

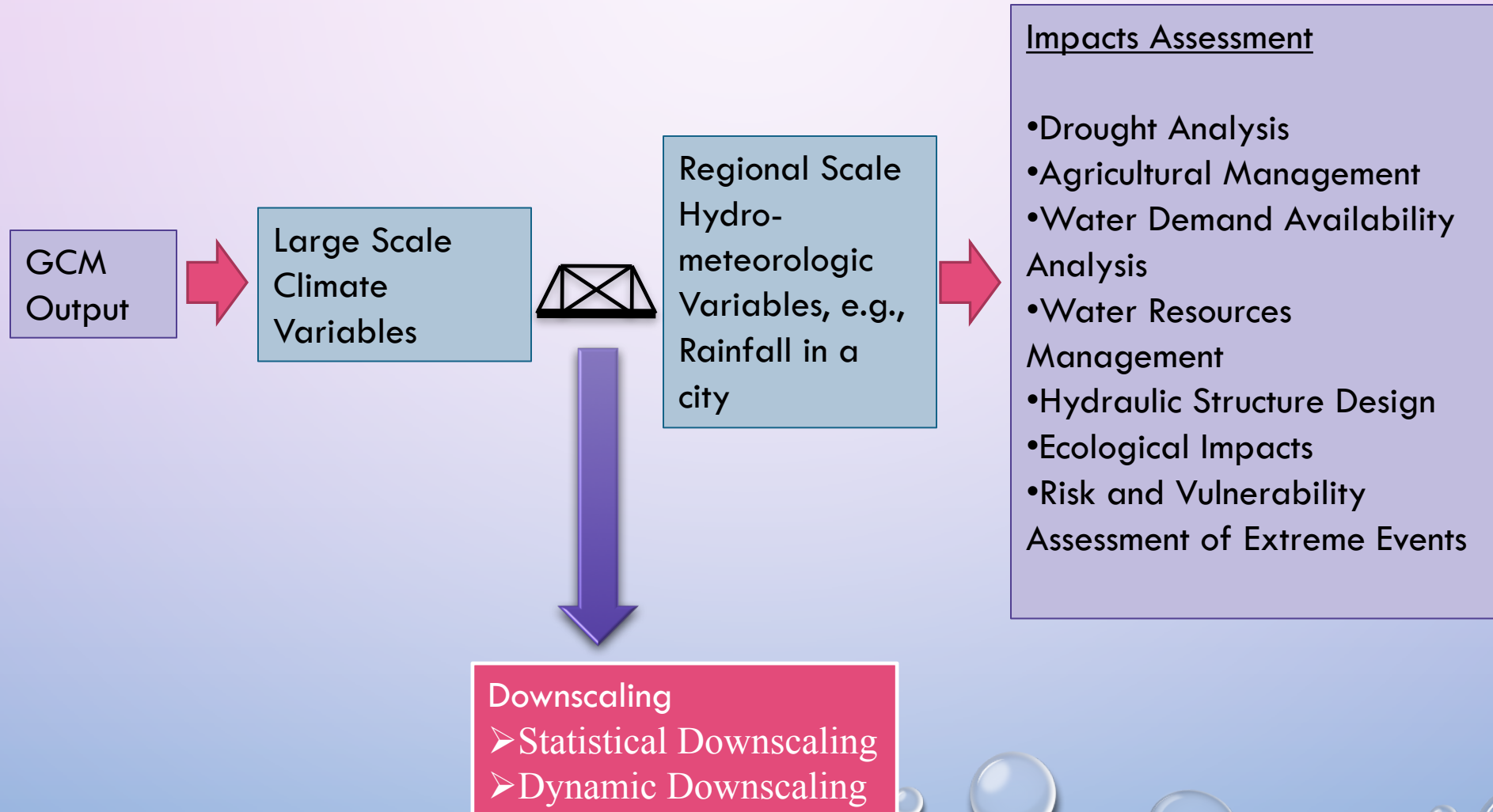
Applications of Downscaling in Assessing Impacts of Climate Change: Challenges and Unanswered Questions

Subimal Ghosh

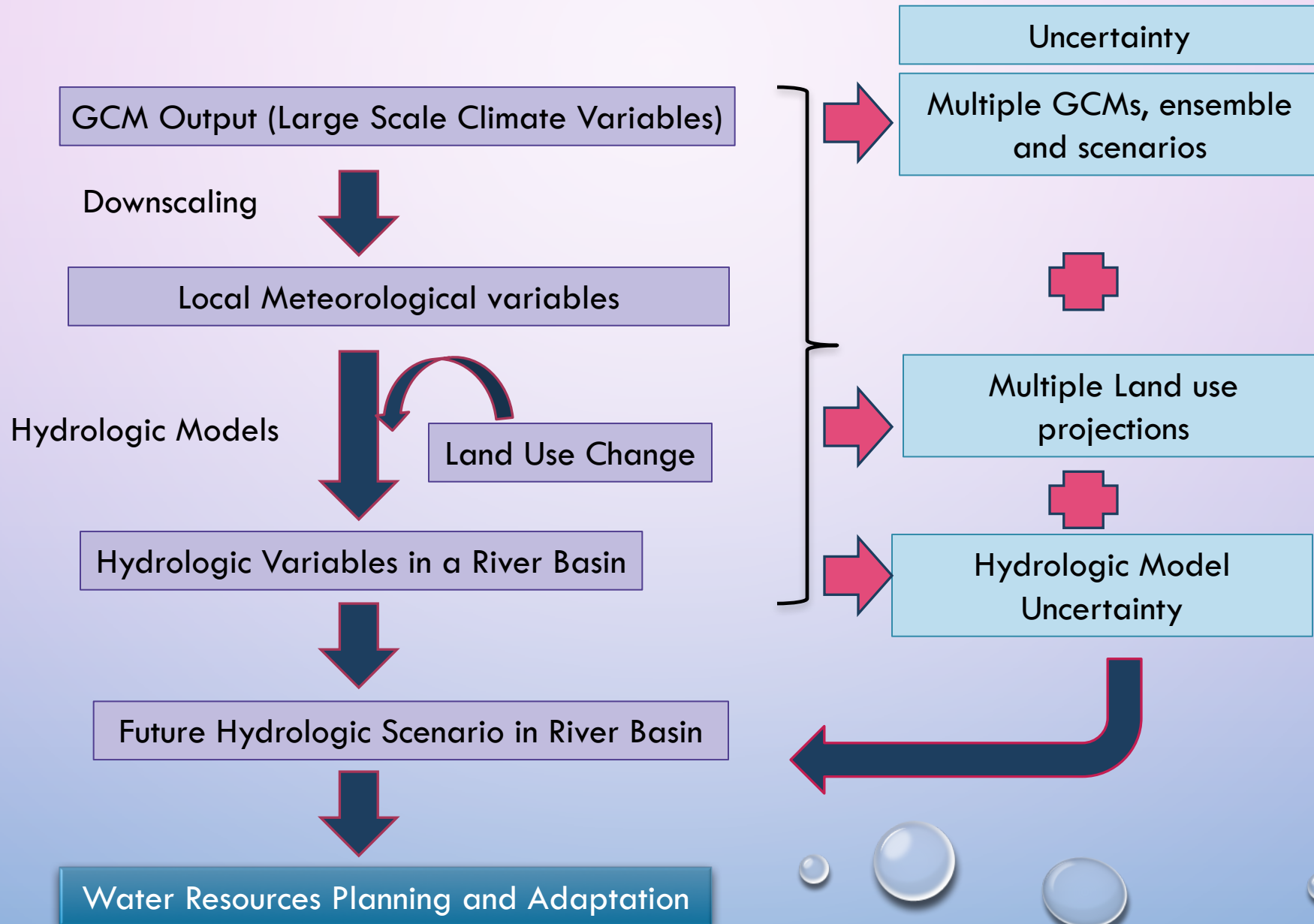
Department of Civil Engg. and IDP in Climate Studies

