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IMPROVED SCHEME OF AXISYMMETRIC TYPHOON BOGUS MODEL AND ITS IMPACT ON NUMERICAL SIMULATION OF TYPHOON NOCKTEN (NO.0405)

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Abstract: There is distinct difference in the tangential wind profile between different typhoons in the western North Pacific. At present, only two parameters, maximum wind and radius of maximum wind, are used in NCAR-AFWA bogus for MM5 mesoscale numerical model. As a result, sometimes the outer structure of typhoon cannot be described accurately. The tangential wind profile of NCAR-AFWA bogus is improved by introducing radii of 25.7 m/s and 15.4 m/s, and then the track and intensity of Typhoon Nockten (No.0425) are simulated. The results show that the simulations of track and intensity of typhoon both have been improved by simultaneously introducing the radii in the tangential wind profile of typhoon bogus. At the same time, there is improvement in the gale wind range of the typhoon simulated.

Key words: improvement of tangential wind profile; MM5 model; typhoon Nockten (No.0425); simulations of track and intensity

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1 INTRODUCTION

Present prediction of typhoon abnormal track, intensity, distribution of strong winds and heavy rain has not been accurate enough, which is a problem that needs to be tackled sooner rather later. As typhoons are generated over vast surface of the ocean that only has scarce observations, the numerical simulation of typhoons depend much on the initial structure. It is then essential to apply typhoon parameters to numerical models in optimal ways. There has been much work on the initialization of typhoons. It is discovered that typhoon tracks are mainly affected by the winds at the periphery of the storms and have little relation with the intensity of the eye[1]. A scheme of tangential wind profiles is put forward[2], which introduces the mean radii of 25.7 m/s and 15.4 m/s to the one by Chan et al.[3] and Gao et al.[4] and forecasts of typhoon intensity have been greatly improved. In this work, the above wind radii are directly introduced to the bogus scheme of NCAR-AFWA to improve the tangential wind profile of typhoons at the initial stage. Then, Typhoon Nockten is selected for simulation study, for it has abnormal track and varies much in both intensity and radius of strong winds.

2 IMPROVEMENT OF TANGENTIAL WIND PROFILE IN THE BOGUS AND NUMERICAL SIMULATION

2.1 *Improvement of tangential wind profile in the bogus and numerical simulation*

In the bogus scheme of NCAR-AFWA of the MM5v3 model, the initial vortex uses the axisymmetric structure with the profile of the tangential wind velocity of $v(r,z)$ expressed as

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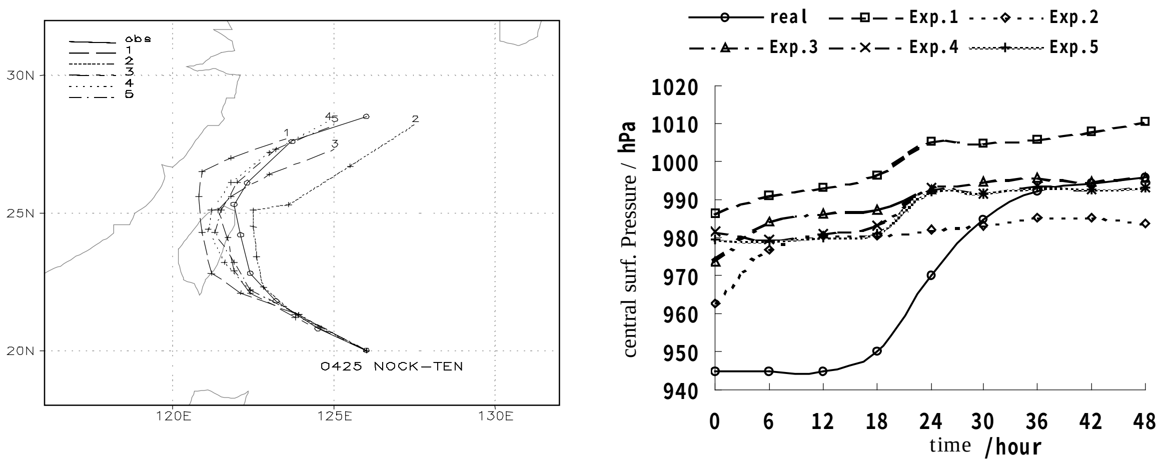


