

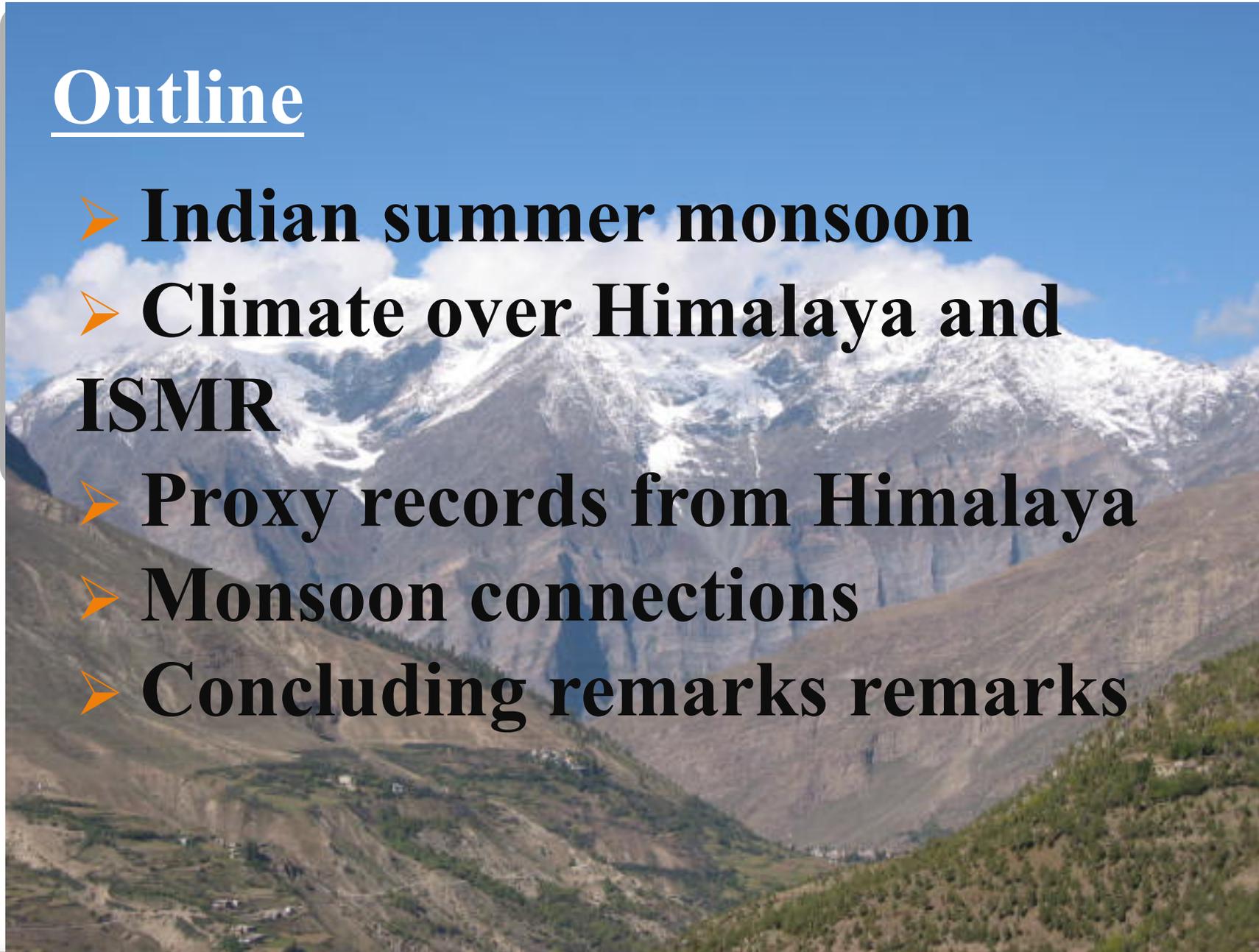
CLIMATE OVER THE HIMALAYAS DURING THE LAST MILLENNIUM AND SOUTHWESTH SUMMER MONSOON CONNECTIONS

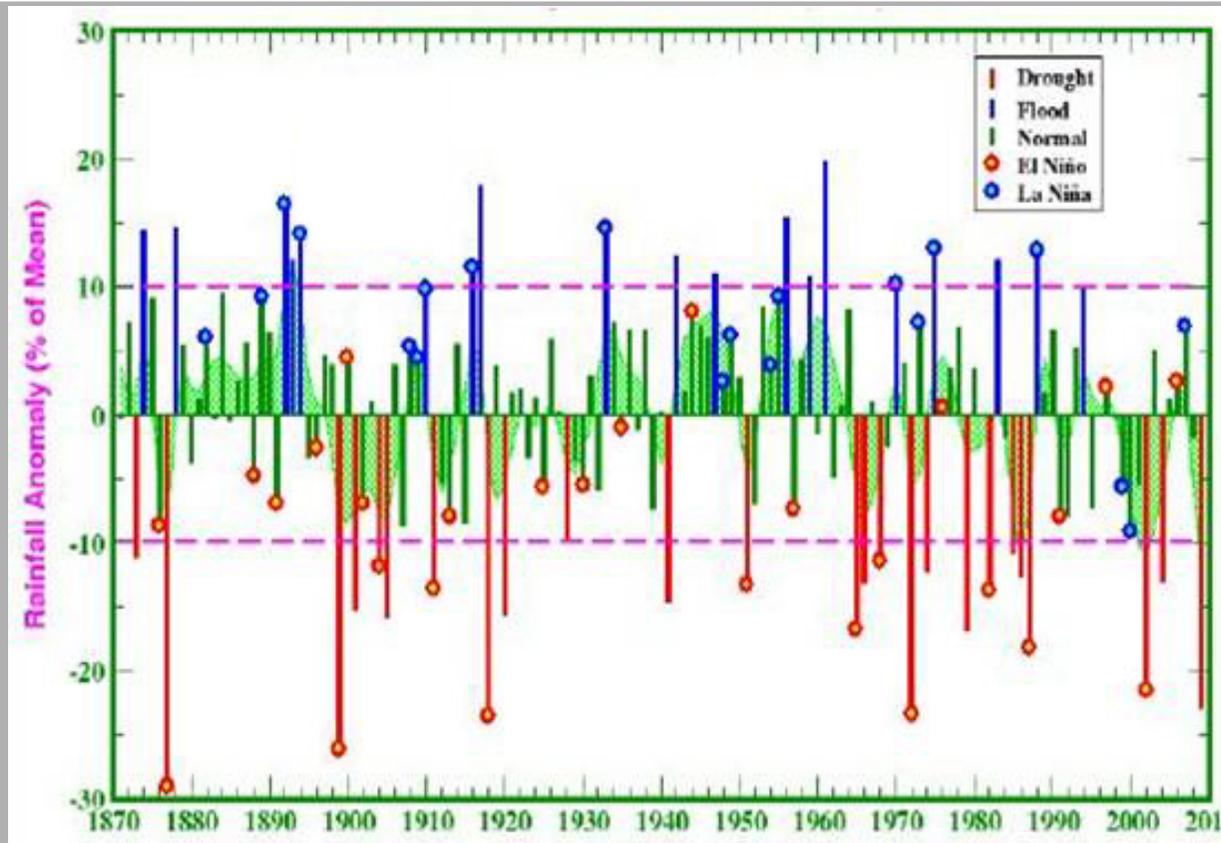
Ram R Yadav
Birbal Sahni Institute of
Palaeobotany, Lucknow, India



Outline

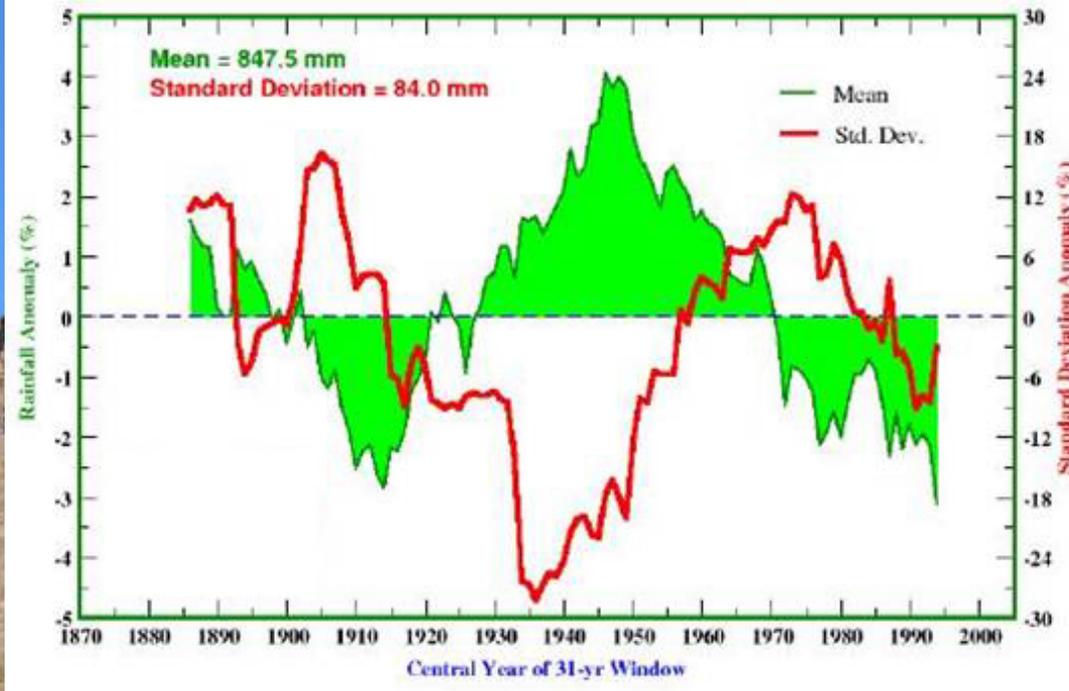
- **Indian summer monsoon**
- **Climate over Himalaya and ISMR**
- **Proxy records from Himalaya**
- **Monsoon connections**
- **Concluding remarks**





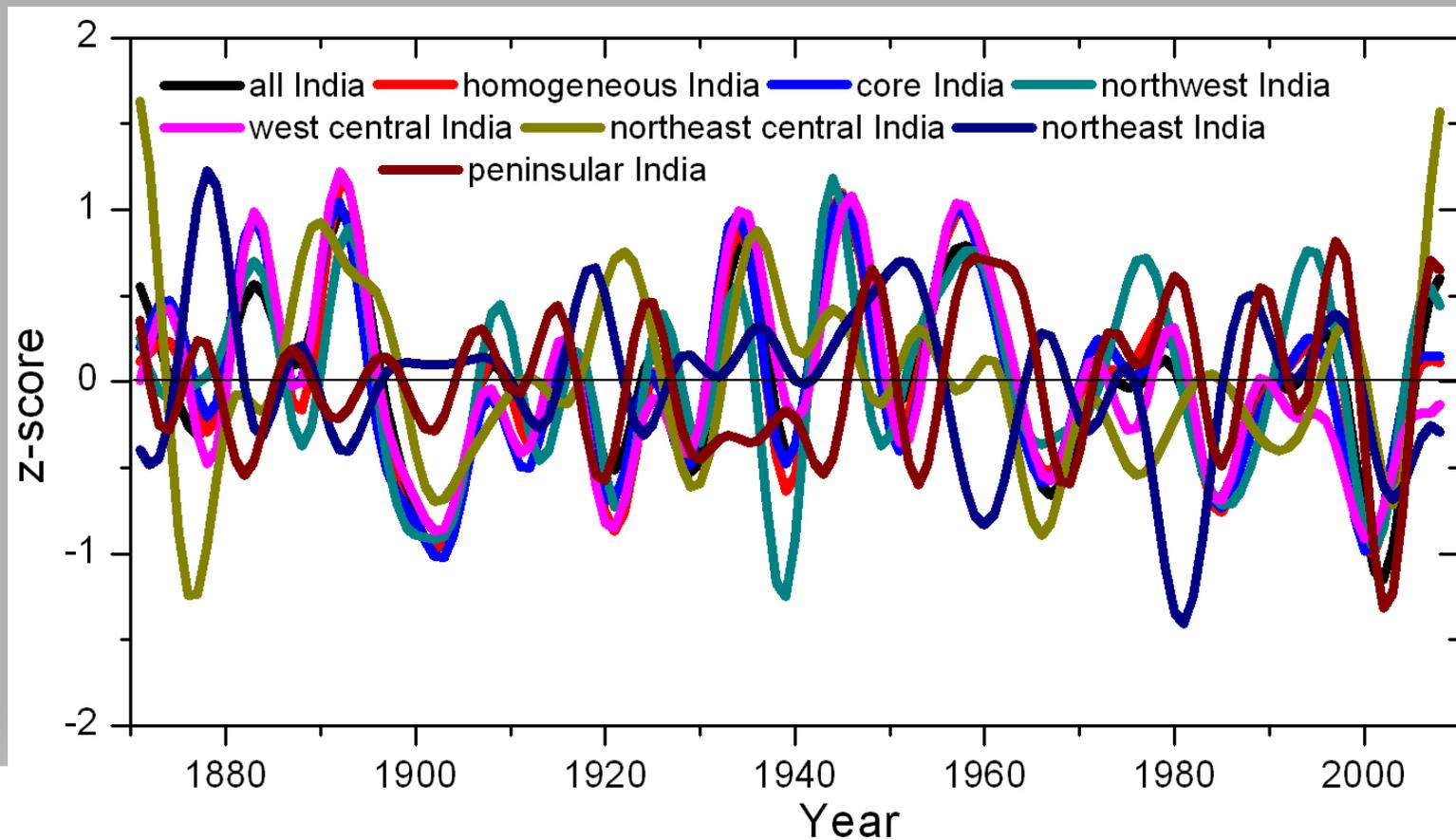
ISMR high inter annual variability associated with ENSO and Eurasian temperature and a host of other forcing

