Atmos. Chem. Phys. Discuss., 13, C5643–C5659, 2013
www.atmos-chem-phys-discuss.net/13/C5643/2013/

Atmospheric Chemistry and Physics Discussions

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

R. Locatelli et al.

rlocat@lsce.ipsl.fr

Received and published: 8 August 2013

We are very grateful to anonymous referee 2 to have reviewed the manuscript and submitted other helpful comments and suggestions to improve the text. Here we respond to the reviewer point by point.
The reviewer comments are copied hereafter in italics with our detailed answers inserted in standard font.

General comments

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.

With the help of one of the native English-speaking co-author, many changes have been done in order 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.

'Methane is the second most potent anthropogenic greenhouse gas in the atmosphere.' → 'Methane is the second most **important** anthropogenically emitted **long-lived** greenhouse gas in the atmosphere.'

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).

'Emissions also involve thermogenic (fossil fuel extraction, transportation and use)' → 'Emissions also involve thermogenic (**geological sources,** fossil fuel extraction,

ACPD
13, C5643–C5659, 2013

transportation and use)'

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).

We have added a reference to Stephens et al., 2007.

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.

Yes, this sentence is very important for the understanding of the methodology of this study. We have rephrased the paragraph to clarify this point.

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

Yes, we have changed this sentence.

P10972, L9: errors should be covariances

ACPD
13, C5643–C5659, 2013

Ok.

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

Done.

P10975, L18: since all models use the same prior emissions, then it is not due to 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 CO_2

Yes, the differences in the covariance of the surface emissions and transport are here only due to differences in transport alone since we use the same methane emissions. However, we have decided to remove the explanations about the rectifier effect. Indeed, reviewer 1 asked us to shorten some parts of the text and we consider that clarifying the non central point about the rectifier effect would require further discussions.

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.

ACPD
13, C5643–C5659, 2013

We did not mention the influence of vertical resolution because we did not see any correlations between vertical resolution and synoptic variability of methane concentrations. For example, on the Figure 7 we can see that synoptic variability simulated by TOMCAT are smaller than LMDZ-SACS. But IFS, which has the same number of vertical levels than TOMCAT, simulates higher synoptic variability at continental stations of the Northern hemisphere than LMDZ-SACS. This is one example which shows that we can not conclude about vertical resolution impacts in this study. It would have been very interesting to have two versions of a model with different vertical resolutions in order to clarify this point.
However, we carefully study the impact of horizontal resolution on the modelling of synoptic variability. The results are exposed in Section 3.3 (Sensitivity to the model horizontal resolution).

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

Yes, we have specified in the revised version that deficiencies in the modelling of synoptic variability are larger for continental stations located close to large emission areas.

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

This is the average of flux variability for all inversions. We have clarified this sentence in the text.

ACPD
13, C5643–C5659, 2013

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?

Unfortunately, using the TransCom-CH_4 experiment, it is not possible to separate the impacts of these different processes (IH mixing rate, position of ITCZ, tropical convection) on the estimated fluxes. In this study, we can only suggest the main deficiencies in the modelling (like synoptic variability or IH exchange time), which impact the estimates of inverse modelling in relation with the general characteristics of the models. In order to quantify more accurately the impacts of these different processes, we could run several inversions using the same CTM but with different physic parameterizations.
The major goal of our study was to quantify the impact of transport model errors on the inversions in order to know how we can trust estimations of fluxes derived with different models. However, we agree that a future step could be to investigate more deeply the deficiencies in the models by separating these effects.

P10986, L20: lower compared to the target emissions?

No, lower compared to emissions derived in NET1 configuration. We have rephrased the sentence to specify it.

P10986, L24: given that there are transport errors that are not taken into account then more observations would lead to greater potential bias, there

ACPD
13, C5643–C5659, 2013

is no reason to expect that the inverted fluxes would be closer to the target ones.

Yes, but we are speaking here about an ideal case with errors taking properly in account transport errors in covariance matrix. We rephrased this sentence by saying: "If errors were unbiased and properly accounted in inversion, more constraints should ideally bring the estimated fluxes closer to the target fluxes."

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 the modelled transport errors, therefore the posterior emissions are closer to the prior.

We agree with the reviewer and we have added this assumption in the manuscript.

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

We added the reference to Rödenbeck et al. (ACP, 2003). We also mentioned the method of Bergamaschi et al. (JGR, 2010). Thanks for pointing out these omissions in

ACPD
13, C5643–C5659, 2013

the manuscript.

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

Yes, we have specified that transport errors in Western Europe are correlated with those within regions crossed by the storm tracks (North Atlantic for example but also Western Europe itself).

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)

Done.

Technical comments

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

Done.

ACPD
13, C5643–C5659, 2013

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

Done.

Pl0963, L23: should say that these are "emissions" estimates e.g. replace "estimations" by "emission estimates"

Ok.

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

Done.

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

Done.

P10965, L20: "focus" should be "focusing"

Ok.

ACPD
13, C5643–C5659, 2013

P10966, L1-2: sentence does not make sense

This paragraph has been completely modified. Please look at this section in the revised manuscript.

P10966, L22: "take into consideration"

Ok.

P10968, L4: change "The TransCom experiment does not allow separating..." to "In the TransCom experiment is was not possible to separate..."

Done.

P10970, L9: "additional"

Done.

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"

Ok.

ACPD
13, C5643–C5659, 2013

P10976, L16: "relationship"

Ok.

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

Done.

P10972, L9: "split"

Ok.

P10975, L19: "in relation to.."

Ok.

P10977, L19: "smaller differences"

Ok.

P10982, L6: "the vast majority"

ACPD
13, C5643–C5659, 2013

Ok.

P10982, L18: "synoptic variability"

Ok.

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

Ok.

P10982, L25: "relative to"

Ok.

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

Ok.

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

Done.

ACPD
13, C5643–C5659, 2013

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

Done.

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.

We have rephrased this sentence.

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."

Done.

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

We have chosen "displays".

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

ACPD
13, C5643–C5659, 2013

Done.

P10984, L4: ”coasts”

Ok.

P10984, L6: remove ”identical”

Ok.

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

Done.

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

Done.

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

Ok.

ACPD
13, C5643–C5659, 2013

P10984, L25: "which facilitates the investigation of the impact..."

Ok.

P10985, L8: after "IMPACT," replace "what" by "which"

Done.

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

Yes, we have especially revised use of articles with the help of a native English-speaking co-author.

P10985, L11: "difference" (i.e. singular)

Ok.

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

Done.

ACPD
13, C5643–C5659, 2013

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

Ok.

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

Done.

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

Ok.

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"

Done.

P10989, L24, remove "also" before "partially"

ACPD

13, C5643–C5659, 2013

Done.

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

Ok.

P10987, L14: "Boreal Eurasia"

Ok.

P10987, L11: "airplanes" (plural)

Ok.

ACPD
13, C5643–C5659, 2013