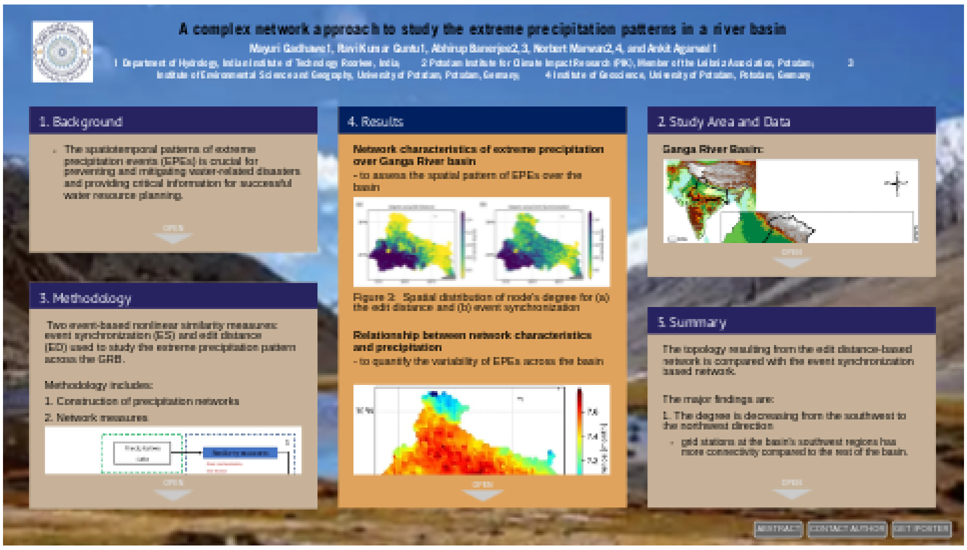
A complex network approach to study the extreme precipitation patterns in a river basin



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PRESENTED AT:

1. BACKGROUND

- The spatiotemporal patterns of extreme precipitation events (EPEs) is crucial for preventing and mitigating water-related disasters and providing critical information for successful water resource planning.

- As traditional methods are insufficient to capture the nonlinear interrelationships between extreme event time series, therefore, defining a principled nonlinear approach is required for analyzing the dynamics of extreme events over a river basin with diverse climate zones and complicated topography.

- Furthermore, topography significantly impacts precipitation, but the relationship between topographical characteristics and precipitation is poorly understood.

3. METHODOLOGY

Two event-based nonlinear similarity measures: event synchronization (ES) and edit distance (ED) used to study the extreme precipitation pattern across the GRB.

Methodology includes:

