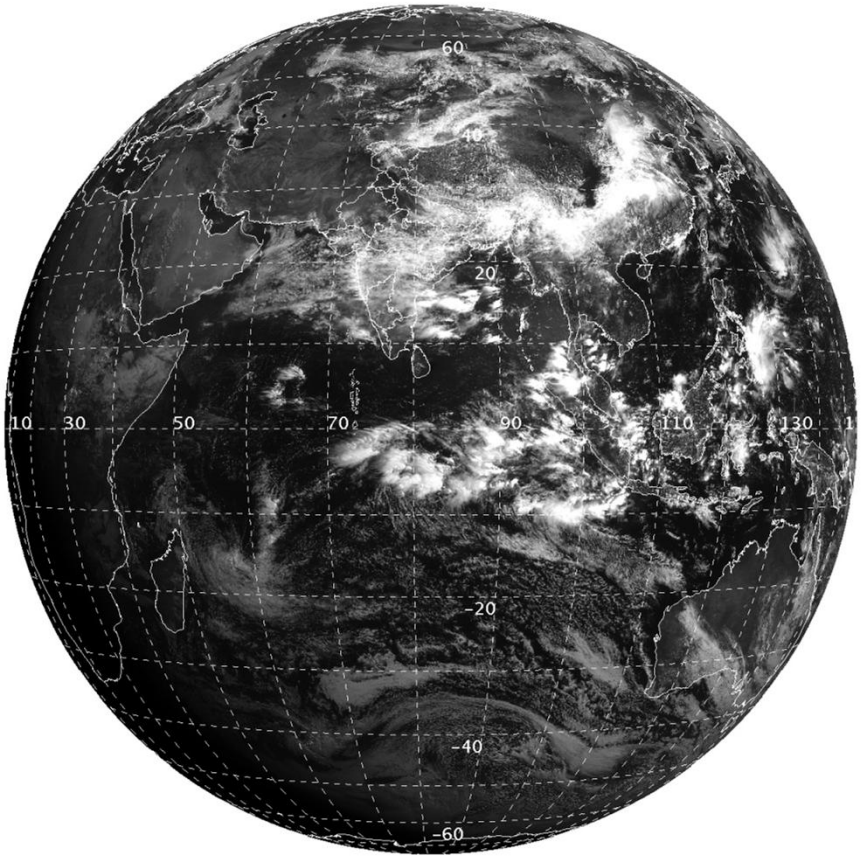
Monsoon Prediction: Seasonal



Suryachandra A. Rao & Group Members

Indian Institute of Tropical Meteorology

DEFINITIONS OF METEOROLOGICAL FORECASTING RANGES

1. Nowcasting
A description of current weather parameters and 0 -2 hours description of forecasted weather parameters

2. Very short-range weather forecasting
Up to 12 hours description of weather parameters

3. Short-range weather forecasting
Beyond 12 hours and up to 72 hours description of weather parameters

4. Medium-range weather forecasting
Beyond 72 hours and up to 240 hours description of weather parameters

5. Extended-range weather forecasting
Beyond 10 days and up to 30 days

6. Long-range forecasting
From 30 days up to two years

Two kinds of Atmospheric Predictability

Predictability of 1st kind

Originates from **Initial condition**

Deterministic forecast fails beyond two weeks due to the growth of errors contained in the initial states.

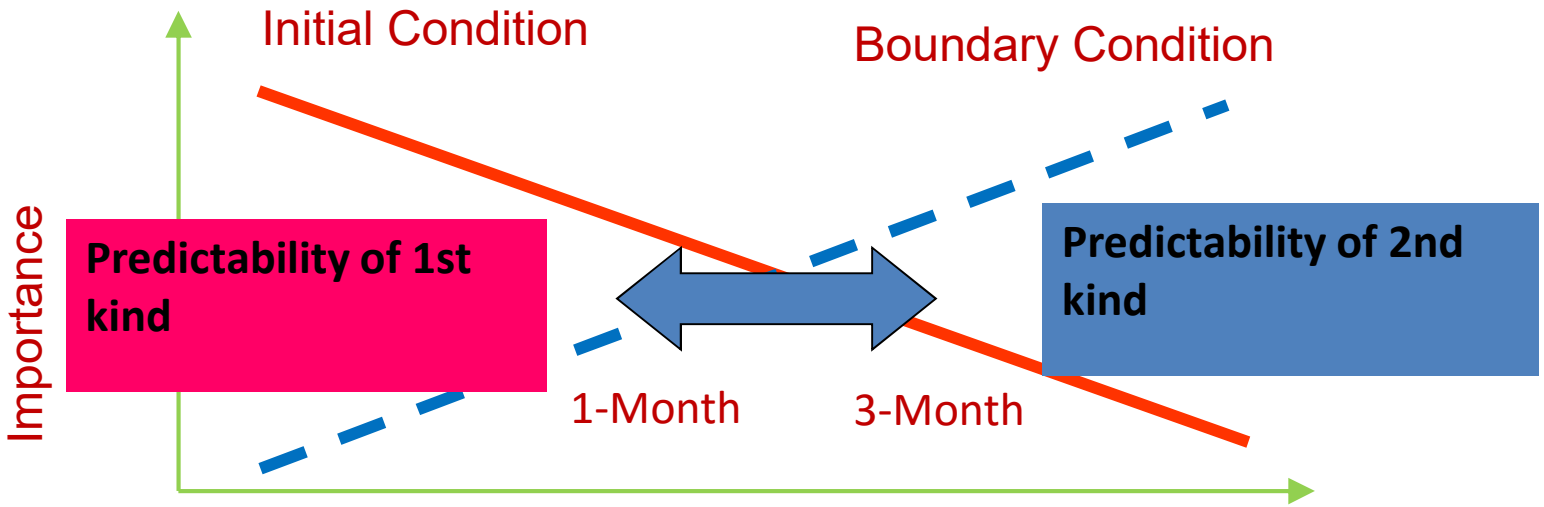
Chaotic behavior of atmosphere comes from its strong non-linearity.

Predictability of 2nd kind

Originates from **lower boundary condition**

Effective for longer time scale; Month to season

Relative importance of Initial Condition and Boundary Condition



Hour Day Week Month Season Year

Average Time Scale

Meso

Intra-seasonal Oscillation

Typhoon
Tropical disturbances

ENSO

Global Warming

Lower Boundary Condition of Atmosphere

◎ **Ocean**

Sea Surface Temperature (SST)

Sea Ice

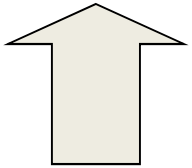
◎ **Land Surface**

Soil Temperature

Soil Moisture

Snow Cover, Snow Depth

Vegetation (Grass, Tree etc.)

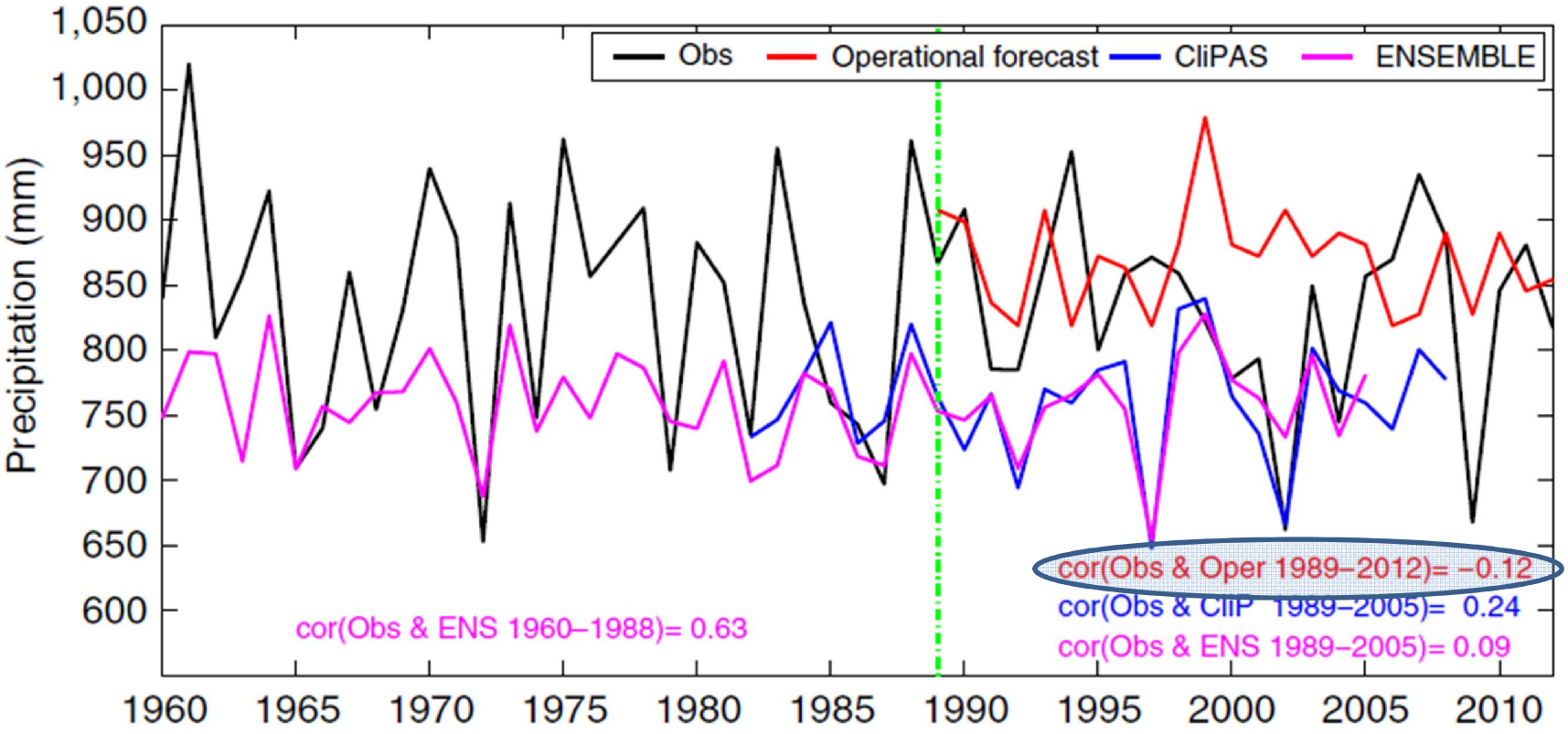


Most IMPORTANT to the atmospheric variability !

