

Precipitation extremes and their relation to climatic indices in the Pacific Northwest, USA

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Introduction

- Extreme precipitation can cause devastating damages to human society and wildlife.
- Therefore, identification of extreme precipitation events in the future plays an important role since it helps in effective allocation of resources which enhances the level of preparedness.
- Moreover, understanding the spatial and temporal patterns of change is also critical thus helping mitigate the negative effects of extreme precipitation.
- To understand patterns of change in extreme precipitation, it is required to learn from the historical extremes and analyze their potential causes and its pattern.
- Two fundamental explanations of spatiotemporal patterns of precipitation extremes are (1) long term climate change caused by human activities and (2) climate variability caused by large-scale climate patterns.
- This study aims at (1) understanding the future projections of precipitation extremes and (2) realizing the effects of climate variability on precipitation extremes.
- This study analyzes the precipitation extremes over Columbia River Basin (CRB) located in the Pacific Northwest, USA (Fig. 1).
- CRB is the fourth largest basin in the United States.
- This basin is mainly drained by the Columbia River and its largest tributaries including Snake River and Willamette River.

Study Area

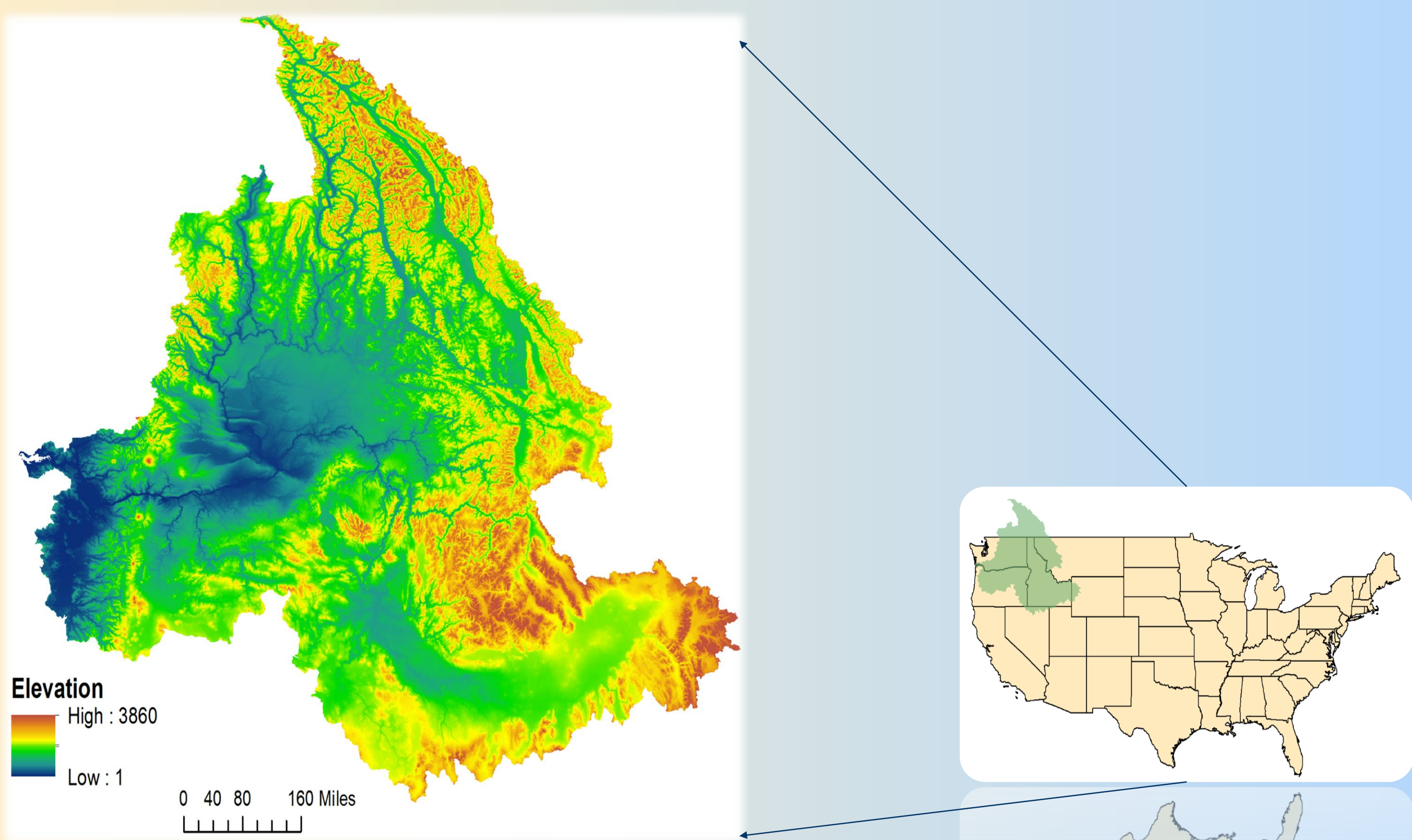


Fig. 1: Study area, Columbia River Basin in the Pacific North-West USA

Data

- Currently, GCMs are most common tools for projecting historical and future values of climatic variables.
- This study employs 10 GCMs from CIMIP5 dataset (Ahmadalipour et. al. 2015).
- GCMs are downscaled to the spatial resolution of 1/16 degree employing the bias correction and spatial downscaling (BCSD) method (Rana and Moradkhani 2015).
- Downscaled daily precipitation data are extracted for 4 time periods, namely historical (1970-2000), near future (2010-2040), intermediate future (2040-2070), and future (2070-2100).
- These periods were then evaluated for various changes in precipitation based extremes (Table 1), e.g. CWD (Fig. 2) in all the historical and scenarios periods.
- Moreover, To study the correlations of precipitation extremes and large-scale climate patterns (Table 2), climate indices (which reflect the patterns) are utilized and evaluated against.

