Modeling of C-band Radar Backscatter from Snow Covered First-Year Sea Ice

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Microwave radar remote sensing has been extensively used for detecting dynamic and thermodynamic changes in sea ice [1]. In light of the recent drastic reduction in Arctic sea ice, more accurate algorithms for extracting key parameters of sea ice from radar observations, such as synthetic aperture radar (SAR) imagery, are particularly required. An important step in advancing these algorithms is development and validation of new modeling techniques for electromagnetic wave scattering from sea ice which would link the geophysical properties of sea ice with radar signatures.

In this study we present an analytical formulation for electromagnetic wave scattering from snow-covered sea ice. The solution was derived through the application of a first-order approximation of the small perturbation theory to the Maxwell equations. Complex dielectric constants (CDC) of snow and sea ice are known functions of the vertical coordinate. The solution for normalized radar cross-sections (NRCS) is expressed through generalized reflection and transmission coefficients for the layered snow cover and sea ice. These coefficients are numerically calculated using the invariant embedding method [2] for layered media.

We validate the presented theory against C-band scatterometer measurements collected in high Arctic onboard the research icebreaker Amundsen during the Circumpolar Flow Lead (CFL) system study project in 2008. The dielectrics profile of the snow was calculated using the Debye-like model [3], while the dielectrics profile of the sea ice was estimated using the Polder-van-Santen/de Loor (PVD) mixture model described e.g. in [4]. The obtained CDC profiles of snow and sea ice served as the scattering model’s inputs. The calculated angular dependencies of the NRCSs (HH- and VV- polarizations) were found in a good agreement with corresponding in-situ C-band scatterometer measurements.

REFERENCES