Walker's Contributions

- Sir Gilbert Walker made significant contribution to long range forecasting research.
- He introduced the correlation and regression techniques and objective models.
- His research for global predictors led to the discovery of Southern Oscillation and North Atlantic Oscillation.
- His regression methods have been more or less followed by IMD for the operational work.

IMD Operational Model Prediction Skill of ISMR



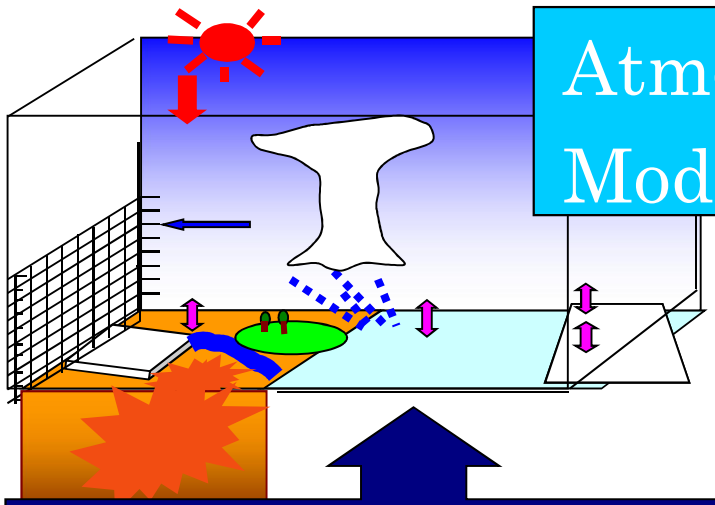
Wang et al., (2015; Nature Communications)

Two Methods for Numerical Seasonal Prediction

Past

Two-Tiered Way

Atomosphere-Land
Coupled Model



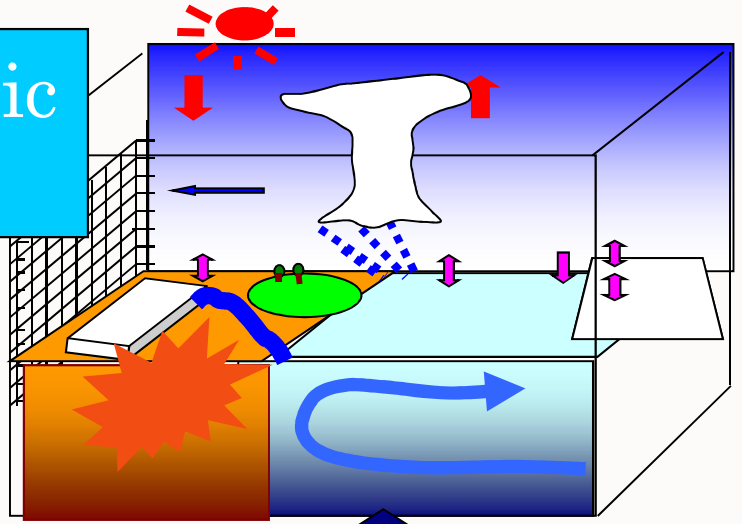
Atmospheric Model

Separately predicted SST
is prescribed as boundary

Present

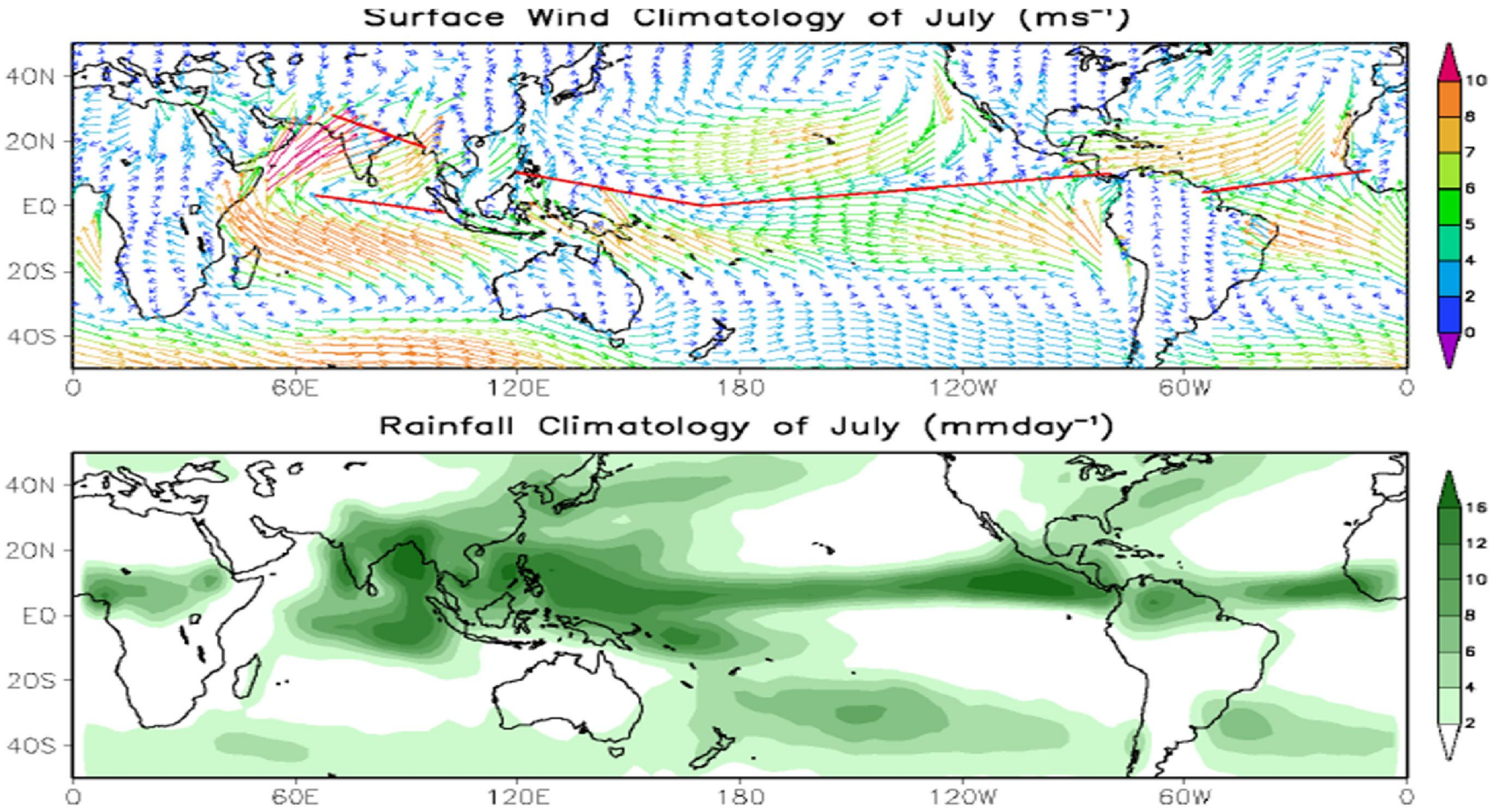
One-Tiered Way

Atmosphere-Land-Ocean Coupled Model

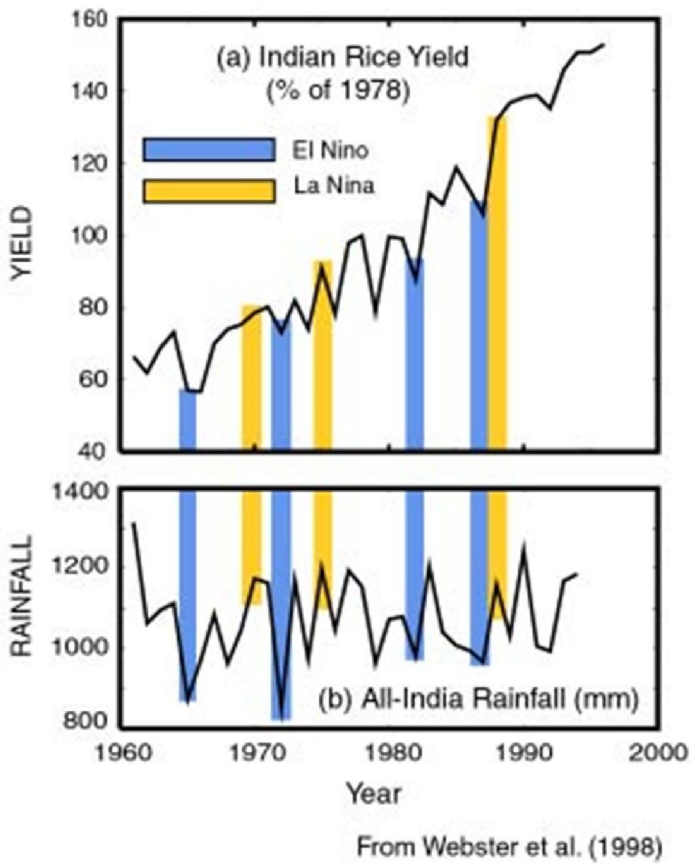


Ocean model is coupled

Monsoon


Surface Wind Climatology of July (ms⁻¹)
40N
20N
EQ
20S
40S
0
60E
120E
180
120W
60W
0
10
8
7
6
5
4
2
0
Rainfall Climatology of July (mmday⁻¹)
40N
20N
EQ
20S
40S
0
60E
120E
180
120W
60W
0
16
12
10
8
6
4
2

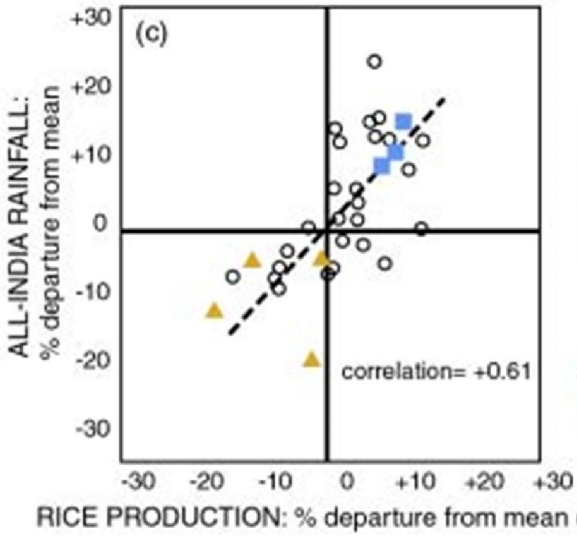
Indian Monson and Agriculture



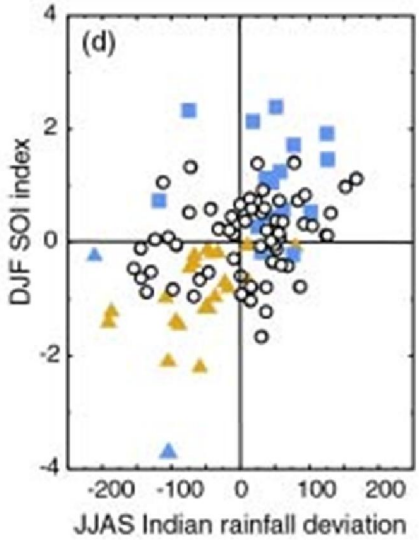
From Webster et al. (1998)

(a) The relationship between Indian rainfall and rice production from 1960 to 1996 relative to 1978 production.

