Envisat GDR
Quality Assessment Report

Cycle 021

20-10-2003 24-11-2003

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SALP-RP-P2-EX-21121-CLS021
Edition 01.0, March 2004

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

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

At the end of cycle some passes have been produced with IPF V4.56.
IPF V4.56 Level 1B upgrade:
1. Correction of the AGC evaluation for Ku and S-band. IPF V4.56 Level 2 upgrade:
2. Neural Network algorithm for evaluation of Wet Tropospheric Correction, Water Vapor and Liquid Water Content.
3. Refinement in Level2 Ice2 Retracker Algorithm.
4. Auxiliary Data File (ADF) updates:
a. Level 1 ADF: New IF mask ADF (RA2_IFF_AX)
b. Level 2 ADF:
- Updated rain flag through Ocean/Ice2 Configuration (System) file (RA2_SOI_AX)
- Sea State Bias Table file (RA2_SSB_AX)
- Updated OCOG retracker thresholds through Ice1/Sea Ice Configuration file (RA2_ICT_AX)
- CLS01 Mean Sea Surface (RA2_MSS_AX)
- GOT00.2 Ocean Tide Solution 1 Map file (RA2_OT1_AX)
- FES 2002 Ocean Tide Solution 2 Map file (RA2_OT2_AX)
- FES 2002 Tidal Loading Coefficients Map file (RA2_TLD_AX)

Previous IPF version was V4.54 operational since April 7, 2003. The above Level 2 upgrades are implemented in the F-PAC Level 2 processing chain since Version V6.1.

The 2 main impacts are described in **section 4**.

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

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

4 passes have no radiometer correction (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. 41 passes are impacted by the S-Band anomaly (see **section 3.2**).

High SSH-MSS are found on 32 passes (see **section 4**).

Main impacts of the new IPF version V4.56 (see **section 4**).

2.4 Platform and instrument events

Inclination Maneuver (2003/10/28 04:56:18 to 2003/10/28 07:09:44 TAI)

RA-2 is in RS/WT/INT mode. 29 Oct 2003 06 :47 :04 to 29 Oct 2003 12 :58 :35)

Orbit Maintenance Maneuver (2003/10/31 01:13:10 to 2003/10/31 03:13:25 TAI)

RA-2 is in RS/WT/INT mode. TM format header error (02 Nov 2003 15 :16 :56 to 03 Nov 2003 12 :08 :35)

Orbit Maintenance Maneuver (2003/11/18 23:02:30 to 2003/11/19 01:52:55 TAI)

2.5 Cycle quality and performances

Good general results are obtained for this cycle of data.
The crossover standard deviation is 8.56 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 11.4 cm. When using a selection to remove shallow waters (1000 m), areas of high ocean variability and high latitudes (> |50| deg) it lowers to 9.9.

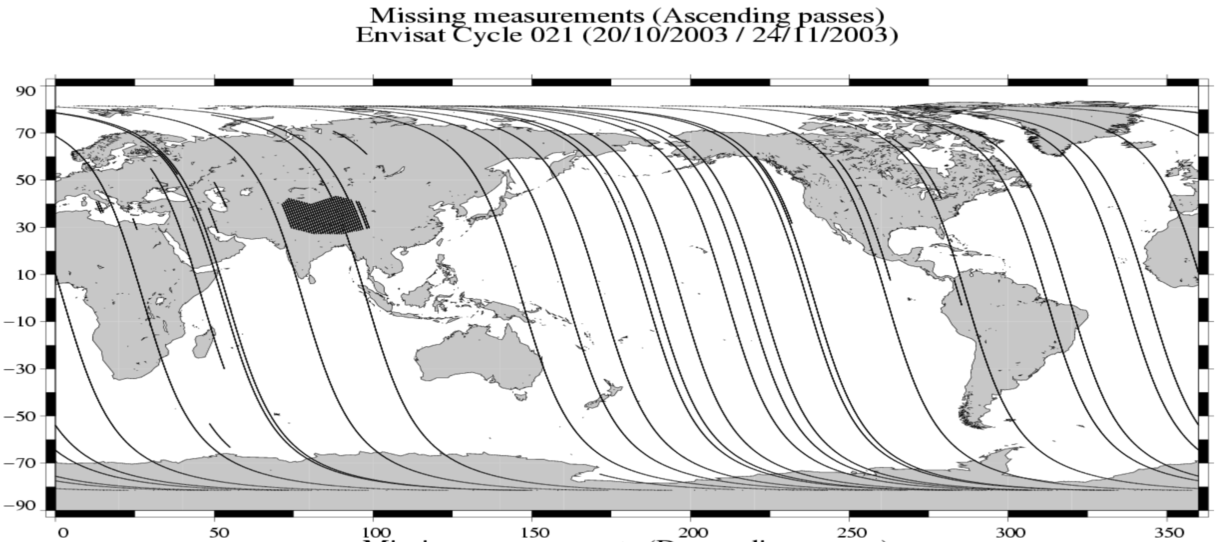
Detailed CALVAL results are presented in **section 3**.

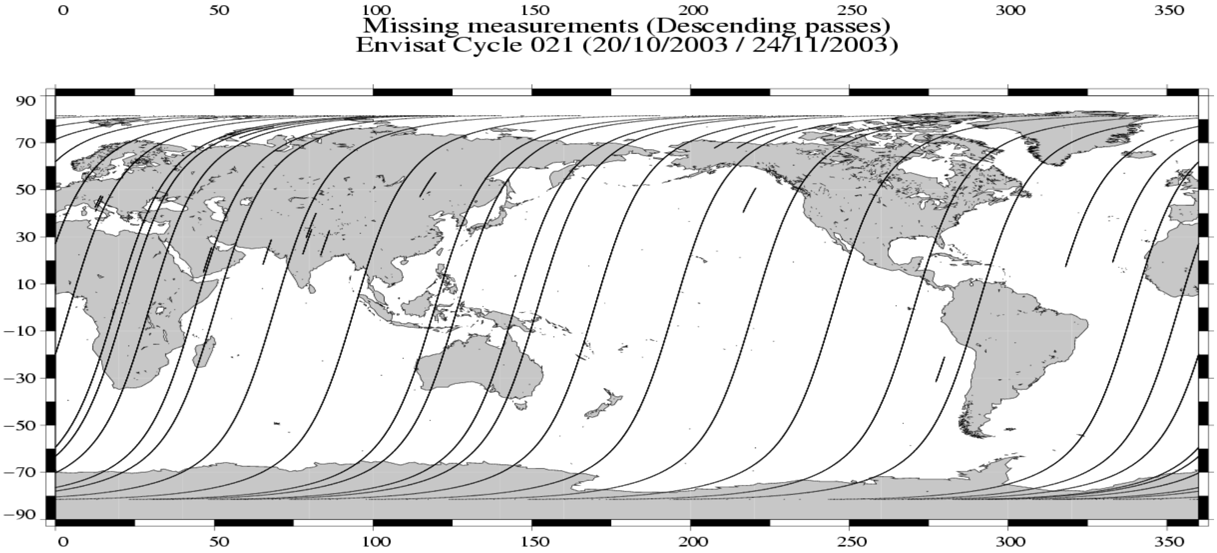
3 CALVAL main results

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

2582265 are present, and 132619 (4.9%) are missing. The maps below illustrate missing 1Hz measurements in the GDRs, with respect to a 1 Hz sampling of a nominal repeat track.





40 passes are missing all due to level1 B data unavailability:
- 6 passes (242 to 247) are missing due to: RA-2 is in RS/WT/INT mode
- 24 passes (366 to 389) are missing due to: TM format header error
- 10 passes are missing due to: either to LRAC_PDHSs data generation to level1 problems or ingestion pbs on F-PAc side

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	900450	40.99
Ice flag	773077	35.19
S-Band anomaly flag	384728	17.51

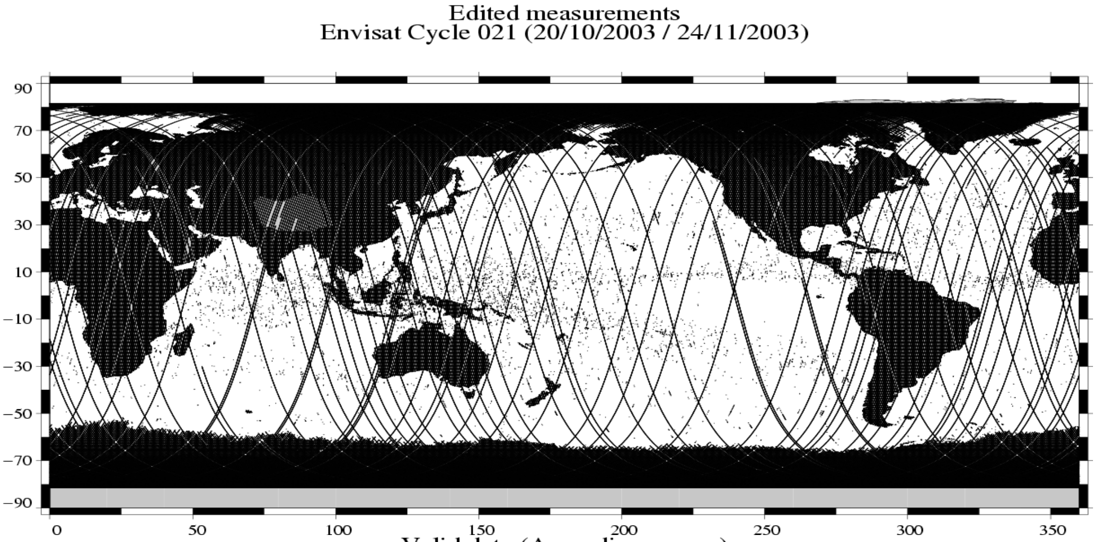
Then, measurements are edited using thresholds on several parameters. These thresholds are expected to remain constant throughout the Envisat mission, so that monitoring the number of edited measurements allows a survey of data quality.
The next table gives for each tested parameter, minimum and maximum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

