POLARIMETRIC BACKSCATTERING FROM THIN SALINE ICE RELATED TO ICE PHYSICAL AND MORPHOLOGICAL CHARACTERISTICS

S. V. Nghiem, R. Kwok, and S. H. Yueh
Jet Propulsion Laboratory, California Institute of Technology
4800 Oak Grove Dr., MS 300-235, Pasadena, California 91109
Tel: 818-354-2982, Fax: 818-393-5285, E-mail: nghiem@Malibu.jpl.nasa.gov

J. A. Kong, M. A. Tassoudji, and C. C. Hsu.
Department of Electrical Engineering and Computer Science and Research Laboratory of Electronics
Massachusetts Institute of Technology, Cambridge, Massachusetts 02139

A. J. Gow and D. K. Perovich
U. S. Army Cold Regions Research and Engineering Laboratory
Hanover, New Hampshire 03755

A model for polarimetric backscattering from thin saline ice, including volume and surface scattering mechanisms, is used to relate the backscattering to ice physical and morphological characteristics. The model is based on the analytic wave theory and considers ice characterization such as ellipsoidal brine inclusions, rough interfaces, vertical anisotropy, and permittivity tensor determined with brine volume governed by thermodynamic phase equations during the process of ice growth. Theoretical results are compared with measured data at 5 GHz for thin saline ice up to 12 cm in thickness under controlled laboratory conditions.

The thin ice sheet is modelled with an anisotropic layered configuration. The underlying saline water is described as a homogeneous medium with permittivity obtained at measured temperature and salinity. The ice layer is an anisotropic inhomogeneous medium containing ellipsoidal brine inclusions. The vertical anisotropy is due to the preferential vertical alignment of brine inclusions while the ice crystallographic c-axes are randomly oriented in azimuth rendering the statistical azimuthal symmetry of the medium. This results in a vertically uniaxial effective permittivity tensor, calculated with the strong permittivity fluctuation theory, for the saline ice medium. Thin ice can be cover-ed by a brine or slush layer. This brine layer is modelled as a medium with higher permittivity due to the high salinity, which significantly affects electromagnetic scattering signatures from the lower thin ice layer. The contribution to backscattering from rough interfaces is included with consideration of absorption and scattering losses and phase difference effect in the anisotropic ice medium. Polarimetric covariance matrices for thin ice are derived under the distorted Born approximation and the total results are compared with data from the CRRELEX '93 indoor experiment.