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ENVISAT CYCLIC ALTIMETRIC REPORT

CYCLE 49 from 26-06-2006 to 31-07-2006

Quality Assessment Report

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TABLE OF CONTENTS

1 INTRODUCTION

This document aims at reporting on the performance of the EnviSat Radar Altimeter, Microwave Radiometer and DORIS sensors, on the data quality of the corresponding Fast Delivery products as well as on the main events which occurred during cycle 49.

This report covers the period from the 26th of June 2006 until the 31st of August 2006.

2 DISTRIBUTION LIST

This report is available in PDF format at the internet address
http://earth.esa.int/pcs/envisat/ra2/reports/pcs_cyclic/

3 ACRONYMS

AGC	Automatic Gain Control
APC	Antenna Pointing Controller
DORIS	Doppler Orbitography and Radiopositioning Integrated by Satellite
DSR	Data Set Record
EPC	Electronic Power Converter
ERS	European Remote Sensing satellite
ESRIN	European Space Research Institute
ESOC	European Space Operations Centre
FD	Fast Delivery products
GS	Ground Segment
GTS	Globa l Telecommunication System
HTL	Height Tracking Loop
ICU	Instrument Control Unit
IECF	Instrument Engineering Calibration Facility
IF	Intermediate Frequency
IE	Individual Echoes
IPF	Instrument Processing Facility
LUT	Look Up Table
MCMD	MacroCommand
MPH	Main Product Header
MSS	Mean Sea Surface
MWR	MicroWave Radiometer
MPS	Mission Planning System
NRT	Near Real Time
OBT	On-Board Time
OCM	Orbit Control Mode/Manoeuvres
PCS	ERS Products Control Service
PCF	EnviSat Product Control Facility

PDHS-E	ESRIN Processing and Data Handling Station
PDHS-K	Kiruna Processing and Data Handling Station
PLSOL	Payload Switch-Off Line
PMC	Payload Main Computer
PSO	On-orbit Position
PTR	Point Target Response
RA-2	EnviSat Radar Altimeter bi-frequency
RSL	Resolution Selection Logic
SAD	Static Auxiliary Files
SBT	Satellite Binary Time
SEU	Single Event
SLA	Sea Level Anomalies
SFCM	Stellar Fine Control Mode
SPH	Specific Product header
SPSA	Signal Processing Sub-Assembly
SYSM	Stellar Yaw Steering Mode
S/W	Software
TM	Telemetry
TRP	Transponder
TWT	Traveling Wave Tube
UTC	Coordinated Universal Time
USO	Ultra Stable Oscillator
YSM	Yaw Stellar Mode

4 REFERENCE DOCUMENTS

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[R – 1b] F-PAC MONTHLY REPORT, SALP-RP-M-OP-15387-CN, August 2005
[R – 2] ENVISAT Microwave Radiometer Assessment Report Cycle 044, CLS.DOS/05.147, http://earth.esa.int/pcs/envisat/mwr/reports/
[R – 3] Envisat RA-2 IF Mask weird behavior: Investigation Report
[R – 4] Instrument Performance Evaluation and Analysis Summary, PO-TR-ALS-RA-0042
[R – 5] Instrument Corrections Applied on RA-2 Level 1b products, Paper presented at the ENVISAT Calibration Review in September 2002
[R – 6] ENVISAT Phase E Cal/Val Acquisition Plan, ENVI-SPPA-EOPG-TN-03-0008
[R – 7] RA-2 S-Band Anomaly Investigation, PO-TN-ESA-RA-1342, http://earth.esa.int/pcs/envisat/ra2/articles/
[R – 8] RA-2 Performance Results, Paper presented at the ENVISAT Calibration Review in September 2002
[R – 9a] ECMWF Report on ENVISAT RA- 2 for July 2005, Report on ENVISAT Radar Altimeter - 2 (RA- 2), Wind/ Wave Product with Height Information (RA2_ WWV_ 2P),
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[R – 10] Envisat GDR Quality Assessment Report, SALP-RP-P2-EX-21121-CLS015

[R – 11] Envisat RA-2 Range Instrumental correction: USO clock period variations and associated auxiliary file, ENVI-GSEG-EOPG-TN-03-0009
[R – 12] Defining a Rain flag for the Envisat altimeter, G. Quartly, study presented to the final CCVT plenary meeting, http://earth.esa.int/pcs/envisat/ra2/articles/
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[R – 15] ENVISAT-1 Products Specifications - Vol. 14: RA-2 Products Specifications, PO-RS-MDA-GS-2009, Iss 3, Rev. K, 24/05/2004
[R – 16] Algorithm for Flag identification and waveforms reconstruction of RA-2 data affected by "S-Band anomaly", ENVI-GSEG-TN-04-0004, Issue 1.4
[R-17] Envisat Cyclic Report Cycle 28, ENVI-GSOP-EOPG-03-0011
[R-18] ENVISAT RA-2 IF MASK AUX FILE - Updating Strategy: Investigation Report; C. Bignami and C.Loddo and N. Pierdicca.

5 GENERAL QUALITY ASSESSMENT

5.1 *Cycle Overview*

- The Envisat RA-2 has been operating nominally with the RFSS configured to the A side.
- The analysis of the RA-2 data confirmed the persistence of the abnormal RA-2 Ultra-Stable Oscillator (USO) behaviour affecting the Altimetric Range by few meters. No other altimeter parameter has been affected during the anomaly period.
  <u>WARNING:</u> Users are advised not to use the range parameter in Ku and S Band for the period covered by cycle 49 without correcting the data.
- Three USO corrections have been developed for the different Envisat Level 2 altimetry data products for correcting the abnormal RA-2 USO behaviour affecting the Altimetric Range by few meters w.r.t. the Mean Sea Surface:
  1. NRT orbit basis USO correction for FDGDR products , available from http://earth.esa.int/pcs/envisat/ra2/auxdata/;
  2. An Interim daily USO correction for IGDR products, available at the same F-PAC location as for IGDR, in the directory igdr_ous_corr
  3. An OFL cycle USO correction for GDR products, available at the same F-PAC location as for GDR, in the directory gdr_ous_corr.

- The NRT USO correction has been made available from July 24, 2006 onwards.
- The number of valid IF masks are 20 (32% of acquired masks). The auxiliary file RA2_IFF_AX has been updated once, on date 21 July 2006.
- The S Band Anomaly only affected 6 orbits, corresponding to 1.19% of the data.
- Tracking performances in the different resolutions are well in line with the output figures and objectives of the Commissioning Phase.
- During cycle 49, no update of the RA2_USO_AX has been done.

- The Radar Altimeter was never unavailable, RA-2 Data availability is around 98.77%
- DORIS was never unavailable, with data availability of 99.16%
- MWR was never unavailable, with data availability of 99.46%

5.2 Payload status

5.2.1 ALTIMETER EVENTS

The Radar Altimeter 2, during cycle 49, was never unavailable.

5.2.1.1 RA-2 instrument planning

The RA-2 instrument planning was performed as follows:

- IF Calibration Mode according to the nominal operational acquisition scheme: 100 seconds of data twice per day over Himalayan region (ascending and descending passes).
- Individual Echoes background planning: the buffering of 20 Data Blocks of Individual Echoes (1.114 sec.) transmitted every 160 Data Blocks starts after flying over the Himalayan region (both ascending and descending passes) and is operated for half a day.
- Individual Echoes acquisitions during PLO activity over ESA transponder located in Rome (1 second length acquisition, 1 repetition)
- Individual Echoes acquisition (1 second length acquisition, 1 repetition) over the following sites:
  Capraia, Toulon D, Vostok , Dome C. Appendix 6 contains a table with the coordinates.
- Individual Echoes acquisitions over the Uyuni Salar
- Preset Loop Output mode for GAVDOS Range transponders, located in Creta.
- Preset Loop Output mode over the ESA transponder located in Rome (permanent location); high chirp resolution.

Hereafter the map is reported showing the acquisition sites for both the Range and Sigma_0 transponders.

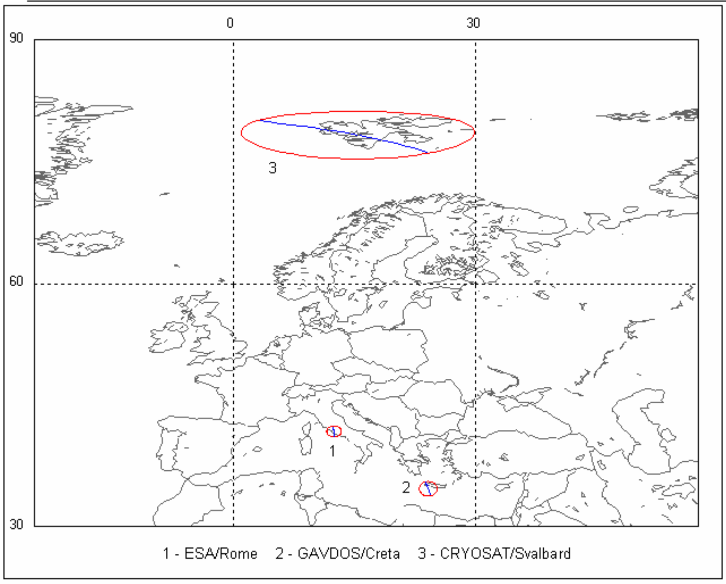

Figure 1: Transponder Acquisition sites

5.2.2 MWR EVENTS

The MWR, during cycle 49 was never unavailable [R-13].

5.2.3 DORIS EVENTS

The DORIS, during cycle 49 was never unavailable [R-13].

5.3 Availability

The summary of the RA-2 data products availability for this cycle is reported in Appendix 2.
Data availability was 98.77% for RA2 products, 99.46% for MWR and around 99.16% for DORIS products.

5.4 Orbit quality

During cycle 49 no orbit manoeuvres were executed.

The spacecraft ground track exited on July 4, 2006 (DOY 185) at around 06:00 utc the +/- 1km deadband around the reference ground track on its western boundary at ascending node.
The maximum deadband violation was observed on July 22, 2006 (DOY 203) at around 12:00 utc, of the order of 200 metres west of the western deadband boundary at ascending node.
This deadband violation is the combined effect of the currently very low level of air drag and of the debris collision avoidance manoeuvre performed on June 20th 2006.

5.5 Ground Segment Processing Chain Status

5.5.1 IPF PROCESSING CHAIN

5.5.1.1 Version

The current version of the IPF processing chain is V5.02, installed in both PDHS-E and PDHS-K on 24th October 2005. It contains the following algorithms and auxiliary data files upgrade:

1. USO instrumental correction within the RA-2 L1b processor.
2. New MWR Side Lobes correction algorithm within MWR L1b processor
3. Correction of the mispointing evaluation algorithm within the RA-2 L2 processor
4. Inclusion of the loading tide for the GOT2000.2 model.
5. Addition of the peakiness fields in Ku and S band to the RA-2 and MWR FD/I/MAR meteorological products
6. Inclusion of the square of the significant wave height in Ku and S band
7. Inclusion of an S-band anomaly flag, see [R – 16]
8. Upgrade of the Level 1B and Level 2 processing for DORIS NRT orbital information computation
9. New ADF for Digital Elevation Model (DEM): AUX_DEM_AX
10. Adjustment of the S Band computation for the rain flag
11. New ADF for wind table: RA2_SOI_AX
12. New ADF for Sea State Bias: RA2_SSB_AX

A new version of the IPF should be released soon in order to fix some discrepancies related to points 5 and 7. Given some planning problems encountered, point 8 could only be covered at the last part of cycle 42, i.e. since the 21st of November products have been processed using DORIS NRT orbital information computation.

The previous IPF version V4.58 was operational at the Envisat PDHS-K and PDHS-E since 16th July 2004. A complete table of IPF Level1b and Level2 upgrades is reported in Appendix 1.

5.5.1.2 Auxiliary Data File

The Auxiliary files actually used by the IPF ground processing are reported in Appendix 3.
The RA2_POL_AX, RA2_SOL_AX and RA2_PLA_AX have been regularly updated without problems. The RA2_IFF_AX has been updated during the reporting period. The RA2_USO_AX has never been updated during the reporting period given the anomaly in the USO clock period, see Chapter 6.1.3. Data are corrected with the RA2_USO_AX estimated before the USO Clock anomaly (USO_Clock_Period = 12499999726, USO_Range_Correction= 17.3 mm).

The RA-2 Auxiliary Data Files (ADF) are accessible from the Envisat Web pages under
http://www.envisat.esa.int/services/auxiliary_data/ra2mwr/ .

5.5.2 F-PAC PROCESSING CHAIN

The current version of CMA is V7.1 operational since 24th October 2005.
F-PAC CMA anomalies are detailed in the F-PAC Monthly Report [R – 1a] and [R-1b].
The F-PAC CMA processing chain includes all the IPF evolutions plus some others like:
- Inclusion of GPS Ionospheric correction
- Inclusion of MOG2D Inverse Barometer Geophysical Correction in Level 2 products
- FES2004
- Addition of a field for Level 1B SW ID in Level 2 products
- Inclusion of nadir location not corrected for slope model

6 INSTRUMENT PERFORMANCE

6.1 RA-2 Performance

6.1.1 TRACKING CAPABILITY

The percentages of acquisition in the different resolutions subdivided by surface type are given in the Table bellow:

Surface type	320 MHz	Commissioning Phase objectives 320 MHz	80 MHz	20MHz
Open Ocean	99,99	>99%	0,01	0,00
Costal Water (ocean depth < 200 m)	98,44	No specific requirement	1,35	0,21
Sea Ice	99,19	>95%	0,74	0,07
Ice Sheet	96,30	>95%	3,07	0,63
Land	81,76	No specific requirement	14,34	3,90
All world	95,29		3,74	0,97

Table 1: RA-2 Tracking capability: Chirp ID percentages discriminated by surface type

The figures given for the RA-2 tracking performances during this cycle are in line with the ones recorded at the end of the Commissioning Phase reported in the last column and presented in [R – 8].

In Figure 2, Figure 3 and Figure 4 the cyclic tracking percentages for the three RA-2 bandwidths are reported.
The worsening in performance noticeable for cycle 20 was due to the up-load of wrong on-board software parameters which lasted for about three days whilst for cycle 47 a special operation has been performed to limit RA-2 Chirp Bandwidth to fixed values.

In general, even if a tiny evolution can be observed, the tracking performances are well in line with the output figures and objectives of the Commissioning Phase as given in Table 1.

