Association of Indian Summer Monsoon Variability with Mid-latitude Teleconnection in CFSv2

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Abstract

This study identifies the role of mid-latitude teleconnection in determining the interannual variability of the Indian summer monsoon in the CFSv2 model. Since CFSv2 has been identified as a potential forecast model for the Indian summer monsoon, it is important to understand the factors that determine its prediction skills at seasonal timescales. ENSO is one of the most important factors driving Indian monsoon variability at seasonal timescales. It is represented realistically in CFSv2. The model, however, misses associated mid-latitude teleconnections. We show that the inadequate strength of mid-latitude teleconnections, especially from the North Atlantic and North-western Pacific can be the primary reasons for the weaker monsoon variability, despite strong ENSO-Monsoon relationship in the model.

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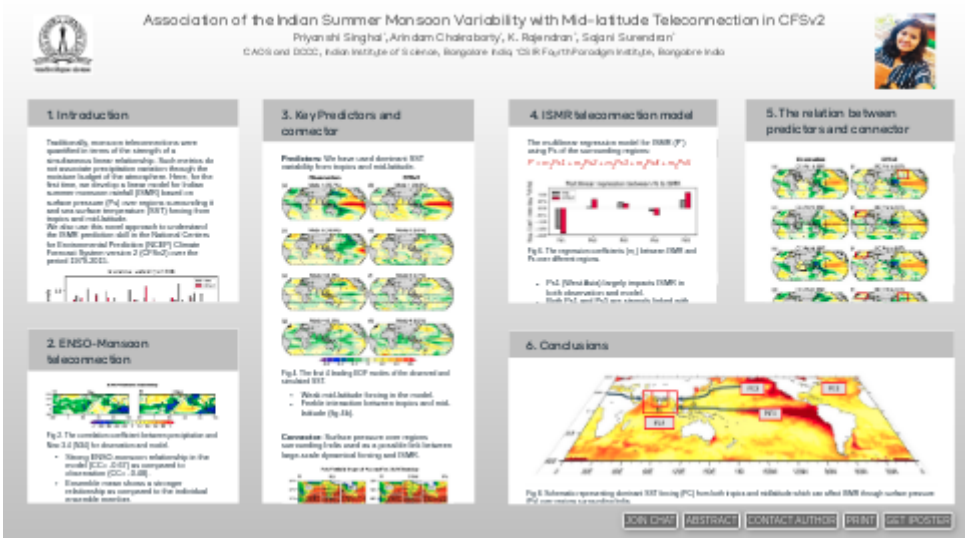

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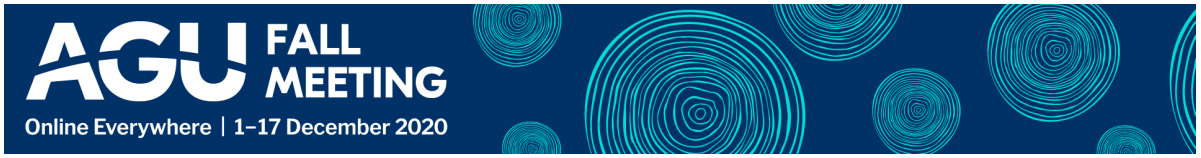


1. INTRODUCTION

Traditionally, monsoon teleconnections were quantified in terms of the strength of a simultaneous linear relationship. Such metrics do not associate precipitation variation through the moisture budget of the atmosphere. Here, for the first time, we develop a linear model for Indian summer monsoon rainfall (ISMR) based on surface pressure (Ps) over regions surrounding it and sea surface temperature (SST) forcing from tropics and mid-latitude.
We also use this novel approach to understand the ISMR prediction skill in the National Centers for Environmental Prediction (NCEP) Climate Forecast System version 2 (CFSv2) over the period 1979-2015.

