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ERS-2 AOCS Mono-Gyro Attitude Software Qualification Period

Radar altimeter data analysis

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1 INTRODUCTION

The ERS-2 AOCS mono-gyro attitude software Qualification Period started on February 7 2000, with the up-link of the new software developed under an ESA contract by Matra Marconi Space (MMS). After the initial safety tests performed by ESOC, the sensors have been switched back on, on February 10 2000.
During the two weeks Commissioning Phase, different AOCS on-board configurations have been tested as defined in [R-5] and [R-6], providing sensors data for analysis.
This document presents the analysis results of the impact of the new attitude software on the Radar Altimeter data.

2 ACRONYMS AND ABBREVIATIONS

AOCS	Attitude and Orbit Control System
BUFR	Binary Universal Form for the Representation of meteorological data
ECMWF	European Centre for Medium range Weather Forecasting
ERS	European Remote Sensing satellite
ESRIN	European Space Research INstitute
ERAC	Extracted Radar Altimeter data for Calibration
ESOC	European Space Operations Centre
FD	Fast Delivery products
MMS	Matra Marconi Space
RA	Radar Altimeter
SPTR	Scanning Point Target Response
WAM	ECMWF WAve Model
YSM	Yaw Steering Mode

3 REFERENCE DOCUMENTS

R-1 Impact of the mispointing on the altimeter measurements by simulation, IFREMER Contract N.99/2.210 833, October 99, CLS/DOS/NT/99.195

R-2 Analysis of the impact of mispointing on altimeter measurements using OPR data, IFREMER Contract N.99/2.210 833, October 99, CLS/DOS/NT/99.199

R-3 Radar altimeter off-nadir pointing evaluation tool: Description and results, Annalisa Martini, ESRIN/PCS, January 28 2000, APP-ADQ/AM/00-01

R-4 Mispointing correction algorithm, IFREMER Contract N.99/2.210 833, January 2000, CLS/DOS/NT/99.219

R-5 ERS-2 Mission Operation Plan, Sergio Vazzana, ESRIN/APP-ADU, January 7 2000, ER-TN-ESA-GS-xxxx, draft version

R-6 Mono Gyro AOCS Software In-Flight Commissioning, Ian Harrison ESOC/TOS, January 10 2000, ERS2-TST-TP-1001-TOS-OF, issue 2.0

R-7 AOCS Impact on ERS Radar Altimeter Data Quality, mono-gyro s/w Qualification Phase and routine monitoring, Pierre Féménias, D-APP/ADQ, January 28 2000, ER-TN-AOCS/PF-0100.1.

R-8 ERS-2 RA Commissioning Phase data analysis, E. Schied, ER-TN-DSF-RA-1514

R-9 Analysis of the mispointing angle obtained during the AOCS test, Ifremer contract No 99/2.210 833, March 2000, CLS/DOS/NT/00.244

R-10 ERS-2 FDS/ESRIN Interface Control Document for Attitude Reconstitution, ESOC/Flight Dynamics, DTOS-FDOS-GEN-ICD-nnnn-TOS-GFM, issue draft, Rev. 0, January 2000.

4 ALTIMETER DATA AND PRE-PROCESSING

Two levels of Radar Altimeter products have been used to do the work presented in this document. The mispointing information retrieval has been performed using the ERAC raw data, which contain the altimetric waveforms (20 Hz) as they come from the sensor. The data requested for this exercise are defined in the document R-5. For this purpose the Maspalomas ERAC orbits data have been sent in Fast Delivery to ESRIN/PCS as well as small segments of Kiruna orbits to allow a rapid analysis of the data. The complete daily set of the Kiruna orbits was then shipped to ESRIN/PCS later on for deeper analysis.
The geophysical validation of the ERS RA Wind Speed (WS) and Significant Wave Height (SWH) fields has been completed from the information contained in the URA Fast Delivery products, nominally generated at the ground stations and disseminated to ESRIN/PCS. ECMWF did also support ESA in this exercise making use of the BUFR data, received on the GTS network.

5 ATTITUDE FILES

The attitude files computed from the platform data were highly recommended to validate both the method used to retrieve the mispointing information from the RA data but also to validate the obtained results. These files have been received at ESRIN/PCS in a form as presented in the document [R-10], providing information on the three attitude angles (Yaw, Pitch and Roll).
A mispointing value has then been derived at ESRIN/PCS as defined in chapter 4.3.

It rapidly appears that the accuracy of the files content was not optimal with an uncertainty of +/- 0.3 degrees on the Roll and Yaw information. The number of harmonics (5), used to describe the variations of the three attitude angles along the orbit, has also been noted as a restrictive factor for the validation exercise. The results of comparison between the ESRIN retrieved mispointing information and the one derived from the attitude files is presented in this document.

The dissemination of the attitude files (5 harmonics) to ESRIN/PCS stopped on February 19 2000. In a near future, the generation at ESOC/Flight Dynamics of more accurate attitude files is expected, based on 100 harmonics. After validation, they could be used to, first monitor the spacecraft attitude, second correct the sensor data from any mispointing degradation.

6 RA MISPOINTING RETRIEVAL

The retrieval of the Radar Altimeter antenna off-nadir pointing has been performed by mean of an in-depth study of the RA extracted data for calibration (ERAC). As described in [R-3], the mispointing value is evaluated based on a processing of the RA waveform shape within the filter bank. Two versions of the algorithm have been developed for the need of the study:

- The first version allows the calculation of one average mispointing value over a certain period of time (usually ten minutes).
- The second version gives as output, a time series with one mispointing value per second, smoothed over a time sloth of one minute.

Two important considerations have to be made at this point:

- The RA waveforms have to undergo several corrections during the processing. One of them, the IF Filter shape correction, does influence a lot the outcome of the processing. In other words, the processing done to retrieve the mispointing information is very sensitive to the IF filter shape correction used.
  To illustrate this and as a result of our analysis, we noticed that our software implementation of the mispointing retrieval algorithm and the IF filter shape correction we used, did lead to results higher than the ones obtained before in others studies. As an example, the mispointing values obtained by processing the data from the ERS-2 Commissioning Phase period are higher by 0.05 degrees when compared to the Eberhard Schied's results as presented in [R-8].

- The algorithm itself is affected by an error, which is exponentially growing as the absolute mispointing value decreases. This means that the mispointing values obtained during the period before the AOCS commissioning phase, which are often used as reference, could suffer of a bigger error than the values relative to the mono-gyro piloting period.

6.1 Pre-analysis work

In order to have a reference for the data validation of the AOCS Commissioning Campaign; a pre-analysis work has been performed on the ERAC products disseminated in fast delivery since the beginning of the ERS-2 mission. Every three days, ten minutes of raw data arrive in fast delivery at ESRIN/PCS. They are sensed over the Pacific Ocean within 0° and 35° latitude north. Those data have been analysed using the first version of the method previously described, giving as output (see Figure 1), one mispointing value every three days for the whole mission.

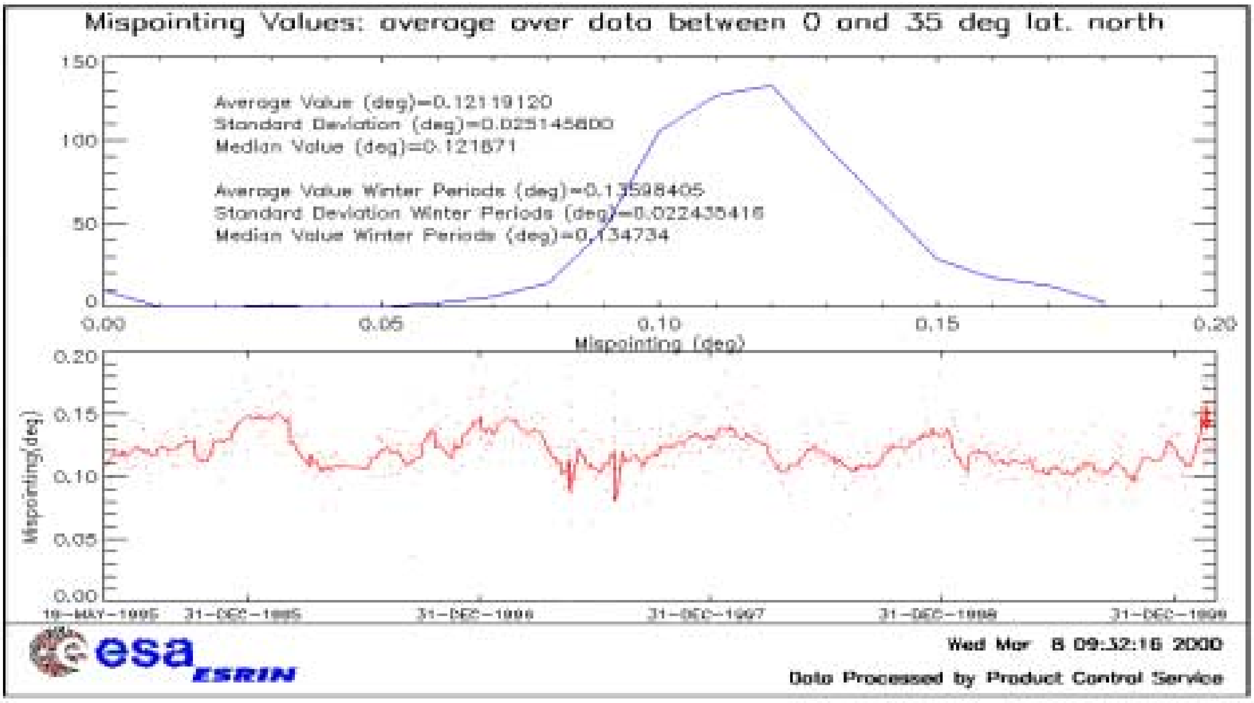

Figure 1: Mispointing Trend over the whole ERS-2 mission.

