Perspectives on Climate Change Modelling: Results for Puducherry UT

Climate Change Webinar Series 5
Govt. of Puducherry, DSTE
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Saurabh Bhardwaj

Flow of presentation

- Context/Theory
  - Definitions
  - Causes
  - Attribution
- Evidences & projections
  - India/Coasts
- Work for Policy Makers
  - Types of policy making
  - How modelling helps
- Results for Puducherry

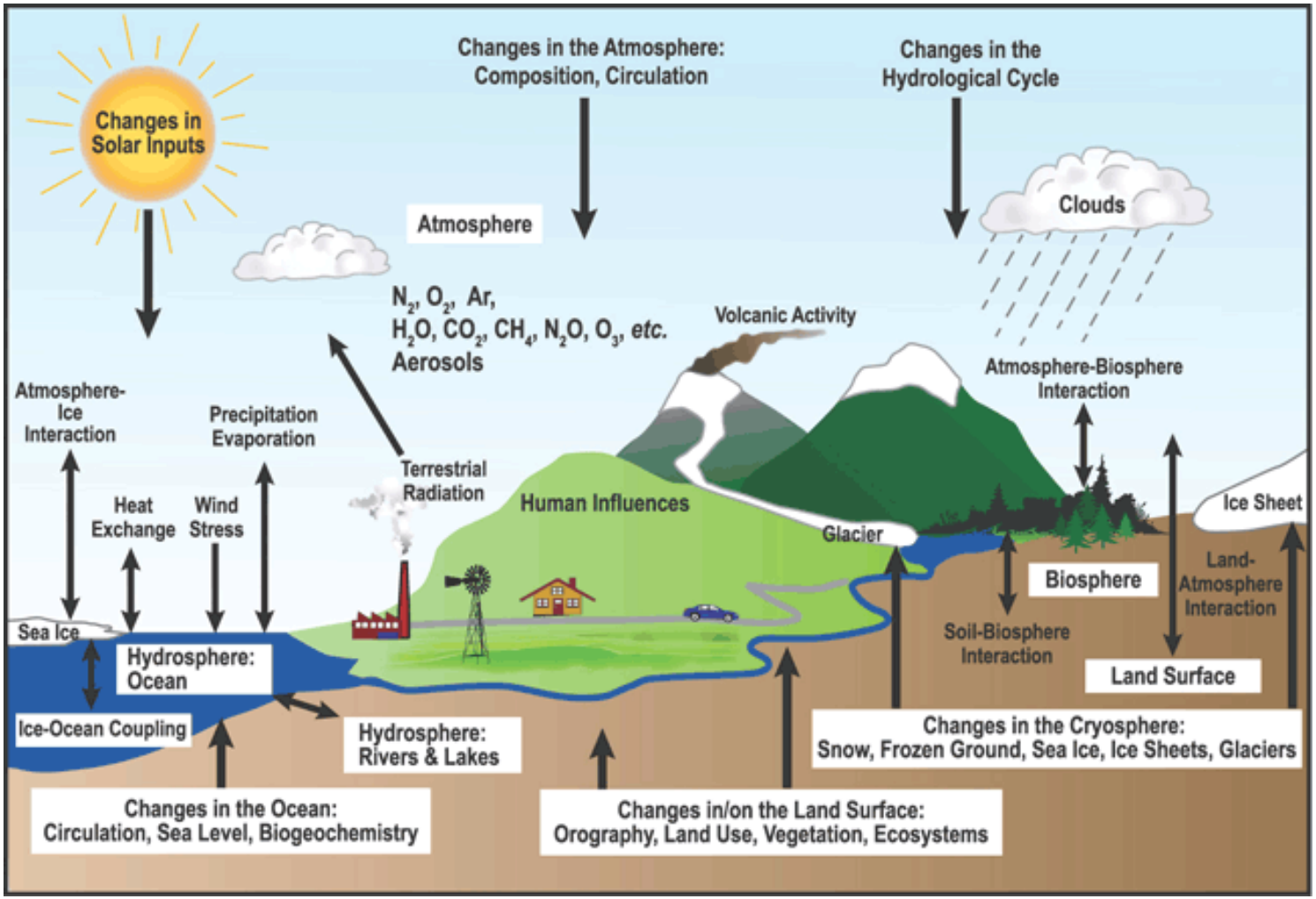
Basic Definitions

- **Weather** is the state of the atmosphere—its temperature, humidity, wind, rainfall and so on—over hours to weeks.
  - It is influenced by the oceans, land surfaces and ice sheets, which together with the atmosphere form what is called the 'climate system'.

- **Climate**, in its broadest sense, is the statistical description of the state of the climate system.

- **Climate change** is a change in the statistical properties of the climate system that persists for several decades or longer—usually at least 30 years.
  - These statistical properties include averages, variability and extremes.

Interactions



Pic . NOAA

The non-linear interaction among the components leads to climate variability at a range of spatial and temporal scales

What is a Model ?

"a simplified description, esp. a mathematical one, of a system or process, to assist calculations and predictions"

- dictionary

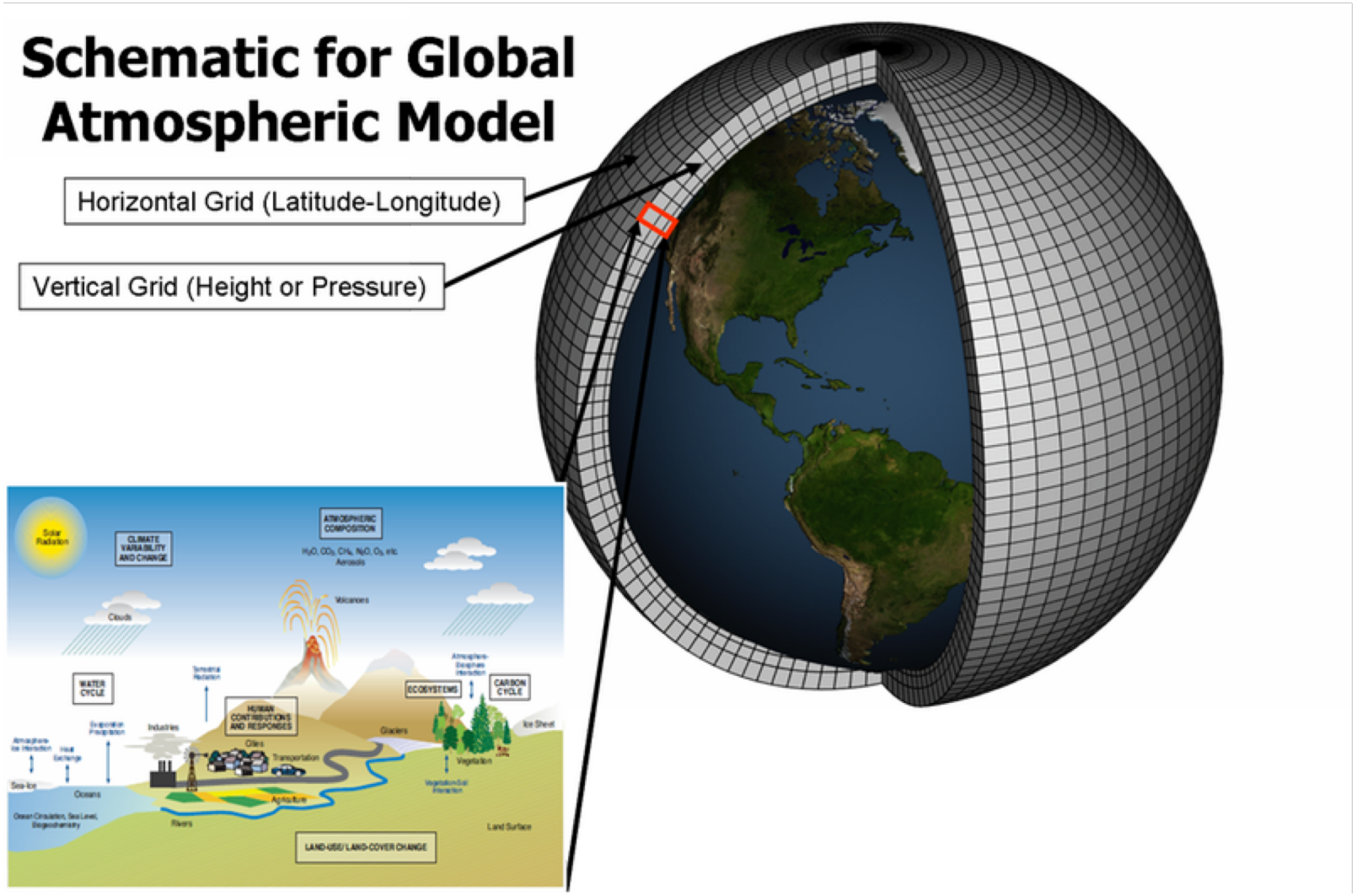
How do we define a Climate Model ?

"A climate model is a mathematical representation of the physical processes that determine climate"

Why do we need Climate Models ?

- To create an understanding of the climate processes.
- To create plausible-scenarios, reflecting the current state of scientific understanding.
- To plan for the future.

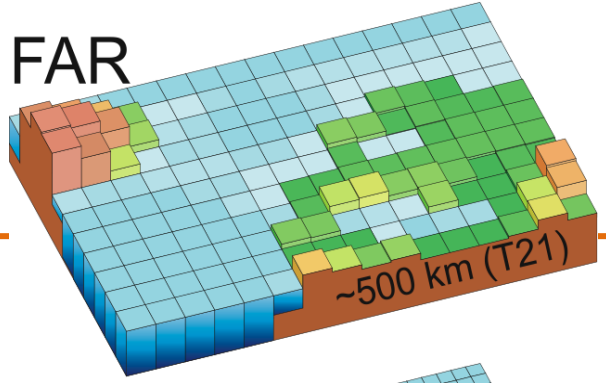
Numerical Solution: Time steps and Grid boxes

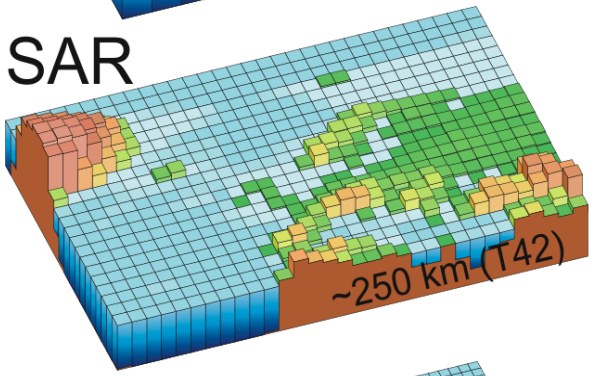


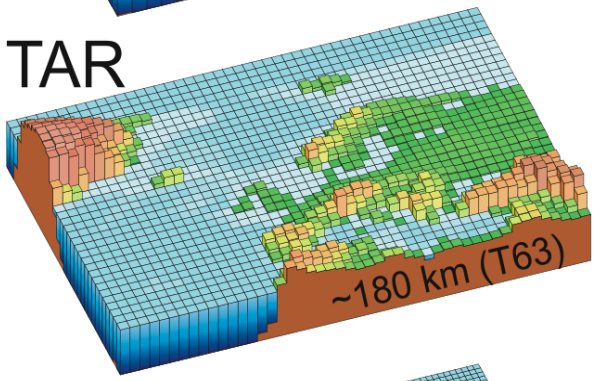
All the physical processes occurring in the climate system are resolved at individual grid and the coupling occurs at these grids.

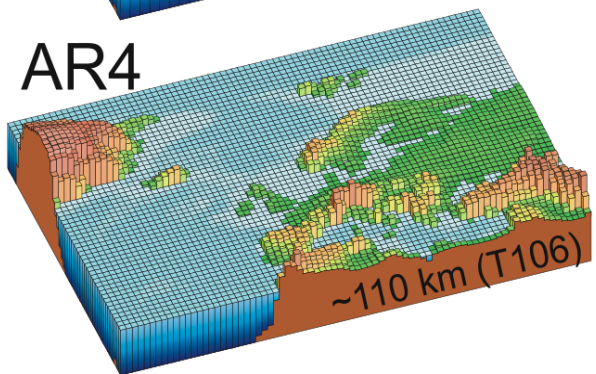
Source: NASA

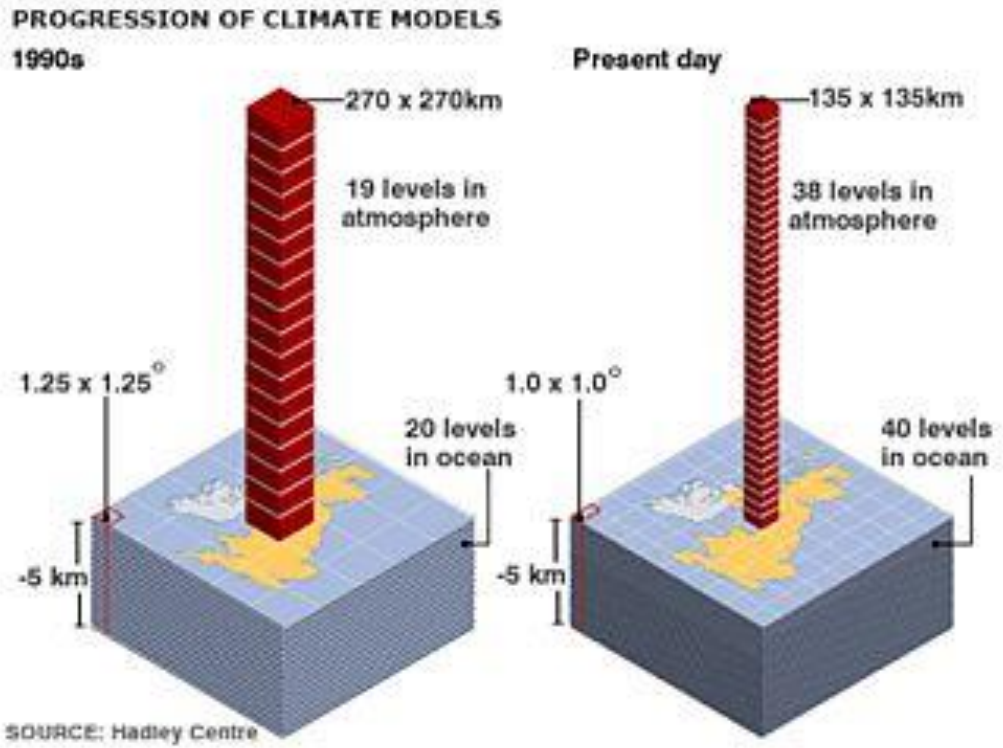
Improvements in Grid resolution





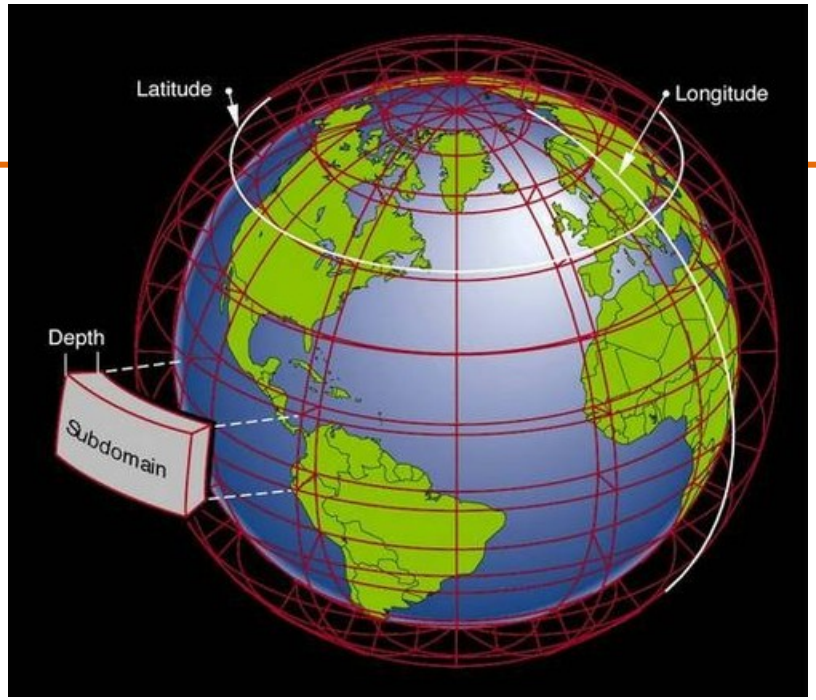




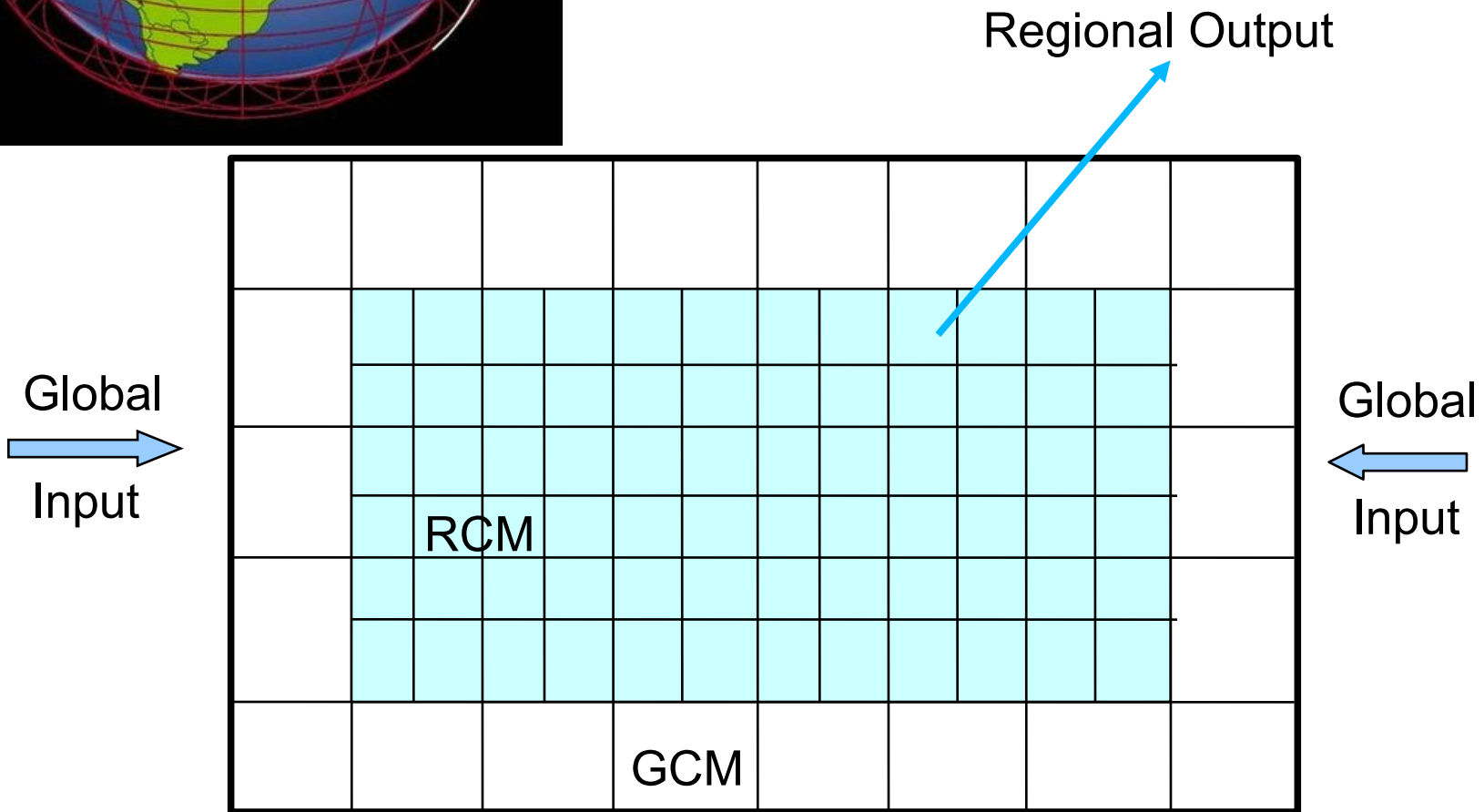


AR5: ~70km maximum horizontal resolution; up to 90 layers in the atmosphere and over 60 in the ocean.

