Envisat GDR
Quality Assessment Report

Cycle 047

17-04-2006 / 22-05-2006

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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 ocean Envisat mission. The document is associated with data dissemination on a cycle by cycle basis.

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
CALVAL main results
Long term performance monitoring
Particular investigations

2 Cycle overview

2.1 Data and software version

This cycle has been produced with the IPF processing chain V5.02 and the CMA Reference Software V7.1_07.

The content of this science software version is described in a document available on the ESA PCS web site ([2]). The main impacts of these evolutions on the SSH are described in section Impact of CMA version 7.1 for the SSH calculation (page 4).

2.2 Parameters

The parameters used to compute the sea surface height (SSH) for Envisat 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

2.3 Warnings and recommendations

-Passes 1 to 789 are impacted by the USO anomaly. This quality assessment has been performed using the USO correction provided by ESA. Users are strongly advised not to use the range parameter in Ku and S Band without this correction (see section 5).
-Due to the switch of the RA2 RFSS to side B redundancy on 15 May 2006 at 14:21:50, 213 passes (790-1002) have not been delivered to the users (see section 3.3).
-27 passes (710-737) have a degraded quality due to RA-2 Chirp Bandwidth changes(see section 5)
-5 passes are missing due to level1 B data unavailability (see section 3.1).
-1 passes have no radiometer correction (see section 3.3).
-8 passes are impacted by the S-Band anomaly (see section 3.3).

2.4 Platform and instrument events

-On 12th-13th May, a special operation was executed to limit RA-2 Chirp Bandwidth to 80MHz (starting from 12/05/2006 at 15:51:37, pass 710) and then 20 MHz (starting from 13/05/2006 at 03:57:57, Pass 724). The instrument was returned to 320MHz on 13/05/2006 at 15:10:17, Pass 738.

-The instrument sub-system Radio Frequency Module (RFM) was switched to its B-side on 15 May 2006 at 14:21:50

-RA-2 BACK TO OPERATIONS AFTER 2 CONSECUTIVE SEU ANOMALIES (19 May 2006 09:24:32 and 19 May 2006 19:13:00)

2.5 Cycle quality and performances

Good general results are obtained for this cycle of data.

The crossover standard deviation is 6.32 cm rms when using a selection to remove shallow waters (1000 m), areas of high ocean variability and high latitudes ($>$ |50| deg). The standard deviation of Sea Level Anomalies (SLA) relative to the CLS01V1 Mean Sea Surface is 10.4 cm. When using a selection to remove shallow waters (1000 m), areas of high ocean variability and high latitudes ($>$ |50| deg) it lowers to 9.5 cm .

Detailed CALVAL results are presented in section 3.

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

The evolutions having a direct and strong impact on the SSH estimation are described hereafter:

2.6.1 Usage of actual USO clock period

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 ([3]).

2.6.2 Improvement of the SSB correction

The Sea-State bias table has been recomputed (Labroue, 2005 [4])) accounting for the impact of the new orbit and the new geophysical corrections (MOG2D, GOT00 ocean tide correction with the S2 component corrected once only, new wind speed algorithm from Abdalla, 2006). The new SSB correction is shifted in average by +2.0 cm in comparison with the previous one.

2.6.3 New POE orbit solution

New standards are used for the computation of the Envisat Precise Orbit Estimation. One of the main evolutions is the use of the GRACE gravity model EIGEN_CG03C. This new model implies a strong reduction of the geographically correlated radial orbit errors: the systematic differences between ascending and descending passes which were locally higher than 4 cm in South West Pacific and South Atlantic are almost fully removed.

2.6.4 MOG2D correction

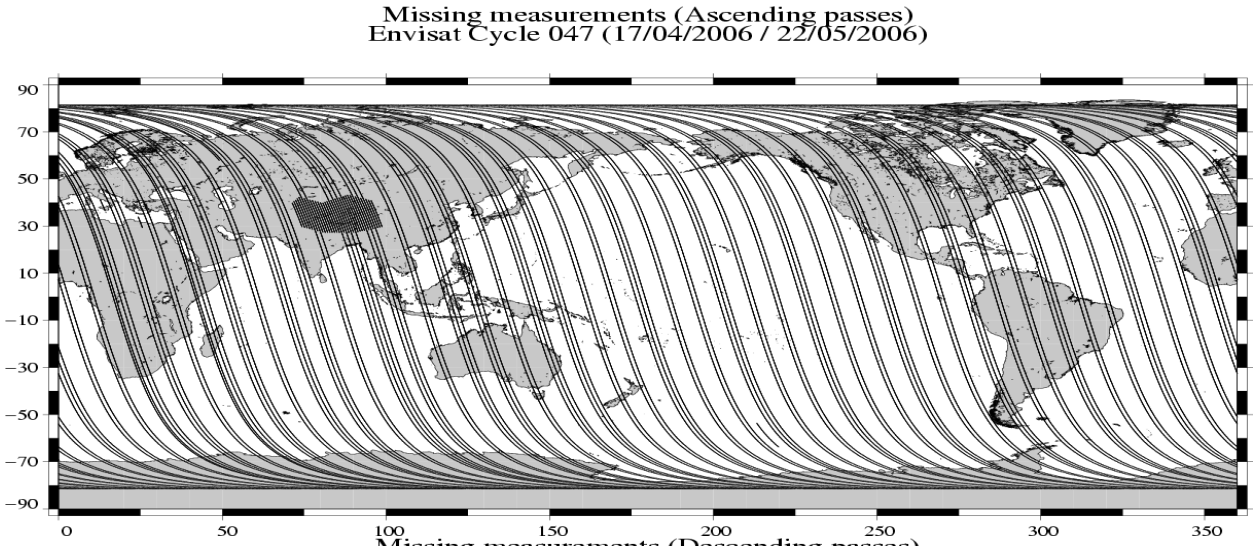
In order to take into account the dynamical effects and wind forcing, a new correction is computed from the MOG2D (Carrere and Lyard, 2003) barotropic model forced by pressure (without S1 and S2 constituents) and wind. The use of such a correction in the SSH strongly improves the performances.

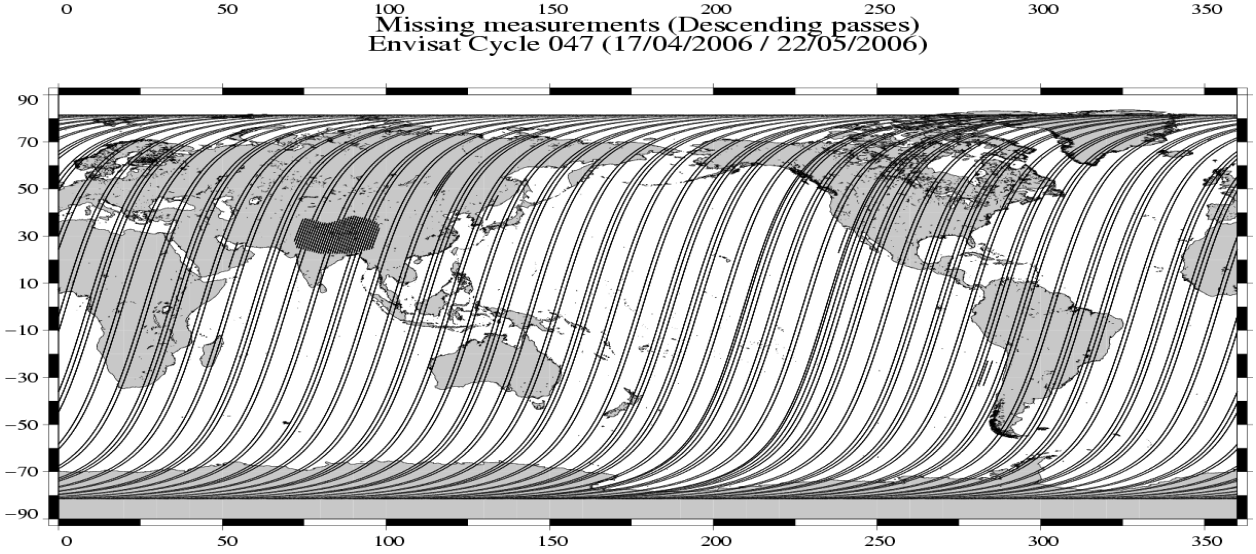
3 CALVAL main results

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.

3.1 Missing measurements

1401214 are present, and 606133.00000000 (30.2%) are missing. The maps below illustrate missing 1Hz measurements in the GDRs, with respect to a 1 Hz sampling of a nominal repeat track.





