Introduction of a mixed-layer ocean model into the MRI interactive multiply-nested movable mesh tropical cyclone model

Akiyoshi Wada* and Wataru Mashiko

Meteorological Research Institute, Tsukuba, Ibaraki, 305-0052, Japan
**E-mail:awada@mri-jma.go.jp*

1. Outline of the MRI tropical cyclone model.

The Meteorological Research Institute (MRI) interactive (or 2-way) multiply-nested movable mesh tropical cyclone model (MRI typhoon model) has been developed for a few years (Mashiko and Muroi,2003) . One of notable features of this model is to possibly simulate detailed structure of tropical cyclones such as the eyewall and rainbands with efficiency for computational resources (e.g. Mashiko, 2005). The model consists of a 'parent' main program and some 'children' modules written in Fortran language. The algorism is shown in Fig. 1. The parent model controls some children parts, which the number of children is determined by the number of nest. An interpolation procedure from one nest to another, a procedure of making boundary condition, and setting of domains, all are implemented by the parent main program. Detailed description of the model can be referred to Mashiko and Muroi (2003).

2. Introduction of a mixed-layer ocean model.

A mixed-layer ocean model is introduced into the children parts of the model respectively. Details of the mixed-layer ocean model can be referred in Wada (2005). The mixed-layer ocean model is divided into some module parts as defining oceanic variables, making oceanic initial conditions, defining oceanic topography, forecasting oceanic variables, and outputting results of the time integration every a specified time. Making oceanic initial conditions and spin up procedure are implemented only in the first nest. The initial oceanic fields in the other domains are given by interpolation from the coarse domain of the first nest. One of the noteworthy improvements of the coupled model is to enable computed sea surface temperature (SST) to be interactive between two nests even in the land-sea interface. However, topographic information in both the atmosphere and the ocean in the other domains is determined using model topography with the coarsest horizontal resolution.

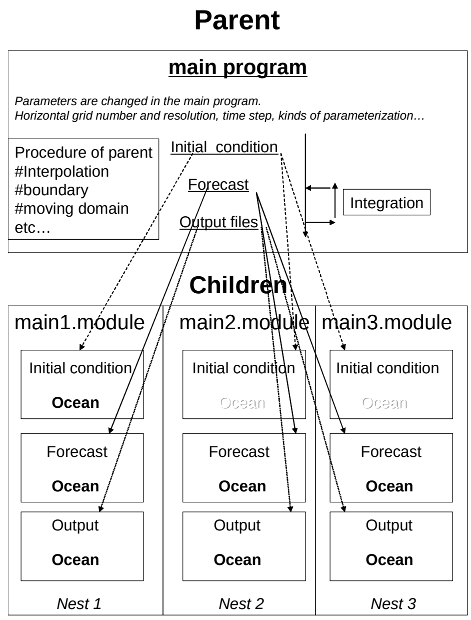

Figure 1. The system of MRI interactive multiply-nested movable mesh tropical cyclone model.

3. Performance of the MRI typhoon model coupled with the mixed-layer ocean model.

3-1 Numerical experiment

A primarily numerical experiment in the case of Typhoon Namtheun (T0410) is performed to check the performance of the MRI typhoon model coupled with the mixed layer ocean model (MRI typhoon-ocean model). The number of nests is set to be two of which horizontal resolutions are 6km (391x391 grids) and 2km (391x391 grids) with 40 vertical layers. To make the initial condition, we run the global spectral model (GSM: T213L40) during 72 hours at first. After that, we further run the hydrostatic typhoon model (TYM) with 20km horizontal resolution and 40 vertical layers during 72 hours using the GSM output as initial and boundary conditions in order to downscale the initial condition. The initial time of GSM and TYM is at 12UTC on July 28. In the experiment of the MRI typhoon model, the initial time is at 00UTC on July 29, T+12hour integration time of TYM where T indicates the initial time of TYM. As for the oceanic initial condition, reanalysis data of sea temperature and salinity by the MRI Ocean Variational Estimation (MOVE) system is used. The initial mixed layer depth is analyzed from MOVE data. In the present study, the data on July 27, 2-day before the initial time of the initial time, is used as the oceanic initial condition. As for the physics of the MRI typhoon-coupled model, sea spray parameterization is included in the speculation of numerical experiments, but cumulus parameterization is not included in it.

