Detection of Changes in Temperature in Upper Ganga River Basin

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Abstract

Ganga river basin is the lifeline of the most of the North Indian population. Upper Ganga river basin is the source of Ganga river where Ganga river originates form Gangotri glacier. Many articles, researches are claiming that most of the Himalayan glaciers are receding due to rising temperature caused by climate change. In this study it is tried to find the changes in average temperature in the month of December. High resolution gridded monthly temperature data provided by Climate Research Unit (CRU) for 116 years, i.e., from year 1901 to 2016 is used. Least square linear trend shows upward trend in most of the regions. Significance of these trends is checked using non-parametric Mann-Kendal (MK test) at 5% significance level and found significance for most of the Southern regions of basin. Assessment of time of change detection is one of the important tasks for any climate change study. Here, time of change is found out using Non-parametric Cumulative -Deviation test at 5% significance level. It is found that most of the regions of Gangetic plains show change in the year 1988. No change in detected in the upper reaches of Ganga river. So, the plains of Upper Ganga river basin are found to be highly affected by climate change and winter temperature is rising significantly.

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Background

Upper Ganga river basin is the source of Ganga river where Ganga river originates form Gangotri glacier. Effect of climate change, urbanization on hydrology of Ganga river basin have been studied (Misra, 2011; Singh & Bengtsson, 2004). Researches are claiming that most of the Himalayan glaciers are receding due to rising temperature caused by climate change (Barnett et al., 2005; Kehrwald et al., 2008). Sharma & Ojha, (2018) found that annual precipitation in Upper Ganga river basin have been significantly decreased. However, changes of Winter (December) temperature in Upper Ganga basin are not yet assessed. Winter temperature highly affect the snowfall and plays important role in maintain pre-monsoon flows.

We have tried to find the trends of winter temperature and to detect change point, if any, in Upper Ganga river basin. Cumulative Deviation Test (CD) is used to detect change point in winter temperature.

Study area

Study Area: Upper Ganga river basin

Data used

- High resolution gridded precipitation data provided by Climate Research Unit (CRU) (Harris et al., 2014).
- Location data of grid points in the form of Latitude (Lat) and Longitude (Long)

Methodology

The following steps are involved in this study

1. Trend estimation using least square linear slopes
2. Mann-Kendal test (MK) to find significance of trends

   The test static 'S' of the MK test is defined as

$$S = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} \operatorname{sgn}\left(x_j - x_i\right)$$

$$Z = \begin{cases} \dfrac{S-1}{\sqrt{VAR(S)}} & \text{if } S > 0 \\ 0 \text{ if } S = 0 \\ \dfrac{S+1}{\sqrt{VAR(S)}} & \text{if } S < 0 \end{cases} \qquad VAR(S) = \frac{n(n-1)(2n+5) - \sum_{i=1}^{m} t_i(t_i-1)(2t_i+5)}{18}$$

   if $Z > Z_\alpha$ the trend is significant

3. Cumulative Deviation (CD) test to find location of change point. Cumulative deviation tests is a test to detect heterogeneity in time series.

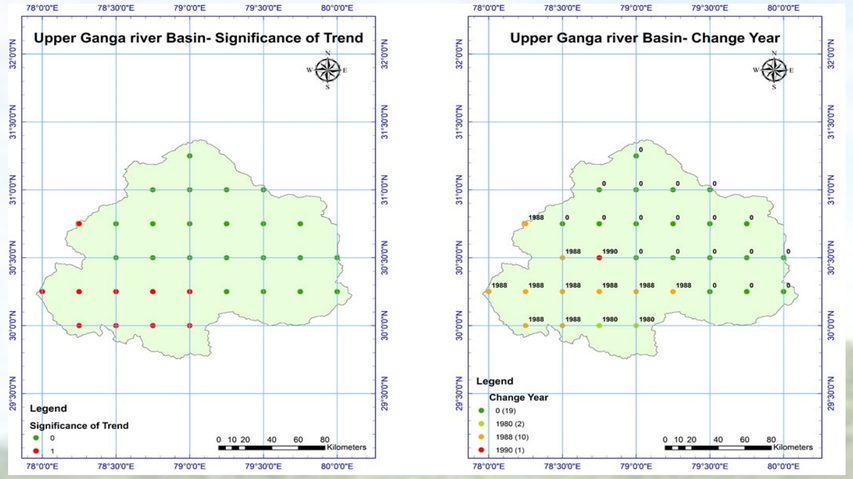
   For a time series X_t with N data points

$$S_k = \sum_{i=1}^{k} (X_i - \bar{X}) \qquad S_k^* = \frac{S_k}{\sigma_Y}$$

   A test static Q is defined $Q = \max(|S_k|)$

   The series is said to be heterogeneous, if the value of $Q/\sqrt{N}$ exceeds critical value at defined significance level.

Results



Significance of Trends

Change Point Detection- Detected Change point years using CD Test

Discussions and Conclusions

Trend estimation and change point detection is one of the important task for climate change study. Winter temperatures in the Upper Ganga river basin showing warming trends. Some of the location are showing **rise in winter temperature** by approximately **1°C**. This indicates serious effect of climate change on the glacier dominated region. Most of the Southern regions are showing significant positive trends. The change detection study indicates that change is detected mostly in the Southern regions of Upper Ganga river basin. **The year 1988** is detected **change year** for most of the regions. So, it can be seen that climate change is affecting the minimum temperatures in Upper Ganga river basin.

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