Monsoon Mission Coupled Forecast System Ver. 2

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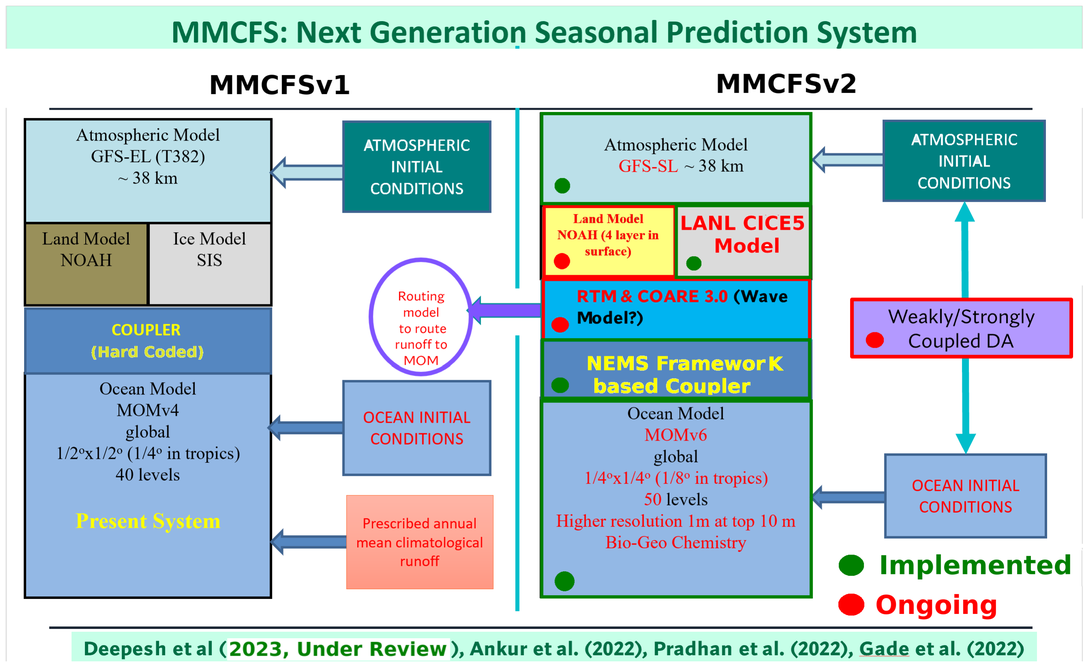
Abstract

We describe the Monsoon Mission Coupled Forecast System version 2 (MMCFSv2) model, which substantially upgrades the present operational MMCFSv1 (version 1) at the India Meteorology Department. We evaluate MMCFSv2 based on the latest 25 years (1998-2022) of retrospective coupled hindcast simulations of the Indian Summer Monsoon with April initial conditions from Coupled Forecast System Reanalysis. MMCFSv2 simulates the tropical wind, rainfall, and temperature structure reasonably well. MMCFSv2 captures surface winds well and reduces precipitation biases over land, except in India and North America. The dry bias over these regions remained similar to MMCFSv1. MMCFSv2 captures significant features of the Indian monsoon, including the intensity and location of the maximum precipitation centres and the large-scale monsoon circulation. MMCFSv2 improves the phase skill (anomaly correlation coefficient) of the interannual variation of ISMR by 17% and enhances the amplitude skill (Normalized Root Mean Square Error) by 20%. MMCFSv2 shows improved teleconnections of ISMR with the equatorial Indian and Pacific oceans..