IIT Bombay

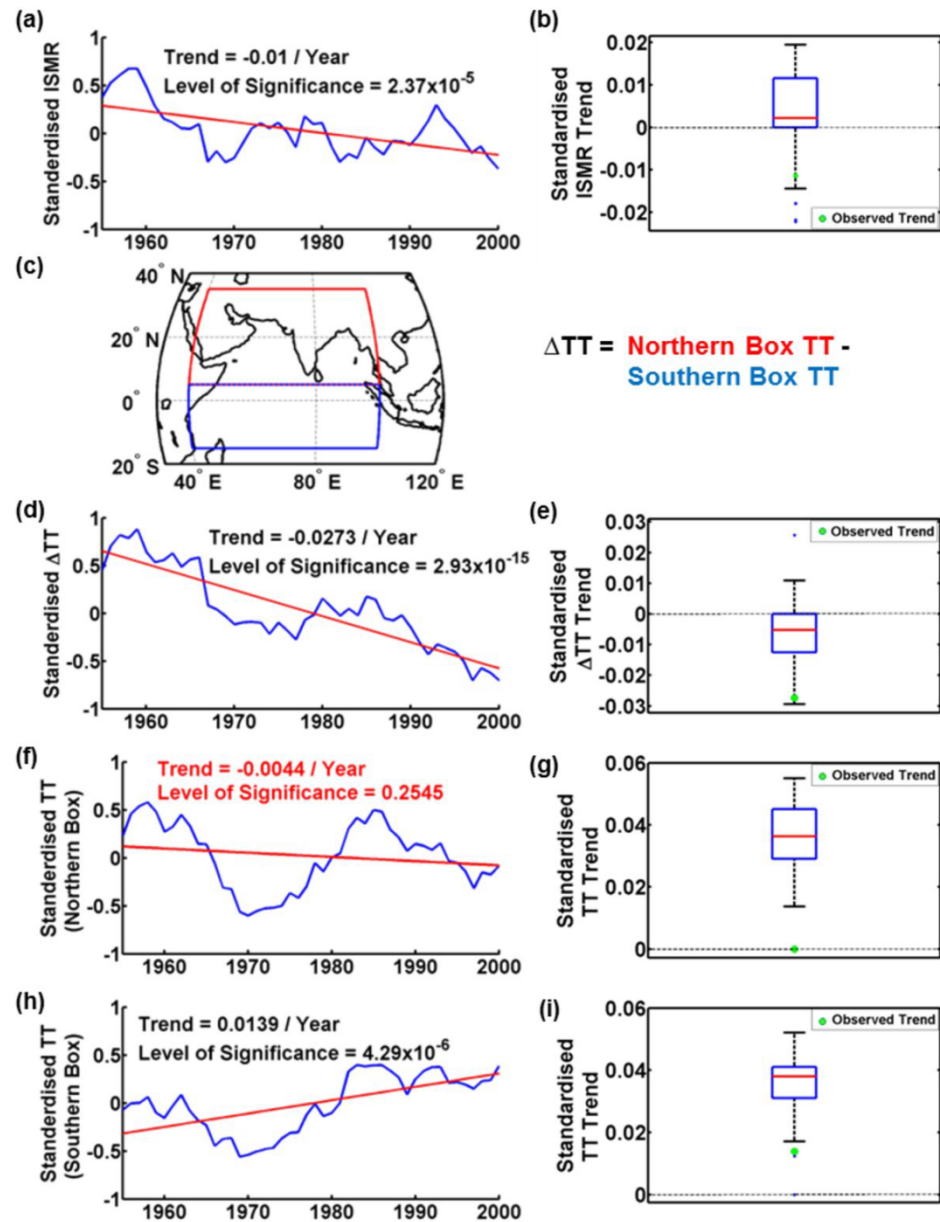
Downscaling



General Framework

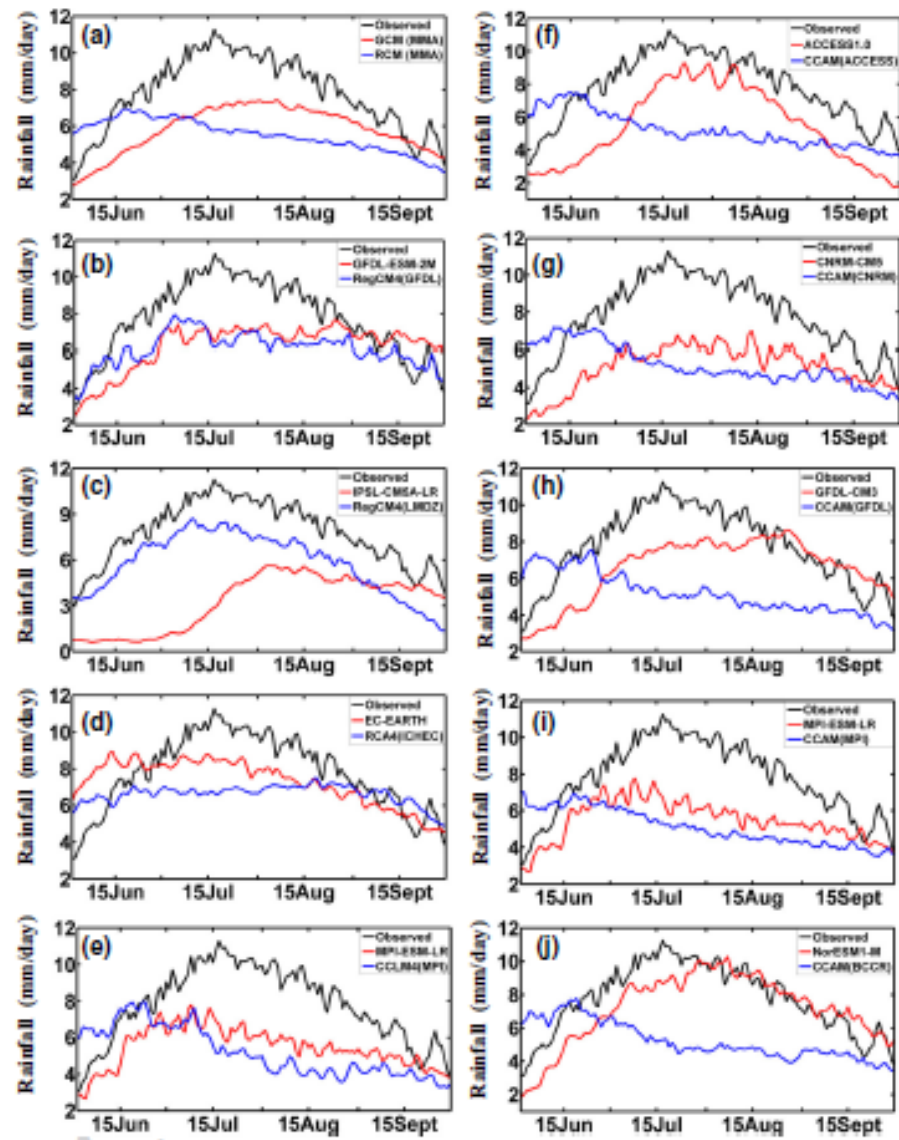
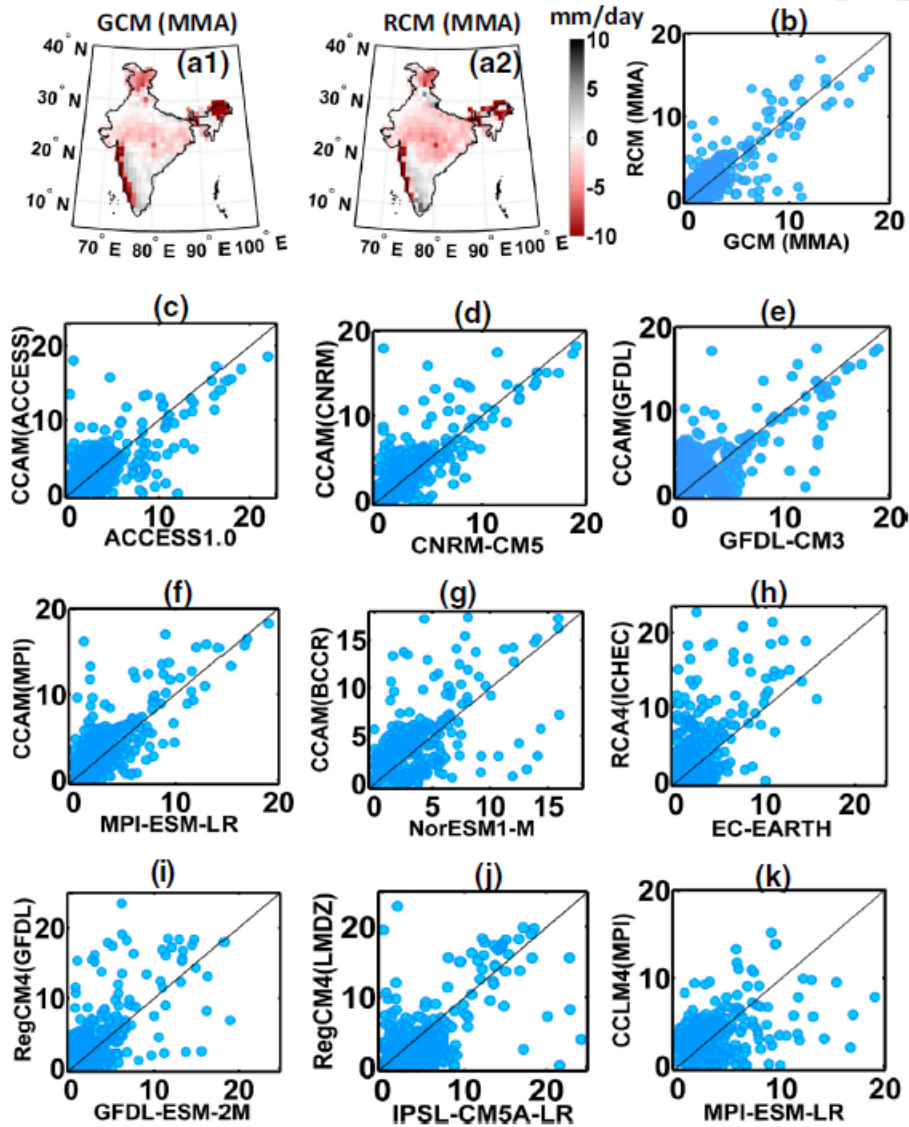


Can GCMs simulate observed trend?



Even if you consider Multi-Model Average \rightarrow it will give opposite trend

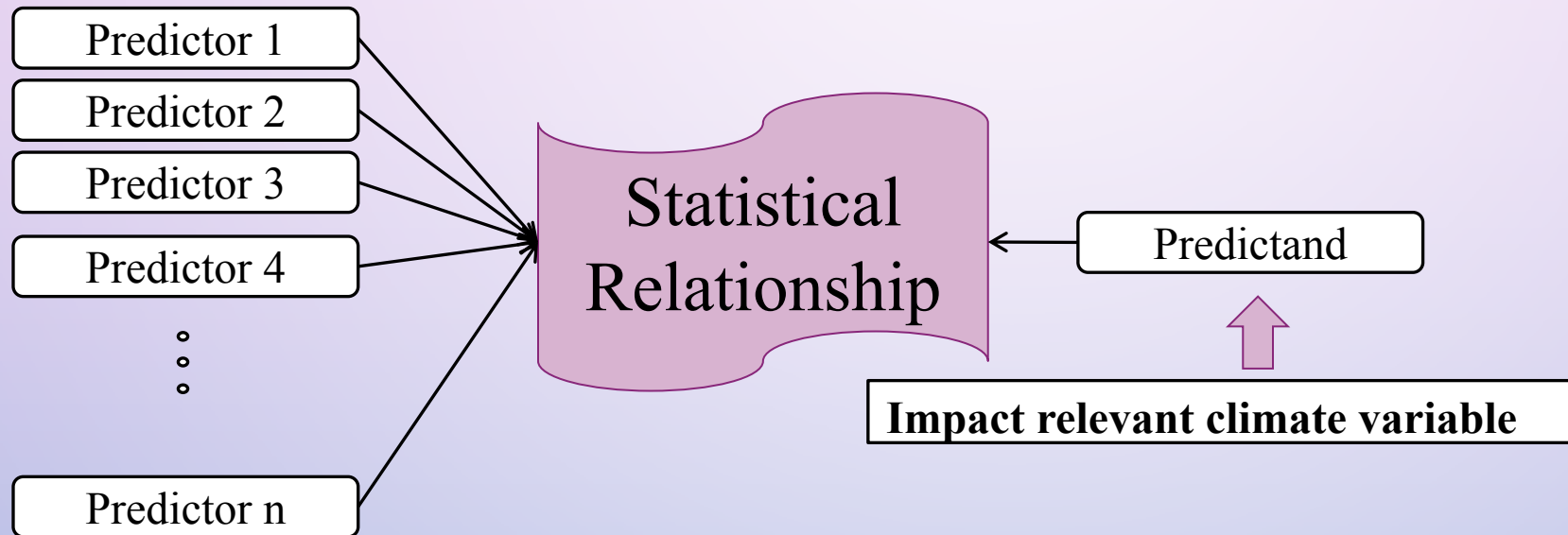
CORDEX Models are great but may need Improvements



