



# Envisat GDR Quality Assessment Report

**Cycle 076**

**26-01-2009 / 02-03-2009**

Prepared by :	Y. Faugere, CLS A. Ollivier, CLS N. Granier, CLS	
Accepted by :	G. Dibarboure, CLS	
Approved by :	N. Picot, CNES	



## 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

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This cycle has been produced with the IPF processing chain V5.06 and the CMA Reference Software V9.2\_03.

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

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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

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-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 ).

-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

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Orbit Inclination Maneuver from 2009/01/27 03 :35 :18 to 2009/01/27 05 :49 :30 TAI) with a weak impact on data quality (see editing part).

### 2.5. Cycle quality and performances

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Good general results are obtained for this cycle of data.

The crossover standard deviation is 6.85 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 9.6 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 associated to 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**

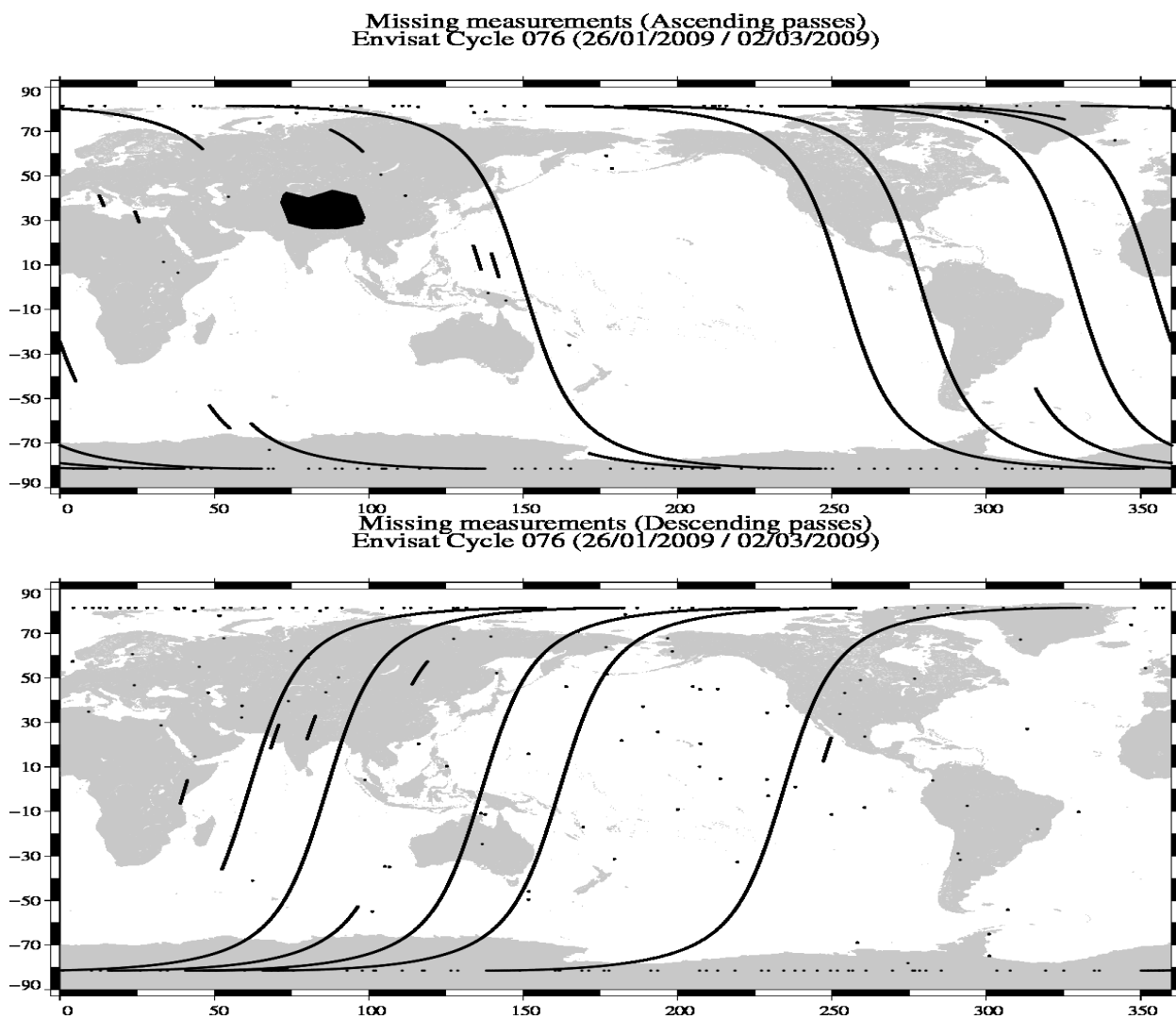
From the cycle 68 onward, data are produced with the new Dynamic Atmospheric Correction (DAC/MOG2D High Resolution).

### 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

1773693 are present, and 37417 ( 2.1%) are missing. The maps below illustrate missing 1Hz measurements in the GDRs, with respect to a 1 Hz sampling of a nominal repeat track.



995 passes produced over 1002. 7 passes are missing :

- Pass 346 to 348 : ARTEMIS problem
- Pass 351 to 353 : ARTEMIS problem
- Pass 512 : 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  $> 10$ cm
- Peakiness  $> 2$

Parameter	Nb rejected	% rejected
Radiometer land flag	50392	3.28
Ice flag	269662	17.57
	14	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.

