Surface zonal flows induced by anelastic thermal convection in a rapidly rotating spherical shell

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Banded structures and alternating zonal jets observed in the surface atmospheres of Jupiter and Saturn have attracted many researchers in planetary atmospheric sciences, however, satisfactory physical explanations and understandings are not yet obtained. In this study, we perform massive parallel numerical experiments treating both small scale convection and planetary scale flows simultaneously, solve fine structures of turbulent motions which have not yet been resolved by the previous numerical models so far, and try to illustrate dynamical origin of global scale structures of surface flows of Jovian planets.

For this purpose, we developed and parallelized an anelastic model of thermal convection in a rotating spherical shell considering basic radial density variation. The spectral transformation library used in this model was improved to introduce MPI parallelization not only in the latitude direction but also in the radial direction. As a result, we succeeded in increasing the number of parallel processes which had been limited by the number of latitudinal grid points, and more massive parallel numerical experiments became possible.

Followup and extended numerical experiments of Case 2 in Gastine et al.(2014) were performed with the developed anelastic convection model. When the time integration is as short as viscous diffusion time, the latitudinal profile of induced surface zonal flow is consistent with that of Gastine et al. (2014). However, when time integration is further extended, prograde surface zonal flows in high latitudes start to develop, and become prominent. This result suggests that surface zonal flows obtained by the previous studies may not be statistically steady states.

Keywords: Jovian planets, anelastic system

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