Envisat GDR
Quality Assessment Report

Cycle 081

20-07-2009 / 24-08-2009

Prepared by :	A. Ollivier, CLS M. Guibbaud, CLS	
Accepted by :	G. Dibarboure, CLS	
Approved by :	N. Picot, CNES	

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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 V2.1 reprocessing configuration : IPF processing chain V6.04 and the CMA Reference Software V9.3_05

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 product version V2.1 for the SSH calculation.

2.2. Parameters

The parameters used to compute the sea surface height (SSH) for Envisat are :
- Ku range (ocean retracking)
- POE orbit
- Bifrequency ionospheric correction before 65, GIM ionospheric correction afterwards (S-Band Loss)
- MWR derived wet troposphere correction
- ECMWF dry tropospheric correction
- Non parametric sea state bias
- MOG2D
- Total geocentric GOT4.7 ocean tide height
- Geocentric pole tide height
- Solid earth tide height

2.3. Warnings and recommendations

Users are warned that :

– WARNING : 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 and rain flag 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.
– WARNING : Unrelevant USO Anomaly flag : it is regularly set to 1 for non anomaly periods (already mentioned in [SALP-FT-8115]). Users are advised not to use this flag.

2.4. Platform and instrument events

2009/07/21, from 04 :40 :21 to 04 :44 :35 : orbit inclination maneuver.

2.5. Cycle quality and performances

Good general results are obtained for this cycle of data.

The crossover standard deviation is 5.61 cm rms when using a selection to remove shallow waters (1000 m), areas of high ocean variability and high latitudes ($> |50|$ deg) with an additional selection of 10 days on the crossovers datation. The standard deviation of Sea Level Anomalies (SLA) relative to the CLS01V1 Mean Sea Surface is 10.1 cm. When using a selection to remove shallow waters (1000 m), areas of high ocean variability and high latitudes ($> |50|$ deg) it lowers to 8.7 cm .

Detailed CALVAL results are presented in section Calval Main Results.

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 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).

2.8. Impact of product version V2.1 (IPF v6.04 and CMA v9.3_05) for the SSH calculation

2.8.1. Instrumental corrections impacting the range

Two major changes were performed in the new IPF chain :

– The introduction of USO correction directly in the range at the L1b level. Users are advised NOT to correct any more the range with the auxiliary data provided in the past.

– The improvement of the PTR resolution. This has 2 impacts on the data :
- A direct impact on the Calibration factors included in the Level2 Instrumental Corrections :
o On the range through the Time Delay Calibration Factor.
o On the sigma0 through the Sigma0 Calibration Factor.
- An undirect impact on the data provided that the retracking is performed on a slighlty modified waveform :
o On all retracked parameters (Range through Epoch, SWH through SigmaC2, Wind through Sigma0, Mispointing, Peakiness)

2.8.2. Changes impacting SWH and SSB correction

2 changes were performed impacting the SSB correction :

– The Sea-State bias table has been recomputed (Labroue, 2007) 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 mm in comparison with the previous one.
– Furthermore, the improvement of the PTR SigmaC estimation has an impact on the SWH value ($SWH^2 = SigmaP^2 + SigmaC^2$). It has a mean impact of -13cm with a slight dependence in SWH.

2.8.3. New MWR

Changes were performed on the MWR characterisation files with an impact on the brightness temperatures. These changes have a small impact for users on the wet tropospheric correction.

2.8.4. New/Updates quality flags

– Updated Rain flag : In the algorithm the coefficients and look-up tables have been updated, in order to set the value of the flag. It is a 6 states flag using MWR, and Ku and S band inputs. It is thus not possible to validate this flag for cycle 85 (No S band data). Note that the method was presented in a paper ("Validation of Envisat Rain Detection and Rain Rate Estimates by Comparing With TRMM Data" N. Tran et al. IEEE Geoscience and Remote Sensing Letters, oct 2008).
– New Sea-Ice algorithm includes a 2-state sea ice flag (ice-free ocean and sea-ice) and 4 values indicating the membership of the pixel to each class (ice-free ocean, first-year ice, multi-year ice and wet ice). They are provided as percentages between 0 and 100 in the product.

2.8.5. Ocean Tide and Tidal Loading

Evolution on FES2004 : new loading tide + K2 and S1 coefficients. This has no impact on our analysis as we used the GOT tidal model.

2.8.6. Slope model used over ice sheets

New slope models have been implemented. This has no impact on our analysis as this is only applicable over ice sheets.

2.8.7. Total bias evaluated on the SLA monitoring

The global impact noticed on the SLA monitoring due to the new IPF+CMA versions consists of the sum of :

– Around **-6.4mm** due to the increase of the PTR resolution (included in the range instrumental correction)
– Around **-4.3mm** due to the new SSB solution (algorithm part : +2mm and 4 to 5% of 13cm SWH bias part)

==> Resulting in a **-10.7 mm jump** with geographical patterns (see map of figure **??**).

Note that those statistics result from the comparison of the previous SLA corrected from USO with auxiliary files with a SLA using a range now directly corrected from USO.

Impact is also noticed on SWH monitoring :
- Around **-13cm** biais on the SWH due to the PTR width modification

Due to this global reduction of SWH, the population of null SWH increases. The managing of those null values has slighly changed between the previous and new SSB model. Users must be advised that this might cause a slight over editing due to the SSB if thresholds are not updated accordingly.
Thus,we suggest to relax the thresholds on this parameter (ex, for DUACS processing, this threshold was relaxed from [-50cm,0] to [-50cm,1cm]).

Other parameters are not or slighly impacted (weak impact on the range of the MWR new caracterisation files).

Sigma0 : +0.016dB through Atmospheric attenuation + resolution noise from the sigma0 calibration factor.
Atmospheric attenuation : +0.016dB
Wind : -0.05m/s
Brightness Temperature 23.8 GHz : +0.9K (0.5K expected on all surfaces)
Brightness Temperature 36.5 GHz : +2.7K (1K expected on all surfaces)
Radiometer wet correction : +0.3mm

All these aspects including Geographic and temporal differences of New and Old versions, are detailed and can be consulted in the dedicated note comparing data with both successive IPF/CMA versions on the same cycle (85) :
CalVal status on the Envisat V2.1 reprocessing impact on main altimetric parameters - A. Ollivier, J.F. Legeais, N. Granier, Y. Faugere, F-PAC Calval Team
It is available with the release notes and all GDR and SGDR on the following adress :
ftp://diss-nas-fp.eo.esa.int
under the directory : altimetry_dataset_v2.1.
with the name : V2.1_reprocessing_impact_on_altimetric_parameters.pdf

Compared with the previous version of April (IPF V6.02L04 and CMA 9.3_02 / Cycles 86 to 92), the only change concerns the USO algorithm. The anomalous behaviour previously noticed (jumps and default values) is now solved.
From cycle 93 onwards (and for the future reprocessed data), no more USO auxiliary file is needed.
This version is the one used for the global reprocessing initiated in January 2011.

