COMPARISON WITH CLPX II AIRBORNE DATA

AT ALASKA AND COLORADO WITH DMRT THEORY

Xiaolan Xu[1], Ding Liang[1] , Konstantinos M. Andreadis[2], Leung Tsang[1] and Edward G. Josberger[3]

Affiliation:

[1] Department of Electrical Engineering, Box 352500, University of Washington, Seattle, WA 98195-2500, USA

[2] Department of Civil and Environmental Engineering, Box 352700, University of Washington, Seattle, WA 98195

[3] United States Geological Survey, 1201 Pacific Avenue, Tacoma, WA 98042

E-mail: Xiaolan Xu xlxu@u.washington.edu Ding Liang: dliang@ee.washington.edu, Konstantinos M. Andreadis: kostas@hydro.washington.edu, Leung Tsang: tsang@ee.washington.edu, Edward G. Josberger: ejosberg@usgs.gov

Abstract

As the Snow and Cold Land process (SCLP) Satellite Mission that has been recommended by the Decadal Study, carefully study the airborne dataset and ground-based measure will advance the satellite product to better understand the snow hydrology and global water cycle. The SCLP will utilize radar for active microwave remote sensing and radiometer passive microwave remote sensing. A single forward physical model which can be consistent used in both active and passive is very useful way to help understand the scattering properties of snow[1] [2]. We have shown with one set of physical parameters, the multi-layer dense media transfer theory (DMRT) model can match all 4 channels of ground-based brightness temperature measurement in CLPX I simultaneously. In this paper, the DMRT is applied in CLPX II at Alaska and Colorado to match the backscattering of radar response. CLPX II datasets were all collected by NASA Jet Propulsion Laboratory (JPL) POSCAT radar which achieve four channel (VV HH HV VH) at Ku-band. Different land surface heterogeneity was considered in this paper.

In Alaska region, there are two field campaigns was flied during the winter of 2007-2008. The in-situ ground observation was also sampled at the same time. The in-situ ground observation indicates that no forests covered in the filed campaigns. There are only a few of short grass embedded in the snow at some of the places. Our snow model can be used directly. The input parameters for DMRT such as snow depth, grain sizes and snow density, were obtained by ground measurement. Both analytical method (QCA) [3] and numerical method (NMM3D)[4] are introduced to calculate the phase matrixes and extinction coefficient which are used in the RT equations. QCA/DMRT can match the co-polarization backscattering. NMM3D/DMRT can match cross-pol as it predicts non-zero cross-pol in phase matrixes.

The backscattering data observed at Colorado in CLPX II was from Dec. 2006 to Mar.

2008. As there is no in-situ measurement taken in Colorado region, a coupled snow hydrology (Variable Infiltration Capacity, VIC) and microwave emission (Dense Media Radiative Transfer, DMRT) model was used. VIC is a macroscale hydrology model that essentially solves the energy and water balance over a gridded domain. It can provide snow properties as the input for the DMRT model. We first test the coupled-model in the lake catamount region which is only covered by snow. The model prediction agree with the observation pretty well. For the rest of the flight campaigns, the coniferous forests and sagebrush cover were reported. Therefore, we used a vegetation model to include the scattering and attenuation of the vegetation.

The DMRT theory takes into account the collective scattering effects of the particles by including the wave interactions among the particles. The analytical method use quasi-crystalline approximation (QCA) and Percus-Yevick approximations to describe relative positions and the adhesion of ice grains to form aggregates. Multi-layered DMRT are also developed to account layering effect of the snow and ice layer [6]. The numerical method is solved the Maxwell equations rigorously for each realization. For scattering by a collection of spheres, multiple scattering can be formed by using Foldy-Lax equations. The positions of the particles are generated by random shuffling and bonding.

Key words：active microwave remote sensing, dense media, QCA/DMRT, NMM3D/DMRT, CLPX II, VIC

Acknowlegement: Thanks to Dr. Con Cline's group at NOAA to provide NASA CLPX II dataset at Alaska. Thanks to Dr. Simon Yueh's group at JPL to provide CLPX II dataset at Colorado.

REFERENCES

[1] L. Tsang. and J. A. Kong (2001b) *Scattering of Electromagnetic Waves,* vol. 3, *Advanced Topics*, Wiley Intersci., Hoboken, N. J.

[2] L. Tsang, J. A. Kong, K. H. Ding, and C. O. Ao (2001a) *Scattering of Electromagnetic Waves,* vol. 2, *Numerical Simulations*, Wiley Intersci., Hoboken, N. J.

[3] L. Tsang, J. Pan, D. Liang, Z. X. Li, D. Cline, and Y. H. Tan, "Modeling active microwave remote sensing of snow using dense media radiative transfer(DMRT) theory with multiple scattering effects," *IEEE Trans. Geosci. Remote Sens.*, vol. 45, no. 4, pp. 990-1004, Apr. 2007.

[4] K. K. Tse, L. Tsang, C. H. Chan, and K. H. Ding, "Multiple Scattering of Waves by Dense Random Distribution of Sticky Particles for Applications in Microwave Scattering by Terrestrial Snow," *Radio Sci.,* vol. 42, RS5001, doi:10.1029/2006RS003476

[5] L. Tsang, C. T. Chen, A. T. C. Chang, J, Guo and K. H. Ding, "Dense Media Radiative Transfer Theory Based on Quasicrystalline Approximation with Application to Passive Microwave Remote Sensing of Snow", *Radio Sci.*, vol.35, no.3; p.731-49, May-June 2000

[6] D. Liang, X. Xu, L. Tsang, K. M. Andreadis and E. G. Josberger, " Multi-layer Effects in Passive Microwave Remote Sensing of Dry Snow Using Dense Media Radiative Transfer Theory (DMRT) Based on Quasicrystalline, " *IEEE Transactions on Geoscience and Remote Sensing,* vol. 46, no. 11, pp. 3663-3671, Novermber 2008