Spatiotemporal variation of extreme precipitation and its relations to teleconnections (Large scale oscillations)

Table 1: Precipitation based extreme indices used in the study to evaluate the historical events and changes in same for future scenario period

Index	Indicator name	Indicator definition	Units
CWD	Consecutive wet days	Largest length of consecutive wet days within 30 years	days
R20mm	Number of days with heavy precipitation	number of days with precipitation more than 20 mm within 30 years	days
R95pTOT	Precipitation amount in very wet days	Total precipitation amount in very wet days (days with precipitation heavier than 95 th percentile of daily precipitation) during 30 years	mm
R95p	Number of very wet days	Number of days in which precipitation is very high (larger than 95 th percentile of daily precipitation) within 30 years	days
R99p	Number of extremely wet days	Number of days in which precipitation is extremely high (larger than 99 th percentile of daily precipitation) within 30 years	days
R99pTOT	Precipitation amount in extremely wet days	Total precipitation amount in extremely wet days (days with precipitation heavier than 99 th percentile of daily precipitation) during 30 years	mm
Rx5day	The amount of maximum 5-day precipitation	Maximum total precipitation over 5 continuous days within 30 years	mm

Table 2: Teleconnections/Climatic Indices analyzed in study for their relation with precipitation extreme events in the study region

Index	Description
PNA	Indicator of Pacific North American Index
WP	Western Pacific Index
EA/WR	Eastern Asia/Western Russia
NAO	North Atlantic Oscillation
SOI	Southern Oscillation Index
NP	North Pacific index
NOI	Northern Oscillation index
TNI	Trans Nino Index
NINO 3.4	East Central Tropical Pacific SST*
ONI	Oceanic Nino Index*
NINO 3	Eastern Tropical Pacific SST*

Methods

- Climatic extremes are frequently evaluated through some indices.
- A suite of 27 different indices is suggested (by ETCCDI) so as to unify extreme indicators on international scale.
- Seven extreme precipitation indices are calculated for downscaled daily precipitation data (Table 1).
- Delta change is calculated for each of the precipitation extremes in 3 future scenario periods with historical dataset.
- Principal component analysis (PCA) and Singular decomposition value (SVD) methods are applied for identification of correlations between climate indices and precipitation extreme indices.
- The relation of climatic indices with precipitation extremes is carried out in historical data period.

