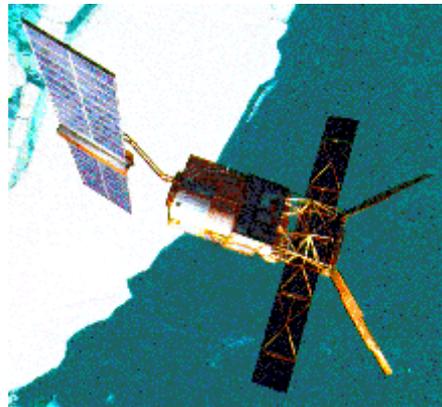

ERS-2 SAR CYCLIC REPORT

C Y C L E 1 0 1

14-DEC-2004 to 18-JAN-2005

Orbit 50456 to 50957



| | |
|----------------|----------------|
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1 INTRODUCTION

This document addresses the results of the analysis made on the ERS-2 SAR instrument for the cycle 101 concerning the following activities:

1. external calibration in section 2
2. antenna pattern monitoring in section 4.
3. internal calibration for High rate and Low bit rate mode in section 5
4. attitude/Doppler monitoring in section 6

For further information or comments please write to eohelp@esa.int.

2 MISSION EVENTS

The ERS-2 payload was piloted in YCM mode during the whole current cycle. Please note an increase of the platform instability since approximatively orbit 50600 on 24-DEC-2004. The yaw bias has jumped by $\sim 0.4^\circ$.

The AMI instruments works nominally except for the following events where the instruments was switched off:

- 16-DEC-2004 19:24:13 to 17-DEC-2004 09:17:41: unavailability due to a wrong AMI ICU memory test execution.
- 26-DEC-2004 12:45:36 to 27-DEC-2004 18:55:50: due to an on-board anomaly
- 27-DEC-2004 20:29:48 to 27-DEC-2004 20:36:07: due to a PL synchronisation of RA instrument
- 27-DEC-2004 22:17:21 to 28-DEC-2004 20:44:51: due to an on-board anomaly
- 06-JAN-2005 21:53:09 to 06-JAN-2005 22:01:54: due to a PL synchronisation of RA instrument

3 EXTERNAL CALIBRATION

External calibration is specific activity performed since the beginning of the ERS-2 mission in order to calibrate the instrument against ground target transponders with a known radar cross section (RCS).

The SAR calibration site is Flevoland in The Netherlands (NL), with 3 transponders having the following coordinates:

| Transponder | Latitude | Longitude |
|---------------|---------------|--------------------------|
| 1: Pampushout | +52.36651429N | +5.15197438E |
| 2: Lelystad | +52.45806341N | +5.52755628 ^E |
| 3: Minderhout | +52.55502077N | +5.66896505 ^E |

Table 1: Flevoland Transponders coordinates

3.1 ERS-2 Transponder monitoring

Please note that transponder 1 was last detected in 2 Feb 1997, and it has been no longer active ever since. Detection of point targets has continued on transponder 2 and 3, with alternating shuts off. Transponder 2 was last visible on 17 Oct 2001, and finally Transponder 3 was last visible on 22 Mar 2002.

From this date, there has been no detection of point targets in the designated areas in all the following NL scenes.

| Date | Value | ERSTran2 | ERSTran3 | Aalsmeer | Edam |
|------------------|-------------------|------------|------------|----------|----------|
| 23/06/2000 10:34 | Relative_rcs [dB] | 0.551746 | | | |
| | Measured_rcs [dB] | 58.2417 | | | |
| | K [dB] | 120.603494 | | | |
| 19/07/2000 21:41 | Relative_rcs [dB] | | -0.189056 | | |
| | Measured_rcs [dB] | | 57.6609 | | |
| | K [dB] | | 119.121888 | | |
| 28/07/2000 10:35 | Relative_rcs [dB] | 0.493343 | 0.170734 | | |
| | Measured_rcs [dB] | 58.1833 | 58.0207 | | |
| | K [dB] | 120.486688 | 119.84147 | | |
| 01/09/2000 10:35 | Relative_rcs [dB] | 0.381512 | 0.165394 | | |
| | Measured_rcs [dB] | 58.0715 | 58.0154 | | |
| | K [dB] | 120.26302 | 119.830789 | | |
| 10/11/2000 10:35 | Relative_rcs [dB] | 0.381512 | -0.503609 | | |
| | Measured_rcs [dB] | 58.0715 | 57.3464 | | |
| | K [dB] | 120.263025 | 118.492784 | | |
| 15/12/2000 10:35 | Relative_rcs [dB] | 0.46516 | -0.050087 | | |
| | Measured_rcs [dB] | 58.1552 | 57.7999 | | |
| | K [dB] | 120.430322 | 119.399827 | | |
| 25/04/2001 21:40 | Relative_rcs [dB] | | -0.370335 | | |
| | Measured_rcs [dB] | | 57.4797 | | |
| | K [dB] | | 118.759332 | | |
| 04/05/2001 10:34 | Relative_rcs [dB] | 0.287502 | | | |
| | Measured_rcs [dB] | 57.9775 | | | |
| | K [dB] | 120.075006 | | | |
| 12/02/2003 10:36 | Relative_rcs [dB] | | | -1.14894 | |
| | Measured_rcs [dB] | | | 60.2111 | |
| | K [dB] | | | 117.2021 | |
| 09/05/2003 10:33 | Relative_rcs [dB] | | | | -0.31983 |
| | Measured_rcs [dB] | | | | 61.8902 |
| | K [dB] | | | | 118.86 |

With:
 $\text{relative_rcs[dB]} = \text{measured_rcs[dB]} - \text{nominal_RCS[dB]}$

$\text{K [dB]} = \text{relative_rcs[dB]} + \text{K annotated [dB]}$

4 ANTENNA PATTERN MONITORING

The Amazon Rain-Forest (RF) presents a well-known and very stable backscattering characteristic. Its homogeneity and isotropic properties provide a stable and constant gamma nought allowing the SAR Antenna Pattern monitoring. SAR data are acquired in ascending and descending pass over RF to investigate changes in the antenna pattern. Since transponders are no more available, acquisitions over the RF also support the radiometric stability analysis mainly based on transponders up to now.

