Introduction to JMA's new Global Ensemble Prediction System

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1. Introduction

The Japan Meteorological Agency (JMA) put a new ensemble prediction system (EPS) called the Global EPS (GEPS) into operation in January 2017. Covering both medium- and extended-range forecasting, the system supports the issuance of five-day tropical cyclone (TC) forecasts, one-week forecasts, early warning information on extreme weather, and one-month forecasts. GEPS took over the roles of three previous JMA systems (the Typhoon EPS (TEPS; JMA 2017), the One-week EPS (WEPS; Yamaguchi et al. 2014) and the One-month EPS). The objectives of the integration were to utilize computational resources more effectively and to concentrate efforts into a single EPS system. TEPS and WEPS were replaced by GEPS in January 2017, and GEPS inherited the role of the One-month EPS in March 2017. Along with the introduction of GEPS, JMA also implemented an upgrade of the forecast model and an initial perturbation technique involving the Local Ensemble Transform Kalman Filter (LETKF; Hunt et al. 2007) and the singular vector (SV) method. A perturbation technique for sea surface temperature (SST) was additionally incorporated. This report gives an overview of GEPS with focus on TC track forecasting and one-week forecasting.

2. Global Ensemble Prediction System Specifications

Table 1 shows the specifications of GEPS and the previous TEPS, WEPS and One-month EPS systems. Parameterization scheme revisions include updating of treatments for land/sea surfaces, deep convection, cloud, gravity waves, boundary layers and radiation. The number of vertical layers was increased from 60 to 100, and the top-level pressure was changed from 0.1 to 0.01 hPa. SST perturbations were introduced, and LETKF was incorporated for revision of the initial perturbation production method.

The unperturbed initial condition is produced via interpolation of JMA's higher-resolution Global Analysis. SST and sea ice analysis is performed independently from the atmospheric initial condition and used as the lower boundary condition, which is then used to represent anomalies from the climatology. SST and sea ice anomalies at the initial time are fixed and added to the varying climatology during time integration.

Initial perturbations are generated using a combination of LETKF and SV. The ensemble spread based on perturbations from LETKF represents uncertainty in the initial conditions. SV-based perturbations are adopted to help ensure reasonable spreads for a medium-range lead time, and SST perturbations are designed to represent uncertainty in the prescribed SST. A stochastically perturbed physics tendency scheme is used in consideration of model uncertainties associated with physical parameterizations.

3. Impact of EPS Upgrade on TC Track Forecasting and One-week Forecasting

GEPS was examined for the period covering 2015 and 2016 to evaluate the results of TC track forecasting and one-week forecasting. As shown in Figure 1, the average TC track forecast errors of ensemble means determined using GEPS for the western North Pacific region were smaller than those determined using TEPS. As shown in Figure 2, Brier skill scores for probabilistic forecasts of 24-hour cumulative precipitation exceeding 1 mm over Japan during winter 2015/16 determined using GEPS were higher than those determined using WEPS. The upgrade of the forecast model significantly contributed to these improvements. The initial perturbation techniques of GEPS provide more appropriate distribution of initial spreads than the former system. Excessive initial perturbations in a limited area were observed with WEPS forecasts. The adoption of SST perturbations improves the spreads of atmospheric temperature over the ocean and large-scale convections in the tropics, but this improvement is unremarkable since other changes contribute more.

References

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Table 1: Configurations of the current and previous systems. Bold red text represents major upgrades over the previous systems.

