Understanding South Asian Monsoon Variability In a Changing Climate

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Time-mean monsoon response

- Meehl and Washington (1993); Kitoh (1998, 2006); Annamalai et al. (2007); Turner and Slingo (2007);

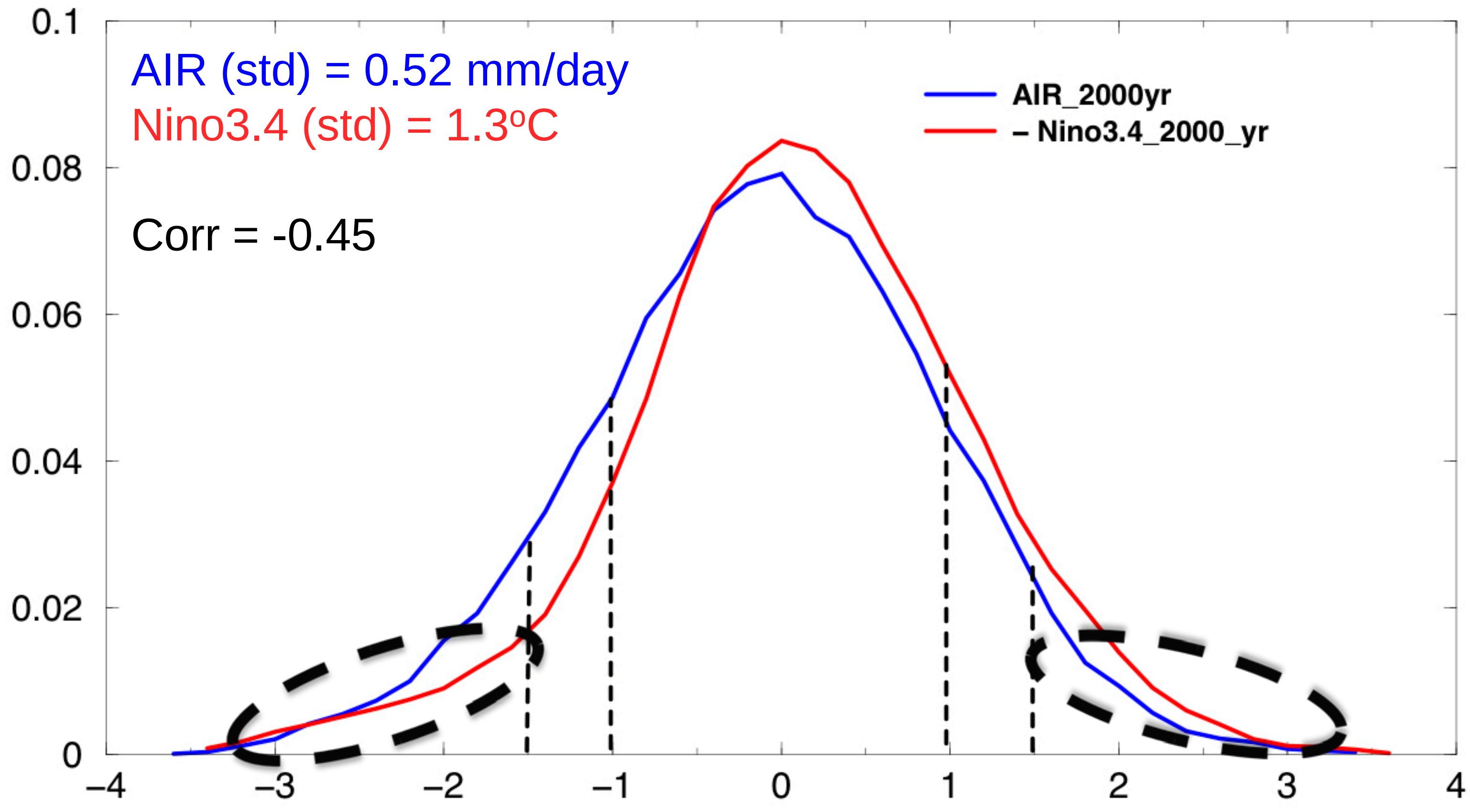
- Ueda et al. (2008); Stowasser, Annamalai et al. (2009); Chou et al. (2009)

- Annamalai (2011-dynamic vs thermodynamic)

Increase in rainfall (5 – 25%) – Adaptation is feasible

CM2.1 Control simulation (2000-years)

