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Monitoring evapotranspiration and water stress of Mediterranean oak savannas using optical and thermal remote sensing-based approaches

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In water-controlled systems, the evapotranspiration (ET) is a key indicator of the ecosystem health and the water status of the vegetation. Continuous monitoring of this variable over Mediterranean savannas (landscape consisting of widely-spaced oak trees combined with pasture, crops and shrubs) provides the baseline required to evaluate actual threats (e.g. vulnerable areas, land-use changes, invasive species, over-grazing, bush encroachment, etc.) and design management actions leading to reduce the economic and environmental vulnerability. However, the patched nature of these agropastoral ecosystems, with different uses (agricultural, farming, hunting), and their complex canopy structure, with various layers of vegetation and bare soil, pose additional difficulties. The combination of satellite mission with high/medium spatial/temporal resolutions provides appropriate information to characterize the variability of the Mediterranean savanna, assessing resource availability at local scales.

The aim of this work is to quantify ET and water stress at field-scale over a dehesa ecosystem located in Southern Spain, coupling remote sensing-based water and energy balance models. A soil water balance has been applied for five consecutive hydrological years (between 2012 and 2017) using the vegetation index (VI) based approach (VI-ETo model), on a daily scale and 30 m of spatial resolution. It combines FAO56 guidelines with the spectral response in the visible and near-infrared regions to compute more accurately the canopy transpiration. Landsat-8 and Sentinel-2 images, meteorological, and soil data have been used. This approach has been adapted to dehesa ecosystem, taking into account the double strata of annual grasses and tree canopies. However, the lack of available information about the spatial distribution of soil properties and the presence of multiple vegetation layers with very different root depths increase the uncertainty of water balance calculations. The combination with energy balance-based models may overcome these issues. In this case, the two-source energy balance model (TSEB) has been applied to explore the possibilities of integrating both approaches. ET was estimated using TSEB in the days with available thermal data, more accurately assessing the reduction on ET due to soil water deficit, and allowing the adjustment of water stress coefficient in the VI-ETo model.

The modeled ET results have been validated with field observations (Santa Clotilde; 38°12’N, 4°17’ W; 736 m a.s.l.), measuring the energy balance components with an eddy covariance system and

complementary instruments. The VI-ETo model has proven to be robust to monitor the vegetation water use of this complex ecosystem. However, the integration of the energy balance modelling has improved the estimations during the dry periods, with highly stressed vegetation, enabling a continuous monitoring of ET and water stress over this landscape.