

Authors' Responses to Reviewer #2 of 'Radiance-based Retrieval Bias Mitigation for the MOPITT Instrument: The Version 8 Product' by M. Deeter et al.

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

Replies to Comments of Reviewer #2

The authors provide an interesting, comprehensive, and well-written account of the latest MOPITT CO retrieval update (V8). This article can be published after minor revisions, which ideally address the following two points at least:

(a) Page 4 lines 11-12 mentions that the “Values of these parameters [. . .] were obtained by minimizing retrieval biases for the TIR-only validation results.” The last paragraph of Section 3.1 again mentions the methodology in terms of the NOAA and HIPPO ‘validation’ for bias minimization, versus the campaign validation for verification of the minimization method. This type of phrasing (terminology) and text structure is very confusing and to some extent incorrect: The TIR-only comparisons are a validation for V7 only, while they are merely a bias minimization methodology check for V8. One cannot call the latter a validation any longer. It is therefore recommended to move the content of Section 3.2 to Section 2.2 (or clearly restructure differently), and adopt the terminology from ‘validation’ to comparative ‘verification’ accordingly. This shift would also bring more focus on the bias mitigation that is mentioned in the manuscript title.

Response: We agree that it is important to distinguish uses of in-situ datasets for algorithm development (e.g., bias minimization) as opposed to independent validation. This issue is fully addressed in the last paragraph of Section 3.1 and is mentioned as well in both the Introduction and Conclusion. Thus, we don't believe readers will be confused about this issue. The last column in the added table (as suggested by the first Reviewer) will emphasize this point even further.

(b) Section 3: It would be very helpful to provide a map of the in-situ reference data flights with an indication of where collocations have been used for data comparison. It should become very clear than where the validation results are valid, and which data have been used for bias mitigation only.

Response: See the response to the next-to-last comment by Reviewer #1 above. The new table emphasizes which datasets are used for algorithm development and which for independent validation.

Minor / technical remarks: - The introduction is quite long. The general description of the MOPITT retrieval process could go into a separate section.

Response: The Introduction currently includes five paragraphs, providing an overview of the MOPITT mission, MOPITT products, and validation results for the Version 7 product. We feel that this section provides the necessary background for the remaining sections of the paper without delving too deeply into the details.

- Page 1, line 10-11: “MOPITT [. . .] which produces retrievals” does not sound correct.

Response: The word 'produces' has been replaced with 'permits'. The full sentence now reads 'MOPITT (“Measurements of Pollution in the Troposphere”) is a gas correlation radiometer instrument on the NASA Terra satellite which permits retrievals of CO vertical profiles using both thermal-infrared (TIR) and near-infrared (NIR) measurements.'

- Page 1, line 21: “the ultimate CO product” rather sounds either conceited or fatalist. Something more neutral might have been the intention.

Response: The phrase 'ultimate CO product' was meant to indicate the product which results from the bias mitigation strategy. 'Resulting CO product' is now used instead.

- Page 2, second paragraph: Please mention the TIR and NIR wavelength ranges.

Response: Agreed. The following sentence has been added: 'TIR-only retrievals are based on the 5A, 5D, and 7D radiances in the 4.7 micron band, whereas NIR-only retrievals are based solely on the ratio of the 6D and 6A radiances in the 2.3 micron band.'

- Page 2: Figure numbering in the text jumps from 1 to 3; Figure 2 is not mentioned.

Response: This is an error which has been corrected in the revised manuscript - Fig. 2 is now introduced at the beginning of the last paragraph of the Introduction (between the initial discussions of Fig. 1 and Fig. 3).

- Section 2: Please briefly introduce the four aspects of the retrieval enhancement at the beginning of this section.

Response: Such a paragraph has been added at the beginning of Section 2. The paragraph reads: 'As detailed in the sections below, the Version 8 retrieval algorithm incorporates updated spectroscopic information used in the radiative transfer model, improved methods for radiance bias correction and averaging kernel calculations and, finally, the most recent version of the MODIS cloud mask.'

- Page 5 lines 13-17 are not fully clear. Why change the relative channel 7 average radiance in order to obtain consistency between V7 and V8 processing?

Response: What actually changed for V8 was the specified threshold ratio between the 7A calibrated radiance and model-simulated radiance (based on the assumption of clear sky) which is used for cloud testing. A threshold ratio of 1 would be ideal given a perfect clear-sky radiative transfer model. The change in the threshold ratio was required because of changes in the radiative transfer model detailed in Section 2.1. Since we have no evidence that the cloud detection for V7 was either too aggressive or too conservative, we feel that the goal of achieving consistency in cloud detection yield for V7 and V8 is justified.

- Section 3.1: Please briefly elaborate on the “flask sampling system”

Response: Several sentences have been added describing the NOAA in-situ analysis system and measurement accuracy. The following text has been added: 'Typical profiles are derived from a set of twelve flasks. Reproducibility of the laboratory-measured CO dry-air mole fractions, which are measured by either a vacuum UV-resonance fluorescence spectrometer or a reduction gas analyzer is better than 1 ppb.'

- Page 7 lines 1-6 are not fully clear. First it is said that the in-situ measurements are vertically extended, then it is said that validation results for the 100 hPa level are not reported because of a lack of in-situ measurements above this level.

Response: These statements are both correct. The purpose of vertically extending the in-situ measurements measured from aircraft is to fill in the 'gap' of missing data in x_{true} (at the top of the profile) required to calculate $x_{\text{sim}} = x_{\text{a}} + A(x_{\text{true}} - x_{\text{a}})$. Retrievals of CO at the 100 hPa level (representing the layer from 100 to 50 hPa) cannot be reliably validated, however, because they heavily depend on extended (extrapolated) CO measurements from lower altitudes. At lower retrieval levels the associated averaging kernels are weighted towards lower altitudes and the sensitivity to the extrapolated CO measurements is much weaker. The end of the paragraph has been revised and now reads: 'Validation results for the MOPITT 100 hPa retrieval level are not reported below, since apparent retrieval errors due to reliance on the model-based extension at the top of the profile is much greater than for lower retrieval levels. Reliable validation of the MOPITT 100 hPa retrieval level would require in-situ profiles that reach higher altitudes than are currently available.'

- Page 8 lines 28-29: Does the last sentence of Section 3.4 indicate that all significant bias has been removed and that only 5 % spread remains? This is not fully clear from the current phrasing.

Response: The last sentence just indicates that retrieval biases obtained with the AC and KORUS datasets are generally consistent (to within about 5%) with the biases obtained using the NOAA profiles.

- Figures: The authors should explain in the text how the “bias drift”, “slope”, and the uncertainties thereon are calculated.

Response: Bias drift calculations are discussed in the second paragraph of Section 3.2: 'Bias drift is calculated as the slope of a least-squares best fit applied to the timeseries data presented in Fig. 5, and converted to units of %/yr.' The sentence has been revised to provide a reference for the conversion in units to %/yr. Uncertainties in the slope (drift) are calculated according to the standard method for least-squares calculations, which we believe most readers know well.