PDF of rainfall over South Asia (7°N-28°N, 65°E-100°E) and Nino3.4 SST

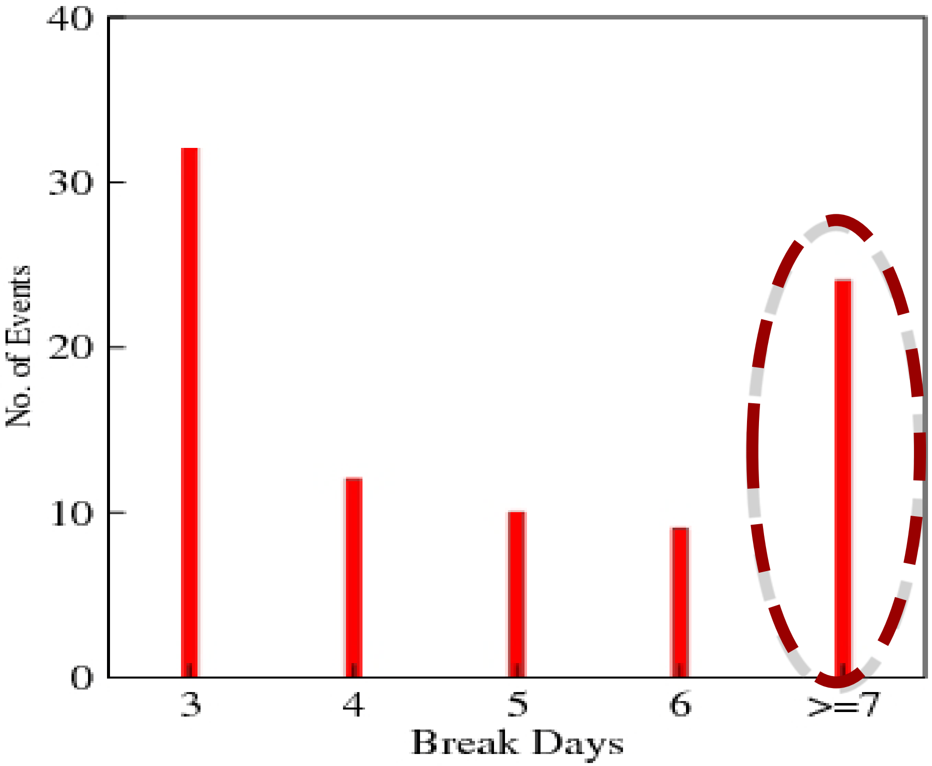


Severe Weak (droughts)

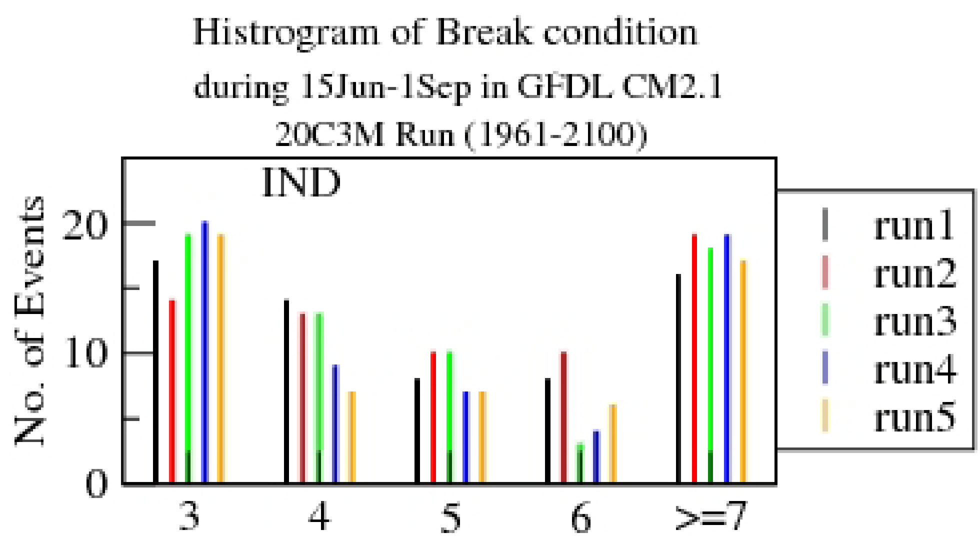
Severe Strong (floods)

Extended monsoon breaks over central India

IMD – Station rainfall (1951-2008)



GFDL_CM2.1

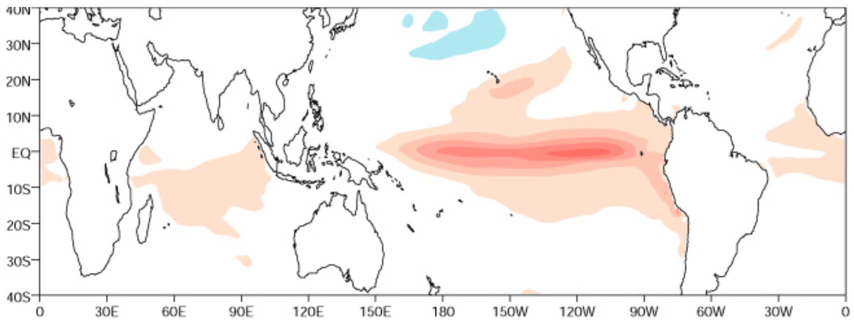


Break days

Extended breaks – Intraseasonal variability + boundary forcing

Prasanna and Annamalai (2011, J. Climate)

(a) April-May SST

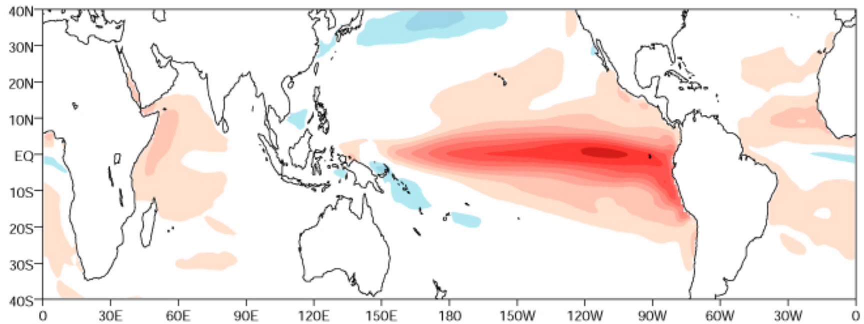


Forced AM2.1 with CM2.1 composite

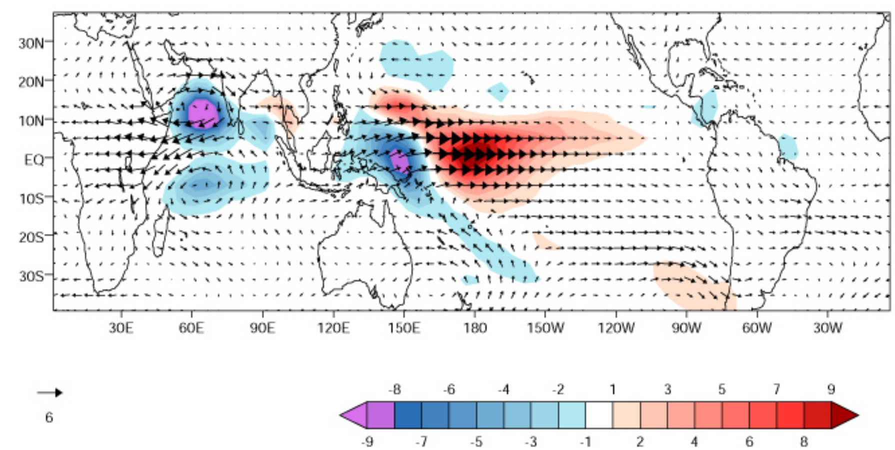
El Nino SST anomalies + 20c3m climatology