(b) the All-India rainfall Index for the corresponding years:,



(c) linear regression plot. Yellow indicate El Nino years; blue indicate La Nina years.

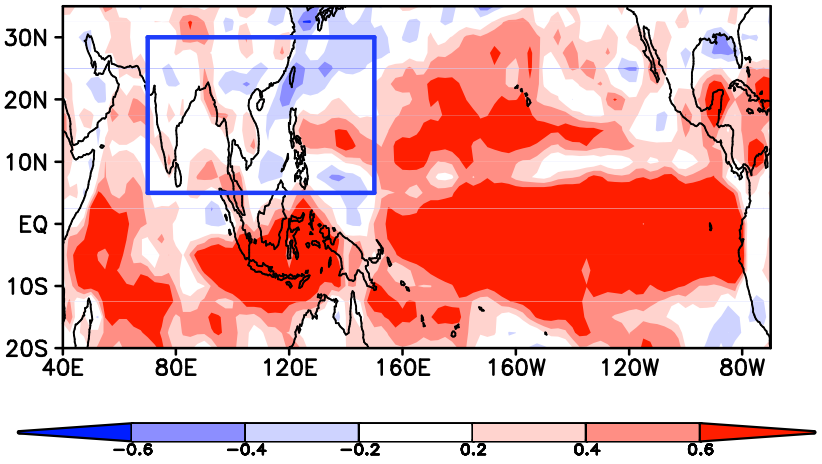


(d) Association of Indian rainfall and ENSO

Two-tier MME hindcast of summer Monsoon rainfall

Hindcast Skill is nearly Zero in ASM region

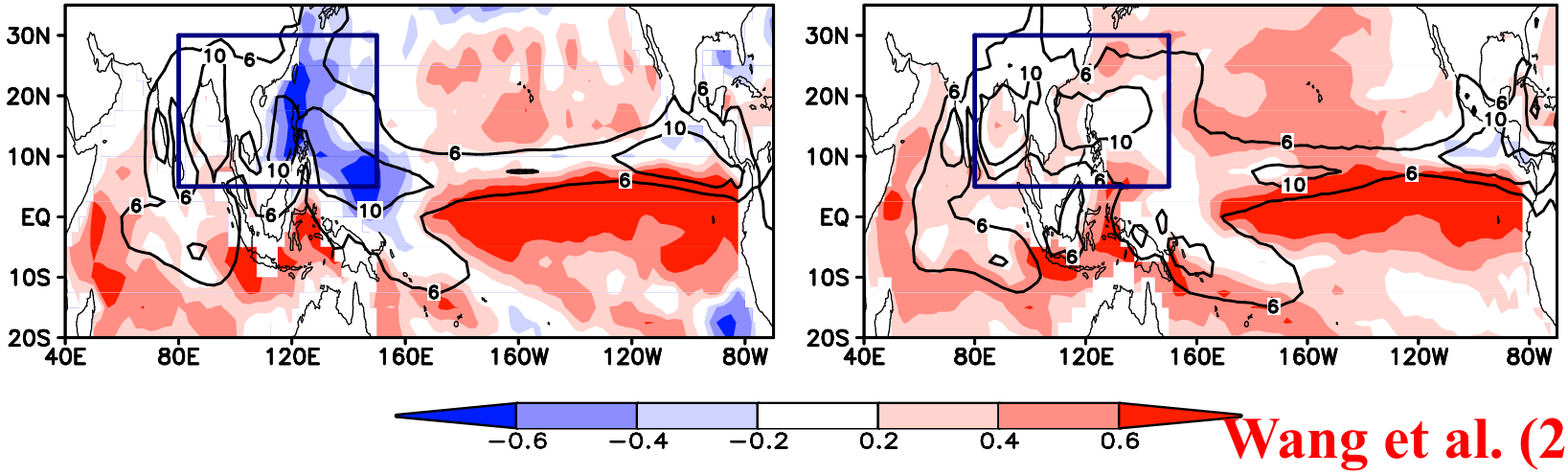
5-AGCM EM hindcast skill (21Yr)



- Two-tier system was unable to predict ASM rainfall.
- TTS tends to yield positive SST-rainfall correlations in SM region that are at odds with observation (negative).
- Treating monsoon as a slave to prescribed SST results in the failure.

OBS SST-rainfall correlation

Model SST-rainfall correlation

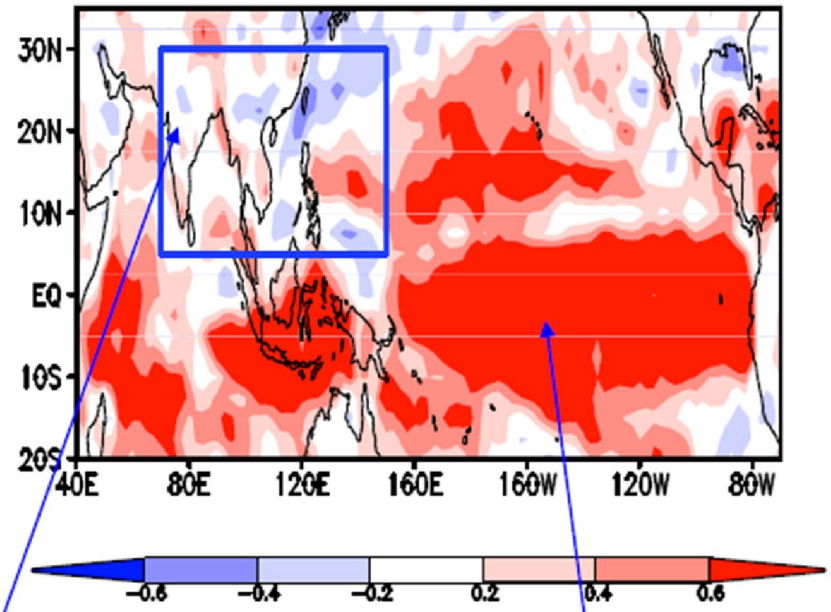


Wang et al. (2005)

STATE OF THE ART COUPLED MODELS PREDICTION SKILL (Correlation between observed and Predicted) OF TROPICAL PRECIPITATION (Prior to Monsoon Mission)

Earlier version models

1979-1999



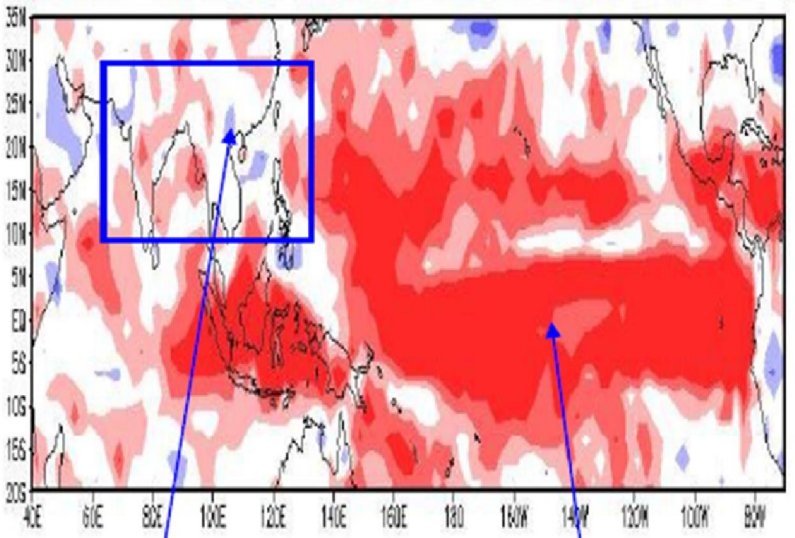
Poor skill

High skill

Preeti et al., (2009)

Latest models (ENSEMBLES)

