सत्यमेव जयते

Ministry of Earth Sciences

Next Generation Monsoon Mission Coupled Model (MMCFS-v2): Indian Summer Monsoon simulation and Prediction

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Geoscientific Model Development

Monsoon Mission Coupled Forecast System version 2.0: model description and Indian monsoon simulations

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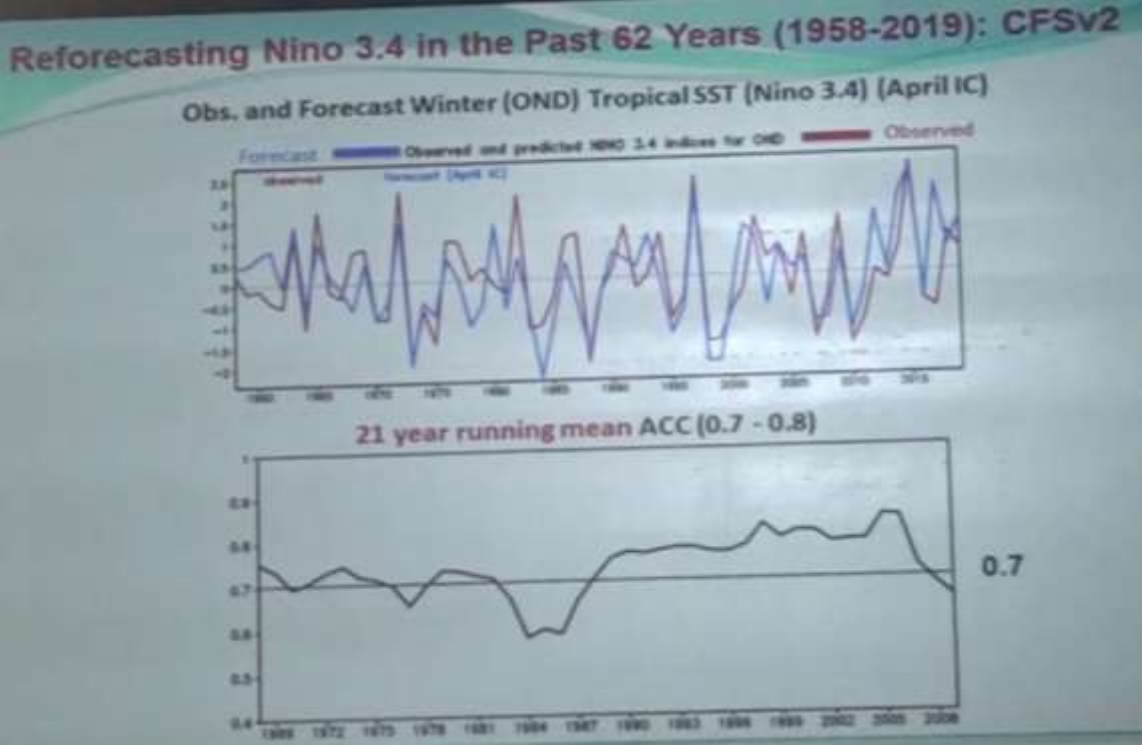
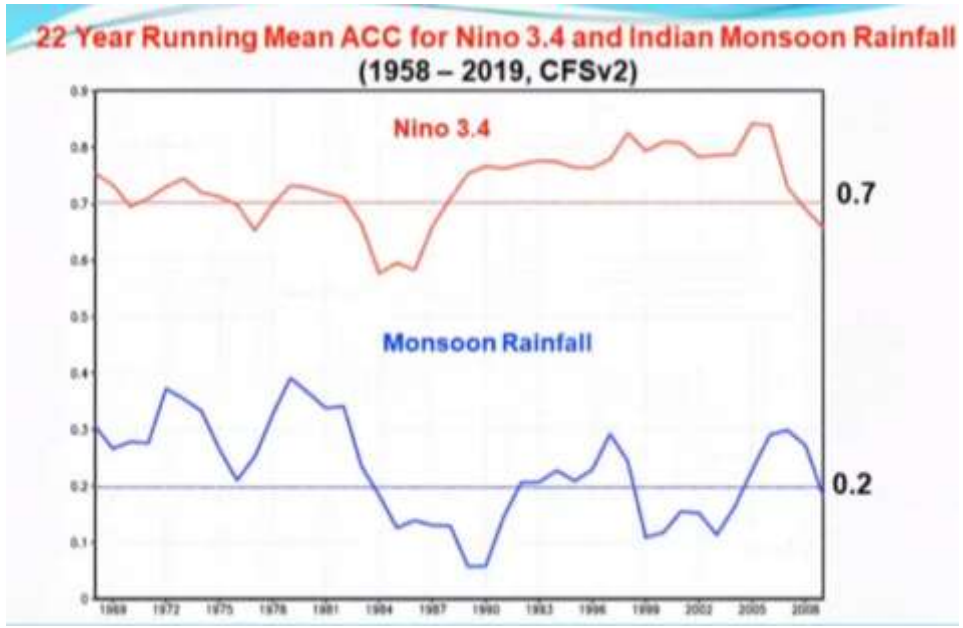
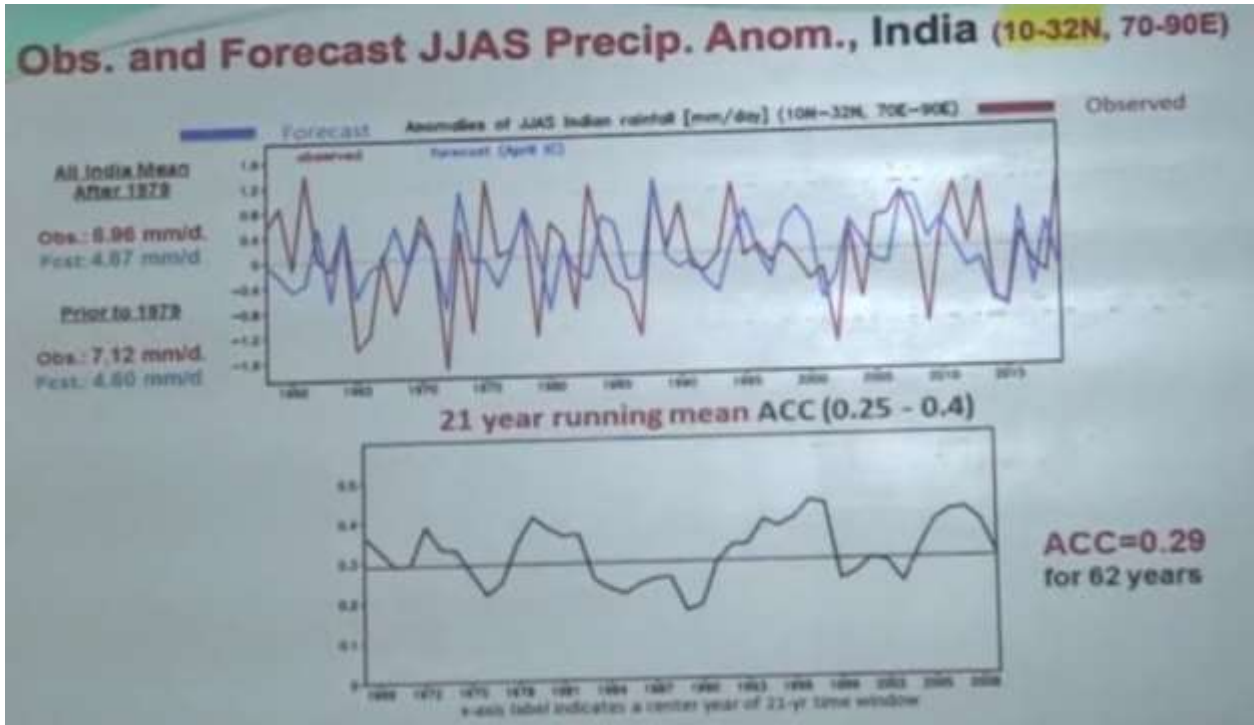




