What can we do to improve our understanding and prediction monsoon

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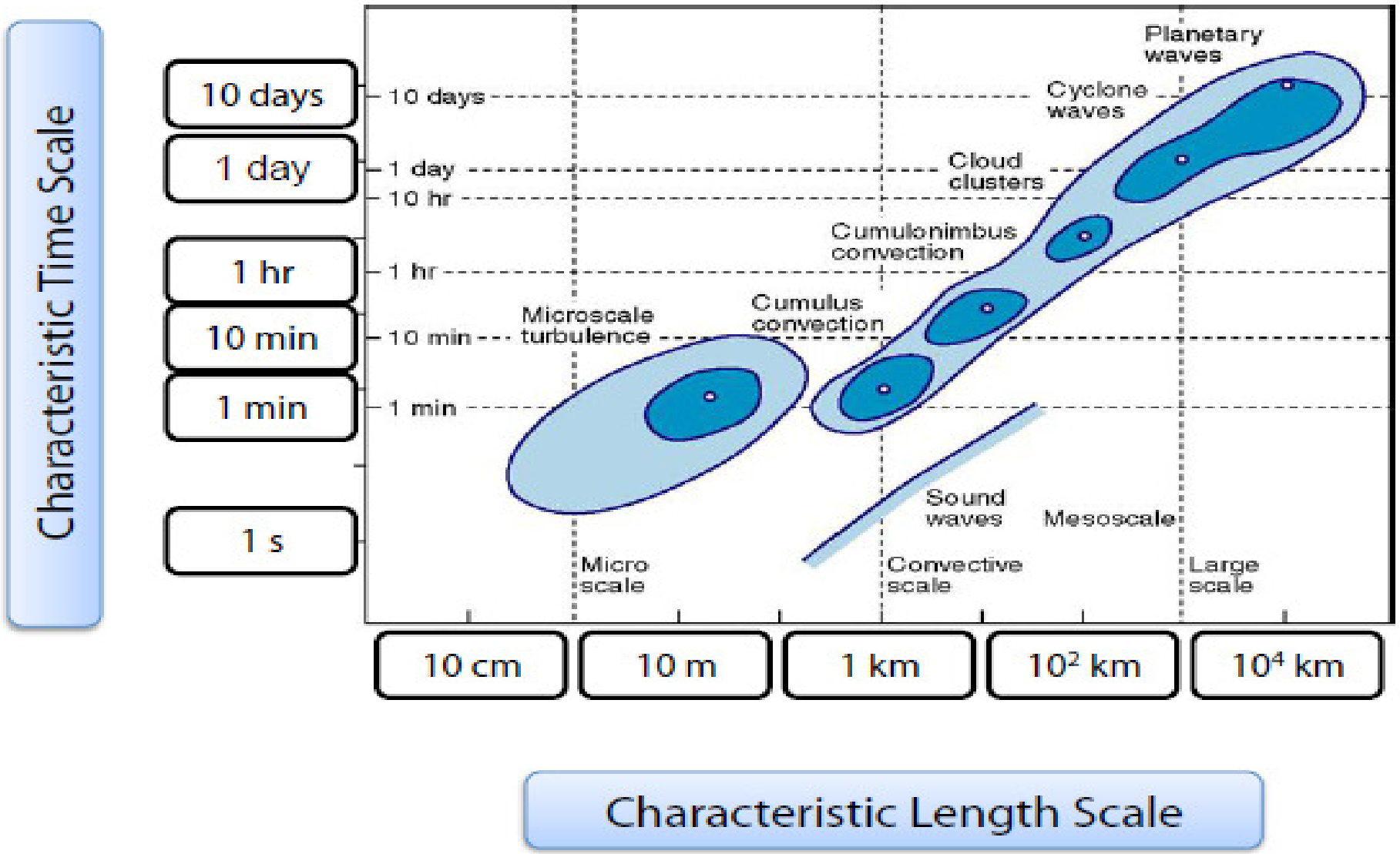
Monsoon

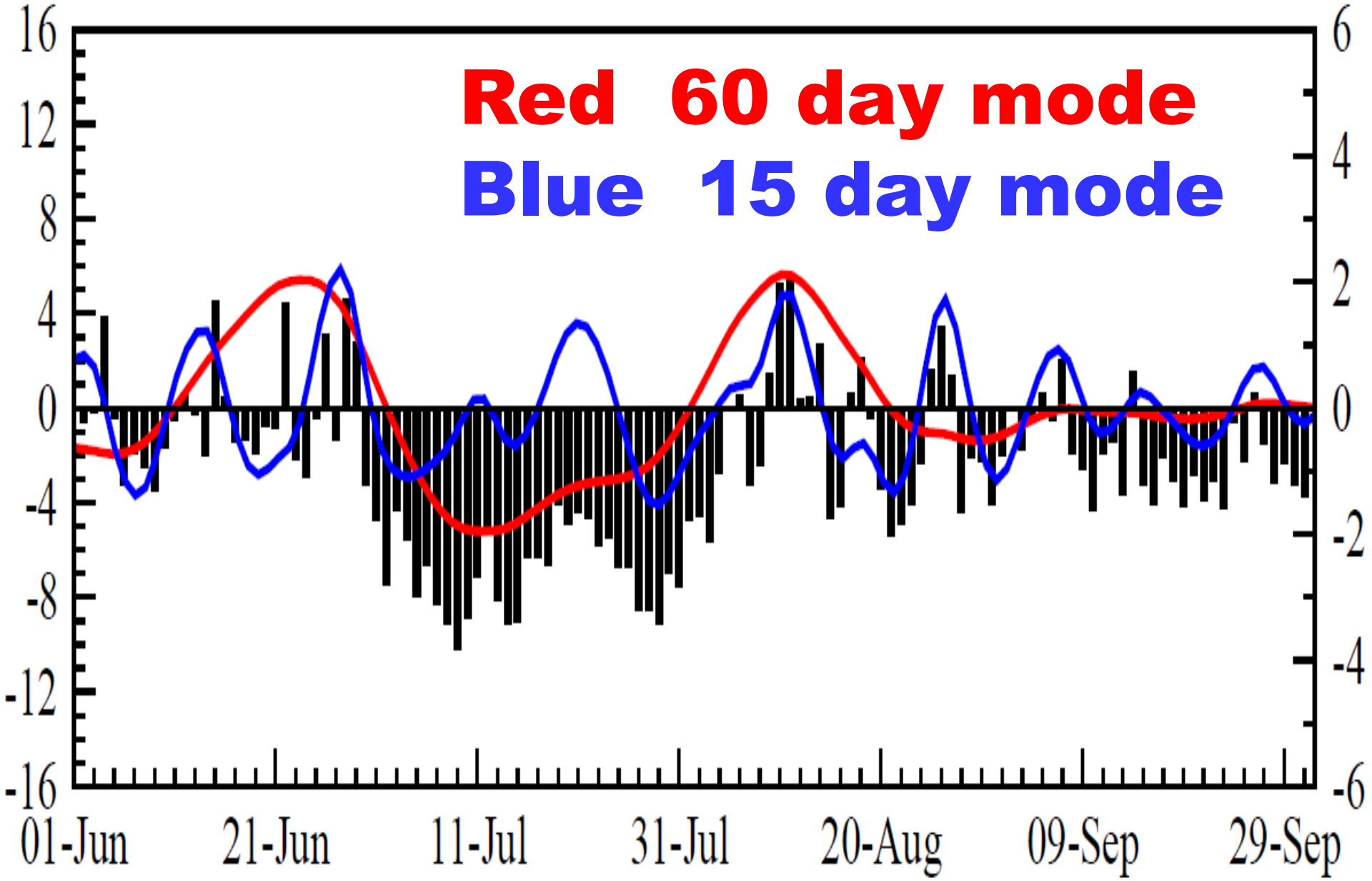
Temporal and spatial scales

Temporal: diurnal, daily, sub-seasonal, seasonal, interannual, decadal, centennial and millennial

Spatial: bacteria, aerosols, cloud drops, ice particles, cumulus, mesoscale, inter-tropical convergence zones

Cloud parameterization approximates everything not resolved by the model




2002 (690)
Red 60 day mode
Blue 15 day mode
16
12
8
4
0
-4
-8
-12
-16
6
4
2
0
-2
-4
-6
01-Jun
21-Jun
11-Jul
31-Jul
20-Aug
09-Sep
29-Sep

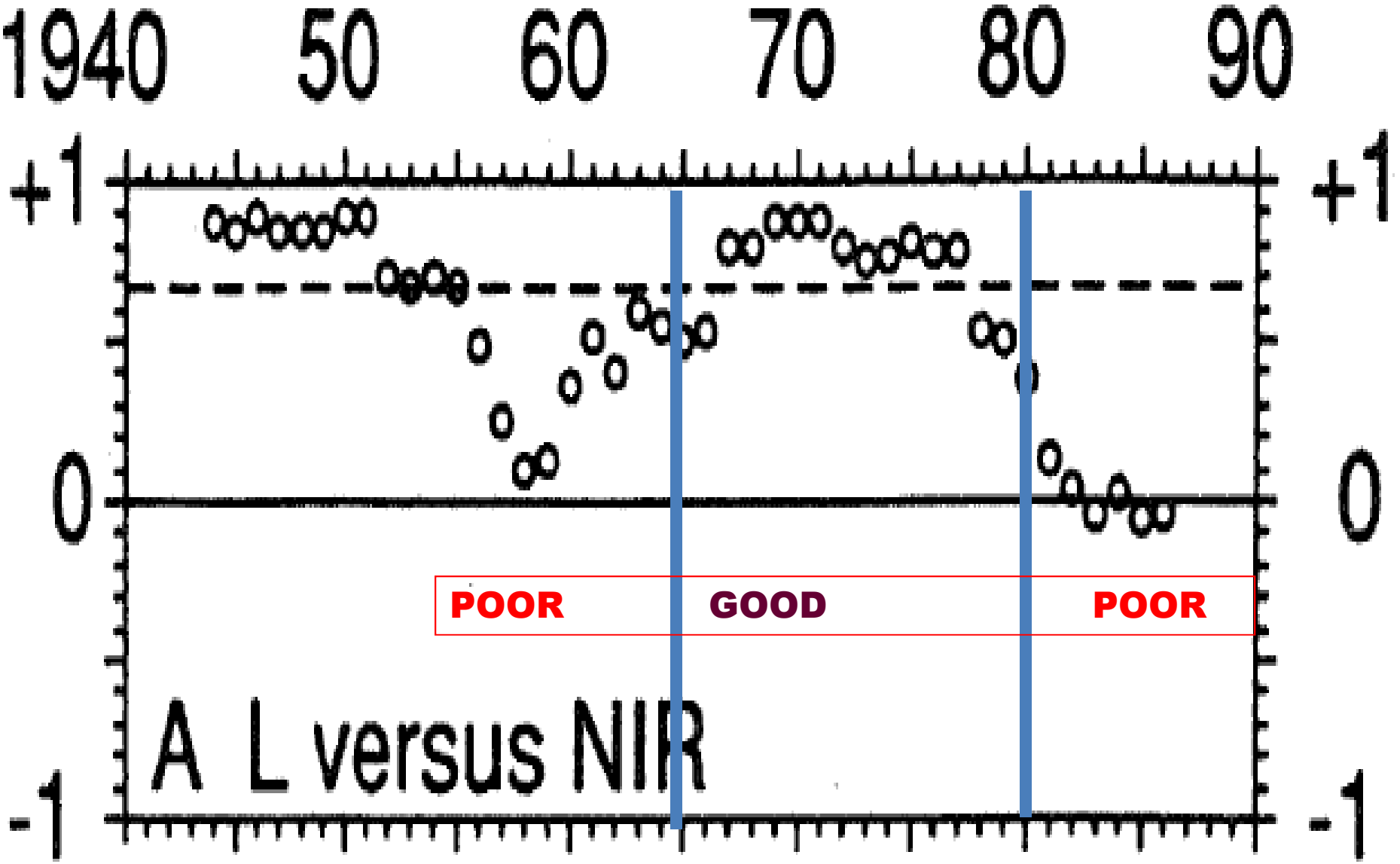
MODELS

SIMPLE,DYNAMICAL AND STATISTICAL

Statistician R.A.Fisher 1922

"no new meteorological fact had been discovered by means of correlation coefficients; certainly up to the present no practical forecasts had been obtained from correlation coefficients"

Correlation between 500mb ridge in April and Indian summer monsoon rainfall



Verification of the seasonal mean Indian monsoon rainfall forecast by linear regression for the period 1924 to 1987 indicated that it was correct about 63% of the time

If we assumed that there will be no droughts during this period, we would have been right 77% of the time!

DYNAMICAL MODELS

Can laws of physics predict monsoon better than statistical models?