Epochal Patterns of All-India Summer Monsoon Rainfall



**Epochal variations of around 30 yr
high and low ISMR**

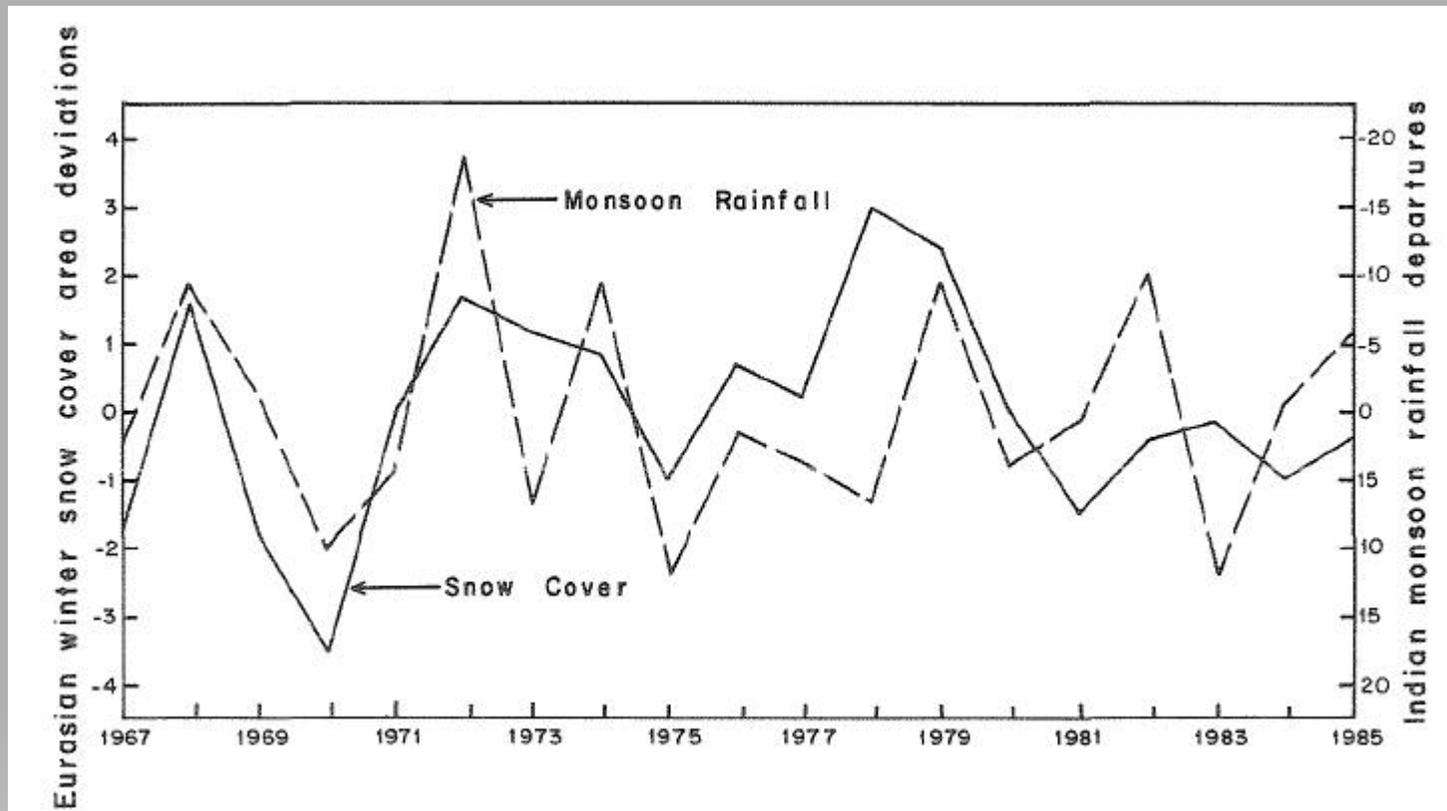
Summer monsoon precipitation has strong regional variability- different forcing



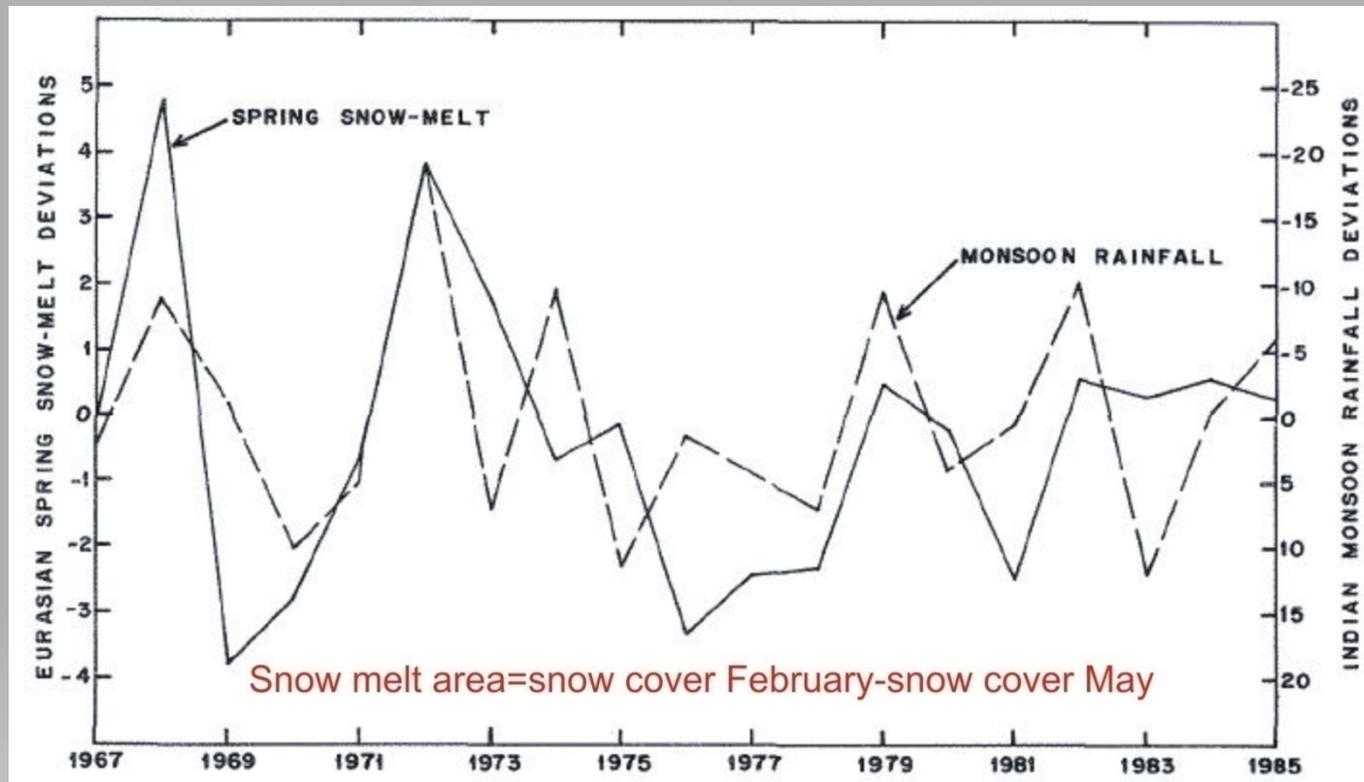
Land-sea thermal gradient: driver of monsoon currents

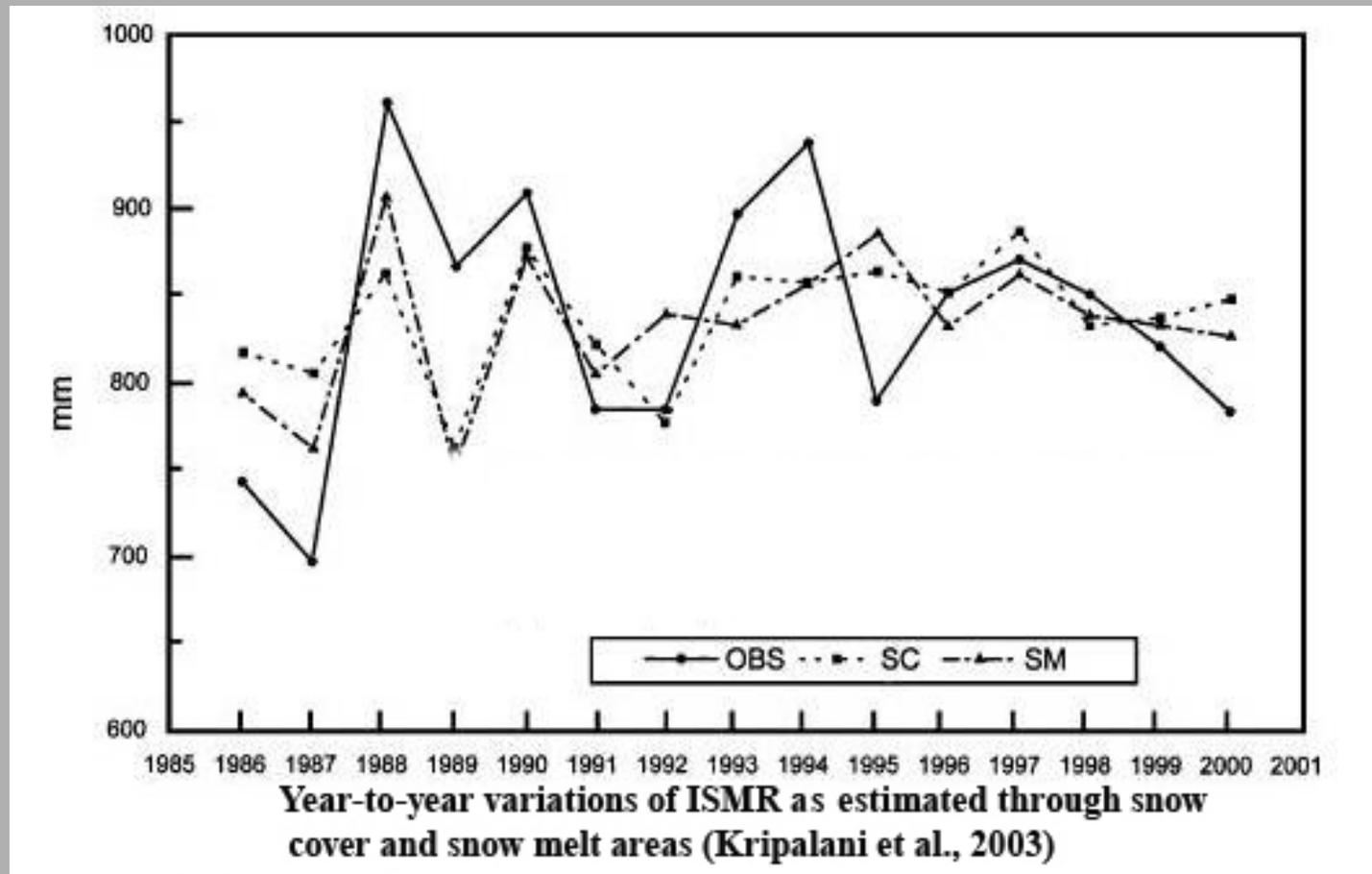
Land-Sea thermal gradient- driver of monsoon currents

Eurasian snow cover - inverse relationship with ISMR (Bhanukumar, 1988)



Eurasian snow melt area (snow cover in February – May) and ISMR. Snow cover and snow melt area together account 36% of variance in monsoon rainfall (1966-1985) (Bhanukumar, 1988)





ISMR and Western Himalayan snow cover area ($r=-0.48$), snow melt area ($r=-0.59$, 1986-2000)

**Monsoon prediction models
(India)-statistical where monsoon
rainfall and predictor relationship
in many cases is not stationary,
has gone under epochal changes-**

when and how?