The data will be acquired at the station of Cotopaxi (Ecuador) and Cuiaba (Brazil) and shipped to ESRIN/CPRF for processing. The RF data analysis is usually performed each cycle for the previous one due to the time needed to process HR data, causing a delay in the images availability. For cycle 100 (8-Nov-2004 / 13-Dec-2004) no data is available over the area of interest so no analysis has been performed.

Refer the cyclic report of cycle 100 for the last available results.

5 INTERNAL CALIBRATION

5.1 Image mode internal calibration

During the cycle 82, a gain increase of 3.5dB has been performed in two steps:

- Increase of the Image up-converter level by 2.5dB on 26-FEB-2003
- Decrease of the Image receiver attenuation gain by 1dB on 28-FEB-2003

During the cycle 98, an erroneous command uploaded on board causes a significant decrease of 4dB of the replication pulse power. Images acquired from 04-SEP-2004 10:04:14 to 14-OCT-2004 14:37:11 UTC are affected by this power drop. Since this drop affects only the instrument calibration, it can be corrected afterwards using the good replica power as given in the section below.

No major event occurred during the reported period.

5.1.1 High rate products analysis

5.1.1.1 Replica pulse power monitoring

The replica pulse power is extracted from the annotations of the level 1 High Rate SLC and PRI products. As shown in the following plot, the replica pulse power has lost ~5dB since the beginning of the mission with a regular slope of -0.61 dB/year until the gain increase of 3.5B performed in February 2003. Figure 1 shows that the calibration pulse power has retrieved the level of May 1998. Since the gain increase, the replica pulse power is decreasing with a slope of -0.33 dB/year. Figure 2 shows the evolution of the HR calibration pulses during the cycle 98 to 99. On cycle 98, the calibration pulse power drops by 4dB from 50.16dB to 45.799dB. After correction, the power level went back on cycle 99 to a nominal value of 49.911dB.

The mean replica power level is of 49.21dB for the current cycle.

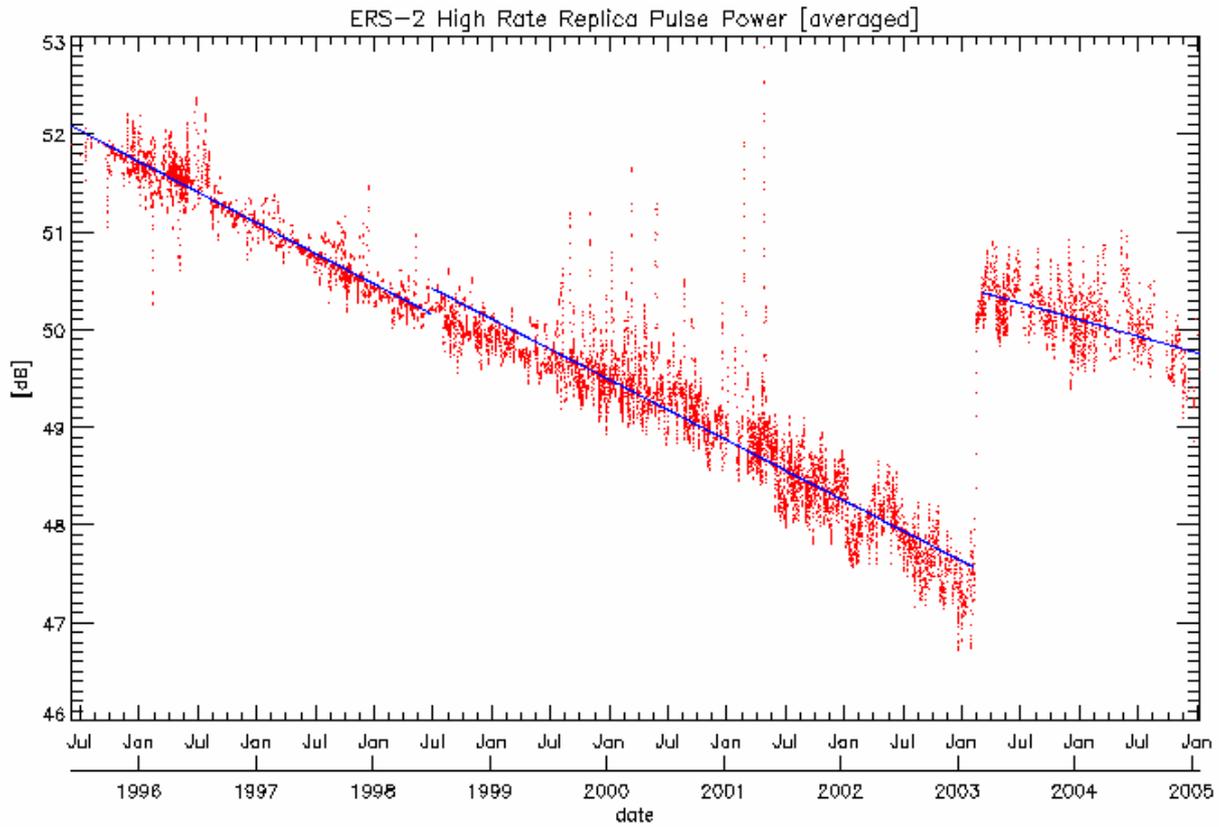


Figure 1: Evolution of Replica pulse power for High Rate products. In order to don't bias the trend the data relative to the temporary power jump have been removed.