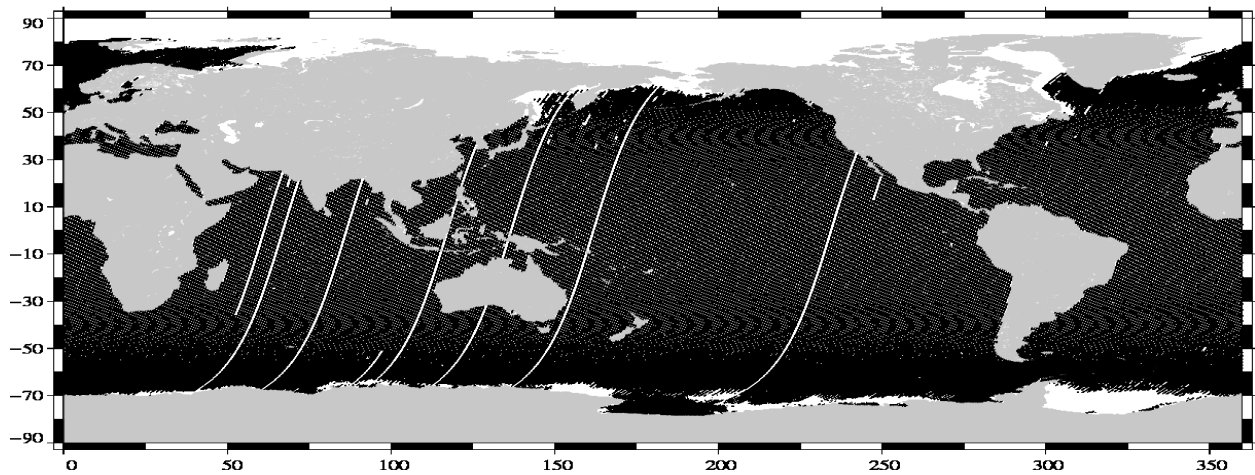
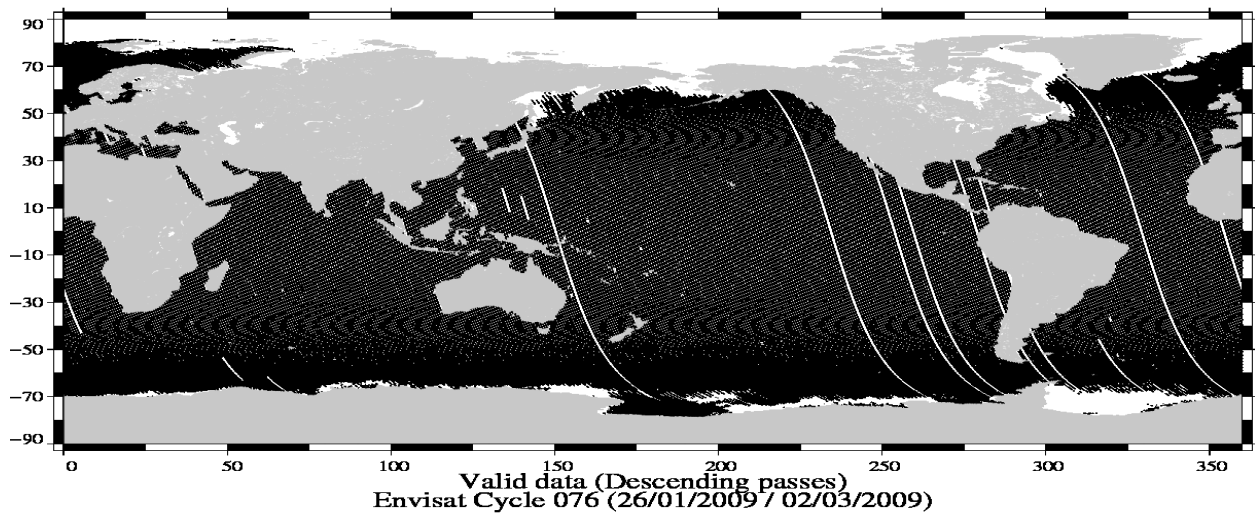
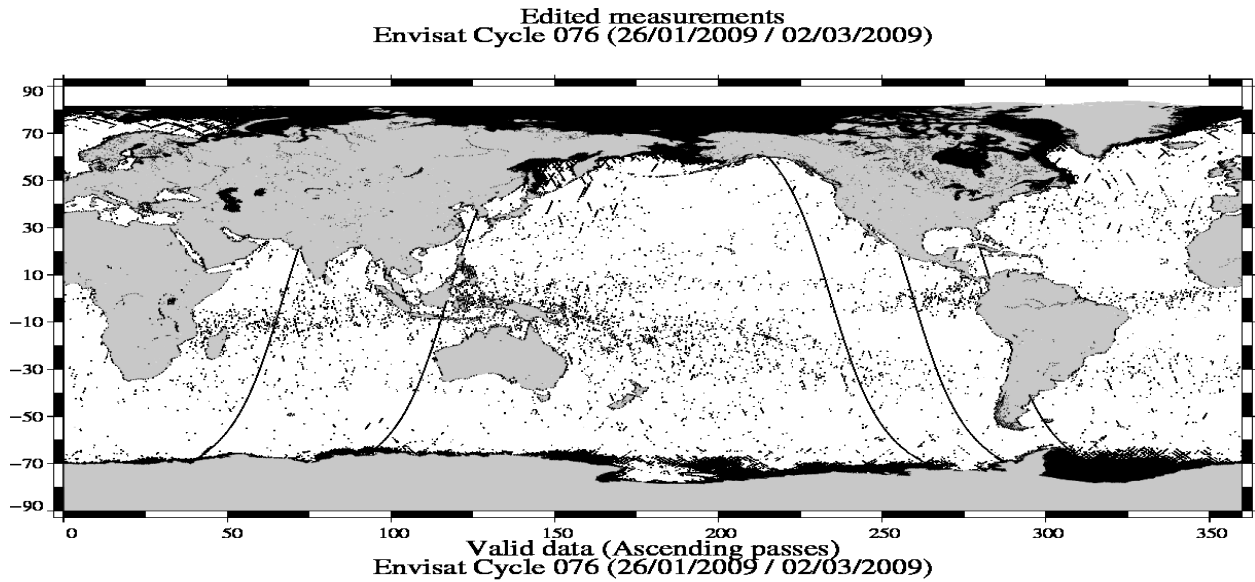
The next table gives for each tested parameter, minimum and maximum thresholds, the number and the percentage of points removed.

Parameters	Min Thres.	Max Thres.	Nb rejected	% rejected
Sea surface height (m)	-130.000	100.000	887	0.06
Variability relative to MSS (m)	-2.000	2.000	6236	0.43
Number of 18Hz valid points	10.000	-	331	0.02
Std. deviation of 18Hz range (m)	0.000	0.250	14525	0.99
Off nadir angle from waveform (deg2)	-0.200	0.160	5534	0.38
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	3601	0.25
GIM Ionospheric correction (m)	-0.400	0.040	0	0.00
Significant wave height (m)	0.000	11.000	1635	0.11
Sea state Bias (m)	-0.500	0.000	2914	0.20
Backscatter coefficient (dB)	7.000	30.000	2723	0.19
GOT00 ocean tide height (m)	-5.000	5.000	2154	0.15
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	195	0.01

A final editing is then performed on corrected sea surface height, using a spline fitting procedure, leading to remove 712 ( 0.05 %) 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

4 passes (6 7 10 11 ) are entirely edited on the radiometer land flag (no MWR correction)

Manoeuvres from 27 and 28/01/2009 have impacted the tracks for passes :

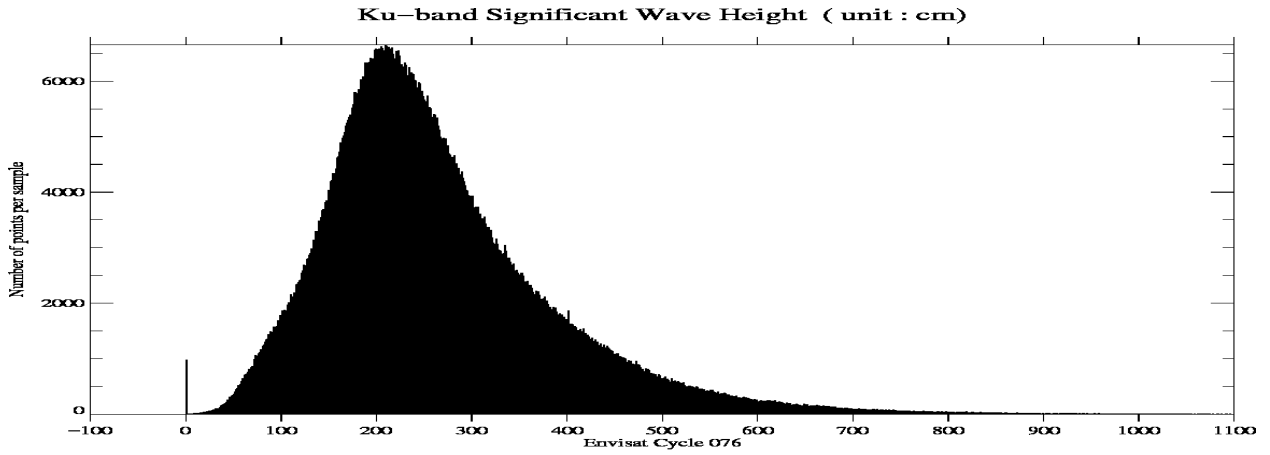
- 9 and 10 (27-01-2009 04 :16 :38 to 05 :57 :14) on a too high editing criteria
- 36 (28-01-2009 02 :54 :43) on a too high SLA criteria

