Altimetric Ku-band Radar Observations of Snow on Sea Ice Simulated with SMRT

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ABSTRACT

Sea ice thickness is essential for climate studies and numerical weather prediction. Radar altimetry has provided sea ice thickness measurement since the launch of ERS-1 and currently through CryoSat-2, but uncertainty in the scattering horizon used to retrieve sea ice thickness arises from interactions between the emitted signal and snow cover on the ice surface. Therefore, modelling the scattering of the electromagnetic waves with the snowpack and ice is necessary to retrieve the sea ice thickness accurately. The Snow Microwave Radiative Transfer (SMRT) model was used to simulate the altimeter waveform echo from the snow-covered sea ice. A new field campaign was conducted in the Deese Strait near Cambridge Bay, Nunavut, Canada in April 2022. Measurements included microstructure from x-ray tomography and roughness measurements from structure from motion. These data and datasets from ground campaigns linked to CryoVex 2017 near Alert, Canada, and Operation Ice Bridge 2016 in Eureka Sound, Canada, were used to parameterize SMRT. Evaluation of SMRT in altimeter mode was performed against CryoSat-2 waveform data in pseudo-Low Resolution Mode. Simulated and observed waveforms showed good agreement, although it was necessary to retrieve ice surface roughness. Retrieved ice surface roughness in Cambridge Bay was 1.7 mm, which was close to the observed value of 1.4 mm for flat ice. A pseudo low resolution mode correction factor was required in the radar equation to capture the pulse peakiness in Cambridge Bay. Simulation of Ku-band and Ka-band backscatter in preparation for the ESA CRISTAL mission demonstrated the dominance of scattering from the snow-sea ice interface at Ku-band, with some surface scattering particularly for first year ice. However, at the Ka-band, while the scattering from the snow surface dominates, the snow-sea ice return is non-negligible for first year ice, and volume scattering is more prevalent for multiyear ice. This is the first study to consider scattering within the snow and demonstrate the origin of CryoSat-2 signals. SMRT can be used to develop a physical retracker algorithm to retrieve snow depth and sea ice thickness for radar altimeter missions.

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