Assessing Spatio-temporal Precipitation Variability and Extreme Events in India

Eoraptor_Lindyhop_Allegro

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Introduction

- Regional precipitation variability refers to the natural fluctuation in the amount of precipitation experienced in different geographical areas over time.
- This variability is influenced by a combination of factors including Climate Patterns, Geographical Features, Topography, Oceanic Conditions, Atmospheric Circulation, Latitude, Urbanization and Land Use changes.
- It is an essential aspect of the Earth's Climate System.
- Extreme events are the climate related phenomena which is unusual and have severe impact on the environment, society and economy due to its rarity, intensity and unpredictable nature. Ex: Heat waves, Drought, Floods, Cyclone, wildfires, storm surges etc..
- Agriculture is the backbone of the Indian economy hence nature of precipitation is very important being a developing country

Research Gap

- Mostly the observed data from Indian Meteorological Department (IMD) is used to analyse the variations in the weather events or climate phenomena in India. Hence we find the lack of usage of Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS) for Indian Region.
- It combines satellite-derived precipitation estimates with ground-based station data to provide gridded precipitation data at a quasi-global scale between 50°S-50°N.
- CHIRPS is a combination of model data and observed data from different sources, which gives a comprehensive picture of the total precipitation.
- Majority of the existing study are about the different regions of India, very few studies only there as considered India as a whole to analyse precipitation.

Study Area

- India is a vast and diverse country located in South Asia. It is the 7th largest country in the world by land area.
- India’s geography is diverse and it comprising mountains, plains, plateaus and coastline.
- The northern region is dominated by the Himalayan mountain range, while the southern part with Indian ocean, the Arabian Sea to the west and Bay of Bengal to the east.

Literature Review

Precipitation variability

- Investigated the primary mode of variability in Indian Summer Monsoon (ISM) precipitation over the past one thousand years. The natural climate variability has dominantly influences the variability of monsoon rainfall in the Indian subcontinent (**Sinha et al 2011).**
- The study assessed the spatial and temporal precipitation variability of precipitation over himalayan region. It found that spatial and temporal variations in precipitation, including the seasonal patterns and extreme precipitation events and intensity are increasing (**Swain et al 2022).**

Rainfall extreme events

- The extreme precipitation events has been increased due to anthropogenic climate change in India. Particularly the emission of greenhouse gases, have influenced the frequency and intensity of heavy rainfall events in the country **(Mukherjee et.al 2018)**.
- The spatial patterns and variations in temporal shifts of extreme precipitation events across different regions of India has changed. Also the timing and intensity of extreme precipitation have changed over time and these shifts vary across the country **(Khan et. al 2019)**.

Literature Review

Floods and Drought

- Droughts are linked to low monsoon rainfall that affects water, agriculture, and society **(Sikka 1999)**.
- Floods are linked to intense rainfall and stream flows that affect smaller areas **(Dhar and Nandargi 2003)**.
- Both droughts and floods have increased in frequency and severity since 1950, especially over central and southern India **(Mujumdar et al.2020)**.
- Floods occur mainly during the SW monsoon season, but also during the NE monsoon season in south peninsular India **(Dhar and Nandargi 2000)**.
- Floods depend on many factors, such as rainfall, soil moisture, drainage, urbanisation, dams, and coastal proximity **(Rosenzweig et al. 2010)**.
- Floods are also influenced by the monsoon intraseasonal oscillations, which cause different rainfall patterns over different regions of India **(Dhar and Nandargi 2003; Kale 2003; Krishnan et al. 2009)**.

Methodology

Data used: CHIRPS Version 2.0 Global Daily 0.25°

Time Period: 1981-Present

Annual Mean Precipitation

- Calculate the average precipitation for each year.
- Plot the annual mean precipitation.

Consecutive Dry Days (CDD) Index

- Identify dry days (precipitation < 1mm) using a boolean array.
- Calculate the maximum number of consecutive dry days each year.

Consecutive Wet Days (CWD) Index

- Identify wet days (precipitation > 0mm) using a boolean array.
- Calculate the maximum number of consecutive wet days each year.

Simple Daily Intensity Index (SDII)

- Calculate the average daily precipitation for each year.

Visualizing CDD, CWD, and SDII

- Create bar plots to visualize CDD, CWD, and SDII per year.

