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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Modeling the effect of plume-rise on the transport of carbon monoxide over Africa and its exports with NCAR CAM" *by* H. Guan et al.

Anonymous Referee #1

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This paper presents a model study of a relatively short period in September 2000 over Africa with a global transport model. The model is equipped with a recently presented plume-rise algorithm. Compared to earlier simplified approaches this plume-rise parameterization uses the maximum and minimum heat input of biomass burning fires to calculate the height range over which the effluents of the fires are added to the model. Comparisons with satellite and aircraft data show that the parameterization improves the agreement with observations.

The paper is generally well written and presents a detailed analysis with nice illustrations. A more careful phrasing can sometimes be recommended (see below).

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Discussion Paper

After reading the paper I am however left with a feeling that the paper does not really present much new information or methods. The analysis period is short (what about other seasons, inter-annual variations?), the number of simulations is limited (what about the short-comings of the parameterization and other possible choices that are possible to simulate plume rise?). Moreover, the real quantitative information that is presented in figures 8-12 does not really provide numbers that are useful for a wider community (an enhancement of a flux with 88 kg/s is relatively meaningless to me).

A very useful addition to the paper would be a budget analysis of CO over Africa. In such an analysis all the budget terms are analyzed for the two simulations. These terms include the initial burden, final burden, emission, transport to the east, west, south and north, and transport fluxes through certain vertical layers (e.g. the transition between boundary layer and free troposphere). Finally, the 3D production (by NMHCs?) and oxidation by OH should complete the budget.

In such an analysis, one could immediately compare the fraction of the emissions that is transported to e.g. the East and West in both simulations (similar to figures 10-12). Given the limited quantitative value of the current analysis for other researchers this budget analysis would be a welcome addition to the paper that would greatly enhance the usefulness of the paper. Other models could attempt a similar analysis, and the same analysis can be made over different time periods (e.g. to study inter-annual variability).

I have some additional comments listed below. I think the proposed budget analysis is "a must" for this paper to be acceptable for ACP.

Minor and some major Comments:

Title: I do not see how Transport over Africa is studied in the paper. The effect of plume rise on CO export is studied. So I suggest: Modeling the effect on plume-rise on the Carbon Monoxide export from Southern Africa.

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Abstract "The scheme was first adapted from a regional model." Unclear and not relevant for an abstract.

Introduction P18147: l1: a sensitive tracer of incomplete combustion: a tracer indicative for incomplete combustion

L28,29 : to create the correct injection height for biomass burning : to calculate/estimate

P18149, l10: Non-methane hydrocarbons (NMHCs) are not included as a volume source of CO? This prevents a proper comparison with available CO observations, since oxidation of NMHCs constitutes an important source for CO, especially in the tropics.

L27:"daily fire count data as a solution";. The authors should indicate some major limitations of this approach also. (i) the 10:30 a.m. and 10.30 p.m. overpasses tend to miss the most active fires in the afternoon (ii) simply using fire counts to distribute the monthly emissions (what are they?) is prone to errors due to e.g. cloud contamination of the MODIS observations.

P18150: l28: "Preliminary test runs, using fire sizes of 10, 20, and 40 ha have shown that the patterns and magnitudes of simulated biomass plumes"; Since the parameterisation is essentially 1D, I do not see how the horizontal fire size is taken into account in the subgrid parameterisation. Some more explanation is needed if you mention the fire size.

P18151:";at local afternoon (13:45 p.m.)"; I think it should be either 1.45 p.m, or 13.45.

P18152: "Both of the simulations and MOPITT measurements also show that CO flowed into the Southern Atlantic Ocean from southern Africa directly from the east."; Strictly spoken, this is not correct. Figure 2 only shows that high CO concentrations are present, but it does not show the flow. Caption figure 2;White areas are regions not seen by MOPITT during this period";: White areas indicate regions where the MOPITT

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observations are obscured by clouds.

P18152, l28, "As the results indicate, the plume-rise parameterization does not substantially improve the difference between the retrieved model and MOPITT CO at 700 hPa level.";. This statement is a bit unclear in the sense that first the focus is on improvements in the fit, and now the results are marginalized. I would replace "not substantially improve"; by "not complete resolve";. The main point, that including plume rise works in the right direction, should more clearly be made.

P18153: l1 "the retrieved CO concentrations also include the contributions from other levels, the increased CO concentration due to the plume-rise parameterization at 700 hPa level is partly offset by the decreased CO at lower levels"; The MOPITT averaging kernels decrease rapidly towards the surface. Without further investigation (i.e. consider modeled profiles, different MOPITT levels, etc.) this statement misses scientific back-up and should be removed. One reason that could be added is the missing NMHC contribution.

L12: "The approaches in selecting a priori profiles": Earlier it was mentioned that a single a prior profile was used in the retrieval.

L15: "Consequently, better consideration of the profile retrieval process and utilization of additional data describing the retrievals would improve the accuracy in CO retrievals."; This statement is not substantiated. Is this a statement made in the Luo et al, 2007 paper, or by the authors?

L24: "The good agreement between the model and ground measurement at Cape Point implies the simple formulations of the model can simulate the background CO" (i) Why are daily averaged data compared, and not hourly data? Now only 11 data points are left. (ii) The background CO is overestimated, while the important NMHC source is missing. Some explanation is needed here.

P18154: L16: ";Specifically, we would look at whether, within the vicinity of the flights,

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the model is capable of predicting plumes with similar mixing ratios and distributions."; It remains unclear whether the model is sampled exactly at the times the aircraft took air samples. Since the campaign was specifically focusing on pollution events, not doing so could result in a significant bias. If co-sampling is not performed, it should clearly be stated.

L23 "The CO vertical profiles around Sun Pan, Botswana (20;24 S and 24-30 E) for 3 September 2000 between the model runs and aircraft observations is compared in Fig. 6."are compared". It would also be instructive to include the model spread in figure 6.

P18155, l14: long-distance: long-range

P18156: l8: to re-iterate: the transport is not shown in figure 2.

P18157: l11: "The CO depletion by plume-rise process in the lower troposphere leads to less CO lofting by deep convection process";. By THE plume-rise process.... by deep convection. This statement is not trivial and I would spend a few more words. Where does the deep convection take place? Probably in a different latitude (ITCZ) than the fires occur. That means that large scale transport should bring (i) the CO-depleted BL air to the updraft (ii) the air that has experienced deep-convection to the upper troposphere at 12S. Why does this phenomenon show a stronger feature over South America?

L20: ";The larger westward flux of CO for the PR run induced the higher middle-tropospheric CO in the Southern Atlantic Ocean (Fig. 9c)";. This is not obvious: why could outflow from South America not play a role? From figure 9c itself that is not clear.

L27: which dose : which does

L28: on the horizontal transport pattern: To be strict: on the horizontal transport pattern of CO. The general transport pattern is not influenced in an off-line set-up.

P18159, l1: ";by clean background atmosphere";: by clean background air. Or: by the clean background atmosphere.

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L10: Future work will simulate and understand;I would say: Future work will focus on;. Promising understanding in this stage is a bit too much!

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