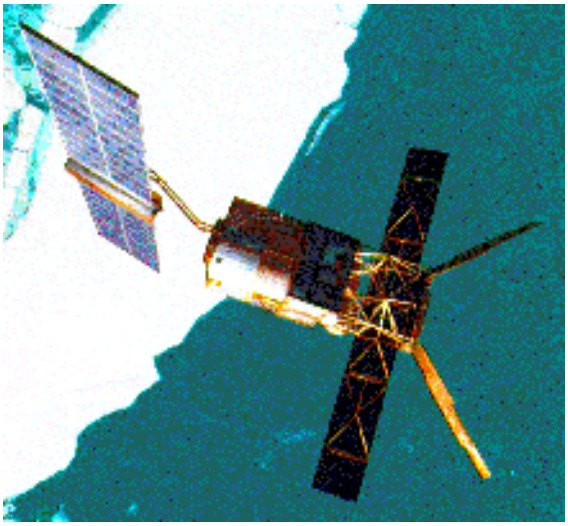
ERS-2 Radar Altimeter Cyclic Report

from 19th March to 23rd April 2001
Cycle 62



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Issue:	1.0
Reference:	ERE-TN-ADQ-ALT-0002
Date of Issue:	02/05/2001
Status:	Approved
Document type:	Technical Note
Approved by:	Pascal Lecomte

Distribution List

This report is available in PDF format at the internet address: http://pcswww.esrin.esa.it/ra

Acronyms

AGC	Automatic Gain Control
DSR	Data Set Record
EBM	Extra Backup Mode
HTL	Height Tracking Loop
IF	Intermediate Frequency
LUT	Look Up Table
MPH	Main Product Header
PCS	Products Control Service
PTR	Point Target Response
RA	Radar Altimeter
SPH	Specific Product header
SPSA	Signal Processing Sub-Assembly
SPTR	Scanning Point Target Response
USO	Ultra Stable Oscillator

1.0 Introduction and summary

This document reports on the performances of the ERS-2 RA during nominal operations and on the quality of the RA fast delivery products (URA) in the period between the 19th of March and the 23rd of April 2001, corresponding to cycle 62.

The document will report only the outcome of the several quality assessment procedures performed during the period under discussion. For a description of the methods used and for a more detailed description of the different instrument sub-systems under study, the reader should refer to "ERS-2 Radar Altimeter performance monitoring, Theoretical Background", ref. APP-ADQ/PCS/RA01-002, available at http://pcswww.esrin.esa.it/ra.

The results reported in each section concern, apart from a summary of the daily quality control made within the PCS, an explanation of the major events that have impacted the performance during the last cycles.

The AGC values suffered of a clear spreading in the period between the 5th and the 13th of February 2001. This is the consequence of the up-loading of non correct on-board parameters as described in par. 4.5 of the "ERS-2 Radar Altimeter Cyclic Report for cycle 61, ref. APP-ADQ/PCS/RA01-003". After the recovery the AGC trend remained stable within the error due to the nominal variability. (ref. par 2.1.1)

For the period covering cycle 62 the instrument was unavailable during one period of time (ref. par. 3.2.2), in relation to this, a jump in the HTL trend is easy to notice at the end of the time series. (ref. par 2.1.2)

With the contribution of the measurements recorded up to cycle 62 the USO drift slope has changed value to 6.8 mm/year, for the data after the 28th of November 1998. This due to the fact that few measurements during cycle 61 were distributed quite far from the typical trend as from November 1998. The measurements acquired during cycle 62 are located closer to the overall trend causing the general drift slope to assume a value very similar to the one recorded until cycle 60. (ref. par. 2.2)

During cycle 62, the unavailability of the Radar Altimeter is visible at the end of the SPTR correction plot as a jump. (ref. par. 2.3)

Since the 5th of February, when the instrument was switched on after the long unavailability period, the Tracking Performance results to be very degraded. During the first days after the recovery the Acquisition Percentage was assuming average values of about 2.4%. Throughout the whole cycle 61 and 62 extent, the Acquisition Percentage has been following a very slow decreasing trend until to arrive at a figure very close to the 1.5% it assumed before the January unavailability. (ref. par. 3.1)

During cycle 62 all the instrument internal parameters maintained a stable behaviour preserving the values they had at the end of cycle 61. For the temperature parameters, that value was ~1° lower than the one recorded previous the long anomaly occurred in January 2001. (ref. 3.2)

The IF Filter Shape was monitored during cycles 62. The difference of the IF Filter Shape with reference to the beginning of the mission was limited to ca. 0.04 dBs, where the highest difference

average and standard deviation values occurred after the 1st of April 2001 instrument anomaly. (ref. par. 3.3)

Starting from cycle 61, because of the implementation of a new piloting scheme called Extra Backup, Mode (ref. par. 4.5) more data were available in operational mode, allowing ESRIN/PCS to perform a discriminated analysis for ascending and descending tracks. The overall mispointing time series, considering both ascending and descending tracks results, lies around a value of 0.089°. The last increase, occurred after the 17th of January 2001 when the Extra Backup Mode Started to be operational, with a value of about 0.02° resulted to be the most significant. Nevertheless, the software change performed on the 30th of March 2001; which upgraded the Extra Backup Mode to geocentric pointing; led to a substantial decrease of the mispointing value to a figure comparable to the ones measured before for the Mono-Gyro Piloting. On the other hand, because of all the uncertainties present in the mispointing retrieval algorithm, the retrieved figures over the whole mission could be considered assuming values from 0° to 0.15°. (ref. par. 3.4)

The fast delivery products performance during cycle 62 was reasonably good. The significant percentage of missing products was mostly due to the anomaly occurred at the beginning of April 2001. The significant percentage of blank products was both due to a few acquisition problems occurred and to the acquisition over ocean operation mode events. Those last have been decreasing in number during the first period of cycle 62 until they disappeared after the first few days in April 2001. The performance of the geophysical parameters have been slowly improving during the whole cycle; none of the out of range event was recorded for either Wind Speed and SWH while the once occurred for Sigma_0 and Peakiness were due to Sea Ice presence. (ref. par. 4.2 and 4.3)

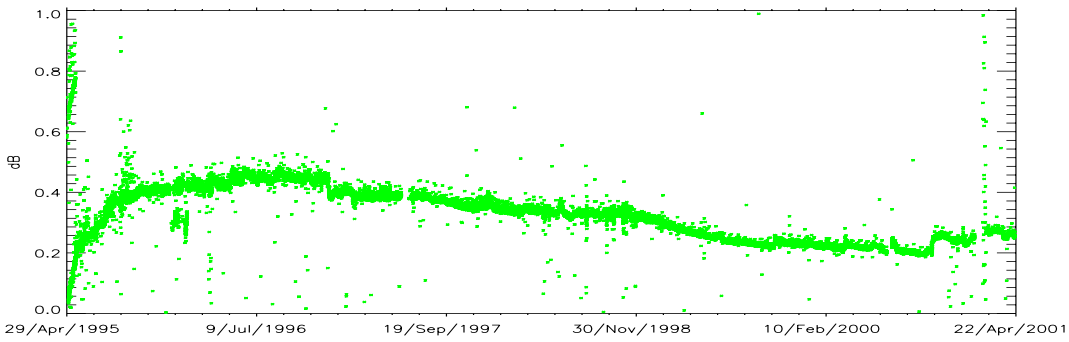
2.0 Calibration Performances

In this paragraph the performance of the different internal calibration procedures for the Radar Altimeter will be described. For the theoretical background and the instrument description related to the subject, the reader should refer to chapter 2 of the document: “ERS-2 Radar Altimeter Cyclic Report, Theoretical background”, APP-ADQ/PCS/RA01-002 available at http://pcswww.esrin.esa.it/ra.

2.1 Openloop Calibration

2.1.1 Automatic Gain Control (AGC)

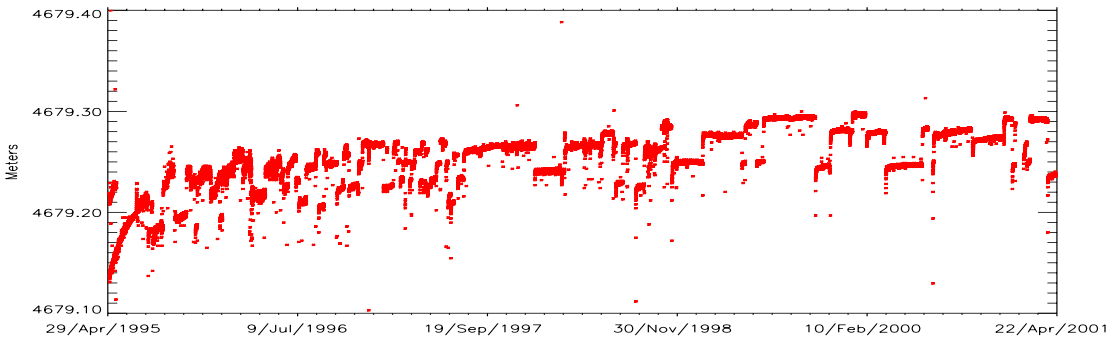
The AGC Openloop Calibration trend since the beginning of the mission is plotted in the following picture. Every value represents the average over one orbit; this hides the orbital variations in the AGC values, which otherwise would be clear. The increasing pattern at the beginning corresponds to the commissioning phase. The decreasing pattern covering the last few years can be related to instrumental ageing. In correspondence of the anomaly occurred on the 7th of October (ref. par. 3.2.2, APP-ADQ/PCS/RA00-008, “ERS-2 RA Cyclic Report for Cycles 57 and 58”) a small increase of the AGC values is noticeable. The AGC values just after the recovery from the anomaly were about 0.05 dBs higher than the previous trend while this difference was reduced to 0.02 dBs at the end of cycle 58. Because of these small values, the AGC variation occurred should not have had a very big impact in the backscattering quantity measured by the Radar Altimeter. Anyway the problem has been investigated in detail and no impact has been found on the sigma_0. Indeed an equivalent but opposite variation has been detected in the internal gain settings which the AGC calibration loop has to compensate for. On the other hand, since the 5th and until the 13th of February 2001, a clear spreading of the values is evident in the plot. This is the consequence of the up-loading of non correct on-board parameters as described in par. 4.5 of the “ERS-2 Radar Altimeter Cyclic Report for cycle 61, ref. APP-ADQ/PCS/RA01-003”. After the recovery the AGC trend remained stable within the error due to the nominal variability.



OPEN LOOP AGC CALIBRATION CORRECTION
ERS–2 RADAR ALTIMETER
From 29–APR–1995 to 23–APR–2001

2.1.2 Height Tracking Loop (HTL)

The HTL Openloop Calibration trend since the beginning of the mission is plotted in the following picture. Every value represents the average over one orbit; this hides the orbital variations in the HTL values, which otherwise would be clear. The overall increasing pattern is easy to notice, being the first part related to the commissioning phase. It is superimposed to sudden variations (jumps) of the values in correspondence to instrument anomalies. For the period covering cycle 62 the instrument was unavailable during one period of time (ref. par. 3.2.2), in relation to this, a jump in the HTL trend is easy to notice at the end of the time series.



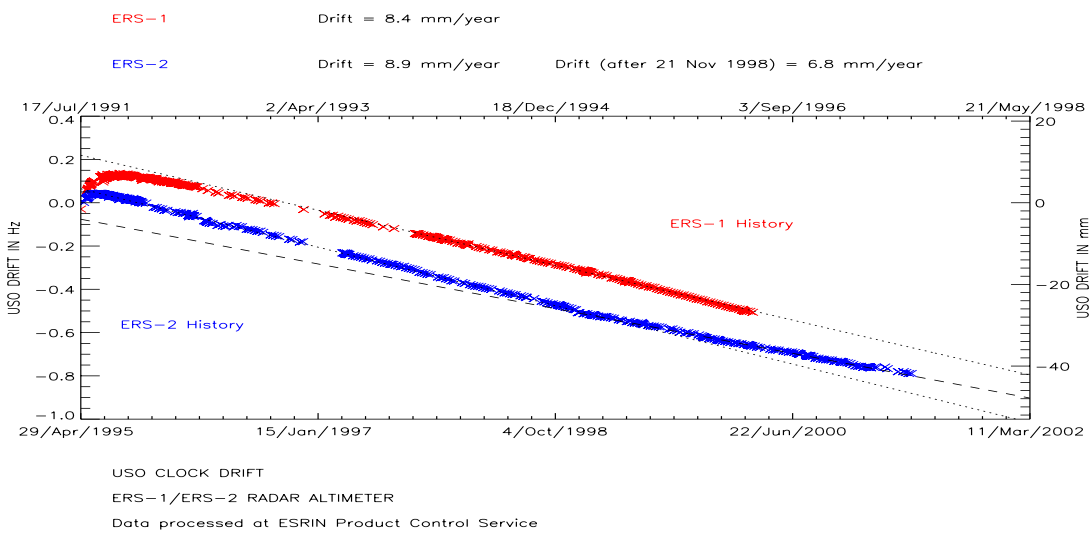
OPEN LOOP HTL CALIBRATION CORRECTION
ERS−2 RADAR ALTIMETER
From 29−APR−1995 to 23−APR−2001

2.2 Ultra Stable Oscillator (USO)

The following picture shows the USO measurements trend since the beginning of the mission. It has to be noticed that during the last period, the Ultra Stable Oscillator drift measurements slope tend to be lower than it was before (smaller negative value). Since the beginning of the year 1999 the values of the USO frequency are likely to follow a different trend respect to whet they did before that date. Since cycle 46 we had noticed that the amount of values following that different trend was big enough to cause the overall drift passing from a negative value of 8.9 mm/year to a negative value of 8.7 mm/year. After specific investigations it has been found that since November the 21st 1998 the slope had assumed a value of 7.1 mm/year until cycle 53 and has been continuing to increase until a value of 6.9 mm/year at the end of cycle 60. This fact cannot be correlated to a particular event regarding the instrument itself; the explanation could be a high amount of magnetic or X rays in the space outside the spacecraft which often cause a frequency change in this kind of devices. Anyway this does not introduce further errors in the Radar Altimeter measurements, being the USO frequency regularly measured and the appropriated correction evaluated.

With the contribution of the measurements recorded up to cycle 62 the USO drift slope has changed value to 6.8 mm/year, for the data after the 28th of November 1998. This due to the fact that few measurements during cycle 61 were distributed quite far from the typical trend as from November 1998. The measurements acquired during cycle 62 are located closer to the overall

trend causing the general drift slope to assume a value very similar to the one recorded until cycle 60.

