EGU2020-19534
https://doi.org/10.5194/egusphere-egu2020-19534
EGU General Assembly 2020

Multi-Peak Retracking of CryoSat-2 SARIn Waveforms: Potential for Sea Ice Applications

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For the last 25+ years, satellite altimetry has proven to be a powerful tool to estimate sea ice thickness from space, by measuring directly the sea ice freeboard. Nevertheless, available thickness estimates from satellite altimetry are affected by a relatively high uncertainty, with the largest contributions originating from the poor knowledge of both the Arctic snow cover and the sea surface height (SSH) in ice-covered regions. The ESA's CryoSat-2 (CS2) radar altimetry mission is the first mission carrying on board an altimeter instrument able to operate in Synthetic Aperture Radar Interferometric (SARIn) mode. Previous studies showed how the phase information available in the SARIn mode can be used to reduce the random uncertainty of the SSH in ice-covered regions [1] and, consequently, the average uncertainty of along-track freeboard retrievals [2].

This work shows that it is possible to extract even more information from level 1b SARIn data. In fact, while it is not possible to perform full swath processing [3] over sea ice, the contribution from sea ice reflections originating close to the satellite nadir is successfully separated from the specular returns from off-nadir leads for some SARIn waveforms. We find that retracking multiple peaks, in combination with the respective phase information, enables to obtain more than one valid height estimate from single SARIn waveforms over sea ice. The resulting larger amount of freeboard estimates, together with the more precise SSH, is found to contribute to an average reduction of the gridded random and total sea ice thickness uncertainties of ~40% and ~25%, respectively, compared to a regular SAR processing scheme. This study also investigates how the CS2 SARIn phase information can aid thickness estimation in coastal areas, using ESA Sentinel-1 SAR images and airborne data from NASA Operation IceBridge campaigns as a mean of validation.

The more precise and, potentially, more accurate freeboard retrievals, as well as the potential for coastal freeboard and thickness estimation shown in this work, support the design of future satellite altimetry missions, e.g. Sentinel-9, operating in SARIn mode over the entire Arctic Ocean.

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