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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Inverse modelling of European CH_4 emissions during 2006–2012 using different inverse models and reassessed atmospheric observations" *by* Peter Bergamaschi et al.

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This study presents a multi-model top-down assessment of European methane emissions using the European measurements network. As mentioned, these measurements are performed with the aim to verify bottom-up inventories reported to the UNFCCC. As such this study can be seen as an assessment of where we are in this process, extending the number of years that were reported in a previous assessment. The results highlight the importance of taking into account natural emissions of methane. Combining natural and anthropogenic emissions the reported total for EU-28 ends up

in close agreement with the inventories. The study is a useful reference, and as such it makes a good contribution to ACP. However, as will be explained below, it also misses some useful opportunities to add value to the previous assessment with the potential to substantially increase the significance of this work. Having gone through the major effort of organizing this model inter-comparison already, the points listed under 'discussion' should receive serious consideration in my opinion.

We thank the reviewer for the very positive overall evaluation of our study.

DISCUSSION

In the context of emission verification, testing the EU-28 total is relevant, however, the network probably resolves additional independent pieces of information. The question is how many, and what this means for the capacity of the European network to resolve country scale emissions. This applies not only to average emissions, but also to their trends. One may argue that in the framework of the COP21 climate agreement the ability to evaluate trends is even more important than the average. Looking at the results that are presented, information about trends is clearly visible in the time series, but to my surprise it is not discussed at all. Even if it turns out that these trends are not significant it is useful to quantify and discuss how far we are from this target. It is a bit surprising that the multi-year time dimension, which is the new element of this study compared to the previous one, is left unexplored.

The anthropogenic CH4 emissions reported to UNFCCC have indeed decreased between 2006 and 2012 by 11.6%. The models show rather smaller trends (which are in most cases indeed probably not significant). An evaluation of the uncertainties of the trends, however, is very difficult, since this requires information about the error correlations between subsequent years (which is not available). We will include a short discussion of the trends in the revised version.

A useful attempt is made to assess biases in transport models using vertical profile measurements. However, what is missing is the link between these biases and the *inverted emissions. It is mentioned that those models that overestimate PBL average CH4 should overestimate emissions. In fact, all the ingredients are available to quantify this link and assess the impact of transport biases on emissions. It raises the question why this is not done. Is it an important factor explaining the range of emission that are found or not?*

Following the suggestion of the reviewer we analyzed the relationship between the estimated relative bias (based on the enhancement compared to the background integrated over the boundary layer) and the model emissions in the area around the regular aircraft profiles sites. The analysis showed significant correlations between model emissions and estimated model bias. We will include this analysis in the revised version.

SPECIFIC COMMENTS

page 4, line 6: Which targets are set by the quality control mentioned here? Are they met?

No specific threshold values have been set. The typical range for the "working standard repeatability" is $\sim$1-4 ppb. Since this "working standard repeatability" is used by the inverse models, measurements with higher "working standard repeatability" are weighted less in the inversion.

page 5, line 16: Using constant a priori flux uncertainties also? How do these emissions / uncertainties relate to those of the other scenarios?

For inversion S3 very large uncertainties of the homogeneous a priori fluxes were assumed (ranging between 200% and 500% per grid-cell and month; see model description in the supplementary material) in order to give the inversion enough degree of freedom to retrieve regional emission hot spots (which have much higher emissions than the applied homogeneous a priori fluxes). In contrast, the assumed uncertainties per grid cell and months are much smaller for the other scenarios (typically 100%).

page 5, line 24: Do the regional models (apart from NAME) prescribe boundary conditions, or allow further optimization?

Apart from NAME, the boundary conditions are further optimized also in CHIMERE, while the other regional models used prescribed boundary conditions. These boundary conditions were derived from optimized concentrations of global inversion systems (STILT: from TM3, COMET: from TM5-4DVAR, CHIMERE: from LMDZ).

page 8, line 10-15: It would be good to mention some typical numbers here for the bottom up and top down derived seasonal amplitudes (it is not so clear to see from figure 4)

We will add the numbers of the derived seasonal amplitudes in the revised version.

page 8, line 30-35: How about the seasonality in the energy sector? (domestic heating etc.)

No or only small seasonal variations were found in the limited number of studies investigating natural gas distribution system [Wennberg et al., 2012; McKain et al., 2014]. Wong et al. [2016] argued that "the natural gas distribution pipeline system is pressure-regulated at several points, and leakage should be independent of consumption to first order", but that natural gas storage facilities may have seasonally varying leakage rates, depending on energy demands.

page 9, line 7: The difference between the observed vs simulated amplitude of variability (as used in Taylor diagrams for instance) provides a piece of information that is more independent from correlation as the RMS that is used here.

Following the suggestion of the reviewer we will analyze also the difference between the observed vs simulated amplitude of variability.

References

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