Upper air circulations associated with two extreme epochs in the Indian summer monsoon rainfall

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Rainfall Data

Summer monsoon (June through September) rainfall over meteorological subdivisions of India

Duration

1871- 2005

Upper wind data

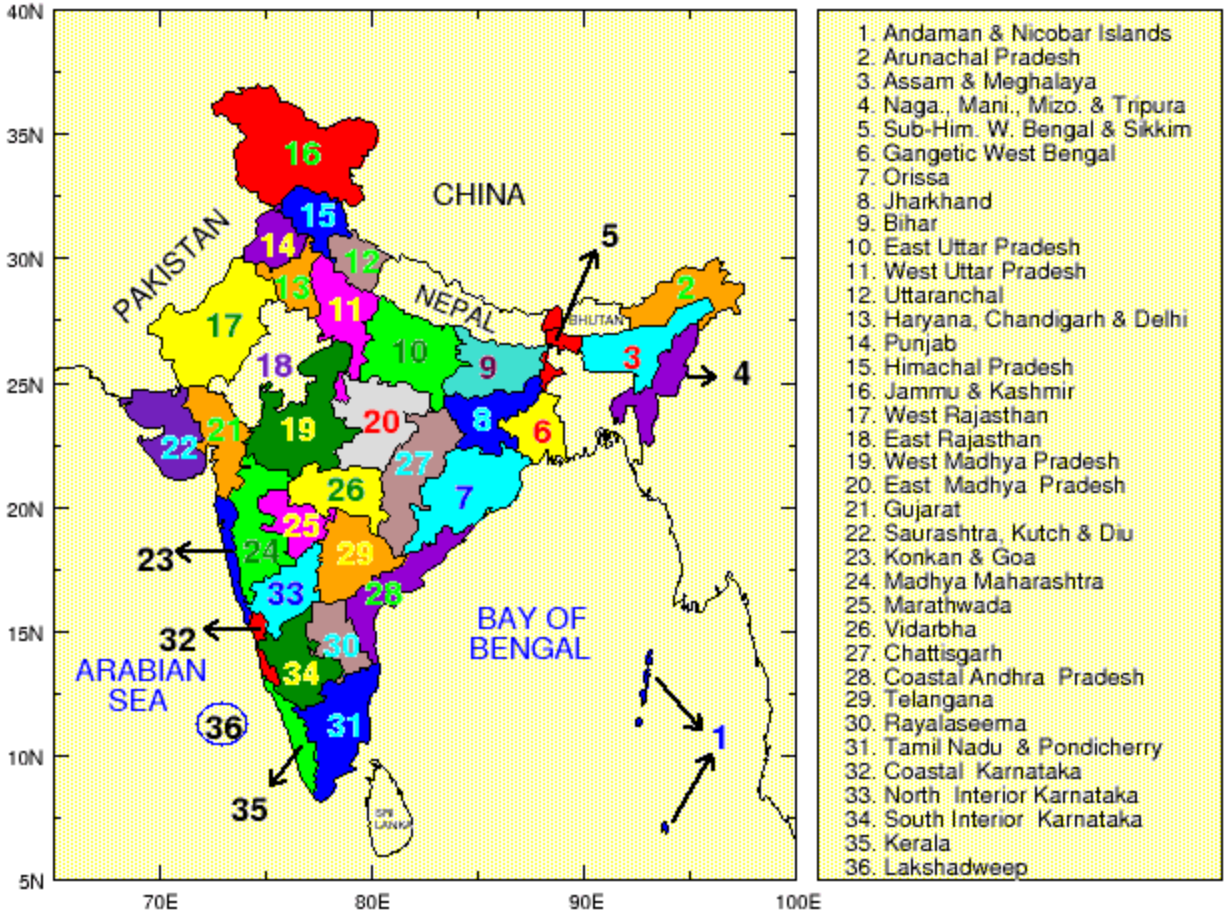
Monthly mean winds of Indian stations published by NOAA/WMO

Duration

1959-1990

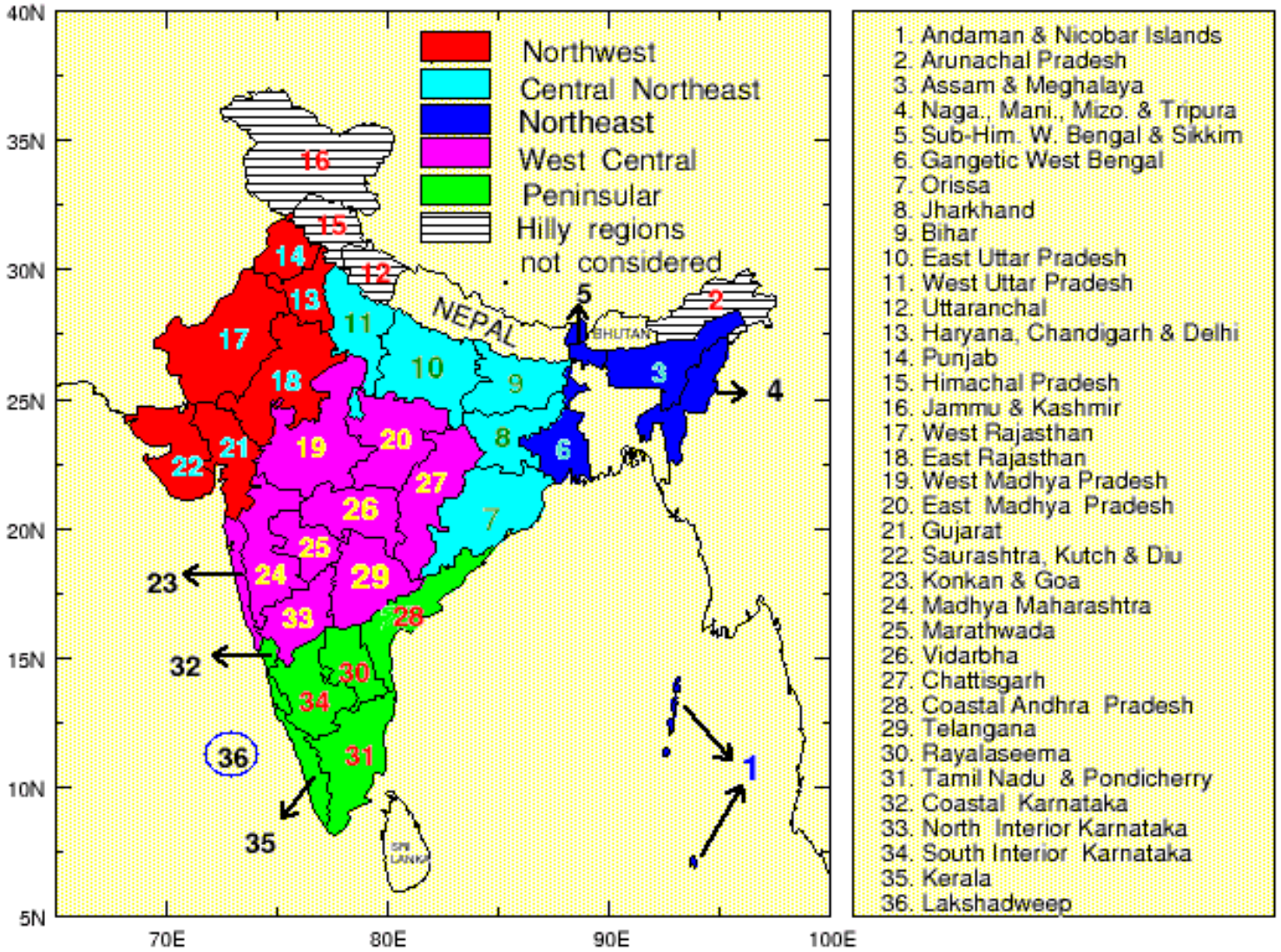
- **Time series graphs are prepared for rainfall.**
- **11-year running averages are calculated.**
- **Linear trends for different segments of all-India monsoon rainfall series are calculated.**
- **Extreme events are identified.**
- **Composite upper air circulations for the extreme events are prepared.**

