Scattering Mechanics of Freshwater Ice Derived Through Polarimetric Decomposition from Sledborne Scatterometers

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ABSTRACT

From the outset of radar observation of geophysical variables, studies investigating time series of radar backscatter from freshwater ice have hypothesized that the timing and regional distribution of high backscatter was caused by vertical columnar bubbles encapsulated within the ice. Bubbles would cause coherent scatter in the forward direction, followed by specular reflection off the high dielectric-contrast ice-water interface and back to the sensor (dubbed "double-bounce"). Technological improvements have allowed for the acquisition of the full scattering matrix, allowing for the calculation of co-polarized phase differences, and the application of polarimetric decomposition algorithms that separate the signal into surface, double bounce and volume scatter interactions. Spaceborne acquisitions using a range of frequencies from L- to X-band (1.2 to 9.6 GHz) have revealed the dominant scattering mechanism to be surface bounce regardless of the timing of observation (early *vs.* late winter), however the understanding of the physical properties of the ice is limited by the spatial resolution of synthetic aperture radar (SAR) acquisitions.

A time-series of co-pol phase difference and scattering mechanisms were derived from fully polarimetric backscatter collected at X- and Ku-band (9.6, 17.2 GHz, respectively) using the University of Waterloo Scatterometer (UWScat) on Malcolm Ramsey Lake near Churchill, MB. Interactions near the snow-ice and ice-water interfaces are able to be separated during processing and can be combined for comparison with spaceborne observations. Single bounce was the overall dominant signal interaction for both interfaces at incidence angles typically observed by SAR (e.g. 27 - 54°). UWScat backscatter was positively correlated to increases in bubble density, however the polarimetric parameters consistently indicate the source of backscatter to be roughness at the ice-water interface. This study contributes to the emerging body of evidence that supports the hypothesis that bubble density serves to increase height deviations at the ice-water interface sufficient to appear rough at wavelengths commonly used on spaceborne SAR.

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