Upgrade of JMA's Typhoon Ensemble Prediction System

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1. Introduction

Since February 2008, the Japan Meteorological Agency (JMA) has operated its Typhoon Ensemble Prediction System (TEPS) designed to improve track forecast targeting for tropical cyclones (TCs) in the Regional Specialized Meteorological Center (RSMC) Tokyo - Typhoon Center's area of responsibility within the framework of the World Meteorological Organization. The forecast model employed in TEPS is a low-resolution version of JMA's Global Spectral Model (GSM). A singular vector (SV) method is adopted in TEPS to generate its initial perturbations, and dry SVs targeting the mid-latitude area are calculated for the Center's area of responsibility. The system also calculates moist SVs targeting TC surroundings where moist processes are critical. A stochastic physics scheme is used in TEPS in consideration of model uncertainties associated with physical parameterizations. JMA published a detailed description of its EPS suite including TEPS in 2013 (see reference).

2. Major upgrade of JMA's TEPS in March 2014

A major upgrade of JMA's TEPS was implemented in March 2014. The improvement included enhancement for the horizontal resolution of the forecast model from TL319 to TL479, revision of its physical processes (such as the stratocumulus and radiation schemes) and an ensemble size increase to 25. The major differences between the previous and upgraded TEPSs are listed in Table 1.

Table 1: Major upgrades applied to JMA's Typhoon EPS in March 2014

	Previous system	Upgraded system
Forecast model version	GSM1011	GSM1304 - Upgraded stratocumulus scheme - Upgraded radiation scheme
Horizontal resolution	TL319 (approx. 55 km)	TL479 (approx. 40 km)
Time step	1,200 sec.	720 sec.
Ensemble size	11 (Control run + 10 perturbed runs)	25 (Control run + 24 perturbed runs)
Perturbation generator	Singular vector method (SV)	SV with reduced initial spread

3. Impact of each enhancement on typhoon forecasting

A preliminary experiment involving the use of TEPS with the TL479-version GSM was conducted to investigate the impact of a higher-horizontal-resolution model on typhoon forecasting. The results showed that the higher-resolution TEPS supported sharper representation of TCs than the previous TEPS not only for typhoon-category storms but for all tropical depressions. The error of TC tracks predicted using the higher-resolution TEPS was also smaller than that of the previous TEPS, mainly due to the reduction of systematic biases.

In order to investigate the impact of a larger ensemble size on probabilistic TC track forecasting, another experimental configuration in which the ensemble initial conditions were increased from 11 to 25 was tested. Comparison of Brier skill scores (BSSs) for TC strike probabilities showed higher values from the experiment than for the previous TEPS, indicating that

the ensemble size increase in the order of a dozen was associated with a higher level of skill. However, the enhancement produced excessive ensemble spread, causing negative impacts on ensemble TC track forecasting such that the initial ensemble spread needed to be reduced. Accordingly, initial perturbation with a reduced amplitude was applied to TEPS. The results of another experiment after the revision indicated that the reduced amplitude provided better performance in combination with the increased ensemble size.

4. Performance of the upgraded TEPS

An experiment was conducted for the period from 2011 to 2013 on the upgraded TEPS before it was put into operation. The verification period included 2,056 TC forecasts over the northwestern Pacific in 1,527 TEPS runs. Figure 1 illustrates the position errors of the ensemble mean tracks derived from the previous and upgraded TEPSs, and shows that those of the latter were significantly smaller. The probabilistic verification results for the upgraded TEPS are also better than those for the previous TEPS (Figure 2). These outcomes indicate that the upgrade increased the appropriateness of the ensemble spread and improved TC track forecast skill.

REFERENCE

Japan Meteorological Agency, 2013: Outline of the operational numerical weather prediction at the Japan Meteorological Agency (JMA). Appendix to the WMO Technical Progress Report on the Global Data-Processing and Forecasting System and Numerical Weather Prediction, JMA. 188pp.

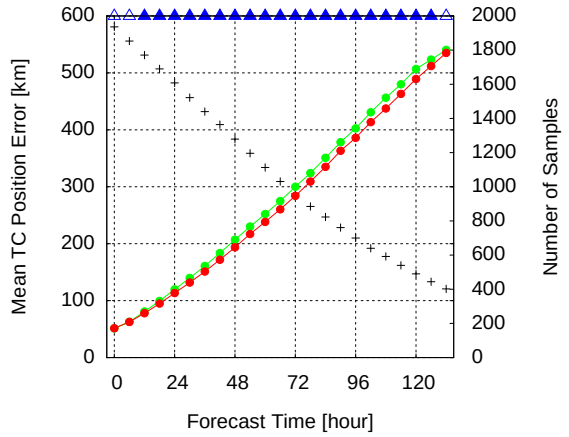

Figure 1: Mean position errors of ensemble mean TC tracks. Verified samples are all from TCs over the northwestern Pacific from 2011 to 2013. The horizontal axis shows the forecast range up to 132 hours ahead, and the green and red lines represent the results of verification for the previous and upgraded Typhoon EPSs, respectively. Plus marks indicate the numbers of verified samples based on the vertical scale on the right. The filled (open) triangles indicate that the differences of the two EPS results are statistically significant (insignificant) at a 95% confidence level.

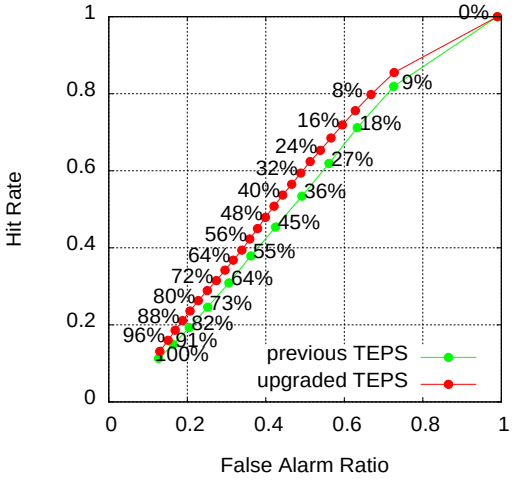

Figure 2: Probability of detection (POD) as a function of the false alarm ratio (FAR) for TC strike probability, defined as the fraction of ensemble members passing within 120 km of a given location in a five-day period. Verified samples are all from TCs over the northwestern Pacific from 2011 to 2013. The green and red lines represent the results of verification for ensemble TC tracks derived from the previous and upgraded Typhoon EPSs, respectively.