Source: Shukla, J
IITM Diamond Jubilee Lecture



Model: NCEP CFS, T126 AGCM and 0.25 OGCM in tropics

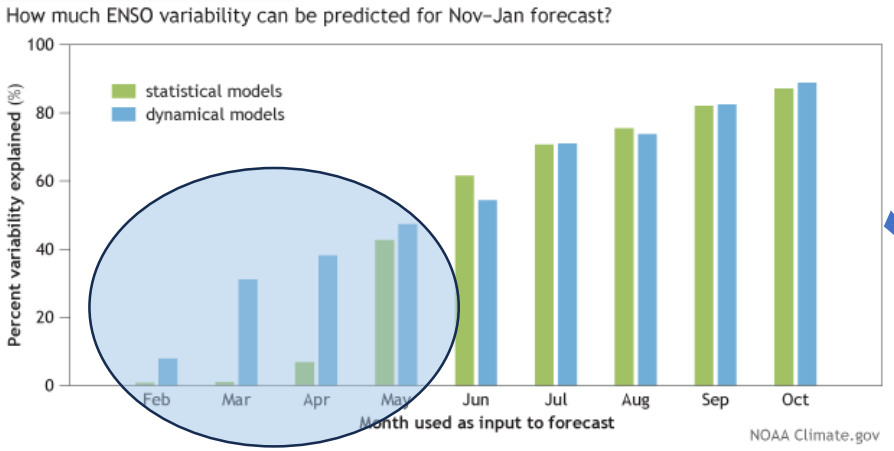
ENSO Prediction Skill over time in SEAS5

Correlation between % rainfall anomaly (JJAS) and detrended Niño3.4 SST anomaly (JJAS) over the four homogeneous zones of India during the two periods.