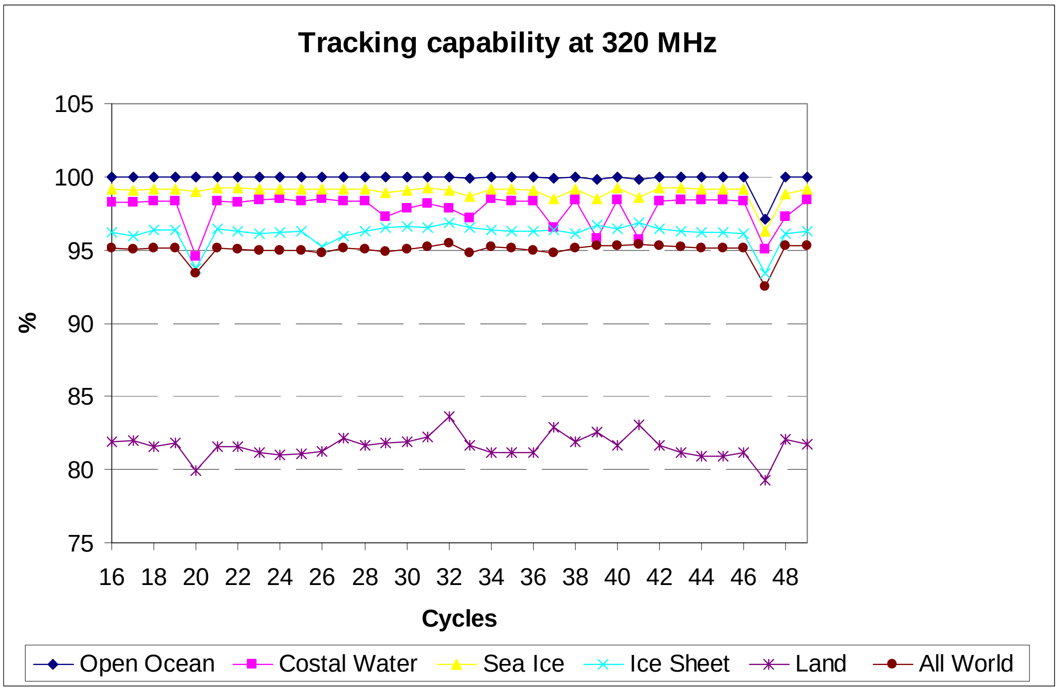

Figure 2: RA-2 Tracking percentage at 320MHz for different surfaces

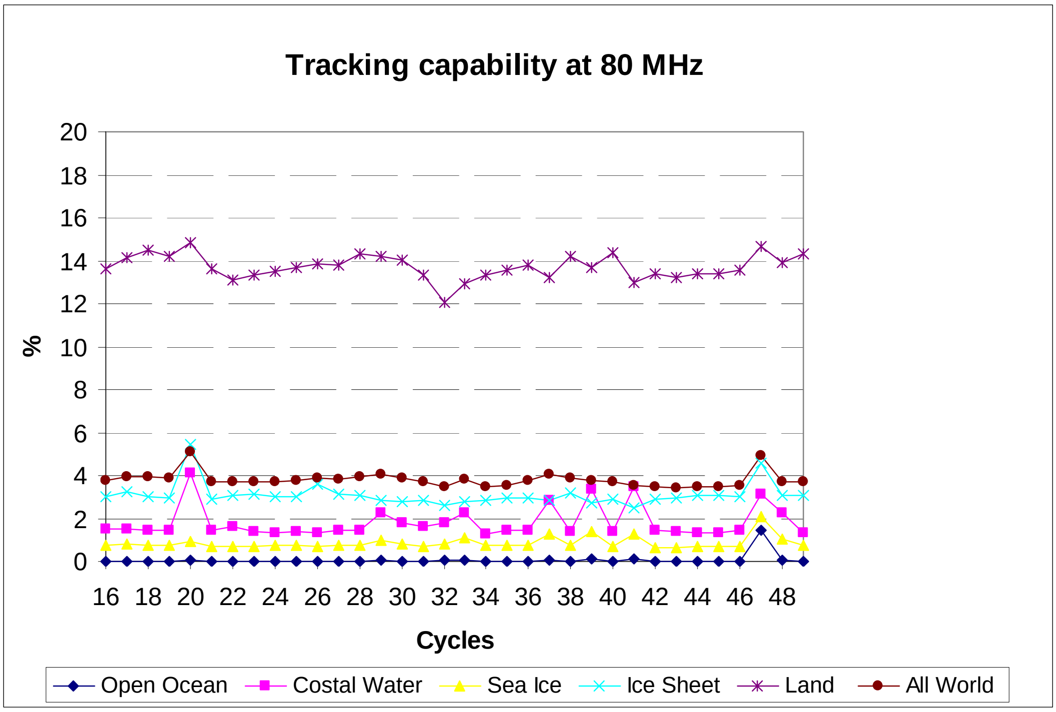

Figure 3: RA-2 Tracking percentage at 80MHz for different surfaces

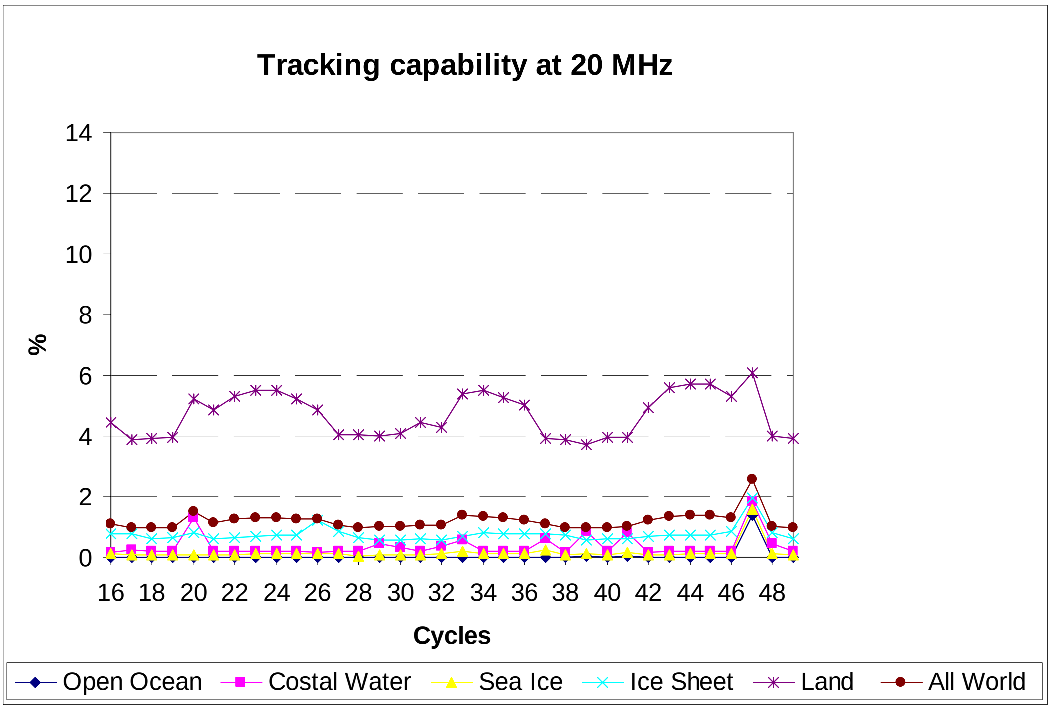

Figure 4: RA-2 Tracking percentage at 20MHz for different surfaces

6.1.2 IF FILTER MASK

In Figure 5 all valid IF masks retrieved during cycle 49 are plotted in the left panel. The on-ground measured IF mask (ref [R – 4]) is also plotted in that panel with a solid line. In the right panel, the difference of each of the calculated IF masks with respect to the on-ground measured one is reported. The average difference with respect to the on-ground is used as the criteria for defining valid masks: if it is lower than 0.01 dbs, the mask is considered valid.

During cycle 49, the number of valid IF masks has been 20, representing 32 % of the acquired IF masks.

Only valid IF masks are used to generate the final IF mask used in the Level 1B ground processing; the method used for generating it consists in a monthly average according to the strategy defined in [R-18] with an editing criteria based on the comparison between each of the single IF masks and the reference one (on-ground).

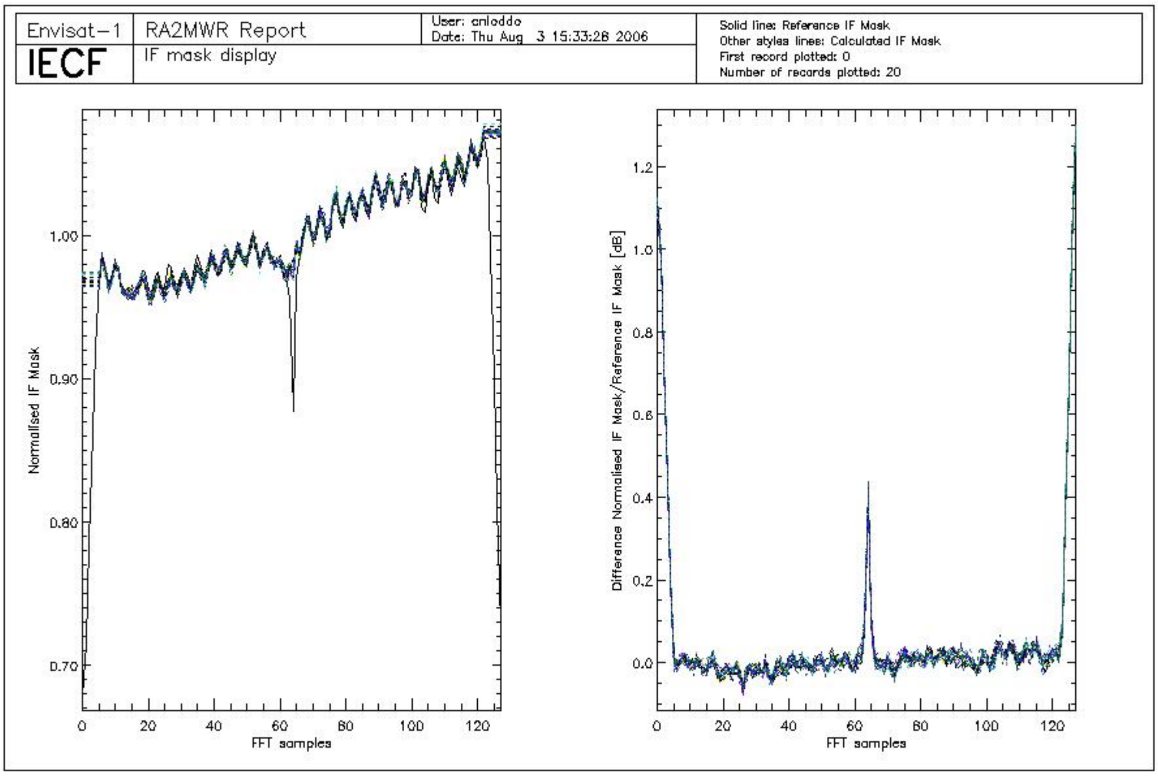

Figure 5: Valid IF masks retrieved daily during cycle 49 plotted together with the on-ground reference.

Since the 24th of October, the auxiliary file RA2_IFF_AX have been updated regularly once per month. In Figure 6 the new IF Mask, updated on the 21 of July, and the previous IF Mask used for processing are plotted.

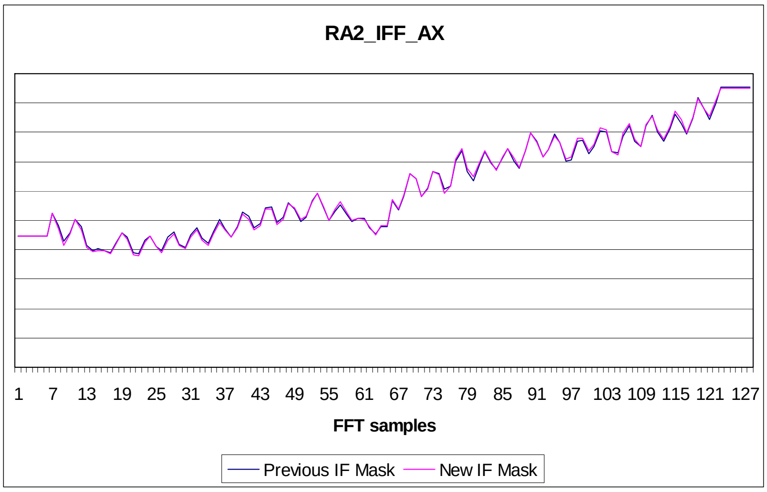

Figure 6: Previous and New IF Mask

In Figure 7 the evolution of the IF mask quality parameters evaluated as in [R – 4] is reported only for valid data. It can be observed that the difference with respect to the on-ground reference stays quite constant around 0.07 dBs.
Four peaks are visible on the plot that correspond to the data acquired on September the 27th 2003 at 15:48, on October the 29th 2003 at 15:42, on May the 10th 2004 at 15:45 and on April 9th 2006. The reason of this could be found in the instrument warming up considering that the IF Cal acquisition has been made, in the three first cases, only a couple of hours after an anomaly recovery. In the last case the unavailability was very long, more than two days, and the warming up effect lasted longer. The residual noise and the accuracy show a very constant behavior over the whole period.
During cycle 49 the IF Calibration Mode still shows the weird behavior described in [R – 3]. This problem, present since the beginning of the mission, is under investigation. The anomaly directly affects the number of valid RA-2 IF masks obtained per cycle, but does not prevent the generation of the IF mask correction file, used in input to the Level 1B ground processing.

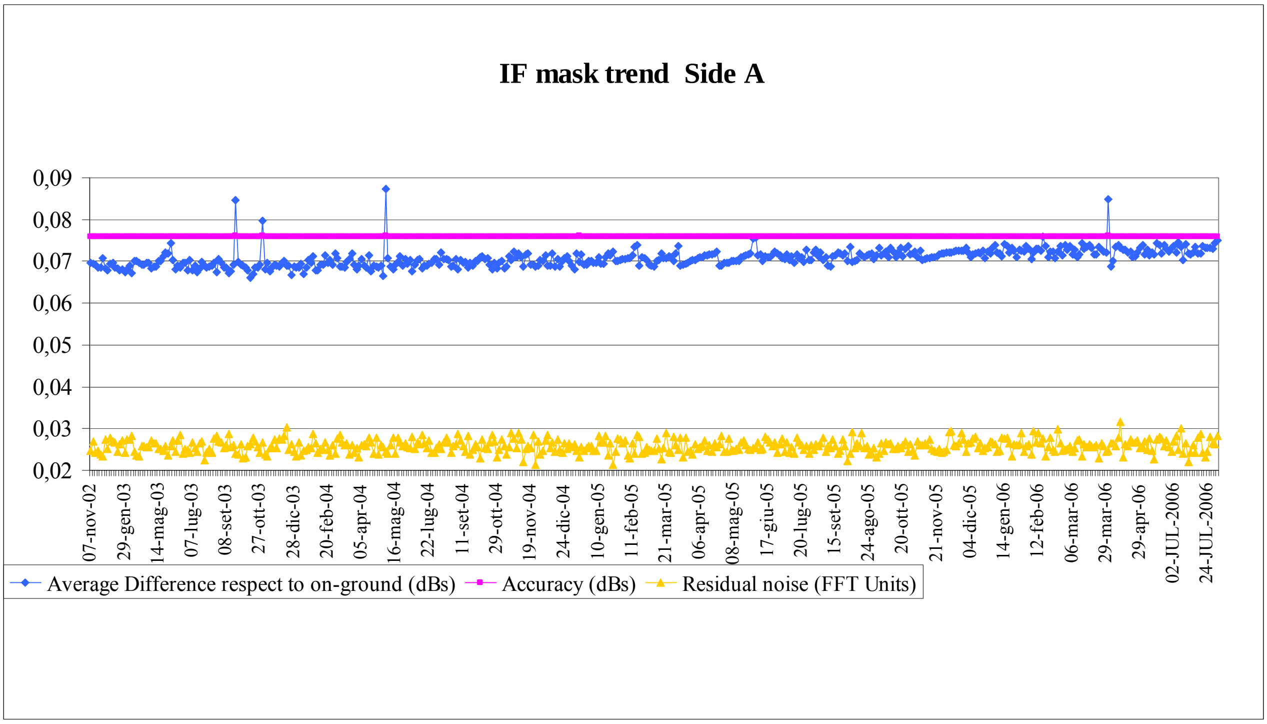

Figure 7: Evolution of the IF mask related parameters for valid IF masks retrieved up to cycle 49

In Figure 8 the percentages of valid IF masks from cycle 20 up to cycle 49 are reported. This percentage is computed with reference to the acquired masks per cycle. The higher number of valid IF Masks in cycle 48 is a consequence of the special IF Calibration operations which took place on 8 and 9 June 2006.

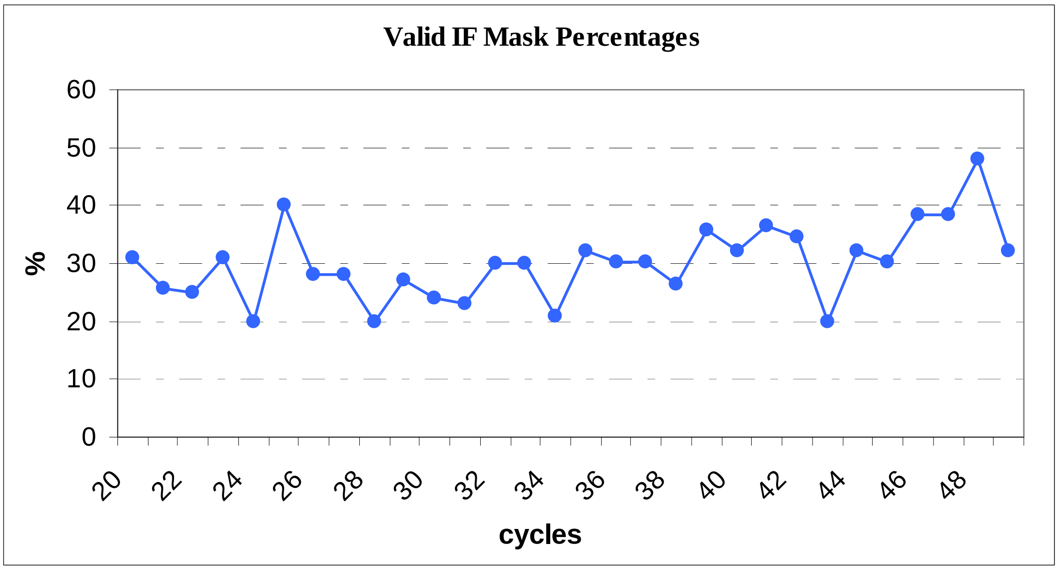

Figure 8: Percentages of valid IF Mask up to cycle 49

6.1.3 USO

Since the 24th of October, with the new IPF V5.02, the actual value of the USO clock period has been used within the L1b processing; this means that the data are corrected for the bias and the drift correlated to the actual USO clock period.
The evaluation of the actual USO clock period is performed off-line respect to the IPF processing and it is updated once per week in the auxiliary file RA2_USO_AX.
Note: Since the 9th of March this file hasn't been updated given the anomaly of the USO clock period described bellow.

In Figure 9 the USO clock period trend is reported. 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.