(25 members; 01 March – 30 November)

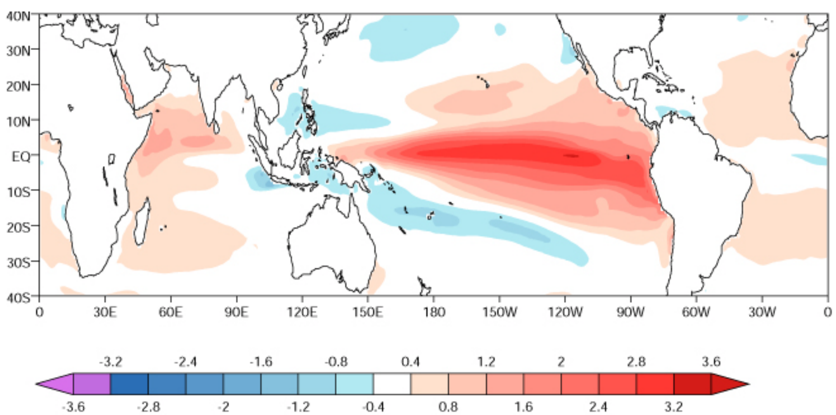
(b) June-September



JJAS rainfall and 850hPa wind response

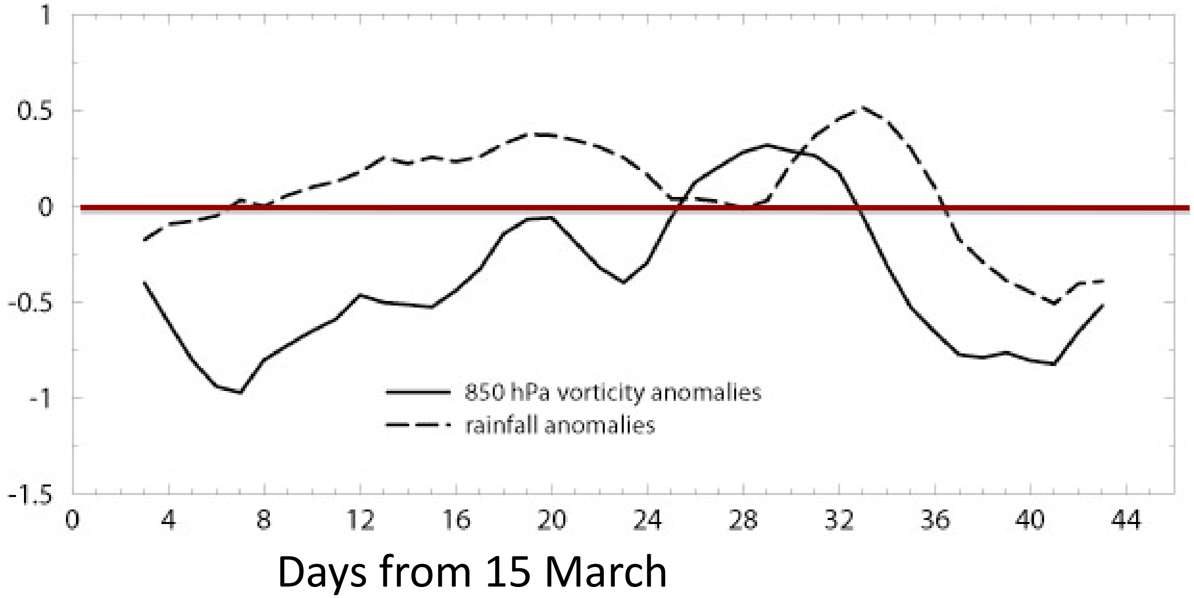


(c) October - December



SST used to force is from CM2.1

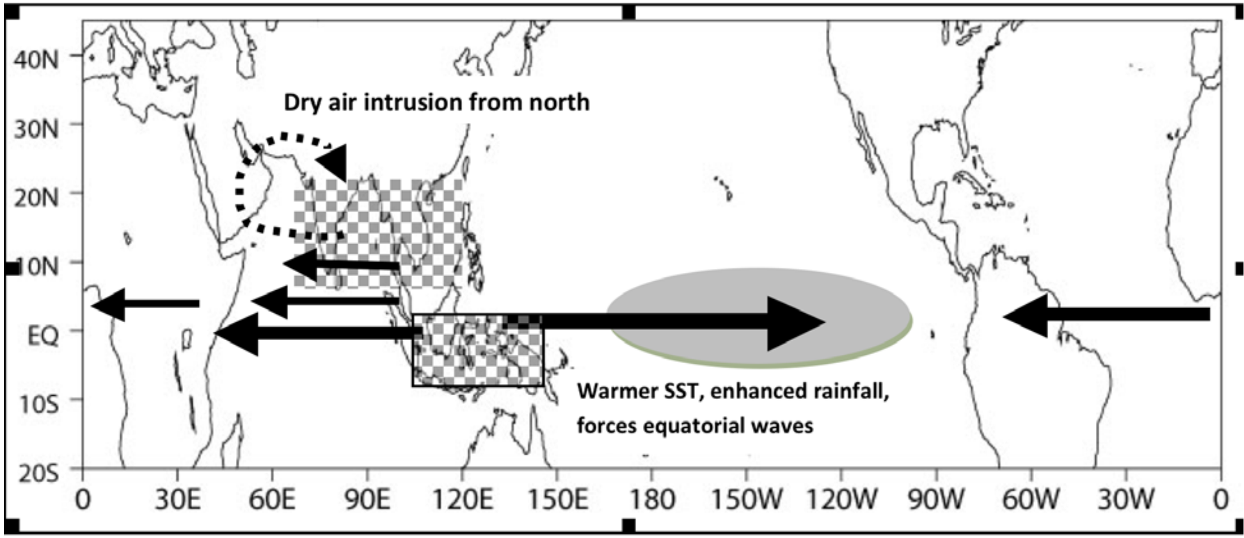
AM2.1 solutions – Forced with CM2.1 composite SST anomalies (El Nino)



