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Modelling microwave emission of stratified snowpack in Antarctica

L. Brucker, G. Picard and M. Fily

Laboratoire de Glaciologie et Géophysique de l'Environnement (CNRS/UJF), 54 rue Molière, 38400 St-Martin d'Hères, France

Monitoring the Antarctic climate is an important but difficult task. Some studies have investigated the climate evolution using observations from the meteorological stations but the sparcity of the stations is a major issue, for instance for assessing the spatial variability. Spaceborne microwave radiometers are attractive tools, they offer the opportunity to map spatial variations of surface temperature from 1979 to nowadays. However, the microwave observations are not simply related to the surface temperature, the emissivity which depends on the snowpack characteristics is an important factor. Modelling the microwave emissivity is then a prerequisite for future retrieval of surface temperature. Our work aims at explaining the observed emissivities at large scales in Antarctica, by the way of electromagnetic models, with different snowpack characteristics.

Two radiative transfer models are used, the Dense Media Radiative Transfer theory (DMRT) based on rigourous theoretical basis and the Microwave Emission Model of Layered Snowpacks (MEMLS) developed from numerous experimental measurements. The modeled emissivities at 19 GHz and 37 Ghz for both horizontally and vertically polarized waves are compared with observed emissivities. The observed emissivities are computed as the ratio between the mean annual brightness temperature measured by the SSM/I radiometer and the mean annual temperature from the ERA-40 reanalysis. We observe that the emissivities at 37 GHz are of the same order as the emissivities at 19 GHz (within 0.05). This is unexpected as, for most snow covered areas over the world, emissivity sharply decreases with increasing frequency.

Emissivities estimated by DMRT and MEMLS for homogeneous snowpacks are similar. However, they decrease with increasing frequency and thus disagree with the observations. Heterogeneous snowpack needs to be considered. First, MEMLS is used in the case of layers with randomly distributed density and grain size. But, this setting does not explain the large range of observed emissivities. Then a structure with increasing density and grain-size in the first three meters is tested. Such a structure results from low accumulation combined with strong metamophism, which is usual in Antarctica. In this case, MEMLS is almost able to reproduce the range of observed emissivities over Antarctica.

As a conclusion, we find that a realistic snow metamorphism is necessary to estimate the observed brightness temperatures.