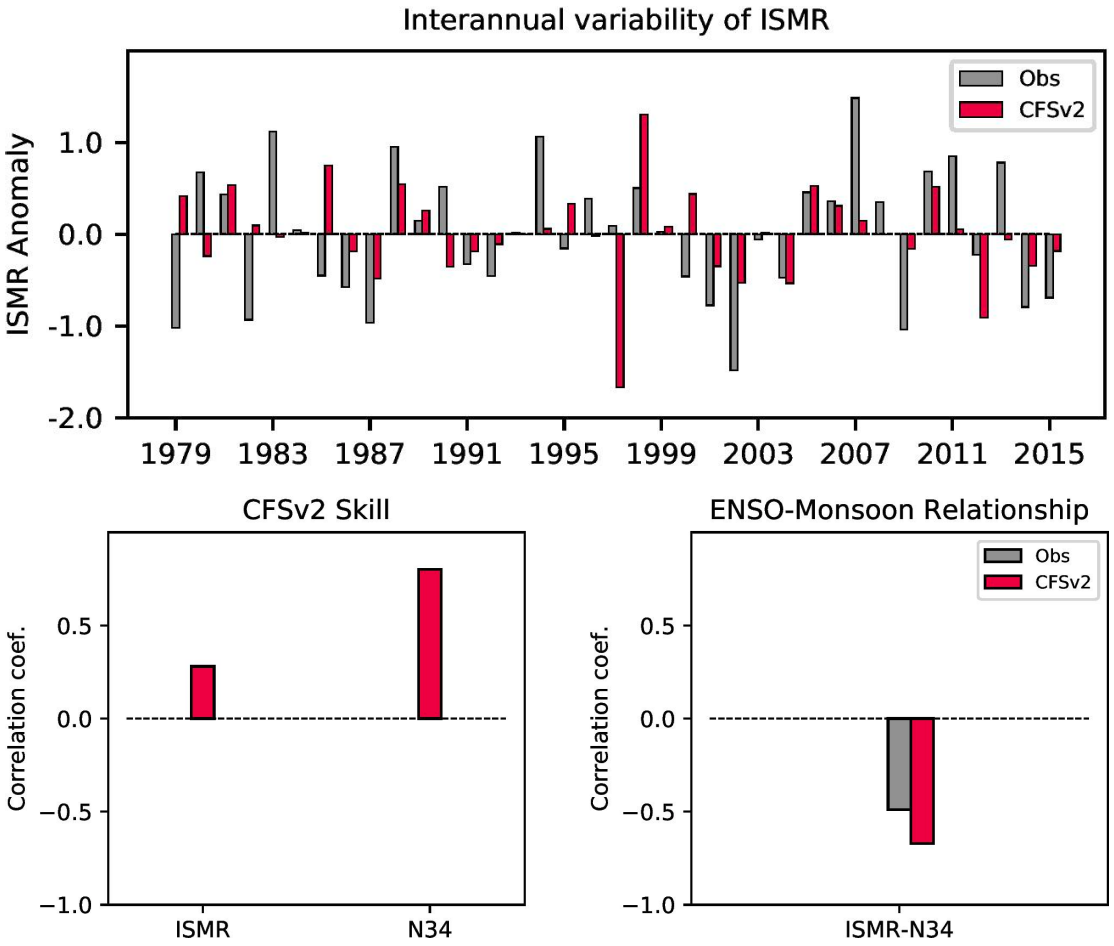


Fig 1. The interannual variability of ISMR anomaly in observation and model (top panel). The bottom panel represents the CFSv2 skill in predicting ISMR, El Nino Southern Oscillation (ENSO), and its teleconnection.

- Despite having high skill in predicting ENSO and a strong ENSO-monsoon relationship, CFSv2 has a low skill in predicting the interannual variability of ISMR.
- Does CFSv2 has a problem with ENSO-ISMR teleconnection?