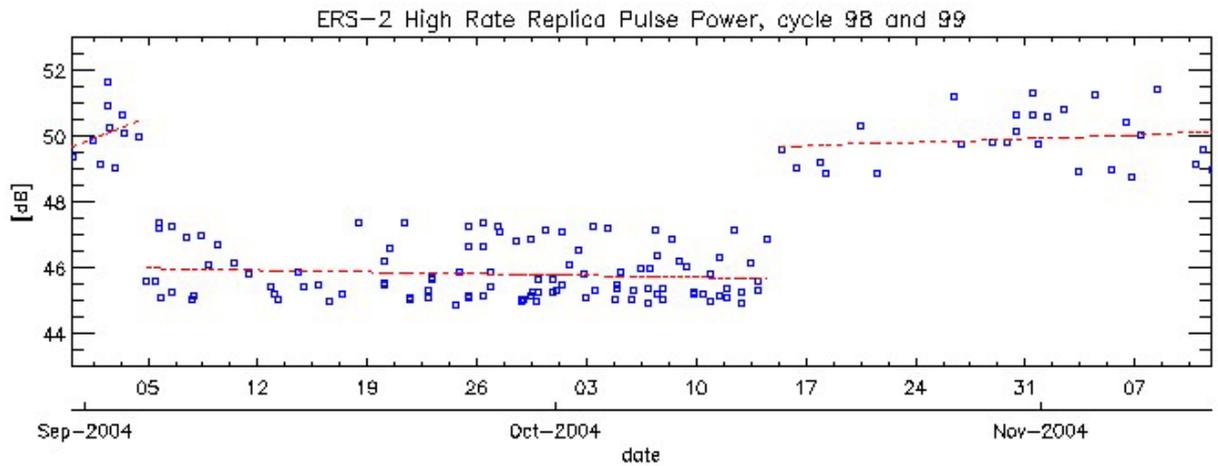


Figure 2: Evolution of replica pulse power for cycle 98 and 99

Table 2 gives the replica pulse power correction factor averaged over 3 months.

| Year | Jan-Feb-Mar | Apr-May-Jun | Jul-Aug-Sep | Oct-Nov-Dec |
|------|----------------|---------------|----------------|-------------|
| 1995 | Not available | Not available | 215.23 | 210.835 |
| 1996 | 203.534 | 201.705 | 196.501 | 184.085 |
| 1997 | 178.818 | 173.012 | 164.666 | 159.916 |
| 1998 | 155.797 | 150.462 | 146.509 | 140.186 |
| 1999 | 139.446 | 133.889 | 132.352 | 129.449 |
| 2000 | 127.202 | 121.463 | 120.669 | 115.158 |
| 2001 | 110.416 | 109.128 | 99.859 | 98.068 |
| 2002 | 91.014 | 93.22 | 86.05 | 82.954 |
| 2003 | 76.578 /151.28 | 153.464 | 153.805 | 148.575 |
| 2004 | 146.281 | 149.892 | 147.715/77.274 | 137.193 |
| 2005 | 125.573 | | | |

Table 2: Evolution of the Replica Pulse Power correction factor from the HR products. The yellow case is relative to the gain increase of March 2003 and to the power drop of September 2004.

5.1.2 QCP analysis

As a replacement of the UIND¹ and UIC² products, the QCP files are used to monitor the evolution of the:

- replica pulse power,
- calibration pulse power and
- noise power (not calibrated)

In particular, QCP gives two measures of the above parameters: at the start/end of the acquisition. For further details on QCP, please see annex B. Please see Figure 3 for trend plots where red points are for the measures at the beginning of the product and green are the ones at the end.

Replica Pulse Power

The replica pulse power measurements (start/stop) are almost identical. Since the gain increase, the level decreases with a slope -0.57dB/year . Due to the anomaly of cycle 98, the power level drops from 49.29dB to 45.12dB. After correction, the power level went back on cycle 99 to a nominal value of 49.04dB. For the current cycle, the power level is of 48.89dB as shown in Figure 4. As done previously with the HR products, the mean replica pulse power derived from the QCP is given in Table 3.

2. Calibration Pulse Power

As the measure made at the end of the segment is noisier, only the first is used. For the current cycle the power level has reached a mean level of 42.77dB. As shown in Figure 5 there is (as expected) a linear correlation between replica and calibration pulse power. However, the effect

¹ UIND gives information on noise power level and the calibration pulse power level

² UIC gives on the replica Pulse power

of the power drop is clearly visible as it appears like outliers to this linear relationship. Since the gain increase, the mean calibration pulse power is decreasing with a regular slope of -0.53dB/year.

3. Noise Power

The noise power level seems to be constant during the whole mission. It decreases with a low slope of -0.08dB/year from the last gain increase. During the current cycle it has reached a mean level of 7.23dB.

| Year | Jan-Feb-Mar | Apr-May-Jun | Jul-Aug-Sep | Oct-Nov-Dec |
|------|---------------|-------------|----------------|-------------|
| 1996 | 211.622 | 205.018 | Not available | 184.384 |
| 1997 | 182.15 | 173.055 | 167.219 | 162.305 |
| 1998 | 155.998 | 151.48 | 144.595 | 138.553 |
| 1999 | 135.867 | 128.822 | Not available | 127.188 |
| 2000 | 115.325 | 109.939 | 109.38 | 105.205 |
| 2001 | 101.302 | 97.039 | 91.881 | 88.518 |
| 2002 | 83.486 | 81.575 | 77.354 | 72.151 |
| 2003 | 70.864/145.35 | 139.799 | 134.951 | 129.152 |
| 2004 | 122.444 | 123.601 | 121.708/ 47.42 | 113.769 |
| 2005 | 107.916 | | | |

Table 3: Evolution of Replica Pulse correction factor for QCP files. The yellow case is relative to the gain increase of March 2003 and to the power drop of September 2004.