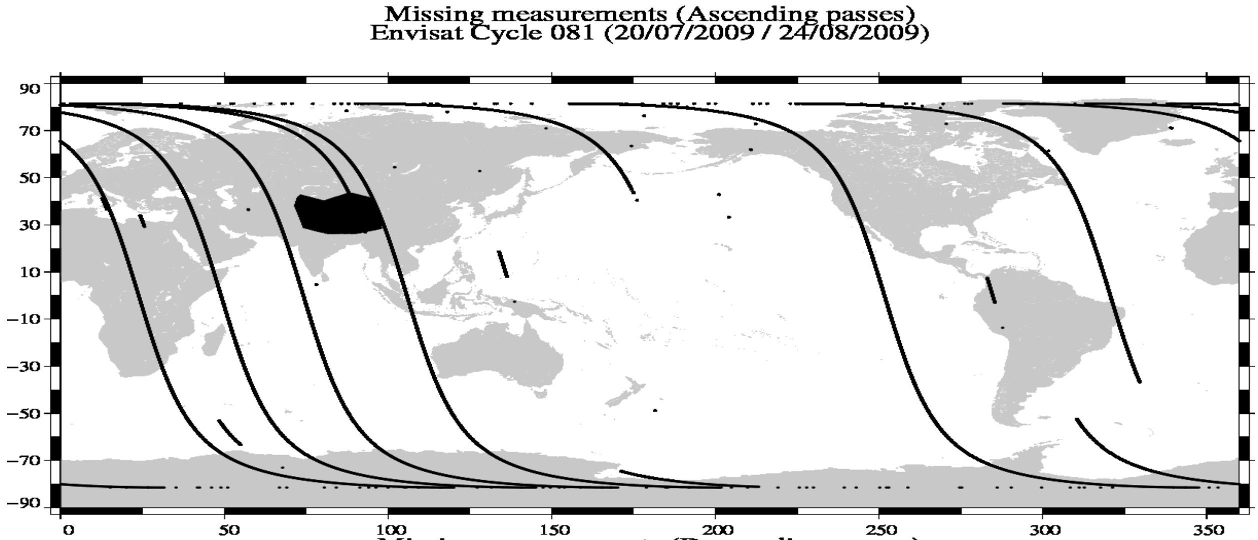
3. CALVAL main results

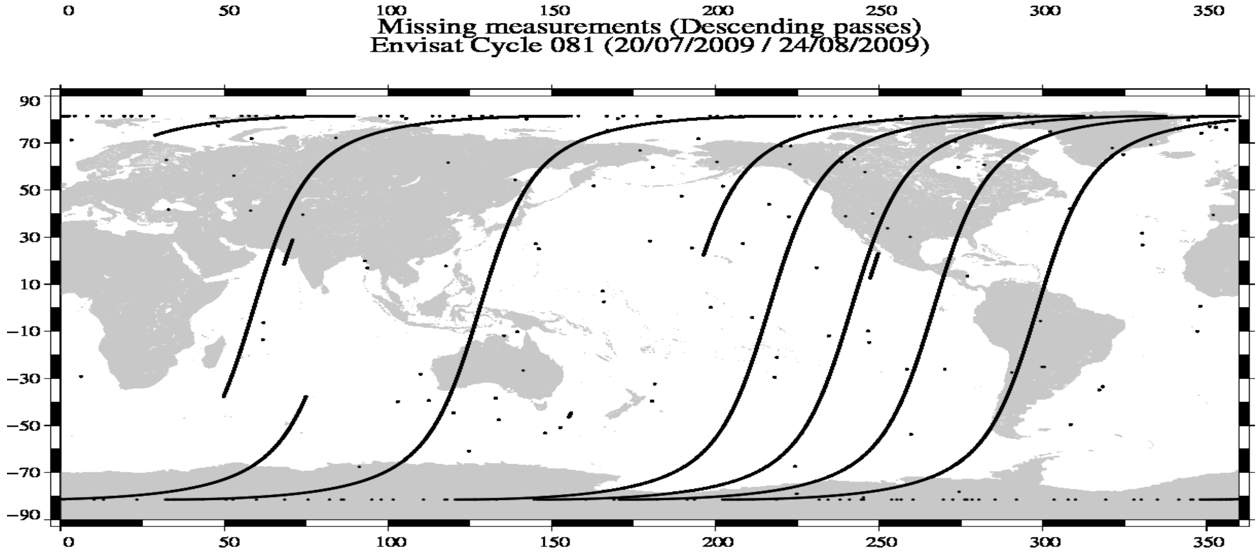
This section presents results that illustrate data quality during this cycle. These verification products are produced operationally so that they allow systematic monitoring of the main relevant parameters.

After that it follows a drifting orbit with a pseudo period of 30 days and each cycle contains 862 tracks instead of the 1002 previous splitting.

3.1. Missing measurements

1771196 are present, and 43658 (2.4%) are missing. The maps below illustrate missing 1Hz measurements in the GDRs, with respect to a 1 Hz sampling of a nominal repeat track.





994 passes produced over 1002. 8 passes are totally missing due to level 0 and level 1 B data unavail- ability :
-Passes 80-85 : [2009/07/23 15 :30 :22 => 21 :08 :36] - Gap RA2-0
-Pass 864 : [2009/08/20 00 :27 :12 => 02 :03 :19] - Gap RA2-0 + MWR-0 - ARTEMIS unavailability on 20/08 from 01 :35 to 02 :08
-Pass 983 : [2009/08/24 04 :33 :43 => 06 :14 :22] - Gap RA2-0 + MWR-0 - ARTEMIS unavailability on

24/08 from 05 :37 to 06 :24

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	50186	3.39
Ice flag	317916	21.50
	3044	0.21

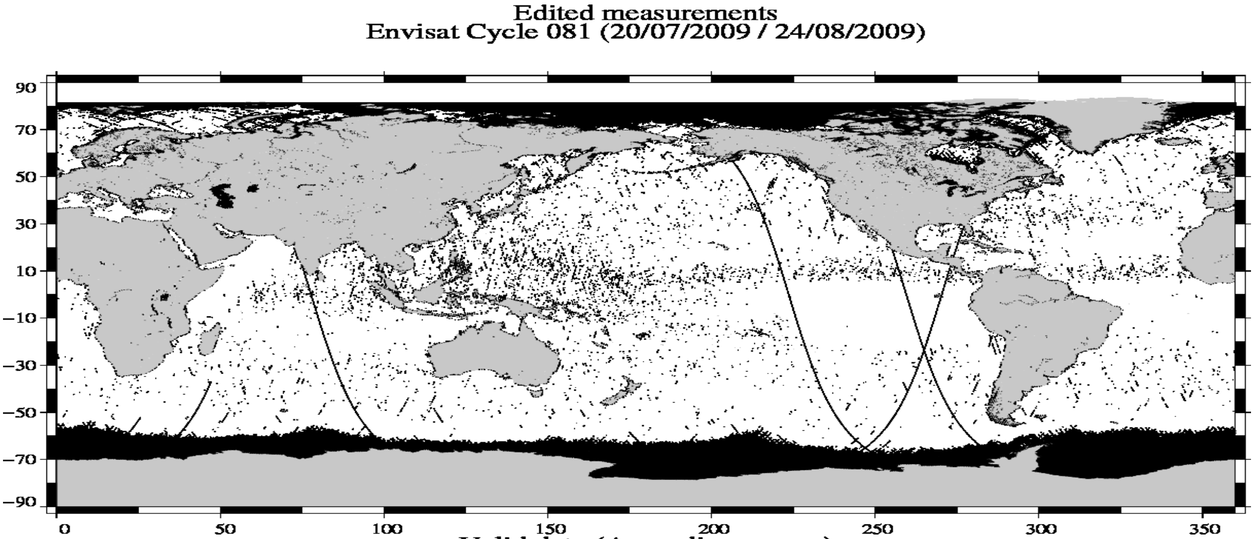
Then, measurements are edited using thresholds on several parameters. These thresholds are expected to remain constant throughout the Envisat mission, so that monitoring the number of edited measurements allows a survey of data quality.
The next table gives for each tested parameter, minimum and maximum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

