Typhoon Ensemble Prediction System developed at Japan Meteorological Agency

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1. Introduction

Japan Meteorological Agency (JMA) has developed a new ensemble prediction system (EPS), the Typhoon EPS, aiming to improve both deterministic and probabilistic forecasts on tropical cyclone (TC) movements. Its full operation will start no later than the beginning of the typhoon season in 2008, following a preliminary operation which has been conducted since May 2007.

2. Specifications of the Typhoon EPS

In the Typhoon EPS, eleven initial conditions including a non-perturbed one are prepared for integration by the JMA Global Spectral Model (GSM) with horizontal spectral truncation TL319 (L representing the linear grid) and 60 vertical layers. The initial field of the non-perturbed run (control run) is made by interpolating the analysis field of the 20km (TL959) GSM which was implemented in November 2007 (Iwamura and Kitagawa 2008). The EPS focuses on TCs in the western North Pacific Ocean and the South China Sea (0-60N, 100E-180E), and runs four times a day at 0000, 0600, 1200, 1800 UTC with the forecast range of 132 hours, which covers five day forecasts. A singular vector (SV) method is employed to make initial perturbations. For the ten perturbed forecasts, five initial perturbations are created by linearly combining SVs targeted on both TCs (up to three TCs in one forecast event) and a mid-latitude region. Binding coefficients are determined so that the spatial distributions of the perturbations could widely spread. In the SV calculations targeted on TCs, moist SVs (Barkmeijer et al. 2001) are computed, on the other hand, SVs for mid-latitude are dry SVs. The norm to evaluate the growth rate of SVs is based on the moist total energy norm (Ehrendorfer et al. 1999). The evaluation time is 24 hours for both moist and dry SV calculations.

3. Performances of the Typhoon EPS

Forecast performances during the preliminary operation from May to December in 2007 are shown in this section[1]. The verifications include TCs with the maximum sustained wind speed of 34kt or more. Best track data provided by RSMC Tokyo – Typhoon Center was used as analysis data. Through the verifications, we found three benefits from the EPS. First, the position errors in deterministic track forecasts are decreased. Using ensemble mean track forecasts, we obtained 40 km reduction in the position errors in the five day forecasts on average (see Fig. 1), which corresponds to the gain of about half a day lead time (not shown). Second, reliabilities become available regarding track forecasts. Referring to the amount of the ensemble spread of track forecasts, we succeeded in extracting uncertainty information on track forecasts. Based on this information, we categorized the reliability of track forecasts at each forecast time of each forecast event and assigned a reliability index, A, B, or C, to the forecast, where A, B, and C represented categories of the highest, the middle-level, and the lowest reliability, respectively, (see Fig. 2) and the frequency of each category was set to 40%, 40%, and 20%. As shown in Fig.3, when gathering all forecasts judged as A, it proved that the average position errors were considerably smaller than those of all track forecasts shown in Fig.1. On the contrary, when gathering forecasts judged as C, the average position errors were larger than the average position errors of all forecasts. This result reflects the fact that there is a strong spread-skill relationship in the track forecasts by the EPS. Last, alternative track scenarios to an ensemble mean track become available. Because of the possibility that an ensemble mean track forecast may miss a true TC movement, identifying all possible track scenarios is important. More importantly, one of the scenarios should have smaller errors than those of an ensemble mean track, particularly in cases where it had quite large errors. Figure 4 shows the comparison of position errors of three day forecasts (12 UTC initials only); the blue bars represent the position errors by ensemble mean track forecasts, which are sorted in ascending order, and the red bars represent the corresponding errors by a cluster whose errors proved to be the lowest among several scenarios which are identified using a cluster analysis method. In this method, we combined the Typhoon EPS (11 members) with the One-week EPS (51 members, Sakai et

[1]. Though the specifications of the preliminary operation are a little different from those of the full operation, we confirmed through some experiments that the differences of the performances are small.

al. 2008) at JMA and made an ensemble with 62 members so as to capture as many scenarios as possible and reduce the risk of missing. As Fig. 4 shows, it is found that one of some scenarios could represent a true TC movement rather than an ensemble mean forecast in cases where it had more than 500 km position errors.

