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Numerical modeling of cloud convection with high condensation threshold: Implication to methane convective clouds in Titan's atmosphere

K. Nakajima (1), M. Ishiwatari (2), S.Takehiro (3), Y.-Y. Hayashi(4)

(1) Faculty of Sci., Kyushu Univ., Fukuoka, Japan (kensuke@geo.kyushu-u.ac.jp), (2) Graduate School of Environmental Earth Sci., Hokkaido Univ., Sapporo, Japan (momoko@ees.hokudai.ac.jp), (3) Inst. of Mathematical Sci., Kyoto Univ., Kyoto, Japan (takepiro@gfd-dennou.org), (4) Graduate School of Sci., Hokkaido Univ., Sapporo, Japan (shosuke@gfd-dennou.org)

Recent ground-based observations and the first Cassini flyby reveal prominent cloud activities near the south pole of Titan. Their characteristics imply their convective origin. On the other hand, it has been proposed that a large degree of super-saturation is required for condensation of methane to occur. Here, we examine how such high condensation threshold affects the nature of cloud convection and over-all structure of the atmosphere through explicit numerical modeling of cloud convection. As a first step, we perform sensitivity experiments designed to isolate the effects of the large super saturation in the setup of the earth's tropical atmosphere because the condition for Titan's atmosphere is not well constrained.

We conduct long-term integrations of a two-dimensional non-hydrostatic cloud convection model that extends 4,096km in the horizontal direction including three-category (vapor-cloud-rain) parameterized microphysics. We compare the simulated cloud convection in the case with "ordinary" condensation scheme with that in the case with "Titan's" condensation scheme, where water vapor is allowed to condense into cloud water only at a highly super saturated condition; after the nucleation, water vapor rapidly condense onto the cloud water toward exactly saturated state, and cloud water also evaporates towards exactly saturated state in appropriate conditions (e.g., in the downward flow of the air).

The results show that, in "Titan's" case, individual convective clouds are much stronger, larger and longer-lived. The convective towers occur only at one or two limited locations in the 4,096km domain instead of occurring in rather scattered manner in the "ordinary" case. The average atmosphere in the "Titan’s" case is super saturated around the condensation level and the tropopause, but the degree of super saturation is much smaller than that specified as the condensation criterion. The temperature structure is maintained to be conditionally unstable.

Although direct comparison between the present results and the real situations on Titan requires cautions, the simulated cloud convection shares some common properties with Titan’s convective clouds, which are rather long-lived and concentrated around a localized area.

Additional numerical experiments including methane as the condensible component are under way, and the results will be reported at the meeting.