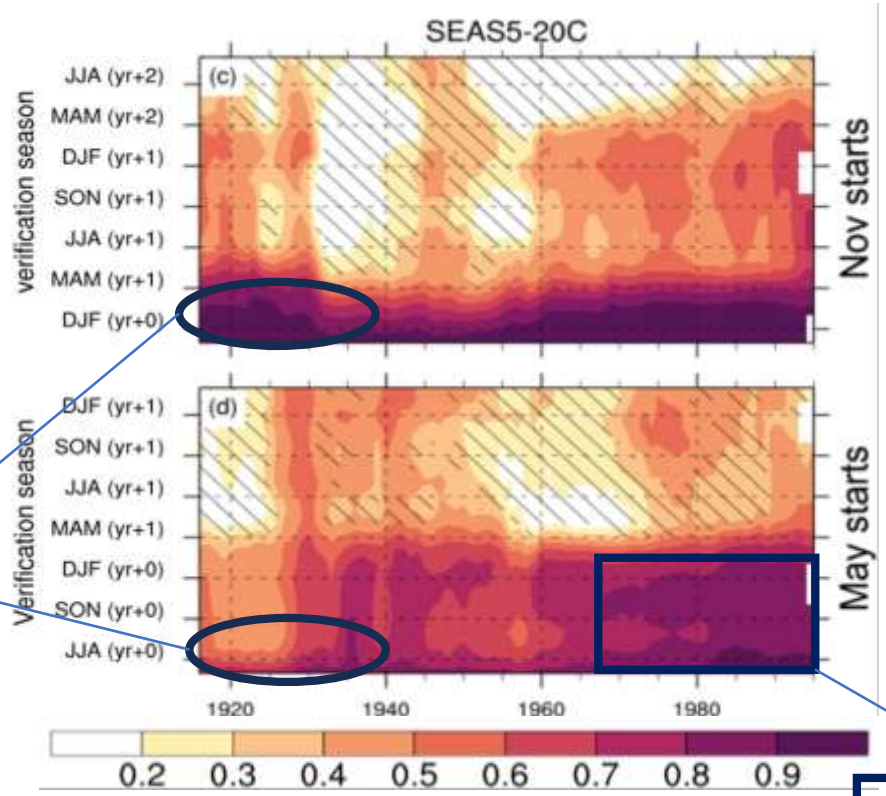
	1961–1990	1991–2020
North-West India	-0.71*	-0.34
Central India	-0.51*	-0.20
North-East India	-0.17	-0.13
South Peninsular India	-0.58*	-0.42*
All India	-0.65*	-0.41*

*Statistically significant correlation values with 95% confidence level.

Sharma et al (2023)



Spring Predictability Barrier



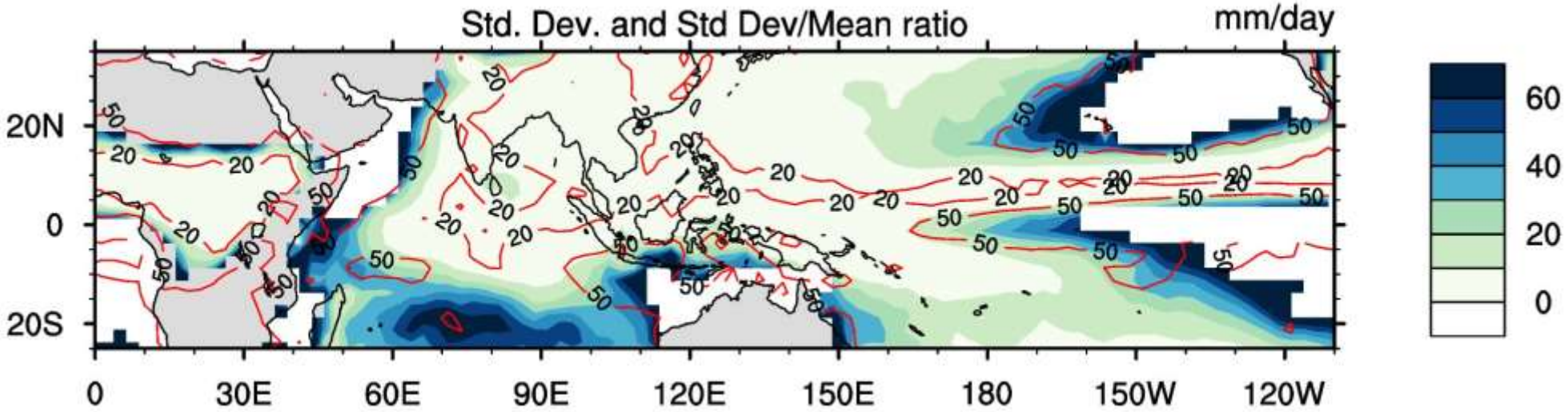
TOGA/TAO Period

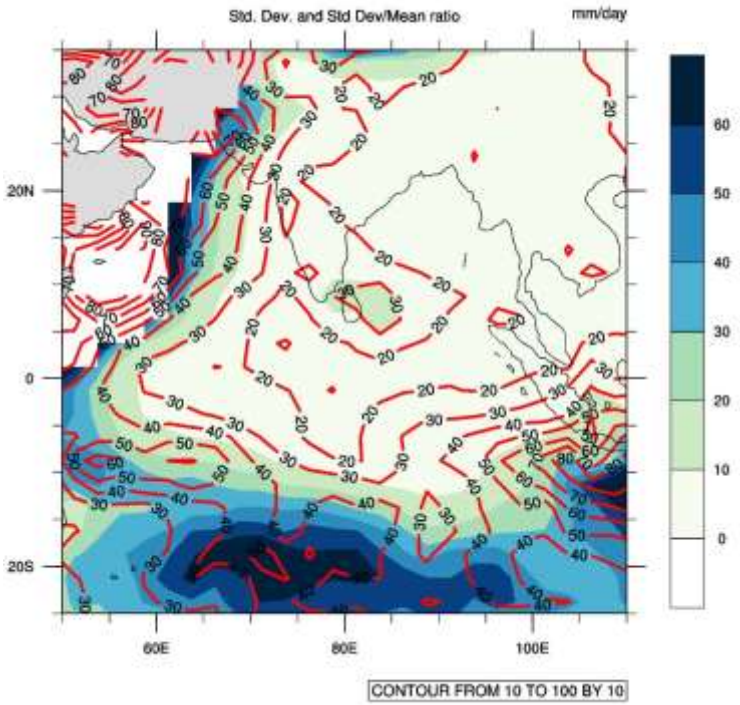
Lou et al (2023)

