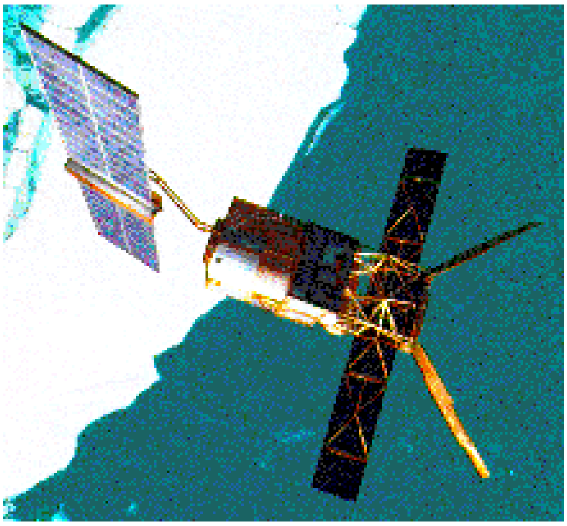
ERS-2 Radar Altimeter Cyclic Report

from 3rd April to 12th June 2000
Cycles 52 and 53



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Document No: APP-ADQ/PCS/RA00-004
Issue: 1.0
Date: 17th July 2000

Distribution List

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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 3rd April and 12th June 2000, corresponding to cycles 52 and 53.

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 cycle.

After the increasing pattern at the beginning which corresponds to the commissioning phase; in the last period the AGC Openloop Calibration values are following a decreasing pattern which can be related to instrumental ageing.

For the HTL Openloop Calibration 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. In particular, for these two cycles, no jumps in the Openloop HTL Calibration are noticeable since no anomaly occurred.

Over 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 what they did before that date. Starting from cycle 46 the amount of values following that different trend is big enough to cause the overall trend 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 starting from November the 21st 1998 the slope has assumed a value of 7.1 mm/year. This fact cannot be correlated to a particular event regarding the instrument itself; anyway it does not introduce further errors in the Radar Altimeter measurements, being the USO frequency regularly measured and the appropriated correction evaluated.

Within the single cycle time extent, the trend for all the instrument internal parameters appears to be quite stable. On the mission time scale among the parameters not affected by orbit-synchronous variation only the HPA Transmitted Power and the Helix Current show a variable behaviour. Among those parameters which do suffer of orbit-synchronous variations the temperature ones show a very slow increasing trend while the only current parameter reveals a slow decreasing drift.

The IF Filter Shape was monitored during cycle 52 and 53. This exercise showed that the changes with reference to the beginning of the mission (reference shape evaluated on 5-May-1995) were, in average, limited to ca. 0.035 dB; being the biggest variations relative to the first part of the filter bank (low filter numbers). 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. Investigations are on going in order to assess the impact of the IF Filter shape variations on the RA retrieved geophysical parameters.

During cycles 52 and 53 the Radar Altimeter off-nadir pointing continued to be monitored. It has been found that the overall mispointing time series lies around a value of 0.084 and that the change of the piloting system (ref. Cyclic Report for cycles 50 and 51, APP-ADQ/PCS/RA00-003, par. 4.6), did not have a relevant impact on it. Special investigations have been performed to assess the influence on the RA geophysical parameters and the conclusions are the following:

- The SWH has not been influenced by the change of the platform piloting system (result confirmed also by ECMWF); the impact is of -4.9 mm.
- The impact on the Range, being of -1.2 mm, can be considered negligible.
- The impact on the Sigma_0, being of 0.047 dBs, can be disregarded.

In relation to the fast delivery products analysis the following conclusions can be drawn:

- During cycle 52 all the parameters showed very good performances.
- During cycle 53 the parameters which behaviour have been worse than average are: Wet Tropospheric Correction and Blank Products.

Starting from the beginning of November 1999 the Sigma_0 and the Wind Speed have been surveyed more carefully and it has been found out that:

- On the 16th of January the Sigma_0 was affected by a decrease of about 0.2-0.3 dBs which caused the Wind Speed to increase of about 0.5 m/s. Even if it has been extensively investigated during the last period, no instrumental problem has been pin-pointed to explain the event. This allow us to identify the cause of the drop in a anomalous event regarding the antenna or the Front End Electronics which are not included in the Internal Calibration path. The value of the Fast Delivery parameters will be soon corrected with the introduction of a new Look Up Table.

2.0 Calibration Performances

The calibration measurements performed operationally for the Radar Altimeter are executed with the internal calibration technique. It is not an end-to-end absolute calibration because some elements like some ferrite circulators, waveguides and the antenna are outside the calibration path, but makes a relative calibration of time dependent variations in the instrument measurements caused by thermal variation around the orbit as well as ageing effects. There are three types of calibration measurements: The Openloop Calibration, the Scanning Point Target Response (SPTR) Calibration and the Ultra Stable Oscillator (USO) Calibration. The Openloop Calibration, is related to two parameters: the altimetric range and the received power which is then related to the normalized backscattering coefficient (Sigma_0). The Openloop Calibration is dedicated in particular to correct for the thermal orbital variation. It does anyway take into account variabilities due to instrument ageing. The SPTR and USO Calibration are performed to keep under control time-related effects on some reference parameters used in the evaluation of the altimetric range.

2.1 Openloop Calibration

2.1.1 Automatic Gain Control (AGC)

The received power in the Radar Altimeter, during nominal tracking operations, is automatically attenuated of amplified by the instrument aiming to have the best detection of the signal. In order to calibrate the value of that attenuation, a measurement is performed every minute using a special transmitted impulse called Point Target Response. In this case the impulse is not sent to the ground but, after transmission, is redirected to the receive along the calibration path. The calibration mode measures the variations of the Point Target Response power due to the internal electronics of the instrument. The attenuation or amplification of the signal is performed respect to a Reference Power defined at the beginning of the mission as described by the following formula:

$$A^F = \frac{\sum_{1}^{64} MWA(i)}{K_4}$$

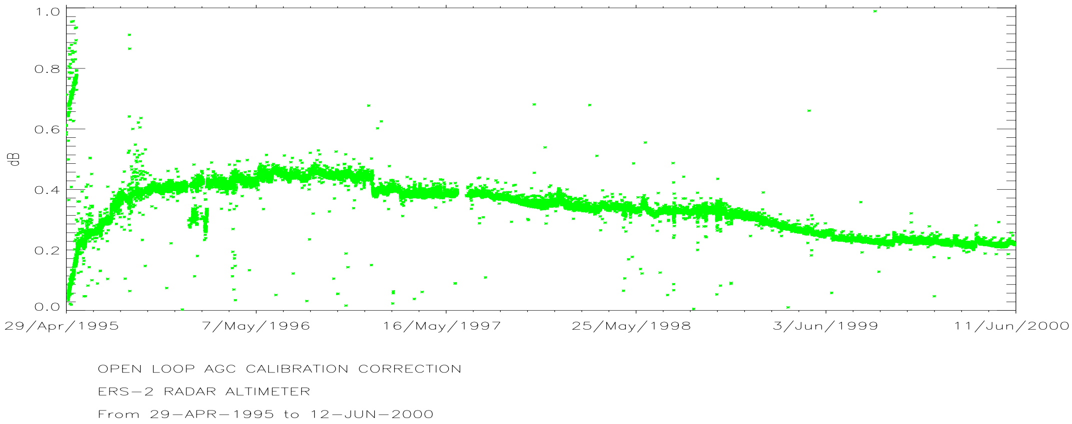
Where:

A^F: Calibration sigma_0 correction value

$MWA(i)$: Waveform Samples

K_4: Power reference value for Openloop Calibration

The values measured with this technique, after smoothing, are added to the sigma_0 measurements during the on-ground processing. 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. In the last period the AGC Openloop Calibration values are following a decreasing pattern which can be related to instrumental ageing.



2.1.2 Height Tracking Loop (HTL)

The Radar Altimeter, during nominal tracking operations, measures the time delay the transmitted impulse takes to travel to the ground and back, including the internal path. In order to calibrate the equivalent length of the internal path, a measurement is performed every minute using a special transmitted impulse called Point Target Response (PTR). In this case the impulse is not sent to the ground but, after transmission, is redirected to the receive along the calibration path. The calibration measures the variations in the delay time the Point Target Response signal takes to travel through the entire length of the calibration path; or, in other words, the variation of the calibration path equivalent length. The measurements are performed with reference to the centre of the tracking window. The overall calibration correction value is given by the following formula:

$$T^F = (N_f - 32)k_f + K_1$$

where:

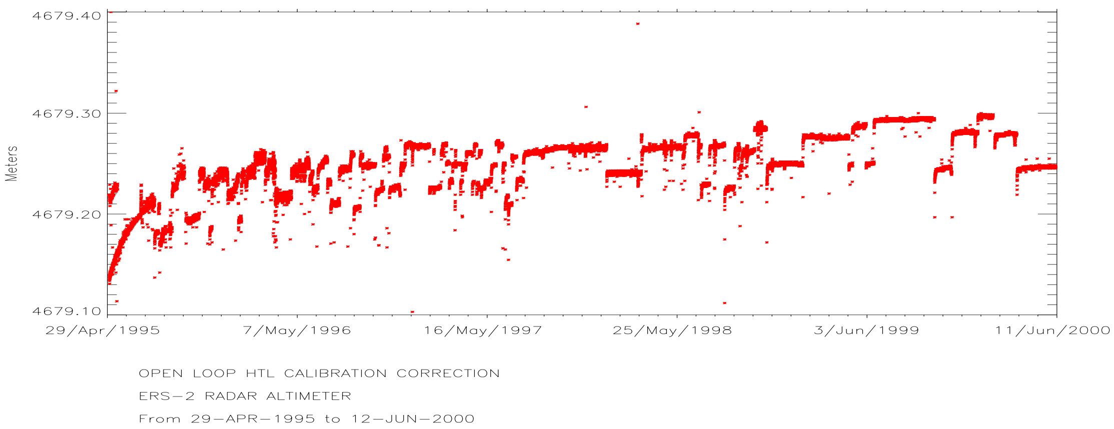
T^F: Calibration height correction value

N_f: derived centre of the Point Target response

k_f: conversion factor from filter units to time

K_1: delay time to the range window position

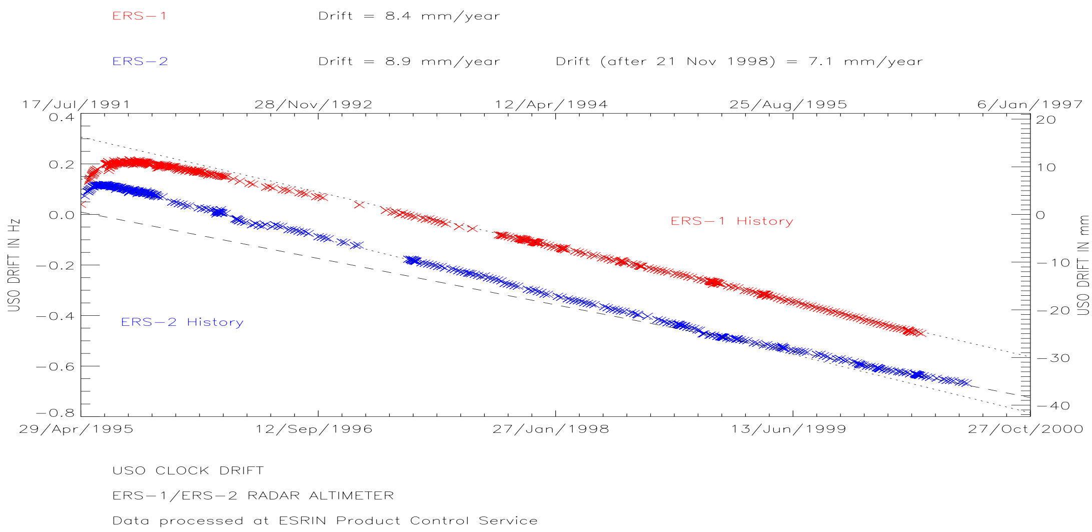
First the position of the PTR in the tracking window is determined (where the centre of the tracking window is identified by filter number 32) and then the position of the tracking window is established and added. During the openloop calibration only the position of the PTR within the tracking window is observable and the window position is assumed as know. Anyway for the calibration to be accurate, also this last parameter has to kept under control and its stability to be assessed. This can be done via the SPTR Calibration described in par. 2.3. The values measured with this technique, after smoothing, are added to the altimeter measurements during the on-ground processing. As for all the time delay measurements in the Radar Altimeter, the measurement unit for the Openloop HTL calibration is a frequency derived from the USO one. In case of instrument anomaly, the HTL measurements can show very sudden variations in their values; they are probably due to an asymmetry of the reference clock and to a variation of the equivalent length of an internal subsystem. 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. In particular, for these two cycles, no jumps in the Openloop HTL Calibration are noticeable since no anomaly occurred.



2.2 Ultra Stable Oscillator (USO)

Every time delay measurement performed by the Radar Altimeter, both in tracking and calibration modes, uses, as measurement unit, a clock frequency derived from the Ultra Stable Oscillator one. Any variation in that reference clock could cause an error the time delay measurements and consequently on the altimetric range estimation. For this reason the USO is kept under control by mean of a weekly measurement of a derived frequency, which nominal value is 15 MHz. The output of this campaign is used by ESRIN/PCS to calculate, every week, a correction value to be added to the range measurements in order account for any variation of the internal clock and so to enhance the quality of the data. 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).

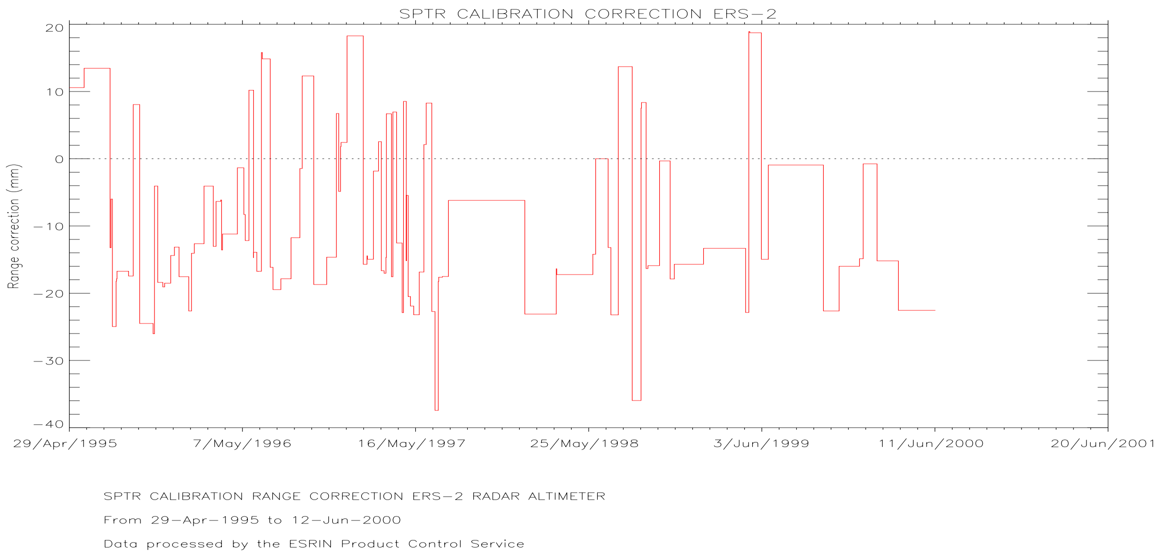
Since the beginning of the year 1999 the values of the USO frequency are likely to follow a different trend respect to whet they did before that date. Since cycle 46 we had noticed that the amount of values following that different trend was big enough to cause the overall trend passing from a negative 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 has assumed a value of 7.1 mm/year. 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.



2.3 Scanning Point Target Response (SPTR)

During the Radar Altimeter operations all the time delay measurements are performed calculating the position of the received echo within the tracking window with reference to its centre. The range value equivalent to the tracking window centre has been evaluated prior to launch and was considered to be stable. After launch it has been noticed that value was not stable, on the contrary, it was affected by abrupt changes in correspondence to instrument anomalies. The original value is anyway still used as reference for the time delay measurements both in tracking and calibration modes. The cause of those jumps has been identified in an internal clock asymmetry; in order to determine the position of the tracking window centre, correcting for the clock asymmetry effects, a dedicated Scanning Point Target Response campaign is performed every day. The basic concept for the measurement campaign is the study of the positions, within the tracking window, of different PTR related to different trigger positions. Every day, the output of this campaign is used by ESRIN/PCS to calculate a range correction value which takes into account the discrepancies between the operationally used tracking window position values and the measured one. Those correction values have to be added to the range measurements in order to improve the quality of the data. The campaign was previously performed every three days and it could happen that two subsequent anomalies occur without that an SPTR campaign was performed. Knowing that the position of the tracking window is affected by abrupt changes related to instrument anomalies, in the period between the two anomalies it would not have been possible to determine the exact position.

The SPTR correction values history is reported in the following picture 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. During cycles 52 and 53 the instrument did not suffer of any anomaly, indeed no jump is visible during this period of time.



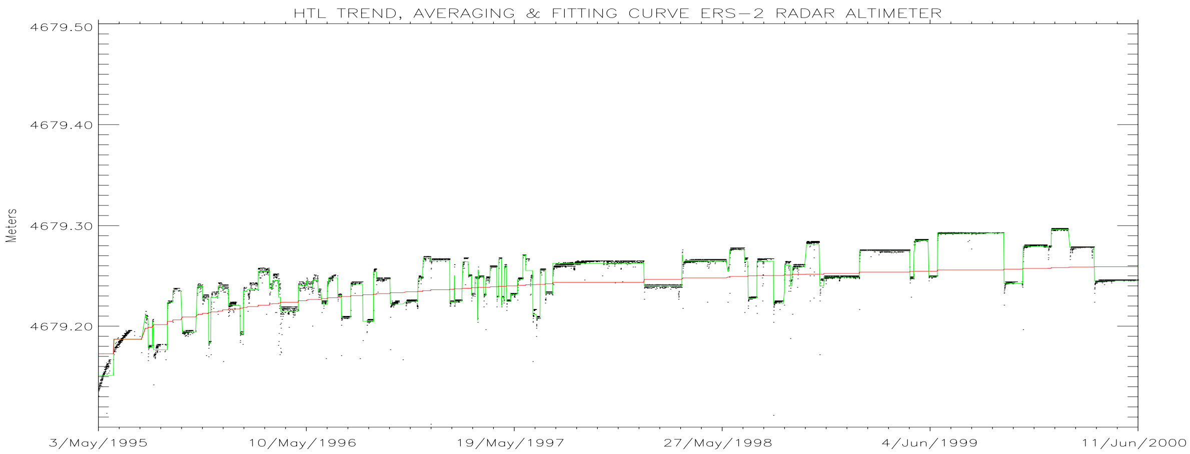
2.3.1 SPTR and HTL Openloop Calibration Corrections Correlation

Observing the plots related to the SPTR and the HTL Openloop Calibration corrections trends, both affected by jumps in their values in correspondence to instrument anomalies; it would be reasonable to think that the values of the two corrections could be in some way correlated. This idea could be furthermore supported by the fact that the techniques the two calibrations are implemented with are very similar, both basing on the measurement of the Point Target Response internal delay.

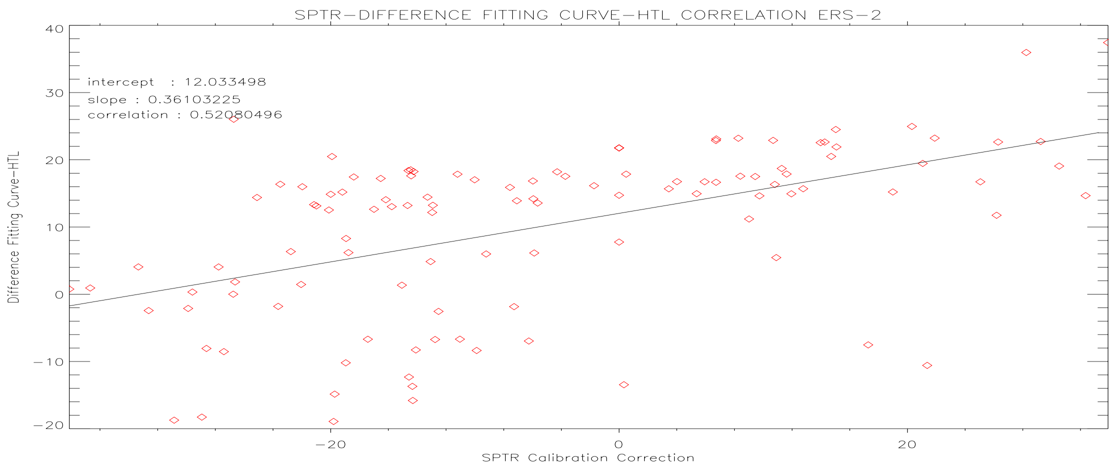
Considering that the SPTR calibration is aimed to correct for the abrupt changes in the tracking window centre position which is the reference for the HTL Openloop calibration and supposing that the HTL Openloop calibration would follow a logarithmic trend when not affected by jumps; the following algorithm was implemented. For each interval between two instrument anomalies (inter-anomaly period), a differential value was calculated between the theoretical HTL logarithmic trend and the average over that period of the real HTL Openloop calibration series. That value was then correlated with the corresponding SPTR correction one.