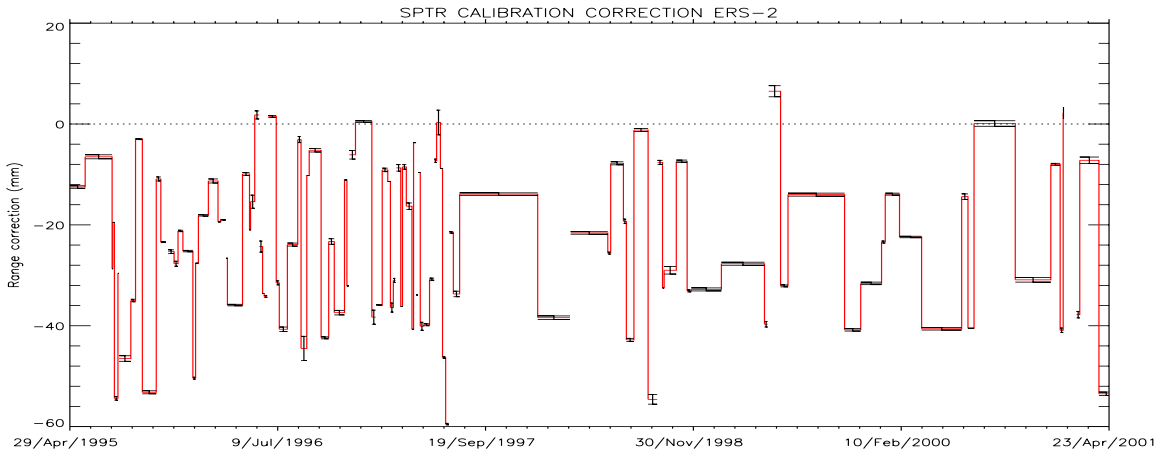


2.3 Scanning Point Target Response (SPTR)

The SPTR correction values history is reported in the following picture (the black lines on both the side of each value represent the relative standard deviation) showing clearly the jumps in correspondence to the instrument anomalies. It is worthwhile to notice in the plot that the jumps in the SPTR correction value are much less frequent after the summer 1997. This is related to a patch in the on-board software performed on July the 14th 1997, aimed to reduce the frequency of occurrence of the most common anomaly for the Radar Altimeter. That anomaly is denominated “Memory Checksum Violation” and consists in the change of a bit’s value in the internal memory due to casual electric discharge. The black straight line plotted around each correction represent the standard deviation related to each correction. The period of time for which no correction is plotted are the ones for which no correction could be calculated due to missing measurements in SPTR Calibration Mode.

The SPTR calibration correction has been operationally evaluated for the users to correct the range data, since the beginning of the mission. However, new algorithm was developed and implemented during the year 2000 and on the 15th of December it was rendered operational. For this reason, since then an upgraded SPTR correction value is operationally available for the users at the following address: http://pcswww.esrin.esa.it/ra. An overview of the algorithm and the outcome of the validation process preformed on the results are available at the same URL in the document: ERE-TN-ADQ-GSO-6001.

During cycle 62, the unavailability of the Radar Altimeter is visible at the end of the SPTR correction plot as a jump.



SPTR CALIBRATION RANGE CORRECTION ERS−2 RADAR ALTIMETER
From 29−Apr−1995 to 23−Apr−2001
Data processed by the ESRIN Product Control Service

3.0 Instrument performance

In this paragraph the results of the Radar Altimeter instrument performance monitoring assessment will be described. For the theoretical background and the instrument description related to the subject, the reader should refer to chapter 3 of the document: “ERS-2 Radar Altimeter Cyclic Report, Theoretical background”, APP-ADQ/PCS/RA01-002 available at http://pcswww.esrin.esa.it/ra.

3.1 Acquisition Percentage

The amount of ocean products in Acquisition and Tracking Modes for cycle 62 are reported in the second plot hereafter together with the percentage of products in Acquisition Mode respect to the total.

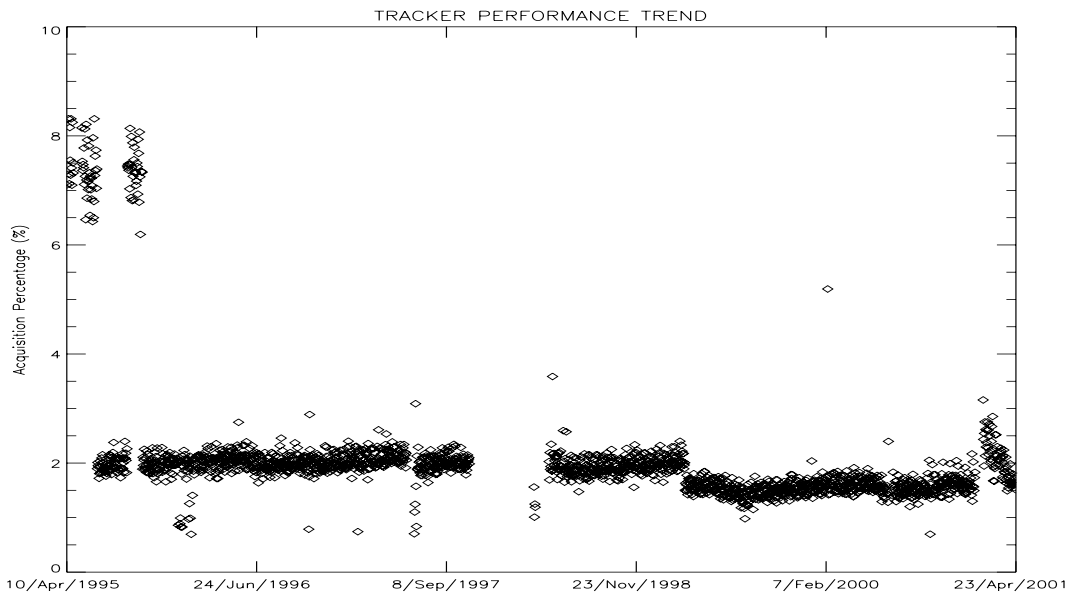
DAY	ACQUISITION Number	TRACKING Number	ACQUISITION Percentage(%)
19-MAR-2001	1231	54198	2.220
20-MAR-2001	1086	63108	1.691
21-MAR-2001	1289	59939	2.105
22-MAR-2001	1028	57941	1.743
23-MAR-2001	1294	59418	2.131
24-MAR-2001	1189	58177	2.002
25-MAR-2001	1195	52169	2.239
26-MAR-2001	1103	58883	1.838
27-MAR-2001	1169	62984	1.822
28-MAR-2001	1133	58895	1.887
29-MAR-2001	1016	58939	1.694
30-MAR-2001	1274	59145	2.108
31-MAR-2001	1003	60464	1.631
01-APR-2001	923	46832	1.932
02-APR-2001	691	45639	1.491
03-APR-2001	1141	60427	1.853
04-APR-2001	1003	56430	1.746
05-APR-2001	992	63335	1.542
06-APR-2001	1130	60446	1.835
07-APR-2001	944	57875	1.604
08-APR-2001	1074	63844	1.654
09-APR-2001	1181	58306	1.985
10-APR-2001	1013	60642	1.643
11-APR-2001	983	59261	1.631
12-APR-2001	1121	62873	1.751
13-APR-2001	969	59515	1.602
14-APR-2001	951	59120	1.583
15-APR-2001	1158	63152	1.800
16-APR-2001	1001	60238	1.634
17-APR-2001	960	58947	1.602
18-APR-2001	1058	63167	1.647
19-APR-2001	1065	60559	1.728
20-APR-2001	967	58612	1.623
21-APR-2001	976	63431	1.515
22-APR-2001	1084	60662	1.755

TRACKER PERFORMANCE
ERS-2 RADAR ALTIMETER/CYCLE 62
From 19-Mar-2001 to 23-Apr-2001

For the period until the 17th of January, the percentage of products in Acquisition Mode follows the same trend as for all the previous cycles since number 41. The values of that parameter during cycle 40 and all the previous ones, were, in average, lying around 1.95%; for cycle 41 and the following ones the values lye around 1.5%. This was due to the change of the Ice/Ocean mask used for the Radar Altimeter operations, mentioned more in detail in the chapter dedicated to the Instrument Mode, avoiding the instrument to often switch to Acquisition Mode when flying over costal zones. The decrease of Acquisition Mode percentage starting from cycle 41, can be noticed also in the Tracking Performance Trend plotted just behind, since the beginning of the mission. Here the two burst of higher values close to the beginning are relative to periods when the internal parameters have been manually changed for tests.

On the other hand, since the 5th of February, when the instrument was switched on after the long unavailability period, the Tracking Performance results to be very degraded. During the first days

after the recovery the Acquisition Percentage was assuming average value of about 2.4%. All this is most due to the piloting scheme used for the attitude control since those days (Extra Backup Mode) and the effects of a contemporary astronomical event called “Sun Blinding”. The combination of those two events, which are anyway correlated to each others, had, the effect to degrade the attitude control of the platform. The degradation of the attitude control is such that the RA antenna experiences a big off-nadir pointing and consequently the on-board tracker cannot “maintain the lock” with the received signal. Throughout the whole cycle 61 and 62 extent, the Acquisition Percentage has been following a very slow decreasing trend until to arrive at a figure very close to the 1.5% it assumed before the January unavailability. During the last period of cycle 62, the astronomical conditions of the earth respect to the sun have been slowly changing in a way that the Sun-Blinding events are not occurring any more. Furthermore, the piloting software has been upgraded in such a way that the pointing performance results much improved (ref. par 3.4 for off-nadir pointing, par. 4.3 for Instrument Mode, par. 4.5 EBM).



3.2 Internal Instrument Parameters

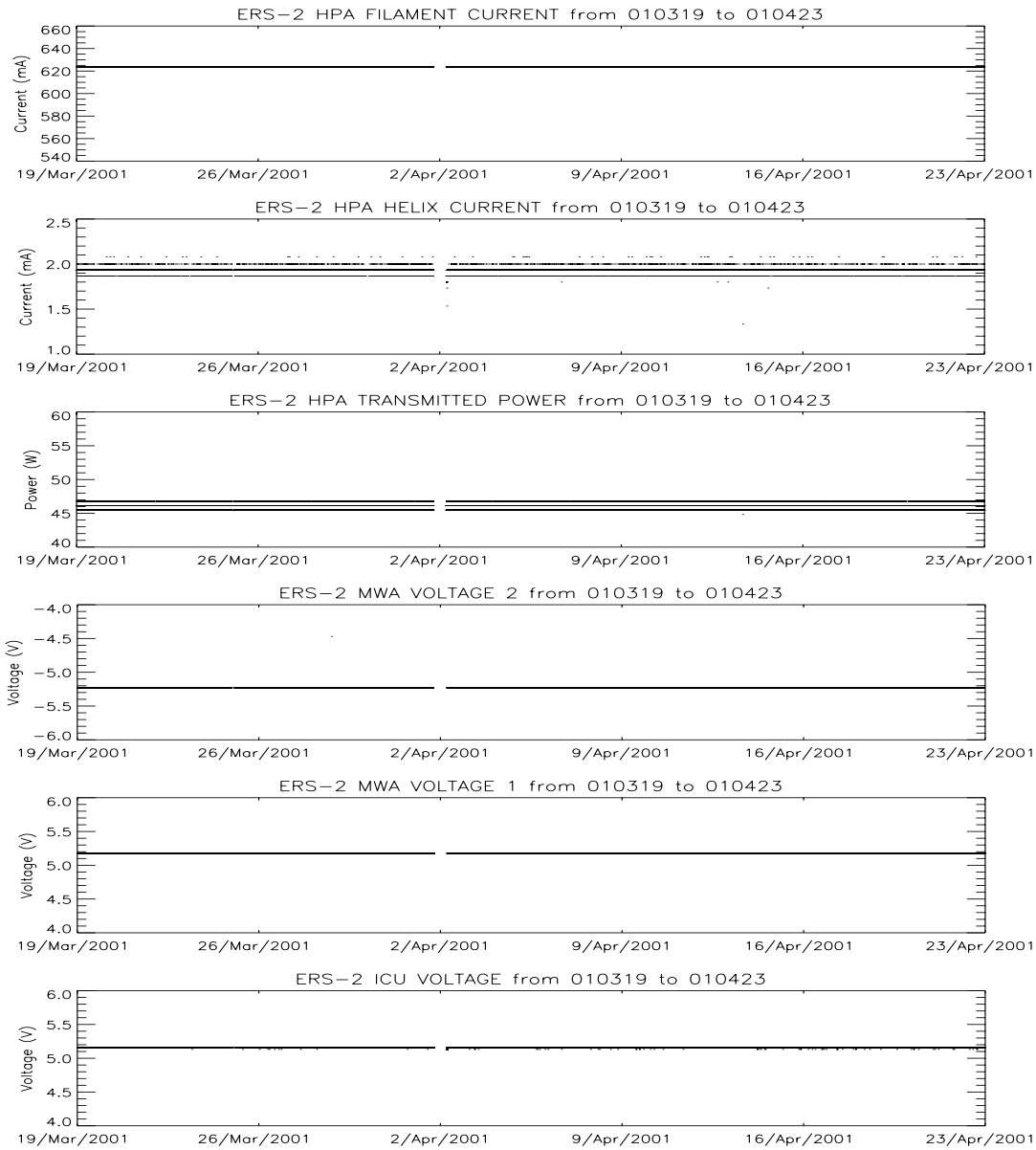
3.2.1 Internal Instrument Parameters Trends

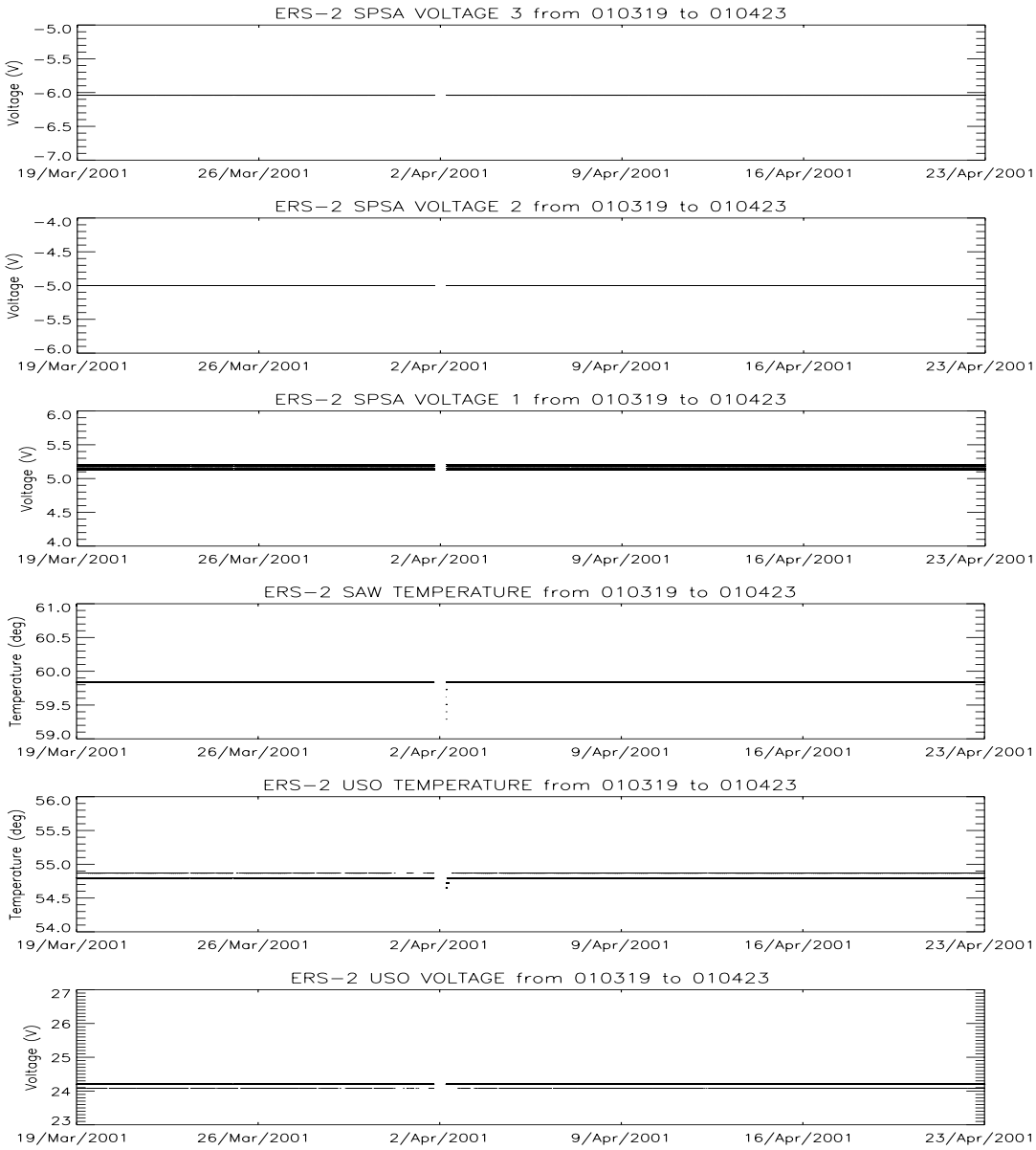
The internal instrument parameters can be subdivided into two categories:

- Parameters not influenced by the temperature outside the instrument thus not presenting variations synchronous with the orbit. They are plotted in the following pictures where all the values (one every 16 seconds) are displayed and the discrimination due to the quantization is easy to notice.

