VALIDATION OF ENVISAT RADAR ALTIMETRY WITHIN THE OSCAR PROJECT

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ABSTRACT

The LEGOS based OSCAR project (observing continental surfaces with radar altimetry) intend to maintain and develop the use of satellite radar altimetry over continental surfaces. Here we show the processing chain that has been developed at LEGOS and which we use to qualify the ENVISAT and ERS data. The validation is based on a crossover analysis. We show the steps of the validation process, the results on various parameters, like height, but also backscatter, leading edge and trailing edge of the waveforms. The validation process allows us to deliver reports, but also a validation table which is available on our website as well as other meta product. The validation table gives for each track of each cycle a validity flag and a qualifying flag giving the reason of rejection if necessary. The waveform parameters as well as the geophysical and instrumental corrections are checked during the validation process. Over ice caps further echo and geographic corrections are computed which allows surveying the altimetric accuracy with time, area, surface slope.

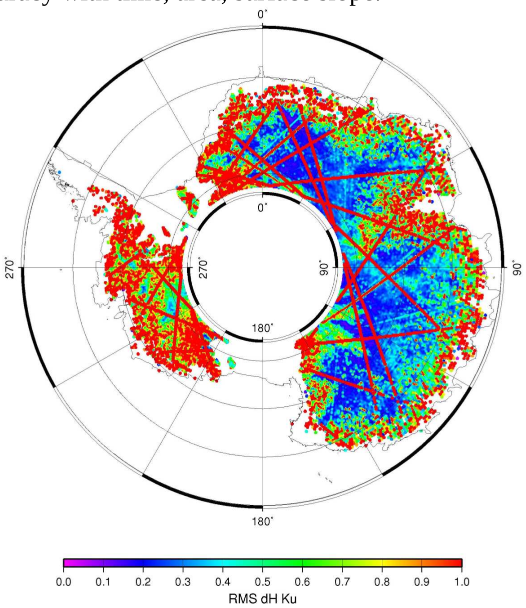


Figure 1: RMS of the crossover surface height difference (m) over Antarctica for cycles 9 up to 85. A few tracks have a large RMS due to outliers or instrumentals problems. In the coastal areas, the radar echo is sensitive to the strong slope. It produces a deformation of the wave shape which impacts the RMS of the ICE-2 parameters by being stronger.

1. INTRODUCTION

Users of altimetric data are facing a work to detect and to isolate the GDR data they collect on the databases. These GDR data supplied contain lot of default values, outliers and instrumental problems as we can see figure 1. In order to facilitate the usage of the data, we develop accurate and efficient editing tools, expecting the editing job to be minimized for the users. By the same process we can assess the quality of the data and ensure a cycle by cycle and long term monitoring of the altimetry over these surfaces. We also provide estimates of the measurements accuracy.

2 ICE-2 RETRACKER

The study of the cryosphere satellite altimetry has enabled the development of the ICE2 retracker [1] suited for the study of snow. The objective of this retracker is to collect not only information on the distance from the satellite to the Earth's surface but also the characteristics of the waveform shape (figure 2), which depend on the properties of the snow surface.

The parameters of ICE2 retracker are:

- The range: the distance between the satellite and the middle of the leading edge. We deduce the altitude of the land surface (H) by subtracting the corrected range to the satellite altitude.
- The Leading Edge Width (LEW): the time between the first echo and the maximum of the waveform.
- The Trailing Edge Slope (TeS): calculated by fitting an exponential decay of the waveform trail.
- The backscatter coefficient (Bs): is related to the integral of the power returned by the snow surface relative to the emitted power.

This ICE-2 retracker is particularly adapted to validation process. With these four parameters (H, Lew, TeS and Bs), we can statistically examine and judge the quality of the echo shape and the validity of the measurement.

