Envisat GDR
Quality Assessment Report

Cycle 030

30-08-2004 / 04-10-2004

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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 V4.58
and the CMA Reference Software V6.3_03.

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
- Inverted barometer correction with time varying pressure
- Total geocentric GOT00 ocean tide height
- Geocentric pole tide height
- Solid earth tide height

2.3 Warnings and recommendations

32 passes are missing due to level1 B data unavailability (see **section 3.1**).

High SSH-MSS are found on 50 passes (see **section 6**).

2.4 Platform and instrument events

RA2 in ICU RS/WT/INI. (SDU problem in RAM) (2004/09/26 13:39:50 to 2004/09/27 16:23:30, Pass 765-795)

Abnormal behaviour of the RA-2 sensor (2004/09/27 16:23:30 to 2004-09-29 10:21:07, Pass 796-846)

Collision avoidance Maneuver (2004/09/01 22:52:27 to 2004/09/02 00:52:37, Pass 60-62)

Collision avoidance Maneuver (2004/09/02 23:44:27 to 2004/09/03 01:44:37, Pass 89-91)

Orbit Maintenance Maneuver (2004/09/21 04:14:37 to 2004/09/21 06:29:19, Pass 610-612)

Orbit Maintenance Maneuver (2004/09/24 03:53:38 to 2004/09/24 05:53:46, Pass 695-697)

2.5 Cycle quality and performances

An unexpected behaviour of the Envisat RA-2 sensor was observed on passes 796-846. Those passes have high SSH-MSS values. After editing of degraded passes, the performances are good.

The crossover standard deviation is 7.52 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 11.0 cm. When using a selection to remove shallow waters (1000 m), areas of high ocean variability and high latitudes (> |50| deg) it lowers to 9.3 cm .

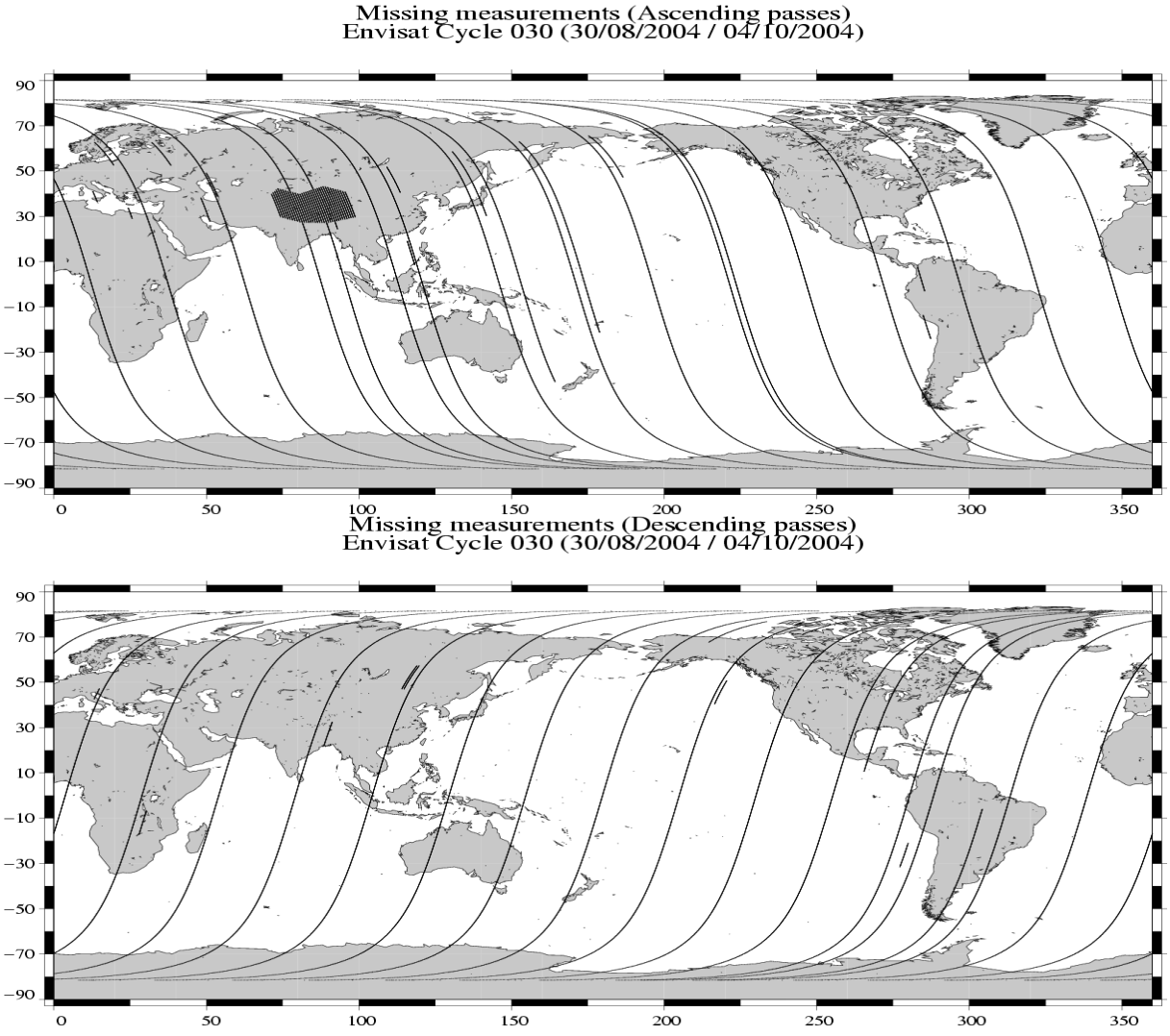
Detailed CALVAL results are presented in **section 3**.

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

2611809 are present, and 103092 (3.8%) are missing. The maps below illustrate missing 1Hz measurements in the GDRs, with respect to a 1 Hz sampling of a nominal repeat track.



31 passes (765-795) are missing due to : "RA2 in ICU RS/WT/INI"
1 pass is 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 the 01-September-2004, a 1-burn in-plane collision avoidance manoeuvre was executed as planned.

On the 03-September-2004, a 1-burn in-plane drift stop manoeuvre was executed as planned.

On 21-September-2004 an orbit inclination correction manoeuvre took place.

On 24-September-2004 an in-plane correction manoeuvre took place, in order to start a new ground track control cycle.

3.2.2 Doris and Laser performances

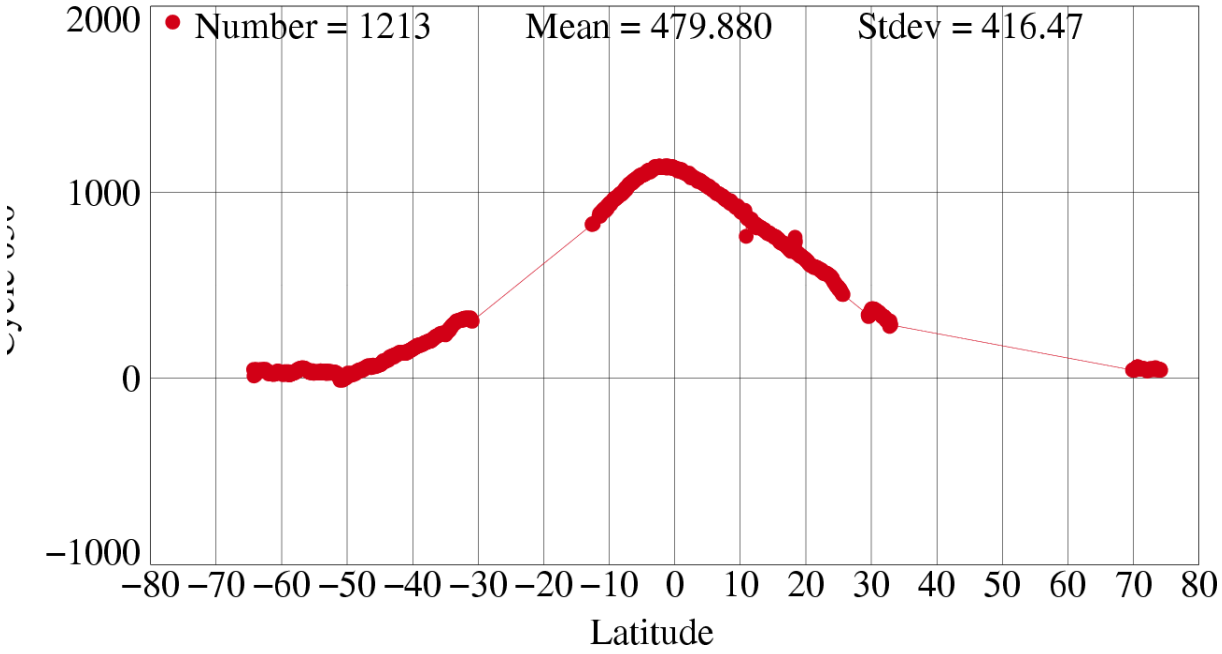
The next table gives statistics on Doris and Laser residuals:

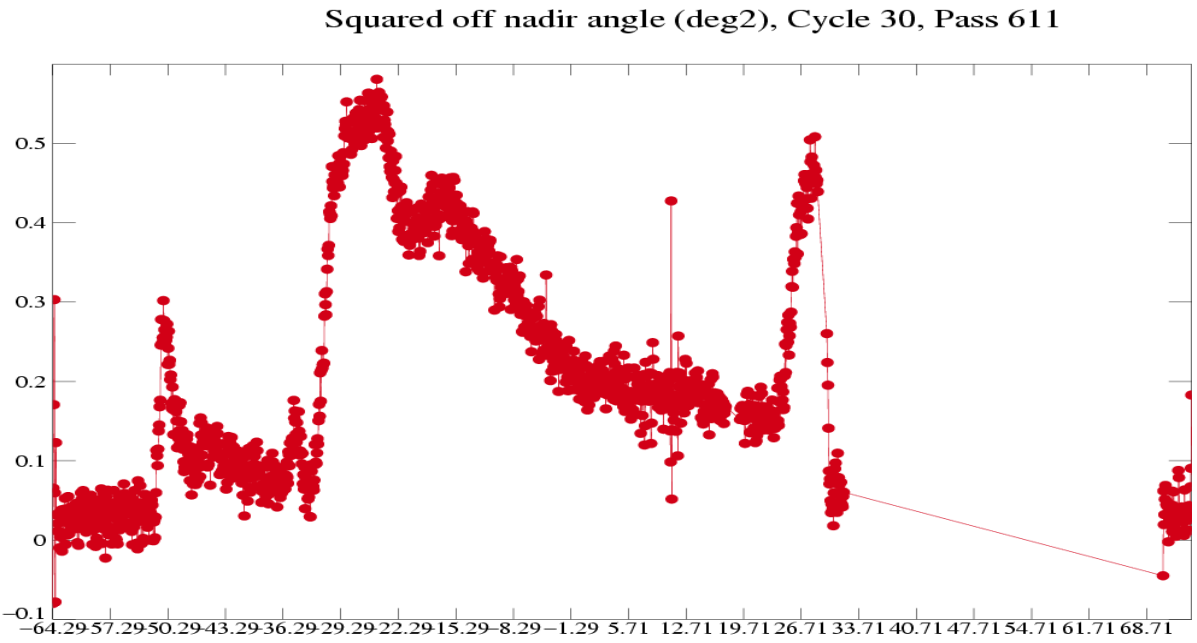
7-day Period	Number of Doris measurements	Number of Laser measurements	RMS of Laser measurements (cm)
30/08/2004 to 06/09/2004	32312	1244	2.01240
06/09/2004 to 13/09/2004	30199	1812	1.58900
13/09/2004 to 20/09/2004	30305	1697	1.69620
20/09/2004 to 27/09/2004	33528	581	11.00000
27/09/2004 to 04/10/2004	31355	821	1.60300

3.2.3 Impact on SLA

noticed on SLA.
The SLA is impacted by the 21-September maneuver. High SSH-MSS values and high squared off nadir angle from wave form are found on pass 611. The following figure shows these parameters .