Monsoon rainfall predictions

- **Short term(3 days) : Very good**
- **Medium term(7 days); getting better**
- **Extended range (15 days): great promise**
- **Long range(> 30 days): tough**

Hybrid forecasting

- **Dynamical models good in prediction winds but not rainfall**

- **Statistical method to link model predicted winds to observed rain**

Understanding the monsoon implies a theory which will explain the observed variability and model simulations

The traditional Land-sea contrast theory has failed to improve our understanding of monsoon processes

Tropical precipitation, SSTs and the surface energy budget: a zonally symmetric perspective

Sarah M. Kang · Isaac M. Held

Climate Dynamics,2012

Atmospheric energy budget is more fundamental to the control of tropical precipitation than SSTs in these simulations

$$P = E + \{Q_{NET}\} / \{\text{Vertical Stability}\}$$

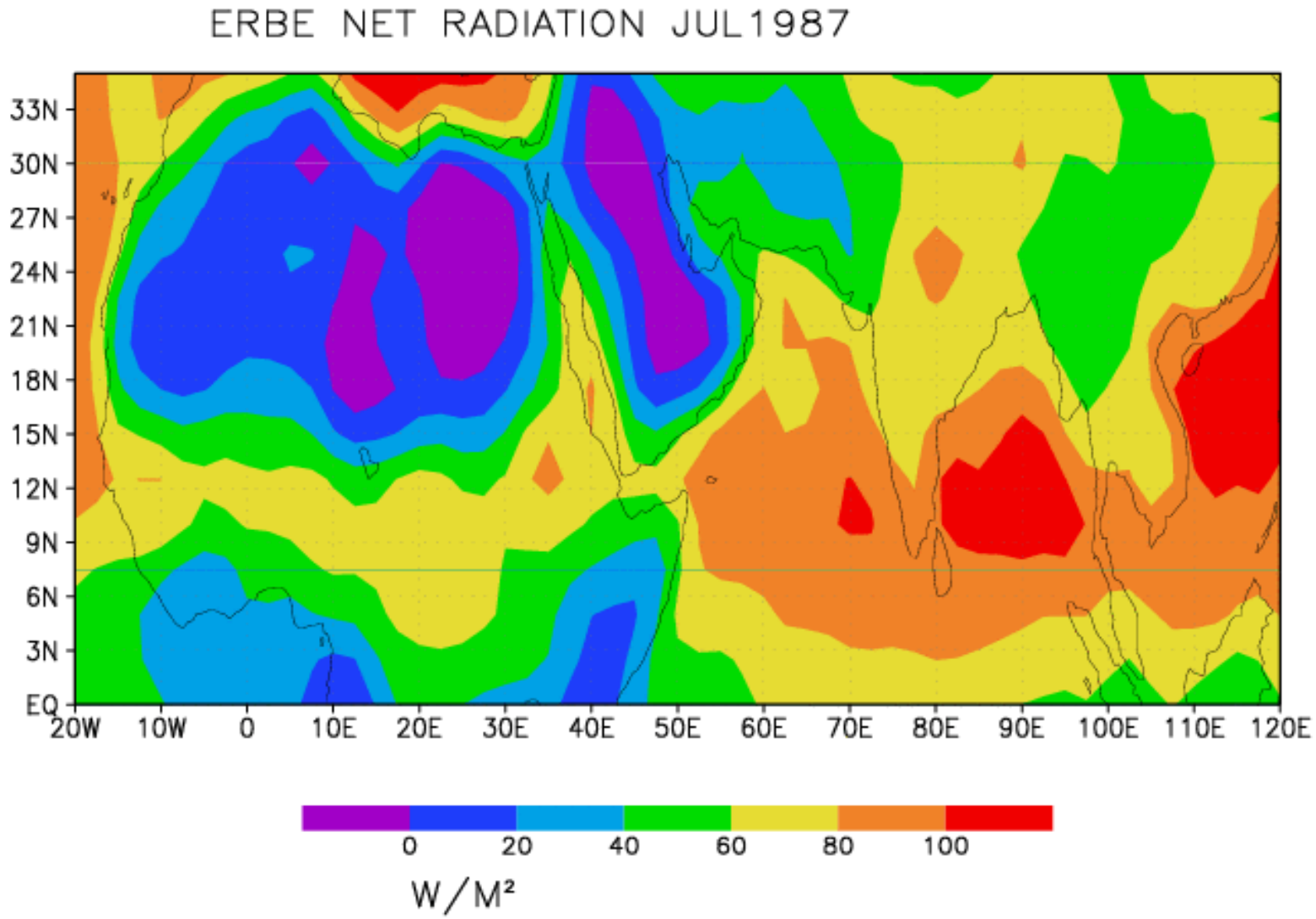
P = RAINFALL

