ANALYSIS OF PRECIPITATION DATA USING SELECTED CLIMATE INDICES IN THE HIMALAYAN REGION

Tejas Warathe (16410029)

Supervised By: Dr Ajanta Goswami

Topics to be discussed

- Introduction
- Objectives
- Study area
- Literature review
- Methodology
- Results
- Conclusion

Introduction

- Climate change is one of the biggest challenge that humanity is facing.
- Affecting sectors like water resources, agriculture, energy, and tourism.
- Climate change has a direct link with changes in precipitation, hydrological cycle, atmospheric water content.
- The Earth’s average temperature is likely to increase in future due to global warming.
- Changes will be observed in hydrological cycle, precipitation patterns, extreme conditions, melting of ice, changes in soil moisture, changes in frequency and intensity of extreme events.

Introduction

- The Indian monsoon season overcomes during July-September, 80% of the annual precipitation occurs during monsoon months.
- Due to climate change, there can be two types of extreme events that can occur related to precipitation.
- The decrease in monsoon rainfall over the years is alarming for the policy makers as it may hamper agricultural activities having repercussions on the economy.
- High amount of rainfall concentrated in short/long time span is also harmful and destroys infrastructure, economy and human lives.
- Examples, Chennai in December 2015, Uttarakhand flood of July 2013.

Objectives

- To study the rainfall pattern in the Himalayan region, including the five major states and Union territories: Jammu and Kashmir, Ladakh, Himachal Pradesh, Uttarakhand, and Arunachal Pradesh over the past 40 years (1981-2020).
- Use ten different precipitation indices to analyze different possible conditions such as drought, flood, water abundance, and scarcity.
- To apply the same analysis to the next 80 years of generated synthetic data to study possible change and trends in the rainfall patterns in the region in future using statistical tests like the Mann Kendall trend test.

Study area

Latitudes: 25º to 38º
Longitude: 72º to 100º

Union Territories of J&K and Ladakh, States of Himachal Pradesh, Uttarakhand, Sikkim and Arunachal Pradesh

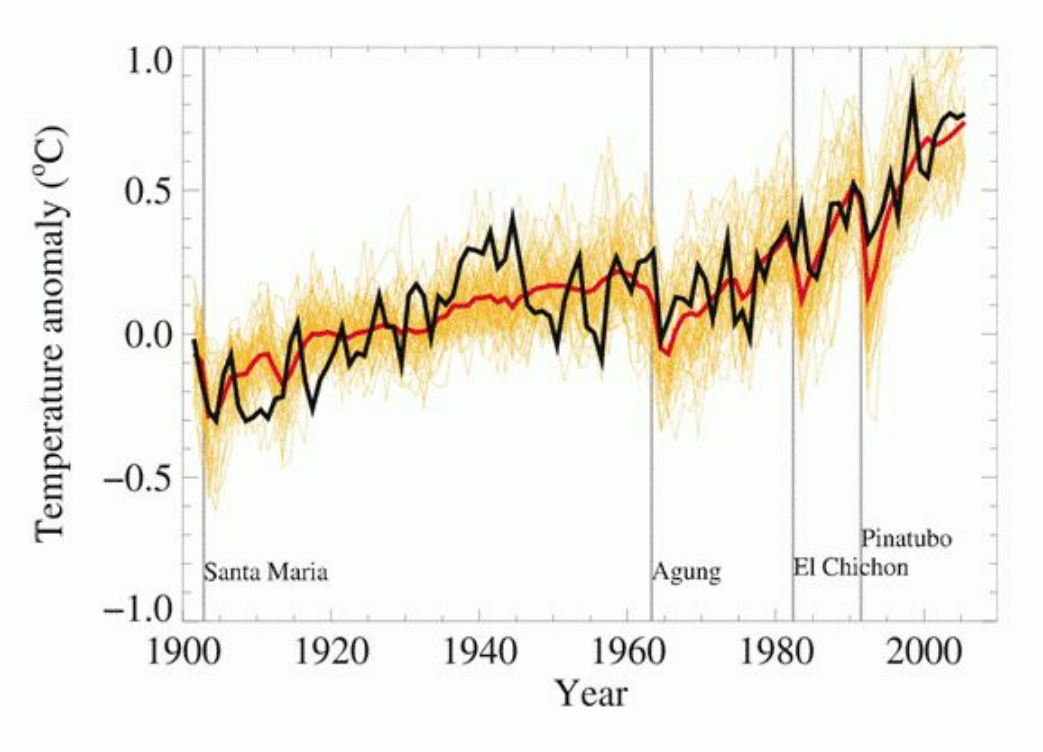
Why study precipitation in the Himalayas?

- The Himalayas are an important physical feature of the Indian Subcontinent and are responsible for the monsoon season in India.
- The Himalayas are one of the biggest cryosphere on the planet.
- It is the source of 3 major river systems: The Ganges, The Indus and The Brahmaputra river system.
- The entire region is inhabited by about 200M people and more than a billion people live downstream of these river systems.
- Water for irrigation in the agriculture dominant northern plains comes from the river systems originating in the Himalayas.
- Extreme rainfall events rising in the Himalayas last decade, for example, 2013 floods of Uttarakhand, and the recent flash flood in Chamoli district, Uttarakhand.

Literature Review

Global Climate Model

- Complex mathematical representation of the significant climate system components (atmosphere, ocean, land surface, and sea ice) and their interactions.
- GCMs divide the earth into a 3D grid of cells, each specifying a mathematical value corresponding to variables like temperature, precipitation flux, solar radiation, etc.
- Atmospheric-Ocean General Circulation Model (AOGCM) are used in modern day studies. Atmosphere and Ocean systems continuously transfer heat and moisture with each other.
- Different research groups around the world run these simulations to create an estimate of change in climate using different physical characteristics such as change in greenhouse gas concentrations.



Global Mean surface temperature, relative to 1901-1950.

- Observation: Black line
- 58 Simulations by 14 global climate models reported in the IPCC Fourth Assessment: Yellow lines
- Average of all models: Red line
- Dates of large volcanic eruptions: Grey vertical lines

Figure from IPCC (2007), Chapter 8, FAQ8.1]

Literature Review

Representative Concentration Pathways

- To simulate global climate models, scenario assumptions about greenhouse gas concentrations should be made.
- Intergovernmental Panel on Climate Change (IPCC) has defined one such set of pathways called Representative Concentration Pathways (RCPs).
- Four main: RCP8.5, RCP6, RCP4.5, and RCP2.6
- Based on several assumptions regarding population growth energy sources, economic activity and other socio-economic factors.
- Similar to a global spatial dataset, with time series data at each cell.

Literature Review

Change in radiative forcing relative to pre-industrial conditions.

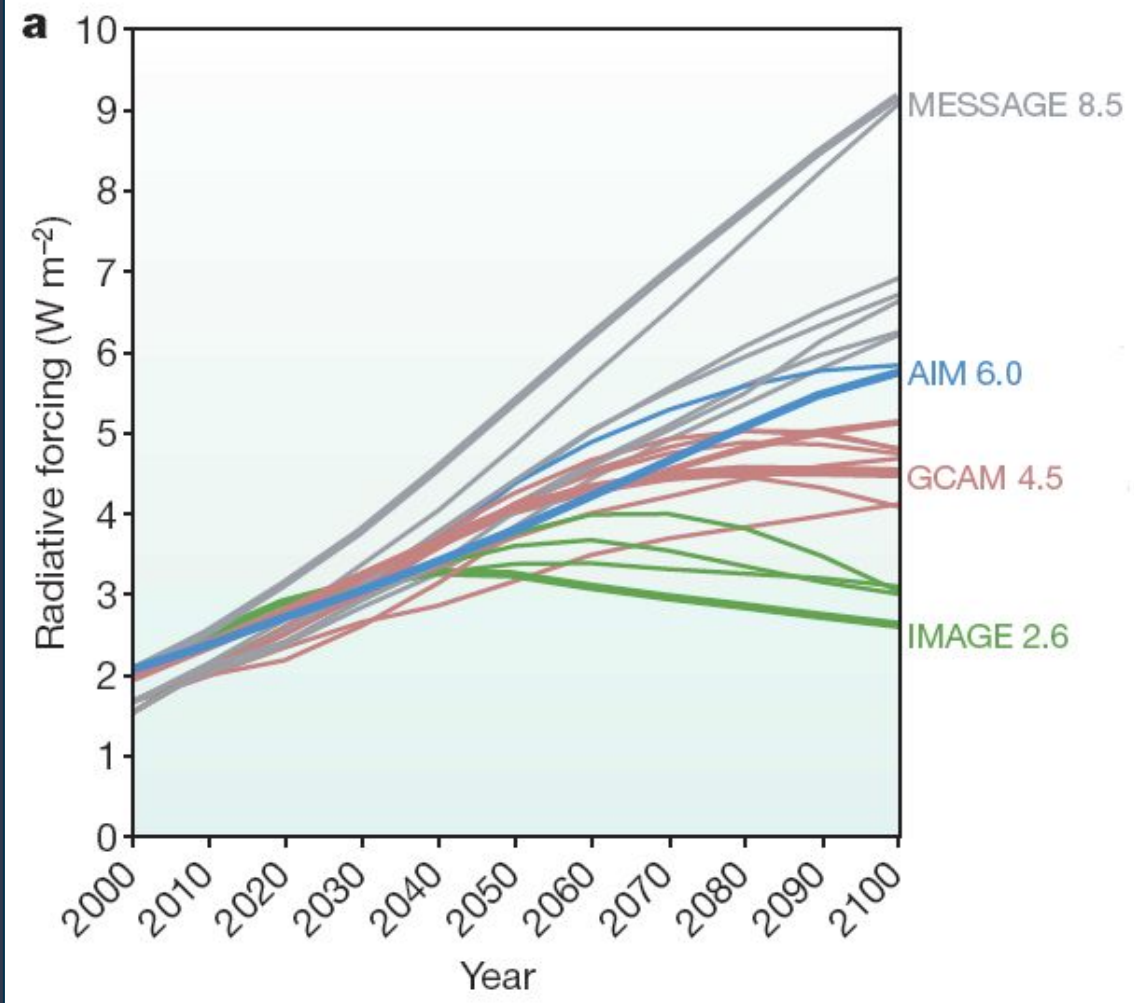


Figure from Moss et.al., 2010

Literature Review

GCM ensemble

- Multiple research teams run a number of simulations for global climate models.
- A GCM ensemble forms by keeping the rate of change in greenhouse gases same in a simulation, and only changing the point of initiation of increase in the timeline.
- The long term changes are similar between ensembles but year by year and decade by decade variability can be seen in the resulting climate.
- The different members of an ensemble are then averaged together to form a more robust climate model.

