Assessment of a New Dense Media Radiative Transfer Model Based on the Quasicrystalline Approximation (QCA/DMRT) in Assimilation of Passive Microwave Satellite Observations

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Satellite observations of snow properties have been available for more than 40 years from both passive microwave sensors and active microwave radiometers. We developed a model for both active and passive microwave remote sensing of layered dry snowpack based on dense media radiative transfer (DMRT) theory with the quasicrystalline approximation (QCA). In the new model snow layer with ice fractional volume less than 50\% is modeled as ice particles imbedded in air background. Snow layer with ice fractional volume larger than 50\% is modeled as air bubbles imbedded in ice background. This provides more accurate results compared to the current multilayer QCA/DMRT model when highly packed snow layers or thick ice layers exist.

The multilayer Dense Media Radiative Transfer Theory Based on the Quasicrystalline Approximation (multilayer QCA/DMRT) model has been developed to simulate both passive and active microwave remote sensing signatures from layered snowpacks [1], [2]. In former model, all snow layers were modeled as ice particles imbedded in air regardless of ice fractional volume. When forced with snow ground measurements, this multilayer QCA/DMRT model simulations are in good agreement with Ground Based Passive Microwave Radiometer (GBMR-7) measurements, ground-based and airborne Ku band polarimetric scatterometer (POLSCAT) observations. Andreadis et al. [3] showed that coupled multilayer snow hydrology model and this multilayer QCA/DMRT model resulted in improved snow depth estimates in assimilation of Special Sensor Microwave Imager (SSM/I) observations.

Ice particles in snow adhere to each other and form large clusters. Scattering from a single ice particle follows Rayleigh or Mie scattering depending on the particle size comparison to wavelength. If ice particles are clustered, electromagnetic field interacts among the particles need to be considered when calculating total scattering. By taking into account these field interactions, the QCA/DMRT theory calculate collective scattering effects of the ice particles and predicts different scattering properties of snow from classical theory. However, QCA/DMRT simulations of extinction coefficient deviate from numerical simulations when scatterers fractional volume is large. Taking this into consideration, in this new model, we apply air bubbles instead of ice particles as scatterers for snow layer with large density.

We assess this new multilayer QCA/DMRT model by forcing it with ground snow truth measurement and compare with both ground based and space based brightness temperature observations.

References