Clim. Past Discuss., 5, C1091–C1095, 2010
www.clim-past-discuss.net/5/C1091/2010/

Climate of the Past Discussions

Interactive comment on "Mountain uplift and the threshold for sustained Northern Hemisphere Glaciation" *by* G. L. Foster et al.

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Received and published: 21 January 2010

We thank the reviewer for their insightful comments on our paper. We agree with the reviewer that this paper on North American glaciation (Foster et al, Climate of the Past Discussions, henceforth FCPD) will benefit from a clarification of its relationship with our previous paper on Greenland glaciation (Lunt et al, 2008a, henceforth L08). Here we present this clarification, which we will include in a slightly condensed form in our revised submission. In further online comments and in the revised submission we will also address the reviewer's other comments, and those of the other reviewers. The key issues here are the relationship between North American, Greenland, and Northern Hemisphere glaciation, the setup of our control GCM simulations, and the lack of albedo-climate feedbacks in the ice sheet simulations.

First of all, in FCPD we are only addressing North American glaciation. In the revised manuscript we will remove all reference to 'Northern Hemisphere glaciation'. Similarly, L08 addressed only Greenland glaciation.

Secondly, in FCPD, our 'control' simulation is different to that of L08. In FCPD our control simulation is pre-industrial but with lower Canadian Rockies (fully glaciated modern Greenland ice sheet, 280 ppmv, modern vegetation). Our perturbation experiment is the same as our control but with modern Canadian Rockies. In L08, our control experiment is mid-Pliocene (low Rockies as defined by the PRISM reconstruction, reduced Greenland ice sheet, 400ppmv, Pliocene vegetation), and we carried out several perturbation experiments, one of which with low CO2 (280 ppmv) and one with high modern Rockies. This is summarised in Table R1.

It is important to stress that 'Low Rockies' in L08 is different from 'Low Canadian Rockies' in FCPD (a larger area is lower in L08 - compare Figure 3 in the supplement of L08 and Figure 3 in FCPD).

Furthermore, in L08 we present 3 set of ice sheet results with 3 different orbital forcings - 'modern', 'cold-orbit', and 'warm orbit' (see L08, Supplementary information, Figure 9, red lines, blue lines, white shading). In FCPD we only present cold-orbit simulations. So, it is actually more difficult to make direct comparisons between the two papers than the reviewer suggests. We also acknowledge that FCPD is more idealised in that it is carried out under largely pre-industrial boundary conditions, as opposed to Pliocene.

In L08, the GCM has an ice sheet (albeit reduced compared to modern) over Greenland for all simulations. In the 'low CO2' simulation in L08, the ice sheet predicted by the ice sheet model is actually larger than that prescribed in the GCM. Therefore, it is likely that albedo feedbacks will lead to an even larger ice sheet. For all other simulations in L08, including the high Rockies, however, the ice sheet predicted by the ice sheet model is smaller than the ice sheet prescribed in the GCM. Therefore, it is likely that albedo feedbacks will lead to an even smaller ice sheet. Hence, we agree with the

reviewer that in L08 the orography experiment is not a 'minimum response' and we will modify the text of FCPD accordingly. In FCPD, there is no ice sheet in the GCM over North America, so any expansion of the ice sheet predicted by the ice sheet model following uplift is probably a minimum response.

Finally, we stress again that in L08 we are discussing the effects of uplift on Greenland only. In that paper it was concluded that, of the mechanisms investigated, a CO2 drop from 400 to 280 ppmv has the largest effect on the modelled ice sheet. However, it is also true that of all the "non-CO2" drivers, topographic change was the most significant for Greenland. What we aimed to investigate in FCPD was how topography influences that threshold for glaciation in North America. We do not dispute the conclusions of L08, but suggest that, for North American glaciation, uplift (as well as CO2) may play a role in delaying glaciation.

The idealised conceptual Figure R1 hopefully clarifies our hypothesis and the relationship between North American and Greenland glaciation.

Interactive comment on Clim. Past Discuss., 5, 2439, 2009.

	FCPD, control	FCPD, uplift	L08, control	L08, low CO2	L08, uplift
Orography	Low Canadian Rockies	Modern	Low Rockies	Low Rockies	Modern
Vegetation	Modern	Modern	Pliocene	Pliocene	Pliocene
CO_2	280ppmv	280ppmv	400ppmv	280ppmv	400ppmv
Ice	Modern	Modern	Pliocene reduced Greenland	Pliocene reduced Greenland	Pliocene reduced Greenland

Fig. 1. Table R1

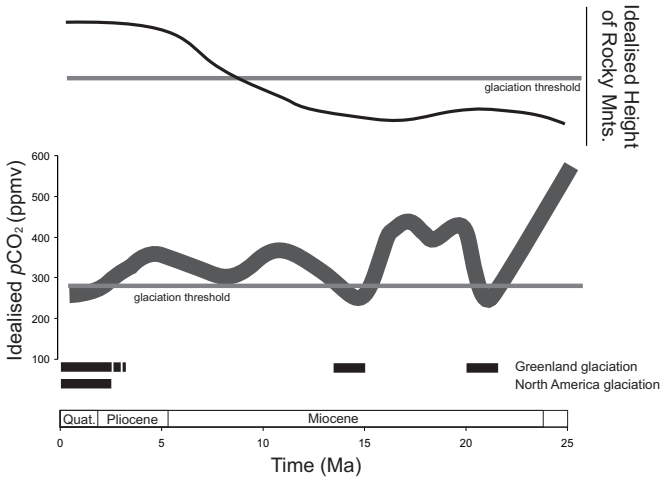

Fig. 2. Figure R1