Envisat GDR
Quality Assessment Report

Cycle 075

22-12-2008 / 26-01-2009

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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 V5.06 and the CMA Reference Software V9.2_01.

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 3).

2.2. Parameters

The parameters used to compute the sea surface height (SSH) for Envisat are :
- Ku range (ocean retracking)
- POE orbit
- GIM 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

-This cycle is not impacted by the USO anomaly. However, users are strongly advised not to use the range parameter in Ku and S Band without the USO correction provided by ESA. (see section efParticular).
-The S-band parameters, as well as the dual ionospheric correction are not relevant and must not be used from Cycle 65 pass 289. Users are advised to use the Ionospheric correction from GIM model, which is available in GDR data products (see section).

2.4. Platform and instrument events

None.

2.5. Cycle quality and performances

Good general results are obtained for this cycle of data.

The crossover standard deviation is 7.05 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 .

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.

2.7. Impact of product evolution CMA version 9.2_01 for the SSH calculation

2.7.1. New POE orbit solution

From the cycle 68 onward, new standards are used for the computation of the Envisat Precise Orbit Estimation (POD GDR-C configuration).
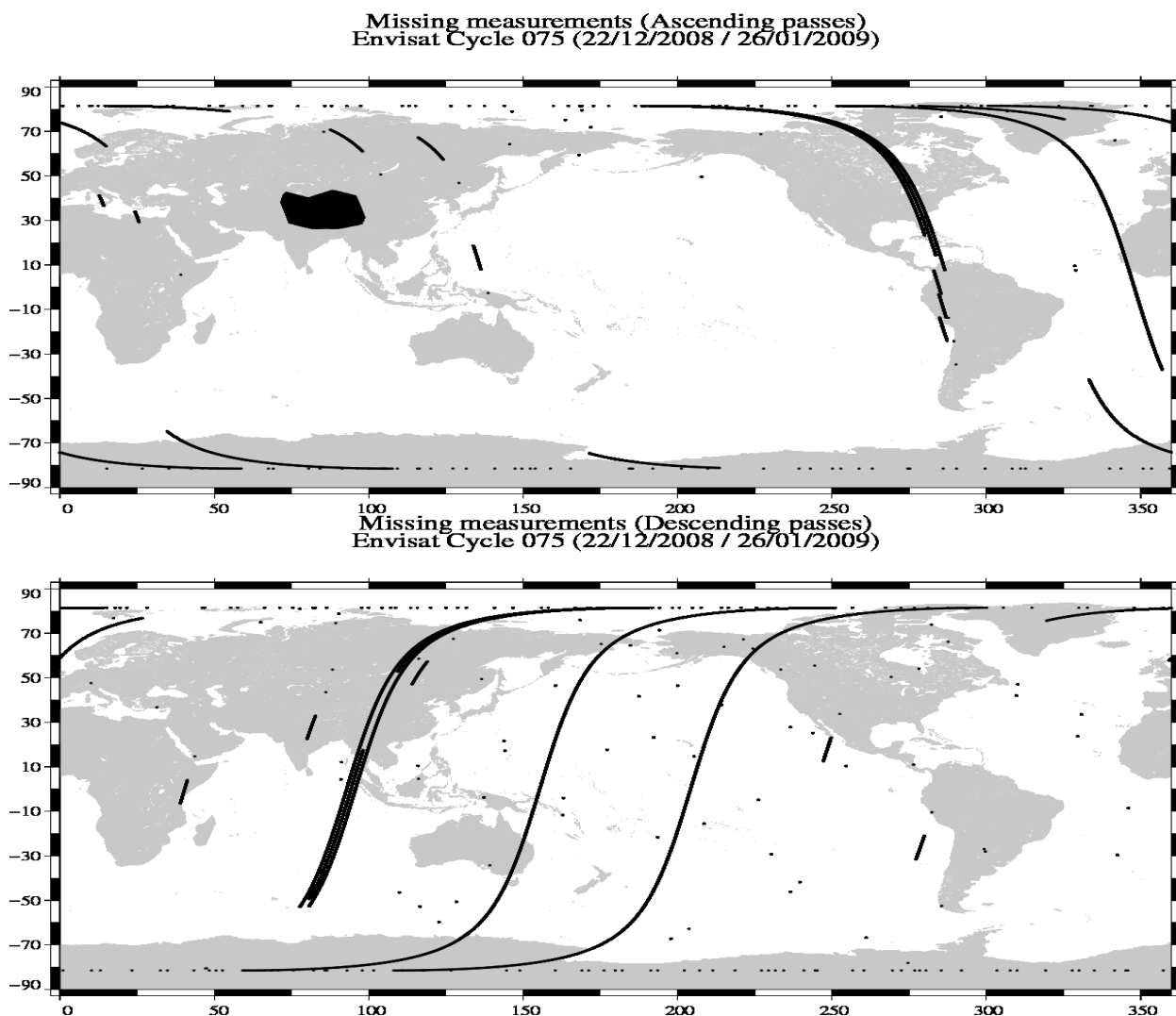
2.7.2. MOG2D correction

From the cycle 68 onward, data are produced with the new Dynamic Atmospheric Correction (DAC/MOG2D High Resolution).

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

1780551 are present, and 28720 (1.6%) are missing. The maps below illustrate missing 1Hz measurements in the GDRs, with respect to a 1 Hz sampling of a nominal repeat track.

Missing measurements (Ascending passes)
Envisat Cycle 075 (22/12/2008 / 26/01/2009)

Missing measurements (Descending passes)
Envisat Cycle 075 (22/12/2008 / 26/01/2009)

1000 passes produced over 1002. 2 passes are missing :
- Pass 232 : No Level 1B data
- Pass 314 : No Level 1B data

3.2. Orbit quality

Good.

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

Parameter	Nb rejected	% rejected
Radiometer land flag	46069	3.05
Ice flag	301697	20.00
	10	0.00

