Atmos. Chem. Phys. Discuss., 8, S6677–S6679, 2008
www.atmos-chem-phys-discuss.net/8/S6677/2008/

Atmospheric Chemistry and Physics Discussions

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8, S6677–S6679, 2008

Interactive Comment

Interactive comment on "Technical Note: Four-dimensional variational data assimilation for inverse modelling of atmospheric methane emissions: method and comparison with synthesis inversion" *by* J. F. Meirink et al.

J. F. Meirink et al.

Received and published: 4 September 2008

We thank the reviewer for his/her comments. Here is our point-by-point reply.

P12025, L15-24: By 'adjoint technique' we refer to the technique used in the studies by Houweling et al. and Kaminski et al., in which the adjoint model is used to calculate the adjoint sensitivity of emissions to perturbations in the observations. Doing this for all observations yields a complete characterization of the transport matrix, after which the optimal solution can be easily calculated. By saying that 'other techniques are required', we do not mean 'techniques that do not use the adjoint model', but 'techniques that can handle large amounts of observations in combination with a large

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control vector (which the convential synthesis and adjoint techniques cannot handle)'. Indeed, 4D-Var uses the adjoint model, but it also uses the forward model, just like the synthesis inversion! To avoid confusion we add '(the latter of which also uses the adjoint model)' in line 22.

P12028, L8: The machine precision may depend somewhat on the representation of double precision (64 bits) numbers in computer memory. In our case we found that it was about 10^{-14}. This is a typical number (see e.g. S. Prata, The Waite Group's C Primer Plus, Third Edition, ISBN 1-57169-161-8, p. 64, 1999).

P12032, L19: Thanks for pointing this out! The formulation was actually not correct. The representativeness error estimate is based on the modelled concentration *differences* with neighbouring grid cells (instead of gradients). With increasing resolution, these differences will generally decrease, leading to a lower representation error as should be the case. The text has been corrected.

P12033, L23-25: As the text states, this factor of 2.5 was chosen to arrive at the same globally aggregated prior uncertainty in both scenarios, so that (global) uncertainty reductions would be better comparable between the two scenarios. Indeed, multiplication by a factor 2.5 leads to large *grid-cell* prior errors of, for example, 200% for wetland emissions. It is difficult to say whether this makes sense. Certainly, prior errors much larger than 100% imply a significant probability of negative emissions, which is not realistic. On the other hand, 200% higher grid-scale emissions than the prior estimate may be perfectly reasonable for wetlands in many places. However, we want to stress that the multiplication factor was adopted merely for technical reasons, i.e. to make the two scenarios better comparable.

P12038, L18-19: We agree with the reviewer, and have modified the text to: 'A useful diagnostic, indicating whether the assimilation may not be optimal, i.e. measurement and prior errors have been improperly set, is ...'

P12038, L25: We did not state that Eqs. (12) and (13) were equivalent, but Eqs. (11)

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and (12). These equations are really equivalent, also if the system is non-optimal.

P12041, L5-9: The reviewer has a point here. High-resolution (in time and/or space) observations are very likely to have correlated errors. Taking these error correlations into account is indeed difficult, not so much because a non-diagonal **R** matrix has to be inverted, but mainly because one generally has no idea what the error correlations look like. We have added the following sentence in line 7 (addressing at the same time a comment from the second reviewer): 'It has to be noted that these advantages weaken considerably if the prior error correlations of emissions and observations cannot be properly determined, which is unfortunately often the case.'

Interactive comment on Atmos. Chem. Phys. Discuss., 8, 12023, 2008.

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