Verification of JMA/MRI-CPS3 and JMA Global Ensemble Prediction System in the sub-seasonal forecast

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1. Introduction

The Japan Meteorological Agency (JMA) operates the Global Ensemble Prediction System (GEPS; Yamaguchi et al. 2021) for the sub-seasonal forecast. In February 2022, JMA upgraded its seasonal forecast system (JMA/Meteorological Research Institute - Coupled Prediction System version 3 (JMA/MRI-CPS3, or “CPS3” for short)). CPS3 has better skill in sub-seasonal and seasonal prediction than the previous CPS2 system, and entered operation on a trial basis in October 2021. This report outlines the operational sub-seasonal prediction skill of GEPS and CPS3 during and after the pilot operation period.

2. GEPS and CPS3 configuration

Table 1 shows the specifications of GEPS and CPS3. The initial atmospheric perturbation in CPS3 uses the Breeding of Growth Modes (BGMs), while that in GEPS uses a combination of Singular Vectors (SVs) and Local Ensemble Transform Kalman Filter (LETKF). Sea surface temperature (SST) in CPS3 is predicted using a related coupled ocean model, while that in GEPS is prescribed using the persisting anomaly with daily climatological SSTs up to 11 days of forecast time, then relaxed to the ensemble-mean SST operationally predicted by CPS2 in the tropics and sub-tropics. CPS3 has 5 members per day, while GEPS has 25. Verification involves the use of a common subset of 5 members and 2 initial dates with 24-hour lagged average forecasts to avoid the effects of different operational ensemble configurations. Forecasting starts at 12 UTC for GEPS and 00 UTC for CPS3 (12 hours behind) due to the operational schedule for ocean data assimilation.

3. Verification of operational sub-seasonal prediction

Figures 1 and 2 show time-series of anomaly correlation coefficients (ACCs) verified against the Japanese Reanalysis for Three Quarters of a Century (JRA-3Q; Kobayashi et al., 2021) in the Northern Hemisphere (NH) and Tropics (TR), respectively. The ACC of CPS3 in the NH tends to be lower than that of GEPS until a 2-week lead time, while that of CPS3 in the TR tends to be neutral to higher from a 1-week lead time. This implies the importance of tropical atmospheric-ocean interaction in sub-seasonal prediction.

Figure 3 shows the ratio of the spread to root mean square error (RMSE) in the NH. The spread of CPS3 with a 1-week lead time tends to be excessive compared to RMSE. In CPS3, the initial perturbation in the BGM is increased from CPS2 so that a sufficiently large spread can be obtained for seasonal forecasts. The excessive spread of CPS3 at the beginning of the forecast may be suboptimal for sub-seasonal application.

4. Conclusion

Overall, prediction skill tends to be higher for GEPS in the first and second weeks of prediction, and neutral to higher for CPS3 in the third and fourth weeks. These verification results are also consistent with re-forecast verification for the last 30 years (not shown). Based on these encouraging results, JMA continues to investigate the feasibility of using CPS3 in operational sub-seasonal forecasting.

References

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Table 1: GEPS and CPS3 specifications

	GEPS (as of March 2021)	CPS3
Atmospheric general circulation model	**Model:** JMA-GSM2103 (Ujiie et al. 2021) **Horizontal resolution:** Up to 18 days, TL479 (approx. 40 km) and after 18 days, TL319 (approx. 55 km) **Vertical levels:** 128 up to 0.01 hPa	**Model:** Improved version of the physical process of JMA-GSM2003 (Yonehara et al. 2020) for seasonal forecasting **Horizontal resolution:** TL319 (approx. 55 km) **Vertical levels:** 100 up to 0.01 hPa
Oceanic general circulation model	N/A	**Model:** MRI.COM (Tsujino et al. 2017) **Horizonal resolution:** 0.25° x 0.25° **Vertical levels:** 60
Initial conditions	**Atmosphere:** JMA Global Analysis **Land:** JMA land surface analysis	**Atmosphere:** JMA Global Analysis **Ocean:** MOVE/MRI.COM-G3 (Low-res. 4DVAR + High res. downscaling) **Land:** Offline model runs (forced by JRA-3Q and JMA Global Analysis)
Boundary conditions	**SST:** Prescribed SSTs using persisting anomaly with daily climatological SSTs up to 11-day forecasting. Thereafter, SST relaxation for the tropics and sub-tropics to the ensemble-mean SST operationally predicted by CPS2 **Sea ice:** Prescribed sea ice concentration using persisting anomaly with daily climatological sea ice concentration	**SST:** Predicted by ocean model **Sea ice:** Interactive sea ice model
Ensemble perturbation method	Combination of SV, LETKF, stochastic physics scheme and SST perturbations	Combination of BGM, stochastic physics scheme (atmosphere) and ocean analysis perturbation (ocean)

