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Climate of the Past Discussions

Interactive comment on "Pleistocene glacial variability as a chaotic response to obliquity forcing" *by* P. Huybers

Anonymous Referee #2

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This manuscript presents a new simple model for glacial-interglacial oscillations, that has several interesting new and original features. In particular, the solutions of this model are chaotic and can switch spontaneously from oscillations at about 41 kyr to oscillations at a mean periodicity of 100 kyr, in a way reminiscent of the mid-Pleistocene transition (MPT). The idea is quite interesting and certainly deserves being published. Still, I would strongly recommend that the author discusses not only the points that compare favourably with the paleoclimatic data, but also the difficulties that such a model may have. In particular:

1 - I tried to reproduce the author's results shown on Fig.2, but I found it extremely difficult to choose an initial condition that gave a succession of eleven successive 'almost 40-kyr cycles' as shown on Fig. 2c. The typical results look more like the second

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half of Fig. 2c, with a mix of 80-kyr and 120-kyr cycles, while the first half is extremely unlikely. The author mention that "the model intermittently happens to land near the unstable fixed point (at the g-G boundary) and then requires many g-G cycles to escape the fixed point influence". In my rapid implementation of the model, "many g-G cycles" typically means about 5 or 6 cycles, which is quite small compared to the duration of the "41-kyr world", even near the fixed point zn = 1.34 mentionned in Fig. 2b. In other words, the 41-kyr oscillation appears far too unstable to be relevant to the Plio-Pleistocene climate.

2 - The author is justifying the need for such a model in the introduction of the manuscript, by the lack of a well accepted forcing for the MPT. Still, it must be emphasized that, though there is no consensus on a long term forcing for the climate system on this time scale, there is a clear climatic trend over the last 15 Myr, since the Mid-Miocene. The last events fitting into this trend are the start of significant Northern hemisphere glaciations (about 3 or 4 MyrBP) and the MPT (about 1 MyrBP) which corresponds to a transition towards larger and longer glacial cycles. The MPT appears therefore naturally as part of a climatic trend, even if the underlying forcings are not clear. It is consequently not so obvious to me that a model simulating the MPT as a purely stochatic event has an advantage over other models.

3 - This lack of external forcing trend may on the contrary become a difficulty, since the ice volume needs to be initialized to zero (or almost zero) at the beginning of glaciations (about 3 or 4 MyrBP ago). When starting from V near zero, the author's model jumps immediately into 100-kyr like oscillations (since this is far away from the unstable limit cycle). Without some external parameter changes, this model therefore cannot reproduce the start of Plio-Pleistocene glaciations.

Other minor comments: - On fig 1a: "glacial cycles lasting more than 60 ky are indicated by vertical bars". And page 239 line 4: "multiple switches observed between short and long-period glacial cycles". Without a clear definition of what a "glacial cycle" is, it is difficult to assign a length to each individual cycle. Please be more precise when

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suggesting that these lengths switched from 41 to "more than 60", back and forth, several times during the last 2 million years. For instance, i don't understand on Fig. 1a why stage 15 is not grayed out (since I don't see any 41-kyr oscillation in it). - page 239 line 19. "Fig.2c" to be replaced by "Fig.1c". - Units. In equation (1) everything is dimensionless (except time ?). Then if the constant T is measured in kyr, so should also be accumulation and forcing ? Clearly, there is a problem with a dimensional T. - page 238 line 17. "In the absence of substantial change in the external forcing". I think the author is meaning "astronomical forcing" which is more adequate.

Interactive comment on Clim. Past Discuss., 5, 237, 2009.