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Interactive comment on "Sensitivity analysis of methane emissions derived from SCIAMACHY observations through inverse modelling" *by* J. F. Meirink et al.

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General comments:

This paper describes Observing System Simulation Experiments (OSSEs) to show the effect of various error sources on the estimation of CH4 surface fluxes from SCIAMACHY observations. A 4D-Var set-up is used for the inverse problem. The paper concludes that SCIAMACHY observations at a precision of 1 - 2 % will contribute considerably to uncertainty reduction in methane source strengths. The study shows interesting results, but it would have been nice if inversions with real data were included

or at least commented on. An OSSE is a good tool to get a feeling of the various error components, but real data contain (almost) always more error sources. Also, the effect of systematic errors is often the most critical component of using real data for flux inversions. Flux inversions obtain their information from the gradients in the measured tracer concentrations, which means that any regional bias will create artificial gradients and therefore incorrect surface fluxes. The authors are very brief in mentioning these systematic errors in their conclusions. I think it the paper coyuld be much improved by also taking the effect of systematic errors into account. Finally, how do these inversion simulations compare to the error reduction in flux inversions from surface observations.

Specific comments:

Page 9412: The notation in Equation 1 should be consistent. Either use x instead of v in the background term or use v instead of x in the observation term. Keep this consistency in the notation below the equation as well. Also, the description is for a general 4D-Var system where only the initial state is perturbed in the minimization. Adding the (monthly mean???) flux to the state vector assumes a flux model equal to the identity matrix. Adding this disctinction between the model transport and the static flux model would help the presentation of the 4D-Var.

Page 9412, line 6: A more technical point: the term background or a priori is generally used for the vector Vb, while the first-guess is the starting point for the minimzation. Most of the time the background is used for the first-guess.

Page 9413: Did the authors consider adjusting the correlation lenght scales to reflect land-sea contrast in the surface fluxes? I realize this would complicate the set-up of the 4D-Var, but it seems quite important to me. Fluxes over ocean are definitely not correlated with fluxes over land.

Page 9413, bottom: The NMC method used in this way only accounts for the errors in the model transport. It neglects errors and error correlations in the starting fields of methane used for the 24 hour and 48 hour forecasts.

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Page 9415, 1st paragraph: What is the effect of CO2 variability on this normalization method?

Page 9420, line 27: for clarity, please add the word 'incremental' to 'the result of the inversion'.

Page 9421, line 27: I think this is a bit overstated. There is still significant aliasing of the incorrect initial methane distribution into the estimated fluxes.

Page 9423, section 3.2.1: Is only the observation error covariance matrix changed for these experiments or are the actual errors of the simulated observations changed as well (as they should)?

Page 9425, bottom lines: This is always a trade-off when there is insufficient information from the observations. One can either increase the background constraint by (in this case) increasing the correlation lenght (to a value that is most likely incorrect), or leave more freedom to the inversion with the risk of creating spurious small scale variability

P9429: I didn't see any comment on the contribution of transport model errors to the estimated fluxes. These can be quite significant. Please, comment on that at least in your conclusions.

P9440: In Figure 4b, why are the column-averaged mixing ratios much lower over high terrain (Greenland and Himalaya)? Is this purely an effect of vertical gradients in methane?

Interactive comment on Atmos. Chem. Phys. Discuss., 5, 9405, 2005.