

Interactive comment on “Carbon monoxide climatology derived from the trajectory mapping of global MOZAIC-IAGOS data” by M. Osman et al.

Anonymous Referee #3

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General comments

The authors present a new climatology based on the unique dataset of CO profile observations from MOZAIC and IAGOS measured since 2001. This data is an invaluable complement to the existing global observations from surface stations and satellite retrievals, particularly for the free troposphere and UT/LS regions. An attempt is made to widen the unevenly distributed observations by calculating forward and backward trajectories. As can be seen from the comparison with MOPITT retrievals this works out quite well in most parts of the Northern Hemisphere and the Tropics, while the lack of flight data in the Southern Hemisphere hampers the climatology completeness and probably also its correctness there. The paper structure is sound and the data and methods used for this study are relevant and of importance for global chemistry and air

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quality monitoring. I'd like to see the manuscript published, if the following basic items will be addressed:

- The influence of the available number of MOZAIC/IAGOS observations on your climatology should be examined in more detail. Particularly for the southern edges of the MOZAIC flight corridors the agreement of forward and backward trajectories and the comparisons to MOPITT seem to be weak as also pointed out in my specific comments. Can you give an error estimate for each grid box of the climatology simply based on the number of trajectories calculated or give at least a (map) overview of the number of trajectories used in each grid box?
- In several cases it would be more comprehensive to compare zonal averages instead of maps. Moreover the chosen months and years in the Figures often look arbitrary. Please stick to seasonal climatologies or to a few same examples wherever possible. Total column comparisons to MOPITT could be added to Figures 13 and 17.
- The manuscript is too long which can be seen most prominently in the number of Figures. I propose to shorten section 6.1 (including Figures S4-S6) significantly as well as the discussion of Figures 19-21, skipping Figures 19-20. Figures 2 and 9 can be minimized and Figures 4 and 5 can be combined into one Figure.

Specific comments

p.29875, l.10-14: You could give upper limits of observed values for these polluted regions. Values can be higher than 1000 ppb (see e.g. Wang et al., 2004)

p.29877, l.3-5: The sentence only repeats your statement on p.29876, l. 25-28. Please combine.

p.29877, l.5-7: Please give some short information (or reference) here on how the source distribution of CO can be derived from the O₃-CO correlations.

p.29878, l.13: Please insert here that you are using only profile data from takeoff and landing.

C10309

p.29879, l.6-8: Are there any references available for these MOPITT products? What is the version of the total column product?

p.29879, l.19-29: To which versions of the MOPITT retrievals do these bias estimates refer to? What is the expected or reported difference of version 6 retrievals to those products?

p.29880, l.3: In the abstract you limit the maximum altitude to 14 km. Please clarify.

p.29880, l.2-6: Did you use the exact horizontal position of the airplane during ascent/descent to start the trajectories or did you always start from the airport geographical location? The aircraft position can deviate considerably from the airport position, particularly for higher flight altitudes.

p.29882, l.2: Please give the exact path to the CO data. On the given ftp server, several directories would fit.

p.29883, l.25-26: I don't understand why a horizontal mapping from $1^{\circ} \times 1^{\circ}$ to $5^{\circ} \times 5^{\circ}$ needs a linearity in log pressure and CO mixing ratio. Please expand or omit. Figure 2 could be shortened to one example.

p.29884, l.24 – p.29885, l.3: From Figures 3 and S1 I can see quite large differences for many occasions, e.g. regions in Northern Asia or the tropical Atlantic ocean, where differences are higher than 50%. The quality of Figure 3 needs to be improved.

p.29885, l.13: Why did you choose the month of May?

p.29885, l.14 – p.29886, l.11 and Figures 4-5: You should consider to combine Figures 4 and 5 to one Figure with less examples. Please give total numbers of profiles which contribute to the mean MOZAIC-IAGOS profiles from the airports shown in the Figures. Airports shown here can be marked additionally in Figure 1. I doubt that all selected airports represent basically different conditions (e.g. Cairo / Tel Aviv or Atlanta / Houston).

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p.29886, l.18-20: You should emphasize that the MOZAIC data for the Southern Hemisphere is almost entirely related to flight tracks over the land surfaces. The higher SON values could be mostly related to biomass burning events and the values over the southern oceans may be much lower.

p.29887, l.12: Which product? V6L3?

p.29888, l.25-27: Correlations in Figure 7 are only shown for January, land and ocean are not distinguished. Even then you report a correlation coefficient of 0.68 for 300 hPa. Thus I can't believe that correlation coefficients of 0.7 are always reached.

p.29888, l.28: Do you mean for height levels above 700 hPa or for levels with pressures above 700 hPa?

p.29889, l.9-14: What exactly is compared in Figure 8? Is it monthly means of in-situ-profiles which afterwards have been transformed using the averaging kernels against monthly means of MOPITT retrievals or was the transformation being done with the single profiles?

p.29889, l.3-19: What are the conclusions you draw from this paragraph?

p.29889, l.24-28: I cannot see the dispersion towards the Arabian peninsula from Figure 9.

p.29889, l.28-29: Which region exactly?

p. 29890, l.1-14: There is not much new insight for the CO comparison from this paragraph. Also your comments on the MOPITT retrieval refer to an older version. You can skip this.

p.29890, l.17-20: I don't agree with this statement. From Figure S2, there are many regions where MOPITT is lower than MOZAIC. Showing zonal averages instead of maps could help here to quantify.

p.29891. Eq. 5: How did you derive this equation? Is there any reference?