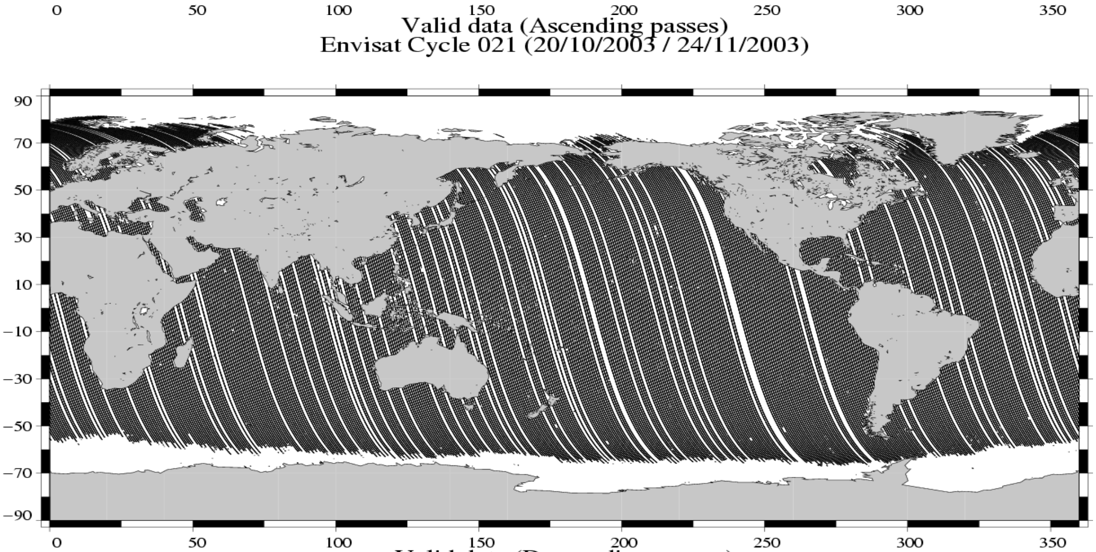
Parameters	Min Thres.	Max Thres.	Nb rejected	% rejected
Sea surface height (m)	-130.000	100.000	916	0.07
Variability relative to MSS (m)	-2.000	2.000	4472	0.35
Number of 18Hz valid points	10.000	-	102	0.01
Std. deviation of 18Hz range (m)	0.000	0.250	13103	1.03
Off nadir angle from waveform (deg2)	-0.200	0.160	9106	0.71
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	1391	0.11
Dual Ionospheric correction (m)	-0.400	0.040	1238	0.10
Significant wave height (m)	0.000	11.000	974	0.08
Sea state Bias (m)	-0.500	0.000	2037	0.16
Backscatter coefficient (dB)	7.000	30.000	1439	0.11
GOT00 ocean tide height (m)	-5.000	5.000	1168	0.09
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

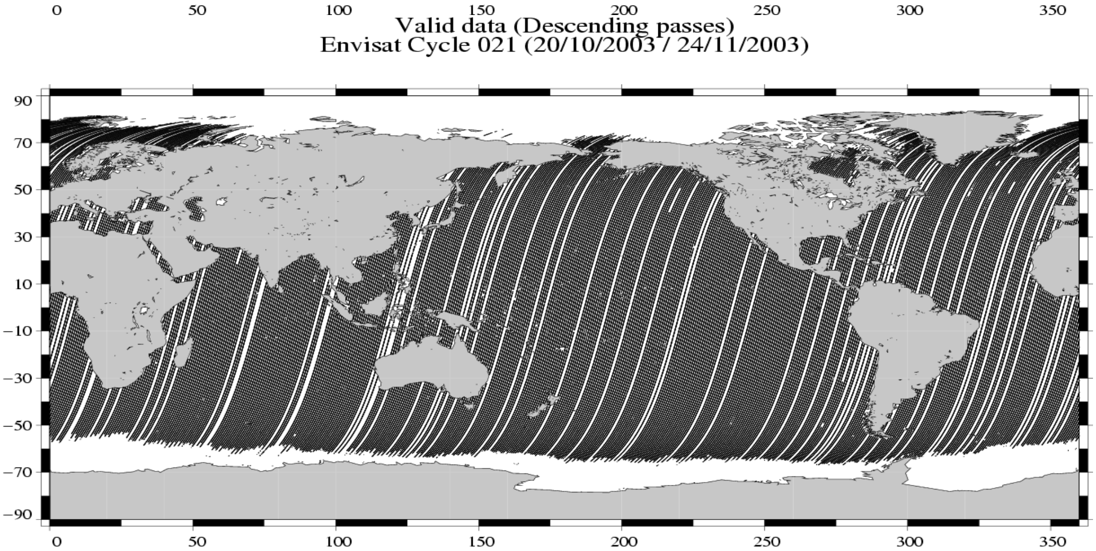
A final editing is then performed on corrected sea surface height, using a spline fitting procedure, leading to remove 455 (0.04 %) measurements.

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

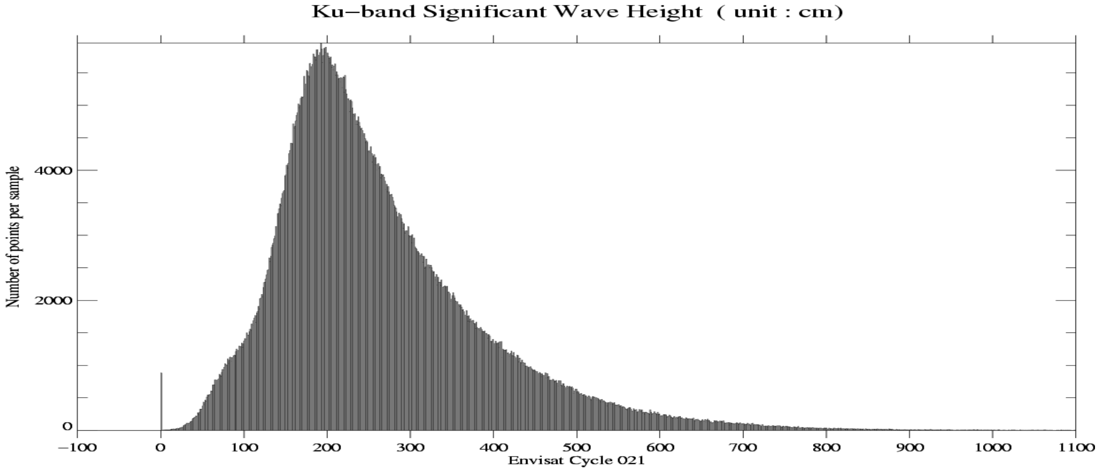
962 passes have been delivered. Among these passes:
- 4 passes are entirely edited over ocean on the radiometer land flag (no MWR correction)
- 41 passes (211, 476 to 481, 498, 528 to 537, 659 to 681) are edited because of S-Band anomalies. Users are advised not to use the S-Band parameters and the dual ionospheric correction on these passes.

A special processing has been necessary to remove 32 passes with high SSH-MSS (see **section 4**). Users are advised to remove these points from their data set.

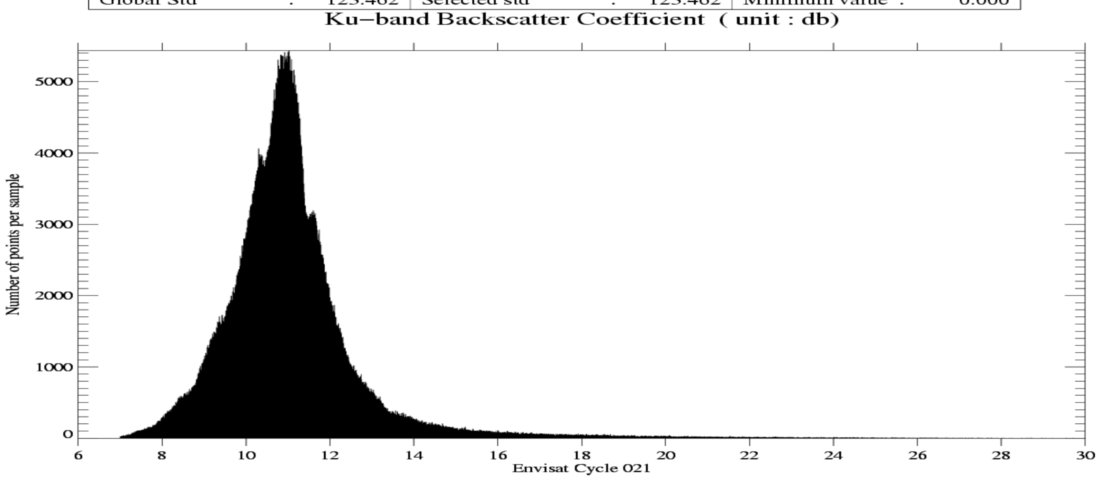
Wet areas appear in the plot of removed data. Similar features are observed with other altimeters (T/P, Jason) mainly due to rain comtamination.

3.3 Altimeter parameters

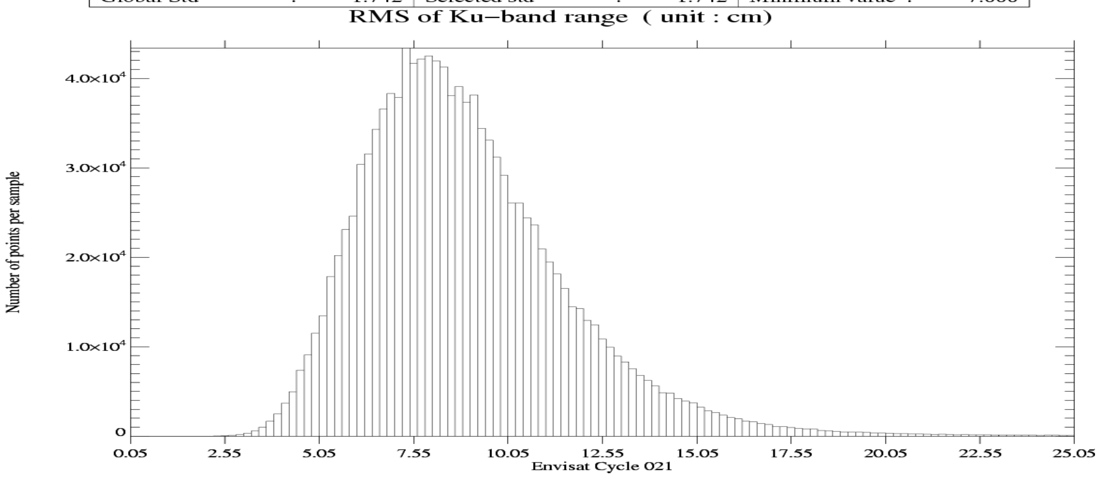
In order to assess and to monitor altimeter parameter measurements, histograms of Envisat Ku-band Significant Wave Height (SWH), Backscatter coefficient (Sigma0) and RMS of altimeter range are computed.