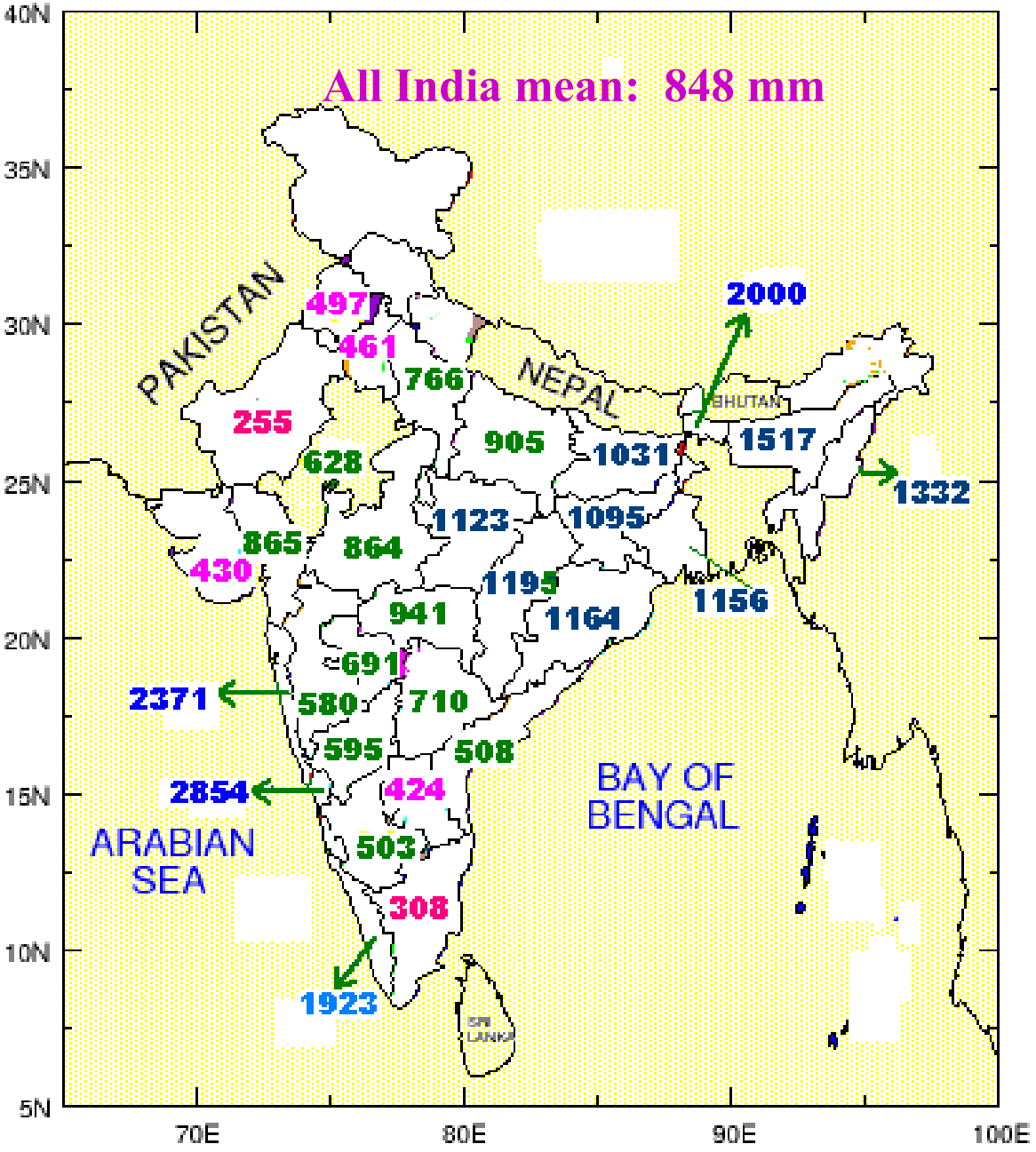
Meteorological Subdivisions of India



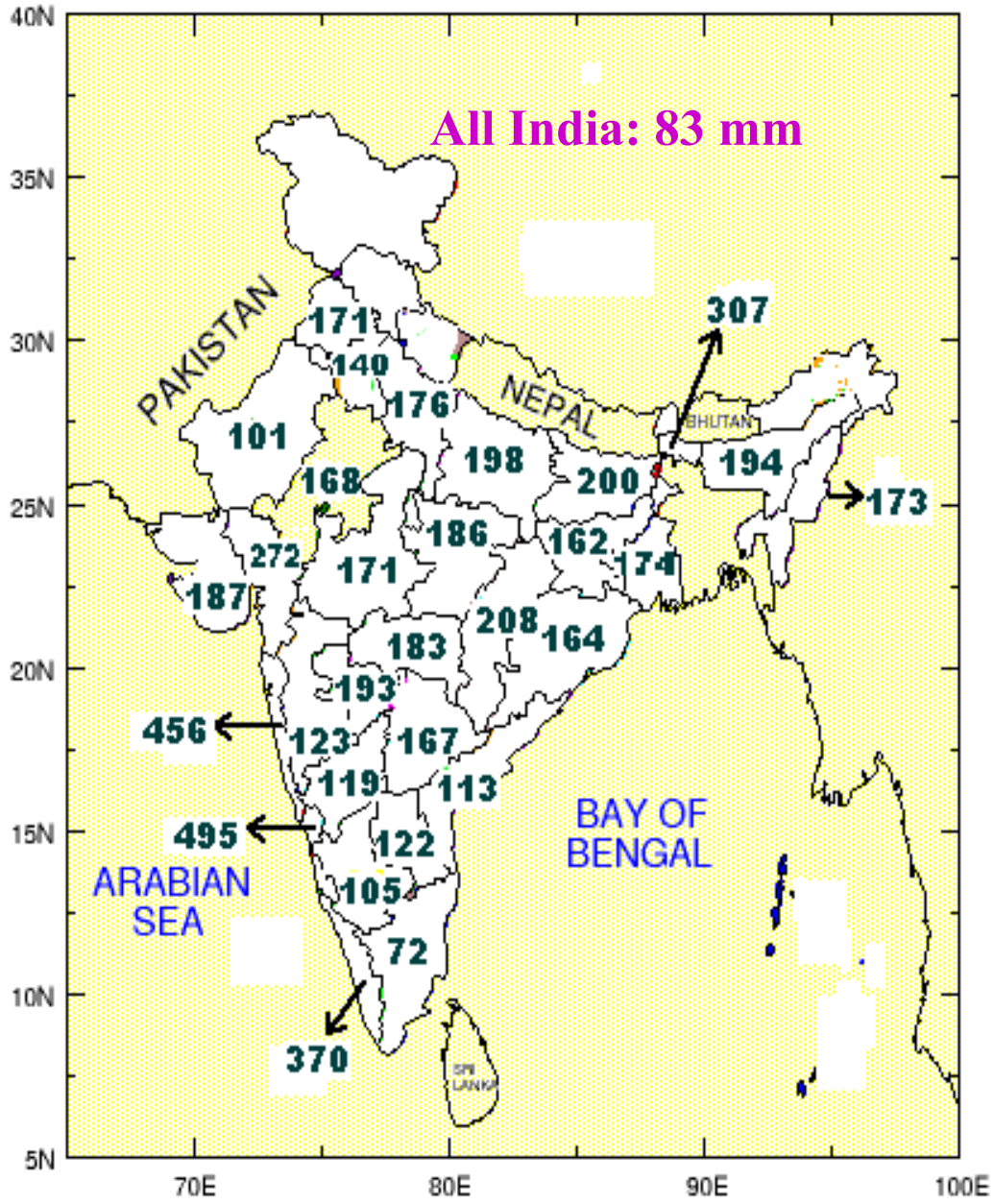
1. Andaman & Nicobar Islands
2. Arunachal Pradesh
3. Assam & Meghalaya
4. Naga., Mani., Mizo. & Tripura
5. Sub-Him. W. Bengal & Sikkim
6. Gangetic West Bengal
7. Orissa
8. Jharkhand
9. Bihar
10. East Uttar Pradesh
11. West Uttar Pradesh
12. Uttaranchal
13. Haryana, Chandigarh & Delhi
14. Punjab
15. Himachal Pradesh
16. Jammu & Kashmir
17. West Rajasthan
18. East Rajasthan
19. West Madhya Pradesh
20. East Madhya Pradesh
21. Gujarat
22. Saurashtra, Kutch & Diu
23. Konkan & Goa
24. Madhya Maharashtra
25. Marathwada
26. Vidarbha
27. Chattisgarh
28. Coastal Andhra Pradesh
29. Telangana
30. Rayalaseema
31. Tamil Nadu & Pondicherry
32. Coastal Karnataka
33. North Interior Karnataka
34. South Interior Karnataka
35. Kerala
36. Lakshadweep

