Envisat GDR
Cross calibration Report

Cycle 051

04-09-2006 09-10-2006

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1 Introduction. Document overview

The purpose of this document is to report the major features of the cross-calibration between Envisat and the ERS-2 and Jason-1 missions. The document is associated with data dissemination on a cycle by cycle basis.

The objectives of this document are :

To present the major useful cross-calibration results for the current cycle

To report any change likely to impact the comparison between Envisat and other missions, from instrument status to software configuration

It is divided into the following topics:

2 Cycle overview

Envisat cycle 051 has been produced with the IPF processing V5.02 until pass 7, V5.03 for the passes 8 to 1002 and the CMA Reference Software V7.1_09. The content of this science software version is described in a document available on the ESA PCS web site ([3]). The Envisat quality assessment report ([4]) summarizes the major features of the Envisat data quality for this cycle of data.

The cross-calibration with ERS-2 OPR2 version 6.5 from CERSAT centre has been performed with ERS-2 OPR cycle 119. The main results for cycle 119 are reported in the ERS-2 Quality assessment report [10]. All the necessary updates were performed on ERS-2 data to be homogeneous with the Envisat data set.

The cross-calibration with Jason-1 GDRs (CMA Reference Software V7.1_09) has been performed with Jason-1 GDRs cycles 171 to 175. The content of this science software version is described by N.Picot (electronic communication, October 21, 2005) [12]). The Jason-1 quality assessment report ([1]) summarizes the major features of the Jason-1 data quality for these cycle of data.

3 Cross Calibration with ERS-2

The Envisat/ERS-2 cross-calibration results are not available for this cycle of data.

4 Cross Calibration with Jason-1

Jason-1 GDRs data (cycle 171 to 175) are used for this cross calibration The parameters used to compute the sea surface height (SSH) for Envisat and Jason-1 are:
- Ku range (ocean retracking)
- POE orbit
- Dual frequency ionospheric correction
- MWR derived wet troposphere correction
- ECMWF dry tropospheric correction
- Non parametric sea state bias
- MOG2D
- Total geocentric GOT00 ocean tide height
- Geocentric pole tide height
- Solid earth tide height

Note that within the IPF version 5.02, the actual value of Ultra Stable Oscillator clock period is used within the L1b processing instead of the nominal one as it was used in previous IPF versions. This evolution implies a +2.5 cm jump on the Envisat SSH between cycle 40 and 41. To avoid this jump, and correct for the USO drift, users are advised to apply the correction provided by ESA on cycles 9 to 40 ([9]).

Some comparisons were also performed using the ECMWF wet troposphere correction for both Envisat and Jason-1, to prevent possible discrepancies from radiometer corrections.

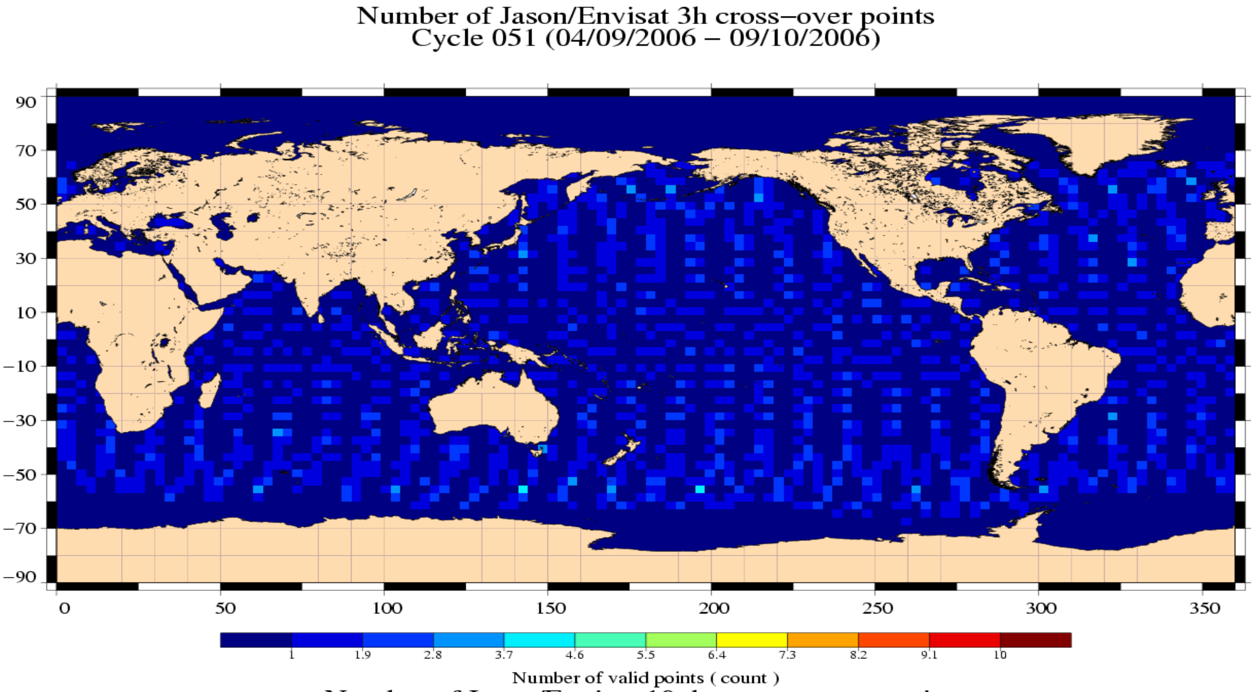
Several analyses were performed for this cross calibration study:
- comparison of altimeter and radiometer parameters
- comparison of Sea Level Anomalies relative to a Mean Sea Surface
- computation of a long wavelength error on Envisat
- comparison on a same time/space sampling

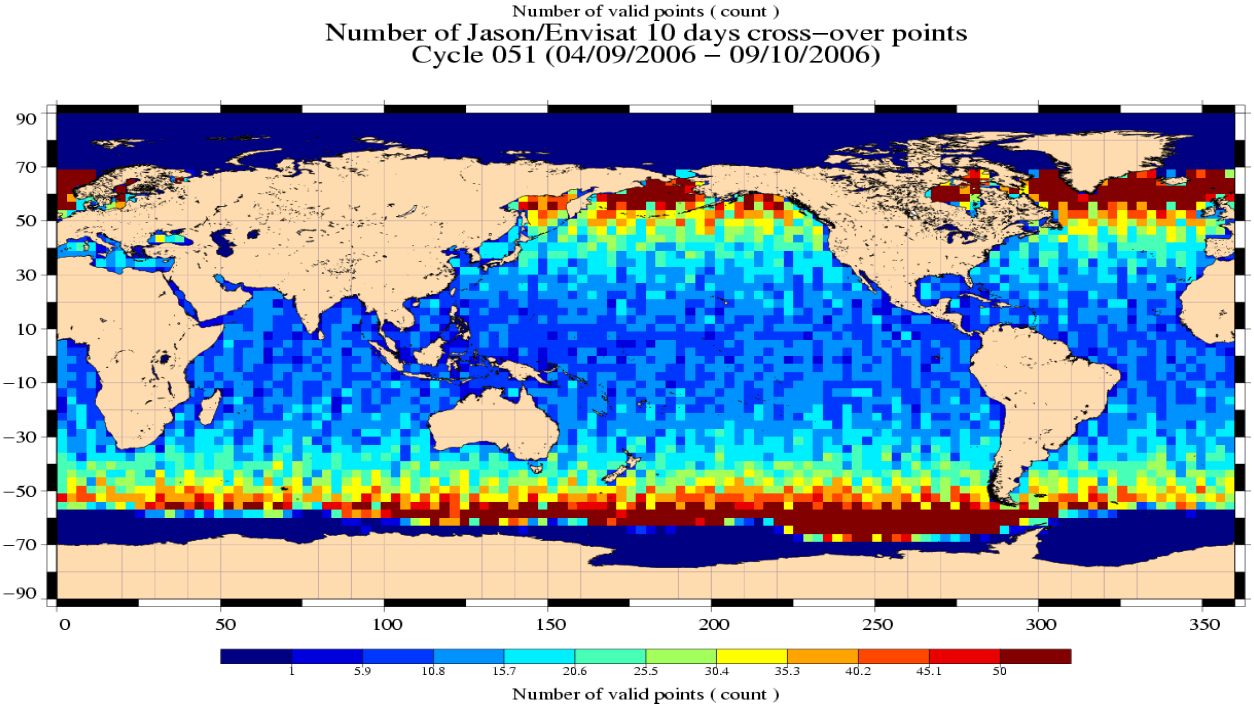
10 day crossovers are used to compare SSH estimations from Envisat and Jason-1 while shorter time lags (3 hours) are selected for altimeter and radiometer parameters.

4.1 Dual-crossover points

4.1.1 3-hour and 10-day crossover points location

For Envisat Cycle 051 the location of crossover points with 3-hour and 10 day time lags between Envisat and Jason-1 are given on the following figures:

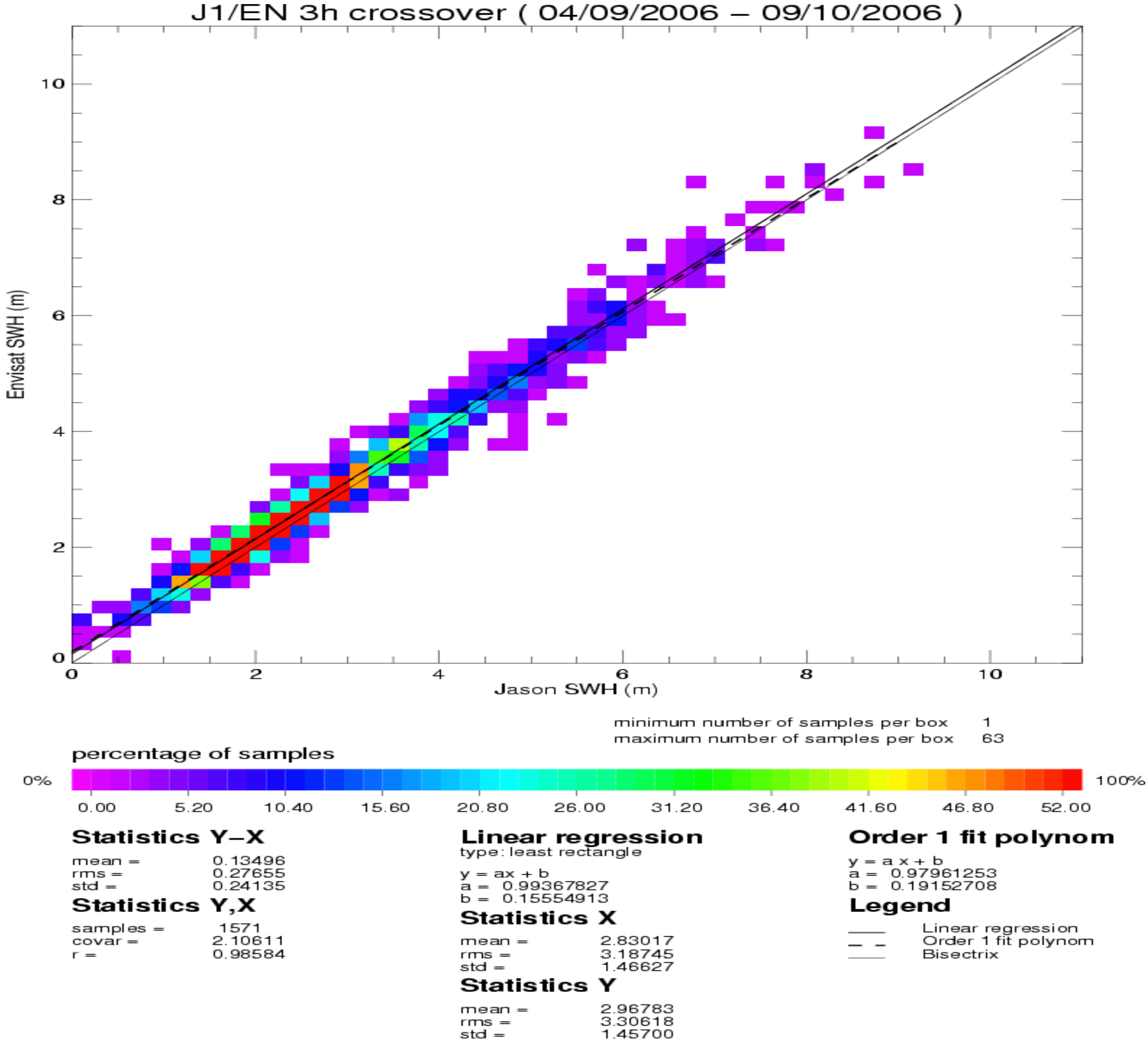




Most of the crossover points are located at high latitude. With 3-hour time lag there are only a few crossover points at mid and low latitudes. This geographical pattern is not constant for every Envisat cycle since Jason-1 is not sun-synchronous. When more Envisat data become available, (Jason-1/Envisat) comparisons will be performed over 12 Jason-1 cycle windows, so that the geographical sampling by Jason-1/Envisat crossovers will be constant.

4.1.2 [Envisat - Jason-1] Ku-band SWH differences

The scatter plot of crossover points with 3-hour time lag between Envisat and Jason-1 Ku-band SWH measurements is given on the following figure:

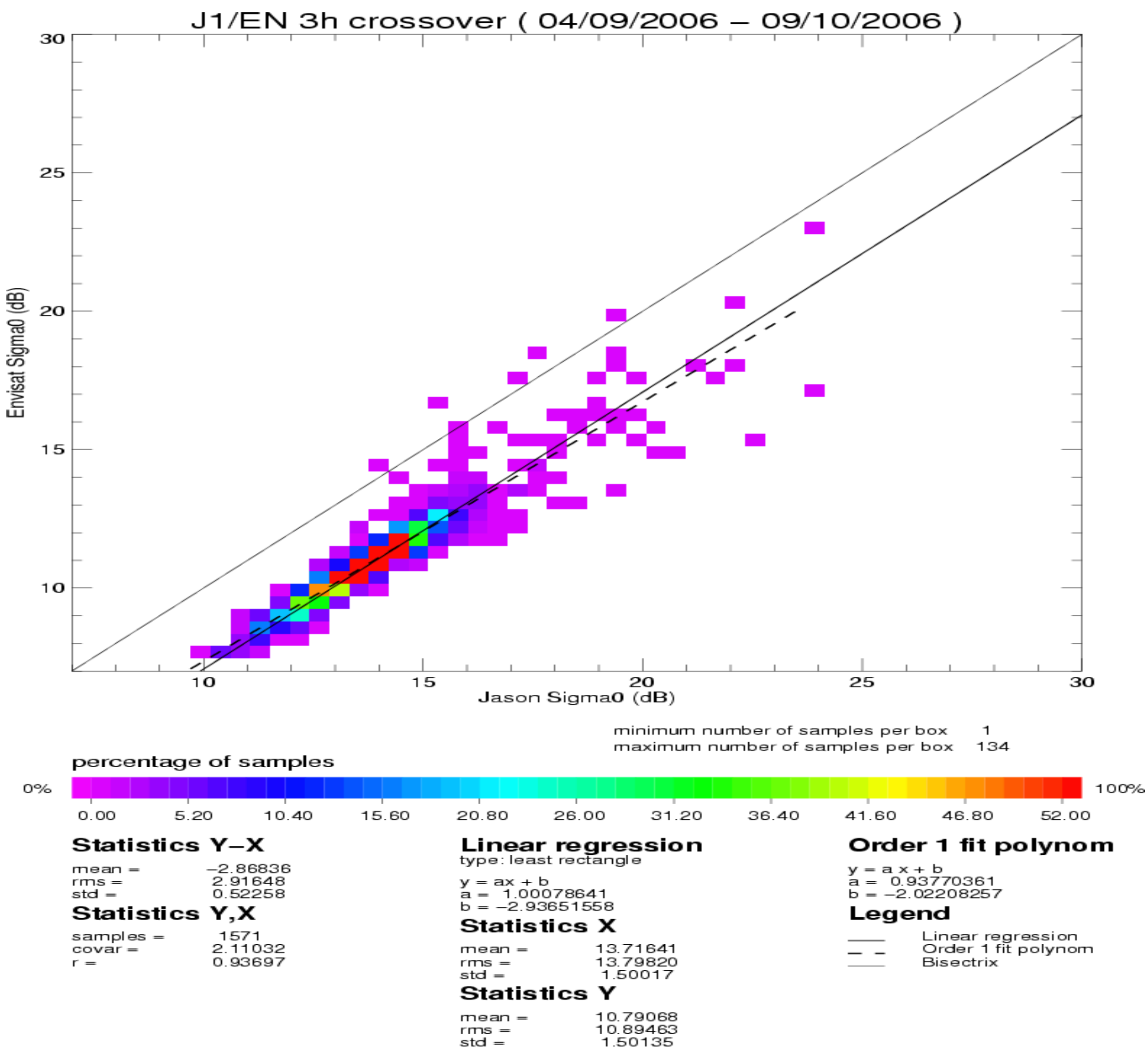


Analysis	Number	Mean (m)	Std. dev. (m)
EN-J1 SWH (m)	1571	0.14	0.23

There is a small bias between the two satellites: Envisat waves are slightly higher than Jason-1 ones.

4.1.3 [Envisat - Jason-1] Ku-band Sigma0 differences

The scatter plot of crossover points with 3-hour time lag between Envisat and Jason-1 Ku-band Sigma0 measurements is given on the following figure:

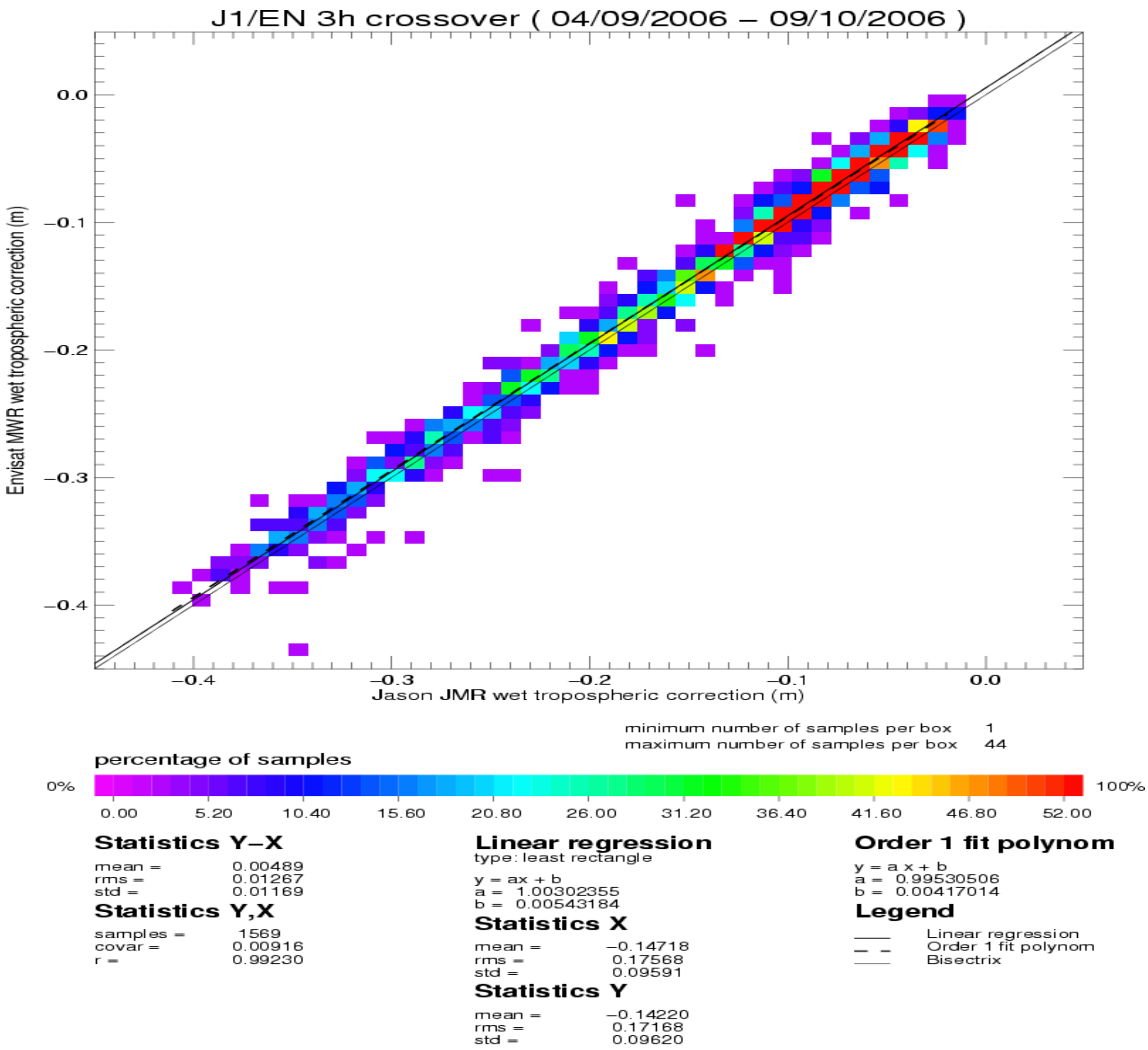


Analysis	Number	Mean (dB)	Std. dev. (dB)
EN-J1 Sigma0 (dB)	1571	-2.94	0.50

Jason-1 Ku-band sigma0 is 2.8 dB higher than Envisat. Envisat Ku-band sigma0 has been aligned on ERS-2 to satisfy the MWC wind model. Notice that Jason-1 Ku-band sigma0 is 2.3 dB higher than TOPEX. This difference is described in (Vincent et al., 2003 [14]).

4.1.4 [Envisat - Jason-1] radiometer wet troposphere differences

The scatter plot of crossover points with 3-hour time lag between Envisat and Jason-1 radiometer wet troposphere correction is given on the following figure:



Analysis	Number	Mean (cm)	Std. dev. (cm)
EN-J1 radiometer wet troposphere correction (m)	1571	0.50	1.20

Results are consistent over dry areas. There are not enougth crossover points at low latitudes to comment the differences in wet areas.