1979-1999

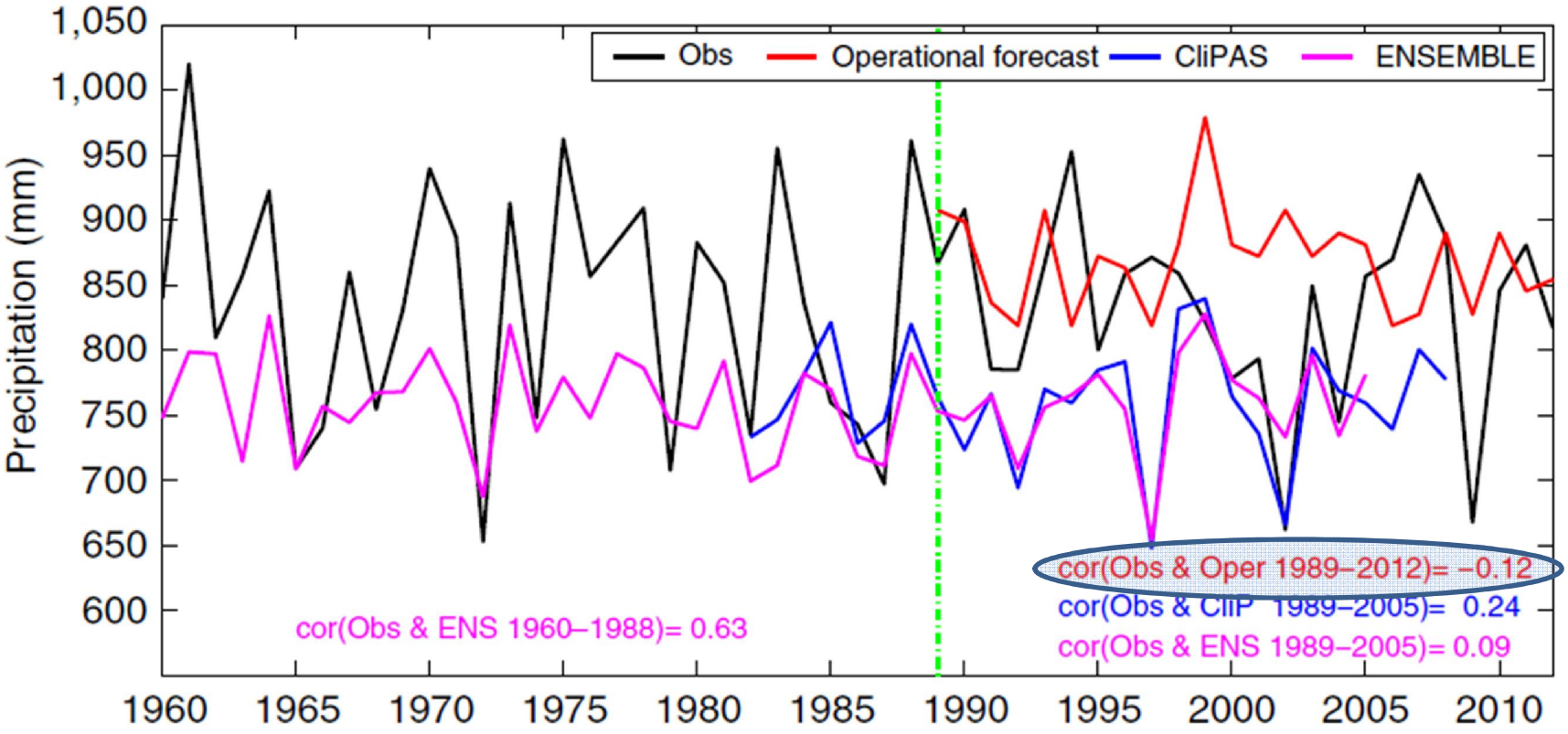


Improved skill

High skill

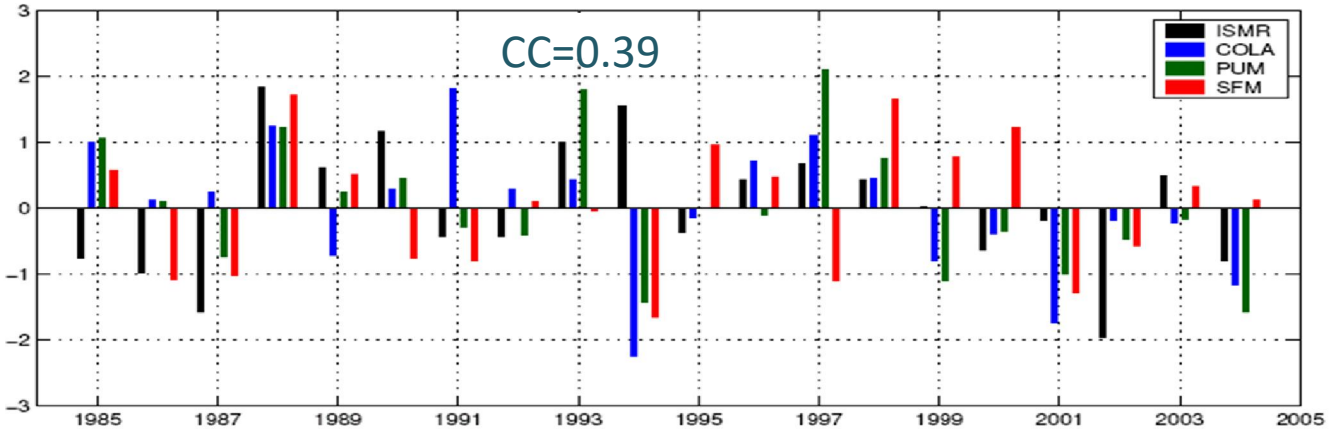
Rajeevan et al., (2011)

IMD Operational Model Prediction Skill of ISMR



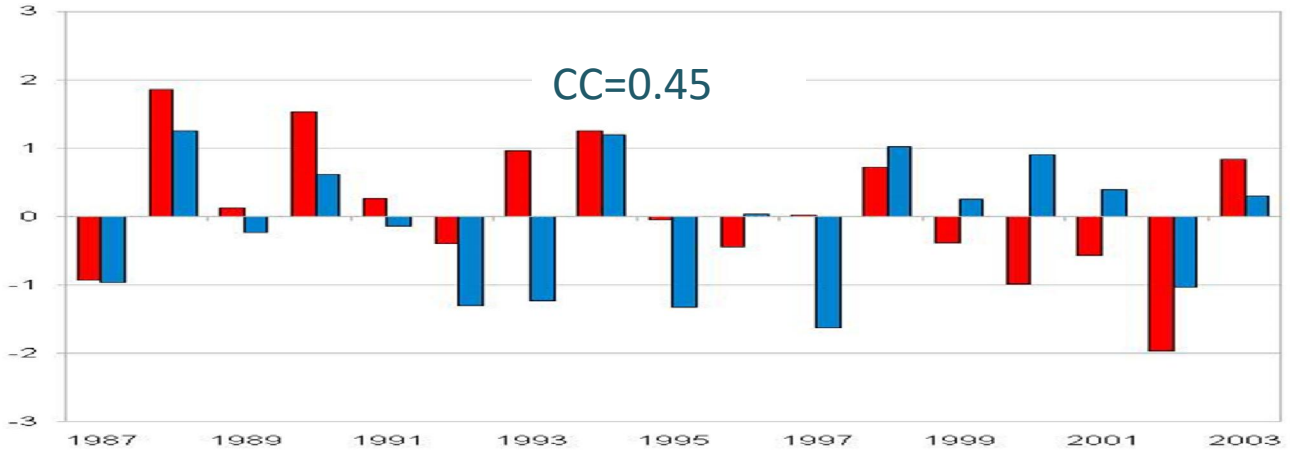
Wang et al., (2015; Nature Communications)

Dynamical AGCM
Potential Prediction Skill



Gadgil & Sreenivasan, (2012)

Dynamical CGCM
CFS Prediction Skill
(T62L64)



Rajeevan (Pers. Communication)
& Pattanaik and Arun Kumar (2014)

Major Biases in CFSv2

Main Biases:

Dry bias over India

Cold bias in SST

Cold land and trop. Temperature

Excess Eurasian snow

Excessive convective rainfall over tropics

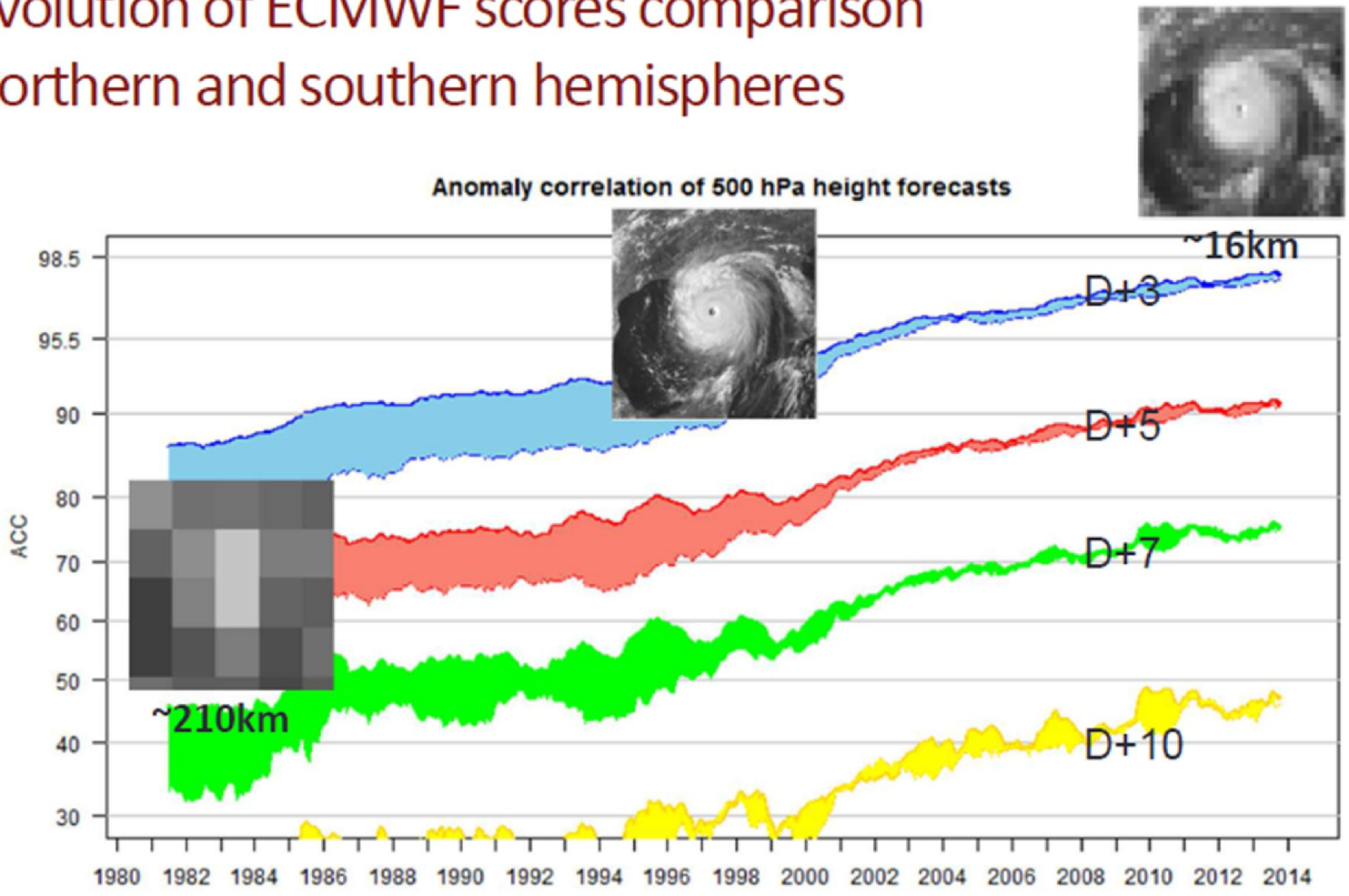
Saha et al., (2013)

