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Assessment of innovative algorithms for CryoSat-2 in the frame of the CP4O project

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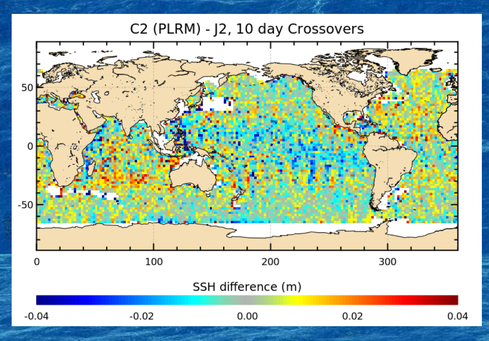
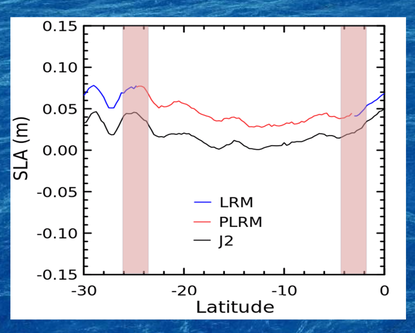
➔ Abstract The ESA CryoSat-2 mission is the first space mission to carry a SAR-mode radar altimeter, which is expected to provide better performances than a conventional radar altimeter: finer along-track spatial resolution and improved precision. However, the real issue being addressed today is the elaboration of new altimetric models, since the SAR echo power exhibits a different shape than the conventional one, and the evaluation and validation of their output. The Cryosat Plus for Oceans (CP4O) project aims precisely at quantifying skills and drawbacks of the different innovative methods (SAMOSA, CPP, DDA3 from Halimi) and see whether they will enable the full exploitation of the capabilities of the Cryosat-2 SIRAL altimeter or not. For this purpose, CLS has conducted an assessment of performances of each new algorithm (from instrumental to geophysical corrections) that consisted in comparing accurately their impacts against those obtained with other algorithms, through the use of robust and standard diagnoses.

➔ Validation of PLRM CPP method (CNES) / LRM

To allow the assessment of the in-orbit performances of the SAR-mode data and the quality of the processing method, a reduced SAR (aka PLRM) methodology has been developed that aims at emulating LRM echoes, similar to the conventional pulse limited waveforms, from SAR mode data to make direct comparisons of their measurements over identical sea state.

Map at crossovers J2 / (LRM+PLRM) shows no apparent discontinuities at LRM/PLRM transitions. Long wavelength error pattern in the 30N–30S band are correlated with geomagnetic equatorial where GIM errors are largest.

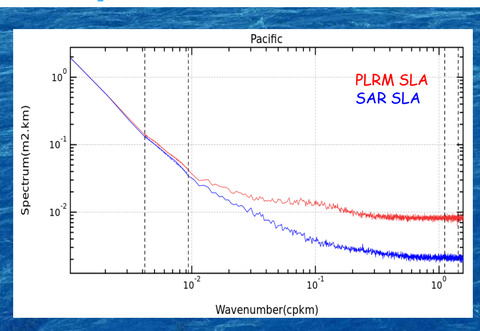


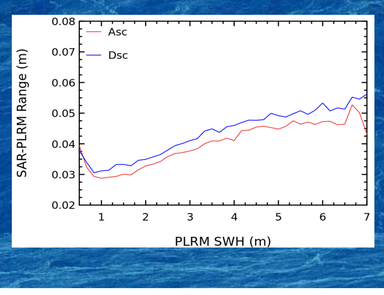


PLRM and LRM provide a seamless continuity for range and SWH values at transitions of Cryosat-2 LRM/SARM mask.
The remarkable agreement obtained between PLRM and LRM standard (that we are used to in altimetry), fully validates the PLRM CPP processing for assessing in-orbit performances of the SAR mode data.

➔ Validation of SAR CPP retracking (CNES) / PLRM CPP

Due to the ~300 m footprint in the along-track direction, SAR CPP shows improved content for SLA, SWH and Sigma-naught for scales lower than 100 km.





Long wavelength errors correlated with SWH (around 0.4% SWH) has been found. These differences may suggest a different SSB behavior between SAR and LRM modes with the CPP processing.

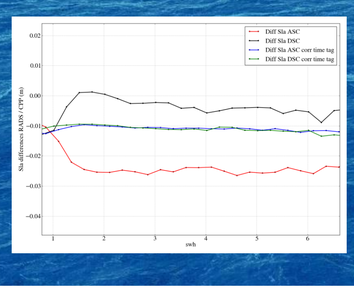
➔ Assessment of PLRM RADS processing (TUDelft)

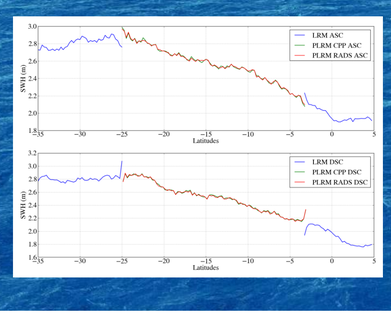
To assess the 20-Hz echo generation methods and make this assessment meaningful, a same MLE4 retracker has been applied over averaged waveforms from CPP and RADS.

This analysis also helped to identify errors in the processing:

- CPP has been appropriately corrected for the one-gate shifted waveform error
- A time tag bias of -540 us has been found on TUDelft data which explains SLA differences between ascending and descending satellite passes

The updated PLRM methods show quite close behavior and similar performances afterwards.



