CLIMATE CONUNDRUMS: HEAT RISE, DUST STORMS AND DESERTIFICATION

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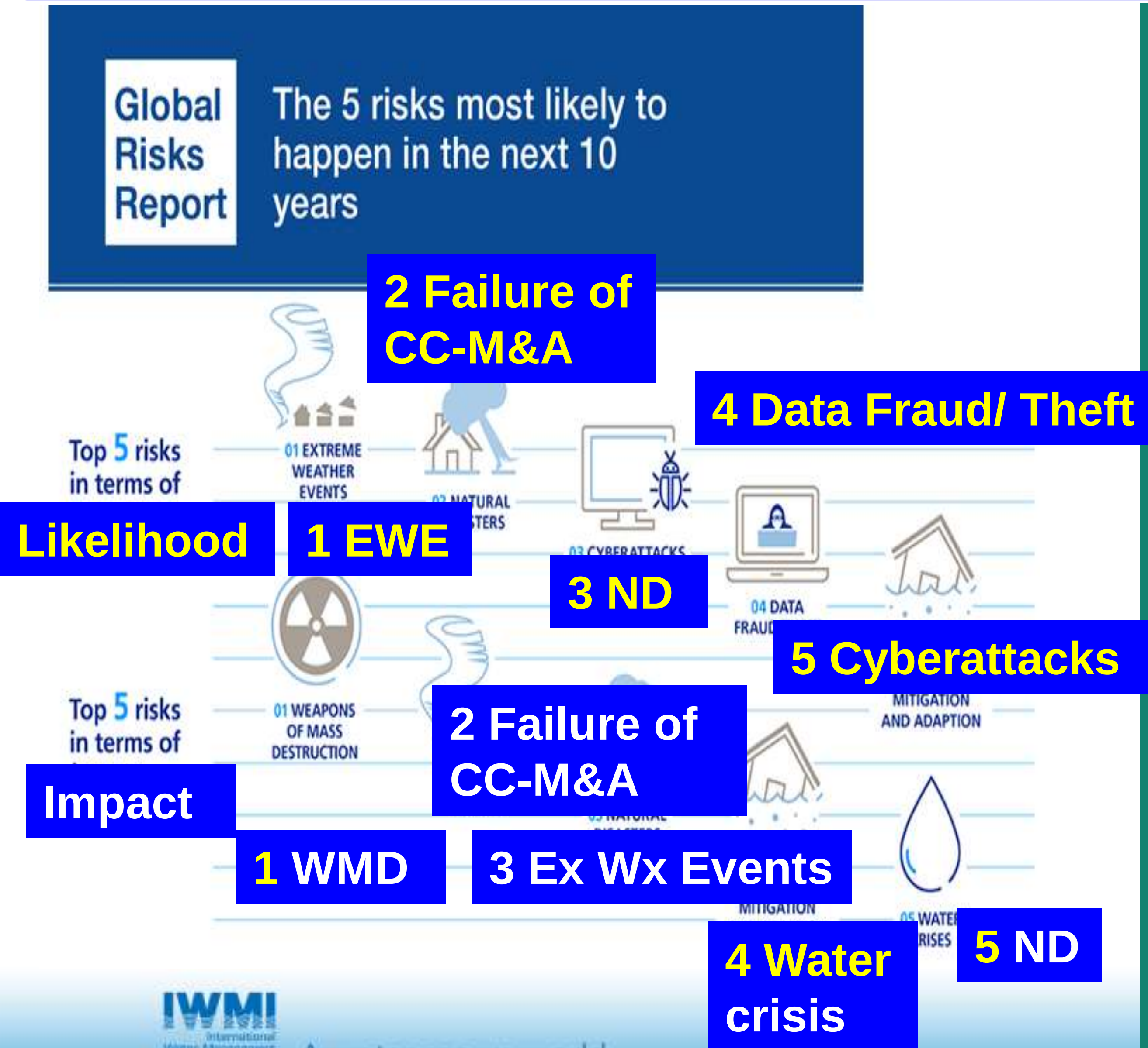
UNCCD-COP14

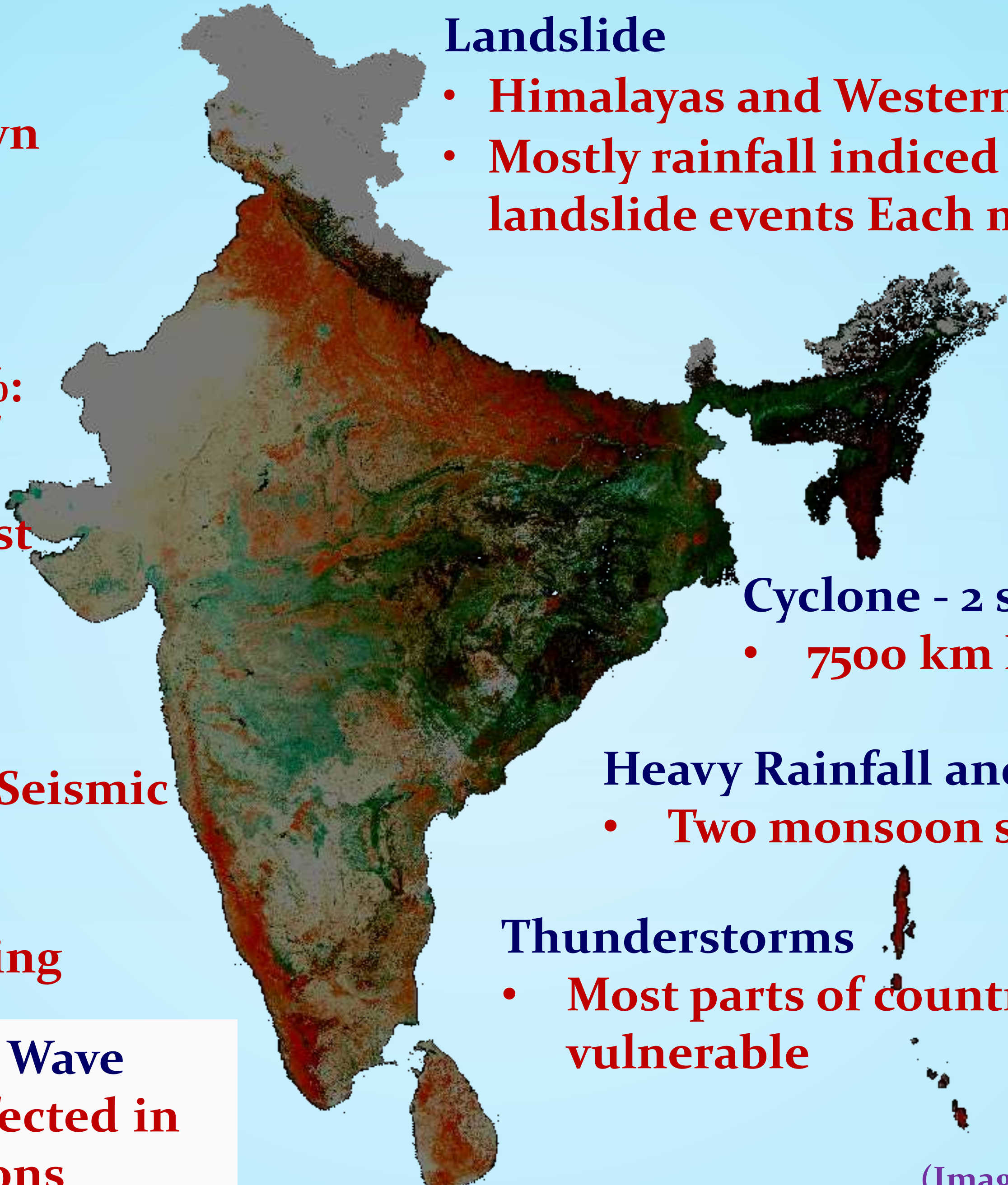
- 3 out of every 4 hectares of land altered from their natural states & the productivity of about 1 in every 4 hectares of land is declining.
- Poor land health is on the rise impacting 3.2 b people in the world.
- Land degradation working in tandem with climate change and biodiversity loss may force up to 700 m people to migrate by 2050.
- Focus on the over 1.3 billion people who rely directly on land to survive and suffer the most land degradation and drought.
- Changes like rise in ocean temp., acidification & diminished capacity to absorb heat and carbon is happening. Rising warming level may gradually affect upper-ocean mixing, nutrient supply and cycling of carbon through marine life
- The changes could take anywhere between 30 to 100 years to manifest. The ph levels of the oceans have already dropped from 8.2 to 8.1 and could further go down to 7.8.
- **Target-Land degradation neutral by 2030 and restore 2 billion ha of degraded land**

WEF-THE GLOBAL RISKS REPORT 2019 (15 Jan.)



- Economic loss US$330 billion; 97% from extreme weather damage
- Disaster risk is growing due to unplanned urbanization, persistent poverty and ecosystem degradation.
- Insurance industry suffered losses of US$135 billion in 2018- highest in 40 yrs.

NATURAL HAZARDS IN INDIA LEADING TO DISASTERS



Drought
- 68% net sown area in 116 dist.

Forest Fire
- 44 M ha (≈ 65%: Deciduous) of India's 67.5 M ha (total) forest cover is prone to forest fires

Earthquake
- 55% of area in Seismic Zone III-IV-V

Flood
- 40 M ha flooding

Heat Wave/Cold Wave
- Same areas affected in different seasons

Landslide
- Himalayas and Western Ghats
- Mostly rainfall indiced - 6 - 7 major landslide events Each monsoon,

Cyclone - 2 seasons
- 7500 km long coastline

Heavy Rainfall and Flash Floods
- Two monsoon seasons

Thunderstorms
- Most parts of country vulnerable

(Image Courtesy: ISRO)

EXTREME WEATHER EVENTS

Winter (Jan-Feb): Western Disturbances, Cold Wave, Fog

Pre-Monsoon (Mar-May): Cyclonic Disturbances, Heat Wave, Thunder Storms , Squalls, Hail Storm, Tornado

Monsoon (Jun-Sep): Southwest Monsoon Circulation, Monsoon Disturbances

Post-Monsoon (Oct-Dec): Northeast Monsoon, Cyclonic Disturbances

FWCC 1979 (Scientific Knowledge)

'Climate Variability and Change as an issue of concern worldwide '

- IPCC

SWCC 1990
Political Awareness

'More momentum to address Climate Variability and Change'

- GCOS
- UNFCCC

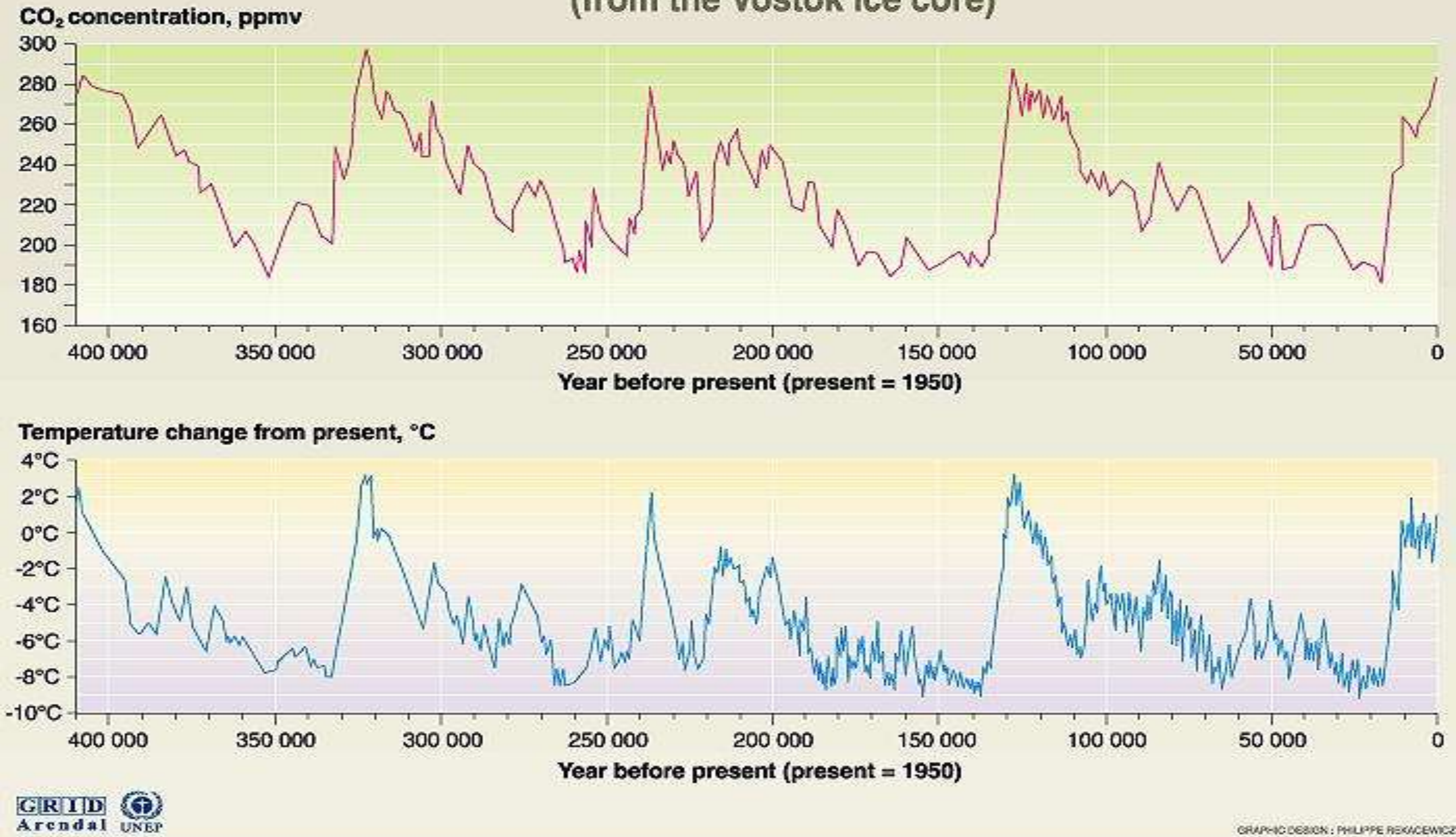
Development policy

WCC-3 (31 Aug-4 Sept. 2009)
Societal services

'Climate prediction and information for decision-making

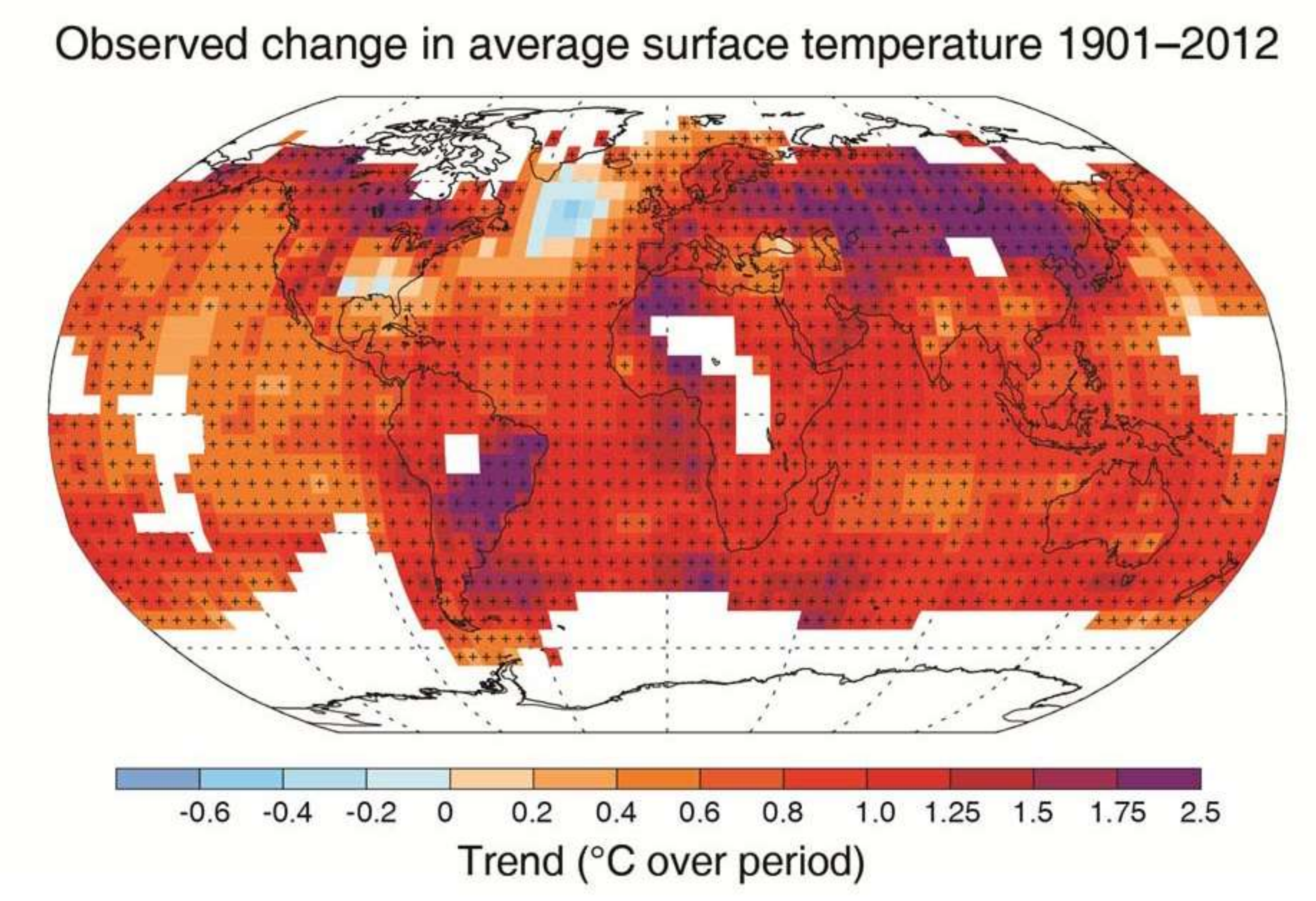
- GFCS
  - Observation & Monitoring
  - Climate Research & Modeling
  - Climate Services & Information System
  - Climate Services Application Programme

Temperature and CO_2 concentration in the atmosphere over the past 400 000 years (from the Vostok ice core)



Source: J.R. Petit, J. Jouzel, et al. Climate and atmospheric history of the past 420 000 years from the Vostok ice core in Antarctica, Nature 399 (3JUne), pp 429-436, 1999.

