Two-tiered sea surface temperature approach implemented to JMA's Global Ensemble Prediction System

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1. Introduction

The Japan Meteorological Agency (JMA) operates the Global Ensemble Prediction System (GEPS) to support issuance of operational typhoon information as well as one-week, two-week and one-month forecasts. Sea surface temperature (SST) is recognized as an important variable in forecasting on subseasonal to seasonal scales, and the SST data used in this system are prescribed as persisting anomalies from the climatological SST throughout the forecast period. The SST configuration can potentially cause large errors in forecasts over weeks 3 and 4. To tackle this issue with limited computational cost, a two-tiered SST approach was applied for the GEPS lower-boundary condition to force the atmospheric model with more realistic SST data. Specifically, the lower boundary condition of the atmospheric model in the tropics and subtropics was relaxed from anomaly-fixed SST to operationally precomputed SST by the seasonal EPS, and the approach was evaluated via 30-year reforecast experiments.

2. Experimental design

The specifications of the reforecast experiments were as per Sekiguchi et al. (2018), except the ensemble size was 13 and the initial dates were only for the end of the month from 1981 to 2010. In the CNTL experiment, the model was forced using anomaly-fixed SST as a lower boundary condition. A two-tiered SST approach (e.g., Zhu et al. 2018) was applied in the TEST experiment, and the lower boundary condition was relaxed from anomaly-fixed SST to the ensemble mean SST of JMA's seasonal EPS (JMA/MRI-CPS2: JMA/Meteorological Research Institute-Coupled Prediction System version 2; Takaya et al. 2018) reforecast data. The SSTs were as per CNTL for the first 11 days, and the relaxation was introduced linearly from day 12 to day 18 exclusively to the tropics and subtropics, since comparison suggests that higher-latitude SSTs are still better prescribed using fixed anomalies.

3. Results

Figure 1 shows the anomaly correlation coefficient (ACC) averaged for all initial dates over weeks 3 and 4. The ACC of surface temperature showed particular improvement for the area over the Indian Ocean and the Asian monsoon region. Since SSTs in these regions vary on a subseasonal time scale, the accuracy of anomaly-fixed SST data exhibits a significant decreasing tendency. Improvement is also observed for the ACC of the 200-hPa stream function and velocity potential over the Indian Ocean and the Asian monsoon region. Although the two-tiered SST approach was applied only to the tropics and the subtropics, these positive effects in the upper level extend to the mid-latitudes. Madden-Julian Oscillation (MJO) forecast skill was also improved in the latter period of the forecast. Specifically, the correlation of the MJO index (Matsueda and Endo, 2011) was improved by 0.1 over weeks 3 and 4 (Figure 2) due to reduced phase error. However, amplitude error increased slightly because forecast activity tended to degrade in relation to the use of relatively coarse SSTs from the seasonal EPS (not shown).

The relationship between SST and precipitation was closer to that of analysis with application of the two-tiered SST approach. The correlation in analysis shows negative values for the area over the Western Pacific region, but was strongly positive in the CNTL experiment due to a lack of cloud-shortwave radiation-SST feedback (Figure 3). Overly enhanced convective activity is in fact a known issue in the GEPS. The correlation in the TEST experiment was positive but better than that of the CNTL experiment because the precomputed SST indirectly incorporates negative feedback effects.