SLA Envisat (cm) – Pass 611





Users are advised to remove pass 611 from their data set. After editing of degraded passes, the performances at crossover are 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

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	895202	38.76
Ice flag	735564	31.85
S-Band anomaly flag	322450	13.96

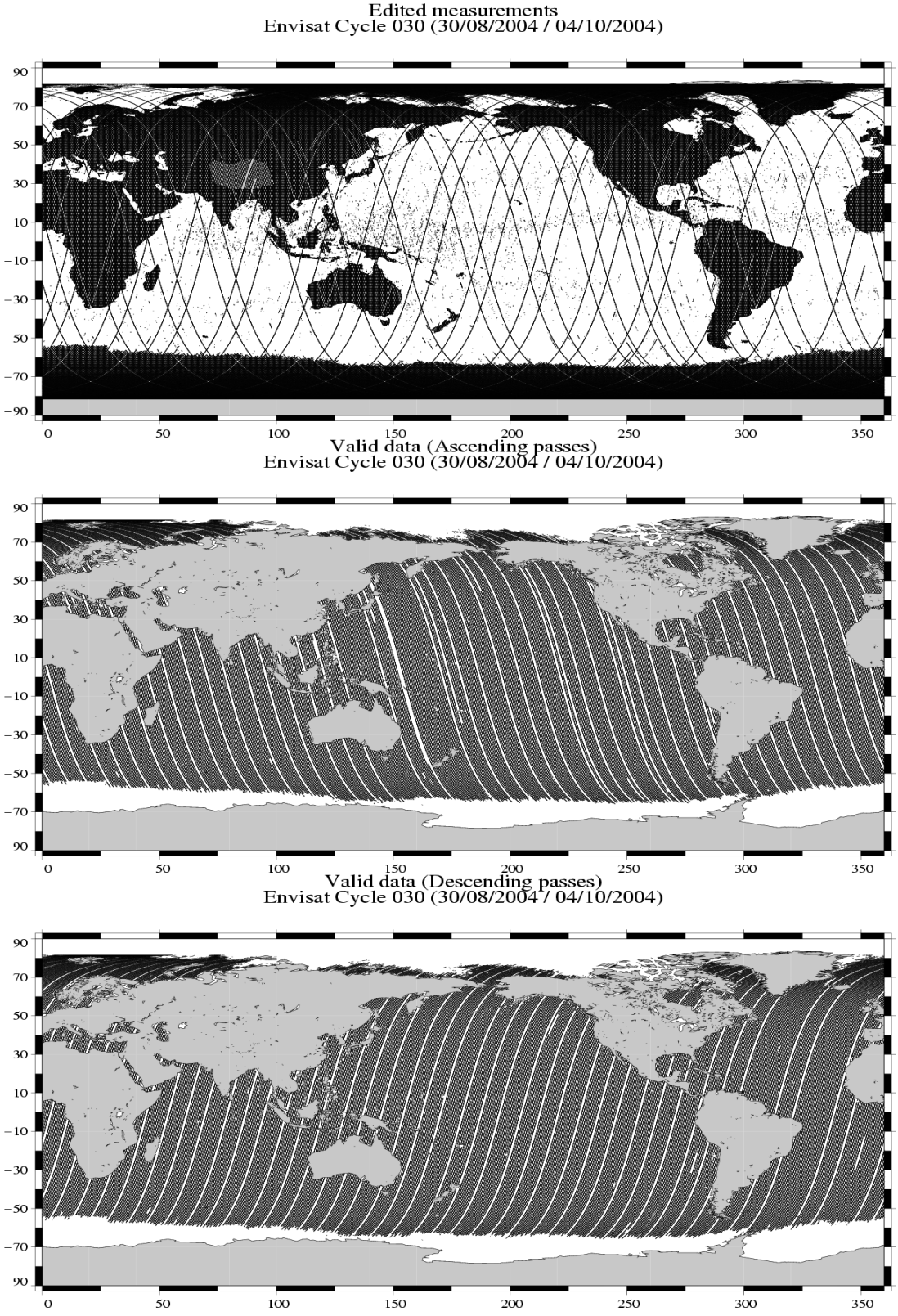
Then, measurements are edited using thresholds on several parameters. These thresholds are expected to remain constant throughout the Envisat mission, so that monitoring the number of edited measurements allows a survey of data quality.
The next table gives for each tested parameter, minimum and maximum 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	995	0.08
Variability relative to MSS (m)	-2.000	2.000	78120	5.92
Number of 18Hz valid points	10.000	-	98	0.01
Std. deviation of 18Hz range (m)	0.000	0.250	15427	1.17
Off nadir angle from waveform (deg2)	-0.200	0.160	10556	0.80
Dry tropospheric correction (m)	-2.500	-1.900	0	0.00
Invert barometer correction (m)	-2.000	2.000	0	0.00
MWR wet tropospheric correction (m)	-0.500	-0.001	1608	0.12
Dual Ionospheric correction (m)	-0.400	0.040	3313	0.25
Significant wave height (m)	0.000	11.000	1181	0.09
Sea state Bias (m)	-0.500	0.000	2454	0.19
Backscatter coefficient (dB)	7.000	30.000	2165	0.16
GOT00 ocean tide height (m)	-5.000	5.000	1387	0.11
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 614 (0.05 %) measurements.

3.3.2 Figures

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



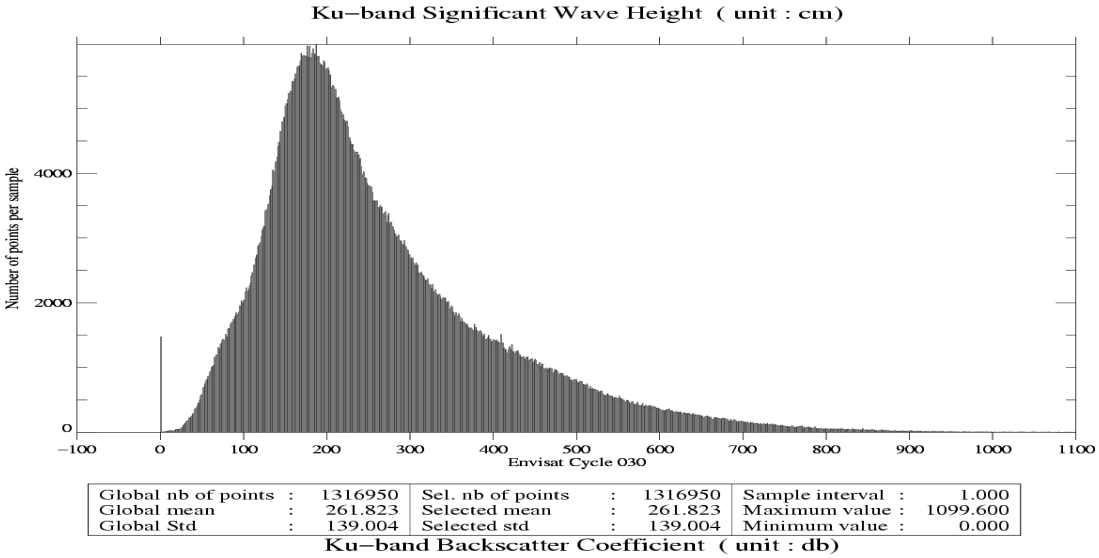
3.3.3 Comments

970 passes have been delivered. Among these passes:
Note than MWR correction is always present and no pass is edited on S-Band anomaly.

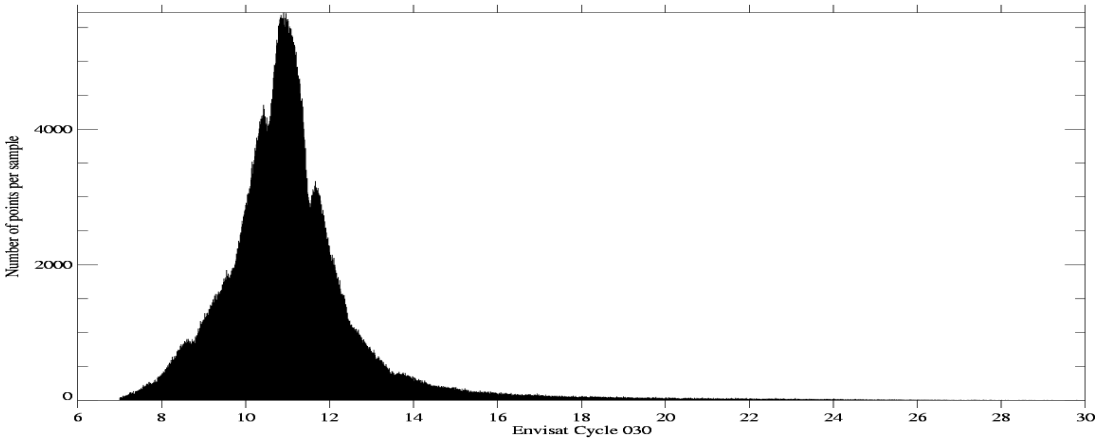
Wet areas appear in the plot of removed data. Similar features are observed with other altimeters (T/P, Jason) mainly due to rain comtamination.

