CICS Science Conference
November 29, 30 & December 1, 2016
College Park, MD, USA

Abstract: **Scientific Applications of Fully-Focused SAR Altimetry**

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The delay/Doppler algorithm implemented in CryoSat-2 and Sentinel-3 applies a coherent processing the 64 echoes within each burst (about 3.5 milliseconds of flight), which allows narrowing the footprint in the direction along the track to about 300 m. However, by accounting for the phase evolution of the targets in the scene, it is possible to focus the complex echoes along the aperture, and perform inter-burst coherent integration potentially as long as the target illumination time. This process, similar to SAR imaging systems, reduces the along-track resolution down to the theoretical limit equal to L/2, where L is the antenna length. We call this the fully focused SAR Altimetry processing. For the development of the technique we have used the CryoSat-2 SAR Mode data, but our methods could also be used with similar data from Sentinel-3 or Sentinel-6/Jason-CS.

The footprint of a fully focused SAR altimeter measurement is an elongated strip on the surface, which is pulse-limited across-track and SAR focused along-track. The technique has been demonstrated using transponder data, showing an achievable along-track resolution of 0.5 meters. Despite the asymmetry of the altimeter footprint, the fully focused technique may be useful for applications in which one needs to separate specific targets within highly heterogeneous scenes, such as in the case of sea-ice leads detection, hydrology, and coastal altimetry applications. Applying this technique on CryoSat-2 data over land and sea-ice, we can correctly measure the along-track extent of water bodies and ice-leads only a few meters long in the along-track dimension. On a random rough surface, independent fully focused SAR waveforms can be obtained, potentially, every 0.5 meters, leading to an increase on the effective number of looks that can be obtained of the surface, with respect to delay/Doppler altimetry.

In this paper we concentrate on the different scientific applications of fully-focused SAR altimetry, and on the results that we have obtained so far by processing CryoSat-2 FBR SAR mode data. In hydrology and sea-ice applications the improved along-track resolution can be exploited to obtain a better representation of the surface features. In addition, we developed a

simple retracker to estimate the sea surface height (SSH) estimations from sea-ice leads. The precision of the obtained SSH measurements is better by a factor of square root of two than the ESA L2 Baseline-C product, due to the higher multilooking capabilities of FF-SAR. We also demonstrate the use of the technique for the open ocean, where a similar result is obtained. In this case we determined that the effective number of looks of the multilooked echoes increases by a factor of 2 with respect to delay/Doppler, leading to a significant improvement in the estimation of the ocean geophysical parameters.