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Title : **IDEAS – Report on the ENVISAT 2010+ Mini-commissioning and Cal/Val Phase for RA2 System**

Abstract : The scope of this document is to provide an overview of the monitoring and Cal/Val results of the mini-commissioning phase for the RA2 System.

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Approval : **Pierre Femenias (ESA)**

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AMENDMENT POLICY

This document shall be amended by releasing a new edition of the document in its entirety. The Amendment Record Sheet below records the history and issue status of this document.

AMENDMENT RECORD SHEET

ISSUE	DATE	DCI No	REASON
1.1	17 January 2011		First draft

1. INTRODUCTION

Starting from 22 Oct 2010 the ENVISAT satellite was placed in a new orbit, 17.4 km lower than the original one, and a new mission phase (E3) was initiated allowing to save fuel and operate all payloads up to end of 2013 and to maintain orbit manoeuvre capabilities afterwards. The fuel saving will be realized in this new mission phase via the termination of the inclination control manoeuvres at the price of a drifting Mean Local Solar Time (MLST).

The new ENVISAT orbit scenario represents the start of a “new” mission for all payload instruments with significantly changed orbit parameters. Therefore a re-characterization (mini-commissioning) of each system has to be performed. The impact of these changes on the various ENVISAT instruments is variable depending on the different measurement techniques, viewing geometries and processing assumptions.

A mini-commissioning phase was designated to provide a validation of the measurements from ENVISAT, and of the functioning of the Fast Delivery Processing chain. IDEAS has provided the coordination of the reporting, but many Expert Support Laboratories have contributed to the mini-commissioning phase activities. It was agreed that the analysis of data would include data up to the end of cycle 97 (26 December)

1.1 Purpose and scope

This document provides the final report on the calibration/validation activities on the ENVISAT altimeter system, and incorporates results from Expert Support Laboratories (ESLs) and from IDEAS.

The report provides summaries of the full analyses provided in weekly and then bi-weekly reports. A full report listing is provided in an annex.

Activities included geophysical calibration and validation of the fast delivery products, and the verification of the Instrument Processing Facility (IPF) in producing fast delivery data products. Figure 1 describes the commissioning phase organisation for the Envisat Altimetry System.

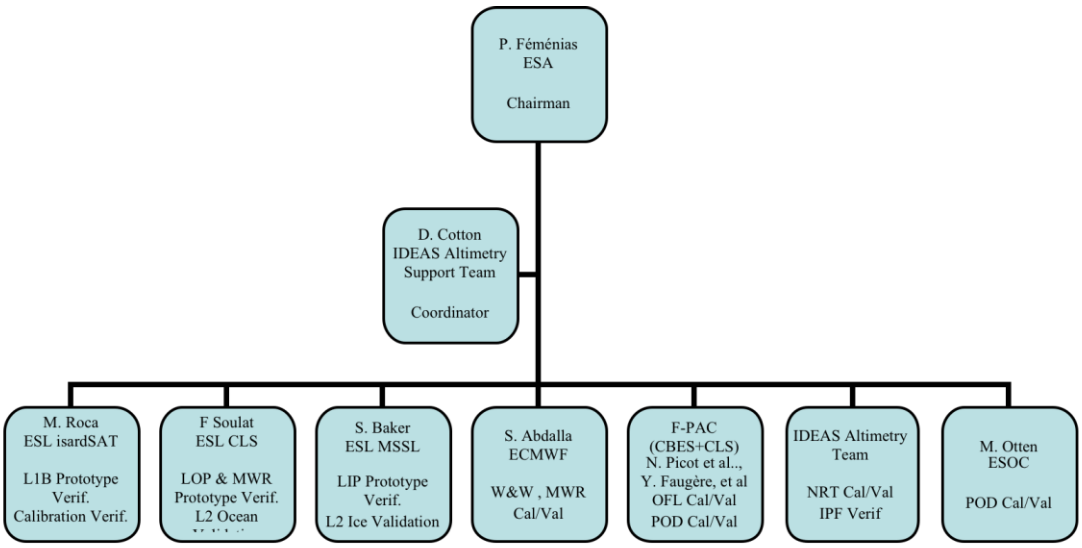


Figure 1: Envisat 2010+ Mini Commissioning Phase Organisation.

1.2 Structure of the Document

The document is divided into a number of major sections that are briefly described below:

Section 2: Overview E2010+ mission extension

Section 3: RA2 Overview, Products availability, and IPF information

Section 4: RA2 System Geophysical Validation

Section 5: IPF Verification

Section 6: Summary

1.3 Referenced Documents

The following is a list of documents with a direct bearing on the content of this report. Where referenced in the text, these are identified as RD.n, where 'n' is the number in the list below:

RD.1 **ENVISAT 2010+ Orbit Change Operations Plan v 0.3, 20/05/2010**

RD.2 **ENVISAT 2010+ Commissioning Phase Altimetry CalVal Plan v1.0 01/11/2010**

RD.3 **ESL Support to the ENVISAT 2010+ Commissioning Phase report: RA-2, CLS, v.2.2, 14/01/11, Ref: CLS-DOS-NT-10-261**

RD.4 **ESL Support to the ENVISAT 2010+ Commissioning Phase report: RA2-MWR, CLS, 17/01/11, 6rev0, Ref: CLS-DOS-NT-10-270**

RD.5 **Envisat IGDR Quality Assessment Report 14th January, 2011, FPAC**

RD.6 **ECMWF Report on ENVISAT RA-2 for Week XX, 2010/11. Weekly reports.**

RD.7 **ECMWF Report on ENVISAT RA-2 for November 2010**

RD.8 **E2010+ RA2 Mini-commissioning Phase 3 – IDEAS QC Final Report, 18 January 2011, Reference IDEAS-SER-OQC-REP-0733**

RD.9 **ENVISAT 2010+ Commissioning Phase RA-2 LIP Final Report, MSSL, 14/01/2011, Doc ID PO-RP-MSL-RA-2010-F**

RD.10 **5th Report on ENVISAT 2010 De-Orbiting RA2 L0 and L1b, IsardSAT, 12/01/2011, Ref ISARD_ESA_L1B_ESL_MCP_TN_078**

1.4 Definitions of Terms

The following terms have been used in this report with the meanings shown.

Term	Definition
ADF	Auxiliary Data File
CFI	Customer Furnished Item
CTI	Configurable Transfer Item
ESL	Expert Support Laboratory
EO	Earth Observation
EOM	End Of Mission
EOP	Earth Observation Program department
EOP-GQ	EO Data Quality & Algorithms Management Office
ESA	European Space Agency
ESOC	European Space Operation Centre
ESRIN	European Space Research Institute
ESTEC	European Space Technology Centre
FOCC	Flight Operations Control Center
FOS	Flight Operations Segment
IDEAS	Instrument Data quality Evaluation and Analysis Service
IOP	In-Orbit Performance
IPF	Instrument Processing Facility
ISP	Instrument Source Packet
NRT	Near Real Time
OCM	Orbital Control Manoeuvre
OCR	Orbit Change Request
OSDF	Orbit Sequence Definition File
PDGS	Payload Data Ground Segment (excluding Product Quality control Service) Synonym of PDS
PDS	Payload Data Segment (excluding Product Quality control Service) Synonym of PDGS
PLSO	(ESTEC) Post Launch Support Office
QC	Quality Control
QWG	Quality Working Group
RGT	ROP Generator Tool
ROP	Reference Operation Plan
TDS	Test Data Set

2. ENVISAT ORBIT LOWERING

2.1 Mission extension strategy

The ENVISAT extension orbit was implemented through an altitude decrease of 17.4 km and via the interruption of the inclination control manoeuvres in order to save fuel. The new orbit is characterized by a different repeating cycle, going from the actual 35 days/501 orbits to 30/431, and by a drifting MLST that will be vary in the +/- 10 min range, while now it is maintained in the +/-5 min range. This is depicted in the figure below.

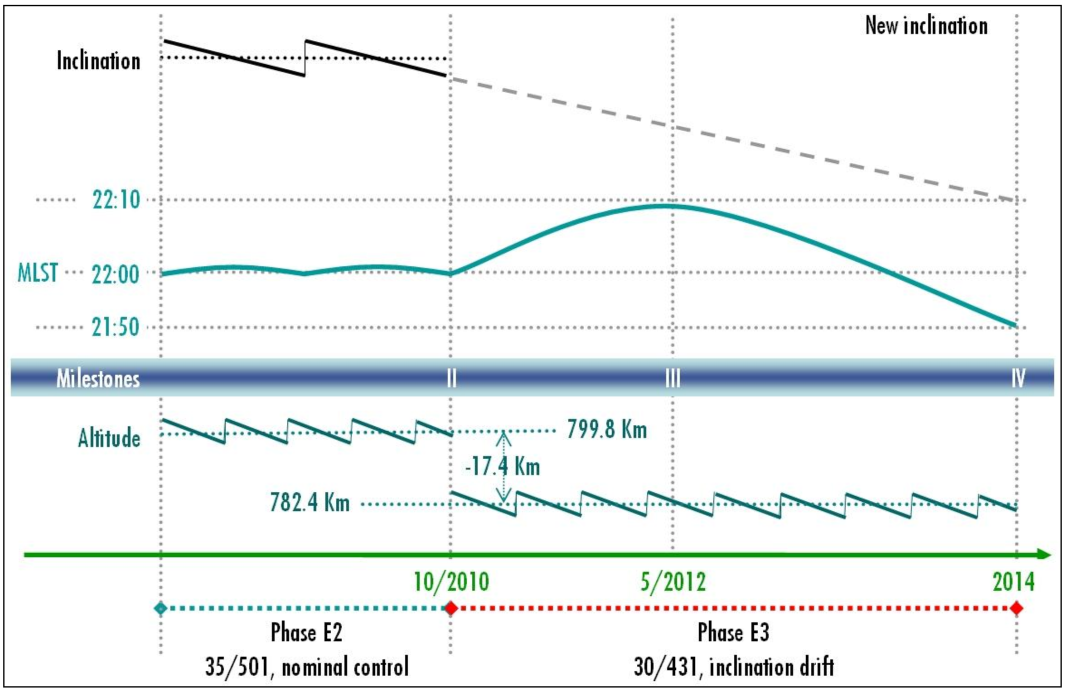


Figure 2: Envisat 2010+ selected Orbit Control Strategy; from RD.1.

2.2 Orbit lowering status

The first two critical steps of the ENVISAT orbit lowering manoeuvre were successfully completed during 22 – 26 Oct 2010 and all payloads were slowly switched back on starting on 27 October. Further details can be found at the following web page:

http://www.esa.int/esaCP/SEMEZX1PLFG_index_0.html

Between 22 October and 02 November ENVISAT was in Yaw Steering Mode (YSM). Since 2 November, 10:25 UTC, ENVISAT is in Stellar Yaw Steering Mode (SYSM), which is the nominal mode of operations. Since 4 Nov 2010 ENVISAT was moved into the final orbit corresponding to the new scenario of the mission phase 3.

Table 1 – ENVISAT orbit lowering manoeuvres.

Time	Mode	PSO [deg]	Target size [m/s]	Nominal size [m/s]	Calibrated size [m/s]
First burn 2010/10/22 06:50:00	OCM	78.973	2.5	-2.5	2.4797
Second burn 2010/10/22 09:20:44	OCM	258.973	-2.5	-2.5	-2.4784
Third burn 2010/10/26 14:00:00	OCM	313.943	-2.012	-2.0120	-2.0294
Fourth burn 2010/10/26 16:30:26	OCM	133.943	-2.012	-2.0120	-2.0109
Fifth burn 2010/11/04 20:40:27	SFCM	58.006	-0.02	-0.0203	-0.0204
Sixth burn 2010/11/04 21:30:32	SFCM	238.006	-0.02	-0.0203	-0.0204

2.3 ENVISAT Cycle Numbering

As a consequence of the orbit change the cyclic period was changed from the previous 35 days to 30 days (thought not exactly repeating). An agreed numbering of cycles was established, as described in below. Note that two short cycles have been introduced immediately before and after the orbit change, with the first full cycle of Phase 3 starting on 21:57 on 27th October 2010. Most of the geophysical calibration and validation will concentrate on data from cycles 96 and 97.

Table 2 – ENVISAT Cycle Numbers during and after the orbit change.

Phase	Cycle	First Orbit	Last Orbit	Start	UTC	REL start orbit	REL Stop orbit	Tot Orbit
2	*93*	*44644*	*45144*	*13-Sep-10*	*21:59:59*	*1*	*501*	*501*
2	*94*	*45145*	*45221*	*18-Oct-10*	*21:59:59*	*1*	*77*	*77*
3	95	45222	45273	24-Oct-10	07:05:25	380	431	52
3	96	45274	45704	27-Oct-10	21:57:36	1	431	431
3	97	45705	46135	26-Nov-10	21:58:25	1	431	431

3. RA2 INSTRUMENTS AND PRODUCTS

3.1 Instrument and products availability

In this section we summarise the mission planning and availability of instrument and products.

3.1.1 Instrument Planning

The planning for the RA2 system was that all altimeter instrumentation (RA2, DORIS and MWR) should remain switched on throughout the orbit change manoeuvres.

3.1.2 Instrument and Products availability

Instrument and products availability are summarised in Tables 3 to 5. The first two rows of each table correspond to cycles 94 and 95. Starting from Cycle 96 (27/10/2919) statistics are calculated on a 6-day basis to align with statistics from other ENVISAT instruments.

It can be seen that the RA2 and DORIS instruments remained switched on and 100% available throughout the period covered. The MWR instrument was not available for a large part of cycle 94 and some of cycle 95, but has been fully available since.

Similarly availability of Level 0 products (RA2 > 97%), (MWR > 96%), (DORIS > 92%), Level 1b products (> 97%) and Level 2 FGDR products (> 97%) has remained high since the beginning of cycle 96 (27th October).

