

**Dynamics governing 21st century South Asian summer Monsoon
changes in a multi-member CAM3 ensemble experiment**

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Purdue Climate Change Research Centre

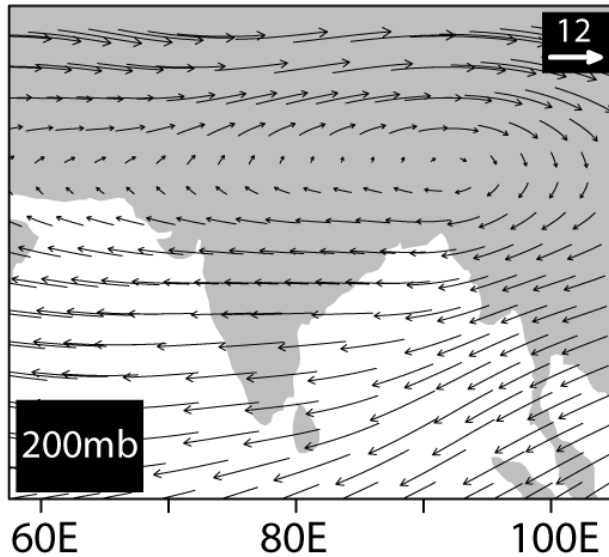
and

Department of Earth and Atmospheric Sciences

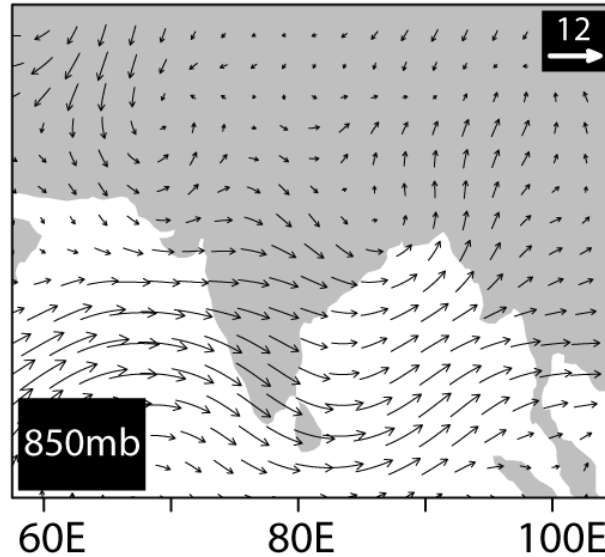
Purdue University

Introduction

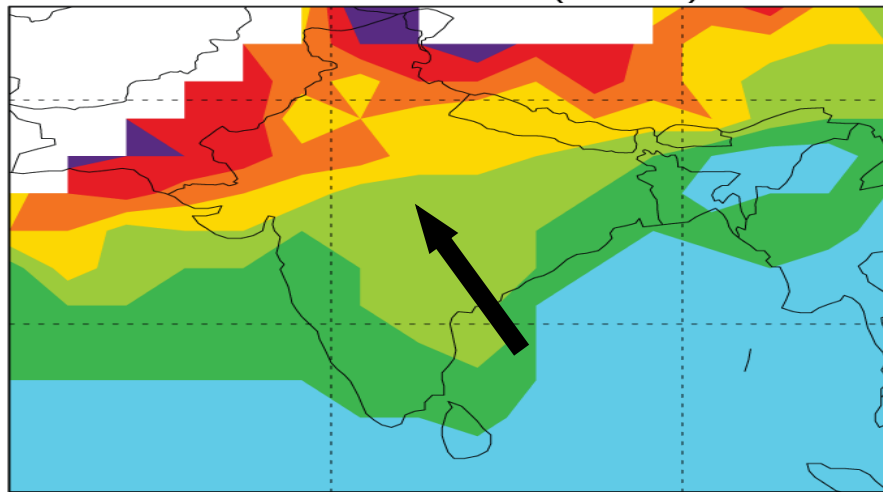
NCEP/NCAR (Reanalysis)



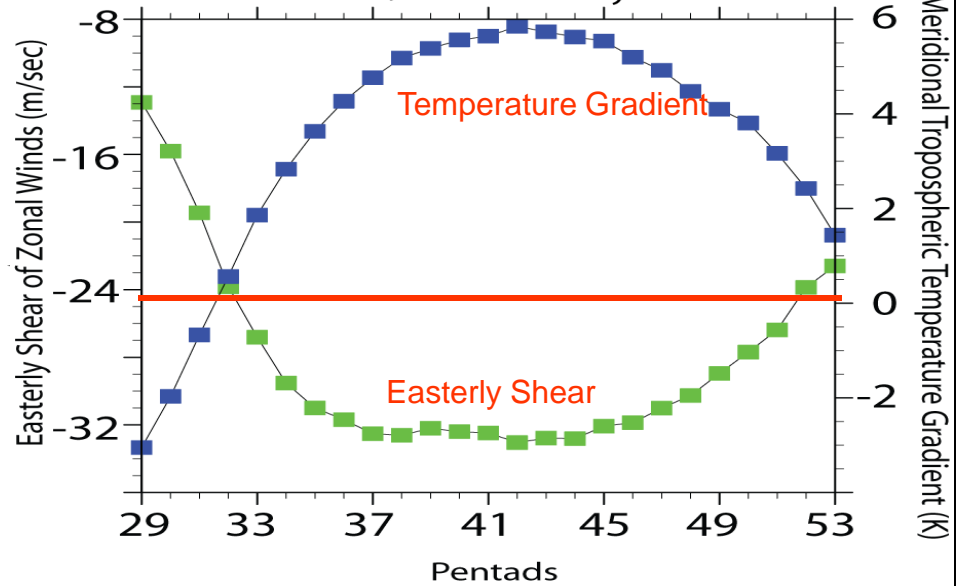
NCEP/NCAR (Reanalysis)



Monsoon Onset (CMAP)



