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Climate of the Past Discussions

Interactive comment on "Southern Ocean warming and hydrological change during the Paleocene–Eocene thermal maximum" *by* A. Sluijs et al.

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Paper: Southern Ocean warming and hydrological change during the Paleocene-Eocene thermal maximum

Authors: Sluijs et al.

Journal: Climate of the Past Discussions

Reviewer: Dorian S. Abbot

Overview: This is a good study that presents very interesting data. The paper is

clear and well-written. I am not qualified to evaluate the data collection and processing methodology. I have therefore tried to focus on trying to make sure claims and suppositions are backed up by the evidence. I hope the authors will find my comments, which I have arranged in order of importance, useful.

Comments:

1. **Identification of CIE with the PETM:** As the authors note in the introduction, there are at least four hyperthermal events between $\sim$52-56 Ma. My understanding is that each of these hyperthermals have a CIE associated with them, and that the CIE gets smaller for subsequent hyperthermals. If I am correct about this, then using a CIE as the main source of identification of the section of the core investigated with the PETM could be problematic, given that the CIE the authors record is roughly 50% smaller than the CIE recorded elsewhere during the PETM. This could be because the CIE the authors have found corresponds to a smaller, later hyperthermal. To me the stratigraphic arguments made in section 3.1 do not seem strong enough to positively identify the CIE as the PETM, given the potential variation in sedimentation rate and the closeness of the hyperthermals. I suggest either the authors discuss their data as an example of a hyperthermal, but not necessarily the PETM, or make the argument that the CIE belongs to the PETM and not one of the other hyperthermals stronger and clearer.

2. **Comparing the EECO and the PETM:** On page 1713 the authors use the fact that the TEX_{86} values for the EECO and the PETM are similar to argue that: (1) GHG levels were similar in the two periods and (2) the hyperthermals and the EECO were caused by carbon injection from the same reservoir (speculated to possibly be methane hydrates). The logic underpinning such statements is, in my opinion, tenuous. An easy counterexample would be if TEX_{86} becomes relatively insensitive to temperature

beyond some value (which I think it does), and the temperature of all these events is beyond this value, then you would get about the same TEX_{86} value even if all the events had different maximum temperatures. Even if we accept that TEX_{86} maps well to temperature in this range, another counterexample would be if there is some sort of maximum to how warm you can get the climate (like the Iris hypothesis, or pick your own example). Then no matter how much carbon you put in the system or where you got it from, you would only get back to this maximum. I'm not saying this is the case, but to me it seems more plausible than (2) at least! Point (2) doesn't make sense to me, even using the example given. If the release of a methane hydrate reservoir causes a rapid warming followed by a fairly rapid cooling, how can this explain the slow warming to the EECO? I suggest removing (2), and some caveats to (1).

3. **TEX_{86} calibrations and relation to oxygen isotopic data**: On page 1713 the authors note that the temperatures of a nearby region of Antarctica are much cooler at the time based on oxygen isotopes. It would be good to give more quantitative information on this difference. The authors then conclude that either there was a large temperature gradient between the regions (unlikely, because I think the difference we're talking about here is huge) or that TEX_{86} and oxygen isotopes yield different paleotemperature estimates. This point deserves a lot more attention and a much more prominent position in the discussion. Do the authors really believe the TEX_{86} temperature values they report? If we try to understand the Eocene and PETM climate, it makes a big difference whether the temperature at this latitude is $\sim$30-35°C or $\sim$15-20°C! I think the authors should come out and say which estimates they think are right, and what the drawbacks of each temperature estimation are.

A related point is that it feels a bit strange to me to be continually switching between temperature calibrations. If this paper is to be useful to people interested in understanding ancient climates, we need the authors to try a bit harder to pin down what their data mean, rather than just a preference for one calibration over the other based

on consistency with oxygen isotopes in some other core (using this for a preference seems particularly problematic given that TEX_{86} from both calibrations do not seem to agree with oxygen isotopes here).

4. **Sea-Level Rise:** The author's discuss "eustatic" sea-level rise in a few places, most notably on page 1712 and 1716. This is problematic, given that Jerry Mitrovica and colleagues have shown that eustatic sea level change is basically a meaningless concept. According to Mitrovica's work, melting small ice sheets in Antarctica, which the authors discuss, might actually DECREASE sea level near Antarctica (where the core is), because you would lose the gravitational attraction of the ice sheet.

5. **The "dynamic" PETM:** The authors refer to the climate of the PETM as "dynamic" a few times, as if to draw a distinction with previous conceptions of the PETM. This seems like a strange word choice, since the PETM is defined by the fact that there's a rapid and large change in temperature and the carbon system (so of course it's dynamic, and always has been!). I like it when you say "intra-PETM variability" better. Perhaps it would be better to replace "dynamic" with "shows intra-event variability" in all cases.

6. **EECO:** The authors refer to the maximum temperature period during the Eocene as the Early Eocene Climatic Optimum (EECO). I know some other people use this wording, but I don't like it. For whom or for what was this climate optimal? It certainly wouldn't be optimal for polar bears if we go back to a climate like that in the future! Some other people use Eocene Thermal Maximum, which I like better, although this has problems to since the hyperthermals might get as hot or hotter as the Eocene "thermal maximum." Even so, I think this is better than EECO because it is at least descriptive of the characteristic that causes us to identify it as a distinct period.