

BOREAL FOREST SOIL MOISTURE MEASUREMENTS USING HUT-2D SYNTHETIC APERTURE RADIOMETER

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In 2007-2009 two airborne measurement campaigns were conducted over the Sodankylä test area in Northern Finland. The goal of these measurement campaigns was to examine the retrieval of the moisture of a coniferous forest soil utilizing data from our airborne L-band 2-dimensional synthetic aperture radiometer HUT-2D, as well as the emission from bogs and partially frozen forest soil.

Soil moisture is an important parameter in research of the Earth's hydrosphere, but so far no operational remote sensing instruments have been introduced. European Space Agency's Soil Moisture and Ocean Salinity (SMOS) satellite, launched in November 2009, is a satellite for global monitoring of soil moisture, as well as sea surface salinity. Microwave Imaging Radiometer by Aperture Synthesis (MIRAS), the sole instrument on SMOS utilizes aperture synthesis to achieve a ground resolution of 30 to 50 km, while retaining a relatively small antenna diameter of 8 m.[1]

Low frequency microwave radiometry has high potential for remote sensing of soil moisture [2, 3, 4, 5]. The operating frequency of MIRAS, 1.4 GHz, was preferred over higher frequencies because of a lower sensitivity to vegetation. However, at L-band the effects of vegetation are still significant and must be modeled appropriately [6]. While soil moisture can be retrieved quite accurately in areas where vegetation is thin or absent [5], a dense vegetation layer is more problematic. Still, it has been noted, and our preliminary results from 2007 suggest, that retrieval may be possible even when a dense canopy is present [4].

HUT-2D (Figure 1, left) is an airborne L-band interferometric radiometer designed, manufactured and tested by Helsinki University of Technology. [7] It has been used in research of soil moisture retrieval since its completion in spring 2006 and was used to make the first airborne 2-dimensional interferometric imaging of the Earth [8]. HUT-2D has 36 dual-polarization receivers in U-shape formation, operating at 1.4 GHz frequency. Major technical characteristics of HUT-2D are similar to those of MIRAS and it can thus be used to collect datasets similar to those of SMOS.

Two airborne campaigns were carried out in the Sodankylä test area (Figure 1, right) 2007 and 2009 with HUT-2D in order to examine the capabilities of the radiometer to measure soil water content in different conditions, as well as emissivity properties of different soils. A dataset was collected over selected land areas with variable vegetation properties. While the biome of the Sodankylä test area located in Finnish Lapland, taiga, is characterized mainly by coniferous forests, there are also some mixed forests and bogs are abundant.

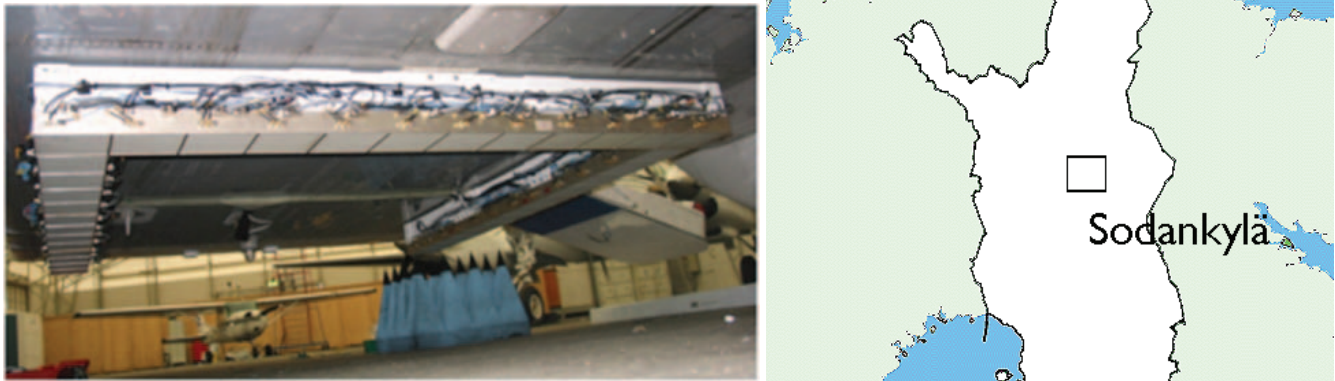


Fig. 1. Left: HUT-2D radiometer fitted under the Short SC.7 Skyvan Research Aircraft. Right: The test site is located in the Finnish Lapland.

One goal of the measurement campaigns was to collect more information of soil moisture retrieval in forested areas. To model the above-surface layer of forests, satellite measurements of vegetation and in situ measurements of litter were used. Using measurements of litter layer to model an understory layer beneath the forest canopy was found very useful in modeling of the total emission of a forest covered soil.

The relatively coarse surface resolution of SMOS causes the pixels to cover several different types of soil and vegetation. In order to reliably retrieve soil moisture it is vital to know the properties of all the emitters. While bogs are abundant in the boreal forest zone, there are few measurements of them at L-band. The effect of freezing to soil emission was also considered interesting. In addition to measurements of forests the campaign location and weather conditions offered an opportunity to examine emission of both bogs and partly frozen soils.

This paper presents results of the soil moisture retrieval experiments made with HUT-2D radiometer in the Sodankylä test area in 2007 and 2009. The accuracy of the measurements and the retrieval process is assessed and applicability of HUT-2D for retrieval purposes is discussed.

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