-3 passes (512-514) are missing due either to LRAC PDHSs data generation, level1 problems or ingestion pbs on F-PAc side
-2 passes (709,712) are missing due to: anomaly in Level1B
-213 passes (790 to 1002) have not been delivered to the users due to the switch of the RA2 RFSS to side B redundancy on 15 May 2006 at 14:21:50

3.2 Orbit quality

3.2.1 Doris and Laser performances

The next table gives statistics on Doris and Laser residuals:

7-day Period	Number of Doris measurements	Number of Laser measurements	RMS of Laser measurements (cm)
17/04/2006 to 24/04/2006	33915	2083	1.56640
24/04/2006 to 01/05/2006	71745	1697	1.71990
01/05/2006 to 08/05/2006	72122	1916	1.53960
08/05/2006 to 15/05/2006	69251	2225	1.43600
15/05/2006 to 22/05/2006	67041	1350	1.82330

3.2.2 Impact on SLA

The orbit quality is good for this cycle of data.

3.3 Edited measurements

3.3.1 Statistics

Data editing is necessary to remove altimeter measurements having lower accuracy.
First, there is an editing using flags. Compared to the GDR product, two additional flags are computed:
An ice flag to detect sea ice measurements. A measurement is set to ice if, at high latitudes ($>$ |50| deg), one of the following criteria is valid:
- Number of 20Hz measurement $<$ 17
- |MWR - ECMWF| wet tropospheric correction $>$ 10cm
- Peakiness $>$ 2

A S-band anomaly flag: this flag is set if |Sigma0(Ku)-Sigma0(S)| $>$ 5dB
Notice that this flag is set over land and ice, even when no S-band anomaly occurs.

Parameter	Nb rejected	% rejected
Radiometer land flag	38652	3.30
Ice flag	239746	20.48
S-Band anomaly flag	49807	4.25

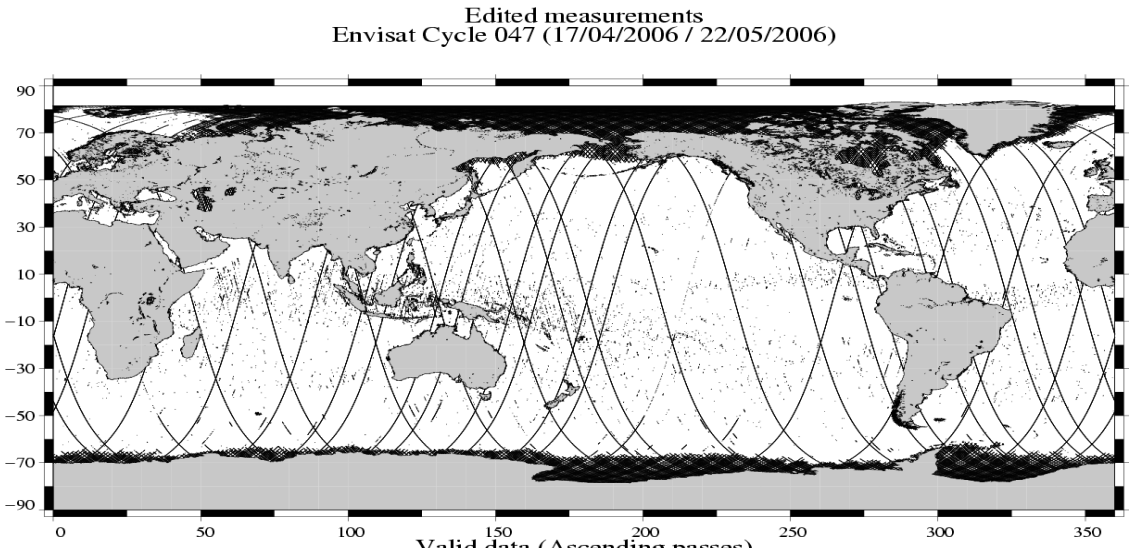
Then, measurements are edited using thresholds on several parameters. These thresholds are expected to remain constant throughout the Envisat mission, so that monitoring the number of edited measurements allows a survey of data quality.
The next table gives for each tested parameter, minimum and maximum thresholds, the number and the percentage of points removed.

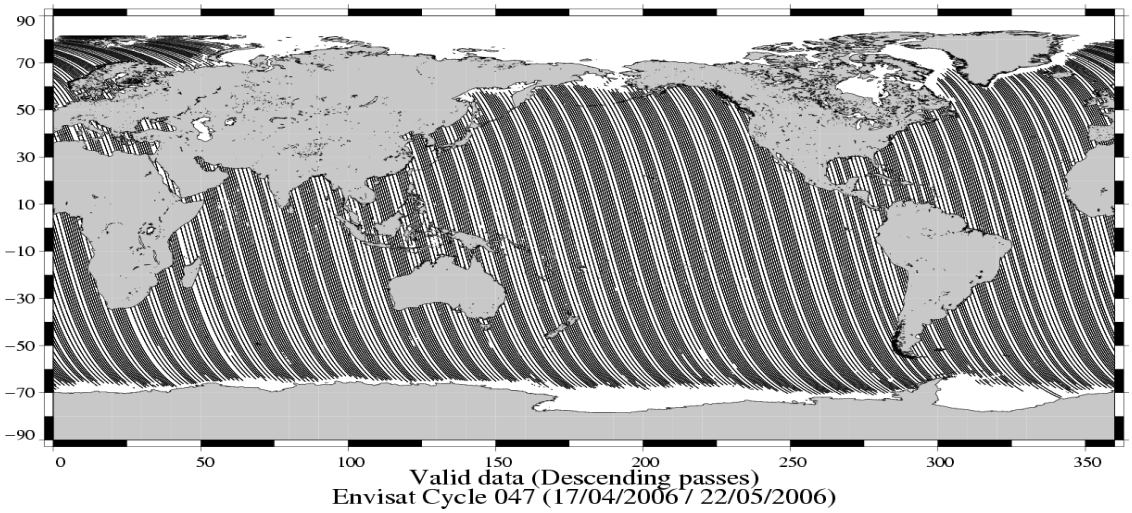
Parameters	Min Thres.	Max Thres.	Nb rejected	% rejected
Sea surface height (m)	-130.000	100.000	644	0.06
Variability relative to MSS (m)	-2.000	2.000	32145	2.96
Number of 18Hz valid points	10.000	-	75	0.01
Std. deviation of 18Hz range (m)	0.000	0.250	28107	2.58
Off nadir angle from waveform (deg2)	-0.200	0.160	3537	0.33
Dry tropospheric correction (m)	-2.500	-1.900	0	0.00
MOG2D correction (m)	-2.000	2.000	0	0.00
MWR wet tropospheric correction (m)	-0.500	-0.001	915	0.08
Dual Ionospheric correction (m)	-0.400	0.040	30696	2.82
Significant wave height (m)	0.000	11.000	809	0.07
Sea state Bias (m)	-0.500	0.000	1595	0.15
Backscatter coefficient (dB)	7.000	30.000	1580	0.15
GOT00 ocean tide height (m)	-5.000	5.000	2088	0.19
Long period tide height (m)	-0.500	0.500	0	0.00
Earth tide (m)	-1.000	1.000	0	0.00
Pole tide (m)	-5.000	5.000	0	0.00
RA2 wind speed (m/s)	0.000	30.000	0	0.00

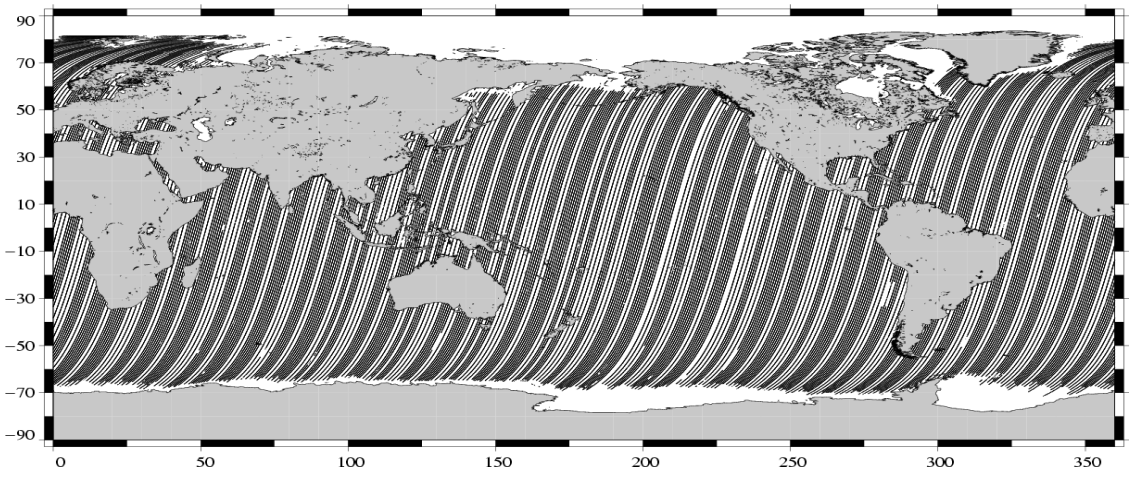
A final editing is then performed on corrected sea surface height, using a spline fitting procedure, leading to remove 380 (0.03 %) measurements.