Homogeneous Monsoon Regions

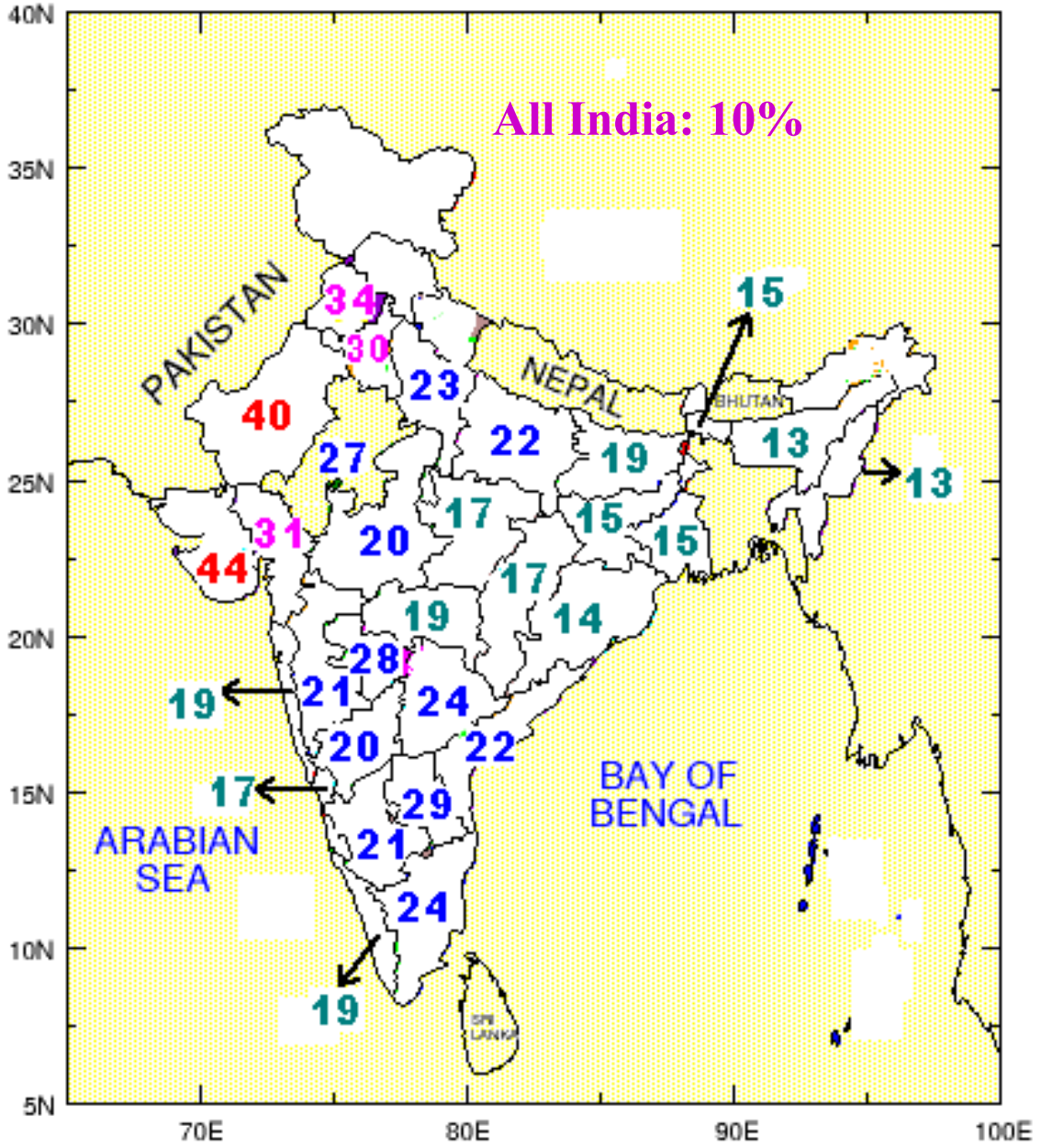




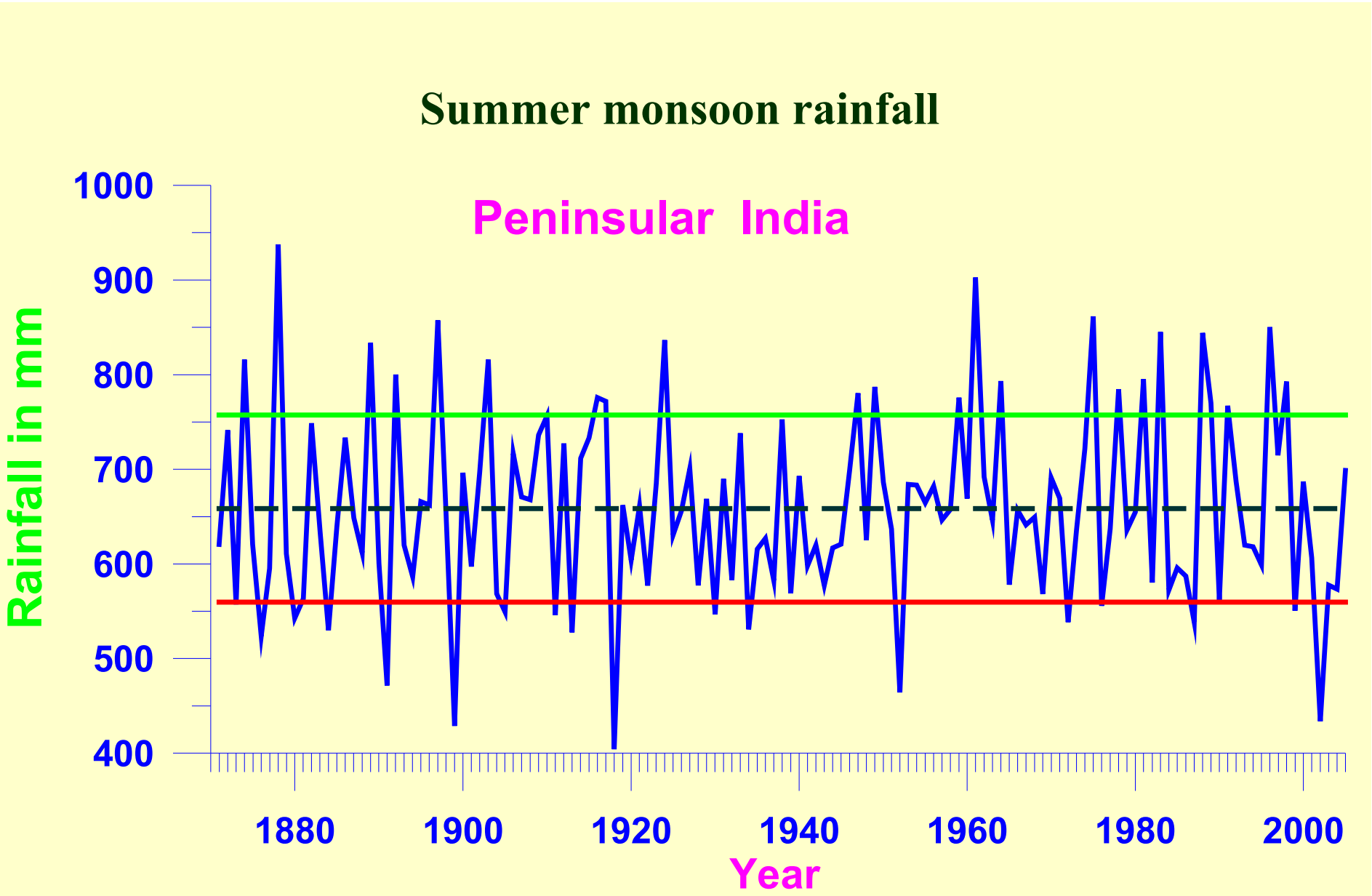
Mean summer monsoon rainfall in mm

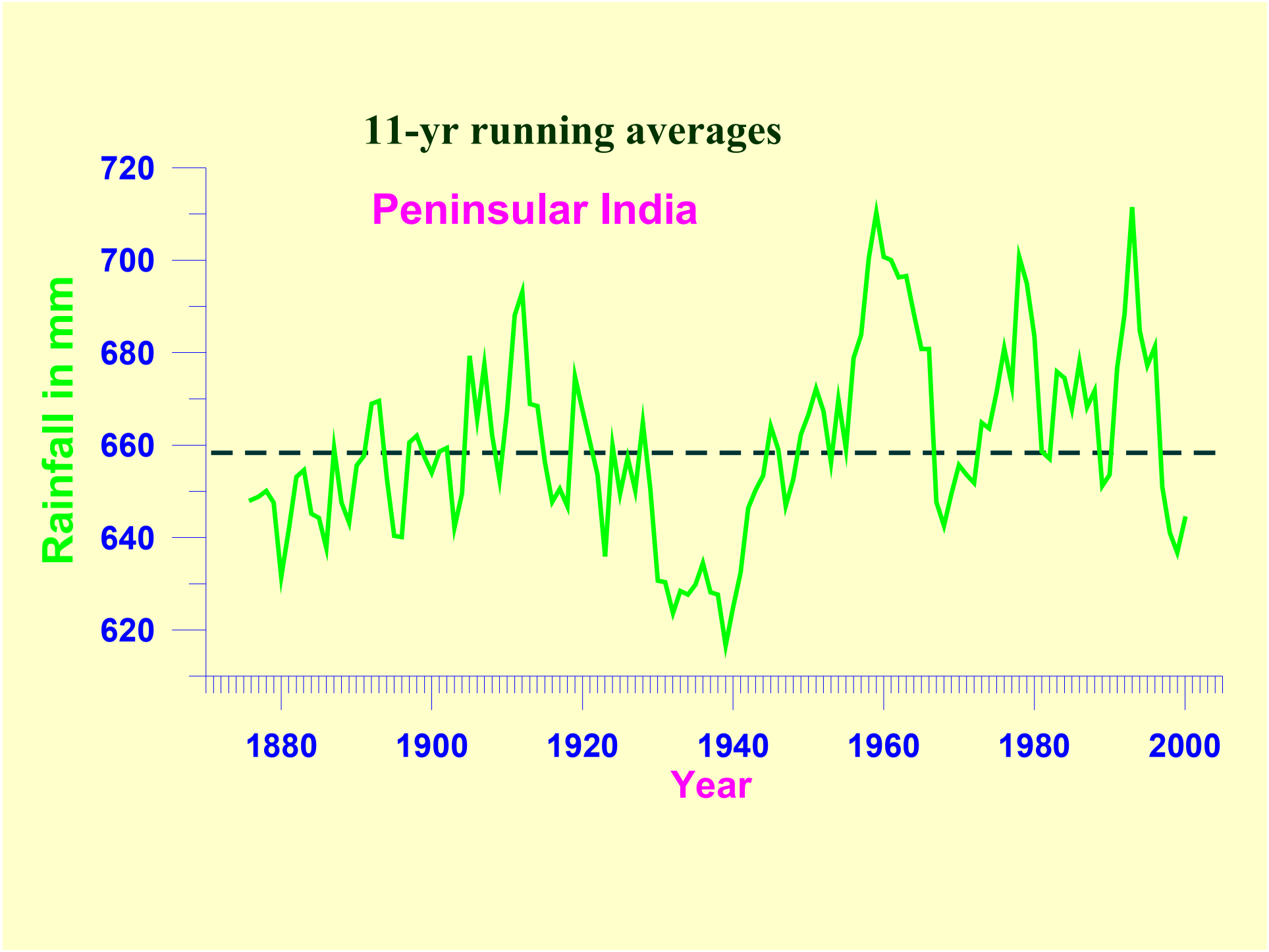


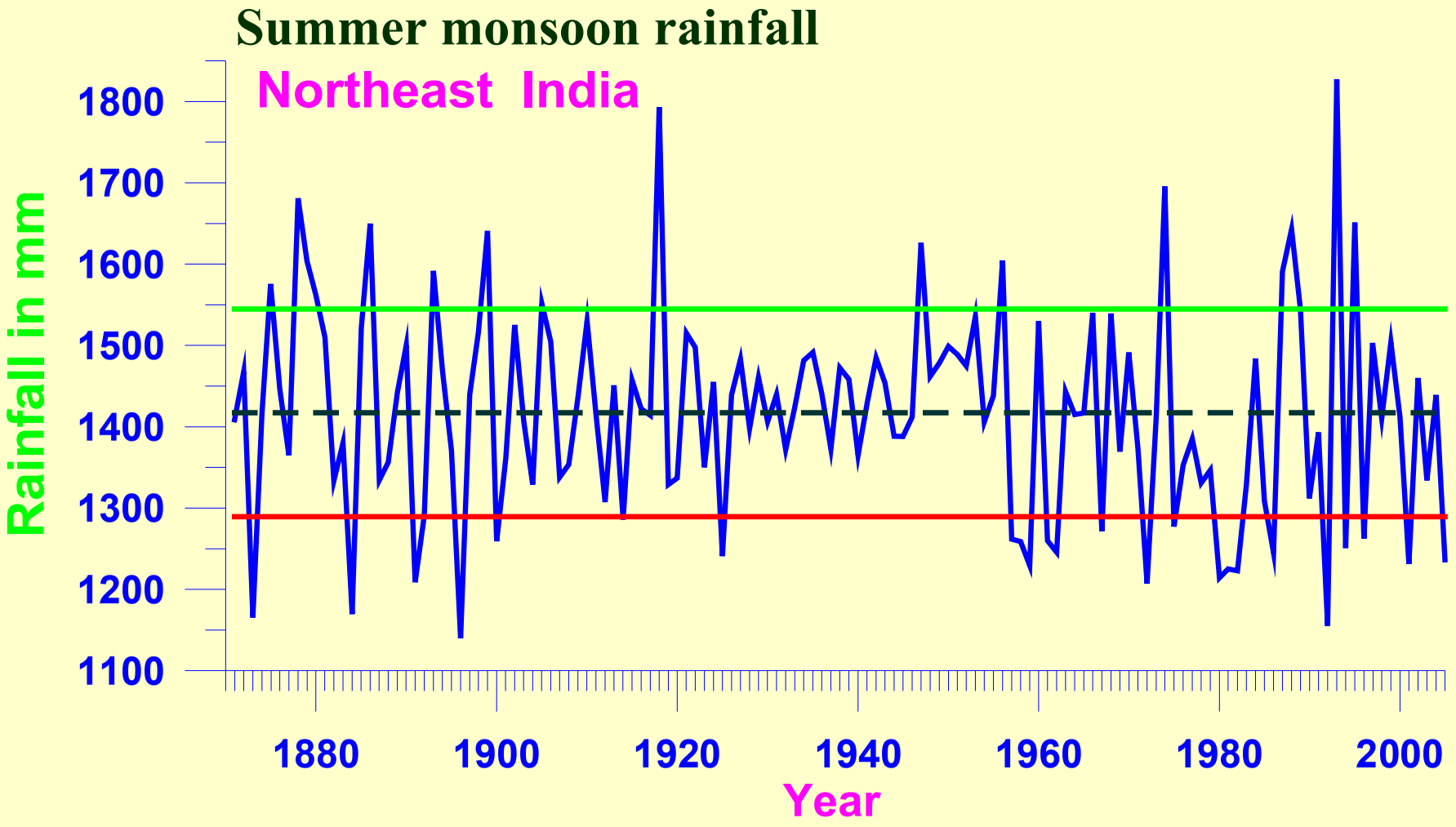
Standard devaition of summer monsoon rainfall

