Hindcast verification of JMA's GEPS for one-month prediction with a globally expanded two-tiered sea surface temperature approach

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1. Introduction

The Japan Meteorological Agency (JMA) upgraded its Global Ensemble Prediction System (GEPS) on March 14 2023 to incorporate recent Global Spectral Model developments and revised sea surface temperature (SST) boundary conditions (Ota et al. 2023). For the new SST boundary conditions, a two-tiered SST approach (Takakura and Komori 2020) is applied to the whole globe instead of limited areas centered on the tropics and sub-tropics. This paper outlines the results of studies focused on the new SST boundary conditions and the performance of the upgraded GEPS in one-month prediction based on 30-year hindcast experiments.

2. Global Application of the Two-tiered Sea Surface Temperature Approach

In the two-tiered SST approach adopted for the GEPS, SST boundary conditions are prescribed with anomaly-fixed SSTs based on a daily SST analysis (MGDSST; JMA, 2023) at lead times of up to 144 hours, and here are replaced with SSTs derived via bias-corrected ensemble mean forecasts from JMA's Seasonal EPS model (JMA/MRI-CPS3; Hirahara et al. 2023) for lead times of 264 hours or more (with lead times of 144 – 264 hours as relaxation periods). In the previous GEPS, the two-tiered SST approach was applied only to the tropics and sub-tropics because CPS3 SST forecasts exhibit greater levels of error than anomaly-fixed SSTs in the mid-latitudes.

In this study, SSTs were separated into two spatial scales via application of a 1-1-1 filter (a three-point running average) on a 0.25-degree latitude-longitude grid with 30 iterations. The filtered-out spatial variation is referred to as sub-synoptic, and the residual application as synoptic. Sub-synoptic variation included ocean mesoscale eddies in the mid-latitudes. Figure 1 shows that the CPS3-derived SST outperformed the anomaly-fixed SST with respect to synoptic variation but insufficiently represented sub-synoptic variation in the mid-latitudes, partly because the CPS3 ocean model (0.25-degree horizontal resolution) was unable to fully resolve mesoscale eddies. As a result, CPS3-derived SSTs exhibited greater errors than anomaly-fixed SSTs in the mid-latitudes (not shown).

Despite this apparent defect in CPS3-derived SSTs, application of the two-tiered SST approach to the whole globe improved GEPS forecast performance in the mid-latitudes, including improved temperature data for the lower troposphere (especially surface temperature; not shown). Sensitivity experiments clarified that GEPS performance was far more sensitive to synoptic SST variations than to sub-synoptic variations, and the better synoptic variation in the mid-latitudes represented in CPS3-derived SSTs therefore benefited GEPS forecasting skill.

3. Verification Results for the Upgraded GEPS

To verify system performance for one-month forecasts, hindcasts were conducted for 1991 to 2020 for the new GEPS (TEST) and the previous GEPS (CNTL), with use of the latest Japanese reanalysis (JRA-3Q; Kobayashi et al. 2021) for atmospheric initial conditions. The initial dates were the 15th and the end of each month, and the ensemble size was 13 members. Initial perturbations were created from a combination of initial singular vectors (SVs) and evolved SVs, in contrast to the operational system approach (Sekiguchi et al. 2018). Figure 2 shows that the new GEPS was superior to the previous GEPS for surface temperature over oceans in the mid-latitudes, which was consistent with the effects of the new two-tiered SST approach described above.

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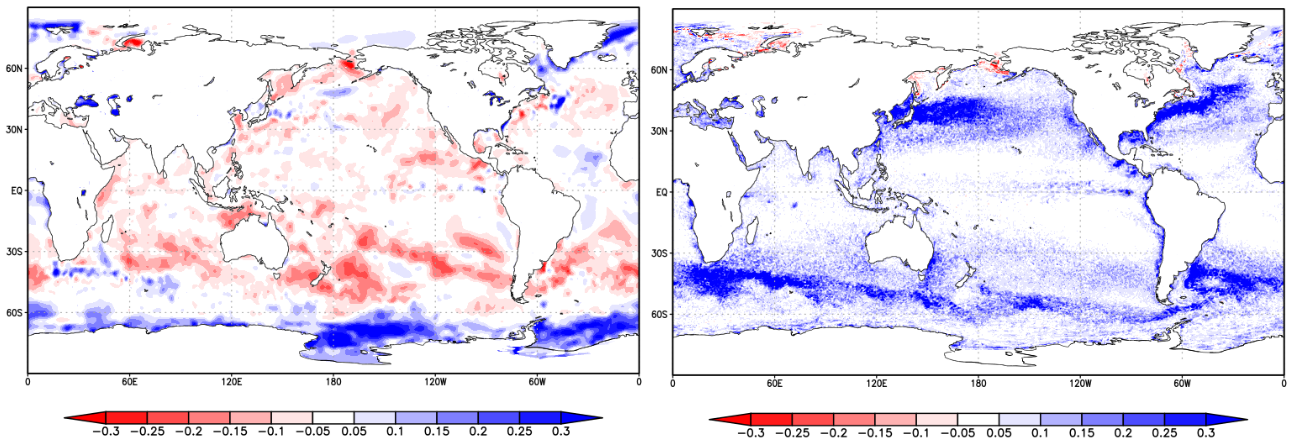

Figure 1: Differences in scale-separated RMSEs between CPS3-derived SSTs and anomaly-fixed SSTs given for forecasts with a 10-day lead time verified against MGDSST. Left: synoptic scale; right: sub-synoptic scale. Negative values indicate smaller CPS3-derived SST errors. Verification period: DJF 2019/2020.

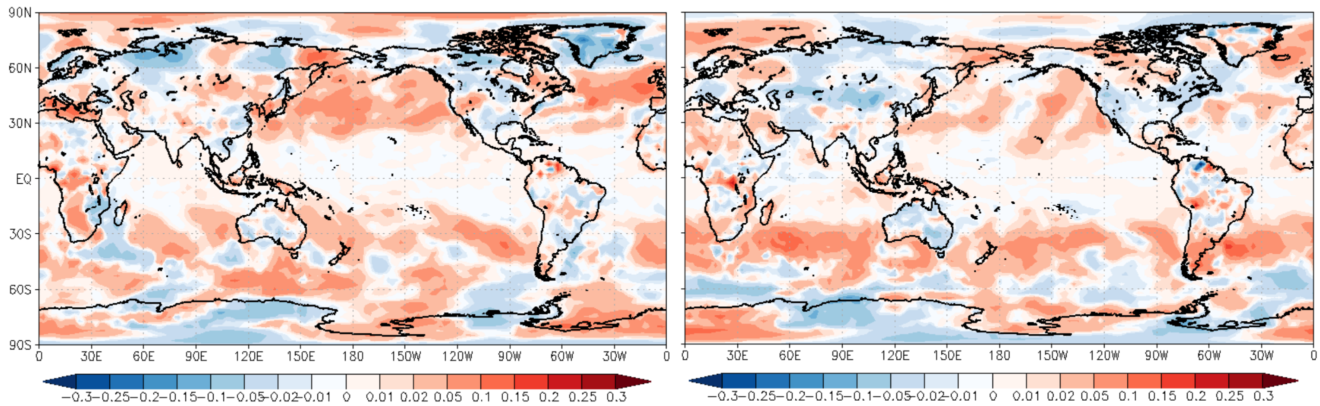

Figure 2: Difference between TEST and CNTL with respect to ensemble-mean anomaly correlation coefficients averaged for initial dates in JJA (left) and DJF (right) over a lead time of the second week (day-10 to 16) for surface temperature verified against JRA-3Q. Positive values: better TEST forecast skill.