3.3.2 Figures

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





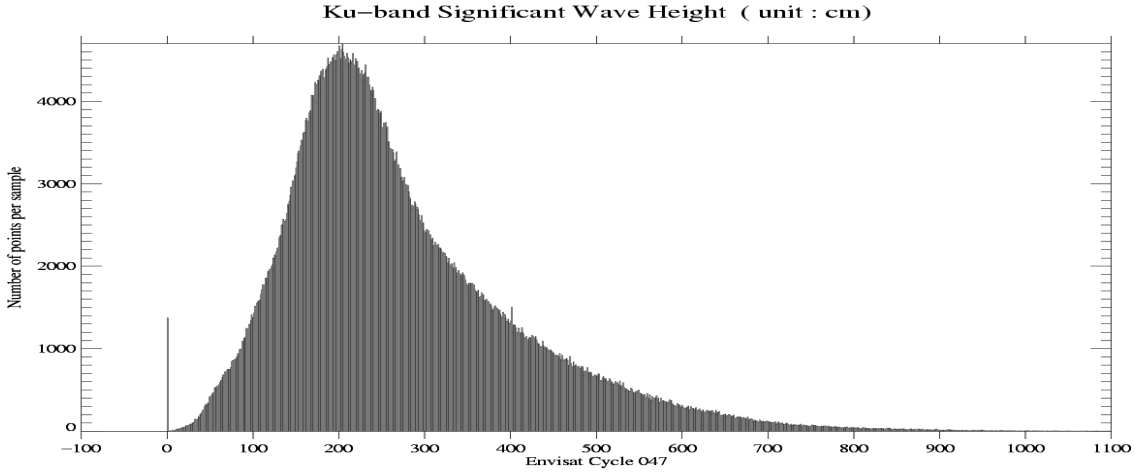


3.3.3 Comments

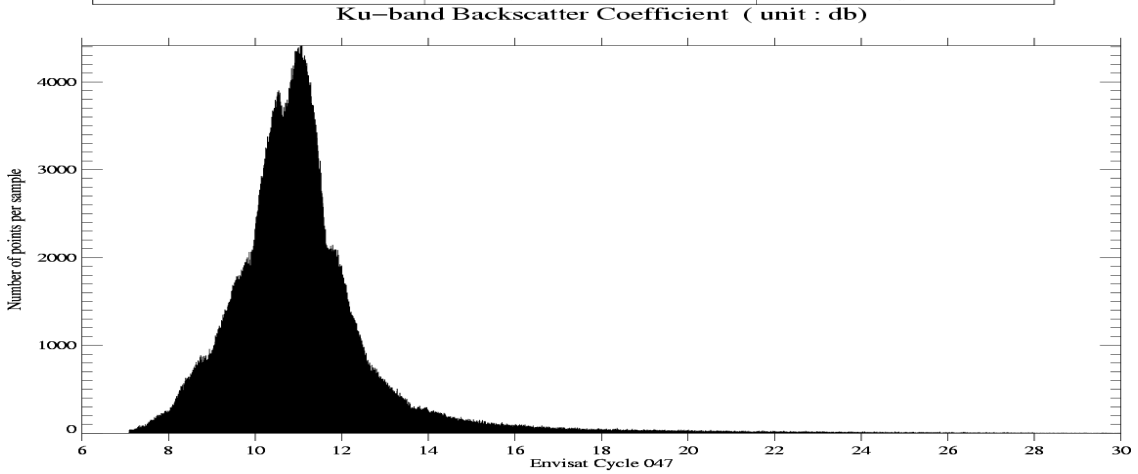
784 passes have been delivered. Among these passes:
- 1 pass (789) is entirely edited on the radiometer land flag (no MWR correction) - 8 passes (688-695) are edited because of S-Band anomalies. Users are advised not to use the S-Band parameters and the dual ionospheric correction on these passes.
- 27 passes 710-737 are edited on the several altimeter criteria due the change of bandwith on the Ra2 (see section 5).
Wet areas appear in the plot of removed data. Similar features are observed with other altimeters (T/P, Jason) mainly due to rain comtamination.

3.4 Altimeter parameters

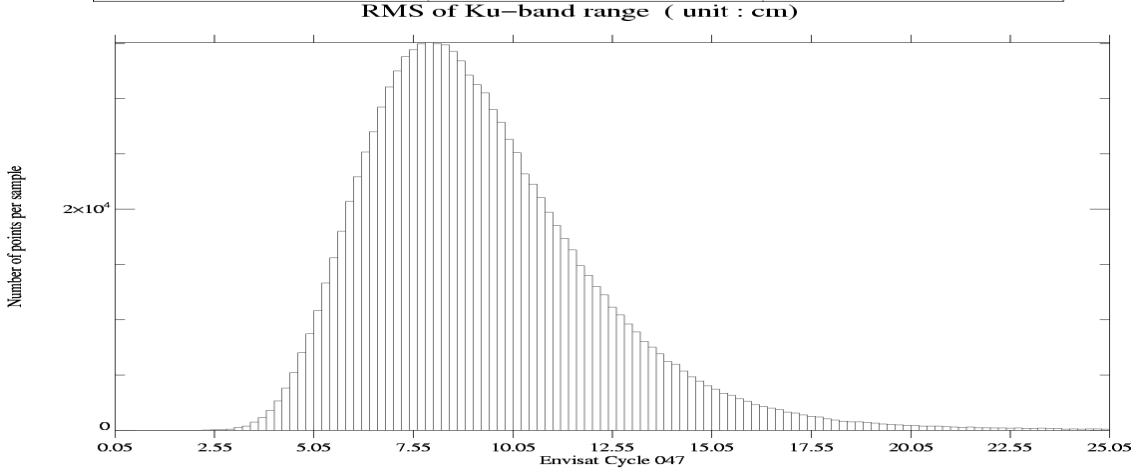
In order to assess and to monitor altimeter parameter measurements, histograms of Envisat Ku-band Significant Wave Height (SWH), Backscatter coefficient (Sigma0) and RMS of altimeter range are computed.



Global nb of points	:	1086604	Sel. nb of points	:	1086604	Sample interval	: 1.000
Global mean	:	271.784	Selected mean	:	271.784	Maximum value	: 1099.700
Global Std	:	135.040	Selected std	:	135.040	Minimum value	: 0.000



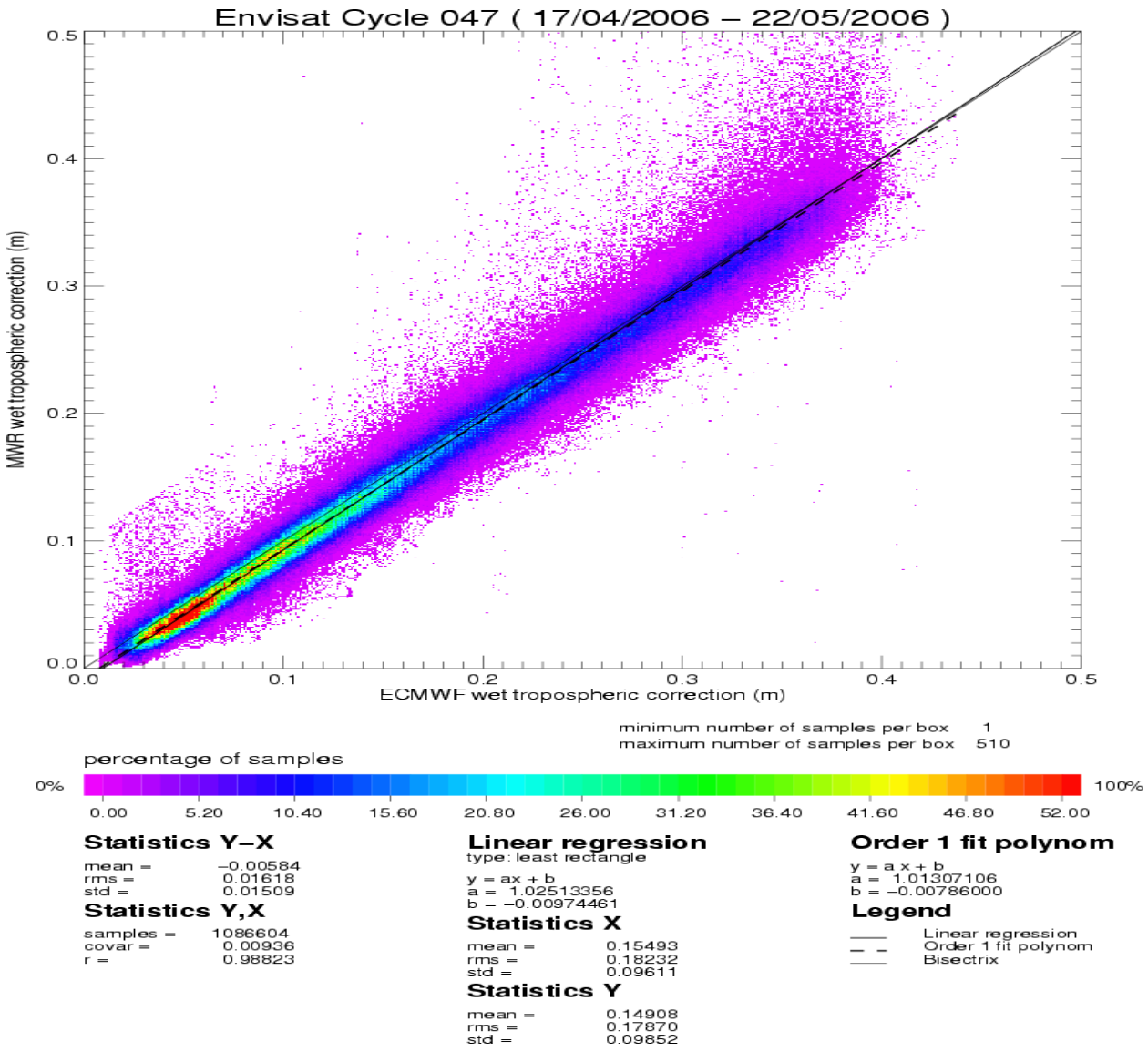
Global nb of points	:	1086604	Sel. nb of points	:	1086604	Sample interval	: 0.010
Global mean	:	11.114	Selected mean	:	11.114	Maximum value	: 29.980
Global Std	:	1.940	Selected std	:	1.940	Minimum value	: 7.080