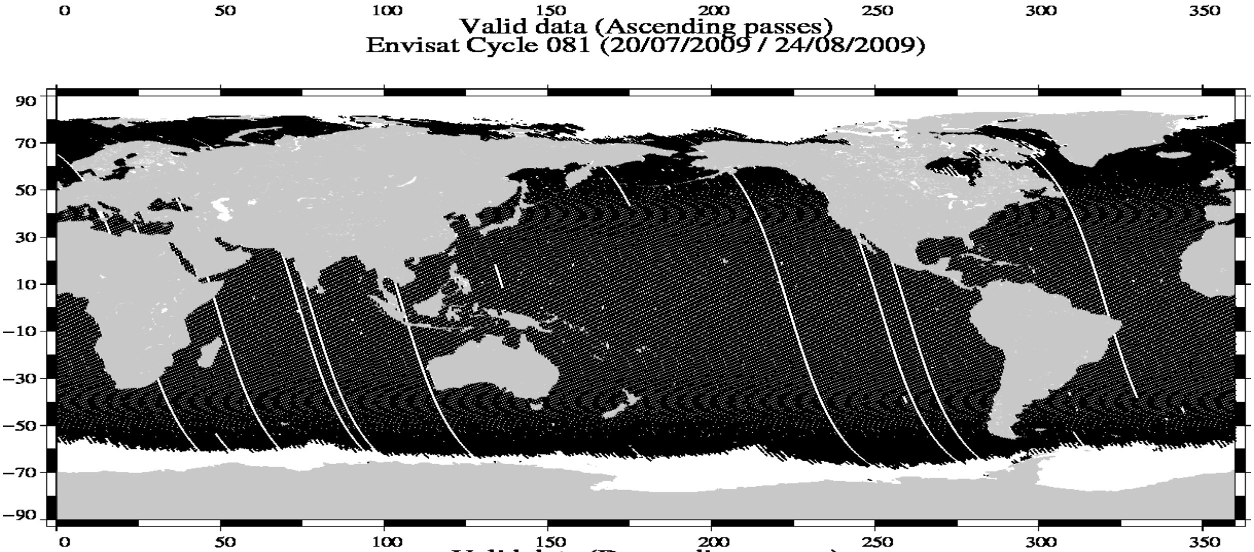
Parameters	Min Thres.	Max Thres.	Nb rejected	% rejected
Sea surface height (m)	-130.000	100.000	1053	0.07
Variability relative to MSS (m)	-2.000	2.000	2973	0.21
Number of 18Hz valid points	10.000	-	228	0.02
Std. deviation of 18Hz range (m)	0.000	0.250	15596	1.11
Off nadir angle from waveform (deg2)	-0.200	0.160	5407	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	2523	0.18
Bifrequency iono before cycle 65, GIM Ionospheric correction afterwards (S-Band loss) (m)	-0.400	0.040	0	0.00
Significant wave height (m)	0.000	11.000	1015	0.07
Sea state Bias (m)	-0.500	0.010	154	0.01
Backscatter coefficient (dB)	7.000	30.000	2332	0.17
GOT4.7 ocean tide height (m)	-5.000	5.000	2937	0.21
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)	-15.000	15.000	0	0.00
RA2 wind speed (m/s)	0.000	30.000	138	0.01

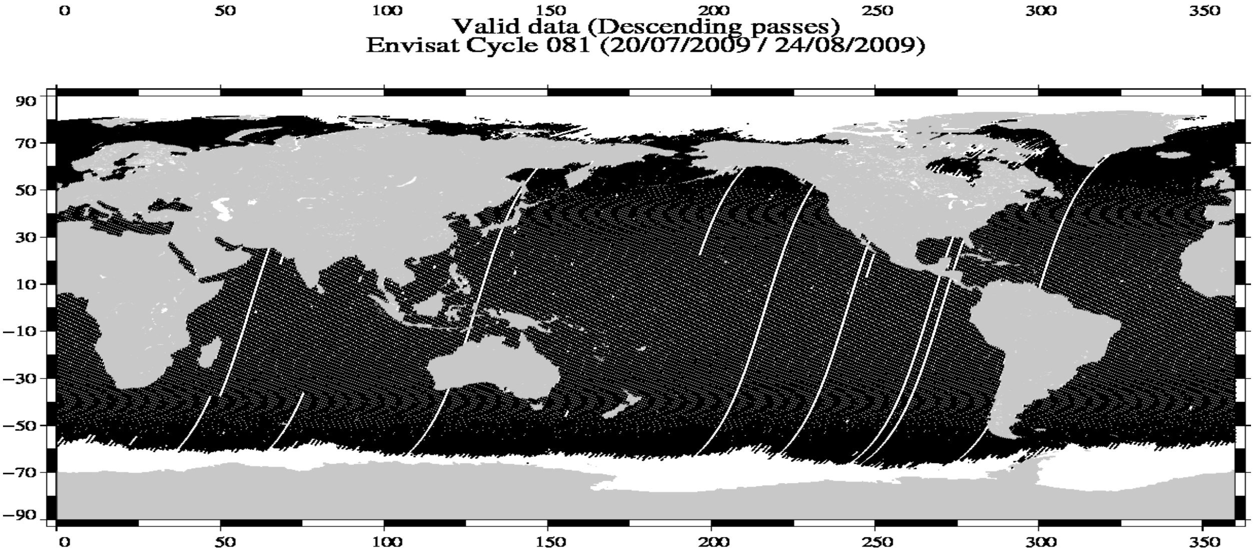
A final editing is then performed on corrected sea surface height, using a spline fitting procedure, leading to remove 562 (0.04 %) measurements.

3.3.2. Figures

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







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

3.3.3. Comments

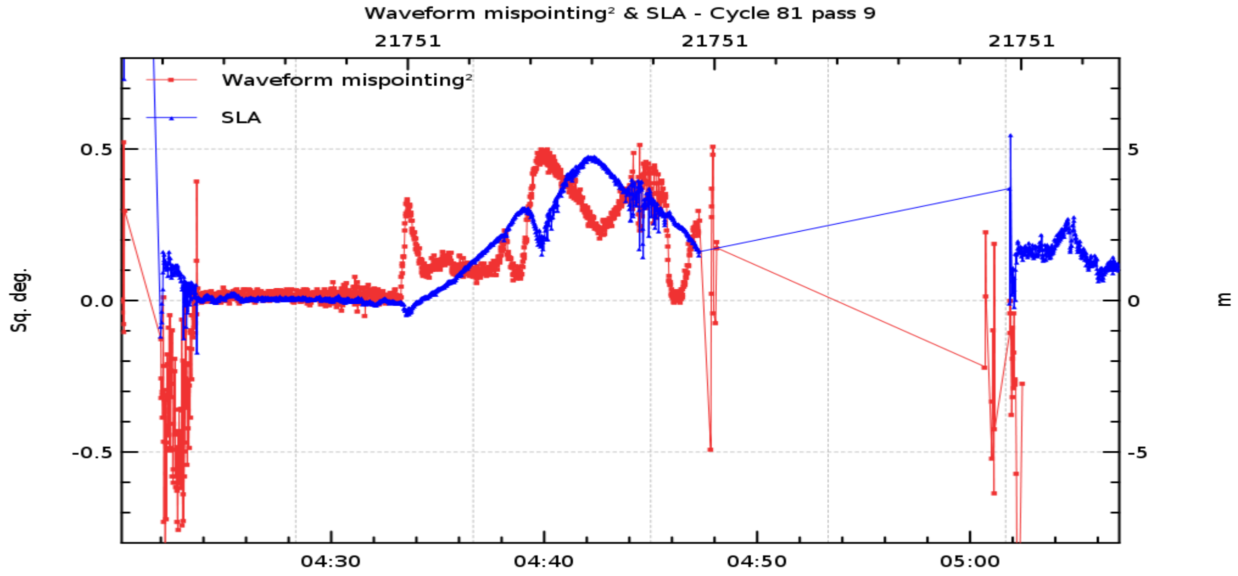
3.3.3.1. Missing MWR

2 passes (155 366) are entirely edited on the radiometer land flag (no MWR correction).

3.3.3.2. Other editing

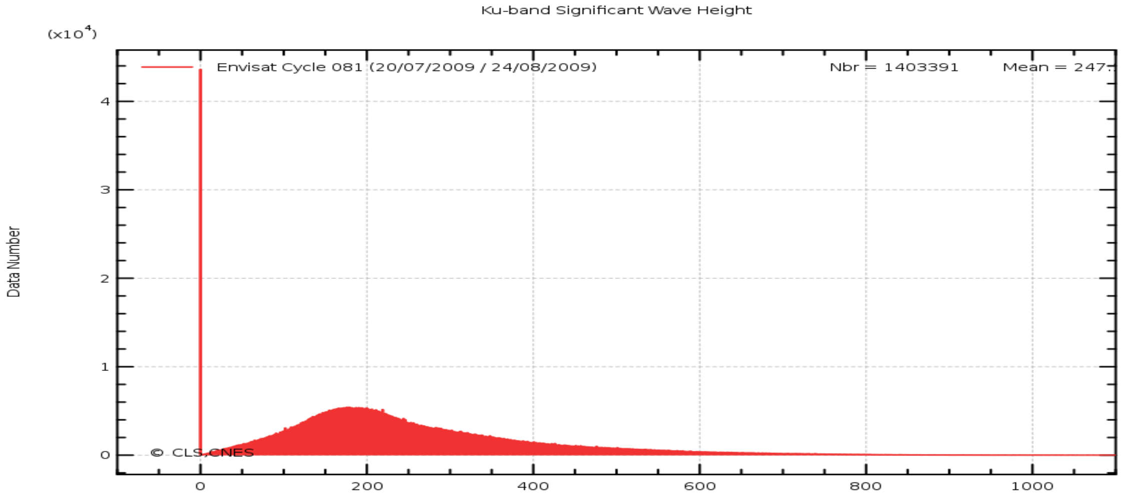
One pass is entirely edited by SLA stats per track out of threshold :
- Pass 9 : 2009/07/21, from 04 :16 :42 to 05 :07 :00 ;

