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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.

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This paper begins by noting one of the major paradoxes of paleoclimatology: evidence from several proxies that show CO2 concentrations falling by 25-20 million years ago to values as low as those in the last million years, but with the onset of sustained glacial cycles delayed until 3 million years ago. This paradox seems to have two possible explanations. Either the paleo-CO2 proxies are wrong (despite showing trends that are first-order similar), or some other factor or factors have subsequently changed in such a way as to favor glaciation in the last few million years.

The other factor explored here is uplift of the northern North American Cordillera. Foster et al assemble a large amount of data that argues for substantial uplift in that region between 13 and 8 million years ago, thus potentially pre-conditioning parts of North

America for glaciation. As evidence that their view is balanced, they also note evidence from Wolfe and others that much of the rest of the American west did not undergo uplift during this time.

Their model simulations show large climatic effects within the immediate uplifted region of the N Cordillera (lapse-rate cooling, increased orographic precipitation, and stronger rain shadows) but far smaller effects elsewhere in North America. It is difficult to make a strong case that these rather small and patchy far-field effects are really significant.

On the other hand, the authors correctly note that albedo feedback from growing ice sheets could have amplified these small effects. And, perhaps more critically, many modeling experiments in the last decade have shown that including various feedback effects (such as vegetation/albedo feedback and fully dynamical ocean circulation) amplifies the responses to initial forcings. The HadCM3 model used here apparently did not include deep-ocean circulation and it is not clear whether or not it included vegetation-albedo feedbacks. This needs clarification.

The authors may also want to consider (at least briefly) the larger context of their results. For example, much of the planet shows clear evidence of ongoing cooling during the last 25-20 Myr. If this is not due to CO2 (as assumed by the authors), why did it occur? Such a pervasive cooling cannot possibly be due to uplift of a small part of the N Cordillera. So what is its cause?

Molnar and colleagues have voiced the legitimate criticism that the extent of surface uplift in the last 10 million years or more has been greatly overestimated in many regions, yet abundant evidence in the last two decades has confirmed that net surface uplift has indeed occurred in several regions: the northern and eastern Tibetan Plateau, the Andes, and a large part of eastern Africa. This evidence may leave in play the possibility that widespread (but not global) surface uplift was sufficiently pervasive to provide at least a partial explanation for the ongoing Miocene cooling.

The authors mention using a pre-industrial control-case simulation. It would help if they

specified what CO2 and CH4 levels they used.

One point that needs to be addressed more clearly — Figure 1 shows uplift of the North American cordillera occurring between ∼13 and 8 million years ago, but that interval matches a halt in the benthic O18 trend toward heavier values. Northern glaciation doesn't really get going until 5 million years after the main interval of uplift. It seems worth commenting on this mismatch.

The choice of contour intervals and colors (especially the very similar blue hues) make it difficult to track the amount of cooling caused by N Cordilleran uplift.

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