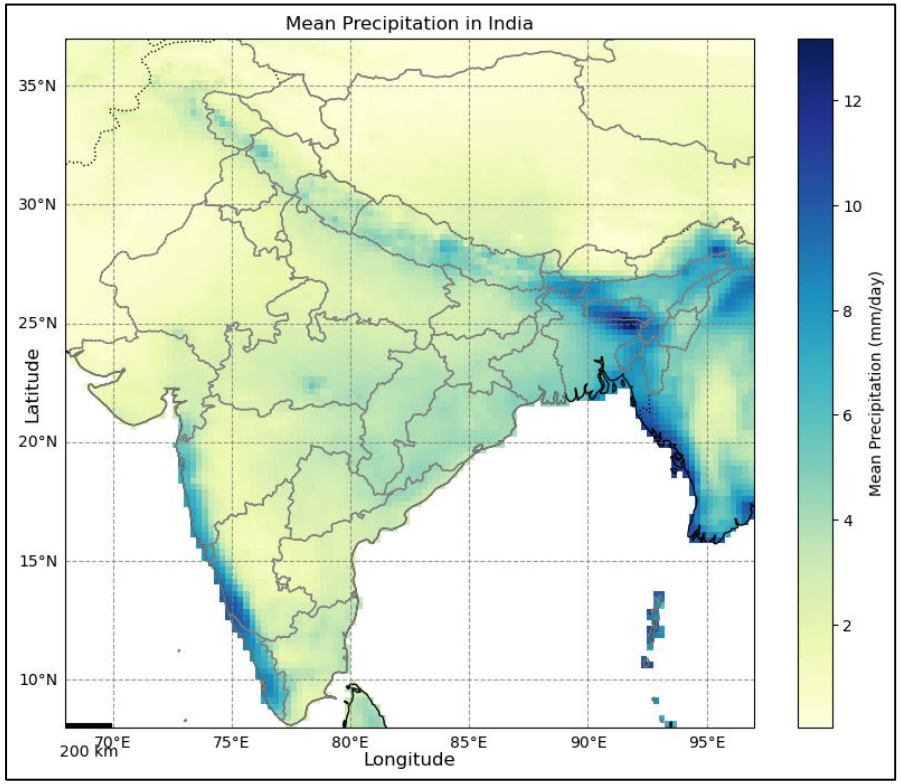
Identifying Extreme Wet Spells

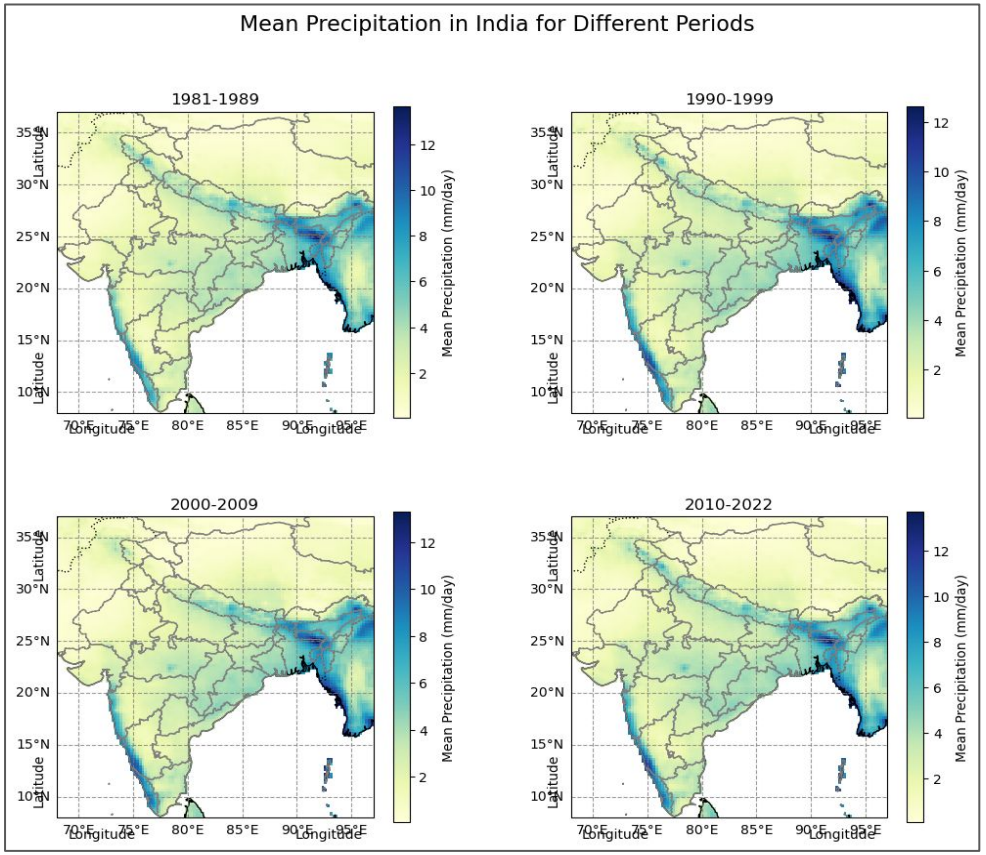
- Calculate the 90th percentile of rainfall above CWD.
- Identify years with frequent CWD above the 90th percentile.

