NUMERICAL STUDY OF ANGULAR AND FREQUENCY CORRELATION FUNCTION OF SEA ICE AT VHF: ONE-DIMENSIONAL CASE WITH THE FINITE-DIFFERENCE TIME-DOMAIN METHOD

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Angular and frequency correlation function (ACF/FCF) of the electromagnetic wave scattered from sea-ice in the VHF band is studied using the finite-difference time-domain method (FDTD). The problem is modeled as four-layered medium with air, snow, sea-ice, and ocean. The medium intefaces are modeled as one-dimensional random rough surfaces (two-dimensional in scattering). Snow and ocean medium are assumed homogenous with the appropriate bulk permittivities at VHF. The sea-ice consists of homogeneous host ice medium with random distribution of scatterers to represent the effects of brine and air pockets. The accuracy of the FDTD model is tested with the first-order small perturbation, integral equation, and finite element models for a single rough surface interface. Also, the FDTD results are compared with that of a theoretical multi-layer model to further validate the FDTD model. Next, the ACF/FCF are calculated by taking the correlation between the backscattering fields at two different set of incidence angles and frequencies (a1 = 30 degrees, f1 = 137 MHz ; a2=25 degrees f2=162 MHz) for varying snow and sea-ice thickness for sensitivity analysis. Backscattering angles are selected based on where the ACF/FCF of the surface is much larger than the volume to minimize the volume scattering contribution. The snow and sea-ice parameters for these cases are chosen to represent a typical young sea-ice type with dry snow cover and smooth ice-ocean interface. Results show that the backscattered power contributions from the snow layer are typically less than -20 dB below that of the ice-ocean interface and the phase of the AFC/FCF changes linearly with increasing sea-ice thickness. The linear relationship between the AFC/FCF phase and sea-ice thickness is lost for sea-ice thickness greater than 3 meters due to significant signal attenuation and smooth ice-ocean interface used in this simulation. The ACF/FCF phase is most sensitive to the ice-thickness, but it is also sensitive to snow thickness and bulk permittivity. Therefore, accurate sea-ice thickness retrieval will require a priori information about the snow parameters. Nevertheless, this study shows that the sea-ice thickness can be estimated from the ACF/FCF phase information where the scattering contribution from the ice-ocean interface is dominant.