OBSERVING SEASONAL SNOW CHANGES IN THE BOREAL FOREST AREA USING ACTIVE AND PASSIVE MICROWAVE MEASUREMENTS

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1. INTRODUCTION

Spatial variability and long-term trends in snow cover distribution and related climate patterns have been analysed based on observation data and climate change prediction models. The models project changes in the spatial and temporal distribution of snow in boreal and arctic terrestrial regions. Thus, changes in seasonal snow cover evidently lead to changes in hydrological processes, in Earth's radiation balance through changes in albedo feedback and also in e.g. in CO_2 balance, as snow cover directly effects the respiration (carbon sources) and increase of forest and other vegetation biomass (magnitude of carbon sinks).

Because of the high spatial and temporal variability of snow cover, spatially detailed information on snow extent and physical properties is required as input for land surface process models and physical snow process models. Snow extent, water equivalent (SWE), wetness and metamorphic state are key input parameters for these models. Presently, no satellite system is in operation that provides this information with sufficient spatial detail and accuracy. Theory, ground-based signature research and analysis of spaceborne scatterometry suggest that high frequency (Ku- and X-band) active microwave sensors are excellent tools for sensing snow physical properties. For this reason a dual frequency (Ku- and X-band) SAR mission, CoReH$_2$O, has been selected as a candidate Earth Explorer Core Mission of ESA. This mission is currently investigated in further detail in a Phase-A mission feasibility study. Among the priority activities for mission preparation are the analysis of the SWE retrieval performance; as well as the analysis of the impact of the mission for snow cover mapping, consolidation of sensor specifications and geophysical algorithm development. The presented experimental campaign NoSREx (Nordic Snow Radar Experiment) will directly contribute to the (1) CoReH$_2$O geophysical algorithm development and (2) to the studies of the synergistic use of CoReH$_2$O measurements with other observational data, such as microwave radiometer observations (AMSR-E, SSM/I, SMOS).

2. METHODOLOGY

The presented activities are aimed at acquiring a comprehensive experimental dataset on the backscattering characteristics of snow at Ku-band and X-band frequencies, and using these data for testing theoretical models and retrieval algorithms. The dataset spans the whole winter season from autumn soil freezing and shallow snow cover conditions, to the peak snow period and snow melt season in the spring. Active microwave observations with the ESA SnowScat-system, a reference scatterometer for the CoReH$_2$O-mission, are accompanied with tower-based radiometer observations at L-, X-, K-, Ka- and W- band. This will enable the study of the feasibility of snow monitoring by combined passive/active remote sensing observations. Comprehensive in situ measurement of snow cover, soil and atmospheric properties give the necessary model input information to active and passive models (e.g. [1], [2], [3], [4]). Particular attention is given to snow stratigraphy and its evolution during the snow season, also during e.g. relatively fast diurnal phenomena. Emerging technologies for measuring snow properties, such as near-infrared photography of snow stratigraphy, are used.

Whereas in-situ backscattering measurements of snow have been carried out in the past by various investigators (e.g. [5]), experimental data on Ku-band backscattering of snow and ice are sparse. In recent years limited data sets combining ground-based X- and Ku-band data sets have been acquired. However, there is a major lack of these data for certain globally important regions, such as the circumpolar boreal forest belt. Additionally, time-series of backscattering information ranging from very thin snowpacks to deep snow packs covering the whole seasonal variation are lacking. The presented activities are a first initiative in closing this gap, with emphasis on (a) measuring seasonal X- and Ku-band backscatter signatures of boreal snow, (b) investigation on the synergistic use of active and passive microwave observations and (c) on studying the feasibility for retrieving SWE under such conditions.

3. SUMMARY

The NoSREx campaign was initiated on November, 2009, at the Arctic Research Centre of FMI in Sodankylä, Finland. The campaign measurements span the entire winter season until May, 2010. In this study, we present initial results of the campaign, including an account on the quality of the observational microwave data (in terms of calibration) and in situ data collected, and give first comparisons with existing microwave forward models on snow cover backscatter and emission. Recommendations for further retrieval algorithm development and the synergistic use of active and passive data are given.

The NoSREx campaign is funded by the European Space Agency (ESA). The Finnish Meteorological Institute acts as the campaign coordinator. The main collaborative partners are GAMMA Remote Sensing Research and Consulting AG (Switzerland), and ENVEO-Environmental Earth Observation Information Technology GmbH (Austria).

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