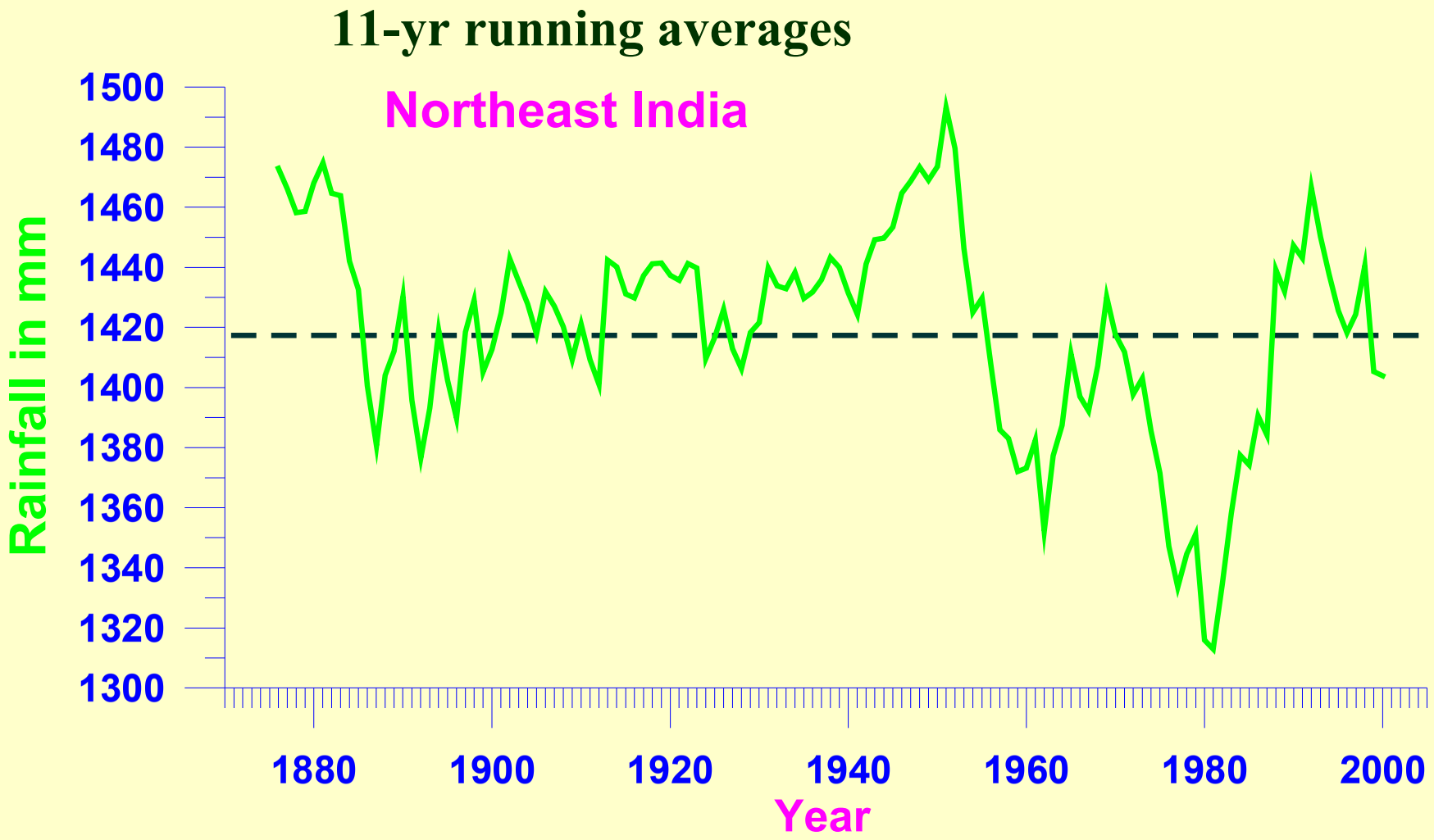


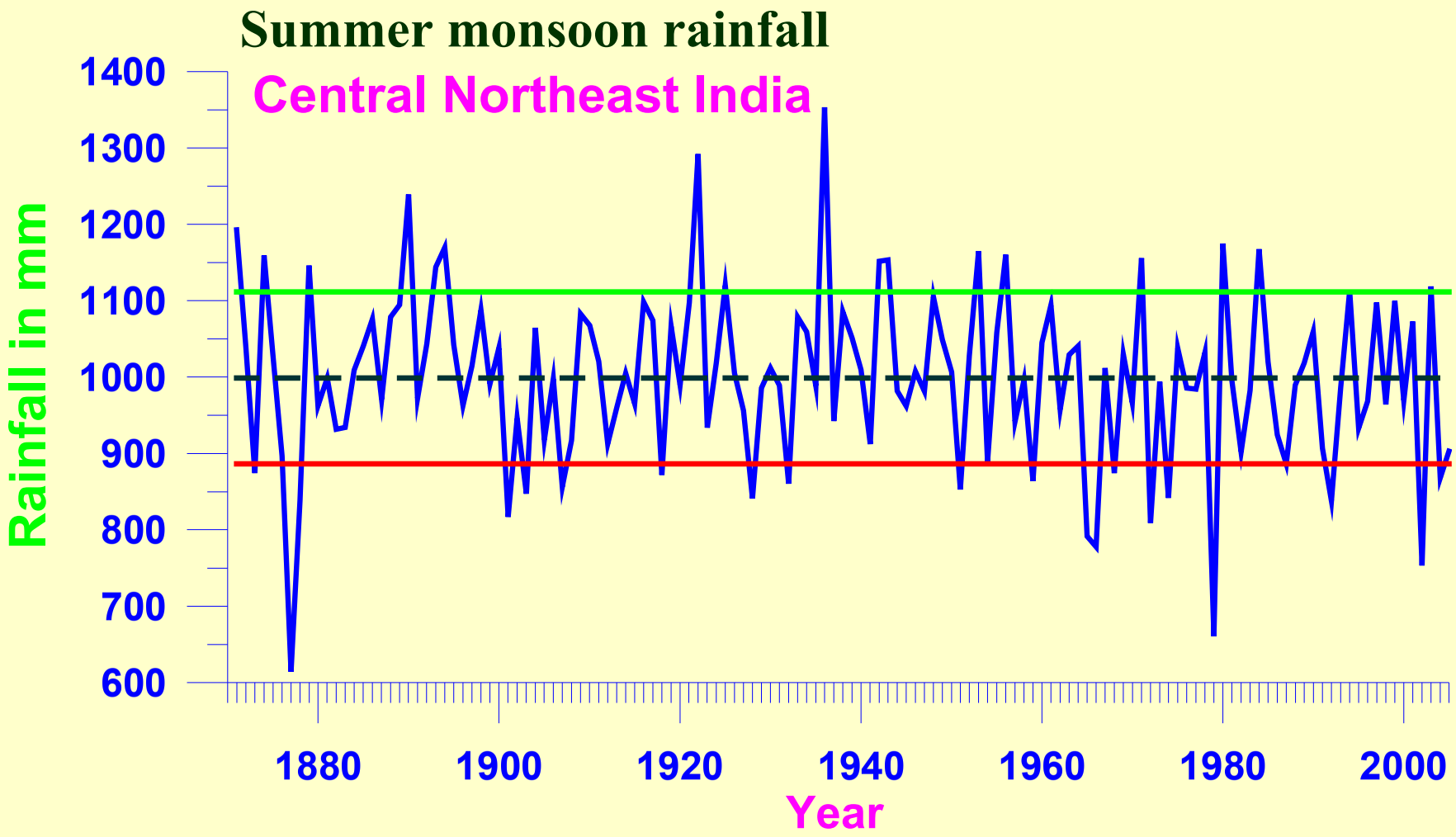
Coefficient of variation of summer monsoon rainfall

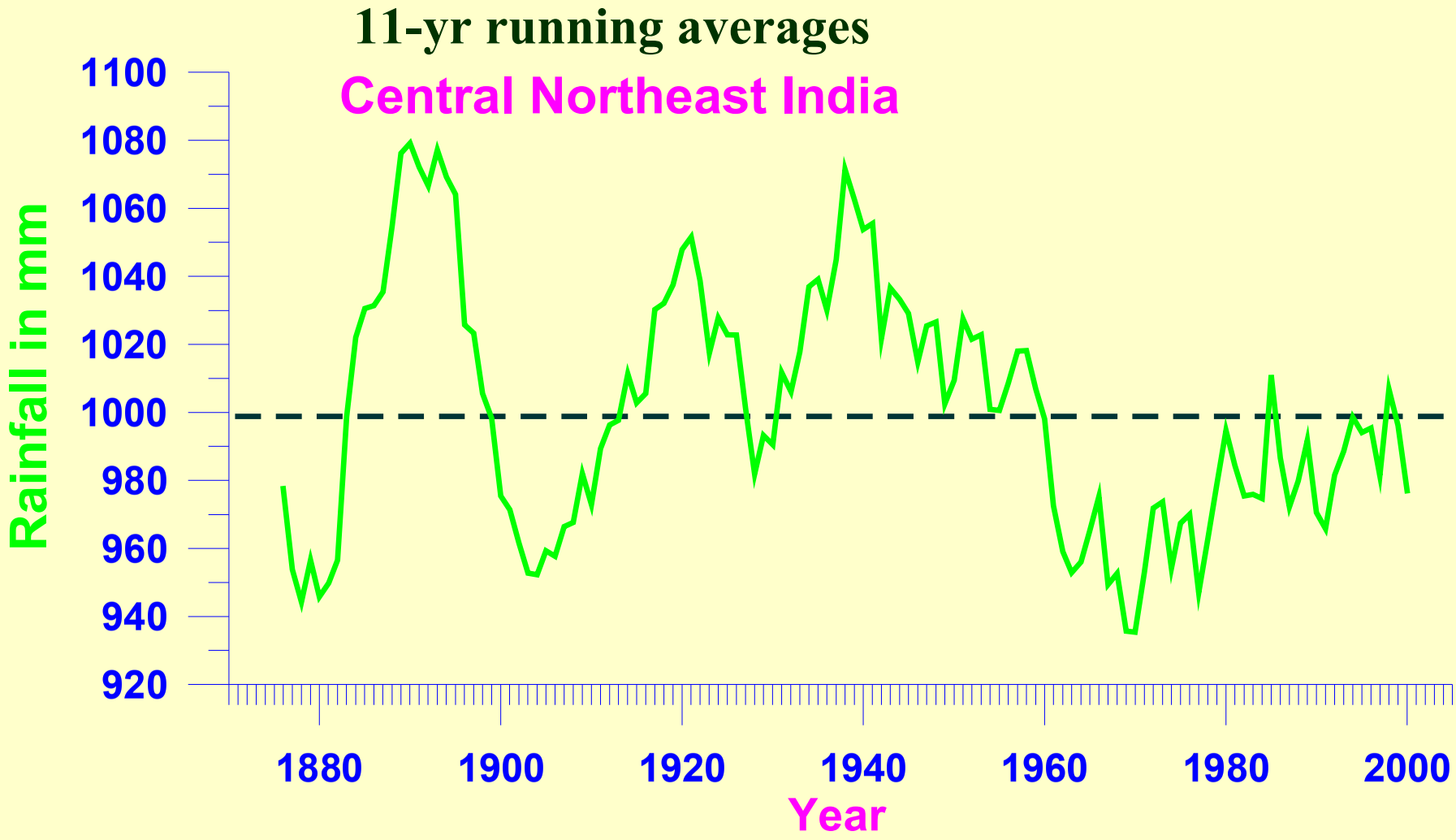

Summer monsoon rainfall
Peninsular India
Rainfall in mm
1000
900
800
700
600
500
400
1880
1900
1920
1940
1960
1980
2000
Year

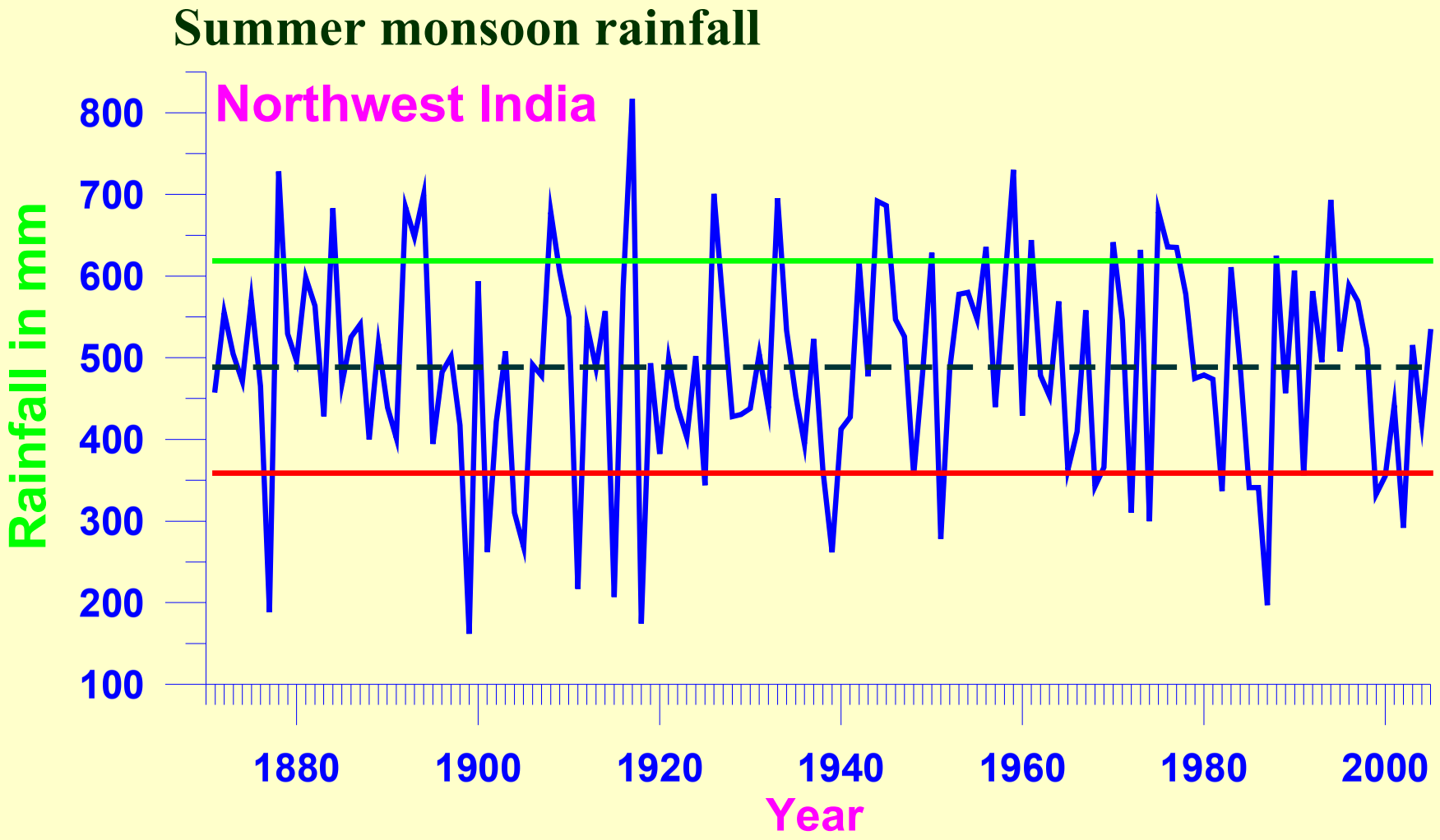

11-yr running averages
Peninsular India
Rainfall in mm
720
700
680
660
640
620
1880
1900
1920
1940
1960
1980
2000
Year