  Considering the whole mission time extent, the trend of most of the parameters appears to be quite stable. The only parameters showing variations are the HPA Transmitted Power and the Helix Current. The two parameters had been following a very slow decreasing trend since the beginning of the mission until cycle 37 (November 1998) when the decreasing became slightly more important. Since cycle 45 (August 1999) the Helix Current trend started slowly to increase while the decreasing of the HPA Transmitted Power became again less noticeable. Those variations are so slow that they are not detectable in one or two cycles time scale.

On the other hand, an anomalous event occurred at the beginning of July 2000 caused a small but abrupt change on several of the parameters hereafter reported. Among them the HPA Transmitted Power, for example, has recorded a decreased of about 0.5 W. During cycle 62 all the parameters maintained a stable behaviour.



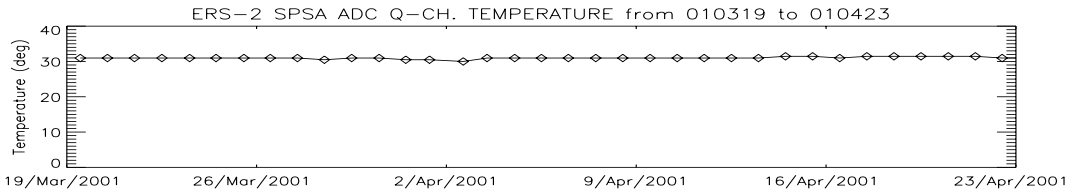


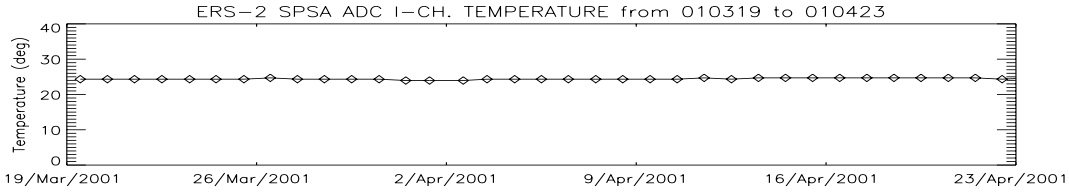
- Parameters influenced by the temperature outside the instrument thus presenting variations synchronous with the orbit. They are displayed in the following pictures after the daily mean has been calculated.

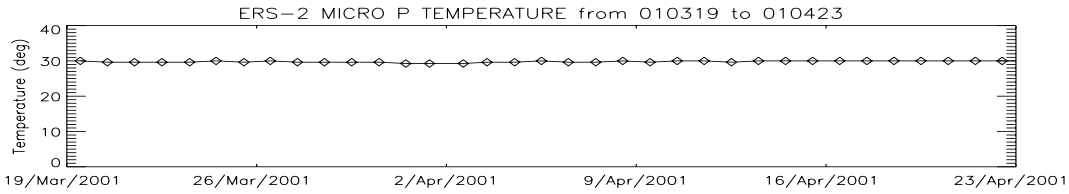
  In general, within few cycles time extent, the trends for all the parameters are quite stable; the most of them even maintain the same value during the whole period.

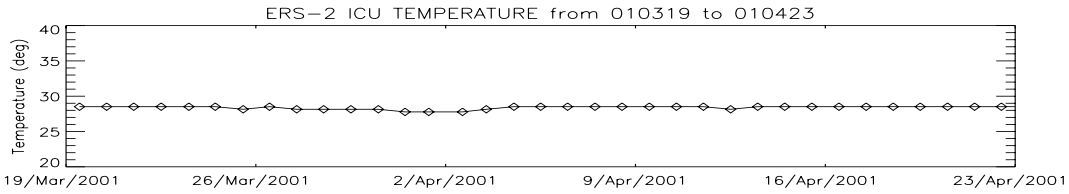
  The Instrument Control Unit (ICU) temperature is the parameter which suffered the most of an instrument anomaly occurred at the beginning of July 2000; this is easy to understand considering that a malfunction of this component caused a failure of the whole payload. After the anomaly the ICU temperature was more than 7° lower than before and actually it is stable at around 29°. Furthermore, the July anomaly caused a SPSA Panel temperature decrease of 1° while the LVPS temperatures experienced a 1° increase.

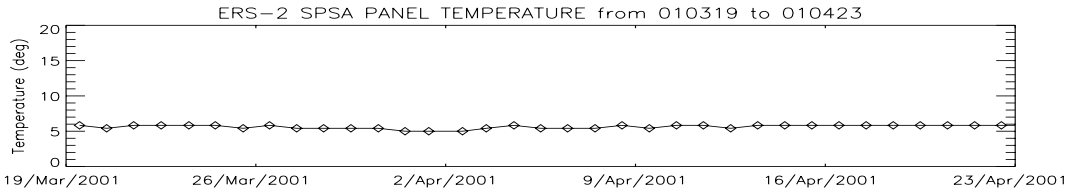
  During cycle 62 all the parameters preserved constantly the values they had at the end of cycle 61. For the temperature parameters, that value was ~1° lower than the one recorded previous the long anomaly occurred in January 2001.

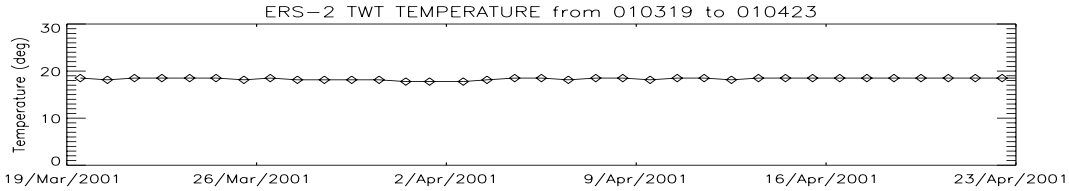

ERS−2 SPSA ADC Q−CH. TEMPERATURE from 010319 to 010423
Temperature (deg)
40
30
20
10
0
19/Mar/2001
26/Mar/2001
2/Apr/2001
9/Apr/2001
16/Apr/2001
23/Apr/2001

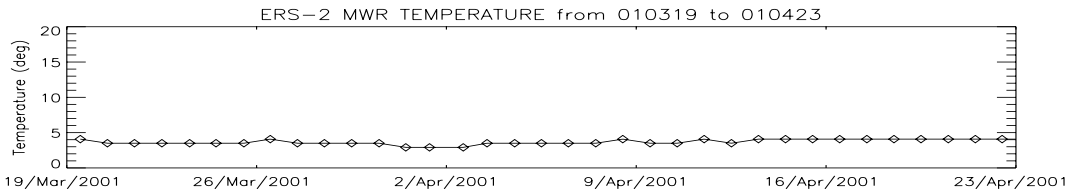

ERS−2 SPSA ADC I−CH. TEMPERATURE from 010319 to 010423
Temperature (deg)
40
30
20
10
0
19/Mar/2001
26/Mar/2001
2/Apr/2001
9/Apr/2001
16/Apr/2001
23/Apr/2001


ERS−2 MICRO P TEMPERATURE from 010319 to 010423
Temperature (deg)
40
30
20
10
0
19/Mar/2001
26/Mar/2001
2/Apr/2001
9/Apr/2001
16/Apr/2001
23/Apr/2001


ERS−2 ICU TEMPERATURE from 010319 to 010423
Temperature (deg)
40
35
30
25
20
19/Mar/2001
26/Mar/2001
2/Apr/2001
9/Apr/2001
16/Apr/2001
23/Apr/2001


ERS−2 SPSA PANEL TEMPERATURE from 010319 to 010423
Temperature (deg)
20
15
10
5
0
19/Mar/2001
26/Mar/2001
2/Apr/2001
9/Apr/2001
16/Apr/2001
23/Apr/2001


ERS−2 TWT TEMPERATURE from 010319 to 010423
Temperature (deg)
30
20
10
0
19/Mar/2001
26/Mar/2001
2/Apr/2001
9/Apr/2001
16/Apr/2001
23/Apr/2001


ERS−2 MWR TEMPERATURE from 010319 to 010423
Temperature (deg)
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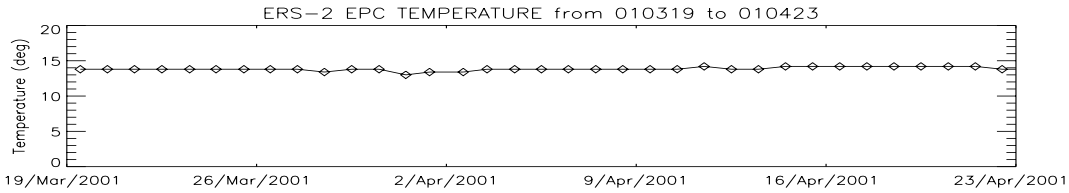
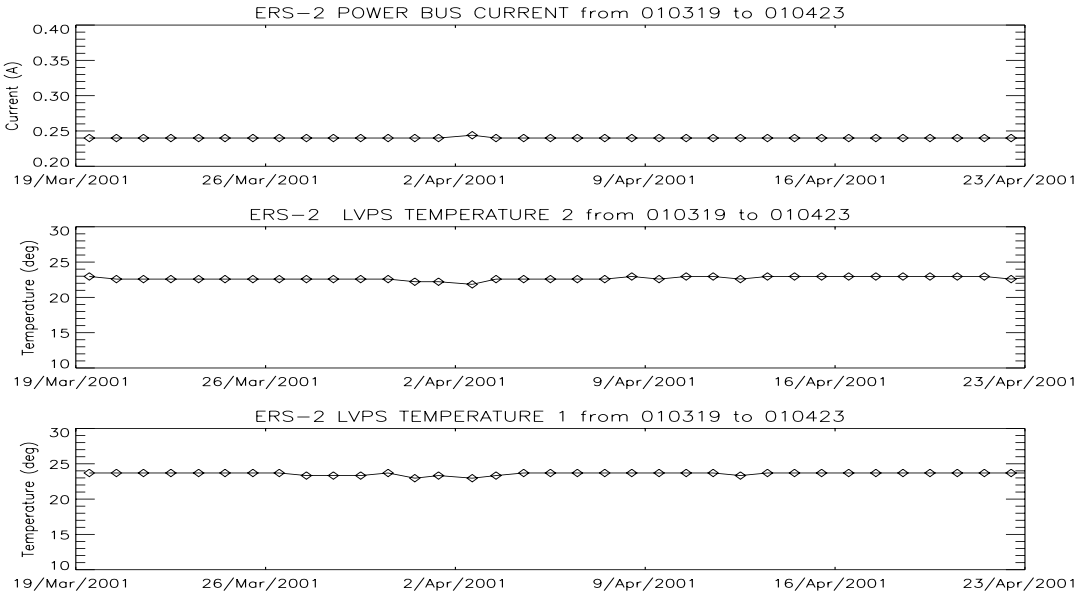
10
5
0
19/Mar/2001
26/Mar/2001
2/Apr/2001
9/Apr/2001
16/Apr/2001
23/Apr/2001


ERS−2 EPC TEMPERATURE from 010319 to 010423
Temperature (deg)
20
15
10
5
0
19/Mar/2001
26/Mar/2001
2/Apr/2001
9/Apr/2001
16/Apr/2001
23/Apr/2001



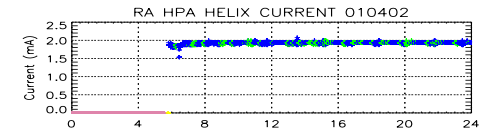
3.2.2 Internal Instrument Parameters and Instrument Anomalies

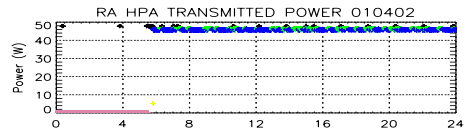
During cycle 62 the instrument was unavailable once. The table hereafter reports the date and a short explanation of the event, if known at the time of the report. The information is made available at ESRIN/PCS by the ERS Mission Control Centre at ESOC.

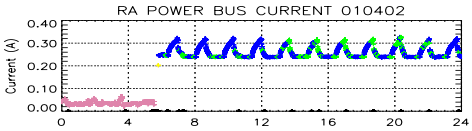
In the pictures reported afterwards all the internal instrument parameters are plotted for day April 2nd 2001. For every plot all the values of the parameters (one every 16 seconds) are displayed together with the relative instrument mode (represented by the colours). In some cases the parameters values were not available while the instrument mode information was. In those cases the parameter value has been chosen to be a value out of the nominal range; so the displayed points much higher or much lower than the overall trend do not represent real values of the parameters but they have been used just to show the instrument mode.

