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Modelling the sensitivity of seasonal gross primary productivity to water and light limitations along a tropical forest moisture gradient

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The tropical forests of Amazonia contribute to 15% of global photosynthesis and provide a variety of globally significant ecosystem services. However, the sensitivity of this large carbon flux to climate and the relative roles of light and soil moisture limitation are uncertain. A large source of this uncertainty results from the structural characteristics inherent to tropical wet forests that are difficult to measure and monitor. For example, high leaf area index and fpar (a measure of leaf absorption of photosynthetically active radiation) are difficult to measure in tropical regions due to the remoteness of field sites and challenges posed to remote sensing observations from cloud contamination and fpar saturation. In addition, soil depths and rooting distributions are difficult to determine beyond individual site measurements which have measured water extraction to depths of at least 10 meters. Recently, long-term flux tower measurements and new remote sensing indices from the MODIS sensor have revealed that the seasonal pattern of leaf area and productivity are limited by a combination of light and soil moisture so they are maximized in the 'dry-season.' In this study, we developed a light limitation module for the LPJ dynamic global vegetation model that maximizes leaf area index and fpar in the dry season. We tested this model in combination with a sensitivity analysis for soil depths and rooting distributions to evaluate the seasonal cycle of gross primary productivity (GPP). The results are compared among 12 sites along a gradient of dry season length with flux tower measurements and the MODIS Enhanced Vegetation Index (EVI), leaf area index (LAI), fpar, and GPP. The model

results suggest that soil moisture limitations and the seasonality of Vcmax (maximum photosynthetic capacity) are the primary drivers of the seasonality in GPP and that adding a seasonal dynamic to LAI has little effect on fpar. LPJ simulates a similar seasonal cycle of GPP to field observations when soil moisture limitations are removed by increasing soil depth from 3 meters to 10 meters. This model assessment and update will help interpret and explain ecosystem response to recent and projected droughts for the Amazon region.