

Title: Multiscale approaches characterize microbial metabolic feedbacks to hydrological perturbation

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Project Goals: The microbial feedbacks project seeks to characterize and predict microbial (fungal, bacterial, and archaeal), and viral responses to rapid environmental fluctuations. The project examines responses across multiple scales, from analysis of metabolic response to environmental change at the single-cell level to whole community responses to drought along precipitation gradients in a humid tropical forest. This approach integrates multiple streams of data, including multi-omic datasets, infrared spectroscopy, isotope geochemistry, and gas flux data with an end goal of linking soil biogeochemistry, and organic matter composition to the traits and trade-offs selected for during drought.

Abstract: Model projections predict that climate change impacts on the tropics will include an increased frequency of drought and precipitation cycles. Such environmental fluctuations at the soil pore scale play an important role in shaping microbial adaptive capacity, and trait composition of a community, which feeds back on to the breakdown and formation of soil organic matter (SOM). Humid tropical forest soils contain vast soil carbon stocks due to high productivity. Therefore, developing a predictive understanding of the factors controlling soil carbon balance remains a social imperative. Improved characterization of microbial feedbacks to the composition and stability of SOM pools is critical. Herein, we examine the microbial response to drought perturbations across 3 different, but complementary scales. At the largest scale, we explored the impacts of drought across a 1 m precipitation gradient spanning four sites from the Caribbean coast to the interior of Panama. At each site, 4 throughfall exclusion plots (10 x 10 m) were constructed to reduce precipitation by 50 %. We sampled these exclusion plots, and the corresponding controls, 18-months into the treatment to characterize the traits selected for across the gradient and under throughfall exclusion. To increase the signal: noise ratio intact cores from one site were taken at mid-rainfall from infertile soils and subject to 3 different hydrological treatments (control, drought, rewetting-drying cycles) in the laboratory over a 5-month period. For the field and meso-scale experiments, we evaluated changes imparted by hydrological perturbations using multi-omic approaches, and physico-chemical measurements. Finally, to improve our holistic understanding of traits expressed by microorganisms under either osmotic or matric stress (both characteristic of drought), we reduced the complexity again, by isolating a range of gram-positive and negative bacteria and subjected them to acute stress at the scale of the single-cell and simple communities. Single-cells

were subjected to osmotic or matric stress and short-term physiological responses determined using non-destructive synchrotron radiation-based Fourier Transform-Infrared spectromicroscopy. Through this approach we identified changes in metabolic allocation within different cells, in particular to the secondary metabolome of the different bacteria. Our contribution will discuss the outcomes of these multi-scale experiments. Specifically focusing on how shifts in the microbial community and physiological changes may influence tropical soil carbon stability under future scenarios of altered drought and precipitation cycles.