Interpretation and Analysis

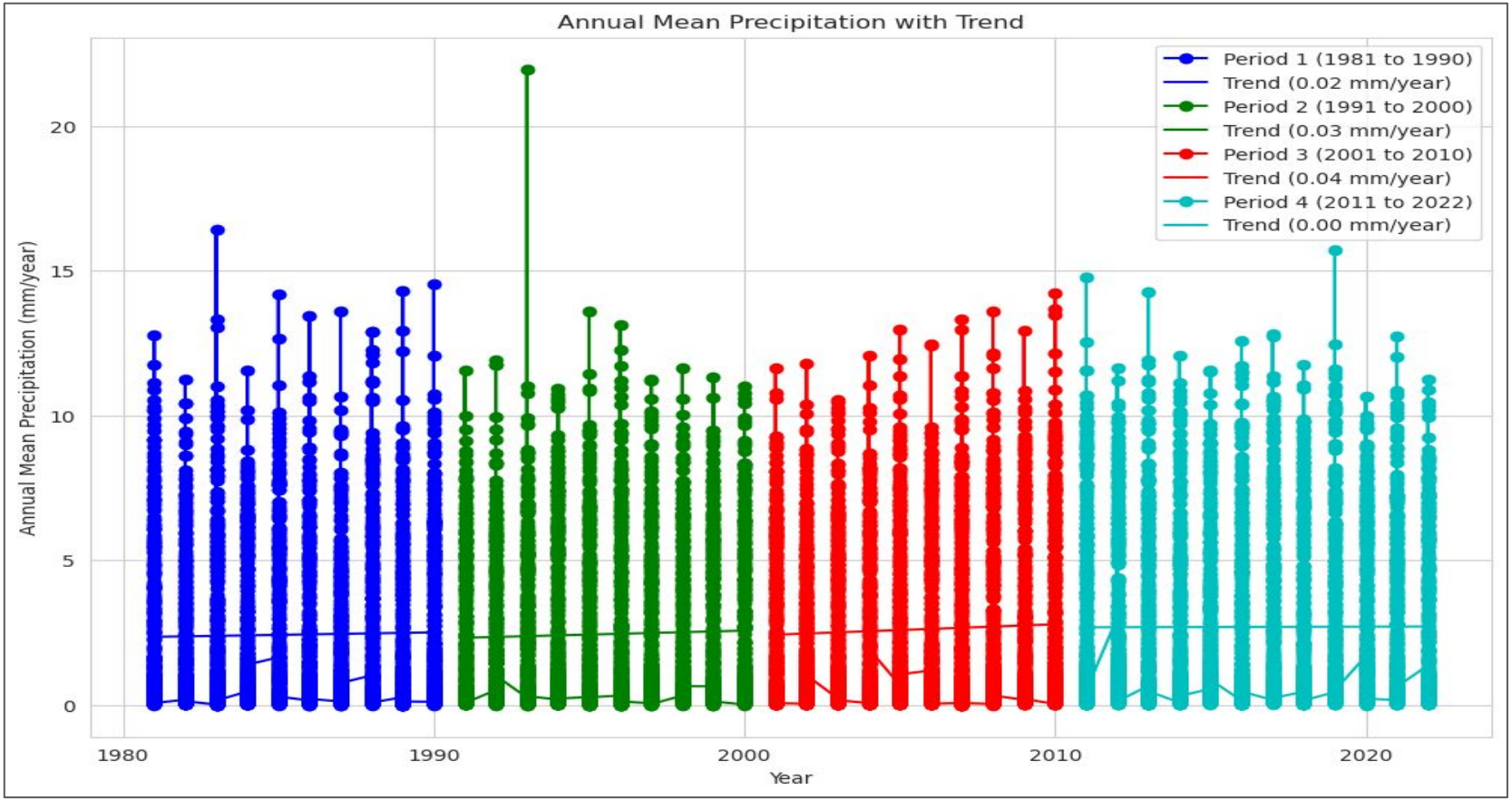
- Analyze trends and patterns in CDD, CWD, and SDII.

