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Weighing lysimeter and eddy-covariance measurements in a vineyard to evaluate the potential of thermal-based estimation of surface energy fluxes and evapotranspiration in sparse crops

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Monitoring land surface energy fluxes from satellite platforms has become essential to face the new challenges in the current climate change context. Some spatiotemporal limitations remain when high resolution is required for hydrology or agricultural purposes. This is particularly critical in arid and semiarid areas where water management requires accurate estimation of crop evapotranspiration (ETc), and fields are rather small size and sparse crops dominate. Validation of model estimates under these conditions is a challenge since weighing lysimeter facilities are quite scarce and eddy-covariance (EC) or scintillometer instrumentation have some experimental limitations.
In this work, we test the Simplified Two-Source Energy Balance model (STSEB) combined with radiometric thermal measurements in a 4-ha vineyard located in a semiarid area of central Spain. A set of 5 thermal infrared radiometers were installed over a 9-m^2 weighing lysimeter, providing representative measurements of ETc. A full-equipped flux tower was set to register net radiation and ground heat fluxes besides sensible and latent turbulent heat fluxes. Data for the period June-September in the growing seasons of 2014 and 2015 were used to intercompare model estimates and lysimeter and eddy-covariance ground measurements.
Results show the feasibility of the EC measurements in this row vineyard, despite the experimental challenge of fitting the flux footprints within the small field dimensions. After forcing the energy balance closure through the residual technique, errors in ETc of ±0.1 mm/h and ±0.6 mm/day were observed at hourly and daily scales, respectively, compared to lysimeter measurements.
Model results showed correlations close to 1 for net radiation, around 0.70 for soil and sensible heat fluxes, and 0.80 for latent heat fluxes, with RMSE values of ±50 W m^{-2} for the turbulent fluxes and lower than ±30 W m^{-2} for the rest of the terms. The accuracy of modelled hourly and daily ETc values is of ±0.1 mm/h and ±0.6 mm/day, respectively, with negligible bias, using lysimeter measurements as gound-truthing. Accumulated ETc for the whole campaigns resulted in an underestimation of 15% in 2014 and an overestimation of only 6% in 2015. Partition of ETc in soil evaporation and plant transpiration components resulted in similar ratios close to 40%/60% for both years.
These results reinforce the potential of the STSEB model combined to thermal radiometry to monitor surface energy fluxes and evapotranspiration to be used in water management applications also in sparse crops.