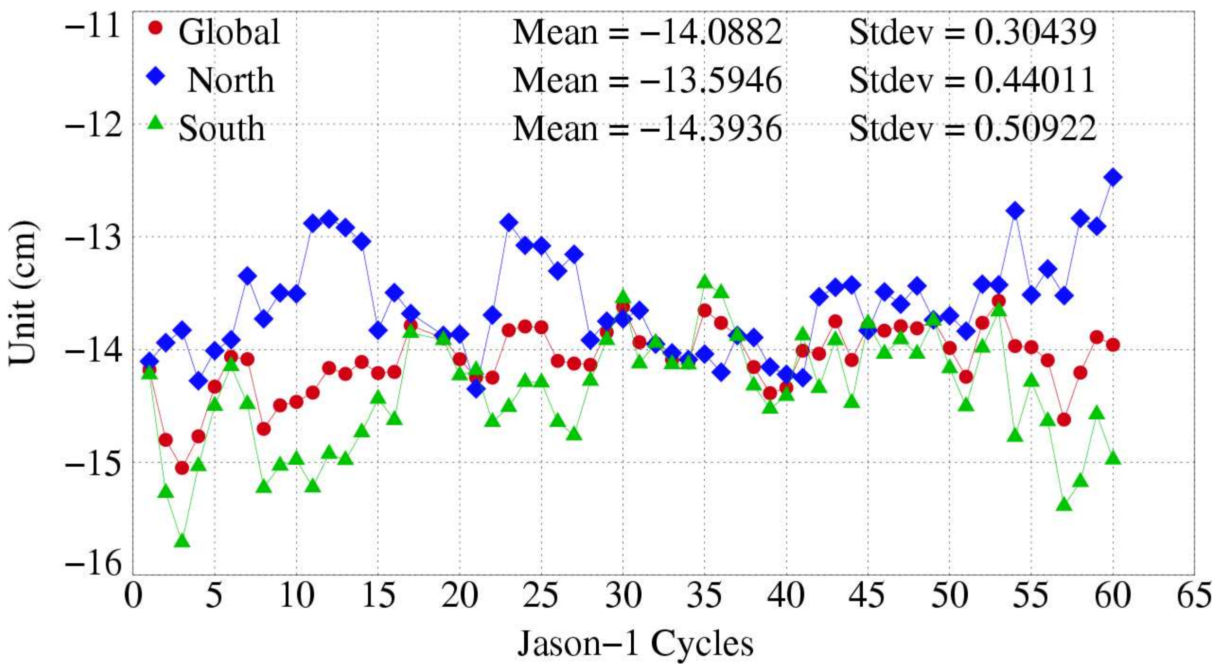


Figure 29 : Cycle per cycle mean of (T/P – Jason-1) SSH differences by hemisphere