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.
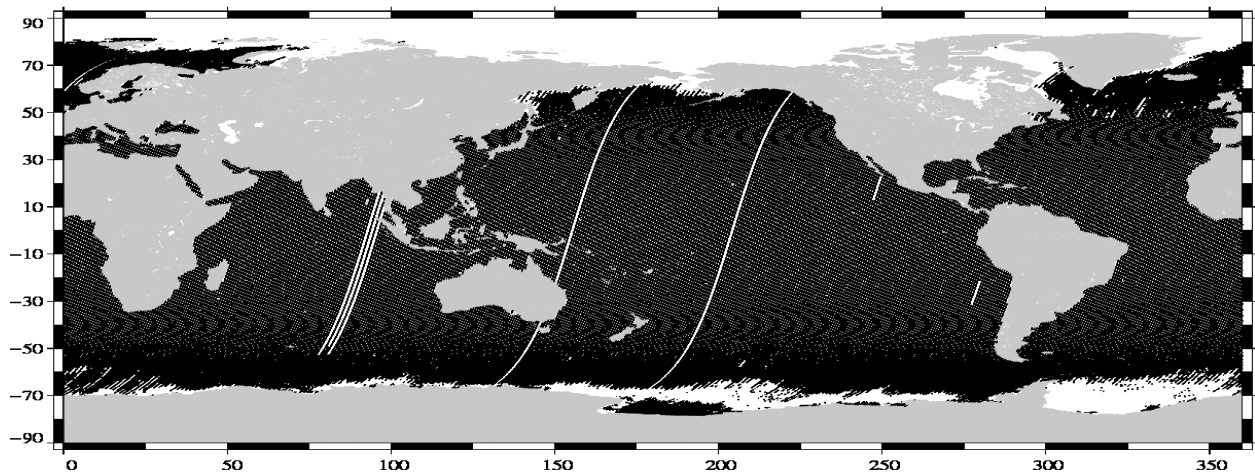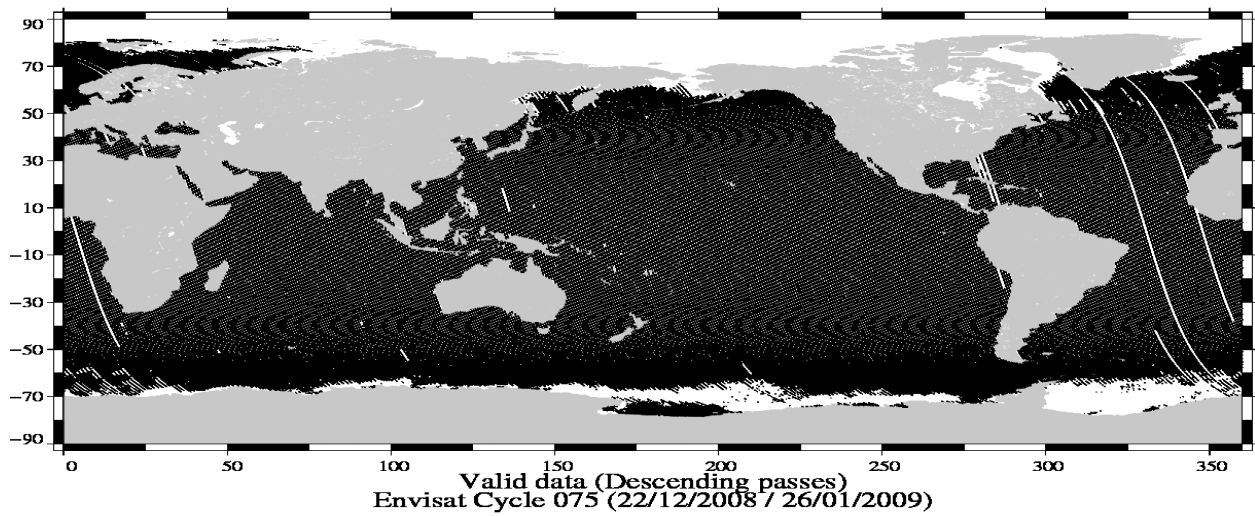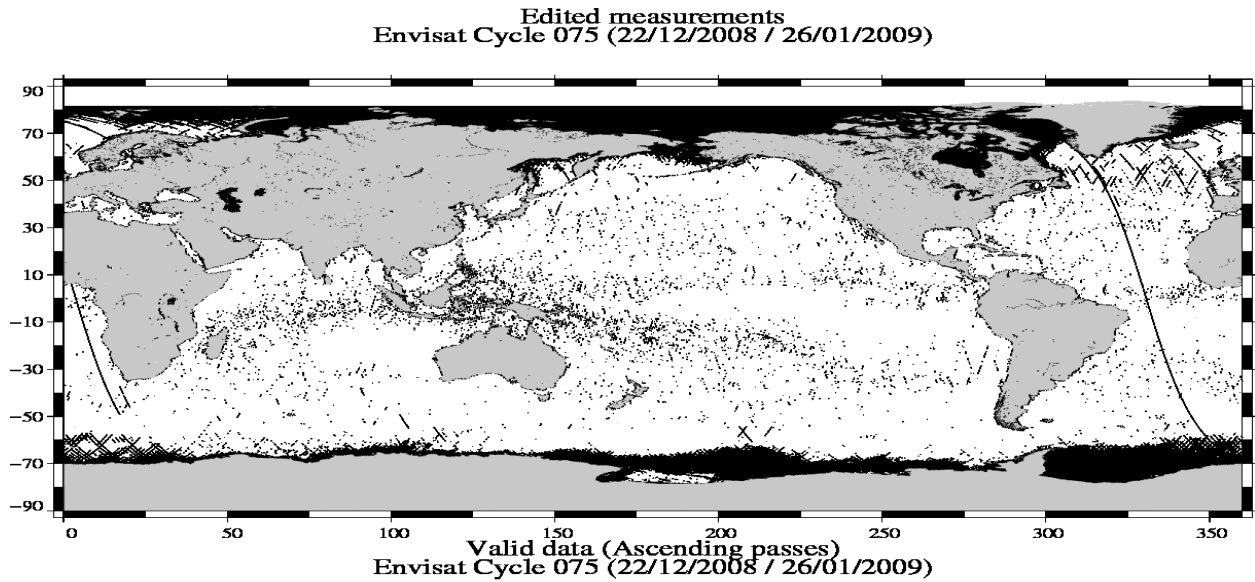
The next table gives for each tested parameter, minimum and maximum thresholds, the number and the percentage of points removed.

Parameters	Min Thres.	Max Thres.	Nb rejected	% rejected
Sea surface height (m)	-130.000	100.000	991	0.07
Variability relative to MSS (m)	-2.000	2.000	7318	0.51
Number of 18Hz valid points	10.000	-	335	0.02
Std. deviation of 18Hz range (m)	0.000	0.250	14034	0.98
Off nadir angle from waveform (deg2)	-0.200	0.160	4788	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	4576	0.32
GIM Ionospheric correction (m)	-0.400	0.040	0	0.00
Significant wave height (m)	0.000	11.000	1559	0.11
Sea state Bias (m)	-0.500	0.000	3254	0.23
Backscatter coefficient (dB)	7.000	30.000	2685	0.19
GOT00 ocean tide height (m)	-5.000	5.000	2300	0.16
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	204	0.01

A final editing is then performed on corrected sea surface height, using a spline fitting procedure, leading to remove 661 (0.05 %) measurements.

3.3.2. Figures

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

Edited measurements
Envisat Cycle 075 (22/12/2008 / 26/01/2009)

Valid data (Ascending passes)
Envisat Cycle 075 (22/12/2008 / 26/01/2009)

