Envisat GDR
Quality Assessment Report

Cycle 097

26-11-2010 / 26-12-2010

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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 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 "c" (IPF v6.02 / CMA v9.3) 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
- 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

Since GDR cycle 93, users do not have anymore to correct data from any external USO correction.
-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 **Particular investigations**).

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 6.86 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 0.0 cm. When using a selection to remove shallow waters (1000 m), areas of high ocean variability and high latitudes ($> |50|$ deg) it lowers to 10.3 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 (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 "c" (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 sigma0 through the sigma0 calibration factor.
   – An undirect impact on the data through the retracking applied on a slighlty modified waveform :
      – On all retracked parameters (Range through Epoch,SWH through SigmaC2, Wind throught 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 ($SWH2 = SigmaP2 + SigmaC2$). 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 biais on the SWH due to the PTR width estimation - Expected

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

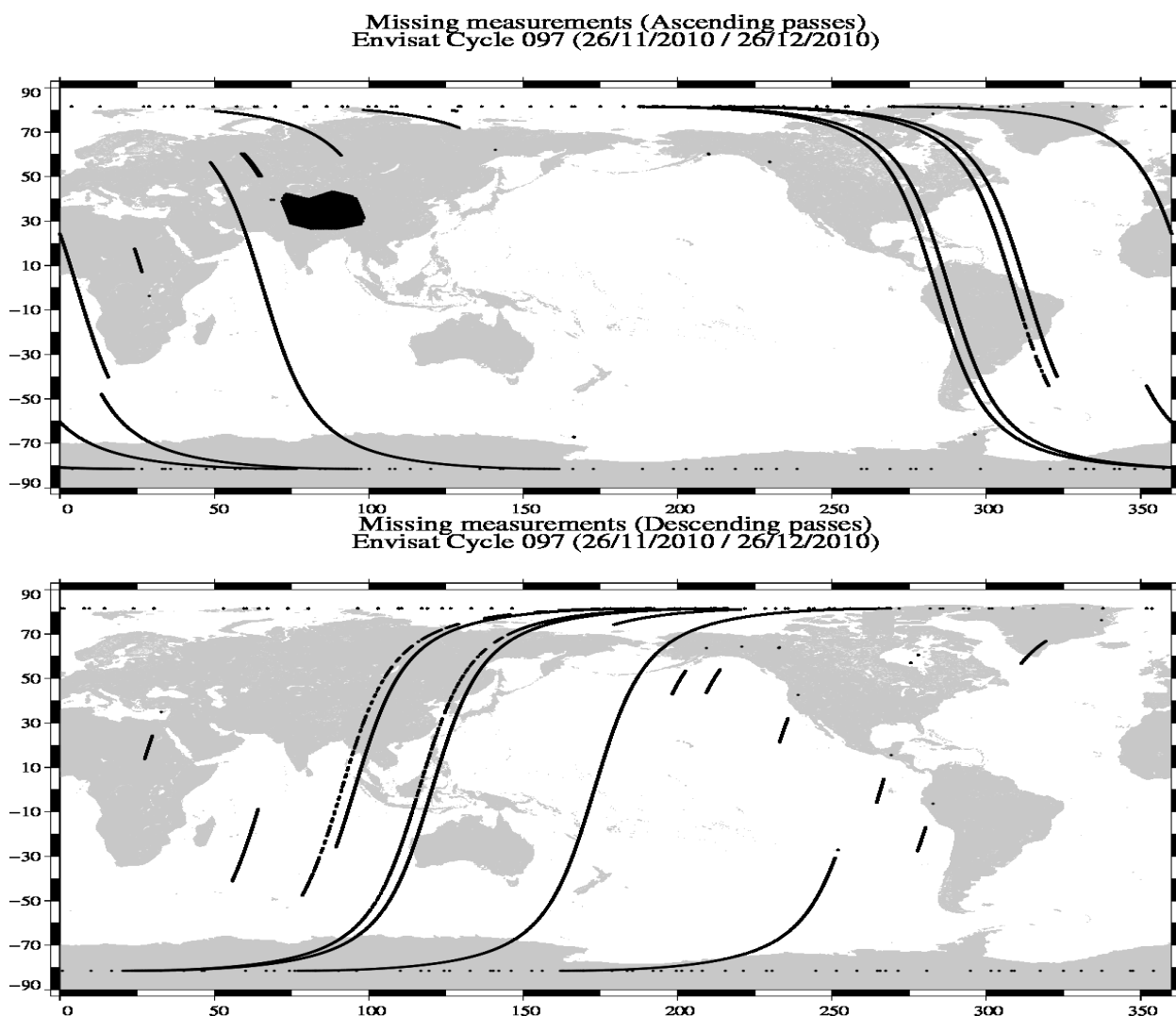From cycle 93 onwards (and for the future reprocessed data), no more USO auxiliary file is needed.