Results and Summary

- Spatiotemporal distribution of extreme precipitation indices are projected for historical, near future, intermediate future, and future periods (Fig. 2).
- It is noted that all the precipitation extremes are depicting spatial variability in the basin, with increase in North/Northwest parts and decrease in South of the study region.
- The changes would have severe impact on floods and droughts in the region (Rana et. al. 2016).
- The correlation of precipitation extreme indices and climate indices are also investigated in this study.
- Analysis demonstrate that precipitation indices are mostly affected by North Atlantic Oscillation (NAO), Eastern Asia (EA), and Western Pacific (WP).

References

- Ahmadalipour, A., Rana, A. and Moradkhani, H. (2015) Multi-criteria evaluation of CMIP5 GCMs for climate change impact analysis. Theoretical & Applied Climatology. DOI: 10.1007/s00704-015-1695-4
- Rana, A. and Moradkhani, H. (2015) Spatial, temporal and frequency based climate change assessment in Columbia River Basin using multi downscaled-Scenarios, Climate Dynamics. DOI: 10.1007/s00382-015-2857-x
- Rana, A., Moradkhani, H., and Qin, Y. (2016) Understanding the Joint Behavior of Temperature and Precipitation for Climate Change Impact Studies, Theoretical and Applied Climatology. DOI: 10.1007/s00704-016-1774-1

