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Constructing the Middle-Atmosphere Version of Non-hydrostatic Global Atmospheric Model NICAM

KODAMA, Chihiro[1*] ; NASUNO, Tomoe[1] ; WATANABE, Shingo[1] ; KUBOKAWA, Hiroyasu[2] ; SATOH, Masaki[2]

[1]Japan Agency for Marine-Earth Science and Technology, [2]University of Tokyo

Atmospheric gravity wave, which is generated by topography, convective activity, frontal system, jet, and/or so on, affects the formation of the basic state in the troposphere and middle atmosphere through wave convergence. It is difficult for a GCM (general circulation model) to explicitly simulate processes of generation, propagation and convergence of the gravity wave, and gravity wave drag scheme is often used in such a model. Watanabe et al. [2008] successfully simulated realistic gravity wave and basic state of the middle atmosphere using high resolution GCM (60 km in horizon and 300 m in vertical) without gravity wave drag scheme. However, propagation characteristics of the gravity wave cannot be appropriately simulated by the GCM based on the hydrostatic system, since dispersion relationship of the gravity wave is different between the hydrostatic and non-hydrostatic system. In addition, GCM cannot explicitly simulate convection, which is one of the source of the gravity wave.

We are constructing the middle-atmosphere version of the non-hydrostatic global atmospheric model, NICAM (Non-hydrostatic Icosahedral Atmospheric Model). Horizontal resolution of the NICAM is 220 km, 56 km, or 14 km. We adopt hybrid-z∗system as a vertical coordinate, in which the horizontal surface is almost flat in the middle atmosphere. Vertical level is located up to 80 km with the uniform interval in the middle atmosphere; the vertical interval is 2 km (61 layers), 1 km (91 layers), 500 m (162 layers), or 300 m (261 layers). We do not use gravity wave drag scheme and cumulus convection scheme. Other configurations are almost same as those in the standard NICAM, which is mainly used for the tropospheric research.

In this presentation, we will show initial results of the performance in the reproducibility of the basic state. Overall, zonal mean structure of the temperature and zonal wind are well simulated in both the troposphere and the middle atmosphere. Though axis of the polar night jet is biased poleward, it is somewhat improved as the vertical resolution is increased. Higher vertical resolution also brings better performance in the strength of the easterly jet in the summer hemisphere and in the QBO-like structure in the tropical lower stratosphere. In the winter hemisphere, cold bias is found around the pole in the upper stratosphere and the mesosphere, and too strong polar night jet is found. At present, the simulation tends to be numerically more unstable as the horizontal and/or vertical resolutions are increased. We will show the above points and wake up debate about the potential of the non-hydrostatic atmospheric model for future research of the whole atmosphere.

Keywords: nonhydrostatic global atmospheric model, atmospheric gravity wave, middle atmosphere, tropical convection