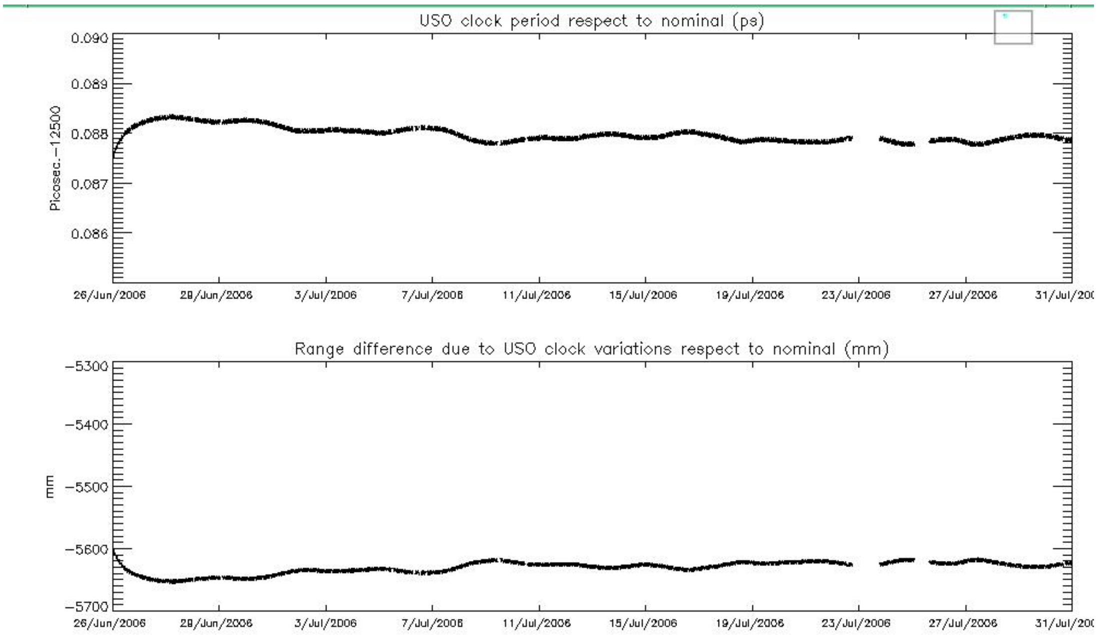

Figure 9: USO clock period for cycle 49

<u>WARNING:</u>

- **Users are advised not to use the range parameter in Ku and S Band during cycle 49**

The USO Clock Period anomaly is still present in cycle 49. It started in cycle 44, on date 1 Feb 2006 12:04:30, Orbit = 205181. It directly happened after the recovery of a RA-2 on-board anomaly occurred on the 2006/02/01 at 05:17:56. The range correction jumped by several meters and presented some oscillations at the orbital period that make the range unusable for both Ku and S Band, see Chapter 7.4.1. The anomaly persisted intermittently until the 15th of May 14:21:50, Orbit = 21994, when the instrument was configured to its RFSS B-side. It appeared again when the instrument was reconfigured to its nominal RFSS A-side on date 21 June 13:20:15, Orbit = 22523.

Three USO corrections have been developed for the different Envisat Level 2 altimetry data products for correcting the abnormal RA-2 USO behaviour affecting the Altimetric Range by few meters w.r.t. the Mean Sea Surface, see Chapter 7.2.5.
The NRT USO correction has been made available from July 28, 2006 onwards.

In Figure 10, the USO clock period trend retrieved from the beginning of the mission until the last week of cycle 49 is reported. Three different periods can be distinguished:

1. From the beginning of the mission until the 24th of October the Nominal USO clock period has been used in the processing. The data was not corrected for the bias and the drift correlated to the actual USO clock period;

2. From the 24th of October until the 1st of February, and from the 11th of February until the 13th of March, the actual USO clock period has been used within the processing. The data was corrected for the bias and the drift correlated to the actual USO clock period. Those values, translated into altimetric range figures, are respectively of 28.5 mm and –4.58 mm/year as calculated with data covering the period 13 June 2003 to 01 February 2006 (the data covering the anomalous period between 2004/09/27 at ~16:00 and 2004/09/29 at ~12:00 AM have not been used to evaluate these figures);
3. From the 1st of February until the 11th of February and from the 13th of March onwards, data has not been corrected with the proper value of the USO Clock period.

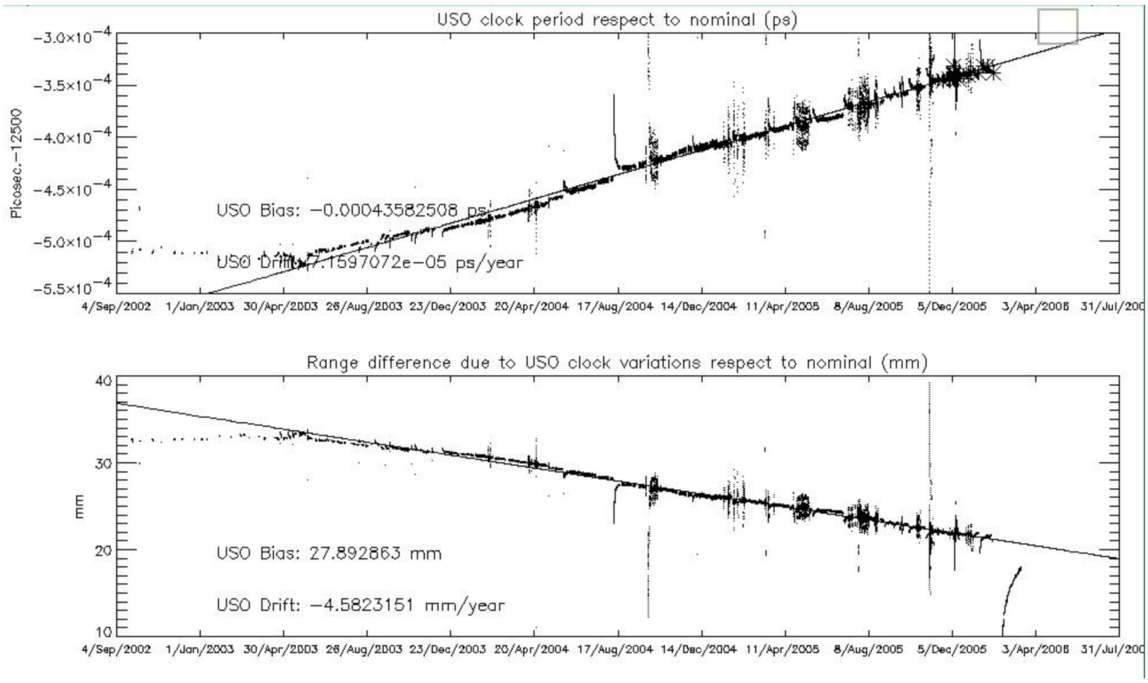

Figure 10: USO clock period until cycle 49

6.1.4 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. In the upper panel of Figure 11, the differences between the extrapolated UTC values and the corresponding real UTC values measured at the next Kiruna dump, are reported. In the lower panel, the ICU clock step for the same period is shown.

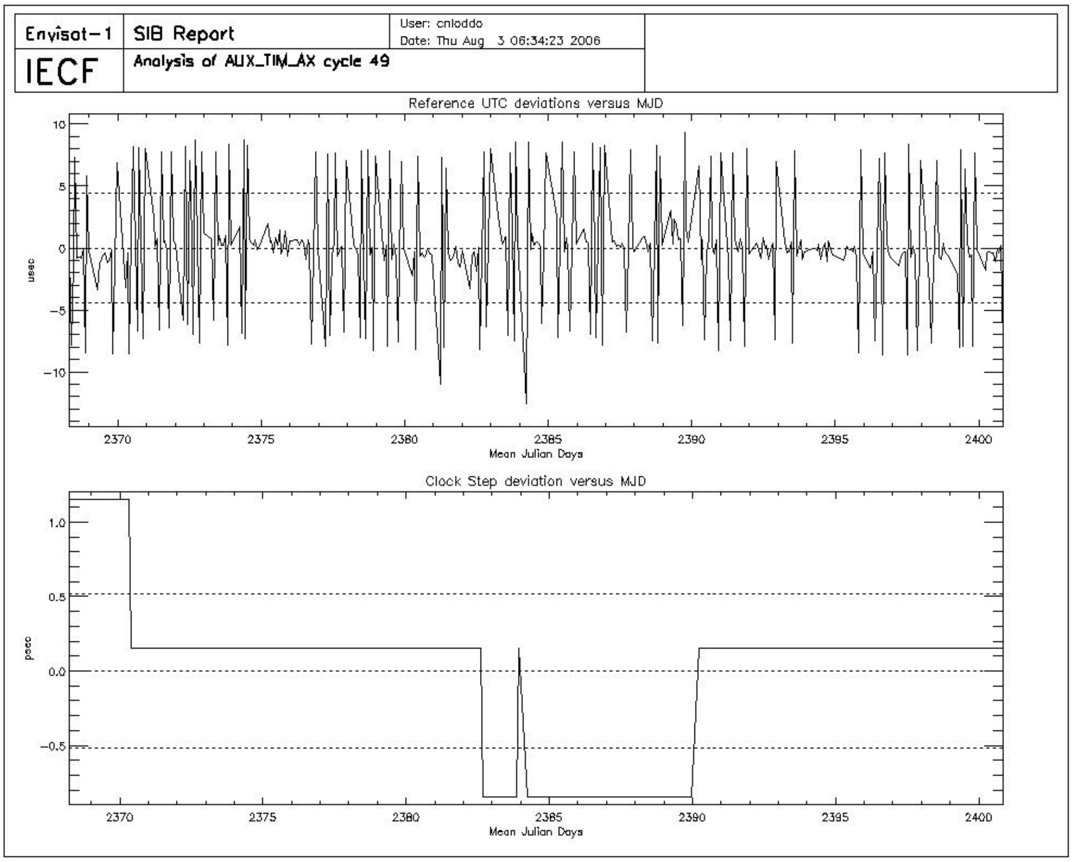

Figure 11: UTC deviations and ICU clock period for cycle 49

In Figure 12 (upper panel) the differences between the extrapolated UTC values and the corresponding real UTC values measured at the next Kiruna dump, are reported for data up to cycle 32. The UTC deviations for cycle 33 up to cycle 49 are reported in Figure 13.
Only a few anomalous events can be observed at the beginning of the period (cycles 16/17) for which the difference rises above the 20 microseconds warning threshold. However, starting from cycles 22/23, the number of small differences (10 microseconds plus or minus) has increased a lot. Furthermore, during the last ten days of the cycle 32 and for all cycle 33 and 34, the variability of the deviations has increased reporting many peaks just over the 20 microseconds threshold (first part of Figure 12); this phenomenon is now fixed. In the lower panel of both figures the ICU clock step for the same period is shown where big variations are reported. The jump observed around MJD 2288 (07-APR-2006) on Figure 13 is related to the reconfiguration of the Precise Time Correlation process, which became blocked with invalid data after the Service Module anomaly and reconfiguration occurred on 6 April 2006. This is however not a problem because the ICU clock period variations are included in the algorithm for the SBT/UTC correlation evaluation.

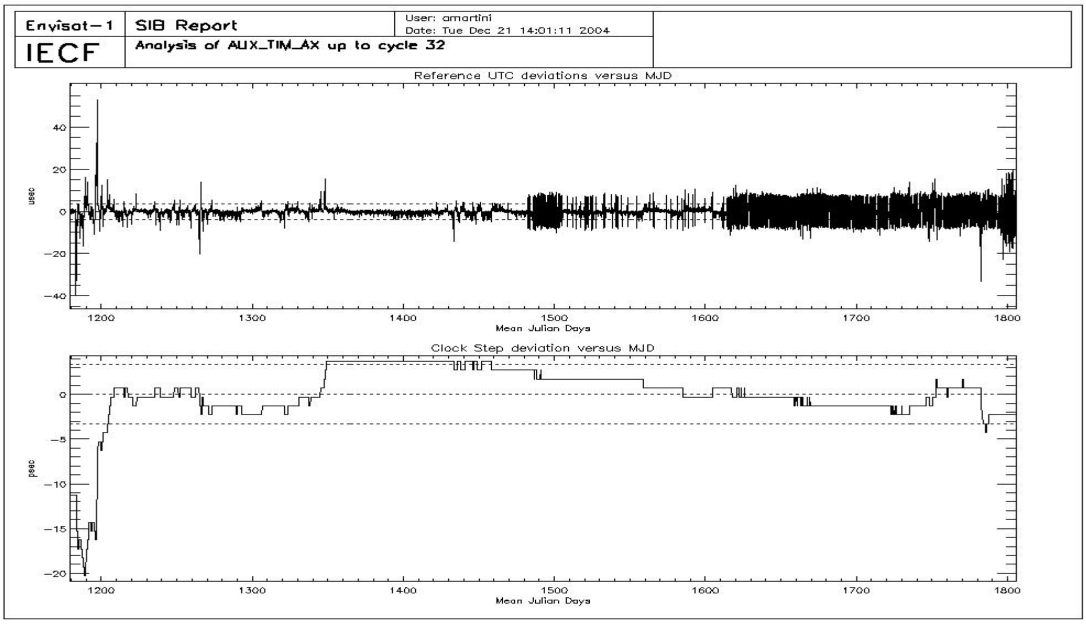

Figure 12: UTC deviations and ICU clock period up to cycle 32

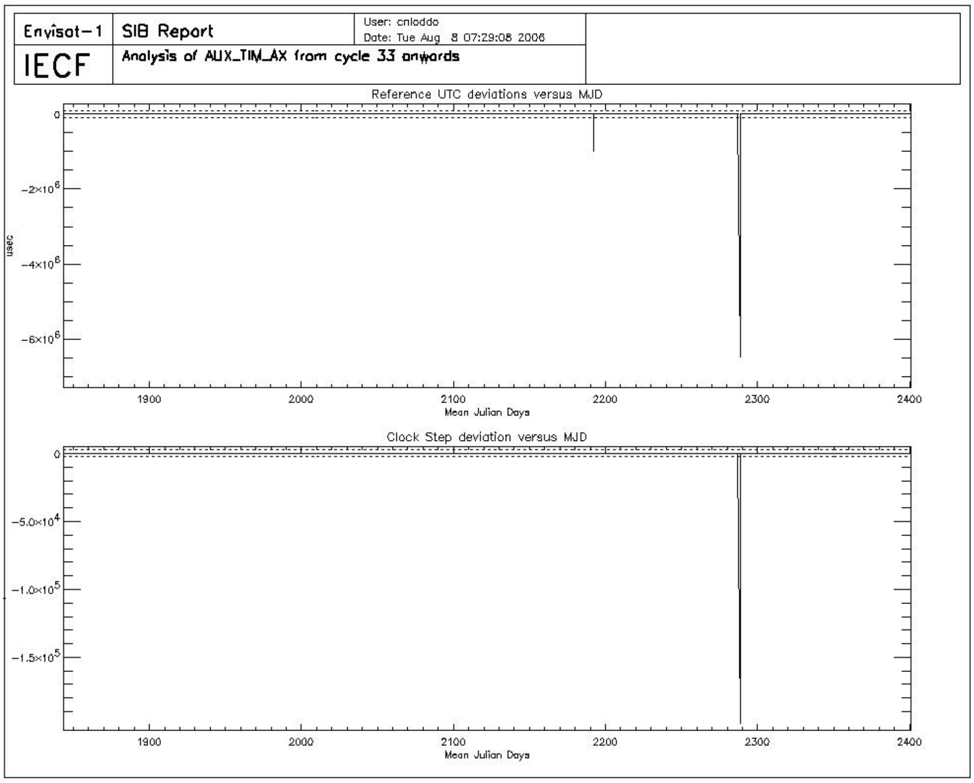

Figure 13: UTC deviations and ICU clock period from cycle 33 up to cycle 49

6.1.5 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 cycle 49 (averaged per day) are reported in the next figures.

The Time delay in-flight calibration factor and the Sigma0 calibration factor, reported in Figures 14 and 15, show a regular behaviour as observed on previous cycles.

