惑星大気大循環モデル DCPAM を用いた火星大気中の水蒸気分布の計算

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A numerical simulation of water vapor distribution in the Martian atmosphere by the use of the DCPAM

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Distributions of minor constituents have been observed not only in the Earth's atmosphere, but also in the other planetary atmospheres, since they have important information on the strucutures of atmospheric circulations as well as on photochemical reactions. For example, a distribution of water vapor in the Martian atmosphere was observed by Viking orbiter in 1970s. From 1997 to 2006, Mars Global Surveyor conducted a long term observation of water vapor in the Martian atmosphere, and provided information on atmospheric transport and mixing.

Our group has been working on development of a general circulation model for planetary atmospheres, DCPAM. Up to now, we performed simulations of the Earth's atmosphere and Earth-like ideal atmospheres which include water vapor. However, we have not intensively worked on simulations of minor constituent distributions in other planetary atmospheres. In this study, we perform a simulation of the water vapor distribution in the Martian atmosphere, since it has been observed for a long time and the observed result can be used for validation of the model.

The general circulation model used in this study is composed of dynamical process and physical processes. The dynamics is based on a primitive equation system. Almost all equations are solved by the use of the spectral method, while the continuity equations for minor constituents are solved by a semi-Lagrangian method. The semi-Lagrangian method used in the model incorporates interpolation method by Enomoto (2008). In addition, an arcsine transformation proposed by Kashimura et al. (2013) is used to avoid negative values. The physics includes radiation, turbulent mixing, and surface processes. By the use of this model, we have performed a simulation of the water vapor distribution in the Martian atmosphere. Following the similar simulations performed previously by other groups, a large amount of water ice is placed on the northern high latitudes. In addition, surface temperature is fixed at 145 K at south pole to mimic southern permanent CO2 ice cap. The resolution of the simulation is T21L36, which corresponds to about 5.6 degrees longitude-latitude grid, and 36 vertical layers. The model is integrated for 10 Mars years from an isothermal and motionless initial condition.

The result of our simulation shows existence of large amount of water vapor at two locations at two seasons. One is the northern high latitudes around northern summer and the other is the southern high latitudes around southern summer. However, the amount of water vapor at the low latitudes is small compared to the observed one. This implies insufficient transport of water vapor from high latitude to low latitude in our model.

In order to check sensitivity of the transport behavior on the choice of atmospheric transport scheme, another simulation is performed without using arcsine transformation in our transport method. The result shows an increase of water vapor amount in the low latitudes by about a factor of 4. This result shows that water vapor transport represented in our model is very sensitive to transport schemes. In the presentation, we will discuss the difference between results by two schemes and address possible causes of the difference.