

The circulation structure of the Martian atmosphere: mixing processes and their effects on the planetary scale fields

Yoshi-Yuki Hayashi[1], Yoshiyuki Takahashi[2], Masatsugu Odaka[1], Masaki Ishiwatari[3]

[1] Earth and Planetary Sci., Hokkaido Univ., [2] Science, Tohoku Univ., [3] Graduate School of Environmental Earth Science, Hokkaido University

<http://www.gfd-dennou.org/arch/mars/>

The circulation field of the Martian atmosphere has been estimated from the temperature distribution by the use of thermal wind relationship. Observations from the earth and exploration satellites have accumulated radiation data from the Martian atmosphere, by which the distributions of temperature have been calculated by the use of inversion method. The wind field can be estimated as geostrophic wind by the equation of thermal wind. The general circulation models (GCMs) of the Martian atmosphere have been developed by comparing their calculated fields with thus obtained observed values of temperature and wind.

Now, the problem is that one is tempted to imagine that the circulation structure of the Martian atmosphere is well understood, since the procedure summarized above produces a reasonable circulation field. However, the GCMs have not been fully developed. The important point is that we have accumulated only a little information on the dissipative structures in the Martian atmosphere. The current GCMs are obtained, without any reasoning, by adapting models of dissipative structures developed for the terrestrial atmosphere. The formulation of turbulent mixing caused by subgrid scale wind is given from the experience on the terrestrial atmosphere. There is no reason that the dissipation structure of the Martian atmosphere is similar to that of earth. Actually, it is expected to be quite different.

It has been recognized that radiative heating caused by dust is one of the most important factors in determining the structure of the Martian atmosphere. However, the Martian GCMs developed so far have not succeeded in the prognostic calculation of the amount of dust in the Martian atmosphere. Starting from a dusty atmosphere as the initial condition, the GCMs produce intense large scale wind to inject dust into the atmosphere to maintain the dust amount in the atmosphere. However, starting from a dust-free or a small amount of dust atmosphere, the intensity of large scale wind calculated in the GCMs is so weak that the model surface stress is not large enough to raise dust from the surface. Current GCMs can not describe a spontaneous transition from dust-free Mars to dusty Mars.

The reason is speculated that the formulation of turbulent fluxes implemented in the GCMs has been developed for those of the terrestrial atmosphere and thus does not represent the turbulent structures of the Martian atmosphere very well. The wind stress by which dust is injected from the ground surface to the atmosphere is contributed from the resolved wind flow and the subgrid scale disturbances. If the contribution of the latter is not well evaluated, a good estimation of the surface momentum flux cannot be obtained. The problem is that the Martian small scale structures of wind fields, such as convection, waves, and turbulence, which cannot be estimated from geostrophy, have been little observed so far.

It is considered that the structures of vertical convection which contribute to the formation of troposphere is quite different between Mars and Earth. The vertical structure of the terrestrial atmosphere is determined by moist convection which is characterized by water vapor condensation and precipitation, while that of the Martian atmosphere is determined by dry convection. The intensity of surface wind, thickness of the planetary boundary layer, intensity of turbulence, wavelength and intensity of waves, and the amounts of momentum and material transports into the atmosphere at the surface are determined by the nature of vertical convection. The intensity of disturbances associated with dry convection is expected to be quite large (Odaka et al. 2001). It is desired that some method is proposed to measure the structures of those small scale features in the Martian atmosphere.

Reference

Odaka et al. 2001: <http://www.nagare.or.jp/mm/2001/odaka/>, Nagare Multimedia 2001.