

Downscaling transpiration from the field to the tree scale using the neural network approach

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Estimating actual evapotranspiration (ET_a) spatial variability in orchards is key when trying to quantify water (and associated nutrients) leaching, both with the mass balance and inverse modeling methods. ET_a measurements however generally occur at larger scales (e.g. Eddy-covariance method) or have a limited quantitative accuracy. In this study we propose to establish a statistical relation between field ET_a and field averaged variables known to be closely related to it, such as stem water potential (WP), soil water storage (WS) and ET_c . For that we use 4 years of soil and almond trees water status data to train artificial neural networks (ANNs) predicting field scale ET_a and downscale the relation to the individual tree scale. ANNs composed of only two neurons in a hidden layer (11 parameters on total) proved to be the most accurate (overall RMSE = 0.0246 mm/h, $R^2 = 0.944$), seemingly because adding more neurons generated overfitting of noise in the training dataset. According to the optimized weights in the best ANNs, the first hidden neuron could be considered in charge of relaying the ET_c information while the other one would deal with the water stress response to stem WP, soil WS, and ET_c . As individual trees had specific signatures for combinations of these variables, variability was generated in their ET_a responses. The relative canopy cover was the main source of variability of ET_a while stem WP was the most influent factor for the ET_a / ET_c ratio. Trees on drip-irrigated side of the orchard appeared to be less affected by low estimated soil WS in the root zone than on the fanjet micro-sprinklers side, possibly due to a combination of (i) more substantial root biomass increasing the plant hydraulic conductance, (ii) bias in the soil WS estimation due to soil moisture heterogeneity on the drip-side, and (iii) the access to deeper water resource. Tree scale ET_a responses are in good agreement with soil-plant water relations reported in the literature, and well supported by an independent analysis of the soil water balance on the same site, which is encouraging for the future use of ANNs in the context of ET_a downscaling.