RECENT CLIMATE CHANGE



IPCC, 2013

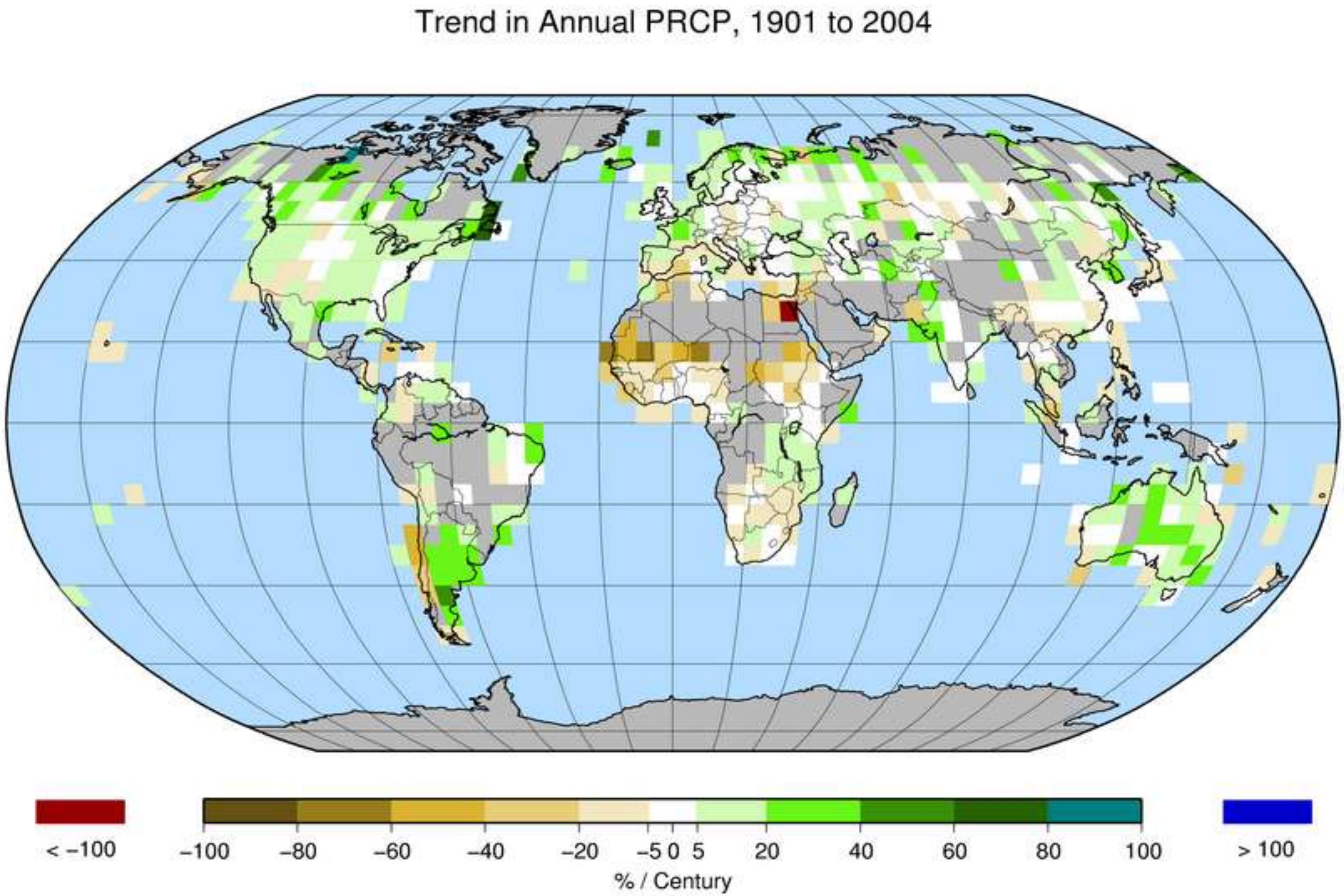
WARMEST YEARS (1880–2018)

Year	Anomaly in respect of the 1981–2010 average (°C)
2016	+0.56
2017	+0.46
2015	+0.45
2014	+0.30
2010	+0.28
2005	+0.27
2013	+0.24
2006	+0.22
2009	+0.21
1998	+0.21

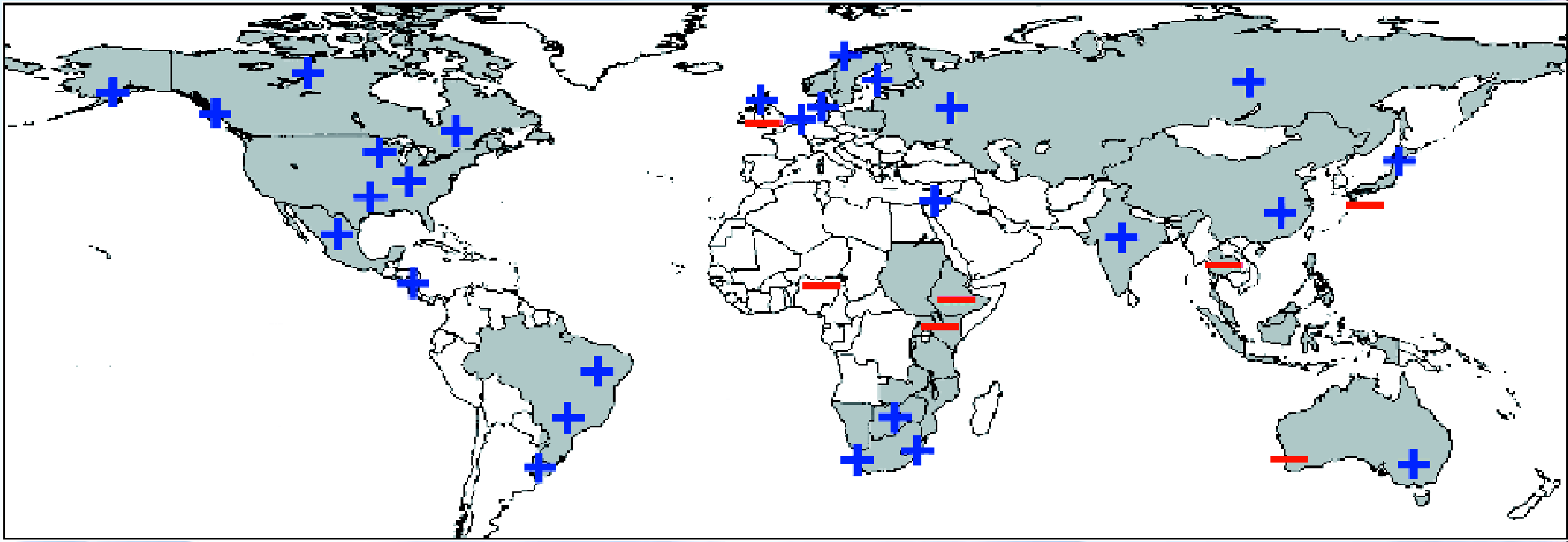
2006-2015: 0.86°C
2009-2018: 0.93°C
2014-2018: 1.04°C
(Above the pre-industrial baseline: 1850-1900)

IPCC1.5 (2018)

- 18 out of 19 warmest years on record in the 21st century
- 2001-2010 as the warmest decade on record.

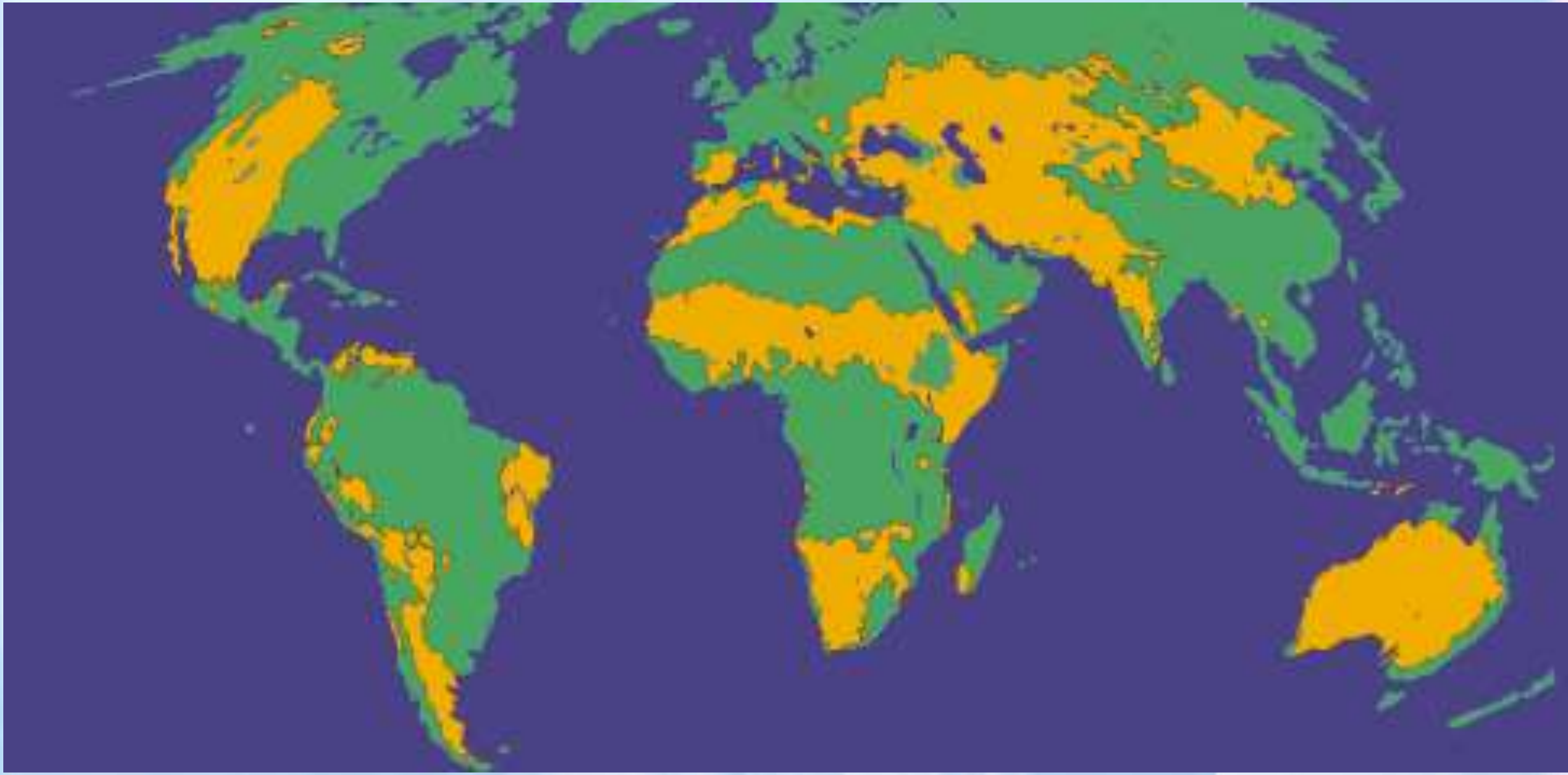

Trend in Annual PRCP, 1901 to 2004
< −100
−100
−80
−60
−40
−20
−5 0 5
20
40
60
80
100
> 100
% / Century

Proportion of heavy rainfalls: increasing in most land areas

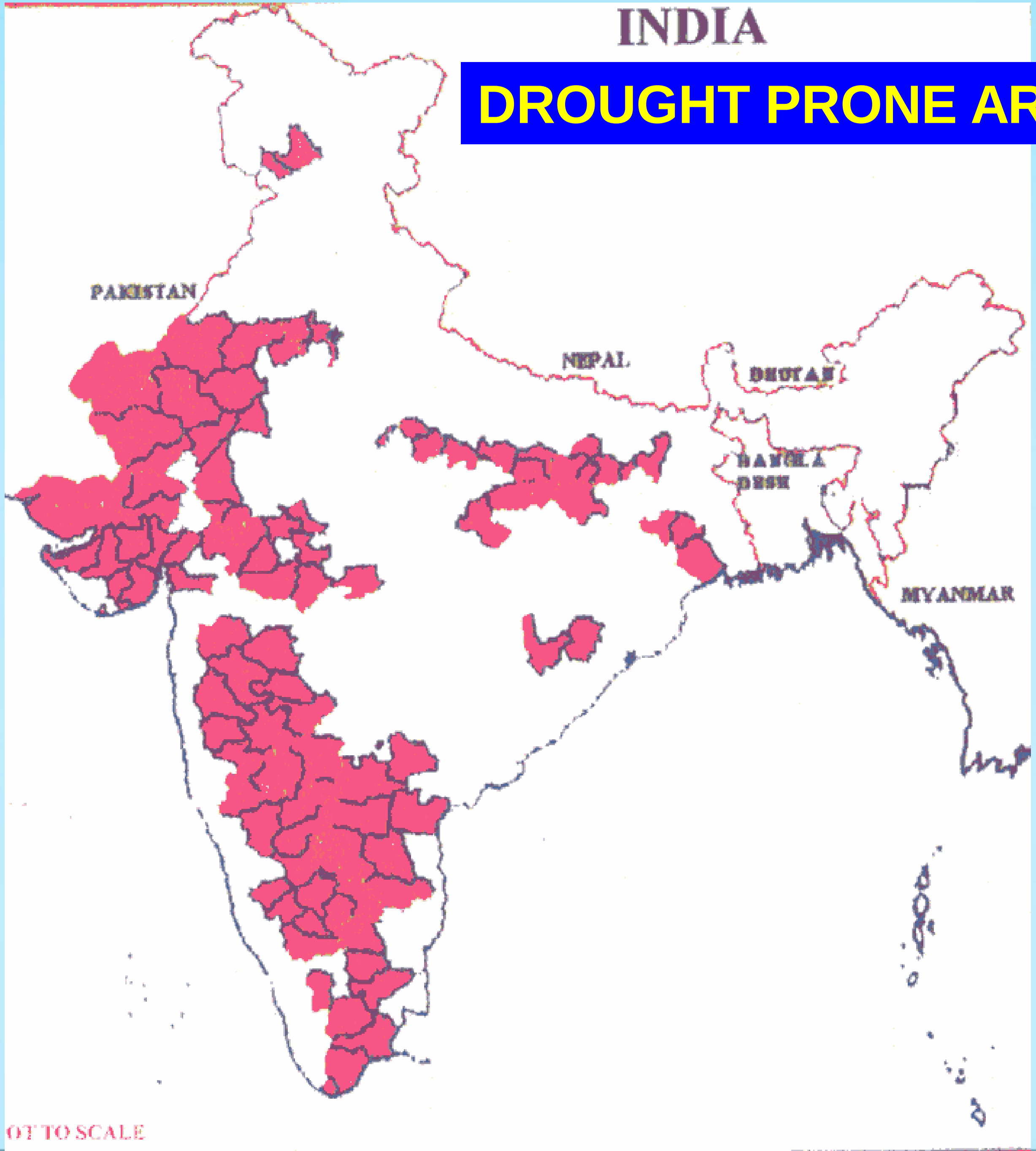


IPCC

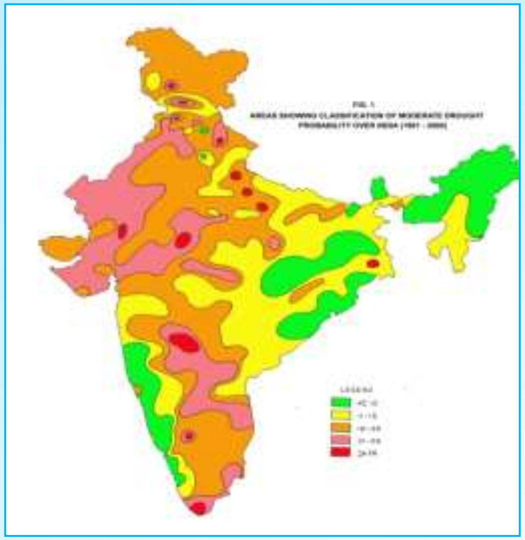
Areas sensitive to desertification (yellow)