Table 3 – ENVISAT RA-2 L0, L1b and L2 FGD Data products availability summary

Date start	Date stop	Inst. Unav Time (sec)	Data Unav Time (sec)	Time L0 gaps (sec)	Time L1b gaps (sec)	Time L2 FGD gaps (sec)	Inst. Avail %	Data Avail %	L0 Avail %	L1b Avail %	L2 FGD Avail %
18/10/2010	24/10/2010	0	33156	33156	72892	72907	100	90.24	90.24	77.27	77.27
24/10/2010	27/10/2010	0	80743	80743	135470	135476	100	73.18	73.18	49.10	49.10
27/10/2010	02/11/2010	0	5275	5275	5301	5315	100	98.98	98.98	98.97	98.97
02/11/2010	08/11/2010	0	906	906	906	916	100	99.82	99.82	99.82	99.82
08/11/2010	14/11/2010	0	909	909	909	924	100	99.82	99.82	99.82	99.82
14/11/2010	20/11/2010	0	4911	4911	4913	4926	100	99.22	99.22	99.22	99.22
20/11/2010	26/11/2010	0	6276	6276	6278	6288	100	98.72	98.72	98.72	98.72
26/11/2010	02/12/2010	0	11865	11865	11866	11878	100	97.7	97.7	97.70	97.70
02/12/2010	08/12/2010	0	9634	9634	9637	9653	100	98.14	98.14	98.14	98.14
08/12/2010	14/12/2010	0	10230	10230	10231	10247	100	98.02	98.02	98.02	98.02
14/12/2010	20/12/2010	0	906	906	906	914	100	99.82	99.82	99.82	99.82
20/12/2010	26/12/2010	0	816	816	816	825	100	99.88	99.88	99.88	99.88

Table 4 – MWR L0 Data products availability summary

Date start	Date stop	Inst. Unav Time (sec)	Time L0 gaps (sec)	Instrument Availability %	L0 Availability %
18/10/2010	24/10/2010	247157	0	6.73	6.73
24/10/2010	27/10/2010	18540	117630	93.84	60.95
27/10/2010	02/11/2010	0	4657	100	99.02
02/11/2010	08/11/2010	0	360	100	99.94
08/11/2010	14/11/2010	0	336	100	99.94
14/11/2010	20/11/2010	0	4368	100	99.11
20/11/2010	26/11/2010	0	6745	100	98.88
26/11/2010	02/12/2010	0	11039	100	97.86
02/12/2010	08/12/2010	0	16752	100	96.77
08/12/2010	14/12/2010	0	8040	100	98.45
14/12/2010	20/12/2010	0	4200	100	99.19
20/12/2010	26/12/2010	0	6144	100	98.81

Table 5 – DORIS L0 Data products availability summary

Date start	Date stop	Inst. Unav Time (sec)	Time L0 gaps (sec)	Instrument Availability %	L0 Availability %
18/10/2010	24/10/2010	0	43993	100	83.4
24/10/2010	27/10/2010	0	114094	100	64.35
27/10/2010	02/11/2010	0	33343	100	93.6
02/11/2010	08/11/2010	0	28622	100	93.76
08/11/2010	14/11/2010	0	26467	100	94.89
14/11/2010	20/11/2010	0	38660	100	95.54
20/11/2010	26/11/2010	0	39634	100	92.31
26/11/2010	02/12/2010	0	35933	100	93.06
02/12/2010	08/12/2010	0	38570	100	92.56
08/12/2010	14/12/2010	0	36023	100	93.05
14/12/2010	20/12/2010	0	29642	100	94.28
20/12/2010	26/12/2010	0	29970	100	94.22

During cycle 94 main issues were:
• All data missing on 21/10/10 from ESRIN station due to K2-band antenna failure.
• MWR data unavailability starting from 19/10/10 03:00 UTC (orbit #45147) to 25/10/10 11:56 UTC (orbit #45236)

During cycle 95:
• MWR data unavailability ended on 25/10/10 11:56 UTC (orbit #45236)

During period 27/10 – 2/11:
• RA2 Level 0 and MWR: one orbit missing on 29/10/10 12:50-13:52

During period 2/11 – 8/11:
• RA2 Level 1b and Level 2: missing production on 03/11/10 starting from 22:30 due to problem with meteo files format
• MWR: one orbit missing on 07/11/10 4:32-6:12

• RA2 Level 1b and Level 2: production blocked 03/11/10 22:30 – 05/11/10 20:00 and 08/11/10 11:45 – 09/11/10 3:17 due to wrong meteo files format. All files have been reprocessed on 09/11/10

During week 14/11 – 20/11 main issue has been:
• All products: one orbit #45550 missing on 16/11/10 between 04:33 and 05:43 due to acquisition problem in ESRIN station.

During week 20/11 – 26/11 main issue has been:
• MWR and RA2: one orbit #45680 missing on 25/11/10 between 05:25 and 06:53 due to acquisition problem in ESRIN station.

During cycle 97 main issues have been:
• All products: orbits 45748-45750 30/11/10 not acquired due to a scheduling problem occurred @Esrin due to an anomaly on Pas system;
• All products: one orbit 45790@ES on 02/12/10 not acquired due to ARTEMIS unavailability;
• All products: one orbit #45961 lost due to KIR antenna problem on 14/12/10;
• Orbits missing on 05/12/10 between #45821@ES and 45823@ES

3.2 Processing Software information

In this section we list the versions of IPF used during this period, and give the dates of any updates

- Level 0 products during reporting period were processed using E-XTPS v4.504

- Near Real Time Level 1b and Level 2 products during current reporting period were processed with IPF v6.03 (compliant with new ENVISAT orbit) on the Linux chain installed both in PDHS-E and PDHS-K.

- Intermediate and consolidated L1b products are generated with the IPF Processing chain V6.04, and level 2 products with CMA reference software V9.3_05

- Two auxiliary files have been updated on 29/11/10 for the computation of ice slopes over Antarctica and Greenland for the new ENVISAT orbit geometry (RA2_SL1_AX and RA2_SL2_AX).

- The static auxiliary files actually used by the IPF ground segment processing are reported in Appendix 1, with updated RA2_SL1_AX and RA2_SL2_AX.

4. PRODUCT VALIDATION

4.1 CLS RA2 Report

Authors: Stephanie Urien, Francois Soulat

Reference Document RD.3

4.1.1 Introduction

This section provides a summary of the results from the validation activity carried out by CLS for ESA as an Expert Support Laboratory. The full report is provided in RD.3

All parameters related to the altitude, to the altimeter measurement and to the radiometer were analyzed using statistical and visualization tools. In particular, a special attention is paid to the main following parameters:

- Orbit parameters (altitude, altitude rate)
- Doppler correction (depends on the altitude rate), Tracker Range, Distance Antenna-COG
- Tracking capabilities
- Ku-band altimetric parameters (range, SWH, sigma0, square mispointing)
- SSH
- Sea State Bias

This validation uses a small set of data since no long-term validation is planned, as agreed with ESA

Ice related data were also analyzed. The four parameters provided by the ICE-2 algorithm (altitude, sigma0, leading edge slope and trailing edge slope) were checked and validated.

4.1.2 Ocean Surfaces

The validation addressed the following measurements data sets:

- **26/10/10**: RA2_FGD_2PNPDK20101026_080108_000055423095_00409_45251_4957.N1
- **27/10/10**: RA2_FGD_2PNPDK20101027_104218_000059283095_00425_45267_5237.N1
- **28/10/10**: RA2_FGD_2PNPDK20101028_100718_000055583096_00008_45281_5518.N1
- **29/10/10**: RA2_FGD_2PNPDK20101029_093110_000059203096_00022_45295_5848.N1

The following main parameters were monitored:

- Altitude
- Altitude rate
- 18-Hz Ku-band tracker range referenced to the CoG
- Ku-band ocean range
- 18-Hz Ku-band ocean ranges
- 18-Hz Ku-band range instrumental corrections
- 18-Hz Ku-band Doppler correction
- Ku-band SSB correction
- Ku-band SWH
- Square of the off-nadir angle
- MWR derived wet tropospheric correction

The analysis showed that all monitored parameters demonstrated nominal behaviour

The full set of figures are not reproduced here, but are available in RD3

4.1.3 Ice Surfaces

Validation of cycle 96 over ice surface

CLS applied the same validation chain on the IGDR records of cycle 96 as has been used for analysis of earlier data. We look at the statistics at the cross-over points, e.g., the difference between ascending and descending points for the four ice-2 algorithm parameters. These parameters are the height (H), the backscattering (Bs), and two waveform parameters: the leading edge width (lew) and the trailing edge slope (Tes). More information about this validation chain can be found on the Oscar web site (http://oscar.legos.obs-mip.fr/).

Figure 3 (left panels) shows the histogram of the four parameters. The statistics are exactly the same than for the cross-over points of previous cycles.

Figure 3 right panels shows the r.m.s of each parameter with respect to the slope. In average, they increase with the slope amplitude in a same manner than previously observed.

Figure 4 shows the map over Antarctica over the difference at cross-over. The geographical signal that can be observed (mostly at low latitude near the ice sheet periphery) is due to the antenna polarisation. Indeed, the ice surface exhibits anisotropic structures due to the katabatic winds that affected the observation in function of the local orientation of the antenna polarisation. These patterns are also the same as previously observed.

We have also investigated the cycles before the new orbit (92 and 93) and 97 and have the same conclusions about the conformity of the statistics.

Conclusions

To conclude, up to now, with this preliminary analysis, we can say that the statistics of the cycle 96 are the same than for previous ones.

To go further, we propose also to investigate an inter-cycle analysis, e.g. to compare ascending tracks of cycle 96 with descending tracks of previous cycles (and inversely). This would be the opportunity to look at the impact of the altitude change over a sloping surface, the slope error being proportional to the altitude.

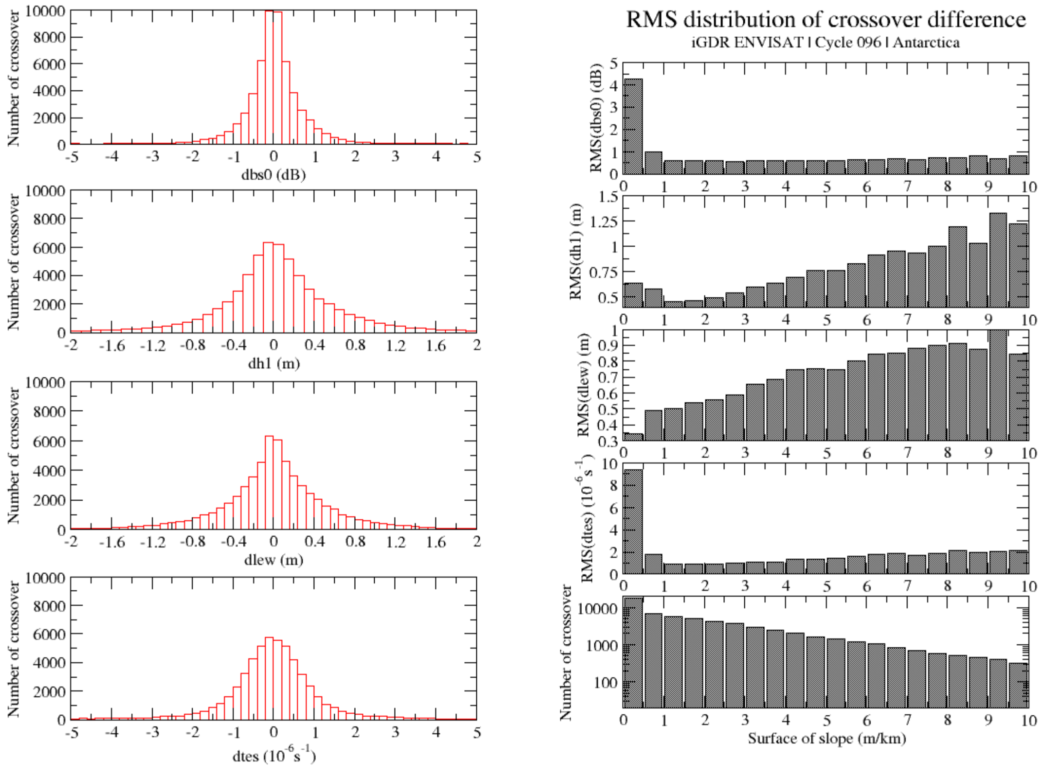


Figure 3: Left: Histograms of crossover difference over Antarctica for ENVISAT cycle 096. Backscatter (top), Surface height, Leading edge width, Trailing edge slope. Right: RMS **distribution of crossover difference versus the surface slope over Antarctica for ENVISAT cycle 096. Backscatter (top), Surface height, Leading edge width, Trailing edge slope and crossover number.**

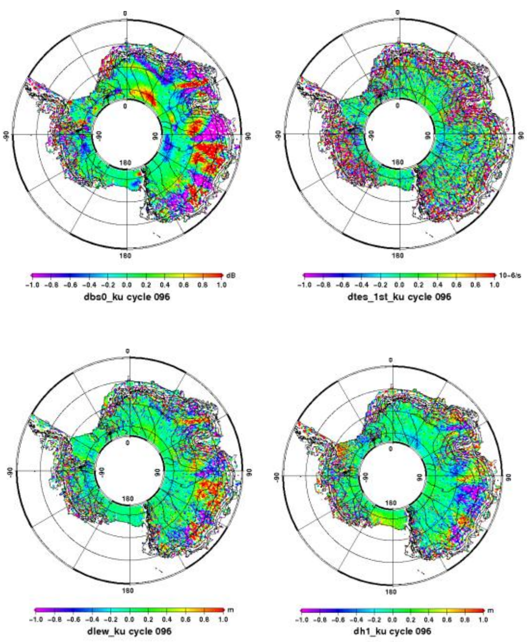


Figure 4: Crossover difference (ascending/descending) of ICE-2 parameters for cycle 96 over Antarctica. Backscatter (top left), Trailing edge slope (top right), Leading edge width (bottom left) and Surface height (bottom right).

4.2 CLS MWR Report

Authors: B. Picard, J-R Deboer, M-L Frery, E. Obligis

Reference Document RD.4

4.2.1 Introduction

This report summarises the activities carried out as a support to the Envisat 2010+ Commissioning Phase, and the results of the analysis.

This report aims at delivering a quality check of the RA2-MWR radiometer data, from L0 to L2. This validation uses a small set of data since no long-term validation is planned, as agreed with ESA.

4.2.2 Level 0 Parameters

A pseudo-periodic signal (maximal observed period of almost 20-days, peak-to-peak amplitude of less than 2 counts) has been distinguished on the 23.8 GHz hot counts until begin of December. After this phenomenon, the 23.8 GHz hot counts signal converges and seems yet stabilized at 547.5 counts.

Concerning the 36.5 GHz hot counts, a slow decrease of about 2 counts is seen during the first week. For the last data available, it seems that this decrease rapidly rose to about 3.5 counts to next tend to stabilization.

