Why Monsoon Mission CFSv2 has better skill for ISMR compared to present generation models?

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Introduction

A series of past studies indicated that Monsoon Mission CFSv2 (MM-CFSv2), which is having a high resolution (T382) atmospheric model has a skill of 0.55 for Indian summer monsoon rainfall (ISMR) at around a season lead hindcast (Pillai et al 2017a,b), which is far better than the previous generation coupled models. The present study compares the ISMR skill of MM-CFSv2 model with that of the present day seasonal prediction models participating in U.S National Multi-Model Ensemble (NMME) project. Even in the present generation models also there is strong cold bias in the majority of tropics and extra tropics. Associated with the SST pattern, there is strong dry bias over major monsoon land regions and wet bias over tropical Indian Ocean, northwest Pacific and north Atlantic regions. At the same time they have comparable skill for tropical SST and rainfall too.

Working hypothesis

The present study is based on the hypothesis that the skill of model rainfall depend on its ability to represent the basic state and the spatial pattern of teleconnection patterns associated with different SST boundary forcing.

Methodology

Present study uses Feb IC hindcasts from MM-CFSv2 and other 14 models participated in the NMME project. Each model has at least 10 ensembles and ensemble mean seas surface temperature (SST) and precipitation data are used here. Multimodal mean (MME) including NMME models and MM-CFSv2 is also . MM-CFSv2 is at higher resolution of 38km and all other models are on common resolution of 110km. The study uses 29 year data from 1981-2009. The analysis is concentrated on the season from June to September (JJAS) only.

How these models simulate the boreal summer SST and rainfall patterns

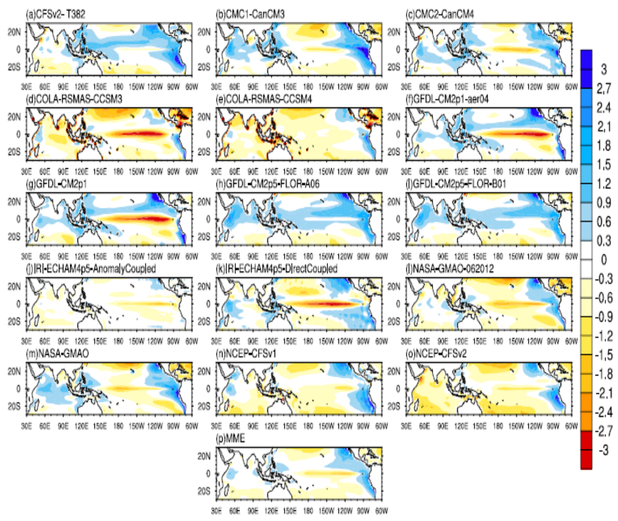


Figure 1: JJAS SST bias for the models. Biases are calculated from HadISST as observations for the period 1981-2009