Attempts to reduce these biases

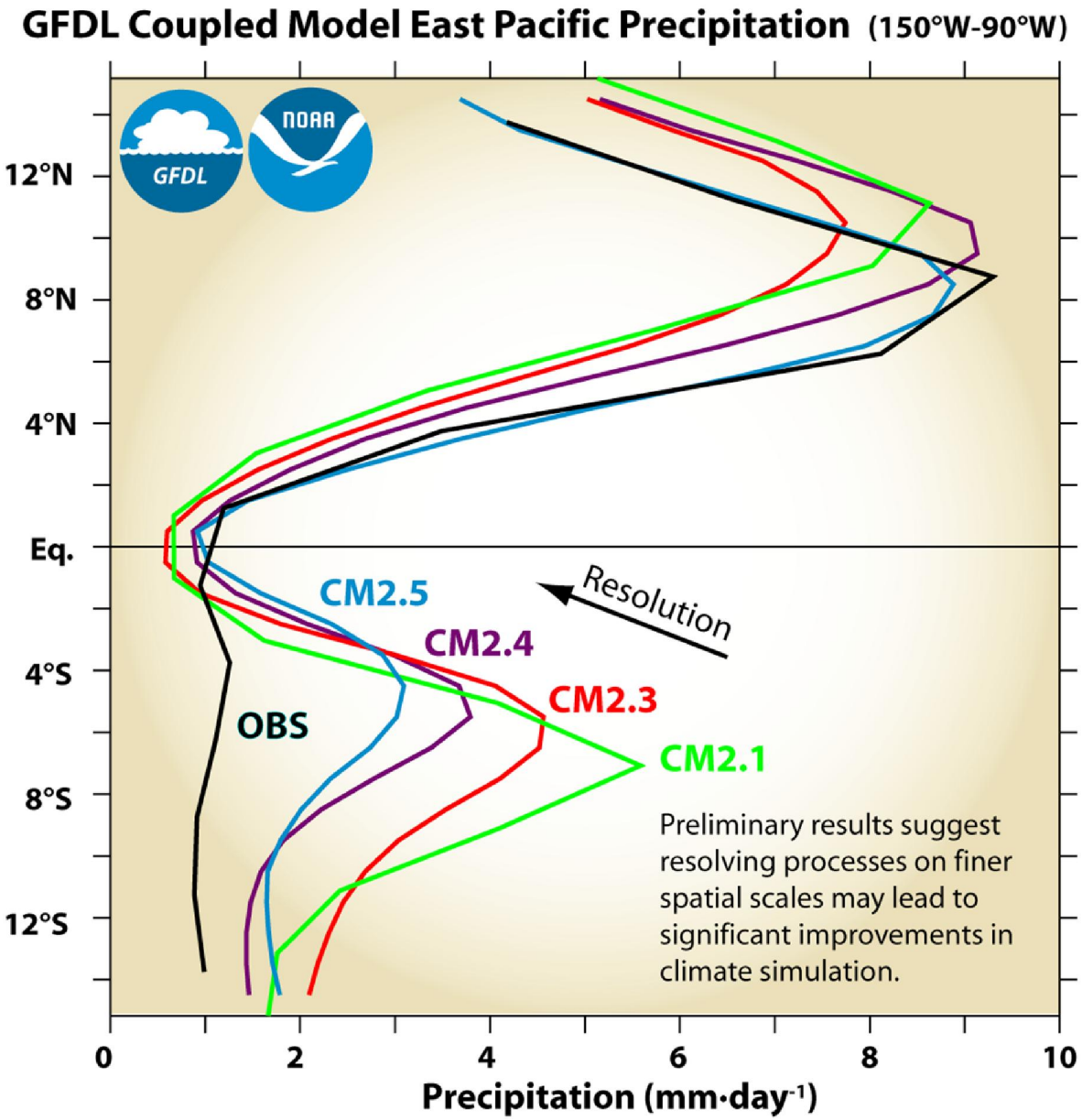
- Convective Parameterization (New SAS, Han & Pan, 2011; Ganai et al., 2014)
- Cloud Microphysics (Hazra et al., 2015; Abhik et al., 2016 communicated)
- Super Parametrization (Goswami et al., 2015)
- Improved snow physics in Land Surface Model Saha et al., (2016. to be submitted)
- High Resolution Model (Ramu et al., 2015)
- Stochastic Parametrization (in progress)
- New Ocean model (in progress)

Importance of High Resolution

Evolution of ECMWF scores comparison northern and southern hemispheres



Courtesy of ECMWF. Adapted and extended from Simmons & Hollingsworth (2002)