Downscaling

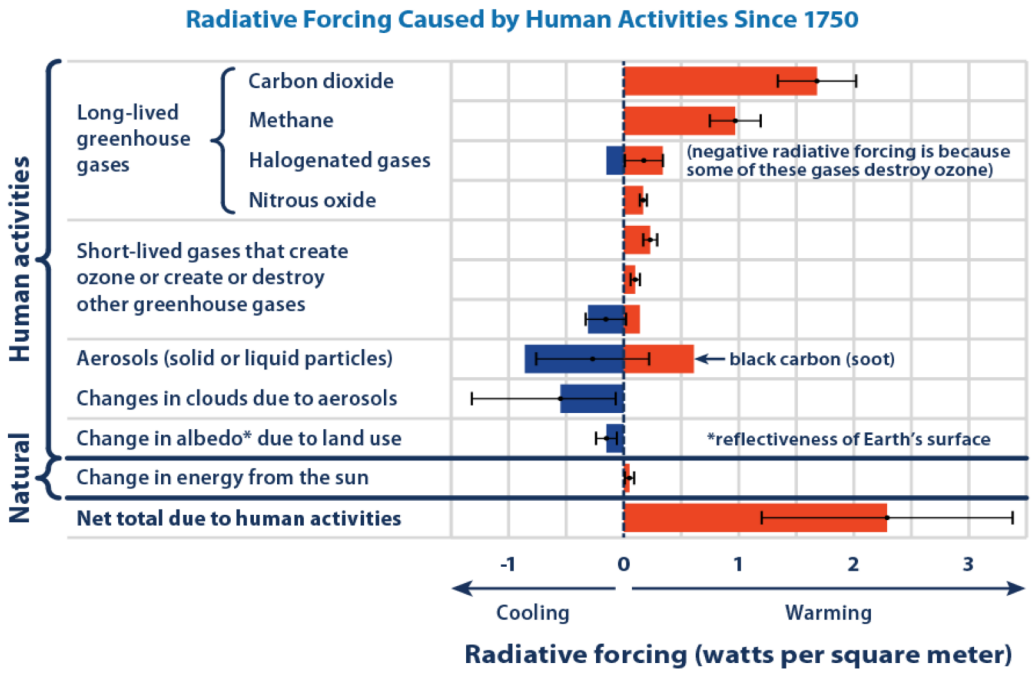


Dynamical Downscaling



Causes – Climate Variability

- Natural processes, such as changes in the Sun's radiation, volcanoes or internal variability in the climate system, or
- Due to human influences such as changes in the composition of the atmosphere or land use.

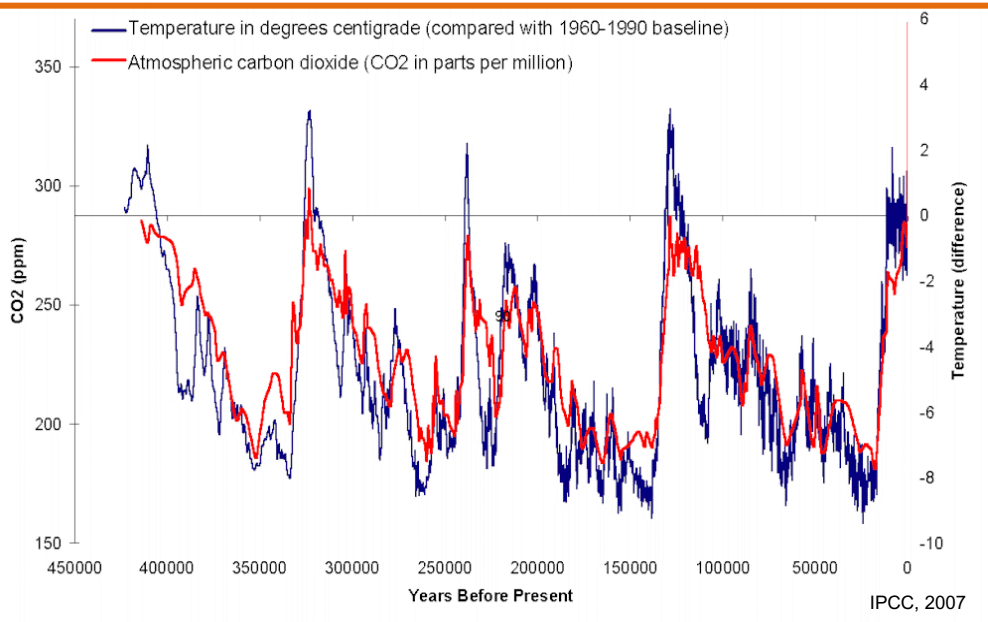


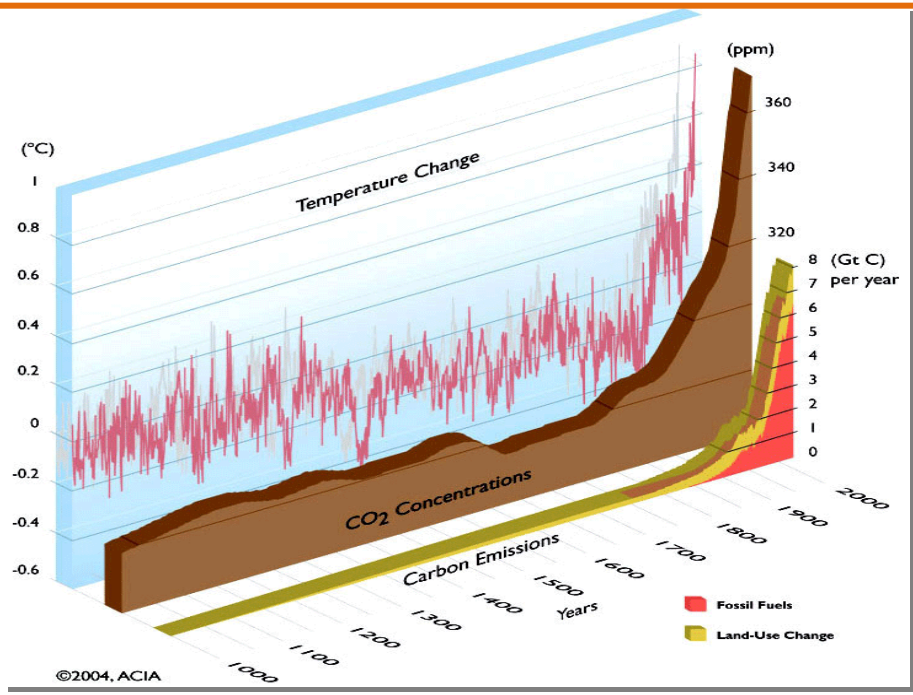
Data source: IPCC (Intergovernmental Panel onClimate Change). 2013. Climate change 2013: The physical science basis. Working Group I contribution to the IPCC Fifth Assessment Report. Cambridge, United Kingdom: Cambridge University Press. www.ipcc.ch/report/ar5/wg1.

For more information, visit U.S. EPA's "Climate Change Indicators in the United States" at www.epa.gov/climate-indicators.

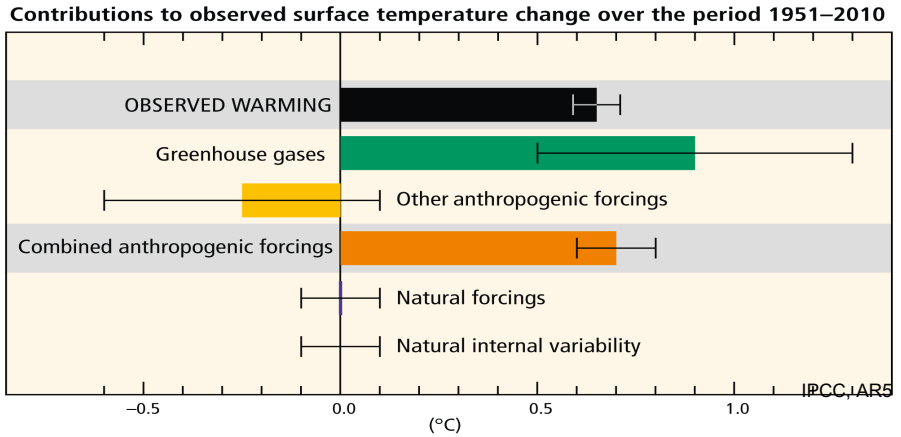
Carbon dioxide is causing the bulk of the forcing.
On average, it lives more than a hundred years in the atmosphere and therefore affects climate over long time scales.

CO2 – the culprit?



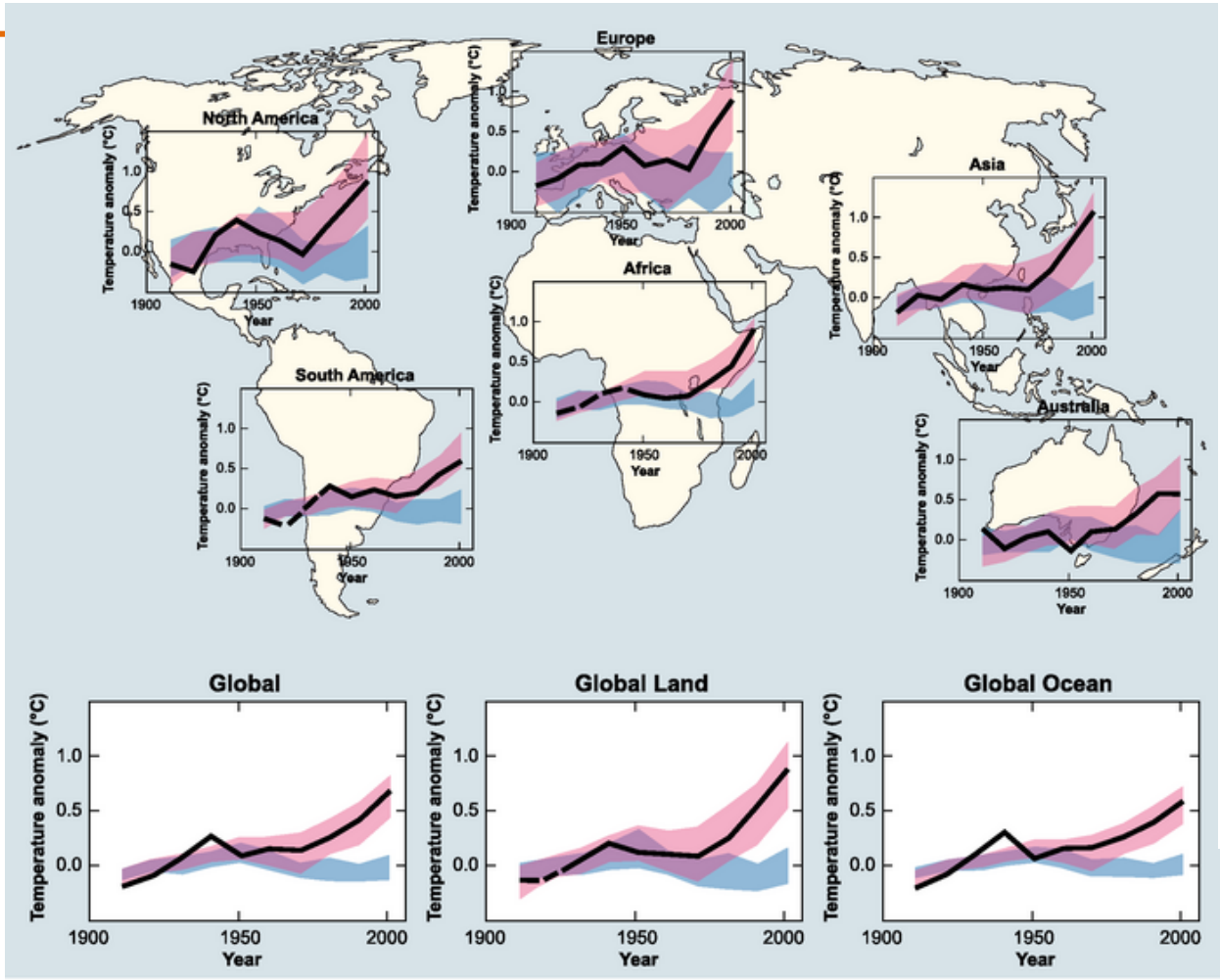


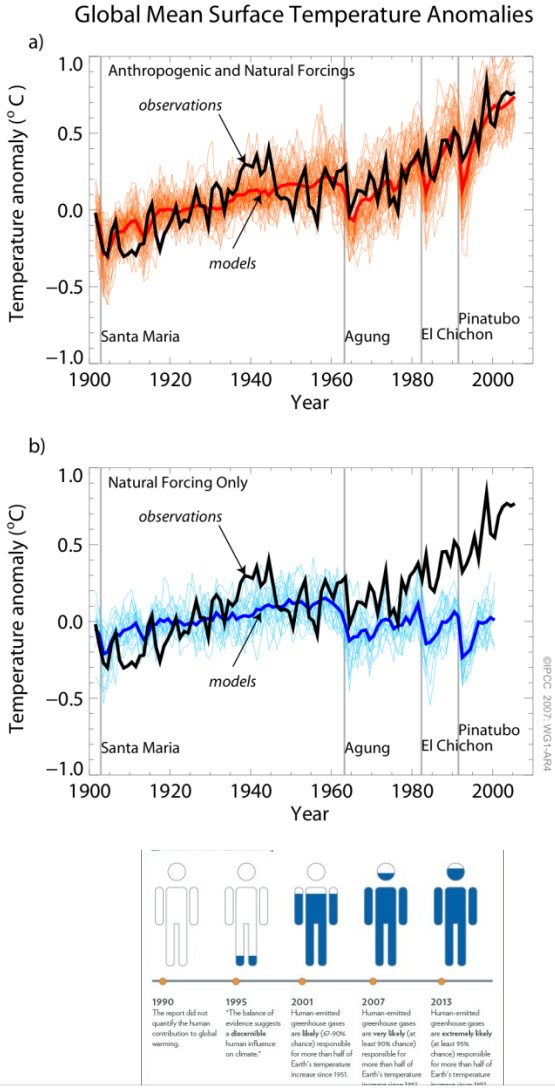
- Atmospheric CO2 concentrations have increased by more than 40% since pre-industrial times, from approximately 280 parts per million by volume (ppmv) in the 18th century to over 400 ppmv in 2015.
- The current CO2 level is higher than it has been in at least 800,000 years.



Attribution

Asks whether observed changes are consistent with expected responses to forcings.

