General methods for visualization of Hydro-climatic data

Hydro-Climatic data

Hydro-climatic data typically includes various hydrology (water) and climate variables. Here's a list of common variables found in hydro-climatic datasets:

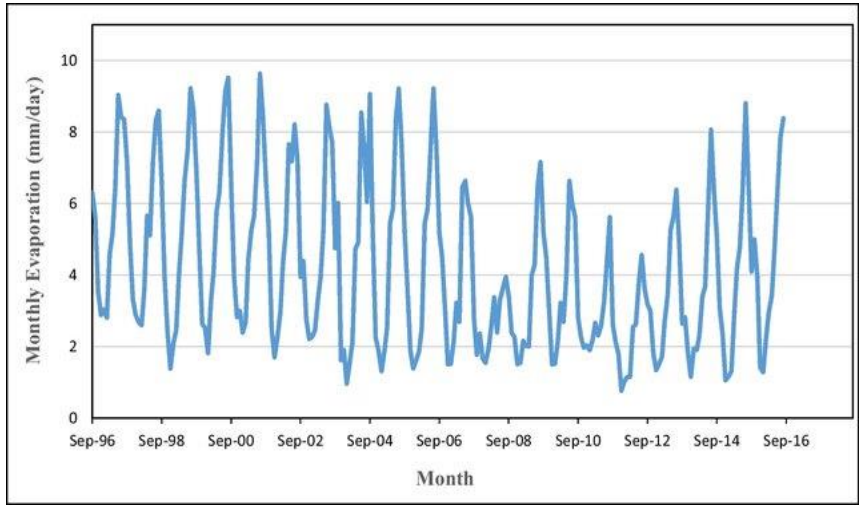
1. Precipitation
2. Temperature
3. Humidity
4. Evaporation
5. Streamflow
6. Snow Water Equivalent (SWE)
7. Soil Moisture
8. Groundwater Level
9. River Discharge
10. Relative Humidity
11. Wind Speed and Direction
12. Solar Radiation
13. Atmospheric Pressure
14. Cloud Cover
15. Potential Evapotranspiration (PET)
16. Water Temperature
17. Soil Temperature
18. Drought Indices
19. Flood Indices

Visualization techniques used for hydro-climatic data

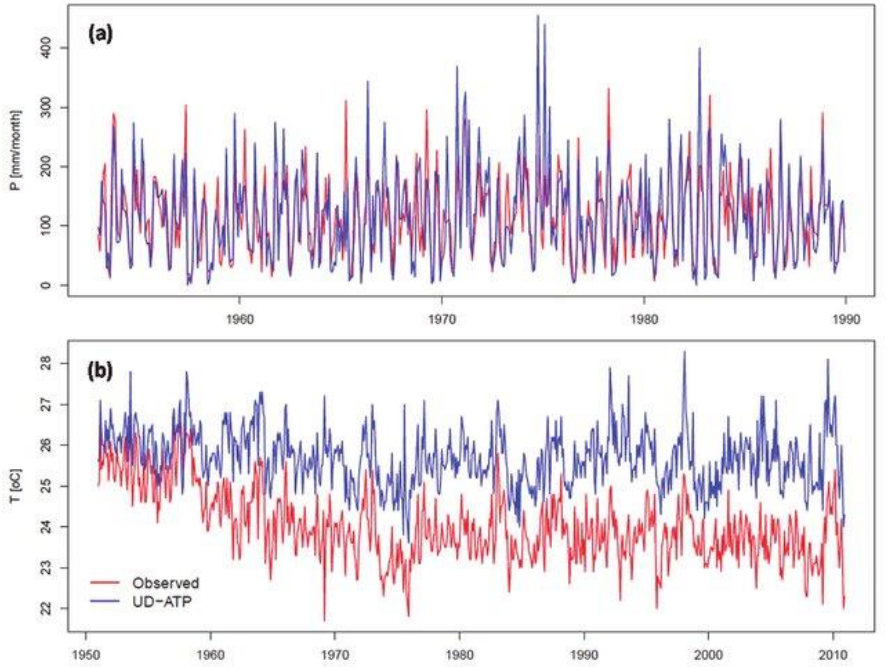
1. Time Series Plots
2. Scatter Plots
3. Heat maps
4. Contour Plots
5. GIS Maps
6. Animated Visualizations
7. Box Plots and Violin Plots
8. Radial Plots

Time Series Plots:

- Time series plots are widely used to visualize the temporal variation of hydro-climatic variables over time.
- The x-axis represents time (e.g., days, months, years), while the y-axis represents the variable of interest (e.g., precipitation, temperature).
- Multiple time series can be plotted on the same graph to compare different variables or locations.