Data used

- Global Climate model from **Coupled Model Intercomparison Project – Phase 5** (CMIP5) database by the **Working Group on Coupled Modelling (WGCM)** under the **World Climate Research Programme (WCRP)**.
- **Model: MIROC5** (Model for Interdisciplinary Research On Climate – version 5)
- **Historical** and **RCP8.5** dataset.
- **Spatial resolution:** 1.4008º (Latitude with an extent -89º to 89º) and 1.40625º (Longitude with an extent -180º to 180º)
- **Data variable:** Precipitation flux
- **Time-frequency:** Day

Methodology

Data sorting and Interpolation

- First step required to subset the data between the latitudes 25º-38º and longitudes 72º-100º
- Interpolation from 1.4º spatial resolution to .25º special resolution using a 2D Spline Interpolation technique which uses a 5 degree polynomial quintic function.
- Used Python's **scipy** library which has an inbuilt function **interp2d** to do the same.
- Convert precipitation flux ($kg/m^2/s$) to daily precipitation (mm/day) by multiplying all values with 24*60*60.

Methodology

- Next step was to write the code for calculating the following 10 climate indices for each pixel in the dataset.

1. **CDD**: Maximum length of dry spell, maximum number of consecutive days with precipitation < 1mm.
2. **CWD:** Maximum length of wet spell, maximum number of consecutive days with PRCP ≥ 1mm
3. **PRCPTOT**: Annual total precipitation in wet days.
4. **R95pTOT**: Annual total PRCP when PRCP > 95p
5. **R99pTOT:** Annual total PRCP when PRCP > 99p
6. **Rx1day:** Monthly maximum 1-day precipitation

Methodology

Calculations and Spike removal

- The whole dataset was divided into 4 parts:
- Base Period (for calculating percentile): 1st Jan 1961 to 31st Dec 1990
- Historical Period: 1st Jan 1981 to 31st Dec 2020
- Period 1: 1st Jan 2021 to 31st Dec 2060
- Period 2: 1st Jan 2061 to 31st Dec 2100
- For all the indices except SDII, annual or monthly values were calculated.
- A spike removal method was applied on annual and monthly values to only include **mean ± 3 standard deviation** values.
- Spike was replaced by the mean value.
- The choice of 3SD was made keeping in mind not more than 3-5% of data was removed.

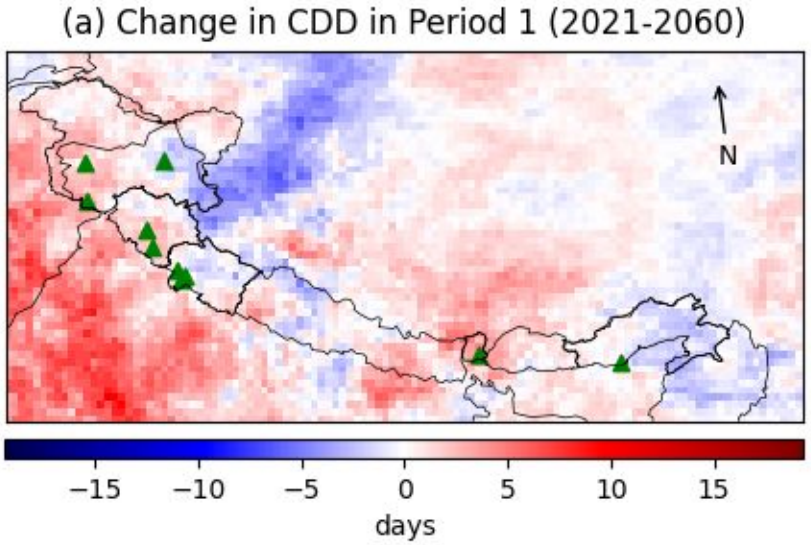
Methodology

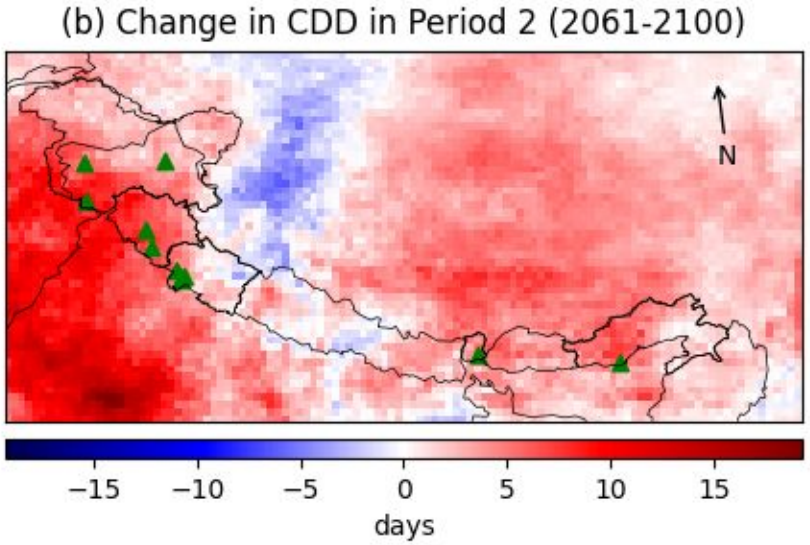
Calculations differences and Mann Kendall Trend Analysis

- Difference between the 2D grids for each of the 10 indices were calculate between the following:
- Difference 1 = Period 1 – Historical
- Difference 2 = Period 2 – Historical
- These differences were then plotted on a map of the study area using python libraries Basemap and matplotlib.
- Yue and Wang Modified Mann Kendall Test were carried out for 10 major cities in the study area: **Srinagar, Jammu, Leh, Shimla, Mandi, Dehradun, Haridwar, Rishikesh, Gangtok, and Itanagar.**
- Pixel nearest to the geographical location of these cities were chosen for the test.
- Climate index values along with Mann Kendall trend were plotted on a time series graph for 120 years for these 10 cities.

Results

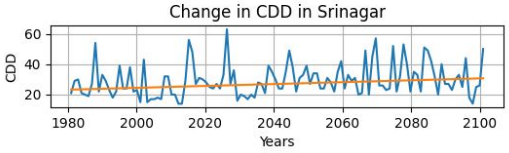
- Climate Indices are simple diagnostic quantity to characterize an aspect of geophysical system such as temperature or precipitation.
- They allow us to carry out statistical study of different climatological aspects such as means, extremes, trends and time series.
- Each climate index has a defining mathematical equation.
- The next few slides are the results we got from calculations of these indices.

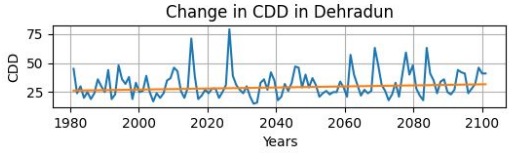


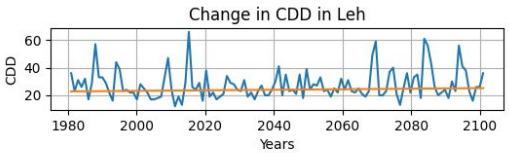


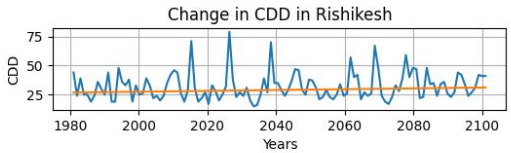
- CDD is a drought index, Maximum number of consecutive days with precipitation < 1 mm
- Used to determine long spells of dryness.
- Increase indicates chances of drought.

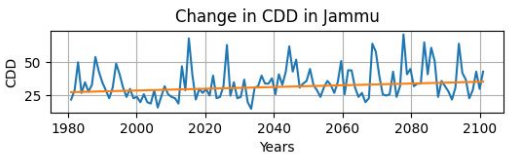
Difference between future and historical periods

