Atmospheric
Chemistry
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Discussions

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Interactive comment on "TransCom N$_2$O model inter-comparison, Part II: Atmospheric inversion estimates of N$_2$O emissions" by R. L. Thompson et al.

Anonymous Referee #2

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1   General comments

The authors studied the estimates of N$_2$O emissions from five inversion frameworks. They are doing a rigorous study imposing the same constraints on each inversion system (priori emissions and N$_2$O observations). They first compared the atmospheric N$_2$O as simulated by the systems using the posterior fluxes. Then they compared the results of the inversion systems in terms of posterior emissions.

Using 5 systems is one of the strength of this paper. This allows to highlight the parameters that influence the results of the inversion process. That also allows to produce

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the uncertainty associated with the estimated emissions.

The discussion of the results is very well conduced. The comparison of the result with results from independent study is welcome. The list of key results in the summary is appreciated. Overall, the paper is suitable for ACP.

2   Specific comments

• page 5273, line 1: The abstract is focused on the N_2O emission estimates. One line could be added on the validation with atmospheric observations.

• page 5273, line 3: It could be useful to precise that the atmospheric inversion are performed using chemistry transport model (CTM). This would explain for example why they can use different meteorological data (next line).

• page 5275, line 21: "posterior emissions" should be defined so that all readers could understand that these are the result of the inversion process.

• page 5277, lines 4 to 9: Iterative descent algorithms do not necessary require the gradient (even if this is usually the case for geophysical applications). Please rephrase. Lines 12 and 13 should be changed accordingly. Analytical methods can also work with a non linear operator H as soon as the operator is differentiable and its linear $\mathbf{H}$ is defined. Then Eq. 3 can be

$$\mathbf{x} = \mathbf{x}_b + \mathbf{B}\mathbf{H}^T(\mathbf{H}\mathbf{B}\mathbf{H}^T + \mathbf{R})^{-1}(\mathbf{y} - H\mathbf{x}_b)\,.$$

An outer loop can then be implemented in order to have a better approximation of $\mathbf{H}$. Please rephrase the paragraph.

• page 5277, line 10: Eq. 2 should be

$$\mathbf{x} = \mathbf{x}_b + (\mathbf{H}^T\mathbf{R}^{-1}\mathbf{H} + \mathbf{B}^{-1})^{-1}\mathbf{H}^T\mathbf{R}(\mathbf{y} - H\mathbf{x}_b)$$

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• page 5277, lines 10 and 11: Eqs. 2 and 3. The left hand side of the equation could be $\mathbf{x}_a$ instead of $\mathbf{x}$ and you could specify that $\mathbf{x}_a$ is the posterior emission.

• page 5277, lines 15 to 19: The sentence is too long and not clear. Please clarify.

• page 5278, lines 2 to 7: For people that are not familiar with inversion, it is difficult to understand why the methodology needs a spin-up period and why the last year is not well constrained. Please add a reference that explain this or provide justification.

• page 5281, lines 6 to 8: It's not clear to me how the "observed annual mean meridional gradient" was derived from the observations. Is the explanation can be found in the following sentence? Or does the following sentence explain how the gradients are computed from the model? Please add more details on how the gradients are computed (from both the observations and the models).

• page 5281, line 11: Please clarify if the agreement is for all the models. Does the correlation coefficient $R^2 > 0.9$ mean that the correlation coefficients between each model and the observations are all greater than 0.9? Moreover, instead of "observed gradient at the surface", wouldn't it be better to use the term "gradient derived from observations at the surface"?

• page 5281, lines 11 to 14: Why do you discuss the case of MOZART4-I and you don't discuss the results of all the other models?

• page 5283, lines 5 to 7: Do you mean that at MLO, all CTMs simulate a too early minimum, as it was also the case from the simulations using the a priori emissions? Please rephrase. Please also rephrase the second part of the sentence with for example: "The amplitude of the seasonal cycle in the simulations using the a posteriori emissions is closer to the observed amplitude (compared to the amplitude from the simulations using the prior emissions)."

• page 5284, lines 23 and 24: The a priori is not plotted Fig. 5. This makes the last part of the sentence difficult to see ("close to that a priori"). Would you please add the

a priori map of N$_2$O fluxes on Fig. 5?

• page 5286, line 10: Could you add a horizontal line on each panel of Fig. 9 with the median value for the region?

• pages 5291 to 5293, summary and conclusions: One useful information you could add is a summary of the parameters that influence the most the inversion. For example the inter-hemispheric exchange time is one of them as discussed Sec. 3.2.1. The way the observation are assimilated (monthly/weekly means versus sampled time) is another one as also discussed Sec. 3.2.1. Moreover, Sec. 3.2.2 explains the difference in the posterior estimates by a lack of observation in some regions. Would it be possible to add a paragraph on where we should have more data in order to reduce the uncertainty in the estimations?

3   Minor revisions/comments

• page 5275, line 22: "analyse the posterior emissions" instead of "analyse the emissions"

• page 5275, line 23: "and investigate their cause" instead of "and their cause"

• page 5277, line 2: "the minimum of the cost function (Eq. 1) is searched" instead of "is found".

• page 5277, line 2: "Approaches for finding x that minimises" instead of "Approaches for finding x to minimise"?

• page 5277, line 15: Pleas insert "(see Table 2)" at the end of this sentence.

• page 5277, line 19: "changed" instead of "change"?

• page 5279, line 24: "nmol.mol^{-1}" instead of "nmol mol^{-1}"?

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• page 5283, line 12: "the latitude of MLO" instead of "this latitude".

• page 5284, line 18: "MOZART4-I" instead of "MOZART-I".

• page 5284, line 23: "global spatial distribution" instead of "global distribution"?

• page 5284, line 28: " i.e. the annual mean posterior flux minus the annual mean prior flux" instead of "i.e. the mean posterior minus prior flux"?

• page 5286, line 8: "there is" instead of "is there"?

• page 5286, line 10: "plus or minus MAD" instead of "and MAD"?

• page 5299, Tab. 1: Could you centre "Resolution" on top of "spatial" and "temporal" in the header of the table? Same for Tab. 2.

• page 5304, Tab. 5: the NIES and MPI-BGC do not appear in Tab. 4.

• page 5307, Fig. 1: "atmospheric N_2O observations" instead of "atmospheric observations"? Could you have two panels for this figure, one with the global map and one with a zoom over Europe as it seems that there's a lot of sites there?

• page 5308, Fig. 2: "with gradient derived from surface observations" instead of "with surface observations"?

• page 5309, Fig. 3: Could you please add a title at each panel. For example: "Surface / Jan.", "Surface / Nov.", "HIPPO / Jan.", "HIPPO / Nov.".

• page 5310, Fig. 4: The X-axes of the panels have no label.

• page 5313, Fig. 7: Do you need to have your colour bar ranging until 0.4? Looking at the plot, the value of 0.3 should be enough.

• page 5315, Fig. 9: You could add where to find the regions in the caption with for example: "for the 7 land regions (2 first rows) and 3 ocean regions (last row)". Same for the next figure.

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• page 5320, Fig. A3: You could change the limits of the Y-axis with respectively 0.5 and 1.1 ppb.yr^{-1}.

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