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Making Clouds: 3D Simulations of cloudy hot-Jupiter atmospheres

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Abstract

Recent HST observations of hot Jupiter atmospheres have revealed a continuum in atmospheric composition from cloudy to clear skies. The presence of clouds is inferred from a grey opacity in the near-IR that mutes key absorption features in the transmission spectra. This observational challenge inhibits the retrieval of key information including the atmospheric chemical composition and thermal structure. Unlike the L-T Brown Dwarf sequence, this transition does not correlate well with equilibrium temperature, suggesting that a cloud formation scheme more comprehensive than homogenous cloud growth at the condensation temperature is required. In our work, we follow and extend the pioneering study of Lee et al., (2016) by performing 3D simulations of cloud nucleation, growth, advection, evaporation and gravitational settling in the atmospheres of HD209458b and HD189733 using the kinetic and mixed-grain cloud formation code DIHRT, coupled to the Met Office GCM, the 'Unified Model'. We explore cloud composition, vertical structure and particle sizes, as well as highlighting the importance of the strong atmospheric dynamics seen in tidally locked hot-Jupiters on the evolution and distribution of the cloud. The completeness of the radiative transfer (i.e. inclusion of scattering) and the dynamics provided by our new model, will represent the most physically complete theoretical tool for the study of hot-Jupiters.