

Impact of applying two-tiered sea surface temperature approach to Global Ensemble Prediction System



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1. Introduction

- ✓ The Japan Meteorological Agency (JMA) operates the Global Ensemble Prediction System (GEPS) to support medium- and extended-range forecasts, including operational One-month Forecasts.
- ✓ In the GEPS of JMA, the SST is prescribed as persisting anomaly from the climatological SST throughout the forecast period.
 - This SST configuration can potentially make a large error for forecasts over sub-seasonal range.
- To tackle this issue with limited computational cost, I applied the two-tiered SST approach to the lower boundary condition of GEPS in order to force the model with more realistic SST.

2. Method

Two-tiered SST approach

- ✓ The lower boundary condition of atmospheric model is relaxed from anomaly-fixed SST to operationally precomputed ensemble-mean SST by coupled Seasonal EPS.
- ✓ Required computational cost is much smaller than a fully coupled system.

Evaluation of SST data

Comparison of anomaly-fixed SST and the SST of Seasonal EPS

- **Data**
 - **Analysis data** : MGDSSST (Kurihara et al., 2006) [$0.25^\circ \times 0.25^\circ$]
 - **Anomaly-fixed SST** : Persisted SST anomaly using MGDSSST
 - **SST of Seasonal EPS** : Reforecast data operational of JMA/Meteorological Research Institute-Coupled Prediction System version 2 (JMA/MRI-CPS2)

Table.1: Configuration of reforecast in JMA/MRI-CPS2

Atmospheric model	GSM1011C (TL159L60 (approx. 110 km))
Oceanic model	MRI.COM v3.2 (1.0°(lon) x 0.3-0.5°(lat) L52+BBL)
Ensemble size	5
Initial dates	Twice a month from 1981 to 2010

Area mean score

- Bias correction was applied to the data of JMA/MRI-CPS2.
- Each score was calculated on the grid of TL319.

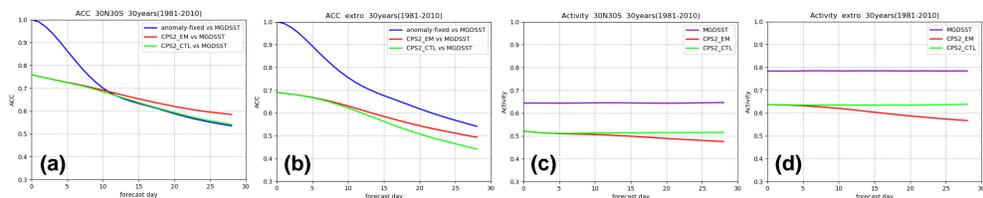


Fig.1: Area mean of (a), (b) Anomaly Correlation Coefficient (ACC) of SST and (c), (d) activity of SST. (a) and (c) are average for 30°S-30°N. (b) and (d) are average for 30°S(N)-60°S(N). Blue line is anomaly-fixed SST, red (green) line is ensemble-mean (control member) of JMA/MRI-CPS2 and purple line is MGDSSST.

- ✓ The ACC of ensemble-mean JMA/MRI-CPS2 was better than anomaly-fixed SST after D+10 in the tropics.
- ✓ The activity of the JMA/MRI-CPS2 was smaller than that of MGDSSST.
 - The reason was Seasonal EPS has lower resolution.

3. Experimental design and data

- ✓ Two reforecast-type experiments of the GEPS were executed.

Table.2: Configurations of each reforecast-type experiment in the GEPS.

	CNTL	Two-tiered SST
Model	GSM1603E	
Resolution	TL479L100 (approx. 40 km) up to 18 days, TL319L100 (approx. 55 km) afterwards	
Ensemble size	13	
Initial dates	Every end of month from 1981 to 2010	
Initial perturbation	SV	
Boundary perturbations	Perturbations on SST	
Model ensemble	Stochastically Perturbed Physics Tendency (SPPT)	
Initial data	Japanese 55-year Reanalysis (JRA-55 : Kobayashi et al., 2015)	
Lower boundary	Anomaly-fixed MGDSSST	Two-tiered SST (the specification is in Table.3)

Table.3: Specification of the two-tiered SST.