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

1510746 are present, and 35157 (2.3%) 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 097 (26/11/2010 / 26/12/2010)

Missing measurements (Descending passes)
Envisat Cycle 097 (26/11/2010 / 26/12/2010)

858 passes produced over 862. 4 passes are missing : -Passes 92-93 : [2010/11/30 00 :57 :45 => 03 :46 :34] - Scheduling anomaly - pass not captured [EOFC 58467 + EOFC 58445] -Pass 174 : [2010/12/02 21 :27 :14 => 23 :06 :24] - Acquisition problem at Esrin [EOFC 58501] (1PN) -Pass 237 : [2010/12/05 02 :31 :44 => 03 :31 :06] - Problem occured at Esrin during acquisition (problem rcv signal many discarded) [EOFC 58537] (DOR_DOP) [DOR-ACQ] [2010/12/05 02 :19 :00 ; 03 :03 :00]

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	36273	2.90
Ice flag	279458	22.33
	2	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.
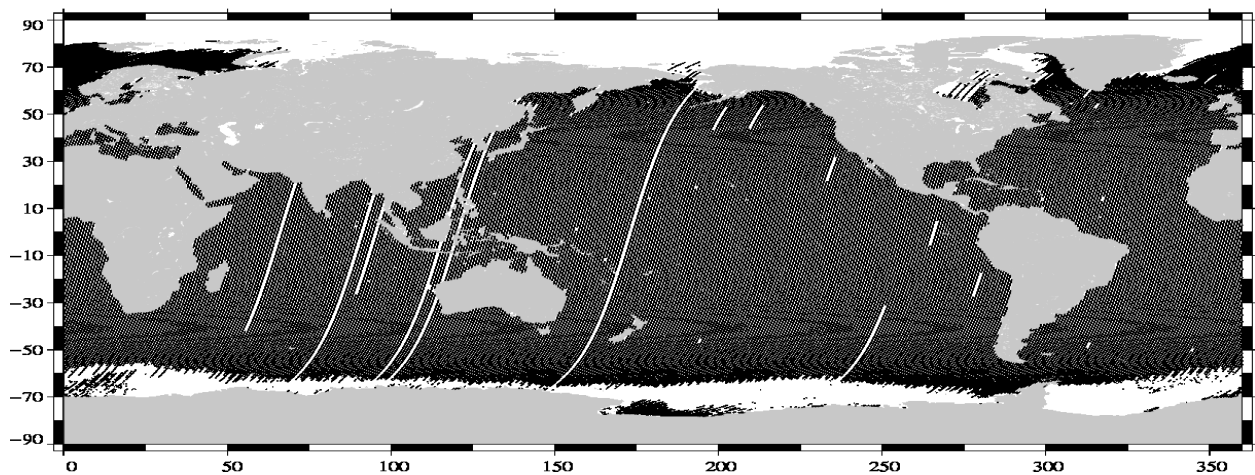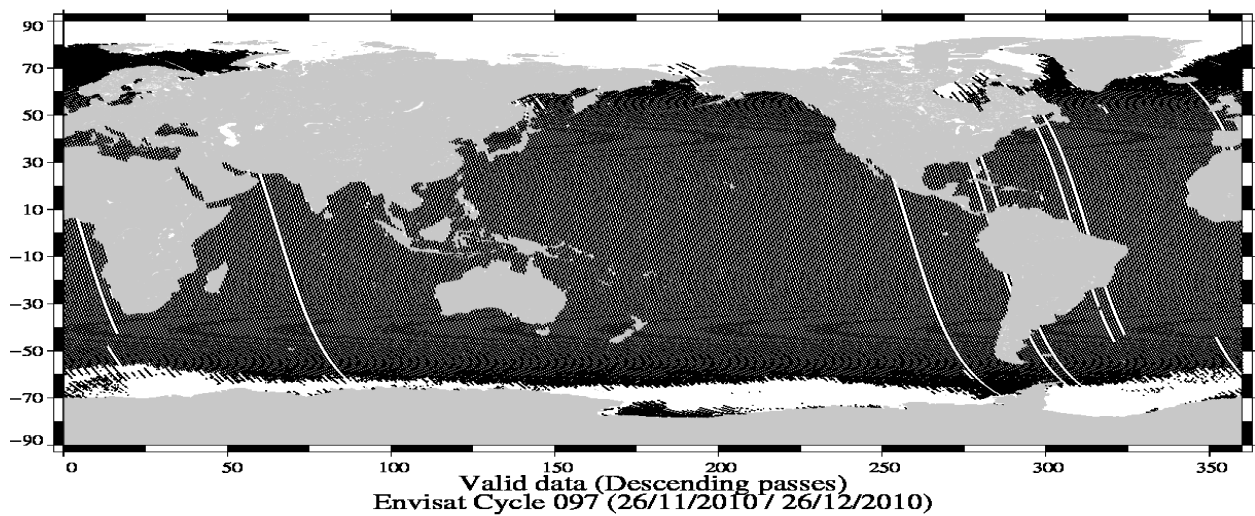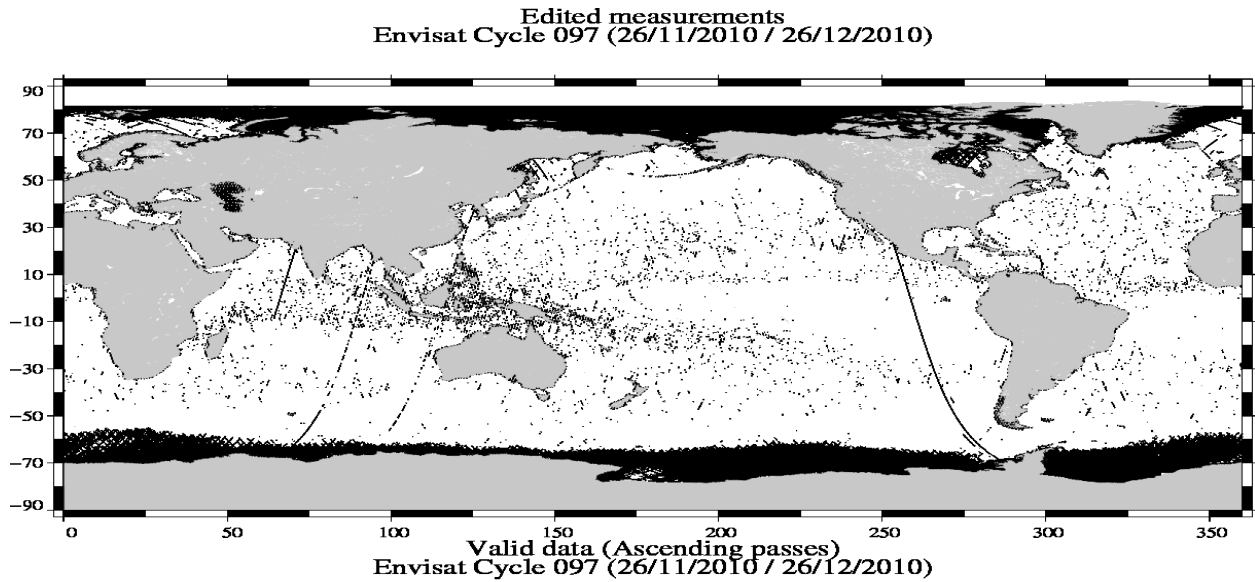The next table gives for each tested parameter, minimum and maximum thresholds, the number and the percentage of points removed.

