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Comment on acp-2021-733

Anonymous Referee #2

Referee comment on "Contribution of Asian emissions to upper tropospheric CO over the remote Pacific" by Linda Smoydzin and Peter Hoor, Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2021-733-RC2, 2021

Reviewer's comments on "Contribution of Asian emissions to upper tropospheric CO over the remote Pacific" by Linda Smoydzin and Peter Hoor.

General Comments

The manuscript describes the use of satellite CO data for the 2000-2019 period to investigate trends over the Pacific region at 400 hPa. Trajectory calculations are used to determine the source regions of CO enhancements observed over the same area. MOPITT thermal infrared (TIR) L3 CO data from version 8 are used. This is an interesting topic and the MOPITT dataset is well suited to the goals stated.

Some key points need to be clarified in order to demonstrate if the data selection method is appropriate to reach the goals stated, though. According to the manuscript, "to capture only severe pollution outflow events from Asia" the highest 2 % MOPITT mixing ratio values (or CO-maxima) are selected. Regions with 3 or more neighbouring CO-maxima (a CO-maxima cluster) are then analyzed. The adoption of the 2 % method seems to be based on "potential undetected slow drifts of the data over the 20 years of available data (Yoon et al., 2013)"; the Yoon reference discusses version 5 of the MOPITT dataset. For completeness, the manuscript should consider other relevant studies. For example, Deeter et al. (2019) demonstrated that bias drift at 400 hPa (i.e., the pressure level analyzed and discussed in the manuscript) is 0.0 % / year for the MOPITT version 8 TIR dataset, which is the same version of the dataset analyzed in this manuscript. Since the premise of "potential undetected slow drifts" has not been sufficiently demonstrated, the use of the 2 % method needs to be better justified.

Was the number of MOPITT L2 observations that went into each L3 data point taken into consideration? Some L3 data points are based on a few L2 observations, sometimes as few as 2. L3 data points based on a few L2 observations may not be representative.

It is not clear if the possible effects of missing data (due to clouds, calibration events, etc.) have been taken into consideration when calculating statistics and interpreting results. If they have, then the manuscript should clarify how. Missing data may follow seasonal/annual patterns and could affect the results and interpretations, if not properly accounted for.

The two lower panels in Fig. 1 seem to indicate that nighttime MOPITT CO values (half of the daily measurements) were not included in this analysis. This point should be clarified and, if true, justified.

In general, global CO maps from MOPITT and other instruments show that pollution plumes emitted in China, other Asian regions, Siberia, etc. are transported across the Pacific and often reach North America and beyond. The manuscript mentions fires as the source of the CO; that would be the case for emissions from Siberia during the northern summer months and in some cases for emissions from SE Asia. However, most emissions from China are due to fossil fuel combustion and they occur during all seasons. This should be discussed in the manuscript.

The manuscript does not discuss the seasonal effects on CO lifetime and overall CO background values which would result in more frequent/persistent CO enhancements during the winter months.

The descriptions of results and their interpretations are hard to follow.

Specific Comments

An explicit definition of "elevated CO event", "severe pollution events" should be provided.

Do CO-maxima clusters represent elevated CO events/severe pollution events? Do CO values/statistics support the idea that CO-maxima cluster represent only severe pollution events as intended? CO-maxima clusters may or may not represent actual pollution events, since they are relative. It would be more appropriate to call those "relative daily CO maxima" or similar. Using an absolute CO threshold value would have resulted in the selection of absolute CO-maxima, most likely corresponding to severe pollution events only.

What are "neighbouring CO-maxima"? Do CO-maxima need to be adjacent to each other? Within some fixed distance?

Why is 3 the minimum number of neighbouring CO-maxima to form a cluster?

It is unclear if the 2 % method does "capture only severe pollution outflow events from Asia". Elevated CO at 400 hPa (the only pressure level discussed in the manuscript) could potentially come from other regions, including Europe or even North America.

Fig. 2. Blue (low) values in the upper half of the DJF map may indicate that the number of data points is very low. If the CO-maxima data points are basically the only data points available, then difference values will be close to 0. Season and geographical location are consistent with clouds resulting in a low number of data points.