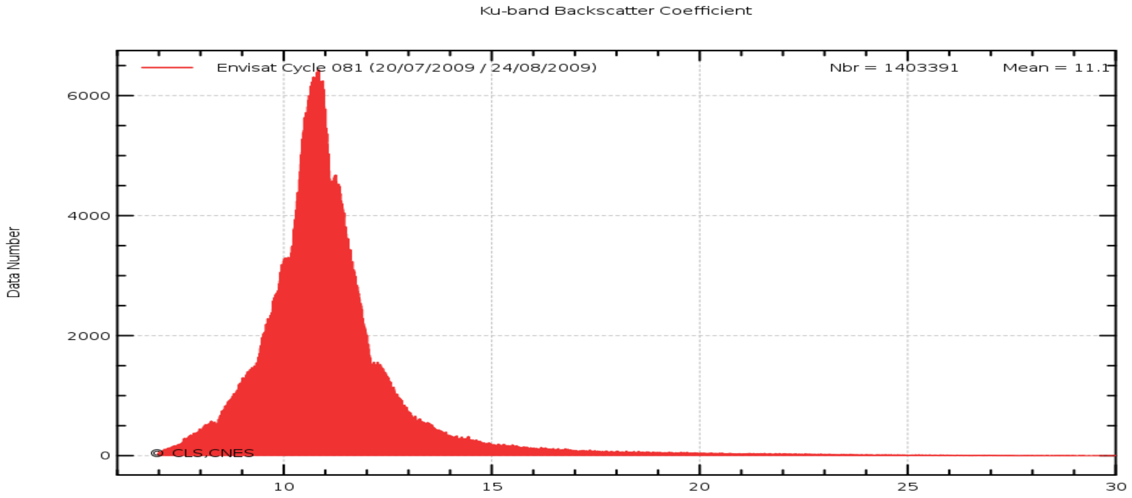
Pass 9 is impacted by the orbit inclination maneuver performed as planned on 2009/07/21, from 04 :40 :21 to 04 :44 :35 :

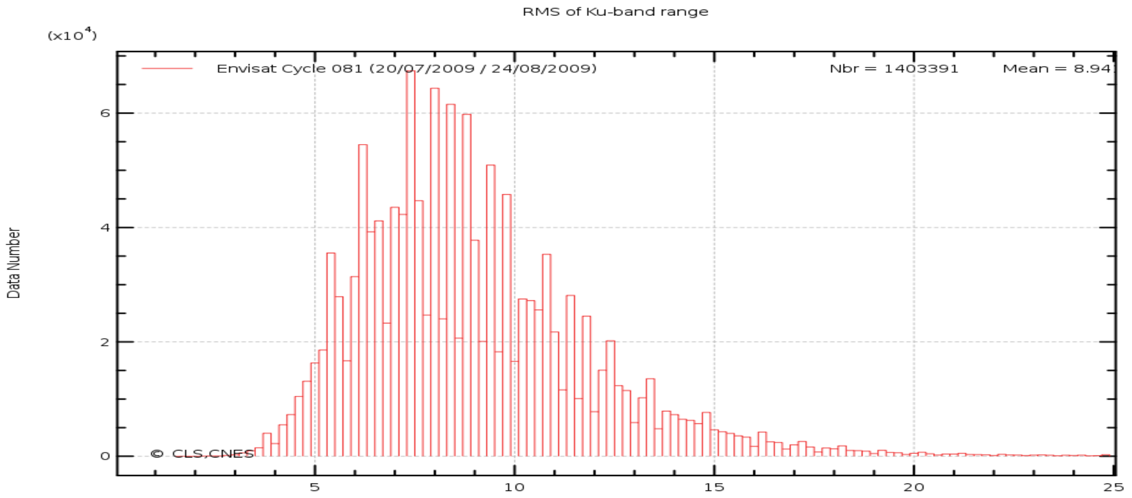


3.4. Altimeter parameters

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.

