



Envisat GDR Quality Assessment Report

Cycle 010

30-09-2002 / 04-11-2002

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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 V6.04 and the CMA Reference Software V9.3_05

The main impacts of these evolutions on the SSH are described in section .

The content of this science software version is described in a document available on the ESA PCS web site ([2]).

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

- WARNING : For the first time the 6 state rain flag available in the CMA 9.3 version could be validated (it uses S-Band parameters in input and could therefore not be computed during S-Band loss period). Users are advised to use it within +/-50 deg Latitude only (high latitude ice above 50 deg South is uncorrectly interpreted as rain). See Particular Investigation Part.
- WARNING : Unrelevant S Band anomaly flag (abnormaly set to 1) even since the S Band anomaly is now solved. Users are advised not to take into account this flag anymore. See Particular Investigation Part.
- WARNING : Short USO anomaly periods were identified (Flag USO Anomaly set to 1) and related to unrelevant values of USO applied to the range. The comparison to a CMA reference correction field seems to evidence short periods of USO anomalies associated to wrong USO corrections applied to the range (jumps of several meters visible on the SLA). See Particular Investigation Part.

2.4. Platform and instrument events

None.

2.5. Cycle quality and performances

Good general results are obtained for this cycle of data except for tracks impacted by the USO anomaly (cf warning and particular investigations).

The crossover standard deviation is 7.54 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 11.1 cm. When using a selection to remove shallow waters (1000 m), areas of high ocean variability and high latitudes ($> |50|$ deg) it lowers to 10.0 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 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 (POE 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 (IPF v6.02L04 and CMA v9.3) for the SSH calculation

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

2.8.1. Instrumental correction impacting the range

3 Major changes were performed in the new IPF chain :

- The introduction of USO correction directly in the range at the L1b level. This shall not have any impact on the data except that users shall not correct the products afterwards (see section **Particular investigations**) .
- The improvement of the PTR resolution from 3cm to 1.8mm.
This has 2 impacts on the data :
 - A direct impact on the Calibration factors included in the Level2 Instrumental Corrections :
 - On the range through the Time Delay Calibration Factor.
 - On the σ_0 through the σ_0 calibration factor.
 - An undirect impact on the data through the retracking applied on a slightly modified waveform :
 - On all retracked parameters (Range through Epoch, SWH through SigmaC2, Wind through Sigma0, Mispointing, Peakiness)

2.8.2. Improvement of the SSB correction

2 changes were performed impacting the SSB correction :

- The Sea-State bias table has been recomputed according to Labroue, 2007 [5]. The method used provides a reduced time tag bias and orbit error on the whole mission period and makes profit of an adapted period for waveforms processing. Differences with previous SSB model are due to the orbit error which is taken into account and the radiometer wet tropospheric correction which explains the observed differences related to younger seas.
- Furthermore, the improvement of the PTR SigmaC estimation has an impact on the SWH value ($SWH2 = \text{Sigma}P2 + \text{Sigma}C2$). It is estimated to -13cm with a slight dependence in SWH.

2.8.3. New MWR

Changes were performed on the MWR characterisation files with an impact on :

- Wet Tropospheric correction
- Brightness temperatures

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.
- 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 from FES2002 to FES2004 : new Ocean Tide and Tidal Loading. This will have no impact on the data provided our SLA is computed with GOT tidal model.

2.8.6. Total bias expected/evaluated on the SLA monitoring

The global impact noticed on the SLA monitoring (-10.6mm jump with geographical patterns) consists in the sum of :

- Around -6.3mm due to the new PTR resolution increasing (included in the range instrumental correction) - Expected
- Around -4.3mm due to the new SSB solution (algorithm part : +2mm and 4% of 13cm SWH bias part : -5mm) - Expected

Impact is also noticed on SWH monitoring :

- Around -13cm bias on the SWH due to the PTR width estimation - Expected

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

- Sigma0 : +0.025dB and 0.0003dB from the sigma0 calibration factor
- At_atmo : +0.016dB
- Wind : -0.06m/s
- TB2 : +0.9K (0.5K expected on all surfaces)
- TB3 : +2.3K (1K expected on all surfaces)
- USO : 1.8mm / 1mm / 0.4mm

All these aspects are detailed and can be consulted in the dedicated note comparing data with both successive IPF/CMA versions on the same cycle (85) :

http://earth.eo.esa.int/pcs/envisat/ra2/articles/RA2_GDR_REPROCESS_CYCLE_085_RELEASE_NOTE.pdf

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

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.

2.10. Reprocessing

A global reprocessing from the beginning of the mission has started from cycle 10 with the V2.1 product version.

