Envisat GDR
Quality Assessment Report

Cycle 014

17-02-2003 24-03-2003

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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
Particular investigations
Cross Calibration with ERS-2

2 Cycle overview

2.1 Data and software version

This cycle has been produced with the IPF processing chain V4.56
and the CMA Reference Software CMA V6.3_01 and V6.3_02.

The IPF V4.56 upgrades convcerning GDRs are:
- Correction of the AGC evaluation for Ku and S-band. - New IF mask Auxiliary Data File (RA2_IFF_AX)

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

No CTI tables uploaded on-board between pass 799 and 1002 (see **section 4**).

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

57 passes have no radiometer correction (see **section 3.3**).

As mentionned by J. Benveniste (internet communication, 9 nov 2002) an anomaly occasionally occurs on the S-Band. Consequently the Dual Frequency ionosphere correction is not available during these periods. 54 passes are impacted by the S-Band anomaly (see **section 3.3**).

2.4 Platform and instrument events

Following failure of the PMC TT Q Pack procedure the PMC was switched to SUSPEND manually by command. The SUSPEND command will also issue an SM_SOL switching the payload OFF. The decision was made to stop operations because the PACK flag prevents update of the TT queue and the PMC telemetry clearly showed a major failure of the OBSW. Just before the SOL was issued the PMC CPU load showed inconsistency and a number of instrument destinations were disabled indicating error recovery actions (2003/02/20 07:27:06 to 2003/02/22 14:20:09).

SEU's caused a Software Anomaly (2003/03/02 02:46:44 to 2003/03/03 16:46:35).

Subsystems unavailable - Autonmous P/L switch-off (2003/03/15 04:21:08 to 2003/03/17 19:00:13)

RA2 in HTR0/Refuse due to HPA primery bus undercurrent (2003/03/17 21:09:32 to 2003/03/18 18:50:40)

Orbit Maintenance Maneuver (2003/02/21 03:42:57 to 2003/02/21 05:53:24)

Orbit Maintenance Maneuver (2003/03/03 23:51:14 to 2003/03/04 01:51:22)

2.5 Cycle quality and performances

Good general results are obtained for this cycle of data.

The crossover standard deviation is 7.62 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 10.8 cm. When using a selection to remove shallow waters (1000 m), areas of high ocean variability and high latitudes (> |50| deg) it lowers to 9.7.

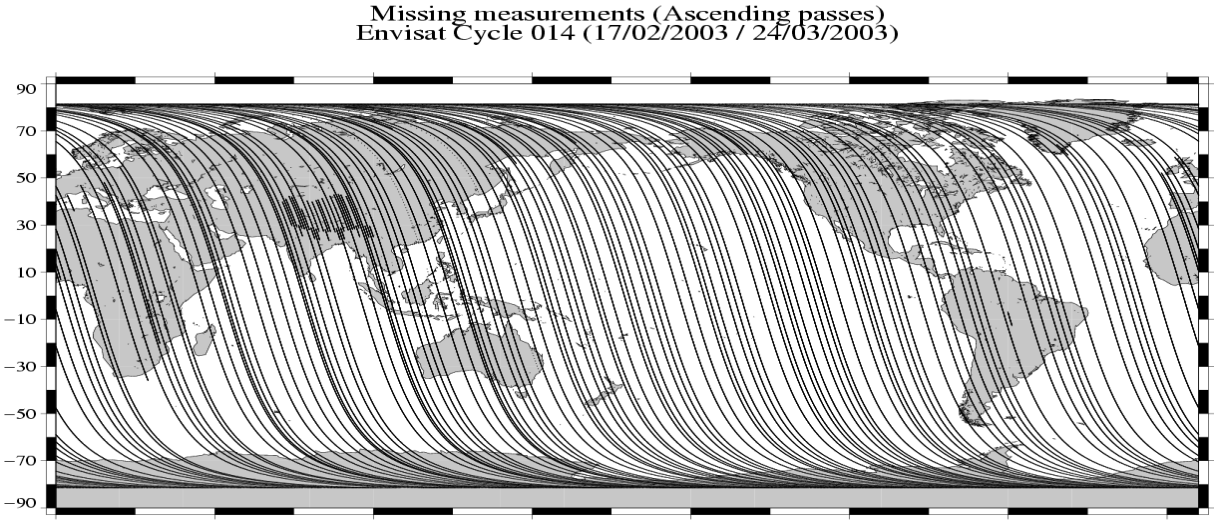
Detailed CALVAL results are presented in **section 3**.

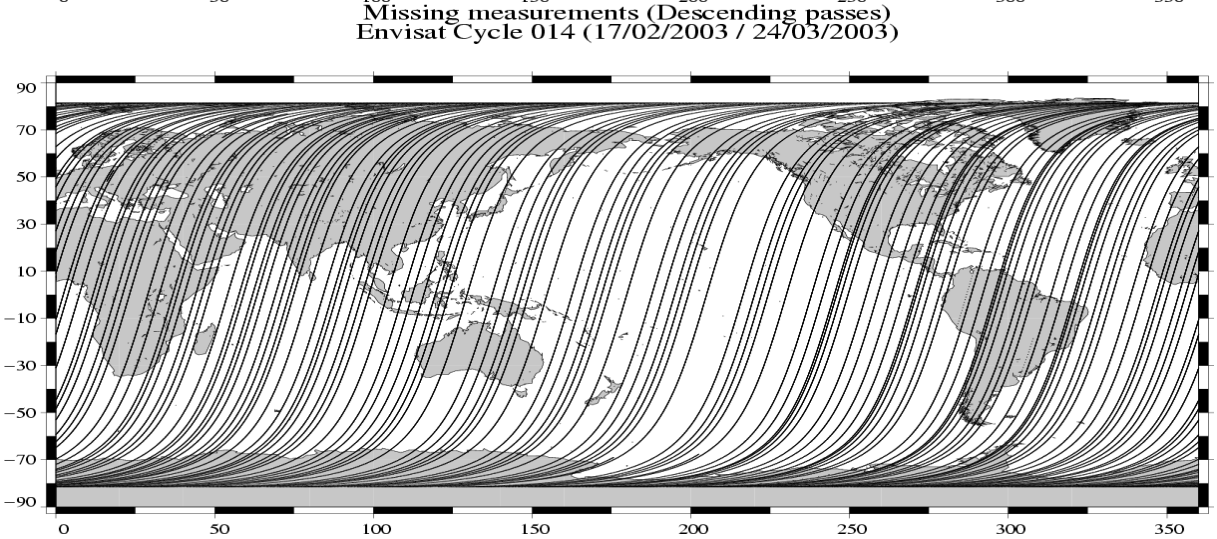
3 CALVAL main results

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

2114929 are present, and 599910 (22.1%) are missing. The maps below illustrate missing 1Hz measurements in the GDRs, with respect to a 1 Hz sampling of a nominal repeat track.





204 passes are missing all due to level1 B data unavailability:
- 66 passes (69-134) are missing due to: "PMC was switched to SUSPEND" - 32 passes (363-395) are missing due to: "SEU's caused a Software Anomaly" - 74 passes (724-798) are missing due to: "Subsystems unavailable - Autonmous P/L switch-off" - 23 passes (803-826) are missing due to: "RA2 in HTR0/Refuse due to HPA primery bus undercurrent" - 9 passes 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 the 21st February 2003 a single burn out-of-plane orbit inclination maintenance manoeuvre was programmed. Initially planned for execution on the 25thIt it was re-scheduled for the 21st February, during a RA-2 unavailability, allowing reduction of planned instrument unavailability time.

On the 4th March 2003, a single burn in-plane orbit maintenance manoeuvre was executed as planned.

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)
17/02/2003 to 24/02/2003	11895	795	1.27610
24/02/2003 to 03/03/2003	36602	1635	1.69940
03/03/2003 to 10/03/2003	36666	1561	1.92570
10/03/2003 to 17/03/2003	17445	1207	2.13780
17/03/2003 to 24/03/2003	18426	1363	1.48680

3.2.3 Impact on SLA

The orbit quality is good for this cycle of data. No Impact is noticed on SLA.

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	822819	44.65
Ice flag	603589	32.76
S-Band anomaly flag	395398	21.46

