Plants, vital players in the terrestrial water cycle

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Plants transpiration accounts for about half of all terrestrial evaporation (Jasechko et al., 2013). Plants need water for many vital functions including nutrient uptake, growth, maintenance of cell turgor pressure and leaf cooling. Due to the regulation of water transport by stomata in the leaves, plants lose 97% of the water they take via their roots, to the atmosphere. They can be viewed as transpiration-powered pumps on the interface between the soil and atmosphere.

Measuring plant-water dynamics is essential to gain better insight into their role in the terrestrial water cycle and plant productivity. It can be measured at different levels of integration, from the single cell micro-scale to the ecosystem macro-scale, on time scales from minutes to months. In this contribution, we give an overview of state-of-the-art techniques for transpiration measurement and highlight several promising innovations for monitoring plant-water relations. Some of the techniques we will cover include stomata imaging by microscopy, gas exchange for stomatal conductance and transpiration monitoring, thermometry for water stress detection, sap flow monitoring, hyperspectral imaging, ultrasound spectroscopy, accelerometry, scintillometry and satellite-remote sensing.

Outlook: To fully assess water transport within the soil-plant-atmosphere continuum, a variety of techniques is required to monitor environmental variables in combination with biological responses at different scales. Yet this is not sufficient: to truly solve for spatial heterogeneity as well as temporal variability, dense network sampling is needed.

In PLANTENNA (https://www.4tu.nl/plantenna/en/) a team of electronics, precision and microsystems engineers together with plant and environmental scientists develop and implement innovative (3D-)sensor networks that measure plant and environmental parameters at high resolution and low cost. Our main challenge for in-situ sensor autonomy ("plug and forget") is energy: we want the sensor nodes to be hyper-efficient and rely fully on (miniaturised) energy-harvesting.

REFERENCES: