Forecast Skill of MJO with the JMA's One-month Ensemble Prediction System

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Introduction

The Madden-Julian oscillation (MJO) is a dominant mode of intraseasonal variability in the tropics and influences weather and climate over not only tropics but also extratropics. The MJO has been thought to have a potential predictability up to one month and to be a forecast signal for this time scale. This article shows forecast skill and reproducibility of MJO in the hindcast of the JMA's one-month Ensemble Prediction System (EPS).

Data

The forecast data is a set of hindcasts with JMA's operational one-month EPS. The five-member hindcasts were carried out with the atmospheric general circulation model with the resolution of T_L159L60. Initial dates are 10th, 20th and the end of month during 1979 to 2001 (23-year). Verification data is 200-hPa (U200) and 850-hPa wind (U850) from JRA-25/JCDAS (Onogi et al. 2007), outgoing longwave radiation (OLR) provided by NOAA (Liebmann and Smith 1996) and precipitation from GPCP analysis (Huffman et al. 2001). A diagnostic package used in this verification was developed and offered by the U.S. Climate Variability and Predictability (CLIVAR) MJO Working Group (Gottschalck et al. 2010).

Verification method

A MJO index is computed following Wheeler and Hendon (2004). A combined Empirical Orthogonal Function (EOF) analysis is applied for daily fields averaged in the tropics (15S-15N) OLR and zonal wind (U850 and U200) for the period of 1979 to 2001. Before the EOF analysis, the long-term (23-year) mean and the most recent 120-day mean are removed, and each field is normalized by the square-root of its global mean variance. MJO phases (1-8) are defined as the eight sections in a PC1-PC2 phase space.
The MJO amplitude is defined as $\sqrt{(PC1)^2+(PC2)^2}$.

Verification scores are defined as follows:

$$RMSE(\tau)=\sqrt{\frac{1}{N}\sum_{t=1}^{N}\left(\left(f_1(t,\tau)-a_1(t)\right)^2+\left(f_2(t,\tau)-a_2(t)\right)^2\right)}$$

$$COR(\tau)=\frac{\sum_{t=1}^{N}\left(a_1(t)f_1(t,\tau)+a_2(t)f_2(t,\tau)\right)}{\sqrt{\sum_{t=1}^{N}\left(a_1(t)^2+a_2(t)^2\right)}\sqrt{\sum_{t=1}^{N}\left(f_1(t,\tau)^2+f_2(t,\tau)^2\right)}}$$

$$PERR(\tau)=\frac{1}{N}\sum_{t=1}^{N}\tan^{-1}\left(\frac{a_1(t)f_2(t,\tau)-a_2(t)f_1(t,\tau)}{a_1(t)f_1(t,\tau)+a_2(t)f_2(t,\tau)}\right)$$

$$AERR(\tau)=\frac{1}{N}\sum_{t=1}^{N}\left(\sqrt{f_1(t,\tau)^2+f_2(t,\tau)^2}-\sqrt{a_1(t)^2+a_2(t)^2}\right)$$

where a_1 and a_2 are analyzed PC1 and PC2, f_1 and f_2 are predicted PC1 and PC2 and τ is forecast lead time. Root Mean Square Error (RMSE) denotes the MJO index error, and correlation coefficient (COR) denotes a phase error of the MJO. Phase error (PERR) denotes the bias of the MJO phase speed, and relative amplitude difference (AERR) denotes the bias of the MJO amplitude.

Verification result

Verification scores depending on lead time are shown in Figure 1. COR falls below 0.6 on day 13, which provides an estimate of skillful time range. Predicted MJO phase speed is faster and predicted MJO amplitude is smaller compared with the analysis. It is found that the model poorly represents eastward propagation of active convection over the Indian Ocean (Figure 2). Moreover, the model does not well reproduce the northward propagation of the active convection in the Indian Ocean (Figure 3).

Summary

The MJO forecast in the JMA's one-month EPS hindcast is skillful up to a lead time of 13 days. But the model fails to reproduce the realistic eastward and northward propagation of active convection. It is necessary to further improve the model for more realistic representation of the MJO.