4.1.5 [Envisat - Jason-1] SSH differences

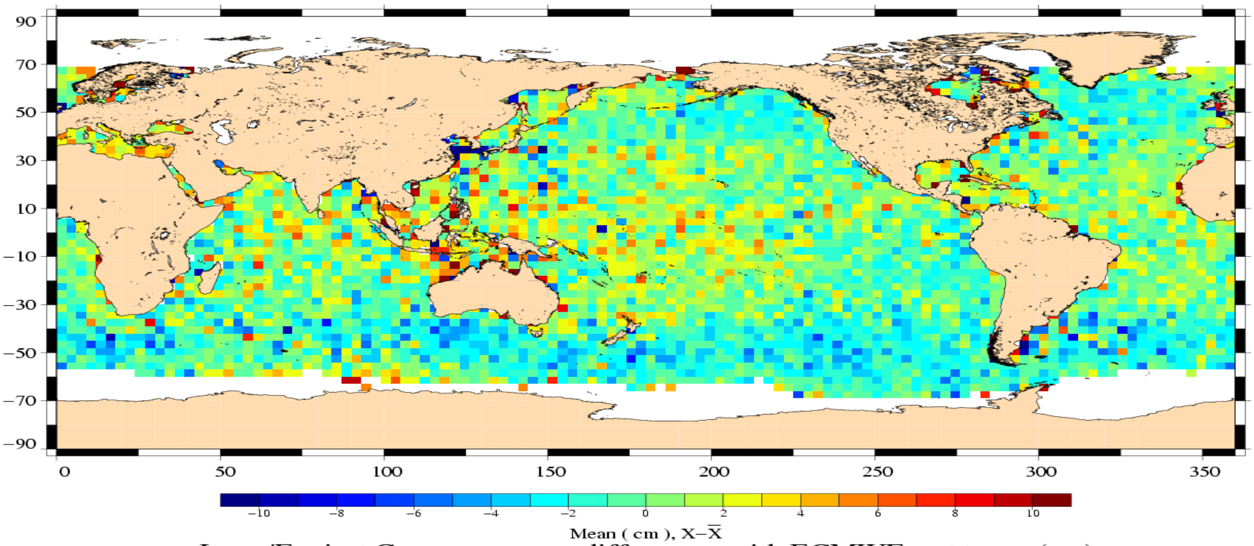
[Envisat - Jason-1] SSH differences at crossover points with 10 day time lag are computed in two configurations:
- using the radiometer wet troposphere correction
- using the ECMWF wet troposphere correction

When using a selection to remove shallow waters (1000 m), global statistics are:

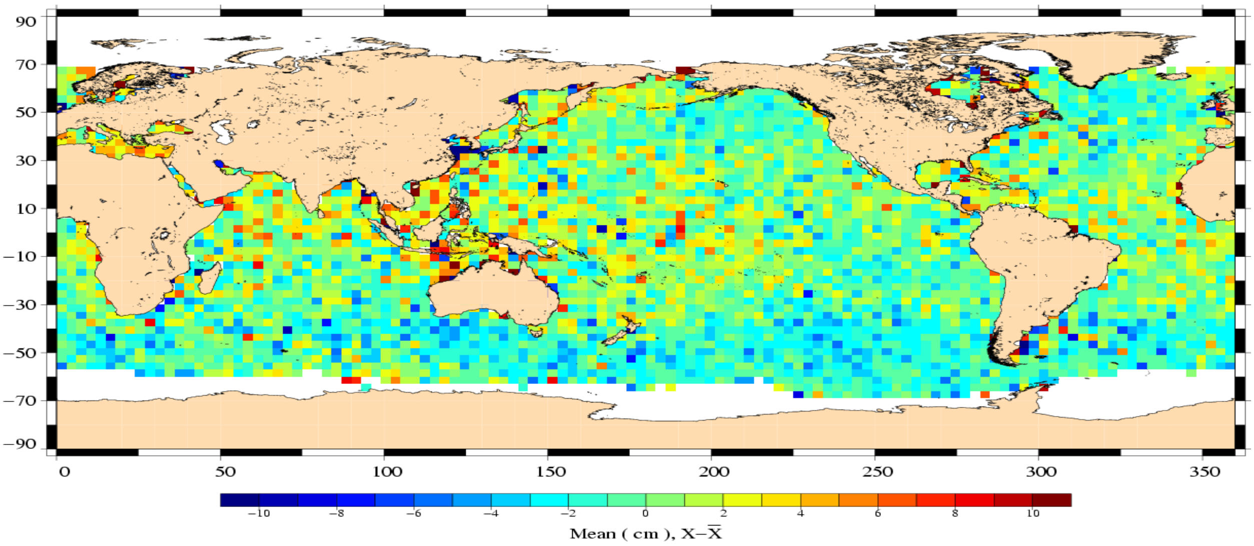
Analysis	Number	Mean (cm)	Std. dev. (cm)
EN-J1 SSH	72069	32.15	6.94
EN-J1 SSH with ECMWF wet troposphere	72069	32.64	7.03

The differences are plotted on the following figure (data are centered about the mean value):

Jason/Envisat Crossover mean differences (cm)
cycle 051 (04/09/2006 – 09/10/2006)



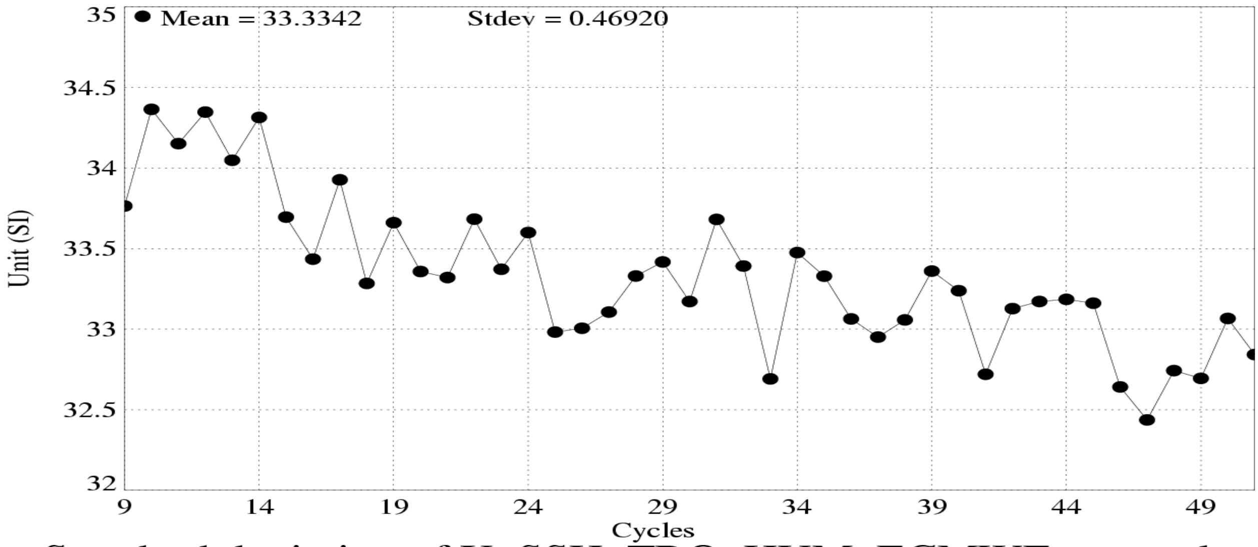
Jason/Envisat Crossover mean differences with ECMWF wet tropo (cm)
cycle 051 (04/09/2006 – 09/10/2006)



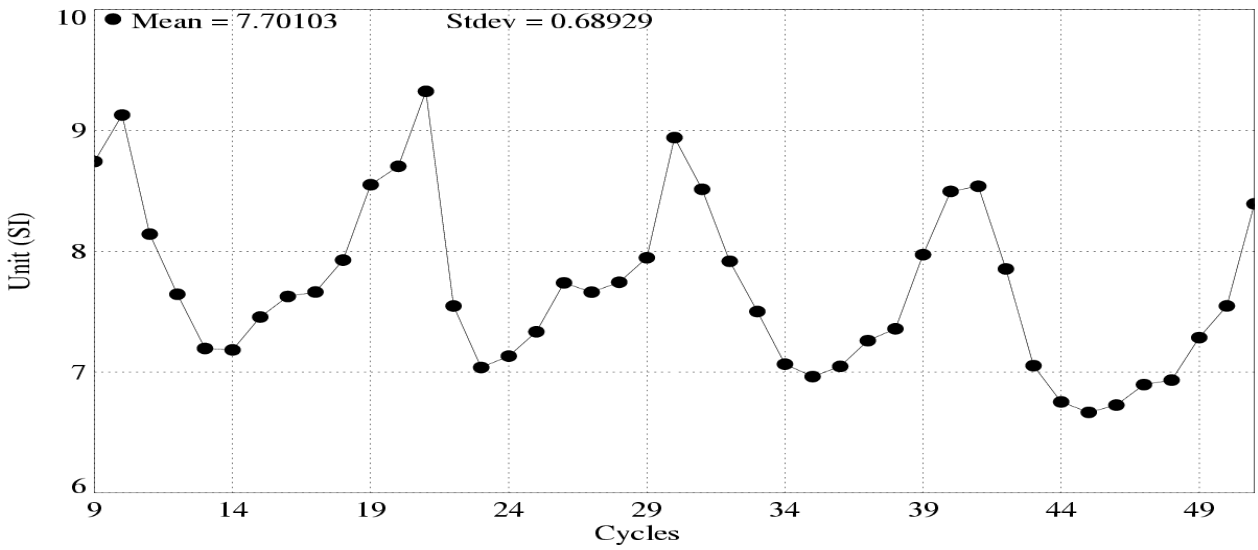
The two maps are very close. There are small scale [Envisat - Jason-1] differences in high variability areas, but also large scale differences in the Pacific ocean.