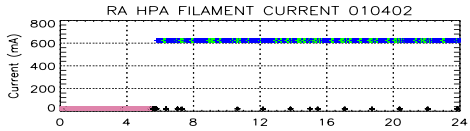
Table 1: Anomalies occurred during cycle 62

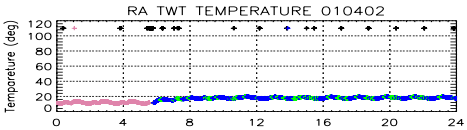
Anomaly	Reason
1st April 2001 17:50:57 - 2nd April 05:48:11	Emergency Switch Down

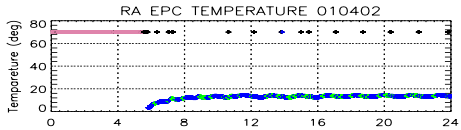

RA HPA HELIX CURRENT 010402
Current (mA)

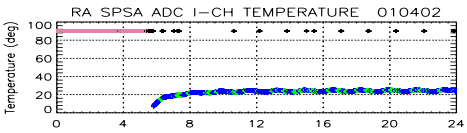

RA HPA TRANSMITTED POWER 010402
Power (W)

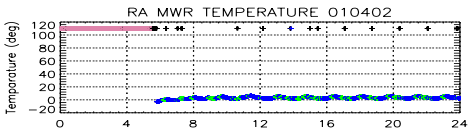

RA POWER BUS CURRENT 010402
Current (A)

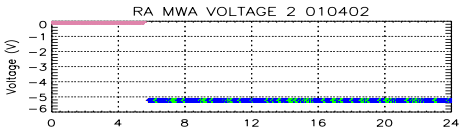

RA HPA FILAMENT CURRENT 010402
Current (mA)

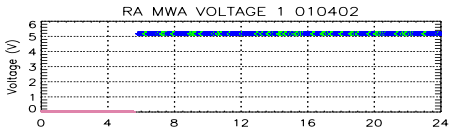

RA TWT TEMPERATURE 010402
Temperature (deg)

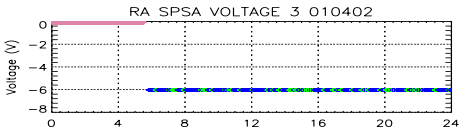

RA EPC TEMPERATURE 010402
Temperature (deg)

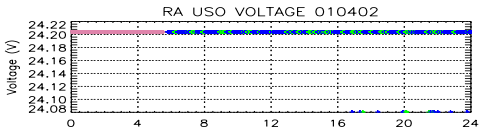

RA SPSA ADC I-CH TEMPERATURE 010402
Temperature (deg)

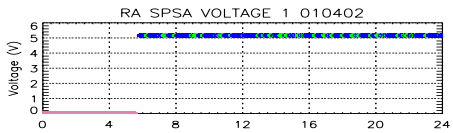

RA MWR TEMPERATURE 010402
Temperature (deg)

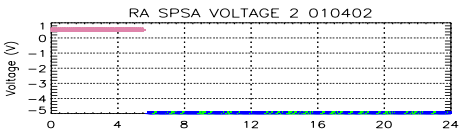

RA MWA VOLTAGE 2 010402
Voltage (V)

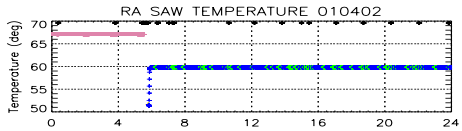

RA MWA VOLTAGE 1 010402
Voltage (V)

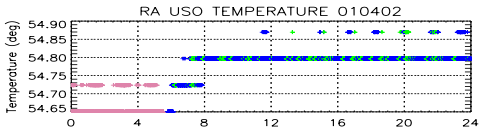

RA SPSA VOLTAGE 3 010402
Voltage (V)

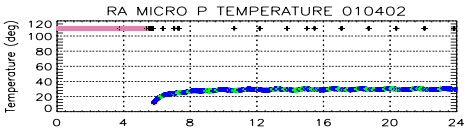

RA USO VOLTAGE 010402
Voltage (V)

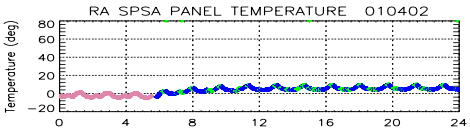

RA SPSA VOLTAGE 1 010402
Voltage (V)

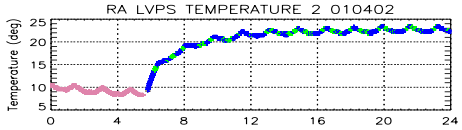

RA SPSA VOLTAGE 2 010402
Voltage (V)

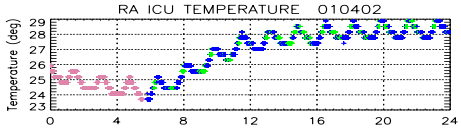

RA SAW TEMPERATURE 010402
Temperature (deg)

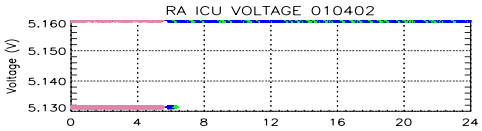

RA USO TEMPERATURE 010402
Temperature (deg)

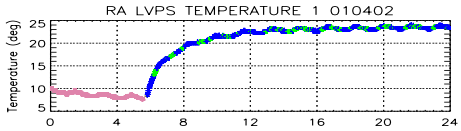

RA MICRO P TEMPERATURE 010402
Temperature (deg)


RA SPSA PANEL TEMPERATURE 010402
Temperature (deg)

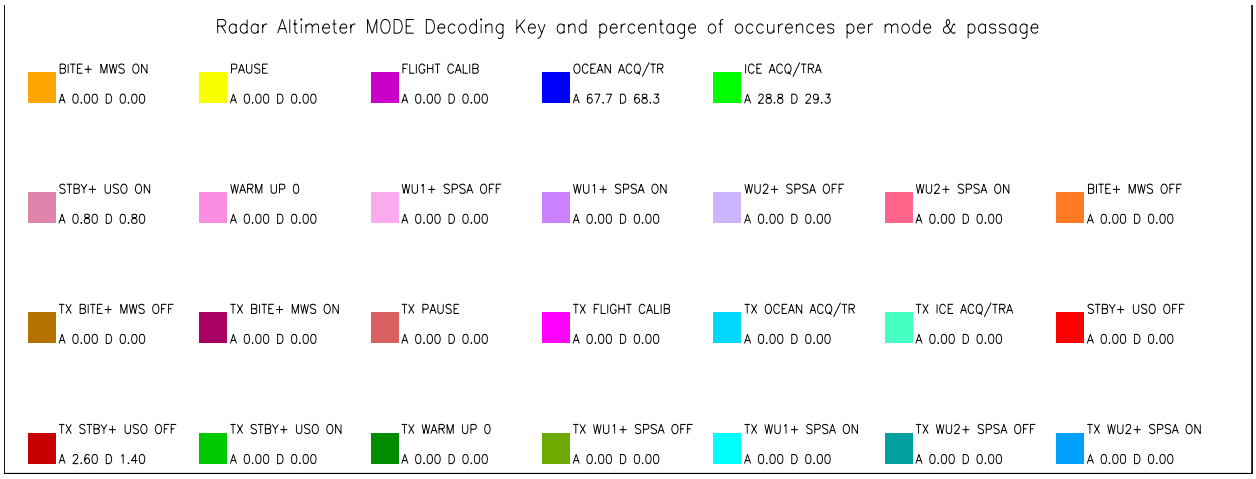

RA LVPS TEMPERATURE 2 010402
Temperature (deg)


RA ICU TEMPERATURE 010402
Temperature (deg)


RA ICU VOLTAGE 010402
Voltage (V)


RA LVPS TEMPERATURE 1 010402
Temperature (deg)

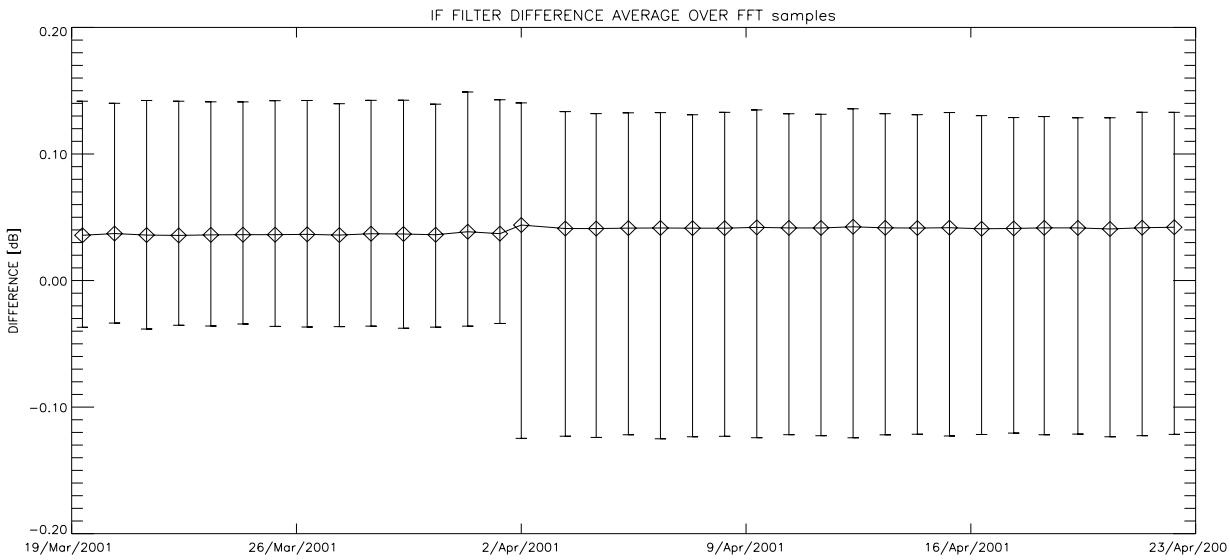
Hereafter the legend relative to the previous plots is given showing all the possible instrument modes for the Radar Altimeter. The percentages of every mode occurred during cycle 62 are also reported.

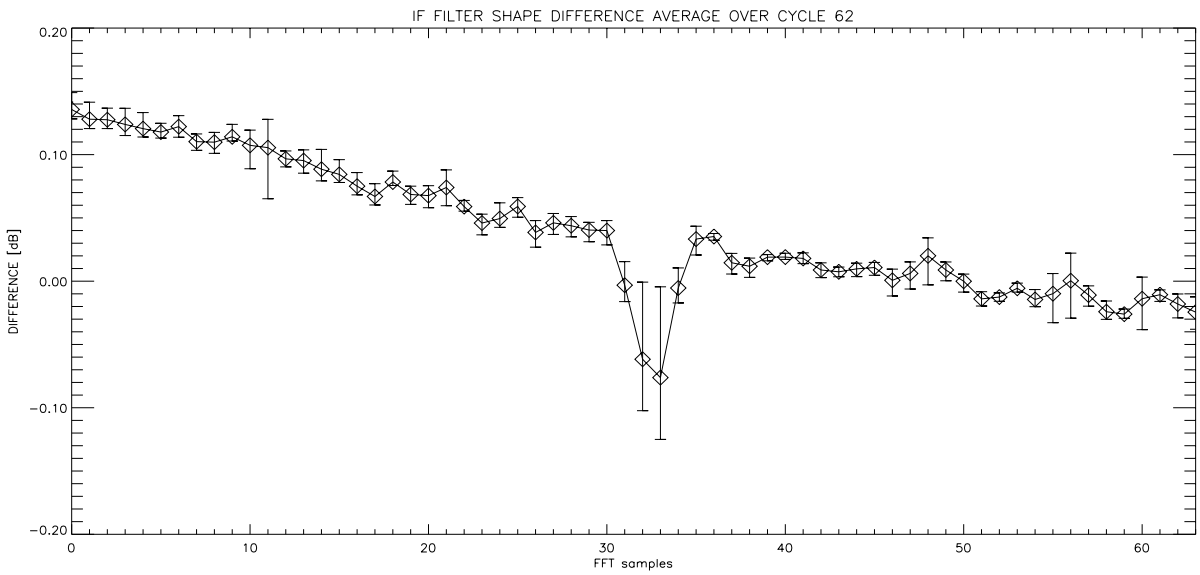


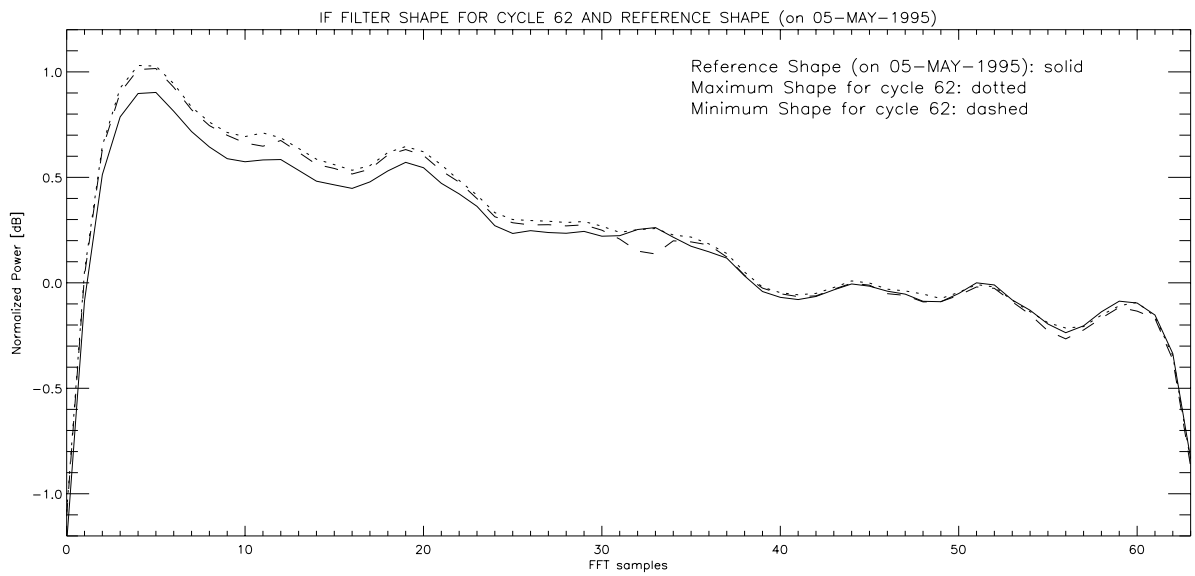
3.3 IF Filter Shape

The first picture reported hereafter give a vision of the IF Filter Shape behaviour for cycle 62.

- The IF Filter Shape reported in the lowest panel of either picture is the filter impulse response power spectum normalised to the average integrated power in the filters range 30 to 59. The middle panel represents the difference between the IF Filter Shape of the current cycle respect that evaluated on the 5th of May 1995 (reference shape); the diamond represents the mean difference over the cycle for each of the 64 FFT samples while the bar is ranging from the minimum to the maximum in the cycle. The highest panel shows the IF Filter Shape difference with the reference shape averaged over all the 64 FFT samples (also here the each bar is ranging from the minimum to the maximum over each filter) in function of time.
- In the lowest panel it is easy to notice that the normalised power values for FFT samples 30 to 33 have a big variations over the cycles and on the middle panel those samples show the biggest differences respect to the reference. What is estimated over those samples is not the real IF filter behaviour but it is caused by another instrumental effect (probably A/D conversion and DC offset) acting over the PTR pulses used in the retrieving process.
- What is evident is that the changes of the IF Filter Shape with reference to the beginning of the mission are limited to ca. 0.04 dBs, where the highest difference average and standard deviation values occurred after the 1st of April 2001 instrument anomaly (ref. par 3.2.2).
- Within the filter bank, the biggest variations are relative to the first part of it, that is low filter numbers. This fact should insure that those shape variations have a low impact on the Radar Altimeter performances since the waveform samples related to the low number filters assume usually values close to zero. Anyway the different behaviour of the low and high filter numbers, which causes a variation of the filter shape slope, has been demonstrated to affect the instrument performance.

