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# Numerical Modeling of Moist Convection in Jovian Planets

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It is now widely accepted that moist convection is a common phenomenon in Jovian planets' atmosphere. The moist convection is thought to play an important role in determining the mean vertical structure of the atmosphere; the mean vertical profiles of temperature, condensed components, and condensible gases in the moist convection layer is thought to be maintained by the statistical contribution of a large number of clouds driven by internal and radiative heating/cooling over multiple cloud life cycles. However, the averaged structure of the Jovian planets' atmosphere and its relationship to moist convection remain unclear. For the purpose of investigating the above problem, we developed a cloud resolving model and investigated a possible structure of moist convection layer in Jupiter's atmosphere with using the model (Sugiyama et al., 2009, 2011, 2014). In this presentation, we perform two-dimensional calculations of moist convection and demonstrate a possible structure in the atmospheres of Saturn and Uranus.

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). We simplify the radiative process, instead of calculating it by the use of a radiative transfer model. The model atmosphere is subject to an externally given body cooling that is a substitute for radiative cooling. Because the vertical profile of net radiative heating is not observed in Saturn and Uranus, the layer between 2 bar level and the tropopause, which corresponds to the observed cooling layer in Jupiter, is cooled. The body cooling rate is set to be 100 times larger than that observed in Jupiter's atmosphere in order to save the CPU time required to achieve statistically steady states of the model atmosphere. The domain extends 7680 km in the horizontal direction. The vertical domains of the planets are 480 km for Saturn's case and 650 km for Uranus' case. The spatial resolution is 2 km in both the horizontal and the vertical directions. The temperature and pressure at the lower boundary are based on the one-dimensional thermodynamical calculation (Sugiyama et al., 2006). As the first step of the experiments, the abundance of each condensable gas is set to be solar abundance.

In Saturn and Uranus, the obtained characteristic of vertical motion is that many narrow and strong downdrafts are found in the upper moist convection layer, while strong updrafts are found near the bottom of the moist convection layer that is associated with the H2O lifting condensation level. This characteristic is obviously different from that obtained in Jupiter. The vertical motion in the whole moist convection layer of Jupiter is characterized by narrow, strong, cloudy updrafts and wide, weak, dry downdrafts. In Saturn and Uranus, the velocity of downdrafts is over 50 m/s, which is comparable to the updrafts, and the skewness of vertical velocity is negative in the upper moist convection layer. The skewness obtained in Uranus' case is the smallest, which indicates the downdrafts are more dominant in Uranus than in Saturn. The existence of strong downdrafts is caused by the following two reasons. One of the reasons is that convective motion is driven by not a heating from the bottom of the moist convection layer but a cooling layer near the tropopause ($0.1 < p < 2$ bar). Another reason is that the atmospheric temperature in the upper moist convection layer is colder than that of Jupiter. H2O condensation occurs at lower level (high pressure level). The value of H2O mixing ratio is almost zero and the effect of latent heat is very small in the upper part of the layer.

Keywords: atmosphere of Jovian planets, moist convection, numerical modeling, cloud resolution model