Clim. Past Discuss., 7, C2435–C2437, 2012
www.clim-past-discuss.net/7/C2435/2012/

Climate of the Past Discussions

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

R. Rondanelli and R. S. Lindzen

ronda@dgf.uchile.cl

Received and published: 18 January 2012

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 coverage 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 principle 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

Chou, M., Lindzen, R., and Hou, A.: Comments on "The iris hypothesis: A negative or positive cloud feedback?", Journal of Climate, 15, 2713–2715, 2002a.

Chou, M., Lindzen, R., and Hou, A.: Impact of albedo contrast between cirrus and boundary-layer clouds on climate sensitivity, Atmospheric Chemistry and Physics, 2, 99–101, 2002b.

Fu, Q., Baker, M., and Hartmann, D.: Tropical cirrus and water vapor: an effective Earth infrared iris feedback, Atmos. Chem. Phys, 2, 31–37, 2002.

Hartmann, D. and Michelsen, M.: No evidence for iris, Bulletin of the American Meteorological Society, 83, 249–254, 2002.

Lindzen, R., Chou, M., and Hou, A.: Comment on" No Evidence for Iris", Bulletin of the American Meteorological Society, 83, 1345–1349, 2002.

Rondanelli, R. and Lindzen, R.: Can thin cirrus clouds in the tropics provide a solution to the faint young Sun paradox?, Journal of Geophysical Research, 115, D02 108, 2010.

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