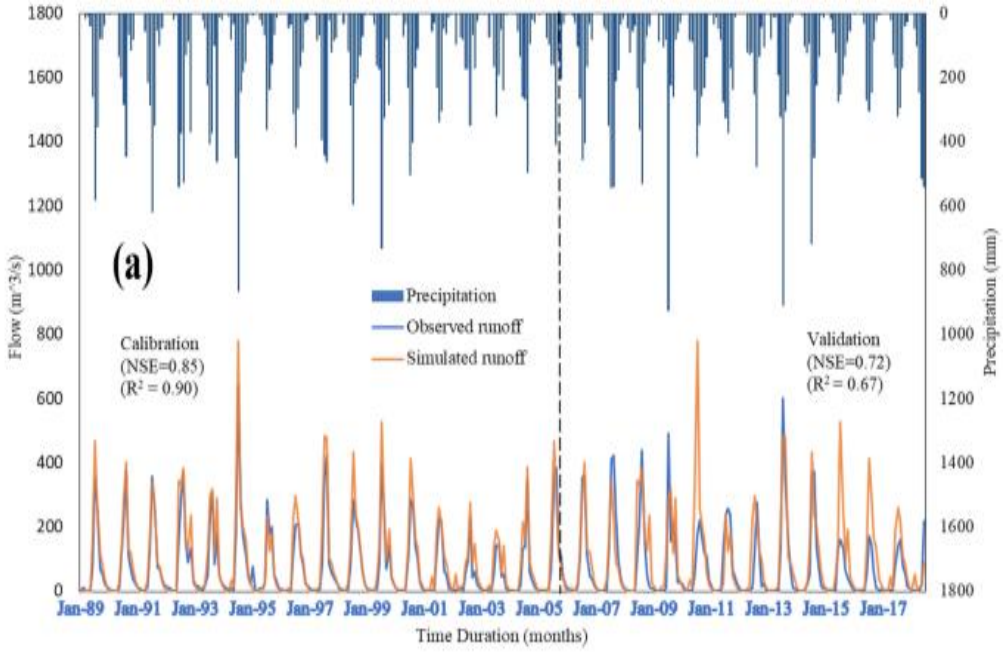


Time series of observed evaporation

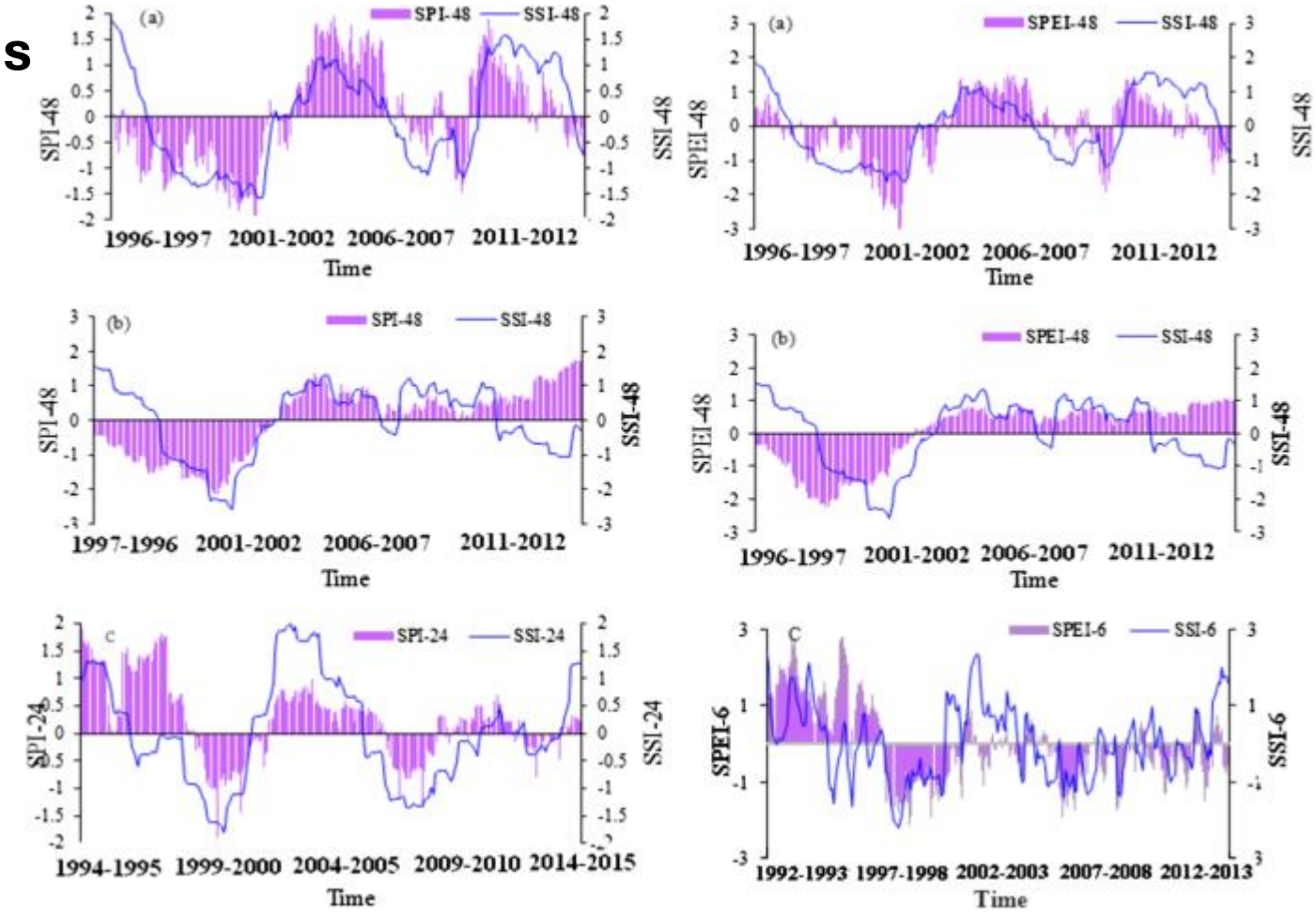


(a) Precipitation and (b) temperature time series plots

Time Series Plots for other variables



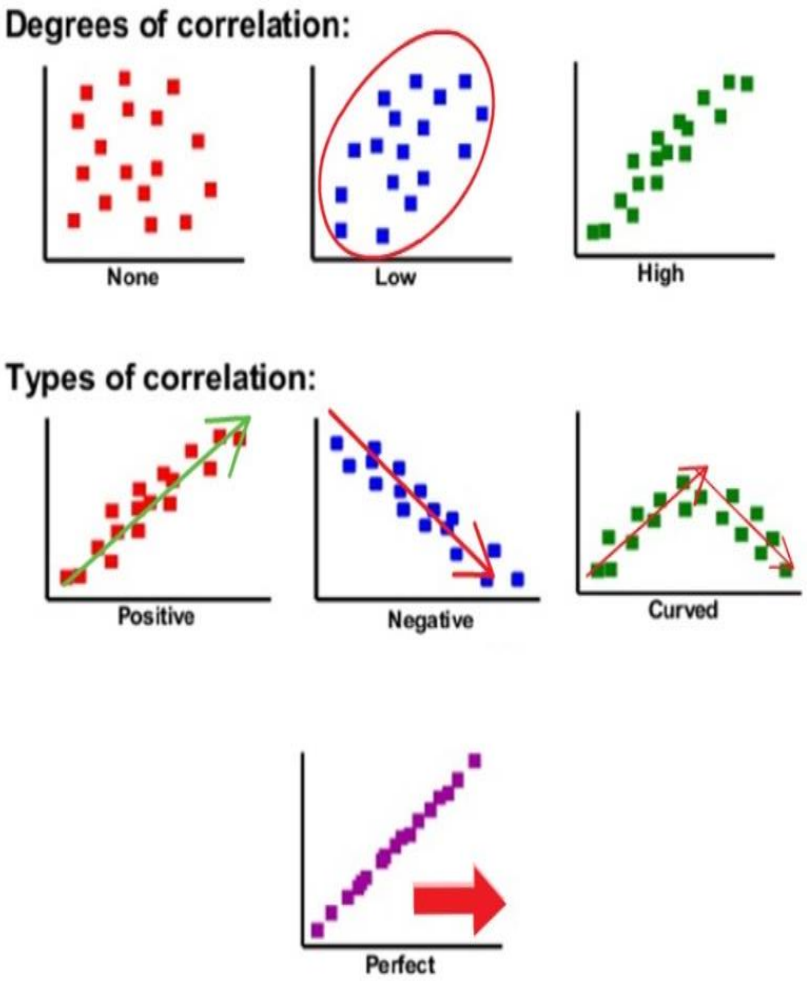
- Monthly time series plot showing the variation of observed and simulated runoff at the bottom axis and precipitation at the top axis.
- Best example for multiple time series plot where two variables are plotted on the same graph to compare.



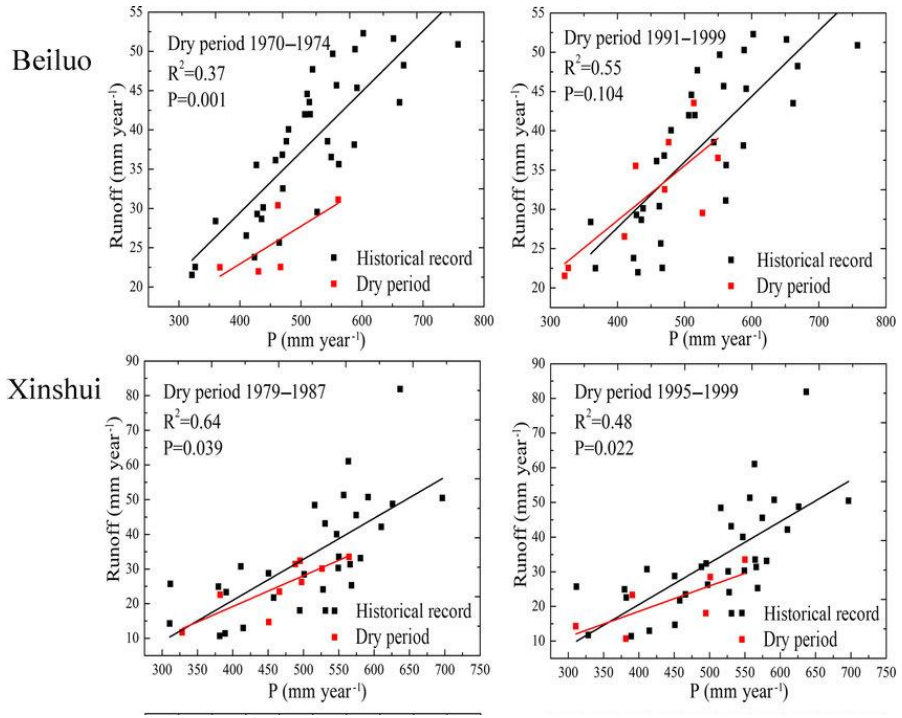
Time series of drought indices with high cross-correlation coefficient in the **a** Navroud, **b** Lighvan, **c** Seqez
Source: https://doi.org/10.1007/s13201-020-01345-6

Scatter Plots:

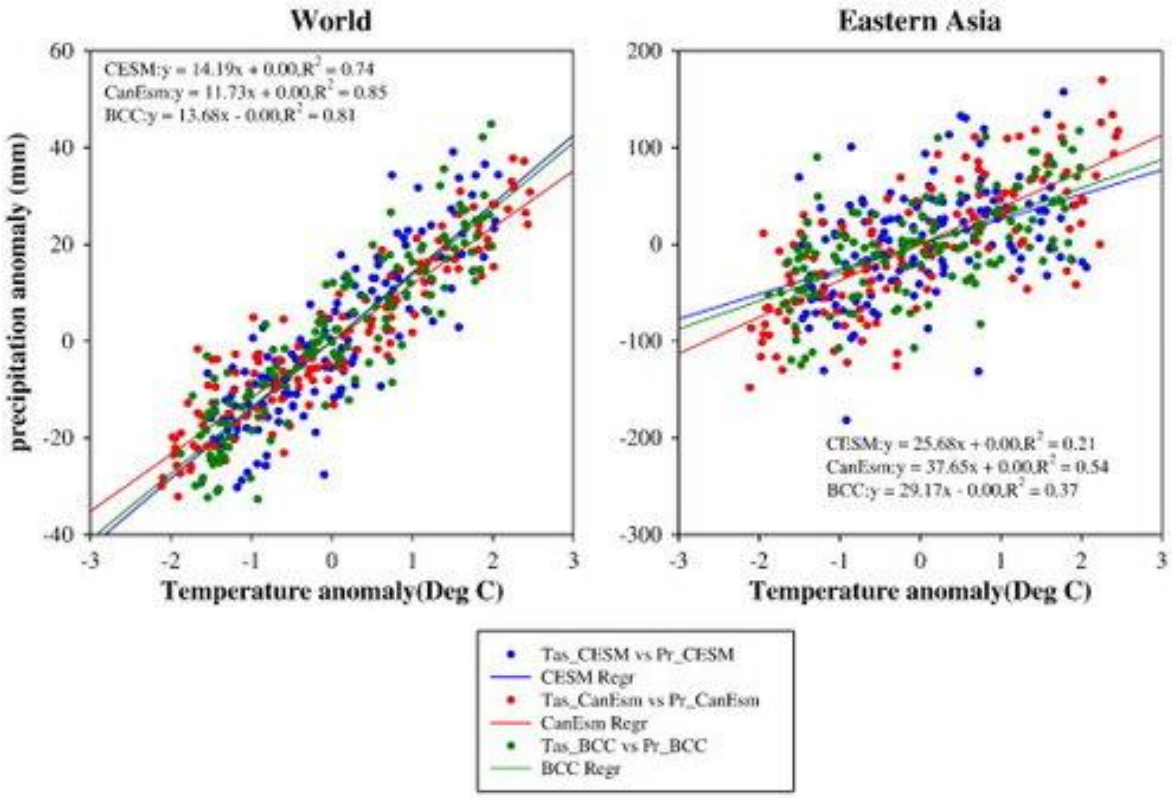
- Scatter plots are useful for exploring relationships between two continuous variables, such as precipitation and stream flow.
- Each data point represents a combination of values for the two variables, with one variable plotted on the x-axis and the other on the y-axis.
- Trend lines or regression lines can be added to identify patterns or correlations in the data.



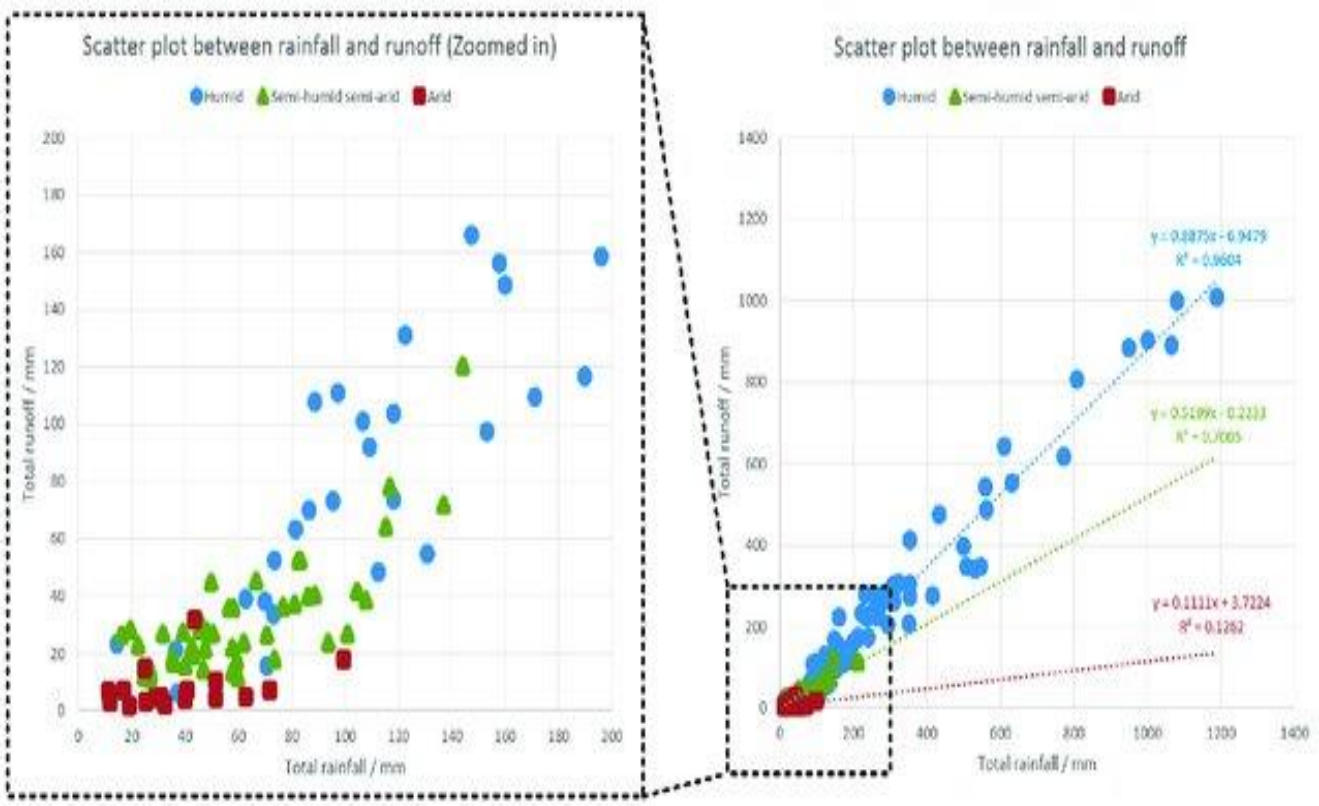
The annual precipitation-runoff scatter plot for each watershed.
Source: https://doi.org/10.5194/hess-22-1749-2018