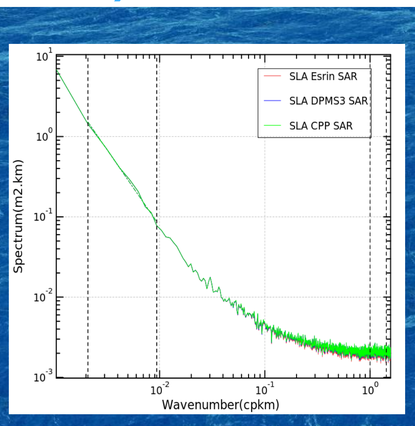


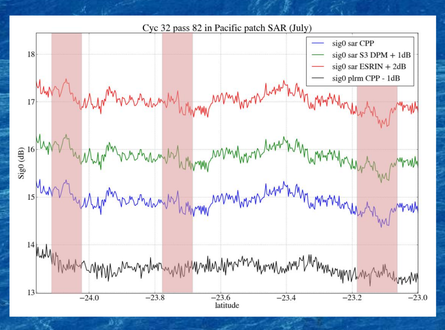
➔ Assessment of SAR retrackers : SAMOSA (ESRIN), SAMOSA3 (S3 DPM 2.3.0), DDA3 (ENSEEIHT) / SAR CPP

The agreement between estimated parameters from SAR ESRIN solution, SAR S3 DPM and SAR CPP are near perfect.

- Both retrackers measure exactly the same content of the oceanic signal from low to high wavelength

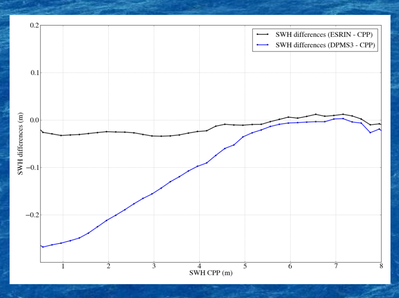
Only few millimeters differences are observed on range parameter.

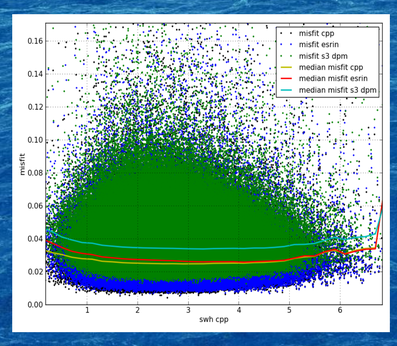




- On Sigma0 parameter, only a tenth of dB difference is observed (primarily dependent on roll angle parameter).
Small scales variations are better captured with SAR mode than PLRM (shown in shaded pink areas).

- Differences on SWH between the ESRIN and CPP solutions are of centimetre-level, whereas the differences with S3 DPM solution do not match as well so good (high differences clearly correlated with SWH values may be due to the missing application of the SWH LUT in the S3 PDM dataset that instead was applied in case of ESRIN SAR). This missing LUT application leads to residual waveform misfit and possible errors of estimates (only seen on SWH).



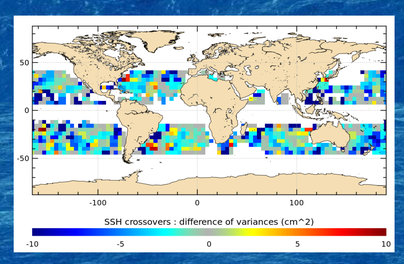


- Same analysis has been performed to assess the performances of the semi-analytical SAR ocean retracker (DDA3) from A. Halimi in comparison with the SAR CPP solution. Differences are mainly explained by the circular antenna pattern modeled in DDA3 (but particularly adapted to the on-going Sentinel-3 and Jason-CS missions embarking circular antenna).

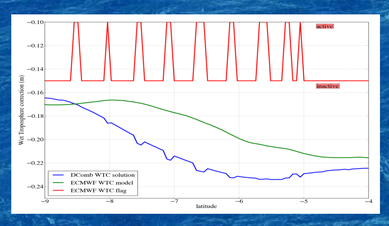
➔ Wet Troposhere Correction Dcomb (U.Porto) / ECMWF

Dcomb WTC improves the Cryosat-2 SSH accuracy for latitudes between 50N and 50S where a variance reduction at crossovers of about 1 cm² is noticed.

In coastal area the Dcomb solution reduces the SLA variance by 2.4 cm².



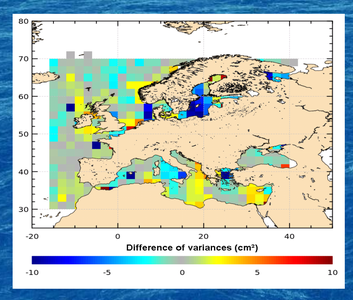
This analysis has also highlighted noticeable discontinuities in Dcomb WTC data sets related to a lack of sensor measurements. The Dcomb solution has been lately improved for better handling of the along track discontinuities.



➔ Ionospheric Correction model SPECTRE (NOVELTIS) / GIM

SPECTRE and GIM ionospheric correction models have been compared in term of reduction of the altimeter residual variance as function of the local time.

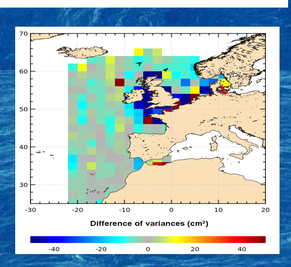
Despite the higher temporal and spatial resolution of SPECTRE model, results do not highlight a clear improvement of the Cryosat-2 SSH accuracy. A test area with higher spatial and temporal variations in ionospheric electron density may better appreciate the potential of this new ionospheric correction.



➔ Oceanic Tide model COMAPI (NOVELTIS) / GOT4V8

COMAPI and GOT4.8 tidal models have been compared in term of reduction of the altimeter residual variance:

- Variance reduction greater than 3 cm² is observed in shallow water area
- Models are quite equivalent in deep Ocean



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