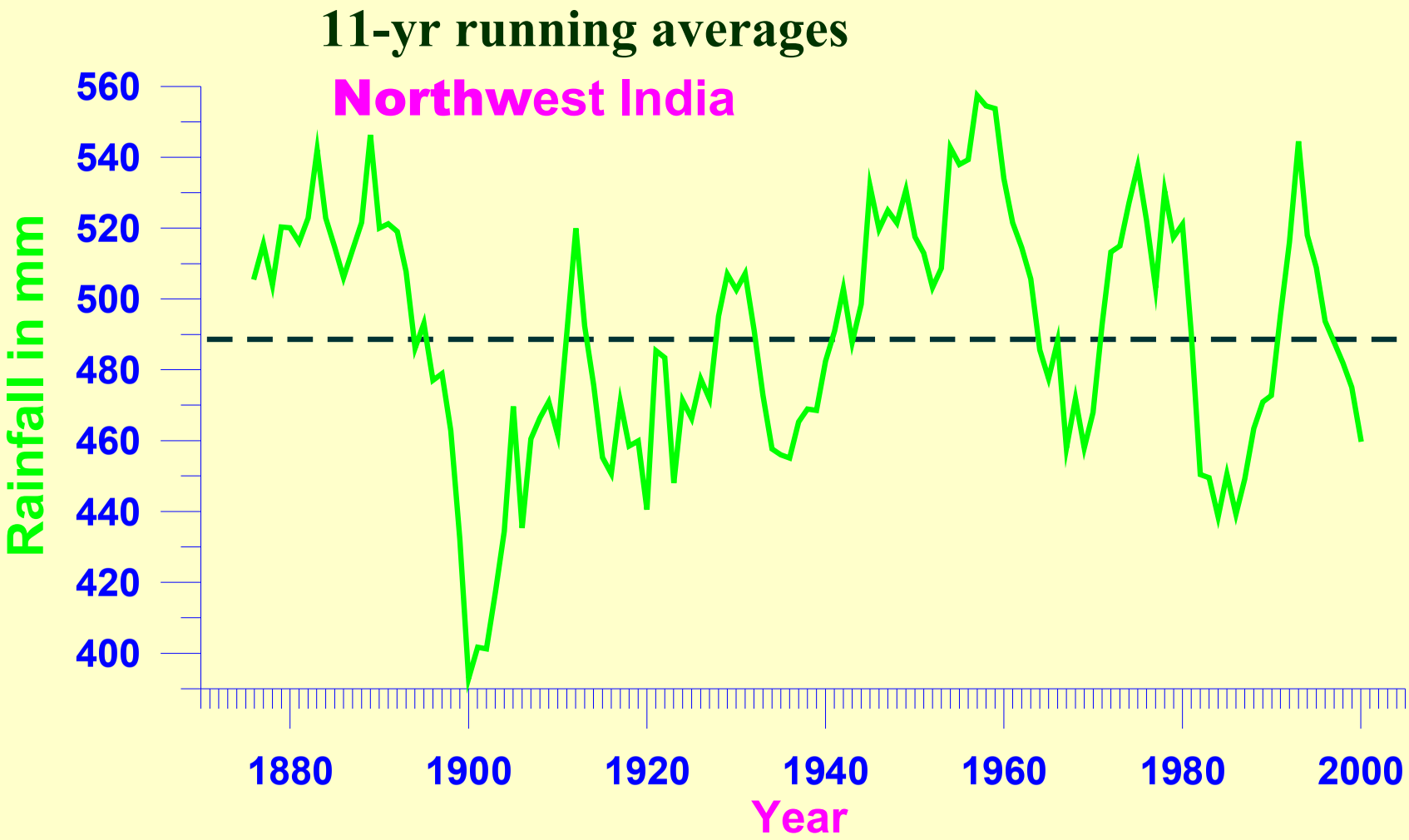

Summer monsoon rainfall
Northeast India
Rainfall in mm
1800
1700
1600
1500
1400
1300
1200
1100
1880
1900
1920
1940
1960
1980
2000
Year

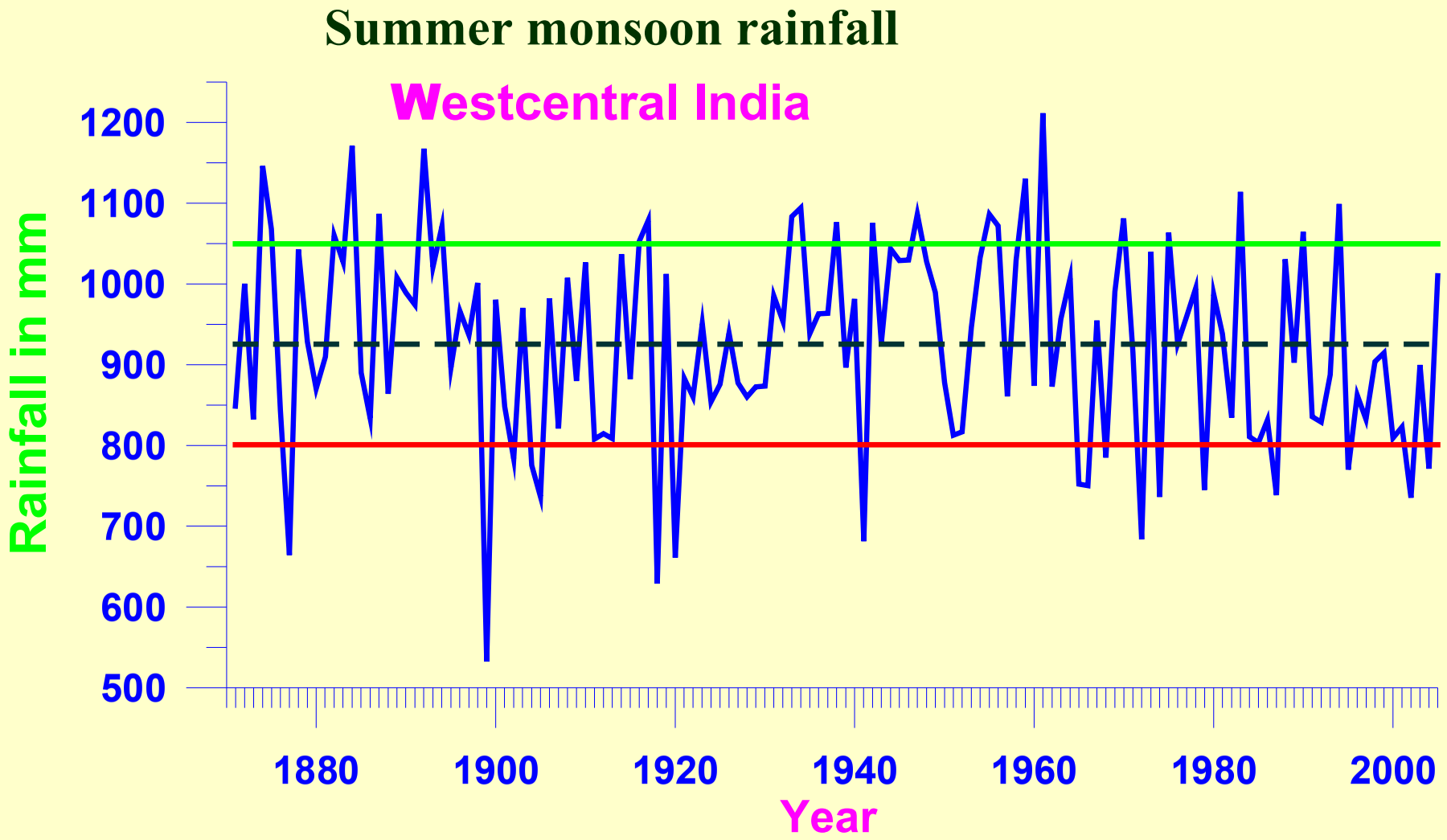

11-yr running averages
Northeast India
Rainfall in mm
1500
1480
1460
1440
1420
1400
1380
1360
1340
1320
1300
1880
1900
1920
1940
1960
1980
2000
Year

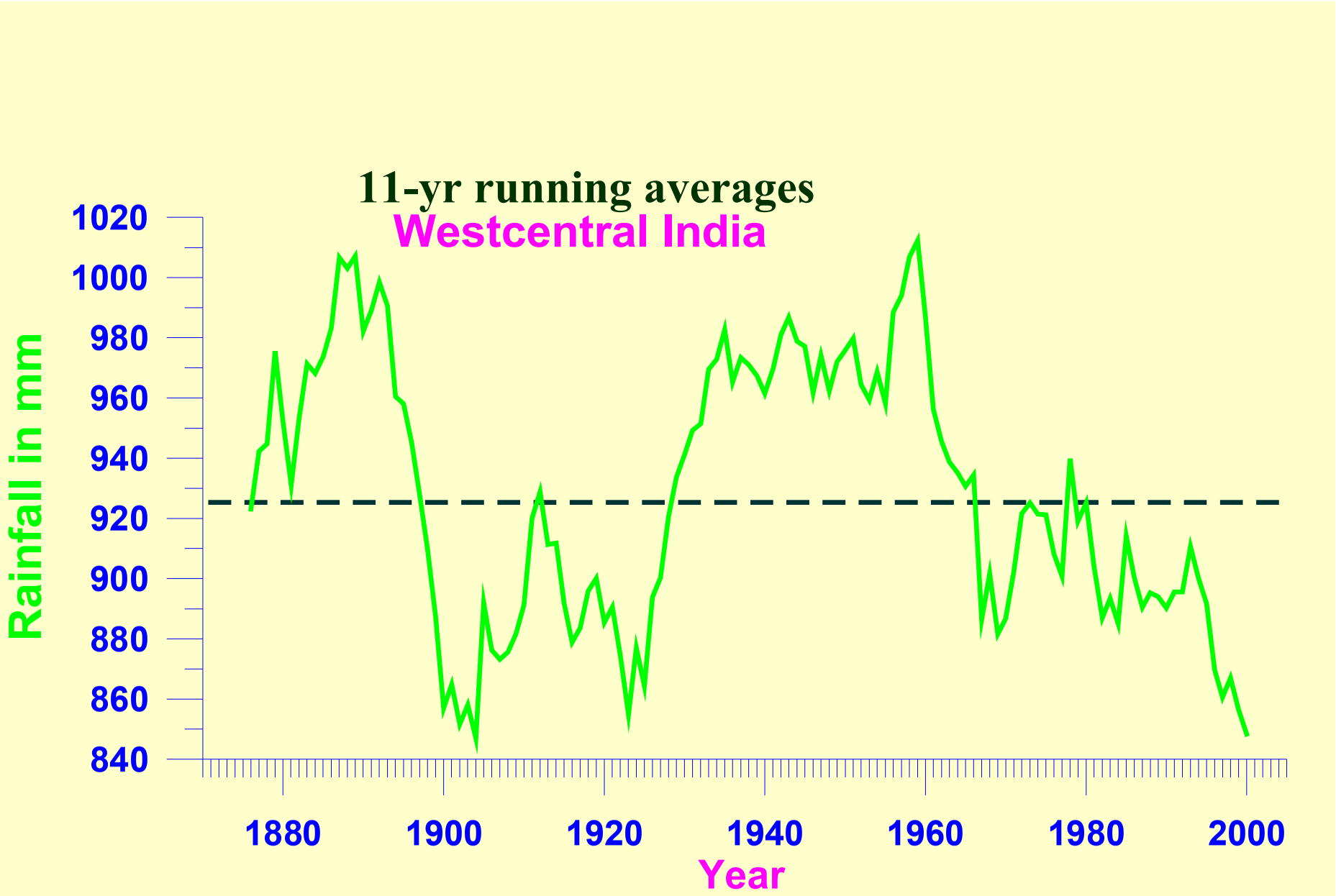

Summer monsoon rainfall
Central Northeast India
Rainfall in mm
1400
1300
1200
1100
1000
900
800
700
600
1880
1900
1920
1940
1960
1980
2000
Year

