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The difference of cloud formation process between Jupiter and Saturn.

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Gas giant planets have hydrogen-rich, thick atmospheres, and their styles of cloud activities are thought to be closely related to the profile of radiative cooling rate in troposphere. For example, Recent studies indicate that it basically controls the intermittency of cumulonimbus clouds. In spite of its significance, however, no systematic estimate has been made for the radiative cooling profiles of gas giant planets.

Recently, we have developed a 1D radiative-convective equilibrium model for such hydrogen-rich atmospheres. The model atmosphere continues to a lower boundary where the optical depth from the top of atmosphere is sufficiently large and the thermal structure follows convective equilibrium. The atmospheric composition and potential temperature of each planet are given from observational constraints. The mixing ratios of H2O, CH4, NH3, H2S, PH3 and NH4SH follow their saturation vapor pressure in the altitudes where their condensation occurs. Collision induced absorption of H2-H2 and H2-He, and line absorption of H2O, CH4, NH3, H2S, PH3 are included while the extinction by condensates is neglected. Under these settings, our model can calculate a reasonable atmospheric vertical structure by the iteration of radiative transfer calculation and convective adjustment.

For the case of Jupiter, the peak of radiative cooling rate is 1.6e-7 K/sec at 0.7 bar level. Also, our model predicts the radiative-convective boundary i.e., tropopause to be located around 0.3-0.4 bar level, where is slightly higher than the uppermost NH3 condensation layer ˜0.5 bar. For the case of Saturn, the peak of radiative cooling rate is 3.5e-8 K/sec at 0.53 bar, and the separation of tropopause and NH3 cloud layer is larger than that of Jupiter. This implies that the Saturnian NH3 cloud formation is essentially confined in the troposphere, whereas the Jovian one is also affected by the stratospheric processes.

Figure description : Radiative heating rate profile (solid lines, bottom x axis, K/sec) and Volume mixing ratio of NH3 profile (dashed lines, top x axis, mole fraction). Y axis is pressure (bar). Shaded area represents between NH3 condensation level and tropopause level. Red means Jovian model, and blue means Saturnian model. Note that these results are calculated with the polytropic temperature profiles for preliminary calculation, not thermal equilibrium profiles.

Keywords: Jupiter, Saturn, Cloud, Radiative transfer, Convection