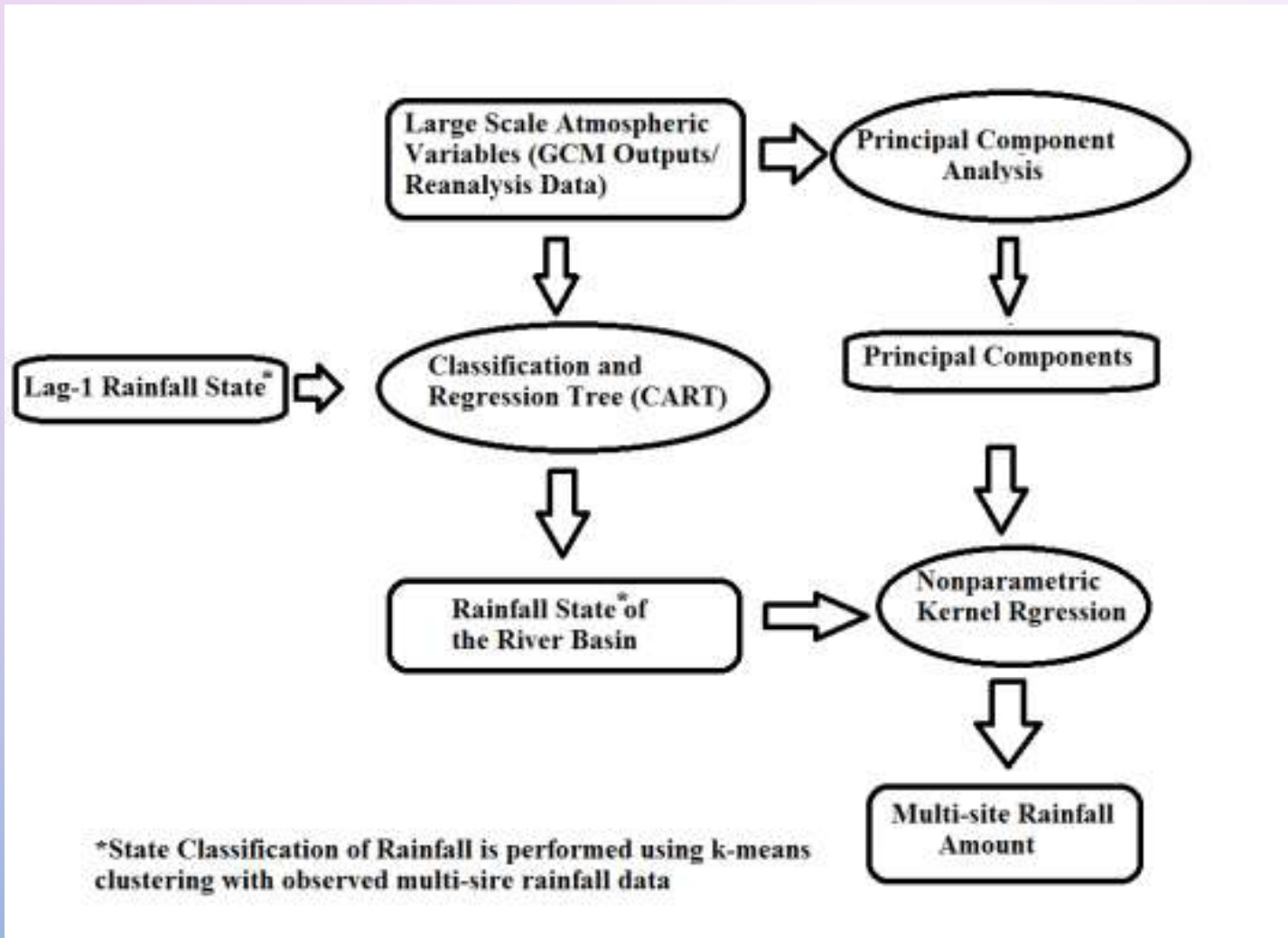
Singh et al. (2016)
Climate Dynamics

What about statistical downscaling?

Standard Approach

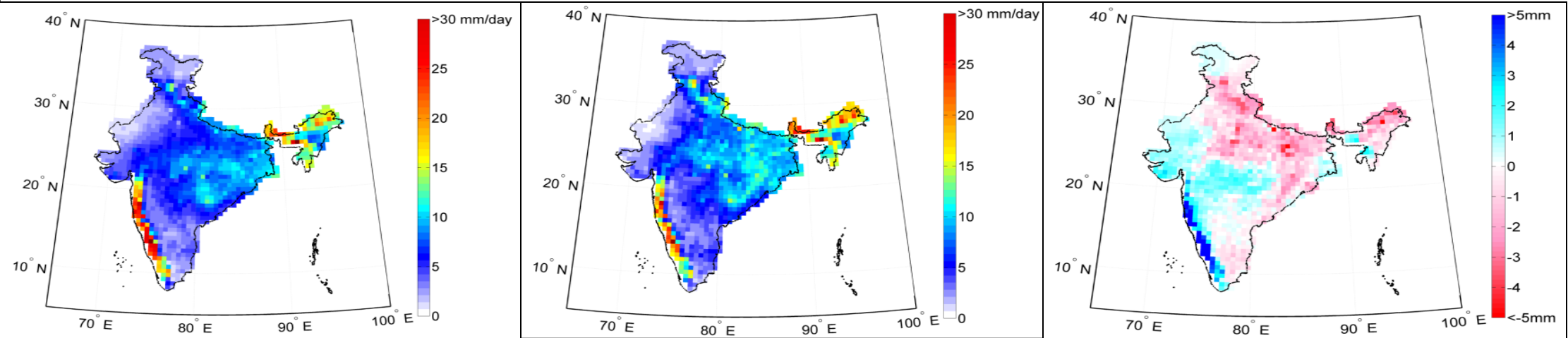


Our Approach



Kannan and Ghosh (2013), WRR

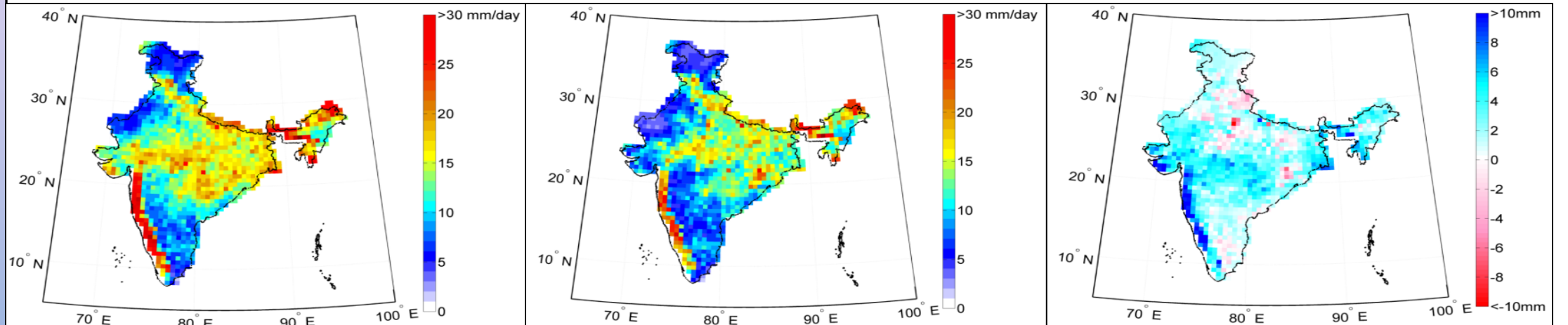
Historic Period Simulations: Comparison of Statistical Properties (1971-2000)



Observed Mean rainfall

Projected Mean rainfall

Difference in mean (mm/day)