Valid data (Descending passes)
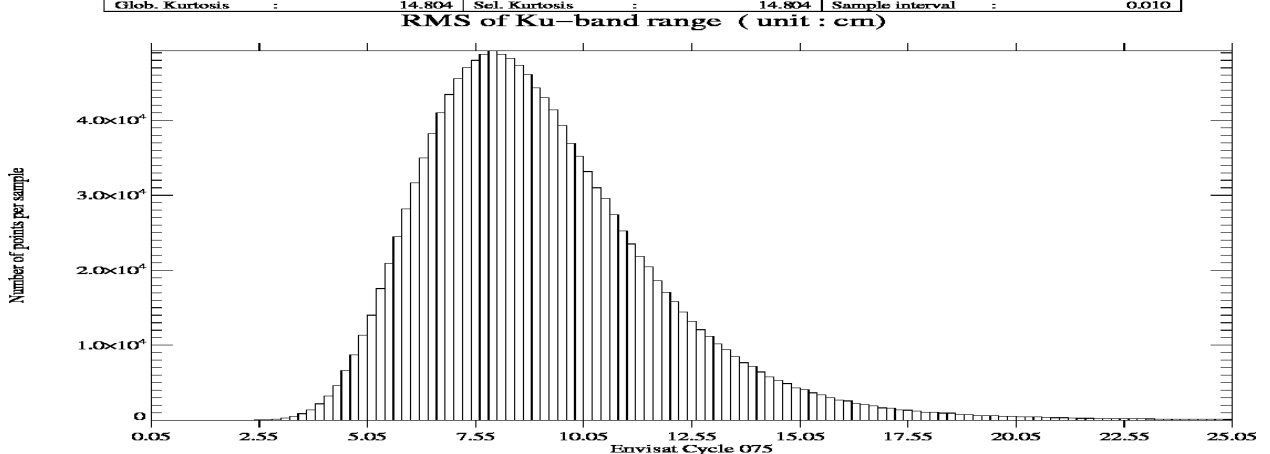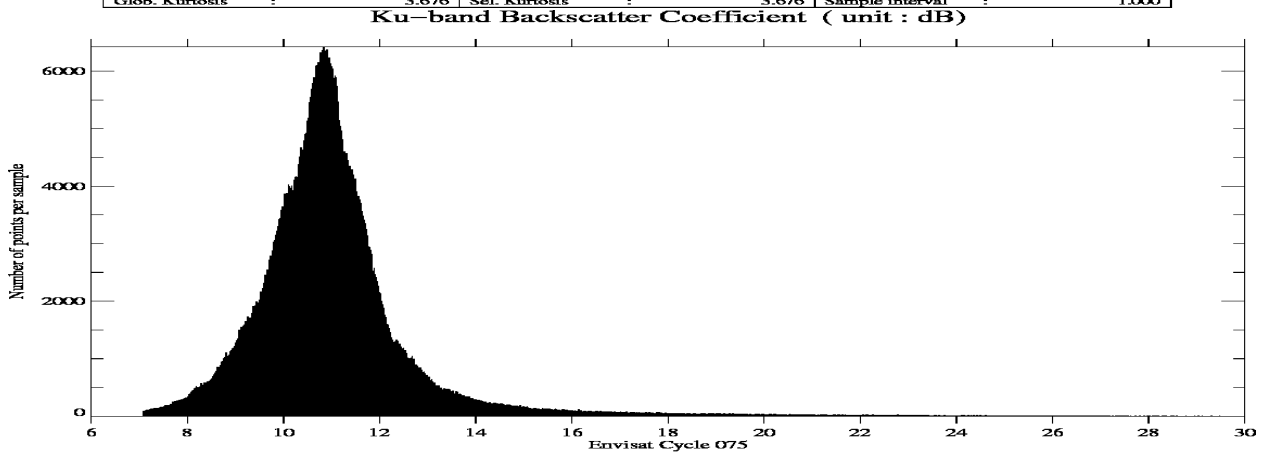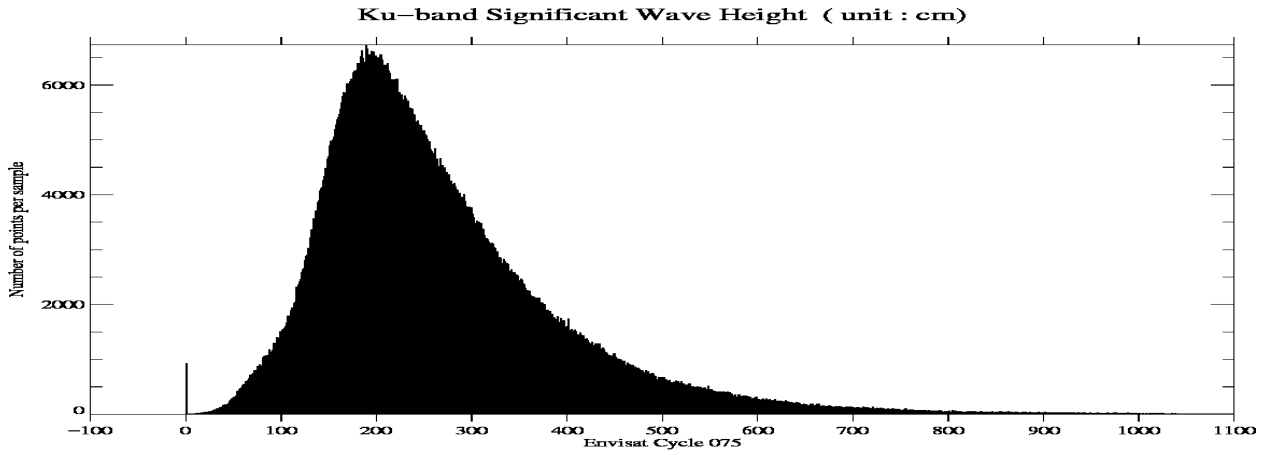**Envisat Cycle 075 (22/12/2008 / 26/01/2009)**

3.3.3. Comments

Wet areas appear in the plot of removed data. Similar features are observed with other altimeters (T/P, Jason) mainly due to rain comtamination.
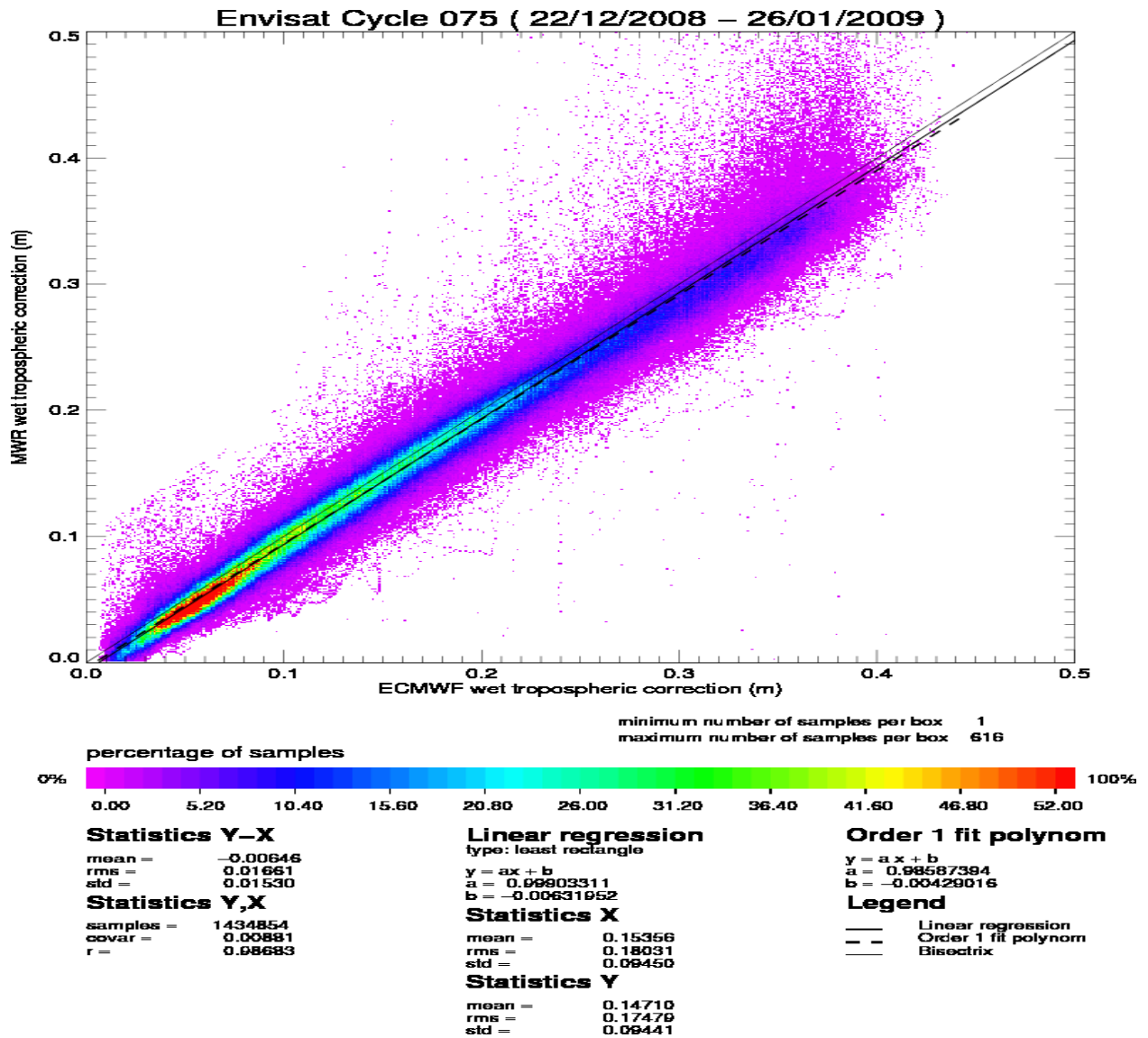
3.4. Altimeter parameters

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.

