

## ***Interactive comment on* “Field data to benchmark the carbon-cycle models for tropical forests” by Deborah A. Clark et al.**

**Anonymous Referee #1**

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### Review

The article presents a critical review of the currently available data to test the land-surface and vegetation/carbon dynamic components of Earth System Models in lowland tropical forests. After introducing general criteria for field data to be useful and trustable with regards to benchmark model results (Section 2 and 3), the authors reviewed the available data and associated issues in terms of standing carbon pools (LAI, aboveground and belowground biomass pools, soil organic carbon), ecosystem fluxes (NEE, GPP, respiration, NPP, litterfall) and tree mortality. A couple of final sections mentioned ecosystem C-fluxes sensitivity to climatic trends and availability of local meteorological conditions. The article is very well-written and touches on a sensitive topic of interest for the field experimentalist and modeling communities, bringing upfront many issues that are well-known but not explicitly written in a scientific manuscript. It is

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a review, therefore does not introduce any new methods or dataset but it clearly frames the picture of data availability for model comparison in the tropics. Therefore, the article type should be “Reviews and syntheses” and not “Research article”. My knowledge of the empirical literature of tropical forest is forcefully partial but I have the impression the authors are including most of what I am aware of in their discussion, even though the reference selection is by far not exhaustive, especially for the flux-tower data. In any case, I strongly agree with almost everything is written in the manuscript and I have mostly suggestions on points to stress or minor comments as listed below.

What clearly emerges from the manuscript is a gloomy picture of data availability to benchmark model in lowland tropical forests that let me wonder if the correct title should rather be “Field data to benchmark the carbon-cycle models for tropical forests are mostly lacking”. Unfortunately, such unsatisfactory amount of data availability corresponds to reality; we do not have almost anything to compare models with at the landscape scale in the tropics. This remarks the challenge of collecting model-meaningful data or add reasonable uncertainty bounds to the current available data in the tropics. It further suggests that some of the model-to-data comparisons carried out in the past for tropical forests might have compared apples to oranges or that the confidence given to certain type of “observed” data (e.g., GPP or aboveground wood production) in previous articles is unjustified. This criticism, which I completely share, is evident throughout the article but it is never really made explicit and probably can be reinforced in a revised version. Additionally, I suggest reinforcing a few other points. (i) It is extremely important collecting sub-daily resolution meteorological data for a number of variables simply to run the models. Practically, for many experimental sites, these data are missing and modelers have to rely on “re-analysis forcing” introducing additional discrepancies in the model-to-data comparison. (ii) Analysis of climatic sensitivities as the one reported in Table 12 (results from Clark et al 2013) are fundamental because they allow to test if the mechanistic nature of the model is able to capture the correct direction and magnitude of a given response and are typically less subjected to local biases than matching a given carbon pool or an uncertain flux. (iii) Given the paucity

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of data and their uncertainties, there should be some clear statement about the weakness of automatic calibration or to “force” models to reproduce as close as possible specific observations or set of observations (e.g., eddy covariance fluxes). With all the issues described in this manuscript, it is very unlikely that we are able to constrain several of model parameters using current data. In other words, there should be an effort from modelers in using observations very critically and not blindly and from experimentalists in communicating properly the limitations of measurements and accept model estimates (which are, at least, constrained by mass and energy conservation) critically and not simply as “wrong numbers.

#### Minor Comments

Page 2, Line 1-4 and elsewhere. I wonder if the article really needs these citations at the beginning of sections. I find a bit unconventional for a review paper and the main message of the citation can be or is already embedded in the main text.

Page 2 and Line 10-13. There are also studies that attributes a large part of the variability of the land CO<sub>2</sub> sink to semi-arid ecosystems (Ahlstrom et al 2015). Maybe it can be mentioned together with the role of tropical forest.

Page 5 – Line 5-6. It is a quite trivial statement that the most meaningful variables to compare with are the ones directly observed. At the same time, it is also true that there is some value in comparing model simulations with variables, which are somehow inferred from field observations, even though not directly observed. I would make this a bit more nuanced.

Page 8. Line 14-15. I completely agree on the importance of capturing interannual variability and long-term trends, ultimately this is what we are really interested in, at the same time, it is important to understand the mechanisms leading to these trends/variability, otherwise we risk that models are forced to reproduce something for the wrong reason or through the wrong process.

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Page 9. Line 1. “high-resolution local meteorological data” are simply fundamental. For instance, many or almost all the RAINFOR plots will be impossible to simulate properly with models because meteorological data are not available or are not properly released.

Table 1. While there are not estimates for tropical forest, plant-C export to mycorrhizal and root exudates are typically thought to be at the maximum 10-15%. Maybe calling it a “large fraction” is a bit excessive and subjective statement.

Table 7. The estimate for VOC: 10-90 gC/m<sup>2</sup> yr<sup>-1</sup> seem to me too large (almost one order of magnitude), when compared to other estimates in the tropics (Kuhm et al 2007) and generally to the expected mass contribution of VOC (Keenan et al 2009)

Page 21. Leaf – litterfall. One point, I would made explicit is that litterfall estimates should be coherent with the leaf turnover rates and the product of average “leaf mass area” [gC/m<sup>2</sup> LAI] and LAI [m<sup>2</sup> LAI/m<sup>2</sup> ground] observed in a given site. My experience, from published observations, not only on the tropics, is that this is rarely the case. Probably, this is the result of the problems you mentioned.

Page 21. Line 26-27, see also Wu et al 2016, for the link between leaf-production and litterfall, even though not completely synchronous.

Page 24. Line 2-10. I would still mention that some observations of fine root production even though sub-optimal is very important, if it is not used blindly in models.

Page 25. Line 12-28. See also Gloor et al 2009.

Page 29. Line 21-22. I do not want to downplay the importance of C-Exudation and export to mycorrhizal, but with uncertainties in NPP and GPP estimates in the order of 20-30%, I would emphasize this aspect in the conclusions not only the missing components, which is likely smaller. In the conclusions, I would also suggest to emphasize more the temporal dynamics of pools and fluxes in line with the Section 3.3 and 4.5.

#### References

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Kuhn, U., et al. (2007), Isoprene and monoterpene fluxes from Central Amazonian rainforest inferred from tower-based and airborne measurements, and implications on the atmospheric chemistry and the local carbon budget, *Atmos. Chem. Phys.*, 7, 2855–2879.

Ahlström A, et al. (2015) Carbon cycle. The dominant role of semi-arid ecosystems in the trend and variability of the land CO<sub>2</sub> sink. *Science* 348(6237):895–899.

Wu, J., et al. (2016). Leaf development and demography explain photosynthetic seasonality in Amazon evergreen forests. *Science*, 351(6276), 972-976.

Gloor, M., et al. (2009), Does the disturbance hypothesis explain the biomass increase in basin-wide Amazon forest plot data?. *Global Change Biology*, 15: 2418–2430. doi: 10.1111/j.1365-2486.2009.01891.x

Keenan, T., Niinemets, Ü., Sabate, S., Gracia, C., and Peñuelas, J. (2009) Process based inventory of isoprenoid emissions from European forests: model comparisons, current knowledge and uncertainties, *Atmos. Chem. Phys.*, 9, 4053-4076, doi:10.5194/acp-9-4053-2009.

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