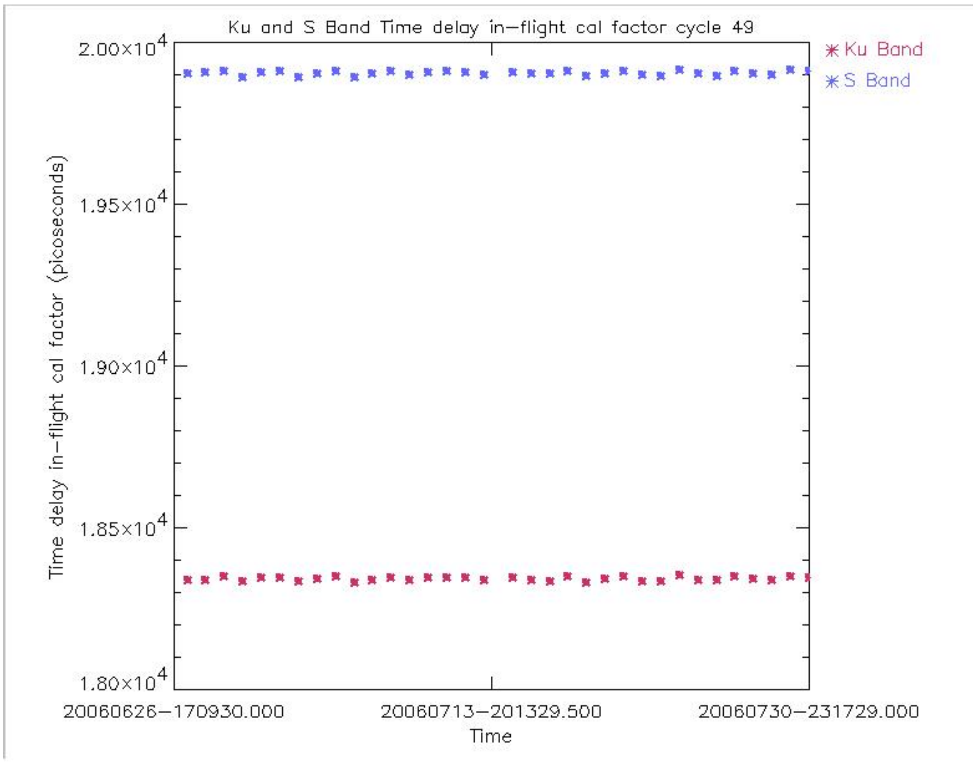

Figure 14: Ku and S Band in-flight time delay calibration factor for cycle 49

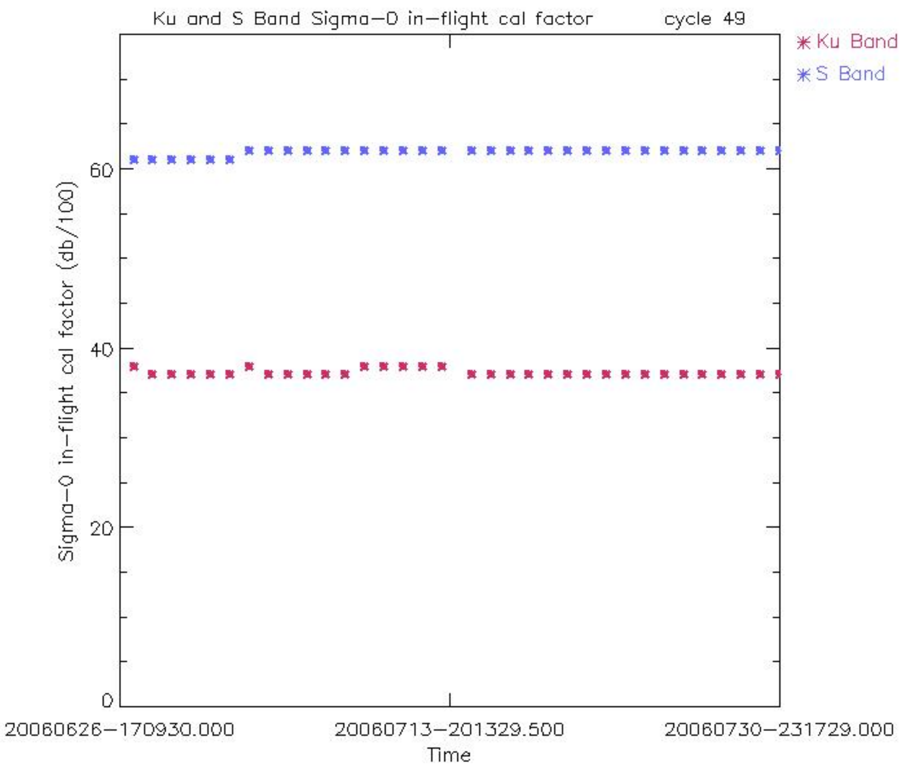

Figure 15: Ku and S Band in-flight Sigma0 calibration factor for cycle 49

Figure 16 and Figure 17 report Ku and S Band in-flight calibration factors for Time Delay and Sigma0 respectively, daily averaged, up to the current cycle. The Time Delay factor is shown to be very stable for both the working frequencies. The Ku band Sigma0 factor reveals a decrease of about 0.2 dBs over the period starting from cycle 16. As this instability is quite small, it is not being considered a problem for the moment, since the calibration factor is indeed introduced especially to correct for eventual instrumental changes. However, special attention is kept on the monitoring of this parameter. The jump observed on the last part of the plot is related to the period on which the instrument sub-system Radio Frequency Module (RFM) was switched to its B-side, occurred between 15 May and 21 June 2006.

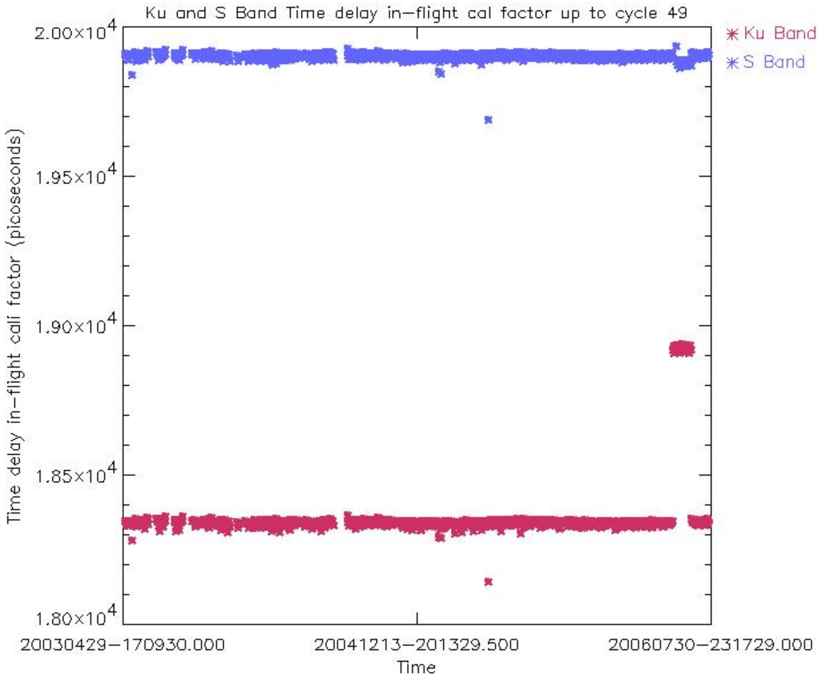

Figure 16: Ku and S Band in-flight time delay calibration factor up to cycle 49

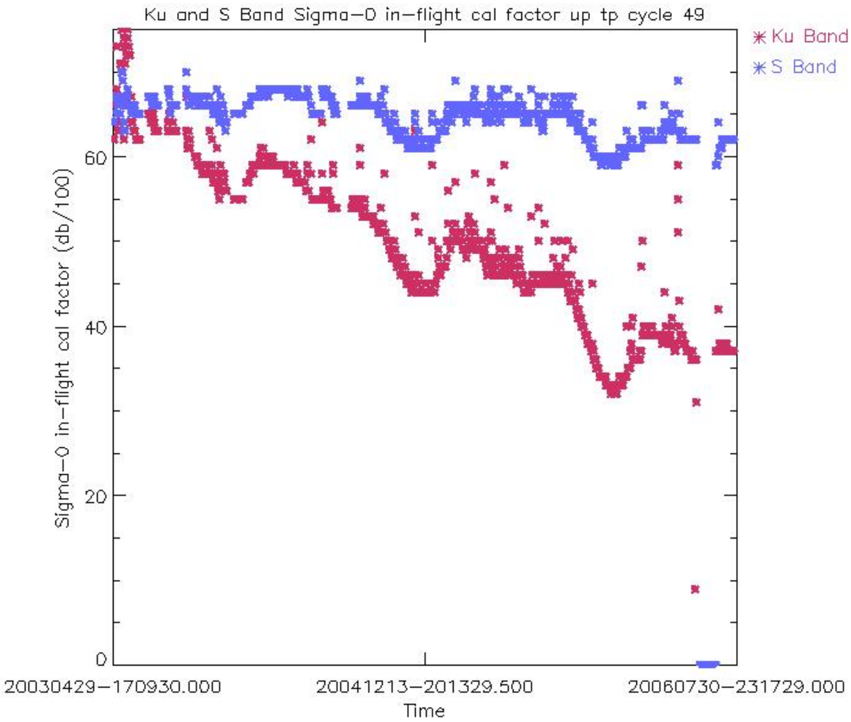

Figure 17: Ku and S Band in-flight Sigma0 calibration factor up to cycle 49

6.1.6 SIGMA0 TRANSPONDER

The σ° absolute calibration of the RA-2 is performed using a reference target given by a transponder that has been developed at ESTEC. This has been exploited during the 6 month Commissioning phase to generate early calibration results. In order to consolidate the calibration results and to monitor the RA-2 calibration of σ° during the Envisat lifetime, continual monitoring is accomplished by operating the transponder for as many Envisat overpasses as possible.
Since the 11^{th} of October the transponder has been moved to a permanent site located in Rome. The acquisition planned for the 18^{th} of July has been performed but the estimated bias was much higher then expected probably due to some problems with the attenuator setting of the transponder.

Appendix 4 reports the transponder measurements from cycle 24 up to cycle 48.
The mean value of the estimated bias at High Resolution is 0.99 dB with a standard deviation of 0.1 dB. It is possible to notice that the Low Resolution measurements are coherent among themselves but there is a bias with respect to the High Resolution ones. This is due to a processing problem with the internal calibration factor not taken into account in Low Resolution Mode.

In Figure 18, the time behavior of the bias is plotted for both Low and High Resolution. The green line represents the corrected bias for the internal calibration factor (only for the Low Resolution data) and the tropospheric attenuation. The latter is estimated by using the ECMWF meteorological data. The low value of the corrected bias for the orbit 14397 is due to the dew air condition and a probable underestimation of the tropo-attenuation.

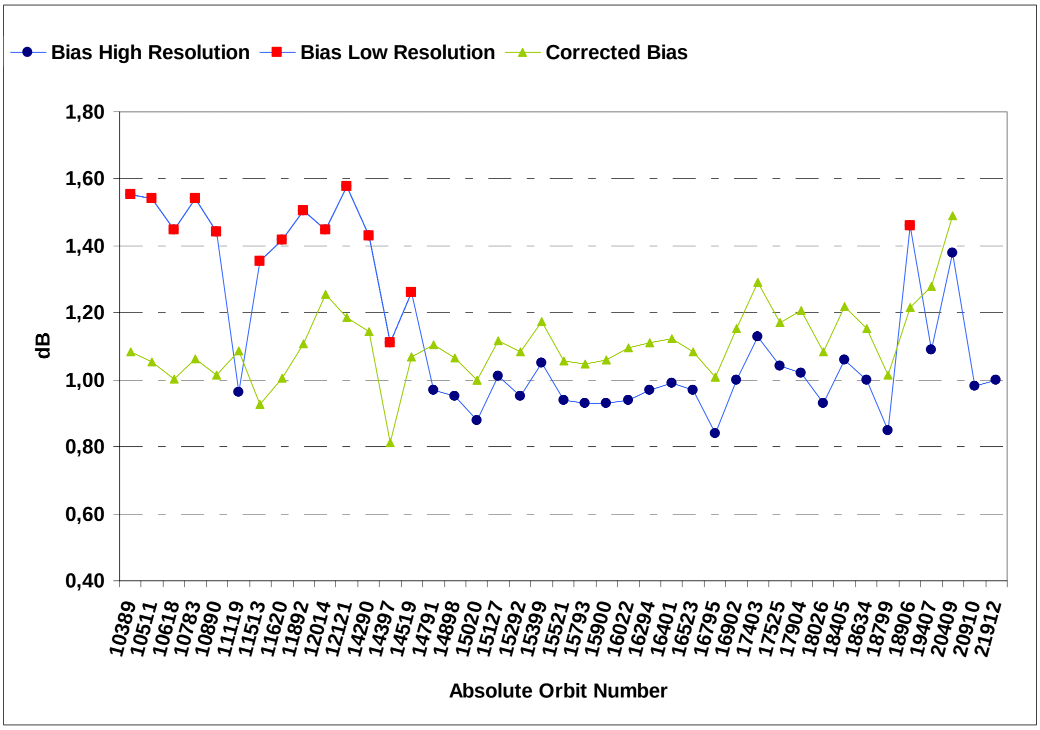

Figure 18: Time behavior of the transponder bias

6.1.7 MISPOINTING

In Figure 19, the trend of the mispointing squared (averaged every orbit) is reported in deg^2*10e-4. The average squared mispointing value, as extracted from the RA2_FGD_2P data products, has decreased from about 0.028 deg^2, to 0.0075 deg^2. This is due to the new algorithm currently used to retrieve the mispointing value from the RA-2 waveform data, see section 5.1.1.1.
With the new IPF version 5.02, the mispointing is estimated through the waveform trailing edge slope using an optimum and fixed gate and no longer an adaptive window as defined previously. This allows avoidance of the filter bump effect that leads to high values of the mispointing.

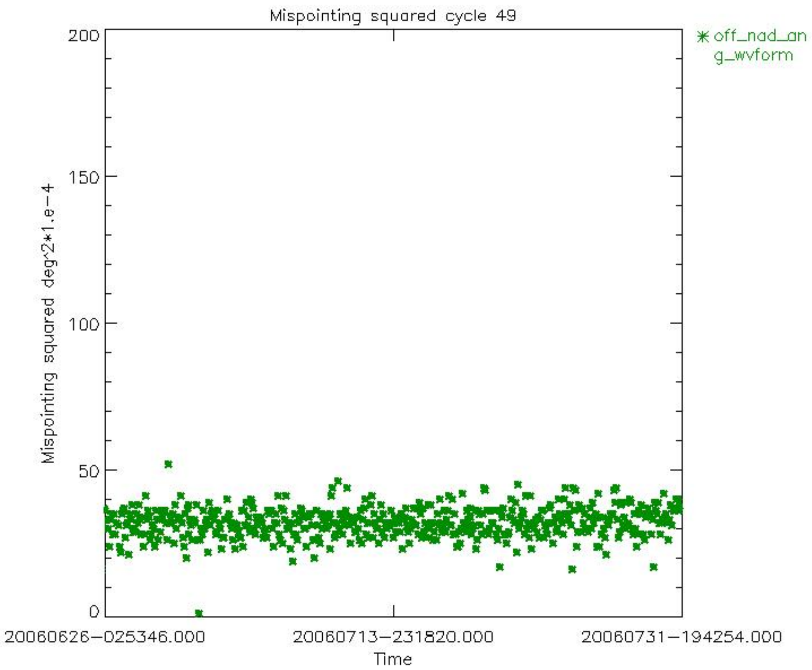

Figure 19: Smoothed mispointing squared trend for cycle 49 (deg^2*10^4)

In Figure 20, the overall mispointing squared trend (averaged over each orbit) is plotted for cycles 16 to 49.

The low values at the end of the plot are related to the acquisition in RFFS B-Side, occurred between 15 May and 21 June 2006.
The jump which occurred on date October 24th is related to the upload of IPF version 5.02. The abrupt decreasing of the mispointing squared value is related to the new algorithm, as described in the previous paragraph.
The jump which occurred on November the 26th 2003 is correlated to the upload of IPF version 4.56; the abrupt decrease of the mispointing squared value is due to the usage of a new RA2_IFF_AX IF mask auxiliary file. After the drop a very tiny increase of the mispointing

squared could eventually be detectable. The most probable cause of this phenomenon could be a change in the Intermediate Frequency Filter slope due to ageing effects. For this reason, the RA2_IFF_AX will be updated regularly, once per month.

On the other hand, it can be noticed that the mispointing squared assumes lower values just after an instrument anomaly, showing an increasing trend until it reaches a standard mispointing value. This particular behavior can be explained by the different shape that the over-ocean average waveform has before and after an anomalous event as visible in Figure 21. Observe, in particular, the disappearance of the small dip in the waveforms acquired after the anomaly. This problem has been reduced with the introduction of the updated mispointing retrieval algorithm as described in the previous paragraph.

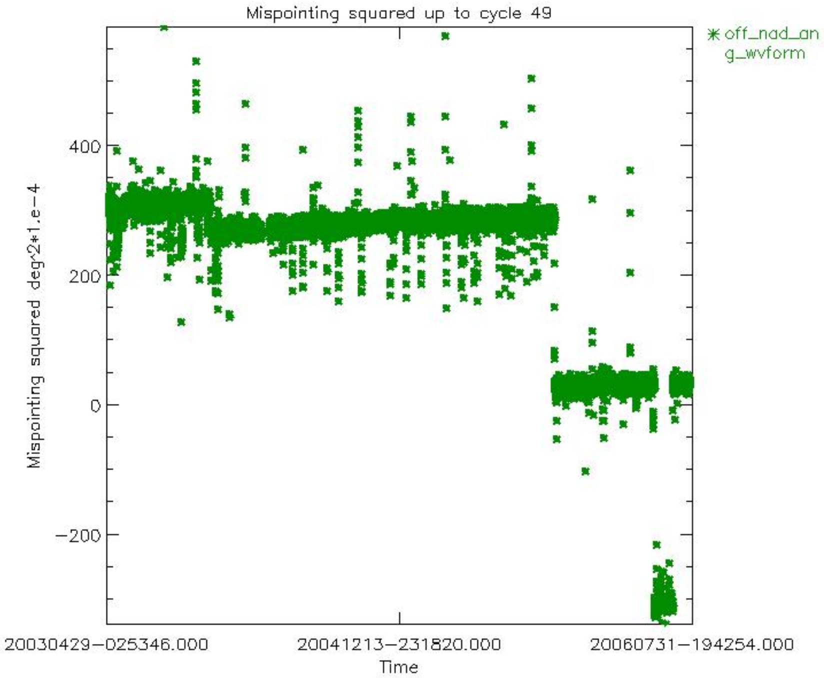

Figure 20: Smoothed mispointing squared trend until end of cycle 49 (deg^2*10e-4)

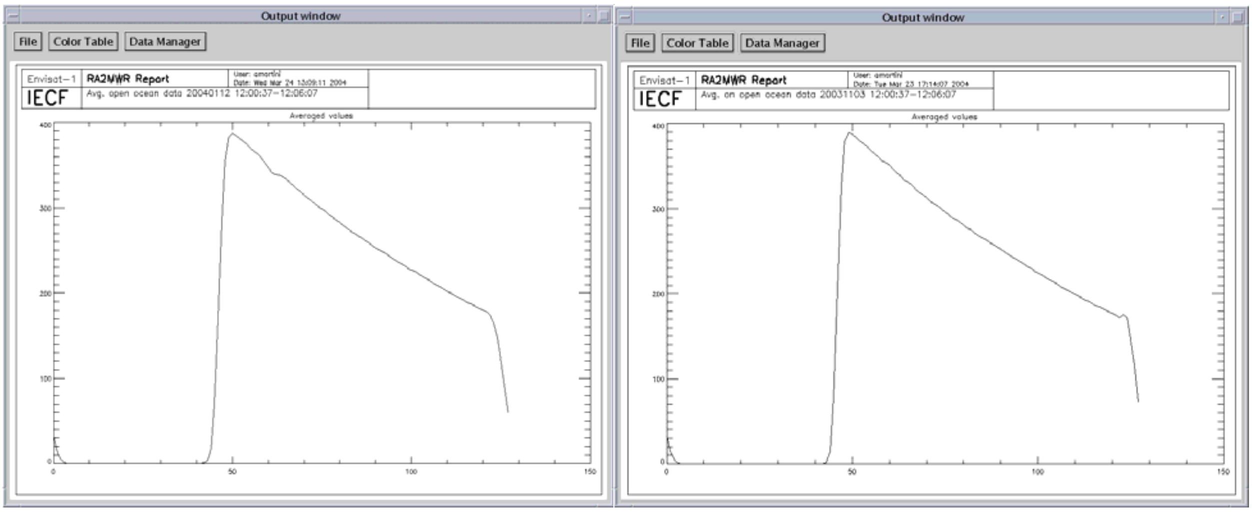

Figure 21: Open Ocean average waveforms before (left) and after an anomaly (right)

6.1.8 S-BAND ANOMALY

The so-called "S-Band anomaly" affects the RA-2 data products quality.
The list of product files affected by the S-band anomaly problem during cycle 49 is reported in appendix 5. Only six consecutive orbits were affected by the S-Band anomaly during Cycle 49, corresponding to 1.19% of data.