3.4 Altimeter parameters

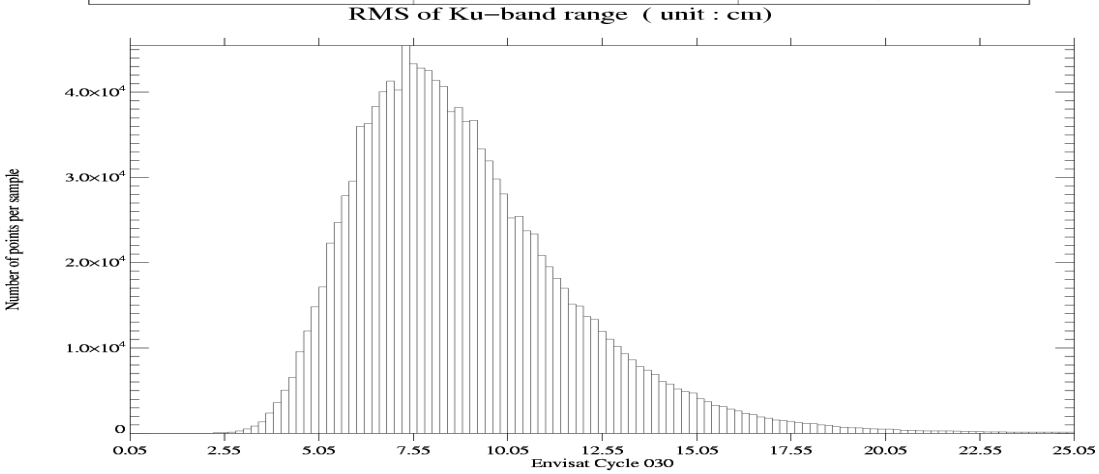
In order to assess and to monitor altimeter parameter measurements, histograms of Envisat Ku-band Significant Wave Height (SWH), Backscatter coefficient (Sigma0) and RMS of altimeter range are computed.



Global nb of points	:	1316950	Sel. nb of points	:	1316950	Sample interval	: 1.000
Global mean	:	261.823	Selected mean	:	261.823	Maximum value	: 1099.600
Global Std	:	139.004	Selected std	:	139.004	Minimum value	: 0.000



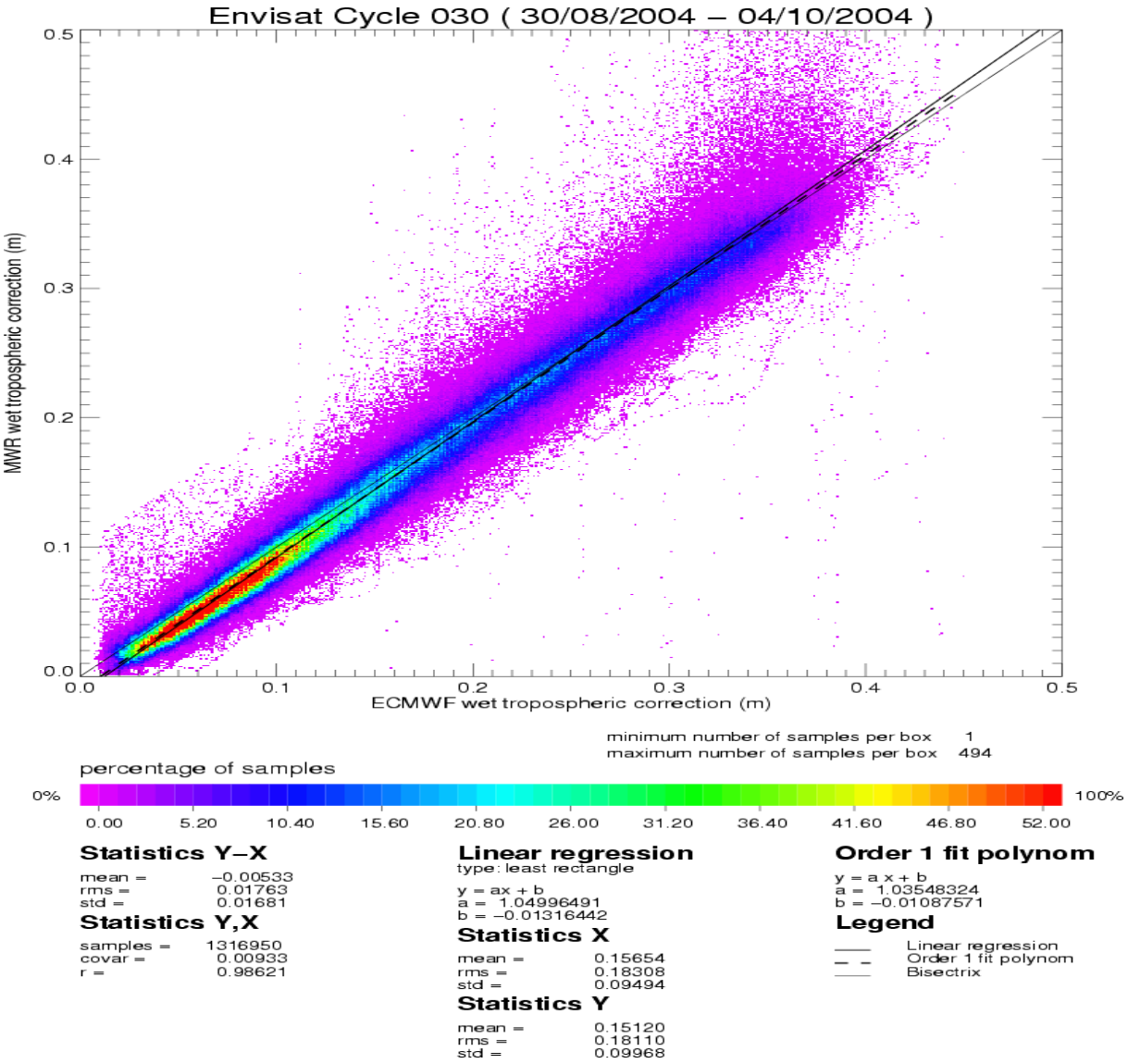
Global nb of points	:	1316950	Sel. nb of points	:	1316950	Sample interval	: 0.010
Global mean	:	11.101	Selected mean	:	11.101	Maximum value	: 30.000
Global Std	:	1.848	Selected std	:	1.848	Minimum value	: 7.000



Global nb of points	:	1316950	Sel. nb of points	:	1316950	Sample interval	: 0.200
Global mean	:	8.907	Selected mean	:	8.907	Maximum value	: 25.000
Global Std	:	2.887	Selected std	:	2.887	Minimum value	: 1.400

3.5 Radiometer

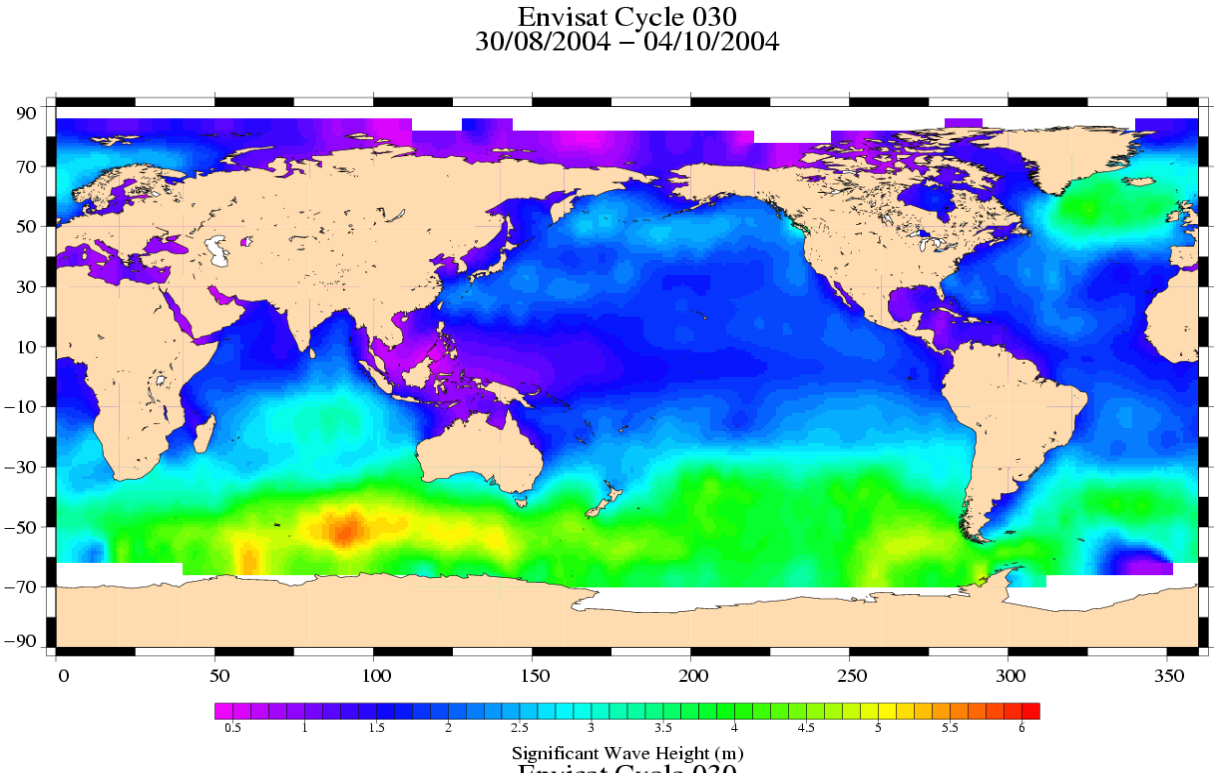
In order to assess and to monitor radiometer measurements, a scatter plot between the radiometer wet troposphere correction and the ECMWF model is computed for the valid data set previously defined.