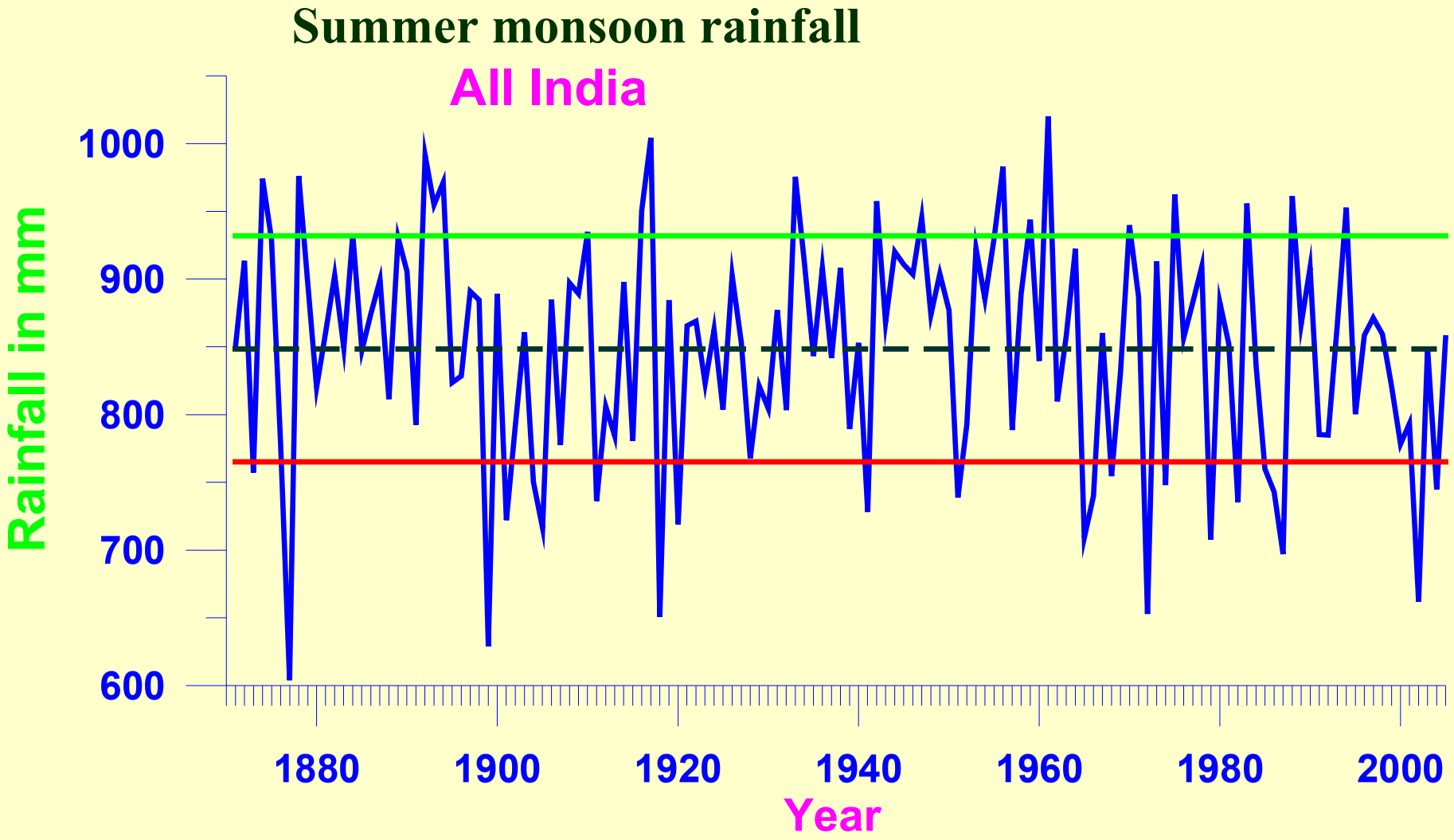

11-yr running averages
Central Northeast India
Rainfall in mm
1100
1080
1060
1040
1020
1000
980
960
940
920
1880
1900
1920
1940
1960
1980
2000
Year

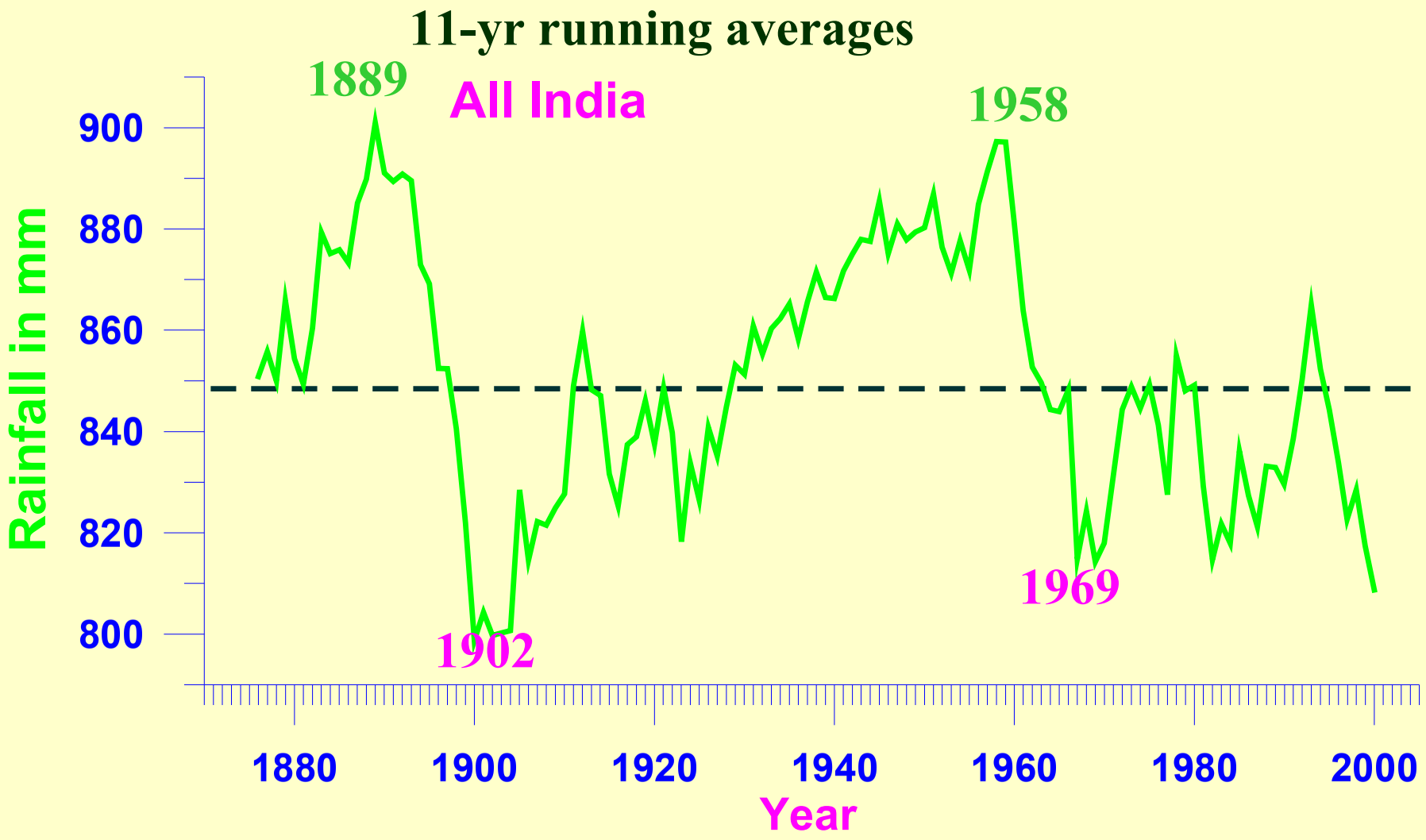

Summer monsoon rainfall
Northwest India
Rainfall in mm
800
700
600
500
400
300
200
100
1880
1900
1920
1940
1960
1980
2000
Year


11-yr running averages
Northwest India
Rainfall in mm
560
540
520
500
480
460
440
420
400
1880
1900
1920
1940
1960
1980
2000
Year


Summer monsoon rainfall
Westcentral India
Rainfall in mm
1200
1100
1000
900
800
700
600
500
1880
1900
1920
1940
1960
1980
2000
Year


11-yr running averages
Westcentral India
Rainfall in mm
1020
1000
980
960
940
920
900
880
860
840
1880
1900
1920
1940
1960
1980
2000
Year