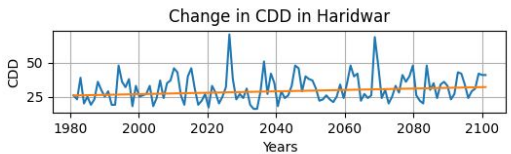


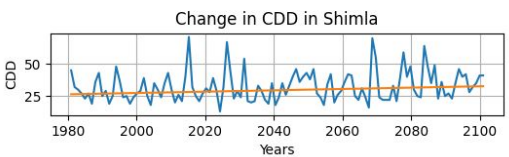


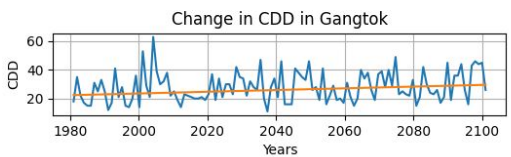


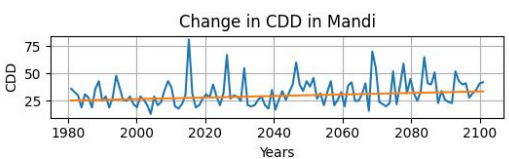


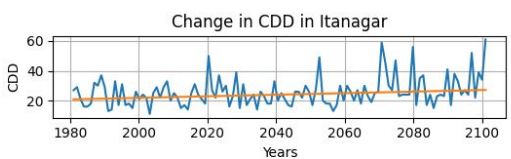






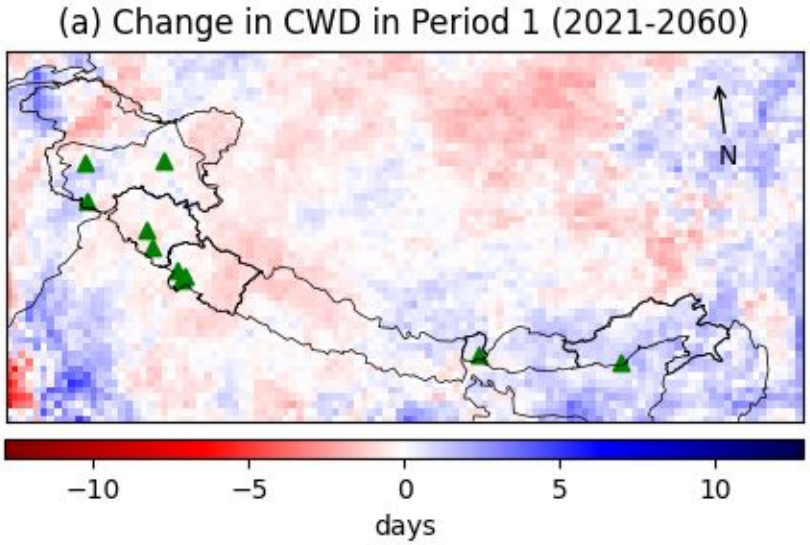


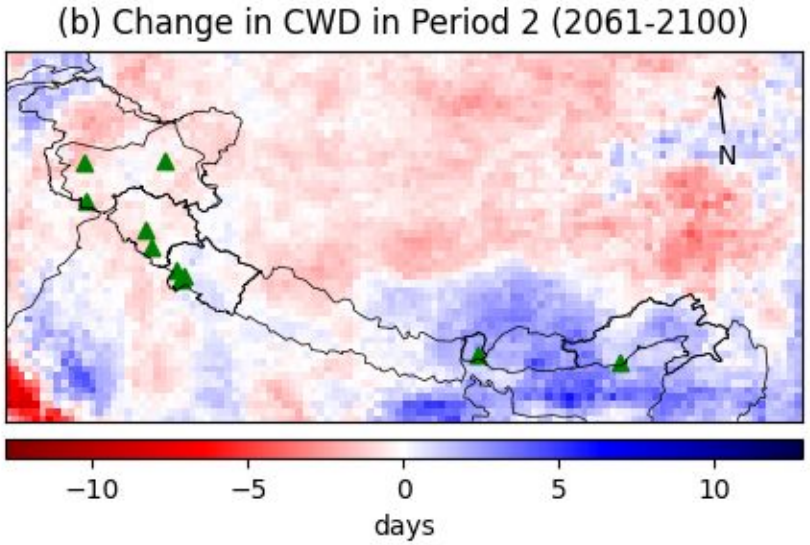




City	Trend	z value	Mann Kendall score	Sen's slope	Intercept
Srinagar	increasing	8.103295	1174	0.0625	23.28125
Leh	no trend	1.886431	455	0.019901	22.81589
Jammu	increasing	5.909133	1180	0.065914	27.57814
Shimla	increasing	7.485543	885	0.052632	26.36842
Mandi	increasing	8.531078	1245	0.070175	25.32456
Dehradun	increasing	7.660605	866	0.045455	26.29545
Rishikesh	increasing	7.484632	688	0.036364	26.83636
Haridwar	increasing	10.82331	988	0.052083	25.90104
Gangtok	increasing	6.957925	1051	0.060424	22.4048
Itanagar	increasing	3.738137	1104	0.052632	20.86842

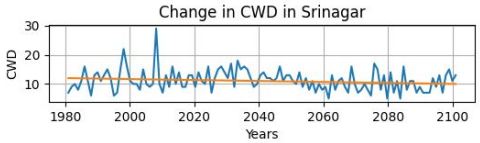
Time series, trend plots, and Yue and Wang Modified MK Test for CDD

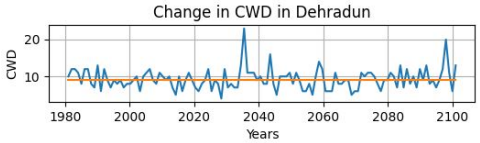


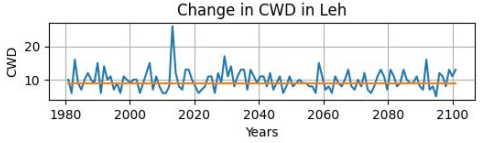


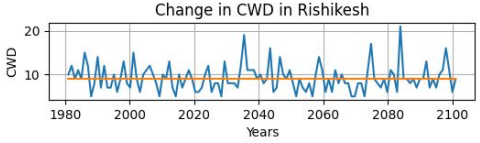
- CWD is a precipitation index, Maximum number of consecutive days with precipitation ≥ 1 mm
- Used to determine long spells of wetness.
- Increase with time indicates flood favouring conditions

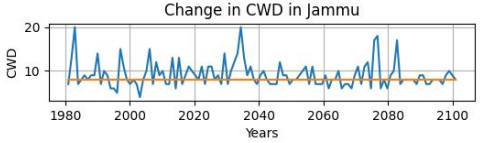
Difference between future and historical periods

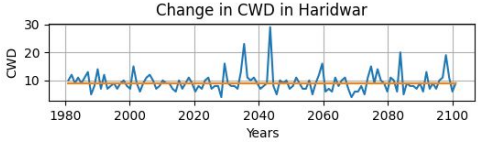


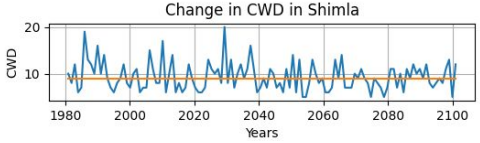


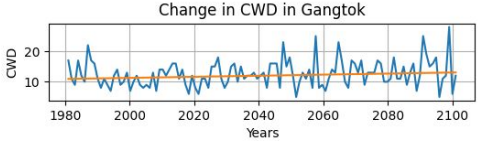


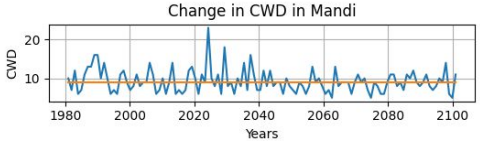


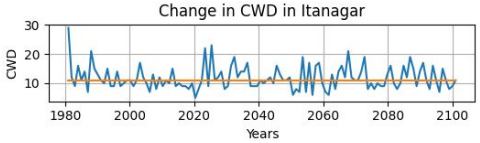






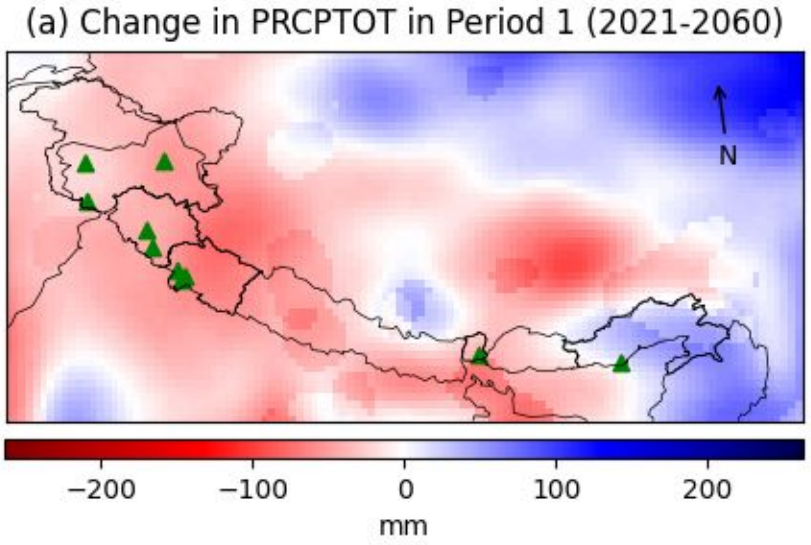


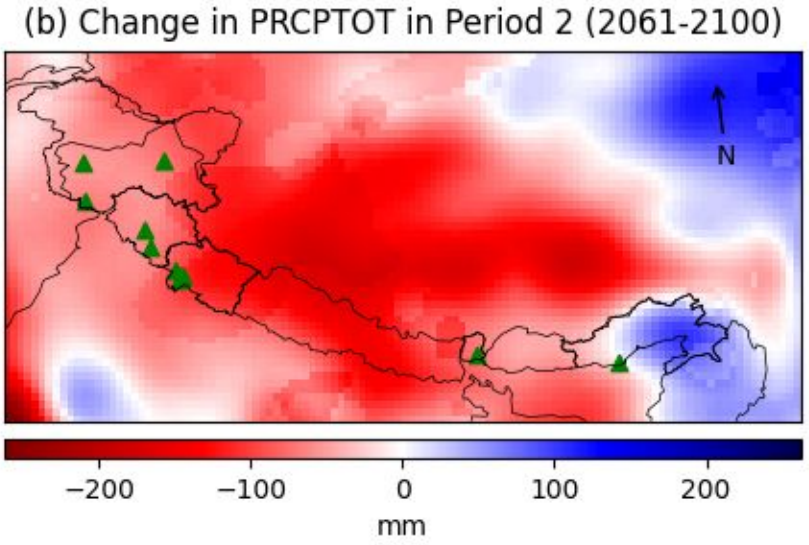




City	Trend	z value	Mann Kendall score	Sen's slope	Intercept
Srinagar	decreasing	-3.10648	-828	-0.01667	11.99167
Leh	no trend	-0.08875	-16	0	9
Jammu	no trend	-1.71916	-449	0	8
Shimla	no trend	-1.07125	-344	0	9
Mandi	no trend	-1.41929	-565	0	9
Dehradun	no trend	0.246375	53	0	9
Rishikesh	no trend	-1.84556	-300	0	9
Haridwar	decreasing	-2.69291	-336	0	9
Gangtok	increasing	4.689209	793	0.017857	10.9375
Itanagar	no trend	-0.44672	-77	0	11

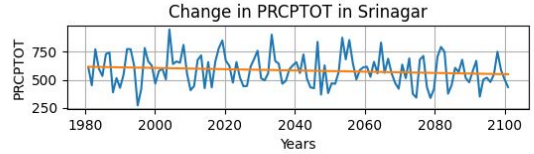
Time series, trend plots, and Yue and Wang Modified MK Test for CWD

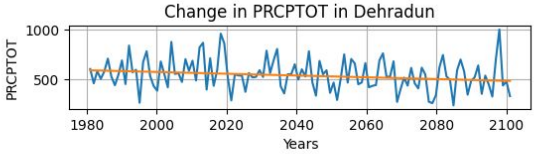


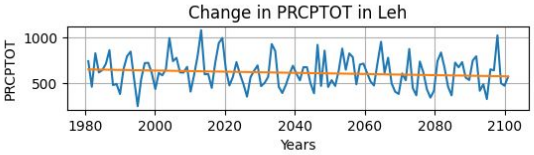


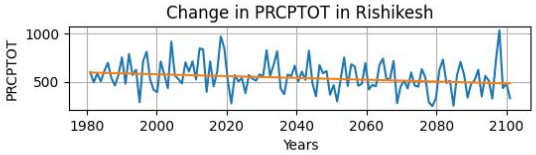
- PRCPTOT is a precipitation index, Annual total amount of precipitation on wet days (precipitation ≥ 1 mm)
- Used to determine average total precipitation in an area.
- Decrease with time indicates decrease in rainfall/water scarcity.

