Upgrade of JMA's Global Ensemble Prediction System

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1. Introduction

The Japan Meteorological Agency (JMA) upgraded its Global Ensemble Prediction System (Global EPS) on March 30 2021 to incorporate recent Global Spectral Model (GSM) developments, an increased ensemble size and improved initial perturbations.

2. Major Updates

(1) Incorporation of Recent GSM Developments

The forecast model was upgraded to a low-resolution version of the newly revised Global Spectral Model (GSM; Ujiie et al. 2021) with enhanced vertical resolution based on an increased number of model levels (100 to 128) with the top level maintained at 0.01 hPa.

(2) Increased Ensemble Size

The ensemble size was increased (Table 1) for forecasts with lead times up to 264 hours from 27 to 51. For others from 264 to 432 hours, and the ensemble size was increased from 13 to 51, and operation frequency was reduced to once a day (12 UTC) from twice a day (00 and 12 UTC), thereby almost doubling the daily total ensemble size. For forecasts at lead times from 432 to 816 hours, operation at the 00 UTC initial time was also terminated and the ensemble size was enhanced from 13 to 25.

(3) Improved Initial Perturbations

Singular vector (SV)-based initial perturbations were improved by implementing up to 50 modes as opposed to the 25 modes of the old system for each target area of the Northern Hemisphere (30 – 90°N) and the Southern Hemisphere (90 – 30°S). In combination with the adjusted amplitudes for initial perturbations, this change reduced overestimation of ensemble spread for 500-hPa geopotential height forecasts in mid-latitudes at lead times of around 24 to 72 hours as well as ensemble mean forecast errors. The total SV energy norm was also modified to terminate contribution from above 50 hPa to avoid SV computation with a large peak of energy in the upper stratosphere.

3. Verification Results

To verify system performance for medium-range forecasts with lead times of up to 11 days, retrospective forecast experiments covering periods of three months or more in summer 2019 and winter 2019/20 were conducted. The results showed improved CRPS performance for several elements, including 850 hPa temperature, 500 hPa geopotential height and 250 hPa winds, in mid-latitudes for both seasons. Figure 1 shows CRPSs for 500 hPa geopotential height in winter. Brier skill scores for precipitation forecasts in Japan were also improved (not shown).

To examine the effects of increased ensemble size up to 18 days, hindcast experiments for the period from 2014 to 2018 were also conducted using the Japanese 55-year Reanalysis (JRA-55; Kobayashi et al. 2015) dataset for atmospheric initial conditions. The ensemble sizes per initial day were 26 (CNTL) and 51 (TEST), and the same forecast model was used. The results showed that forecast skill for several elements such as temperature at 850 hPa, geopotential height at 500 hPa and mean sea level pressure were improved for all seasons. Figure 2 highlights improved Brier skill scores for geopotential height at 500 hPa in the Northern Hemisphere (20 – 90°N).

References

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Ujiie, M., M. Higuchi, T. Kadowaki, Y. Kuroki, K. Miyaoka, M. Oda, K. Ochi, R. Sekiguchi, H. Shimizu, S. Yokota, and H. Yonehara, 2021: Upgrade of JMA's Operational Global NWP system. *Res. Activ. Earth Sys. Modell.*, WGNE Rep.No. 51. WCRP Rep. No.4/2021. July 2021, WMO, Geneva. pp. 6-09-6-10.

Table 1: Ensemble sizes and initial times for the old and new Global EPS. NUM represents ensemble size per initial time, and INI represents initial times (UTC).

Lead time		Old	New
Initial time – 132 hours	NUM	27	51
	INI	06, 18	06, 18
Initial time – 264 hours	NUM	27	51
	INI	00, 12	00, 12
264 – 432 hours	NUM	13	51
	INI	00, 12	12
432 – 816 hours (Tuesday and Wednesday runs only)	NUM	13 11 for Tuesdays at 00 UTC	25
	INI	00, 12	12

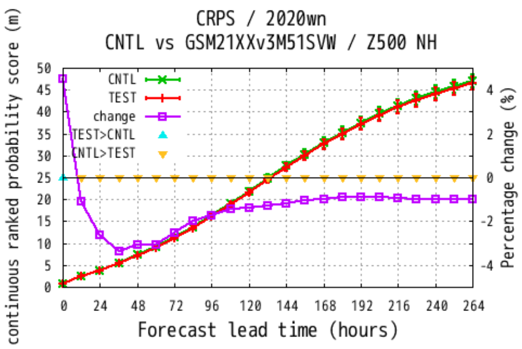

Figure 1: CRPSs of 500 hPa geopotential height forecasts against analysis for the Northern Hemisphere (20 – 90°N) during winter 2019/20 as a function of forecast lead times up to 264 hours. The red and green lines represent verification results for the new (TEST) and previous (CNTL) Global EPS (left axis; unit: m), and the purple line represents ratios of change in scores ([TEST − CNTL]/CNTL, right axis; unit: %). Error bars indicate two-sided 95% confidence levels, and triangles (TEST < CNTL or CNTL > TEST) indicate a statistically significant difference of 0.05.

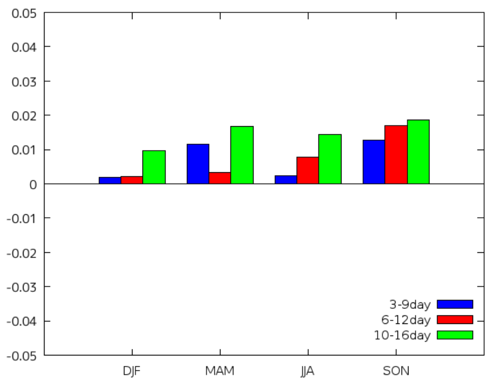

Figure 2: Brier skill score (BSS) differences for geopotential height at 500 hPa in the Northern Hemisphere (20 – 90°N) for each season. Positive values represent BSSs of the new Global EPS exceeding those of the previous Global EPS. BSSs are for the above-, near- and below-normal probability categories.