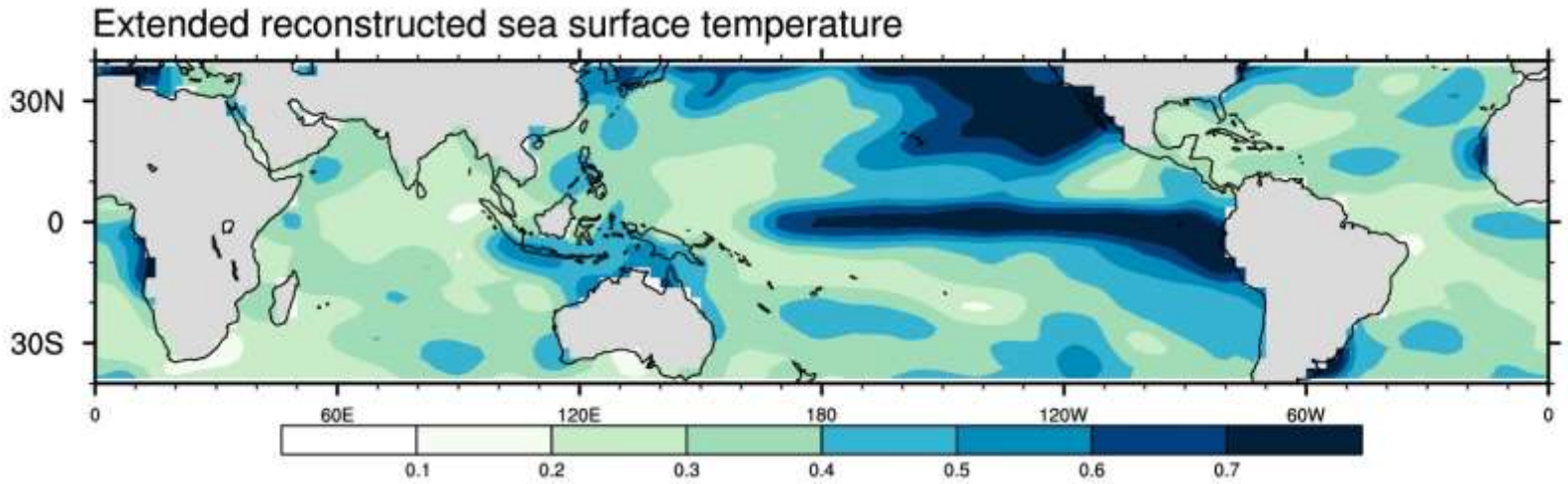
Challenge# 1: Monsoon Forecasts needs to initialized in spring (Despite of strong association with ENSO)

Resolution: AGCM: 50 km, OGCM:110 km

Challenge#2: Low variability both in SST/Rainfall







Challenge #3 Overestimation of ENSO-ISMR relationship in the coupled model

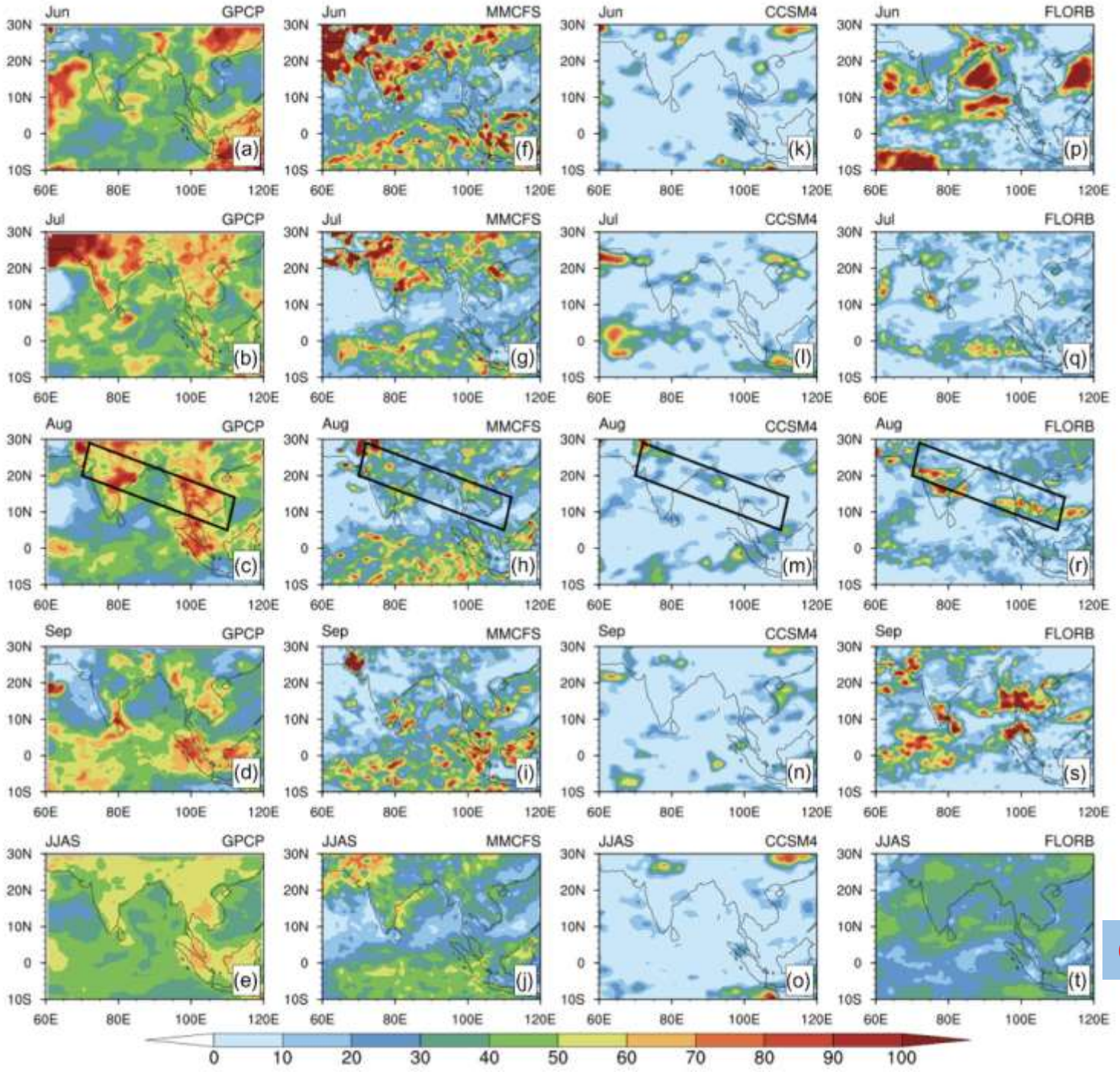
a) Observations					
Correlation coefficient between ISMR and SST indices	June	July	Aug	Sep	JJAS
Niño 1+2	-0.36	-0.21	0.18	-0.16	0.03
Niño 3	-0.3	-0.45	0.01	-0.41	-0.3
Niño 3.4	-0.23	-0.48	-0.03	-0.53	-0.42
Niño 4	-0.2	-0.27	-0.04	-0.54	-0.35
EMI	0.1	-0.11	-0.14	-0.43	-0.34
IOD	0.08	0.05	0.22	-0.19	0.03
East IOD	-0.43	-0.02	-0.3	0.15	0.08
West IOD	-0.28	0.05	-0.04	-0.11	0.13