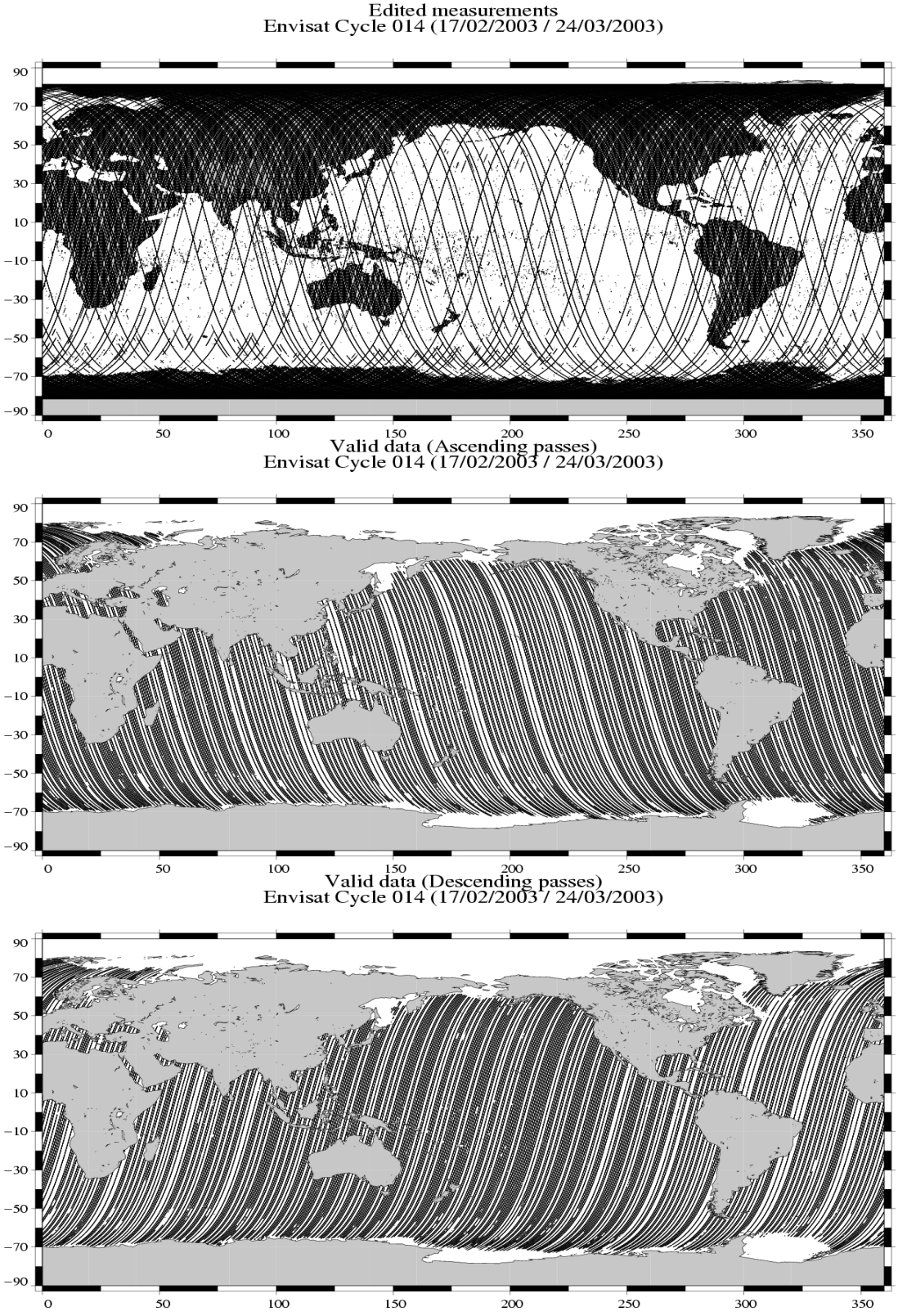
Then, measurements are edited using thresholds on several parameters. These thresholds are expected to remain constant throughout the Envisat mission, so that monitoring the number of edited measurements allows a survey of data quality.
The next table gives for each tested parameter, minimum and maximum 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	656	0.07
Variability relative to MSS (m)	-2.000	2.000	3157	0.32
Number of 18Hz valid points	10.000	-	2143	0.21
Std. deviation of 18Hz range (m)	0.000	0.250	11167	1.12
Off nadir angle from waveform (deg2)	-0.200	0.160	9107	0.91
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	1549	0.15
Dual Ionospheric correction (m)	-0.400	0.040	3301	0.33
Significant wave height (m)	0.000	11.000	858	0.09
Sea state Bias (m)	-0.500	0.000	1798	0.18
Backscatter coefficient (dB)	7.000	30.000	1899	0.19
GOT00 ocean tide height (m)	-5.000	5.000	810	0.08
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 361 (0.04 %) measurements.

3.3.2 Figures

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



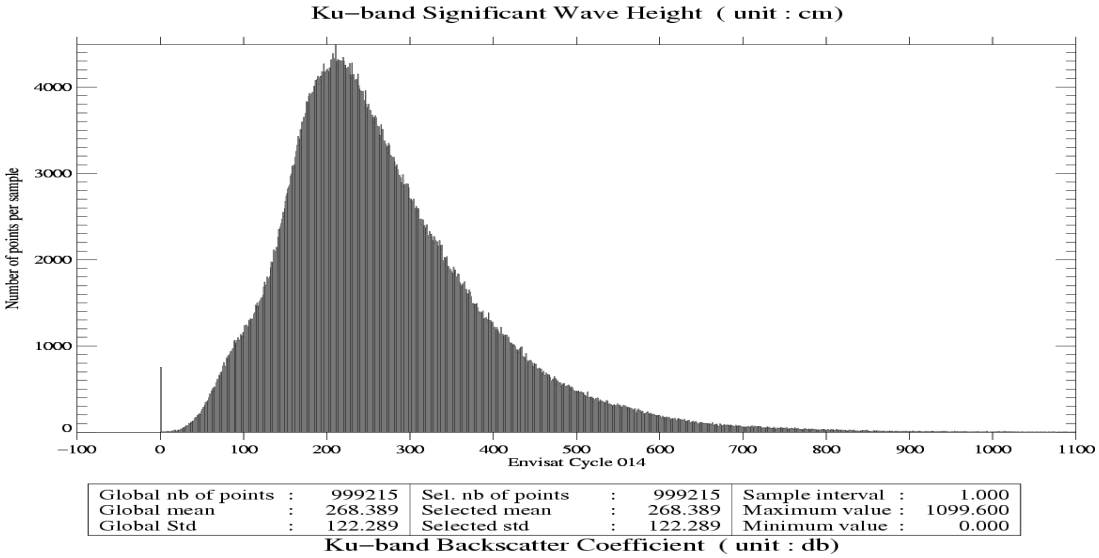
3.3.3 Comments

798 passes have been delivered. Among these passes:
- 57 passes are entirely edited on the radiometer land flag (no MWR correction). Passes 136-191 have no MWR correction: after the PMC event, RA-2 recovered on pass 136 whereas MWR recovered on pass 192
- 54 passes (174-193, 498-509, 556-567, 870-881) 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.

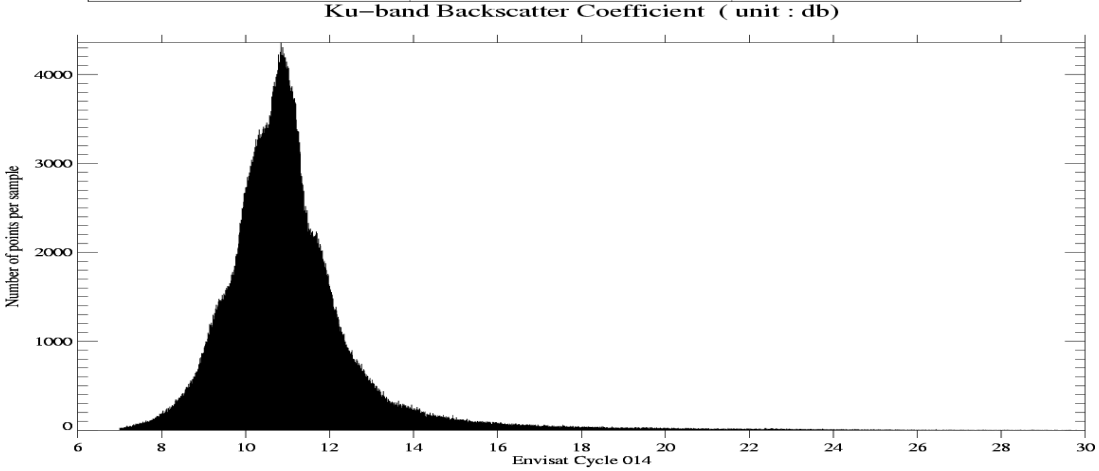
Wet areas appear in the plot of removed data. Similar features are observed with other altimeters (T/P, Jason) mainly due to rain comtamination.

3.4 Altimeter parameters

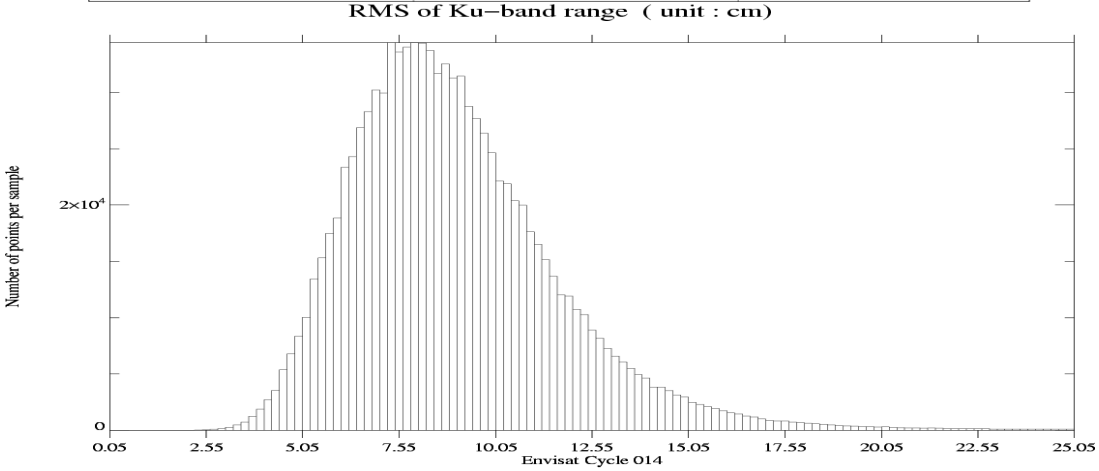
In order to assess and to monitor altimeter parameter measurements, histograms of Envisat Ku-band Significant Wave Height (SWH), Backscatter coefficient (Sigma0) and RMS of altimeter range are computed.



Global nb of points	:	999215	Sel. nb of points	:	999215	Sample interval	: 1.000
Global mean	:	268.389	Selected mean	:	268.389	Maximum value	: 1099.600
Global Std	:	122.289	Selected std	:	122.289	Minimum value	: 0.000



