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Climate of the Past Discussions
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Interactive comment on "The middle-to-late Eocene greenhouse climate, modelled using the CESM 1.0.5" *by* Michiel Baatsen et al.

Anonymous Referee #2

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The purpose of this work was to study the Middle-to-Late Eocene climate using a coupled model. The Middle-to-Late Eocene represents a key period of the Cenozoic characterized by the demise of the greenhouse period. The manuscript is quite long but clearly written. Its structure is logical despite some overlapping between the sections (for instance between sections 2.6 and 3.4. Moreover, these two sections have the same title). The paper relies on a large number of figures: 10 figures in the main text and 16 figures in supplementary materials. Unfortunately, the authors used a colour scale that makes the figures difficult to interpret. In addition, the superimposition of shading and contours which does not help matters. The authors do not show differences (or very occasionally) between simulations which can be very helpful (with a more classical colour scale). The authors should rewrite the abstract to better high-

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Discussion paper

light the key results of this work. Beyond this general comment, some points need to be clarified. My first comment concerns ice sheet. The authors simulate the Late Eocene climate using a pCO2 of 1120ppmv (4x) and 560ppm (2x). These values are classically used to study this period. However, the absence of ice sheet in Antarctica in the experiment at 560ppmv is more disputable. Indeed, the glaciation threshold is estimated between 560 and 920ppmv. A pCO2 as low as 560ppmv thus represents the lower limit for glaciation threshold. Moreover, it is clearly model dependent. In this work, the simulated mean annual temperature in Antarctica is below the freezing point (figure S6a), which may potentially represent required conditions for the onset of glaciation. Thus, how to be certain that an experiment without ice sheet and a pCO2 as low as 560ppmv is representative of the Priabonian period (when the CESM version 1 is used). The vegetation biomes for the Late Eocene experiments should be shown at the model resolution (Fig.1c). The cold mixed forest in the Andes seems to spread over Brazilian lowlands. The authors do not indicate how runoff was represented in the model.

L135: It can useful to better explain how the CH4 level in the Late Eocene experiments has been fixed.

L163: The distribution of aerosols is calculated using the land surface properties. Can the authors be more precise?

L190: A change in vegetation has been adjusted at the end of simulations causing a significant cooling at global scale. The explanation is not cleared. Which vegetation is shown in figure 1c?

L216: the acronym SST is used for the first time in the main text. Replace “SST” by sea surface temperature.

L245 and after (section 3.3): The authors compare their results with those of Goldner et al. (2014) and Hutchinson et al. (2018). What vegetation map were used in these two experiments? The authors argue that a lower global land fraction at Eocene induce

a lower albedo and thus a global warming. The authors should estimate the changes in earth's albedo between pre-industrial and Eocene experiments. The simulations done by Hutchinson (H18) use the same paleogeography. The only difference is the model. The authors should better explore the impact of model version.

L370: "smaller but still considerable". The authors should estimate the changes in temperature.

L380: The annually averaged (daily) minimum temperature is plotted in figure 3a. The northeastern Siberia is concerned by temperatures below the freezing point (main text) which do not appear in figure 3a.

L387: The authors should indicate where the effects of orographic lift can be observed.

L406-409: These two sentences seem to be redundant.

L465: The paleogeography of Douglas et al. (2014) is different. The difference in latitude between Tasmania and the tip of Antarctica peninsula is about 5° in Douglas' work but reaches 15° in this study. Can it explain the difference of temperature?

L467-472: How can the authors explain the absence of strong sub-polar gyre in the Ross Sea? Is it due to the paleogeography (Antarctica) or the depth of Tasmanian Gateway?

L488: The authors should indicate in table S2 and S3 where the SST proxies are located (Gulf of Mexico, Blake Nose . . .).

Minor comments: L45: reference missing : Toumoulin et al., 2020, Quantifying the effect of the Drake Passage opening on the Eocene Ocean, https://doi.org/10.1029/2020PA003889

L65: reference missing : Tardif et al., 2020, Clim. Past, https://doi.org/10.5194/cp-16-847-2020

Figure 1 caption: typo error (needleleaf)

L347: typo error (° is missing)

L432 : typo error (Indo-Pacific)

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