Decade Development of the CWB Numerical Typhoon Forecast System after Morakot

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Abstract

Due to its unique geographical location, typhoons (TCs in the western Pacific) are the greatest threats to Taiwan's civilian lives and properties. In the past hundred years, roughly 3 to 4 typhoons hit Taiwan each year with some have caused severe damage and loss of lives. Accurate and timely predictions of typhoons could save lives, provide sufficient time for preparedness and also critical for optimal resource managements. While the prediction of TC tracks has improved substantially in past decades, prediction of TC intensity and structure change have progressed much less. In the study, the track and intensity forecast error trends for the two-decade period covering from 1985 to 2005 were compared. Results showed that the percentage track forecast improvement was almost an order of magnitude larger than that for intensity, indicating that intensity forecasting still has much room for improvement. This disparity can be contributed by the lack of sufficient in situ observations near the core, complex multi-scale processes, and air-ocean interactions.

Taiwan Island is located in an area frequently impacted by tropical cyclones (typhoons). Improving the tropical cyclone forecast is the highest priority task of the Central Weather Bureau (CWB) in Taiwan. A version of the Advanced Research Weather Research and Forecasting Model (ARW WRF), identified as TWRF (Typhoon WRF), was developed and implemented in CWB for operational tropical cyclones prediction since 2011, following prior operational implementation of a general-purpose regional model. Improvement and enhancement of the system have been carried out and implemented since including partial update cycling, tropical cyclone synthetic data bogus scheme, relocation scheme, 3DVAR with outer loop, analysis field blending scheme, new cumulus physics schemes in TWRF to improve the model (Hsiao et al. 2010, Hsiao et al. 2012, and Hsiao et al. 2015). The averaged 24/48/72 hours cyclone track

forecast errors of TWRF are 91/152/210, 91/147/223, and 84/133/197km in year 2013, 2014, and 2015 respectively. TWRF is one of the best models for tropical cyclone prediction over the Western North Pacific.

With the increase of computer resource, the TWRF configuration has been future improved from a triple nested to a double nested one with higher resolutions covering a larger domain in the vicinity of Taiwan. The model resolution was increased from 45/15/5 km, 45-levels (Fig. 1) to 15/3 km, 52-levels (Fig. 2). The increase of model resolution improving the track, intensity and rainfall forecast and the new system is in operational since July 2016. By increasing the size of inner domain and increasing its resolution, the system can resolve the fine-scale features without suffering much the inconsistency between the inner domain and the outer domain at eh lateral boundary blending zone, TWRF is now one of leading dynamical TC track prediction systems in the western North Pacific. This study is focused on presenting the benefit of high resolution in a big domain in tropical cyclone prediction. Predictions of the track (Fig. 3), intensity (Fig. 4), and rainfall distribution from the two versions for typhoons over the Western North Pacific Ocean in 2016, 2017 are analyzed and compared. The results show that increasing the model resolution improving the track, intensity and rainfall forecast. The 120h track error improved from 450 km in version 1.5 to 333 km in version 2.0 for all cases in 2016, 2017. The track error from TWRF version 2.0, also compares favorably with other models in 2018 for the Northern Hemisphere typhoon season (Fig. 5). The high-resolution model improved the precipitation, illustrated by a case study for Typhoon Nesat and Haitang in July 2017.

Key word: tropical cyclone forecast, high-resolution model, TWRF

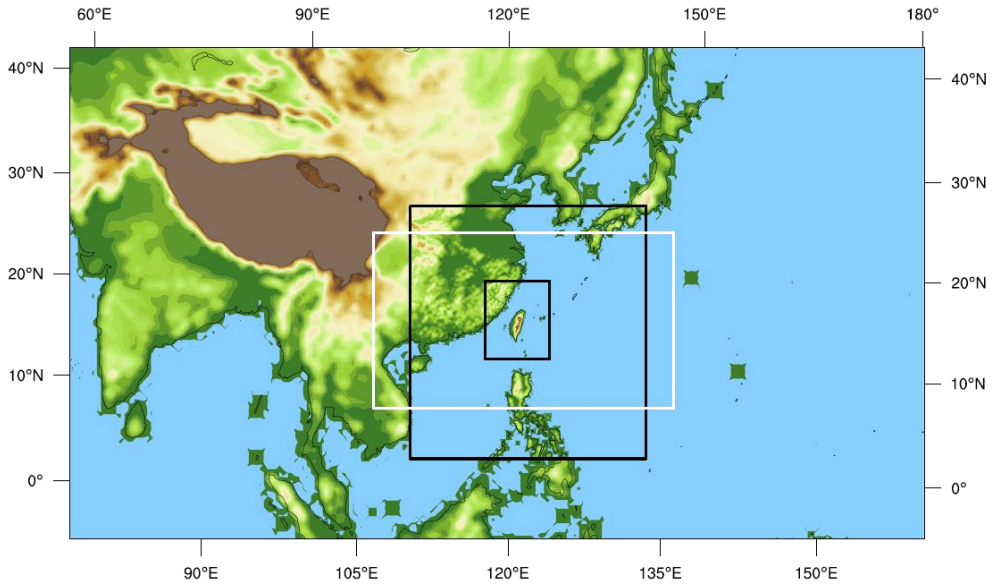

Figure 1. Domains of the three-nested grids in the TWRF old version. The resolution is 45/15/5 km for the three grids. The array sizes for the two domains are (662x386) and (1161x676) with 52 levels for both.

