Envisat GDR
Quality Assessment Report

Cycle 016

28-04-2003 02-06-2003

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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
Cross Calibration with ERS-2

2 Cycle overview

2.1 Data and software version

This cycle has been produced with the IPF processing chain V4.54 and the CMA Reference Software V6.1_01.

The following algorithms have been implemented in this version:
- Neural MWR algorithm
- CLS01.1 Mean Sea Surface
- GOT2000 and FES2002 tide models
- Non parametric Sea State Bias
- DORIS ionospheric correction

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

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

57 passes have no radiometer correction (see **section 3.2**).

Pass 610, 611 and a portion of pass 388 have high SSH-MSS values (see **section 3.2**).

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. 35 passes are impacted by the S-Band anomaly (see **section 3.2**).

2.4 Platform and instrument events

RA2 unavailability (known SEU failure) from 5 May 2003 12:30:17.000 to 6 May 2003 10:01:10.000.

RA-2 unavailability (ICU in SUSPEND due to TM FMT Error when a Reduced FMT was requested) from 11 May 2003 11:06:33.000 to 12 May 2003 10:14:35.726.

RA-2 unavailability (Switch-down for PMC SW upgrade and OCM) from 18 May 2003 06:25:17.000 to 19 May 2003 15:59:28.000.

MWR unavailability (Switch-down for PMC SW upgrade and OCM) from 18 May 2003 06:25:24.000 to 19 May 2003 14:45:40.000.

DORIS unavailability (Switch-down for PMC SW upgrade and OCM) from 18 May 2003 06:25:25.000 to 19 May 2003 13:21:28.000.

RA-2 unavailability (ICU went to RS/WT/INI) from 1 Jun 2003 14:36:40.000 to 2 Jun 2003 09:20:35.000.

Orbit Maintenance Maneuver (from 2003/05/20 04:11:53 to 2003/05/20 06:23:31 TAI).

Orbit Maintenance Maneuver (from 2003/05/14 22:40:13 to 2003/05/15 00:40:19 TAI).

2.5 Cycle quality and performances

Good general results are obtained for this cycle of data.
The crossover standard deviation is 7.94 cm rms when using a selection to remove shallow waters (1000 m) and a selection to remove 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 9.7 cm.

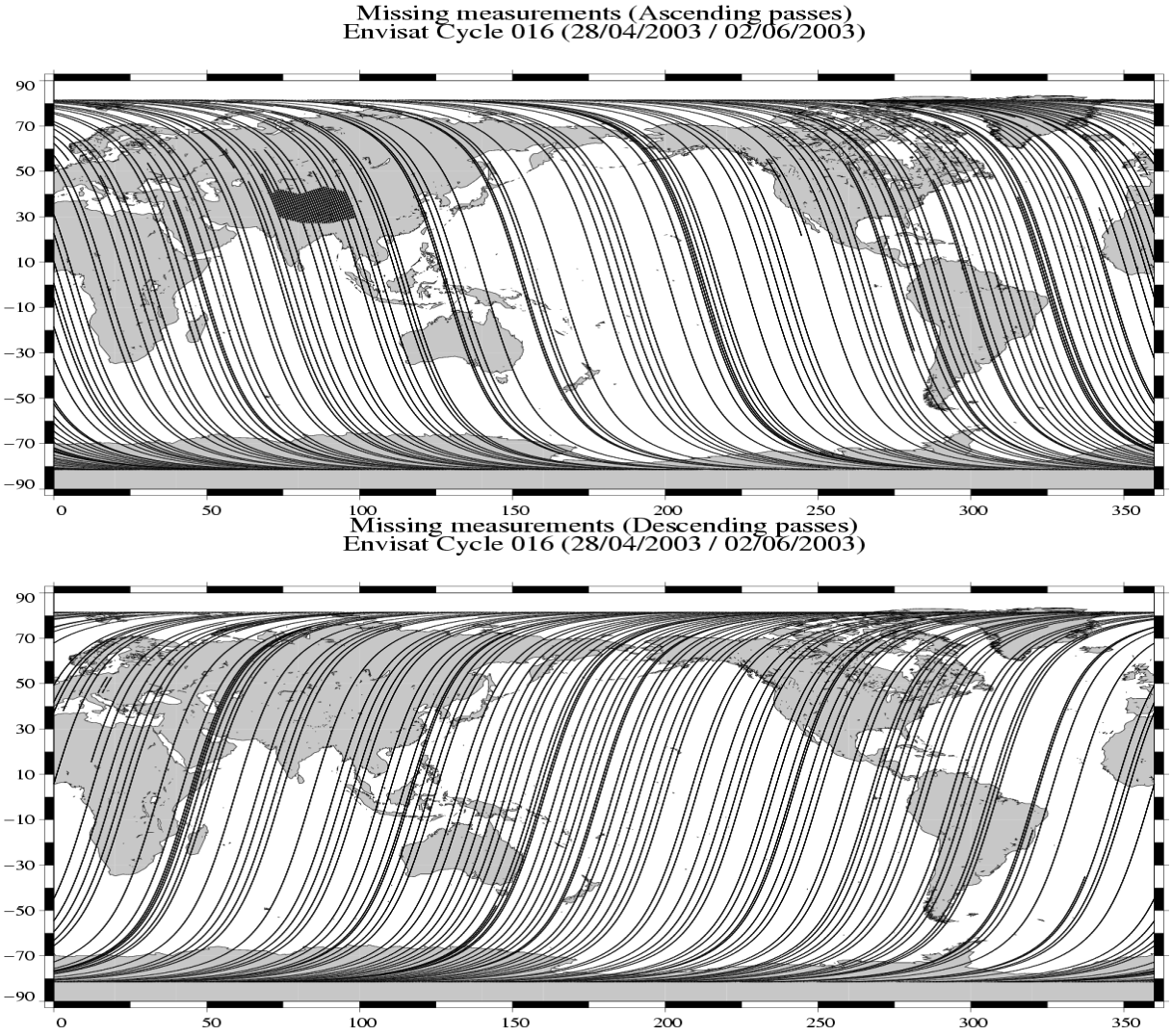
Detailed CALVAL results are presented in **section 3**.

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

2171824 are present, and 543009 (20.0%) are missing. The maps below illustrate missing 1Hz measurements in the GDRs, with respect to a 1 Hz sampling of a nominal repeat track.



171 passes are missing all due to level1 B data unavailability:
- Passes 191 to 215 are missing due to RA-2 unavailability (known SEU failure)
- Passes 361 to 387 are missing due to RA-2 unavailability (ICU in SUSPEND due to TM FMT Error when a Reduced FMT was requested)
- Passes 548 to 602 are missing due to RA-2 unavailability (Switch-down for PMC SW upgrade and OCM)
- Passes 967 to 987 are missing due to RA-2 unavailability (ICU went to RS/WT/INI)

3.2 Edited measurements

3.2.1 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	859543	45.70
Ice flag	625728	33.27
S-Band anomaly flag	353031	18.77