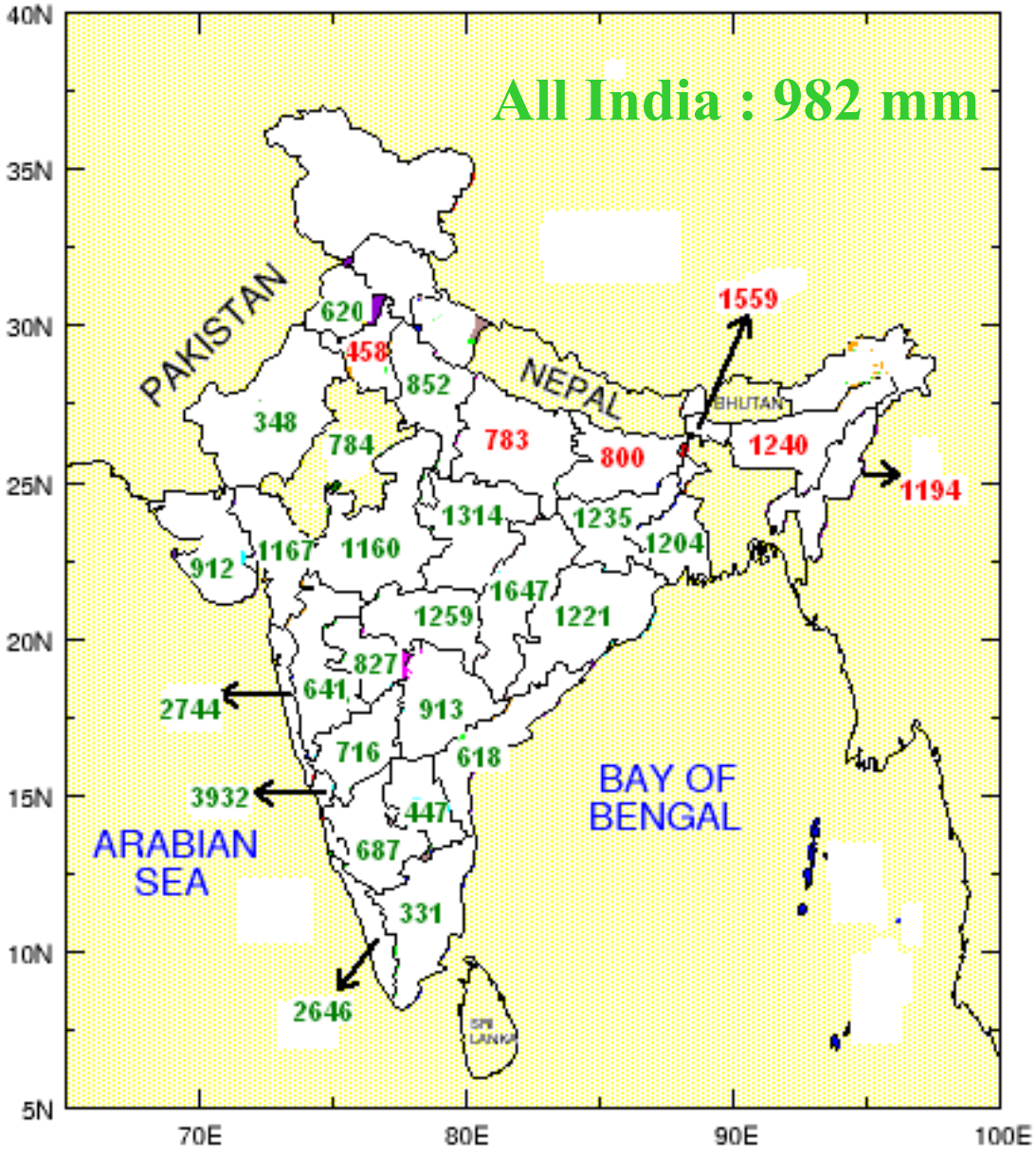

Summer monsoon rainfall
All India
Rainfall in mm
1000
900
800
700
600
1880
1900
1920
1940
1960
1980
2000
Year



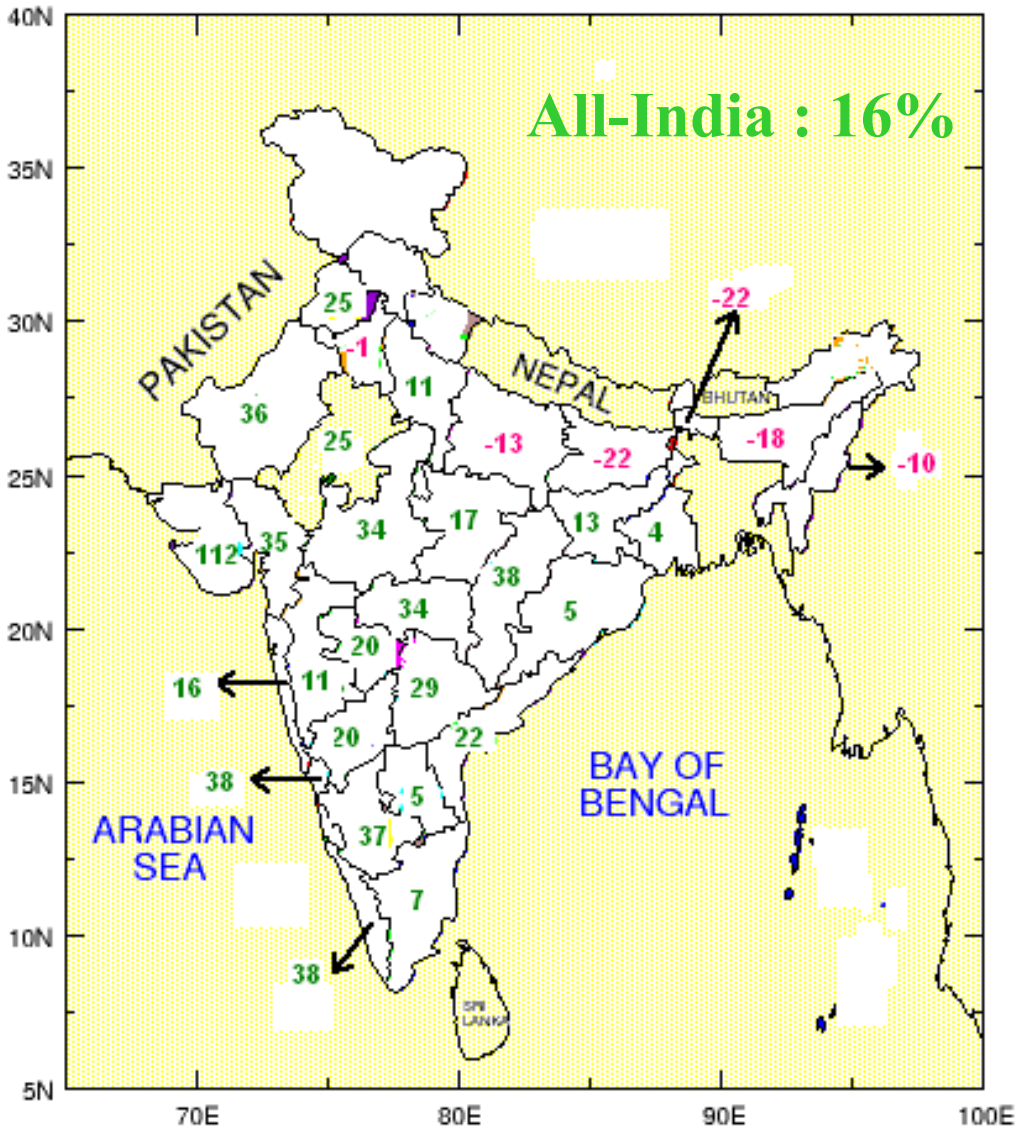
1889-1902 trend: -13mm/yr (significant at 95% level)

1958-1969 trend: -13 mm/yr (90% level)

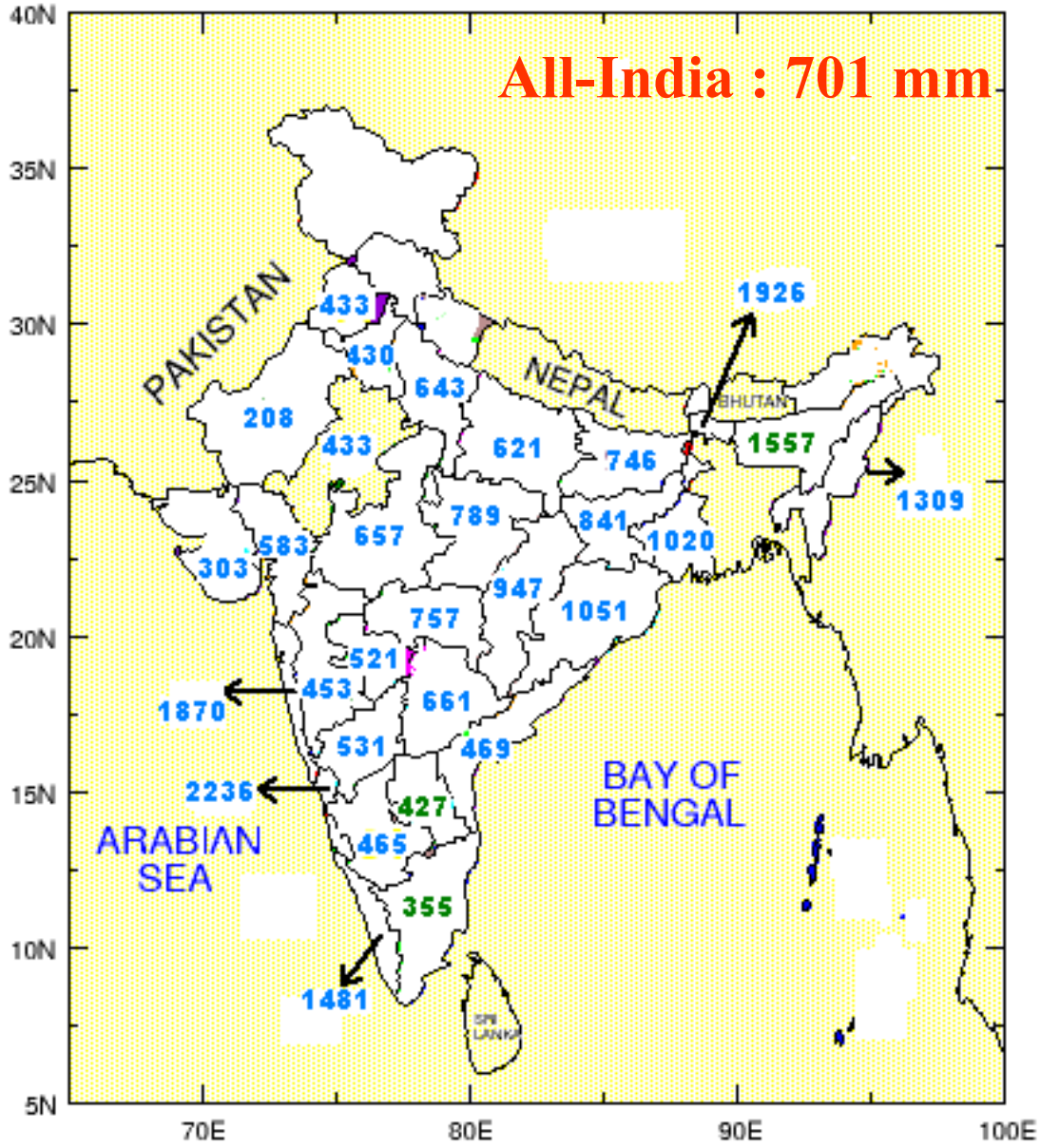
1902-1958 trend: 1.29 mm/yr (95% level)



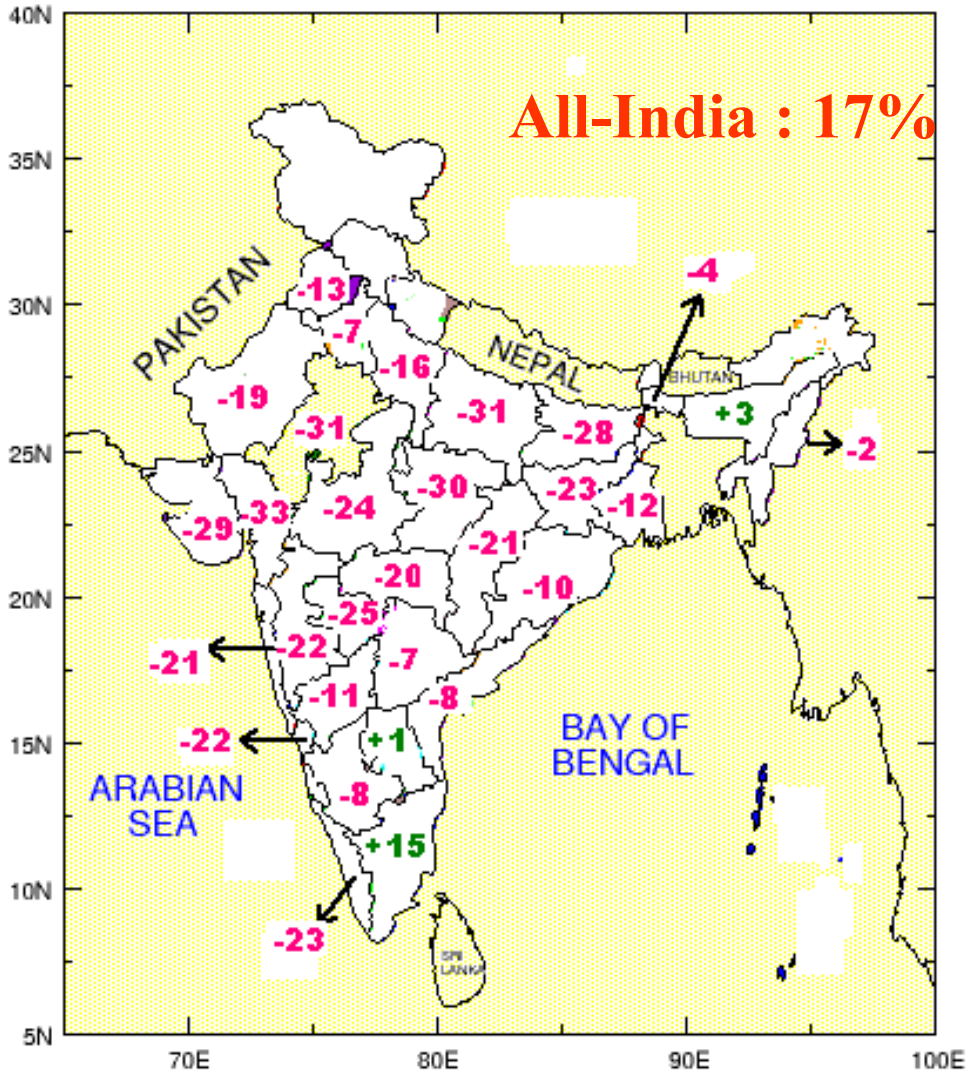
Monsoon rainfall (mm) in positive events (1959, 1961)