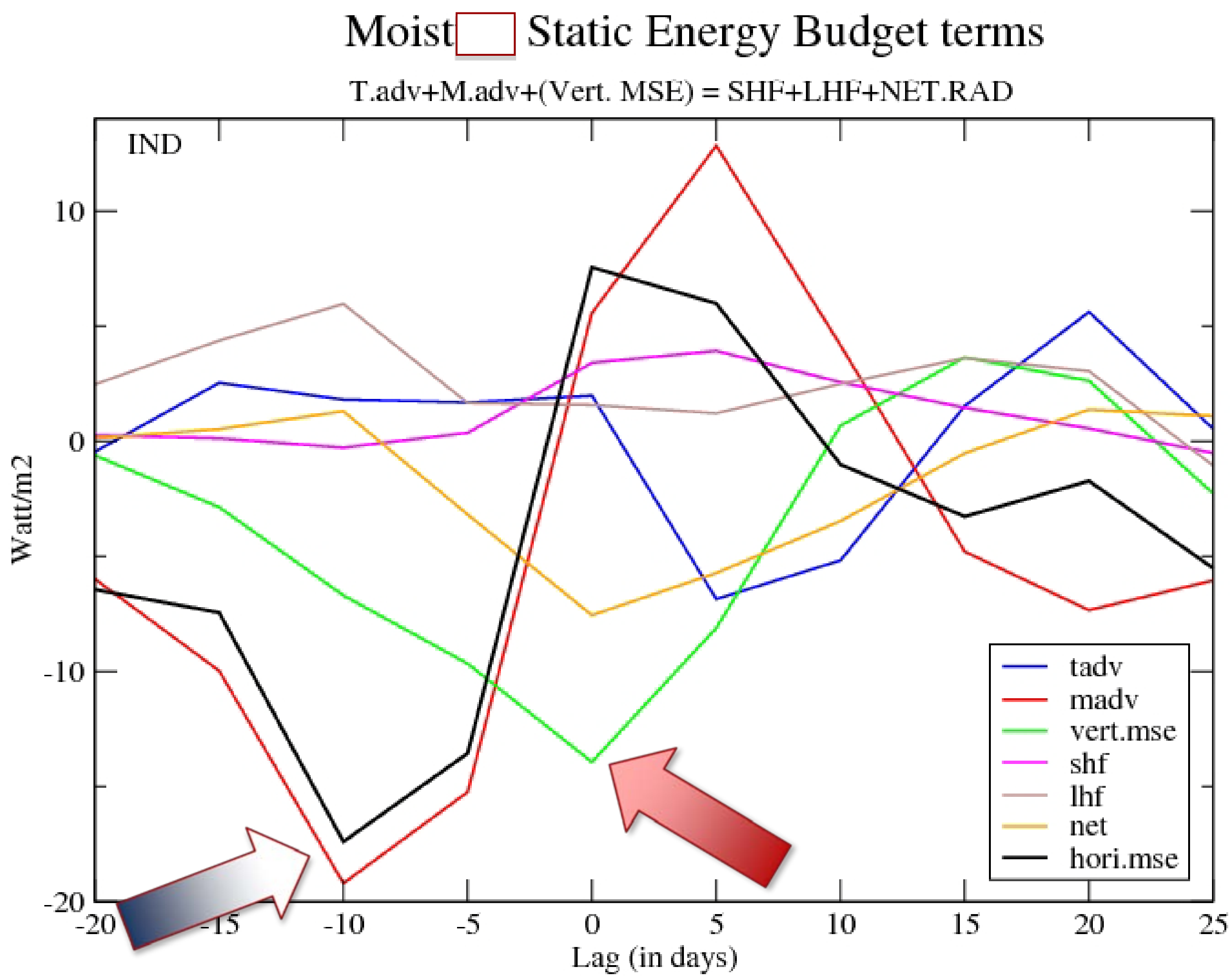
Rainfall over S. Asia

850 hPa Vorticity

(west of rainfall maximum)



Pillai and Annamalai (2011) J. Atmos. Sci (in press)

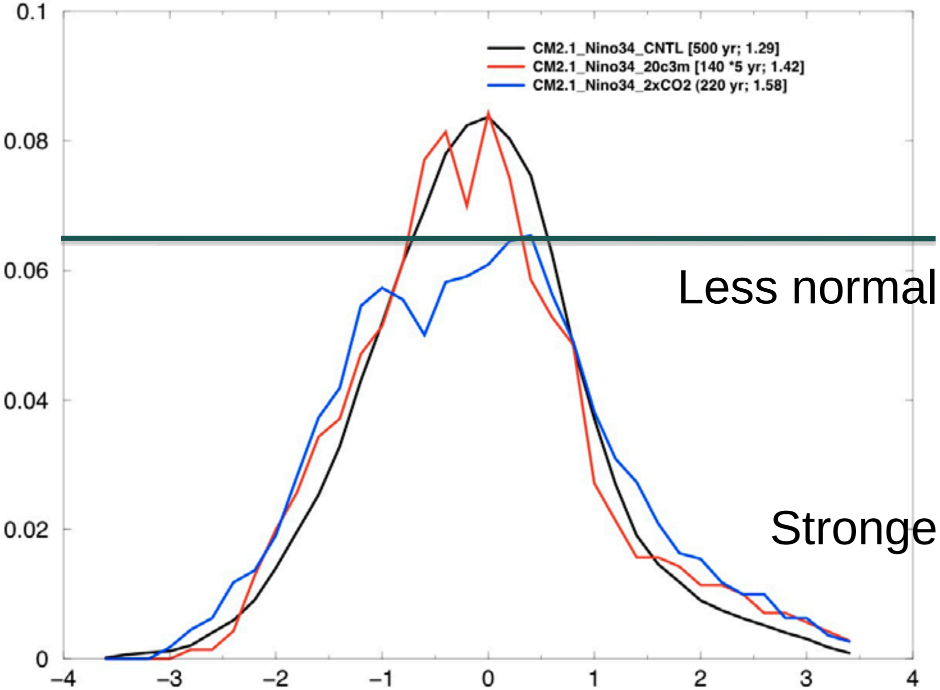


ERA – Interim reanalysis

(1989-2009)

