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Light use efficiency in Amazon ecosystems: a multi model-data inter comparison

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In wet evergreen tropical forests, water is never limiting and photosynthesis levels are maintained high even during dry months due to deep roots and/or hydraulic redistribution. Although light availability and phenology are supposed to drive the seasonality of carbon fluxes in the Amazon forests, it remains unclear what the driving factors are of the observed seasonal patterns in gross primary production (GPP) and how adaptable tropical forest canopies are to light limitations. Biophysical ecosystem models generally have difficulties to predict the seasonal responses of carbon fluxes to dry wet periods. Several efforts have been done to improve models in order to capture the observed seasonality in carbon fluxes by introducing deeper soils or rooting profiles, or a phenological response.

Recent remote sensing studies observed a "greening" of large parts of the Amazon forest during the dry season, suggesting that tropical forest canopies may be more adaptable to light than previously considered. The observed greening is based on an increased enhanced vegetation index (EVI), which is a composite of leaf area and chlorophyll content. EVI is therefore not able to distinguish if the canopy adaptation is structural (LAI) or biochemical (chlorophyll). Although these remote sensing studies have been contested by satellite data quality, the study of canopy responses to dry/wet seasonality remains highly important given the fact that the Amazon showed to be sensitive for the recent droughts in 2005 and 2010 and that future drought events are expected to increase in severity and frequency in the Amazon. Because the drivers of these remotely-sensed seasonal canopy adaptations and their consequences on GPP remain unclear, this study is using a bottom-up approach. We try to resolve the issue by looking at the dynamics of light use efficiency (LUE) for GPP derived from eddy covariance flux tower data and multiple model outputs collected in the data model inter comparison project of the Large-Scale Biosphere-Atmosphere Experiment in Amazonia (LBA-DMIP). LUE is a well-known ecological concept and can be defined in many different ways but it is essentially the ratio of the production by photosynthesis to radiant energy absorbed by or available for foliage. Many GPP models are based on the LUE concept, where the intercepted radiation is multiplied by a constant or variable maximum LUE. Typically a series of environmental constraints that regulate the actual LUE are taken into account.

This study addresses the adaptation of tropical forest canopies to light limitation by investigating the seasonality of LUE for multiple eddy covariance sites and the mechanisms behind these adaptations. These findings are used to test if the ensemble of carbon cycle models of LBA DMIP is able to reproduce the temporal and site-to-site variability of LUE and how this contributes to intra-annual variability of carbon fluxes.