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Separating plant and soil carbon fluxes under field conditions

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A major obstacle to understanding plant-soil-microbe interactions governing soil carbon (C) turnover is a lack of measurement systems for field conditions. Measurements of soil-atmosphere C fluxes necessarily conflate the flux from the plant and recent plant inputs with that from existing soil C. However, it is essential to separate plant from soil fluxes to disentangle the true responses of soil C turnover to driving variables, and to follow plant-derived C into soil pools. We have developed a field laboratory with which to do this, giving near-continuous measurements of plant and soil C fluxes and their drivers in field soils.

The laboratory contains 24 0.8-m diameter, 1-m deep, naturally-structured soil monoliths in lysimeters. The monoliths are two contrasting C3 soils sown with a C4 grass (*Bouteloua dactyloides*); the very different C isotope signature of C4 plant respiration and C3 soil organic matter (SOM) decomposition is used to partition the net C flux. The soil monoliths are fitted with gas flux chambers (26-cm head space) with pneumatically operated lids. Gases accumulated when the lids are closed are passed through a loop to a Picarro G2201-i C isotope analyser and, as necessary, a Picarro G2508 CO_2, CH_4 and N_2O analyser, housed in an instrument building. The closing of the flux chambers and the directing of gas flow through the sample loop is controlled by software. Each monolith is fitted with temperature and moisture sensors and solution samplers at different depths, and there is a complete weather station at the site.

We have made gas flux and C isotope measurements thrice daily from each of the 24 planted lysimeters over 6 months. This has shown the precision of the system is sufficient to partition soil and plant C fluxes and detect diurnal fluctuations in both. Our results show clear, repeated patterns in both plant and soil C fluxes at diurnal timescales, with plant respiration varying by a factor of four during the day, and SOM decomposition by a factor of two. Broader seasonal variation in both fluxes is evident in both soils. Through examination of the relationships between soil moisture and temperature and C fluxes we have found temperature to be the major driver of plant respiration.