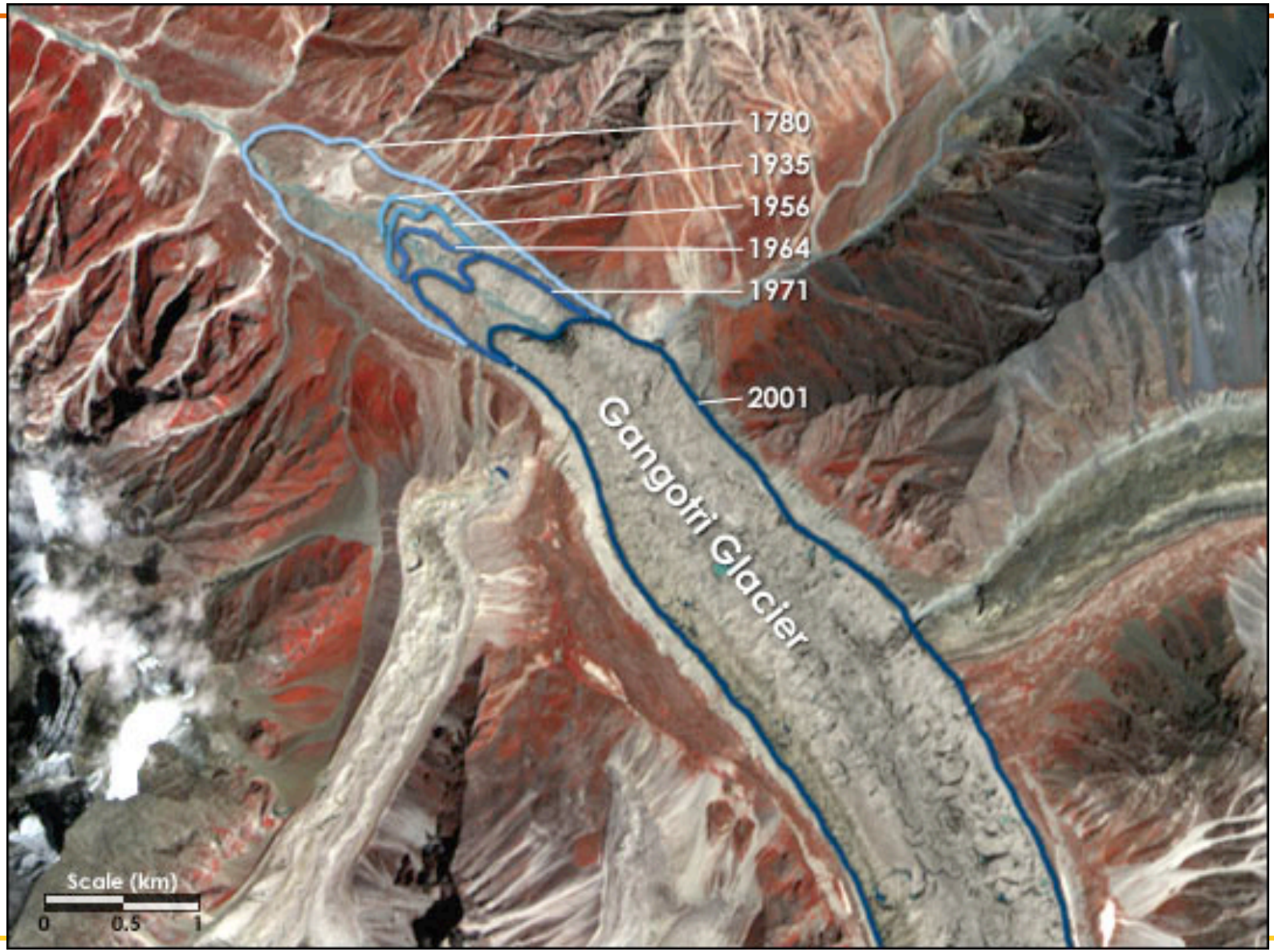




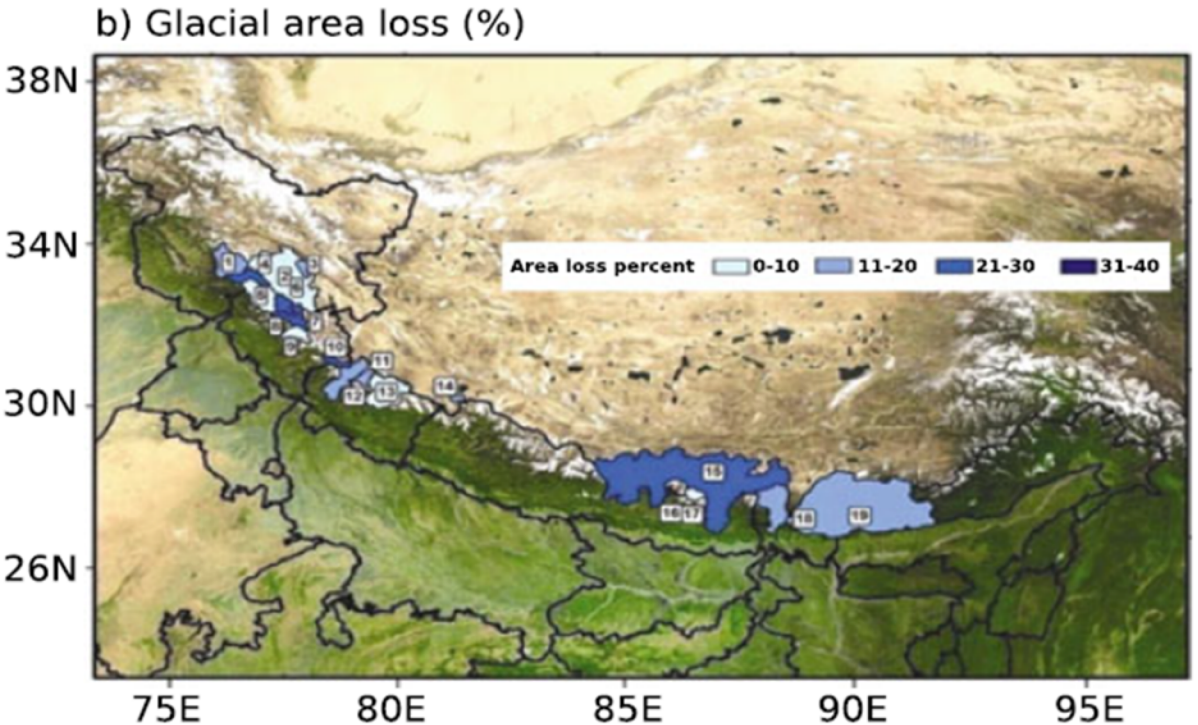
Most of the observed increase in globally averaged temperatures since the mid-20th century is extremely likely (>95% certainty) due to the observed increase in anthropogenic greenhouse gas concentrations.

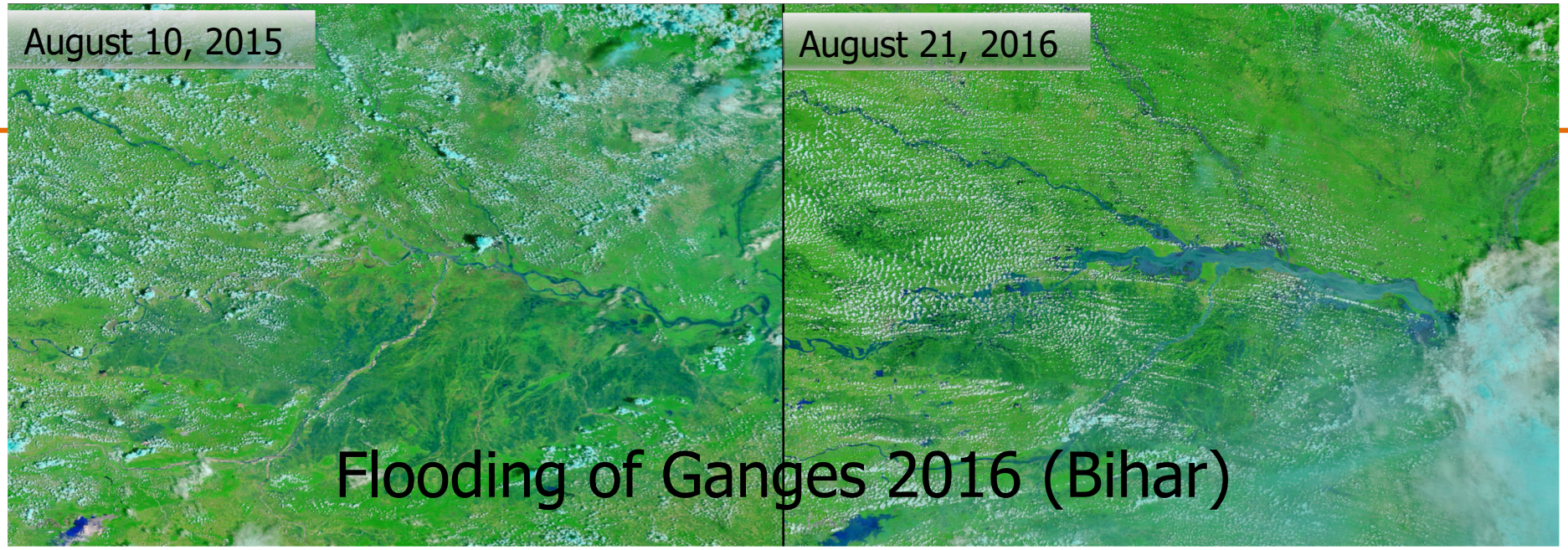
Evidences and Indicators of climate change (India context)

Gangotri Glacier

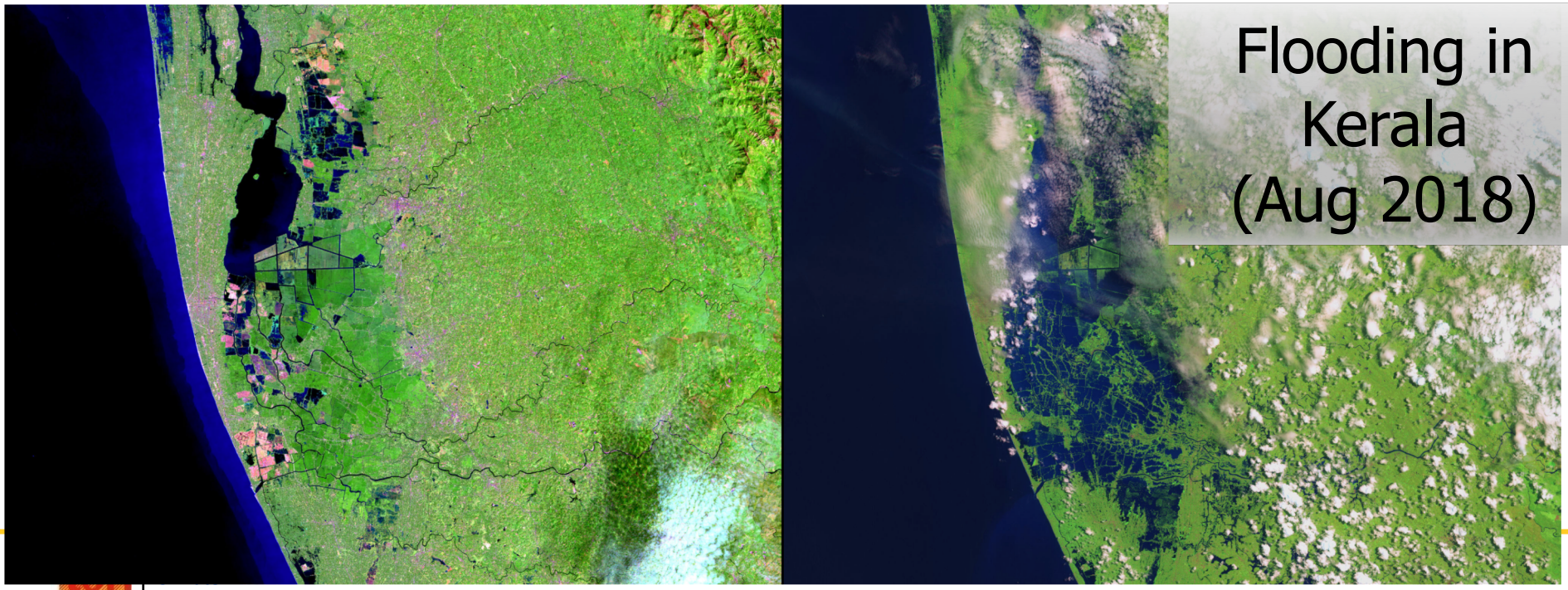


Glacial Retreat And Loss





Flooding of Ganges 2016 (Bihar)



Flooding in Kerala (Aug 2018)

Multiple complementary indicators of a changing global climate

Each line represents an independently derived estimate of change in the climate element.

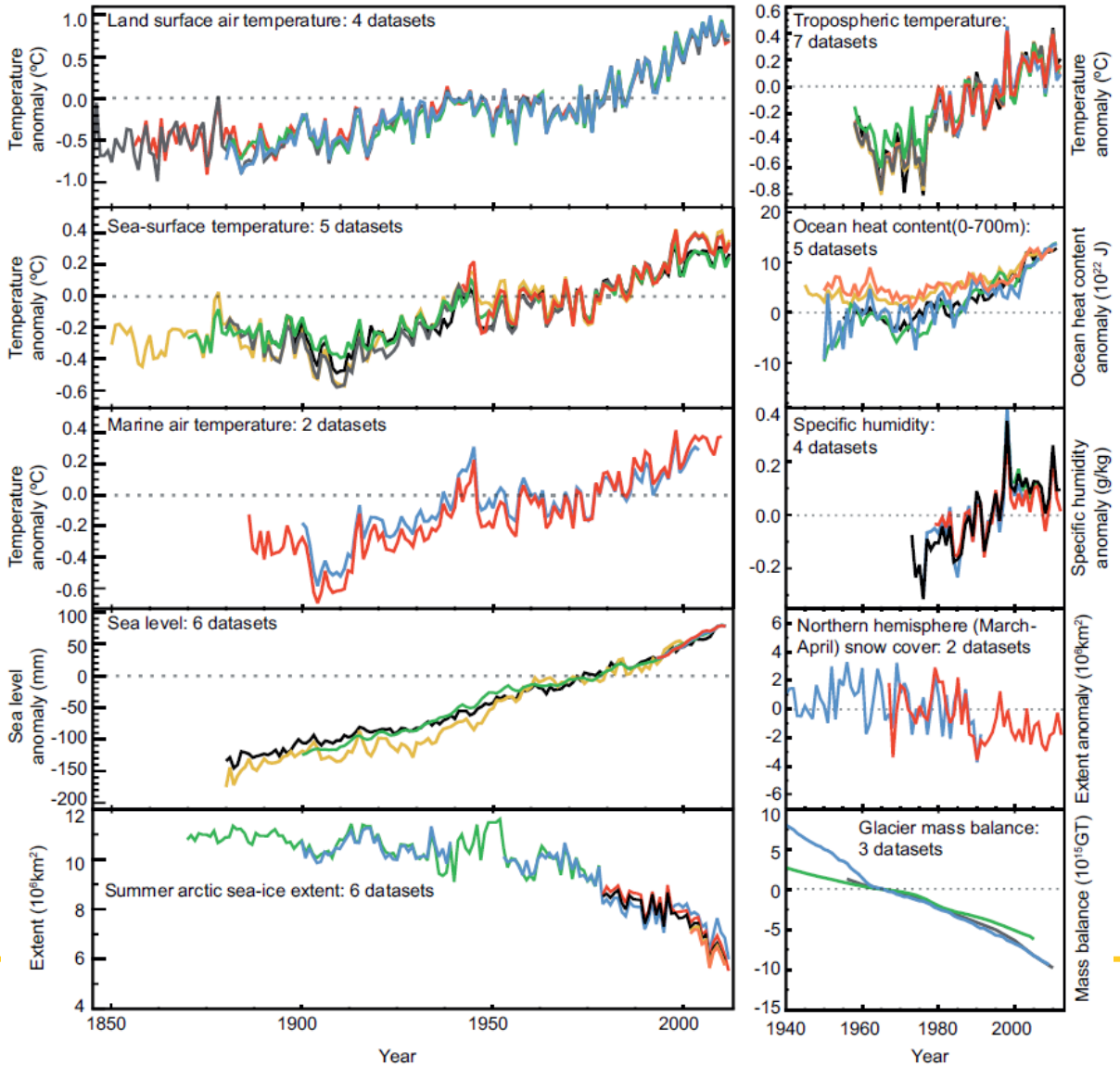
Land surface temperature increasing

Sea surface temperature increasing

Marine air temperature increasing

Sea level rising

Sea-Ice declining



Troposphere is warming

Oceans are warming

Humidity increasing

N-H snow cover declining

Glacial Mass declining

teri | Climate

IPCC, 2013, AR5 WG1

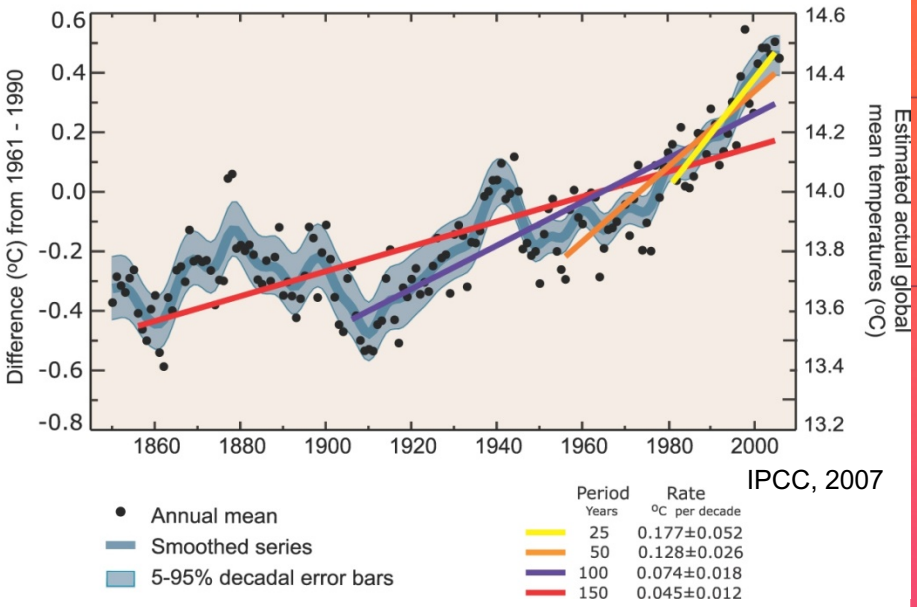
Climate Change Evidences and projections – Global to regional

