The Study of Precipitation Trend in North Alborz Basin (Iran)

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Abstract
All climatic parameters in an area such as precipitation, temperature, humidity and etc. can affect the region and study of these parameters can help a researcher to know the area better. This paper studies the precipitation variability in North Alborz basin using Mann-Kendall Method. This research has studied and analyzed the annual precipitation in North Alborz basin using synoptic and climatology stations data in a statistical period of 46 years (1960-2005). The research then uses Mann-Kendall Method to study the variables. The findings of the research show that the negative trend of precipitation in South of basin and the positive trend in East of basin.

Keywords: Mann-Kendall Method, North Alborz Basin, Trend

1. Introduction
In the last decade, climate changes have been a great environmental matter of concern to different world organizations. Issues such as water and air pollution, decrease in soil production rate, destruction of natural resources, reforestation and similar issues, especially global warming are of great importance because of their role in increasing the greenhouse gases. Such issues may have different effects on different aspects of human life on the earth, especially on human settlements, agricultural products, energy consumption, etc. These factors have motivated man to trace the history of evidences, causes and future of climate changes [1].

Iran, a vast country has a variety of weather because of the special location has been estimated around 244-275 mm that is about one third of the global mean precipitation (800 mm) and less than one third of the global mean precipitation (1133mm). [2]

Precipitation is as the most unstable climate variable in the arid and semi-arid zones its changes reflected directly on the soil humidity, surface and underground flows. For this reason, precipitation is the first factor may be taken into account when studying the drought especially meteorology drought [3].

Lots of studies have been conducted about the trend of climate changes. For instance, Buffoni et al. [4] have analyzed the precipitation trends in Italy. They collected the precipitation data of 32 dispersed stations across Italy. The stations were divided into two homogenous climate regions, to analyze the...
seasonal and annual precipitation trends in Italy in a 164-year period. They used Mann-Kendall test to analyze the trend. They came to this conclusion that different regions and seasons have different trends. Having collected data from 25 stations, Stafford et al. [5] obtained the trend of temperature and precipitation for a 50-year period in Alaska (1949-1998). For linear analysis, they used mean maximum and minimum temperature, daily temperature and overall precipitation, they concluded that mean seasonal and annual temperature across the state had risen and most of them are statistically in 95% or upper level. Tomozeiu et al. [6] analyzed the variations in winter precipitation in 40 stations from 1960 to 1995. They used Mann-Kendall and Petit tests to analyze the variability of time series and to estimate trends and change points. They found that in this period, nearly all stations were manifesting a significant falling trend in the winter precipitation. Domonkos [7] analyzed precipitation trend in Hungary. He analyzed monthly time series in Hungary's stations in 1901 to 1998 to discover long term changes in the precipitation of 20th century. In his study, he particularly investigated the changes in recent decades and their relations with long scale climate changes in Europe and Atlantic Ocean. Furthermore, systematic changes were analyzed by linear trend and Mann-Kendall test. Long-term changes were explained by a 15 point Gaussian filter in time series. Gemmer et al. [8] analyzed monthly precipitation in 160 stations in China from 1951 to 2002, using Mann-Kendall test. They succeeded to determine the positive and negative monthly trends in 90%, 95% and 99% level of significance. Using single season index, Livida and Asimakopolous [9] studied seasonal precipitation trend in Greece and compared the linear co-relation of this index with mean single season index. In the following step, they used regression analysis of this index along with latitude and discovered a significant reverse co-relation. Eventually, the analysis of time series of this index showed that there has been no significant change in seasonal precipitation of this region. Using daily precipitation data of 494 stations from 1961 to 2000, Qian and Lin [10] analyzed regional trend of precipitation indexes in China. Of precipitation indexes, precipitation accumulation, enduring precipitation was used and their decimal differences were investigated. Amini Niya et al [11] have analyzed heavy snowfall variations in northeast of Iran. The analysis showed that heavy snowfall in all stations and during the common statistical period has had many variations and falling trend. The use of ranked Mann-Kendall test in stations having long term statistics shows a falling trend in receiving heavy snowfall in Tabriz and Uremia stations and the absence of any trend in Ardebil and Khoy. Nader [12] has studied climate changes in the last 50 years, with particular emphasis on northwest region of Iran. To analyze and discover trends in time series, he had used Mann-Kendall t-test and Mann-Kendall statistical-graphic method. The study results showed that hypothesis of “accidental data” was utterly rejected, and a trend was dominating the data. Furthermore, graphic figure analysis show changes in U and U’, mean minimum temperature and precipitation in the last 50 years are quite significant. Azizi and Roshani [13] have also used Mann-Kendall method to analyze climate changes in southern shore of Caspian Sea. The study results reveal that elements of climate change from 1950 to 1990. These changes were short term weather variations and trends, which are found in some monthly, seasonal and annual time series. Using Mann-Kendall, Feizy et al. [14] have analyzed climate changes in Sistan and Baluchistan. The study results show that in all stations, except for Zahedan, temperatures have had a falling trend during the year. Using Mann-Kendall method, Omidvar and Khosravi [15] have investigated the changes of some climate factors in northern shore of Persian Gulf. The study results show that changes in mean temperature in all stations are similar to changes in minimum temperature trend. Furthermore, minimum temperature was the factor which has raised the mean temperature of the stations in the study area. Besides, relative temperature had either significant falling trend or had no significant trend. As of precipitation frequency in the study area, there has been a significant falling trend and there was no significant rising trend. Using none-parametric Mann-Kendall test and sensor estimator slop, Hojam et al. [16] have investigated seasonal and annual precipitation trends. The study results show a significant falling trend in some of the time series of the study which was verified by both tests, but no rising trend was mutually verified by the two test
methods.
In this research, considering all the above mentioned points, there has been an effort to show all the climatic changes and their effects on the region and precipitation changes which have a great effect in the climatic changes and shows the changing trend in the North Alborz basin.

