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Atmospheric Measurement Techniques Discussions

Interactive comment on "Reduced-Cost Construction of Jacobian Matrices for High-Resolution Inversions of Satellite Observations of Atmospheric Composition" *by* Hannah Nesser et al.

Anonymous Referee #2

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Review of Reduced-Cost Construction of Jacobian Matrices for High Resolution Inversions of Satellite Observations of Atmospheric Composition.

My first comment (and very important one) here is that this paper has nothing to do with atmospheric measurement techniques and therefore its exact home is GMD and not AMT. Specifically, no "new" measurements are collected or discussed as part of this paper or for that matter no new measurement techniques are also suggested as part of this paper. [Outside the scope of the Journal]

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Discussion paper

The authors suggest two new techniques for reducing the cost of computing the Jacobian i.e., reduced rank and reduced dimension methods. First, these are not the only way to reduce the computational size of the problem.

(1) The generally accepted solution to reduce the size of the problem is the one suggested in the paper: "Measuring information content from observation for data assimilation: relative entropy versus Shannon entropy difference" and I would suggest the authors to review this paper. Thus, I would like to see the techniques suggested in this paper in comparison to those mentioned in the paper mentioned above. Note, these issues are nothing new and have been dealt with since 1974. (see paper the information content of remote measurements of atmospheric temperature by satellite infra-red radiometry and optimum radiometer configurations.). Eventually, it is the question of the information content of the observations and not reducing the size of the Jacobian or the information content as expressed through an Averaging Kernel. I would like to see the difference in the answer as received from the method described in Xu's paper in comparison to what is shown in this paper.

(2) Please also look at the paper "Stable Signal Recovery from Incomplete and Inaccurate Measurements from Candes, Romberg and Terence Tao" to understand the mathematical theory behind it. For application in atmospheric inversions see: A sparse reconstruction method for the estimation of multi-resolution emission fields via atmospheric inversion

(3) Following with the previous discussion if you have prior information, then you can aggregate grids where you do not have any chances of encountering methane fluxes without doing a two-step inversion. What is the point of solving for methane fluxes in the deserts of Nevada, Utah and Arizona (see Figure 2 in paper; you have regular grid) unless you expect deserts of Nevada to be big sources of methane emissions? For example, if you do this exercise globally then you would not be solving for methane fluxes in Sahara Desert (no unique information is provided by multitude of observations, even if theoretically a satellite can collect thousands of them). Hence even if the trace of

the averaging kernel might show that you can better resolve fluxes in the Sahara Desert solving for these fluxes would be just meaningless implying that you can aggregate your grid.

(4) Please also remember that once you go from coarser resolution to finer resolution your posterior variance of the inverse problem is guaranteed to increase. Hence, please explain or mathematically show how does the reduction in posterior variance translate from coarser resolution to finer resolution (not in terms of R i.e., correlation). Can an upper bound be found and does it have spatial structure i.e., what has happened to the error you obtained from the inversion (second part of equation 2)? Furthermore, what has happened to the trace of the averaging kernel. How has it distributed your trace at finer resolution?

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