Atmos. Chem. Phys. Discuss., 9, C8836–C8840, 2009
www.atmos-chem-phys-discuss.net/9/C8836/2009/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Inverse modeling of European CH_4 emissions: sensitivity to the observational network" *by* M. G. Villani et al.

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Received and published: 22 December 2009

Replies to the second reviewer's comments

Specific comments

1. *" P.21078 what was the magnitude of estimated "model representativeness error" ? Why 50%? "*

   We chose 50% on an arbitrary base. We assumed this value to represent a proper estimate for potential errors (see also the answers to the third reviewer).

   However, we did not perform analyses with larger or smaller percentages. In the revised manuscript, we will provide values for the estimated "model representativeness error".

2. *" P.21080 control vector? Please explain. "*

   The control vector x represents a set of model parameters with a corresponding background error covariance matrix B. In our case, the control vector can be written as $x = \left(s^T, c^T\right)^T$, where s is the monthly-mean surface emissions, and c is the three-dimensional concentration field at the start of the assimilation window (from Meirink et al., 2008).

3. *" P.21082 'a typical boundary layer station'– during the day this will be true (i.e. when you take the observations) but during the night this could very easily be above the boundary layer. Therefore can a tower be described as a boundary layer station?"*

   We do agree with the reviewer. In the revised manuscript we will add: 'a typical boundary layer station during daytime" .

4. *" P.21084 units in ppb/(kg/s) – I assume this is per grid box? "*

   Units are in ppb/(kg/s). They do not depend on the grid cell size.

5. *" P.21084 over all of Europe but can be effective on small regions. "*

   Indeed this is true, in particular on areas close to single stations. In the revised manuscript we can include at pg 21084 after line 27:" However, it can be effective on small regions close to its location."

6. *" P.21085 All of the values are reported in this page with no uncertainty. E.g. "are 45% lower than" etc. Surely there is not one single value? With all the sensitivity analysis this is shown very clearly. I think ranges would be much more appropriate. "*

   Total emissions at the country scale were calculated by adding the values at the pixel-grid scale within the region analysed. Therefore, the difference between the known total true emissions and the total emissions calculated in scenarios S1-S3, already represents a measure of the error in our synthetic experiment framework. To include ranges, we would need to perform the calculation of the *a posteriori* uncertainty estimates, which is currently not implemented in our semilinear 4DVAR system (see details also in Bergamaschi et al., 2009).

7. *" P.21087 MHD, CB4 and SIL all show reasonable sensitivities in this region so I think it is a bit strong to say "no observational sites". "*

   None of the three stations have a proper sensitivity to retrieve the high emitting areas over the North Sea (fig. 3 and fig. 4). Furthermore, the influence of a single station is modified when considering scenarios with a larger number of stations in the observational network. By analysing results from scenarios S1 to S3, we noticed that adding more stations close to the GBout area, helped to retrieve emission patterns closer to the true ones (see fig.4). However, we can take the reviewer's point and we can modify the sentence as: "(there are few observational sites located close to the GBout area)"

8. *" P21088 The inability of the method to find the emissions in the North Sea is a limitation of the need to use a priori constraints. "*

   The authors do not fully understand the point raised here..

9. *" P21089 As individual grid cells should not be "over-interpreted" could not the inversion be performed at a coarser scale and produce similarly accurate results? "*

   This could definitely be done, similarly to other studies (e.g. Bergamaschi et al., 2005), which aimed at optimizing emissions at coarser resolution- regional scale. However, inversions performed at a coarser scale have the disadvantage that continental stations will not be adequately represented. Furthermore, this test would be beyond the scope of our work, as here we want to analyse our current TM5-4DVAR system setup, and its capability to retrieve emissions at the highest resolution of 1x1 degree.

10. *" Conclusion – this method of testing is good and useful but it should be noted that not all stations can be equally well modelled in reality e.g. mountain stations, coastal station etc. "*

    We definitely agree with the point raised by the reviewer. We are aware of the problem of assessing the representativeness/reproducibility of sites such as mountain, coastal stations, and more in general stations over heterogeneous terrains. The issue becomes even more relevant when these stations are considered in global models operating at a coarse resolution (e.g. 3x2 or 6x4 degree), which might detect physical and chemical processes occuring at the subgrid scale.

    Given the simple setting, we do not expect our method to provide results directly applicable to real cases, as stated in the introduction, since we are not considering major issues (such as the one just mentioned) to tackle in real case scenarios. Our study becomes relevant to set thresholds indicating the limits and potential of our model framework.

Technical corrections

1. *" P21089 "The issue is currently investigated more closely" – please re-word. "*

   We will correct this as: "We are currently investigated why grid points close to boundary layer stations show a clear tendency to overestimate *a posteriori* emissions."

2. *" P21090 "to design and optimal" – replace "and" with "an" "*

3. *" P21090 "In absence" - add a"the" "*

Items 2 and 3 will be corrected in the new version.

References

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Meirink, J. F., Bergamaschi, P., and Krol, M. C.: Four-dimensional variational data assimilation for inverse modelling of atmospheric methane emissions: method and comparison with synthesis inversion, Atmos. Chem. Phys., 8, 6341–6353, 2008.