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Exploring The Birch Effect In The Subsurface Using Diffusive Soil Probes

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Soil gases are efficient messengers of the subsurface biogeochemical processes that underlie important nutrient cycles. Recent advances in subsurface gas sampling techniques can be combined with high precision trace gas instrumentation to yield novel insights into these processes and their mechanisms.

We present measurements of a wide range of trace gases before, during, and after a simulated rainfall upon northeastern US temperature forest soil in meso-scale columns. Subsurface concentrations and above-ground fluxes of N_2O and its isotopes, CH_4 and its isotopes, CO_2, NO, NO_2, NH_3, and a wide range of volatile organic compounds (e.g. monoterpenes, sesquiterpenes, isoprene, acetonitrile, aromatics) were quantified in real time with 30 minute temporal resolution. Small molecules were measured using Aerodyne TILDAS instruments, while VOCs were measured using a Vocus mass spectrometer.

Addition of water to the dried soil column produced a classic Birch effect pulse of both C and N species, including for VOCs. We explore correlations between responses of trace gases above- and below-ground, and relate the small molecule pulses to the larger VOC responses. In addition, we demonstrate the value of isotopic signatures for these studies, with the observation of fast, large isotopic shifts in the $^{15}N_2O$ isotopomers. We compare these isotopic signatures to simple kinetic models to provide insight into the mechanisms underlying the nitrogen Birch effect.