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Climate of the Past Discussions

Interactive comment on "Initiation of a Marinoan Snowball Earth in a state-of-the-art atmosphere-ocean general circulation model" *by* A. Voigt et al.

Anonymous Referee #3

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This is an interesting paper focused on the conditions required to initiate a global glaciation within a fully coupled model. This is very nice to see that an up-to-date OAGCM is now used to investigate the most extraordinary event undergone by the Earth during its long history. The paper is well written and well organized. The authors show that a 6% reduction in solar constant triggers a snowball Earth in the ECHAM-MPI OM model. They also show that an atmospheric CO2 concentration of 1120 ppm is necessary to prevent a global glaciation when using the Neoproterozoic solar constant. Using 0-D and 1-D energy balance models, they discriminate the processes in terms of long-wave and shortwave radiative forcings. In fact I have just 2 comments but I think that the paper can be published as it is. My first comment is about the slushball. Pollard

and Kasting in an AGU monograph have done some simulations using an atmospheric GCM coupled to a slab ocean in which they test the conditions required to have land ice down to the sea level at the equator with an ice-free equatorial ocean. Using an offline ice-sheet model, they find that high topography closed to the ocean may allow to initiate ice-sheet on the equatorial continents. I know that there are many differences between the Pollard and Kasting model and the Voigt et al. model. Nevertheless, it may be fair to relate these results in the paper in order to counterbalance the discussion. One critical issue is the tropical (or even global) temperature calculated by both models before going into a snowball Earth. Indeed, both models have the sea-ice line around 30° of latitudes but maybe the Pollard and Kasting model is colder than the Voigt et al. model in that particular state. The tropical temperature arising from the stable state with the maximum ice cover but still equatorial ice-free ocean is probably the result of the ocean-atmosphere dynamics as well as the cloud radiative forcings. My second comments is on the nice formulation the authors get to estimate the transition time to snowball Earth. I find very impressive the fact that it takes 232 (355 in the GCM) years to obtain a snowball Earth when imposing a 6% decrease in solar constant. Indeed, several large igneous provinces have occurred during the Phanerozoic and I suspect that their effects on the atmosphere transparency may have been on the same order than a 6 % decrease in solar constant. The question that remains is for how many times.

Interactive comment on Clim. Past Discuss., 6, 1853, 2010.