More on Scatter Plots



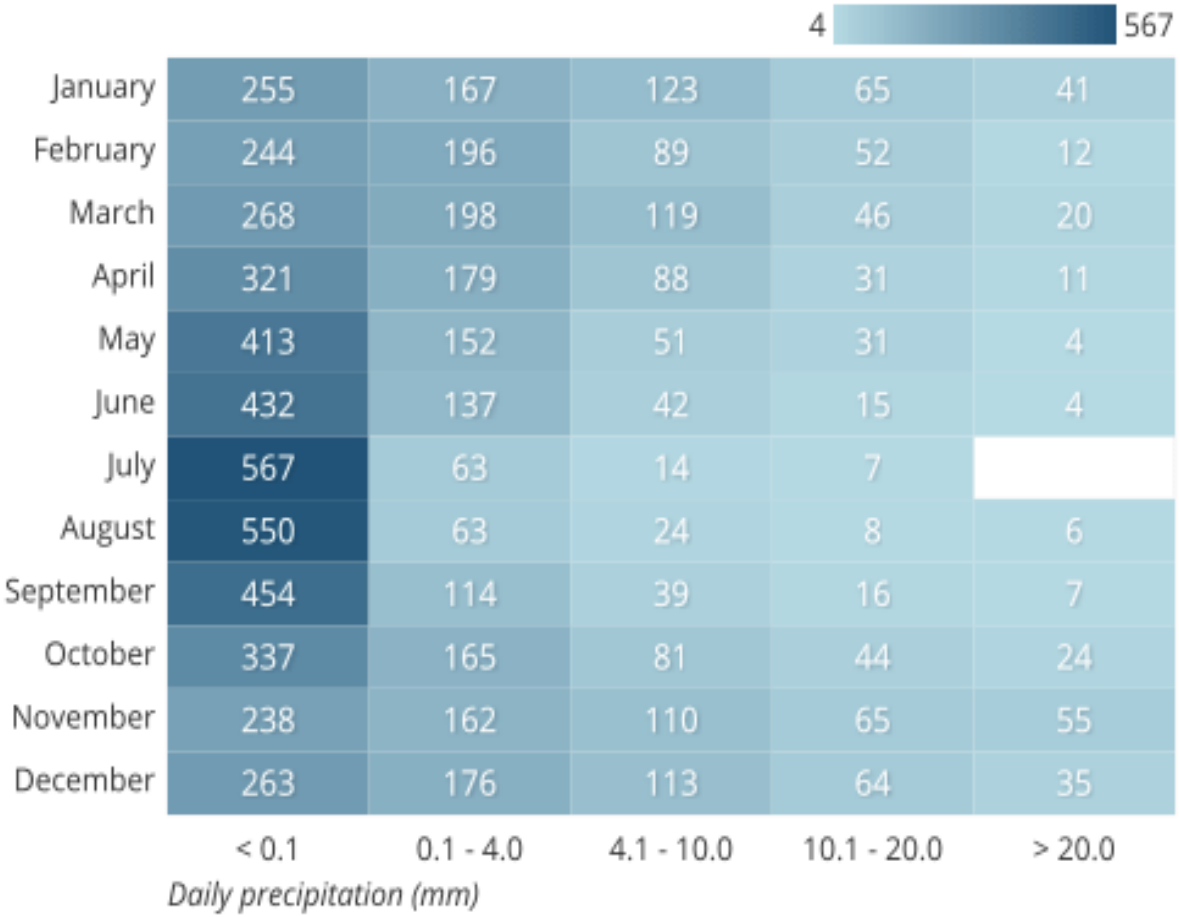
Scatter plots of temperature anomaly and precipitation anomaly over the world and Eastern Asia during the period of 1850–1989. Solid lines indicate linear relationships between temperature anomaly and precipitation anomaly.
Source:
https://doi.org/10.1016/j.gloplacha.2013.11.007



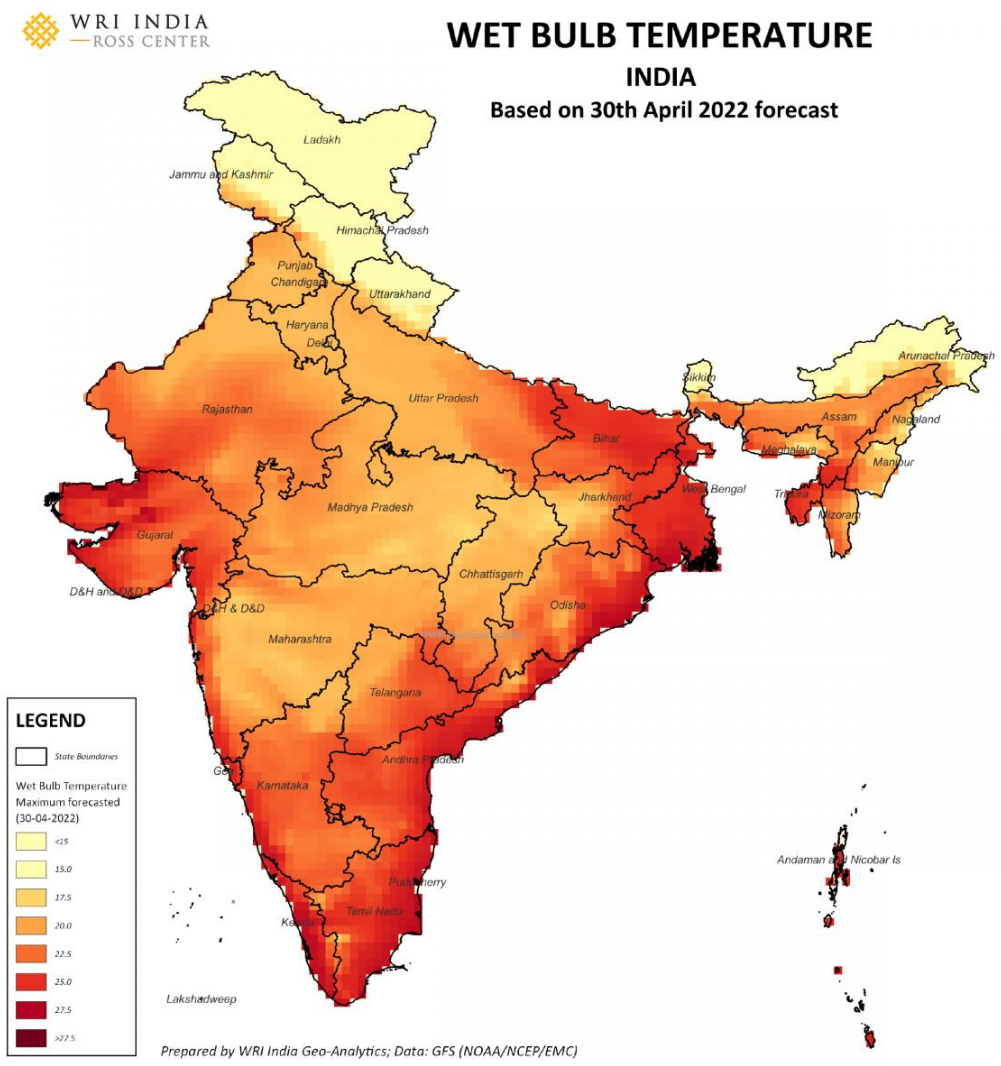
Scatter plot between rainfall and runoff.
Source: https://doi.org/10.3390/w9100719

