

Assessment of the Wet Tropospheric Correction from the SWOT RADIOMETER

T. Pirotte⁽¹⁾, M-L. Frery⁽²⁾, B. Picard⁽³⁾, L. Amarouche⁽¹⁾, H. Roinard⁽¹⁾, F. Bignalet-Cazalet⁽²⁾, G. Dibarboure⁽²⁾, M. Raynal⁽²⁾

⁽¹⁾ CLS, ⁽²⁾ CNES, ⁽³⁾Fluctus

Contact: tpirotte@groupcls.com



Introduction

The SWOT mission aims to measure ocean topography and water levels with high precision and spatial resolution. It carries a Ka-band wide-swath interferometric altimeter (KaRIn), a Ku-band conventional nadir altimeter (Poseidon-3C), and a dual-beam radiometer (MWR) to correct for water vapor delays in the troposphere, known as the Wet Tropospheric Correction (WTC).

Unlike nadir radiometers, SWOT's dual-beam radiometer matches KaRIn's wide swath, enabling WTC interpolation across the swath using an algorithm developed by JPL. The WTC is also interpolated at nadir using a CNES/CLS algorithm. Comparisons with models (ECMWF) and independent instruments (GPM/GMI, Sentinel-6 AMR-C) show that SWOT's interpolated WTC provides accurate, stable corrections over the open ocean, outperforming ECMWF-based corrections in areas with sharp water vapor gradients.

Challenges remain in complex environments (rain, coastal areas, ice) and regarding limited sensitivity to fine-scale atmospheric variations. These issues highlight opportunities for improving WTC retrieval and guiding future wide-swath altimeter missions.

