Collaborative Research on Ecophysiological controls on Amazonian precipitation seasonality and variability

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The Amazon currently plays a critical role in the terrestrial climate system. Over the last decade, Amazonian forests have begun experiencing more frequent dry periods, including two extreme drought episodes in 2005 and 2010. However, the future of the Amazon as projected by current generation climate or earth system models is highly uncertain: how global warming and other aspects of anthropogenic change such as deforestation and degradation will ultimately impact this system is far from clear. A dominant source of uncertainty regarding Amazonian climate and its future evolution is the role of land-vegetation-atmosphere coupling, especially interactions between vegetation and precipitating deep convection occurring during the late dry season/early wet season when land-vegetation-atmosphere coupling has been shown to be stronger. Quantitative understanding of this coupling is critical since forest productivity is sensitive to the duration and intensity of the dry season. Thus, in the present proposal, our principal objective is to address how vegetation influences climate variability and precipitation over Amazonian rainforests, with an emphasis on plant physiological controls on deep convection triggering along a geographical water stress gradient. To support this objective, our proposed research comprises three interrelated activities: (i) in situ measurements of plant physiological water stress with a focus on fluorescence and its control on surface energy and water budgets as observed at existing flux tower sites; (ii) diagnostic analysis of plant physiological parameters and processes, observed surface turbulent fluxes, boundary layer properties, and cloud cover and precipitation along a moisture gradient; and (iii) process- based model studies of the pathways through which the surface energy partitioning (Bowen ratio) and transpiration, as modified by water stress, influence convection both locally and non-locally.

We have incorporated equations for SIF into a land surface model, the National Center for Atmospheric Research Community Land Model version 4 (NCAR CLM4), to better estimate terrestrial GPP. First, we use existing theory and data to explain how SIF was incorporated into CLM4.. We then demonstrate that our simulated fluorescence values are reasonable when compared with satellite (Greenhouse gases Observing SATellite; GOSAT) and in situ flux-tower measurements. Our results overestimate GPP in tropical forests and thus indicate that maximum carboxylation rate, Vmax, may be too high in tropical forests. Photosynthesis influences energy, water and carbon cycles, and we expect that the incorporation of SIF, along with satellite and in situ measurements, will improve estimates for GPP and thereby play a critical role in improving land