Monitoring Snow Properties on Greenland with ERS Scatterometer and SAR

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Abstract

Since August, 1991, the wind scatterometers aboard the ERS satellites provide operationally measurements of the normalised radar cross section (NRCS) of the Earth's surface. The excellent calibration and maintenance of the instrument guarantee high quality data which, for the first time, allow a precise evaluation of the spatial and temporal variability of the NRCS of Greenland's snow and ice cover. The surface can be divided into four shell-like zones: the central dry snow zone at high altitudes is surrounded by the percolation zone, the wet-snow zone, and the ablation zone. These facies result from different diagenesis of the snow and ice cover which is determined by the amount of snow-accumulation and melt and, therefore, on the local climate at the respective elevation. A large lateral shift of the borderlines between the different snow and ice facies will result even from a slight climate change due to the very gentle slope of the ice shield. Therefore, monitoring these borders can provide information on climate change. The analysis of the scatterometer data obtained between August, 1991, and October, 1996, gave the following results :

The different snow zones can be discriminated by their radar cross sections.
During the summer months the melting of snow is detectable by a strong decrease in radar cross section due to the increase in snow wetness. The yearly maxima of snow melt extent and snow wetness increased almost linearly until summer 1995 while this trend was interrupted in summer 1996.
Until summer 1995 an extension of the dry-snow zone was observed resulting in a shift of the dry-snow line downhill towards the southwest coast. In summer 1995 this trend was suddenly interrupted when the snow melting reached further uphill than the dry-snow line and within a few days the dry-snow in this region was transformed into firn. Thus the dry-snow line was shifted back uphill by appr. 100 km. ERS SAR imagery acquired in May and August 1995 across the dry snow line confirm this observation.
In the transition region between the percolation and dry-snow zone a gentle decrease in radar cross section was observed. A 2-layer radar backscatter model for a dry-snow covered firn layer was used to estimate the snow accumulation rates from this change in radar cross section. The spatial pattern of these rates as well as their absolute values are in very good agreement with observations reported in literature.