交通部中央氣象局委託研究計畫成果報告

IMPROVEMENTS FOR THE TYPHOON FORECAST SYSTEM (TFS) OF THE CENTRAL WEATHER BUREAU

計畫類別：□國內　■國外
計畫編號：MOTC-CWB-91-3M-04
執行期間：91 年 2 月 1 日至 91 年 12 月 31 日
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執行單位：MPENG Sciences & Applications

中華民國九十一年十二月

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Final report submitted to the Central Weather Bureau

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December 2002

In this year, we continue to improve the TFS by improving the physical parameterization of the TFS, concentrated on the cumulus parameterization and the linkage between the convective scheme and the surface fluxes.

Among the physical parameterizations needed for numerical prediction system to account for the sub-grid scale effects, deep convective parameterization plays the most important role in the prediction of tropical cyclones. A fairly new convective parameterization scheme, the Emanuel scheme (Emanuel 1991, Emanuel and M. Zivkovic-Rothman, 1999) has been successfully implemented in the TFS. The unique characteristics of the Emanuel scheme include: 1) determination of cloud base mass flux, 2) distribution of cloud base mass flux in the vertical to mixing cloud mass at each level, and 3) division of mixing cloud mass into sub-cloud drafts based on buoyancy sorting.

Whereas other details address the important issue of the nature of the convection, the cloud base mass flux determines the amount of convection that occurs. The Emanuel scheme assumes that this mass flux increases according to the difference in temperature between a parcel near and below cloud base and the environment. The cloud base mass flux that is computed in this manner depends strongly on the selection of the updraft source level. Different source levels can correspond to different cloud base levels, and different cloud properties in general. In the Emanuel's original formulation, the source level is chosen to be that which has the greatest moist static energy below the level where the moist static energy is a minimum. This level often lies very near the surface. If the source level air is near saturation, the parcel may not have far to rise before reaching the corresponding cloud base level. Hence the parcel may have little buoyancy near cloud base, resulting in only a small amount of convective mass flux.

In reality, one expects that air rising through the cloud base level should be a mixture of air entrained from multiple levels rather than a single source level. The cloud base level and the parcel buoyancy near cloud base would depend on the properties of this mixture. Development and testing is currently underway to determine the sensitivity of parameterized convection to the manner in which the parcel properties below cloud base are modeled. The modification to the source-level selection implemented here represents a first-order attempt to correct for the most serious problems associated with the present scheme. This change retains the use of a single source-level, but uses a different criterion to select that level. The source-level in the modified treatment is that level below the level of minimum moist static energy that results in the greatest difference between the parcel and environmental air at the corresponding cloud base level. This choice of source-level tends to maximize the cloud base mass flux. Column model tests suggest that the modification performs as expected, increasing convective mass flux and rainfall under certain conditions where the present scheme is deficient.

By allowing more freedom of choosing source level of cloud base, the revised scheme is capable of catching more mid-level convective clouds and thus generating more intense localized precipitation. This modification has been demonstrated to have improvement on both the track and intensity predictions in a global prediction system (Peng et al. 2002). This resort shows the results of the forecasts from the Kuo scheme, the original Emanuel scheme, and the revised Emanuel scheme.

One of the weaknesses of the TFS is that the simulated storm intensity is usually weak so that sometimes it is difficult to track a storm in the model. Our remedy to this is to include artificial heating around the storm center. For a consistent comparison, we compare the results from the Emanuel scheme and the results from the Kuo scheme without artificial heating. For Typhoon Zeb, 1998 (Fig. 1), the tracks predicted with Kuo scheme and Emanuel scheme are similar for the case started on October 13, 0000UTC (Fig. 2). Indicated on the upper left of the figures are the minimum sea-level pressures associated with the storm in the forecast model. The predicted intensities using the Emanuel scheme are about 3 mb lower (higher intensity) than those using the Kuo scheme. The predicted track for the same case using the modified version of the Emanuel scheme is given in Fig. 3. This track is similar to those shown in Fig. 2. The intensities of the storm are about 2 mb lower than the old Emanuel scheme, a positive.