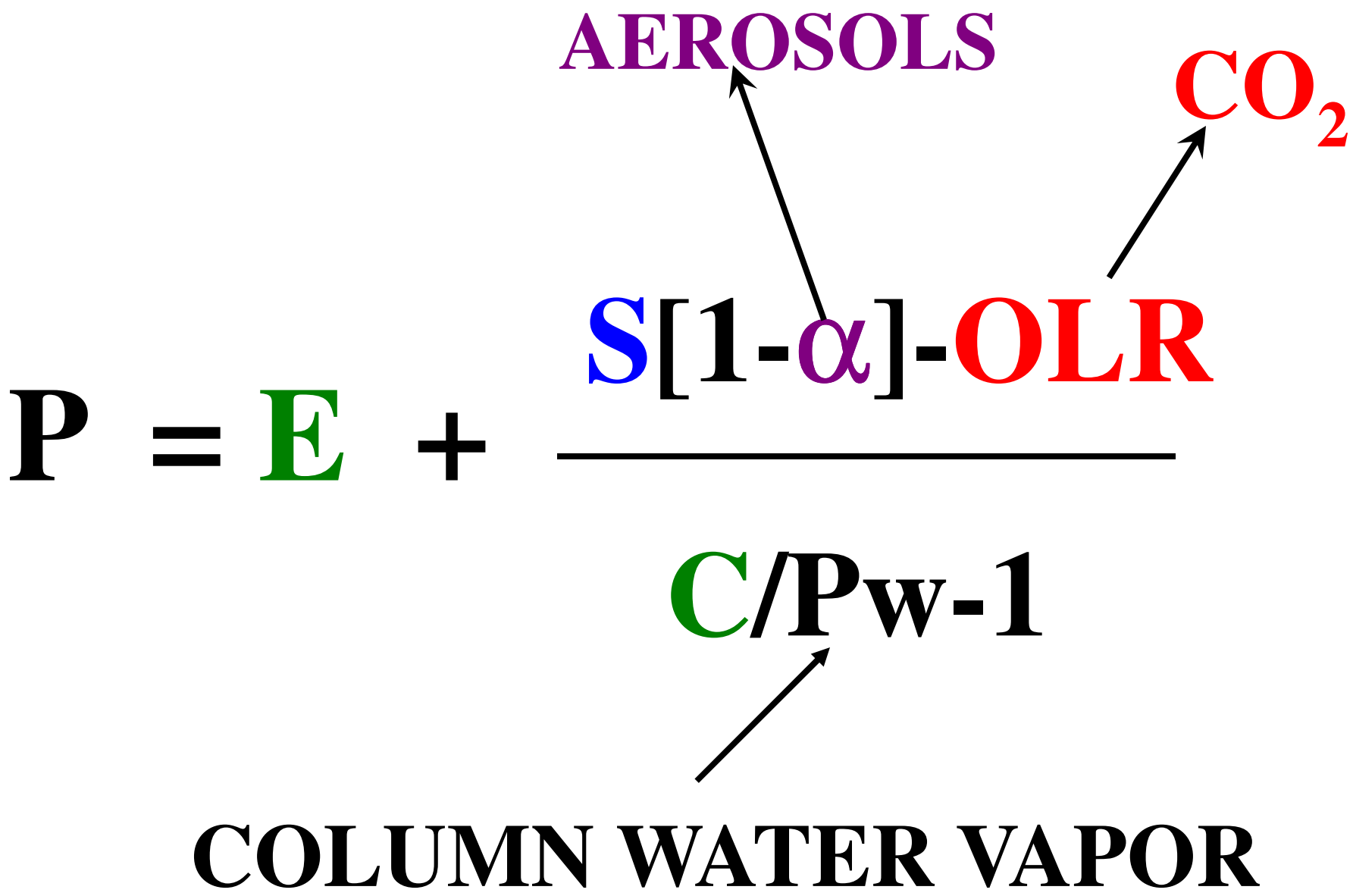
E= EVAPORATION

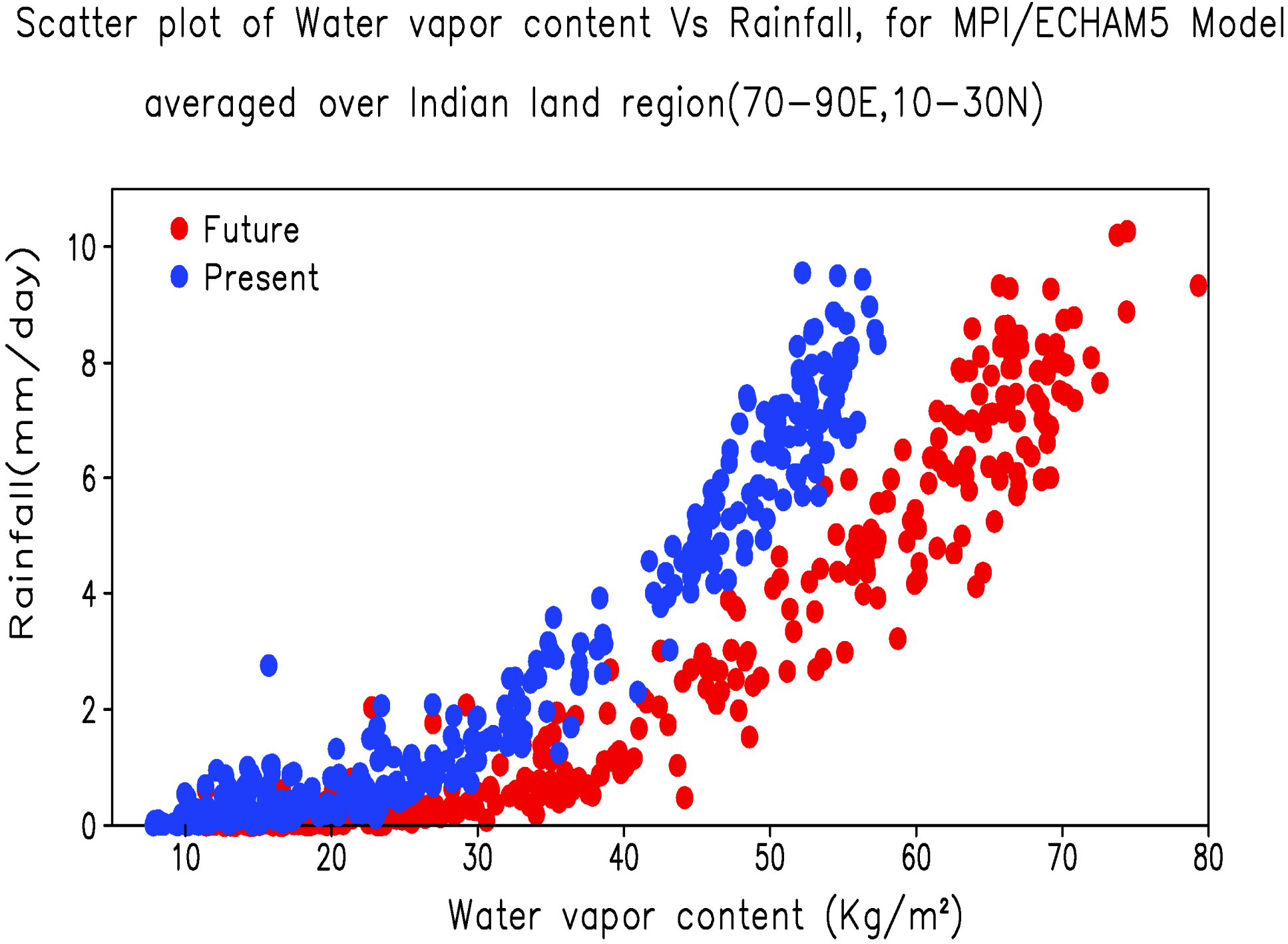
Q_{NET} = NET ENERGY CONVERGENCE

Therefore, (P-E) > 0 if $Q_{NET} > 0$

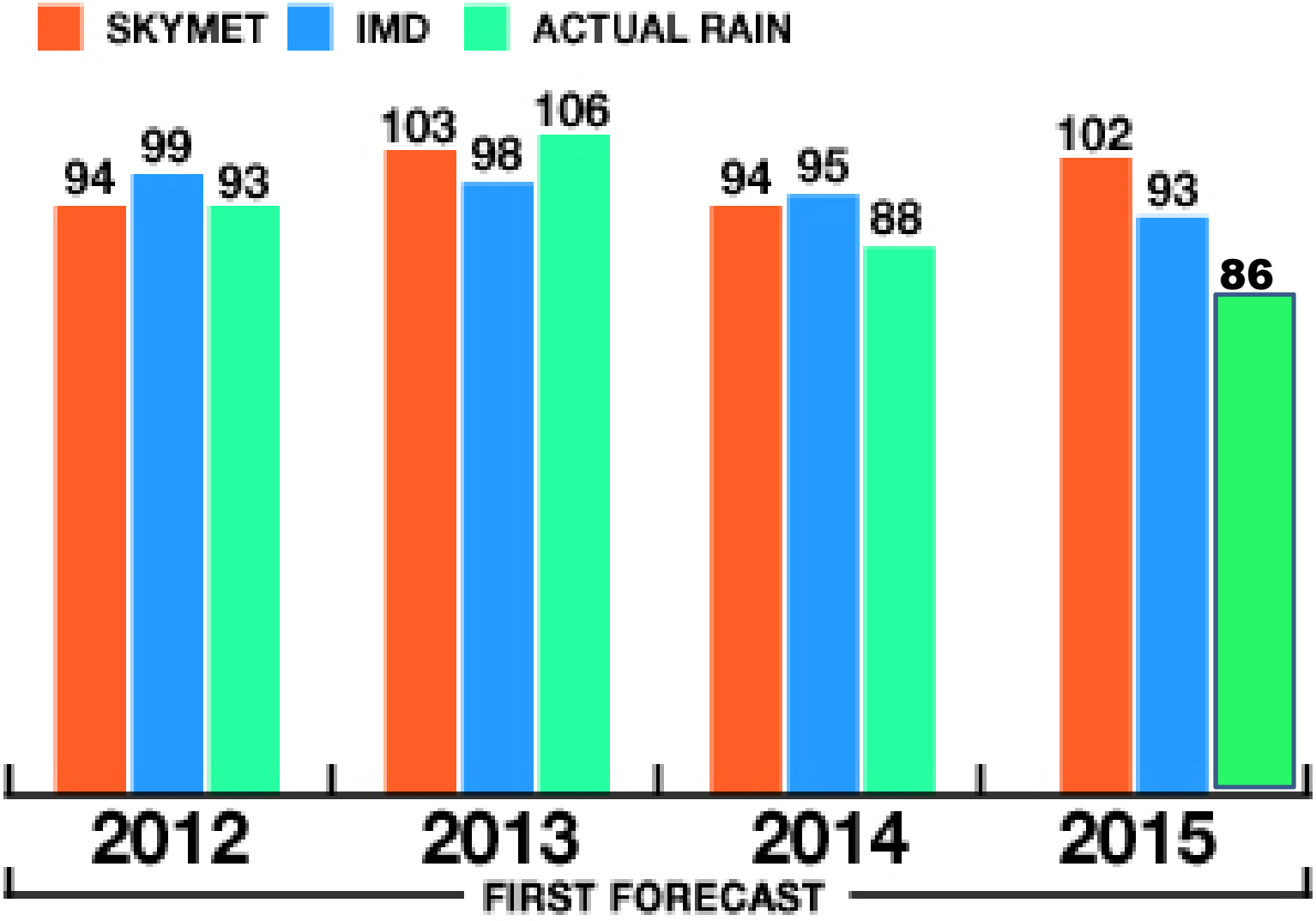
This is can be verified!


ERBE NET RADIATION JUL1987
33N
30N
27N
24N
21N
18N
15N
12N
9N
6N
3N
EQ
20W
10W
0
10E
20E
30E
40E
50E
60E
70E
80E
90E
100E
110E
120E
0
20
40
60
80
100
W/M²


AEROSOLS
CO_2
P = E + S[1-α]-OLR / C/Pw-1
COLUMN WATER VAPOR


Scatter plot of Water vapor content Vs Rainfall, for MPI/ECHAM5 Model
averaged over Indian land region(70–90E,10–30N)
Future
Present
Rainfall(mm/day)
0
2
4
6
8
10
10
20
30
40
50
60
70
80
Water vapor content (Kg/m²)

TRACK RECORD

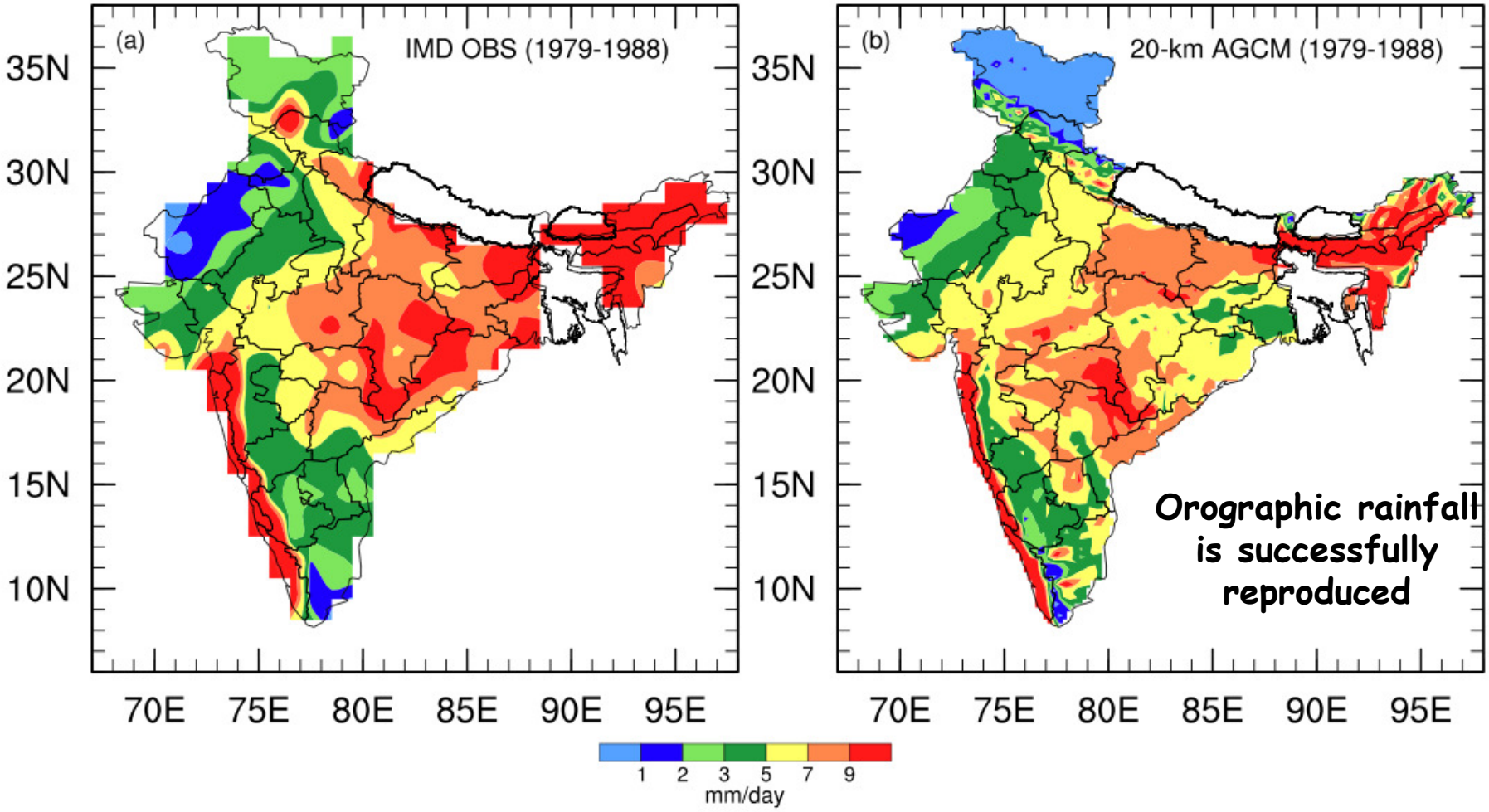


Note: Skymet forecast is with a model error of plus & minus four percent; numbers indicate percentage of long- period average

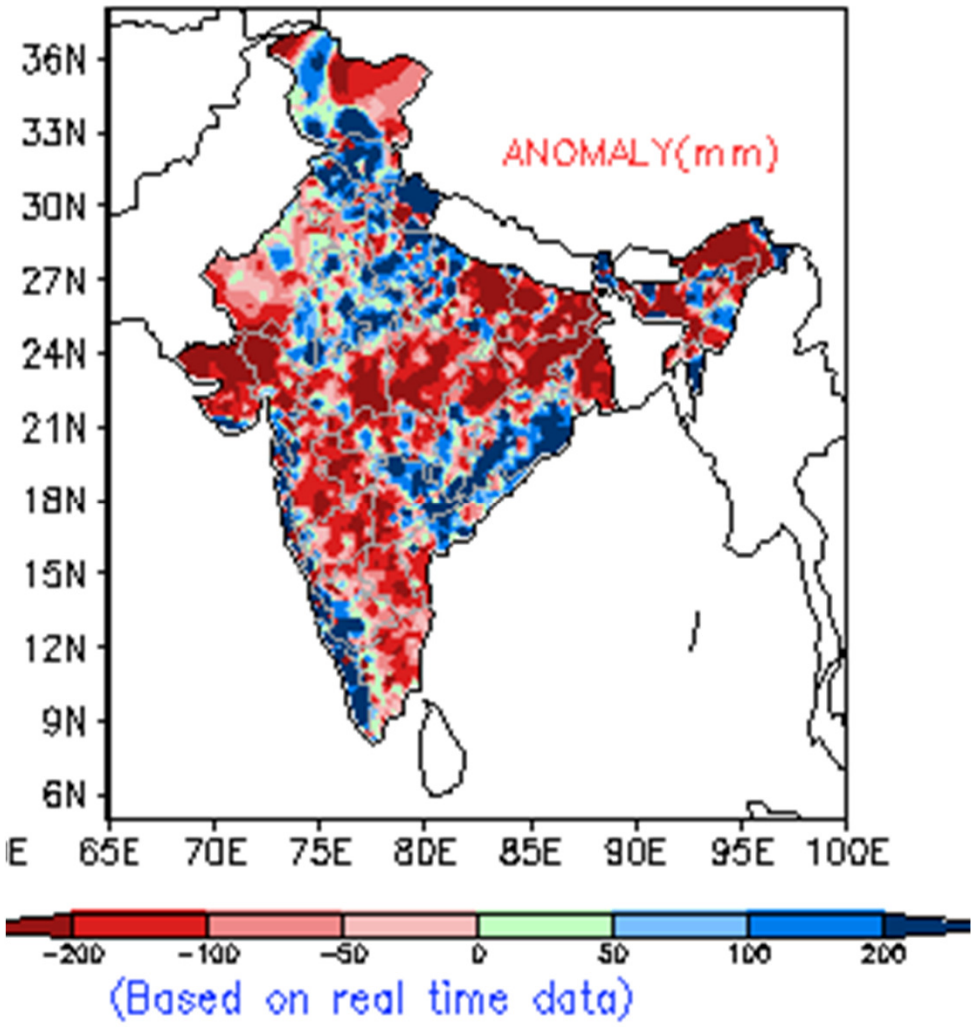
Indian summer monsoon rainfall from MRI GCM(Rajendran et al,2005)