b) MMCFS					
Correlation coefficient between ISMR and SST indices	June	July	Aug	Sep	JJAS
Niño 1+2	-0.39	-0.7	-0.77	-0.69	-0.81
Niño 3	-0.25	-0.69	-0.72	-0.67	-0.74
Niño 3.4	-0.2	-0.64	-0.66	-0.64	-0.68
Niño 4	-0.23	-0.61	-0.64	-0.61	-0.68
EMI	0.21	-0.13	-0.49	-0.54	-0.34
IOD	-0.5	-0.42	-0.63	-0.6	-0.63
East IOD	0.28	0.12	0.43	0.51	0.34
West IOD	-0.19	-0.33	-0.39	-0.38	-0.34

Table 1: Correlation coefficient of ISMR and SST anomalies for different indexes of Observations (a) , MMCFS (b)model.

Challenge #3 underestimation of IOD-ISMR relationship

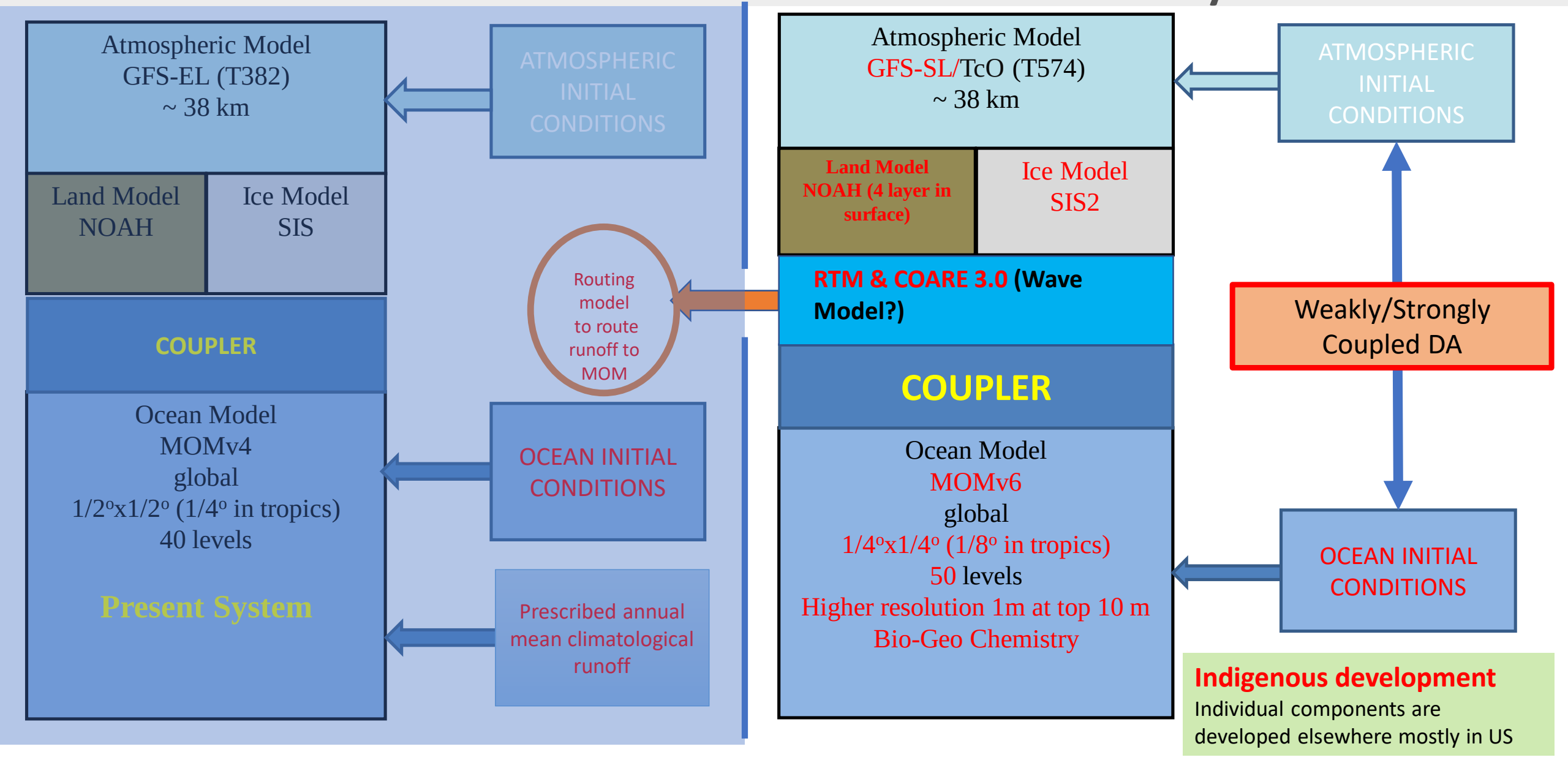
From: Renu S. Das



Ratio of synoptic scale (2–10 days band pass filter) variance to total variance in GPCP for June (a), July (b), August (c), September (d), and JJAS (e). f–j is similar to (a–e) but for MMCFS, k–o is CCSM4 and (p–t) is similar as (a–e) but for GFDL-FLORB (values are given in percentage)

Challenge#4: Getting reasonable Synoptic variability

MMCFS: Next Generation Seasonal Prediction System