NCEP/NCAR Reanalysis

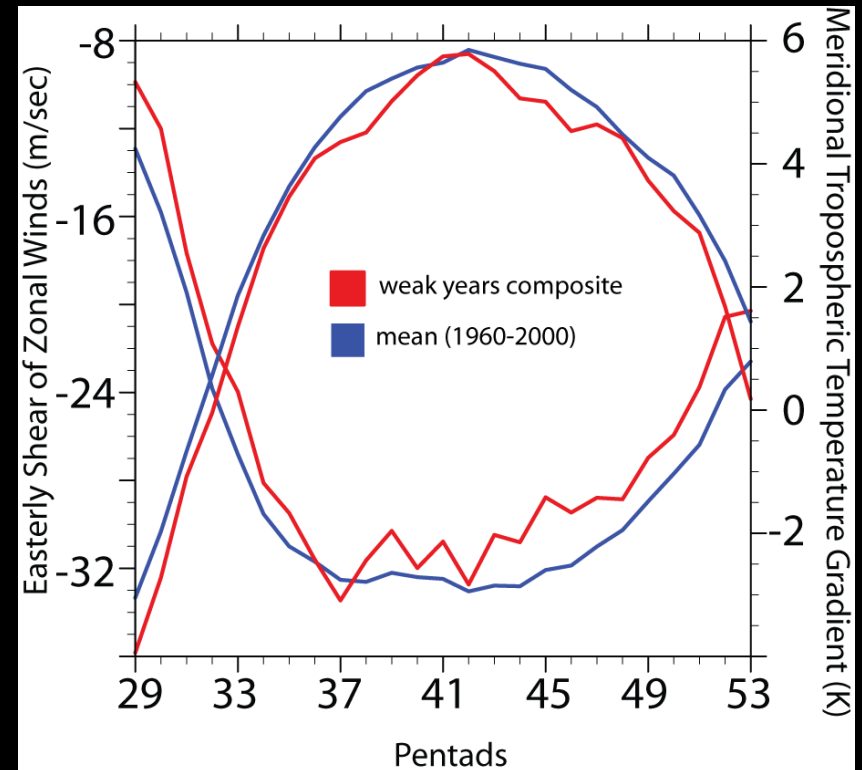
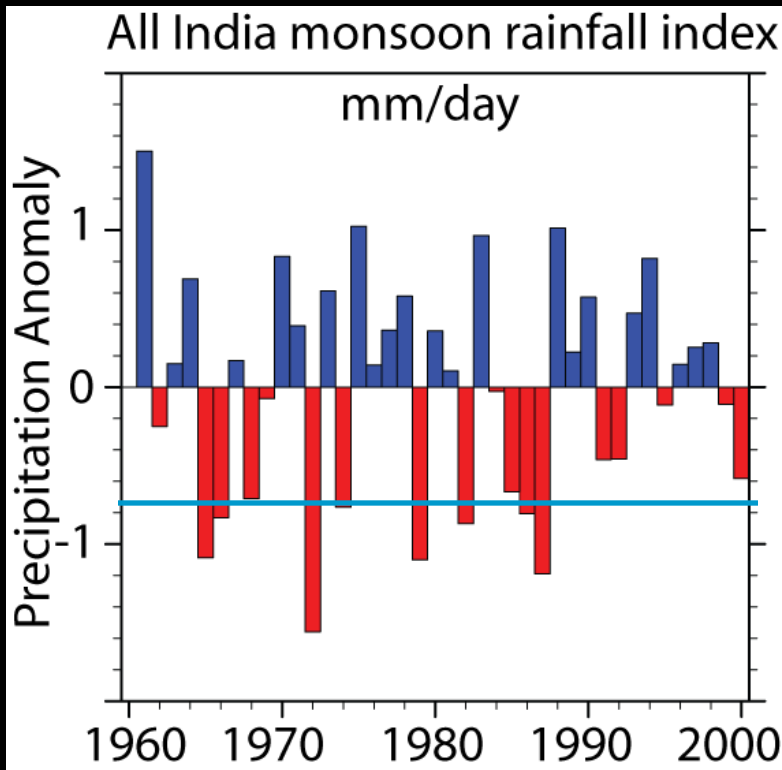


$$MTG = T_{500\text{mb to }200\text{mb}} [30\text{N}, 52\text{E}-85\text{E}] \text{ minus } T_{500\text{mb to }200\text{mb}} [5\text{N}, 52\text{E}-85\text{E}]$$

$$\text{Shear} = U_{850\text{mb}} \text{ minus } U_{200\text{mb}} \text{ (Domain Average: } 50\text{E}-90\text{E}, 0\text{N}-15\text{N})$$

Onset= Following Wang and LinHo, 2002

Introduction



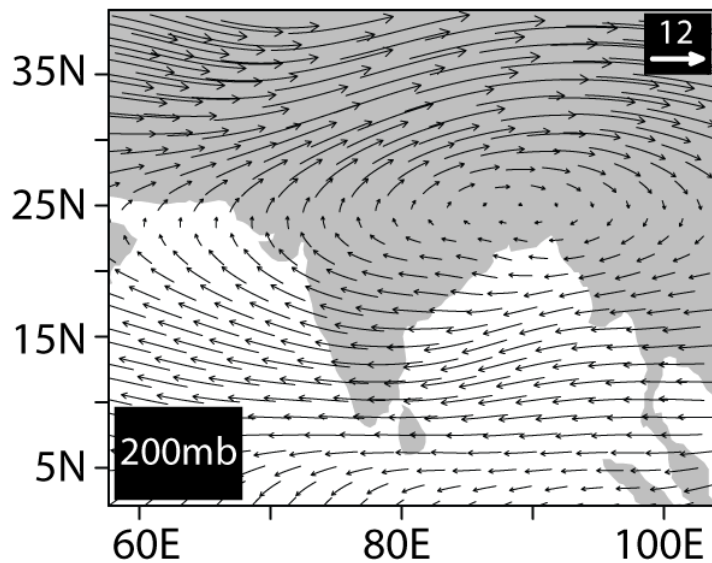
- o Anomalies in in local Hadley circulation and South Asian summer monsoon rainfall are positively correlated (*Goswami, et al., 1999*).
- o Anomalies in the tropical easterly jet and anomalies in the number of cyclonic systems over Bay of Bengal are positively correlated (*Rao et al., 2004*).

Experimental Details

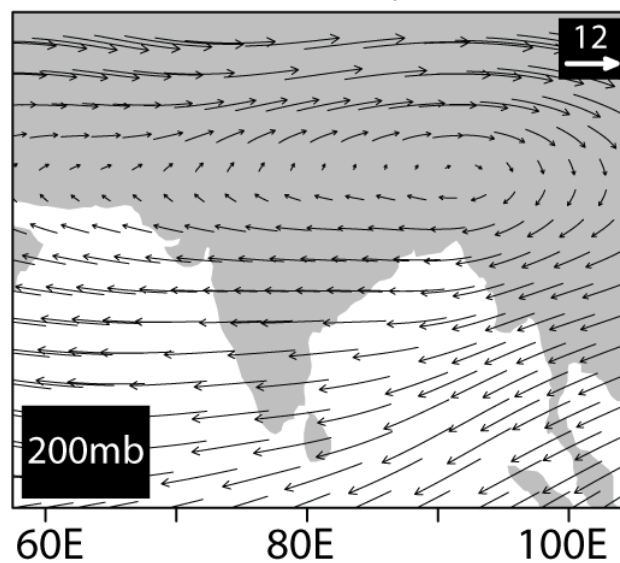
- We have re-run NCAR climate change simulations to analyze sub-monthly data
- CAM3-T85 multi-ensemble (c, e, bES, fES, gES) simulations (1950-2000, 2000-2099)
- CCSM SSTs
- Analysis for summer monsoon season (Jun, Jul, Aug, Sep; JJAS)
- 1970-1999 (control/RF) and 2070-2099 (future/A1B)