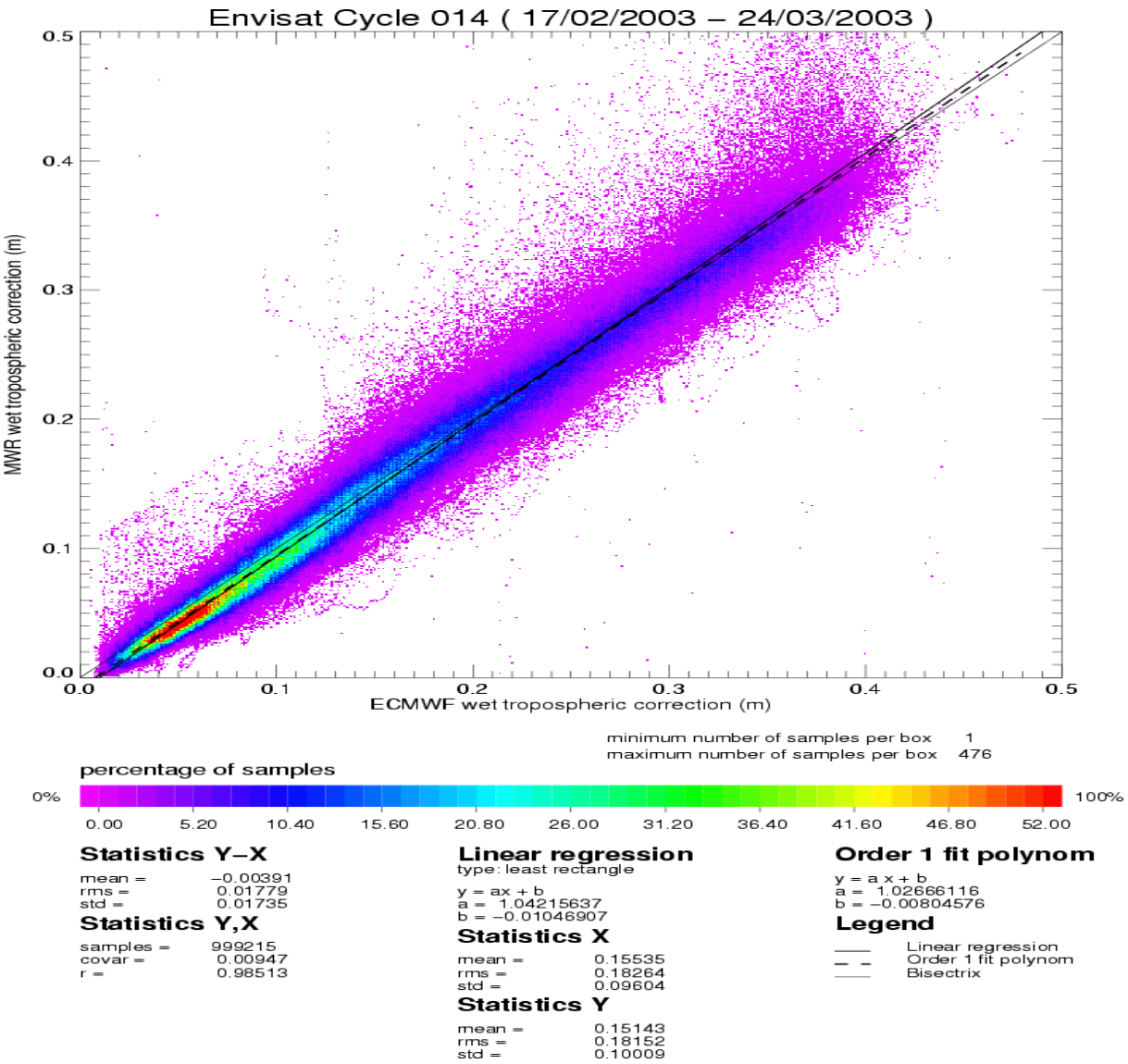
Global nb of points	:	999215	Sel. nb of points	:	999215	Sample interval	: 0.010
Global mean	:	11.071	Selected mean	:	11.071	Maximum value	: 29.790
Global Std	:	1.775	Selected std	:	1.775	Minimum value	: 7.000



Global nb of points	:	999215	Sel. nb of points	:	999215	Sample interval	: 0.200
Global mean	:	8.991	Selected mean	:	8.991	Maximum value	: 25.000
Global Std	:	2.691	Selected std	:	2.691	Minimum value	: 1.400

3.5 Radiometer

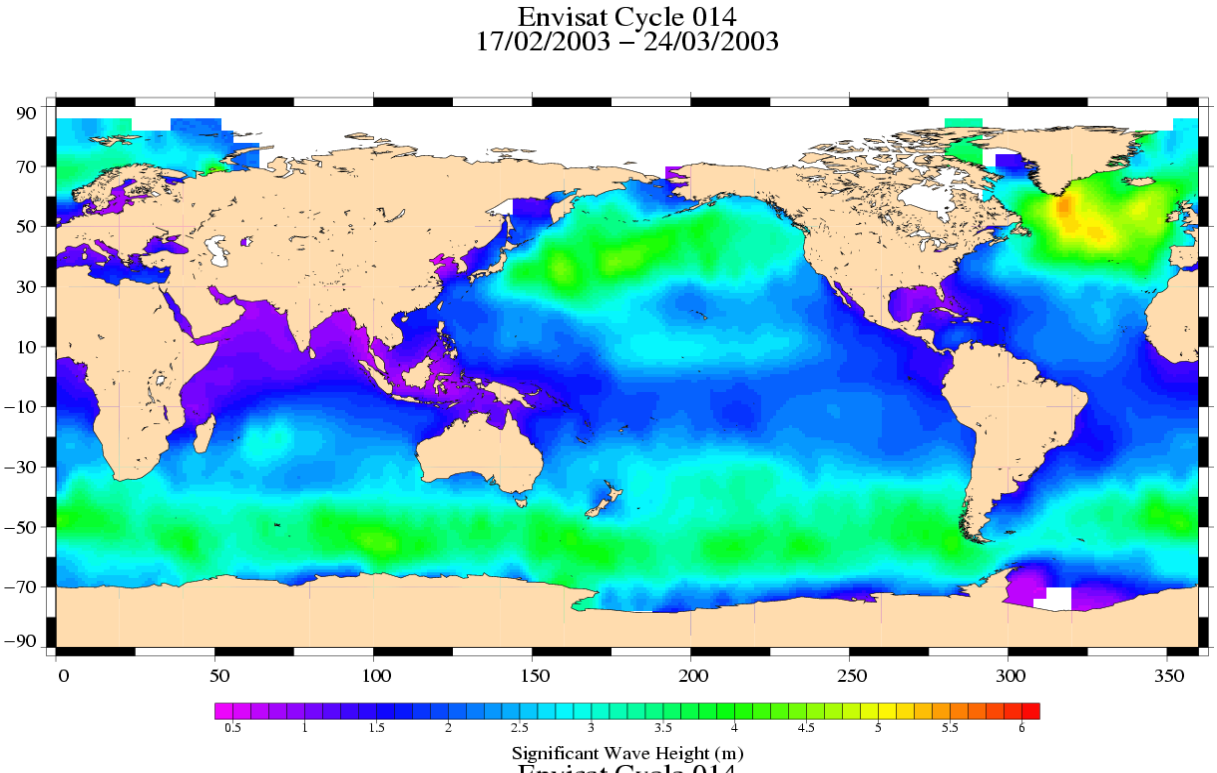
In order to assess and to monitor radiometer measurements, a scatter plot between the radiometer wet troposphere correction and the ECMWF model is computed for the valid data set previously defined.

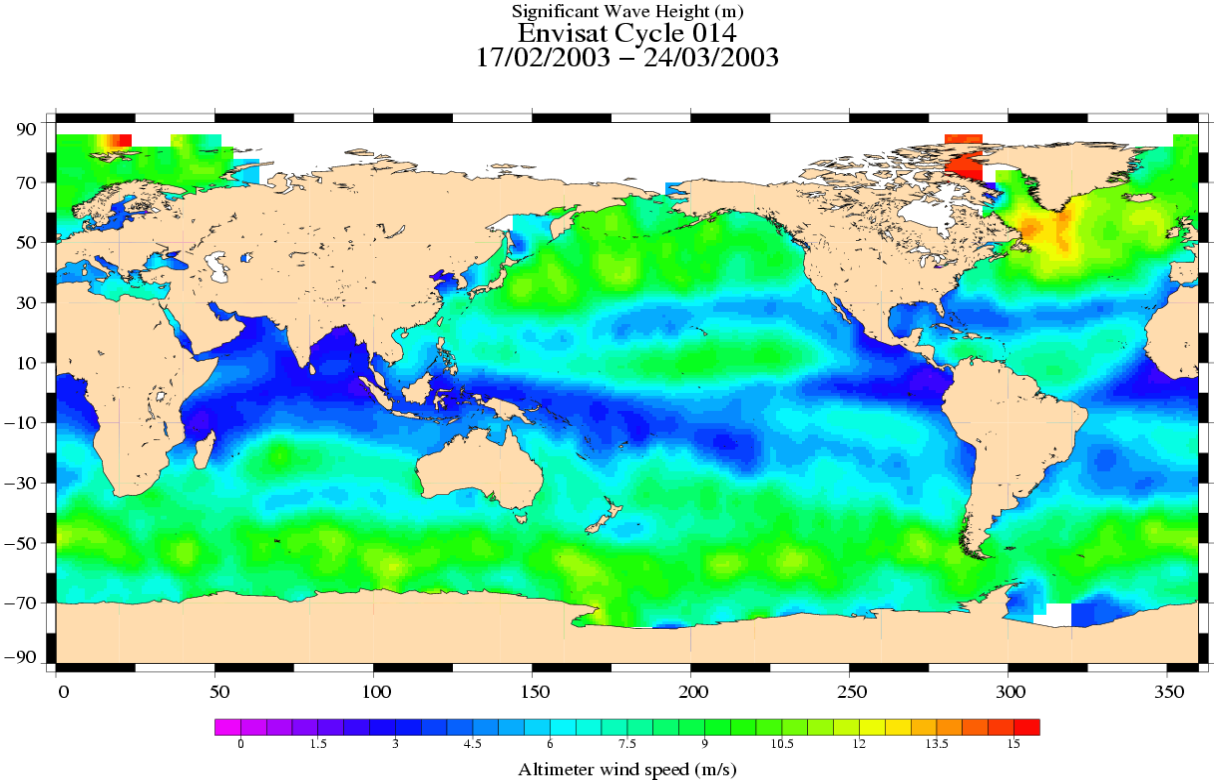


The radiometer-model mean difference is 0.4 cm. A drift on the Envisat 23.8GHz brightness temperature has been detected and has to be monitored on the long term. Note that the neural algorithm is now implemented on Envisat.