**Clues from High-resolution long-
term land and ocean records!**

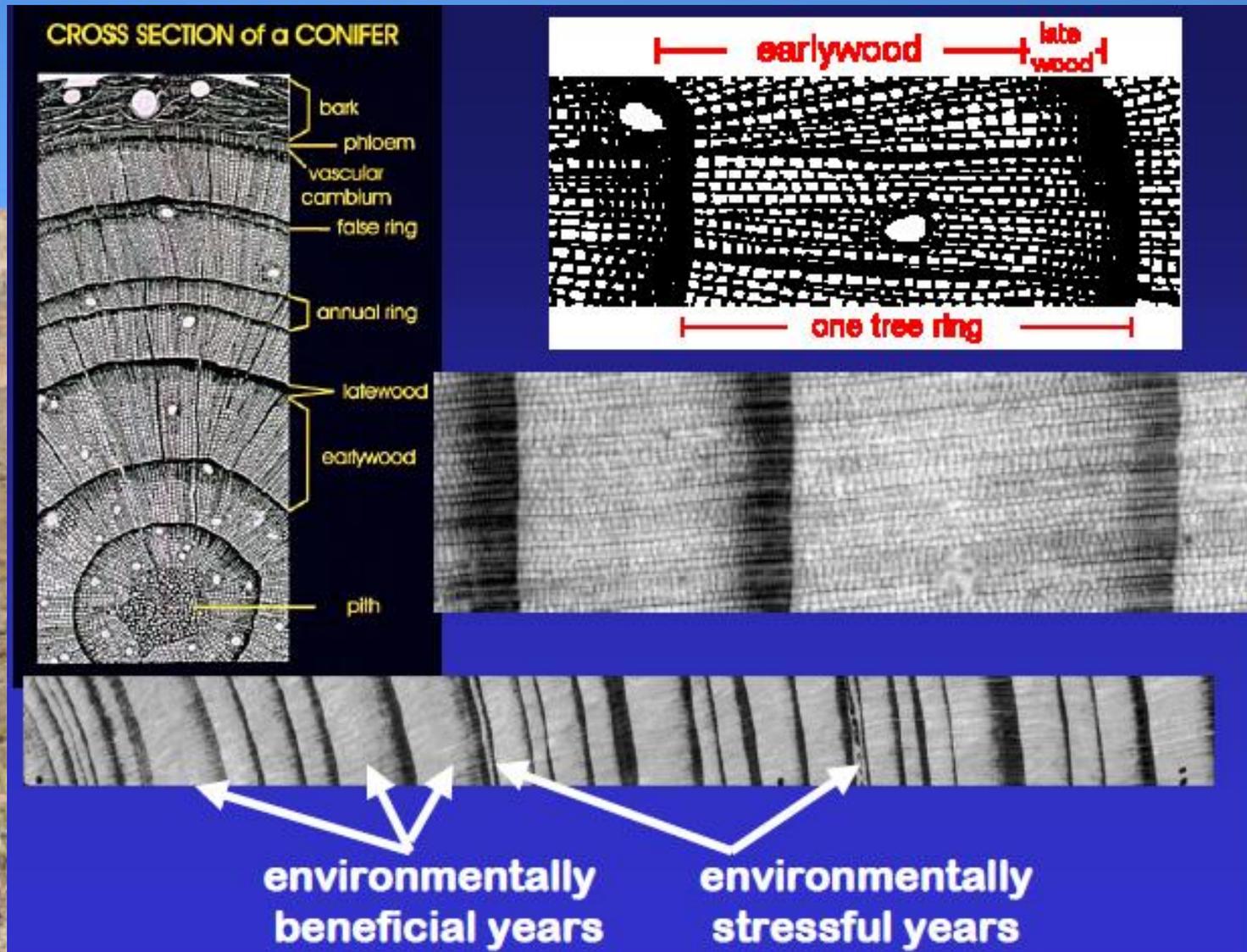
Weather data from the High Himalayas

Long-term records from high Himalayas not available to understand association with ISMR in longer perspective

High-resolution proxies: tree rings, lake and varve deposits, ice cores



Tree rings and millennial records



Study area

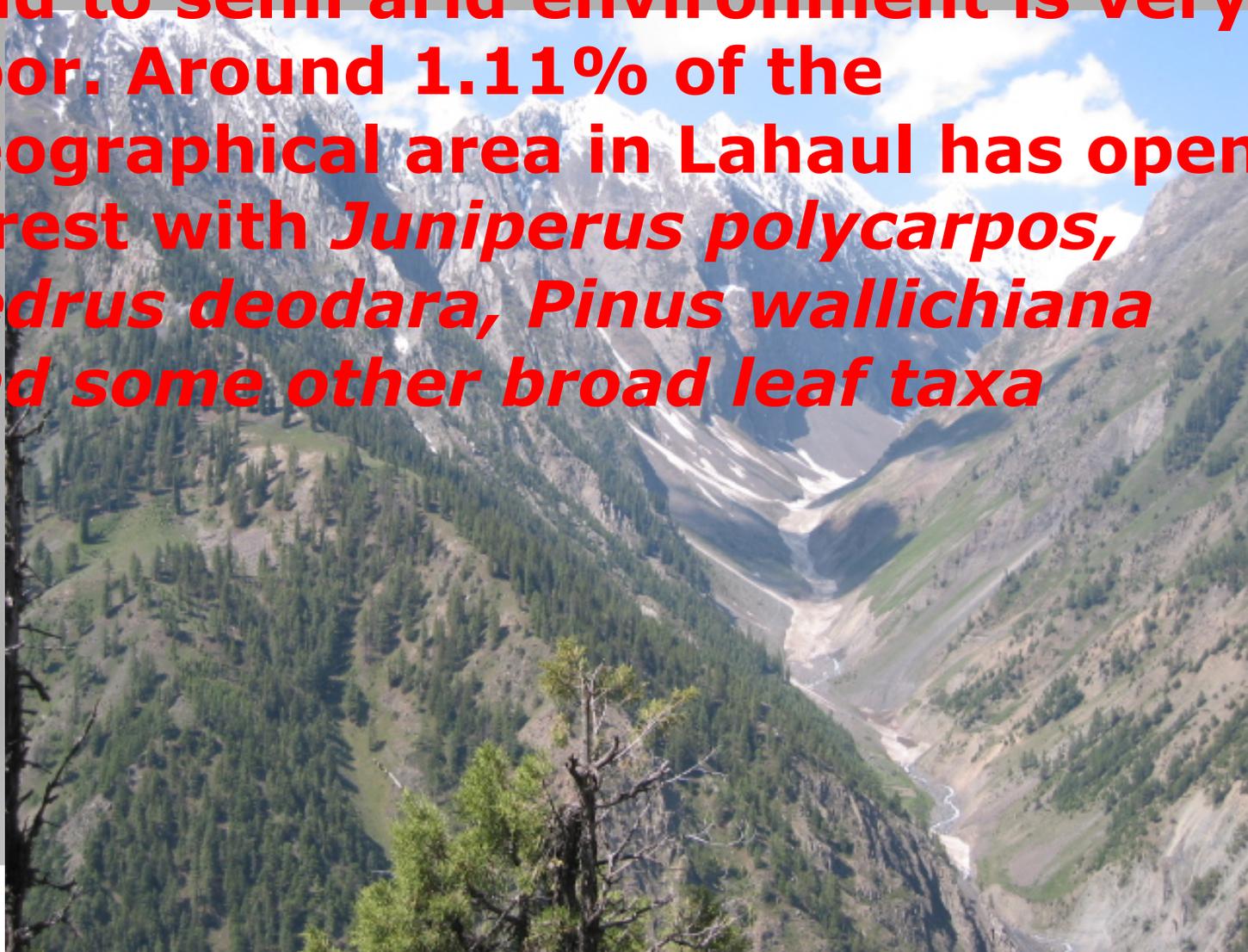
- Semiarid western Himalaya
- Winter and premonsoon precipitation
2/3rd of the annual
- 1.11% of the geographical area has
open forest
- **Many tees are very old more than 2000**
years and could be used as proxy of
temperature and precipitation



Tree ring sampling locations



Vegetation cover in the area under arid to semi arid environment is very poor. Around 1.11% of the geographical area in Lahaul has open forest with *Juniperus polycarpus*, *Cedrus deodara*, *Pinus wallichiana* and some other broad leaf taxa