From Figure 1, an annual trend of the RA antenna off-nadir pointing values is clear. During the summer months, the values tend to be lower than during the winter periods. The average and median values calculated considering only winter data (December, January and February) are about 0.01° higher than the overall average. No peculiar explanation to this seasonal trend is given for the time being. The IF filter shape used in this processing has not been restricted to the one computed during the ERS-2 Commissioning Phase. The IF filter shape has been calculated and updated for the whole mission each time it was feasible, i.e. every 3 days.

It can also be noted that the global mispointing mean value of 0.12 (deg) we processed is much bigger than the mispointing affirmed by ESOC which is equivalent to 0 +/- 0.003 (deg) for the whole ERS-2 mission until the installation of the new AOCS mono-gyro software.

The higher density of points visible at the end of the plot represent the data set recorded during the AOCS commissioning period.

6.2 IF filter shape correction

The IF filter characteristics are nominally derived from the integrated power of the SPTR ice curve. Their determination is made on ground by processing of the internal calibration data. It is normally characterised during the pre-launch campaign and then during the Commissioning Phase (See [R-8]). For information, the IF filter shape characterised for the ERS-2 Radar Altimeter is the same as the one used today in the ERS OPR level processing chain.
This brief chapter on the ERS-2 IF filter shape has been added to this document just to mention that, during the preparation of the ERS-2 mono-gyro software campaign an evolution of the filter shape has been observed.
The IF filter shape calculated during the ERS-2 Commissioning Phase is shown in Figure 2 along with a new IF filter calculated with data from February 20, 2000. The difference between the two shows that the ERS-2 RA IF filter has evolved. A clear slope is present.
It has been established in the CLS report (See [R-9]) that the non-use of an updated IF filter shape would correspond to the effect of a mispointing equivalent to 0.016 deg^2 (0.13 degrees) for the data of the same time period, i.e. February 2000.
The simulated impact on the Radar Altimeter parameters is the following, considering a SWH of 2m:

- Impact on the altimetric range: 2.5 cm
- Impact on the SWH: from 2.5 to 4.5 cm
- Impact on sigma0: 0.23 dB

This has been noticed as constant biases for a platform mispointing below 0.6 degree.

These results do raise the need to develop in an operational way the monitoring of the ERS-2 RA IF filter shape and to apply updated data to the ground processing or a correction to the data themselves. In a first step, a deeper analysis of the evolution of the IF filter shape will be undertaken both for ERS-2 and ERS-1 and corrective solutions will then be proposed.

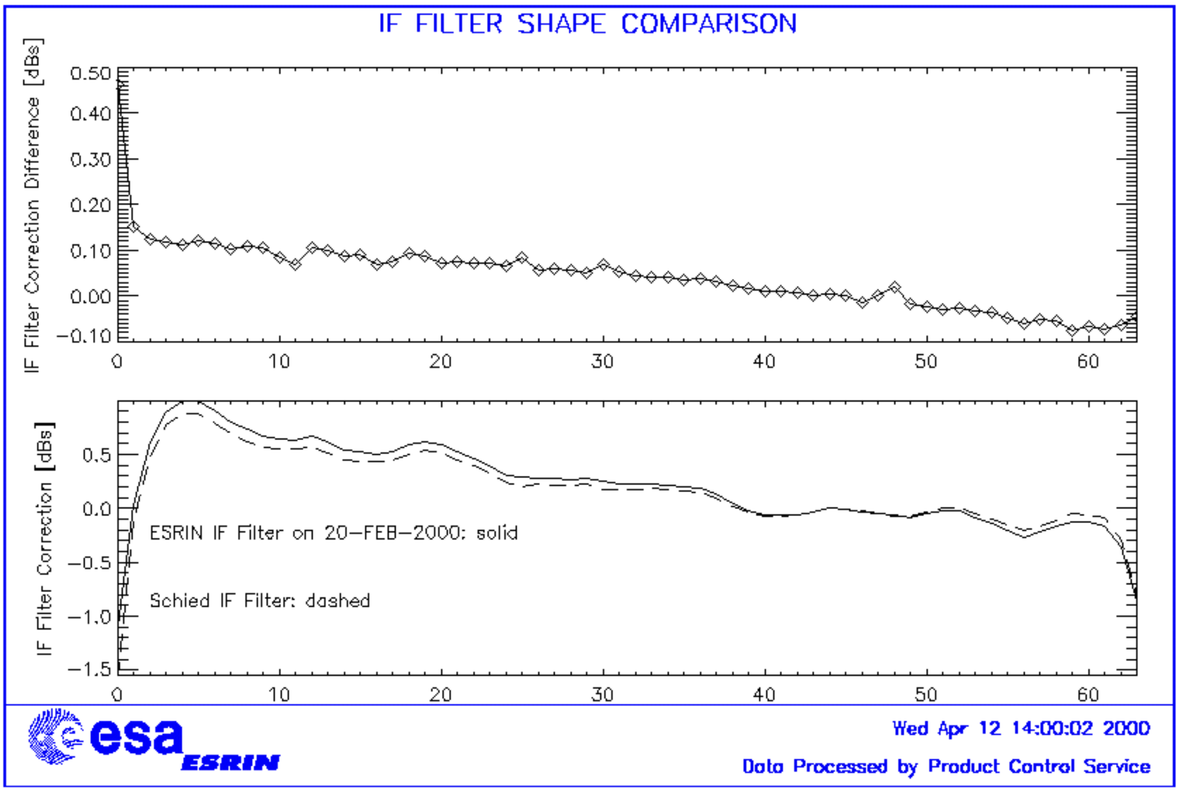

Figure 2: Plot of 2 IF filter shapes and of the difference between the two. The dashed curve corresponds to the IF filter calculated during the ERS-2 Commissioning Phase in 1995. The solid one has been calculated in ESRIN/PCS with data from February 20, 2000. A slope in the difference is clearly visible.

6.3 Comparison with ESOC Attitude files

From the Flight Dynamics group in ESOC, ESRIN-PCS has received files describing the variations of the three attitude angles (Yaw, Roll and Pitch) over several orbits. From the Pitch and Roll values, the RA antenna off-nadir pointing value has been evaluated using the formula hereafter reported:

$$misp = \arcsin\left(\sqrt{\sin(pitch)^2 + \sin(roll)^2}\right)$$

By means of the second method illustrated in [R-3], trends of mispointing values over those orbits have been computed. With the intention of validating the results, a comparison has been performed between the mispointing values obtained from the RA waveforms and those coming from attitude calculations performed in ESOC.

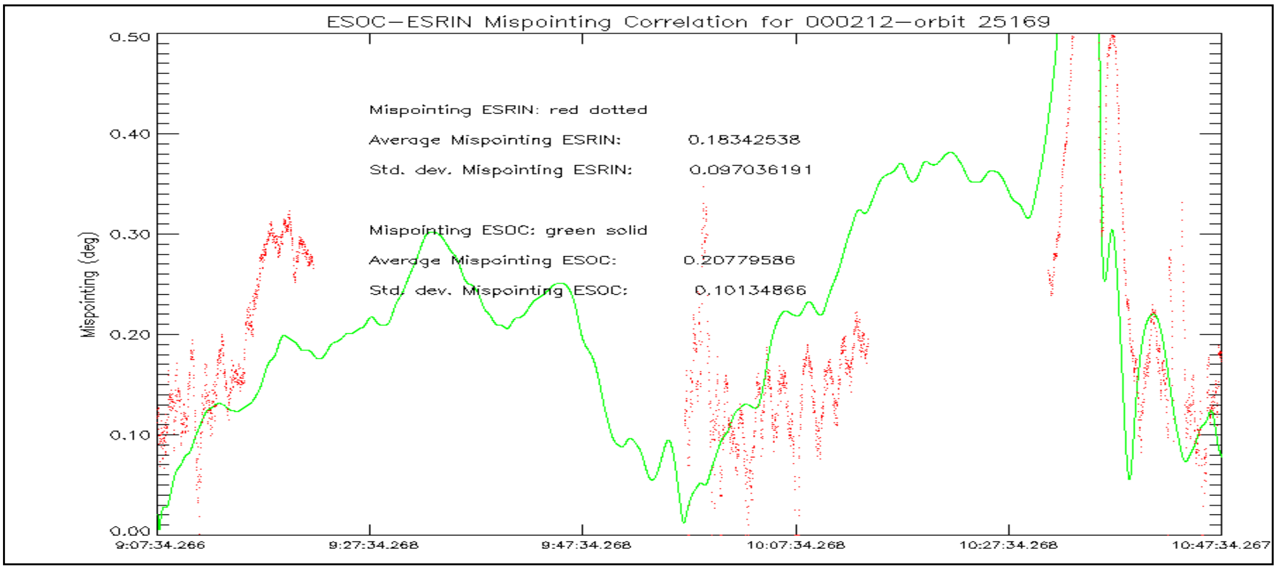

Figure 2: Plot of the ESOC derived attitude information and of the ESRIN mispointing calculations for the orbit number 25169.

