Mesoproterozoic climate – equability in the absence of high CO_2

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Recent reconstructions based on microfossils [1], carbon isotopes [2], and paleosols [3] all indicate very low (<10x pre-industrial levels) atmospheric pCO_2 in the late Mesoproterozoic, which contrasts strongly with reconstructions from the Archean and Paleoproterozoic [4-5] that indicated pCO_2 >25x pre-industrial levels. Thus, an important question is whether the relatively low atmospheric pCO_2 indicated by proxy data is sufficient to result in the equable climate indicated by the rock record. Recent climate model results [6] indicate that even at pre-industrial pCO_2, a "hard snowball" scenario (i.e., low-latitude ice) is difficult to generate in the Neoproterozoic (Marinoan) if there is signficant tropical land in the NCAR CAM3.1 model. There are two fundamental differences between that previously modeled scenario and the late Mesoproterozoic CO_2 minimum at ~1.1 Ga: 1) total solar irradiance was even lower (by ~3%), 2) there is no geologic evidence for significant ice at any latitude at that time. To investigate whether equable (and potentially ice-free) conditions are possible during the late Mesoproterozoic under a low CO_2 regime we have undertaken a series of sensitivity analyses using NCAR's CAM3.1 model coupled with a 50 m slab ocean, variable continental land mass (including land-free), and uniform low topography. Those preliminary results indicate: 1) CH_4 was likely also important in maintaining equability during the Mesoproterzoic, which has implications for atmospheric pO_2, 2) paleogeography is an important control on water vapor and surface albedo feedbacks; failure to consider it produces biased estimates of paleoclimate sensitivity, and 3) equable (but not warm) conditions conditions are possible at low pCO_2. Ongoing work using CESM1.2 will add a fully coupled ocean, examine variable CO_2:CH_4 mixing ratios, and explore the role of adding in paleotopography.

[1] Kah & Riding (2007) *Geology* **35** 799–802; [2] Kaufman & Xiao (2003) *Nature* **425** 279–282; [3] Sheldon (2013) *Chem. Geo.* **362** 224–231; [4] Driese *et al* (2011) *Precam. Res.* **189**:1–17; [5] Sheldon (2006) *Precam. Res.* **147**:148–155; [6] Fiorella & Poulsen (2013) *J. Clim.* **26** 9677–9695