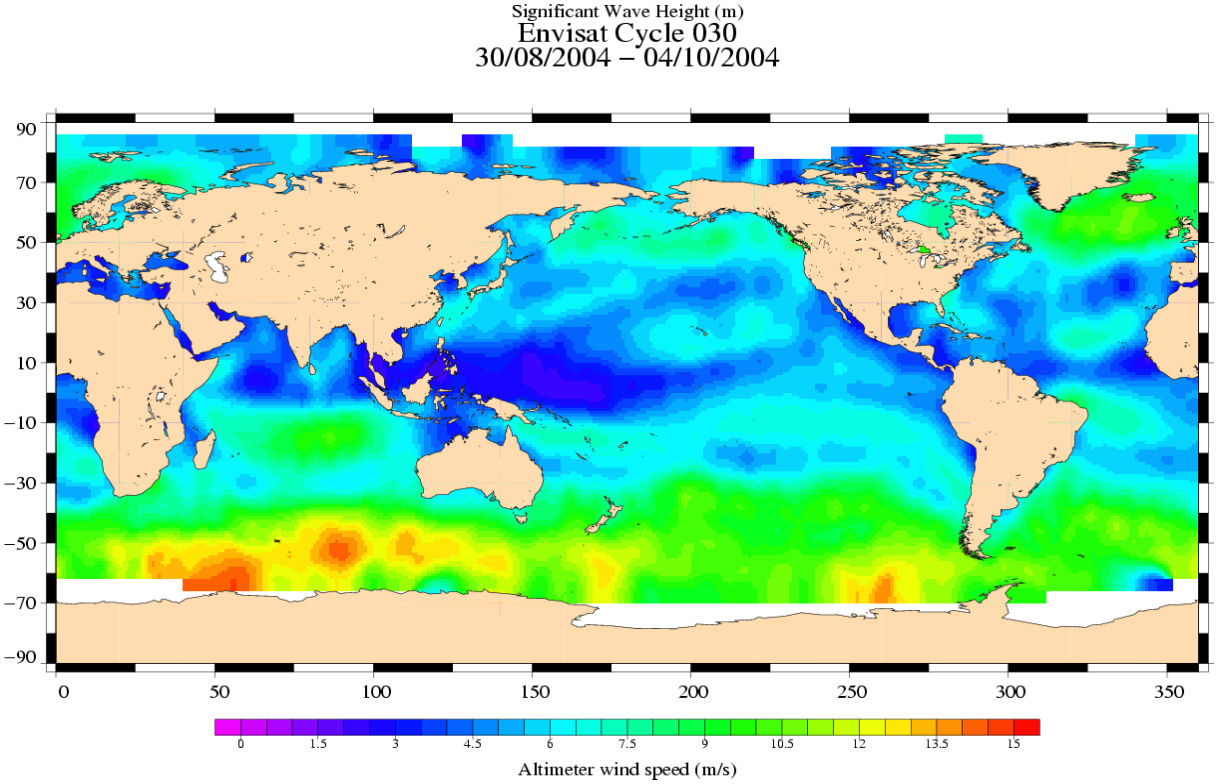


The radiometer-model mean difference is 0.5 cm. A drift on the Envisat 23.8GHz brightness temperature has been detected and has to be monitored on the long term. Note that the neural algorithm is now implemented on Envisat.

3.6 Wind and wave maps

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





3.7 Crossover statistics

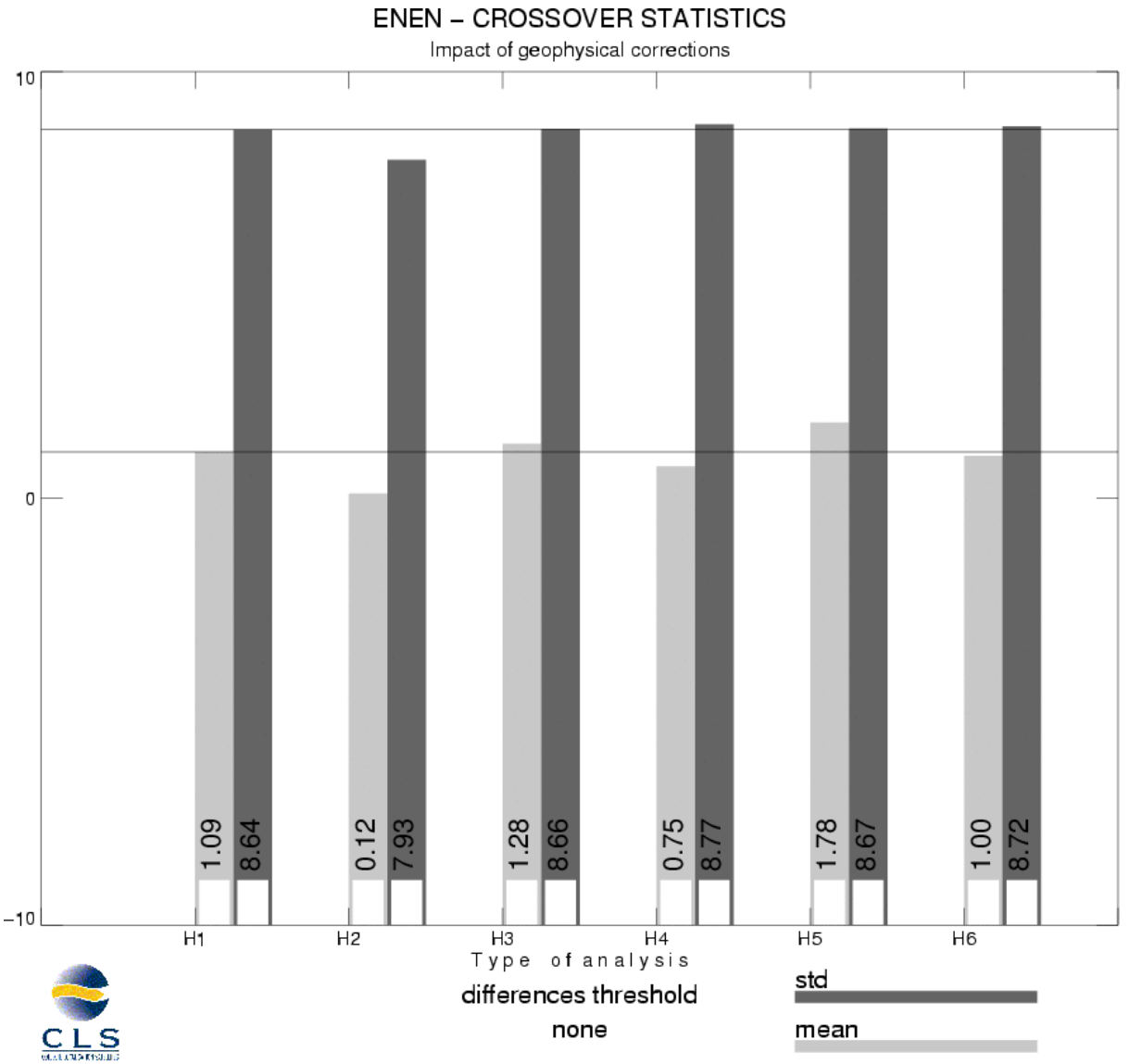
3.7.1 General comment

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 8.64 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 7.52 cm rms. This statistic is a stable estimation of the system performance as it is not influenced by sea ice coverage.

3.7.2 Impact of geophysical corrections

This figure shows the impact of geophysical corrections on crossover mean and rms. A selection is used to remove shallow waters (1000 m).

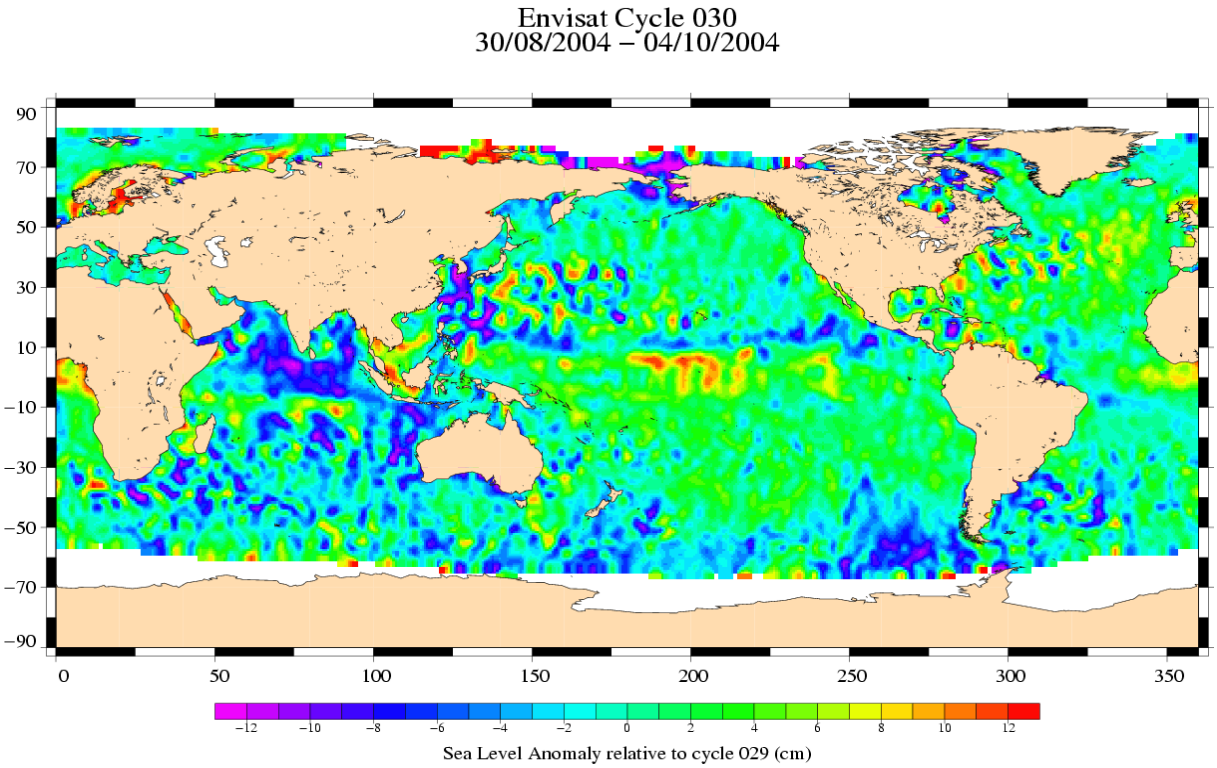
For this analysis two corrections have been computed: a long wave length and a model ionospheric correction. The long wave length estimation is performed by a global minimization of crossover differences using a (1 and 2 cycles/revolution) sinusoidal model. The model ionospheric correction is computed using the JPL's version of the GPS Ionosphere Maps (JPL GIM) thanks to the procedures provided by Remko Scharro (internet communication to the CCVT community, December 12, 2002).