Hereafter, in the first plot, the HTL Openloop calibration trend, its average over every inter-anomaly period and the theoretical logarithmic behaviour are plotted. Only HTL Openloop calibration values lower than the median over every inter-anomaly period have been considered in order to eliminate the influence of the high HTL variability. The scatter plot between the just described differential values and the corresponding SPTR correction values is reported in the second figure.

The low correlation coefficient value and the scatter plot itself reveal that the expected correlation is not in practice realised. The knowledge of the instrument and the calibrations techniques can explain the evidence as follows. Even if both the SPTR and HTL Openloop calibrations are effected by the clock asymmetry which causes a certain similarity in the their behaviours, the HTL Openloop calibration is affected by a secondary effect, also happening in correspondence to instrument anomalies, which causes the numerical uncorrelation. The secondary effect just mentioned can be identified in the delay line equivalent length variation due to the internal temperature change often associated with instrument anomalies.



HTL TREND, AVERAGING & FITTING CURVE ERS-2 RADAR ALTIMETER
From 29-APR-1995 to 12-JUN-2000
Data processed by the ESRIN Product Control Service



SPTR-DIFFERENCE FITTING CURVE-HTL CORRELATION ERS-2 RADAR ALTIMETER
From 29-APR-1995 to 12-Jun-2000
Data processed by the ESRIN Product Control Service

3.0 Instrument performance

The instrument performances are assessed monitoring the following parameters:

- Acquisition Percentage: the percentage of products in Acquisition Mode both for cycles 52-53 and since the beginning of the mission. It is useful to determine the capability of the instrument in performing meaningful measurements.
- Internal Instrument Parameters for cycles 52 and 53. They are important to keep track of the status of every subsystem internal to the instrument, try to establish correlation with eventual variations in the measured quantities (e.g. Range, Sigma_0 and Significant Wave Height) and with instrument malfunctioning.
- IF Filter Shape for cycles 52-53 and trend of the difference respect to the shape the IF Filter had at the beginning of the mission (e.g. on the 5^{th} of May 1995). This is important in order to monitor if and how the waveforms are distorted by this component inside the instrument and if how distortions have been changing during the mission lifetime.
- Off-nadir pointing trend since the beginning of the mission. This is important in order to asses if the RA antenna really points at nadir being this one the of the main requirements for all the RA data processing.

3.1 Acquisition Percentage

During nominal operations the Radar Altimeter works alternatively in Acquisition and Tracking Modes. In Acquisition Mode the instruments adjust cyclically its internal parameters in order to reach the best reception of the backscattered echo. In this mode the instrument cannot perform any meaningful measurement. When the internal parameters are set to their optimum values for the best reception of the echo in those particular conditions, the instrument switches automatically to Tracking Mode. In Tracking Mode the instrument can perform meaningful measurements. A change in the environment the instrument is flying over (in particular the slope of the terrain) cause the instrument to adjust again its internal parameters to obtain the best reception. If it is able to perform the adjustment without switching again to Acquisition Mode, we can affirm that the instrument “maintains the lock” with the backscattered signal; the most the instrument stays in Tracking Mode, the better its performances can be considered. Considered the working concept just described, it easily to understand that zones characterised by high terrain slope variations (like mountainous and coastal zones) cause the instrument to loose the lock and consequently force him to work in Acquisition Mode for an high percentage of time. The amount of ocean products in Acquisition and Tracking Modes for cycles 52 and 53 is reported in the following pictures together with the percentage of products in Acquisition Mode respect to the total. The percentage of products in Acquisition Mode is, in general, lower than the one reported for any other cycle previous cycle 41. The values of that parameter during, for example, cycle 40, were, in average, lying around 1.95% (in previous reports the value 1.8% had been reported but a more accurate observation allows us to affirm that a higher value is more appropriate); in this case the values lye around 1.6%. This is 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 can be noticed also in the Tracking Performance Trend since the beginning of the mission plotted subsequently. 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.

DAY	ACQUISITION Number	TRACKING Number	ACQUISITION Percentage(%)
03-APR-2000	874	54599	1.575
04-APR-2000	954	63306	1.484
05-APR-2000	1045	60212	1.705
06-APR-2000	845	58120	1.433
07-APR-2000	1021	64051	1.569
08-APR-2000	1061	58308	1.787
09-APR-2000	825	58663	1.386
10-APR-2000	427	30426	1.383
11-APR-2000	592	30303	1.916
12-APR-2000	492	27478	1.759
13-APR-2000	904	59094	1.506
14-APR-2000	1167	62986	1.819
15-APR-2000	970	60359	1.581
16-APR-2000	986	58783	1.649
17-APR-2000	1007	63302	1.565
18-APR-2000	1042	60576	1.691
19-APR-2000	945	58373	1.593
20-APR-2000	943	63404	1.465
21-APR-2000	1063	59349	1.759
22-APR-2000	857	58004	1.455
23-APR-2000	1000	63976	1.539
24-APR-2000	1087	58432	1.826
25-APR-2000	885	58576	1.488
26-APR-2000	934	59315	1.550
27-APR-2000	1095	62940	1.710
28-APR-2000	945	59521	1.562
29-APR-2000	972	59101	1.618
30-APR-2000	1123	63191	1.746
01-MAY-2000	989	60285	1.614
02-MAY-2000	986	58897	1.646
03-MAY-2000	997	59095	1.659
04-MAY-2000	959	55901	1.686
05-MAY-2000	957	58581	1.607
06-MAY-2000	986	63393	1.531
07-MAY-2000	1111	64106	1.703

TRACKER PERFORMANCE

ERS-2 RADAR ALTIMETER/CYCLE 52

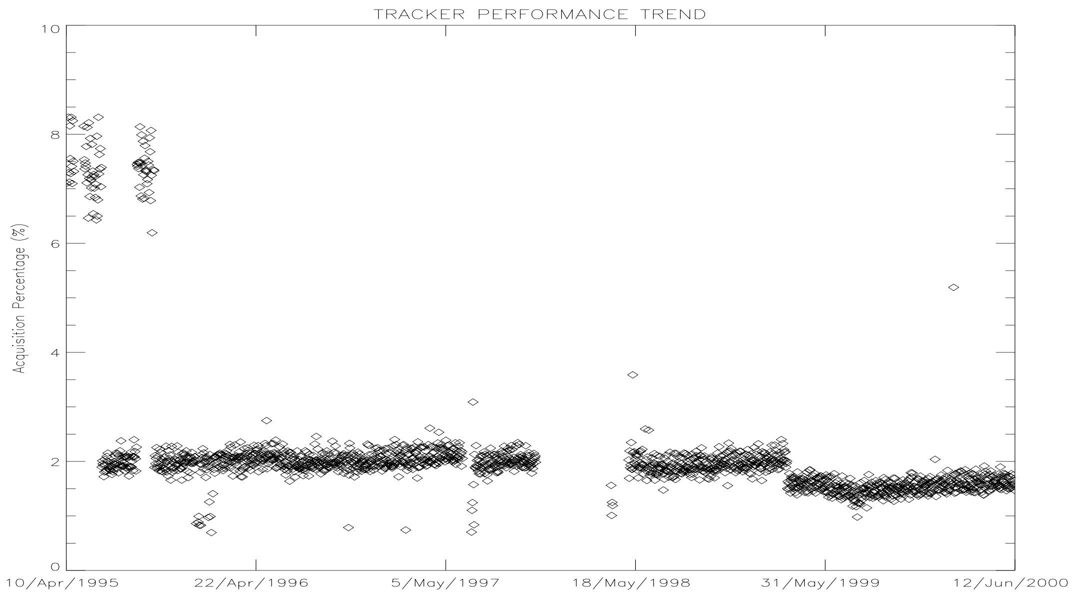
From 03-Apr-2000 to 08-May-2000

DAY	ACQUISITION Number	TRACKING Number	ACQUISITION Percentage(%)
08-MAY-2000	875	54944	1.567
09-MAY-2000	974	62255	1.540
10-MAY-2000	1084	60169	1.769
11-MAY-2000	900	59207	1.497
12-MAY-2000	1016	63924	1.564
13-MAY-2000	1118	57771	1.898
14-MAY-2000	933	60234	1.525
15-MAY-2000	891	59194	1.482
16-MAY-2000	1097	62548	1.723
17-MAY-2000	1025	60692	1.660
18-MAY-2000	948	59033	1.580
19-MAY-2000	1131	62436	1.779
20-MAY-2000	1012	60952	1.633
21-MAY-2000	1039	59215	1.724
22-MAY-2000	1032	63130	1.608
23-MAY-2000	1085	60287	1.767
24-MAY-2000	953	59671	1.571
25-MAY-2000	942	63423	1.463
26-MAY-2000	1054	60617	1.709
27-MAY-2000	880	57492	1.507
28-MAY-2000	1015	63811	1.565
29-MAY-2000	1088	61461	1.739
30-MAY-2000	891	58744	1.494
31-MAY-2000	946	59307	1.570
01-JUN-2000	1093	62368	1.722
02-JUN-2000	1078	70688	1.502
03-JUN-2000	913	59179	1.519
04-JUN-2000	1131	62584	1.775
05-JUN-2000	1007	60853	1.627
06-JUN-2000	1013	63465	1.571
07-JUN-2000	1015	62724	1.592
08-JUN-2000	1084	60790	1.751
09-JUN-2000	943	58863	1.576
10-JUN-2000	947	63372	1.472
11-JUN-2000	1017	60663	1.648

TRACKER PERFORMANCE

ERS-2 RADAR ALTIMETER/CYCLE 53

From 08-May-2000 to 12-Jun-2000



3.2 Internal Instrument Parameters

During nominal operations several engineering parameters characterizing many of the instrument subsystems are constantly measured and transmitted to the ground. The parameters are measured with a frequency of one sample every 16 seconds and mainly consist of power, current, voltage and temperature at different points inside the instrument. They are useful in order to have a better insight of the behaviour of the instrument and can be used to identify eventual malfunctioning or anomalous functioning.

3.2.1 Internal Instrument Parameters Trends

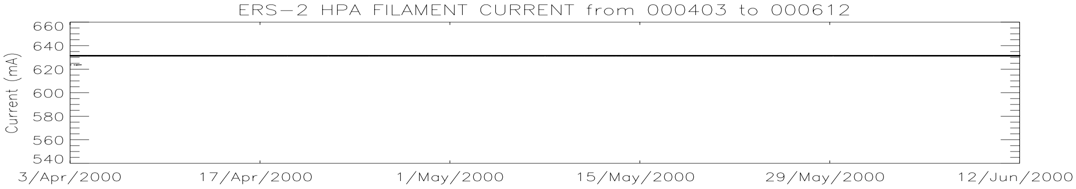
For detailed information on the internal instrument parameters long term trends: http://ersmon-rp.esoc.esa.de/

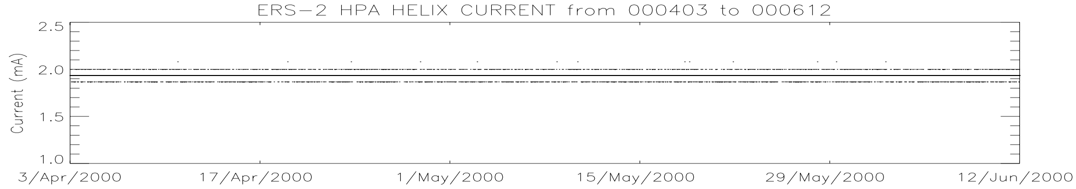
The internal instrument parameters can be subdivided into two categories:

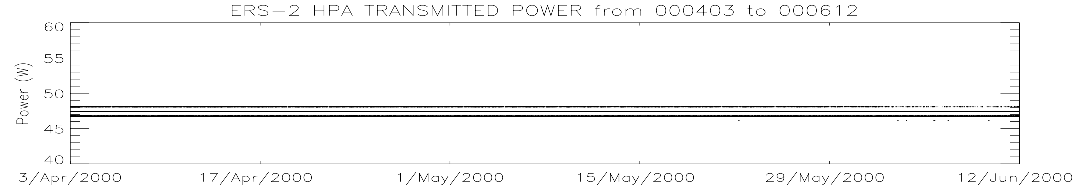
- Parameters not influenced by the temperature outside the instrument thus not presenting variations synchronous with the orbit. They are plotted in the following pictures where all the values (one every 16 seconds) are displayed and the discrimination due to the quantization is easy to notice.

  The trend for all the parameters appears to be quite stable.

  The only parameters showing variations over the mission time scale 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.


ERS−2 HPA FILAMENT CURRENT from 000403 to 000612
Current (mA)
660
640
620
600
580
560
540
3/Apr/2000
17/Apr/2000
1/May/2000
15/May/2000
29/May/2000
12/Jun/2000


ERS−2 HPA HELIX CURRENT from 000403 to 000612
Current (mA)
2.5
2.0
1.5
1.0
3/Apr/2000
17/Apr/2000
1/May/2000
15/May/2000
29/May/2000
12/Jun/2000


ERS−2 HPA TRANSMITTED POWER from 000403 to 000612
Power (W)
60
55
50
45
40
3/Apr/2000
17/Apr/2000
1/May/2000
15/May/2000
29/May/2000
12/Jun/2000


ERS−2 MWA VOLTAGE 2 from 000403 to 000612
Voltage (V)
−4.0
−4.5
−5.0
−5.5
−6.0
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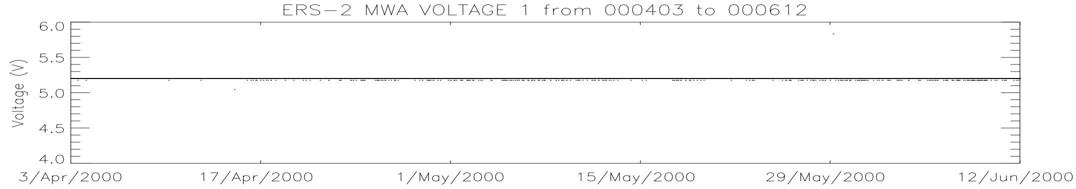
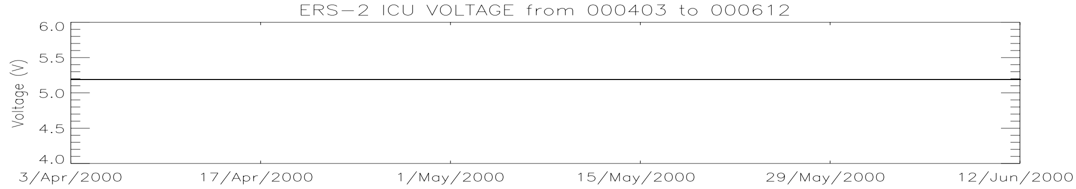
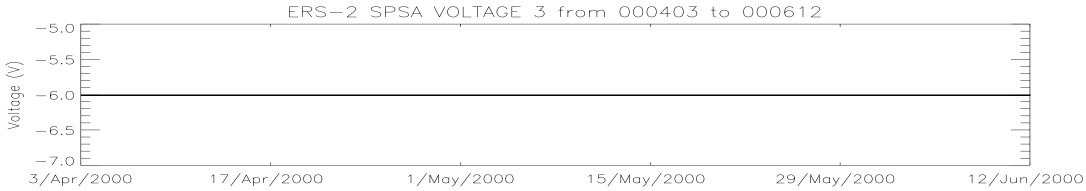
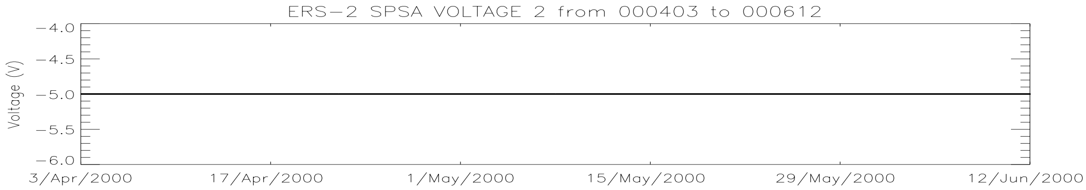
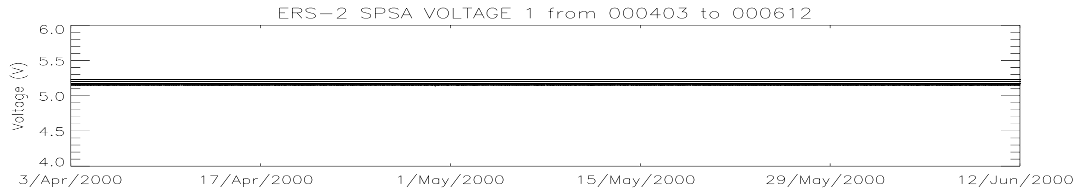
1/May/2000
15/May/2000
29/May/2000
12/Jun/2000

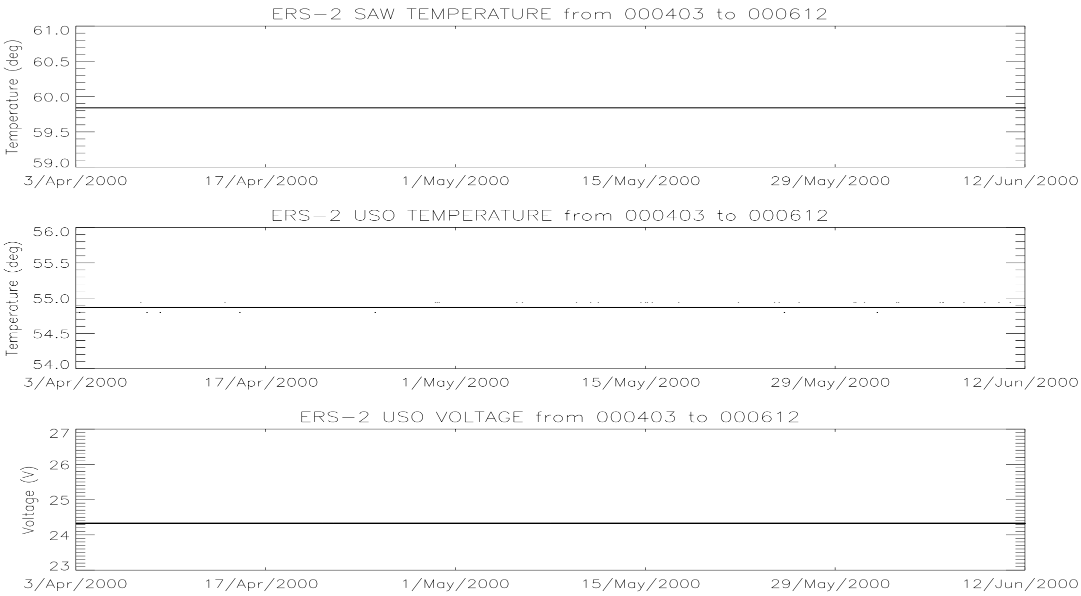

ERS−2 MWA VOLTAGE 1 from 000403 to 000612
Voltage (V)
6.0
5.5
5.0
4.5
4.0
3/Apr/2000
17/Apr/2000
1/May/2000
15/May/2000
29/May/2000
12/Jun/2000


ERS−2 ICU VOLTAGE from 000403 to 000612
Voltage (V)
6.0
5.5
5.0
4.5
4.0
3/Apr/2000
17/Apr/2000
1/May/2000
15/May/2000
29/May/2000
12/Jun/2000


ERS−2 SPSA VOLTAGE 3 from 000403 to 000612
Voltage (V)
−5.0
−5.5
−6.0
−6.5
−7.0
3/Apr/2000
17/Apr/2000
1/May/2000
15/May/2000
29/May/2000
12/Jun/2000


ERS−2 SPSA VOLTAGE 2 from 000403 to 000612
Voltage (V)
−4.0
−4.5
−5.0
−5.5
−6.0
3/Apr/2000
17/Apr/2000
1/May/2000
15/May/2000
29/May/2000
12/Jun/2000