Global nb of points	:	1234963	Sel. nb of points	:	1234963	Sample interval	:	1.000
Global mean	:	262.088	Selected mean	:	262.088	Maximum value	:	1099.000
Global Std	:	123.462	Selected std	:	123.462	Minimum value	:	0.000



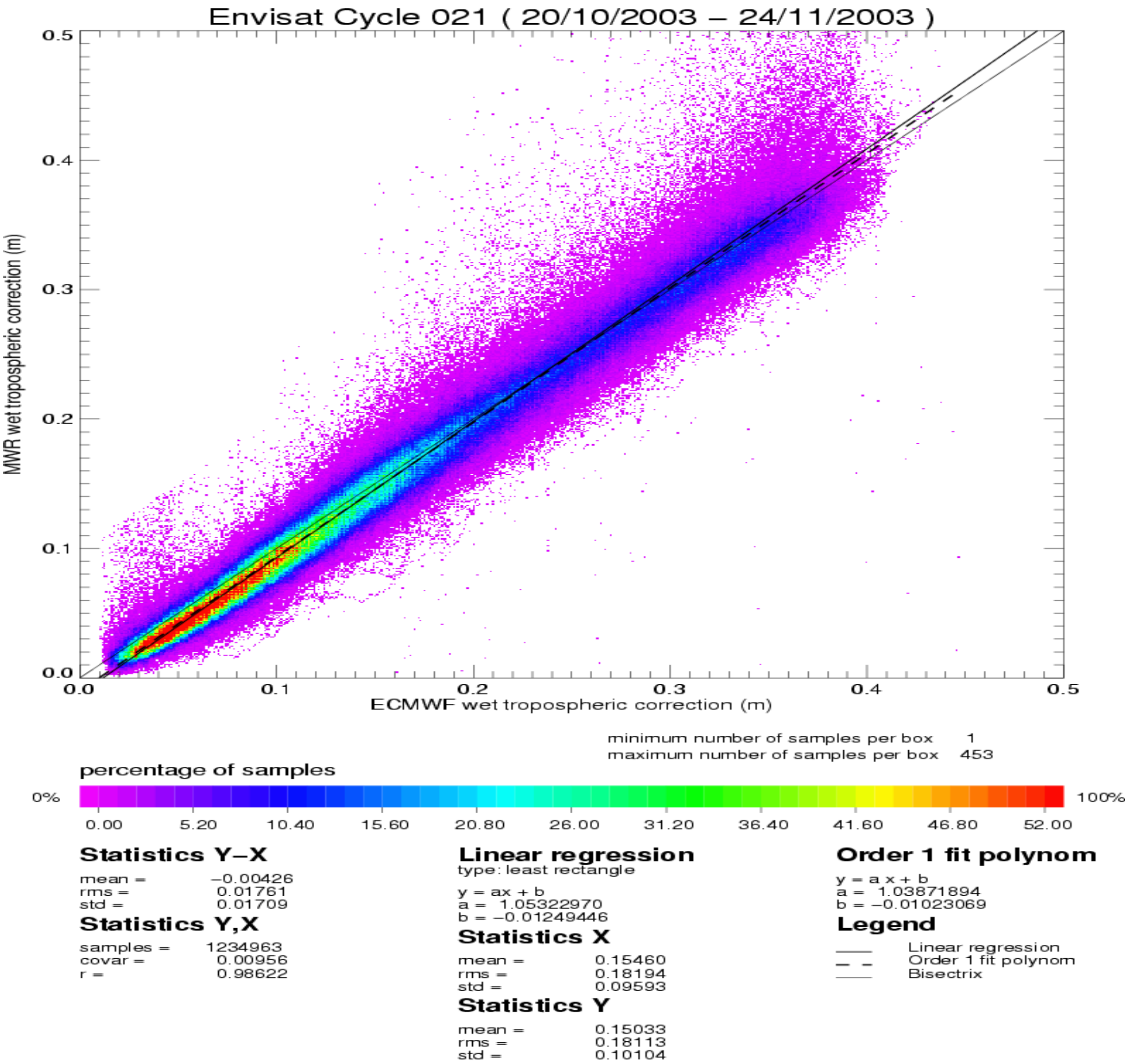
Global nb of points	:	1234963	Sel. nb of points	:	1234963	Sample interval	:	0.010
Global mean	:	11.065	Selected mean	:	11.065	Maximum value	:	30.000
Global Std	:	1.742	Selected std	:	1.742	Minimum value	:	7.000



Global nb of points	:	1234963	Sel. nb of points	:	1234963	Sample interval	:	0.200
Global mean	:	8.926	Selected mean	:	8.926	Maximum value	:	25.000
Global Std	:	2.706	Selected std	:	2.706	Minimum value	:	1.800

3.4 Radiometer

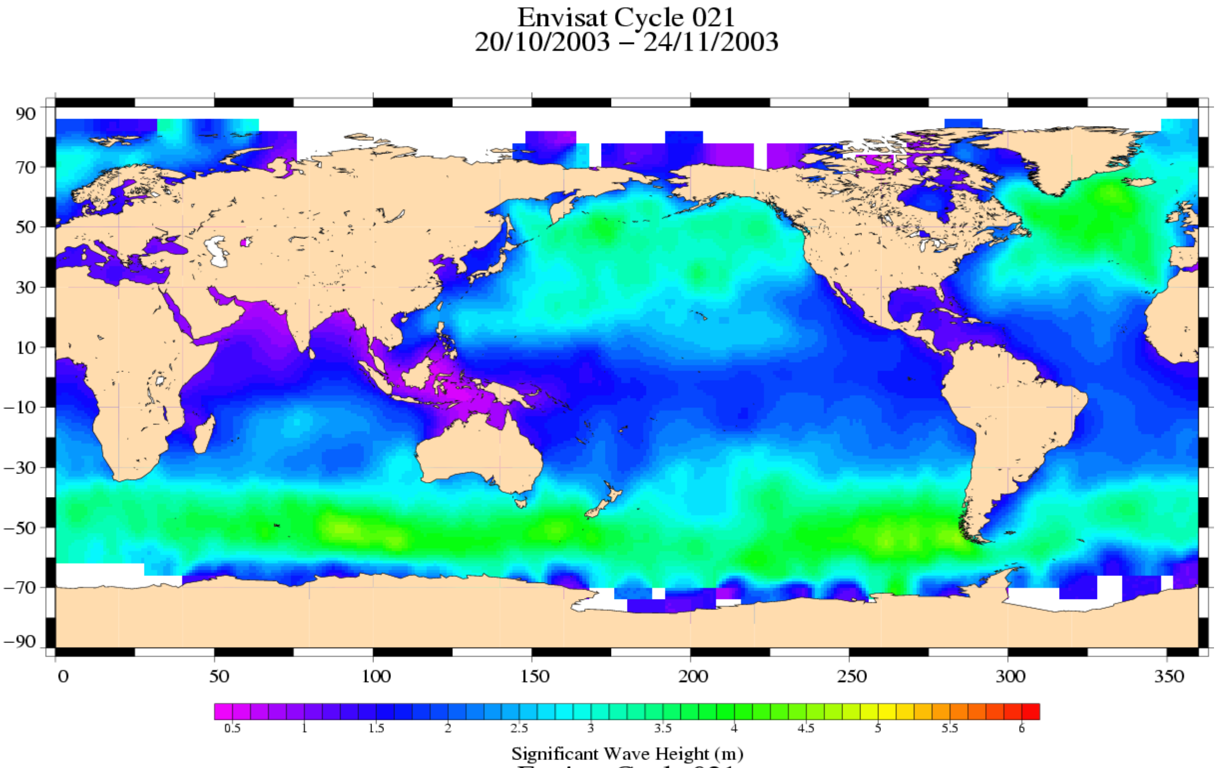
In order to assess and to monitor radiometer measurements, a scatter plot between the radiometer wet troposphere correction and the ECMWF model is computed for the valid data set previously defined.

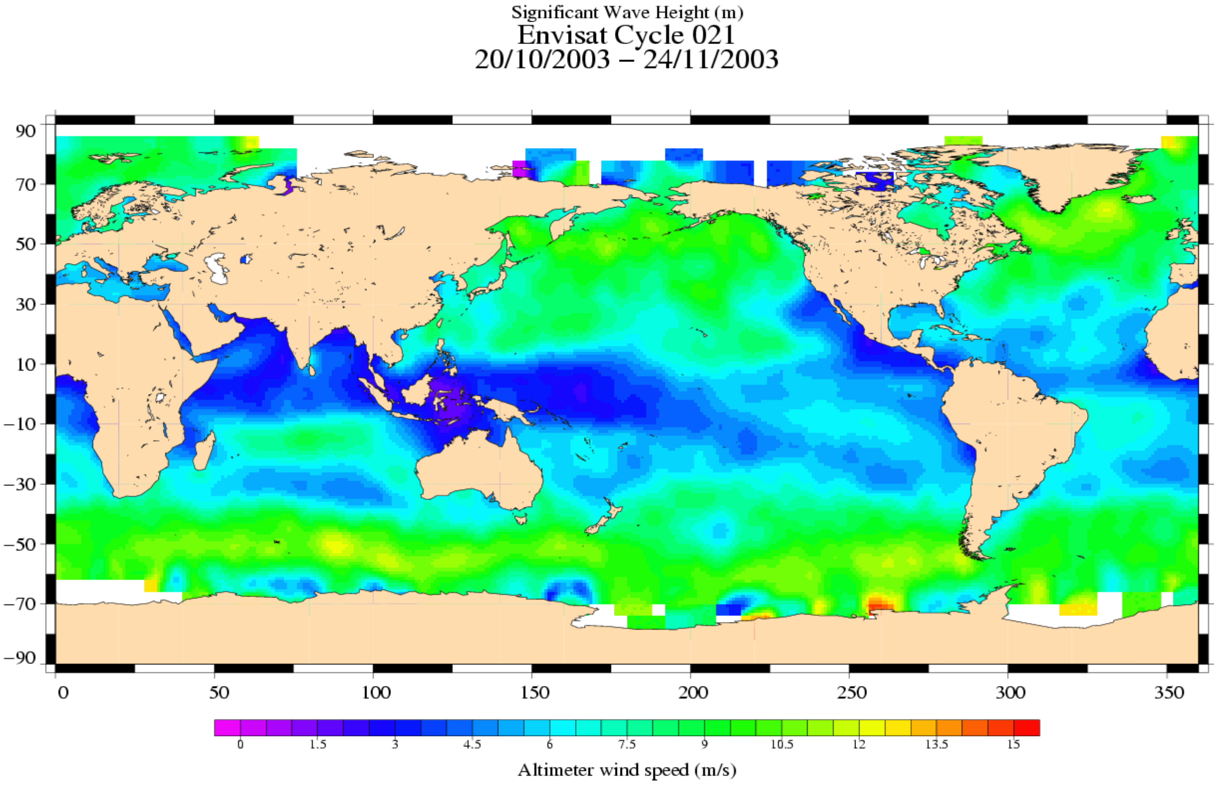


The radiometer-model mean difference is 0.4 cm. A drift on the Envisat 23.8GHz brightness temperature has been detected and has to be monitored on the long term. Note that the neural algorithm is now implemented on Envisat.