Fig.1 Tracks of typhoon movement determined with 48-h simulation in the five experiments (the dotted, dashed, dotted and dashed lines with "+") and the best track (the solid line with "○"). The time interval is 6 hours (left panel) and the pressure at the typhoon center with the 48-h simulation and observations (right panel).

$$
\begin{cases}
F(r) = \dfrac{V_{max}}{R_{max}} \cdot r & (r \le R_{max}) \\
F(r) = \dfrac{V_{max}}{R_{max}^{a}} \cdot r^{a} & (r > R_{max}) \\
v(r,z) = A(z) \cdot F(r) &
\end{cases}
\qquad (1)
$$

Here, V_{max} is the maximum wind speed near the eye, R_{max} the radius of maximum wind speed, a the shape factor of the profile and $A(z)$ the function of vertical weighting.

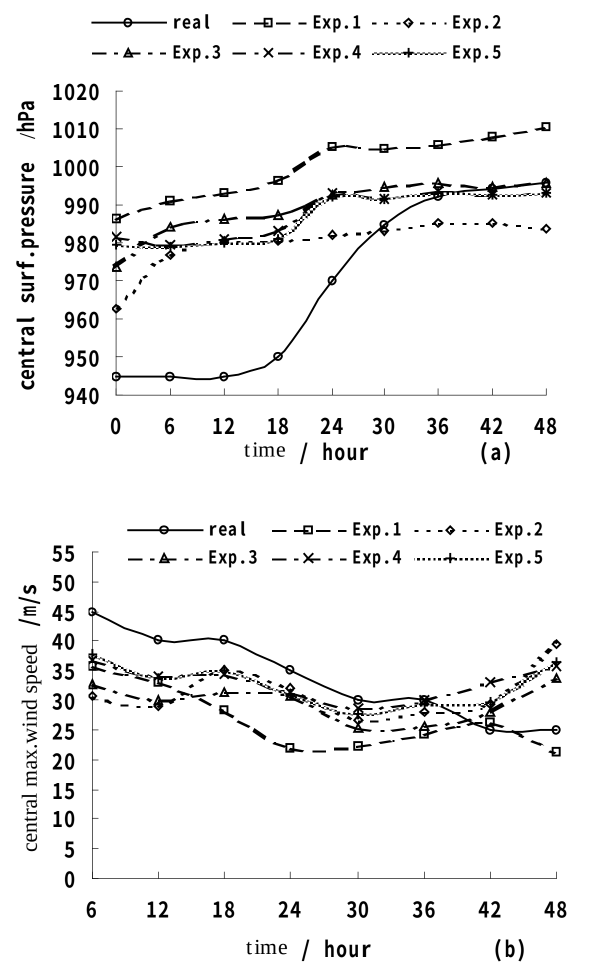
For the shape factor a, study has been done to propose different values[5, 6, 7]. In this work, some improvements have been made in view of the fact that a is a constant, i.e. the mean radii of 25.7 m/s and 15.4 m/s winds are introduced in the bogus scheme so that a can change with different typhoons. The values of a are listed in Tab.1.

Tab.1 The shape factor a of the tangential wind profile of the initial typhoon for the five experiments

Scheme	a ($r \le R_{max}$)	a ($r > R_{max}$)
Exp.1	1.0	-0.75
Exp.2	1.0	-0.46
Exp.3	1.0	-0.53
Exp.4	1.0	-0.91
Exp.5	1.0	-0.76

2.2 *The model, data and design of the experiments*

The non-hydrostatic mesoscale model MM5v3 of PSU/NCAR, U.S.A., was used in this work. The integration domain is a two-way nesting with the center set at 23.5°N, 124.5°E. The gridpoint interval is 54 km for the outer model with an integration domain of 5292 km×3996 km; the gridpoint interval is 18 km for the inner model with an integration domain of 2484km×2052 km. The vertical direction uses 23-layer s - coordinates. The Dudhia scheme is used for explicit treatment of water vapor. The Grell scheme is adopted for the parameterization of cumulus convection. The MRF scheme is used for the planetary boundary layer. Cloud-radiation physics and feedback of two-way