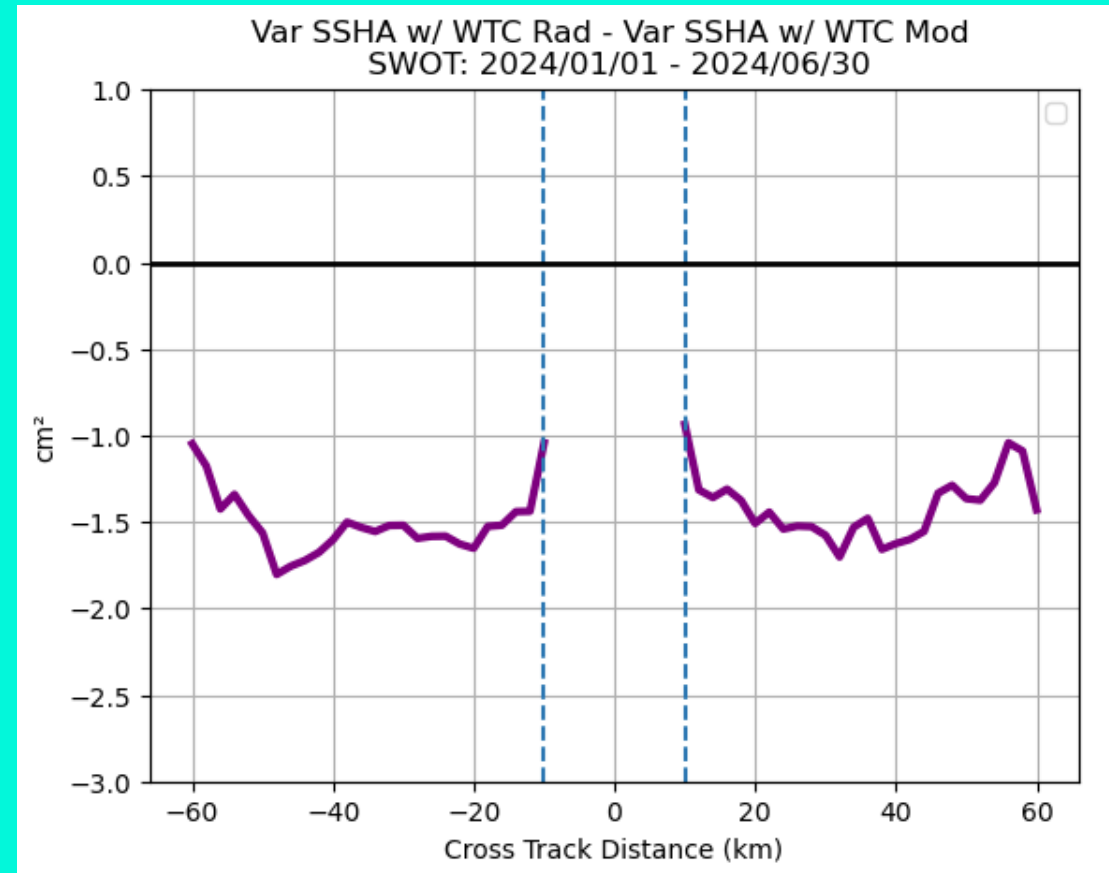
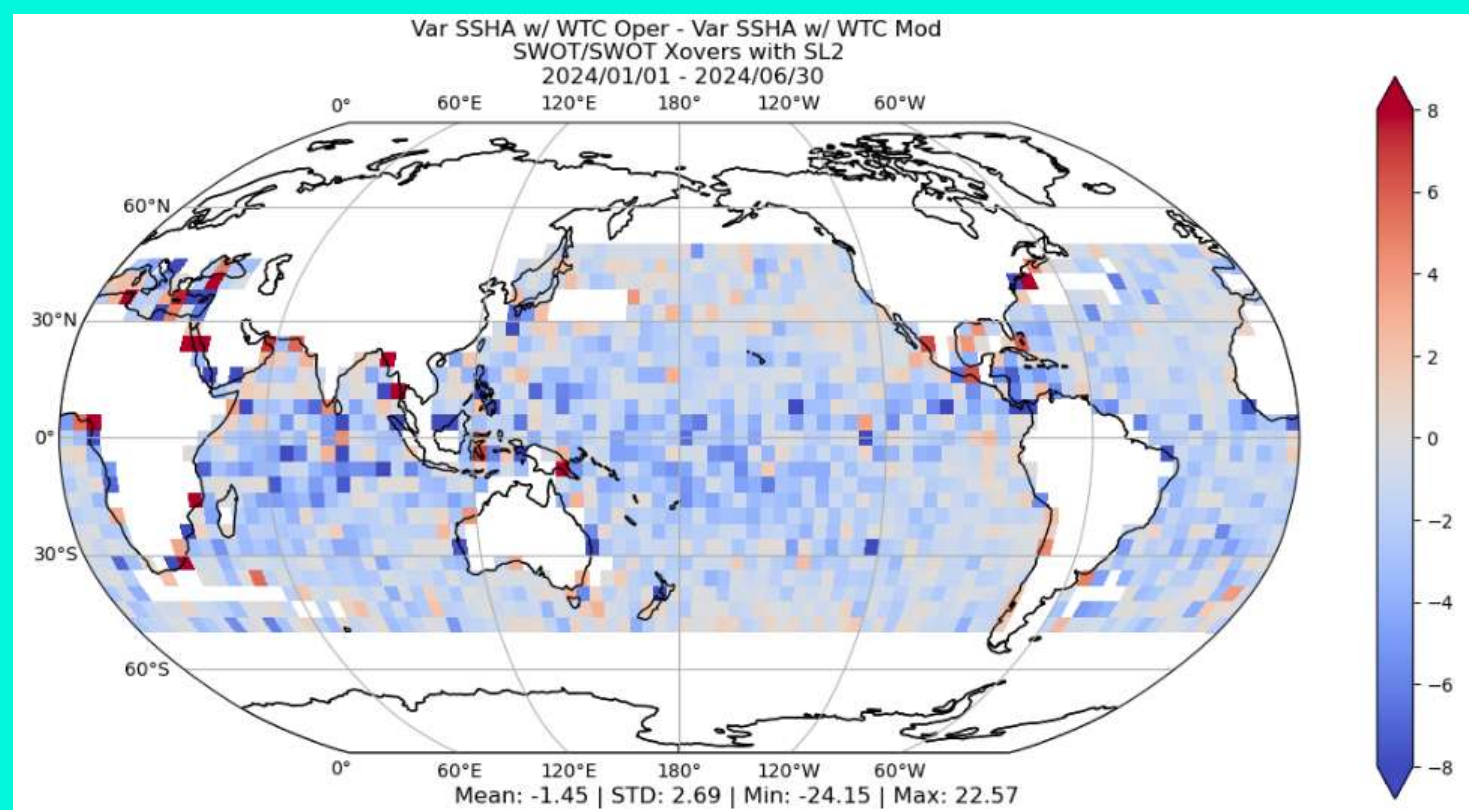
Assessment of the Karin Wet Tropospheric Correction

The Wet Tropospheric Correction featured in Karin products is derived from an algorithm developed by JPL using data from the radiometer aboard SWOT.

Crossovers analysis

Analysis of the SSHA variance at crossovers using Wet Tropospheric Correction either from the MWR or ECMWF highlights the quality of radiometer data compared to model in a global context with a reduction of variance of **1.45 cm²** on average.

Reduction of variances as function of the cross-track distance shows that the improvement is more significant in the middle of both KaRIn swath, where the data are closer to the radiometer measurements.



Comparison with GMI radiometer

GMI is a multi-channels conical-scanning microwave radiometer with gridded products resolution equal to 1/4 degrees, providing highly accurate water vapor content, from which a WTC can be derived and used as a reference.

Comparison with GMI highlights the good performance of the interpolated KaRIn Wet Tropospheric Correction compared to the model in specific cases like water vapor fronts.

