Envisat GDR
Quality Assessment Report

Cycle 041

19-09-2005 / 24-10-2005

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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**
- **Cross Calibration with ERS-2**
- **Particular investigations**

2 Cycle overview

2.1 Data and software version

This cycle has been produced with the IPF processing chain V5.02 and the CMA Reference Software V7.1_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 CMA version 7.1 for the SSH calculation (page 3).

2.2 Parameters

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

16 passes are missing due to level1 B data unavailability (see section 3.1).
13 passes have no radiometer correction (see section 3.3).
39 passes are impacted by the S-Band anomaly (see section 3.3).

2.4 Platform and instrument events

RA-2 went to ICU in RS/WT/INI (2005/09/20 12:19:17 to 2005/09/20 18:56:00,19 to 25)
RA-2 went in RS/WT/INI (2005/10/04 12:47:33 to 2005/10/04 16:35:30,420 to 423)
Orbit Maintenance Maneuver (2005/10/06 02:19:10 to 2005/10/06 02:19:14 TAI)

2.5 Cycle quality and performances

Good general results are obtained for this cycle of data.

The crossover standard deviation is 6.89 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 8.9 cm .

Detailed CALVAL results are presented in section 3.

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

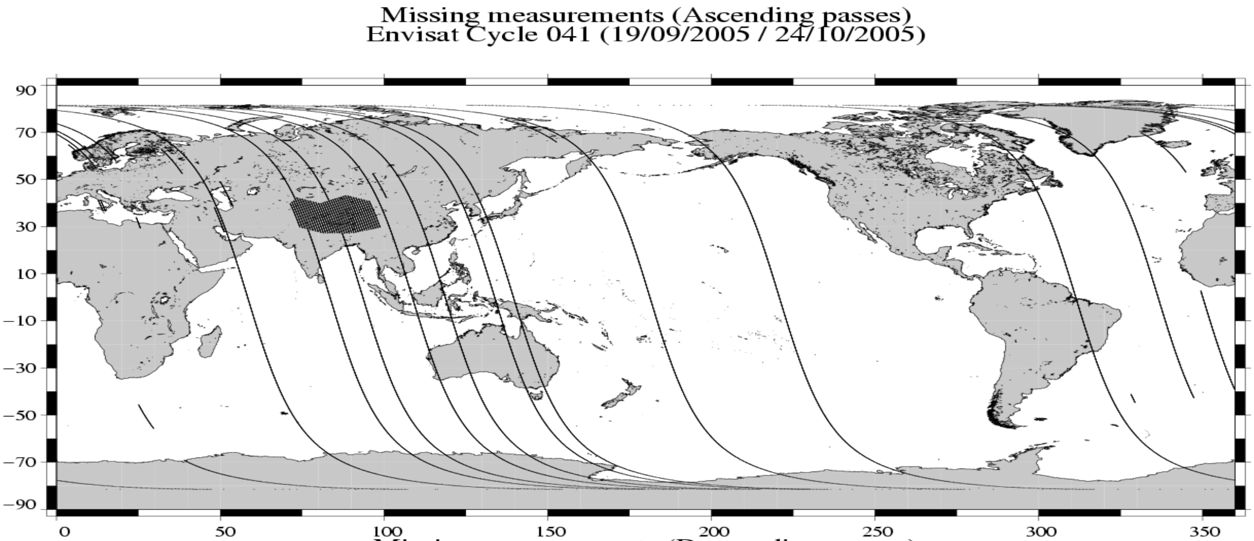
In order to take into account the dynamical effects and wind forcing, a new correction is computed from the MOG2D (Carrere and Lyard, 2003) barotropic model forced by pressure (without S1 and S2 constituents) and wind. The use of such a correction in the SSH strongly improves the performances.

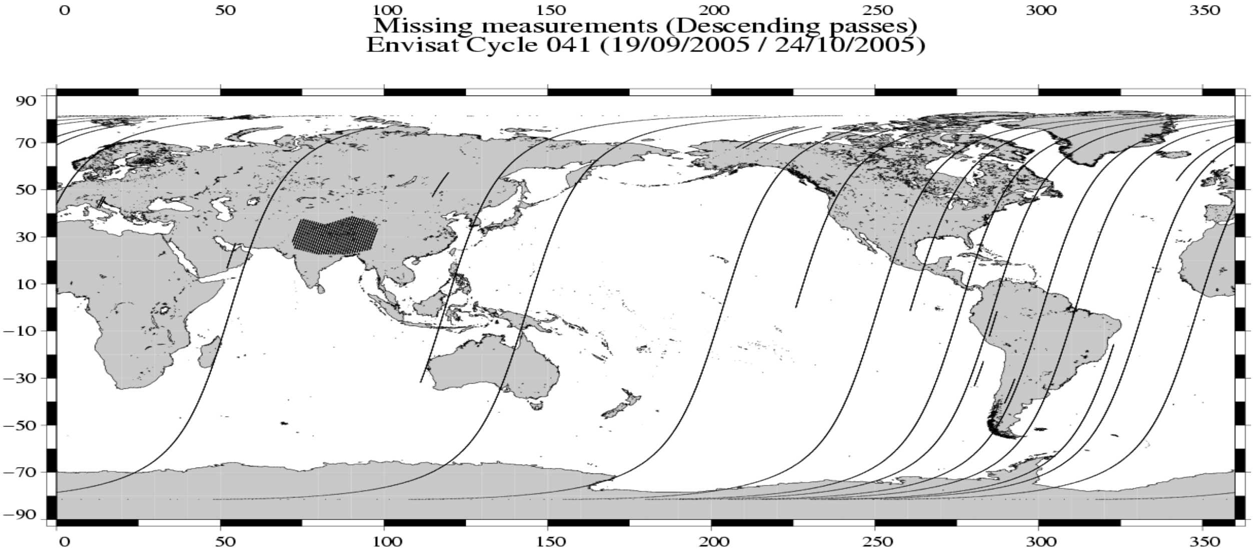
3 CALVAL main results

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

2632396 are present, and 82488 (3.0%) are missing. The maps below illustrate missing 1Hz measurements in the GDRs, with respect to a 1 Hz sampling of a nominal repeat track.





11 passes (19-25,420-423) are missing due to : "RA-2 is in RS/WT/INI Mode".
5 passes (187,188,858,920,921) are missing due to either to LRAC_PDHSs data generation to level1 problems or ingestion pbs on F-PAc side.

3.2 Orbit quality

3.2.1 Manoeuvres

On June 06th, 2005 Orbit Maintenance Maneuver took place

3.2.2 Doris and Laser performances

The next table gives statistics on Doris and Laser residuals:

7-day Period	Number of Doris measurements	Number of Laser measurements	RMS of Laser measurements (cm)
19/09/2005 to 26/09/2005	64535	2074	1.76990
26/09/2005 to 03/10/2005	66228	1287	1.79190
03/10/2005 to 10/10/2005	68083	1612	1.55100
10/10/2005 to 17/10/2005	69876	2741	1.55830
17/10/2005 to 24/10/2005	68733	1466	1.43360

3.2.3 Impact on SLA

The orbit quality is good for this cycle of data.

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

A S-band anomaly flag: this flag is set if |Sigma0(Ku)-Sigma0(S)| > 5dB
Notice that this flag is set over land and ice, even when no S-band anomaly occurs.

Parameter	Nb rejected	% rejected
Radiometer land flag	918593	40.42
Ice flag	744755	32.77
S-Band anomaly flag	401603	17.67

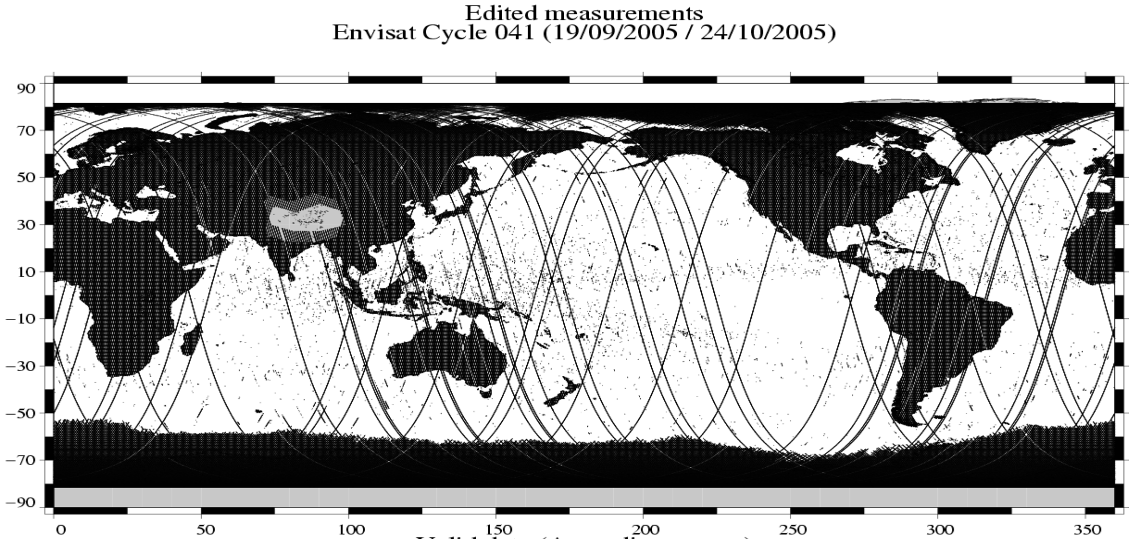
Then, measurements are edited using thresholds on several parameters. These thresholds are expected to remain constant throughout the Envisat mission, so that monitoring the number of edited measurements allows a survey of data quality.
The next table gives for each tested parameter, minimum and maximum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

