Schuck et al., The interhemispheric gradient of SF6 in the upper troposphere

Response to comments by Anonymous Referee #1

We thank the anonymous reviewer #1 for the thorough reading of the manuscript and their suggested improvements. All comments are addressed in the following with the reviewer's comments printed in blue, and the responses in black.

This article analysed long-term measurements of SF6 from many aircraft campaigns, covering a period of 2006-2020. They have calculate the age of air based on the aircraft observations in the upper troposphere, in reference to continuous surface measurements. Further explanation to the observed results are derived from 12-box model of the atmospheric transport. The paper is very well written and organised.

My main concern is the use of a very low resolution of the transport model, which I think would be very difficult convince the reader as a state-of-the-art. The limitation of 12-box model are known and I do not need to elaborate (overstretched to compare with measurements). Given the importance of the data set prepared for this analysis and discussion of the possible outcome, I would recommend publication of the article after minor revision. Hopping that the results presented will inspire future research activity.

The 12-box model was chosen as a very simple setup, which allowed us to test a large set of parameters. One purpose of the study was to investigate the potential of upper tropospheric observations as an additional constraint for estimates of global emissions. The limited 12-box model enabled us to investigate the influence of emissions and transport parameters on the model output, which would not have been possible to such an extent with a complex model driven by meteorological data and parametrizations of individual transport processes.

Minor comments:

Line 21 : Aren't SF6 lost also " by electron attachement" ?

Electron attachment has been identified as a relevant loss process of atmospheric SF6, occurring in the mesosphere. This fact has been added to the manuscript text including Kovács et al. 2017 as an additional reference.

Line 24 : I think the age of air concept was laid out first in Bischof et al., 1985

Bischof et al 1985 and Hall et al. 1998 were added to the selected references cited in this part. The latter was chosen as one of the very first publications discussing SF6 stratospheric mean age.

Line 38 : This phenomena was first reported elsewhere, using CO2 in a landmark paper (Nakazawa et al., 1991).

We agree that Nakazawa et al. 1991 report similar observations for CO2, comparing the interhemispheric difference in the upper troposphere and lowermost stratosphere to results of ground-based measurements. Owing to the strong seasonal cycle, the interhemispheric and

vertical gradient of CO2 is much more complex than that of SF6. Therefore, the citation was limited to Gloor et al. 2007 who report on observations of SF6.

Page 11: TransCom-CH4 experiment (Patra et al. 2011) found dependency of the lag time with emission patterns and rates. Are the differences between the campaigns arising from emission dependency or the interannual viability in transport itself ?

Campaigns were chosen to have a large latitudinal coverage and to include a large portion of data without selections of special meteorological features, but took place at different locations and times. Thus, inter-annual variability in transport certainly contributed to the differences. In addition, the deployed instrumentation has different sampling characteristics, which must not be neglected and is mostly reflected in the larger variability of the higher resolution data. Taking this into account, data from the different campaigns agree well and we are confident that data can be combined and evaluated as a whole.

Line 240 : It would have been good to check using the model experiments in TransCom-CH4, to probe the trends in inter-hemispheric exchange rates.

We agree that such an investigation of the trends in interhemispheric transport would be scientifically valuable, and this has also been suggested by Krol et al. (2018) in their TransCom AoA study. For the current study, deliberately a very simple model was chosen to investigate the potential of upper tropospheric observations as an additional constraint for estimates of global emissions and interhemispheric transport. Analysing the transport trends from the complex models participating in the TransCom-CH4 experiment should certainly be addressed in separate study.

Figure 5 (tropics north; green triangle), and line 9/10: are they consistent ?

The initial wording in lines 9/10 was indeed not fully consistent and has been changed to:

" (…) lag times decrease over the period 2006-2020 in the extra-tropics and the southern tropics."

Finally, regarding the data availability: will it be possible to create a dataset for all the aircraft campaigns with troposphere flagging for further research. I see that as a useful outcome of this paper.

We agree that the dataset is one important outcome of the study. To make it usable in further studies, we followed the reviewer's suggestion and, the dataset was made available publicly with doi 10.5281/zenodo.10018398 and may be downloaded from https://zenodo.org/records/10018398. This information including the URL was added to the data availability statement of the manuscript.

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