Not enough H_2O_2 to warm early Mars

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There exist strong geomorphological, sedimentary and mineralogical evidences that Mars had an active surface hydrological cycle during the Noachian eon, about 3.8 Gyr ago (Ga). However, how surface temperatures compatible with perennial liquid water could be sustained in spite of the faint young Sun has remained elusive, leading to the faint young Sun paradox for Mars. Recently, the greenhouse effect of hydrogen peroxide (H_2O_2) has been proposed as a solution by [Ito et al., 2020, DOI 10.3847/1538-4357/ab7db4]. Indeed, H_2O_2 has a strong infrared absorption window near the peak emission of early Mars, which complements absorption of both CO_2 and water vapor.

Radiative transfer models have shown that a few ppmv H_2O_2 in a 1 or 2 bar CO_2 atmosphere could solve the faint young Sun paradox on early Mars. In a warm and wet CO_2 atmosphere, H_2O_2 is produced by photochemistry and contributes to the stabillity of the CO_2 atmosphere along with the HOx (H, OH and HO_2) catalytic cycles. Nevertheless, a thorough assessment of the viability of such a high H_2O_2 abundance is still lacking. Using the 1- and 3-D Planetary Climate Models (PCM) coupled with a C-H-O photochemistry solver, we show that in the most favorable case for H_2O_2 to build up, it is still several orders of magnitude short from its required abundance to have a significant radiative effect. We therefore rule out H_2O_2 as a warming agent for early Mars, and based on results from the literature, we favor CO_2-H_2 collision-induced absorption over other gases greenhouse effect.