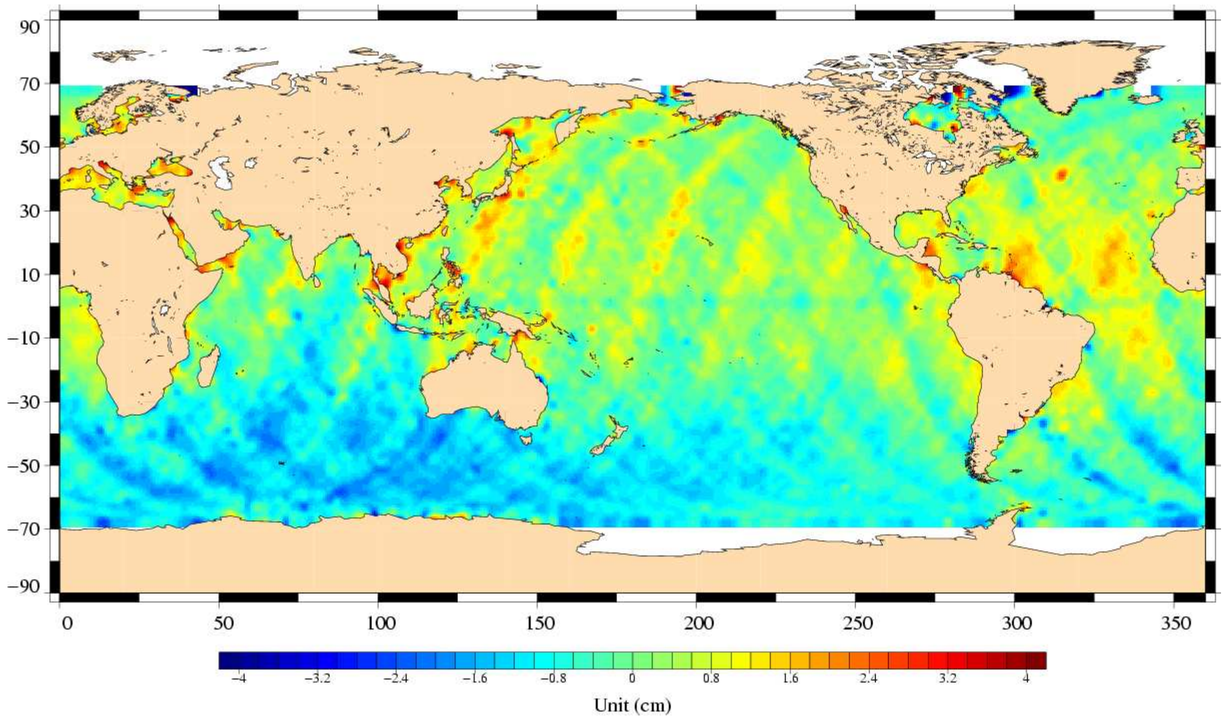


Figure 30 : Map of (T/P – Jason-1) SSH differences from cycle 1 to 21

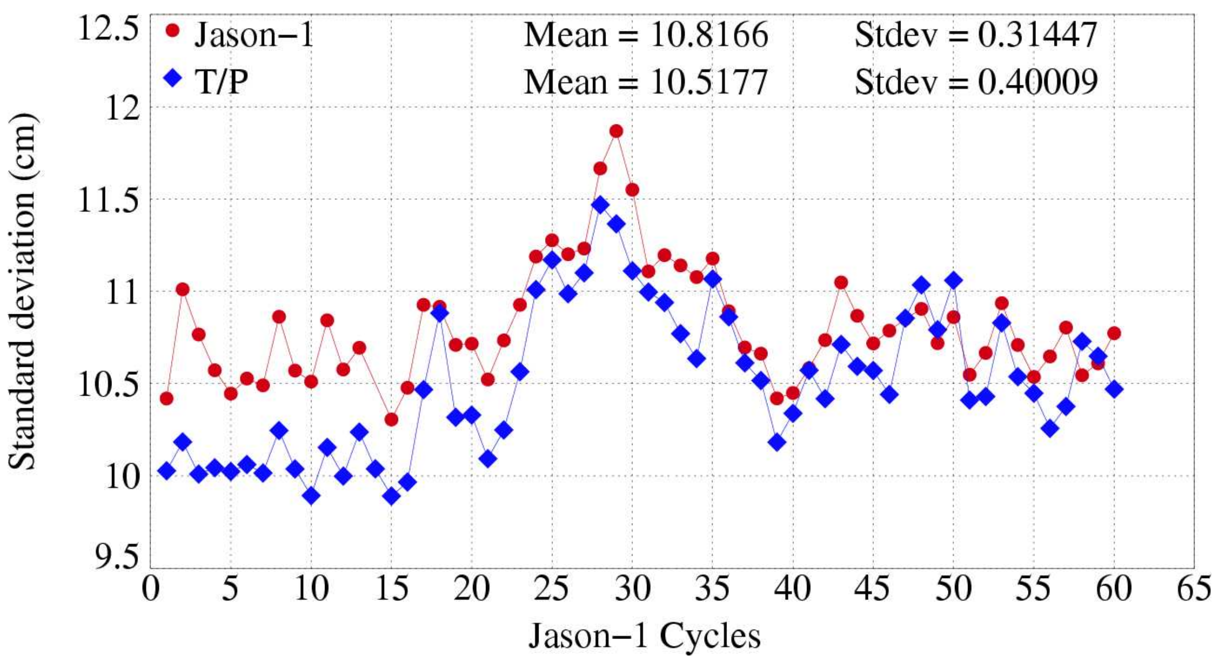


Figure 31 : Cycle per cycle SLA standard deviation