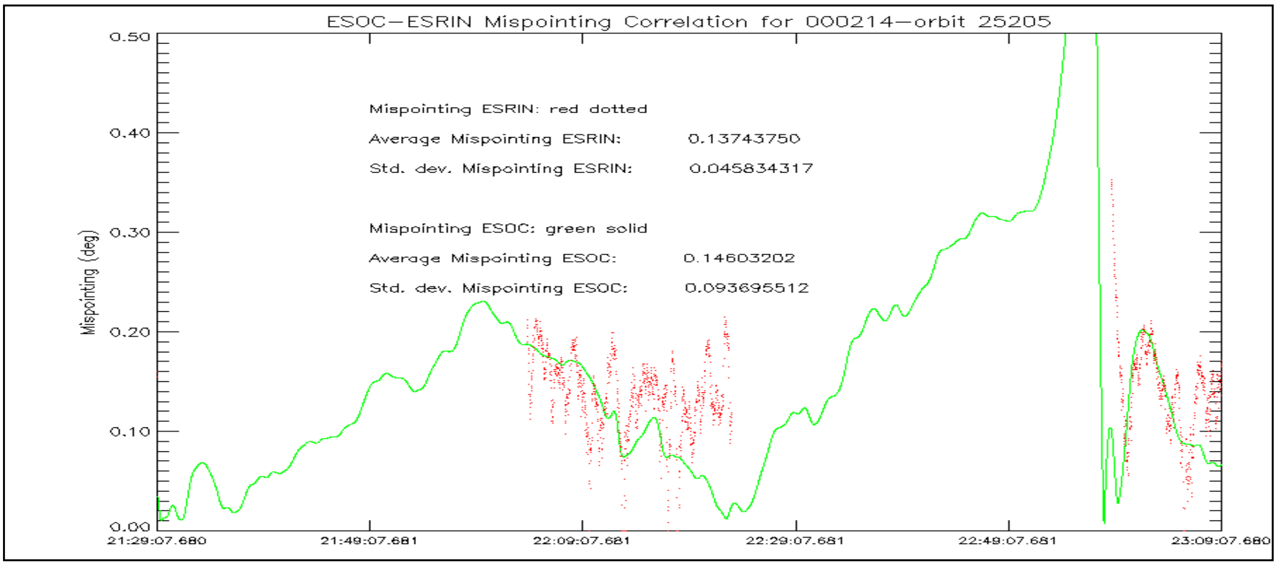

Figure 3: Plot of the ESOC derived attitude information and of the ESRIN mispointing calculations for the orbit number 25205. It has to be noted that the ESRIN processing of the RA waveforms is performed only on the data acquired in Ocean mode. This explains the discontinuities of this signal.

The plots in Figure 2 and Figure 3, as for all the other orbits we looked at, show that the shapes of the two signals reported are quite similar and that their respective amplitudes are also very close within few hundredths of degrees. The peak values visible on the above plots and bigger than 0.4 degrees are due to the so-called sun blinding effect, which occurs in winter. During this period, the configuration sun-earth-satellite is such that the Digital Sun Sensor (DSS) is being blinded by the

sun when coming from the South Pole, i.e. for all the ascending tracks around 50-55 degrees south latitude. This effect is principally visible on the data acquired with the AOCS mono-gyro software, which now relies more on the DSS and requires also more input data from this sensor to compensate for the 2 other missing gyroscopes.
The agreement is anyway acceptable, even if a shift in amplitude seems to be necessary in order to make them better aligned. This hypothesis is also supported by the presence of an uncertainty, reported by the ESOC Flight Dynamics group, in the computation of the roll and yaw values. This uncertainty would fluctuate between +/-0.3 degrees but would be anyway constant for a given orbit. There is therefore an unknown shift to be considered per orbit on these two axes (personal communication with ESOC). Based on those considerations we tried, in a very empirical manner, to determine this unknown bias which would make the two signals better aligned. An output of this exercise is given in Figure 4, applying a negative bias of 0.115 degrees on the ESOC roll attitude values.

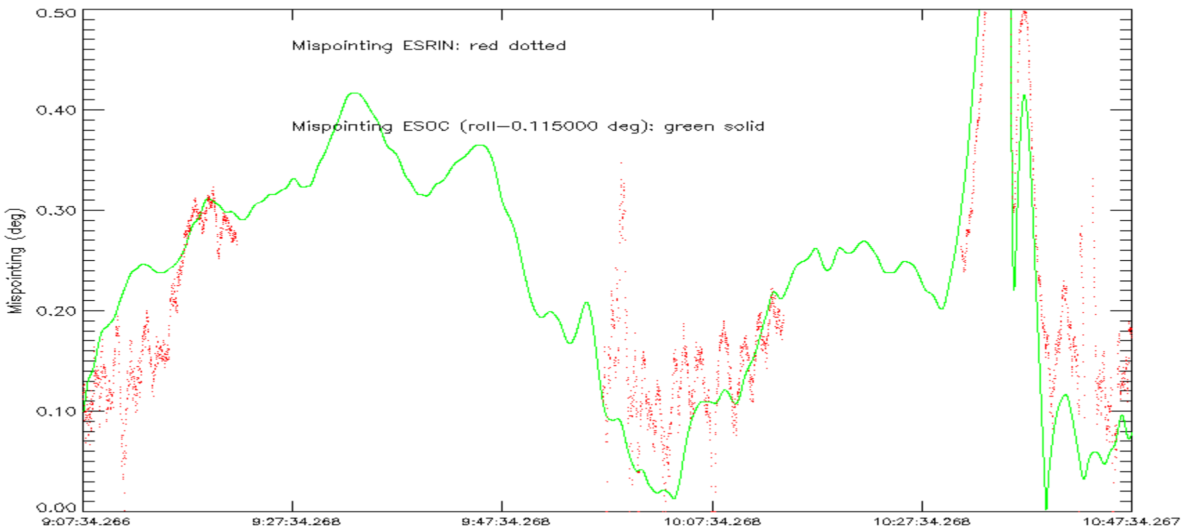

Figure 4: Plot of the ESOC derived attitude information and of the ESRIN mispointing calculations for the orbit number 25169. A bias of -0.115 degrees has been applied on the ESOC roll values.

6.4 Comparison with RA past data

A kind of 'Collinear Tracks analysis' has been implemented with the aim of comparing, for each orbit, the mispointing results relative to the mono-gyro piloting period with a reference trend. The reference trend has been evaluated averaging the mispointing output values over several (4 to 5) orbits associated to the three-gyros piloting period. The reference orbits have been chosen in such a way that they represent the same relative orbit in the cycle as the tested one and that they were all recorded during the winter months. After having calculated the difference between the mono-gyro and reference mispointing results for several orbits, the following considerations can be formulated:

- The different mispointing trends show a good agreement in shape and in amplitude.

- The difference in mispointing gets higher when the satellite is close to the South or to the North poles (ref. Figure 6 at around 23:12 and 23:45 UTC). This effect is evident even excluding the sun-blinding effect, which is known to happen close to the Antarctica during the ascending passes and causes a very high peak in the mispointing values (ref. Figure 6 at around 23:57 UTC).
- Not Considering the effect of the sun blinding phenomenon, the mean difference between the mono-gyro mispointing values and the reference results lies around 0.01°-0.02° degrees (ref Figure 7). On the other hand, when the sun blinding effect is present, the difference gets bigger than 0.03°. This difference clearly depends on how big that effect is (ref Figure 6). These difference values were expected to be coherent with the ESOC attitude mispointing values. It is not the case. They are quite too low.

- In case of Fine Pointing Mode mono-gyro piloting, the difference is much higher than for any other situation (ref. Figure 5) with a median value for the difference of 0.09 degrees.

