ERS2-ENVISAT cross-validation
CTOH retracking of the tandem phase

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The Centre for the Topography of Oceans and the Hydrosphere (CTOH), the Altimeter Data Service of the LEGOS laboratory pursues an effort to validate and improve the ERS-2 mission altimetry and particularly for the continental surfaces. The CTOH processed the original ERS2 waveforms (WAP data) with the ICE2 retracker with some algorithm improvements with regards to previous versions, using the new Reaper combined orbit (Rudenko et al. 2012).

The cross-validation with the ENVISAT (V2.1) missions is done during the tandem phase. ERS2 and ENVISAT flew over the same orbit with 30 min delay for about 1 year. We developed a number of corrections to be used in conjunction and computed homogeneously for the 2 satellites. The cross-validation strategy consists in looking at the global ocean to check and remove large scale offset functions between the missions.

In a second step we investigate the differences over continental surfaces and quantify the remaining difference and bias. This poster shows the main results observed in the two steps of the cross-validation and how the empirical large scale offset functions are computed and corrected for each waveform parameter (height (H), backscatter(Bs), leading edge width (LeW) and trailing edge slope (TeS)) to make them comparable between ERS2 and ENVISAT.

First order Cross-validation over Ocean

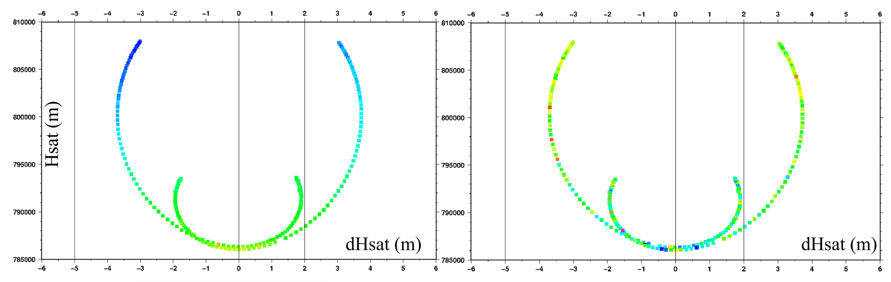


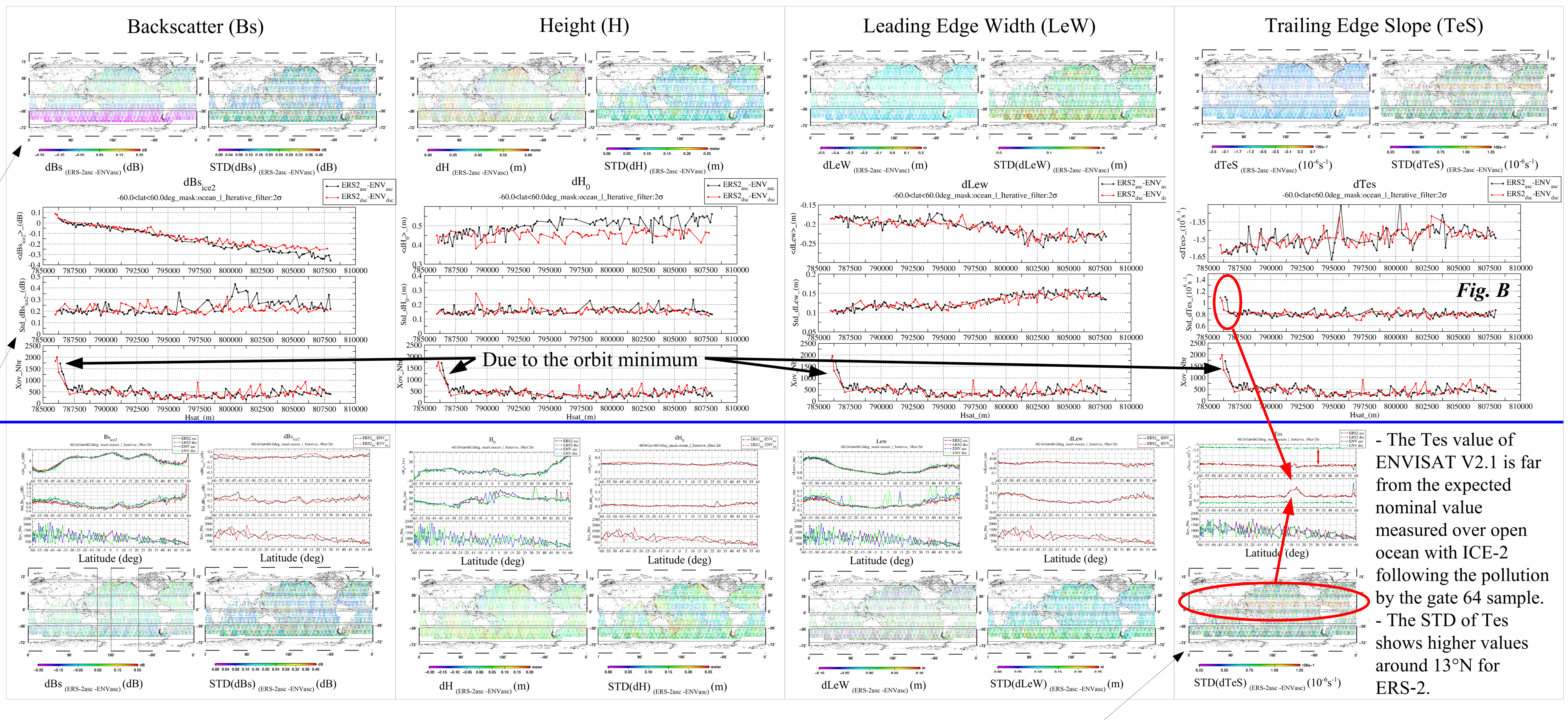
Fig. A

Mean difference of the Bs (left) and the TeS (right) as function of satellite altitude (Hsat) versus satellite altitude variation (dHsat)

Maps of the mean and STD parameter of the crossover difference between ERS-2 and ENVISAT: The map of the mean difference of the Backscatter (Bs) shows a strong North-South gradient and the map of the STD of the difference of the Trailing edge slope (TeS) shows a latitude range (around 13°) where the STD values are stronger.