ENEN – CROSSOVER STATISTICS
Impact of geophysical corrections
10
0
−10
1.09
8.64
0.12
7.93
1.28
8.66
0.75
8.77
1.78
8.67
1.00
8.72
H1
H2
H3
H4
H5
H6
Type of analysis
differences threshold
none
std
mean
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 030
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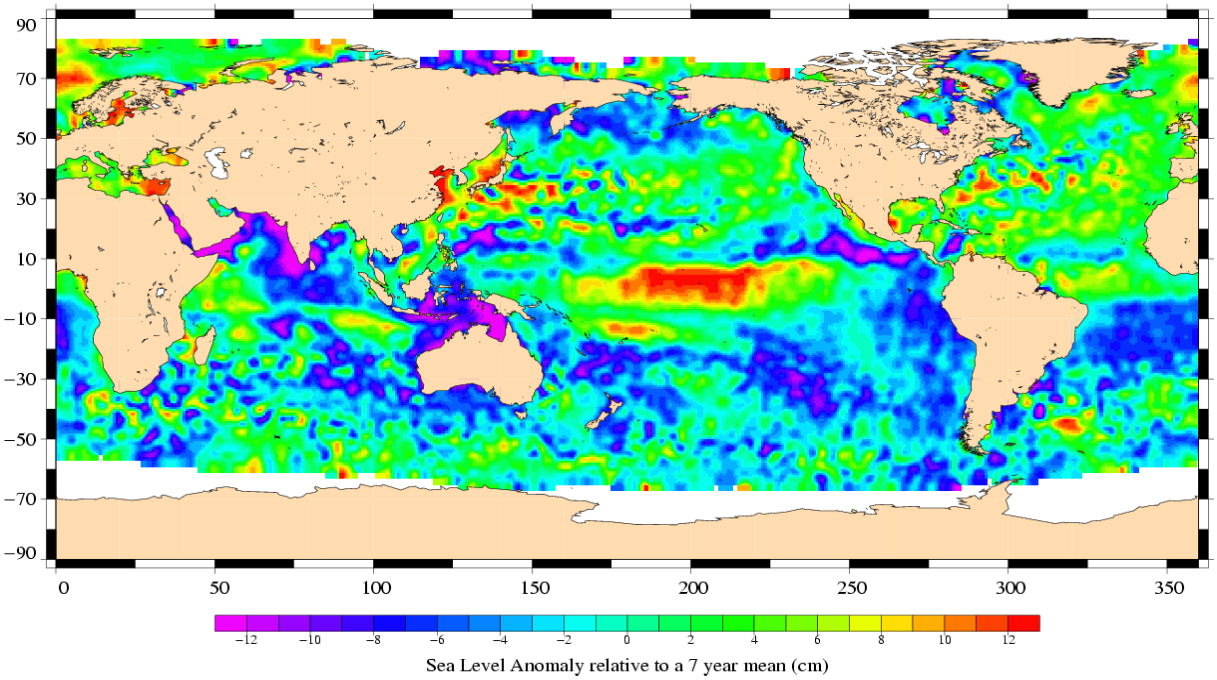


3.8.2 Comparison to a precise Mean Sea Surface

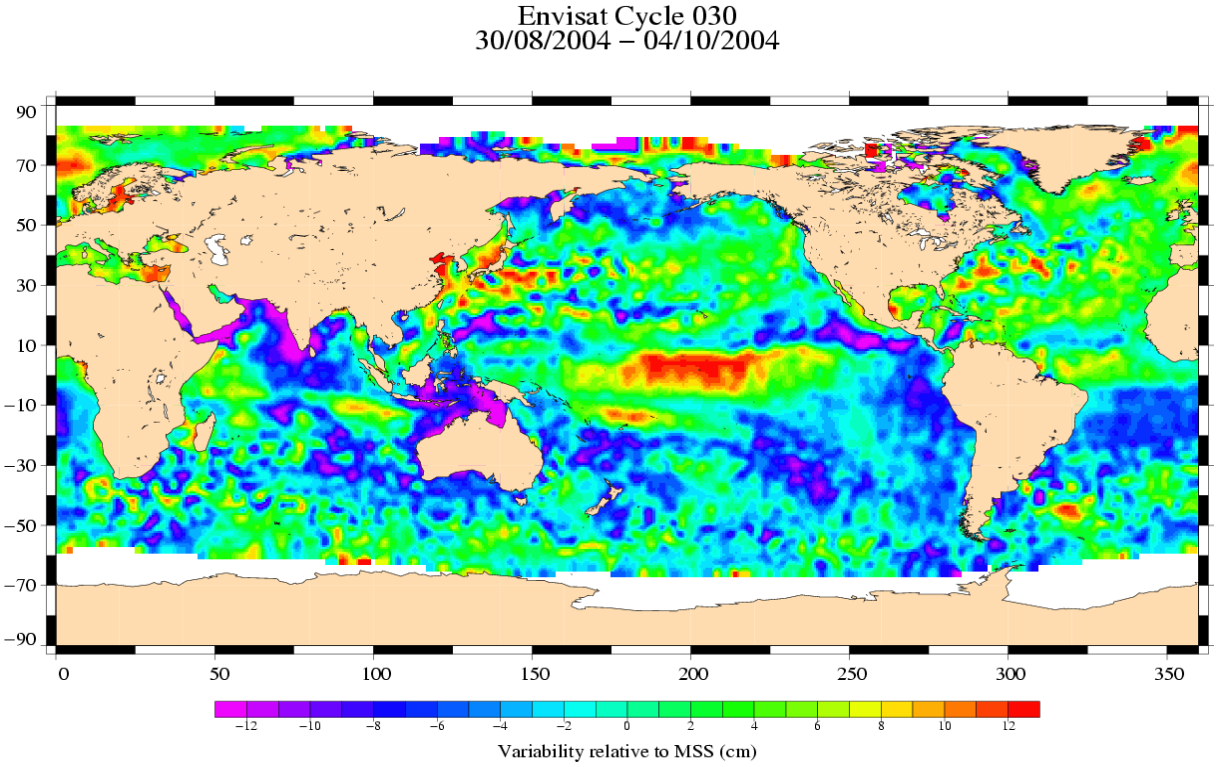
The MSS from the product is used as a reference to compute SLA. Global statistics of Envisat SSH-MSS are (cm):

Number	Mean	Std. dev.
1463985	44.73	11.01

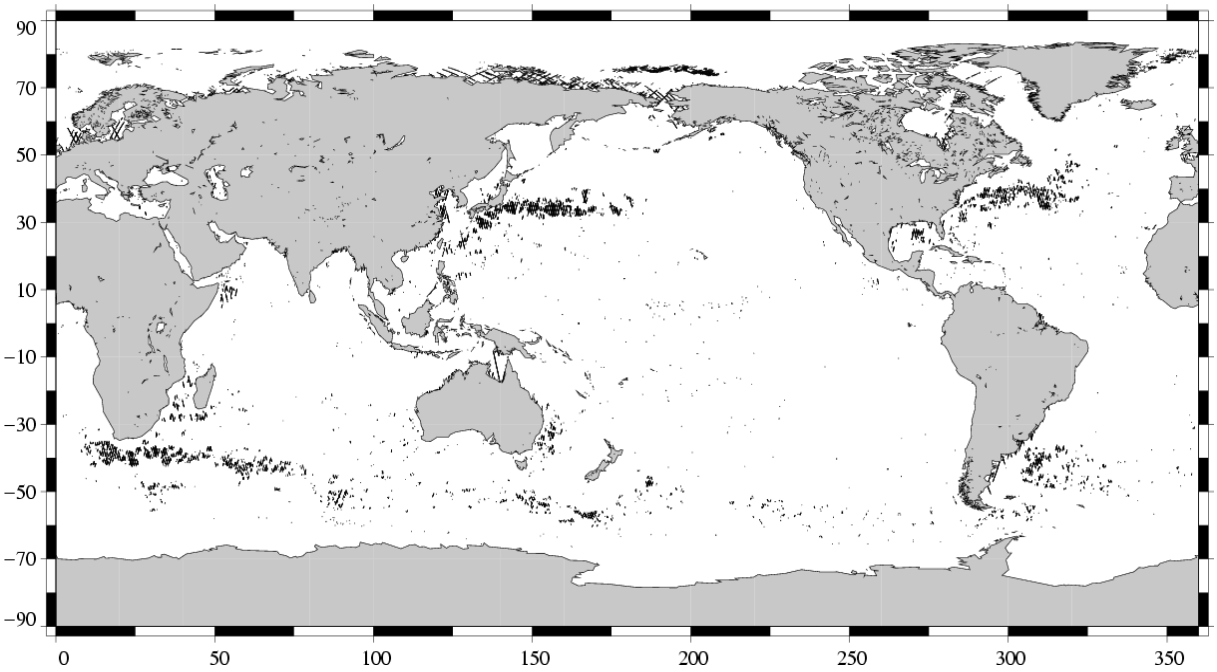
When using a selection to remove shallow waters (1000 m), areas of high ocean variability and high latitudes ($> |50|$ deg) statistics are:

Number	Mean	Std. dev.
901690	44.50	9.34

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 030



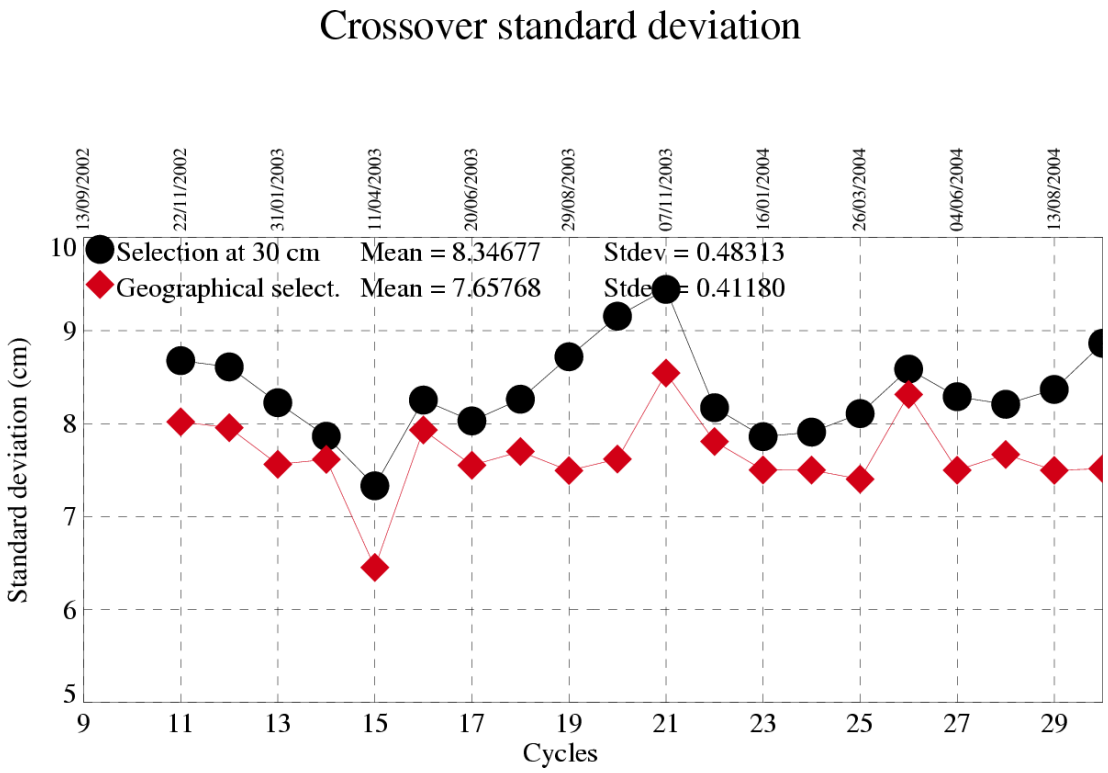
4 Envisat long term performance monitoring