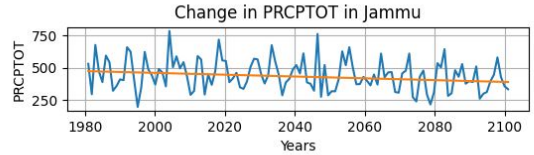
Difference between future and historical periods

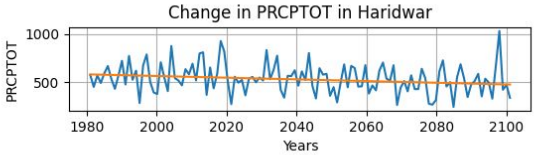


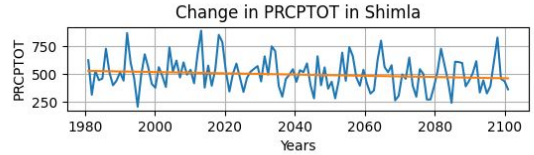


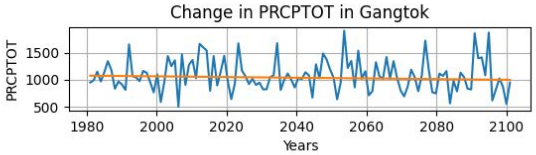


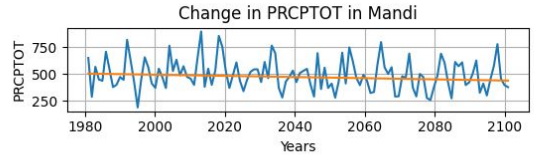


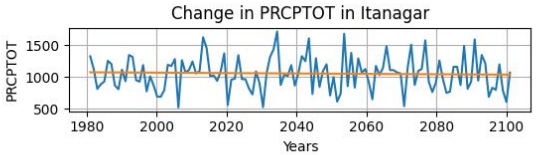






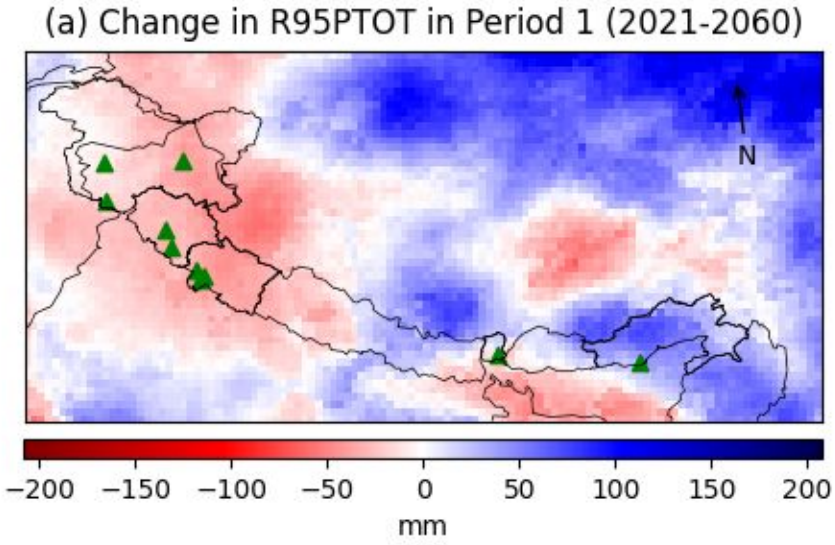


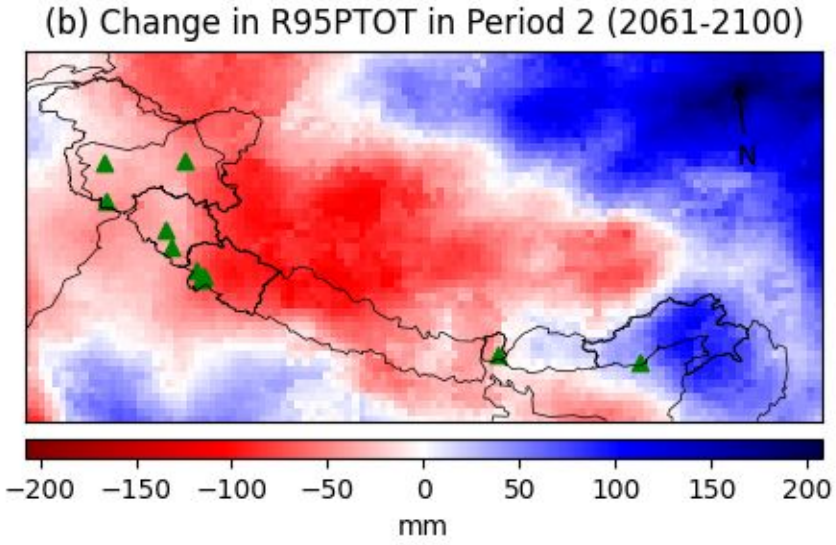




City	Trend	z value	Mann Kendall score	Sen's slope	Intercept
Srinagar	decreasing	-4.86741	-592	-0.56061	616.2509
Leh	decreasing	-5.24838	-588	-0.63556	652.728
Jammu	decreasing	-9.06036	-982	-0.70701	474.5776
Shimla	decreasing	-5.11941	-638	-0.56139	528.187
Mandi	decreasing	-5.45601	-654	-0.54373	503.9684
Dehradun	decreasing	-8.20409	-1026	-0.89456	593.5911
Rishikesh	decreasing	-8.84103	-1080	-0.9612	595.8893
Haridwar	decreasing	-8.78074	-1024	-0.88234	581.3967
Gangtok	decreasing	-2.70452	-368	-0.64239	1076.212
Itanagar	no trend	-1.13393	-176	-0.31304	1072.434

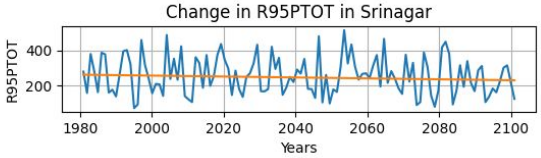
Time series, trend plots, and Yue and Wang Modified MK Test for PRCPTOT

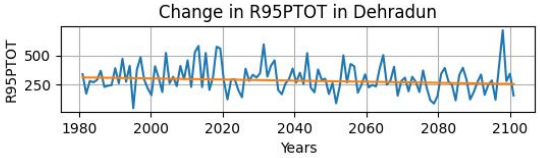


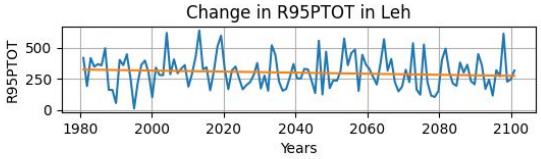


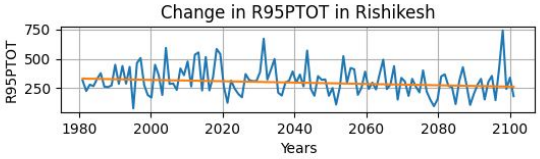
- R95PTOT is a precipitation index, Annual total amount of precipitation when precipitation ≥ 95th percentile of base period
- Used to determine very heavy precipitation events.
- Increase with time indicates increase in the chances of floods or cloud bursts.

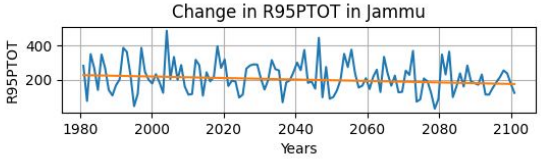
Difference between future and historical periods

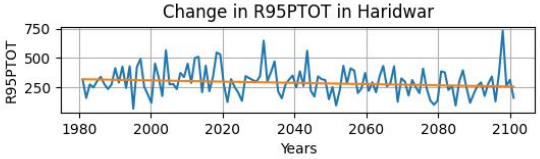


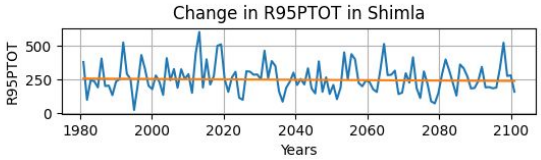


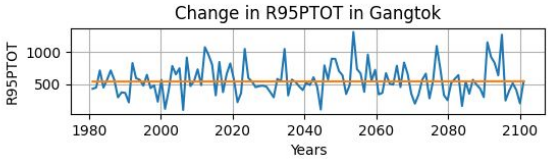


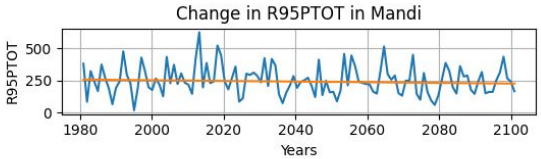


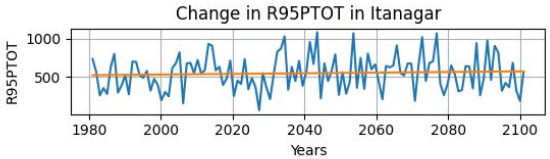






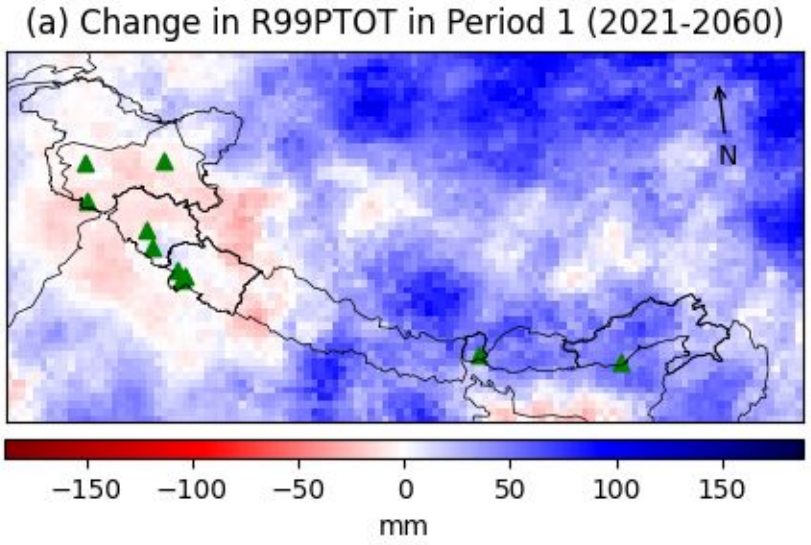


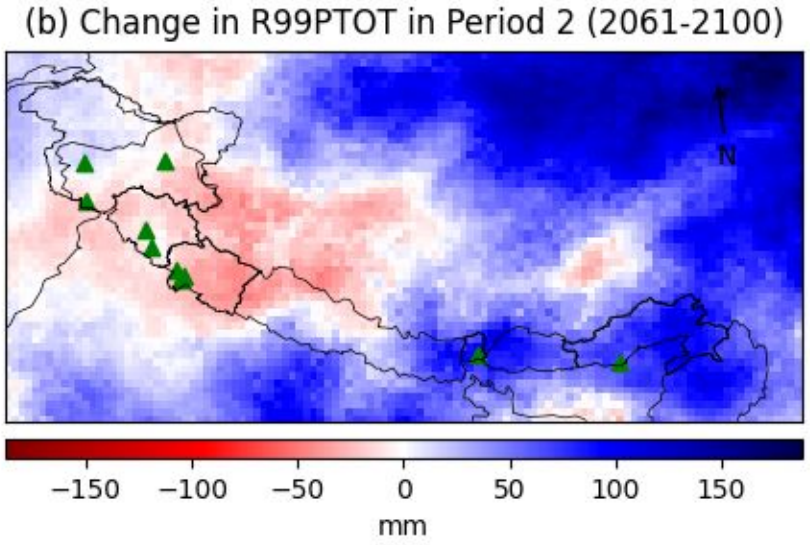




City	Trend	z value	Mann Kendall score	Sen's slope	Intercept
Srinagar	decreasing	-3.04784	-390	-0.26562	261.349
Leh	decreasing	-3.07619	-510	-0.42722	324.5873
Jammu	decreasing	-7.41684	-782	-0.43714	226.6327
Shimla	no trend	-1.90666	-286	-0.15747	257.3789
Mandi	decreasing	-2.39494	-360	-0.25883	256.7359
Dehradun	decreasing	-3.94464	-702	-0.46986	312.6715
Rishikesh	decreasing	-4.82582	-810	-0.57959	330.6619
Haridwar	decreasing	-4.7073	-756	-0.52694	319.2642
Gangtok	no trend	0.170452	30	0.038818	542.8091
Itanagar	no trend	1.545452	276	0.411231	524.1219