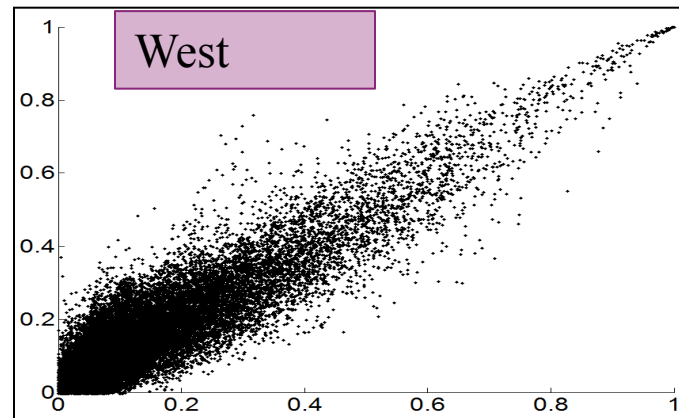
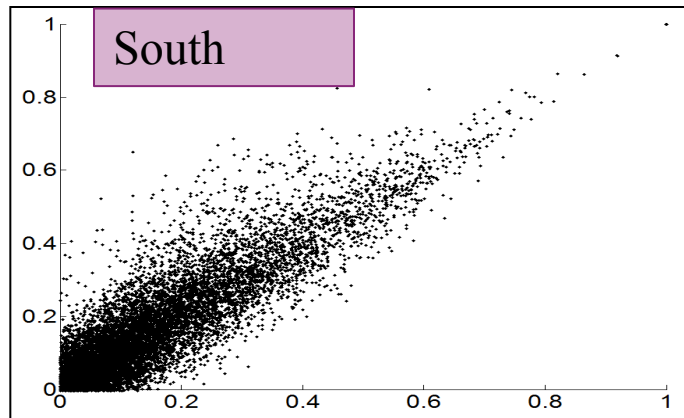
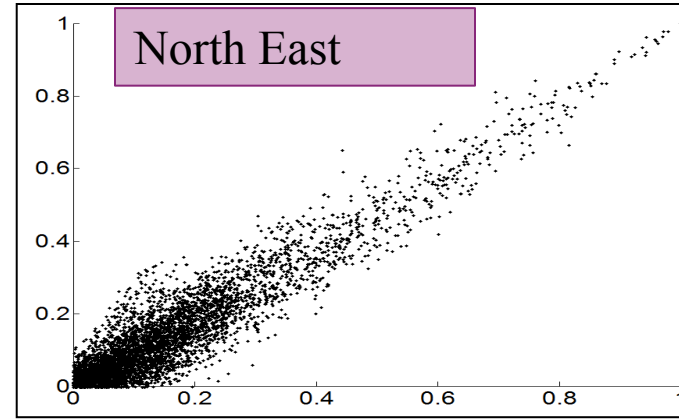
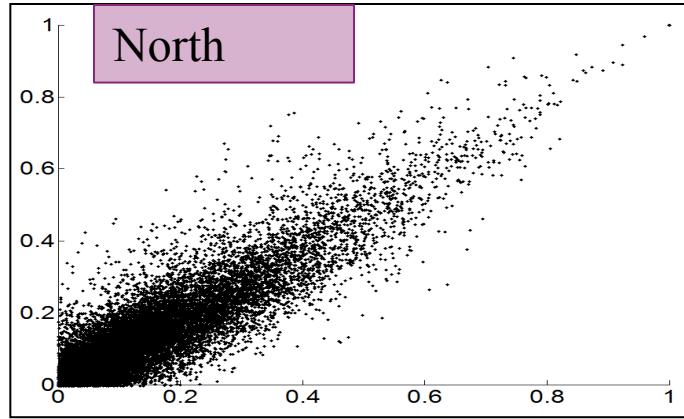
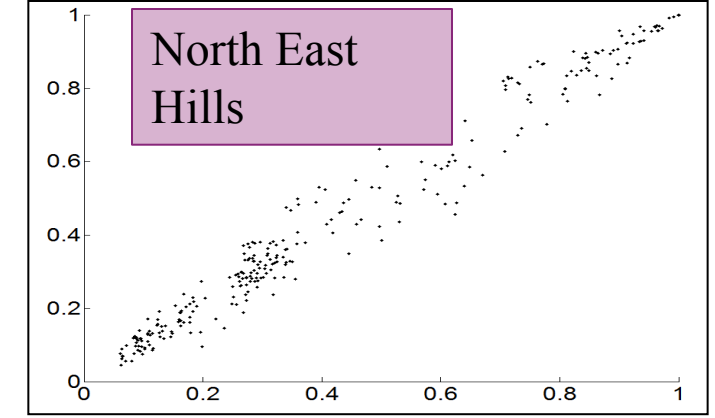
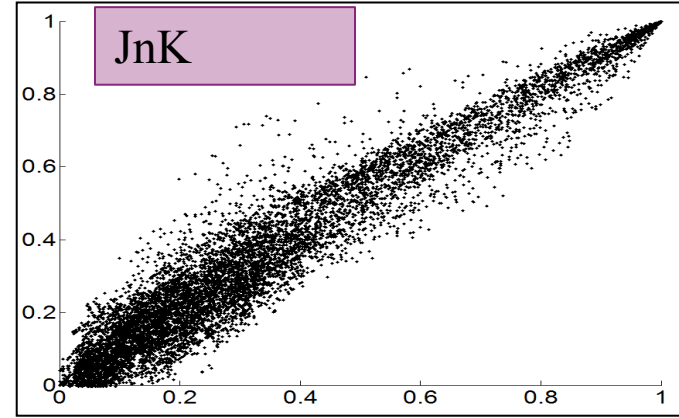
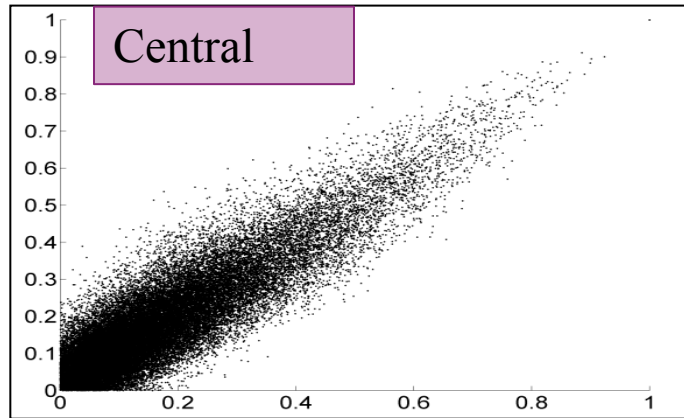
Observed rainfall standard deviation

Observed rainfall standard deviation

Difference in standard deviation (mm/day)

Salvi et al.
(2013)
JGR

Zone-Wise Cross-correlation plots



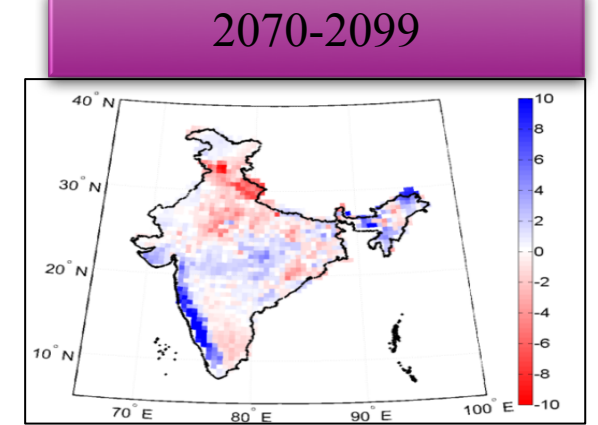
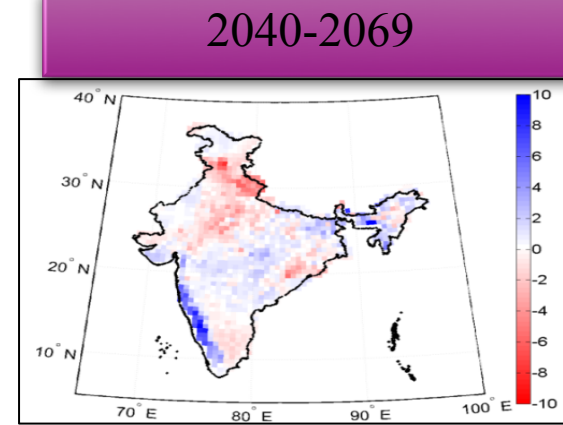
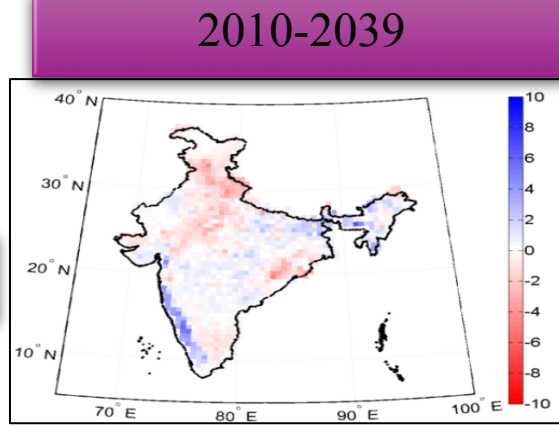
Cross-correlation for observed data on X axis

Cross-correlation for simulated data on Y axis

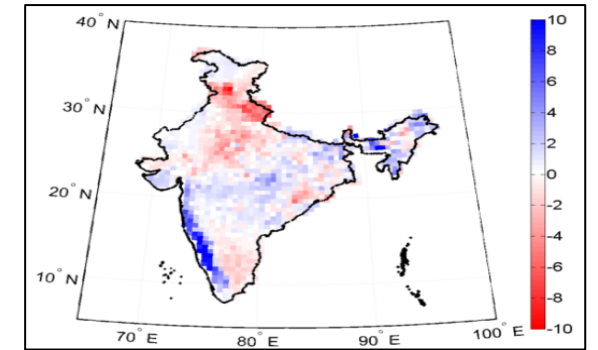
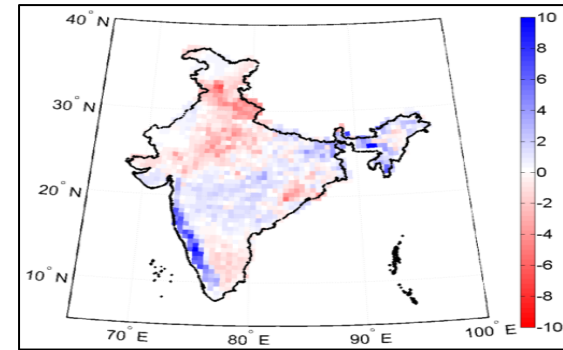
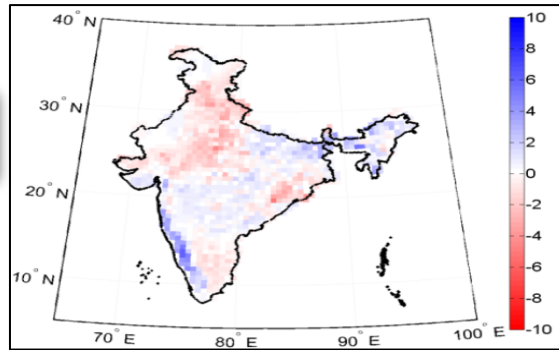
Future Projections

All Dimension are in mm/day

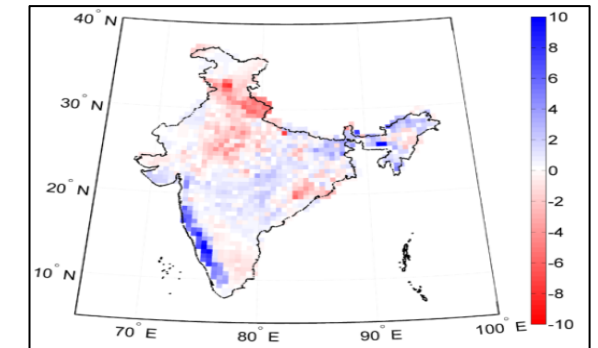
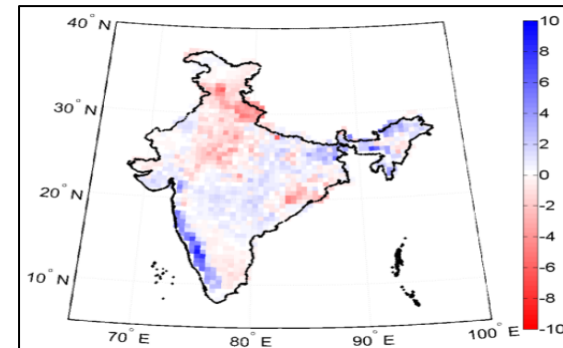
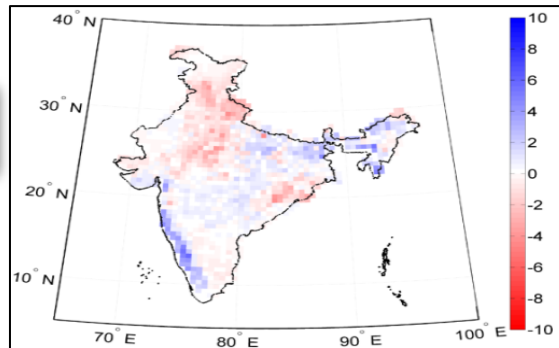
A2



A1B



B1



Do they work in non-stationary climate?

Design of Experiments

Experiment Series 1

Basis-Criteria based training (TR) and testing (TE) period selection

Base Experiment (TR-RAN-TE-RAN):

Rainfall projections obtained using randomly selected training and testing period from 1951-2005.

