Determining the Drivers of Redox Sensitive Biogeochemistry in Humid Tropical Forests

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The availability of soil O2 and associated redox dynamics are key drivers of C cycling and greenhouse gas fluxes in tropical forests. Changes in climate are likely to affect soil O2 availability in tropical forests and feedback on ecosystem biogeochemistry. Few studies have measured soil O2 availability over time and space in tropical forests, and thus this important parameter is absent or poorly represented in Earth systems models. In this study we will use field and laboratory experiments in humid tropical forests to develop a mechanistically derived redox component for the Community Land Model (CLM4) component of the Community Earth System Model (CESM). We will use our empirical and modeling efforts to improve the prediction of C, N, and P cycling and greenhouse gas dynamics in humid tropical forests. Our research will test the following hypotheses:

H1: Soil O2 concentrations vary as a function of soil texture, slope position, and rainfall in humid tropical forests.

H2. The spatial and temporal dynamics of soil O2 availability can be used to predict patterns in redox sensitive biogeochemical processes.

H3. Hot spots and hot moments in greenhouse gas fluxes are derived primarily from high substrate availability and secondarily from soil O2 availability.

Research is being conducted in the Luquillo Experimental Forest (LEF), Puerto Rico. We are using controlled field and laboratory experiments to establish the relationships between soil O2, climate, soil physical properties, and a range of redox sensitive biogeochemical processes including soil respiration, net and gross N2O and CH4 fluxes, and Fe redox impacts on P mobilization. We will use automated sensor and surface flux networks to test the hypotheses. We will also use fertilization experiments to determine the relative importance of substrate availability and soil O2 concentration on gross and net greenhouse gas dynamics. Unlike previous efforts that have clearly established relationships among soil O2 concentrations and redox couples, the objectives of this research are to determine the physical controls on soil O2 availability and biogeochemical cycling to derive mechanistic relationships for modeling. The data will be used to improve the redox representation in CLM4. We will introduce new equations representing diffusion and source/sink behavior of O2 with depth.