Parameters	Min Thres.	Max Thres.	Nb rejected	% rejected
Sea surface height (m)	-130.000	100.000	266	0.02
Variability relative to MSS (m)	-2.000	2.000	1385	0.12
Number of 18Hz valid points	10.000	-	254	0.02
Std. deviation of 18Hz range (m)	0.000	0.250	11515	0.96
Off nadir angle from waveform (deg2)	-0.200	0.160	3742	0.31
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	2240	0.19
GIM Ionospheric correction (m)	-0.400	0.040	0	0.00
Significant wave height (m)	0.000	11.000	834	0.07
Sea state Bias (m)	-0.500	0.010	159	0.01
Backscatter coefficient (dB)	7.000	30.000	1543	0.13
GOT00 ocean tide height (m)	-5.000	5.000	1420	0.12
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	152	0.01

A final editing is then performed on corrected sea surface height, using a spline fitting procedure, leading to remove 575 (0.05 %) measurements.

3.3.2. Figures

The following maps are complementary : they show respectively the removed and selected measurements in the editing procedure.
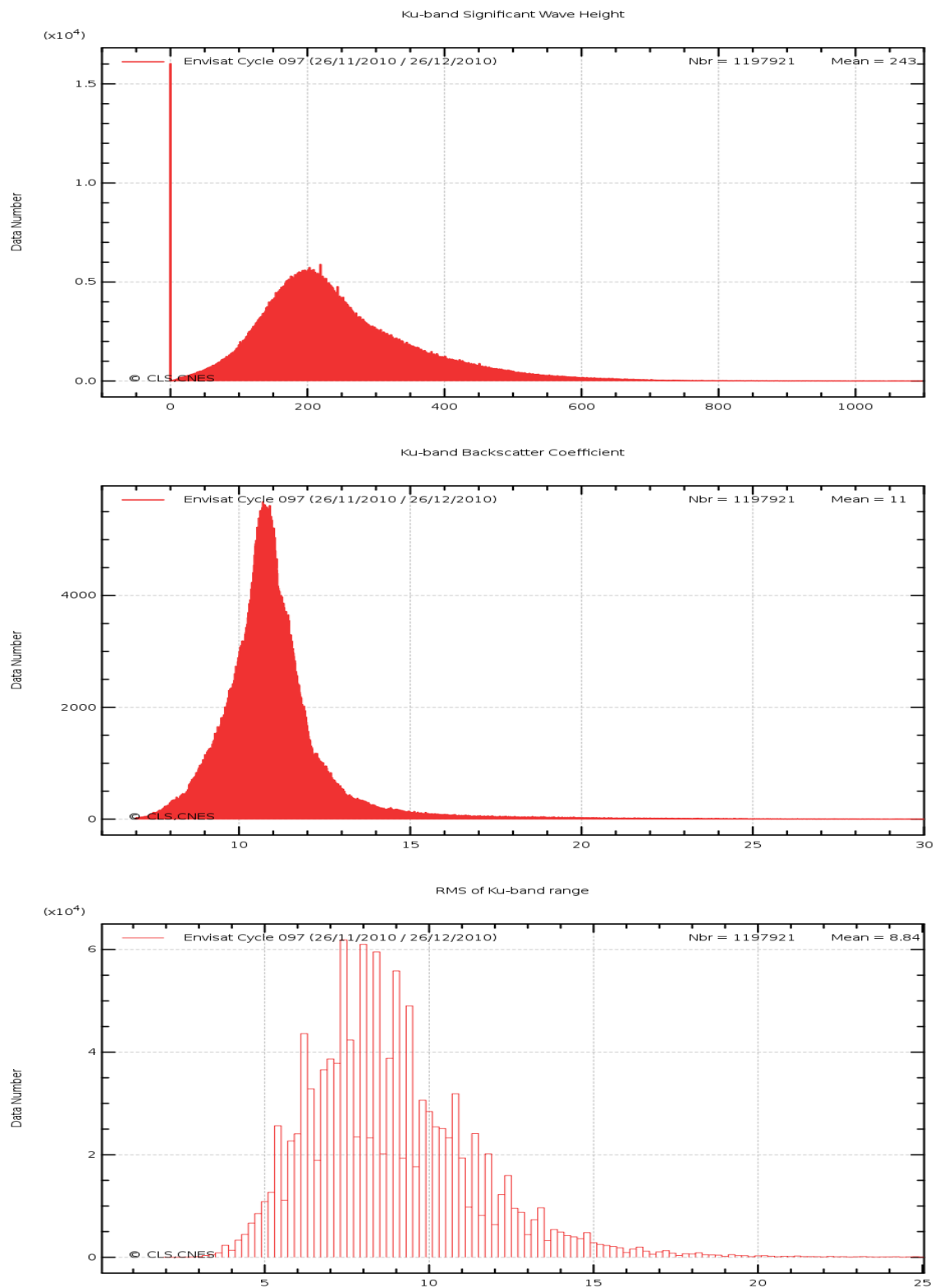
Edited measurements
Envisat Cycle 097 (26/11/2010 / 26/12/2010)

Valid data (Ascending passes)
Envisat Cycle 097 (26/11/2010 / 26/12/2010)

Valid data (Descending passes)
Envisat Cycle 097 (26/11/2010 / 26/12/2010)

3.3.3. Comments

4 passes (236 238 239 513) are entirely edited on the radiometer land flag (no MWR correction)

