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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Characterizing Uncertainties in Atmospheric Inversions of Fossil Fuel CO_2 Emissions in California" *by* Kieran Brophy et al.

Anonymous Referee #1

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Review of "Characterizing Uncertainties in Atmospheric Inversions of Fossil Fuel CO2 Emissions in California" by Brophy et al

This manuscript addresses some of the fundamental uncertainties in a very important problem, namely top-down constraints on fossil fuel emissions from small regions, in this case the monitoring regions in California. It makes several contributions, in particular assessing the conclusions of Graven et al (2018). I am particularly impressed with the inclusion of the primary author on that paper as the second co-author on this manuscript, since it assesses the quality of the conclusions in her paper.

In general, the manuscript is well-written and the methods and results are presented

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in an understandable format. There are a few places where the assumptions as stated do not address a few questions that could lead to confusion on the part of the reader (and on my part) as well as could influence the results. In particular, I am referring to

1) Are the footprints calculated on a grid, and the gridded footprints used for the inversion, or are they averaged for a whole basin, and the basin footprint used for the inversions? The authors comment on sub-basin spatial pattern differences between EDGAR and VULCAN later in the paper, suggesting the latter, but it isn't stated anywhere that I can find. If it is, please point me to the right place.

2)the temporal patterns in the prior uncertainty (i.e. are there any, or do the experiments assume a constant prior uncertainty for the entire year), as well as the spatial patterns in the prior uncertainty (is it fixed for the whole basin, or is it gridded within the basin?).

One assumption that is critical to the applicability of this paper to other studies with real data is an assessment of the interaction between the different types of uncertainties. In particular, spatial and temporal uncertainties in the prior are not independent from each other due to the effects of transport (though the signals here are diminished by the shorter run times). This is even more important for the experiments involving transport error, as the differences in footprints will interact with the differences in the temporal and spatial patterns. A limited set of experiments should be able to address whether these effects are significant, prior to having to do the full suite for multiple more cases.

Specific Comments:

What is the period of simulation?

211-213: The scaling of 0.5 is definitely a free parameter that deserves some sensitivity analysis as it could strongly affect your results. You could look at the covariance between the three transport models as a first guess. How does this covariance compare to the factor of 0.5*mean signal that you assume?

229-231: Correlation in the transport uncertainties assumed in your experimental setup should at least be examined before assuming your uncertainty covariance is diagonal. Again, you could use the 3-model ensemble to test this assumption.

Section 2.5.4: what is the prior flux estimate in this experiment?

390 - 392: isn't this easy to test by looking at footprints?

393-401: I'm not sure I see the connection here. Why does being more concentrated in urban regions change the total? (this also applies to the conclusion in lines 530-533) It also appears that there might be a temporal offset happening, where the fluxes are biased low in summer and high in fall/winter. Is there a pattern in the prior uncertainty causing this? There isn't any way to tell given the lack of temporal information in the flux results images. Another cause is the seasonality in sensitivity of the observations to the fluxes, which can again be tested by looking at footprints.

3.2.4: A nice conclusion of this section is that the removal of outliers improves the results from transport errors alone. That could be a strong recommendation to the community for working at these scales, which is done by many modelers, but not all. - this is mentioned in the discussion, but could be more strongly highlighted here.

I would suggest that a more direct analysis of the impact of transport errors by season could be accomplished by looking at basin-wide sensitivity for each observation location by season, and how that varies by transport model. This would explain a lot of the inter-model differences you are seeing in many of the other experiments as well. That would support your PBLH analysis, which gets to the heart of why the footprints would be different, but doesn't quantify the differences between the flux sensitivities directly.

537-540: This conclusion needs to be tested by altering the estimate of transport error assumed in the inversions themselves. My guess is that the answers might be sensitive to this parameter, but that needs to be tested.

Fig 2: What is "signal"? Is it just the emissions run forward through the transport

model?

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