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Biogeosciences Discussions

Interactive comment on "Accounting for spatial variation in vegetation properties improves simulations of Amazon forest biomass and productivity in a global vegetation model" *by* A. D. de Almeida Castanho et al.

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Authors Reply to Anonymous Referee #2

We thank the referee for the overall comments and detailed contribution to clarification of several aspects along the paper. We address below each of the referees concerns and when pertinent the respective improvements made in the manuscript.

Anonymous Referee #2: Dynamic global vegetation models are nowadays widely used for estimating the impacts of environmental change and therefore, the improvement of

these models is an important task, especially for regional applications of these models. I have however some concerns about the way this was done in the present study. Generally, a more detailed description of the modelled processes and the model setup is needed. Currently it is not possible to evaluate from the description, how Vcmax, τw and NPP allocation influence the simulated woody productivity and above-ground biomass.

Authors reply: We included a brief description of the main processes that involve NPP allocation, τw, Vcmax and in the simulated woody above ground productivity and above-ground biomass in the IBIS numerical model.

(P. 11773, L. 24) "The NPP allocation refers to the partitioning of new growth into different plant tissues including wood, leaf and fine root. Allocation is very important for simulating the carbon cycle as it directly influences long term carbon storage (Malhi et al., 2011). Furthermore, the amount of carbon allocated to leaves influences the canopy photosynthesis of the plant, and the amount of carbon allocated to roots influences the amount of water uptake and nutrient acquisition, among other processes. The concepts of modeling carbon partitioning vary between numerical models. Some use a dynamic carbon allocation while others are based on a predefined ratio between main plant compartments fixed by each plant functional type (PFT) (Malhi et al., 2011). The original configuration of IBIS used a fixed partition of C with 50% to wood (awood), 30% to leaves (aleaf) and 20% to roots (aroot) to the typical Amazonian plant functional type the Tropical Broadleaf Evergreen trees (Equation 1).

NPP_i=α_i NPP Eq. 01

The biomass residence time (τ) defines the lifetime of a unit of biomass in the plant. Many global vegetation models assume a predefined and constant value of τ for each PFT for each plant compartment (wood (τw), leaf (τl) and fine root(τr)). For Broadleaf evergreen trees in IBIS, τw is set to 25 years, while (τl) and (τr) are set to 1 year. Other global vegetation models assume a constant τw for tropical forests, ranging from 20 years to 200 years. The woody biomass residence time is a key parameter for accurately simulating biomass stocks in an ecosystem. The change in the biomass (M) of an individual plant compartment (i : wood, leaf or fine root) over a period of time is described as in Equation 2:

dM_i/dt= α_i NPP - M_i/τ_i Eq. 02

where α represents the fraction of net primary productivity (NPP) allocated to the biomass pool i, and τ is the residence time of that biomass pool, is expressed in years (Foley et al., 1996). Vcmax refers to the photosynthetic capacity of the plant. It is the carboxylation capacity of the enzyme ribulose 1âĂć5-bisphosphate carboxylase/oxygenase (RuBisCO), which catalyzes the CO2 reactions during its assimilation process in the plant leaves (RuBisCO is the CO2 acceptor molecule in the Calvin cycle). It is directly related to the gross primary productivity of the plant, in IBIS it is defined originally for PFT- Tropical Broadleaf Evergreen tree as 65 [umol CO2 m-2s-1]. "

Anonymous Referee #2: How Vcmax and τw were identified as the most important parameters seems to be a subjective estimation.

Authors reply : A sensitivity test analyses was performed to identify the individual impact of each analyzed parameter in the AGBw and NPPw. It was presented in detail in the supplementary material. The reference to the supplementary material is on the main text (P. 11780, L. 20).

Anonymous Referee #2: Another point is that the authors present here a site-specific (or regional) calibration of model parameters rather than an improvement of the modeled processes. This leads to the question of how these improvements will help to better understand the underlying mechanisms that may lead to potential changes in future carbon fluxes and stocks.

Authors reply : We disagree with the assessment that the parameters are calibrated.