The method used for the identification of the "S-Band anomaly" is statistical and requires a minimum of 1000 seconds of data over ocean. This choice is supported by the fact that the "S-Band anomaly" is associated with a particular instrumental behavior that cannot appear and disappear within a short time frame. (ref. [R – 7])
A valuable algorithm to detect the RA-2 DSRs affected by the S-Band anomaly within the L2 products can be found in [R- 12]. Note that the algorithm is only valid for data acquired over open-ocean.
The IPF version 5.02 includes an algorithm that can detect the presence of the so-called "S-Band anomaly" over any surface. In case of S-Band anomaly detection, bit 1 of the L1b products MCD is set to one; the anomaly is properly detected in 99.9% of the cases. Due to several troubles encountered during the implementation of IPF version 5.02, the S-band anomaly detection flag (bit 1 of the RA-2 L1b MCD) cannot be trusted in this IPF version. As reported in chapter 5.5.1, this problem will be solved with the new release of the IPF, at the next coming months.

In Figure 22, the percentage of data per cycle that are affected by the so-called "S-Band" anomaly is reported. The figures are variable between 0% and 8.1%.
The number of occurrences of the S Band anomaly decreased from a mean value of 4% to 2% from cycle 31 until cycle 49 due to the implementation of the IF CAL procedure (including Heater 2 for S Band anomaly suppression) twice per day over the Himalayan region.
The relatively high value recorded for cycle 27 is due to the fact that on the day 1st of June 2004, the S-band anomaly started at around 14:30 while the instrument didn't switch to mode Heater 2

when foreseen (at about 15:50). For this reason the S-Band anomaly continued for the next 24 hours until the next Heater 2 mode on June the 2nd.

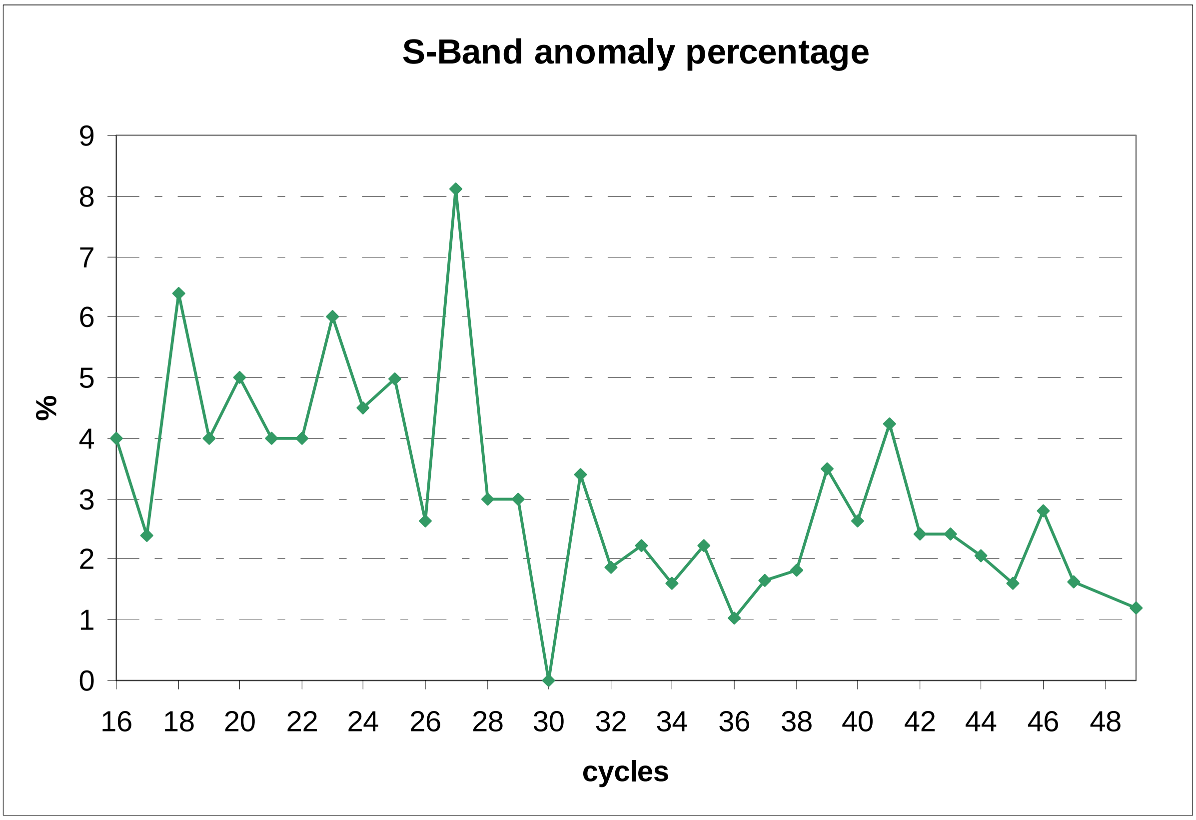

Figure 22: Percentage of data affected by the "S-Band Anomaly" for cycles 16-49

6.2 MWR Performance

For MWR performance please refer to the Reference CLS Cyclic Report of the type of [R – 2].

6.3 DORIS Performance

For DORIS performance refer to the Reference F-PAC Monthly Report of the type of [R – 1a] and [R-1b].

7 PRODUCT PERFORMANCE

7.1 Product disclaimer

A summary of the products released to users and disclaimers on product quality have been established for some products and are available in the following web link: http://envisat.esa.int/dataproducts/availability/

7.2 Data handling recommendations

7.2.1 SEA-ICE FLAG

The following algorithm is proposed for the determination of a sea-ice flag, presently missing in the Level 2 Ra-2 and MWR data products. (See [R – 14]):

|Latitude *(lat: field#4 of L2 data)*| >50 deg
AND
The number of 20Hz valid data *(num_18hz_ku_ocean: field#23 of L2 data)* < 17
OR
|MWR Wet Tropospheric Correction *(mwr_wet_tropo_corr: field#42 of L2 data)*–ECMWF Wet Tropospheric Correction *(mod_wet_tropo_corr: field#42 of L2 data)*| > 10 cm
OR
Peakiness *(Ku_peak: field#139 of L2 data)* >2

7.2.2 OCEAN S-BAND ANOMALIES DETECTION

A valuable algorithm to detect the Level 2 DSR affected by the RA-2 S-Band anomaly is proposed in [R- 12]. Note that its validity is limited to the data acquired over open-ocean.

7.2.3 WARNING ON IPF 4.56 VERSION IDENTIFICATION FIELD

All RA-2 and MWR level 1B and NRT Level 2 products generated after November 26, 2003 report a software version as being 4.54 (available in MPH field 8).

Nevertheless those products have been generated with the IPF V4.56 operational since November 26, 2003. The first nominal generated product, using the new SW version, will be the one relevant to the absolute orbit number 9094.
The software version ID is correct since December 4, 2003.

7.2.4 S-BAND BACKSCATTERING COEFFICIENT

For the data processed with IPF version 4.56 on, the S-Band Backscattering coefficient has been demonstrated to be on average about 0.65 dBs higher than for the previous versions of the processor. This is due to the algorithm used for the retrieval of the AGC in S-Band, corrected in IPF version 4.56 to be closer to the real functioning of the instrument.

An average value of 0.65 dBs is suggested to be added to the old software versions S-Band Sigma0 in order to be in line with the new IPF V4.56 version.

7.2.5 USO RANGE CORRECTION

As reported in chapter 6.1.3, since the 24th of October, with the new IPF V5.02, the actual value of the USO clock period has been used within the L1b processing. Given though the abnormal RA-2 USO behaviour affecting the Altimetric Range by few meters w.r.t. the Mean Sea Surface since the 1st February 2006, a NRT orbit basis USO correction has been developed for the FDGDR products. The actual data of cycle 49 have to be corrected to compensate for the Ultra Stable Oscillator drift, bias and orbital variations. The new correction files are available since the 24 July on the web site http://earth.esa.int/pcs/envisat/ra2/auxdata/NewCorrection

Warning for data acquired after 1st February 2006: This correction has to be **ADDED** to the Ku and S Band altimetric range.

Data acquired from 24th October 2005 until 1st February 2006 should not be corrected given that the proper value of the USO clock period has been used within the L1b processing.

All data acquired before 24th October 2005, beginning of cycle 42, still have to be corrected using the old correction files available on the web site:
http://earth.esa.int/pcs/envisat/ra2/auxdata/OldCorrection.
The measured Range shall be corrected considering a drift of -4.58 mm per year and a bias of 29.6 mm.
Warning for data acquired before cycle 42: bias and drift have to be **SUBTRACTED** from the original altimetric range, according to the following equation:
Rtrue=Roriginal-dR
where Roriginal is the range in the GDR products and Rtrue is the true (corrected) range.

7.2.6 KU-BAND BACKSCATTERING COEFFICIENT CALIBRATION

The results of the Ku-Band Sigma0 absolute calibration performed with a transponder have been presented in par. 6.1.4. Those results are going to be consolidated and are summarized in appendix 4, table 12. In order to absolutely calibrate the backscattering coefficient given in the RA2 L2 products, the following shall be used by the end user to get to the real Sigma0 measurement:

Sigma_0_true = Sigma_0_prod + G_tx_rx_prod - G_tx_rx_real - Bias [dB]

Where:
Bias: Bias retrieved from the Sigma0 Absolute Calibration (see 9.1.4)
G_tx_rx_prod: Current effective Tx-Rx Gain value used in the operational ground processing chain (ADF file RA2_CHD_AX). The value nominally used since IPF V4.54 is (for configuration RFSS=A and HPA=A) is 170.70 dB
G_tx_rx_real: Pre-launch characterization value (configuration value RFSS=A and HPA=A is 167.46 dB)

7.2.7 ABNORMAL RA-2 RANGE BEHAVIOR AFTER ANOMALY RECOVERY

WARNING: Envisat Side A RA-2 was still affected by the on-board anomaly which affects the RA-2 Altimetric Range by few meters. The analysis of the Sea Level Anomaly (SLA) currently shows a bias of ~5 meters and an orbital variability, with average values between ascending and descending passes different by about 30 cm.

The un-expected behavior of the Envisat RA-2 sensor was first observed from 1 Feb 2006 12:04:30, Orbit = 205181 until 11 Feb 2006. This directly happened after the recovery of a RA-2 on-board anomaly occurred on the 2006/02/01 at 05:17:56. The altimetric range jumped by several meters w.r.t. the Mean Sea Surface.

Another un-expected behavior of the Envisat RA-2 sensor was observed in the period from 2004/09/27 at ~16:00 and ending on 2004/09/29 at ~12:00 AM. This directly happened after the recovery of a RA-2 on-board anomaly occurred on the 2004/09/26 at ~13:40. The altimetric range jumped by several meters w.r.t. the Mean Sea Surface; on the other hand everything came back to normal as from the 29th of September around noon. RA-2 data from the above period have to be considered with caution.

7.2.8 RA-2 RADIO FREQUENCY MODULE SWITCHED BACK TO A-SIDE

The Envisat RA-2 sensor has been successfully reconfigured on its nominal side (RFSS A-side) and was commanded back into Measurement Mode on June 21, 2006 at 13.20.15.000 UTC time, Orbit = 22523.

The analysis of the RA-2 data shows an expected behaviour of the RA-2 parameters but also confirmed the persistence of the abnormal RA-2 Ultra-Stable Oscillator (USO) behaviour affecting the Altimetric Range by few meters.

Data from 22 May until 21 June was acquired with RFSS B-side and on-ground data processing has been performed with ADFs configured for A-side. For this reason data should be used with maximum care.

7.3 Availability of data

7.3.1 RA-2

In Figure 23 and Table 9 (Appendix 2) the summary of unavailable RA-2 L0 products is given.
It is easy to notice that close to the Himalayan region two small gaps, about 77 seconds, in the data are present. This is due to the daily instrument switch-offs (Heater 2 mode) performed to prevent the S-Band anomaly lasting more than half a day if it occurs.

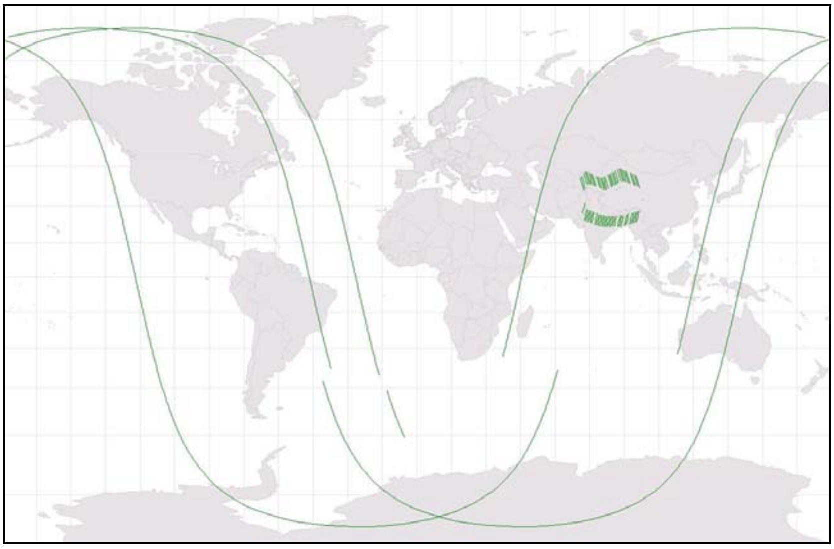

Figure 23: RA-2 L0 unavailable products for cycle 49

In Figure 24 and Table 11 (Appendix 2) the summary of unavailable RA-2 L1b products is given.

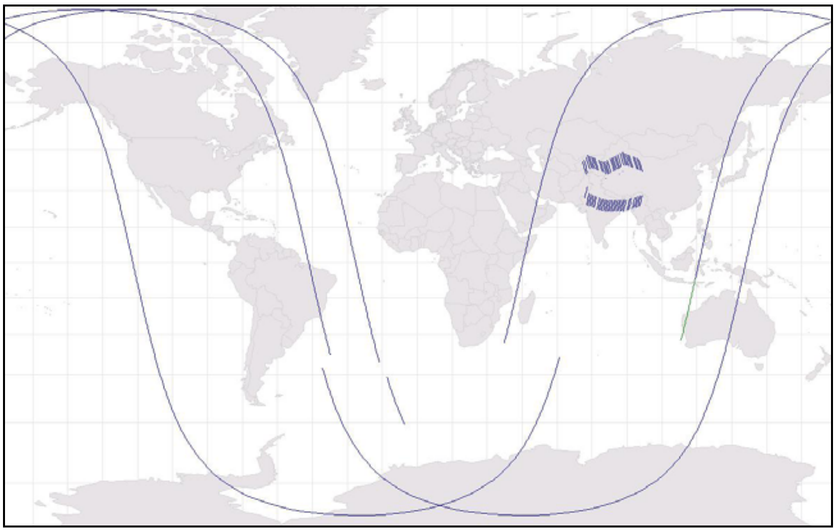

Figure 24: RA-2 L1b unavailable products for cycle 49

Hereafter the percentage of the different levels of products availability is reported. Considering as reference the instrument unavailability, it is possible to notice that since cycle 32 the situation is slightly improved for all levels of products.

