DEVELOPMENT OF A TWO-WAY MULTIPLY-NESTED MOVABLE MESH TYPHOON MODEL USING THE CLOUD RESOLVING NONHYDROSTATIC MODEL

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1. Introduction

In order to get better prediction of typhoon track, intensity, heavy rainfall and strong wind distribution, and inner structure, we are on the way to develop a two-way multiply-nested movable mesh typhoon model based on Meteorological Research Institute/Numerical Prediction Division unified nonhydrostatic model of the Japan Meteorological Agency (MRI/NPD-NHM; Saito et al., 2001).

MRI/NPD-NHM has been used to simulate various cases of mesoscale phenomena. However, numerical experiments of typhoon in high resolution have rarely been conducted due to the limited computer resources.

For the precise prediction of typhoon, enormous computer resources are needed because environment fields around a typhoon largely affect the typhoon evolution and therefore a large model domain is needed. Moreover, since convective processes play an important role in the typhoon dynamics, fine mesh (horizontal grid size; less than 1-2km) that represents convection is desirable especially near the typhoon center.

The major advantage of the two-way nested model is that it can effectively reduce computational time and memory requirements because both the large domain and high resolution can be accomplished together by arranging fine mesh over the typhoon area and coarse mesh over the environment.

2. Model description

The main procedures of the two-way interactive mesh refinement scheme are (1)construction of an interface between coarse mesh and fine mesh, (2)interpolation that is used to provide initial and boundary values of fine mesh, (3)feedback from fine mesh to coarse mesh, and (4)boundaries conditions for fine mesh.

We employed monotone advection algorithms for the interpolation procedure(2) and one point feedback with a smoother–desmoother used in Penn State/NCAR Mesoscale Model (Grell et al., 1995) for the feedback procedure(3). As for boundaries conditions(4), we adopted the radiative-nesting boundary conditions considering the difference between coarse and fine mesh's values (Chen 1991). Some Fortran90 modules concerning two-way nesting were added to MRI/NPD-NHM in such a way that minimizes the change of its original source code.

3. Basic verification against 3-D mountain waves

To check the dynamical core of the model, we performed three-dimensional numerical simulations of a mountain flow with the model. The two-way nested model that covers the near-mountain area with fine mesh and elsewhere with coarse mesh produced almost the same results as those from the model with fine mesh all over the model domain and no erroneous wave reflection occurred near the boundaries (Fig.1). And computational time and memory could be reduced, compared with the model covered with all area fine mesh.

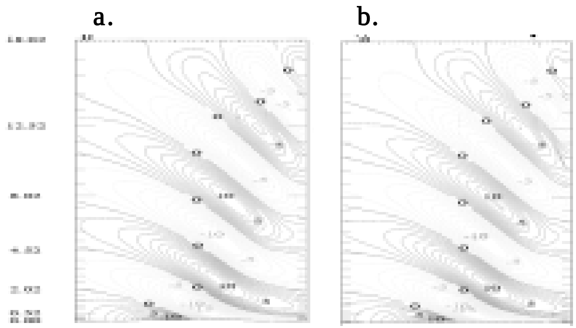

Fig.1 Vertical cross section of vertical wind through mountain top at 2-hour
a. all area fine mesh (magnified corresponding to 2-way fine mesh area) **b.** fine mesh (2way)

4. Numerical experiment of Typhoon Saomai

Numerical experiment of Typhoon Saomai (2000) was conducted with the two-way double-nested movable mesh model. The model is nested with the Regional Spectral Model (RSM : horizontal resolution about 20km), an operational hydrostatic model of JMA. The initial condition is also supplied from RSM. The coarse mesh contains 200x200 grid points horizontally (grid size 18km), which covers a domain of $(3600\text{km})^2$ shown in Fig.3. The squares in Fig.3 show the domain of the fine mesh (horizontal grid size 6km : 151x151), which moves with the typhoon. Further descriptions of the model and nesting procedure are given in Table1 and Fig.2, respectively. Cold-rain explicit cloud microphysics were employed and convective adjustment parameterization is used jointly only in the coarse mesh. Fig.4 compares the central pressure of the model storm with the best track one determined by the RSMC-Tokyo. Fig.5 shows the sea-level pressure field and hourly accumulated rainfall of fine mesh at 34 hour forecast. As a whole, the model reproduced not only typhoon intensity but also rain distribution and the scale of eye well.

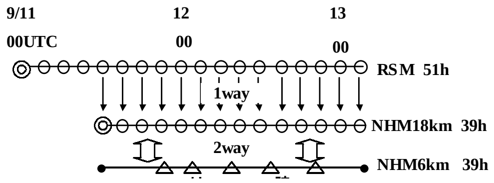

Fig.2 Relationship of nesting between numerical models
△ shows the timing of fine mesh's movement

Table1. The model design

Domain	Coarse mesh	Fine mesh
Dimension (x,y)	200x200	151x151
Area coverage (km^2)	3600x3600	906x906
Vertical levels	38	38
Grid size (km)	18	6
Time step (s)	30	15

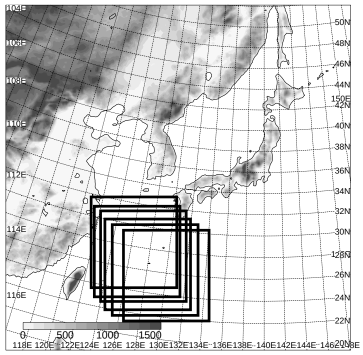

Fig.3 Orography of coarse mesh and domain of fine mesh

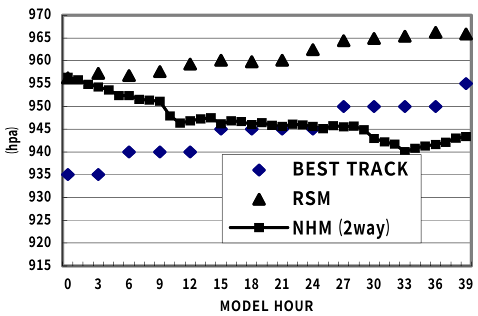

Fig.4 Time series of the minimum central pressure of Typhoon Saomai

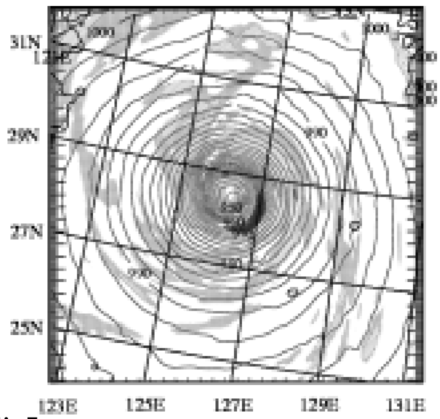

Fig5. Sea-level pressure and hourly rainfall at 34-hour forecast of fine mesh (22UTC 12Sep) Contour interval is 2hpa. The interval of hatch is 0.1,1,10,20mm.

5. Future plan

We are planning to conduct further high resolution experiments near typhoon center with triple-nested model in order to resolve the details of inner structure. Moreover, we'll examine the effect of two-way nesting.

References

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