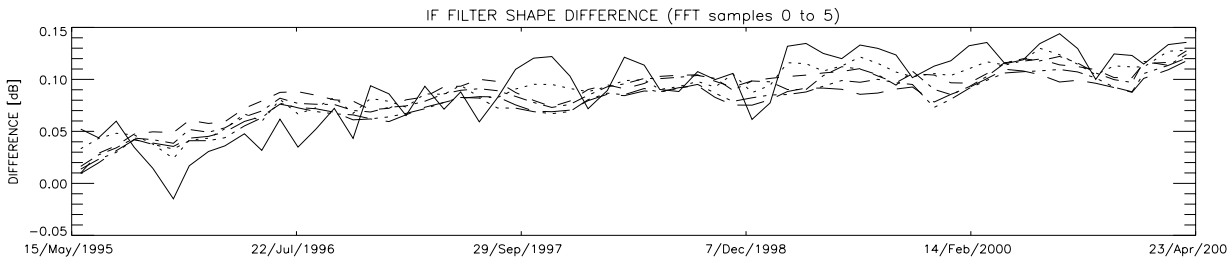

IF FILTER DIFFERENCE AVERAGE OVER FFT samples
DIFFERENCE [dB]
0.20
0.10
0.00
−0.10
−0.20
19/Mar/2001
26/Mar/2001
2/Apr/2001
9/Apr/2001
16/Apr/2001
23/Apr/200

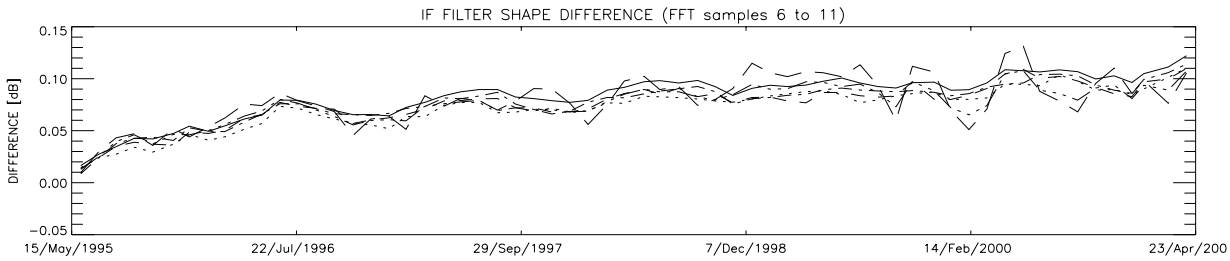

IF FILTER SHAPE DIFFERENCE AVERAGE OVER CYCLE 62
DIFFERENCE [dB]
0.20
0.10
0.00
−0.10
−0.20
0
10
20
30
40
50
60
FFT samples

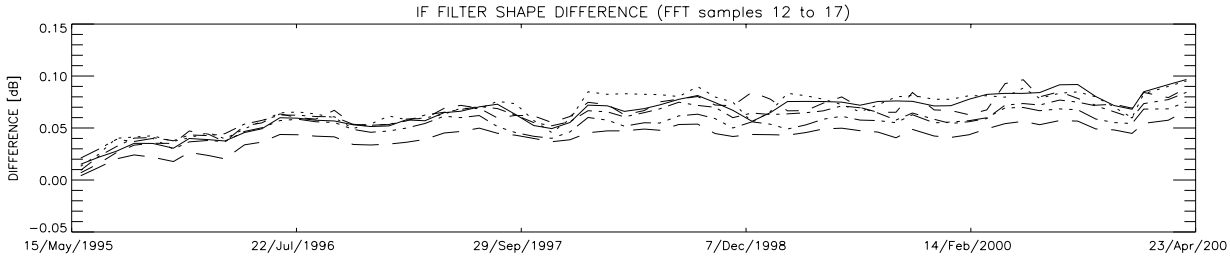

IF FILTER SHAPE FOR CYCLE 62 AND REFERENCE SHAPE (on 05−MAY−1995)
Reference Shape (on 05−MAY−1995): solid
Maximum Shape for cycle 62: dotted
Minimum Shape for cycle 62: dashed
Normalized Power [dB]
1.0
0.5
0.0
−0.5
−1.0
0
10
20
30
40
50
60
FFT samples

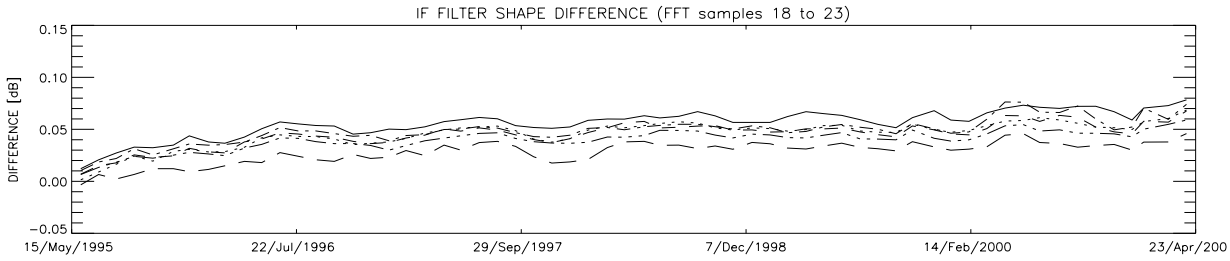
The two pages reported afterwards document trends of the IF filter characteristics difference respect to the reference; for each of the 64 FFT samples averages over cycles have been calculated.

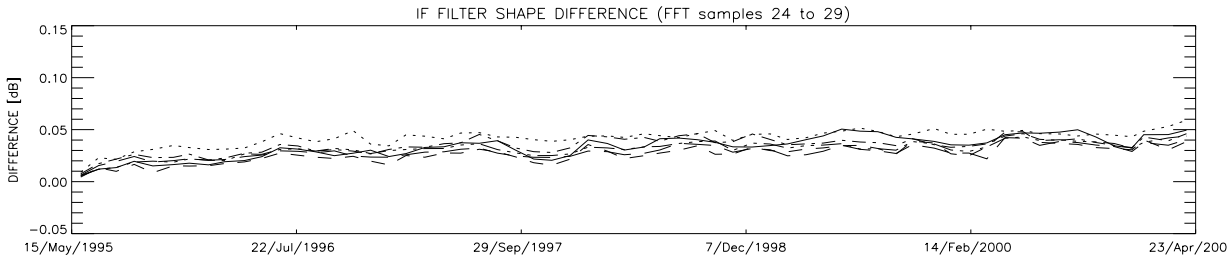
- The same observations can be made as for the cycle results: differences over samples 31 and 32 have been always quite big; being the values even outside our plotted range for a significant time span.
- The low filter number samples, up to filter number 33, show positive differences, respect to the reference one, and they increase with time. On the other hand, the high filter numbers, from 52 to 64, exhibit negative differences, respect to the reference, that tend to slightly diminish with time. This effect causes the variation of the IF Filter shape slope which has been shown to have an impact on the off-nadir pointing value (ref. par. 3.4).
- More generally, the IF Filter shape is affecting the received echo shape within the filter bank. For this reason it has an influence on all the RA retrieved parameters (e.g. Range, Sigma_0 and Significant Wave Height) being their evaluation based on the received waveform profile. Some investigations have been performed in order to assess the impact of the IF Filter shape variations on the RA retrieved geophysical parameters. Unfortunately the results obtained, at a first sight, did not agree with the scientific observations; in order to better understand what was going on, a deeper investigation was needed. On the other hand, the priority on this subject, as well as anything else regarding ERS, is becoming lower and lower; for this reason it has been decided to leave the subject.

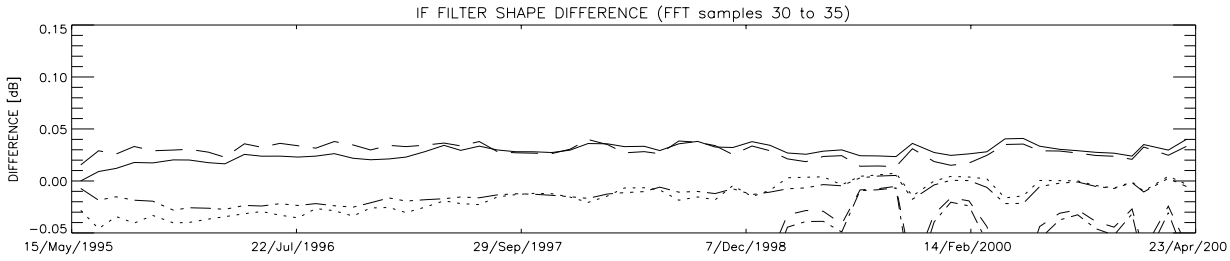

IF FILTER SHAPE DIFFERENCE (FFT samples 0 to 5)
DIFFERENCE [dB]
0.15
0.10
0.05
0.00
−0.05
15/May/1995
22/Jul/1996
29/Sep/1997
7/Dec/1998
14/Feb/2000
23/Apr/200

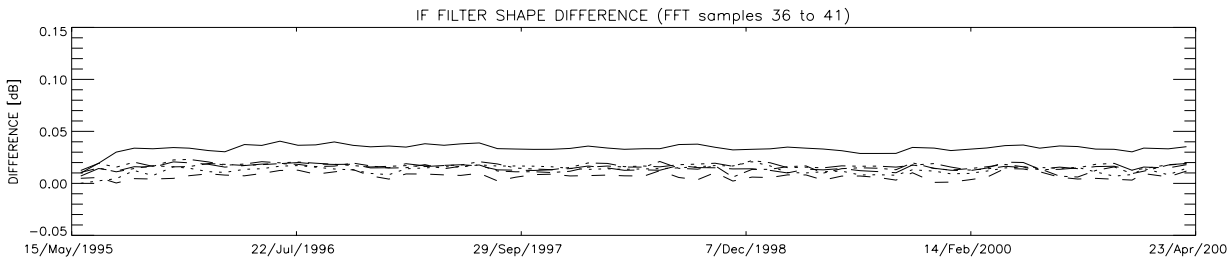

IF FILTER SHAPE DIFFERENCE (FFT samples 6 to 11)
DIFFERENCE [dB]
0.15
0.10
0.05
0.00
−0.05
15/May/1995
22/Jul/1996
29/Sep/1997
7/Dec/1998
14/Feb/2000
23/Apr/200

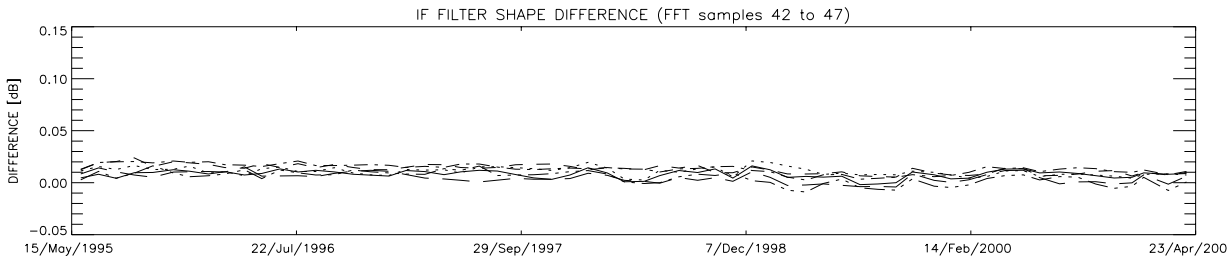

IF FILTER SHAPE DIFFERENCE (FFT samples 12 to 17)
DIFFERENCE [dB]
0.15
0.10
0.05
0.00
−0.05
15/May/1995
22/Jul/1996
29/Sep/1997
7/Dec/1998
14/Feb/2000
23/Apr/200

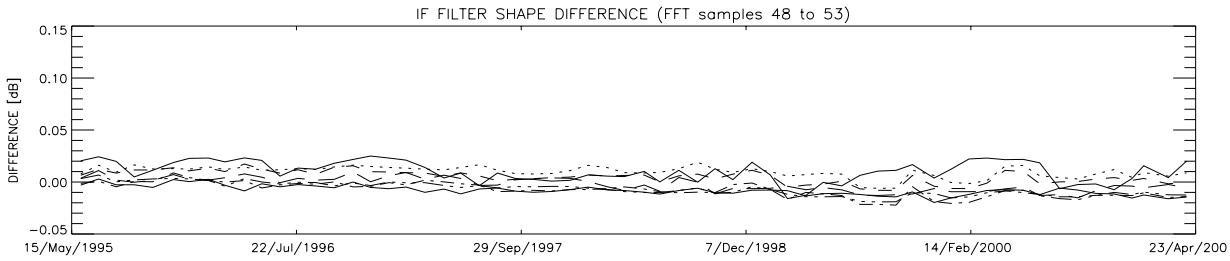

IF FILTER SHAPE DIFFERENCE (FFT samples 18 to 23)
DIFFERENCE [dB]
0.15
0.10
0.05
0.00
−0.05
15/May/1995
22/Jul/1996
29/Sep/1997
7/Dec/1998
14/Feb/2000
23/Apr/200

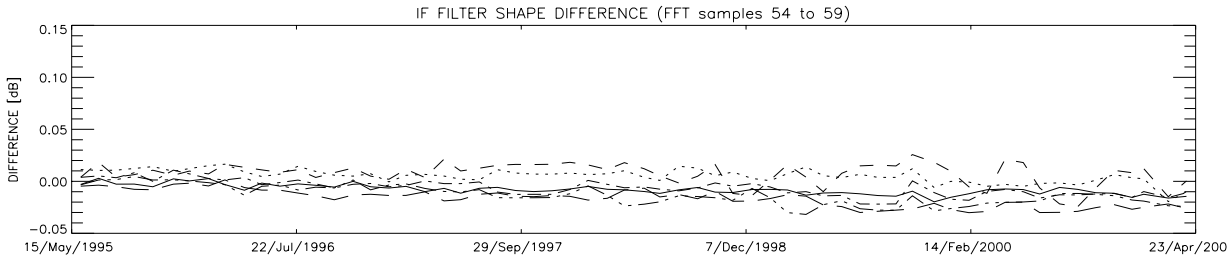

IF FILTER SHAPE DIFFERENCE (FFT samples 24 to 29)
DIFFERENCE [dB]
0.15
0.10
0.05
0.00
−0.05
15/May/1995
22/Jul/1996
29/Sep/1997
7/Dec/1998
14/Feb/2000
23/Apr/200