“dry air advection from north leads MSE or negative precipitation anomalies and initiates extended breaks over central India” Prasanna and Annamalai (2011, J. Climate)

Probability of extended breaks more during El Nino years

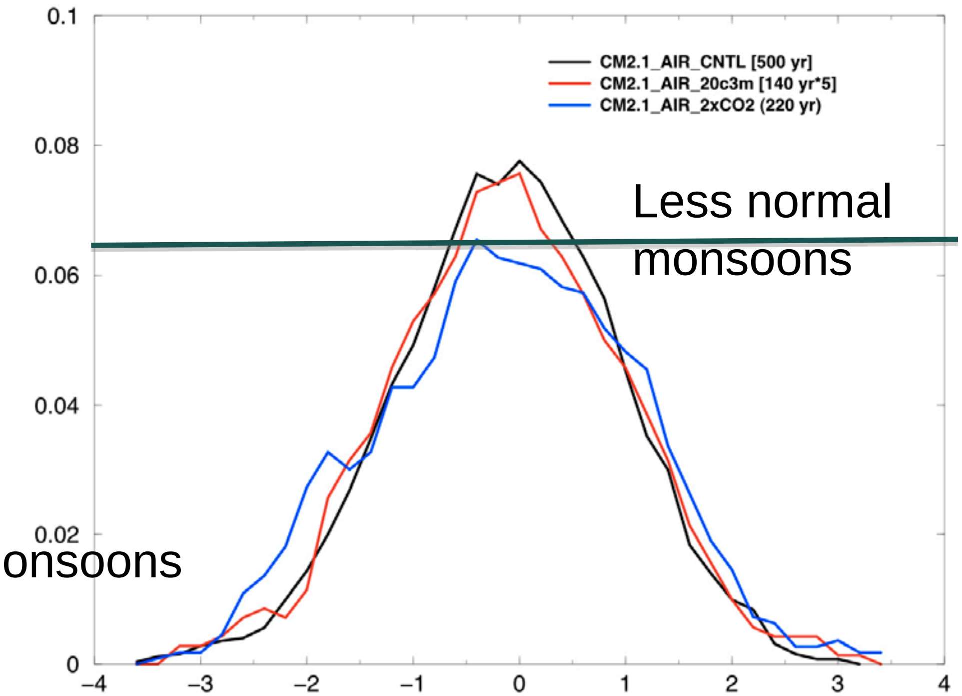


Less normal ENSO

Stronger El Nino

Nino3.4 standard deviations

(pre-industrial control run)

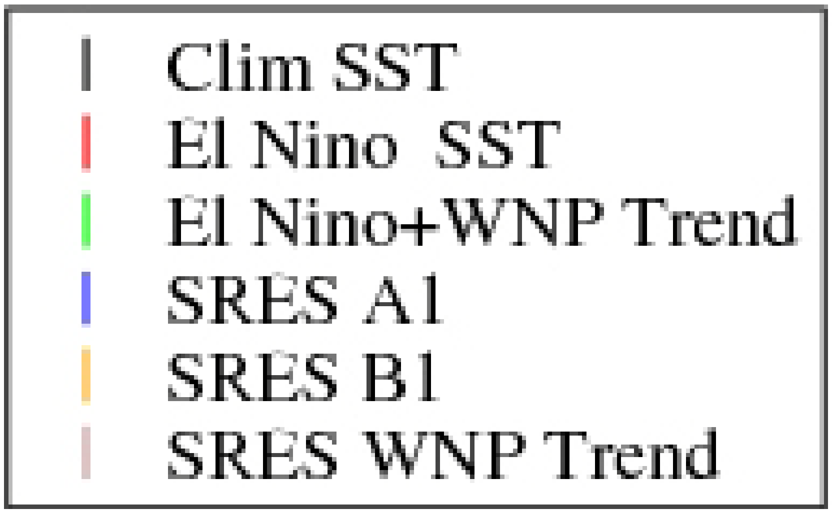


Less normal monsoons

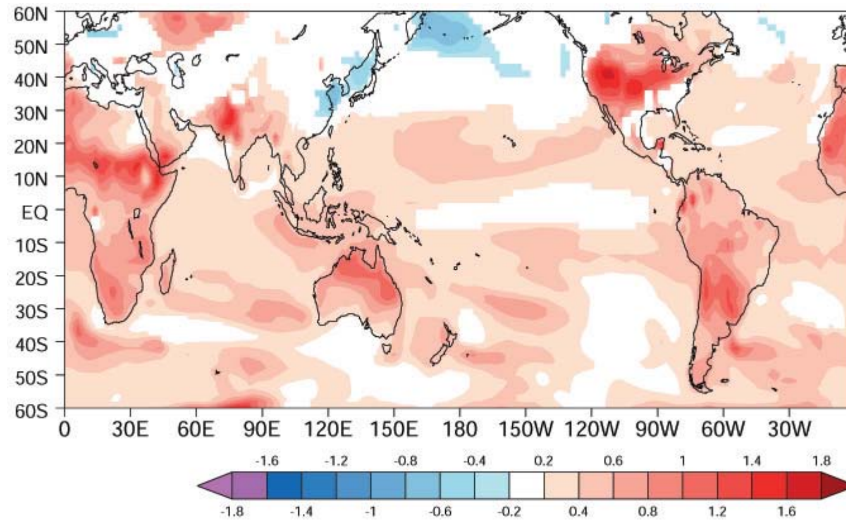
More severe weak monsoons

“sampling problems – robustness”

