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Increase in functional diversity compensates reduction on Amazon basin's net primary productivity in drier climate: exploring a new trait-based model

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Whether the Amazon basin forests will be able to maintain their carbon sink behavior in drier climates predicted for the region is still an open debate. This issue has being widely studied by Dynamic Global Vegetation Models (DGVMs), however they diverge both on the magnitude and direction of change in carbon stocks for this region when the new conditions are considered. The representation of plant diversity through plant functional types (PFTs) adopted by the majority of DGVMs undermine their ability to represent functional diversity, what can lead to a poor representation of the carbon cycle and, consequently, to uncertainties in the predicted carbon stock. The PFT scheme uses a small set of fixed parameters, in space and time (through mean values), to represent the plant functional traits. It does not allow the simulated plants to change their ecological strategy in new climate conditions and reduces the resilience of ecosystems and consequently their capacity to act as carbon sink with the changes in climate. In that sense this study used a new trait-based model named CAETÊ (Carbon and Ecosystem Functional Trait Evaluation model) to understand the impacts of drier climates in the ability of Amazon basin forests to maintain their carbon sink behavior as well as the role of functional diversity on it. As a trait-based model, CAETÊ seeks to represent plant functional diversity more reliably through the usage of variant values for functional traits. Six functional traits highly correlated to carbon stock were used: carbon allocation (%) and carbon residence time (years) on leaves, aboveground woody biomass and fine roots. An environmental filtering scheme together with trade-offs between traits and process restricts the possible combination of value in each grid-cell. We applied a 50% reduction on precipitation throughout the Amazon basin. It leaded to a mean reduction of 49% and 48% on net primary productivity and photosynthesis, respectively. However, the reduction on the carbon stock was only 25%. This lower reduction on carbon stock can be explained by an increase on functional diversity with the new condition both looking at an uni- and a multivariate trait space. For multivariate trait we observed an increase of 95% on the hypervolume occupied by the six traits together. This result is a reflection of the change on the traits separately: for the six traits we observed an increase on richness and on evenness and a decrease on divergence. It indicates an increase on the functional space usage by the ecological strategies after the disturbance and a decrease on the previous dominance. These two results indicate that the change on functional diversity can compensate, in terms of carbon stock, the loss on productivity due to the reduction on precipitation. This study highlights the importance on incorporating functional diversity in DGVMs concerned about climate change effects on ecosystems and shows that the trait-based approach allows researches that goes beyond the prevailing optic that take into account only the effects of climate change on biogeochemical cycles.

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