

On the estimation of stratospheric age of air from correlations of multiple trace gases

By F. Voet et al.

Note:

As an early career researcher, I participated in the Copernicus peer-review training 2024. This community comment, presented in the form of a referee report, is the outcome of that training. I would like to disclose that I have a potential conflict of interest, as I am co-authoring scientific papers with several of the authors of this manuscript.

General comments

This work introduces a new method to derive mean age from remote-sensing observations. This method uses model-derived correlations between six individual trace gases and mean age to create lookup tables, enabling the inference of a weighted mean age from remote-sensing data. The authors show that by using simultaneous measurements of multiple trace gases, the uncertainty of the derived mean age values can be reduced significantly compared to the conventional method that uses one trace gas. The method is applied to data from a balloon flight, and the results are compared to model outputs and to those obtained using the conventional method.

This study provides a valuable and timely contribution to the field of stratospheric transport times. The authors convincingly argue that at least one upcoming satellite mission will likely provide data to which the new method could be applied to in future research, thereby unleashing the full spatio-temporal potential of satellite data for mean age estimation.

The authors provide a thorough uncertainty estimation that emphasizes the value of their new method.

I find the manuscript to be very well-structured and comprehensively written.

On the basis of my read and in light of the comments below, I recommend that the article be accepted, subject to minor revisions.

Main comments

MC1: The abstract is the most-read part of the manuscript. In light of this, I suggest improving the flow to better guide the reader through your study. For example, the abstract mentions satellite measurements very early, even though the new method is not applied to satellite data. I understand that the anticipated availability of satellite data in the near future is the main motivation for implementing this new method. However, I suggest either placing the satellite part later in the outlook section of the abstract or keeping it early but explicitly mentioning that the method has not yet been applied to satellite data. Also please see SC1 for another suggestion.

MC2: While I appreciate that you have included the correlations and lookup tables in the supplementary material for completeness, I believe that it is too much information for the supplementary document. Please consider uploading these images and the corresponding data to a separate repository with a unique DOI.

Specific comments

SC1: Abstract lines 6-7: To describe the background of the method in a more precise way, you could mention, that the correlations are derived from the model, e.g. “The method is based on the compact correlations of these gases with mean age in the *model world*.”

SC2: l 113-114: For me as a non-modeler, this sentence is difficult to follow: “The values of these time series are interpolated latitude-wise onto the Lagrangian air parcels inside the lower boundary layer at the beginning of each new simulation time step.” Do you mean “At the beginning of each simulation time step, the values from these time series are interpolated across latitude onto the Lagrangian air parcels within the lower boundary layer.”?

SC3: l 147-149: Did you shift the lower boundary of SF₆ by a constant, i.e. did you use a long-term average of the mean age values at 2500 K derived from MIPAS measurements? Or did you use a varying time shift? Please clarify.

SC4: l 263: I suggest clarifying “the SF₆ sink correction method described in Garny et al (2024) ...”. This may avoid confusion if the reader stumbles across the similar terms “correction method” and “correlation method”.

SC5: Figure 3: I suggest aligning the y-axis scale to that the individual panels are easier to compare.

SC6: Figure 6 caption: This is an extremely useful figure, congratulations! The caption could be improved however. AoA from clock tracer below one year is attributed as tropospheric air, which is not accurate, since there is obviously stratospheric air involved. too. Do you mean “highly influenced by tropospheric air”? The same applies to Figure 7, 8 and 9 captions

SC7: Throughout the manuscript: I suggest giving the “new method” and the “standard method” a name, so that it is easier to reference in future research. You could ask AI to create an acronym for you. My search suggested e.g. “STAGE – Single-Tracer AGE Estimation” and “MCAGE – Multi-Tracer Correlation-based AGE Estimation”.

SC8: Throughout the manuscript: please double check for consistent use of “AoA”, “mean AoA” and “mean age”. AoA == Mean age?

SC9: l 491 onward: I suppose by “functional relations” you mean the correlations, that your method is based on? I suggest to be consistent here for clarity.

SC10: l. 596 onward: This paragraph could be improved for clarity using a more concise language in order to better guide the reader. As a start, in line 501-502, you could consider adding the new method’s name (e.g. MCAGE), as this method is what requires the lookup table that this paragraph is about.

SC11: Figure 11 discussion, l. 458 onward: How did you generate your zonal mean? Did you use equivalent latitude? Or are you averaging over longer time periods, so that equivalent latitude will be the same as latitude?

SC12: l. 510: By “zonal mean trends” do you mean “zonal mean trace gas concentrations”? Please clarify.