2. ENSO-MONSOON TELECONNECTION

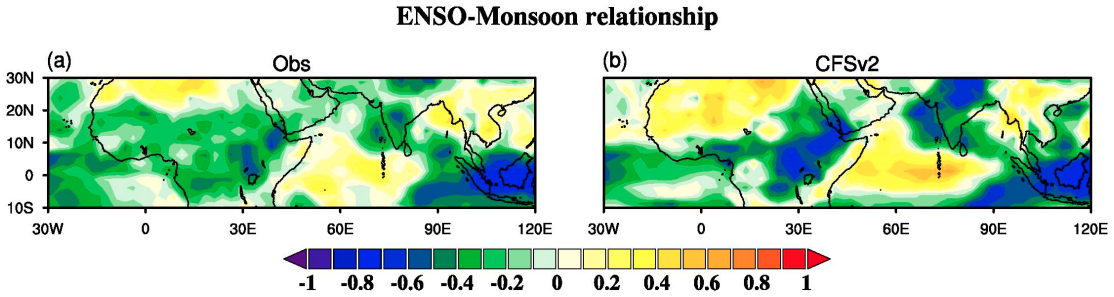


Fig 2. The correlation coefficient between precipitation and Nino 3.4 (N34) for observation and model.

- Strong ENSO-monsoon relationship in the model (CC= -0.67) as compared to observation (CC= -0.48).
- Ensemble mean shows a stronger relationship as compared to the individual ensemble member.

IC	CC -0.48
0421	-0.37
0426	-0.64
0501	-0.57
0506	-0.51
0511	-0.49
Ens mean	**-0.67**

Reason:

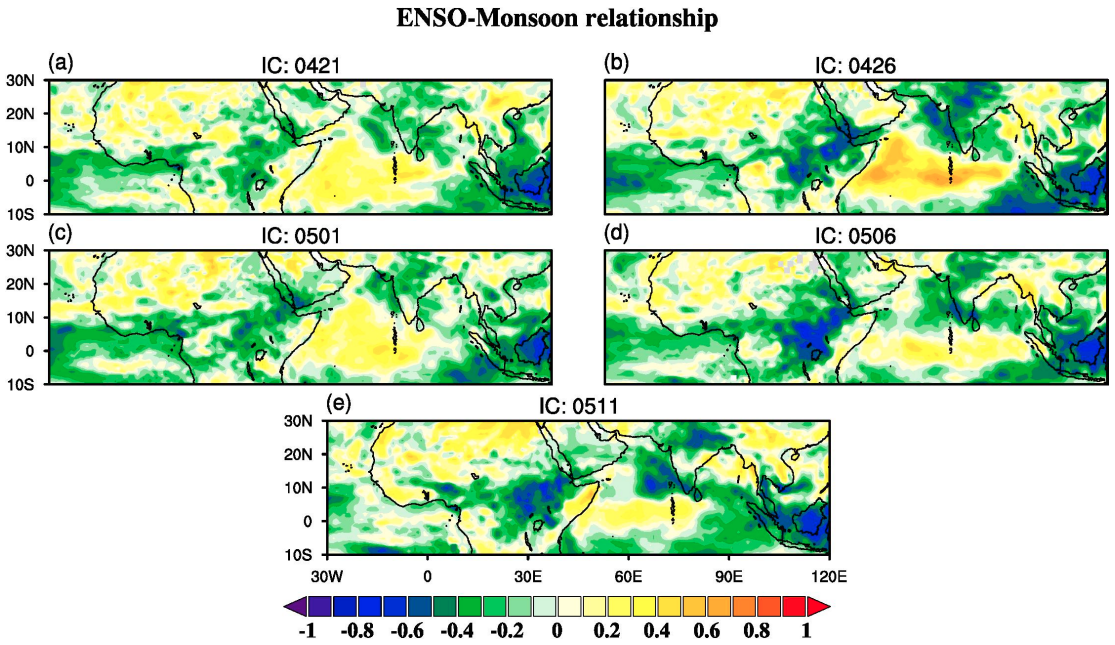


Fig 3. Same as figure 2, but for individual ensemble members.

