Geophysical Research Abstracts, Vol. 8, 00794, 2006
SRef-ID: 1607-7962/gra/EGU06-A-00794

Development and evaluation of a forward snow microwave emission model

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Snow plays a key role in the hydrologic cycle over large areas of the mid-latitudes, through its effects on water storage and surface albedo. In situ measurements of snow properties are not sufficiently dense in either space or time to represent accurately their variability over large areas, and therefore observation efforts have focused on remote sensing. Although passive microwave brightness temperature can be directly related to snow depth, the relationship depends as well on several microphysical parameters, notably grain size. Existing retrieval algorithms are limited by these and other factors, such as forest cover and the presence of liquid water in the snow pack. An alternative approach to direct estimation of snow depth or water equivalent from microwave emissions is the assimilation of remotely sensed observations into a land surface scheme. This approach requires an accurate forward microwave emission model. Here we develop such a model using the Land Surface Microwave Emission Model (LSMEM) as the base modeling framework. The model is evaluated with ground-based (Ground-based Microwave Radiometer), airborne (Multiband Polarimetric Scanning Radiometer) and satellite (AMSR-E) data from the Cold Land Processes Experiment (CLPX), conducted in Colorado, USA in winter 2003. The sensitivity of errors in brightness temperature predictions to errors in the microwave emission model inputs, such as snow grain size and density, are shown. Additionally, the problem of image contamination (i.e. emission from mixed forest and snow surface pixels) is addressed. Finally, we demonstrate the use of a modified version of LSMEM in a data assimilation experiment using AMSR-E brightness temperature to update snow water equivalent (SWE) simulations from a hydrology model applied to two sites of the CLPX (Fraser and North Park). Comparisons are made with snow pit measurements and a benchmark simulation from a detailed snow model (SNTHERM).