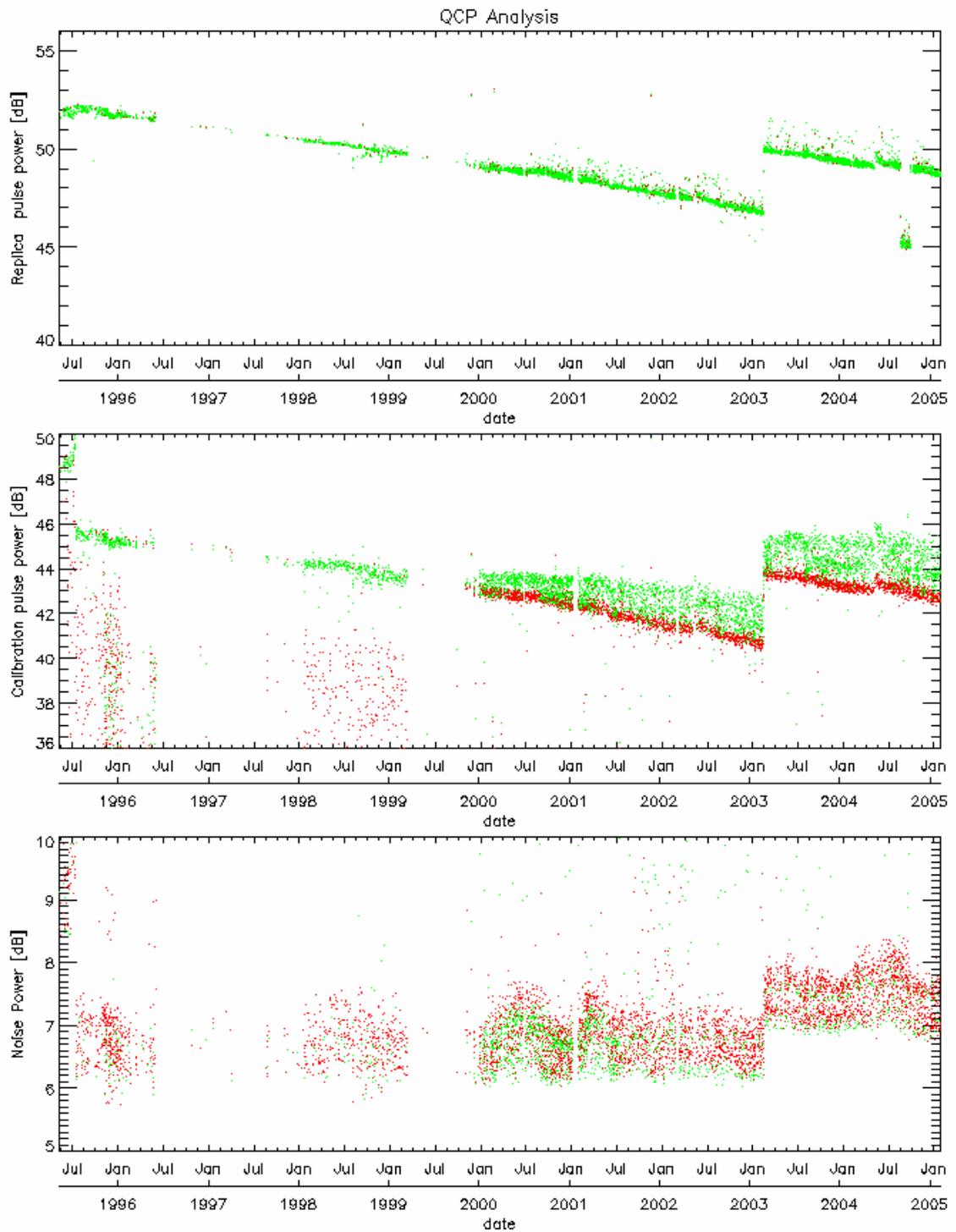


Figure 3: Evolution of Replica, calibration and noise pulses from QCP files. Red points are for the measures at the beginning of the product, while green are the ones at the end.