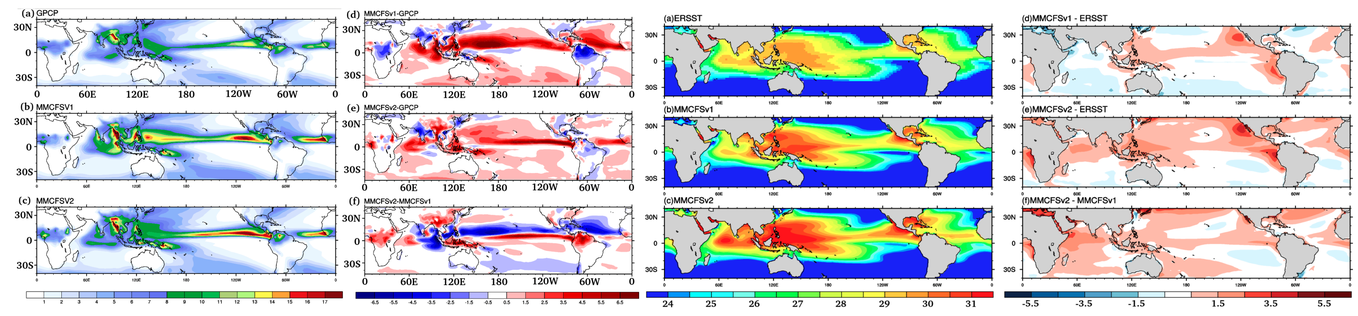
1. MMCFSv2 upgrades over MMCFSv1

- Semi-lagrangian dynamical core over the Eulerian one allows us to use higher atmospheric model resolutions while keeping the time stepping same or much a larger time step for a given resolution.
- MOM6 over MOM4 include the use of C-grid stencil over B-grid stencil. C-grid stencil is preferred for simulations involving an active meso-scale eddy field. Physical closures in MOM6 include scale-aware parameterizations for mesosale eddy-permitting regimes.
- The major improvements of CICE5 over Sea-ice model of MMCFSv1 include ice velocity in atm-ice coupling updates, and allowing a variable coefficient for the ice-ocean heat flux.



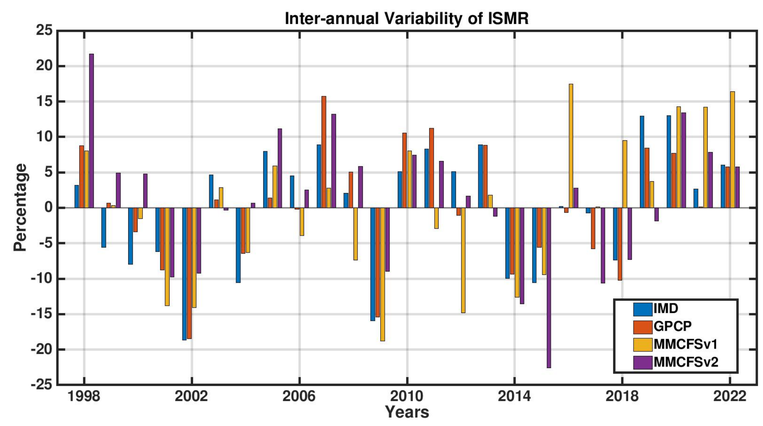
2. Key Results - JJAS Mean Precipitation and SST

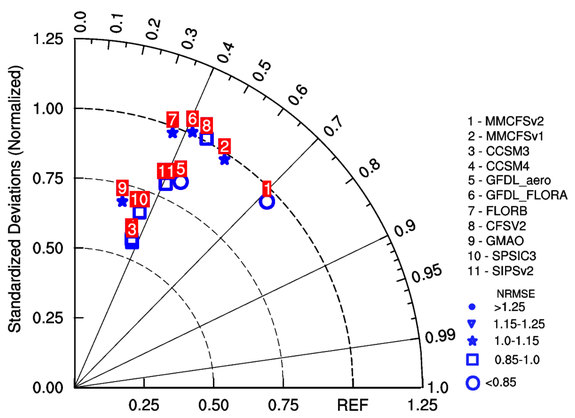
JJAS mean (1998-2022) Rainfall (Left) and SST (Right) (a) GPCP (ERSST - Right) (b) MMCFSv1 (c) MMCFSv2, and bias (d) MMCFSv1-GPCP (ERSST (right)) (e) MMCFSv2-GPCP (ERSST (right)), and (f) Difference between MMCFSv1 and MMCFSv2.