Borrowed from NCEP/COLA

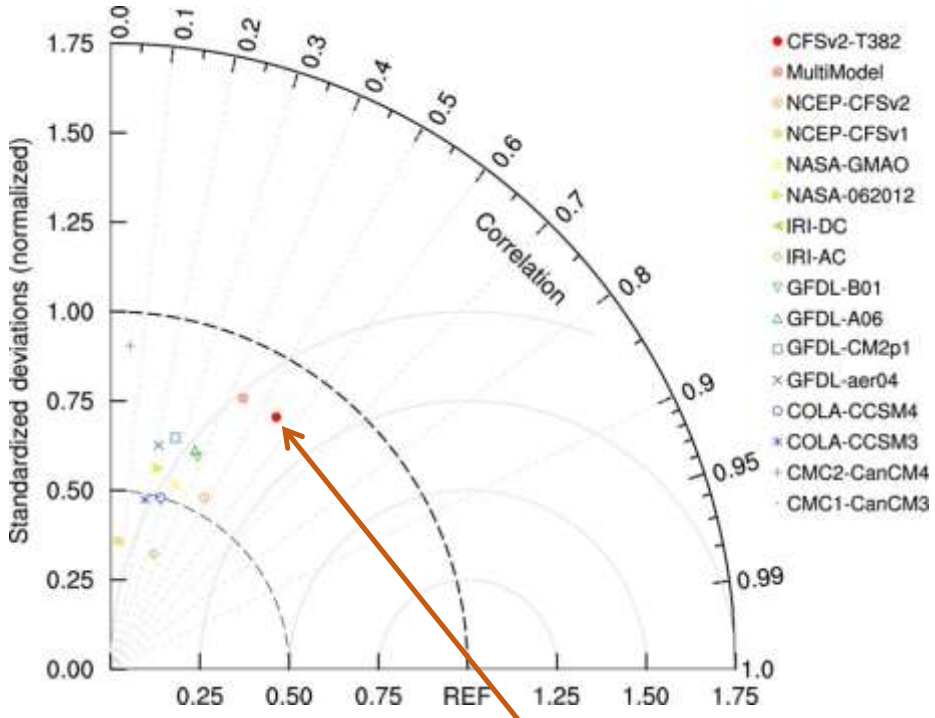
Jain et al (2024), Ankur et al (2022) and Pradhan et al (2022)

Major Changes to MMCFS V2

Table 1. Major changes to model components between MMCFSv1 and MMCFSv2.

Model/component	Atmosphere (resolution)	Ocean (resolution)	Ice model	Land model	References
MMCFSv1	GFS-EL (T382, ~38 km)	MOM4p0d (0.5 × 0.25 between 10° S–10° N)	SIS sea ice	NOAH-LSM	Moorthi et al. (2001) Griffies et al. (2004) Winton (2000) Ek et al. (2003)
MMCFSv2	GFS-SL (T574, ~38 km)	MOM6 (0.25 × 0.25 between 10° S–10° N)	CICE5	NOAH-LSM	Sela (2010) Adcroft (2016) Hunke et al. (2015) Ek et al. (2003)
Parameterizations	Cumulus	Ocean vertical grids	Ocean physical closures		
V1	SAS	Fixed (B stencil)	Non-scale aware		
V2	New SAS	Arbitrary Lagrangian Eulerian (C stencil)	Scale-aware parameterizations		
Horizontal grid size					
V1	1152 × 576	720 × 410	720 × 410	1152 × 576	
V2	1152 × 576	1440 × 1080	1440 × 1080	1152 × 576	

Skill of the Models (During Monsoon Mission)



Pillai et al. (2018)

