

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.

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First of all we would like to thank David Archer for reviewing our work and for his positive comments on it. Here follows our responses to specific points raised, points that are enclosed in quotes below.

“... As this is new modeling territory, it is helpful to have a model description, in the spirit of GMD. The model description is generally detailed but some of the first-order information is omitted, like what an ocean sector is, or how the ocean circulates. I’m sure it’s described elsewhere but it should be here also...”.

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The model is indeed described in great detail in the original DCESS publication (Shaffer et al, 2008, GMD). But in response to the comment above we now will also include several additional figures and additional text on our atmosphere and ocean modules in our revised version.

“...For me, encoding often-repeated phrases into acronyms like CIE, TM, and MH do not make a paper more readable, I don't see the point of it. It's easy to miss the definition, in which case you have to go back and find it, and even after you have it you have to train yourself to decode it every time...”

We can appreciate this point and in the revised version we will replace these acronyms and several additional ones by their full meanings in order to enhance readability.

“...Organic carbon could be liberated from a fossil organic source, or peat degradation; it need not be limited by the size of the terrestrial biosphere...”

In our model we treat weathering of fossil organic sources but this is a process too slow to contribute much carbon on the millennial time scales considered in our paper. Peat and permafrost would represent additional organic carbon sources. There would not be much if any permafrost carbon for the warm climate conditions we consider (see also discussion in Shaffer et al, 2016, GRL). Some additional carbon from peat degradation may be expected. We will discuss and quantify this in our revised version.

“...CO₂ can also be released when magma intrudes into sediments. To the extent that it comes from CaCO₃, it could tend to “dilute” the negative imprint of methane...”

This is a good point and will be discussed in the revision, for example how the release of methane vs CO₂ from organic carbon via magma intrusions may depend upon host rock composition or magma temperature. CO₂ released from CaCO₃ would put another wild card into the mix as will be discussed in the revision.

“... “sustain” solubility misleads, makes it sound like a process, rather than a concentration. Although it is a process, since there is an upward diffusive gradient, but this is

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not explained. . .”

To clarify this, the text in the revised version will be changed to read “. . .Within a hydrate stability zone, methane hydrate is formed where methane release from bacterial remineralization of organic matter exceeds that needed to sustain solubility levels in the face of vertical diffusive transport of methane..”.

“.. Clarify: the ocean model is 1-D (vertical)? What is an ocean sector? Explain the “high latitude zone” of the ocean (page 7). A diagram including the atmosphere and ocean would be very helpful. . .

See comment above about including additional figures and text in the revised version.

“...It might be acknowledged here that much faster oxidation time scales are possible in places with ongoing methane availability, the biota builds up. Like the Gulf of Mexico...”

This is also a good point and will be discussed in the revised version.

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