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

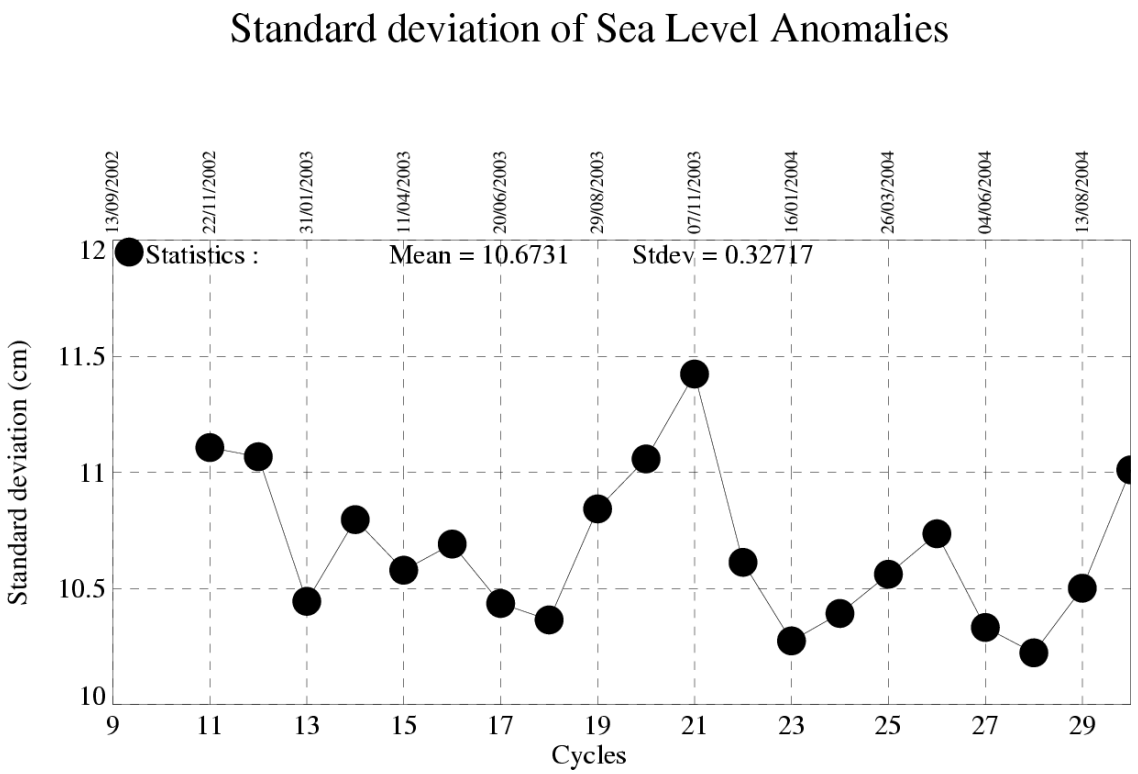
This parameter is plotted as a function of time in a one cycle per cycle basis in the figure below. It is computed after data editing and using 2 aditing selection criteria:

- 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.



5 Cross Calibration with ERS-2

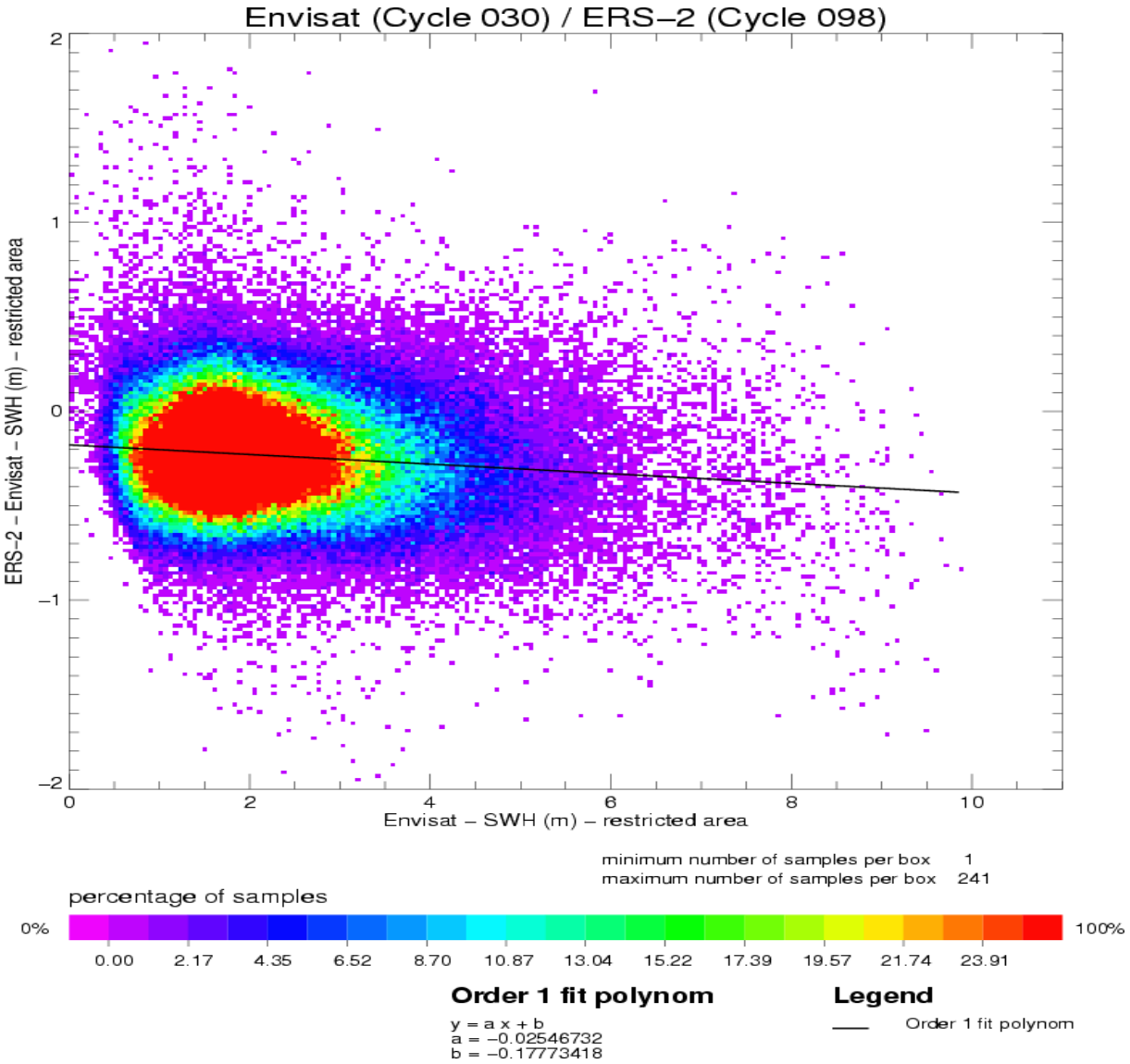
Envisat flies on the same ground track as ERS-2, 30 minutes ahead. This section presents results that illustrate the difference with ERS-2.
A failure of the ERS-2 tape recorder occured on 22 June 2003. The ERS-2 Low Rate mission continues within the visibility of ESA ground stations over Europe: North Atlantic, Arctic and western North America. Nevertheless, cross calibration with ERS-2 can be performed on this zone. Envisat cycle 030 data are collocated to data from ERS-2 GDR cycle 097 in order to compare the main parameters from repeat-track analysis.

5.1 [ERS-2 - Envisat] Ku SWH differences

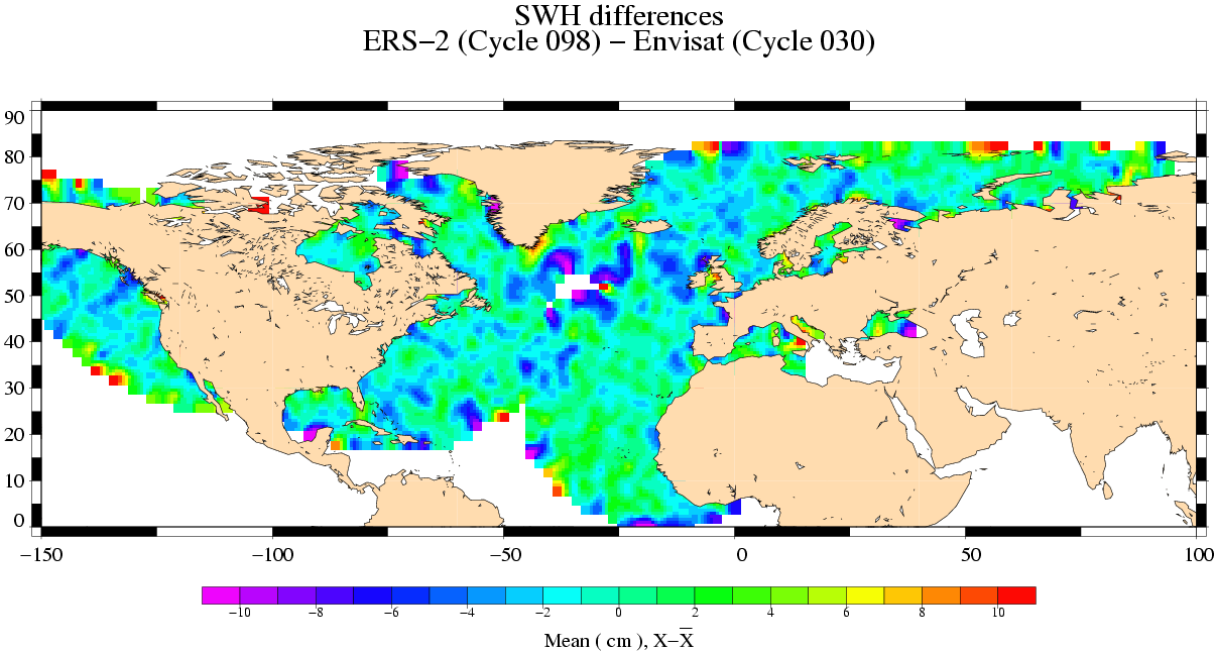
Global statistics of [ERS-2 - Envisat] Ku SWH differences are (cm):