The cycle by cycle mean and standard deviation of [Envisat-Jason-1] differences of SSH at 10-day dual crossover using the ECMWF wet troposphere correction are plotted in the following figure:

Mean of X_SSH_TRO_HUM_ECMWF cycle



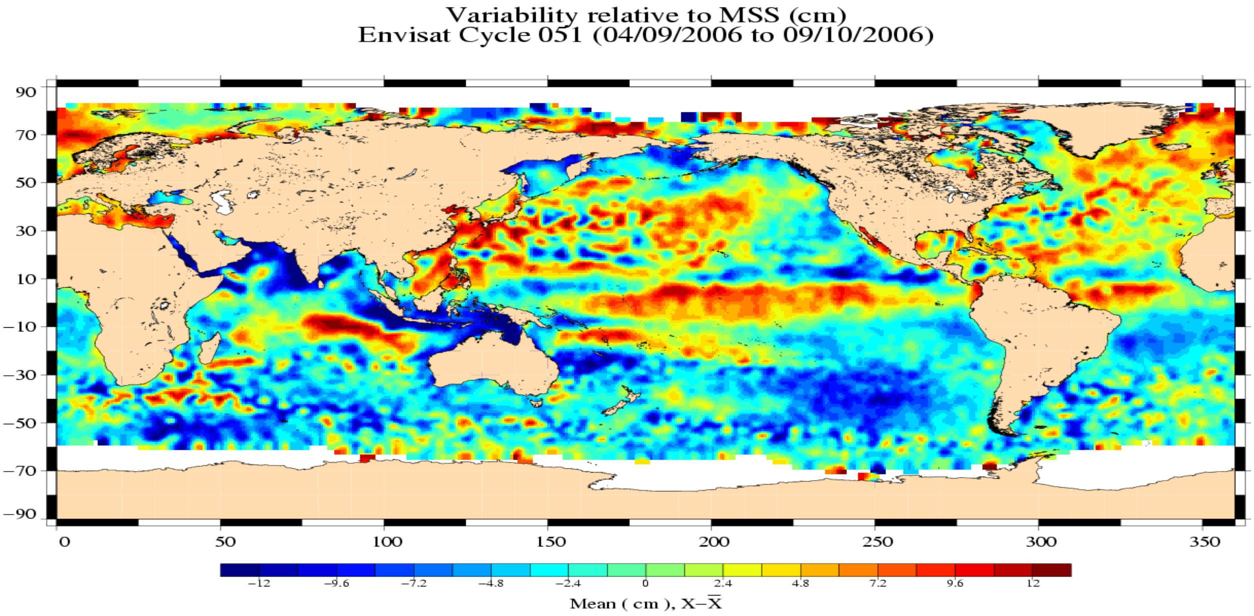
Standard deviation of X_SSH_TRO_HUM_ECMWF per cycle



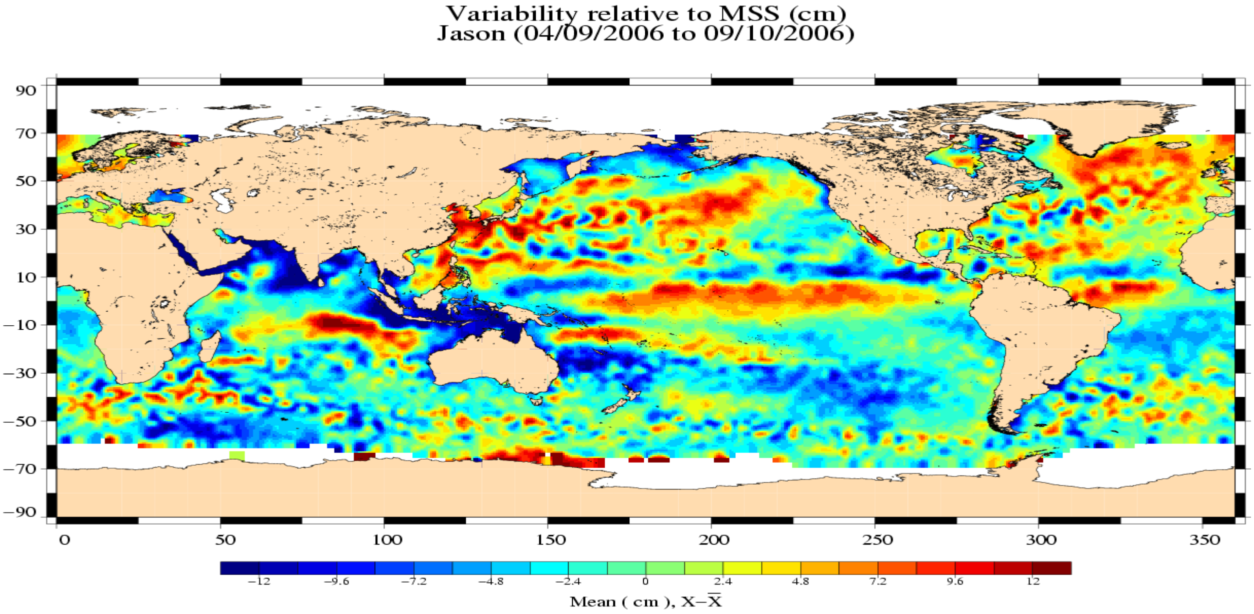
The mean difference decreases during the first year of Envisat (cycles 10-20). Then, the difference stabilizes around 31 cm on cycle 20 onwards. The standard deviation of the difference is reduced on cycle 41 due to the new ground segment configuration.

4.2 SLA Comparisons

Envisat and Jason-1 Sea Level anomalies relative to CLS01 Mean Sea Surface are computed. Global statistics are computed over deep ocean areas (1000 m) and low variability. In order to see fine features, maps are centered about the mean value.



Analysis	Number	Mean (cm)	Std. dev. (cm)
Envisat SLA	991328.0000000(	49.45	9.37



Analysis	Number	Mean (cm)	Std. dev. (cm)
Jason-1 SLA	1525672.000000(	16.70	9.46

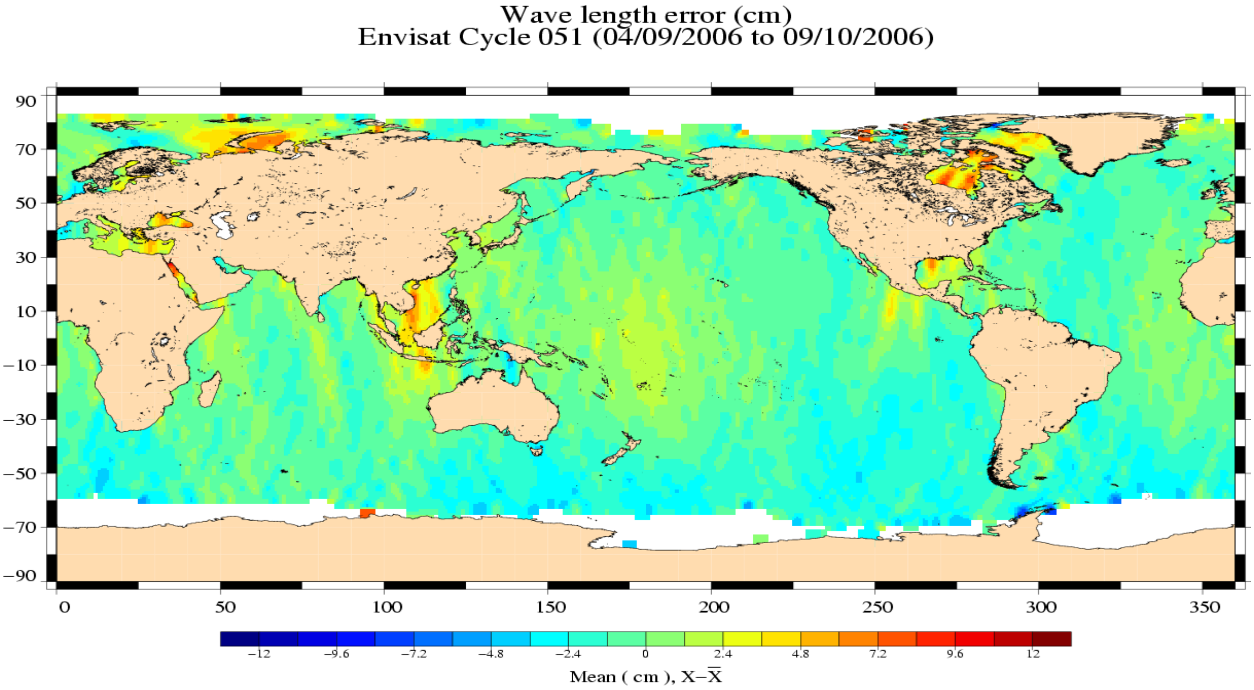
There is a very good correlation between the two maps. The SLA standard deviation for both

Envisat and Jason-1 is about 9.5 cm. Differences are mainly due to the spatial and temporal sampling of the ocean.

4.3 Long wavelength error reduction

4.3.1 Long wavelength error

The Envisat long wavelentgth error has been computed by global minimization of (EN-J1) SSH differences. The method is described in (Le Traon et al., 1998 [7]). The map of the error is plotted on the following figure (data are centered about the mean value):



Analysis	Number	Mean (cm)	Std. dev. (cm)
Envisat lw error	1172672.000000(	32.74	2.70

The estimated long wavelength error has a small variance which confims the good quality of the Envisat orbit.

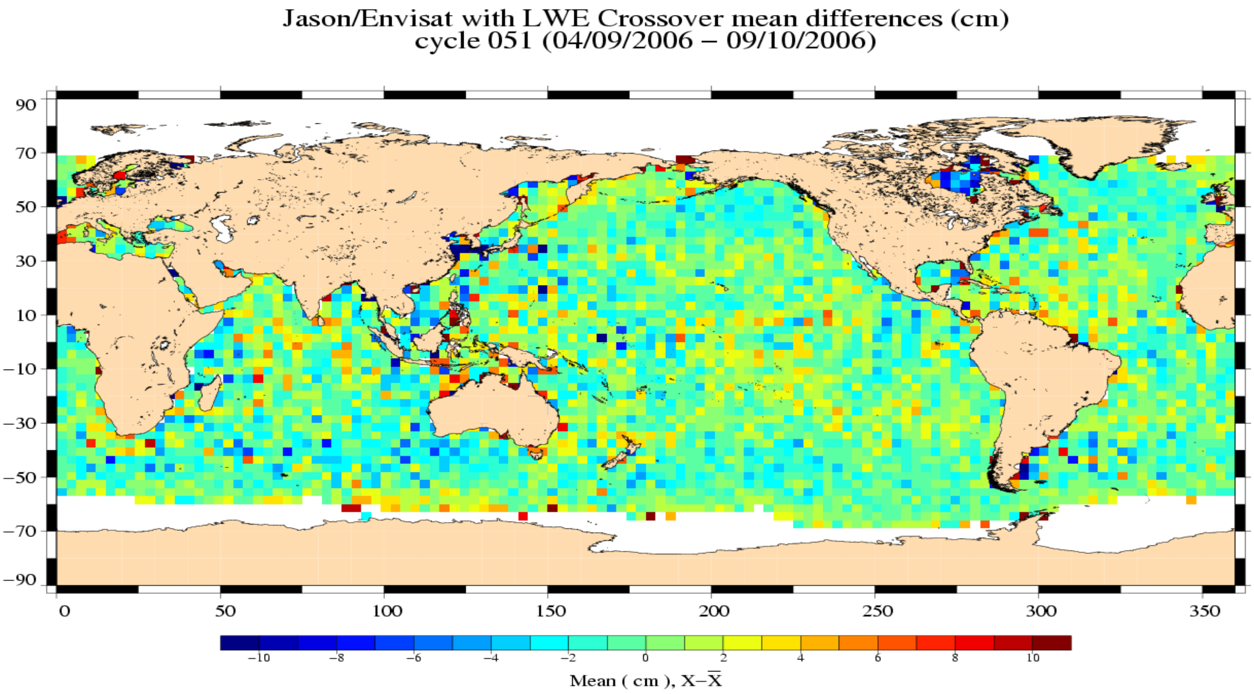
4.3.2 Impact on crossover performances

Global statistics for 35 days [Envisat - Envisat] and 10 days [Envisat - Jason-1] are only computed over deep ocean areas (1000 m) :

Analysis	Number	Mean (cm)	Std. dev. (cm)
EN/EN SSH	25546	-0.08	8.67
EN/EN SSH with orbit error	25546	-0.13	8.07

Analysis	Number	Mean (cm)	Std. dev. (cm)
EN-J1 SSH	72069	32.15	6.94
EN-J1 SSH with orbit error	72069	0.01	6.60