3.6 Wind and wave maps

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





3.7 Crossover statistics

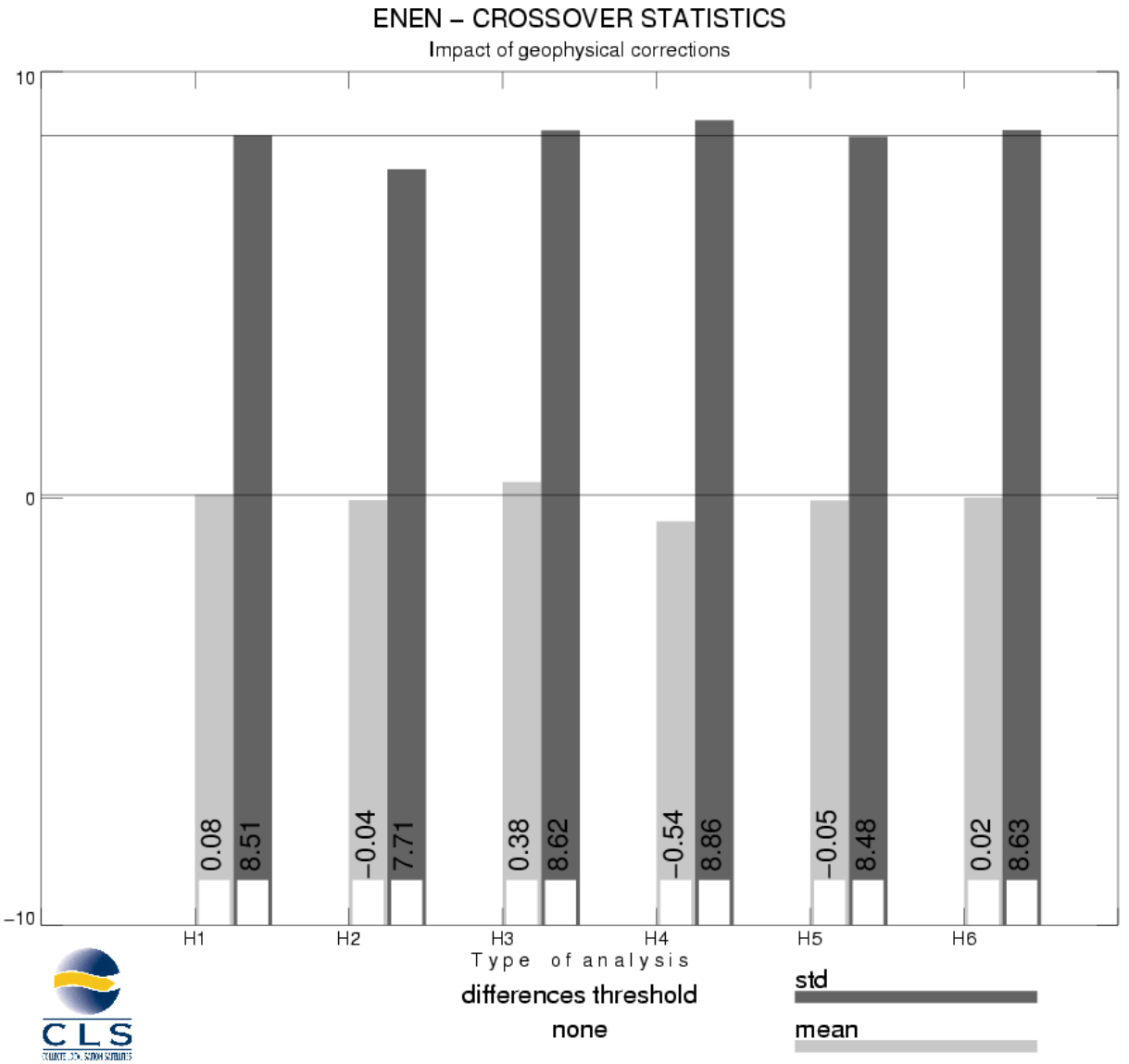
3.7.1 General comment

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 8.51 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 7.62 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)

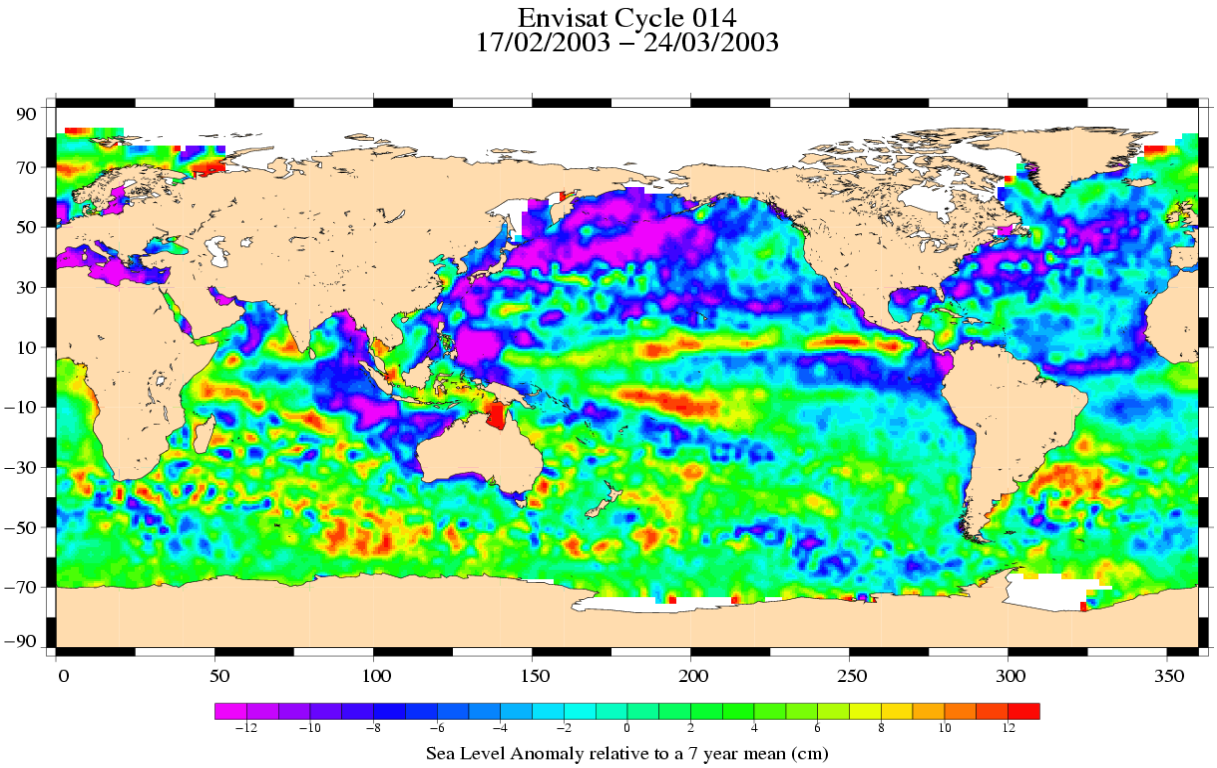
H5 = SSH with FES02 tide model (in product)

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.



3.8.2 Comparison to a precise Mean Sea Surface

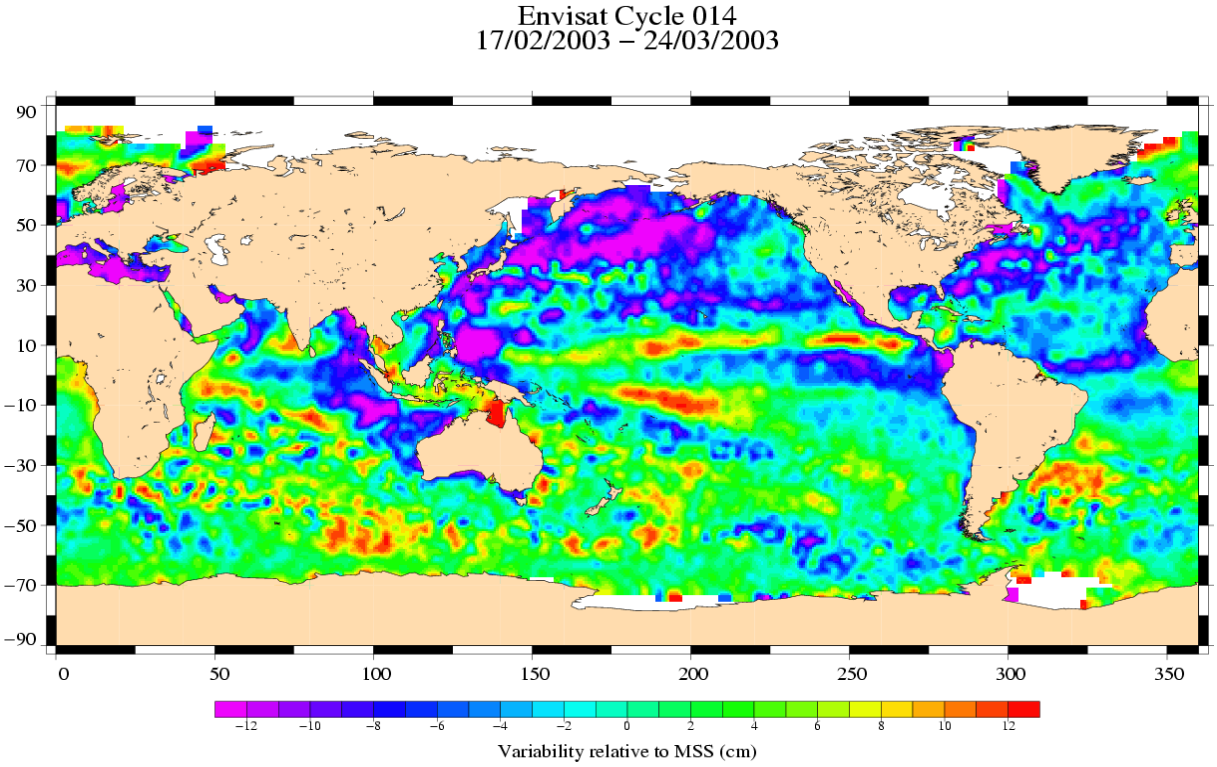
The MSS from the product is used as a reference to compute SLA. Global statistics of Envisat SSH-MSS are (cm):