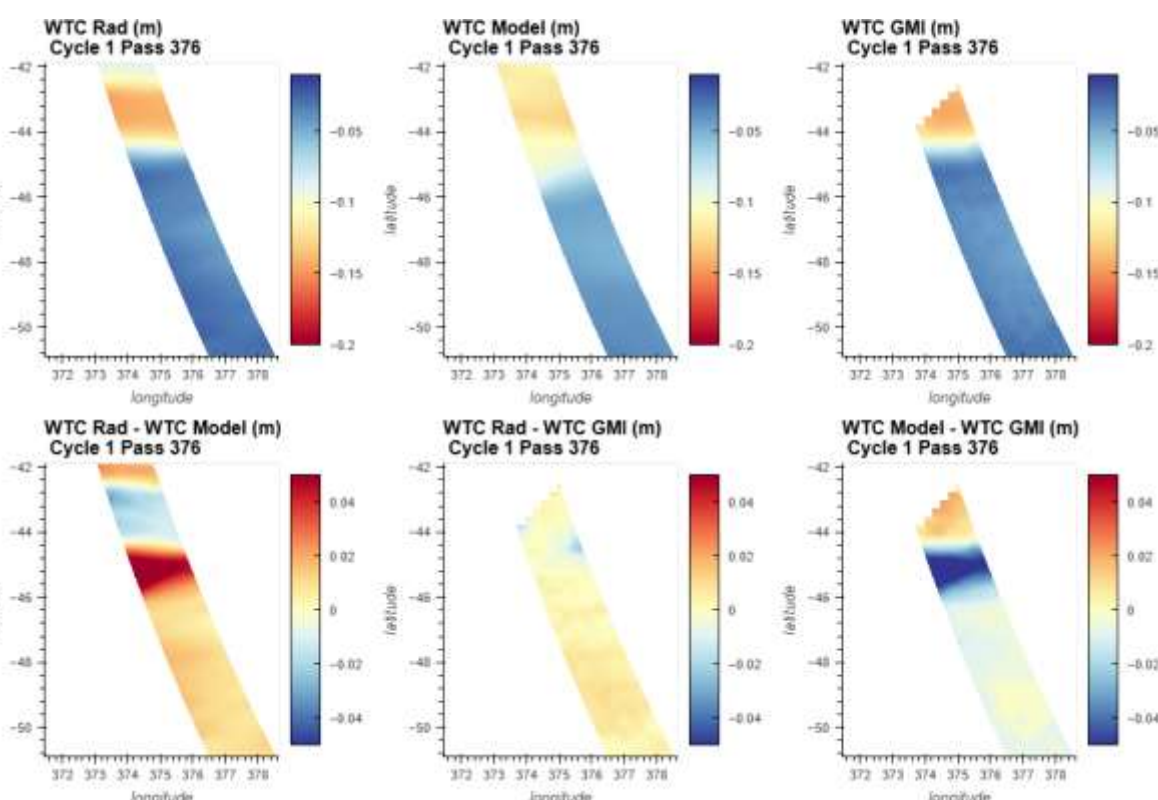


Fig: Comparison between SWOT AMR derived WTC, model derived WTC and GMI derived WTC in a region with strong water vapor variations.

SWOT Radiometer description

- Three frequencies radiometer derived from the Advanced Microwave Radiometer (AMR) flown on Jason-2 & 3 with 18.7 GHz, 23.8 and 34 GHz channels, with 16 observations per second. The WTC is then derived using the brightness temperatures from the three frequencies. [Brown, 2010].
- The distinctive feature is to have two beams measuring the brightness temperatures on either side of the Nadir, roughly in the middle of each KaRIn swath.

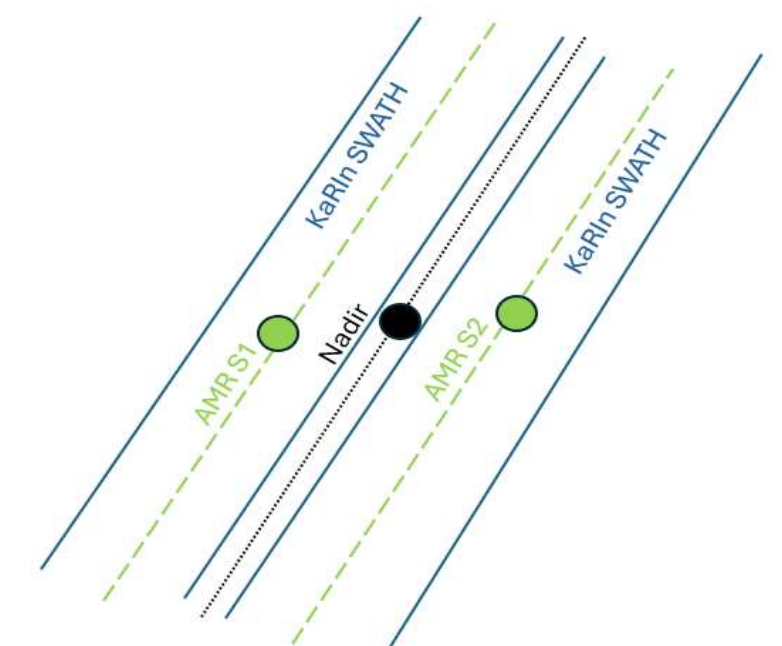


Fig: Diagram showing the position of radiometer measurements relative to KaRIn swath and Nadir

