Interactive comment on “Comment on “Clouds and the Faint Young Sun Paradox” by Goldblatt and Zahnle (2011)” by R. Rondanelli and R. S. Lindzen

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We appreciate comments by I. Halevy, J. Kasting and by C. Goldblatt and K. Zahnle.

In reply to our comment, Goldblatt and Zahnle (hereafter G&Z) question some of the points we raise in our reply. We will answer briefly, following the numbering of previous comments and replies.

1) It is interesting to note that during most of the last million years, changes in the climate forcing have been only modest with respect to the changes associated with the Archean, and yet very different climates have arisen, the latest glacial-interglacial period being just one example. Much warmer climates have occurred, for instance during
the Miocene and Eocene, with no significant change in the forcing of either greenhouse
gases or solar input (again significant, with respect to changes in solar forcing expected
to have occurred during the Archean). Atmospheric and oceanic processes are able
to modify meridional heat transport in such a way as to allow for very different climates
even without changing the greenhouse or solar forcing. This may partially answer the
question posed by G&Z as to what mechanism can be invoked for heating the high
latitudes.

It is indeed of interest that no record or very little record of glacial evidence exists during
the Archean, however, as pointed out by I. Halevy in his review, the resolution of the
stronger version of the paradox is not justified based on the interpretation of the current
geological evidence.

2) With respect to the Iris effect, the controversy is amply described in the literature
and need not be repeated here (e.g. Hartmann and Michelsen, 2002; Fu et al., 2002;
Lindzen et al., 2002; Chou et al., 2002a,b). When G&Z ask for a "robust physical
mechanism" one should be aware that presently, tropical convection behaves in such
a way as to produce high thin cirrus clouds that have an observed radiative forcing of
the sign and magnitude that our proposed solution requires. So the robust physical
mechanism only has to account for an increased coverage of such clouds. Being an
observed physical mechanism working during present climate, one would consider this
to be a much more robust mechanism than many of the competing mechanisms to
explain or mitigate the faint young sun paradox.

3) With respect to the issue of coverage. First, we do not argue for 100% global cov-
erage by thin cirrus clouds, but only for 100% coverage in the tropics. 100% of the
tropics might seem a large leap in coverage; however, relatively modest changes in the
fractional cloud coverage (γ parameter in Rondanelli and Lindzen (2010)) can in prin-
ciple produce a tropical atmosphere completely covered by thin cirrus clouds. Again,
the definition of optimal cloud for G&Z seems to be what the model he uses is capable
of producing as radiative forcing. In our case the selected cirrus cloud is one that is
observed and that is representative of the clouds that have a positive radiative forcing in the present climate, and therefore the qualifications of "perfect" and "optimum" misrepresent the actual nature of the cloud. Also, 100% cirrus coverage was considered by us to be a limiting value. Smaller coverage still profoundly reduces the need for additional greenhouse forcing.

References


Interactive comment on Clim. Past Discuss., 7, 3577, 2011.