

Interactive comment on “Clouds and the Faint Young Sun Paradox” by C. Goldblatt and K. J. Zahnle

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This is a useful and well-written paper that quantifies the effect of clouds, or lack thereof, in models of Archean climate. The paper is timely, in the sense that two different cloud albedo feedback mechanisms for solving the faint young Sun (FYS) problem have recently been proposed (Rondanelli and Lindzen (2009) and Rosing et al. (2010)). The present authors argue convincingly that neither of these mechanisms is sufficient by itself to resolve the FYS problem. They also show that models published by my group (Kasting) that lack clouds altogether probably overestimate the effect of added CO₂, and hence may underestimate the amount of CO₂ or other greenhouse gases needed to resolve the FYS problem.

The methodology of the paper is appropriate, and the results appear to be sound.
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We might disagree slightly, though, about the final conclusions. The authors conclude that clouds must be included in models of Archean climate in order to get realistic answers, whereas I would say that if clouds are not included, one should estimate their effects by using the results of this paper. Indeed, I would go one step further and note that the omission of clouds in the Kasting group models leads to an underestimate of the required greenhouse gas radiative forcing (to solve the FYS problem) by 5-10 W/m², whereas plausible cloud feedback mechanisms (specifically, changes in droplet size caused by fewer CCNs) lead to an overestimate of the required greenhouse gas radiative forcing by ~15 W/m². These effects cancel; hence, the cloud-free model may not be too far from the mark.

Some minor quibbles about grammar, and one additional substantive remark, are listed below:

1. (p. 1175, line 11) “difference” should be “different”
2. (p. 1176, line 21) “then” should be “than”
3. Discussion section: This should probably also reference the paper(s) by Hans Svensmark (Astron. & Geophys., 2007, and earlier papers). Svensmark proposes that cloud albedo was low on the early Earth because the stronger solar wind from the active young Sun created a stronger magnetic field that deflected cosmic rays, thereby lowering the availability of cloud condensation nuclei. How important are cosmic rays as compared to sulfate particles as CCNs? The authors should probably weigh in on this issue.
4. (p. 1181, line 14) “The Archean is that the...” –What? This sentence doesn’t make sense.