Comparison between NCEP/NCAR and CAM - JJAS Circulations

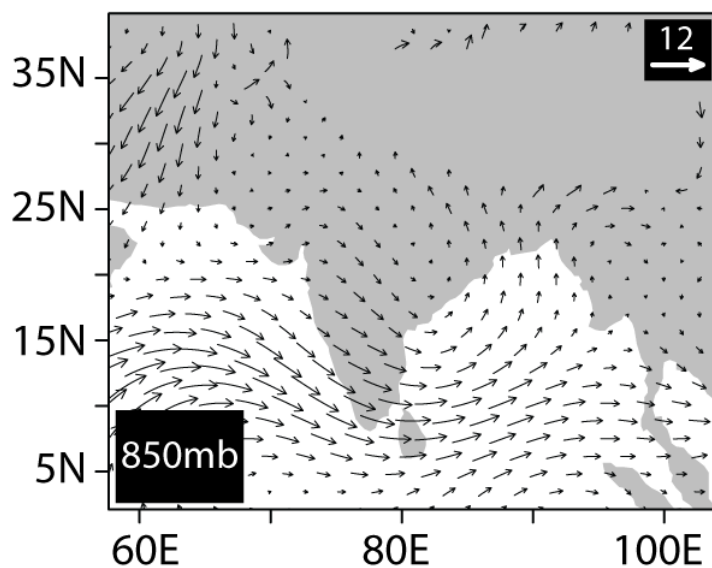
CAM (Ensemble Mean) 1970-99



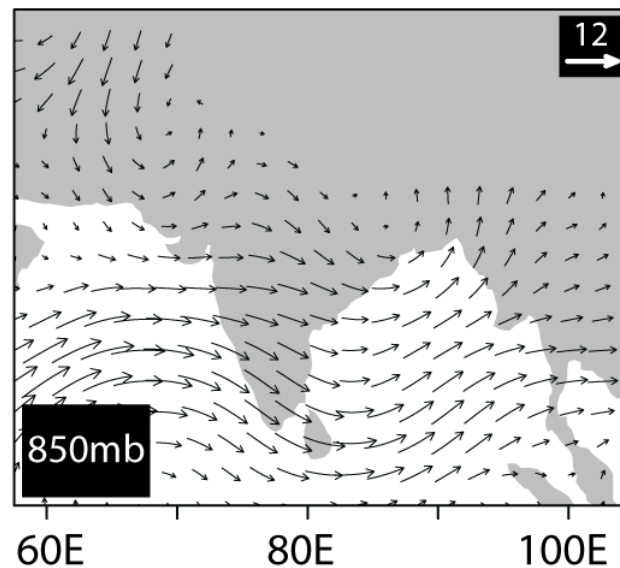
NCEP/NCAR (Reanalysis) 1970-99



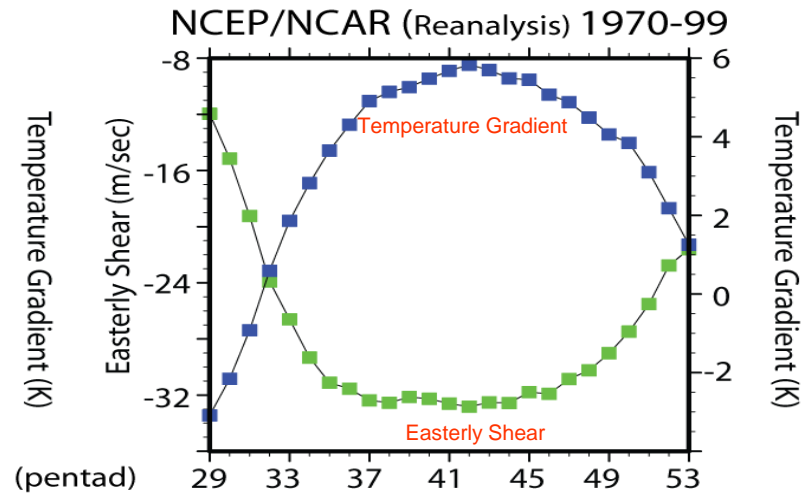
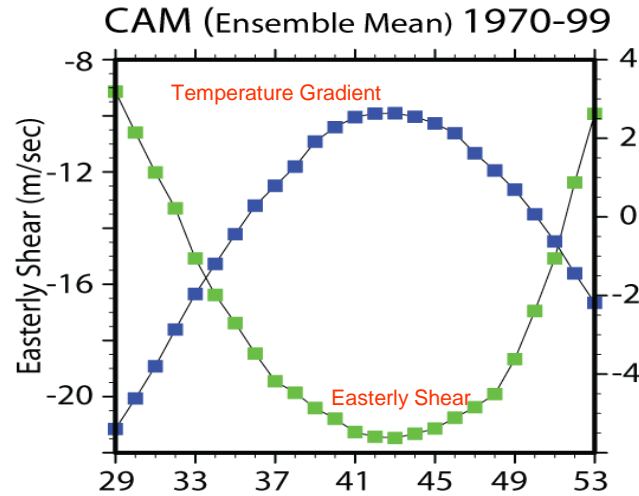
CAM (Ensemble Mean) 1970-99



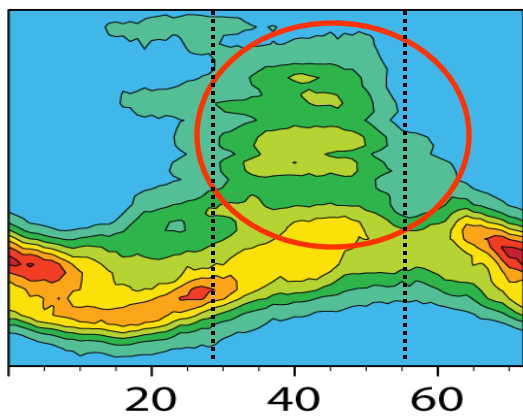
NCEP/NCAR (Reanalysis) 1970-99



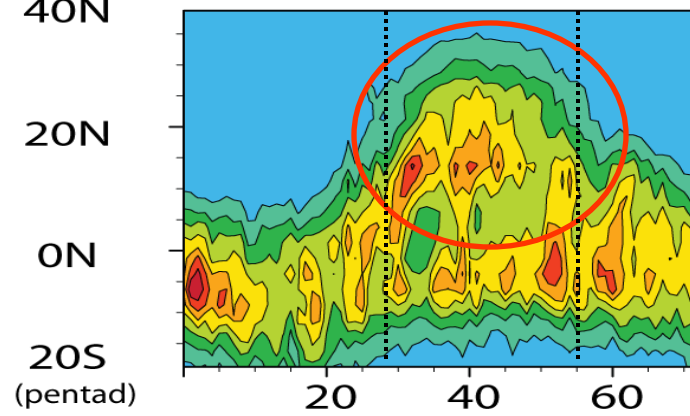
Comparison between CAM3 and Observations



