Extended Range Prediction of Madden-Julian Oscillation (MJO) using IITM CFS v2 and the Role of Initial Error on the Prediction Skill

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Introduction

- MJO serves as a dominant mode of tropical intra-seasonal variability
- Different studies have attributed the MJO prediction skill to the initial error, initial phase and amplitude, model processes involved, ocean-atmospheric coupling etc.
- The skill of Indian Institute of Tropical Meteorology (IITM) , extended range prediction system (ERPS) in predicting strong MJO events during MJJAS is analyzed.
- Strong MJO events (PC amplitude > 1.0) have been classified into least initial day error cases (LIDE) and highest initial day error cases (HIDE).
- This stratification allows to evaluate the role of initial basic state error assuming other factors affecting predictability have identical effects in both scenarios.

Objectives

The objectives of the study are:

(a) To investigate the effect of initial day error on the extended range forecast skill of the MJO in the IITM CFSv2 model

(b) To highlight the source of the large model error cropping up from the very initial lead days in the high initial error cases as compared to low initial error cases.

Data & Methodology

Baroclinic structure along with the convection and propagation characteristics associated with MJO, is captured using the outgoing longwave radiation (OLR), zonal winds at 850 hPa and 200 hPa levels following Wheeler & Hendon, 2004 (WH04) method.

- Daily averaged OLR is obtained from NOAA polar orbiting satellites from 1979-2018. (Liebmann & Smith, 1996)
- Zonal wind data are taken from NCEP-NCAR reanalysis dataset for same period (Kalnay et al., 1996). All data are analysed on 2.5^0 X 2.5^0 grids.

Model data is from IITM CFSv2 hindcast of the IITM-ERPS. It is using MME from NCEP's CFSv2 and GFS, both of two resolutions T382 and T126. Model data is used for a period from 2003-2018.

Multivariate EOF are computed using OLR, u850 and u200 following the WH04 method.

EOF 1 : Enhanced convection over Indian Ocean

EOF 2 : Near-quadrature with EOF 1.

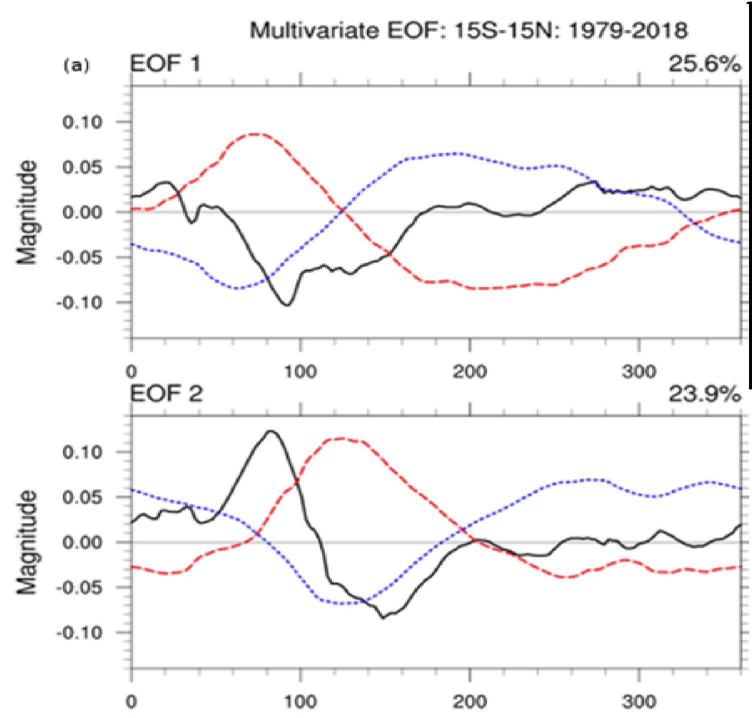

Figure 1: Spatial structure of EOF 1 and EOF 2 and the explained variance.

Results & Discussion

- Analysis is done for strong MJO events with initial PC amplitude greater than 1.0 during MJJAS (185 ICs).
- LIDE &HIDE cases: 25% of events with least initial day error and highest initial day error (46 cases each).