Table 6 – Trends on Physical Temperatures

Element	Stabilized?	bias
IF	Yes	+0.5 K
LO	Yes	+0.0 K
Mixer	Yes	+0.0 K
Receiver	Yes	+0.2 K
Dicke Load	Yes	-0.1 K
Dicke Switch	Yes	-0.1 K
Hot Load	Yes	-0.1 K
Sky Horn	Yes	+0.2 K
Hot/Cold Switch	Yes	0.0 K
Ant/Cal Switch	Yes	0.0 K
Reflector Temperature	Yes	+5.5 K

An increase of more than 6 counts have been seen on the 23.8 GHz cold counts until begin of December. Since this phenomenon, it seems that the 23.8 GHz cold counts signal tends to stabilization with an increase of approximately 1 count.

There is not yet stabilization for the 36.5 GHz cold counts and the counts have been decreased by about 25 counts. This decrease can be explained through the previously observed drift existing on the 36.5 GHz cold counts data.

The above table sums up the trends observed on the physical temperature. Note that the receiver temperature seems to be stabilized at a level larger of +0.2 K than before the manoeuvre, idem for the sky horn temperature. A larger signal is seen on the reflector temperature which seems to be stabilized yet at a level of +5.5 K larger than before the manoeuvre.

Figures of time series are available in the full report (RD.4)

4.2.3 Level 1 Parameters

The validity of estimated gain and residual temperature was checked. A small increase on the 23.8 GHz gain is seen during the first 15 days but it seems to stabilize to the same value recorded during the last few days before the manoeuvre.

A decrease is observed on the 36.5 GHz gain, larger than for the first channel and with no real stabilization yet observable. This decrease can be explained through the previously observed drift existing on the 36.5 GHz gain.

The same pseudo-periodic signal already observed on the 23.8 GHz hot counts can be reported for the 23.8 GHz residual temperature with a peak-to-peak amplitude of about 0.2 K. After this phenomenon, the 23.8 GHz residual temperature signal converges and seems yet stabilized at 0.6 K.

The 36.5 GHz residual temperature has decreased during the first week by about -0.2 K. For the last data available, as in the case of the 36.5 GHz hot counts, it seems that this decrease rapidly rose to about -0.4 K to next tend to stabilization.

Again figures (time series) are available in the full report, RD.4

4.2.4 Level 1B / L2 Parameters

At level 1B the validity of the Brightness Temperature, and Cold Ocean Brightness Temperature was checked, and at Level 2 the Wet Tropospheric Correction, Liquid Water Content and Water Vapour content were checked.

Natural geophysical variability in the measurements means that is not possible yet to draw any clear conclusion on any possible long-term bias on these parameters but it seems that there is no impact on these parameters.

4.2.5 Summary

It was concluded from the analysis that the L0 and L1 RA2-MWR parameters are very close to nominal values and that all instrumental parameters are now stabilised.

No impact of the new orbit on L1B or L2 data could be observed, thus the state of the RA2-MWR is nominal.

4.3 FPAC IGDR Quality Assessment

Authors: A Ollivier, G Valladeau, N Granier

Reference Document RD.5

4.3.1 Introduction

The FPAC IDGR Quality Assessment reports on the major features of data quality within the IGDR products produced since the ENVISAT orbit lowering manoeuvres, and includes:

- Monitoring the quality of relevant geophysical parameters (from altimeter and radiometer) over oceans.

- Monitoring of the RA2/MWR availability over oceans.

The analysis includes all data from cycles 95, 96 and 97, and some early data from cycle 98. We do not include all the figures here, but just the summary information

4.3.2 Coverage

RA2 missing measurements

32 IGDR passes have been delivered for cycle 95 (starting on pass 818) (26 Oct - 27 Nov 2010)

859/862 IGDR passes have been delivered since the beginning of cycle 96 (27 Oct - 26 Nov 2010)

856/862 IGDR passes have been delivered since the beginning of cycle 97 (26 Nov - 26 Dec 2010)

433/433 IGDR passes have been delivered since the beginning of cycle 98 (26 Dec - 11 Jan 2010)

On cycle 96, note that passes 7, 204 and 862 are completely missing and passes 6, 8, 48, 49, 117, 203, 352, 555, 556, 815 and 816 are partially missing.

On cycle 97, 6 passes are completely missing:

- passes 92-93: Scheduling anomaly (telemetry downlink problem)

- 174 acquisition problem at ESRIN

- 237 antenna problem: orbit not acquired at ESRIN.

- 513-514 (14/12) Bad data acquired at Kiruna EOFC

Moreover passes 91, 173, 235 are partially missing.

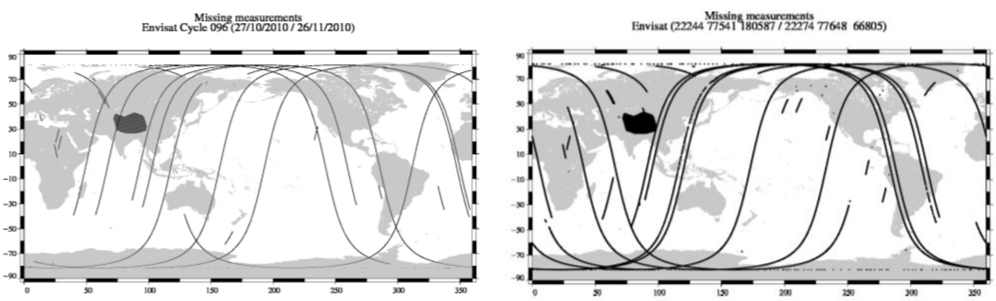


Figure 4: Cycle 96 (left) and cycle 97 (right) maps of RA2 missing measurements.

MWR missing measurements

Cycle 96:

1 pass is entirely edited on radiometer land flag since the beginning of cycle 96.

Pass 613 has no radiometer.

Passes 45, 242, 270, 298 and 614 are partially edited on radiometer land flag

Cycle 97:

Passes 236,238,239 have no radiometer available.

Cycle 98:

So far no passes entirely without radiometer data

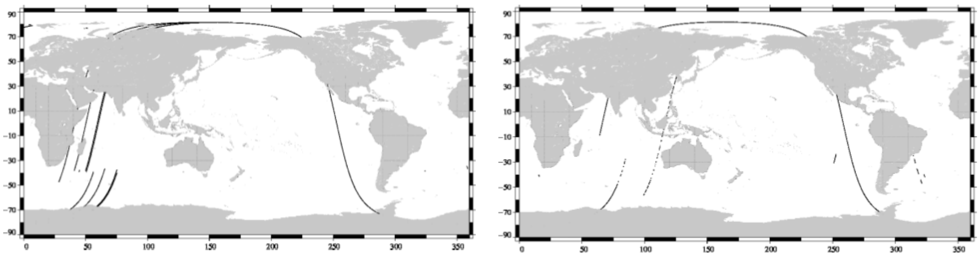


Figure 5: Cycle 96 (left) and cycle 97 (right) maps of MWR missing measurements.

Data Editing

Data were edited according to specified editing criteria (land, ice, data quality flags and thresholds) before inclusion in the analysis. Details are available in RD.5

4.3.3 Altimeter Parameter Monitoring over Ocean

Backscatter Coefficient

Global daily averages of backscatter over the ocean were consistent with values prior to the orbit change, and with those from other missions.

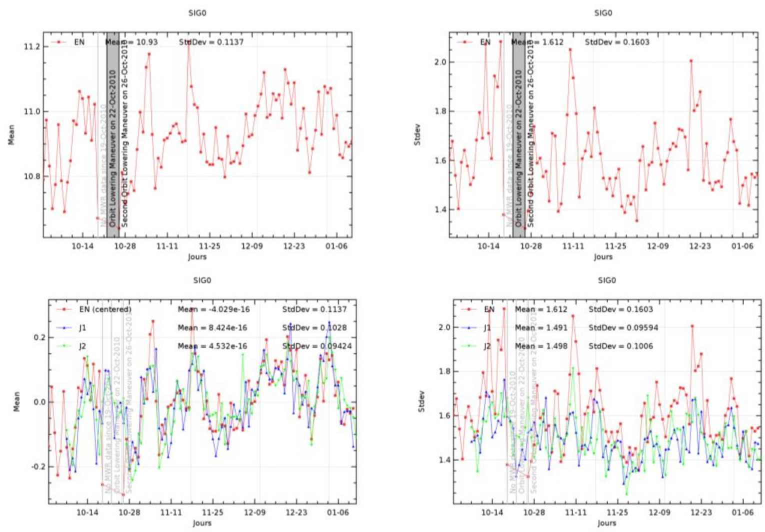


Figure 6: Ocean surface backscatter: Daily Mean (left) and Standard Deviation (right). Lower panels compared against Jason1- and Jason-2

Significant Wave Height

Global daily averages of significant wave height were consistent with values prior to the orbit change, and with those from other missions.

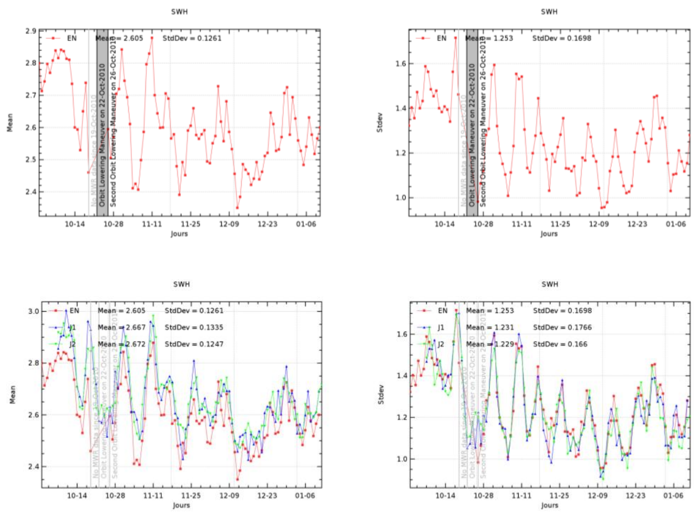


Figure 7: Significant Wave Height: Daily Mean (left) and Standard Deviation (right). Lower panels compared against Jason1- and Jason-2

Wind Speed

Global daily averages of ocean surface wind speed were consistent with values prior to the orbit change, and with those from other missions.

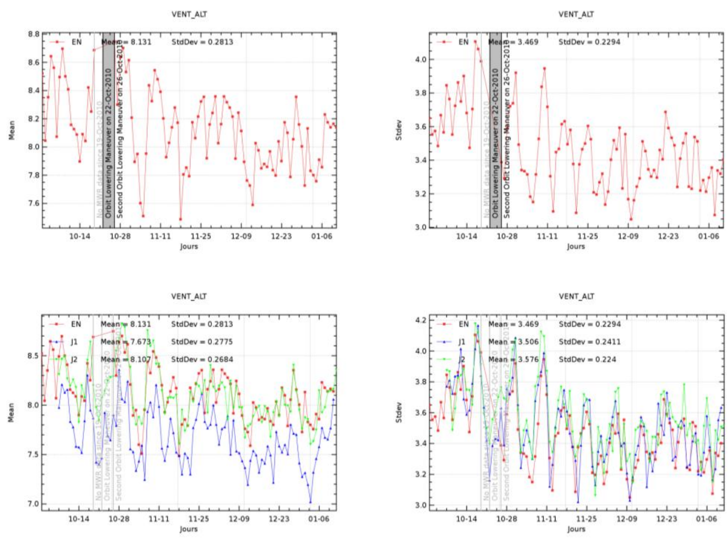


Figure 8: Ocean surface wind speed: Daily Mean (left) and Standard Deviation (right). Lower panels compared against Jason1- and Jason-2

Mispointing

Global daily averages of mispointing indicate a slight reduction after the orbit change, with a small increase after December 26 2010

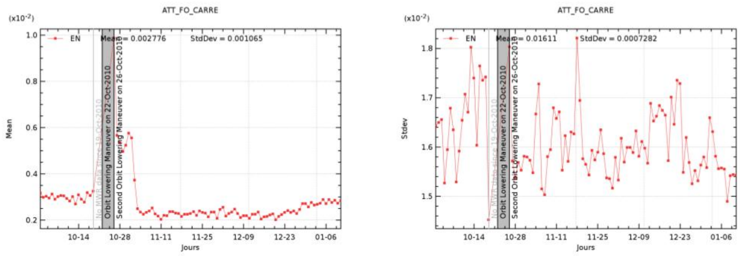


Figure 9: Mispointing: Daily Mean (left) and Standard Deviation (right).

Range

The impact of the orbit lowering can be seen clearly in the daily mean range

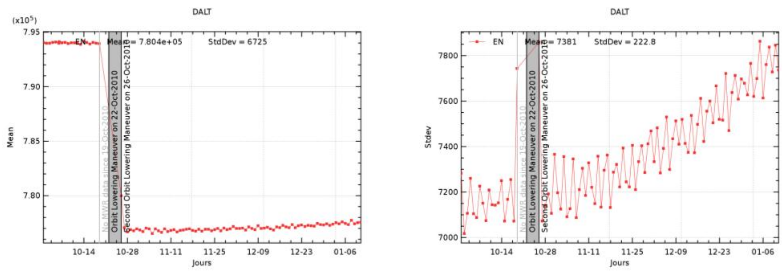


Figure 10 Range: Daily Mean (left) and Standard Deviation (right).

The new orbit results in a maximum latitude that varies from day to day, see figure 12.