Ku-band Significant Wave Height (unit : cm)

Glob. Nb of pts	:	1434854	Sel. Nb of pts	:	1434854	Glob. Maximum	:	1099.500
Glob. Mean	:	264.917	Sel. Mean	:	264.917	Glob. Minimum	:	0.000
Glob. Std	:	127.262	Sel. Std	:	127.262	Sel. Maximum	:	1099.500
Glob. Skewness	:	1.504	Sel. Skewness	:	1.504	Sel. Minimum	:	0.000
Glob. Kurtosis	:	3.676	Sel. Kurtosis	:	3.676	Sample interval	:	1.000

Ku-band Backscatter Coefficient (unit : dB)

Glob. Nb of pts	:	1434854	Sel. Nb of pts	:	1434854	Glob. Maximum	:	29.820
Glob. Mean	:	11.003	Sel. Mean	:	11.003	Glob. Minimum	:	7.080
Glob. Std	:	1.724	Sel. Std	:	1.724	Sel. Maximum	:	29.820
Glob. Skewness	:	2.699	Sel. Skewness	:	2.699	Sel. Minimum	:	7.080
Glob. Kurtosis	:	14.804	Sel. Kurtosis	:	14.804	Sample interval	:	0.010

RMS of Ku-band range (unit : cm)

Glob. Nb of pts	:	1434854	Sel. Nb of pts	:	1434854	Glob. Maximum	:	25.000
Glob. Mean	:	8.970	Sel. Mean	:	8.970	Glob. Minimum	:	1.700
Glob. Std	:	2.745	Sel. Std	:	2.745	Sel. Maximum	:	25.000
Glob. Skewness	:	1.132	Sel. Skewness	:	1.132	Sel. Minimum	:	1.700
Glob. Kurtosis	:	2.382	Sel. Kurtosis	:	2.382	Sample interval	:	0.200

3.5.   Radiometer

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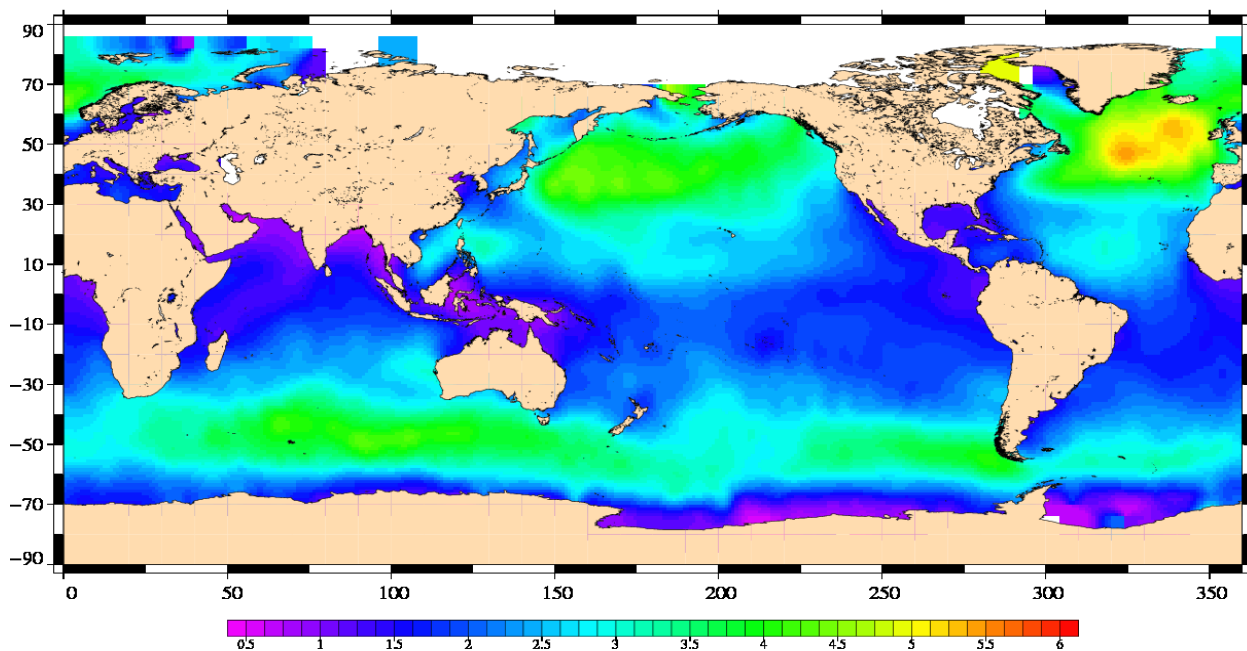

Envisat Cycle 075 (22/12/2008 – 26/01/2009)

minimum number of samples per box   1
maximum number of samples per box   616

percentage of samples

Statistics Y-X	Linear regression	Order 1 fit polynom
mean = −0.00646	type: least rectangle	y = a x + b
rms = 0.01661		a = 0.98587394
std = 0.01530	y = ax + b	b = −0.00429016
	a = 0.99903311	
Statistics Y,X	b = −0.00631952	**Legend**
samples = 1434854	**Statistics X**	____ Linear regression
covar = 0.00881	mean = 0.15356	_ _ Order 1 fit polynom
r = 0.98683	rms = 0.18031	____ Bisectrix
	std = 0.09450	
	Statistics Y	
	mean = 0.14710	
	rms = 0.17479	
	std = 0.09441	

The radiometer-model mean difference is 0.6 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.

Envisat Cycle 075
22/12/2008 – 26/01/2009
Significant Wave Height (m)

Envisat Cycle 075
22/12/2008 – 26/01/2009
Altimeter wind speed (m/s)
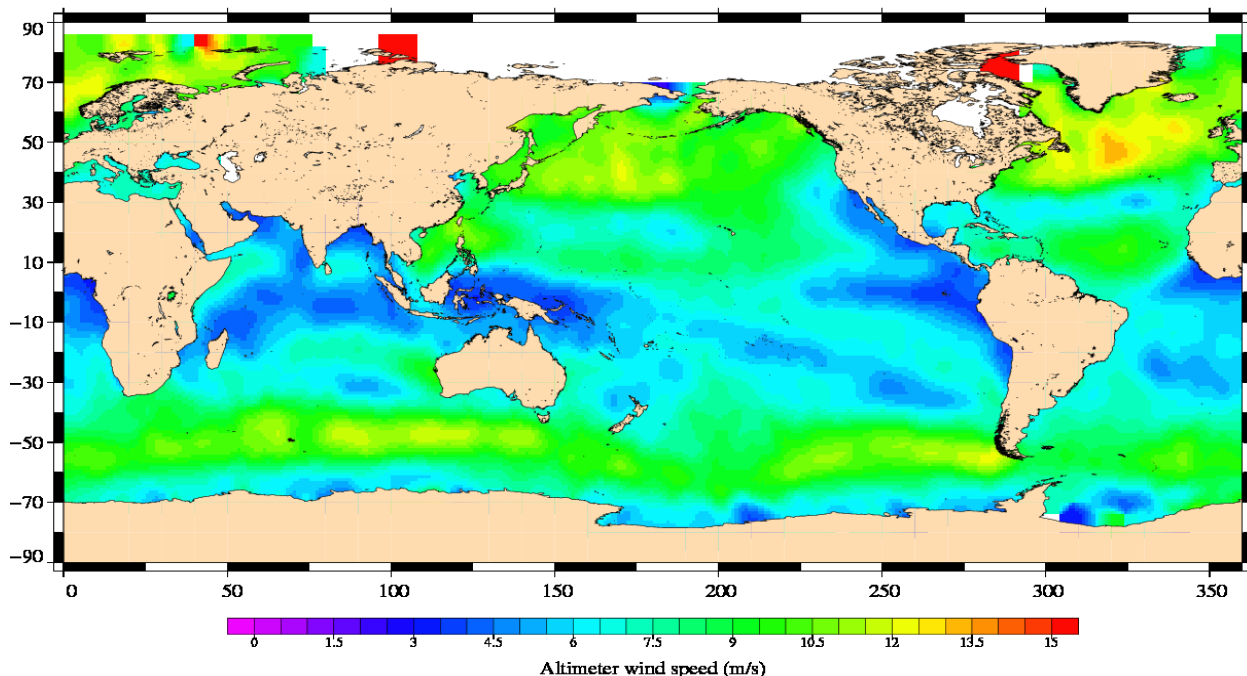
3.7. Crossover statistics

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 8.26 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 7.05 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).