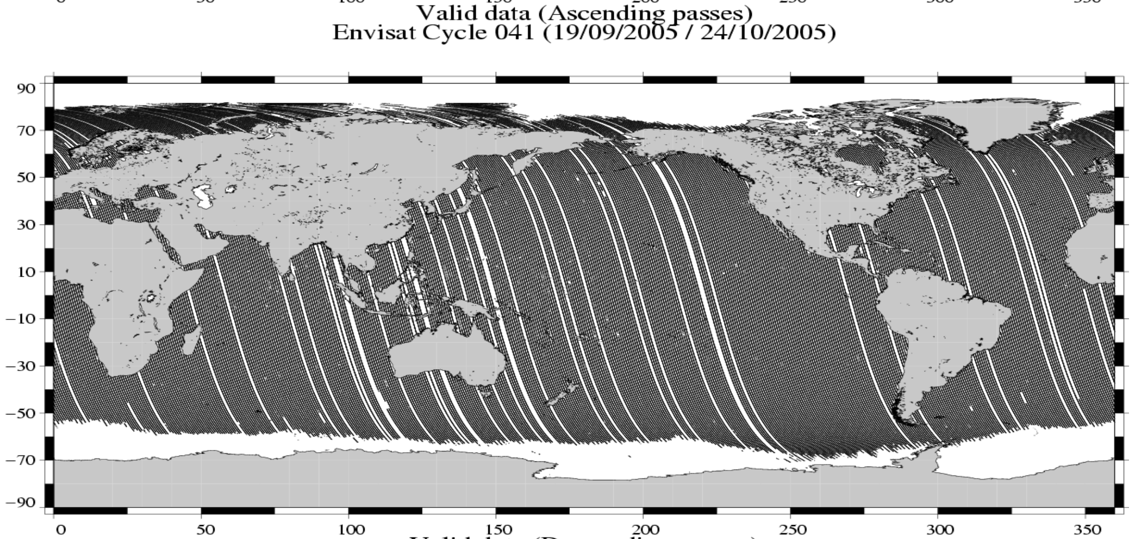
Parameters	Min Thres.	Max Thres.	Nb rejected	% rejected
Sea surface height (m)	-130.000	100.000	978	0.07
Variability relative to MSS (m)	-2.000	2.000	6842	0.51
Number of 18Hz valid points	10.000	-	97	0.01
Std. deviation of 18Hz range (m)	0.000	0.250	15845	1.19
Off nadir angle from waveform (deg2)	-0.200	0.160	5044	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	1259	0.09
Dual Ionospheric correction (m)	-0.400	0.040	3589	0.27
Significant wave height (m)	0.000	11.000	1526	0.11
Sea state Bias (m)	-0.500	0.000	1991	0.15
Backscatter coefficient (dB)	7.000	30.000	1777	0.13
GOT00 ocean tide height (m)	-5.000	5.000	2972	0.22
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	0	0.00

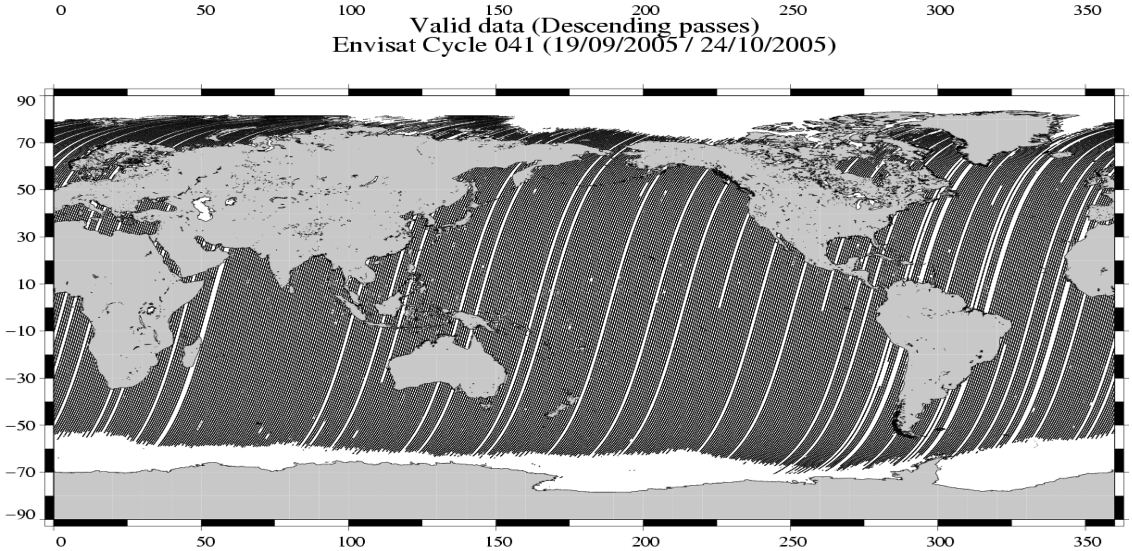
A final editing is then performed on corrected sea surface height, using a spline fitting procedure, leading to remove 737 (0.06 %) measurements.

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

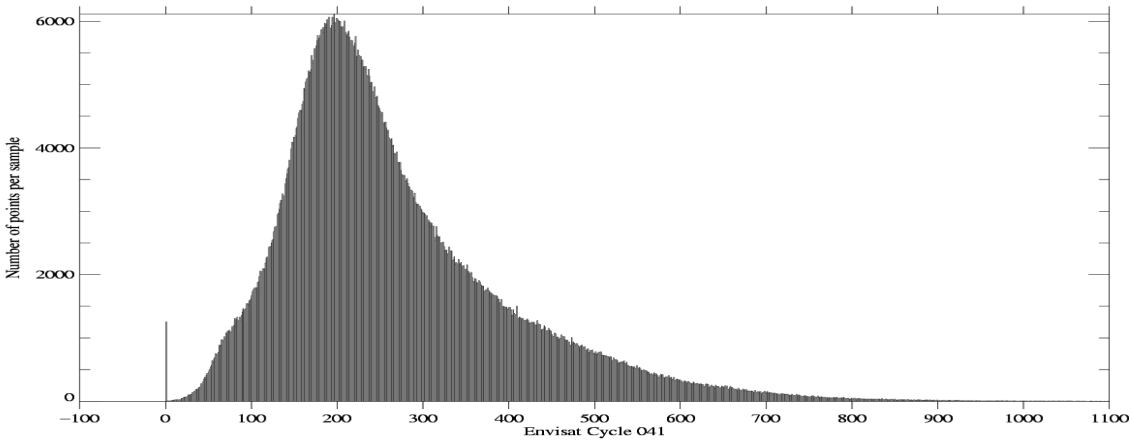
986 passes have been delivered. Among these passes:
- 13 passes are entirely edited on the radiometer land flag (no MWR correction)
- 39 passes (74-79;254-265;328-337;613-623) are edited because of S-Band anomalies. Users are advised not to use the S-Band parameters and the dual ionospheric correction on these passes.

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

3.4 Altimeter parameters

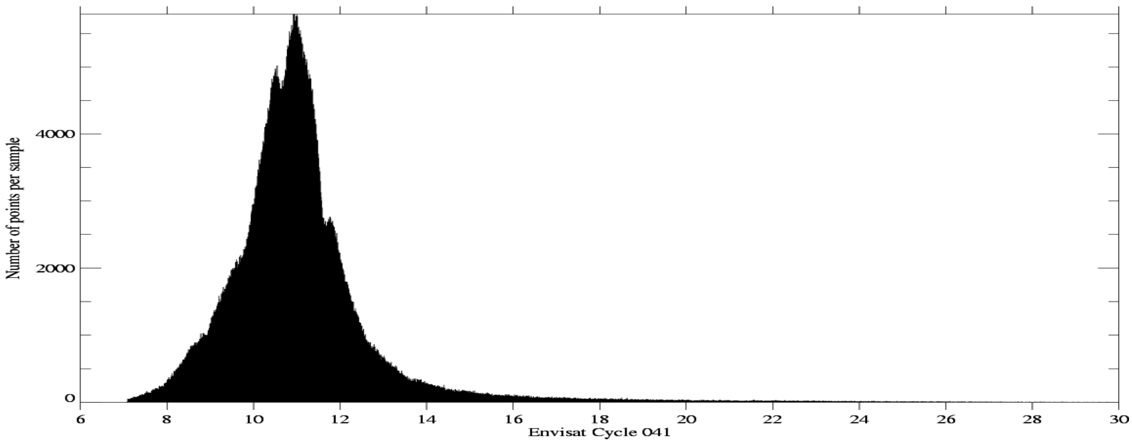
In order to assess and to monitor altimeter parameter measurements, histograms of Envisat Ku-band Significant Wave Height (SWH), Backscatter coefficient (Sigma0) and RMS of altimeter range are computed.

Ku−band Significant Wave Height (unit : cm)



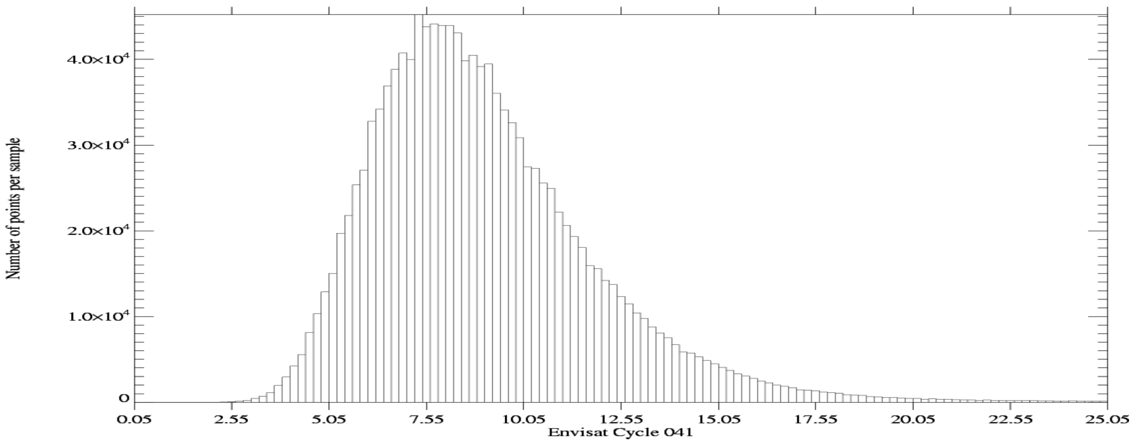
Global nb of points	:	1330127	Sel. nb of points	:	1330127	Sample interval	:	1.000
Global mean	:	266.278	Selected mean	:	266.278	Maximum value	:	1098.300
Global Std	:	132.350	Selected std	:	132.350	Minimum value	:	0.000

Ku−band Backscatter Coefficient (unit : db)



Global nb of points	:	1330127	Sel. nb of points	:	1330127	Sample interval	:	0.010
Global mean	:	11.059	Selected mean	:	11.059	Maximum value	:	29.860
Global Std	:	1.799	Selected std	:	1.799	Minimum value	:	7.080

