Clim. Past Discuss., 8, C1376–C1377, 2012
www.clim-past-discuss.net/8/C1376/2012/

Climate of the Past Discussions

Interactive comment on "Radiative effects of ozone on the climate of a Snowball Earth" *by* J. Yang et al.

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Received and published: 31 August 2012

This is a modest, but useful, contribution to the literature on Snowball Earth. The authors show that changes in atmospheric ozone concentration, which are expected for the Proterozoic atmosphere, can have a modest effect on climate conditions during Snowball Earth and on the CO2 level required to either trigger such a glaciation or to deglaciate it once it has commenced. The largest effect is on the threshold for (hard) Snowball deglaciation, which increases by about 30% for an ozone decrease of 50%.

The radiative effects of ozone are, however, dwarfed by the radiative effects of CO2 and clouds. Since we do not know the CO2 concentration at that time, and since cloud forcing is difficult to calculate accurately, the largest uncertainties lie in those factors, not in the ozone forcing. Even more importantly, there are alternative models

for Snowball Earth, e.g. the thin-ice model of McKay (2000) and Pollard and Kasting (2005), or the Jormungand model of Abbot et al. (2011), that have much lower albedo in the tropics, and hence which deglaciate much more easily. The main goal at this point should be to decide which, if any, of these models represents the most plausible solution to the Neoproterozoic climate problem.

One minor technical comment on the paper, which is otherwise generally well done: On p. 3597, the authors state that "..a decline of stratospheric ozone would decrease stratospheric temperature and downward IR emission, causing a cooling of the troposphere and surface." References are given to two previous papers by other authors. This statement may be trueâĂŤI have not checked it with my own modelâĂŤbut, if so, it cannot be for the reasons given. Decreasing stratospheric ozone should allow solar ultraviolet radiation to penetrate more deeply into the atmosphere. Assuming that it is absorbed, rather than backscattered, allowing UV radiation to penetrate more deeply can only warm the surface, as the region that is heated should radiate less energy to space. But if some of that near-UV radiation is backscattered, and hence reflected to space, when stratospheric ozone is reduced, then the effect may well be to cool the surface.

References:

Abbot DS, Voigt A, Koll D. 2011. The Jormungand global climate state and implications for Neoproterozoic glaciations. Journal of Geophysical Research-Atmospheres 116

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Interactive comment on Clim. Past Discuss., 8, 3583, 2012.