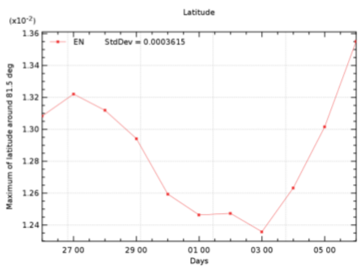


Figure 11 Range: Maximum orbital latitude each day

Corrected Sea Level Anomaly

The Ku Band Sea Level anomaly is calculated from the following terms:

- Ku range (ocean retracking)
- Doris navigator orbit (using the sole interpolated mode)
- GIM model ionospheric correction.
- MWR derived wet troposphere correction
- ECMWF dry tropospheric correction
- Non parametric sea state bias
- Inverted barometer
- Total geocentric GOT00 ocean tide height
- Geocentric pole tide height
- Solid earth tide height
- Mean Sea Surface height (CLS01)

Figure 13 shows the daily variability, and compares against Jason-1 and Jason-2

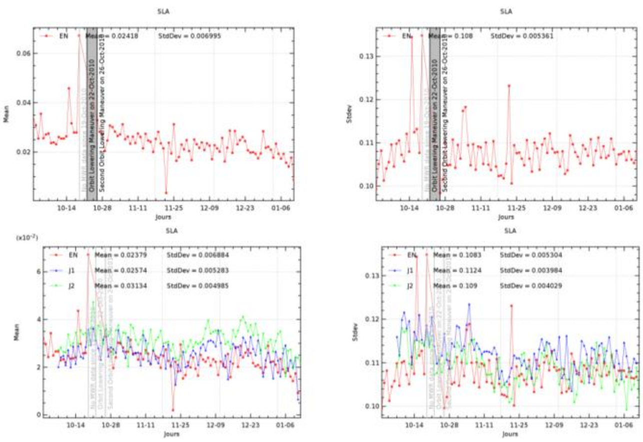


Figure 12: Ku band corrected Sea Level Anomaly: Daily Mean (left) and Standard Deviation (right). Lower panels compared against Jason1- and Jason-2

4.3.4 Radiometer Parameter Monitoring over Ocean

Wet Troposphere Correction

The radiometer wet troposphere differences with ECMWF model display a jump of about 2 mm on 9th November 2010, linked to the evolution of the ECMWF model itself. This jump is more significant on J1 and J2 than on Envisat. This implies, as seen on the monitoring of radiometer and model differences, a decrease of the mean value of the standard deviation to less than 1.2 cm whereas it remains constant around 1.8cm on Envisat.

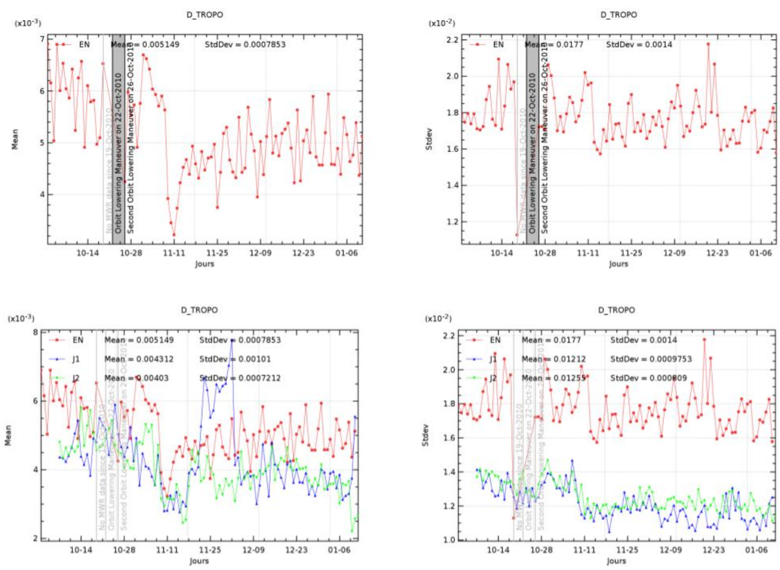


Figure 13: Differences between ENVISAT MWR and ECMWF Wet Troposphere Corrections: Daily Mean (left) and Standard Deviation (right). Lower panels compared against Jason1- and Jason-2

4.3.5 Investigation – Effect on Mean Sea Level

CLS investigated the effect of the orbit change on the mean sea surface, by monitoring the Corrected Seal Level Anomaly. Concerning the SLA standard deviation, no degradation due to the MSS outside of the repeat track can be noticed.

After Jason-1 ground track shift (2009) a degradation of around 2cm rms was noticed on SLA standard deviation (referenced to Jason-2 which remained on the initial track). Here, the degradation is hidden by the absolute SLA variability around 10cm rms: (we compare 100cm^2 to 100+4 cm^2).

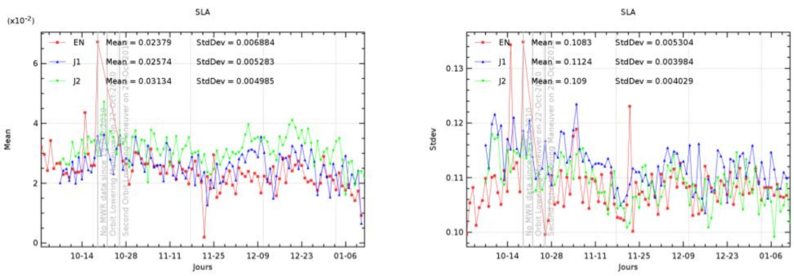


Figure 14: Multi-mission monitoring of KU Band Corrected Sea Level Anomaly: Daily Mean and Standard Deviation

4.3.6 Summary

Apparent squared mispointing is slightly lower than its value before the manoeuvre but its dynamic remains within the nominal values currently observed.

SLA standard deviation: The quality of IGDR products is very good, no strong degradation is visible on results probably hidden by the absolute SLA variability around 10cm rms: (we compare 100cm^2 to 100+4cm^2).

Radiometer wet troposphere differences with ECMWF model seem to be pretty high until the 9th of November and then tend to decrease to a mean value of 3.5 mm, consistent with Jasons' results and linked with the evolution of the ECMWF model. This jump is more significant on J1 and J2 than on Envisat. This implies, as seen on the monitoring of radiometer and model differences, a decrease of the mean value of the standard deviation to less than 1.2 cm whereas it remains constant around 1.8cm on Envisat.

No visible impact is noticed on the other main parameters: SLA bias, SWH, Sigma0, MWR correction, rms of 20Hz range...

Some jumps are noticed on some parameters as the SWH standard deviation/day but cross comparison to other altimeters shows that it is linked to natural ocean variability.

Finally, as shown on figure 16, results obtained on crossover mean differences for cycles 96 and 97 are in agreement with previous cycles with comparable patterns of mean differences on the different basins of the global ocean. Note that due to ground tracks geometry change, crossovers are now missing from some thin bands of latitudes.

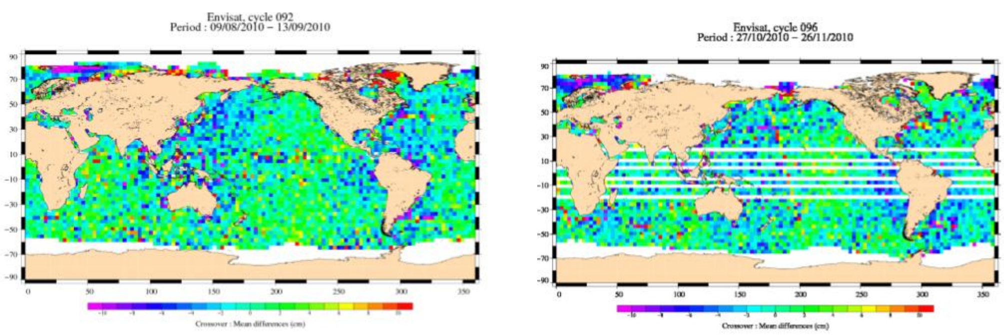


Figure 15: Mean Cross Over Differences before orbit change (left- cycle 92) and after orbit change (right, cycle 96)

4.4 ECMWF Report

Author: Saleh Abdalla

Reference Documents RD.6. RD.7

4.4.1 Introduction

ECMWF provided weekly reports in which ENVISAT RA2 data were compared against buoy measurements and model outputs, and statistics were analysed. Here we provide summary results for November 2010.

4.4.2 Overview

On average 14566 observations arrived at ECMWFY every 6 hour window of which 5567 were initially rejected for being over land, outside the model domain, a double observation or flagged for rain contamination. On average 74.5% of the remaining data passed the further quality controls

4.4.3 Wind Speed

Altimeter wind speed data were compared against ECMWF model output and against buoy measurements. See figures 17, 18 and Table 6

Table 7 – ECMWF Comparison of Surface Wind Speeds

	RA2- ECMWF		RA2 -Buoy	
	Bias (m/s)	SI (%)	Bias (m/s)	SI (%)
Global	+0.30	14.1	+0.13	16.5
Northern Hemisphere	+0.48	14.8	+0.23	16.8
Tropics	+0.24	15.2	-0.27	12.7
Southern Hemisphere	+0.22	12.7	----	-----

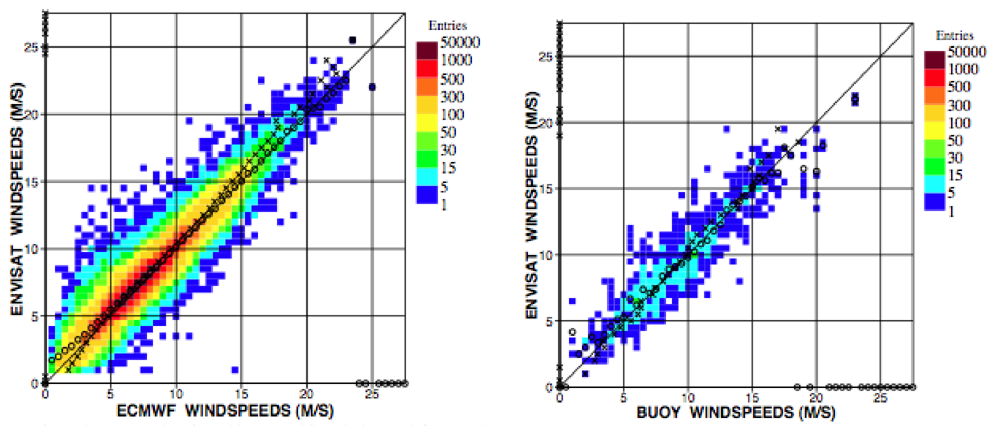


Figure 16: Comparison of ENVISAT RA2 wind speed measurements with ECMWF model output and buoy data

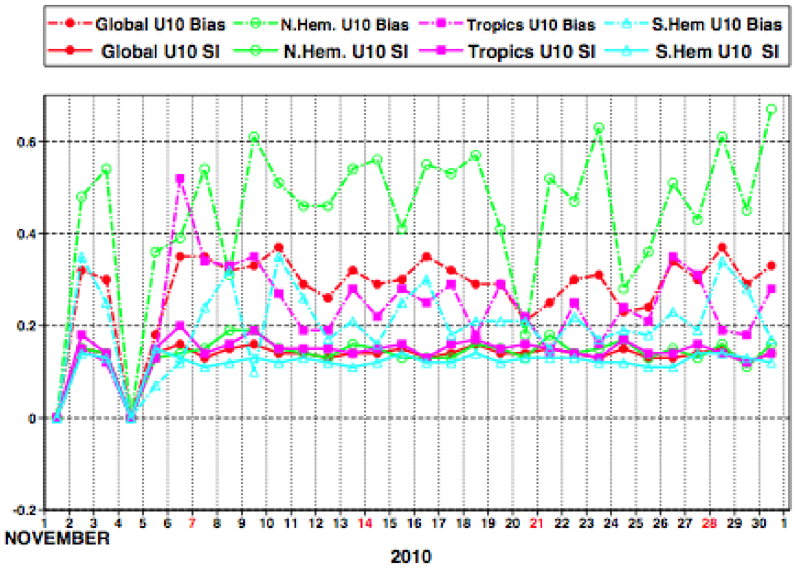


Figure 17: ENVISAT Altimeter wind speeds: Time series of daily bias (RA2 - model) for November.

4.4.4 Significant Wave Height

Altimeter significant wave height data were compared against ECMWF model output and against buoy measurements. See figures 19, 20 and table 7

Table 8 – ECMWF Comparison of Ku Band Significant Wave Heights

	RA2- ECMWF		RA2 -Buoy	
	Bias (m/s)	SI (%)	Bias (m/s)	SI (%)
Global	-0.04	10.8	-0.02	16.0
Northern Hemisphere	-0.01	11.8	-0.02	16.1
Tropics	-0.09	10.2	-0.04	13.0
Southern Hemisphere	-0.02	9.9	----	-----

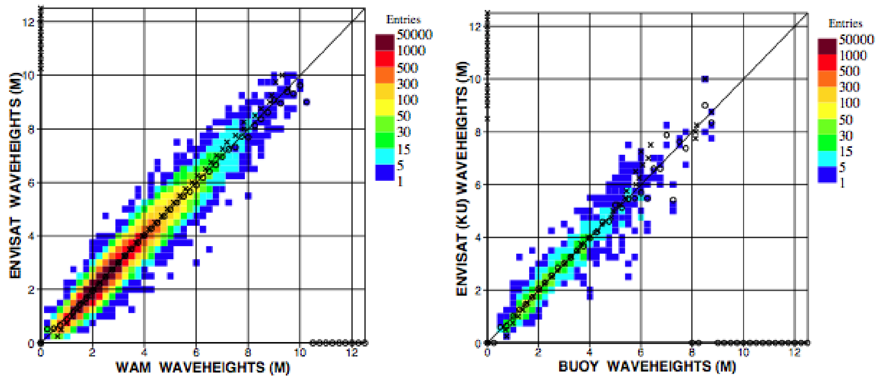


Figure 18: Comparison of ENVISAT RA2 significant wave height with ECMWF model output and buoy data

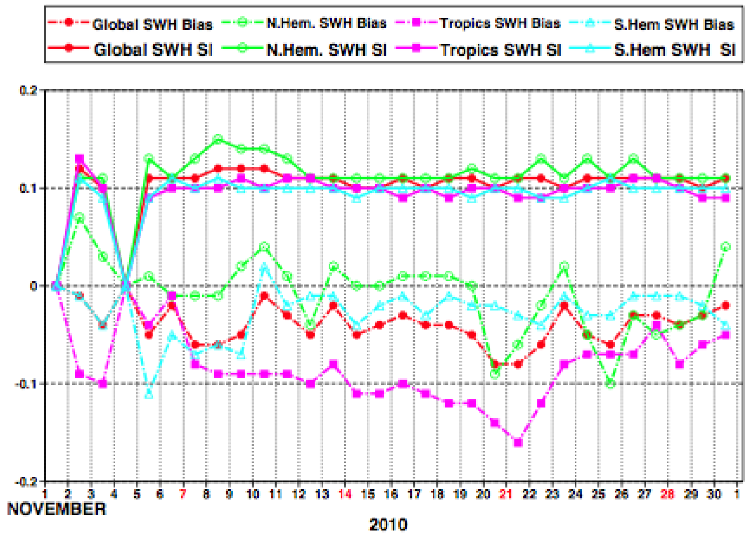


Figure 19: ENVISAT Altimeter significant wave height: Time series of daily bias (RA2 - model) for November.