**Millennium old
Juniperus polycarpos
in western Himalaya**

Growth rings in Himalayan pencil juniper-dateable to calendar year



Millennium old *Cedrus deodara* in western Himalaya



Growth rings in Himalayan cedar





**Millennium old
Pinus gerardiana
in western Himalaya**

Collection of tree samples

- Non destructive sampling with the help of manual increment borers

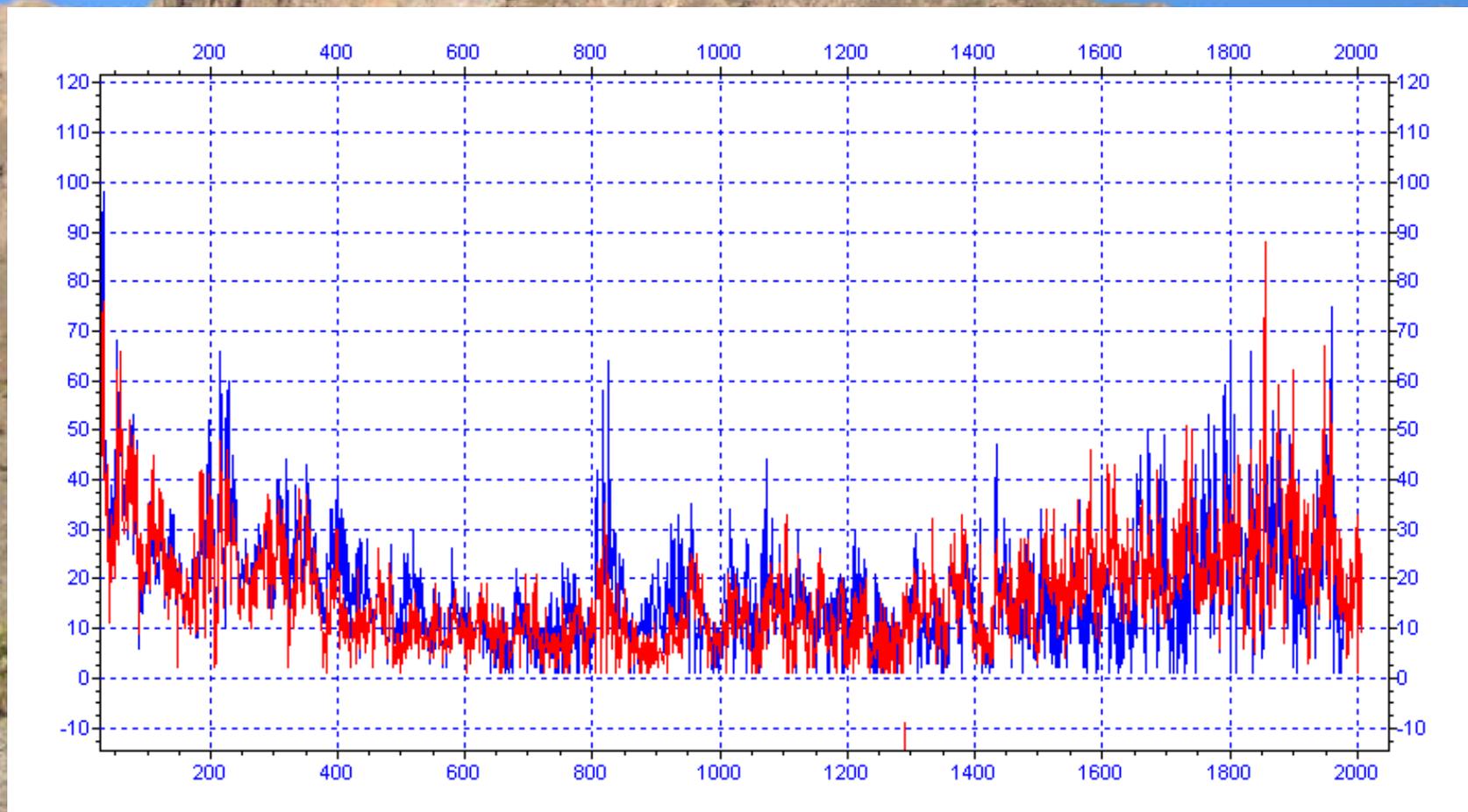


Matching of ring width patterns among trees

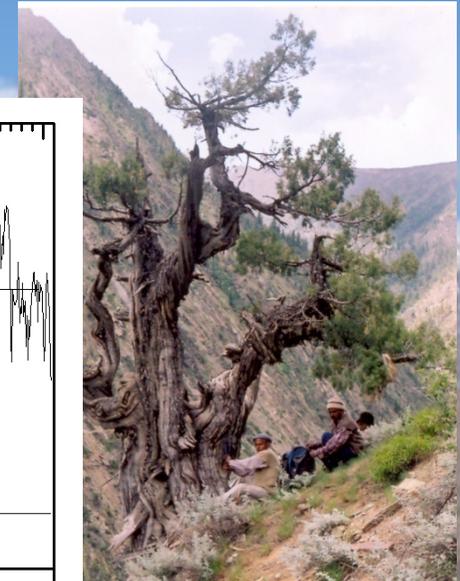
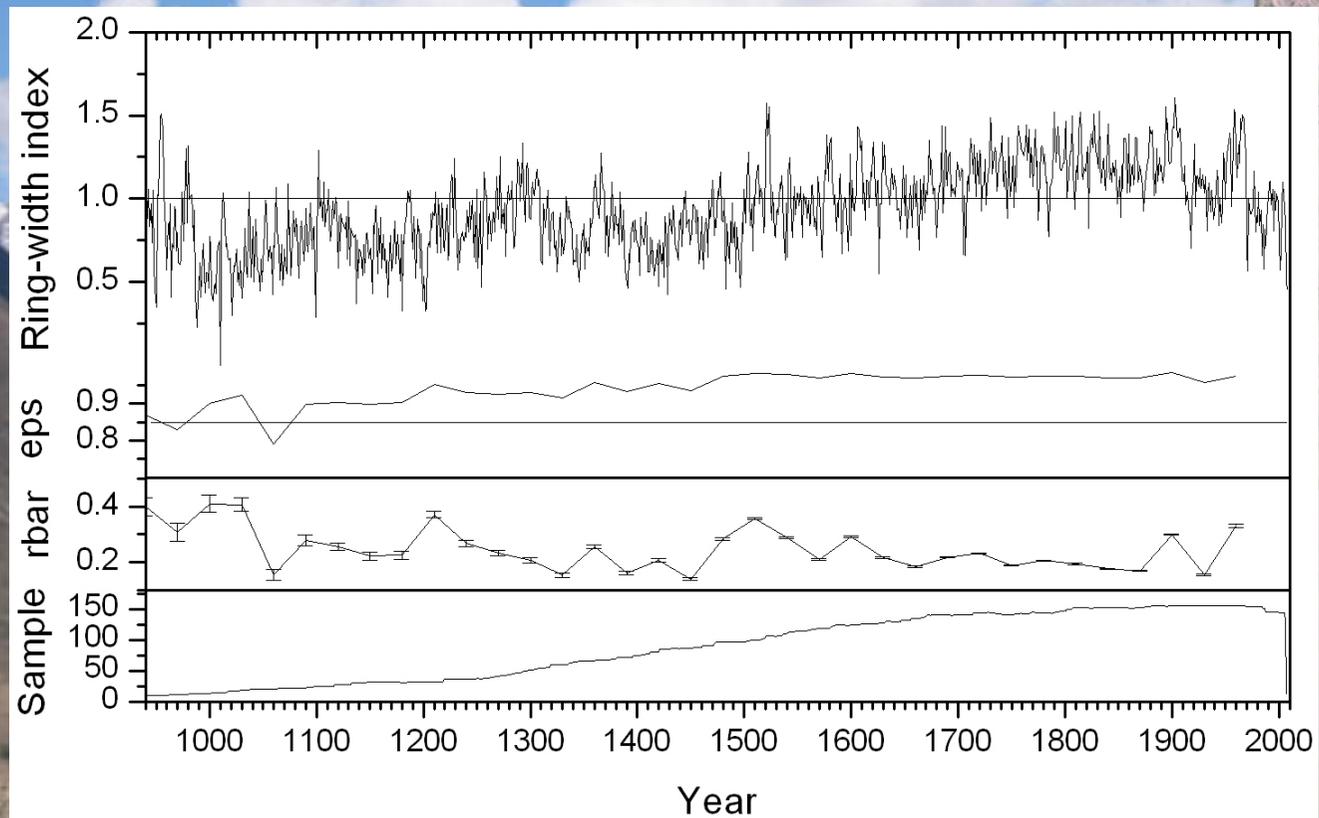


Long tree ring chronologies from India

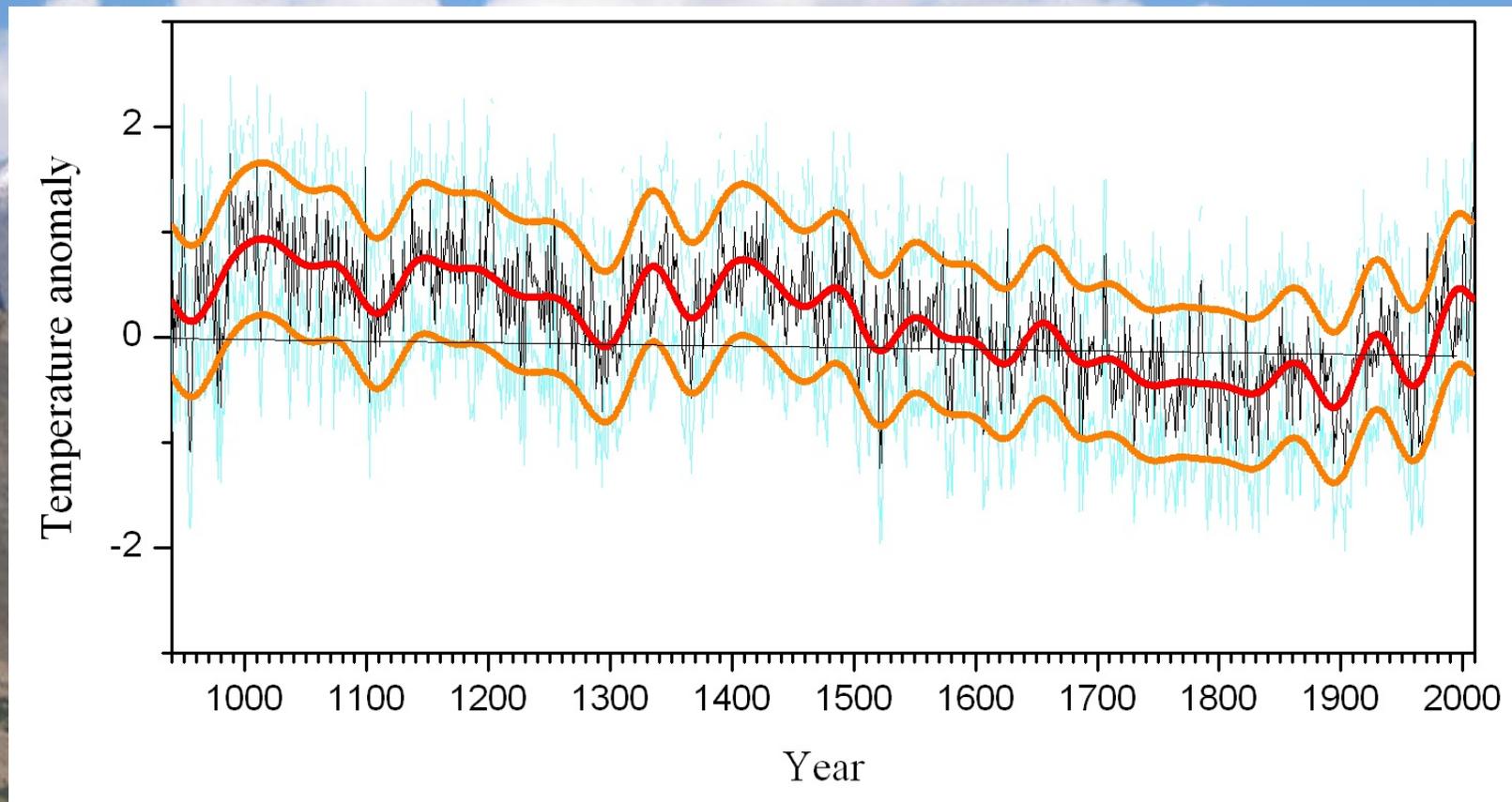
2026 yrs Juniper chronology from Western Himalaya



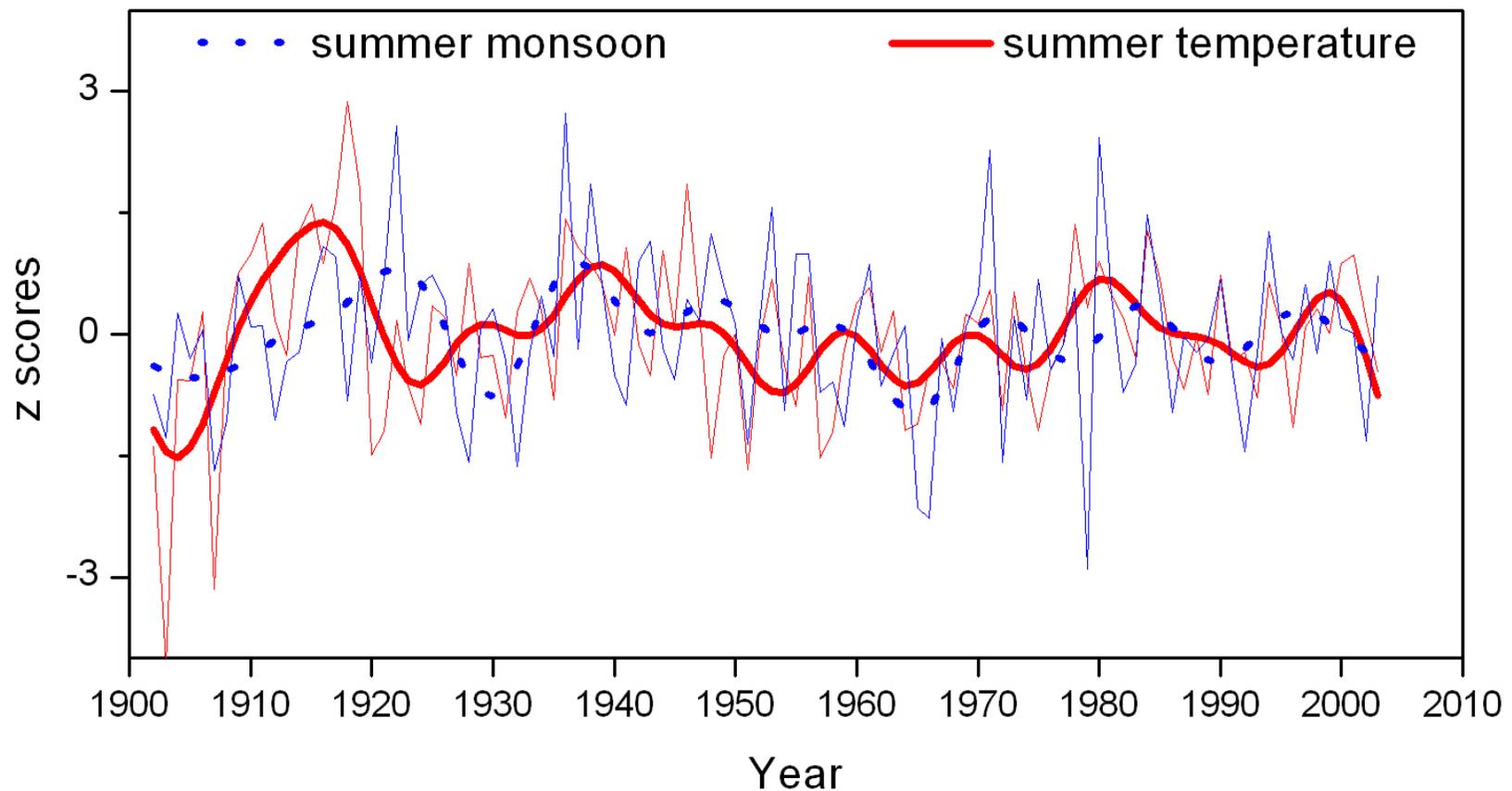
Tree-ring chronologies- *Juniperus polycarpus*



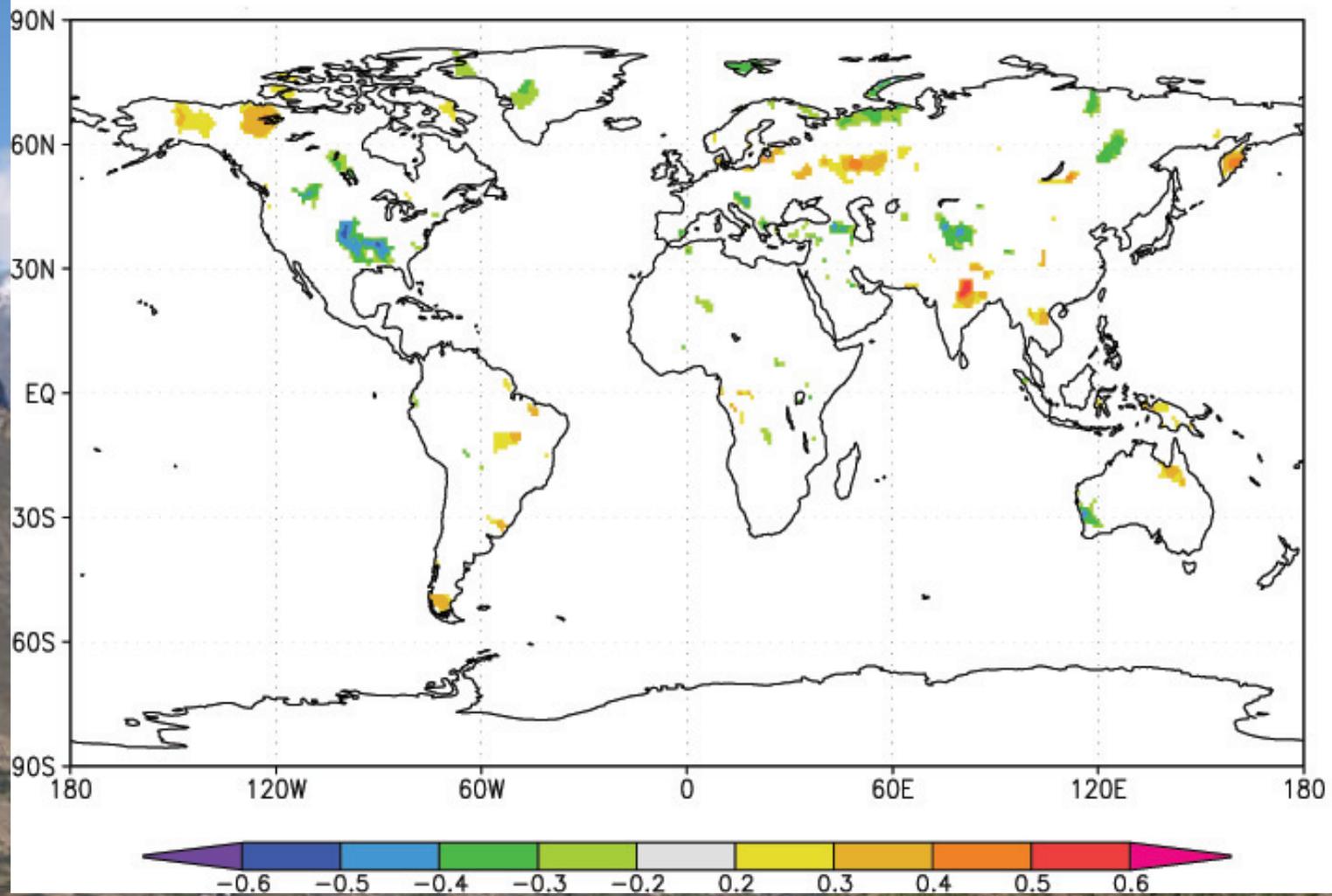
**April-August mean temperature- based
on *Juniperus polycarpos* chronology**