Criteria based Selection:

Criteria 1: Conventional way

- (1) Train with first 30 years (chronological) and test for remaining (TR-CH-TE-CH).

Criteria 2: Hypothetical Climate change scenario

- (1) Train with relatively cold (cooler) years and test for relatively hot (warmer) years (TR-C-TE-H) from 1951-2005.
- (2) Train with non-ENSO years and test for ENSO years (TR-nonEN-TE-EN) from 1951-2005.

Criteria 3: Reverse Climate Change scenario

- (1) Train with relatively hot (warmer) years and test for relatively cold (cooler) years (TR-H-TE-C) from 1951-2005.
- (2) Train with ENSO years and test for non-ENSO years (TR-EN-TE-nonEN) from 1951-2005.

Validations

Magnitude and spatial pattern of Root Mean Square Error (RMSE) for TR-RAN-TE-RAN is compared with that for the set of experiments from series 1.

Experiment Series 2

Basis-Comparison of changes in mean shown by observed and GCM simulated rainfall for years, analogous to Pre-industrial (PI) run and future increased GHG scenarios (showing signatures of GCM simulations)

(SB-AP-PI)

Years from recent past time slice (1981-2005) which are analogous to GCM simulated pre-industrial data.

(SB-AP-RCP85)

Years from recent past time slice (1981-2005) which are analogous to GCM simulated future data.

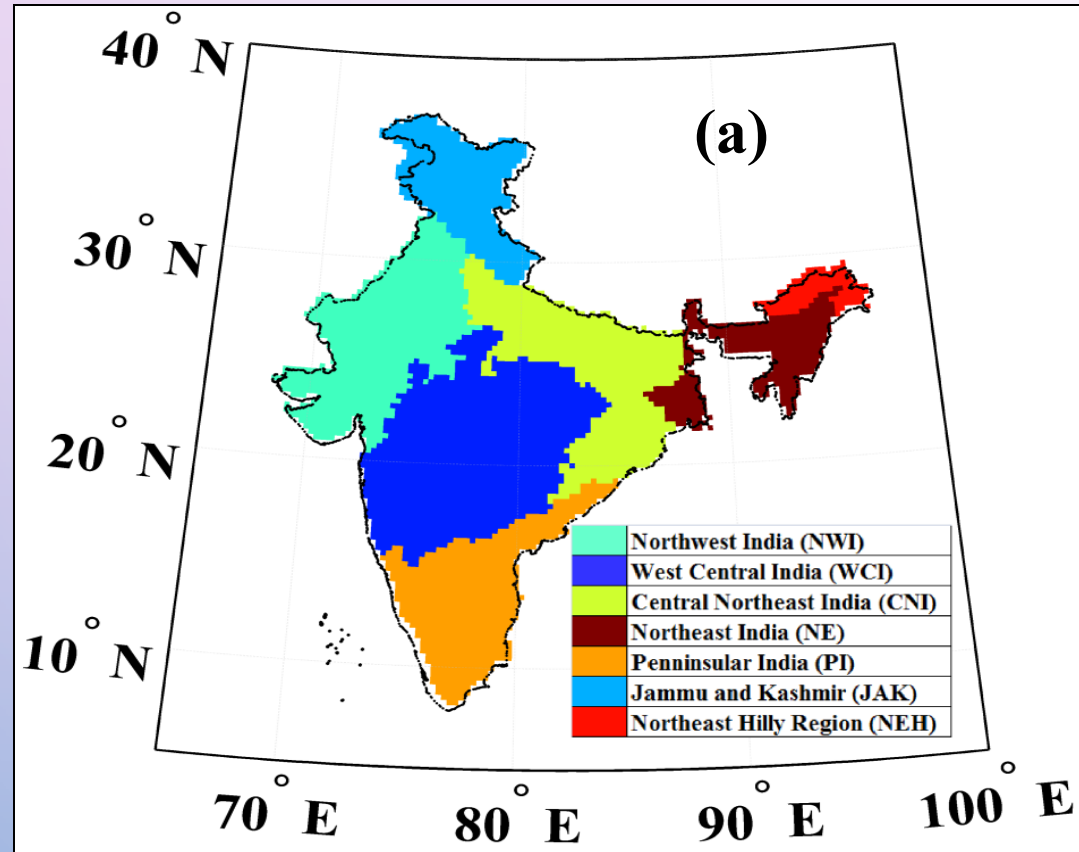
Validations

$X = \text{mean rainfall (SB-AP-RCP85)} - \text{mean rainfall (SB-AP-PI)}$
X shows the changes in mean rainfall because of GHG emissions.
Compare X obtained with observed (X_{obs}) and simulated (X_{sim}) rainfall data.

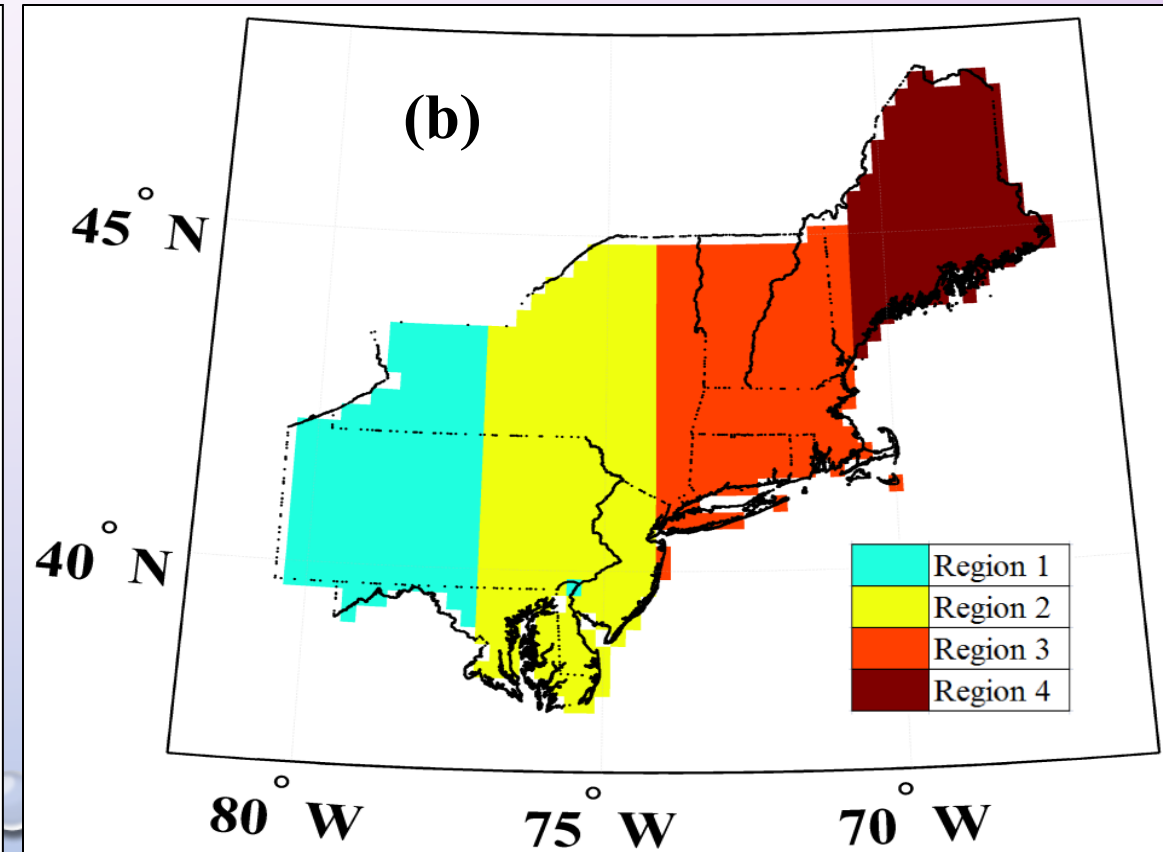
Dissimilarities in Error/Difference Patterns indicates 'Lack of Stationarity'

