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Sensitivity Analysis, Calibration, and Evaluation of Two Source Energy Balance Model using Multi-Scale and Multi-Source Spectral Data for a Tree-Grass System

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Evapotranspiration (ET), the combination of land evaporation and plant transpiration, is a key process that interlinks the surface water and energy budget, along with carbon cycling through the processes of transpiration and photosynthesis. Thus, accurately estimating ET has important implications for atmosphere-land interactions, ecology, agriculture and water resource management. The Two Source Energy Balance (TSEB) model [1], which has been applied in a variety of surface conditions, partitions ET and other energy fluxes between its vegetation and soil components, allowing for the direct estimation of both the soil evaporation and canopy transpiration. Various submodels within TSEB are used to simulate processes affecting turbulent fluxes such as wind attenuation through the canopy, aerodynamic and surface resistances to heat transport and the absorption and transmission of solar radiation. Previous studies pointed out that the TSEB formulation may need to be adapted depending on the characteristics of the study area with adjustments to the less physical based coefficients within the turbulent exchange algorithms. Thus, a global sensitivity analysis is performed on the main bio-physical variables and empirical coefficients. Further, an automatic calibration is tested and evaluated for a wooded savanna in western Spain. Several canopy wind attenuation formulations, a key process to evaluate the exchange of turbulent fluxes between soil, vegetation and the atmosphere, are tested with both original and calibrated schemes. As processes and parameters may be spatially and scale dependent, a calibration procedure is tested on three distinct levels: 1) ground scale with tower forcing data, 2) fine-resolution airborne images (AHS-CASI sensors at 1.5m resolution) and 3) Medium-resolution satellite images (Sentinel-2 and Sentinel-3 at 20m resolution). Results are evaluated against three eddy covariance towers located in the study site. Initial results indicate that the output is most sensitive to bio-physical parameters such as the green fraction of vegetation and canopy height. As well, the simulation of turbulent fluxes (latent heat (LE) and sensible heat (H)) slightly improves with a within-canopy wind attenuation scheme that takes into account canopy foliage distribution (RMSD LE: 44 Wm^{-2} to 41 Wm^{-2}, H: 55 Wm^{-2} to 50 Wm^{-2}).

[1] Norman, J. M., Kustas, W. P., & Humes, K. S. (1995). Source approach for estimating soil and vegetation energy fluxes in observations of directional radiometric surface temperature. *Agricultural and Forest Meteorology*, 77(3–4), 263–293