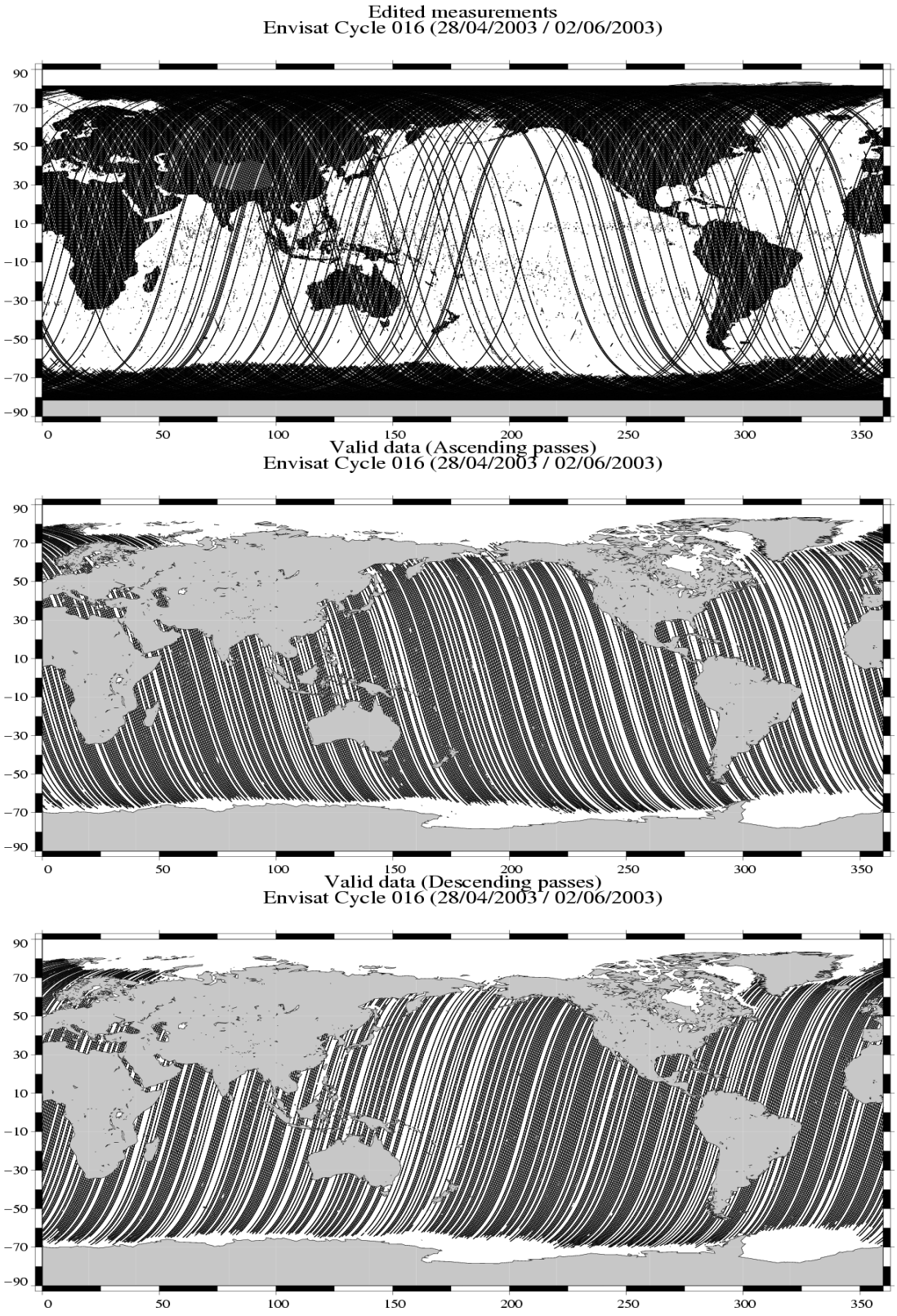
Then, measurements are edited using thresholds on several parameters. These thresholds are expected to remain constant throughout the Envisat mission, so that monitoring the number of edited measurements allows a survey of data quality.
The next table gives for each tested parameter, minimum and maximum 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	622	0.06
Variability relative to MSS (m)	-2.000	2.000	5365	0.54
Number of 18Hz valid points	10.000	-	76	0.01
Std. deviation of 18Hz range (m)	0.000	0.250	10958	1.09
Off nadir angle from waveform (deg2)	-0.200	0.160	7608	0.76
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	1350	0.13
Dual Ionospheric correction (m)	-0.400	0.040	1161	0.12
Significant wave height (m)	0.000	11.000	1075	0.11
Sea state Bias (m)	-0.500	0.000	1728	0.17
Backscatter coefficient (dB)	7.000	30.000	1554	0.15
GOT00 ocean tide height (m)	-5.000	5.000	834	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 350 (0.03 %) measurements.

3.2.2 Figures

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



3.2.3 Comments

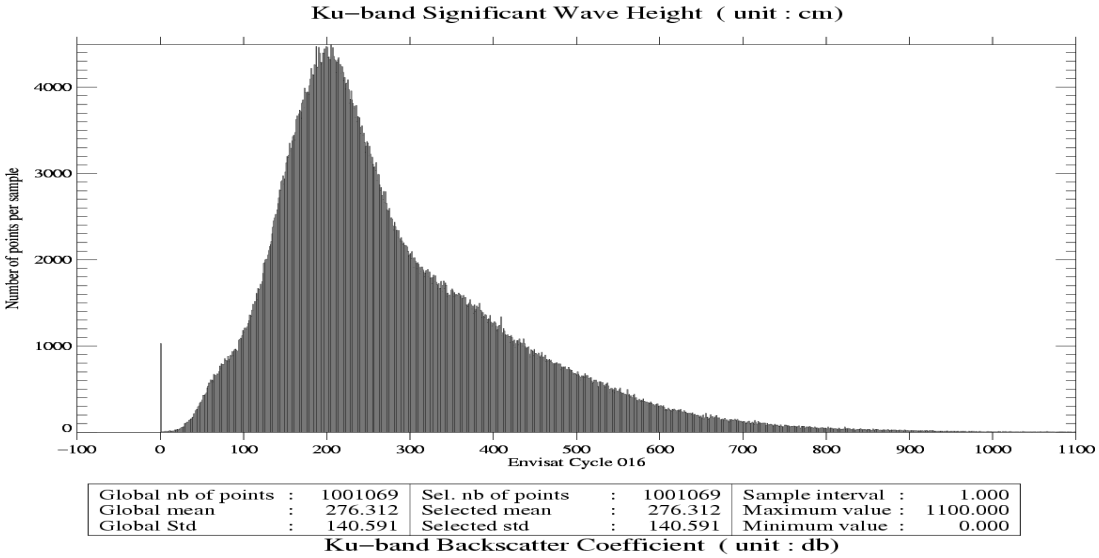
831 passes have been delivered. Among these passes:
- 57 passes are entirely edited on the radiometer land flag (no MWR correction)
- 35 passes (74 to 79, 141 to 145, 152 to 165, 186 to 190 , 965 to 966 and 991 to 993) are edited because of S-Band anomalies. Users are advised not to use the S-Band parameters and the dual ionospheric correction on these passes.

A special processing has been necessary to remove:
- a part of pass 388 between 35N and 40N. Note that the anomalous measurements occur juste after an RA-2 unavailability.
- Pass 610 and 611 are impacted by the 20th may 2003 maneuver
These passes have been identified as degraded measurements with high SSH-MSS values. Users are advised to remove these points from their data set.

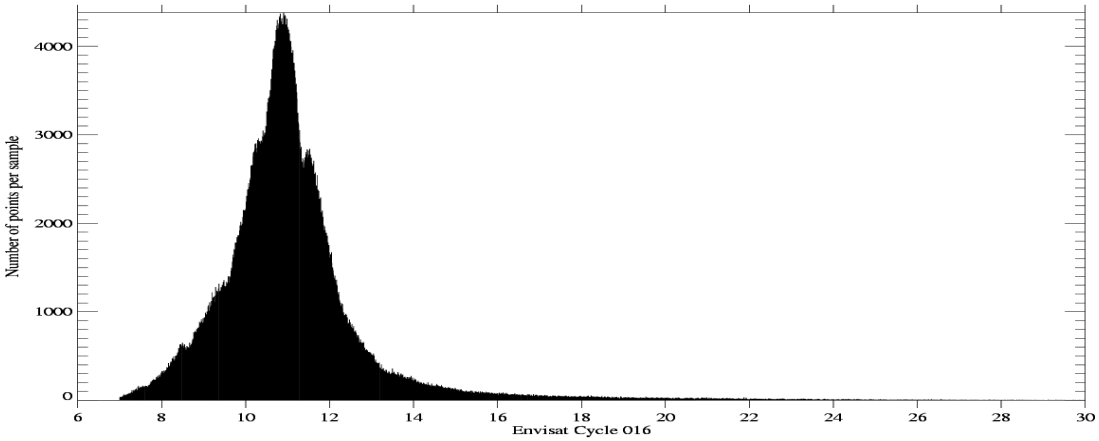
Wet areas appear in the plot of removed data. Similar features are observed with other altimetre (T/P, Jason) mainly due to rain comtamination.

3.3 Altimeter parameters

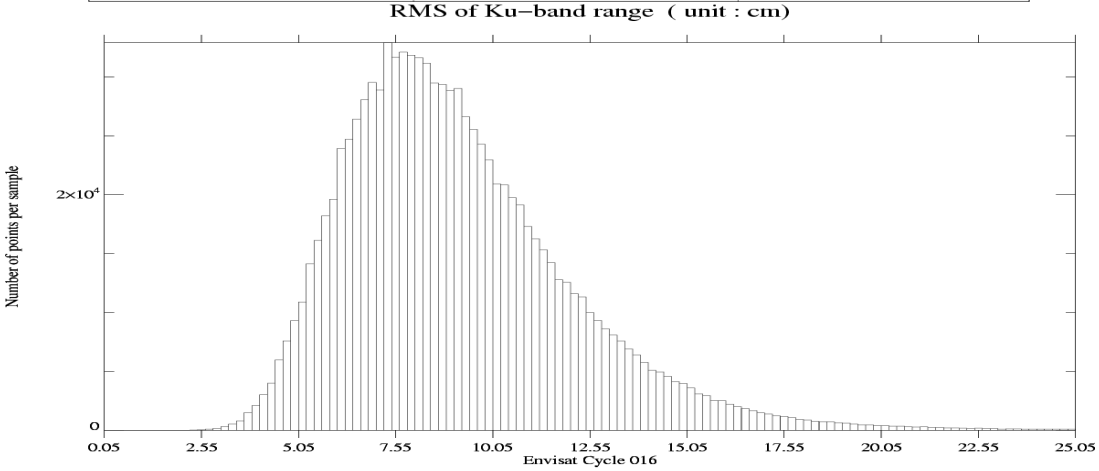
In order to assess and to monitor altimeter parameter measurements, histograms of Envisat Ku-band Significant Wave Height (SWH), Backscatter coefficient (Sigma0) and RMS of altimeter range are computed.