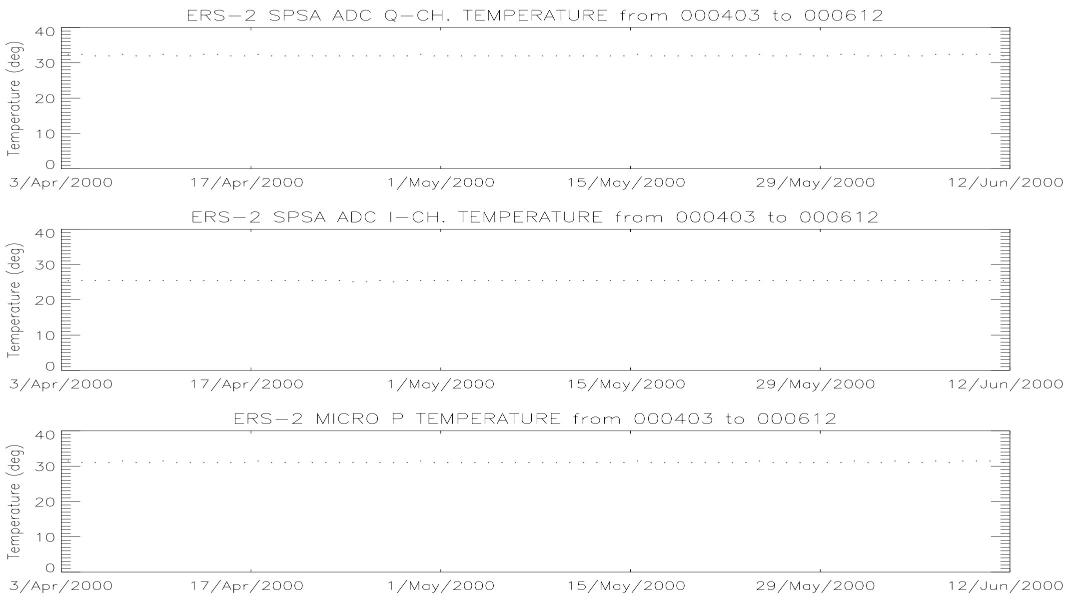

ERS−2 SPSA VOLTAGE 1 from 000403 to 000612
Voltage (V)
6.0
5.5
5.0
4.5
4.0
3/Apr/2000
17/Apr/2000
1/May/2000
15/May/2000
29/May/2000
12/Jun/2000

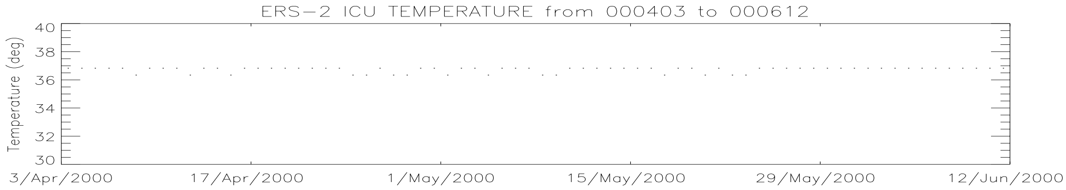


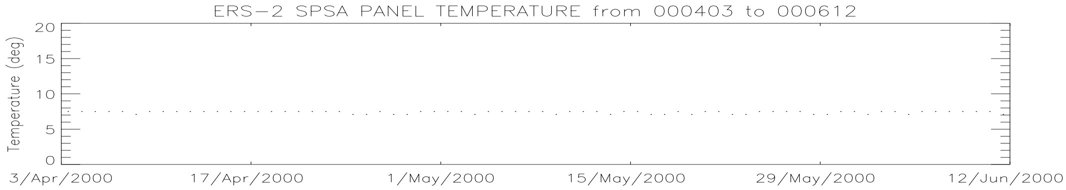
- Parameters influenced by the temperature outside the instrument thus presenting variations synchronous with the orbit. They are displayed in the following pictures after the daily mean has been calculated.

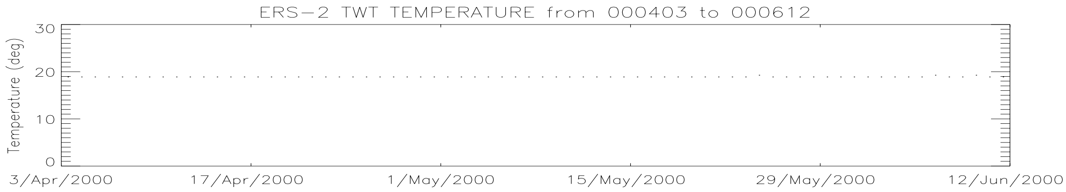
  Within few cycles time extent, the trends for all the parameters are quite stable; the most of them even maintain the same value during the whole period. An exception to this is given by the ICU temperature which shows, in the daily average, variations up to one degree. Most probably the actual variation inside the instrument is not so significant. The more substantial one degree variation noticeable in the plot is, possibly, due to the quantization of the telemetry measurements and the way they are transformed from binary into engineering values.

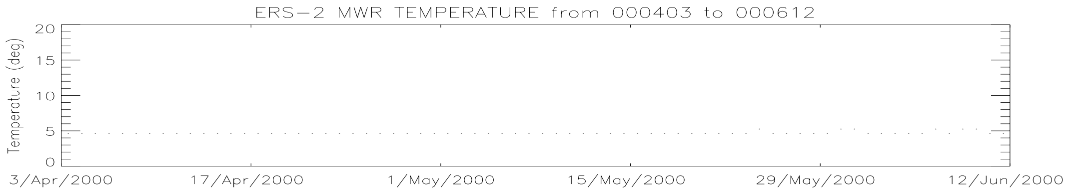
  On the other hand, considering the whole mission period, the temperature parameters hereafter reported show a very slow increasing trend which makes the values being from 4% to 6% higher than they were after the commissioning phase. The only current parameter shows a slow decreasing trend of the same magnitude.

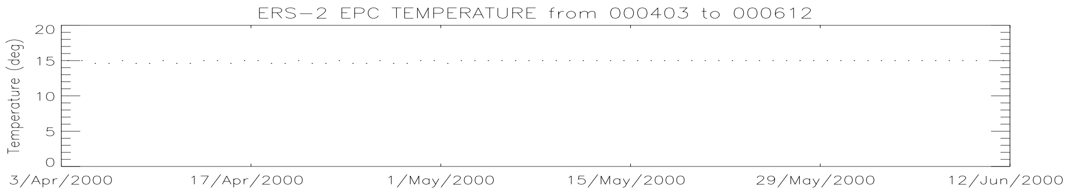


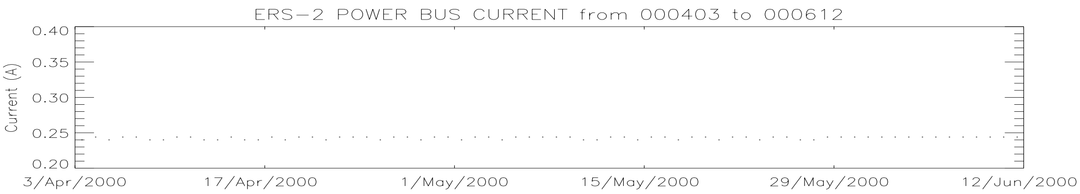

ERS−2 ICU TEMPERATURE from 000403 to 000612
Temperature (deg)
40 38 36 34 32 30
3/Apr/2000 17/Apr/2000 1/May/2000 15/May/2000 29/May/2000 12/Jun/2000

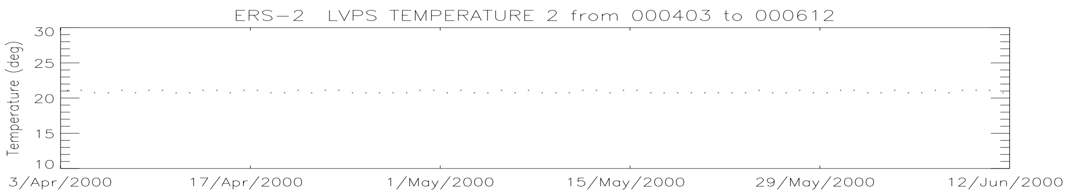

ERS−2 SPSA PANEL TEMPERATURE from 000403 to 000612
Temperature (deg)
20 15 10 5 0
3/Apr/2000 17/Apr/2000 1/May/2000 15/May/2000 29/May/2000 12/Jun/2000

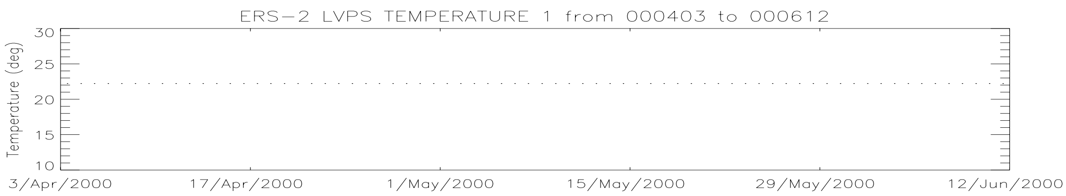

ERS−2 TWT TEMPERATURE from 000403 to 000612
Temperature (deg)
30 20 10 0
3/Apr/2000 17/Apr/2000 1/May/2000 15/May/2000 29/May/2000 12/Jun/2000


ERS−2 MWR TEMPERATURE from 000403 to 000612
Temperature (deg)
20 15 10 5 0
3/Apr/2000 17/Apr/2000 1/May/2000 15/May/2000 29/May/2000 12/Jun/2000


ERS−2 EPC TEMPERATURE from 000403 to 000612
Temperature (deg)
20 15 10 5 0
3/Apr/2000 17/Apr/2000 1/May/2000 15/May/2000 29/May/2000 12/Jun/2000


ERS−2 POWER BUS CURRENT from 000403 to 000612
Current (A)
0.40 0.35 0.30 0.25 0.20
3/Apr/2000 17/Apr/2000 1/May/2000 15/May/2000 29/May/2000 12/Jun/2000


ERS−2 LVPS TEMPERATURE 2 from 000403 to 000612
Temperature (deg)
30 25 20 15 10
3/Apr/2000 17/Apr/2000 1/May/2000 15/May/2000 29/May/2000 12/Jun/2000


ERS−2 LVPS TEMPERATURE 1 from 000403 to 000612
Temperature (deg)
30 25 20 15 10
3/Apr/2000 17/Apr/2000 1/May/2000 15/May/2000 29/May/2000 12/Jun/2000

3.2.2 Internal Instrument Parameters and Instrument Anomalies

The internal instrument parameters are very useful in controlling the status of the instrument especially in case of instrument anomalies. They allow a better understanding of its behaviour during the different phases of the operational status recovery and help to identify the different types of anomalies occurred.

During cycles 52 and 53 no instrument anomaly occurred. The table hereafter reports the date and a short explanation for every of them (in case they are present), if known at the time of the report. The information is made available at ESRIN/PCS by the ERS Mission Control Centre at ESOC.

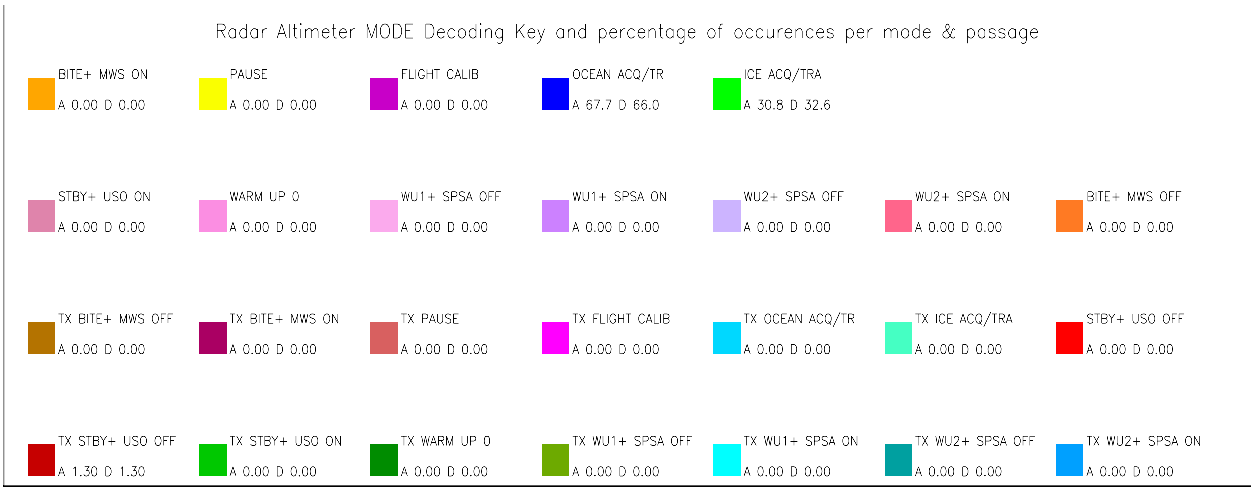
Table 1: Anomalies occurred during cycles 52 and 53

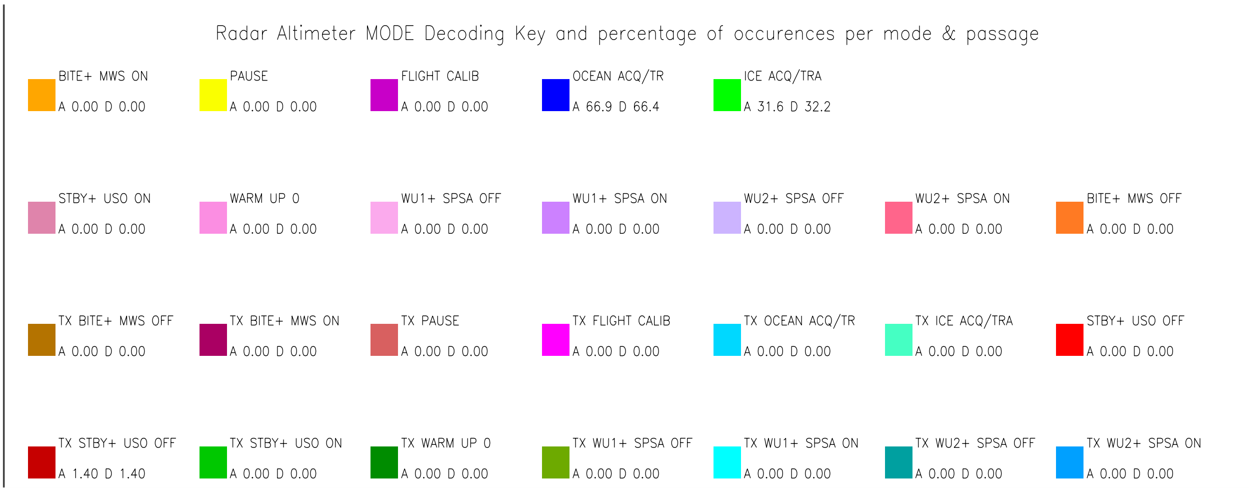
Anomaly	Reason

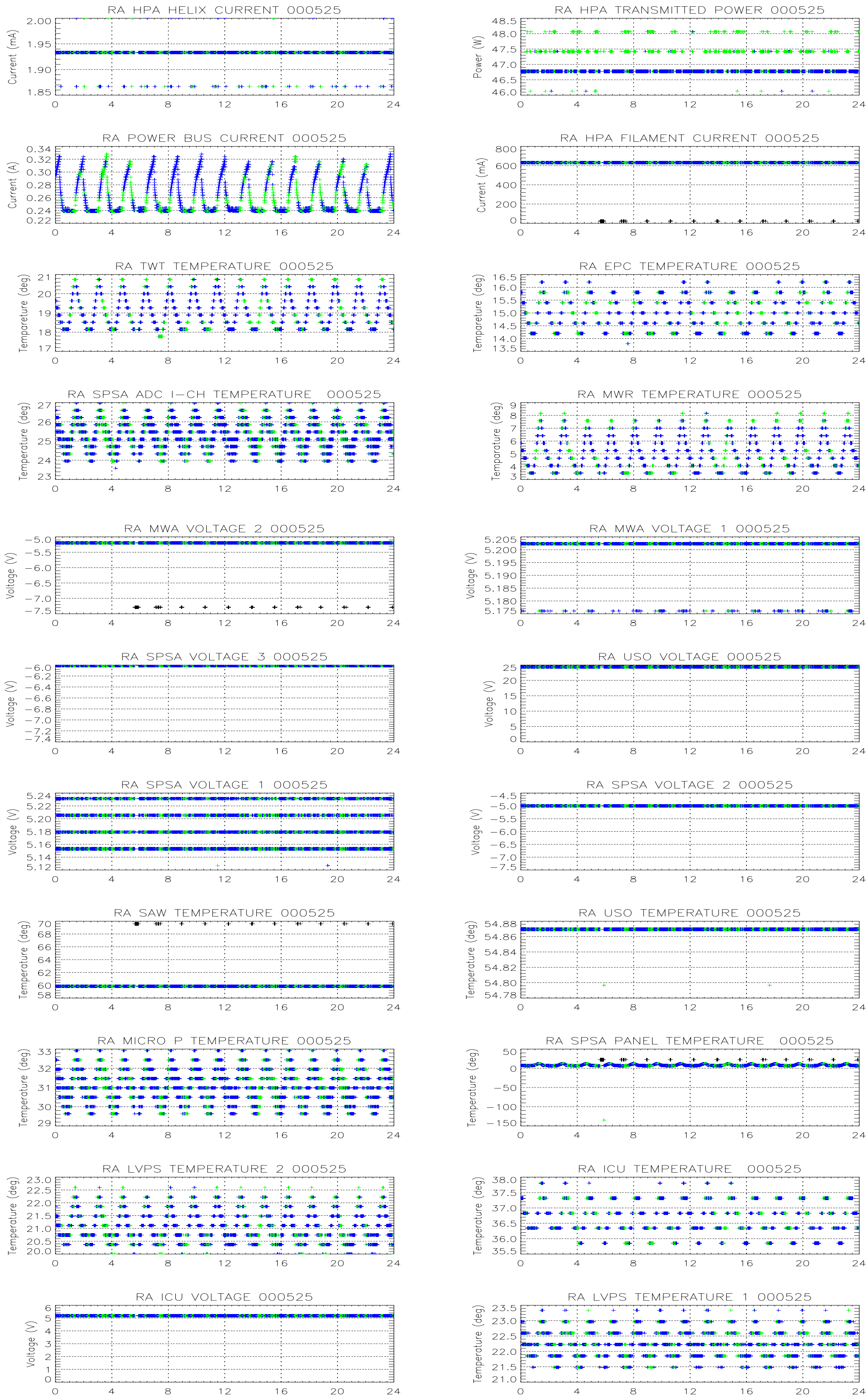
In the following pictures all the internal instrument parameters are plotted for day May the 25th. For every plot all the values of the parameters (one every 16 seconds) are displayed together with the relative instrument mode (represented by the colours). In some cases the parameters values were not 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.

During nominal operations the instrument works alternatively in Ocean and Ice mode. Depending on the type of anomaly, when an anomaly occurs, sometimes the instrumental parameters are not recorded sometimes they are. Anyway during the anomaly, or just after it, the instrument switches to one of the not nominal modes like Stand By USO Off/On, Stand By SPSA Off/On recovering to the operational working modes via some of the following ones: Warm Up 0, Warm Up 1, Warm Up 2. During cycles 52 and 53 there is no example of this since the instrument did not suffer os any anomaly.

Hereafter the legend relative to the following pictures is reported showing all the possible instrument modes for the Radar Altimeter. The percentages of every mode occurred during cycles 52 (in the first table) and 53 (in the second table) are also reported.