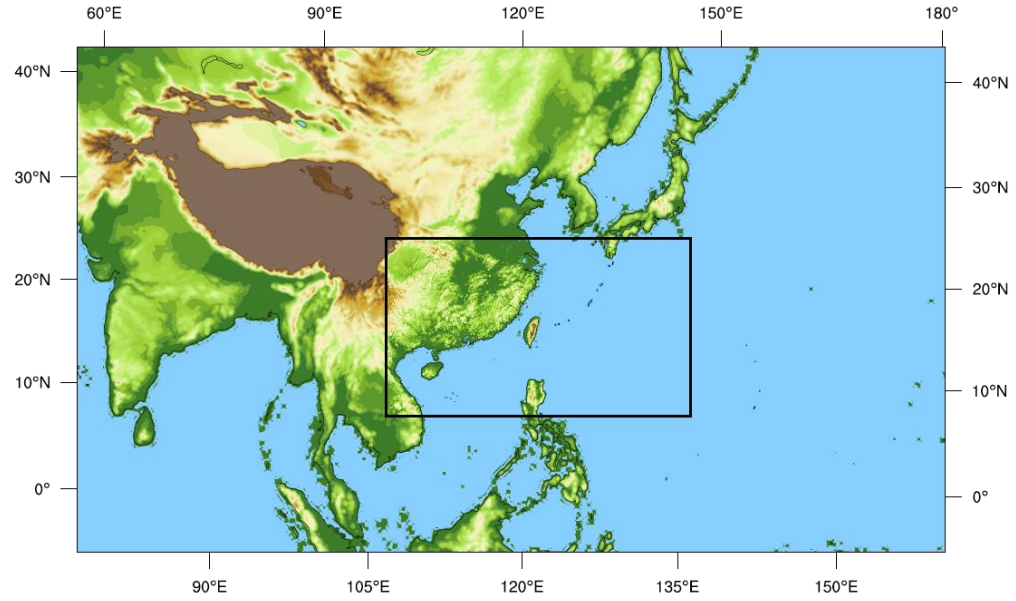

Figure 2. Domains of the two-nested grids in the TWRF new version. The resolution is 15 km for the outer grid and 3 km for the inner grid, respectively. The array sizes for the two domains are (662x386) and (1161x676) with 52 levels for both.

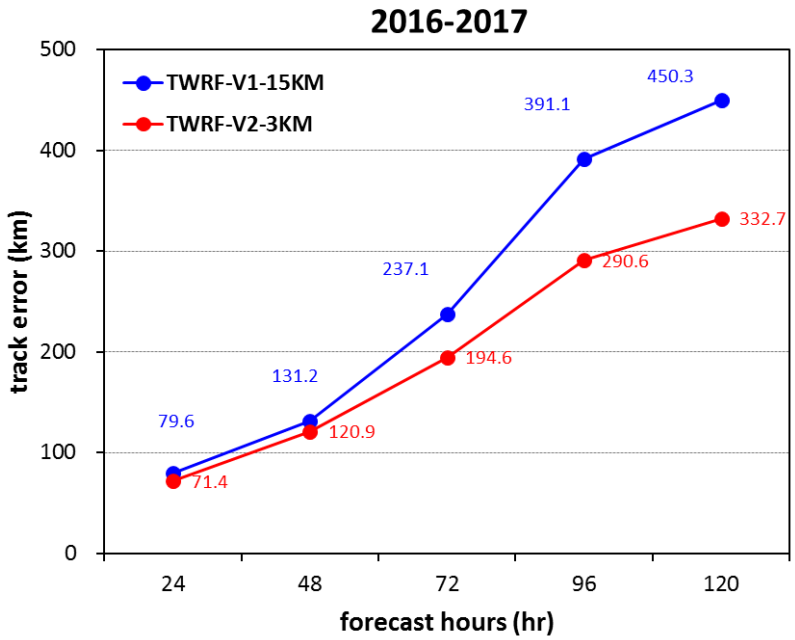

Figure 3. the benefit of high resolution in a big domain in tropical cyclone prediction. Predictions of the typhoon track. The 120h track error improved from 450 km in version 1.5 to 333 km in version 2.0 for all cases in 2016, 2017.