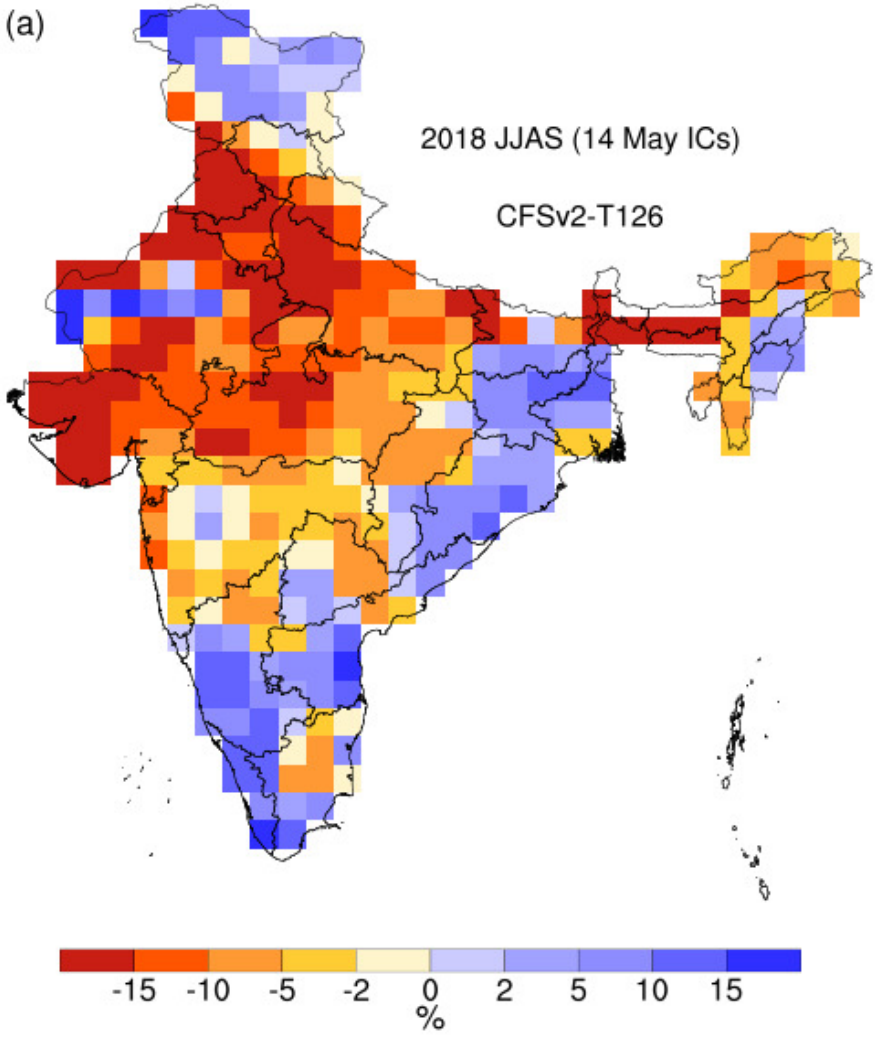
IMD observation

20-km model

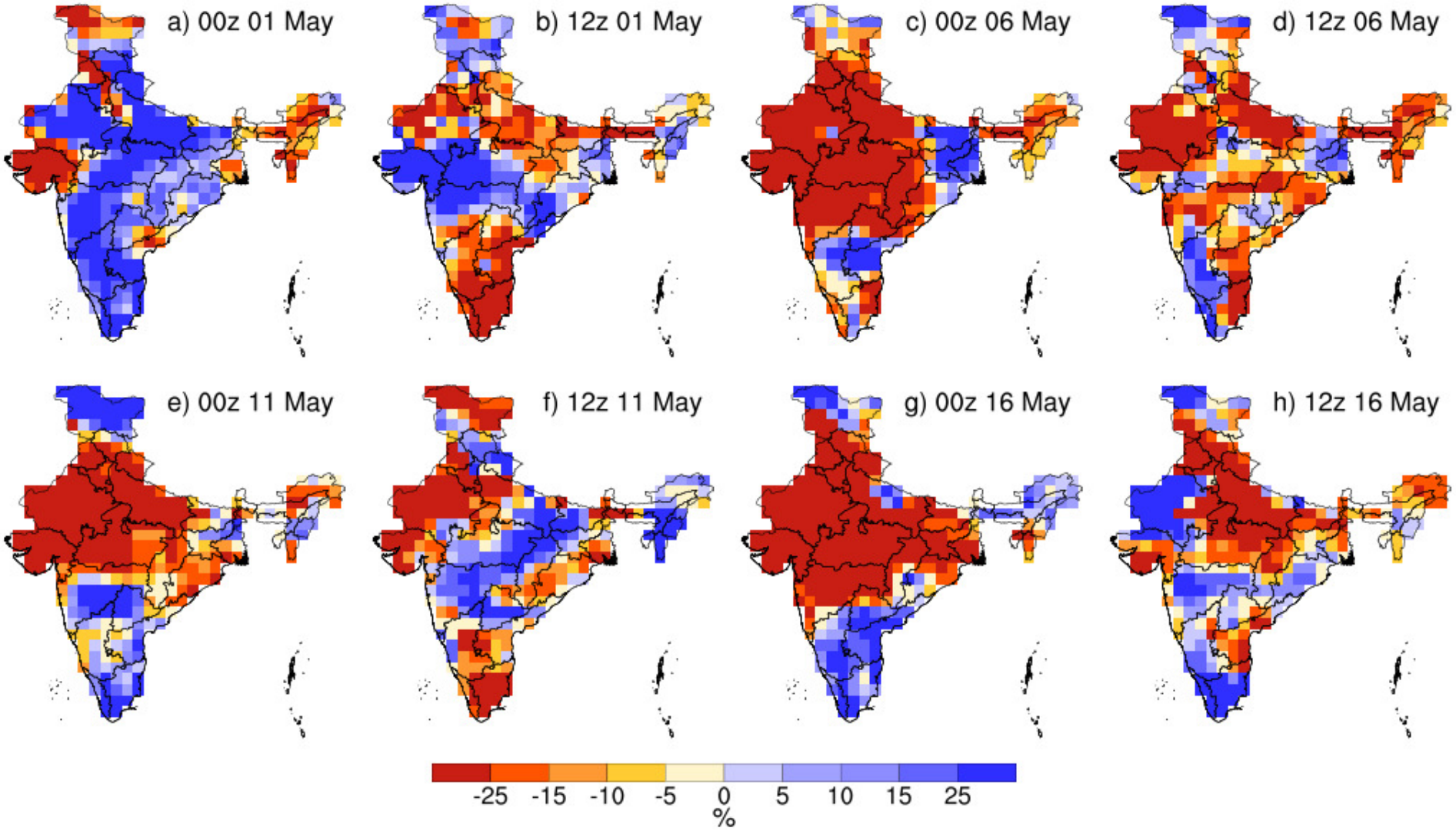


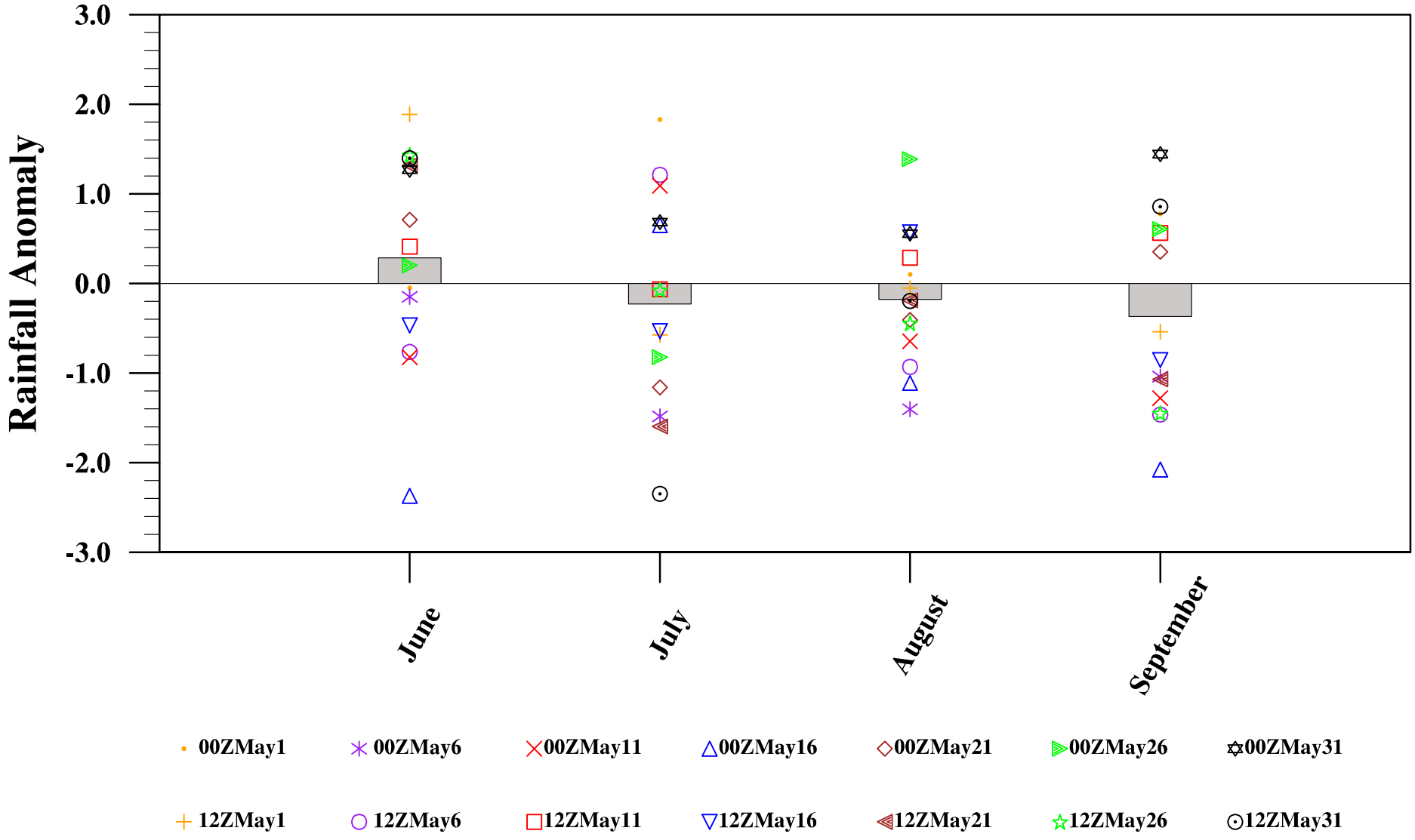
% Deviation of rainfall in 2018





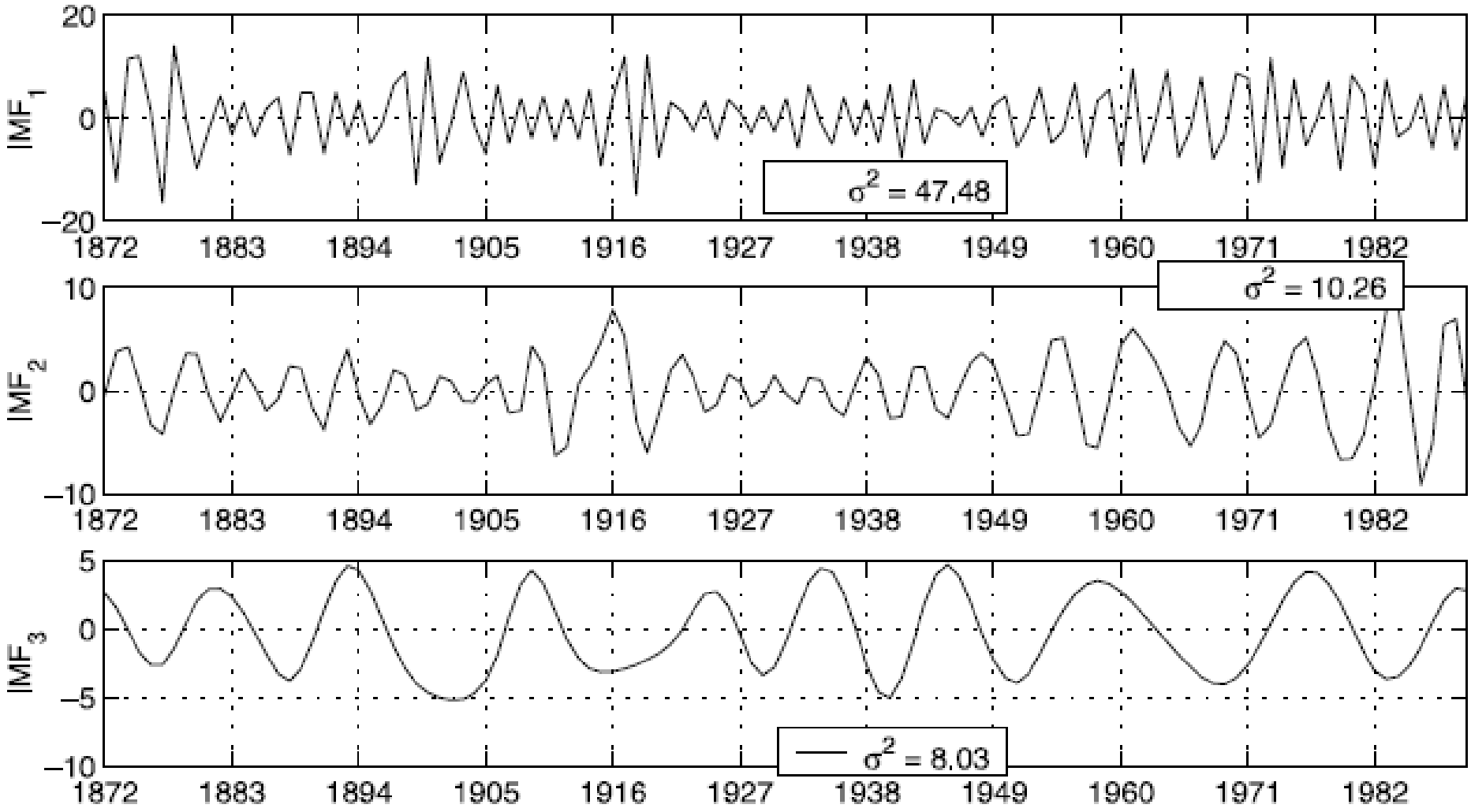
2018 JJAS % Deviation




Rainfall Anomaly
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
June
July
August
September
00ZMay1
00ZMay6
00ZMay11
00ZMay16
00ZMay21
00ZMay26
00ZMay31
12ZMay1
12ZMay6
12ZMay11
12ZMay16
12ZMay21
12ZMay26
12ZMay31