3-2 Results

Figures 2 show horizontal distributions of SST and 1-hour precipitations in the cases of coupled experiments (Fig.2 (a), (b), (d), and (e)) and uncoupled experiments (Fig. 2. (c) and (f)). In northeastward region from the typhoon center, sea surface cooling (SSC) appears notably (Fig.2 (a)). T0410 with concentric and symmetric-like precipitation in the nest with 6km horizontal resolution (Fig.2 (d)) is located southwestward of high pressure in the north Pacific. In the experiment with 2-km horizontal resolution, the SSC appeared in the coupled experiment with 6km horizontal experiment is remarkably evident on the northeastward of the typhoon, which the SSC is located in the rightward of the moving direction (Fig.2 (b)). This SSC does not appear in the non-coupled experiment (Fig.2 (c)). The other notable feature in the experiment with 2km horizontal resolution is that 1-hour precipitation pattern in the coupled experiment (Fig.2 (e)) is different from that in the uncoupled model (Fig.2 (f)). This suggests that ocean coupling could affect not only intensity of the typhoon but also precipitation pattern of it.

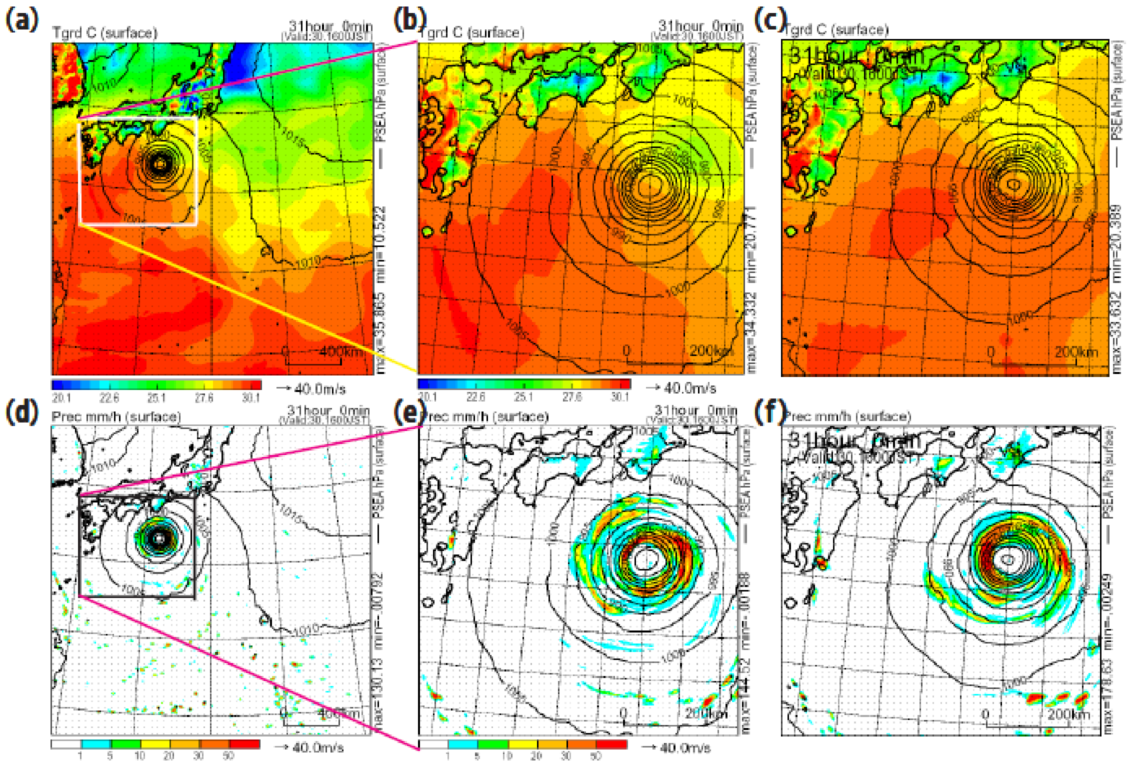

Figure 2 Distributions of SST and precipitation by the MRI typhoon-ocean coupled model. (a) SST with 6km horizontal resolution in the coupled experiment. (b) same as (a) except for 2km horizontal resolution. (c) same as (b) except for one in the non-coupled experiment. (d) same as (a) except for 1-hour precipitation. (e) same as (b) except for 1-hour precipitation. (f) same as (c) except for 1-hour precipitation.

References

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