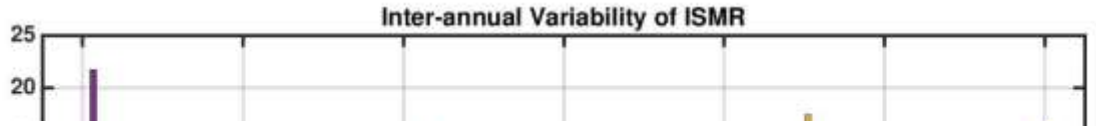
Year	Stat*		Dynamical*		Actual	MMCFS1 (APR IC)	MMCFS2 (APR IC)
	1st Stage*	2nd Stage*	1st stage	2nd Stage			
2011	*98*	95	106		102	*97*	*107*
2012	*99*	96	100	104	93	85	102
2013	98	98	104	108	106	*102*	99
2014	*95*	93	96	96	88	*87*	*86*
2015	93	88	91	86	86	*91*	77
2016	106	106	111	112	97	117	103
2017	*96*	98	96	100	95	*100*	89
2018	97	97	99	105	91	110	*93*
2019	96	96	94	97	110	104	98
2020	100	102	104	107	109	*114*	*113*
2021	*96*	103	114		99	114	108
2022	99	103	116		106	116	*106*
2023	*96*	96			94	*93*	*90*
NRMSE	0.91	0.82	1.17	1.20		1.26	0.84
Skill	0.33	0.53	0.43	0.45		0.56	0.74

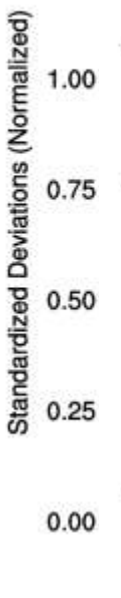
Monsoon Mission Model Performance (Prediction Skill as well as interannual variance) is better than other models for Indian Monsoon.

Skill=Correlation between Observed and Predicted anomalies

*Source: IMD End of Season Reports

Interannual Variability of ISMR and Model Skill





Teleconnection (with ISMR)	Niño 3.4	EIOD	AMM	AZM
– Observations	**–0.64**	–0.04	0.18	0.19
– MMCFSv2	**–0.75**	0.33	–0.07	**0.46**
– MMCFSv1	**–0.83**	**0.68**	0.35	0.08

Skill	Niño 3.4	EIO	AMM	AZM
– MMCFSv2	**0.83**	**0.42**	0.15	0.32
– MMCFSv1	**0.82**	**0.58**	0.01	0.13

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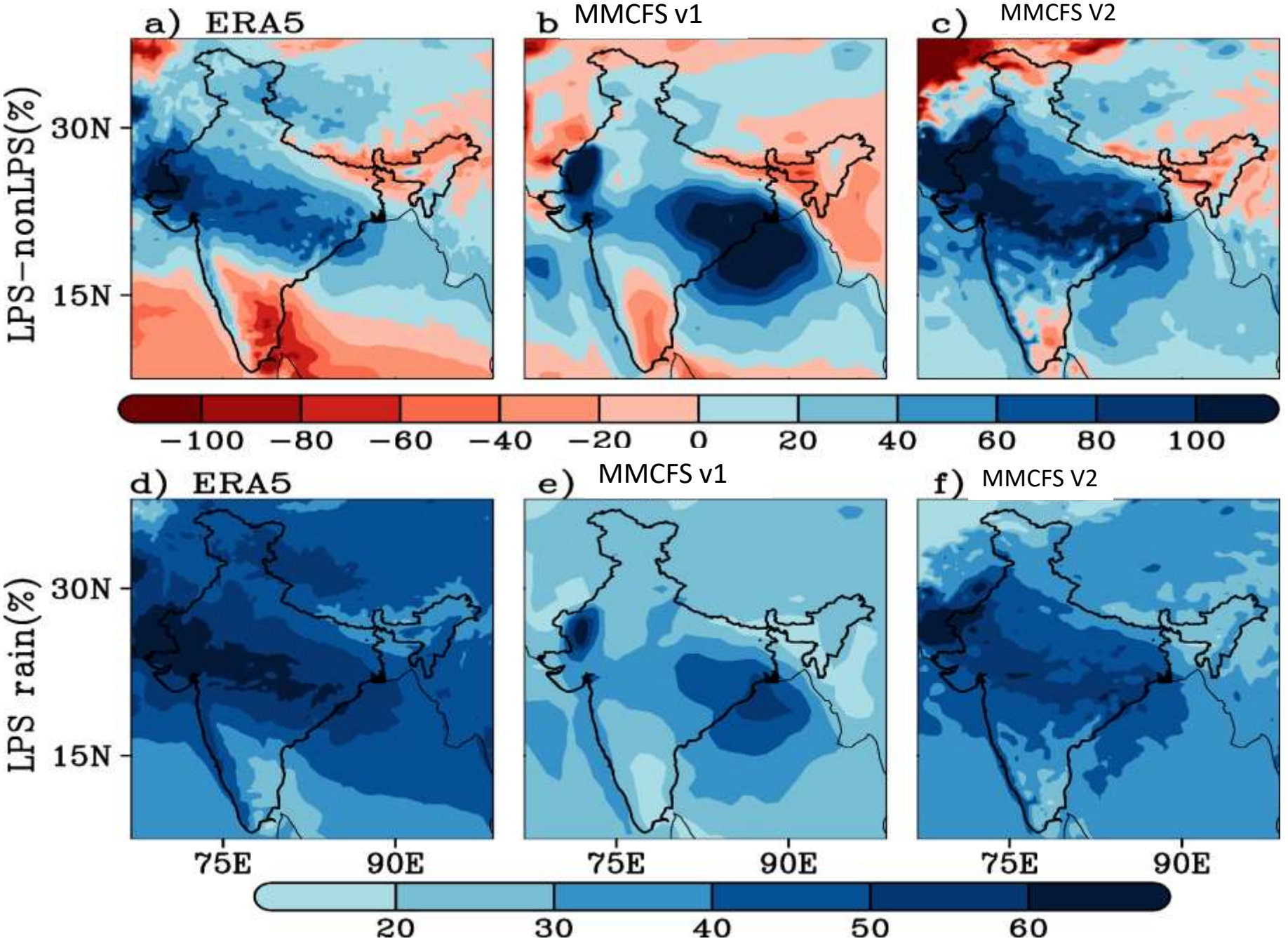
- Higher skill of 0.72 over 0.55 of MMCFSv1 (~ 30% improvement) when GPCP is considered as observation.