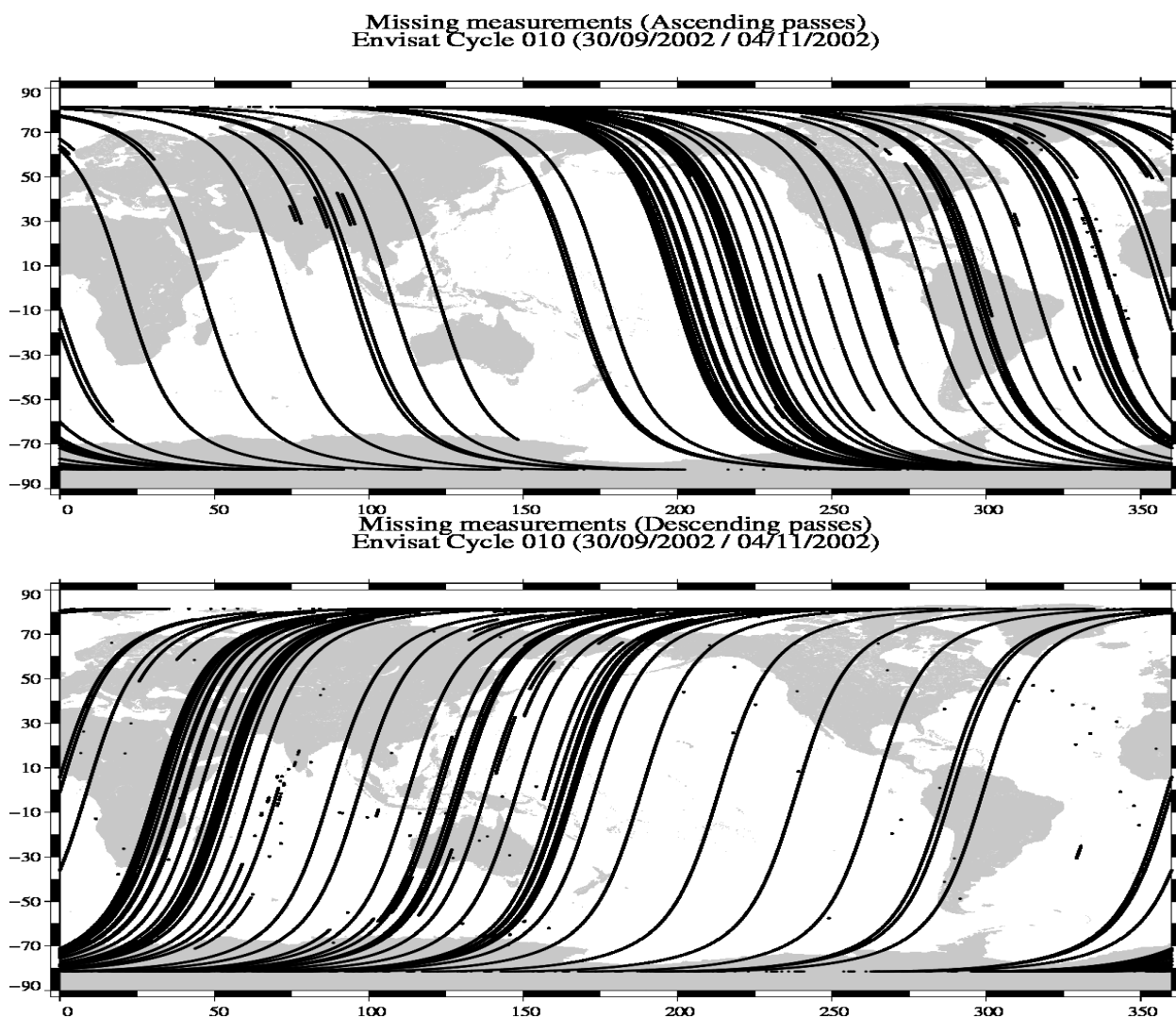
3. CALVAL main results

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

1612601 are present, and 266200 (14.2%) are missing. The maps below illustrate missing 1Hz measurements in the GDRs, with respect to a 1 Hz sampling of a nominal repeat track.



966 passes produced over 1002. 36 passes are totally missing due to level 0 and level 1 B data unavailability :

- Pass 41 : [2002/10/02 06 :17 :35 => 07 :56 :34] - Gap RA2-0 + MWR-0
- Passes 250-271 : [2002/10/09 13 :34 :20 => 2002/10/10 08 :56 :53] - [RA2-INS]
- Passes 297-298 : [2002/10/11 05 :17 :36 => 08 :12 :21] - Gap RA2-0 + L2
- Passes 613-614 : [2002/10/22 05 :50 :13 => 09 :08 :26] - Gap RA2-0 + IPF Error L1 (FA 7960)
- Passes 632-633 : [2002/10/22 21 :51 :12 => 2002/10/23 00 :26 :13] - Gap RA2-0

- Pass 650 : [2002/10/23 13 :38 :30 => 15 :17 :51] - Gap RA2-0 + MWR-0
- Passes 660-664 : [2002/10/23 21 :50 :44 => 2002/10/24 02 :54 :13] - Gap RA2-0 + MWR-0
- Pass 880 : [2002/10/31 14 :25 :54 => 16 :08 :05] - Gap RA2-0 + MWR-0

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	120987	8.98
Ice flag	305177	22.66

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.

