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Geobiological solution to the weak young sun paradox: Biogeochemical implications

Christian Bjerrum (1,2), Minik Rosing (1), Dennis Bird (3), and Norman Sleep (4)

(1) Nordic Center for Earth Evolution, University of Copenhagen, Copenhagen, Denmark (cjb@geo.ku.dk), (2) Dept. of Geography and Geology, University of Copenhagen, Copenhagen, Denmark, (3) Dept. of Geological and Environmental Sciences, Stanford University, Stanford, USA, (4) Dept. of Geophysics, Stanford University, Stanford, USA

An understanding of the mechanisms controlling the biogeochemical cycles through long time scales of earth history require a thorough understanding of how clement climate conditions are maintained on Earth. Early in Earth history liquid water was stable and the sun's luminosity low which required a radiation budget different from today's. We have shown that the mineralogy of Archean sediments is in equilibrium with low concentrations of atmospheric CO2 and CH4 (Rosing et al., in press). Such concentrations are in conflict with previous ideas about high greenhouse gas concentrations in the Archean. Limited biological production of cloud condensing nuclei (CCN) potentially results in an atmosphere transparent to SW-radiation and a low planetary albedo. Together with a small continental area these changes are the most likely ingredients in the solution of the weak young Sun paradox. If correct, the proposed geobiological forcing on Earth evolution requires that we revisit the link between weathering, the carbon-nutrient cycles and life. In particular a climate kept warm by other means than CO2 and CH4 would in part result in a disruption of the silicate weathering – climate feedback, leading to low atmospheric concentrations of these gasses unless compensated by other mechanisms.
An important test of a geobiologically moderated climate history is provided by Earth evolution, proxies of Earth temperature and biogeochemical change over long and intermediate timescales (Mesozoic-Present). Here we perform the test with a long term biogeochemical model, building on a modified version of the GEOCARB model. We highlight additional ways the long term climate and biogeochemical cycles potentially can be stabilized within bounds dictated by observations as well as areas with limited understanding.