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Atmospheric Chemistry and Physics Discussions

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.

Anonymous Referee #2

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The paper by Meirink al. presents an up-to-date method of atmospheric inversion to optimize surface emissions of methane from atmospheric observations, based on 4D-VAR formalism. The paper presents the method and comparison with a previous inversion by Bergamaschi et al. (2007). The 4D-VAR method is an update of previous work (Meirink et al., 2006). The changes made (transport model, algorithm, treatment of posterior uncertainties) justify, for me, the publication of a new paper, although a lot of the basics of the method has been published in previous papers. I find the paper well-structured and clearly-presented. 1 have a series of comment/questions below.

As the paper is not only technical, I suggest to remove “technical note” from the title.

Page2 – col2 : OH Fields : On what times scale is performed the MCF calibration ? Yearly ? monthly ? This should be said because for certain years, MCF calibration produces large changes in OH seasonal cycle. What is the year of MCF observations used to optimize OH ?

Page2 – col2 : “Most complications encountered were related to the merging and division of grid cells, which occurs in the communication between parent and child regions and in the reduced grid that is applied near the poles to ensure numerical stability at reasonably large time steps.” Please provide more clear explanations and precisions on these technical points.

Page3 – col1 : “and p contains any additional parameters, which account, for example, for a bias in the measurements“. These p parameters seem a bit strange to me. Biases are a m ajor problem of inversions as most formalisms assume unbiases variables. The introduction of additional parameters to optimize may be interesting but introduces subjectivity in the system : what is their form ? how do you weight them as compared to other elements of the control vector ? More precisions are to be given here on p

Page3 – col2 : Don’t you think that writing make more clear (qualitatively) that inversions produces an error reduction as compared to B ?

Page4 – col1/2 : “The measurement error is assumed to be 3 ppb….” : please give at least an idea of the range of errors or of the typical errors (marine sites, continentals sites, polluted sites, mountain sites, ..) used at the end in the inversion.

Page4 – Col2 : “In the second cycle only those observations are assimilated that differ less than three times the observation error from the posterior model

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simulation of the first cycle.” Please precise that this trick is applied to avoid interpreting errors in the transport model in terms of surface emission changes with elements having a large weight in the cost function..

page4 – col2 : “The major difference between the present inversion and B07 is …” : is it the only difference ? observations & errors are the same ? Version of TM5 model is the same ? OH field is the same ?

page5 – col1 : “At the end of the inversion, the mean grid-scale uncertainty reduction reaches a value of around 5%” : please also indicate a range and the location of the pixels with the maximum error reduction.

Page5 – col1 : figure 3 appears before figure 2 in the text. Please invert the order of the two figures.

Page5 – col1/2 : The discussion of differences between B07 and the 4D-VAR would be more clear if a map of differences was provided as figure 2c. Page5 – col2 : about difference in Asia : did you try an inversion with even larger correlation length and does it change this result of the 4D-VAR ?

Page 5 – col2 : “synoptic-scale events are captured” : it hard to say on figure 4 with a full year plotted. Maybe add a zoom over a 3-month period would help justifying this sentence ?

Page6 – col2 : “For the reference inversion, a value of _2=n = 1:30” a Chi-2 significantly above 1 means that too much weight (too small errors) is put on observations. You may precise this point here.

Page7- col1 : “It should be noted that _2=ns is considerably influenced by the 2-cycle inversion approach (see Section 2.3)”. What is the chi-2s before the 2nd inversion ? It could be interesting to give it here.

Page7 – col2 : “The possibility to estimate emissions at high resolution is a major advantage of 4D-Var compared to the traditional synthesis approach, since

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…” Yes, … but you also illustrate the importance of properly setting error correlations to propagate information in the space domain. You illustrate the sensitivity of the correlation length on your results. I suggest to precise the sentence by saying that this is an advantage of 4D-VAR only if error correlation can be determined objectively. Also, exponentially decaying correlations may not be the totally adapted to represent error correlations of processes that can be largely influenced by weather or soil parameters (which break the isotropic hypothesis of the exponential decay) such as wetland emissions for instance. I suggest to be more careful on this advantage of 4D-VAR since estimation of error correlation is a hot topic of the moment.

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

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