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Geoscientific Model Development Discussions

Interactive comment on "Carbon monoxide as a tracer for tropical troposphere to stratosphere transport in the Chemical Lagrangian Model of the Stratosphere (CLaMS)" *by* R. Pommrich et al.

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Thank you very much for your positive review. Please find below the answers to your questions and your suggestions.

Sections 3.1.1, 4.1.3: We agree with the referee that it would be better to have convection included in the transport. At this moment we use the vertical winds omega from ECMWF, which contain information on convective uplift, but only to a limited extent. A parametrisation of subgrid-scale convecton for CLaMS is not developed, yet, but is planned for the future.

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Furthermore, are we aware that there is potential for amelioration and that there is a tendence of the model to underestimate. Even above 380 K the mixing ratio of CO is too low with a mean difference of 20 ppbv. This fact is now more clearly stated in section 4.1.3 than in the original version of the paper. One point that is expected to lead to a better agreement in the future would be to use a newer version of the MOPITT data, which would allow to have higher CO values. But for what we want to focus on here, namely anomalies and the form of vertical profiles, the representation of CO in the model is sufficient.

Section 3.1.2 We made some preliminary comparisons with measurements of CH_4, CFC-11, N_2O, and CO_2 from the HAGAR instrument and found a reasonable agreement. But we decided not to show them, because our focus here is solely on CO.

Section 3.2 Pg. 1193, Line 18: Yes, we use ECMWF wind to do the trajectory calculations. This is also remarked now in the paper:

Therefore, we use trajectory calculations using ECMWF winds from the MOPITT measurement locations during a five day period, forward and backward, to 12:00 UTC on the central day of the five day period.

In the description of the CO initialization using MOPITT measurements you start at 500 mb and use a grid filling technique for the lower levels. With this technique it seems like there will be more gaps in the trajectory endpoints at the lower levels. Is that true?

This is not the case. Perhaps the description was misleading. We changed the sentence in question as follows:

The model levels below 500 hPa are set to the CO values of the 500 hPa level, except in the lowest model level, ...

You say you use NOAA ground measurements for the lowest model level but this is a sparse network. How do you interpolate to the whole globe? We added the following sentence to the paper:

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From these measurements of the NOAA/CMDL ground-based measurement network we calculated the zonal mean and thus created a longitude symmetric dataset.

We used the same technique for the other species, which is also now clearly stated in the paper.

For the calculation of mean age and the upper boundary of CO2 I have several issues. First, the upper boundary at 2500 K or roughly 55 km is in the mesosphere. Mesospheric loss of SF6 will make an age estimate using this tracer likely too old. The Stiller (2008) paper only shows age estimates up to 1000 K and even these are affected by SF6 loss. This will make your CO2 upper boundary condition too low. Second, you say that the mean age is determined from a linearly increasing tracer in the boundary layer. So what tracer do you use to calculate age in the model?

First, the reviewer is correct, regarding his point of the mesospheric loss of SF6. This point is now clearly stated in the paper. Second, we use an artificial, strictly linearly increasing tracer (not CO_2). This is now decribed much better in the paper.

If you use CO2 then your estimates of age in the troposphere are going to be affected by the latitudinal origin of the air mass since there is such a large latitudinal gradient in CO2. The ages shown in Figs. 5 and 6 suggest that you are using CO2 to estimate age since the tropospheric ages are not zero at the lowest level shown. The ages are up to several months near the surface, which doesn't seem like a realistic value. You could get these high values near the surface by transport of air from more southern latitudes where surface CO2 is lower than the tropical average. Overall your interpretation of the age estimates in the model and where the convective outflow is located may be correct but it may also be due to a different type of transport. You need to be much more clear in describing the technique you use here and the uncertainties associated with the technique.

We agree. We changed the following sentence:

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Γ at $\zeta = 2500$ K is derived from MIPAS observations of SF_6 (Stiller2008).

to

Γ at $\zeta = 2500$ K is estimated from MIPAS observations of SF_6 (Stiller2008).

and added the following:

Because no corrections for the mesospheric losses are included, this the so-called "apparent" mean age is likely too old although possible differences, caused by mesospheric contributions, are difficult to quantify.

After:

Thus, at the upper boundary, the CO_2 distribution is derived from that in the tropical boundary layer that was observed in the past quantified in terms of the mean age.

we added the following sentence:

Thus, because apparent age is used at the upper boundary, the related CO_2 values at this level are also too low.

The mean age is, in this and also other publication concerning CLaMS results, only used to have a qualitative distinction of air masses to get an idea of the relative contribution of convection or stratospheric in-mixing.

The high age of air in figure 5 and 6 is caused by stratospheric in-mixing; the boundary layer is at around $\zeta = 50$ K, where the age of air is actually 1 day.

Pg. 1193, line 13: Thanks. We changed the sentence following your advice.

Pg. 1194, line 17: Thanks, changed.

Fig 3: Due to the almost quadratic format of the paper the caption disappears if the figure is much bigger. In the final version it will be possible to stretch the figure over the complete page. This is already arranged with the editor.

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We made a difference plot of CLaMS and MOPITT as suggested, but we found it even even harder to see the differences than in the present version of this figure.

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