

Interactive comment on “Implication of extreme atmospheric methane concentrations for chemistry-climate connections” by Franziska Winterstein et al.

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1 General comments

Winterstein et al. use idealised 2xCH₄ and 5xCH₄ experiments to assess chemistry-climate interactions in the ECHAM/MESSy model. This includes effects on OH concentration (and CH₄ lifetime), and how different components of instantaneous forcing and chemistry-driven adjustments combine to arrive at the effective radiative forcing for 2xCH₄ and 5xCH₄.

Overall this is a strong paper and I see no good reason to not publish it in a form that is

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close to as it is now. It is well-written, structured and easy to understand. It should be a useful contribution towards the short-lived climate forcer and energy balance/radiative forcing chapters of AR6.

2 Specific comments

The authors prefer to use "radiative impact" rather than (effective) radiative forcing, and on page 11 discuss the fact that they are equivalent. Is there a good reason to use RI rather than ERF? Perhaps it is because the reference experiment is present-day rather than pre-industrial.

It would make slightly more sense to me for the perturbation experiments to be called S2 and S5 (for 2x and 5x methane respectively). In this context figure 3 could be understood without reading the paper.

page 2, line 32: The way this currently reads implies that in Smith et al. we only used one model. It would be good to highlight that this was a 10-model intercomparison study.

page 5, line 10 (near the bottom): "any possible feedback on tropospheric temperature is largely suppressed...": you mean that climate feedbacks (from increasing global mean surface temperatures) are suppressed. There may be some tropospheric temperature change unrelated to surface temperature, due to changes in tropospheric heating rates in the 2xCH₄ and 5xCH₄ experiments.

The low direct forcing from methane in ECHAM5, mentioned on page 12: is SW absorption of methane included in ECHAM5? This would account for some of the underestimate if not. See Etminan et al., 2016; <https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2016GL071930>. Also, there is a difference between models that include SW absorption of methane in their radiation

schemes and those that do not in Smith et al. (see figure S6 in the supplement to that paper).

The separation of the methane ERF into the "direct" component and the chemistry-driven adjustments (table 1) I like. Stratospheric water vapour and O₃ include stratospheric temperature adjustments, so technically these would include a component of physical adjustment as well as the direct radiative effect of the water vapour and O₃. The authors are correct that these interactive effects are not present in the participating models in Smith et al.

3 Technical corrections

Abstract, line 1 would read better as: Methane (CH₄) is the second most important directly emitted greenhouse gas, the atmospheric concentration of which is influenced by human activities.

Page 3, line 1: "result" > "resulted"

page 5, line 14: "a large part" > "some"

Page 11, last line: "(see 2 for a detailed explanation..." not clear what "2" is a reference to here.

Page 14, line 14: "antarctic" > "Antarctic"

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