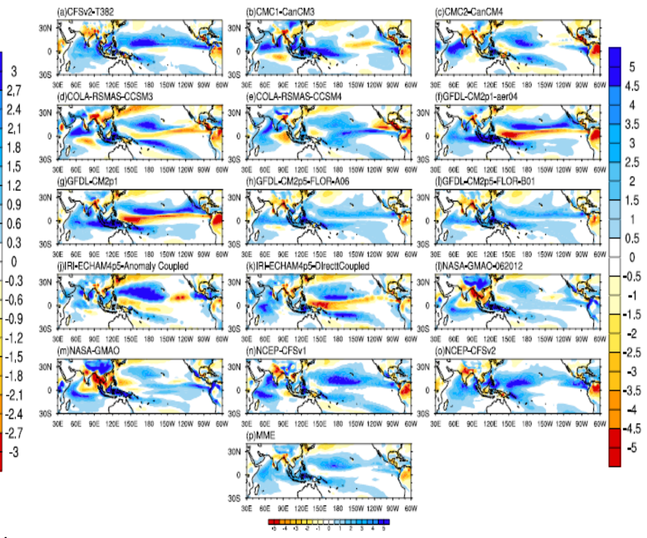
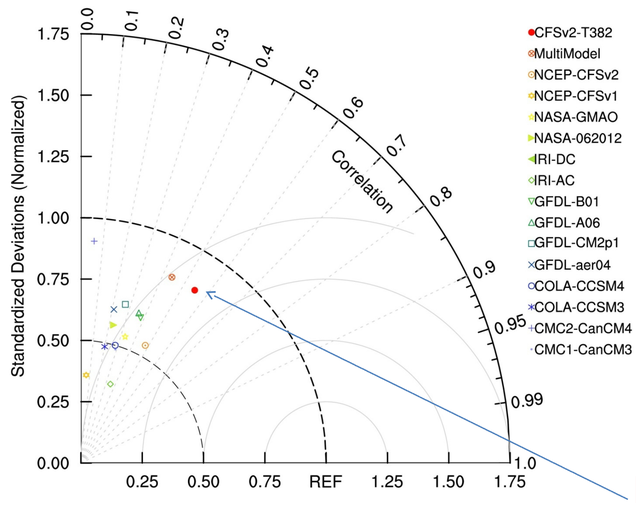


Figure 2: JJAS rainfall bias for the models with respect to GPCP rainfall data for the 1981-2009 period



Even though majority of the models have better/equal skill as MM-CFSv2 for boundary forcing, ISMR skill is higher for MM-CFSv2 only. Inclusion of CFSv2 makes MME as the model with second highest skill model

MM-CFSv2 (T382)

Figure 6: Taylor diagram showing the ISMR skill of models.

- Most of the models have cold bias in the equatorial central Pacific and equatorial Indian ocean, while **MM-CFSv2 and GFDL has slight warm bias**. This will cause difference in SST teleconnection between the models.
- Tropical oceans have wet bias and land region has dry bias in all most all the models.

Thus our working hypothesis is that not only the model skill to capture the boundary forcing, but also proper teleconnection patterns of these boundary forcing are also important for better prediction skill .

How the biases will be reflected in the skill of tropical SST and rainfall?

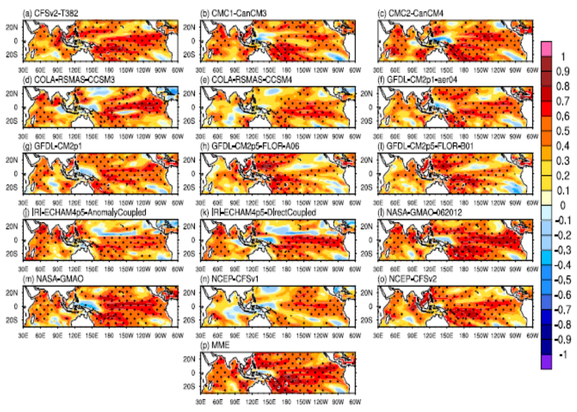


Figure 3: Skill of tropical SST anomalies for all the models and MME

Models have better spatial skill for equatorial Pacific Ocean SST compared to Indian Ocean SST. Meanwhile **the skill is more for the models whose biases in the equatorial Pacific and Indian Ocean are Minimum.**