Global nb of points	:	1001069	Sel. nb of points	:	1001069	Sample interval	: 1.000
Global mean	:	276.312	Selected mean	:	276.312	Maximum value	: 1100.000
Global Std	:	140.591	Selected std	:	140.591	Minimum value	: 0.000



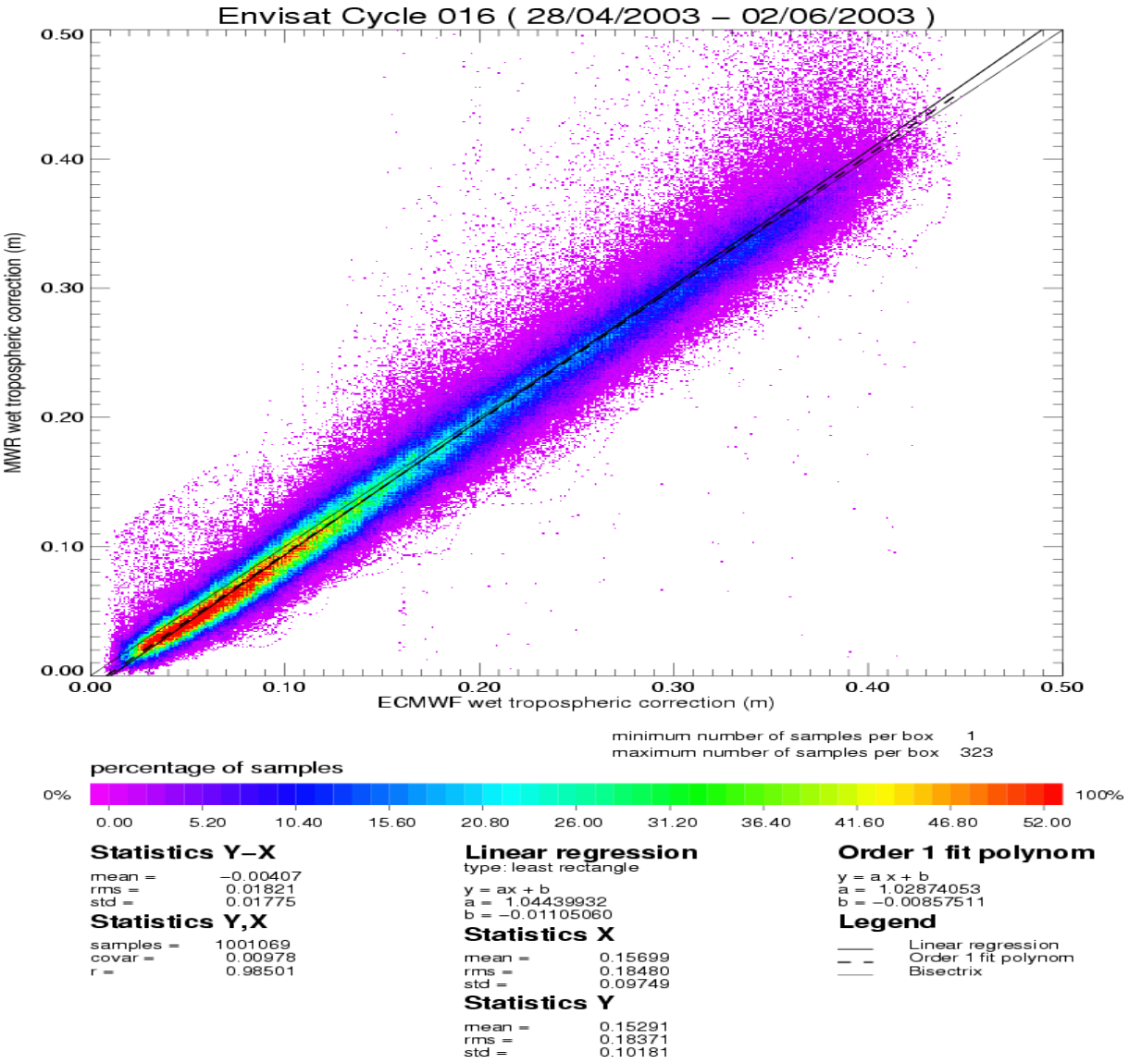
Global nb of points	:	1001069	Sel. nb of points	:	1001069	Sample interval	: 0.010
Global mean	:	11.069	Selected mean	:	11.069	Maximum value	: 30.000
Global Std	:	1.853	Selected std	:	1.853	Minimum value	: 7.000



Global nb of points	:	1001069	Sel. nb of points	:	1001069	Sample interval	: 0.200
Global mean	:	9.149	Selected mean	:	9.149	Maximum value	: 25.000
Global Std	:	2.915	Selected std	:	2.915	Minimum value	: 1.700

3.4 Radiometer

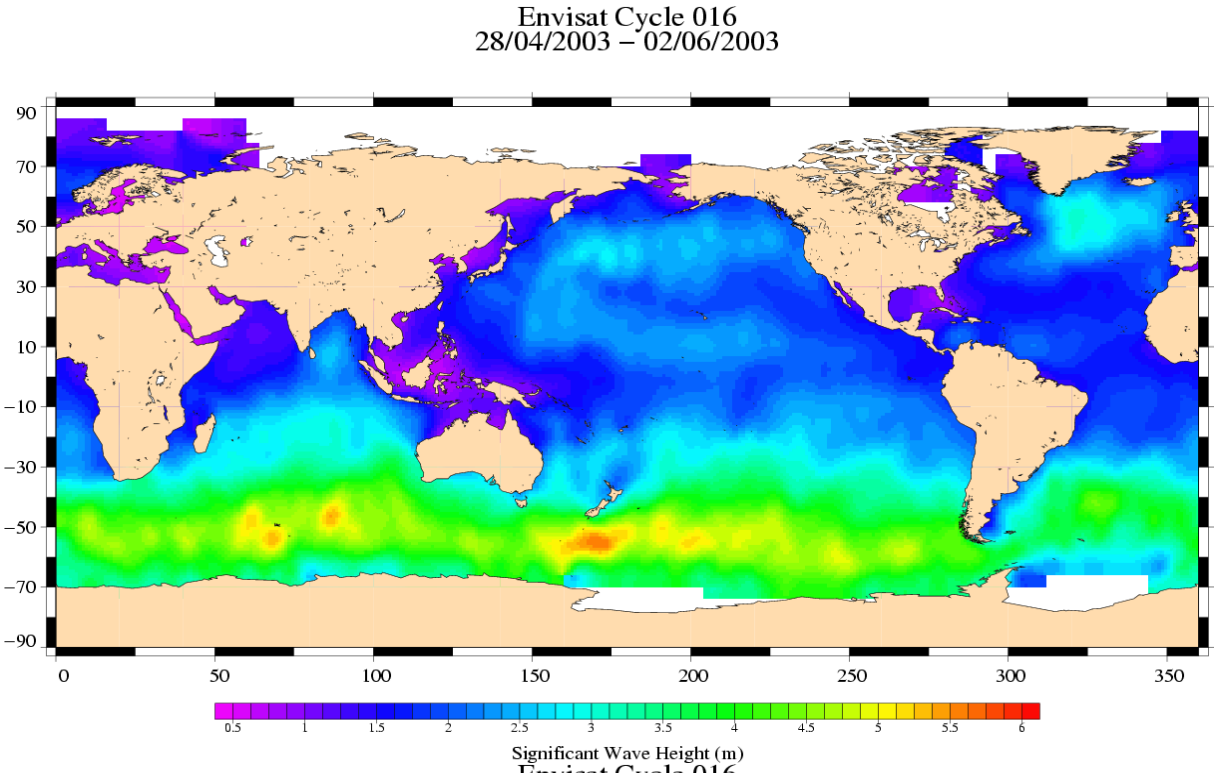
In order to assess and to monitor radiometer measurements, a scatter plot between the radiometer wet troposphere correction and the ECMWF model is computed for the valid data set previously defined.