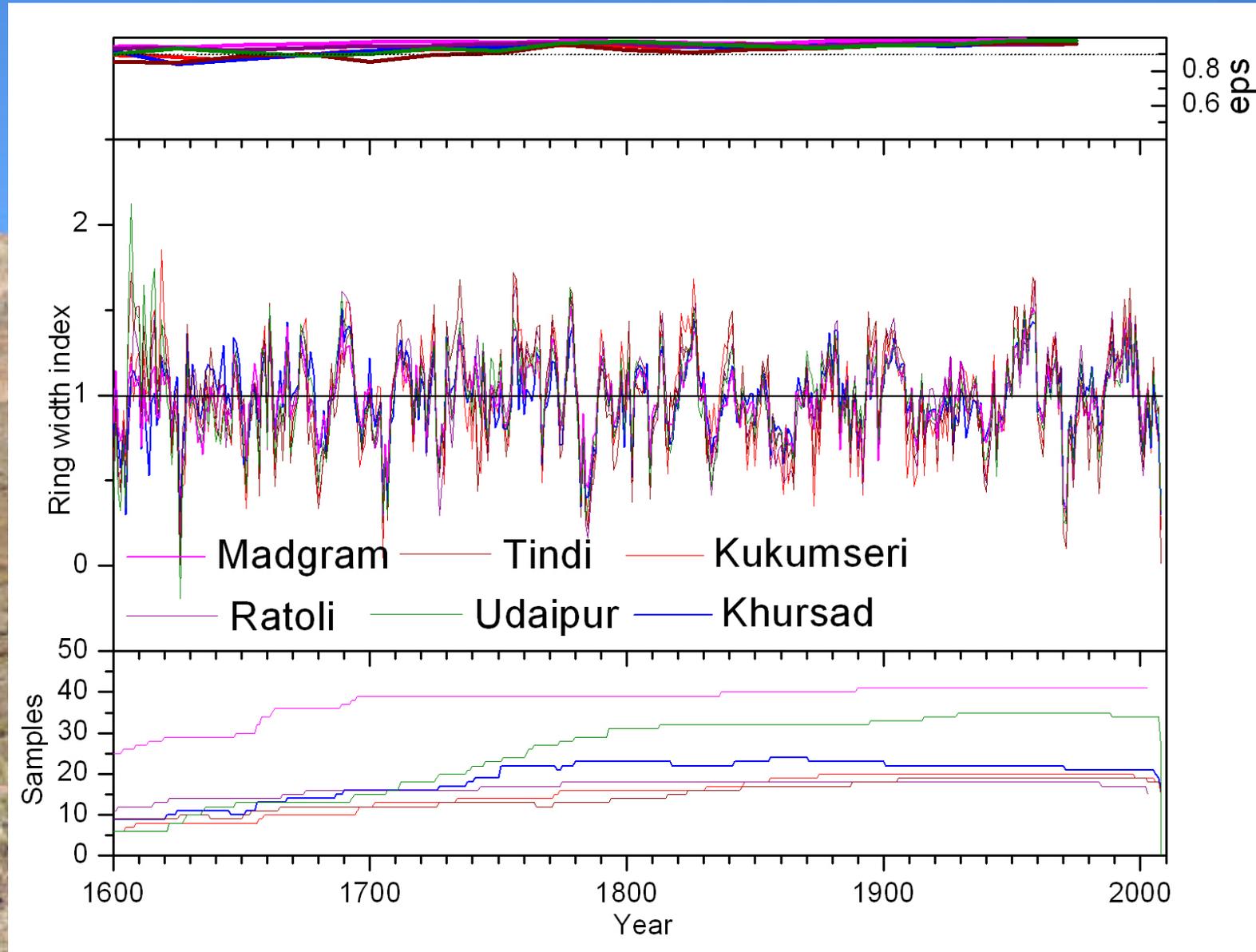
Direct association between mean April-August mean temperature and summer monsoon rainfall over north central India



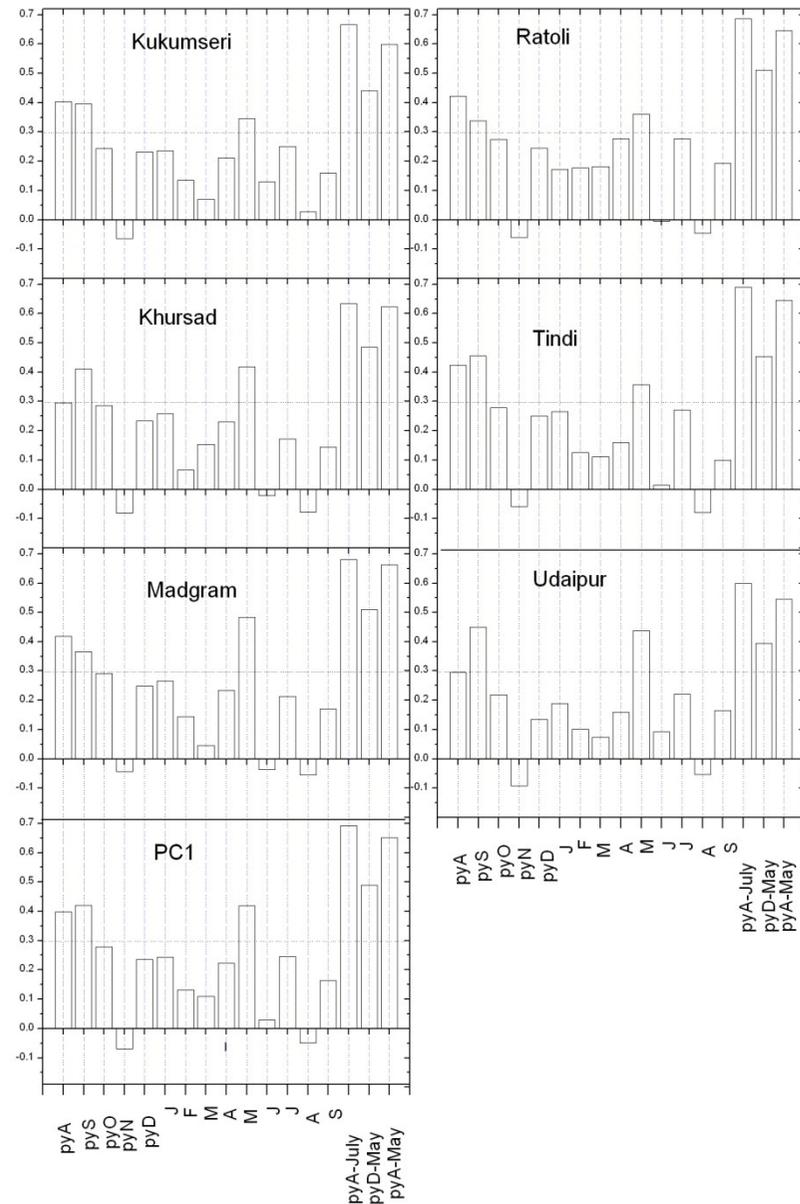
Mean summer (MJJA) temperature correlation with June-September precipitation (1951-2004)



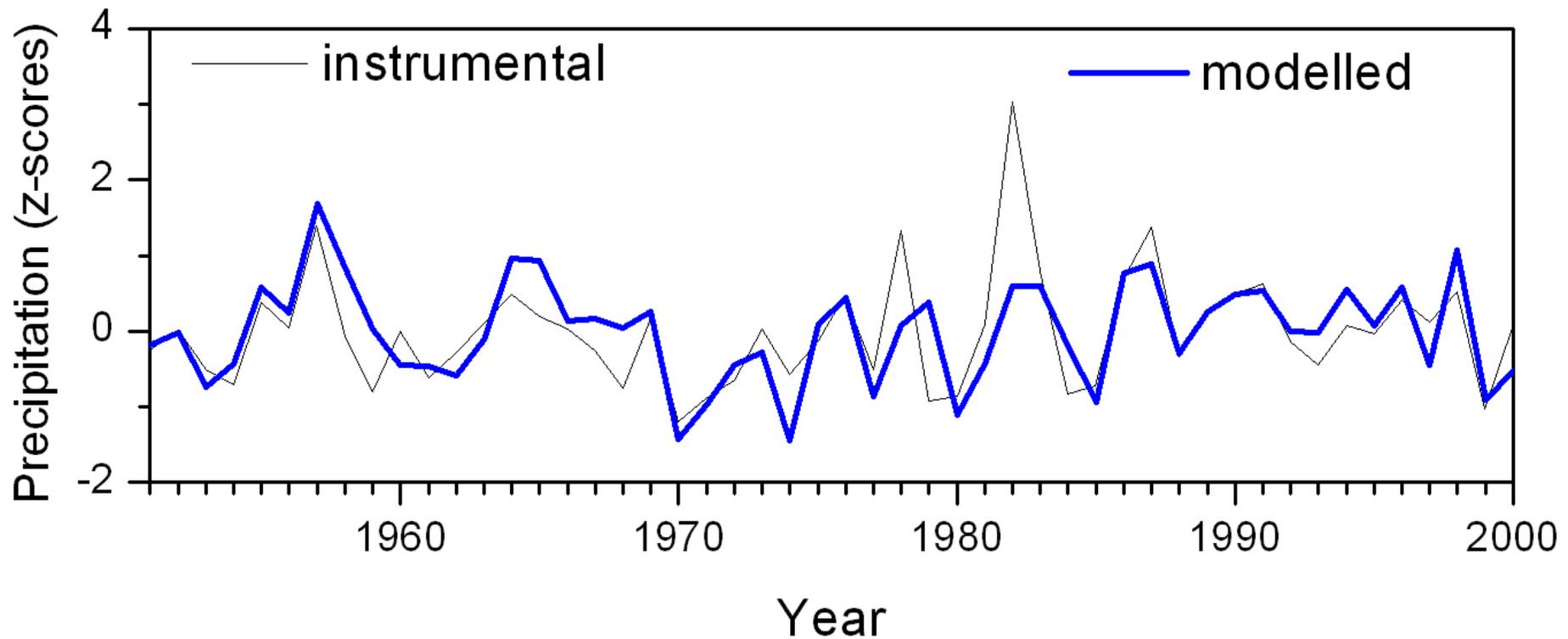
Himalayan cedar chronologies used in precipitation reconstruction



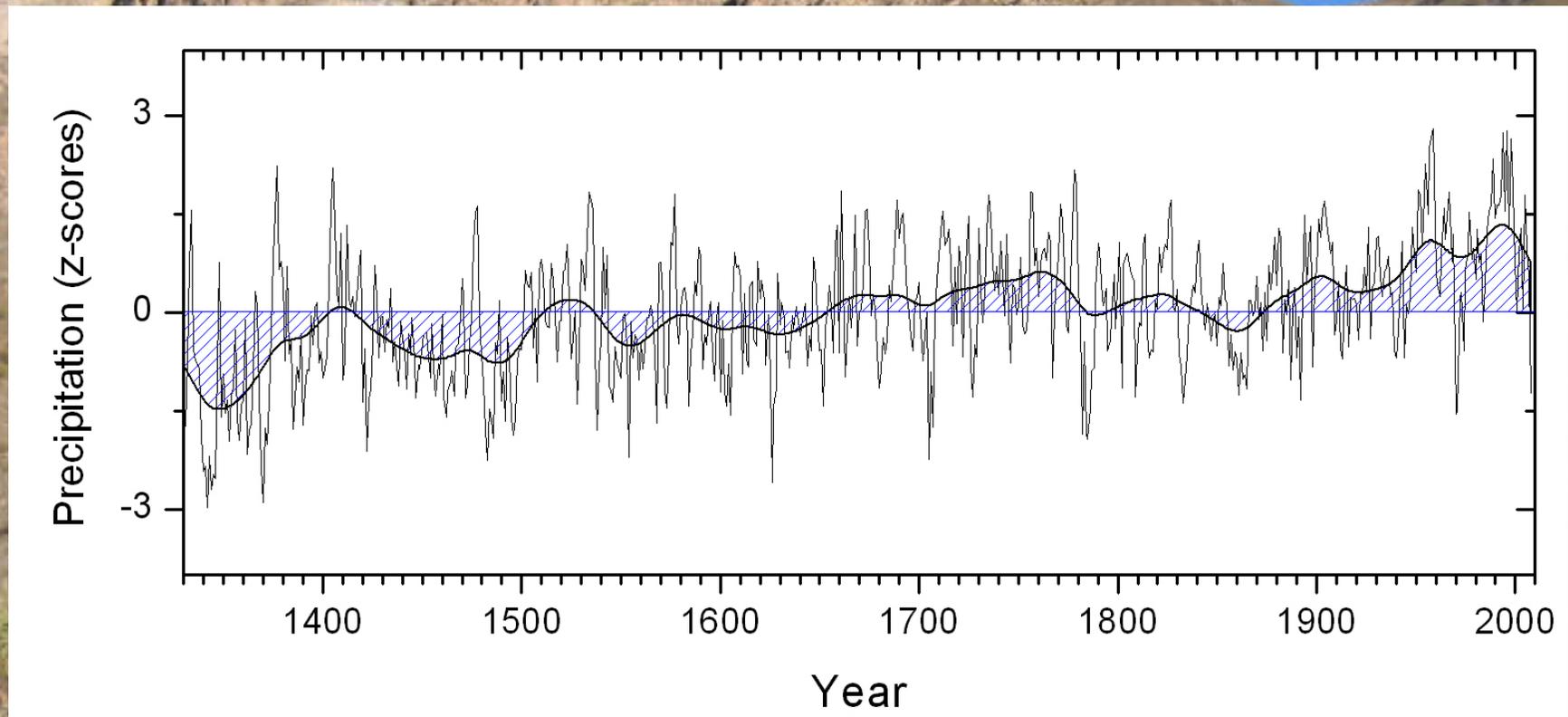
Existence of strong precipitation signal in chronologies