Number	Mean	Std. dev.
1114770	44.02	10.80

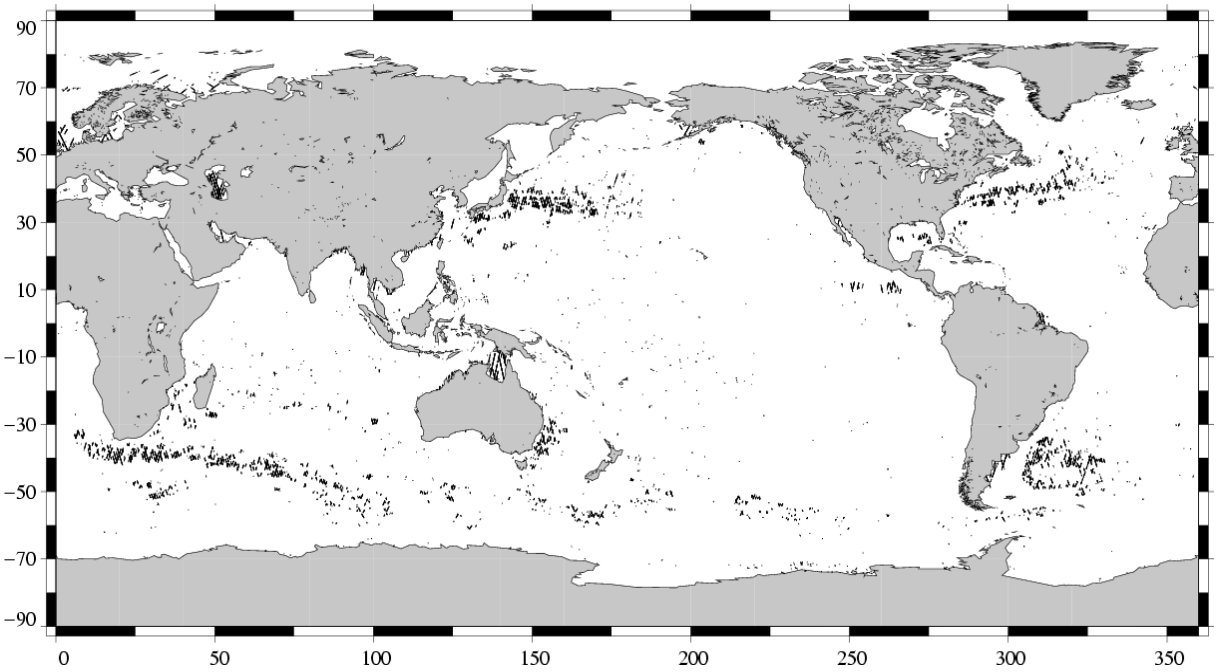
When using a selection to remove shallow waters (1000 m), areas of high ocean variability and high latitudes ($> |50|$ deg) statistics are:

Number	Mean	Std. dev.
683104	43.74	9.71

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 014



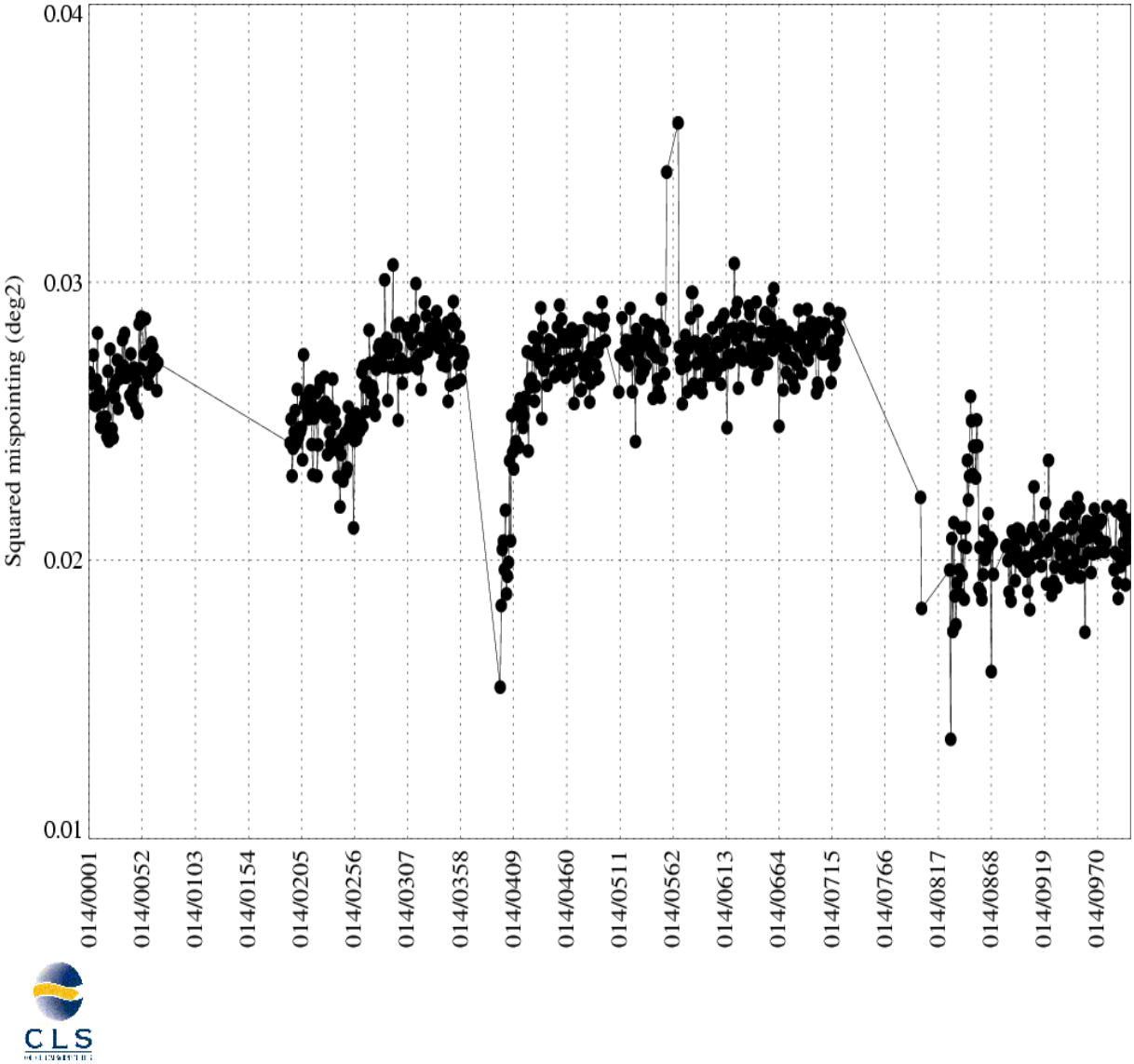
4 Particular investigations

4.1 No CTI tables uploaded on-board between pass 799 and 1002

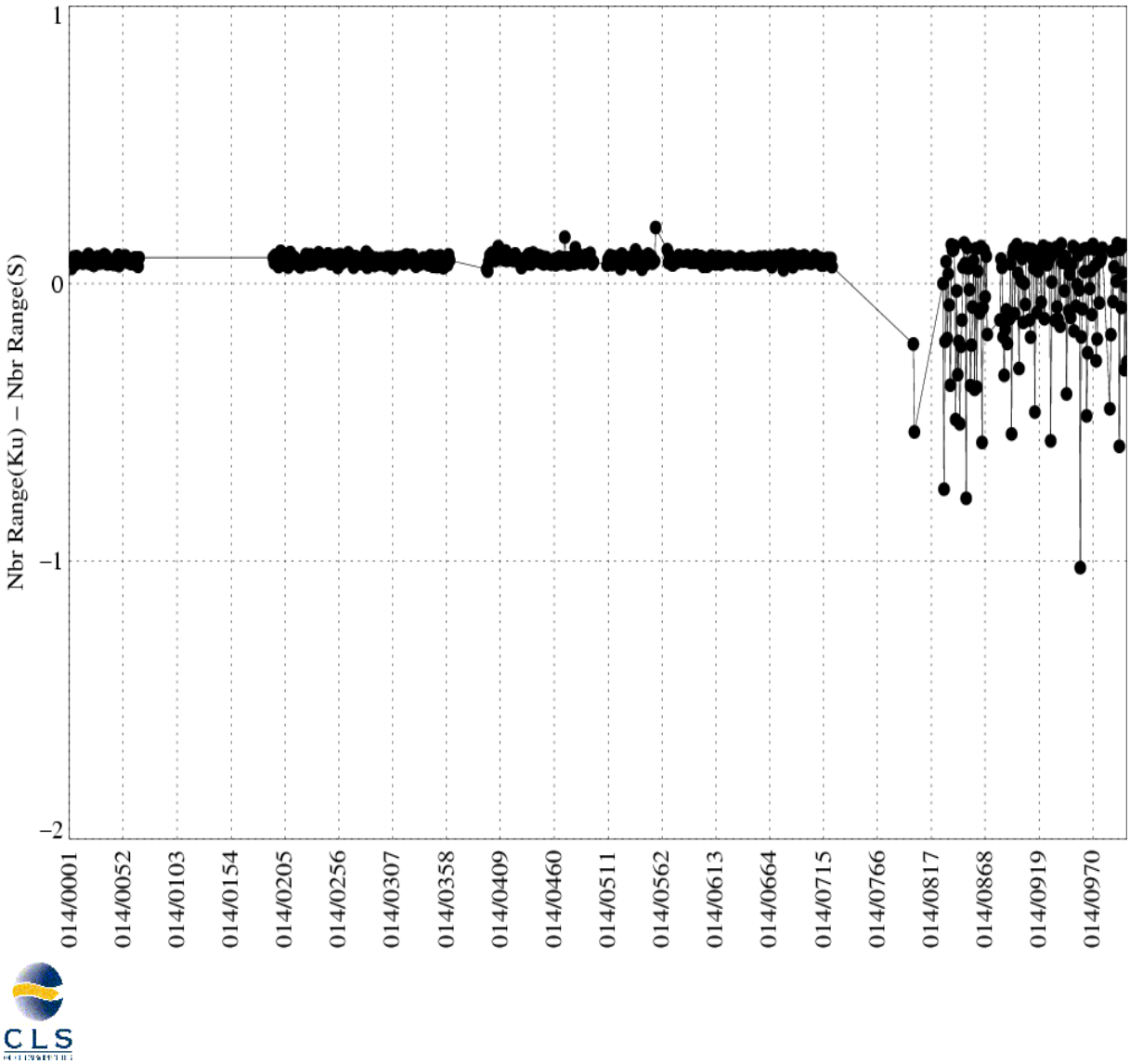
After the recovery of the RA2 unavailability (Subsystems unavailable - Autonmous P/L switch-off) on 2003/03/17 19:00:13, no CTI tables were uploaded on-board. This problem has been cured on 2003-04-09 17:12:24. Consequently, users are advised to use pass 799 to 1002 with care:

- It is not recommended to use any other data than ocean and flat surfaces
- Tracking data over ocean and flat surfaces can be used, given some considerations, e.g.:
Delta_off (10 instead of -18): makes a shorter trailing edge
P_ref (3.5 times bigger): specular waveforms saturate the receiver

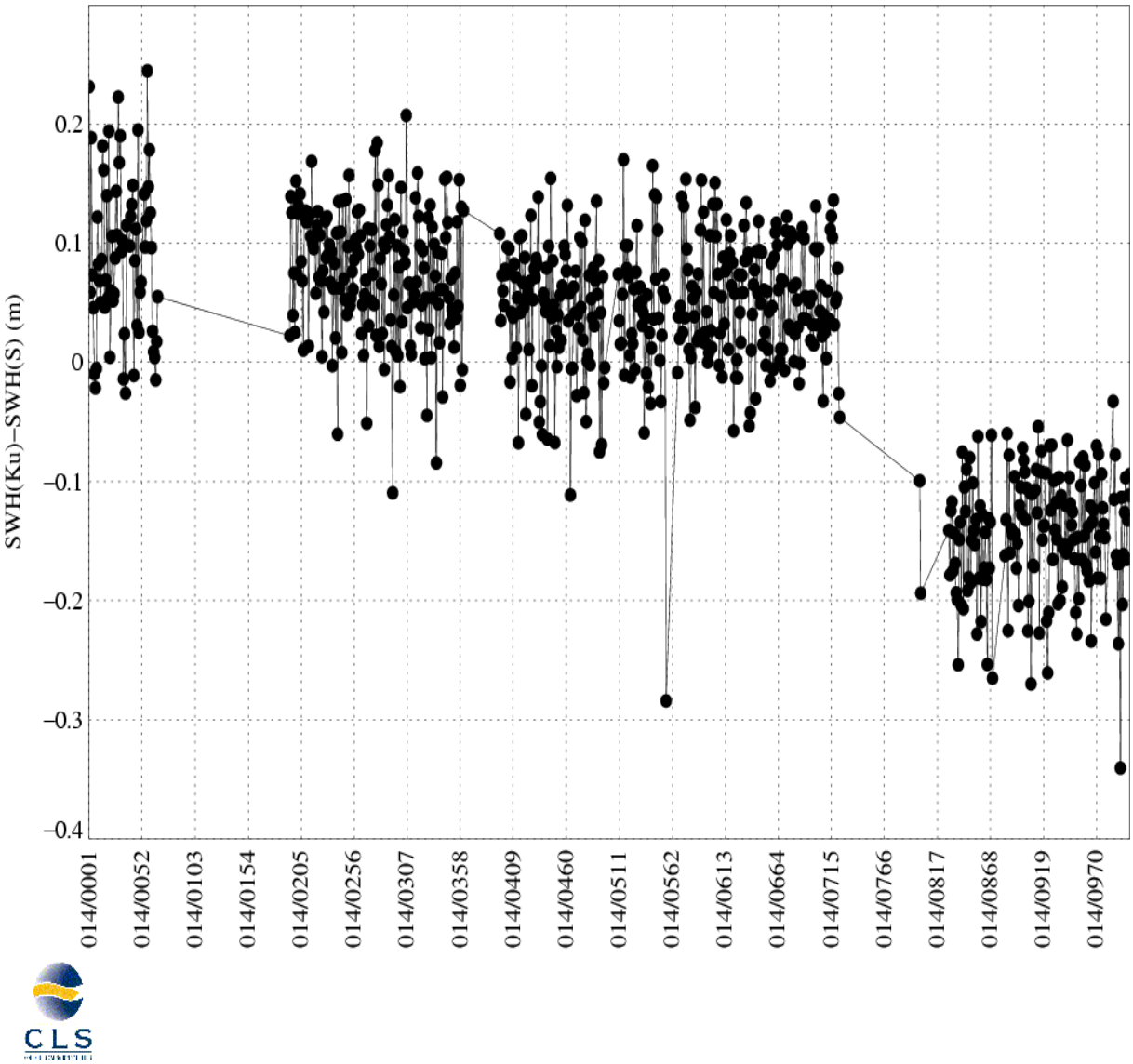
The altimetric parameters are strongly impacted:
- The Off Nadir Angle drops by about 0.01 deg2



- The Number of elementary measurements drops by 0 to 3 %



- The SWH(Ku)-SWH(S) difference drops by about 20cm



- The impact on the range should be several mm, but it can hardly be determined accurately because of the oceanic variability.

5 Cross Calibration with ERS-2

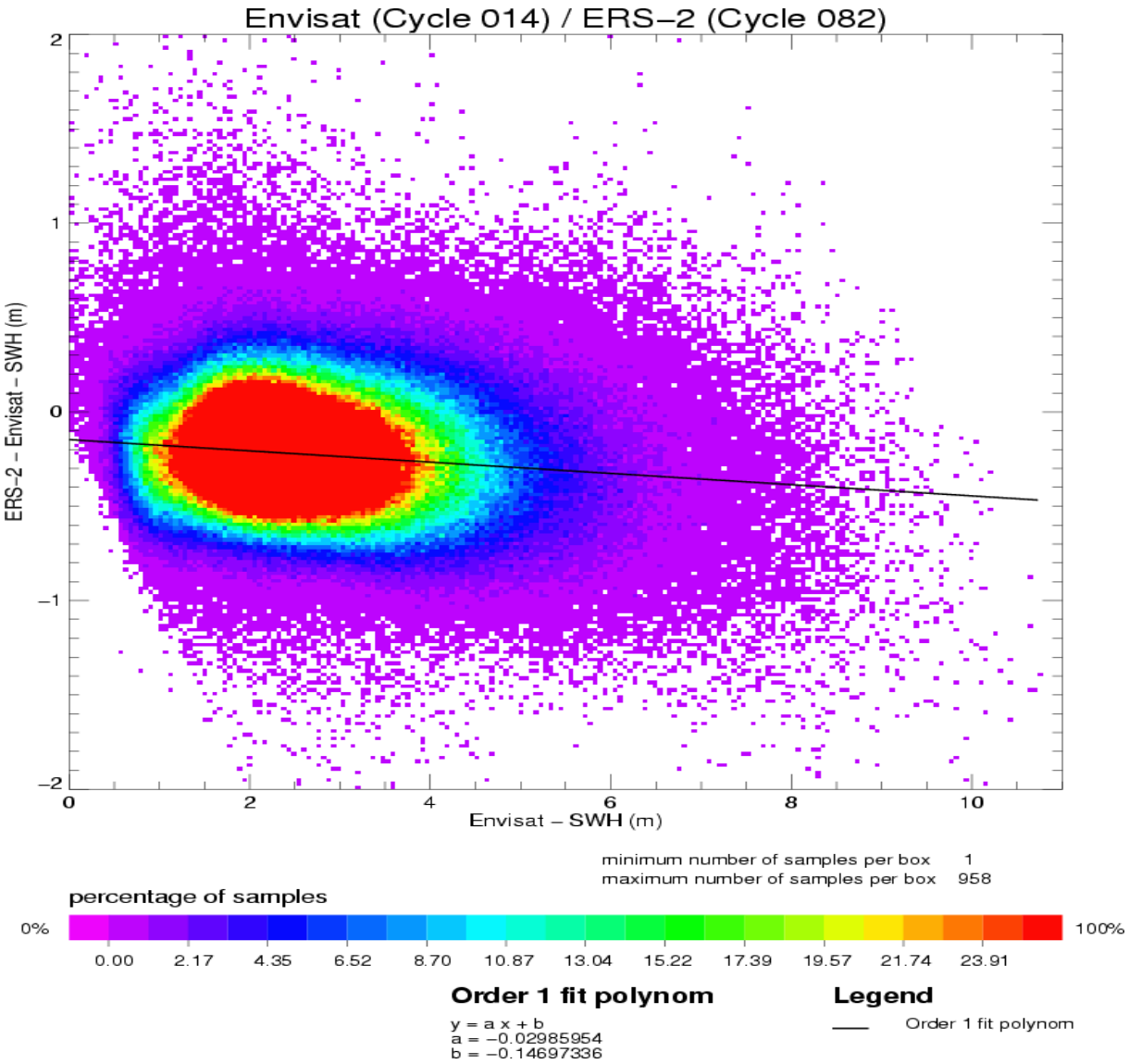
Envisat flies on the same ground track as ERS-2, 30 minutes ahead. This section presents results that illustrate the difference with ERS-2.
Envisat cycle 014 data are collocated to data from ERS-2 GDR cycle 081 in order to compare the main parameters from repeat-track analysis.