Intrinsic mode functions and a strategy for forecasting Indian monsoon rainfall

R.N.Iyengar & S.T.G. Raghukanth
Meterology &Atmospheric Physics,2004



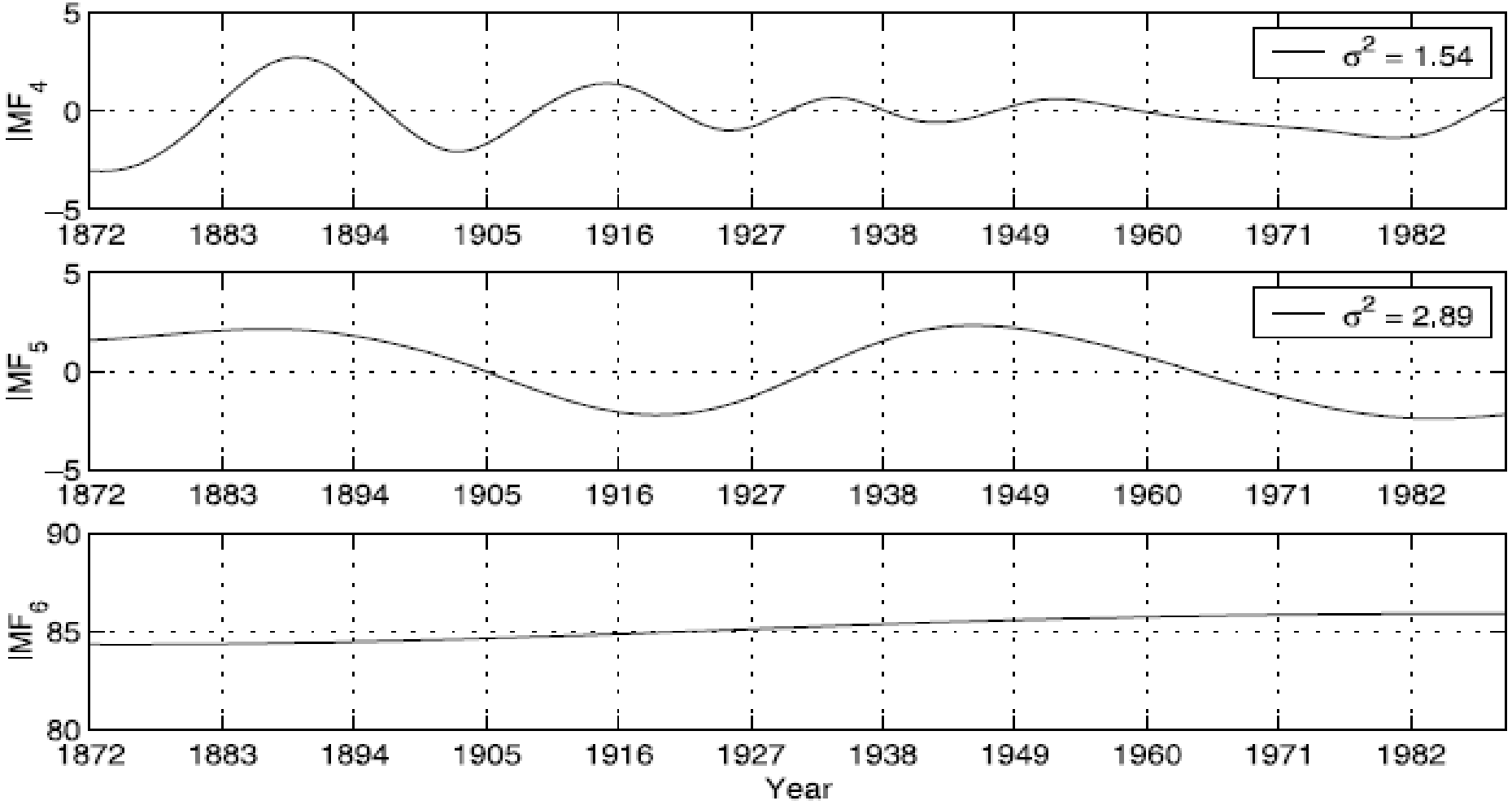
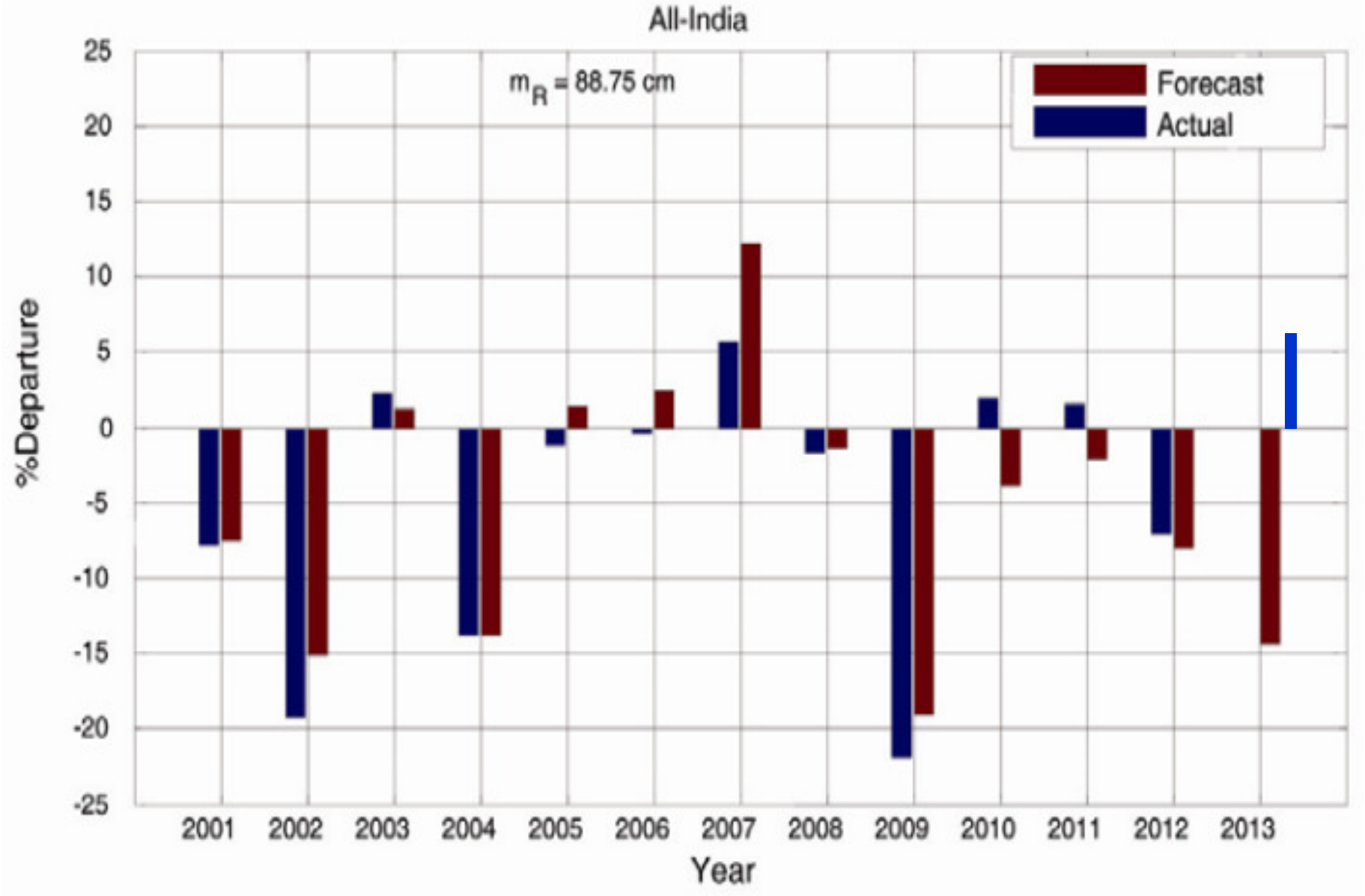


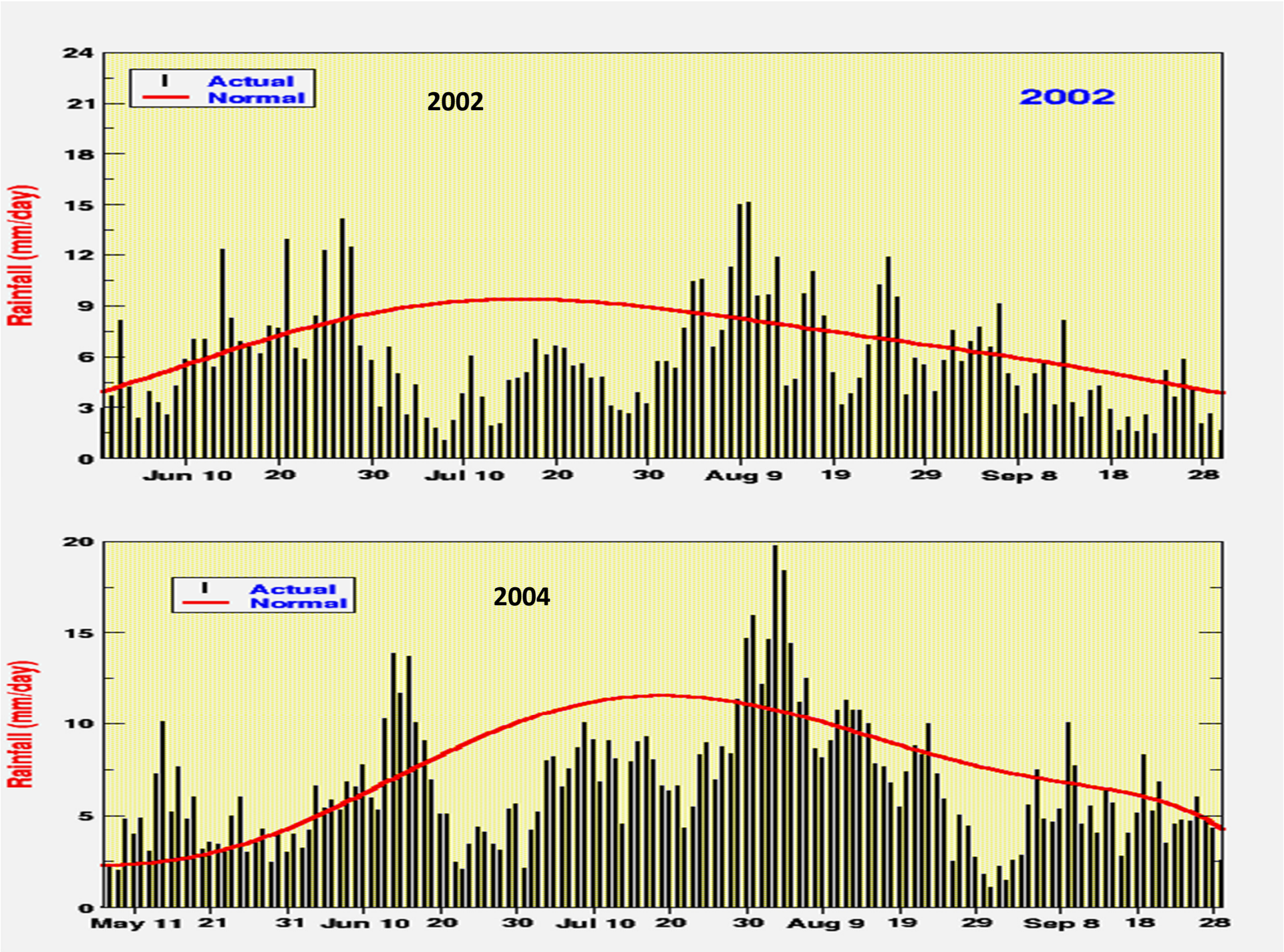
Table 2. Central period of the IMF's in years and % variance contributed to IAV