Observed rainfall

GFDL CM2.1
2° Atmosphere
1° Ocean

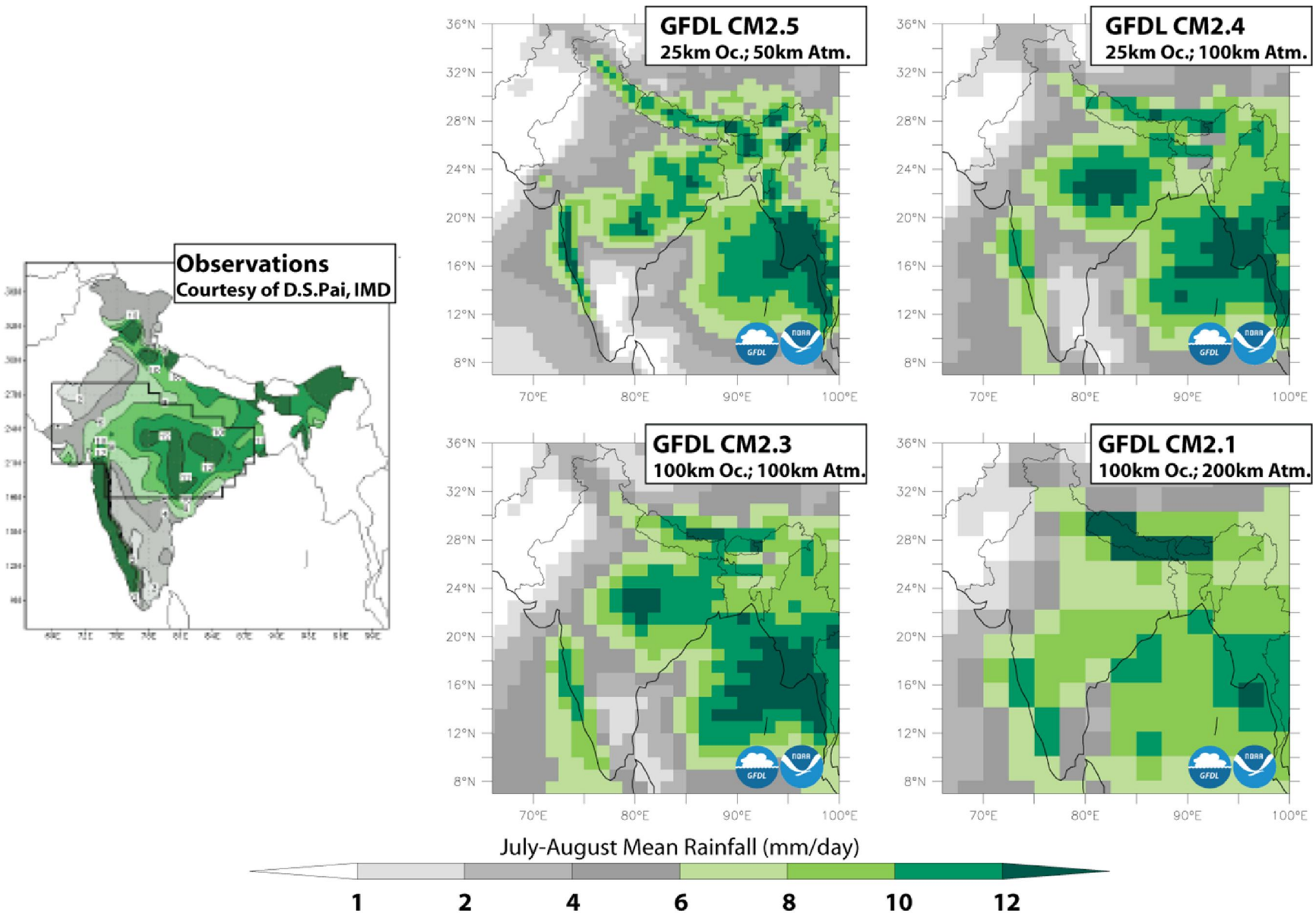
GFDL CM2.3
1° Atmosphere
1° Ocean

GFDL CM2.4
1° Atmosphere
1/4° Ocean

GFDL CM2.5
1/2° Atmosphere
1/4° Ocean

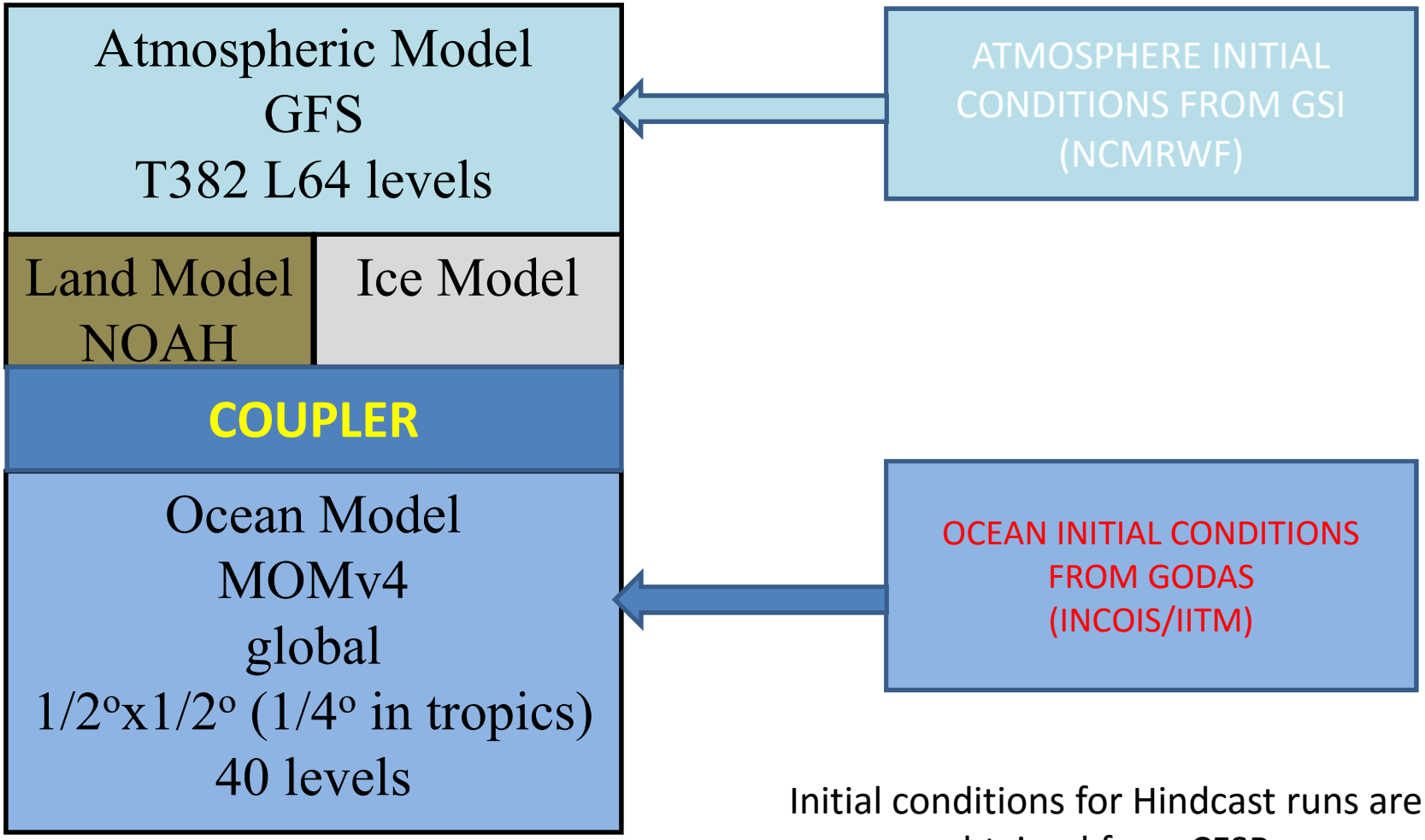
Courtesy: Gabriel Vecchi (GFDL)

Enhanced Resolution and Coupling Improve Monsoon Representation



Courtesy: Gabriel Vecchi (GFDL)

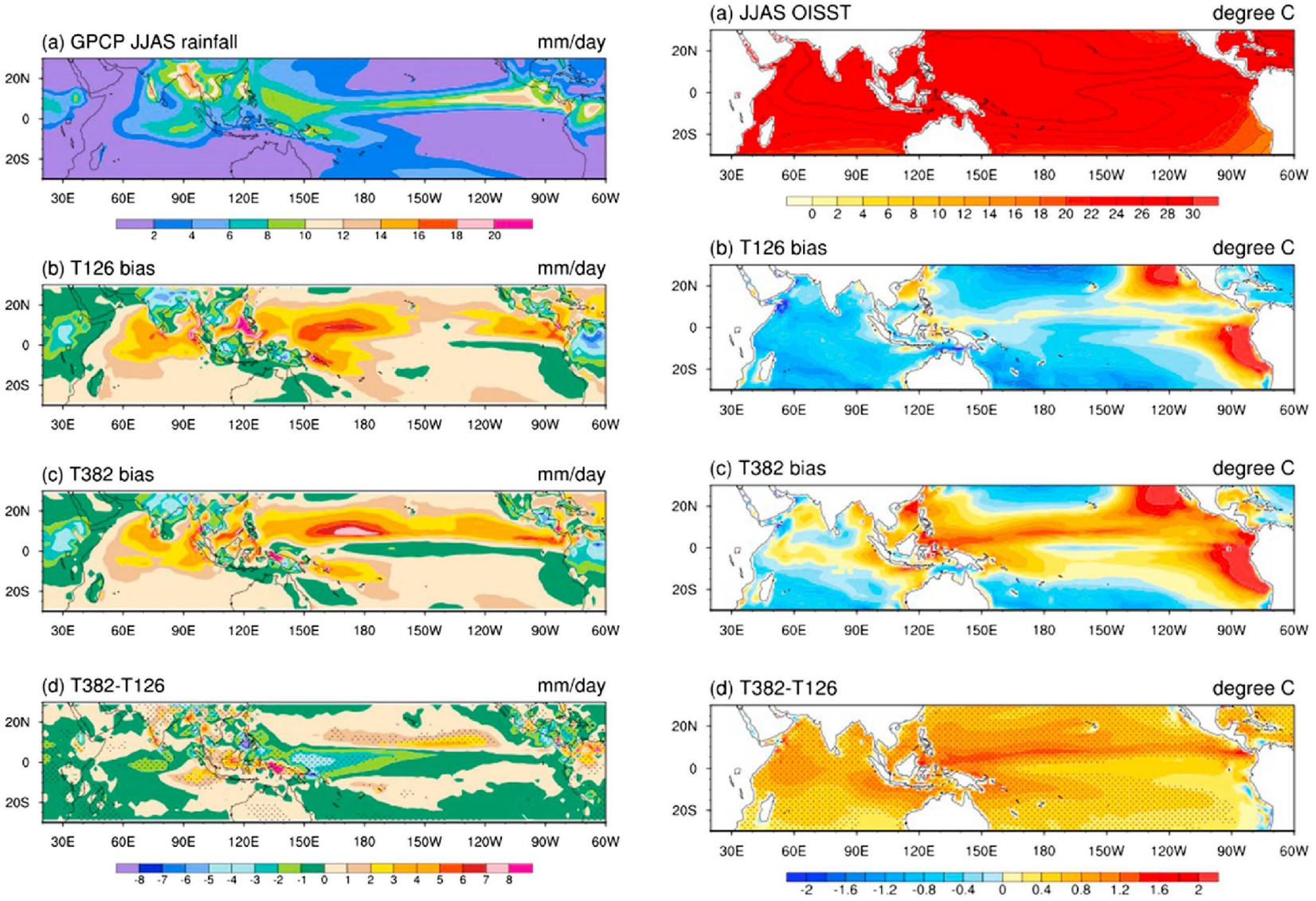
IITM CFS Model: Seasonal Prediction



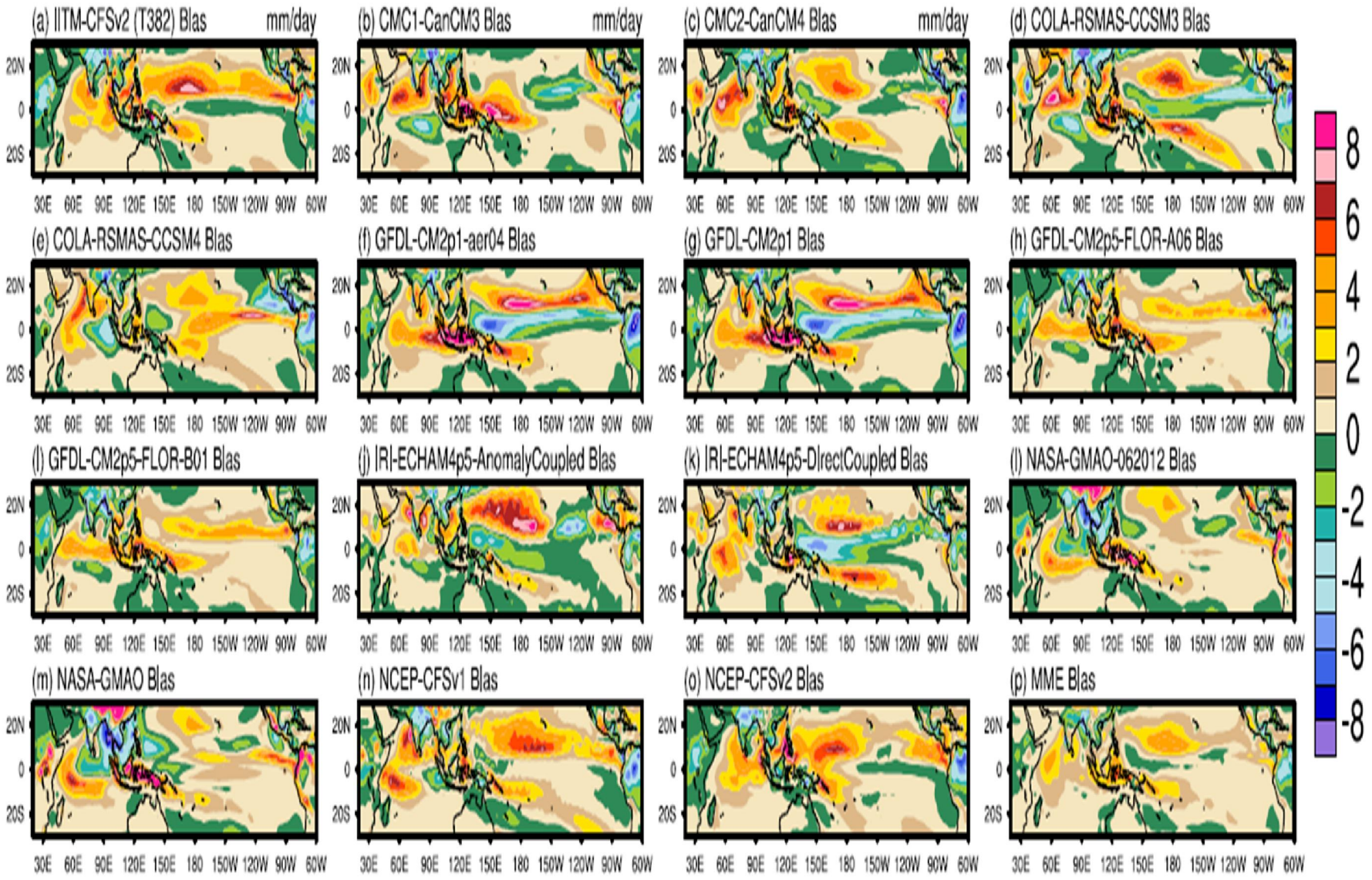
Initial conditions for Hindcast runs are obtained from CFSR

