11A.7 An Experiment on the Impact of Initial Fields and Boundary Conditions on the Typhoon Track Simulation in the Northwest Pacific Ocean

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1. Introduction

Typhoons are the most severe weather system in Taiwan area. In order to provide guidance for the forecasts, a nonhydrostatic region forecast model (NFS) was developed and installed at the Central Weather Bureau (CWB). To improve the NFS is one of the key elements to advance the typhoon forecast of the CWB.

Better specification of the initial state could improve the forecast skill of numerical models. Several studies (Lorenz and Emanuel 1998, Palmer et al 1998) suggested that calculations by using singular vectors, adjoint methods and other techniques identify areas where forecasts are most sensitive to perturbations due to the initial conditions. Meanwhile, the measuring forecast sensitivity in terms of total energy, small-scale structures exhibited the initial uncertainty has a large impact. Wu et al (2005) by using Mesoscale Model (MM5) indicated that the lateral boundary forcing plays a critical role in long-term regional climate modeling.

In this study, simulations with different initial fields and boundary conditions were conducted to examine their impact to the typhoon track simulations. Different initial fields and boundary conditions were from either NCEP (National Centers for Environmental Prediction) global model (NCEPGFS) or from CWB global model (CWBGFS). Potential vorticity(PV) diagnosis was applied to investigate the contribution of different weather systems to the typhoon motion.

2. Model description and experiment design

The forecast of numerical model is impacted not only by the dynamic mechanism, physical schemes, and spatial resolution but also the initial fields and boundary conditions. In the operational environment, the NFS lateral boundary conditions are provide by the CWBGFS. Since the number of daily observation data received from the Global Telecommunication System(GTS) at CWB is less than the other major meteorology Centers, we found that the forecast skills of the major Centers are better that that of CWBGFS. Therefore, it is worth to examine the impact on the NFS forecast of typhoon track with different initial fields and boundary conditions.

Five experiments were designed and illuminated as follows: 1. The initial fields of NFS model were from the 6 hours forecast update cycle and the boundary conditions were interpolated from CWBGFS. In order to prevent the inaccurate forecast over the ocean and Tibetan plateau, where lack of observation data, bogus data from CWBGFS were added per 5 degrees in the objective analysis. This experiment is similar to the operational run and was called **"OP"**. 2. Experiment "GG": both the initial fields and boundary conditions were from CWBGFS. 3. Same as the experiment **"GG"**, but the datasets were from NCEPGFS. The experiment was named **"AA"**. 4. The experiment was denominated **"5G"** with the same initial field of **"OP"** but bogus data for the ocean and Tibetan plateau area, per 5 degrees, came from the NCEPGFS. The experiment **"5A"** was similar with **"5G"**, but the boundary conditions were from NCEPGFS.

3. Results and discussions

From May to September 2005, the averaged errors of NFS for 24, 48 and 72 hours typhoon track forecast are 113, 202 and 296 km, respectively. Among the forecasts for the tropical cyclones, the forecast for Typhoon Talim is relatively worse with error of 276/484 km in 48/72 hours forecast. The model forecast of Talim from 0000UTC 28 August to 30 August was showed in Fig.1. **"OP"** had significantly northward bias and **"5G"** exhibited less error to the north. The experiments with data from NCEPGFS such as **"AA"** and **"5A"** have less forecast error (91/214/305km and 92/202/303km, respectively) in 24/48/72 hours forecast. On the other hand, eight typhoons with total of 51 cases in 2004 and 2005 were also examined. The 72-hour averaged track errors are shown in Fig.2. Comparing the Experiments with bogus data over ocean and Tibetan plateau from CWBGFS (**"OP"**) and NCEPGFS (**"5G"**), the NFS forecast track errors were improved 10.8% in the first 24 hours and 5.5% in the average of the 72 hours forecast. In addition, the boundary conditions by using NCEPGFS (**"5A")** were better than by using CWBGFS (**"5G").** The improvement for the 36 to 72 hours forecast and for the 0-72 hours forecast is 16.4% and 11.3%, respectively. It is indicated that the boundary condition is very important in NFS model forecast, especially for the 36 to 72 hours forecast. Base on the different initial fields and boundary conditions from CWBGFS (**"OP"**) and NCEPGFS (**"5A"**), the performance of NFS by using NCEPGFS improved 16.4% in typhoon track simulation. Particularly, a 20.4% improvement in the 48 to 72 hours forecast.