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

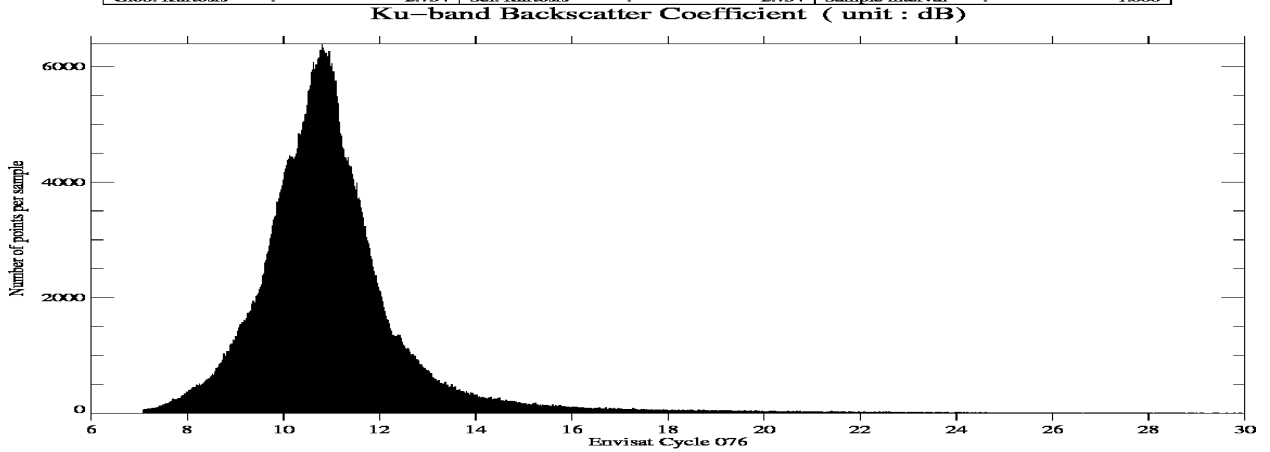


### 3.4. Altimeter parameters

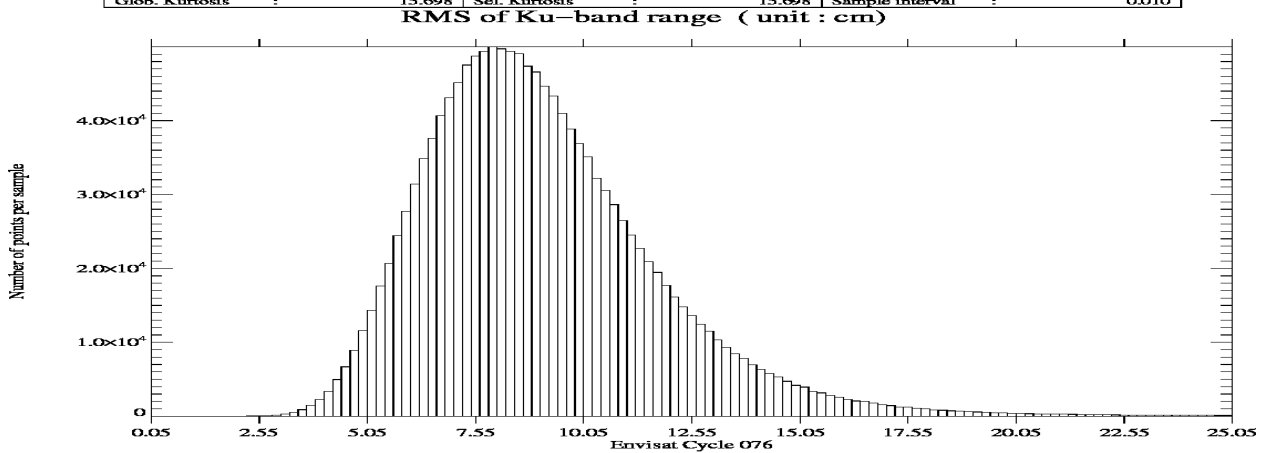
In order to assess and to monitor altimeter parameter measurements, histograms of Envisat Ku-band Significant Wave Height (SWH), Backscatter coefficient (Sigma0) and RMS of altimeter range are computed.



Glob. Nb of pts	: 1459761	Sel. Nb of pts	: 1459761	Glob. Maximum	: 1099.700
Glob. Mean	: 263.584	Sel. Mean	: 263.584	Glob. Minimum	: 0.000
Glob. Std	: 120.520	Sel. Std	: 120.520	Sel. Maximum	: 1099.700
Glob. Skewness	: 1.266	Sel. Skewness	: 1.266	Sel. Minimum	: 0.000
Glob. Kurtosis	: 2.754	Sel. Kurtosis	: 2.754	Sample interval	: 1.000