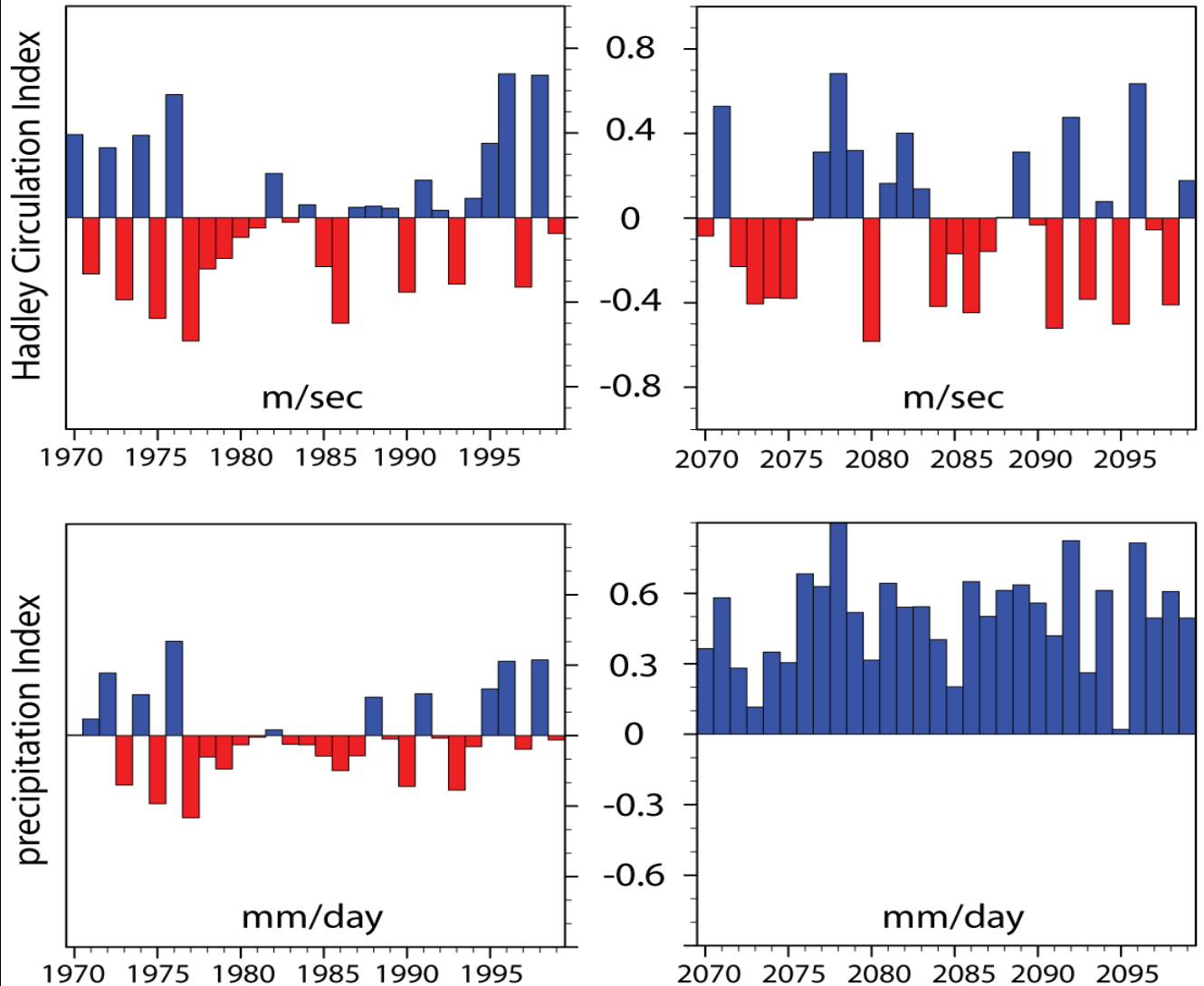
CAM (Ensemble Mean) 1979-99 avg(70E-100E)



CMAP (1979-99)



Local Hadley Circulation Index and Precipitation Index

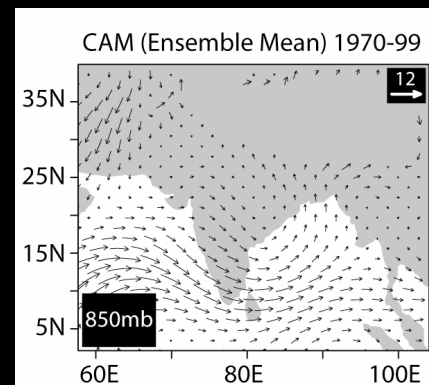
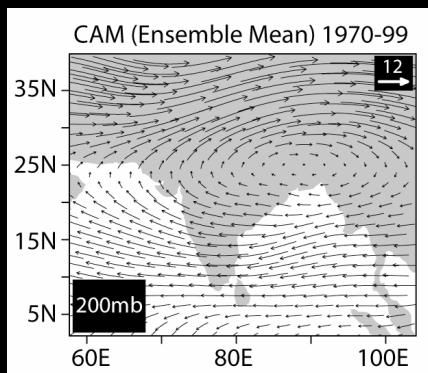


Exp	Correlation Coefficient	
	RF	A2
c	0.84	0.61
e	0.73	0.83
bES	0.80	0.57
fES	0.66	0.86
gES	0.84	0.86
Mean	0.89	0.73

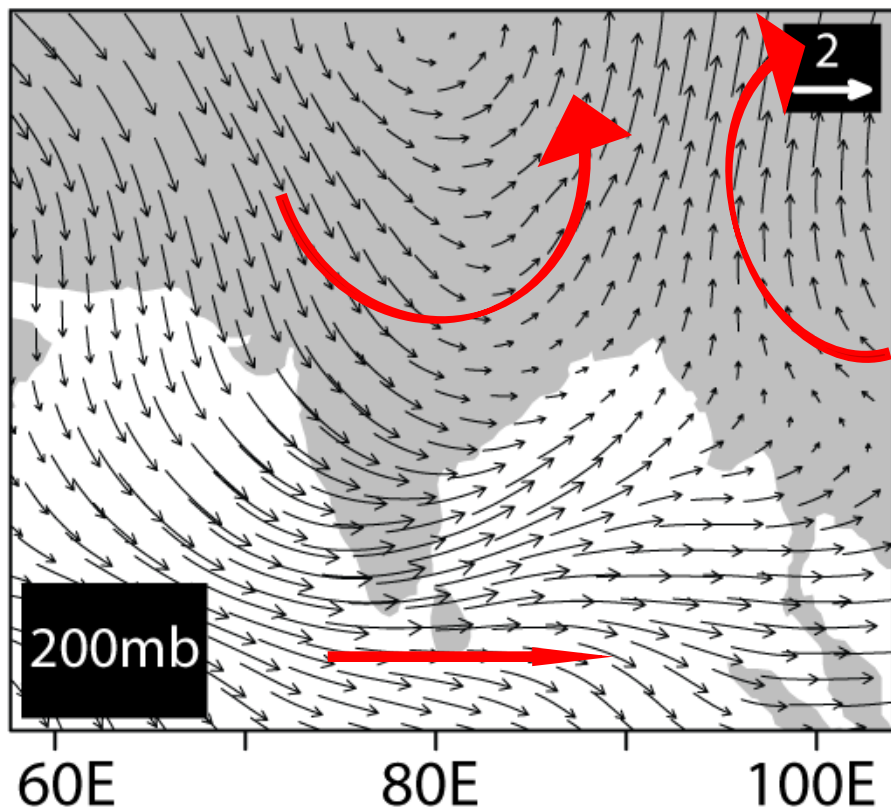
HI = Anomaly of (V_{850mb} minus V_{200mb}) : (Domain Average: 70E-105E, 5N-30N)