The NFS forecast for typhoon Talim on 00UTC 29 August were analyzed by the potential vorticity diagnosis. The time series of the movement of Talim and the steering contributed from five PV

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perturbations for 5G and 5A are shown in Fig.3. The steering flow ($\vec{V}$) is defined as the deep-layer-mean (925-300hPa) wind vector averaged over the inner 3° around the typhoon centers. The PV perturbations included the total (q'), subtropical high (SH), mid-latitude trough (TR), South China Sea low (SL), and the tropical cyclone Nabi (Nabi). Considerable differences in the total perturbation, from 1200 UTC 30 August to 0000 UTC 1 September, were found for **"5A"** and **"5G"**. The northward steering deviation of **"5G"** occurred and increased significantly after 1200 UTC 30 August. And, the steering shifted from northwestward to northeastward at 1200UTC 31. The result is consistent with the significant northward bias of NFS track forecast in experiment **"5G"**. The northward deviation resulted from the PV perturbation shown the major contribution was from the mid-latitude trough. However, the subtropical high somehow also contributed to the northward steering flow.

In conclusion, due to the sparse observation data (over the ocean and some particular areas) received from GTS in CWB, the performance of CWBGFS is worse than that of the major meteorology Centers such as the NCEP. As a result, the initial fields and boundary conditions of NFS and CWBGFS sometime couldn't represent the actual atmospheric environment very well. In that circumstance, the typhoon track forecast error of NFS will increase. Our study shown that with per 5 degrees bogus data in initial fields and using the boundary conditions from NCEPGFS could improve the NFS typhoon track forecast.

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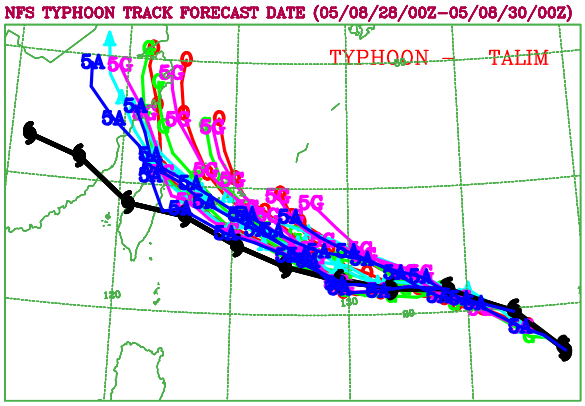

Fig.1 The series of experiments on typhoon track forecast of Talim from 0000UTC 28 August to 30 August.

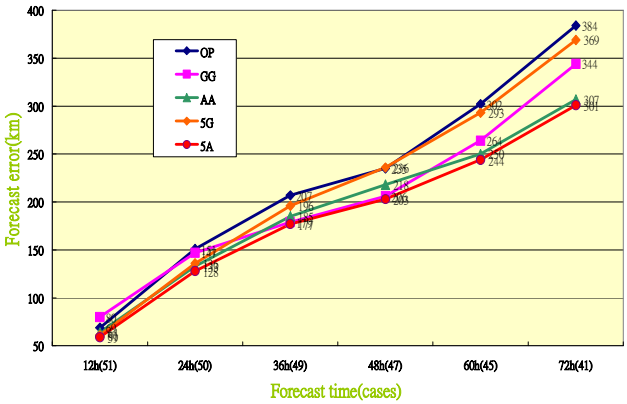

Fig.2 The 72-hour averaged track errors of eight typhoons for 51 cases in 2004 and 2005.

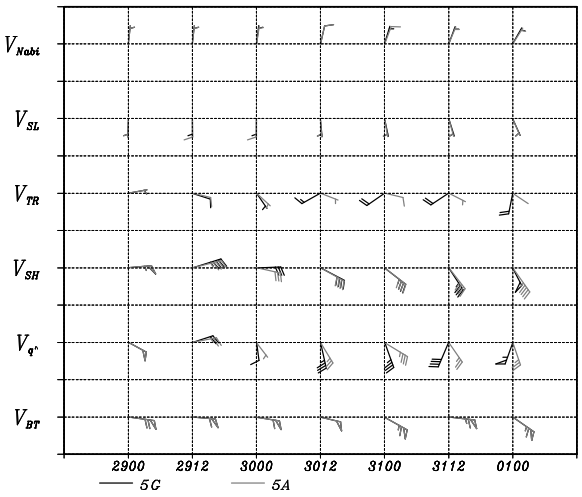

Fig.3. The time series of the movement of Talim and the steering flow associated with the PV perturbation of total ($\vec{V}_{q'}$), SH, TR, SL and Nabi for experiments **5G** (black) and **5A** (gray). One full barb represents 1 ms^{-1}.