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Investigating the Faint young Sun problem with a general circulation model

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The faint young sun problem, the contradiction of a reduced solar luminosity by 15-25% during the Archean and the geologic evidence for relatively high surface temperatures that allowed the presence of liquid water, is still unresolved. It is suggested that the cooling induced by a fainter sun was e.g. offset by higher levels of greenhouse gases (GHGs) during the Archean, but the amounts of GHGs that are necessary to solve the problem can not be supported by proxy data.

We present a study in which we investigate this problem by using the Chemistry Climate model EMAC (ECHAM/MESSy Atmospheric Chemistry) with a, spectrally resolved irradiance dataset valid for the Archean. As proxy for the irradiance of the young Sun at 2.5 Ga before today we use the G0V-dwarf star beta Com, which is scaled to have a total solar irradiance of 82% the present value.
The EMAC model is used in a configuration with the highly resolving short-wave radiative transfer parametrization FUBRad, coupled to a mixed layer ocean, where the sea surface temperatures and the sea ice are derived from the thermodynamics of an ocean layer. We analyse the climatic impact of the spectrally resolved irradiances and other parameters representing the late Archean Earth, such as the composition of the atmosphere and the land/ocean distribution.

We can show that an increase of the CO_2 concentration by a factor of 10 is sufficient to obtain liquid oceans in the tropics. Further analysis concentrates on the thermal and dynamical state of the atmosphere with emphasis on the middle atmosphere.