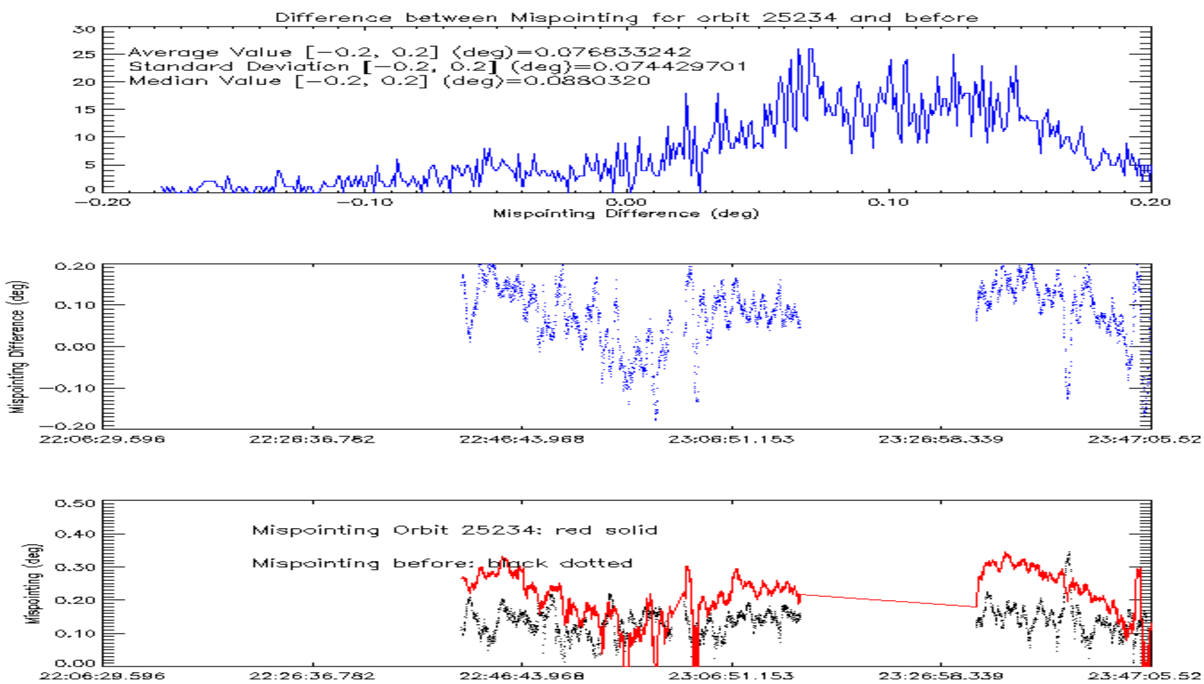

Figure 5: Mispointing results for orbit 25234 and comparison with reference trend (Fine Pointing Mode)

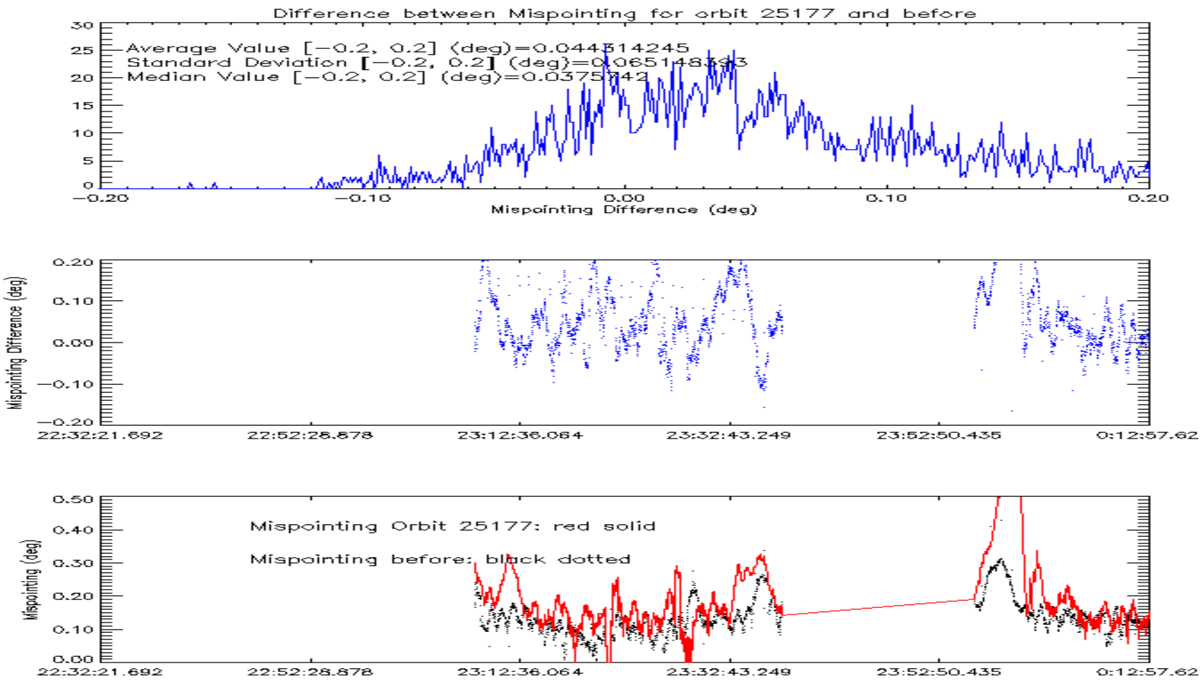

Figure 6: Mispointing results for orbit 25177 and comparison with reference trend

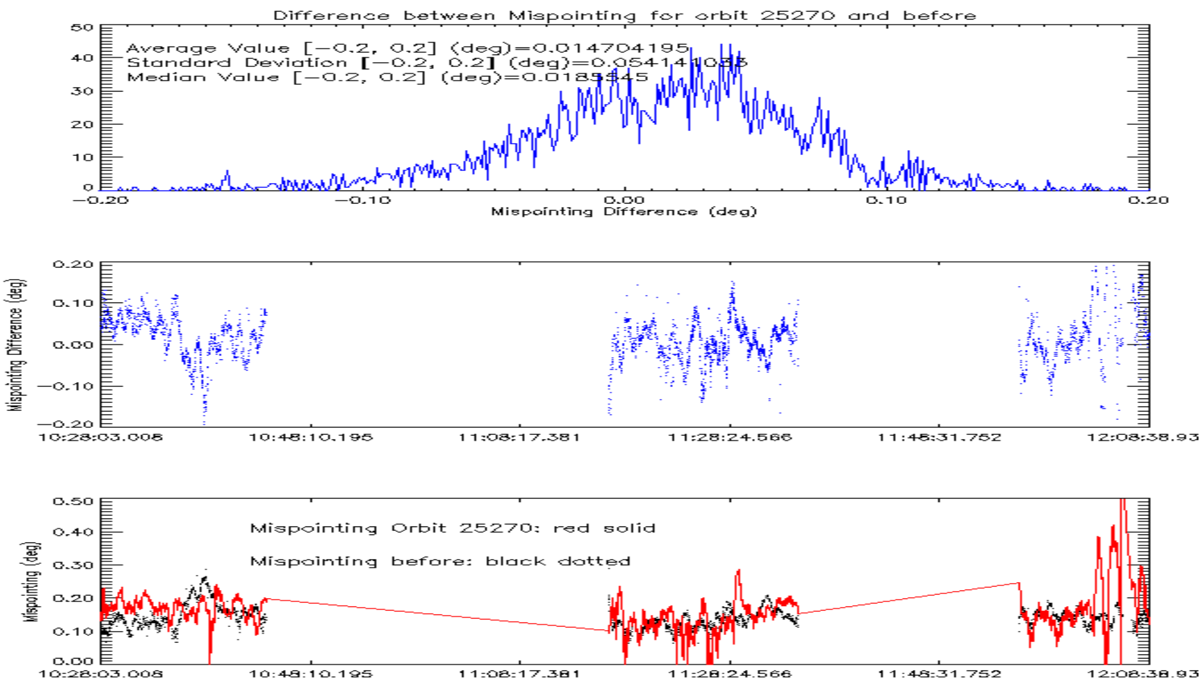

Figure 7: Mispointing results for orbit 25270 and comparison with reference trend

6.5 Mispointing trend analysis

In order to evaluate a more general mispointing orbital trend, an analysis has been performed over several orbits both before and during the AOCS mono-gyro Commissioning Phase.
Since a difference has been noticed in the mispointing trend over winter and summer periods as presented in a previous chapter; in the first instance, only the data sensed during the winter period have been selected and compared to the mono-gyro results. For each orbit the mispointing values time series starting from the ascending node have been calculated for N orbits and then averaged over N.

The AOCS campaign from an instrumental point of view can be seen in 2 phases:

- The first phase with the attitude being controlled with the Gyro 6. This phase lasted from mid-day on Thursday 10 February to the beginning of Wednesday 16 February 2000.
- The second phase with the piloting being performed using the Gyro 5. This phase started on Thursday 17 February 2000 in Yaw Steering mode (YSM) and is still going on.

These 2 different phases have been considered separately.

Mispointing mathematical law:

In order to describe the mispointing trend under a mathematical point of view, the first five harmonics of the averaged mispointing signals have been extracted. The smoothed mispointing behaviour along the orbit can be described with the formula hereafter reported; where $\omega_0=2\pi f_0$ and all the other parameters are given, for two periods of time, in the relative plots, Figure 8 and Figure 9.

It is worthwhile to note that the formula is valid only over certain periods of time. Over two zones along the orbit (when the satellite is flying over Arctic and Antarctica) there is no useful data for calculating the mispointing trend.