Radar Altimeter MODE Decoding Key and percentage of occurences per mode & passage
BITE+ MWS ON
A 0.00 D 0.00
PAUSE
A 0.00 D 0.00
FLIGHT CALIB
A 0.00 D 0.00
OCEAN ACQ/TR
A 67.7 D 66.0
ICE ACQ/TRA
A 30.8 D 32.6
STBY+ USO ON
A 0.00 D 0.00
WARM UP 0
A 0.00 D 0.00
WU1+ SPSA OFF
A 0.00 D 0.00
WU1+ SPSA ON
A 0.00 D 0.00
WU2+ SPSA OFF
A 0.00 D 0.00
WU2+ SPSA ON
A 0.00 D 0.00
BITE+ MWS OFF
A 0.00 D 0.00
TX BITE+ MWS OFF
A 0.00 D 0.00
TX BITE+ MWS ON
A 0.00 D 0.00
TX PAUSE
A 0.00 D 0.00
TX FLIGHT CALIB
A 0.00 D 0.00
TX OCEAN ACQ/TR
A 0.00 D 0.00
TX ICE ACQ/TRA
A 0.00 D 0.00
STBY+ USO OFF
A 0.00 D 0.00
TX STBY+ USO OFF
A 1.30 D 1.30
TX STBY+ USO ON
A 0.00 D 0.00
TX WARM UP 0
A 0.00 D 0.00
TX WU1+ SPSA OFF
A 0.00 D 0.00
TX WU1+ SPSA ON
A 0.00 D 0.00
TX WU2+ SPSA OFF
A 0.00 D 0.00
TX WU2+ SPSA ON
A 0.00 D 0.00


Radar Altimeter MODE Decoding Key and percentage of occurences per mode & passage
BITE+ MWS ON
A 0.00 D 0.00
PAUSE
A 0.00 D 0.00
FLIGHT CALIB
A 0.00 D 0.00
OCEAN ACQ/TR
A 66.9 D 66.4
ICE ACQ/TRA
A 31.6 D 32.2
STBY+ USO ON
A 0.00 D 0.00
WARM UP 0
A 0.00 D 0.00
WU1+ SPSA OFF
A 0.00 D 0.00
WU1+ SPSA ON
A 0.00 D 0.00
WU2+ SPSA OFF
A 0.00 D 0.00
WU2+ SPSA ON
A 0.00 D 0.00
BITE+ MWS OFF
A 0.00 D 0.00
TX BITE+ MWS OFF
A 0.00 D 0.00
TX BITE+ MWS ON
A 0.00 D 0.00
TX PAUSE
A 0.00 D 0.00
TX FLIGHT CALIB
A 0.00 D 0.00
TX OCEAN ACQ/TR
A 0.00 D 0.00
TX ICE ACQ/TRA
A 0.00 D 0.00
STBY+ USO OFF
A 0.00 D 0.00
TX STBY+ USO OFF
A 1.40 D 1.40
TX STBY+ USO ON
A 0.00 D 0.00
TX WARM UP 0
A 0.00 D 0.00
TX WU1+ SPSA OFF
A 0.00 D 0.00
TX WU1+ SPSA ON
A 0.00 D 0.00
TX WU2+ SPSA OFF
A 0.00 D 0.00
TX WU2+ SPSA ON
A 0.00 D 0.00

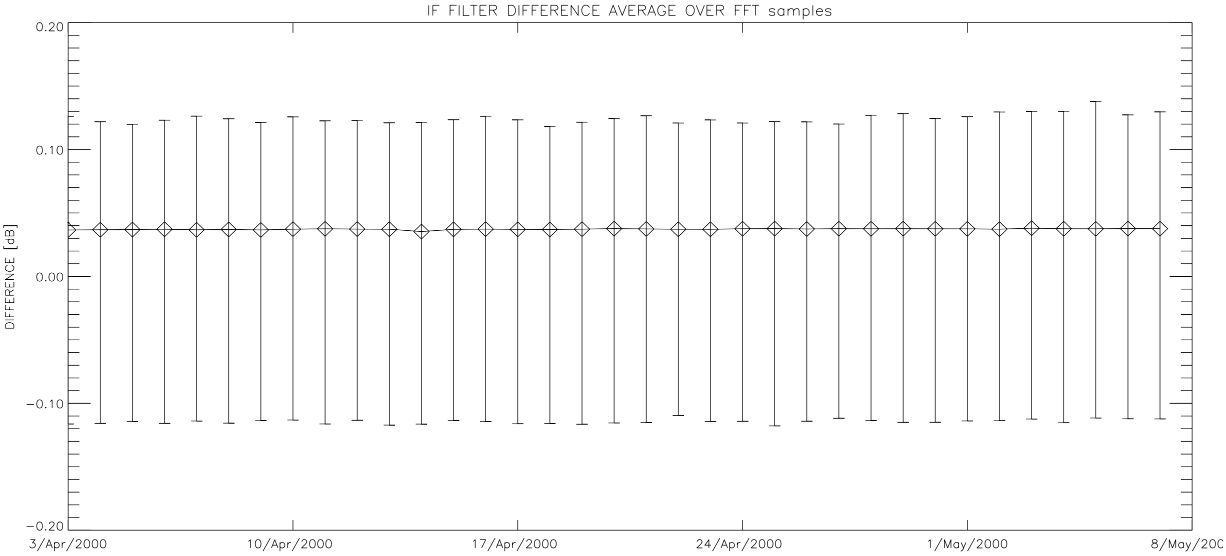

RA HPA HELIX CURRENT 000525
RA HPA TRANSMITTED POWER 000525
RA POWER BUS CURRENT 000525
RA HPA FILAMENT CURRENT 000525
RA TWT TEMPERATURE 000525
RA EPC TEMPERATURE 000525
RA SPSA ADC I-CH TEMPERATURE 000525
RA MWR TEMPERATURE 000525
RA MWA VOLTAGE 2 000525
RA MWA VOLTAGE 1 000525
RA SPSA VOLTAGE 3 000525
RA USO VOLTAGE 000525
RA SPSA VOLTAGE 1 000525
RA SPSA VOLTAGE 2 000525
RA SAW TEMPERATURE 000525
RA USO TEMPERATURE 000525
RA MICRO P TEMPERATURE 000525
RA SPSA PANEL TEMPERATURE 000525
RA LVPS TEMPERATURE 2 000525
RA ICU TEMPERATURE 000525
RA ICU VOLTAGE 000525
RA LVPS TEMPERATURE 1 000525

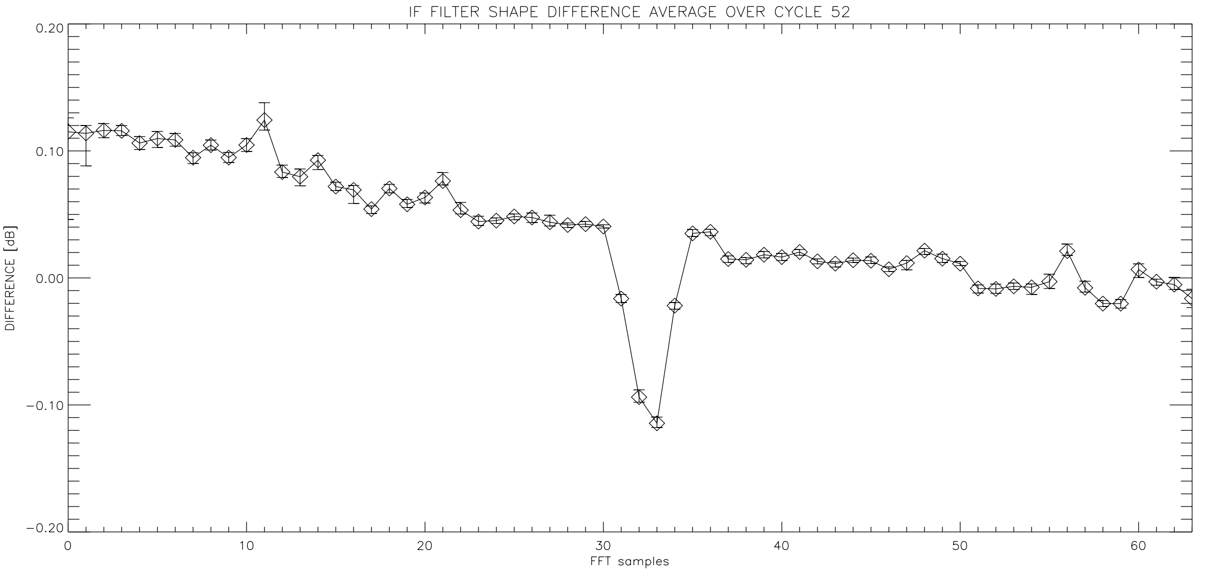
3.3 IF Filter Shape

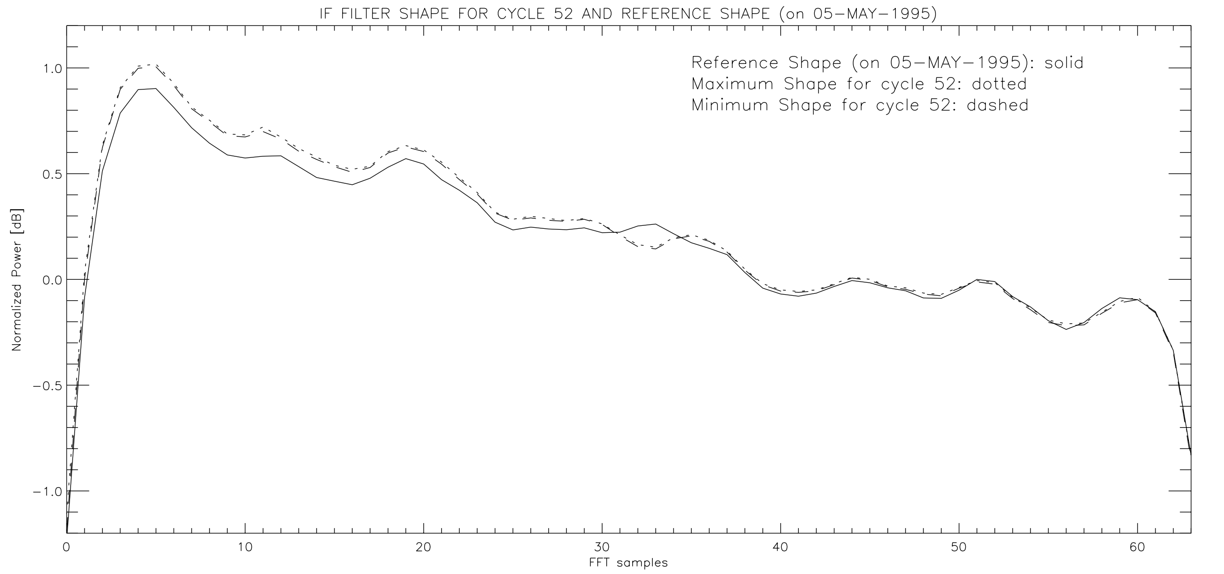
Within the microwave section of the receiver, the Intermediate Frequency filter plays a very important role. After being deramped and downconverted to intermediate frequency, the return signal is filtered in order to remove spurious components. The IF filter is made using a SAW device and has a bandwidth of 3.2 MHz. The characteristics of this filter have a very critical role since they can introduce distortions in the signal, which affect the waveform shape as it is seen within the filter bank. It is easy to understand that, since the retrieval of the geophysical parameters is based on the waveform shape, especially in case of application of retracking algorithms; the waveform should not be distorted by instrumental effects. In any case, the distortions on the signal, due to instrumental effects such as the IF filtering, have to be known and corrected. The impulse response of the filter has been retrieved making use of the Scanning Point Target Response calibration data in ice mode. This operation mode allows to perform a sort of sampling of the IF filter shape in the frequency domain. Using a spline function a more smoothed shape can be reconstructed in order to evaluate the filter attenuation on the signal for any position within the filter bank.

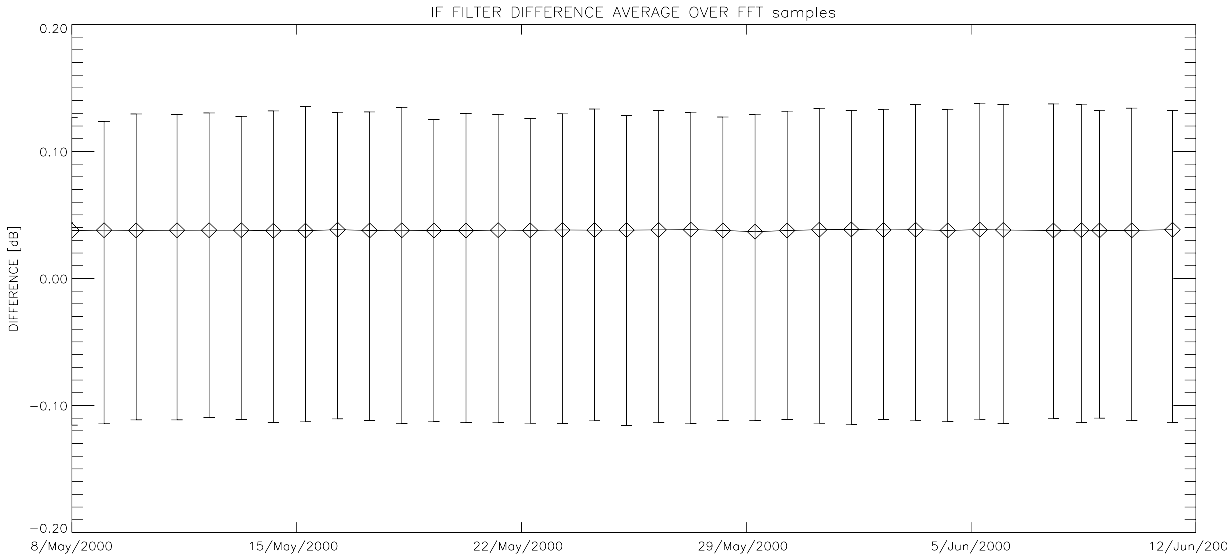
The first two pictures reported hereafter give a vision of the IF Filter Shape behaviour respectively for cycles 52 and 53.

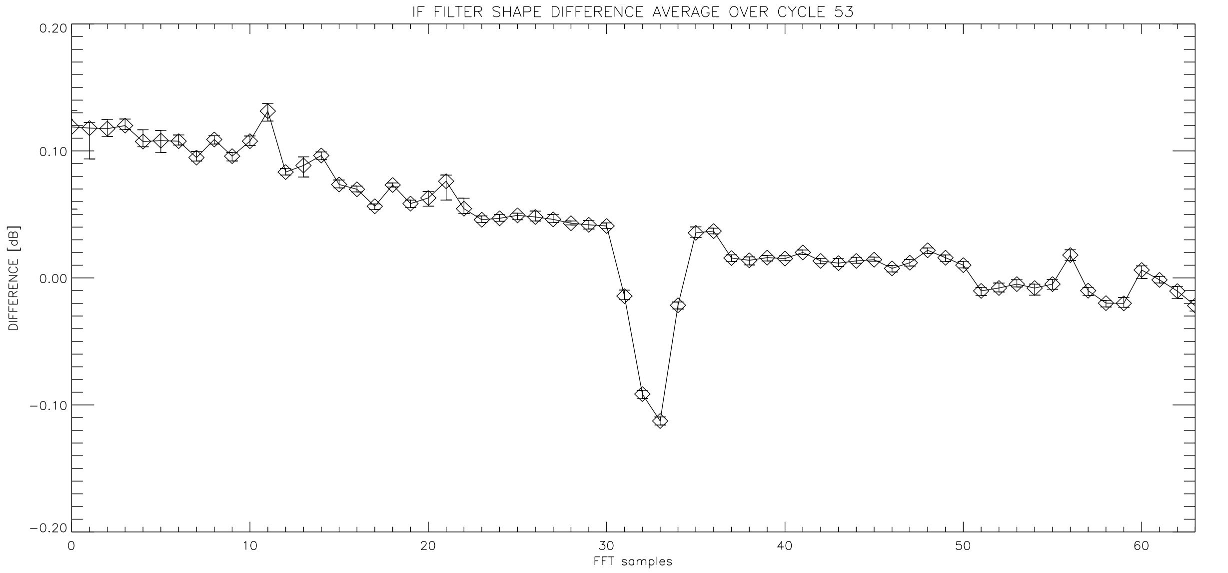
- The IF Filter Shape reported in the lowest panel of either picture is the filter impulse response power spectum normalised to the average integrated power in the filters range 30 to 59. The middle panel represents the difference between the IF Filter Shape of the corresponding cycle (either 52 or 53) respect that evaluated on the 5^{th} 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, in average, limited to ca. 0.035 dBs being the biggest variations relative to the first part of the filter bank (low filter numbers). This fact should insures 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, as mentioned subsequently, the different behaviour of the low and high filter numbers has been demonstrated to affect the performances

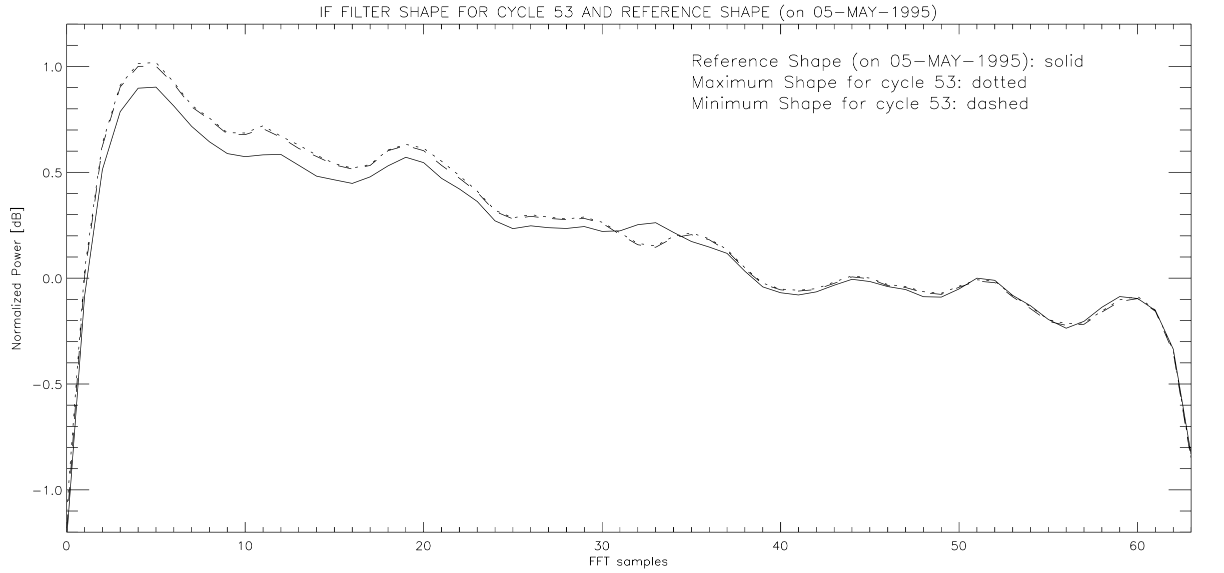

IF FILTER DIFFERENCE AVERAGE OVER FFT samples
DIFFERENCE [dB]
0.20
0.10
0.00
−0.10
−0.20
3/Apr/2000
10/Apr/2000
17/Apr/2000
24/Apr/2000
1/May/2000
8/May/200


IF FILTER SHAPE DIFFERENCE AVERAGE OVER CYCLE 52
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 52 AND REFERENCE SHAPE (on 05−MAY−1995)
Reference Shape (on 05−MAY−1995): solid
Maximum Shape for cycle 52: dotted
Minimum Shape for cycle 52: dashed
Normalized Power [dB]
1.0
0.5
0.0
−0.5
−1.0
0
10
20
30
40
50
60
FFT samples

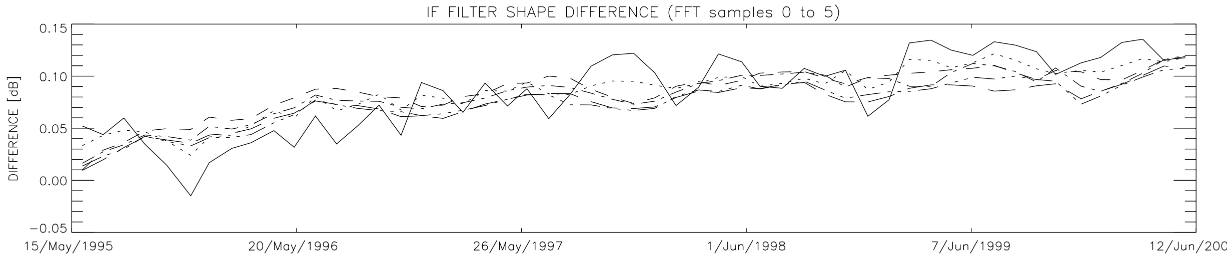

IF FILTER DIFFERENCE AVERAGE OVER FFT samples
DIFFERENCE [dB]
0.20
0.10
0.00
−0.10
−0.20
8/May/2000
15/May/2000
22/May/2000
29/May/2000
5/Jun/2000
12/Jun/200

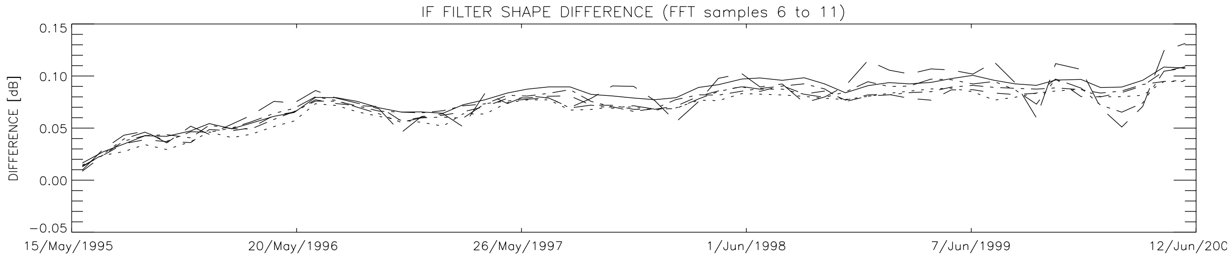

IF FILTER SHAPE DIFFERENCE AVERAGE OVER CYCLE 53
DIFFERENCE [dB]
0.20
0.10
0.00
−0.10
−0.20
0
10
20
30
40
50
60
FFT samples

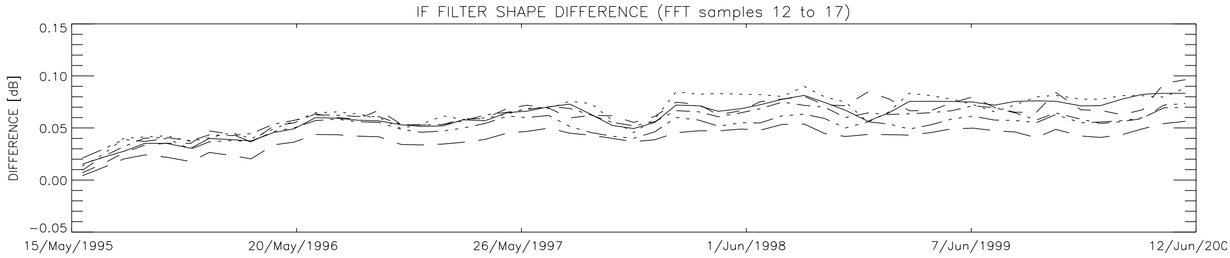

IF FILTER SHAPE FOR CYCLE 53 AND REFERENCE SHAPE (on 05−MAY−1995)
Reference Shape (on 05−MAY−1995): solid
Maximum Shape for cycle 53: dotted
Minimum Shape for cycle 53: dashed
Normalized Power [dB]
1.0
0.5
0.0
−0.5
−1.0
0
10
20
30
40
50
60
FFT samples

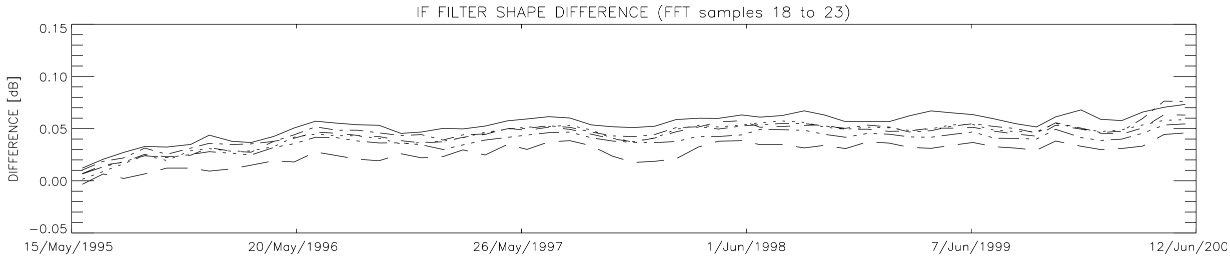
The two pages reported afterwards document trends of the IF filter characteristics difference respect to the reference, for each of the 64 FFT samples averages over cycles have been calculated.

