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Spatio-temporal rainfall variability in Tehri catchment of Himalayan Region, India

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METHODS

- Time-series pre-processing
  - Consistency and Continuity Check (RHtest V4 is used (R Core team 2013)
- Trend Analysis
  - Mann Kendall test (at both annual and monthly scale)
  - Sen's Slope
- Autocorrelation test (Anderson's Correlogram test is used to check the significant autocorrelation at both annual and monthly scales and using three lags).
- Deviation of monthly rainfall from the long-term mean (There are ten five-yearly datasets extracted from 50 years data series to compute the temporal variation of rainfall over the years at both annual and monthly scales. The negative and positive departures, which are more significant than one multiple of the long-term (1971-2020) standard deviation, are shown with dark red and dark green, respectively).

DATA USED

IMD rainfall stations are very scarce in the high elevation region of Uttarakhand states in India. This is due to the non-uniform terrain and unavailability of resources in the area. However, daily IMD gridded data is available for the region. Eight grid points were coming inside the catchment selected for the rainfall stations in further computations. The same is shown in the table (Table 1) below.

Station ID	longitude	Latitude	Elevation	Record length
1	78.5	30.5	1430	1971-2020
2	78.5	30.75	1882	1971-2020
3	78.75	30.5	1498	1971-2020
4	78.75	30.75	3372	1971-2020
5	78.75	31	3770	1971-2020
6	79	30.75	5100	1971-2020
7	79	31	3945	1971-2020
8	79	31.25	5004	1971-2020

RESEARCH GAP/FUTURE SCOPE

- The unavailability of the observed dataset leads to the use of an IMD gridded dataset. Another option available is satellite precipitation products.
- Various global and local precipitation satellite products are readily available, which are very handy for the same purpose. Comparison of the satellite products dataset and IMD gridded dataset can provide the best dataset for the spatial-temporal variability of the rainfall in the catchment.
- Recently, by Goel et al. 2016, a highly accurate instrument setup is installed in the catchment, which is available to check the satellite dataset's correctness.

RESULTS

- The spatial distribution of long-term (1971-2020) annual average rainfall of the Tehri catchment is shown in Fig. 2.
- Trend Analysis
  - Annual rainfall trend (Trends based on long-term data using MK test and percentage Sen's slope is represented by different colours in Fig. 3).
- Monthly rainfall trends (Fig. 6 shows the spatial distributions of monthly rainfall trends among the stations in the catchment area). The significant downward trend shows the temporal variation for October, such that over the years, the rainfall has decreased.
- Departure from Long-term Mean
  - Five-yearly deviation of yearly rainfall from long-term mean (shown in fig. 4).
  - Five-yearly deviation between monthly rainfall and the long-term mean(shown in fig. 6).

ABSTRACT

Spatio-temporal analysis for rainfall variability plays a decisive role in water resource management. The Spatio-temporal variability of rainfall remains more, in general, as compared to plain areas. Still, in contrast, the density of hydro-meteorological stations in mountainous catchments remains very sparse compared to plain areas. This fact particularly stands true in the Himalayan region. The computation using gridded rainfall datasets can help to address water resource-related issues. These grided data sets are available in different spatial resolutions from different agencies, including India Meteorological Department. The present study pertains to the Bhagirathi catchment, up to Tehri dam. RHtest is used to check the correlation between seasonal and annual rainfall time series. The statistical parameters like five years mean rainfall, standard deviation (SD), mean annual Rainfall (MAR) are used to display the catchment's orographic effects over rainfall. To study spatial variability of long-term rainfall trends annual and monthly time scale rainfall records are derived from the daily rainfall dataset. For temporal variability, 5-yearly average rainfall departure from long term mean rainfall is calculated. Mann Kendall test based long term trends are used to show a decrease or increase in rainfall at various stations. The 5-yearly averaged departure from long term mean gives important result related to temporal variation in rainfall magnitude, which allow evaluating current water management actions. Analysis of trends and 5-year departure from the long-term mean at monthly scale provide additional understanding of rainfall variability, not necessarily shown in the annually scaled results. As this could be possible, some stations have a significant variation in monthly scale but averaged out in annual scale. The findings are efficient in identifying the catchment level rainfall variability and statistical parameters of the rainfall dataset. These results will be advantageous for sustainable water resource management and planning actions in the water crisis.