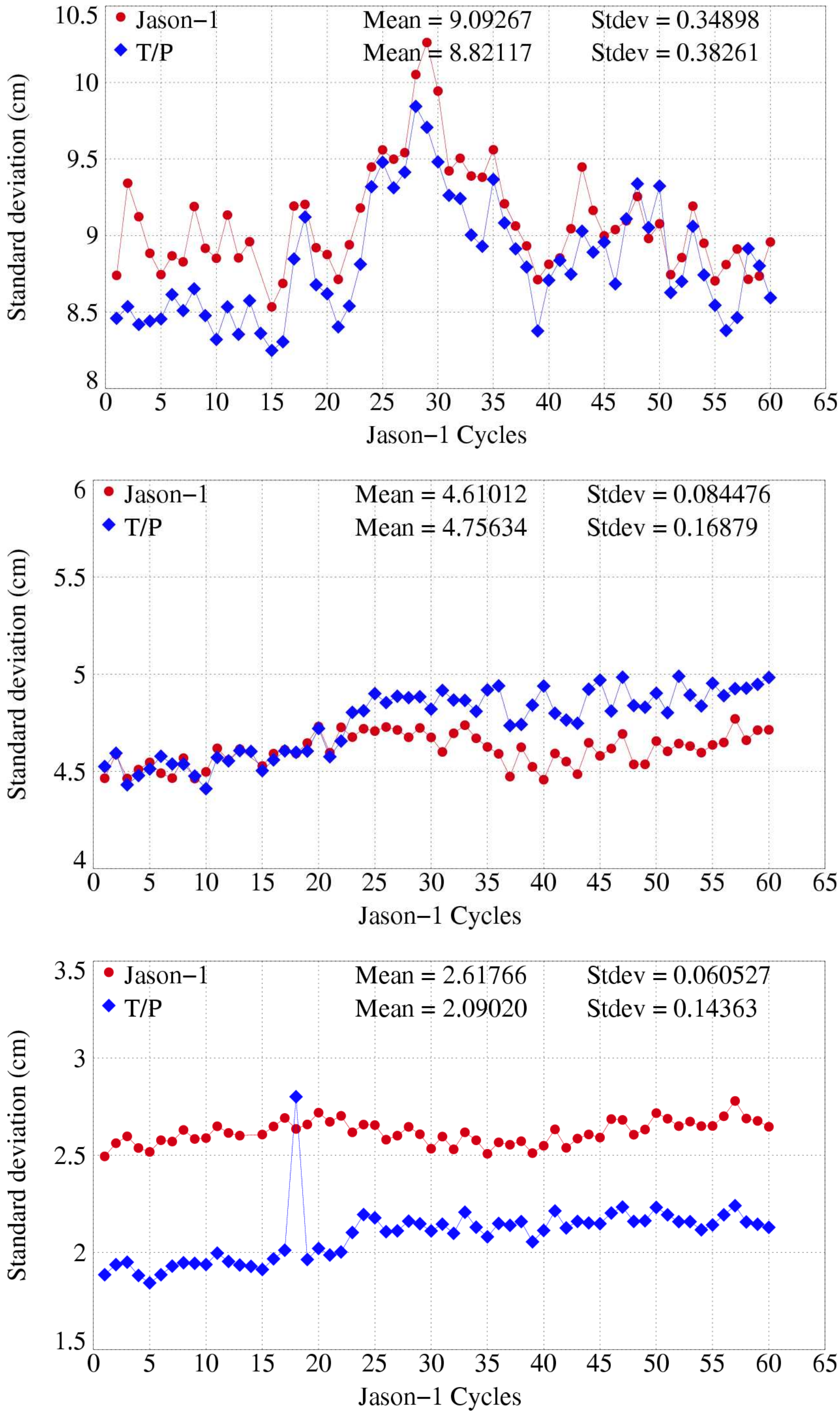


Figure 32 : Cycle per cycle SLA standard deviation for long wavelength content (top), medium wavelength content (middle) and short wavelength content (bottom)