ENEN – CROSSOVER STATISTICS
Impact of geophysical corrections
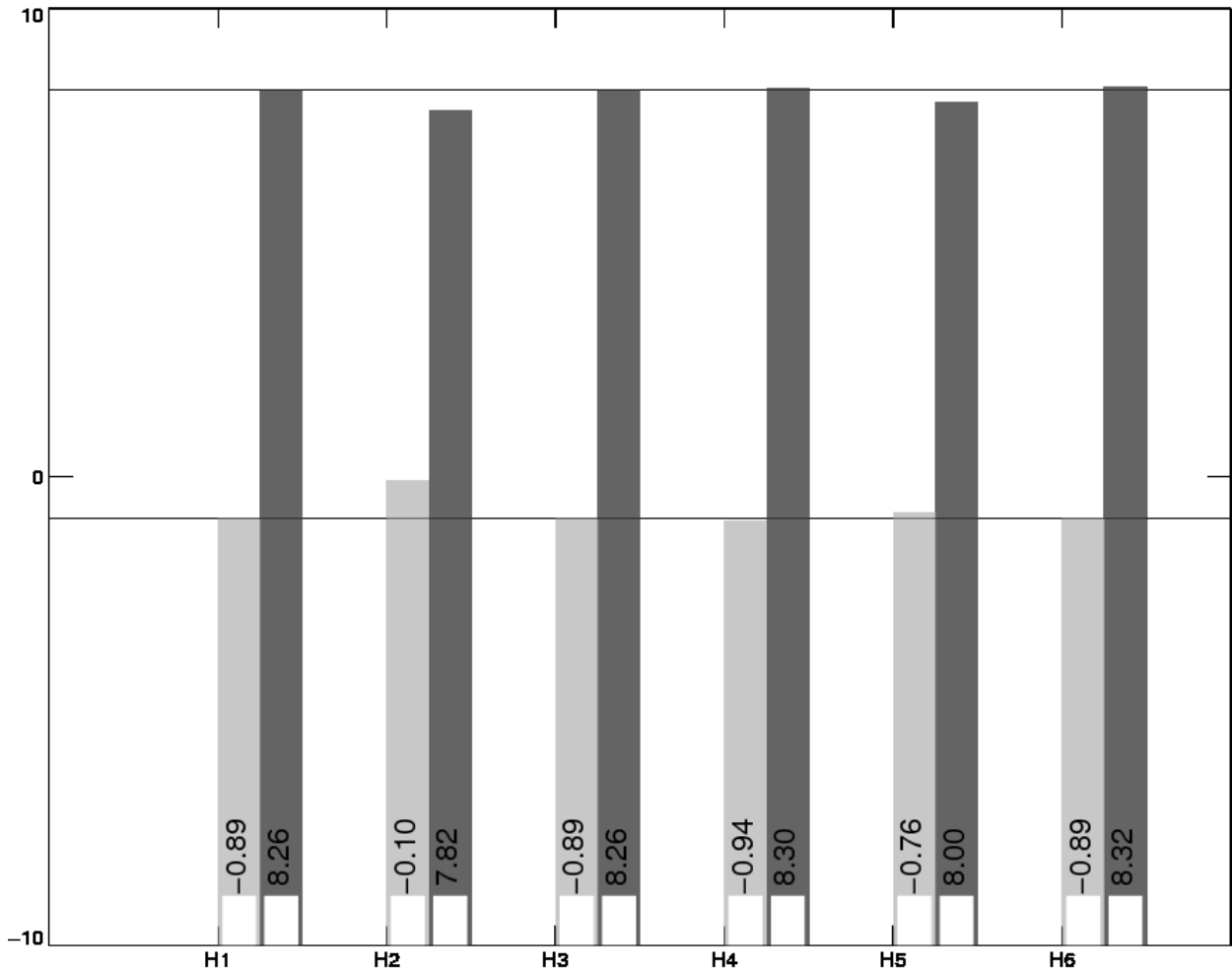
Type of analysis
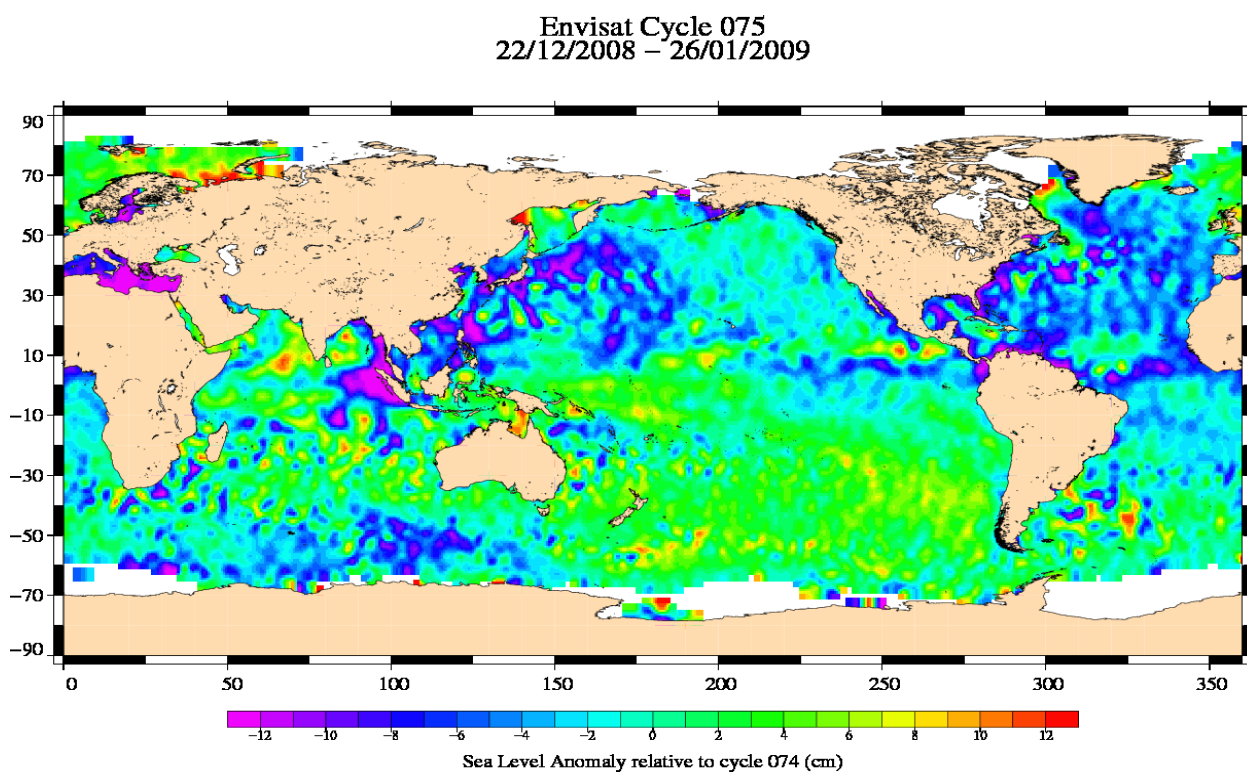differences threshold
none

std
mean

| H1 = SSH | H4 = SSH with DORIS ionospheric correction (in product) |
| H2 = SSH applying a long wave length error (computed) | H5 = SSH with FES tide model (in product) |
| H3 = SSH with GIM ionospheric correction (computed) | 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.