The five warmest years in the global record have all come in the 2010s

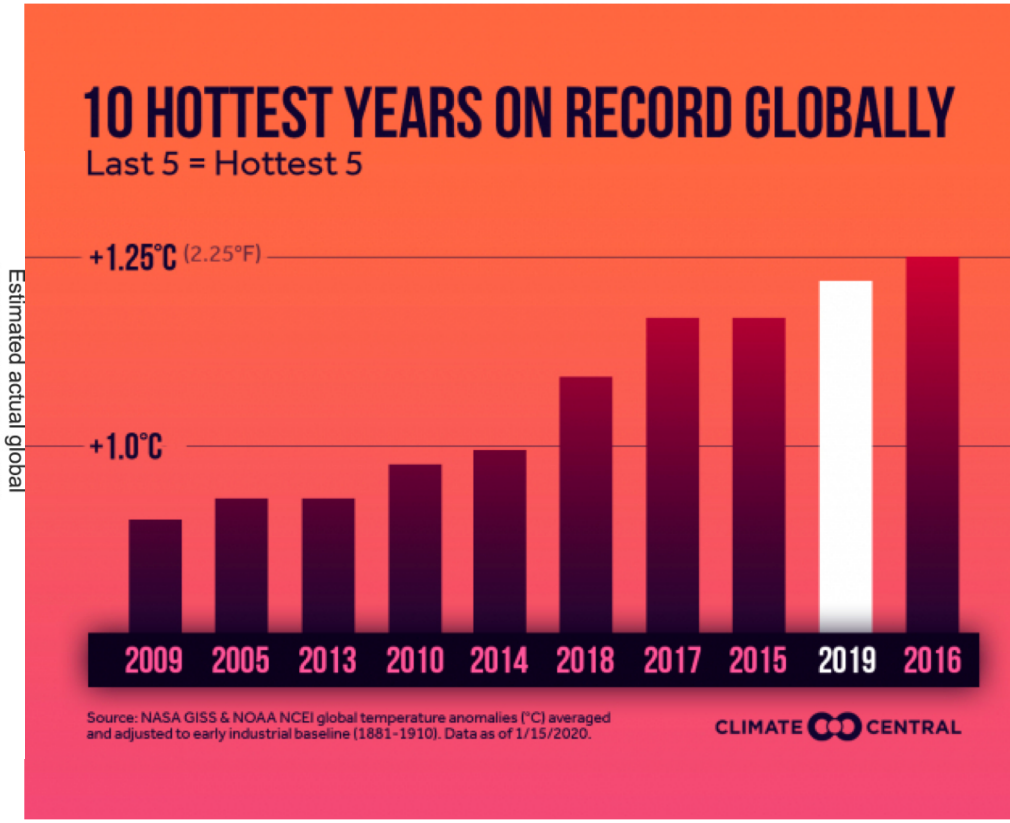
The 10 warmest years on record have all come since 1998

The 20 warmest years on record have all come since 1995

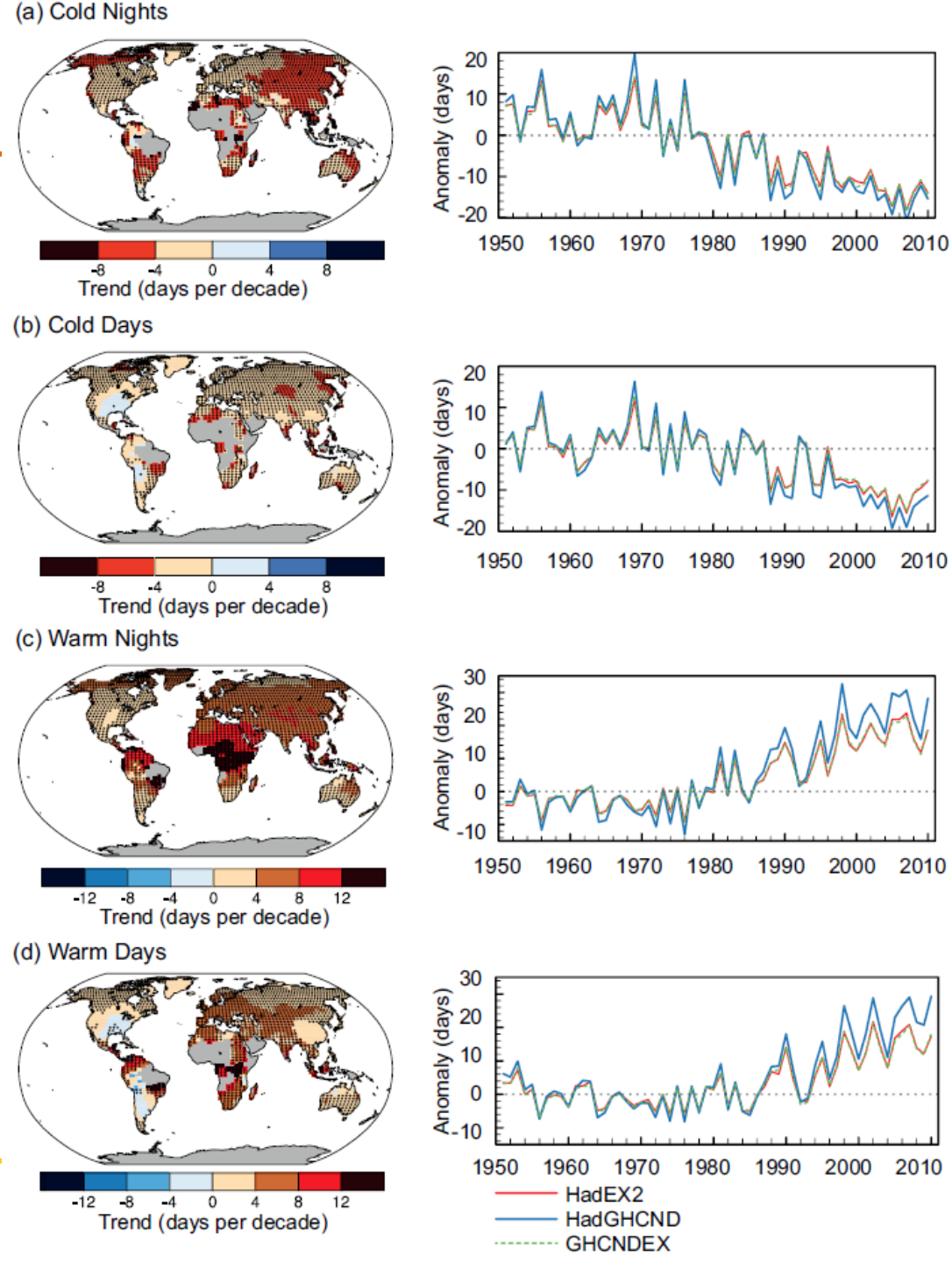
Changes in Global Average temperature



IPCC, 2007



India: Thirteen out of the 15 warmest years since 1901 were the past 15 years (2002-2016) and the last decade (2001-2010/ 2007-2016) was also the warmest on record



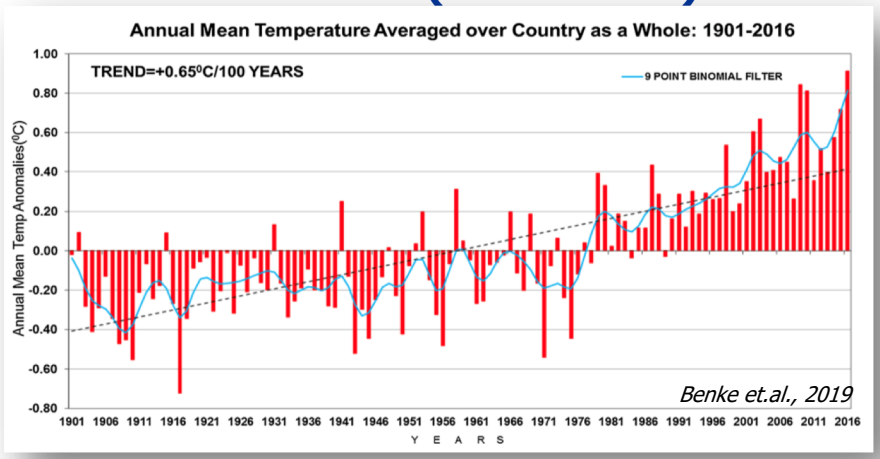
Decreasing cold nights and days

Increasing warm nights and days

IPCC, 2013, AR5 WG1

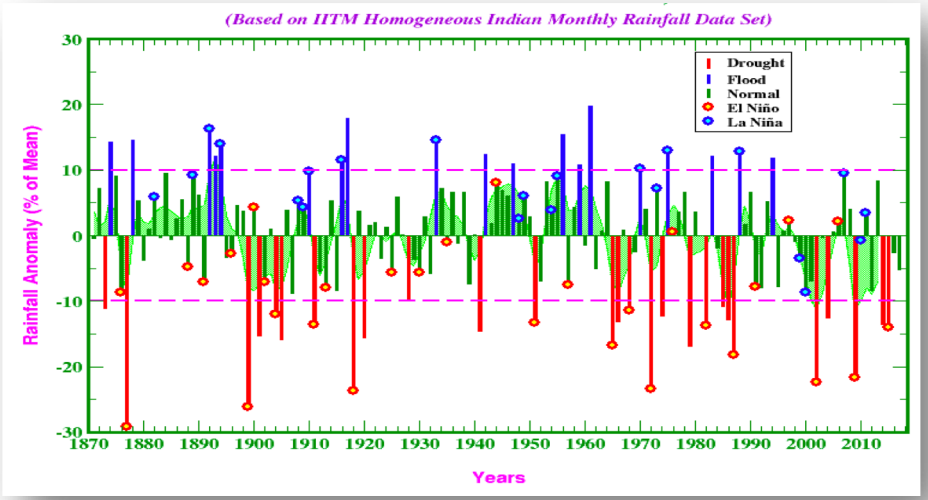
India Context

All India Mean Annual Temperature Anomalies (1901-2016)



The trend of warming in recent past (1971-2016) is higher over India and comparable to global trend in warming

All India Summer Monsoon from 1871-2017



All-India monsoon season rainfall time series shows NO long term trends. It is marked by large year to year variations.

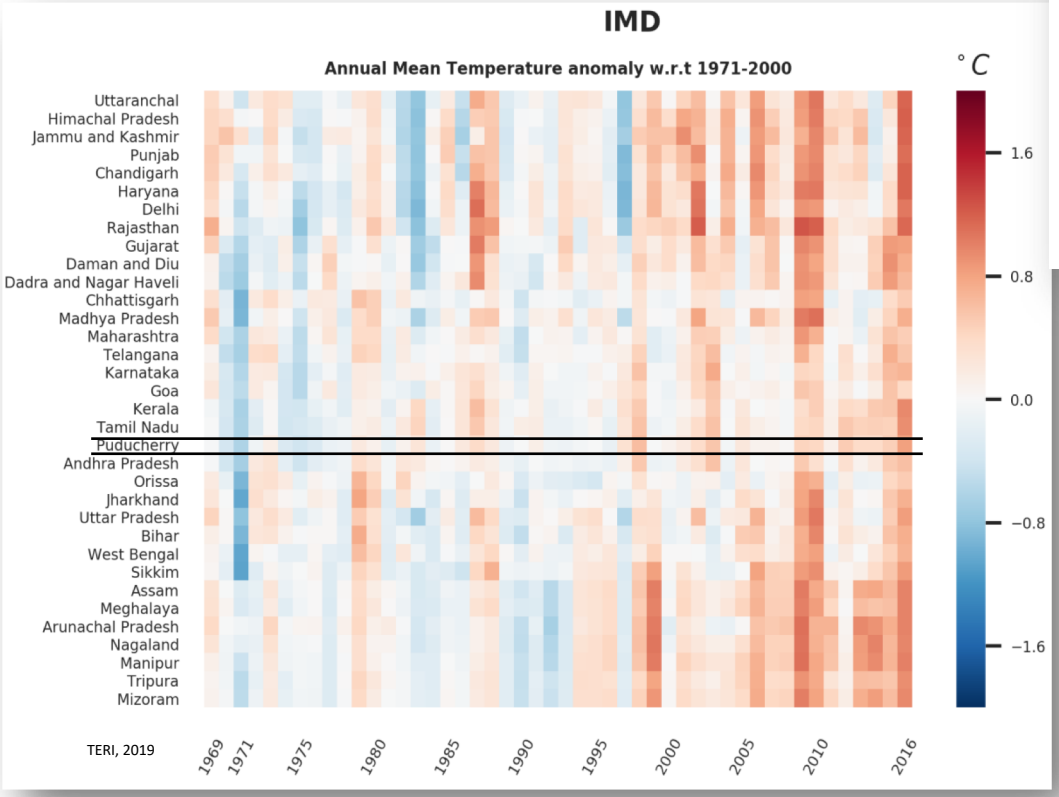
Thirteen out of the 15 warmest years since 1901 were the past 15 years (2002-2016) and the last decade (2001-2010/ 2007-2016) was also the warmest on record.

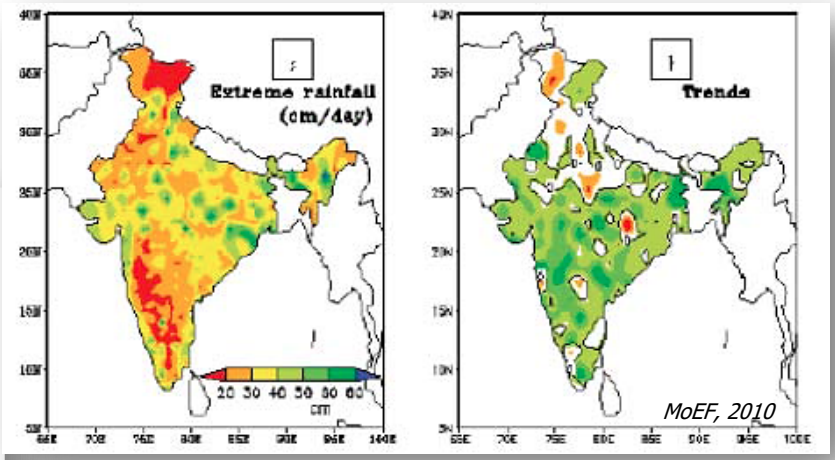
Sea level along the Indian coast has been rising at the rate of about 1.3mm/year on an average and projected to rise due to influences from global rise and regional effects.

Increasing SLR and intense cyclones have caused coastal flooding due to storm surges in the past. The trend will continue in the future with higher surge heights making coastal inundation a big concern.

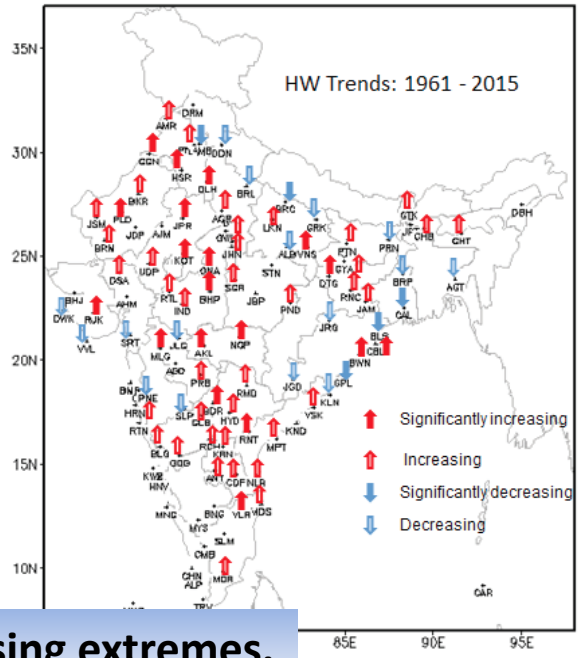
MoEF 2010, SREX, 2012

All India Annual Mean Temperature Anomalies (1969-2016) (Base: 1971-2000)





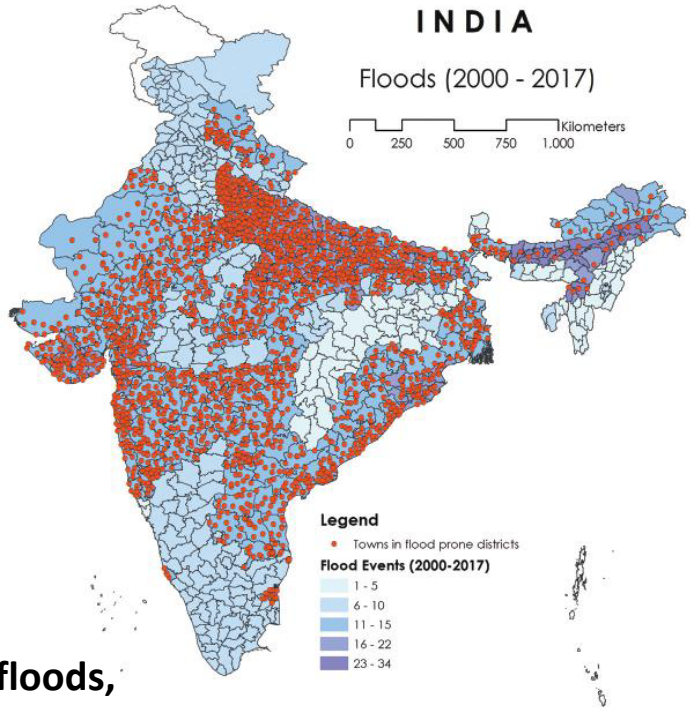
The extreme rainfall have increased over India with positive trends over most places

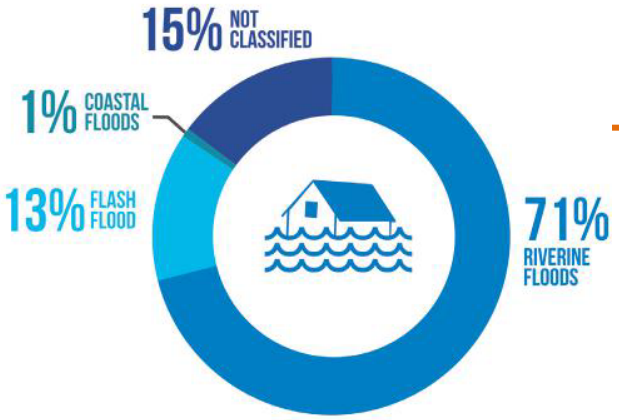


Regional Trends are high with higher warming in recent past.

Significant evidences and analysis on increasing extremes.

