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A simplified two-source energy balance approach using soil and canopy temperatures: Application to a maize crop

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The estimation of the surface energy balance over partial canopy cover with thermal remote sensing has been problematic due to non-unique relationship between aerodynamic and radiative surface temperature. However the development of the Two-Source Energy Balance model (TSEB) has provided a means to accommodate differences in the radiometric-aerodynamic temperature, but requires an assumption concerning canopy transpiration when only a single radiometer is available. Recent progress in the potential of inferring canopy and underlying soil temperatures from multi-directional measurements has encouraged the development of a Simplified Two-Source Energy Balance (STSEB) model that does not require a priori assumption of canopy transpiration and uses a simple algorithm to predict the net radiation partitioning between the soil and vegetation. The objective of this study is to validate the STSEB model under variable vegetation cover conditions, as well as to explore sensitivity of the STSEB model to typical input uncertainties when applied operationally over a landscape. For validation purposes data from maize (corn) crop at a field site in Beltsville, Maryland, USA during the 2004 summer growing season were used. Soil and canopy component temperatures as well as the effective target temperature were measured by Apogee IRTS-P3 infrared radiometers over the course of the growing season from crop emergence to corn cob development. The micro-meteorological and eddy covariance instrumentation were mounted on a 10-m tower. Crop parameters such as corn height or LAI were sampled periodically during corn development.

Comparison with tower flux measurements yielded root-mean-square-difference (RMSD) values on the order of ±10, ±30, ±20, and ±30 W m^{-2} for the retrieval of the net radiation, soil, sensible and latent heat fluxes, respectively. The performance of the STSEB model was supported by comparisons with the TSEB model results for the same dataset. The more general applicability of the STSEB model was explored by means of a sensitivity analysis. Uncertainties in soil and canopy temperatures as well as air temperature were shown to have the greatest effect on STSEB model output. Overall, sensitivity of model output of evapotranspiration as a function of the fractional vegetation cover indicated an error $<$25% for fractional vegetation cover ranging between 0.1 and 0.8. These results indicate that the STSEB model is fairly robust when reliable soil and canopy temperatures are available over partial vegetation cover.