

Toward cloud-cluster resolving AGC – New age of tropical meteorology

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Abstract

In the middle-high latitudes large-scale extratropical cyclones and anticyclones generated by baroclinic instability (latitudinal temperature gradient) dominate and their dynamical mechanisms are well understood. Numerical modeling of these phenomena has a long history and is successful for weather prediction and climate simulation. On the contrary in the tropics the fundamental process is the convection due to the vertical instability appearing as cumulonimbus clouds whose horizontal scale is of the order of 10km. So far the vertical convection process has not been explicitly treated in global atmospheric models because of its small size. At the Frontier Research Center for Global Change (FRCGC), by fully utilizing grand computational power of the Earth Simulator (ES) we have developed a global atmosphere model in which deep convective clouds are directly expressed by grids with 3.5 or 7km size. As the grid system we adopted a quasi-uniform grid based on an icosahedron and the basic equation is non-hydrostatic one, hence its acronym is NICAM (Non-Hydrostatic ICosahedral Atmosphere Model).

First by use of the model aqua-planet (hypothetical ocean-covered earth) experiments were conducted. As the result, super cloud clusters or convectively coupled Kelvin waves appeared spontaneously which travel eastward along the equator. Multi-scale structure including meso scale convective system (MCS) was reproduced as actually observed. This result implies that MCSs, cloud clusters and convectively coupled equatorial waves are natural forms of the vertical convection in the earth's atmosphere. By introducing realistic topography and the sea surface temperature distribution we conducted numerical simulation of a Madden Julian Oscillation event appearing in Dec 06-Jan 07. One month "prediction" reproduced fairly well the movement of convection center, westerly bursts and other characteristics. In this experiment diurnal cycle of convective activity was correctly reproduced both on land and over ocean. Some tropical cyclones appearing in this period were well represented in the numerical experiment.

These first successful results from numerical experiments by use of NICAM strongly indicate that for simulating weather/circulation systems in the tropics direct treatment of convection (MCSs) is essential and that a new age of tropical meteorology will come by using this powerful research tool.