Poster #9-34

Carbon–Nutrient Economy of the Rhizosphere: Improving Biogeochemical Prediction and Scaling Feedbacks from Ecosystem to Regional Scales

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We advance plant-soil-microbial dynamics in terrestrial biosphere/Earth system models in three areas: i) nutrient cycling and plant uptake (nitrogen and phosphorus); ii) root exudation and priming; and, iii) mycorrhizal dynamics. We leverage a multi-site mycorrhizal gradient across the US to update the Fixation & Uptake of Nitrogen (FUN) submodel embedded within CLM 5.0. FUN-CLM specifies the site data collection, which includes soil, leaf chemistry, and litterfall sampling from multiple plots at each site. A remote sensing component expands the observational constraints to the model globally.

Site results show that ECM plots are more nutrient limited than are AM or mixed plots. ECM plots have lower soil pH, higher soil C:N, higher leaf litter lignin:N, and lower microbial growth efficiency than AM plots, the latter likely reflecting the necessity for greater enzyme investment by ECM soil microbes to degrade soil organic matter; this is supported by higher rates of lignolytic enzymes activity. Long-term experiments are monitored with minirhizotron tubes, root ingrowth cores, and 13C isotopically distinct soil cores for belowground inputs.

Concurrently, we developed the C cost of P uptake computational framework in FUN, as well as the additional C and N cost of synthesizing phosphatase enzymes to extract P from soil (FUN-P). The model is currently parameterized with the site data and previous data at a subset of the sites, resulting in differences in costs, uptake, and nutrient cycling between ECM and AM trees in the model. FUN-P accurately estimates measurements of P retranslocation across sites. The inclusion of costs for P uptake improves the ability of the model to capture observed patterns in C allocation to root exudation and mycorrhizal biomass. Collectively, the modeling activity provides a novel framework for understanding how interactions between the C-N-P cycles belowground impact the ability of plants to acquire nutrients and support NPP. We are currently working to couple FUN-P to CLM and to ELM/E3SM.

Finally, we are developing a remote sensing analysis of mycorrhizal association, extending previous work done at 4 sites across 150K trees to the global scale across over 100K plots encompassing millions of trees. This will create the first ever, global, spatially explicit, 30 m resolution, observational dataset of mycorrhizal association. These data will provide a major breakthrough not only in understanding ecosystem carbon-nutrients exchange and links between belowground and aboveground processes, but will also be directly used to initialize and constrain the global modeling developments described above.