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

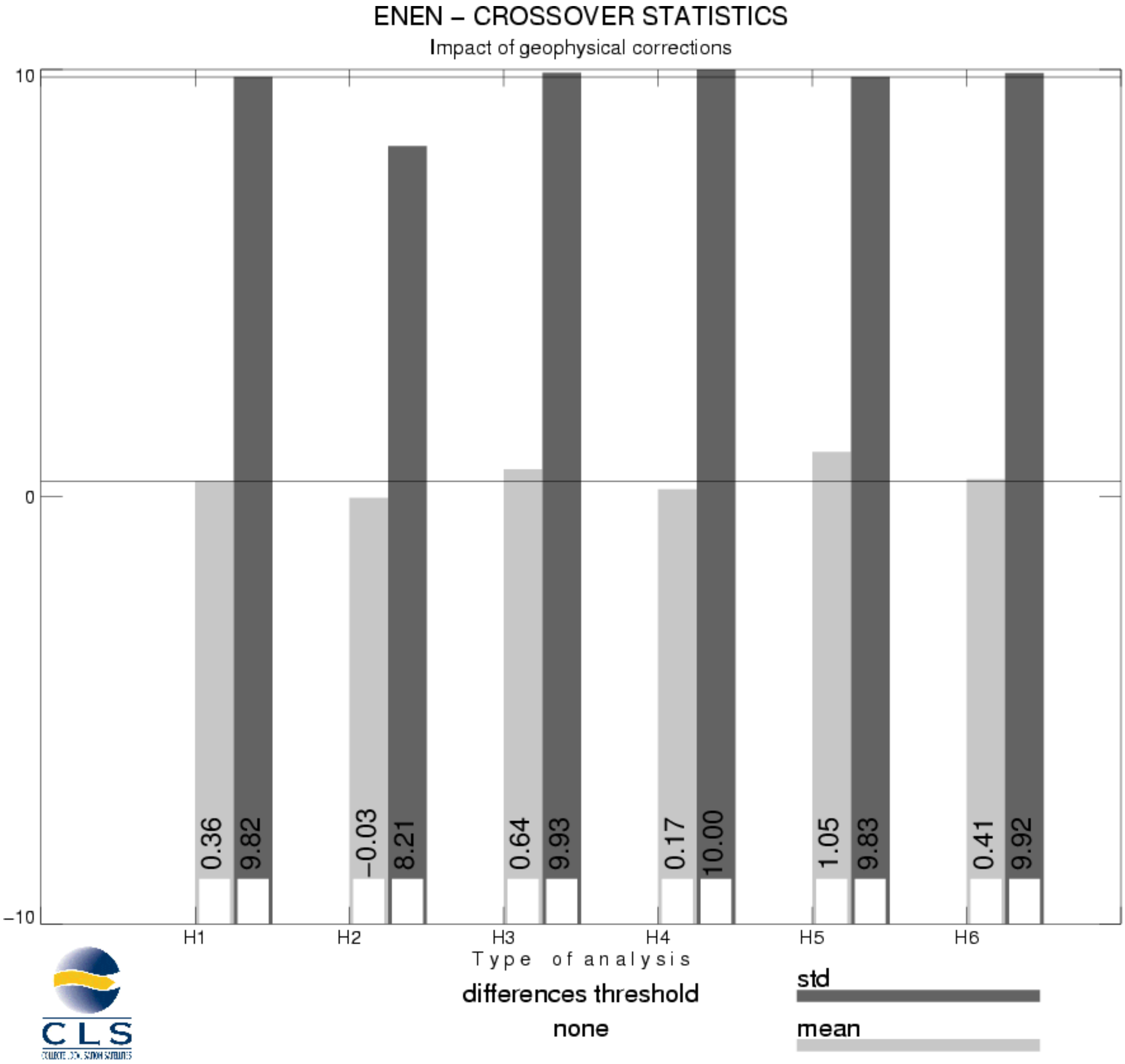
3.6.1 General comment

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 9.82 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 8.56 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).



H1 = SSH

H4 = SSH with DORIS ionospheric correction (in product)

H2 = SSH with orbit error (computed)

H5 = SSH with FES02 tide model (in product)

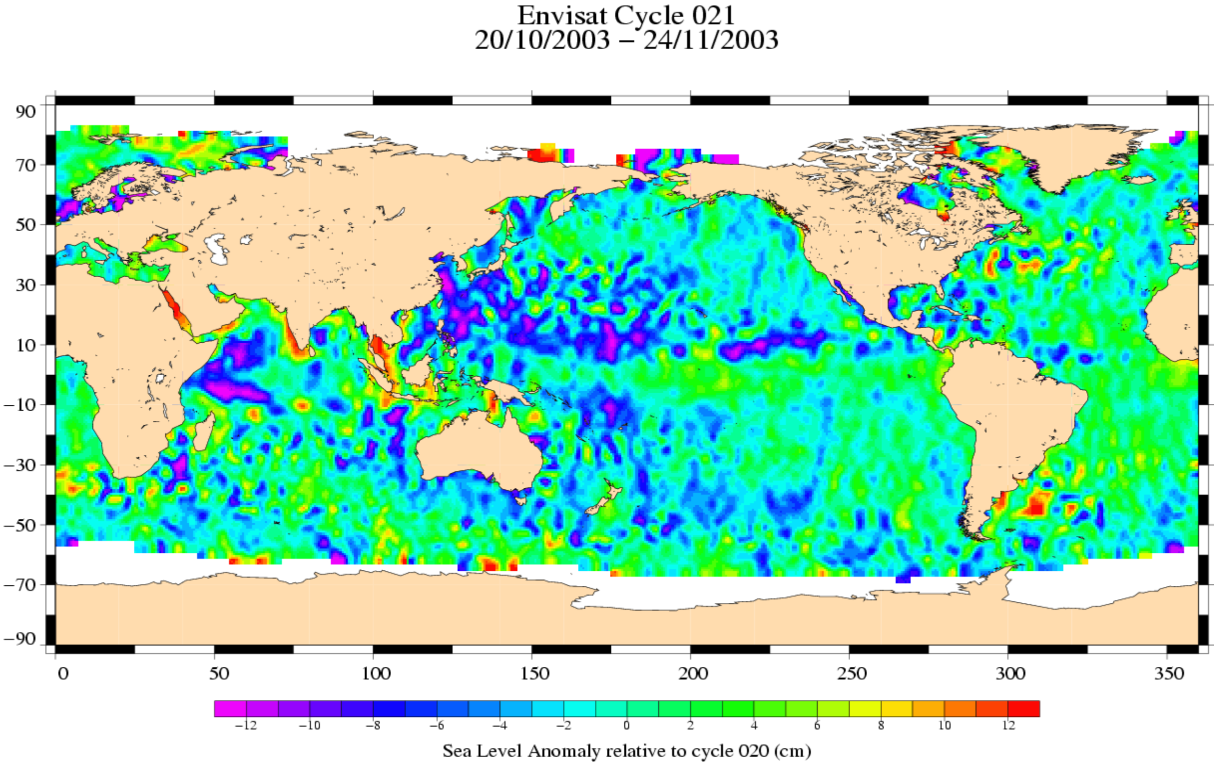
H3 = SSH with GIM ionospheric correction (computed)

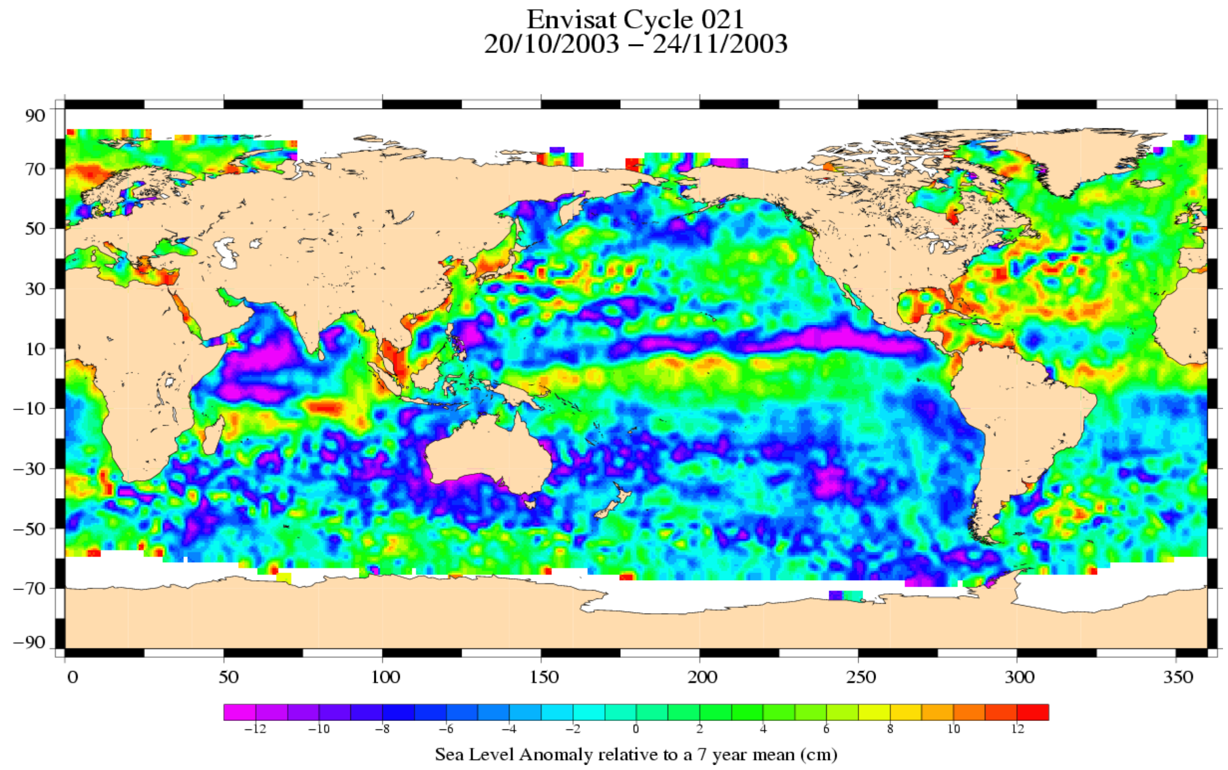
H6 = SSH with ECMWF wet tropospheric correction (in product)

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.