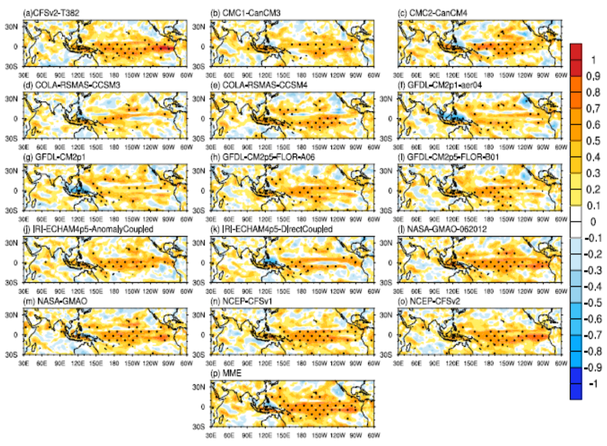


Figure 4: Skill of tropical SST anomalies for all the models and MME

Tropical ocean rainfall skill is comparable in all the models, mainly in the Pacific region. Meanwhile land region rainfall skill is very poor in majority of the models . Similar to the SST skill (figure 3), **rainfall skill is also dependent on the biases** observed in Fig 2. For eg. Models with strong cold bias in the equatorial central Pacific has very less skill in the same region.

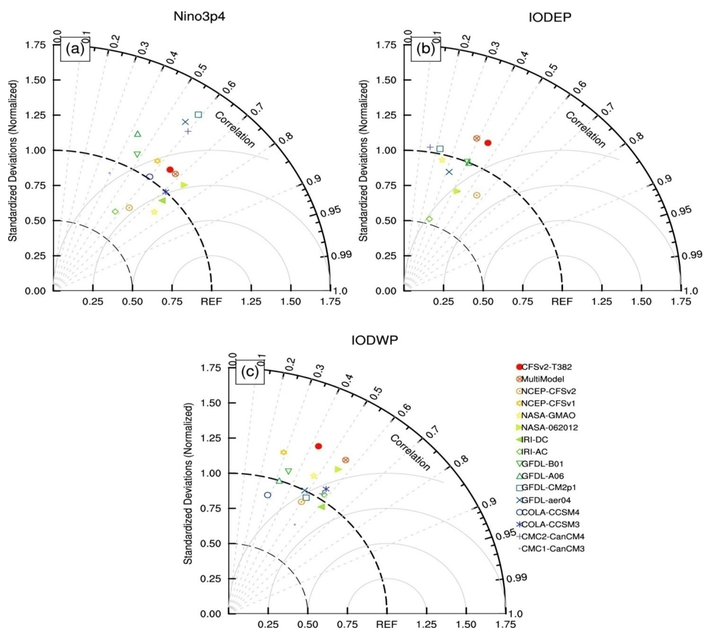


Figure 5 Taylor diagram showing the skill of models in simulating the JJAS SST indices such as (a) Niño 3.4, (b) IODEP and (c) IODWP

Many models have higher skill for ENSO and Indian Ocean SST anomalies compared to MM- CFSv2 model.

Thus majority of the models have comparable skill for tropical Pacific SST and rainfall. Meanwhile the differences in biases give different pattern. If consider the SST indices only, most of the models have similar values and then also the effect of boundary forcing on land precipitation is different in the models .