Global nb of points	:	1086604	Sel. nb of points	:	1086604	Sample interval	: 0.200
Global mean	:	9.138	Selected mean	:	9.138	Maximum value	: 25.000
Global Std	:	2.887	Selected std	:	2.887	Minimum value	: 1.600

3.5 Radiometer

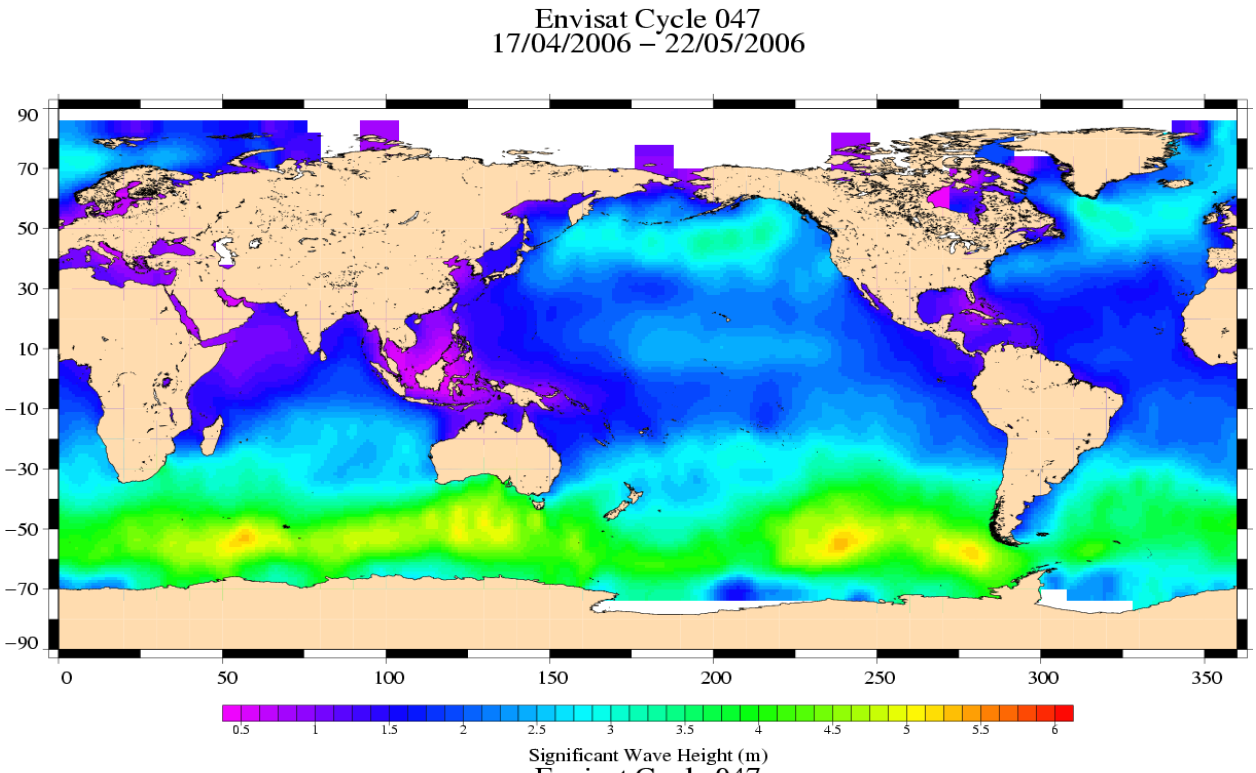
In order to assess and to monitor radiometer measurements, a scatter plot between the radiometer wet troposphere correction and the ECMWF model is computed for the valid data set previously defined.

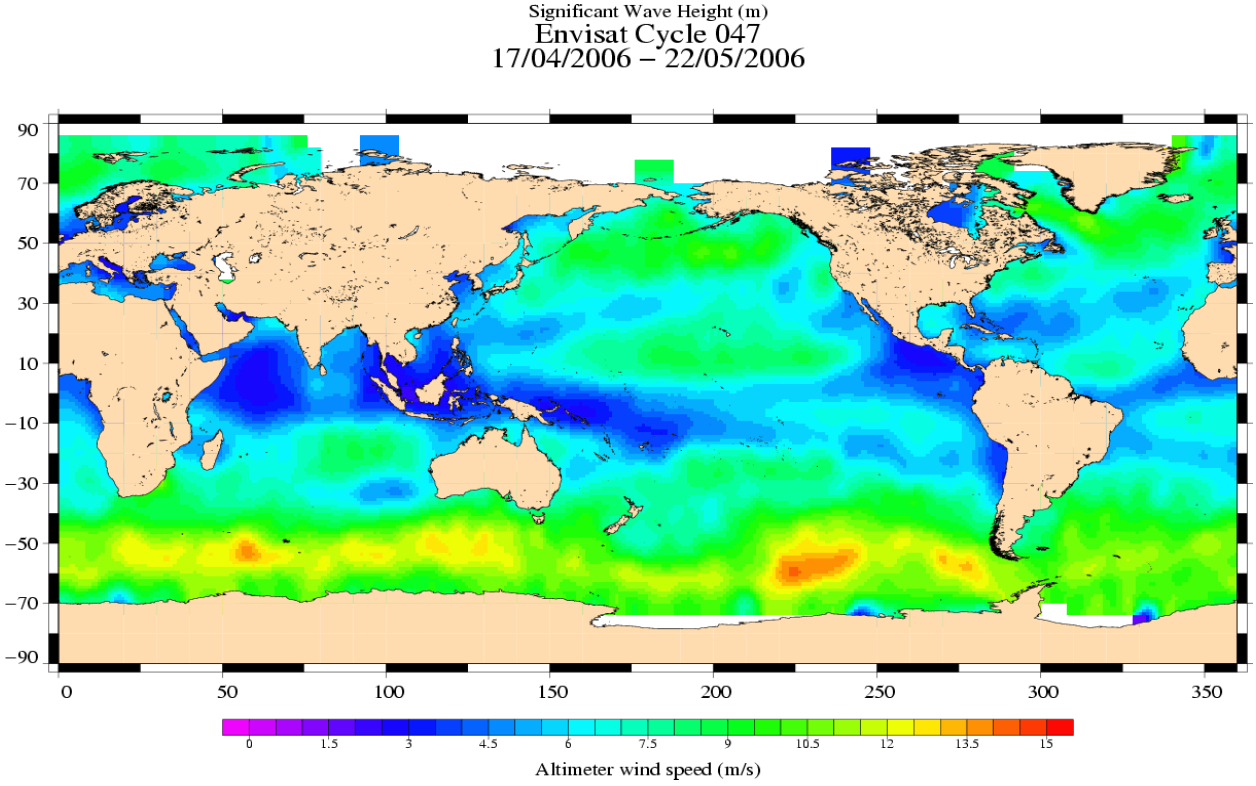


The radiometer-model mean difference is 0.0 cm. A drift on the Envisat 23.8GHz brightness temperature has been detected and has to be monitored on the long term. Note that the neural algorithm is now implemented on Envisat.

3.6 Wind and wave maps

These two figures show wind and wave estimations derived from 35 days of altimeter measurements.