Envisat Cycle 021
20/10/2003 – 24/11/2003
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)

3.7.2 Comparison to a precise Mean Sea Surface

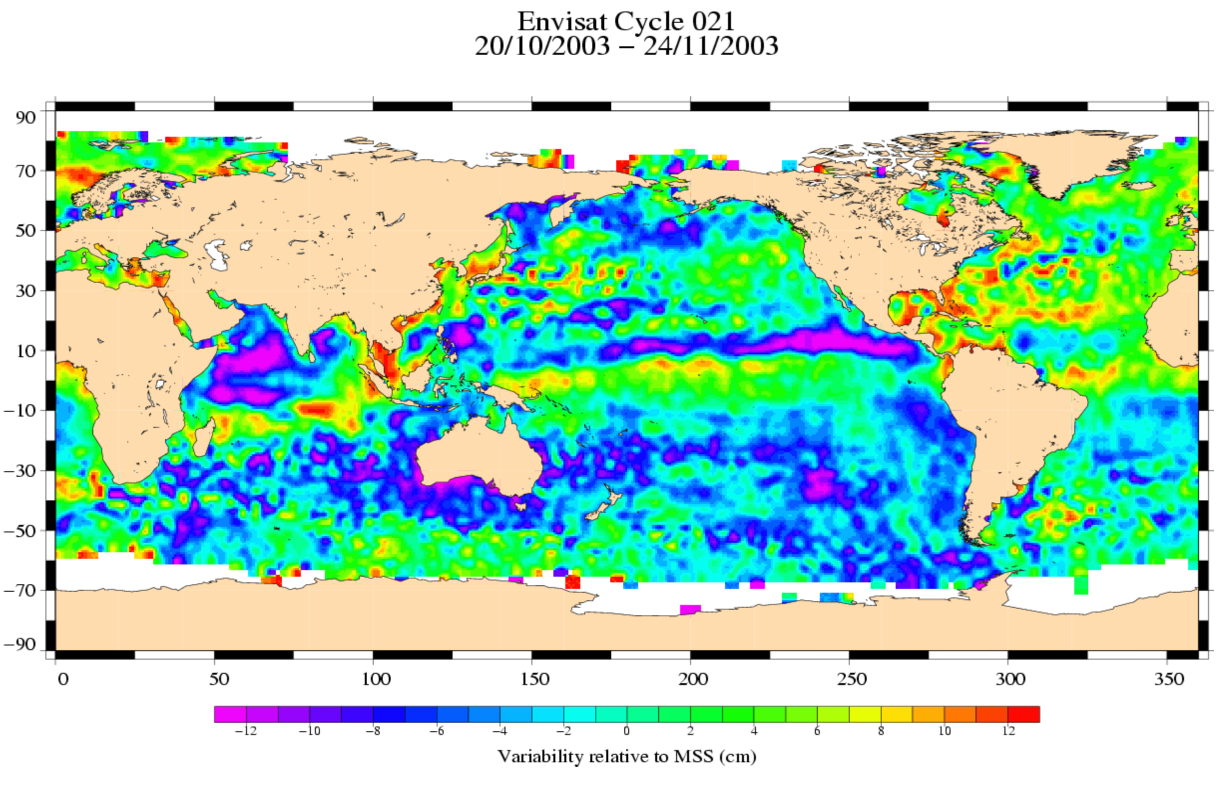
The MSS from the product is used as a reference to compute SLA. Global statistics of Envisat SSH-MSS are (cm):

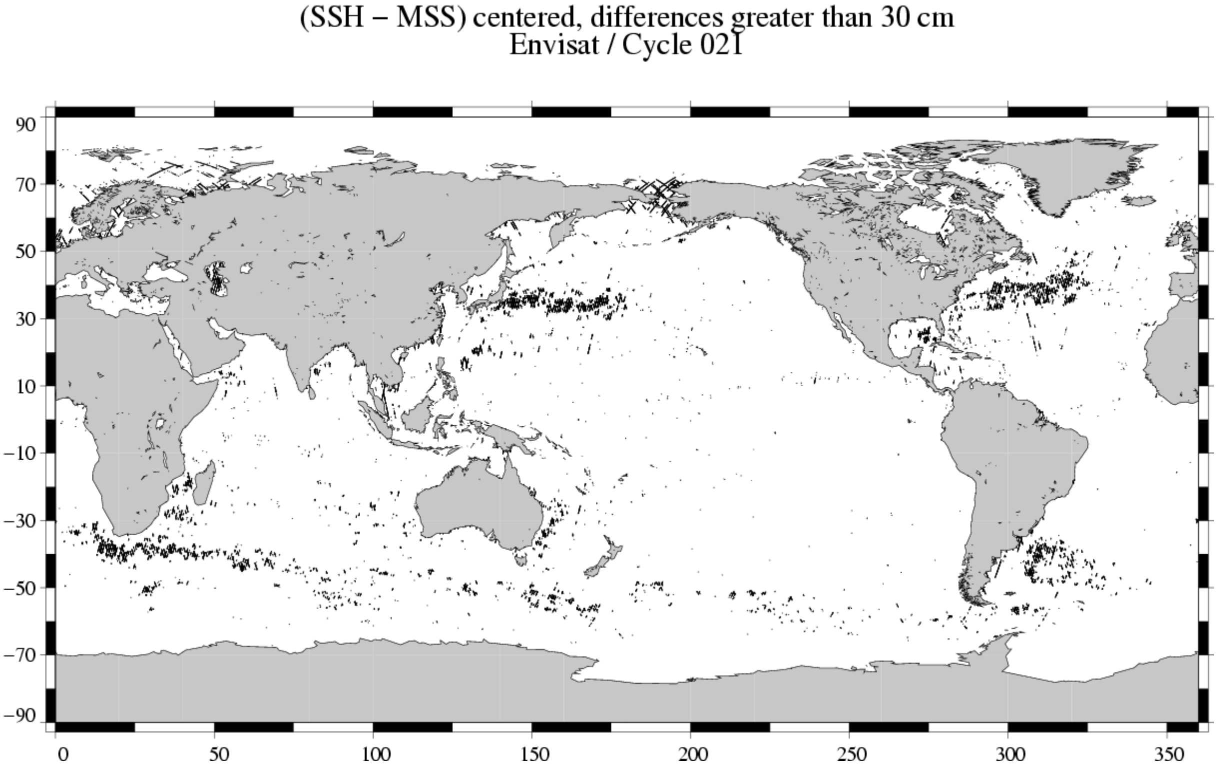
Number	Mean	Std. dev.
1383700	44.16	11.43

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.
867806	43.63	9.85

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 021
90
70
50
30
10
−10
−30
−50
−70
−90
0
50
100
150
200
250
300
350

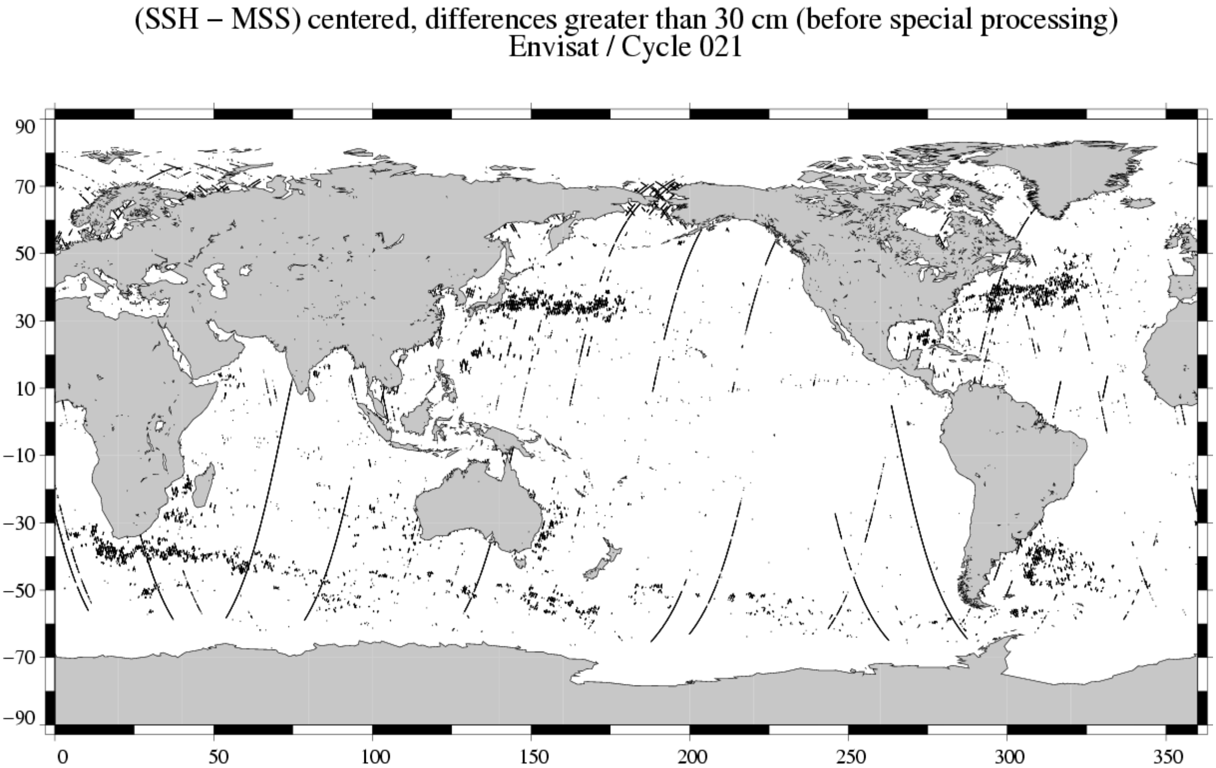
4 Particular investigations

4.1 High SSH-MSS on several passes

High SSH-MSS values are found on the following passes:
206, 208, 209, 210, 211, 248, 250, 251, 252, 259, 261, 262, 277, 279, 284, 285, 287, 289, 290, 292, 302, 390, 876, 880, 883, 885, 886, 887, 888, 889, 890, 893

The reasons for this degraded quality are:
- There are two manoeuvres including an inclination manoeuvre on the 28th October
- The solar activity is intense between this two manoeuvres
- There is not any Laser measurements between this two manoeuvres

This passes have been removed for this quality assessement. The following figure shows the data where $SSH - MSS > 30cm$ before the special editing processing. The effect of the special editing processing is visible in part 3.7.2.



