

Authors' response to reviews of "The MOPITT Version 9 CO Product: Sampling Enhancements and Validation" by M. Deeter et al.

Original reviewer's comments in blue. Authors' responses in black.

Replies to Comments of Reviewer #2

This paper describes the MOPITT V9 products, and compare the calibration results to V8. In general, the paper is very clear and focusses on the effect of modifying the cloud mask. This leads to a larger number of scenes that pass the MODIS/MOPITT filter criteria, specifically in cases in which heavy aerosol loading is present in the boundary layer. Using a number of examples, effects are clearly illustrated.

I will upload an annotated pdf, in which I made some small suggestions that might further improve this excellent paper. Specifically, while figure 4 focusses on the TIR product (only small differences in zonal mean compared to V8), Figure 8 shows results of the TIR-NIR product that show substantial increases. This hints to improved sensitivity to boundary layer pollution, a subject that is not fully exploited in the text. Likewise, Figures 6 and 7 show distinct increases in sampling frequency at higher latitudes. Here, it might be instructive to provide more insight in the physical reasons for this phenomenon. While boundary layer aerosols are mentioned as possible reason, the widespread enhancement in sampling frequency over Canada in Jan 2017 has likely other reasons.

Apart from that I am really satisfied with this paper.

Response to General Comments: We appreciate the reviewer's comments. The new cloud detection method does not affect retrieval sensitivity to CO in the boundary layer (in any particular retrieval), but it does recover significantly more retrievals in highly polluted conditions (e.g., in the North China Plain). As illustrated in the 2021 RSE paper where the new cloud detection method was first described, improved sampling for V9 is the result of both (1) added scenes where extreme pollution confused the MODIS cloud mask and (2) added scenes where possible clouds in the MOPITT field of view (e.g., low clouds or very thin clouds) produce little if any radiative effect. A reference has been added in Section 4.2 to a recent publication by Marey et al. where the added retrievals over Canada were primarily traced to scenes with low clouds.

Responses to comments in annotated pdf:

p. 2, l. 27: I do not think this is "introduction".

Authors' reply: Since we assume some readers will not have used prior MOPITT products, the introduction seems like an appropriate place to briefly describe the salient features of the retrieval algorithm, including the a priori.

p. 2, l. 42: I think "are" is better.

Authors' reply: '... should be relevant ...' has been replaced by '... will be relevant ...'

p. 9, l. 231: please add the MOPITT foot print area for completeness.

Authors' reply: The MOPITT footprint (22 by 22 km) is now mentioned in the second paragraph of Section 3.1.

p. 11, l. 268: Here it might be good to mention that the "extra" measurements (due to less strict cloud filter) did not severely influence the bias. But the question is really how many more profiles are included in the evaluation? Or is it based still on exactly the same valid comparisons?

Authors' reply: Since there were two other algorithm changes made for V9 (the revised NIR calibration method and the radiative transfer model), the V8/V9 comparisons presented in Section 3.1 are not solely related to the revised cloud detection method. The significant increase in the number of retrievals used to validate V9 relative to V8 can be seen in the numbers in the leftmost column of Tables 2-5 and A1.

p. 12, Fig. 3: Maybe good to explain why you do not compare the NIR and TIR-NIR for ATom and HIPPO.

Authors' reply: The following sentence has been added at the end of the first paragraph of Section 3.3: "Since MOPITT retrievals over ocean are based solely on TIR radiances, validation results presented below for the HIPPO and ATom campaigns (which mainly produced over-ocean observations) are limited to the TIR-only variant."

p. 13, last sentence of Section 4.1: mm, this sentence is too vague. Please be concrete. such as means are within ...%.

Authors' reply: The following sentence has been added before the final sentence in that paragraph: "V8T and V9T zonal means are within 2% at most latitude bands." Also, in the preceding sentence, the phrase 'nearly negligible' has been replaced with 'very weak'.

p. 15 l. 362: not clear from the text why a different sampling period is chosen...Is this based on the largest improvement?

Authors' reply: While the improved sampling for V9 is evident year-round, specific months selected for the examples presented in Section 4.2 were chosen because of potential scientific interest in those months. For South America, September is typically the month when CO loading due to biomass burning reaches its peak. For Asia and North America, January also represents a month of relatively high CO loading. However, other months could have been selected without affecting any of the conclusions of the paper.

p. 15, l. 365: Here I miss a bit of context. What is the reason that the sampling frequency increases sharply over Canada? Do not think aerosols are an issue? So, is this related to albedo? Please provide some additional analysis here.

Authors' reply: For this manuscript, the specific causes of the increased sampling for V9 over Canada (as indicated in Fig. 6) were not analyzed. However, a recently published paper by Marey et al. (titled 'Analysis of improvements in MOPITT observational coverage over Canada') analyzed this issue. The following sentence has been added to the last paragraph of Section 4.2: "Improved sampling for V9 over

Canada was found independently to be related to added retrievals in scenes with low clouds [Marey et al., 2022].”

p. 18, l. 375: Clear, but the TIR product in Figure 4 shows no difference, indicating that MOPITT observed wintertime boundary pollution. Options: (1) make a link in the text to outline this (2) include NIR-TIR analysis in Figure 4 (this option has my preference).

Authors’ reply: The area in Fig. 8 showing significant V8/V9 differences is restricted to a 10-by-10 degree area which occupies just a few percent of the area of the corresponding zone (30 N to 40 N) in Fig. 4. Thus, the effect of a strongly localized increase in monthly-mean CO total column of ~ 20% is greatly diminished with respect to its effect on the zonal mean. Figure 4 presents TIR-only data to minimize differences in retrieval sensitivity between ocean and land within each zone (since NIR radiances are only used in daytime/land scenes).