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p.29891, l.13-23: Skip the section “The interface . . . column retrievals.” or explain why this information is necessary here.

p.29892, l.26- p.29893, l.2: Your findings are hard to see from Figure 10. It would be more elucidating to see a climatology of zonal mean values for both data products.

p.29893, l.20-22: Figure 12 shows monthly patterns. Seasonal maps eventually would be sufficient.

p.29893, l.20- p. 29894, l.19: Section 5.1. needs to be reworked. NH concentrations are not higher than SH concentrations for all months, NH biomass burning is negligible in winter. Moreover it is not explained why you find so much CO over the southern oceans, far away from the sources. How strong is your observational basis (even together with trajectory modeling) for these regions? Over Australia and South America there are very few measurements.

p.29894, l.22-24: You can skip either Figure 13a or 13b, basically it shows the same information. Alternatively you could show only one Figure with a comparison to total column CO from MOPITT, but for different latitude bands.

p.28896, l.15-21: As can be seen from the previous figures, large regions of the extratropical SH are not covered by the MOZAIC/IAGOS climatology. It is thus misleading to interpret a zonal average profile from this part of the world. I cannot trust the conclusions you draw from this section.

p.29897, l.5-8: It would be intriguing to add a total column comparison to this interesting Figure 17.

p.39898, l.1 – p.29899, l.2: Given the length of the manuscript and the limited information content of the section, I'd propose to skip the section completely or at least to shorten it significantly.

p.29900, l.8-9: Maximum monthly mean values of about 80 ppbv for ozone at 4.5 km seem to be quite high. Is this supported by the literature?

C10312

p.29900, l.12 – p.29901, l.24: This section can be condensed considerably. Your main conclusions can be drawn from Figure 21, without showing Figure 19 and 20.

p.29901, l.26: Insert: “as well as interannual variability”.

p.29901, l.29 – p.29902, l.5: Skip the sentence referring to Figure 21. The rest of this paragraph belongs to the conclusions section.

p.29902, l.17-20: I have problems to agree with this conclusion about the SH maximum. I don't think your results are based on a solid fundament of observations for this region.

Figure 1: Airports from which profiles are shown later on could be marked here.

Figure 2: Show only one example (max. two).

Figure 4: Combine with Figure 5.

Figure 7: Blue line is missing. The last sentence of the Figure caption can be skipped.

Figure 8: mention Frankfurt in the Figure caption.

Figure 9: e)-f) can be skipped.

Figure 11: Why you do not show here a climatology for e. JAN/JUL? Blue line is not explained.

Figure 13: The last sentence of the Figure caption can be skipped.

Figure 14: How well are the data on the southern edge constrained. Can you compare to MOPITT?

Figures S4-S6 can be skipped when rewriting section 6.1.

Technical corrections

p.29875, l.2: Give a reference for IPCC AR5.

p.29875, l.14: The reference Zbinden et al., 2013 is missing in the reference section.

C10313

p.29875, l.29: NOy is not explained.

p.29879, l.16: The reference Worden et al., 2010 is missing in the reference section.

p.29879, l.16-17: The reference Deeter et al., 2012 is missing in the reference section.

p.29879, l.19: "Lou et al., 2007" should be "Luo et al, 2007".

p.29884, l.14: skip "with".

p.29884, l.13-14: skip "Eq." (two times).

p.29886, l.24: Replace " a increasing" by "an increasing".

p.29889, l.5: The reference Deeter et al., 2010 is missing in the reference section.

p. 29891, l.6: Replace "total column vectors" by "total column operator".

p. 29892, l.8: Replace "times" by "time intervals".

p. 29892, l.13: Insert "is" in between "which" and "not".

p. 29892, l.21: Replace "African" by "Africa".

p. 29893, l.20: Skip "As an example,".

p. 29899, l.6: Please update this reference in the reference section.

p. 29899, l.20: Replace "correlation" by "positive correlation".

p.29901, l.6: Replace "Bowman" by "Bowman et al.".

p.29902, l.25-26: Skip parantheses.

Figure 2: The quality of the Figure needs to be improved.

Figure 3: The quality of the Figure needs to be improved.

Figure 12: The quality of the Figure needs to be improved.

Figure 14: Add "km" in the Figure caption.

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Figure 15: The quality of the Figure needs to be improved.

Figure 18: Replace "winter" by "summer" in the Figure caption.

Interactive comment on Atmos. Chem. Phys. Discuss., 15, 29871, 2015.

C10315