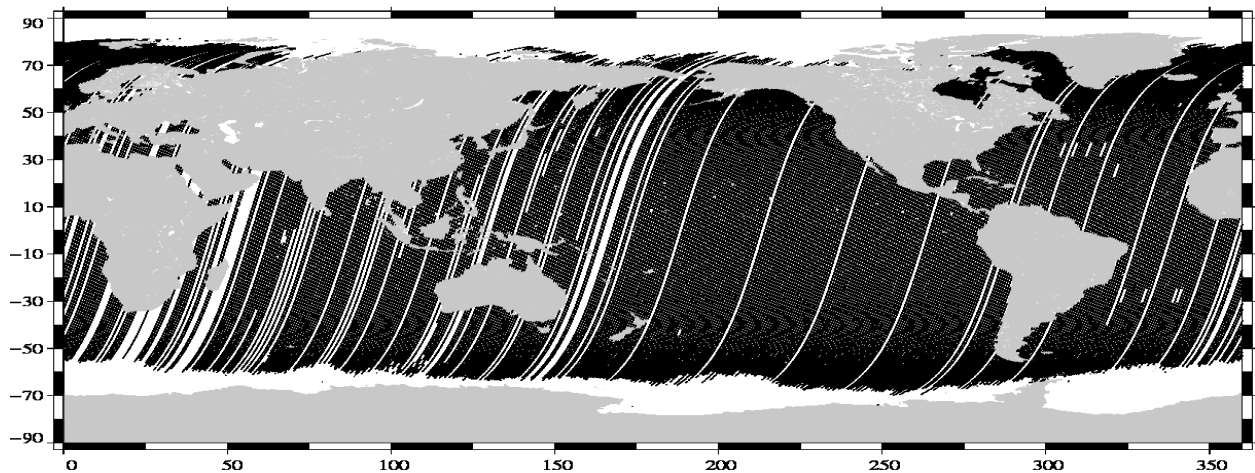
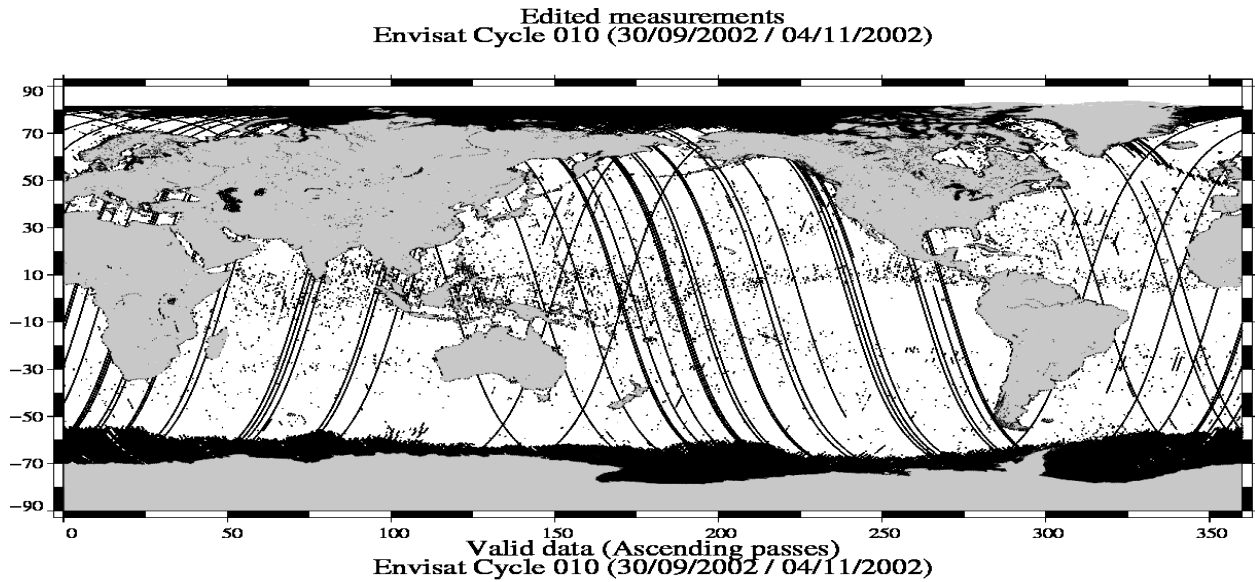
The next table gives for each tested parameter, minimum and maximum thresholds, the number and the percentage of points removed.

Parameters	Min Thres.	Max Thres.	Nb rejected	% rejected
Sea surface height (m)	-130.000	100.000	13137	1.09
Variability relative to MSS (m)	-2.000	2.000	16726	1.39
Number of 18Hz valid points	10.000	-	1505	0.12
Std. deviation of 18Hz range (m)	0.000	0.250	13888	1.15
Off nadir angle from waveform (deg ²)	-0.200	0.160	5651	0.47
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	2340	0.19
GIM Ionospheric correction (m)	-0.400	0.040	2372	0.20
Significant wave height (m)	0.000	11.000	2169	0.18
Sea state Bias (m)	-0.500	0.010	1409	0.12
Backscatter coefficient (dB)	7.000	30.000	3044	0.25
GOT00 ocean tide height (m)	-5.000	5.000	2306	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)	-15.000	15.000	0	0.00
RA2 wind speed (m/s)	0.000	30.000	1400	0.12

A final editing is then performed on corrected sea surface height, using a spline fitting procedure, leading to remove 503 (0.04 %) 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

Missing MWR 46 passes are entirely edited on the radiometer land flag (no MWR correction)- 16 17 39 212 213 294 295 300 301 330 331 356 357 380 381 386 387 409 410 411 420 421 443 576 577 588 616 617 790 791 805 815 816 817 844 845 864 870 872 873 874 875 900 901 958 959

Note that this number is increased compared to the original version (previously 13). Some of the problem occurring at the L1b level was also indicated in a ticket (FA 7957).

S Band anomaly

Compared to the original processing, data are no more affected by the S Band anomaly (previously 336 tracks edited on this criterion).

Note that, however, S Band Anomaly flag is abnormally set to 1 were it used to be S Band anomalies. Users are advised not to take into account this flag anymore.

Other editing

12 passes are edited because of SSH or SLA statistics out of thresholds.

After investigation, these abnormal tracks were edited due to an abnormal behavior of the USO correction taken into account in the product (for the reprocessing IPF version).