References

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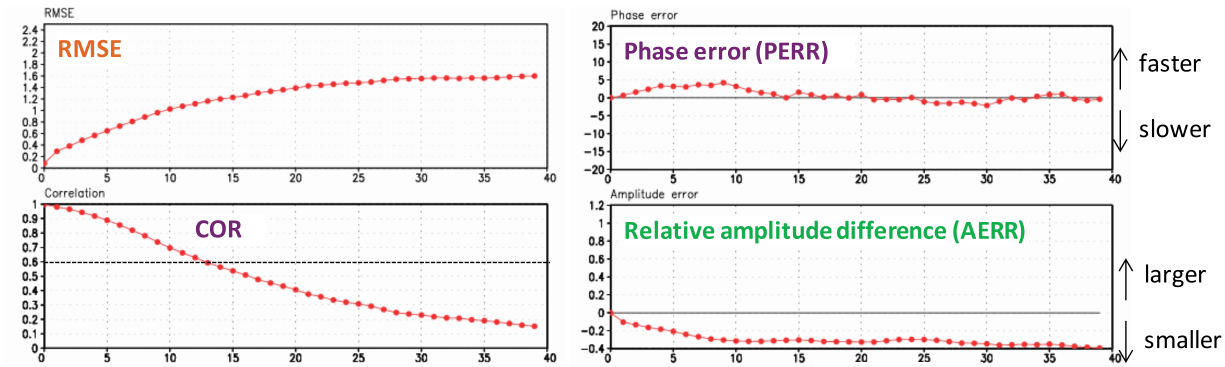

Figure 1 Verification scores of the predicted MJO index depending on the forecast time

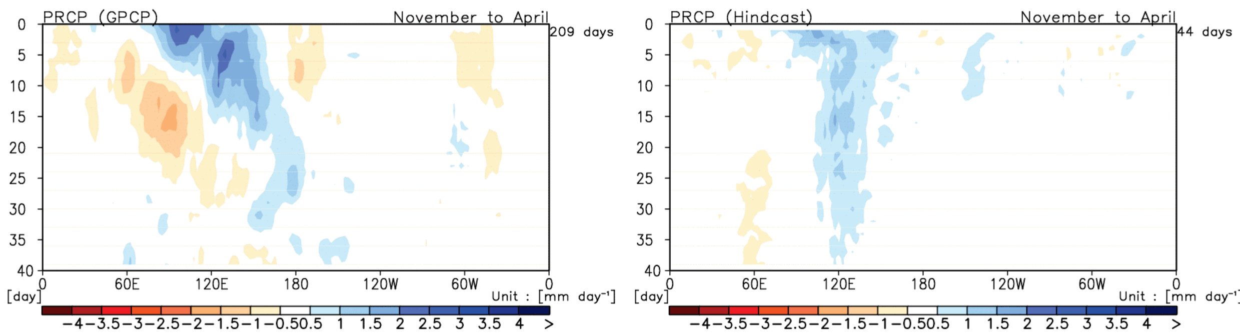

Figure 2 Composite of November-April precipitation averaged in the tropics (15S-15N) for analyses (left) and hindcast (right) started from phase 3 with the initial amplitude of > 1 σ

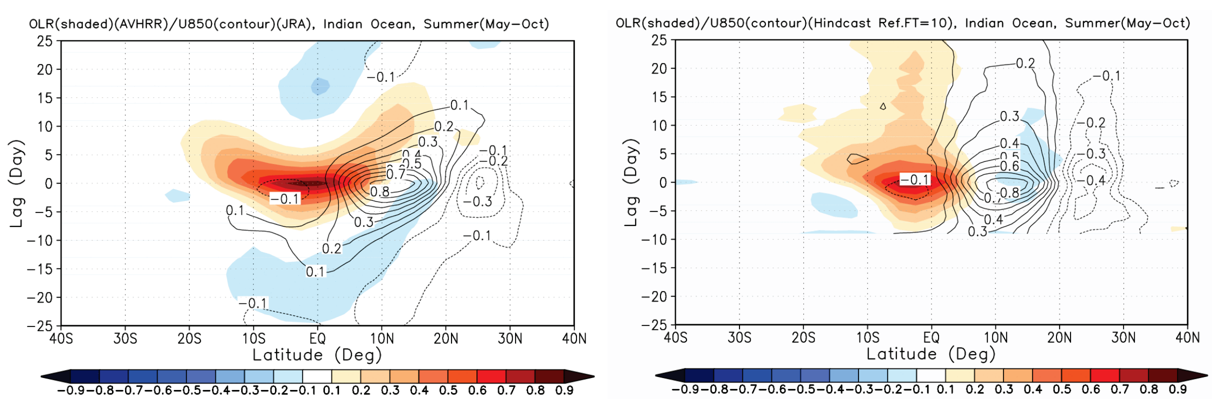

Figure 3 May-October lag correlation of intraseasonal OLR (color) and U850 (contour) averaging 80-100E against OLR and U850 at an Indian Ocean reference point (OLR:10S-5N,75-100E, U850:3.75-21.25N,68.75-96.25E) for analyses (left) and hindcast (right).