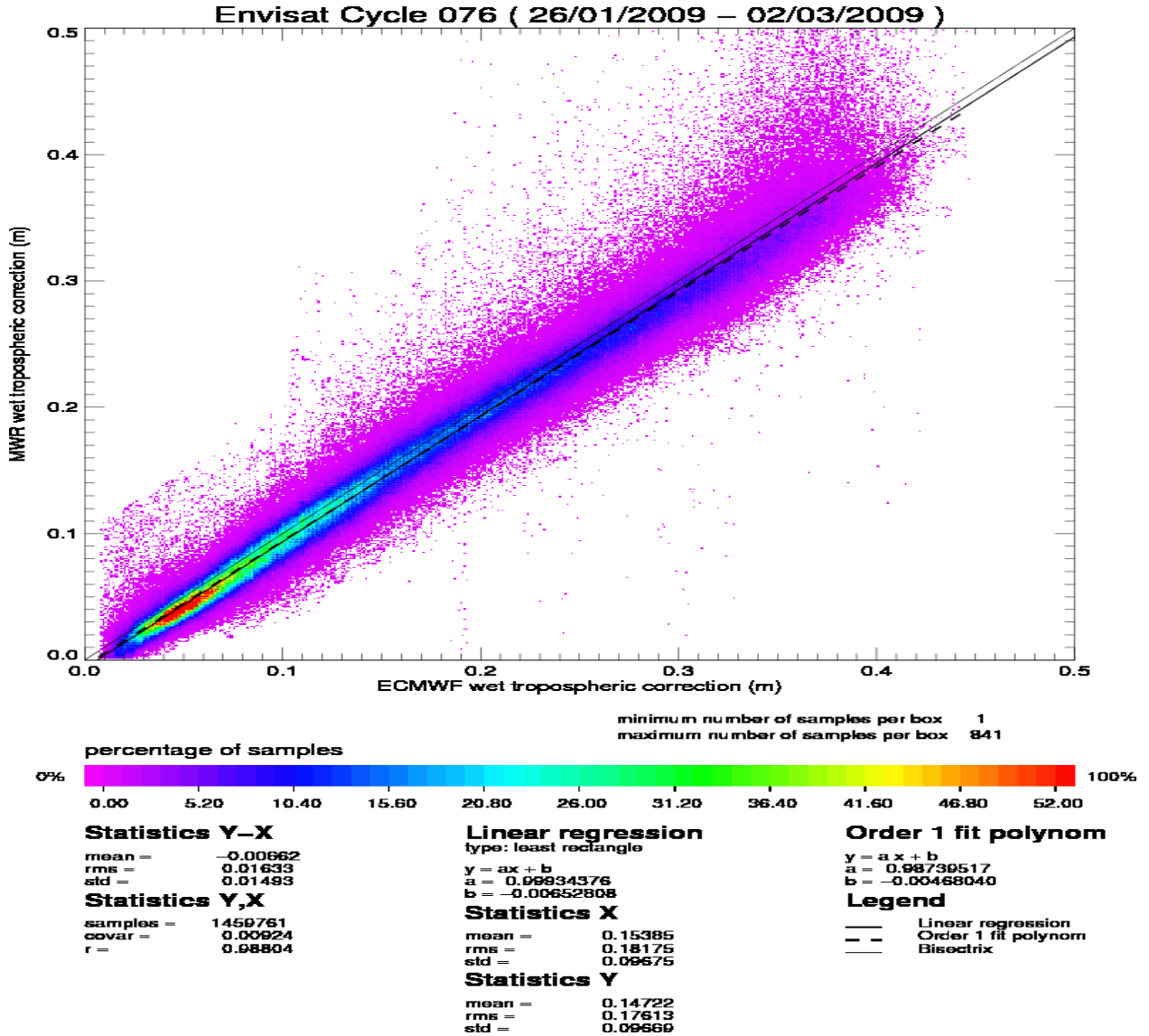
Glob. Nb of pts	: 1459761	Sel. Nb of pts	: 1459761	Glob. Maximum	: 29.910
Glob. Mean	: 11.013	Sel. Mean	: 11.013	Glob. Minimum	: 7.080
Glob. Std	: 1.765	Sel. Std	: 1.765	Sel. Maximum	: 29.910
Glob. Skewness	: 2.846	Sel. Skewness	: 2.846	Sel. Minimum	: 7.080
Glob. Kurtosis	: 15.698	Sel. Kurtosis	: 15.698	Sample interval	: 0.010



Glob. Nb of pts	: 1459761	Sel. Nb of pts	: 1459761	Glob. Maximum	: 25.000
Glob. Mean	: 8.957	Sel. Mean	: 8.957	Glob. Minimum	: 2.000
Glob. Std	: 2.681	Sel. Std	: 2.681	Sel. Maximum	: 25.000
Glob. Skewness	: 1.071	Sel. Skewness	: 1.071	Sel. Minimum	: 2.000
Glob. Kurtosis	: 2.290	Sel. Kurtosis	: 2.290	Sample interval	: 0.200

### 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.

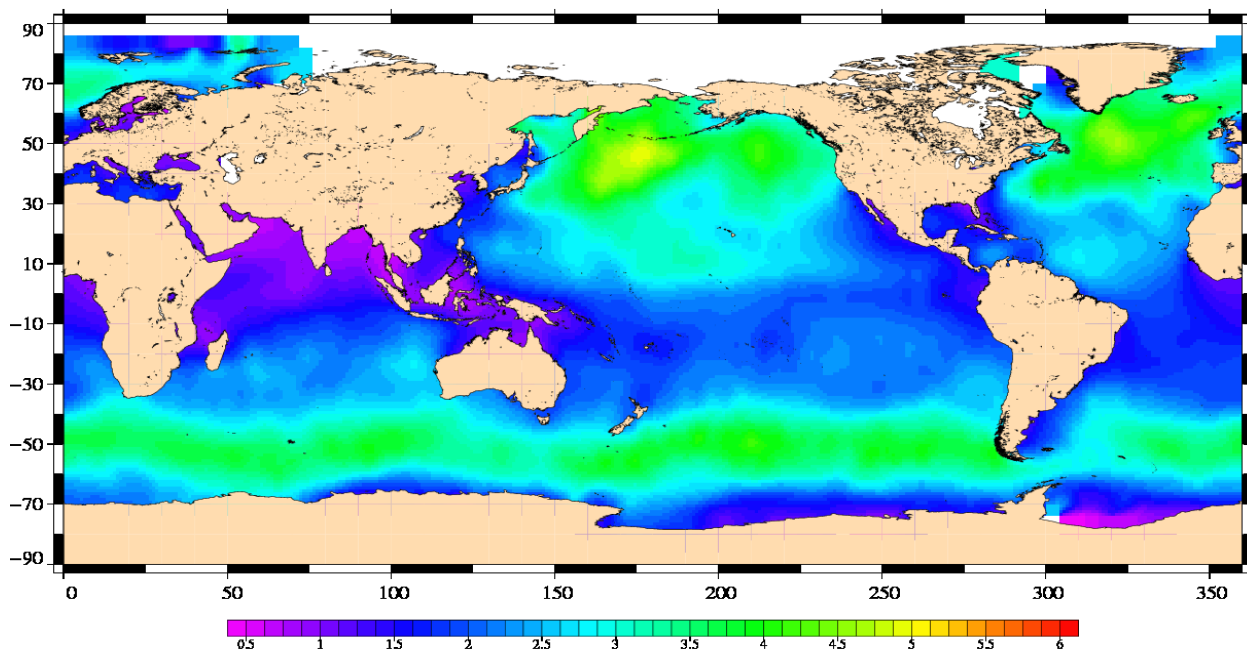


The radiometer-model mean difference is 0.7 cm. A drift on the Envisat 23.8GHz brightness temperature has been detected and has to be monitored on the long term. Note that the neural algorithm is now implemented on Envisat.

