Microphysical Modeling of Mineral Clouds in Warm Super-Earths: Predicting Upper Limits on the Cloud-Top Height

*Kazumasa Ohno[1], Satoshi Okuzumi[1]

1. Department of Earth and Planetary Science, Graduate School of Science and Technology, Tokyo Institute of Technology

Recent observations of transmission spectra have revealed the ubiquity of opaque clouds and/or haze in warm super-Earth atmospheres. The information about the height of cloud top, at which the atmosphere becomes optically thick due to clouds, is necessary to interpret observed spectra correctly. However, the cloud-top height is still highly uncertain for exoplanets because previous studies took the size of cloud particles as a free parameter.
In this study, we investigate the vertical profiles of mineral clouds in warm super-Earths to constrain the cloud-top height using a microphysical model that takes into account the particle growth via condensation and coalescence. We demonstrate that the vertical profiles of mineral clouds significantly vary with atmospheric metallicity and the concentration of seed particles at the cloud base. The cloud-top height increases with increasing seed concentration, but plateaus in the limit of high seed concentrations, because coalescence leads to further growth of cloud particles and prevents particles from ascending. This trend results in the presence of the upper limit of cloud-top height for given atmospheric metallicities, independent of the seed concentrations.
We apply our model to GJ1214 b, known as a super-Earth that exhibits a featureless transmission spectrum implying the presence of cloud and/or haze. We find that the cloud-top height is too low to explain the observations even if the extremely high metallicity is assumed. This indicates that the photochemical haze might be a more plausible explanation for the flat spectrum of GJ1214 b. We also discuss the influences of size distribution and particle porosity on the predicted cloud-top height.

Keywords: Exoplanetary Atmospheres, Mineral Clouds

