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Assessing regional crop water demand using a satellite-based combination equation with a land surface temperature component

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Quantification of daily evapotranspiration at regional levels is fundamental for improving agricultural and hydrological management, especially in water-scarce and climatic change vulnerable regions, like the Mediterranean basin. Regional estimates of daily crop evapotranspiration (ET) have been historically based on combination equations, such as Penman-Monteith or Priestley-Taylor, forced with weather-data inputs. However, the requirements for long term in-situ data, limit the application of such traditional approaches and algorithms using satellite-data without field calibrations bridge this gap by estimating long-term ET at the pixel level from local to global scales. Land surface temperature is a key variable tracking land surface moisture status. However, it has not been included in satellite ET approaches based on combination equations. In this study, a land surface temperature component was used to estimate soil surface conductance based on an apparent thermal inertia index. A process-based model was applied to estimate surface energy fluxes including daily ET based on a modified version of the Priestley-Taylor Jet Propulsion Laboratory (PT-JPL) model at 1km pixel resolution during a chrono-sequence spanning for more than a decade (2002-2013). The thermal-PT-JPL model was forced with vegetation, albedo, reflectance and temperature products from the Moderate-resolution Imaging Spectroradiometer (MODIS) from both Aqua and Terra satellites. The study region, B-XII Irrigation District of the Lower Guadalquivir, is one of the largest irrigated areas in Spain but it has scarce in-situ micrometeorological or eddy covariance data.
The final aim of this study is to evaluate the thermal version of PT-JPL model versus a lumped hydrological model to assess crop evapotranspiration deficits and long-term water consumption trends in the area. The results showed that the thermal-PT-JPL model is a suitable and simple tool requiring only air temperature and incoming solar radiation apart from standard satellites-products freely available. Our results show that in comparison with the hydrological model conceptual rainfall-runoff model, requiring several meteorological and in-situ data to quantify irrigation, the satellite-based model presents a great advantage for regionalization of ET.