SWOT Nadir WTC performance

The Wet Tropospheric Correction featured in Nadir products is derived from an algorithm developed by CNES/CLS using data from the radiometer aboard SWOT. The performance of SWOT Nadir WTC is slightly inferior to Sentinel-6a, the latter being directly measured at nadir, but remains significantly higher than a WTC derived from the ECMWF model.

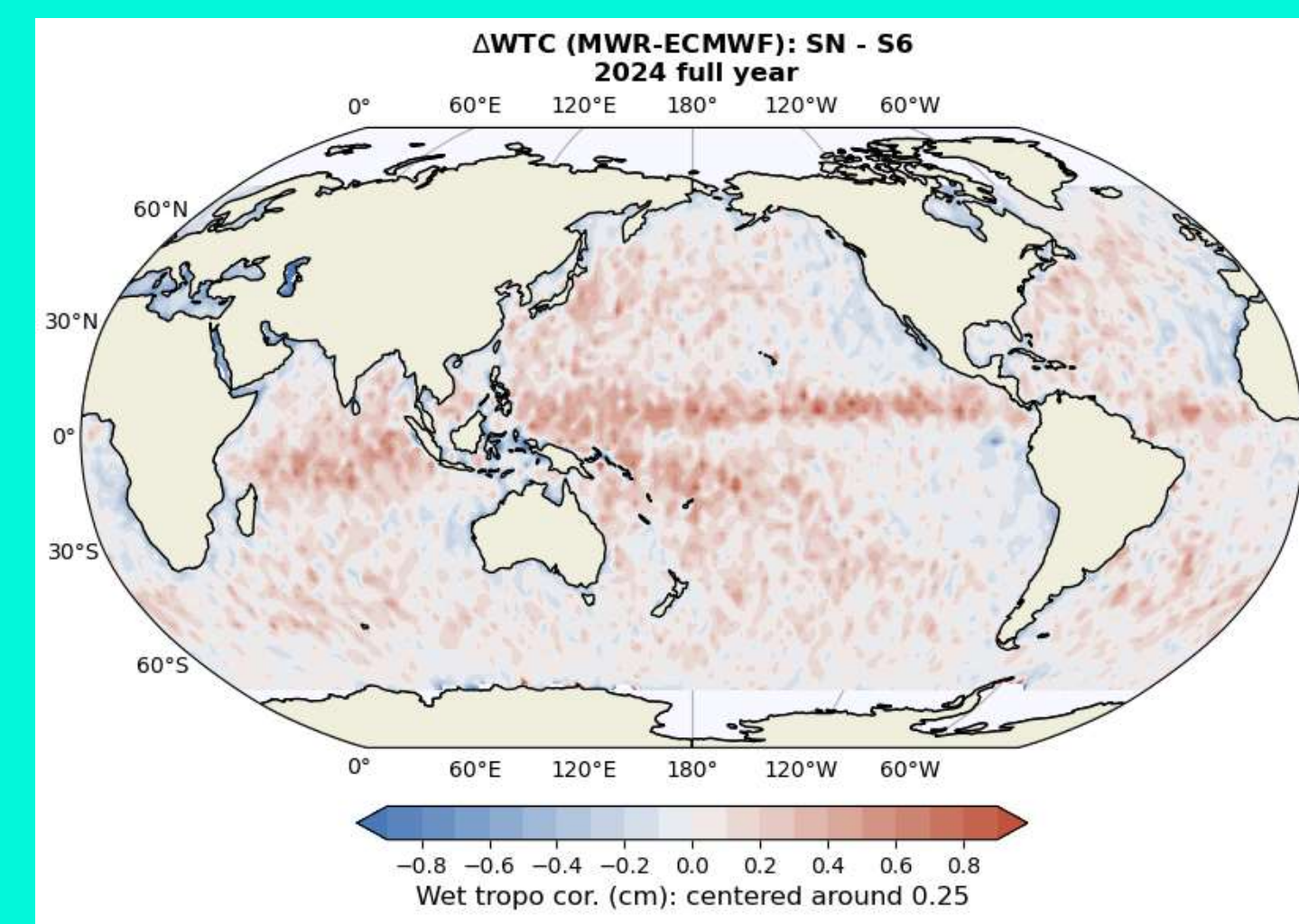


Fig: Geographical variations of the difference of WTC bias (MWR-derived correction minus those from ECMWF model) between SWOT nadir and Sentinel-6A-MF, with a mean difference of 0.25 cm removed.