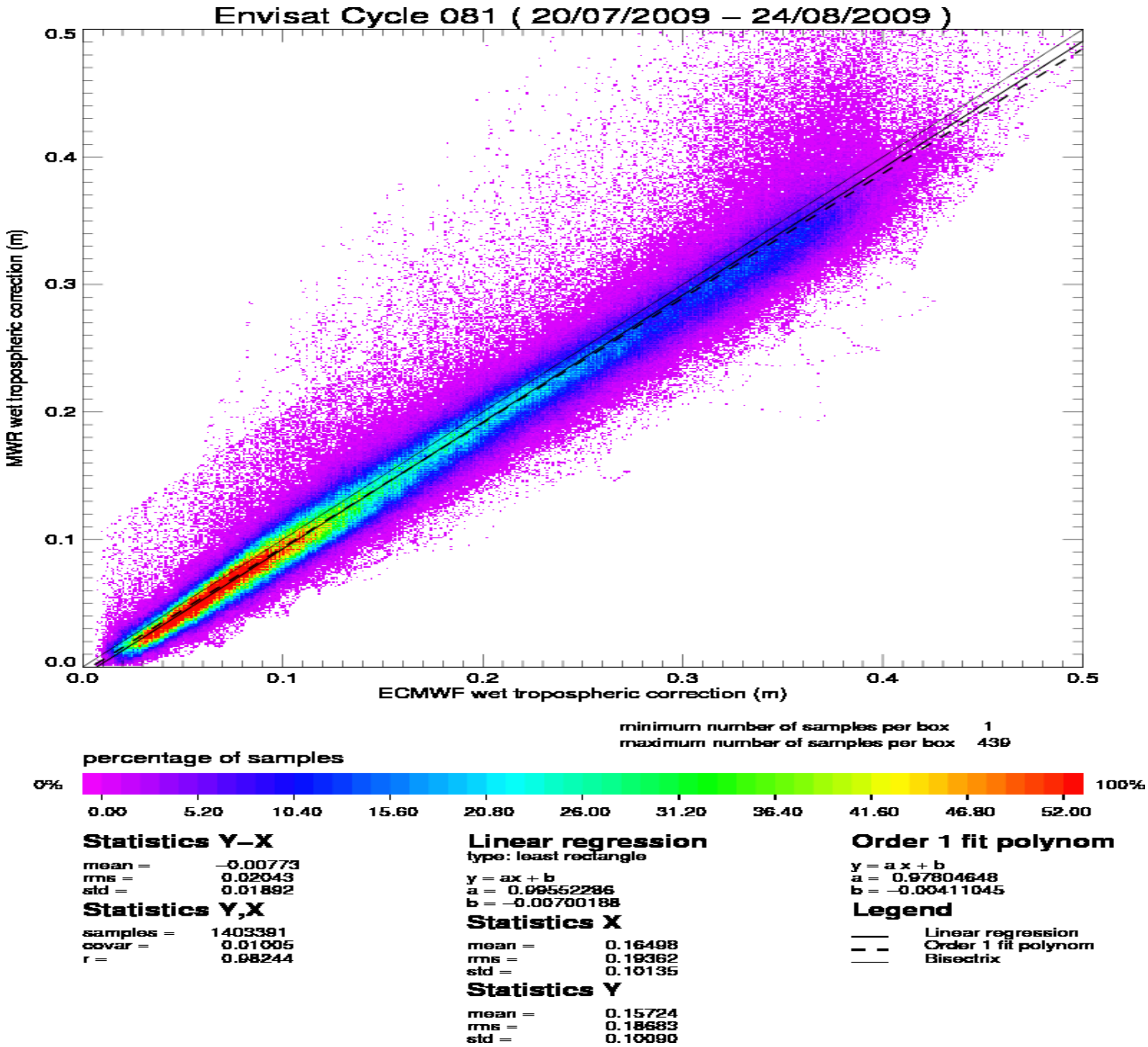






3.5. Radiometer

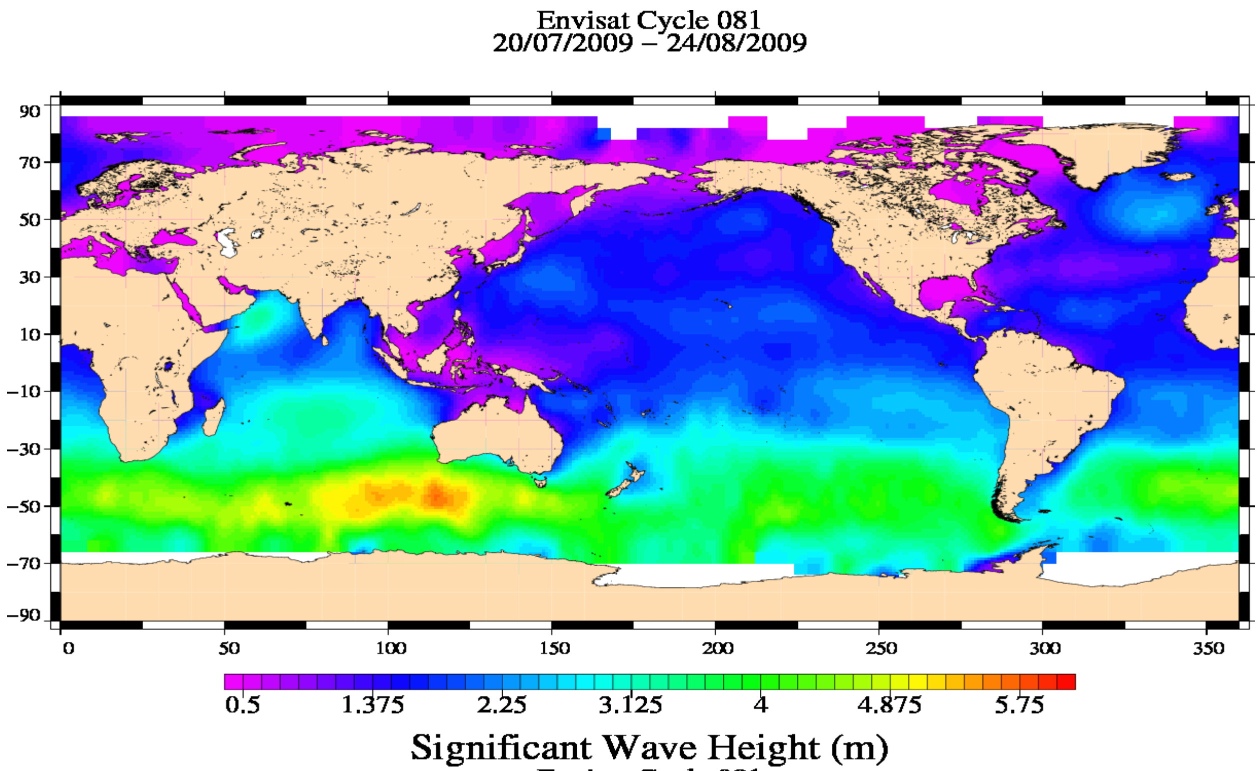
In order to assess and to monitor radiometer measurements, a scatter plot between the radiometer wet troposphere correction and the ECMWF model is computed for the valid data set previously defined.

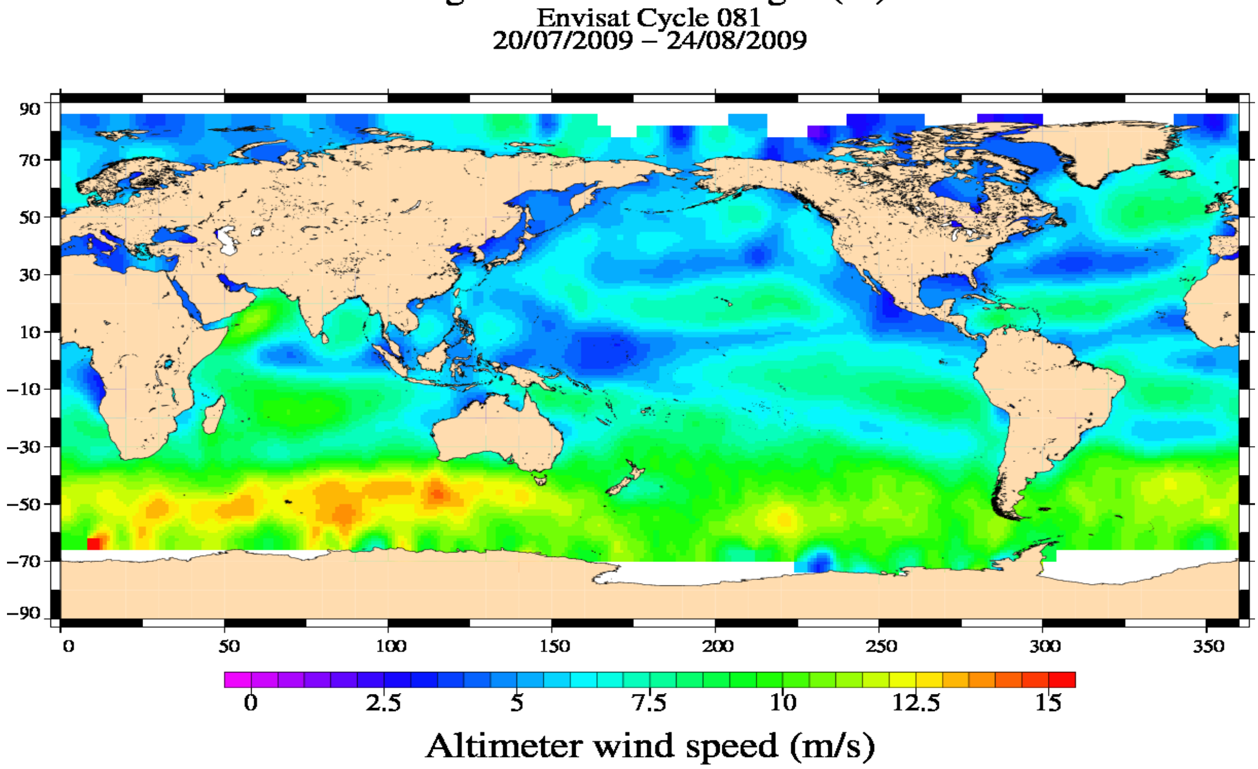


The radiometer-model mean difference is 0.8 cm. A drift on the Envisat 23.8GHz brightness temperature has been detected and has to be monitored on the long term. Note that the neural algorithm is now implemented on Envisat.

