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Discussions

Interactive comment on “Cloud-venting induced downward mixing of the Central African biomass burning plume during the West Africa summer monsoon” *by* Alima Dajuma et al.

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Referee #2 We thank the Reviewer for her/his time to review our manuscript and for the constructive criticism. Please find below our point-by-point answers in red, modifications of the manuscript are in blue while the original Reviewer’s comments are in black.

line 63: emission of what? This sentence is now in line 64 and reads Biomass burning is an important source of aerosols and trace gases, with an estimated combined emission of several thousand Tg a-1 for tropical areas.

line 66: up to 30% This has now been corrected (line 68).

line 76: add reference to Dickerson et al. (1987). This was the first observational evidence of the upward transport of pollutants by deep convection. This reference has now been added in the manuscript in line 83: The hypothesis we investigate in this paper is that clouds play a considerable role in the downward mixing of biomass burning aerosol from the elevated plume. Most previous studies have focused on cloud-induced upward transport of aerosols and chemical species from close to their sources in the PBL to the free troposphere (e.g., Dickerson et al., 1987; Ching et al., 1988; Cotton et al., 1995

line 84: TRACE-A This has been corrected at line 92 in the manuscript.

line 87: Please add another TRACE-A reference: Pickering et al. (1996) simulated observed convective transport of biomass burning emissions over Brazil in TRACE-A and their downwind transport over the Atlantic. Pickering et al. (1996) showed an upward transport of CO mixing ratios, NOx and hydrocarbons by convective clouds during the Brazilian phase of TRACE-A experiment”. This information has now been added in line 96.

Figure 3: need to mention again that the model gets too much cloud over ocean. Also note not enough cloud north of 8 degrees N. This information has now been updated in line 253 in the manuscript: Towards the Sahel, to the north of 8° N, cloud fraction decreases in COSMO-ART but much less so in MODIS, which only shows a prominent minimum over central Ivory Coast. Over the Gulf of Guinea, cloud cover is clearly overestimated by the model. . .

line 220: Is this the monthly mean of CO from the model over each day of the month at the MOPITT overpass time? If so, then you need to say that. If it is not that, then it needs to be corrected. This has been modified in the manuscript at line 262: A gridded monthly mean of CO from MOPITT is computed using the daily mean CO retrieved for the 1000–900 hPa layer.

line 226: How does MOPITT perform for surface CO? You need to cite some literature concerning the validation of the MOPITT product at this level version some in-situ observations. Does MOPITT CO at the surface have a low or high bias? The following text has been added in line 141 in the manuscript: MOPITT data have been shown to distinguish CO pollution from large cities and urban areas from background pollution using only thermal infrared information (Clerbaux et al., 2008) and to perform even better using a combination of thermal infrared and solar radiation in the PBL (Buchwitz et al., 2007; Turquety et al., 2008). Kar et al. (2008) highlighted that retrievals in the lower troposphere over continental areas provide reasonable information on surface emissions of CO, although the measurements suffer from strong thermal contrasts. According to Buchholz et al. (2017), MOPITT measurements overestimate relative to ground-based remote sensing Fourier transform infrared spectrometer with a bias of less than 10% evaluated over 14 stations.

line 248: Are the more pronounced cooler areas over land also related to convective cells? Yes. We added and the adjacent land areas, particularly over southern Ivory Coast in line 293.

Figure 6: Point out again that the model produced too many convective cells over the ocean. We agree that this point should be highlighted. It has been now indicated in the text in line 320: The largest and most intense convective systems are simulated over the ocean with a pronounced north–south elongation along the southwesterly monsoon flow. These were persistent throughout the day (not shown).

line 316: What about convection over land. Did it also show downward mixing? Yes, it does. This has been addressed and further discussed in the manuscript from line 475

onwards. Finally over land, i.e., between 5 and 10°N, the vertical exchange maximizes leading to a reduction in the 2–4 km layer down to almost 50% (Fig. 9d). Consistently, tracer mass in the intermediate layer increases more strongly up to well over 40%, while tracer mass below 1 km reaches 23%. A clear diurnal cycle is evident, particularly in the lower layer, with vertical mixing mostly occurring in the early afternoon when the PBL is deepest. The suppressing of turbulent diffusion reduces the tracer mass by 20% with some evidence of a diurnal cycle in the differences evident from Fig. 9d. As expected, dry mixing is more important in the early afternoon, while cloud-induced mixing peaks later. The important role of clouds in vertical mixing over land is consistent with the large cloud cover shown in Fig. 3. The diurnal cycle is also evident at 1–2km, where switching-off turbulent diffusion leads to a net increase in this layer during the afternoon.

line 339: Figure 8a and 8b are zonal cross sections This has now been corrected.

line 346: I can't see that CO in the PBL is less than at 6.1 degrees W. It is the same color. You are right. We reworded this part: At 4°W (Fig. 8e) there are no pronounced gaps in the pollution plume, suggesting less convective mixing at this time than at 6°W but concentrations at low levels are not much different. There is even a slight increase northwards that may come from turbulent mixing or zonal advection into the section.

line 347: Figure 8f says 1-degree W. The text and caption say 1-degree E. Please correct one or the other. The caption of Fig. 8f has now been corrected. It is 1°E.

line 378: add reference to Figure 9c here This figure has been updated and the discussion of the results of the tracer experiments was extended.

lines 395-396: west to east, i.e., from A to D This sentence has been corrected.

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