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Sensitivity analysis of METRIC-derived crop evapotranspiration to spatial resolution changes on an olive orchard using high-resolution hyperspectral and thermal images

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Remote sensing-based models provide actual evapotranspiration (ET) estimations for large areas and allow the assessment of spatial variability of ET. Many of these models have been developed and validated by using medium-high spatial resolution satellites, as Landsat or MODIS. The quick development that on-board sensors have experienced allows to achieve very-high spatial resolution but require evaluating the suitability of these models to be applied using such high-resolution images, as changes in the spatial resolution may affect the turbulent heat fluxes calculation, and then in ET assessment. Thus, the objective of this study is to analyze how the spatial resolution of input data affects ET estimation using METRIC energy balance model.

An airborne campaign was carried out on DOY 236 in 2012 covering 2600 ha cultivated with olive orchards and located between Córdoba, Málaga and Sevilla provinces (Spain) (37.25° N, 4.70° W). The flight was conducted by the Laboratory for Research Methods in Quantitative Remote Sensing (QuantaLab, IAS-CSIC, Spain) using a hyperspectral (Micro-Hyperspec VNIR model, Headwall Photonics, MA, USA) and a thermal sensor (FLIR SC655, FLIR System, USA) on board a Cessna C172S EC-JYN aircraft. The original 0.5x0.5 m spatial resolution hyperspectral and thermal images were resampled to pixel sizes varying from 5 m to 1 km, encompassing the most frequent scales used in agronomical studies. For each spatial resolution METRIC model was run, considering the 30x30 m pixel size as the reference since METRIC has been widely validated at this resolution.

The average value of net radiation (Rn), soil heat flux (G), sensible heat flux (H) and latent heat flux (LE) varied from 95.4 to 103.4%, 95.3 to 102.7%, 90.6 to 99.8%, and 96.9 to 106.4% for spatial resolution varying from 5 m to 1 km, respectively, compared with 30x30 m spatial resolution values. Thus, Rn and G estimations showed a scale-insensitive behavior, highlighting that emissivity and albedo were not severely affected by changes in pixel size. However, H and LE (and then crop ET) varied depending on the input resolution; small differences were observed for spatial resolutions lower than 30x30 m, whereas more pronounced discrepancies were found at coarser spatial resolutions. Surface roughness parameters and olive orchards characteristic could be the main sources of these differences, although a deeper study is needed to confirm this hypothesis.

Results presented here illustrate the good performance of METRIC model for being used with very high-resolution images, whereas also advised about major errors when medium or large scales were used, and then results of olive orchards from METRIC with resolutions coarser than 100x100 m must be considered with caution.