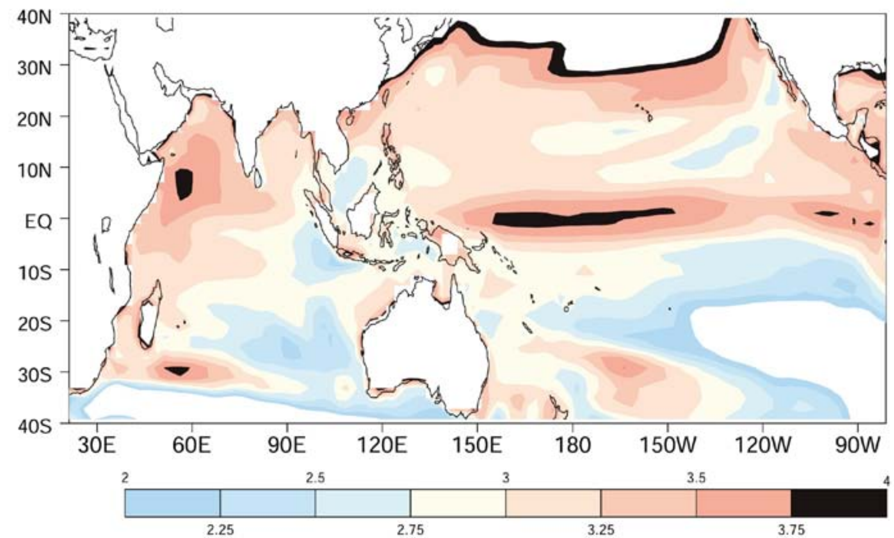
Monsoon rainfall standard deviations



(a) CM2.1 (Ts) trend (1951-2000)



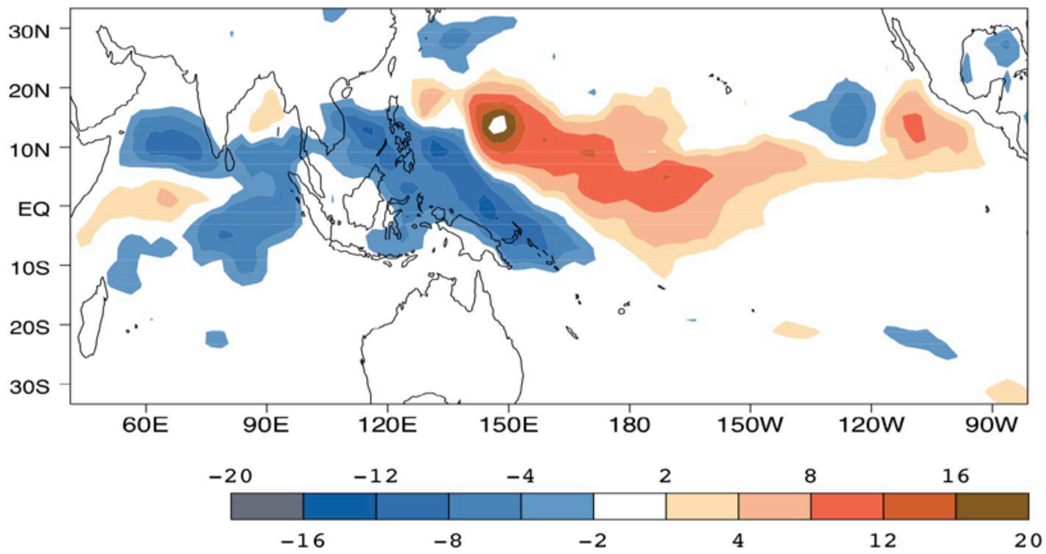
(b) Projected SST JJAS (SRES B1)



First impression of anthropogenic forcing is noticeable in SST (Santer et al. 2006)