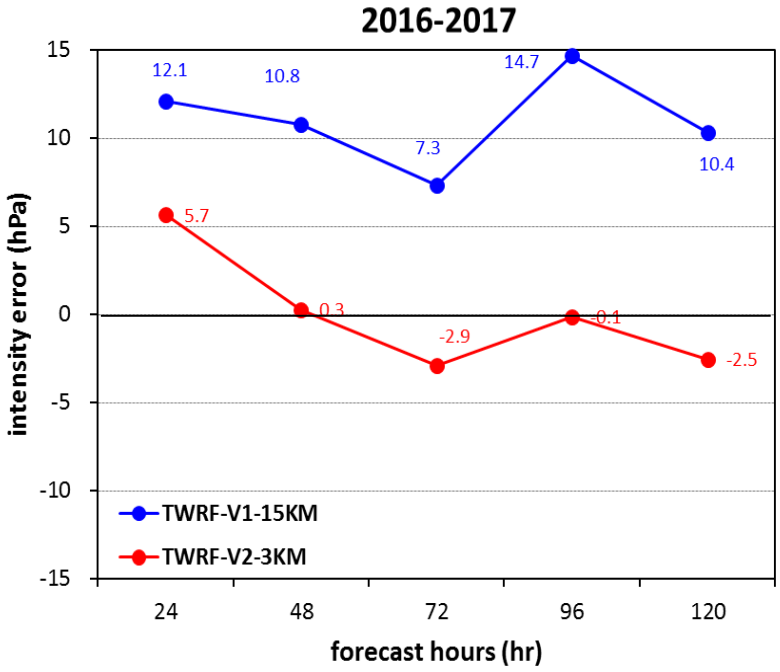

Figure 4. The benefit of high resolution in a big domain in tropical cyclone prediction. Predictions of the typhoon intensity. The 120h intensity error improved from 10.40 hPa(weak bais) in version 1.5 to -2.5 hPa in version 2.0 for all cases in 2016, 2017.

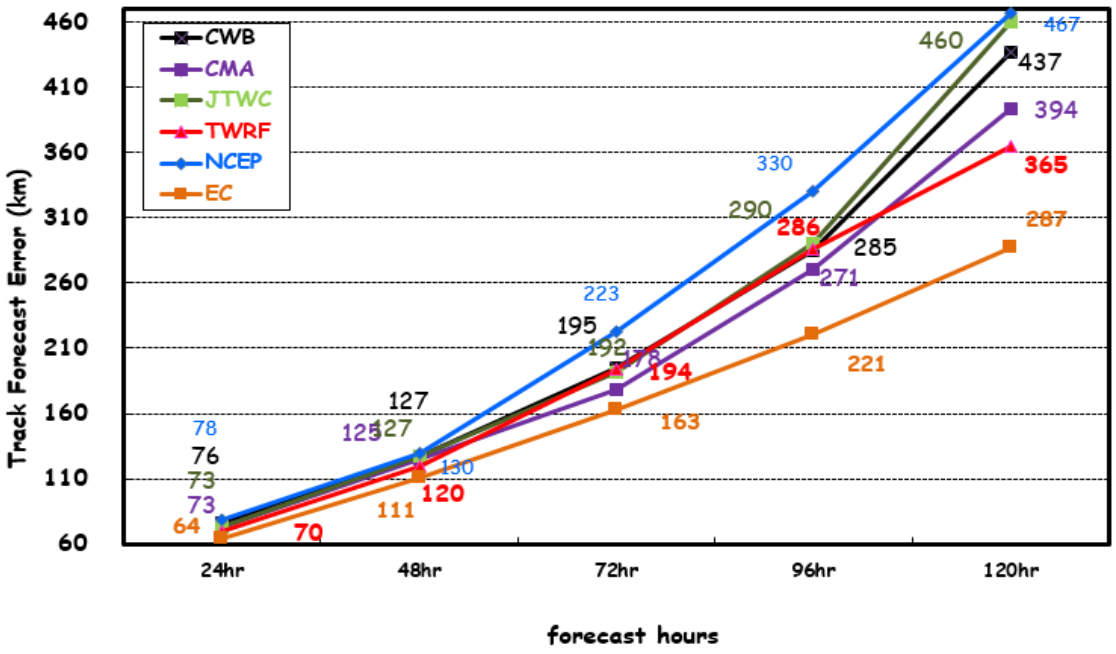

Figure 5. Typhoon track forecast error over NW Pacific in 2018 TWRF, EC, NCEP, CWB, JTWC, CMA. TWRF compares favorably with other models in 2018 for the Northern Hemisphere typhoon season

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