2. Methodology
In this research, the region which has been studied for precipitation changes is North Alborz basin. This basin is located in the northern part of Iran, between Gilan and Mazandaran provinces. This basin is also located South of Caspian Sea. (Figure 1)

Figure 1. Location of North Alborz basin in Iran
To study the annual precipitation changes, the statistics of 16 synoptic and climatology stations were collected from 1960 to 2005, then the statistics were checked for correction and were analyzed statistically again. Then using Kriging method, 46 annual precipitation maps were prepared, and then the maps were changed into data. These data were analyzed using Mann Kendall graphic method. (Figure 2)

![Figure 2. Synoptic and climatology station inside and around basin](image)

This method is widely used for the analysis of trends in metrological and hydrological series [17]. One of the advantages of this method is its applicability for time series, which do not follow a typical statistical distribution. This method is scarcely affected by temperature extreme values of time series [18]. In a given series of data, the following formula is used to see whether data are accidental:

\[
T = \frac{4P}{n(n - 1)} - 1
\]

In which \(t\) is Mann-Kendall value, \(p\) is the total sum of ranks higher than \(n_1\), and is obtained by the following formula:

\[
p = \frac{1}{2}n(n - 1)
\]

For accidental series, the mathematical expectation of \(t\) is zero and variance is obtained by following formula:

\[
Var(t) = \frac{2(n + 5)}{9n(n - 1)}
\]

Mann-Kendall test defines a standard normal variable of \(N\), which is obtained by following formula; this formula is used for calculating the level of significance of \(t\):

\[
N = \frac{r}{\text{Var}(t)^{1/2}}
\]
If the total number of data increases, $N(n)$ would quickly become homogenous by normal standard distribution. If absolute size of $n$ is larger than $n/a/2$ (in 5% level, and, which has used normal distribution table of 1.96), data series would have a significant trend. If the value of $n$ is negative, the distribution would have a falling trend; if $n$ is between 1.96 and -1.96, data series would have no trend.

3. Discussion

Spatial distribution of annual mean precipitation on North Alborz basin shows that the average annual precipitation are about 750 mm in South area of basin to 1550 mm in Northwestern part of basin. (Figure 3)

Figure 3. Spatial distribution of mean annual precipitation in North Alborz basin

Figure 4. Temporal distribution of mean annual precipitation in North Alborz basin
Temporal distribution of annual mean precipitation on North Alborz basin shows that the average annual precipitation is about 750 mm in 1971 to 1413 mm in 1992. (Figure 4)

The results of Mann Kendall test show that the average annual precipitation in the basin has not changed, but in many part of basin, especially on South area the annual precipitation was decreased and in many part of basin, especially on North East area the annual precipitation was increased. (Figure 5)

4. Conclusion
Temporal and spatial distribution of mean annual precipitation in North Alborz basin shows that overall, the total amount of annual precipitation in the basin has changed considerably, temporal distribution of annual precipitation of 750 mm to 1413 mm in 1971 varied in 1992, but the time series of precipitation is not increasing or decreasing trend.

The spatial distribution of precipitation of 750 mm and 1550 mm in the southern region of northwestern varied.

Precipitation time series in different parts of the basin shows that the annual precipitation in the Southern region of North Alborz basin has been the significant decrease trend and in the North Eastern part of North Alborz Basin has been the significant increase trend.

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