2292 Cities & towns located in districts with atleast 11 flood events



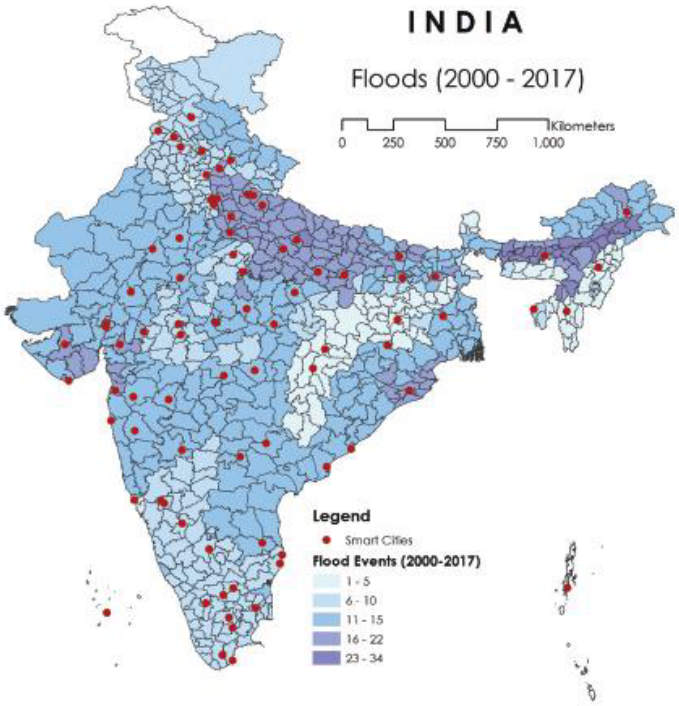


Lakhimpur, Assam: hit by 31 floods, i.e. approximately two flood events every year!

Leh: flash floods of 2010. 9 flood events since 2000.

Rajasthan: have received more than the national average of 11 events over the last 18 years.

Gujarat: mean of 15 events, including Kutch.

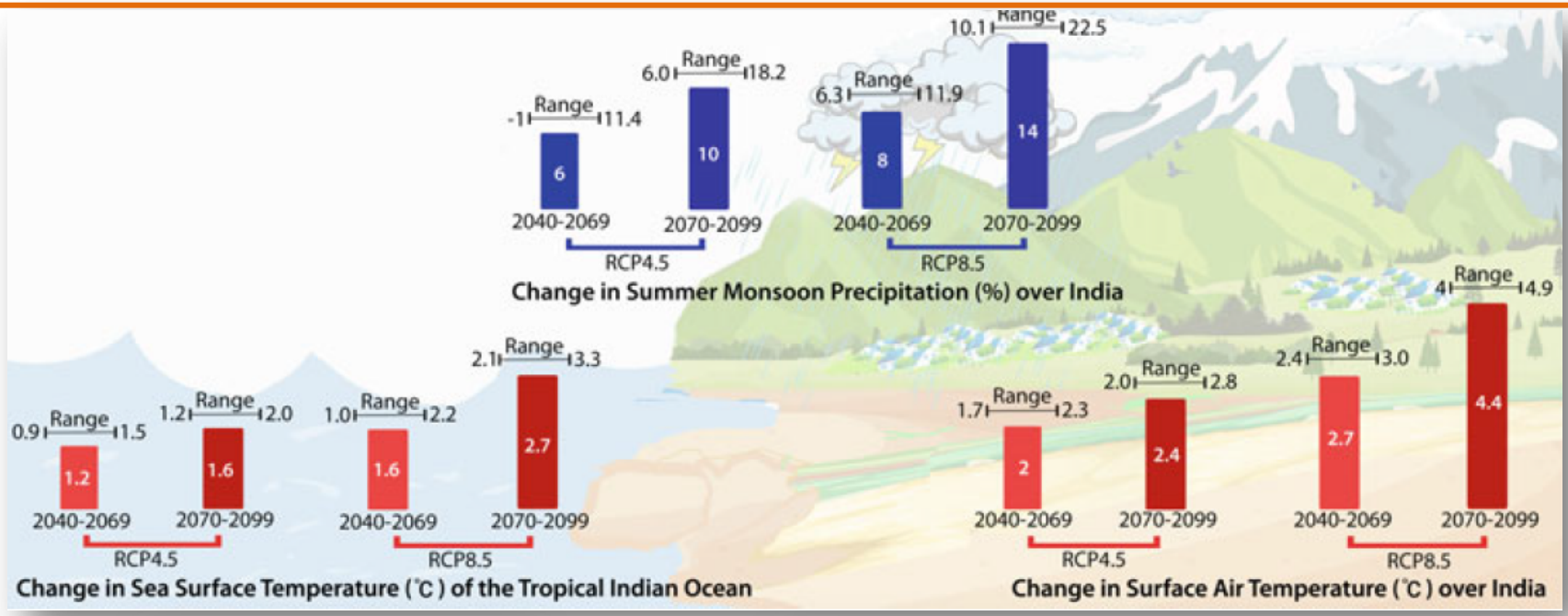


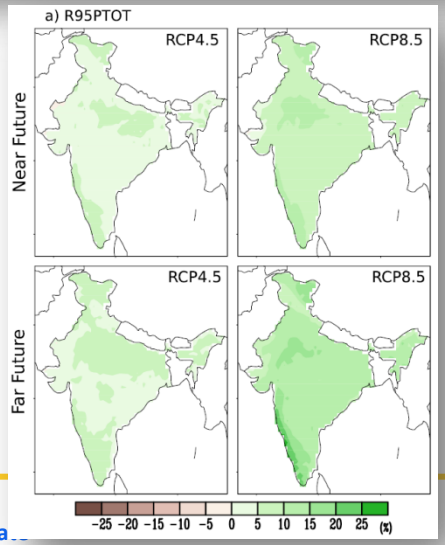
56% smart cities in districts with flood event higher than mean

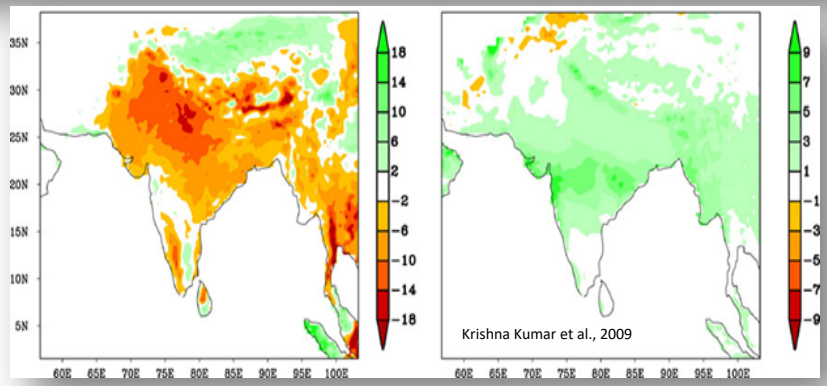
Source: SEEDS and CRED, 2018

PROJECTIONS

India context for future





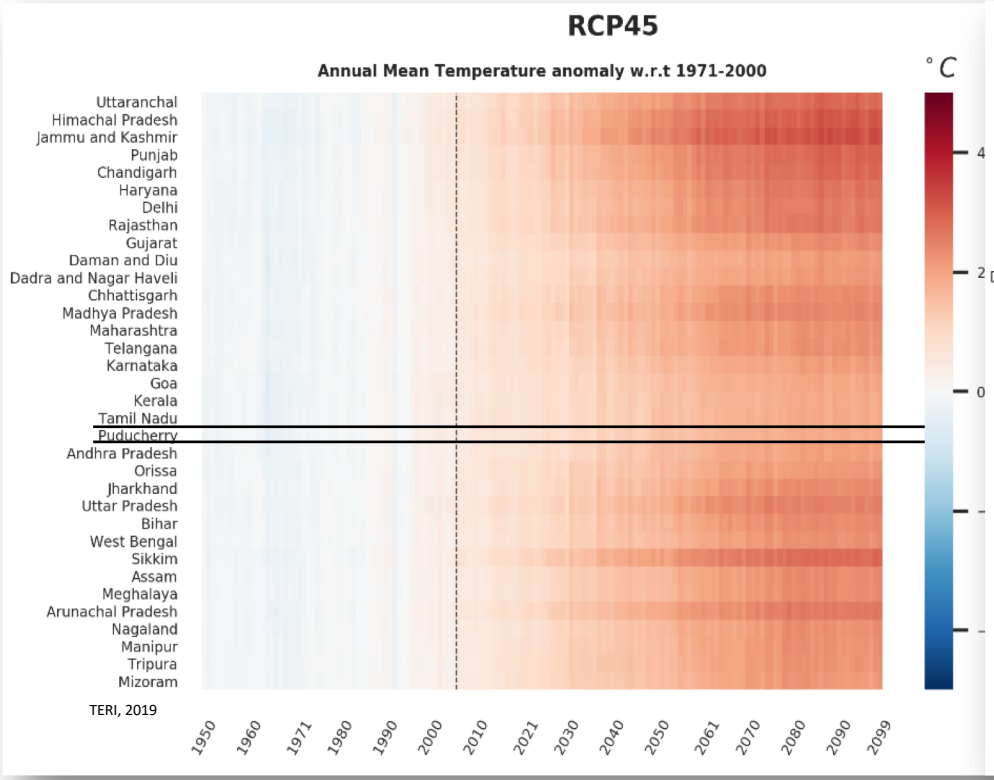


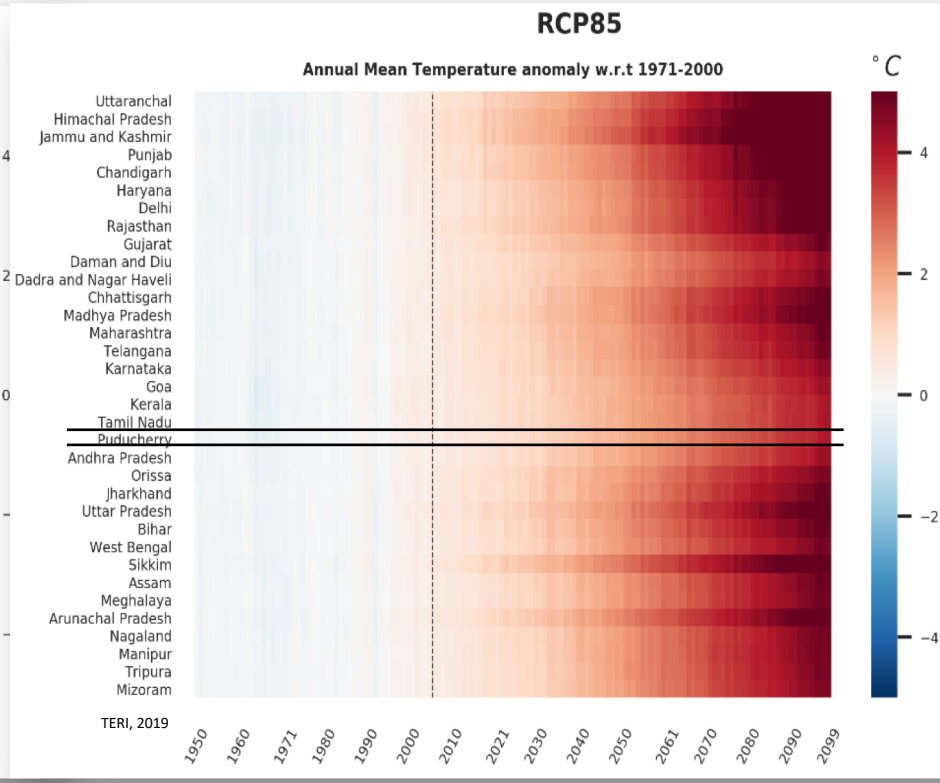
Projected future change in number of rainy days (rainfall >2.5 mm) during monsoon season (JJAS).

Projected change in the intensity (mm/day) of rainfall on a rainy day.

MoES, 2020

India context for future



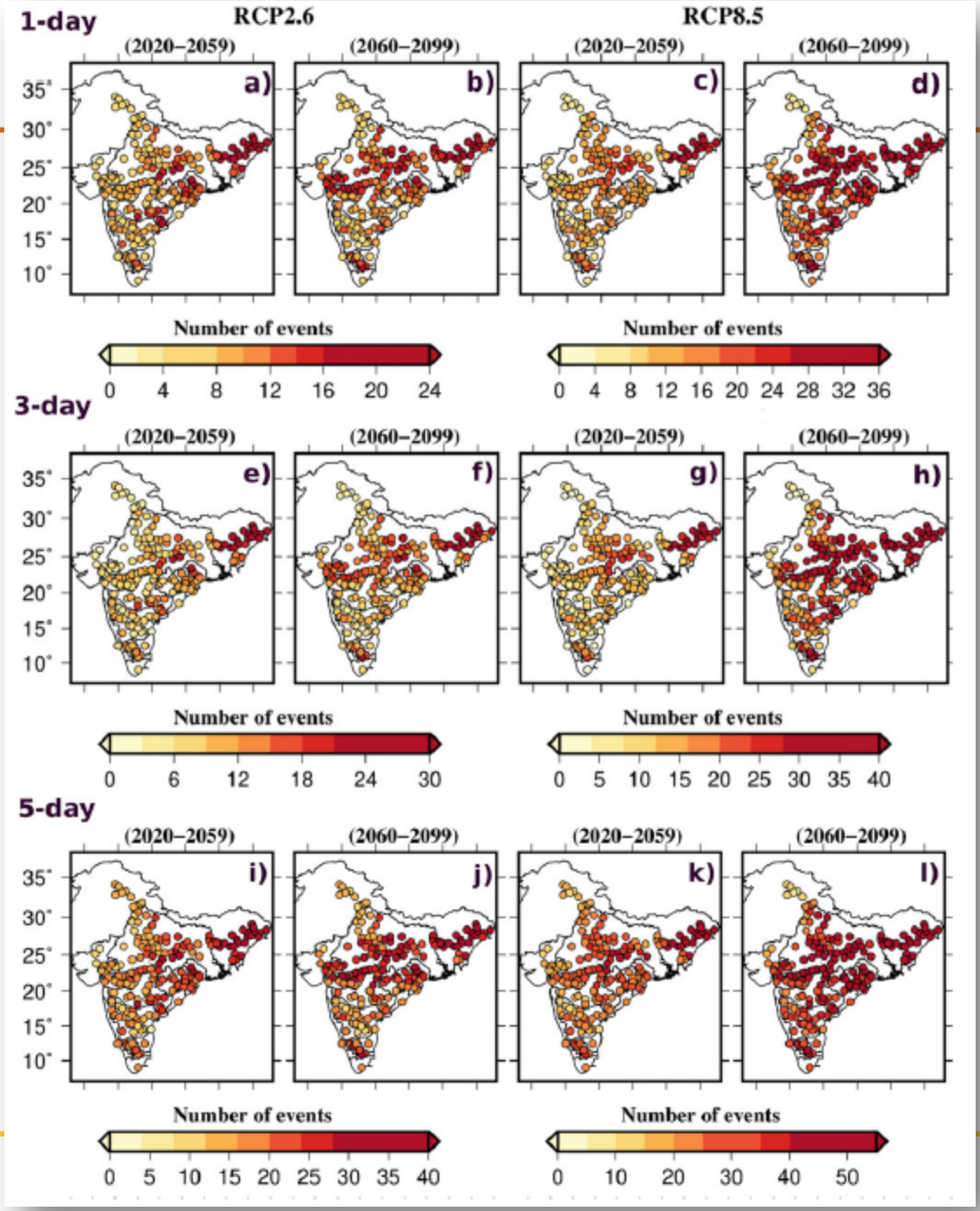


Significant evidences and analysis on increasing extremes in future on India wide / homogeneous scale

Future Flooding

Models indicate an increase in frequency of urban and river floods, under different levels of warming, 1.5 and 2.0 °C, as in association with an expected rise in heavy rainfall occurrences

Flood frequency and associated risk are projected to increase over the major river basins of India, with a higher risk for the Indus-Ganges-Brahmaputra river basins



Expected Effects over India

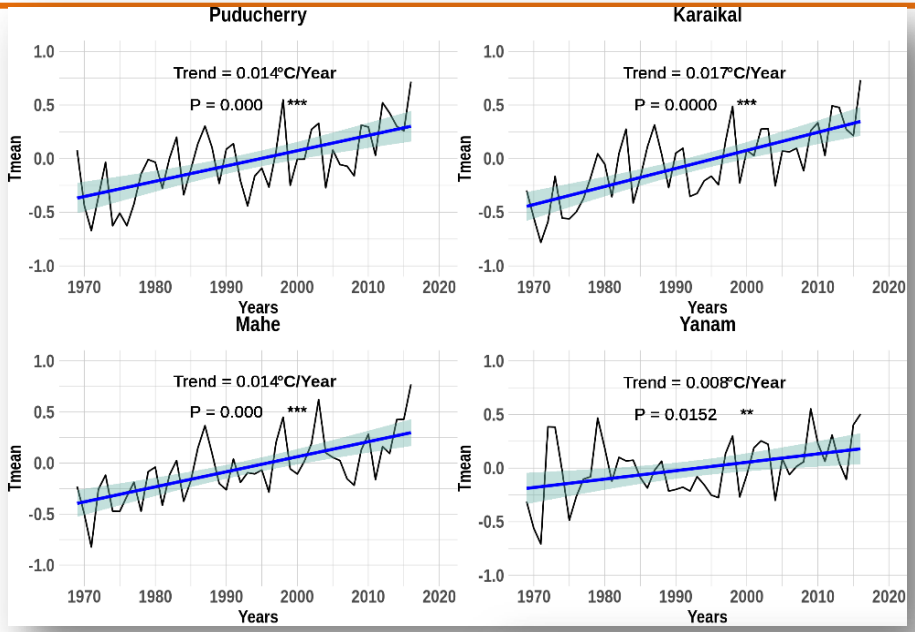
- **Temperature:** Rise between 1.7° to 2.0°C by 2030s and 3.5° to 4.3°C by 2080s
  - on avg. 27 more hot days (>45°) each year and around 1.3 more consecutive hot days (heat waves) events each year for next 30 years.
- **Precipitation:** Highly variable and unpredictable, avg. 0.3%-15% all India by 2030s and 9-15% by 2080s.
  - with around 4 – 18 more days of very high rainfall in near future (till 2050s).
- **Extremes:** Both temp and rainfall extremes to increase in future:
  - higher minimum temperatures and more intense rainy days as well as more drier days
- **Cyclones:** A decrease in projected number of cyclonic disturbances along both the coasts by 2030s but intensity to increase.
- **Storm Surges:** 5%-20% increase in 100-year return periods of storm surges over East coast in 2030s.
- **Sea Level Rise: Sea Level Rise:** At the end of the twenty-first century, steric sea level in the NIO is projected to rise by approximately 300 mm relative to the average over 1986–2005 under the RCP4.5 scenario