vs GPCP			-1.04	0.72	7.01%	0.82
MMCFSv1	5.67	0.59				
vs IMD			-1.34	0.58	8.74%	1.0
vs GPCP			-1.32	0.55	8.99%	1.06

Deepesh et al. (2024)

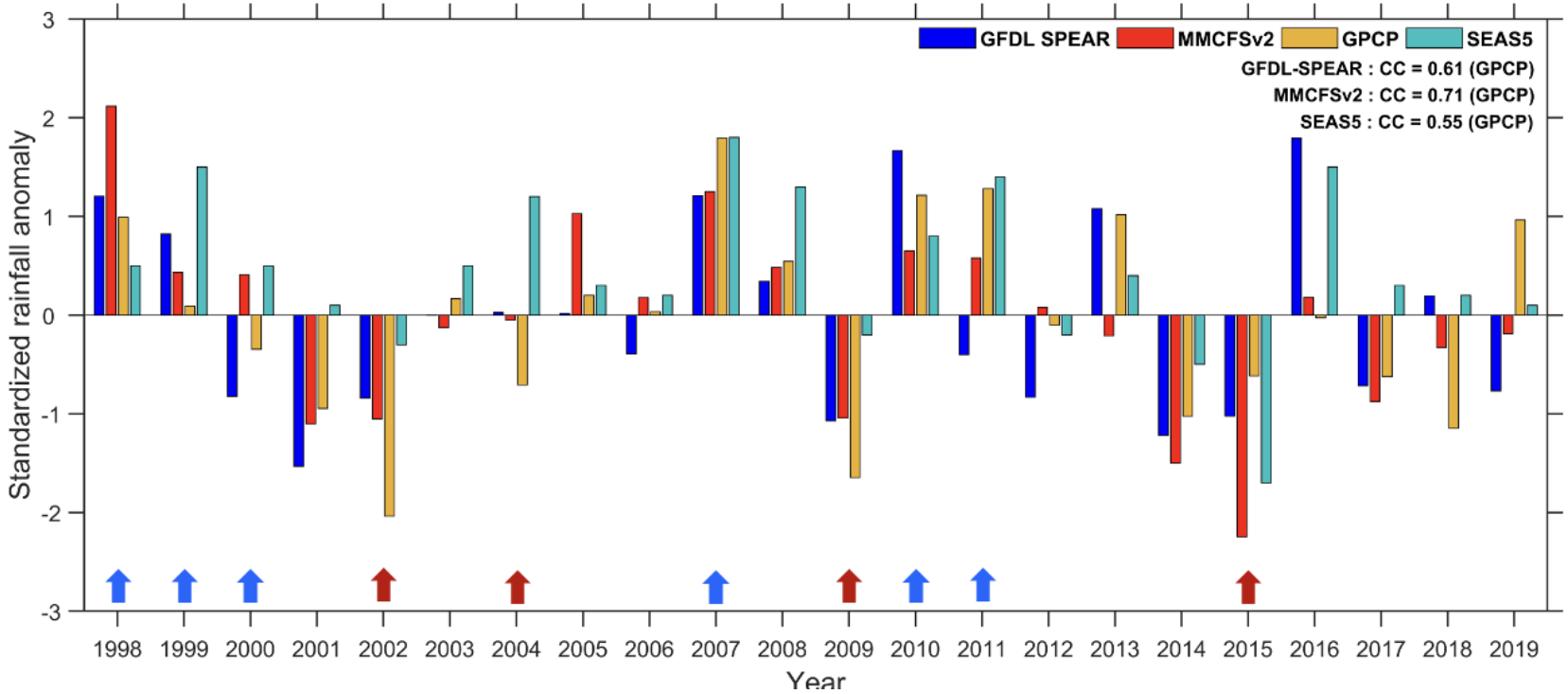
Total precipitation



Improved LPS

Skill of ISMR from Next Generation Models from GFDL, ECMWF and IITM

Model	MMCF Sv2	SEAS5	SPEAR
AGCM	38 km	36 km	50 km (O) 25 km (R)
OGCM (Tropics)	0.25°	0.25°	0.3°



Skill	Nino 3.4	EIOD	WIOD	DMI	AZM	AMM
SPEAR	0.61	0.39	0.34	0.25	0.13	0.30
MMCFSv2	0.85	0.34	0.62	0.27	0.35	0.46

IITM's MMCFSv2 is better in predicting the Indian Summer Monsoon and other drivers of Monsoon Rainfall

Suneeth et al. (2024)


Evaluation of forecast information
Discussions with farmers (ICRISAT)
THANK YOU