EXPERIMENTAL VALIDATION ACTIVITIES OF HUT SNOW EMISSION MODEL

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1. INTRODUCTION

Modeling of snow emission properties on microwave frequencies is necessary in order to understand the complex relations between the snowpack microwave emission and its characteristics, such as density, snow grain size, moisture content and snowpack vertical structure. In addition, satellite-based measurements of snowpack emission need to take into consideration the effect of varying land cover and vegetation within a relatively crude-resolution satellite pixel [1], as well as atmospheric effects. Snowpack characteristics derived from measured microwave emission using an electromagnetic model inversion can be used as an input in data assimilation schemes, potentially improving the retrieval accuracy of snow parameters when compared to traditional direct inversion algorithms. For this purpose, several empirical, semi-empirical and purely theoretical models for the retrieval of snow emission properties have been developed in recent years [2]-[4]. Advanced models include also the possibility of simulating the emission from several differing layers within the snowpack. The restriction of this approach, when considering global or regional scale satellite applications, is that accurate information on snowpack structure is rarely available. Therefore, the model considered in this study is the HUT snow emission model, which simulates the snowpack as a single homogenous layer, thus being easily applied to large areas. Issues arising from heterogeneity of the snowpack structure can potentially be addressed through an assimilation procedure [5], which determines an effective value for parameters such as snow grain size using ancillary data.

However, as the accuracy of single-layer models potentially deteriorates significantly as heterogeneity in the snowpack increases, the HUT model has been modified to accommodate some special cases. The modified model allows the simulation of microwave emission over either frozen ground or water (lakes), covered by two layers consisting of either ice or snow. Again considering applications over large areas, the formation of a distinct depth hoar layer late in the snow season is one potential feature which could be reliably simulated. Another special case is that of snow-covered lake ice, which significantly alters the microwave response over a satellite pixel in lake-rich areas.

2. METHODS

In this study, we present results from recent experimental validation activities of the HUT snow model. These consist of airborne and tower based radiometric measurements, which are used to assess the performance of the HUT snow emission model in diverse conditions. Airborne measurements enable testing of the model for several land cover categories, including the testing of the two-layer modification over snow covered lake and sea ice. Tower-based measurements, together with detailed in situ data of ground and atmospheric conditions, provide a means to investigate methods of determining an effective grain size applicable to the entire snowpack, as well as comparison to other, multi-layered emission models. In addition, point scale model validity is compared to that of an area covering an entire satellite data pixel.

2. RESULTS

The investigated model performance was shown to vary for different land cover types, when compared to airborne measurements. The best correlation of modeled versus measured results at frequencies which are most significant for snow parameter retrieval were obtained for relatively densely vegetated areas. This may be due to the fact that as vegetation masks emission from the snow cover, uncertainties in the simulation of the latter are diminished as vegetation increases. Another possibility is related to uncertainties in determining the effective vegetation cover for sparsely vegetated areas.

Point-scale measurements indicate that the use of a two-layer modification has potential of increasing model accuracy. For a homogenous snowpack, determining an effective grain size inversely from the measured emission gives similar results on both point-scale and satellite scale tests for the used dataset. These values can also be related to in situ measurements of grain size using an empirical equation.

Results of modeling and measurements over lake ice are presented in a separate study.

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