$t < t_0$

$$misp(t) = \sum_{i=0}^{4} A_i(0)\cos[\omega_0(t - t_0)] + \sum_{i=0}^{4} A_i(1)\sin[\omega_0(t - t_0)]$$

$t_1 < t < t_2$

$$misp(t) = \sum_{i=0}^{4} A_i(0)\cos[\omega_0(t - t_1 + t_0)] + \sum_{i=0}^{4} A_i(1)\sin[\omega_0(t - t_1 + t_0)]$$

$t > t_3$

$$misp(t) = \sum_{i=0}^{4} A_i(0)\cos[\omega_0(t - t_3 + t_2 - t_1 + t_0)] + \sum_{i=0}^{4} A_i(1)\sin[\omega_0(t - t_3 + t_2 - t_1 + t_0)]$$

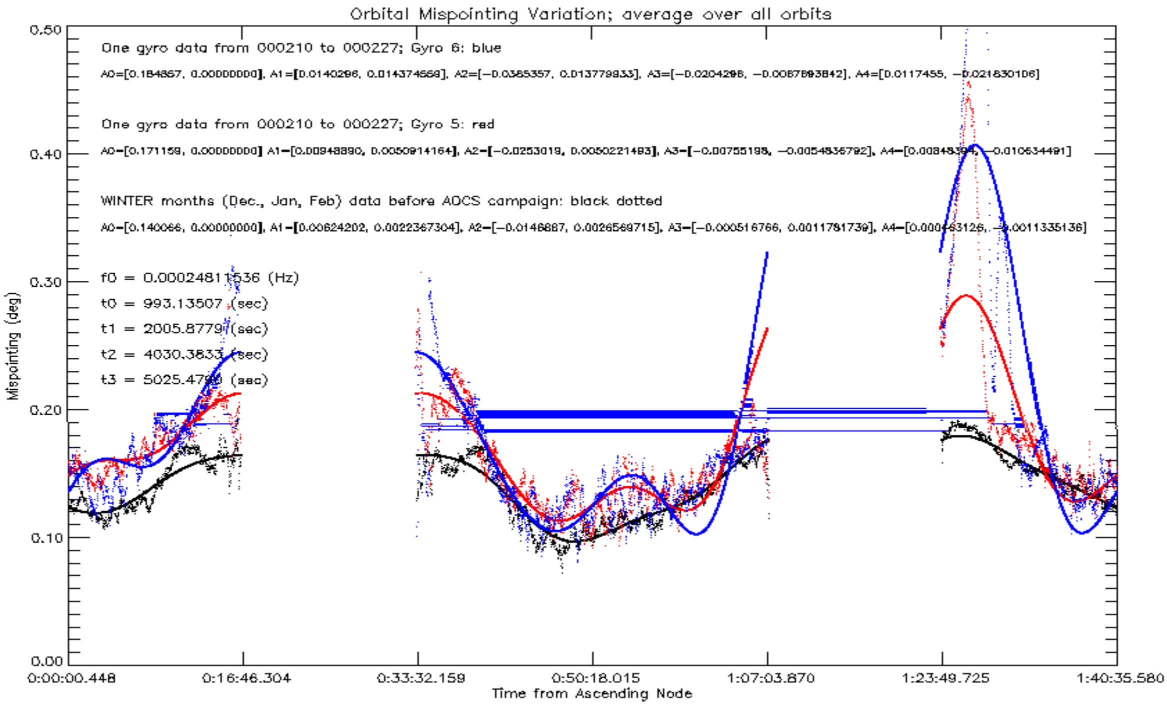

Figure 8: Mispointing trends and relative mathematical functions for the period 11 February to 27 February 2000, compared with the results obtained for winter data before the mono-gyro commissioning phase

From Figure 8, the following conclusions can be drawn:

- The three signals are coherent between themselves with a maximum close to the poles and a minimum close to the equator.
- The different mispointing mean values are the following:
    - Reference signal : 0.140 (deg)
    - Gyro 5 signal : 0.171 (deg)
    - Gyro 6 signal: 0.184 (deg)

Gyro 5 is performing better than Gyro 6 since the average distance from the reference winter results is lower.

- The sun blinding effect is easily noticeable at about 1:23 UTC from the ascending node, when the satellite is flying over the ascending pass departing from Antarctica.
- The biggest differences between the reference winter data and the mono-gyro ones are located close to the poles. No data are available above the North and South poles but we could expect from the curves trend a maximum difference at the poles or very close by.
- The average difference lies around 0.03° for Gyro 5 and is about 0.044° for Gyro 6. Those values are very much prejudiced by the sun blinding effect, which is causing a very high peak in the mono-gyro mispointing results.

In order to investigate the behaviour of the mono-gyro software without the influence of the sun blinding effect, data after the 1st

The analysis of Figure 9 suggests the following considerations:

- The sun blinding effect is no more detectable at around 1:23 UTC from Ascending Node.
- The different mispointing mean values are the following:
    - Reference signal : 0.140 (deg)
    - Gyro 5 signal : 0.156 (deg)

The two signals show a better agreement than in the sun-blinding period with still a maximum close to the poles and a minimum close to the equator.

- As observed in Figure 8 the biggest differences between the reference winter data and the mono-gyro results can be detected when the satellite is flying close to the Arctic and Antarctic Polar Circle (Ascending Node at the equator).
- The average difference for Gyro 5 is lower than in the previous case and lies around 0.016°.

For completeness, we also analysed the mispointing orbital behaviour during the summer months, choosing data recorded during the months of June, July and August in the years 1998 and 1999. Figure 10 reports the outcome of this exercise. The comparison with Figure 9 gives the following:

- The different mispointing mean values are the following:
    - Reference signal : 0.128 (deg)
    - Gyro 5 signal : 0.156 (deg)

The reference mispointing mean value is lower in the summer than in the winter, as already mentioned in chapter 4.1.

- The mispointing values during the summer periods are much lower when the satellite is flying along the first part of the ascending passes (just after the Ascending Node). This includes also the values in the zone over the Arctic Polar Circle.
- When the spacecraft flies over the Antarctic Polar Circle, during the summer periods, the mispointing presents higher values than during the winter.

The deviation of the mono-gyro results from the summer period trend is higher than the one obtained with the comparison with the winter periods. This is logical, as the month of March is closer to the winter season than to the summer one.

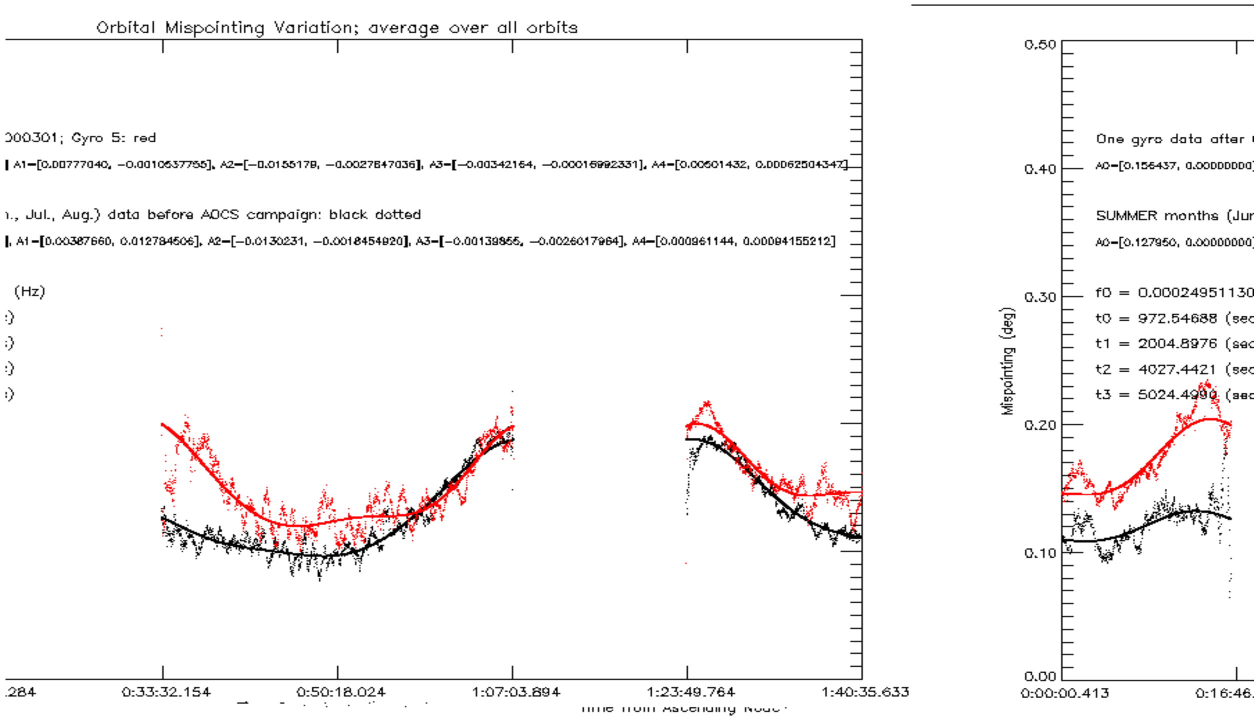

Figure 10: Mispointing trends and relative mathematical functions for the period 1 to 12 March 2000, compared with the results obtained for summer data before the mono-gyro commissioning phase

6.6 Estimated impact on RA parameters

With the aim to estimate the impact of the mispointing degradation caused by the mono-gyro spacecraft piloting software on the RA data quality, the results of the processing described in chapter 6.4 have been applied to the simulation performed by CLS [ref. R-4]. The simulation results are represented by formulas describing the three RA parameters (Sigma0, SWH and Range) variations in function of the mispointing squared.

