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A Carbon-dioxide "Attractor" in the Neoproterozoic

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The Neoproterozoic period of Earth history was marked by several episodes of deep glaciation, possibly the most severe experienced in all of Earth history. The "snowball Earth" hypothesis posits that these episodes were so severe that photosynthesis may have been entirely arrested. The competing "slushball" model has been criticized on the basis of the claim that it would be unable to explain the duration of these glacial episodes, which it has been argued are constrained to have lasted at least 3 million years. We have synchronously coupled a model of the carbon cycle to the energy balance coupled ice sheet model on which basis the "slushball" solutions were originally documented. When this model of the carbon cycle, originally developed by Rothman, Hayes and Summons (2004), is linked to the Neoproterozoic climate model the coupled model exhibits limit cycle behavior, the period of which is shown to depend upon the strength of the dependence of the solubility of oxygen in sea water. As the system cools, oxygen is drawn down into the ocean leading to an increase of the remineralization of organic carbon which causes the carbon dioxide concentration to increase, thus inhibiting further cooling. The period of the limit cycle supported by the model is found to lie in the range 1-25 million years. The "slushball solutions" are not therefore made untenable by the geological constraints on Neoproterozoic ice-age duration.