CryoSat SIRAL: calibration and achievable performance after ten years of operations

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The main payload of CryoSat is a Ku-band pulsewidth limited radar altimeter, called SIRAL (Synthetic interferometric radar altimeter), that is equipped with two antennas for single-pass interferometric capability.

Due to the unique characteristics of SIRAL, a proper calibration approach was developed. In fact, not only corrections for transfer function, gain and instrument path delay have to be computed (as in previous altimeters), but also corrections for phase (SAR/SARIn) and phase difference between the two receiving chains (SARIn only). To summarize, SIRAL performs regularly four types of internal calibrations:

- CAL1 in order to calibrate the internal path delay and long-term power drift.
- CAL2 in order to compensate for the instrument IF transfer function.
- CAL4 to calibrate the interferometer.
- AutoCal, a specific sequence used to calibrate the gain and phase difference for each AGC setting.

After about 10 years of operational activity of the CryoSat satellite, the performance of the SIRAL instrument are revealed to be in line or better than the expected one.

In fact the calibration products, that have been designed to model a wide range of imperfections of the instrument, can be analyzed to highlight whether and how the instrument is changing over the time also as function of its thermal status. It is worth underlining here that each variation of the instrument measured by the calibration data is compensated in the Level1 processing. Inspecting the temporal evolution of the calibration data, SIRAL has been verified to be stable during its life. The performance of the SIRAL will be presented together with the outcomes of the stability analysis on the calibration data, in order to verify that the instrument has reached the requirements and that it is maintaining the performance over its life.
In order to monitor the performance of the CryoSat interferometer along the mission, in orbit calibration campaigns have been periodically performed about once a year. The end-to-end calibration strategy for the CryoSat interferometer uses the ocean surface as the known external target. In fact, the interferometer can be used to determine the across-track slope of the overflown surface and the slope of the ocean surface can be considered as known starting from the geoid. Denoting by $\beta$ the across-track slope of the ocean and assuming that the knowledge error of the geoid slope is negligibly small, $\beta$ can be compared with the across-track slope derived from CryoSat SARin Level1b products which results in $\beta' = \eta (\theta - \chi)$ where $\eta$ is a geometric factor, $\theta$ is the angle of earliest arrival measured by the CryoSat interferometer and $\chi$ is the baseline roll angle. By comparison of the expected across-track slope $\beta$ and the measured across-track slope $\beta'$, the accuracy and the precision of the angle of arrival $\theta$ measured by the CryoSat interferometer can be assessed.

In our analysis, the long-term accuracy (i.e. the closeness of the measurement to the true value) and the long-term precision (i.e. the closeness of agreement among a set of measurements) of the CryoSat interferometer have been assessed.