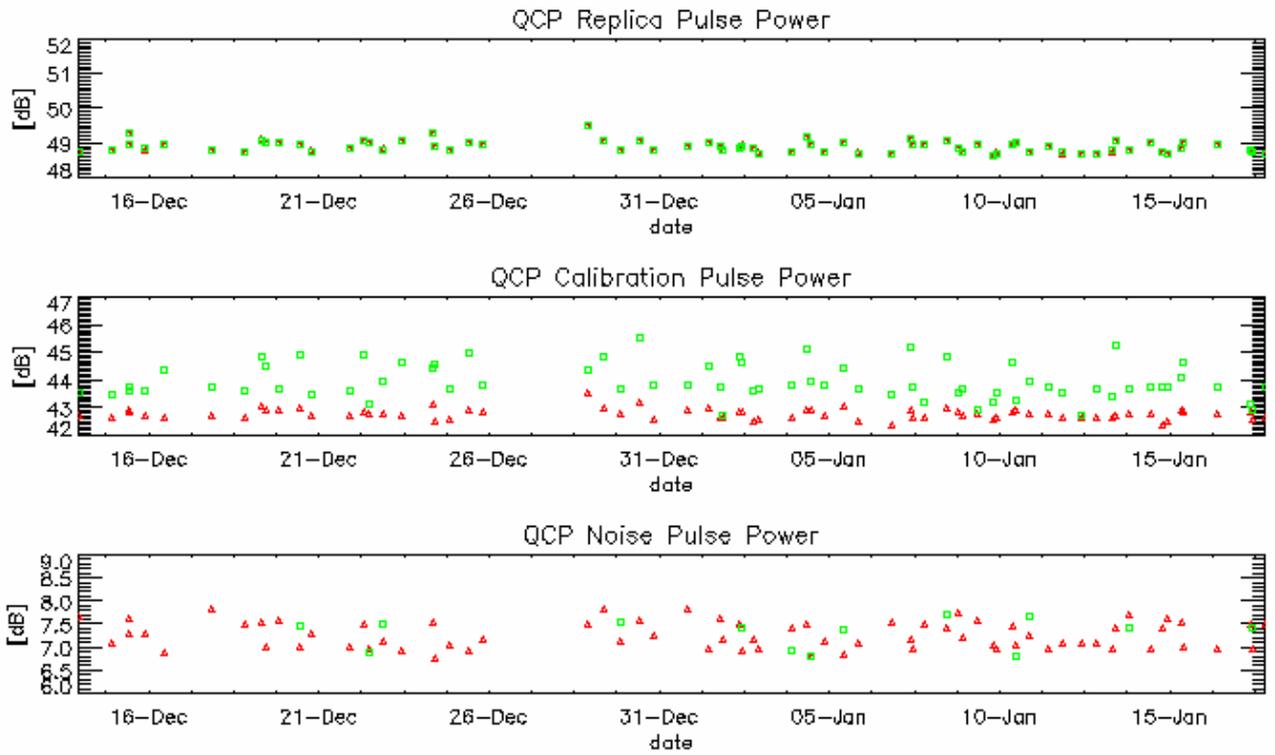


Figure 4: Evolution of Replica, calibration and noise pulses from QCP files for the current cycle

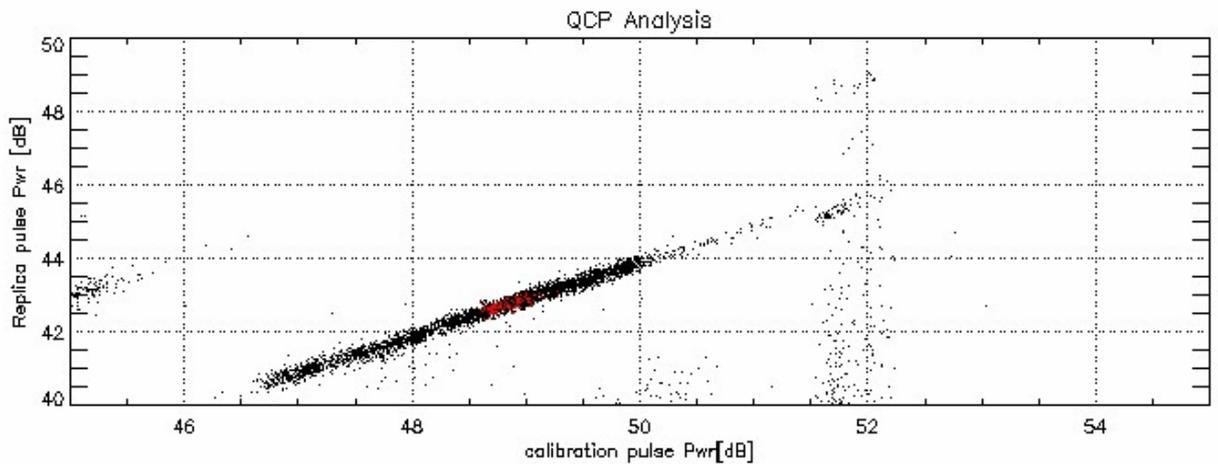


Figure 5: Joint evolution of Replica and calibration pulses. Red dots are the data for the current cycle.

5.2 Wave mode internal calibration

5.2.1 Calibration pulse power monitoring

From cycle 39 to 77 (Jan-1999 to Sep-2002), the calibration pulse power was decreasing with a slope of -0.215dB/year .

On 4th September 2002 an update of the ERS-2 AMI up-converter gain occurred. For wave mode the gain was increased by 3dB. However, only a change of $\sim 1\text{dB}$ has been measured, as shown in Figure 6. The level of the calibration pulse power rose up from 23.5dB to 24.4dB . Since the gain increase, the power level is decreasing with a regular slope of -0.216dB/year .

The calibration pulse power has reached for the current cycle a mean level of 23.94dB as show in Figure 7.

