A change to the physical process of JMA Typhoon Model

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1. Introduction

The Japan Meteorological Agency (JMA) operates the Typhoon Model (TYM) 4 times a day for predicting tropical cyclones in the Western North Pacific. In recent years, TYM has been improved by changing the typhoon bogus system (Sakai et al. 2002), while the JMA Global Spectral Model (GSM) has been improved by changing the physical process as well as data assimilation. Both models have successfully reduced the error on typhoon track forecast. Stimulated by the improvement in GSM, the physical processes of TYM were changed by introducing those implemented in GSM from 1999 to 2001 (Kuma 2001). The major changes are as follows:

(1) Incorporating cloud water content as a prognostic variable (parameterization of precipitation and radiation).

(2) Modifying an Arakawa- Shubert cumulus convection scheme.

(3) In stead of a moist adjustment scheme, introducing a muss-flux type convection scheme for mid-level convection parameterization.

(4) Considering direct effect of aerosols on short-wave radiation.

Some preliminary experiments show, however, that the new TYM often overestimates typhoon intensity. Recent studies report the simulated intensity of a tropical cyclone is sensitive to the ratio of the enthalpy to momentum exchange coefficients, Ck/Cd (Ck: Exchange coefficient for heat and water, Cd: Surface exchange coefficient for momentum). The lower the value of Ck/Cd, the less intense the simulated tropical cyclone (Emanuel 1995; Bao 2003). In order to suppress the overestimation in typhoon intensity forecast, a roughness length on sea surface is changed so that the heat and moisture fluxes on sea surface were decreased (Lower value of Ck/Cd).

(5) The roughness length formulas were changed from Kondo (1975) to Garratt (1992) for the heat and water exchange coefficient and Beljaars (1995) for momentum exchange coefficient.

2. Experiment and Result

Figure 1 shows the track for T0206 (CHATAAN) predicted by the new TYM. Best track and prediction by the old version of TYM as the control run are also indicated. In this forecast period, the typhoon changes its direction from north-westward to north-eastward (re-curvature stage). In the control, the re-curvature is not predicted well and the typhoon continues to move to the north-west. In the case of the new TYM, though the speed of movement is slower than analysis, the re-curvature is predicted well. Figure 2 shows surface pressure and precipitation for 84-hour forecast. In the control, a small low and associated intensive precipitation are predicted in the northeast of the typhoon and the low moves northeastward along the edge of the sub-tropical high. Affected by this small low, the typhoon continues to move northwestward. Actually, the small low nor the intensive precipitation exists around the typhoon. In the new TYM, no spurious low is predicted in the area and the typhoon is predicted well to move along the edge of the sub-tropical high following the anti-cyclonical flow. The new TYM is superior to the control in the prediction of the synoptic field in tropics.

Figure 3 shows the impact of the roughness length formulas to the intensity forecast for T0216 (SINLAKU). Without a change of the roughness length formulas (thin solid line), the predicted central pressure of the typhoon is about 30 hPa stronger than the analysis. By changing the roughness length formulas (broken line), the overestimation is suppressed, and the predicted central pressure is close to the analysis.

Figure 4 shows the result of the forecast experiment targeting T0206 (CHATAAN), T0216 (SINLAKU) and T0221 (HIGOS). The track-forecast error is reduced by 56km in 72 hour forecast compared to operational one. The intensity-forecast error (Figure 5) is similar to the operational one.

The JMA implemented these changes in operational TYM in July 2003.

Reference

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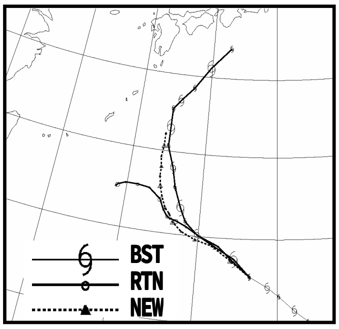

Fig.1 Forecast track for the T0206 (CHATAAN) by TYM (Initial time: 2002/07/06 00 UTC)
BST: Best track, RTN: control, NEW: New TYM. Plotted every 6 hour.

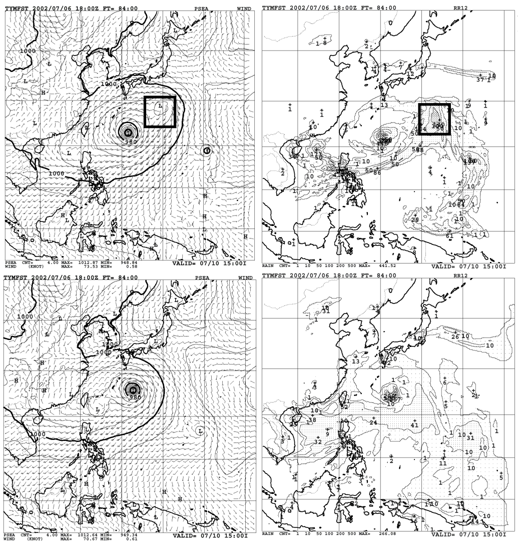

Fig.2 84 hour forecast of the control (upper) and the new (lower) TYM. Mean-sea level pressure (left) and preceding precipitation accumulated 12 hour (right).
(Target: T0206 Initial time: 2003/07/06 18UTC)
A spurious low and associated intensive precipitation are indicated with a square.

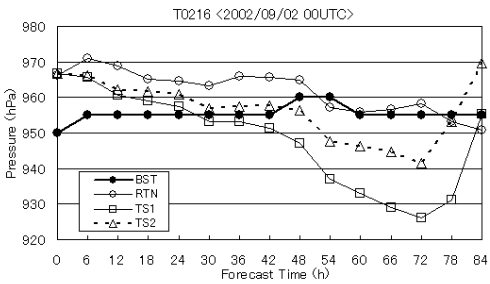

Fig. 3 Intensity forecasts for the T0216 (SINLAKU) by TYM (Initial time: 2002/09/06 00UTC)
BST: Best track, RTN: control, TS1: Without change of the roughness length, TS2: With change of the roughness length.

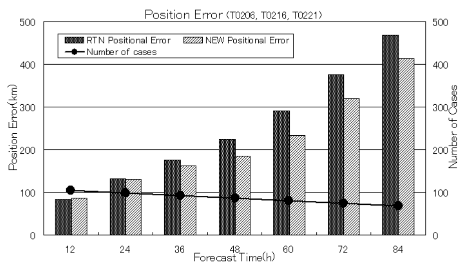

Fig. 4 Mean position error of TYM.
Dark bar is the control. Light bar is the new TYM. Line is the number of cases.

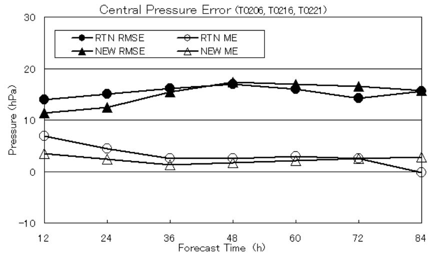

Fig. 5 Central pressure error of TYM.
RTN: control, NEW: new TYM. Closed marker shows root mean square error (RMSE). Open marker shows mean error (ME).