火星大気大循環モデリングの精緻化：重力波と水輸送

黒田 剛史 [1]
[1] 東北大・理

Refinement of a Mars General Circulation Model (MGCM): Gravity waves and water transport

Takeshi Kuroda[1]
[1] Tohoku Univ.

A high horizontal resolution (T106 spectral truncation, equivalent to 1.1^{o}x1.1^o or ~67 km grid size) MGCM has been adopted to the calculations of current atmospheric environment on Mars for a full Martian year. In such simulations, gravity waves (GWs) with the horizontal wavelengths of down to ~200 km, which favorably propagate to the mesosphere/thermosphere and affect the dynamical features there, can be resolved and the generations of such GWs by the orographic and dynamical effects can be reproduced. Kuroda et al. (2019, JGR Planets, doi:10.1029/2018JE005847) showed the seasonal variations of the GW activities on Mars from the simulations, indicating great variances with season and geographical location. In particular, lower-atmospheric GW activity is smaller in polar regions of the troposphere throughout all seasons, and the intensity is larger in southern spring and summer and in winter hemisphere at both solstices. In the mesosphere, the peak of GW activity shifts toward middle and high latitudes, and the interhemispheric symmetry is much larger compared to the lower atmosphere.

In addition, the comparison of MGCM results between T106 and lower horizontal resolution (T21 spectral truncation, equivalent to 5.6^{o}x5.6^o or ~333 km grid size, which is conventional to most MGCMs in the world) has been made. The features of atmospheric circulation in solstitial seasons apparently differ, with up to ~25 K higher winter polar warming and up to ~20 m s^{-1} larger meridional wind velocity in T106 simulations. It shows that resolved GWs work to enhance the meridional circulation. Also, the resolved GWs work to weaken the zonal wind velocity above ~50 km altitude. These features are consistent with the effects of GW drag parameterizations which have been implemented into most of MGCMs with conventional horizontal resolution (e.g. Medvedev et al., 2011, JGR Planets, doi:10.1029/2011JE003848) compensating for the abbreviation of sparse grid interval.

Simulations applying GW drag parameterizations to conventional-grid-interval MGCMs are reasonable for the reproductions of synoptic-scale atmospheric circulations, but it does not applicable for the reproductions of localized features. In fact, the GW drag parameterization implemented into Medvedev et al. (2011) has no spatial and temporal variations, which contradicts the simulated GW features by Kuroda et al. (2019). Therefore, it should be important to progress the horizontal high-resolution approaches for the atmospheric modeling on Mars towards the next step of understanding the Martian environment, with a lot of high-resolution camera data and fast many-core computing systems.

Simulations of water cycle should also be affected by the horizontal resolutions. Pottier et al. (2017, Icarus, doi:10.1016/j.icarus.2017.02.016) indicated that the significant effects of the high horizontal resolution on the simulated water cycle are seen only in local features, but I believe that the resolved GWs should affect also the global transport. In the presentation, the simulated results of water cycle with different horizontal resolutions will also be shown.