Authors' response to Yogesh K. Tiwari

We thank Yogesh K Tiwari for posting the comment. Also, we appreciate the Editor for giving us an opportunity to address this comment and improve the quality of the discussion thread.

We address the comments as follows (comments are given in regular black font, our responses are given in regular blue font, and the changes in the revised version are given in *blue italic font*).

Thank you

Authors

Comments

This is a very interesting and timely paper for the regional carbon cycle and flux inversions. The authors have focused to obtain representative errors in the models leading to significant errors in the source/sink estimations in the inversions. Notably, they have quantified that these REs can be as large as 9 ppm which is well above the observational uncertainty and as comparable to enhancement at any point source region.

Thank you for appreciating the importance of our work.

Unfortunately, the study fails to acknowledge recent other similar studies in the Indian flux inversions. To be specific, Nalini et al., (2019) quantified the potential uncertainty reduction achievable by using data from existing tower-based observations over India. Moreover, they also have proposed 17 new stations spread across various parts of India and put forward this important recommendation to initiate observations to benefit Indian flux inversions especially when satellite constellations fail to capture Indian footprints during the heavy rainy season. A large ensemble of particle trajectories and Bayesian inversions with incremental optimization is done in their OSSE work. It is pity that the authors fail to discuss this paper in their work.

Following the above comment, we considered the reference that is recommended to be cited (Nalini et al., 2019) and made thorough scrutiny of the full article. This brings us to perceive that the work reported in the above article is minimally relevant to our work for the following reasons:

1) Our work addresses the unresolved sub-grid scale variability in the current inverse global models when assimilating observations to retrieve the source-sink distribution of CO_2 over India. The recommended article studies how an optimal network of observations can

be achieved over India, which can reduce the uncertainty of surface flux estimation. {completely different objectives}

2) In our manuscript, we report the representation errors that can be expected in global data assimilation/inverse modeling systems, discuss their impact on flux estimations, and propose an approach that can minimize the uncertainty due to unresolved CO_2 variability. Considering the article in the recommendation, we do not find results in common to be compared or discussed in our manuscript. {outside of the scope for comparing or discussing the results}
3) As may be evident for addressing different focus and objectives, we follow completely different methodology and modelling approaches compared to the article recommended to be cited. {irrelevancy for citing or comparing methodology or approaches}

We, therefore, disagree with the need for the citation of Nalini et al., (2019) in our manuscript.

Tiwari et al, (2013), Ravi Kumar et al., (2016) also discussed the atmospheric concentration variability over India at seasonal and intra-seasonal scales. The authors also discuss the similar RE variation at seasonal and inter-monthly scale due to changes in meteorology. Therefore the above papers should be mentioned in this context.

Thank you for notifying the published information. We do not find that the mentioned research articles report RE variation or their impact. Nevertheless, we see that Ravi Kumar et al., (2016) could be considered to be cited when mentioning intra-seasonal variability of atmospheric CO_2. The citation is included in the revised manuscript.

L102-103: "... spatio-temporal patterns of the biogenic fluxes (e.g., Gadgil, 2003; Valsala and Maksyutov, 2013, Ravi Kumar et al., 2016)."

References

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Ravi Kumar K., Valsala V., Yogesh K. Tiwari, Revadekar J.V., Pillai P., Chakraborty S., Murtugudde R., 2016, Intra-seasonal variability of atmospheric CO2 concentrations over India during summer monsoons, Atmospheric Environment, 142, October 2016, ISSN:1352- 2310, DOI:10.1016/j.atmosenv.2016.07.023, 229-237

Yogesh K. Tiwari, Vinu Valsala, Ramesh K. Vellore, Ravi K. Kunchala, 2013, Effectiveness of surface monitoring stations in capturing regional CO2 emissions over India. Climate Research, Vol. 56: 121–129, 12 March 2013, ISSN 1616- 1572, DOI: 10.3354/cr01149