Study Regions: To illustrate the generic nature of methodology

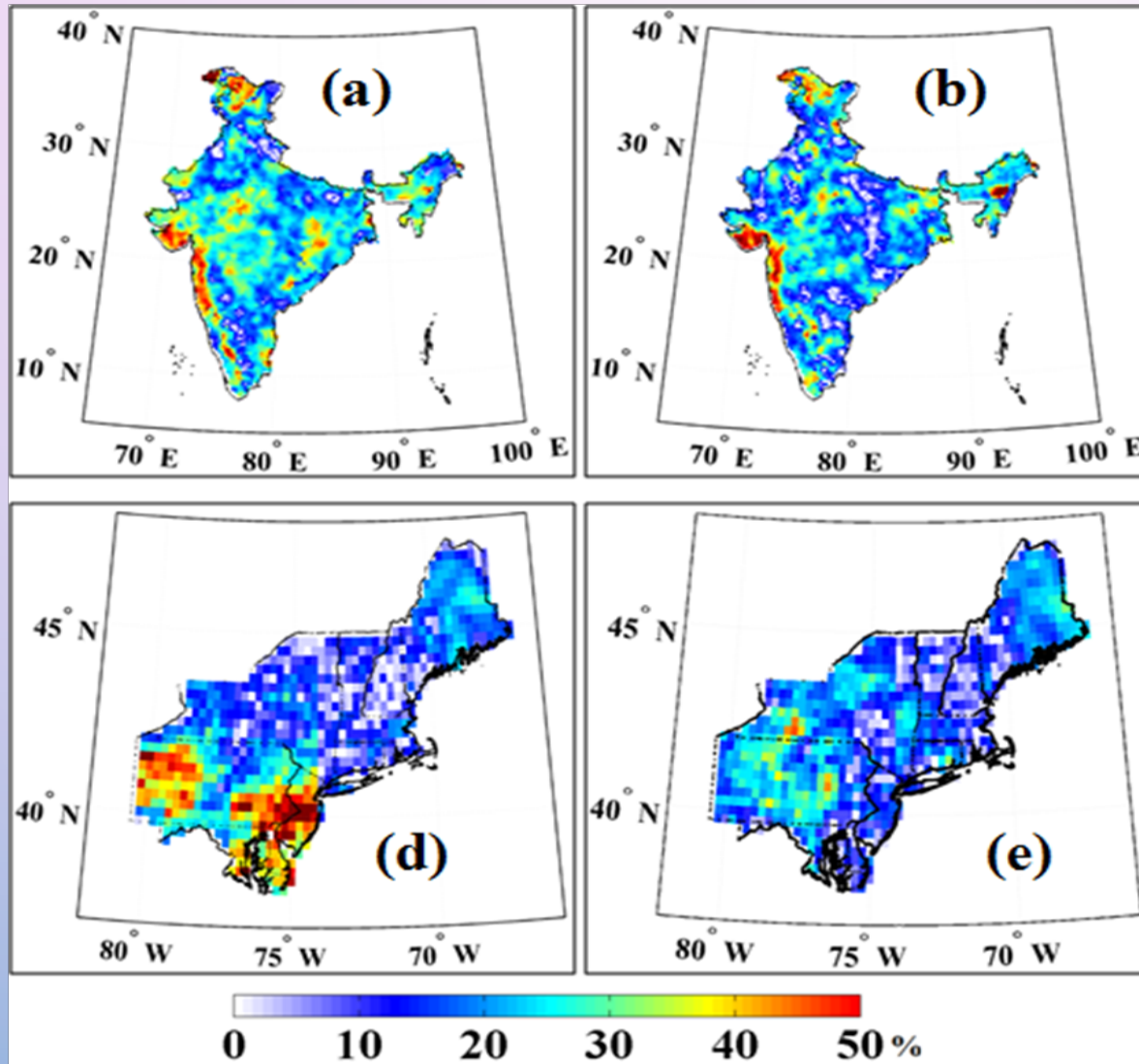
Study Region 1: India



Study Region 2: Northeast US

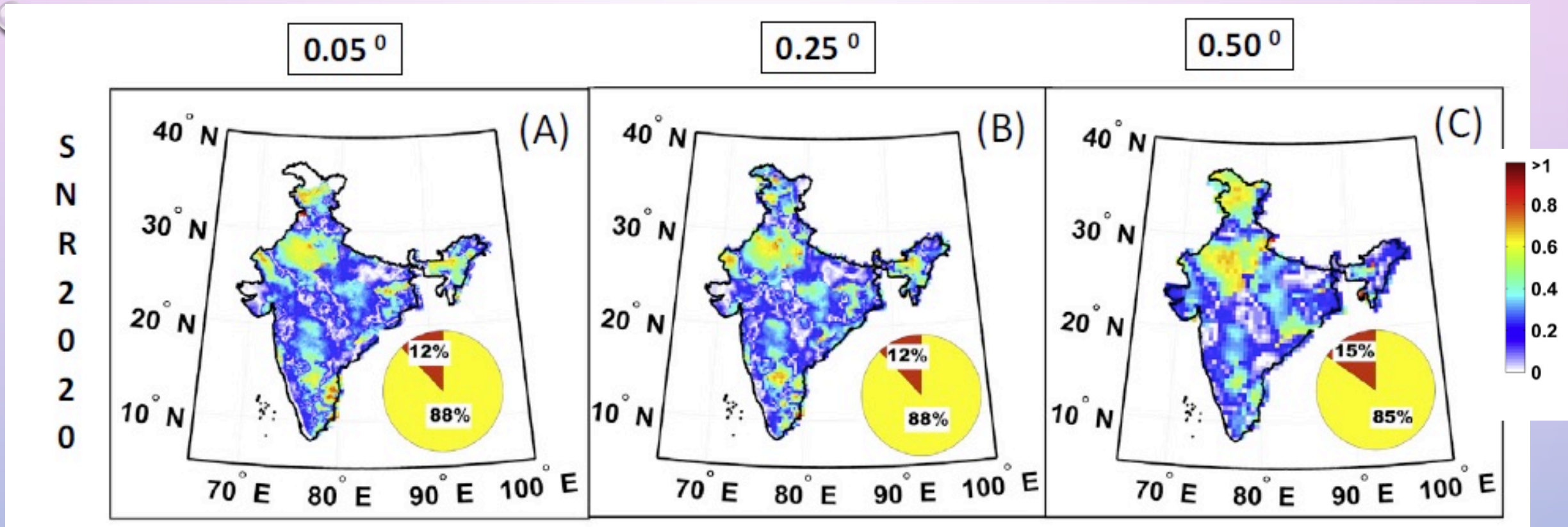


Violation on Non-stationarity



Salvi et al., 2016, Clim Dyn

Do they provide any signal of changes?



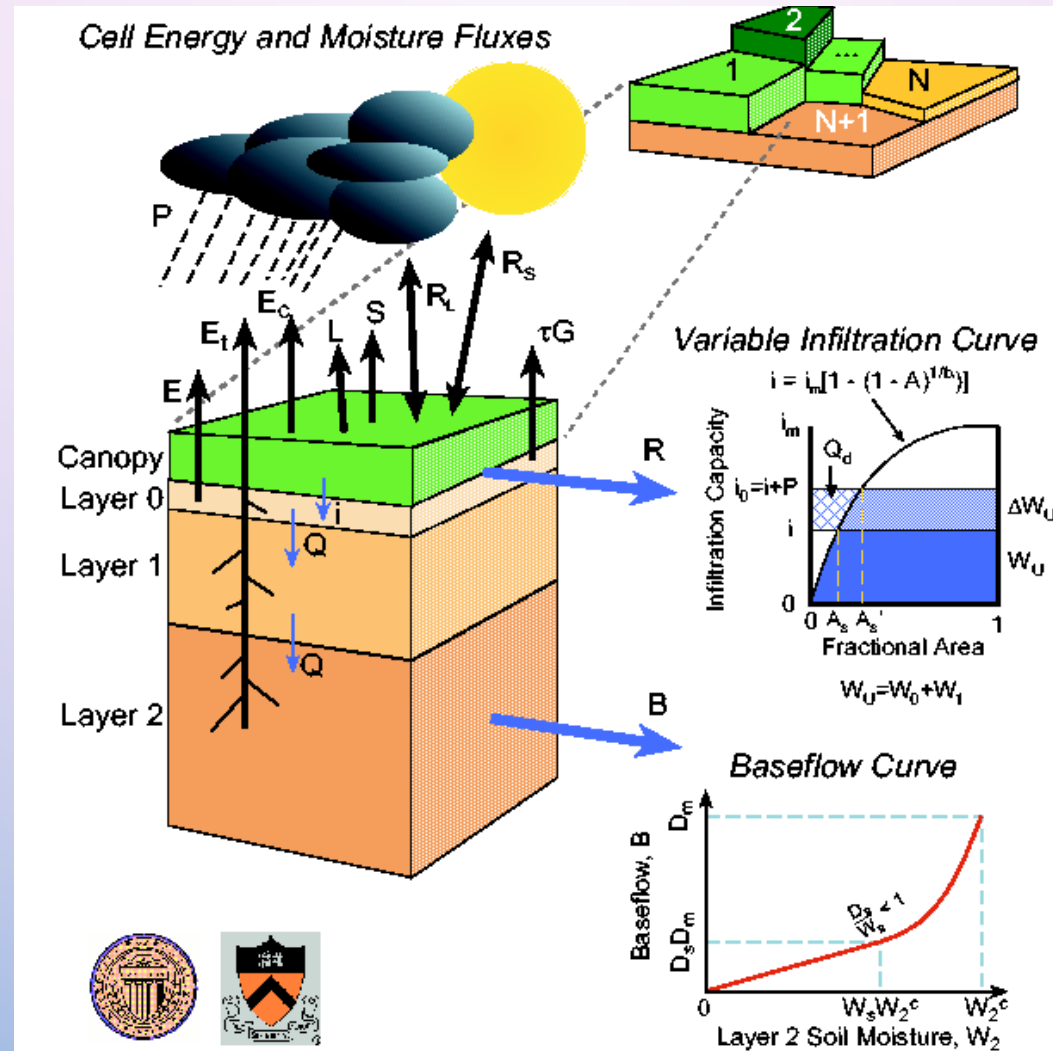
Shashikanth et al. (2014)
Jl. of Hydrology

■ SNR > 0.5 ■ SNR < 0.5

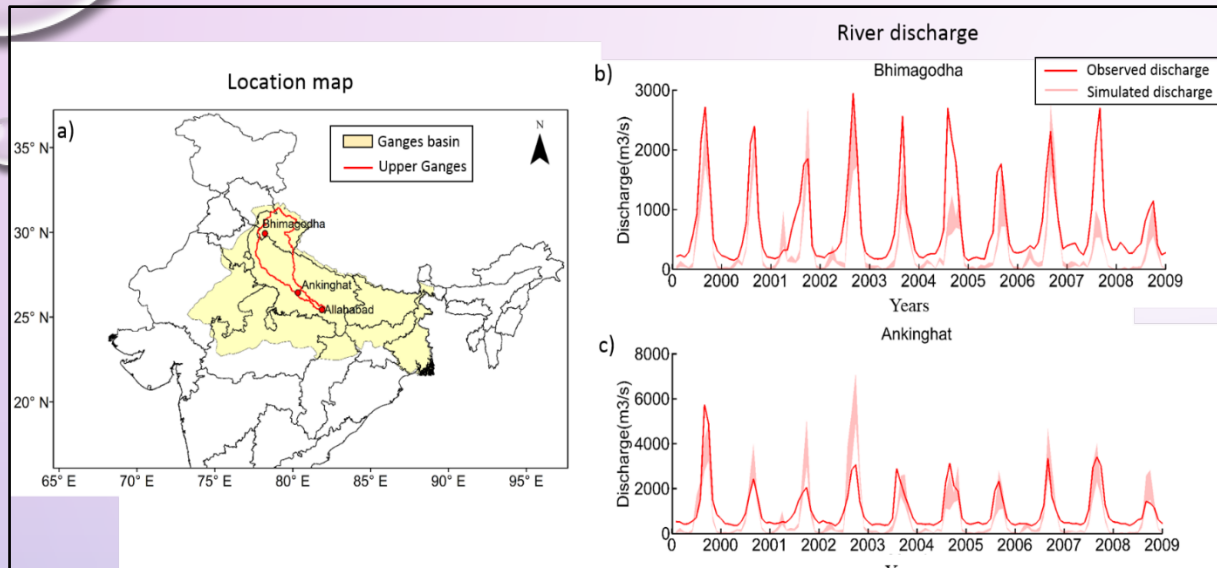
The background features a light purple-to-blue gradient. In the top-left and bottom-right corners, there are clusters of realistic water droplets of various sizes, rendered with soft shadows and highlights to give them a three-dimensional appearance.