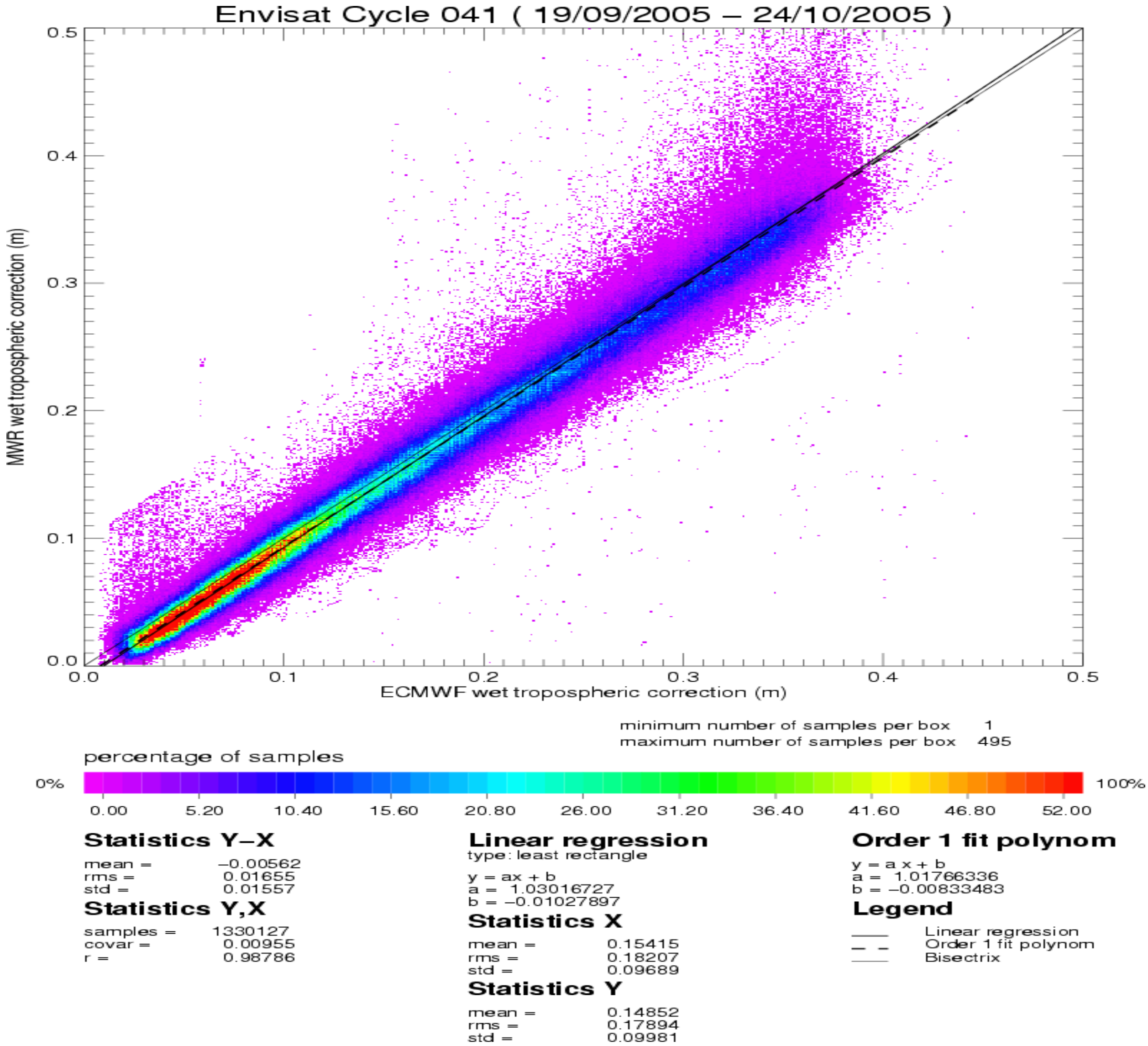
RMS of Ku−band range (unit : cm)



Global nb of points	:	1330127	Sel. nb of points	:	1330127	Sample interval	:	0.200
Global mean	:	9.003	Selected mean	:	9.003	Maximum value	:	25.000
Global Std	:	2.826	Selected std	:	2.826	Minimum value	:	1.600

3.5 Radiometer

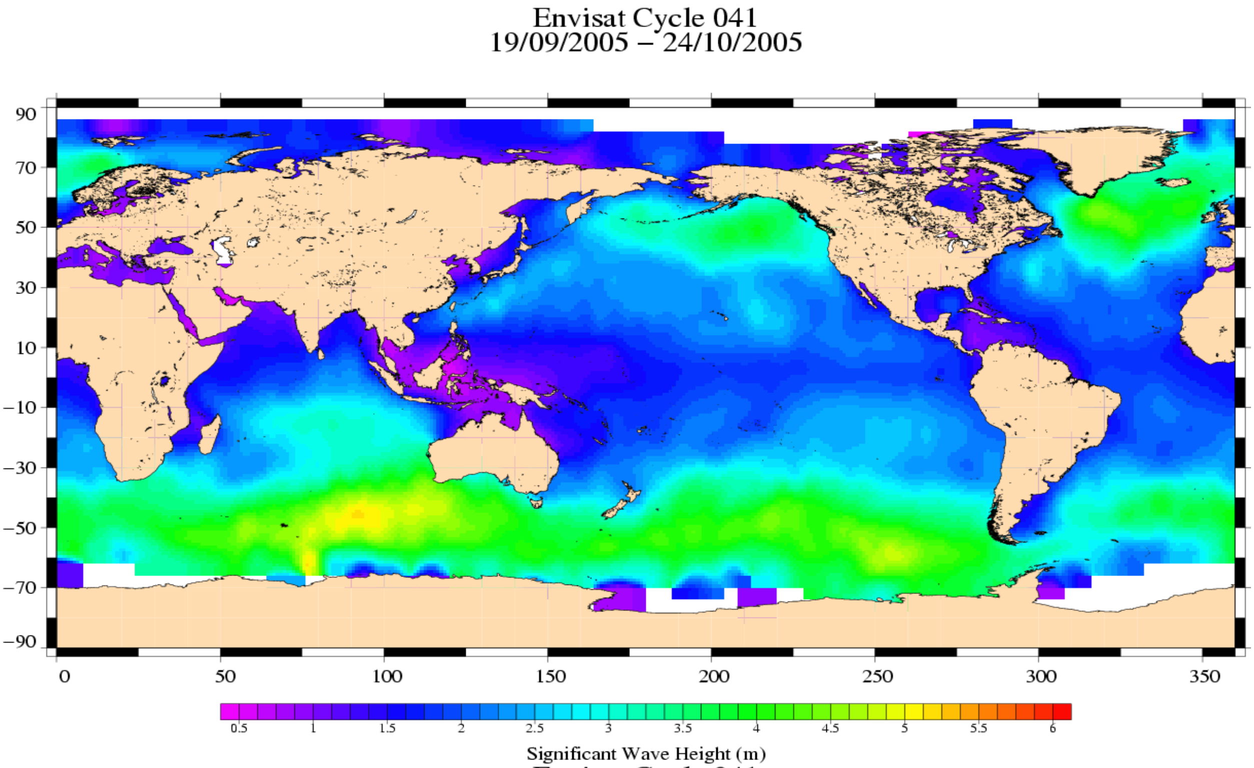
In order to assess and to monitor radiometer measurements, a scatter plot between the radiometer wet troposphere correction and the ECMWF model is computed for the valid data set previously defined.

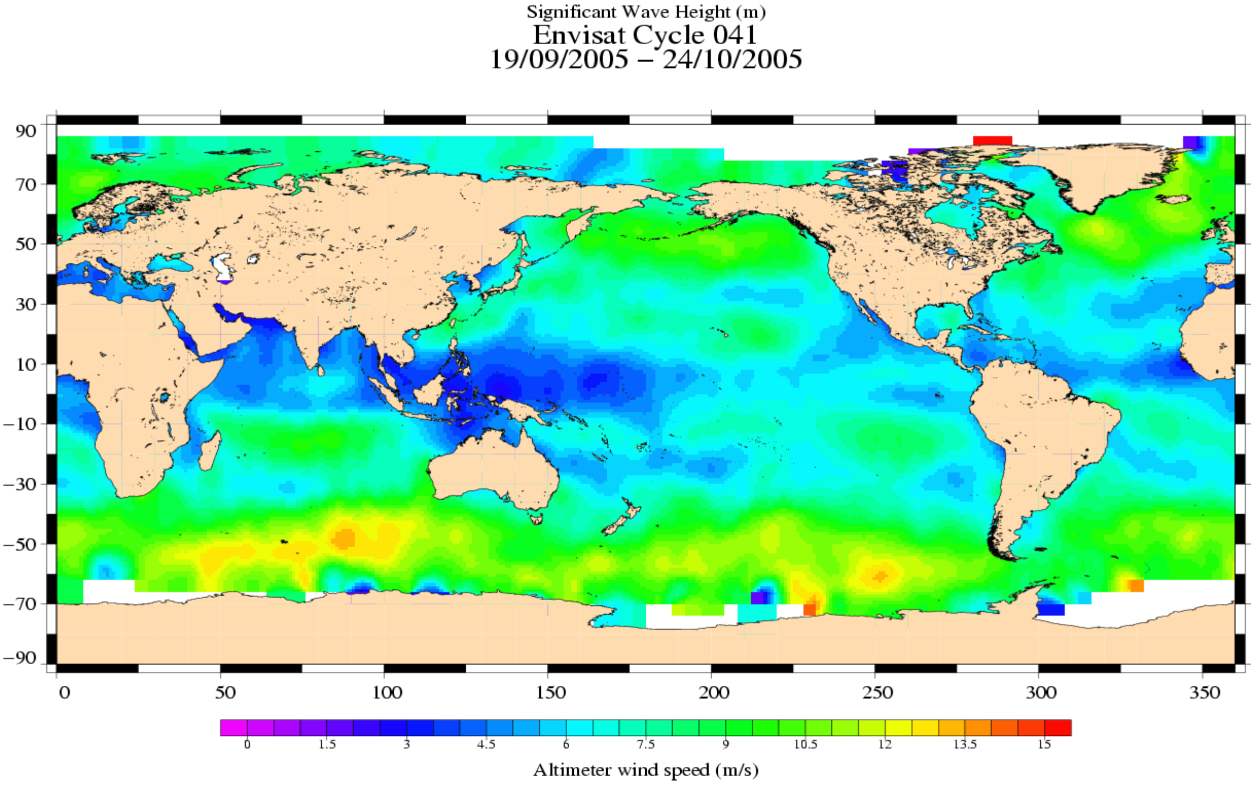


The radiometer-model mean difference is 0.6 cm. A drift on the Envisat 23.8GHz brightness temperature has been detected and has to be monitored on the long term. Note that the neural algorithm is now implemented on Envisat.