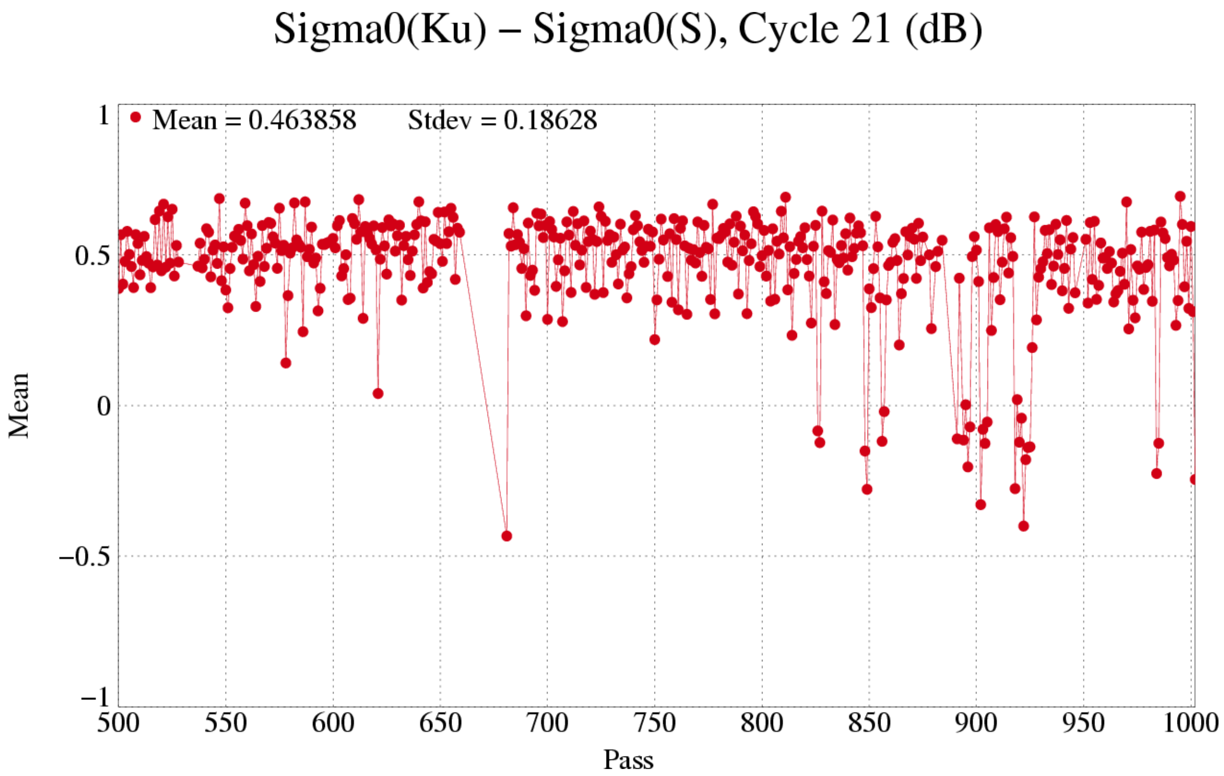
4.2 New IPF version V4.56

IPF version 4.56 included level 1 and level 2 algorithms and ADF (Auxiliary Data File) upgrades, with in particular the two following ones:
- Correction of the AGC evaluation for Ku and S-band.
- Level 1 ADF: New IF mask ADF (RA2_IFF_AX)

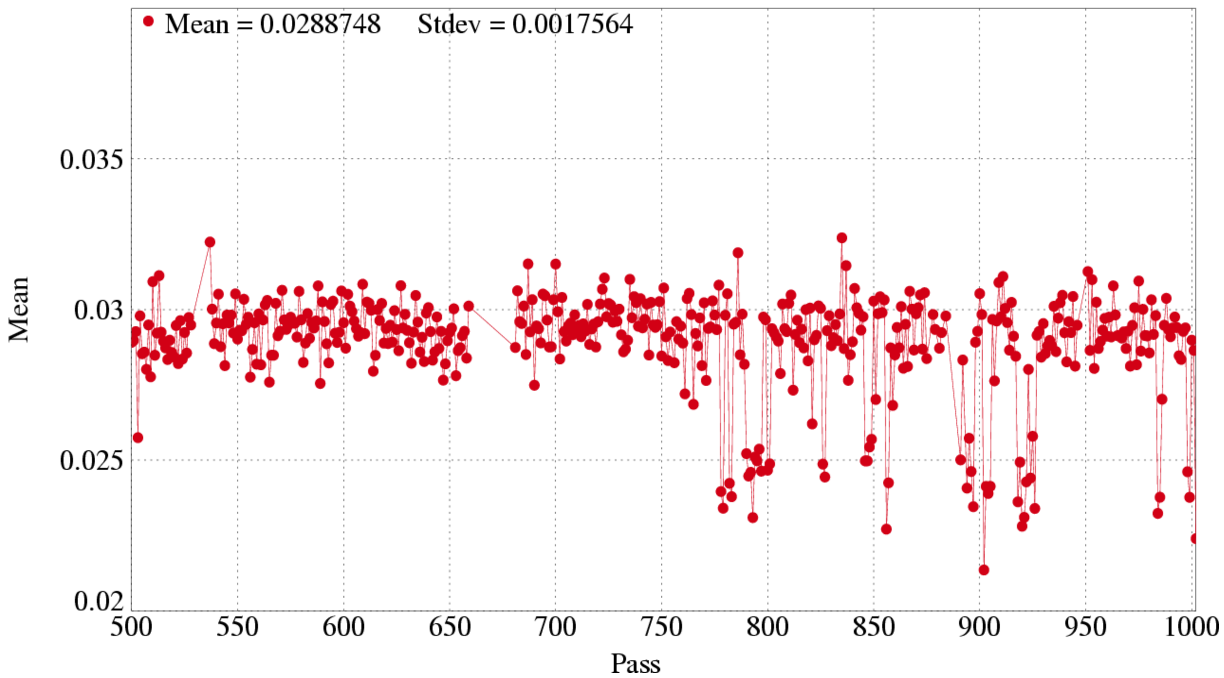
Passes between 1 and 777 have been generated with IPF version V4.54. Passes between 778 and 1002 have been generated either with version V4.54 or with version V4.56.

On the passes produced with the new version, the main impacts are:
- S-Band sigma0 increases by 0.6 dB. Consequently, the rain flag is also impacted
- The rain flag is impacted by the S-Band Sigma0 change
- Squared off nadir angle from waveform drops by 0.005 deg2

The following figures show the mean per pass of the Sigma0(Ku)-Sigma0(S) difference and the squared off nadir angle.



Off nadir angle from wave form, Cycle 21 (deg2)



5 Cross Calibration with ERS-2

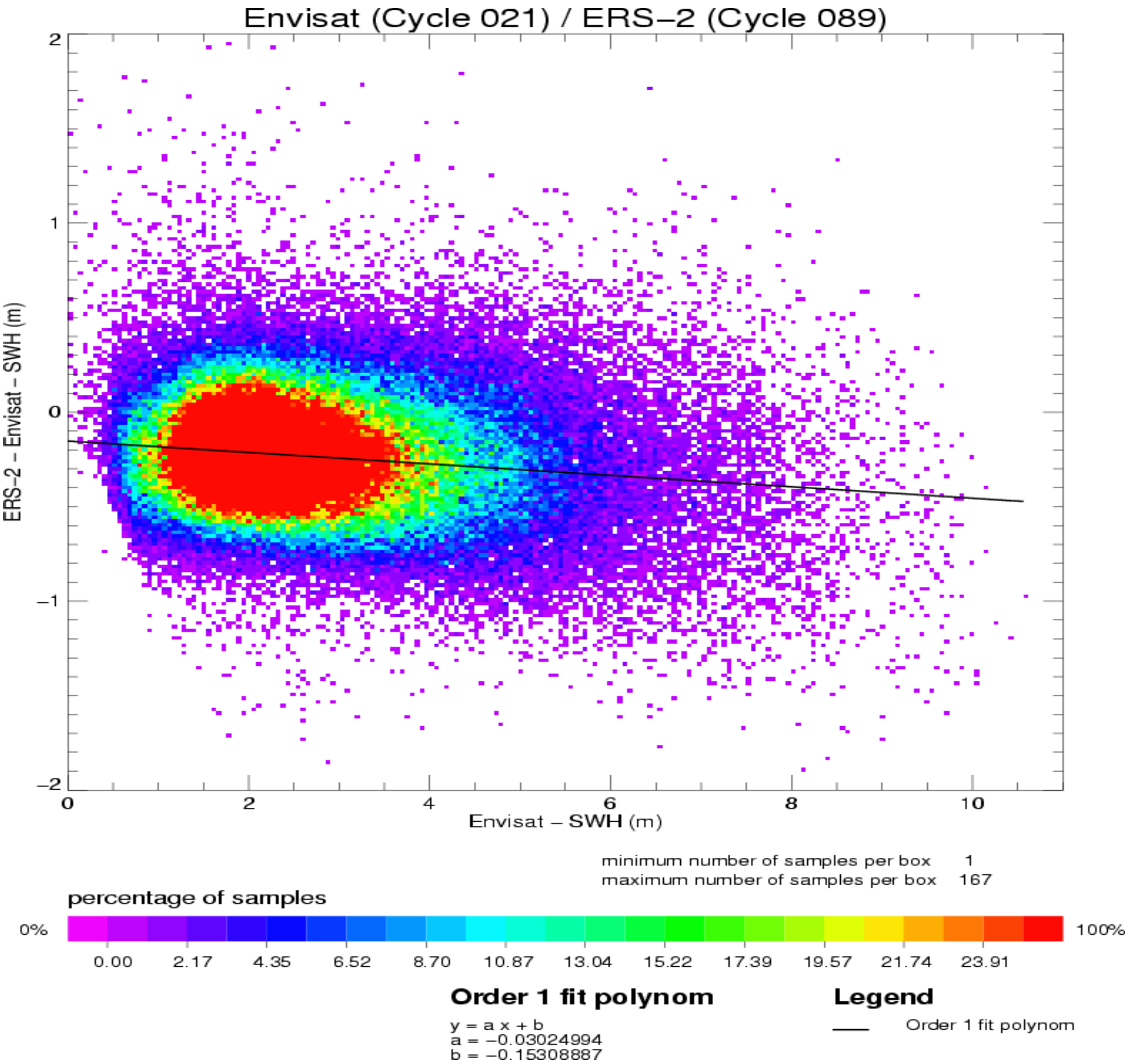
Envisat flies on the same ground track as ERS-2, 30 minutes ahead. This section presents results that illustrate the difference with ERS-2.
A failure of the ERS-2 tape recorder occured on 22 June 2003. The ERS-2 Low Rate mission continues within the visibility of ESA ground stations over Europe: North Atlantic, Arctic and western North America. Nevertheless, cross calibration with ERS-2 can be performed on this zone. Envisat cycle 021 data are collocated to data from ERS-2 GDR cycle 088 in order to compare the main parameters from repeat-track analysis.

