Related articles

Volume 7, issue 4 | Copyright

Model description paper | 03 Jul 2014

Analysing Amazonian forest productivity using a new individual and trait-based model (TFS v.1)

N. M. Fyllas et al.

Received: 24 Jan 2014 – Discussion started: 20 Feb 2014 – Revised: 19 May 2014 – Accepted: 21 May 2014 – Published: 03 Jul 2014

Abstract. Repeated long-term censuses have revealed large-scale spatial patterns in Amazon basin forest structure and dynamism, with some forests in the west of the basin having up to a twice as high rate of aboveground biomass production and tree recruitment as forests in the east. Possible causes for this variation could be the climatic and edaphic gradients across the basin and/or the spatial distribution of tree species composition. To help understand causes of this variation a new individual-based model of tropical forest growth, designed to take full advantage of the forest census data available from the Amazonian Forest Inventory Network (RAINFOR), has been developed. The model allows for within-stand variations in tree size distribution and key functional traits and between-stand differences in climate and soil physical and chemical properties. It runs at the stand level with four functional traits – leaf dry mass per area (M_a), leaf nitrogen (N_L) and phosphorus (P_L) content and wood density (D_W) varying from tree to tree – in a way that replicates the observed continua found within each stand. We first applied the model to validate canopy-level water fluxes at three eddy covariance flux measurement sites. For all three sites the canopy-level water fluxes were adequately simulated. We then applied the model at seven plots, where intensive measurements of carbon allocation are available. Tree-by-tree multi-annual growth rates generally agreed well with observations for small trees, but with deviations identified for larger trees. At the stand level, simulations at 40 plots were used to explore the influence of climate and soil nutrient availability on the gross (Π_G) and net (Π_N) primary production rates as well as the carbon use efficiency (C_U). Simulated Π_G, Π_N and C_U were not associated with temperature. On the other hand, all three measures of stand level productivity were positively related to both mean annual precipitation and soil nutrient status. Sensitivity studies showed a clear importance of an accurate parameterisation of within- and between-stand trait variability on the fidelity of model predictions. For example, when functional tree diversity was not included in the model (i.e. with just a single plant functional type with mean basin-wide trait values) the predictive ability of the model was reduced. This was also the case when basin-wide (as opposed to site-specific) trait distributions were applied within each stand. We conclude that models of tropical forest carbon, energy and water cycling should strive to accurately represent observed variations in functionally important traits across the range of relevant scales.

Download & links

- Article (PDF, 2686 KB)
- Supplement (1780 KB)

How to cite: Fyllas, N. M., Gloor, E., Mercado, L. M., Sitch, S., Quesada, C. A., Domingues, T. F., Galbraith, D. R., Torre-Lezama, A., Vilanova, E., Ramírez-Angulo, H., Higuchi, N., Neill, D. A., Silveira, M., Ferreira, L., Aymard C., G. A., Malhi, Y., Phillips, O. L., and Lloyd, J.: Analysing Amazonian forest productivity using a new individual and trait-based model (TFS v.1), Geosci. Model Dev., 7, 1251-1269, https://doi.org/10.5194/gmd-7-1251-2014, 2014.