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.
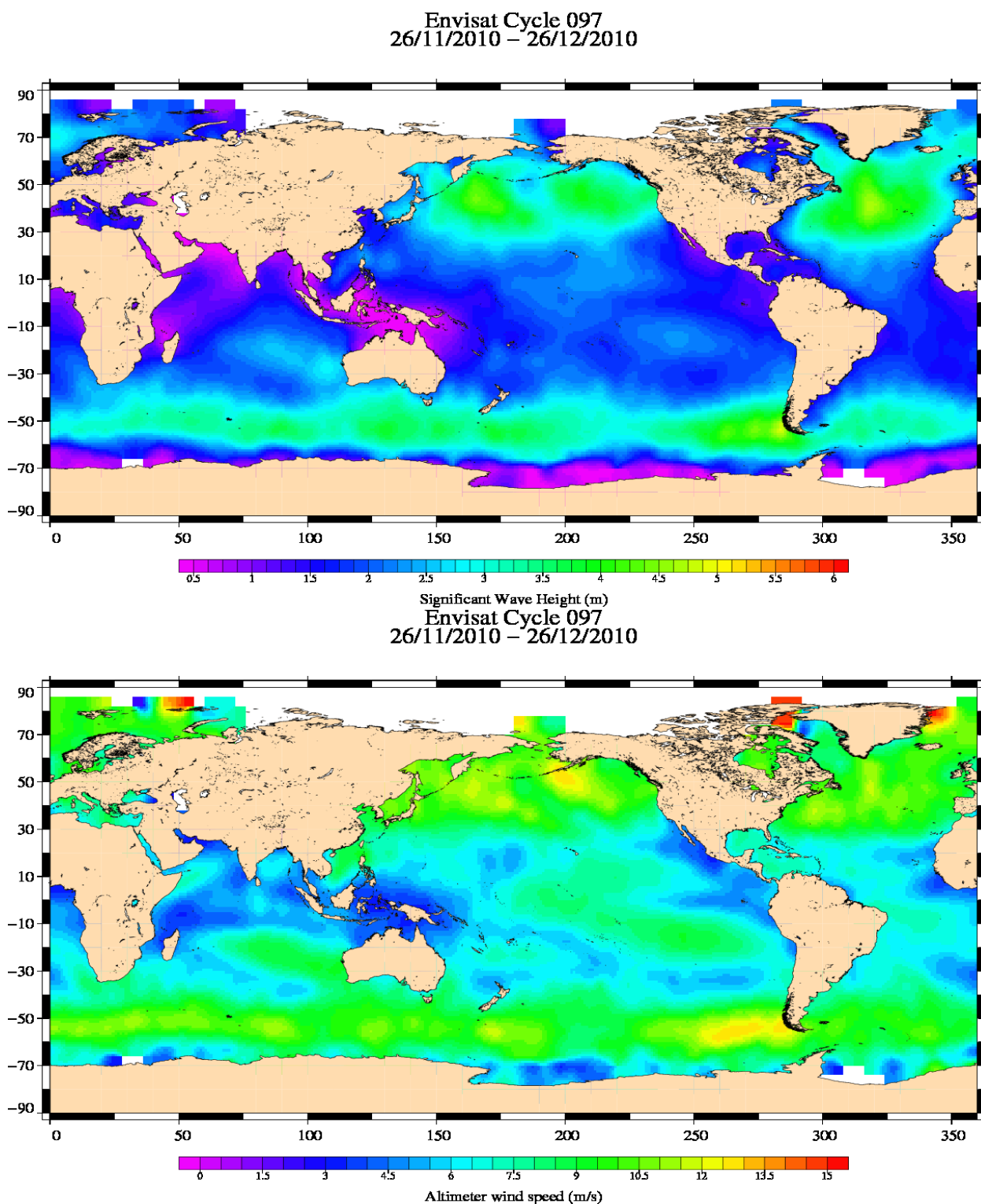

Ku-band Significant Wave Height

Ku-band Backscatter Coefficient

RMS of Ku-band range

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.
