SENSITIVITY OF L-BAND BRIGHTNESS TEMPERATURES TO SOIL ROUGHNESS PARAMETERIZATION. THE SMOSREX CASE STUDY.

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1. INTRODUCTION

The Soil Moisture and Ocean Salinity (SMOS) satellite mission of the European Space Agency (ESA), scheduled for launch in summer 2009, responds to the growing need for an accurate estimate of the root-zone soil water content. SMOS will operate at L-band frequencies, where the microwave signal is more sensitive to the soil water content. The European Centre for Medium-Range Weather Forecasts (ECMWF) is preparing to integrate this new data in its data assimilation chain ([1]). In this context, ECMWF has developed the Comunity Microwave Emission Model (CMEM) forward operator ([2]) to simulate the top of the atmosphere brightness temperatures (TB) in frequencies ranging from 1 GHz to 20 GHz as a function of the land surface conditions and vegetation.

CMEM has a modular design and permits the combination of different parameterizations for each component of the soil microwave emission. [2] and [3] found that the Kirdyashev parameterization for the vegetation optical thickness was the best for the TB simulation. But little investigation was undertaken in the choice of the soil roughness model. A study over the SMOSREX field site [4] demonstrates that the calibration of this component is likely to be the most important in the microwave simulation. This paper investigates which soil roughness parameterization available in CMEM reproduces more accurately the observed TB. This study concentrates in the year 2004 using the operational configuration. Some results are showed in this paper.

2. THE COMUNITY MICROWAVE EMISSION MODEL

CMEM's physics is based on the parameterizations used in the L-Band Microwave Emission of the Biosphere ([5]) and Land Surface Microwave Emission Model ([6]). Different parameterizations for soil dielectric constant, effective temperature, roughness, vegetation and atmospheric contribution opacity models are considered. CMEM is a new highly modular software package providing I/O interfaces for the Numerical Weather Prediction Community.

3. THE SOIL ROUGHNESS PARAMETERIZATION

A semi-empirical approach was proposed by [7] to represent soil roughness effects on the microwave emission as a function of the smooth emissivity and three parameters Q, h, and N :

$$r_{r,p} = (Q \cdot r_{s,p} + (1 - Q) \cdot r_{s,q}) exp(-h \cdot cos^N \Theta)$$

where q and p refers to the polarization states, Q is the polarization mixing factor, N describes the angular dependence, h is the roughness parameter and Θ is the incidence angle. The mixing factor Q is generally set to 0 at L-band. Most of the parameterizations differ in the way the roughness parameter is modelled. In [8] and [9] h is computed as a function of the rms surface height δ, the wave number and a set of empirical coefficients. [10] includes also the correlation length, and [5] searches a relationship with the soil texture, soil moisture and the vegetation type.

4. RESULTS

We run a set of simulations using the five different soil roughness models available, for incidence angles of $20°$, $30°$, $40°$, $50°$ and $60°$ and for H and V polarization. Figure 1 shows the RMSE between observed and simulated TB as a function of the incidence angle over the SMOSREX pixel and for five different models for the soil roughness. It is found that the Choudhury parameterization (relying on just one variable for the soil roughness parameter) is the best among all the others tested for both polarization modes and for most of the tested angles. However, large incidence angles for the H polarization produced very low correlations. It is also found that the simulated TB is very sensitive to the value of the soil roughness parameter.