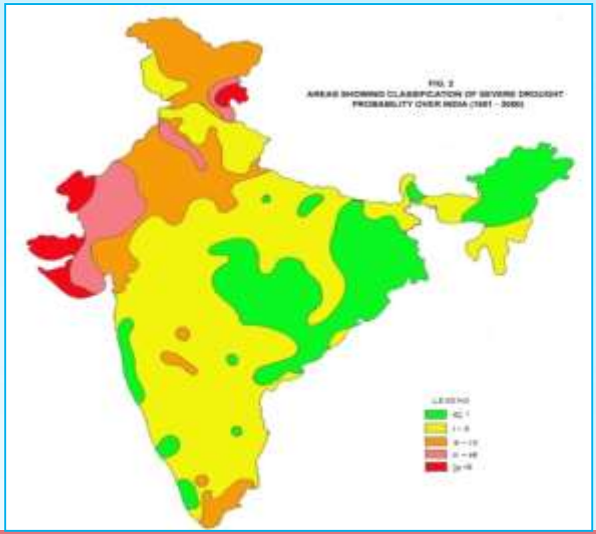


DROUGHT PRONE AREAS

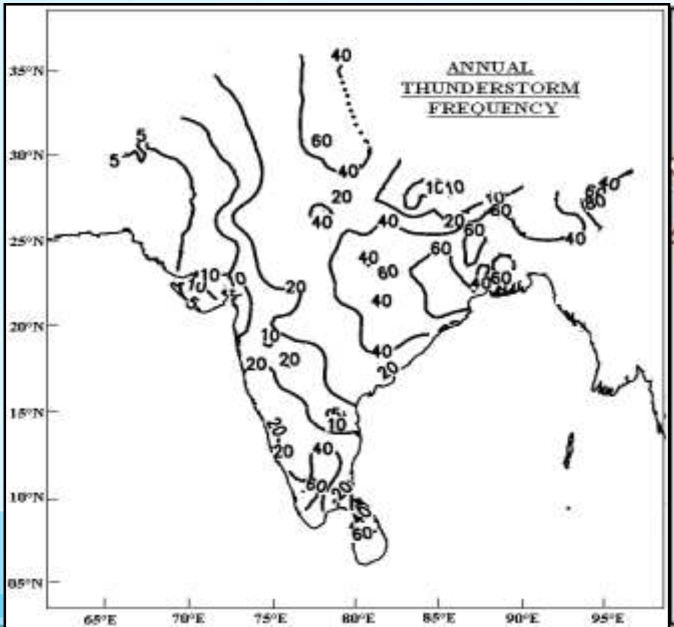


Probability of Moderate Severe Drought (1901-2000)

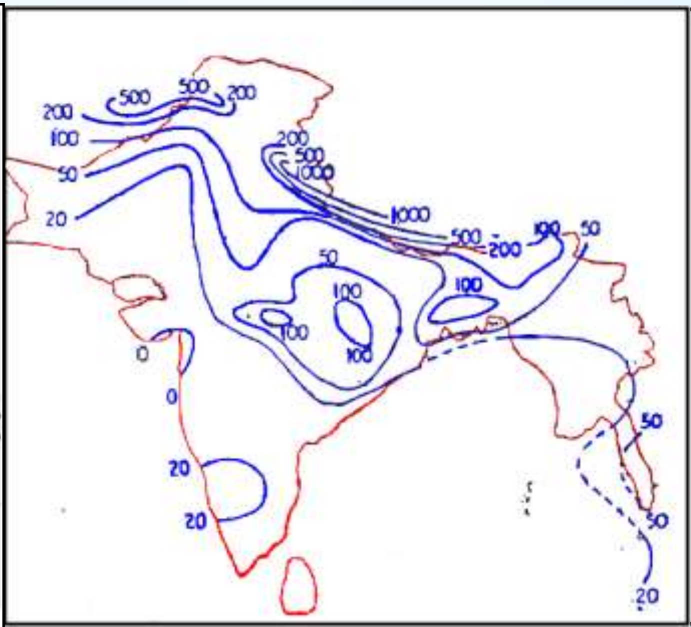




Thunderstorm (Per year)



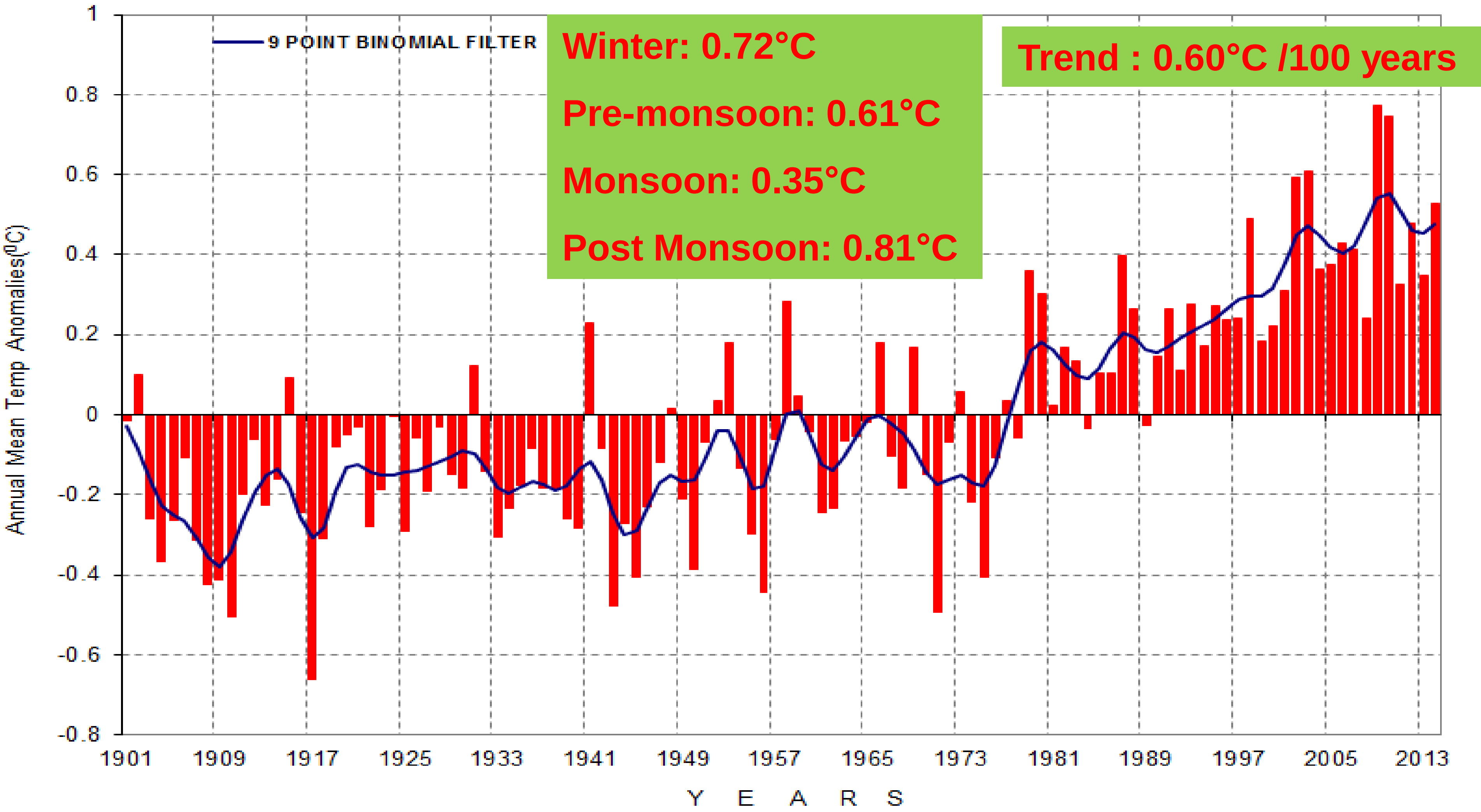
Hailstorm (in 100 years)



Tornado prone areas

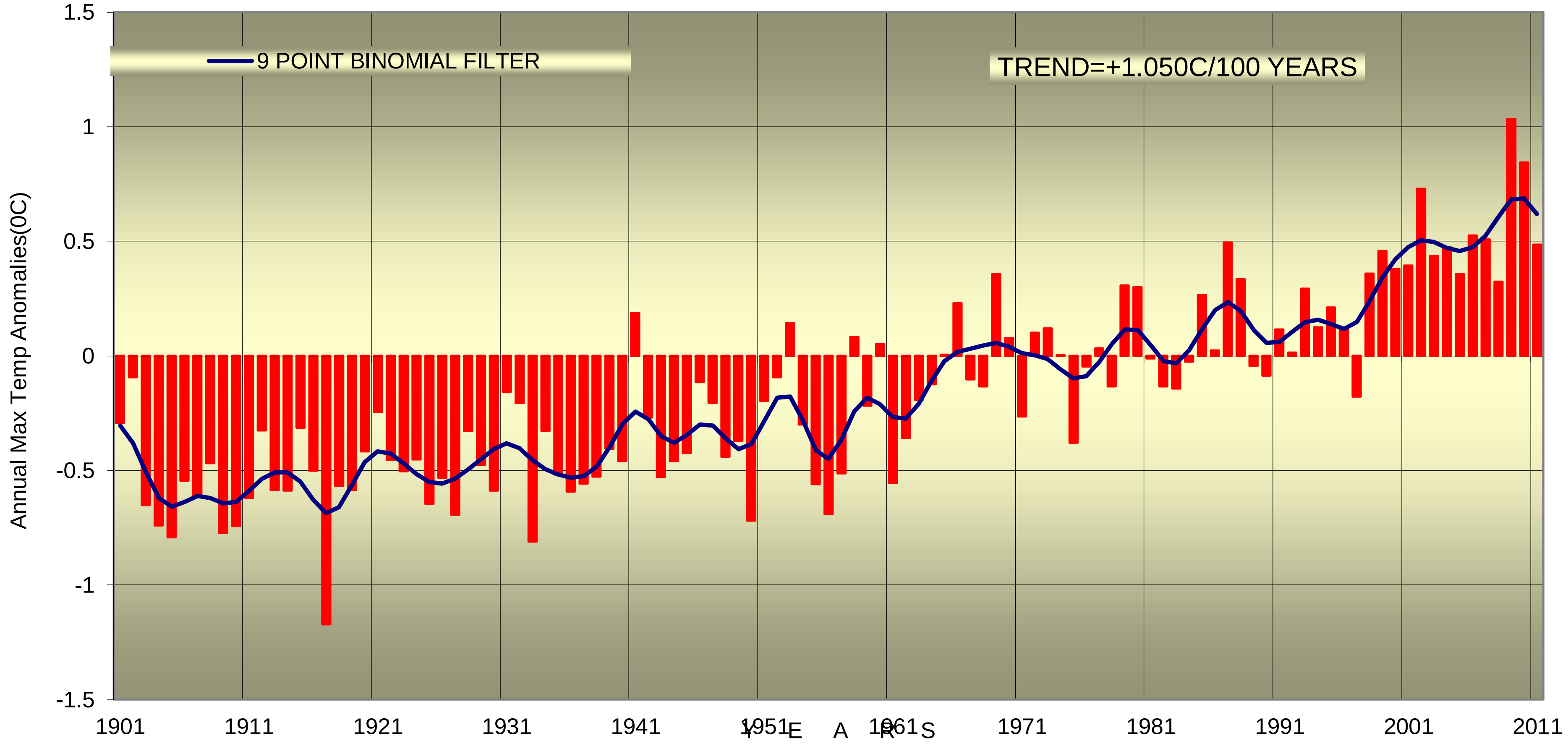
OBSERVED TEMPERATURE TREND OVER INDIA

(1901-2018)



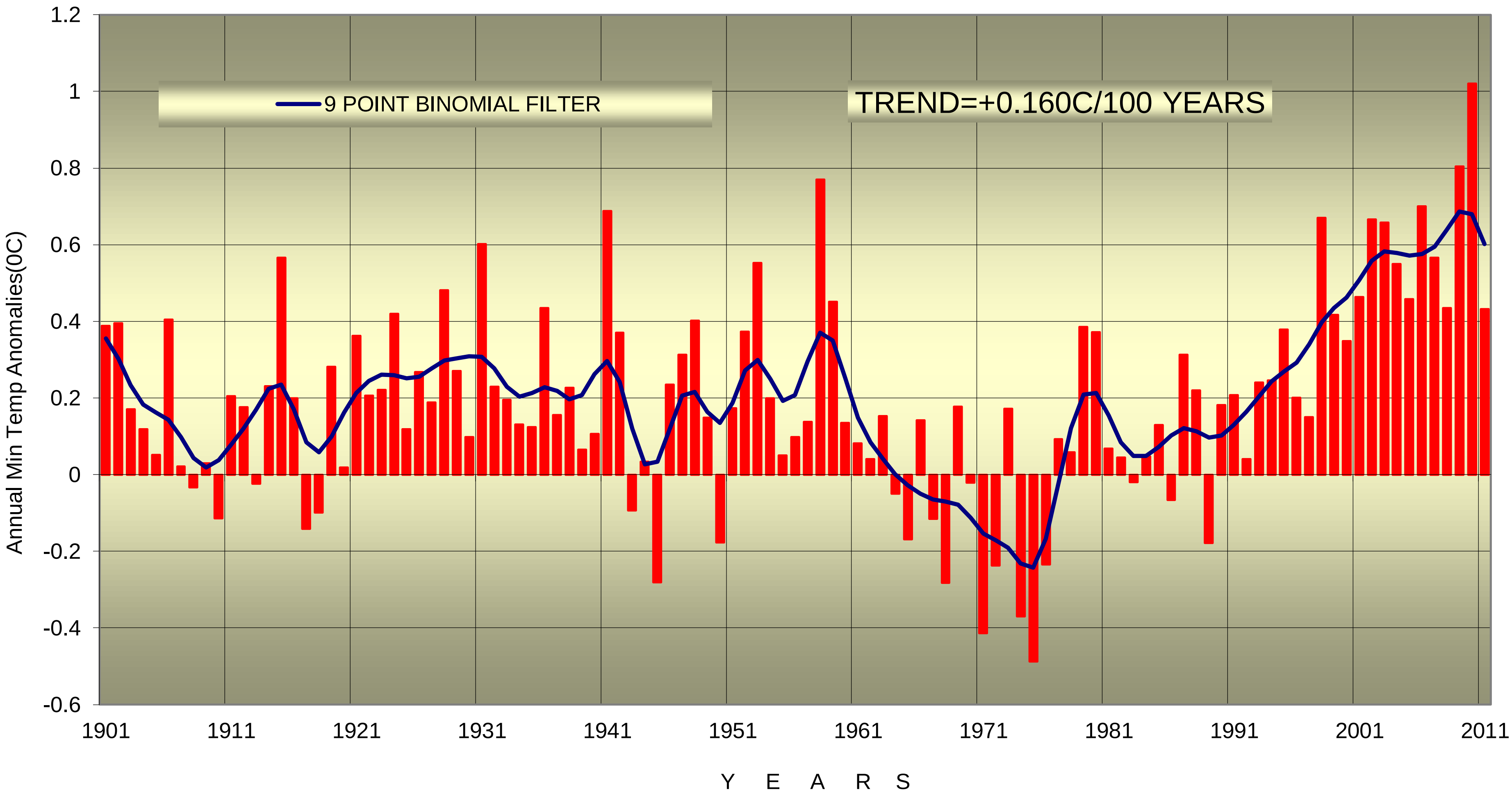
ANNUAL MAXIMUM TEMPERATURE ANOMALIES (1901-2018)

(BASED ON 1961-1990 AVERAGE)