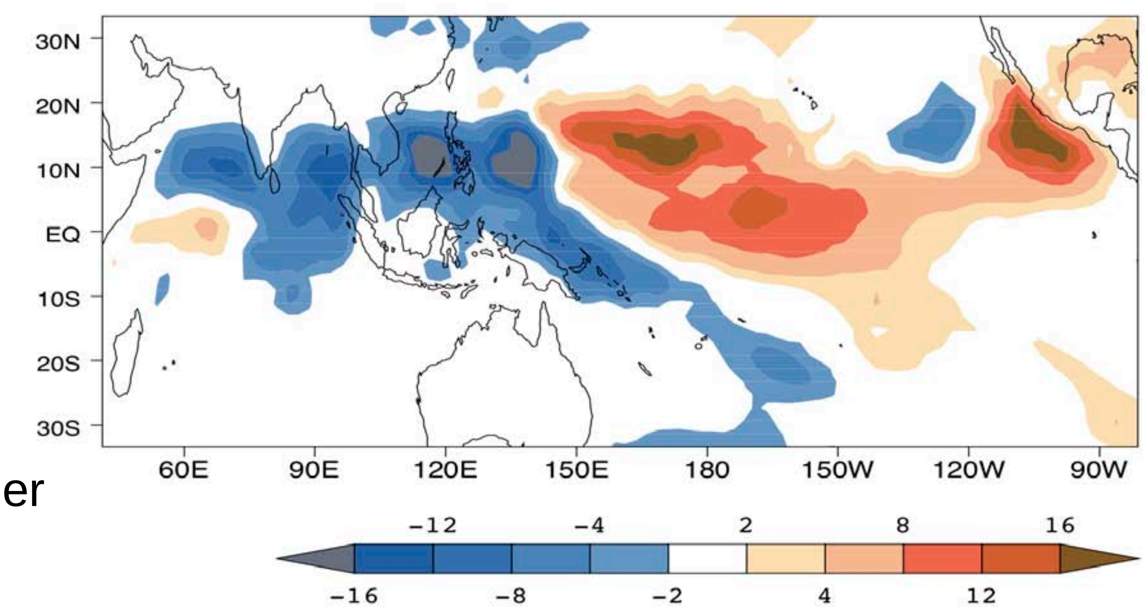
AM2.1 ensemble mean

(a) June-September Rainfall anomalies



West Pacific_trend+ El Nino

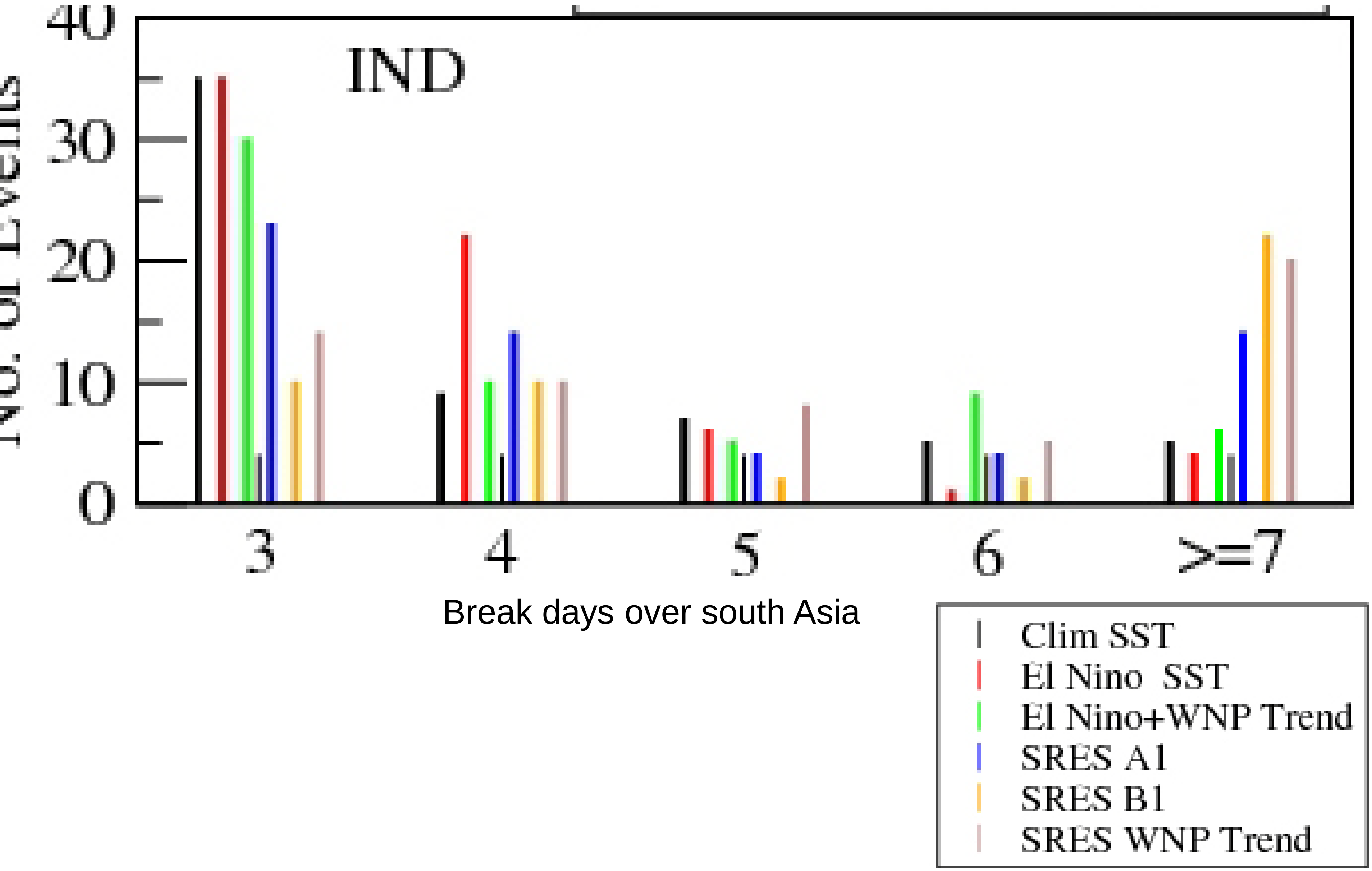
(b) June-September Rainfall anomalies



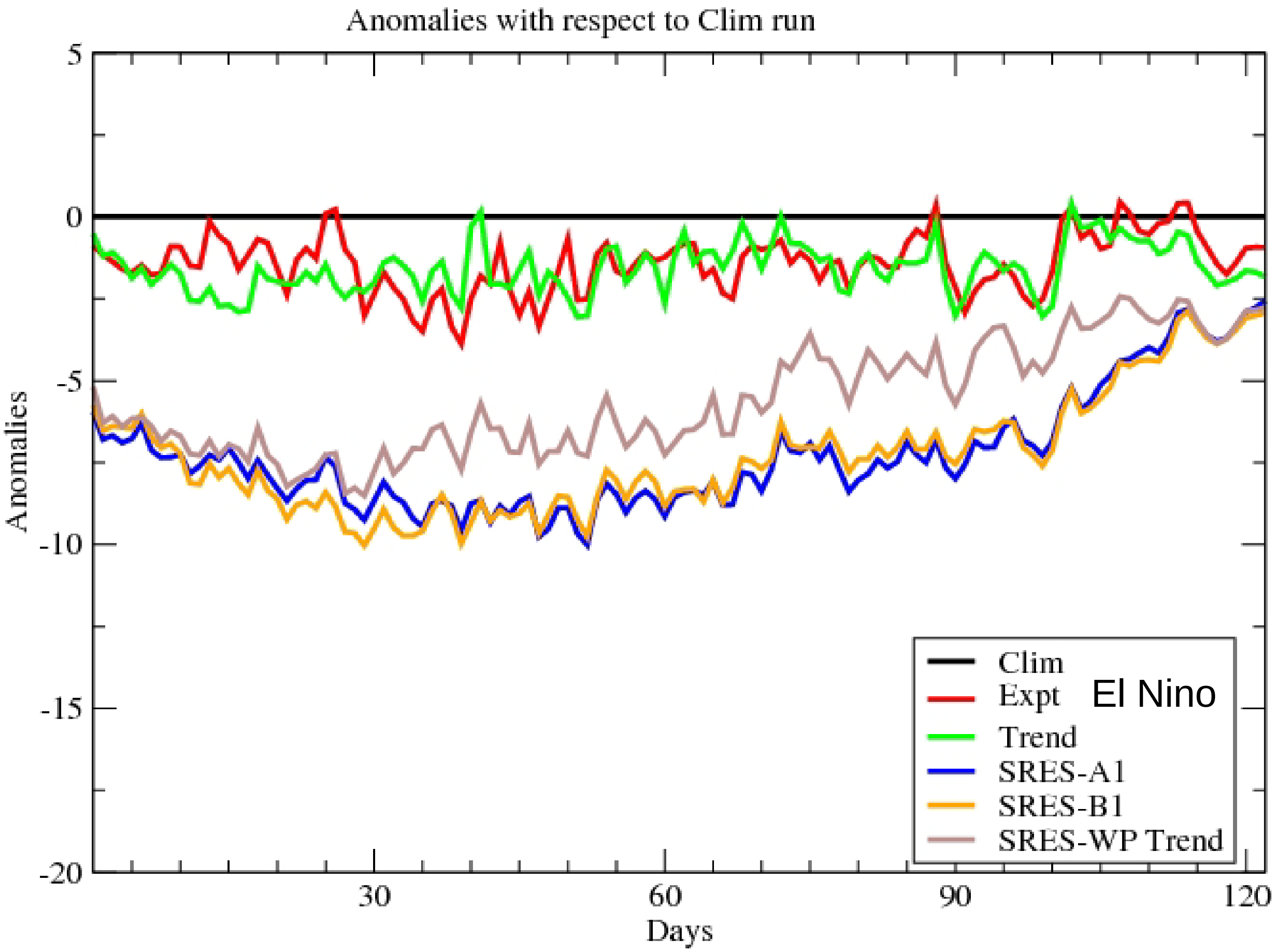
SRES_SST+El Nino

“rainfall anomalies stronger over South Asia”

AM2.1 solutions from various experiments



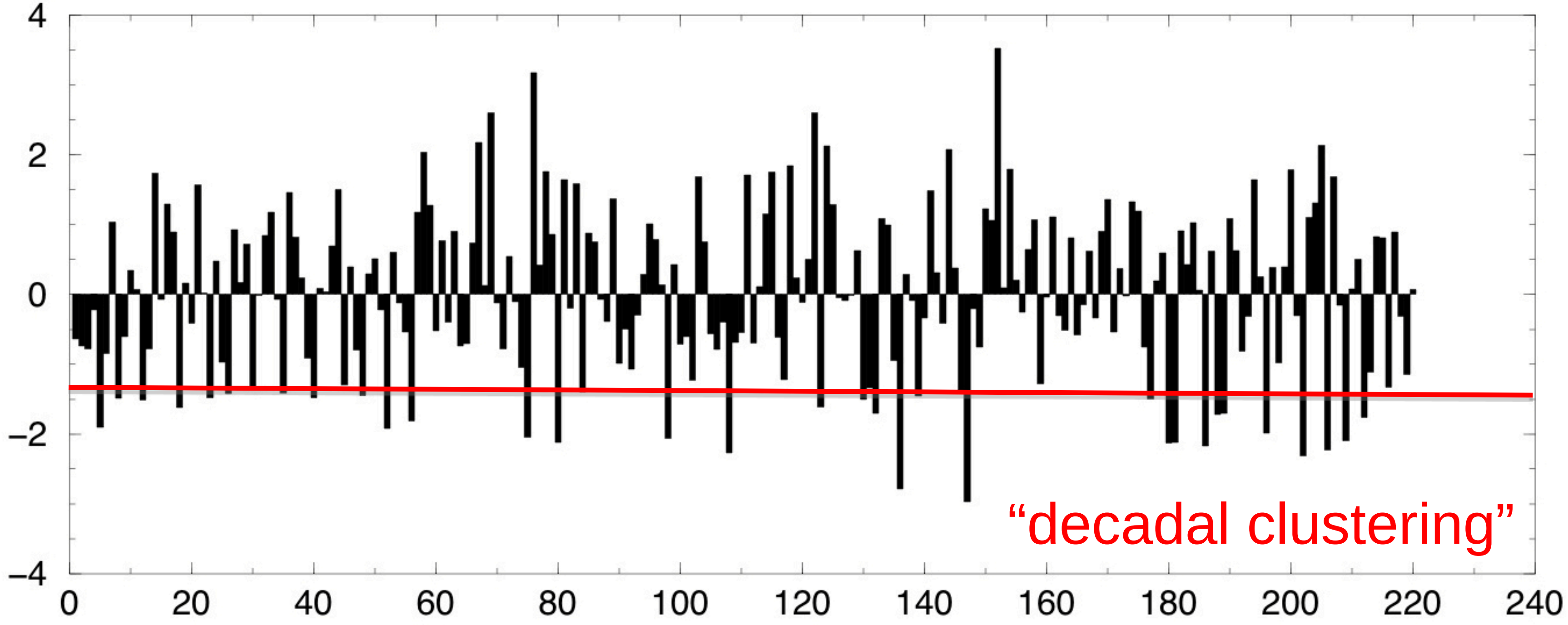
Are the seasonal rainfall anomalies predictable?



Support the hypothesis of Charney and Shukla (1981); Shukla (1998)

What is not so encouraging?

South Asian Monsoon Rainfall – CM2.1 - Projected



adaptation - ?

Summary

- ENSO and monsoon – more variable in the future
- Systematic shift in the PDF shape (sampling?)
- Robustness needs to be verified with CMIP5
- AGCM solutions suggest severe weak monsoons and extended breaks have high predictability