Hindcast verification of JMA's GEPS for one-month prediction

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1. Introduction

The Japan Meteorological Agency (JMA) upgraded its Global Ensemble Prediction System (GEPS) in March 2022 to incorporate recent Global Spectral Model (GSM) developments, horizontal resolution enhancement, improvement of sea surface temperature (SST) boundary conditions and tuning of initial perturbation amplitude (Yamaguchi et al. 2022). This paper outlines GEPS performance in one-month prediction based on 30-year hindcast experiments.

2. Hindcast Experiments

Experiments were conducted for 1991 to 2020 for the new GEPS ("TEST" in Table 1) and the previous GEPS version ("CNTL1"), with the latest Japanese reanalysis (JRA-3Q; Kobayashi et al. 2021) for atmospheric initial conditions. Initial perturbations were created from a combination of initial singular vectors (SVs) and evolved SVs, differently from the operational system approach (Sekiguchi et al. 2018).

In previous hindcast experiments, the Japanese 55-year Reanalysis (JRA-55; Kobayashi et al. 2015) was used for atmospheric initial conditions. To evaluate the effects of atmospheric initial condition updating, additional experimentation was conducted with the previous version of GEPS using the JRA-55 as atmospheric initial conditions ("CNTL2" in Table 1).

3. Verification

The results indicated that forecasting with the new GEPS was superior to that of the previous GEPS for several elements and seasons, especially in the tropics. Figure 1 shows improved anomaly correlation coefficients (ACCs) for surface temperature in the Northern Hemisphere and velocity potential at 200 hPa in the tropics. The ACCs of the new GEPS were also compared with those of the previous GEPS using JRA-55 as atmospheric initial conditions. As per Figure 2, forecast skill was further improved due to the upgraded atmospheric initial conditions. The characteristics of forecast mean errors for the new GEPS were generally comparable to those of the previous GEPS (not shown).

Prediction skill for Madden-Julian oscillation (MJO) was evaluated using the method described by Matsueda and Takaya (2012). As per Figure 3, MJO forecast skill was improved in forecasts with lead times of 10 days or more. The biases of predicted MJO amplitude and the phase speed of the new GEPS were generally comparable to those of the previous GEPS (not shown).

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Table 1 Hindcast experiments

	TEST	CNTL1	CNTL2
Atmospheric forecast model	GSM2103 with improved physical processes (Yamaguchi et al. 2022)	GSM2103 (Ujiie et al. 2021)	
Resolution (model top)	TQ479L128 (0.01 hPa) up to 18 days TQ319L128 (0.01 hPa) afterward	TL479L128 (0.01 hPa) up to 18 days TL319L128 (0.01 hPa) afterward	
Initial conditions (atmosphere)	JRA-3Q (Kobayashi et al. 2021)		JRA-55 (Kobayashi et al. 2015)
Initial conditions (land)	Offline runs of land-surface model in GEPS and atmospheric forcing from JRA-3Q		Offline runs of land-surface model in GEPS and atmospheric forcing from JRA-55
Sea surface temperature (SST)	Two-tiered SST approach (Takakura and Komori 2020) with improvement	Two-tiered SST approach	
Initial perturbation	Singular vector (SV) method (initial and evolved SVs)		
Period (initial date)	1991 – 2020 (15th and end of calendar month)		
Ensemble size	13		
Verification data	JRA-3Q, ERA5 (Hersbach et al. 2020)		

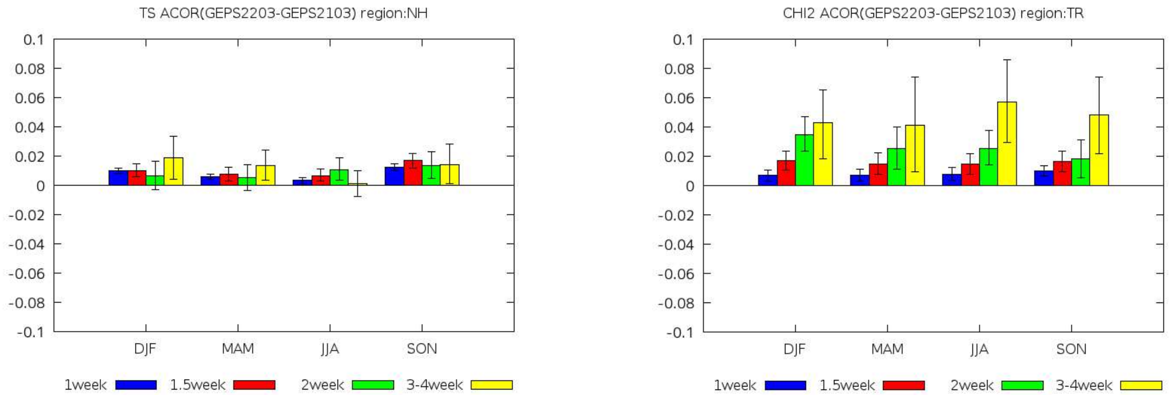

Figure 1 Anomaly correlation coefficient (ACC) differences of TEST from CNTL1 for (left) surface temperature in the Northern Hemisphere (20－90°N) and (right) velocity potential at 200 hPa in the Tropics (20°S－20°N) for all seasons. Positive values represent ACCs of TEST exceeding those of CNTL1. Error bars indicate two-sided 95% confidence levels. ACCs are calculated against JRA-3Q.

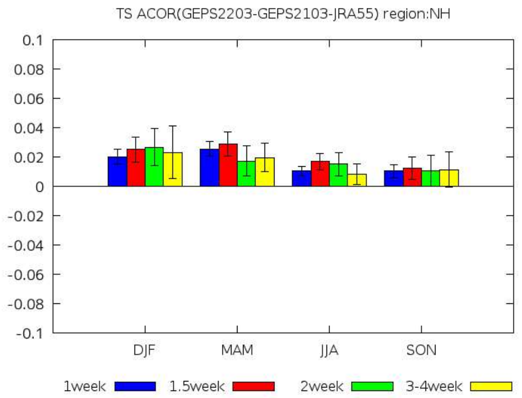

Figure 2 ACC differences of TEST from CNTL2 for surface temperature in the Northern Hemisphere for all seasons
Positive values represent ACCs of TEST exceeding those of CNTL2. ACCs are calculated against ERA5.

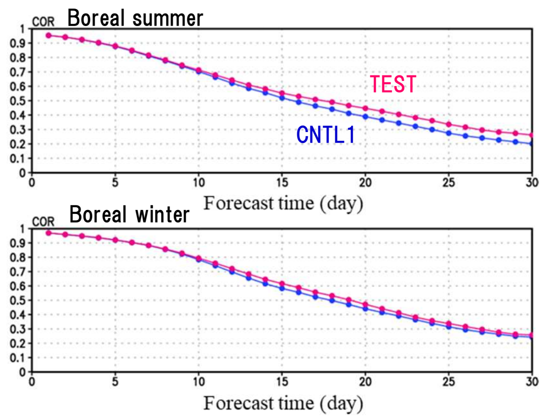

Figure 3 Correlation coefficients of the MJO index for (top) boreal summer and (bottom) boreal winter
Red and blue lines represent results for TEST and CNTL1, respectively.