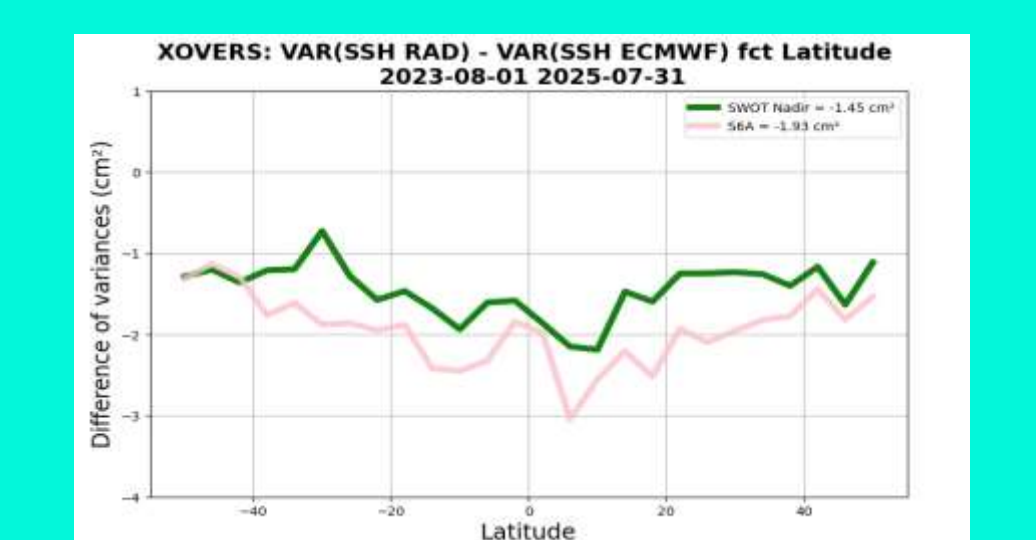
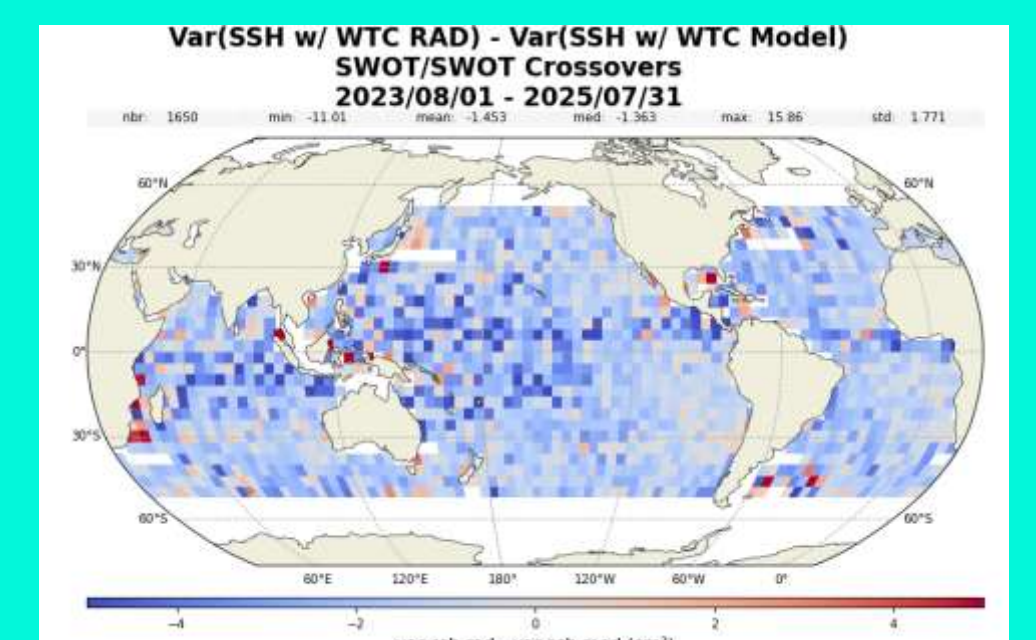


Fig: Geographical variations of the difference of variance of SSHA depending on whether the WTC from radiometer or the WTC from model is used.