MAPS

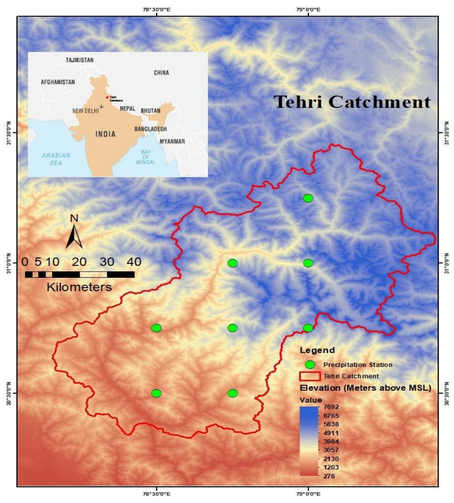


Fig1. Tehri Catchment and Location of Precipitation Stations used in the study (elevation source: SRTM)

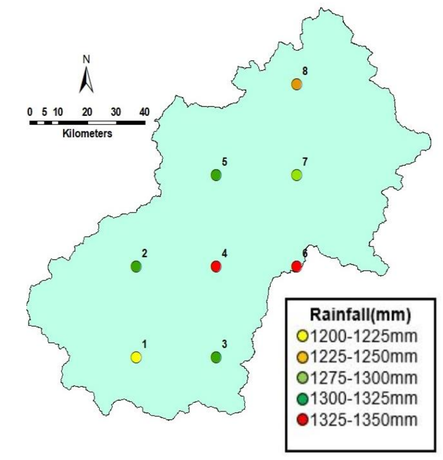


Fig 2. Long-term average annual rainfall spatial distribution (1971-2020) at station selected inside Tehri Catchment.

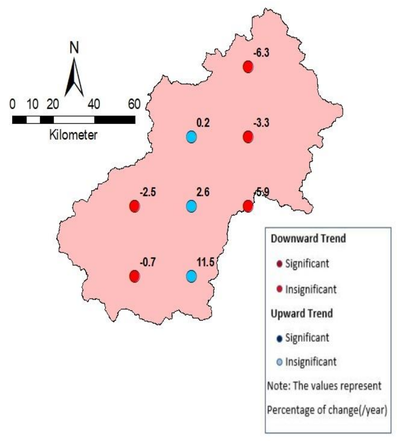
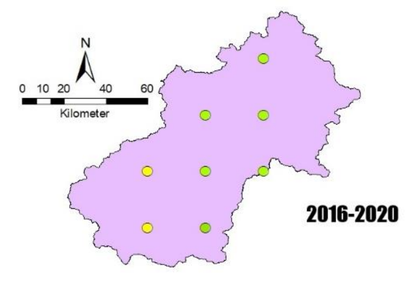
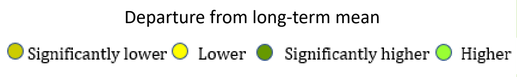


Fig.3 Long- term (1971-2020) annual rainfall trends in Tehri catchment. % Sen's Slope per year represented by values in the figure.





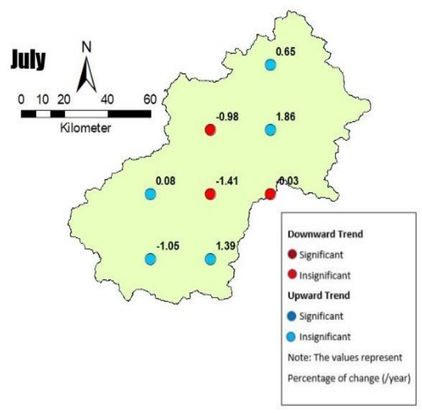


Fig. 5 Long-term (1971-2020) monthly rainfall trend in Tehri catchment. % Sen's Slope per year represented by values in the figure.

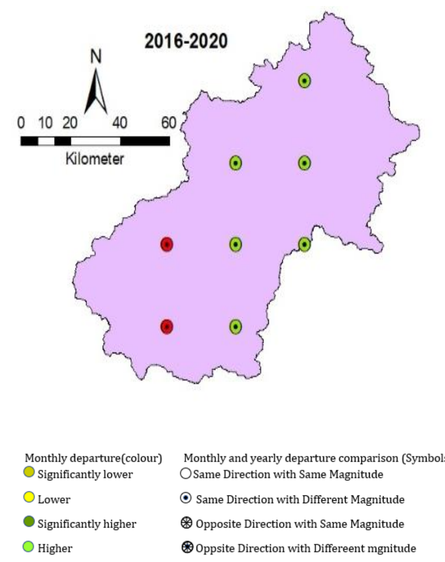


Fig 6. Five-yearly monthly rainfall deviation with respect to the long-term mean. Positive and negative standardized departure greater than one standard deviation is considered as significantly higher and lower respectively. Results for August (representing monsoon season)

Reference:

- Chatterjee S et. al. (2016)
- Shrestha S et. al. (2019)
- IPCC, 2014: Climate Change 2014: Synthesis Report
- Hamed KH (2008)