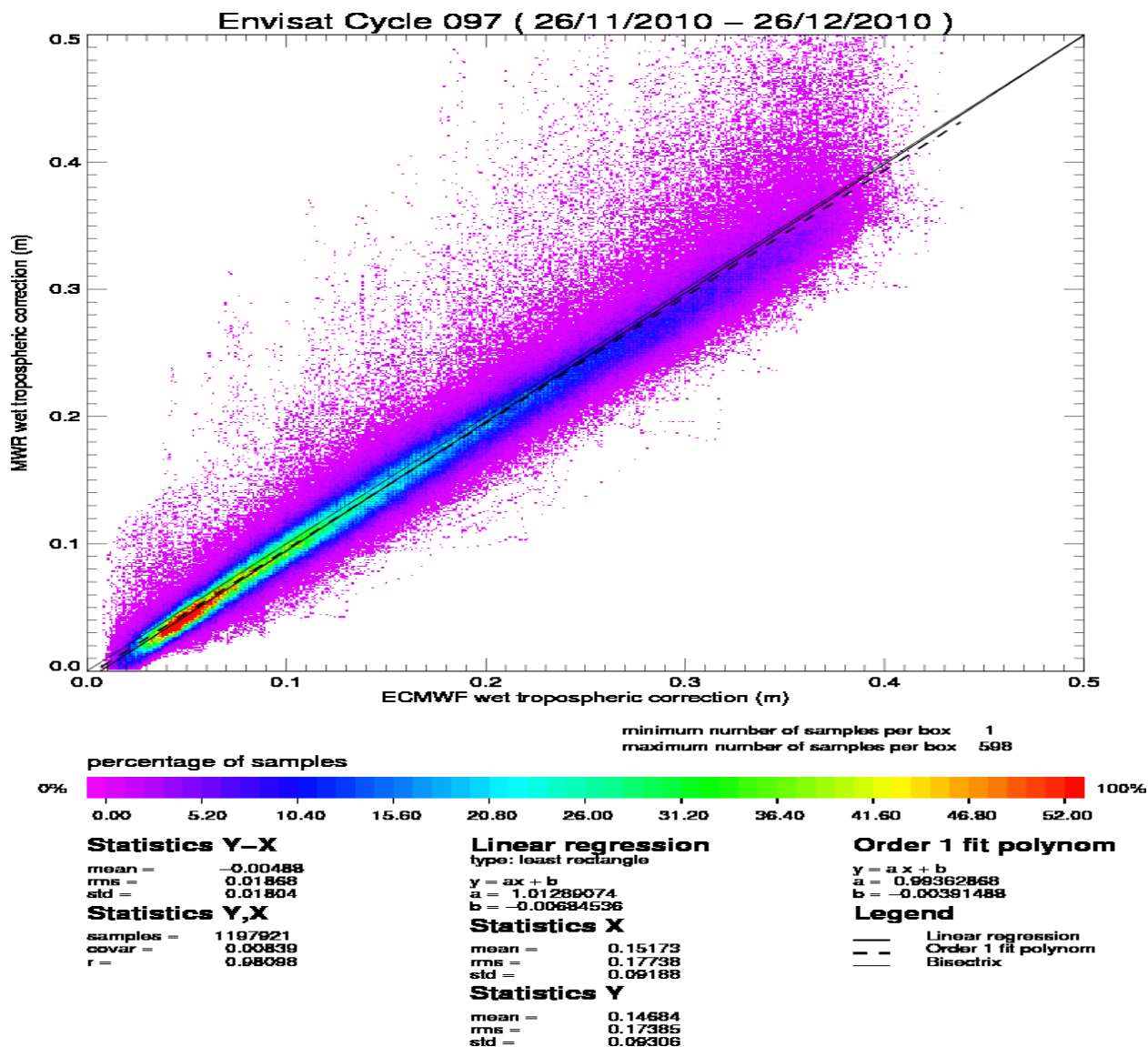
The radiometer-model mean difference is 0.5 cm. A drift on the Envisat 23.8GHz brightness temperature has been detected and has to be monitored on the long term. Note that the neural algorithm is now implemented on Envisat.