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

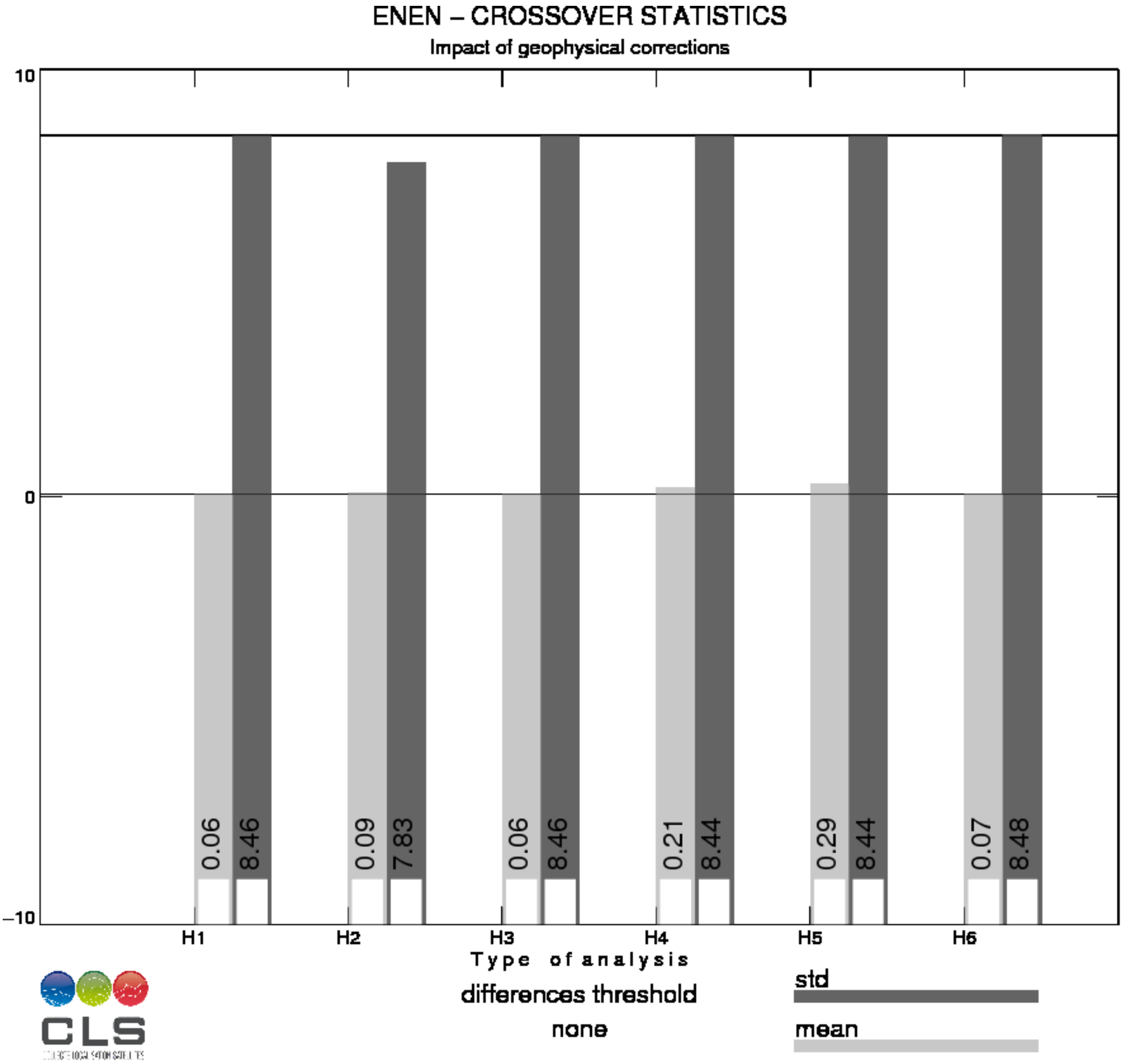
3.7.1. General comment

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 6.23 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 5.61 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).

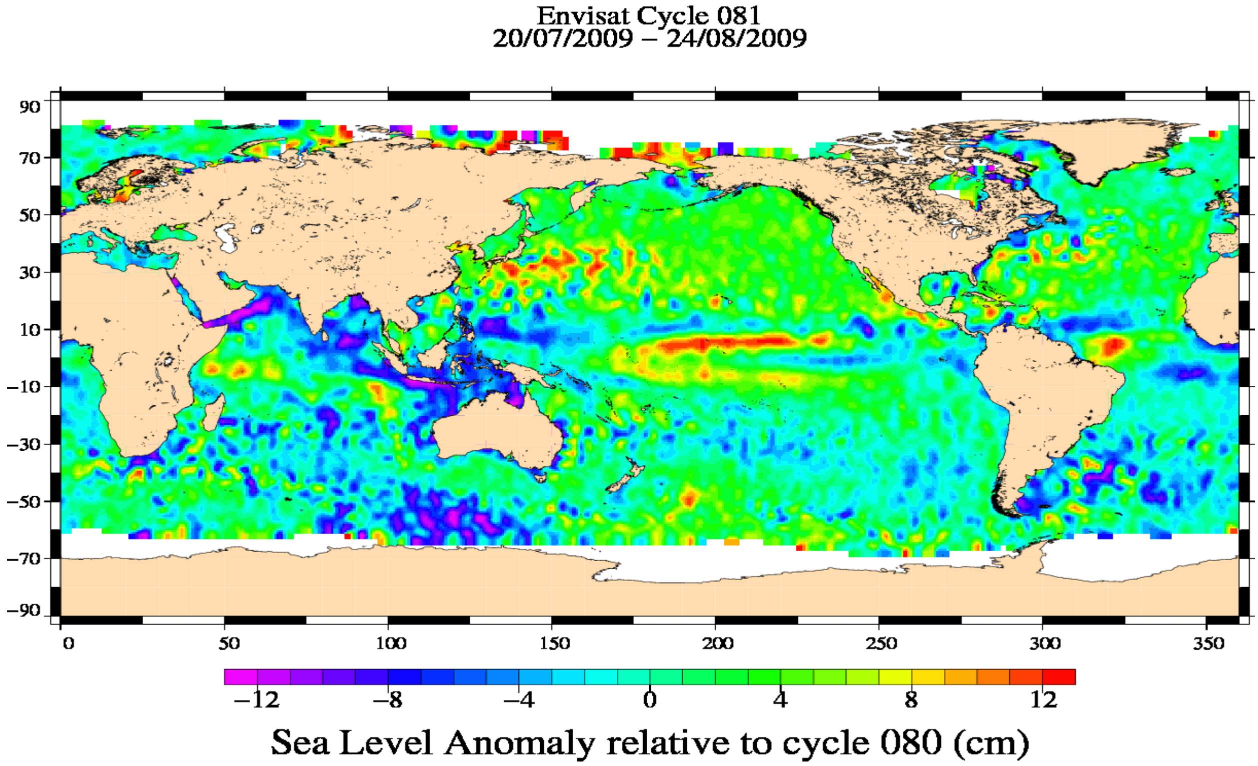


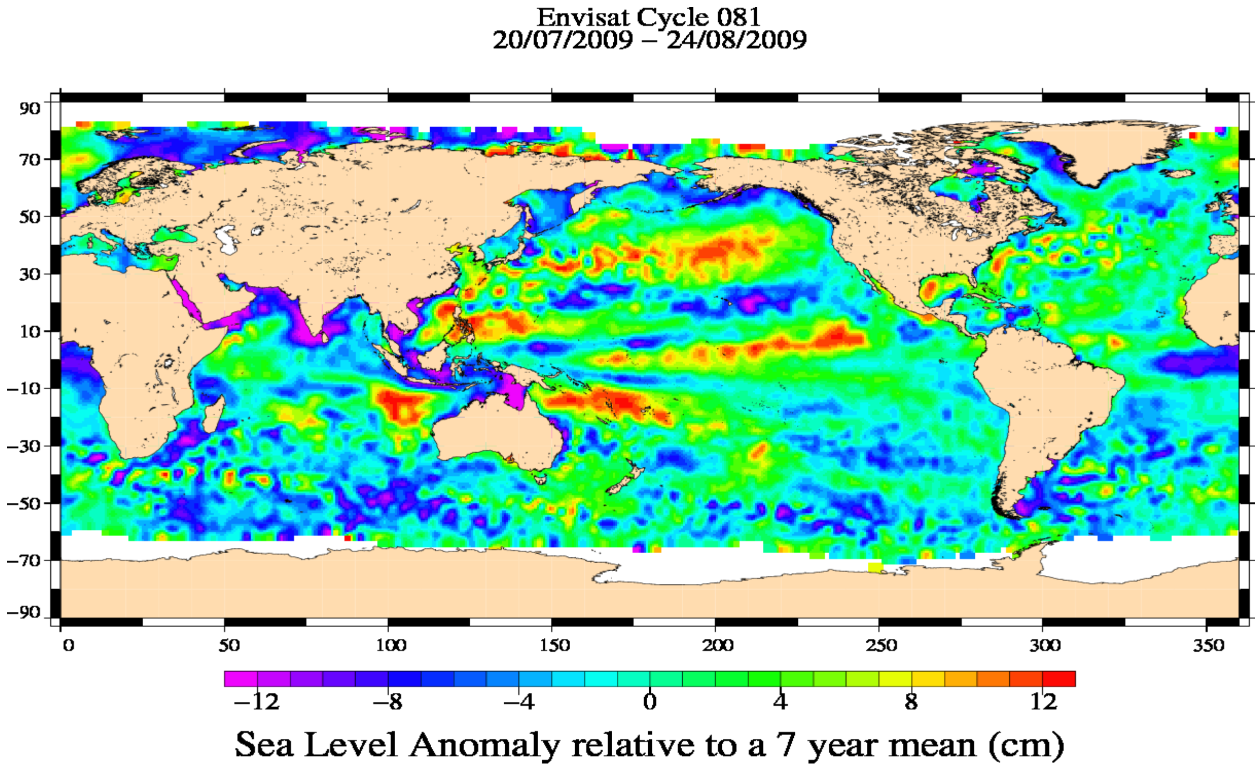
H1 = SSH	H4 = SSH with DORIS ionospheric correction (in product)
H2 = SSH applying a long wave length error (computed)	H5 = SSH with FES tide model (in product)
H3 = SSH with GIM ionospheric correction (computed)	H6 = SSH with ECMWF wet tropospheric correction (in product)

