REFINEMENTS AND TESTS OF A MICROWAVE EMISSION MODEL FOR FORESTS

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1. INTRODUCTION

Forthcoming and future satellite missions, such as SMOS and SMAP, plan to use microwave radiometers working at L band. For land applications, the advantage of these instruments lies in their capability to monitor soil moisture, which is a key variable for environmental studies. In order to exploit successfully the information provided by the instruments, reliable algorithms, based on valid forward models, must be implemented. A large fraction of pixels is filled, at least partially, by forests. In case of dense forests, the wave penetration is limited and the sensitivity to variations of soil moisture is poor. However, most of the pixels are mixed, and a reliable estimate of forest emissivity is important to retrieve the soil moisture of the areas less affected by forest cover. Moreover, there are many sparse woodlands, where the sensitivity to variations of soil moisture is still acceptable. At the scale of spaceborne radiometers, it is difficult to have a detailed knowledge of the variables which affect the overall emissivity.
In order to manage effectively these problems, the electromagnetic model developed at Tor Vergata University was combined with information available from forest literature. Using allometric equations and other information, the geometrical and dielectric inputs required by the model were related to global variables available at large scale, such as the Leaf Area Index. This procedure is necessarily approximate. In a first version of the model, forest variables were assumed to be constant in time, and were simply related to the maximum yearly value of Leaf Area Index. Moreover, a unique sparse distribution of trunk diameters was assumed. Finally, the temperature distribution within the crown canopy was assumed to be uniform. The model is being refined, in order to consider seasonal variations of foliage cover, subdivided into arboreous foliage and understory contributions. Different distributions of trunk diameter distributions are being considered. Also the effects of temperature gradients within the crown canopy are being considered.
The model was tested against radiometric measurements carried out by towers and aircrafts. A new test has been done using the brightness temperatures measured over some forests in Finland by the AMIRAS radiometer, which is an airborne demonstrator of the MIRAS imaging radiometer to be launched with SMOS.

2. PARAMETRIC STUDIES

In this paper, results of parametric simulations are shown. The emissivity at vertical and horizontal polarization is simulated as a function of soil moisture content for various conditions of forest cover. Seasonal effects are considered, and the values of Leaf Area Index in winter and summer are taken as basic inputs. The difference between the two values is attributed partially to arboreous foliage and partially to understory, while the woody biomass is assumed to be constant in time. Results indicate that seasonal effects are limited, but not negligible. The simulations are repeated for different distributions of trunk diameters. If the distributions is centered over lower diameter values, the forest is optically thicker, for a given biomass. Also the variations of brightness temperature due to a temperature gradient within the crown canopy have been estimated.

3. COMPARISONS WITH EXPERIMENTAL DATA

Results of previous comparisons between model simulations and experimental data are summarized. Experimental data were collected by tower, in the Julich and Les Landes forest (Bray site) and by aircraft, over some forests in Tuscany. New comparisons have been done between model simulations and brightness temperature data collected by the AMIRAS demonstrator in southern Finland, in the region of the Lohja Lake. The region was dominated by lakes and dense forests, of both broadleaf and coniferous species. The flights took place on June 2006, and the outputs were made available in an earth fixed grid together with the information describing the geometry between the target and the sensor, similarly to forthcoming

SMOS L1C data. For both forest types, the brightness temperature values predicted by the model are close to the center of the histograms of measured values. The experimental data show a slight difference between vertical and horizontal polarization, which is underestimated by the model.