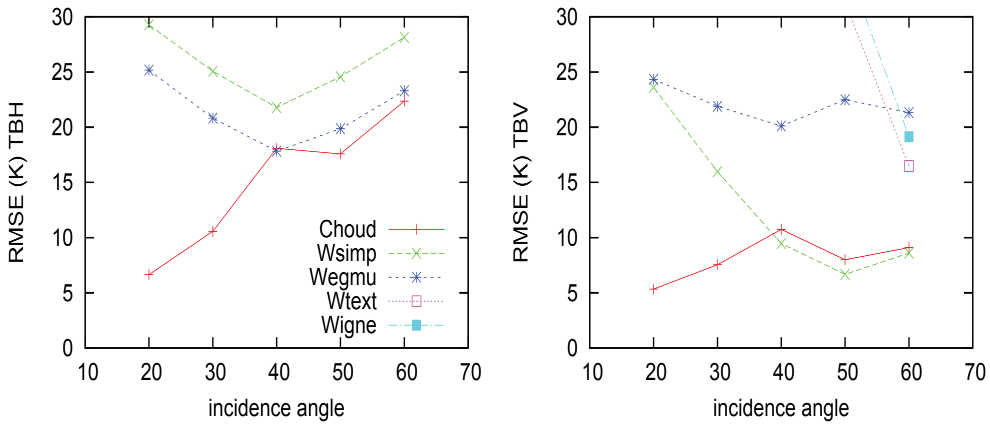

Fig. 1. *RMSE between observed and modelled brightness temperatures for five different soil roughness models during 2004*.

5. REFERENCES

[1] J. Muñoz-Sabater, P. de Rosnay, G. Balsamo, and M. Drusch, "ECMWF activites in preparation for the launch of the SMOS satellite," in *International Geoscience and Remote Sensing Symposium, Cape Town, South Africa, 13–17 July 2009*, 2009.

[2] M. Drusch, T. Holmes, P. de Rosnay, and G. Balsamo, "Comparing ERA-40 based L-band brightness temperatures with Skylab observations : A calibration / validation study using the Community Microwave Emission Model," *Journal of Hydrometeorology*, 2009, doi - 10.1175/2008JHM964.1, in press.

[3] P. de Rosnay, M. Drusch, A. Boone, G. Balsamo, B. Decharme, P. Harris, Y. Kerr, T. Pellarin, J. Polcher, and J. P. Wigneron, "The AMMA land surface model intercomparison experiment coupled to the Microwave Emission Model : ALMIP-MEM," Tech. Rep., ECMWF, Reading, UK, July 2008.

[4] P. de Rosnay, J.C. Calvet, Y. Kerr, J.P. Wigneron, F. Lemaitre, M.J. Escorihuela, J. Muñoz Sabater, and et al., "SMOSREX : A long term field campaign experiment for soil moisture and land surface processes remote sensing," *Remote Sensing of Environment*, vol. 102, pp. 377–389, 2006.

[5] J.-P. Wigneron, Y. Kerr, P. Waldteufel, K. Saleh, M.-J. Escorihuela, P. Richaume, P. Ferrazzoli, P. de Rosnay, R. Gurneye, J.-C. Calvet, J.P. Grant, M. Guglielmetti, B. Hornbuckle, C. Mätzler, T. Pellarin, and M. Schwank, "L-band microwave emission of the biosphere (L-MEB) model : Description and calibration against experimental data sets over crop fields," *Remote Sensing of Environment*, vol. 107, no. 4, pp. 639–655, 2007.

[6] M. Drusch, T. Holmes, P. de Rosnay, and G. Balsamo, "Vegetative and atmospheric corrections for the soil moisture retrieval from passive microwave remote sensing data : Results from the southern great plains hydrology experiment 1997," *Journal of Hydrometeorology*, vol. 2, no. 2, pp. 181–192, 2001.

[7] J. R. Wang and B. J. Choudhury, "Remote sensing of soil moisture content over bare field at 1.4 ghz frequency," *Journal of Geophysical Research*, vol. 86, pp. 5277–5282, 1981.

[8] B. J. Choudhury, T. J. Schmugge, A. Chang, and R. W. Newton, "Effect of surface roughness on the microwave emission for soils," *Journal of Geophysical Research*, vol. 84, pp. 5699–5706, 1979.

[9] U. Wegmüeller and C. Mätzler, "Rough bare soil reflectivity model," *IEEE Transactions on Geoscience and Remote Sensing*, vol. 37, pp. 1391–1395, 1999.

[10] J. P. Wigneron, L. Laguerre, and Y. Kerr, "A simple parameterization of the L-band microwave emission from rough agricultural soils," *IEEE Transactions on Geoscience and Remote Sensing*, vol. 39, pp. 1697–1707, 2001.