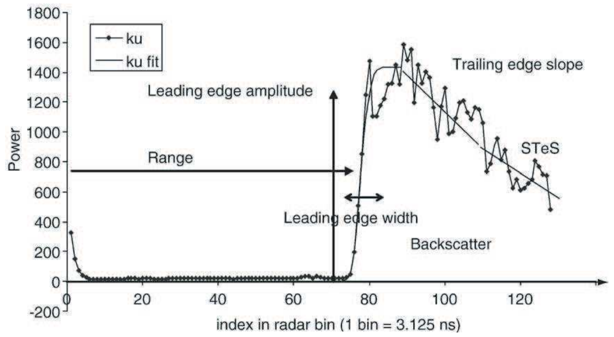


Figure 2: Waveform shape

3 THE ICE VALIDATION PROCESS

3.1 The principle

The ice validation process is based on the statistical study of the difference at the crossover point of the ICE2 parameters [1] and the associated corrections over areas like Antarctica and Greenland. The crossover points have a double interest here. On the one hand, their calculation gives us, in the same period (35 days maximum) and at the same point two measurements which should effectively limit the local topography, and their difference should be minimum. On the other hand the crossover points analysis, allows us to work on a reduced volume of data. To establish a valid statistic, the ice validation process needed crossover points calculated at least on a dozen of cycles.

The process is made of two main steps: crossover editing and track editing (see the diagram below). The figure 3 shows, at each stage of the validation, the number of crossover points available depending on the ENVISAT cycle. The black curve corresponds to the first stage of selection of crossover points (available data).

Crossover editing: The first stage of the ice validation process is the crossover editing. At this stage, we compute statistics on individual crossover time series (Figure 4) to remove outliers (4σ filter on each parameter).

In the next step, the surface slope dependence of ICE-2 parameters is taken into account. The radar echo shape depends on the surface slope over non oceanic surfaces. It produces a deformation of the waveform and the threshold antenna gain is reached for a slope of 0.6 degree (about 10m/km). The crossover having a slope over 0.6 degree are systematically considered bad and removed. To take into account the slope dependence of the ICE-2 parameters, the crossovers are sorted by class of slope.

Once sorted by class of slope, the RMS is calculated. An iterative editing (4σ filter) is ran on each class of slope to reach the RMS convergence to 10% or less from the previous iteration. The convergence results of the RMS are shown in the histograms as a function of the class of slopes (see figure 5).

At the end of this crossover editing process, a cross validation check that all ICE-2 parameters and corrections are simultaneously validated for each crossover to have crossover validated. If one of ICE-2 parameters or corrections is missing or invalidated the crossover is invalidated.

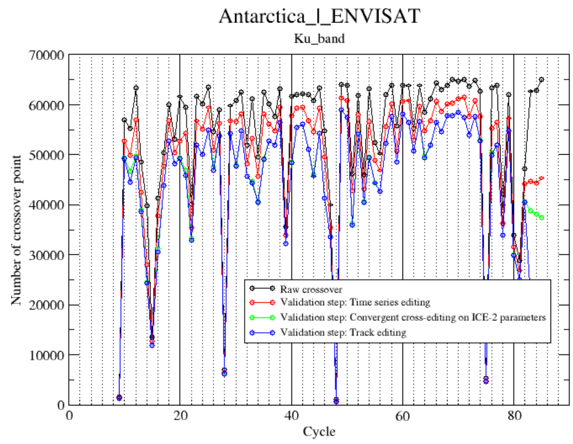


Figure 3*: Number of crossover point over Antarctica at each step of the validation process as a function of the cycle number for ENVISAT over Antarctica. In black is the number of crossovers computed at the beginning of the validation process. In red and green are the number of crossover remaining after the time series editing and the slope class editing respectively (****crossover editing**** step). In blue is the number of crossover at the end of the ****track editing**** step and at the end of the validation process.*

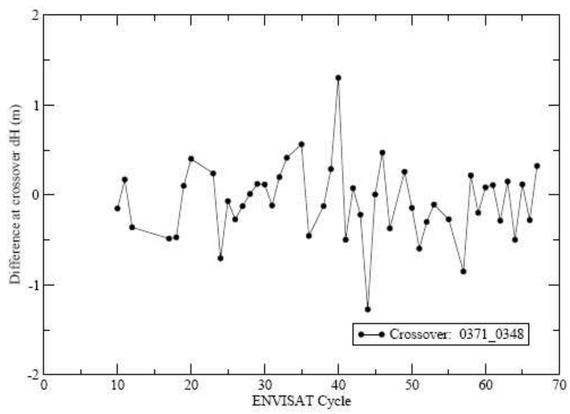


Figure 4: An example of crossover time series between the ascending pass number 371 and the descending pass number 348 of ENVISAT mission. This time series shows the surface height difference (between the ascending and descending passes) as function of the cycle number.

