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Review of “Biomass burning pollution in the South Atlantic upper troposphere: GLORIA trace gas observations and evaluation of the CAMS model” by Sören Johansson et al.

Anonymous Referee #2

Referee comment on "Biomass burning pollution in the South Atlantic upper troposphere: GLORIA trace gas observations and evaluation of the CAMS model" by Sören Johansson et al., Atmos. Chem. Phys. Discuss., <https://doi.org/10.5194/acp-2021-767-RC2>, 2022

In this study, the authors presented detailed analyses of five chemical species (PAN, C₂H₆, HCOOH, CH₃OH and C₂H₄) measured by the Gimballed Limb Observer for Radiance Imaging of the Atmosphere (GLORIA) instrument during the Transport and Composition in the Southern Hemisphere Upper Troposphere/Lower Stratosphere campaign (SouthTRAC) conducted in over the South Atlantic in September-October 2019. In addition to the in-situ measurements, a back trajectory model (HYSPLIT) is used to examine the origins of the pollutants. The Copernicus Atmosphere Monitoring Service (CAMS) model simulations are also used to examine the transport pathways. The enhancements in those five chemical species, which were captured during each flight were found to have varying degree of agreement with the CAMS model results. This study presents a compelling result by utilizing a valuable set of data and the global and trajectory models. I would like to suggest a few minor changes which might add richness to this work.

General Comments:

- I would like to suggest adding a little more background on the five chemical species chosen in this work. What do they have in common? Why were those selected? How much understanding do the community has in terms of their sources, sinks and their chemical lifetime?

- Adding some information about the measurements of those species by satellites would be helpful, if possible. Are there any references comparing the satellite measurements and the model simulations? Do other models have difficulty simulating those species accurately? Adding a few relevant references would help understanding the general aspect of those species.

- Does the CAMS model perform well in general? I would like to see a statement about why the CAMS model is used here. Is the goal to evaluate the model or to improve the model? If the improvement is the goal, a more specific direction would be needed possibly in conclusion.

- It is stated throughout the study that the degree of agreement between the measurements and the model varies depending on the species. I would like to suggest adding more thoughts or references to make the findings valuable. If the agreement is not good, how can we improve it in the future?

Specific Comments:

P1, L14: Are PAN, C₂H₆ and HCOOH longer-lived than CH₃OH and C₂H₄? I am curious why the agreement between the measurements and the model is better for PAN only.

P2, L23 & 24: I recommend listing examples of 'some of these traces gases' and 'some pollution trace gases' here.

P2, L28: It would be helpful to add a reference at the end of this sentence or rephrase this as 'their potential influence on climate may increase over time'.

P2, L29: I recommend making changes to this sentence. For instance, 'and may have other sources in addition to pyrogenic emissions.'

P2, L30: Why those five gases were chosen and what do they have in common?

P2, L36: 'Filamentary structures' have been mentioned throughout the manuscript. It would be helpful to have a definition or description of it.

P2, L37: I recommend modifying the sentence 'Biomass burning events are typically represented by emission data sets in atmospheric models'. I think emission inventories are one of the factors determining how the model represents the biomass burning events. In fact, emissions, chemistry, and transport all make contributions to the model performance.

P2, L43: Adding more explanation about 'atmospheric processes' would be useful here. Does this refer to a chemical reaction or a physical process?

P2, L48: Is there a website or a reference for the SouthTRAC campaign?

P6, L118: Does this mean that only the horizontal motions will be analyzed here? Can we still trust the horizontal motions from the trajectories when the vertical motion is not accurate?

P6, Section 3.1: It would be necessary to include references for FIRMS, MODIS and ERA5 in this section.

P7, Figure 1: This is a very nice set of figures. However, the boxes with various colors make the figure a bit complicated. It would be helpful to add the names of the gases where the maximum exists. For instance, add 'C₂H₆' in the pink box in Fig. 1c. This can also be considered for Fig. 2.

P10, Figs. 3a & 3c: It would be useful to mark the initialization locations in these plots. For instance, add larger dots on the location with the same color with the trajectories.

P11, L197: Have there been any studies showing the CAMS performance on simulating PAN?

P13, Section 5.1: It would be helpful to add some insights on the different degree of agreement between the measurements and the model depending on each species. Is it related to lifetime of the species? Or surface emissions? Why does the model overestimate CH₃OH?

P15, L287: This is one of the most important findings in this work. I would recommend spending more time on the discussion. Are the sources of C₂H₆ and HCOOH underestimated in the models and well known? If CH₃OH and C₂H₄ are overestimated in the model, could that be related to the surface emissions only? A few references on this subject might be useful to include here.

P16, L314: Does 'which has been also observed' refer to the underestimation of C₂H₆ in the Northern Hemisphere as well?

P16, L319: It would be helpful to add a sentence after this. Could this overestimation be related to overestimation of surface emissions or missing sink reactions? Or could this mean that the lifetime estimation is inaccurate?

P16, L326: This paragraph discusses a very important point. I would recommend adding a bit more specific information about the emission inventories. For instance, adding a few different emission inventories and discuss how they underestimate or overestimate specific species might give clearer idea about the future improvements. The current paragraph discusses this issue as a general issue but not specific to this study.