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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Climate versus emission drivers of methane lifetime from 1860–2100" *by* J. G. John et al.

Anonymous Referee #1

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This is a valuable paper analyzing what controls the atmospheric lifetime of methane (CH4) from pre-industrial (1860) to present and into the future (2100, based on the RCP scenarios). Its strengths are a thorough analysis of the GFDL climate-chemistry simulations for the current IPCC/CMIP5 experiments – this is great because it is a consistent comparison in terms of model formulation and different diagnostics, but it is also a weakness because it applies to only one model. The strengths clearly outweigh the weaknesses in terms of being useful to the community. The model experiments and basic analysis are adequate for publication, and no new runs are needed. We do need more details in some places and a better, cleaner layout in others so that the paper is easier to follow.

A detailed critique and suggestions follow the paper:

Abst. The aerosol interactions in this model are confusing and need to be stated clearly up front. To say the AIE plays a significant role climate and . . . needs a more explicit statement – i.e. through what? The aerosols influence chemistry through direct reactions, photolysis, and so forth. This does come out later, but make the caveats up front.

The percentages on CH4 lifetime change in the abstract are welcome, but be consistent - e.g., start with the % change for each scenario, then discuss cause. It is not clear what is meant by "only well mixed GHG" since these gases all affect the chemistry directly, especially the stratosphere and is this included? Or do you mean that the "well mixed GHG forcing" is held constant?

The abstract is not the place to discuss future work, leave that for discussion section.

p.3-4. The budgets for CH4 based on observations really should be up front here. You give some references, but need the latest Montzka, Krol et al Science paper on OH and the CH3CCl3 decay and the Prather et al 2012 GRL paper on using this data to estimate the CH4 budget with uncertainties. Both papers should be much better values for the CH4 lifetime than those quoted here. The second paper clearly lays out the components in the CH4 lifetime (strat, soils, trop-Cl) that are often forgotten in this paper. To avoid confusion and having people pull the wrong numbers from this paper, you really must say something like "CH4 lifetime against trop OH loss" in every paragraph where you quote CH4 numbers. Otherwise people will pull some of your numbers (e.g., 8.44 y vs 7.82 yr on p.17) and think that these are reasonable absolute numbers compared with the total CH4 lifetime of 9 yr in Prather et al. 2012, but in reality these are OH-lifetimes and should be compared with 11 yr based on the CH3CCl3 decay. I am not dinging the GFDL model for the short OH-lifetime, most models suffer from some large bias in CH4 lifetime that we do not fully understand yet, but at least the values should be carefully labeled.

p.4. Why discuss Staffelbach at all, since the polar regions are really irrelevant to the

CH4 lifetime?

p.5. “Here we investigate. . .” This section is key to what is in the paper - please move it to the number 1 or 2 paragraph of the Intro.

p.6. Lightning NOx (LNOx) is one of the major problems in projecting tropospheric chemistry. This paper is not going to solve that problem, but I think it is vital (and beneficial to all) that a critical analysis of what LNOx did/does to the CH4 OH lifetime IN THIS MODEL is presented. For one, how much does the NOx source change, latitudinal effects, and what effect different LNOx has on the CH4 lifetime.

p.7/25 – Note these RCP forcings are only “nominal” as the scenarios cannot and do not specify the RF for aerosols and ozone.

p.8/eqn 1 – the notation for this lifetime should make it clear that it is the OH-only.

p.9/3-7. This 8.1 yr is OK and within the range, but it is much lower that recent estimates of 11 yr.

p.11/6-21. Can you start by listing what effects are or are not included for aerosols in this model. The use of AEROSOL and AEROSOL INDIRECT is confusing here, especially as the issues of chemistry are more complex as to what is included. J’s are not, but cloud changes are? The current tables did not help me here.

p.11/23. Use the same pair of words consistently (increase/decrease) to describe changes in the lifetime, bringing in “shortened” is confusing. It helps the reader.

p.11/29. It is important to have a quantitative understanding of just how important a 4.6% change in LNOx is, since this is only 0.025 Tg-N ?? Trivial compared with surface sources.

p.12/10. Pinatubo also had impact on J’s – what did that do?

p.12/5. I an not sure why you want the correlations listed in Table 4, but the reasoning here as to why there is no correlation in this case (trends?) makes no sense to me, can

you make the logic more simple. The only obvious reason to me is that other forces of variability are confounding the obvious correlation that should exist.

p.12/25. Section 4.3 brings up a serious problem as there is no such decline in the CH3CCL3 observed lifetime (Montzka 2011) – this needs to be a discussion point. I admit that most models get this, but why ? and why is it wrong?

p.13/4. Do not aerosols affect clouds? I thought the AIE was through this.

p.13/10. As noted earlier, the OH lifetime of 9 yr here is much lower than the current best numbers noted above. I am not sure that some of these comparisons are for total lifetime. Why quote a trend that is too small to be meaningful.

p.14/3-18. Very good discussion, clear.

p.15. avoid “shortening”

p.18. It would be best to give %’s for each scenario (to nearest % only, not 4.3%), then discuss the differences. Also you need to assess the % changes in the total CH4 lifetime since that is what determine the future methane abundance. So come up with some ideas for soil, strat, trop-Cl. I would also say that “Further study is needed on LNOx” – I think as a community we have not established clear metrics and diagnostics that let us understand what is important here for future OH.

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