Scattering greenhouse effect of radiatively controlled CO_2 ice cloud layer in a Martian paleoatmosphere

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The scattering greenhouse effect of a CO_2 ice cloud layer has been proposed as a potential mechanism for keeping the Martian climate warm enough to support flowing water under a faint young Sun (e.g. Pierrehumbert and Erlick (1998) JAS, 55, 1897). Previous studies have shown that such warm climate is possibly achieved if a cloud layer with optimal ranges of particle size and optical depth is placed in the atmosphere (e.g. Mischna *et al.* (2000), Icarus, 145, 546). However, it has not been examined whether or not such an optimal cloud layer could be formed.

In this study, we construct a one dimensional, radiative-convective equilibrium model including cloud formation processes due to radiative cooling and estimate the parameters of cloud layer and the cloud-induced greenhouse effect. Our numerical analysis suggests that a CO_2 ice cloud layer which can cause strong greenhouse effect is formed with achieving both radiative and vapor pressure equilibria, and the global mean surface temperature rises above the melting point of H_2O when the surface pressure is larger than 3 bar and the mixing ratio of cloud condensation nuclei is kept within the range $10^5 – 10^7$ kg^{-1}.