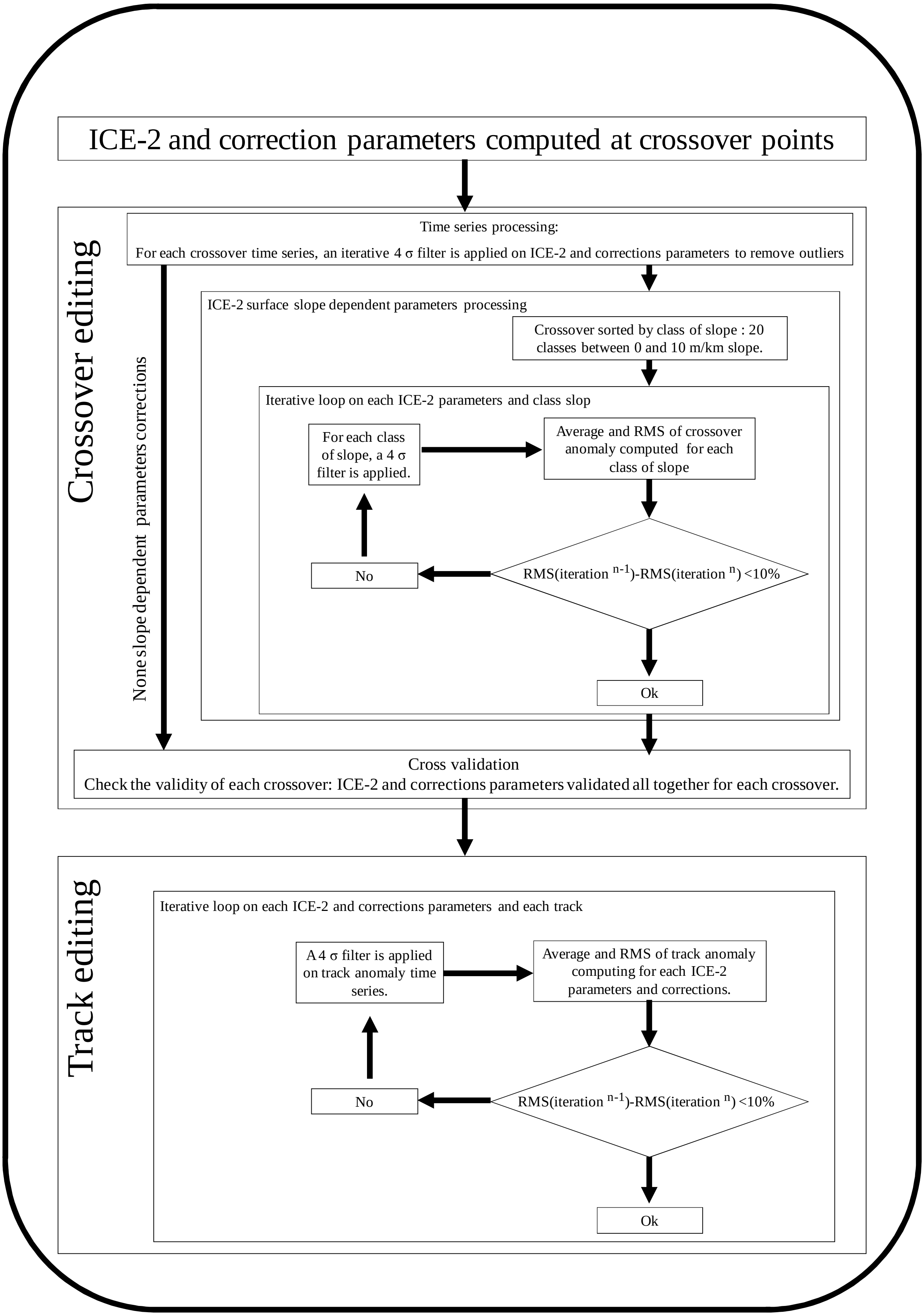


Diagram : Ice validation chain

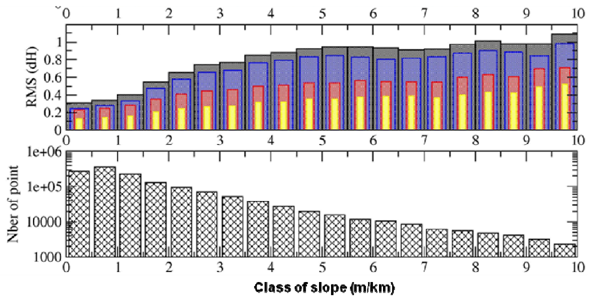


*Figure 5: RMS of the surface height difference at crossovers (top) and the number of remaining crossover points (below) as a function of class of slope (in m/km) over Antarctica. The **gray** histogram shows the dependence of the surface height to the surface slope. It becomes higher as the slope class increases. The figure 4 shows the map associated to this histogram. The **blue**, **red** and the yellow histogram illustrate the impact of the echo, geographical and both corrections respectively. These corrections reduce the RMS by half. The figure 8 shows the map of the yellow histogram.*

Track processing: The track processing aim is to isolate the tracks having large anomaly. From the crossover set previously validated, the anomaly at crossovers is averaged along the track to get the so-called track anomaly. An iterative editing (4σ filter) is run on each track to reach the RMS convergence to 10% or less from the previous iteration. This loop is iterated for each ICE-2 parameters and corrections. The tracks having one or more ICE-2 parameters or corrections with large anomaly are isolated. Figure 6 is the same map as figure 1 but after the ice validation process has detected the tracks having problems (outliers or instrumental).