Fig. 3, MAM panel. Could the region with high number of CO-maxima be a region with few clouds and, thus, more MOPITT observations which could result in more CO-maxima cases? VIIRS true color images show that this may be the case. ISCCP maps of seasonal mean cloud amount (%) support this point. If the statistical analysis did not account for the effect of clouds in the number of observations, then some of the manuscript results and conclusions may be invalid.

Fig. 4. Right panels. The very low value of the JJA 2001 data point coincides with MOPITT not acquiring data between May and August 2001. Similarly suspect points: DJF 2016 (no data acquired some days in the Feb-Mar period), DJF 2009 (no data acquired some days in the Jan-Feb period). Were periods with missing data accounted for? If not, then some results and conclusions may be invalid. Unclear what other results/conclusions could be affected by this issue.

Fig. 4 (left panels) What is the relationship between ENSO and the data points plotted? It is unclear from the text why ENSO is discussed.

Fig. 4: Could those trends be caused by CO emissions elsewhere? Do we see less clusters and/or less CO-maxima days through time in the region studied because other regions in the planet are "dominating" that (relative) top 2 %? Consider a hypothetical scenario with increasing summer CO fire emissions over N America during the 2000-2019 period. Under such scenario: 1) the number of daily observations at the top 2 % would, increasingly, be found over/near N America and 2) conversely, the number of daily observations at the top 2 % over the N Pacific region would decrease during the same period.

Fig. 8b seems to indicate that a very large proportion of the trajectories (most of the

trajectories in some cases; e.g., Russia DJF) initiate over the ocean. Does that mean that the CO source is at the ocean? If so, please explain. What's the relevance/significance of trajectories initiating over land versus over ocean?

Fig 1, top left panel. The sharp contrast in average CO between land and ocean is suspect.

Technical Corrections

- Maps lack latitude and longitude labels (Fig. 1, 2, 3, 5, 7, 8.a).

- Fig. 1. Please label panels. Same comment applies to other figures.

- Fig. 8 caption: please explain yellow area in panel 8.a, not represented by color or name in any other panel. The explanation is in the text (lines 275-276); please include in caption too, for clarity.

- The legends of panels 8.d, 8.e, and 8.f include a "NE-Asia" class in white. Please show its boundaries in panel 8.a.

- Fig 8.c: white bars. According to the text (lines 133-134) those represent the "rest" class. Please add label to panel 8.c for clarity. Rename "rest" to "other" or similar.

- Fig. 8.a. caption: For clarity and to avoid language issues, please consider rewording to, for example: "Figure 8. Summary of trajectory analysis results. (a) Source regions: China (green), NE-Asia (white), India (red), SE-Asia (blue), Russia (gray), and ??? (yellow). (b) Source surface type (land, ocean) per region and season. (c) Uplift type (warm conveyor belt, frontal system, other) per region and season. (d) Source region per season. (e) Same for the NE-Pacific region only. (f) Same for the Southern Pacific region only."

- Revise standard deviation representation in Fig. 8, for consistency. For clarity, consider plotting +- 1 standard deviation lines (not just -1 st. dev. lines) in different colors and/or with an horizontal offset to avoid overlaps.

- Figures need to be arranged in the order in which they are mentioned in the text. For example, Fig. 3 is mentioned in the text after Fig. 1 but before Fig. 2.

- Expressions such as “surprisingly high” (line 7), “extraordinary [sic] high” (165, 172), “extraordinary [sic] large” (212) should be avoided. Objective, quantitative statements should be used instead.

- line 58: “North America”

- line 61: Please consider rewording to “However, in that particular case study” or similar. There are several other cases where “Though” is used at the beginning of a sentence (line 22, 144, 151, 163, 179, 200, 204, 219, 254, 269, 272, 299, 304). Please reword.

- line 125: Please reword “tends to rather underestimate than overestimate” to “ tends to underestimate rather than overestimate”.

- line 154: “top and centre rows”.

- line 234: “both clusters”.

- line 277: “The two case studies indicate that pollution”.