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Differences in the cloud, precipitation, and convection representation between the global sub-km mesh simulation and km simulations

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Global nonhydrostatic models that cover the globe with a kilometer (km)-scale mesh have been developed by various organizations worldwide and are expected to be next-generation models that can explicitly calculate deep convective clouds. However, it is known that convective upward motions are not sufficiently represented at the km-scale resolution, and the mesh size of O(100m) is required to obtain convergence of upward motions. To understand the limitation of global km-scale models, we investigate the representation of cloud, precipitation, and circulation with the resolution in the global simulations between km-scale to sub-km-scales.

We conduct the global atmospheric simulations by the Nonhydrostatic Icosahedral Atmospheric Model (NICAM) for the mesh size of 3.5 km, 1.7 km, 870 m, 440 m, and 220 m using the Supercomputer "Fugaku." The 3.5 km experiment started on August 1, 2016, the same day as DYAMOND-summer, and the next higher resolution was run using the lower resolution simulation results as initial conditions. We analyzed data on August 5, 2016. We conducted the global 220m simulation for 8 hours.

The resolution dependence of cloud, precipitation, and convection was investigated. Lower clouds decrease with increasing resolution. High cloud increased or decreased with respect to resolution depending on the turbulence scheme. The precipitation distribution and zonal mean humidity do not change significantly, but the precipitation intensity changes with resolution. For the grid spacing of less than km, it eliminates overconcentration of precipitation, and the rain area widens as the resolution becomes finer. The coarse-grained rainfall distribution is smoother in the sub-km scale model than in the km scale model. A finer scale convection core is reproduced in the sub-km scale model. Vertical wind speed at grid point scales increases with increasing resolution. However, when horizontally averaged over a few-degree grid, the vertical wind speed decreases, and the circulation becomes weaker with higher resolution. We found that the km-scale model may be creating large strong convection. Uncertainties resulting from the turbulence scheme also appear to be large in the km/sub-km models.