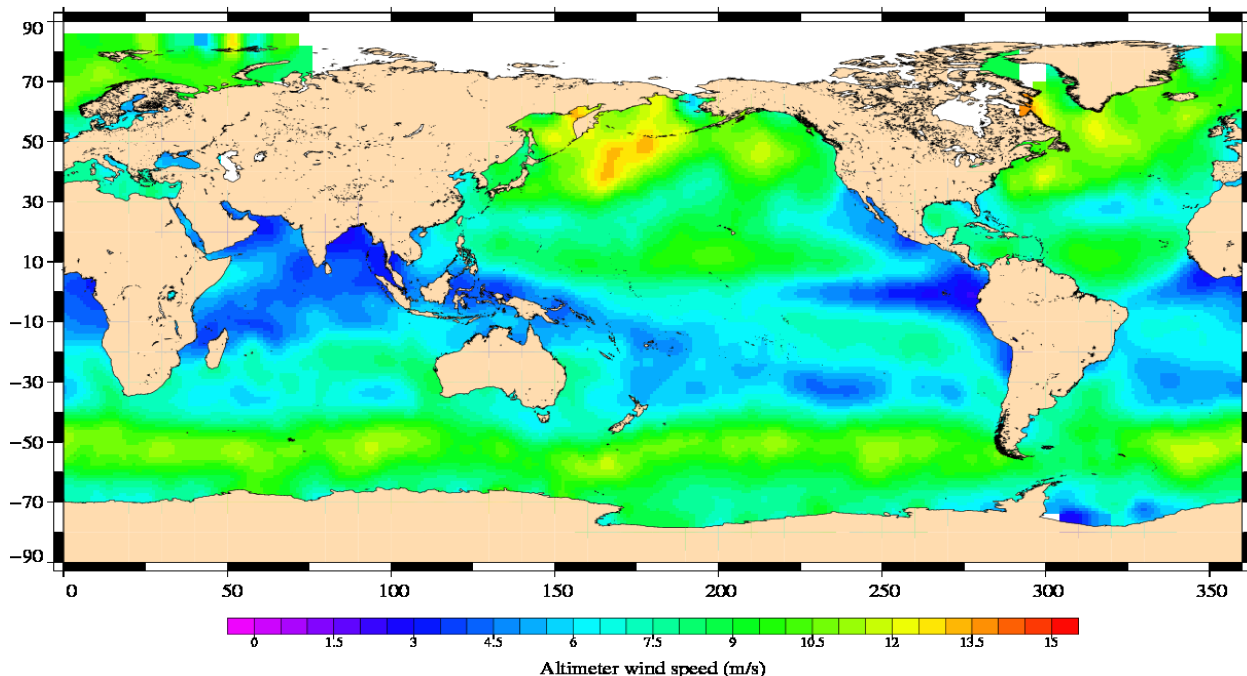
### 3.6. Wind and wave maps

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

Envisat Cycle 076  
26/01/2009 – 02/03/2009



Significant Wave Height (m)  
Envisat Cycle 076  
26/01/2009 – 02/03/2009



## 3.7. Crossover statistics

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### 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 8.03 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 6.85 cm rms. This statistic is a stable estimation of the system performance as it is not influenced by sea ice coverage.

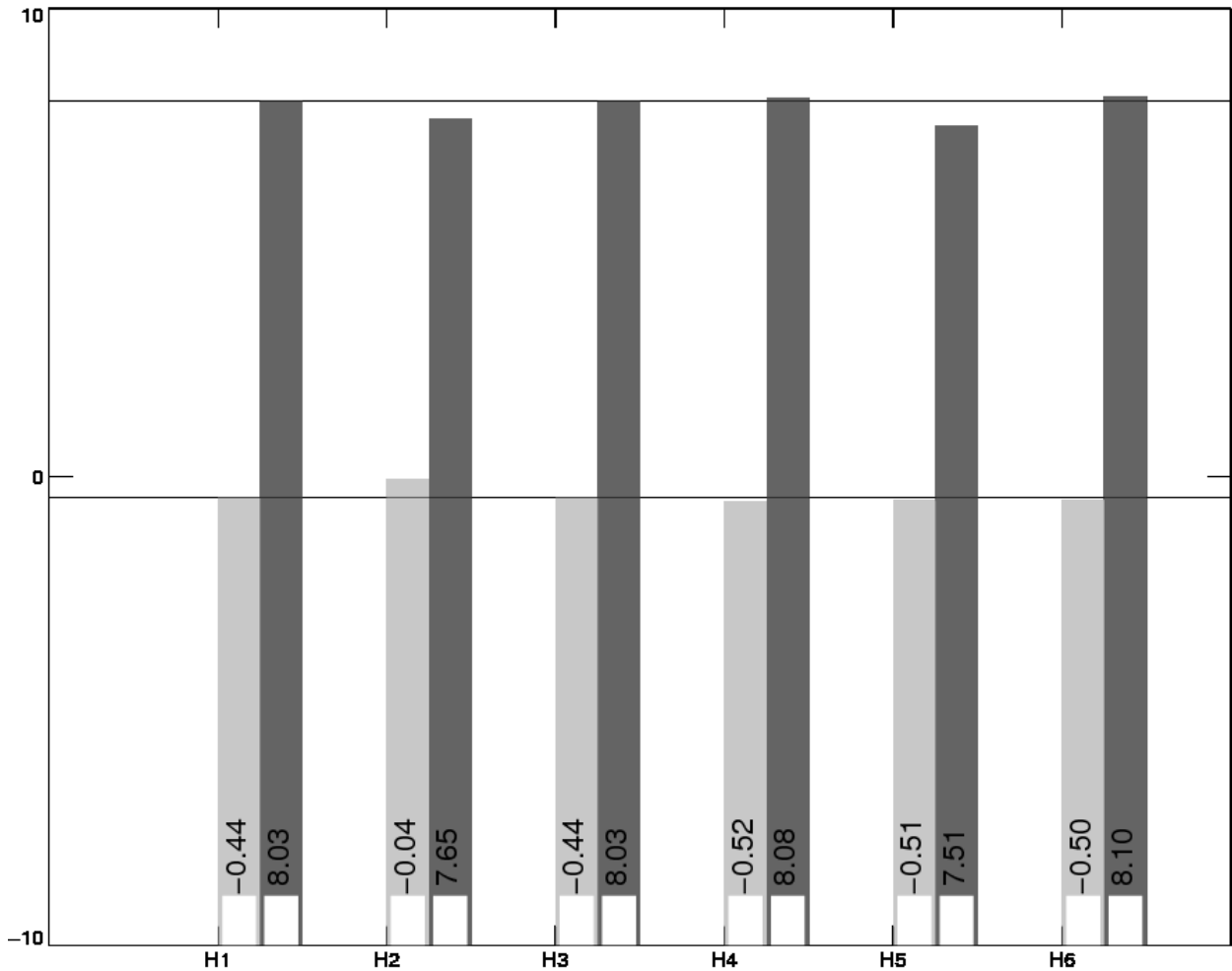
### 3.7.2. Impact of geophysical corrections