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 081
20/07/2009 – 24/08/2009
90
70
50
30
10
−10
−30
−50
−70
−90
0
50
100
150
200
250
300
350
−12
−8
−4
0
4
8
12
Sea Level Anomaly relative to a 7 year mean (cm)

3.8.2. Comparison to a precise Mean Sea Surface

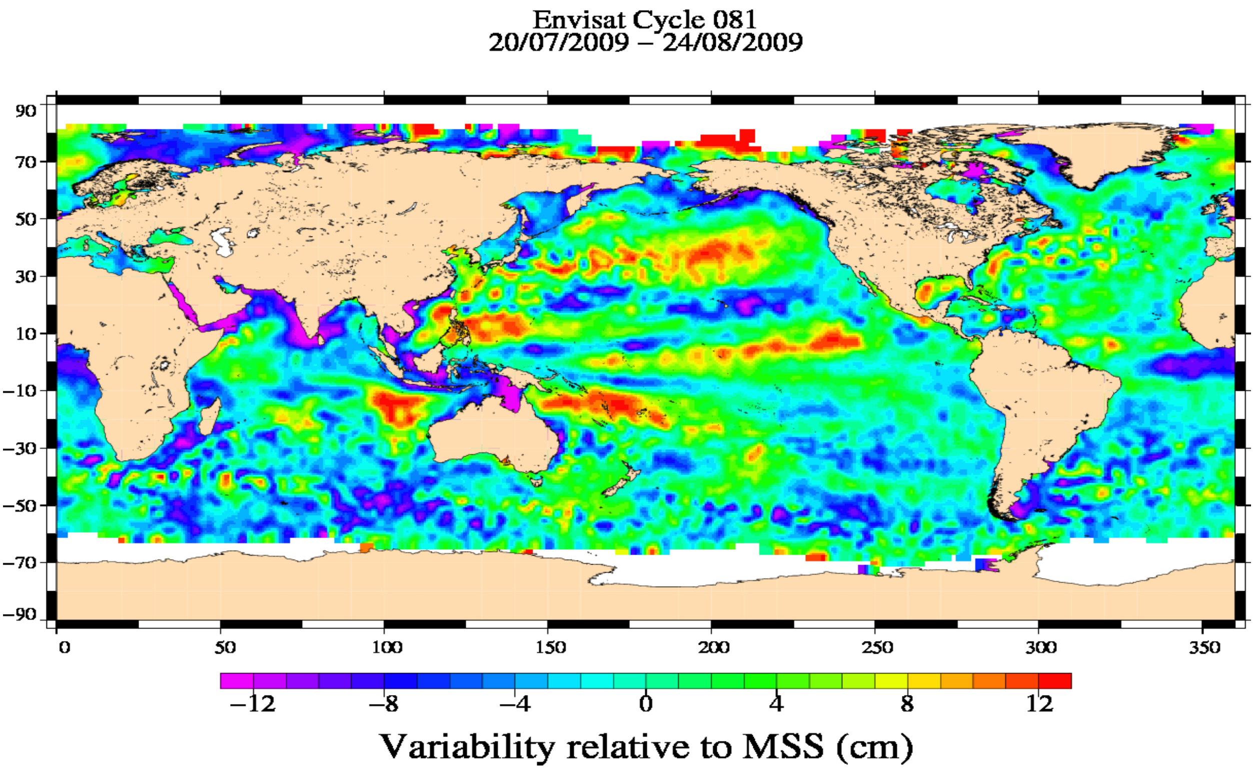
The MSS from the product is used as a reference to compute SLA. Global statistics of Envisat SSH-MSS are (cm) :

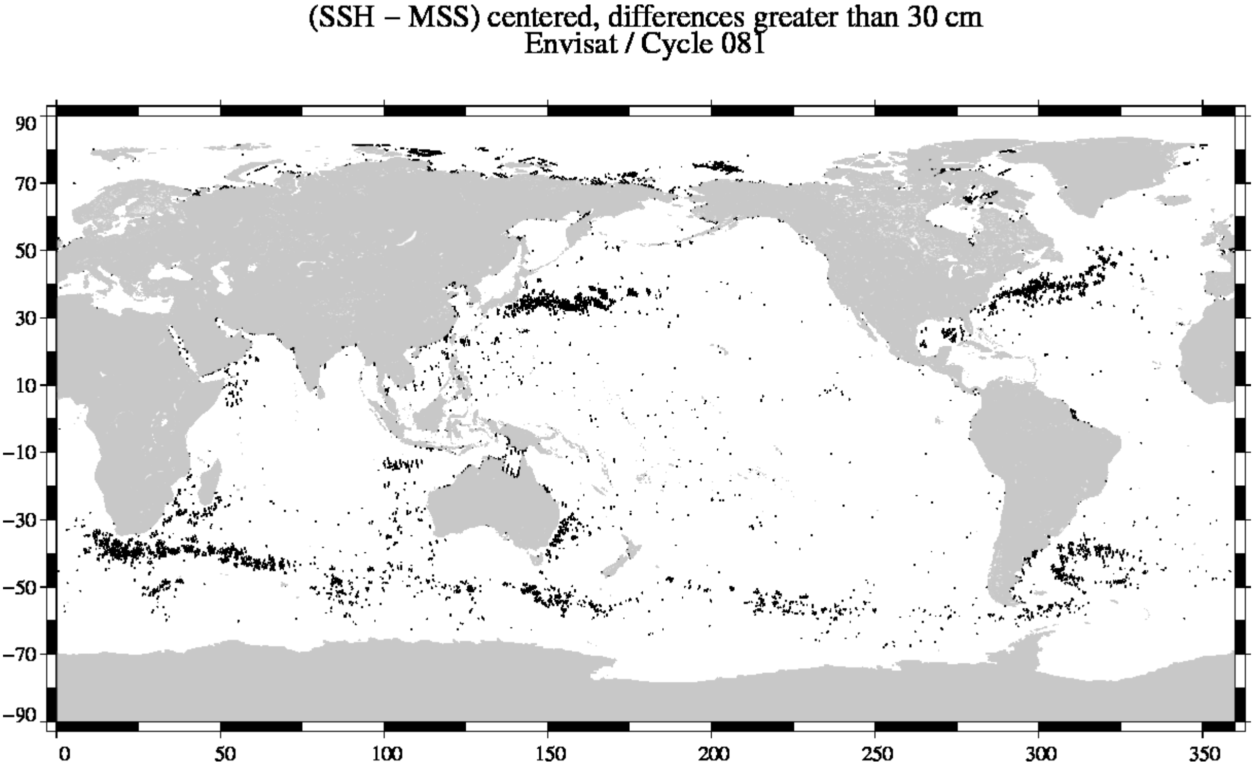
Number	Mean	Std. dev.
1566657	47.68	10.11

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.
971494.00000000	48.36	8.72

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 081
90
70
50
30
10
−10
−30
−50
−70
−90
0
50
100
150
200
250
300
350

