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Numerical Modeling of Moist Convection in Jupiter's Atmosphere: the dependency on the abundances of condensible volatiles

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http://www.gfd-dennou.org/arch/deepconv/

The averaged structure of Jupiter's atmosphere and its relationship to moist convection remain unclear, because it is difficult to observe the structure under the extensive surface cloud layer by remote sensing, We developed a two-dimensional numerical model that incorporates condensation of H_2O and NH_3 and production reaction of NH_4SH in order to examine a structure of moist convection in Jupiter's atmosphere that established through a large number of life cycles of convective cloud elements (Japan Geoscience Union Meeting 2006, M144-P016). Here in this study, we investigate the dependency of vertical cloud distribution and convective motion on the abundances of condensible volatiles by the use of this model.

The basic equation of the model is based on quasi-compressible system (Klemp and Wilhelmson, 1978). The cloud microphysics is implemented by using the terrestrial warm rain bulk parameterization that is used in Nakajima et al. (2000). The domain extends 300 km (30 bar – 0.001 bar in pressure) in the vertical direction and 512 km in the horizontal direction. The spatial resolution is 2km both in the horizontal and the vertical directions. The initial vertical structure of the atmosphere used in the calculations is as follows: the troposphere is adiabatic(temperature is 160 K at 0.6 Bar) and extends up to 200 km (0.1 bar), above which is an isothermal layer of 100 K. To activate moist convection, strong radiation cooling is given. The atmosphere is cooled between 140 km (2 bar) and 200 km (0.1 bar) at a constant rate of 1 K/day. The abundances of condensible volatiles used in the each calculations are taken at 0.1, 1, 5, and 10 times solar.

When the abundances of condensible volatiles are taken at 1 times solar, the results of the numerical simulations show that H_2O and NH_4SH cloud particles is advected above the NH_3 condensation level, and cloud layer which consists of H_2O, NH_4SH, and NH_3 cloud particles forms This characteristic of vertical cloud structure seems to be applicable to the case of 0.1 times solar. As the abundances of condensible volatiles increase, moist convection occurs intermittently. In the active period, the vertical cloud structure is the same as that obtained by 1 times solar. In the quiet period, the results show that the cloud layer which contains both H_2O and NH_4SH cloud particles and the NH_3 cloud layer form at separated levels. The characteristics of the vertical cloud structures obtained by the numerical simulations are obviously different from the static three layer structure that has been expected by using equilibrium cloud condensation model.

The numerical simulations also show that, when the abundances of condensible volatiles are larger than 1 times solar, convective motion tend to be separated at the H_2O condensation level and that the NH_3 condensation level and the NH_4SH reaction level don't act as a stationary dynamical boundary. On the other hands, when the abundances of condensible volatiles are taken at 0.1 times solar, the result show that H_2O condensation level does not act as a stationary dynamical boundary and that downdraft takes dry air from upper levels to several ten bars level. These results suggest that the abundances of condensible volatiles of Jupiter's atmosphere should be quite small, or some effects of large scale motion should be additionally considered to explain the condensible volatile profiles obtained by the Galileo probe measurement.