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 15 2022 to incorporate recent Global Spectral Model (GSM) developments, enhanced horizontal resolution of the model, improved sea surface temperature (SST) boundary conditions and updating of the initial perturbation amplitude.

2. Major Updates

(1) Incorporation of Recent GSM Developments

The forecast model was upgraded to a low-resolution version of the revised Global Spectral Model (GSM), including the following:

- Enhancement of effective resolution, including introduction of a quadratic grid, more subtle coefficients for numerical diffusion operators and more subtle filtering for model orography
- Optimization of parameters for subgrid orographic schemes (Matsukawa et al. 2022)
- Upgrade of diagnostics for effective size of cloud ice for radiation to Sun (2001)
- Improvement for treatment of lake surface temperature, including introduction of climatological data derived from satellite observation
- Upgrade of ozone climatological data based on reanalysis using JMA's latest chemical transport model (MRI-CCM2; Deushi and Shibata 2011) and satellite observation
- Improved calculation of solar zenith angle (Hogan and Hirahara 2016) and treatment of surface albedo (Hogan and Bozzo 2015) for shortwave radiation

(2) Enhanced Horizontal Resolution

As part of plans to improve JMA's GSM (which provides deterministic medium-range forecasts) Global EPS horizontal resolution was enhanced from around 40 to 27 km for forecasts with lead times up to 432 hours and from 55 to 40 km for 432 to 816 hours. The revised model has a quadratic grid with a triangular truncation wave number of 479 (TQ479) for earlier lead times and 319 (TQ319) for later ones. This supports resolution for coastlines, lakes and small islands, and orography is represented more sharply by the upgraded filtering. Benefits in areas including prediction of winter topographical precipitation in Japan have been noted.

(3) Improved SST Boundary Conditions

SST boundary conditions are given via an approach combining SSTs prescribed as persisting anomalies from climatological values and those operationally precomputed using JMA's atmosphere-ocean coupled Seasonal EPS model (JMA/MRI-CPS3; Kubo and Ochi 2022). The period for which SSTs in the tropics and subtropics are linearly relaxed from climatological extrapolation to the bias-corrected ensemble mean SST from the Seasonal EPS was also changed from 11 – 18 to 6 – 11 days.

(4) Update of Initial Perturbation Amplitude

The amplitude of singular vector (SV)-based initial perturbations targeted in the 30 – 90°N and 30 – 90°S areas was reduced by 8.7% to mitigate over-dispersiveness in 500 hPa geopotential height forecasts with lead times of up to four days.

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 winter 2019/20 and summer 2020 were conducted. The results showed improvements of ensemble mean forecasts for several elements, including 850 hPa temperature, 500 hPa geopotential height and 250 hPa winds globally for both seasons. Figure 1 shows RMSEs of ensemble mean forecasts for 500 hPa geopotential height and 850 hPa temperature for the Northern Hemisphere in winter. Brier skill scores for precipitation forecasts in Japan were also improved (not shown). Performance for forecasts beyond 11 days was also verified, as reported by Sekiguchi et al. (2022).

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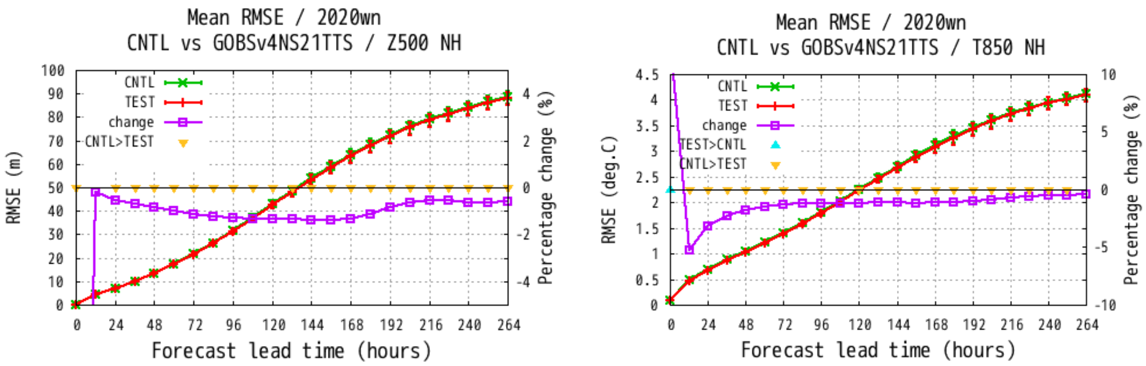

Figure 1: RMSEs of 500 hPa geopotential height [m] and 850 hPa temperature [°C] ensemble mean forecasts against analysis for the Northern Hemisphere (20 – 90°N) during winter 2019/20 as a function of forecast lead times up to 264 hours. The red and green lines represent verification results for the new (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.