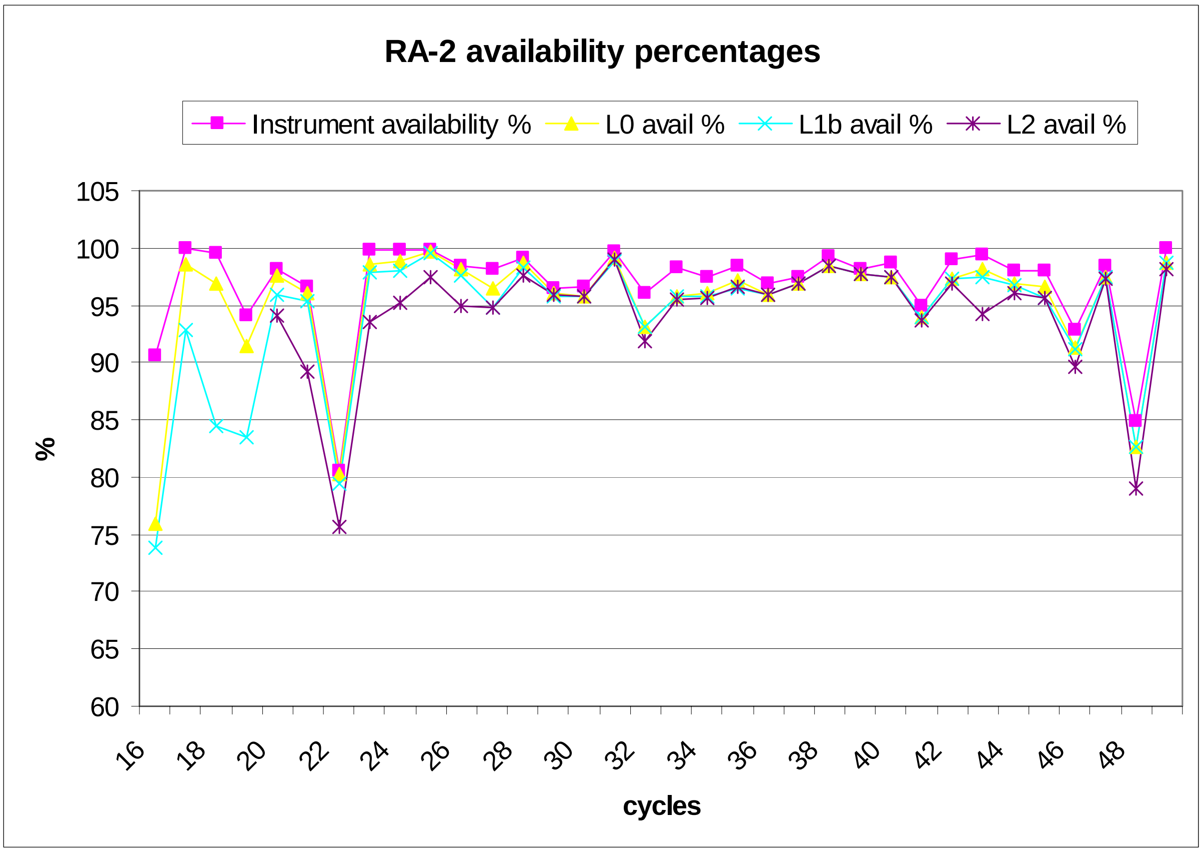

Figure 25: Percentage of Products unavailability up to cycle 49

7.3.2 MWR

In Figure 26 and Table 10 (Appendix 2) the summary of unavailable MWR L0 products is given.

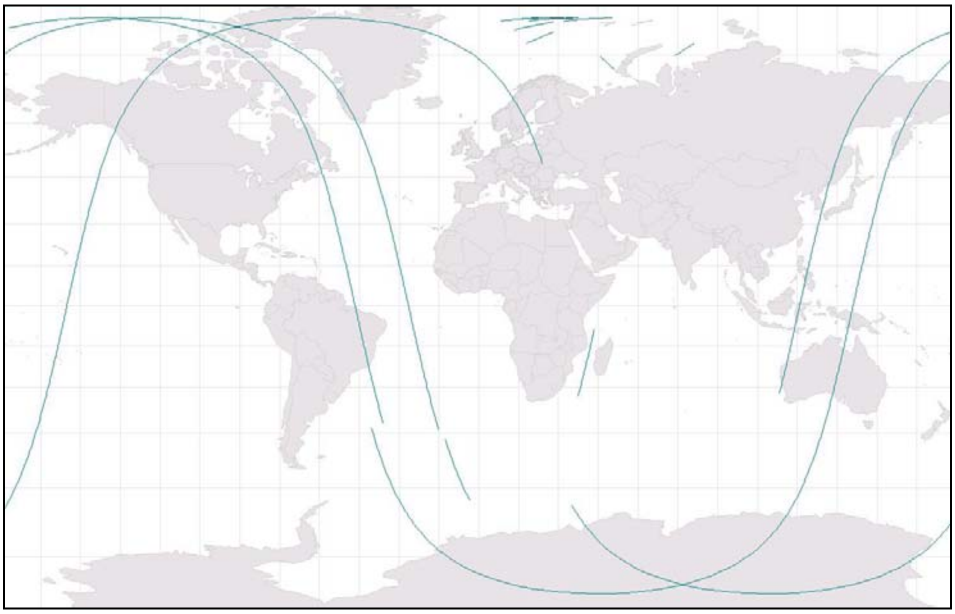

Figure 26: MWR L0 unavailable products for cycle 49

7.4 RA-2 Altimeter Parameters

Hereafter a summary of the main Altimetric parameters performances is reported; these results have been obtained using only ocean surface type and all world zone criteria for RA2_FGD products.

7.4.1 ALTIMETER RANGE

Since the 24th of October, operations date of IPF version 5.02, the DORIS Navigator data were expected to be used to evaluate the location, the altitude and the altitude rate corresponding to any Data Set Record of the products.

The un-expected behavior of the Envisat RA-2 sensor observed since cycle 44 persisted after the RA-2 sensor reconfiguration on its nominal A-side, on date 21 June at 13.20.15, orbit = 22523. The altimetric range jumped by several meters (about 5.6m) w.r.t. the Mean Sea Surface due to an anomaly in the USO clock period (see Chapter 6.1.3). Moreover, oscillations at the orbital period with an amplitude of 20-30 cm affect the Sea Level Anomalies during the anomaly. This behavior is under investigation. The SLA plot for the current cycle is not reported due to operational problems.

Fast Delivery data was corrected with the wrong USO clock period correction, RA2_USO_AX, during cycle 49.

WARNING:

- **Users are advised not to use the range parameter in Ku and S Band for the period of cycle 49 due to USO anomaly problem.**

7.4.2 SIGNIFICANT WAVE HEIGHT

Figure 27 shows the SWH daily mean. The possible high values, plotted outside the figure range, reported for the S-Band data are due to the so-called S-Band anomaly (ref. par.6.1.8). The histogram of the SWH for the current cycle is not reported due to operational problems.

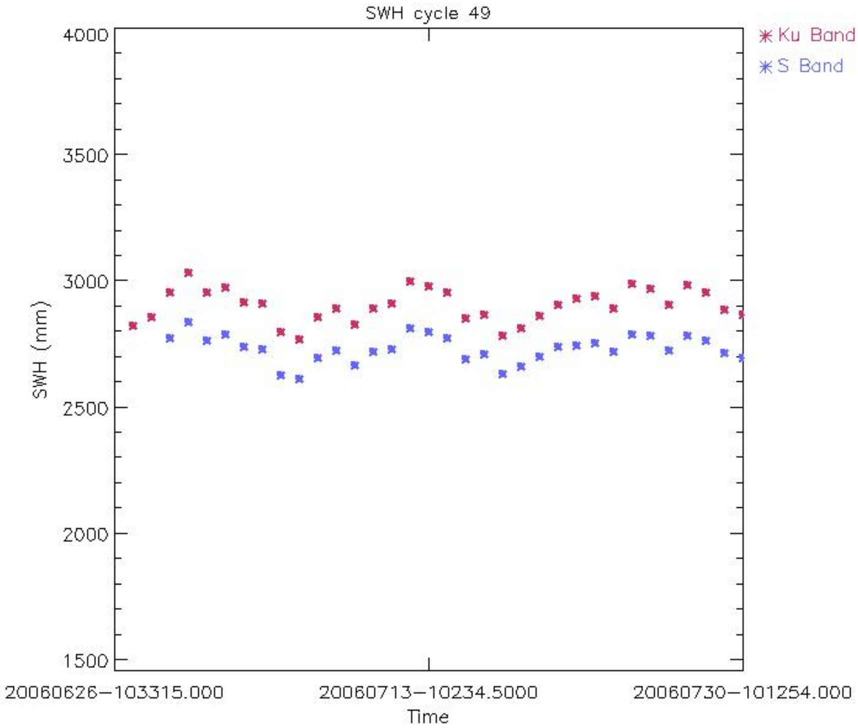

Figure 27: Ku and S SWH daily average for cycle 49 (mm)

In Figure 28, the SWH is reported from cycle 16 until cycle 49. It can be noticed that the SWH in both bands shows a trend which follows the seasonal variability. The high daily averages reported (sometimes plotted outside the figure's range) are due to the so-called S-Band anomaly (ref. par.6.1.8).

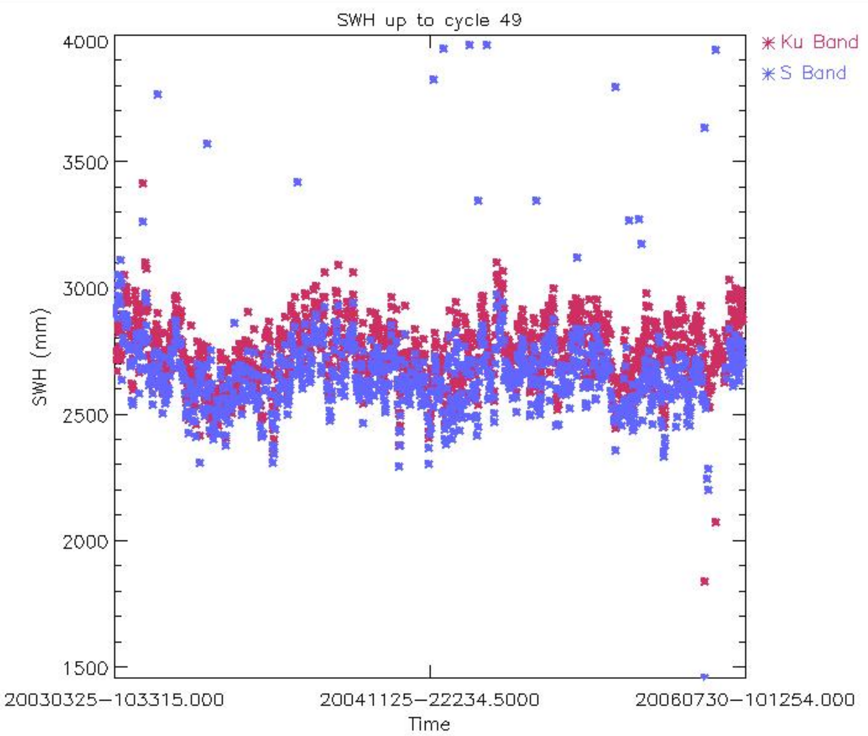

Figure 28: Ku and S SWH daily average up to cycle 49 (mm)

7.4.3 BACKSCATTER COEFFICIENT – WIND SPEED

In Figure 29, the backscattering coefficient daily average, computed for only ocean data, trend is reported. The trend shows a nominal behaviour for both bands. The S-Band Sigma_0 daily means that are plotted outside the figure range can be traced back to the so-called S-Band anomaly (ref. par. 6.1.8). The Sigma_0 histogram is not reported due to operational problems.

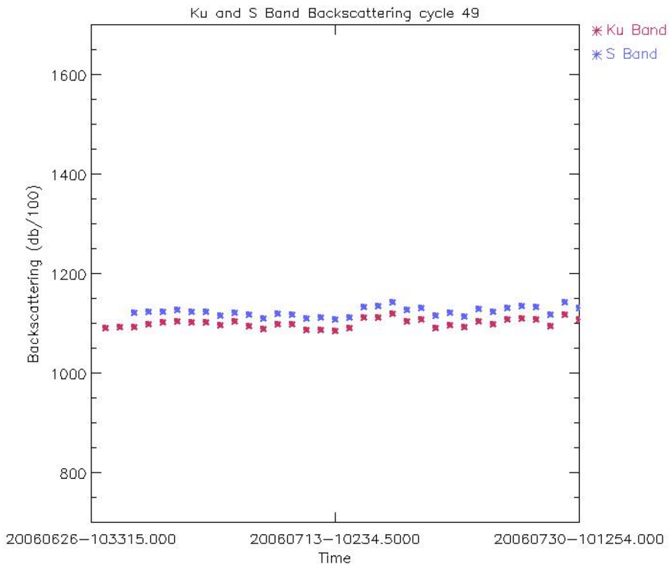

Figure 29: Ku and S Sigma_0 daily average for cycle 49 (dB/100)

In Figure 30 the Ku Band Wind Speed time behaviour is reported for cycle 49.
Given that the wind table has been updated since IPF version 5.02, S.Abdallah Table is now used, the wind takes values between 1.18m/ and 21.30m/s.
The histogram of Wind Speed for the current cycle is not reported due to operational problems.

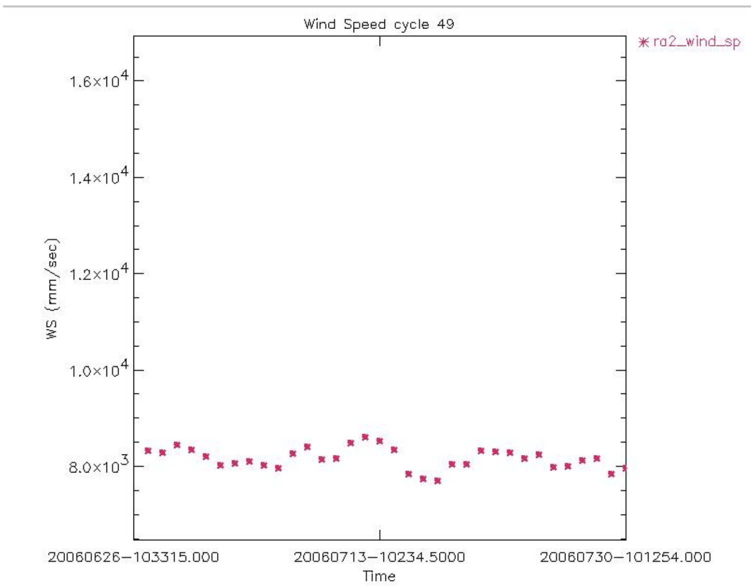

Figure 30: Ku Band Wind Speed daily average for cycle 49 (mm/s)

The Ku-Band Sigma_0 trend, reported hereafter, is characterized by a jump of on average 3.24 dBs concomitant with the operational up-load of IPF version 4.54 which occurred on the 9th of April 2003. This change is due to the upload of a new RA2_CHD_AX ADF file that artificially shifted the RA-2 real Sigma_0 in order to align it with ERS-2 Sigma_0 and make it coherent with the Witter and Chelton empirical wind model. A similar change in trend, but in the opposite direction, is also visible in the Wind Speed trend reported in Figure 32.
Beyond the huge jump that occurred in April 2003, the S-Band Sigma_0 reports a smaller jump occurring on November the 26th 2003. Following the installation of the IPF processing chain V4.56, the average values of the RA-2 S-Band backscattering parameter, shows an increase of ~0.65 dBs, the new S-band sigma0 being higher with respect to the previous versions. The very low values of the S Band Backscattering around 30 July 2006 are related to the S Band Power Drop Anomaly occurred when the instrument was operating on RFFS B-side from 15 May until 21 June 2006.

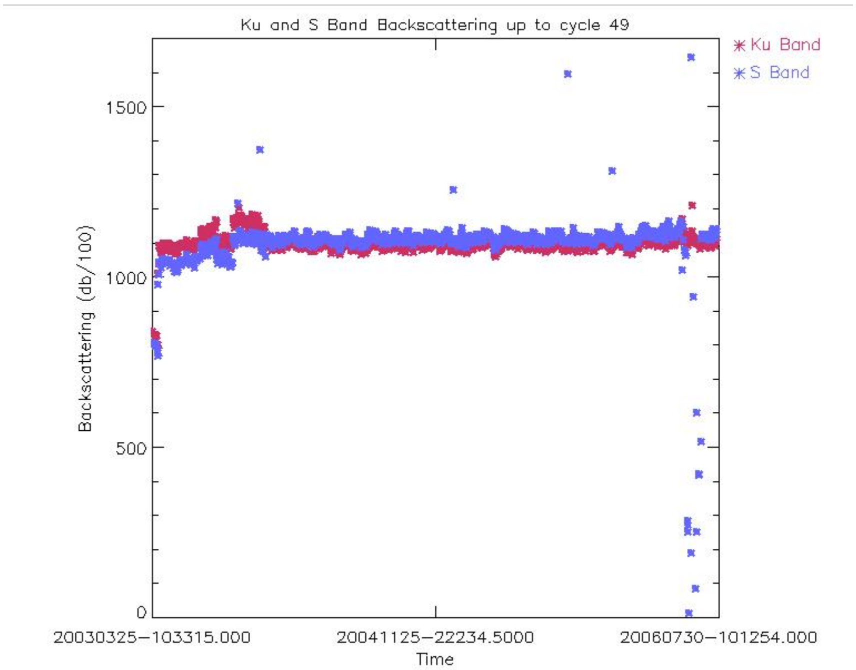

Figure 31: Ku and S band Backscattering daily averages up to cycle 49 (dB/100)

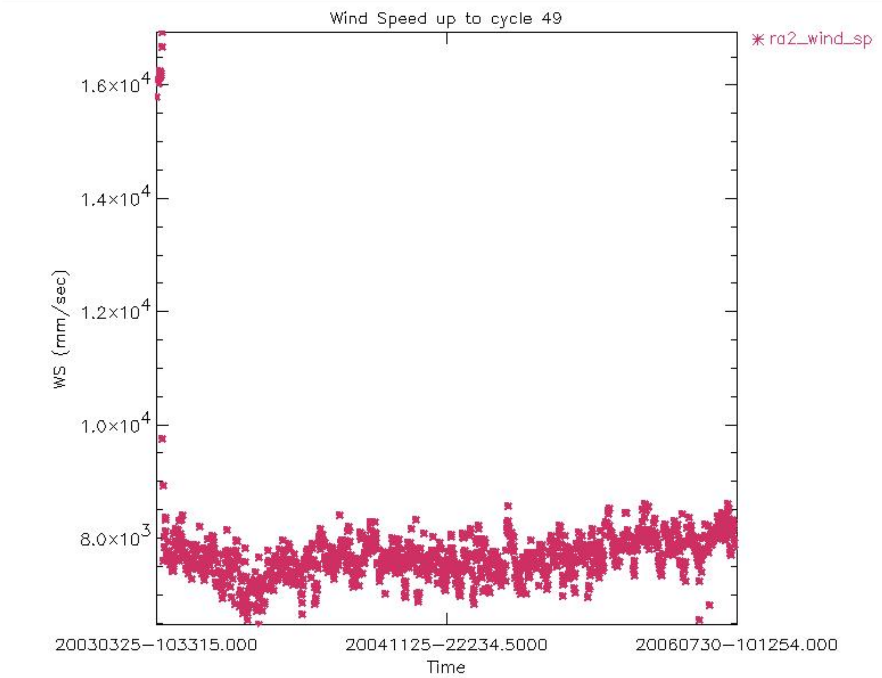

Figure 32: Wind Speed daily averages up to cycle 49 (mm/s)

8 PARTICULAR INVESTIGATIONS

The un-expected behavior of the Envisat RA-2 sensor observed since cycle 44 is still present on cycle 49.
The altimetric range jumped by several meters (about 5.6m) w.r.t. the Mean Sea Surface.
The anomaly was not present when the instrument sub-system Radio Frequency Module (RFM) was switched to its B-side, from 15 May until 21 June 2006.

