

Biogeosciences Discuss., author comment AC2
<https://doi.org/10.5194/bg-2021-85-AC2>, 2021
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Reply on RC2

Dong-Gill Kim et al.

Author comment on "Reviews and syntheses: Enhancing research and monitoring of land-to-atmosphere greenhouse gases exchange in developing countries" by Dong-Gill Kim et al., Biogeosciences Discuss., <https://doi.org/10.5194/bg-2021-85-AC2>, 2021

Response to the comments by Referee 2 on 'bg-2021-85'

We, authors are grateful to the reviewer's criticisms and constructive comments and suggestions. Below we provided our responses following the original comments by the reviewer.

The paper "Reviews and syntheses: Enhancing research and monitoring of land-to atmosphere greenhouse gases exchange in developing countries" provides further insight into addressing the key knowledge gaps regarding the accurate quantification of carbon stocks and greenhouse gas dynamics in developing countries. While this is a valid topic, in relation to the lack of research infrastructure in these regions, this has already been addressed in several other recent publications that approach this issue from multiple cross domain perspectives. The novelty in this paper is not just the identification of gaps and priorities (as this has been documented elsewhere), but it is how this can be addressed.

Response: As the reviewer indicated, there are various on-going efforts to identify uncertainties caused by lack of carbon and greenhouse gases (GHG) research in developing countries. We agree the novelty of this paper is how lack of carbon and GHG research can be addressed. Thus, in our study we wanted to synthesize the current situation and then share ideas and suggestions for enhancing research and monitoring of carbon and GHG exchange in developing countries. In particular, the appropriate technology and approach (AT&A) and its application for GHG research were introduced and their potentials and limitations were discussed. The aim was to contribute to the analysis and discussion for a solution the needed but missing observations globally.

In this paper, the potential solutions are presented through the description of how a focus on the application, or potential application of AT&A approaches can be used to enhance our understanding in these areas. The manuscript in its current form represents a "thinkpiece" or discussion paper rather than a standard scientific paper and presents a very general overview of the background requirements and application of AT&A

approaches rather than the "review and synthesis" as indicated in the title. Further details are required in many parts to provide insight into the technological developments and how these can really be implemented and utilised by the variety of stakeholders who would find this information useful.

Response: We agree with this comment, which was also made by Reviewer 1. In fact, due to a lack of data on AT&A and its application for GHG research on the ground, at this stage it was not possible to write a conventional review and synthesis paper on AT&A for GHG research, their use, and their potential contribution. (Although there are a few research projects currently ongoing in Europe and the US to evaluate the contribution of these technologies.) Thus, this study aimed to share ideas and suggestions of AT&A and its application for enhancing research and monitoring of carbon and GHG exchange in developing countries. In fact, we originally planned to submit the manuscript as "Ideas and Perspectives" (https://www.biogeosciences.net/about/manuscript_types.html) but due to the length limit ("a few pages only") we had to submit as "Review and Synthesis". After a more detailed check however we found that there are Ideas and Perspective papers in *Biogeosciences* with a length comparable or longer than our manuscript (e.g., Wilson et al. 2020- *Biogeosciences*, 17, 5809–5828, <https://doi.org/10.5194/bg-17-5809-2020>). So, our plan, if we will have the chance, would be to resubmit it under "Ideas and Perspectives" category, adding references to the ongoing activities in Europe and USA on the use of the AT&T technologies, and strengthening the paper's insights about application and implementation.

I also agree with R1 in that the paper does not just deal with greenhouse gas exchange and could be revised to better represent the information presented.

Response: We recognize that the title should include "carbon" to better reflect the contents of the manuscript. Therefore, if we can resubmit the manuscript as "Idea and Perspective" we will clearly change the title to make it more in line with the content as below for instance.

Ideas and Perspectives: Enhancing research and monitoring of carbon and land to-atmosphere greenhouse gases exchange in developing countries

Specific comments:

Lines 37/38: Expansion of GHG research not only required in developing countries to reduce uncertainty, this is also required in some systems in more developed areas also.

Response: We agreed with this comment, and will revise considering also that there are ecosystems or specific conditions (e.g. after last disturbances) that are missing also in developed countries, although this is not the main aim of our paper.

Line 44: GHG research is conducted extensively across the globe it is the spatial representative nature of the sites/networks that requires attention.

Response: What we mean is that when a continent is almost entirely excluded, we cannot consider the GHG research global. However, we also agree that the sentence can be better organized; first referring to observation specifically (modeling and satellite RS cover the globe) and second to better specify that it is a problem of distribution and

representativeness. This point will be clarified in the revised manuscript.

Line 49: Do the authors mean that where measurements are being made they meet the standardised protocols of networks elsewhere and it is the spatial aspect that requires attention?

Response: We agree that the sentence is not clear; thanks for pointing out. What we mean is that there have been initiatives to collect measurements in developing countries, but even if all these data would be available (and this is not true) the large spatial variability (in a multidimensional meaning, climate, ecosystem, management, disturbance, soil etc.) is so large that they would be not sufficient for robust inferences and modeling about the global carbon cycle.