3.6 Wind and wave maps

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





3.7 Crossover statistics

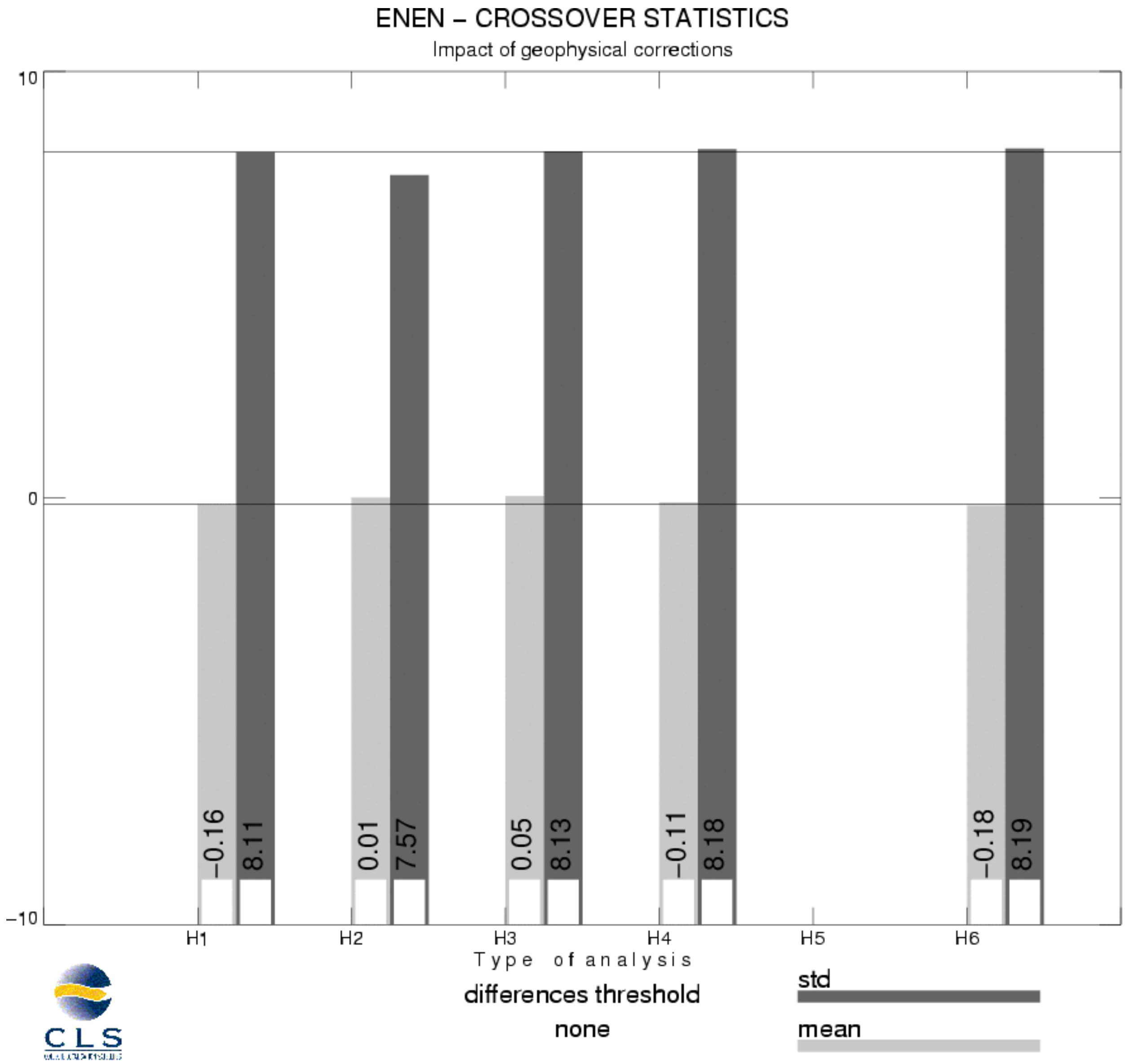
3.7.1 General comment

SSH crossover statistics are computed from the valid data set. They are used to estimate the data quality and to monitor the system performances. After data editing and using the standard Envisat algorithms, the crossover standard deviation is about 8.11 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 6.89 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

H2 = SSH applying a long wave length error (computed)

H3 = SSH with GIM ionospheric correction (computed)

H4 = SSH with DORIS ionospheric correction (in product)

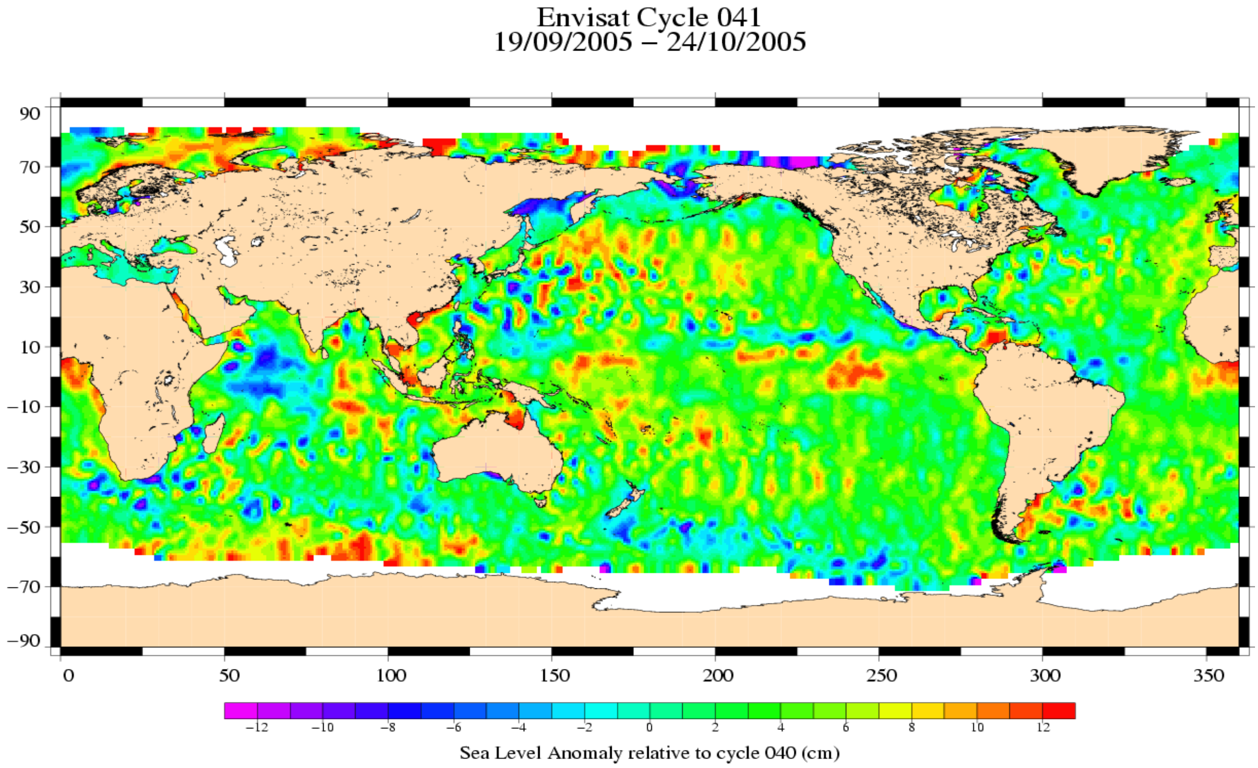
H5 = SSH with FES02 tide model (in product)

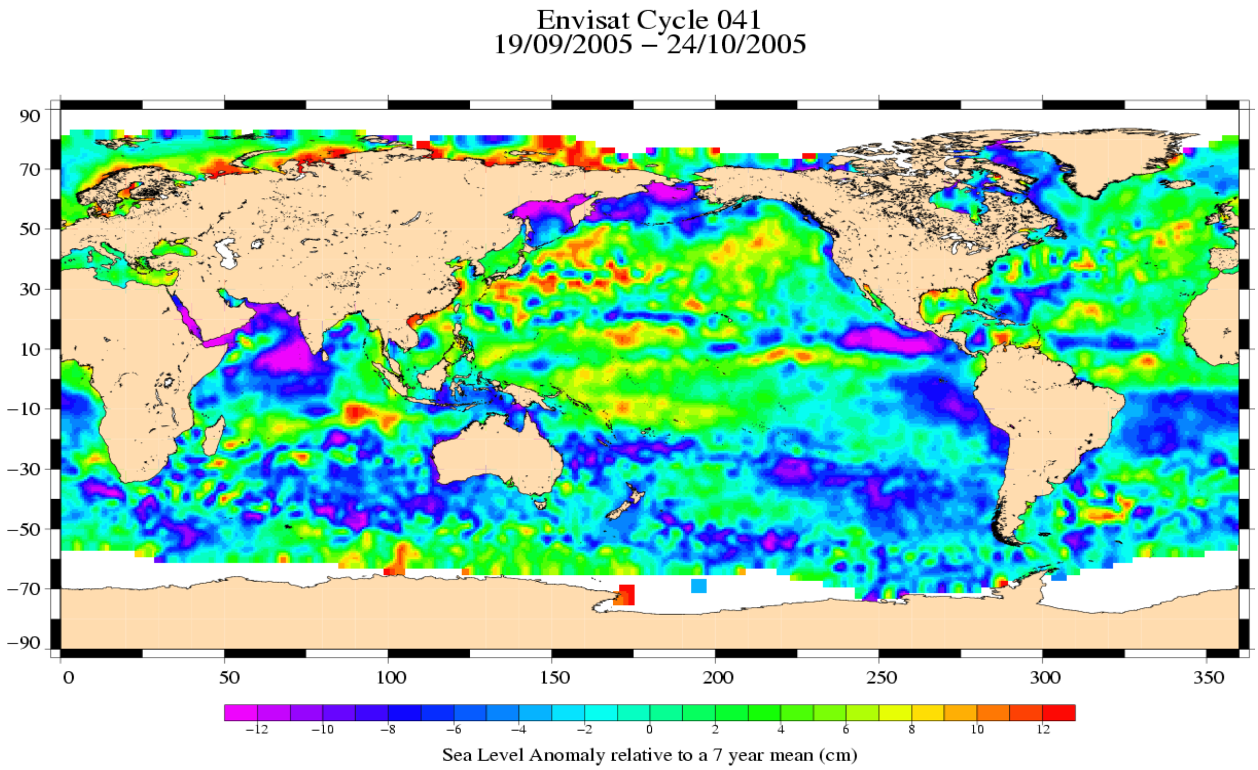
H6 = SSH with ECMWF wet tropospheric correction (in product)

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 041
19/09/2005 – 24/10/2005
90
70
50
30
10
−10
−30
−50
−70
−90
0
50
100
150
200
250
300
350
−12
−10
−8
−6
−4
−2
0
2
4
6
8
10
12
Sea Level Anomaly relative to a 7 year mean (cm)

