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Discussions

Interactive comment on "Seasonality, drivers, and isotopic composition of soil CO_2 fluxes from tropical forests of the Congo Basin" *by* Simon Baumgartner et al.

Anonymous Referee #2

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General comments:

The paper by Baumgartner et al on soil CO2 emissions from tropical rainforests in the Congo Basin is relevant and mostly well written. It addresses the knowledge gap on GHG fluxes from the African continent, which is still critically under-researched and represents one of the main causes of uncertainty in global GHG budgets. The paper is generally well structured, and the results mostly support the drawn conclusions. There are a few areas, however, that could to with a little revision and rewriting, and some of the conclusions based on the isotopic signature of different ecosystem C compartments might be a little speculative and could do with some rephrasing. Furthermore,

some details on the experimental setup are missing and should be added to the materials and methods section. The statistics are sound but could be presented in a more attractive format. But if the authors address these concerns in an adequate manner, I am convinced that this paper can be a valuable contribution to Biogeosciences.

Specific comments:

Introduction p.1 L17: fungi are also considered to be microorganisms. Therefore it is enough to say microbial respiration, or alternatively, fungal and bacterial respiration. L19: the reference for global C flux via soil photosynthesis is a bit old, I suggest using the numbers from the latest IPCC report. p. 2 L15-34: The authors highlight why it is crucial to understand soil respiration especially in ecosystems that are less well researched (i.e. tropical African rainforests). This paragraph is a bit lengthy because I think the reader of Biogeosciences is aware of that fact. Please shorten this paragraph, and instead add some information on 13C partitioning throughout the C cascade of tropical rainforests, and what different d13C values can mean, as this will guide the reader towards the research questions. p. 3 L4-9: what were your hypotheses? Material and methods: p. 3 L15, L19-20, and throughout the manuscript: please don't confuse the terms "average" and "mean". The (geometric) mean is a form of the average, in addition to the median and the modus. It should, therefore, be "mean annual rainfall" and "mean annual temperature". This should also be addressed throughout the results and discussion section (e.g. mean flux, etc). p. 4: the section on soil CO2 flux measurements lacks some important details: how big were the study areas and plots? How many plots were installed per site? What was the vegetation composition (dominant tree species, presence or absence of dense understorey, basal area of trees, etc)? Did you use 3 flux chambers per site or per plot (i.e. more per site)? How were the chambers arranged in plots (e.g. distance from large trees, understorey vegetation, depressions/mounds, etc)?

One more note on the number of replicates for CO2 flux measurements: This is not 100% clear from the authors' description, but if I understand correctly, only 3 flux cham-

bers were installed per study site. This is critical because spatial heterogeneity of soil respiration has been described in numerous previous studies, and this could lead to under- or overestimation of soil flux estimates. However, there are a couple of points that the authors could use to address this shortcoming: first, they have measured soil CO2 flux not only in one but in 3 lowland rainforests, and they could look at the difference between sites to describe spatial heterogeneity in the region. Second, if the flux chambers were always installed following a similar scheme, e.g. always at a fixed distance from trees, they would still be comparable even if not 100% representing absolute fluxes. Third, data on GHG fluxes from Africa are very scarce, and one of the reasons is the difficulty in getting research material into or out of the respective countries. I know from personal experience that it can be very difficult to buy or import even simple building material to construct flux chambers, and shipping of environmental samples can be complicated and often requires a lot of paperwork. I can imagine that the situation in DRC might have been similar. Therefore, for future studies on GHG fluxes in regions that are not easily accessible, I recommend the use of the gas-pooling technique by which gas samples from multiple (usually 3-6) chambers are put into the same GC vial, which can help to cover spatial heterogeneity while at the same time reducing the total number of samples. Nevertheless, even if the number of replicates is low and this probably introduces some uncertainty, this information on the magnitude of fluxes and their dynamics is still highly valuable, and I therefore still recommend the study for publication in BG.

p. 5 d13C measurements L24-25: wouldn't drawing 3 analytical samples of 20 ml each from the headspace of a 110 ml vial create an underpressure? How did the authors address this? L31: how many litter traps were installed per site, and how were they arranged? L33: how many soil samples were collected per site? What was their arrangement (e.g. distance to chambers, distance to trees, etc)? Statistics L6: you assumed little year-to-year variability of your data, but did you actually check if the climatic conditions (rainfall, temperature, moisture) varied between years? p. 6 Figure 2: there are two dips in WFPS in March and October in the lowland forest, where