	Previous systems		Current system
Name	Typhoon EPS (TEPS) (before Jan. 2017)		Global EPS (GEPS)
	One-week EPS (WEPS) (before Jan. 2017)		
	One-month EPS (1 m) (before Mar. 2017)		
Main targets	TEPS	Typhoon forecasts	Typhoon forecasts, one-week forecasts, early warning information on extreme weather, one-month forecasts
	WEPS	One-week forecasts	
	1 m	Early warning information on extreme weather, one-month forecasts	
Frequency	TEPS	Up to 4 times a day	4 times a day (at maximum) when a TC is present, twice a day otherwise
	WEPS	Twice a day	
	1 m	4 times a week	
Forecast range (initial time)	TEPS	5.5 days (00, 06, 12, 18 UTC)	5.5 days (06, 18 UTC)*, 11 days (00, 12 UTC) except for 18 days (00, 12 UTC; Sat. & Sun.), 34 days (00, 12 UTC; Tue. & Wed.)
	WEPS	11 days (00, 12 UTC)	
	1 m	18 days (12 UTC; Sat. & Sun.) 34 days (12 UTC; Tue. & Wed.)	
Ensemble size	TEPS	25	27 up to 11 days, 13 thereafter
	WEPS	27	
	1 m	50 (25 x two consecutive initial times)	
Horizontal resolution	TEPS	TL479 (approx. 40 km)	TL479 up to 18 days, TL319 thereafter
	WEPS		
	1 m	TL319 (approx. 55 km)	
Vertical resolution (model top)	TEPS, WEPS, 1 m	60 levels (0.1 hPa)	**100 levels (0.01 hPa)**
Initial perturbations (targeted area)	TEPS	SV (western North Pacific, TC areas)	SV (Northern Hemisphere, Tropics, Southern Hemisphere) **+ LETKF**
	WEPS	SV (Northern Hemisphere, Tropics, Southern Hemisphere)	
	1 m	Breeding of Growing Modes (Northern Hemisphere, Tropics)	
Model ensemble	TEPS, WEPS, 1 m	Stochastically Perturbed Physics Tendency (SPPT)	
Boundary perturbations	TEPS, WEPS, 1 m	None	**Perturbations on SST**

* GEPS runs from base times at 06 and 18 UTC when any of the following conditions is satisfied:

- A TC of tropical storm (TS; defined as a TC with maximum sustained wind speeds of 34 knots or more and less than 48 knots) intensity or higher is present in the RSMC Tokyo - Typhoon Center's area of responsibility (0 – 60°N, 100°E – 180°).
- A TC is expected to reach TS intensity or higher in the area within the next 24 hours.
- A TC of TS intensity or higher is expected to move into the area within the next 24 hours.

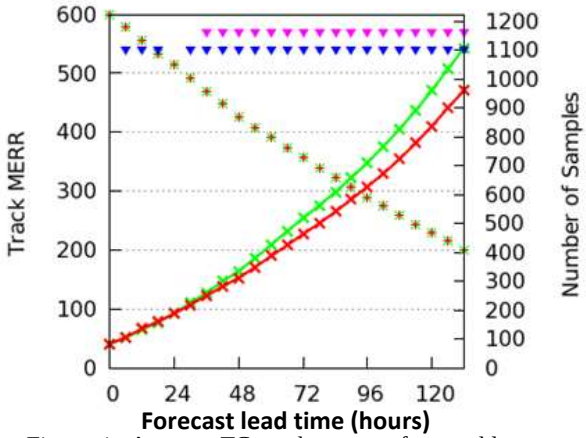

Figure 1: Average TC track errors of ensemble mean forecasts for the western North Pacific region as a function of forecast lead time up to 132 hours. The red and green lines represent positional errors for GEPS and TEPS, respectively. Red plus signs and green x-marks indicate the number of cases included in the statistics. The pink/blue triangles at the top indicate that the difference is statistically significant at the 0.05 level with/without consideration of temporal correlation between the cases.

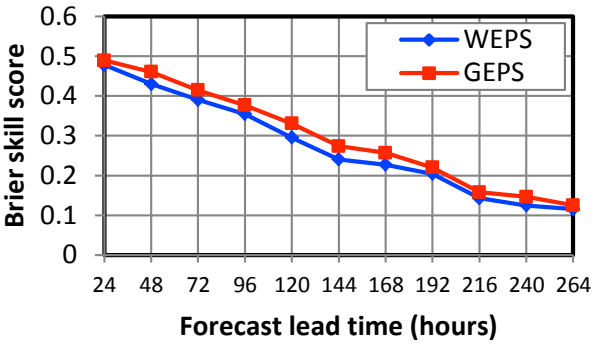

Figure 2: Brier skill scores for probabilistic forecasts of 24-hour cumulative precipitation exceeding 1 mm over Japan during winter 2015/16 as a function of forecast lead time up to 264 hours. The red and blue lines represent verification results for GEPS and WEPS, respectively.