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Atmospheric Chemistry and Physics Discussions

Interactive comment on "A method for evaluating bias in global measurements of CO_2 total columns from space" *by* D. Wunch et al.

Anonymous Referee #1

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The paper under review suggests a method how to empirically correct for bias in CO_2 total column concentrations retrieved from space-based observations. The performance of the proposed bias correction is evaluated by comparing CO_2 retrievals from GOSAT (conducted by the ACOS algorithm) to ground-based observations by the TCCON.

The general approach is based on the assumption that atmospheric variability of total column CO_2 is small in the Southern hemisphere and that a linear relationship exists between retrieval bias and 4 correction parameters. The bias correction is then gauged through observations in the Southern hemisphere mid-latitudes and extrapolated to the global scale. These assumptions are appropriately discussed by the manuscript. In general terms, however, I would prefer correcting forward

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model and instrument deficiencies before the actual retrieval, in particular since physical understanding seems at hand for some aspects discussed here. Concerning the proposed posterior bias correction, one might wonder whether data users that dispose of a modeling framework actually prefer to device their own correction scheme since their modeling framework should provide the generally best estimate of the CO_2 total column concentrations in Southern hemisphere mid-latitudes.

The findings of Wunch et al. are relevant for researchers working on retrieval algorithm development of current and future satellite missions as well as for data users who rely on high accuracy of the space-based retrievals and who might want to adopt the proposed approach or to directly use the bias corrected data. Therefore, I consider the paper suitable for publication in ACP after consideration of the comments listed below.

Comments

1. The manuscript points out that a considerable fraction of the overall XCO_2 bias is due to a bias in retrieved surface pressure (used to calculate the column-average CO_2 mixing ratio, XCO_2). Surface pressure is also one of the parameters for the bias corrections scheme (p.20909, l.2...). I suggest to first evaluate retrieved surface pressure, then retrieved XCO_2, in order to disentangle the related uncertainties. If the observed bias is dominated by contributions from the surface pressure retrieval, one might consider to use the a priori surface pressure (derived from meteorological and topographic databases) to calculate XCO_2.

2. The study justly emphasizes that the bias correction needs extrapolation (beyond the parameter range used for gauging) to cover all ACOS-GOSAT retrievals (p.20911, l.2...). When discussing this assumption, no particular focus is given to

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tropical regions, ie. 25°S to 25°N, which is a very interesting region. Could the bias correction fail there eg. because of generally low air mass or low infrared albedo (and large "blended albedo") of dense tropical vegetation? A figure showing the global distribution of the 4 correction parameters could help identify potentially difficult regions.

3. The study discusses that a comparison of ground-based TCCON data with ACOS-GOSAT retrievals requires taking into account (1) differences in the a priori assumptions and (2) differences in retrieval sensitivity represented by the averaging kernels (p.20911, l.12...). While I agree that step (2) is generally difficult due to the true ensemble covariance being unknown on the global scale, step (1) seems feasible for all TCCON stations since the "ensemble" profile chosen here is actually the TCCON a priori. If this is correct, it would be straightforward to carry out adjustment (1) and to quantify its effect for all stations (not only Lamont) covering a range of latitudes.

4. Evaluation of the proposed bias correction needs more quantification. While the comparison of ACOS-GOSAT zonal averages and TCCON (p.20913, l.9...) seems dispensable to me, the site-by-site comparisons between GOSAT and TCCON lack detailed quantitative discussion. Figures 13 and 14 are not convincing enough:

- The paper requires a table where the residual bias and the number of considered data is listed with/without bias correction with/without T700 criterion. Numbers should be listed per station in order to quantify bias variation on the regional scale.

- What ACOS data are actually shown and evaluated in Fig. 13 and Fig. 14? Is this individual measurements or daily averages or 10-day averages?

- On what grounds do the authors conclude on a "time-dependent difference" (p.20915, l.1) between ACOS-GOSAT and TCCON? This pattern does not seem

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obvious from Fig. 13.

- Likewise, I tend to disagree that "the assumed linear regression reduces the agreement" (p.20915, l. 6) in the Sodankyla time series.

- How does the T700 criterion perform in comparison to relaxed geographic criteria, eg. 5° radius around the TCCON stations?

- Would it be possible to quantify the "noise" in the ACOS-GOSAT data to support the discussion on seasonal cycle amplitudes (p. 20915, l.13...)?

Minor comments:

p.20901, l.2 (due to my comment in the quick review): the method by applying the method -> the method by applying it

p.20901, l.26: There are recent GOSAT validation studies to be referenced here and possibly in other places of the manuscript: Butz et al., 2011, Parker et al., 2011. The authors should consider to discuss their results with respect to these studies, not only with respect to Morino et al., 2011.

Appendix A: Figure references in the text are misleading: Fig. 1 -> Fig. A1 ,. . .

Equations (A5), (A6), (A9): The column of dry air is calculated differently by TCCON and ACOS-GOSAT. Therefore, 2 equations are required to describe the techniques but the third equation seems redundant.

Equations (A16), (A17): Are these required?

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Fig. 9: The terms “variance” and the symbols “σ^2” should read “standard deviation” and “σ”.

Fig. 10, Fig. 13: Plot (averaged) ACOS-GOSAT data in the foreground, TCCON in the background. Consider to reduce the marker size to avoid masking of datapoints.

References:

Butz, A., et al. (2011), Toward accurate CO_2 and CH_4 observations from GOSAT, Geophys. Res. Lett., 38, L14812, doi:10.1029/2011GL047888

Morino, I., et al. (2011), Preliminary validation of column-averaged volume mixing ratios of carbon dioxide and methane retrieved from GOSAT short-wavelength infrared spectra, Atmos. Meas. Tech., 4, 1061–1076, doi:10.5194/amt-4-1061-2011

Parker, R., et al. (2011), Methane observations from the Greenhouse Gases Observing SATellite: Comparison to ground-based TCCON data and model calculations, Geophys. Res. Lett., 38, L15807, doi:10.1029/2011GL047871.

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