The model parameterizations were changed (not calibrated) based on more detailed spatial information derived from available field measurements. They were not systematically altered in a calibration process. In the previous version of the model the parameterizations were defined as being constant throughout a given PFT, in other words they were homogeneous parameterizations with average values assumed from sparse field information, for the entire region. We understand the concerns about how the improvements made in the model will benefit the numerical model performance for the future. To address this more explicitly, we included a paragraph in the conclusion section of the paper. (P.11793, L. 24): as already included in referee 1 comments.

Anonymous Referee #2: Finally, it is not clear to me, why the authors chose a spatial resolution of 1ox1o which seems a rather large scale in the context of improved regional simulations.

Authors reply : That is an important point that should not be misinterpreted. To make it clear we included an explanation on why this resolution is chosen. We could use a higher resolution (0.5 degree) hourly climate but there is no better resolution for soil data available for the entire Amazon basin that would justify that.

(P. 11772, L.24) " The 1ox1o degree spatial resolution has been chosen as a compromise between the spatial resolution of the model drivers (e.g. climate and soil properties) and computer run-time. Therefore increasing the resolution would increase the computer run time without a gain in information."

Anonymous Referee #2: Also, for improved regional simulations of biomass dynamics, it would probably be important to include more than one PFT throughout the Amazon basin. These shortcomings should be discussed.

Authors reply : Yes, we thank the referee for bringing that important aspect of the paper. As well as also pointed out by the first referee, we agree that this is an important point that needs to be clear in the paper, so we included a paragraph discussing the "idea" of more then one PFT to represent a tropical forest, please see in referee 1 comments

(P.11793, L. 24).

Anonymous Referee #2: Other comments

Anonymous Referee #2: Abstract, L.1-2: It is not clear what “spatially homogeneous biophysical parameters” are.

Authors reply : spatially homogenous refers to the biophysical parameters being constant in space

Anonymous Referee #2: Abstract, L. 13-16: What is meant by “spatial variability of 1.8 times in the simulated woody net primary productivity and: : :”?

Authors reply : That means that the spatial variability of some important parameters that are not accounted in the model can if accounted contribute to a spatial variability of NPP of 1.8 times (Max Value/ Min Value) across the basin and similar to AGB wood of 2.8 times.

Anonymous Referee #2: P. 11770, L. 11-12: please define what is meant by “spatial heterogeneity and the temporal variability of the forest biophysical properties”

Authors reply : We agree that was confusing and replaced by: (P. 11770, L. 11-12): “. . . spatial and temporal variability of the forest biophysical properties. . .”

Anonymous Referee #2:P. 11771, L. 23 and throughout the manuscript: How are “plant turnover rates” defined and is it the same as “tree turnover” and “stem turnover”. Similarly, how is “plant residence time” defined, is it the same as “woody biomass residence time” and “carbon residence time”?

Authors reply: We agree with the referee and the term will be carefully defined in P.11773,L 24 and we prioritize a single term “woody biomass residence time” through the manuscript. P.11771, L. 23 P.11775, L. 3 P.11790, L.1 , L. 3, L. 15

Anonymous Referee #2:P. 11772, L. 13: Why are biophysical parameters improved in a first step and only in the second step, the most important parameters are evaluated?

Shouldn’t it rather be the other way around?

Authors reply : We thank the referee for noticing this, we rephrase this paragraph in the correct way.

(P.11772, L. 13) “ In a first step we evaluate which parameters are most important for simulating the spatial variability of above-ground woody net primary productivity and biomass. In a second step we use the Integrated Biosphere Simulator (IBIS) DGVM with observational estimates of key biophysical parameters (woody biomass residence time (w), maximum Rubisco carboxylation capacity (Vcmax), NPP allocation to wood) to simulate AGBw and NPPw and evaluate model performance, in comparison to field data.”

Anonymous Referee #2:P. 11772: 1_x1_ is a rather coarse resolution when improving spatial heterogeneity. Why has this resolution been chosen?

Authors reply : We refer to the answer above, regarding this issue.

Anonymous Referee #2:P. 11773, L. 6: Was the validation and application of the model in these studies Successful

Authors reply : Yes, for the applications that they chose. We rephrase this statement to make it more complete.

(P. 11773, L. 6): “IBIS has been previously validated and applied to the Amazon (Senna et al., 2009; Delire and Foley, 1999; Foley et al., 2002; Coe et al., 2008). In those studies the model adequately simulated the carbon, energy and water budgets of the basin. However, the authors in those studies pointed out the need of better spatial representation of parameterizations to improve model performance in comparison with observations across the Amazon.”

