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Comment on acp-2021-392

Anonymous Referee #1

Referee comment on "Towards monitoring CO2 source-sink distribution over India via inverse modelling: Quantifying the fine-scale spatiotemporal variability of atmospheric CO2 mole fraction" by Vishnu Thilakan et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2021-392-RC1, 2021

Accurate assessment of sources and sinks of CO2 is essential in planning and implementing the mitigation strategies for greenhouse gas emission and associated climate change. In this study using inverse modelling it is demonstrated that there is a need for implementing a high-resolution modelling framework over the Indian subcontinent to better understand processes regulating CO2 sources and sinks.

This is a very interesting and important study, which merits its publication in ACP. The scientific content, the quality of the study and its presentation is good, however in some parts the text is very descriptive and technical. I suggest some minor revisions before publication by ACP.

In general my impression is that the conclusion section is very long and to many things are discussed within. I propose to shorten the conclusion to be more condensed and to focus to the main results.

Specific comments:

P1/L21: `We show that the unresolved variability in the coarse model reaches up to a value of 10 ppm at the surface, which is considerably larger than the sampling errors, even comparable to the magnitude of mixing ratio enhancements in source regions.'

What is the meaning of 'mixing ratio enhancements'? The regional variability of monthly mean surface CO2 concentration
in India as shown in Fig. 4.? Further, the variability of CO2 time series of monthly

averaged CO2 concentration at surface as shown in Fig. 2b are also in the range of 10 ppm, that could be mentioned here.

P2/L91: 'The monsoon convection that transports the boundary layer air into the free atmosphere (mainly to the upper troposphere and to the lower stratosphere with the help of diabatic heating (Vogel et al., 2019)) complicates atmospheric transport simulations (Willetts et al., 2016).'

This sentence sounds odd. I propose to write something like that:

'Monsoon convection transports the boundary layer air to the upper troposphere and to the lower stratosphere, subsequently air parcels are slowly uplifted by diabatic heating to higher altitudes.'

What do 'complicates atmospheric transport' mean? Is that related to uncertainties in the representation of convection in atmospheric transport simulations? Please clarify this statement.

P4/L127: 'synoptic event' I propose to be here more specific. -> 'the cyclonic storm Ockhi'

In general the western Pacific typhoon season (tropical cyclones) peaks from July to October, therefore I am wondering that the impact of cyclones during July 2017 is not mentioned here. It is discussed later within the paper, but I think it could be mentioned here as well.

P6/L213: 'Four global inverse modelling products - CarbonTracker, CarboScope, LSCE v18r3 and LSCE FT18r1- available during the year 2017 are used for our analysis.' I think, it is worth to mention here that none of these models includes ground-based data from the Indian subcontinent. That is first mentioned later within the conclusions. If no ground-based data from the Indian subcontinent are used, it would be helpful to have a comment on the quality of these inverse modelling products, maybe related to other regions around the Indian subcontinent or in the tropics.

P10/L360: 'The seasonal variability of CO2 uptake through photosynthesis, release through ecosystem respiration, and the vertical transport is seen while analysing the monthly averaged CO2 concentration profiles over Indian subcontinent (Figs. 2b and 3). Comparatively lower surface CO2 concentrations are found during months with an active biosphere (June to October) than the rest of the period, owing to the more ecosystem productivity over
Indian subcontinent in response to the availability of monsoon rainfall.'

That is not a central point of the paper, but looking on the Mauna Loa, Hawaii, time series of CO2 (https://gml.noaa.gov/dv/iadv/graph.php?code=MLO&program=ccgg&type=ts) the maxima and minima of monthly averaged CO2 are shifted about ~ 4 weeks later compared to the time series of monthly averaged CO2 concentration at surface over the Indian subcontinent shown in Fig. 2b. Could you make a comment on that?

P11/L402: 'Strong mixing and vertical transport associated with the low-pressure systems are visible from these CO2 concentration figures.'

Please explain this in more detail. Mark or describe the position of the low-pressure systems in Fig. 5 and 6. What is the role of Asian monsoon anticyclone in vertical (horizontal) CO2 distribution during July? In general, tracer distributions of troposperic source gases in the upper troposphere and lower stratosphere during Asian summer monsoon season depends strongly on the location of the Asian monsoon anticyclone, however not sure what that implies for CO2.

P11/L403: 'Compared to July, we find higher representation error in November owing to the wintertime transport with decreased vertical mixing and less biospheric uptake.'

To which Figure do this sentence refer? -> Fig. 7?

P13/L466: 'Though the effect of LLJ and TEJ is visible throughout July (Fig. 5b), strong convective activity associated with the low-pressure systems is visible during July 10-18 (Fig. 5a)

Please be here a bit more specific and explain what is shown in Fig. 5b. The statement 'is visible' is very general.

P16/L586: 'This indicates that the employed models need to be critically improved in terms of capturing mesoscale phenomena and fine-scale flux variability in order to maximize the potential of deducing the information obtained from these high precision measurements, thereby improving the estimation of surface fluxes.'

What about uncertainties in convection?

P31/Fig. 5/6: Please add the used latitude range in the figure captions. Further, I am missing a more detailed discussion of Fig. 5 and 6 e.g. reasons for different CO2 values in July and November. The vertical position of the CO2 maxima is on higher latitudes in November compared to July. Can you comment on that?

Technical Issues:

P2/L52: GHG --> greenhouse gas (GHG)

P3/L111: synoptic events --> synoptic events (e.g. tropical cyclones)

P11/L402: gradients.. --> gradients.

P12/L437: 6ppm --> 6 ppm

P35/Fig.10: x-axis title: 'CO2(ppm)' -> 'CO2 (ppm)'

P37/Tab.1: odd line breaking in 'Versio--n'

P38/Tab.2: odd line breaking in 'CT2019--B'; 'Cabron Tracker' --> 'Carbon Tracker'