1. Construction of precipitation networks

2. Network measures

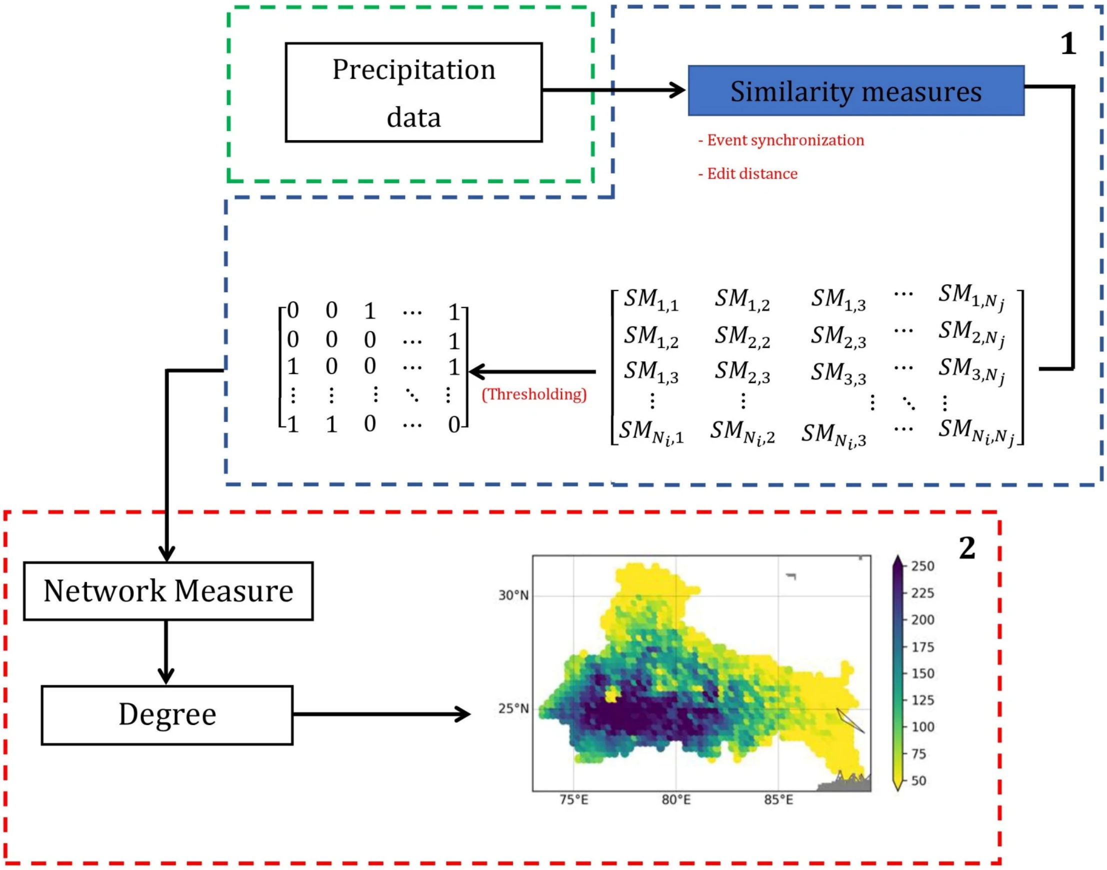

Figure 2: Flow chart of proposed methodology

4. RESULTS

Network characteristics of extreme precipitation over Ganga River basin

- to assess the spatial pattern of EPEs over the basin

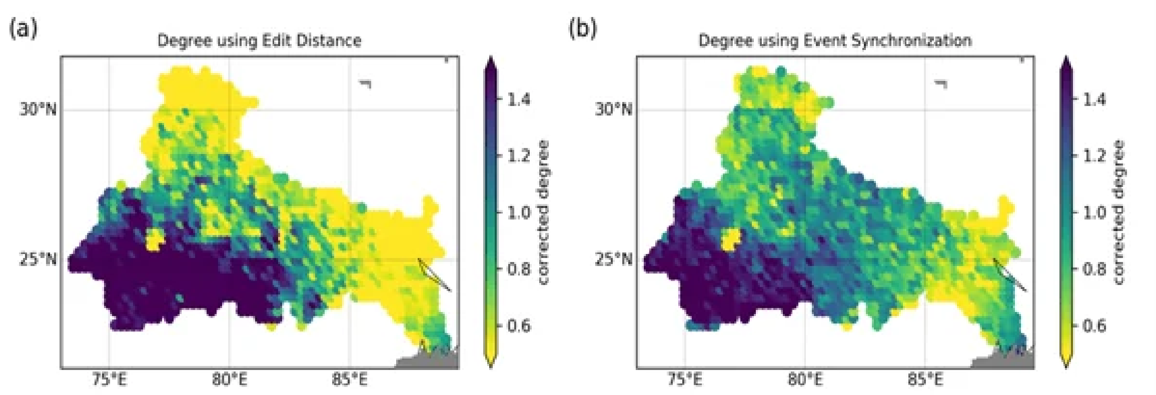

Figure 3: Spatial distribution of node's degree for (a) the edit distance and (b) event synchronization