3.7 Crossover statistics

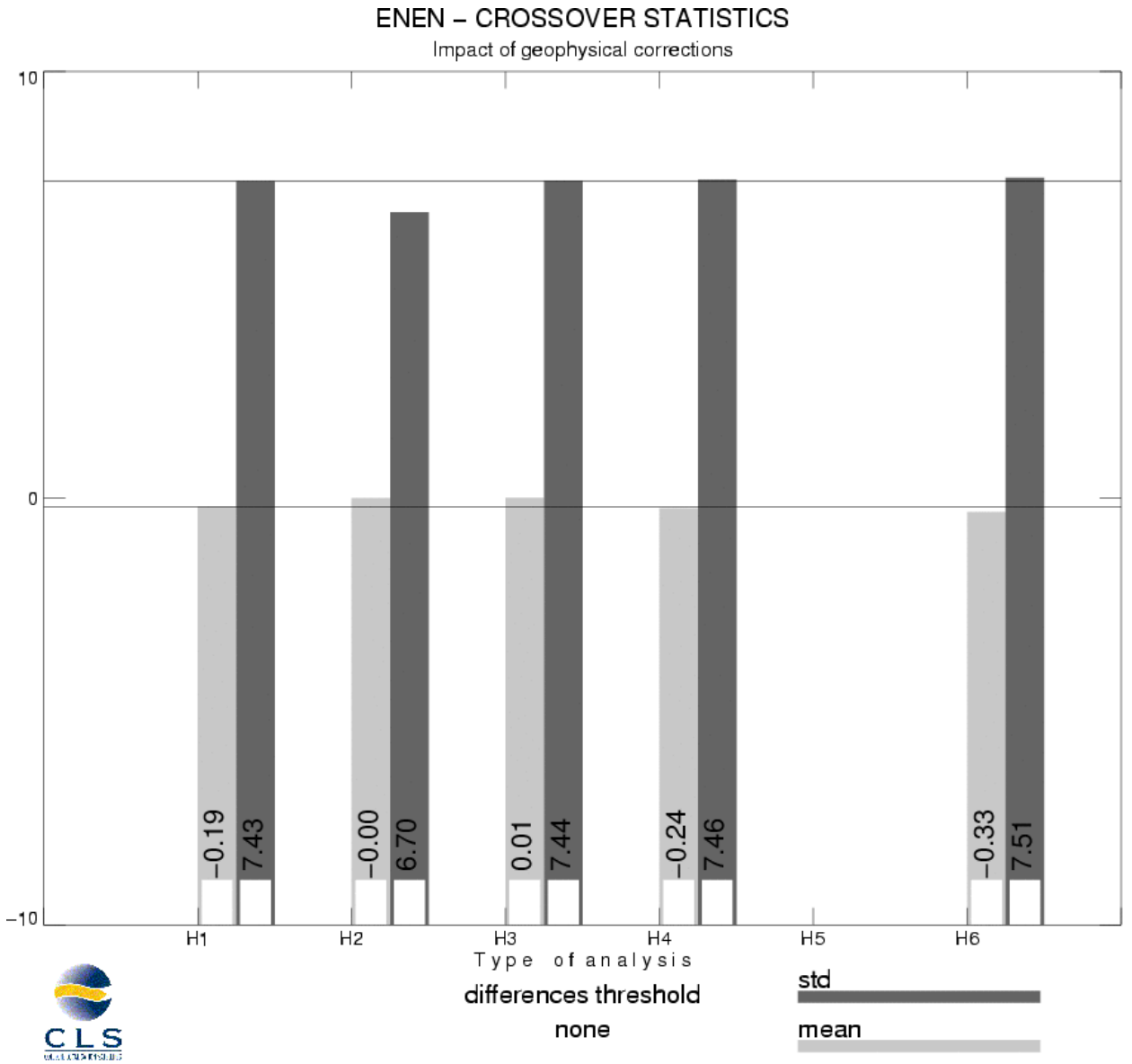
3.7.1 General comment

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 Envisat algorithms, the crossover standard deviation is about 7.43 cm rms, when using a selection to remove shallow waters (1000 m). When using an additional selection to remove areas of high ocean variability and high latitudes ($> |50|$ deg) it lowers to 6.32 cm rms. This statistic is a stable estimation of the system performance as it is not influenced by sea ice coverage.

3.7.2 Impact of geophysical corrections

This figure shows the impact of geophysical corrections on crossover mean and rms. A selection is used to remove shallow waters (1000 m).

For this analysis two corrections have been computed: a long wave length and a model ionospheric correction. The long wave length estimation is performed by a global minimization of crossover differences using a (1 and 2 cycles/revolution) sinusoidal model. The model ionospheric correction is computed using the JPL's version of the GPS Ionosphere Maps (JPL GIM) thanks to the procedures provided by Remko Scharro (internet communication to the CCVT community, December 12, 2002).



H1 = SSH

H2 = SSH applying a long wave length error (computed)

H3 = SSH with GIM ionospheric correction (computed)

H4 = SSH with DORIS ionospheric correction (in product)

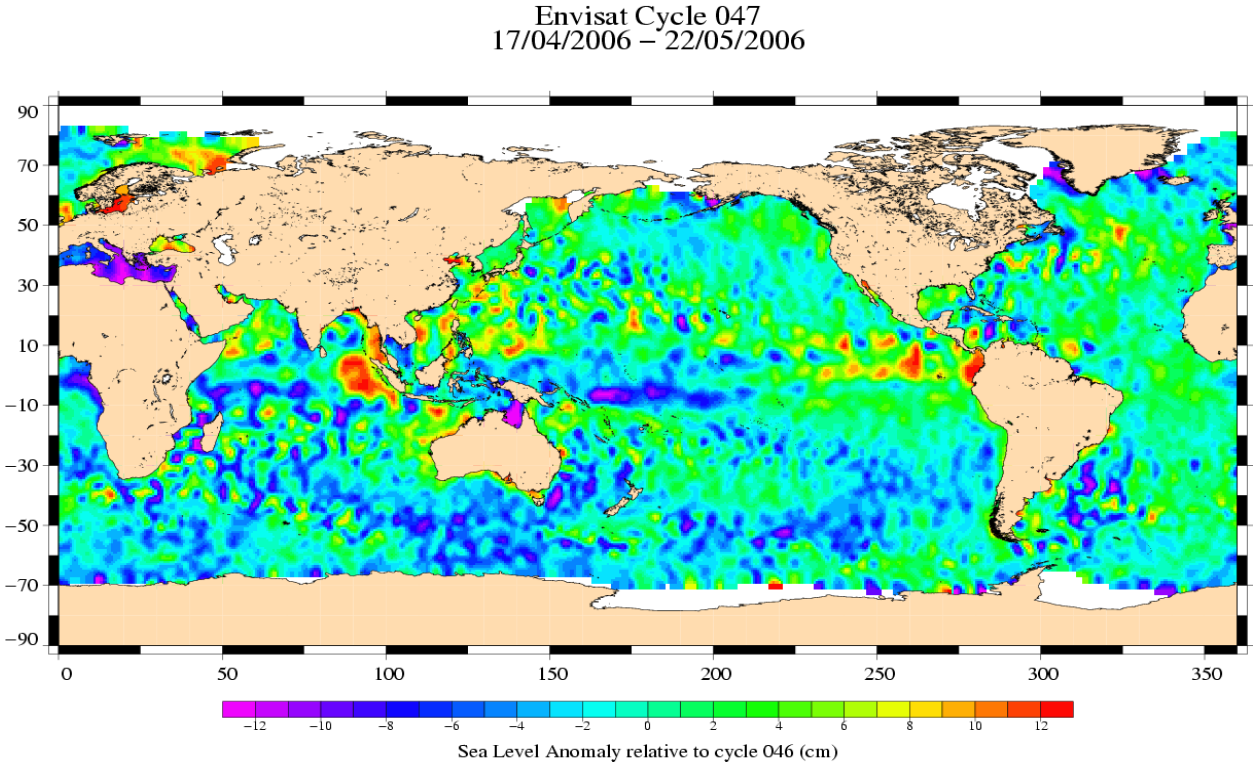
H5 = SSH with FES02 tide model (in product)

H6 = SSH with ECMWF wet tropospheric correction (in product)

3.8 SSH variability

3.8.1 Sea Level Anomaly

Repeat-track analysis is routinely used to compute Sea Level Anomalies (SLA) relative to the previous cycle and relative to a mean profile. The mean profile has been computed using ERS-1 and ERS-2 data and has been ajusted on the 7 year TP mean profile. In order to see fine features SLA are centered about the mean value.



