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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Transport model diagnosis of the mean age of air derived from stratospheric samples in the tropics" *by* Hanh T. Nguyen et al.

Anonymous Referee #2

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The paper by Nguyen et al. investigates different methods with which observations of mean age tracers and mean age of air (AoA) can be reconstructed. While the study is certainly in the scope of ACP and the subject is of significant scientific interest, there are a number of problems I see in the investigations presented here. In my view, the authors misinterpret some aspects of AoA, as detailed below. Further, in my view some aspects are presented (e.g. related to Figures 1 and 2) which are not taken up in the discussion or conclusions of the manuscript and are not necessary for the understanding. Other aspects like experimental details (e.g. where, when and how were the samples taken) and how was AoA calculated from the observations is omitted. There are also a number of important recent papers, which are not included in

the discussion (see details given below). Due to these issues, I believe that the paper is not ready for publication, but needs major revisions before it can be considered for publication.

Major comments

Clock tracers and derivation of AoA

I believe that there is a misinterpretation on what is commonly understood by "clock tracers". Clock tracers are (artificial) tracers which increase not only monotonically, but also linearly. Neither SF6 nor CO2 fulfill this criterion. SF6 increases monotonically, but not linearly, CO2 has in addition a seasonal cycle, thus does not even increase monotonically (except if annually averaged). Therefore, the shape of the assumed age spectrum plays a significant role in deriving AoA from such tracers. This is not sufficiently discussed in the manuscript. The authors may want to consult e.g. a recent paper by Fritsch et al. (2020) in ACP on the issue of how AoA can be derived from such tracers and how that agrees with ideal clock tracers. Using such a clock tracer, AoA can be derived as a lag time without needing any knowledge on the age spectrum. While I have not checked all the papers reference on p.2., l. 22, at least Haenel et al. did not use lag time but did take into account the age spectrum. As in the end the main focus is on the comparison of AoA derived in different ways, the use of clear language and correct referencing is necessary. More details are needed on the calculation of AoA, including which tropospheric reference time series have been used, have these been fitted and AoA derived as in Volk et al., (1997)? Or has AoA been derived by convolution of age spectrum and time series? How many years where taken into account in fitting or in convolution etc. Has CO2-production by oxidation of CH4 been taken into account? These are extremely important details which are needed to understand possible discrepancies. Also, I would strongly suggest to include a real clock tracer in the model, from which AoA can then be derived without any assumptions and which can serve as a reference.

structure of the paper

The paper presents many aspects, many of which are a repetition of previous work, before finally coming to what is really new, the comparison of CO2 and SF6 reconstructed with the two different methods (BIR and Lagrangian). In my view, many parts of section 2 are not necessary, while other parts are missing. Note that none of the aspects discussed with respect to Figure 1 and 2 are in any way mentioned in the discussion, conclusion or summary. Missing parts are details about the observations and how AoA has been derived from them, but also explanation of methods, e.g. the BIR methods should be explained in brief. Section 2 also is called "Model and Experiment", so I was expecting the usual explanations of which model has been used in which set-up and details about the observations. As it stands now, it is a mixture of model description and interpretation, but does not have any experimental part at all.

Specific comments

p.2.l.6: I think that this is a very unlucky formulation and explanation of AoA, as it suggests that an air parcel keeps its integrity during transport.

p.2.l. 9: see discussion above: SF6 and CO2 are not clock-tracers.

p.2.l 13: Note that the results of Engel et al (2009) have been updated in Engel et al., 2017 and Fritsch et al. 2020. (both in ACP)

p.2.l.22. see discussion above: AoA cannot be derived from SF6 or CO2 using the lag-time approach. While this may have been done in the early years of AoA it is certainly not applied in more recent studies.

p.2.l.25: a clock tracer must increase linearly, not only monotonically.

p.3.l.15.: this is only about models, not about experiments. It should include some basic information about the measurements.

p.3.l.26: can this evaluation be summarized?

p.4.l.13: I do not understand this sentence.

p.4.l30-p5.l.13: Is this necessary to understand the rest of the paper?

p.5.l.14: this section should have an introduction to what BIR is.

p.6.l.7: I suggest to use larger AoA, not longer.

p.6.l10: I find it hard to understand this conclusion from the statements above.

p.7.l.11: I find this contradictory: doing a reasonable job enables to do a quantitative assessment?

p.7.l.21: please explain the choice of Tr_{trop} of 355 K. This is quite a bit below the tropical tropopause and transport from 355 K to the tropical tropopause should still take at least several weeks to months.

p.8.l.1: this is a very large uncertainty range, which is even larger than the central value. Can you explain this large variability and the shape of the distribution (which must be quite unsymmetrical).

p.8.l.6: Delta may not in any way be mistaken as an uncertainty in AoA. It is the width of the spectrum. If you have a perfect tracer, this is completely unrelated to any uncertainty in AoA.

p.8.l.11: I strongly suggest not to call these experimental conditions: these are model parameters used in the investigation.

p.9.l.12: I find it hard to derive this conclusion from the results shown.

p.10.l.20. This means that only about 3

p.10.l.22: This statement can only be made if the cut-off time is included (I suppose 5 years) and is highly dependent on the region in the stratosphere.

p.11.l.5: It has recently been shown that other models have a larger ratio of delta^2 to AoA (Hauck et al., 2019, ACP)

p.11.l.14: This statement is not true for clock-tracers, but then as stated above, CO2 and SF6 are no clock tracers.

p.11.l. 23: there are more up to date references for mesospheric loss of SF6, especially Ray et al. (2017, JGR) and Reddmann et al. (2001, JGR).

p.12.l.28: I believe that the authors are wrong: the tail correction is extremely important here, as it has a strong influence on the width of the age spectrum.

p.13.l.6: I am confused: according to Figure A1, AoA is 47 days for sample 03 and delta is 17 days. From this I would derive a ratio of delta^2 to AoA of about 6 (and not 0.08).

Fig 9: the x-axis of panel a should not be age. This is transit time.

Fig 10: as before: delta is not in any way a measure of the uncertainty of AoA.

Fig A1: the x-axis of the left hand panels should not be age. This is transit time.

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