3. Interannual Variability Skill

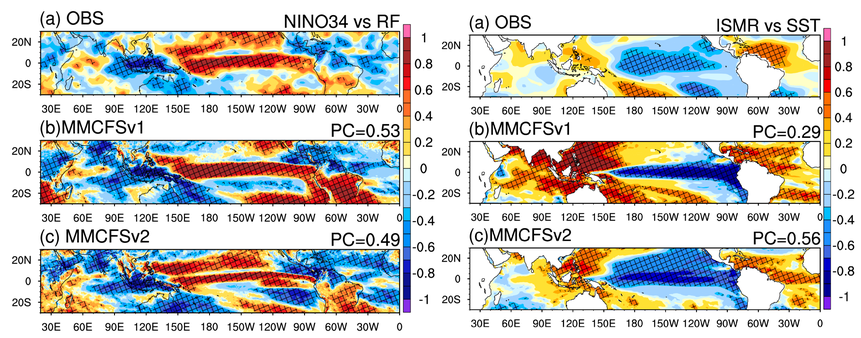
Left) Interannual Variability of area averaged rainfall over Indian land mass from model hindcast (MMCFSv2, MMCFSv1) and different observational datasets (IMD, IITM, and GPCP). Right) Skill comparison with NMME models





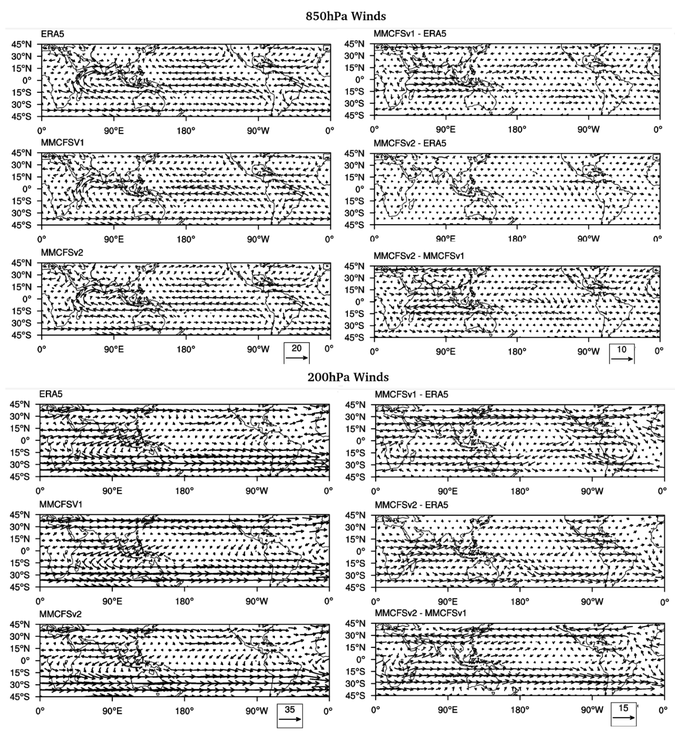
4. Teleconnections

Correlation between Nino 3.4-Rainfall (left), and ISMR-global SST anomalies (right) (a) Observations (ERSST), (b) MMCFSv1, (c) MMCFSv2. The hatching shows statistical significant at 95



5. Winds

JJAS climatological mean winds (m/s) 850 and 200 hPa (a) ERA5 (b) MMCFSv1 (c) MMCFSv2, and bias (d) MMCFSv1-ERA5 (e) MMCFSv2-ERA5, and (f) Difference between MMCFSv2 and MMCFSv1.



6. Summary

- MMCFSv2 model has been deployed at IITM to replace the currently operational MMCFSv1. MMCFSv2 brings in a substantial number of component upgrades over the MMCFSv1.
- MMCFSv2 shows improvements in many large scale meteorological features over MMCFSv1. MMCFSv2 improves the phase skill (anomaly correlation coefficient) of the interannual variation of ISMR by 17% and enhances the amplitude skill (Normalized Root Mean Square Error) by 20%.
- MMCFSv2 shows improved teleconnections of ISMR with the equatorial Indian and Pacific oceans.

Reference - Monsoon Mission Coupled Forecast System Version 2.0: Model Description and Indian Monsoon Simulations, Deepeshkumar Jain, Suryachandra A. Rao, Ramu Dandi, Prasanth A. Pillai, Ankur Srivastava, Maheswar Pradhan, GMD, 2023 (Under Review) - https://doi.org/10.5194/gmd-2023-53