The investigations are currently oriented in understanding the USO anomaly on A-side. In the mean time correction files have been delivered on the web so that the end users can correct the data from the USO anomaly.

APPENDIX 1: IPF UPGRADES

Table 4: L1B IPF version

IPF Version	Date of issue PDHS-K&E, LRAC	L1B Algortihm upgrades	L1B ADF updates	ADF filename
V4.53	Nov. 27, 2002			
V4.54	Apr. 7, 2003	*Wrong sign in AGC calibration estimation *Missing integrity check for the Data Block number read from the Level 0 Data Blocks *The altitude above CoG and the altitude rate have to be included in the records also in case of dummy records *1Hz data should be referenced to data block 9.5 not block 10	Correction of the Tx-Rx gain of Ku and S band parameters (3.5 dB)	RA2_CHD_AX
V4.56	Nov. 26, 2003	1- Extrapolation of AGC value to the Waveform center (49.5) for both Ku- and S-band. 2 - Correction for an error found in the evaluation of S band AGC.	RA2 IF Mask	RA2_IFF_AX
V4.57	PDHS-K: 29-04-2004 PDHS-E: 28-04-2004			
V4.58	Aug. 9, 2004			
V5.0.2	Oct. 24, 2005	MWR Side Lobe correction upgrade	- side lobe table and Config param	MWR_SLT_AX MWR_CON_AX
		USO clock period units correction	New ADF format - clock period un	RA2_USO_AX RA2_CHD_AX RA2_CON_AX
		RA-2 alignment: OBDH & USO datation, IE flags correction		
		Rain Flag tunning to compensate for the increase of the S band Sigma0	New table in SOI file	RA2_SOI_AX
		Monthly IF estimation		RA2_IFF_AX
		Level 1B S-Band anomaly flag	New format	RA2_CON_AX
		DORIS Navigator CFI upgrade (RA-2 & MWR)		

Table 5: L2 IPF version

PF Version	Date of issue PDHS	L2 Algortihm upgrades	L2 ADF updates	ADF filename
V4.53	Nov. 27, 2002			
V4.54	Apr. 7, 2003			
V4.56	Nov. 26, 2003	SPR 26 Tuning of the Ice2 retracking New MWR NN algorithm	MSS CLS01 Rain flag Updated OCOG retracker thresholds Ice1/Sea Ice Conf file	RA2_MSS_AX RA2_SOI_AX RA2_ICT_AX RA2_SSB_AX

			Sea State Bias Table file GOT00.2 Ocean Tide Sol 1 Map file FES 2002 Ocean Tide Sol 2 Map file FES 2002 Tidal Loading Coeff Map	RA2_OT1_AX RA2_OT2_AX RA2_TLD_AX
V4.57	PDHS-K: 29-04-2004 PDHS-E: 28-04-2004	ECMWF meteo files handling		
V4.58	Aug. 9, 2004	Addition of a Pass Number Field in FD Level		
V5.0.2	Oct. 24, 2005	- Handling of the new RA2_CHD_AX ADF - Rain Flag tuning to compensate for the increase of the S band Sigma0 - Improving the mispointing estimation - Export of the Level 1B S-band flag into the Level 2 data product - Export of the Level 1B NRT orbit quality flag - Addition of a Pass Number Field in FD Level 2 SPH product - Addition of peakiness in Ku and S band in FDMAR - Addition of square of the SWH in Ku and S band - Correction of MCD flag - SPH pass number (field 8) set to 0 in SPH NRT Level 2 data products	New table in SOI file Two needed parameters in SOI file New format Addition of GOT2000.2 TLD New DEM AUX file (MACESS) merge of ACE land elevation data and Smith and Sandwell ocean bathymetry	RA2_CHD_AX RA2_SOI_AX RA2_SOI_AX RA2_SOI_AX RA2_TLG_AX AUX_DEM_AX

APPENDIX 2: AVAILABILITY:

Table 6: RA-2 L0, L1b and L2 FGD Data products availability summary for cycle 49

Start orbit	Stop orbit	Time [sec] instrum. Unavail-ability	Data Unav Time [sec]	Time [sec] L0 gaps	Time [sec] L1b gaps	Time [sec] L2 (FGD) gaps	% instrum. avail.	% data avail.	% L0 avail.	% L1b avail.	% L2 (FGD) avail.
22600	22700	0,00	1969,93	7350,02	7348,02	13272,10	100,00	99,67	98,46	98,46	97,48
22700	22800	1206,00	3327,04	10823,61	10813,73	10831,69	99,80	99,45	97,66	97,66	97,66
22800	22901	0,00	2110,66	1095,60	1089,72	6996,92	100,00	99,65	99,47	99,47	98,49
22901	23001	0,00	2067,75	5154,75	5143,66	10966,83	100,00	99,66	98,81	98,81	97,84
23001	23101	0,00	2148,02	1095,65	1089,63	1106,37	100,00	99,64	99,46	99,46	99,46

Table 7: MWR L0 Data products availability summary for cycle 49

Start orbit	Stop orbit	Time [sec] instrum. unavailability	Time [sec] L0 gaps	% instrum. avail.	% L0 avail.
22600	22700	0,00	6384,00	100,00	98,94
22700	22800	1206,00	4448,00	99,80	99,07
22800	22901	0,00	144,00	100,00	99,98
22901	23001	0,00	4200,00	100,00	99,31
23001	23101	0,00	48,00	100,00	99,99

Table 8: DORIS L0 Data products availability summary for cycle 49

Start orbit	Stop orbit	Time [sec] instrum. unavailability	Time [sec] L0 gaps	% instrum. avail.	% L0 avail.
22600	22700	0	16832,00	100,00	98,61
22700	22800	2412	12885,00	99,80	98,74
22800	22901	0	3635,00	100,00	99,70
22901	23001	0	11154,00	100,00	99,08
23001	23101	0	3693,00	100,00	99,69

Table 9: List of gaps for RA-2 L0 cycle 49

Start date	Start time	Stop date	Stop time	Duration [sec]	Start orbit	Stop orbit	Reason
26-JUN-2006	15.25.13	26-JUN-2006	15.25.15	2	22596	22596	PDS_UNKNOWN_FAILURE
26-JUN-2006	15.28.04	26-JUN-2006	15.29.21	77	22596	22596	PDS_UNKNOWN_FAILURE
26-JUN-2006	23.22.43	26-JUN-2006	23.27.01	258	22600	22600	PDS_UNKNOWN_FAILURE
27-JUN-2006	5.23.56	27-JUN-2006	5.25.14	78	22604	22604	PDS_UNKNOWN_FAILURE
27-JUN-2006	16.36.43	27-JUN-2006	16.38.01	78	22611	22611	PDS_UNKNOWN_FAILURE
28-JUN-2006	4.53.01	28-JUN-2006	4.54.19	78	22618	22618	PDS_UNKNOWN_FAILURE
28-JUN-2006	16.04.40	28-JUN-2006	16.05.58	78	22625	22625	PDS_UNKNOWN_FAILURE
29-JUN-2006	4.21.24	29-JUN-2006	4.22.42	78	22632	22632	PDS_UNKNOWN_FAILURE

29-JUN-2006	15.33.55	29-JUN-2006	15.35.13	78	22639	22639	PDS_UNKNOWN_FAILURE
29-JUN-2006	23.34.15	30-JUN-2006	1.14.18	6003	22643	22644	PDS_UNKNOWN_FAILURE
30-JUN-2006	5.28.55	30-JUN-2006	5.30.13	78	22647	22647	PDS_UNKNOWN_FAILURE
30-JUN-2006	16.42.08	30-JUN-2006	16.43.26	78	22654	22654	PDS_UNKNOWN_FAILURE
07-JUL-2006	5.28.36	07-JUL-2006	7.07.44	5948	22747	22748	PDS_UNKNOWN_FAILURE
07-JUL-2006	16.22.13	07-JUL-2006	16.23.31	78	22754	22754	PDS_UNKNOWN_FAILURE
07-JUL-2006	0.55.31	07-JUL-2006	1.58.31	3780	22744	22745	UNAV_ARTEMIS
07-JUL-2006	1.58.31	07-JUL-2006	2.05.39	428	22745	22745	UNAV_ARTEMIS
08-JUL-2006	4.38.40	08-JUL-2006	4.39.58	78	22761	22761	PDS_UNKNOWN_FAILURE
08-JUL-2006	15.50.43	08-JUL-2006	15.52.00	77	22768	22768	PDS_UNKNOWN_FAILURE
10-JUL-2006	5.13.19	10-JUL-2006	5.13.22	3	22790	22790	PDS_UNKNOWN_FAILURE
10-JUL-2006	5.15.32	10-JUL-2006	5.16.49	77	22790	22790	PDS_UNKNOWN_FAILURE
10-JUL-2006	16.28.08	10-JUL-2006	16.29.26	78	22797	22797	PDS_UNKNOWN_FAILURE
11-JUL-2006	4.44.25	11-JUL-2006	4.45.43	78	22804	22804	PDS_UNKNOWN_FAILURE
11-JUL-2006	15.56.18	11-JUL-2006	15.57.36	78	22811	22811	PDS_UNKNOWN_FAILURE
12-JUL-2006	4.12.41	12-JUL-2006	4.13.59	78	22818	22818	PDS_UNKNOWN_FAILURE
12-JUL-2006	15.22.24	12-JUL-2006	15.22.27	3	22825	22825	PDS_UNKNOWN_FAILURE
12-JUL-2006	15.25.08	12-JUL-2006	15.26.25	77	22825	22825	PDS_UNKNOWN_FAILURE
13-JUL-2006	5.21.09	13-JUL-2006	5.22.27	78	22833	22833	PDS_UNKNOWN_FAILURE
13-JUL-2006	16.34.02	13-JUL-2006	16.35.20	78	22840	22840	PDS_UNKNOWN_FAILURE
14-JUL-2006	4.50.10	14-JUL-2006	4.51.28	78	22847	22847	PDS_UNKNOWN_FAILURE
14-JUL-2006	16.01.54	14-JUL-2006	16.03.12	78	22854	22854	PDS_UNKNOWN_FAILURE
15-JUL-2006	4.18.33	15-JUL-2006	4.19.51	78	22861	22861	PDS_UNKNOWN_FAILURE
15-JUL-2006	15.28.03	15-JUL-2006	15.28.06	3	22868	22868	PDS_UNKNOWN_FAILURE
15-JUL-2006	15.31.02	15-JUL-2006	15.32.20	78	22868	22868	PDS_UNKNOWN_FAILURE
17-JUL-2006	4.55.53	17-JUL-2006	4.57.10	77	22890	22890	PDS_UNKNOWN_FAILURE
17-JUL-2006	16.07.29	17-JUL-2006	16.08.47	78	22897	22897	PDS_UNKNOWN_FAILURE
18-JUL-2006	4.21.09	18-JUL-2006	4.21.11	2	22904	22904	PDS_UNKNOWN_FAILURE
18-JUL-2006	4.24.18	18-JUL-2006	4.25.36	78	22904	22904	PDS_UNKNOWN_FAILURE
18-JUL-2006	15.36.44	18-JUL-2006	15.38.02	78	22911	22911	PDS_UNKNOWN_FAILURE
19-JUL-2006	3.50.53	19-JUL-2006	3.50.55	2	22918	22918	PDS_UNKNOWN_FAILURE
19-JUL-2006	3.52.09	19-JUL-2006	3.53.26	77	22918	22918	PDS_UNKNOWN_FAILURE
19-JUL-2006	16.44.51	19-JUL-2006	16.46.09	78	22926	22926	PDS_UNKNOWN_FAILURE
20-JUL-2006	16.13.22	20-JUL-2006	16.14.39	77	22940	22940	PDS_UNKNOWN_FAILURE
20-JUL-2006	4.59.16	20-JUL-2006	4.59.19	3	22933	22933	PDS_UNKNOWN_FAILURE
20-JUL-2006	5.01.30	20-JUL-2006	5.02.47	77	22933	22933	PDS_UNKNOWN_FAILURE
21-JUL-2006	4.30.03	21-JUL-2006	4.31.21	78	22947	22947	PDS_UNKNOWN_FAILURE
21-JUL-2006	15.39.21	21-JUL-2006	15.39.23	2	22954	22954	PDS_UNKNOWN_FAILURE
21-JUL-2006	15.42.20	21-JUL-2006	15.43.38	78	22954	22954	PDS_UNKNOWN_FAILURE
22-JUL-2006	3.58.01	22-JUL-2006	3.59.19	78	22961	22961	PDS_UNKNOWN_FAILURE
22-JUL-2006	15.10.21	22-JUL-2006	15.11.39	78	22968	22968	PDS_UNKNOWN_FAILURE

24-JUL-2006	4.32.40	24-JUL-2006	4.32.43	3	22990	22990	PDS_UNKNOWN_FAILURE
24-JUL-2006	4.35.48	24-JUL-2006	4.37.05	77	22990	22990	PDS_UNKNOWN_FAILURE
24-JUL-2006	15.45.02	24-JUL-2006	15.45.05	3	22997	22997	PDS_UNKNOWN_FAILURE
24-JUL-2006	15.47.55	24-JUL-2006	15.49.13	78	22997	22997	PDS_UNKNOWN_FAILURE
25-JUL-2006	4.03.53	25-JUL-2006	4.05.11	78	23004	23004	PDS_UNKNOWN_FAILURE
25-JUL-2006	15.16.16	25-JUL-2006	15.17.33	77	23011	23011	PDS_UNKNOWN_FAILURE
26-JUL-2006	5.10.31	26-JUL-2006	5.10.33	2	23019	23019	PDS_UNKNOWN_FAILURE
26-JUL-2006	5.12.44	26-JUL-2006	5.14.01	77	23019	23019	PDS_UNKNOWN_FAILURE
26-JUL-2006	16.25.11	26-JUL-2006	16.26.29	78	23026	23026	PDS_UNKNOWN_FAILURE
27-JUL-2006	4.41.33	27-JUL-2006	4.42.50	77	23033	23033	PDS_UNKNOWN_FAILURE
27-JUL-2006	15.50.47	27-JUL-2006	15.50.50	3	23040	23040	PDS_UNKNOWN_FAILURE
27-JUL-2006	15.53.31	27-JUL-2006	15.54.48	77	23040	23040	PDS_UNKNOWN_FAILURE
27-JUL-2006	4.38.37	27-JUL-2006	4.38.40	3	23033	23033	PDS_UNKNOWN_FAILURE
28-JUL-2006	4.09.45	28-JUL-2006	4.11.03	78	23047	23047	PDS_UNKNOWN_FAILURE
28-JUL-2006	15.22.10	28-JUL-2006	15.23.28	78	23054	23054	PDS_UNKNOWN_FAILURE
29-JUL-2006	5.18.20	29-JUL-2006	5.19.38	78	23062	23062	PDS_UNKNOWN_FAILURE
29-JUL-2006	16.31.05	29-JUL-2006	16.32.23	78	23069	23069	PDS_UNKNOWN_FAILURE
30-JUL-2006	4.47.17	30-JUL-2006	4.48.35	78	23076	23076	PDS_UNKNOWN_FAILURE
30-JUL-2006	15.59.06	30-JUL-2006	16.00.24	78	23083	23083	PDS_UNKNOWN_FAILURE