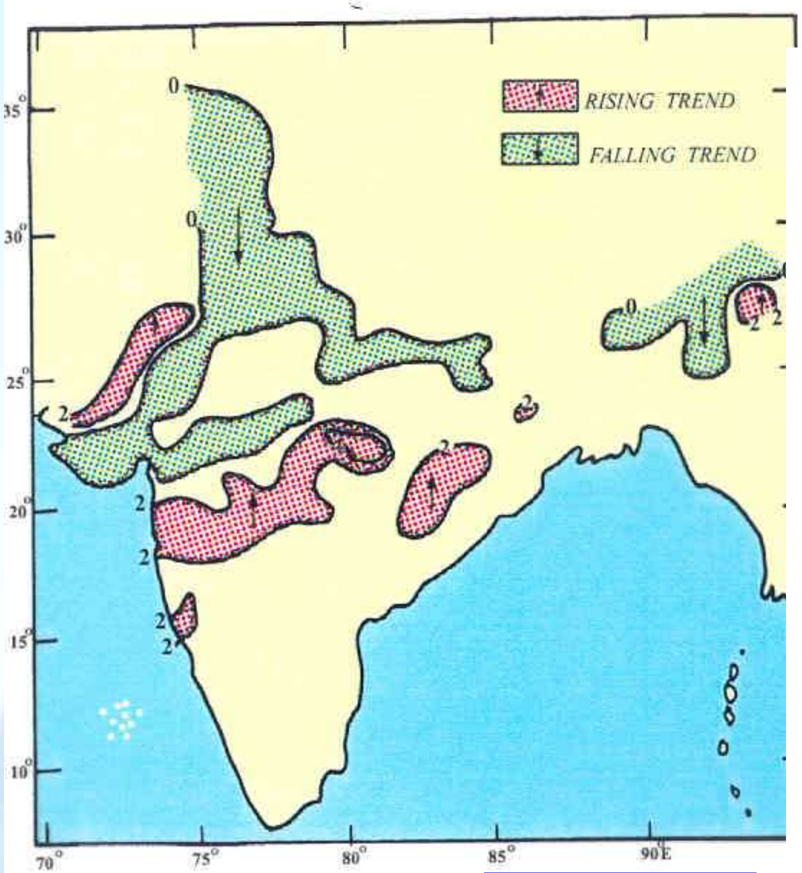


ANNUAL MINIMUM TEMPERATURE ANOMALIES (1901-2018)

(BASED ON 1961-1990 AVERAGE)

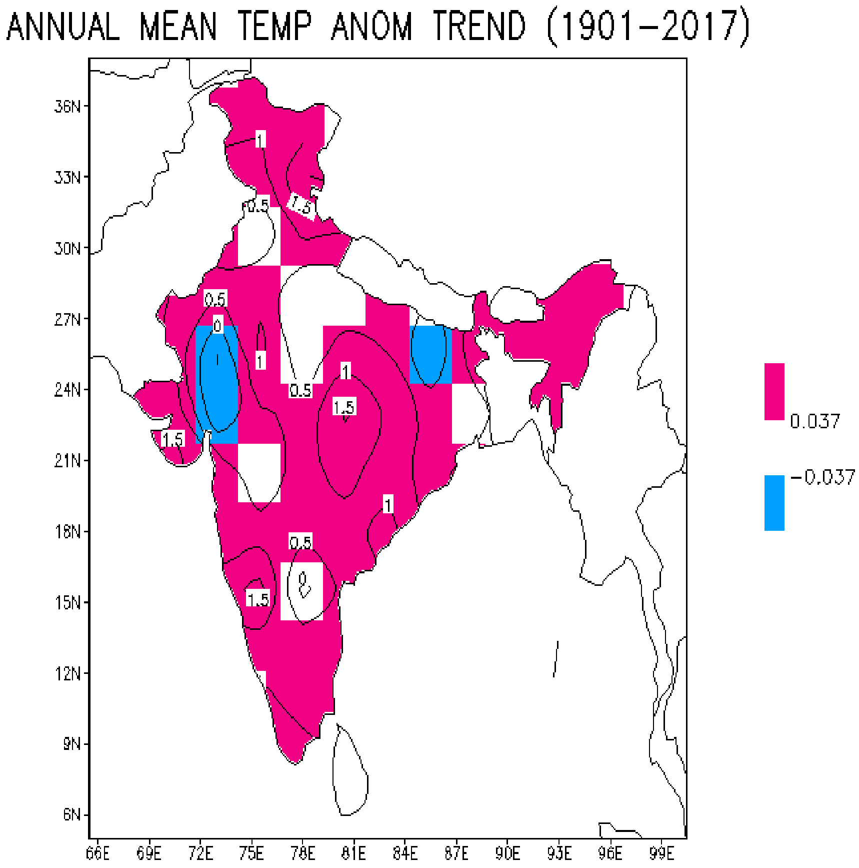


Spatial Variation of mean annual Temperature Changes in last century



1901-92

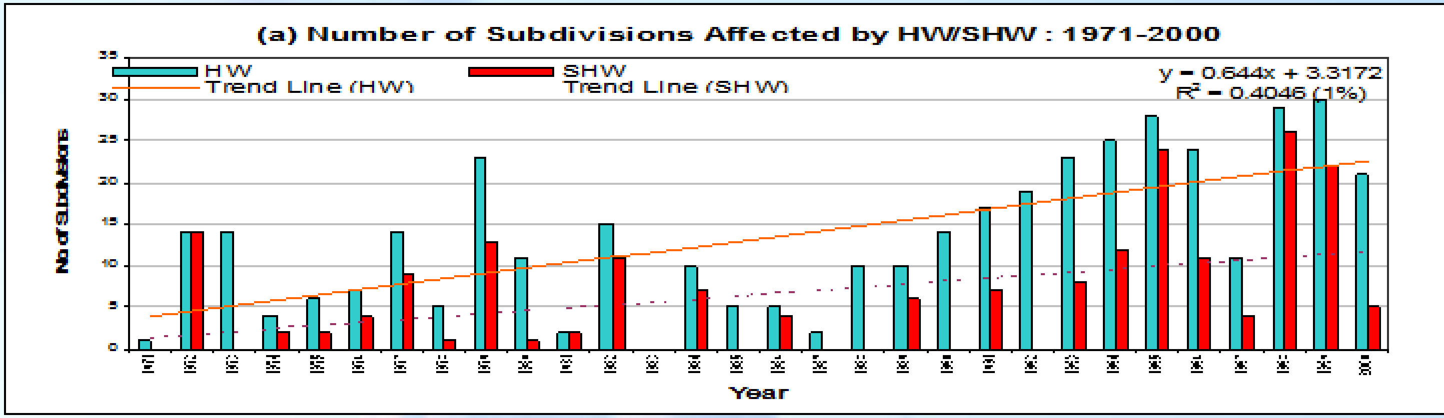
SPATIAL VARIATION IN THE LINEAR TREND OF AIR TEMPERATURE (IN °C/100 YEARS) OVER THE COUNTRY

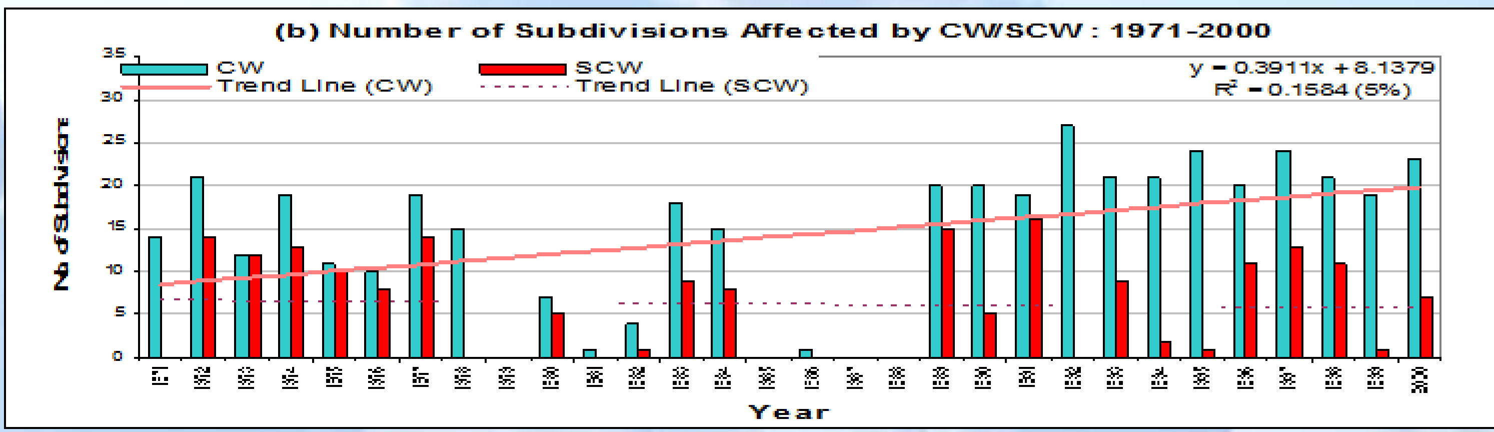


भारत मौसम विज्ञान विभाग
INDIA METEOROLOGICAL DEPARTMENT

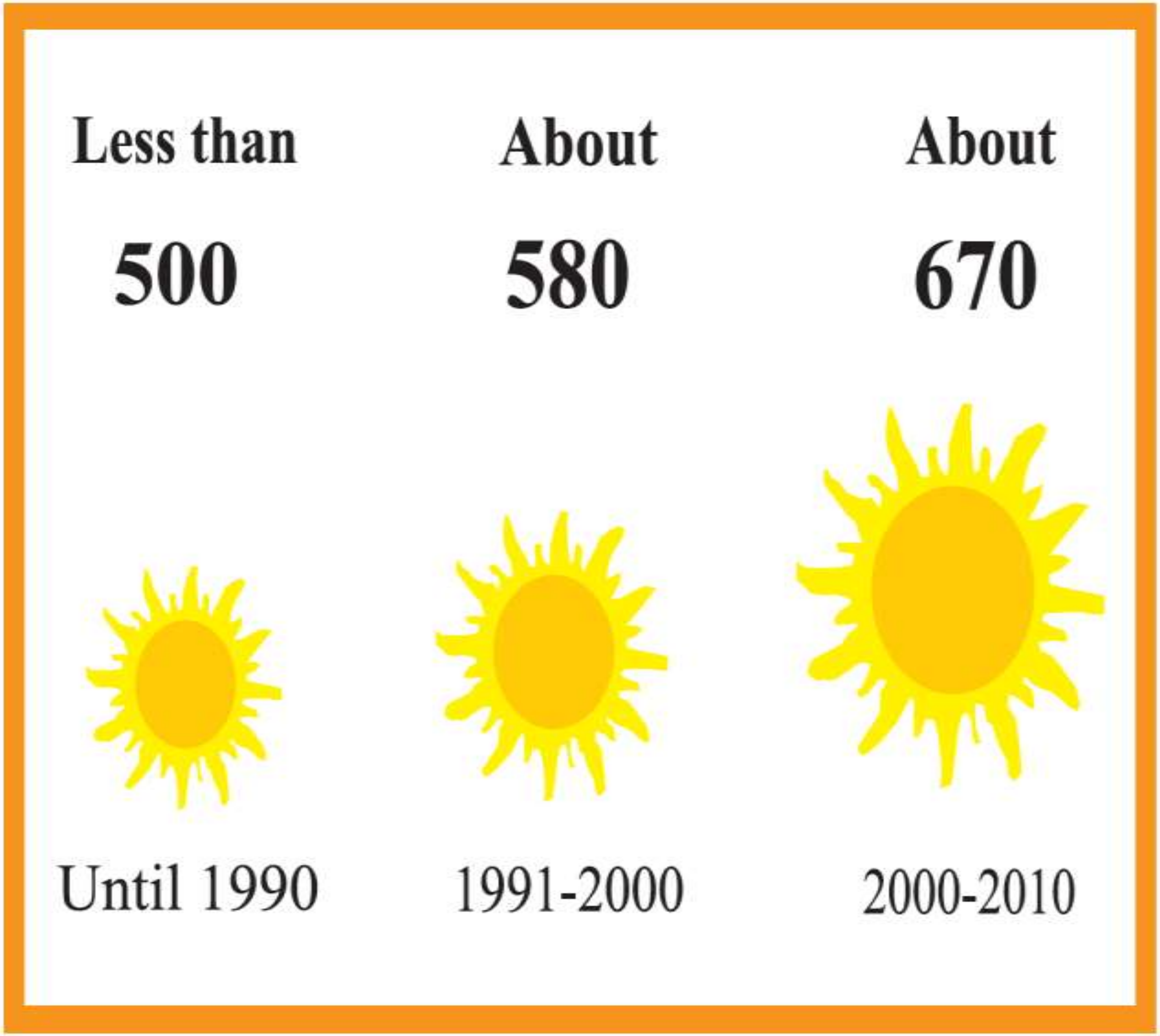
BREAK IN MONSSON

PERIOD	NUMBER OF BREAK DAYS DURING					
	JULY			AUGUST		
	01-10	11-20	21-31	1-10	11-20	21-31
1888-1917	46	49	53	43	84	26
1918-1947	14	36	21	55	54	25
1948-1977	22	44	64	21	33	41
1978-2003	23	32	39	6	14	37


(a) Number of Subdivisions Affected by HW/SHW : 1971-2000
HW
Trend Line (HW)
SHW
Trend Line (SHW)
y = 0.644x + 3.3172
R² = 0.4046 (1%)
No of Subdivisions
Year


(b) Number of Subdivisions Affected by CW/SCW : 1971-2000
CW
Trend Line (CW)
SCW
Trend Line (SCW)
y = 0.3911x + 8.1379
R² = 0.1584 (5%)
No of Subdivisions
Year

Heat waves in India (per year)



HEAT / COLD WAVE

Heat Wave

When maximum temperature of a station reaches ≥40º C for plains and ≥30º C for hilly regions

(a) Based on Departure from normal

Heat Wave: Maximum Temperature Departure from normal 4.5º C to 6.4º C.	
Severe Heat Wave: Maximum Temperature Departure from normal ≥6.5º C	

(b). Based on Actual maximum temperature

Heat Wave: When actual maximum temperature ≥45ºC.	
Severe Heat Wave: When actual maximum temperature ≥47ºC	

(c). Criteria for heat wave for coastal stations

When maximum temperature departure is >4.5ºC from normal. Heat Wave may be described provided maximum temperature ≥37ºC

Warm Night

When maximum temperature remains 40ºC

Warm Night: When minimum temperature departure 4.5 ºC to 6.4 ºC.	
Severe Warm Night: When minimum temperature departure >6.4 ºC.	

Cold Wave

When minimum temperature of a station ≤10°C for plains and ≤0°C for hilly regions.

(a). Based on departure

Cold Wave: Minimum Temperature Departure from normal -4.5 ºC to -6.4 ºC.	
Severe Cold Wave: Minimum Temperature Departure from normal ≥ -6.5 ºC	

(b) Based on actual Minimum Temperature (for Plains only)

Cold Wave : When Minimum Temperature is ≤ 4.0 ºC	
Severe Cold Wave: When Minimum Temperature is ≤ 2.0 ºC	

(c) For Coastal Stations

When Minimum Temperature departure is ≤-4.5 °C or actual Minimum Temperature is ≤ 15 °C

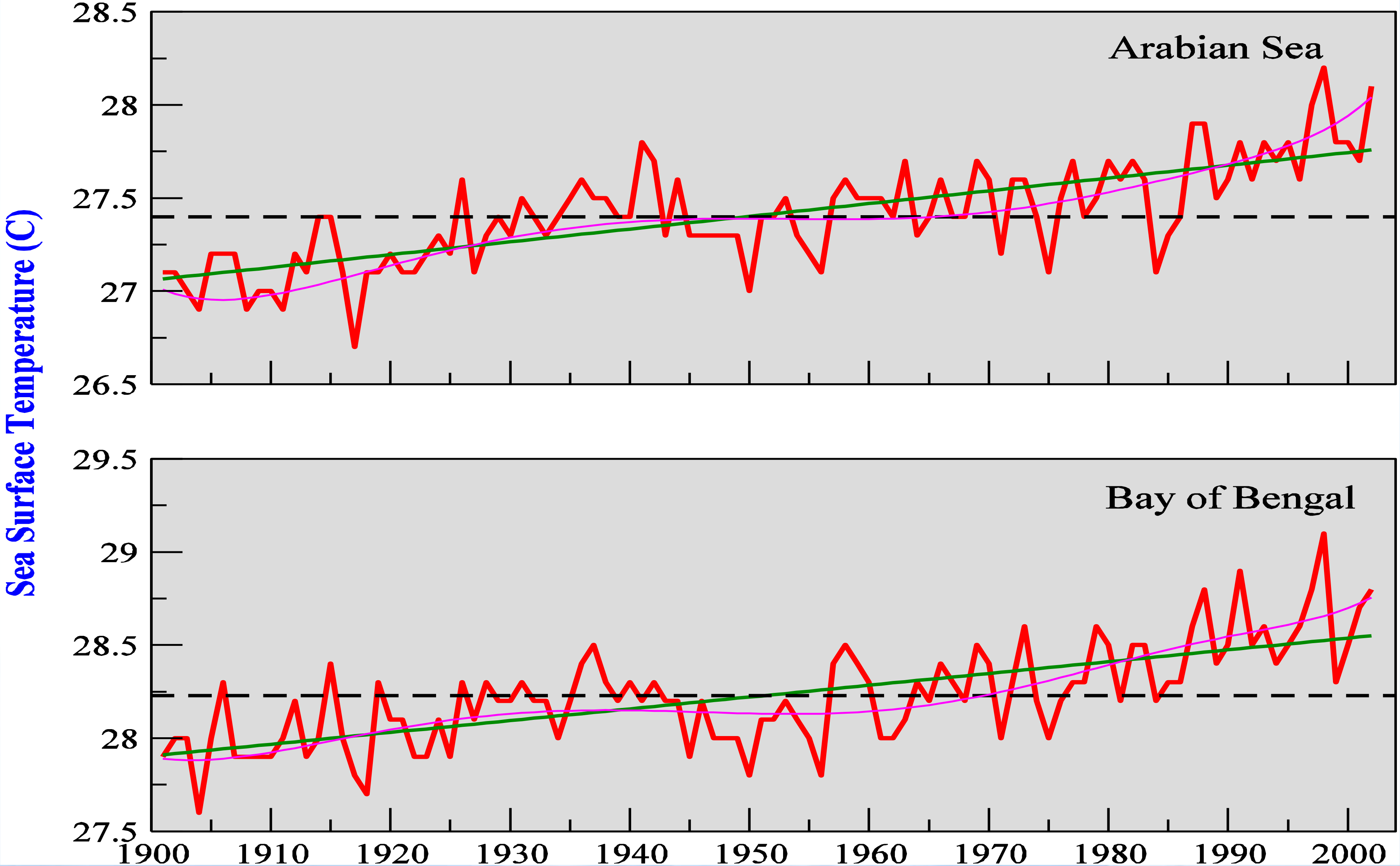
Cold Day

When minimum temperature of a station ≤10ºC for plains and ≤0ºC for hilly regions