(Original model is adopted from NCEP)

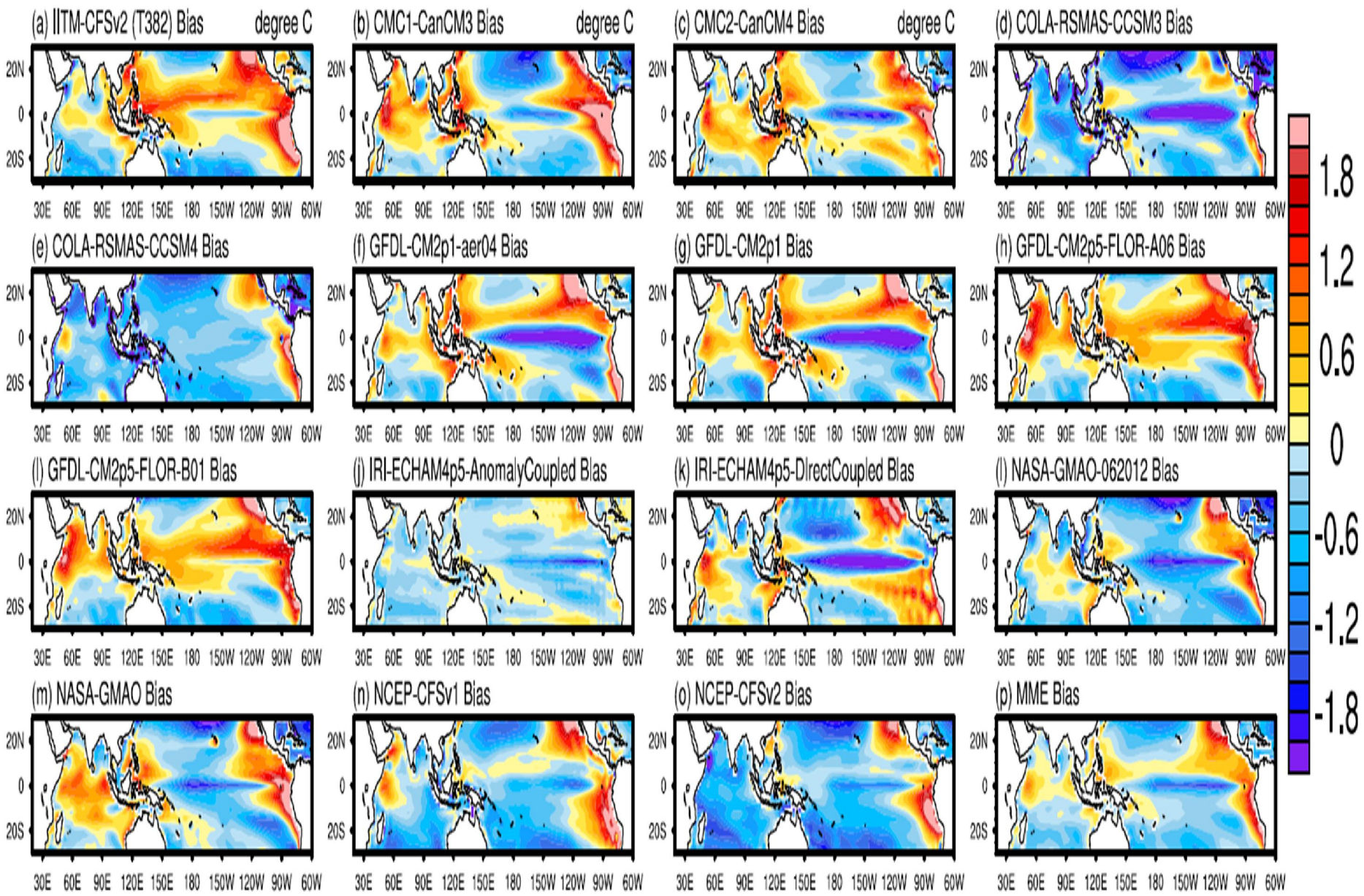
SST/Rainfall Bias in T126 and T382



Ramu et al., (2016, JGR)

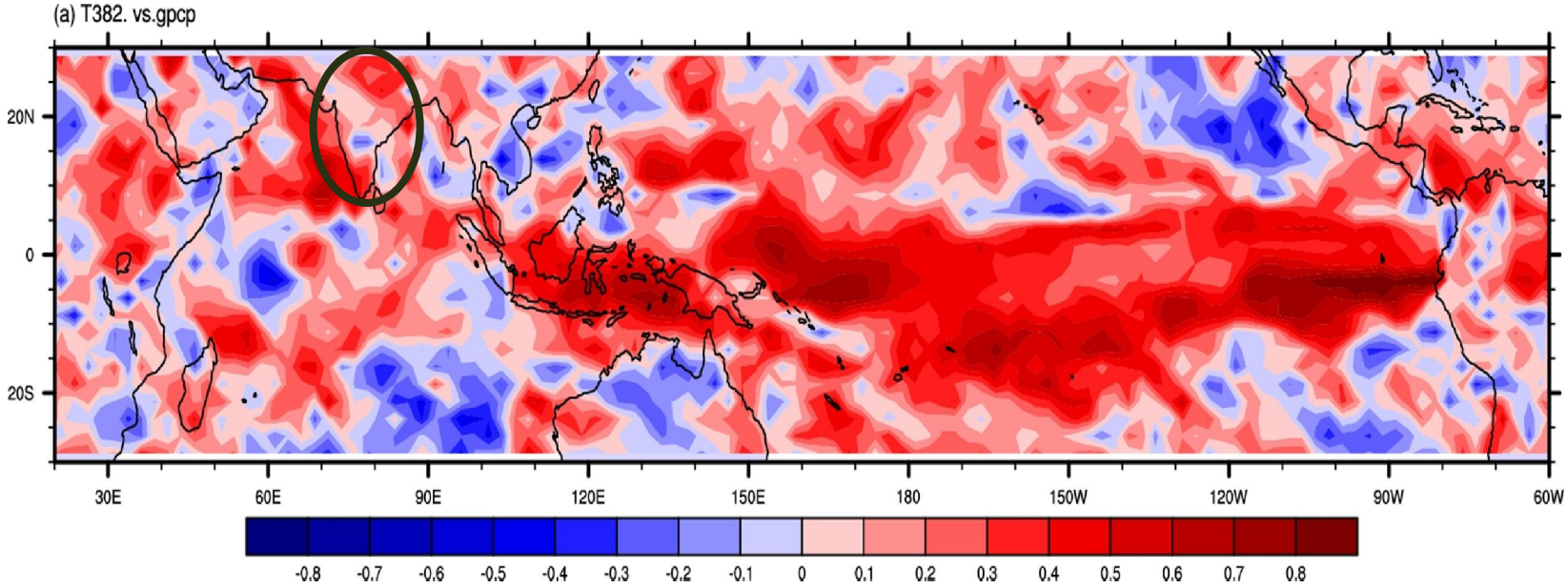


Ramu et al., (2016, Submitted)

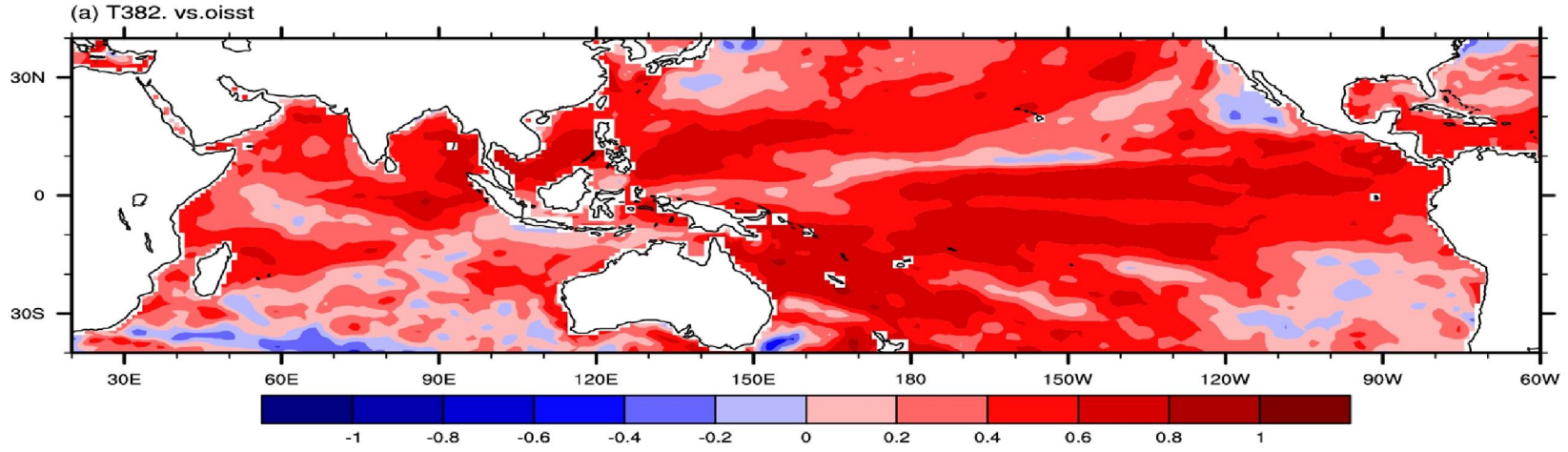


Ramu et al., (2016, Submitted)

