Experimental and Modeling Studies of Microwave Radiometry of Snow

Martti Hallikainen
Helsinki University of Technology, Department of Radio Science and Engineering
P.O. Box 3000, FIN-02015 TKK, Finland
Tel. +358.9.4512371, Fax +358.9.4512898, Email martti.hallikainen@tkk.fi

1. Summary

An extensive set of microwave radiometer measurements of snow cover was made at Kirkkonummi, southern Finland, over the whole snow season from January to April in 1985. The radiometer data include brightness temperatures at 1 GHz, 16.5 GHz and 37 GHz, vertical and horizontal polarization. Continuous recording was done at an incidence angle of 50 degrees off nadir. Daily data collection was conducted as a function of incidence angle with 10-degree steps from 10 degrees to 60 degrees. Aluminium sheets covered the ground near the observation tower, thus providing an opportunity to observe microwave emission from snow only (eliminating ground contribution) for small incidence angles. Daily calibration of radiometers consisted of measurements of absorbing sheets and the sky, conducted at least twice (before and after data take). Results from a sky-measuring 12 GHz precision radiometer at the same site and same elevation angle were also obtained.

Ancillary data for snow include water equivalent, depth, temperature, layering, and surface roughness and grain size (photographs). The ground surface temperature was measured regularly and the vertical distribution of near-surface ground temperature was observed occasionally. A special effort was made to characterize the snow medium: Numerous homogeneous snow samples were taken from various depths in the snow pack and measured using free-space systems resulting in dielectric and extinction properties of snow. The free-space systems were operated at 12 (dielectric properties) and 35 GHz (extinction values) and, occasionally, at 18 GHz (dielectric properties). The results were further transformed into extinction coefficients (dry snow) and wetness values (wet snow), thus providing layered information on the whole snow pack. Equations from [1] were used for computing wetness from the complex dielectric constant.

This paper describes the arrangements for and technical details of the campaign and presents results from radiometer and dielectric measurements of snow. The behaviour of emission from snow-covered terrain and that from snow only (ground covered with aluminium sheets) as a function of snow depth and water equivalent are discussed. The effect of an extensive melt/freeze period to the snow grain size and brightness temperature is reported. Experimental results including measured dielectric, extinction and wetness profiles of snow are discussed. Selected experimental values are compared with results from a single-layer radiative transfer model, which relies on an assumption on scattering being concentrated mostly in the forward direction and on experimental characterization of the snow extinction coefficient. Comparisons are also made with results from a radiative multiple-scattering model, based on experimental characterization of snow over a broad frequency range. In this model snow is assumed to consist of numerous horizontal layers with each layer characterized electrically and physically.

2. Reference

1. M. Hallikainen, F.T. Ulaby, M. Abdelrazik: Dielectric properties of snow in the 3 to 37 GHz range, *IEEE Transactions on Antennas and Propagation*, vol. AP-34, no. 11, pp. 1329-1340, November 1986.