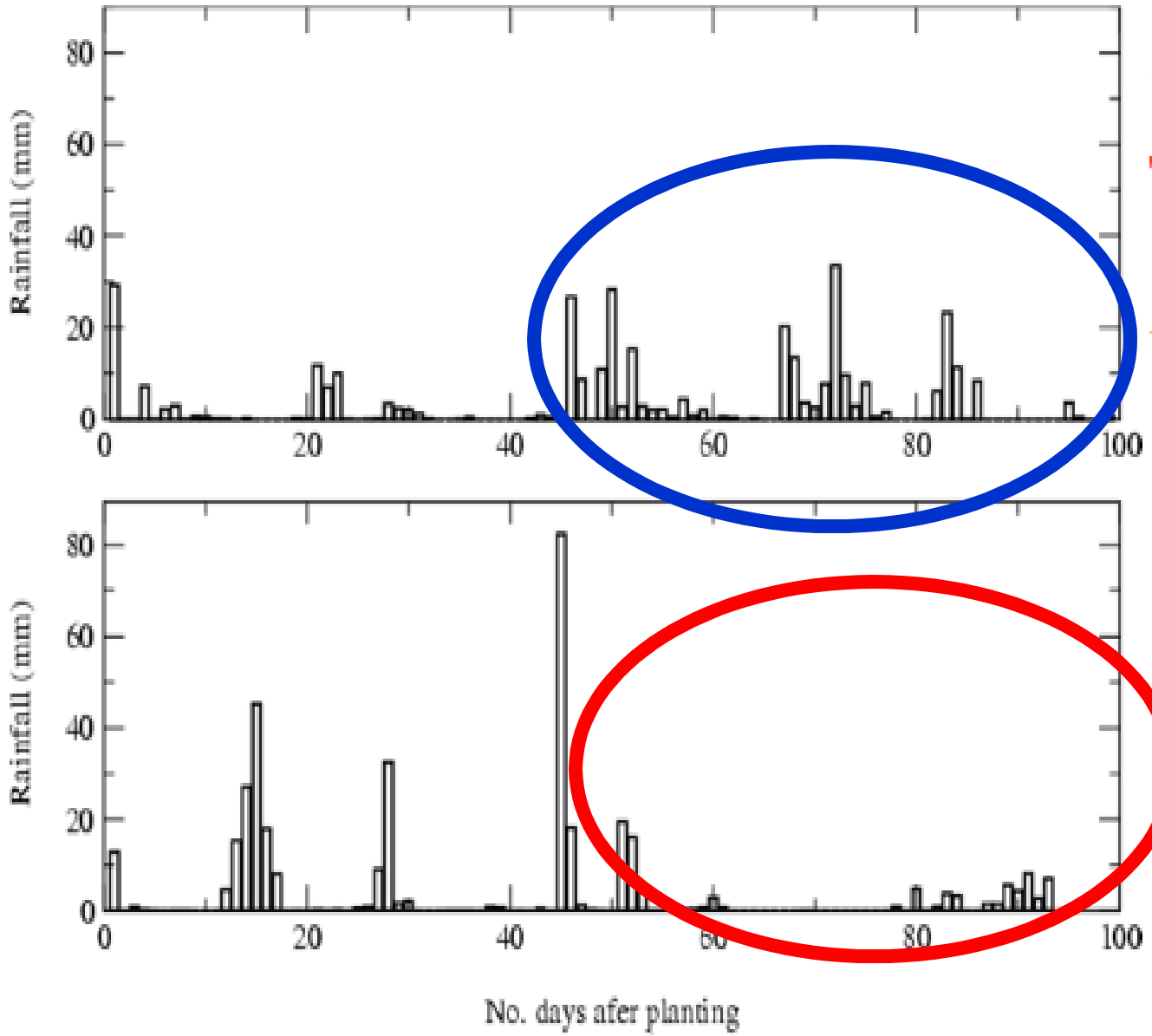
Region	IMF_1		IMF_2		IMF_3		IMF_4		IMF_5	
	T	IAV%	T	IAV%	T	IAV%	T	IAV%	T	IAV%
All India	2.67	66.2	5.45	14.3	12.00	11.2	30	2.2	60	4.0

Prediction of the Indian summer monsoon rainfall for 2013 based on past rainfall data

Current Science, June, 2013




Actual
Normal
2002
2002
Raintall (mm/day)
0
3
6
9
12
15
18
21
24
Jun 10
20
30
Jul 10
20
30
Aug 9
19
29
Sep 8
18
28
Actual
Normal
2004
Raintall (mm/day)
0
5
10
15
20
May 11
21
31
Jun 10
20
30
Jul 10
20
30
Aug 9
19
29
Sep 8
18
28



1975

Total rainfall: 394mm

Yield = 1360 kg/ha

1981

Total rainfall 389mm

Yield = 901 kg/ha

Groundnut crop growing in Andhra Pradesh, India

OPEN ACCESS
IOP PUBLISHING
ENVIRONMENTAL RESEARCH LETTERS
Environ. Res. Lett. 7 (2012) 044023 (9pp)
doi:10.1088/1748-9326/7/4/044023

A statistically predictive model for future monsoon failure in India

Jacob Schewe and Anders Levermann

Potsdam Institute for Climate Impact Research, Telegrafenberg A62, D-14473 Potsdam, Germany
Institute of Physics, Potsdam University, Potsdam, Germany

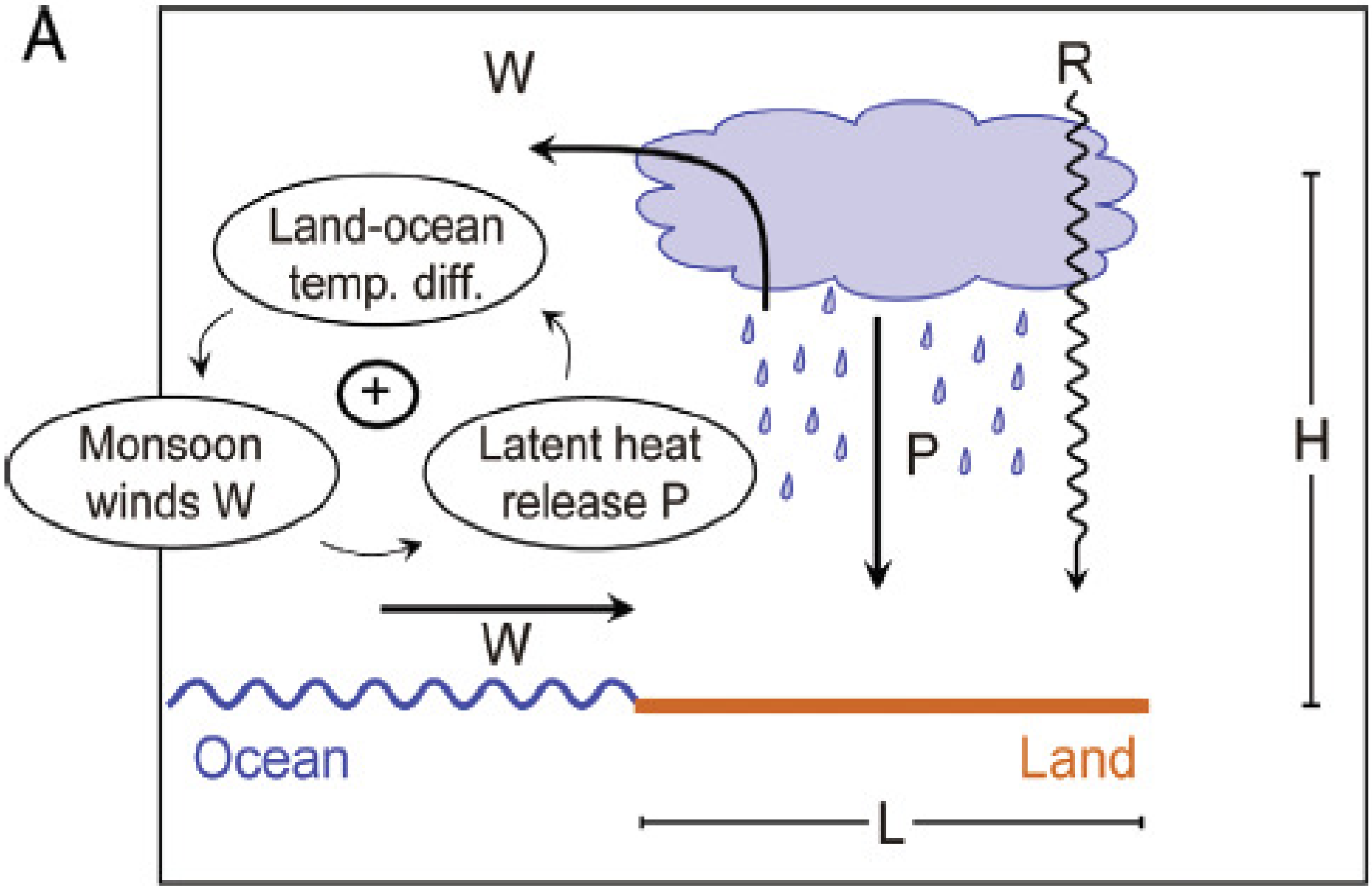
Non-linear intensification of Sahel rainfall as a possible dynamic response to future warming

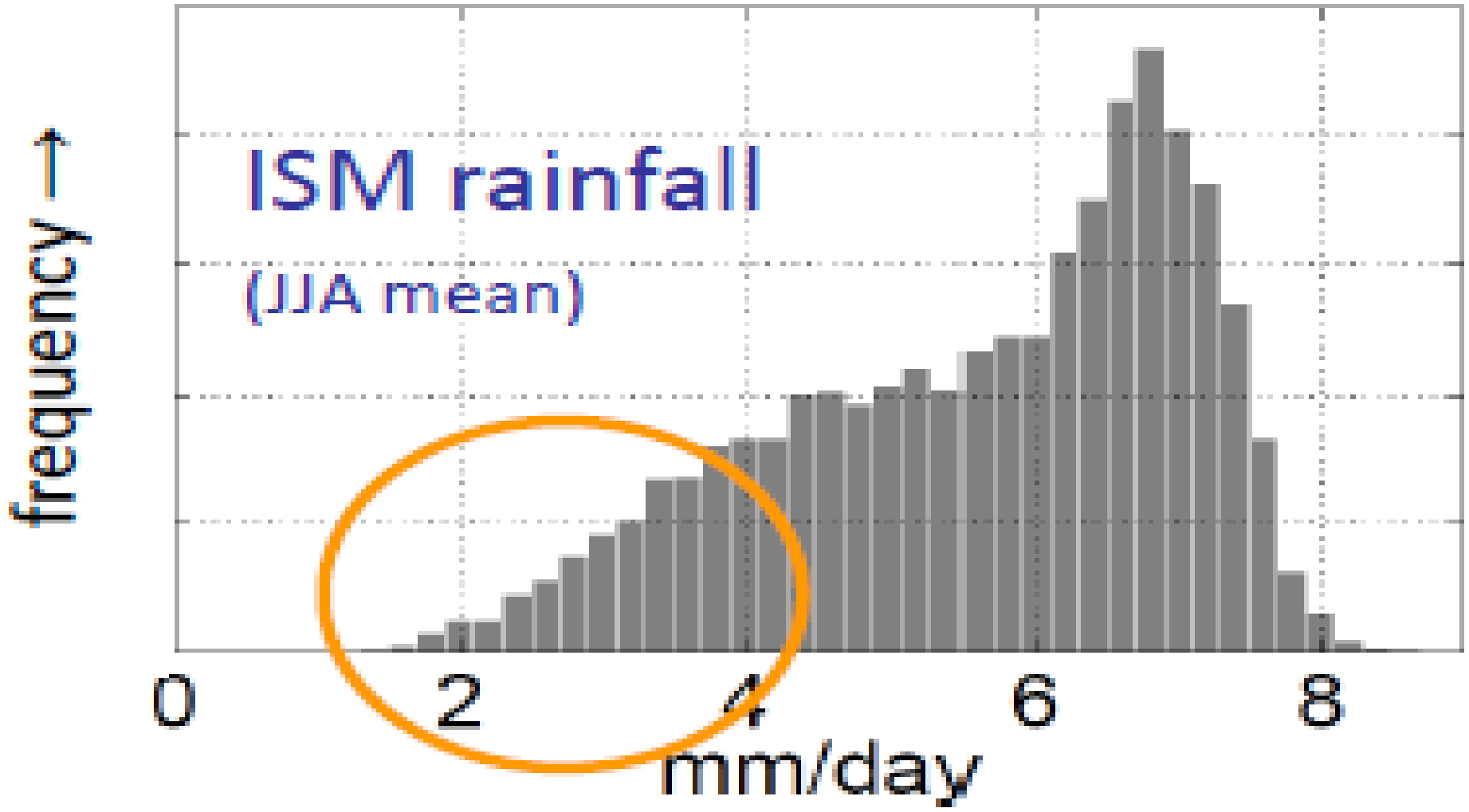
Jacob Schewe[1] and Anders Levermann[1,2,3]