Climate analysis over Puducherry

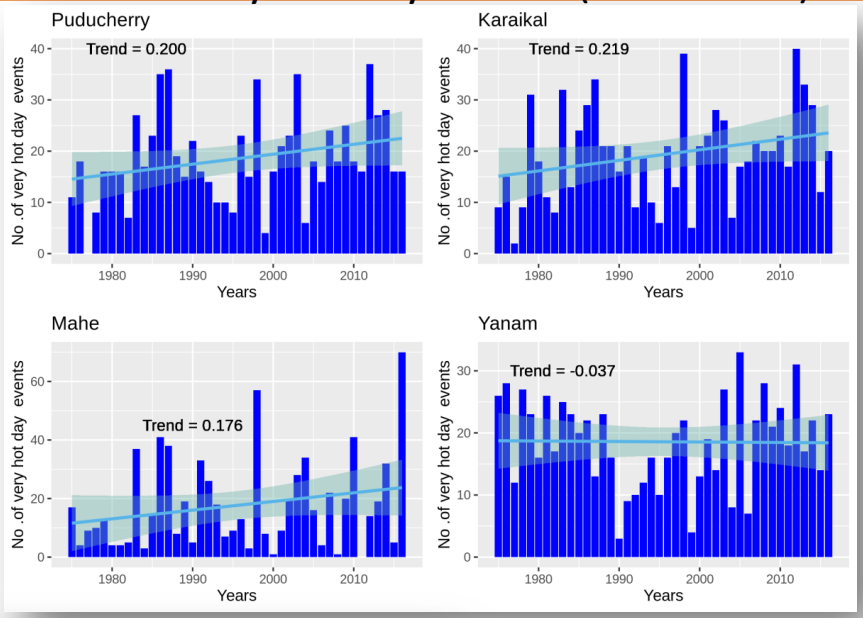
- Data used in this study is from IMD for historical analysis and NEX-GDDP data for future study.
- IMD rainfall data (1951-2016) at 0.25°X0.25° & temperature data 1°X1° (1969-2016). NEX-GDDP @0.25°
- To reduce the uncertainties in future change projections, a robust model selection methodology has been followed to select the best performing models over Puducherry out of the 21 NEX-GDDP models for the multimodal ensemble mean.
- Multimodal Ensemble mean of five best performing NEX-GDDP dataset has been used to assess the projected changes towards Mid-Century period (2021 – 2050)
- The change has been calculated as a difference between the 30 year average of mid-century (2021-2050) with respect to baseline (1975-2005).

Historical Analysis (temp)

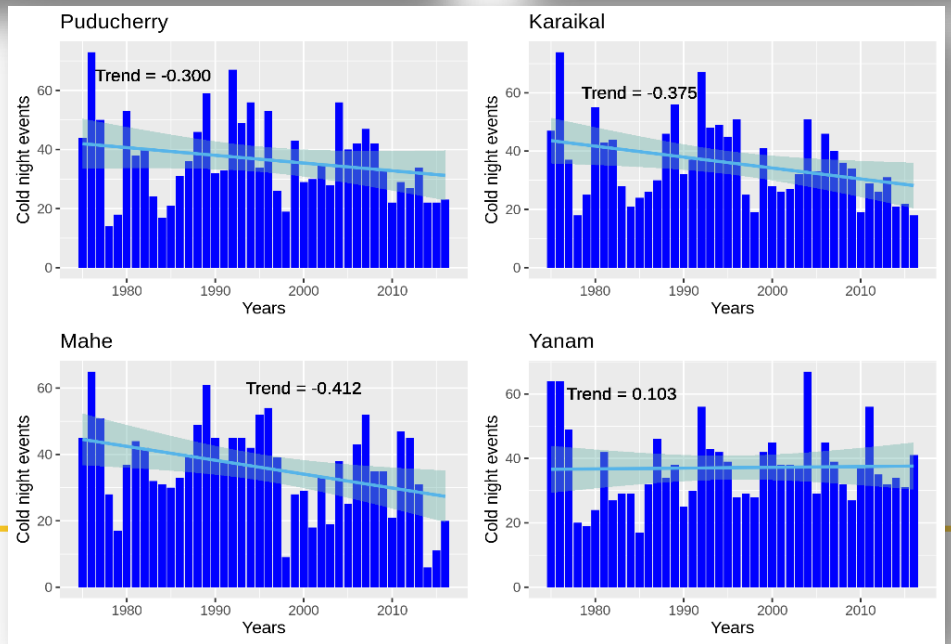
Annual Mean Temp Anomaly 1969-2016



Annual Very hot day events (>95th %tile)

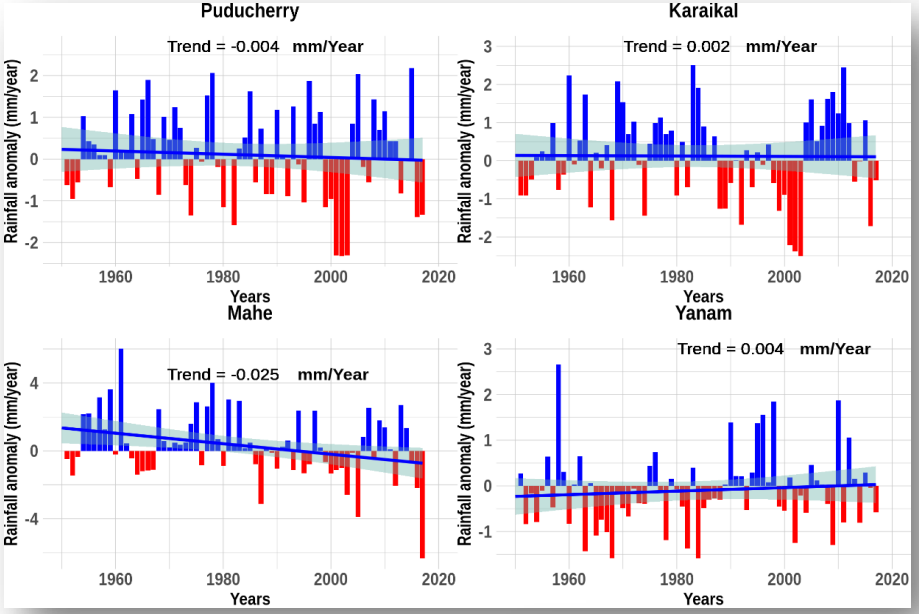


Annual cold nights (<10th %tile)

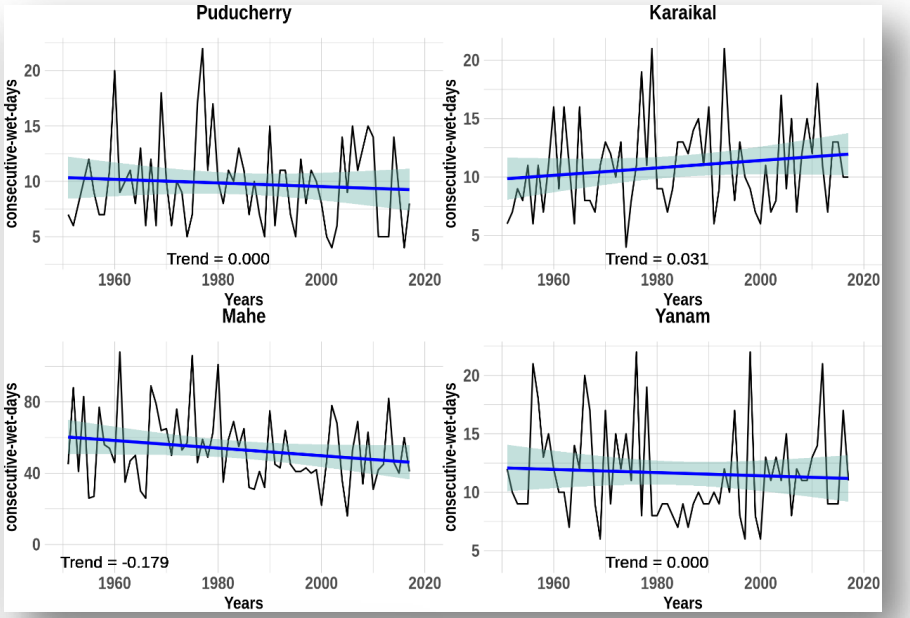


Historical Analysis (rainfall)

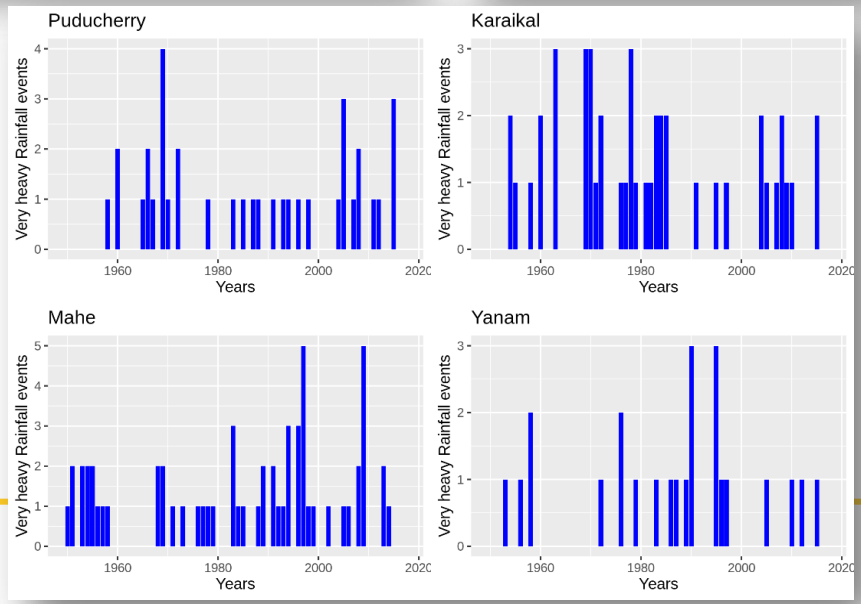
Annual Mean rainfall Anomaly 1951-2016



Consecutive wet days (>3days)

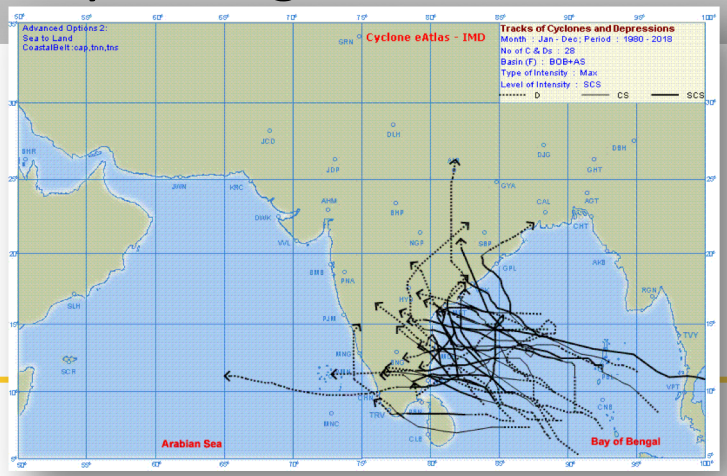


Very Heavy rainfall events (>124.4mm/day)



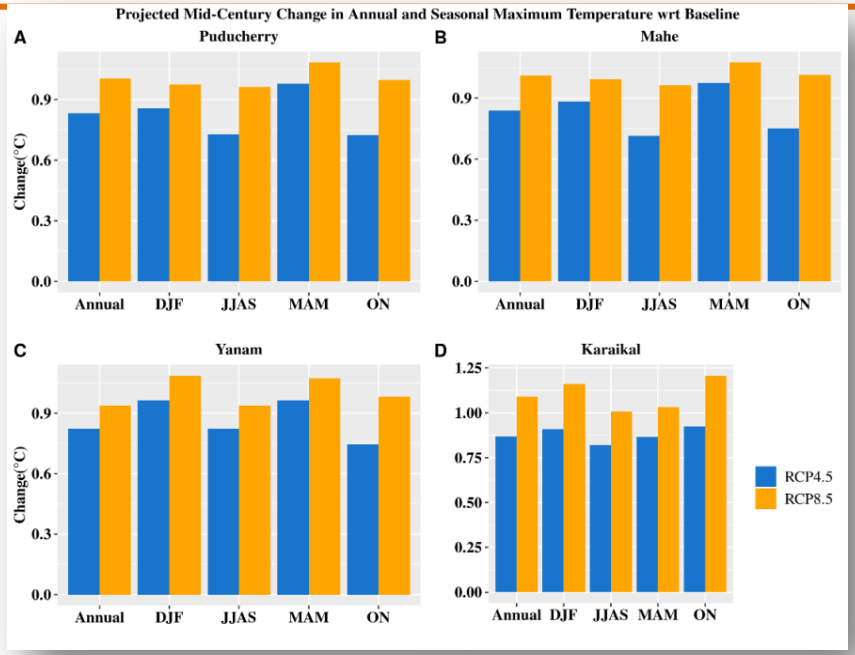
Tropical Cyclones

- During 1980-2018 (38 years): 44 TC have crossed the Bay of Bengal Basin to A.P. & T.N. coastal belt, of which 28 were severe SCS.
- During OND season the TC occurrence are more frequent.
- The Bay of Bengal TC more often strike Odisha-West Bengal coast in October, Andhra coast in November and the Tamil Nadu coast in December.
- More intense CS projected for future however no evidence of increasing frequency in long dataset.

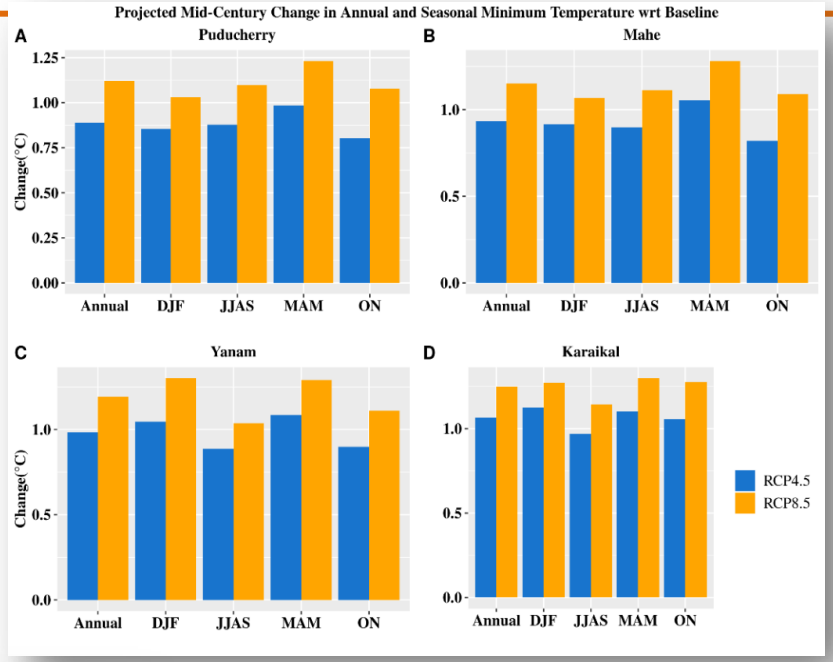


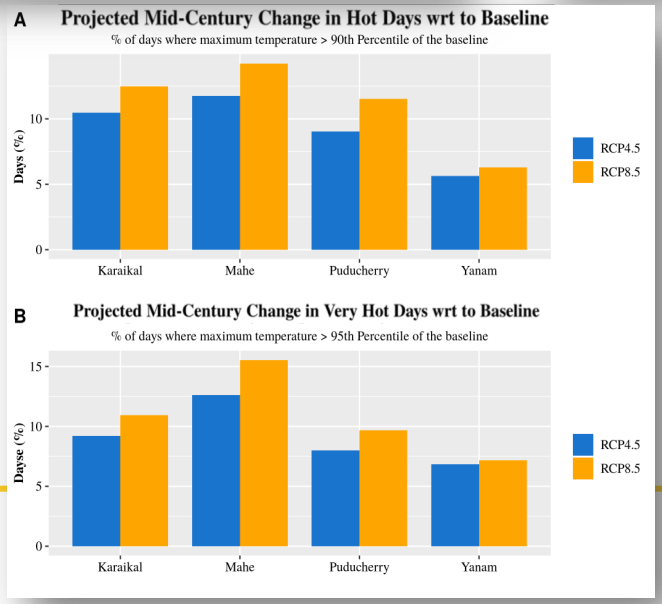
Future Climate Analysis (temp 2021-2050)