Assessing Hydrological Impacts

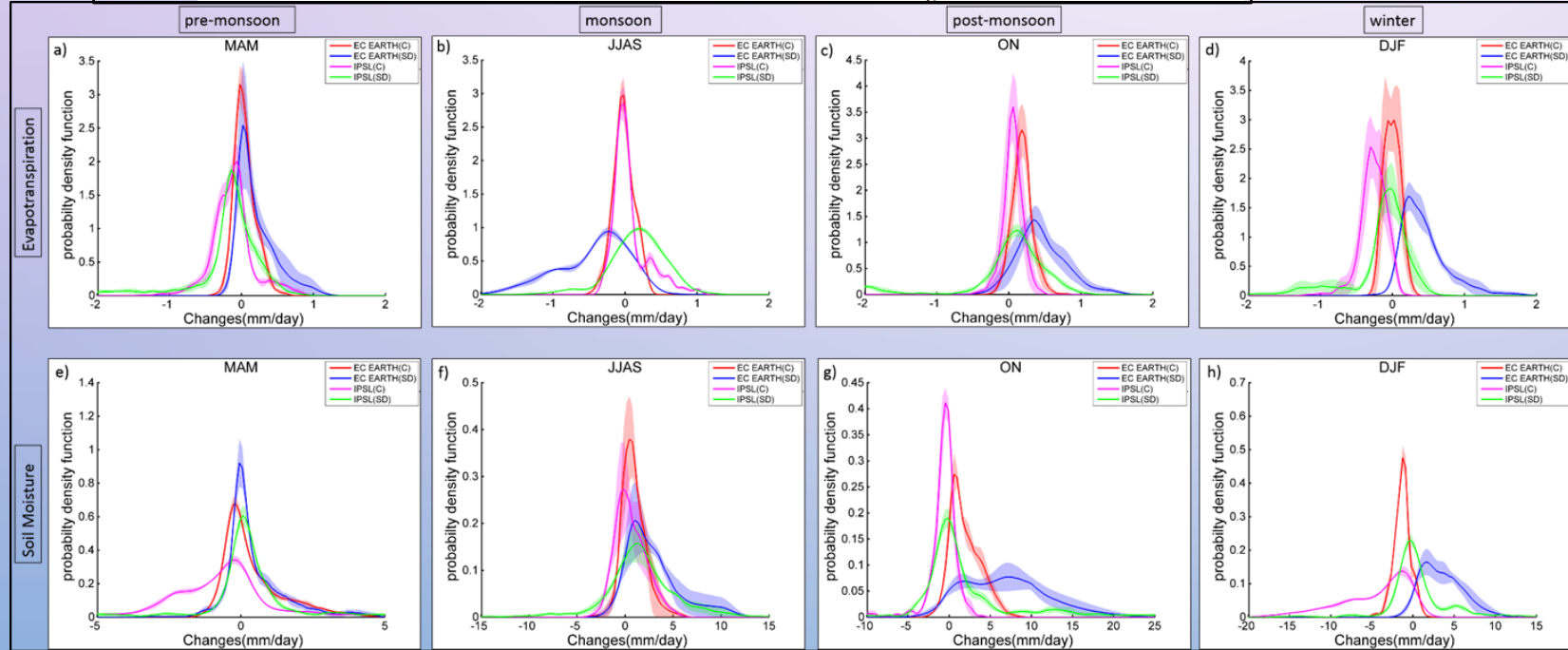
Variable Infiltration Capacity Model



Hydrological Parameterization in the background of Climate Uncertainty

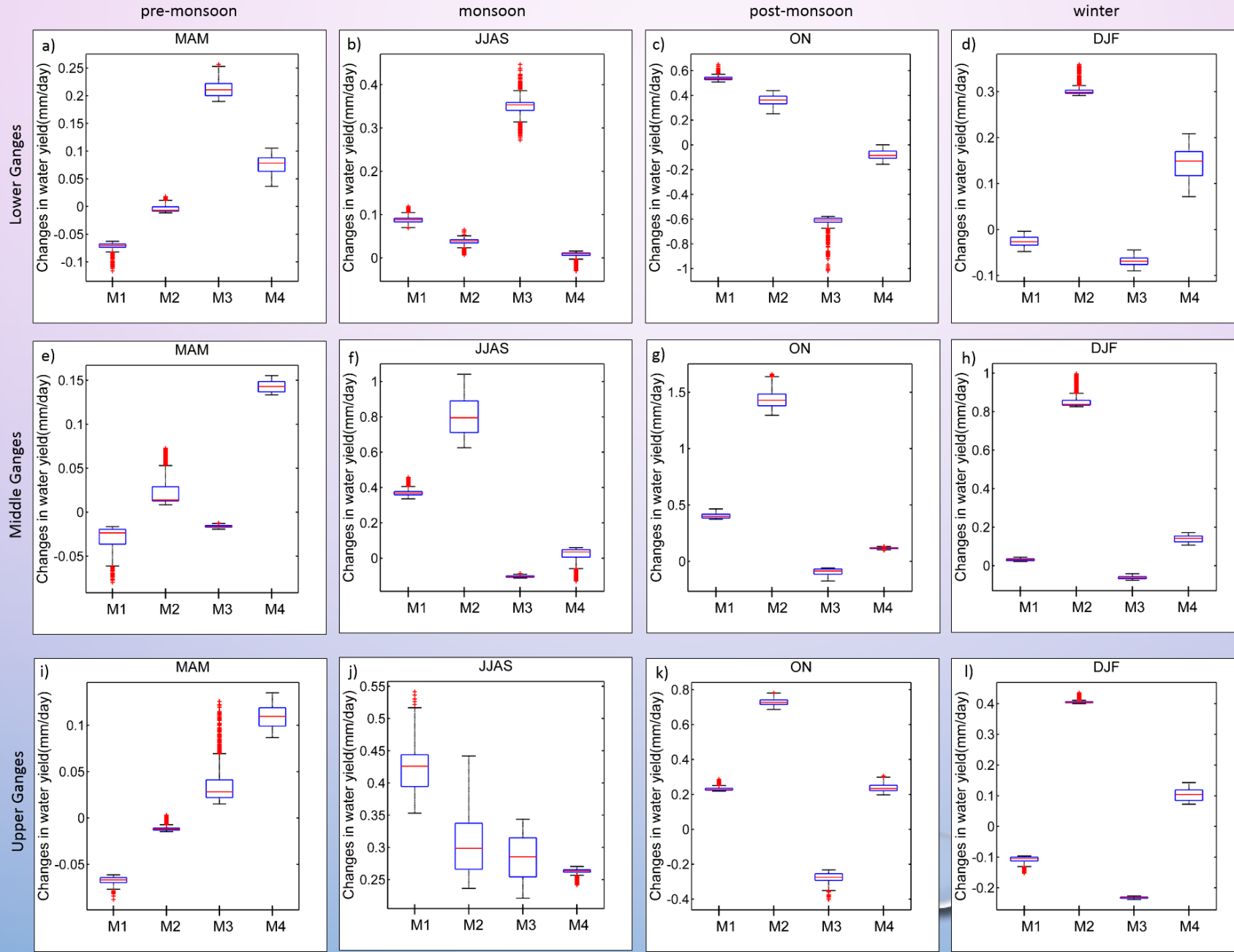


Given the climate uncertainty,
you may not even require any
hydrological parameterization?
😊



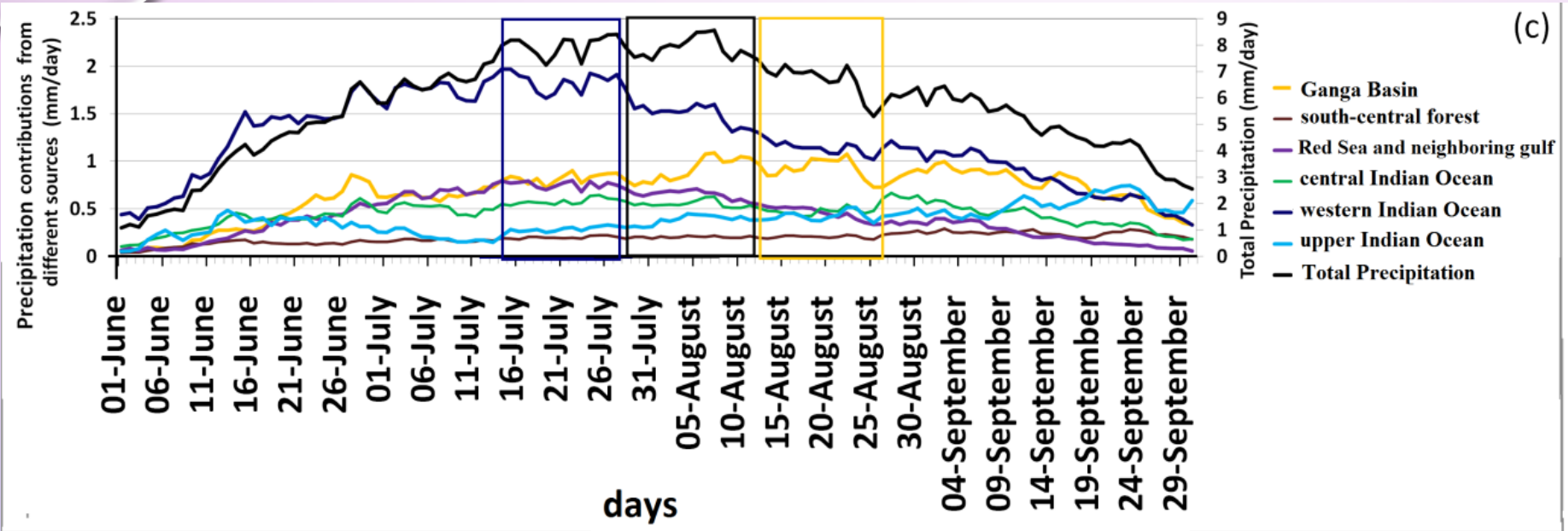
Joseph et al. (2016),
Revised manuscript under
preparation for JH

