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N2-associated surface warming on early Mars

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Early Mars may have had a warmer and denser atmosphere allowing for the presence of liquid water on the surface. However, climate model studies have not been able to reproduce these conditions even with a CO_2 atmosphere of several bars. Recent 3D simulations of the early Mars climate show that mean surface temperatures only slightly below 273K could be reached locally.

We want to investigate the effect of increased partial pressures of N2 on early Mars' surface temperature by including pressure broadening of absorption lines and collision-induced N2-N2 absorption. A 1D radiative-convective cloud-free atmospheric model was used to calculate temperature profiles and surface conditions. We performed simulations for N2 partial pressures of 0-0.5 bar where the CO_2 partial pressure was varied from 0.02 bar to 3 bar, values consistent with existing estimates for both species. Solar insolation was set to be consistent with the late Noachian, i.e. around 3.8 billion years ago.

Our 1D global mean simulations clearly show that enhanced N2 content in the Martian atmosphere could have increased surface temperatures. An additional greenhouse warming of up to 13K was found at a high N2 partial pressure of 0.5 bar. Still, even at this N2 partial pressure, global mean surface temperatures remained below 273K, i.e. the freezing point of water. However, given the magnitude of the N2-induced surface warming and the results of recent 3D studies which show that local mean surface temperatures are not much lower than 273K, our results imply that the presence of atmospheric N2 could have led to almost continously habitable mean surface conditions in some regions. In addition, atmospheric water column amounts increased by up to a factor of 6 in response to the surface warming, indicating that precipitation might also increase upon increasing N2 partial pressure.