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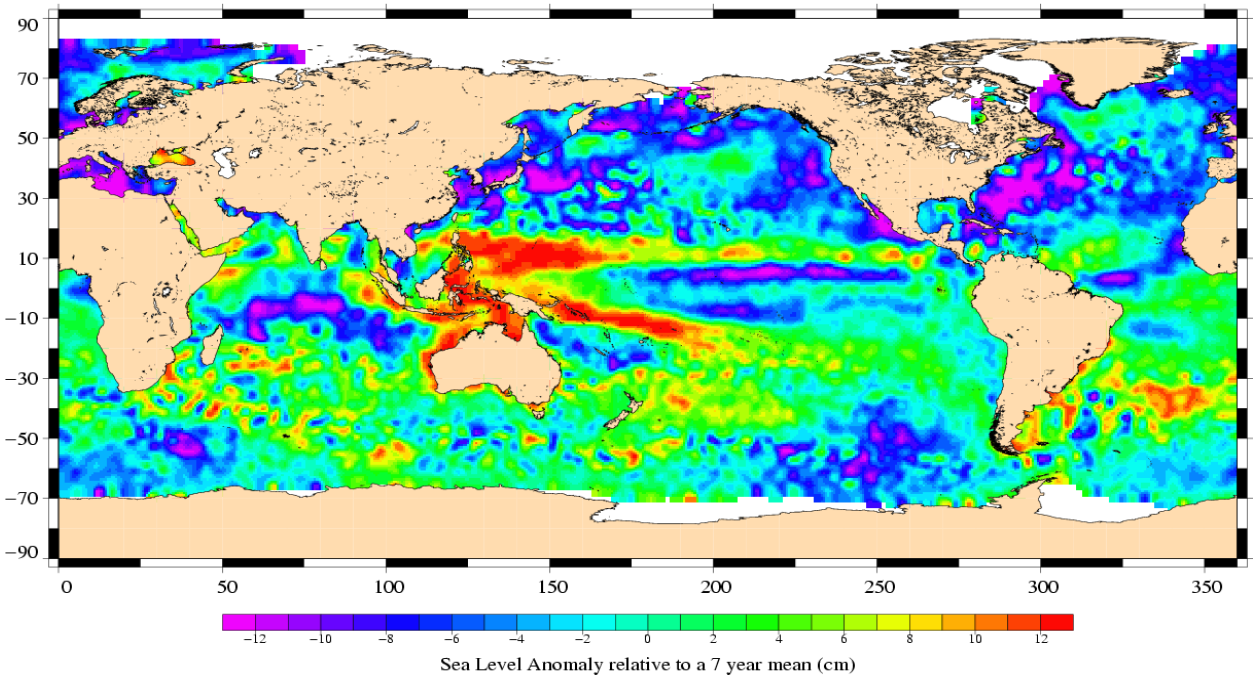


3.8.2 Comparison to a precise Mean Sea Surface

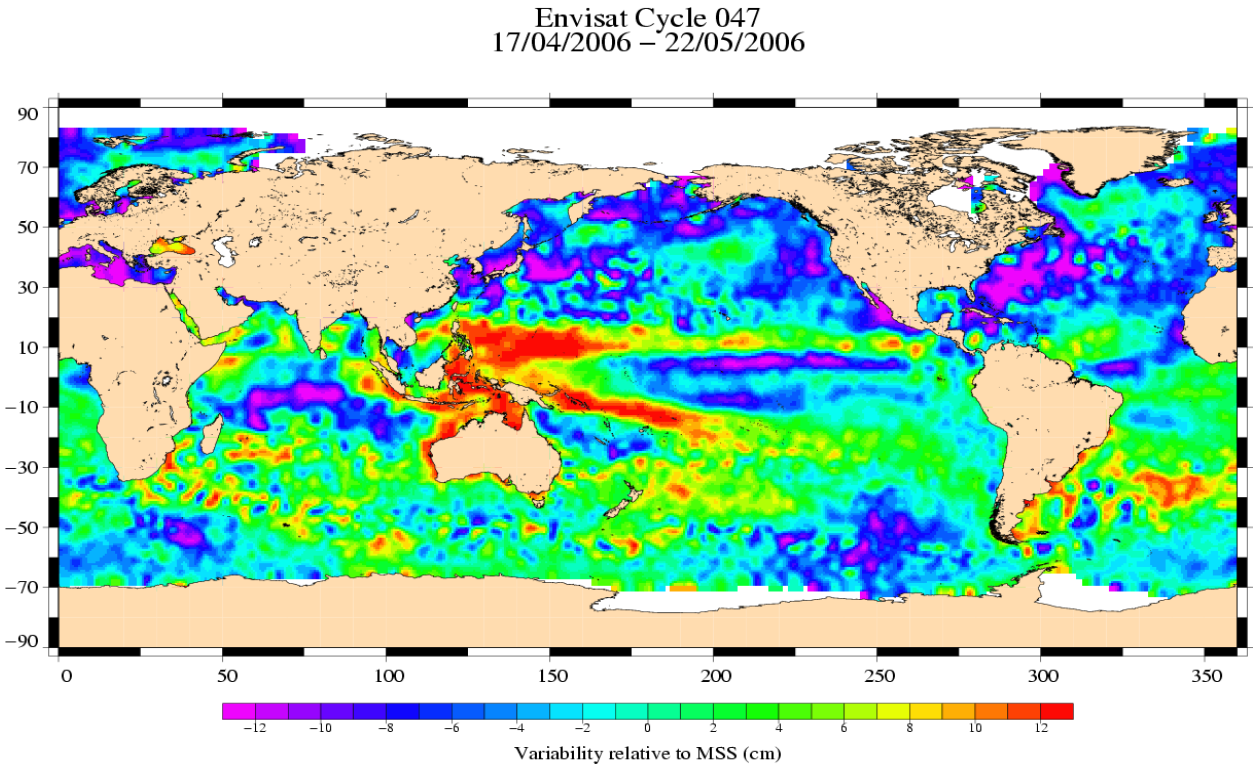
The MSS from the product is used as a reference to compute SLA. Global statistics of Envisat SSH-MSS are (cm):

Number	Mean	Std. dev.
1217186	48.12	10.38

When using a selection to remove shallow waters (1000 m), areas of high ocean variability and high latitudes ($> |50|$ deg) statistics are:

Number	Mean	Std. dev.
735796.00000000	48.81	9.55

The two following maps respectively show the map of Envisat SLA relative to the MSS and differences higher than a 30 cm threshold. In order to see fine features SLA are centered about the mean value. The latter figure shows that apart from isolated measurements, higher differences are located in high ocean variability areas, as expected.



(SSH − MSS) centered, differences greater than 30 cm
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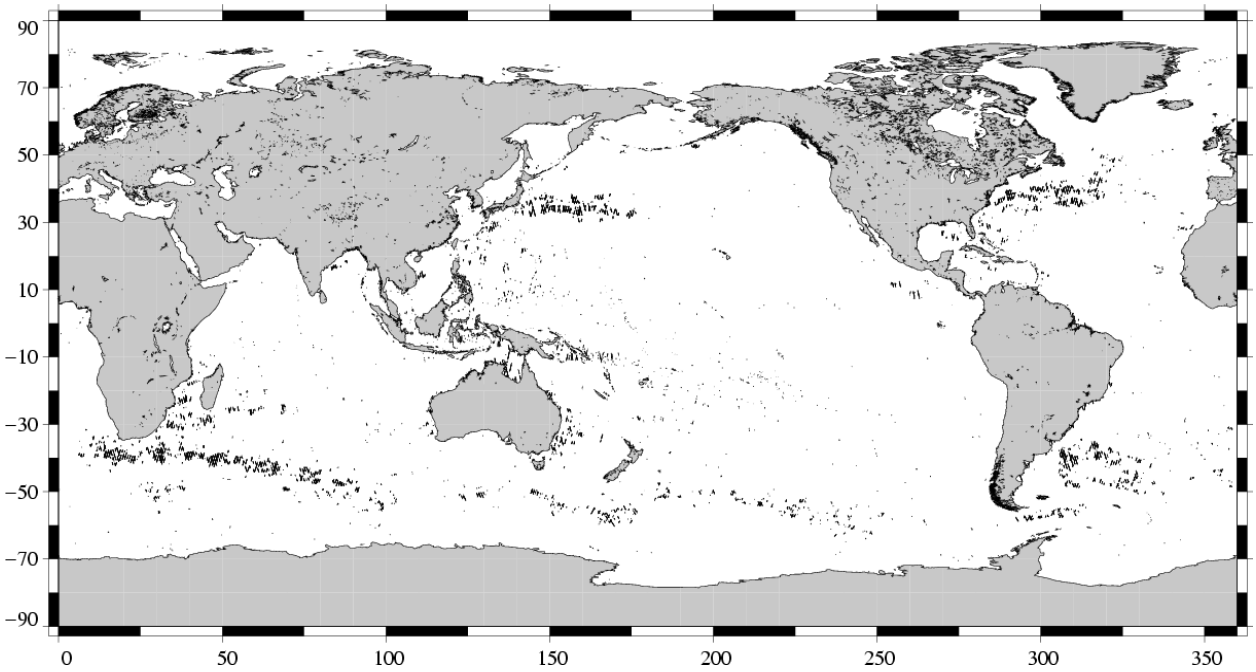


