A soil moisture measurement experiment using HUT-2D aperture synthesis radiometer

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Abstract

HUT-2D is an L-band aperture synthesis radiometer developed in Helsinki University of Technology, Laboratory of Space Technology. It has been designed as a demostrator for MIRAS instrument of ESA's Soil Moisture and Ocean Salinity (SMOS) mission scheduled for launch in 2009. This paper describes a soil moisture measuring experiment with HUT-2D.

Keywords: aperture synthesis, L-band, soil moisture

INTRODUCTION

Soil Moisture and Ocean Salinity (SMOS) is an Earth Observation mission of the European Space Agency scheduled for launch in 2009. The only instrument of the mission is Microwave Imaging Radiometer by Aperture Synthesis (MIRAS) that relies for the first time on two-dimensional synthetic aperture radiometry for measuring both soil moisture and sea surface salinity [1]. Synthetic aperture radiometry enables a relatively small instrument to achieve good spatial resolution. A synthetic aperture radiometer HUT-2D has been designed and built in the Laboratory of Space Technology of Helsinki University of Technology to demostrate the effectiveness of the methods used in SMOS [2].

SOIL EMISSION MODEL

Measuring soil moisture from microwave radiometer measurements is based on changes in soil dielectric constant that are caused by differences in soil water content. These changes were calculated using the Dobson model [3].

A radiometer measures the brightness temperature of the target, which is a function of physical temperature and emissivity. To calculate the emissivity, Fresnel equations and for example a semiempirical model known as the Wang and Choudbury model [4] can be used. If a vegetation layer is present, its effects can be modelled with so called $\tau - \omega$ model [5].

MEASUREMENTS

To examine the capabilities of the HUT-2D instrument and the soil emission model three measurement flights were flown in April and August 2007 in conjunction with ground truth soil moisture measurements. Four vegetation types, namely bare soil, crop fields, bog and coniferous forests were covered. This paper concentrates on the results from the bare soil and crop fields.

RESULTS

Three measurement flights were flown, one in April and another in August 2007. A bare field in Siuntio was measured twice with interval of two days and slightly differing moisture. Results from these measurements were used to tune the emission model to retrieve soil moisture from measurements made on one overflight over a bare field and two later flights of the same, then crop-covered, field in Nummi-Pusula.

Soil moisture was retrieved by applying least squares method to the brightness temperatures modelled by the Wang and Choudbury model from the ground truth measurements of soil type and temperature and those measured by the HUT-2D. Mean error in retrieved moistures was slightly above the target accuracy of SMOS, which is 0.03 m^3/m^3, but are satisfactory as the results of first real moisture measurement.

CONCLUSION

This paper presents results from the first attempts to use HUT-2D for measuring soil moisture. Results show that soil moisture can be retrieved from the measurements of HUT-2D with moderate accuracy. Further measurements with HUT-2D can be used for further development of the soil and vegetation emission models and retrieval algorithms to achieve better results during the actual SMOS mission.

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