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Ocean dynamics and climate during a Neoproterozoic snowball Earth and its aftermath as simulated in a coupled Earth system model

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The Neoproterozoic glaciations, referred to as snowball Earth periods, describe the most extreme transition from a very cold climate to a state of strong greenhouse effect. Atmospheric CO_2 concentrations are rising during the snowball, due to the shutdown of oceanic and terrestrial carbon sinks, until a tipping point is reached and a rapid deglaciation sets in. Subsequently, a warm and completely ice-free climate under very high CO_2 concentrations develops. We show first results of simulations using a coupled atmosphere-ocean general circulation model covering the initiation, as well as the melting of the Marinoan snowball Earth (645 – 635 My ago) and the greenhouse climate in its aftermath. CO_2 concentrations are decreased to initiate a global glaciation and then increased again in order to melt the snowball Earth. As soon as a certain CO_2 threshold is reached, sea-ice melts rapidly, reaching a completely ice-free ocean after only one hundred years, in our model without land glaciers. The ocean becomes strongly stratified, because at the surface the freshwater from the sea-ice melt is warming up quickly, whereas the deeper ocean remains cold and salty. Ocean surface currents return to their pre-snowball behavior soon after the melt, but destratification is slow. The largest mixed layer depths of up to 500 m are reached in the mid latitudes of the winter hemisphere. We compare the climate before and after the snowball state and estimate the time needed for destratification.