- **Constructive addition of the negative correlation of different members.**

3. KEY PREDICTORS AND CONNECTOR

Predictors: We have used dominant SST variability from tropics and mid-latitude.

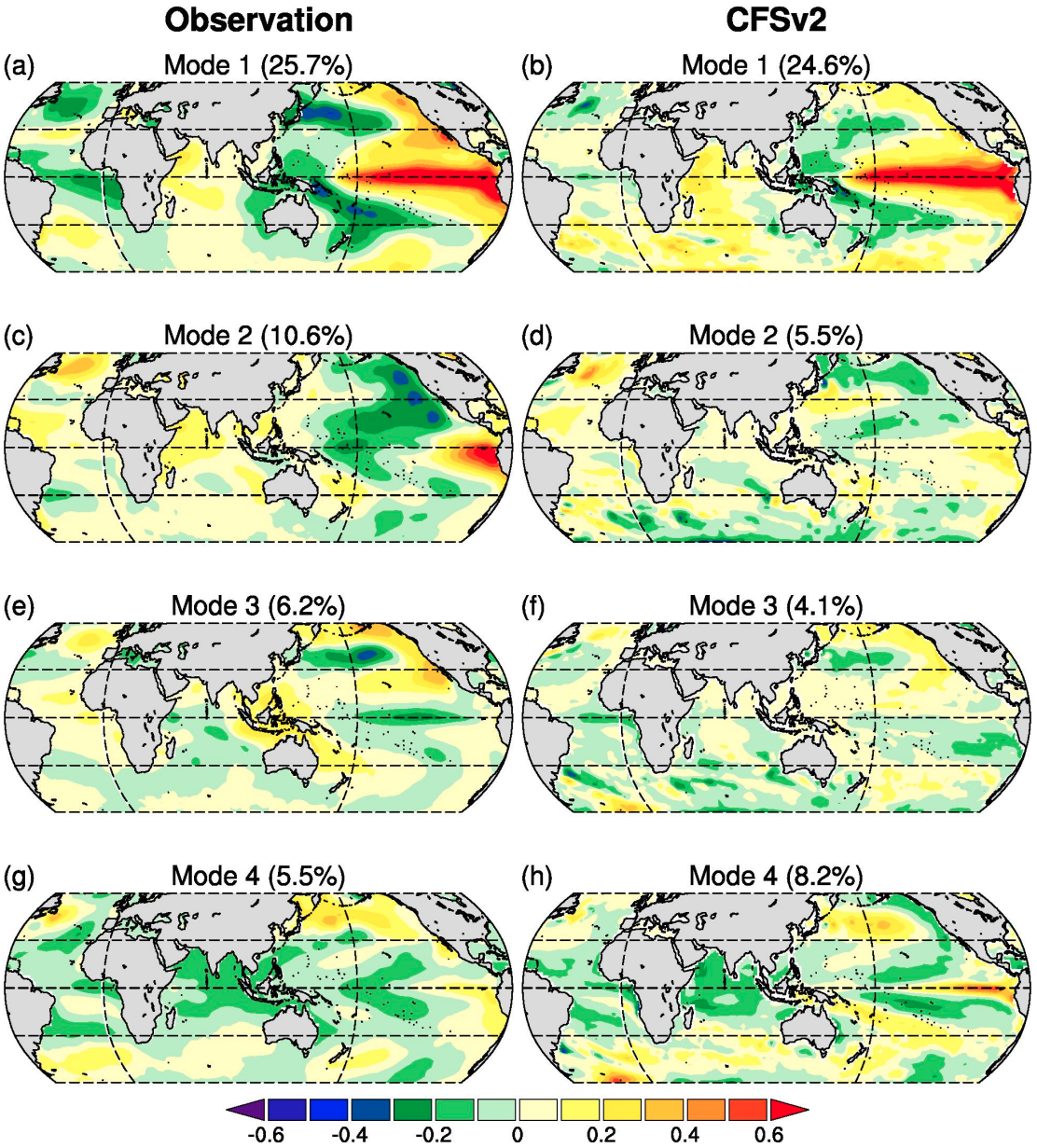
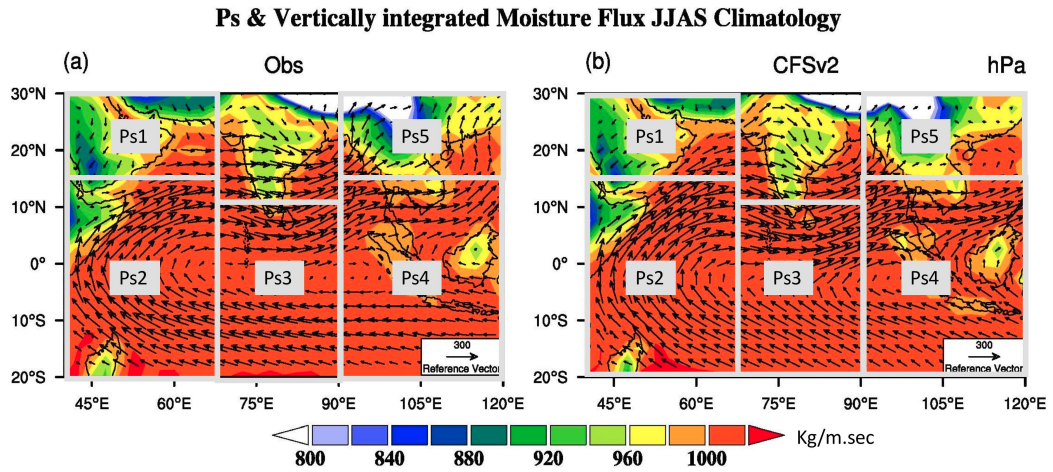