Teleconncetion of ENSO and IOD on tropical SST pattern

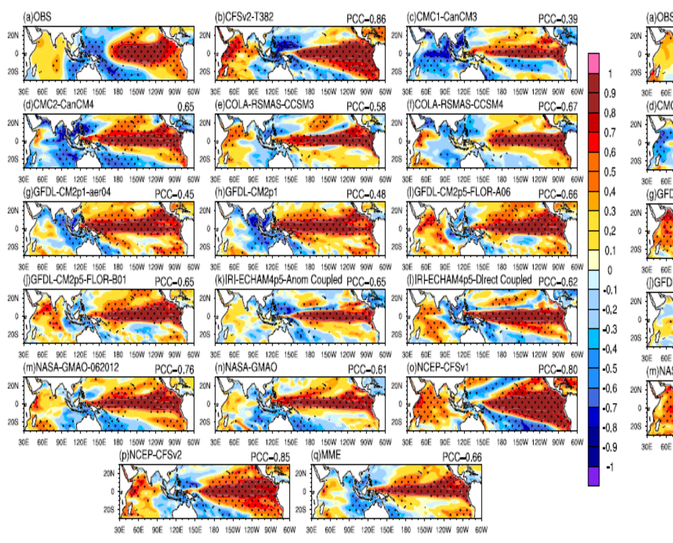


Figure 7: Teleconnection of Nino3.4 with tropical SST

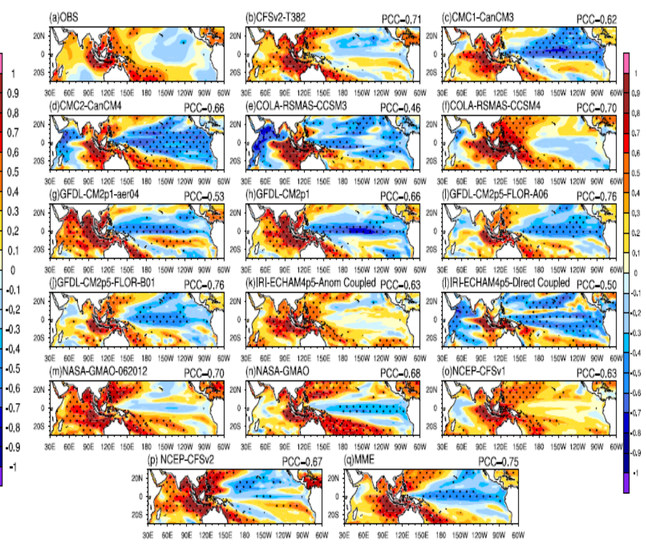


Figure 8: Teleconnection of IOD with tropical SST

Teleconnection patterns of both the Indian and Pacific Ocean SST indices have more resemblance with observations for MM-CFSv2 only. Pattern correlation with observed teleconnection for ENSO is 0.86 and that for Indian Ocean SST is 0.71 for MM model.

ISMR and tropical SST patterns

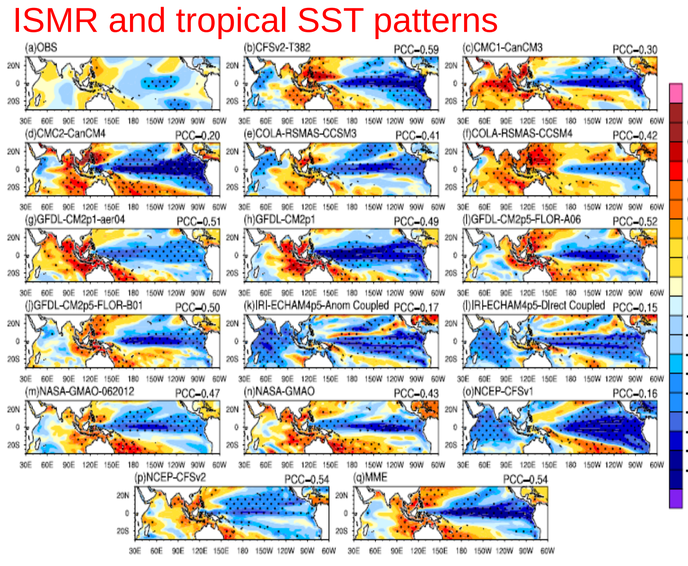


Figure 7: Teleconnection of ISMR with tropical SST

ISMR teleconnection with tropical SST is better in the MM-CFSv2 model with a pattern correlation of 0.59 with observed teleconnection pattern. The models having moderate skill for ISMR has moderate pattern correlation also. *The models having very poor skill for ISMR like CFSv1 and IRI-anomaly coupled, CanCM4 are the models with very low Pattern correlation values for ISMR-tropical SST teleconnections*.

Conclusion

The present study indicates that the better skill of MM-CFSv2 is related to:

- **the reduced bias in the tropics**
- **better skill of SST phenomena like ENSO and IOD and their teleconnections.**
- **Better spatial representation of ISMR relationship with tropical SST anomalies.**

This underlines our hypothesis that along with the proper simulation of boundary forcing, its teleconnections along with their spatial patterns are also important for the better prediction of land region rainfall simulations.

References

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