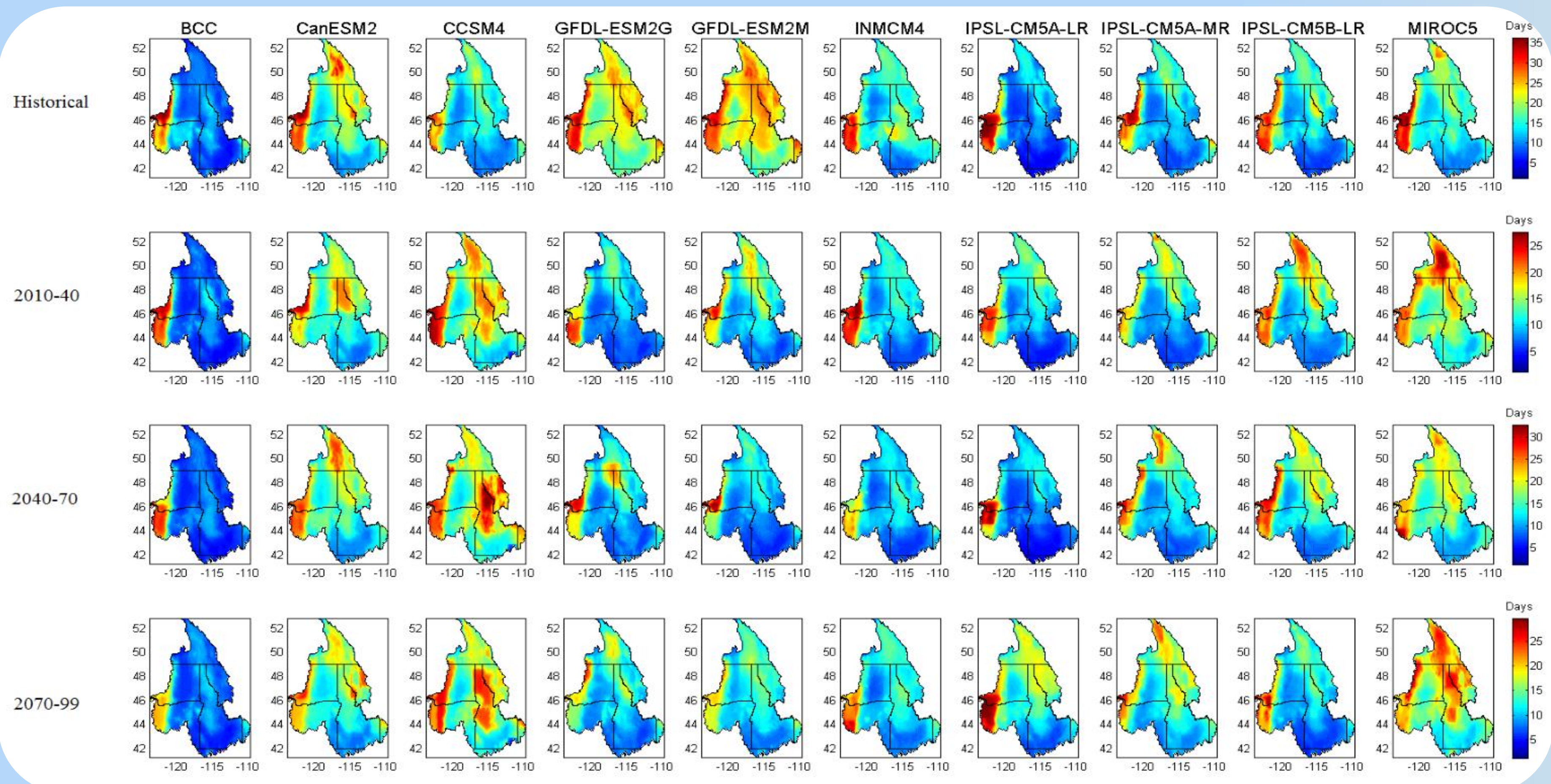


Fig. 2: Consecutive Wet Days (CWD) as predicted by all the 10 statistically downscaled climate models in Historical and future scenario periods in Columbia River Basin (CRB)

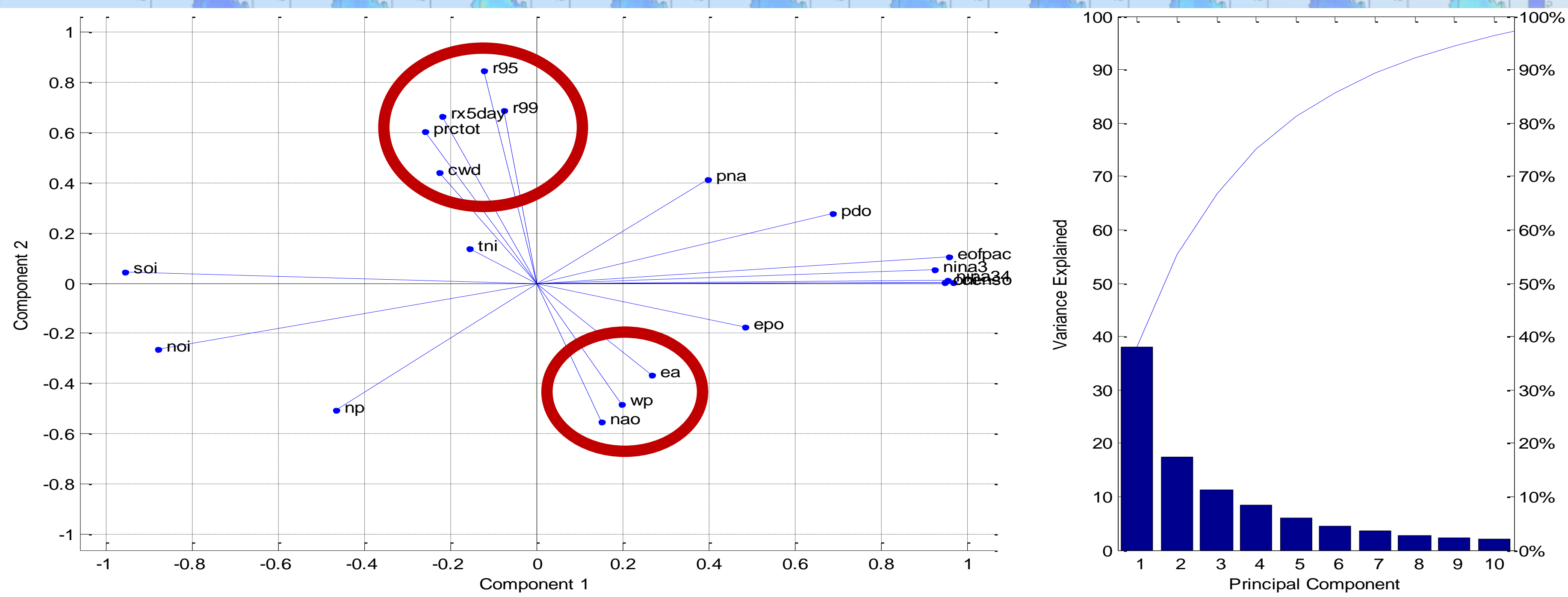


Fig. 3: Relation between climatic indices and precipitation extremes as revealed by PCA in scatter plot along with the variance explained by dataset in various principal components

Acknowledgment: Partial