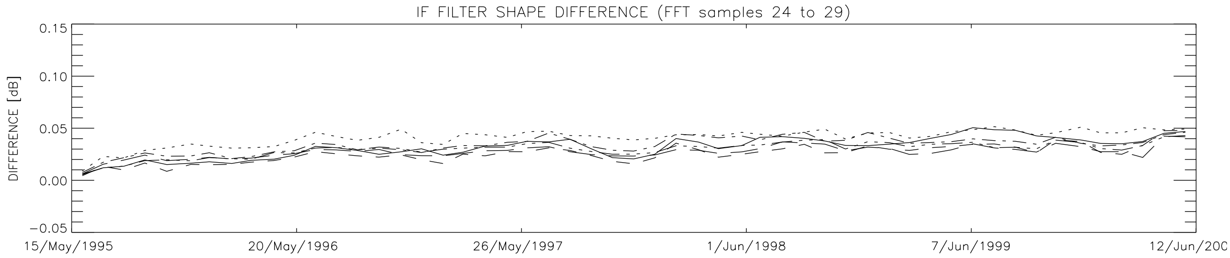
- The same observations can be made as for the cycle results: differences over samples 30 to 33 have been always quite big (being the values related to filters 31 and 32 even outside our plotted range for a significant time span). The low filter number samples show the biggest differences which increase with time while the smaller differences related to the high filter number samples tend to slightly diminish with time. This effect causes the variation of the IF Filter shape slope which has been shown to have a very big 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. Investigations are on going in order to assess the impact of the IF Filter shape variations on the RA retrieved geophysical parameters.

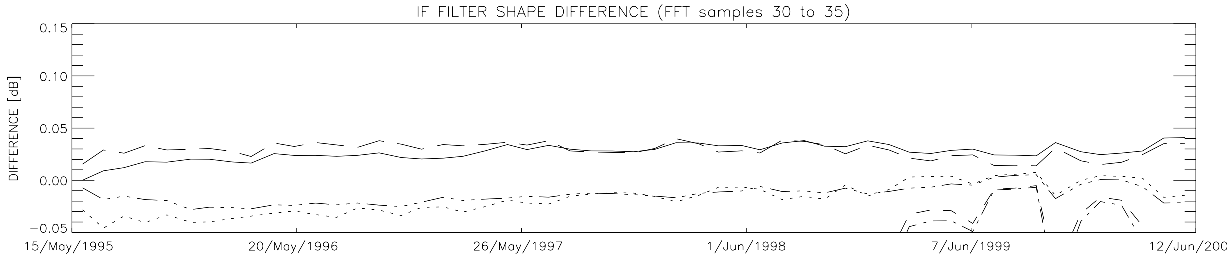

IF FILTER SHAPE DIFFERENCE (FFT samples 0 to 5)
DIFFERENCE [dB]
0.15
0.10
0.05
0.00
-0.05
15/May/1995
20/May/1996
26/May/1997
1/Jun/1998
7/Jun/1999
12/Jun/200

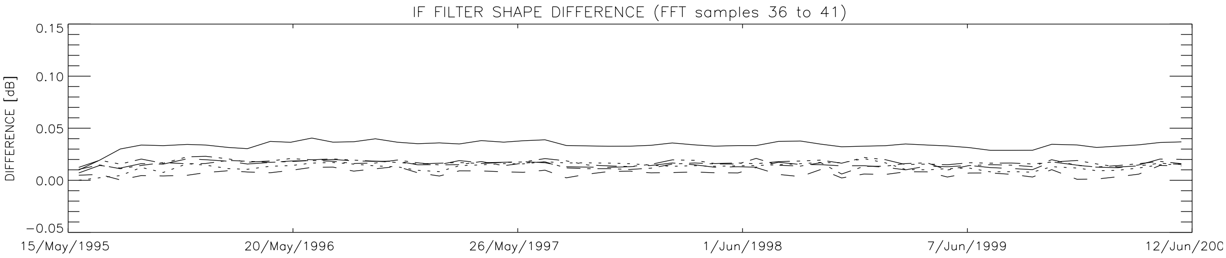

IF FILTER SHAPE DIFFERENCE (FFT samples 6 to 11)
DIFFERENCE [dB]
0.15
0.10
0.05
0.00
-0.05
15/May/1995
20/May/1996
26/May/1997
1/Jun/1998
7/Jun/1999
12/Jun/200

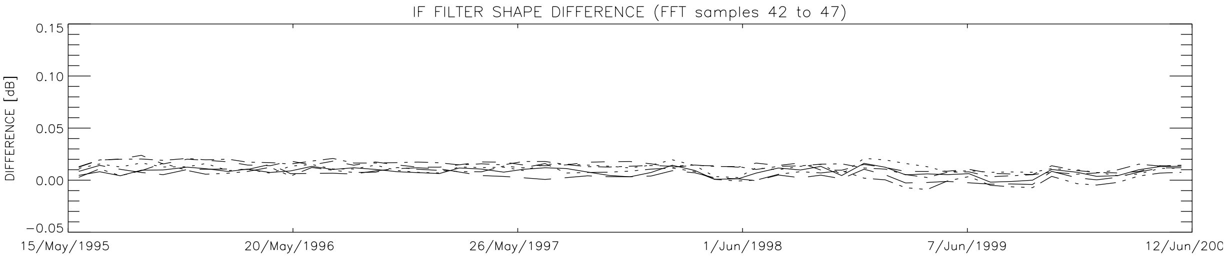

IF FILTER SHAPE DIFFERENCE (FFT samples 12 to 17)
DIFFERENCE [dB]
0.15
0.10
0.05
0.00
-0.05
15/May/1995
20/May/1996
26/May/1997
1/Jun/1998
7/Jun/1999
12/Jun/200

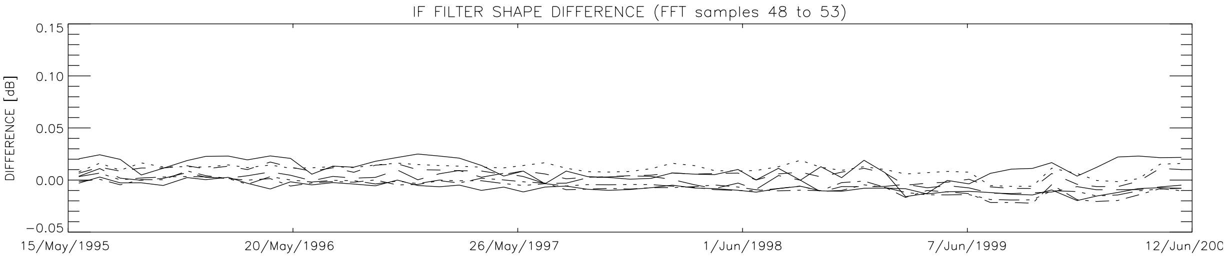

IF FILTER SHAPE DIFFERENCE (FFT samples 18 to 23)
DIFFERENCE [dB]
0.15
0.10
0.05
0.00
-0.05
15/May/1995
20/May/1996
26/May/1997
1/Jun/1998
7/Jun/1999
12/Jun/200

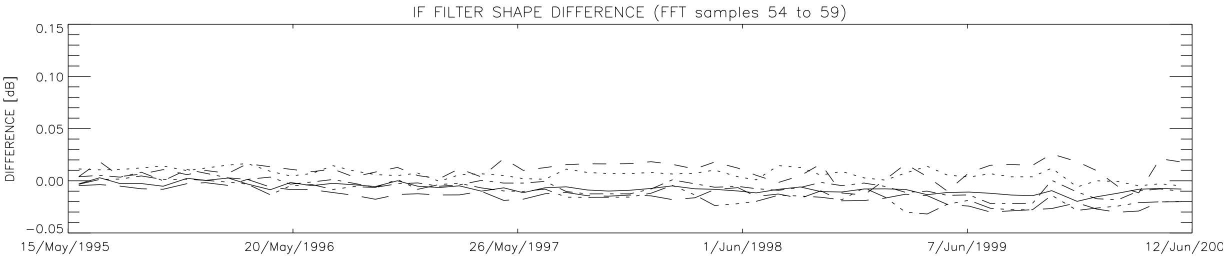

IF FILTER SHAPE DIFFERENCE (FFT samples 24 to 29)
DIFFERENCE [dB]
0.15
0.10
0.05
0.00
-0.05
15/May/1995
20/May/1996
26/May/1997
1/Jun/1998
7/Jun/1999
12/Jun/200

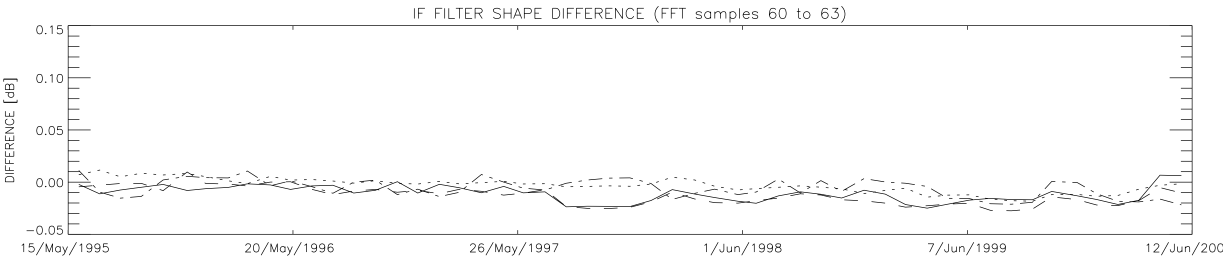

IF FILTER SHAPE DIFFERENCE (FFT samples 30 to 35)
DIFFERENCE [dB]
0.15
0.10
0.05
0.00
-0.05
15/May/1995
20/May/1996
26/May/1997
1/Jun/1998
7/Jun/1999
12/Jun/200











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

The Radar Altimeter is a nadir looking instrument. This means that the bore-sight of its antenna pattern has to be perpendicular to the scene the Radar Altimeter looks at. Any variation of the pointing angle (mispointing) degrades the measurements introducing errors on the three most important geophysical parameters derived from the raw data. For this reason the mispointing angle has to be monitored in order to characterize its behaviour and eventually to evaluate a correction to be applied to the Radar Altimeter measurements.

Furthermore during cycles 50 a special event occurred referring to the scheme with which the ERS-2 satellite attitude is maintained. On the 7th of February 2000 a new software has been uploaded in order to pilote the satellite with only one gyroscope while before the piloting has always been performed with three of them. After a commissioning period of two weeks, the attitude of the ERS-2 platform is operationally maintained with one gyro. Since the change in attitude control could have affected the pointing performances of the Radar Altimeter, a tool was developed which allows to keep under control the mispointing behaviour.

3.4.1 Method Description

The off-nadir pointing of the radar Altimeter has an impact on the shape of the averaged returned waveform in the filter bank. Hereafter the method will be described which has been used to retrieve the mispointing information from those echo waveforms and then to evaluate the mispointing trend from the Radar Altimeter raw data.

The theoretical shape of the return waveform can be described, for small pointing error ξ respect to the nadir direction, by the following formula. This when the echo has already been corrected for the antenna effects and when some approximations, valid for small ξ, have been performed. for $t < 0$

$$P(t) = L\left(1 + erf\left(\frac{t}{\sigma_c\sqrt{2}}\right)\right)$$

for $t > 0$

$$P(t) = L\left(1 + erf\left(\frac{t}{\sigma_c\sqrt{2}}\right)\right)\left[1 + \left(\frac{2}{\gamma}\sqrt{\frac{c\varepsilon t}{H}}2\xi\right)^2\right]$$

In order to put this in relation with the waveform representation in the filter bank (frequency domain) the time variable t has to be related to the FFT filter numbers. A FFT sample n represents a time instant t_n as: $t_n = (n-32)t_c$; where t_c is the time delay corresponding to one FFT unit: 3.012 ns for ERS-2 depending on the chirp slope. The factor L is regulated by the Automatic Gain Control in order to have a predetermined average power value P_{ref}. The factor ε takes into account the non spherical earth; γ depends on the 3dBs antenna aperture and σ_c is a composite parameter taking into account the point target response -3dBs width and the rms height of the backscattering points.

Considering the two equations previously reported it is possible to notice that: the mispointing value ξ has influence on the echo waveforms only for positive values of the time variable t and it has effect on the slope of the trailing edge of the echo shape which is proportional to ξ^2. This allows the mispointing squared to be calculated using the following formula:

$$\xi^2 = \frac{\frac{slope}{L}\gamma^2 H}{16c\varepsilon t}$$

3.4.2 Data Processing Description

The Radar Altimeter raw data contain information over the echo waveforms in the frequency domain with a frequency of 1/20 Hz. They have been processed and corrected in such a way that the waveforms obtained from them could be assimilated to the theoretical ones described in the previous paragraph. Only data over ocean have been selected. For every data file containing several minutes of data the processing algorithm used to assess the average mispointing value can be summarised as hereafter reported:

- The waveform information have been extracted from the raw data; 20 waveforms per seconds are available which have been then normalised in order to prevent errors related to the Automatic Gain Control loop behaviour.
- The waveforms have been corrected for the IF Filter Shape (ref. par. 3.3). This compensate for an instrumental effect affecting the echo waveform in reality but which is not considered in the theoretical model used.
- The waveforms have been averaged over one second and corrected for antenna pattern effects.
- One mispointing squared value per second has been evaluated using the formula reported in the previous paragraph. From the corrected echo shapes, the slope has been identified as the one of the line which best fitted the samples related to FFT numbers 37 to 60.
- A sliding average with one minute window duration has been performed over the mispointing squared ξ^2 time series. The mispointing ξ time series has been obtained from it by mean of a square root operation (eventual ξ^2 negative values have been considered equal to zero).
- Assuming the mispointing squared ξ^2 distribution being gaussian (central limit theorem) and considering that the mispointing can be defined as: $\xi = \sqrt{\xi^2}$ for $\xi^2 \geq 0$ and $\xi = 0$ for $\xi^2 < 0$; the probability density function describing the mispointing statistics behaviour can be represented with the following formula:

  for $\xi \geq 0$

  $$P(\xi) = \frac{1}{\sqrt{2\pi}\sigma_{\xi^2}} 2\xi \exp\left[-\left(\frac{\xi^2 - m_{\xi^2}}{\sqrt{2}\sigma_{\xi^2}}\right)^2\right]$$

  for $\xi < 0$

  $$P(\xi) = 0$$

  from which its mean value m_ξ can be derived as:

$$m_\xi = \sqrt{m_{\xi^2}}\left[0.5 + \frac{1}{2\sqrt{2\pi}}\frac{\sigma_{\xi^2}}{m_{\xi^2}}\right]$$

where m_{ξ^2} and σ_{ξ^2} are respectively the mispointing squared mean and standard deviation.

- The histogram of the mispointing time series has been evaluated and fitted to the theoretical probability density function just described. From this procedure the two values m_{ξ^2} and σ_{ξ^2} have been retrieved with which the mispointing average value m_ξ has been determined.

3.4.3 Results

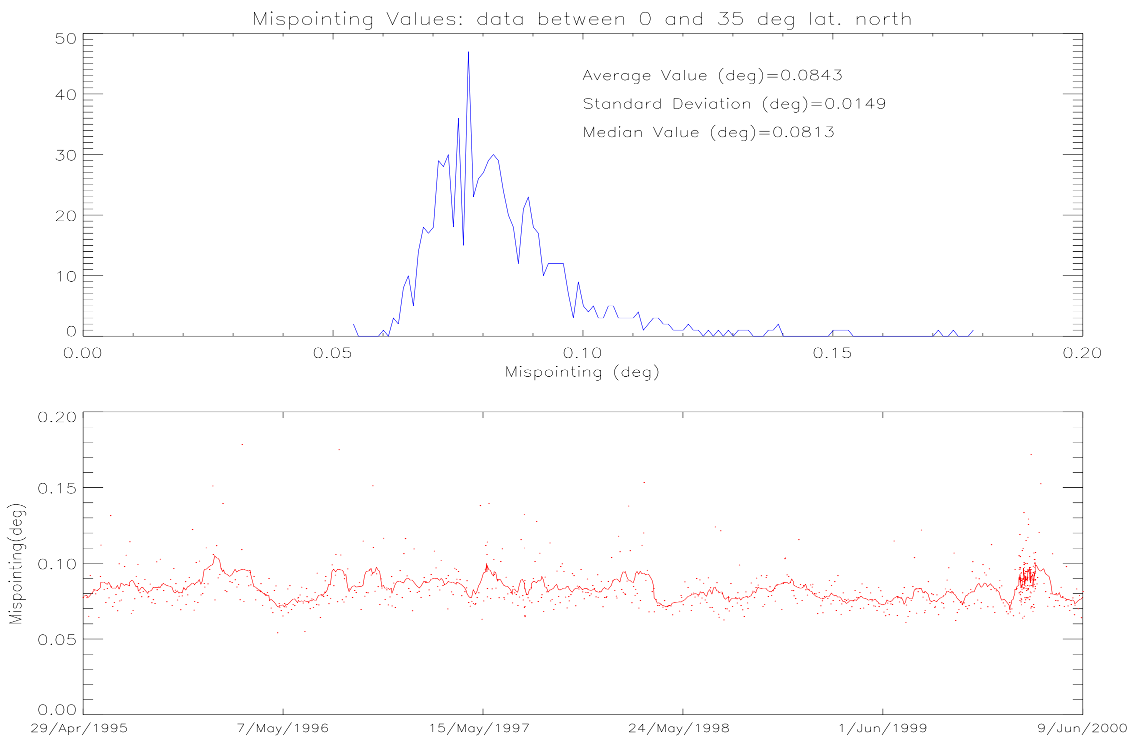
The off-nadir pointing analysis work has been performed on the Radar Altimeter raw data products disseminated in fast delivery since the beginning of the ERS-2 mission. Every three days, ten minutes of raw data are available three hour after sensing. They are measured over the Pacific Ocean within 0° and 35° latitude north. Those data have been analysed with the method described in par. 3.4.1 and 3.4.2 giving, as output, one mispointing value every three days for the main part of the mission.