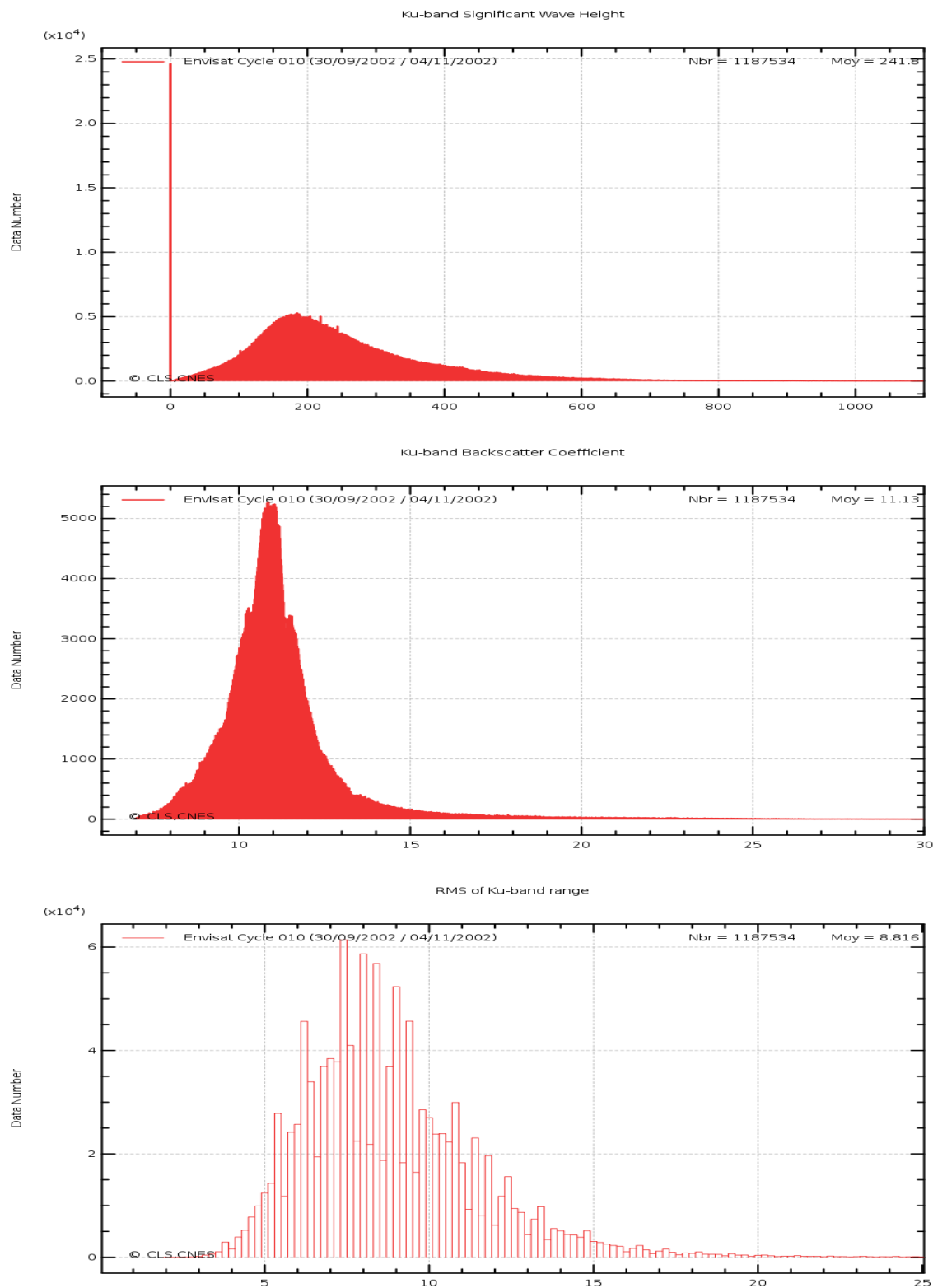
The passes concerned are :

- Pass 031 (out of threshold) : from 2002-10-01 21 :52 :33 to 2002-10-01 23 :22 :34
- Passes 124-125(out of threshold) : from 2002-10-05 04 :40 :42 to 2002-10-05 06 :21 :16
- Passes 210-211(out of threshold) : from 2002-10-08 04 :46 :54 to 2002-10-08 06 :28 :24
- Passes 584-585(out of threshold) : from 2002-10-21 06 :19 :47 to 2002-10-21 07 :55 :09
- Passes 866-867(out of threshold) : from 2002-10-31 01 :04 :38 (voir peut etre avant) to 2002-10-31 04 :24 :48
- Pass 38 (stat per track out of threshold) : from 02/10/2002 04 :36 :51 to 2002-10-02 06 :17 :35
- Passes 288-289 (stat per track out of threshold) : from 2002-10-10 22 :11 :51 to 2002-10-10 23 :51 :53

