Best Practices on the Use of sUAS for the Estimation of Evapotranspiration and ET Partitioning Using the Two-Source Energy Balance Model: Examples from Vineyards, Almonds, Urban Green Areas, and Other Crops in the Western US and World's Arid Regions

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MAIN BODY OF TEXT

Small Unmanned Aerial Systems (sUAS) have emerged as a transformative technology for high-resolution estimation and partitioning of evapotranspiration (ET) in heterogeneous landscapes characterized by tall, clumped canopies and variable interrow conditions. This study synthesizes methodological advances and best practices derived from over a decade of sUAS-based research across vineyards, almond orchards, turfgrass systems, urban green spaces, and other crops in semi-arid regions of the Western United States (California and Utah), as well as collaborative initiatives in Chile, Peru, and Turkey in collaboration with researchers from the US Department of Agriculture Hydrology and Remote Sensing Laboratory, and National Laboratory for Agriculture and the Environment.

The analytical framework is grounded in the Two-Source Energy Balance (TSEB) model [1], integrating drone-acquired thermal, multispectral, and digital surface model (DSM) imagery to quantify total ET and partition fluxes [2] into soil evaporation and plant transpiration.

The synthesis draws upon insights from multiple programs, including:

AggieAir sUAS Research Group at Utah State University,

USDA-led GRAPEX (Grape Remote Sensing Atmospheric Profile & Evapotranspiration Experiment) [3],

USDA-led T-REX (Tree-Crop Remote Sensing of Evapotranspiration Experiment) [4],

USU-led TURF-EX (Turfgrass Evapotranspiration Exp) [5], and

international work: UTALCA-CITRA (Chile, nut crops), Duzce University (Turkey, peppers [6]) and TyC in Peru (ECOSMART RICE)[7].

In this work, we detail critical components of the workflow, including pre-flight planning, sensor calibration, atmospheric correction, generation of TSEB inputs (e.g., canopy structure, meteorological data), model configuration, and validation against ground-based measurements. Results demonstrate the sensitivity of ET estimates to canopy architecture, irrigation practices, and microclimatic variability, emphasizing the importance of temporal resolution for capturing dynamic water use. Comparative analyses with eddy covariance and lysimeter data show that sUAS-TSEB methods can achieve high accuracy (RMSE < 0.8 mm/day) when best practices are applied. This work offers actionable guidance for researchers and practitioners seeking to implement sUAS-based ET monitoring for precision agriculture, urban water management, and satellite product validation. It also opens the door for the integration of sUAS data into scalable workflows and platforms such as OpenET and real-time solutions [8], enhancing decision-making in water resource management.

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