From a qualitative point of view, the outcome of this exercise is coherent with the observed behaviour of the three parameters as reported in chapter 5. More precisely:

- The effects on the parameters are such that during the AOCS commissioning phase the sigma0 is lower than before and the range and SWH are higher.
- The mono-gyro spacecraft piloting with Gyro 6 causes a bigger discrepancy on the parameters with respect to the previous values than when piloting with Gyro 5.

Unfortunately, from a quantitative point of view, we were not able to find the same values.

7 GEOPHYSICAL ANALYSIS

The geophysical analysis of the impact of the AOCS mono-gyro software on the quality of the ERS Radar Altimeter data has been performed with the support of ECMWF. The analysis has been based on a comparison between the ECMWF analysis from the WAM model and the wind speed and wave height fields from the URA Fast Delivery (FD) products, disseminated to ECMWF as BUFR products. An analysis of the sigma0 extracted from the URA FD products has been performed too. An estimation based on simulation is given for the impact of the new mono-gyro software on the quality of the altimetric range.
The two figures here below 11 and 12 show the number of observations disseminated to ECMWF and their quality since September 1997. It can be seen that the dissemination has been degraded since the beginning of 2000 (not related to the AOCS mono-gyro software installation) whereas the data quality remains at the same level.

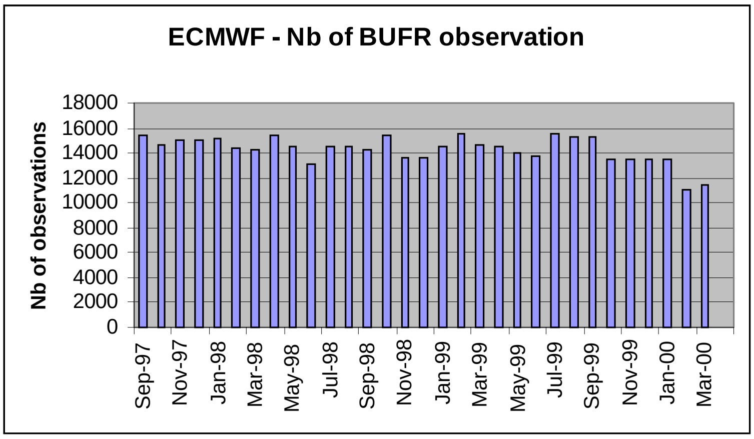

Figure 11: Number of observations arrived at ECMWF since September 1997.

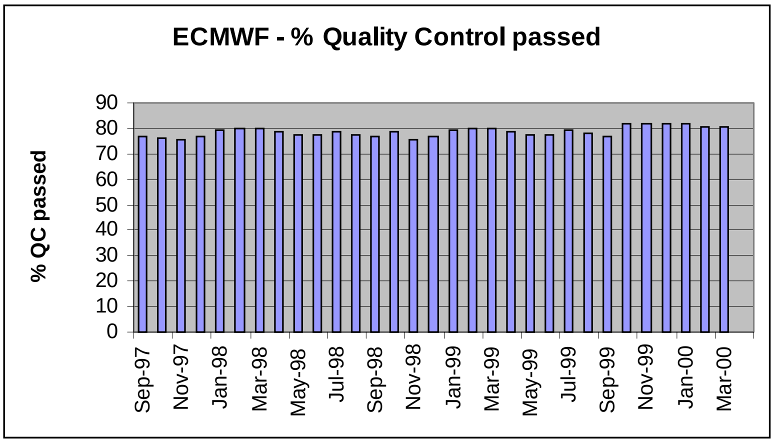

Figure 12: Percentage of observations arrived at ECMWF, which passed the Quality Control.

7.1 Significant Wave Height

Some figures from the ECMWF monthly analysis are given here below in table 1. They represent the difference calculated between the URA FD SWH monthly mean value and the ECMWF SWH one. These mean values have been obtained using the global monthly data set. Figure 14 shows the trend of this difference since September 1997. Figure 13 is an example of scatter plot (ERS/WAM wave heights) produced by ECMWF during the qualification period.

Month	Aug-99	Sep-99	Oct-99	Nov-99	Dec-99	Jan-00	Feb-00	Mar-00
SWH Diff (m)	0.02	0.02	0.006	0.008	-0.016	-0.013	-0.014	-0.022

Table 1: Monthly difference values between the URA FD SWH and the ECMWF SWH

We can see in Table 1, a slight change in the difference SWH ERS/WAM for the 2 months of October 1999 and December 1999 which maybe due to some improvements performed on the WAM model. On the other hand, it appears that the ERS-2 SWH values are not affected by the new mono-gyro software.
As a reminder, the AOCS mono-gyro has been installed early in February and the payload has been put back to operations with the gyroscope 6 operating on February 10 2000.

ECMWF also performed analysis of the SWH along the orbit. Their results confirm that no impact is visible on the RA SWH.
Based on results from simulation and presented in the document [R-9], CLS also confirms that the impact on the ERS-2 SWH is negligible.

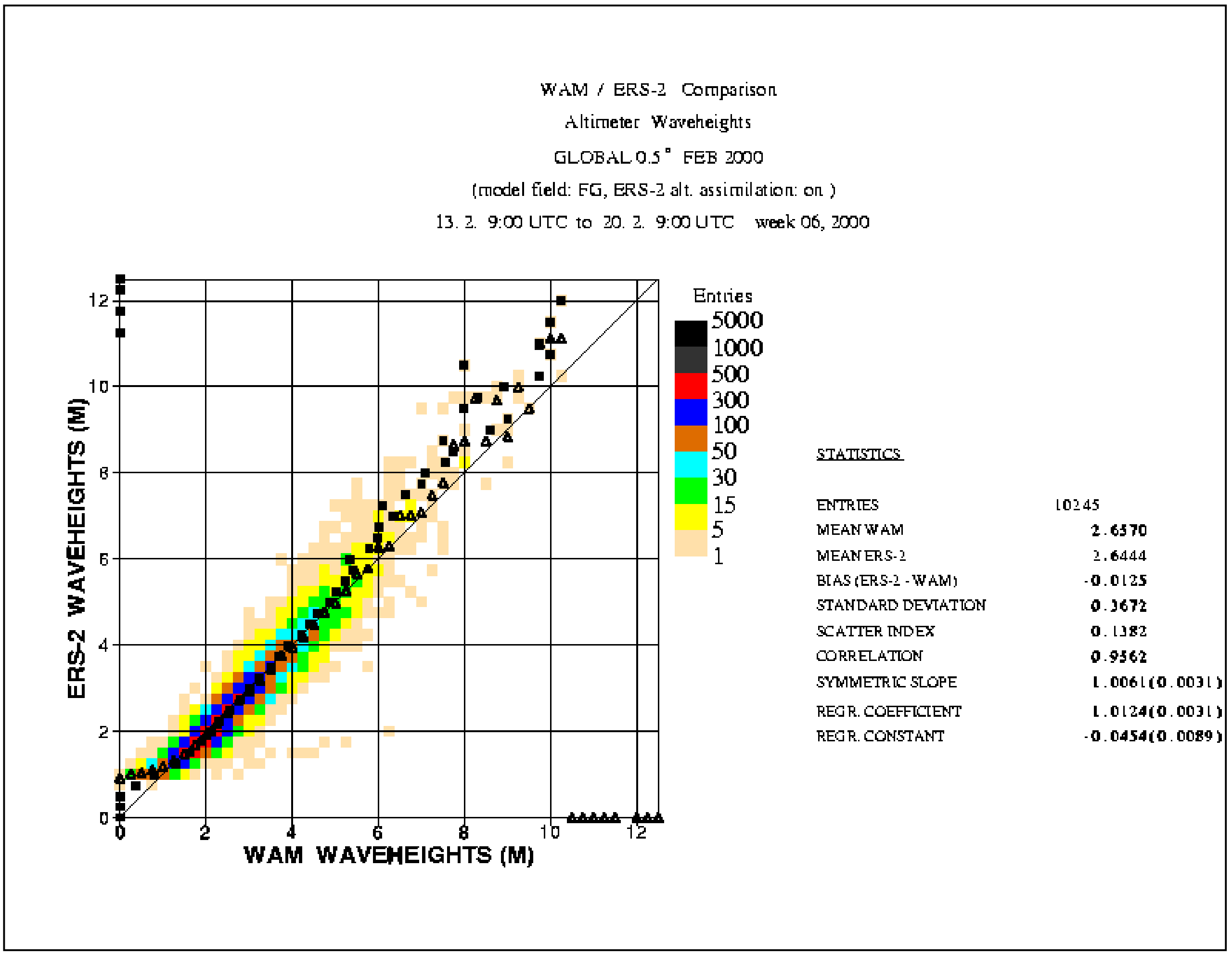

Figure 13: Scatter plot of the ERS SWH versus the ECMWF WAM SWH for the week from 13 to 20 February 2000.