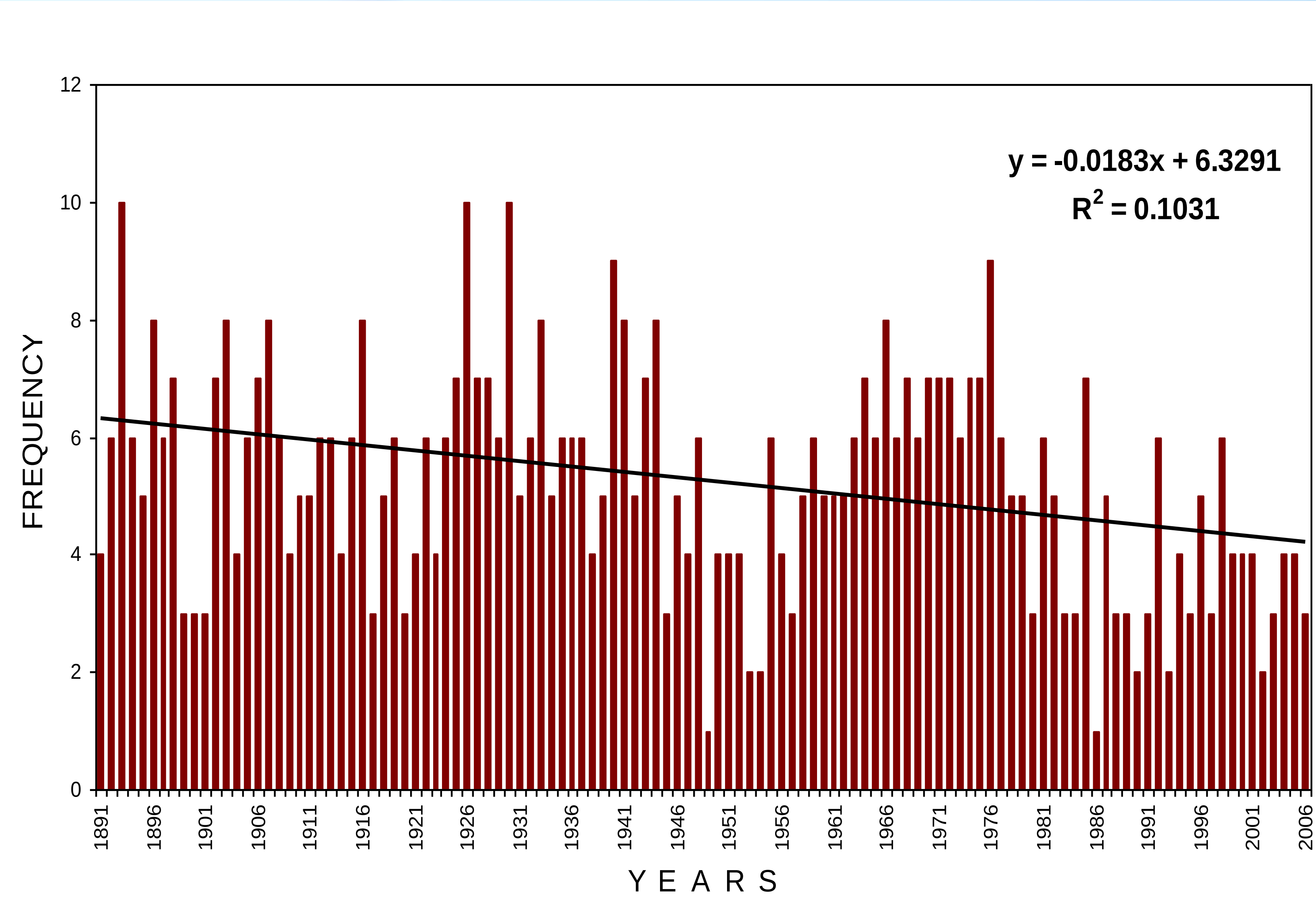
Based on departure

Cold Day: Maximum Temperature Departure from normal -4.5 ºC to -6.4 ºC.	
Severe Cold Day: Maximum Temperature Departure from normal ≤ -6.5 ºC	

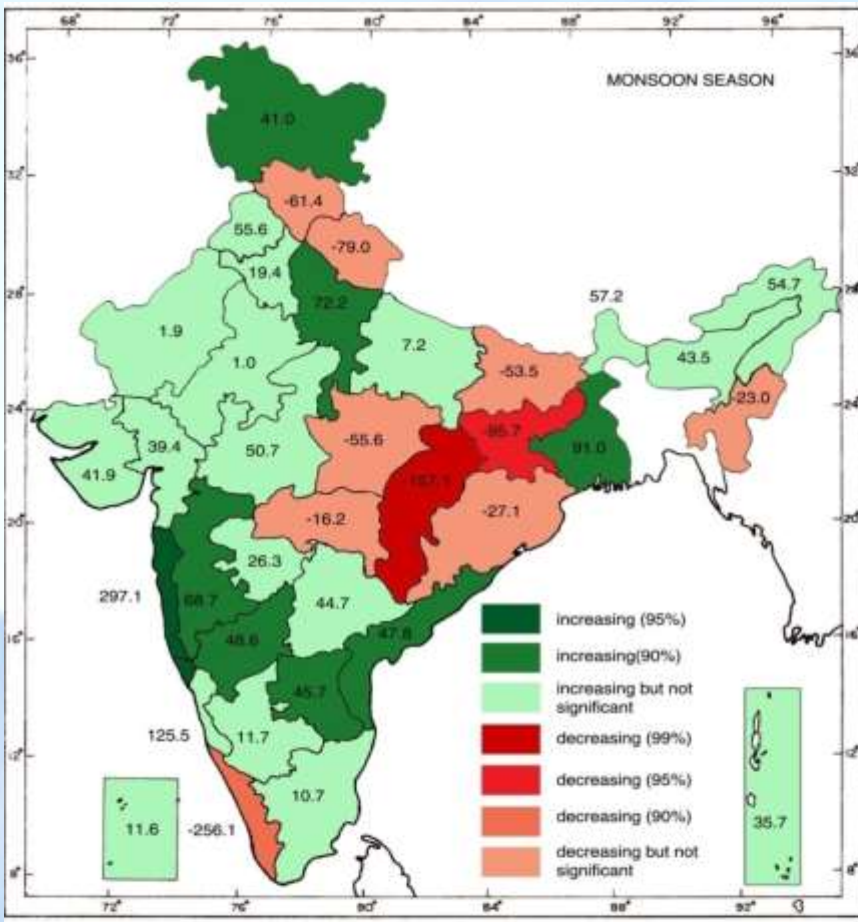
Sea Surface Temperature Variations in the Indian Ocean

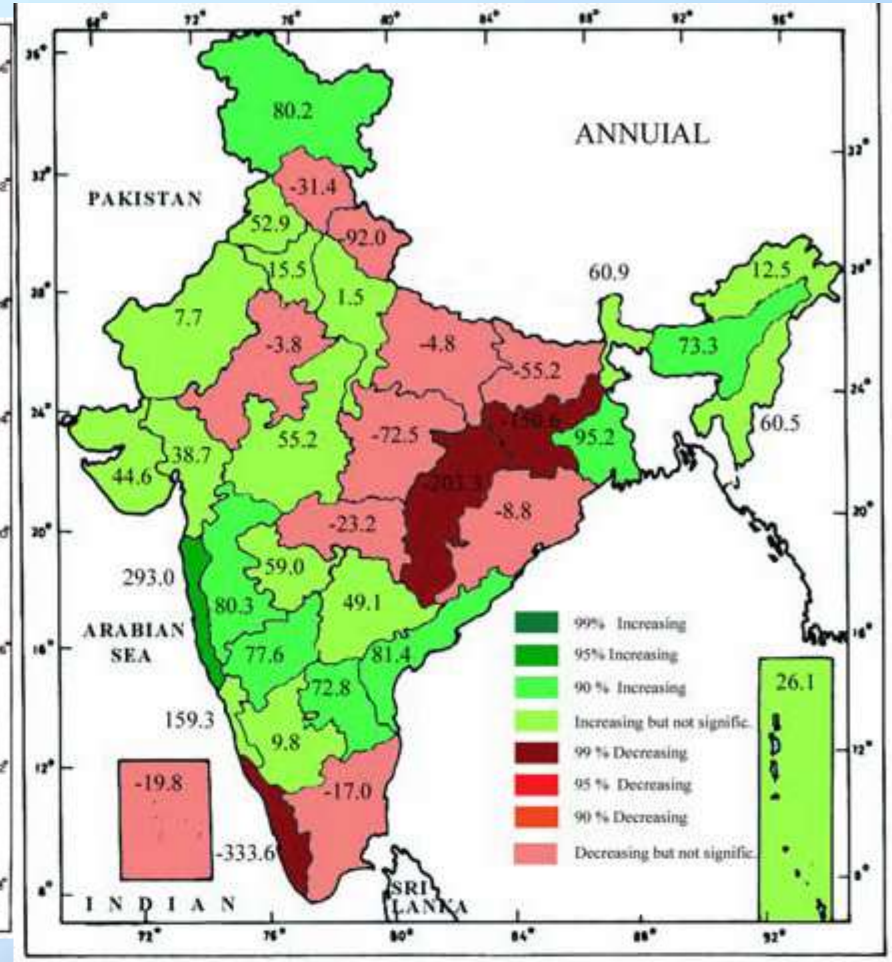


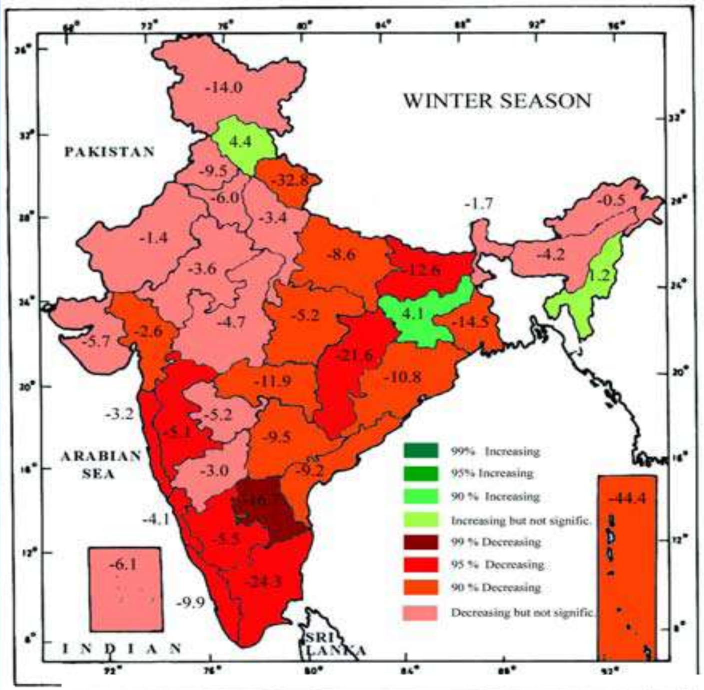
SIGNIFICANT DECREASING TREND IN ANNUAL FREQUENCY OF CYCLONIC STORMS OVER THE NORTH INDIAN OCEAN (1891-2006)



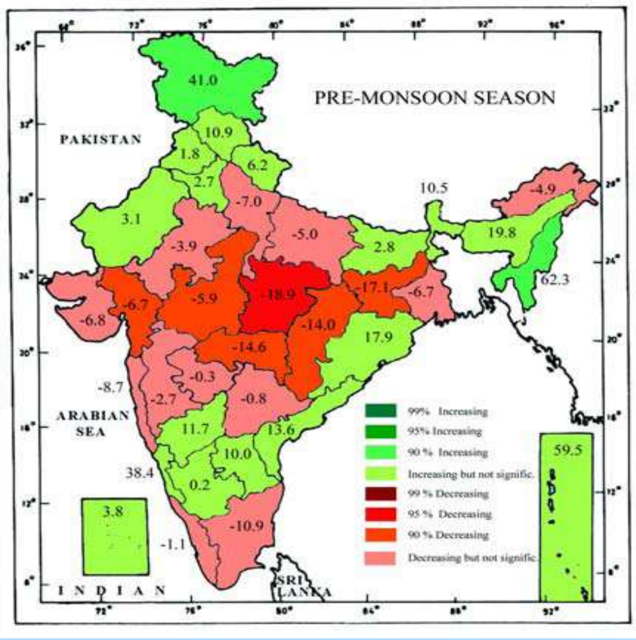
TREND OF RAINFALL DURING SW MONSOON AND ANNUAL (mm of rainfall in 100 years)