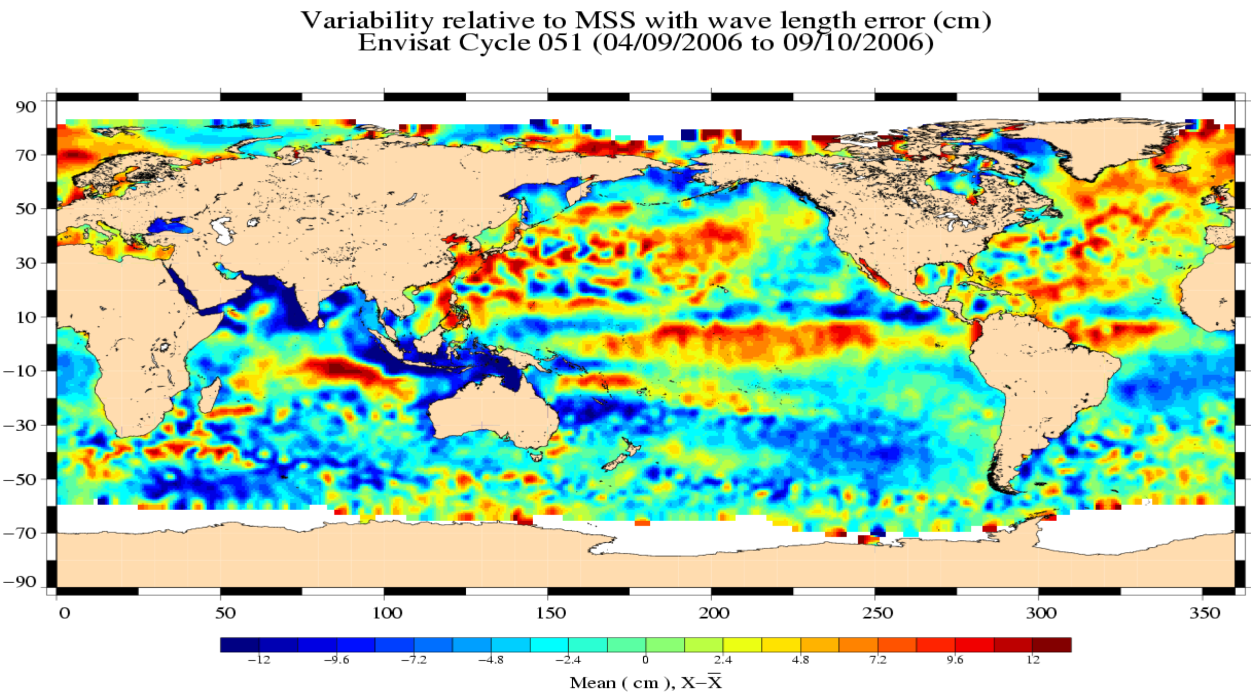
The [Envisat - Jason-1] difference corrected for the estimate Envisat long wavelength error are plotted on the following figure (data are centered about the mean value):



The large scale differences in the Pacific ocean are noticeably reduced.

4.3.3 Impact on SLA performance

Envisat Sea Level anomalies relative to CLS01 Mean Sea Surface using the long wavelength error are computed. Global statistics are computed using a selection to remove shallow waters (1000 m). Map is centered about the mean value.



Analysis	Number	Mean (cm)	Std. dev. (cm)
Envisat SLA	991328.0000000(	16.87	9.20

The slight impact on Envisat SLA variance shows that the Envisat long wavelength error is low.

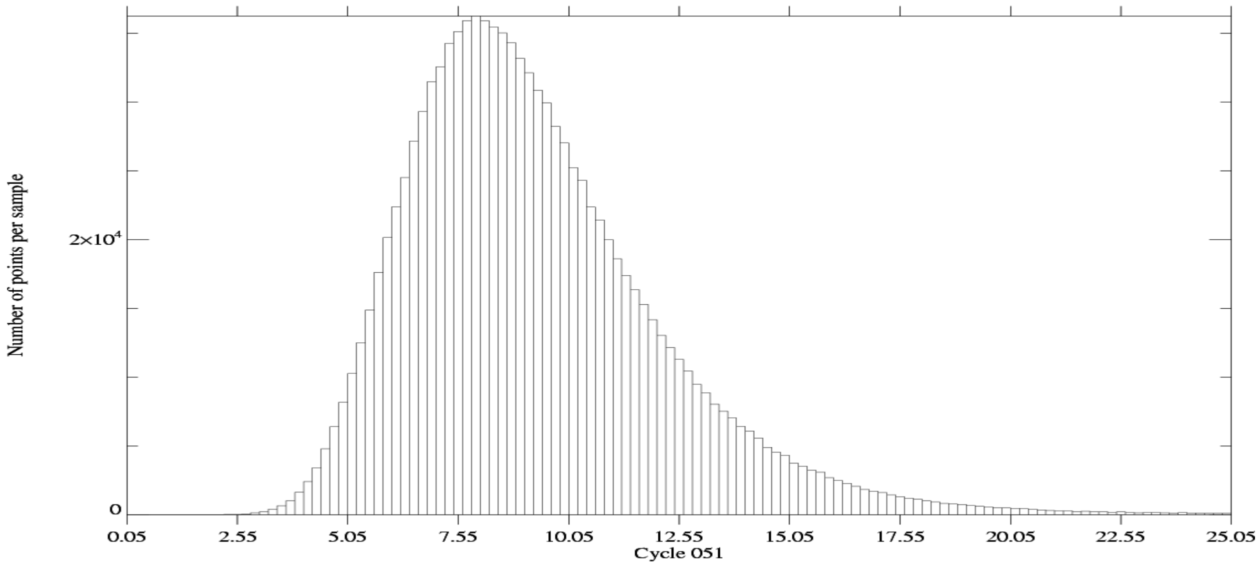
4.4 Comparison on a same time/space sampling

Envisat and Jason-1 are now compared on a same time/space sampling:
- 35 day period
- |latitude| < 66

4.4.1 Rms of Ku-band range statistics

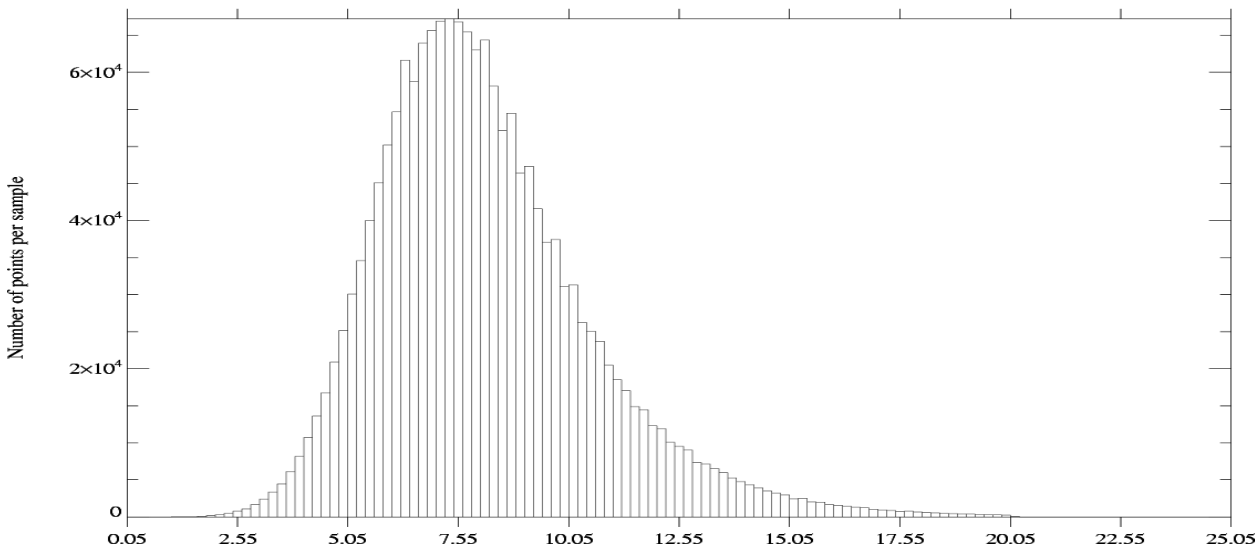
The histograms of Envisat and Jason-1 Rms of Ku-band range are given on the following figures:

Envisat RMS of Ku−band range, |Latitude|<66 (unit : cm)



Global nb of points	:	1095869	Sel. nb of points	:	1095869	Sample interval	:	0.200
Global mean	:	9.172	Selected mean	:	9.172	Maximum value	:	25.000
Global Std	:	2.871	Selected std	:	2.871	Minimum value	:	1.500

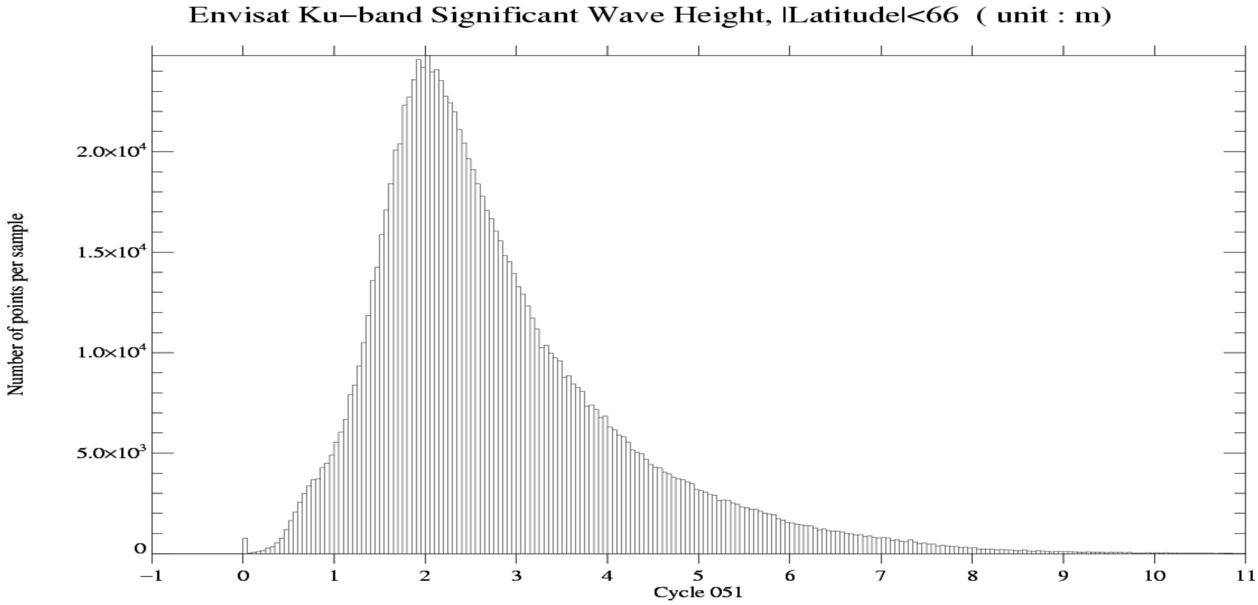
Jason−1 RMS of Ku−band range (unit : cm)