Data	Relaxation from anomaly-fixed MGDSSST to the SST of JMA/MRI-CPS2
Application area	The tropics and the subtropics (Fig.2a)
Relaxation time	From 12 day to 18 day (Fig.2b)

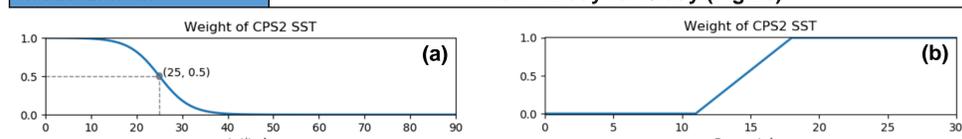


Fig.2: Weight of SST predicted by JMA/MRI-CPS2 (a) in latitude and (b) in forecast time for the two-tiered SST experiment.

- Analysis data : JRA-55
- Precipitation data : Global Precipitation Climatology Project (GPCP : Huffman et al., 2001)

Summary

Reforecast-type experiment of the GEPS with the two-tiered SST approach has been executed.

- The ACC of upper and lower atmosphere in the tropics was improved.
- The forecast activity of each element was degraded, presumably due to precomputed ensemble-mean SST by lower-resolution coupled Seasonal EPS.
- The forecast skill of MJO was improved in the phase error.
- The correlation of SST and precipitation was closer to that of analysis.
- **Future work** : Further feasibility study towards fully-coupled GEPS.

4. Result

Score of upper and lower atmosphere

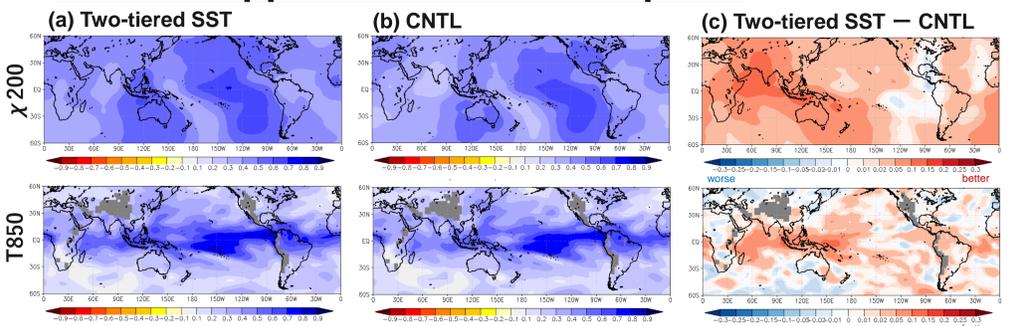


Fig.3: Ensemble-mean ACC of (Upper panels) the 200-hPa velocity potential and (Lower panels) the 850-hPa temperature averaged for all initial dates over week 3 and 4: (a) two-tiered SST, (b) CNTL and (c) difference between two-tiered SST and CNTL.

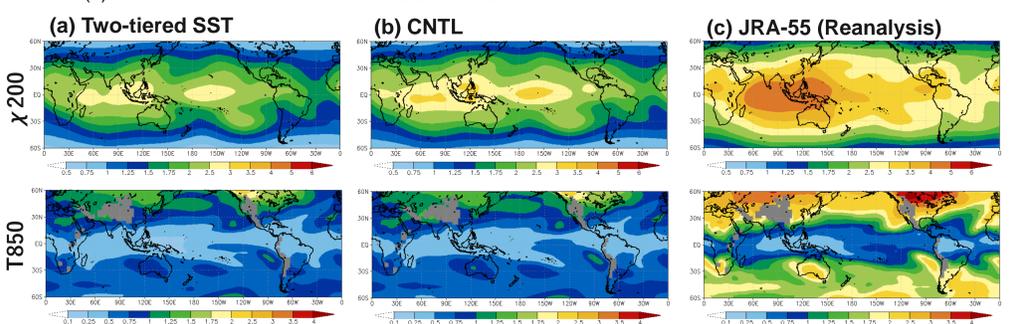


Fig.4: Activity of (Upper panels) the 200-hPa velocity potential and (Lower panels) the 850-hPa temperature averaged for all initial dates over week 3 and 4: (a) two-tiered SST, (b) CNTL, (c) JRA-55.

