Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

PPS03-05 Room:105 Time:May 24 13:45-14:00

Two-dimensional simulation of Martian atmospheric convection with the major component condensation over CO2 ice surface

YAMASHITA, Tatsuya[1*], ODAKA, Masatsugu[1], SUGIYAMA, Ko-ichiro[2], NAKAJIMA, Kensuke[3], ISHIWATARI, Masaki[2], TAKAHASHI, Yoshiyuki O.[4], NISHIZAWA, Seiya[4], HAYASHI, Yoshi-Yuki[4]

[1]Hokkaido Univ., [2]Hokkaido Univ. / CPS, [3]Kyushu Univ., [4]Kobe Univ. / CPS

We have been developing a two-dimensional cloud resolving model and performing numerical simulations for the purpose of investigating characteristics of convection with condensation of the major component(e.g. Yamashita et al., JPGU 2011). In the system where the major component condenses, as a low temperature limit, a state where the surface is covered with the ice of the atmospheric major component can develop. The Martian polar night approximately corresponds to this state, therefore understanding of the Martian polar night contributes to elucidation of the behavior of the system where the major component condenses.

The observation by MOLA suggested that atmospheric major component, CO_2, condenses to form ice cloud in Martian polar region (Pettengill and Ford, 2000). Colaprete et al.(2003) proposed that some of the clouds are formed by convective motions. However, in the system that the major component condenses, the temperature profile of both an ascending air parcel and the surrounding environment follow the moist adiabat, and the air parcel cannot gain buoyancy. Therefore convection with condensation of the major component cannot occur. If the value of critical saturation ratio is greater than 1.0, there is a possibility that convective motions occur(Colaprete et al., 2003). Furthermore, falling cloud particles drag the surrounding air, and this effect can affect the convective motion. In this work, we report the preliminary numerical simulation where surface boundary condition, thermal forcing, and the formulation of cloud microphysics appropriate for the environment over the Martian polar cap are introduced.

The governing equations are based on the quasi-compressible equations(Klemp and Wilhelmson, 1978) and a conservation equation of solid CO_2. In cloud microphysics, the effects of gravitational settling and drag of cloud particles are considered. We set the initial surface pressure and the values of critical saturation ratio to be 7 hPa, 1.0, respectively. The model atmosphere is subjected to an externally-given thermal forcing that is a substitute for the radiative cooling. Because there is no solar radiation in the actual polar night, we do not give any heating, and we give horizontally uniform cooling from 1 km height to 15 km height. The cooling rate is set to be -5.0 K/day. The initial temperature profile is given such that saturation ratio is 0.98(Colaprete et al., 2003) below 15 km height, and isothermal(135 K) above 15 km height. Because the surface temperature of the actual polar cap is expected to be nearly sublimation temperature of CO_2, the air temperature at lower boundary is fixed to be initial value (about 150 K). Random potential temperature perturbations whose amplitudes are 1K are given at the lowest grid point to seed convective motion at initial time. The computational domain is 50 km in the horizontal direction and 20 km in the vertical direction. The spatial resolution is 200 m in both the horizontal and vertical directions. Time integration is 30 days.

The statistical equilibrium state has been established at 30 days. In the statistical equilibrium state, a cloud layer is formed in the uniform cooling region, and there strong convection does not occur except for near the surface. Specifically, a cloud layer is formed below 15 km height, and the density of cloud is maximum at about 2 km height. Vertical motions whose amplitudes are more than 1.0 m/s are found only below 2 km height, and the maximum value of the amplitudes is about 3.0 m/s. The convection found below 2 km height is driven by the effect of drag of cloud particles. Since laboratory experiments suggested that critical saturation ratio of 1.35 are required under the temperature and pressure in Martian polar region(Glandorf et al., 2002), we are also going to report about the case that critical saturation ratio is 1.35 in our presentation.

Keywords: condensation of major atmospheric component, carbon dioxide ice cloud, cloud resolving model