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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Aircraft-based inversions quantify the importance of wetlands and livestock for Upper Midwest methane emissions" *by* Xueying Yu et al.

Anonymous Referee #1

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The authors present an estimate of methane emissions from the upper Midwest in the United States based upon aircraft observations. In general, I think the manuscript is well-written and the analysis is thorough. In a few instances, I would be cautious about not over-interpreting the results of the inverse model or drawing conclusions that are bolder than the constraint afforded by the aircraft observations. Below, I've listed a few specific suggestions and ideas for the authors.

Line 43: There are a bunch of studies that have now looked at trends in methane emissions from the US.

Line 197: Does the number "0.8" refer to a correlation coefficient or something else?

Typically, when people estimate a correlation length, they estimate the length over which the covariances decay by 50% (i.e., analogous to a half-life) or decay to approximately zero. If you're using an exponential covariance model, you'd likely want to estimate the length over which the spatial covariance decays by 50%. If you're using a different covariance model, like a spherical model, you'd want the total decorrelation length.

Line 199: What kind of covariance model are you using here?

Line 200: I don't agree with the assumption that anthropogenic emissions have no spatial covariance. Across regional or continental scales, agricultural production shows spatial patterns; for example, if there are dairy or cattle farms in one model grid box, it's more likely than not that there are other dairy or cattle farms in the region. Also, this approach seems to contradict the approach in Sect. 2.3.3. If emissions were completely uncorrelated, then presumably each cluster in Sect. 2.3.3 would consist of a single model grid box (at least in regions that are dominated by anthropogenic emissions).

Sect. 2.5: I think the information in this section shows that the inverse model performs well and indicates how sensitive the inverse model is to different setup parameters. With that said, this section has a lot of technical detail, and you could consider moving some of this information to the SI. Also, this information feels like it belongs better in a results section, but I think the current results section (Sect. 3) has a really nice structure that emphasizes a discussion of the emissions, not the results of technical sensitivity tests. Hence, the SI could be a good place for some of the information in this section.

Line 406: The wording here ("We saw above...") feels a little awkward.

Lines 465-474: Do you think the aircraft observations can yield a robust constraint at this level of detail? I can imagine that the model domain is a patchwork of grid boxes that are dominated by different types of agriculture (e.g., beef, dairy, or hogs),

and I wonder if the atmospheric observations provide a sufficiently strong constraint to differentiate among these different grid boxes.

Lines 525 - 530: I think that this study provides speculative evidence that manure emissions are driving the discrepancy between top-down and bottom-up emissions, but I'm not convinced that this study makes that link definitively. I think this explanation is an interesting hypothesis that meshes well with a few recent studies. With that said, I think the phrasing in this paragraph is much stronger than what the inverse model actually supports. This statement also goes back to a previous comment about whether the aircraft data are sufficient to differentiate among different types of agricultural facilities.

Lines 548 - 556: I would combine this paragraph with the previous paragraph. I didn't quite understand the purpose of this paragraph or how it related to the research in the manuscript when I started reading it because this paragraph doesn't really have a topic sentence.

Fig. 5: The change between prior and posterior seems very large for the northwest corner of the domain. There's also a lot of agricultural activity in that region. Do you think the inverse model is correctly attributing the increase in methane fluxes to wetlands (versus agricultural emissions)? The results using the 4-DVAR inverse model in Fig. 7 do not show the same change between prior and posterior across that part of the domain, and that makes me wonder about the results for this region of the model domain.

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