

## ***Interactive comment on “Impact of transport model errors on the global and regional methane emissions estimated by inverse modelling” by R. Locatelli et al.***

**Anonymous Referee #1**

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General comments:

The manuscript presents an interesting attempt to quantify the influence of transport model errors on emissions estimated by atmospheric inversions. The authors make use of already existing transport model simulations that were conducted in the framework of the TransCom CH<sub>4</sub> model intercomparison. The simulated CH<sub>4</sub> concentrations are all based on the same CH<sub>4</sub> fluxes and therefore concentration differences are assumed to represent the influence of model transport only. The simulated concentrations are used as synthetic observations in an inversion system and differences in the resulting optimized fluxes are interpreted as impact of model transport. This is

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an interesting approach as it directly quantifies the error in terms of flux differences. However, this can only give an estimate of the lower limit of transport model error impact because (1) the differences between the transport model simulations might still be smaller than the differences between model results and observations and (2) only one inversion system is applied. The authors are aware of these limitations. Furthermore the authors illustrate the misinterpretation of flux estimates that can result from an inadequate specification of transport model errors in the inversions.

The study can be a valuable contribution to better quantify and describe transport model uncertainties that are needed in inversion systems.

Overall, the paper is quite well written and well structured. However, it is rather lengthy for a straightforward modelling experiment like this. The paper could profit from shortening, in particular because it contains many repetitions. Moreover, the grammar and wording should be improved, maybe by one of the native English-speaking co-authors. Some suggestions for correction are listed below as technical comments but the list is definitely not complete.

Specific comments:

P 10963, L 8-10: This sentence is a central part of the abstract as it summarizes the set-up of the study. However, is a bit difficult to understand. Maybe you could explain in more detail what you mean by 'set-up'. The synthetic observations are produced by different transport models. So 'set-up' does not include the model but probably consists of fluxes and observations. Please clarify this important point.

P 10968, L 28-29: This comparison will only provide a realistic quantification of the transport model error, if the models cover the typical range of different transport models, otherwise the error could be underestimated.

P 10985, L 14-18: This seems to be pure speculation because the high emission estimates could be compensated elsewhere.

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P 10987, L 5-9: Also the vertical resolution of the models might play a role, in particular for the benefit from the use of aircraft profiles. Please comment also on this aspect.

P 10987, L 14-17: Does this small difference really imply that the actual number and location of measurement stations in Europe is sufficient to constrain the European fluxes? Please comment on this.

P 10989, L 20-24: This was just mentioned in Sect.3.1 not shown. Please rephrase.

P 10991, L 21-23: This statement follows from Saito et al. (2013). But it remains unclear if a larger interhemispheric gradient is more realistic. If there is any support from observations please mention it here.

Technical corrections:

P 10963, L 18: Should it not be 'involved' rather than 'invoked'?

P 10963, L 23: Don't you mean 'errors in the covariance matrix' rather than 'errors of the covariance matrix'?

P 10964, L 4: Is CH<sub>4</sub> given in volume ratio (ppbv) or mole ratio (ppb)? Usually, measurements are in dry air mole ratio. Your model results are also mole fractions, as you mention later in the text.

P 10965, L 23: Not the 'discrepancies' are limitations to further improvement but rather the 'deficiencies' in the models. From the discrepancies between the models we might even learn - as you nicely show in this study.

P 10966, L 1-3: The sentence is difficult to understand. Maybe replace 'that' by 'because'.

P 10966, L 3-4: 'solicited' and 'appariton' might not be the correct expressions.

P 10966, L 7-8: ...provides... ...requires...

P 10966, L 10: Moreover

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P 10966, L 16: Replace 'applying' e.g. by important or active

P 10966, L 22: ...into consideration...

P 10966, L 28: ... have shown...

P 10967, L 1: ...wind were... or ...wind was...

P 10967, L 26: ... participating in...

P 10968, L 23: ... emission pattern.

P 10969, L 5-10: Please give references for each model / model variant.

P 10971, L 17: Please specify: the maximum of which quantity?

P 10972, L 6: Could be misleading: Y contains just one set of synthetic observations for the whole period.

P 10973, L 2: Rödenbeck

P 10973, L 13: reconsider the choice of words, 'applying' seems strange.

P 10973, L 23-24: Better join both paragraphs.

P 10974, L 17-18: What is meant by 'measurements included in the PBL'? Please rephrase this to be easier to understand.

P 10974, L 21: The difference between NET2 and NET3 will provide this information.

P 10976, L 10: Explain already at this point how STD is split into synoptic and seasonal parts.

P 10976, L 20: The logical connection is 'area impacting these stations' rather than 'area impacted by these stations'.

P 10977, L 1: ... those simulated...

P 10977, L 2: This is not a consequence, remove 'Consequently'

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P 10977, L 10: reconsider choice of words: 'deriving' does not fit.

P 10977, L 19: ... transport of signals from remote methane sources.

P 10977, L 20-22: What is meant by 'amplitude variability'? Please clarify this sentence.

P 10977, L 23: ... is only 2 ppm.

P 10978, L 4: reconsider choice of words: 'solicited' does not fit.

P 10978, L 11-12: ... distinction can be made. ...

P 10978, L 15: These are not the 'smallest' differences. In fact differences are very large, however, the differences are negative. Please rephrase the sentence.

P 10978, L 17: But TOMCAT shows high values around 50N. Please specify in more detail what is meant by 'smallest difference'.

P 10980, L 22: ... yields higher average. ... and lower average. ...

P 10980, L 26: reconsider choice of words: 'exposes' does not fit in this context.

P 10981, L 1: '... derives higher estimates. ... and lower estimates. ...' or 'derives the highest estimates. ... and the lowest. ...'

P 10981, L 4: Time series ... show general. ...

P 10981, L 11: 'twice as large as' or 'two time larger'

P 10981, L 11: Not the average of the seasonal cycle amplitude is a factor of 2 higher than that of the target flux but rather the maximum amplitude.

P 10981, L 13: What is meant by 'emphasizes'? Please reconsider choice of words.

P 10981, L 21-22: ... black lines are the values of. ...

P 10982, L 25: ... relative to. ...

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P 10982, L 27: ...amplitude twice as high as. ...

P 10983, L 15: reconsider choice of words: 'exposes' does not fit.

P 10983, L 24: ... associated with. ...

P 10984, L 4: ..both coasts. ...

P 10984, L 17: reconsider choice of words: 'reminding'

P 10986, L 22: ... fluxes drop to ...

P 10987, L 19: ... what was obtained. ...

P 10987, L 25: ... statistical errors. ...

P 10988, L 25: Hegyhátsál

P 10988, L 8-10: The issue here is not the increase of the estimated emissions themselves but the increase of the differences to the target emissions.

P 10988, L 15-18: The logic behind this sentence becomes not quite clear. Maybe rephrase the statement.

P 10988, L 28-28: the errors are not 'given by the inversion' but 'used in the inversion'.

P 10989, L 7: ... took ... into consideration..

P 10989, L 18: What is meant by 'uneven surface observations'?

P 10989, L 24: ... take into consideration. ...

P 10990, L 20-21: ... IH transport differences play an important role .. one of the shortest IH exchange times.

P 10991, L 10: ... CH4 flux estimates.

P 10991, L 10: Specify what is meant by 'it'.

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Figure 12: The different colors in the maps are difficult to identify, in particular because the maps are very small and the colors in the color scale are partly difficult to distinguish. Better use a simple blue-white-red color scale.

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