4 THE ICE VALIDATION PRODUCTS

All the ice validation products are available on the OSCAR web site (http://oscar.legos.obs-mip.fr).

4.1. The ice validation table:

The ice validation table gives a global view of the mission over an area (Antarctica or Greenland) of the availability of tracks. The colour code gives the information of the major events met during the validation process (like the tracks missing, the tracks validated or not, …).

Figure 7 shows the validation table of ERS-2 and ENVISAT missions over Antarctica and Greenland. This kind of table is made using the code flag which indicate the validation state of each track, each cycle and each band (Ku or S) in the ENVISAT case. A same color code is used for both missions. These tables give a global view of the availability of tracks of both mission and it reveals the major events.

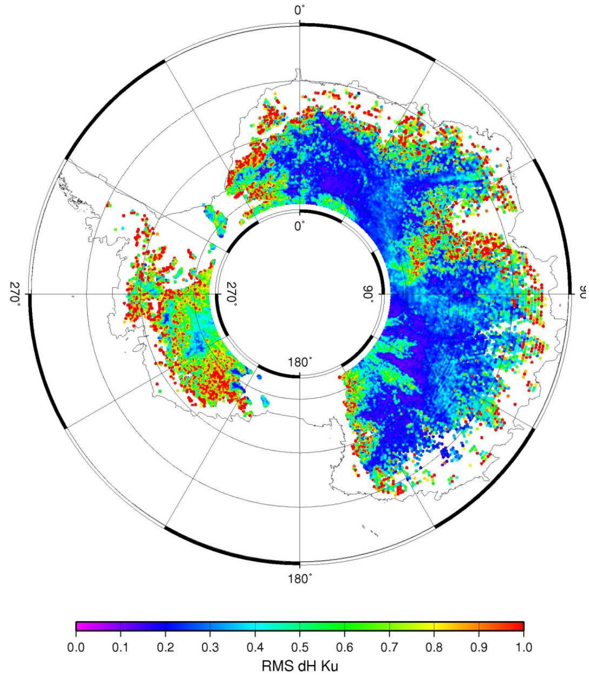


Figure 6: RMS of the surface height difference over Antarctica for cycle 9 up to 85. It is the same map as figure 1 but after the ice validation process. The bad crossovers points and the tracks are edited.