PI = Anomaly of Precipitation : (Domain Average: 70E-90E, 5N-25N) – land only

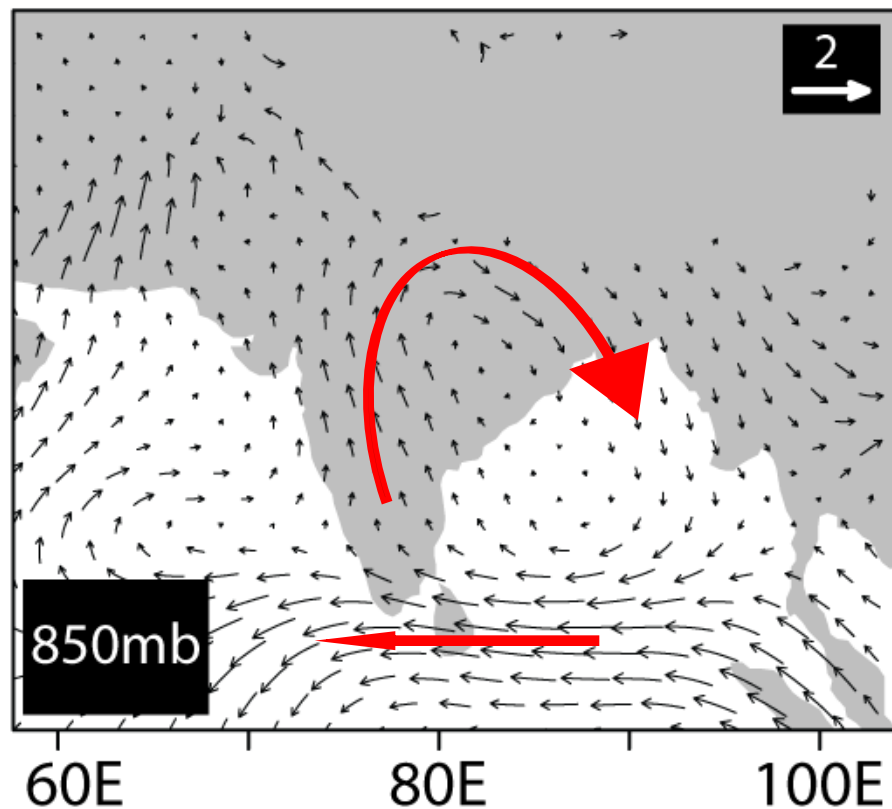
Anomalies (A2 minus RF) in JJAS circulations



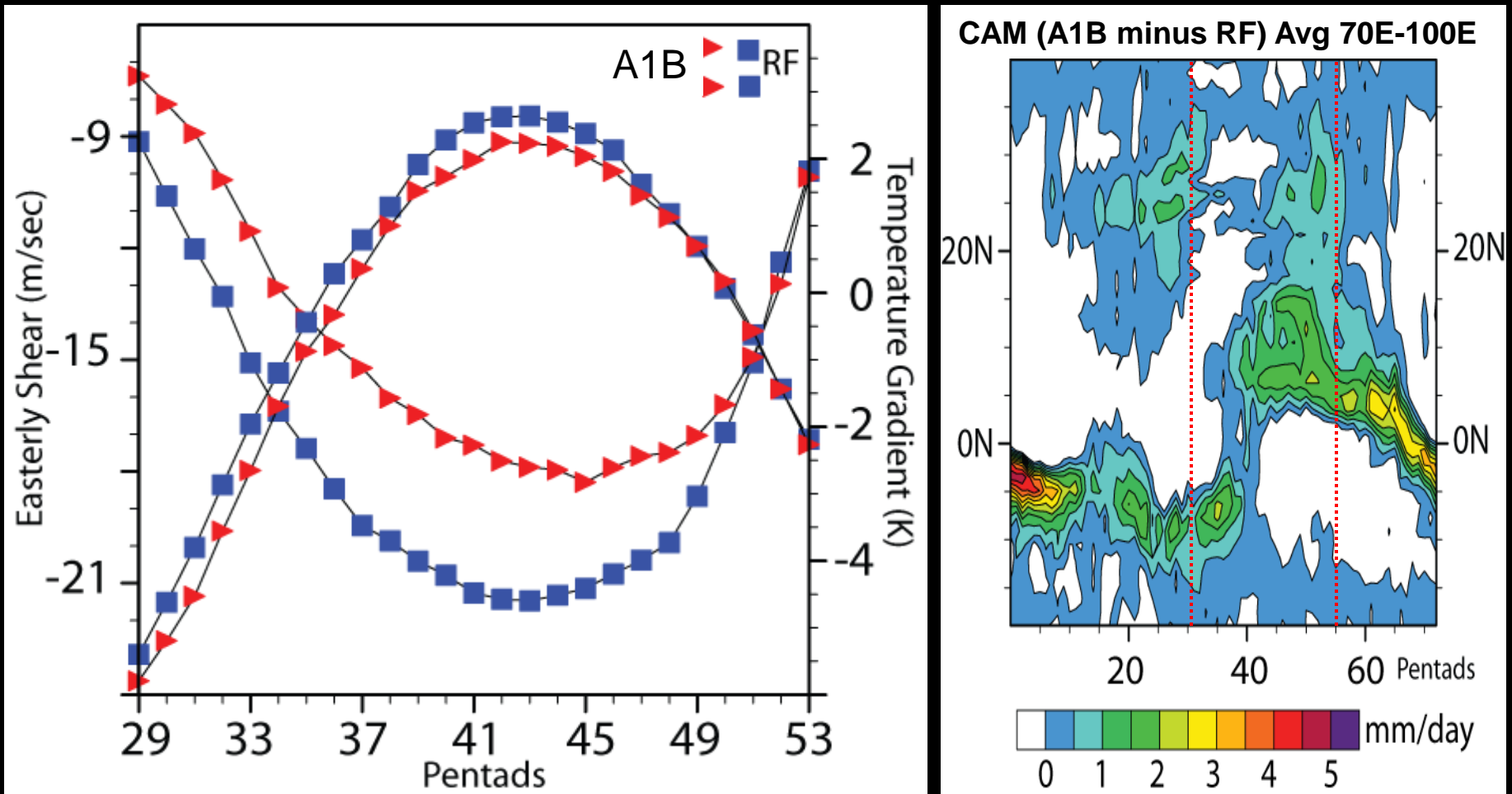
CAM (A1B minus RF)