In this year, much effort has been made to implement an improved convective parameterization scheme, the Emanuel scheme, into the framework of TFS. One complete case is tested for comparison with the Kuo scheme and with the old Emanuel scheme and the track predictions are similar among these three. The intensity forecasts are improved slight. The studies shown in Peng et al. (2002) indicate that the revised Emanuel scheme has a positive impact on global circulation and tropical cyclone predictions. We highly recommend that CWB tests the delivered new version of the Emanuel scheme and tests it with more cases.

On the interaction of the convective process and the surface layer process, we tested the effect of including the downdraft vertical velocity in the determination of surface fluxes. This is achieved by including the convective vertical velocity in the computation of surface frictional velocity. The results indicate a slightly negative effect and the process is not suggested for operational implementation in TFS at the present status.

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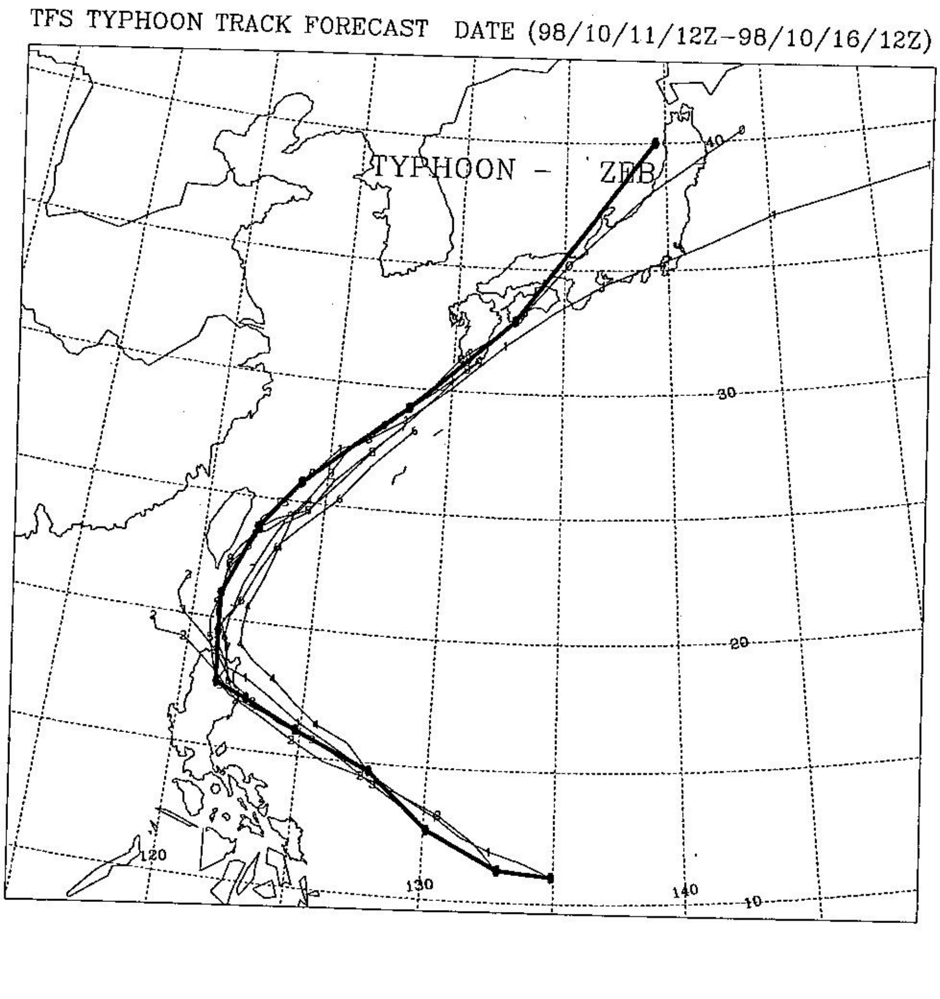

