Poster #1-53

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

Joshua B. Fisher[1*], Richard P. Phillips[2], Edward R. Brzostek[3], Tom Evans[4], Kara Allen[3], and Michala L. Phillips[5]

[1]University of California, Los Angeles, Los Angeles, CA
[2]Indiana University, Bloomington, IN
[3]West Virginia University, Morgantown, WV
[4]Northern Arizona University, Flagstaff, AZ
[5]University of California, Riverside, Riverside, CA

Contact: jbfisher@jpl.nasa.gov

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This MODEX project advances 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 6-site mycorrhizal gradient across the US to develop 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 nine plots (3 ectomycorrhizal, ECM; 3 arbuscular mycorrhizal, AM; 3 mixed) at each of the 6 sites. A remote sensing component expands the observational constraints to the model globally.

Initial site-level results show that ECM plots are more nutrient limited than are AM or mixed plots. ECM plots also have lower soil pH, higher soil C:N, and higher lignin:N in leaf litter. Moreover, ECM plots had lower microbial growth efficiency than AM plots, 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 monitoring and experiments have begun with the installation of minirhizotron tubes, root ingrowth cores, and ^{13}C isotopically distinct soil cores to monitor net belowground inputs.

Concurrently, we are developing 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 initial site-level data, as well as 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. Initial results show that FUN-P accurately estimates empirical measurements of P retranslocation to leaves across the sites. Further, 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. The modeling framework setup will facilitate dynamic ingest of new data as they come online from the empirical work. 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.

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.