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Interactive Comment

Interactive comment on "Monitoring and modelling of soil–plant interactions: the joint use of ERT, sap flow and Eddy Covariance data to characterize the volume of an orange tree root zone" *by* G. Cassiani et al.

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This paper by Cassiani et al. proposes an exciting and novel approach to utilizing multiple soil-plant-atmosphere measurement techniques, not only for qualifying depth of plant water uptake but also for (spatially) quantifying root water uptake (RWU) activity. Well-written and concise, the authors very clearly reviewed our state-of-knowledge, as well as knowledge gaps, with respect to modeling plant water use strategies. Indeed, that RWU dries the soil is not a discovery. It is rather the ability to quantify soil moisture

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variability (due to RWU) – and using this understanding to inform and calibrate root zone hydrological models – that presents the greatest opportunity for new technological and analytical methods in this area. Of noteworthy contribution from this work is the potential widespread utility of using time-lapse 3D ERT for monitoring soil moisture content distribution as it relates to transpiration and micrometeorological data.

These favorable comments notwithstanding, I urge the authors to address the following general comments before the work may be considered for publication: 1) Perhaps, a "hallmark" of techniques in plant water uptake studies is stable isotope tracing. While it is not my intention to impinge upon the authors' liberty to use methods of their preference (i.e. ERT and sap flow), their finding that RWU was greatest at 0.40m might be reinforced if stable isotope tracing methods (e.g. δ2H) also showed the same. There are at least 120 published papers that demonstrated the usefulness of stable isotope tracing methods (δ2H, δ18O or both) in plant water uptake studies. If the authors could demonstrate that their ERT-sap flow method agrees with stable isotope methods, then their (0.4m-depth) finding, in my view, may be regarded as unequivocal. In order to advance our state-of-knowledge in RWU studies, I am of the opinion that it is incumbent upon the new methods/approaches (like the one proposed by Cassiani et al.) to demonstrate "comparability" with what the broader community may regard as "state of practice" (i.e. stable isotopes). 2)Results of this work imply that the orange tree used water from a certain depth ($\sim$0.4m) more than any other depth in the volume. The authors, however, failed to provide possible mechanisms (1) with which water at this depth is being replenished, either from direct percolation from shallower or from capillary rise from deeper parts in the profile; and, (2) for water uptake bias at this depth, i.e. is this related to root length density, root biomass, mycorrhizal fungi density, etc.? For example, Kurz-Besson et al. (2006) in a similar Mediterranean setting in south Portugal showed that the largest amount of fine roots are found in the top soil at 0.2 m depth ($\sim$20% of total root biomass), while between 13 and 17% of total root biomass are found in deeper layers at 0.4 and 0.9 m. Using stable water isotopes, they found that plant water uptake was consistent with water from 0.4-0.9 m depth. Using the same method, they were also able to demonstrate how hydraulic lift and redistribution (Dawson 1993) plays a significant role in this system. While the combined ERT-sap flow method of Cassiani et al. has the benefit of high spatial resolution, it is almost impossible to pin down the actual mechanisms of soil-plant water flow without the use of tracers (like stable water isotopes). Given that the ERT-sap flow method of Cassiani et al. holds promise for better quantification of water fluxes in soil-plant interactions (at a tree level), how these fluxes vary using their method at a stand level and higher are still unknown. Although this can form part of future work, it is imperative that the authors provide explicit statements acknowledging the limitations of their method within the broader context of what other existing methods can resolve in soil-plant-atmosphere studies.

A few other specific points should be addressed:

1) P13359-60: "...the sum of sensible and latent (LE) heat flux is highly correlated..." Much of the paper focused on ERT-sap flow, less on the value that the EC data provided. For example, Fig. 2 is supposed to illustrate something about the site and its value to modeling tree-level measurements. However, nothing was mentioned regarding Figure 2, and related EC measurements as they relate to the overarching research question, after these pages.

2) P13366: Photos of the site do not seem to qualify as having a "dense canopy cover", which partly forms the basis for neglecting direct evaporation from the square meter of soil around the stem. Before ruling out direct evaporation, it may be appropriate to use leaf area index (LAI) values, and make use of their Eddy Covariance data to test whether direct evaporation is worth neglecting. Soil physics work has shown that evaporation is controlled, in series, by both hydraulic continuity (via capillary action) and vapor diffusion mechanisms. The latter mechanism, albeit characterized by low evaporation rates, has been shown to be independent of atmospheric forcing. The authors are referred to a review by Or et al. (2013) for a more comprehensive approach to modeling soil evaporation.

HESSD
11, C5787–C5790, 2014

3) P13367: That soil moisture is much higher than in ERT-controlled block closer to the tree is not surprising. It implies a zone of low soil moisture around the tree, understandably linked to water withdrawal by the plant. Bejan et al. (2008) - Unifying constructal theory of tree roots, canopies and forests – showed scaling relationships between total water mass flow rate and tree length, as well as between tree length and wood mass, among others. Can Cassiani et al. test and show possible relationships between various tree dimensional metrics and their actual ERT-sap flow data? The good agreement between theoretical models (like those of Bejan et al.) and empirical data may provide a potentially powerful premise for upscaling this work's tree-level results to stand level predictions. The authors can perhaps begin with the simple question: Does 0.75 m from the stem of the tree correspond to the radial extent of the crown?

Supporting materials 1) Kurz-Besson, C. et al. Hydraulic lift in cork oak trees in a savannah-type Mediterranean ecosystem and its contribution to the local water balance. Plant Soil 282, 361-378 (2006) 2) Dawson, T. Hydraulic Lift and Water Use by Plants: Implications for Water Balance, Performance and Plant-Plant Interactions. Oecologia 95,565-574 (1993) 3) Or, D., Lehmann, P, Shahraeeni, E., Shokri, N. Advances in soil evaporation physics-A review. Vadose Zone Journal 12. (2013) 4) Bejan, A., Lorente, S. Lee, J. Unifying constructal theory of tree roots, canopies and forests. J Theor Biol 254(3):529-40 (2008)

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