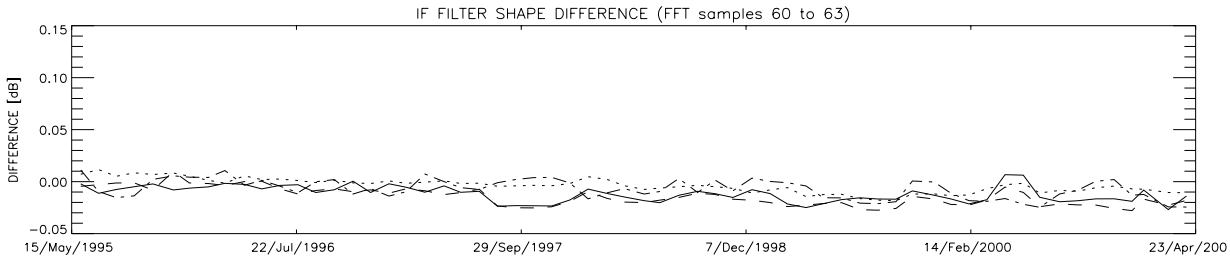

IF FILTER SHAPE DIFFERENCE (FFT samples 30 to 35)
DIFFERENCE [dB]
0.15
0.10
0.05
0.00
−0.05
15/May/1995
22/Jul/1996
29/Sep/1997
7/Dec/1998
14/Feb/2000
23/Apr/200











LEGEND

————————	FFT samples 0, 6, 12, 18, 24, 30, 36, 42, 48, 54, 60
. . . . .	FFT samples 1, 7, 13, 19, 25, 31, 37, 43, 49, 55, 61
— — — — —	FFT samples 2, 8, 14, 20, 26, 32, 38, 44, 50, 56, 62
— . — . — . — . .	FFT samples 3, 9, 15, 21, 27, 33, 39, 45, 51, 57, 63
— . . . — . . . —	FFT samples 4, 10, 16, 22, 28, 34, 40, 46, 52, 58
— — — .	FFT samples 5, 11, 17, 23, 29, 35, 41, 47, 53, 59

3.4 Off-Nadir Pointing

3.4.1 Results

Starting from cycle 61, because of the implementation of a new piloting scheme called Extra Backup, Mode (ref. par. 4.5 of "ERS-2 Radar Altimeter Cyclic Report for cycle 61", APP-ADQ/PCS/RA01-003) and consequently the need of more careful mispointing quality assessment; more data were available in operational mode, allowing ESRIN/PCS to perform a discriminated analysis for ascending and descending tracks.

On the other hand, on the 30th of March 2001 an upgrade of the EBM piloting software was uplinked which modified the mode from geocentric to geodetic (ref. par. 4.5). This had a very big impact, as expected, in the nadir pointing performance of the spacecraft.

Table 2 and Table 3 report the statistics obtained on the mispointing values for the different piloting configurations used until present.

Table 2: Statistics off-nadir pointing angle values in different configurations (Ascending Passes)

Configuration	Average (°)	Median (°)	Std. Dev (°)
Three Gyros piloting (29-Apr-1995 to 3-Feb-2000)	0.0831	0.0801	0.0146
Mono Gyro piloting - Gyro 5 (18-Feb-2000 to 7-Oct-2000)	0.0905	0.0898	0.0145
Mono Gyro piloting - Gyro 6 (10-Oct-2000 to 24-Oct-2000)	0.0897	0.0919	0.0098
Mono Gyro piloting - Gyro 1 (25-Oct-2000 to 16-Jan-2001)	0.0918	0.0913	0.0087
Extra Backup Mode piloting (5-Feb to 29-March-2001)	0.0979	0.0945	0.0132
Extra Backup Mode geodetic piloting (30 March 2001 to present)	0.1031	0.1039	0.0098

In view of the evaluation performed for the ascending tracks, next to the increase of the mispointing values due to the change from the Three Gyros scheme to the Mono-Gyro one; a very tiny further increase is noticeable when passing from Mono-Gyro piloting with Gyro 5 to mono-Gyro piloting with Gyro 1. Again, passing from Mono-Gyro piloting to Extra Backup Mode an additional tiny increase occurred. The upgrade performed at the end of March 2001 caused again a very small increase of the mispointing values for ascending passes, nevertheless the decrease experienced in the descending passes results was so significant to fully compensate this. In any case,

the difference absolute numbers are so small that it can be considered negligible especially considering that the total mispointing figures are still very close to 0.1°.

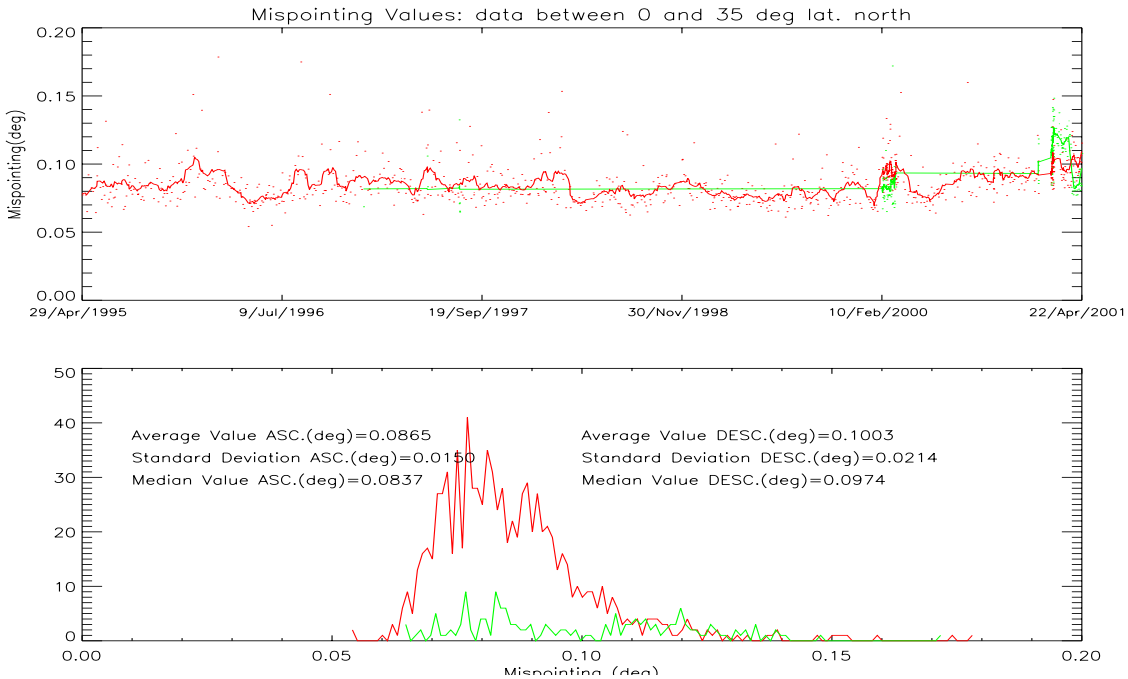
Concerning the evaluation performed on the descending passes, a comparison is possible only between the results with Mono-Gyro/Gyro 5 piloting scheme and Extra Backup Mode. In this sense, a clear increase is observable when passing to the last mentioned piloting scheme. Moreover, when comparing with the ascending tracks results, the outcome appears to be lower in Mono-Gyro/Gyro 5 piloting while it is higher in Extra Backup Mode. This could be eventually identified as an impact of the "Sun-Blinding effect" (ref. par. 4.5) that, until half March, in the northern hemisphere, has been more significant on the descending tracks. The upgrade to the geodetic Extra Backup Mode caused a sharp decrease in the mispointing values recorded during descending tracks.

Table 3: Statistics off-nadir pointing angle values in different configurations (Descending Passes)

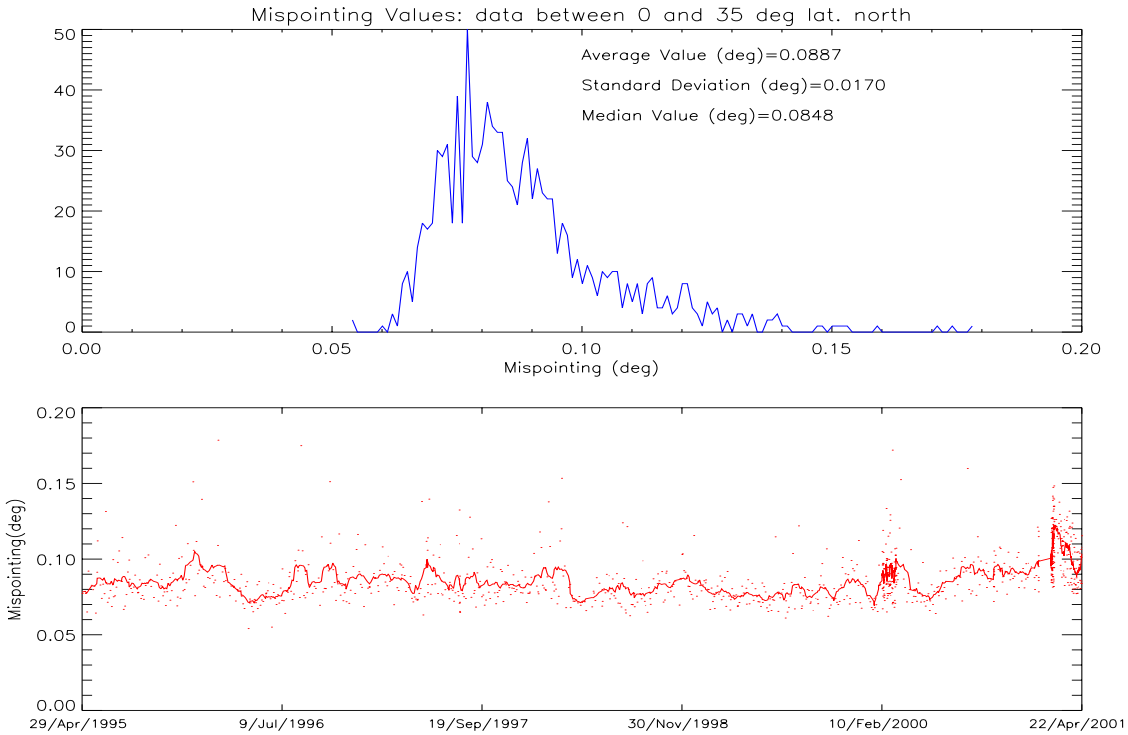
Configuration	Average (°)	Median (°)	Std. Dev (°)
Three Gyros piloting (29-Apr-1995 to 3-Feb-2000)	N/A	N/A	N/A
Mono Gyro piloting - Gyro 5 (18-Feb-2000 to 7-Oct-2000)	0.0846	0.0831	0.0174
Mono Gyro piloting - Gyro 6 (10-Oct-2000 to 24-Oct-2000)	N/A	N/A	N/A
Mono Gyro piloting - Gyro 1 (25-Oct-2000 to 16-Jan-2001)	N/A	N/A	N/A
Extra Backup Mode piloting (5-Feb to 29 March 2001)	0.1163	0.1176	0.0137
Extra Backup Mode geodetic piloting (30 March 2001 to present)	0.0843	0.0839	0.0070

For the descending passes, the overall average value lies around 0.1°, where the highest values, correlated with the Extra Backup Mode before the upgrade, still remain under 0.12°. Taking into account that this figure was the highest off-nadir pointing value retrieved during the Three-Gyros piloting when evaluating the round-the-orbit behaviour, the performance in Extra Backup Mode, over this zone, can be reputed still acceptable. On the other hand, this was only related to a short period of a couple of months until the software upgrade re-established good performance at the end of March 2001. In any case it has to be remembered that the outcome here reported has been evaluated from data sensed over the latitude range [0, 35] deg, this is most probably not properly representing the off-nadir pointing behaviour along the whole orbit. Work is on-going in order to operationally monitor the long the orbit off-nadir pointing pattern.

In the following picture, the off-nadir pointing trend is reported since the beginning of the mission. Results for ascending and descending passes are plotted respectively in red and green.



From the following figure we can notice that the overall mispointing time series, considering both ascending and descending tracks results, lies around a value of 0.089°. A very small increasing trend is evident after middle February 2000 (change of the piloting system); another after the 7th of October 2000 when the Gyro 5 failed and the Gyro 1 was chosen to pilot the platform in nominal operations (after a very short period during which Gyro 6 was used). The total increment, being in average lower than 0.01°, can be anyway considered irrelevant bearing in mind the uncertainties affecting the retrieved figures. A further increase, occurred after the 17th of January 2001 when the Extra Backup Mode Started to be operational, with a value of about 0.02° resulted to be the most significant. Nevertheless, the software change performed on the 30th of March 2001; which upgraded the Extra Backup Mode to geocentric pointing; led to a substantial decrease of the mispointing value to a figure comparable to the ones measured before for the Mono-Gyro Piloting. On the other hand, because of all the uncertainties present in the mispointing retrieval algorithm, the retrieved figures over the whole mission could be considered assuming values from 0° to 0.15°.


Mispointing Values: data between 0 and 35 deg lat. north
Average Value (deg)=0.0887
Standard Deviation (deg)=0.0170
Median Value (deg)=0.0848
50
40
30
20
10
0
0.00
0.05
0.10
0.15
0.20
Mispointing (deg)
0.20
0.15
0.10
0.05
0.00
Mispointing(deg)
29/Apr/1995
9/Jul/1996
19/Sep/1997
30/Nov/1998
10/Feb/2000
22/Apr/2001

4.0 Products performance

In this paragraph the results of the Radar Altimeter products performance monitoring assessment will be described. For the theoretical background and the instrument description related to the subject, the reader should refer to chapter 4 of the document: “ERS-2 Radar Altimeter Cyclic Report, Theoretical background”, APP-ADQ/PCS/RA01-002 available at http://pcswww.esrin.esa.it/ra.

4.1 Availability of Data and Quality Assessment

The fast delivery data (URA) are checked every day by ESRIN/PCS for quality assurance. The summary of all the most important features affecting the quality of the data during cycle 62 is hereafter reported.

Percentage of not available products (relative to the nominal number for a cycle): 2.4%

Percentage of blank DSRs (relative to the nominal number for a cycle): 0.50%, of which 0.23% due to whole blank products and 0.17% due to products not totally blank.

Table 4: Percentage of products having one of the following flags set

Flag name	Percentage(%)
HDDT	less than 0.001
FS to Processor	0.0
Checksum Analysis	0.16
Formats/Sources	0.0
Auxiliary Data	0.0
Arithmetic Fault	0.0
Processor Status	0.0
Enough Measurement	0.93

Table 5: Percentage of products having one of the following parameters outside the respective range

Parameter	Percentage(%)
Peakiness out of [1.2, 1.7]	0.27
Sigma_0 out of [0., 24.] (dB)	0.15
Wind Speed out of [0., 25.] (m/s)	less than 0.001
Significant Wave Height ot of [0., 12.] (m)	0.01

Note that the numbers here above (Table 5) are only relative to ocean products.

