Numerical simulation of Martian atmosphere by using General Circulation Model: A review

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Recent Mars explorations, for examples, Mars Global Surveyor (MGS), performed by U.S. provide us a lot of data on the distribution of atmospheric temperature and minor constituents whose spatial- and time-resolutions are much higher than those obtained by previous missions. By using these dataset, we can quantitatively discuss the general circulation, and dust and water cycles in Martian atmosphere. At the same time, several kinds of numerical models of the Martian atmosphere have been developed by many research groups all over the world. The results of numerical simulation by using Martian atmospheric models would provide us important information to explain the interesting phenomena observed in the Martian atmosphere. In this talk, we focus our attention on the studies on Martian atmospheric circulation by using General Circulation Model (GCM) and review current Mars GCMs and its recent improvement. We also talk about the recent studies on the tracer cycles by using Mars GCM.

Mars GCMs have been developed and improved by several research groups. These Mars GCMs are based on roughly the same framework although the numerical integration method and the representation of the physical processes implemented in each model are different from those in the other. Each Mars GCM consist of dynamical core based on the primitive equation system and a lot of physical process models appropriate for the Martian atmosphere. Physical processes implemented in the Mars GCMs are radiative process associated with carbon dioxide and dust, subgrid-scale turbulent mixing, and condensation and sublimation of carbon dioxide. The distribution of surface orography and albedo in the Mars GCMs are based on observational results. The zonal mean atmospheric fields simulated by the Mars GCMs are qualitatively consistent with those obtained from observations although the dust distribution and the dust optical parameters specified in each GCM are slightly different from those in the other. The amplitude and phase of seasonal variation of the surface pressure, which is caused by condensation and sublimation of carbon dioxide in polar regions, can be simulated by using the Mars GCMs. Therefore, the current Mars GCMs can qualitatively simulate observed thermal and circulation structures of Martian atmosphere.

In recent years, the distribution and time development of atmospheric minor constituents are studied by using Mars GCMs in which the tracer transport and its production/loss processes are implemented. For example, Newman et al. [2002] performed simulations by using the Mars GCM with a dust transport scheme and a parameterization of dust loading process. They showed that the simulated dust storms had similar features to the observed ones in terms of its location, season, and time evolution. The results of GCM simulations would provide us important information on the mechanisms of dust storm and dust cycle in the Martian atmosphere. The simulated dust transport by using Mars GCMs, however, strongly depends on the parameterization and parameters used in the model. The laboratory experiments and/or numerical simulations by using mesoscale models are required to constrain these parameterizations and parameters in order to understand the mechanisms of dust storm and dust cycle quantitatively.