New processing schemes enhancing SAR-mode ocean retrieval performance

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In SAR radar altimetry, the development strategy of the on-ground processing aimed at reducing the noise speckle of the measurements while retaining the high along-track resolution of the data. The actual Cryosat-2 and Sentinel-3 operating systems allow today to resolve Doppler bins with non-overlapping segments on the surface enabling to mitigate the contamination between adjacent Doppler bins. In addition, the SAR-mode processing allows a better measurement precision compared to the conventional altimetry thanks to the higher number of statistically independent looks contributing to the measurement average.

The principle behind the SAR-mode multi-looking process is to gather a stack of multiple Doppler beams, steering at the same ground location from different look directions, and then incoherently average these collocated Doppler beams to produce a lot less noisy echo (so called Doppler echo). The speckle noise, which de-correlates from different look directions, is reduced by the averaging operation. It is found however that the speckle noise reduction on the altimeter-derived parameters (range and wave height) is not as high as expected. This effect is mostly explained by the fact that the contributing beams to the final averaged waveform have different mean shapes and different amplitude values related to the looking angle of measurement. The off-nadir beams of lowest amplitudes thus contribute very little to the noise reduction, as well as to the geophysical parameter estimates. As computed theoretically by Amarouche in 2013, the effective number of looks that are ultimately involved in the noise mitigation process is lower than the number of beams and depends on the waveform sample and wave height. In order to better exploit the capabilities of the SAR altimeter compared to those obtained with the actual ground processing, it is thus essential to develop alternative methods allowing a better processing that would take maximum advantage from the Doppler processing. This is of major interest for Sentinel-3 and Sentinel-6 missions, embarking both a SAR altimeter.

New SAR-mode processing schemes have been investigated and analyzed in R&D studies funded by CNES. For each new proposed approach, a Cryosat-2 data set of at least one-month duration has been produced over open ocean and their performances assessed through the use of common validation tools and protocols and in comparison with operational-like data products (generated with CNES processor CPP).

Currently, in the frame of the SCOOP ESA project, CLS is investigating new SAR/Doppler processing solutions that would provide potential improvement of the Cryosat-2 SAR altimetric measurements’ precision over ocean. The proposed approach is an alternative methodology to the well-known antenna pattern compensation or stack beam weighting techniques. It consists in processing individual echo beams then averaging the estimates such that all Doppler beams may equally contribute to the noise reduction, with no beams weighting, and thus improve the SAR-mode performance.

This paper will present the principle of these methods, and their benefits and drawbacks will be discussed. The aim of this paper is also to determine whether the new processing schemes have a potential impact in operational use or not.