Development of climate records-Calibration

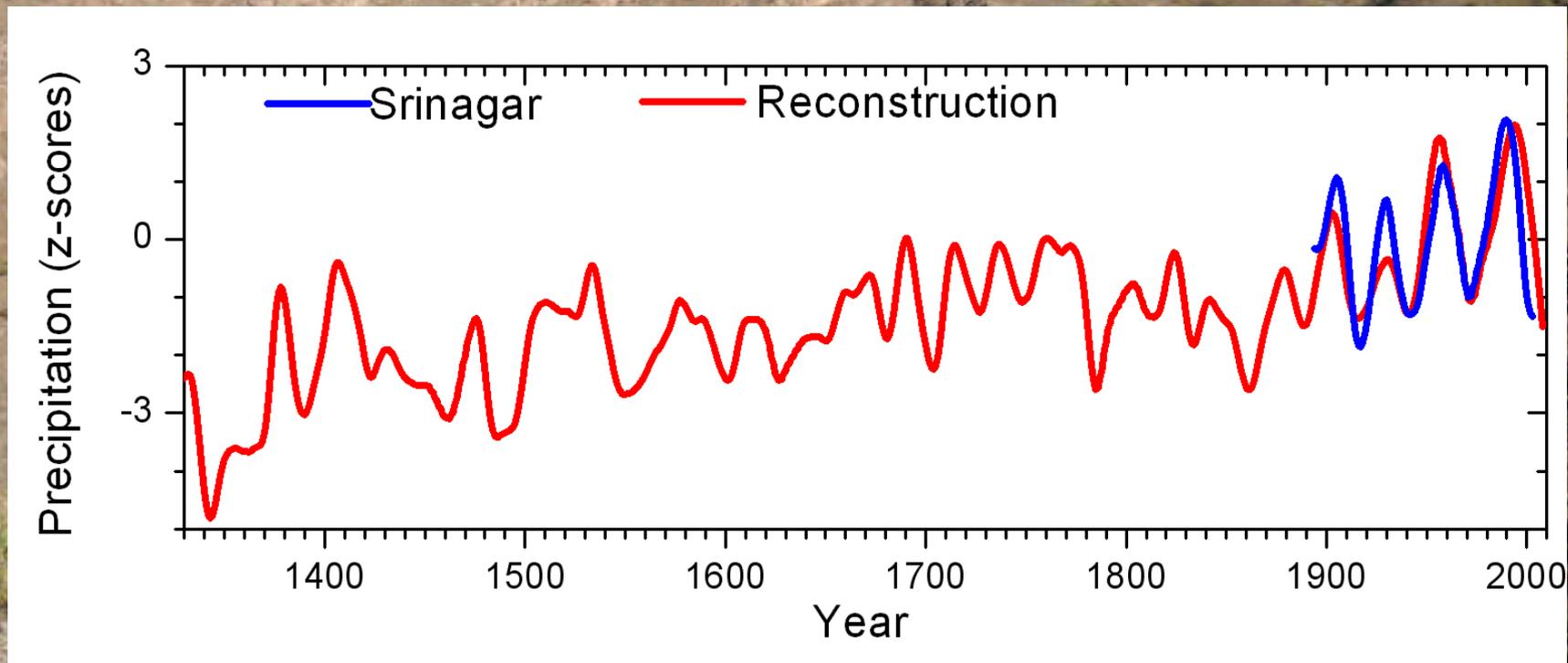


Precipitation (western Himalaya): August-July

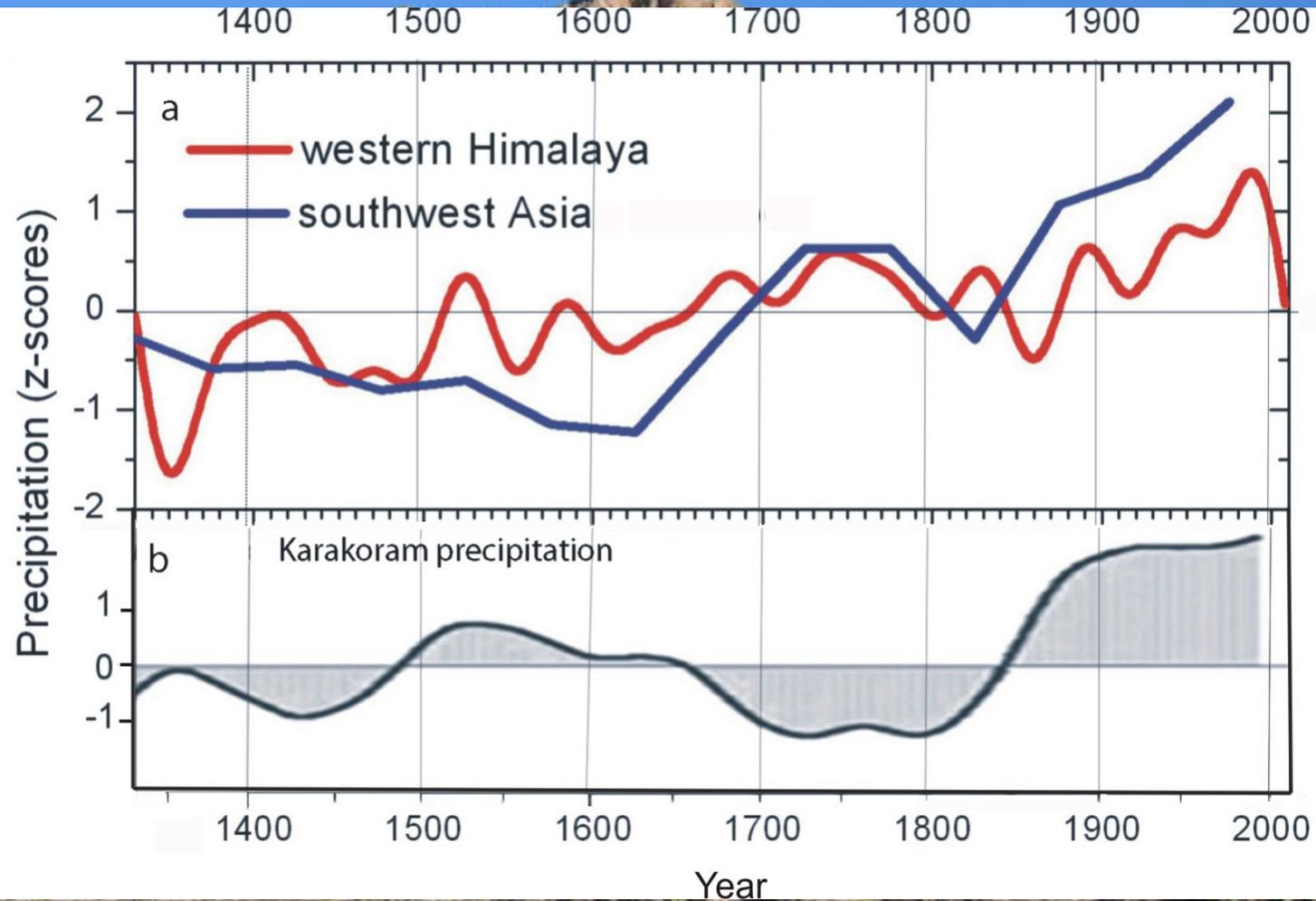


Validation-

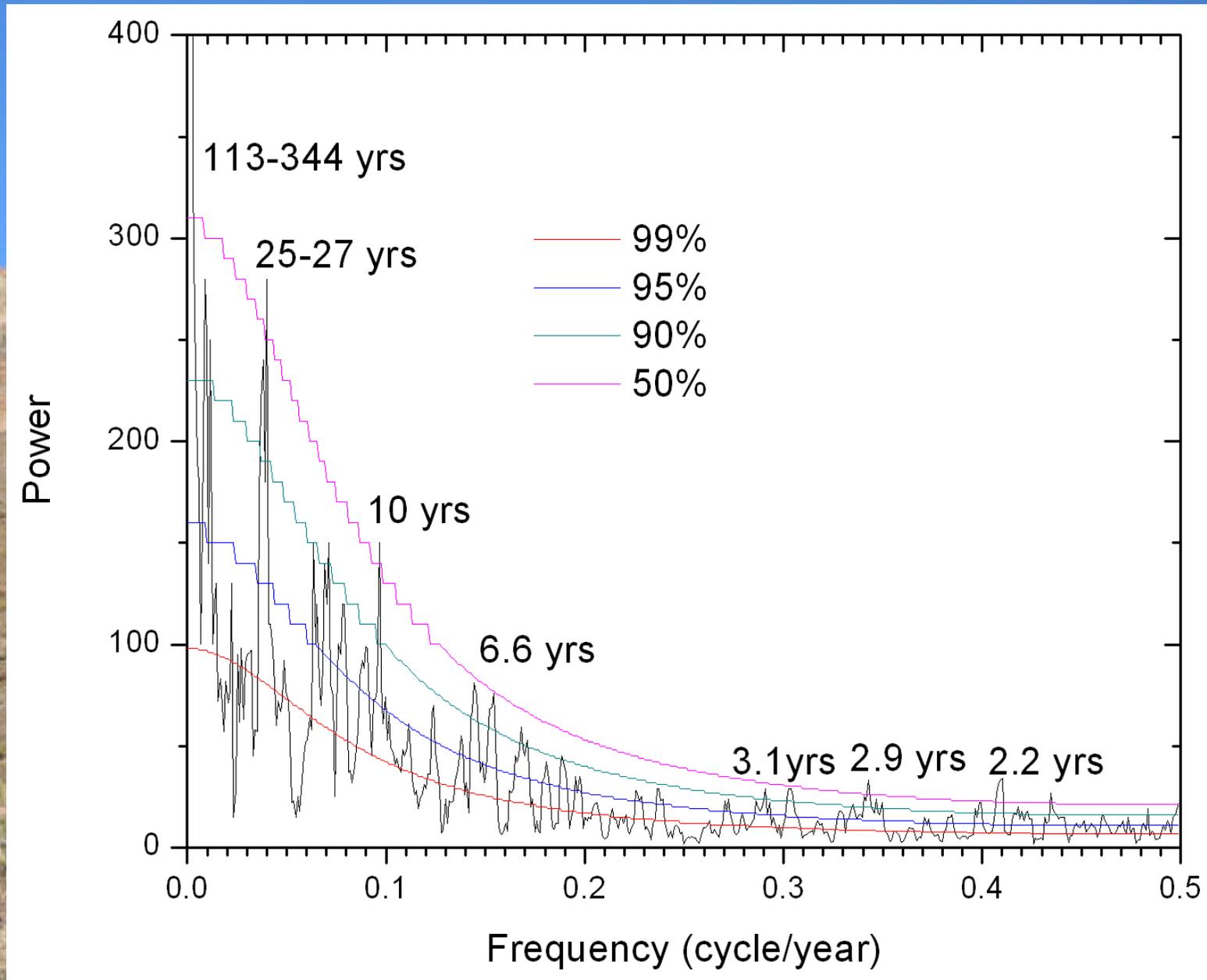
Similarity between reconstructed and Srinagar Precipitation-independent verification