Percentage of flagged products relative to the Wet Tropospheric Correction: 0.2%

(a product is flagged if it contains more than 10 DSRs which all have the default value for the Wet Tropospheric correction instead of a value derived from the MWR measurements).

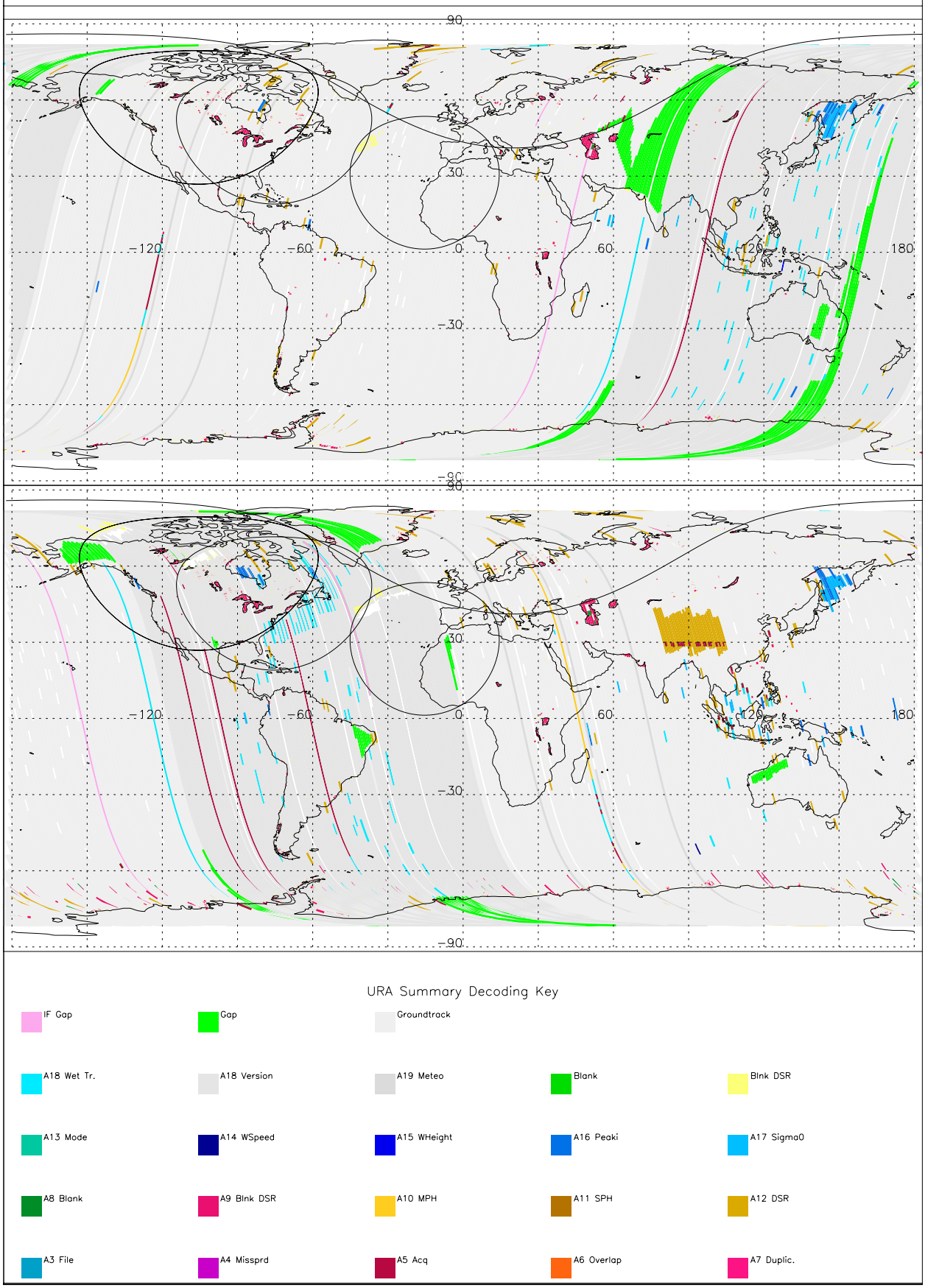
The fast delivery products performance during cycle 62 was reasonably good. The significant percentage of missing products was mostly due to the anomaly (ref. par. 3.2.2).

The significant percentage of blank products was both due to a few acquisition problems occurred and to the acquisition over ocean operation mode events (ref. par. 3.1). Those last have been decreasing in number during the first period of cycle 62 until they disappeared after the first few days in April 2001.

The performance of the geophysical parameters have been slowly improving during the whole cycle; none of the out of range event was recorded for either Wind Speed and SWH while the once occurred for Sigma_0 and Peakiness were due to Sea Ice presence.

The following figure reports the global distribution of flagged parameters detected in the URA products for cycle 62.

ERS-2 URA Products Summary, Cycle 62



In relation to the previous URA Products Summary pictures for cycle 62, here the description of flags meaning:

IF Gap: not nominal gap, between two files (Inter-file Gap)

Gap: nominal gap (due to descoping)

Groundtrack: no flagged products, everything is nominal

Wet Tr.: problem with the Wet Tropospheric correction

Version: problem with the Meteo Table version (auxiliary parameter used for the processing, giving the meteorological forecast)

Meteo: problem with the Meteo Table number (auxiliary parameter used for the processing, giving the meteorological forecast)

Blank: blank product, nominal (due to descoping)

Blank DSR: product with more than 5 blank DSRs over ocean, nominal (due to descoping)

Mode: not nominal instrument mode

Wspeed: problem with the Wind Speed (value out of [0., 25.] (m/s))

WHeight: problem with the Significant Wave Height (value out of [0., 12.] (m))

Peaki: problem with the Significant Wave Height (value out of [1.2, 1.7])

Sigma0: problem with the Significant Wave Height (value out of [0., 24.] (dB))

Blank: blank product

Blank DSR: product with more than 5 blank DSRs over ocean

MPH: Main Product Header flag set

SPH: Specific Product Header flag set

DSR: Data Set Record flag set

File: Missing File

Missprd: Missing Product, product counter not consecutive

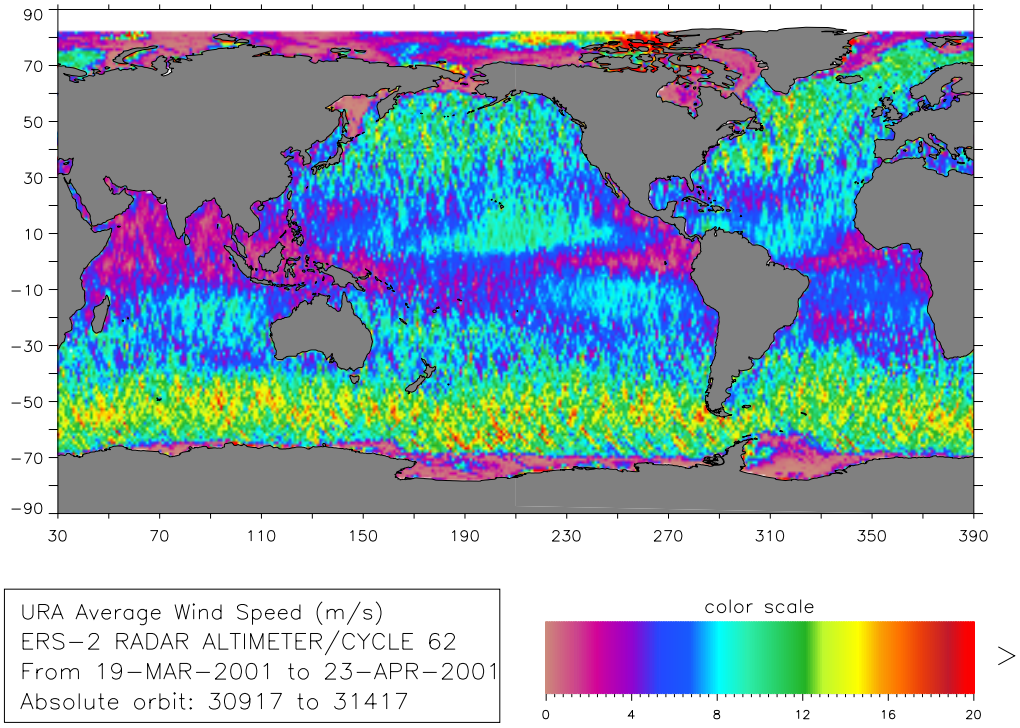
Acq: problem with acquisition, gap within one file

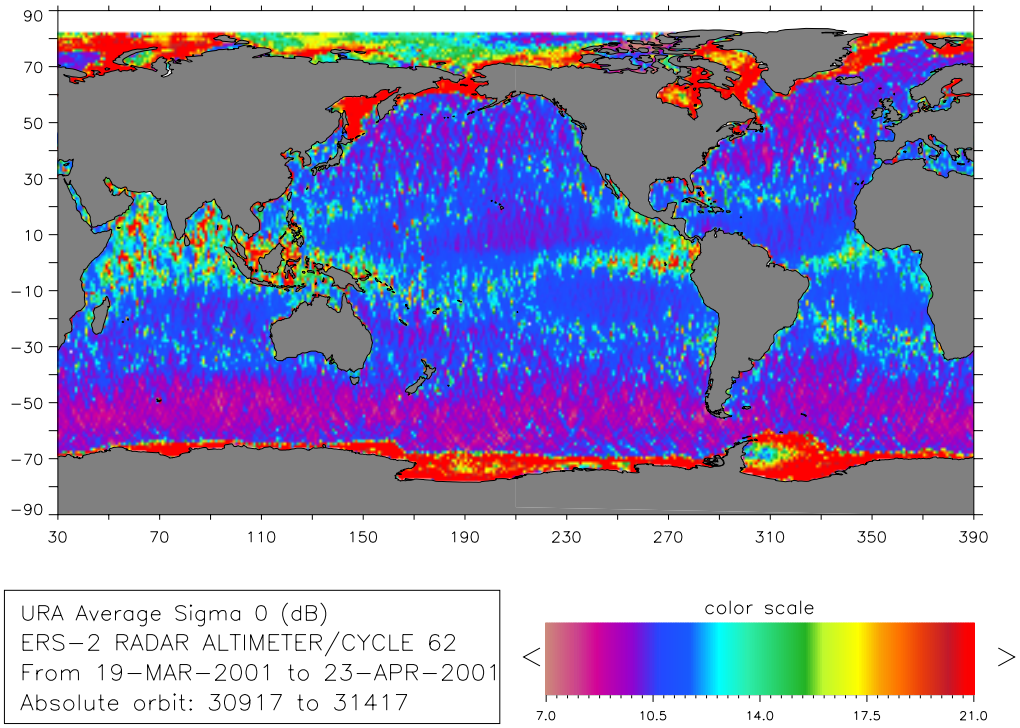
Overlap: product overlapping with another one

Duplic: duplicated product

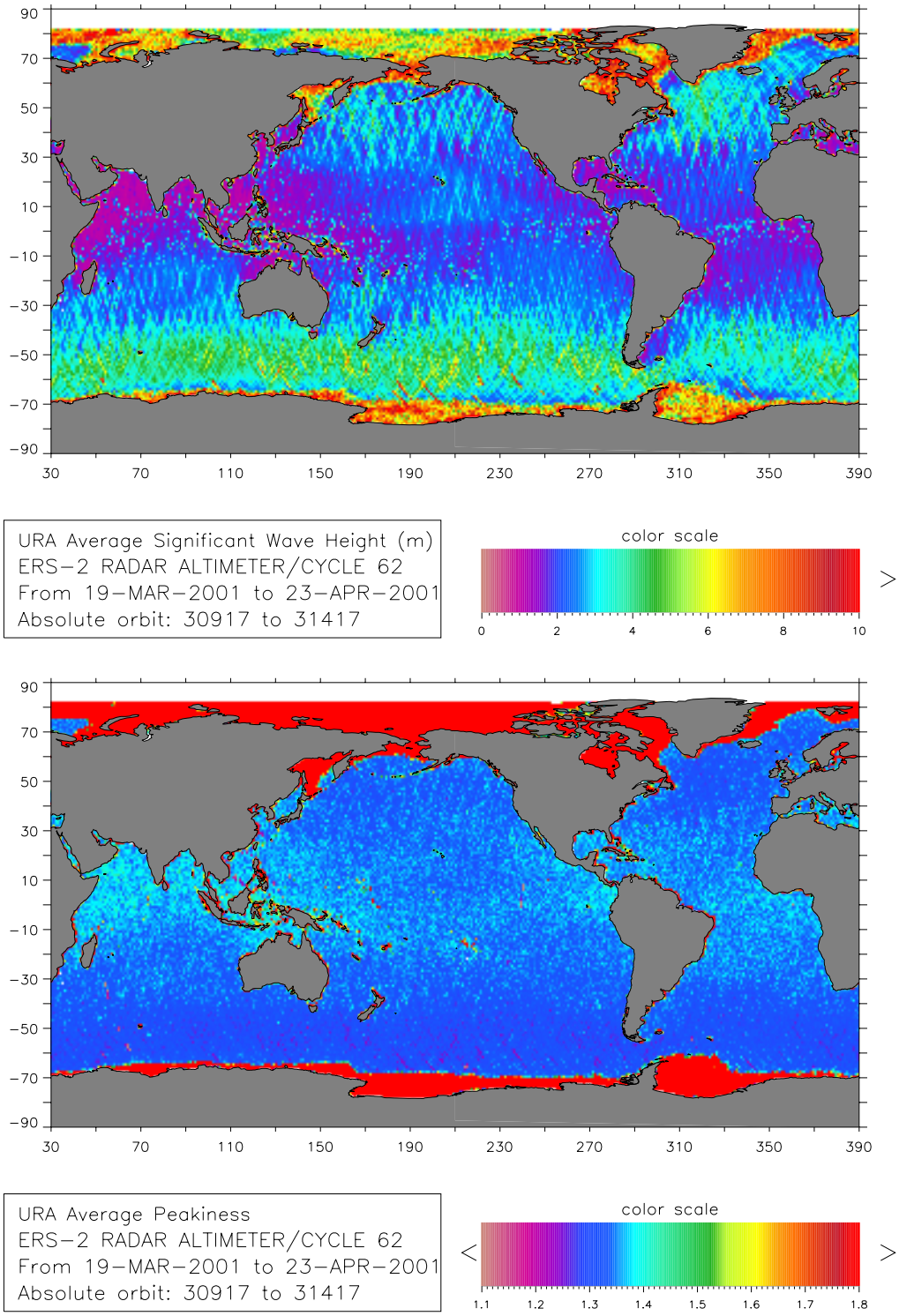
4.2 Fast Delivery Data Summary

They are reported in the following pictures, giving a global overview of the Radar Altimeter data for cycle 62.

