How do Microwaves Interact with Freshwater Ice, and Why is it so Important?

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ABSTRACT

We present the history of literature's understanding of microwave interactions with freshwater ice, and the potential that the current generation of spaceborne SAR sensors present for ice property retrieval. In the 1970s, Side Looking Airborne Radar (SLAR) imaged frozen thermokarst lakes on the coast of the Alaskan north coast as a by-product of observing sea ice features. Elongated lakes were bright in the imagery compared to the dark tundra, which was hypothesized to be the result of long cylindrical bubble inclusions within the ice column causing a double bounce of the incident signal (scattered by the bubble, reflected off the ice-water interface and back to the sensor).

The double-bounce hypothesis was pervasive into the 2010s, until fully polarimetric acquisitions (quad-pol, HH/VV/VH/HV) became accessible over northern lakes. Quad-pol SAR data allowed for the application of polarimetric decomposition algorithms (e.g. Freeman-Durden) which provide a measure of the relative contribution of surface, double-bounce, and volume scatter interactions with targets based on the covariance matrix. Recent publications and the results presented in this study indicate that lakes, regardless of frequency (L- to X-band), incidence angle, ice structure, or morphometry overwhelmingly display odd-bounce surface interactions from the ice-water interface as the dominant scattering mechanism (as opposed to double-bounce). With the understanding that the dominant source of scatter occurs at the ice-water interface, the direct retrieval of changes in ice thickness highlights the potential ice properties that can be obtained using the current generation of SAR satellite constellations. This study presents preliminary analysis of ice thicknesses directly measured from TanDEM-X using repeat-pass interferometry for multiple regions in northern Canada and Alaska.

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