Results & Discussion

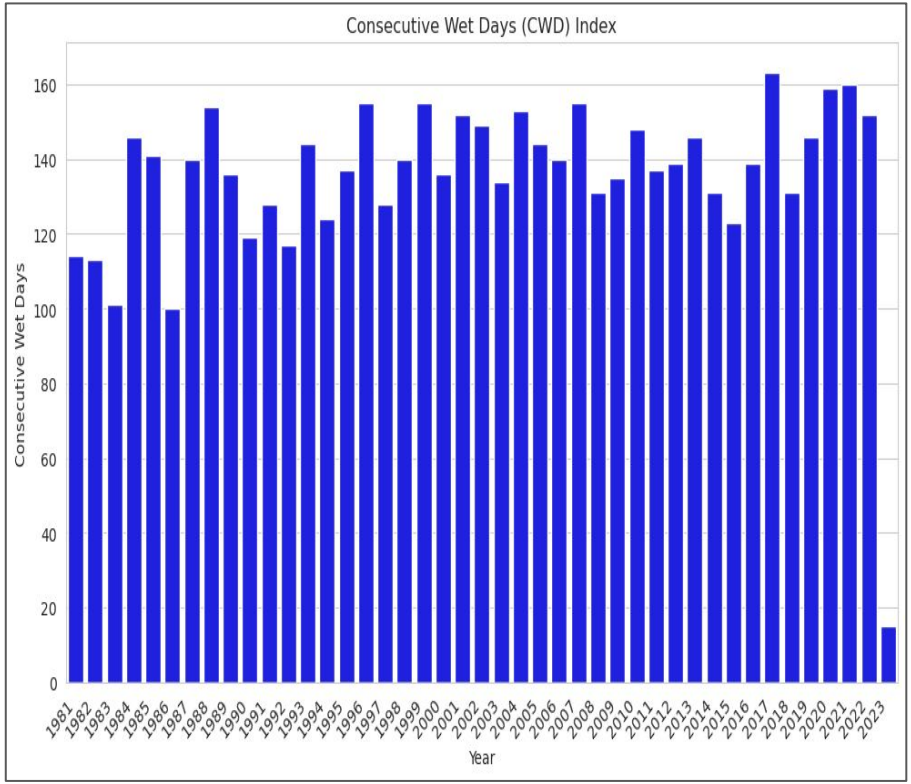


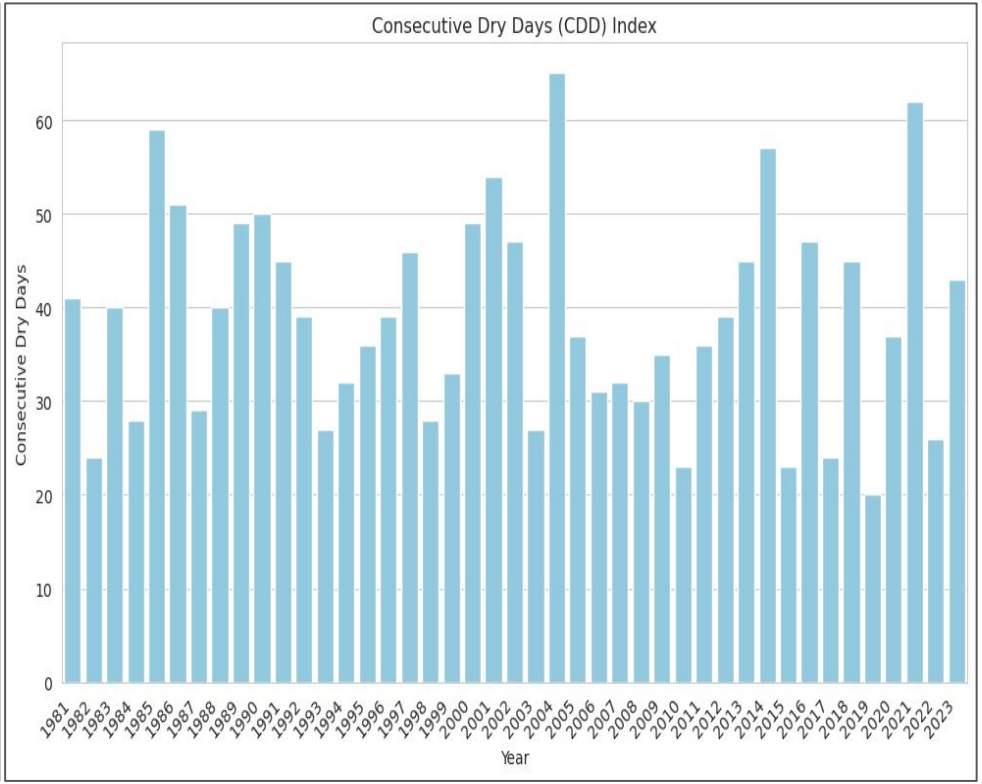


Annual Mean Precipitation (trend)

