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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Quantifying methane emissions from Queensland's coal seam gas producing Surat Basin using inventory data and an efficient regional Bayesian inversion" *by* Ashok K. Luhar et al.

Anonymous Referee #2

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The manuscript presented by Luhar and co-workers presents an analysis of methane emissions from a region in Queensland, Australia, that contains a mix of different source processes of which coal seam gas prodution is the one mostly targeted and discussed in the study. Overall the study used valid and up to date methods. The manuscript is well structured and easy to follow. Quantifying uncertain methane emissions on the regional scale by in-situ observations and atmospheric inversion techniques is an important task supporting emission reductions and as such the study deserves publication. However, the authors should include some additional discussion

of how their results may be used in the future by gas companies and/or authorities. I recommend the manuscript for publication after a number of minor issues (as listed below) are addressed/clarified by the authors.

Minor comments

Page 1, Line 2: Why is the term 'efficient' used in the title? What is efficient about this inversion approach? Further explain or omit from title.

P2, L58: Given the involved uncertainties in transport and inverse modeling, 'verification' may be a too strong term. Validation is often the preferred terminology.

Figure 1: A zoom into the study region including the location of the observational sites would be useful. This would also help to understand any orographic features of the domain.

P4, L90: Were the inlets mounted on small towers or on rooftops? Please briefly mention even if described elsewhere.

Bottom-up inventory: Which emission processes were separated for the agricultural sources? Enteric fermentation, manure handling, etc.? The information in the supplement is very brief and I was not able to obtain the cited report by Katestone. Since this is the dominating emission source in the area, it would be good to give a few more details and also to briefly discuss the uncertainties in these estimates.

P6, L145: What was the number of cattle in the feedlots? How do the emission factors per livestock unit compare between feedlots and free range? How were emissions from animal waste treated in the two cases?

P7, L164f: What is this rough estimate based on? It seems to be rather large considering that the main source is cattle and per livestock emission factors are more certain than 50 %. Is the livestock number that uncertain?

Figure 3: What is the reasoning about showing these specific towns? Is there any

larger population in the area?

Section 4.3: The analysis in the supplement is quite useful. How dose the wind rose comparison look for the filtered observation data. Does it improve? What is the mean bias for the filtered data? Next to wind speeds, mixing layer heights are critical when doing regional scale transport modeling and emission inversions. How is the mixing layer height treated in TAPM? Is there any way of comparing mixing layer heights for the target area and period or are their previous evaluations available for the model?

P12, L249f: Another important source of uncertainty is that of representativeness of the point measurement for the model grid cell (5x5 km). What are the observations compared to? Simulated values interpolated to the location of observation or grid cell containing the observation site? Are there any important sources in the closer vicinity of the sites (<10 km)?

P13, L282: Not immediately clear what top 5 % refers to. How do these top 5 % simulated events compare to the observations? Are these also the highest observed concentrations?

P19, L405ff: So if I understand this correctly, the source receptor relationship for a time t is constructed from output of c* at different times according to the value of tr at individual grid points. First, I am wondering if this could be illustrated for an example case where one would show the field c* for a given time and then the reconstructed source receptor relationship for the same time. Second, it seems that there will remain some form of smearing out of the transport history in time. How much does this conflict with filtering data by time of day instead of using the complete data set. Also what was the rational of using hourly data in this case instead of working with longer aggregation times for which the effect should be smaller?

P20, L436: What about the sub-grid variability of these sources? Is it kept for the transport simulation and a factor for the larger grid boxes optimised or is the emission flux constant within the large grid boxes. What about the different source categories?

Are they treated separately as was done for the forward simulation? Not clear from this description, later on it becomes clear that only total emissions are optimised.

P21, L460: Does high probability mean small uncertainty of the posterior? That would be surprising when starting from larger prior uncertainties.

P21, L461: Above, it was speculated that the uncertainty of the bottom-up approach was 50 %. Here it is suggested that 0.5 % should be used in an inversion. That seems to be a contradiction. Please elaborate on the small sigma_p. Also, is sigma_p the uncertainty of the total emissions in the inversion grid or that of individual grid cells?

Section 6.1: Usually, one would add random or auto-correlated noise to the synthetic observations as a test up to which degree of uncertainty the inversion can obtain useful information. Was this not done here at all?

Page 21, L464: How would the results change if only the synthetic observations were used at times when valid (filtered) observations were actually available? The latter was a considerably larger number of observations, so it is not clear how the results presented in this section can be propagated to the inversion with the more limited data set.

Section 6.2: Next to the posterior emissions it would be good to show simulated time series (synthetic obs, prior, posterior) and some performance stats in order to get a feeling for the inversion performance. This is done later on with additional forward simulations, but it should also be done with the concentrations directly obtained from the source receptor relationships and the coarse resolution emission setup as used in the inversion. Something to add to the supplement.

P22, L491: I don't like the terminology "no prior". There is a prior! Why not call the case "uniform" prior, which would describe the used PDF.

Section 7.1.3: Again it would be useful to see simulation performance for the three uncertainty levels.

P23, L535: So if the best estimate results from using a Gaussian prior distribution, I wonder why an MCMC approach was used at all. Wouldn't it be much more efficient to use the analytical solution of the Bayesian theorem for Gaussian PDFs in this case?

Figure 11b: Why not show the relative posterior uncertainty? Couldn't this be more directly compared to sigma_p?

P25, L551: Not clear which grid point this is referring to. Why is it relevant?

P26, L577: Give information on which case 3 inversion is used here (sigma_p=?).

P28, L611ff: This argument could also be supported by comparing the emissions from the non-CSG sub-domain. Do they differ significantly between bottom-up and posterior? If so, what are the possible reasons?

P29, L629: Which sigma_p level?

Figure 14: Include uncertainties. That would allow judging of how well 3-monthly emissions are constraint and if there is a real difference with time. Other studies have shown seasonality in agricultural emissions. Could this be a possibility here as well? Or does it have to do with a seasonality in the source receptor relationships?

Technical comments

P1,L21: 'identical TO' ...

Figure 5: Add explanation of dashed line to figure caption.

Figure 8: It seems to be more logical to start with the bottom-up emissions on the left (8a) and show the posterior on the right (8b).

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