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Climate of the Past Discussions

Interactive comment on "Sea-ice dynamics strongly promote Snowball Earth initiation and destabilize tropical sea-ice margins" *by* A. Voigt and D. S. Abbot

Anonymous Referee #2

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This contribution explores the respective role of ice albedo, sea-ice dynamics, and ocean heat transport on the initiation of a hard snowball state in a numerical model previously known to easily freeze the whole Earth. The authors demonstrates with a set of well choosen simulations that sea ice dynamics is a key factor. Even if the sea-ice albedo is strongly reduced compared to previously published simulations, the flowing of sea glaciers into the sub-tropical area allows the onset of a hard snowball state at reasonably low CO_2 levels (close to preindustrial value). If sea ice dynamics is removed from the simulations, then unrealistically low CO_2 levels (a few ppm) are required to initiate a global glaciation.

This contribution is well organized, well written and clear. I strongly support its publication. I only have 3 minor comments.

(1) in the discussion section, the authors mention that their (2ppm,85%) state is compatible with the covering of the continents by glaciers. They suggest that continents fully covered with ice might be compatible with the existence of a free water between 20°N-20°S. But 2 ppm is so unrealistically low that such a state would most probably never occurred. Donnadieu et al. (2004) tried to evaluate how much CO_2 was in the atmosphere during the Neoproterozoic, prior to the glacial events, and depending on the continental configuration. Particularly, they explore how much CO_2 can be consumed by weathering of the continental rocks. They found atmospheric values largely above the required 2ppm for a ring of free water to exist (without sea-ice dynamics, which is already highly hypothetical). In the best case, CO_2 levels where around 200 ppmv before the glacial events, a value fully compatible with the present study (with sea-ice dynamics). Maybe Donnadieu et al. (2004) should be cited (Nature, 428, 303-306).

(2) there are several typo errors in the discussion section. This can be easily corrected.

(3) what happens if a high sea-ice albedo is prescribed in a simulation without sea-ice dynamics ? Does the snowball CO_2 threshold rises significantly ? If not, this would definitely confirm the key role played by sea-ice dynamics.

Interactive comment on Clim. Past Discuss., 8, 2445, 2012.