Geophysical Research Abstracts
Vol. 14, EGU2012-13071, 2012
EGU General Assembly 2012

Satellite retrieval of snow accumulation over the Antarctic ice sheet: a new approach based on SAR imagery and scatter-regime bridging

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Ice sheets are regarded as one of the major contributors to sea level rise, and more accurate data on mass gain and loss are required to determine its magnitude. Overall mass balance estimations are based on measurements of changes in gravity and surface elevation. By the budget method gain and loss are estimated separately. This has the advantage to yield further insight into underlying causes of mass imbalance. The main factor of uncertainty rests with the difficulty to correctly determine snow accumulation over large areas using remote sensing methods.

Work from various authors demonstrates the potential for mapping snow accumulation based on microwave (MW) sensors. However, the main deficiencies in the current understanding of MW signatures of snow are the limited ability to effectively measure the most relevant snow properties in a representative way and the difficulty to establish a robust and reliable method for retrieving snow parameters, such as accumulation rate, from MW measurements. We present a new approach for reducing this uncertainty by improving the measurement of snow accumulation based on the simulation and analysis of MW satellite signals. Here the dense medium radiative transfer theory is applied to calculate the volume scattering and absorption coefficients of snow. As model input serve empirically derived profiles of effective grain size of snow as a function of mean surface temperature and accumulation rate. The coefficients for the density transition between low-density snow and dense firn are evaluated using a polynomial interpolation, an approach which we call scatter-regime bridging.

We demonstrate the applicability of the method by comparing simulated backscattering coefficients with measured data from Envisat ASAR and ASCAT data (C-band), as well as QuickSCAT (Ku-band) scatterometer data. Simulations were carried out using accumulation data measured at a 200 km long section of a traverse in Dronning Maud Land, Antarctica. Differences between simulated and measured data are analyzed in view of errors in intensity calibration and geolocation of ASAR imagery, and local incidence angle variation. It is shown that the largest deviations are likely related to wind processes such as the formation of sastrugi, which is not yet included in the model. The simulations confirm that the penetration depths vary significantly with firn characteristics, which has to be considered when comparing accumulation rates from different locations.