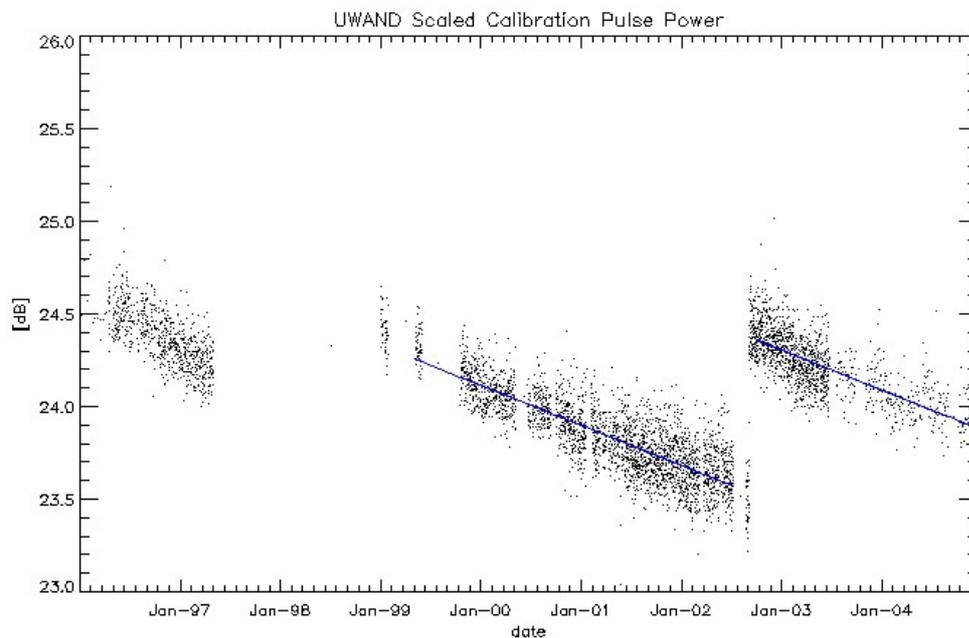


Figure 6: Evolution of Mean Calibration Pulse

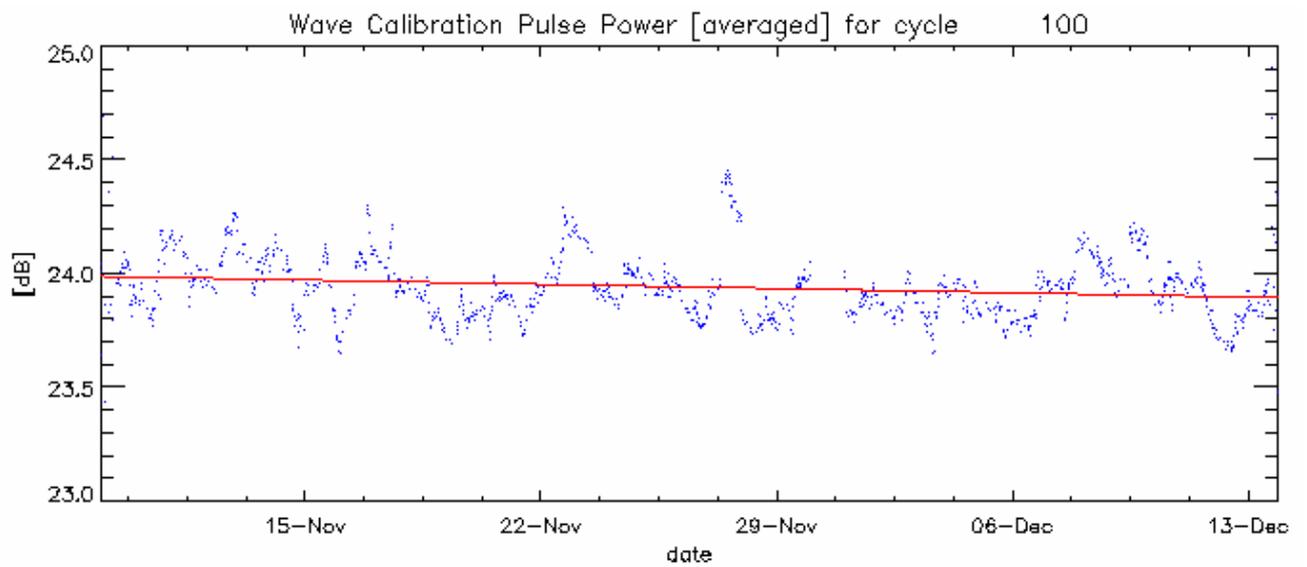


Figure 7: Evolution of Calibration Pulse Power for the current cycle

Please see appendix A for further details on calibration pulse power.

6 SAR PERFORMANCE

6.1 Image/Wave acquisition

Starting from July 2003, due to tape recorders failure, the ERS LR mission continues within the full coverage of ESA LBR receiving stations, which are:

- Maspalomas, Gatineau, Prince Albert, Kiruna: immediately available
- West Freugh, Matera, O'Higgins: available in the near future

Please note that SAR HR mission is not affected. By consequence, SAR image availability is not influenced.

6.2 Doppler/Attitude analysis

6.2.1 AOCS overview

ERS-2 was piloted in yaw-steering mode using three gyroscopes since the beginning of the mission until February 2000, when a new yaw-steering mode using only one gyroscope was implemented. The ERS-2 gyroscopes have experienced several problems during the mission and the new mono-gyro mode (1GP) was intended to ensure the mission continuity even in case of additional failures. In January 2001 a new test piloting mode using no gyroscopes, the Extra-Backup Mode (EBM), was implemented as a first stage of a gyro-less piloting mode. The aim of this challenging mode was to use the remaining gyroscopes only for those activities absolutely requiring them, such as some orbit manoeuvres. A more accurate version of this yaw-steering zero-gyro mode (ZGM) was operationally used since June 2001 and the performance was further improved with the implementation of the Yaw Control Monitoring mode (YCM) on the beginning of 2002. The evolution from the nominal and extremely stable three-gyro piloting mode (3GP) to the YCM has allowed to successfully continuing the ERS-2 operations despite of the gyroscopes failures. Nevertheless, this evolution has significantly affected the stability of the satellite attitude and the SAR Doppler Centroid frequency. Figure 8 gives a summary of the ERS-2 piloting modes.

