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High resolution general circulation model experiments of the Martian atmosphere: Resolution dependence of disturbances

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High resolution experiments of Martian atmosphere have been performed by using a general circulation model (GCM). One of purposes of the experiments is to investigate the small and medium scale disturbances whose horizontal scales range from thermal convection to baroclinic waves on Mars. The other purpose of the experiments is to have some insights into dust lifting processes on Mars. Dust suspended in the atmosphere has significant impact on the thermal and circulation structure of Martian atmosphere through radiative processes. In the followings, some features of atmospheric disturbances observed in our model are presented. In this study, the circulation structure and effects of disturbances on dust lifting are investigated by examining its resolution dependence.

The model used in this study consists of the dynamical core of AFES (Ohfuchi et al., 2004), and the physical processes introduced from the Mars GCM which has been developed by our group so far (Takahashi et al., 2003, 2004, 2006). The AFES is a spectral primitive equation model and is based on CCSR/NIES AGCM 5.4.02. The introduced physical processes include the radiative, the turbulent mixing, and the surface processes. In addition, the dust lifting process is implemented to diagnose the dust mass flux in the model. The horizontal variation of surface orographic height, albedo, and thermal inertia are given following the observational results. However, in some experiments, uniform surface properties are used to investigate atmospheric disturbances that are not forced by variations of surface properties. By the use of this GCM, experiments at northern fall condition are performed with horizontal resolutions of T79, T159, T319, and T639, and number of vertical layers of 96. Horizontal resolutions of T79, T159, T319, and T639 are equivalent to about 89, 44, 22, and 11 km grid size, respectively. In these experiments, the dust distribution used for radiative heating rate calculation is assumed to be uniform horizontally with dust optical depth of 0.2.

A lot of atmospheric disturbances are observed in the results of experiments. Some of those are baroclinic waves in northern middle and high latitude, fronts associated with them, vortices in the lees of mountains, several streaks with horizontal scale of tens of kilometers, and a lot of small scale vortices in low latitudes. Comparing the result of T319 resolution experiment with that of T79, many disturbances, such as baroclinic wave, fronts, and lee vortices with several hundred kilometers, are observed in both experiments. Further, the existence of small scale streaks and vortices in low latitude is implied. However, by increasing the model resolution, the structures of streaks become very clear, and the horizontal size of the small scale vortices in low latitude decreases and the strength increases as the increase of horizontal resolution. In addition, the local time when the small scale vortices develop tend to become early by the increase of horizontal resolution. It is considered that these small scale vortices are caused by convective activity represented by the model, and these are the results of the change of model representation of convective motion.

In the presentation, the disturbances observed in experiments with uniform surface properties and the effects of atmospheric disturbances on dust lifting will be shown and discussed.

Keywords: Mars, planetary atmosphere, general circulation model, small and medium scale disturbance, Earth simulator