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** : MGDSST (Kurita et al., 2006) [0.25° x 0.25°]
    - **Anomaly-fixed SST** : Persisted SST anomaly using MGDSST
    - **SST of Seasonal EPS** : Reforecast data of JMA/Meteorological Research Institute-Coupled Prediction System version 2 (JMA/MRI-CPS2)
  - **Table.1**: Configuration of reforecast in JMA/MRI-CPS2

<table>
<thead>
<tr>
<th>Atmospheric model</th>
<th>Oceanic model</th>
<th>Ensemble size</th>
<th>Initial dates</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSM1011C (TL195L60 approx. 110 km)</td>
<td>MRLCOM v3.2 (1.0°lon x 0.3-0.5°lat, S2-BBL)</td>
<td>5</td>
<td>Twice a month from 1981 to 2010</td>
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</tbody>
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**Area mean score**
- **Bias correction** was applied to the data of JMA/MRI-CPS2.
- **Each score** was calculated on the grid of TL319.

3. Experimental design and data

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

<table>
<thead>
<tr>
<th>Table.2: Configurations of each reforecast type experiment in the GEPS.</th>
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<tbody>
<tr>
<td><strong>Model</strong></td>
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<tr>
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</tr>
<tr>
<td>CNTL</td>
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<tr>
<td>Two-tiered SST</td>
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**Table.3**: Specification of the two-tiered SST
- **Initial dates**
  - Relaxation from anomaly-fixed MGDSST 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 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)

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, (c) CPS2, and (d) 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) CPS2, and (d) difference between two-tiered SST and CNTL.
- 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 15ºS-15ºN 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.
- 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.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 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.

**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.