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Atmospheric Measurement Techniques Discussions

Interactive comment on "Quantification of Uncertainties in OCO-2 Measurements of XCO_2: Simulations and Linear Error Analysis" *by* Brian Connor et al.

Anonymous Referee #2

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The paper by Connor et al. uses retrieval simulations and linear error propagation to estimate uncertainties to be attributed to OCO-2 XCO2 measurements. The study builds on the paper by Connor et al., JGR, 2008, but goes substantially beyond by considering OCO's actual instrument performance and by extending the sounding ensemble to a large range of geophysical conditions. The paper contributes new and very relevant aspects, it is well written, methods are robust. I recommend publication after considering my comments below:

1. Why is the "bottom-up" error estimate not compared to the "top-down" error calculated from retrieved and true XCO2 (known from the simulation input)? It would be a first step toward the recommended TCCON comparisons (L519). I would consider

such a comparison essential to confirm the estimated bottom-up sounding errors.

2. Since the paper is a follow-up of Connor et al., JGR, 2008, it might be useful to highlight differences and refinements. In particular, the present study identifies aerosols as a driving error contribution while aerosols were considered less important by the precursor study. I presume the reason is that the present study considers foreign aerosols ie. aerosols which are not part of the retrieval state vector.

3. The definition of "variable error" in contrast to "fixed error sources" could be misleading in a sense that readers could easily conclude that the "fixed error sources" such as spectroscopy and instrument calibration are not really to worry about. In fact, it could be exactly those "fixed error sources" (eg. spectroscopic line shape errors or instrument line shape errors) that induce spurious XCO2 gradients on large spatial and on seasonal scales (eg. through Gy depending on viewing geometry, etc. (L204)). In my opinion, bias correction has a hard time to catch such "slow" variability in contrast to what is written in the manuscript (L455).

Statements such as the following could augment the chance for misunderstanding:

(L29) "we also estimate the 'variable error' which differs between soundings, to infer the error in the difference of XCO2 between any two soundings". Is it really the difference between any two soundings or rather the difference between two spatiotemporally close soundings?

(L 231) "On the other hand, an error which is constant, or at least has a well-defined mean value, can be subtracted from all soundings with minimal or no effect on gradients of XCO2." While this is certainly true, spectroscopy and instrument calibration are constant error sources, but induce variable XCO2 errors (L203). The induced variability is "slow" (seasonal and continental-scale) but this could be particularly detrimental for carbon cycle insights.

4. What about foreign spectroscopic interference e.g. H2O spectroscopic errors induc-

ing XCO2 errors?

5. Section 3.1.1: As far as I understand, the linear error analysis for aerosols (and clouds) uses the Jacobians at the retrieved state for both, the retrieved and the non-retrieved aerosol parameters. Is this in any way significantly different from and better or worse than using the Jacobians at the true state?

6. Instrument calibration: The correction of radiometric in-orbit degradation might be source of error. Is this source included in the radiometric gain error (<1.6% (table 2))?

7. Check whether the supplemental material is referred to by the manuscript. The error maps in the supplemental material show that, assuming errors of 0.1 AOD (at what wavelength?), XCO2 errors are factors larger than the composite errors shown in Fig. 4a (main manuscript). Does this mean that the ensemble AOD error used for generating Fig. 4a is typically factors less than 0.1 (in particular for the upper layer)? It might be better to plot AOD standard deviation instead of AOD itself in Fig. 4b. Could it be that aerosol variability on MERRA's horizontal resolution is not representative for OCO's ground-pixel size?

8. References: There is a wealth of publications that aim at estimating retrieval errors and retrieval performance from OCO-2, GOSAT, future missions. While I am in favor of conciseness, I find the paper very sparse in citing those.

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