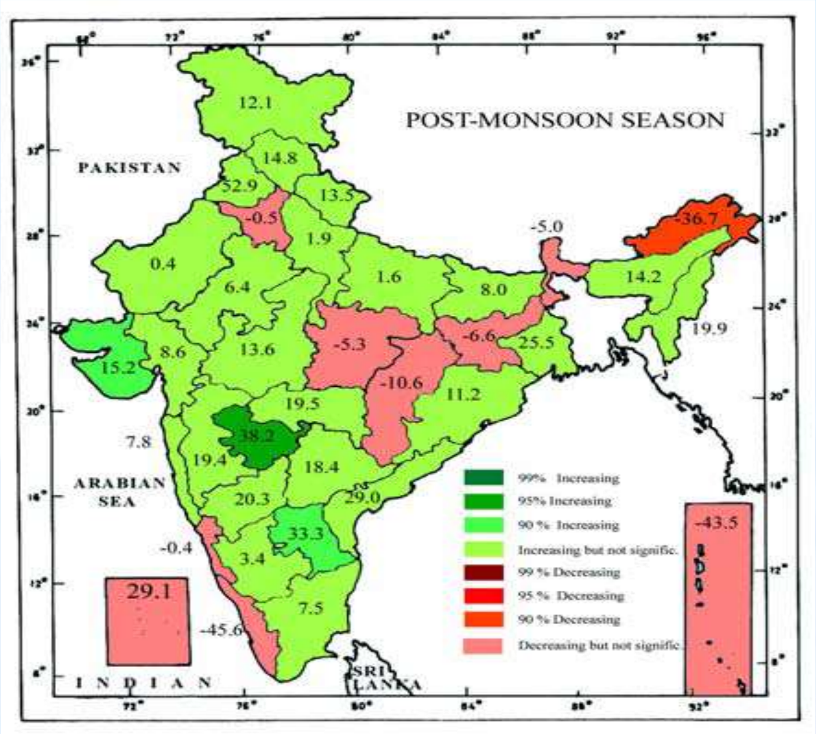






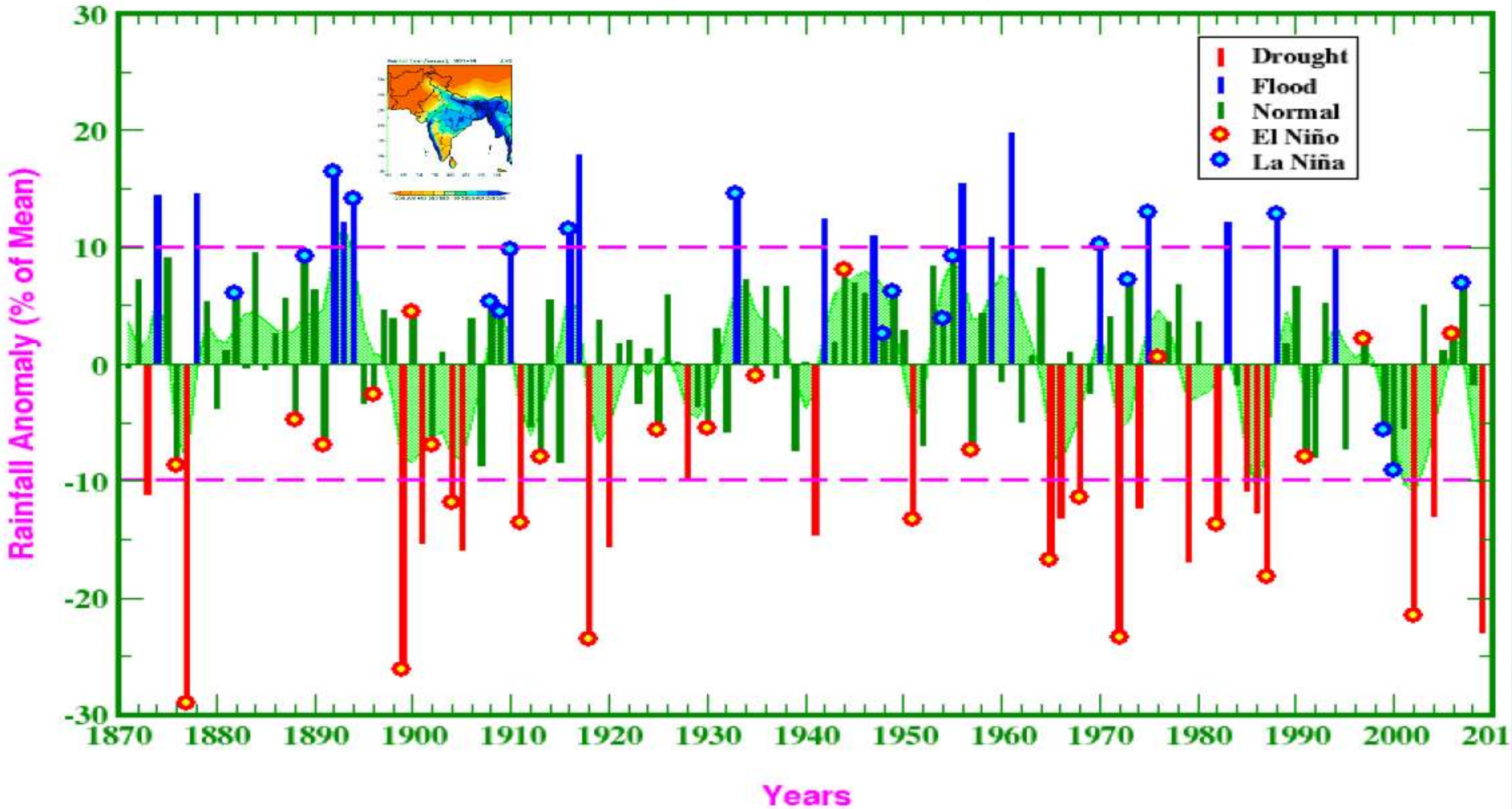
Trend in sub- divisional rainfall data (increase/ decrease in rainfall in mm) for different seasons (1901-2003).





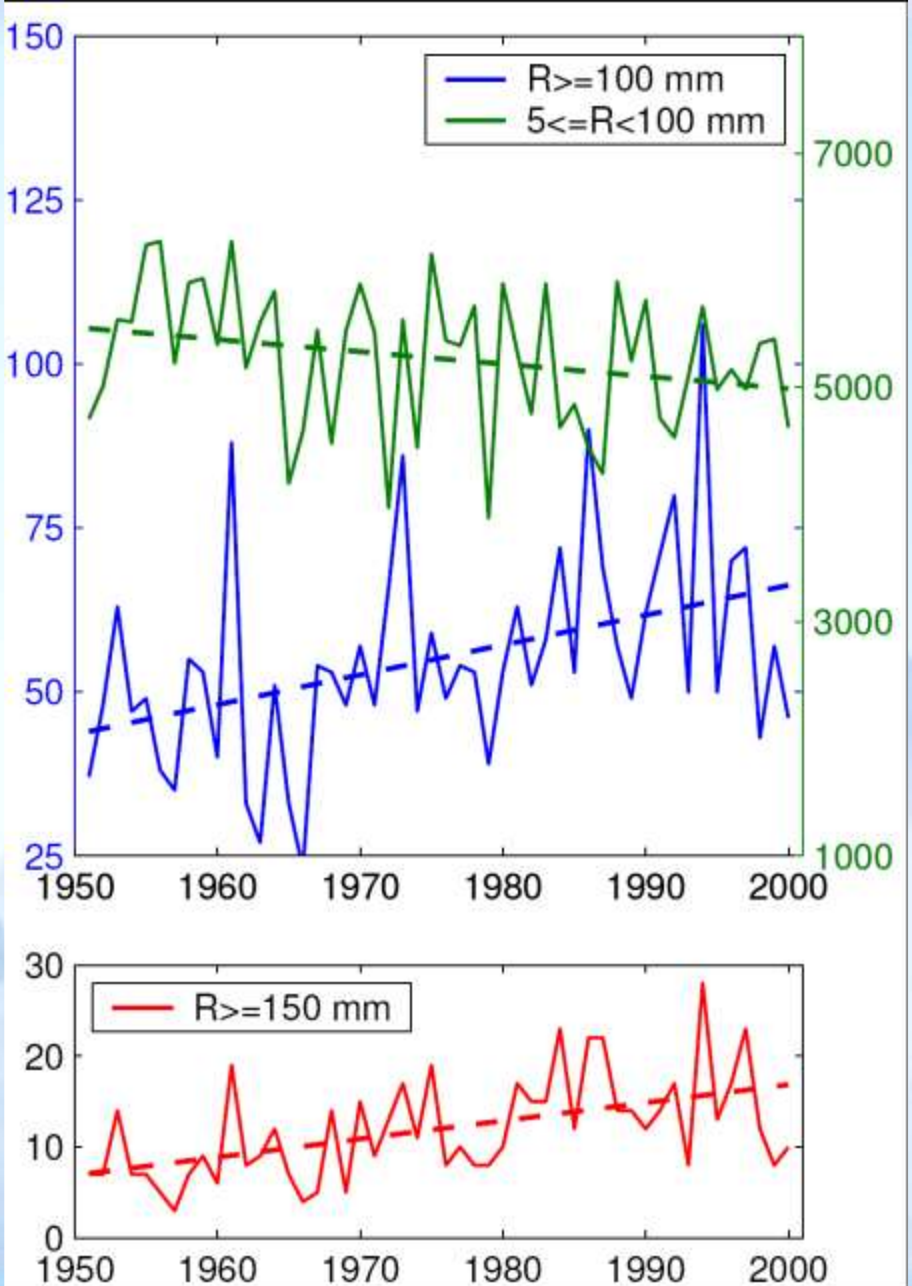
All-India Summer Monsoon Rainfall, 1871-2009

(Based on IITM Homogeneous Indian Monthly Rainfall Data Set)



1901-2018 : 23 drought years (16 El Nino)

13 excess years (6 La Nina)



Low & Moderate events

Heavy events (>10cm)

Goswami et al. 2006, Science, 314, 1442

V. Heavy events (>15cm)

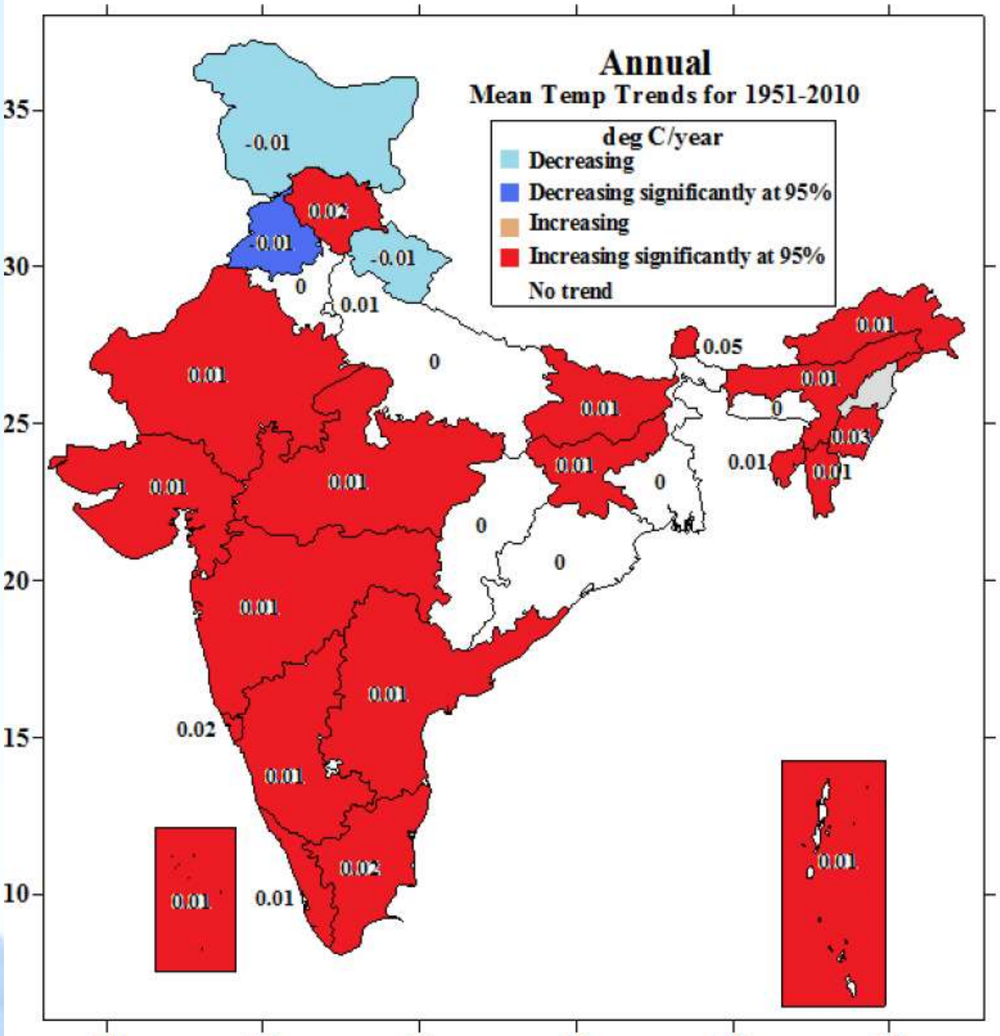


Figure 5: State level annual mean temperature trends.

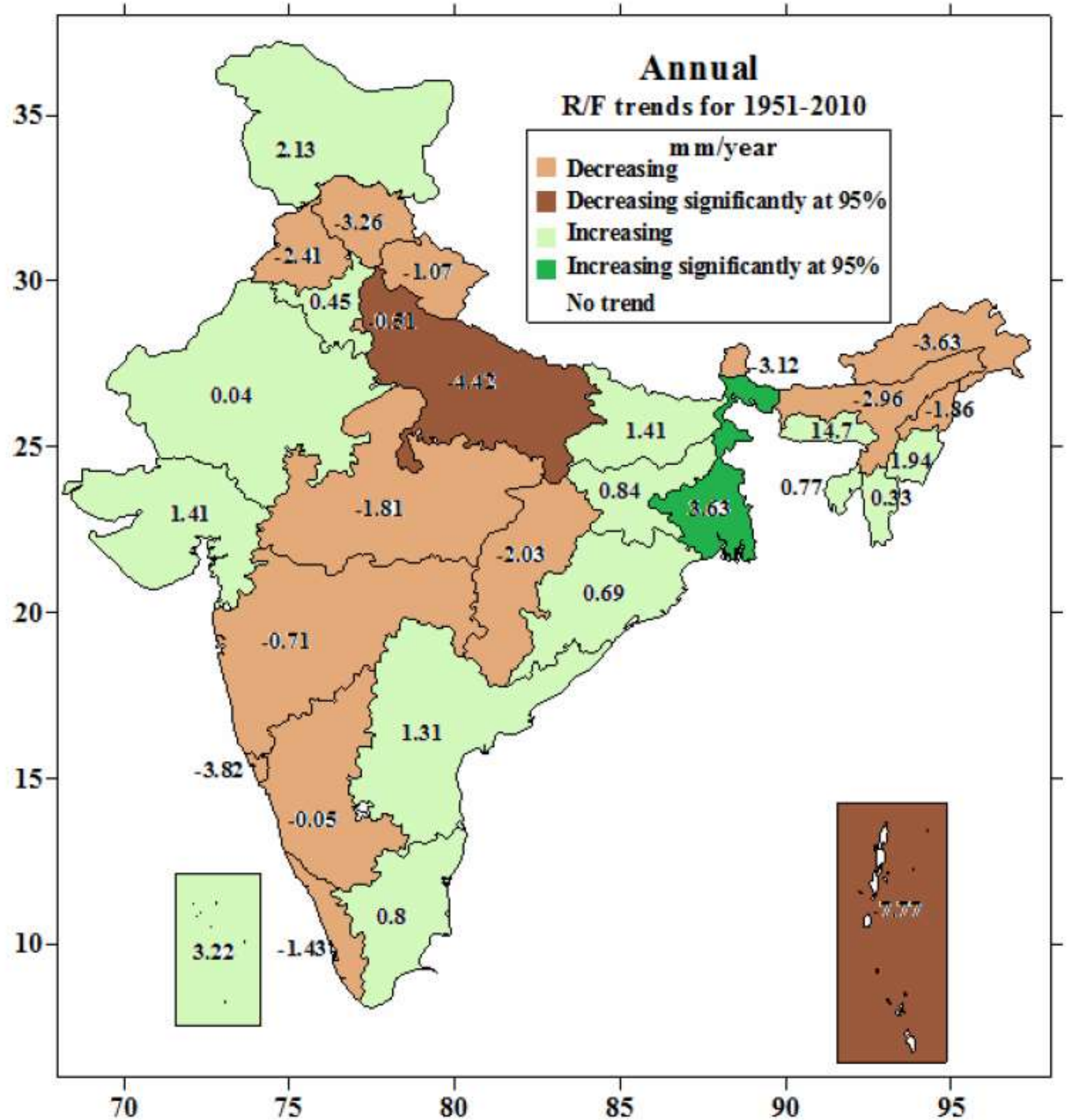
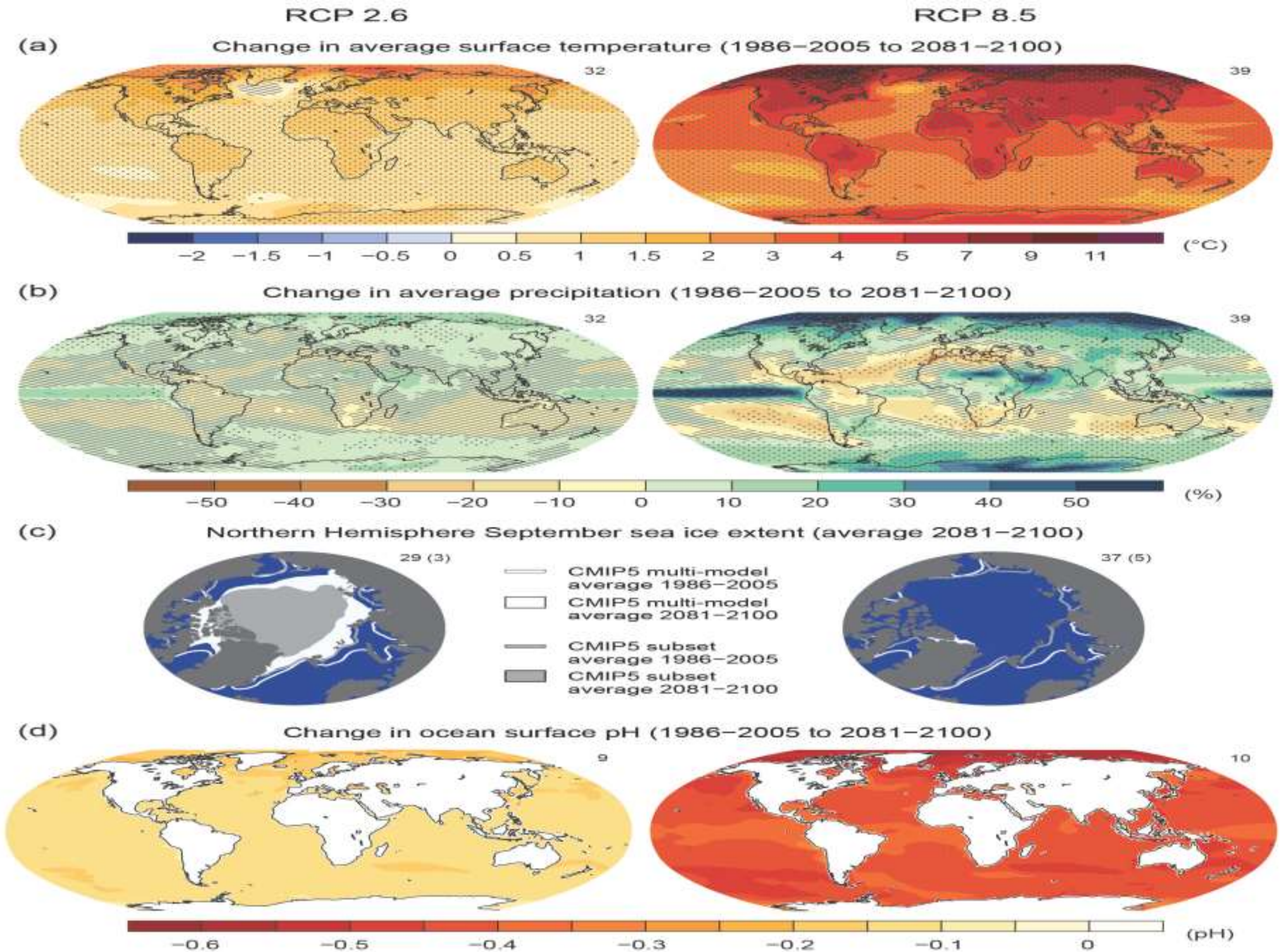