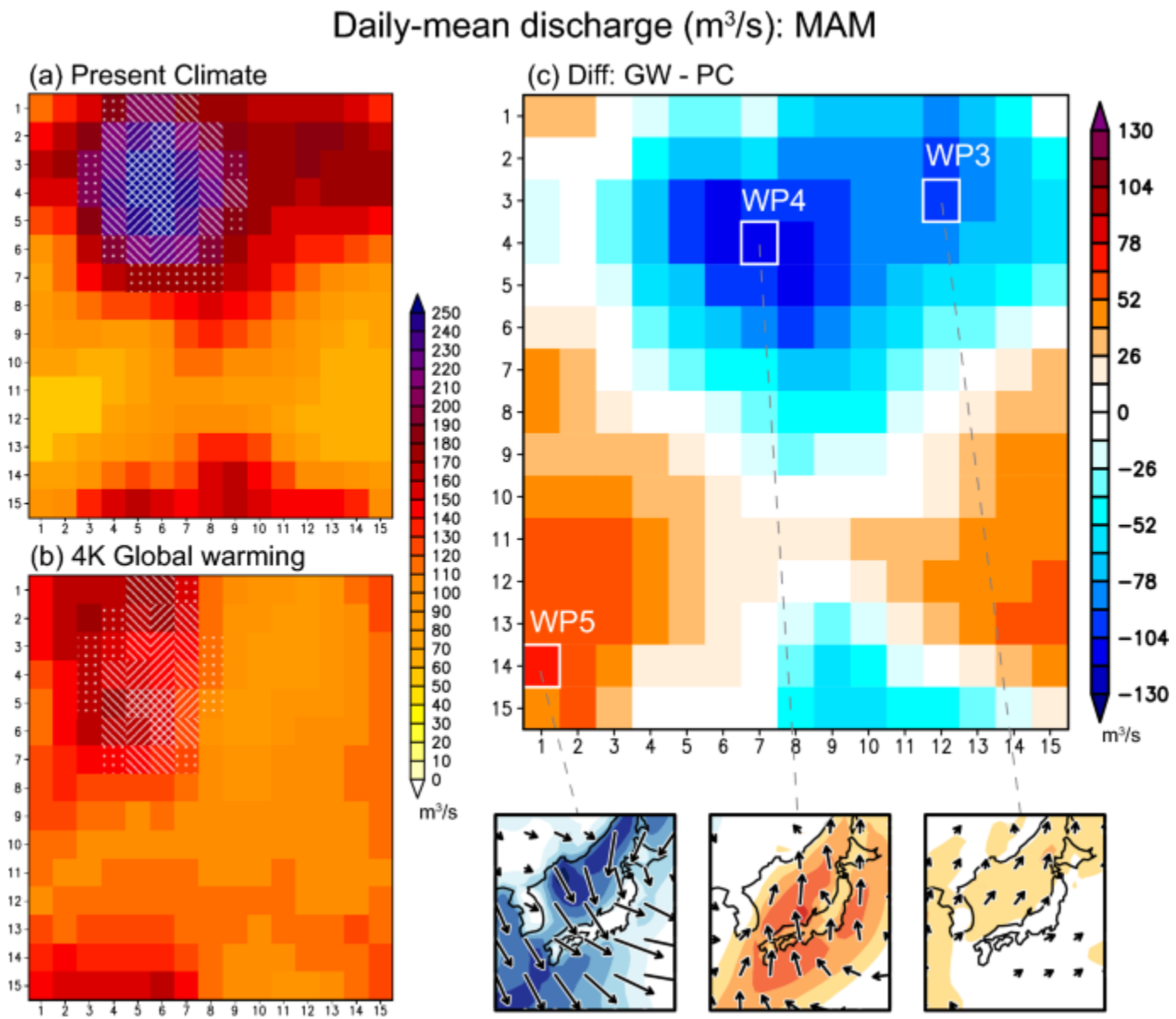
Heatmaps:

- Heatmaps are effective for visualising spatial patterns and distributions of hydro-climatic variables across a geographic area.
- They use colour gradients to represent variations in intensity or magnitude, with warmer colours indicating higher values and cooler colours indicating lower values.
- Heatmaps can be generated for variables like precipitation, temperature, or soil moisture over a specific region or watershed.



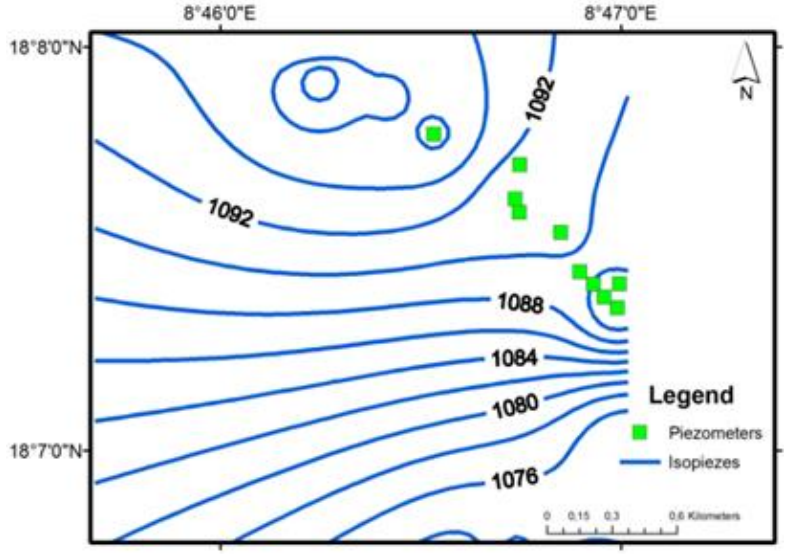
Heatmap for precipitation by month, 1998-2018


WRI INDIA
ROSS CENTER
WET BULB TEMPERATURE
INDIA
Based on 30th April 2022 forecast
Ladakh
Jammu and Kashmir
Himachal Pradesh
Punjab
Chandigarh
Uttarakhand
Haryana
Delhi
Rajasthan
Uttar Pradesh
Bihar
Sikkim
Arunachal Pradesh
Assam
Nagaland
Meghalaya
Manipur
Tripura
Mizoram
West Bengal
Jharkhand
Madhya Pradesh
Gujarat
Chhattisgarh
Odisha
Maharashtra
Telangana
Andhra Pradesh
Karnataka
Puducherry
Tamil Nadu
Andaman and Nicobar Is
Lakshadweep
LEGEND
State Boundaries
Wet Bulb Temperature
Maximum forecasted
(30-04-2022)
<15
15.0
17.5
20.0
22.5
25.0
27.5
>27.5
Prepared by WRI India Geo-Analytics; Data: GFS (NOAA/NCEP/EMC)

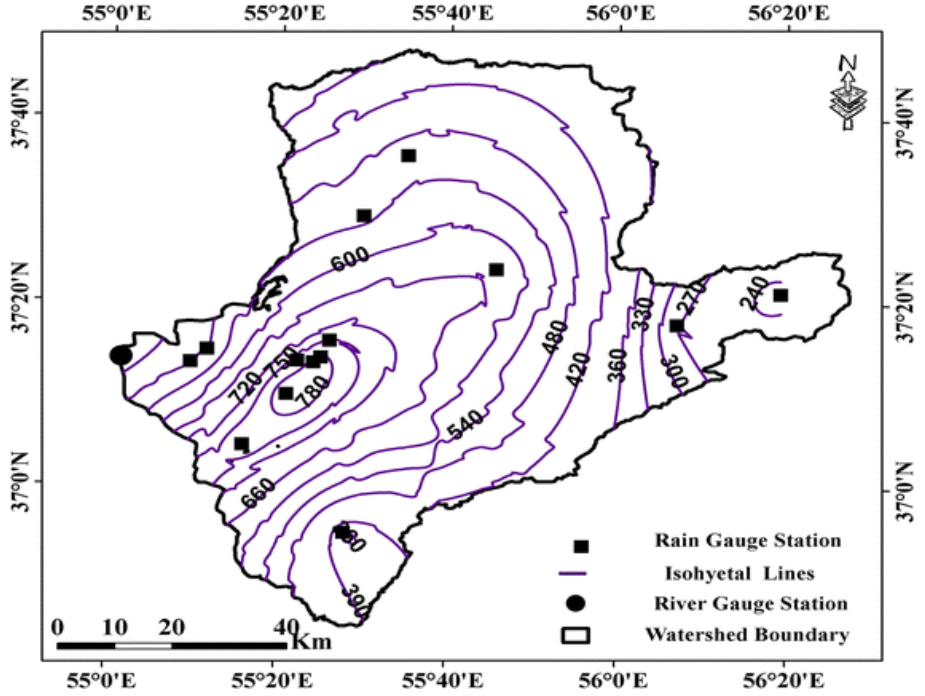

Daily-mean discharge (m³/s): MAM
(a) Present Climate
(b) 4K Global warming
(c) Diff: GW - PC
WP3
WP4
WP5
m³/s

Contour Plots:

- Contour plots are similar to heatmaps but use contour lines to represent isovalues (lines of constant value) of a hydro-climatic variable.
- They provide a visual representation of elevation or gradient changes in the variable across a geographic area.
- Contour plots are commonly used for variables like precipitation, temperature, or groundwater levels.



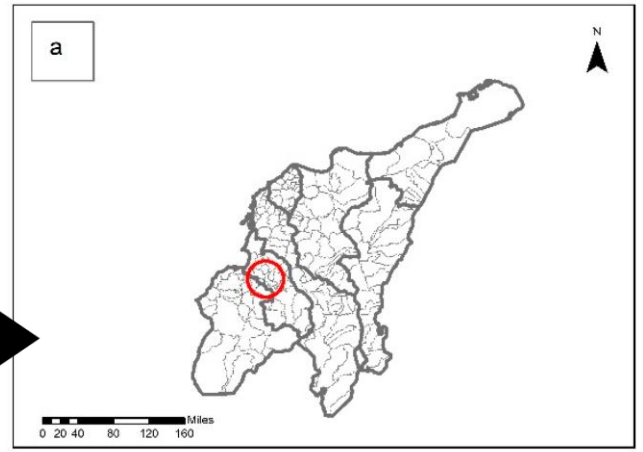
Piezometric map showing groundwater levels

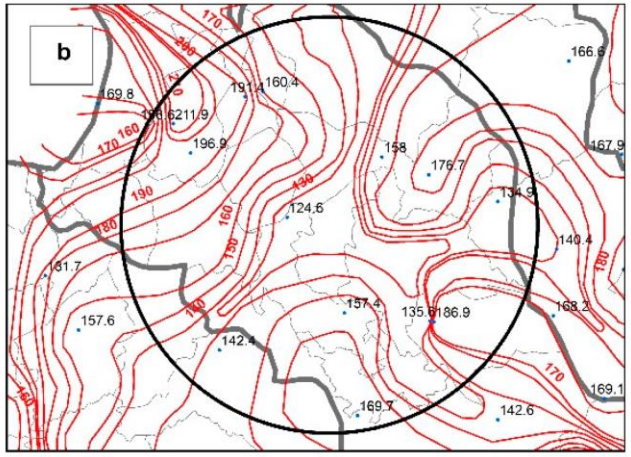


Isohyetal lines depicts the variations in precipitation

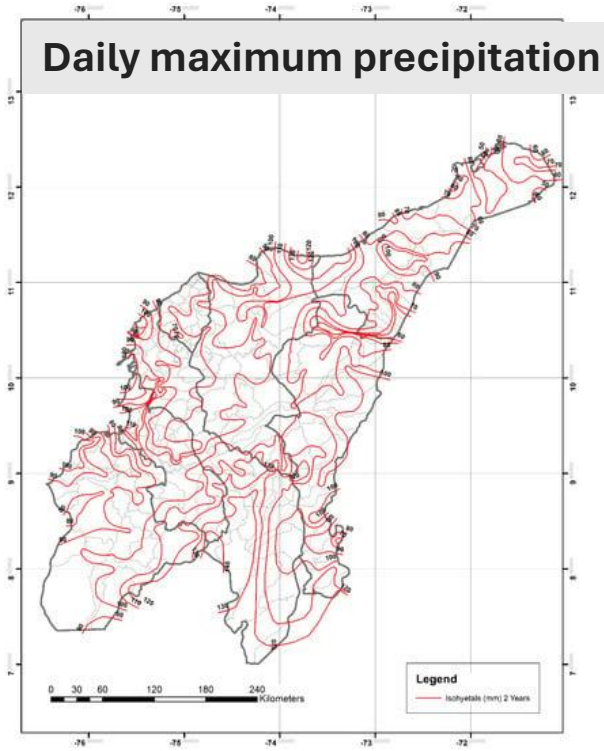
Case Study : Isohyetal Maps of Daily Maximum Rainfall for Different Return Periods for the Colombian Caribbean Region
(Álvarez et.al 2019**)**