Envisat Cycle 075
22/12/2008 − 26/01/2009

Sea Level Anomaly relative to cycle 074 (cm)

Envisat Cycle 075
22/12/2008 − 26/01/2009

Sea Level Anomaly relative to a 7 year mean (cm)
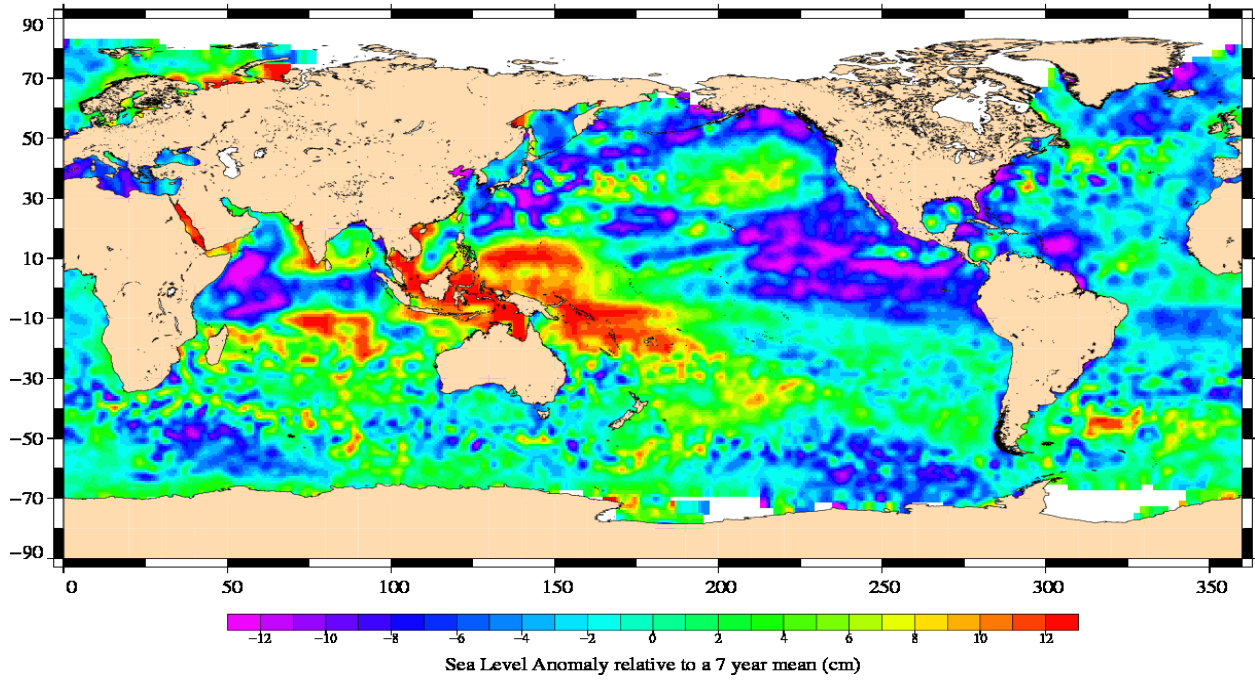
3.8.2. Comparison to a precise Mean Sea Surface

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.
1603990	49.10	10.43

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.
979615.00000000	49.34	9.46

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.

Envisat Cycle 075
22/12/2008 − 26/01/2009

Variability relative to MSS (cm)
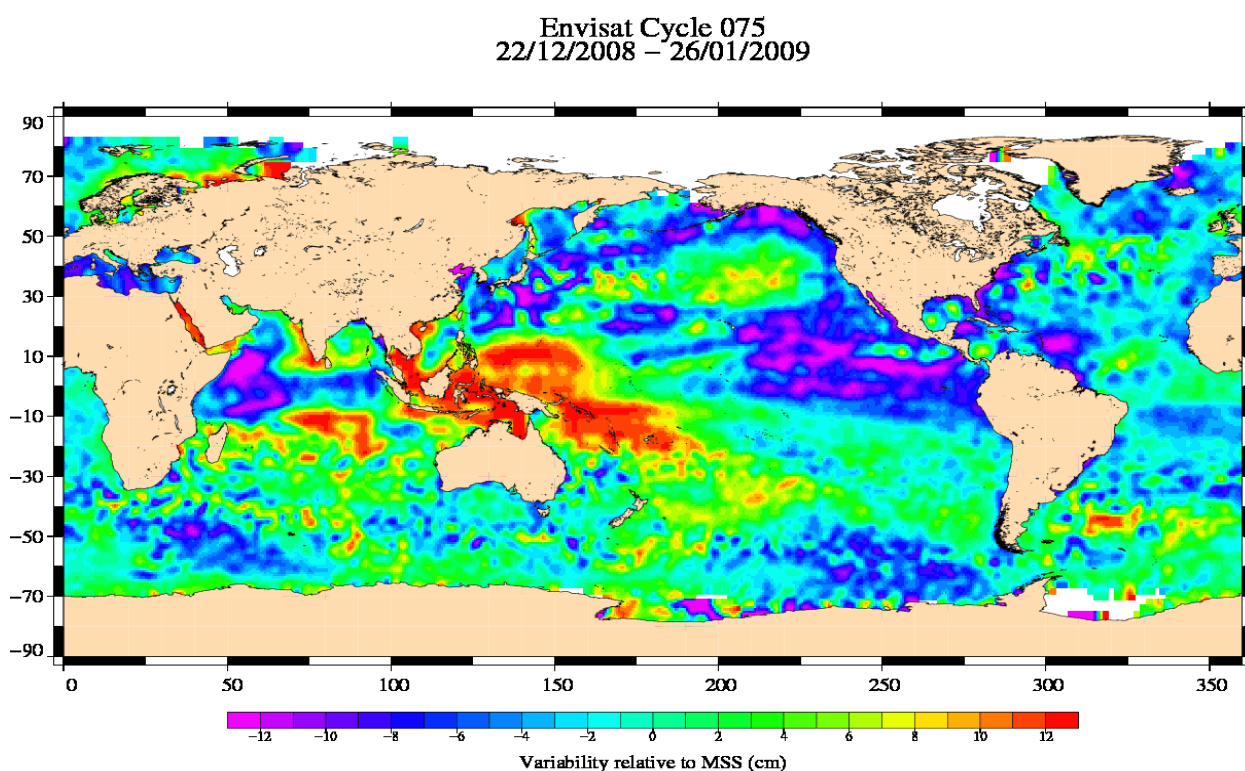
(SSH − MSS) centered, differences greater than 30 cm
Envisat / Cycle 075
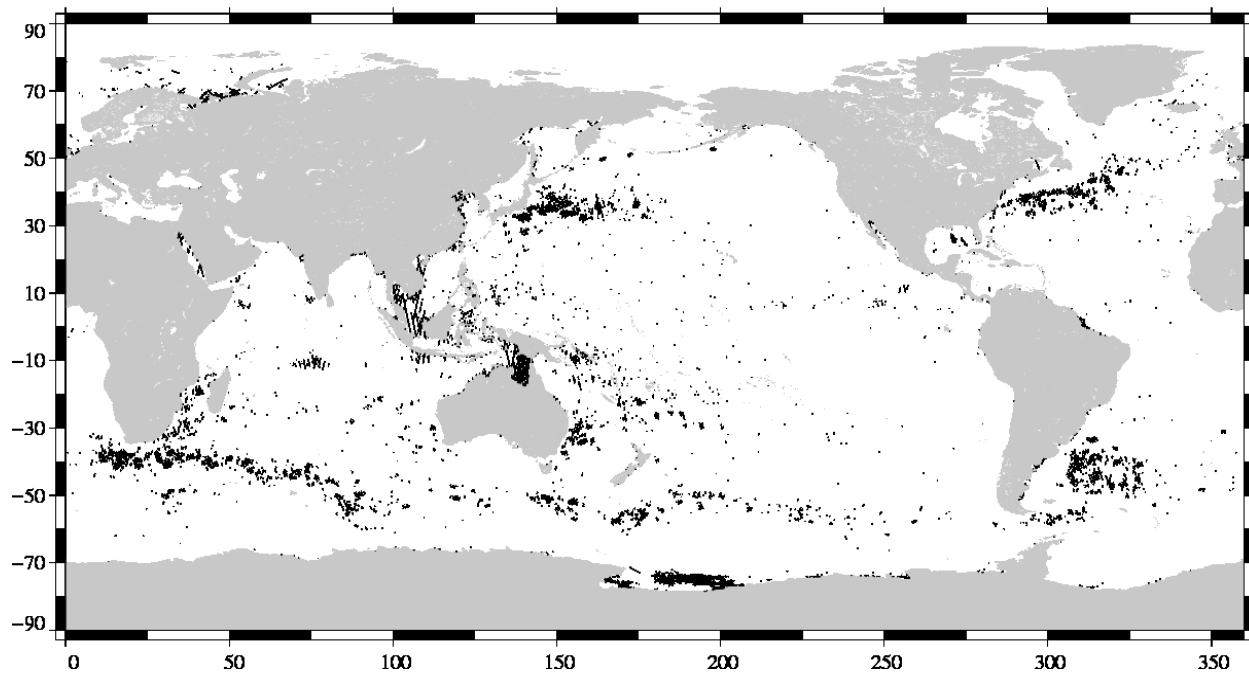
# 4. Envisat long term performance monitoring