Figure 1. Best track and operational forecast track of Typhoon Zeb of 1998

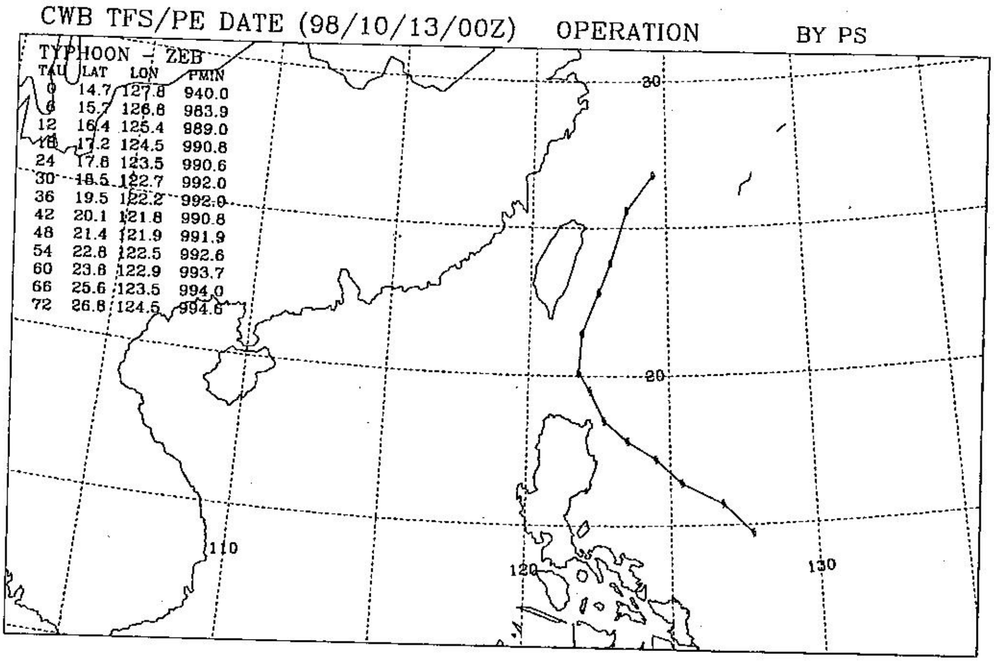

Figure 2. Forecast track for Typhoon Zeb on 0000 UTC October 2, 1998: a) using Kuo scheme without artificial heating. Note that the forecast tracks generated by operational TFS in Fig.1has artificial heating .

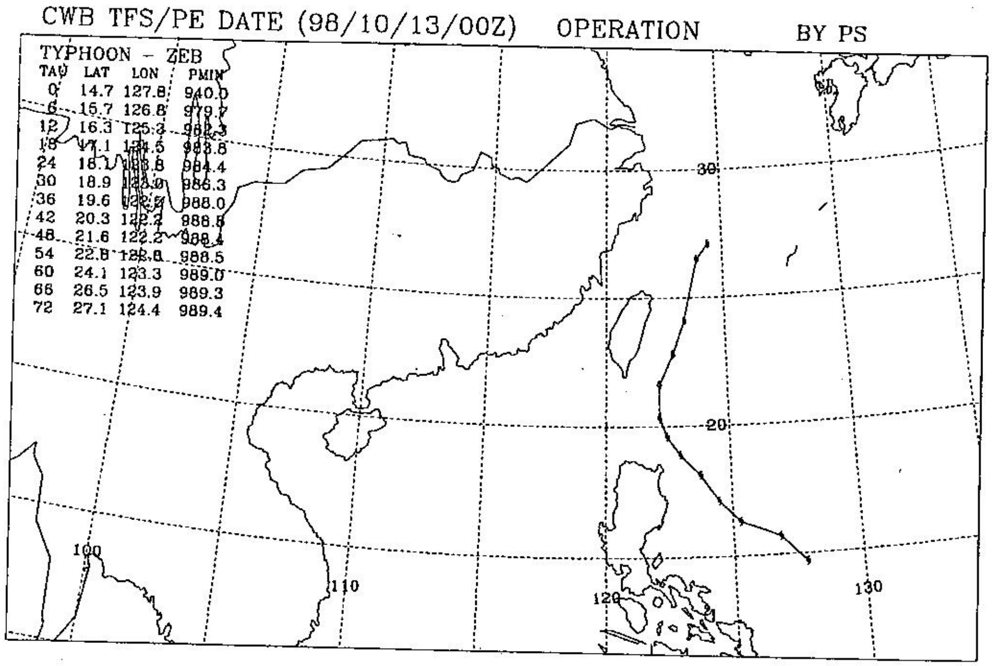

Figure 3. As in Fig. 2 except using the modified version of the Emanuel scheme.