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Soil hydraulic constraints on transpiration

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Plants are continuously subject to changes in climate and soil conditions and their ability to promptly adapt to these changes is a key trait for the resilience against drought stress. These adaptation mechanisms take place locally at different temporal scales, ranging from seconds (e.g. for stomatal closure) to weeks (for growth and development).

Stomatal regulation controls most plant carbon acquisition and regulates 60% of terrestrial water fluxes going from the soils to the atmosphere through plants. The primary function of stomata regulation is thought to prevent cavitation in the vascular system. When the soil dries out, its hydraulic conductivity decreases by several orders of magnitude and large gradients in water potential develop around the roots. The drop in water potential around the root is extremely abrupt and it depends on soil properties, transpiration rates and active root length. Practically, there is a threshold soil water potential beyond which the transpiration losses can no longer be sustained by the water flow in soils. At this critical point the water potential at the root-soil interface drops to very negative values extremely fast and so makes the xylem water potential, with consequent high risks of embolism.

Our hypothesis is that plants close stomata when the gradients in soil water potential around the roots start to significantly influence the overall soil-plant hydraulic conductance. Practically, this means the relation between transpiration rate and leaf water potential, at a given soil water potential, deviates from a linear relation. This hypothesis implies that soil hydraulic conductivity is a primary constraint to transpiration. The objectives of this presentation are: 1) to provide theoretical and experimental data on the role of soil hydraulics on the relationship between transpiration, leaf water potential and soil water potential; 2) to discuss in what conditions soil hydraulics cause non-linearities in the relationship between transpiration and leaf water potential; 3) to provide experimental evidences that stomata close when the relationship between transpiration and leaf water potential becomes non linear; and 4) to propose below-ground strategies that plants developed to cope with these soil hydraulic constraints.