Supplemental Material

Description of the Community Land Model (CLM):

The Community Land Model (CLM) is the land component of the Community Earth System Model (CESM) (Collins et al., 2006; Gent et al., 2011) that models global climate systems and makes projections of future climate change. In this study we used the stand-alone version of CLM4.5. This version used a data atmosphere model, a "stub" ocean, a stub sea-ice model, and the CLM-CN (carbon-nitrogen) version 4.5. Detailed descriptions of updates to version 4.0, algorithms used, and the general structure of CLM can be found in the CLM4.0 Technical Description (www.cesm.ucar.edu/models/cesm1.0/clm/CLM4_Tech_Note; Oleson et al., 2010; and Lawrence et al., 2011). This CN model included a prognostic carbon and nitrogen cycle in vegetation, litter, and soil organic matter (description in Thornton et al., 2007). For model comparisons against the gap model ZELIG-TROP, and observed field data, we used CLM results from a single grid point located at 2°35'S, 60°W, close to exact coordinate as the Central Amazon field transects. (Additional definitions of terms and parameters used in CLM are defined below).

In CLM, disturbance rates and realistically calculated plant mortality rates are ill represented. Currently, CLM includes two independent mechanisms for plant mortality: fire and natural senescence. In this study, mortality caused by fire was turned off. Mortality rates (representing natural senescence) are calculated as a whole-plant mortality that is intended to represent death of plants from all causes other than fire. This annual whole-plant mortality is calculated by removing 2% yr^{-1} of global total vegetation mass, regardless of differences in plant age, size, regional location, distribution of individuals, competition, or plant functional types (PFTs) (Oleson et al., 2010). We believe CLM could benefit from a more mechanistic approach of calculating plant mortality and disturbance. Developing a platform for CLM and CESM to model tropical disturbance in a dynamic approach greatly enhances our understanding of future changes to carbon fluxes and atmospheric carbon dioxide levels. Another benefit of this new development to CESM is the capability to address disturbance within the newly coupled Integrated Earth System Model (iESM) (Jones et al., 2013; description available at http://climatemodeling.science.energy.gov/sites/default/files/iESM_Fact_Sheet.pdf). The iESM model combines the natural-human system with the biophysical and climate system by coupling three models: (1) CESM with the (2) Global Change Assessment Model (GCAM), which focuses on an energy/economic framework, and the (3) Global Land-Use Model (GLM). Therefore, the iESM project creates the capabilities to test the carbon market and energy market response to changes in forest mortality and increased disturbances.

Definition of the mortality algorithm in ZELIG-TROP and terms in each model

Plant mortality is determined in ZELIG-TROP by three separate means: age-related natural death, stress-related death, and external disturbance (evaluation of gap model mortality described in more detail in Keane et al. 2001). Natural mortality, or intrinsic death, is a tree level event that is stochastically determined, based on the assumptions that 1% of trees reach their maximum age, and that mortality was constant with respect to age (Botkin et al., 1972; Shugart, 1984). Stress related death, or growth-dependent mortality, is also a stochastic event in which death occurred to individuals that have a slow growth rate for two years or more due to suppression or environmental stressors. The model assumes that 1% of stressed individuals will live for 10 years (Shugart, 1984; Van Daalen and Shugart, 1989).

Within ZELIG-TROP the production of new organic matter from interval t_1 to t_2 is prognostically determined and given by: growth = $M_{t2} - M_{t1}$, where M_t is woody mass at time t. Growth is a component needed to measure ANPP given by: ANPP = $M_{t2} - M_{t1}$ + L, where L is both old and new litter loss. The annual loss of coarse woody material is given by: coarse litter production rate = $W_{L1} + W_{L2} + W_{L3}$, where W_{L1} are losses from natural death, W_{L2} are losses from stress related death, and W_{L3} are losses from disturbance (all trunks and branches >10cm in diameter). All flux values given in Mg C ha^{-1} yr^{-1}.

Within CLM the production of new organic matter from interval t_1 to t_2, is also prognostic, responding to environmental differences and in this study was estimated using the wood carbon allocation variable: woodc_alloc, which is given by: $growth_{CLM}$ = carbon to liveStem + carbon to deadStem + liveStem to storage + deadStem to storage. In CLM, ANPP (leaf, live stem, and dead stem) is given by: $ANPP_{CLM}$ = GPP – AR where AR is autotrophic respiration and is the sum of maintenance and growth respiration. Lastly, the annual loss of coarse woody material was estimated by the wood loss variable: woodc_loss, which is given by: coarse litter production $rate_{CLM}$ = liveStem to litter + deadStem to litter. All flux values given in Mg C ha^{-1} yr^{-1}.