The Mann–Kendall statistical test has been frequently used to quantify the significance of trends in meteorological time series (Subash et al. 2011; Yue et al. 2002; Tabari and Marofi 2011; Duhan and Pandey 2013; Silva et al. 2013). The Mann–Kendall test (Mann 1945; Kendall1975) is calculated as Eq.(1)

$$S = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} \mathrm{sgn}(x_j - x_i) \qquad (1)$$

Where n is the number of data points, x_i and x_j are the data values in the time series i and j (j＞i), respectively, and sgn(xj – xi) is the sign function, Eq.(2).

$$\mathrm{sgn}(x_j - x_i) = \begin{cases} +1 & if \quad x_i - x_j > 0 \\ 0 & if \quad x_i - x_j = 0 \\ -1 & if \quad x_i - x_j = 0 \end{cases} \qquad (2)$$

The variance is computed as Eq.(3).

$$\mathrm{Var}(S) = \frac{n(n-1)(2n+5) - \sum_{i=1}^{p} t_i (t_i - 1)(2t_i + 5)}{18} \qquad (3)$$

Where n is the number of data points, P is the number of tied groups, the summation sign (Σ) indicates the summation over all tied groups, and t_i is the number of data values in the Path group. If there are no tied groups, this summation process can be ignored (Kisi and Ay 2014). A tied group is a set of sample data that have the same value. In cases where the sample size n ＞30, the standard normal test statistic ZS is computed using Eq. (4):

$$Zs = \begin{cases} \frac{S-1}{\sqrt{\mathrm{Var}(S)}}, & if \quad S > 0 \\ 0 & if \quad S = 0 \\ \frac{S+1}{\sqrt{Var(S)}}, & if \quad S < 0 \end{cases} \qquad (4)$$

Positive values of ZS indicate increasing trends, while negative ZS values show decreasing trends. Testing trends is performed at the specific α significance level. When |ZS| ＞|Z1-α/2|, the null hypothesis is rejected, indicating that a significant trend exists in the time series. Z1-α/2 is obtained from the standard normal distribution table. In this study,α= 0.05 was used. At the 5 % significance level, the null hypothesis of no trend is rejected if |ZS|＞1.96.