3.6.   Wind and wave maps

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

Envisat Cycle 097
26/11/2010 − 26/12/2010

Significant Wave Height (m)

Envisat Cycle 097
26/11/2010 − 26/12/2010

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 ajusted 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) : FILE NOT FOUND !

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.
837008.00000000	47.84	10.33

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.

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Variability relative to MSS (cm)
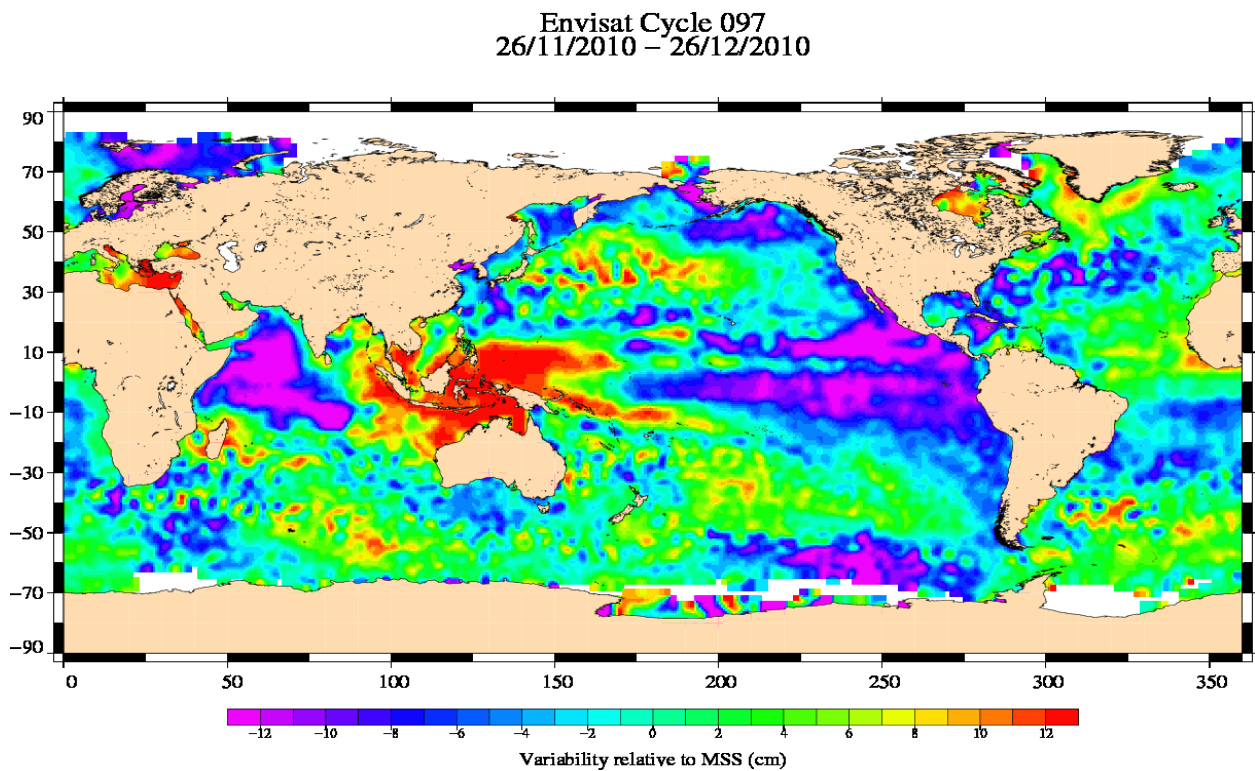
(SSH − MSS) centered, differences greater than 30 cm
Envisat / Cycle 097
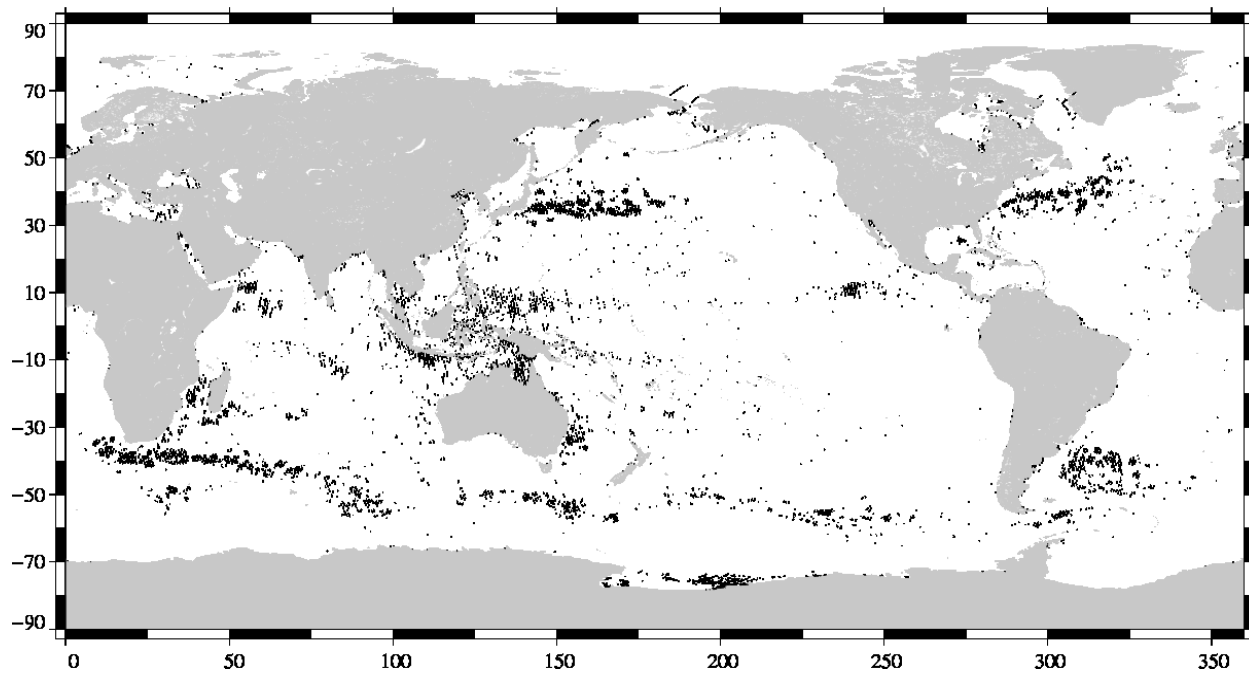
4. Envisat long term performance monitoring

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, 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.

Crossover standard deviation
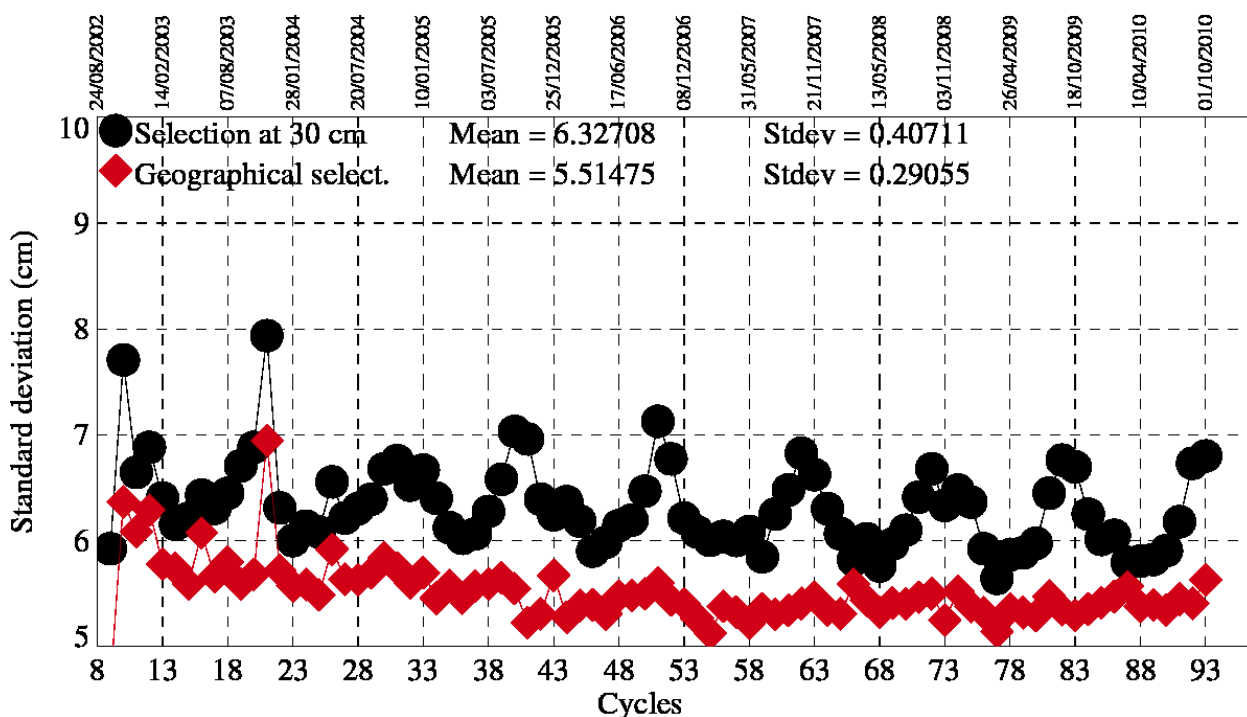
4.2.   RMS of Sea Level Anomaly