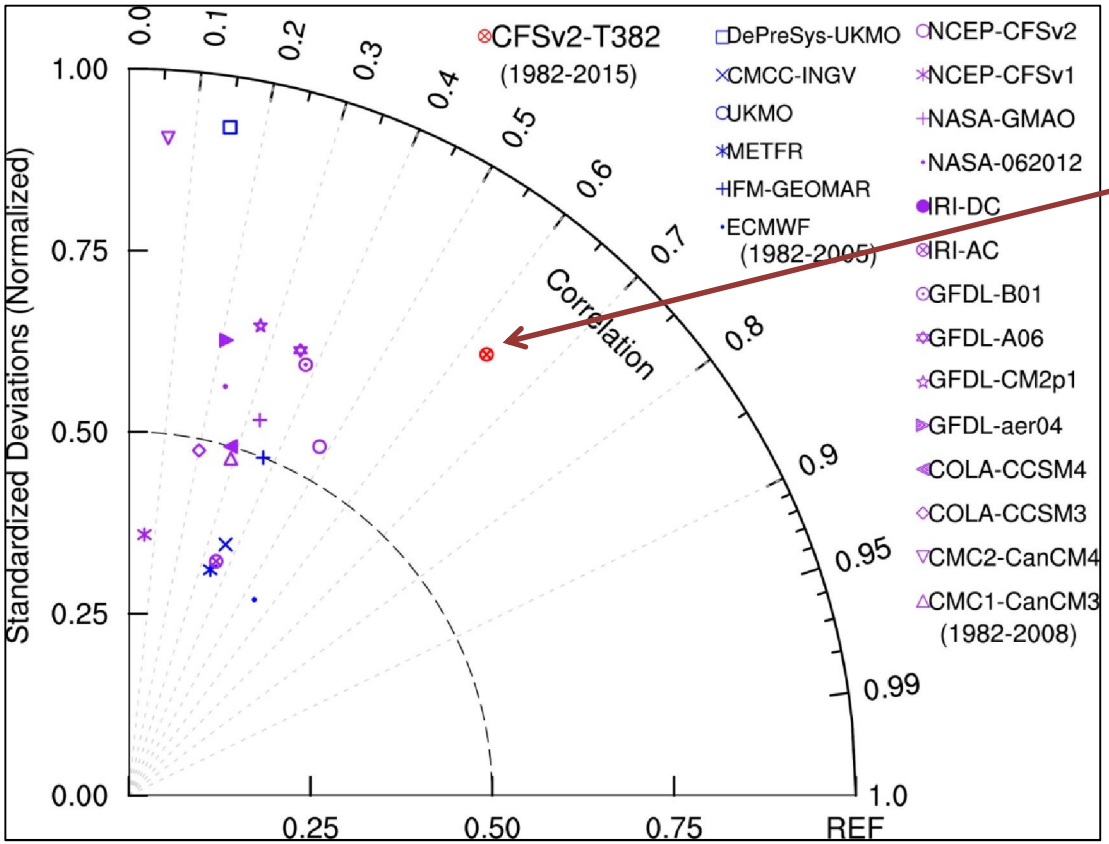
T382L64 Skill of Rainfall/SST



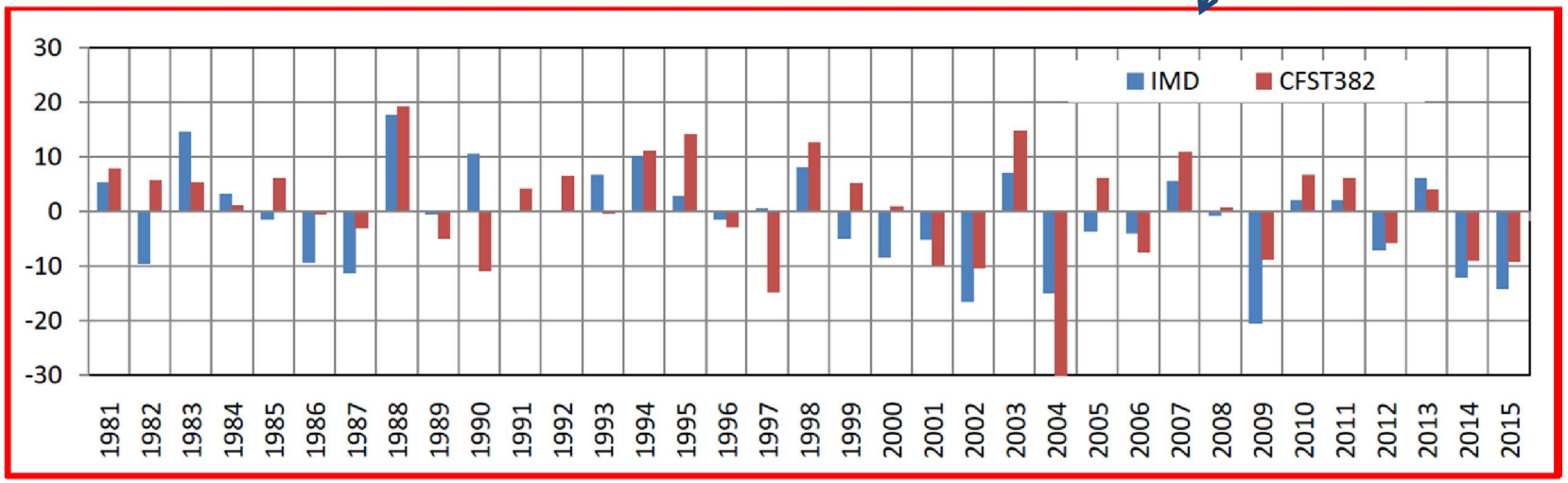
GPCP VS T382



ERSST VS T382



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



Prediction Skill of Monsoon Rainfall in 5 Homogenous Regions

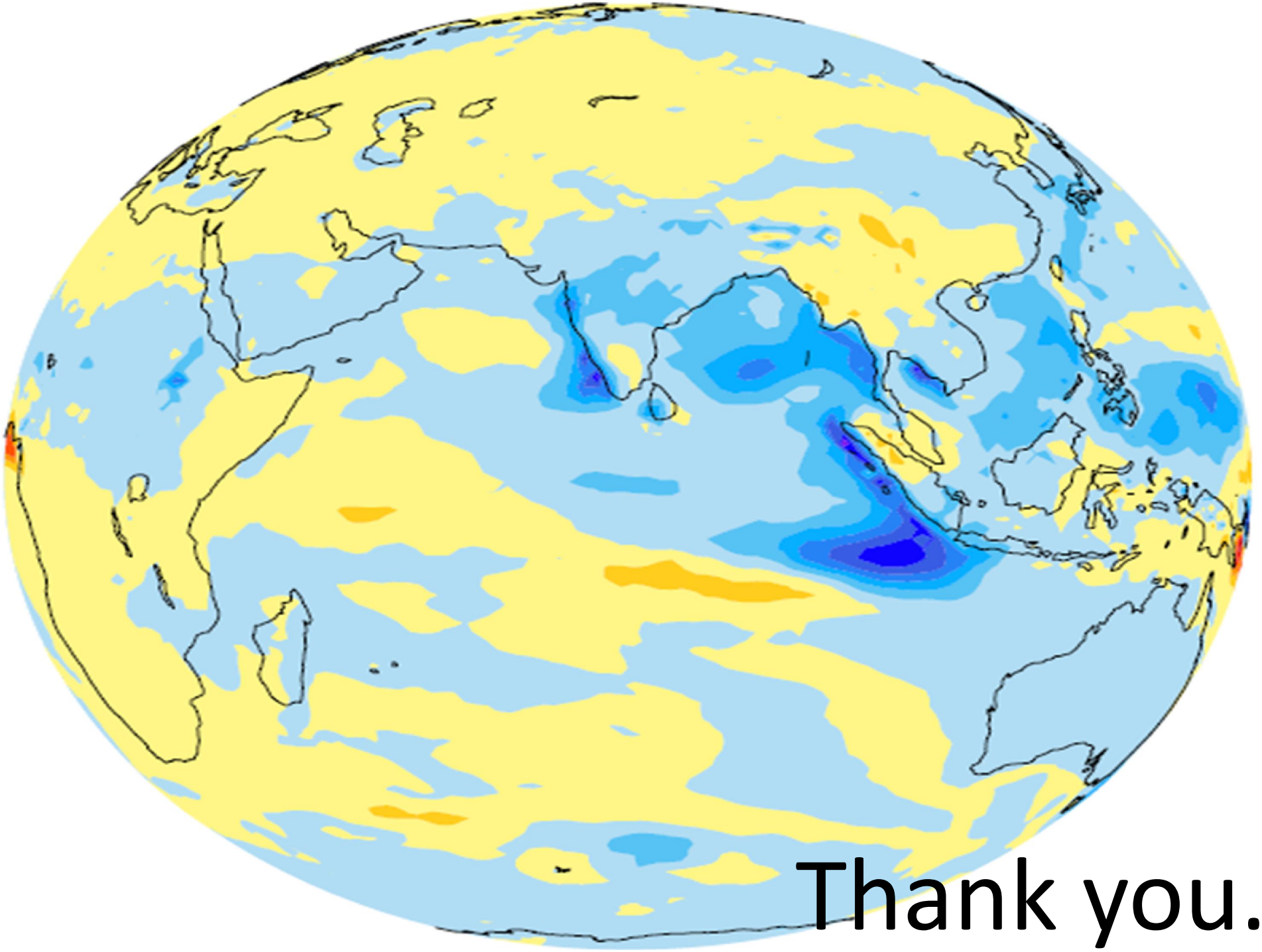
ISMR Skill (correlation between model JJAS rainfall and observation rainfall) for all the homogenous regions over India. Green colour indicate indicates 95% confidence level. February IC during 1981-2008.

Region	T126 (≈100km)	T382(≈38km)
Central North East Indian (CNEI)	0.22	0.43
North East India (NEI)	0.08	0.45
North West India (NWI)	0.21	0.41
West Central India (WCI)	0.14	0.22
South Peninsular India (SPI)	0.43	0.26

Impact of the New SAS on Indian Summer Monsoon Prediction in CFS V2

	ORIG	NEWSAS
AILR (IMD)	0.30	0.37
AILR (GPCP)	0.34	0.52
NINO 3.4	0.55	0.56
NINO 3	0.54	0.58
NINO 4	0.50	0.48
IOD E	0.49	0.61
IOD W	0.59	0.33

Following Han and Pan (2011) and Ganai et al (2014)'s long integrations with new SAS, we have tested impact of new SAS Parametrization on seasonal prediction. [Ens. Size:5, Period: 1982-2008] Phani et al., (2016, Submitted)



Thank you.