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Resolution dependence of dust mass flux simulated by Mars general circulation model

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There are always dust suspended in the Martian atmosphere, and its radiative heating and cooling have significant impact on the thermal budget of the atmosphere. On the one hand, it is well known that the dust storms with various sizes occur on Mars, and those cause variations of temperature and wind on a various temporal and spatial scales. However, the lifting process of dust suspended in the atmosphere and the generation processes of dust storms have not been understood fully. Numerical experiments with a high resolution model would provide new insights into those processes, because a previous study pointed out that small and medium scale disturbances with a horizontal scales less than a few hundreds of kilometers would contribute to the dust lifting. Based on these ideas, we have been investigating the structures of small and medium scale disturbances in the Martian atmosphere by using a Mars general circulation model with horizontal resolutions of 89 and 22 km. In this presentation, the resolution dependence of those experiments is presented. Further, it is investigated that what kind of atmospheric disturbances cause the dust lifting.

The model used in this study consists of the dynamical core of AFES, and the physical processes introduced from the Mars GCM which has been developed by our group so far. AFES is based on CCSR/NIES AGCM 5.4.02, and is optimized to perform high resolution simulations on the Earth Simulator. As for the physical processes, the radiative, the turbulent mixing, and the surface process are introduced from our Mars GCM. In addition, the dust lifting process and the gravitational sedimentation are implemented. The dust lifting process is the same as one of 'threshold-sensitive surface stress lifting' parameterizations proposed by Newman et al. (2002). This parameterization is an GCM implementation of the process of dust lifting by the surface wind, whose characteristics is that dust is not ejected unless the surface friction velocity exceeds a certain threshold value. By the use of this GCM, we performed simulations at northern fall season with resolutions of T79L96, T159L96, and T319L96, which are equivalent to about 89, 44, and 22 km grid size, respectively, and with 96 vertical layers.

The comparison of global mean dust lifting amounts in these experiments shows that the dust lifting amount increases with increasing resolution. The latitudinal variation of dust lifting amount shows that the lifting amount in the middle and high latitude regions is almost the same regardless of resolution, and the increase of global mean value can be attributed to increase in the low latitude region. The structures like a front of the baroclinic waves in the middle and high latitude regions would be represented better as the model resolution is increased. However, our result implies that the details of fine structures of fronts would not have a significant impact on the dust lifting process.

Two reasons are considered for the result that the dust lifting amount increases with increasing the resolution. First one is that the representation of small scale disturbances becomes better by increasing resolution. Second one is that the circulation strength changes due to better representation of small scale orographic variation and steep slope of orography. In order to identify which process is dominant, a T319 experiment with orographic variation truncated at total wavenumber 79 was performed. In this experiment, the dust lifting amount is almost the same as that in the T79 experiment. This result implies that the strong wind associated with steep slope and small scale orographic variation would play important roles to lift dust into the atmosphere.