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

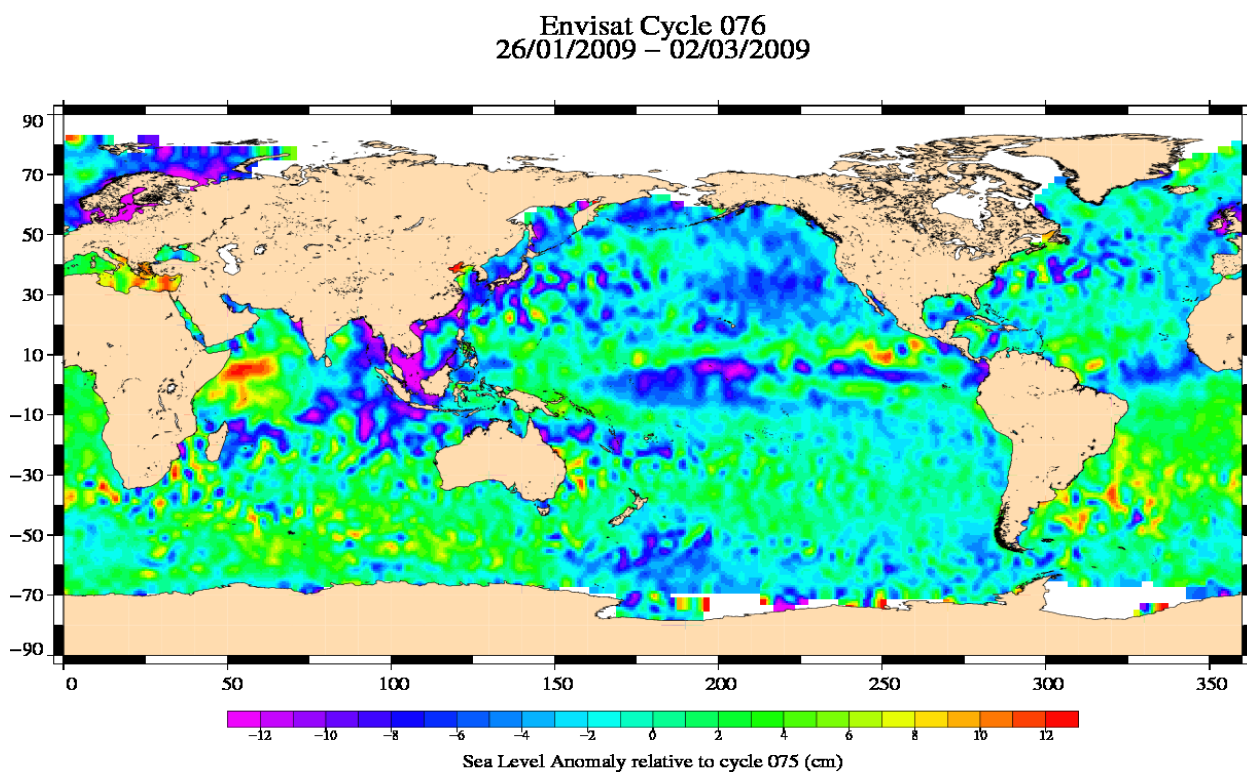
std  
mean

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)

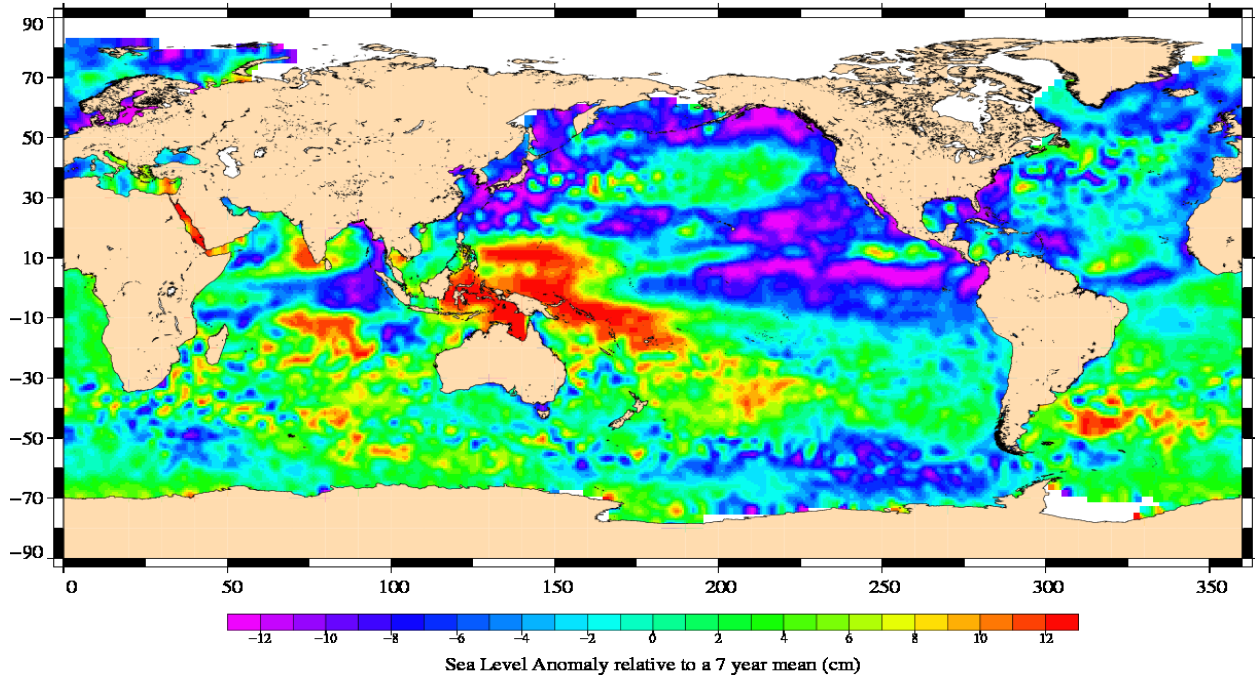
### 3.8. SSH variability

#### 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 adjusted 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

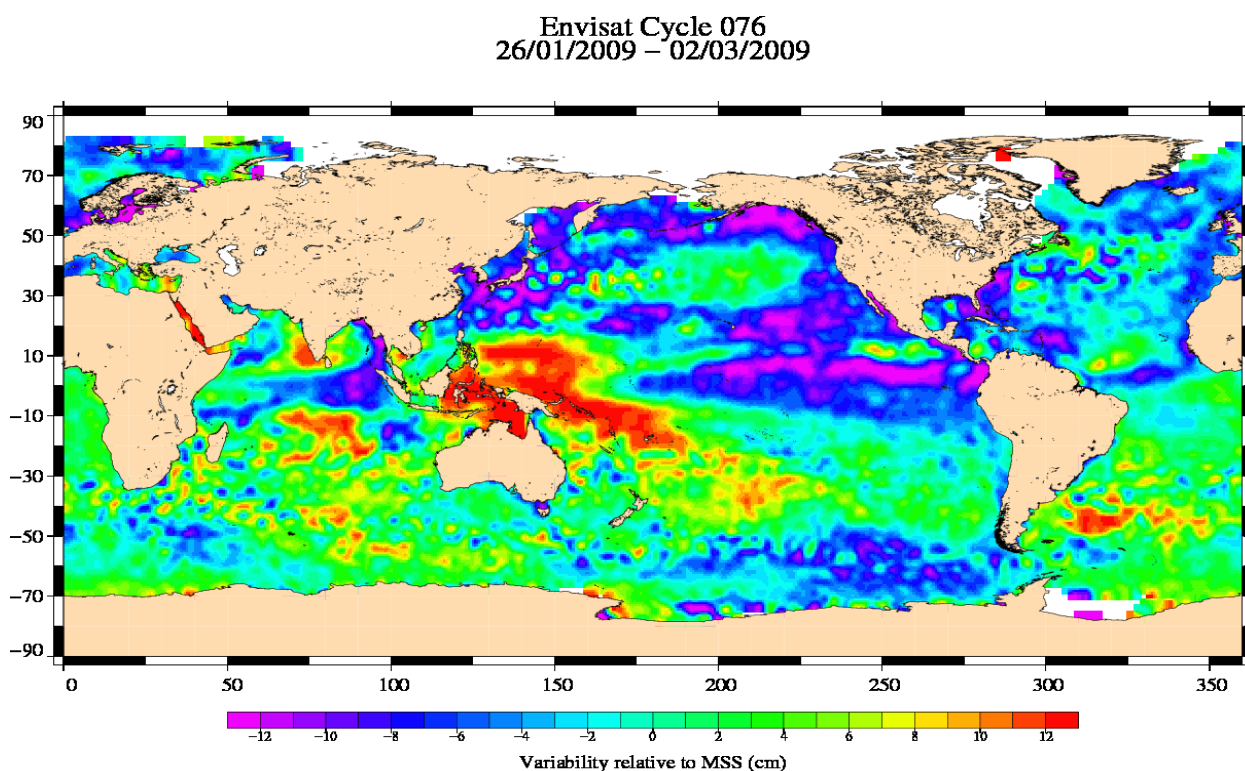
The MSS from the product is used as a reference to compute SLA. Global statistics of Envisat SSH-MSS are (cm) :

