TEST OF THE SAIL-THERMIQUE RADIATIVE TRANSFER MODEL FOR SIMULATING THERMAL INFRARED EMISSIVITY AND EMISSIVITY SPECTRA OF PLANT CANOPIES

Albert Olioso (1), José Sobrino (2), Guilhem Soria (2), Michaël Chelle (3), Benoit Duchemin (4), Frédéric Jacob (5)

(1) INRA/EMMAH, Domaine Saint Paul, Agroparc, F-84914 Avignon Cedex 9, France.
(2) Department of Thermodynamics, Faculty of Physics, University of Valencia, Burjassot, Spain.
(3) INRA, UMR Environnement et Grandes cultures, F-78850 Thiverval-grignon, France.
(4) CESBIO – Centre d'Etudes Spatiales de la Biosphère, F-31401 Toulouse cedex 9, France.
(5) Laboratoire de Télédétection et de Gestion des Territoires, Ecole Supérieure d'Agriculture de Purpan, Toulouse, France.

Correspondence to A. Olioso: EMMAH, INRA, Site Agroparc, F-84914 Avignon Cedex 9, France.
tel.: 33-4-32 72 24 06, fax.: 33-4-32 72 23 62, email: olioso@avignon.inra.fr

1. INTRODUCTION

Land surface spectral emissivity in the thermal infrared is requested for the interpretation of multispectral and hyperspectral sensor data in the thermal infrared (e.g. DAIS, ASTER, IASI...). Only little information is available for vegetated surfaces since almost no field instrument makes it possible to measure spectral emissivity in the field. The only information available relates to soil surfaces and plant leaf for which laboratory spectrometer can be used. One possibility to overcome the lack of information for vegetated surfaces lies in the use of radiative transfer models that compute land surface emissivity from leaf and soil emissivities and information on the vegetation canopy architecture.

Due to the difficulty to measure land surface emissivity, no land surface emissivity model has ever been validated against ground measurements. In this study, several datasets extracted from the literature and from various databases were used in order to evaluate emissivity simulations by the SAIL-Thermique model.

2. DATA AND METHODS

The SAIL model was developed by Verhoef (1984 [1]) for simulating land surface directional spectral reflectances in the solar domain. Olioso (1995 [2]) adapted the model for simulating radiative transfers in the thermal infrared, and particularly for simulating land surface emissivity. This version of the model was called SAIL-Thermique.

We used data acquired in Barrax (Spain, EFEDA and DAISEX experiments), in Marrakech (Morocco, WATERMED European project, Olioso et al. 2007 [3]), in the Alpilles test site (South East of France, ReSeDA European project), in Ardèche and Hérault (South East of France, Valor and Caselles, 1996 [4]), in Tsukuba (Japan, Sugita et al. 1996 [5]), and in Bostwana (Van de Griend et al. 1991 [6]). These datasets were acquired on several types of land surfaces including natural and agricultural vegetations at different levels of growth and of water status. Compiled land surface emissivities in the 8-14µm spectral band ranged between 0.92 and 0.99.

Model simulations were performed from the knowledge of leaf area index, leaf inclination distribution, direction of observation, and leaf and soil emissivities. As data on leaf inclination and leaf emissivity were usually not available for a specific experiment, stochastic simulations were performed from an a priori knowledge on their distribution which was extracted from an intensive survey of the literature.

3. RESULTS

In general, simulated 8-14 µm emissivities were favorably compared to measurements with a root mean square difference around 0.006. When considering only herbaceous species, the root mean square difference was 0.004 (which might be explained by a better knowledge of leaf emissivity than of branch and trunk bark emissivity). Similar results were obtained in shorter wavebands (8.2-9.2 µm, 10.3-11.3 µm, 11.5-12.5 µm).

The model was able to catch the evolution of emissivity when the density of vegetation cover was increasing: land surface emissivity in the thermal infrared usually increases when the vegetation amount increases, reaching values which are larger than 0.98. However, during an experiment in Morocco over dry barley crops, it was found that emissivity may be significantly lower than 0.98 at full cover and that in some situations, it might decrease with increasing amount of vegetation, which was unexpected. Older data acquired in Barrax, Spain, over senescent barley also exhibited emissivity values significantly lower than 0.98. The main reason for such behavior might be found in low leaf emissivity due to leaf dryness, which was confirmed by the simulations done from dry leaf spectra. This result also stresses that knowledge on leaf and canopy emissivities and on their variation as a function of water content is still very limited.

After being validated over the various wavebands (8.2-9.2 µm, 10.3-11.3 µm, 11.5-12.5 µm, 8-14 µm), the model was used to simulate emissivity spectra as a function of soil and leaf types, leaf area index, mean leaf inclination and direction of observation.

4. REFERENCES

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