- ✓ The ACC over week 3 and 4 was improved in particular over the Indian Ocean and the Asian Monsoon region.
- ✓ The forecast activity of each element was degraded, presumably due to precomputed ensemble-mean SST by lower-resolution coupled Seasonal EPS.

MJO (Madden-Julian Oscillation) forecast

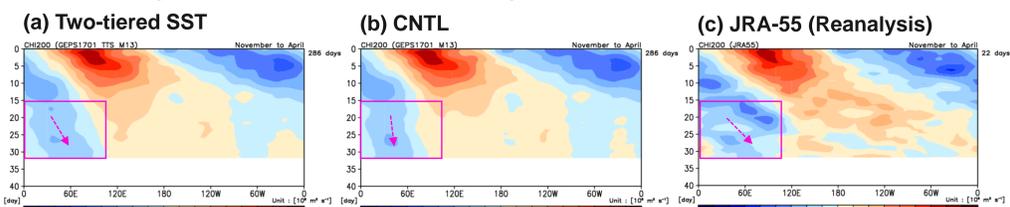


Fig.5: Longitude-time cross-sectional composite map of the 200-hPa velocity potential anomaly averaged in 15°S-15°N for the case that the phase of MJO is 7 and the amplitude is above 1 at initial date in winter (from November to April): (a) two-tiered SST, (b) CNTL and (c) JRA-55

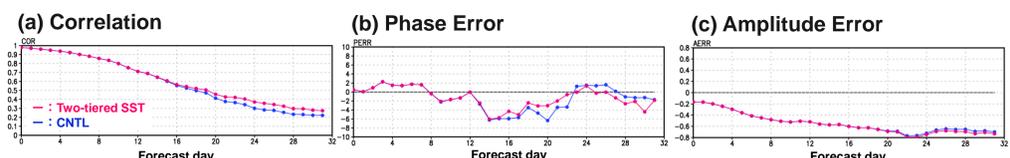


Fig.6 : (a) Correlation, (b) Phase Error and (c) Amplitude Error of MJO index (Matsueda and Endo, 2011) for the case that the amplitude is above 1 at initial date in winter (from November to April). Red line is two-tiered SST and blue line is CNTL.

- ✓ The eastward propagation of MJO became better, resulting in smaller phase error.
- ✓ Correlation skill was improved, but there is still room for improvement for the too small amplitude.

Correlation of SST and precipitation

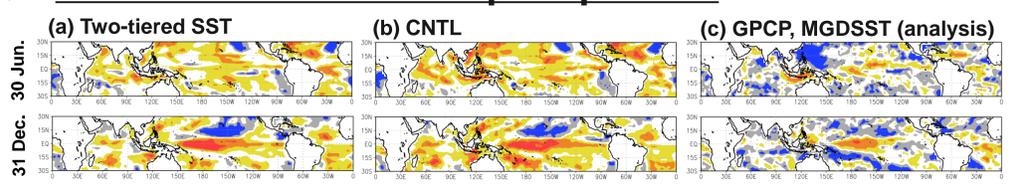


Fig.7: Correlation of SST and precipitation over week 3 and 4 on (Upper panels) 30 June (Lower panels) 31 December: (a) two-tiered SST, (b) CNTL and (c) GPCP and MGDSSST.

- ✓ The correlation of SST and precipitation was closer to that of analysis.
 - Two-tiered SST approach improved the relationship between SST and precipitation towards fully-coupled system.