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Evolution of a steam atmosphere for early Earth with coupled interior-atmosphere interactions

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The evolution of Earth's early atmosphere and the emergence of habitable conditions on our planet are intricately coupled with the development and duration of the magma ocean phase during the early Hadean period (4 to 4.5 Ga). We study the atmosphere-interior interaction of the Hadean Earth during the magma ocean period for an atmosphere consisting of pure steam built as a result of outgassing from the interior. We obtain the outgoing longwave radiation using a line-by-line radiative transfer code GARLIC. We find out the solidification timescale of the magma ocean to be 1 Myr for a pure steam atmosphere. We also study the effect of the thermal dissociation of H_2O at higher temperatures by applying atmospheric chemical equilibrium which results in the formation of H_2 and O_2 during the early phase of the magma ocean. A 1-6 % reduction in the outgoing longwave radiation is seen. The effective height of the atmosphere is obtained by calculating the transmission spectra for the whole duration of the magma ocean. A depth of 100 km is seen for pure water atmospheres. In this work, we also investigate the effect of thermal dissociation on the effective height of the atmosphere. The spectral features of H_2 and O_2 are seen at different altitudes of the atmosphere due to the difference in the absorption behaviour at different altitudes. Therefore, these species along with H_2O have a significant contribution to the transmission spectra and could be useful for placing observational constraints upon magma ocean exoplanets.