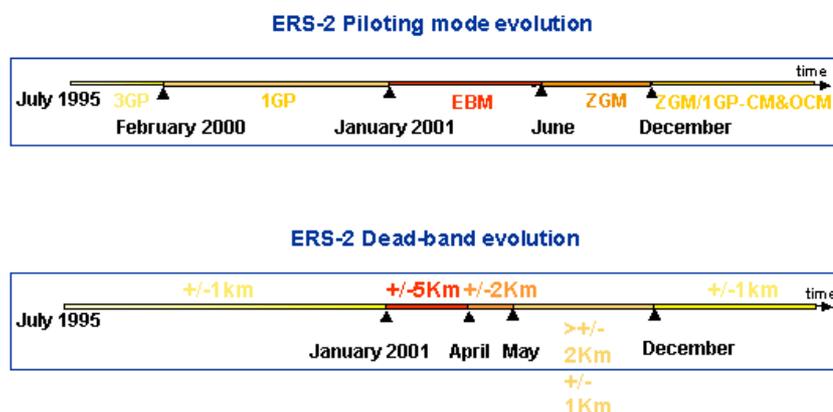


Figure 8: Summary of ERS-2 Piloting Mode

As an example of the attitude instability Figure 9 shows the evolution of the Doppler Centroid since the beginning of the ERS-2 mission.

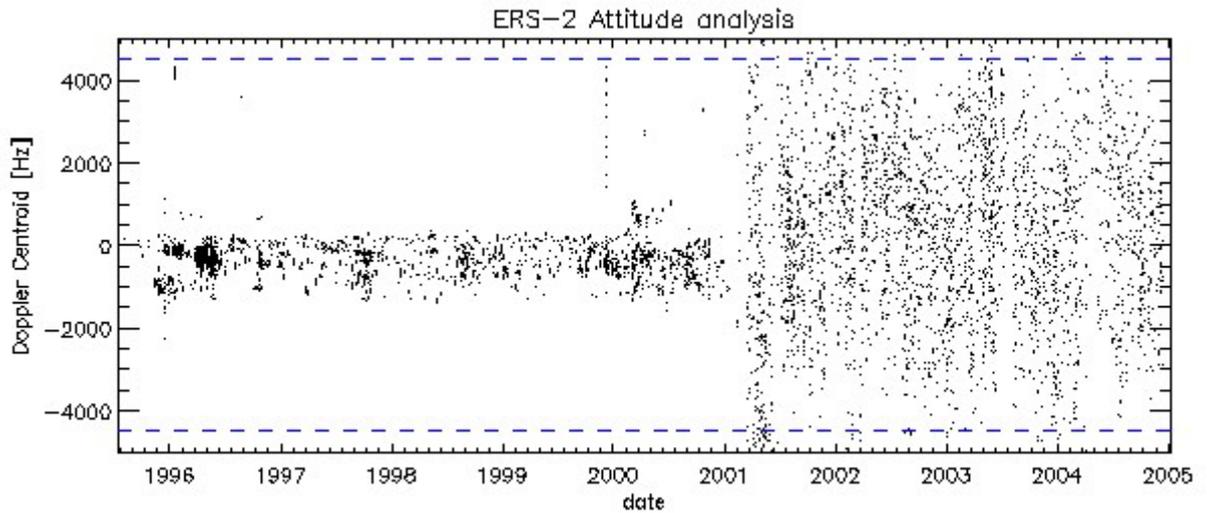


Figure 9: Evolution of Doppler Centroid Frequency since the beginning of the mission

6.2.2 Attitude monitoring

The YCM piloting mode requires a monitoring in near real time of the yaw angle. The mean yaw per orbit angle is currently derived HEY (scatt) products.

From January to March the payload is in the sun blinding period where for ~4minutes per orbit the satellite flies with uncontrolled attitude due to sensor blinding. During this period increase in the dispersion of the yaw values is expected.

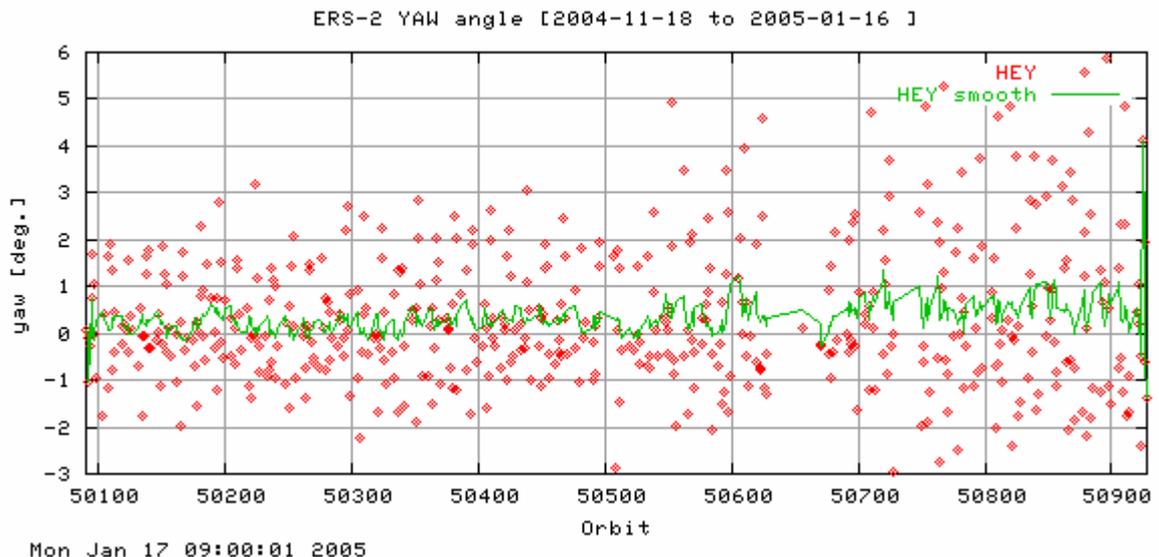


Figure 10: Mean yaw angle/orbit derived from HEY data since 06-JUN-2004

Please note an increase of the platform instability since approximately orbit 50600 on 24-DEC-2004. The yaw bias has jumped by $\sim 0.4^\circ$.

