



Modelling orange tree root water uptake active area by minimally invasive ERT data and transpiration measurements

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The comprehension of the hydrological processes involving plant root dynamics is crucial for implementing water saving measures in agriculture. This is particular urgent in areas, like those Mediterranean, characterized by scarce water availability. The study of root water dynamics should not be separated from a more general analysis of the mass and energy fluxes transferred in the soil-plant-atmosphere continuum.

In our study, in order to carry this inclusive approach, minimal invasive 3D time-lapse electrical resistivity tomography (ERT) for soil moisture estimation was combined with plant transpiration fluxes directly measured with Sap Flow (SF) techniques and Eddy Covariance methods, and volumetric soil moisture measurements by TDR probes. The main objective of this inclusive approach was to accurately define root-zone water dynamics and individuate the root-area effectively active for water and nutrient uptake process.

The monitoring was carried out in Eastern Sicily (south Italy) in summers 2013 and 2014, within an experimental orange orchard farm. During the first year of experiment (October 2013), ERT measurements were carried out around the pertinent volume of one fully irrigated tree, characterized by a vegetation ground cover of 70%; in the second year (June 2014), ERT monitoring was conducted considering a cutting plant, thus to evaluate soil water dynamics without the significant plant transpiration contribution.

In order to explore the hydrological dynamics of the root zone volume surrounded by the monitored tree, the resistivity data acquired during the ERT monitoring were converted into soil moisture content distribution by a laboratory calibration based on the soil electrical properties as a function of moisture content and pore water electrical conductivity.

By using ERT data in conjunction with the agro-meteorological information (i.e. irrigation rates, rainfall, evapotranspiration by Eddy Covariance, transpiration by Sap Flow and soil moisture content by TRD) of the test area, a spatially distributed one-dimensional (1D) model that solves the Richards' equation was applied; in the model the van Genuchten parameters were obtained by laboratory analysis of soil water retention and soil permeability at saturation.

Results of the 1D model were successfully compared with both ERT-based soil moisture dynamics and TDR measurements of soil moisture. The modelling allows to defining the soil volume interested by root water uptake process and its extent. In particular, this volume results significantly smaller (i.e. surface area of 1.75 m², with 0.4 m cm thickness) than expected, considering the design of the drip irrigation scheme adopted in the farm.

The obtained results confirm that ERT is a technique that (i) can provide a lot of information on small scale and vegetation related processes; (ii) the integration with physical modelling is essential to capture the meaning of space-time signal changes; (iii) in the case of the orange orchard, this approach shows that about half of the irrigated water is wasted.