WFPS dropped rapidly from c. 30 to 20%, and then recovered within a week or so – do you have an explanation for this? p. 7 Table 1: I know that the R output of lmer looks like this, but it's not very convenient for the reader to understand the results of the statistical analysis. For example, for d13C there is a significant effect of "Montane forest – stream CO2". This is ambiguous: does it mean that the d13C of stream-CO2 is different in montane and lowland forests? Or that the d13C of stream-CO2 is different from the d13C of the other compartments (soil CO2, litterfall, SOC) only in the montane but not the lowland forest? Please use a different way to present these results as they are critical. For example, as a start you could add letters/starts to Figure 2, presenting sign. differences between compartments via different letters, and differences between forests via stars (or something like that). L4-6: You state that stream-CO2 was significantly depleted in the wet season in lowland forests but not montane forests. However, in Table 1 you state "montane forest – wet season – stream CO2" to be significant. Isn't this contradictory (or just another example of how Table 1 could be misinterpreted)? Discussion p. 8 L5-7: Move this to the results section. p. 10 L9-12: Careful, while it is true that with increasing dry season length soil CO2 fluxes might decrease, but it is not clear how future more erratic rainfall patterns and the corresponding more extreme drying-rewetting events will affect respiration, and whether potential CO2 pulses after rewetting compensate or outweigh reduced soil respiration. L25-30: Good call! I agree that the correlations between soil CO2 flux and temperature in tropical systems that show very little annual variation should be handled with care. In your case, they might be significant simply because your sample size is large enough, but I would not over-interpret them. As you correctly state, moisture and C availability are likely the bigger players here. p.11 L1-4: soil moisture not only controls O2 diffusion but also the diffusion of C substrates to soil microorganisms. Therefore, the response of respiration to moisture is more often an effect of C limitation (at low moisture) than an effect of O2 limitation (which really only becomes critical at very high moisture contents). Please add this to the discussion, and I recommend these papers on the mechanisms underlying this: Manzoni S, Moyano F, Kätterer T, Schimel J (2016)

Modeling coupled enzymatic and solute transport controls on decomposition in drying soils. Soil Biol Biochem 95:275–287. doi: 10.1016/j.soilbio.2016.01.006 Moyano FE, Manzoni S, Chenu C (2013) Responses of soil heterotrophic respiration to moisture availability: An exploration of processes and models. Soil Biol Biochem 59:72–85. doi: 10.1016/j.soilbio.2013.01.002 Moyano FE, Vasilyeva N, Bouckaert L, et al (2012) The moisture response of soil heterotrophic respiration: Interaction with soil properties. Biogeosciences 9:1173–1182. doi: 10.5194/bg-9-1173-2012 L20: you mention photosynthesis, yet this was not measured and is therefore a bit speculative. p. 12 L4: which canopy processes other than photosynthesis could those be? Furthermore, how do you think that vegetation composition might affect d13C, and could this explain differences between lowland and montane forests? Can different trees have different leaf d13C signatures, which could be reflected throughout the C cascade? L6: what are the mechanisms underlying the enrichment of 13C at lower temperatures? Conclusions This is mostly a repetition of the results. Please instead give the “message of the story” – what are the implications of the results you found? What are questions that remain open? And what have we learned? L24: how were the sites different in vegetation composition? Please describe in the M&M section and also address in discussion L27: what does this indicate, that that there was no temperature dependency of soil respiration between sites? p. 13 L4: you conclude the paper with the statement that these forests might become C sources under a warming climate, yet you did not find a strong effect of temperature! Instead, you could state that changes of C balance might happen in response to more erratic rainfalls and weather extremes. Appendix A: Method supplement L6-25: please use the past tense throughout this section. p. 16 Figure 3A: change x-axis labels of panel d to the format HH:MM (e.g. 10:00, 15:00, . . .) to make it clear that those are hours. Technical corrections: p. 5 L30: please correct ". . .during the wet season from October to May“ p. 6 L9: please correct "values were found“ (use past tense throughout the results section) L8 and elsewhere: You very often use the term "respectively“; however, I’m not a big fan of it, for two reasons: first, sentences become very complex and sometimes hard to understand when using this

term, and second, it forces the reader to jump back and forth between the end and the start of the sentence, which disrupts the flow of reading. Very often, you’ll find that your sentence won’t actually become any longer if instead of using "respectively“, you describe the results one after the other, in this case, this could be "The mean [instead of "average“, see my earlier comment] annual values we measured in this study in the Congo basin, which are 3.83 μmol m-2 s-1 for the montane forest and 3.69 μmol m-2 s-1 for the lowland forest, are within the range of reported values from other tropical forests.“ I propose that you revise the MS and try to reduce the use of "respectively“. This will make the paper easier to follow. L14: please rearrange ". . . and they were rather low compared to our flux rates“ p.9 L2: ". . .showed marked seasonality [comma] with a 34 % decrease during the dry season [comma] whereas. . .“ L4: please rephrase "however, the decrease they found was not as pronounced as. . .“ p. 10 L22: "statistically significant correlation“ L18: please rephrase "play a crucial role in controlling soil respiration“ p. 11: L4: please add a comma here, otherwise the phrase is misleading: "stress soil microbial communities, and autotrophic respiration“ L10: please rephrase as this is otherwise misleading "While soil respiration in lowland forests is most likely C-limited, respiration in montane forests seems to be more sensitive to environmental conditions and could represent a potentially large C source with climate change.“ p. 12 L17: enrichment does not occur in the “location” but in the movement from one compartment to another. Please rephrase “the highest enrichment occurs in the last step from soil to stream-dissolved CO2”. L25: please rephrase: “However, in contrast to the lowland forest, the montane forest site exhibited strong seasonality of soil respiration, primarily driven by WFPS during the dry season.”

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