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

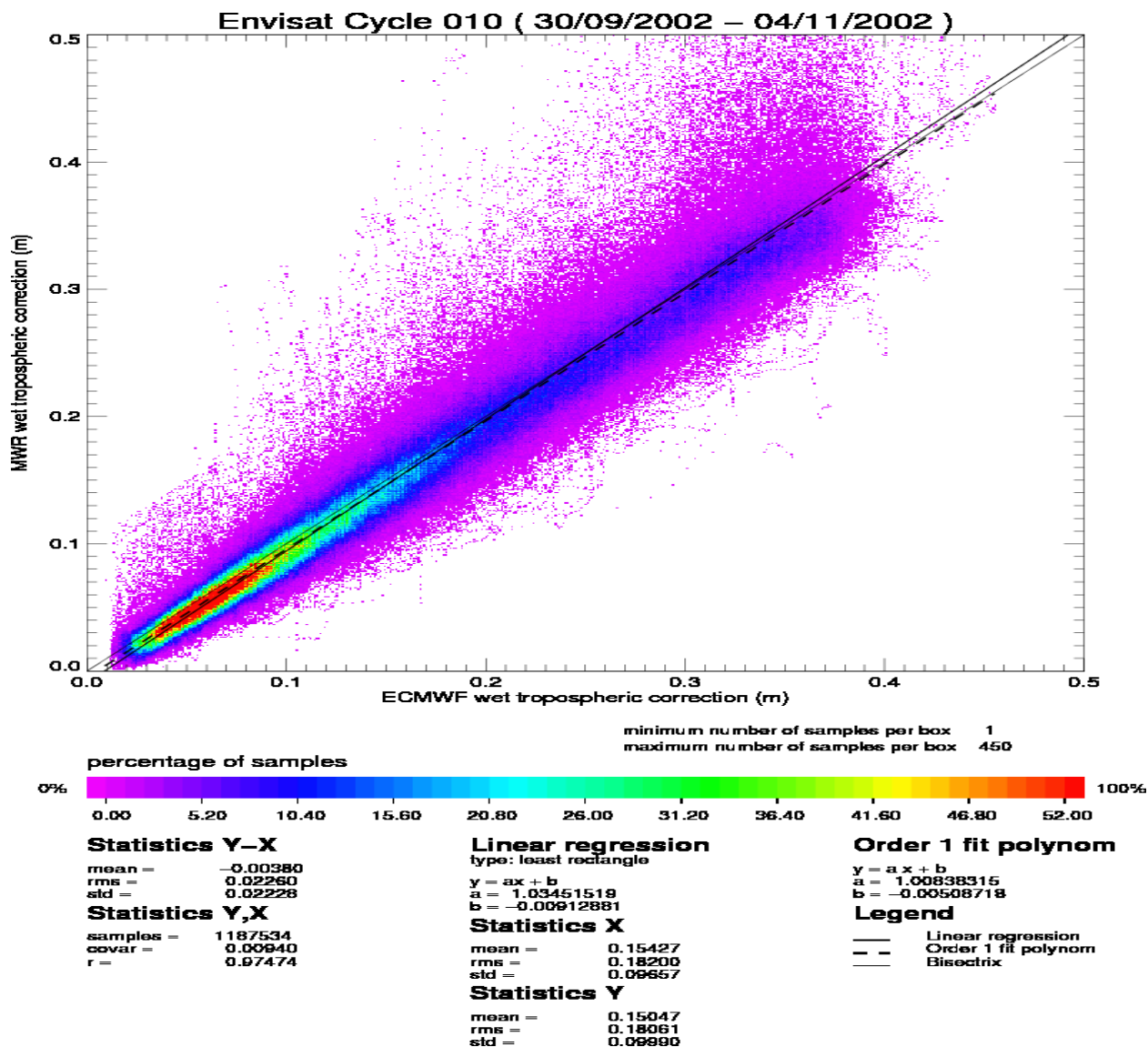
3.4. Altimeter parameters

In order to assess and to monitor altimeter parameter measurements, histograms of Envisat Ku-band Significant Wave Height (SWH), Backscatter coefficient (σ_0) and RMS of altimeter range are computed.



3.5. Radiometer

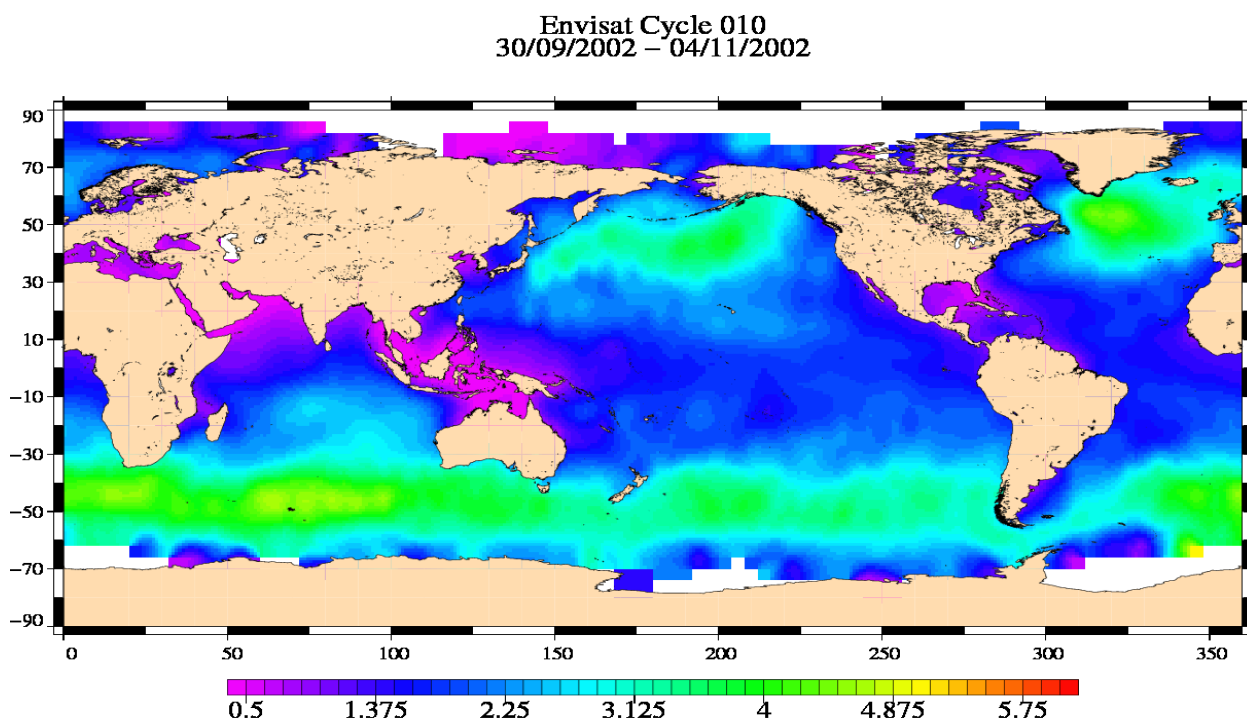
In order to assess and to monitor radiometer measurements, a scatter plot between the radiometer wet troposphere correction and the ECMWF model is computed for the valid data set previously defined.



The radiometer-model mean difference is 0.4 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.