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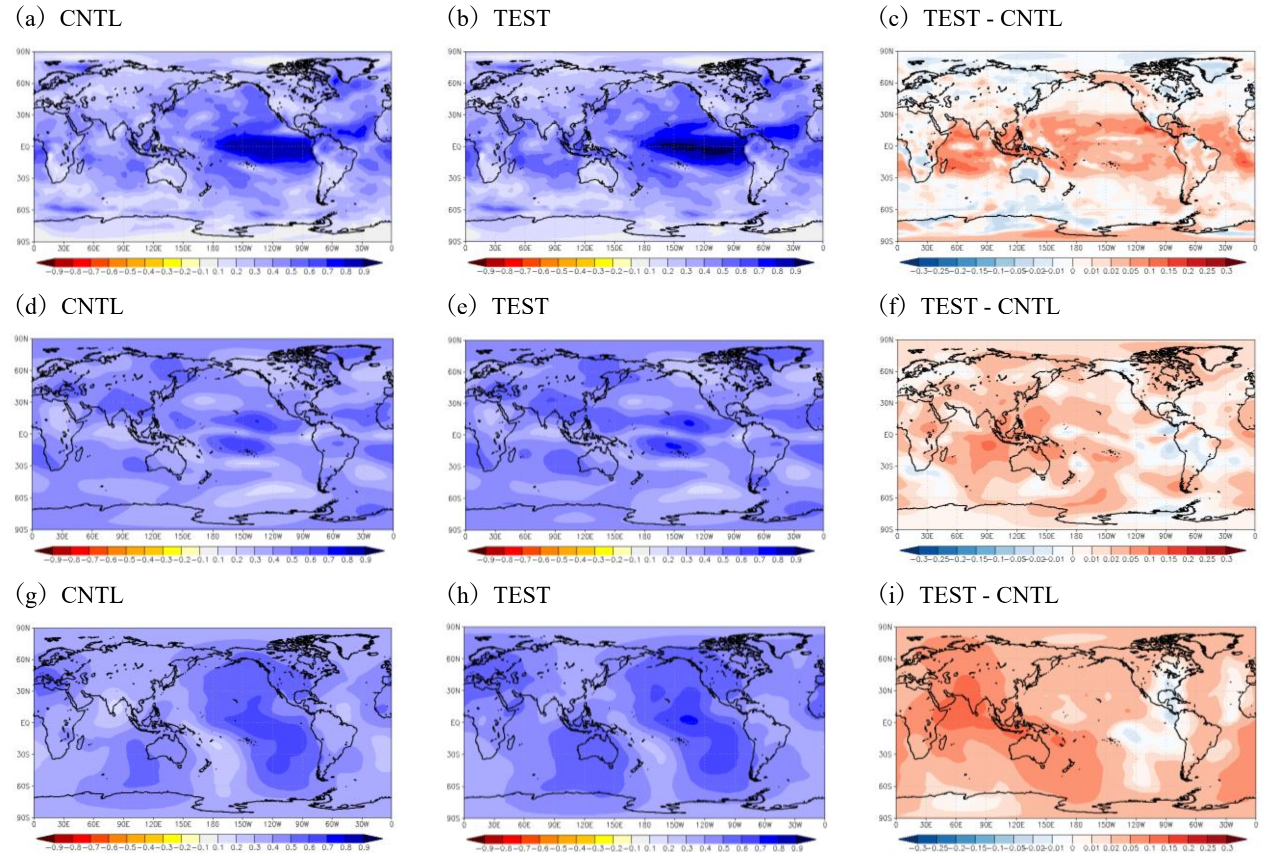

Fig. 1 Ensemble-mean anomaly correlation coefficient averaged for all initial dates over weeks 3 and 4 for (a) – (c) surface temperature, (d) – (f) 200-hPa stream function, and (g) – (i) 200-hPa velocity potential. Left: CNTL experiment; center: TEST experiment; right: difference between TEST and CNTL.

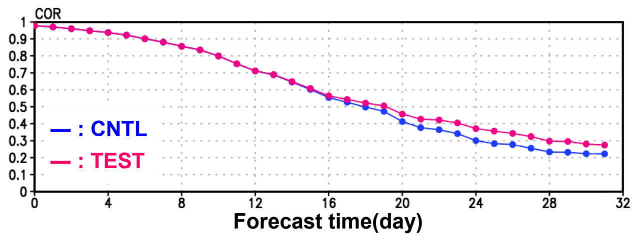

Fig. 2 Correlation of MJO index (Matsueda and Endo, 2011) for the case that the amplitude is above 1 at an initial date in winter (from November to April). Red line; TEST experiment; blue line: CNTL experiment.

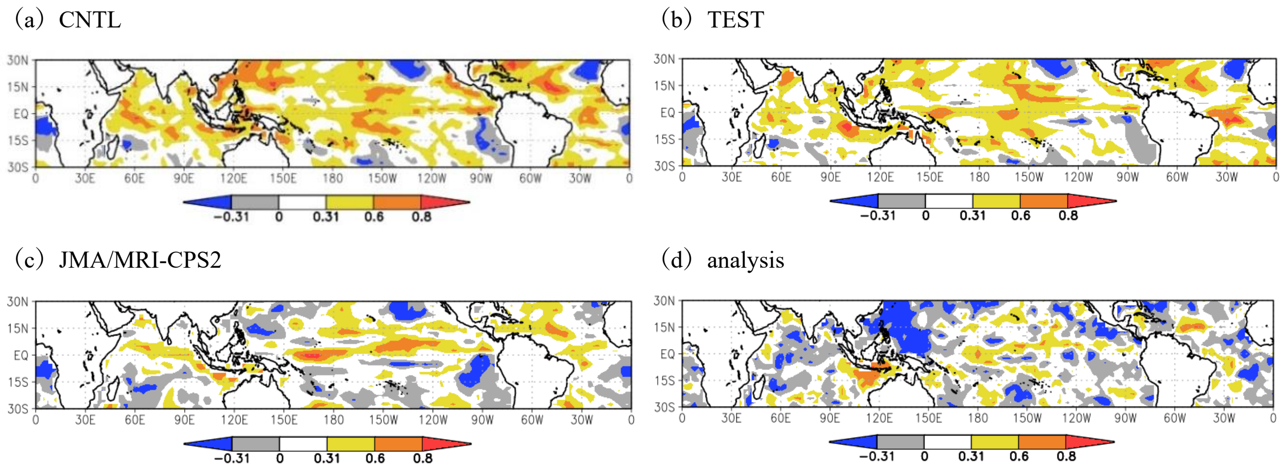

Fig.3 Correlation of SST and precipitation over week 4 on 30th June. The correlation of (d) is calculated under the Global Precipitation Climatology Project (GPCP: Huffman et al., 2001) and MGDSST (Kurihara et al., 2006)