Limitation of the current KaRIn interpolation algorithm

Regions without interpolated WTC

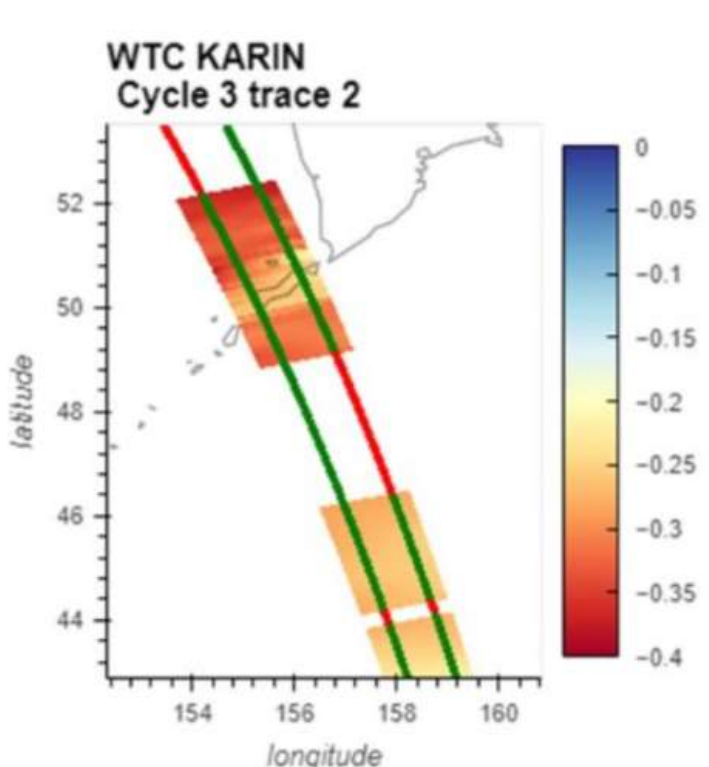


Fig: Example of failed interpolation due to loss of validity of the WTC on one side of the radiometer (even if the other side is valid)

The WTC is not interpolated whenever the measurements from one radiometer beam are identified as invalid. This occurs even if the beam on the opposite side provides valid data. Such invalid cases are due to:

- Rain
- Ice
- Land

Valid SSHA points with no WTC interpolated - % per box SWOT KaRIn

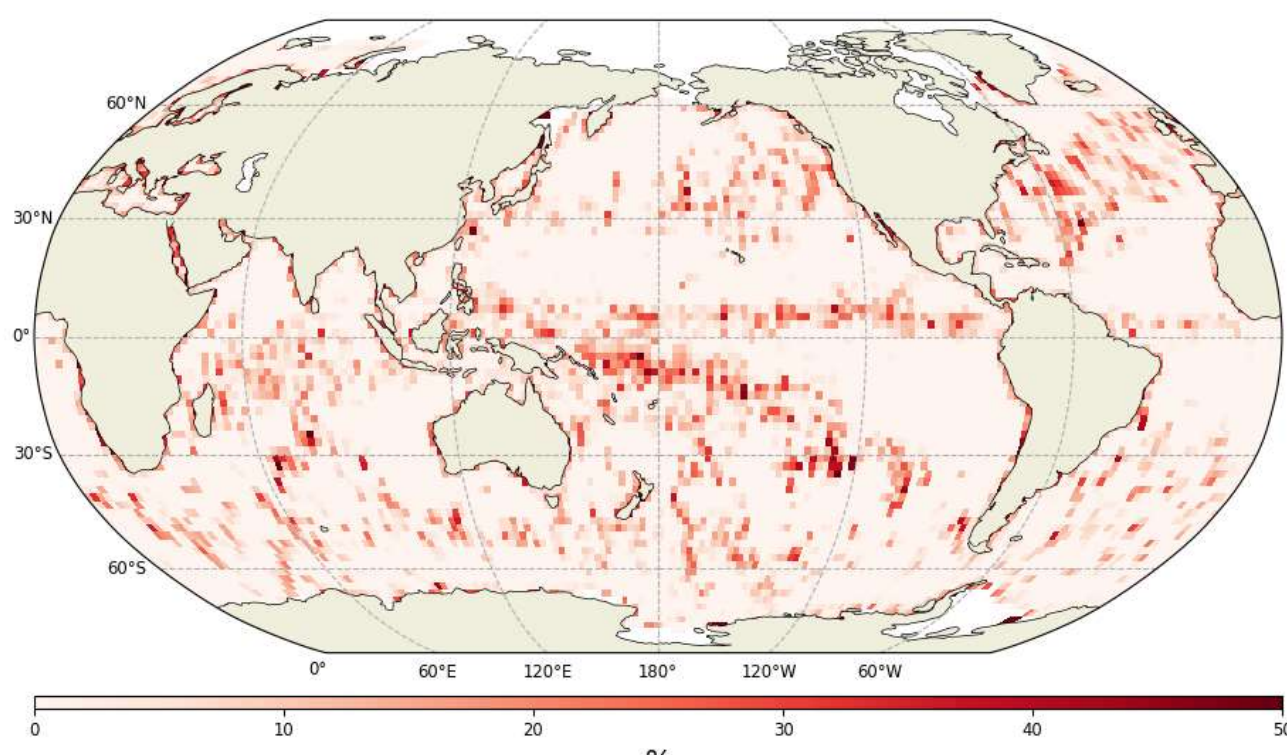


Fig: Geographical distribution of valid KaRIn SSHA measurements without WTC interpolated

