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Vegetation water stress monitoring with remote sensing-based energy balance modelling

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Drought is one of the major hazards faced by agroforestry systems in southern Europe, and an increase in frequency is predicted under the conditions of climate change for the region. Timely and accurate monitoring of vegetation water stress using remote sensing time series may assist early-warning services, helping to assess drought impacts and the design of management actions leading to reduce the economic and environmental vulnerability of these systems. A holm oak savanna, known as dehesa in Spain and montado in Portugal, is an agro-silvo-pastoral system occupying more than 3 million hectares the Iberian Peninsula and Greece. It consists of widely-spaced oak trees (mostly Quercus ilex L.), combined with crops, pasture and Mediterranean shrubs, and it is considered an example of sustainable land use, with great importance in the rural economy. Soil water dynamics is known to have a central role in current tree decline and the reduction of the forested area that is threatening its conservation.

A two-source thermal-based evapotranspiration model (TSEB) has been applied to monitor the effect on vegetation water use of soil moisture stress in a dehesa located in southern Spain. The TSEB model separates the soil and canopy contributions to the radiative temperature and to the exchange of surface energy fluxes, so it is especially suited for partially vegetated landscapes. The integration of remotely sensed data in this model may support an evaluation of the whole ecosystem state at a large scale. During two consecutive summers, in 2012 and 2013, time series of optical and thermal MODIS images, with 250m and 1 km of spatial resolution respectively, have been combined with meteorological data provided by a ground station to monitor the evapotranspiration (ET) of the system. An eddy covariance tower ($38^\circ 12'$ N; $4^\circ 17'$ W, 736 m a.s.l), equipped with instruments to measure all the components of the energy balance and 1 km of homogeneous fetch in the predominant wind direction has been used to validate model results. The departure of actual ET from the potential rate, expected under optimum soil water conditions, has been used to assess the water stress of the system.

The quality of the measured data fluxes has been tested with the energy-balance closure criterion yielding an average closure of 86%, which is within the error range found in similar studies. The root-mean-square-difference (RMSD) between modeled and observed ET was 30 Wm-2, with a relative error (RMSD/average flux) of 20%. These figures are similar to that obtained in other studies over natural vegetation and Mediterranean tree crops. In conclusion, the TSEB model is well suited to monitor ET and water stress over the complex and strongly clumped canopy architecture of the dehesa landscape.