Number	Mean	Std. dev.
1633297	48.86	10.38

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

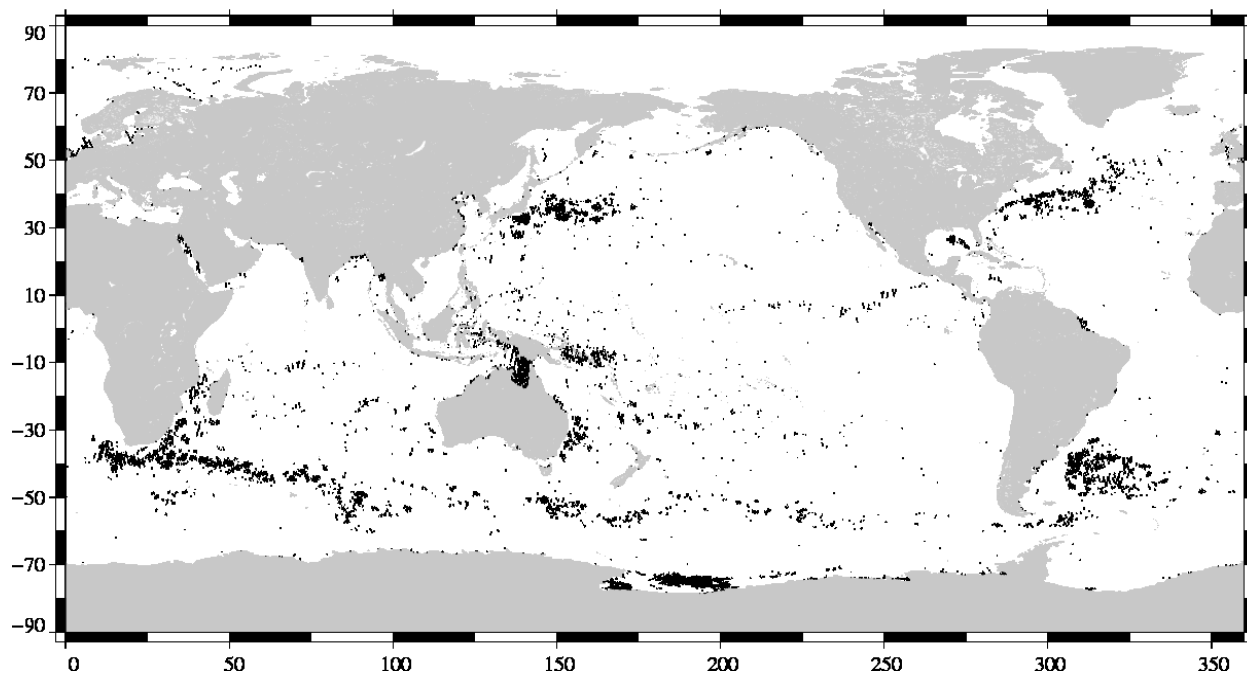
Number	Mean	Std. dev.
973411.00000000	49.32	9.56

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  
Envisat / Cycle 076



## 4. Envisat long term performance monitoring

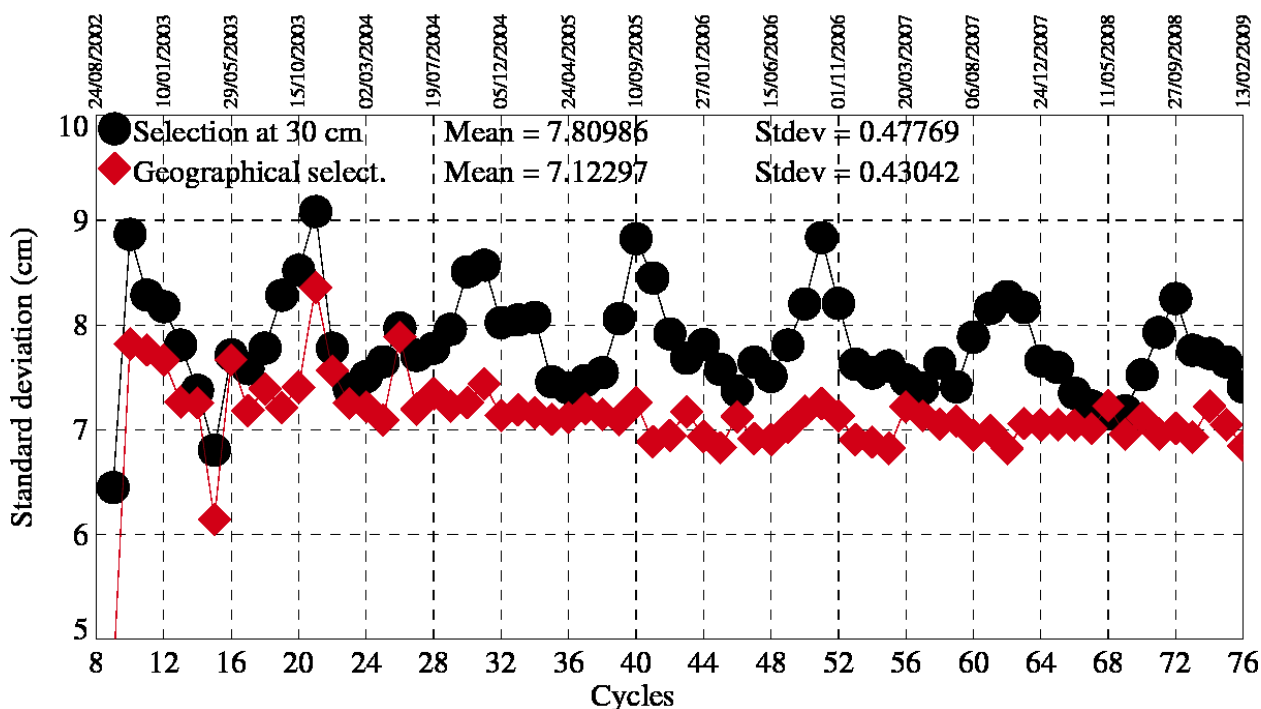
Statistics of SSH variability are computed after crossover and repeat-track analyses. This allows to estimate how Envisat data fulfill the mission objectives in terms of performances.