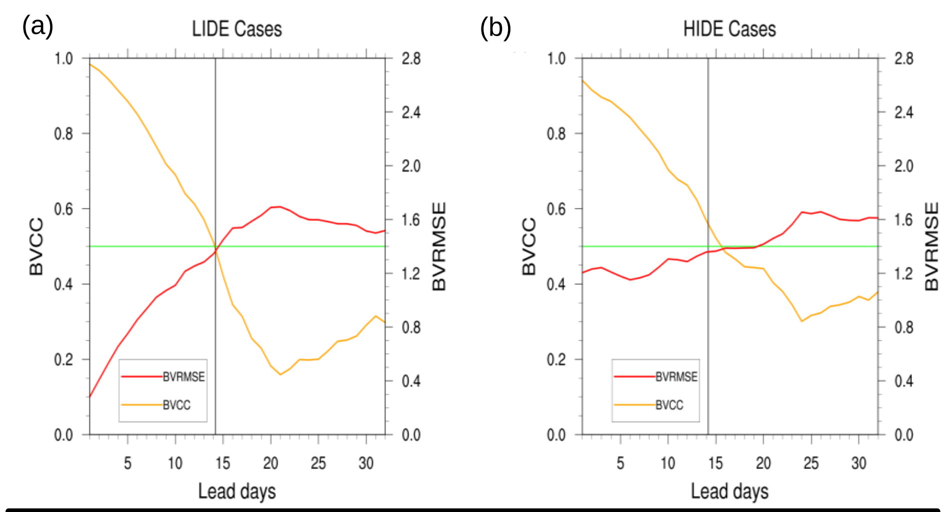

Figure 2: BVRMSE and BVCC of MJO Events as predicted using IITM CFSv2 model from 2003-2018 MJJAS (a) LIDE cases (b) HIDE cases

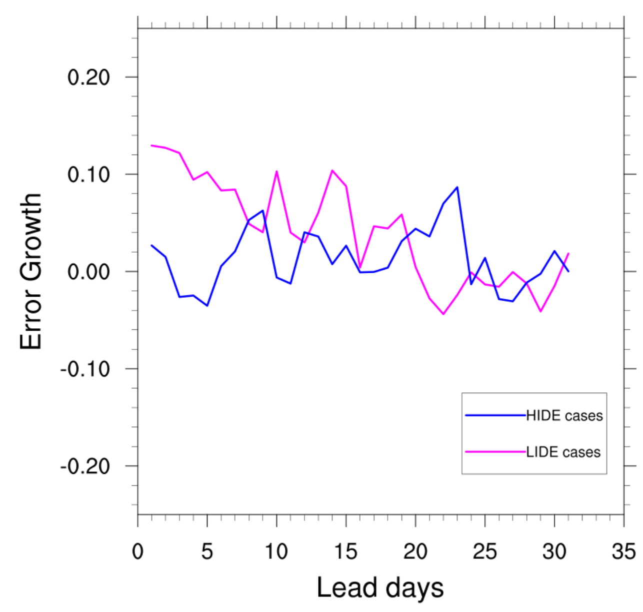

Figure 3: Growth of BVRMSE of the LIDE and HIDE cases with lead days. Blue line shows the error growth of HIDE cases and magenta line shows that of LIDE cases.

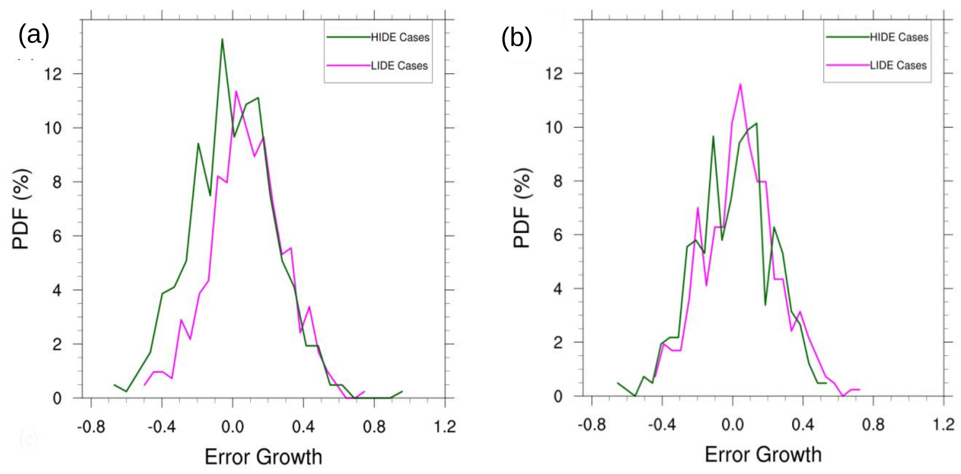

Figure 4*:* (a) PDF of growth of BVRMSE during 1-10 days lead (b) PDF of growth of BVRMSE during 10-20 days lead.