Relationship between network characteristics and precipitation

- to quantify the variability of EPEs across the basin

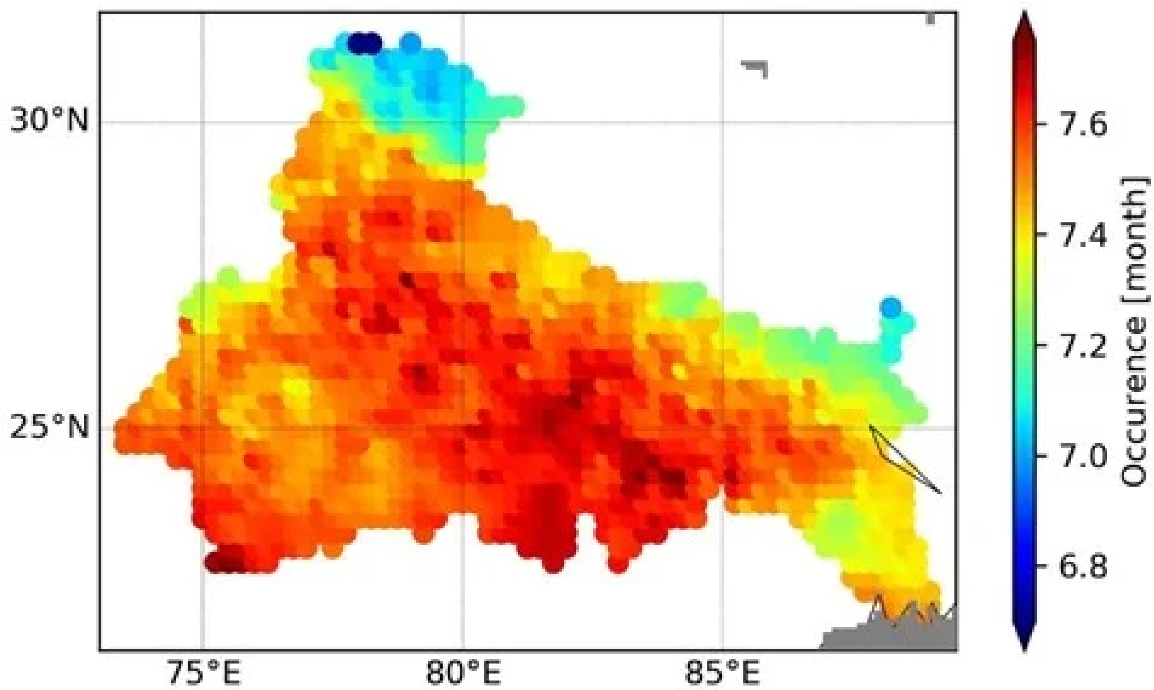

Figure 4: Pattern of the timing of peak precipitation for 1998-2019 and the timing is represented in the month

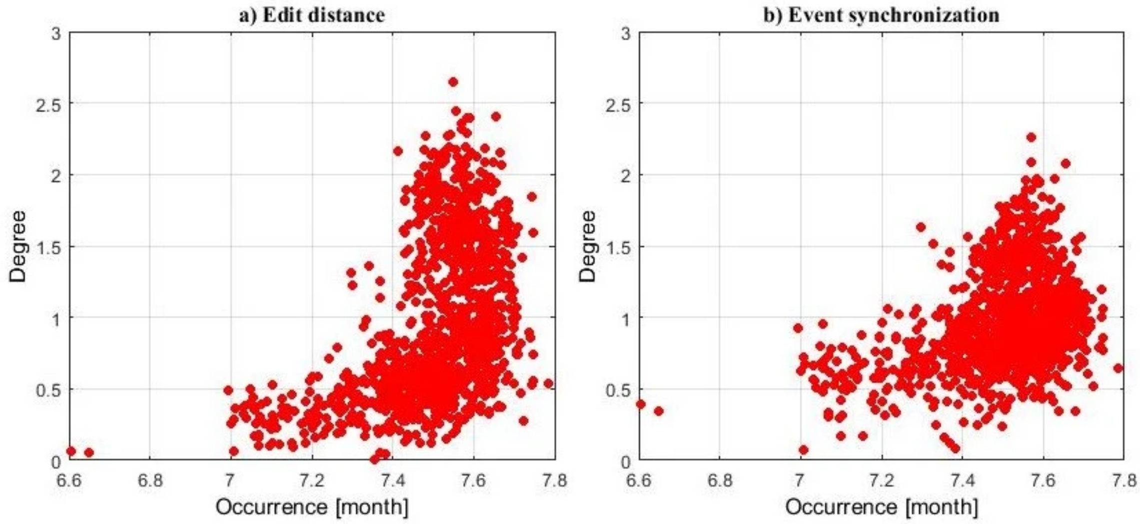

Figure 5: The relationship between occurrences of peak precipitation and degree for the (a) edit distance and (b) event synchronization