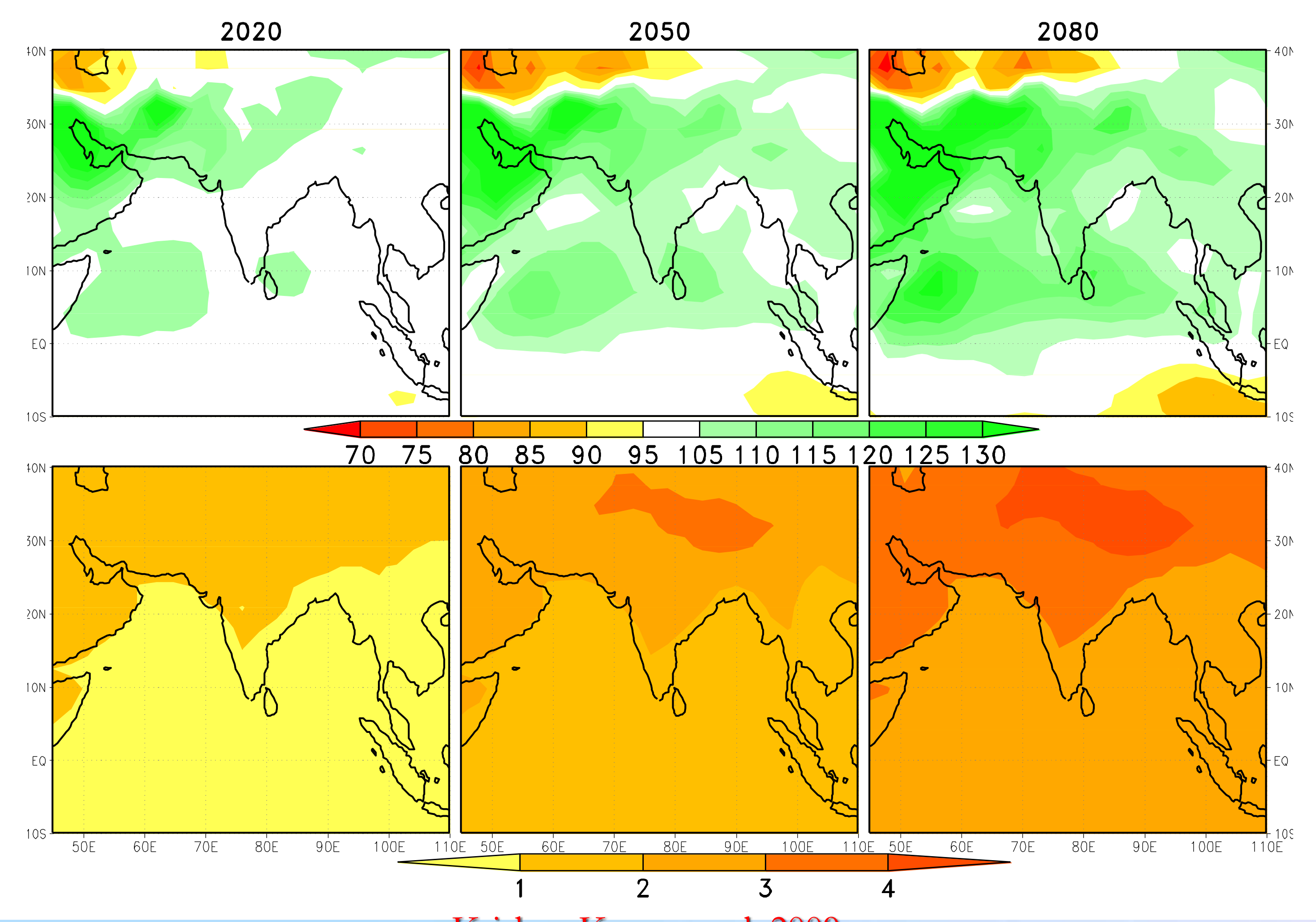
Figure 7: State level annual rainfall trends.


RCP 2.6
RCP 8.5
(a)
Change in average surface temperature (1986−2005 to 2081−2100)
32
39
−2 −1.5 −1 −0.5 0 0.5 1 1.5 2 3 4 5 7 9 11
(°C)
(b)
Change in average precipitation (1986−2005 to 2081−2100)
32
39
−50 −40 −30 −20 −10 0 10 20 30 40 50
(%)
(c)
Northern Hemisphere September sea ice extent (average 2081−2100)
29 (3)
37 (5)
CMIP5 multi-model average 1986−2005
CMIP5 multi-model average 2081−2100
CMIP5 subset average 1986−2005
CMIP5 subset average 2081−2100
(d)
Change in ocean surface pH (1986−2005 to 2081−2100)
9
10
−0.6 −0.5 −0.4 −0.3 −0.2 −0.1 0
(pH)

Expected Future Change in Monsoon Rainfall and Annual Surface Temp for 2020's, 2050's and 2080's under A1B scenario in AR5

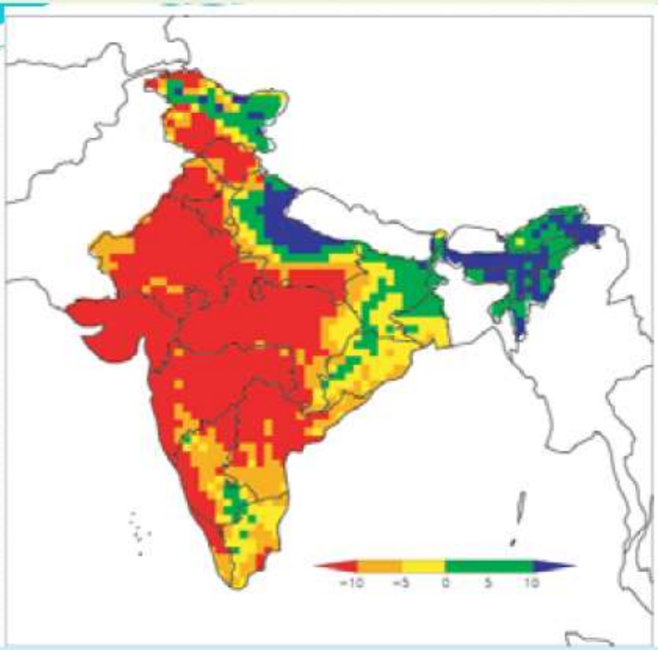
Rainfall

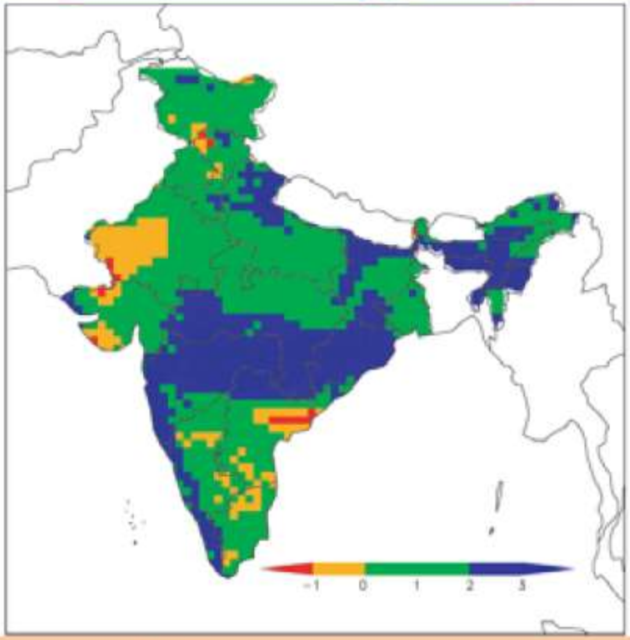
Temp



Krishna Kumar et al, 2009

Projections of extremes in rainfall (2041-2060)





- Overall **decrease** in the number of **rainy days** over a major part of the country.
- Decrease in the western and central part of the country (by more than 15 days),
- Foothills of Himalayas and in northeast India the number of rainy days is found to **increase by 5–10 days**.

- Increase in the **rainfall intensity** by 1–4 mm/day,
- Northwest India - the rainfall intensities decrease by 1 mm/day
- **Increase in the highest 1-day rainfall** over a major part - may be up to **20 cm/day**

(Source:IITM)

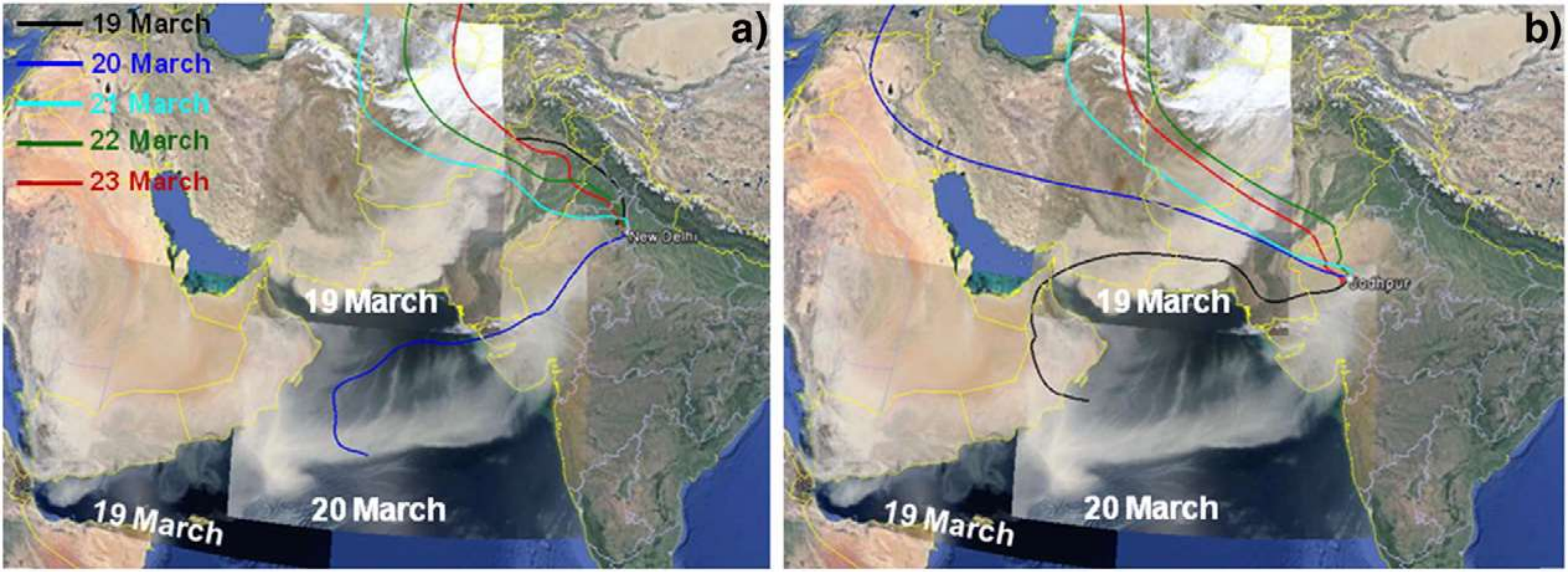
WMO Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS)

- The SDS-WAS established in 2007- a joint WWRP and GAW activity in response to the interest of 40 WMO member countries to improve capabilities for more reliable sand and dust storm forecasts
- The WMO SDS-WAS has been established with the objective to develop, refine and provide monitoring and prediction products that are useful in reducing the adverse impacts of SDS and to assess numerous impacts of the SDS process on society, climate and environment

SDS-WAS Asian Node (hosted by China)

SDS-WAS Northern Africa-Middle East-Europe Node (hosted by Spain)

SDS-WAS Americas Node (hosted by Bermudas)



Dust storm events observed from MODIS along with the air mass back-trajectories at (a) New Delhi, (b) Jodhpur during 19–23 March 2012.

Srivastava A.K., Soni V.K., Singh S., Kanawade V.P., Singh N., Tiwari S. and **Attri S.D**. (2014) "An early South Asian dust storm during March 2012 and its impacts on Indian Himalayan foothills: A case study", ***Science of Total Environment***, 493, 526-534 http://dx.doi.org/10.1016/j.scitotenv.2014.06.024.

DESERTIFICATION & CLIMATE CHANGE

- Rainfall significantly below normal for an extended period for several years (→ Drought)
- Degradation of land in arid, semi-arid, and dry sub-humid areas (→ Desertification)
- Global warming → rising temp → lower soil moisture→ hinder condensation & rainfall → drop of water table → further drop of soil moisture → loss of vegetation cover (protection) →loss of organic matters →less cohesive soil → easy erosion by wind & water → desertification→ climate change → land degradation → loss of vegetation → higher CO_2 emissions →global warming → lower evaporanspiration → lower air humidity → less & infrequent rainfall …..
- Temporary / high magnitude drought periods in semi-arid areas

Effects of desertification

Atmosphere

-local climate
↓PPT
drought
-macro climate
global warming

Hydrosphere

-water cycle
breaks down

Lithosphere

-loss of arable
salinization
-land intensify the
soil erosion

Biosphere

-extinction of
plants &
animals
-↓biodiversity

Upset the balance of ecosystem

Drought Management

WEATHER/CLIMATE FORECAST SPECTRUM

- **Prediction of land, atmospheric and Oceanic states at different scales to provide weather and climate forecast in different spatial and temporal range**
  - **Nowcasting (few hours)**
  - **Short range (1-2 days)**
  - **Medium range (3-10 days)**
  - **Extended Range (10-30 days)**
  - **Seasonal (Few months, e.g. Jun-Sep Monsoon)**
  - **Climate Scales**

  Spatial range : Location, Block, District, Meteorological Sub-division, River catchment, State and Homogeneous regions

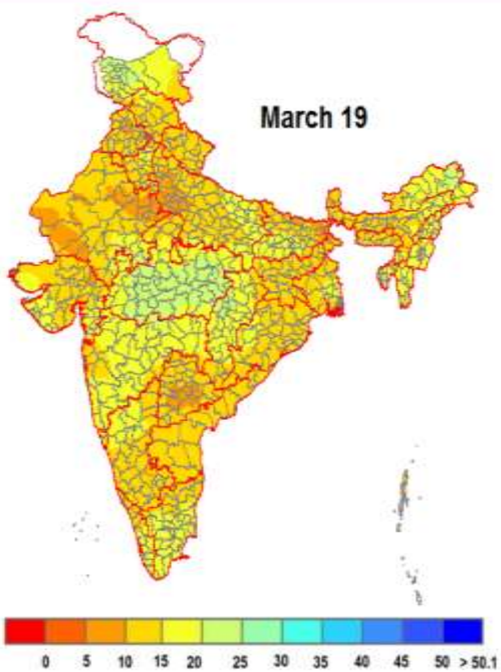
➢ **Early warning system on extreme events**

