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Climate of the Past Discussions

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

Anonymous Referee #2

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In this paper, the authors investigate a potential causal connection between orographic uplift of the northern American Cordillera in the late Miocene and the onset of northern hemisphere glaciation ∼3 Ma. Their study aims to solve the question of why the onset of sustained glaciation did not take place until the Late Pliocene, regardless of atmospheric carbon dioxide concentrations close to pre-industrial values during the Miocene (∼24 to ∼5 Ma). The authors present orographic uplift as a possible environmental factor that changed the climate to make it favorable to glacial inception when forced with pCO2 concentrations close to pre-industrial.

Two of the authors of the manuscript, Foster and Lunt, are also authors of other paper investigating the causes of glacial inception at ∼3 Ma, which is referenced as Lunt et al. 2008a. While it is referenced several times along the text, the authors do not justify

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in a clear way a fundamental issue: the papers have contradictory conclusions. In Lunt et al. 2008a, the authors compare several mechanisms proposed for glaciation, and state in the abstract: "our model results suggest that climatic shifts associated with the tectonically driven closure of the Panama seaway, with the termination of a Permanent El Niño state, or with tectonic uplift are not large enough to contribute significantly to the growth of the Greenland ice sheet; moreover, we find that none of these processes acted as a priming mechanism for glacial inception triggered by variations in the Earth's orbit". In the Foster et al., CPD paper, they state at the end of the abstract "This suggests uplift of the North American Cordillera in the Late Miocene may have played an important role in priming the climate for the intensification of Northern Hemisphere glaciation in the Late Pliocene". In the Discussion of Foster et al., CPD, there is only a vague justification of the conflicting conclusions ("Lunt et al (2008a) did model a small increase in the ice present on Greenland. . ."), without an explanation of why what is considered a "small" effect in one paper is taken as a "significant" response in the other.

The paper explores ice sheet growth only in North America, while its aim is to investigate Northern Hemisphere glaciation. The authors should justify the non-inclusion of other regions in this study. For instance, Greenland has been removed from Figure 5, without any explanation.

The authors explain the small increases in ice in their model results by insisting in the fact that these simulations lack important ice sheet-climate feedbacks, and the model results should therefore interpreted as a "minimum response". In the Discussion they claim that this was also the case in Lunt et al., (2008b). However, in that paper, a great part of Greenland was prescribed to have an albedo of more than 0.7 as boundary condition of the atmospheric model (figure 4, Supplementary Information). That is, while the ice sheet model had as initial condition an ice-free Greenland, the atmosphere was seeing already an ice sheet there. This, presumably, should facilitate a rapid growth of an ice sheet. Unless I am missing something, the statement of a "minimum response" is incorrect for Lunt et al. (2008b). In the current version, Foster et al. lacks details on

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the chosen boundary conditions (ice sheet, vegetation) for the simulations. I suggest the authors to clarify these issues.

Other minor suggestions: - the Ruddiman hypothesis should be clearly explained in the introduction.

- what is the spin-up time of the simulations?

- what is the resolution of the ice sheet model?

- the name “pre-industrial control” (Fig. 5) is perhaps a bit confusing

- The use of anomaly coupling between the ice sheet and atmospheric components is problematic: while the ice sheet model might see melting in a specific area, the atmospheric model might see a non-melting surface, with a high albedo. The reader should be cautioned about the limitations of the use of anomaly coupling.

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