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.

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

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 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 (2007 [5]) 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 6 months and 6 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.
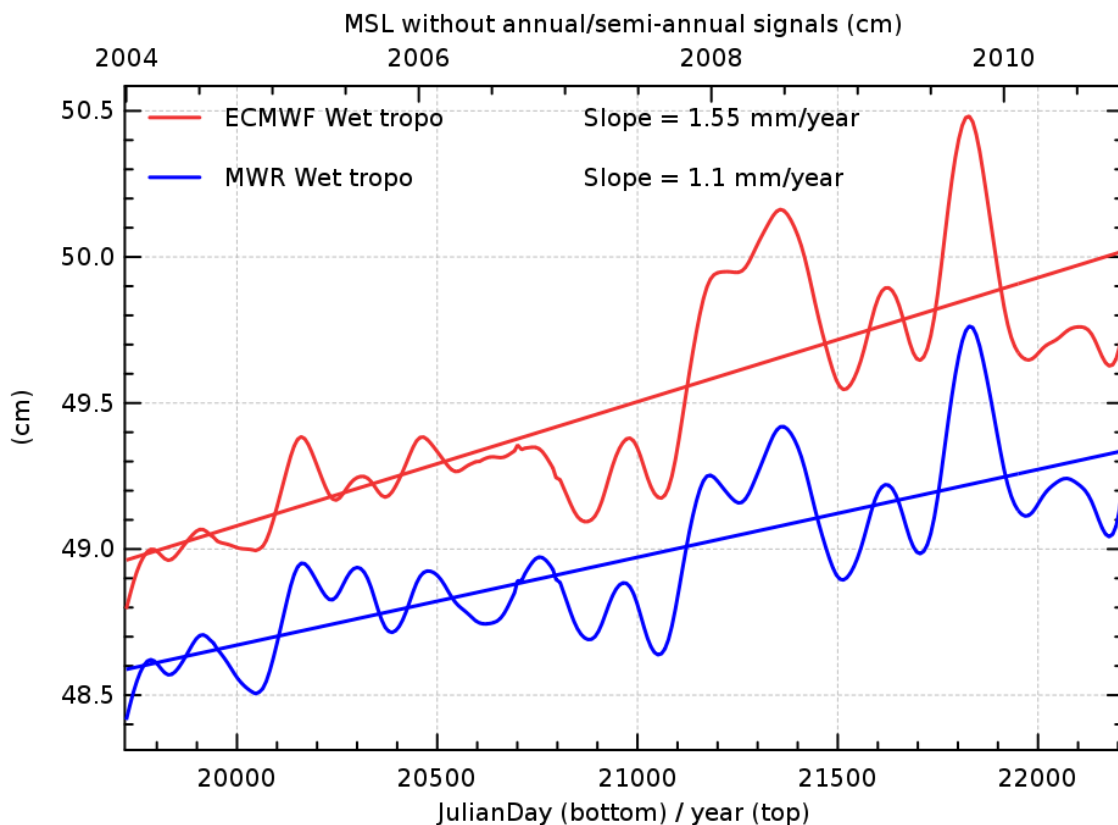
5. Particular investigations

– 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.
– With the new IPF/CMA version, even in USO anomaly period, the range is corrected from the proper USO Period.

User warning on the use of auxiliary USO files :
From cycle 93 onwards (and for the future reprocessed data), no more USO auxiliary file is needed.

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