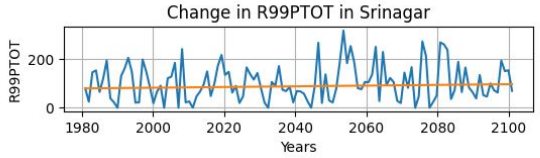
Time series, trend plots, and Yue and Wang Modified MK Test for R95PTOT

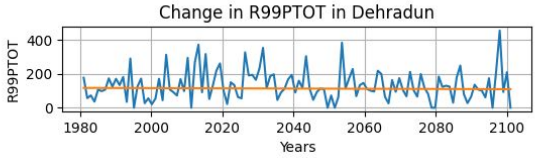


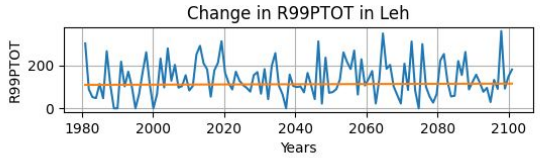


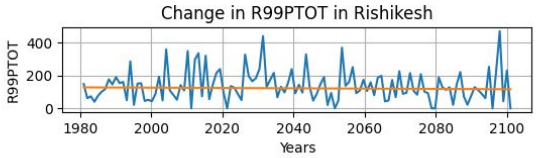
- R99PTOT is a precipitation index, Annual total amount of precipitation when precipitation ≥ 99th percentile of base period
- Used to determine extreme precipitation events.
- Increase with time indicates increase in the chances of floods or cloud bursts.

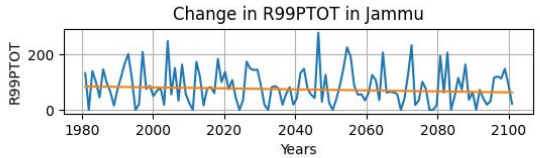
Difference between future and historical periods

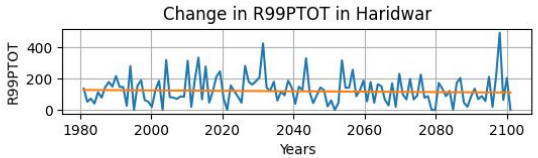


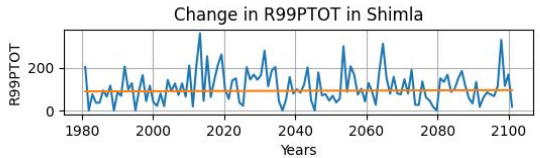


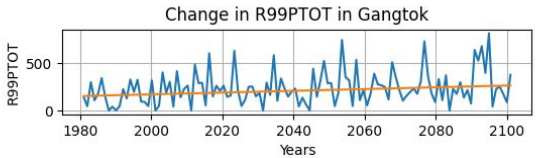


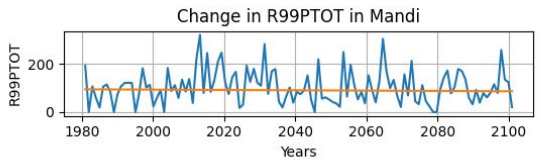


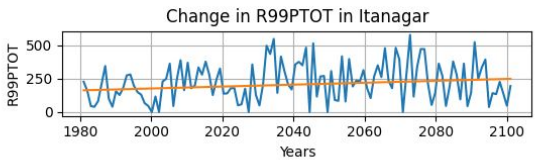






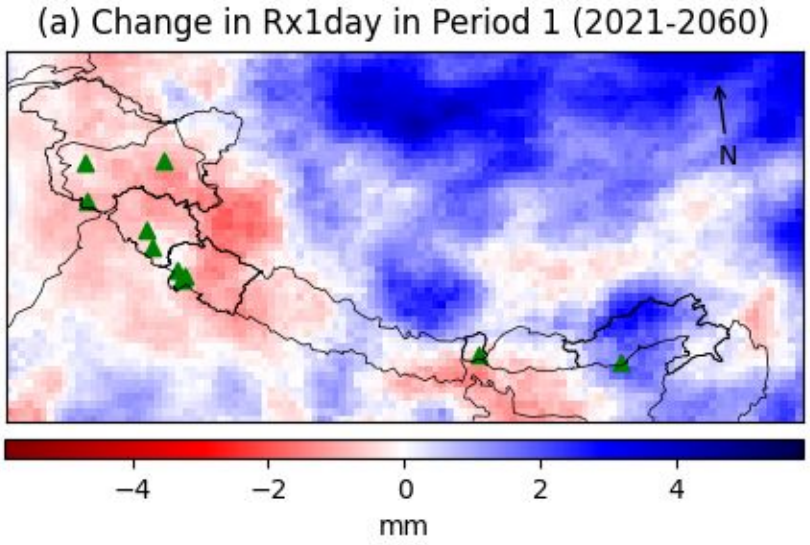


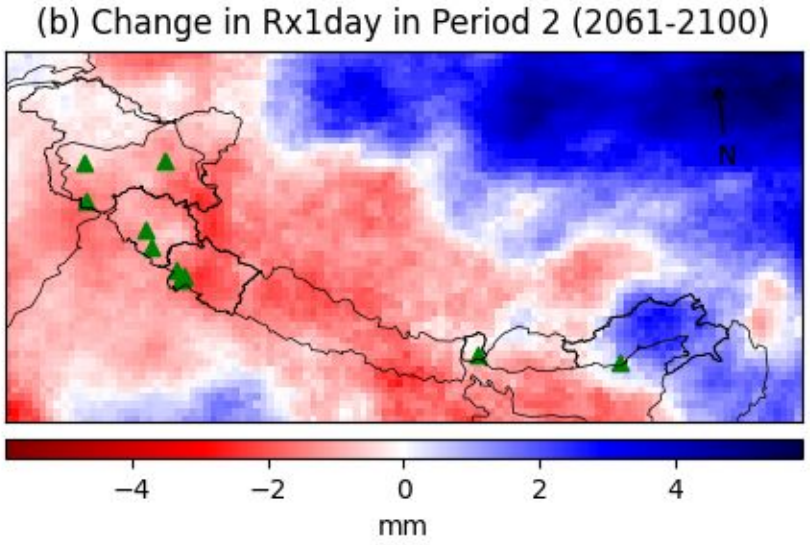




City	Trend	z value	Mann Kendall score	Sen's slope	Intercept
Srinagar	increasing	2.258844	382	0.145655	79.61408
Leh	no trend	0.799903	111	0.048721	109.8802
Jammu	decreasing	-5.89191	-499	-0.18229	84.73298
Shimla	no trend	0.60876	143	0.051521	89.1801
Mandi	no trend	-0.77229	-167	-0.06884	94.9345
Dehradun	no trend	-0.62307	-130	-0.06343	116.6862
Rishikesh	no trend	-0.98912	-211	-0.09467	127.4132
Haridwar	no trend	-1.78367	-304	-0.13735	127.7664
Gangtok	increasing	6.459885	1063	0.937446	153.4102
Itanagar	increasing	3.166161	825	0.722226	163.1675

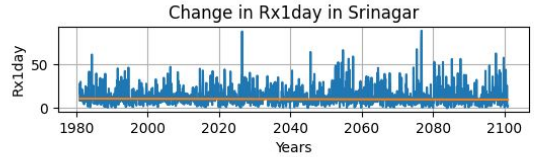
Time series, trend plots, and Yue and Wang Modified MK Test for R99PTOT

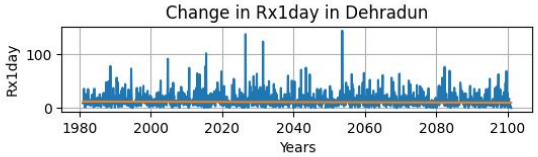


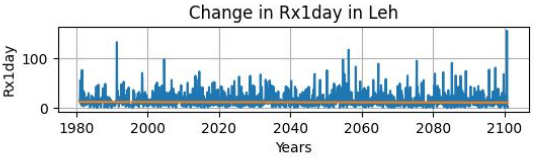


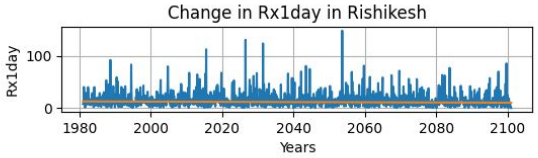
- Rx1day is a precipitation index, Monthly maximum single day precipitation
- Used to determine most intense one day precipitation.
- Increase with time indicates increase in the chances of flash floods or cloud bursts.