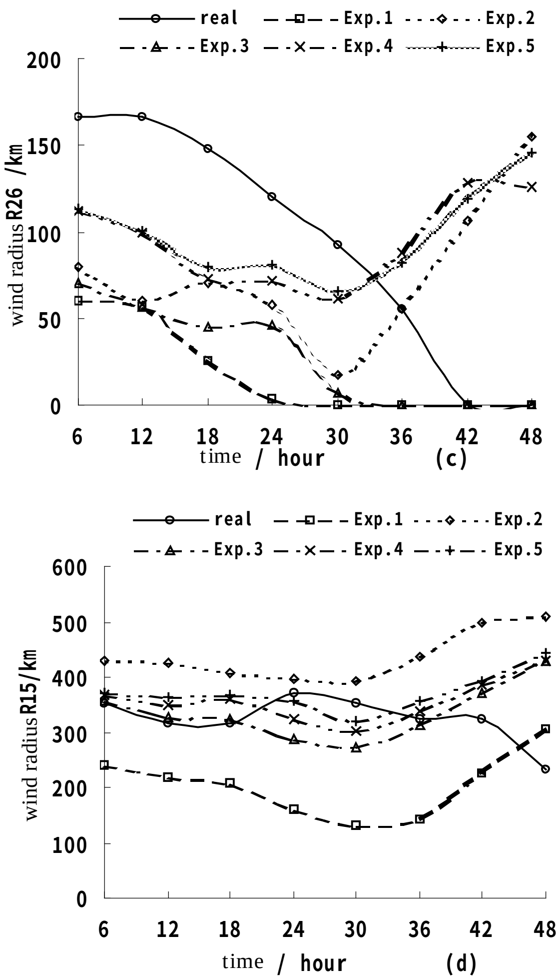


Fig.2 Temporal changes of 48-h simulations in the five experiments and corresponding results. a. sea level pressure at the eye; b. maximum wind speed near the eye; c. mean radius of 25.7 m/s wind; d. mean radius of 15.4 m/s wind. The time interval is 6 hours for all.

nesting are taken into account. The initial and lateral boundary fields of the model are determined by interpolating with the 2.5° × 2.5° reanalysis of data from NCEP / NCAR available four times daily.

For different a, five experiments were designed. They started at 2004102400 UTC and the valid duration was all 48 hours.

3 ANALYSIS OF THE RESULTS

With the five experiments, Nockten's 48-h track and best track were determined (Fig.1, left panel). All of the experiments were able to simulate the abnormal recurvature, but there were still some improvement with the addition of the mean radii of 25.7 m/s and 15.4 m/s winds in the initial typhoons. Tab.2 gives the distance errors of Nockten's center position simulated in the five experiments. It shows that gradual introduction of the wind radii would help improve the simulation of tracks while the introduction of the radius of 25.7 m/s winds is not as good as that of both the radii of 25.7 m/s and 15.4 m/s winds.

It is shown in the right panel of Fig.1 that the sea level pressure of the eye is much weaker than the observation in the early stage of all five experiments but much closer to reality in the late stage of Exps.3, 4 and 5. In the five experiments, the maximum simulated wind speed near the eye (Fig.2) is weaker than reality in the early stage but stronger than reality in the late stage, but a decreasing trend with time is generally reproduced in the first 36 hours. In general, the simulation is slightly better with Exp.3 than the rest. The introduction in the tangential wind profile of both the mean wind radii of 25.7 m/s and 15.4 m/s improves the simulation of Nockten's track and intensity, with some larger than the others.

Tab.2 Distance errors of the center of Nockten simulated in the five experiments

Schemes	24-h error / km	48-h error / km
Exp.1	146.2	285.9
Exp.2	55.6	167.2
Exp.3	55.6	157.2
Exp.4	126.8	133.4
Exp.5	102.5	111.7

Analyzing the tangential wind speed through the eye and the vertical, zonal profile of geopotential temperature reveals that there is sharp difference between them. It indicates that the radius of the maximum wind speed of the typhoon does not affect the vertical structure. As shown in the horizontal distribution of wind speed on the 850-hPa isobaric surface in all of the experiments (Fig.3), different schemes lead to greatly different distribution of horizontal wind speed and strong wind coverage. Similarly, zonal, vertical profiles of the vertical velocity through the eye also show different simulations of the eye. There is no well-defined structure of the eye wall in the simulation with Exp.1; there is obvious structure of "V"-shaped eye wall in the simulation with Exp.3; there are poorly-defined eye walls in the simulations of Exps.4 and 5. It is also noted that changes in the profile of the tangential wind profile of the initial typhoon will affect the variation of the vertical structures of the typhoon dynamics and thermodynamics, and then further affect the changes in typhoon track and intensity.

