Upgrade of JMA's Mesoscale Ensemble Prediction System

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1. Introduction

The Japan Meteorological Agency (JMA) began operating the regional ensemble prediction system (Mesoscale Ensemble Prediction System: MEPS; Ono et al. 2021) in June 2019 to provide uncertainty information for its regional Meso-Scale Model (MSM). In September 2020, initial and lateral boundary perturbations in the MEPS were optimized for more appropriate determination of forecast uncertainties around Japan. This report outlines the upgrades and related effects on probabilistic verification scores.

2. Initial Perturbation Upgrade

Mesoscale singular vectors (MSVs) are used for initial perturbations in the MEPS. As detailed in Ono et al. (2021), MSV calculation is based on the simplified version of the JMA non-hydrostatic model (Saito et al. 2006). In the previous system, MSVs tended to be localized over sea areas far south of Japan even when heavy rainfall events were observed around the country (Fig. 1 (a)).

For more efficient clarification of uncertainties related to extreme weather events over the Japan area, adaptive targeting in which a target MSV area is adaptively limited depending on weather conditions was introduced. Here, grid points with 925 hPa vorticity lower than a certain threshold were removed from the predetermined rectangular target area. Figure 1 shows horizontal distributions of total energy (TE) peaks for each MSV with and without adaptive targeting. Here, MSVs corresponding to the uncertainty of rainfall prediction around Japan were successfully calculated as a result of adaptive targeting excluding grid points within the

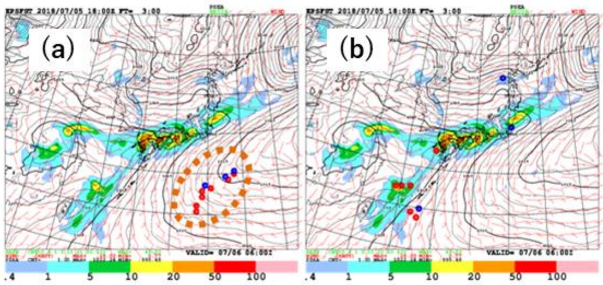

Figure 1. Peak distribution of TE norms for MSV40 (horizontal resolution: 40 km) for the (a) previous and (b) upgraded configurations. The red (blue) points indicate that the corresponding SVs have relatively high (low) growth rates. The initial time is 18 UTC on 5 July 2018.

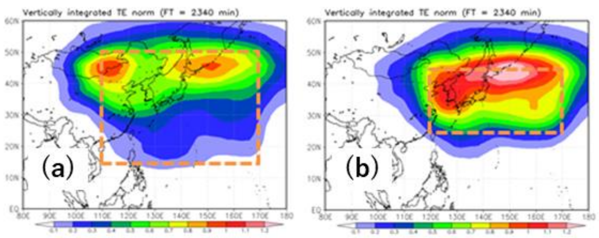

Figure 2. The target area (dashed lines) and normalized total energy distribution at the final time for GSV in the (a) previous and (b) upgraded configurations. Distribution is averaged from 18 June to 21 July 2018.

high-pressure system over sea areas south of Japan from the whole target area.

3. Upgrade of Lateral Boundary Perturbations

3.1 Global SV (GSV) Target Area

Another concern regarding MEPS perturbations was the tendency of the GSVs used as lateral boundary perturbations as well as initial perturbations to focus on uncertainties over desert areas at the northwest edge of the target area (Fig. 2 (a)). GSVs over such areas usually led to poor performance in identifying uncertainties around

Japan, especially with longer lead times. Hence, the GSV target area was reduced to enable focus on the area of interest. This modification contributed to more efficient determination of perturbations over Japan (Fig. 2 (b)).

3.2 Total Energy Norm for GSVs

Following Yamaguchi et al. (2009), the weight of the temperature term in the TE norm adopted in calculating GSVs was changed from 1 to 3 to make perturbations comparable in magnitude to typical analysis errors. This upgrade helps to reduce excessive GSV temperature perturbations and temporary falls in the ensemble spread of temperature at the beginning of simulation.

4. Upgrade Effects

To evaluate the effects of these modifications, experiments with the upgraded configurations (TEST) were compared with the original MEPS (CNTL) over 136 instances in summer 2018 and winter 2017/18. Figure 3 depicts the ensemble spread and the RMSEs of ensemble mean forecasts for 500 hPa geopotential height, with results indicating that the excessive ensemble spread seen in CNTL (particularly in winter) is improved in TEST. Figure 4 illustrates Brier skill scores for three-hour cumulative precipitation forecasts over Japan. Clear improvements in the first half of the forecast range in both summer and winter are seen in TEST, mainly due to the initial perturbation upgrades.

5. Summary

The upgrades to the initial and lateral boundary perturbations introduced into the MEPS in September 2020 enabled more appropriate evaluation of MSM prediction uncertainties around Japan, thereby improving probabilistic precipitation forecasts.

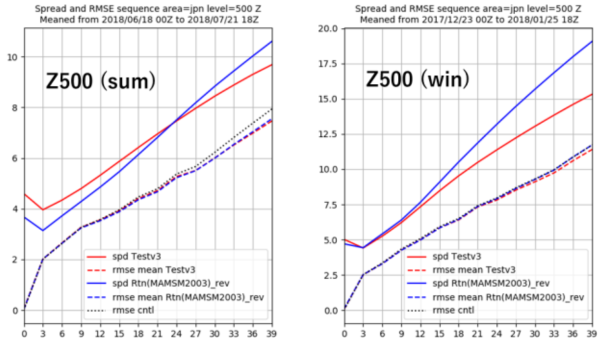

Figure 3. Time-series representations of ensemble spread (lines) and RMSEs of the ensemble mean (dashed lines) for 500 hPa geopotential height in CNTL (blue) and TEST (red).

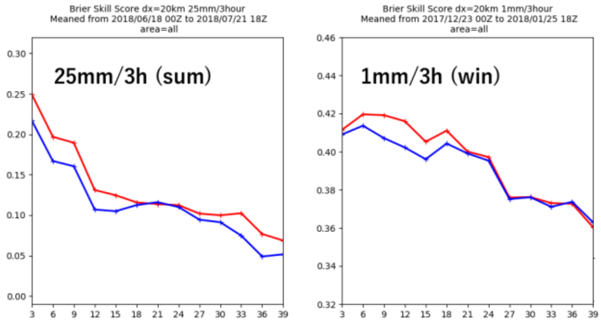

Figure 4. Time-series representations of Brier skill scores for three-hour cumulative precipitation probabilistic forecasts in CNTL (blue) and TEST (red).

Reference

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