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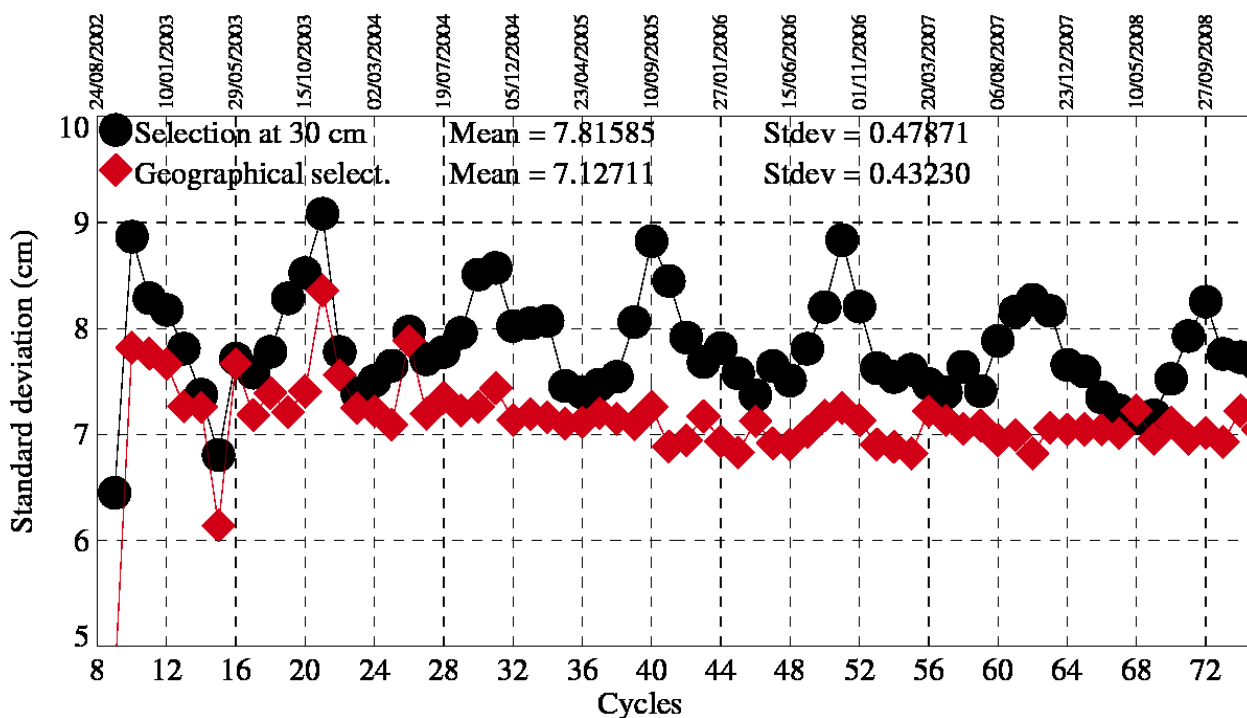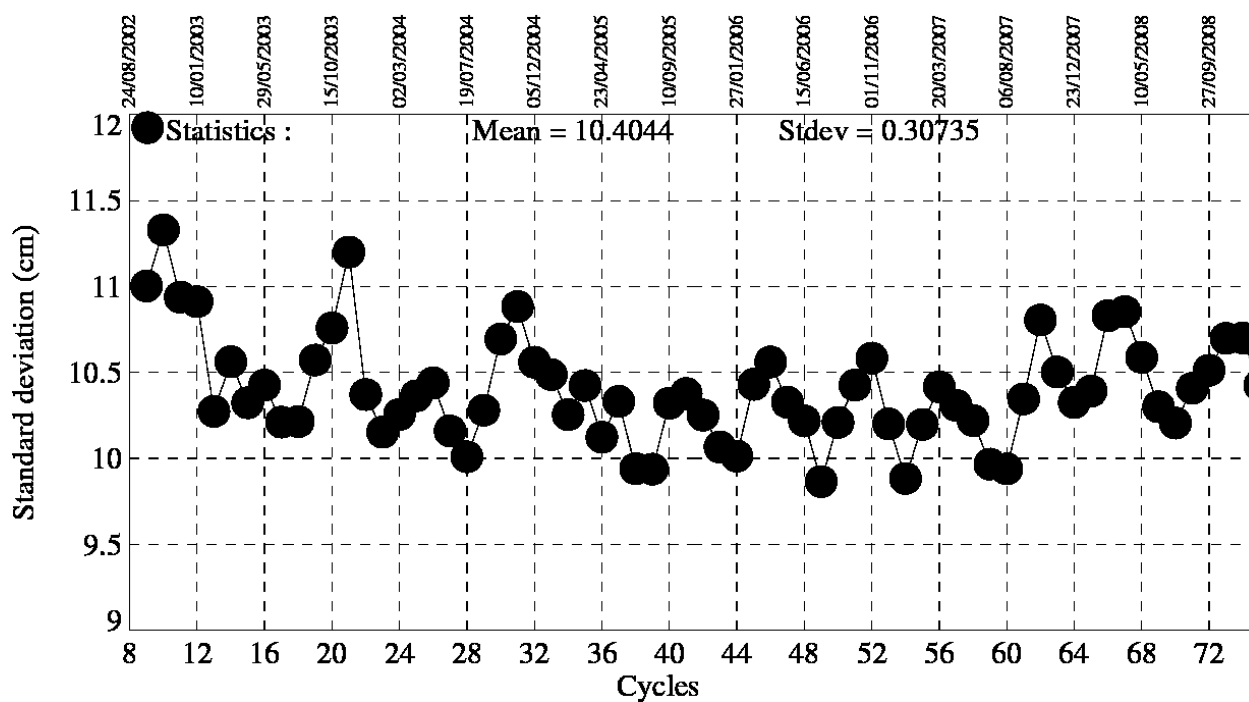
Sea Level Anomalies relative to a mean profile are computed using repeat-track analysis for each Envisat cycle. To monitor Envisat performances and ocean signals, the cycle per cycle standard deviation of the SLA is plotted as a function of time.