CAM (A1B minus RF)



Changes in Meridional Tropospheric Temperature Gradient, Easterly Shear and Precipitation

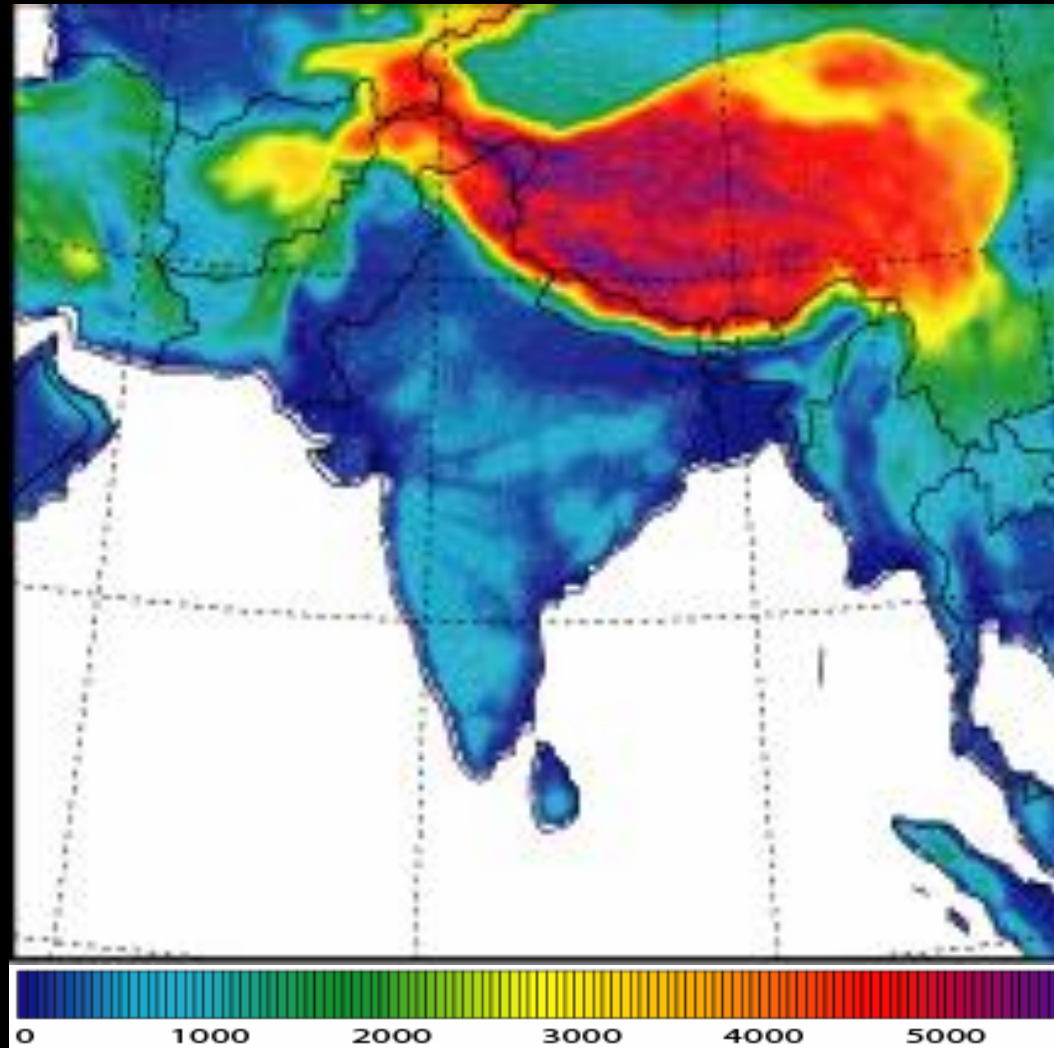


$$\text{MTG} = T_{500\text{mb to } 200\text{mb}} [30\text{N}, 52\text{E}-85\text{E}] \text{ minus } T_{500\text{mb to } 200\text{mb}} [5\text{N}, 52\text{E}-85\text{E}]$$

$$\text{Shear} = U_{850\text{mb}} \text{ minus } U_{200\text{mb}} \text{ (Domain Average: } 50\text{E}-90\text{E}, 0\text{N}-15\text{N})$$

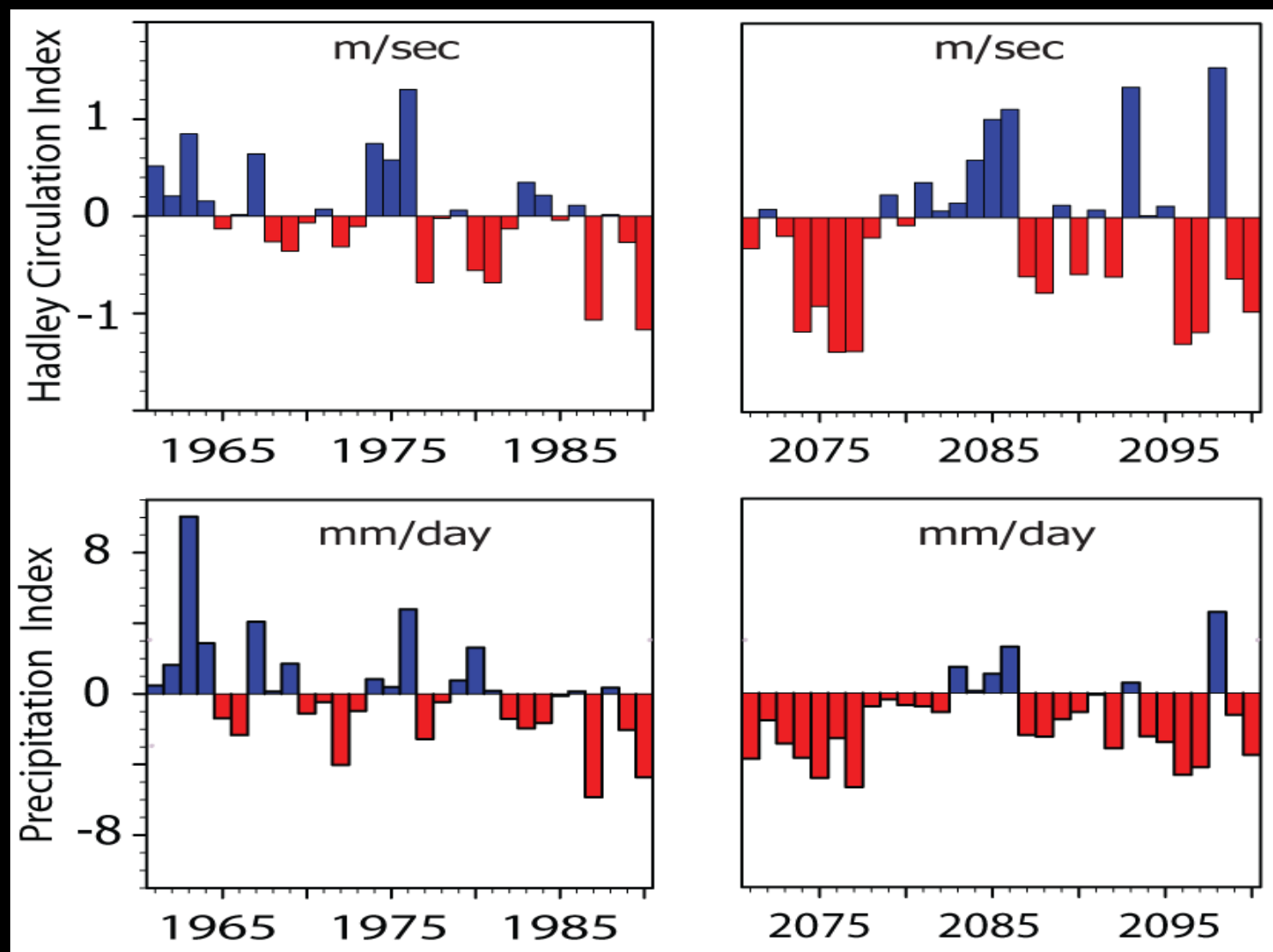
High-resolution limited-area model simulation domain

