

## ***Interactive comment on “Changes in the high latitude Southern Hemisphere through the Eocene-Oligocene Transition: a model-data comparison” by Alan T. Kennedy-Asser et al.***

**Anonymous Referee #1**

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The aim of the work was to produce a compilation of climatic proxies across the EOT and use this compilation to measure the performance of low-resolution AOGCM of different time slices across the EOT (performed in a previous study by the same lead author). Different boundary conditions are considered, i.e. varying pCO<sub>2</sub> and or Antarctic ice sheet extent, opening of closing Drake Passage. The main conclusions of this work is that on one hand, in general the paucity of data cannot really allow for a strong benchmark of AOGCM; on a second hand, the model-data comparison suggest that drop in CO<sub>2</sub> have driven the sharp global cooling across EOT rather than the Drake passage opening.

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I see this paper as on of the first step necessary for the DEEP MIP project. In fact, proxy validation is critical to measure the ability of models to reproduce different extreme climatic states.

I am not fully convinced by this work because there are critical aspects that are not addressed properly and needs to be clarify and properly justified. At least main points needs to be address in this contribution before elaborating discussion on climatic interpretation. Moreover, those kind of results are also very model dependent:

1- A discussion on the impact of horizontal resolution of the simulations on the modeled variables is necessary before comparing to proxies. How many grid points are considered in the Drake Passage? There is also the Tasman gateway that opens toward 33.5 Ma (Scherer et al., 2015) and also impact on ocean circulation as much as the Drake passage opening. This is not considered here. So it is difficult to conclude that those ocean gateways do not matter too much.

2- Please also discuss the performance of both model for present-day day and other paleo periods? Do they present systematic cold bias as shown here?

3- Where are localized the main biases compared to the proxies? Pacific sector, Atlantic sector? Indian sector?

4- the number of proxies is really little, because only few sites allow to reach those time periods int he Southern Ocean and around the Antarctic margins. However, the number of sites considered in each latitudinal average points, especially in Figure 3, should be indicated to understand the weight of those proxies.

5- Orbital configuration impact is briefly discussed for the model simulations. But what about the proxies? Have they record more glacial transitions or interglacial transitions?

I think that without at least discussing those points in the paper, the comparison made here remains too weak and highly qualitative.

I report only few comments below that are mostly redundant with those general com-

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ments.

Major comments:

Page 10 - line 33: Actually the steeper Oligocene gradient discussed here is only caused by one point as shown in Figure 3b. This proxy-based average also has a HUGE uncertainty. Thus I question the validity of this steeper Early Oligocene gradient because only based on one averaged point. See next comment about figure 3.

Figure 3: To really understand the strength of the proxy-based latitudinal T. reconstructions, it would be critical to report below each points shown for Eocene and Oligocene, how many sites are considered in those averaged numbers and associated uncertainty, given their already small numbers. I would be more clear and immediate to the reader than going through all Tables shown in the Supplementary.

Resolution of simulations: In general the impact of coarse resolution simulation is not discussed. However, some recent on-going works (e.g. from Isabel Sauermilch) carried out with high-resolution ocean simulations definitely suggest different conclusions than you work (ISAES or ICP meetings 2019 presentations). This point highlight the fact that the interpretation of EOT in models is highly model dependent and resolution dependent. A discussion on this aspect here is necessary before trying to interpret the difference between your model and the data.

Minor comments:

Figure 1: please insert intermediate tick mark on Y axis to help the reader understand the range of temperature for each sites.

Table 1: Provide the nominal averaged horizontal resolution at high latitudes for both models in order to make it more understandable. Also because horizontal resolution impacts a lot on those reconstructions. ... Please make it more clear here in this table.

Figure 4: in the caption it is indicated that simulations considered in this figure are "ice free", however, I see that for the Oligocene, simulations are reported with some

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antarctic ice sheet. Please correct the caption or clarify.

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