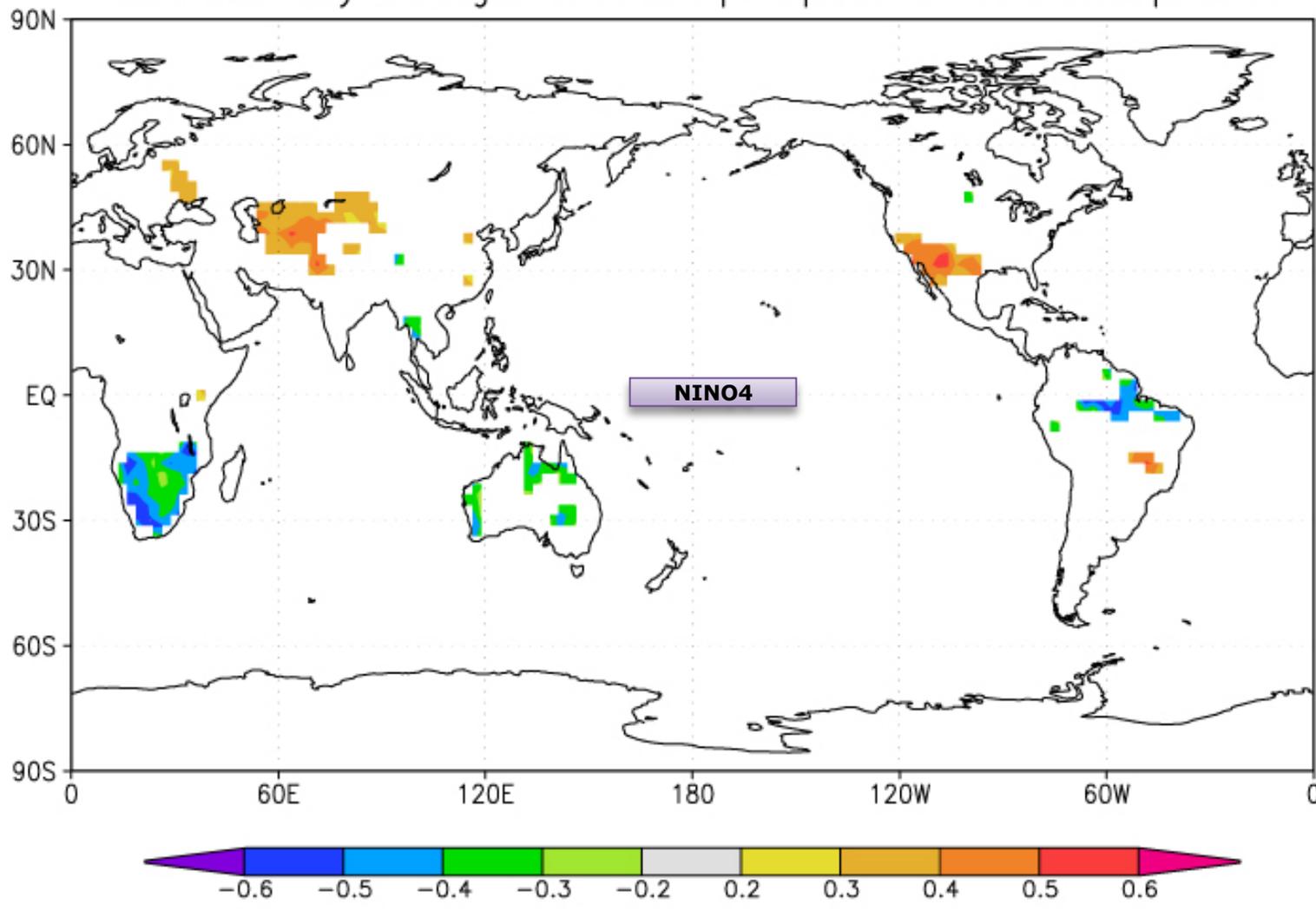
Pluvial 20th century



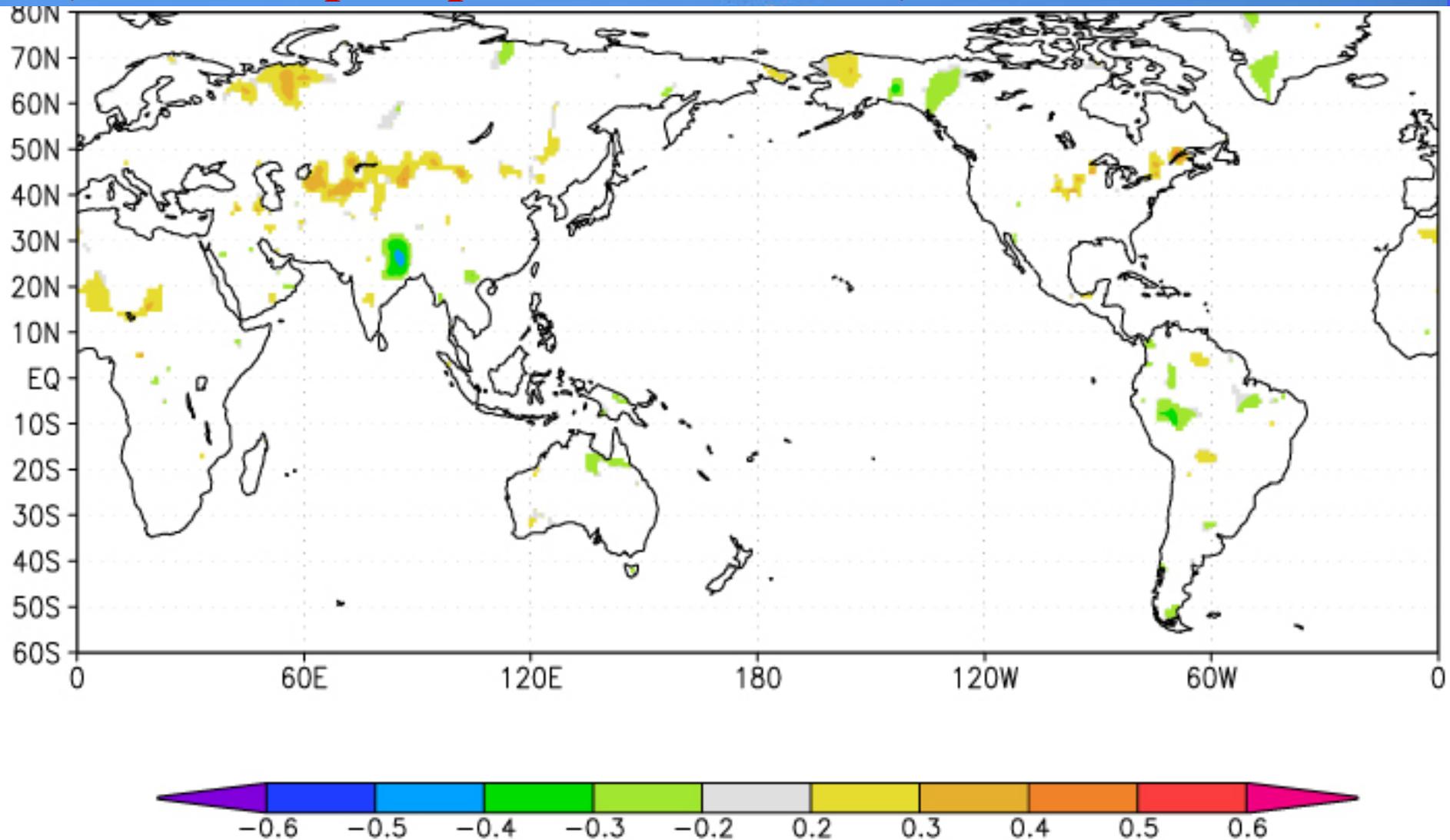
Significant periodicity in reconstruction

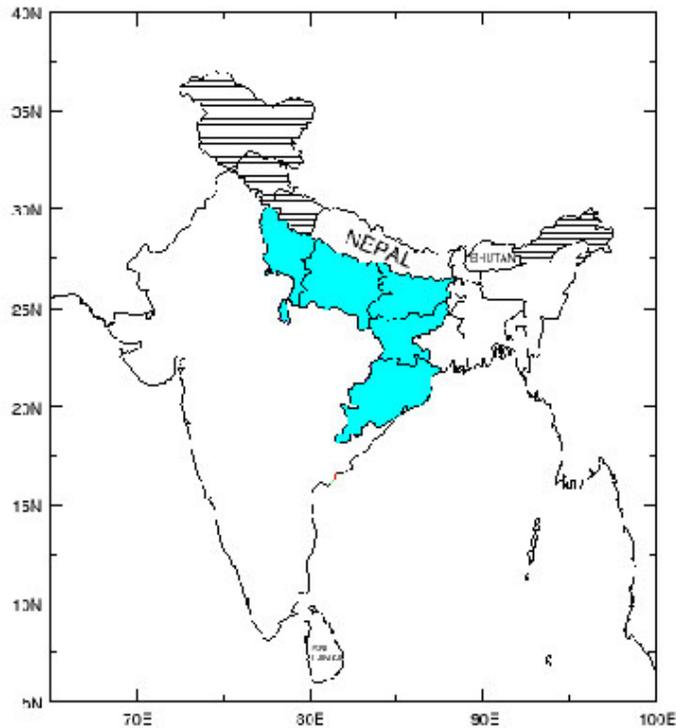


corr Dec-May averaged NINO4
with Dec-May averaged CRU TS3 precipitation 1960:1999 $p < 10\%$



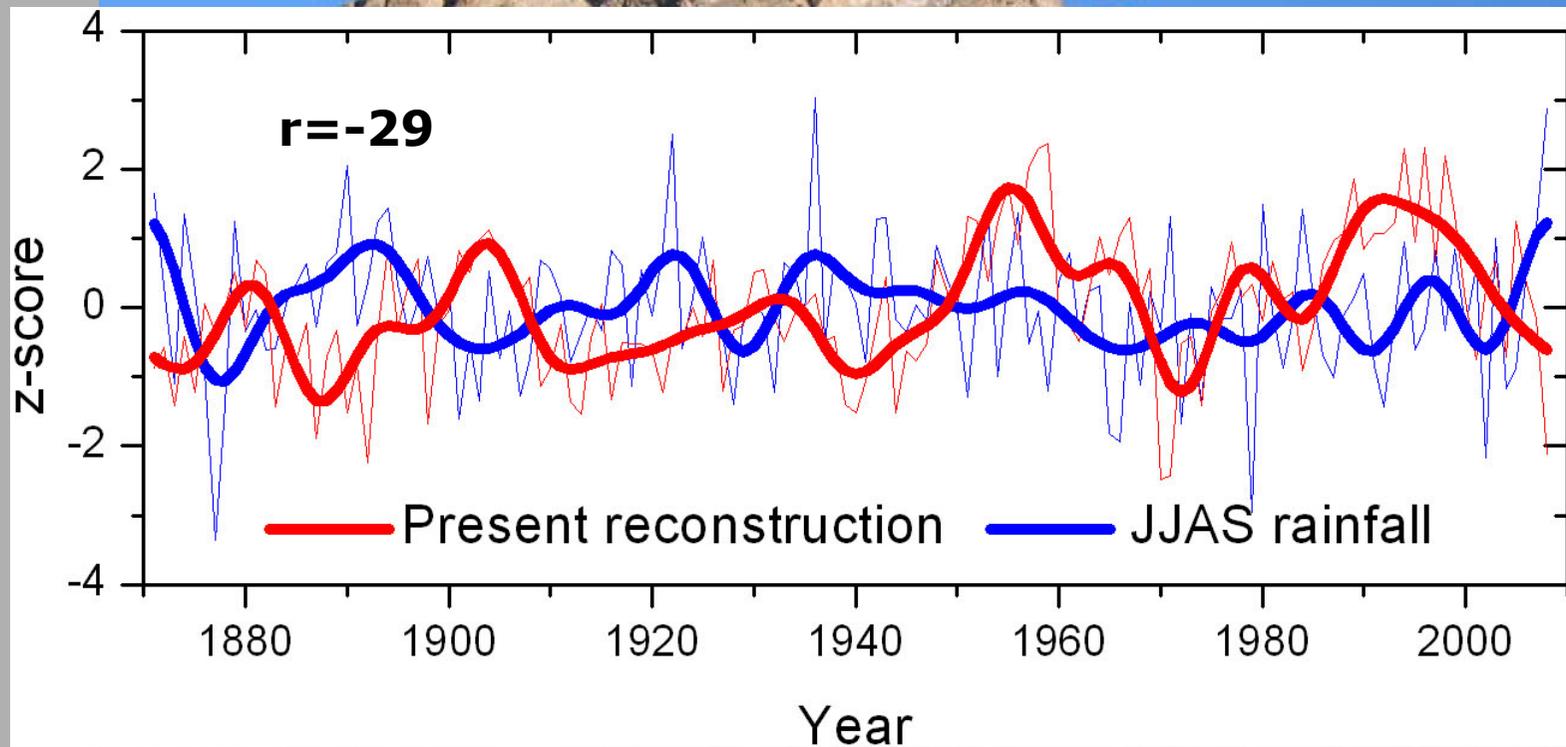
Correlation between August-July reconstructed precipitation and June-September monsoon rainfall (CRU TS3 precipitation 1901-2000)