Anonymous Referee #2:P. 11773, L. 22: Why not implementing more plant functional types? This would be more logical from the ecological perspective. For biomass production, also biotic interactions such as competition for e.g. light and nutrients are important.

Authors reply : We agree that a more detailed discussion regarding this topic is relevant and included a paragraph in the Discussion section (P. 11793, L. 24) as discussed in the previous referee.

Anonymous Referee #2: Section 2.2 is very hard to read, some sub-headings would be useful.

Authors reply : We accepted the referee suggestion and included sub-headings to improve the item comprehension.

Anonymous Referee #2:P. 11774, L. 18: "For similar reasons: : :" The reasons and analyses are not clear.

Authors reply: We make this point better explained in the manuscript.

(P.11774, L18): "Following the hypothesis of Aragao et al. (2009) we tested the correlation between carbon in fine roots with soil sand percentage and also carbon in leaves with soil sand percentage. We obtained similar correlations as in that study, as shown in Fig. (2) and respective equations (Eq. 1 in Table 1)."

Anonymous Referee #2:P. 11774, L.28-29: Not clear where the numbers were calculated from.

Authors reply : We rephrase this sentence.

(P.11774, L.28-29): "Applying Eq. 1 to the entire basin the estimated woody carbon allocation estimated for the region varies between 30–40% (Fig. 5a, background map). The estimate does not reproduce the amplitude of the site-specific measurement of carbon allocation (25–50 %) (Fig. 5a, bullets)."

Anonymous Referee #2:P. 11775, L. 13: "For this reason we opted to: : :" What would have been the other option?

Authors reply : The referee is right that should mean the best solution and not an option we replaced the phrase by:

(P.11775, L. 13): "For this reason we scale up the τw to the entire basin using simple kriging interpolation of the field data points (Fig. 5b)."

Anonymous Referee #2:P. 11777, L.17-19: This should be stated in the model description. Not clear why allocation to fine roots needs to be estimated (Fig. 2) and how this is applied in the model. Section 2.3 and Table 2 is difficult to understand without a detailed model description. It is not clear, how the parameters were spatially varied in the model. Is Equation 1 in Table 1 used for the heterogeneous parameterization described in Table 2?

Authors reply : As suggested before by the referee (in the first comment), we included a paragraph in the IBIS description, explaining the NPP allocation to the plant components (wood, leaf and root) in the model (P. 11773, L. 24).

We changed Table 2 and included just the reference to the Fig 5, for a straight reference of the data use in the simulation. The source and method for upscaling the data has already been described in Table1.

Anonymous Referee #2:P. 11778, L. 18: It is not clear how NPP is allocated to wood, foliage and roots in the model. In P. 11777, L.17-19 it is stated that the model does not differentiate between above-ground and belowground components.

Authors reply : We agree and replaced the sentence. (P. 11777, L.17): "IBIS, like many other ecosystem models, simulates a generic woody biomass pool that includes all above-ground wood and coarse roots."

Anonymous Referee #2:P. 11784, L. 14: Reference to Castanho et al. 2012 is not in the Reference list.

Authors reply : we thank the referee for noting, that reference has been replaced by: (P. 11784, L.14): " . . .in a different study we will. . . "

Anonymous Referee #2:P. 11785, L. 10: Sentence is not clear: “ The spatial scale and diverse topography of the Amazonian basin allows a large variability of climatological scenarios for a single tropical forest.”

Authors reply : we rephrase the sentence and that would make the point that despite of the fact that there is a significant climate variability within the basin that is not enough to explain the observed woody biomass and net primary productivity spatial variability (P. 11785, L. 10): “The spatial scale and diverse topography of the Amazonian basin allows a large variability of climate.”

Anonymous Referee #2:Table 1: Caption: the shaded cells are not indicated in the table. Table: “Based on Sand Fraction from: : :”, “Based on Quesada: : :”, “Based on Soil total Phosphorus map..” is not describing the method of upscaling. It is not clear to which of the equations Equation (1) and Equation (2) refers to.