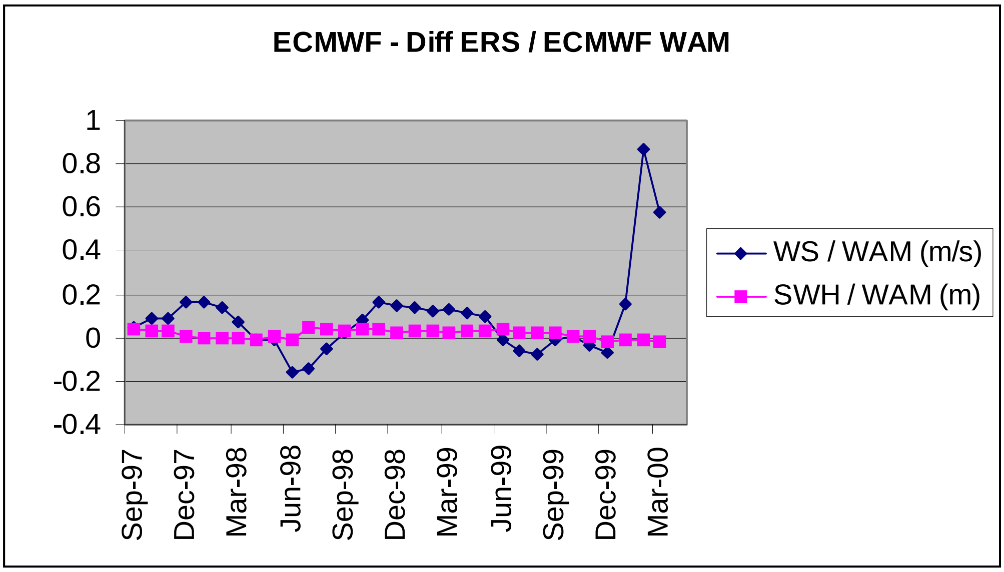

Figure 14: Trend of the difference between the ERS Wind Speed and SWH with the ECMWF WAM Wind Speed and SWH since September 1997. A departure from the apparent sigma0 trend is visible from the beginning of year 2000. This is partly due to an anomaly, which occurred on-board ERS-2 on January 16 2000 and to the impact of the new AOCS mono-gyro software.

7.2 Sigma0 / Wind Speed

In table 2, the values of the ECMWF monthly averaged sigma0 are given along with the difference calculated between the ERS Radar Altimeter Wind Speed values and the ones from the ECMWF WAM model. These mean values have been obtained using the global monthly data set. Figure 14 shows the trend of this Wind Speed difference since September 1997.

Month	Aug-99	Sep-99	Oct-99	Nov-99	Dec-99	Jan-00	Feb-00	Mar-00
Sigma0 (dB)	11.33	11.11	10.99	11.04	10.99	11.03	10.72	10.84
Wind Speed Diff (m/s)	-0.08	-0.01	0.007	-0.037	-0.069	0.156	0.865	0.58

Table 2: Monthly mean sigma0 values and monthly difference values between the URA FD Wind Speed and the ECMWF WAM Wind Speed.

Figure 15 shows the trend of the mean sigma0 values, calculated by ECMWF since September 1997. The deviation from the apparent trend is clearly visible starting from February 2000. Two phenomena, which explain this drop have been in fact more or less concomitant:

- The first event is an anomalous drop in the ERS-2 sigma0 values of about 0.2-0.3 dB. The anomaly occurred on January 16 2000 and was reported by ECMWF who noticed that the

Wind Speed data were degraded, noisy and showing a huge bias after this date. This is visible from the values in Table 2. Investigation on this anomaly is still going on.

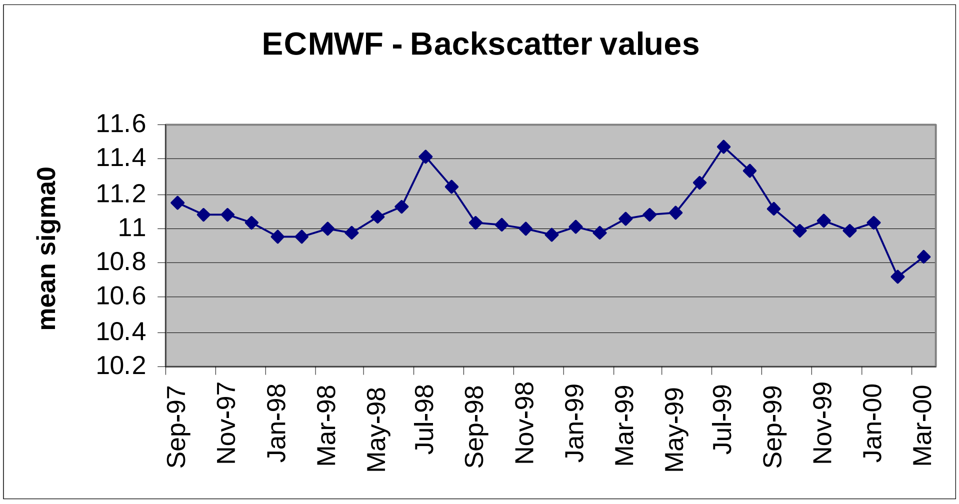

Figure 15: Trend of the ERS-2 RA sigma0 values, from ECMWF monthly report.

- The second event is clearly the AOCS mono-gyro software installation and its impact on the backscatter coefficient. This is shown in Figure 16. The impact of the 3 different configurations (gyro 6, FPM, gyro 5) on the sigma0 values are clearly visible in Figure 16 with a mean value around 10.9 dB with the gyroscope 6 and a mean value of 11 dB with the gyroscope 5. The less accurate pointing of the configuration FPM even shows lower backscatter values, as expected. A circle in Figure 16 identifies the data related to this attitude configuration.

It has also to be noted that the qualification period coincided with a special configuration earth-sun-satellite generating a sun blinding effect of the Digital Sun Sensor (DSS) when coming from the South Pole, i.e. impacting the attitude accuracy for the ascending tracks only. This is noticeable on the along track analysis performed by ECMWF (Figure 18). An abrupt increase of the ERS wind speed values of about 8-9 m/s appears around 50 degree South latitude when compared to the ECMWF WAM data. This phenomenon did impact the attitude control of the platform during all the qualification period and as a consequence did also impact the quality of the acquired data till March 3, 2000 which corresponds to the end of the sun-blinding effect period.

In order to determine the real effect of the new attitude software, it is therefore necessary to consider the Sigma0 values after March 3, 2000. After that date, the sigma0 value came back to a higher mean value of 11.1 dB (see Figure 18) which is 0.1 dB below the mean value of the backscatter coefficient after the 16 January drop.

The above results show that:

- There is an impact of the AOCS mono-gyroscope software on the backscatter coefficient of the Radar Altimeter (small decrease of 0.1 dB) and therefore on the wind speed (rough increase of 20-30 cm/s). See Figure 17.
- The gyroscope number 6 is less stable or reliable than the gyroscope number 5 as already stated in chapter 4.5.
- The mono-gyro attitude control accuracy is largely sensitive to the sun blinding effect (this effect was not visible before when using 3 gyroscopes, as the DES values were less preponderant in the attitude control system). It would be therefore recommended during this kind of events to go back to 3 gyroscopes.

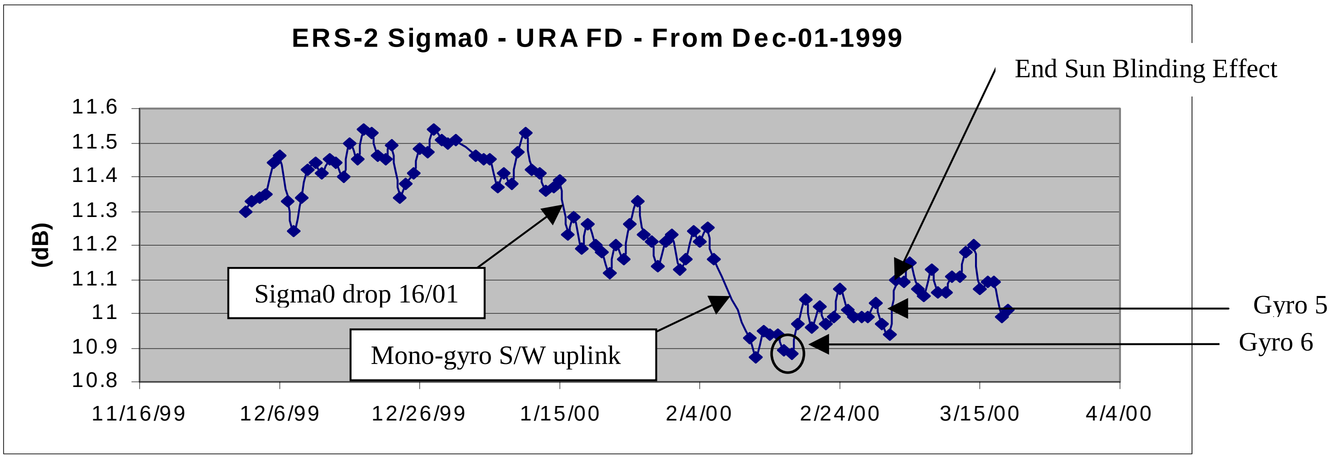

Figure 16: URA FD Sigma0 daily mean values since December 1 1999 (processed in ESRIN)