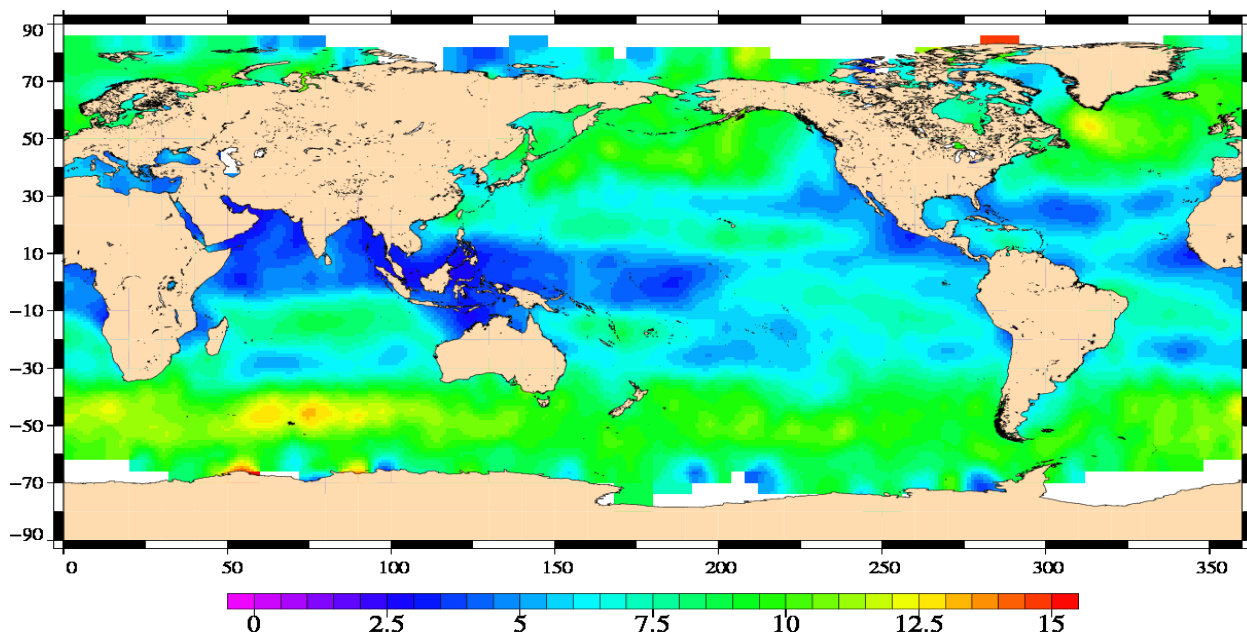
3.6. Wind and wave maps

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



Significant Wave Height (m)

Envisat Cycle 010
30/09/2002 – 04/11/2002



Altimeter wind speed (m/s)

3.7. Crossover statistics

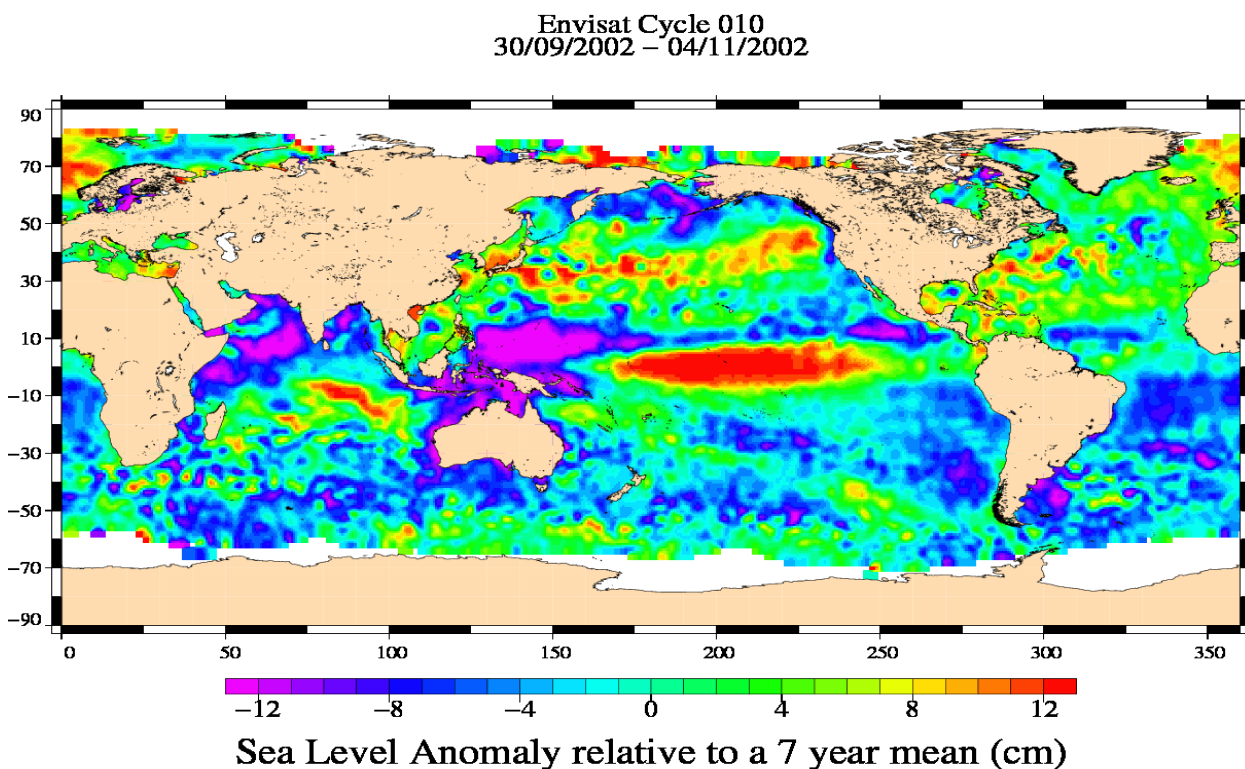
Not communicated for this uncomplete cycle.