Topography



meters

RegCM3 Hadley circulation Index and Precipitation Index

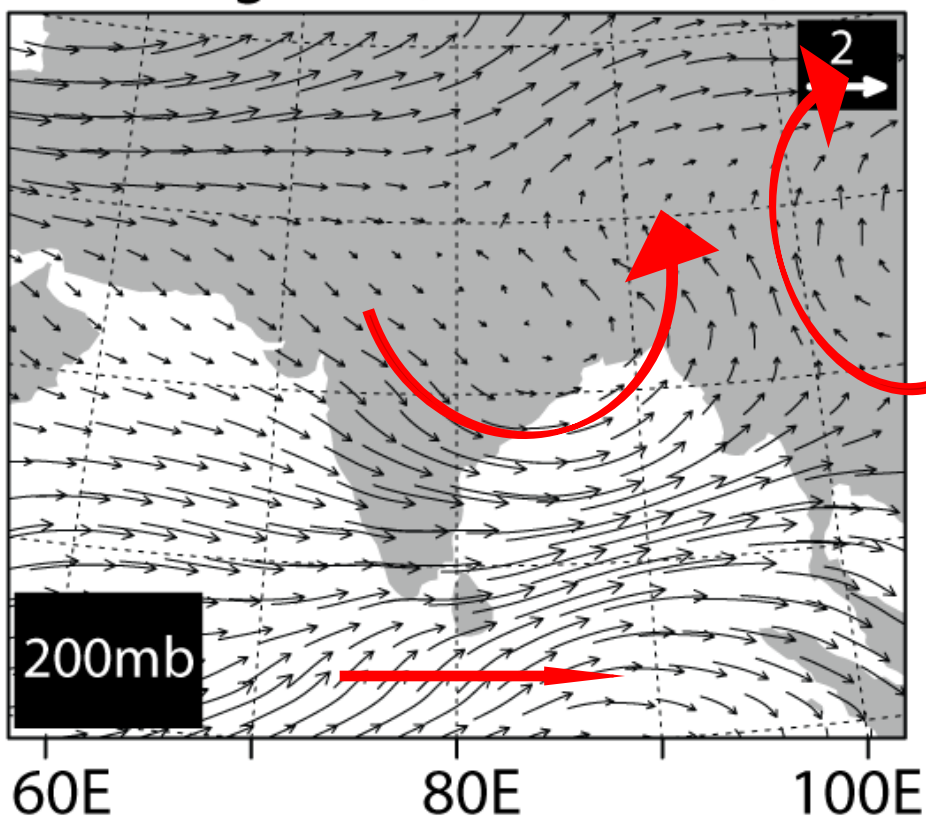


HI = Anomaly of (V_{850mb} minus V_{200mb}) : (Domain Average: 70E-105E, 5N-30N)

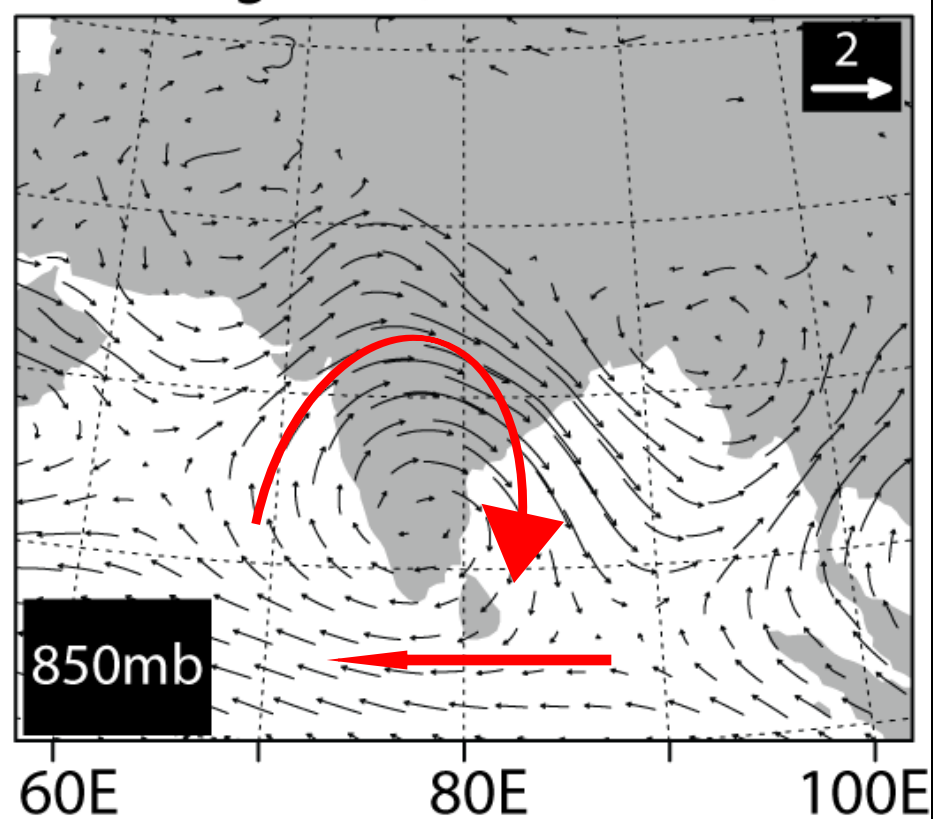
PI = Anomaly of Precipitation : (Domain Average: 70E-90E, 5N-25N) – land only