4.4.5 Wet Troposphere Correction and Total Column Water Vapour Values

The Wet Troposphere Correction and Total Column Water Vapour calculated from MWR measurements were compared against ECMWF model output. See figures 21-23 and table 8.

Table 9 – ECMWF Comparison of Surface Wind Speeds

	MWR WTC- ECMWF WTC		MWR TCWV- ECMWF TCWV	
	Bias (m/s)	SI (%)	Bias (m/s)	SI (%)
Global	-0.012	9.7	-0.54	7.8
Northern Hemisphere	-0.011	11.3	-0.65	10.1
Tropics	-0.015	7.5	-0.33	5.7
Southern Hemisphere	-0.011	11.4	-0.61	9.7

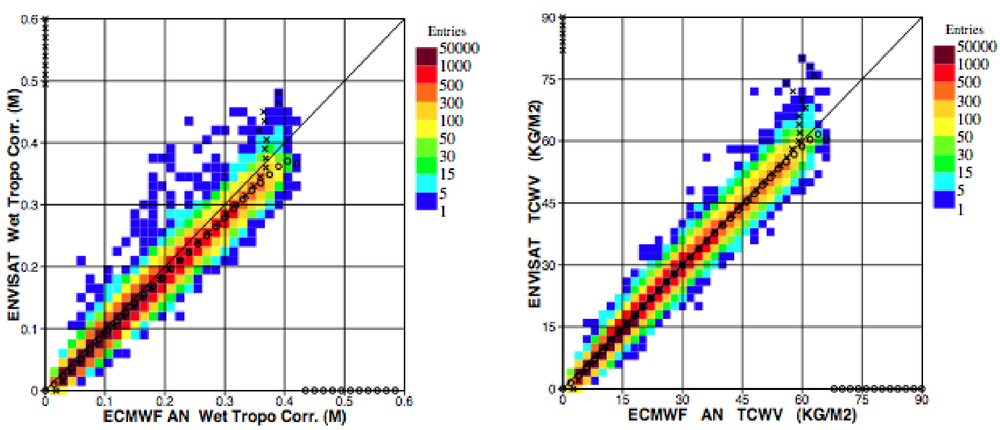


Figure 20: Comparison of ENVISAT MWR Wet Troposphere Correction and Total Column Water Vapour with ECMWF model output and buoy data

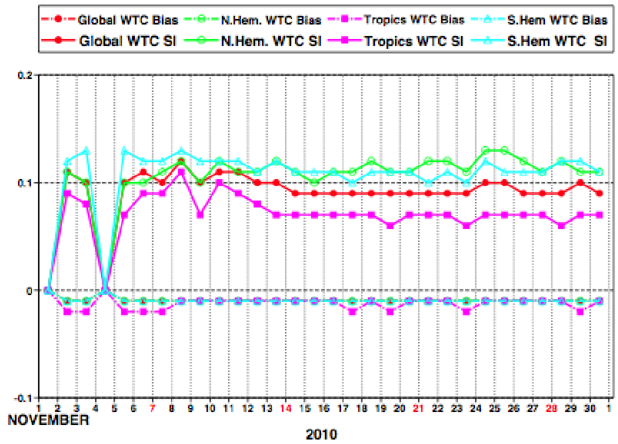


Figure 21: ENVISAT MWR Wet Troposphere Correction: Time series of daily bias (RA2 - model) for November.

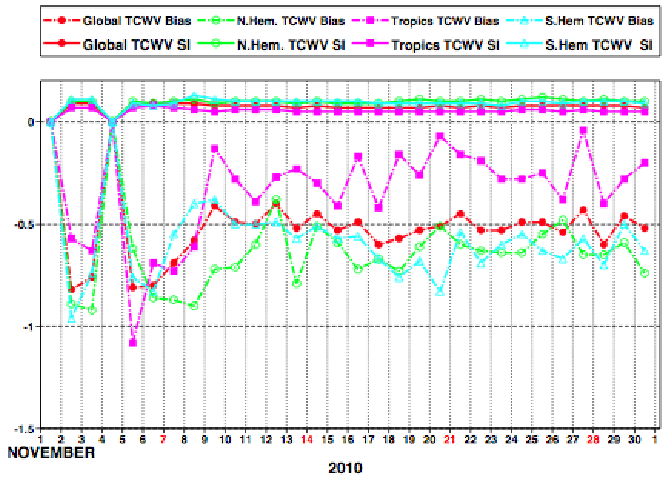


Figure 22: ENVISAT MWR Wet Troposphere Correction: Time series of daily bias (RA2 - model) for November.

4.4.6 Summary

The rain flag is responsible for the rejection of about 3.1% of the data. This seems to be due to the change in the NRT processing chain to IPF 6.02L04.The continuously increasing number of rejections from month to month is worrying and an explanation may be needed if this continues.

The wind speed data are in good agreement with the ECMWF model. ENVISAT wind speed product is globally about 30 cm/s higher than the model for this month. On the other hand, it is almost 13 cm/s higher than the buoy measurements for this month.

The overestimation of the Altimeter wind speed noticed just after the change of the orbit has totally disappeared.

The Ku-band significant wave heights are almost unbiased (lower by ~ 4 cm) when compared to WAM model results (0.3% higher in the NH, 3.8% lower in the Tropics and 0.2% lower in the SH) over the whole month. On the other hand, the RA-2 Ku-band wave heights are about 0.3% lower compared to the buoy wave heights for this month as can the implementation of IPF 6.02L04.

The quality of the data is nominal after the change of orbit at end of October 2010.

While the MWR derived TCWV is in good agreement with the model counterpart (MWR TCWV is slightly dryer than the model especially in the Extra Tropics), the MWR WTC is still consistently smaller (drier) than the model values.

There was an anomaly with the MWR starting from the early hours of the 19th of October and lasted until the orbit change (~25th of October 2010). The rain flag was set leading to the rejection of almost all the received data. A missing value would have been much helpful.

The ECMWF models were changed on the 9th of November 2010. The change led to a significant improvement in the water vapour products. For example, the bias between the MWR and the model WTC was reduced by about 2 mm and the standard deviation of the difference between the two was reduced by about 2 mm as well. The current operational IFS cycle is CY36R4 (since the 9th of November 2010).

4.5 IDEAS Report

Author: Sabrina Pinori

Reference Document RD.8

4.5.1 Introduction

This section summarises the analysis within the weekly QC analysis performed in IDEAS Team after the ENVISAT orbit lowering started on 21 October 2010. QC has been performed on ENVISAT RA2 NRT data.

4.5.2 Instrument Performances

USO Monitoring

The RA-2 Ultra-Stable Oscillator (USO) was nominal during reporting period.

In order to make the variability visible, the difference of the actual USO clock period with respect to the nominal one has been plotted in the upper panel. In the lower panel the Range error due to the USO clock variability has been reported taking a satellite altitude of 800 Km as a nominal value.

Times of two main manoeuvres have been highlighted in yellow.

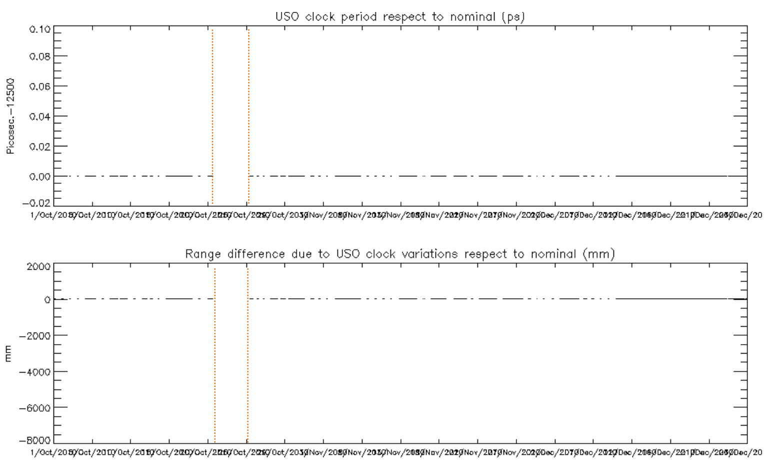


Figure 23: ENVISAT MWR Wet Troposphere Correction: Timeseries of daily bias (RA2 - model) for November.

Datation

A significant part of an eventual error in the RA-2 products datation could result from imperfect synchronisation between the Satellite Binary Time and the UTC Time due to a drift of the ICU clock period. A correlation between those two times is performed at every Kiruna orbit dump and then extrapolated for the four non-Kiruna orbits The differences between the extrapolated UTC values and the corresponding real UTC values measured at the next Kiruna dump, are shown in the top panel of the figure below. In the lower panel, the ICU clock step for the same period is shown.

Times of two main manoeuvres have been highlighted in yellow (corresponding to MJD 3948 and 3952 respectively).

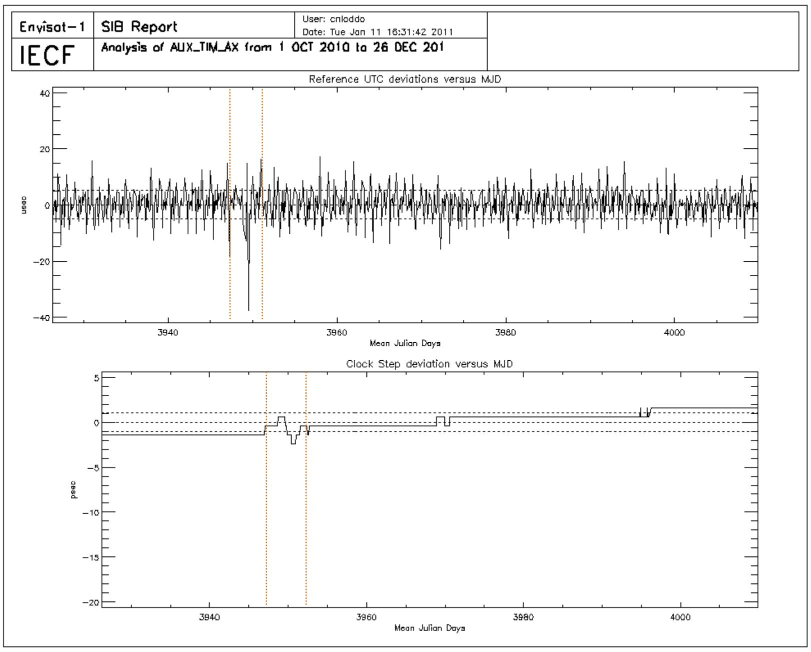


Figure 24: UTC deviations and ICU clock period from 1 October to 26 December 2010

Some small variations are visible only during the manoeuvre period (22-26 October 2010).

IF Mask

According to the planning defined for the IF Calibration acquisition during reporting period, one daily pass over the Himalaya (ascending) has been performed with the “New” procedure for IF calibration.

The “New” procedure consists in setting all the AGC’s to 3dB before entering the IF Calibration Mode and resetting all the parameters to the original values before entering in the Measurement mode. It is operationally used since cycle 66 for all IF Calibrations and this ensures 100% of valid IF Masks to be acquired.

61 RA2_CAL_0P products were received starting from 27 October 2010, according to new mission planning. All masks are in good agreement with on ground calibration and with IF masks acquired before the ENVISAT orbit lowering.

First 36 IF mask have been used to generate the RA2_IFF_AX file, generated, validated and nominally disseminated on 13 December 2010 and with start validity on 24th October 2010. This mask was validated by IsardSAT

In Flight Internal Calibration

The RA-2 Range and Sigma0 measurements are corrected to take into account the internal path delay and attenuation, respectively. This is done by measuring those two variables in relation to the internal Point Target Response. The two correction factors are calculated during the L1b processing and directly applied. They are also continuously monitored and the results for the current cycle (averaged per day) are reported in the next figures.

The Ku Band Time delay in-flight calibration factor, shown in the left panel below, shows a regular behaviour as observed on previous cycles. The Ku band Sigma0 calibration factor, reported in the right panel, is nominal even if with negative values slowly decreasing. A small peak is visible in correspondence with ENVISAT manoeuvres.

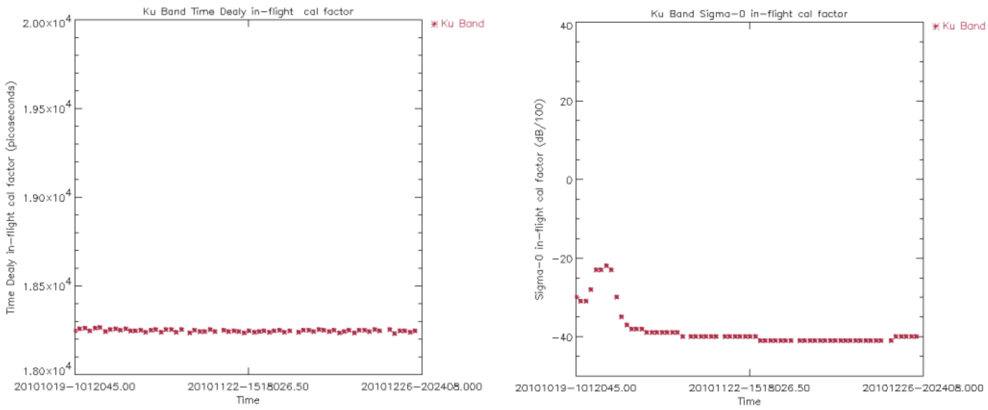


Figure 25: Ku Band Time Delay (left panel) and sigma 0 (right panel) in-flight calibration factors from 19 October 2010 (averaged per day).

Mispointing

In the figure below, the trend of the mispointing squared (averaged every orbit) is reported in deg^2*10e-4.

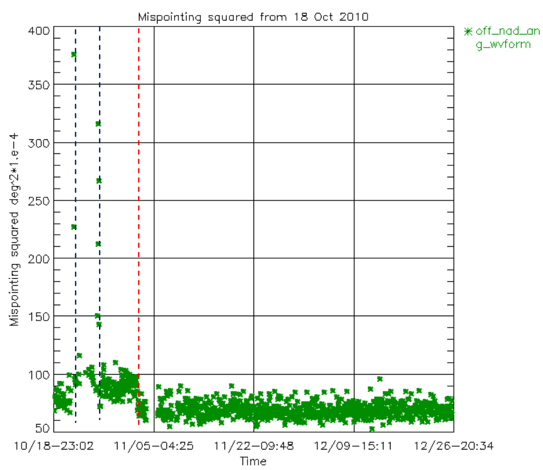


Figure 26: Smoothed mispointing squared trend (deg^2*10^-4)

Times of two main manoeuvres have been highlighted in blue, while the transition from Yaw Steering Mode (YSM) to Stellar Yaw Steering Mode (SYSM) occurred on 2 November 2010 at 10:25 UTC is highlighted in red. Since the transition to SYSM the mispointing squared is almost back to nominal behaviour.