3.8.2 Comparison to a precise Mean Sea Surface

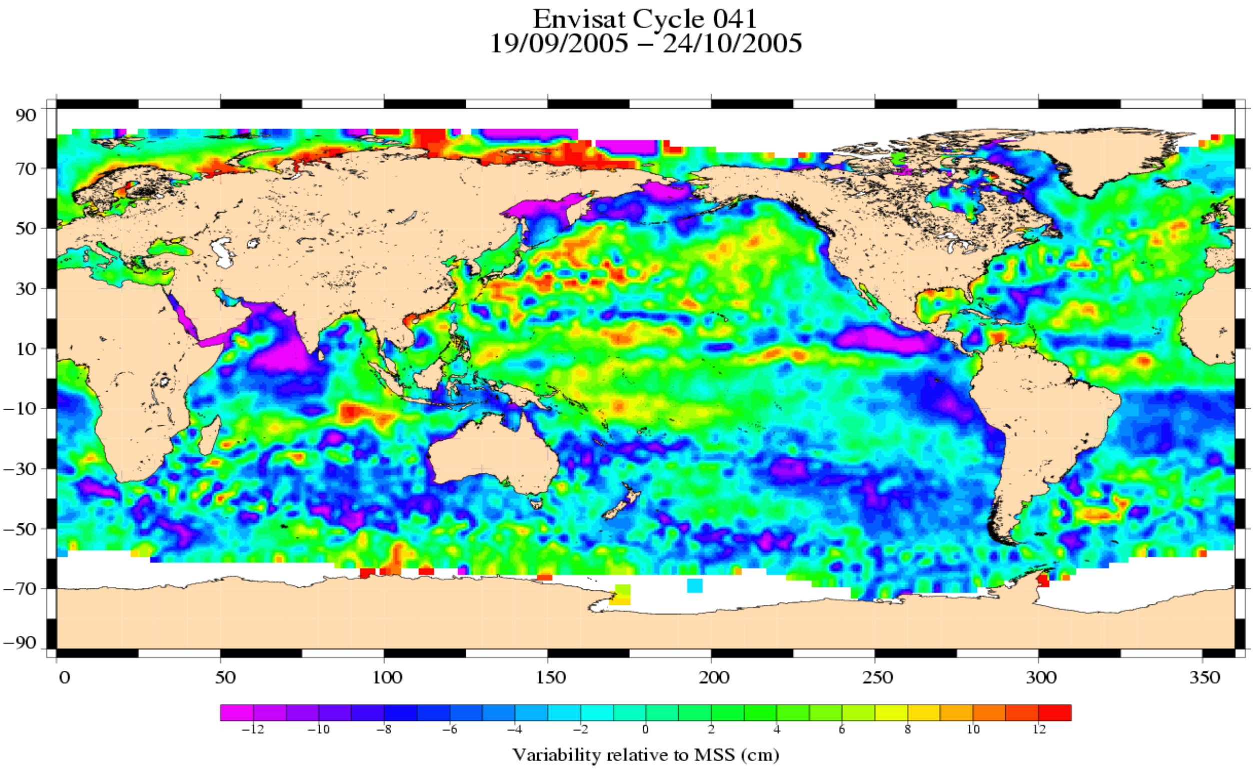
The MSS from the product is used as a reference to compute SLA. Global statistics of Envisat SSH-MSS are (cm):

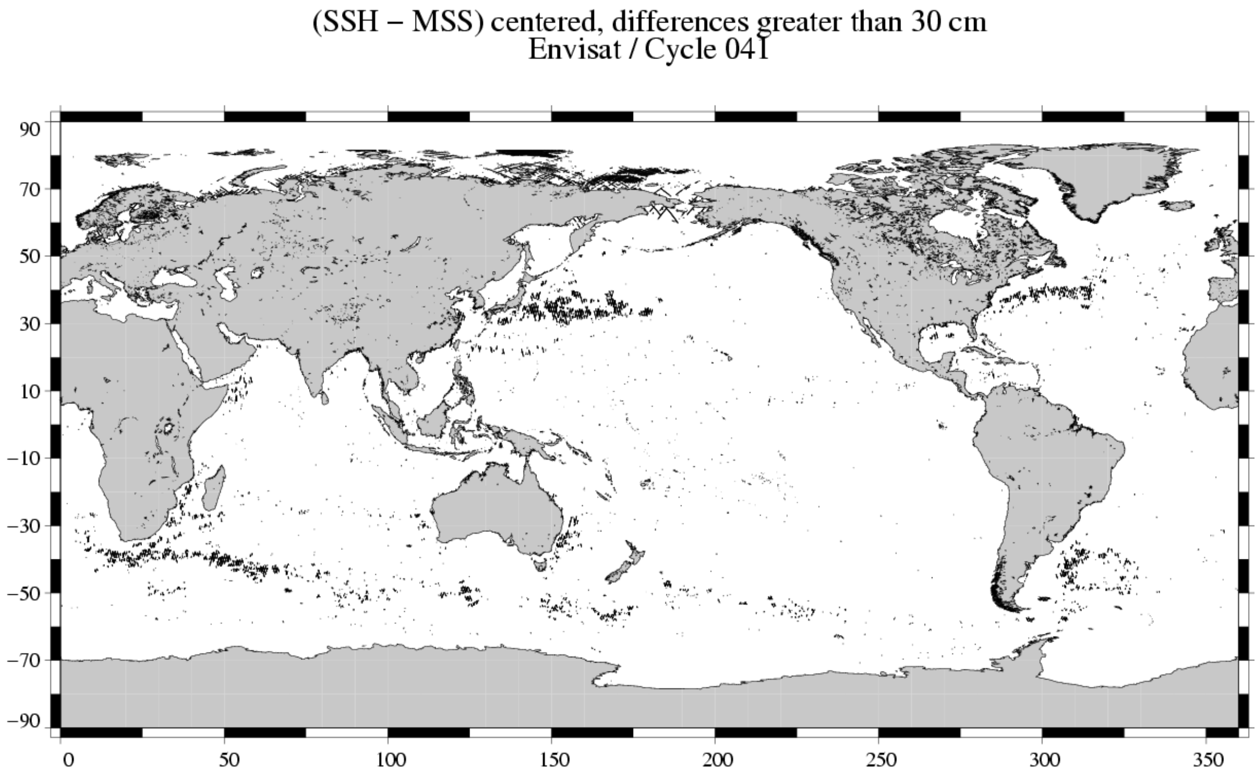
Number	Mean	Std. dev.
1480148	49.29	10.38

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.
914968	49.21	8.87

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 041
90
70
50
30
10
−10
−30
−50
−70
−90
0
50
100
150
200
250
300
350

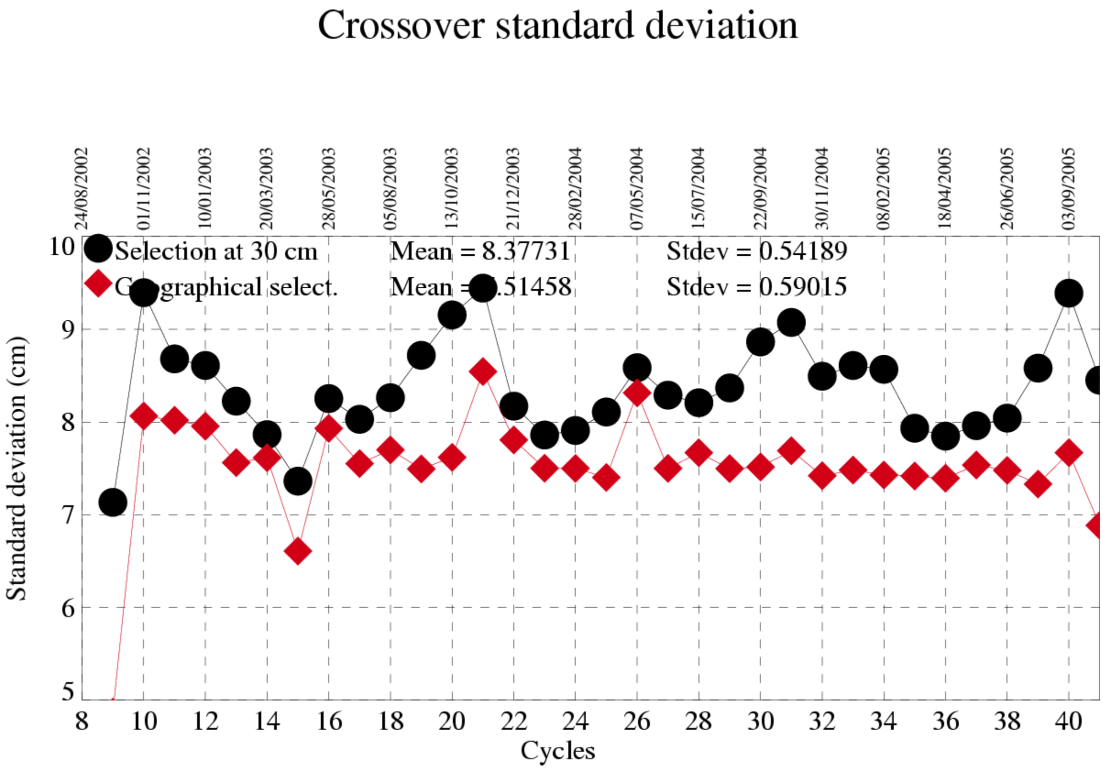
4 Envisat long term performance monitoring