5.1 [ERS-2 - Envisat] Ku SWH differences

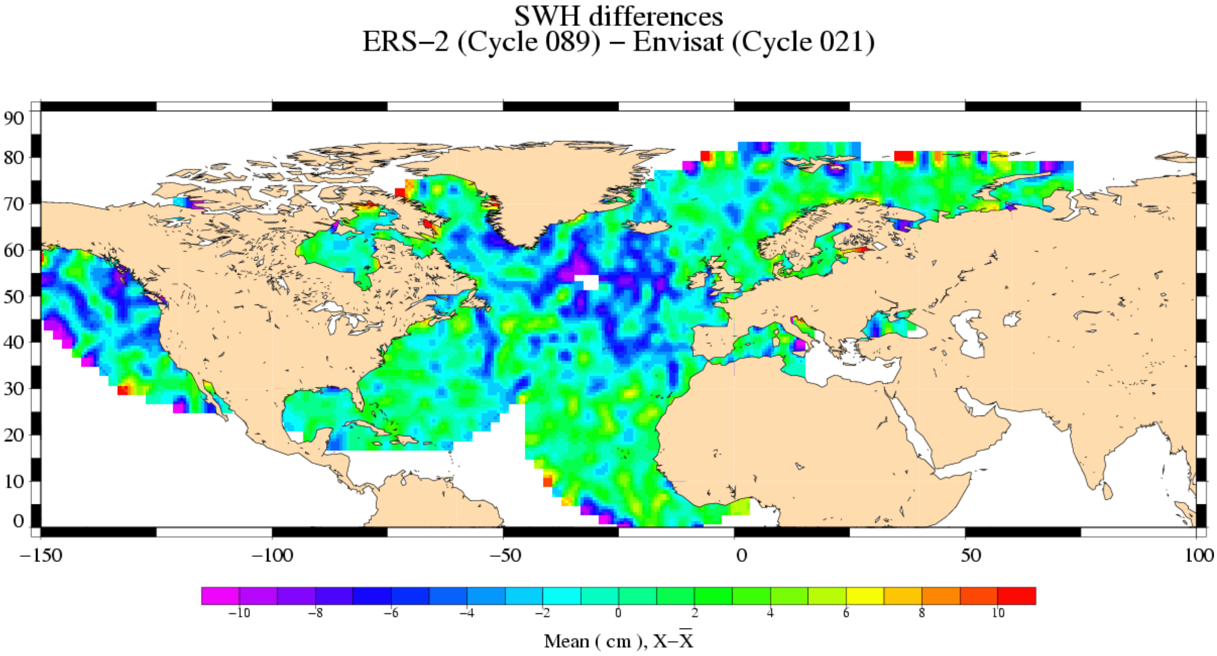
Global statistics of [ERS-2 - Envisat] Ku SWH differences are (cm):

Number	Mean	Std. dev.
170850	-22.63	27.77

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


Envisat (Cycle 021) / ERS−2 (Cycle 089)
ERS-2 – Envisat – SWH (m)
Envisat – SWH (m)
minimum number of samples per box 1
maximum number of samples per box 167
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 = −0.03024994
b = −0.15308887
Legend
Order 1 fit polynom

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

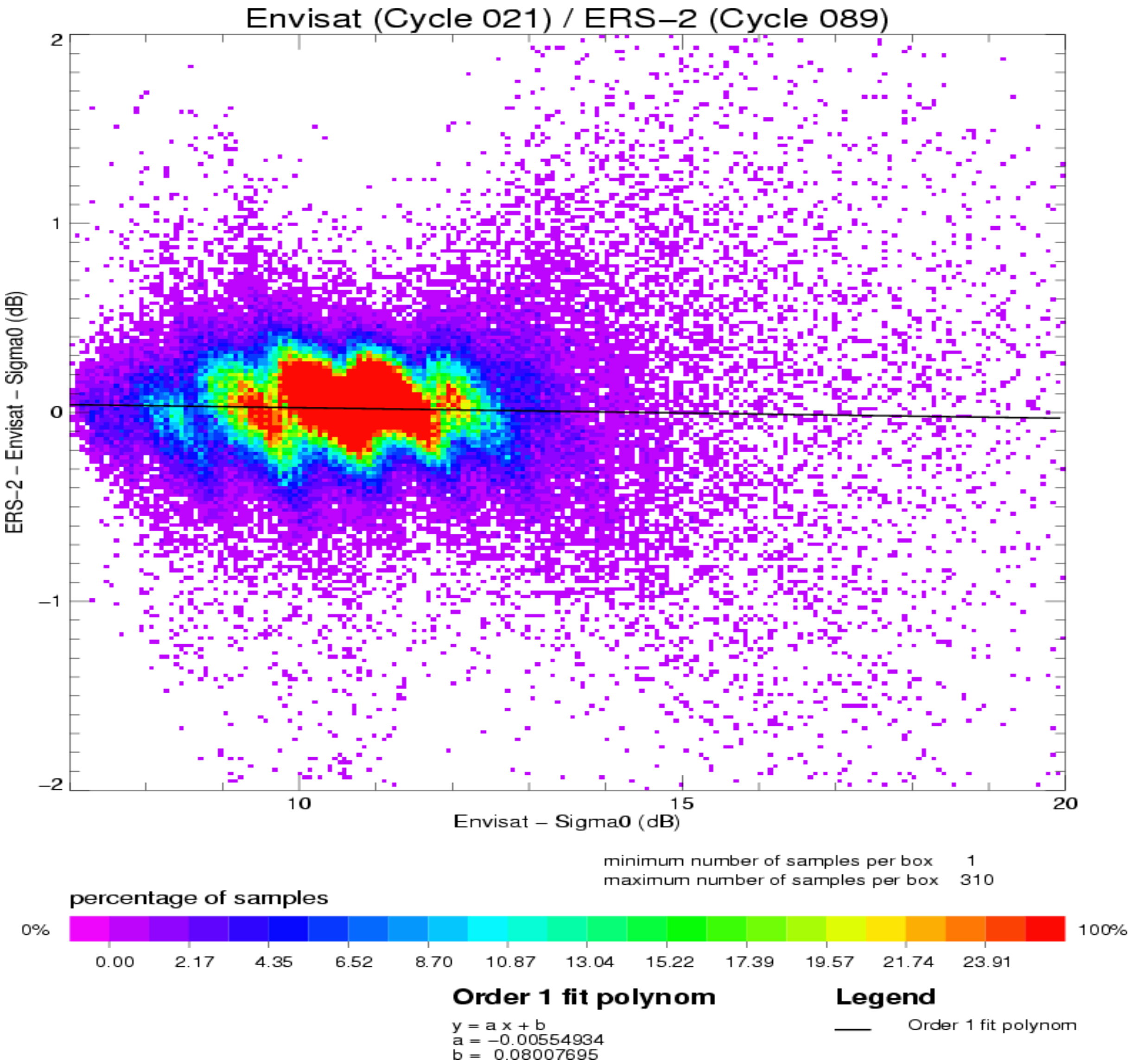


5.2 [ERS-2 - Envisat] Ku Sigma0 differences

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

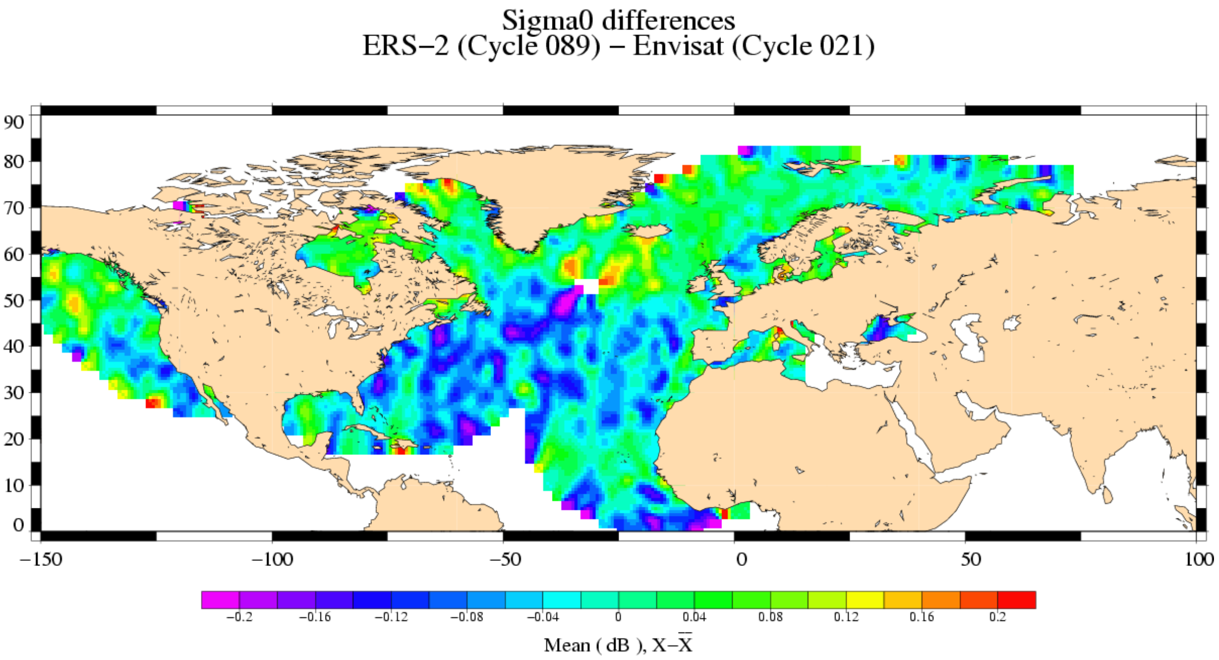
Number	Mean	Std. dev.
170850	0.03	0.28

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).