5.1 [ERS-2 - Envisat] Ku SWH differences

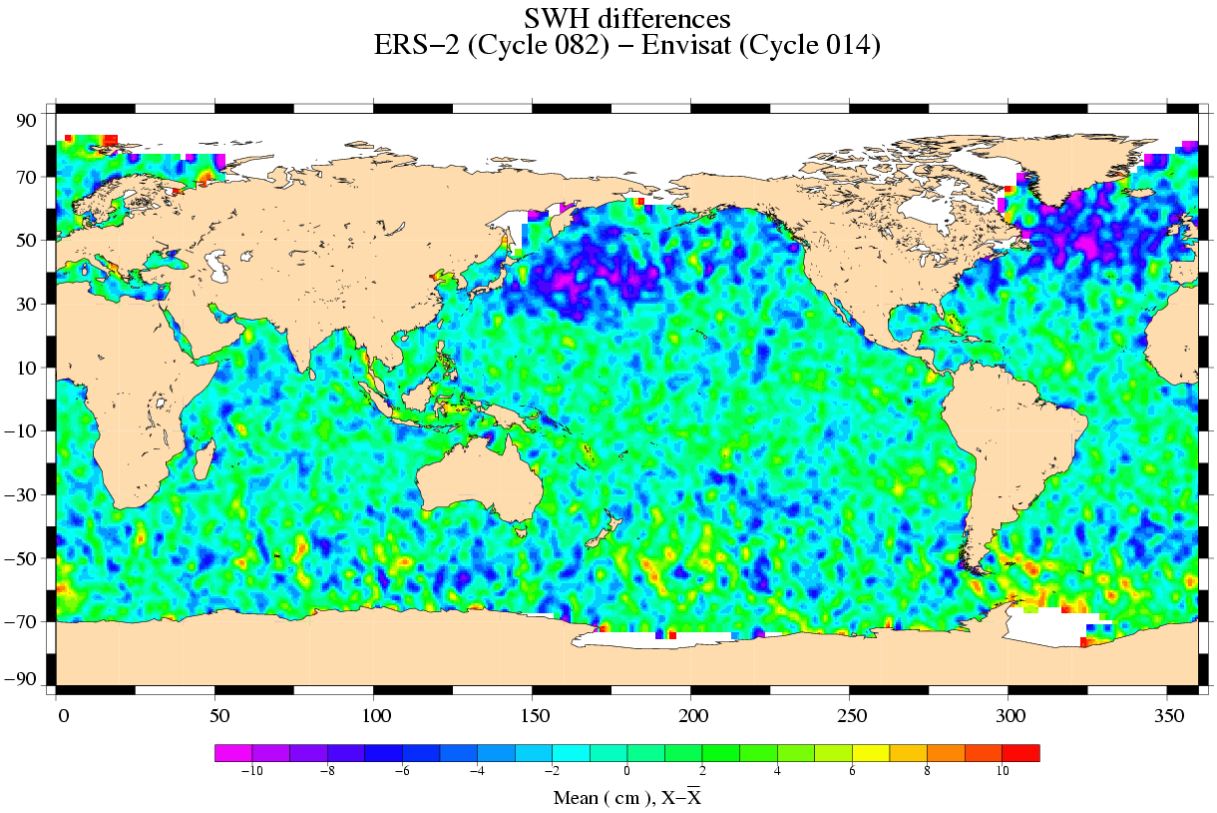
Global statistics of [ERS-2 - Envisat] Ku SWH differences are (cm):

Number	Mean	Std. dev.
1069568	-21.78	27.45

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



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



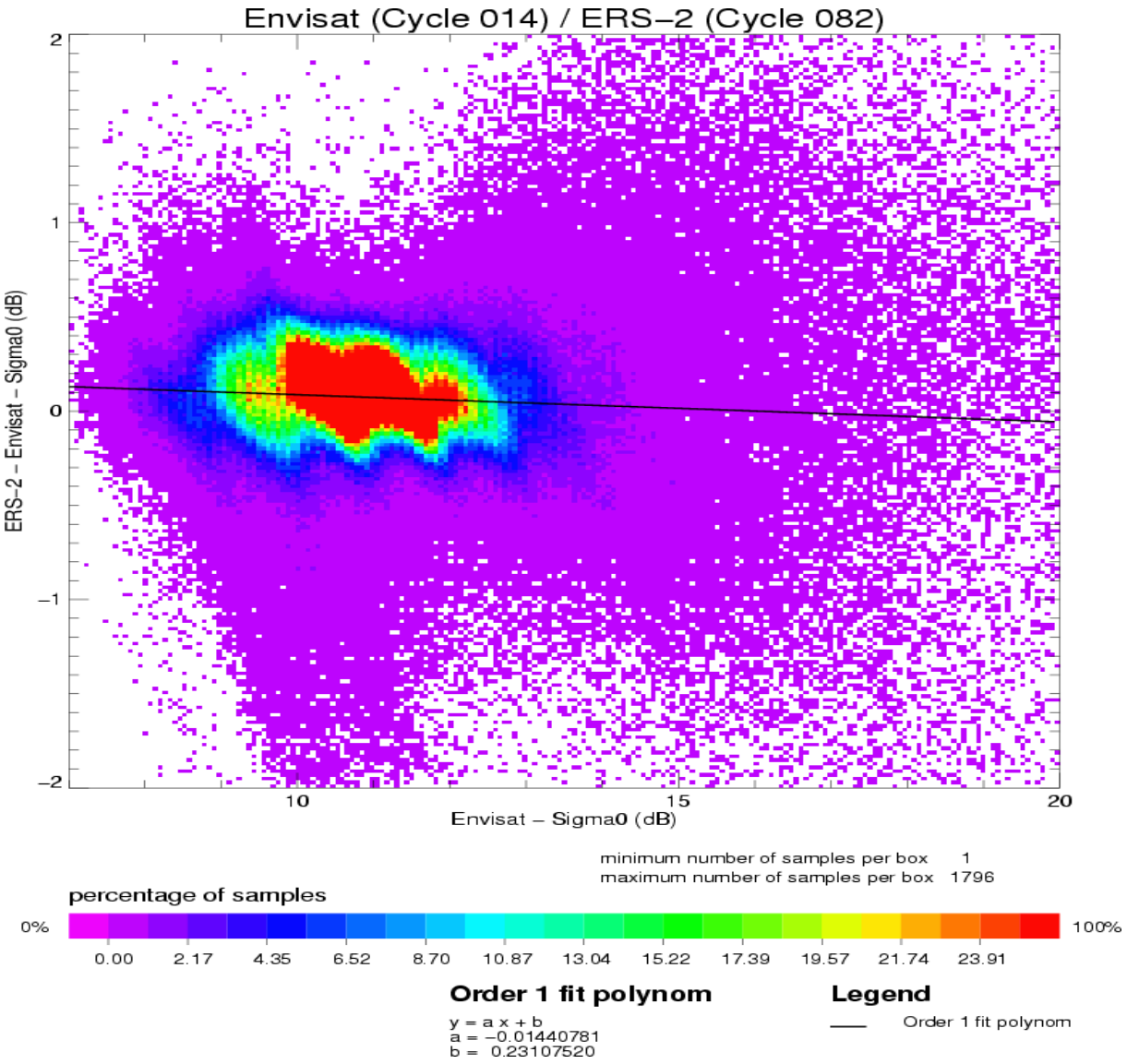
High SWH areas appear due to greater differences for high SWH values.

5.2 [ERS-2 - Envisat] Ku Sigma0 differences

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

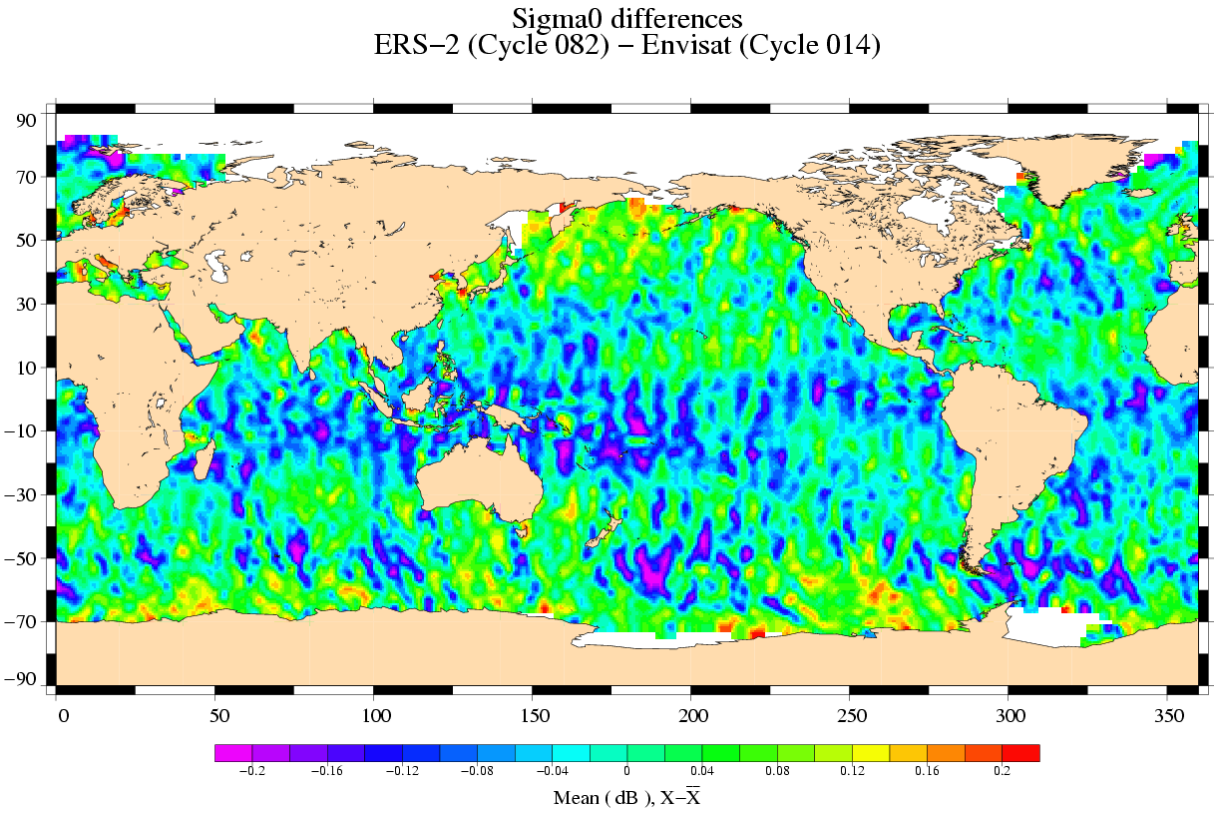
Number	Mean	Std. dev.
1069568	0.08	0.32

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).