Projected change in MaxT over UT wrt 1975-2005



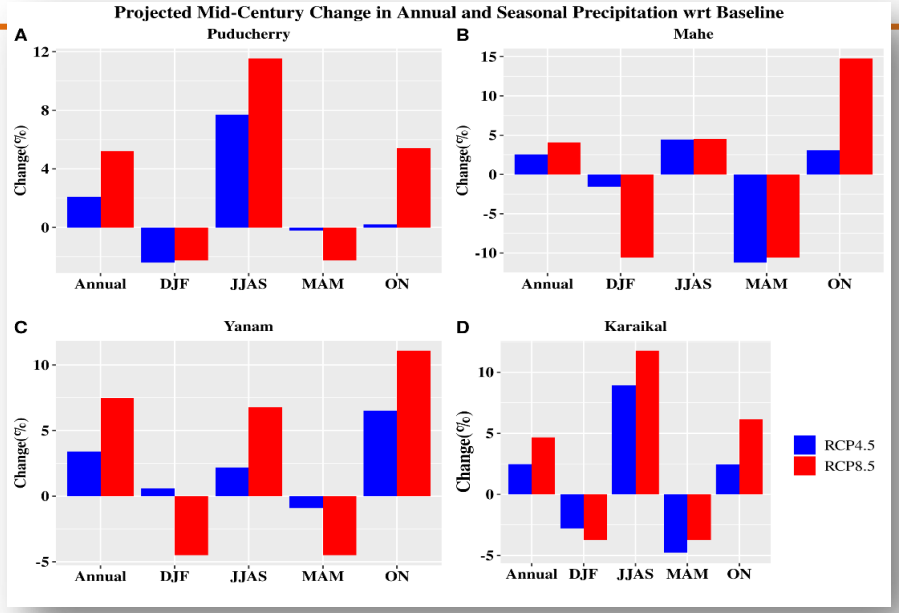
Projected change in MinT over UT wrt 1975-2005

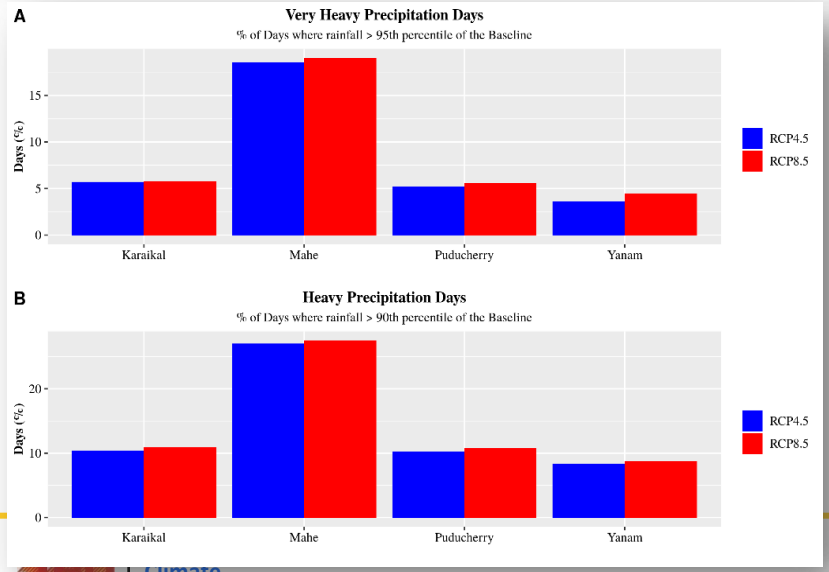




- Annual/Seasonal warming for the UT under both RCPs
- Change in MinT more than MaxT
- Extremes Temp also show increase in future with Mahe showing the most changes.

Future Climate Analysis (Rainfall 2021-2050)

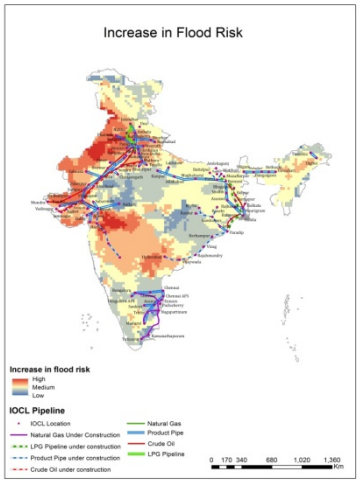


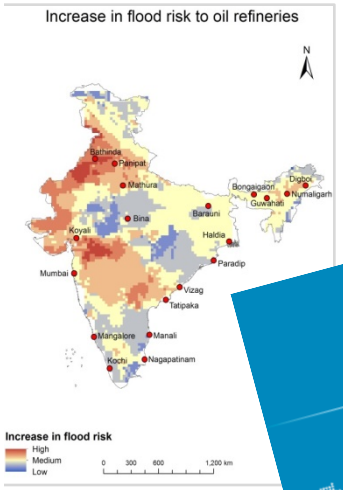


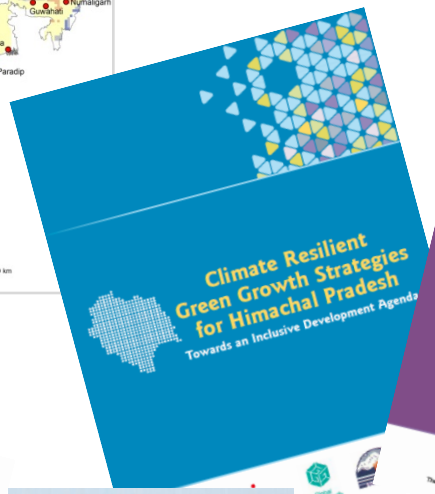
- **Annual average and Monsoon rainfall is projected to increase for all the districts** in the UT of Puducherry for both RCP4.5 and RCP8.5 scenarios for the 2021-2050
- **Puducherry** shows a projected change in annual rainfall of **2% and 6%** for RCP 4.5 and RCP8.5.
- **Mahe** shows a projected change in annual rainfall of **2% and 4%** for RCP4.5 and RCP8.5.
- **Yanam** shows a projected annual change of **3% and 7%** for RCP4.5 and RCP8.5.
- **Karaikal** shows a projected increase in rainfall of **3% and 4%** for RCP4.5 and RCP8.5.
- Heavy and very heavy precipitation are projected to increase over all the districts of the UT of Puducherry .
- Wet days and dry days also shows high variability but overall it shows increase for most of the UTs for the future.

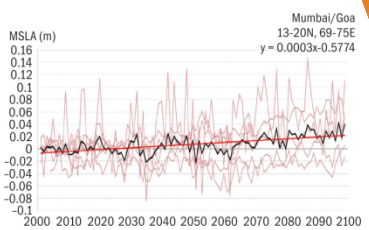
Need for regional modelling

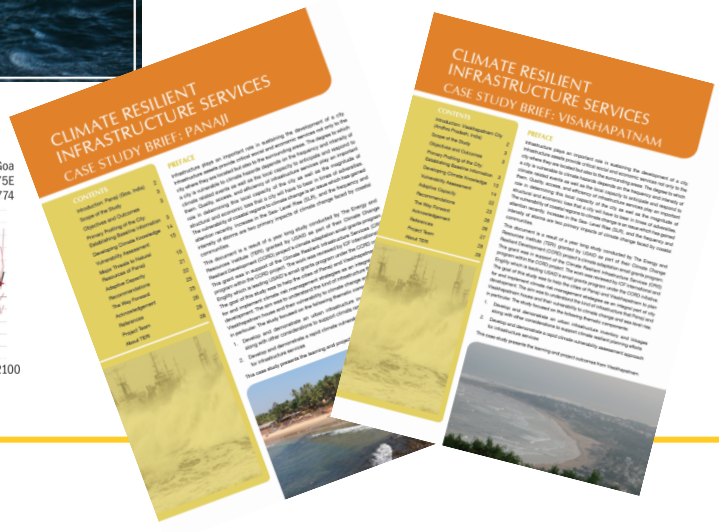
Increasing demand from climate sensitive businesses and stakeholders

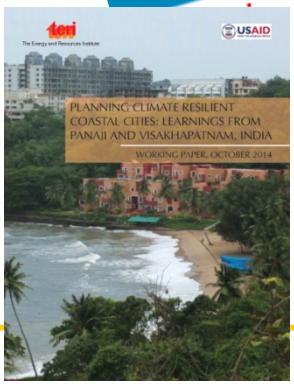


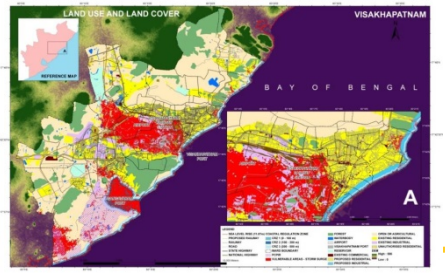






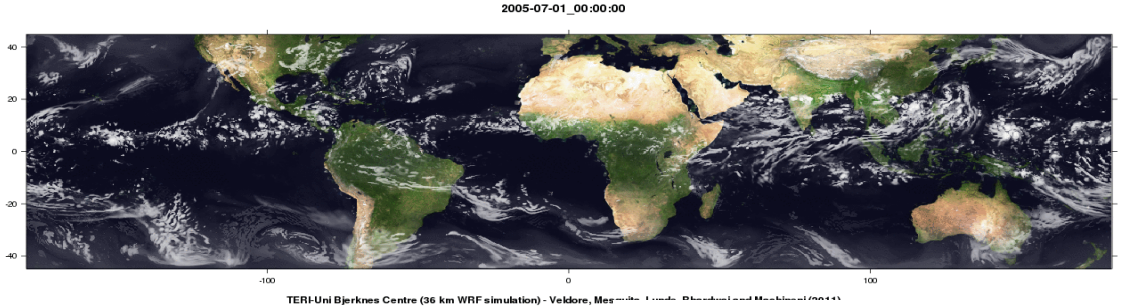


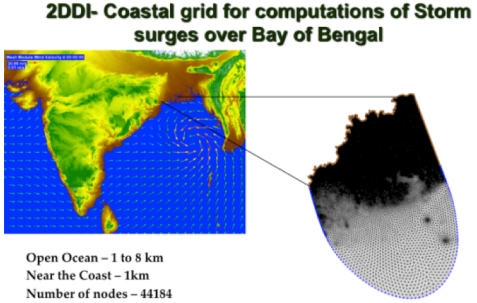


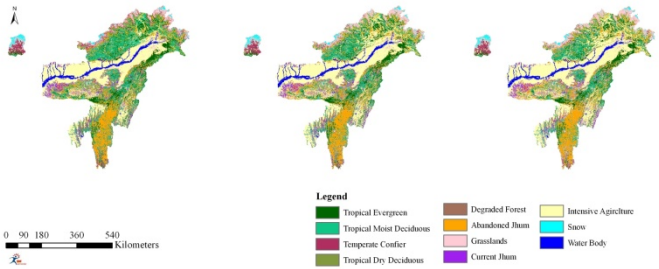


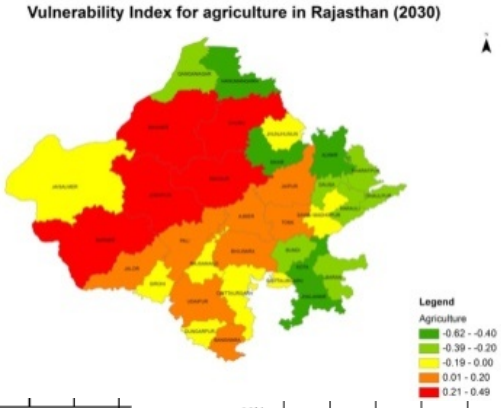
Need for regional modelling … Cont.

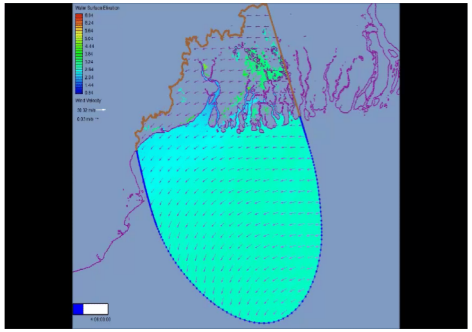
Regional state action plans to combat climate change



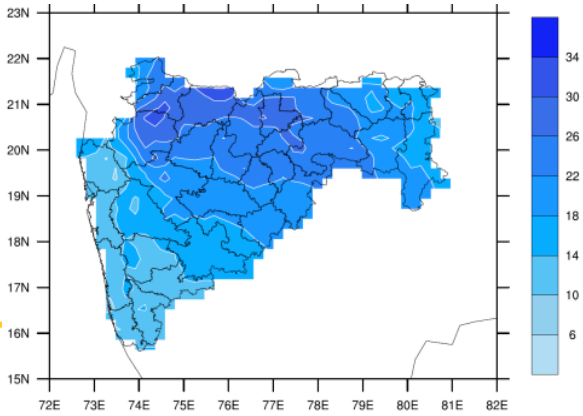


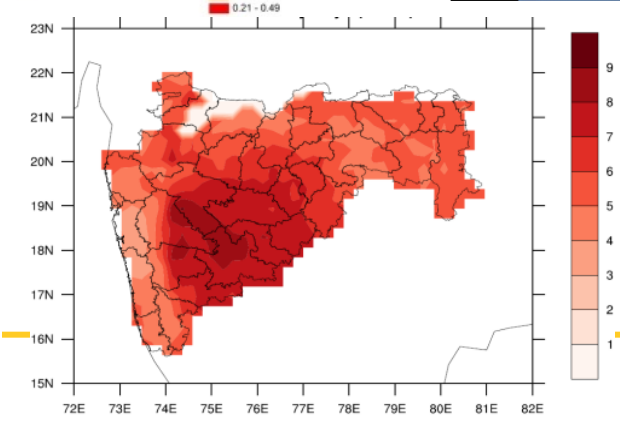






Increase in Extreme rainfall in 2030s relative to baseline (in %)





Number of low rainfall days in 2030s relative to baseline

Need for regional modelling … Cont.

Local level risk assessment needs

Climate Change Mitigation and Adaptation in ULBs of Telangana

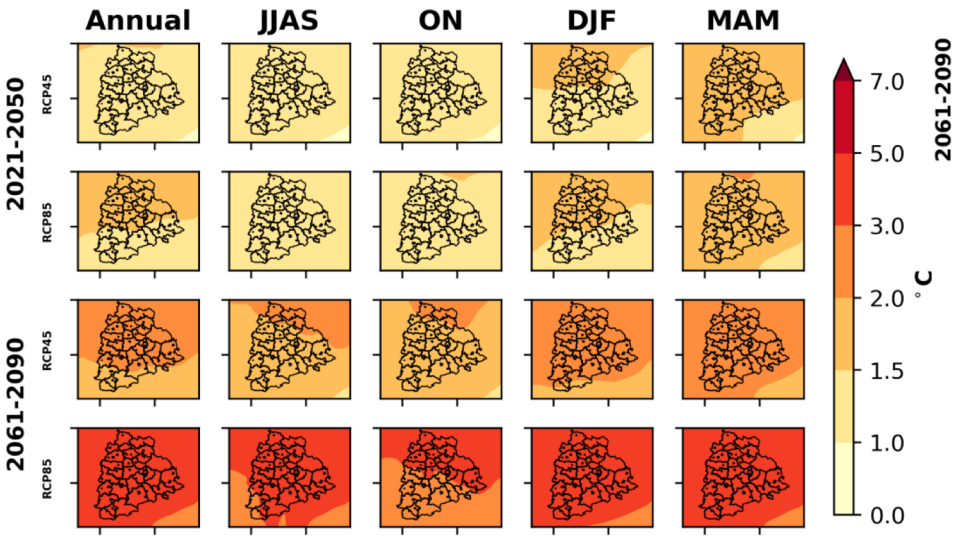


Fig. Seasonal change in T_{mean} for two scenarios (RCP4.5 and RCP8.5) for the near future (2021-2050) and long term future (2061-2090). The figure is centered over the telanagana region.

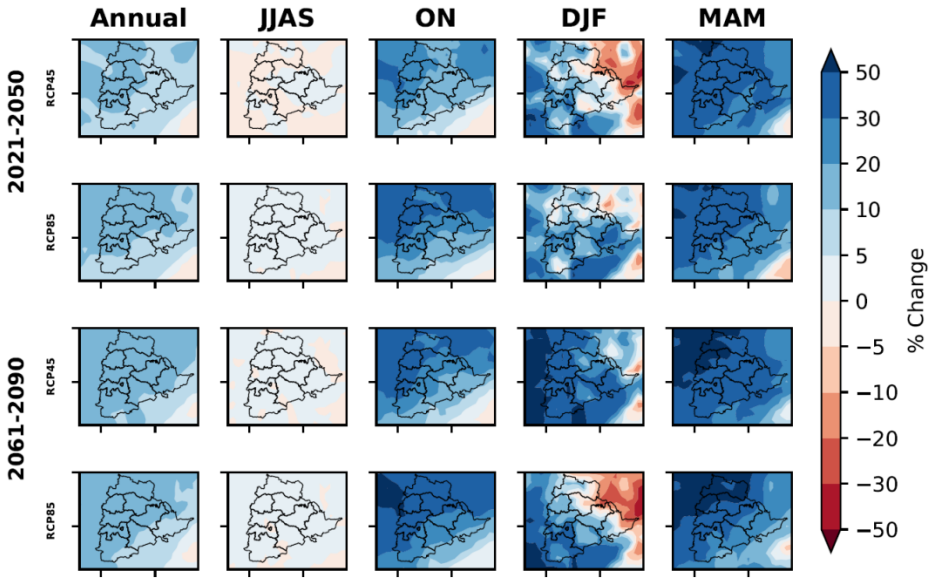


Fig. Season-wise % change in wet-day (precip > 1mm) frequency for two scenarios (RCP4.5 and RCP8.5) in the near future (2021-2050) and long term future (2061-2090) with reference to baseline simulation (1971-2000). The figure is centered over the Telangana region.

