# Large Eddy Simulation of Entire Tropical Cyclone

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Most numerical models of a tropical cyclone do not have a resolution to explicitly simulate turbulent eddies, but their effects are parameterized. Such parameterizations must introduce significant uncertainties. Large Eddy Simulation (LES) which resolve the eddies can mitigate the uncertainties, while it requires more computational resources.

Taking advantage of the huge computational power of a massive parallel supercomputer (K-supercomputer, AICS, RIKEN), LES of entire tropical cyclones is realized. A regional numerical weather predicition model used in this study is Japan Meteorological Agency's Non-Hydrostatic Model (JMA-NHM). The computational domain covers 2000 km by 2000 km in the horizontal and 23 km in the vertical directions, and horizontal boundary conditions are doubly cyclic. The grid number is 20000 by 20000 in the horizontal directions, and 60 in the vertical direction where grid spacing increases with increasing height. Before starting the LES, a preliminary run with JMA-NHM with dx=2km is made. In this preliminary run, a tropical cyclone develops from a weak initial vortex to a mature stage after 120 hours integration. The grid point values of this mature stage are interpolated to prepare the initial condition for the LES. The time integration of the LES is then performed for 10 hours.

Figure exhibits the cloud amount (mixing ration of hydrometers) of a reproduced tropical cyclone in the LES. The wall cloud around the eye consist of a number of cumulus clouds. Although the fine scale structures are resolved in the LES, the maximum of the near-surface wind changes little from that simulated based on coarse-resolution runs. The boundary layer height is smaller in the LES, and this may shrink the radius of the maximum wind

We explore especially near-surface coherent structures in the TC boundary layer. Three kinds of coherent structures appeared inside the boundary layer: Type-A roll, which is caused by an inflection-point instability of the radial flow and prevails outside the radius of maximum wind. The second is a Type-B roll that also appears to be caused by an inflection-point instability but of both radial and tangential winds. Its roll axis is almost orthogonal to the Type-A roll. The third is a Type-C roll, which occurs inside the radius of maximum wind and only near the surface. It transports horizontal momentum flux in an up-gradient sense and causes the largest gusts.

Keywords: Tropical Cyclone, Large Eddy Simulation, Supercomputer, Turbulence, Regional Weather Prediction Model