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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 #2

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General comments

This manuscript examines the influence of model transport and representation errors on CH₄ emissions estimates from inverse modelling. The authors use a suite of 10 state-of-the-art atmospheric chemistry-transport models (CTMs) from the TransCom CH₄ inter-comparison as examples. Their method of inverting synthetic observations generated by the 10 CTMs in a single inverse system, i.e. PYVAR-LMDZ-SACS to calculate the error induced in the retrieved emissions is a novel approach for determining the potential influence of transport and representation errors. Their results show that these errors alone (i.e. excluding errors in the CH₄ sink etc.) represent a significant

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error in CH₄ emissions estimated by inversions, which is likely to be at least 5% of the global total CH₄ emission and substantially more at regional scales.

I recommend this manuscript for publication in *Atmos. Chem. Phys.* after minor revisions (as outlined below) have been made. Also before publication, English language editing is needed, especially for the use of articles and punctuation but also to improve the general readability of the manuscript.

Specific comments

P10964, L1: “potent” can be misleading as it suggests that it is the “strongest”, which in terms of radiative forcing it is not. I would suggest to replace “potent” by most “important” and specify that this is for long-lived greenhouse gases avoiding possible confusion with tropospheric ozone, which is also be very important.

P10964, L9: should also add geological sources of CH₄ such as from natural gas seeps and volcanoes (see e.g. Etiope et al., *GRL*, 2008).

P10966, L22: Gloor et al. (1999) is already 14 years ago, surely there has been an improvement in the CTMs in terms of physical parameterization and resolution since then. A more recent reference would be more appropriate to show that this is still a problem in state-of-the-art models. Could use e.g. Stephens et al., 2007 (but there are also other references).

P10968, L18: Do the authors mean that the prior emission dataset used in LMDZ-SACS is “INV” i.e. the target emissions, this should be made more clear.

P10971, L17: I think this should be the square of the 100% maximum value

P10972, L9: “errors” should be “covariances”

P10974, last paragraph: should include the number of the figure to which the authors are referring

P10975, L18: since all models use the same prior emissions, then it is not due to

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differences in the covariance of the surface emissions and transport, but to transport alone

P10975, L21: perhaps say why these are likely to be smaller than those for CO₂

Section 3.1.1: The authors do not mention the influence of model resolution horizontally, and in the lower troposphere, vertically, on the simulated synoptic variability.

P10982, L20-21: It would be good to briefly reiterate the reasons for this (i.e. from section 3.1.1)

P10982, L26: “The flux variability” is this across all inversions? If so, please state this.

P10986, last paragraph of 3.3: How much do the differences in emissions in the tropics and subtropics (Asia, South America, Africa and Oceania) from inversions with the standard and high resolution versions of IMPACT and TM5 depend on differences in modelling e.g. the IH mixing rate, the position of ITCZ, and tropical convection?

P10986, L20: lower compared to the target emissions?

P10986, L24: given that there are transport errors that are not taken into account then more observations would lead to greater potential bias, there is no reason to “expect” that the inverted fluxes would be closer to the target ones.

P10987, L10-20: from Fig. 10 and Fig. 15 it looks as though the NET3 inverse emissions are also closer to the target (and prior) emissions for the regions of North America and Boreal Asia as well as having reduced spread (i.e. compared with NET2 and NET1). Introducing more measurements alone would not necessarily reduce the spread since these observations also have transport and model errors, but rather suggests that the LMDZ-SACS inversion cannot match all observations (i.e. towers and aircraft) owing to the modelled transport errors, therefore the posterior emissions are closer to the prior.

P10989, L8: This gradient method was first used by Rödenbeck et al. ACP, 2003 so

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this reference should be included here. Also, it is pertinent to mention the method of Bergamaschi et al., JGR, 2010 for estimating the error due to lack of sub-grid scale variability in emissions.

P10989, L23-24: it does not necessarily mean that transport errors in Western Europe are correlated with those in the Atlantic, it could be due to transport errors in Western Europe alone

Fig. 15: Would be good to include the value of the target emissions in this figure to see in which direction the inversion emissions are biased (as is shown in Fig. 10)

Technical comments

P10963, L24: replace “consistently” with “accurately” since consistency does not help if the errors are still unrealistic.

P10963, L18: replace “invoked” with e.g. “examined” (invoked is not used in the right context here)

P10963, L23: should say that these are “emissions” estimates e.g. replace “estimations” by “emission estimates”

P10964, L6: cut “, as” so that it reads “reaching a global mean..”

P10964, L20: “conduces” is not the right word, replace with e.g. “is pertinent”

P10965, L20: “focus” should be “focusing”

P10966, L1-2: sentence does not make sense

P10966, L22: “take into consideration”

P10968, L4: change “The TransCom experiment does not allow separating. . .” to “In the TransCom experiment it was not possible to separate. . .”

P10970, L9: “additional”

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P10970, L13: sentence is poorly written, suggest something like: “We have chosen only to focus on the model and forcing errors and neglect all other sources of error on the estimated fluxes”

P10976, L16: “relationship”

P10970, L16: change to “. . .in the GEOS-Chem simulation influences the chemical sink and may lead to misinterpretation. . .”

P10972, L9: “split”

P10975, L19: “in relation to.”

P10977, L19: “smaller differences”

P10982, L6: “the vast majority”

P10982, L18: “synoptic variability”

P10982, L18-19: “has estimates. . .that are in . . .”

P10982, L25: “relative to”

P10982, L27: replace “twice higher than” with “two times that of”

P10982, L29: replace “dispersion” by “the distribution” and replace “higher” by “larger”

P10983, L2: replace “have stronger activities” by “are more active”

P10983, L9-11: please rewrite this to make it clearer, i.e. the say that the inverted fluxes tend to underestimate the emissions compared to the target.

P10983, L13: Replace with e.g. “This section examines one of the advantageous aspects of inversions using the variational approach, i.e. the ability to infer optimal fluxes at grid-box scale.”

P10983, L15: replace “exposes” with e.g. “shows” or “displays”

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P10984, L1: replace by “For example, in North America most model inversions derive higher emissions than the target methane emission.”

P10984, L4: “coasts”

P10984, L6: remove “identical”

P10984, L12: remove “the” before “Fig. 13”

P10984, L17: replace “reminding the dipole of emissions” with “owing to the emission dipole”

P10984, L19: replace “may also notice” by “also see”

P10984, L25: “which facilitates the investigation of the impact. . .”

P10985, L8: after “IMPACT,” replace “what” by “which”

P10985, L11-13: revise use of articles “the” and “a” (and generally throughout the manuscript)

P10985, L11: “difference” (i.e. singular)

P10987, L24: replace “Besides” by e.g. “Moreover” and remove the comma after “several results” and after “study”

P10987, L25: remove “statistics” since these are not statistical errors but rather non-random errors in atmospheric transport and model representation

P10988, L19: again, remove “statistic” (and in all following instances)

P10989, L21: “in Sect. 3.1 that the spread of fluxes in Western Europe may be higher. . .”

P10989, L22: it is not the “storm track” per se that is active but rather the storms themselves, therefore, replace “intense activity of storms track” by “more frequent and/or intense storms”

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P10989, L24, remove “also” before “partially”

P10987, L14 (and all instances): proper names should be with capitals e.g. “North America”, “South America”

P10987, L14: “Boreal Eurasia”

P10987, L11: “airplanes” (plural)

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