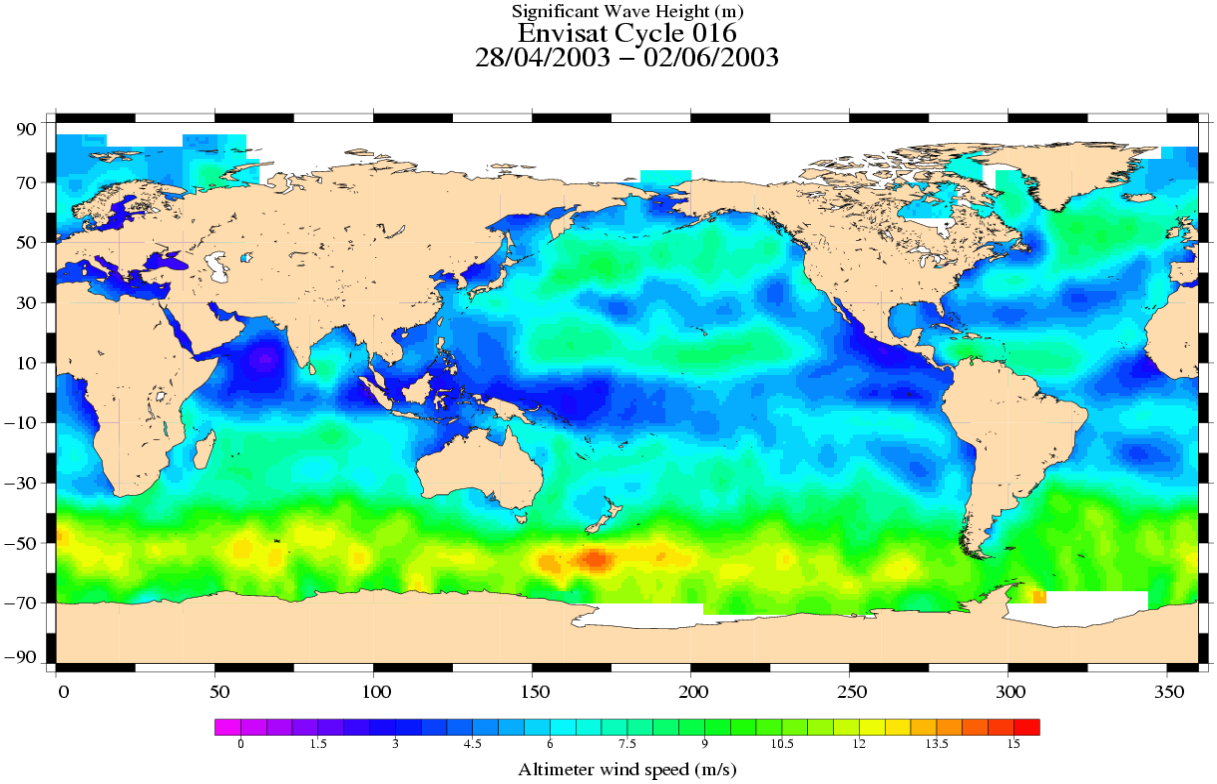


The radiometer-model mean difference is 0.4 cm. A drift on the Envisat 23.8GHz brightness temperature has been detected and has to be monitored on the long term. Note that the neural algorithm is now implemented on Envisat.

3.5 Wind and wave maps

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





3.6 Crossover statistics

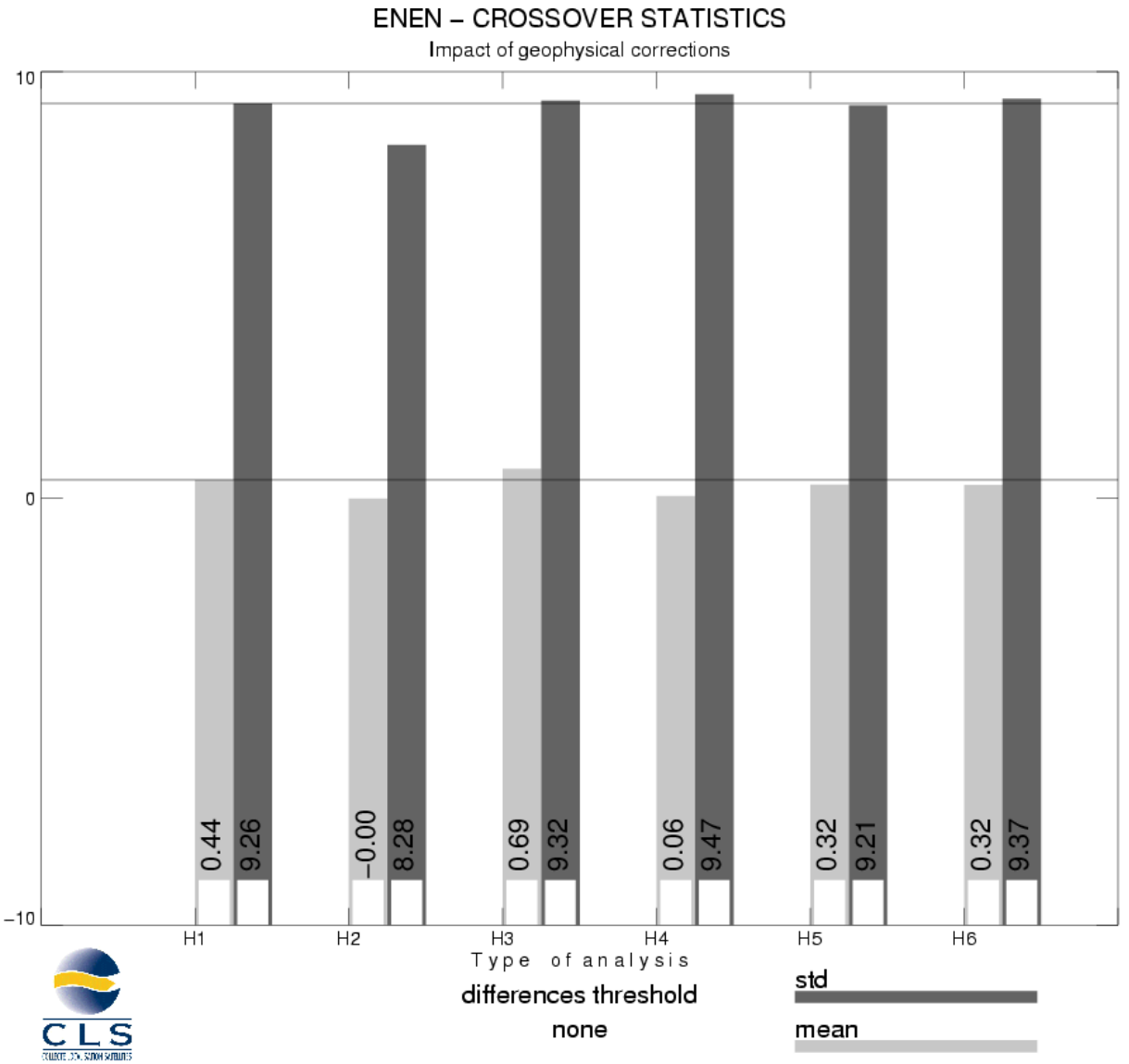
3.6.1 General comment

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 9.26 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 7.94 cm rms. This statistic is a stable estimation of the system performance as it is not influenced by sea ice coverage.

3.6.2 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).

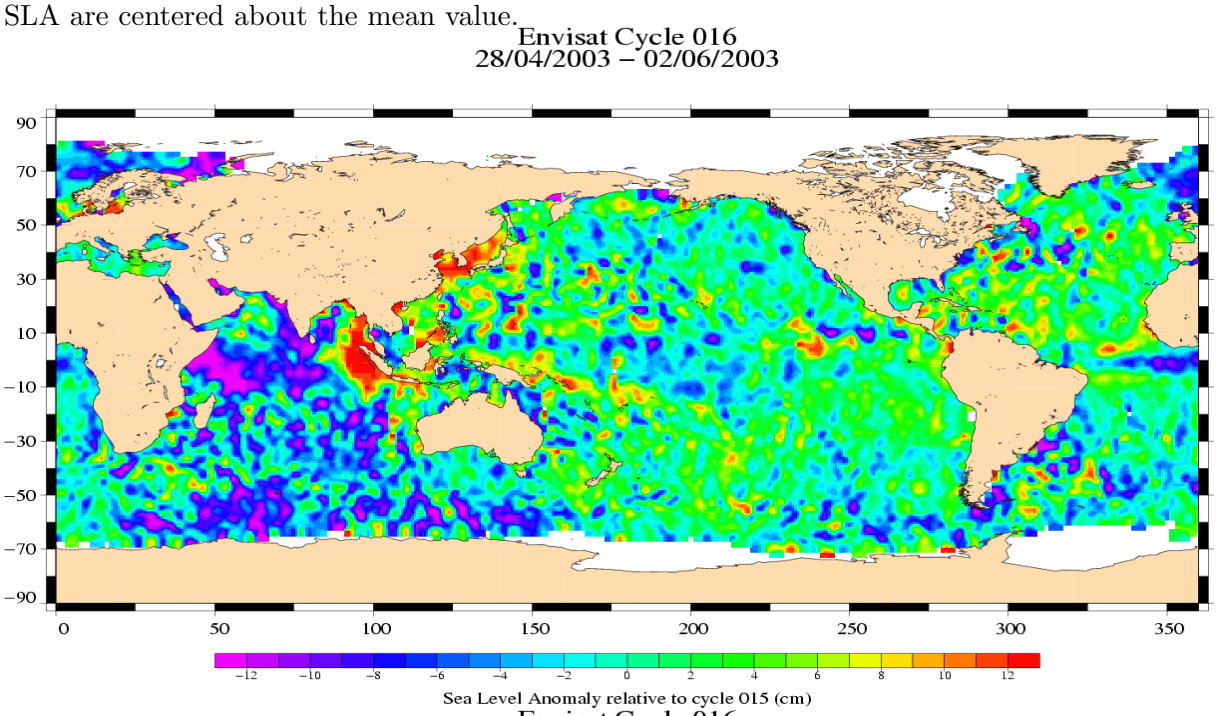
For this analysis two corrections have been computed: an orbit error and a model ionospheric correction. The orbit error estimation is performed by a global minimization of crossover differences using a (1 and 2 cycles/revolution) sinusoidal model. The model ionospheric correction is computed using the 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).