Area showing isohyetal alignment discrepancies (a) isohyetal IDW method (b)

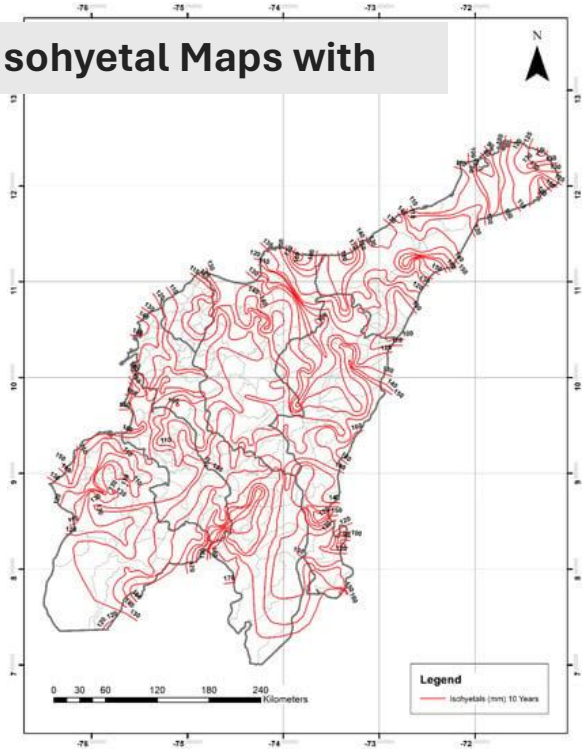




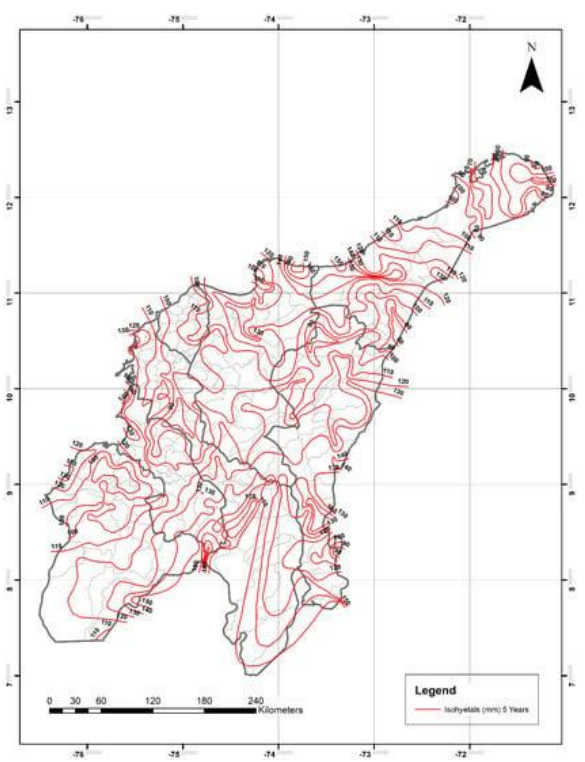
Daily maximum precipitation Isohyetal Maps with



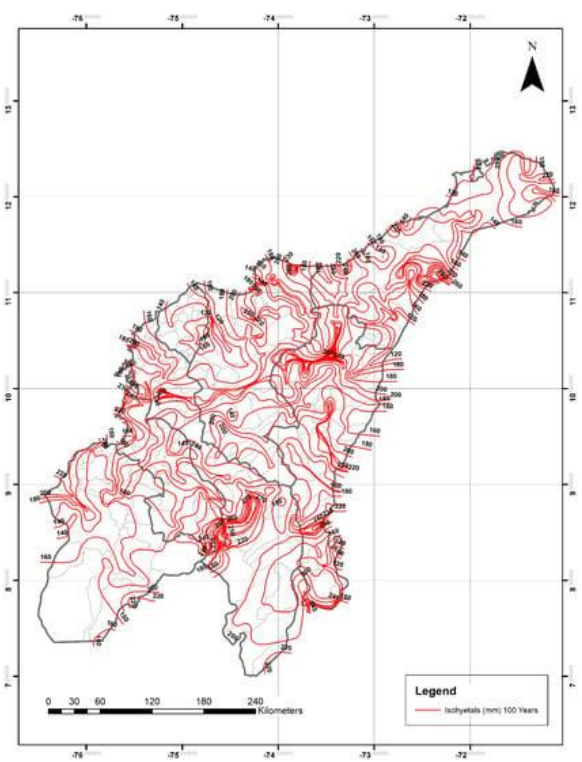
2-year return period



5-year return period



10-year return period



100-year return period

GIS Maps:

- Geographic Information System (GIS) maps are powerful tools for visualizing hydro-climatic data in a spatial context.
- They allow users to overlay different layers of data, such as precipitation, land cover, elevation, and hydrological features, to analyze spatial relationships and patterns.
- GIS maps can be used to create thematic maps, flow maps, or 3D terrain visualizations, depending on the specific application.

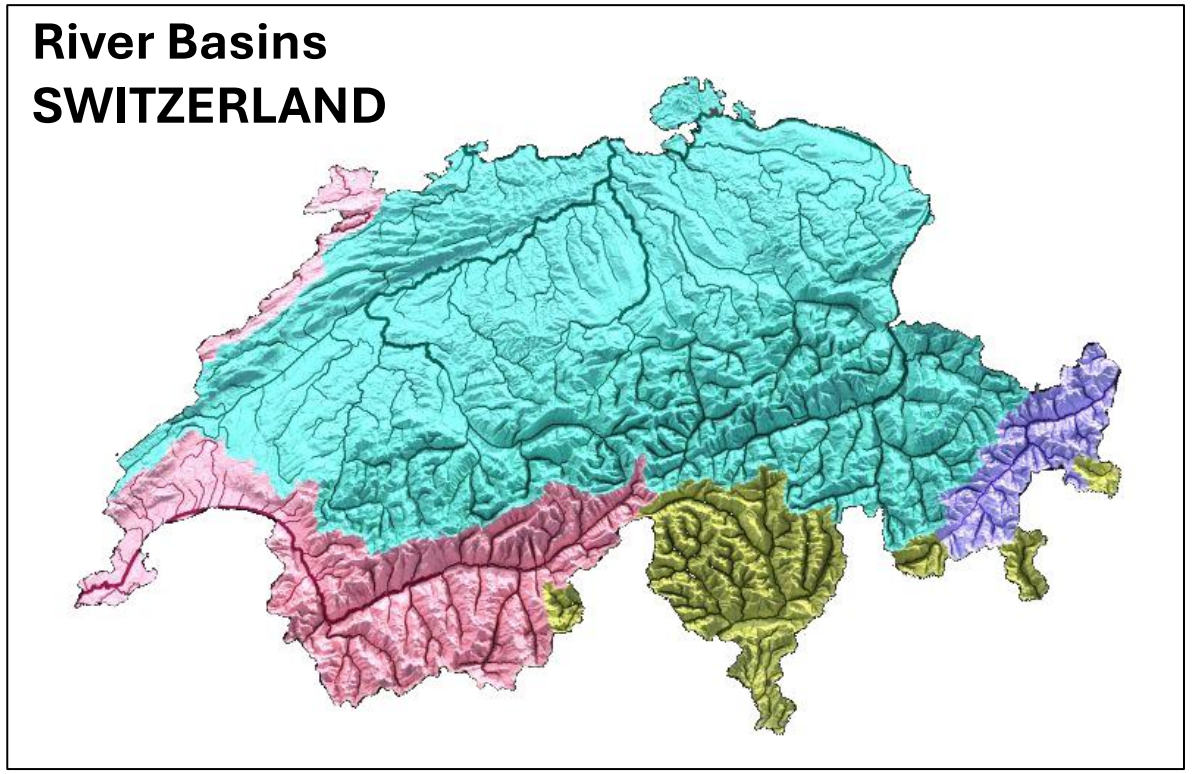


Figure showing the River Basins of Switzerland
Source : ©2024 Milos Popovic (https:// milospopovic.net)

GIS Maps:

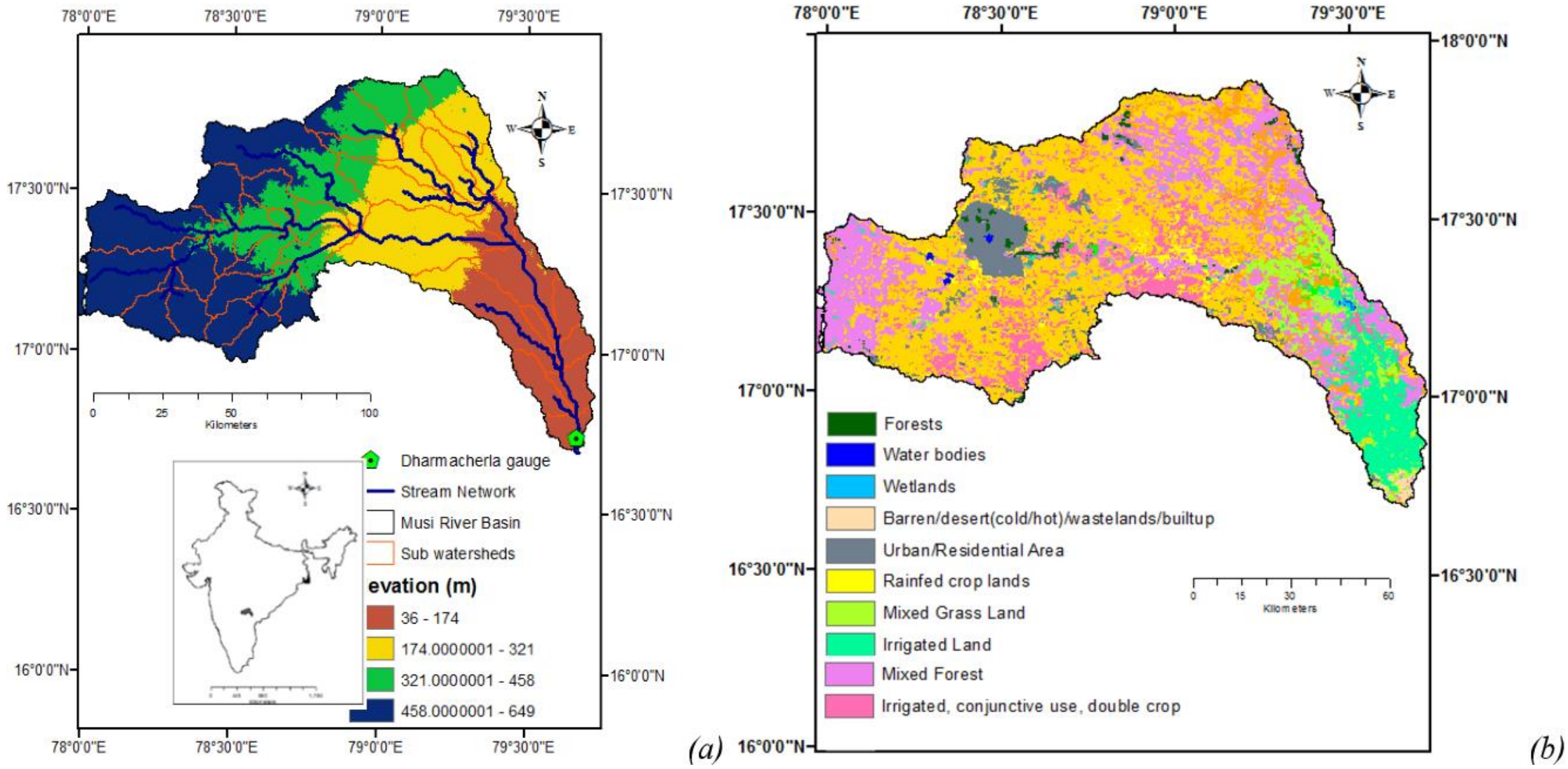
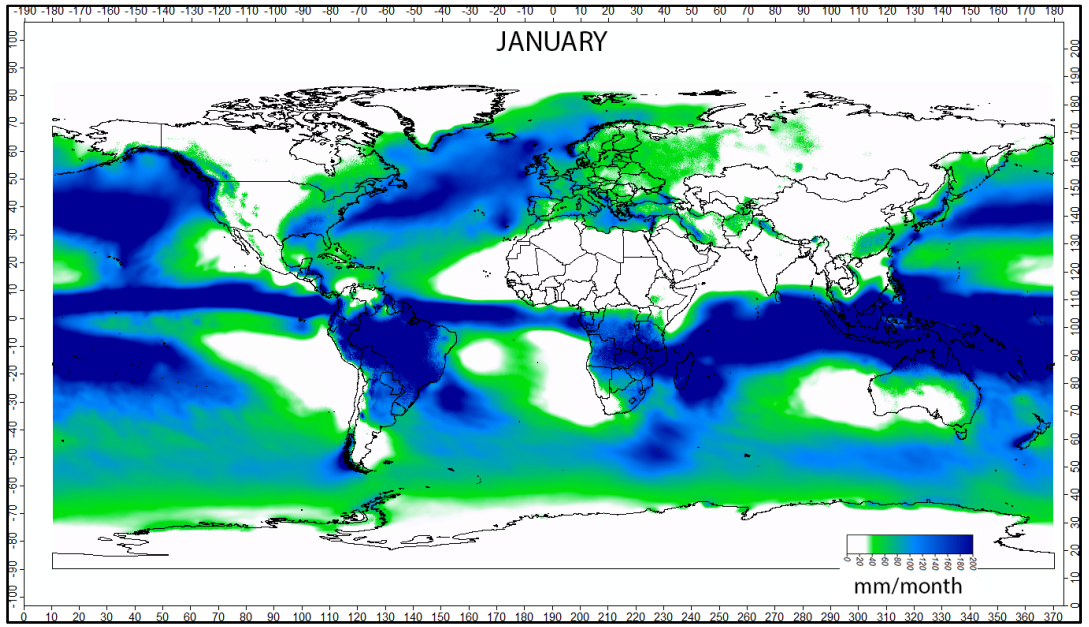


Figure showing the Stream network, sub watersheds, elevation (a) and Land use characteristics (b) of Musi River Basin

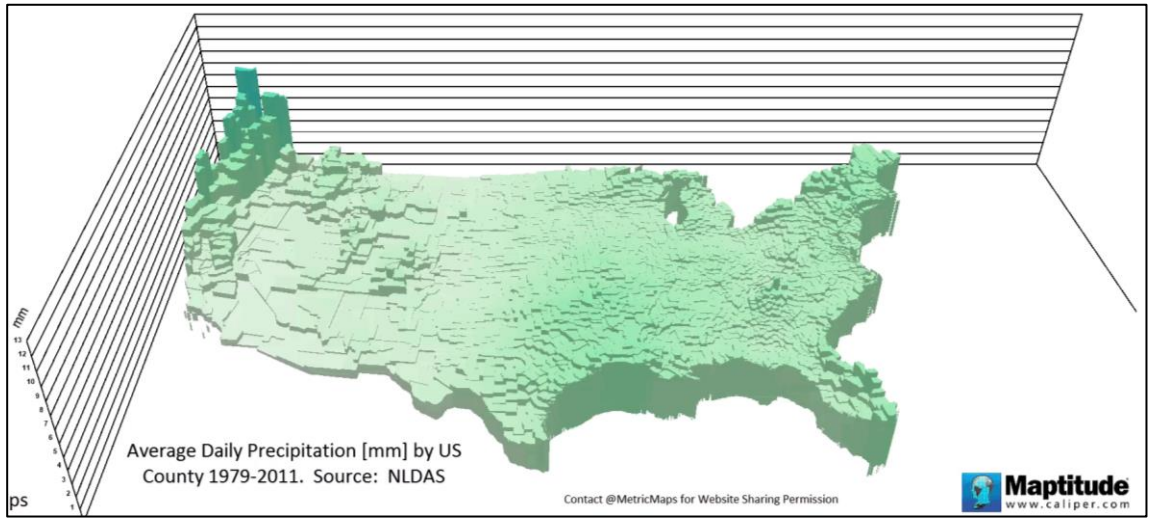
Source : Jothiprakash et al. 2017

Animated Visualizations:

- Animated visualizations are effective for illustrating temporal changes or dynamic processes in hydro-climatic data.
- They can be used to show seasonal variations, trends over time, or the progression of extreme events like storms or droughts.
- Animation techniques include time-lapse sequences, animated line graphs, or spatial animations of changing variables over a geographic area.



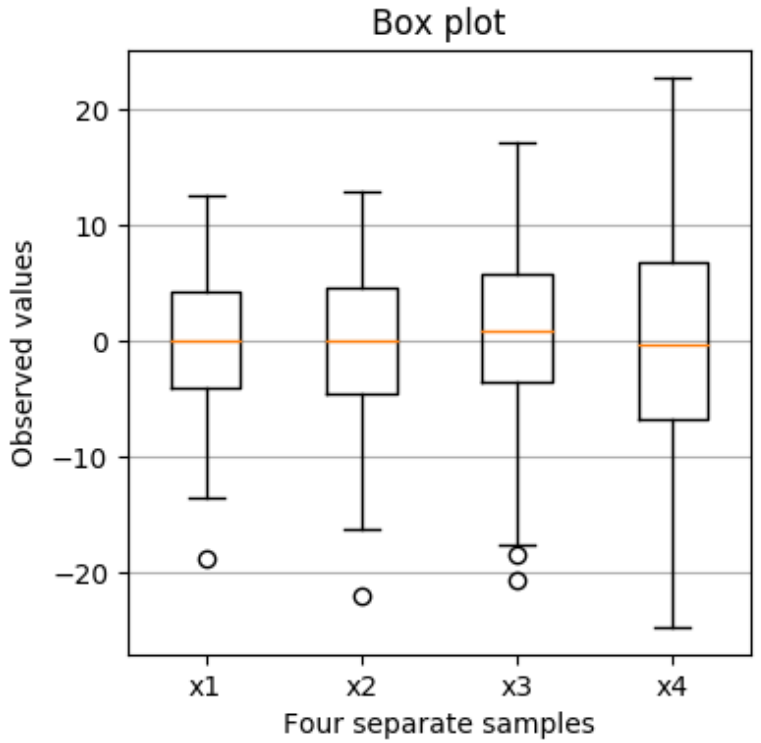
Average Precipitation variation of the year 2016
Source :https://en.m.wikiversity.org/



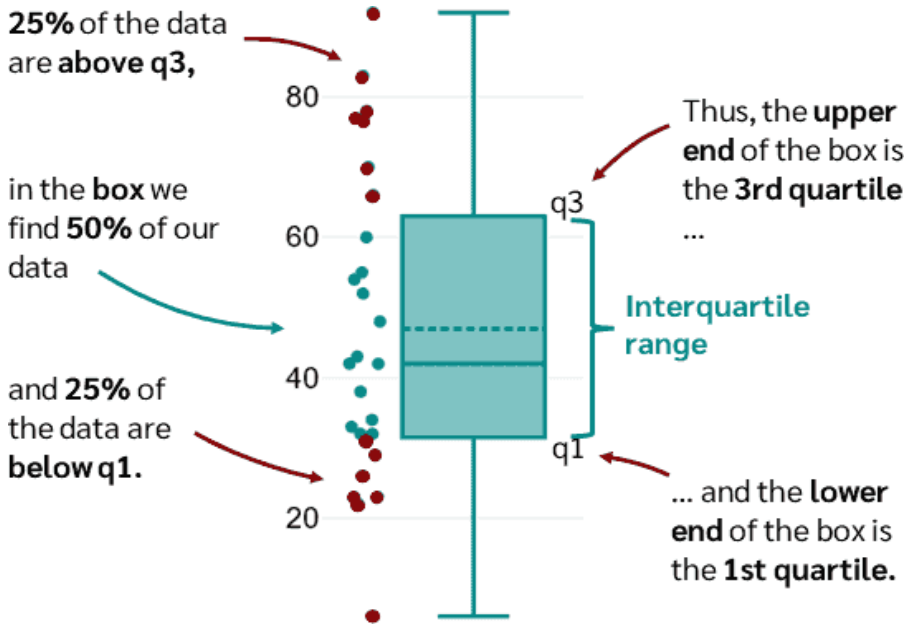
Average Daily precipitation of US during 1979-2011
Source : NLDAS