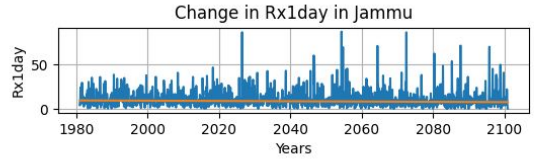
Difference between future and historical periods

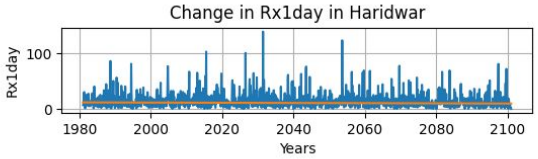


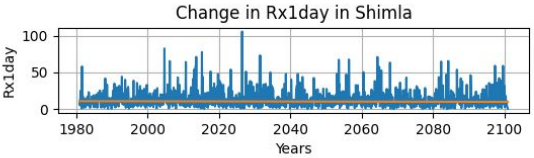


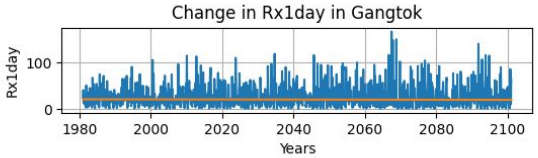


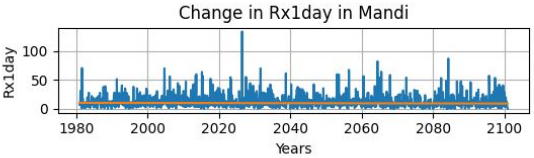


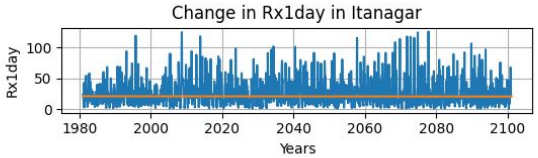






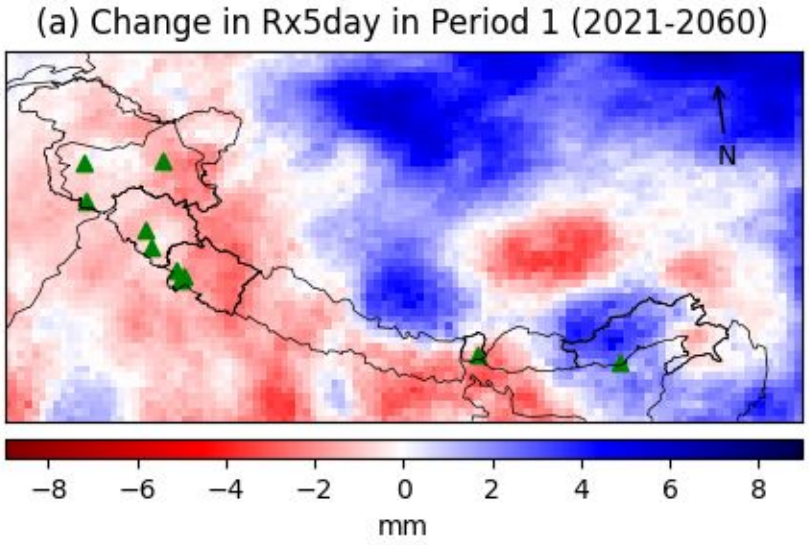


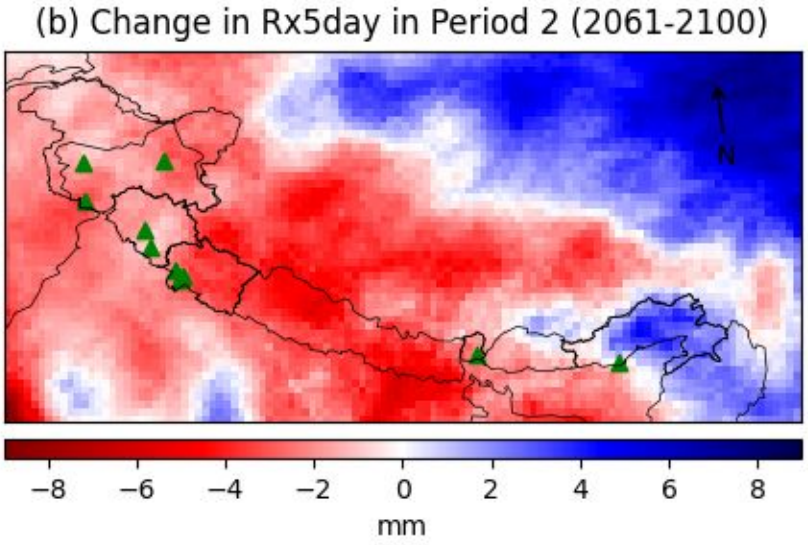




City	Trend	z value	Mann Kendall score	Sen's slope	Intercept
Srinagar	decreasing	-2.1907	-31520	-0.00082	10.83438
Leh	decreasing	-2.8669	-23916	-0.00075	12.45472
Jammu	decreasing	-7.01211	-59538	-0.00132	9.68573
Shimla	decreasing	-3.01432	-27242	-0.00071	10.70425
Mandi	decreasing	-3.85856	-32902	-0.00084	10.44352
Dehradun	decreasing	-5.61691	-48996	-0.00142	12.12382
Rishikesh	decreasing	-7.25883	-56762	-0.0017	12.66728
Haridwar	decreasing	-7.01457	-50902	-0.00146	11.97289
Gangtok	no trend	-1.05121	-15688	-0.00089	21.2643
Itanagar	no trend	-0.44935	-6172	-0.00033	20.79189

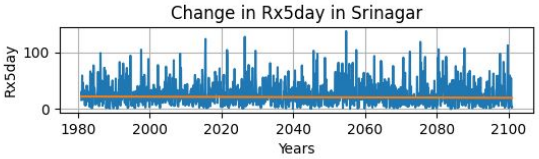
Time series, trend plots, and Yue and Wang Modified MK Test for Rx1day

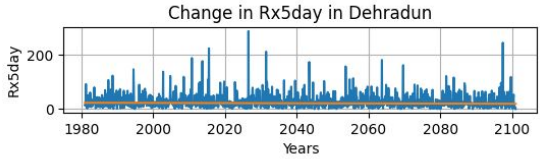


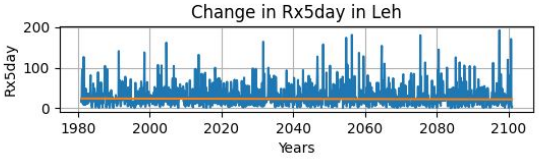


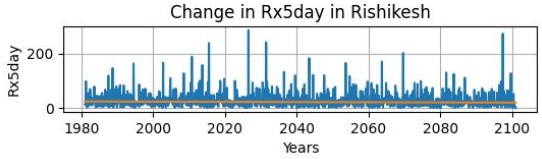
- Rx5day is a precipitation index, Monthly maximum 5 day precipitation
- Used to determine most intense five day precipitation.
- Increase with time indicates increase in the chances of flash floods or cloud bursts.

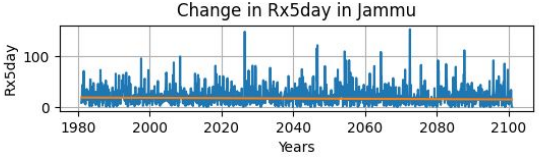
Difference between future and historical periods

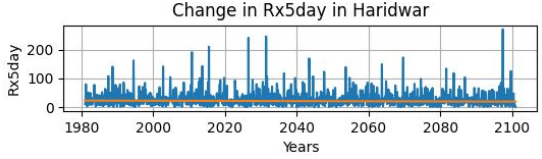


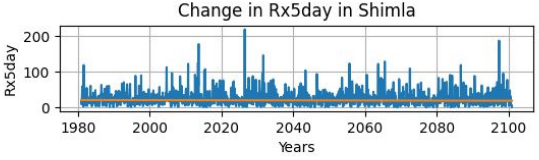


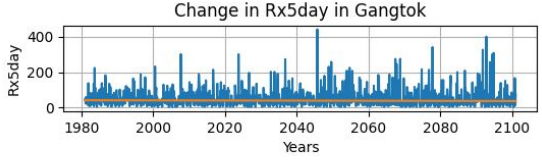


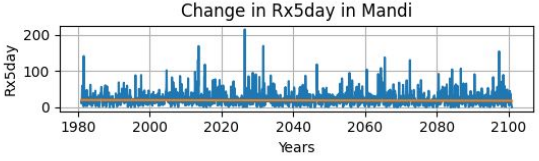


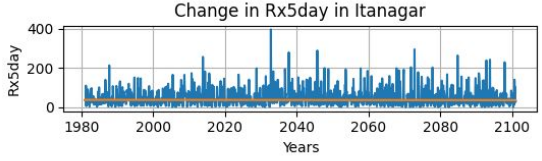






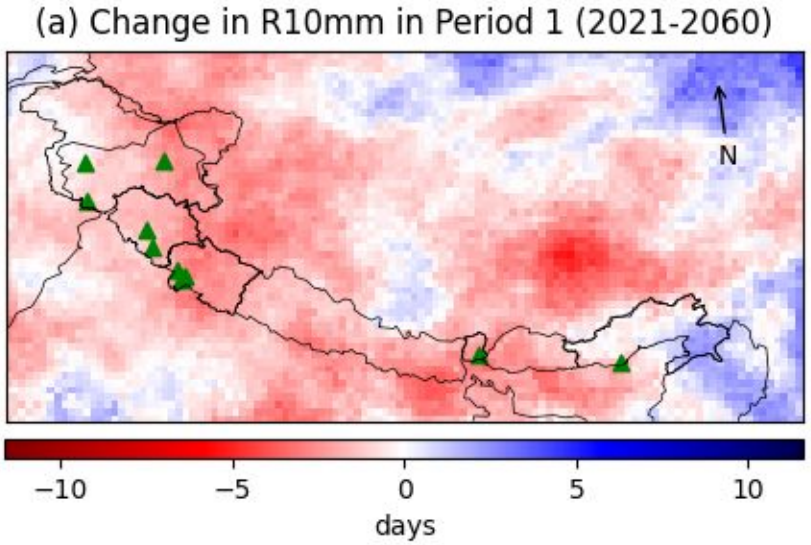


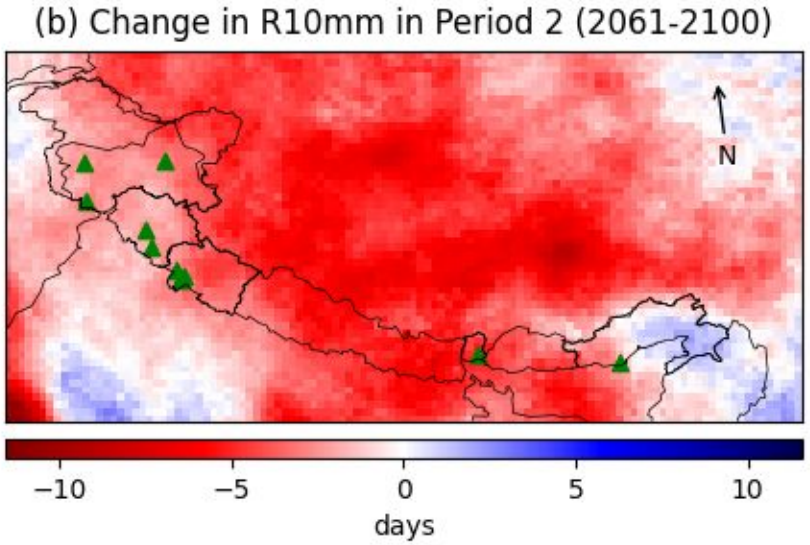




City	Trend	z value	Mann Kendall score	Sen's slope	Intercept
Srinagar	decreasing	-3.17355	-28760	-0.00154	22.04289
Leh	decreasing	-3.58776	-25382	-0.00152	24.00635
Jammu	decreasing	-8.82777	-60100	-0.00266	18.98831
Shimla	decreasing	-3.60973	-26140	-0.00138	20.39797
Mandi	decreasing	-3.88319	-26842	-0.00136	20.23529
Dehradun	decreasing	-7.38798	-45276	-0.00256	23.11391
Rishikesh	decreasing	-8.33046	-49172	-0.00284	24.21862
Haridwar	decreasing	-7.2767	-43880	-0.00247	23.04283
Gangtok	decreasing	-2.0762	-28588	-0.00297	40.62916
Itanagar	no trend	-0.82781	-11160	-0.00111	38.38604