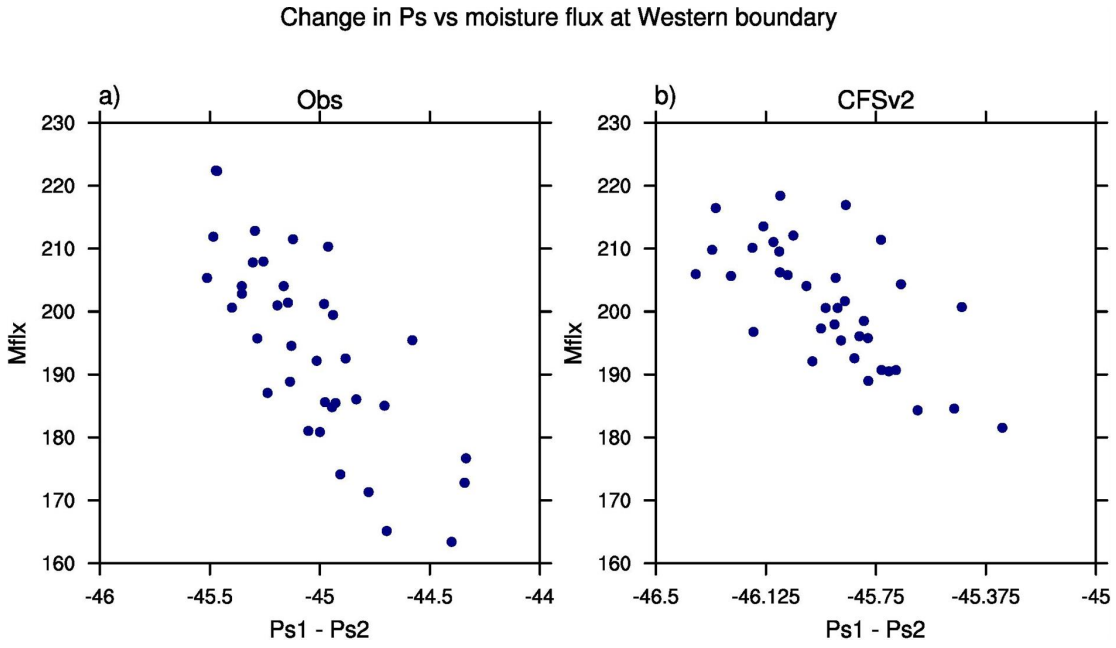
Fig 4. The first 4 leading EOF modes of the observed and simulated SST.