RegCM3 Anomalies (A2 minus RF) in JJAS circulations

RegCM3 (A2 minus RF)



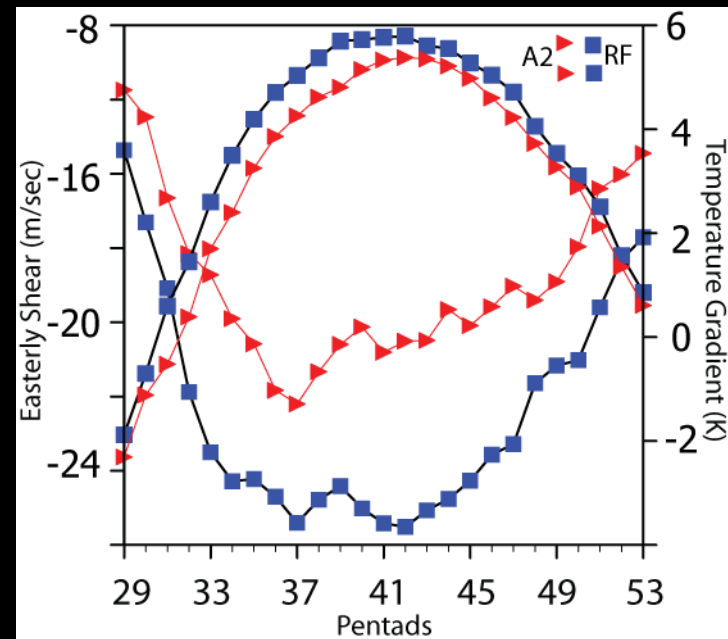
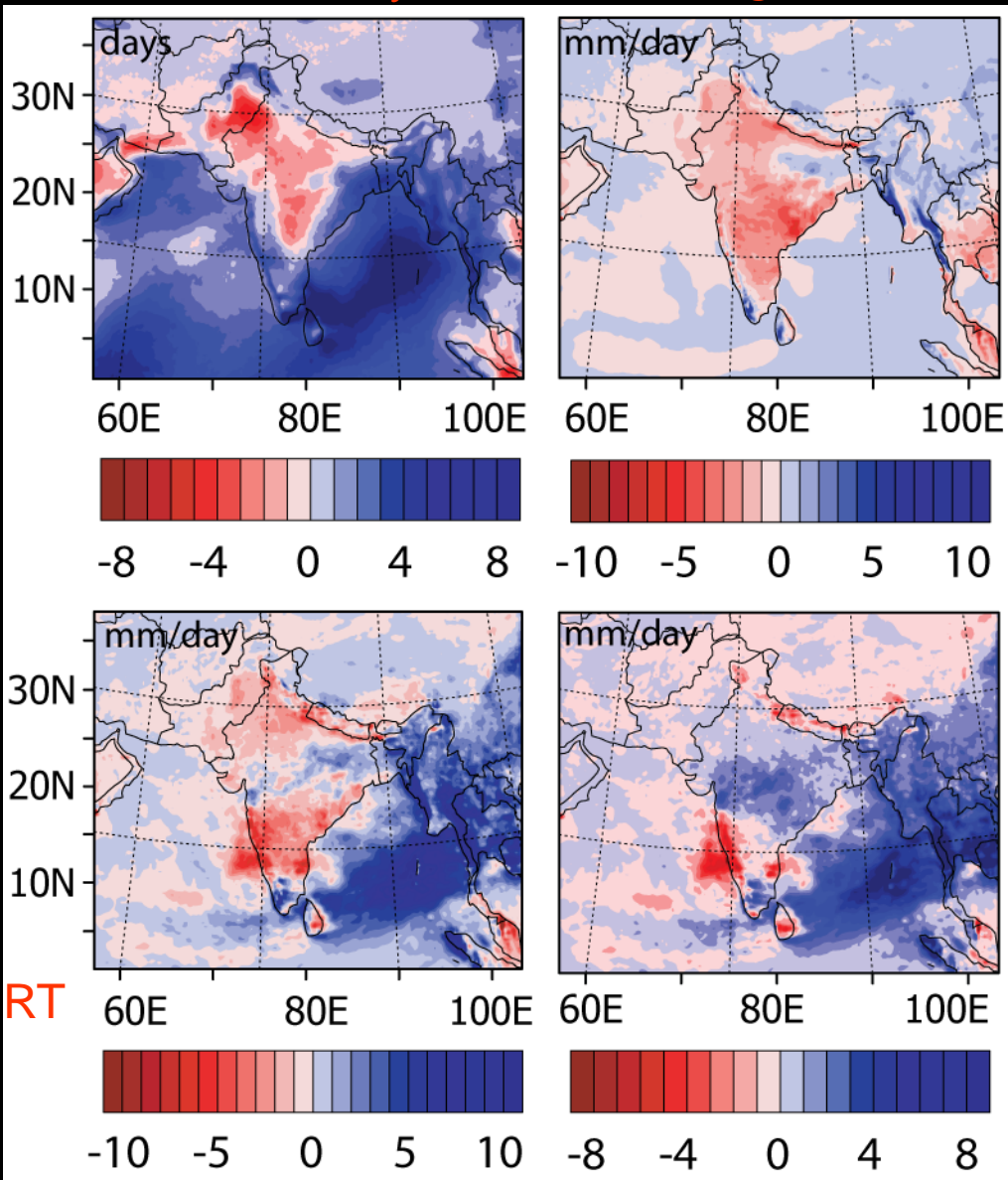
RegCM3 (A2 minus RF)



Changes in meridional tropospheric temperature gradient, easterly shear, CAPE-days and Precipitation in RegCM3

CAPE-days

RC



$$MTG = T_{500\text{mb to } 200\text{mb}} [30\text{N}, 52\text{E}-85\text{E}] \text{ minus } T_{500\text{mb to } 200\text{mb}} [5\text{N}, 52\text{E}-85\text{E}]$$

$$\text{Shear} = U_{850\text{mb}} \text{ minus } U_{200\text{mb}} \text{ (Domain Average: } 52\text{E}-90\text{E, } 0\text{N}-15\text{N)}$$

RL

RC = Convective precipitation

RT = Total precipitation

RL = Large-scale precipitation

Summary and Conclusions

- CAM3 is able to simulate the general characteristics of South Asian summer monsoon.
- Lower magnitude of meridional tropospheric temperature gradient and easterly shear affect northward migration of ITCZ.
- Summer monsoon gets weaker in future CAM3 integrations, however, anomalies of summer monsoon precipitation are positive.
- A high-resolution RCM integration not only shows similar weakening of South Asian monsoon but also suppressed summer precipitation over land.
- Different anomalies of precipitation in CAM3 and high-resolution limited-area-model signify the importance of how convection has been parameterized in the climate model.