6.2.3 SAR high rate Doppler monitoring

For monitoring purposes a specific HR product ordering (~ 90 products per cycle) is made to follow the evolution of the platform attitude/Doppler Centroid frequency.

For the current cycle too few HR products are available to present reliable trends.

ANNEX A: WAVE CALIBRATION PULSE POWER

Noise power density, scaled and unscaled calibration pulse power can be calculated extracting the following parameters from **UWAND** products:

- σ_I the standard deviation of I part noise data on SPH
- σ_Q the standard deviation of Q part noise data on SPH
- I and Q part of the 4 calibration pulse datasets

Noise power density

The noise power density is defined as follows:

$$npd = \sigma_i^2 + \sigma_q^2$$

Calibration pulse power

For each four DSRs, we search the peak intensity of the calibration pulses. In order to take into account only the energy of the main lobe of the calibration pulses only 16 samples are used around the peak. If p is the position of the peak the calibration pulse power for one DSR is defined as following:

$$powerDSR = \frac{1}{16} \sum_{n=p-8}^{p+7} I_n^2 + Q_n^2$$

The Calibration Pulse Power is obtained by averaging:

$$CalibrationPulsePower = \frac{1}{4} \sum_{j=1}^4 powerDSR(j)$$

- a) Unscaled calibration pulse power

The unscaled calibration power is identical as the previous formula:

$$UnscaledCalibrationPulsePower = CalibrationPulsePower = \frac{1}{4} \sum_{j=1}^4 powerDSR(j)$$

- b) Scaled calibration pulse power

The scaled calibration pulse power is defined as follows:

$$scaledCalibrationPulsePower = CalibrationPulsePower - 16 * npd = \left[\frac{1}{4} \sum_{j=1}^4 powerDSR(j) \right] - 16 * npd$$

ANNEX B: PRODUCTS QUALITY ANALYSIS

This activity is principally dedicated to the user support. The two main types of activities are:

- Verification of products with a high Doppler value (rejected products)
- Product quality/format anomalies

Rejected products during the cycle

Rejected products are those having Doppler Centroid frequencies outside the interval $[-4500, 4500]$ Hz. In this case VMP ambiguity estimation is not reliable so the product's focusing has to be checked.

Product quality anomalies

Products quality anomalies are detected internally or via the users complaints. The action is to analyze the faulty products and report the analysis results.

ANNEX C: EXAMPLE OF QCP FILE

Processing - ERS_2_\$QCP200_027387.\$EXCHANGE

Filename = ERS_2_\$QCP200_027387.\$EXCHANGE
 File size in bytes = 3551
 Time of last access = 01-NOV-2002 19:33:37.000
 Time of last data modification = 27-JUL-2000 09:38:23.000
 Time of last file status change = 27-JUL-2000 09:38:23.000

[QCP200Header]

Filename = ERS_2_\$QCP200_027387.\$EXCHANGE
 ArrivalTime = 2000-07-27 09:38:23
 Platform Id = 2
 NumOfPasses = 1
 PassId = 1
 NumOfImagingSeqs = 1

[ImageSeqId_1]

NumberOfValidNoisePulsesStart = 3
 NumberOfValidCalibPulsesStart = 4
 NumberOfValidRepPulsesStart = 8
 MeanPowerOfValidRepStart = 78166.750000
 MeanPowerOfValidRepFlagStart = 0.000000
 IndexOfFirstValidRepSampleWindowStart = 29
 FirstValidReplicaSampleWindowFlagStart = 1
 RangeCompressionNormFactorStart = 77990.000000
 RangeCompressionNormFactorFlagStart = 0
 MeanPowerOfValidCalibStart = 18861.839990
 MeanPowerOfValidCalibFlagStart = 0
 MeanPowerOfValidNoiseStart = 5.681800
 MeanPowerOfValidNoiseFlagStart = 1
 NumberOfValidNoisePulsesEnd = 6
 NumberOfValidCalibPulsesEnd = 4
 NumberOfValidRepPulsesEnd = 8
 MeanPowerOfValidReplicaEnd = 77995.250000
 MeanPowerOfValidReplicaFlagEnd = 0
 IndexOfFirstValidReplicaSampleWindowEnd = 28
 FirstValidReplicaSampleWindowFlagEnd = 1
 RangeCompressionNormFactorEnd = 77890.000000
 RangeCompressionNormFactorFlagEnd = 0
 MeanPowerOfValidCalibEnd = 18015.237350
 MeanPowerOfValidCalibFlagEnd = 0
 MeanPowerOfValidNoiseEnd = 5.276930
 MeanPowerOfValidNoiseFlagEnd = 1
 MeanReplicaPulsePowerUpperThreshold = 255000.000000
 MeanReplicaPulsePowerLowerThreshold = 85000.000000
 MeanNoiseSignalPowerUpperThreshold = 7.500000
 MeanNoiseSignalPowerLowerThreshold = 2.500000
 MeanCalibSignalPowerUpperThreshold = 3750.000000
 MeanCalibSignalPowerLowerThreshold = 1250.000000
 RangeCompressNormFactorUpperThreshold = 255000.000000
 RangeCompressNormFactorLowerThreshold = 85000.000000