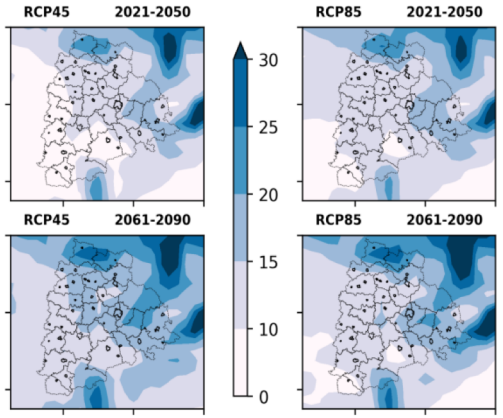
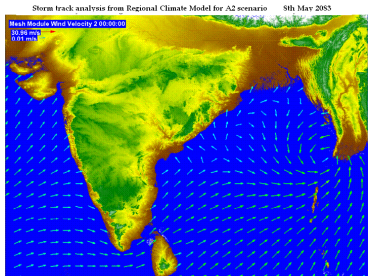
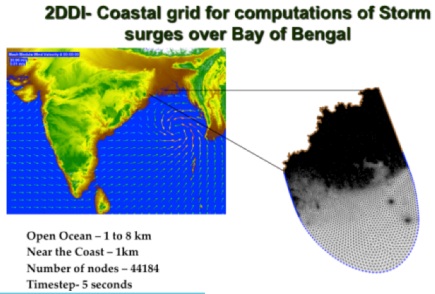
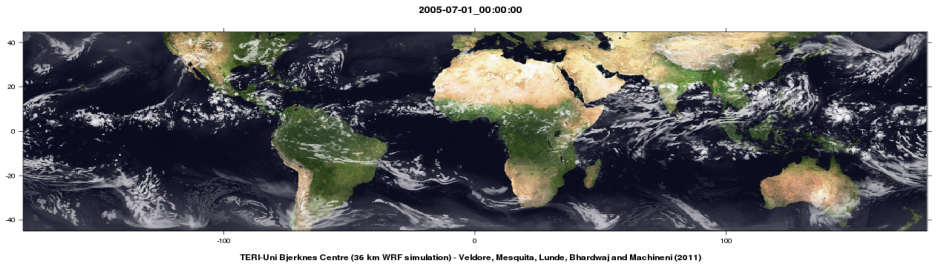


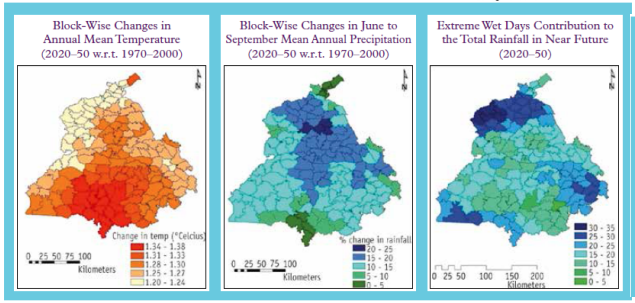
Fig. Percentage of days with Monsoonal precipitation above 90th percentile calculated from baseline simulation (1971-2000), for two scenarios (RCP4.5 and RCP8.5), for the near future (2021-2050) and long term future (2061-2090). The figure is centered over the telangana region.

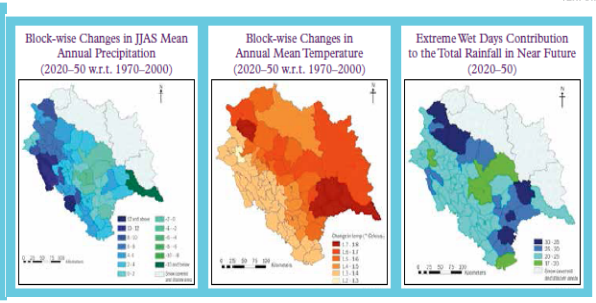
Modelling Products/Services

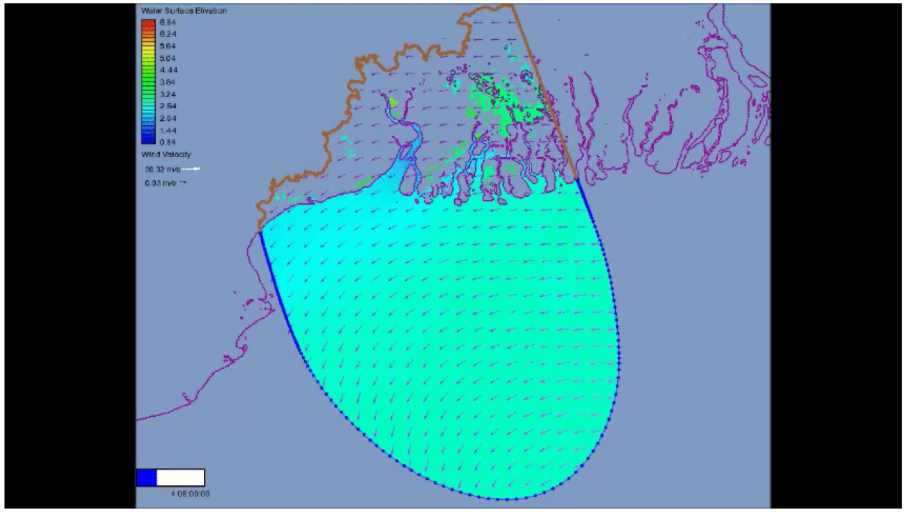


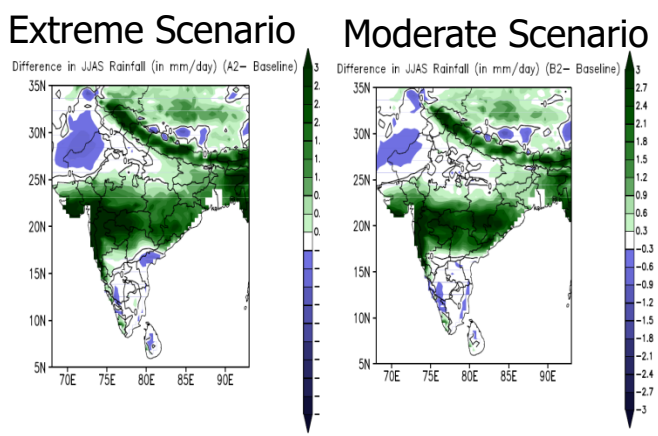


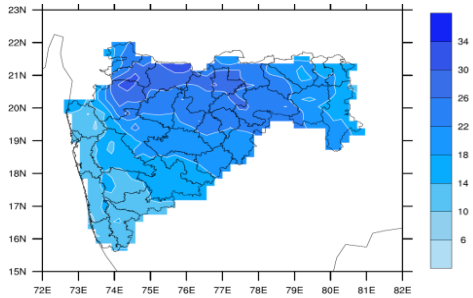




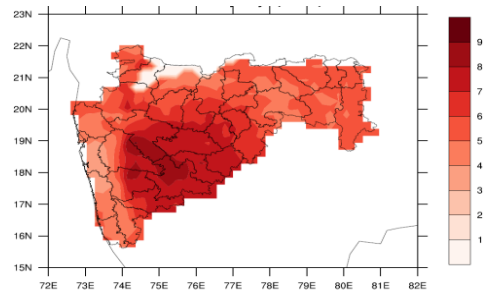








Increase in Extreme rainfall in 2030s relative to baseline (%)



Number of low rainfall days in 2030s relative to baseline

Climate Services and tool

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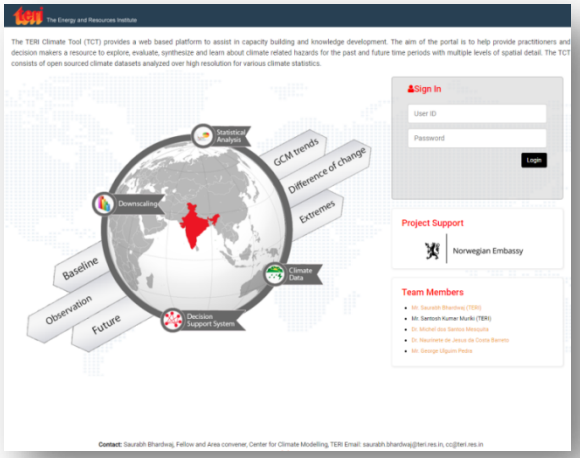

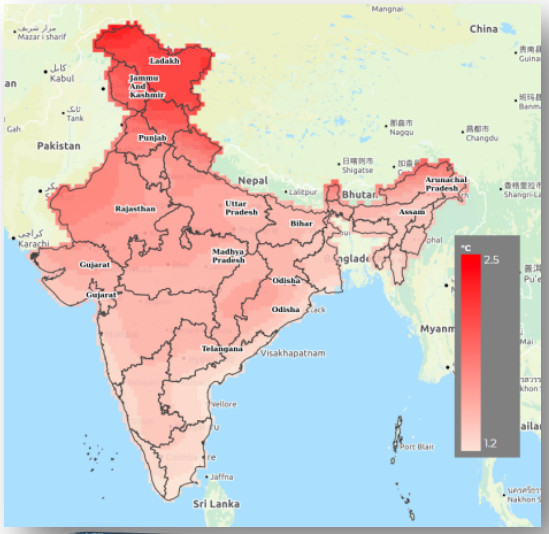

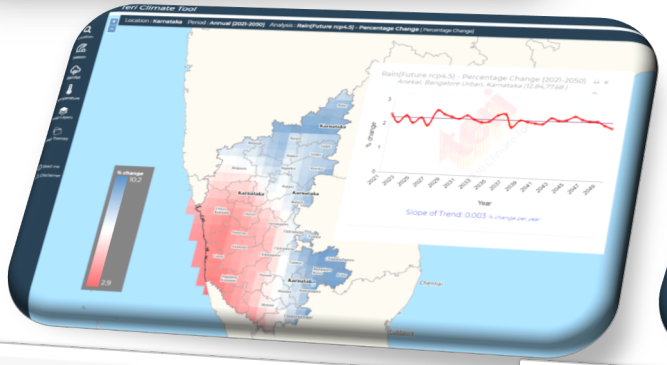

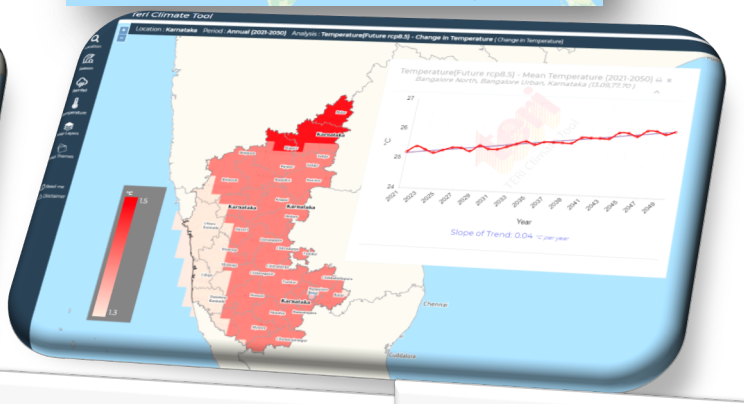

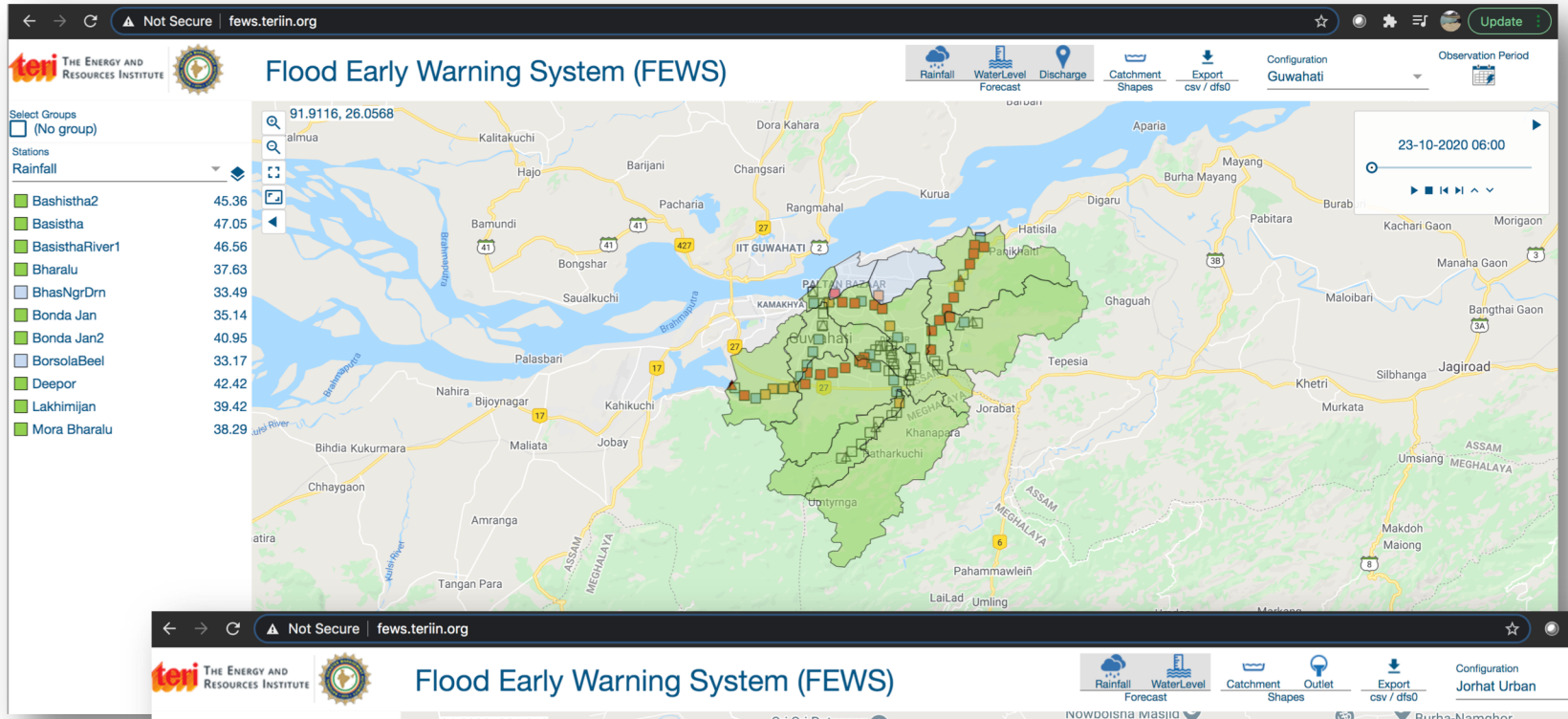
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Discharge
Forecast
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Guwahati
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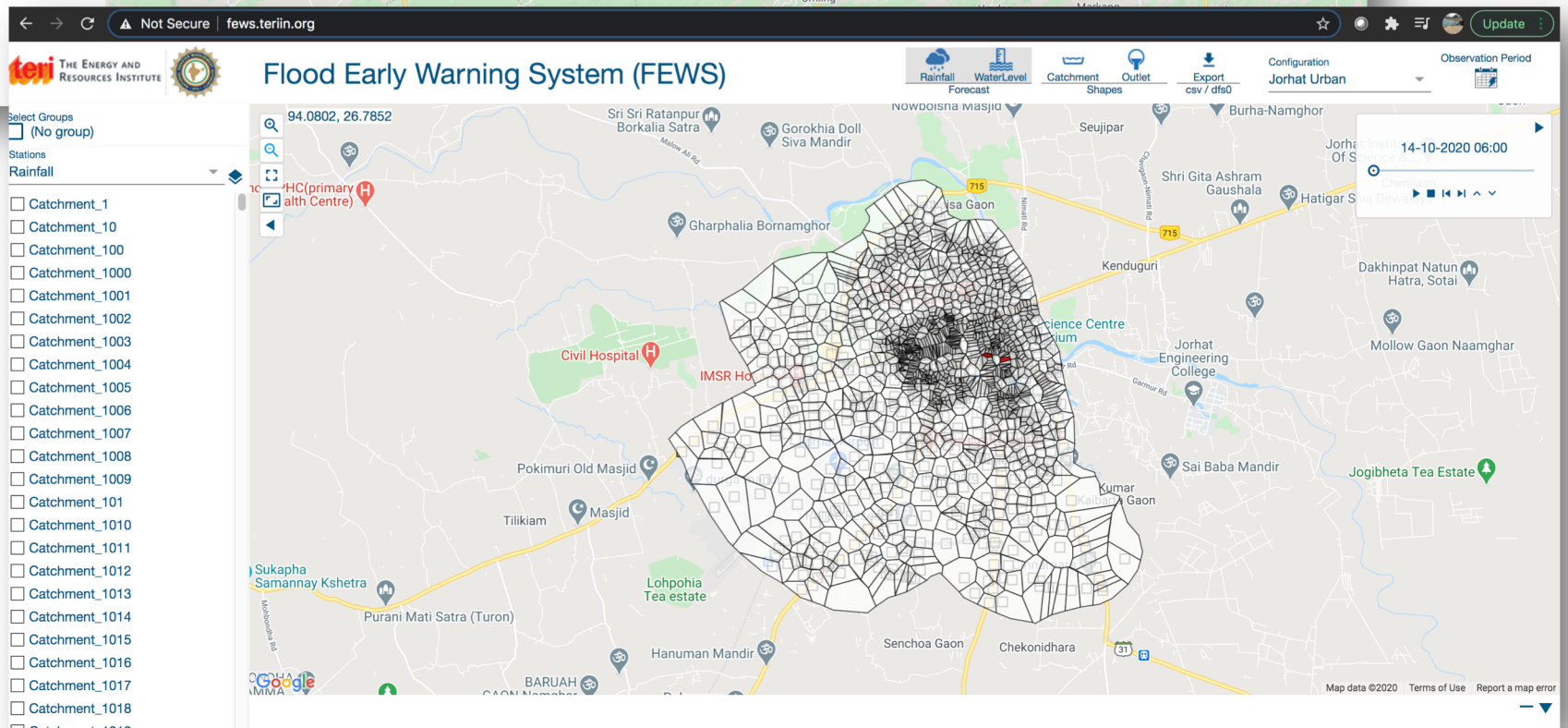
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Gorokhia Doll Siva Mandir
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Burha-Namghor
Shri Gita Ashram Gaushala
Gharphalia Bornamghor
Kenduguri
Dakhinpat Natun Hatra, Sotai
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Jorhat Engineering College
Mollow Gaon Naamghar
Pokimuri Old Masjid
Sai Baba Mandir
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Tilikiam
Masjid
Sukapha Samannay Kshetra
Lohpohia Tea estate
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Hanuman Mandir
Senchoa Gaon
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Questions?

Pic: Main Rhonebuk Glacier 1921 and now