

Interactive comment on “Sensitivity simulations with direct radiative forcing by aeolian dust during glacial cycles” by E. Bauer and A. Ganopolski

Anonymous Referee #2

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This paper presents the feedback between dust, climate and ice sheets in the past glacial cycles for the first time, using an earth system model, CLIMBER. It aims at showing the potential importance of aeolian dust for the evolution of glacial cycles, which is the central theme of the series of studies by the authors' group (Ganopolski, Calov and Claussen, 2010, Ganopolski and Calov, 2011, Bauer and Ganopolski, 2010). The paper shows and stresses in the end the importance of dust cycle.

The work of the paper is very important for the community since the work contributes to two of the central topics, which this journal, Climate of the Past (CP), deals with; one is the mechanism of glacial cycle and the other on the earth system climate sensitivity (ESCS). It is therefore highly recommended for publication in CP. However, the

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paper needs to be restructured and edited so that readers understand the content and the new contribution more easily. The paper should be published after some minor revisions as followings.

(1) Method section is extremely long, while the results and discussion are too short. I had to look for all the information I need to understand the paper with hard time, but now I see that this could be improved by re-editing the “Method” section and “Results” section. Especially, the method and results could be understood much better by explaining the difference to the former studies of the same group, since this is the natural development of the series of papers by them with the heart of the theme of analyzing the fully coupling between the dust, climate and ice sheets in the past glacial cycles.

(2) Method section needs to be much shorter but understandable and reproducible and shall be divided into 2 main parts, one the model description and the other the experimental design, which is difficult to find now. The current method section includes mixed information of the whole general description, parameter tuning and even some results and validation under present day climate. It needs only the model description which was mainly changed from the previous work such as the Ganopolski, Calov and Claussen, 2010, Ganopolski and Calov, 2011 and Bauer and Ganopolski, 2010. I had personally a hard time to see the difference and understand what the highlights of improvement and changes are. Please help us understand them. As far as I understand the method introduces the link between the “dust” and the “radiative forcing” so why don't you write what was changed from the method section of paper of Ganopolski, Calov and Claussen, 2010 for example (ex. their section 2.2 Radiative forcing of atmospheric dust).

(3) For the “dust feedback” processes (Rad. Forcing, ice darkening effect etc...), please explain which part is new and which is switched on and off in the introduction and method consistently. The “revision” of the “Flow diagram of the model version in this study” (Fig.1 of Ganopolski, Calov and Claussen, 2010) might be also highly helpful. Were the RDST and/or DDST improved or switched on? Explain what was

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changed there referring to the diagram!!!

(4) The word “online” and “offline” is very confusing in the paper, since even in the earlier paper you had the feedback from the dust to climate and ice sheet by darkening of ice for example, which was the highlight of previous papers. When you say, “offline” (as defined only in section 2.2 line 24, very briefly!!!), I think you mean by “offline” only for the radiative forcing, but this is unclear, since you say, “the one-way coupling between the climate model and dust cycle model” (even including the darkening effect?!). Please specify which dust-climate processes are coupled and uncoupled for the “offline” model. May be the word “Base-line model” in your previous papers or “control experiment” is better than “offline”, since it is not really “offline”, isn’t it? Any-way please write about these “experimental design” more precisely in an independent sub-section (experimental design) so that readers see what is the reference and what is done newly.

(5) Please explain the link between your RI (which you change in the experiments) and the radiative forcings with the key equations. Please explain the validity and uncertainty with it.

(6) For the dust cycle model, what is new since Bauer and Ganopolski, 2010? Re-edit, shorten and minimize the section 2.2.

(7) Is the dust feedback to ice albedo (darkening) the same as in Ganopolsky and Calov, 2011 even in the “offline” simulation?

(8) For the glacial simulation results, how much was the radiative forcing and the climate sensitivity modified? The Figure 7a, I guess, is showing only the difference between the fully coupled dust effects and the Mahowald distribution (which still takes into account the dust RF change!) It is appreciated to know the role of dust (with and without dust RF “glacial- interglacial change” upon RF, climate, and sea level (without the change because of RF effect by specifying Mahowald’s dust change).

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(9) The results and discussion on the effect of dust-climate coupling upon sea level and ice sheet in section 3.2, although shown in Figure 7c and 8, are still missing, while it was expected to be one of the central issue. Please show and discuss the sea level change of all the 4 glacial cycles (cf only one cycle in Fig.7 c) and also the ice sheet distribution in the whole northern hemisphere (especially east of Fenno-Scandian IS) as in Figure 8 for the glacial maximums. (By the way, the figure is not shown fully from -180 to 180 degree, which has mismatch with the longitude axis showing -180 to 180 in Figure 8).

(10) For the ice sheet, which is more important, the darkening effect or the radiative forcing change effect? This aspect of dust-climate-ice sheet “feedback” processes could be discussed a bit more in the discussion section after showing the results in 3.2.

(11) Introduction and discussion on the estimation of dust radiative forcing constrained by dust proxy are needed referring to other studies such as Lambert et al, 2013, *Nature Climate Change*.

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