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

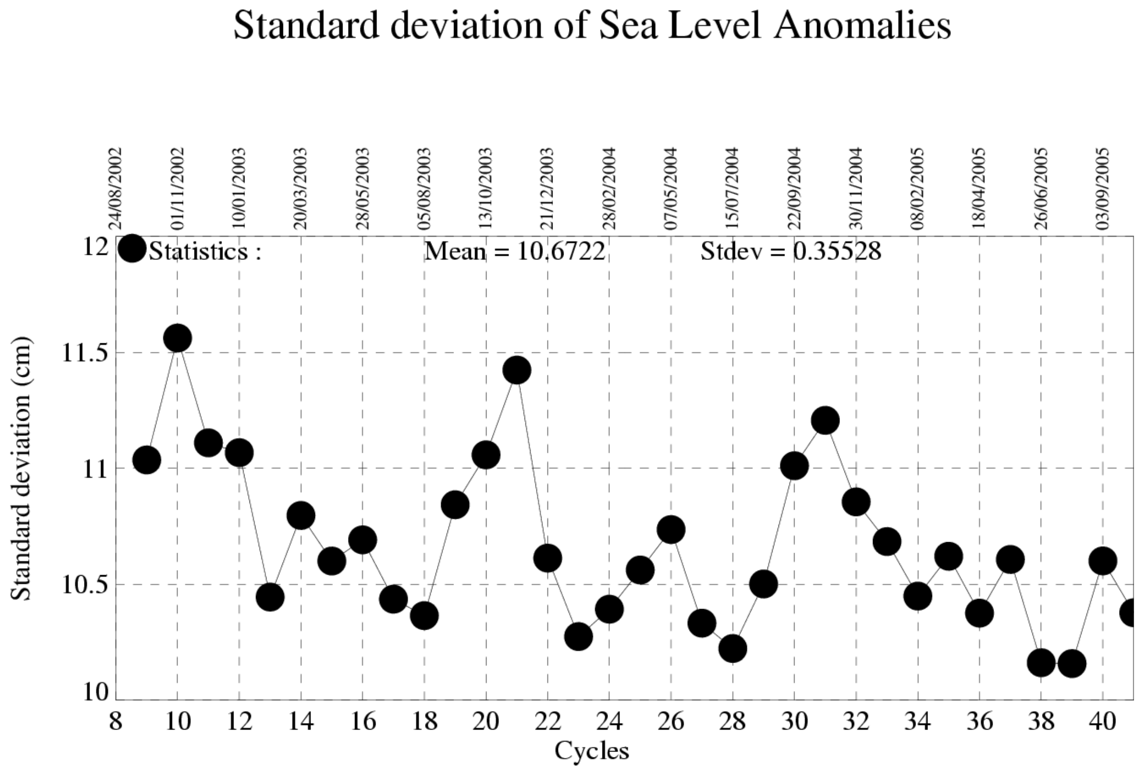
This parameter is plotted as a function of time in a one cycle per cycle basis in the figure below. It is computed after data editing and using 2 aditing selection criteria:

- 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.



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.



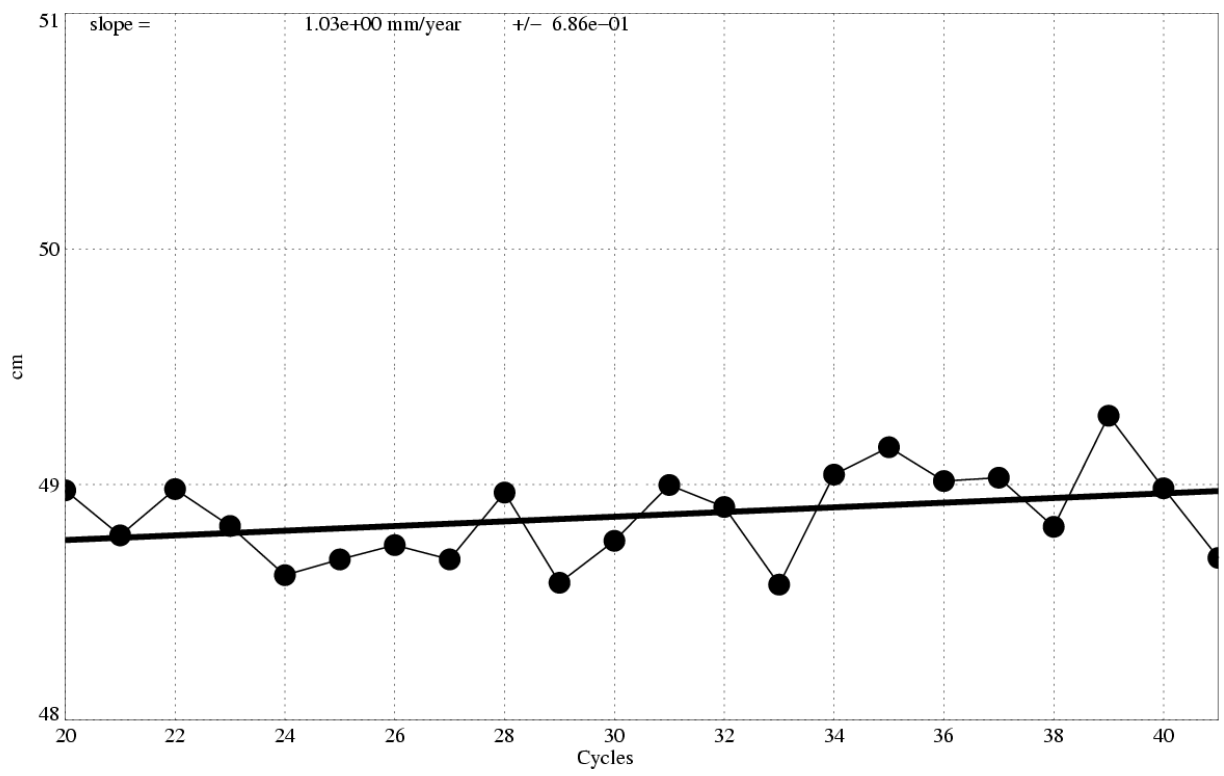
4.3 Mean Sea Level

MSL estimations are performed on a cycle basis averaging Sea Level Anomalies relative to a mean profile.
The SSH is computed using:

- the ECMWF model wet troposphere correction in order to remove the effect of the drift of the 36.5 GHz Brightness Temperature
- the correction provided by ESA to correct the range from the USO drift and bias ([3]) for cycle 9 to 40
- the Labroue (2005 [4]) sea state bias for all cycles

The value for each cycle is calculated from averaging over 2 by 3 degree bins, then weighting by latitude to take into account the relative geographical area represented by the bin. Results plotted on the following figure is obtained after annual and semi-annual signals reduction.

During the first year (cycles 10 to 20) Envisat MSL global trend is not consistent to other flying satellites. This unexplained behavior is under investigation. The following figure shows the MSL global trend from cycle 20 onwards.



5 Cross Calibration with ERS-2

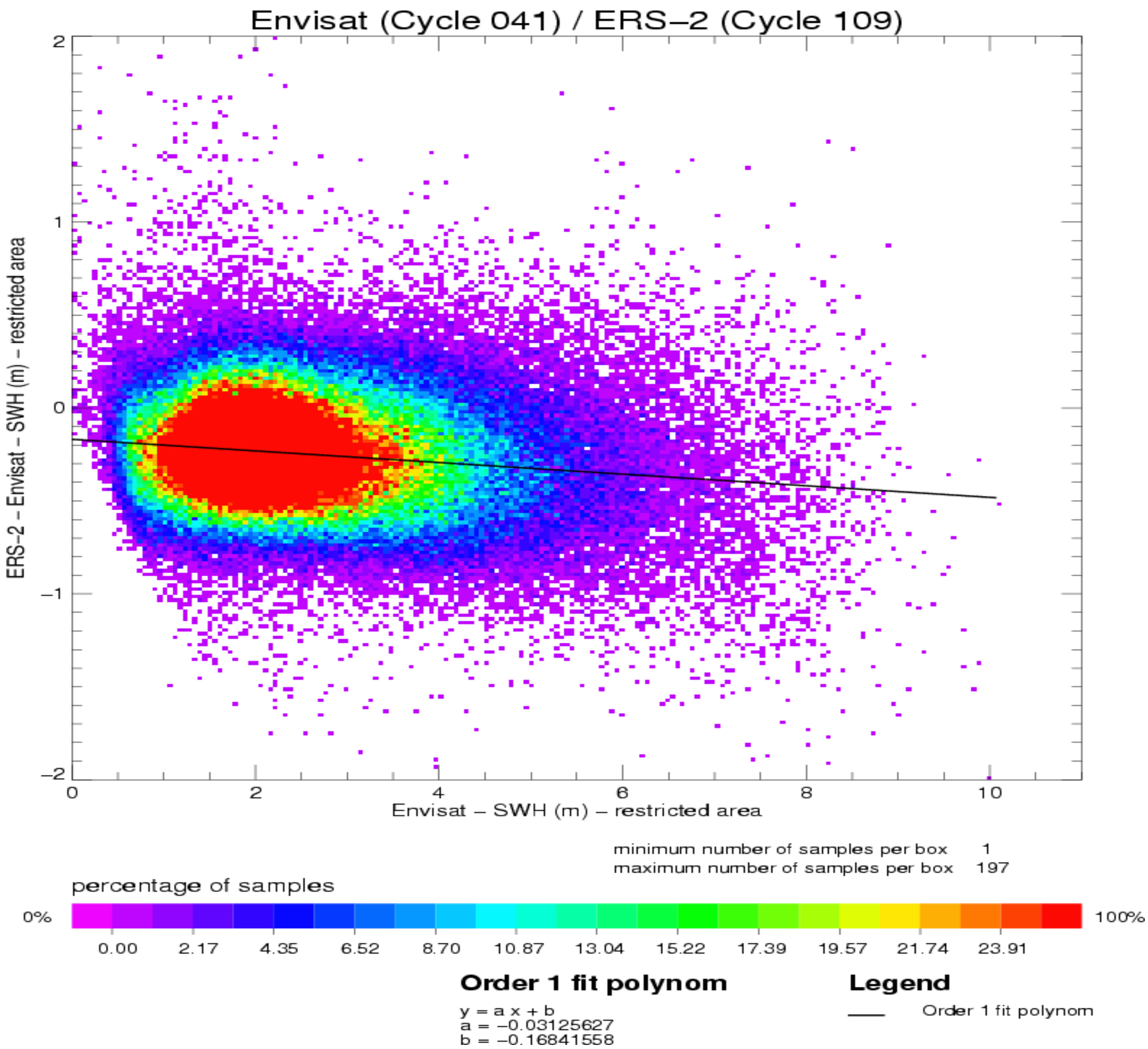
Envisat flies on the same ground track as ERS-2, 30 minutes ahead. This section presents results that illustrate the difference with ERS-2.
A failure of the ERS-2 tape recorder occured on 22 June 2003. The ERS-2 Low Rate mission continues within the visibility of ESA ground stations over Europe: North Atlantic, Arctic and western North America. Nevertheless, cross calibration with ERS-2 can be performed on this zone. Envisat cycle 041 data are collocated to data from ERS-2 GDR cycle 108 in order to compare the main parameters from repeat-track analysis.

