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Numerical Modeling of Moist Convection in Jupiter's Atmosphere: the mechanism of the intermittent cloud activity

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The mean vertical profiles of temperature, condensed components, and condensible gases in the cloud layer of Jupiter's atmosphere 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. For the purpose of investigating the above problem, we developed a two-dimensional cloud resolving model that incorporates condensation of H_2O and NH_3 and production reaction of NH_4SH and investigated a possible cloud layer structure in Jupiter's atmosphere with using the model (Sugiyama et al., 2009, Nagare Multimedia; Sugiyama et al., 2011, GRL, 38, L13201). Prominent result obtained in Sugiyama et al. (2011) is intermittent emergence of vigorous cumulonimbus clouds rising from the H_2O condensation level to the tropopause. Due to the active transport associated with these clouds, the mean vertical distributions of cloud particles and condensible gases are distinctly different from the hitherto accepted three-layered structure based on the thermodynamical equilibrium calculations. However, they did not perform enough discussion about a mechanism that causes their most remarkable characteristic, intermittent emergence of vigorous cumulonimbus clouds. In this presentation, we investigate the above character in detail and discuss the mechanism.

Saw-tooth like temporal variation of overall temperature synchronizing with the intermittent cloud activity obtained in our calculations means that the intermittent cloud activity is caused by the fact that amount of heating due to H_2O condensation of the vigorous cumulonimbus clouds is quite large compared to the body cooling that is a substitute for radiative cooling. At the start of the active cloud development, downward plumes that reach below the H_2O condensation level trigger the release of latent instability; vigorous cumulonimbus clouds develop due to returning updrafts associated with the downward plumes. At the end of the active cloud development, relatively heavy air parcel containing large amount of condensible gases cannot rise from H_2O condensation level to the tropopause. The condition of the termination of the active periods can be quantitatively expressed as that the value of cloud work function (Arakawa and Schubert, 1974), which is a vertical integrated measure of buoyancy, is almost zero. The period of the intermittency is roughly estimated by using both the temperature variation due to the intermittency and the radiative cooling rate.

Keywords: Jupiter's atmosphere, moist convection, numerical modeling, cloud resolving model