

## ***Interactive comment on “Implementation of methane cycling for deep time, global warming simulations with the DCESS Earth System Model (Version 1.2)” by Gary Shaffer et al.***

### **Anonymous Referee #2**

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The authors have helped ground our theoretical understanding of past major CIEs by introducing methane cycling to an Earth System Model. I found the paper clear and thorough. My comments are few. The first is to reiterate David Archer’s comments that some first order description of the model being modified would be useful – in the atmosphere, how is water vapor, heat transport, and temperature calculated? How does the ocean evolve? etc.

The second is that the relationship expressed in section 3.1 between the lifetime of atmospheric methane and its concentration seems to implicitly include an assumption of the water vapor concentration dependence on temperature, and a temperature

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dependence on the methane concentration. Clarifying the nature of that assumption (what climate sensitivity is used?), and its robustness (does it matter the precise values chosen?), would be useful.

The third is that in the last paragraph of page 11, an exponential fit is used. It is not clear to me, but it seems possible that this fit is being applied in regions outside where the fit is performed, which seems like a potential issue.

The fourth is that I wish there was a more quantitative comparison of the changes induced by the new radiative forcing values, as well as a more explicit discussion of how the addition of the mechanisms that have been added to the Earth system model either confirm or complicate the more schematic picture paleoclimatologists may typically have of these events.

Finally, and building on the last point, following the causal chains of physical processes discussed in Chapter 4 can sometimes get confusing. It might be useful if there were some diagrams illustrating how the various graphed quantities from the figures influence (and feedback on) each other, illustrating the chain of connections leading out from the initial methane release. Comparing these diagrams between cases could then help clarify the qualitative difference between, for example, deep ocean and surface release of methane.

All in all this is a clear paper that shows how its modelling efforts have gained an important foothold on this problem, while also making clear what steps remain ahead. I endorse its publication.

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