Number	Mean	Std. dev.
202927	-22.42	25.91

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


Envisat (Cycle 030) / ERS–2 (Cycle 098)
ERS–2 – Envisat – SWH (m) – restricted area
Envisat – SWH (m) – restricted area
2
1
0
–1
–2
0
2
4
6
8
10
minimum number of samples per box 1
maximum number of samples per box 241
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 = –0.02546732
b = –0.17773418
Legend
Order 1 fit polynom

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

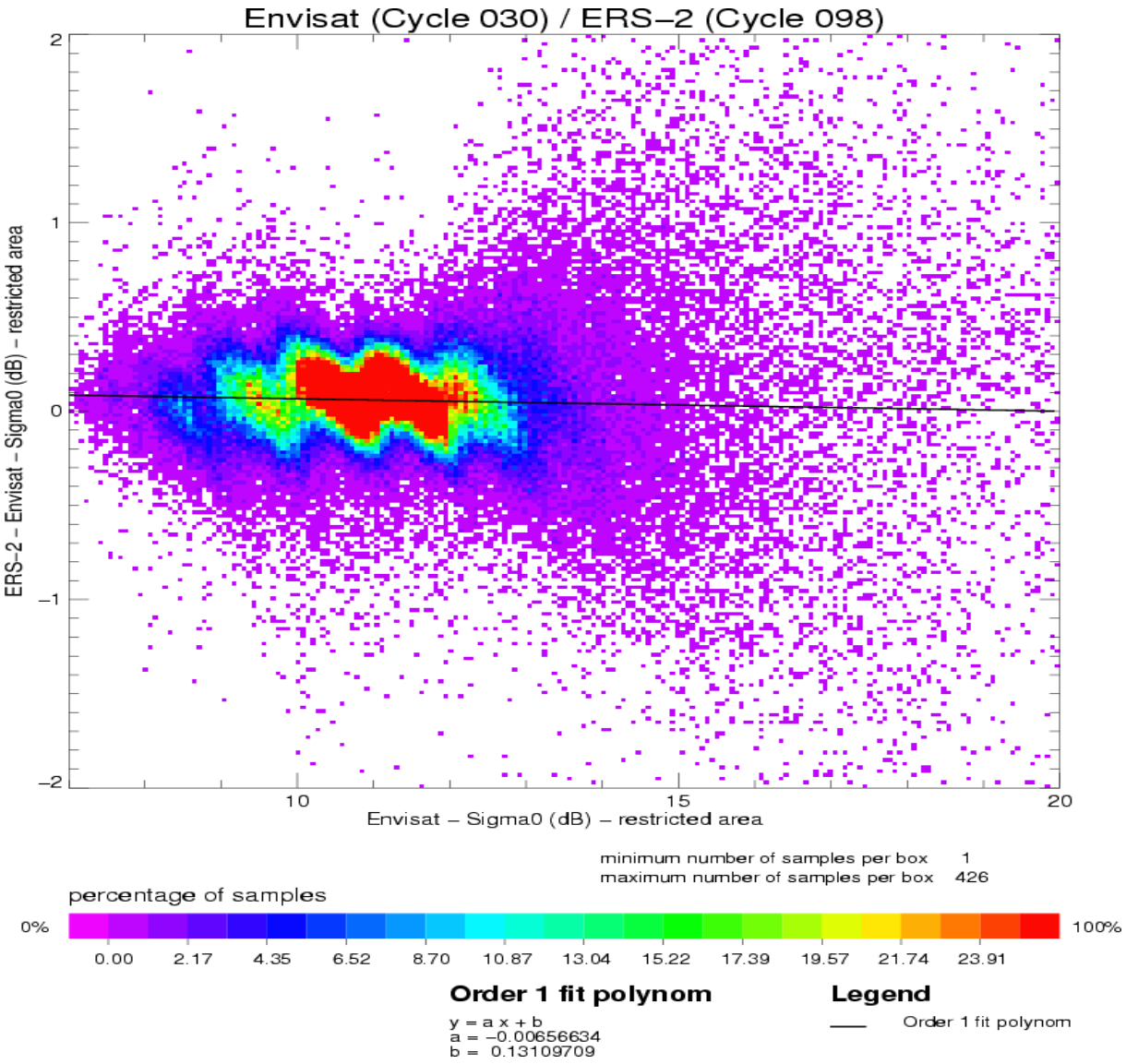


5.2 [ERS-2 - Envisat] Ku Sigma0 differences

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

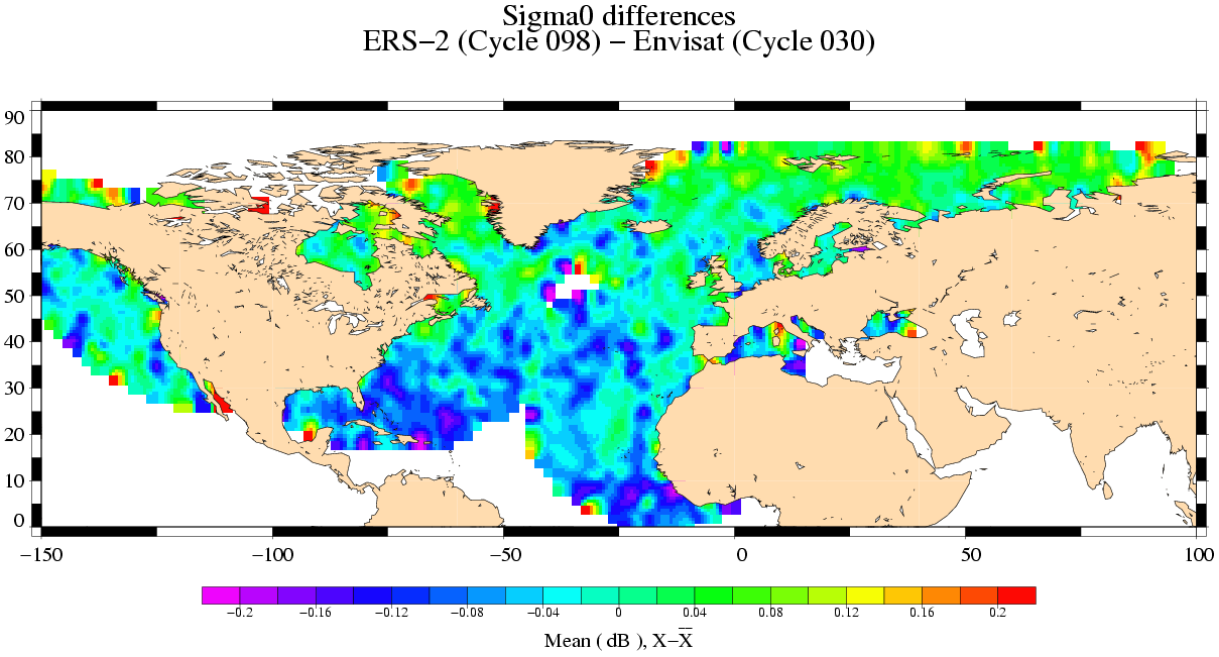
Number	Mean	Std. dev.
202927	0.06	0.28

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).