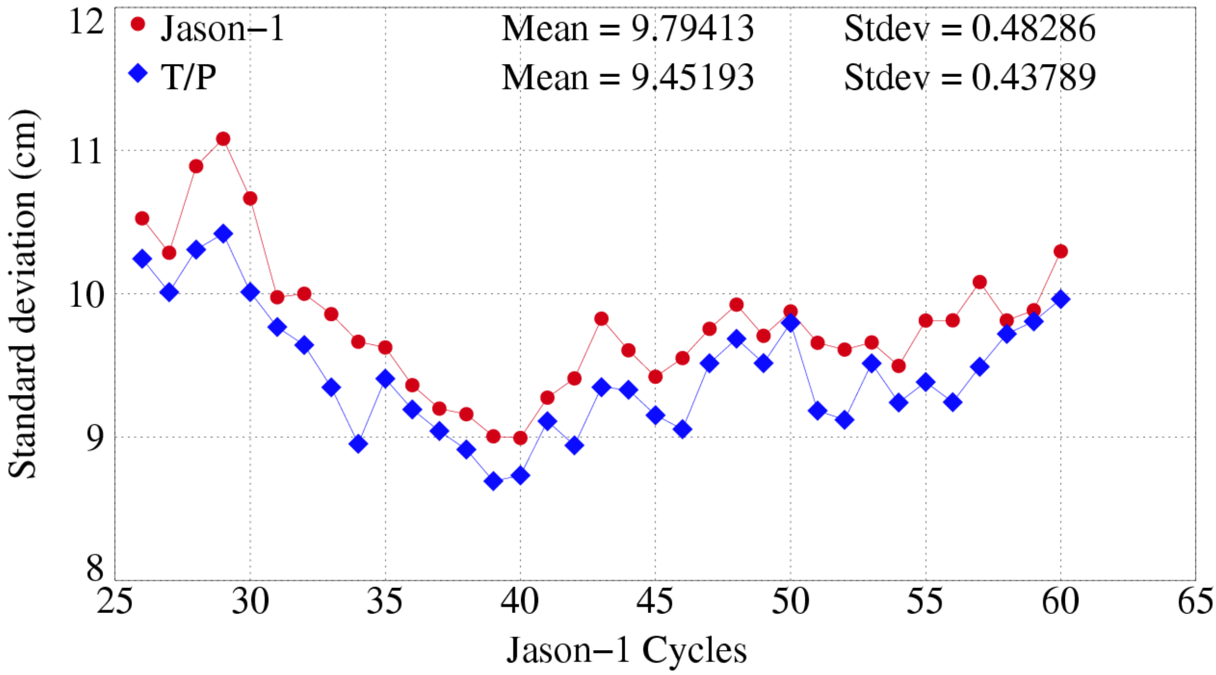
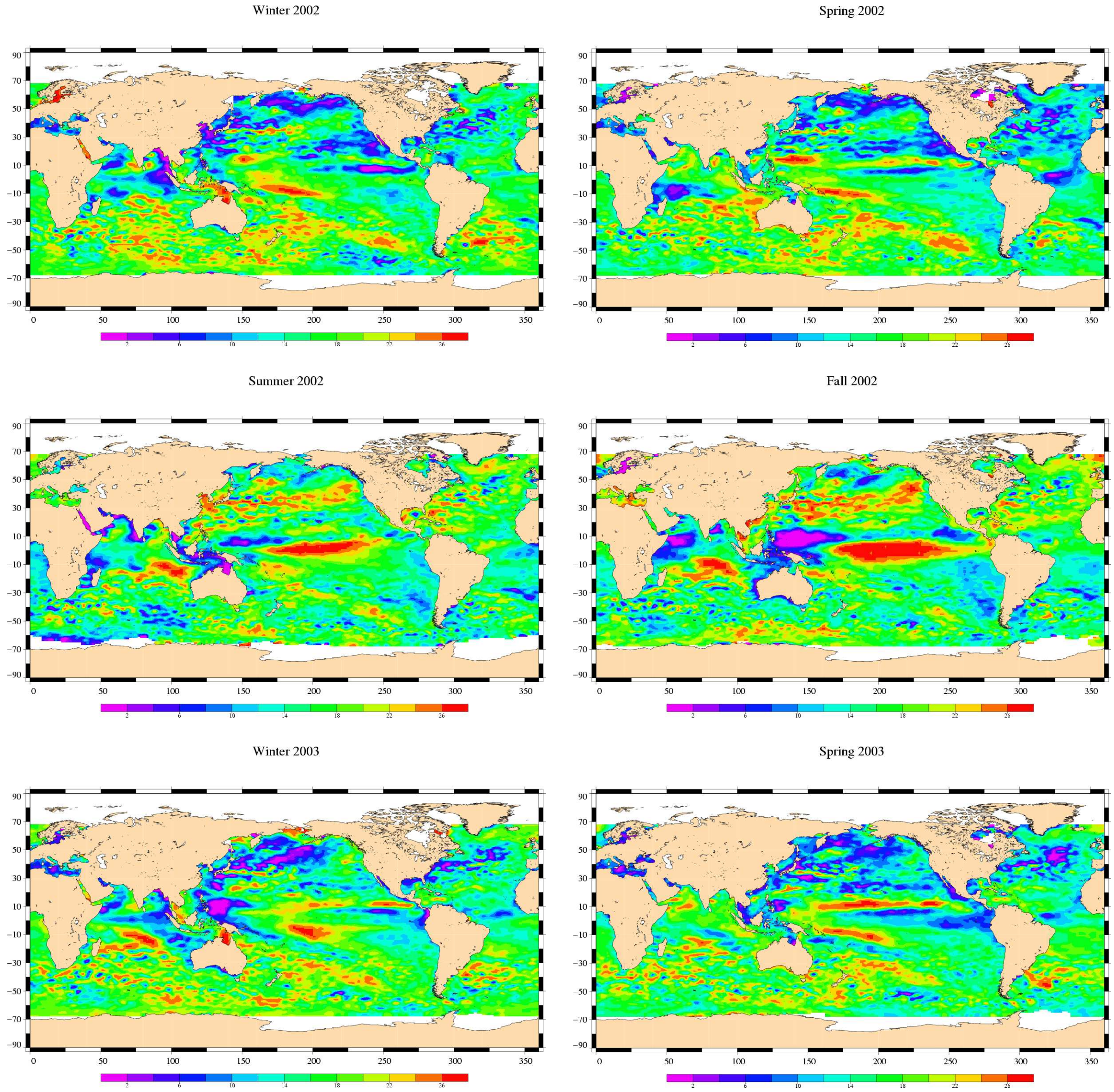


Figure 33 : Cycle per cycle SLA standard deviation with dedicated T/P and Jason mean profiles



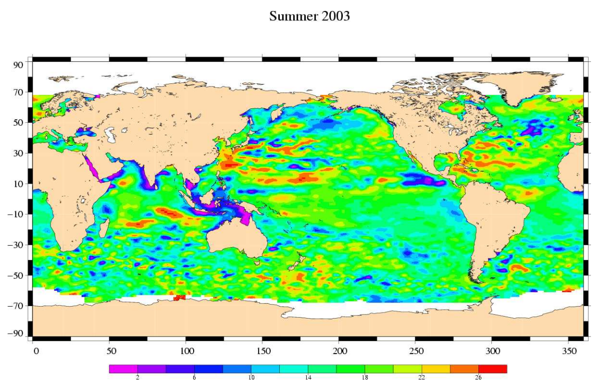


Figure 34 : Seasonal variations of Jason SLA (cm) relative to a MSS CLS 2001.