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Linking ultra-fine timescale root dynamics to above-ground observations

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Fine roots are critical plant organs for nutrient and water uptake and thus integral for ecosystem function. In many ecosystems, they are a substantial proportion of the total vegetation biomass pool and when specifically studied, are often found to be partly decoupled from leaf dynamics, even in systems dominated by herbaceous species. However, methods to measure roots at real ecosystem scale are very limited and typically require very high effort. Compared to the large volumes of remote-sensed measurements now commonly available aboveground (e.g. phenocams, satellite instruments) and to carbon budgets from frequent trace gas flux measurements, root data on biomass and traits are usually collected at time intervals of at least several weeks. Understanding of root phenology may also be biased by sampling at times of the year when sampling is easiest and/or at periods where the biggest absolute experimental differences in root biomass are expected. Additionally, it is usually impossible to make repeat measurements of the same individual root due to the destructive sampling. Consequently, specific effects of global change factors on root phenology are difficult to identify as changes may occur on the scale of days and fall outside intensive measurement campaigns. This leads to the common assumption, that root phenology is highly functionally linked to leaf phenology and responds in an allometrically coupled fashion to observed above-ground changes.

Here, we will show data from custom built robotic minirhizotron systems where we match sub-daily minirhizotron sampling with above ground and environmental timeseries such as phenocam images, CO_2 fluxes, and soil moisture. Minirhizotrons are buried camera-observatory systems which can take non-destructive images of roots in the area around the observatory and thus uniquely well suited for the study of root dynamics at phenology-relevant timescales, if data can be collected and processed at high frequency able to capture critical phenological periods. Hence, we will also discuss rapid computer-aided processing of images from frequently sampled minirhizotrons to obtain phenology-relevant information without simply replacing physical handling of soil samples with slow manual image markup. We show results from both, a simple mesocosm system, with tight spatial pairing of measurements and simple soil and vegetative structures, and the first results from field installation at a seasonally dry and highly instrumented tree-grass system in Spain (Las Majadas del Tietar). At this site, seasonal minirhizotron and phenocam observations indicate decoupling of root and leaf phenology in some periods of the year and seasonal responses to short-term rain events. Deployment of automatic systems allows this coupling to be studied in more depth and related to short-term environmental forcing in unprecedented detail.