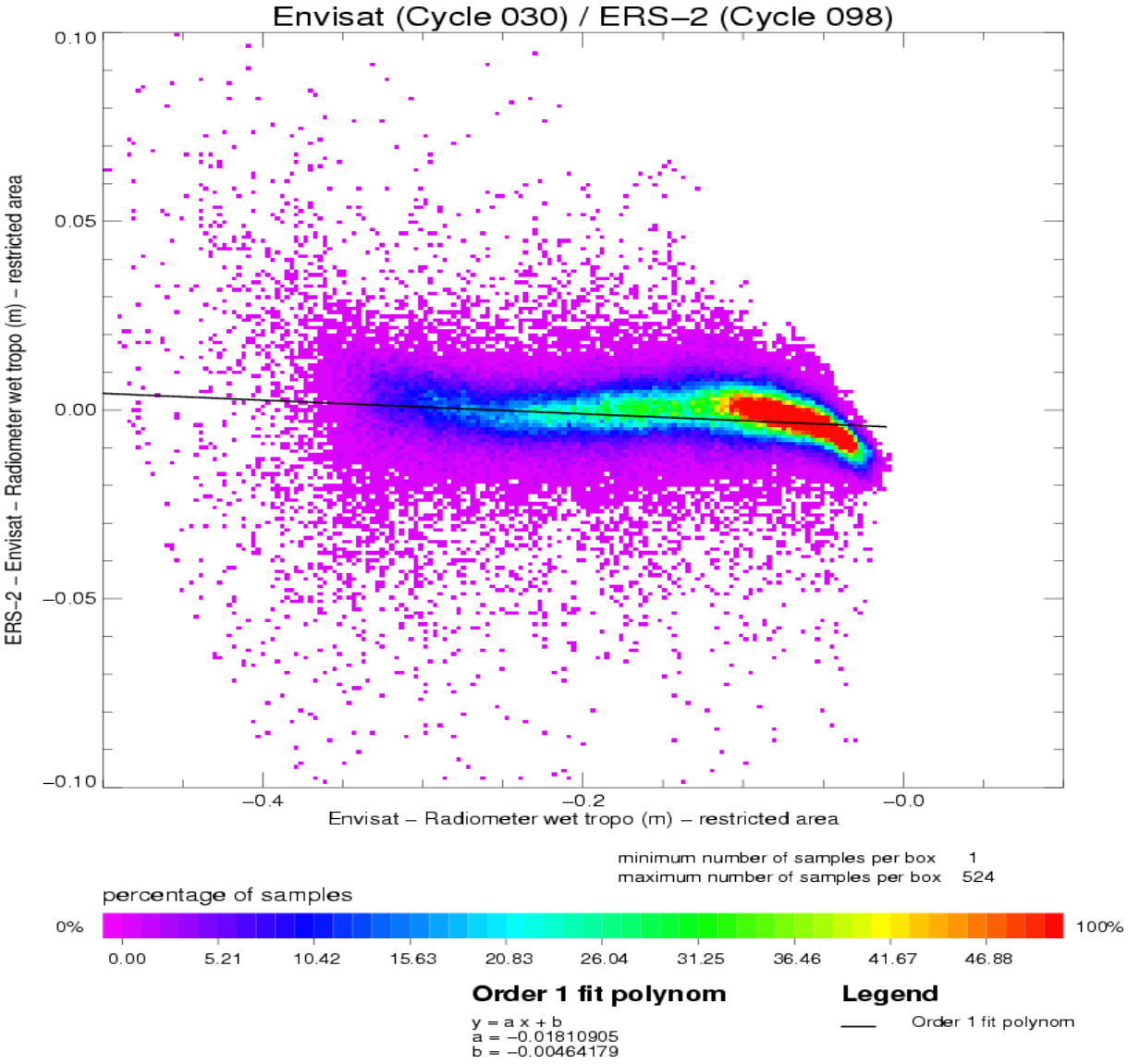


5.3 [ERS-2 - Envisat] radiometer wet troposphere correction differences

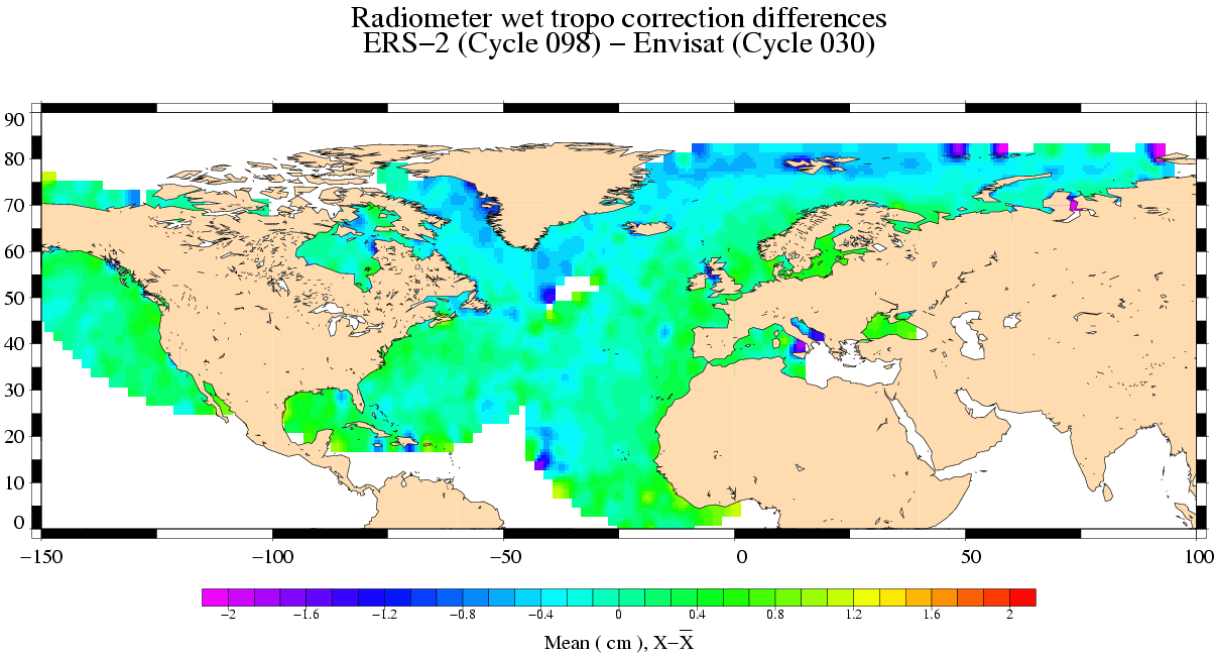
The ERS-2 radiometer correction is recomputed to correct the gain drop and the drift of the 24 GHz brightness temperature (Obligis et al., 2003).
Global statistics of [ERS-2 - Envisat] radiometer wet troposphere correction differences are (cm):

Number	Mean	Std. dev.
202927	-0.16	0.81

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

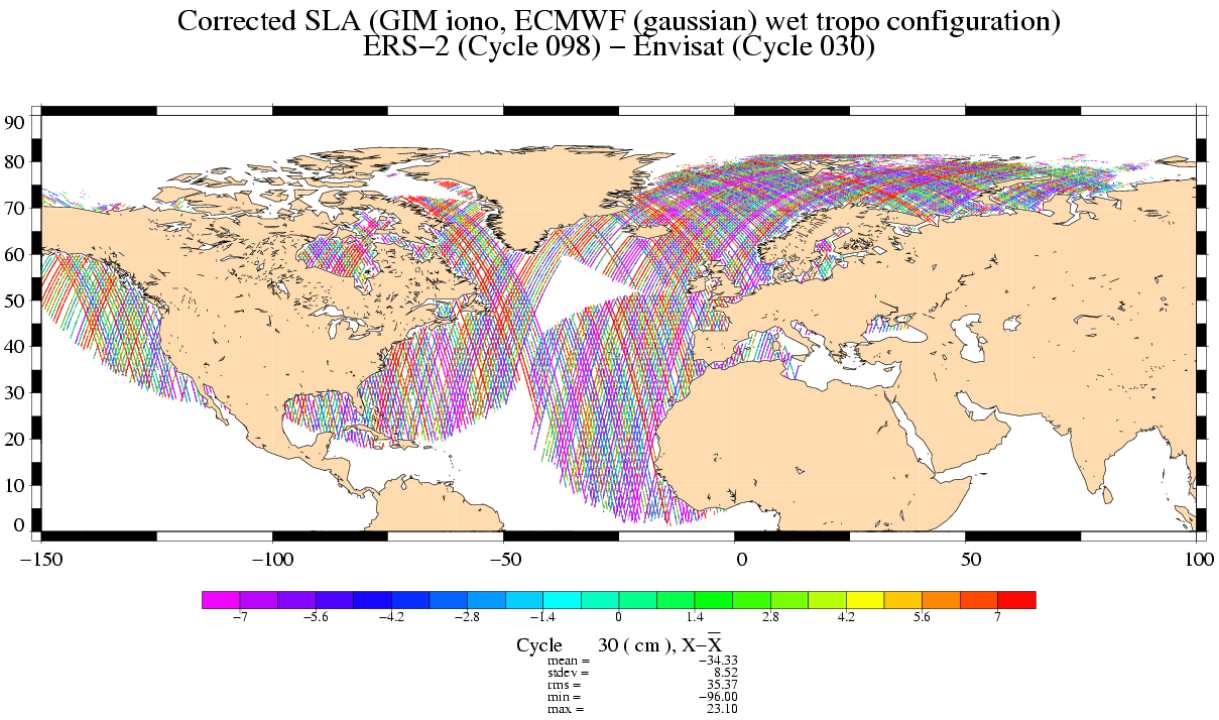
In order to compare the ERS-2 SSH with the Envisat SSH, ERS-2 GDRs have been updated with algorithms and corrections similar to Envisat:
- Range corrected from SPTR, USO, time tag bias
- ECMWF wet tropospheric correction
- Model dry tropospheric correction
- 3-parameters sea state bias
- Inverted barometer 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 097, the initial orbit is then used).

The correction used for Envisat are those described in **section 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.
202927	-34.32	8.52

These SSH differences are plotted on the following figure.



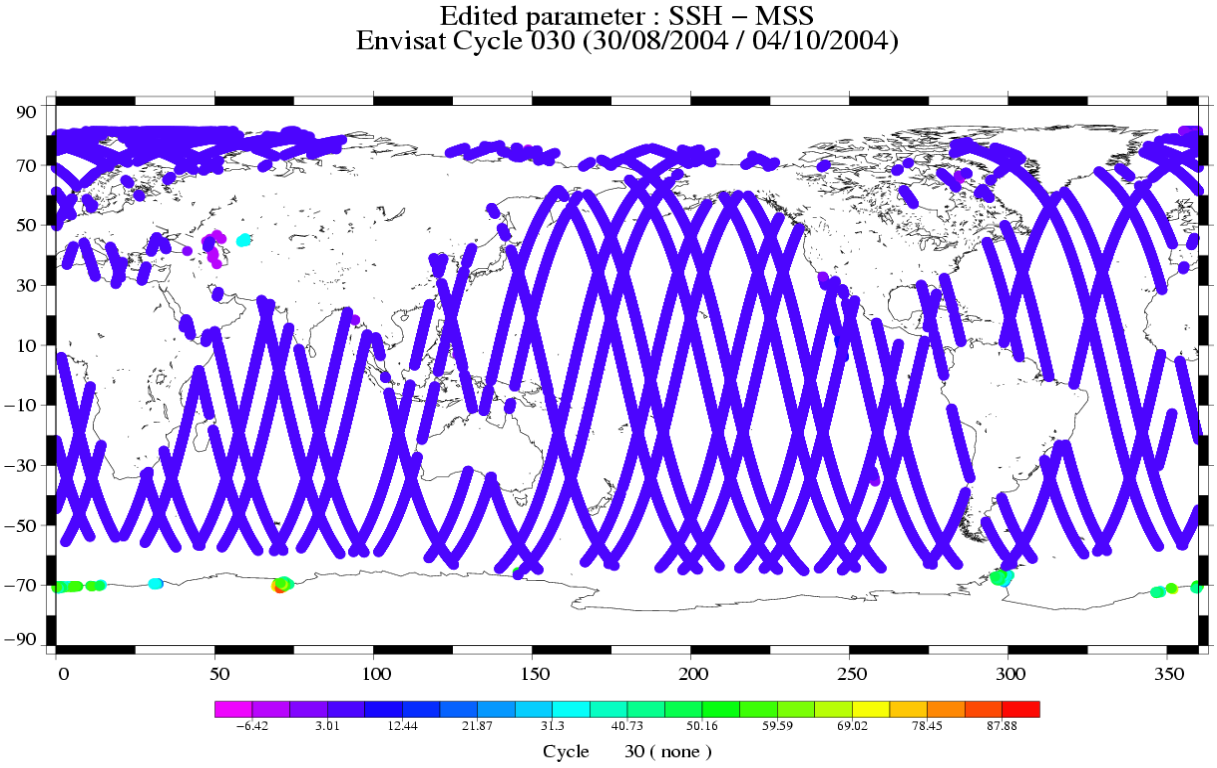
The main source of differences is the ERS-2 orbit errors.

6 Particular investigations

An unexpected behaviour of the Envisat RA-2 sensor was observed in the period from 2004/09/27 to 2004/09/29. This directly happened after the recovery of a RA-2 on-board anomaly occurred on the 2004/09/26. The altimetric range jumped by several meters w.r.t. the Mean Sea Surface. This abnormal behaviour of the RA-2 sensor is currently under investigation.

Users are advised to remove passes 796-846 from their data set.

The following figure shows the edited passes.



After editing of degraded passes, the performances at crossover are good.