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Climate of the Past Discussions

Interactive comment on "The effect of high dust amount on the surface temperature during the Last Glacial Maximum: A modelling study using MIROC-ESM" *by* Rumi Ohgaito et al.

Anonymous Referee #2

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The manuscript by Ohgaito and colleagues presents results of a study on the impacts of dust on the Last Glacial Maximum climate, conducted with different configurations of the MIROC-ESM global model. Attention is given to the role of glaciogenic source of dust. Dust feedbacks on climate include direct effects, cloud effects, and snow darkening. Dust effects are discussed, in terms of perturbation to the atmospheric radiation budgets and surface temperatures. The study is an interesting contribution to both the dust community and the paleoclimate community. In my opinion the manuscript still need some improvement before publication.

General comments

The abstract seems all focused on glaciogenic dust, whereas the title and the manuscript deal with both glaciogenic and non-glaciogenic dust. I suggest to make more clear in the abstract that both aspects are analyzed, and what are the relative contributions to the net dust effects.

A more detailed description of what glaciogenic sources represent, and how glaciogenic sources are embedded in the model setup are strongly encouraged, given the relevant role they play in this manuscript.

The discussion should be improved by comparing more extensively with existing results from the literature, and by enhancing the last section which is an original contribution.

Specific comments

1/14: "the impact of glaciogenic dust". Do you mean "glacial climate dust"? In fact your study explores the effect of both glaciogenic and non-glaciogenic dust.

1/18: "sources" rather than "provenances"

1/21: one gets curious here: is the enhanced cloud cover caused by semi-direct or indirect effects?

1/22-23: It's not clear what you mean by "a first trial of glacial dust modelling" in the specific context of fully-coupled simulations, rather than the atmosphere-only ones.

2/7-8: Rather than "capturing past climate sensitivity", I would say "estimating climate sensitivity by looking at past climates", or perhaps more appropriate for the scope of this manuscript, "capture past climate conditions".

2/21-3/2: Repetition that higher dust fluxes are more pronounced at higher latitudes

Pages 3-4: In this historical review section some recent, relevant papers are not cited, e.g. Albani et al. (2014), Sagoo and Storevlmo (2017). I would recommend to consider them along with other also studies in the discussion section, in terms of global dust budget and impacts.

3/11-13: This sentence is not grammatically correct, please rephrase. Also, moraine debris does not appear to be itself a potential dust source type, but rather fine grained material would be. Please try to be more specific in your definition of glaciogenic sources (e.g. see Bullard et al. 2016).

4/9-10: it's not very clear what is the difference between Sections 3.2. and 3.3 in this brief description.

5/11-13: I do not understand this sentence, i.e. how this weighting occurs

5/14-15: Are you using this kind of off-line model in this study? If not, it seems irrelevant yo mention this fact here.

5/20: Maybe "specific" rather than "particular" would be more appropriate here?

6/9-10: How is this implemented in the model? At the level of grid cells (do you have the same horizontal grid?)? Or rather you are redistributing total emissions on your own grid cells matching the spatial coverage of the same geographical area? Are the emission fluxes prescribed as a repeated monthly varying quantity, or some other way? Please provide more details on this central part of your methodology, and list the geographical location of these glaciogenic sources.

Table 1: Does the integration length refer to the length of your simulations only, or does it also correspond to the period averaged to derive the diagnostic quantities discussed and compared in the manuscript? Please specify how long was our spin-up and how many years you averaged for analysis.

6/18-19: Indeed Australia is the major missing dust source, but also South Africa and the SW North America would fall into this category. Can you comment on how the present day simulations with the same model perform in this respect?

7/3-4: "enhancement" is repeated twice

7/5-6: expressing these quantities in Tg/year would help the reader relating to the

existing literature. Actually it would be very useful to report global budgets of dust emissions, load, and deposition in a table.

7/11: What do you mean exactly by "higher uplift"? Transport to higher levels in the troposphere? Please clarify this aspect, as it may be confused with larger emissions (which should not be case, since glaciogenic sources appear to be prescribed to a fix emissions flux).

Figure 4: please specify if the data reported from Albani et al. (2014) refer to the bulk or to the fine fraction in terms of particle size range. In the caption, please change to "Crosses represent terrestrial sediments, circles marine sediment cores, and diamonds ice core data" - terrestrial sediments are typically loess sections.

7/21: Do you mean "the main source of dust deposited in this region"?

8/6: What do you mean by "glacial dust"? Glaciogenic dust or glacial climate dust? IF you mean the second one, it would be useful to explicitly clarify the distinction, better in earlier sections of the manuscript. If not, you should consistently use "glaciogenic" rather than "glacial" to avoid confusion, I think.

8/11: Do you mean "Figure 7 shows a reduction in the shortwave radiation anomaly . . ."? Similarly, in the following lines, I would suggest referring to "-wave radiation anomaly".

8/15-16: What do you mean by "radiative perturbation by the dust"? And how is that different from the analysis just carried out in the previous lines?

8/6-16: A comparison with Mahowald et al. (2006) seems in order here, being the only other study discussing directly the impacts of glaciogenic sources.

8/17-19: This paragraph is repeated twice.

9/6: Please indicate where we can see this effect, i.e. "the cooling effect of the dust loading in the atmosphere" - it is not self-evident.

9/6-9: Again, where can the reader see these features?

9/6-16: It would seem appropriate to compare you results for this process at least with the study by Krinner et al. (2006).

9/20: A net cooling of . . . how much?

Table 2: Could you further split aerosol-radiation interactions between snow darkening and atmospheric impacts? Also, can you indicate the total dust radiative perturbation (from all types of feedback)?

10/1-18: There is ample space here to compare the results in terms of aerosol-radiation interactions with additional existing work, e.g. see Albani et al. (2014) and Hopcroft et al. (2015).

10/16-18: Please rephrase, this sentence is not very clear to me.

10/19-20: The link between this statement an Figure 10 is not clear to me. Please review this passage.

11/2-6: A comparison with Sagoo and Storelvmo (2017) would be appropriate here.

11/7: A more precise title for this section could be “Influence of glaciogenic sources on the ocean SST”?

11/7-21: This section is potentially very interesting. Unfortunately in its present form the discussion is quite superficial in my opinion. I would recommend to expand the section and perhaps enhance Figure 12 with a scatterplot or some other representation that would allow the readers to appreciate the effects on SST and land temperature anomalies.

13/1-3: As discussed in the manuscript, the mismatch is to be attributed to the lack of dust emissions in regions such as Australia in the model used for this study. I fail to see what’s the link with the prescribed glaciogenic sources.

14/6: see also Mahowald et al. (2014) or Albani et al. (2014)

References

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