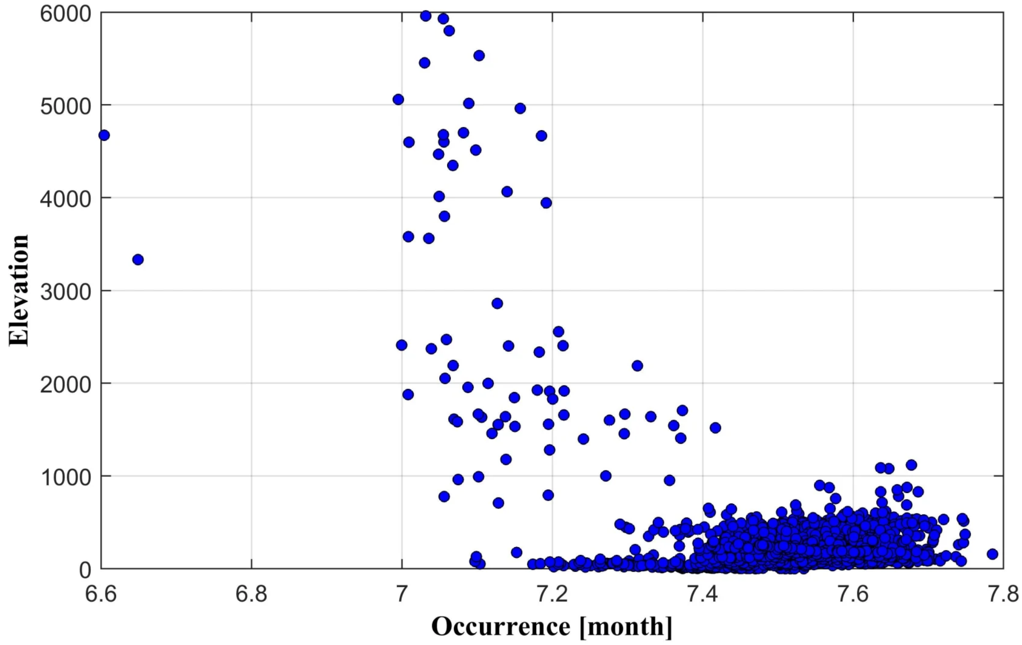

Figure 6: Scatter plot between Occurrence (or timing) of peak precipitation and elevation.

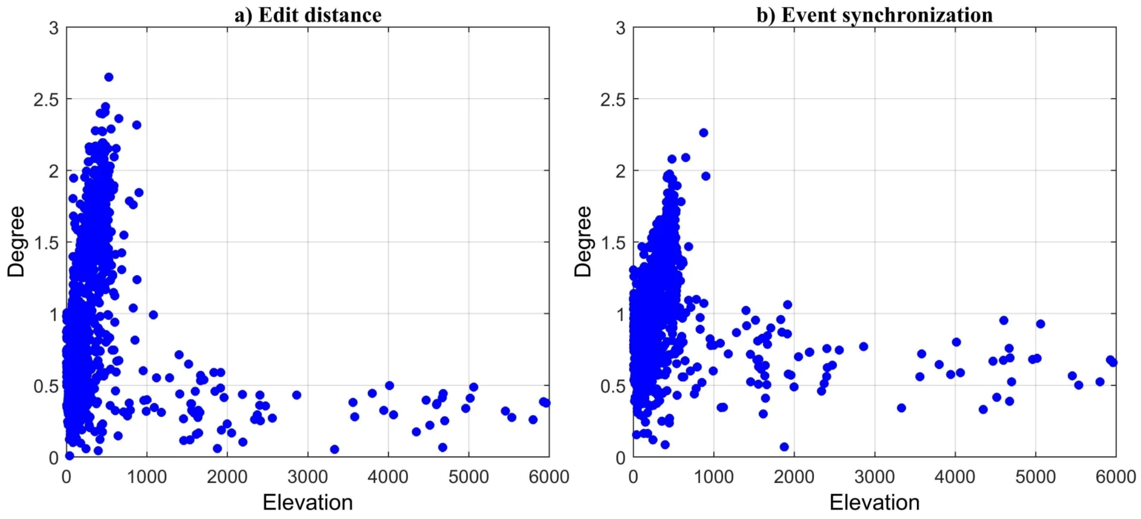

Figure 7: Characterize the relationship between degree and elevation for the precipitation network constructed using (a) Edit distance and (b) Event synchronization