Although LIDE and HIDE cases represent the two extremes in the initial day error, their error growth patterns are the same.

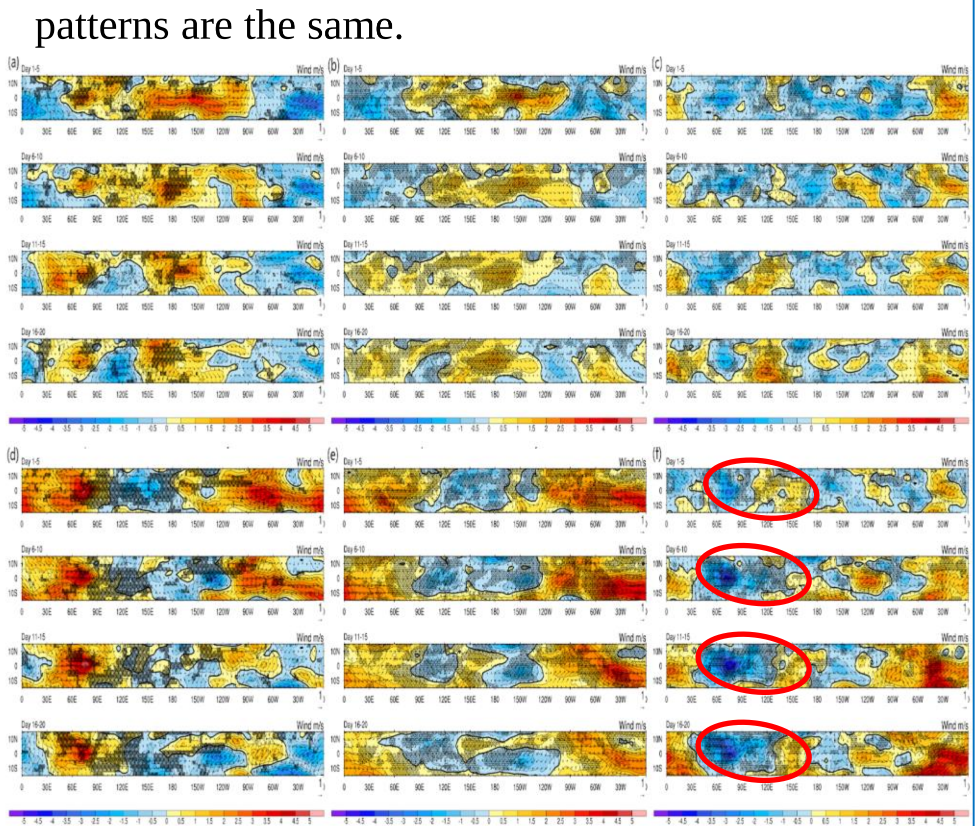

Figure 5*:* Spatial distribution of zonal winds at 200 hPa level for the LIDE from the (a) observations, (b) model hindcast and (c) Model-Observation. The same for HIDE cases are shown in the second row (d, e and f). The dotted regions represent the t values which having confidence above 90%.

Strong bias is seen in the lower level and the upper level circulation features over the Western Pacific and the Indian Ocean

