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Modelling basin-wide variations in Amazon forest photosynthesis

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Given the importance of Amazon rainforest in the global carbon and hydrological cycles, there is a need to use parameterized and validated ecosystem gas exchange and vegetation models for this region in order to adequately simulate present and future carbon and water balances.

Recent research has found major differences in above-ground net primary productivity (ANPP), above ground biomass and tree dynamics across Amazonia. West Amazonia is more dynamic, with younger trees, higher stem growth rates and lower biomass than central and eastern Amazon (Baker et al. 2004; Malhi et al. 2004; Phillips et al. 2004). A factor of three variation in above-ground net primary productivity has been estimated across Amazonia by Malhi et al. (2004). Different hypotheses have been proposed to explain the observed spatial variability in ANPP (Malhi et al. 2004). First, due to the proximity to the Andes, sites from western Amazonia tend to have richer soils than central and eastern Amazon and therefore soil fertility could possibly be highly related to the high wood productivity found in western sites. Second, if GPP does not vary across the Amazon basin then different patterns of carbon allocation to respiration could also explain the observed ANPP gradient. However since plant growth depends on the interaction between photosynthesis, transport of assimilates, plant respiration, water relations and mineral nutrition, variations in plant gross photosynthesis (GPP) could also explain the observed variations in ANPP.

In this study we investigate whether Amazon GPP can explain variations of observed ANPP. We use a sun and shade canopy gas exchange model that has been calibrated and evaluated at five rainforest sites (Mercado et al. 2009) to simulate gross primary productivity of 50 sites across the Amazon basin during the period 1980-2001. Such simulation differs from the ones performed with global vegetation models (Cox et al. 1998; Sitch et al. 2003) where i) single plant functional type parameter values are assigned and assumed invariant with environmental condition but also ii) these models use leaf N as a factor that limit photosynthesis. Instead, since leaf P may also limit photosynthesis of the tropical forest (Reich et al. 2009), we use a more specific description of photosynthetic capacity across the basin based on the model evaluation done in Mercado et al. (2009) in which canopy photosynthetic capacity is related to foliar P but also using the relationships derived between canopy photosynthesis and leaf nutrients (N and P) from measurements in tropical trees (Domingues et al.In review).

A study of this kind can inform the global vegetation/climate community as to the need for variability in key model parameters in order to accurately simulate carbon fluxes across the Amazon basin.

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