Fifteen Years of TSEB Applications in the Semi-Arid Southeastern Spain: Lessons From Field Experiments on Crop Water Use

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ABSTRACT

Accurate estimation of crop evapotranspiration (ET) and its partitioning into soil evaporation (E) and canopy transpiration (T) is essential for improving water management in semi-arid agricultural systems. Over the past 15 years, a series of experimental studies have been conducted in southeastern Spain, primarily in the agricultural area of Albacete province, aimed at evaluating and applying the Two-Source Energy Balance (TSEB) model across a wide range of crops and management conditions.

These long-term efforts have combined thermal radiometry with comprehensive ground-based measurements, including radiometric canopy and soil temperatures, eddy-covariance flux towers, large weighing lysimeters, and detailed meteorological and biophysical observations. The experimental sites have provided a unique infrastructure for the assessment of surface energy balance models under Mediterranean semi-arid conditions.

A simplified version of TSEB framework (STSEB) has been applied to multiple crop types, including annual crops (maize, sorghum, sunflower, canola, and wheat), vineyards, and woody perennial systems such as almond and pistachio orchards. Across these experiments, model estimates of ET showed strong agreement with lysimeter and eddy-covariance observations, with typical uncertainties on the order of ±0.1-0.2 mm h^{-1} at hourly scales and ±0.5-1.0 mm d^{-1} at daily scales. These studies also enabled the derivation of locally adjusted crop coefficients and provided insights into the seasonal dynamics of E and T partitioning.

Beyond ET estimation, this research has explored the implications of energy balance modeling for irrigation management and water-use efficiency. Applications include evaluating soil management practices in vineyards to reduce soil evaporation, assessing irrigation system performance in maize and almond orchards, and linking evapotranspiration dynamics with vegetation structure and remote sensing indicators. More recently, multispectral and thermal imagery acquired from UAV platforms has been also integrated with STSEB to spatialize monitor crop water status at field scale.

These experiments for the past 15 years illustrate the robustness and versatility of the two-source energy balance approach for monitoring crop water use across diverse agricultural systems. They also highlight the value of combining proximal thermal measurements, flux observations, and remote sensing techniques to advance operational applications of TSEB-based models in irrigation management and precision agriculture.