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Predicting terre firme forest stand level photosynthesis across the Amazon Basin

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Amazon forest canopies have high foliar [N] and low foliar [P] compared to their temperate broadleaf counterparts, this especially being the case on older ferralsol-type soils (Fyllas et al., 2009) with stand level analyses also suggesting a P limitation on the overall productivity of such forests (Quesada et al., 2009a). There is, however, considerable variability in soil types across the Amazon Basin (Quesada et al., 2009b), with stands on relatively fertile soils (generally closer to the Andes) having a much higher phosphorus status than is the average and therefore, along with forests on white-sand soils, these forests are possibly limited by nitrogen (Quesada et al., 2010). Despite the likelihood that tropical forest productivity might be limited by phosphorus, at least in some cases, global models still simulate tropical forest photosynthesis based on the assumption of N limitations.
Here we simulate canopy photosynthesis across low land tropical forest in the Amazon basin using a method to determine two of the main parameters in photosynthesis based on an assumption on N or P limitation. This is done using a dependency on leaf nutrients and structure, which are scaled up to the whole Amazon rainforest using pedotransfer functions and a soil classification map (Quesada et al., 2009b; 2010). Specifically, we use the Domingues et al. (2010) model that predicts photosynthetic capacity (Vcmax) and maximum electron transport rate (Jmax), from leaf nutrients (N and P) and a leaf structure trait, specific leaf area (SLA), assuming either a N or P limitation to photosynthesis. To predict N, P and SLA across the Amazon forest, we use mathematical relationships derived from measured soil type and the correspondent above mentioned canopy traits. Such relationships were estimated using data from 1040 trees at 62 plots in the Amazon Basin. We then map foliar [N],[P] and SLA using the soil classification map under lowland forest in the Amazon basin from Quesada et al. (2009b) to create 14 soil plant functional types, each of which defines an upper-canopy value for [N],[P] and SLA. This is then implemented regionally using the JULES land surface model. The model has been evaluated at single sites using data from eddy correlation and/or derived from bottom up approaches. Initial results show i) good agreement between model predictions and measurements from the few available observational sites and ii) considerably more variation in stand-level photosynthetic rates across the Basin that simulated by the base line model.

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