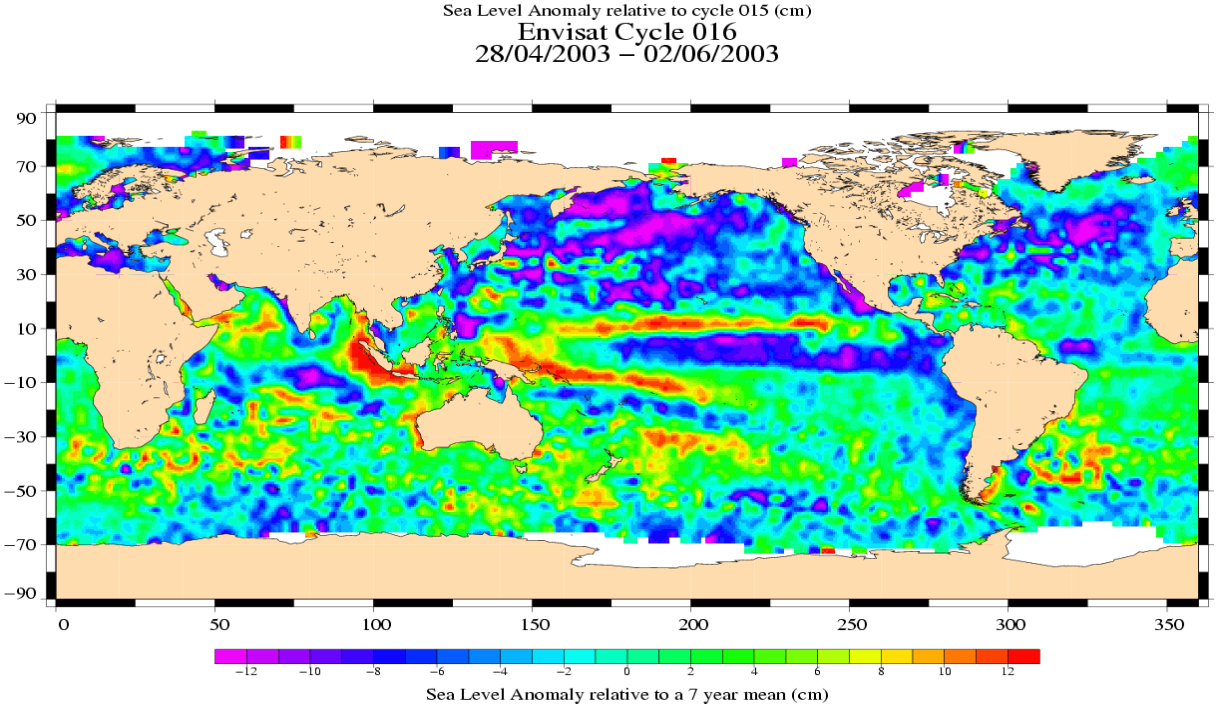

ENEN – CROSSOVER STATISTICS
Impact of geophysical corrections
10
0
−10
0.44
9.26
−0.00
8.28
0.69
9.32
0.06
9.47
0.32
9.21
0.32
9.37
H1
H2
H3
H4
H5
H6
Type of analysis
differences threshold
none
std
mean
H1 = SSH
H2 = SSH with orbit error (computed)
H3 = SSH with GIM ionospheric correction (computed)
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)

3.7 SSH variability

3.7.1 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.



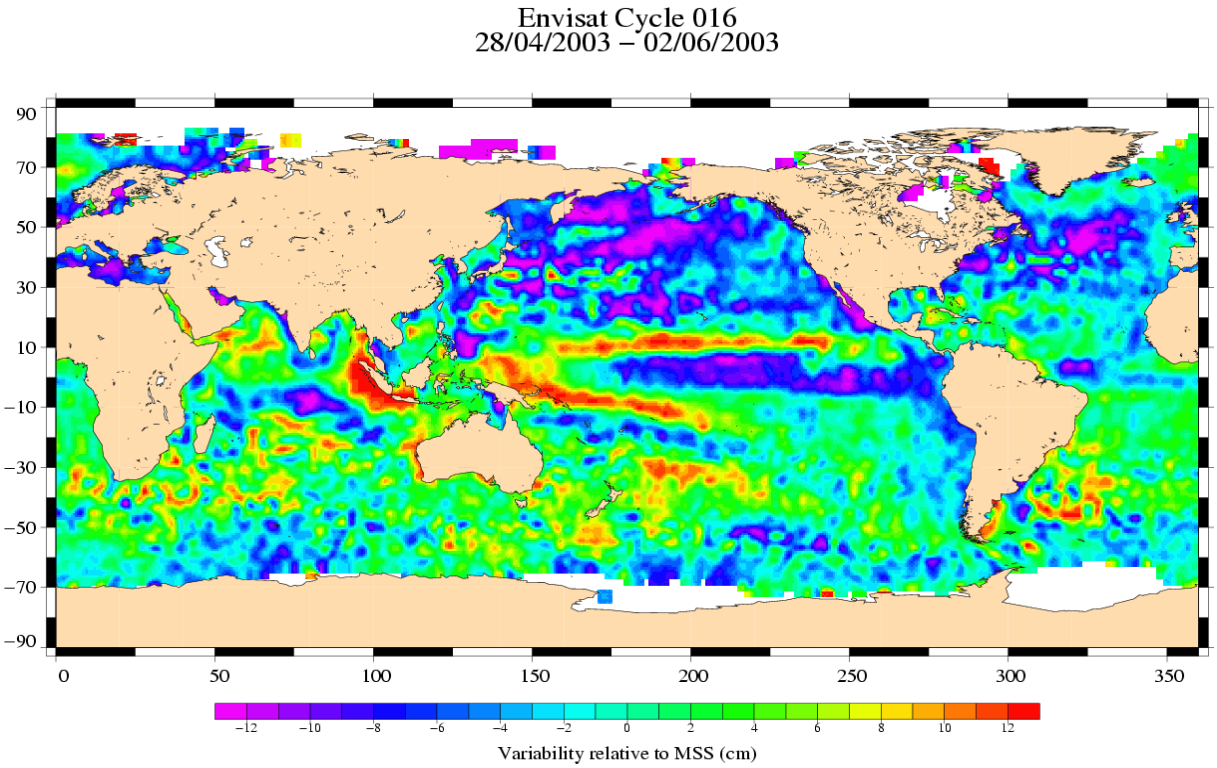


3.7.2 Comparison to a precise Mean Sea Surface

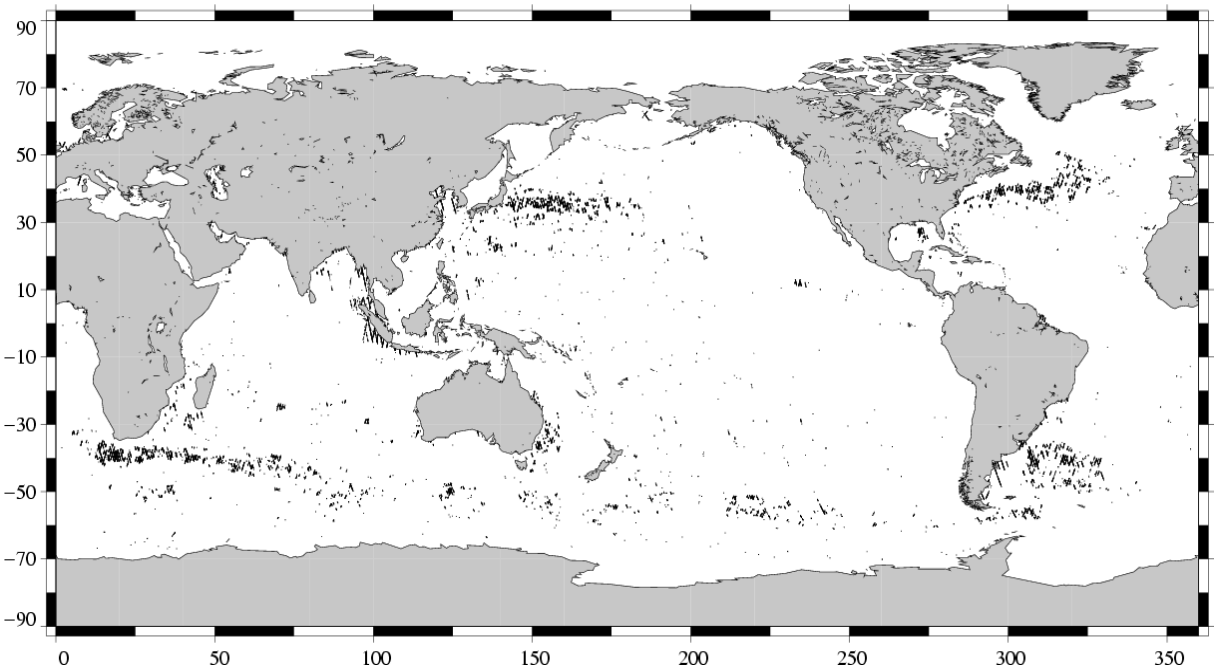
The MSS from the product is used as a reference to compute SLA. Global statistics of Envisat SSH-MSS are (cm):