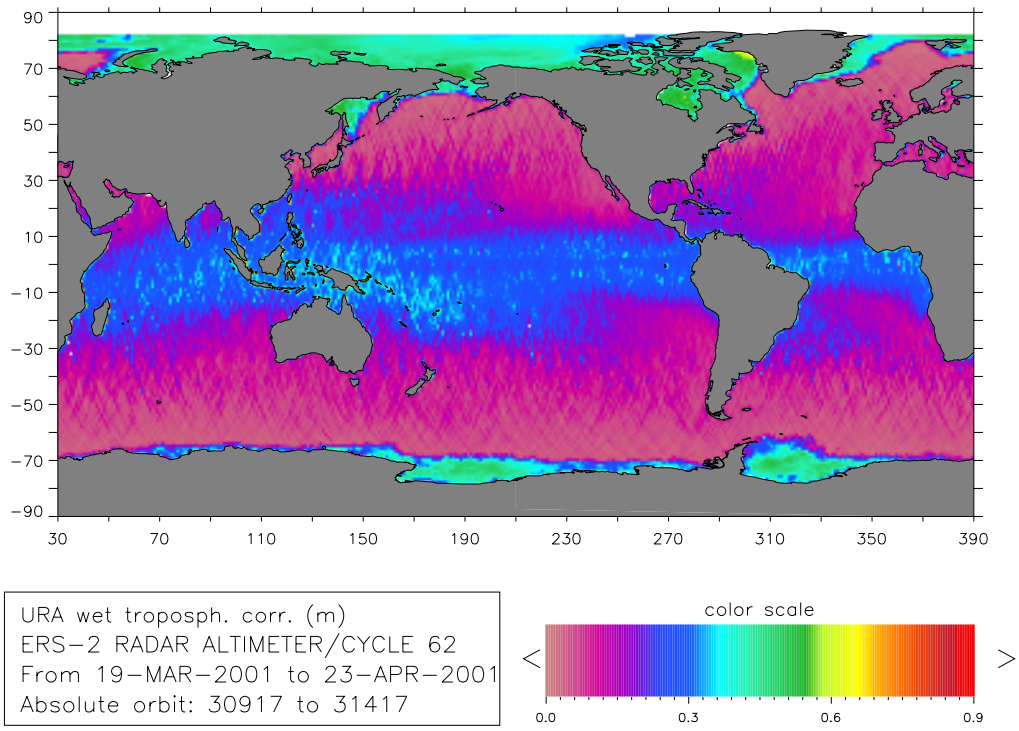




Worthwhile to notice the Wind Speed values over the polar regions. Those value are quite often identically equal to zero; they correspond to sigma_0 values higher than 20 dBs for which the wind speed retrieval algorithm used for the fast delivery URA data gets saturated.



The Peakiness, being related to the peakedness of the returned echo waveforms, represents a valuable quality parameter for the raw data. Over Ocean areas you expect smooth waveforms (ref. par. 3.4) while over Ice area the expected shape is more peaky. For ocean-like waveforms the peakiness should be in the range [1.2, 1.7].

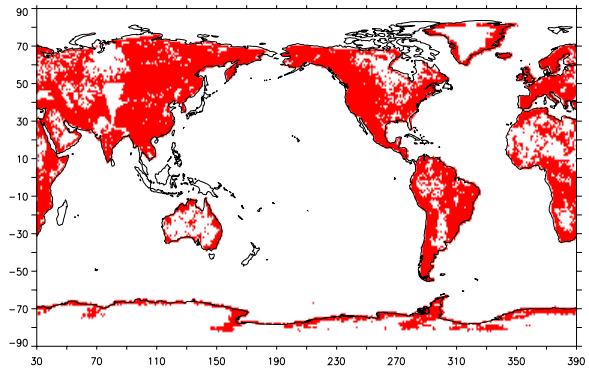


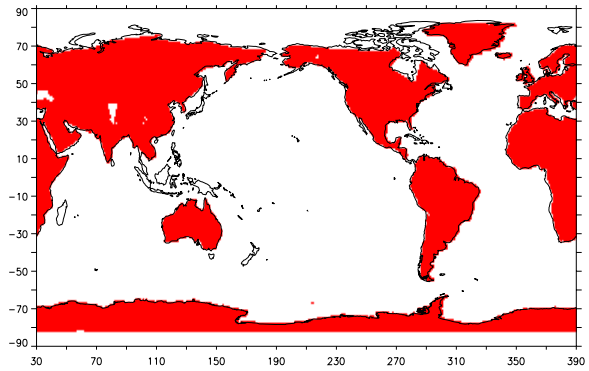
Together with the Wind Speed mentioned before, also the Wet Tropospheric correction values over the polar regions deserve a comment: the high values are not a consequence of the geophysical conditions in those areas; they are due the fact that the algorithm used to retrieve the correction from the brightness temperatures gives valid results only over ocean areas.

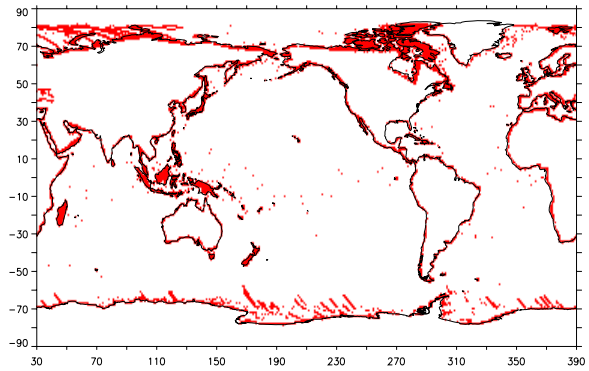
During cycle 61 it had been observed that, between 70 and 40 degrees latitude south, the Peakiness and the Sigma_0 assumed often values lower than nominal, while the opposite occurred for Wind Speed and SWH. That was due to the coexistence of two events: the Extra Backup Mode used for the spacecraft attitude control and a special astronomical configuration of the earth-sun positions causing the Sun Blinding effect (ref. par. 4.5). At the beginning of cycle 62 the effect was till present but its impact has been decreasing until disappearing after the first week of April 2001. Indeed only few point with high values are still noticeable in the Wind Speed and SWH plots while a small amount of points with low values are present in the Sigma_0 and Peakiness maps. This, most probably, because of the changing in the earth-sun relative positions and of the piloting software upgrade.

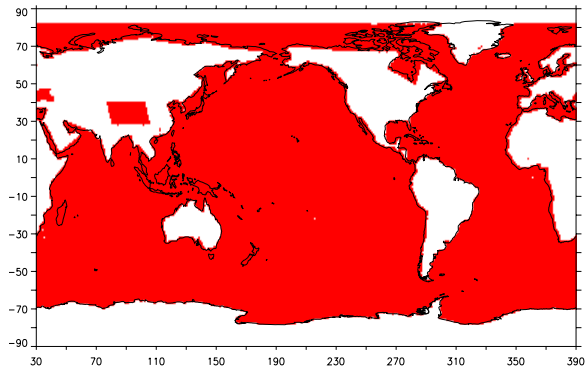
4.3 Instrument Mode

The following maps report a summary of the four principal operative working modes during cycle 62.





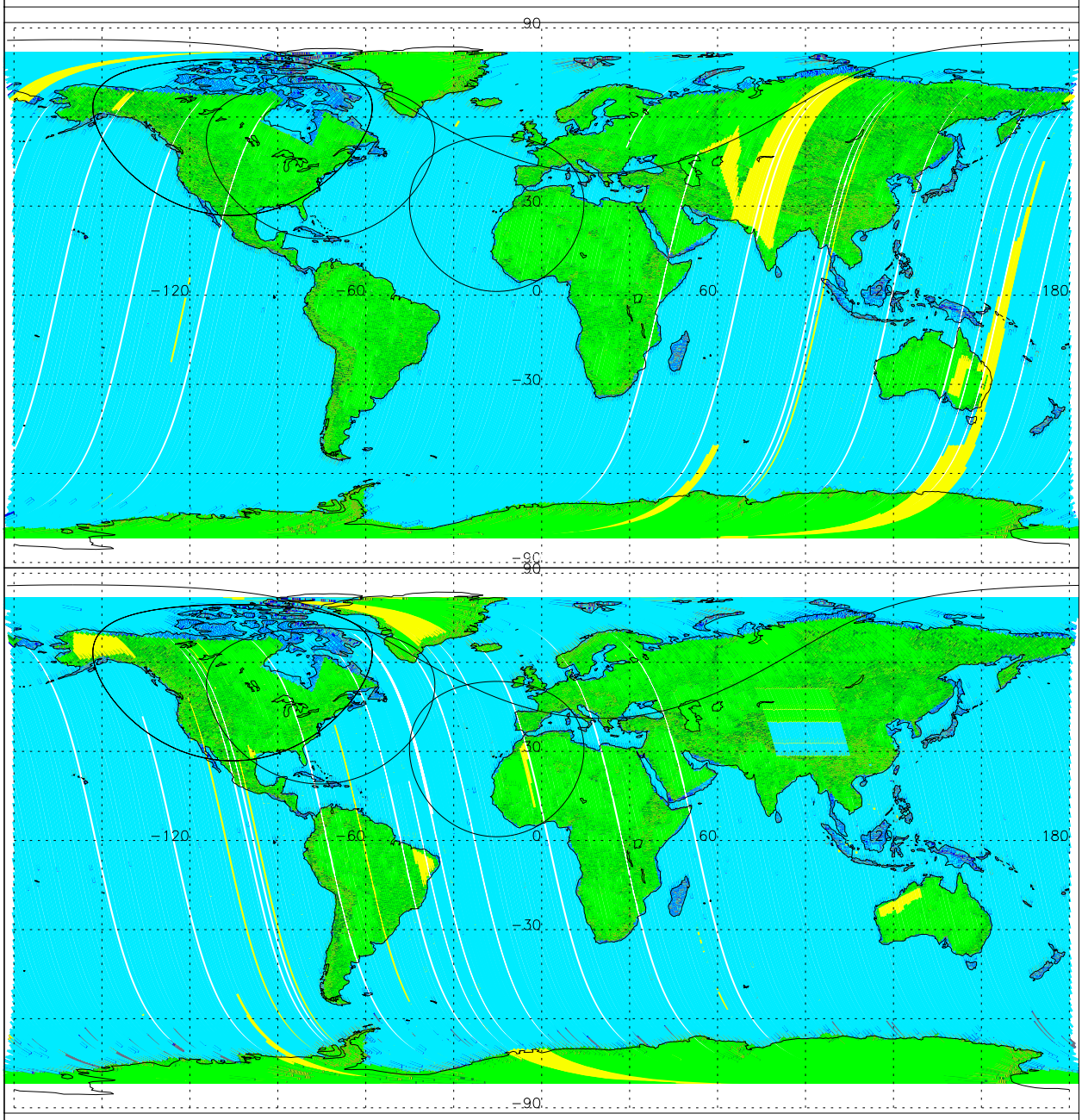




The following picture reports a global view of the modes the Radar Altimeter was operationally working in, during cycle 62.

Note, in all the Instrument Mode plots, that the amount of products in Ocean Acquisition mode between -70 and -40 deg latitude; which used to be very high for cycle 61; is reduced for the current cycle. This, as mentioned in par. 3.1, was due to the coexistence of EBM piloting scheme and Sun Blinding effect; which induced the RA antenna off-nadir pointing to be so big that the instrument loses the tracking capability even over ocean. The modification of the Sun-Earth relative position and the upgrade of the on-board piloting software were, most probably, the cause of the decreasing.

ERS-2 Radar Altimeter: Working modes, Cycle 62



4.4 Look Up Tables Status

The Look Up Tables (LUT) contain auxiliary parameters used in the on-ground processing. Those parameters need, from time to time, to be updated. In those cases, new versions of the tables containing the parameters have to be produced and loaded in memory at the ground stations. During the period covering cycle 62 no change on the look Up Tables was implemented.

Radar altimeter LUT Summary

ID	LUT Name	Version
70	STATIC	13004
71	DYNAMIC	13003
72	TAU_G_REF	10006
73	TAB_TAU_1	10001
74	TAB_TAU_2	10001
76	SIG_G_REF	10001
77	TAB_S	10001
79	AGC_G_REF	13005
81	TAB_A2	10001
82	TAB_LOC	10001

LUT SUMMARY

ERS–2 RADAR ALTIMETER/CYCLE 62

From 19–MAR–2001 to 23–APR–2001

4.5 Special Events

During cycle 62 the following events occurred that influenced the products performance:

- During the whole cycle 62 the spacecraft was still piloted with Extra Backup Mode scheme. The EBM rules the satellite attitude without gyros, it uses a Digital Earth Sensor for pitch and roll control and a Digital Sun Sensor for yaw steering. Originally it was a geocentric mode, this means that the satellite nadir pointed to the centre of the earth; later it was upgraded to geodetic.
- On the 30th of March an upgrade of the piloting software was performed due to which the Extra Backup Mode became geodetic. This means that the nadir of the spacecraft is coincident with the normal to the local tangent plane. In these conditions the nadir pointing performance should extremely improve.
- The Sun Blinding effect started to have an impact on the payload attitude already at the beginning of January 2001, when the satellite was still piloted in Mono-Gyro Mode. This effect continued to have an evident impact on the products quality until the first week of April 2001. It is caused by a malfunctioning of the Digital Earth Sensor, that, during special periods of the year and at certain orbital positions, gets blinded by the sun light. Actually, at those positions, the sensor is switched off in order to avoid failures. The occurrence of this effect is seasonally de-

pendent since it is strictly related to the earth-sun relative position. Furthermore it depends also on the piloting scheme and its behaviour with the EBM attitude control is not exactly known. Most probably the end of the Sun-Blinding impact on the data was also caused by the EBM software upgrade due to which the position of the Sun respect to the earth and consequently to the satellite, has less impact on the piloting performance.

- During the period 3rd to 6th April 2001 an On-Board Manoeuvre was performed.

4.6 Data Comparison with forecasts

Extracted from the ECMWF report on ERS-2 RA for March and April 2001, we can report the following results related to the comparison between the ERS-2 measured parameters and the ones evaluated at the ECMWF (For more information: ecmwf.alt.mar01.pdf and ecmwf.alt.apr01.pdf available at http://pcswww.esrin.esa.it/ra).

Wind Speed Comparison between the ECMWF and the ERS-2 RA wind speeds (bias):

March 2001

- Global: 1.291 m/s
- Northern Hemisphere: 0.950 m/s
- Tropics: 0.214 m/s
- Southern Hemisphere: 2.172 m/s

April 2001

- Global: 0.425 m/s
- Northern Hemisphere: 0.250 m/s
- Tropics: 0.213 m/s
- Southern Hemisphere: 0.649 m/s

Significant Wave Height Comparison between the ECMWF and the ERS-2 RA significant wave heights (bias):

March 2001

- Global: -0.037 m
- Northern Hemisphere: 0.081 m
- Tropics: -0.094 m
- Southern Hemisphere: -0.057 m

April 2001

- Global: -0.044 m
- Northern Hemisphere: 0.027 m
- Tropics: -0.074 m
- Southern Hemisphere: 0.059 m

Of particular interest the comments related to the April results:

“The quality of the received data, especially that of the wind speed in the southern emisphere, seems to be improved compared to previous months.....The Altimeter data quality seems to be as good as that before January 2001...”