A small decrease with respect to its nominal value is visible since 03/11/2010

4.5.3 Altimeter Parameters

Significant Wave Height

The figure below shows the Ku Band SWH daily mean starting from 18 October 2010. Times of two OCM manoeuvres have been highlighted in cyan, the SFCM manoeuvre in red. After each manoeuvre a decrease of SWH is present.

SWH shows some jumps, also detected by CLS, but they report that “cross comparison to other altimeters shows that it is linked to natural ocean variability”.

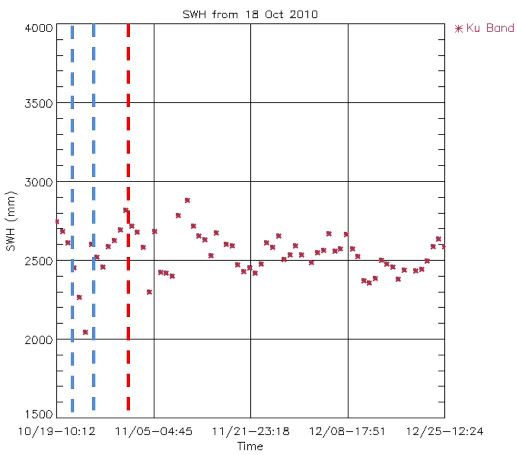


Figure 27: Ku Band SWH daily average from 18 October 2010.

Backscatter Coefficient and Wind Speed

The figure below shows the Sigma-0 and wind speed daily mean starting from 18 October 2010. Times of two OCM manoeuvres have been highlighted in cyan, the SFCM manoeuvre in red. No impact of the manoeuvres is visible.

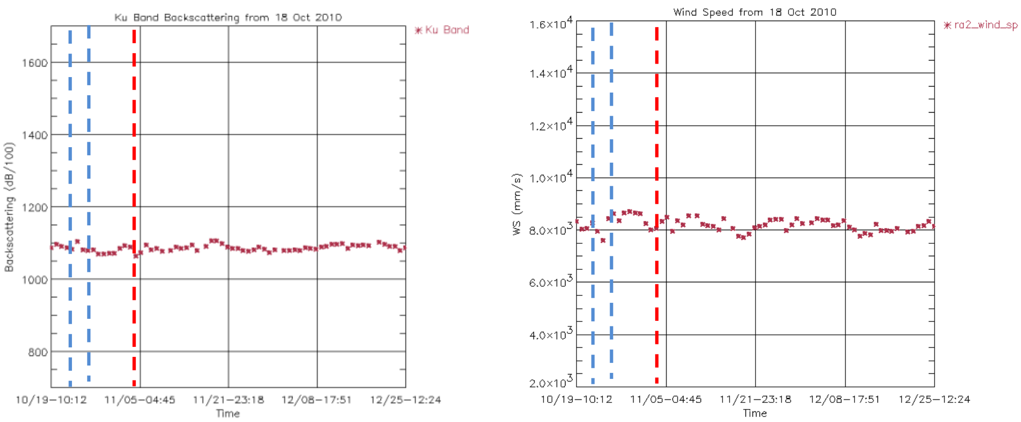


Figure 28: Ku Band sigma-0 and wind speed daily average from 18 October 2010.

Sea Level Anomaly

The figure below shows the time series of the Sea Level Anomaly from 11 november to 26 December, and the probability distribution function for the same period. Nominal behaviour is seen

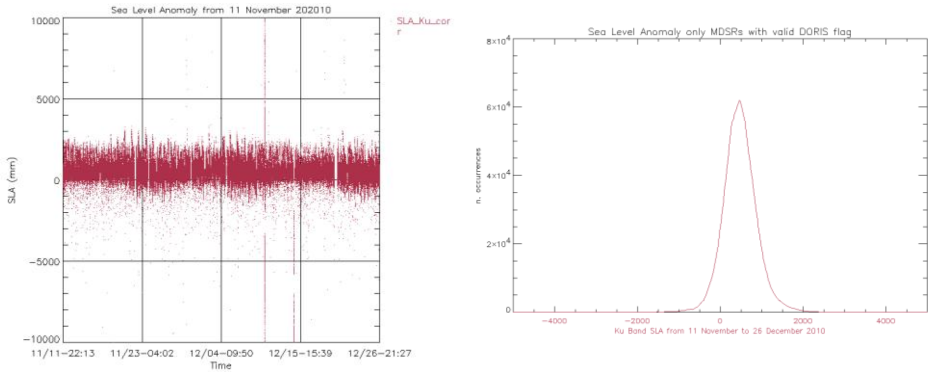


Figure 29: Sea Level Anomaly (SLA) time series (left) and probability distribution function (right) for reporting weeks.

4.5.4 Summary

RA2 Level 0, Level1b and Level 2 availability for reporting cycle 97 are 98.71 % for all product level. MWR availability is 98.22%. DORIS availability is 93.43%.

The RA-2 Ultra-Stable Oscillator (USO) was nominal during reporting period.

61 IF masks have been acquired from 27 October to 26 December 2010, according planning.

RA2_IFF_AX file has been generated with IF mask acquired from 27 October and 1 December 2010. The RA2_IFF_AX file was validated and disseminated on 13 December 2010. A second IF mask has been generated and disseminated on 28 December 2010 using data from 1 December to 26 December 2010.

Since the transition to SYSM (Stellar Yaw Steering Mode) occurred on 2 November 201010:25 UTC the mispointing squared is back to nominal behaviour, with a small decrease with respect to nominal values.

Level 1b (Sigma-0 calibration factor and Time delay calibration factor) and Level 2 parameters (SWH, Wind Speed and backscattering) are nominal.

To be noted that, as part of the new planning strategy, all the acquisitions over transponders as well as all the specific IE acquisitions over calibration sites have been suspended.

4.6 UCL Report

Author: Julia Gaudelli

Reference Documents RD.9

4.6.1 Introduction

This report is produced by MSSL to:

• summarise the LIP ESL activities in monitoring; the RA2 tracking performance, the USO clock period, and the L2-Ice algorithm performance and products,

• to report on any changes detected in behaviour or performance

• to report on any other anomalies observed

This final report covers the period 28th October – 26th December 2010 i.e. the first two complete cycles (96 and 97) after the orbit lowering manoeuvres.

RA-2 tracking performance and USO statistics are based on L1B data.

All other monitoring plots and statistics are based on L2 data. This is IGDR unless otherwise specified.

The plots shown on the RA2QA website at http://ra2qa.mssl.ucl.ac.uk/ are based on GDR data up to cycle 92 (the latest available GDR cycle), and IGDR data for cycles 93 to 97.

In order to detect any immediate changes in performance we have compared data from cycles 96 and 97 after the orbit lowering with cycles 84 and 85, which correspond to the same months 1 year before. These two cycles were selected to minimise the effect of seasonal variability.

Additionally we have looked for changes in long-term trends by comparing against the mean from the most recent full year ie cycles 84 to 93.

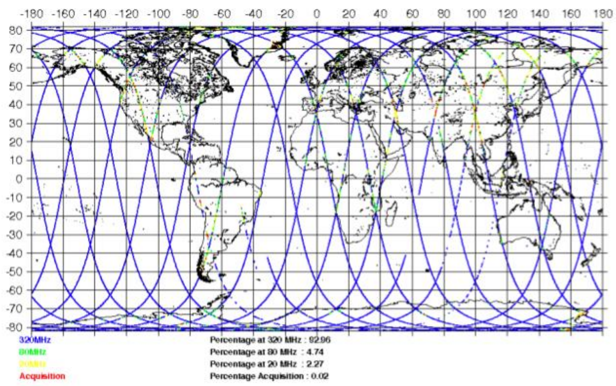
Note that only IGDR data is currently available for cycles 96 and 97. When making comparisons with the performance from before the orbit change we have also used IGDR data so that we are comparing like with like.

Cycles 94 and 95 were short cycles of 4 and 5 days each, and have been discarded in this report since they would introduce erroneous statistics.

Additional monitoring plots and statistics, updated on a daily and per-cycle basis, are available on :- http://ra2qa.mssl.ucl.ac.uk/

4.6.2 Daily Tracking – Mode Statistics

RA-2 near real-time tracking mode performance statistics were on the whole nominal during this time period. Plots displayed at ra2qa.mssl.ucl.ac.uk/cgi-bin/mode.pl show values that are in line with expected values.
An exception was seen on 5th December, when there were anomalies, evident in the non-continuous ("gappy") tracks in the daily plot:



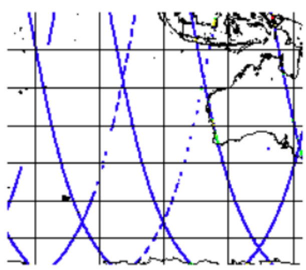


Figure 30: Tracker Autonomous Mode Switching 05/12/2010, and zoomed view

A close-up view shows gaps in several orbits. The gaps occurred when there were unusual values in the L1B Instrument Operations Flags field. This was related to IDEAS-PR-10-05478I when several problems were found on the data processed in ESRIN, with all products from 01:00 to 04:00 UTC being anomalous.
On 27th December it was noted that fewer orbits of L1B data had been routinely transferred from the ESA server. There were enough to prevent the automatic email warning system from triggering, but the first plot for the day showed around 30% fewer orbits then normal. More data was later received and replotted, and performance was

confirmed as nominal.

4.6.3 Daily Tracking – Mode Statistics: Trends

Global

No significant change in the global trend can be seen after the orbit lowering manoeuvres (cycles 96 & 97) compared to cycles 84 & 85 in the previous year. In the table below cycles 96 and 97 are compared against the same statistics from the same time period in the previous year (cycles 84 and 85), and against the mean from the previous full year (cycles 84 - 93). Cycles 94 and 95 were short cycles and are discarded to avoid distorting the statistical results.

Table 10 – Comparison of mode switching statistics - Global

Cycles	320 MHz	80 MHz	20 MHz	Acq
96 & 97	93.24	4.67	2.908	0.02
84 & 85	93.17	4.62	2.18	0.02
84-93 (1 year mean)	93.00	4.92	2.06	0.02

Antarctic

No significant change in the Antarctic trend can be seen after the orbit lowering manoeuvres (cycles 96 & 97) compared to cycles 84 & 85 in the previous year. The results below indicate no significant change in the behaviour of the autonomous mode switching over Antarctica.

Table 11 – Comparison of mode switching statistics - Antarctic

Cycles	320 MHz	80 MHz	20 MHz	Acq
96 & 97	96.35	2.81	0.83	0.01
84 & 85	96.25	2.88	0.80	0.01
84-93 (1 year mean)	96.31	2.83	0.85	0.01

Ocean

No significant change in the Ocean trend can be seen after the orbit lowering manoeuvres (cycles 96 & 97) compared to cycles 84 & 85 in the previous year. The results below indicate no significant change in the behaviour of the autonomous mode switching over global oceans.

Table 12 – Comparison of mode switching statistics - Ocean

Cycles	320 MHz	80 MHz	20 MHz	Acq
96 & 97	99.96	0.03	0.01	0.00
84 & 85	99.96	0.03	0.01	0.00
84-93 (1 year mean)	99.96	0.03	0.01	0.00

Land

No significant change in the Ocean trend can be seen after the orbit lowering manoeuvres (cycles 96 & 97) compared to cycles 84 & 85 in the previous year. Tracking mode behaviour over land exhibits a strong seasonal signal (see ra2qa.mssl.ucl.ac.uk/DATA/CUMULATIVE_STATS/land_18month_trend.gif).
The results from cycles 96-97 are very close to those from 84-85, which are at the same time of year. The difference, in particular at 80MHz, when compared with the annual mean is attributed to this seasonal variability.

Table 13 – Comparison of mode switching statistics - Land

Cycles	320 MHz	80 MHz	20 MHz	Acq
96 & 97	73.77	17.76	8.40	0.07
84 & 85	73.84	17.43	8.66	0.07
84-93 (1 year mean)	73.08	18.68	8.18	0.07

Sea Ice

No significant change in the Ocean trend can be seen after the orbit lowering manoeuvres (cycles 96 & 97) compared to cycles 84 & 85 in the previous year. The results below indicate no significant change in the behaviour of the autonomous mode switching over Sea Ice.

Table 14 – Comparison of mode switching statistics – Sea Ice

Cycles	320 MHz	80 MHz	20 MHz	Acq
96 & 97	99.37	0.52	0.11	0.00
84 & 85	99.39	0.50	0.11	0.00
84-93 (1 year mean)	99.45	0.55	0.12	0.0

Coastal

No significant change in the Coastal trend can be seen after the orbit lowering manoeuvres (cycles 96 & 97) compared to cycles 84 & 85 in the previous year. The results below indicate no significant change in the behaviour of the autonomous mode switching over coastal regions.

Table 15 – Comparison of mode switching statistics – Coastal

Cycles	320 MHz	80 MHz	20 MHz	Acq
96 & 97	96.49	3.04	0.46	0.00
84 & 85	96.58	2.94	0.47	0.00
84-93 (1 year mean)	96.59	2.95	0.45	0.00

4.6.4 RA2 USO Monitoring

The USO period is extracted from the L1B products and daily averages are displayed on the RA2QA website at http://ra2qa.mssl.ucl.ac.uk/cgi-bin/uso.pl

There are no significant changes in the USO since before the orbit lowering manoeuvres.