For analyses of other aspects, refer to the Chinese edition of the journal.

4 CONCLUSIONS

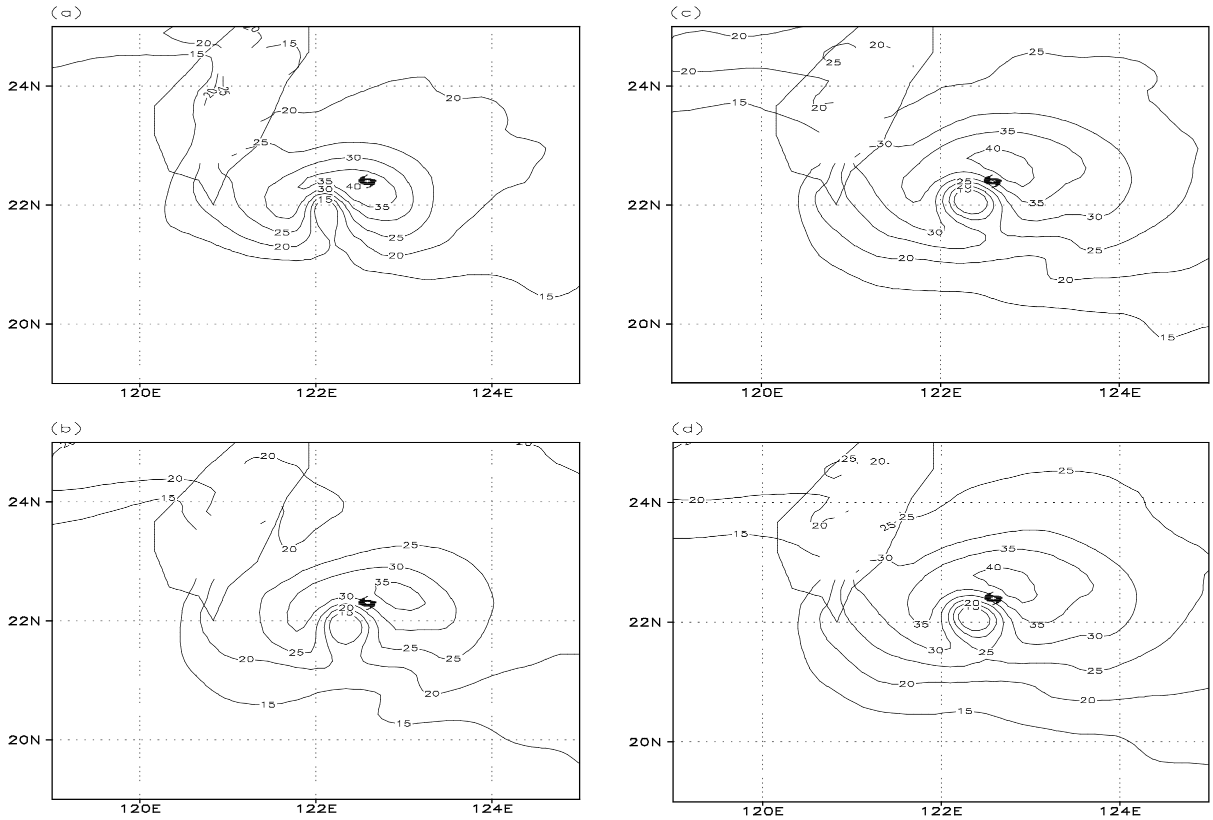


Fig.3 Horizontal distribution of wind speed on the 850-hPa isobaric surface determined with 12-h simulation with the experiments (unit: m/s). a. Exp.1; b. Exp.2; c. Exp.3; d. Exp.4; e.Exp.5.

By improving the bogus scheme of NCAR-AFWA for MM5 mesoscale numerical model, the current work has conducted 48-h simulation experiments of Typhoon Nockten (No.200425). The results show that the introduction in the initialization scheme of both the mean radii of 25.7 m/s and 15.4 m/s winds can gradually improve the shape of the tangential wind profile of the typhoon to make it closer to the observation. In addition, it also improves the numerical simulation of typhoon track and intensity by altering the vertical structure of typhoon dynamics and thermodymics. For typhoons with different intensity and track, the introduction in the profile of tangential wind of the mean radii of 25.7 m/s and 15.4 m/s winds may have different effect on the simulation of track and intensity.

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