Number	Mean	Std. dev.
894448	43.45	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 016



4 Cross Calibration with ERS-2

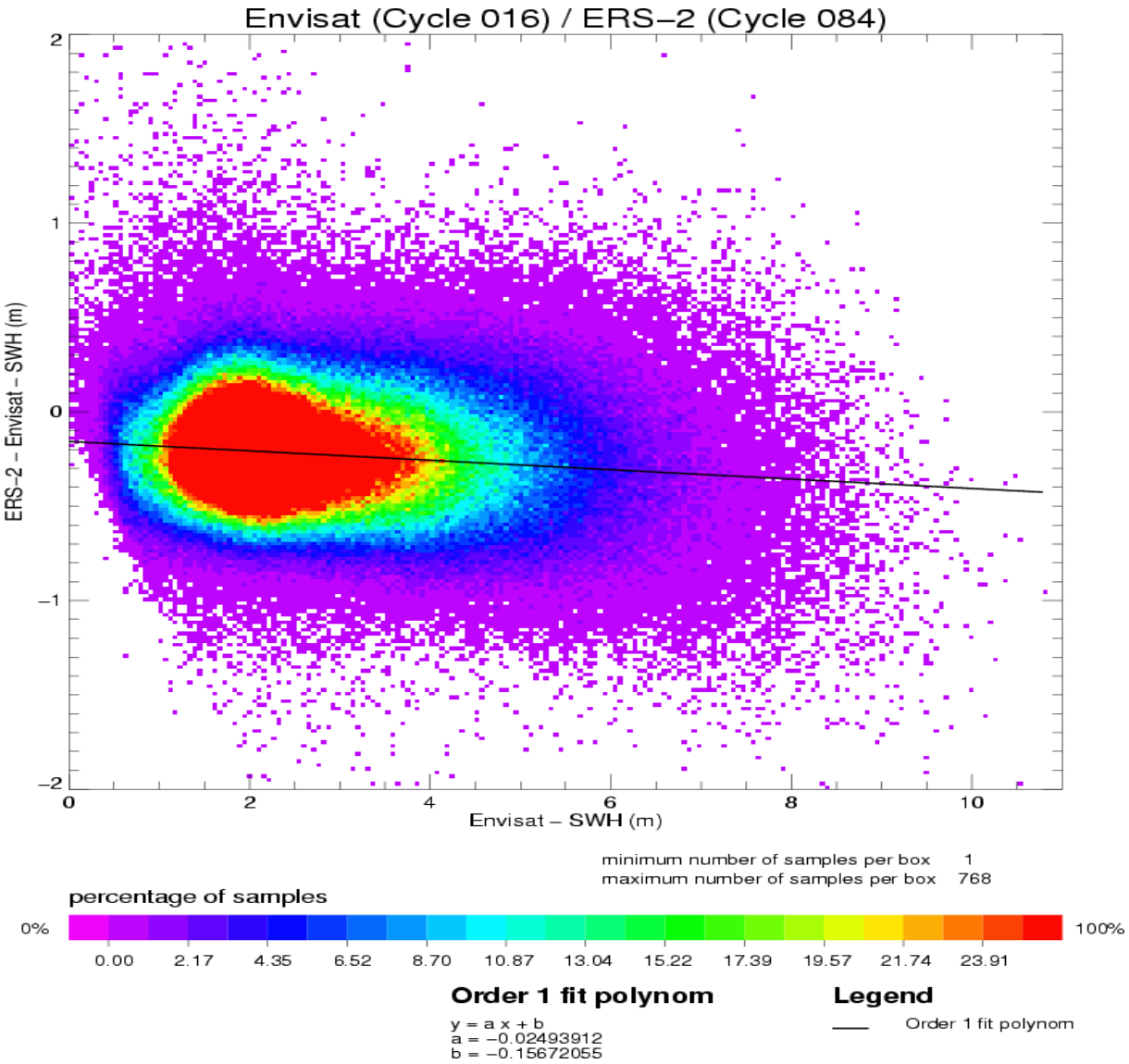
Envisat flies on the same ground track as ERS-2, 30 minutes ahead. This section presents results that illustrate the difference with ERS-2.
Envisat cycle 016 data are collocated to data from ERS-2 GDR cycle 079 in order to compare the main parameters from repeat-track analysis.

4.1 [ERS-2 - Envisat] Ku SWH differences

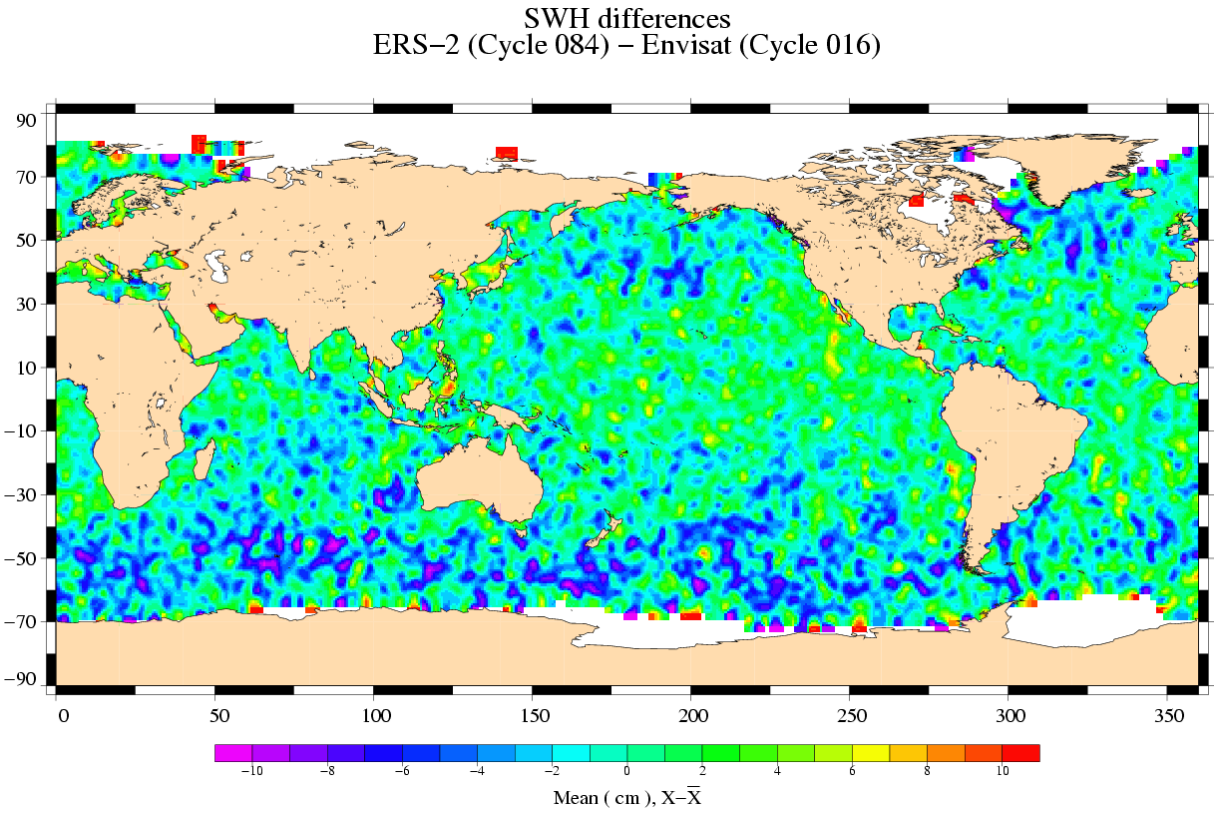
Global statistics of [ERS-2 - Envisat] Ku SWH differences (cm):

Number	Mean	Std. dev.
803285	-21.64	27.55

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).