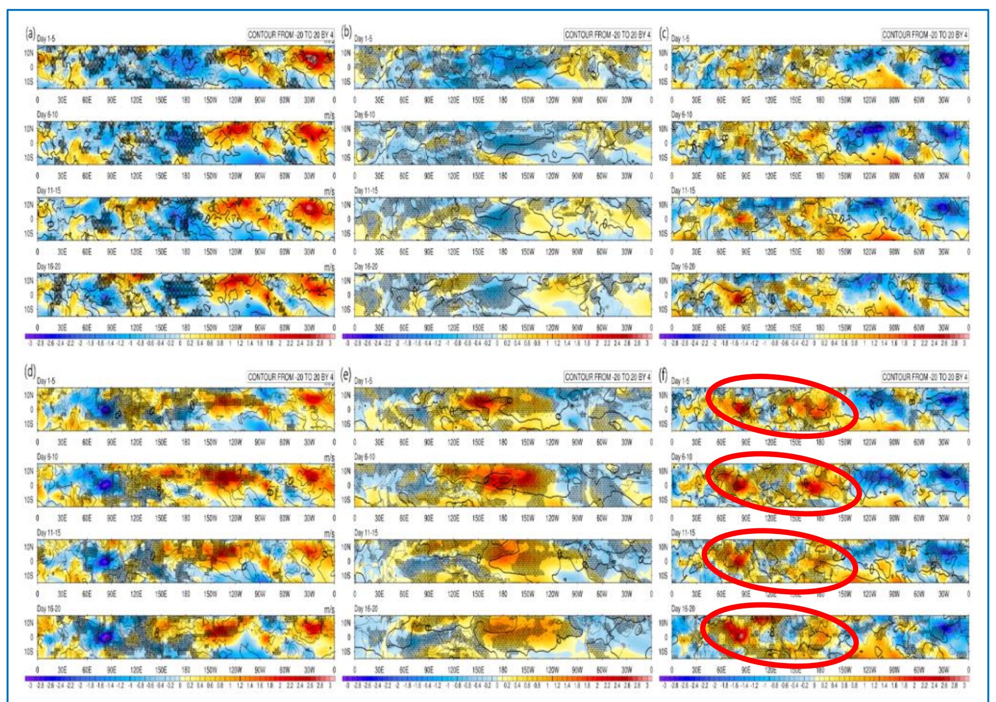

Figure 6*:* Same as that of Figure 5 with the contours showing zonal winds at 850 hPa level.

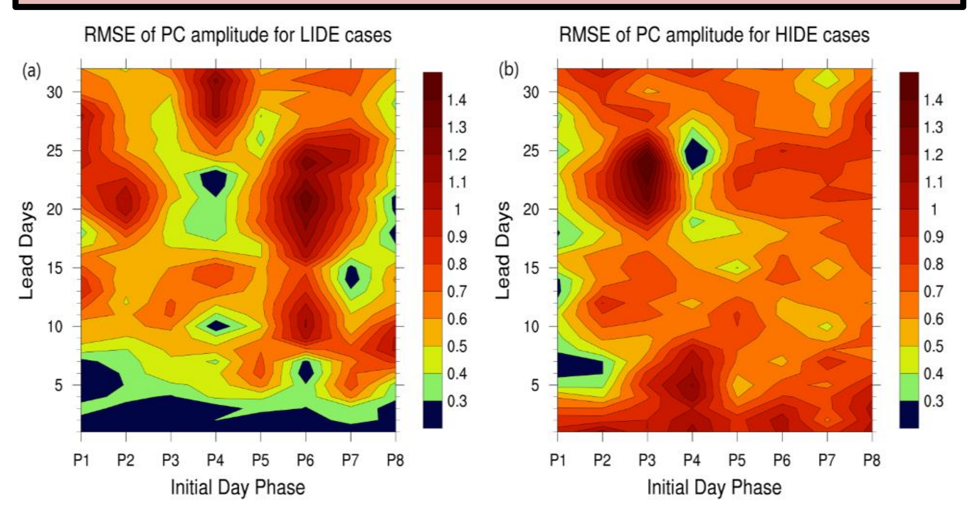

Figure 7*:* Root mean square error of bivariate PC amplitude as a function of initial day phase and lead time. (a) for LIDE cases (b) for HIDE cases.

Summary/Conclusion

- There is a widely accepted hypothesis that improving the initial conditions can improve a climate model's performance in a longer lead-time.
- The effect of initial error in the forecasts of lead time greater than ten days is much limited while predicting MJO using the IITM CFSv2 model.
- Difference in error growth in HIDE and LIDE cases is related to the constraints in model physics.
- The incorrect model forecast over the Western Pacific and Indian Ocean region reduces the model prediction skill.
- Initial improvement of error in PC is not carried beyond a lead time of 10 days in this model.
- More emphasis is to be given to sorting out the biases in model dynamics and physics rather than focusing only on improving the ICs

Acknowledgements & References

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For more details refer: Lekshmi, S., Chattopadhyay, R., Kaur, M. *et al.* Role of initial error growth in the extended range prediction skill of Madden-Julian Oscillation (MJO). *Theor Appl Climatol* **147,** 205–215 (2022). https://doi.org/10.1007/s00704-021-03818-3

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