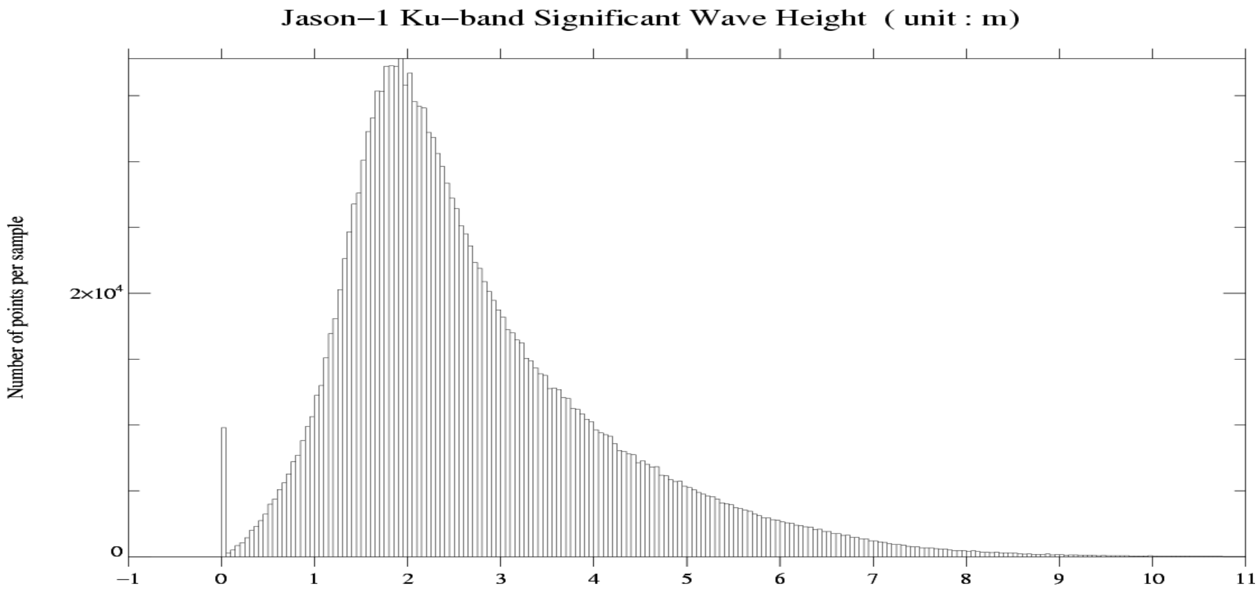
Global nb of points	:	1745180	Sel. nb of points	:	1745180	Sample interval	:	0.200
Global mean	:	8.040	Selected mean	:	8.040	Maximum value	:	20.000
Global Std	:	2.436	Selected std	:	2.436	Minimum value	:	0.820

4.4.2 Ku-band SWH statistics

The histograms of Envisat and Jason-1 Ku-band SWH are given on the following figures:

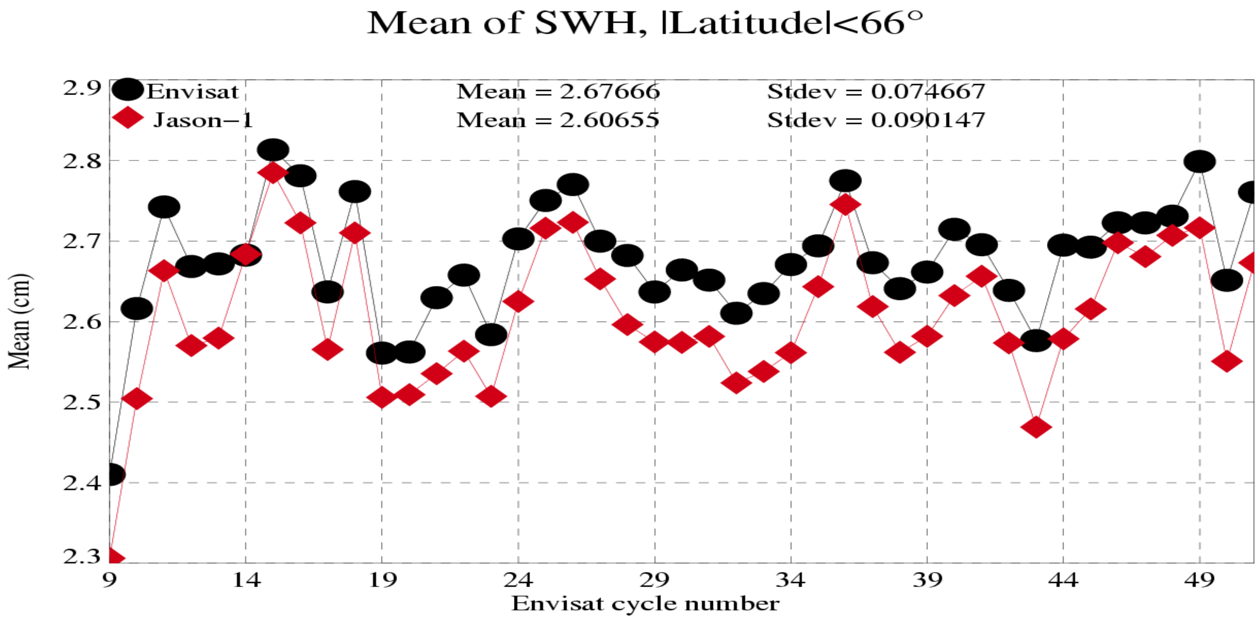


Global nb of points :	1095869	Sel. nb of points :	1095869	Sample interval :	0.050
Global mean :	2.761	Selected mean :	2.761	Maximum value :	10.998
Global Std :	1.375	Selected std :	1.375	Minimum value :	0.000

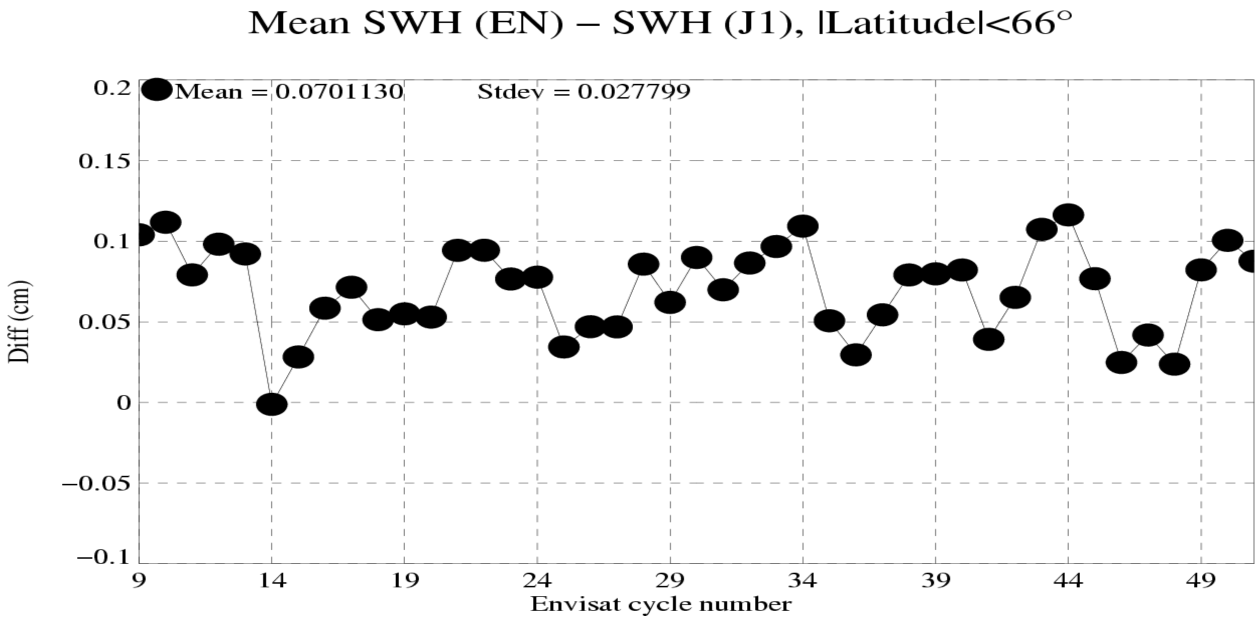


Global nb of points :	1745180	Sel. nb of points :	1745180	Sample interval :	0.050
Global mean :	2.673	Selected mean :	2.673	Maximum value :	10.999
Global Std :	1.437	Selected std :	1.437	Minimum value :	0.000

The cycle per cycle mean of Ku-band SWH measurements for Envisat and Jason-1 is plotted as a fonction of the cycle number on the following figure:

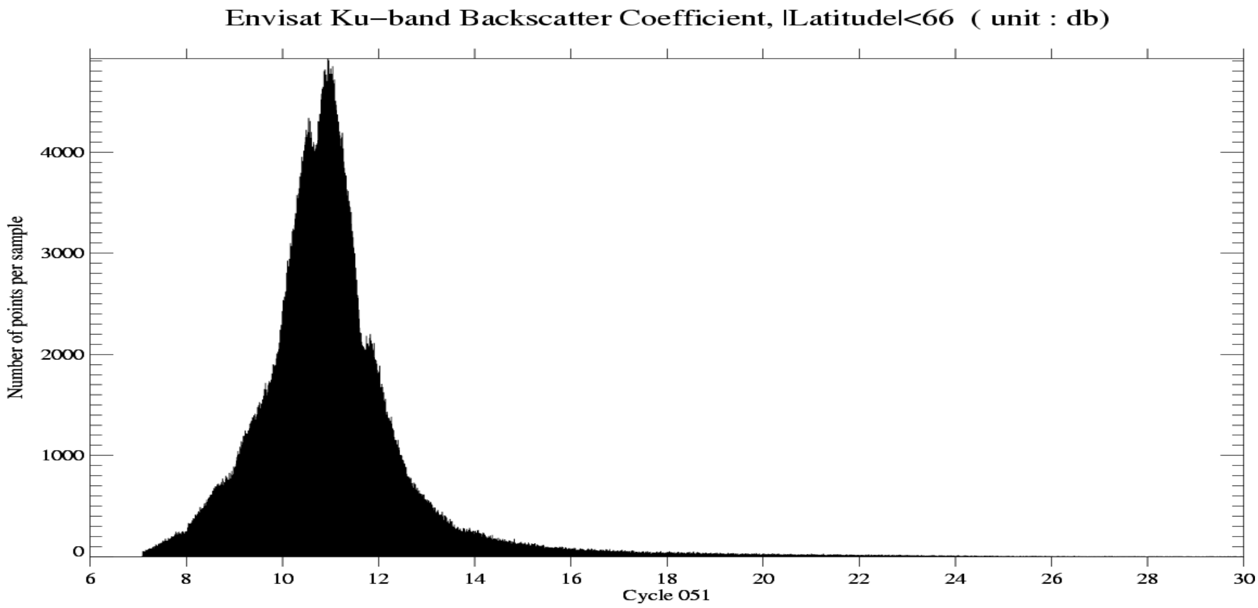


The cycle per cycle mean difference of Ku-band SWH measurements between Envisat and Jason-1 is plotted as a fonction of the cycle number on the following figure:

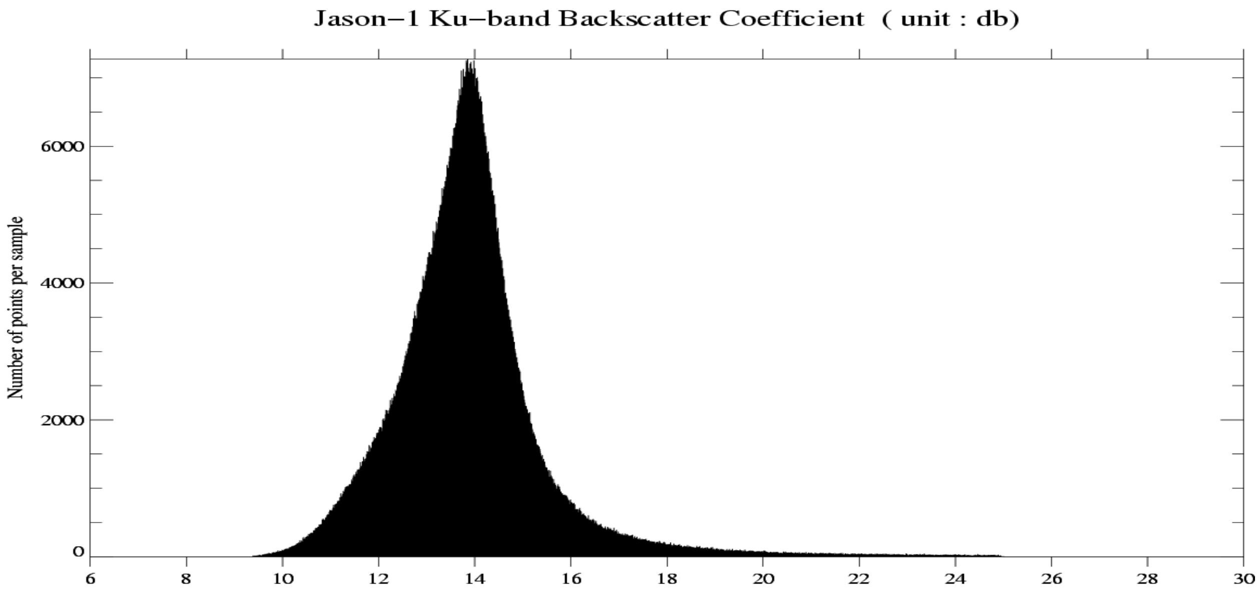


4.4.3 Ku-band Sigma0 statistics

The histograms of Ku-band Sigma0 for Envisat and Jason-1 are given on the following figures:



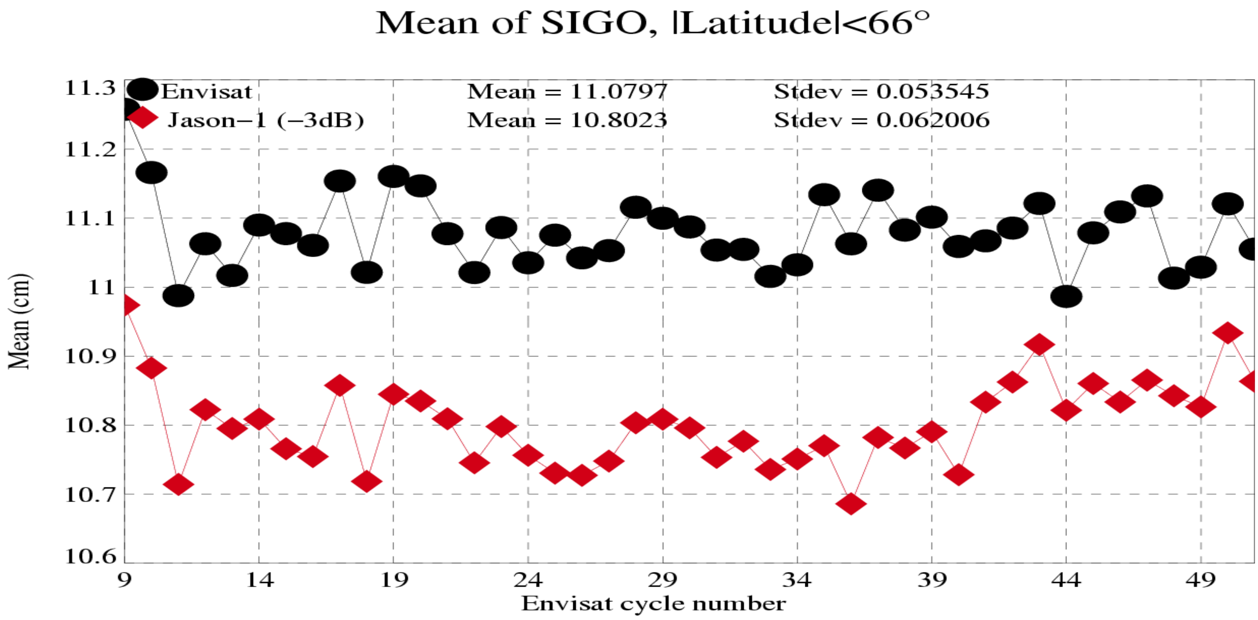
Global nb of points	:	1095869	Sel. nb of points	:	1095869	Sample interval	:	0.010
Global mean	:	11.055	Selected mean	:	11.055	Maximum value	:	29.950
Global Std	:	1.759	Selected std	:	1.759	Minimum value	:	7.080



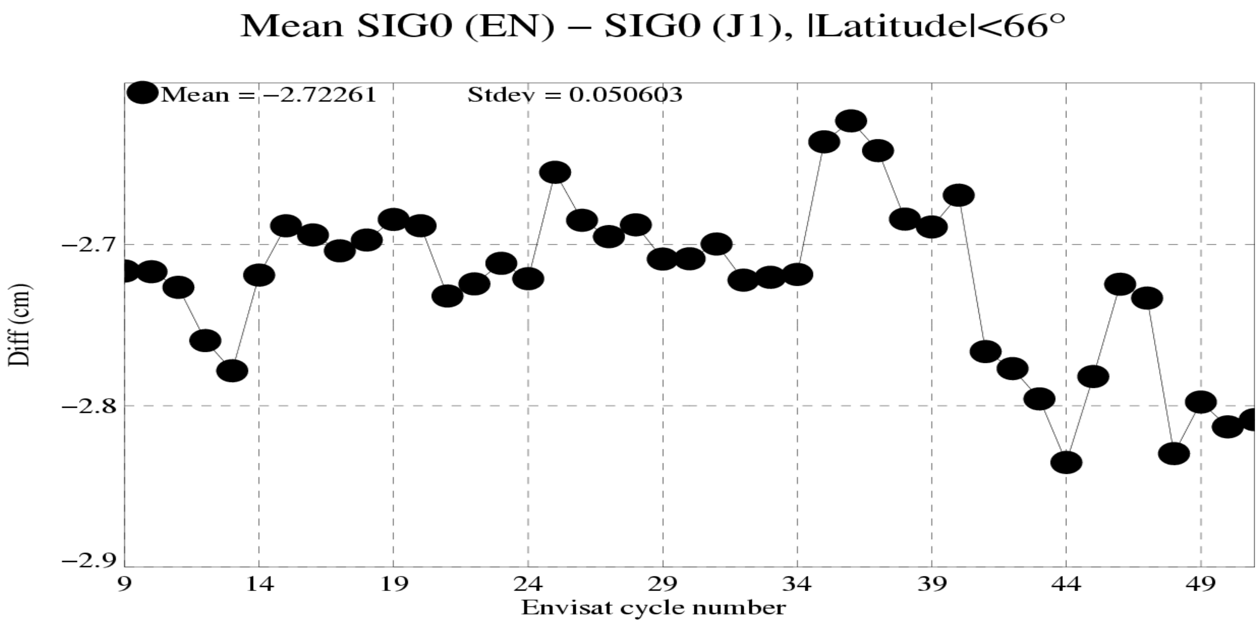
Global nb of points	:	1745180	Sel. nb of points	:	1745180	Sample interval	:	0.010
Global mean	:	13.864	Selected mean	:	13.864	Maximum value	:	25.010
Global Std	:	1.603	Selected std	:	1.603	Minimum value	:	9.380

The general shape of the Envisat histogram is not significantly different from the one obtained at global scale.

The cycle per cycle mean of Ku-band Sigma0 measurements for Envisat and Jason-1 is plotted as a fonction of the cycle number on the following figure:

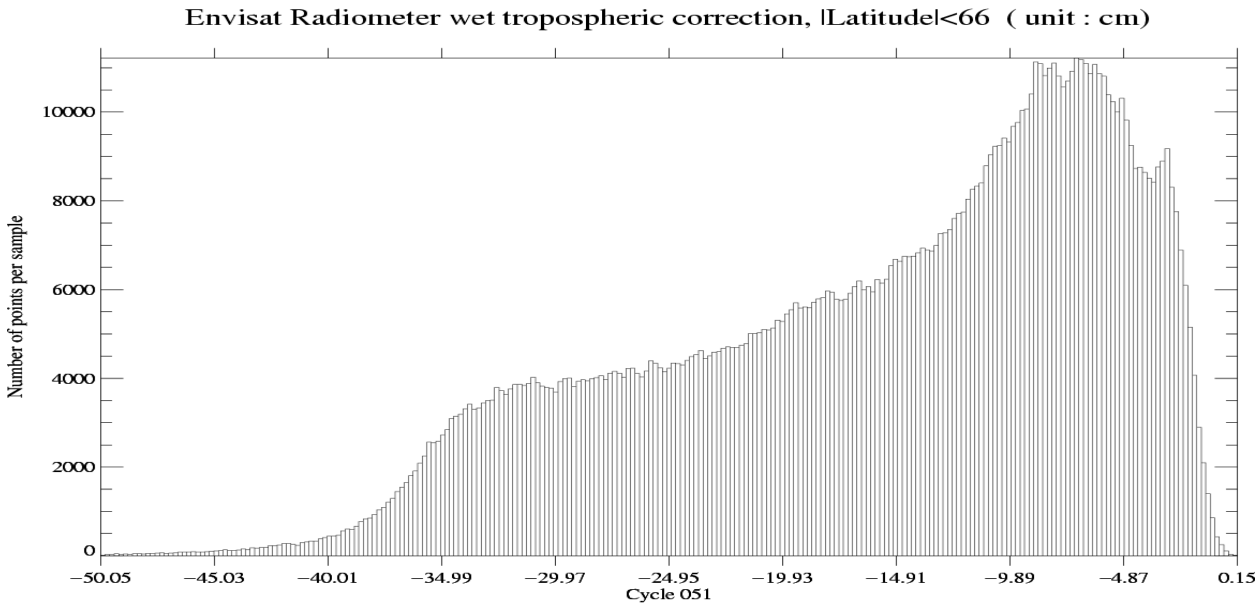


The cycle per cycle mean difference of Ku-band Sigma0 measurements between Envisat and Jason-1 is plotted as a fonction of the cycle number on the following figure:

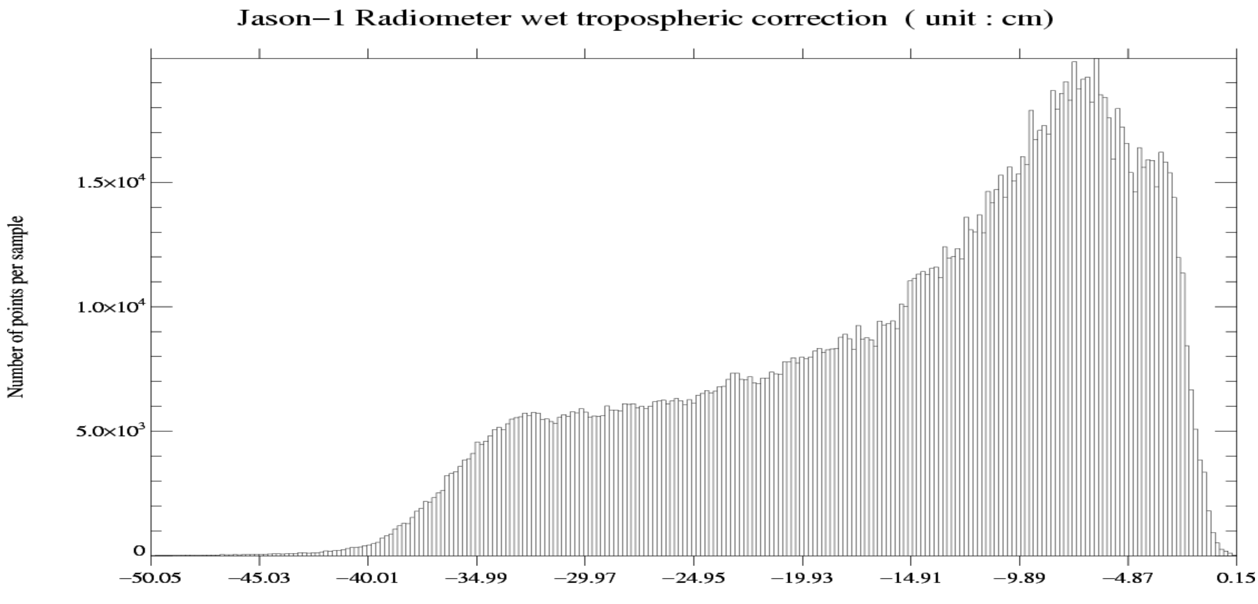


4.4.4 Troposphere statistics

The histograms of Envisat and Jason-1 radiometer wet troposphere correction are given on the following figures:



Global nb of points	:	1095869	Sel. nb of points	:	1095869	Sample interval	:	0.200
Global mean	:	−15.802	Selected mean	:	−15.802	Maximum value	:	−0.100
Global Std	:	9.941	Selected std	:	9.941	Minimum value	:	−50.000



Global nb of points	:	1745180	Sel. nb of points	:	1745180	Sample interval	:	0.200
Global mean	:	−15.301	Selected mean	:	−15.301	Maximum value	:	−0.100
Global Std	:	9.759	Selected std	:	9.759	Minimum value	:	−50.000

4.4.5 SSH crossover performances

10-day crossover points are computed for both Jason-1 and Envisat. Global statistics of SSH differences at crossovers are computed using a selection to remove shallow waters (1000 m):

Analysis	Number	Mean (cm)	Std. dev. (cm)
EN/EN SSH	11687	-0.10	6.81

Analysis	Number	Mean (cm)	Std. dev. (cm)
J1/J1 SSH	16926	-0.93	6.63

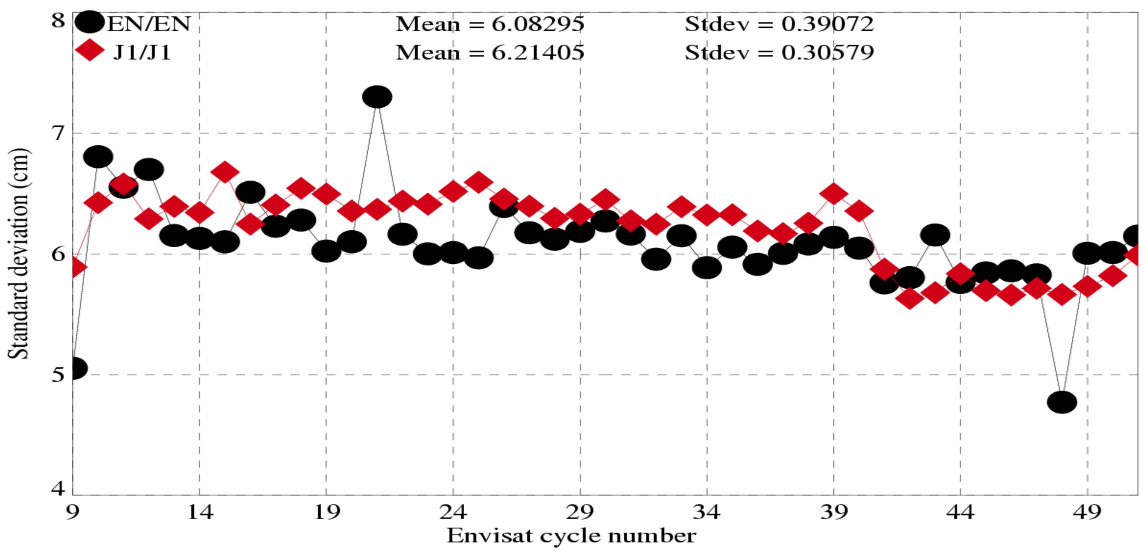
Using an additional selection to remove areas of high ocean variability and high latitudes (> 50 deg) leads to:

Analysis	Number	Mean (cm)	Std. dev. (cm)
EN/EN SSH	8042	-0.11	6.15

Analysis	Number	Mean (cm)	Std. dev. (cm)
J1/J1 SSH	9056	-0.84	5.99

The cycle per cycle standard deviation of SSH measurements is plotted as a fonction of the cycle number on the following figure:

Std dev. of crossover points, |Latitude|<50°, Bathy<−1000m, Var<20cm



These results show comparable performances for Envisat and Jason-1.

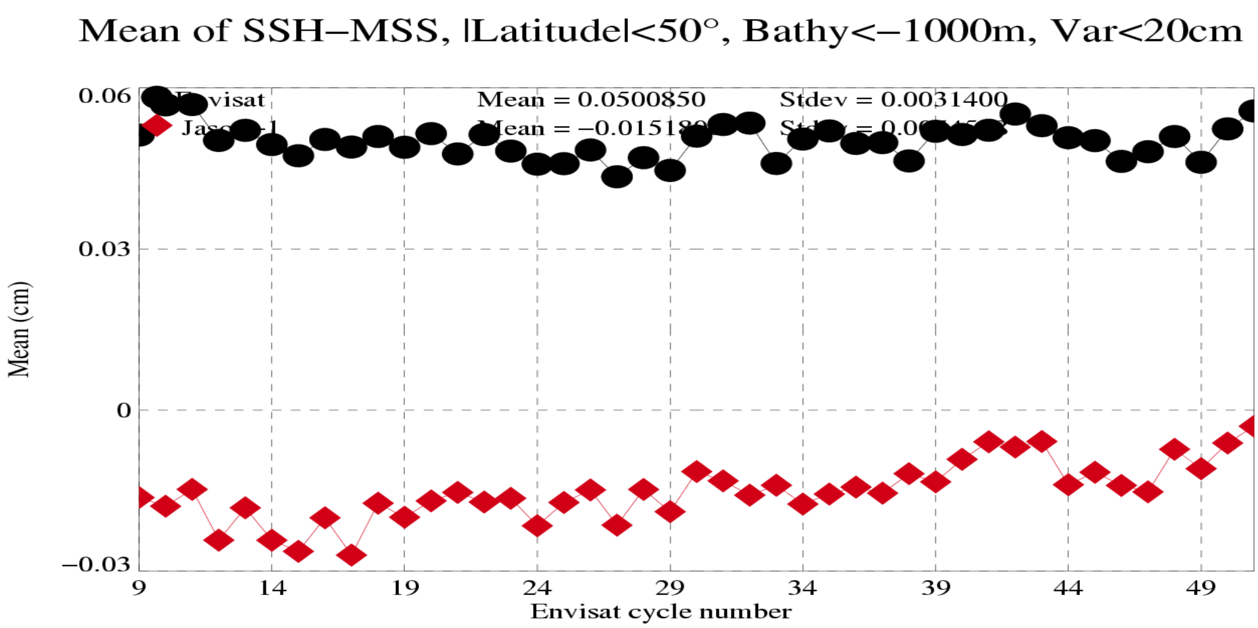
4.4.6 SLA relative to MSS

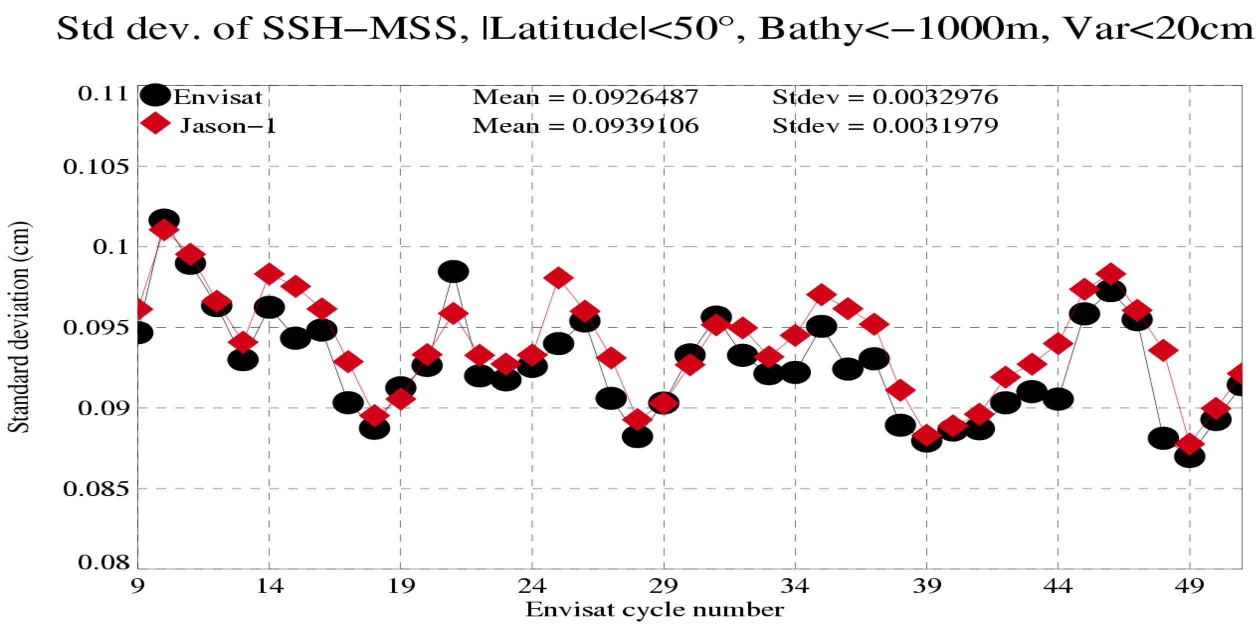
Envisat and Jason-1 Sea Level anomalies relative to CLS01 Mean Sea Surface are computed. Global statistics are computed removing shallow waters (1000 m) and areas of high ocean variability (20 cm).

Analysis	Number	Mean (cm)	Std. dev. (cm)
Envisat SLA	1000409.000000(	49.42	10.25

Analysis	Number	Mean (cm)	Std. dev. (cm)
Jason-1 SLA	1525672.000000(	16.70	9.46

The cycle per cycle mean and standard deviation of SLA relative to MSS for Envisat and Jason-1 are plotted as a fonction of the cycle number on the following figures:





These results show comparable performances in terms of SLA variability (standard deviation), and also confirm the crossover estimation of the (Envisat-Jason-1) bias.

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