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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 constructive review. Please find below the answers to your questions and your suggestions.

1. Underestimation of the modelled CO. We agree with the referee that the model underestimates the measured CO. There are many factors influencing these underestimation. First, we don't have convection in the model, if it is not included in the vertical winds of ECMWF. No parametrisation of convection is developed, yet. Second, in Ploeger et al. (2010) the uncertainties of different vertical velocity schemes

are discussed, which will have an impact on simulated CO values in the TTL. Another point is that we use MOPITT CO in version 3, which brings additional uncertainties. It is expected that the more recent versions 4 and 5 would bring amelioration, because for instance the retrieval used for this versions allows higher values. The issue of the underestimation of simulated CO is now more explicitly discussed.

Note that the comparisons COLD-CLAMS on both 5 and 15 February 2005 (Figs. 5 and 6, respectively) are really bad around 350 K with a factor of 2 difference that cannot be solely explained by the convective activity on one date and not on the other one.

We agree. Around 350 K is the region of main convective outflow, which has high influence at both days, although the influence (and the resulting underestimate of CO) is stronger on 5. February 2005.

We state now in the paper: ...

2. Long-lived species. It is not obvious why all the molecules listed in the simplified scheme of CLAMS like O3, N2O, CH4, CCl3F, and CO2 are so important in the model runs since, for some species (e.g., N2O and CCl3F), it is even impossible to understand how they can contribute on the CO variabilities from Reactions (R1-R10). If these molecules are so important, some CLAMS results need to be presented and assessed against measurements since that could explain the systematic underestimation of model CO.

We did not mean to say that N_2O or CFC-11 contribute to the CO variability. Rather, these long-lived tracers are an independent element of the simplified chemistry. This is now more clearly stated in the paper already in the introduction.

3. Chemical reactions. Again, regarding these reactions, we first need to understand why they are so important to track the CO variability in the TTL, and second, they need to be correct. For instance, (R4) should produce HCl. (R8) cannot produce 2xO3. A simplified reaction as 3 O2 -> 2 O3 could be more understandable. Finally, (R9) and

(R10) are somewhat difficult to understand before having read the manuscript.

Thanks for raising this issue. Indeed, the simplified chemical reaction scheme is designed not only to simulate CO but, in addition, also the species O3, N_2O, CH_4, and CFC-11 in the TTL (see also comment above). Radical species (OH, HO2, O(1D), Cl) are prescribed and their function is only the decomposition of the long-lived species. Other products like HCl (that is indeed produced of the reaction CH4+Cl) are not important in this context and are therefore combined into "products". Reaction R8 is an abbreviation of the oxygen photolysis O_2+hν-> 2O that is followed immediately by 2 times the reaction O + O_2 (+M) -> O_3. To clarify this, we added "(+2O_2)" to reaction R8. Further, we added the brackets for reaction R9 and R10 as suggested. We believe that these changes will make the discussion of the simplified chemistry scheme easier to read.

P1188, L8: We agree and added the following:

The paper is structured as follows. We first present the measurements of tropical CO we use, then we described the model system, namely the transport and the simplified chemistry scheme, as well as the upper and lower boundary conditions. In chapter 4 we show the model results in comparison with the measurements and discuss our findings. Chapter 5 contains our conclusions.

and we added to the sentence:

Here, the focus is on a limited set of trace species in the TTL, in particular on CO.

the following text:

, but also O_3, N_2O, CFC-11, CO_2 and H_2O from which information about mixing and transport in the TTL can be derived.

P1188, L7: Done.

P1188, L25: Fixed, thanks.

P1188, L25: The discussion on DFS relates to the tropospheric, the stratospheric, the tropospheric-stratospheric or the total contents of the MOPITT measurement information?

It relates to the total contents of the MOPITT measurement information.

P1189, L10: Fixed, thanks.

P1189, L18: Fixed, thanks.

P1193, L3: Fixed, thanks.

P1195, L24: We changed the sentence:

Differences occur mainly in the tropics.

to

Differences occur mainly over tropical Africa and the Atlantic Ocean in winter spring and autumn.

P1197, L4: We follow Fueglistaler (2008), where 100 hPa is considered as TTL.

P1197, L20: Fixed, thanks.

P1197, L21: Since this flight was above and within isolated thunderstorms (Konopka et al., 2007) the contribution of horizontal transport can be neglected as long as the main problem, the insufficient representation of convection, is not resolved.

Fig 1: We wanted to show a result of the described procedure to demonstrate that the procedure applied here yields meaningful results. We also note that Rev. 1 required more detailed information on our initialization procedure for CO. We therefore decided to keep the Figure.

Fig 2: We changed the y-axis of every plot as suggested.

Fig 3: We show one day as example, not averages. This is now clearly stated in the figure caption.

Fig 4: The black line appears just in the lower panel, if we would show it in the upper panel, one could see nothing. We changed the sentence:

The black lines indicates where the anomaly is zero.

to

The black line in the bottom panel indicates where the anomaly is zero.

Fig 5–6: Fixed, thanks.

References

Fueglistaler, S., A. E. Dessler, T. J. Dunkerton, I. Folkins, Q. Fu, and P. W. Mote (2009), Tropical tropopause layer, Rev. Geophys., 47, RG1004, doi:10.1029/2008RG000267.

Konopka, P., Günther, G., Müller, R., dos Santos, F. H. S., Schiller, C., Ravegnani, F., Ulanovsky, A., Schlager, H., Volk, C. M., Viciani, S., Pan, L. L., McKenna, D.-S., and Riese, M.: Contribution of mixing to upward transport across the tropical tropopause layer (TTL), Atmos. Chem. Phys., 7, 3285-3308, doi:10.5194/acp-7-3285-2007, 2007.

Ploeger, F., P. Konopka, G. Günther, J.-U. Grooß, and R. Müller (2010), Impact of the vertical velocity scheme on modeling transport in the tropical tropopause layer, J. Geophys. Res., 115, D03301, doi:10.1029/2009JD012023.

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