Figures of mean and STD parameter of the crossover difference between ERS-2 and ENVISAT as function of the ERS-2 orbit altitude: The plot of dBs shows that there is a linear relationship between the dBs and the orbit altitude (corr. coef. R=0.8). This observation explains the gradient of dBs observed above (*Fig. A*). For the other parameters linear relationships to the orbit altitude are also observed. The STD of the dTeS is strongest around the lowest part of the orbit (*Fig. B*).

A linear regression is calculated in order to correct the dependancy of the parameter difference to the orbit altitude and remove the large scale bias inter-mission ERS-2/ENVISAT.



The following figures (under the blue line) show a good inter-mission agreement and limited differences at all latitudes. The Tes parameter has two issues. The first one clearly identified as ENVISAT V2.1 bug which is coming from the impact of the aliasing on the gate number 64 unfixed. The second one problem is the strong STD of TeS observed between latitude 5 and 20° N with a pic at 13° N for the ERS-2 mission. This phenomenon is robustly identified but we do not have a clear explanation.

Cross-validation over continental surfaces

Cryosphere

In order to assess the reprocessing over the continental surfaces, the data are corrected of the bias and trend at large scale observed in the preliminary cross-validation over ocean. The cross-validation strategy over continentals surfaces is different to the global ocean. Due to the topography, the crossover is sensitive to the position variation and less sensitive to the time delay between two measurements. As a result the inter-mission crossover is done by making the difference between ERS2 ascending track and ENVISAT descending track and vice versa:

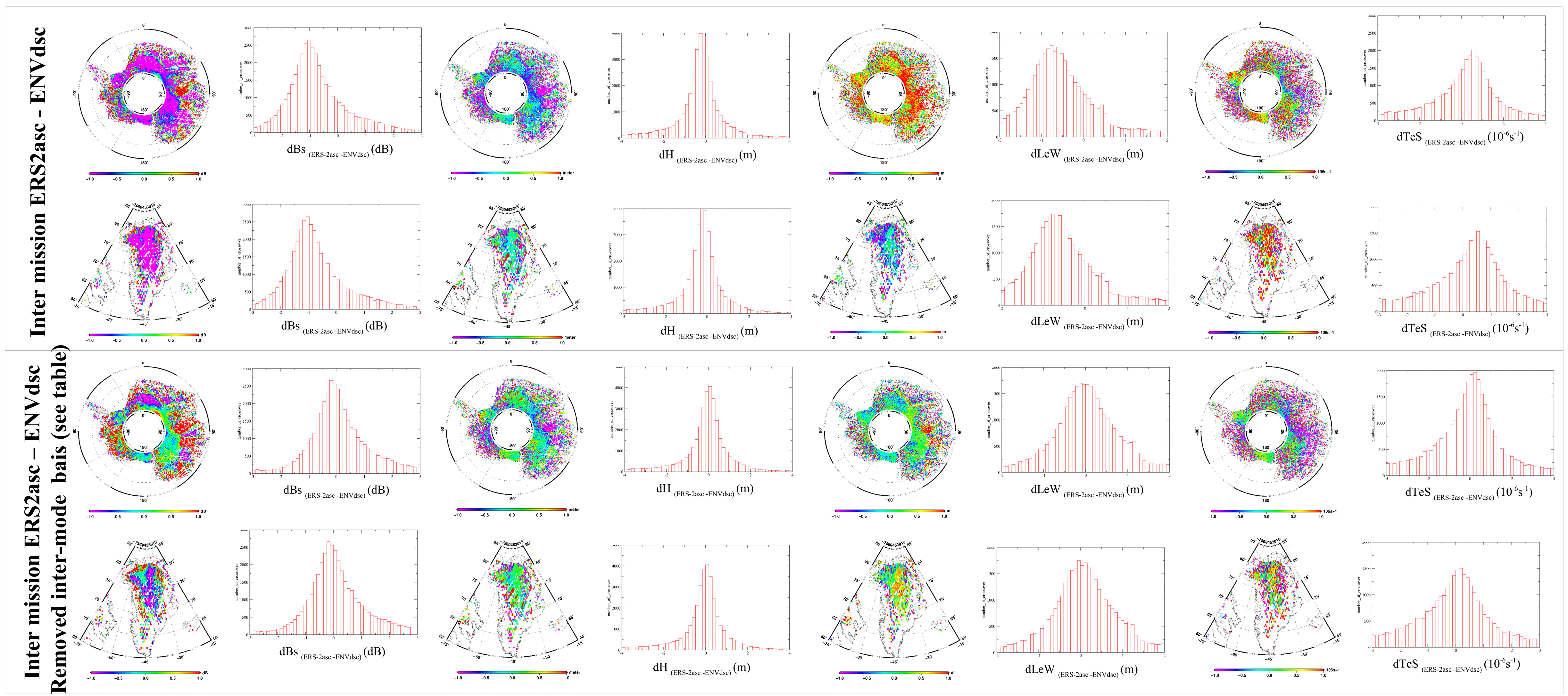
ERS2asc-ENVdsc and ERS2dsc-ENVasc.

The maps and the histograms show similar results for each parameter, regardless of the difference sign (asc-dsc or dsc-asc) and whatever the area: Antarctica or Greenland. On the left(/right) before(/after) removing the large scale offset functions.

Below the bias observed (median value) over Antarctica and Greenland:

Bais ERS2/ENVISAT	Antarctica ERS2asc-ENVdsc / ERS2dsc-ENVasc	Greenland ERS2asc-ENVdsc / ERS2dsc-ENVasc
dBs (dB)	0.925 / 0.907	0.925 / 0.907
dH (m)	0.214 / 0.201	0.214 / 0.202
dLew (m)	0.689 / 0.717	0.688 / 0.720
dTes ($10^{-6}s^{-1}$)	-0.371 / -0.312	-0.403 / -0.342

The observations over continental surfaces are done in "ice mode" (BW=82.5MHz) with different bandwidth than ocean mode (330MHz). The biases summarized in the table therefore represent an inter-mode bias within ERS2. Finding very close numbers over Antarctica and Greenland suggest that these inter-mode biases are robust and mostly constant.

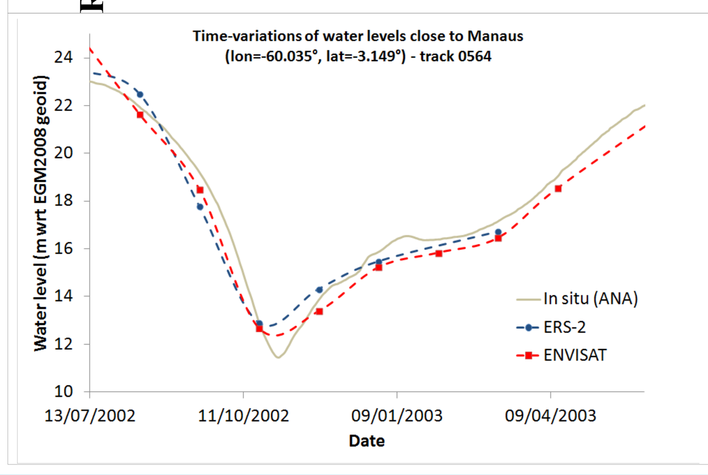


Monitoring of water levels

Both ERS-2 and Envisat demonstrate the potential of using radar altimetry for the monitoring of water levels in drainage catchments. In this example, altimetry-based water levels from ERS-2 and ENVISAT measurements provide a realistic monitoring of the changes in stage of the Negro River, exhibiting annual variations larger than 10 m.