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.

For the drifting phase (after cycle 95) no mean profile exists. The only possible reference is the MSS, available everywhere see hereafter.



3.8.2. Comparison to a precise Mean Sea Surface

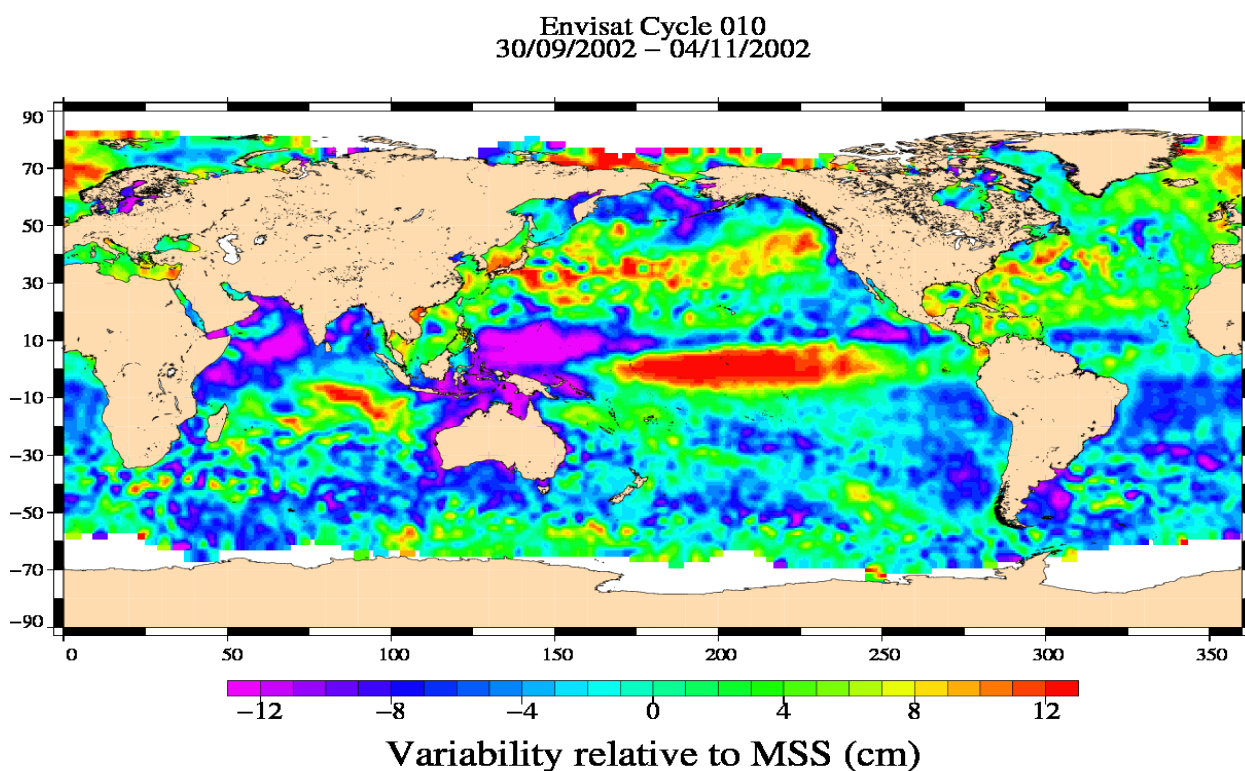
The MSS from the product is used as a reference to compute SLA. Global statistics of Envisat SSH-MSS are (cm) :

Number	Mean	Std. dev.
1330468	48.52	11.08

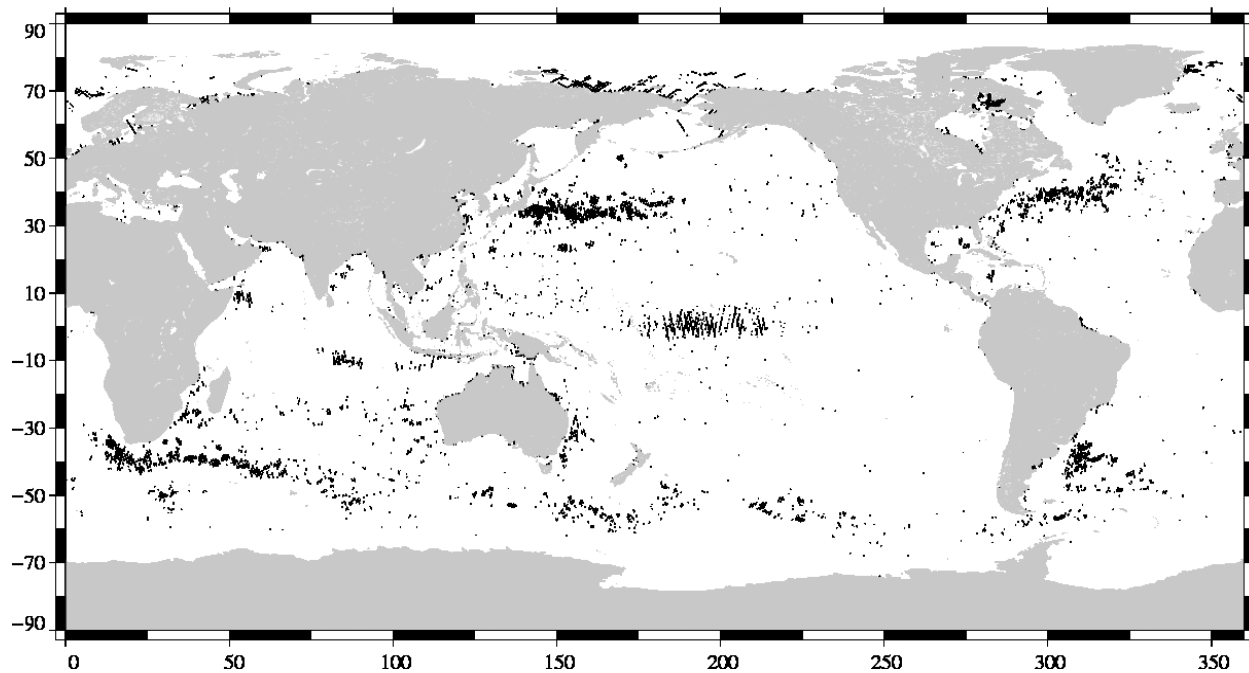
When using a selection to remove shallow waters (1000 m), areas of high ocean variability and high latitudes ($> |50|$ deg) statistics are :