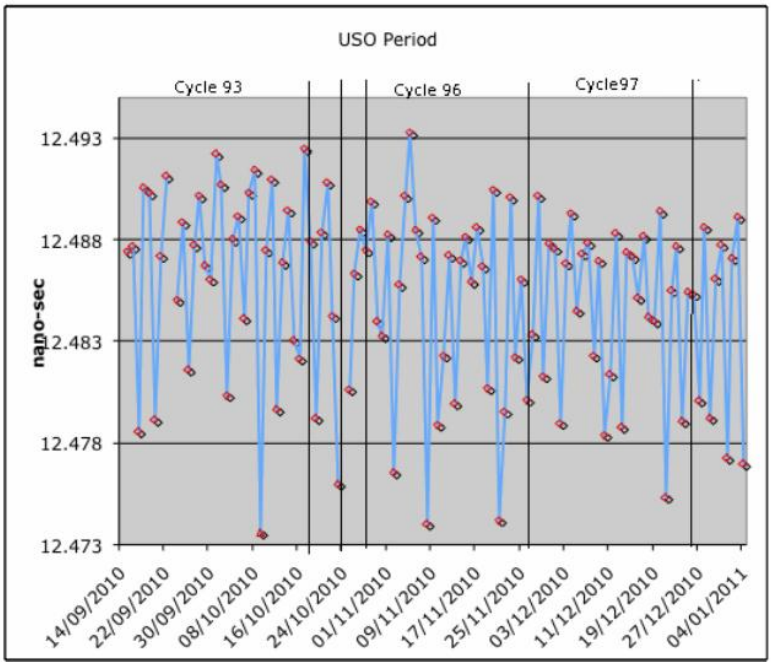


Figure 31: Monitoring USO clock period stability

4.6.5 RA2 Ice Surfaces Monitoring

Peakiness

Peakiness values, extracted from L2 IGDR data acquired in cycle 96 and thresholded (0.25 > < 10.0), have been plotted for the Arctic and Antarctic and compared against equivalent data from cycle 84 (approximately 12 months earlier. Patterns of peakiness before and after the orbit change are consistent. Those for the Antarctic are shown below

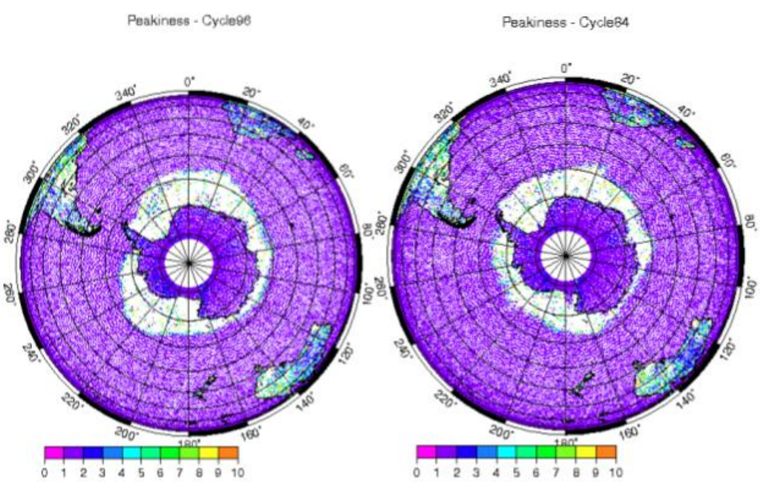


Figure 32: Peakiness values for the Antarctic. Cycle 96 (left) and cycle 84 (right)

Crossovers

Crossovers are easier to analyse if the mode of both crossing arcs is the same. If the mode is mixed, the crossover is discarded to avoid the effect of biases between modes. A target of > 95 % was set for Antarctic crossovers at 320 MHz.

Crossover processing has been performed on cycles 96 and 97 and preliminary results show nominal values. The results below show no significant change in the behaviour of the autonomous mode switching is seen at Antarctic or global crossovers.

Table 16 – Percentage mode at crossovers, cycle and year comparison: Antarctic

Cycles	320 MHz	80 MHz	20 MHz	Acq
97	95.78	0.22	0.02	3.98
96	95.89	0.17	0.01	3.93
85	95.83	0.24	0.01	3.92
84	95.85	0.22	0.01	3.92
84-93 (1 year mean)	95.90	0.20	0.02	3.88

Table 17 – Percentage mode at crossovers, cycle and year comparison: Global

Cycles	320 MHz	80 MHz	20 MHz	Acq
97	99.92	0.00	0.00	0.08
96	99.89	0.00	0.00	0.11
85	99.89	0.00	0.00	0.11
84	99.88	0.00	0.00	0.12
84-93 (1 year mean)	99.89	0.00	0.00	0.10

End to End Measurements

All crossover results, including Ice2 and Seaice retrackers are displayed at http://ra2qa.mssl.ucl.ac.uk/cgi-bin/end2end.pl

Crossover analysis was performed for heights computed from the Ice1 retracker plus auxiliary corrections, the Ice2 retracker plus corrections and the Sea ice retracker plus corrections. The trend in crossover RMS is monitored for long term drift. Trends remain consistent through cycles 96 and 97. Results from cycles 96 and 97 were compared against those form cycles 84 and 85, and even though the comparison was between IGDR and GDR results there was no significant difference in results from before and after the orbit change.

Auxiliary Corrections in the Polar Regions

For each full cycle of RA-2 Level 2 IGDR data, auxiliary corrections are monitored and displayed at http://ra2qa.mssl.ucl.ac.uk/cgi-bin/auxgen.pl

For the Polar regions (<= - 60 degrees, >= +60 degrees) the percentages of available corrections are calculated. The desired target is 100 %. The amounts for Cycle 94 and 95 are not representative due the small data sample in these cycles.

Percentages shown are percent of available correction data for all points within the polar regions (< -60 degrees, > +60 degrees) acquired during each cycle.

Table 18 – Percentage mode at crossovers, cycle and year comparison: Global

Cycles	Inv Barometric	Mod Dry Trop	Mod Wet Trop	DORIS Iono	Modelled Iono
97	91.98 %	100.00%	100.00%	96.47%	100.00%
96	90.86 %	100.00%	100.00%	93.31%	100.00%
85	91.92 %	100.00%	100.00%	98.32%	99.94%
84	91.84 %	100.00%	100.00%	96.96%	99.92%
84-93 (1 year mean)	91.13 %	100.00%	100.00%	98.92%	99.99%

Percentages remained consistent for all corrections in cycles 96 and 97, with the exception of DORIS Ionospheric corrections (highlighted above), where some orbits were seen with the corrections missing.

Trackable Echoes

For each cycle of Envisat RA-2 Level 1B data, the percentage of trackable echoes is calculated for each surface type and tracking mode by analysing the waveform power ratio between the first and second halves of the window to detect the presence of trackable leading edges. The percentage of trackable echoes for each surface should remain approximately constant over the mission lifetime.

Analysis is made over the following surface types: ocean, land, Antarctic, ice, desert, wetlands. The percentage of trackable echoes for each of the modes 320MKz, 80MHz, 20MHz, and all, is shown for cycles 96 and 97, for comparison with 84 & 85, and the year mean (cycles 84-93).

Table 19 – Trackable Echoes: Ocean

Cycles	All	320 MHz	80 MHz	20 MHz
97	99.98	99.98	93.93	94.07
96	99.98	99.98	93.47	95.25
85	99.98	99.98	91.65	95.40
84	99.98	99.98	93.55	94.94
84-93 (1 year mean)	99.98	99.98	92.85	92.28

Table 20 – Trackable Echoes: Land

Cycles	All	320 MHz	80 MHz	20 MHz
97	70.44	71.46	62.97	75.34
96	69.52	69.99	64.13	75.45
85	70.11	71.30	62.29	75.38
84	69.34	70.15	63.02	75.46
84-93 (1 year mean)	69.88	70.20	64.78	77.05

Table 21 – Trackable Echoes: Antarctica

Cycles	All	320 MHz	80 MHz	20 MHz
97	95.88	96.56	79.24	73.74
96	95.88	96.56	78.82	74.73
85	95.97	96.63	79.12	74.81
84	95.89	96.58	78.57	73.42
84-93 (1 year mean)	95.95	96.61	79.30	73.89

Table 22 – Trackable Echoes: Ice

Cycles	All	320 MHz	80 MHz	20 MHz
97	99.55	99.71	80.49	77.33
96	99.52	99.69	79.38	75.07
85	99.50	99.66	78.25	78.63
84	99.58	99.71	79.23	77.51
84-93 (1 year mean)	99.53	99.67	80.40	76.06

Table 23 – Trackable Echoes: Desert

Cycles	All	320 MHz	80 MHz	20 MHz
97	80.14	82.71	64.77	77.29
96	79.85	82.60	64.25	76.08
85	79.65	82.12	64.91	78.80
84	79.95	82.63	63.81	78.60
84-93 (1 year mean)	80.24	82.79	64.52	79.07

Table 24 – Trackable Echoes: Wetlands

Cycles	All	320 MHz	80 MHz	20 MHz
97	67.25	63.17	84.53	96.76
96	66.64	62.09	81.93	94.21
85	66.00	62.21	83.34	98.21
84	65.97	60.85	83.60	97.03
84-93 (1 year mean)	65.78	60.88	83.22	96.96

All the results above indicate no significant change in the number of trackable echoes acquired after the orbit change.

Retrackers

The percentage of echoes successfully retracked by the Ice1, Ice2 and Seaice retrackers (as flagged in the L2 IGDR) has been calculated

Analysis is made over the following surface types: ocean, land, Antarctic, ice, desert, wetlands. The percentage of trackable echoes for each of the modes 320MKz, 80MHz, 20MHz, and all, is shown for cycles 96 and 97, for comparison with 84 & 85, and the year mean (cycles 84-93).

Table 25 – Percentage of echoes successfully retracked, cycle and year comparison

Cycles	Global Echoes retracked by Ice1 retracker	Global Echoes retracked by Ice2 retracker	Global Echoes retracked by Sea Ice retracker	Global Echoes retracked by L1b leading edge reprocessing
97	95.85	91.61	95.99	90.05
96	95.82	91.64	95.86	89.75
85	95.92	91.56	95.86	89.95
84	95.81	91.59	95.86	89.69
84-93 (1 year mean)	95.82	91.56	95.87	89.87

Performance of the LIP retrackers has been seen to be consistent through cycles 96 to 97. The full report (RD.9) compares cycle 97 with cycle 85 in geographical plots of mean along track values of:

- Ku Ice1 Backscatter
- Ku Ice2 Backscatter
- Difference Ku Ice2-Ice1 Backscatter
- Ku Ice2 leading edge width
- Ku Ice2 trailing edge slope
- Difference Ku Ice2-Ice1 Range

No appreciable difference in backscatter or the other retracker metrics could be seen.

4.6.6 Summary

Assessment of the RA2 instrument and ice products has been performed using available data products (L1b and IGDR) from the time of the orbit manoeuvre until 4th January 2011.

In the period covered in this report, performance of the USO, the on-board tracker and the products relative to Ice surfaces, is nominal. There are no discernable deviations from nominal trends i.e. there is no indication of any degradation in sensor performance.

There were two exceptions to nominal values:

1. Some DORIS Iono corrections were unavailable in cycles 96 and 97
2. On 5th December, unusual values in L1B Instrument Operations Flags field

Based on our analysis of the parameters reported above, we conclude that there has been no significant change in the RA2 instrument behaviour, and no significant change in performance over ice surfaces.

The targets set at the end of the Calibration Phase are still met since the orbit lowering. There is no indication of any degradation in sensor performance.

Further work on a longer time series of the precise data (GDR), when it becomes available, would be beneficial and lead to more accurate statistics on which to base further conclusions.

4.7 IsardSAT Report

Author: Pablo Nilo Garcia

Reference Documents RD.10

4.7.1 Introduction

IsardSAT Product validation is divided in two parts:

1- Analysis of the parameters most affected by the de-orbiting.

2- Analysis of the instrumental calibration variables: PTR, USO, IF-mask.

4.7.2 Analysis of the on-board and CON parameters most affected by the de-orbiting

As a result of a lower orbit, the waveforms are received earlier and with higher power. Therefore, the L0 and L1b parameters most affected by this condition are related to the window reference positioning and the AGC attenuation.

The window reference position must be between a minimum and a maximum limit, conditioned mainly by the PRI, taking instrument times and tolerances into account. With the new orbit the limit to be monitored is the lower one (orbit decreased).

The waveform will be received earlier, so the window will be positioned earlier. In the case that we reach the window position's lower limit, it is interesting to check the waveform and detect if we are really loosing the signal.

Table 26 – Summary Table of limits set for relevant parameters, and if limits are reached in data since the orbit change

Parameter	Minimum	Maximum	Testing result
ku_win_delay	5.09 ms	5.50 ms	Limit not reached
time_delay_corr	80 μs	487 μs	Limit not reached
ku_agc	200	6600	Limit reached once
agc_corr_val	-10 dB	70dB	Limit reached several times

The AGC attenuation is also limited, being in this case the upper limit the affected one. The same procedure as before must be done. In this case we check the AGC limits, and in case the maximum attenuation is reached, the maximum value of the waveform is checked in order to determine if the received signal is saturated.

Full details of the analysis are provided in RD.10. The Table above summarises the findings. As seen in the table, the only limit reached often is the AGC corrected value, that corresponds to the α branch of the AGC αβ-tracker. This is expected, being the attenuation maximised in cases of received signals with power values close to the maximum allowed on-board.

It is important to notice that the checking we are doing in this analysis is only for the limits logically affected by the orbit lowering: minimum time and maximum attenuation. As we will see later, the maximum limits of time and attenuation may be over-passed by the same cause, but as we were only showing time results related to the minimum limit, the maximum limit alarm was not detected.

A number of the occasions when limits were passed were further investigated, and it was concluded that no instrument misbehaviour has been detected so far in the analysis of the on- board and CON parameters. The causes of exceeding the limits were not related to the instrument behaviour.

4.7.3 Analysis of the calibration variables: PTR, USO, IF-mask

The instrumental calibration parameters are also monitored. In principle a change in the satellite orbit should not affect the PTR (internal path delay) and the USO (RA-2 internal clock frequency) parameters; however they shall be analysed to ensure its correct behaviour.

The results show a normal behaviour, in line with the values before the de-orbiting.

USO

We have observed a NO-ANOMALY behaviour of the USO clock frequency, around nominal values. The figure below shows a time series of the average USO clock correction, calculated with the reference processor and with the current version of the IPF. For the IPF version 6.03 we have computed a USO_smooth average of the whole orbit (only 1 value representing the product is showed), and is presented in red. In green are showed the results of the reference processor version v07.357 (equivalent to the IPF version 6.04). We can observe that both USO values are smooth and stable, all values of each processing are within 1mm after October 29. The mean value differs, and is around 3mm for the IPF 6.03 version and 5mm for the 6.04 version. The first values after the de- orbiting are have a similar behaviour as the AGC_Ku previously commented, and we believe that it has the same cause: the temperature on-board.