Frappart F., Calmant S., Cauhopé M., Seyler F., Cazenave A. (2006). Preliminary results of ENVISAT RA-2 derived water levels validation over the Amazon basin, Remote Sensing of Environment, 100, 252-264, doi:10.1016/j.rse.2005.10.027.

Frappart F., Papa F., Marieu V., Malbeteau Y., Jordy F., Calmant S., Durand F., Bala S. (under revision). Preliminary assessment of SARAL/AliKa observations over the Ganges-Brahmaputra and Irrawaddy Rivers, Marine Geodesy.



Time-series of water derived from altimetry measurements from ERS-2 (blue) and ENVISAT (red) at a crossing between track 564 and the Negro River. For comparison, daily in situ records from Manaus gauge station, managed by the Brazilian water agency (Agencia Nacional de Aguas - ANA) are presented (grey). These time-series are obtained using the Multi-mission Altimetry Processing Software - MAPS (Frappart et al., under revision) from ranges obtained using Ice-1 retracking algorithm that currently provides the best results for the monitoring of land waters (e.g., Frappart et al., 2006).

Acknowledgements

We are grateful to the **ESA** for providing the WAP data and **REAPER** improved orbits. Thanks to Sara Fleury and Nicolas Fuller for their help.

Conclusion & Results

- From the cross-validation over ocean and for each ICE-2 parameters, we calculated linear functions of the orbit altitude and systematic bias which we characterize as empirical large scale offset functions. Once corrected for these large scale offset functions, the two missions show an overall good agreement.
- This dependency in orbit altitude is robustly observed although we do not know of a determinate technical explanation.
- The **STD of the ERS2 TeS shows an anomalous feature around 13°N** which is consistently observed but remains unexplained. Those ICE-2 data between latitude 5 to 20°N are to be used with caution.
- The Trailing Edge Slope of ENVISAT V2.1 is still affected by the gate 64 we recommend to exclude the samples around gate 64 in any future reprocessing.

The cross-validation over the continental surfaces show good results:
- The bias observed over Antarctica and those over Greenland are very similar for all ICE-2 parameters
- The difference between the ERS2 and ENVISAT over ice surfaces show significant regional patterns with significant difference amplitude. For example the STD of BsENV-BsERS over ocean is 0.13dB while it is 1.07dB over Antarctica. This suggest a difference in polarisation effects for both missions (identified by Legresy et al., 1999 for ERS and found different between ERS and ENVISAT by Legresy et al., 2013).
- For the hydrology, the monitoring of water levels obtained by ERS-2 is conform to the ENVISAT mission during the tandem phase.

For this re-processing and this cross-validation, we developed a **new Doppler correction** accounting for the range rate (as proposed in Blarel and Legresy, 2012) and **new wet and dry troposphere corrections** with ERA-INTERIM fields valid over all surfaces (as proposed in Blarel and Legresy, 2013) for both satellites.

This CTOH re-processed dataset and the added new corrections are fully validated for the ERS-2 and ENVISAT V2.1 tandem phase.

The details of this cross-validation will be soon available on line on the CTOH web site (see the companion poster: ERS-2 CTOH product). A validation of the whole ERS-2 mission will be also done for continental surfaces as well a concurrent evaluation of the REAPER reprocessing.

Legresy, B., F. Remy and P. Schaeffer. 1999. Difference ERS altimeter measurements between ascending and descending tracks caused by wind induced features over ice sheets, Geophys. Res. Let., 26 (15), 2231-2234.

Legresy, B., M. Horwarth, M. R. Van den Broeke, S. R. M. Ligtenberg and F. Blarel. 2013. How accurately can radar altimetry contribute to estimate the Antarctic ice sheet volume and mass balance? Int. Glaciol. Society. Beijing. 2013.