Number	Mean	Std. dev.
825930.00000000	48.28	9.95

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 010



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.

Note, since cycle 86 and future cycles processed, a selection at 10 days is applied to generate the crossover differences. This selection explain the jump on the monitoring of standard deviation of the differences at crossovers.

For the first reprocessed cycle this plot is not available because unrelevant (1 point).

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.

For the drifting phase (after cycle 95) no mean profile exist. The only possible reference is the MSS, available everywhere see hereafter.

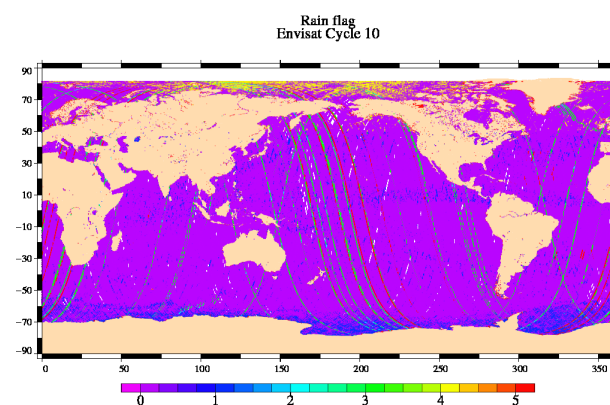
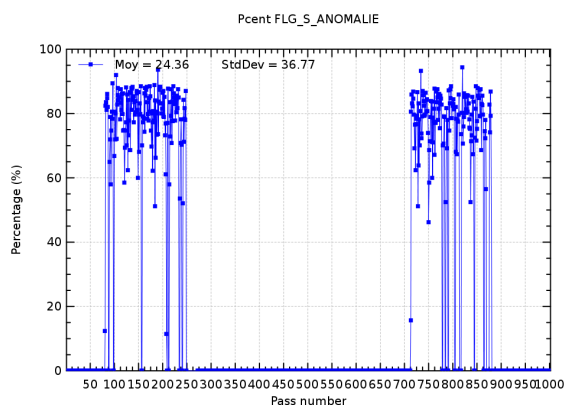
For the first reprocessed cycle this plot is not available because unrelevant (1 point).

4.3. Mean Sea Level

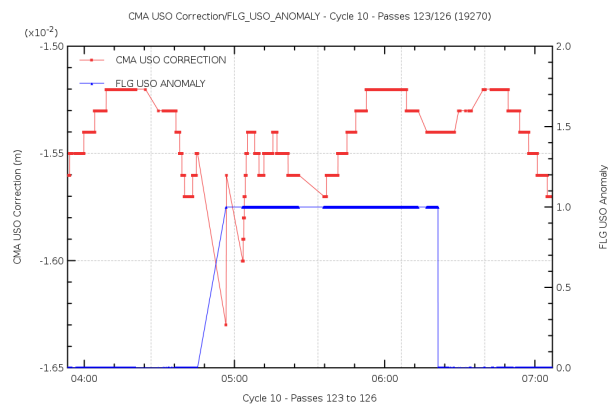
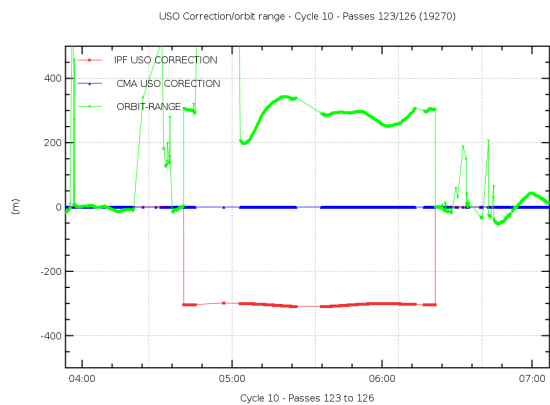
For the first reprocessed cycles this part is not available because irrelevant.

5. Particular investigations

- WARNING : For the first time the 6 state rain flag available in the CMA 9.3 version could be validated (it uses S-Band parameters in input and could therefore not be computed during S-Band loss period). Users are advised to use it within +/-50 deg Latitude only (high latitude ice above 50 deg South is uncorrectly interpreted as rain).
- WARNING : Unrelevant S Band anomaly flag (abnormally set to 1) even since the S Band anomaly is now solved. Users are advised not to take into account this flag anymore.



- WARNING : Short USO anomaly periods were identified (Flag USO Anomaly set to 1) and related to unrelevant values of USO applied to the range. The comparison to a CMA reference correction field seems to evidence short periods of USO anomalies associated to wrong USO corrections applied to the range (jumps of several meters visible on the SLA). See hereafter.



- [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