5.1 [ERS-2 - Envisat] Ku SWH differences

Global statistics of [ERS-2 - Envisat] Ku SWH differences are (cm):

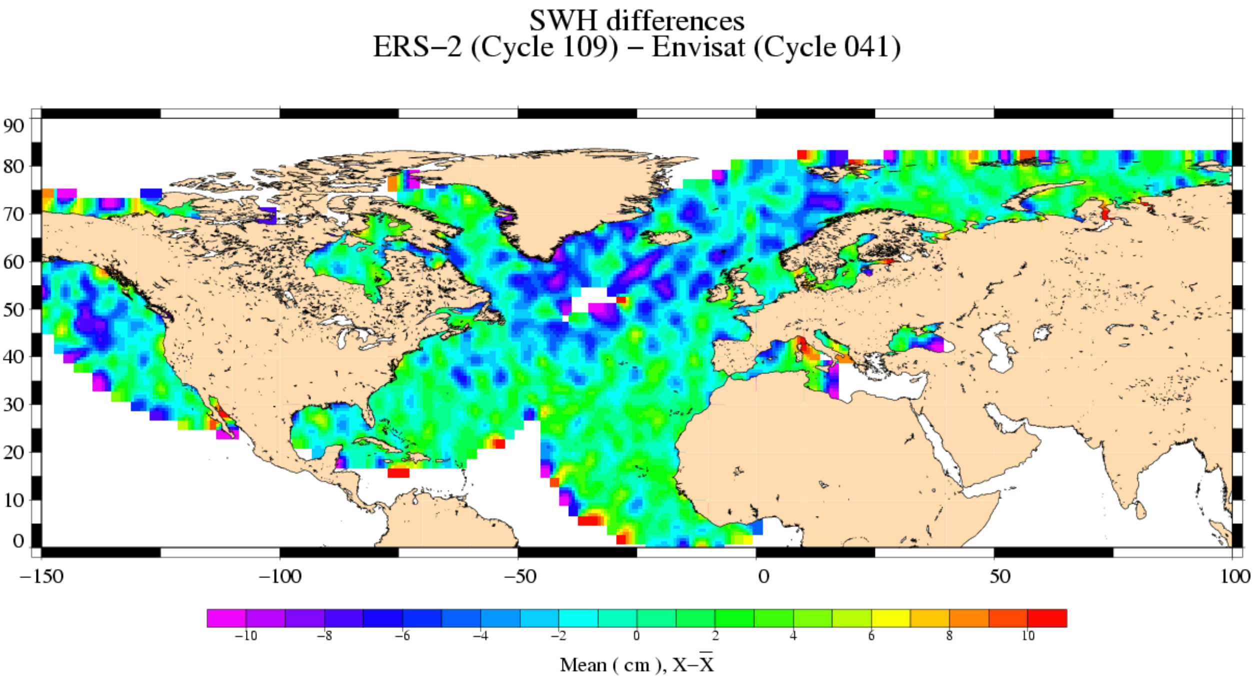
Number	Mean	Std. dev.
194756	-23.92	27.37

The scatter plot between Envisat and ERS-2 Ku SWH measurements is given on the following figure:



Envisat (Cycle 041) / ERS−2 (Cycle 109)
ERS-2 – Envisat – SWH (m) – restricted area
Envisat – SWH (m) – restricted area
minimum number of samples per box 1
maximum number of samples per box 197
percentage of samples
0%
100%
0.00
2.17
4.35
6.52
8.70
10.87
13.04
15.22
17.39
19.57
21.74
23.91
Order 1 fit polynom
y = a x + b
a = −0.03125627
b = −0.16841558
Legend
Order 1 fit polynom

These differences are plotted on the following figure (data are centered about the mean value).

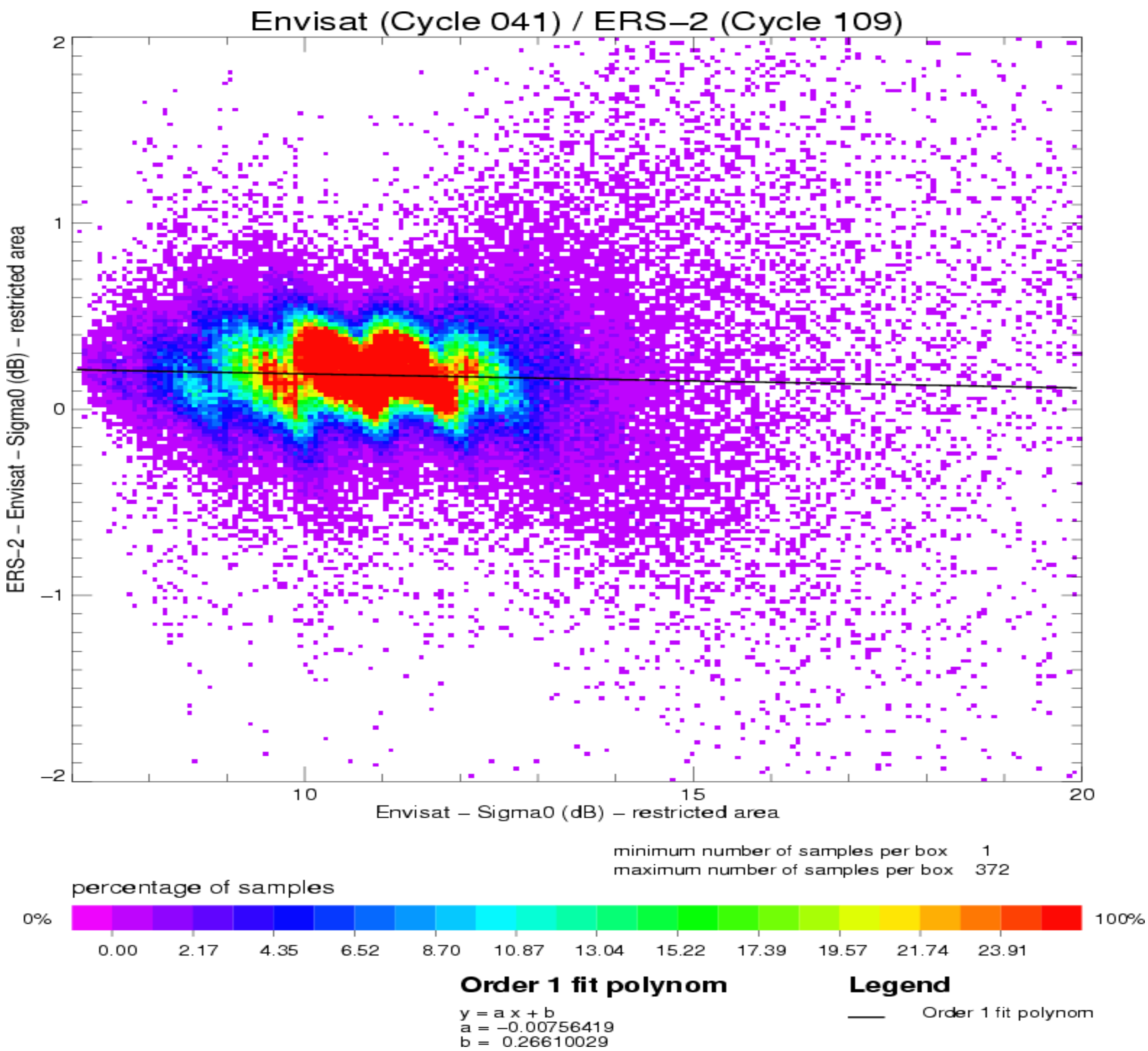


5.2 [ERS-2 - Envisat] Ku Sigma0 differences

Global statistics of [ERS-2 - Envisat] Ku Sigma0 differences are (dB):

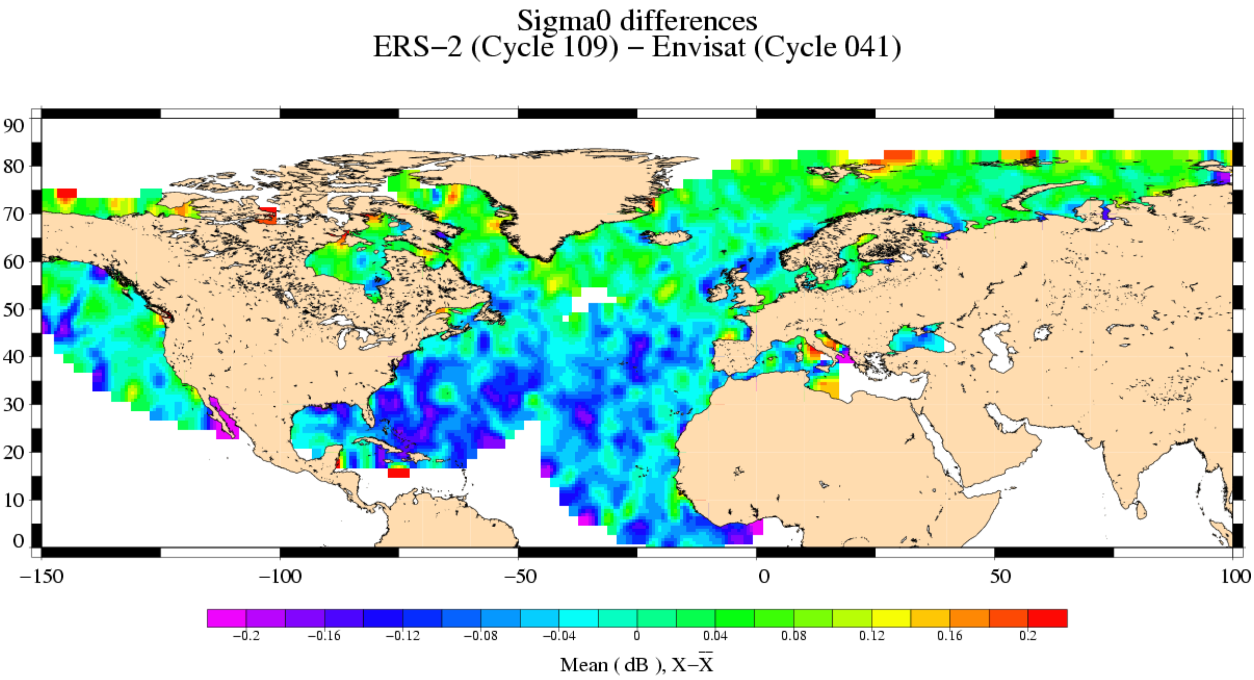
Number	Mean	Std. dev.
194756	0.19	0.28

The scatter plot between Envisat and ERS-2 Ku Sigma0 measurements is given on the following figure:



Particular features on the scatter plot mainly come from the shape of ERS-2 histogram.

The differences are plotted on the following figure (data are centered about the mean value).