Box Plots:

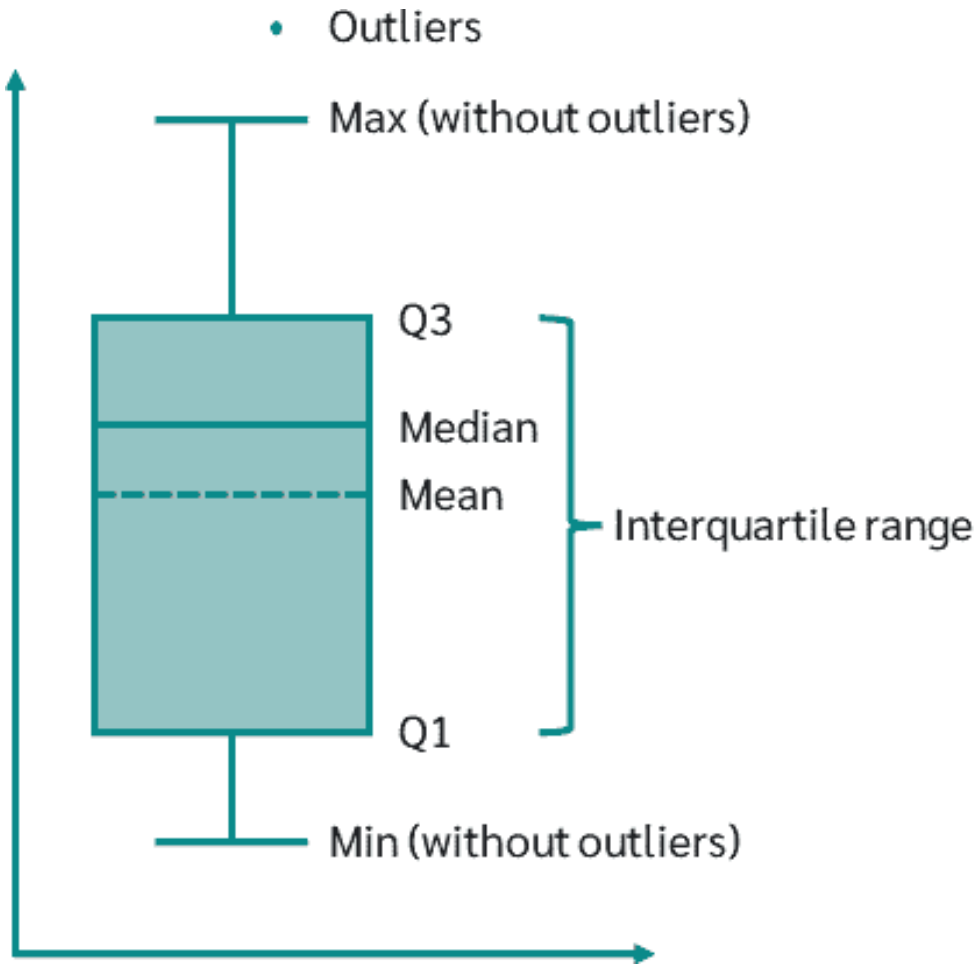
- Box plots are useful for visualizing the distribution and variability of hydro-climatic variables.
- They display summary statistics such as median, quartiles, and outliers, providing insights into the central tendency and spread of the data.
- Box plots are particularly useful for comparing the distribution of variables between different groups or categories.



Figures showing Box plots of observed parameters of four different samples



Box Plots:



The box indicates the range in which the middle 50% of all data lies

Thus, the lower end of the box is the 1st quartile and the upper end is the 3rd quartile

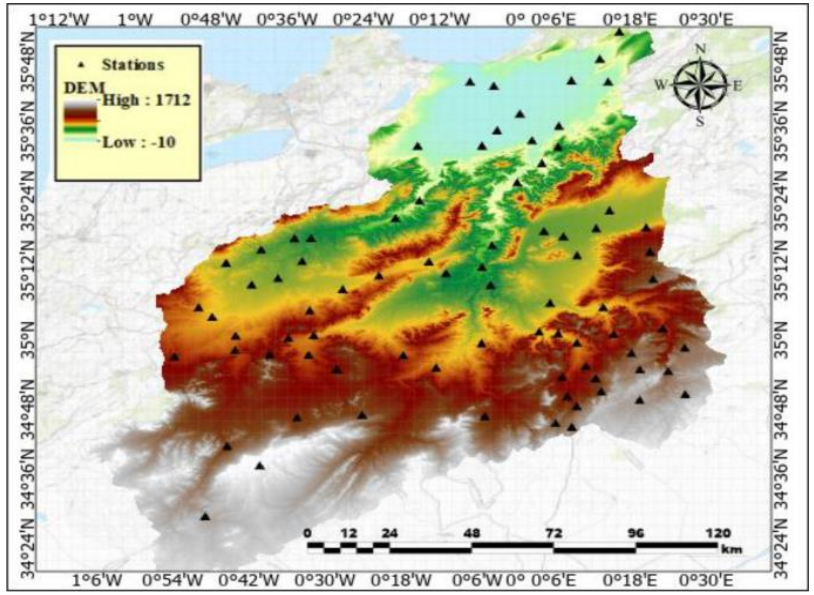
Between Q1 and Q3, is the interquartile range

In the boxplot, the solid line indicates the median and the dashed line indicates the mean.

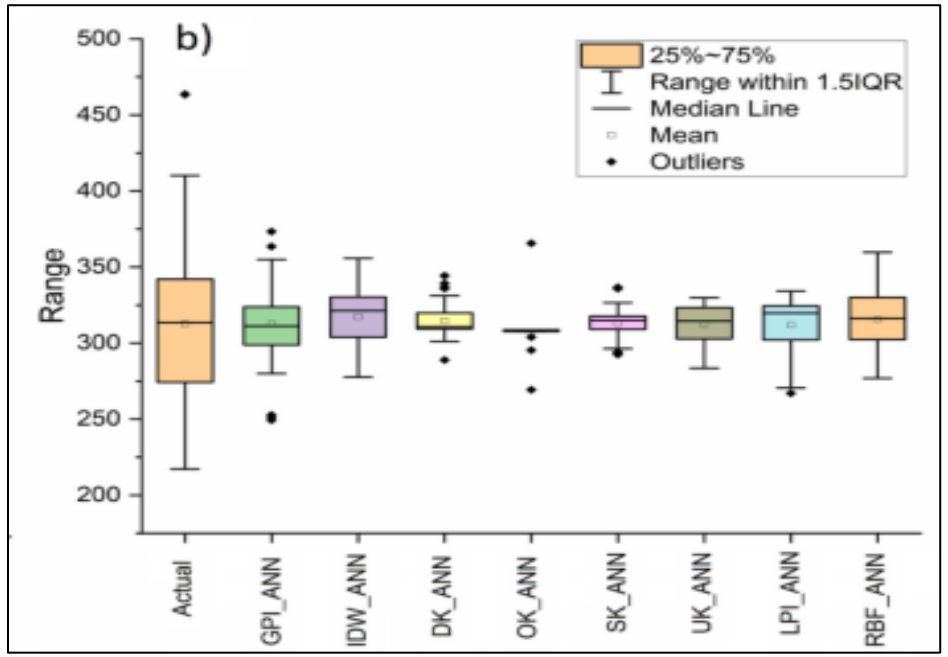
The T-shaped whiskers go to the last point, which is still within 1.5 times the interquartile range.

Points that are further away are considered extreme values (outliers).

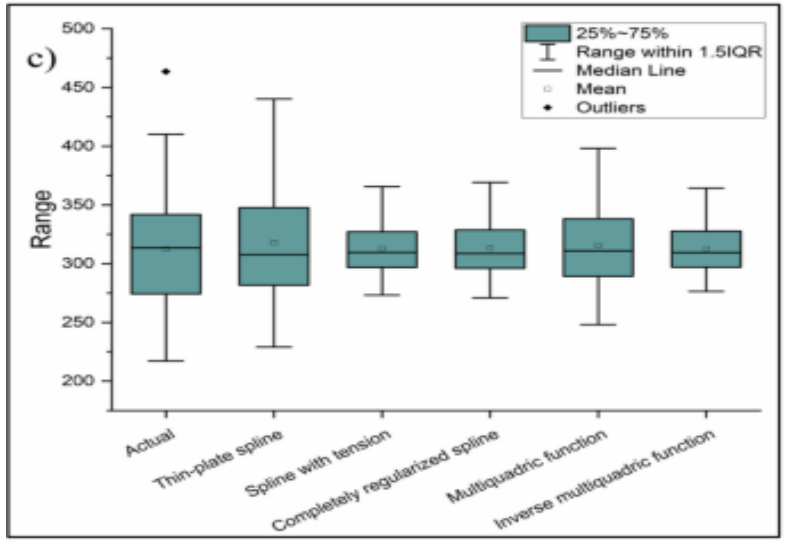
Spatial variation of annual precipitation in the Macta basin (Achite et al. 2023)

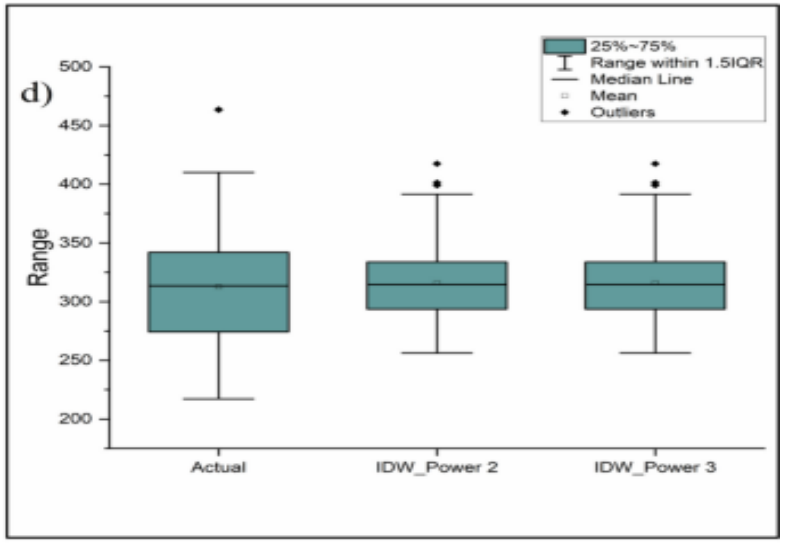


DEM & Rain Gauges of Macta basin



Prediction results to ANN-based precipitation forecast interpolations. **b** Boxplot plots





