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Atmospheric Chemistry and Physics Discussions

Interactive comment on "The potential of OCO-2 data to reduce the uncertainties in CO_2 surface fluxes over Australia using a variational assimilation scheme" *by* Yohanna Villalobos et al.

Anonymous Referee #3

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This paper describes a regional flux inversion system to estimate fluxes over Australia with column CO2 observations from OCO-2. The authors test the performance and sensitivity of the system with a series of Observing system simulation experiments (OSSE). The performance of the system is primarily presented with the metric of uncertainty reduction assuming unbiased prior fluxes and pseudo observations. With increasing of satellite observations and the need to understand regional fluxes, the regional flux inversion is highly desirable. Therefore, the topic is important. The overall testing of the regional system roughly follows the traditional global inversion system, which I find is not sufficient. Though uncertainty reduction is a useful quantity to show the performance of the system, which highly depends on experimental setup as also

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discussed in this paper. In the following, I suggest a few more experiments and other metric to test the sensitivity and performance of the regional inversions.

1. Different from global flux inversions, the regional flux inversions are sensitive to boundary conditions. I would suggest adding one experiment to show the sensitivity of the system to prescribed boundary conditions. For example, if the boundary conditions has random error of 1ppm, what does the result look like? Better yet is to assess the uncertainty of the boundary condition from CAMS, and then add that uncertainty in the OSSE.

2. Since the inversion assimilation window is short, the regional inversion must be sensitive to initial conditions as well. Therefore, testing the sensitivity of the system to initial condition and whether including the initial condition as part of state vector improve the performance would be very useful.

3. Satellites provide much denser observation coverage compared to surface CO2 observations, especially over tropics and the Southern Hemisphere. But at the same time, it is prone to bias in observations. The OSSEs are perfect to test the sensitivity of the inversion to potential bias in the observations. I suggest adding one experiment that assimilate biased pseudo observations. The bias could be based on the bias correction algorithm used in the OCO-2 retrieval products.

4. Unbiased prior fluxes certainly satisfy the theoretical assumptions in the variational optimization, but it is rarely the case in estimating land fluxes in atmospheric CO2 flux inversion. Scientifically, it is more useful to estimate a mean offset between the true fluxes and the prior fluxes. So I suggest to have a prior fluxes that have different mean values from the truth, and then test how the inversion could recover the mean fluxes.

Some minor comments:

1) I don't see the necessity to have section 5, since no real fluxes are presented. Also, the numbers on figure 10 are not consistent with the text.

2) The observation operator is different from several previous studies(e.g., Basu et al., 2013 cited in your paper). In equation (12), you interpret the averaging kernel to model levels. In a lot studies, the model vertical profiles are interpolated to the vertical levels of the retrievals, and pressure weighting function from retrievals is used in calculating model equivalent column CO2. I think if the observation operator is done in this way, you will not have the problem having to remove 1-second averaging observations if they span several grids.

3) Line 6 on page 11, seems missing a word.

4) Line 3 on page 17, remove “uncertainty”.

5) Line 3 on page 19, what could be other reasons? You used “partly” in the sentence.

6) Line 14 on page 25, double check the sentence. “the potential to more accurately observations”

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