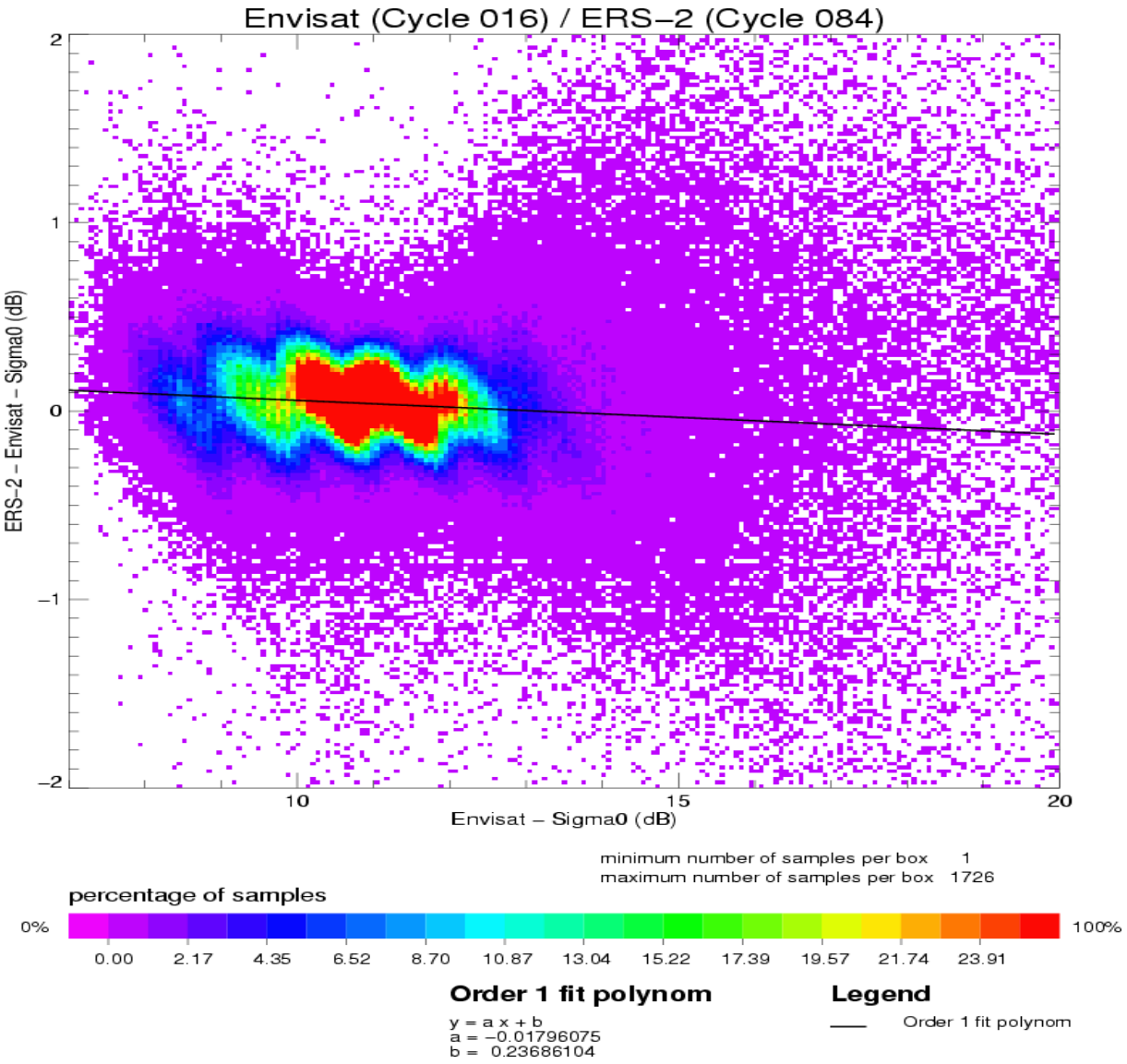
High SWH areas appear due to greater differences for high SWH values.

4.2 [ERS-2 - Envisat] Ku Sigma0 differences

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

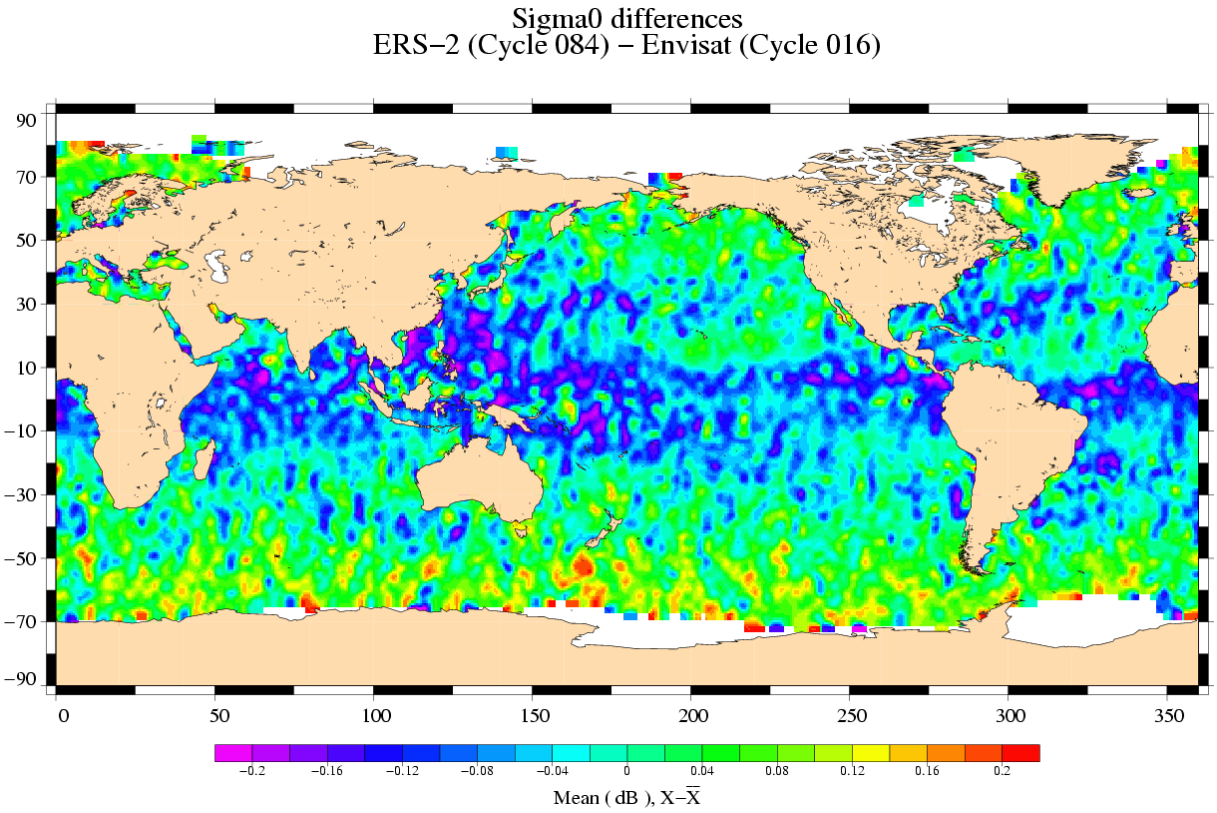
Number	Mean	Std. dev.
803285	0.05	0.28

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).



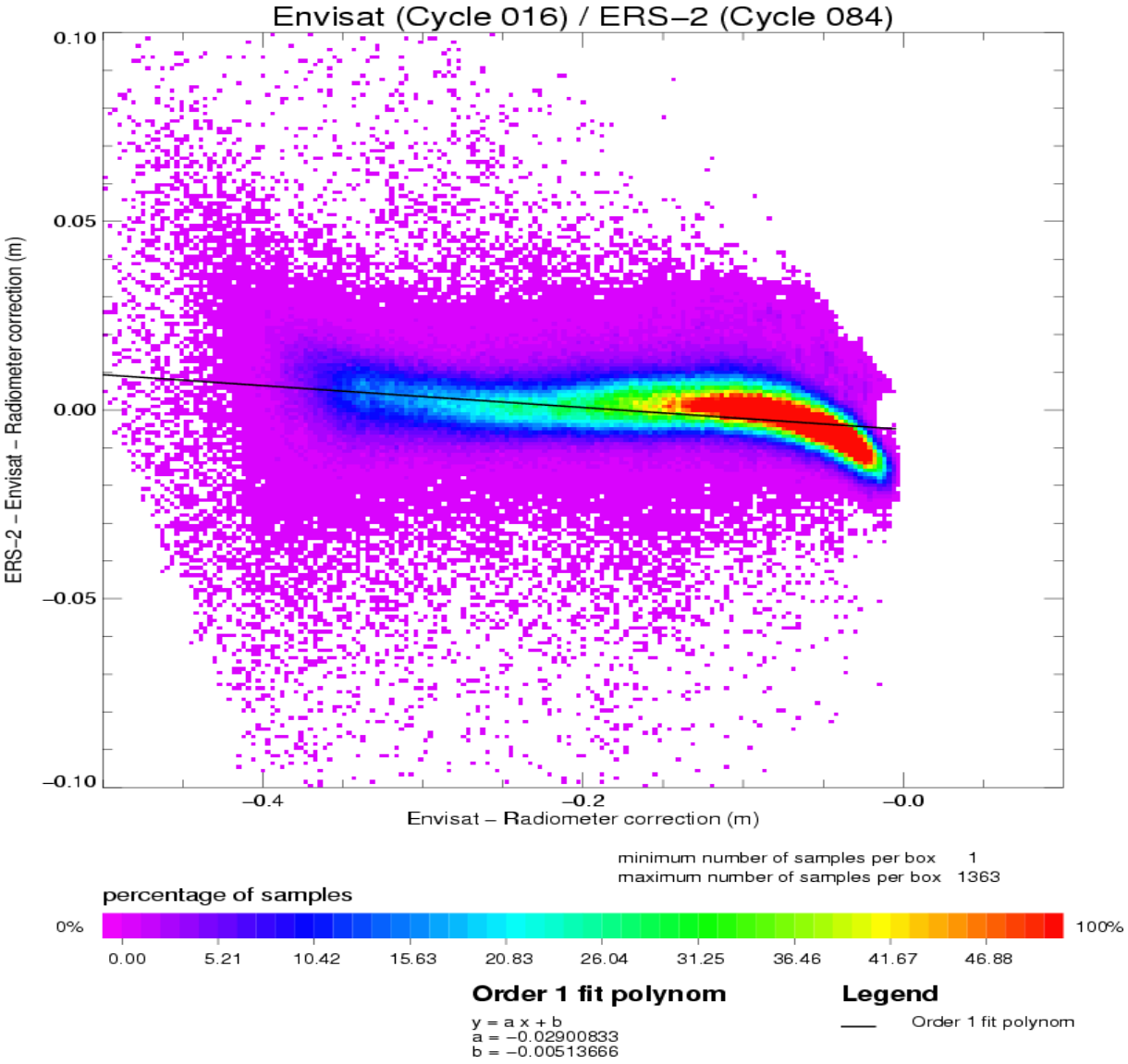
Wet areas appear because the ERS-2 atmospheric attenuation on Sigma0 is uncomplete (it only contains cloud liquid water path attenuation), contrary to Envisat one.