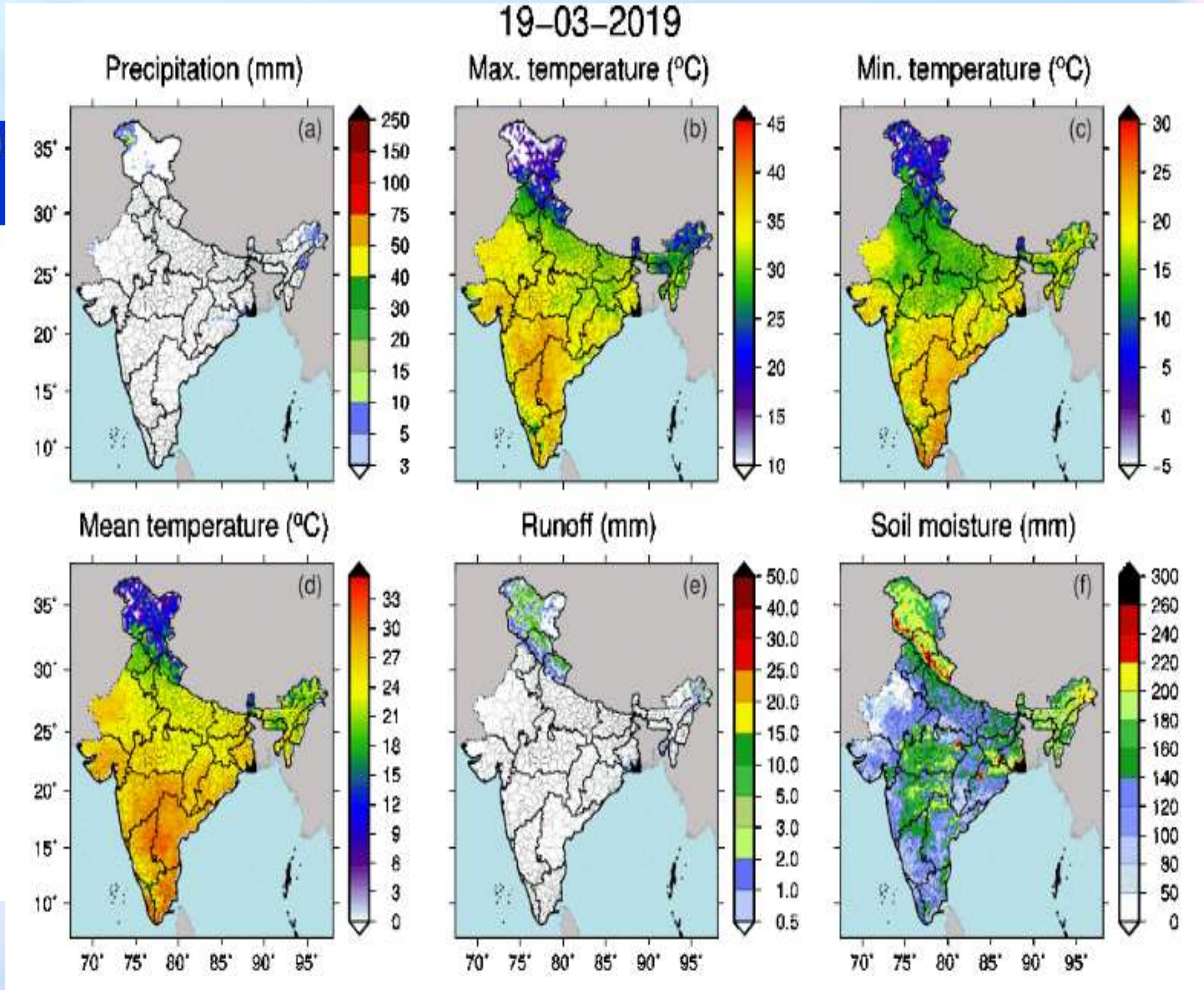
Climate Predictions Reports / Services

Sr. No.	Forecast for	Region for which forecast issued	Issued in
1	Winter Season (Jan- March) Precipitation	Northwest India	December
2	Hot Weather Season Temperature (March to May) & (April-June)	Subdivision wise	February & March
3	SW Monsoon Season (June to September) Rainfall	Country as a whole	April
4	SW Monsoon Season (June to September) Rainfall	Country as a whole	June
5	South-West Monsoon Onset	Kerala	May
6	SW Monsoon Season (June to September) Rainfall	Four broad geographical regions: Northwest India, Northeast India , Central India and South Peninsula	June
7	SW Monsoon Monthly Rainfall for July and August	Country as a whole	June
8	SW Monsoon Second half of the Season (August- September) Rainfall	Country as a whole	July
9	September Rainfall	Country as a whole	August
10	NE Monsoon Season (October to December) Rainfall	South Peninsula	September
11	Cold Weather Season (December - February) Temperature	Subdivision wise	November

Monitoring and prediction of Land-Surface Fields

Daily Soil Moisture (%) 19 March for 2019 (ending at 0830 IST) for 60 cm depth

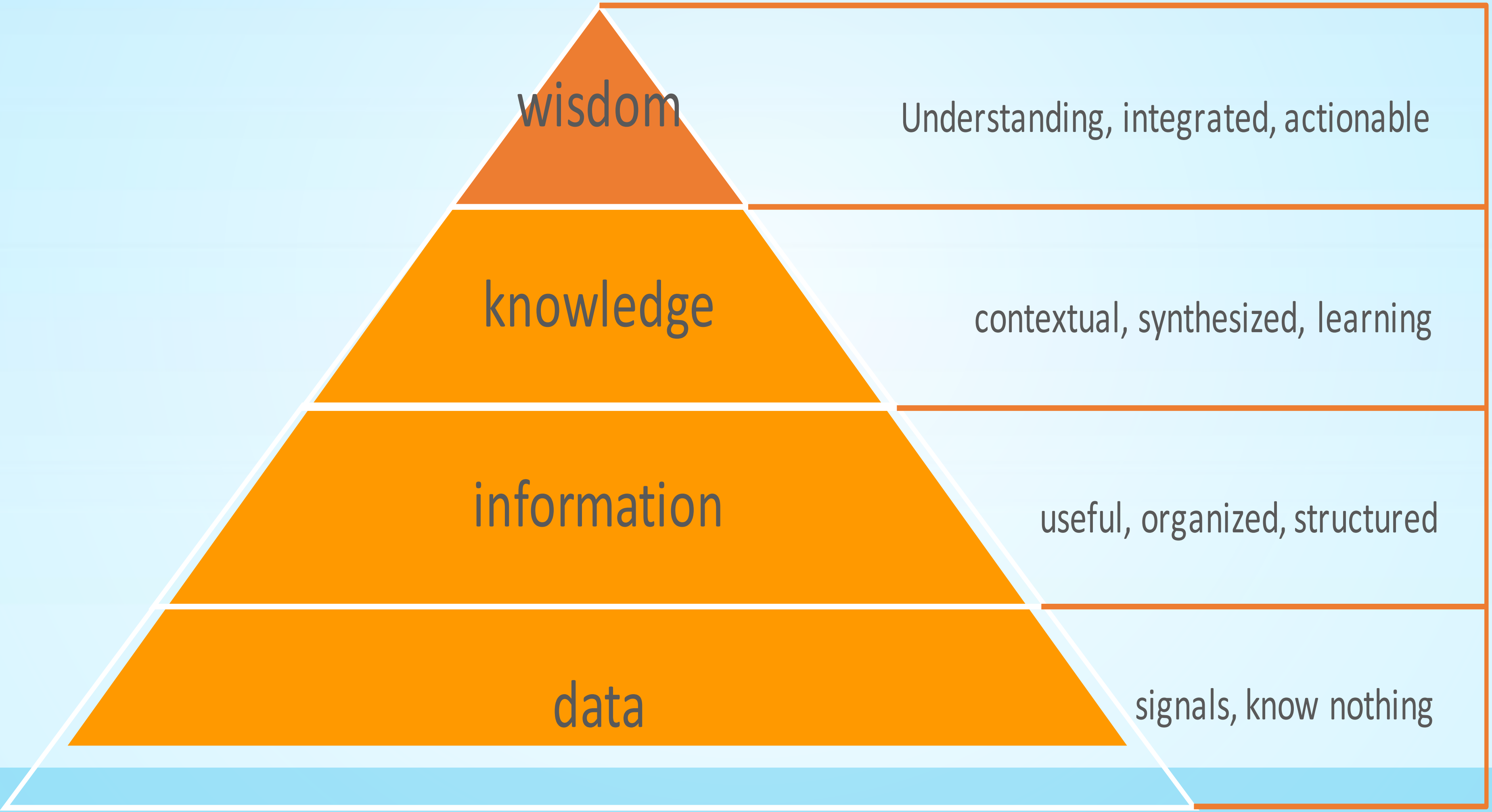




Impact Based Forecasting

CHALLENGE METHODOLOGY SOLUTION PRACTICE

Big data enabling impact-based decision-making



DRY SPELL

- A dry spell is a short period, usually 4 weeks (upto 3 weeks in case of light soils), of low rainfall or no rainfall.
- Thus, consecutive 3-4 weeks after the due date for the onset of monsoon with rainfall less than 50% of the normal in each of the weeks is defined as a Dry spell.

- This indicator is important in that it quantifies the extent of intra-season rainfall variations which is so critical for the health of crops and maintenance of soil and hydrological regime.

Monitoring and Preparedness at Policy level

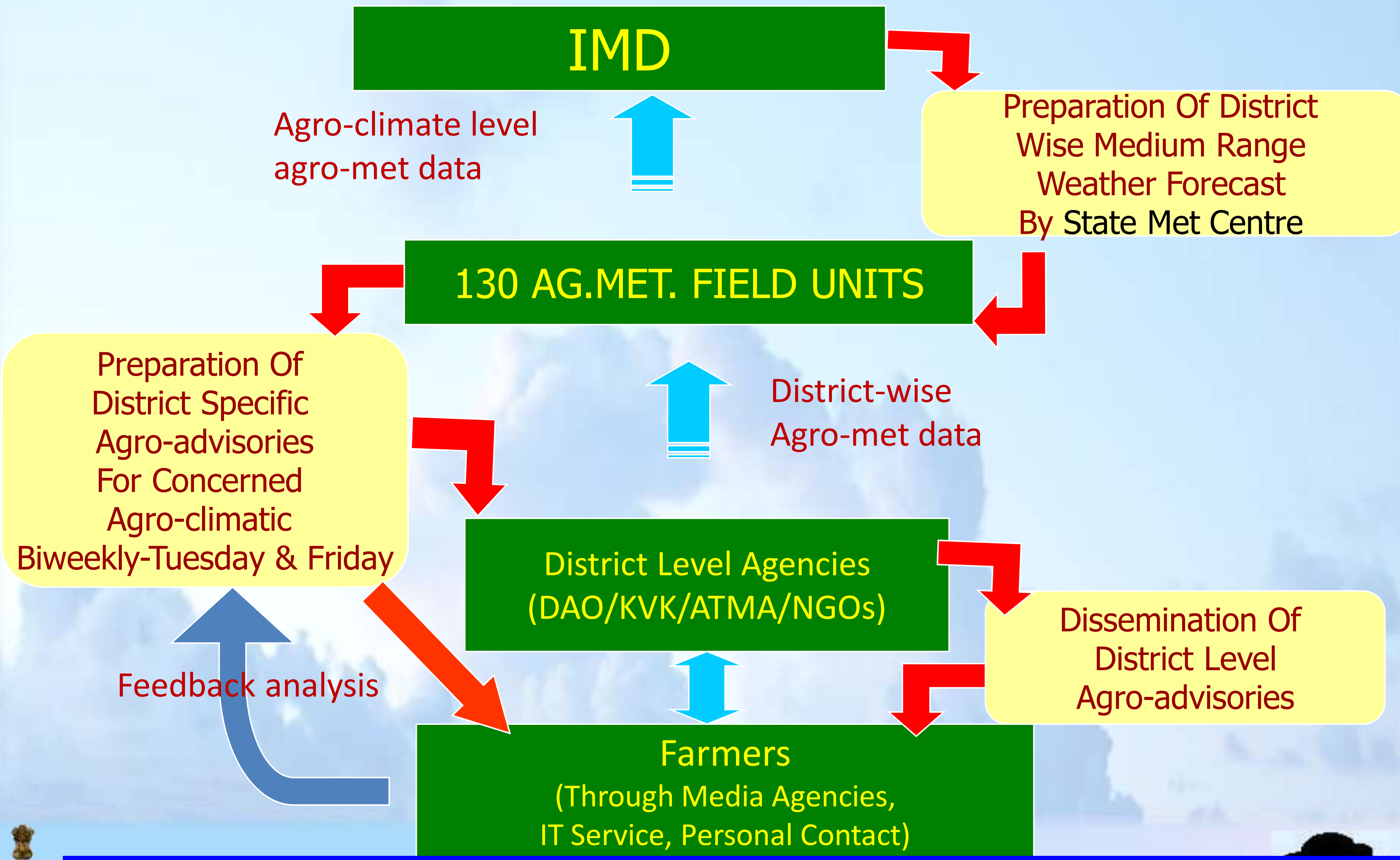
- ✓ Office of Prime Minister and other Ministers including Agriculture
- ✓ Crop Weather Watch Group (every Friday) by Ministry of Agriculture
  - Weather and climate
  - Water resources- reservoir position
  - Agriculture input and tools availability for enabling micro irrigation system
  - Credit availability
  - Insurance mechanism
- ✓ Provinces likely to be affected by deficient / excess rainfall forecast for coordination at province level to enhance action oriented preparedness.

INSTITUTIONAL MECHANISM FOR DROUGHT MONITORING

Category	Institutions/ Systems
Government of India	• Central Drought Relief Commissioner • Crop Weather Watch Group
State Level	• State Drought Monitoring Centres
Scientific & Support Organisations	• India Meteorological Department (IMD) • Mahalanobis National Crop Forecast Centre(MNCFC) • Central Research Institute for Dryland Agriculture (CRIDA) • Ministry of Water Resources, River Development and Ganga Rejuvenation (MoWR, RD & GR) • Indian Space Research Organisation (ISRO) • State Remote Sensing Application Centres (SRSACs)

Drought Management Policy (2016)

District Level Agromet Advisory Service System



Expansion of Agromet Network at District level to support district (660) / block (6500) level advisory at KVKs with outreach to Panchyat level

Economic Impact of Agromet Services

NCAER Study 2015

- 95% of surveyed farmers experienced improved reliability of service in recent years.
- The incremental profit due to AAS is assessed to be 10 to 25% of their net income.
- The Annual Economic Profit of 24% of farmers cultivating 4-principal crops (wheat, paddy, sugarcane and cotton), after using AAS in 2010, was assessed at Rs. 38,463 Crs which raised to Rs. 42,000 Crs in 2015.
- It (for 22-principal crops) has potential of generating net economic benefit up to Rs. 3.3 lakh Crs if AAS is fully utilized by 95.4 million farmer's households.

IMD Agromet–Decision Support System

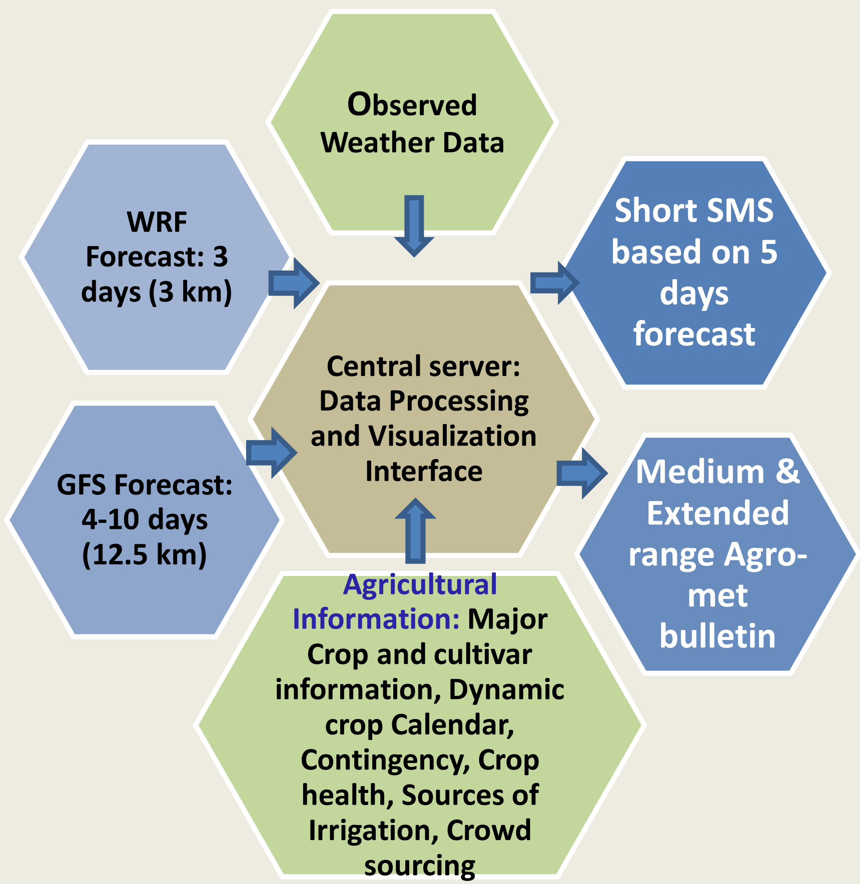
agromet.imd.gov.in

Automation of Location and Farming System specific Agromet Advisories

Modules in Use

- Forecast
  - District level
  - Block level
- Value added forcast
- Forecast Analysis
- Forecast verification
- Download
- Upload
- Access to Agromet Units

Overview



Products

Daily Soil Moisture

In Progress

- ✓ Populating agromet data
- ✓ Dynamic Crop Calendar
- ✓ Contingency plan linking
- ✓ Platform for automatic advisory preparation


THANK YOU