On the other hand, during the period between 11th February and 11th March 2000, a larger number of data has been processed in order to keep the off-nadir pointing behaviour under control in occasion of the new mono-gyro piloting software commissioning phase (ref. Cyclic Report for cycles 50 and 51, APP-ADQ/PCS/RA00-003, par. 4.6).

Two important considerations have to be made at this point:

- The Radar Altimeter waveforms undergo several corrections during the processing. They are the antenna and the IF Filter correction which do influence a lot the outcome of the exercise. In particular, during this study, the processing to retrieve the mispointing squared figures from the echo shape has been found to be very sensitive to the IF Filter Shape used for the correction. The analysis has been anyway performed using the proper IF Filter Shape, the most updated for each measurement, in order to minimize the IF Filter Shape impact on the off-nadir pointing results (ref. par. 3.3).
- The algorithm itself is affected by an error, which is exponentially growing as the absolute mispointing value decreases.

From the following figure we can notice that the overall mispointing time series lies around a value of 0.084° and that a very small increasing trend is evident after middle February (change of the piloting system). That increment, being lower 0.01°, can be anyway considered irrelevant bearing in mind the uncertainties affecting the retrieved figures. On the other hand, because of those uncertainties, the mispointing figures during the whole mission could be considered assuming values from 0° to 0.15°. Please note that none of the values hereafter reported are suffering from the sun blinding effect, being evaluated from data sensed over the latitude range [0, 35] deg.


Mispointing Values: data between 0 and 35 deg lat. north
Average Value (deg)=0.0843
Standard Deviation (deg)=0.0149
Median Value (deg)=0.0813
Mispointing (deg)
Mispointing(deg)
29/Apr/1995
7/May/1996
15/May/1997
24/May/1998
1/Jun/1999
9/Jun/2000

4.0 Products performance

The four ESA ground stations (Gatinueau, Kiruna, Mas Palomas and Prince Albert) process ERS-RA raw data to produce URA products and distribute them within three hours after sensing. Before the beginning of cycle 44, the raw data received by the fourth ground station (Prince Albert) were processed a week later at Gatineau; since the 28th June 1999 a network connection has been established between Prince Albert and Gatineau which allows also the data received in Prince Albert to be processed and distributed in near real time. The quality of these URA products is checked by PCS at ESA/ESRIN. (For more information on the ground stations; http://earth1.esrin.esa.it/f/eeo3.324/0xc1cce41c_0x00006d3b).

The performance of the fast delivery products is determined by mean of the following criteria:

- Availability of Data and Quality Assessment: a summary of the percentages of available/not available products and of all the features affecting their quality during cycles 52 and 53.
- Fast Delivery Data Summary
- Instrument Mode: an overall picture of the modes the instrument worked in during cycles 52 and 53.
- Look Up Tables (LUT) Status
- Data Comparison with Forecasts: the comparison of the fast delivery data with the forecasts performed by ECMWF is useful to validate the URA products

4.1 URA Fast Delivery Products Short Description

Each product of the RA fast delivery data consists of:

- **1 MPH (Main Product Header)**: general information of the product such as sensing and generation time, the satellite position at sensing time, the ground station which acquired the product, the software used to process the data and some quality flags.
- **1 SPH (Specific Product Header)**: information on the auxiliary parameters used in the processing of the product and some quality flags.
- **77 DSRs (Data Set Record)** include information as wind speed and significant wave height, instrument mode, geophysical corrections and some quality flags are part of it.

Note that only the data in ocean tracking mode are processed within the on-ground processing chain and reported in the fast delivery products.
For more information on the URA products: http://earth1.esrin.esa.it/f/eeo2.267/pgersaltura

4.2 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 52 is hereafter reported.

Percentage of not available products (relative to the nominal number for a cycle): 0.61%

Percentage of blank DSRs (relative to the nominal number for a cycle): 0.126%, of which 0.063% due to whole blank products and 0.063% due to products not totally blank.

Table 2: Percentage of products having one of the following flags set

Flag name	Percentage(%)
HDDT	0.31
FS to Processor	0.0
Checksum Analysis	0.15
Formats/Sources	0.0
Auxiliary Data	0.0
Arithmetic Fault	0.0
Processor Status	0.0
Enough Measurement	1.09

Table 3: Percentage of products having one of the following parameters outside the respective range

Parameter	Percentage(%)
Peakiness out of [1.2, 1.7]	0.256
Sigma_0 out of [0., 24.] (dB)	0.185
Wind Speed out of [0., 25.] (m/s)	0.0
Significant Wave Height ot of [0., 12.] (m)	less than 0.01

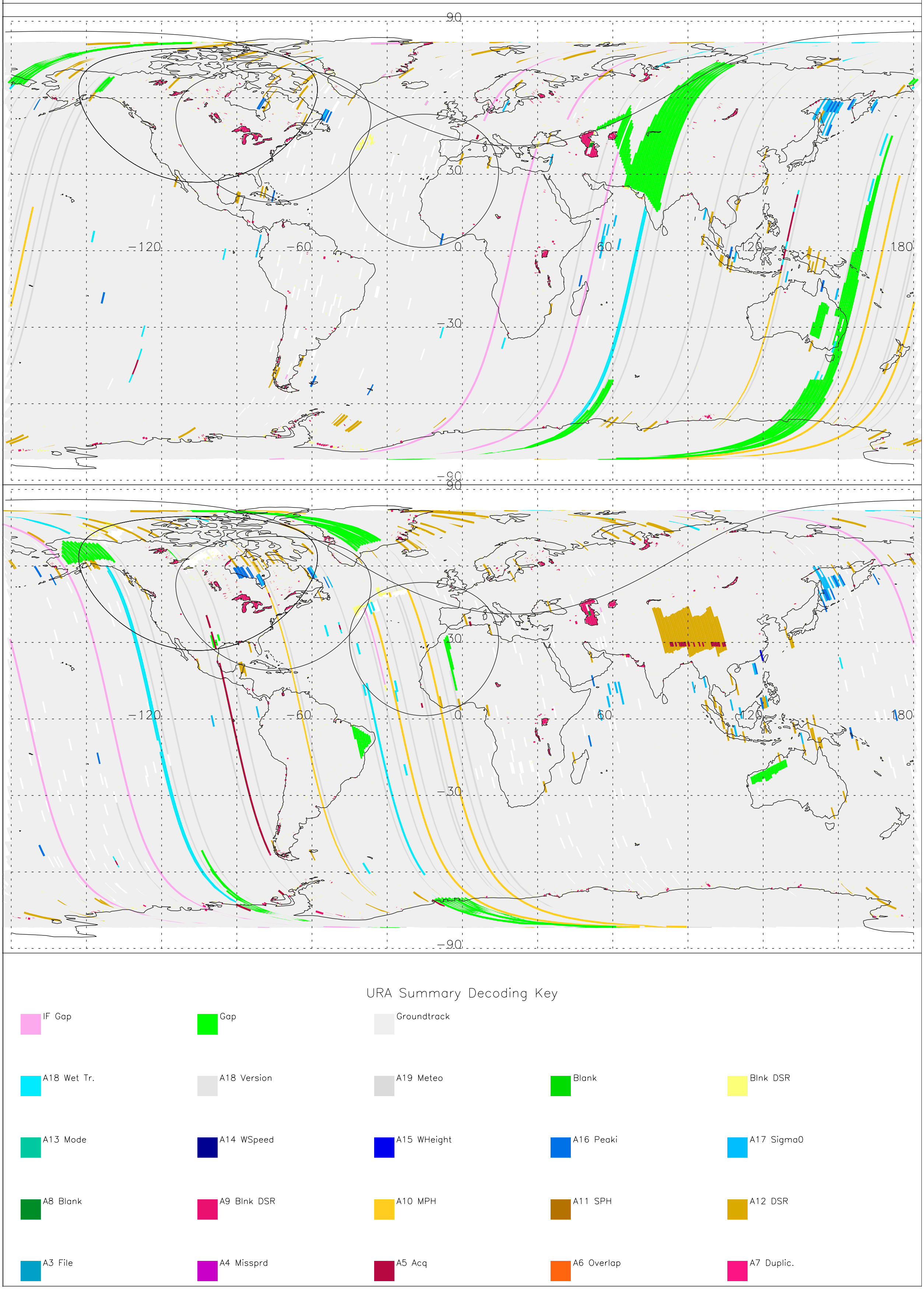
Note that the numbers here above (Table 3) are only relative to ocean products.

Percentage of flagged products relative to the Wet Tropospheric Correction: 0.11%

(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).

During cycle 52 all the parameters showed very good performances as it can be noticed in the following figure which reports the global distribution of flagged parameters detected in the URA products for the cycle.

ERS-2 URA Products Summary, Cycle 52



The summary of all the most important features affecting the quality of the data during cycle 31 is hereafter reported.

Percentage of not available products (relative to the nominal number for a cycle): 0.46%

Percentage of blank DSRs (relative to the nominal number for a cycle): 0.215%, of which 0.065% due to whole blank products and 0.15% due to products not totally blank.

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

Flag name	Percentage(%)
HDDT	1.52
FS to Processor	0.0
Checksum Analysis	0.54
Formats/Sources	0.0
Auxiliary Data	0.0
Arithmetic Fault	0.0
Processor Status	0.0
Enough Measurement	1.12

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

Parameter	Percentage(%)
Peakiness out of [1.2, 1.7]	0.14
Sigma_0 out of [0., 24.] (dB)	0.085
Wind Speed out of [0., 25.] (m/s)	0.01
Significant Wave Height ot of [0., 12.] (m)	less than 0.01

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

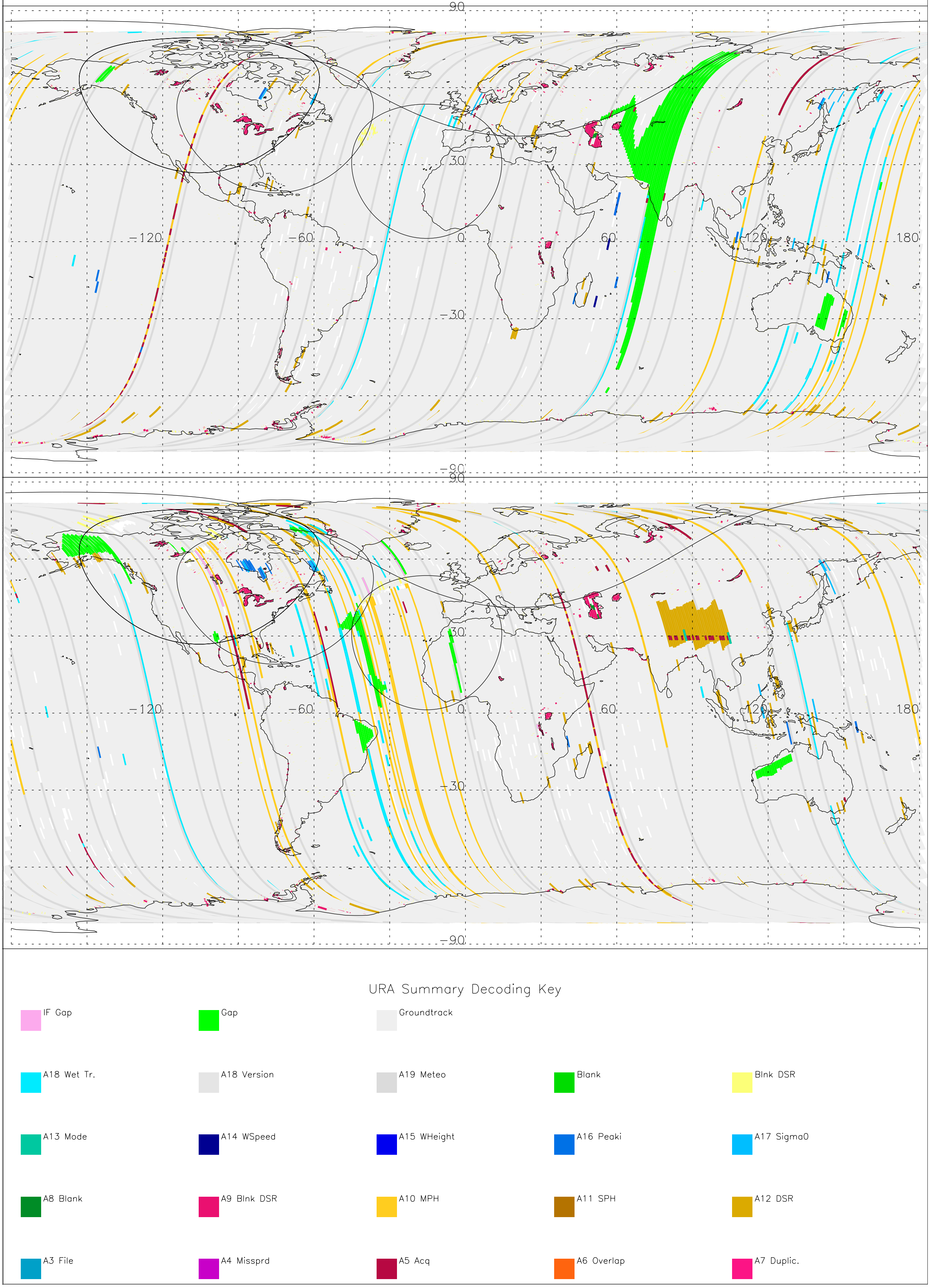
Percentage of flagged products relative to the Wet Tropospheric Correction: 0.29%

(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).

During cycle 53 the parameters which behaviour have been worse than average are: Wet Tropospheric Correction and Blank Products.

The following figure shows the global distribution of flagged parameters detected in the URA products for cycle 53, the ground stations visibilities can be noticed in the plots.

ERS-2 URA Products Summary, Cycle 53



In relation to the previous picture 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

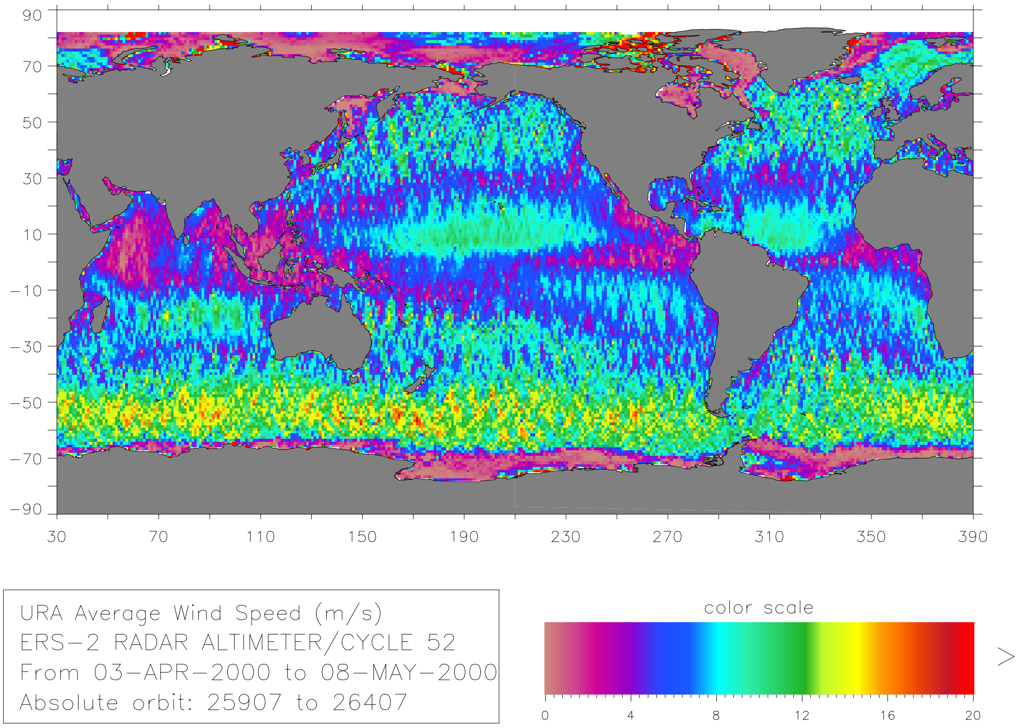
Acq: problem with acquisition, gap within one file

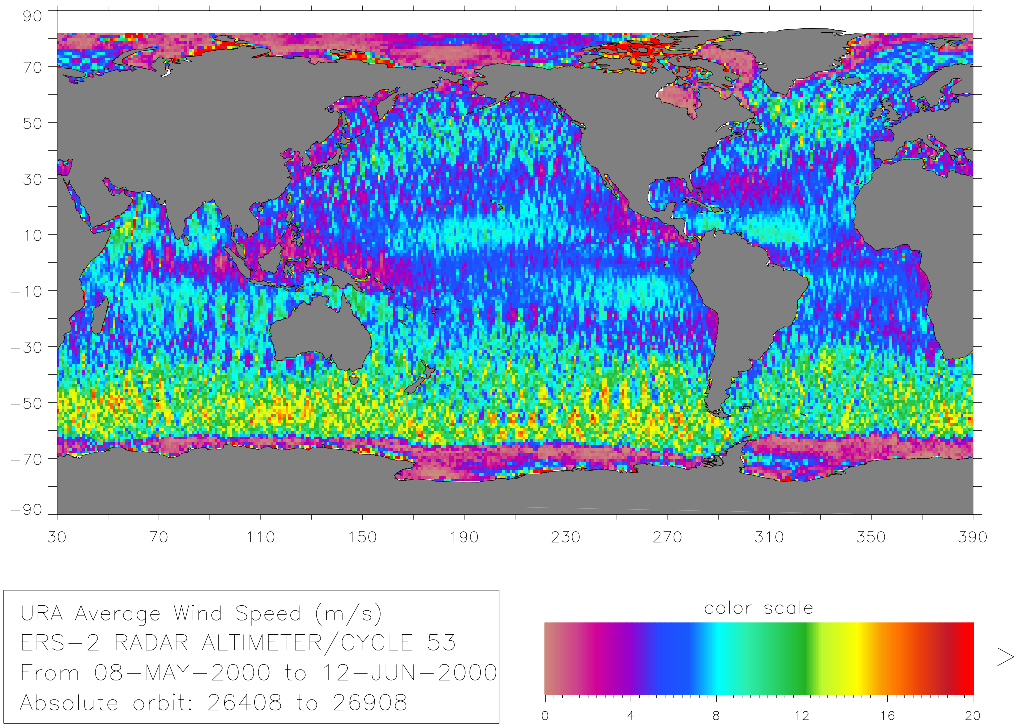
Overlap: product overlapping with another one

Duplic: duplicated product

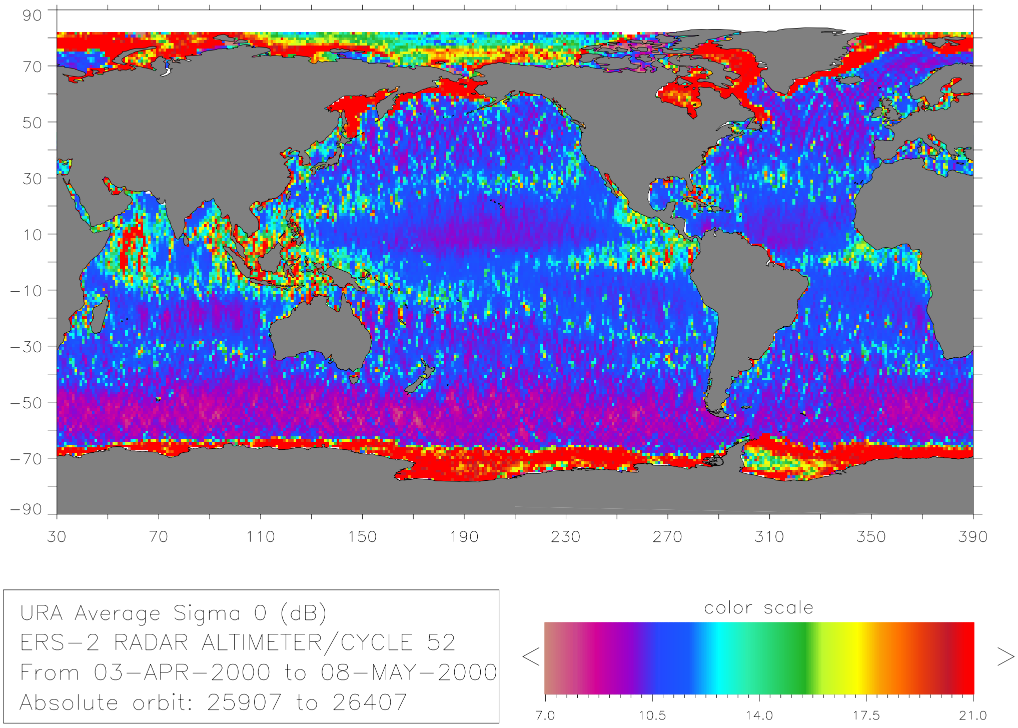
4.3 Fast Delivery Data Summary

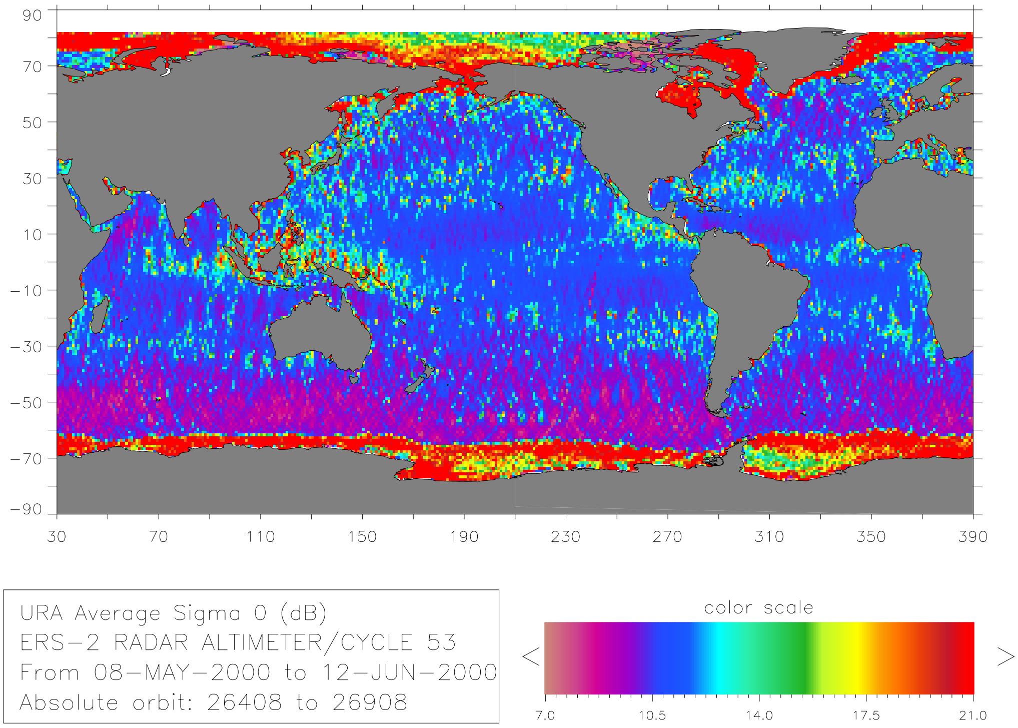
From the fast delivery data arriving every day at ESRIN/PCS, the relevant parameters are extracted on a daily basis. For every parameter all the information relative to every cycle have been averaged on a geographical basis over pixels of 1 deg latitude per 1 deg longitude. They are reported in the following pictures, giving a global overview of the Radar Altimeter data for cycles 52 and 53.