Authors reply : We removed the reference to the shaded cells. We agree with the referee and better explained the upscaling method in Table (1).

Anonymous Referee #2:Table 2: What is meant by “fixed space”?

Authors reply : We agree that was awkward it has be changed to: (Tabel 2): “constant in space”

Anonymous Referee #2:Figure 2b: There seems to be an error in the y-axis labels.

Authors reply : Figure 2b has been replaced, and the number of decimal places was increased to 2 in the y-axis.

Interactive comment on Biogeosciences Discuss., 9, 11767, 2012.

Table 1. List of field data used in this study with the respective reference in literature. The original number of plots from each study is presented in column A, the respective number of grid cells at $1^o x 1^o$ resolution is presented in column B. The methods for upscaling and the regression equations used are presented. The table is divided into field data used for input parameterization in the model and field data of woody net primary productivity and woody above-ground biomass used for model output validation.

	Property [unit]	Paper	# plots . (A)	# grid cells in studied region (B)	Method of Upscaling	Regression Equations
Model Parameterization	Carbon allocation to wood, leaves and roots [fraction]	Malhi et al., 2011; Aragão et al., 2009	10	6	Use Equ. (3) to retrieve Carbon allocation as a function of Sand Fraction given by Quesada et al., 2010 Soil Texture Map	Equation (3) C_{root}= 0.0039 * Sand[%] + 0.137 R^2=0.97; p<0.004 C_{leaf} = -0.0025 * Sand[%] + 0.44 R^2=0.69; p<0.04 C_{wood} = 1 – C_{root} – C_{leaf}
	Woody Biomass Residence Time [yr]	Galbraith et al., 2012	129	34	Kriging Interpolation	-x-
	Soil Total Phosphorus Content (P) [mg/kg]	Quesada et al., 2010	71	26	Use relation obtained (Fig. 3a) to retrieve Soil total P as a function of Soil Class given by Quesada et al., 2011 Soil Class Map	(Soil total P site level) x (Soil Class Site Level) Fig. 3a
	Maximum carboxylation capacity of Rubisco (V_{cmax}) [$\mu molCO_2/m^2/s$]	Fyllas et al., 2009 (Phosphorus leaf site)	62	22	Use Equ. (4) to retrieve V_{cmax} as a function of Soil total Phosphorus Map (defined above)	Equation (4) V_{cmax}=0.1013*P [mg/kg] +30.037 R^2=0.77 p<0.005
	Specific Leaf Area Index (SLA) [m^2/kg]	Fyllas et al., 2009	62	22	Kriging Interpolation	-x-
Model Output Validation data	Woody Net Primary Productivity NPP_w[kg-C/m^2/yr]	Malhi et al., 2004	104	25	-x-	-x-
	Woody Above-ground Biomass AGB_w[kg-C/m^2]	Malhi et al., 2006	227	69	-x-	-x-

Fig. 1. Table1

Table 2. Summary of the parameterization setup for each of the simulation experiments: the control simulation (CA) with the original IBIS prescribed homogeneous parameterization; the SA3a with corrected carbon allocation, with homogeneous parameterizations in space; site-level simulation (SS) with heterogeneous parameterizations represented; and the regional simulation (RS) with the upscale of the respective parameters.

		Homogeneous Parameterization		Heterogeneous Parameterizations	
		(CA) Control Simulation IBIS original setup	(SA3a) (CA) with Change in C allocation	(SS) Site-level Simulation Site observation data	(RS) Regional Simulation Regional estimated data
Carbon Allocation to wood, leaves and roots	%	Constant in space 50%Wood 30%Leaves 20%Roots	Constant in space 34%Wood 33%Leaves 34%Roots	Dots in Fig. 5a	Map in Fig. 5a
Woody Biomass Residence Time	years	Constant in space 25	Constant in space 25	Dots in Fig. 5b	Map in Fig. 5b
Maximum carboxylation capacity of Rubisco (V_{cmax})	μmol $CO_2/m^2/s$	Constant in space 75	Constant in space 75	Dots in Fig. 5c	Map in Fig. 5c
Specific Leaf Area Index (SLA)	m^2/kg	Constant in space 25	Constant in space 25	Dots in Fig. 5d	Map in Fig. 5d

Fig. 2. Table2