

SAIL-Thermique: a model for land surface spectral emissivity in the thermal infrared. Evaluation and reassessment of the temperature-emissivity separation (TES) algorithm in presence of vegetation.

Oliosio A.¹, Jacob F.², Rivalland V.³

¹Ecology of Mediterranean Forest Lab (URFM), INRAE, Avignon, France;

²IRD, UMR LISAH, Montpellier, Montpellier, France;

³CESBIO, Toulouse, France;

Correspondance to albert.oliosio@inrae.fr

The SAIL-Thermique model was developed to simulate thermal infrared (TIR) radiative transfers inside vegetation canopies and land surface emissivity. It is based on the SAIL model developed by Verhoef (1984) for simulating spectral reflectances in the solar domain. Due to the difficulty to measure land surface emissivity, no emissivity model was validated against ground measurements. In this study, several datasets extracted from the literature and from spectral libraries were used for evaluating emissivity simulations. Model simulations were performed from the knowledge of leaf area index, leaf inclination distribution, direction of viewing, and leaf and soil optical properties. As data on leaf inclination and leaf optical properties were usually not available, stochastic simulations were performed from a priori knowledges on their distribution (extracted from the literature and recent databases).

Simulated 8-14 μm emissivities were favorably compared to measurements with a root mean square difference (RMSD) around 0.006 (0.004 when considering only herbaceous species). The model was then used for simulating emissivity spectra for providing information for the interpretation of TIR multispectral data. The SAIL-Thermique model has the advantage of simulating the cavity effect that results in increasing emissivities of a vegetation canopy in comparison to a simple linear scaling between soil surface and vegetation, or leaf, emissivities.

We simulated a large number of land surface emissivity spectra that were used for re-assessing the TES algorithm developped to separate emissivity and land surface temperature. We showed that the inclusion of vegetated land surfaces significantly modified the relationship between minimum emissivity and minimum maximum difference ($\epsilon_{\text{min-MMD}}$) which is at the heart of the TES algorithm. This relationship was originally established on the ASTER spectral library which did not include vegetated land surface (Schmugge et al. 1998). On a synthetic database, estimations of spectral emissivities and surface temperature were significantly improved when using the new $\epsilon_{\text{min-MMD}}$ relationship in comparison to the classical one: RMSD dropped from ~ 0.012 to ~ 0.006 for spectral emissivity and from 0.60 K to 0.33 K for surface temperature.

This showed the importance of including vegetation canopies when establishing the $\epsilon_{\text{min-MMD}}$ relation. The approach was applied to the development of TES and the direc-TES algorithms for ASTER, ECOSTRESS and the future TRISHNA multispectral sensors.