Line 53: recognition of GHG sources, useful to link this to methods used to develop national inventories and the need for data to inform this. This would also align with the IPCC reporting approaches described in the C stock section.

Response: Thanks, yes this was the meaning. We will clarify this sentence if we have the opportunity to submit a new version.

Lines 54/55: Provide further details on topics described to expand on the research that has been undertaken using the AT&A approach, its utility and relevance here.

Response: The requested details are provided in the section "4 Appropriate technology and approach (AT&A) applicable for GHG research in developing countries" but we will review this part to ensure that the link is clear, and as noted above deepen the recommendations and insights presented in the manuscript.

Line 77: Define abbreviations before wider use.

Response: Thanks for pointing out- we will revise it to "carbon dioxide (CO₂)". We will be careful to check that all the abbreviations are defined throughout the manuscript.

Line81/82: What are the "quickly-developing, highly advanced instruments using relevant technologies" and does this influence the measurements made across the distribution of sites detailed (developed/developing nations)?

Response: We refer here to the fact that gas analyzers and chamber systems became more and more available, from more than one companies, reducing their costs and making them relatively easy to use. This has helped increase the number of measurement locations, but not homogeneously, so the impact was to generally increase the sites but also increase the difference in distribution ((Figure 1) with the exception of China.-. We will clarify this.

The authors have compiled the literature to provide summary statistics from studies that address the key C stocks, GHG emissions and land use (predominantly land use change and the agricultural sector). Would it be worth including a section on the information available from the application of potential mitigation strategies to reduce GHG emissions from the land use sector (there is some literature on this for Africa)?

Response: We agree that information about mitigation strategies to reduce GHG emissions in land use and land-use change would be interesting, but we also think that it is somewhat out of the scope of the paper and would not be well integrated, since here we focus on measurements and observations.

Section 2.5. Is it also worth making the point that in many cases we don't have adequate data to effectively use biogeochemical models at the site-scale to better understand fluxes and potential impacts of management or climate?

Response: This is a good point, and we will address it in the new version.

Section 2.5. Also have any ML or RS approaches been trialled/ground-truthed using/against sites/datasets in Africa?

Response: Yes, the few African data available have been used in ML activities like in Tramontana et al. (2016) or Jung et al. (2019). However, a proper evaluation at a continental level is difficult due to the lack of data. In the Supplement of Tramontana et al. (2016), there is a validation against sites in different climate regions, but the training of the ML was done with the sites in all the other areas.

Line 215: 80 published studies?

Response: Yes; we will clarify this.

Line 215-219: valid point but securing long-term funding to maintain the study sites/measurement infrastructure is a problem globally.

Response: This is true but—we hope that the reviewer would agree—the issue is much more critical in developing countries. The history of the measurements networks in developed countries confirms that, fortunately and in spite of difficulties, many measurements sites are being maintained and the networks are growing. We will however review to avoid misinterpretations because we agree that the need to secure long term funding is a global issue.

Section 3.3. Possible to link the measurements infrastructure and variables derived to the systems that can inform strategies to deal with the issues faced?

Response: Thanks, you are right and we should discuss in this section the contribution, role and importance of a good measurement infrastructure to monitor and early detect the climate related issues. Clearly also the contribution to a better understanding of the global

C cycle and climate would help to reduce the events and impacts

Section 4.1. Why does this only refer to forest systems?

Response: because of the dominance of forests in global biomass. We agree however that savanna and agricultural lands are important with respect to soil carbon and carbon mineralization, and we will update with soil carbon and carbon mineralization of savanna and agricultural lands in this section in addition to what we already provided.

Section 4.4/4.5: Further details are required to really provide critical insight, e.g. how RS derived GHG data can be used in practice or the developments and application of the "deep-learning playground" are required.

Response: Our aim here is not to provide insight on the use of these data but on the availability and accessibility of data and related tools. There are more and more satellite GHG related product (e.g., GPP, biomass, and CO₂ concentration; Cusworth et al. 2021) available that can be used to get basic information for areas where the measurements are still missing. They cannot substitute for direct observations, but they can still provide important information and a good background. We will try to clarify this point and the meaning of the section in a possible new version.

Section 5.6. What about addressing the combination of accuracy, time and cost in the recognition of the AT&A use in Africa?

Response: We tried to address uncertainty of detectable variability as a function of GHG measurement accuracy, time, and cost (theoretically only) in Figure 7. However, at the stage it is not possible to have a real quantification specific for the AT&T due to lack of data (even in the developed countries).

Section 6.1. Have the outputs from the researchers who have implemented the AT&A approach been fully described, discussed and evaluated here?

Response: We tried to report and summarize the outcomes from AT&A implemented research in section 4 and their limitation and potential solutions were discussed in section 5. This section is more about defining the strategy, so we will add references and recall to what we presented before.

Section 6.2. The recommendations are very general e.g. the technological aspects, if this is really to be used to stimulate new research and fill knowledge gaps further details are needed throughout.

Response: It is not easy to be more specific and detailed without being repetitive and too long, but we agree that we could give more details and clearer suggestions about development and paths going forward. We will work on this section to improve quality and potential impact.