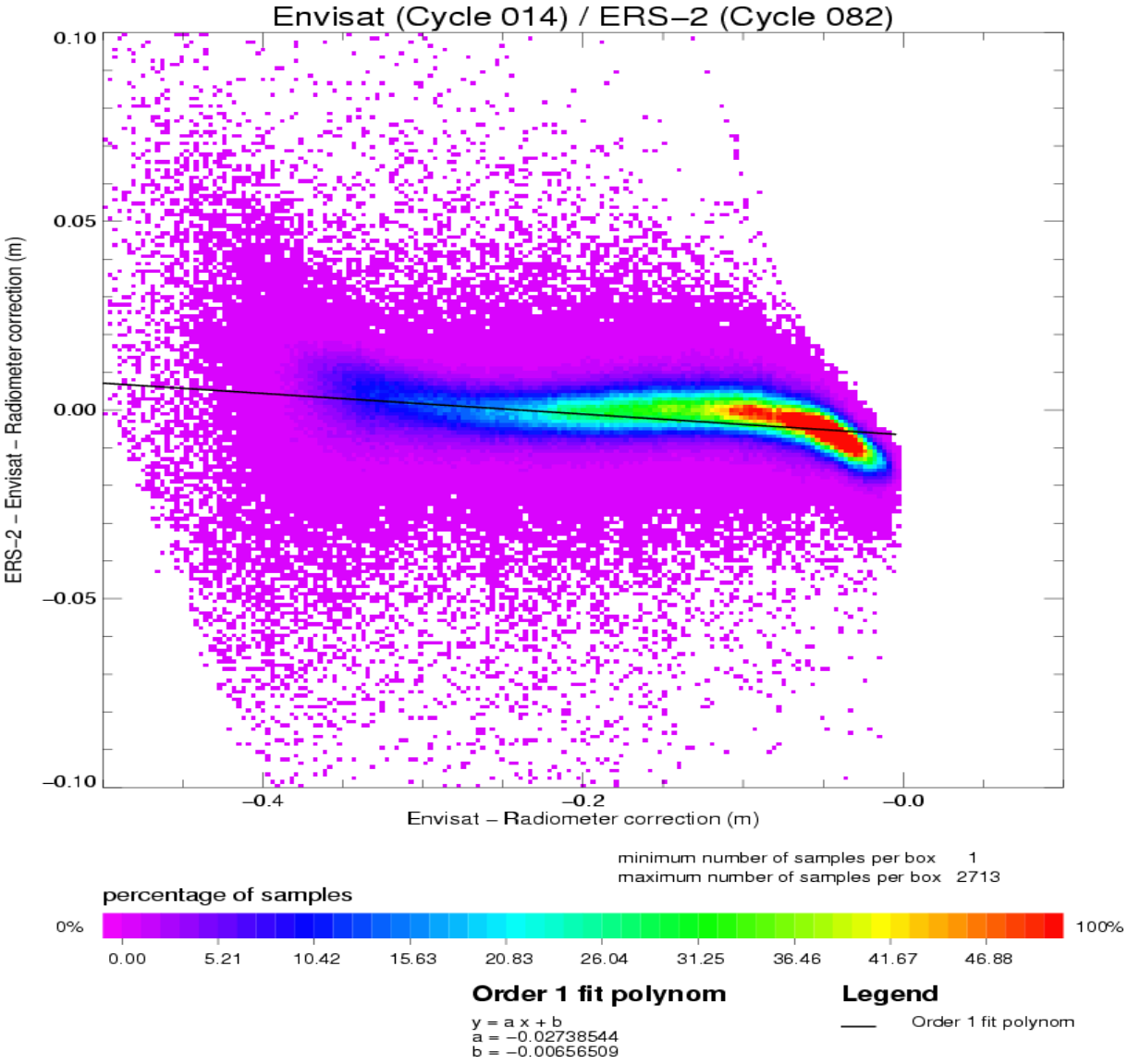
Wet areas appear because the ERS-2 atmospheric attenuation on Sigma0 is uncomplete (it only contains cloud liquid water path attenuation), contrary to Envisat one.

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

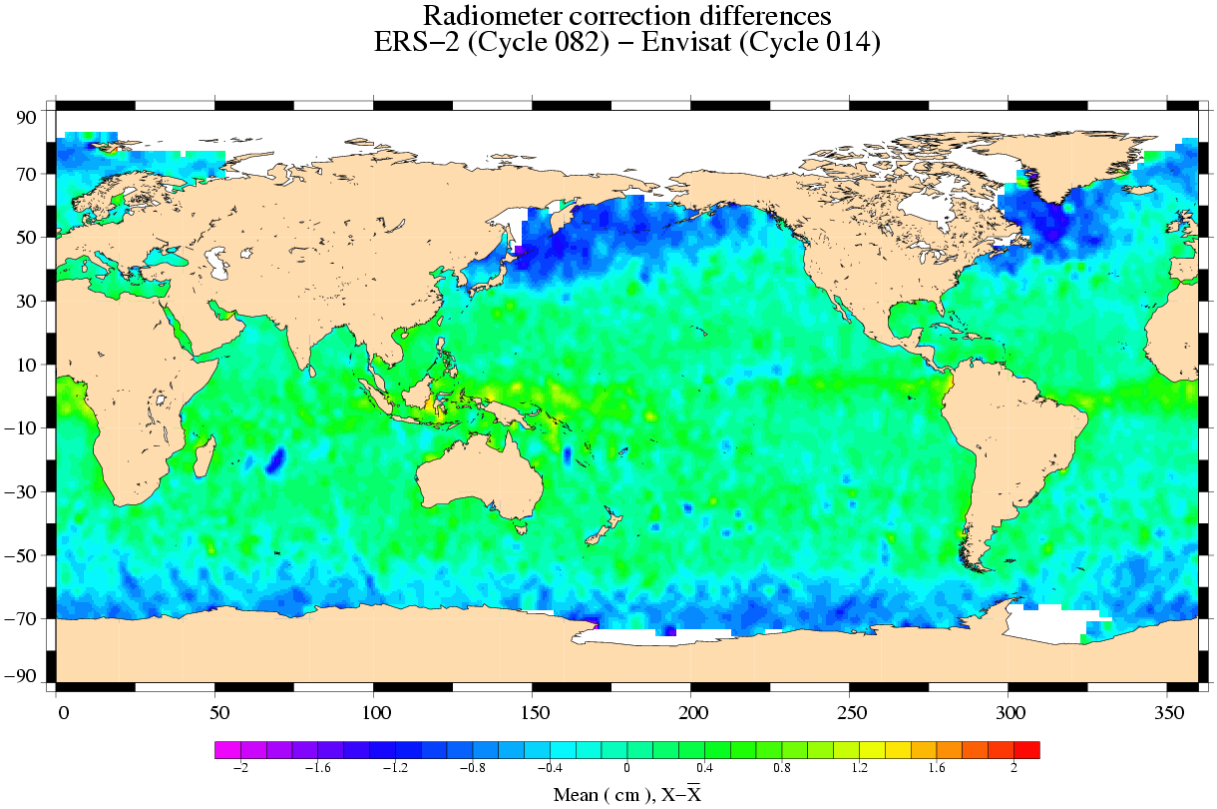
The ERS-2 radiometer correction is recomputed to correct the gain drop and the drift of the 24 GHz brightness temperature (Obligis et al., 2003).
Global statistics of [ERS-2 - Envisat] radiometer wet troposphere correction differences are (cm):

Number	Mean	Std. dev.
1069568	-0.19	0.83

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).



The two MWR corrections are consistent except in dry areas where ERS-2 under-estimates this correction.

5.4 [ERS-2 - Envisat] SSH differences

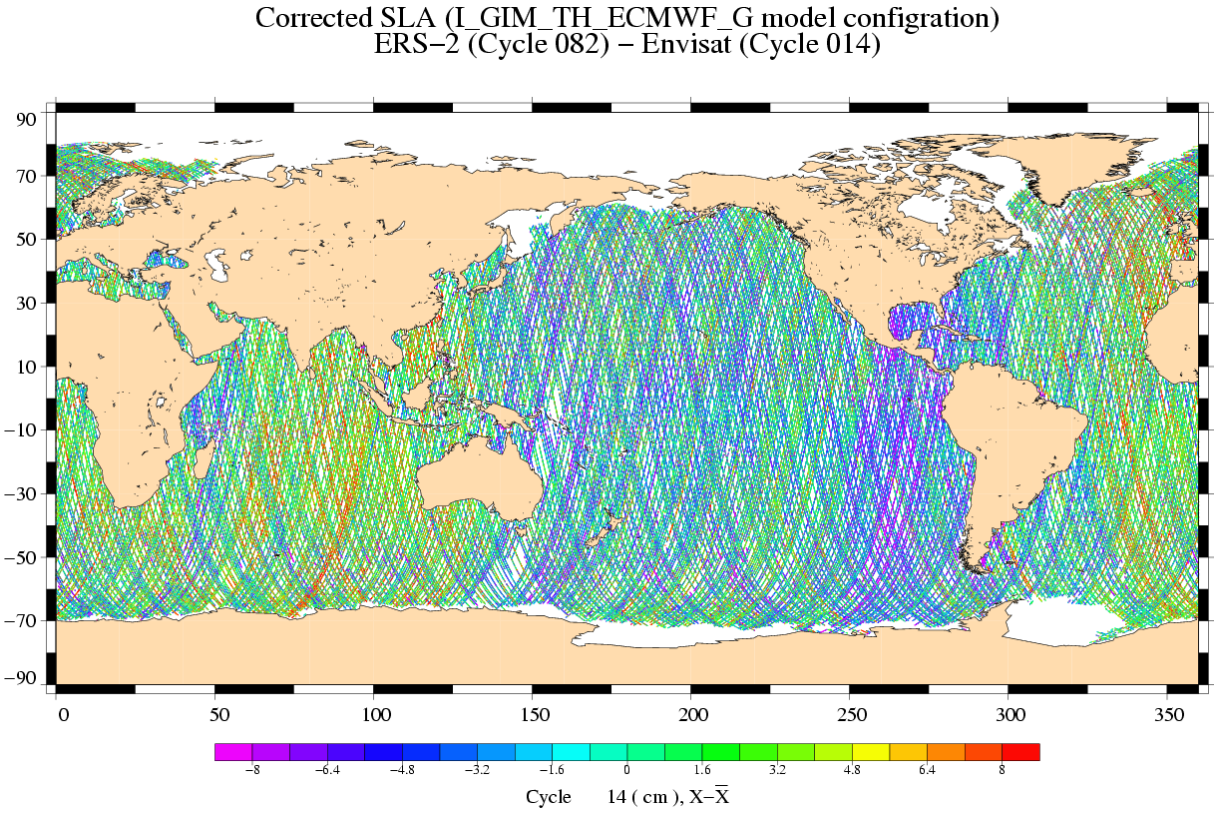
In order to compare the ERS-2 SSH with the Envisat SSH, ERS-2 GDRs have been updated with algorithms and corrections similar to Envisat:
- Range corrected from SPTR, USO, time tag bias
- DGME04 orbit
- ECMWF wet tropospheric correction
- Model dry tropospheric correction
- 3-parameters sea state bias
- Inverted barometer correction with time varying pressure
- Total geocentric GOT00 ocean tide height
- Geocentric pole tide height
- Solid earth tide height
- GIM ionospheric correction

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.
1069568	-35.18	5.14

These SSH differences are plotted on the following figure.



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