- Weak mid-latitude forcing in the model.
- Feeble interaction between tropics and mid-latitude (fig 4b).

Connector: Surface pressure over regions surrounding India used as a possible link between large-scale dynamical forcing and ISMR.



- A stronger pressure gradient at the western (Ps1-Ps2) and eastern boundary (Ps5-Ps4) can impact the moisture flux entering and leaving the Indian region (Fig 5), thus affecting convection over India.
- CFSv2 has a weaker pressure gradient.



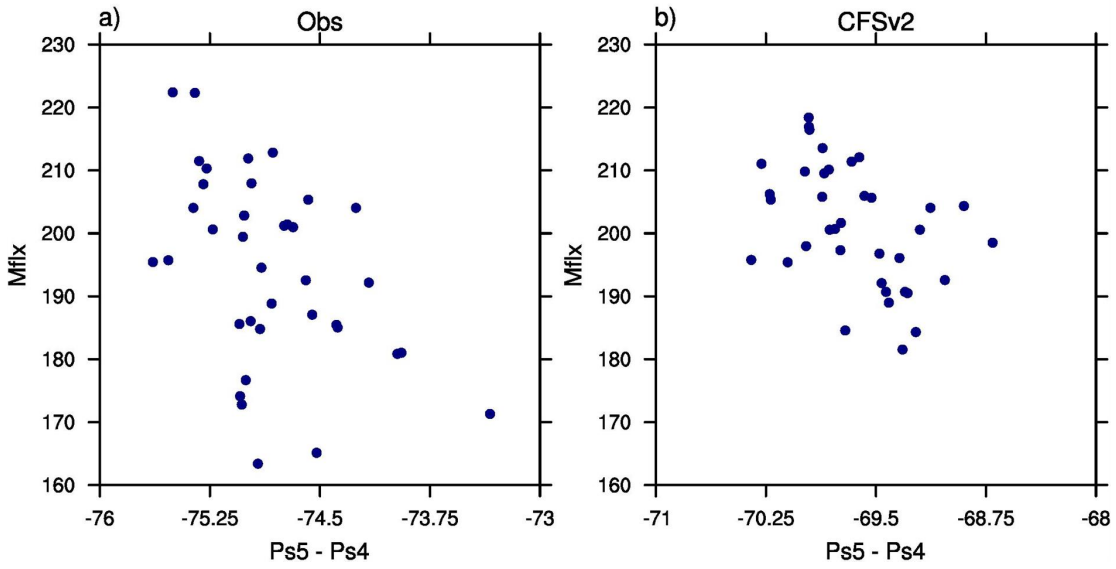


Fig 5. The scatter plot between vertically integrated moisture flux and pressure gradient at the western and eastern boundaries.