Table 10: List of gaps for MWR L0 cycle 49

Start date	Start time	Stop date	Stop time	Duration [sec]	Start orbit	Stop orbit	Reason
26-JUN-2006	23.22.00	26-JUN-2006	23.26.48	288	22600	22600	PDS_UNKNOWN_FAILURE
29-JUN-2006	14.07.18	29-JUN-2006	14.08.06	48	22638	22638	PDS_UNKNOWN_FAILURE
29-JUN-2006	23.33.19	30-JUN-2006	1.14.07	6048	22643	22644	PDS_UNKNOWN_FAILURE
04-JUL-2006	11.31.05	04-JUL-2006	11.31.53	48	22708	22708	PDS_UNKNOWN_FAILURE
05-JUL-2006	12.39.07	05-JUL-2006	12.39.55	48	22723	22723	PDS_UNKNOWN_FAILURE
05-JUL-2006	14.18.20	05-JUL-2006	14.19.08	48	22724	22724	PDS_UNKNOWN_FAILURE
07-JUL-2006	0.54.23	07-JUL-2006	1.58.31	3848	22744	22745	UNAV_ARTEMIS
07-JUL-2006	7.00.47	07-JUL-2006	7.07.35	408	22748	22748	PDS_UNKNOWN_FAILURE
07-JUL-2006	1.58.31	07-JUL-2006	2.05.35	424	22745	22745	UNAV_ARTEMIS
12-JUL-2006	7.18.59	12-JUL-2006	7.19.47	48	22820	22820	PDS_UNKNOWN_FAILURE
13-JUL-2006	13.27.02	13-JUL-2006	13.27.50	48	22838	22838	PDS_UNKNOWN_FAILURE
13-JUL-2006	16.43.50	13-JUL-2006	16.44.38	48	22840	22840	PDS_UNKNOWN_FAILURE
18-JUL-2006	12.29.37	18-JUL-2006	12.30.25	48	22909	22909	PDS_UNKNOWN_FAILURE
23-JUL-2006	19.43.49	23-JUL-2006	20.52.13	4104	22985	22985	PDS_UNKNOWN_FAILURE
24-JUL-2006	12.42.15	24-JUL-2006	12.43.03	48	22995	22995	PDS_UNKNOWN_FAILURE

Table 11: List of gaps for RA-2 L1b cycle 49

Start date	Start time	Stop date	Stop time	Duration [sec]	Start orbit	Stop orbit	Reason
26-JUN-2006	15.28.04	26-JUN-2006	15.29.21	77	22596	22596	PDS_UNKNOWN_FAILURE
26-JUN-2006	23.22.44	26-JUN-2006	23.27.01	257	22600	22600	PDS_UNKNOWN_FAILURE
27-JUN-2006	5.23.56	27-JUN-2006	5.25.14	78	22604	22604	PDS_UNKNOWN_FAILURE
27-JUN-2006	16.36.43	27-JUN-2006	16.38.01	78	22611	22611	PDS_UNKNOWN_FAILURE
28-JUN-2006	4.53.01	28-JUN-2006	4.54.19	78	22618	22618	PDS_UNKNOWN_FAILURE
28-JUN-2006	16.04.40	28-JUN-2006	16.05.58	78	22625	22625	PDS_UNKNOWN_FAILURE
29-JUN-2006	4.21.24	29-JUN-2006	4.22.42	78	22632	22632	PDS_UNKNOWN_FAILURE
29-JUN-2006	15.33.55	29-JUN-2006	15.35.13	78	22639	22639	PDS_UNKNOWN_FAILURE
29-JUN-2006	23.34.16	30-JUN-2006	1.14.18	6002	22643	22644	PDS_UNKNOWN_FAILURE
30-JUN-2006	16.42.08	30-JUN-2006	16.43.26	78	22654	22654	PDS_UNKNOWN_FAILURE
30-JUN-2006	5.28.55	30-JUN-2006	5.30.13	78	22647	22647	PDS_UNKNOWN_FAILURE
07-JUL-2006	5.28.37	07-JUL-2006	7.07.44	5947	22747	22748	PDS_UNKNOWN_FAILURE
07-JUL-2006	16.22.13	07-JUL-2006	16.23.31	78	22754	22754	PDS_UNKNOWN_FAILURE
07-JUL-2006	0.55.32	07-JUL-2006	1.58.31	3779	22744	22745	UNAV_ARTEMIS
07-JUL-2006	5.09.55	07-JUL-2006	5.11.12	77	22747	22747	PDS_UNKNOWN_FAILURE
07-JUL-2006	1.58.31	07-JUL-2006	2.05.39	428	22745	22745	UNAV_ARTEMIS
08-JUL-2006	4.38.40	08-JUL-2006	4.39.58	78	22761	22761	PDS_UNKNOWN_FAILURE
08-JUL-2006	15.50.43	08-JUL-2006	15.52.00	77	22768	22768	PDS_UNKNOWN_FAILURE
10-JUL-2006	5.15.32	10-JUL-2006	5.16.49	77	22790	22790	PDS_UNKNOWN_FAILURE
10-JUL-2006	16.28.08	10-JUL-2006	16.29.26	78	22797	22797	PDS_UNKNOWN_FAILURE
11-JUL-2006	4.44.25	11-JUL-2006	4.45.43	78	22804	22804	PDS_UNKNOWN_FAILURE
11-JUL-2006	15.56.18	11-JUL-2006	15.57.36	78	22811	22811	PDS_UNKNOWN_FAILURE
12-JUL-2006	4.12.41	12-JUL-2006	4.13.59	78	22818	22818	PDS_UNKNOWN_FAILURE
12-JUL-2006	15.22.25	12-JUL-2006	15.22.27	2	22825	22825	PDS_UNKNOWN_FAILURE
12-JUL-2006	15.25.08	12-JUL-2006	15.26.25	77	22825	22825	PDS_UNKNOWN_FAILURE
13-JUL-2006	5.21.09	13-JUL-2006	5.22.27	78	22833	22833	PDS_UNKNOWN_FAILURE
13-JUL-2006	16.34.02	13-JUL-2006	16.35.20	78	22840	22840	PDS_UNKNOWN_FAILURE
14-JUL-2006	16.01.54	14-JUL-2006	16.03.12	78	22854	22854	PDS_UNKNOWN_FAILURE
14-JUL-2006	4.50.10	14-JUL-2006	4.51.28	78	22847	22847	PDS_UNKNOWN_FAILURE
15-JUL-2006	4.18.33	15-JUL-2006	4.19.51	78	22861	22861	PDS_UNKNOWN_FAILURE
15-JUL-2006	15.31.02	15-JUL-2006	15.32.20	78	22868	22868	PDS_UNKNOWN_FAILURE
17-JUL-2006	4.55.53	17-JUL-2006	4.57.10	77	22890	22890	PDS_UNKNOWN_FAILURE
17-JUL-2006	16.07.29	17-JUL-2006	16.08.47	78	22897	22897	PDS_UNKNOWN_FAILURE
18-JUL-2006	4.24.18	18-JUL-2006	4.25.36	78	22904	22904	PDS_UNKNOWN_FAILURE
18-JUL-2006	15.36.44	18-JUL-2006	15.38.02	78	22911	22911	PDS_UNKNOWN_FAILURE
19-JUL-2006	3.52.09	19-JUL-2006	3.53.26	77	22918	22918	PDS_UNKNOWN_FAILURE
19-JUL-2006	16.44.51	19-JUL-2006	16.46.09	78	22926	22926	PDS_UNKNOWN_FAILURE
20-JUL-2006	4.59.17	20-JUL-2006	4.59.19	2	22933	22933	PDS_UNKNOWN_FAILURE
20-JUL-2006	5.01.30	20-JUL-2006	5.02.47	77	22933	22933	PDS_UNKNOWN_FAILURE
20-JUL-2006	16.13.22	20-JUL-2006	16.14.39	77	22940	22940	PDS_UNKNOWN_FAILURE

21-JUL-2006	15.42.20	21-JUL-2006	15.43.38	78	22954	22954	PDS_UNKNOWN_FAILURE
21-JUL-2006	4.30.03	21-JUL-2006	4.31.21	78	22947	22947	PDS_UNKNOWN_FAILURE
22-JUL-2006	3.58.01	22-JUL-2006	3.59.19	78	22961	22961	PDS_UNKNOWN_FAILURE
22-JUL-2006	15.10.21	22-JUL-2006	15.11.39	78	22968	22968	PDS_UNKNOWN_FAILURE
24-JUL-2006	4.32.41	24-JUL-2006	4.32.43	2	22990	22990	PDS_UNKNOWN_FAILURE
24-JUL-2006	4.35.48	24-JUL-2006	4.37.05	77	22990	22990	PDS_UNKNOWN_FAILURE
24-JUL-2006	4.37.05	24-JUL-2006	4.37.06	1	22990	22990	PDS_UNKNOWN_FAILURE
24-JUL-2006	15.47.55	24-JUL-2006	15.49.13	78	22997	22997	PDS_UNKNOWN_FAILURE
25-JUL-2006	4.03.53	25-JUL-2006	4.05.11	78	23004	23004	PDS_UNKNOWN_FAILURE
25-JUL-2006	15.16.16	25-JUL-2006	15.17.33	77	23011	23011	PDS_UNKNOWN_FAILURE
26-JUL-2006	5.12.44	26-JUL-2006	5.14.01	77	23019	23019	PDS_UNKNOWN_FAILURE
26-JUL-2006	16.25.11	26-JUL-2006	16.26.29	78	23026	23026	PDS_UNKNOWN_FAILURE
27-JUL-2006	15.53.31	27-JUL-2006	15.54.48	77	23040	23040	PDS_UNKNOWN_FAILURE
27-JUL-2006	4.38.38	27-JUL-2006	4.38.40	2	23033	23033	PDS_UNKNOWN_FAILURE
27-JUL-2006	4.41.33	27-JUL-2006	4.42.50	77	23033	23033	PDS_UNKNOWN_FAILURE
28-JUL-2006	4.09.45	28-JUL-2006	4.11.03	78	23047	23047	PDS_UNKNOWN_FAILURE
28-JUL-2006	15.22.10	28-JUL-2006	15.23.28	78	23054	23054	PDS_UNKNOWN_FAILURE
29-JUL-2006	5.18.20	29-JUL-2006	5.19.38	78	23062	23062	PDS_UNKNOWN_FAILURE
29-JUL-2006	16.31.05	29-JUL-2006	16.32.23	78	23069	23069	PDS_UNKNOWN_FAILURE
30-JUL-2006	4.47.17	30-JUL-2006	4.48.35	78	23076	23076	PDS_UNKNOWN_FAILURE
30-JUL-2006	15.59.06	30-JUL-2006	16.00.24	78	23083	23083	PDS_UNKNOWN_FAILURE

APPENDIX 3: LEVEL 2 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_LSF_AXVIEC20020313_172218_20020101_000000_20200101_000000
MWR_CHD_AXVIEC20021111_131410_20020101_000000_20200101_000000
MWR_LSF_AXVIEC20020313_172218_20020101_000000_20200101_000000
MWR_SLT_AXVIEC20050426_120000_20020101_000000_20200101_000000
RA2_IFA_AXVIEC20050216_125529_20020101_000000_20200101_000000
RA2_IFB_AXVIEC20050216_125738_20020101_000000_20200101_000000
RA2_CHD_AXVIEC20051017_093900_20020101_000000_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_AXVIEC20031208_150159_20020101_000000_20200101_000000

RA2_SET_AXVIEC20020122_150917_20020101_000000_20200101_000000
RA2_SL1_AXVIEC20030131_100228_20020101_000000_20200101_000000
RA2_SL2_AXVIEC20030131_101757_20020101_000000_20200101_000000
RA2_SOI_AXVIEC20051003_170000_20020101_000000_20200101_000000
RA2_SSB_AXVIEC20051129_111810_20020101_000000_20200101_000000
RA2_TLD_AXVIEC20031208_151137_20020101_000000_20200101_000000
RA2_TLG_AXVIEC20040310_110000_20020101_000000_20200101_000000

APPENDIX 4: SIGMA0 ABSOLUTE CALIBRATION

Table 12: Transponder measurement results up to cycle 49

Absolute Orbit nb	Date of Measurement	Location / Rel. track	RA-2 resolution	Transponder Bias [dB]	ECMWF Wet Tropo. Corr. [dB]
10389	24-feb-04	Rome / 315	Low	1,552	0,120
10511	04-mar-04	Valmontone / 437	Low	1,542	0,102
10618	11-mar-04	Fiuggi / 43	Low	1,447	0,135
10783	23-mar-04	Maccarese / 208	Low	1,540	0,142
10890	30-mar-04	Rome / 315	Low	1,442	0,152
11119	15-apr-04	Fiuggi / 43	High	0,963	0,122
11513	13-mag-04	Valmontone / 437	Low	1,353	0,133
11620	20-mag-04	Fiuggi / 43	Low	1,427	0,139
11892	08-giu-04	Rome / 315	Low	1,504	0,154
12014	17-giu-04	Valmontone / 437	Low	1,448	0,348
12121	24-giu-04	Fiuggi / 43	Low	1,576	0,149
14290	23-nov-04	Maccarese / 208	Low	1,43	0,164
14397	30-nov-04	Rome / 315	Low	1,11	0,142
14519	9-dic-04	Valmontone / 437	Low	1,26	0,248
14791	28-dic-04	Maccarese / 208	High	0,97	0,134
14898	4-gen-05	Rome / 315	High	0,95	0,114
15020	13-gen-05	Valmontone / 437	High	0,88	0,118
15127	20-gen-05	Fiuggi / 43	High	1,01	0,108
15292	1-feb-05	Maccarese / 208	High	0,95	0,132
15399	8-feb-05	Rome / 315	High	1,05	0,124
15521	17-feb-05	Valmontone / 437	High	0,94	0,115
15793	8-mar-05	Maccarese / 208	High	0,93	0,116
15900	15-mar-05	Rome / 315	High	0,93	0,128
16022	24-mar-05	Valmontone / 437	High	0,94	0,154
16294	12-apr-05	Maccarese / 208	High	0,97	0,140
16401	19-apr-05	Rome / 315	High	0,99	0,134
16523	28-apr-05	Valmontone / 437	High	0,97	0,114
16795	17-may-05	Maccarese / 208	High	0,84	0,168
16902	24-may-05	Rome / 315	High	1,00	0,152
17403	28-jun-05	Rome / 315	High	1,13	0,16
17525	7-jul-05	Valmontone / 437	High	1,04	0,13
17904	02-aug-05	Rome / 315	High	1,02	0,188
18026	11-aug-05	Valmontone / 437	High	0,93	0,154
18405	06-sep-05	Rome / 315	High	1,06	0,16
18634	22-Sep-05	Fiuggi/43	High	1,00	0,152

18799	04-Oct-05	Maccarese/208	High	0,85	0,164
18906	11-Oct-05	Perm site Rome / 315	Low	1,46	0,156
19407	15-Nov-05	Perm site Rome / 315	High	1,09	0,19
20409	24-Jan-06	Perm site Rome / 315	High	1,38	0,110
20910	28-Feb-06	Perm site Rome / 315	High	0,98	0,124
21912	9-May-06	Perm site Rome / 315	High	1,0	0,138

APPENDIX 5: S-BAND ANOMALY

Table 13: List of L2 FGD Files affected by S-Band anomaly during cycle 49

File name	Start date	Start time	Stop date	Stop time
RA2_FGD_2PNPDE20060627_200301_000043992049_00014_22613_0018.N1	27-JUN-2006	20.03.01	27-JUN-2006	21.16.20
RA2_FGD_2PNPDE20060627_211519_000061182049_00014_22613_0017.N1	27-JUN-2006	21.15.19	27-JUN-2006	22.57.17
RA2_FGD_2PNPDE20060627_225612_000061292049_00015_22614_0023.N1	27-JUN-2006	22.56.12	28-JUN-2006	0.38.21
RA2_FGD_2PNPDE20060628_003717_000058862049_00016_22615_0026.N1	28-JUN-2006	0.37.17	28-JUN-2006	2.15.23
RA2_FGD_2PNPDE20060628_021420_000045542049_00017_22616_0027.N1	28-JUN-2006	2.14.20	28-JUN-2006	3.30.14
RA2_FGD_2PNPDE20060628_032939_000048552049_00018_22617_0021.N1	28-JUN-2006	3.29.39	28-JUN-2006	4.50.34

APPENDIX 6: IE SITES COORDINATES

ZONE_ID="CapraiaA"
RECORD polygon_pt: LONG=+009.934000<deg> LAT=+042.970000<deg>
ENDRECORD
RECORD polygon_pt: LONG=+009.863000<deg> LAT=+042.970000<deg>
ENDRECORD
RECORD polygon_pt: LONG=+009.863000<deg> LAT=+043.166000<deg>
ENDRECORD
RECORD polygon_pt: LONG=+009.934000<deg> LAT=+043.166000<deg>
ENDRECORD
ZONE_ID="Toulon_D"
RECORD polygon_pt: LONG=+005.500000<deg> LAT=+043.070000<deg>
ENDRECORD
RECORD polygon_pt: LONG=+005.473000<deg> LAT=+043.070000<deg>
ENDRECORD
RECORD polygon_pt: LONG=+005.473000<deg> LAT=+043.160000<deg>
ENDRECORD
RECORD polygon_pt: LONG=+005.500000<deg> LAT=+043.160000<deg>
ENDRECORD

ZONE_ID="Vostok_x"
RECORD polygon_pt: LONG=+106.500000<deg> LAT=-078.000000<deg>
ENDRECORD
RECORD polygon_pt: LONG=+105.500000<deg> LAT=-078.000000<deg>
ENDRECORD
RECORD polygon_pt: LONG=+105.500000<deg> LAT=-077.500000<deg>
ENDRECORD
RECORD polygon_pt: LONG=+106.500000<deg> LAT=-077.500000<deg>
ENDRECORD
ZONE_ID="Dome_x__"
RECORD polygon_pt: LONG=+124.000000<deg> LAT=-075.250000<deg>
ENDRECORD
RECORD polygon_pt: LONG=+122.000000<deg> LAT=-075.250000<deg>
ENDRECORD
RECORD polygon_pt: LONG=+122.000000<deg> LAT=-074.750000<deg>
ENDRECORD
RECORD polygon_pt: LONG=+124.000000<deg> LAT=-074.750000<deg>
ENDRECORD