Worthwhile to notice in the previous plots the Wind Speed values over the polar regions. Those value, for cycles 52 and 53, 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.



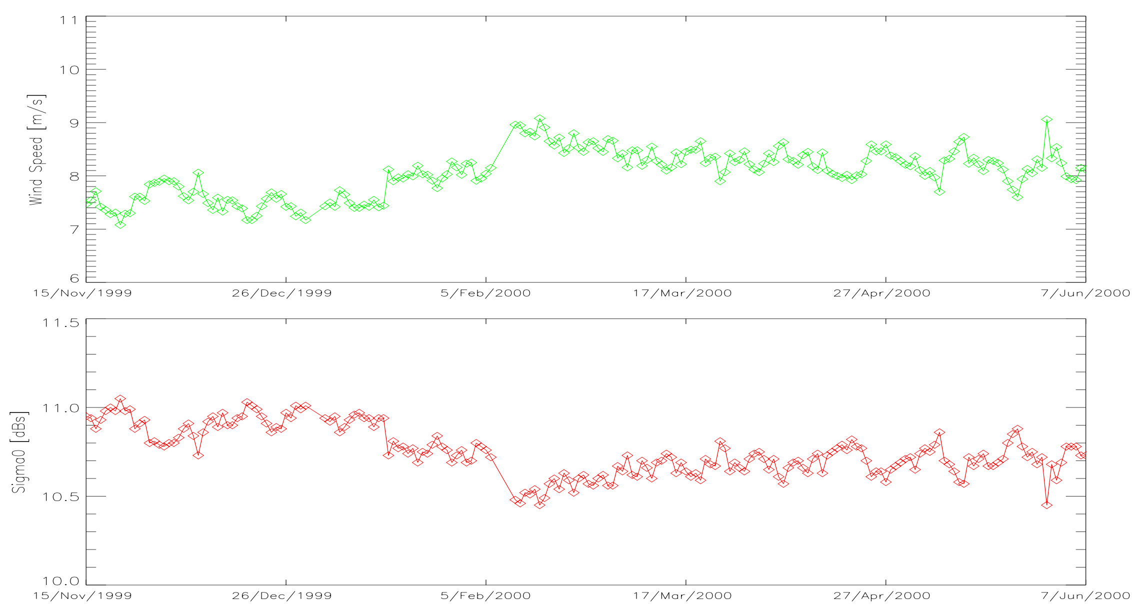


During cycles 50 and 51 the special event regarding the up-load of the mono-gyro piloting software (ref. Cyclic Report for cycles 50 and 51, APP-ADQ/PCS/RA00-003, par. 4.6) has had influence on the quality of the fast delivery products. For this reason the three most important geophysical parameters retrieved from the Radar Altimeter measurements (Significant Wave Height, Sigma_0/Wind Speed and Range) have been carefully analysed. This in order to establish if and how the event could have caused changes on their values. This analysis has been re-performed, in a more accurate way, after the publication of the Report dedicated to cycles 50 and 51. For this reason the results are published here even if they are related to data recorded during cycles 50 and 51.

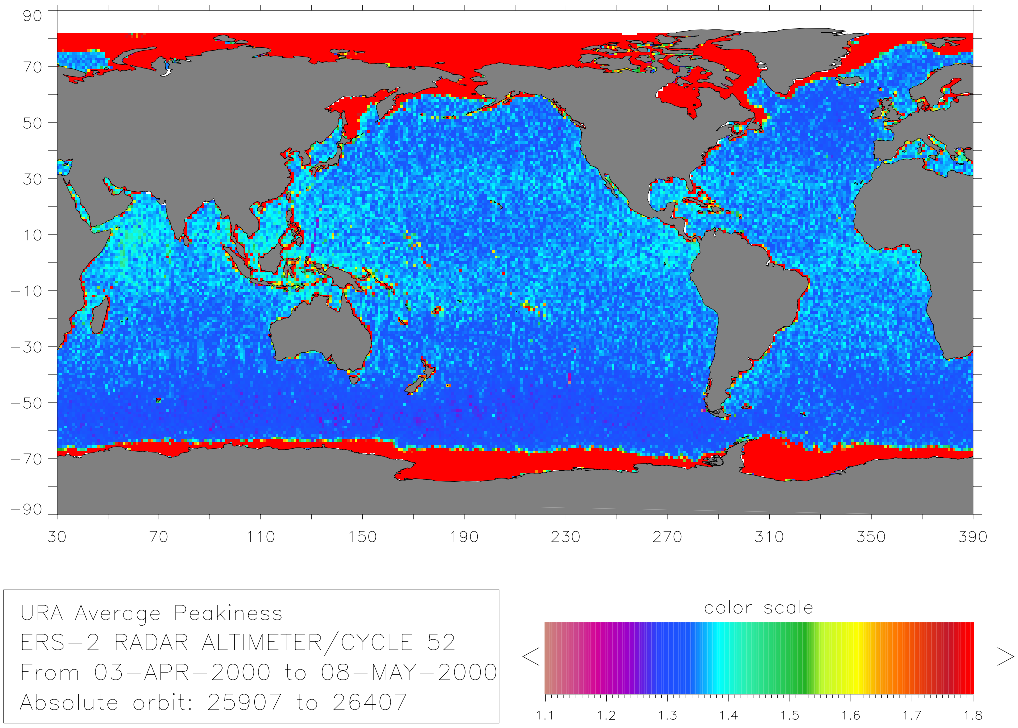
After having performed a simulation using the mispointing values along the orbit which had been retrieved with a method very similar to the one in par 3.4.1, the conclusions are the following (for Gyro 5 piloting and no Sun Blinding effect):

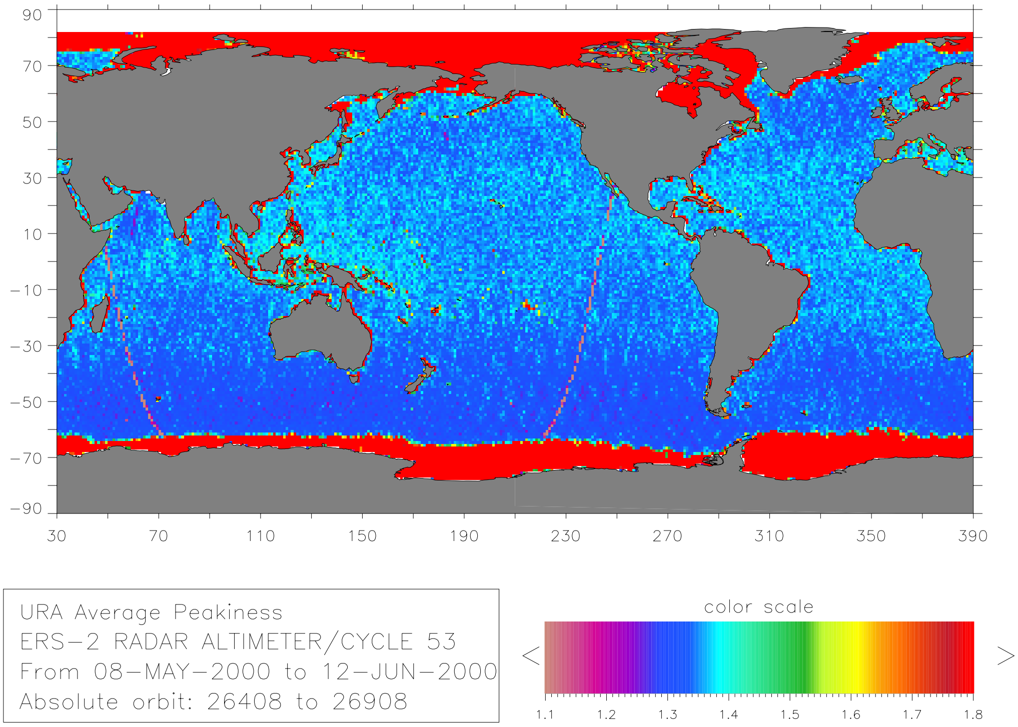
- The SWH has not been influenced by the change of the platform piloting system (result confirmed also by ECMWF); the impact is of -4.9 mm.
- The impact on the Range, being of -1.2 mm, can be considered negligible.
- The impact on the Sigma_0, being of 0.047 dBs, can be disregarded.

The results obtained with the simulation are confirmed by the real data averaged Sigma_0 values plotted hereafter. The impact of the of the different configurations tested after the software up-load are clearly visible in the following plot. It has to be remarked anyway that this parameter had suffered of a anomalous drop already on January the 16th when its value had decreased of 0.2-0.3 dBs. After that anomaly but before the mono-gyro software up-load, the average value for the back-scatter coefficient was about 10.75 dBs. The Sigma_0 had then a mean value of 10.49 dBs for Gyro 6 (-0.26 dBs) and of 10.58 dBs for Gyro 5 (-0.17 dBs) while the less accurate pointing related to the Fine Pointing Mode caused even lower backscattering values. In order to determine the real effect of the new attitude configuration, avoiding the Sun Blinding effects it is necessary to consider the data after March the 3rd. After that date the Sigma_0 average values comes back to a higher figure of 10.69 dBs which is 0.06 dBs below the average back-scatter coefficient after the 16th January drop; for the wind speed this means an increase of 20 cm/s.

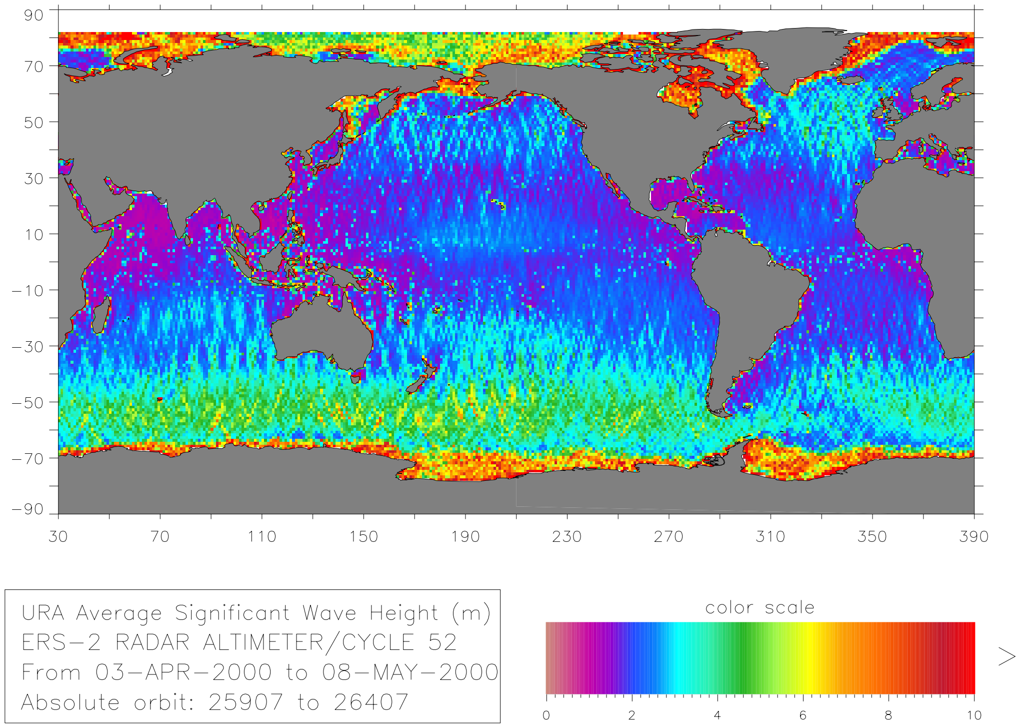


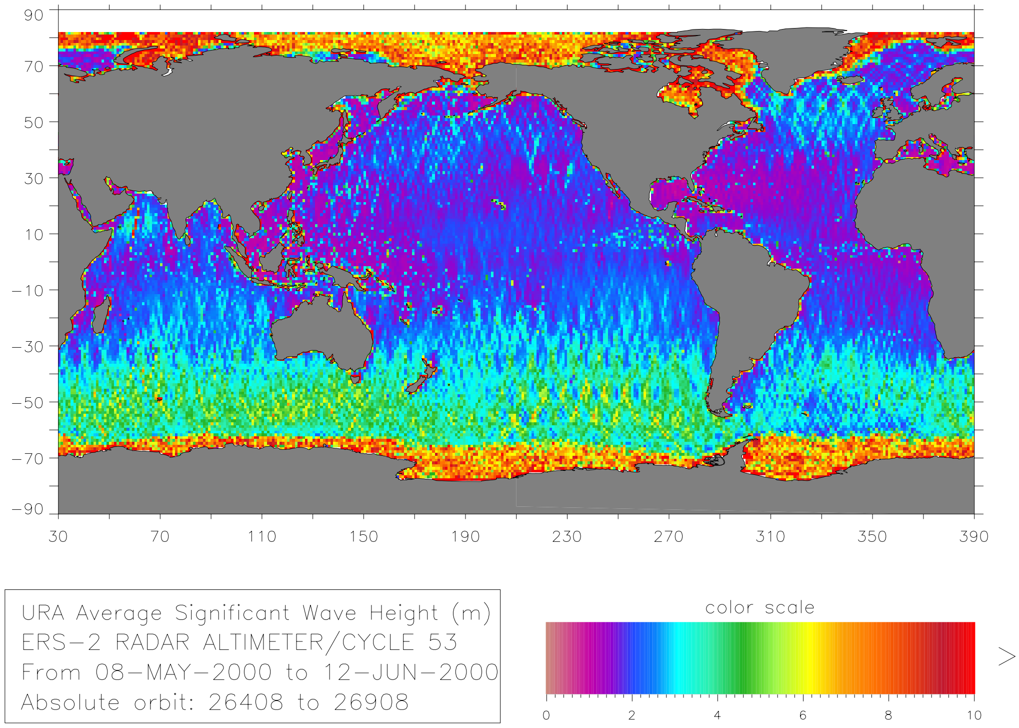
The Sigma_0 drop occurred on the 16th of January deserves a further comment. Even if it has been extensively investigated during the last period, no instrumental problem has been pin-pointed to explain the event. This allow us to identify the cause of the drop in a anomalous event regarding the antenna or the Front End Electronics which are not included in the Internal Calibration path. The value of the Fast Delivery parameters will be soon corrected with the introduction of a new Look Up Table.



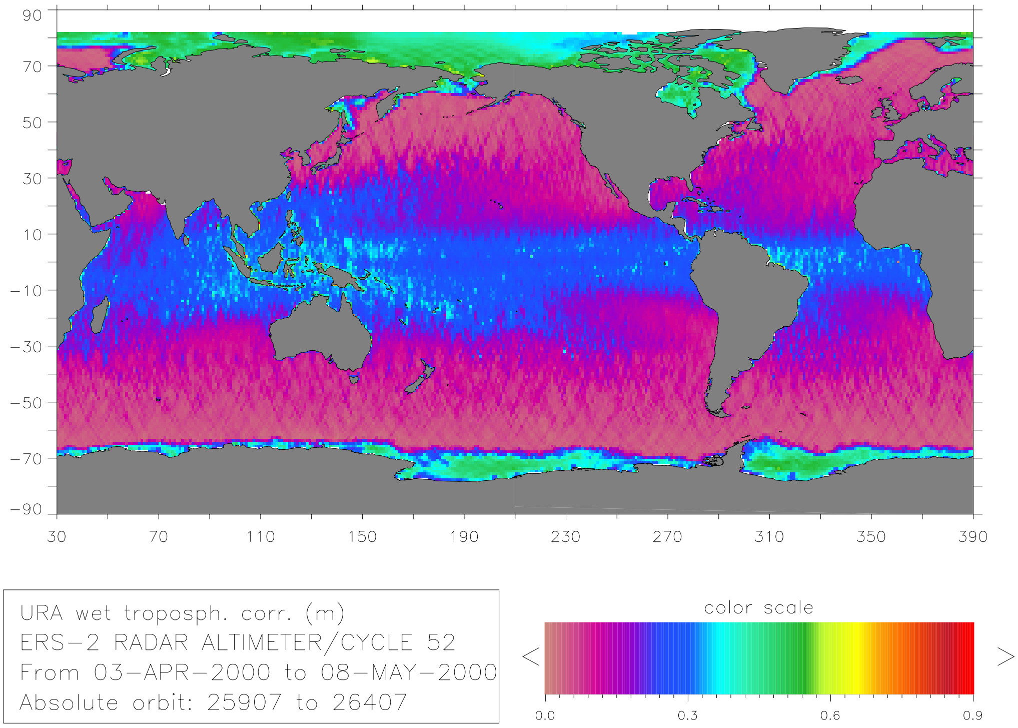


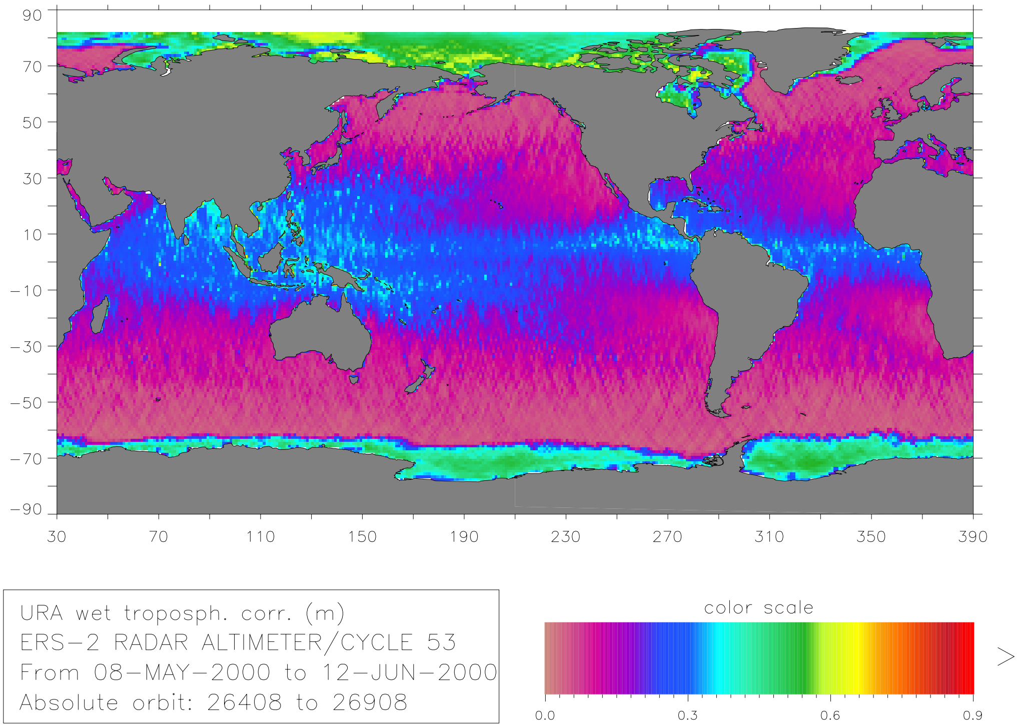
The Peakiness, being related to the peakedness of the returned echo waveforms, represents a valuable quality parameter for the raw data. Over Ocean areas you expect smooth waveforms (ref. par. 3.4) while over Ice area the expected shape is more peaky. For ocean-like waveforms the peakiness should be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





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.