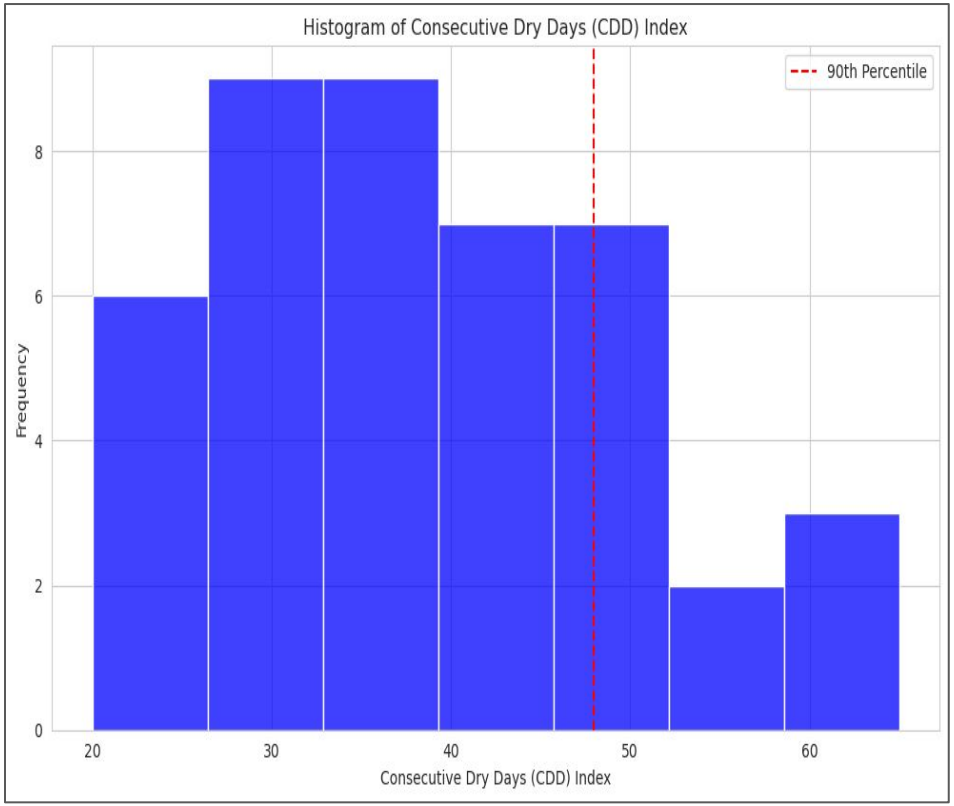


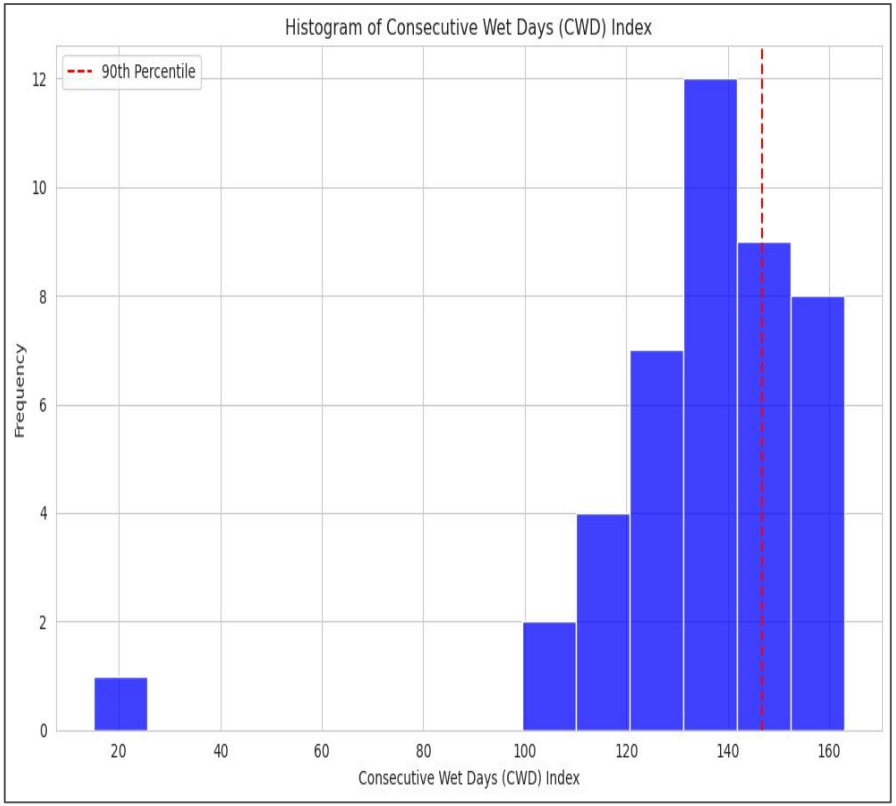
Consecutive Dry Days & Consecutive Wet Days