4. Envisat long term performance monitoring

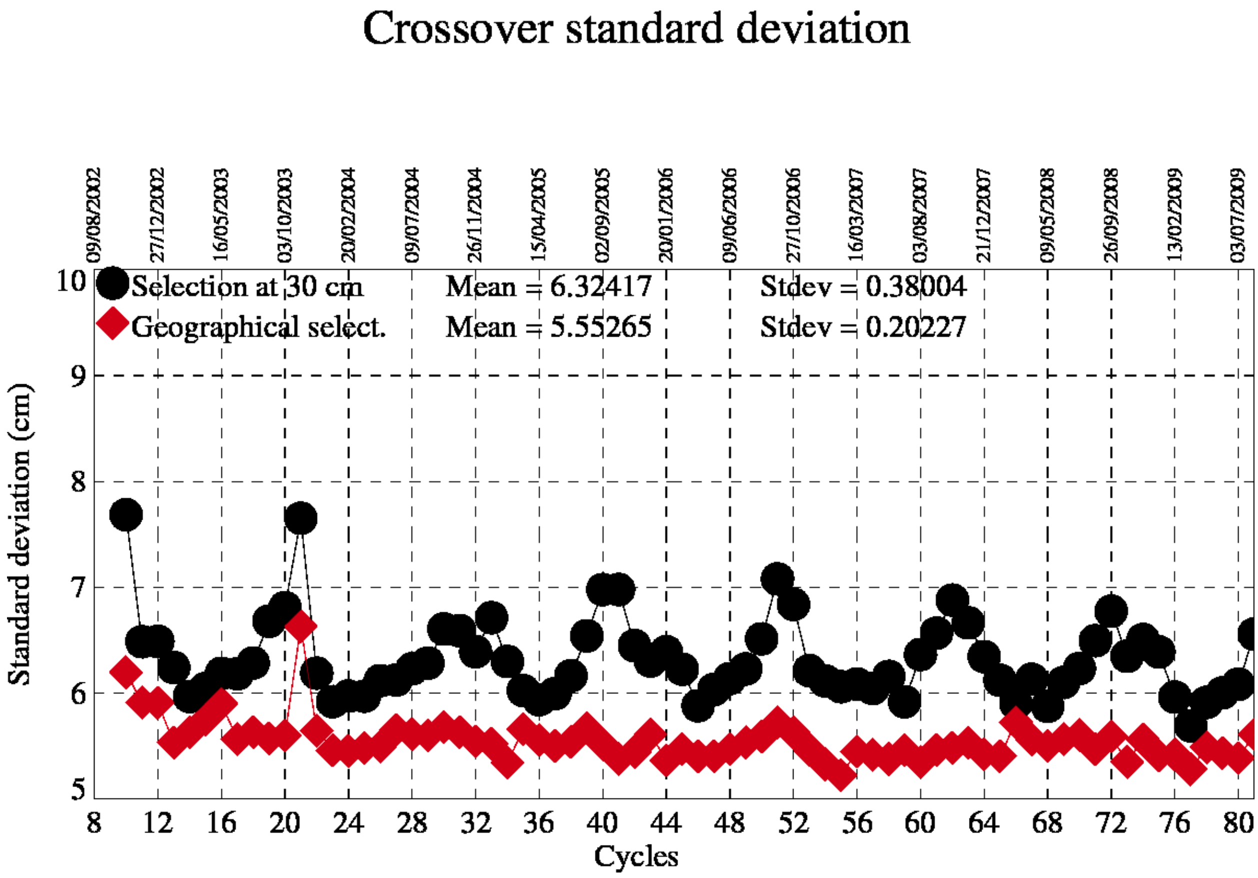
Statistics of SSH variability are computed after crossover and repeat-track analyses. This allows to estimate how Envisat data fulfill the mission objectives in terms of performances.

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 :

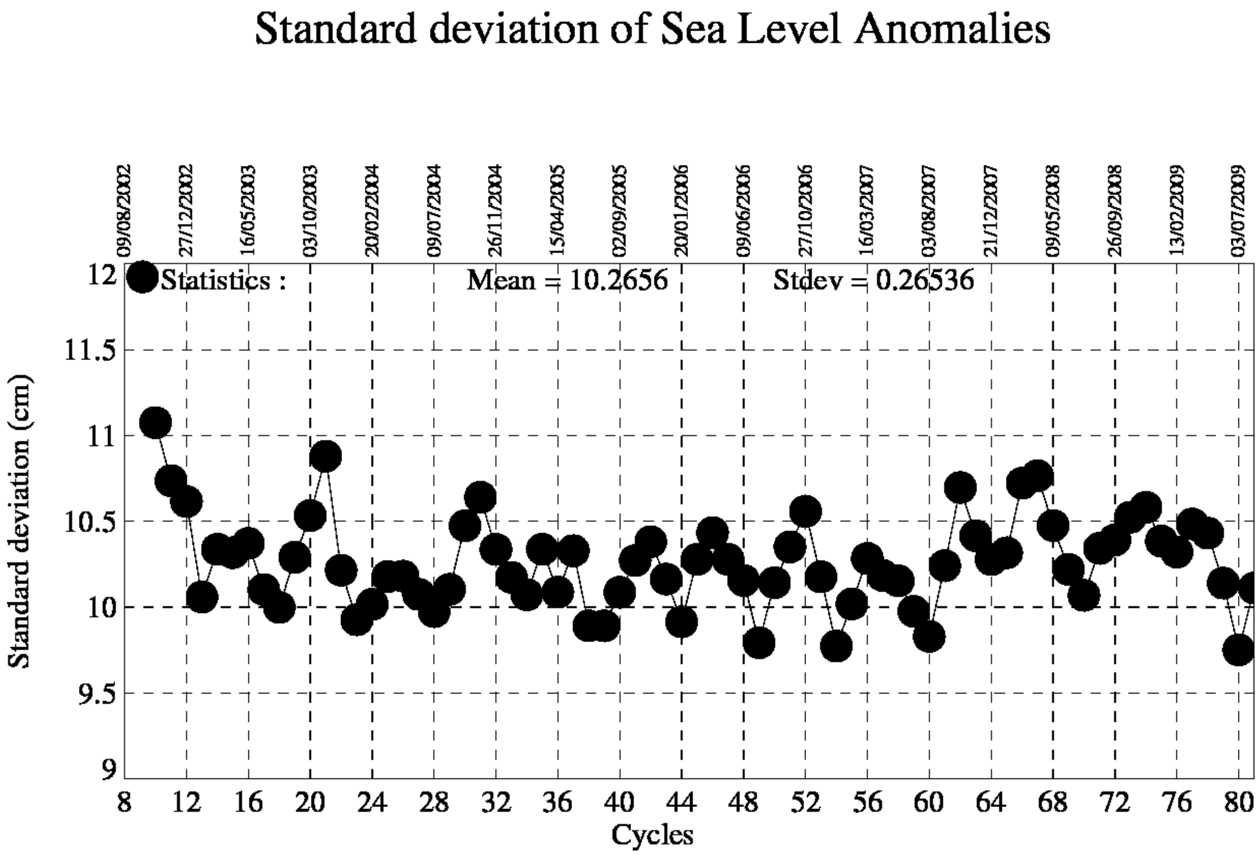
– Selecting crossover differences lower than 30 cm to avoid contamination by remaining spurious data.
– Removing shallow waters (1000 m), areas of high ocean variability and high latitudes (> |50| deg.) to avoid ice coverage effects.

Note, from cycle 86 onwards and for all reproccessed cycles, a selection at 10 days is applied to generate the crossover differences. This selection explains the jump on the monitoring of standard deviation of the differences at crossovers (not visible on the reprocessed time series).



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

The global mean level of the oceans is one of the most important indicators of climate change. It incorporates the reactions from several different components of the climate system. Precise monitoring of changes in the mean level of the oceans, particularly through the use of altimetry satellites, is vitally important, for understanding not just the climate but also the socioeconomic consequences of any rise in sea level. This subject is developped in http ://www.aviso.oceanobs.com/en/news/ocean-indicators/mean-sea-level.

More reprocessed data is needed to provide any meaningful Mean Sea Level monitoring.

5. Conclusion

Cycle fully certified for distribution to users from CALVAL point of view.

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

[5] Labroue, S., 2007 : RA2 ocean and MWR measurement long term monitoring, 2007 report for WP3, Task 2 - SSB estimation for RA2 altimeter. Contract 17293/03/I-OL. CLS-DOS-NT-07-198, 53pp. CLS Ramonville St. Agne