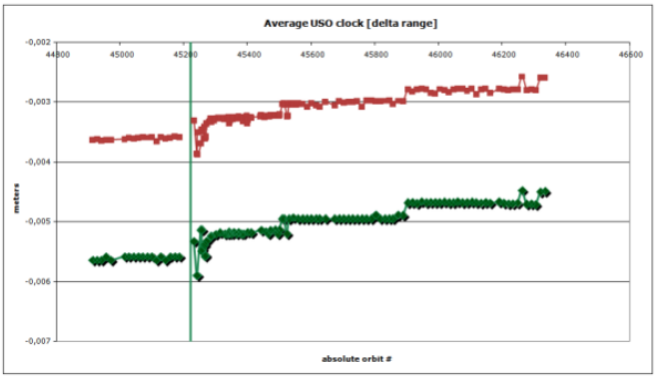


Figure 33: Average USO clock correction [meters]. Red line corresponds to the IPF solution, green line to the reference processor output. Green vertical line indicates the moment of the change of orbit.

PTR

No anomaly behaviour on this parameter, see Figure 14. The values are around 18272 ps, near the PTR delay values before de-orbiting around 18275 ps. The difference between the two values on range is under 0.5mm.

We can observe in the Figure from 25th October 2010, right after the change of orbit, an increase of the PTR correction (the correction is decreasing in absolute terms, getting closer to the reference). This behaviour lasts for few days before it reaches the nominal value. We believe that this behaviour is due to the on-board temperature, because of the switch-off of the different instruments on-board EnviSat.

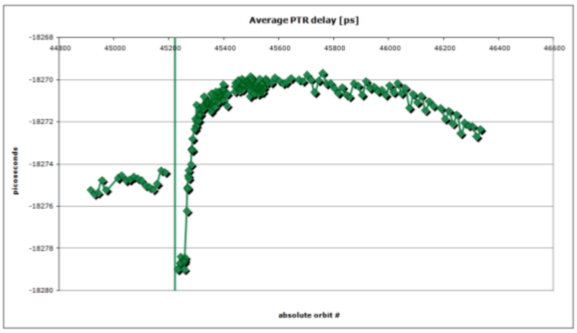


Figure 34: Average PTR delay [ps] per orbit. Green vertical line indicates the moment of the change of orbit.

IF Mask Results

The first IF-mask after the orbit lowering was generated on December 02. The auxiliary IF-flight file is:

RA2_IFF_AXXIEC20101202_162843_20101027_000000_20200101_000000.

We have found no anomaly on the IF-mask generated. The shape of the mask is perfectly matched with the other eight IF-masks generated on 2010 and provided for this study. The shift in samples or in power with respect to the other IF-masks is similar to the observed between them.

In the figure below we can observe the above mentioned. Therefore, the IF-mask has been disseminated by Sabrina Pinori (Serco) on 13th of December, with a starting validity date on 24th of October.

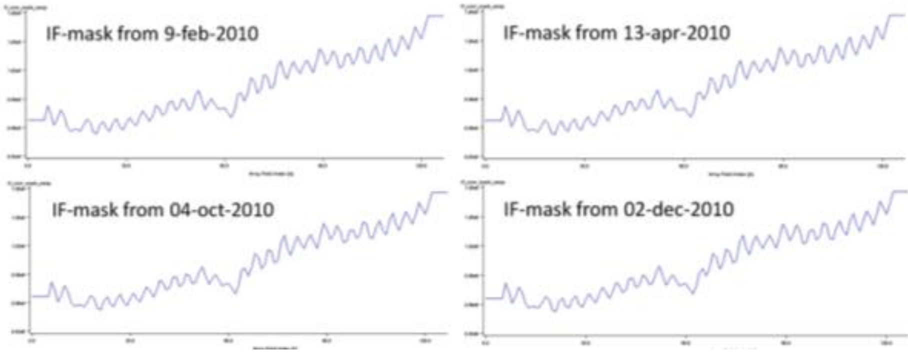


Figure 35: IF masks generated on 2010. On bottom right, the IF-mask generated after the orbit lowering. Courtesy of Sabrina Pinori (Serco).

5. INSTRUMENT PROCESSING FACILITY VERIFICATION

5.1 Introduction

5.2 CLS Report

Authors: Stephanie Urien, Francois Soulat

Reference Document RD.3

5.2.1 Introduction

CLS carried out a verification of the RA2 LOP reference processor on a Test Data Set after the orbit change. It consisted of:

- a functional check of the "Ocean and Ice-2 re-tracking" functionality of the processor.
- a comparison between an L2 product generated by the reference processor and the same product generated by IPF.

The comparison was mainly performed on the Ku-band Ocean and Ice-2 data fields, which excluded the following fields:

- Ice-1 parameters,
- S-band parameters,
- Bi-frequency ionosphere correction (linked to S-band),
- rain flag and rain attenuation (linked to S-band).

S-band and S-band linked parameters comparison were also performed.

A first comparison was carried out on the whole product, without any data selection.

A second comparison was carried out taking into account only ocean measurements, using the 4-states altimeter surface type and a bathymetry criteria (bathy < -1000.) for the selection.

5.2.2 Results

DADs

The "AUX_ATT_AXVIEC20020924_131534_20020703_120000_20781231_235959" file cannot be used by the reference processor. As the platform off-nadir angle is always set to 0 in both files (AXVCLS from 1998 and AXVIEC from 2002), it has no impact.

Configuration parameters

We have noticed a difference on one 20-Hz measurement for the "flag_instr_mode" parameter. The reference processor "flag_instr_mode" values have been checked, and are in line with the L1B values.

Ku-band parameters

The comparison on Ku-band parameters shows some differences greater than field resolution on a few measurements. These differences are consistent with the ones encountered by IDEAS team during Linux IPF validation phase on the October 2003 data set, and reported in the document "IDEAS – IPF Validation Report: RA2-MWR, version V06.02L0 » (consistency in term of fields impacted, number of points impacted for each field, and range of differences).

S-band parameters

The comparison on S-band parameters shows discrepancies on a large amount of measurements.

These differences seem not to be related with the ENVISAT orbit change, but only with S-band lost. The existence of important differences on the S-band parameters is not blocking because of the lost of the S-band, but it could be symptomatic of differences between the reference processor and the IPF processing chain in the management of bad data.

Among these S-band parameters differences, we can notice the following:

- The altimeter rain flag should be set to 5 (“evaluation not possible”) when the S-band Sigma0 is lower than 0. It is in reference processor, not in IPF one.
- The number of 20-Hz measurements taken into account in parameter compression is often lower in reference processor than in IPF one, what could come from a difference in the selection criterion.

Conclusions

The analysis shows that the functional check is nominal. The observed discrepancies are relatively small (as usual in such verification scheme) and are not related to the change of orbit.

5.3 IsardSAT Report

Author: Pablo Nilo Garcia

Reference Documents RD.10

5.3.1 Introduction

IsardSAT carried out a field to field comparison between L1b files processed by the IPF and by the reference processor.

5.3.2 Results

No major difference has been found between the IPF and the reference processor L1b products, in particular with what relates to the orbit change. The main parameters to be checked would be the ones that make use of the CFI, as this is the major change with respect to the previous version.

These parameters do not show any significant (> 1 digit) difference.

Several parameters, however, differ 1 digit between the two processors (reference and IPF), throughout the complete product. A few examples are listed below:

• USO smooth: 12499999950 (ref. proc.) vs. 12499999949 (IPF)

• ku_agc: 4061 (ref. proc.) vs. 4060 (IPF)

• lon: 22.675518 (ref. proc.) vs. 22.675517 (IPF)

• dsr_time: 29-OCT-2010 14:28:07.772786 (ref. proc.) vs. 29-OCT-2010 14:28:07.772787

(IPF)

These differences are not related to the orbit change and they have always been accepted when validating the IPF against the reference processor.

One other case in which we have observed differences which are not related to the orbit change is the PTR in-flight time calibration value. This presents serious differences between the reference processor and the IPF.

Moreover, and related to a particular product, we have detected large differences. This is the case of the orbit 45350. As these differences are not related to the orbit change they are not discussed here, but they are subject to an ongoing investigation.

6. SUMMARY

The main conclusion to be drawn is that following the orbit lowering manoeuvre, based on an analysis of the first 2 full cycles (or 60 days data), the ENVISAT RA2 system is performing nominally and that no degradation in performance has been observed. Subsequent analyses of GDR data are planned, when these data sets become available.

Specifically, it has been found that:

- Mispointing has stabilised at a value slightly lower than that observed prior to the orbit lowering, though most recent values suggest an increase back towards that level
- All instrument parameters and geophysical measurements over ocean and ice appear nominal, though full analysis of some level 2 and further derived parameters (e.g. sea level anomaly) will require an analysis of a longer period of data so that the effect of natural variability can be factored out.
- The MWR radiometer measurements took some period to stabilise, but are now nominal, and level 2 measurements consistent with previous measurements.
- A validation of the IPF against the reference processors by CLs and IsardSAT found that there were no major differences. Those that did exist were not related to the change in orbit.

APPENDIX 1: STATIC AUXILIARY DATA FILES

AUX_DEM_AXVIEC20031201_000000_20031201_000000_20200101_000000
AUX_ATT_AXVIEC20020924_131534_20020703_120000_20781231_235959
AUX_LSM_AXVIEC20020123_141228_20020101_000000_20200101_000000
MWR_CON_AXVIEC20040810_145011_20020101_000000_20200101_000000
MWR_LSF_AXVIEC20020313_172218_20020101_000000_20200101_000000
MWR_CHD_AXNIEC20090713_172710_20020101_000000_20200101_000000
MWR_SLT_AXNIEC20090713_172949_20020101_000000_20200101_000000
RA2_IFA_AXVIEC20050216_125529_20020101_000000_20200101_000000
RA2_IFB_AXVIEC20050216_125738_20020101_000000_20200101_000000
RA2_CHD_AXNIEC20100112_160023_20020101_000000_20200101_000000
RA2_CON_AXNIEC20100107_163055_20080123_140000_20200101_000000
RA2_CST_AXVIEC20020621_135858_20020101_000000_20200101_000000
RA2_DIP_AXVIEC20020122_134206_20020101_000000_20200101_000000
RA2_GEO_AXVIEC20020314_093428_20020101_000000_20200101_000000
RA2_ICT_AXVIEC20031208_143628_20020101_000000_20200101_000000
RA2_IOC_AXVIEC20020122_141121_20020101_000000_20200101_000000
RA2_MET_AXVIEC20020204_073357_20020101_000000_20200101_000000
RA2_MSS_AXVIEC20031208_145545_20020101_000000_20200101_000000
RA2_OT1_AXVIEC20040120_082051_20020101_000000_20200101_000000
RA2_OT2_AXNIEC20090713_142737_20020101_000000_20200101_000000
RA2_SET_AXVIEC20020122_150917_20020101_000000_20200101_000000
RA2_SL1_AXVIEC20101102_114416_20101022_100500_20200101_000000
RA2_SL2_AXVIEC20101102_115709_20101022_100500_20200101_000000
RA2_SOI_AXNIEC20090713_132100_20020101_000000_20200101_000000
RA2_SSB_AXNIEC20090713_130625_20020101_000000_20200101_000000
RA2_TLD_AXNIEC20090713_140728_20020101_000000_20200101_000000
RA2_TLG_AXVIEC20040310_110000_20020101_000000_20200101_000000
RA2_USO_AXVIEC20070618_133225_20070620_000000_20200101_000000

APPENDIX 2: NEW PLANNING STRATEGY

The Envisat RA-2 planning has been changed with the new Envisat orbit scenario as follows:

- Procedure for IF calibration (through Digital BITE Mode command) over Himalaya for the entire cycle, 1 ascending pass per day
- Background IE acquisitions starting just after the IF calibration zones and continuing for half day. (1 second length acquisition, in the 'ocean mode' approach)
- As a baseline requirement, the "background IE" acquisition shall be applied whenever no IF calibration and no IE specific acquisition is taking place

All the acquisitions over transponders as well as all the specific IE acquisitions over calibration sites have been suspended.

APPENDIX 3: LIST OF REPORTS PROVIDED DURING MINI-COMMISSIONING PHASE

CLS RA2 Reports

CLS-DOS-NT-10-261

CLS-DOS-NT-10-261-1rev1

CLS-DOS-NT-10-261-1rev2

CLS-DOS-NT-10-261-1rev3.docx

CLS-DOS-NT-10-261-2rev0

CLS-DOS-NT-10-261-2rev1

CLS-DOS-NT-10-261-2rev2

CLS MWR Reports

RA2-MWREnvisat2010+CommissioningPhaseReport_CLS-DOS-NT-10-270

RA2-MWREnvisat2010+CommissioningPhaseReport_CLS-DOS-NT-10-270_3rev0

RA2-MWREnvisat2010+CommissioningPhaseReport_CLS-DOS-NT-10-270_4rev0

RA2-MWREnvisat2010+CommissioningPhaseReport_CLS-DOS-NT-10-270_6rev0

FPAC IGDR Reports

F-PAc_status_2010-11-02_V1

F-PAc_status_2010-11-10

F-PAc_status_2010-11-17

F-PAc_status_2010-11-23

FPAC_IDGR_WeeklyReport_20101102

FPAC_IGDR_WeeklyReport_09112010

FPAC_IGDR_WeeklyReport_16112010

FPAC_IGDRWeeklyReport_23112010

WeeklyReport_30112010

WeeklyReport_091210

WeeklyReport_161210

WeeklyReport_060111

WeeklyReport_130111

ECMWF Reports

ecmwf.RA2.2010w44

ecmwf.RA2.2010w45

cmwf.RA2.2010w47

ecmwf.RA2.2010w49

ecmwf.RA2.2011w01

IDEAS Reports

RA2MWRDOR-Mini-comm-phase-Weekly Report#2

RA2MWRDOR-Mini-comm-phase-Weekly Report#3

RA2MWRDOR-Mini-comm-phase-Weekly Report#4-5

RA2MWRDOR-Mini-comm-phase-Weekly Report#6-7

RA2MWRDOR-Mini-comm-phase-Final Report

E2010+_RA2_IPF_v603_with_new_AUX_validation

UCL / MSSL Reports

LIP-RA2status-rep1

LIP-RA2status-rep2

LIP-RA2status-rep3

LIP-RA2status-rep4

LIP-RA2status-rep5

LIP-RA2status-rep6

LIP-RA2status-Final

IsardSAT Reports

isardSAT_report_20101111_v1a

IsardSAT_report_20101118_v1b

isardSAT_report_20101206_v1a

isardSAT_report_20101206_v1b

isardSAT_report_20101222_v1b

isardSAT_report_20110112_v1a.