

Poster #92

Understanding the Response of Photosynthetic Metabolism in Tropical Forests to Seasonal Climate Variations

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This project focuses on one of the fundamental questions in terrestrial system science and tropical forest ecology: what controls the response of photosynthesis in evergreen tropical forests to seasonal variations in climate? Photosynthesis seasonality in Amazon tropical forests simulated by state-of-the-science Earth system models largely disagrees with observations: while modeled soil hydrologic dynamics during drought spells dictate water shortage and, as a result, constrained photosynthesis, satellite-based retrievals of forest “greenness” and tower-based measurements of carbon dioxide exchange indicate that production remains nearly constant or increases during dry periods. This research addresses this paradigm by providing insights on seasonal climate-photosynthesis relations in two tropical forests of the Brazilian Amazon, across a gradient of dry season length between Manaus (with a short dry season) and Santarem (with a long dry season). The methods involve intensive field campaigns to measure physiological and hydraulic characteristics of leaves and trees, camera systems to monitor forest growth at tree crown and canopy scales, and ecohydrologic system continuously tracking water tree flows and their hydration status. The integration of individual tree responses over a range of light exposure conditions highlights temporal changes of the forest response to 2015-2016 El Nino conditions as well as variability of tree-scale carbon and water uptake strategies. Our tower-based phenology cameras showed that synchronization of new leaf growth with dry season litterfall shifts canopy composition toward younger, more light-use efficient leaves, thus explaining large seasonal increases (~27%) in ecosystem photosynthesis. Analysis of hydraulic relations in trees shows a spectrum of successfully co-existing strategies, ranging from tight control against xylem failure, to a near lack of regulation of the water flux through the stomata. These strategies also exhibit coupling with tree growth patterns and dynamics of non-structural carbohydrates, hinting the linkage between individual tree drought response and ecosystem-scale dynamics. We thus conclude that accounting for age-dependent variation among individual leaves and crowns as well as representation of hydraulic traits is necessary for reliable modeling of the seasonal dynamics of photosynthesis. The results suggest a new approach for integrating hydraulic traits and carbon-cycle dynamics, and a strategy for mapping traits to function of tropical forests in the next generation of predictive models of ecosystem dynamics.