For ERS-2 for instance, one can see the period when the orbit had drifted due to a gyroscope problem between cycle 65 and 70 (in cyan). The validation flagged these data to advise the users. For ENVISAT for example, the S band is absent since cycle 65 (passing from green to yellow) and lot of tracks have been lost during cycle 48 (in gray) due to the switching manoeuvre of the RA-2 sensor between side A and side B (in May 2006).

This table is used to select the GDR data and works directly with validated set of data. This product is available for Antarctica and Greenland on the OSCAR web site.

4.2. The ice validation report

The outputs of the validation chain are collected and sorted in two kinds of reports generated automatically. The first one is the cyclic validation report, detailed for all the parameters (ICE-2 and corrections) showing behaviour for the particular cycle. The second one is the so-called annual validation report where it merges the information from the cycle reports to have a global vision over all cycles of the parameters behaviour. We update it once a year.

They include comments, curves plots, statistic tables and maps for each parameter and each ice sheet (Greenland and Antarctica).

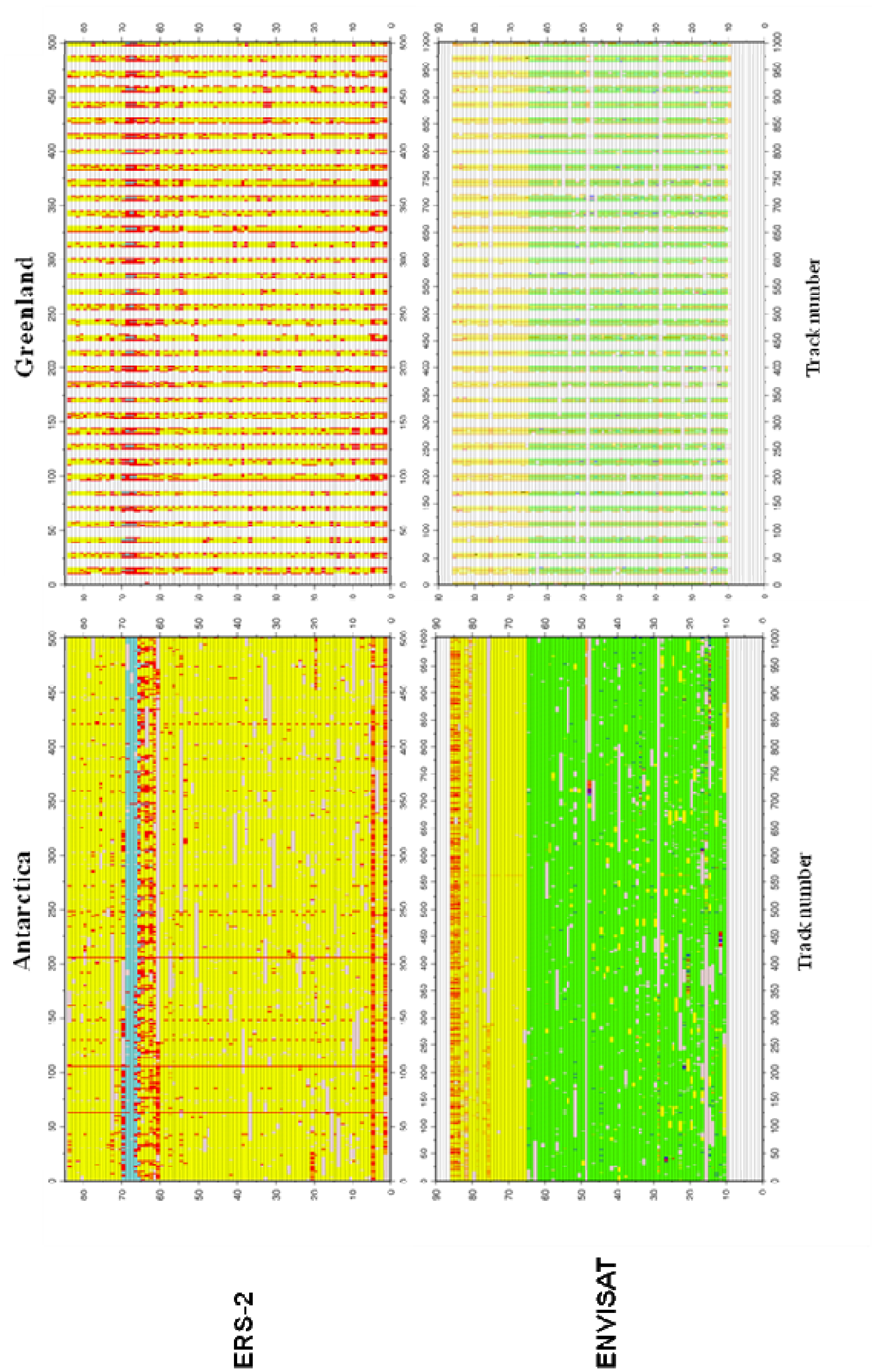
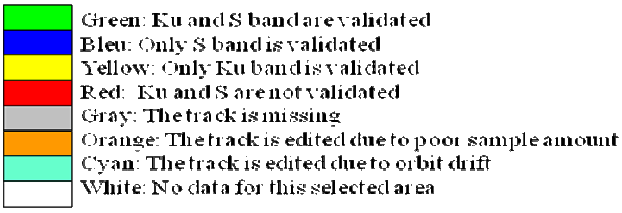


