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Automating Dynamic Root Measurements to Understand Soil and Ecosystem GHG Fluxes

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Root dynamics are difficult to measure at biogeochemical-relevant scales of space and time and the source of many uncertainties in models and scaling.

Because roots grow, respire, host mycorrhizal fungi, produce exudates and eventually turn over, they drive carbon exchanges with both the soil and atmosphere which are just as critical, but more complex, than leaf-level exchanges. But because roots are hard to measure, their temporal dynamics are often ignored or assumed to be coupled to leaves (e.g. root seasonal cycles align with leaf phenology). This paradigm dominates design of field experiments, and vegetation components of climate models assume a simple parameterisation based on broadly untested assumptions.

In contrast, when root dynamics are studied directly, there is ample evidence that roots and leaves are rarely in sync and respond differently to environmental conditions. Triggers and limits to root dynamics are poorly understood. Roots and their partner organisms may grow, function, and turn over coupled, uncoupled or offset from leaves or greenhouse fluxes, as plant resource allocation shifts due to both environmental and physiological constraints.

We are implementing custom automated minirhizotron ('root camera') systems across a network of eddy covariance sites to make measurements of root dynamics and phenology directly. Building on previous work, where we measured root dynamics with these systems at unprecedented time frequency, we are now linking these dynamics to measured greenhouse gas fluxes from eddy covariance systems and soil respiration autochambers. But making indirect and image-based measurements belowground is challenging – many aspects of minirhizotron systems are not optimised for high frequency measurements and timeseries data

Here I will show both some of the results from these systems, and some of the advances in the design and implementation of field root imaging which we are making to improve understanding of this critical component of ecosystems at scales from seasonal to sub-daily.