Percentage departures of monsoon rainfall
for **good monsoon events (1959 and 1961)**

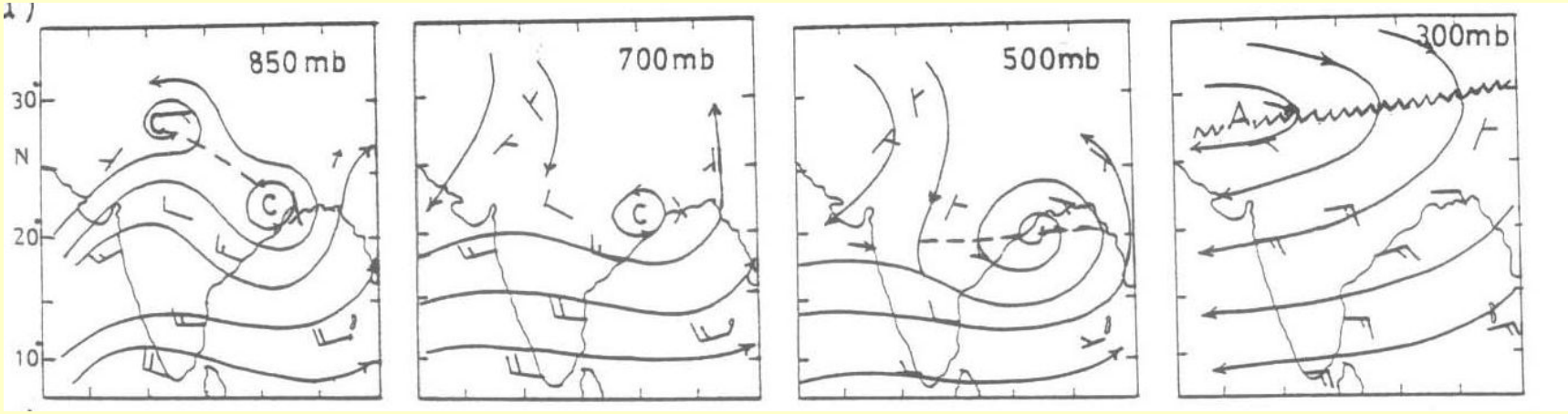


Monsoon rainfall (mm) **in Negative events (1965, 1966 and 1972)**

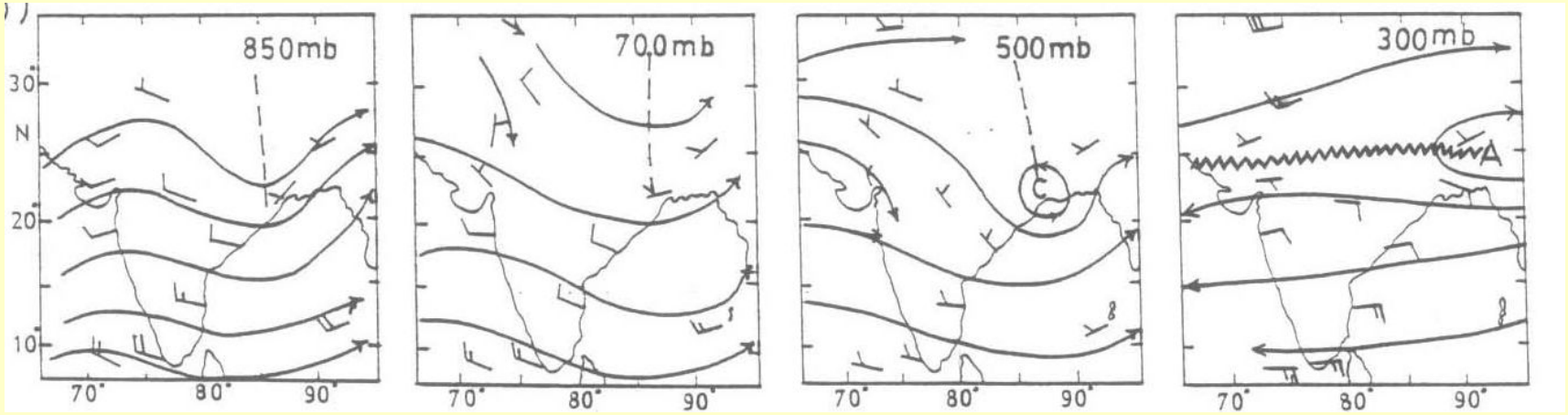


Percentage departures of summer monsoon rainfall for Negative events (1965, 1966 and 1972)

Good monsoon (1959 and 1961)

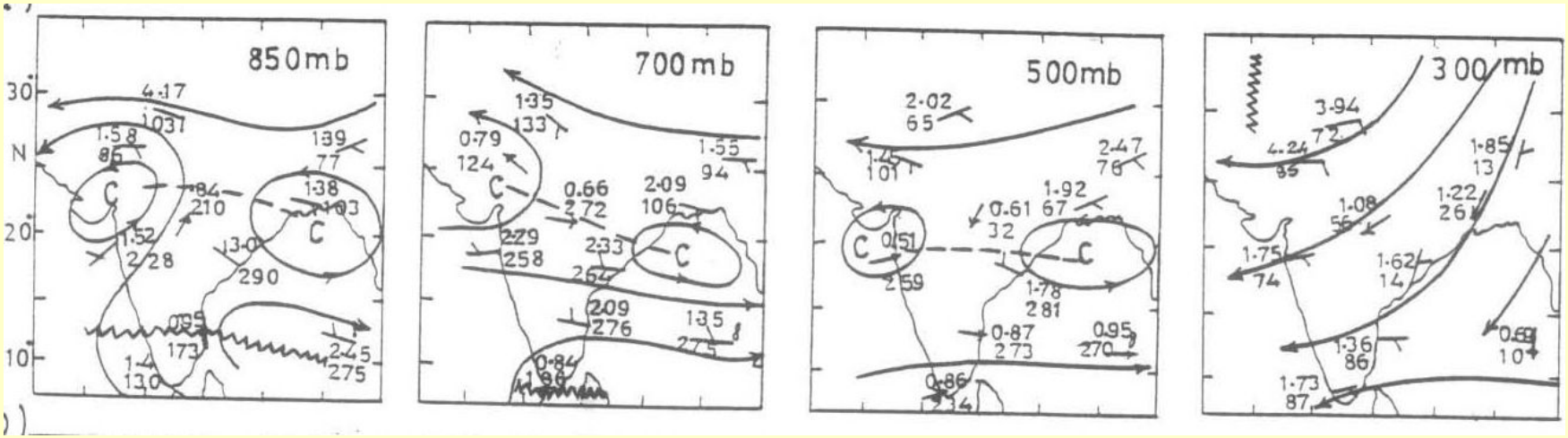


Poor monsoon (1965, 1966 and 1972)

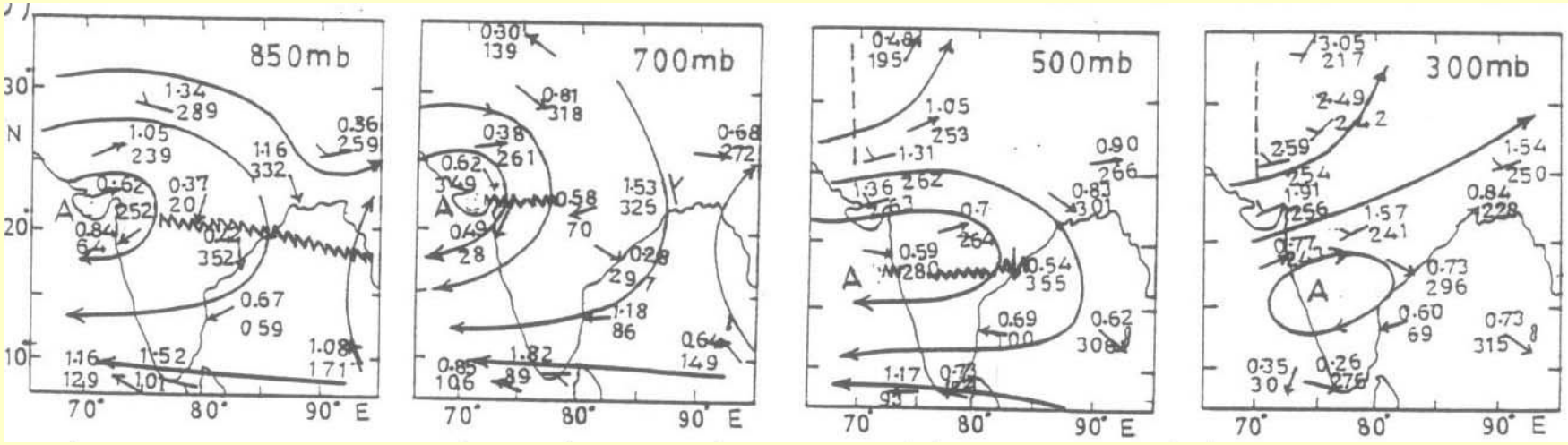


Mean wind circulations

Good monsoon (1959, 1961)



Poor monsoon (1965, 1966, 1972)



Mean anomaly wind circulations

Conclusions

- **In good monsoons the seasonal monsoon trough was well defined and extended upto the middle troposphere.**
- **The monsoon westerlies over south-peninsula were stronger.**
- **The subtropical ridge in the upper troposphere was located considerably north of its position in good monsoon epochs.**
- **The easterlies in the upper troposphere were strong over peninsula.**
- **In poor monsoon episode, the monsoon westerlies over peninsula were relatively weaker and the monsoon trough was not clearly apparent.**
- **A north-south trough was dominant over northeast India in lower and middle troposphere.**
- **In the upper troposphere, the subtropical ridge was situated at lower latitude.**
- **The upper easterlies over peninsula were weak, while the subtropical westerlies over North India were strong.**

Conclusions (contd..)

- **The anomaly circulations in good monsoon years showed an east-west trough at 25^0N extending unto the middle troposphere, while in the case of poor monsoon an anomaly ridge around 20^0N was present.**

- **In the upper troposphere, there were northeasterlies with anticyclonic curvature and a ridge over northwest India in good monsoon, while in poor monsoon there were west-north-westerlies with cyclonic curvature in north India.**

- **A trough over northwest India and anticyclonic anomaly over central peninsula were present in the upper troposphere in poor monsoon.**

Thank you