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SNOWMIP2: Comparing simulation of the deep Snowball and the nearly deglaciating Snowball among GCMs

D.S. Abbot (1), A. Voigt (2), M. Branson (3), D. Pollard (4), D. Koll (1), R.T. Pierrehumbert (1), G. Le Hir (5), D. Randall (3), and Y. Donnadieu (6)

(1) University of Chicago, Geophysical Sciences, Chicago, United States (abbot@uchicago.edu), (2) Max Planck Institute for Meteorology, Hamburg, Germany, (3) Colorado State University, Atmospheric Sciences, Fort Collins, United States, (4) Pennsylvania State University, Earth and Environmental Systems Institute, State College, United States, (5) Université Paris, Institut de Physique du Globe de Paris, Paris, France , (6) LSCE, CNRS-CEA-UVSQ, Gif sur Yvette Cedex, France

A variety of global climate models (GCMs) has been used to examine the Snowball Earth Hypothesis for Neoproterozoic glaciations, often with conflicting results. If such models are to be used to increase theoretical understanding of Neoproterozoic glaciations, the sources of discrepancies among models must be understood.

A previous SNOWball Model IntercomParison (SNOWMIP) established that even with ocean dynamics turned off differences in model ice and snow albedo schemes can cause large differences in the estimate of the CO_2 threshold for Snowball initiation. Furthermore, it was found that important model differences, likely due to atmospheric dynamics and cloud scheme behavior, remain even when ice and snow albedos are made uniform among models.

Here we describe a new SNOWball Model IntercomParison (SNOWMIP2) that is designed to compare GCM simulation of the deep Snowball, at low CO_2 (10^2 ppm), and the Snowball near deglaciation, at high CO_2 (10^5 ppm=0.1 bar). SNOWMIP2 includes six different GCMs, all of which have been used in previous Snowball Earth modelling. Each model is run with uniform land glaciers everywhere, a uniform surface albedo of 0.6, zero aerosols and ozone, the same CO_2 concentration, all other greenhouse gases set to zero, and with the same orbital parameters and solar constant.

Because of the uniform boundary conditions, the GCMs produce fairly similar climate simulations, although there are important differences. For example, equatorial temperatures differ by as much as 15 K, at a given CO_2, between the warmest and coldest models. This compares to a warming of 3 K produced in the CAM GCM when the CO_2 is increased from 0.1 bar to 0.2 bar. We are able to attribute these differences mainly to cloud behavior. This means that until we can be more confident in cloud schemes, it will be difficult to use GCMs to accurately assess whether a Snowball would deglaciate at a particular CO_2 value. The models produce qualitatively similar circulations and hydrological cycles, although they differ in magnitude. This is important for theories of sea glacier flow in a Snowball.