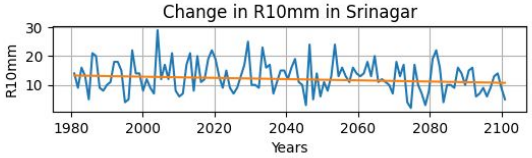
Time series, trend plots, and Yue and Wang Modified MK Test for Rx5day

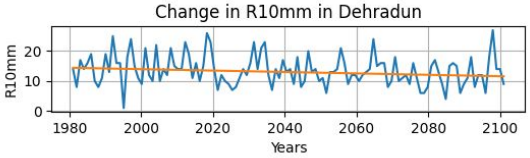


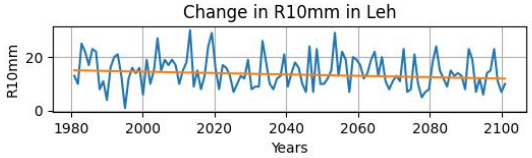


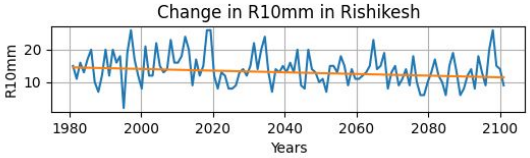
- R10mm is a precipitation index, Annual number of days with precipitation ≥ 10 mm
- Used to determine heavy precipitation days.
- Increase with time indicates increase in the chances of floods.

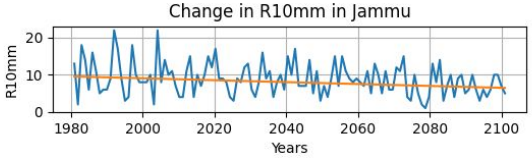
Difference between future and historical periods

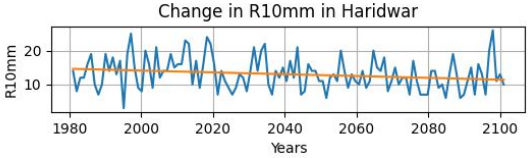


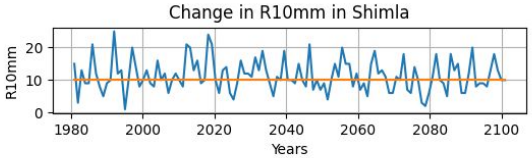


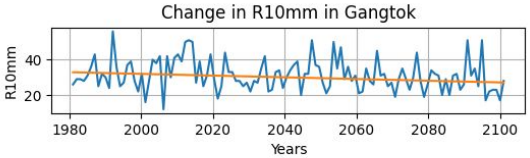


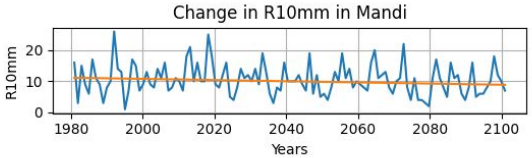


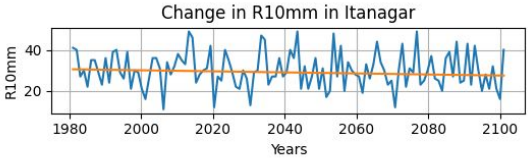






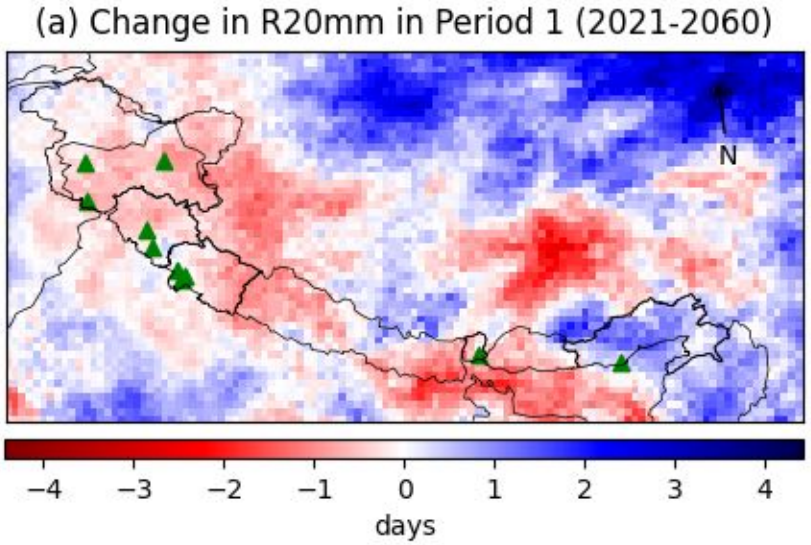


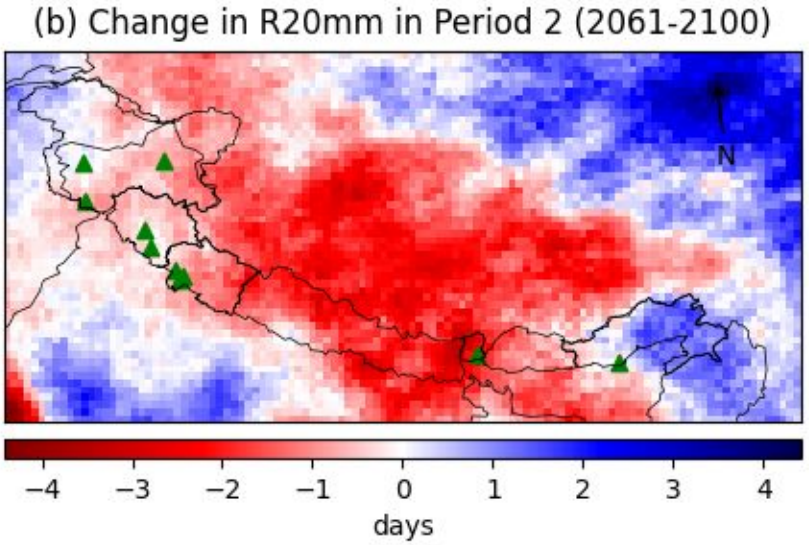




City	Trend	z value	Mann Kendall score	Sen's slope	Intercept
Srinagar	decreasing	-3.72175	-662	-0.02128	13.26596
Leh	decreasing	-5.74885	-735	-0.02597	15.04545
Jammu	decreasing	-7.94264	-1024	-0.02592	9.542124
Shimla	no trend	-1.52537	-367	0	10
Mandi	decreasing	-5.27074	-679	-0.01896	11.12799
Dehradun	decreasing	-7.07466	-853	-0.02381	14.41667
Rishikesh	decreasing	-6.00891	-941	-0.02597	14.54545
Haridwar	decreasing	-6.43148	-1007	-0.02703	14.60811
Gangtok	decreasing	-5.81619	-939	-0.04866	32.89539
Itanagar	decreasing	-3.82767	-511	-0.02581	30.53555

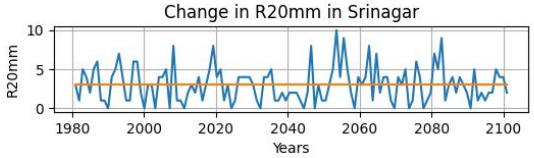
Time series, trend plots, and Yue and Wang Modified MK Test for R10mm

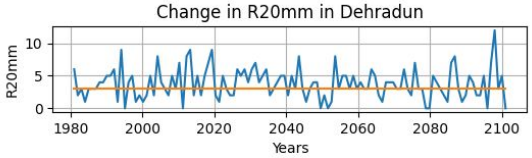


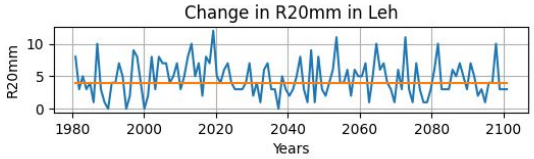


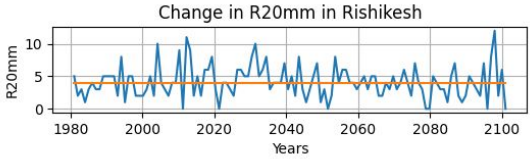
- R20mm is a precipitation index, Annual number of days with precipitation ≥ 20 mm
- Used to determine very heavy precipitation days.
- Increase with time indicates increase in the chances of floods.