Node importance

- to identify essential sites (or nodes) in the river basin to create effective networks

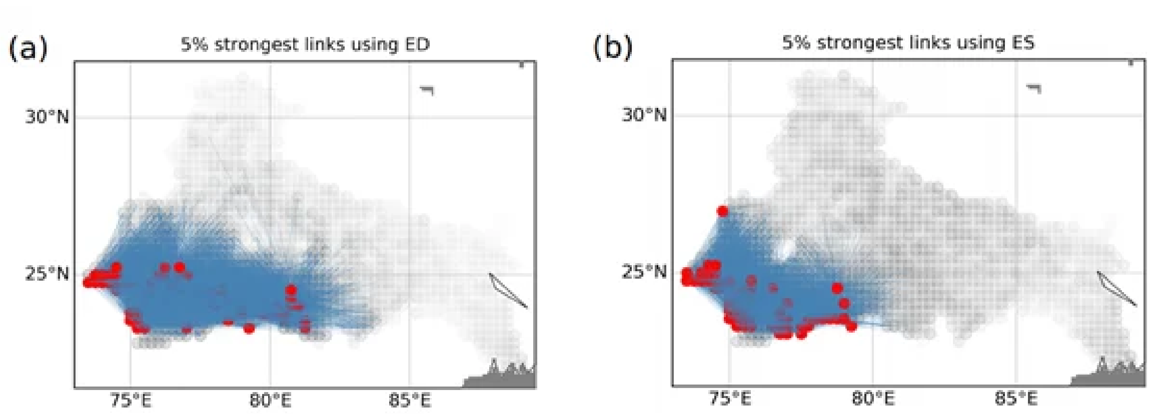

Figure 8: Spatial distribution of strongest 5% of nodes over the GRB

2. STUDY AREA AND DATA

Ganga River Basin:

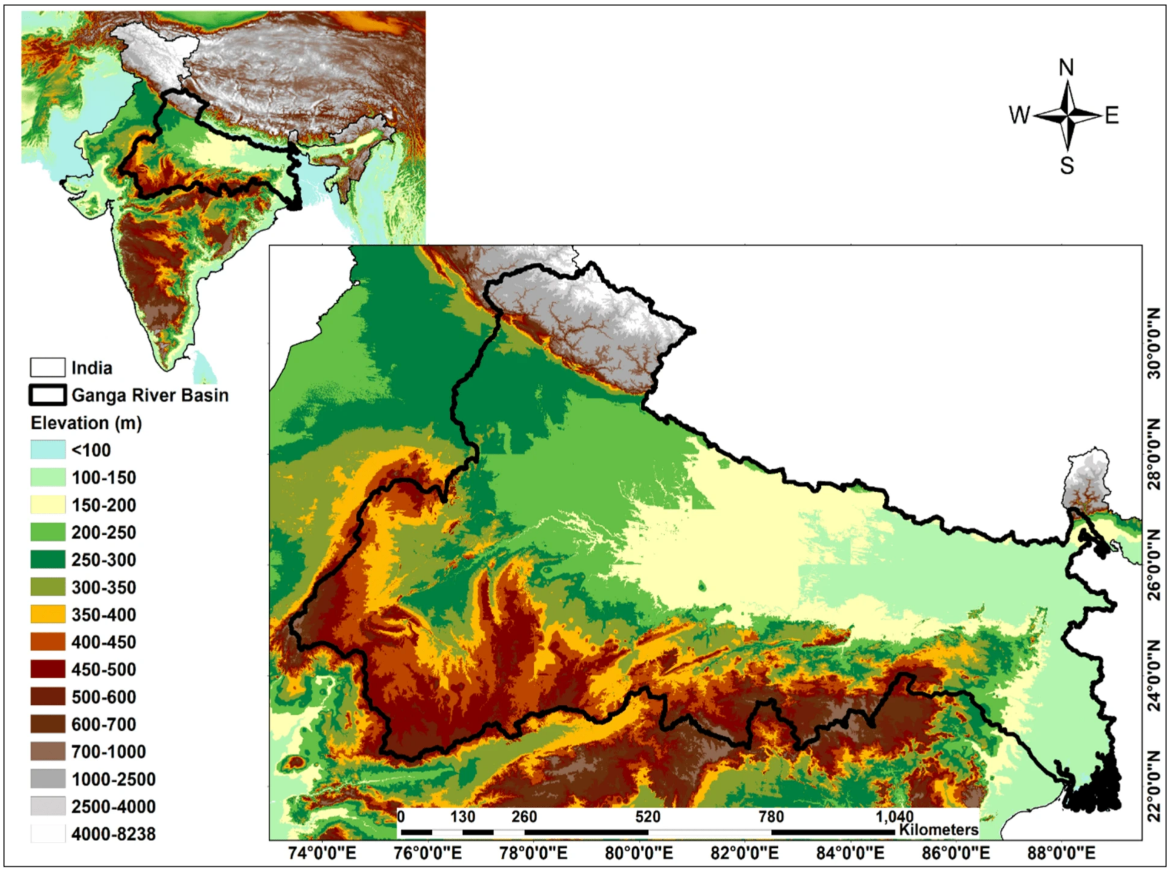

Figure 1: The geographical location of the Ganga river basin in India and the colour bar shows the elevation of the study area in meters above the mean sea level

Coverage:

Latitude range: 22˚30ˈN - 31˚30ˈN

Longitude range: 73˚30ˈE - 89˚00ˈE

- Elevation ranges from about 7000 metres north to less than 100 metres above mean sea level in the south (Fig.1).

- This complex topography leads to high spatiotemporal variability in precipitation and diverse climate classifications ranging from semi-tropical to semi-arctic.

- Average annual rainfall ranges from 300 mm (western side) to 3700 mm (eastern end).

Data:

Indian Meteorological Department (IMD) developed daily precipitation data for 22 years (i.e. from 1998 to 2019)

5. SUMMARY

The topology resulting from the edit distance-based network is compared with the event synchronization based network.

The major findings are:

1. The degree is decreasing from the southwest to the northwest direction

- grid stations at the basin's southwest regions has more connectivity compared to the rest of the basin.

2. The timing of peak precipitation influences the degree

- when an extreme event occurs across the sub-basins under the southwest region contributes to higher flooding risk and this region can be used as a proxy for predicting floods across the basin.

2. The connectivity is greatly affected by elevation

- lower elevation greatly influences the connectedness of the grid stations

3. An inverse relationship between elevation and timing of peak precipitation

- the Himalayan region (north side) receives its peak precipitation during June beginning, in the middle of July over the plain region (i.e., south region) and at the end of July over the northeast, deltaic region (south-west region) of the GRB

Edit distance can be considered as an alternative to event synchronization accounting for the sequences and the magnitude of events.

ABSTRACT

The spatiotemporal patterns of precipitation are critical for understanding the underlying mechanism of many hydrological and climate phenomena. Over the last decade, applications of the complex network theory as a data-driven technique has contributed significantly to study the intricate relationship between many variable in a compact way. In our work, we conduct a study to compare an extreme precipitation pattern in Ganga River Basin, by constructing the networks using two nonlinear methods - event synchronization (ES) and edit distance (ED). Event synchronization has been frequently used to measure the synchronicity between the climate extremes like extreme precipitation by calculating the number of synchronized events between two events like time series. Edit distance measures the similarity/dissimilarity between the events by reducing the number of operations required to convert one segment to another, that consider the events' occurrence and amplitude. Here, we compare the extreme precipitation patterns obtained from both network construction methods based on different network's characteristics. We used degree to understand network topology and identify important nodes in the networks. We also attempted to quantify the impact of precipitation seasonality and topography on extreme events. The study outcomes suggested that the degree is decreased in the southwest to the northwest direction and the timing of peak precipitation influences it. We also found an inverse relationship between elevation and timing of peak precipitation exists and the lower elevation greatly influences the connectivity of the stations. The study highlights that Edit distance better captures the network's topology without getting affected by artificial boundaries.

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