4.3 [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 (cm):

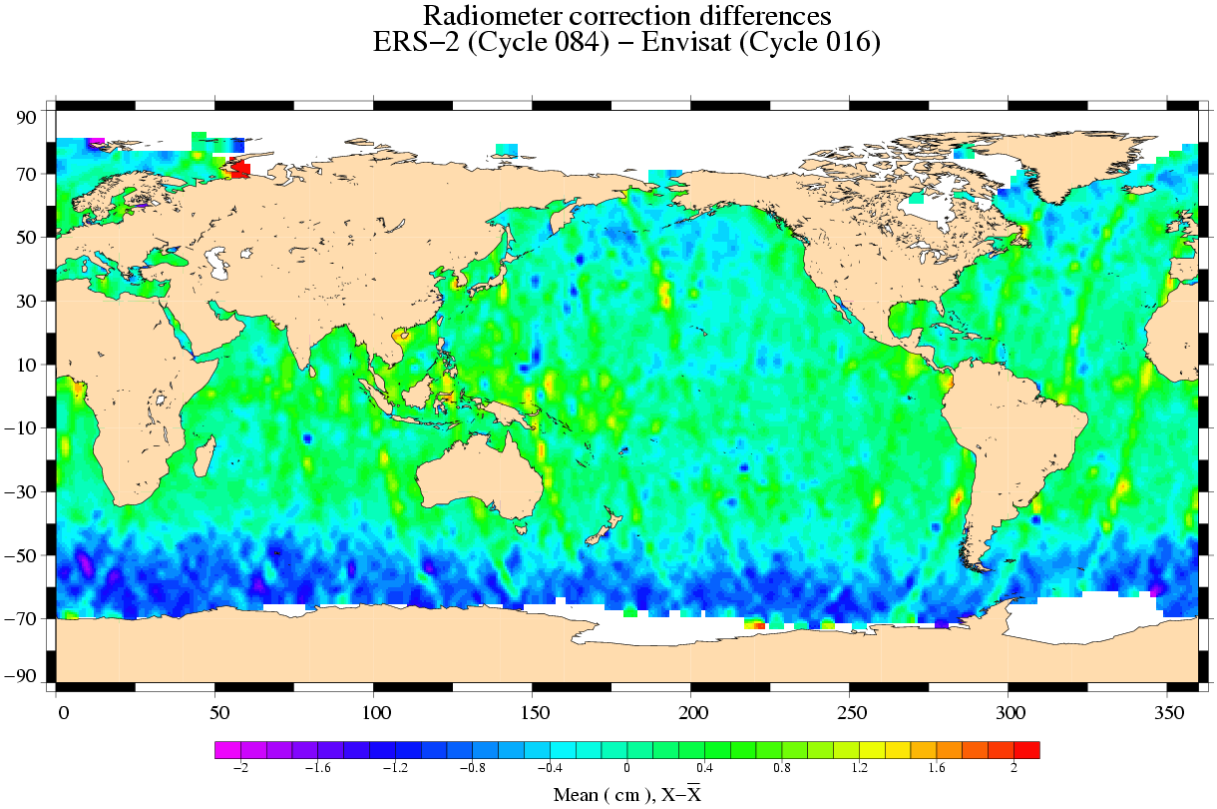
Number	Mean	Std. dev.
803285	-0.02	0.94

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



A special feature is observed on this scatter plot for low values. Using a neural algorithm on ERS-2 instead of a parametric one removes this pattern.

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. High differences are found on pass 614 to 641. These differences are probably due to the Envisat MWR Switch-down (for PMC SW upgrade and OCM).

4.4 [ERS-2 - Envisat] SSH differences

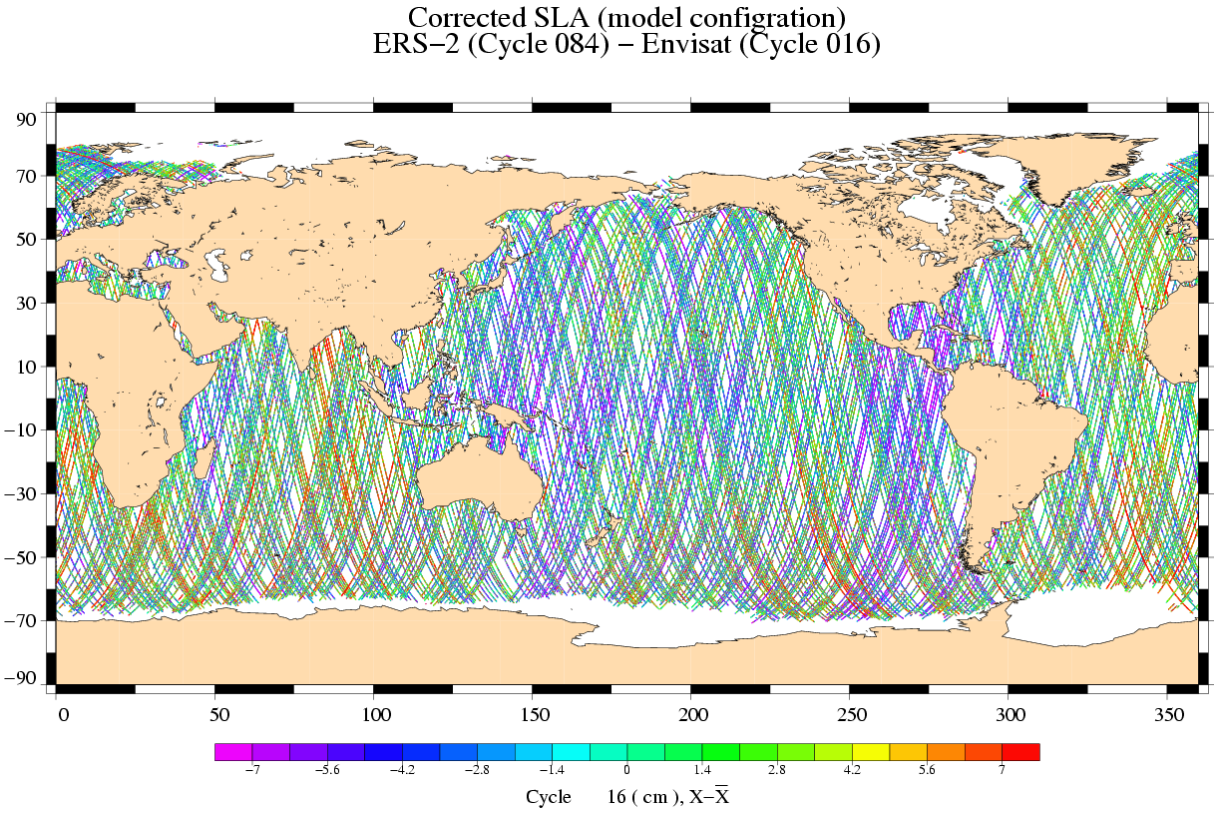
In order to compare the ERS-2 SSH with the Envisat SSH, ERS-2 GDRs have been updated with algorithms and corrections similar to Envisat:
- Range corrected from SPTR, USO, time tag bias
- DGME04 orbit
- ECMWF wet tropospheric correction
- Model dry tropospheric correction
- 3-parameters sea state bias
- 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:
- GIM ionospheric correction
- ECMWF wet tropospheric correction

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

Number	Mean	Std. dev.
802578	-35.48	5.37

These SSH differences are plotted on the following figure.



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