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Modelling bulk surface resistance from MODIS time series data to estimate actual regional evapotranspiration

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Estimation of actual evapotraspiration by means of Penman-Monteith (P-M) equation requires the knowledge of the so-called “bulk surface resistance”, $r_{c,act}$, representing the vapour flow resistance through the transpiring crop and evaporating soil surface. The accurate parameterization of $r_{c,act}$ still represents an unexploited topic, especially in the case of heterogeneous land surface. In agro-hydrological applications, the P-M equation commonly used to evaluate reference evapotranspiration (ET_0) of a well-watered “standardized crop” (grass or alfalfa), generally assumes for the bulk surface resistance a value of 70 s m^{-1}. Moreover, specific crop coefficients have to be used to estimate maximum and/or actual evapotranspiration based on ET_0.

In this paper, a simple procedure for the indirect estimation of $r_{c,act}$ as function of a vegetation index computed from remote acquisition of Land Surface Temperature (LST), is proposed.

An application was carried out in an irrigation district located near Castelvetrano, in South-West of Sicily, mainly cultivated with olive groves, in which actual evapotranspiration fluxes were measured during two years (2010-2011) by an Eddy Covariance flux tower (EC). Evapotranspiration measurements allowed evaluating $r_{c,act}$based on the numerical inversion of the P-M equation. In the same study area, a large time series of MODIS LST data, characterized by a spatial resolution of 1x1 km and a time step of 8-days, was also acquired for the period from 2000 to 2014.

A simple Vegetation Index Temperatures (VTI), with values ranging from 0 to 1, was computed using normalized LST values. Evapotranspiration fluxes measured in 2010 were used to calibrate the relationship between $r_{c,act}$ and VTI, whereas data from 2011 were used for its validation.

The preliminary results evidenced that, for the considered crop, an almost constant value of $r_{c,act}$, corresponding to about 250 s m^{-1}, can be considered typical of periods in which the crop is well-watered and VTIs are lower than 0.5 (from September to mid-April) whereas, during dry periods the values of $r_{c,act}$ increased exponentially with VTI, until reaching a maximum of about 1100 s m^{-1}, corresponding approximately to a VTI of 0.98.

Using estimated values of $r_{c,act}$in the P-M equation made it possible to identify the seasonal trend of actual evapotranspiration, with errors of about 0.5 mm d^{-1}. The proposed approach can be suggested for estimating crop water requirements at regional scale and, potentially, as a tool to manage water resources in agriculture.