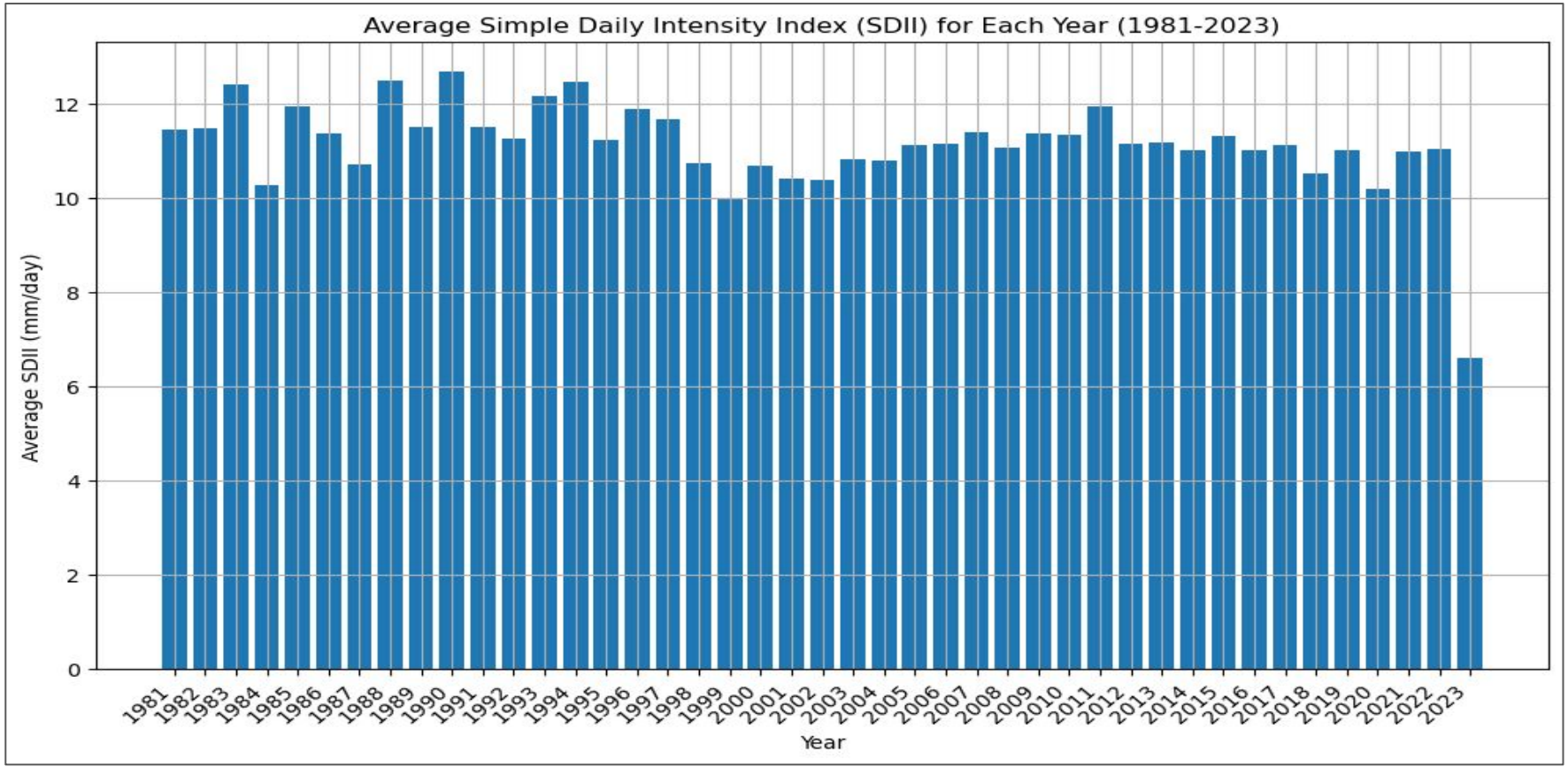


90th percentile of CDD & CWD

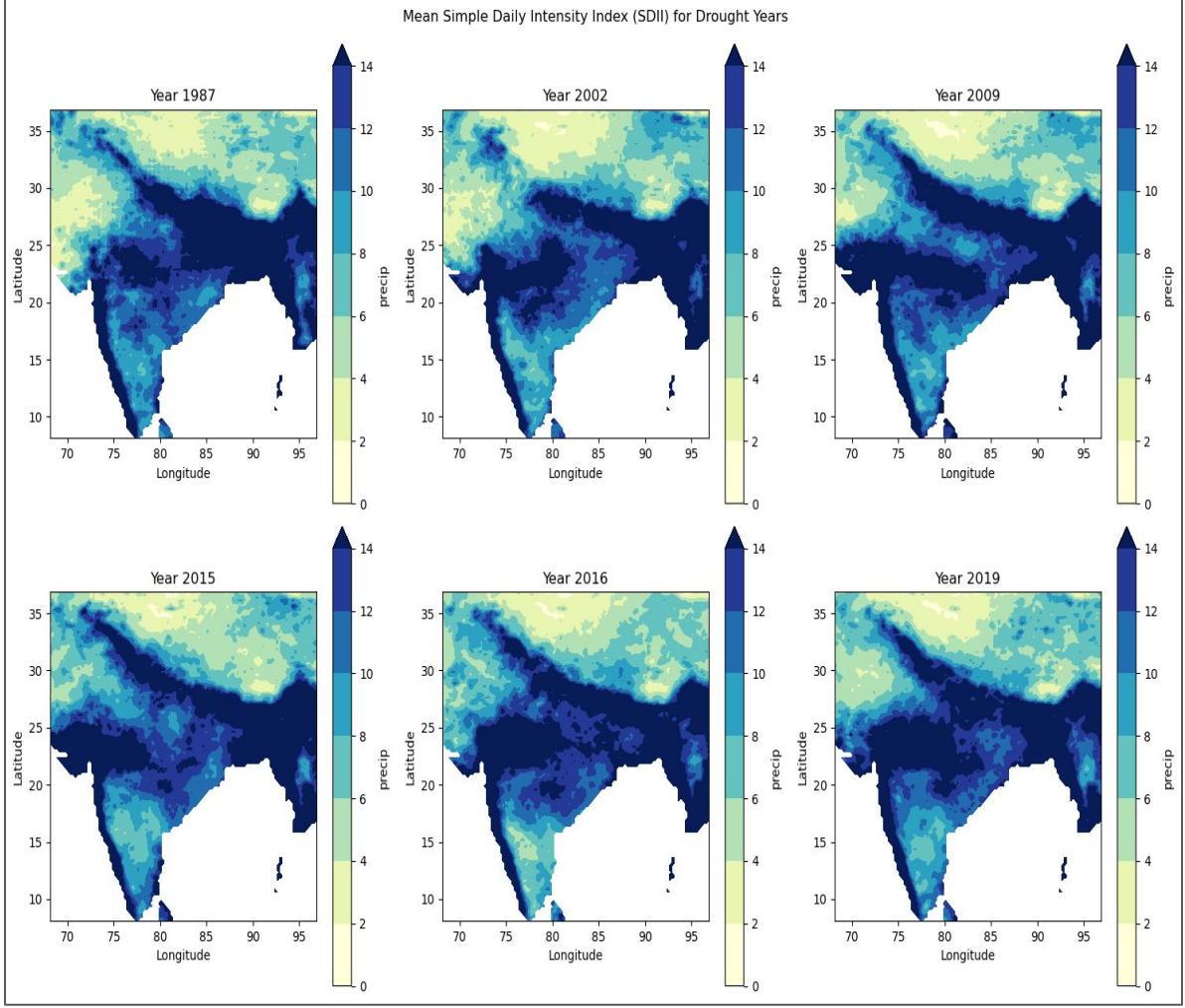




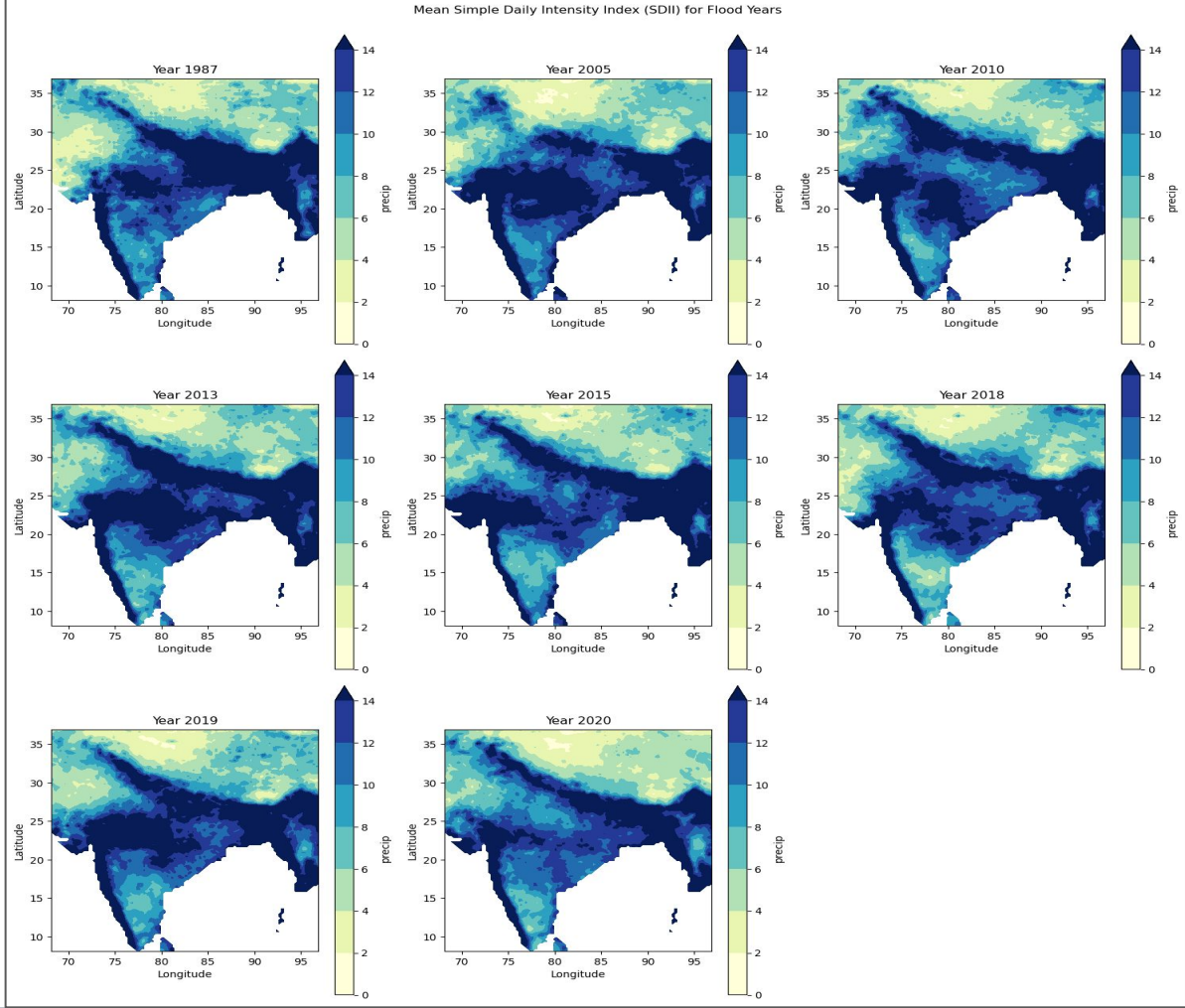
Simple Daily Intensity Index (SDII)



SDII for Drought years



SDII for Flood Years



Conclusions

- Annual mean precipitation is not showing much variation over the years
- From the decadal plot - consecutive decades is not showing much variation, but the last decade [2010-2022] shows much higher values for annual mean precipitation than first decade [1981-1989]
- The trend observed:
  - 0.02mm per year 1981-1990
  - 0.03 mm per year - 1991 - 2000
  - 0.04 mm per year - 2001 - 2010
  - 0.00 mm per year - 2011-2022

Conclusions

- SDII is not showing much variation
- 1985, 2001, 2004, 2014 & 2021 - Above 90th percentile CDD
- 2017, 2020 & 2021 - Above 90th percentile CWD
- It was also observed that the CWD is increasing after 2017 pointing to the changing climate.
- Precipitation data for at least 50 years should be analysed to get a generalized idea about trends.

References

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