4. ISMR TELECONNECTION MODEL

The multilinear regression model for ISMR (P') using Ps of the surrounding regions:

$$P' = m_1Ps1 + m_2Ps2 + m_3Ps3 + m_4Ps4 + m_5Ps5$$

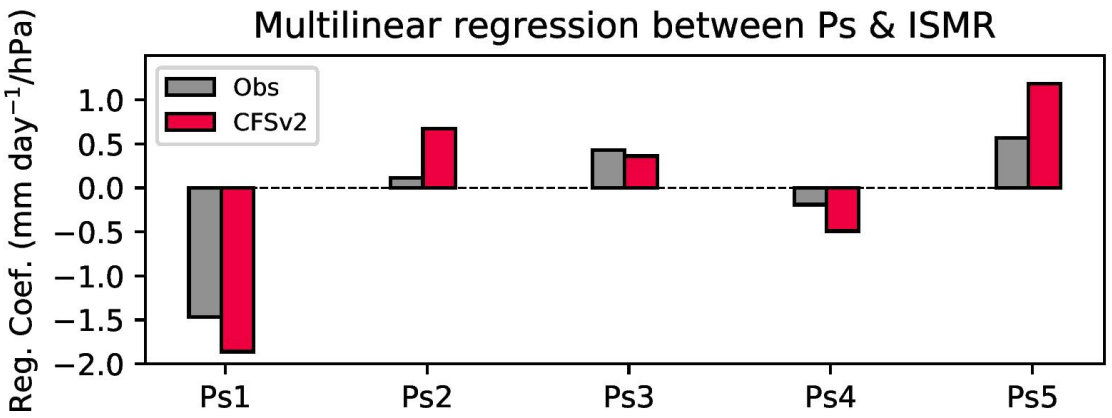


Fig 6. The regression coefficients (m_i) between ISMR and Ps over different regions.

- Ps1 (West Asia) largely impacts ISMR in both observation and model.
- Both Ps1 and Ps5 are strongly linked with ISMR in the model.