Standard deviation of Sea Level Anomalies

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 dual ionopheric correction for cycle 9 to 64 and the GIM ionospheric correction from cycle 65 onwards, with an 8 mm offset applied to take into account the change from the dual ionospheric correction to the GIM ionospheric correction
- 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.
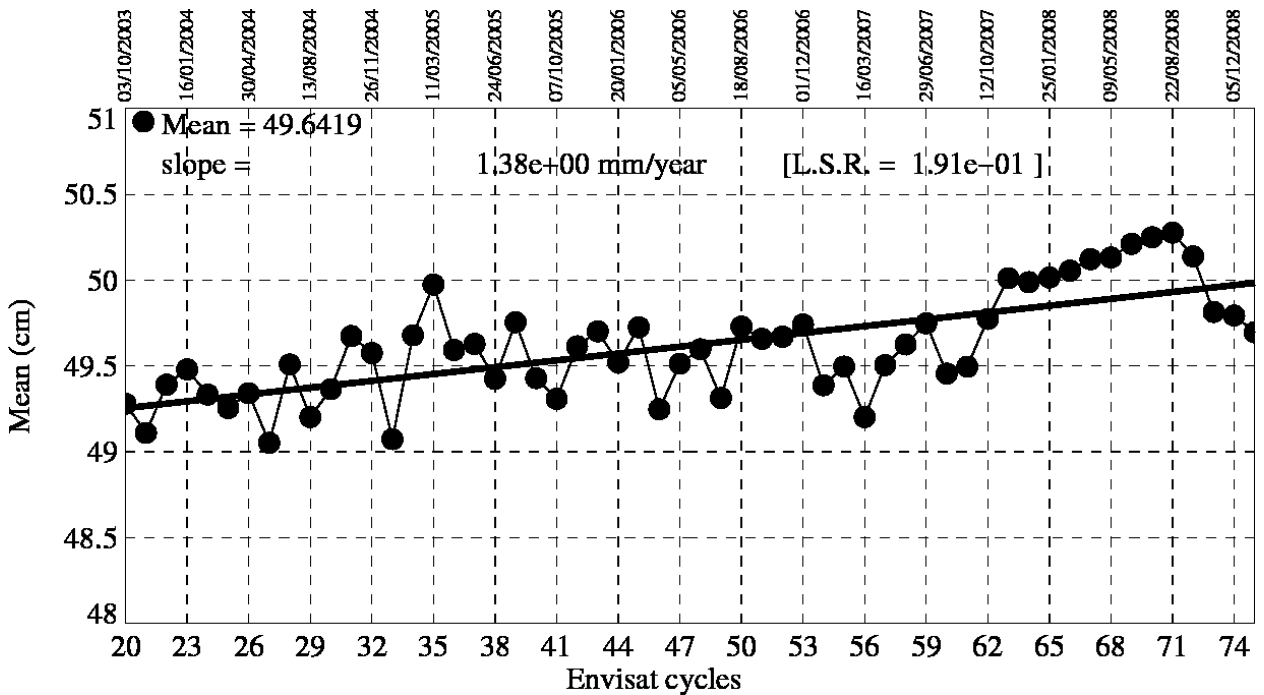
5. Particular investigations

– After a particularly low value of the cyclic crossover mean monitoring on cycle 74, this statistic is now back to a more usual value for cycle 75

– Pass 261 was edited on the SLA criteria (see plot) probably due to a bad handling of the Leap second correction

SLA Envisat Cycle 75, Pass 261 (cm)
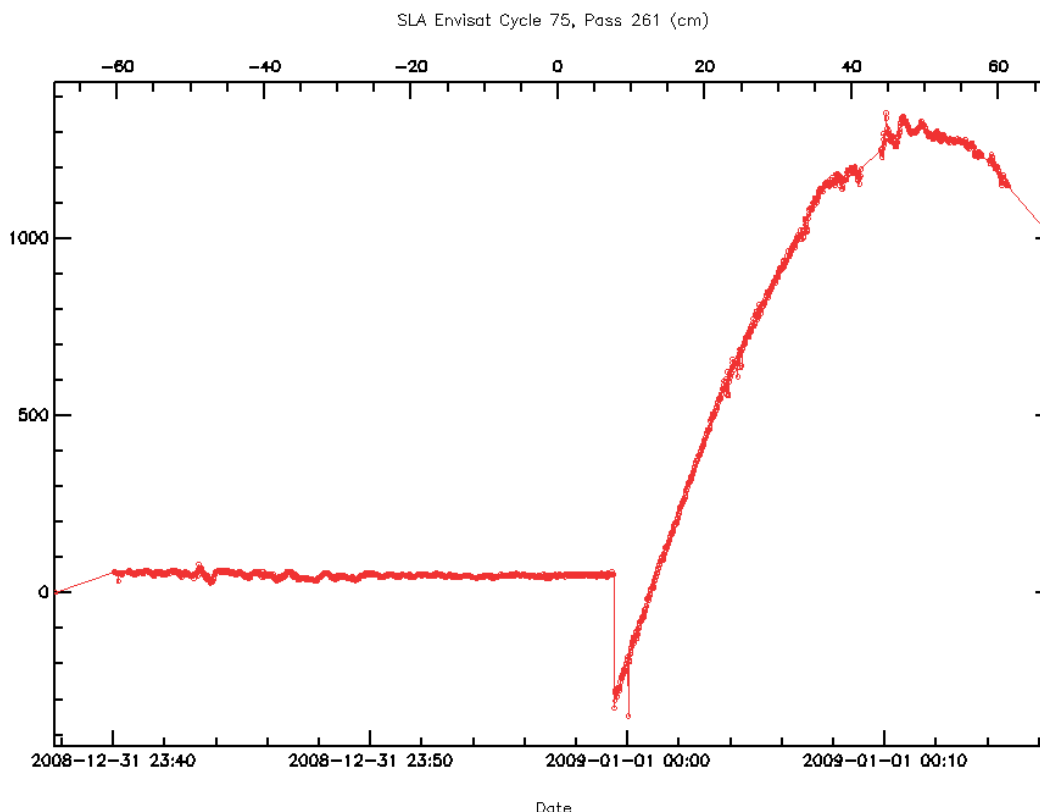
– For an unknown reason, a change of behaviour of the Ultra Stable Oscillator (USO) clock frequency occurred in January 2008. Since Cycle 65 (pass 451 2008/01/23), the anomaly has disappeared. This quality assessment has been done using the USO temporary correction provided by ESA. Users are strongly advised not to use the range parameter in Ku and S Band without this correction, even for the non-anomalous periods, in order to correct the range from the long term drift of the USO device. More information is available on http ://earth.esa.int/pcs/envisat/ra2/auxdata/

– Ten hours after the recovery of the HSM anomaly on the 17 January 2008, a drop of the RA2 S-band transmission power occurred. Consequently, all the S-band parameters, as well as the dual ionospheric correction are not relevant and MUST NOT be used from the following date : 17 January 2008, 23 :23 :40 (Cycle 65 pass 289). Users are advised to use the Ionospheric correction from GIM model, which is available in GDR data products.

Références

[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