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Sap flow measurements combining sap-flux density radial profiles with punctual sap-flux density measurements in oak trees (Quercus ilex and Quercus pyrenaica) – water-use implications in a water-limited savanna-

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Sap flow measurement is a key aspect for understanding how plants use water and their impacts on the ecosystems. A variety of sensors have been developed to measure sap flow, each one with its unique characteristics. When the aim of a research is to have accurate tree water use calculations, with high temporal and spatial resolution (i.e. scaled), a sensor with high accuracy, high measurement efficiency, low signal-to-noise ratio and low price is ideal, but such has not been developed yet. Granier's thermal dissipation probes (TDP) have been widely used in many studies and various environmental conditions because of its simplicity, reliability, efficiency and low cost. However, it has two major flaws when is used in semi-arid environments and broad-stem tree species: it is often affected by high natural thermal gradients (NTG), which distorts the measurements, and it cannot measure the radial variability of sap-flux density in trees with sapwood thicker than two centimeters. The new, multi point heat field deformation sensor (HFD) is theoretically not affected by NTG, and it can measure the radial variability of the sap flow at different depths. However, its high cost is a serious limitation when simultaneous measurements are required in several trees (e.g. catchment-scale studies). The underlying challenge is to develop a monitoring schema in which HFD and TDP are combined to satisfy the needs of measurement efficiency and accuracy in water accounting.

To assess the level of agreement between TDP and HFD methods in quantifying sap flow rates and temporal patterns on Quercus ilex (Q.i) and Quercus pyrenaica trees (Q.p.), three measurement schemas: standard TDP, TDP-NTG-corrected and HFD were compared in dry season at the semi-arid Sardon area, near Salamanca in Spain in the period from June to September 2009. To correct TDP measurements with regard to radial sap flow variability, a radial sap flux density correction factor was applied and tested by adjusting TDP measurements using the HFD-measured radial profiles.

The standard TDP daily mean of sap-flux density was 95% higher than the 2cm equivalent of the HFD for Q. ilex and 70% higher for Q. pyrenaica. NTG–corrected TDP daily mean of sap-flux density was 34% higher than HFD for Q. ilex and 47% lower for Q. pyrenaica. Regarding sap flow measurements, the standard TDP sap flow was 81% higher than HFD sap flow for Q. ilex and 297% for Q. pyrenaica. The NTG-corrected TDP sap flow was 24% higher than HFD sap flow for Q. ilex and 23% for Q. pyrenaica. The radial correction, for TDP-NTG-corrected sap-flux density, produced sap-flow measurements in well agreement with HFD, just slightly lower (-3% Q.i. and -4% Q.p.).

The TDP-HFD sap flow data acquired in dry season over the savanna type of sparsely distributed oak trees (Q. ilex & Q. pyrenaica) showed that the TDP method must be corrected for NTG and for radial variability of sap flux density in trees with sapwood thicker than 2 cm. If such corrections are not taken into consideration, the amount of accounted water used by the trees is prone to overestimation, especially for Quercus pyrenaica. The obtained results indicate also that the combination of HFD and TDP leads to an efficient and accurate operational sap flow measurement schema that is currently in the optimization stage.