Figure 7 : The Ice validation table over Antarctica and Greenland areas for ERS-2 and ENVISAT missions. The table shows the validation state of each cycle as function of the track number. See the color code next page. http://oscar.legos.obs-mip.fr/products/validation then follow the desired mission.



Color code of the ice validation table.

5 CONCLUSION

This validation has been tested positively on Greenland and Antarctica and is currently used by the LEGOS to validate the data of the ERS-1, ERS-2 and ENVISAT missions. This ice validation chain helps to validate the altimetric data consistently over all these missions (figure 6). We further developed a geographic and echo corrections to correct for the miss-repeat of the ground crossover position and echo shape change with time. Figure 8 shows the average RMS difference at crossover points after validation and echo and geographic corrections are applied [1] [2] [3] [4]. This work opens perspectives on the long term monitoring of the ice cap over Antarctica and Greenland. It can easily be extended to new missions (Cryosat, saral Altika, Sentinel…)

6 REFERENCES

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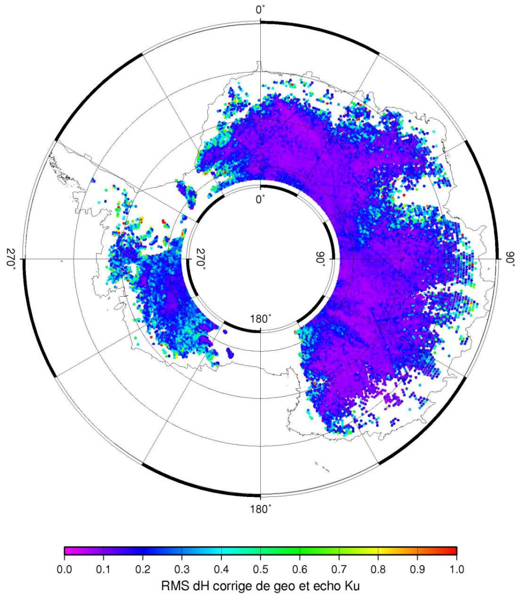

Figure 8: RMS of the surface height difference (m) over Antarctica for cycle 9 up to 85. It is the same map as figure 6 where the echo and geographical corrections are applied.