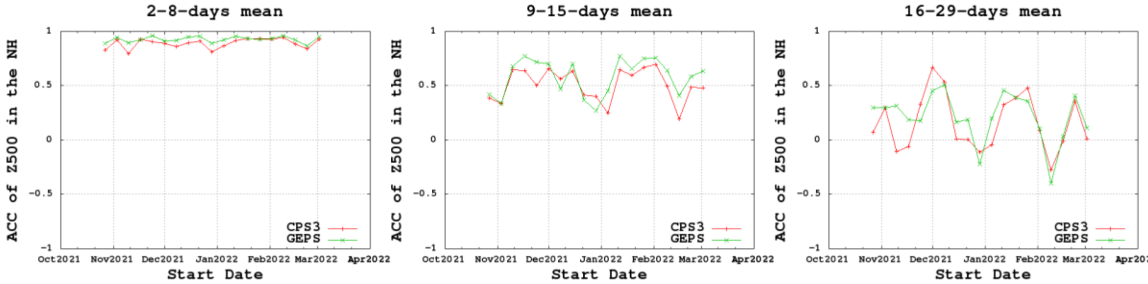

Figure 1. Time-series of ACC for 500 hPa geopotential height in the NH (20 – 90°N). The left, middle and right panels show predictions for week 1 (2 – 8 days), week 2 (9 – 15 days) and week 3 – 4 (16 – 29-days) means, respectively. The horizontal axis shows the start date of the forecasts. Green: GEPS; red: CPS3.

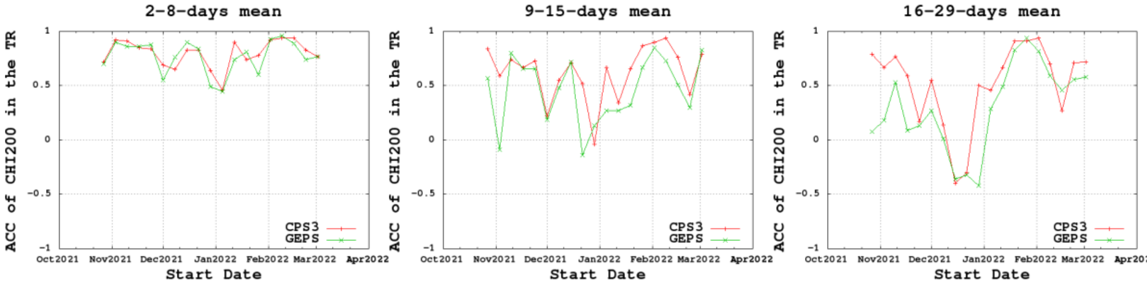

Figure 2. Time-series of ACC for 200 hPa velocity potential in the TR (20°S – 20°N). Details as per Figure 1.

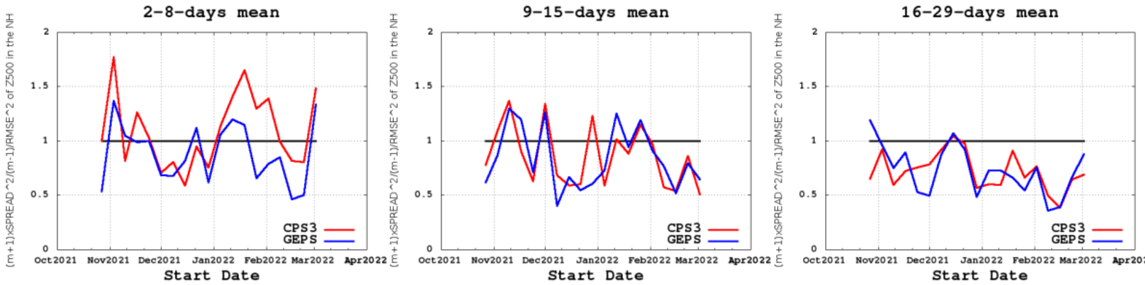

Figure 3. Time-series of the ratio of spread to RMSE in 500 hPa geopotential height for the NH. Blue: GEPS; red: CPS3. Details as per Figure 1.