### 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 editing 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.

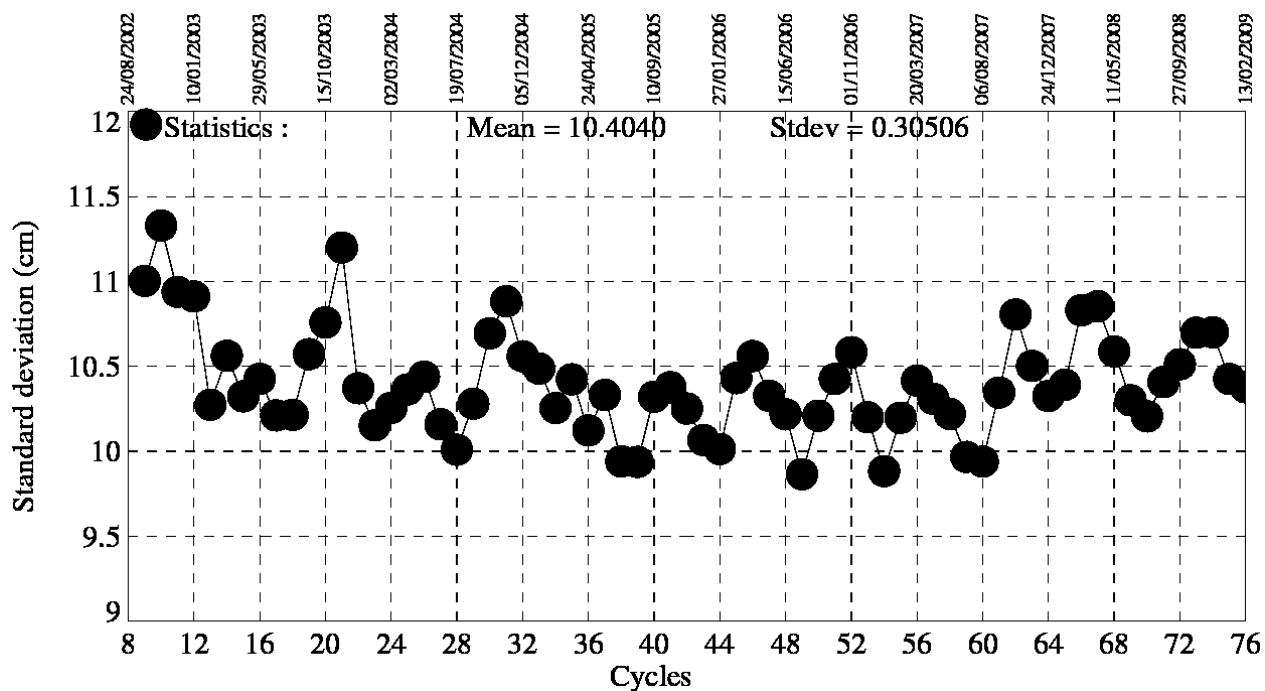
### Crossover standard deviation



## 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.

### Standard deviation of Sea Level Anomalies



### 4.3. Mean Sea Level

MSL estimations are performed by averaging Sea Level Anomalies relative to a mean profile.

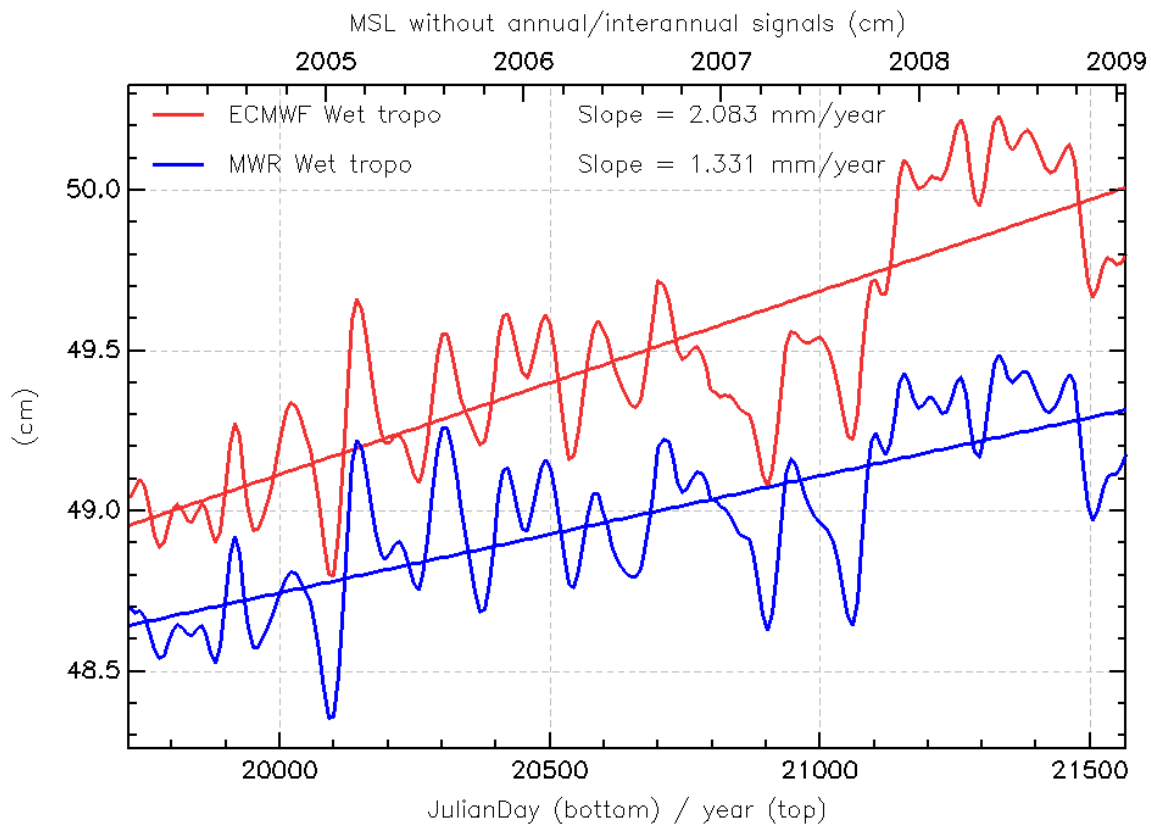
The SSH is computed using :

- the ECMWF model and the radiometer MWR wet troposphere correction corrected from side lobes in order to compare both results.
- the correction provided by ESA to correct the range from the USO drift and bias ([3]) for cycle 9 to 40
- the dual ionospheric 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

Unlike other statistics, it is not performed on a cyclic basis but on a 250 tracks basis (around 9 days), in order to have approximately a temporal sampling close to Jason-1 mission (around 10 days). The curve is then filtered with a 2 months cut of frequency for a better readability.

The value for each point is calculated from an average over 2 by 3 degree bins, then weighted by latitude to take into account the relative geographical area represented by the bin.

During the first year (cycles 10 to 22) Envisat MSL global trend is not consistent to other flying satellites. This unexplained behavior is under investigation. Results plotted on the following figure is obtained after annual and semi-annual signals reduction after cycle 22.



## 5. Particular investigations

- For an unknown reason, a change of behaviour of the Ultra Stable Oscillator (USO) clock frequency occurred in February 2006. 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.

- [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/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