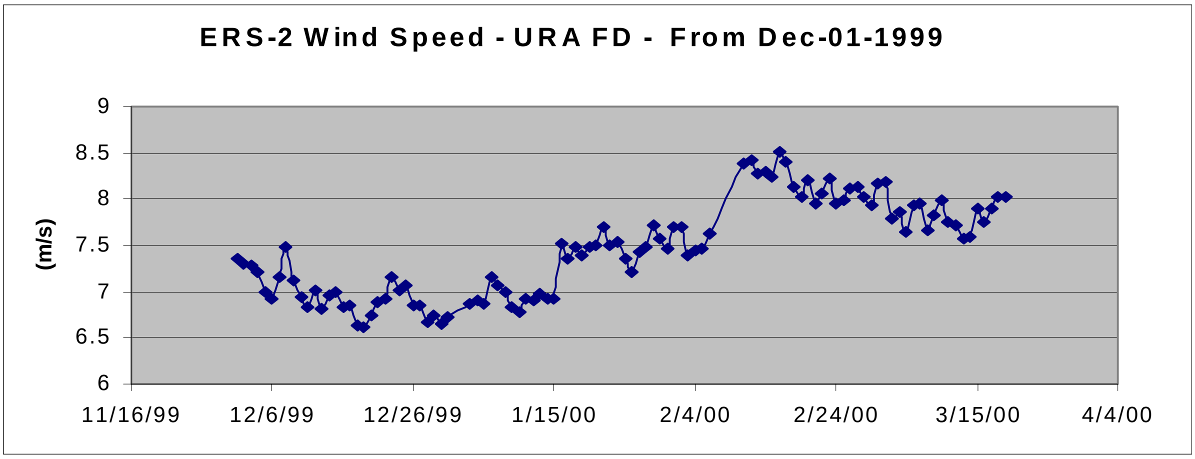

Figure 17: URA FD Wind Speed daily mean values since December 1 1999 (processed in ESRIN)

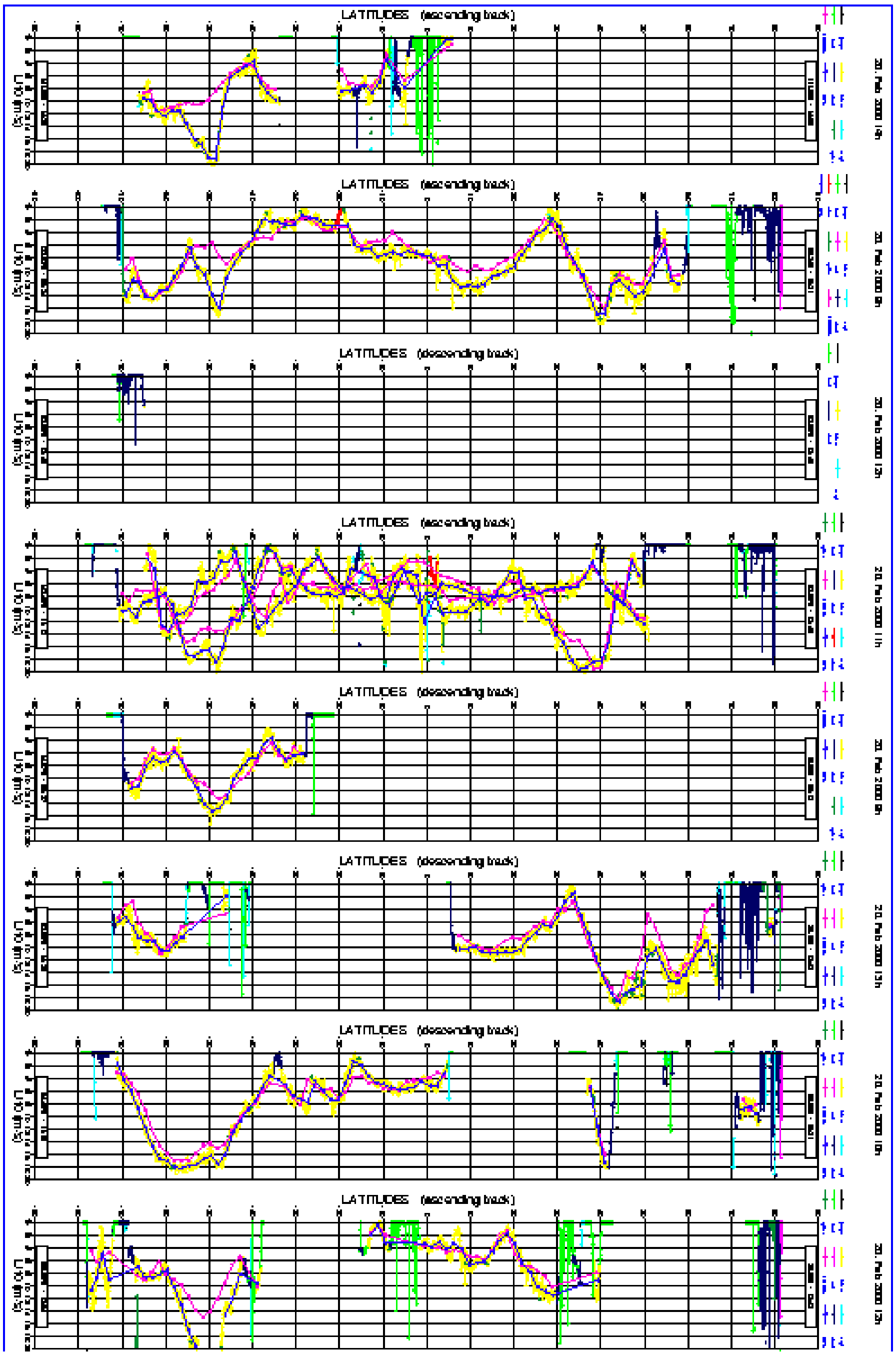

Figure 18: ECMWF along track Wind Speed analysis. An increase of the ERS Wind Speed compared to the ECMWF WAM values is clearly visible about -50 degrees latitude for the ascending tracks. This is due to the so-called sun blinding effect.

7.3 Altimetric Range

The impact of the mono-gyro attitude software on the altimetric Range has only been estimated by simulation. This result is given in a CLS report computed from the maximum mispointing information of the ESOC attitude files. During the commissioning phase, the mispointing (from the attitude files) showed high variations with high values up to 0.44 degrees. The error induced on the altimetric range for such a value is a delta range of 3.6 cm for a mean SWH of 2m.

8 SUMMARY AND DISCUSSION

The analysis of the Radar Altimeter data during the Commissioning Phase of the mono-gyro attitude software showed the following:

- No on-ground processing problem has been noticed. This means that the ESA processing chains are able to handle the RA waveforms even if slightly 'corrupted' by an apparent platform-mispointing angle.

- The behaviour of the gyroscope number 5 is more stable and reliable than the gyroscope number 6. It is therefore recommended to keep on using the number 5.

- The new AOCS mono-gyro software is very sensitive to the sun-blinding effect. It is therefore highly recommended, during these events, to go back to 3 gyroscopes to ensure the data quality.

- The difference between the retrieved mispointing values obtained before and after the AOCS qualification period lies around 0.016 degrees for data not affected by the sun-blinding effect. The simulated impact of such mispointing angle on the RA sigma0 parameter is quite lower compared to what we observe from the data.

- The retrieved mispointing values are affected by an error, which is inversely proportional to the mispointing value. Lower the platform-mispointing angle, higher the error on the measurement. The obtained results lie anyway within the error range, based on the accuracy of both the IF filter and of the antenna beam width, which lead to a pointing angle between 0 and 0.15 degrees (see [R-8]).

- The analysis of the retrieved mispointing trend from the RA waveforms shows an annual signal with the maximum in the winter period. The analysis of the round-orbit mispointing values also shows a maximum value at the poles and a minimum value at the equator. For the later, the accuracy of the YSM could be suspected.

- The IF filter shape used today in the ERS OPR processing chain needs to be updated and the past ERS-1 and ERS-2 data corrected to fit with the evolution of these characterisation values.

The evolution of the ERS-1 IF filter along the years has not been yet confirmed but is highly suspected.

- No impact of the new attitude software is visible on the ERS-2 RA Significant Wave Height.

- The new attitude software induces a mean sigma0 drop of 0.1 dB. This correspond to an increase in the ERS Wind Speed of about 20-30 cm/s.

- Based on the ESOC attitude files, the maximum impact on the altimetric range would correspond from simulation to a delta range of 3.6 cm. This maximum value is not negligible but can be considered as acceptable.

- New and valid ESOC/Flight Dynamics attitude files are expected to be received nominally at ESRIN to correct the errors induced in the altimetric parameters. The ESA processing chain would then be upgraded with a corrective algorithm already developed (See [R-4]).