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Development of a moist convection model for the Jovian atmosphere including H2O, NH3, and NH4SH clouds

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'Moist convection' i.e., convection associated with phase change and cloud physics of condensible volatiles, is supposed to occur in the Jovian atmosphere. For example, many convective clouds and lightning exist in a number of images obtained by the Galileo solid state imager (SSI). Moist convection should regulate structure of convection because of latent heats of these volatiles and radiative heating or cooling by cloud particles. Nakajima et al. (2000) perform numerical simulation of the Jovian moist convection by using a two-dimensional model and examine its structure established through a large number of life cycles of convective cloud elements. They show that the thin stable layer corresponding to water condensation distinctively separates vertical convective motion, and the aspect ratio of the convective motion is nearly one.

However, the value of radiative forcing used by Nakajima et al. (2000) is about 100 times larger than that observed in the Jovian atmosphere, and ammonia cloud and ammonium hydrogensulfide cloud are not considered. Because of using the stronger radiative forcing, the aspect ratio of convective motion obtained by Nakajima et al. (2000) is expected to be smaller than that of actual convective motion in Jupiter. Moreover, because latent heat of ammonia and reaction heat of ammonium hydrogensulfide alter the vertical profile of stability, these stable layers corresponding to ammonia and ammonium hydrogensulfide may affect to the vertical structure of convection. Indeed, our estimation of static stability evaluated from the difference between moist and dry adiabats show that each static stability corresponding to ammonia and ammonium hydrogensulfide is 1/3 and 1/5 times smaller than that corresponding to water, respectively (Sugiyama et al.,2006). Therefore, for the purpose of understanding the structure of the Jovian convection, it is necessary to use more realistic radiative forcing and to consider the effects of latent heat of ammonia and reaction heat of ammonium hydrogensulfide. Especially, considering such multi clouds physics must be needed for comparison with the observed cloud distribution, because the cloud most widely observed in Jupiter is ammonia cloud.

In this study, we develop a two-dimensional numerical model that incorporates condensation of water and ammonia and production reaction of hydrogensulfide in order to simulate the Jovian moist convection. The basic equation of the model is based on quasi-compressible system (Klemp and Wilhelmson, 1978). The cloud microphysics is implimented by using the warm rain bulk parameterization that is used in Nakajima et al.(2000). In this parameterization, each condensible speceis is divided into three categories 'vaper', 'cloud', and 'rain', and the conversion rate between each category is parameterized. We assume that water, ammonia, and ammonium hydrogensulfide do not mix with among others in gas or condensed phase. Radiative forcing is given as a function of height.

We almost complete the development of numerical model, and now perform preliminary numerical simulation. In our presentation, we will present a result of a direct numerical simulation of Jupiter's moist convection, and discuss how the convective structure of Nakajima et al. (2000) changes by considering more realistic radiative forcing and cloud microphysics of ammonia and ammonium hydrogensulfide.