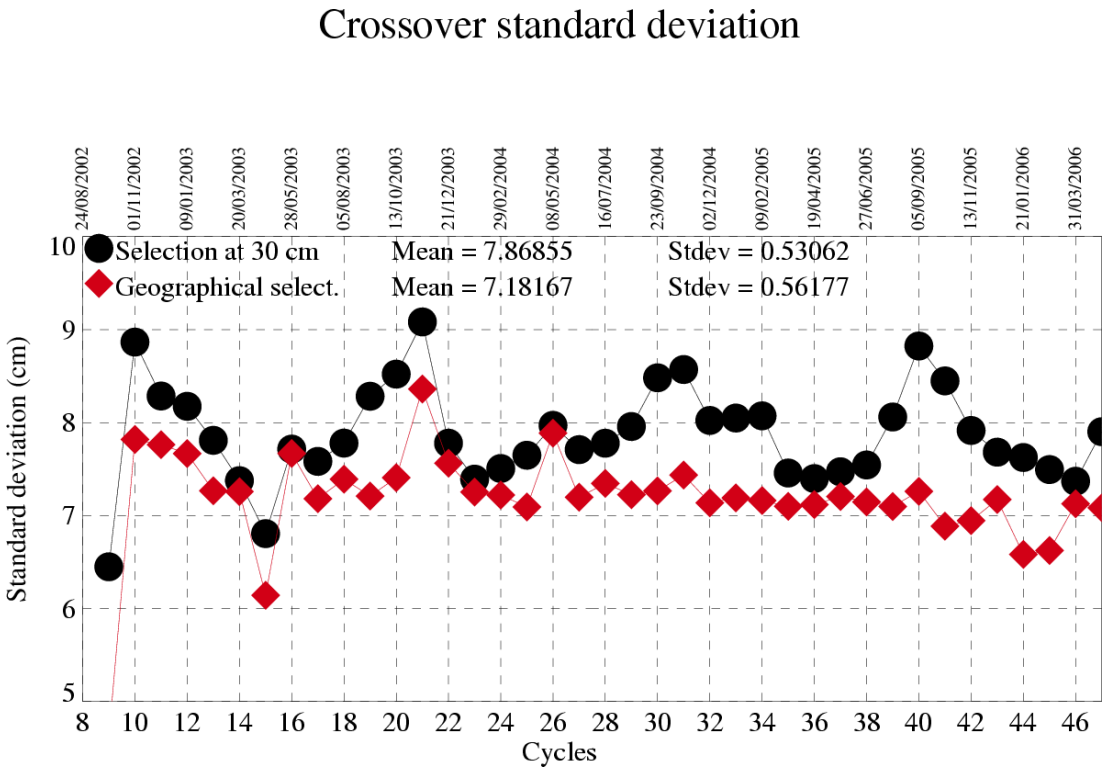
4 Envisat long term performance monitoring

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

4.1 Standard deviation of the differences at crossovers

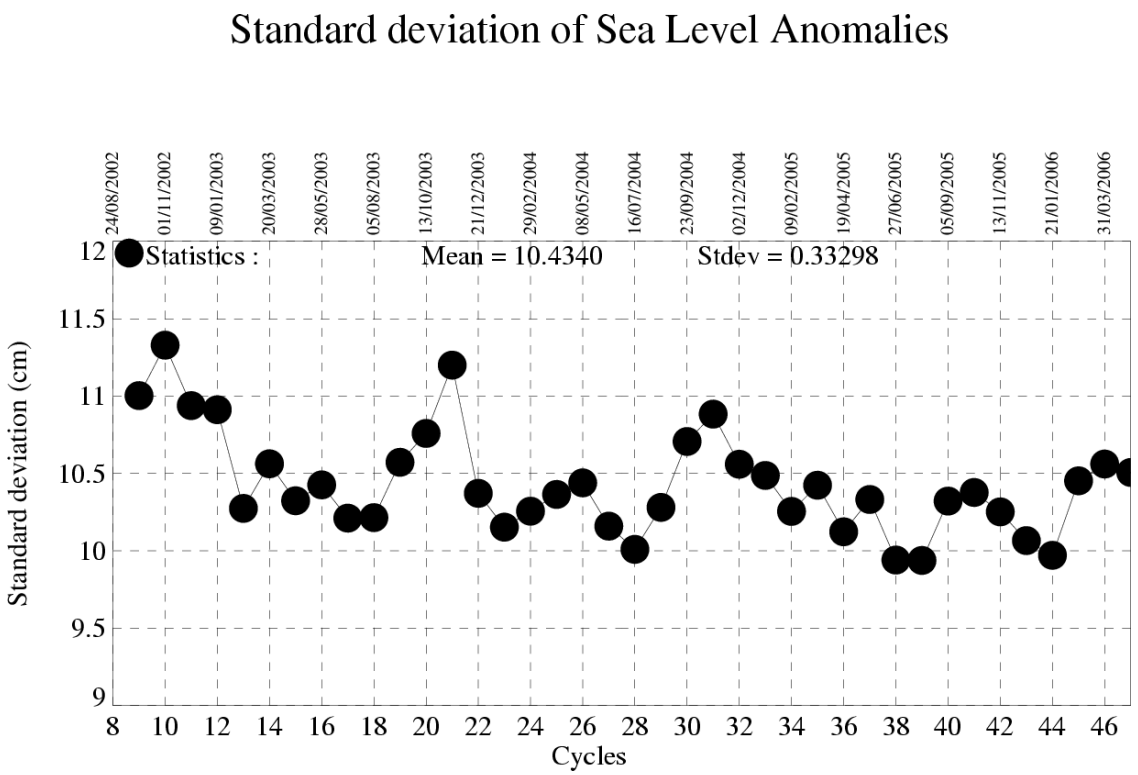
This parameter is plotted as a function of time in a one cycle per cycle basis in the figure below. It is computed after data editing and using 2 aditing selection criteria:

- 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.



4.2 RMS of Sea Level Anomaly

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



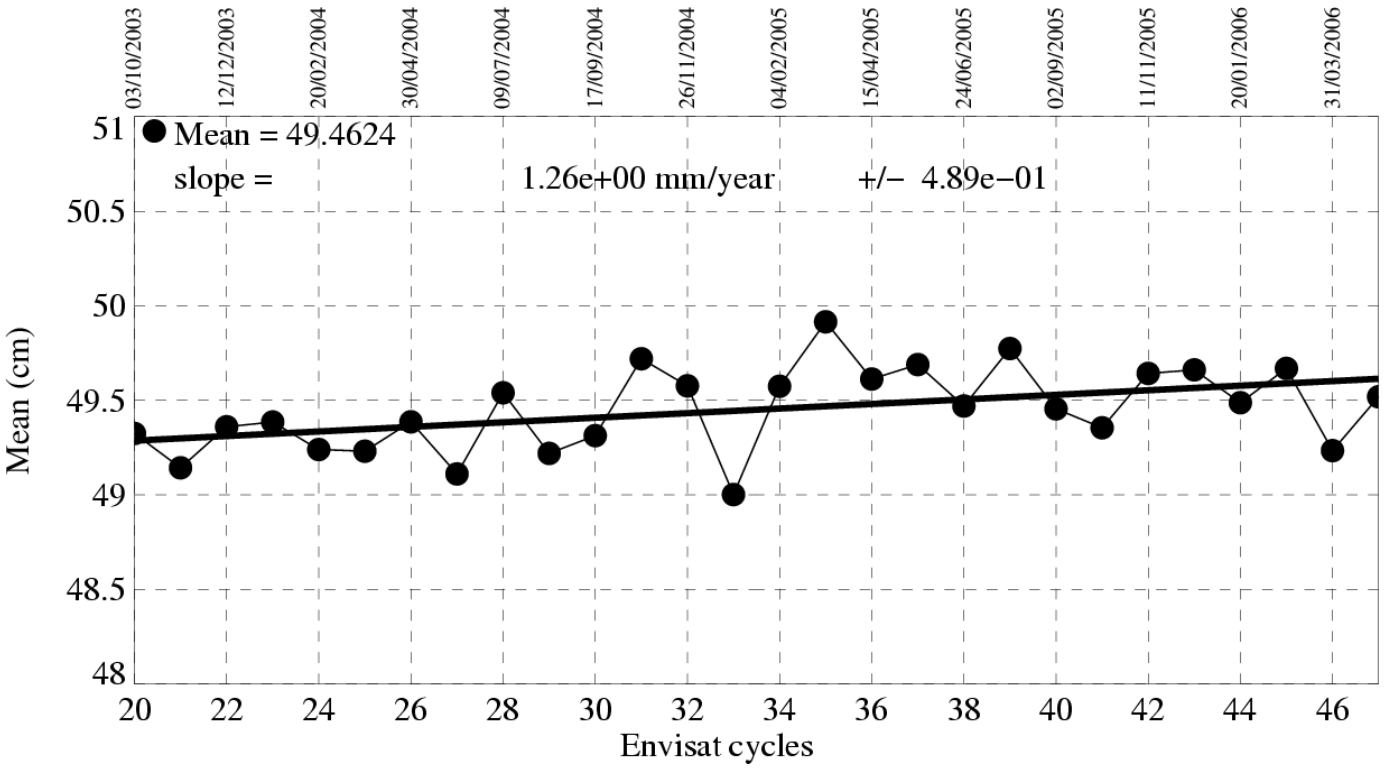
4.3 Mean Sea Level

MSL estimations are performed on a cycle basis averaging Sea Level Anomalies relative to a mean profile.
The SSH is computed using:

- the ECMWF model wet troposphere correction in order to remove the effect of the drift of the 36.5 GHz Brightness Temperature
- the correction provided by ESA to correct the range from the USO drift and bias ([3]) for cycle 9 to 40
- the Labroue (2005 [4]) sea state bias for all cycles

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 and semi-annual signals reduction.

