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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Sensitivity of the recent methane budget to LMDz sub-grid scale physical parameterizations" *by* R. Locatelli et al.

Anonymous Referee #2

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This study investigates the impact of various sub-gridscale parameterizations in atmospheric transport within one modelling framework on the optimized methane budget for one test year. Overall the experiment was sensible and clearly laid out, and is a natural extension of Locatelli et al. (GMD, 2015). The additional consideration of three different observation systems is interesting, and should be further expanded upon before being published (see following paragraph for more information). Overall the manuscript is clearly structured, but needs a very good, thorough proof-reading before resubmission.

In general the discussion would benefit from a clearer analysis and separation of the two major sources of error which were identified in the introduction: observations vs. transport errors. Of course representation error kind of mixes up these two categories, but for the purposes of this study the two have been effectively separated. When I

look at Figure 5 it seems that for these large regions it's often the case that the three different observing systems cause a spread as large or larger than what is seen for the same observing system with three different version of physical parameterizations (i.e. the difference between the three reds is as big or bigger as the difference between the red, blue and green for each region). The material is there to clearly describe and define this, but the discussion of this point is lacking. An improvement of this point would benefit the manuscript overall.

What was missing in this study was a discussion of the sinks of methane. I read it quite carefully, and I'm not entirely sure if the OH sink was being optimized (let alone the soil sink, or if the Cl sink was even considered). If it was being optimized, it would be interesting to see how the vertical mixing affected the magnitude and location of the tropospheric methane loss. If it is not being optimized, the differences in vertical mixing likely impact the lifetime simulated under each version of the model, and thus the global fluxes shown in Figure 4. In any case, it needs to be explicitly discussed.

Although many numbers are used to describe the differences, the reader is left unsure about how significant an effect this is. Having the mean spread over several years for the surface-based inversions (in Table 2) is a start, but it doesn't show whether the patterns are consistent over these years, or whether the differences are more random in nature. Having only one year analyzed for GOSAT inversions exacerbates this. Although it might be significant extra work, considering the uncertainty on the posterior flux estimates would be an appropriate way to address this.

More minor concerns:

What is used for the driving meteorology? ERA-interim? I couldn't find this information easily in the paper. If ECMWF driving meteorology is used, did you consider using the convective mass fluxes that are stored? This is more consistent with the underlying transport of the model, which might solve some of the interhemispheric gradient problems associated with inconsistent schemes used to address sub-gridscale convection.

The reference to Grooß and Russel in the text states that it's from 2014, but it's actually from 2005. But more importantly, details are missing with respect to how the comparison was carried out. Were the data corrected to account for trends in methane between 1991(the beginning of the period used to compute the HALOE climatology) and 2010? Furthermore, is the model subsampled in a way consistent with the measurements (in terms of space and season)? HALOE didn't measure much at high latitudes (> 50 degrees or so), where stratospheric methane is particularly variable. Was this taken into account? Why not use a more modern sensor such as MIPAS or ACE-FTS in addition (or instead)?

I'm also slightly confused by what is shown in the "percentage" profiles in Figure 3. Is this the contribution of each of the GOSAT retrieval layers? And if so, for an average of all columns for 2010? Or something else? This needs to be better explained. Although chronologically in the manuscript it might be hard to work in, I was wondering what the different versions of the LMDz-39 looked like on this plot. Perhaps it would be instructive to include a similar comparison, perhaps for zonally-averaged columns in the tropics, NH extra-tropics, and SH extra-tropics. This might work well in a discussion of the photochemical sink, and how that effects the estimated lifetime across model versions (see comment above).

To be honest, I'm surprised that the transport differences don't result in larger flux discrepancies in Figure 4. How do these differences compare to the posterior uncertainty? Is this something that your system can easily calculate? This question arises again when looking at Figure 5. How significant are the differences between the different implementations of transport? Do they result in posterior flux estimates that do not have overlapping uncertainties? The information to judge this is not provided. A 5% range due to transport differences is significant if the uncertainty is 1%, but not if it's 4%. Was the lifetime/OH sink fixed between simulations?