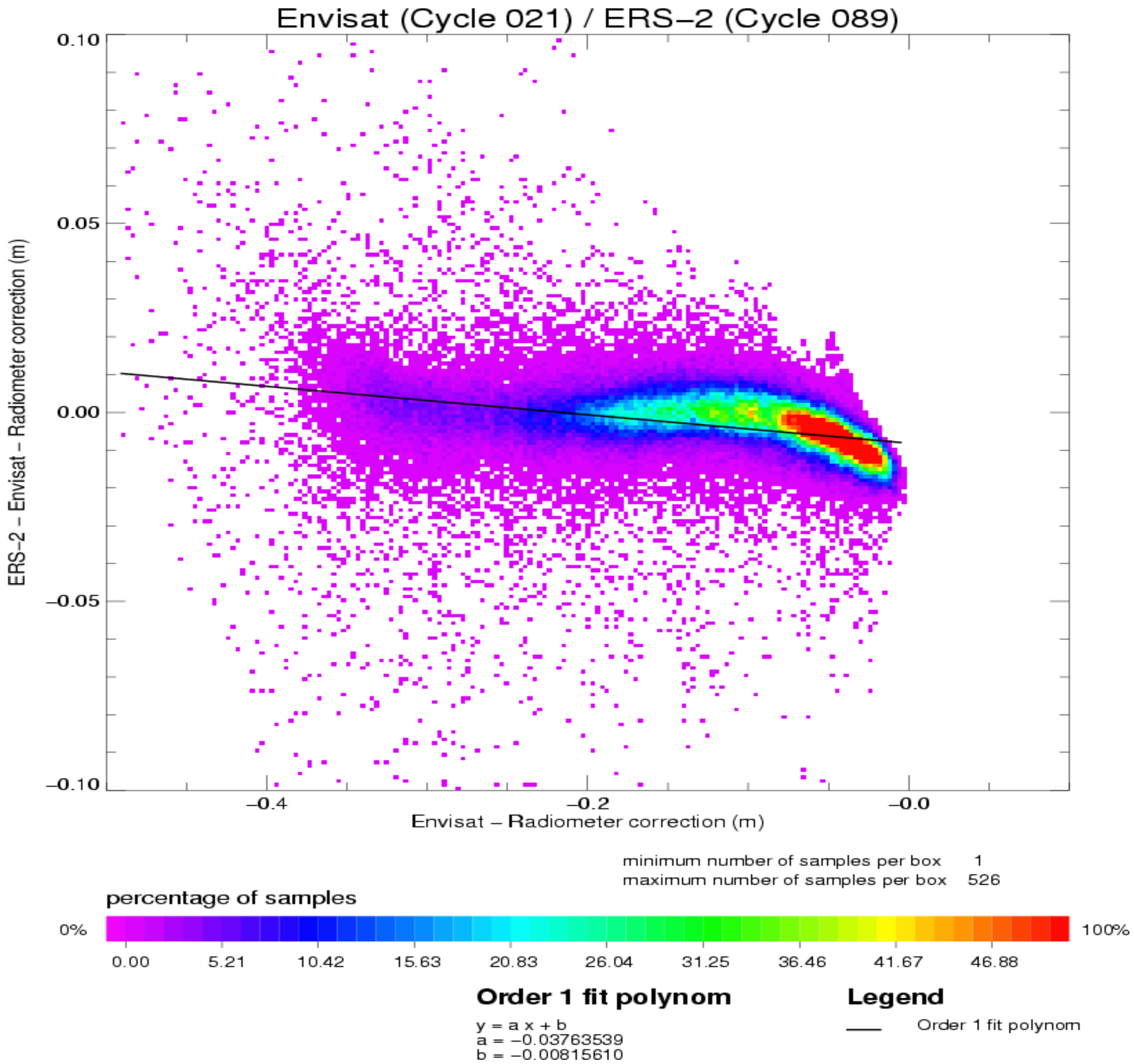


5.3 [ERS-2 - Envisat] radiometer wet troposphere correction differences

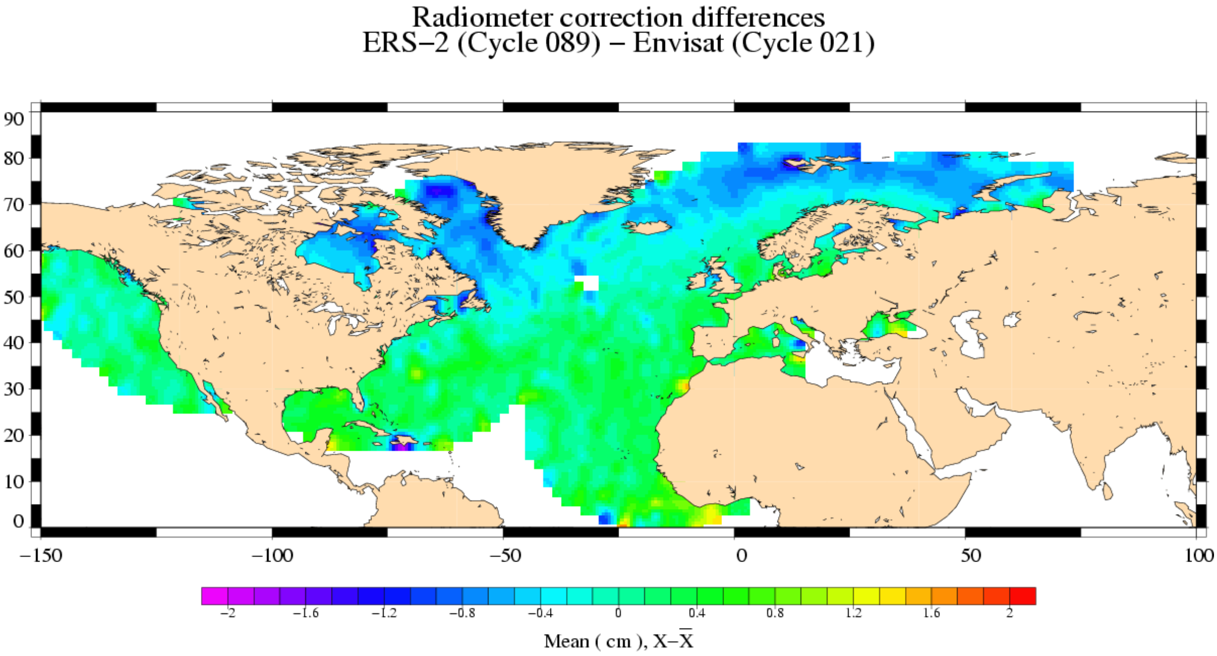
The ERS-2 radiometer correction is recomputed to correct the gain drop and the drift of the 24 GHz brightness temperature (Obligis et al., 2003).
Global statistics of [ERS-2 - Envisat] radiometer wet troposphere correction differences are (cm):

Number	Mean	Std. dev.
170850	-0.33	0.90

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

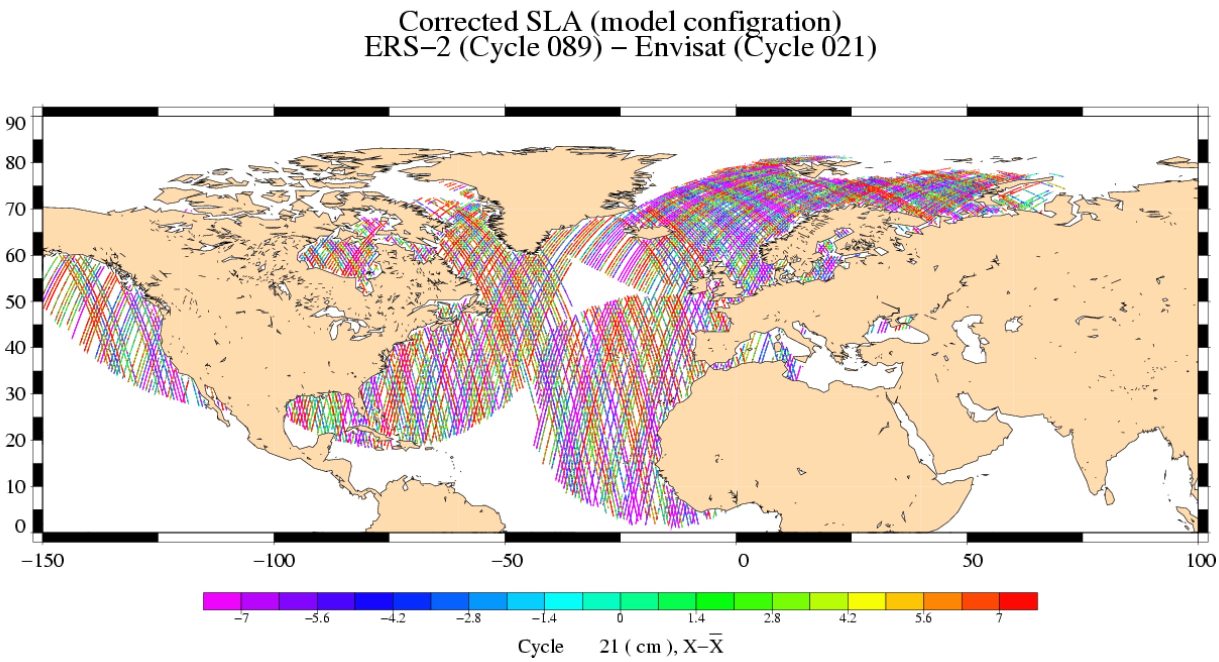
In order to compare the ERS-2 SSH with the Envisat SSH, ERS-2 GDRs have been updated with algorithms and corrections similar to Envisat:
- Range corrected from SPTR, USO, time tag bias
- ECMWF wet tropospheric correction
- Model dry tropospheric correction
- 3-parameters sea state bias
- Inverted barometer 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 088, 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.
170618	-35.30	9.19

These SSH differences are plotted on the following figure.



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