Hydrological Parameter Calibration lost its value? ☺

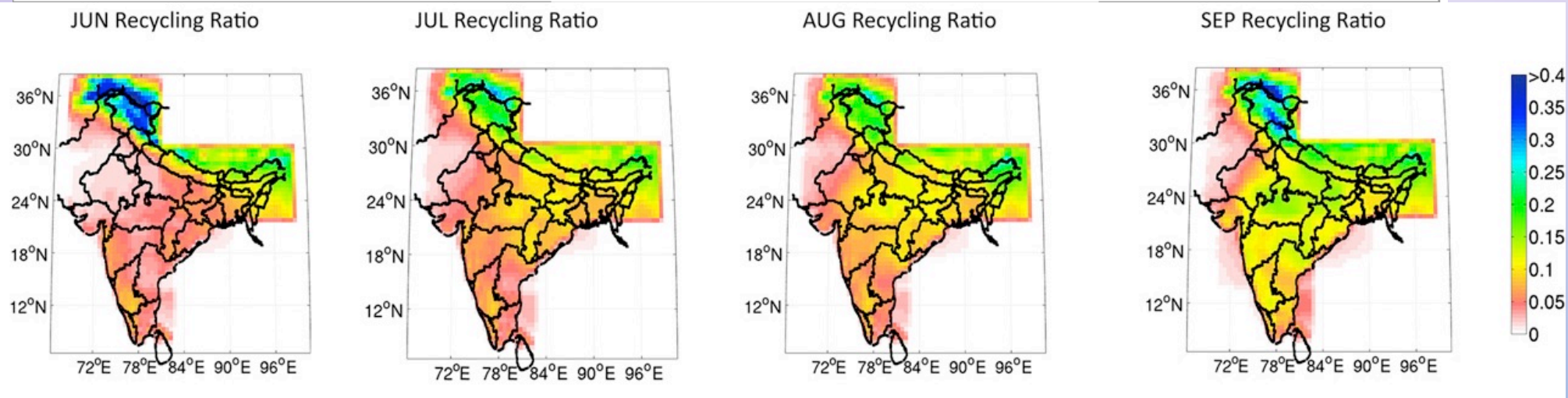


M1- EC EARTH CORDEX
M2- EC EARTH SD
M3- IPSL CORDEX
M4- IPSL SD

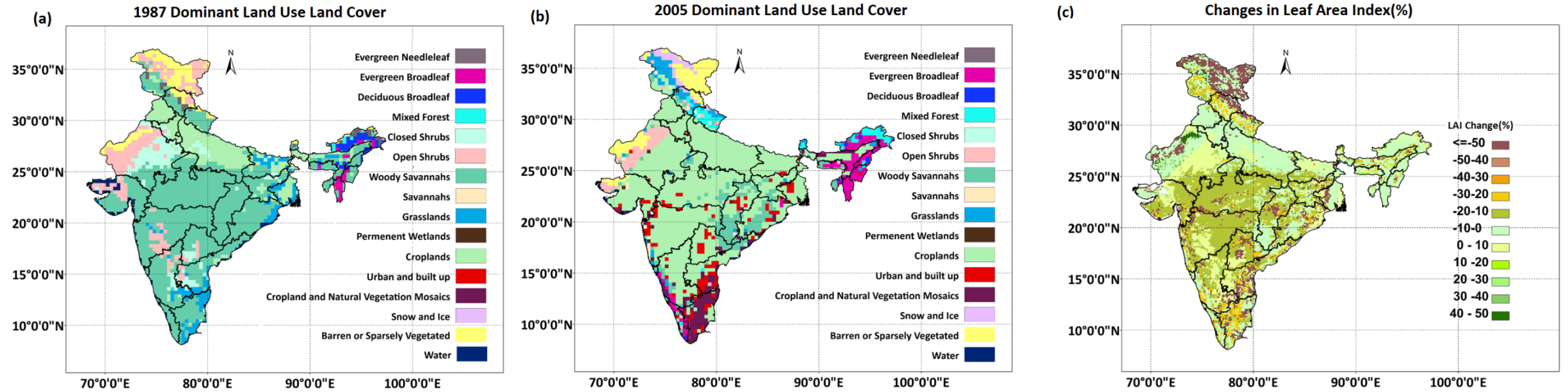
Land Surface Feedback



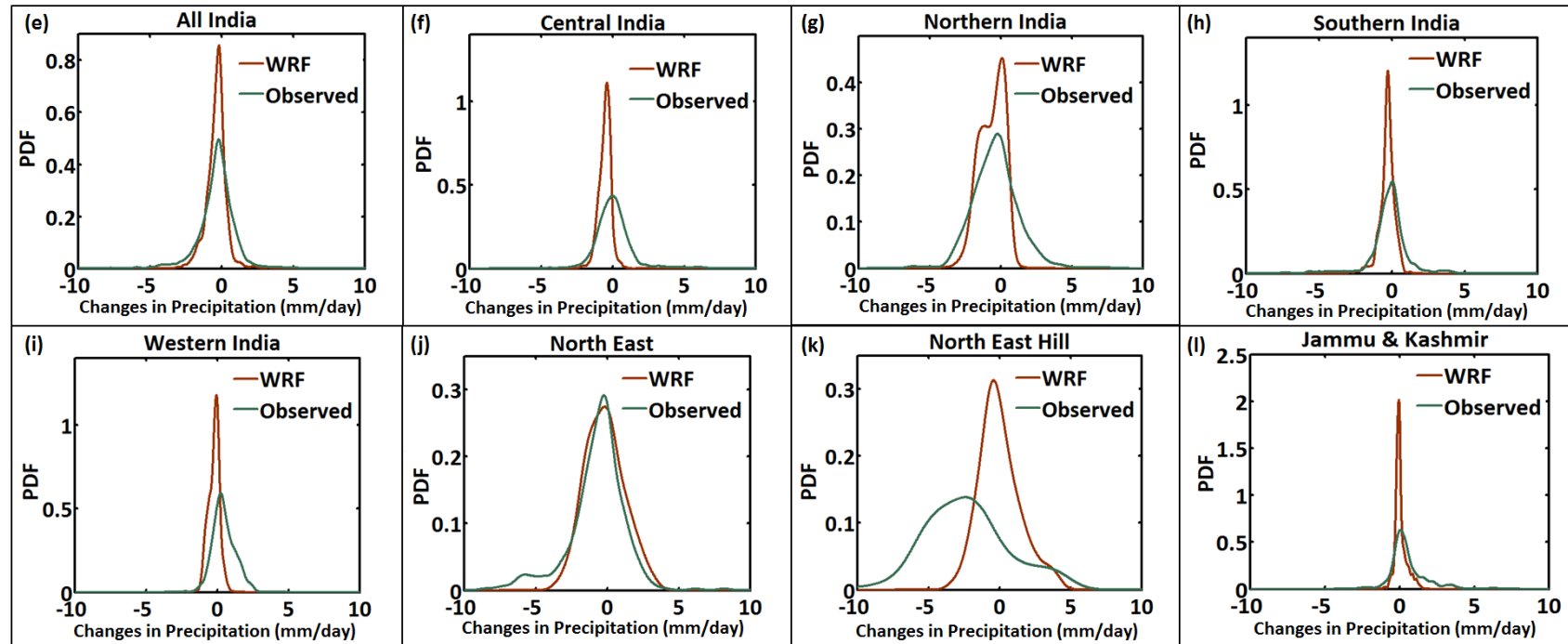
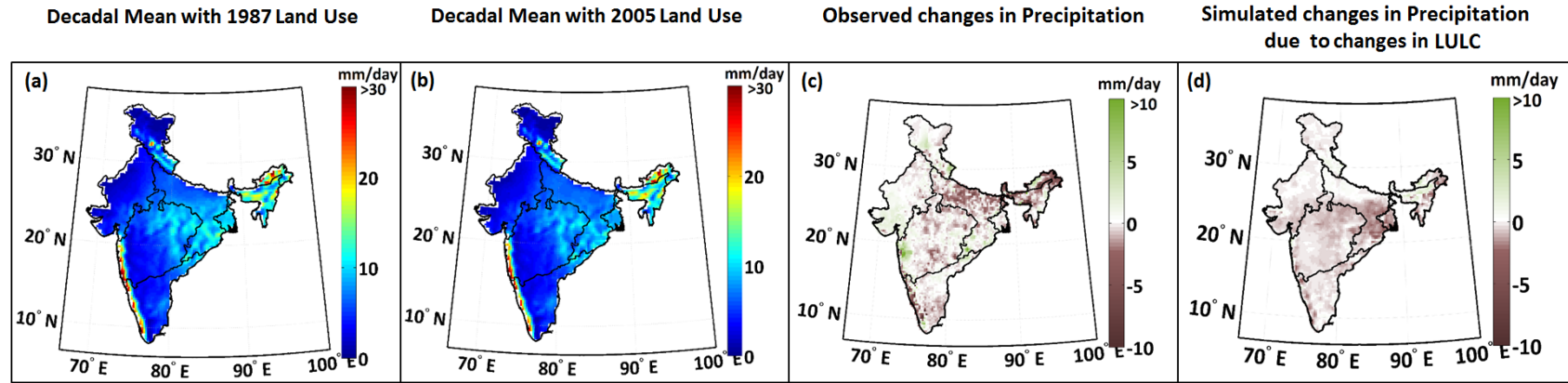
Pathak et al. (2016),
JHM and JI of Climate



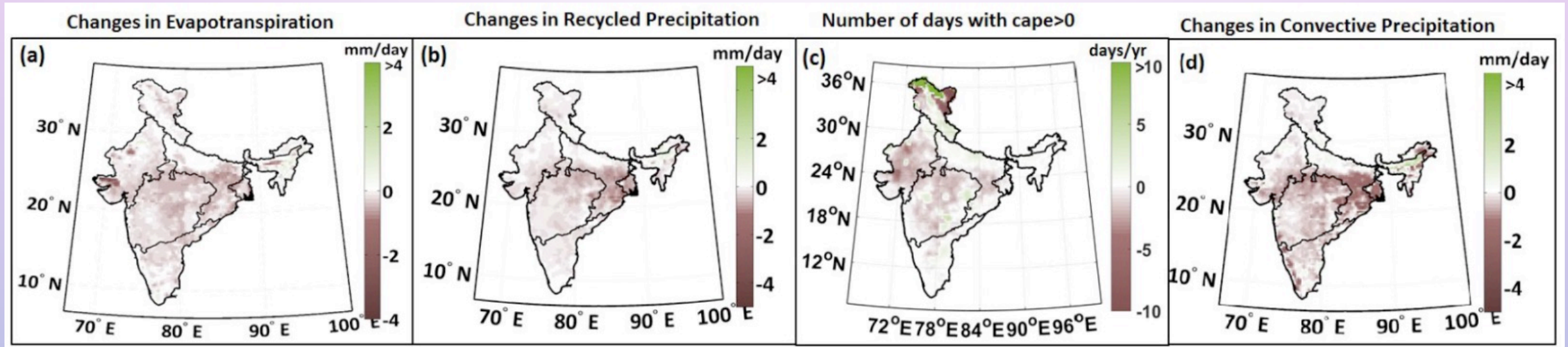
LULC Changes in India



Impacts of LULC: Changes Partially Consistent with Observed Changes



Processes



Paul et al. (2016),
Scientific Reports
(Nature Publishing
Group)

Open Questions

- We use the word “Uncertainty”, but are we really “Confident” enough in providing regional projections with different changing sign and magnitudes to water resources managers for developing adaptation strategies?
- Shouldn't we consider feedback from regional LULC changes and growing urbanization?
- We are worried about ‘stationarity’ in statistical downscaling relationship; but with a high bias in Dynamic downscaling, we have to use bias correction... are regional biases stationary?

Thank you