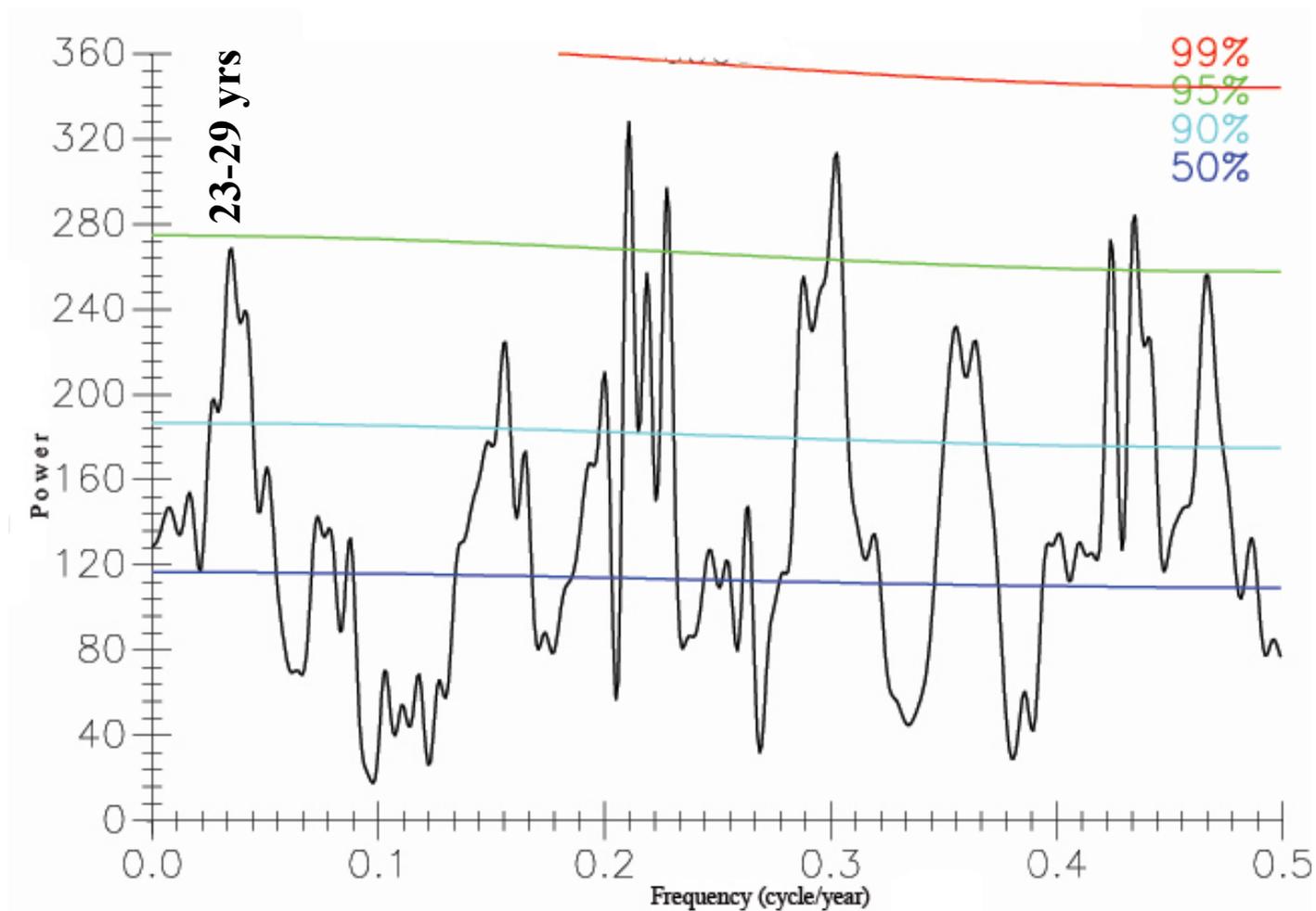


➤ **Precipitation reconstruction for the area in Himalaya where 2/3rd of the annual precipitation occurs in winter and premonsoon season is inversely related with summer monsoon over the central northeast India**

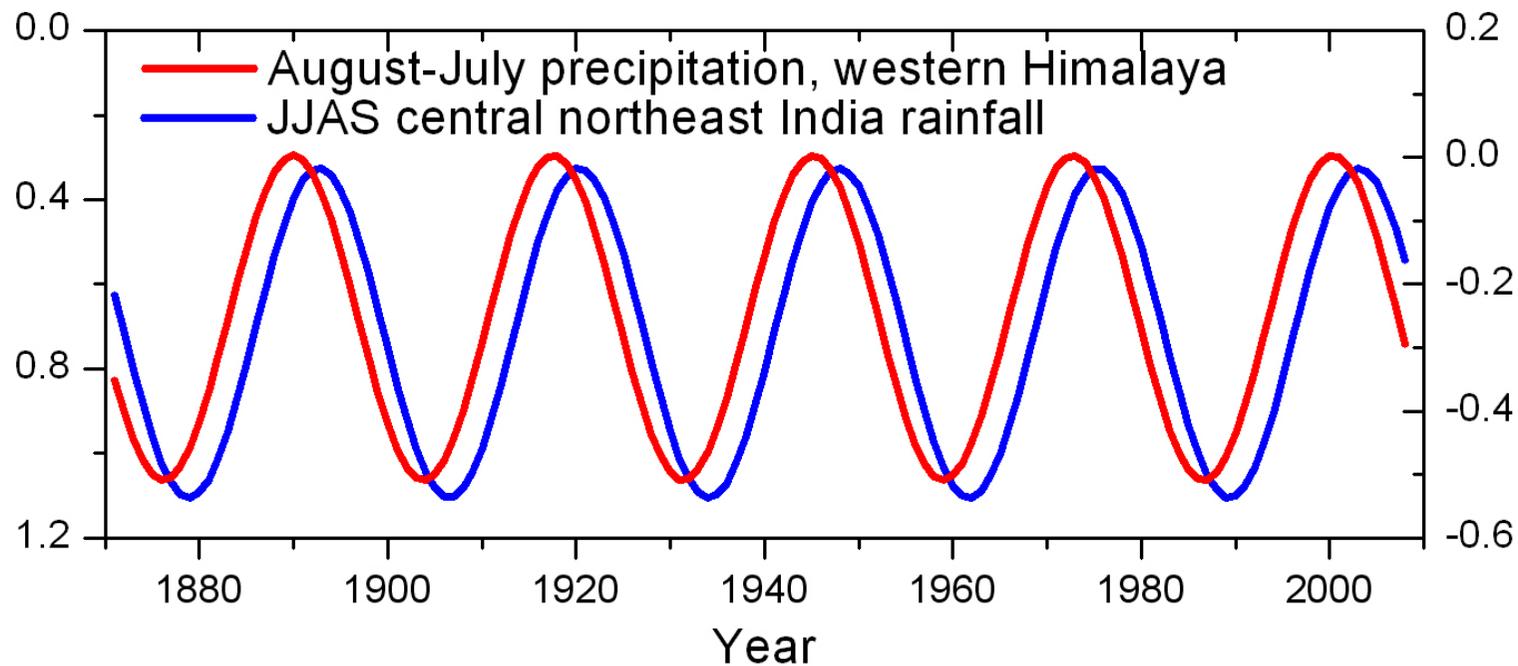
August-July precipitation over western Himalaya and central northeast India summer monsoon



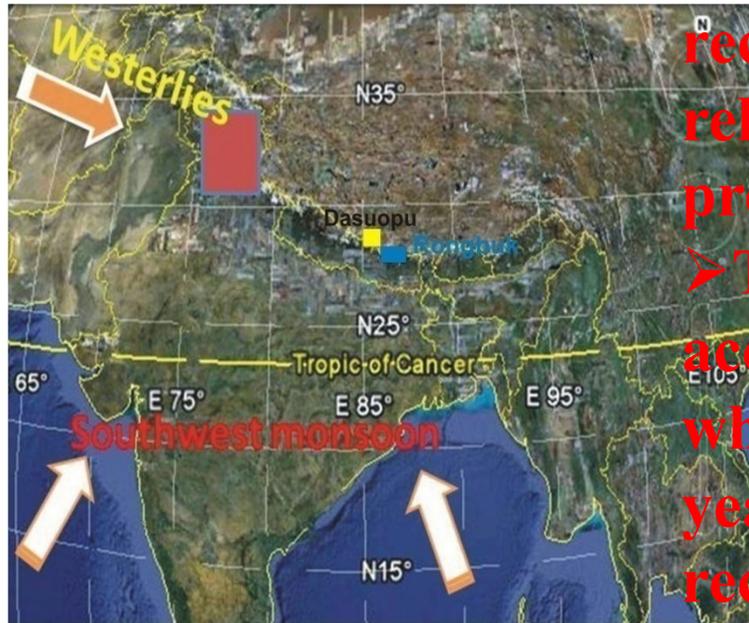
Central northeast JJAS precipitation variability in ENSO and PDO range



Relationship between precipitation over the western Himalaya and northeast central India summer rainfall (25-27 band pass filtered data)- reconstruction plotted in reverse scale

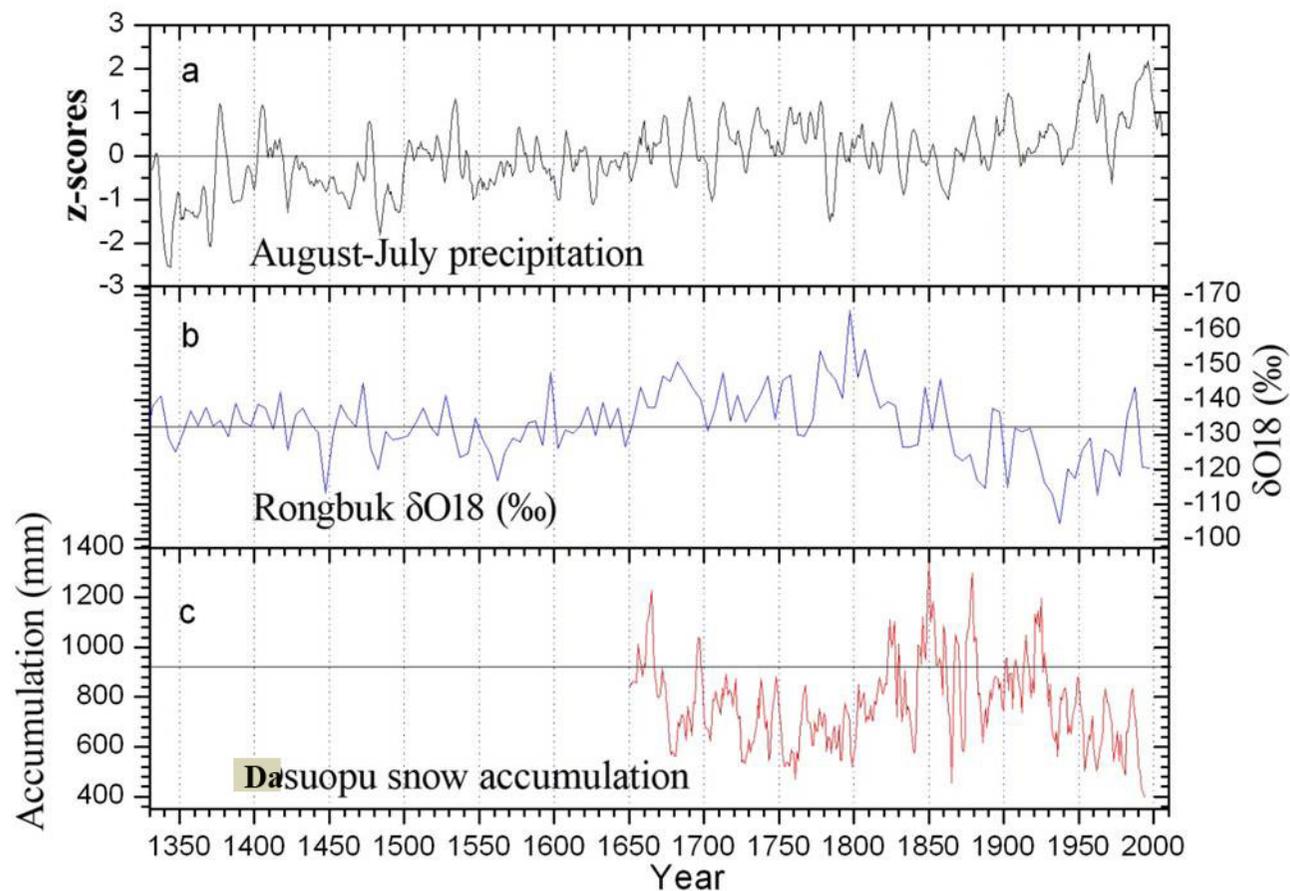


Comparison with monsoon proxies from Himalayas



- **August-July precipitation reconstruction showed inverse relationship with summer monsoon proxies from Dasuopu and Rongbuk**
- **The correlation with Dasuopu snow accumulation is -0.15 , 1650-1994, which increased to -0.23 , when 10-year averaged precipitation reconstruction was used in correlation**
- **Dasuopu snow accumulation series has 27yrs cycle, similar to that in present reconstruction- PDO variability (Davis et al., 2005)**

20th century August-July precipitation surge in the western Himalaya consistent with the decreased ISMR



Conclusions

- **Tree-ring chronologies from moisture stressed sites in western Himalaya show direct relationship with precipitation during winter non-monsoon months**
- **Precipitation (August-July) reconstruction showed unprecedented surge in 20th century in context of the past 700 years**
- **Possibility of extending this reconstruction back to two millennia using longer series from moisture stressed sites** cont...

- **The precipitation over the western Himalaya affects the southwest summer monsoon through its influence on land-ocean thermal gradient**
- **The reconstructed precipitation over the region has significant negative relationship with summer monsoon rainfall over the central northeast India**
- **20th century precipitation surge in the western Himalaya is consistent with the decreased intensity of southwest summer monsoon**

cont...

➤ **Precipitation in non-monsoon zone of the western Himalaya, especially during winter and spring seasons is influenced by SSTs over the central Pacific Ocean**

➤ **Precipitation reconstruction, Dasuopu snow accumulation and summer monsoon rainfall show periodicity suggestive of Pacific Basin influence**

➤ **The relationship noted above show that long-term precipitation records from monsoon shadow zone in western Himalaya might provide valuable insight into summer monsoon variability in long-term perspective**



THANK YOU VERY MUCH