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Partitioning ET measurements for sparse vegetation: application to an olive orchard

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The study of dynamic processes evolving in the continuum Soil-Plant-Atmosphere (SPA) can be fundamental for agricultural water management, especially when water resource is the factor limiting the productions and precision irrigation is applied.
At the present, studies of the dynamic of trees transpiration, field evapotranspiration (ET) and soil water content in sparse vegetation areas represent one of the most appealing challenges in the agro-hydrological research. Particular relevance assumes the ET partitioning between transpiration (T) and evaporation (E), because only the first term is essentially related to crop water requirements and stress conditions.
Objective of the research is to separate the ET components at the field scale, in an olive orchard constituted by sparse vegetation, throughout a combination of sap-flow and eddy covariance measurements. Moreover, the contextual analysis of the soil moisture contents dynamic allows to establish, for the investigated crop, the beginning of the water stress condition.
The mentioned measurements techniques were applied in a study area, located in the Western Sicily (Italy), mainly cultivated with table olive orchard and characterized by typical Mediterranean climate.
Olive trees are planted on a regular grid of about 8 $\times$ 5 m2 ($\approx$ 250 crops ha-1), the mean canopy height is approximately 3.3 m and the average fraction coverage is of about 35%. The area was interested by in-situ measurements during 2009 and 2010, including dry stage, rainfall events and irrigation. Irrigation volumes, applied in the two seasons with a trickle irrigation plant, were quite different, with higher volumes in 2009.
Tree transpiration was monitored by using Thermal Dissipation Probes (TDP) and applying the Granier method. The daily field-scale transpiration was obtained by scaling up the plant-scale sap flow measurements, adopting, as proxy variable, the remotely-observed Leaf Area Index (LAI).
The eddy covariance system includes a CSAT3-3D sonic anemometer and a LI7500 open-path gas analyzer, installed at 6 m above the ground level, a NR-Lite-L net radiometer, and two soil heat flux plates. The experimental lay-out allowed the measurement of all surface energy balance terms. Surface energy budget closure was forced by redistributing the errors to the observed sensible and latent heat fluxes, preserving the measured Bowen-ratio.
Temporal variability of soil moisture content was monitored by using a set of 15 TDR (Time Domain Reflectometry) probes located around a tree, nearby the eddy covariance system. The acquisition time step was set to 3 hours, even if in the post-processing phase the data were aggregated to a daily temporal step.
Auxiliary meteorological data (e.g., solar radiation, air temperature and humidity, wind speed) have been collected by a weather station of the SIAS (Servizio Informativo Agrometeorologico Siciliano) network, located within the study area.
The comparison of field-scale T data with ET allowed the evaluation of the amount of soil evaporation in the experimental area during dry, rainy and irrigation periods.
The measured daily data showed that higher difference between T and ET were observed only after rainfall events, due to the increased surface soil water content. On the contrary, no significant differences between T and ET were observed after irrigations, as a consequence of the adopted trickle irrigation system.
Considering as stress index the ratio between actual and potential evapotranspiration, high levels of water stress were observed during both the monitored years. Moreover, in 2009 a season-average stress significantly lower then in 2010 was observed, probably due to the different irrigation volumes supplied in the two years.