A critical humidity threshold for monsoon transitions

J. Schewe[1,2], A. Levermann[1,2], and H. Cheng[3,4]

[1]Earth System Analysis, Potsdam Institute for Climate Impact Research, 14473 Potsdam, Germany
[2]Institute of Physics, University of Potsdam, 14476 Potsdam, Germany
[3]Institute of Global Environmental Change, Xi'an Jiaotong University, Xi'an, 710049, China
[4]Department of Geology and Geophysics, University of Minnesota, Minneapolis, 55455, USA

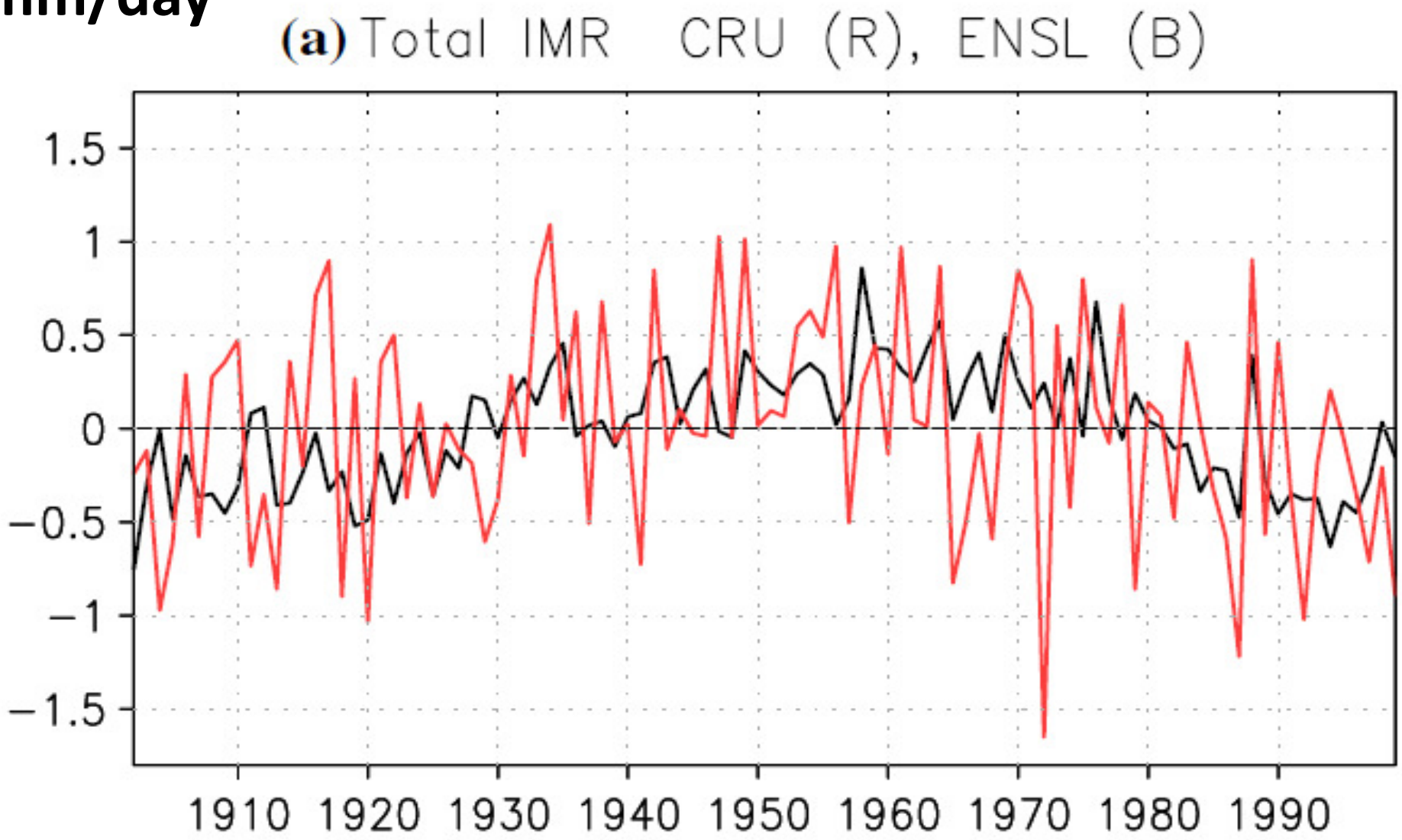

A
W
R
Land-ocean
temp. diff.
+
Monsoon
winds W
Latent heat
release P
P
H
W
Ocean
Land
L



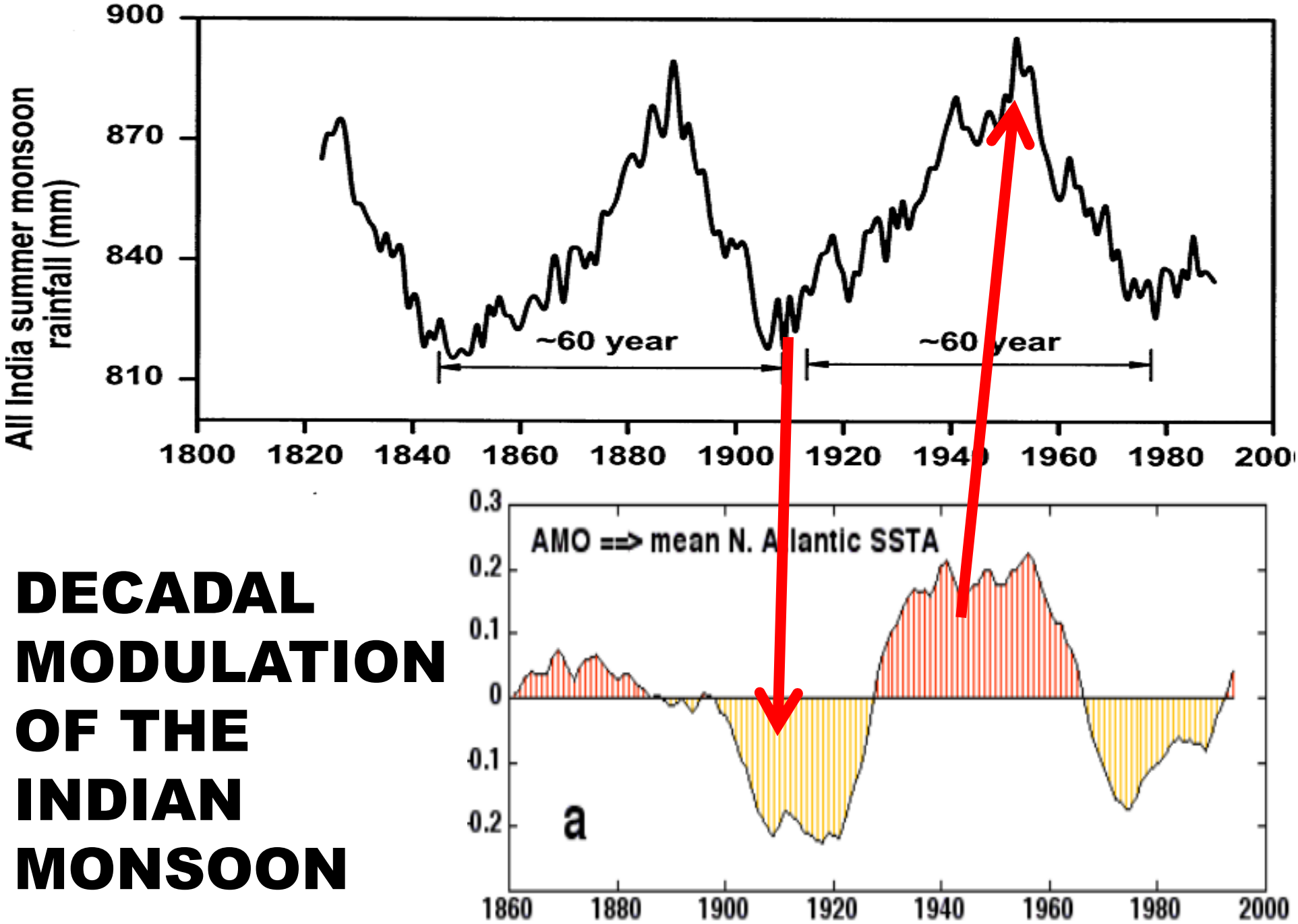
Schewe & Levermann (2012, subm.), ERL

Kucharski et al , Climate Dynamics, 2009
Observations(Red) Model Ensemble (Black) 6 AGCM

mm/day



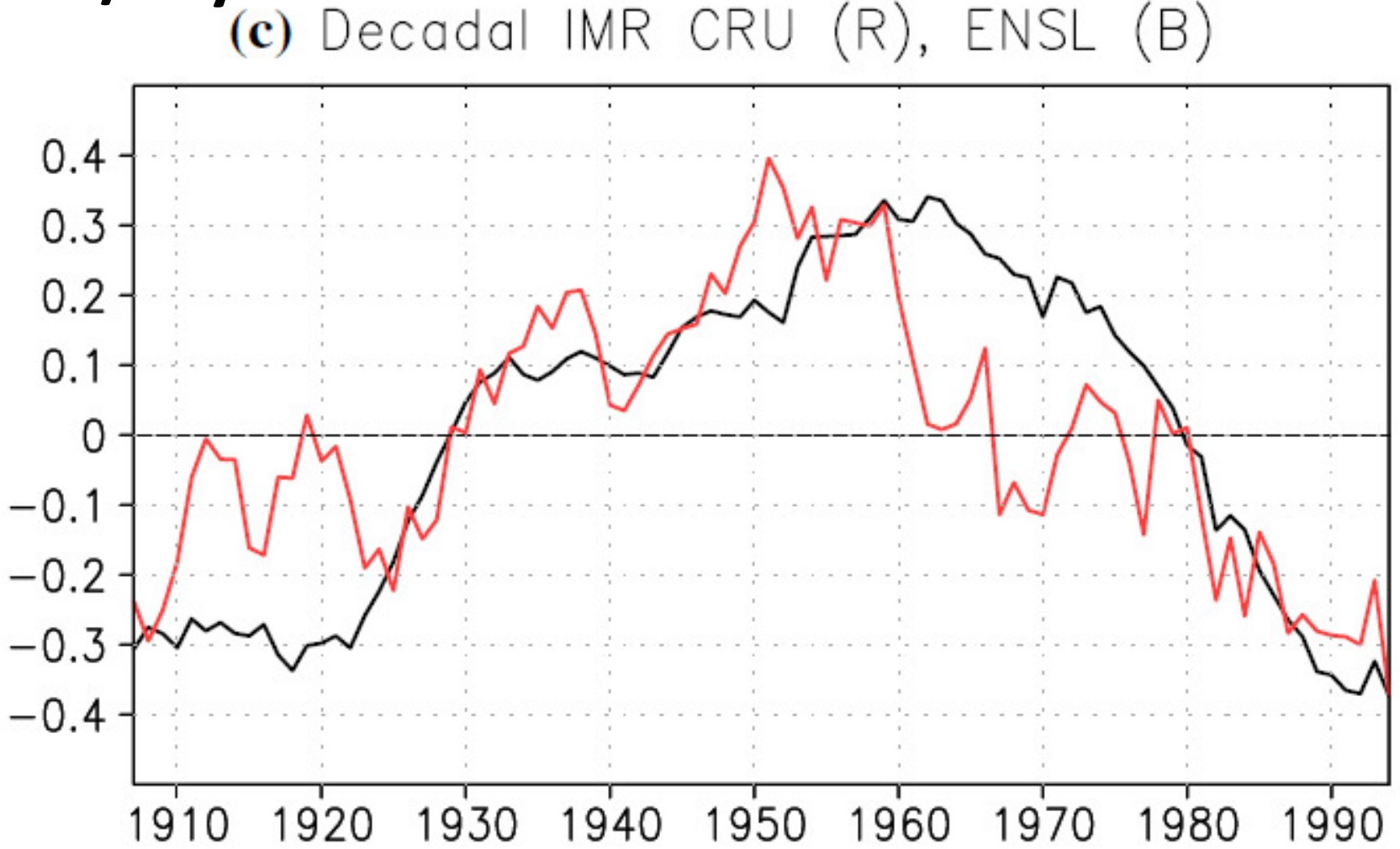
DECADAL MODULATION OF THE INDIAN MONSOON