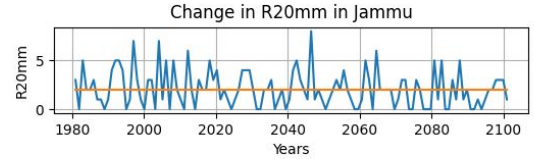
Difference between future and historical periods

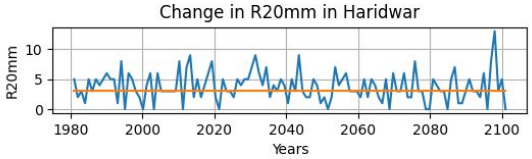


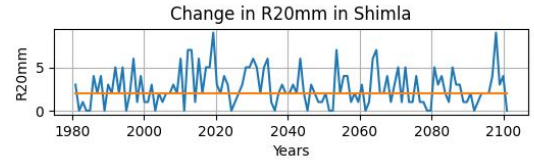


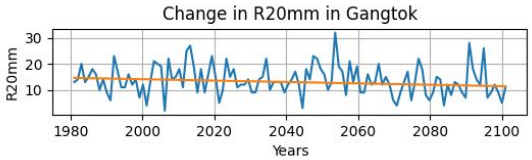


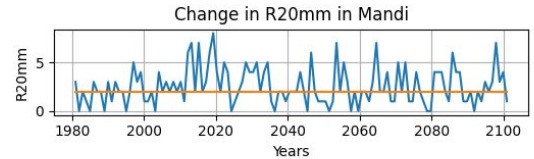


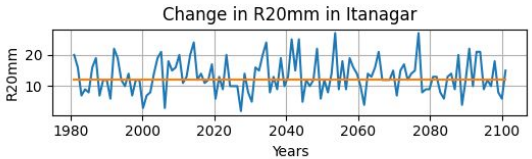






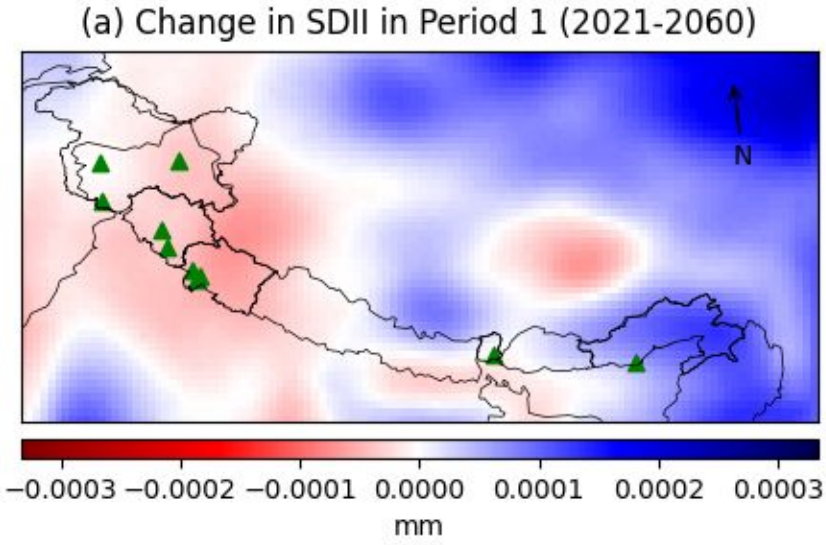


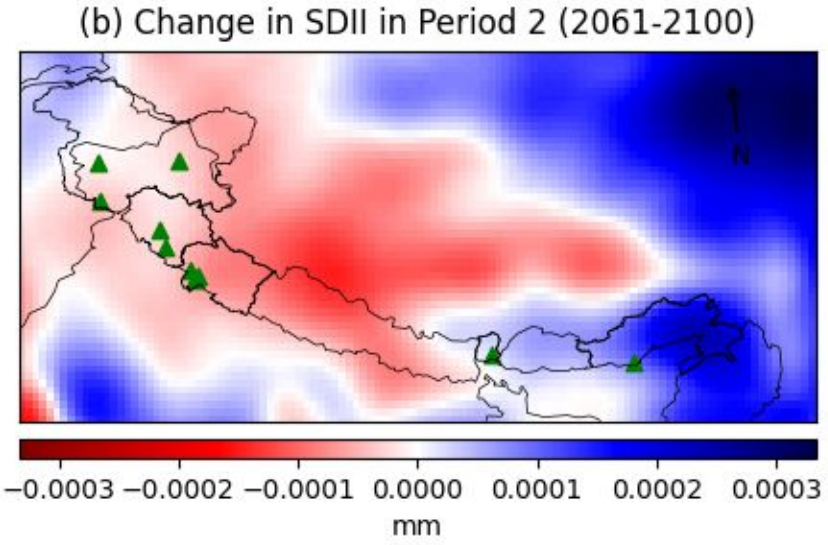




City	Trend	z value	Mann Kendall score	Sen's slope	Intercept
Srinagar	no trend	0.05071	8	0	3
Leh	no trend	-1.75815	-341	0	4
Jammu	no trend	-1.87795	-670	0	2
Shimla	no trend	-0.41481	-94	0	2
Mandi	no trend	0.105459	26	0	2
Dehradun	no trend	-1.38707	-259	0	3
Rishikesh	no trend	-1.03696	-263	0	4
Haridwar	decreasing	-2.31299	-492	0	3
Gangtok	decreasing	-4.78187	-907	-0.02703	14.60811
Itanagar	no trend	0.064745	9	0	12

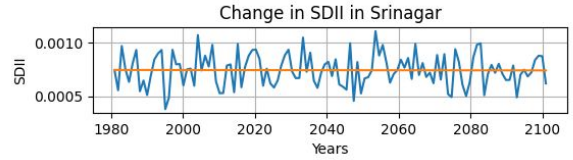
Time series, trend plots, and Yue and Wang Modified MK Test for R20mm

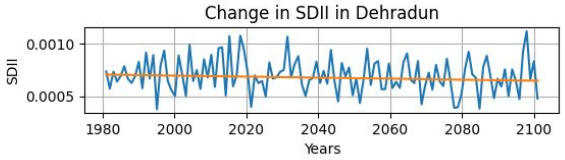


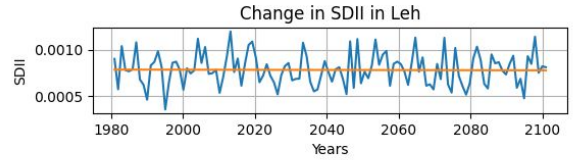


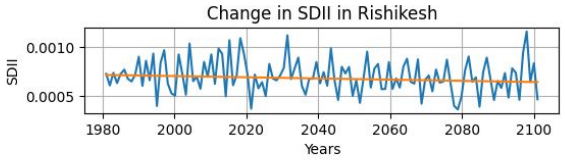
- SDII (Simple Daily Intensity Index) is a precipitation index, Average daily precipitation on a wet day (precipitation ≥ 1 mm)
- Used to determine the intensity of precipitation on a day.
- Increase with time indicates increase in concentration of precipitation in less amount of time.

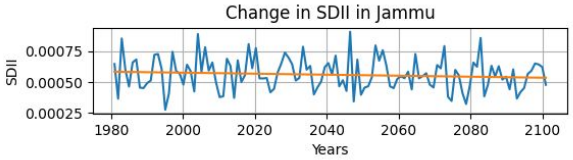
Difference between future and historical periods

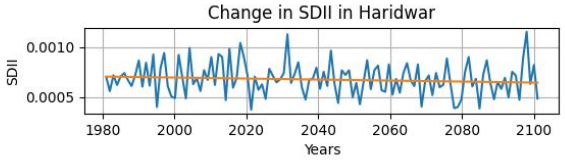


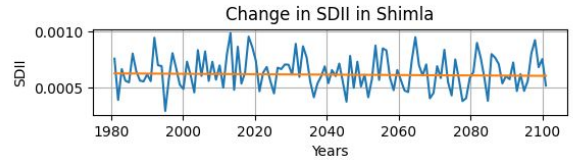


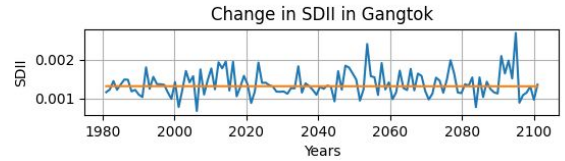


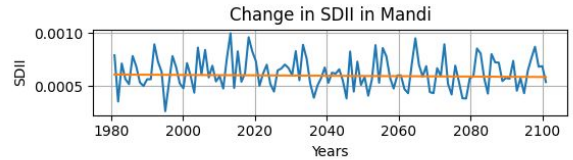


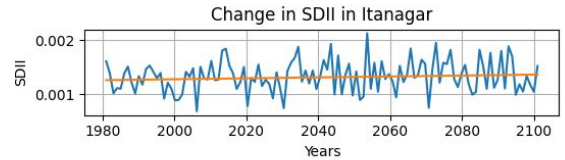












City	Trend	z value	Mann Kendall score	Sen's slope	Intercept
Srinagar	no trend	-0.25701	-28	-3.5E-08	0.000747
Leh	no trend	-0.49886	-56	-6.7E-08	0.000787
Jammu	decreasing	-4.89753	-490	-4.1E-07	0.000584
Shimla	no trend	-1.37042	-184	-1.8E-07	0.000627
Mandi	no trend	-1.57567	-202	-1.9E-07	0.00061
Dehradun	decreasing	-3.92232	-528	-4.9E-07	0.000707
Rishikesh	decreasing	-4.73744	-606	-6.1E-07	0.000717
Haridwar	decreasing	-4.08953	-512	-5.1E-07	0.000704
Gangtok	no trend	-0.10942	-22	-2.6E-08	0.001314
Itanagar	increasing	3.138096	452	8.64E-07	0.001262

Time series, trend plots, and Yue and Wang Modified MK Test for SDII

Conclusions

- There is an overall decrease in precipitation in the western Himalayas and increase in the eastern Himalayas.
- CDD are likely to increase with a minimum change in CWD.
- Extreme indices like R95PTOT, R99PTOT, R20mm, R10mm are likely to decrease in the middle Himalayas than in the western or eastern Himalayas.
- Single-day and five-day max precipitation are likely to consistently decrease in the western and middle Himalayas.
- Northeast India already sees the highest rainfall and is likely to see an increase in future.
- Eastern Himalayas show the highest increase in very extreme precipitation events shown by R99PTOT.

Conclusions

- Further this study was only carried out on one Global climate model.
- A more robust study will consist of average data from more number of GCMs.
- Due to uneven terrain of the Himalayas, a single model can have biases in the data.
- Hence this study needs to be carried out on more Global climate models.

References

- Pradhan, Rajani & Sharma, Devesh & Panda, S. & Dubey, Swatantra & Sharma, Aditya. (2019). Changes of precipitation regime and its indices over Rajasthan state of India: impact of climate change scenarios experiments. Climate Dynamics. 52. 10.1007/s00382-018-4334-9.

- Jain, Sharad & Kumar, Vijay. (2012). Trend analysis of rainfall and temperature data for India SK Jain, V Kumar Current Science(Bangalore) 102 (1), 37-49. Current Science. 102.

- Dash, Sushil & Saraswat, Vaishali & Panda, Sumit & Sharma, Neha. (2013). A study of changes in rainfall and temperature patterns at four cities and corresponding meteorological subdivisions over coastal regions of India. Global and Planetary Change. 108. 175-194. 10.1016/j.gloplacha.2013.06.004.

- Moss, R., Edmonds, J., Hibbard, K. et al. The next generation of scenarios for climate change research and assessment. Nature 463, 747–756 (2010). https://doi.org/10.1038/nature08823

- IPCC, 2007: Summary for Policymakers. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Thank You!