During the first year (cycles 10 to 20) Envisat MSL global trend is not consistent to other flying satellites. This unexplained behavior is under investigation. The following figure shows the MSL global trend from cycle 20 onwards.



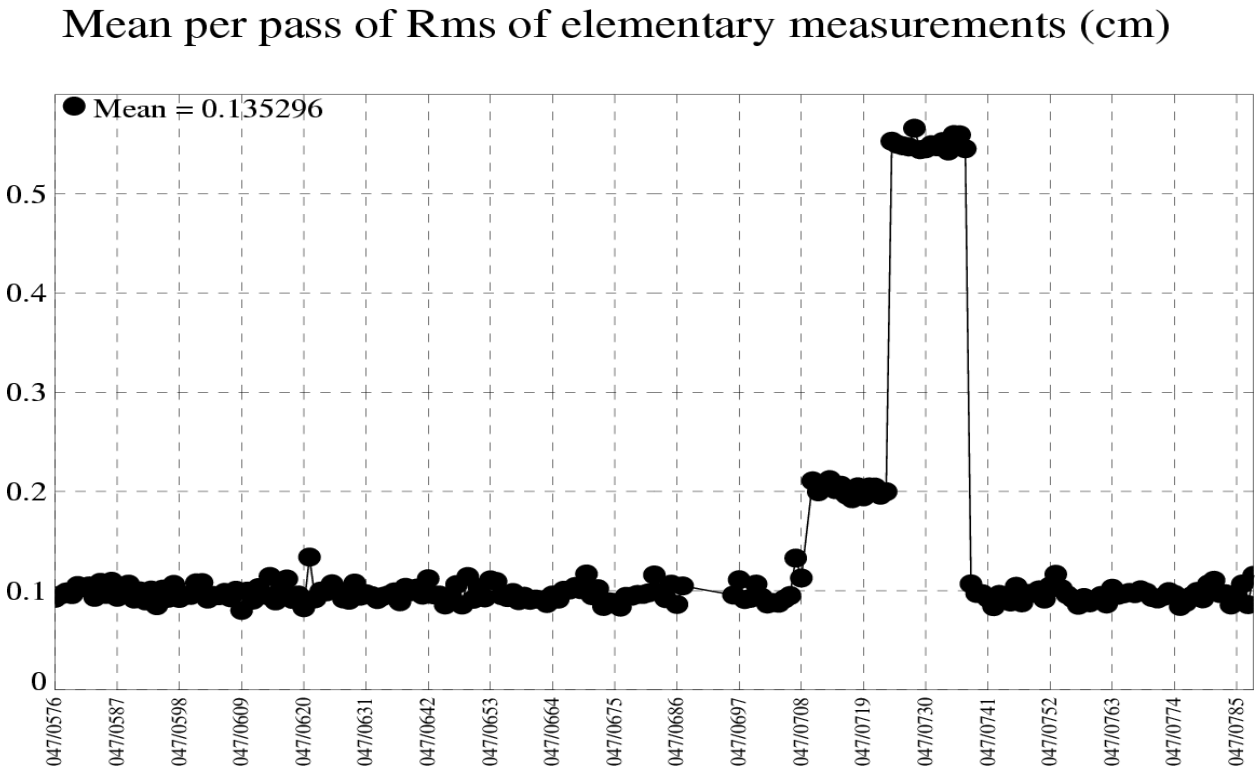
5 Particular investigations

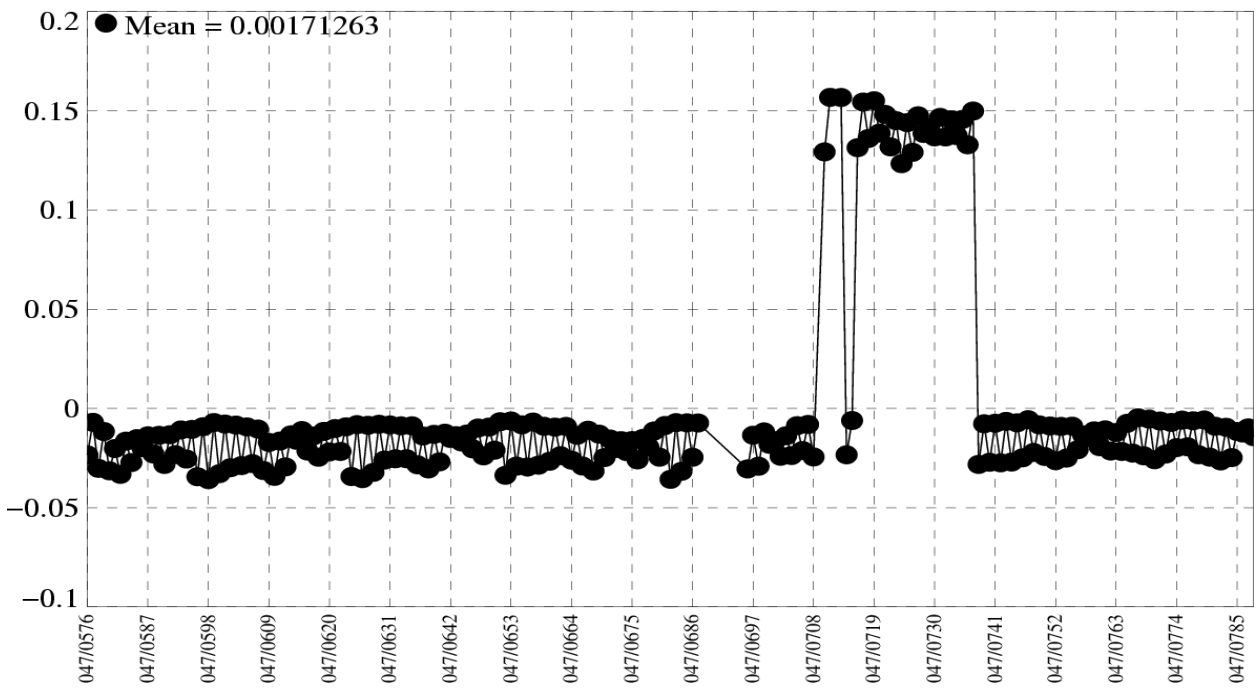
5.1 USO anomaly

For an unknown reason, a change of behaviour of the Ultra Stable Oscillator (USO) clock frequency occurred in February 2006. Cycle 47 in Ra2 side A is entirely affected by this anomaly. The quality assessment of these data has been done using the USO temporary correction provided by ESA. Users are strongly advised not to use the range parameter in Ku and S Band without this correction. More information is available on http://earth.esa.int/pcs/envisat/ra2/auxdata/.

5.2 RA-2 Chirp Bandwidth changes

Before the switch, on 12th-13th May, a special operation was executed to limit RA-2 Chirp Bandwidth to 80MHz (starting from 12/05/2006 at 15:51:37, pass 710) and then 20 MHz (starting from 13/05/2006 at 03:57:57, Pass 724). The instrument was returned to 320MHz on 13/05/2006 at 15:10:17, Pass 738. The figures below show the changes visible on the monitoring of the rms of elementary measurements and the dual ionosphere correction over ocean.





Users are strongly advised not to use passes 710-737.

References

[1] Abdalla, S., "A wind retrieval algorithm for satellite radar altimeters", ECMWF Technical Memorandum, in preparation, 2006.

[2] EOO/EOX, October 2005, Information to the Users regarding the Envisat RA2/MWR IPF version 5.02 and CMA 7.1 Available at http://earth.esa.int/pcs/envisat/ra2/articles/

[3] Martini A., 2003: Envisat RA-2 Range instrumental correction : USO clock period variation and associated auxiliary file, Technical Note ENVI-GSEG-EOPG-TN-03-0009 Available at http://earth.esa.int/pcs/envisat/ra2/articles/USO_clock_corr_aux_file.pdf http://earth.esa.int/pcs/envisat/ra2/auxdata/

[4] Labroue S., 2005: RA2 ocean and MWR measurement long term monitoring 2005 report for WP3, Task 2 SSB estimation for RA2 altimeter, Technical Note CLS-DOS-NT-05-200