Kucharski et al , Climate Dynamics, 2009

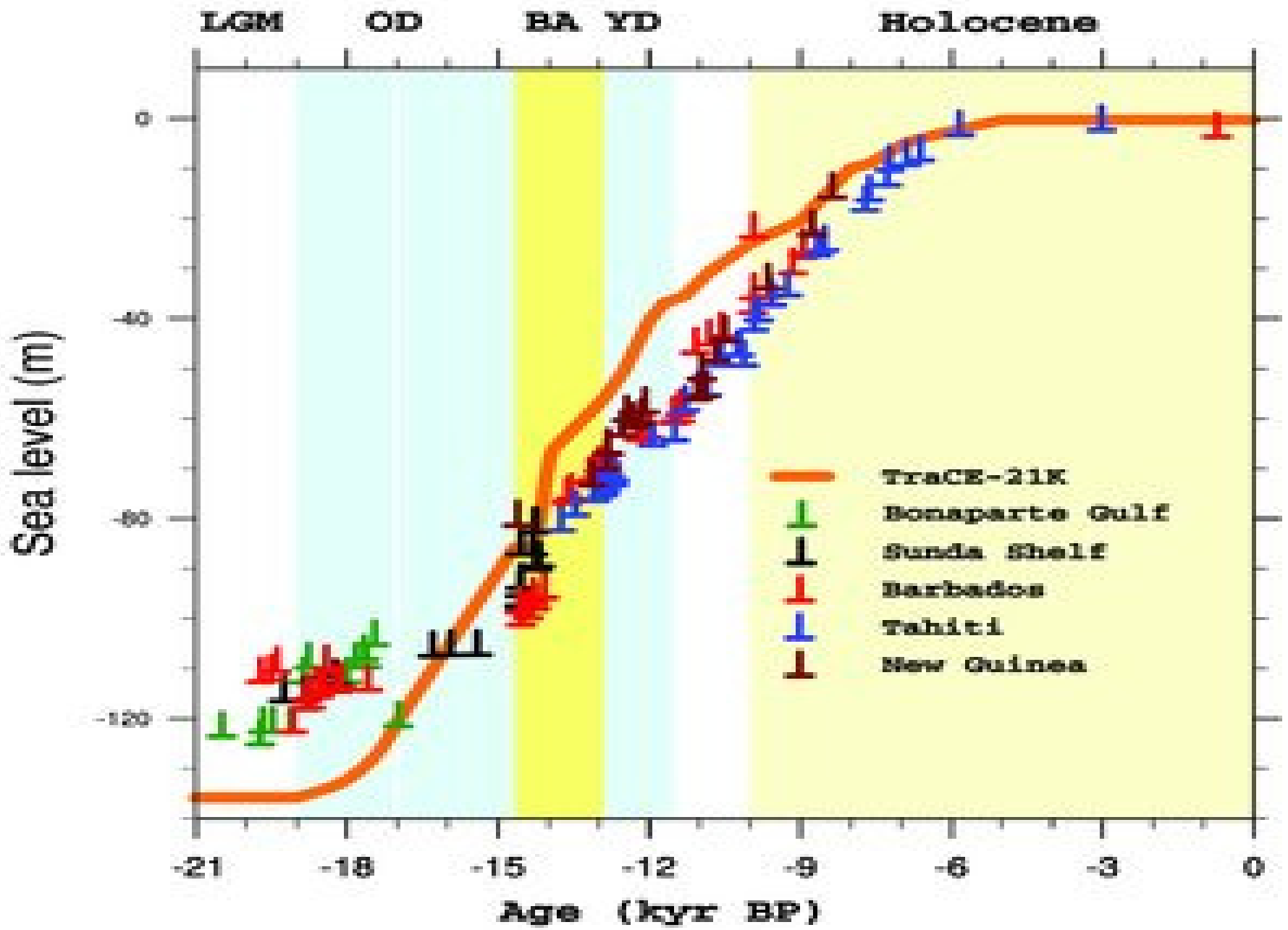
Observations(Red) Model Ensemble (Black) 6 AGCM

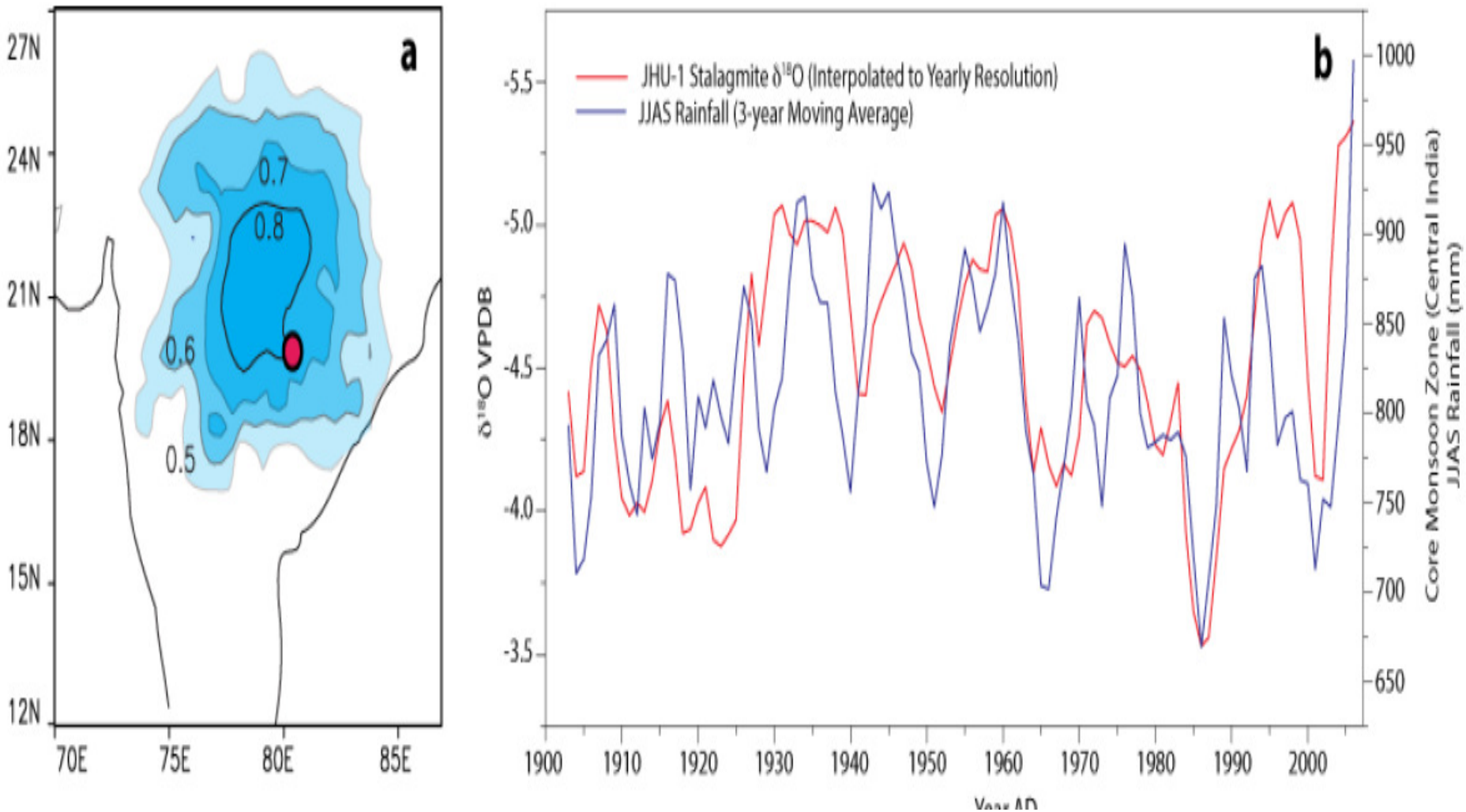
mm/day

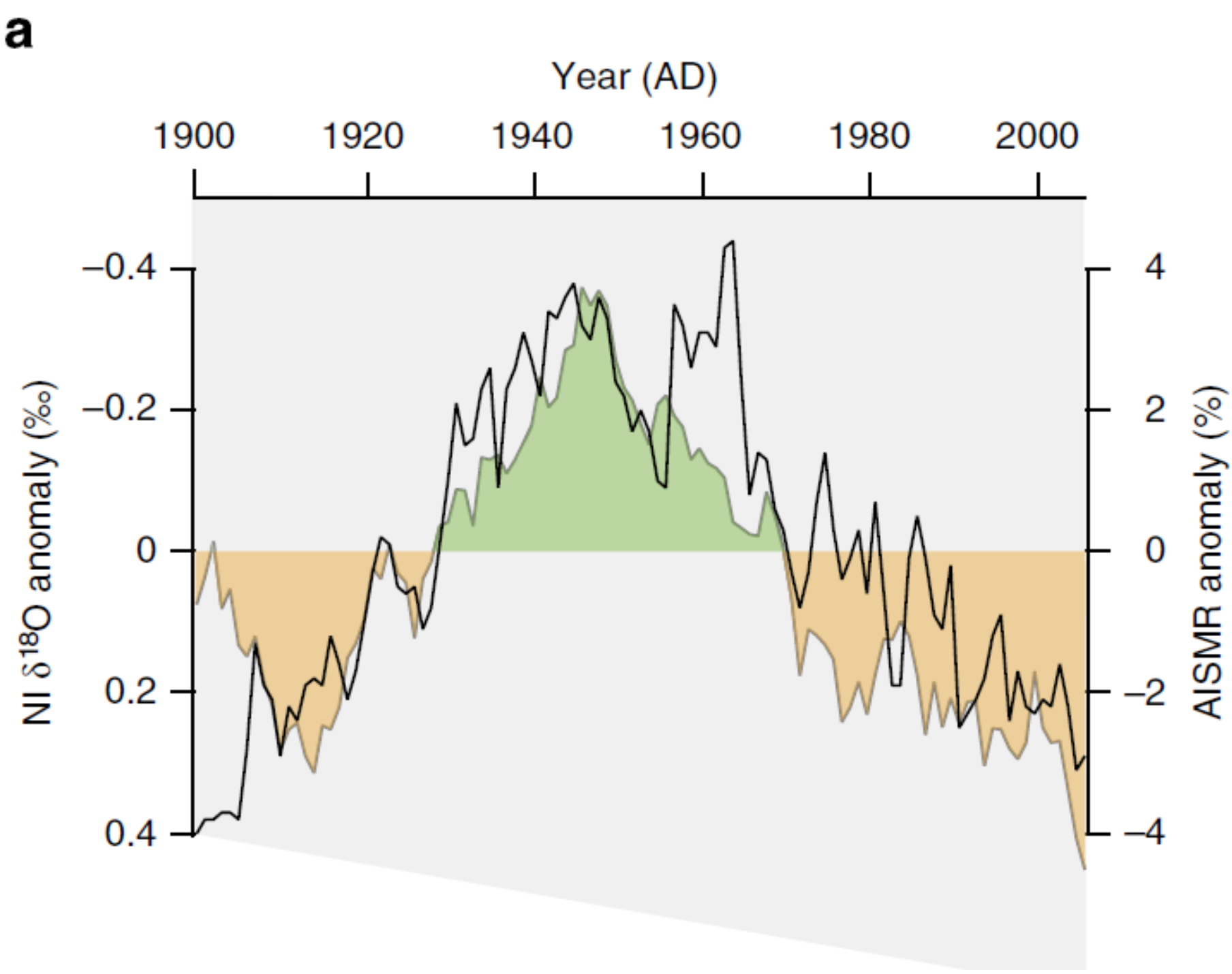


TraCE-21ka
Simulation of Transient Climate Evolution over the last 21,000 years

CCSM3 is a global, coupled ocean-atmosphere-sea ice-land surface climate model without flux adjustment. All the simulations were performed at T31 with a dynamic global vegetation model (DGVM). The atmospheric model is the Community Atmospheric Model 3 (CAM3), a three-dimensional primitive equation model solved with the spectral method in the horizontal (T31, ~3.75o latitude-longitude resolution) and with 26 hybrid coordinate levels in the vertical.


LGM
OD
BA
YD
Holocene
Sea level (m)
0
-40
-80
-120
-21
-18
-15
-12
-9
-6
-3
0
Age (kyr BP)
TraCE-21K
Bonaparte Gulf
Sunda Shelf
Barbados
Tahiti
New Guinea


a
27N
24N
21N
18N
15N
12N
70E
75E
80E
85E
0.7
0.8
0.6
0.5
b
JHU-1 Stalagmite δ18O (Interpolated to Yearly Resolution)
JJAS Rainfall (3-year Moving Average)
δ18O VPDB
-5.5
-5.0
-4.5
-4.0
-3.5
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
Year AD
Core Monsoon Zone (Central India)
JJAS Rainfall (mm)
1000
950
900
850
800
750
700
650


a
Year (AD)
1900
1920
1940
1960
1980
2000
−0.4
−0.2
0
0.2
0.4
NI δ18O anomaly (‰)
4
2
0
−2
−4
AISMR anomaly (%)

BETTER UNDERSTANDING
VERSUS
ACCURATE PREDICTION

Thank You