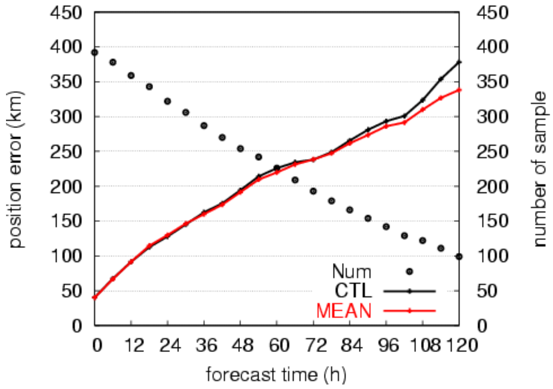

Fig. 1. Position errors of ensemble mean track forecasts (red) up to five days compared with those of track forecasts by control run (black). Y-axis on the left represents the position errors (km). Dots mean the number of sample at each forecast time's verification (see y-axis on the right).

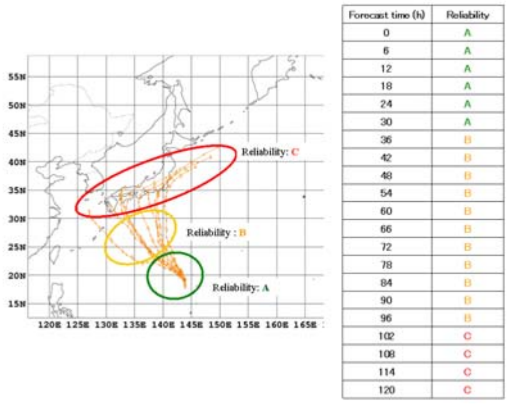

Fig. 2. An example of applications of the Typhoon EPS. A, B and C on the figure represent reliabilities on track forecasts, where A means the highest reliability. Each index is given based on the ensemble spread of track positions at each forecast time.

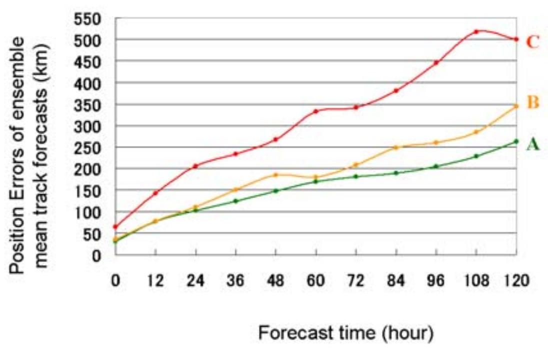

Fig. 3. Position errors of ensemble mean track forecasts of each reliability; A, B and C, where A represents the highest reliability. Green line shows the position errors of track forecasts with the highest reliability; A. Yellow and red lines correspond to the results of reliability B and C, respectively.

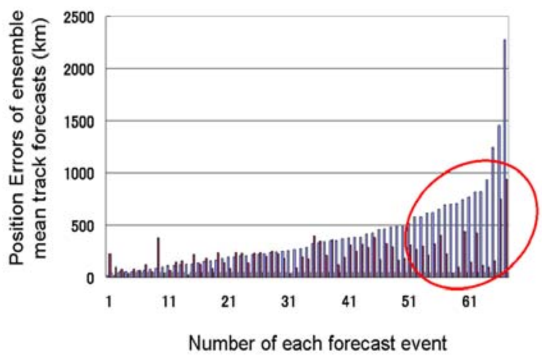

Fig. 4. Comparison of position errors of three day forecasts (12 UTC initials only). Blue bars represent the position errors by ensemble mean track forecasts, which are sorted in ascending order, and red bars represent the corresponding errors by a cluster whose errors proved to be the lowest among several scenarios. X-axis shows a number of each forecast event and y-axis does position errors (km).

Reference

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