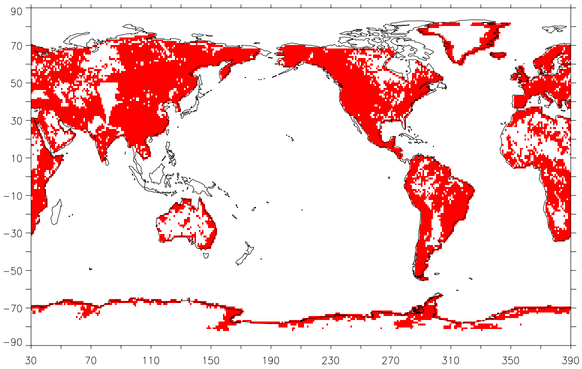




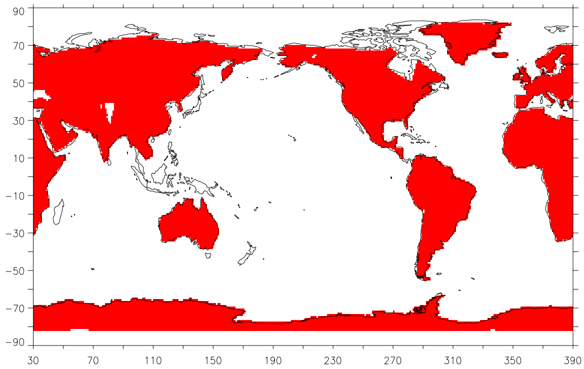
4.4 Instrument Mode

During nominal operations the Radar Altimeter works alternatively in Ocean and Ice Modes. The two modes differ basically on the resolution of the altimetric range measurements and on the capability to maintain the “lock” with the backscattered echo. In Ocean Mode the resolution is higher but the instrument can easily loose the tracking when flying over surfaces characterised by high slope variations. On the other hand in Ice Mode the resolution is lower but the instrument succeeds in keeping the tracking also when flying over very steep terrains. The switch from Ocean to Ice Mode and vice-versa is not performed automatically by the instrument, but it is commanded following the water/ground borders indicated by the Ice/Ocean mask. Within both the Ice and Ocean Modes, two sub-modes can be distinguished: Tracking and Acquisition Modes, which have been already mentioned in the paragraph dedicated to the Instrument Performances.

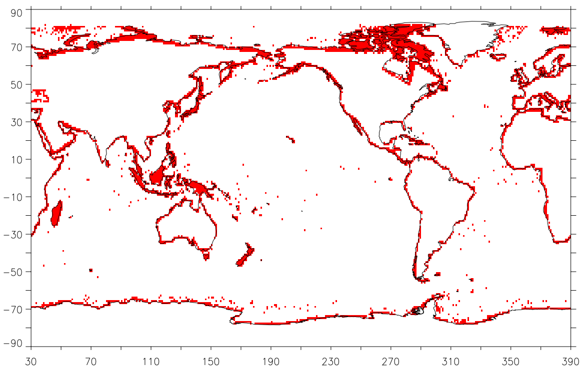
The following maps report a summary of the four principal operative working modes during cycles 52 and 53.



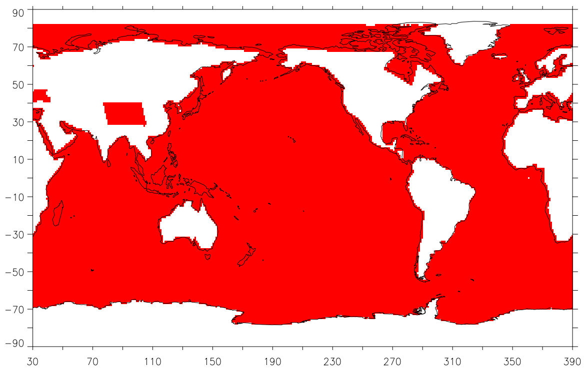
URA Acquisition on Ice
ERS−2 RADAR ALTIMETER/CYCLE 52
From 03−APR−2000 to 08−MAY−2000
Absolute orbit: 25907 to 26407



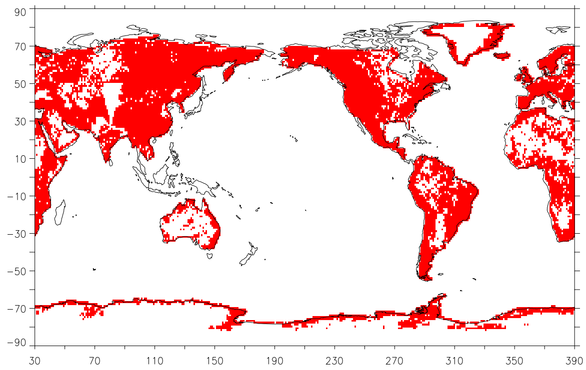
URA Tracking on Ice
ERS−2 RADAR ALTIMETER/CYCLE 52
From 03−APR−2000 to 08−MAY−2000
Absolute orbit: 25907 to 26407



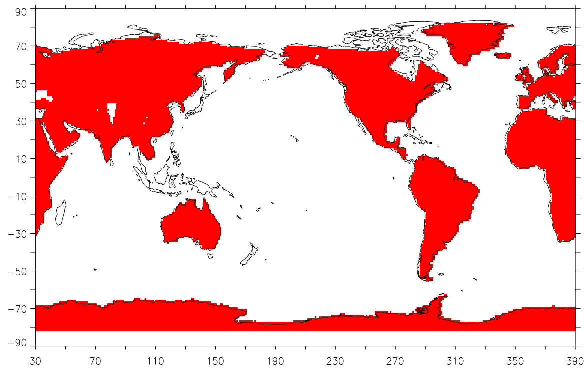
URA Acquisition on Ocean
ERS−2 RADAR ALTIMETER/CYCLE 52
From 03−APR−2000 to 08−MAY−2000
Absolute orbit: 25907 to 26407



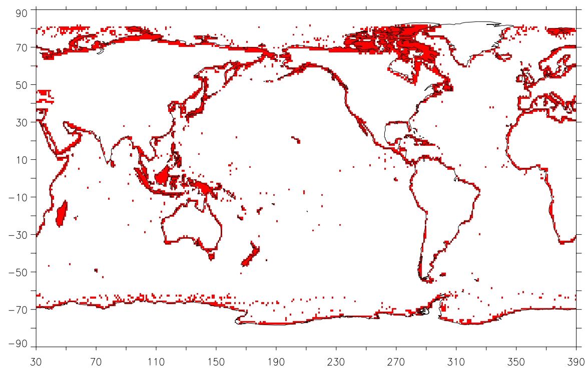
URA Tracking on Ocean
ERS−2 RADAR ALTIMETER/CYCLE 52
From 03−APR−2000 to 08−MAY−2000
Absolute orbit: 25907 to 26407



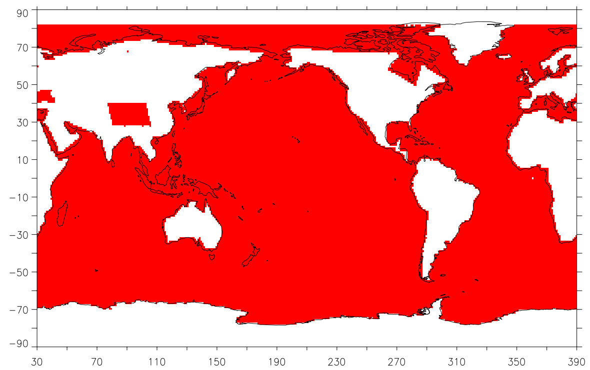
URA Acquisition on Ice
ERS−2 RADAR ALTIMETER/CYCLE 53
From 08−MAY−2000 to 12−JUN−2000
Absolute orbit: 26408 to 26908



URA Tracking on Ice
ERS−2 RADAR ALTIMETER/CYCLE 53
From 08−MAY−2000 to 12−JUN−2000
Absolute orbit: 26408 to 26908



URA Acquisition on Ocean
ERS−2 RADAR ALTIMETER/CYCLE 53
From 08−MAY−2000 to 12−JUN−2000
Absolute orbit: 26408 to 26908



URA Tracking on Ocean
ERS−2 RADAR ALTIMETER/CYCLE 53
From 08−MAY−2000 to 12−JUN−2000
Absolute orbit: 26408 to 26908

The following picture reports a global view of the modes the Radar Altimeter was operationally working in, during cycles 52 and 53.

The descoping strategy can be seen from to the clusters of blank products (yellow). After a temporary strategy was adopted in cycle 41 and 42 due to GOME operational requirements (http://earth1.esrin.esa.it/f/eeo4.10069/eeo4.96), starting from cycle 43 the nominal strategy has been reintroduced, so during cycles 52 and 53 the descoping has been implemented using the nominal plan. (For more information on the descoping strategy: http://earth1.esrin.esa.it/f/eeo4.42/oppla)

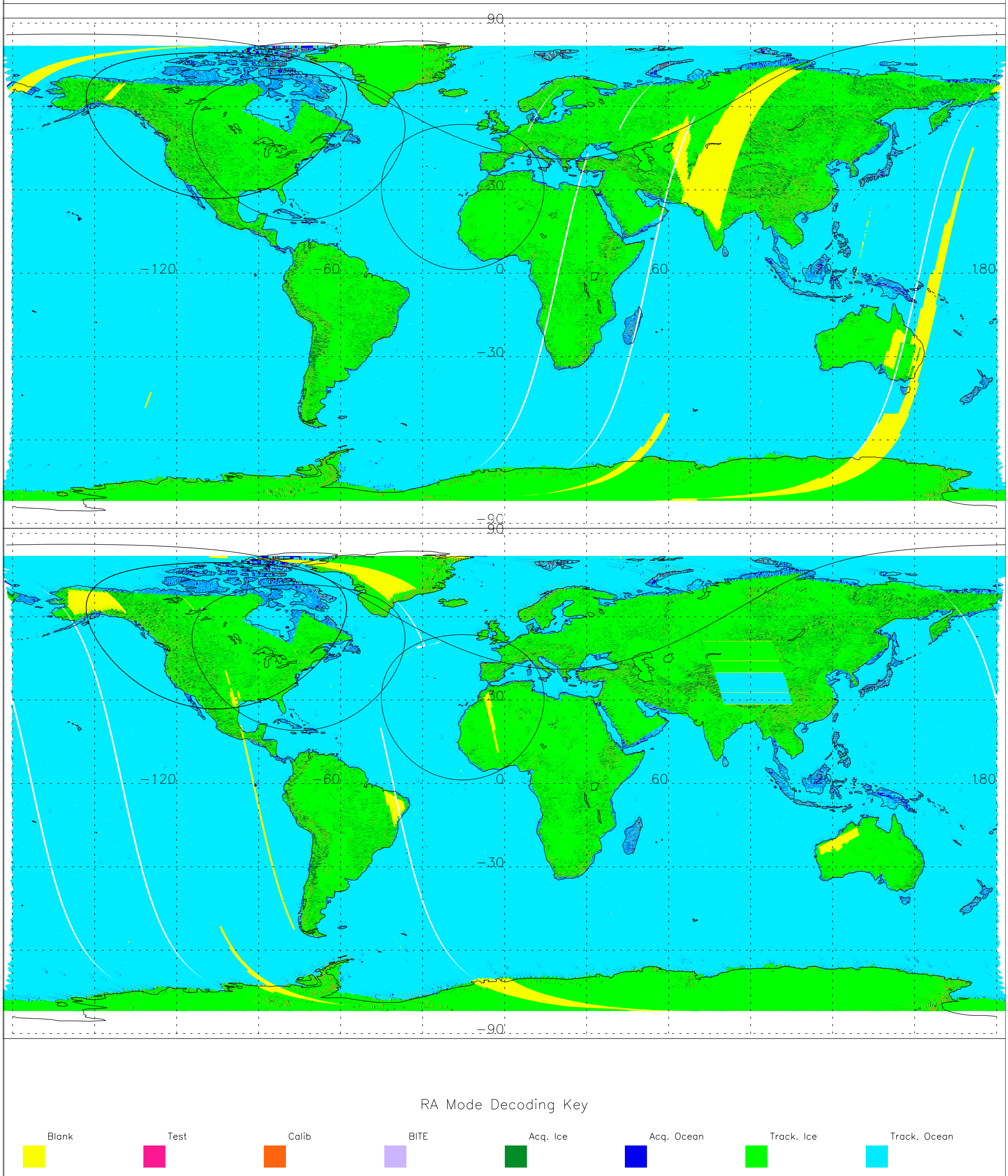
The SPTR/PTN calibration strategy performed over central Asia is easily discernible. The Instrument works permanently first in Ocean Tracking and then in Ice Tracking Mode, due to the presetting mode used during the calibration. The data in SPTR Ice Mode measured during this campaign are used to evaluate the IF Filter Shape presented in par. 3.3.

The area covered by the SPTR/PTN campaign, starting from cycle 43, has been and will be in the future bigger than before. This because, from cycle 43 on, the campaign has been and will be performed in the future every day instead of every three days as it was previously planned. The decision of performing the calibration campaign more often has been taken in order to minimize the probability to have periods between two anomalies without any SPTR measurement. Being the SPTR measurements affected by quasi-random abrupt changes in case of instrument anomalies, the situation of having two subsequent anomalies without any SPTR calibration campaign will cause the impossibility to produce a completely trustable SPTR calibration correction for the altimetric range values recorded during that period. A solution to this problem had been proposed by Richard Francis and Monica Roca in early 1996, but it has been not yet operationally implemented due to difficulties in the operational retrieval of several parameters useful for the algorithm execution.

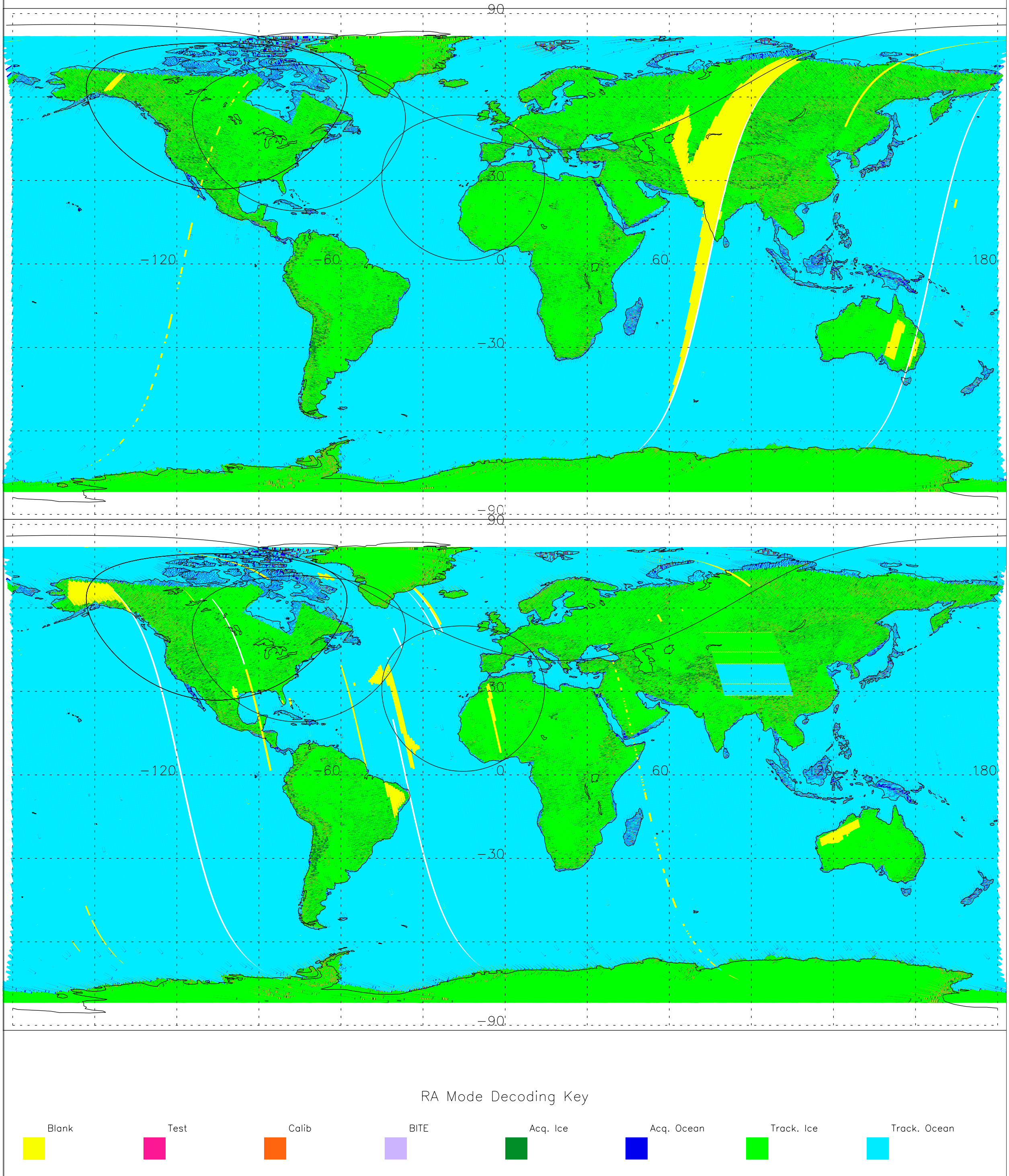
The mountainous structures can be noticed in relation to the dark green signs representing Ice Acquisition mode. Of course this is due to the loose of lock caused by the steep ground morphology in those zones.

In comparison to the previous cycles up to cycle 40, the Ice/Ocean discrimination follows much better the shape of the continents. From cycle 41 a new Ocean/Ice mask have been used operationally. The improvements are related to the shape of the land (see South America, North Europe and Africa) and to the shape of the ice caps in Antarctica and in Greenland. (For more information http://earth1.esrin.esa.it/f/eeo4.39/RA-Altimeter).

ERS-2 Radar Altimeter: Working modes, Cycle 52



ERS-2 Radar Altimeter: Working modes, Cycle 53



4.5 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 cycles 52 and 53 no change occurred in the LUT status as shown in the following figures.

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	10005
81	TAB_A2	10001
82	TAB_LOC	10001

LUT SUMMARY

ERS-2 RADAR ALTIMETER/CYCLE 52

From 03-APR-2000 to 08-MAY-2000

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	10005
81	TAB_A2	10001
82	TAB_LOC	10001

LUT SUMMARY

ERS-2 RADAR ALTIMETER/CYCLE 53

From 08-MAY-2000 to 12-JUN-2000

4.6 Special Events

During cycles 52 and 53 no special event influenced the instrument performances.

4.7 Data Comparison with forecasts

Extracted from the ECMWF report on ERS-2 RA for April and May 2000 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_apr00.pdf and ecmwf_alt_may00.pdf):

For April 2000:

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

- Global: 0.555 m/s
- Northern Hemisphere: 0.459 m/s
- Tropics: 0.375 m/s
- Southern Hemisphere: 0.723m/s

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

- Global: -0.012 m
- Northern Hemisphere: 0.055 m
- Tropics: 0.043 m
- Southern Hemisphere: -0.026 m

For May 2000:

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

- Global: 0.569 m/s
- Northern Hemisphere: 0.184 m/s
- Tropics: 0.484 m/s
- Southern Hemisphere: 0.838 m/s

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

- Global: -0.011 m
- Northern Hemisphere: 0.056 m
- Tropics: -0.050 m
- Southern Hemisphere: -0.020 m

The ECMWF remarks the problem of a too high bias between their wind speed and the RA recovered one. This value has been influenced by two problems: the 16th January drop (already happened in cycle 49, ref. par. 4.3) and the impact of the new attitude control software (ref. Cyclic Report for cycles 50 and 51, APP-ADQ/PCS/RA00-003, par. 4.6) has been demonstrated to have a very limited effect (ref. par. 4.3).