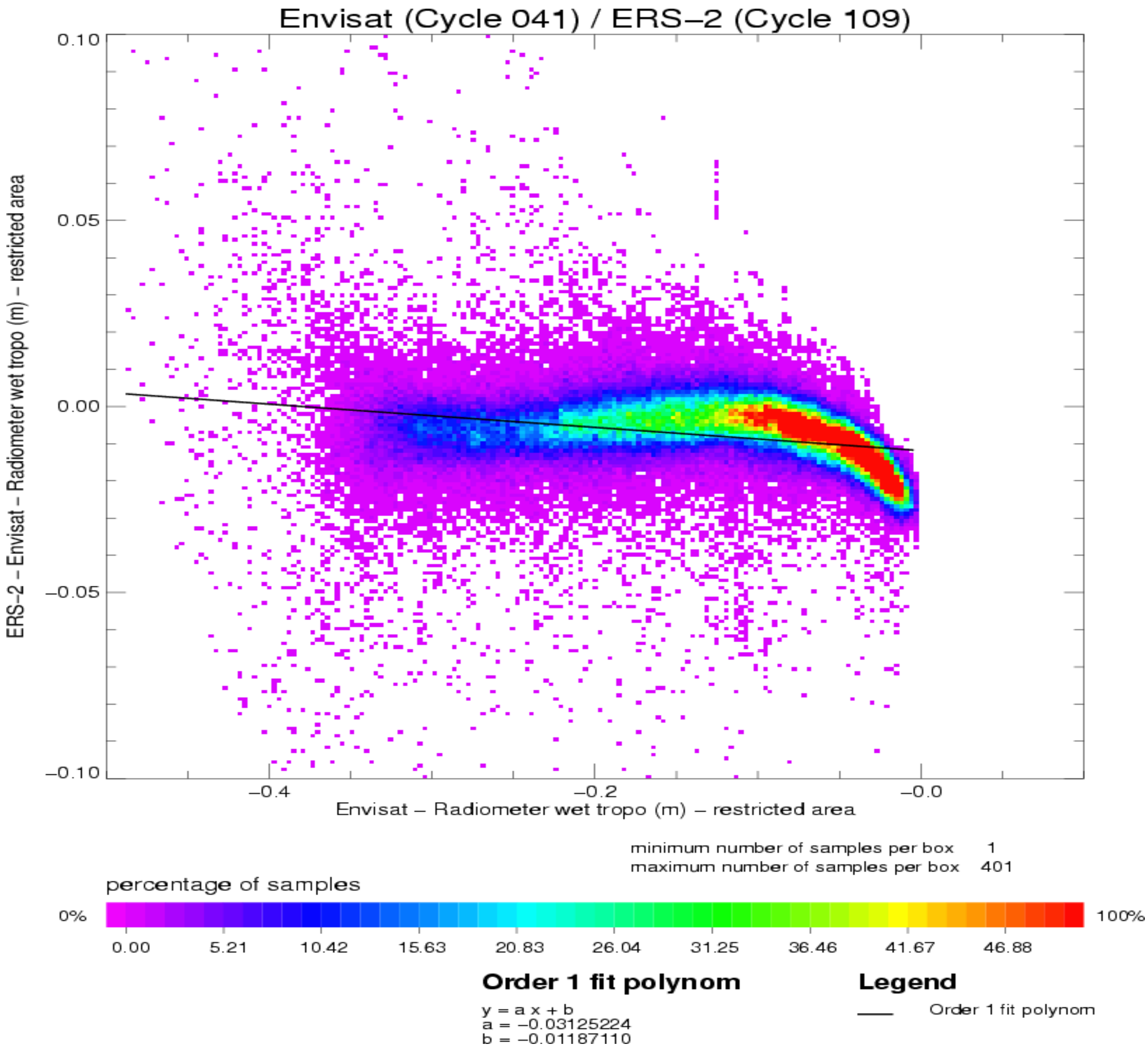


5.3 [ERS-2 - Envisat] radiometer wet troposphere correction differences

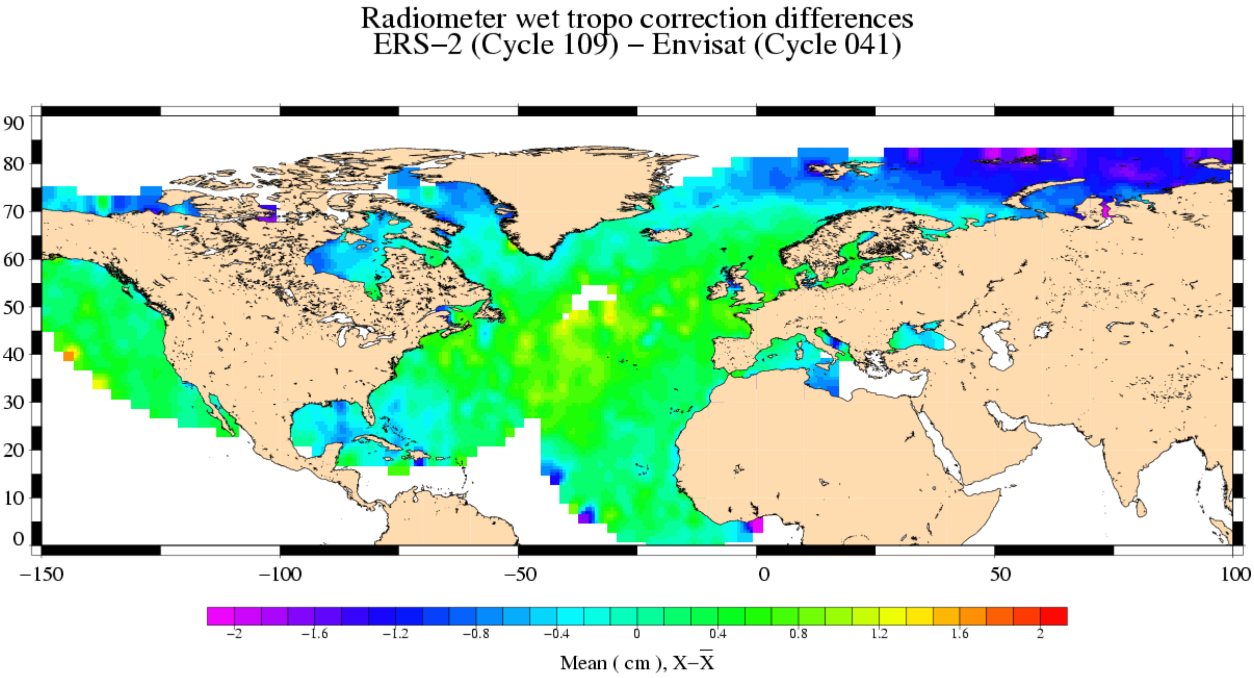
The ERS-2 radiometer correction is recomputed to correct the gain drop and the drift of the 24 GHz brightness temperature (Obligis et al., 2003).
Global statistics of [ERS-2 - Envisat] radiometer wet troposphere correction differences are (cm):

Number	Mean	Std. dev.
194756	-0.74	1.00

The scatter plot between Envisat and ERS-2 radiometer wet troposphere corrections is given on the following figure:



The differences between Envisat and ERS-2 radiometer corrections are plotted on the following figure (data are centered about the mean value).



5.4 [ERS-2 - Envisat] SSH differences

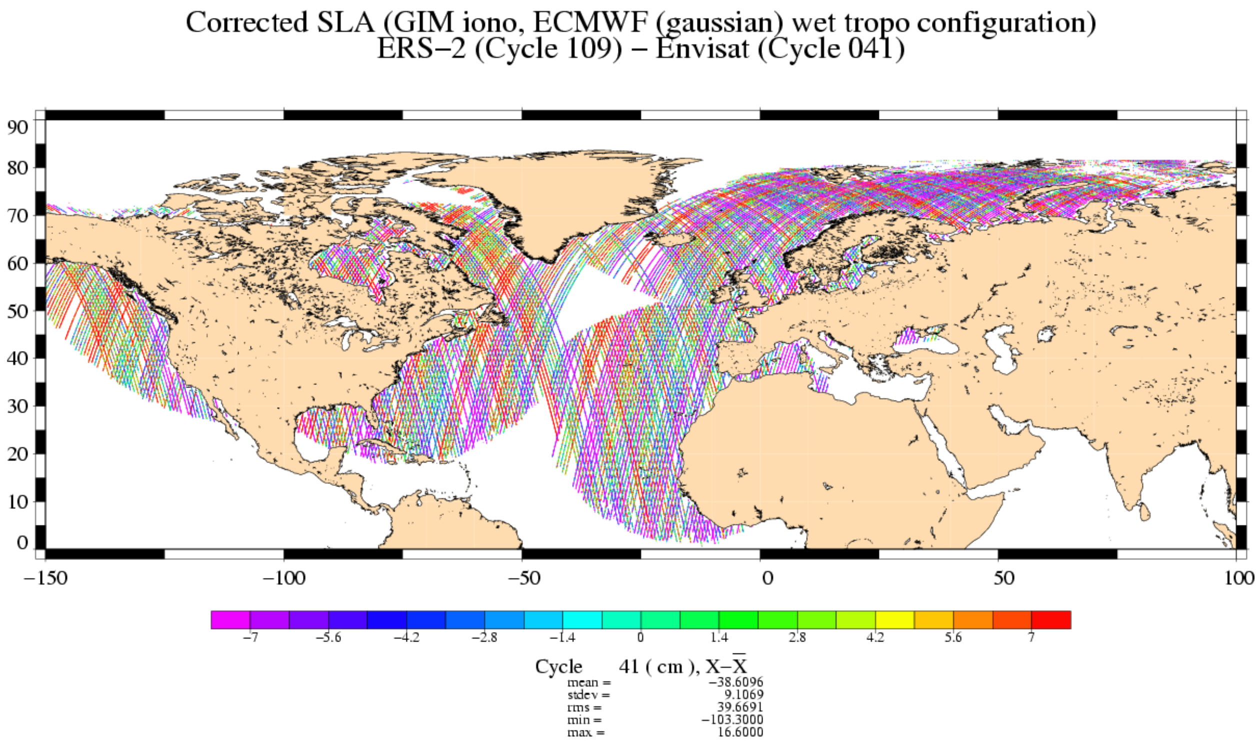
In order to compare the ERS-2 SSH with the Envisat SSH, ERS-2 GDRs have been updated with algorithms and corrections similar to Envisat:
- Range corrected from SPTR, USO, time tag bias
- ECMWF wet tropospheric correction
- Model dry tropospheric correction
- 3-parameters sea state bias
- Inverted barometer correction with time varying pressure
- Total geocentric GOT00 ocean tide height
- Geocentric pole tide height
- Solid earth tide height
- GIM ionospheric correction
- DPAF orbit (No DGME-04 orbit files are available for cycle 108, the initial orbit is then used).

The correction used for Envisat are those described in 2.2 except for:
- Total geocentric GOT00 ocean tide height
- GIM ionospheric correction
- ECMWF wet tropospheric correction

Global statistics of [ERS-2 - Envisat] SLA differences (cm):

Number	Mean	Std. dev.
194756	-38.61	9.10

These SSH differences are plotted on the following figure.



The main source of differences is the ERS-2 orbit errors.

References

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