5. THE RELATION BETWEEN PREDICTORS AND CONNECTOR

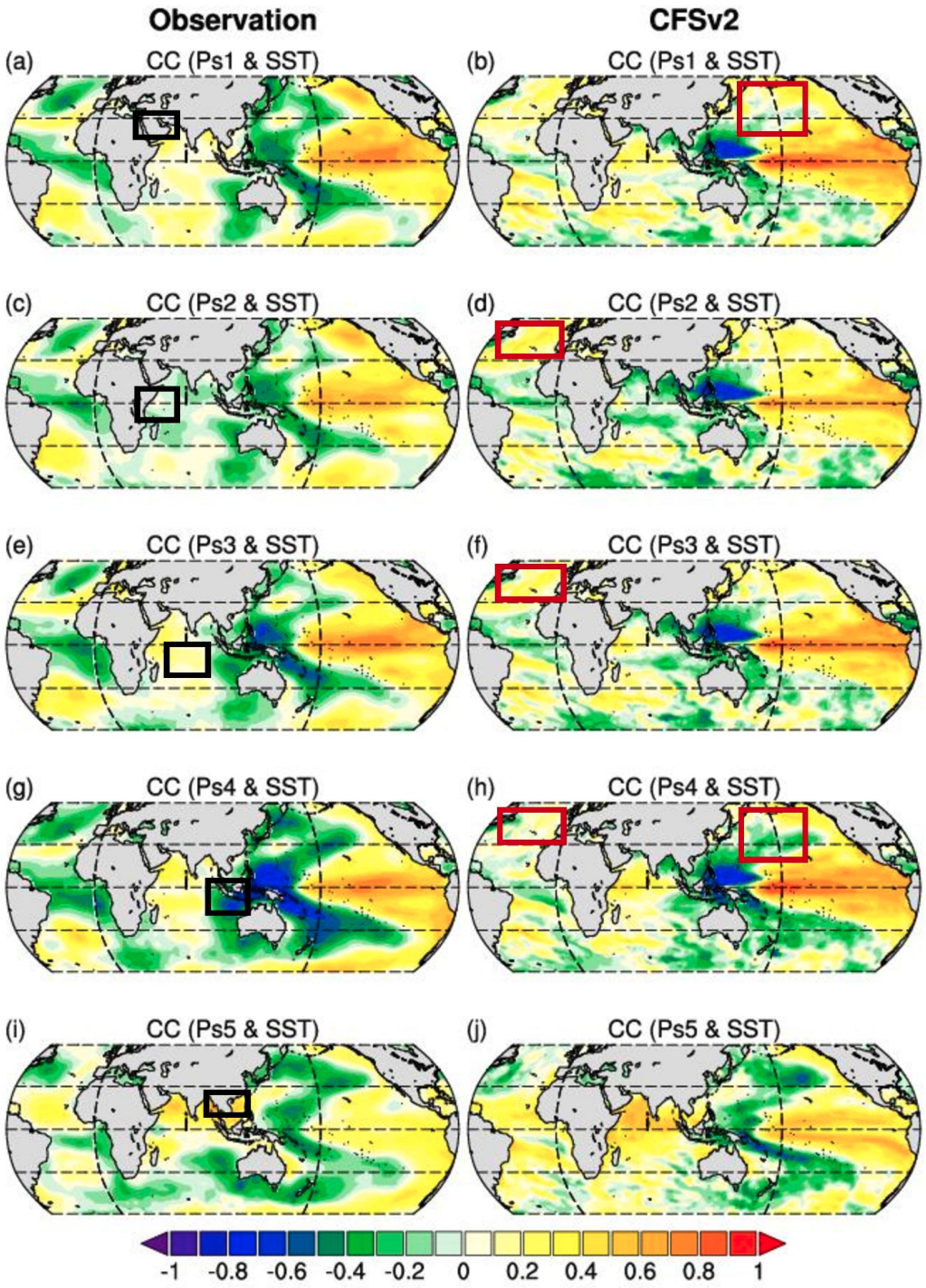


Fig 7. The correlation coefficient between surface pressure over the different surrounding regions and SST.

- The teleconnection between SST forcing from mid-latitude and Ps are missing or opposite in the model.
- These missing teleconnections can alter the moisture flux by modulating surface pressure.
- This could be a possible reason for the low prediction skill of CFSv2.

6. CONCLUSIONS

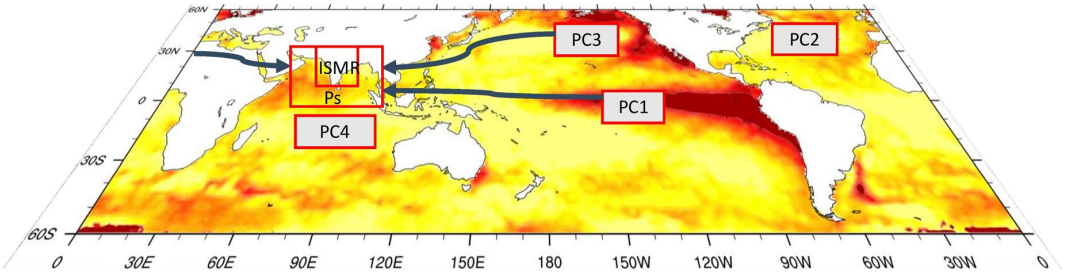


Fig 8. Schematic representing dominant SST forcing (PC) from both tropics and midlatitude which can affect ISMR through surface pressure (Ps) over regions surrounding India.

- Weak mid-latitude forcing could be the reason for the low prediction skill of the CFSv2.
- Feeble interaction between tropics and mid-latitude in CFSv2.

ABSTRACT

This study identifies the role of mid-latitude teleconnection in determining the interannual variability of the Indian summer monsoon in the CFSv2 model. Since CFSv2 has been identified as a potential forecast model for the Indian summer monsoon, it is important to understand the factors that determine its prediction skills at seasonal timescales. ENSO is one of the most important factors driving Indian monsoon variability at seasonal timescales. It is represented realistically in CFSv2. The model, however, misses associated mid-latitude teleconnections. We show that the inadequate strength of mid-latitude teleconnections, especially from the North Atlantic and North-western Pacific can be the primary reasons for the weaker monsoon variability, despite strong ENSO-Monsoon relationship in the model.