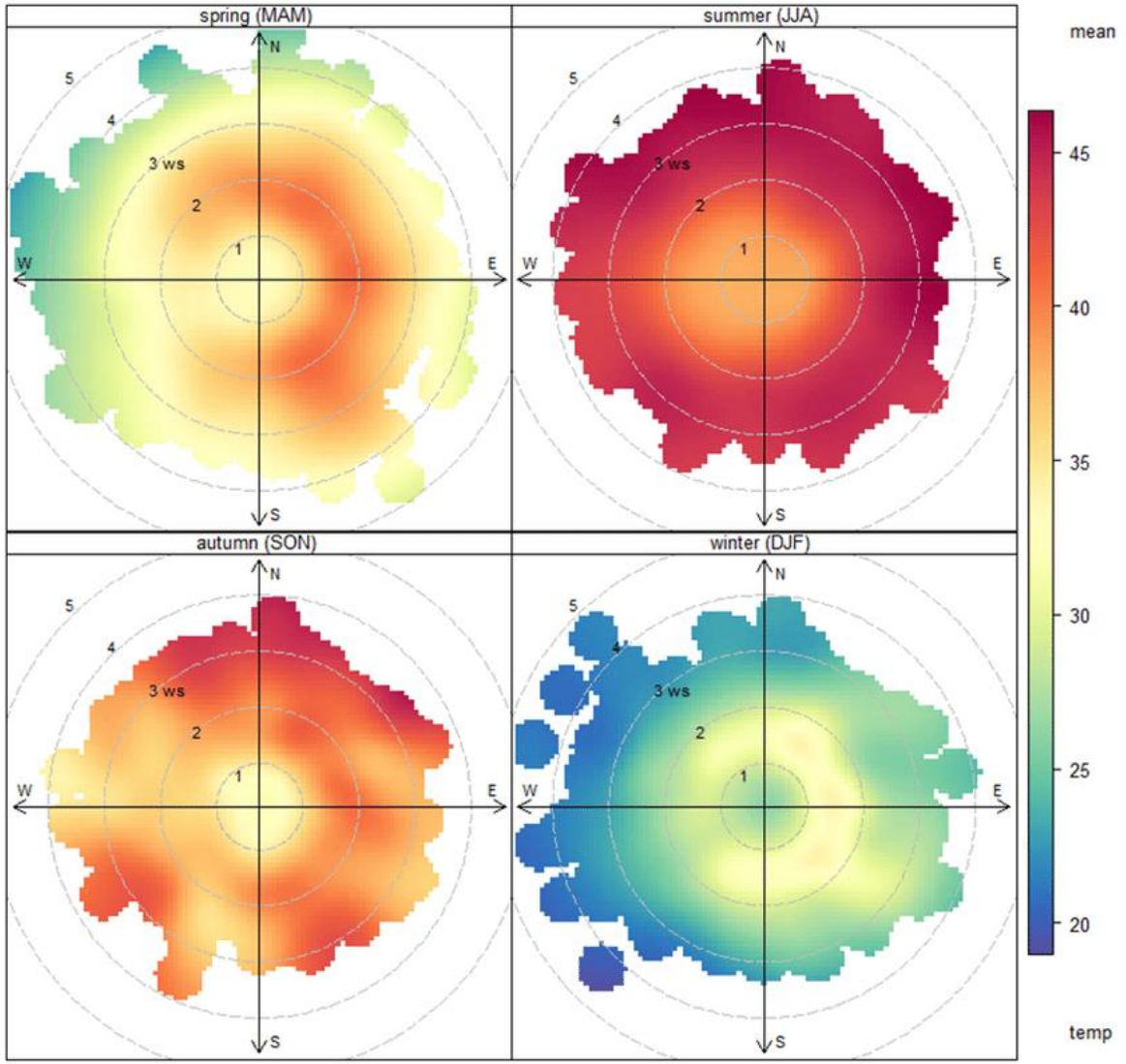
Boxplot graphs of annual precipitation

Radial Plots:

- Radial plots, also known as polar plots, are unconventional but effective for visualizing cyclic or periodic patterns in hydro-climatic data.

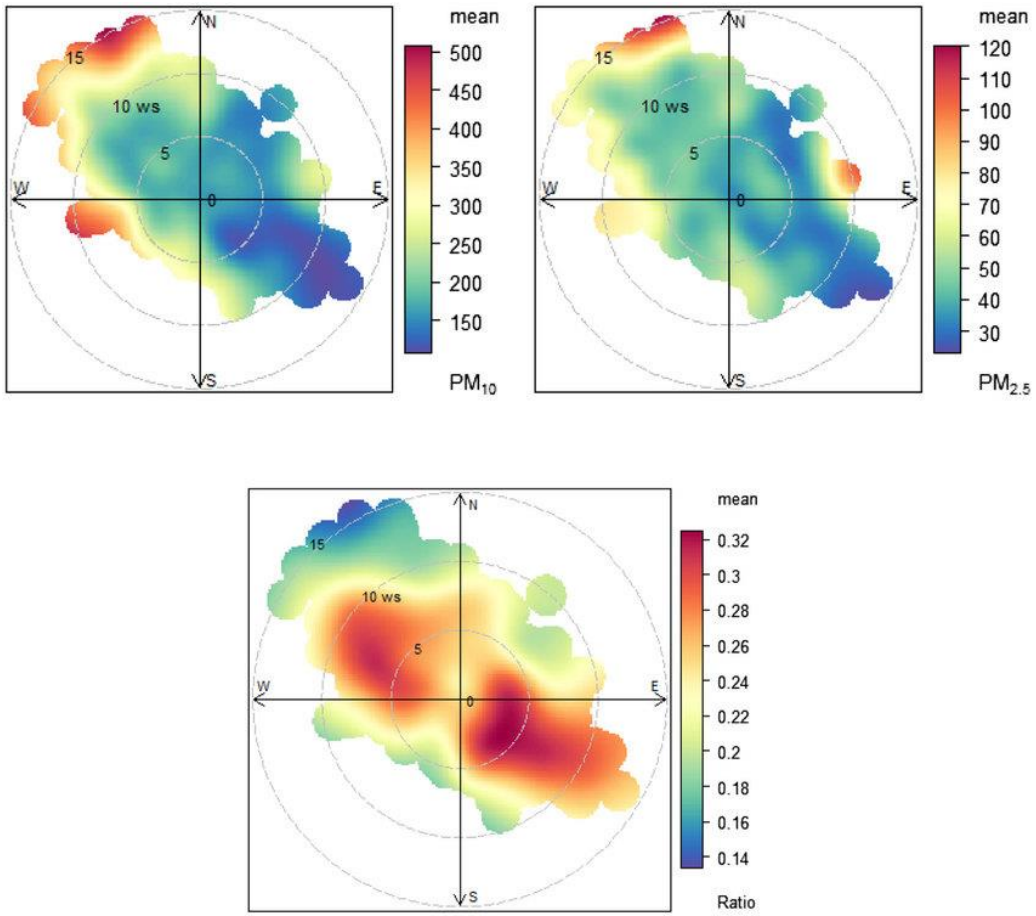
- They represent data around a circular axis, with each data point plotted at a specific angle and distance from the center.

- Radial plots are often used to analyze diurnal or seasonal variations in variables like temperature, wind speed, or solar radiation.



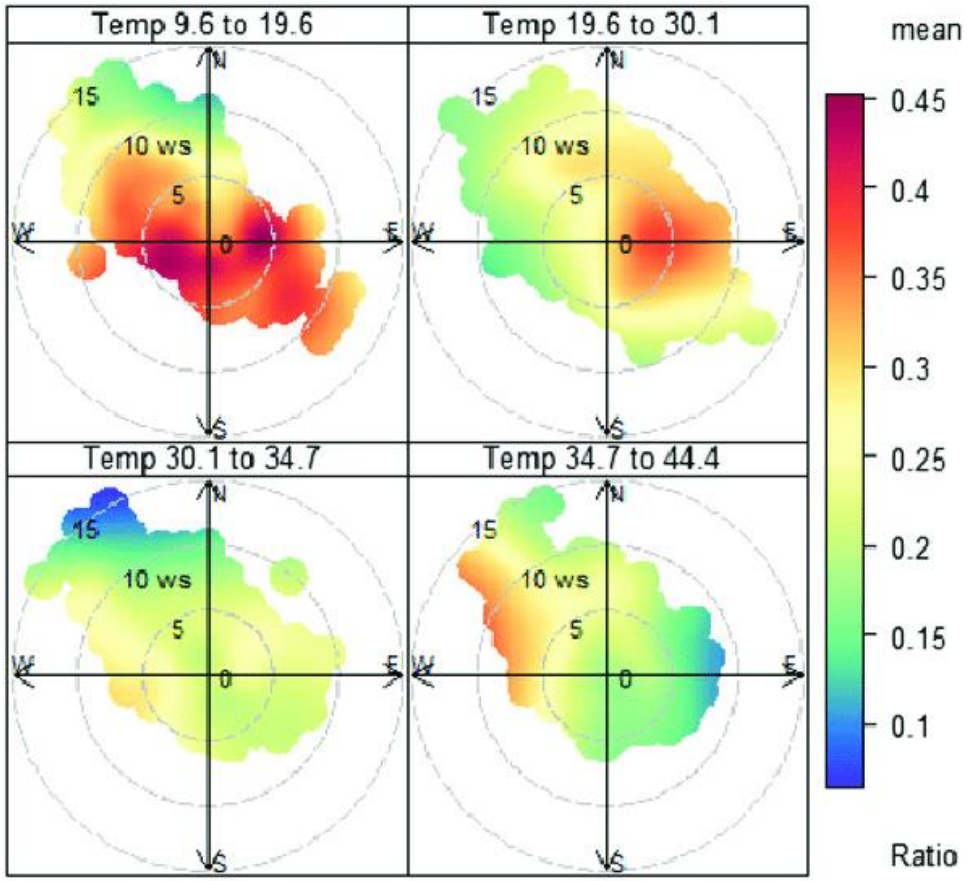
Polar plot of wind speed, wind direction and temperature using data from January 2014 to September 2015 in Makkah
Source : Munir et al. 2016.

Radial Plots Characterizing temporal variability with meteorological parameters in Bahrain (Coskuner et al. 2018) :



Bivariate polar plots of wind speed, wind direction against PM 2.5 and PM 10 concentrations and their ratios

Source : Coskuner et al. 2018



Bivariate polar plots showing the combined effect of wind speed, wind direction, and temperature on the ratios of PM 2.5 /PM 10 in Bahrain

Source : Coskuner et al. 2018