Overall, **3.7%** of KaRIn data with valid SSH measurements do not have an associated interpolated Wet Tropospheric Correction

Wet Tropospheric correction behavior in coastal areas

The radiometer measurements on coastal areas are strongly contaminated by land and appears to be noisy when the distance to the coast is less than 60 km. The noise is then reflected on the KaRIn interpolated WTC, which appears streaked in coastal areas, and thus potentially on the SSHA corrected with MWR WTC

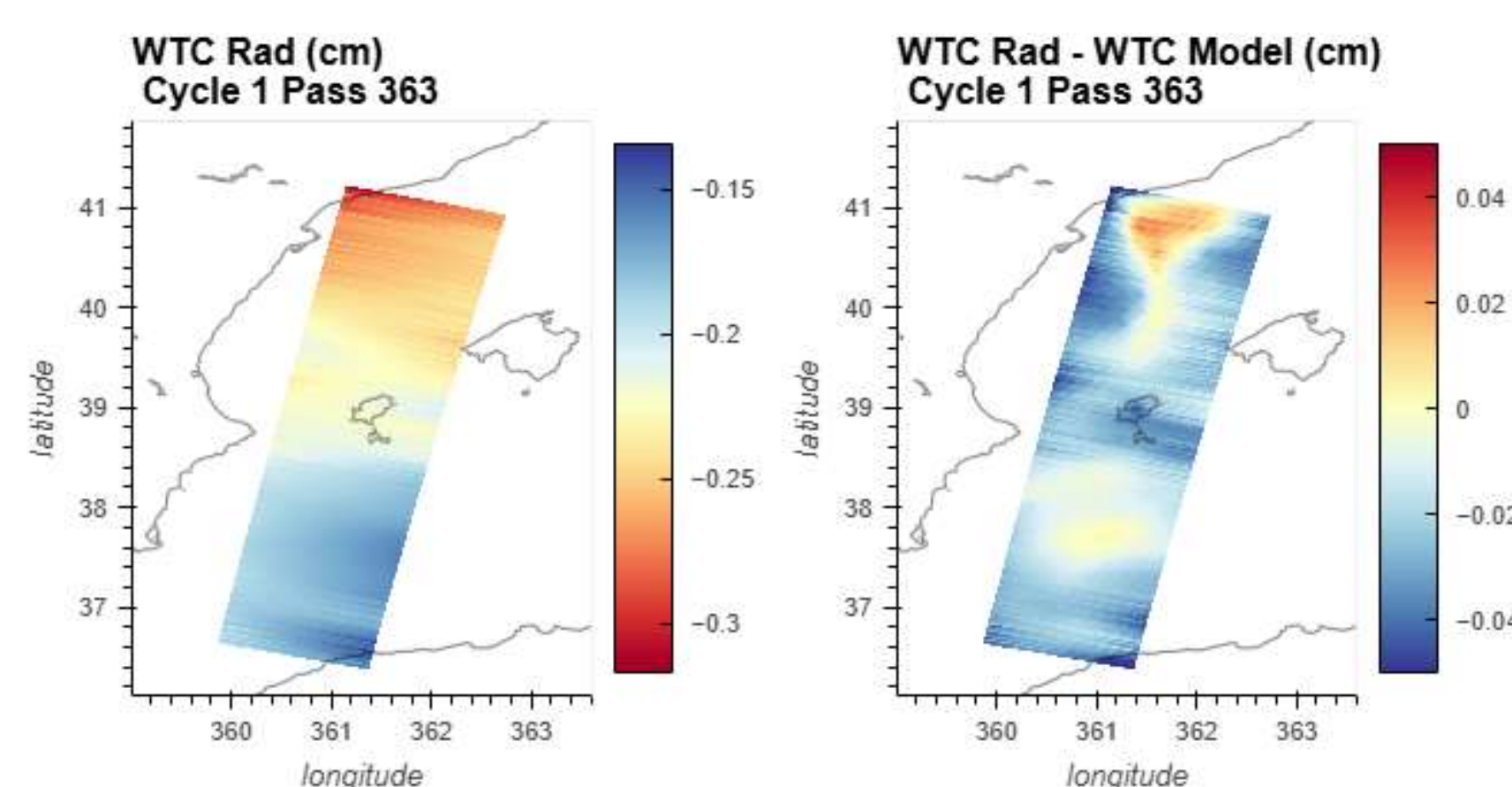
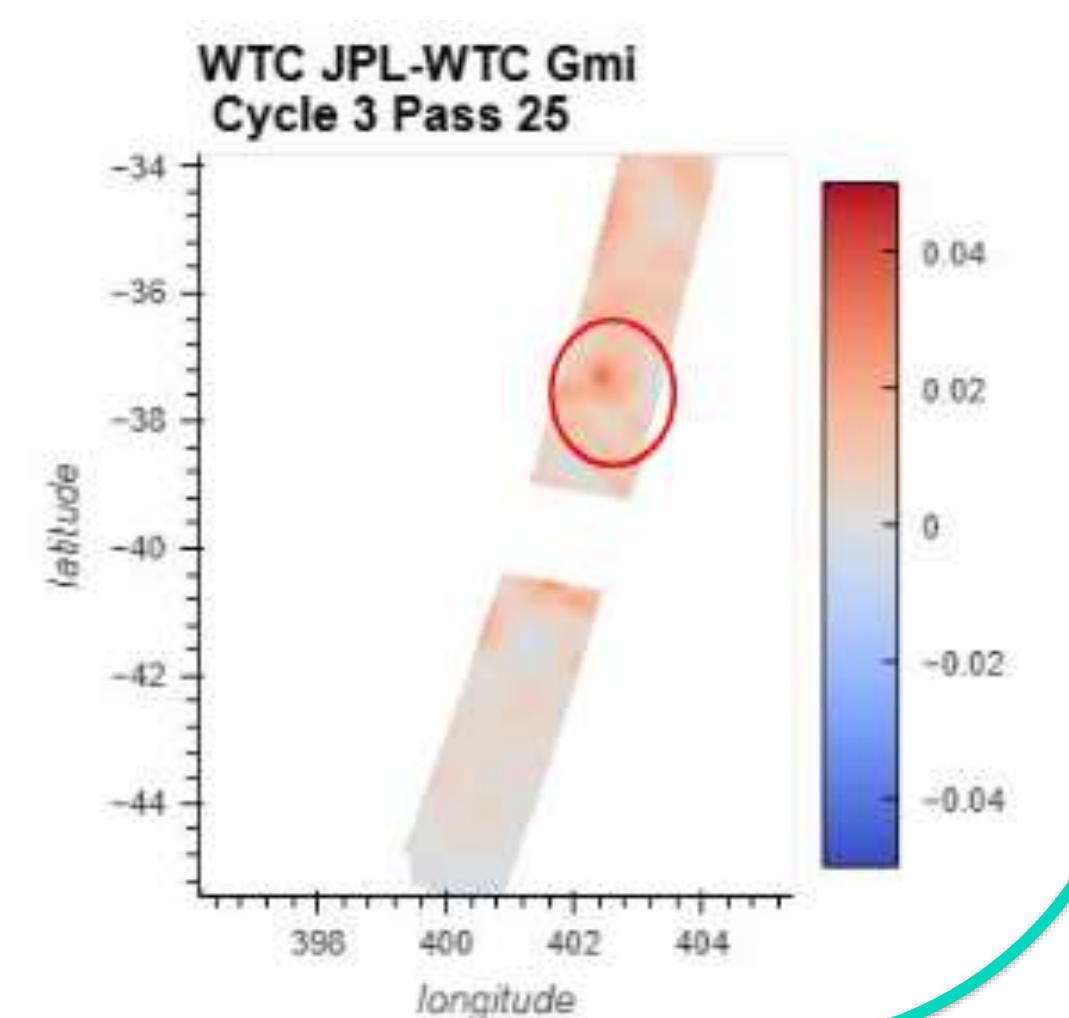


Fig. left: Example of KaRIn interpolated WTC on coast degraded by noise

Fig. bottom: Example of Water Vapor artifact detected by GMI but not by SWOT

Fine-scale atmospheric structures

The specific nature of SWOT, with interpolation on points tens of kilometers away from the radiometer measurements, which themselves have a footprint of approximately 30 km, means that subtle atmospheric variations occurring in the KaRIn measurement may not be seen, leading to a possible small error in the KaRIn Wet Tropospheric Correction and thus potentially on the SSHA corrected with MWR WTC. This is highlighted by comparisons with GMI.



Perspectives

A new interpolation algorithm, using Objective Analysis, is currently under development and analysis by CNES and CLS, with the aim of overcoming the limitations of the current operational algorithms and to be used for both KaRIn and nadir data. (See Marie-Laure Frery presentation: Objective Analysis Method for SWOT Microwave Radiometers).

References

Brown, S. (2010). A novel near-land radiometer wet path-delay retrieval algorithm: Application to the Jason-2/OSTM Advanced Microwave Radiometer. IEEE Transactions on Geoscience and Remote Sensing, 48(4 PART 2), 1986–1992.