Typos/language issues: This manuscript really needs a proper proof-reading. This is by no means an exhaustive list of minor errors, and I know it's not really my job as a

reviewer, but I tried to jot something down any time that I had to reread something to make sense of it.

p11854, line 15: total-column what? total-column abundances, or total column methane mixing ratios, etc., something is missing there.

p11854, line 18: gradient -> gradients

p11855, line 1: relatively -> relative

p11855, line 12: supplement the issue? Or rather ameliorates the problem? Or they supplement the existing measurement network...

p11855, line 14: become -> becomes. Also, it was already a major issue, perhaps now it becomes the leading issue?

p11855, line 19: satisfactory -> satisfactorily

p11856, line 1: SCHIAMACHY -> SCIAMACHY

p11856, line 5: carry on -> carry out

p11856, line 5-6: have also -> also have

p11859, line 19-20: "by Tiedke (1989) scheme" -> "by the scheme from Tiedke (1989)" or "by the Tiedke (1989) scheme", similar with Yamada

p11859, line 24: "by Emanuel" -> "according to Emanuel" or similar

p11859, line 27: an -> a

p11860, line 5: "On the opposite" -> "On the other hand"

p11860, line 6: "has been also" -> "has also been"

p11860, line 7-10: Rework the sentence a bit. Perhaps: "The interhemispheric (IH) exchange, which is known to be too fast in LMDz-TD, agrees better with the indirectly measured IH exchange when using the Emanuel (1991) scheme, as is done in LMDz-

SP and LMDz-NP."

p11860, line 11: "which justify to test it as well" -> "which justifies its inclusion"

p11861, line 19: "that CO2" -> "that the CO2"

p11863, line 22: "that CH4" -> "that the CH4"

p11864, line 11: "Consequently, the inverse system derives lower methane fluxes with LMDz-19 to simulate lower tropospheric methane mixing ratio compensating the over-contribution of stratospheric methane mixing ratio to the total-column." -> "Consequently, the inverse system derives lower methane fluxes with LMDz-19 to simulate a lower tropospheric methane mixing ratio, compensating the over-contribution of the stratospheric methane mixing ratio to the total-column."

p11864, line 18: "modelling of" -> "modelling of the"

p11864, line 19: "reasons of" -> "to determine the reason for", "need" -> "needs"

p11864, line 25: fluxe -> fluxes

p11864, line 28: "we only focus and present results associated to " -> "we focus on and present only results associated with "

p11865, line 10: "which was estimated as a “total” transport model errrors" -> "which was an estimate for "total" transport model errors"

p11865, line 13: "although smaller than" -> "although a smaller impact than"

p11865, line 23: "on China methane flux estimates" -> "on the methane flux estimates for China"

p11866, lines 1 and 4: "simulated total-column" -> "the simulated total column"

p11866, line 8: "total-column" -> "the total column"

p11866, line 17: "have been" -> "has been"

p11867, line 23: "wrong repartition between Northern and Southern Hemisphere of emissions" -> "incorrect repartitioning of emissions between the Northern and Southern Hemispheres"

p11868, line 1: southern -> Southern

p11868, line 5: extra-tropics -> the extra-tropics

p11868, lines 10-11: reach 7.5 unitTg CH4 year$-$1 -> reaches 7.5 Tg CH4 year-1

p11868, line 14: impact strongly -> strongly impacts

p11868, line 20: than -> that

p11868, line 21: impacts -> impact

p11869, line 19: LMDz-SP and LMDz-SP -> I guess this should be LMDz-SP and LMDz-NP, right? and also "the Emanuel"

p11869, line 21: dependent ON

p11869, line 23: "Then, LMDz-SP and LMDz-NP derives also" -> "Thus LMDz-SP and LMDz-NP also derive"

p11871, lines 6-7: "where modelling of boundary layer mixing impact much atmospheric methane levels" <- I’m not entirely sure what is meant here, please reword it. Does boundary layer mixing have a large impact on the concentration of atmospheric methane? Or does boundary layer mixing impact the atmospheric methane concentration across several model levels?

p11871, line 16: are ranged from -> range from

p11871, line 27: deriving -> derive

p11873, lines 4-7: " Indeed, inversions using Emanuel (1991) scheme (based on LMDz-SP or LMDz-NP model) have smaller interhemispheric 5 methane emission gradients than inversions using Tiedtke, 1989, scheme (based on LMDz-TD model), which

are known to simulate too fast interhemispheric exchange (Patra et al., 2011)." -> " Indeed, inversions using the Emanuel (1991) scheme (LMDz-SP or LMDz-NP) have smaller interhemispheric methane emission gradients than inversions using Tiedtke (1989) (LMDz-TD), which are known to overestimate interhemispheric exchange (Patra et al., 2011)."

Figure 3, caption: profils -> profiles

Figure 4, plot: Physic -> Physics; subscript of 4 in CH4

Figure 4, caption: change "Leicester institute", remove comma after "and" (or move it before)

Interactive comment on Atmos. Chem. Phys. Discuss., 15, 11853, 2015.