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RESEARCH NOTES

Investigation of Annual Rainfall Trends in Iran

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ABSTRACT

This paper presents an analysis of annual precipitation trends in Iran. Mean annual rainfalls were collected from 30 synoptic stations with a reasonable geographic distribution and with data equal to or less than 50 years. Trend analysis was investigated using a "regression line slope" method (annual rainfall as a dependent variable and year as an independent variable). The results showed that for the entire period, and at a 95% level of significance, seven stations showed a negative trend, while a positive trend was found at six stations. The same data over the period of last 40 years demonstrated that four and 8 stations had negative and positive trends, respectively. Decreasing the record length, up to the last 30 years, resulted in fewer stations with any significant trend. The results identified that, in any case, the trend did not depend on the mean annual rainfall but rather record length could have some effects on it.

Keywords: Annual rainfall, Iran, Record length, Regression line slope, Trend analysis.

INTRODUCTION

Information pertaining to a decrease or increase in the amount of rainfall have significant effects on agricultural and municipal water management, especially in arid and semi-arid countries like Iran. Although some climatic parameters have been shown to have a distinct trend globally (a positive trend for temperature, for example), rainfall behavior varies depending on the location. Forland *et al*. [2] showed a positive precipitation trend for Northern Europe. Both Hess *et al*. [5] for the North East arid zone of Nigeria (over the period 1961-1990) and Manton *et al*. [7] for South East Asia and the South Pacific (over the period 1961-1998) identified a decrease in annual rainfall. Schonwiese and Rapp [8] found a positive trend in the North and a negative trend in the South of Europe. Herath and Ratnayake [4] reported a decrease in the annual rainfall in the Sri Lanka for 1964 to 1993. One third of stations considered by Ceballos *et al.* [1] in Spain, possessed negative trend. Khalili and Bazrafshan [6] observed no trends in annual rainfall of 4 major stations of Iran for a 108 year period. In this research we examined the rainfall trend in stations with equal or less than 50 years of collected data. These stations were located throughout Iran following no particular pattern.

MATERIALS AND METHODS

Thirty synoptic stations were chosen with equal or less than 50 years of collected data (up to 2000), but the length of period was not equal for all stations. Then the stations were ranked on the basis of mean annual rainfall in increasing order (Table 1). Ceballos *et al*. [1] also used stations with different

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record lengths and categorized them on the basis of mean annual rainfall. We used a regression line slope method for trend analysis. With the exception of one station, the others were normally distributed, based on the "Test for normality for a sample size of less than 150". Trend studies were conducted for the entire record length, the last 40 years (1961-2000), and the last 30 years (1971-2000).

RESULTS AND DISCUSSION

Results of Trend Analysis

Analyzing all Recorded Data:

At a 99% level of significance, the results showed that two stations possessed a significant trend (both of the stations had a negative trend). On the other hand, at a 95% level of significance, 13 stations followed a significant trend (7 and six stations had negative and positive trends, respectively). Bandar Anzali (station number 30) showed the highest significant trend (-10.1 mm yr^{-1}). Greenland and Kittel [3], after analyzing 18 stations in USA over the period of 1957-1990, reported values of -4.2 mm yr^{-1} and +17.1 mm yr^{-1} for the highest negative and positive trends, respectively. The average negative and positive trends were -2.9 mm yr^{-1} and +1.7 mm yr^{-1}, respectively. Khalili and Bazrafshan [6] investigated the annual rainfall trends of 4 Iranian stations (Esfahan, Tehran, Mashhad, and Bushehr station number 4, 11, 12 and 13) and observed no trend over a 108 year period.

Analyzing the Last 40 Years of Collected Data

At a 99% level of significance, four stations had a significant trend (two stations were positive, while the other two were negative in their trend). At a 95% level of significance, 12 stations demonstrated a significant trend (8 and four stations followed a positive and negative trend, respectively). Gorgan (station number 26) showed the highest significant trend with the rate of -4.0 mm yr^{-1}. Values of -3.1 mm yr^{-1} and +2.6 mm yr^{-1} were attributed to the average of decreasing and increasing trends, respectively.

Analyzing the Last 30 Years of Collected Data

At a 99% level of significance, two stations showed a negative trend. At a 95% level of significance, three stations demonstrated a negative trend with an average rate of -4.5 mm yr^{-1}. Table 1 shows the line slope values for all stations.

Dependence of Trend to Mean Annual Rainfall

It may be interesting to note whether humid and dry stations exhibit different behavior, as far as trend analysis is concerned. Figure 1 shows such a relationship between the trend rate in mm yr^{-1} (as a dependent variable) and station number, since they are sorted from low to high rainfall amounts (as an independent variable). In all of the three stages of analysis (all available data, the last 40 years, and the last 30 years) a significant relationship is hardly envisaged. Greenland and Kittel [3] confirmed that no specific relationship between these two variables can be defined.

Dependence of Trend to Data Record Length

We investigated the probable effects of record length on rainfall trends in Iran. Data length may have an influence on trend behavior from two different view points: number of stations demonstrating the trend and the trend value. Results of this research

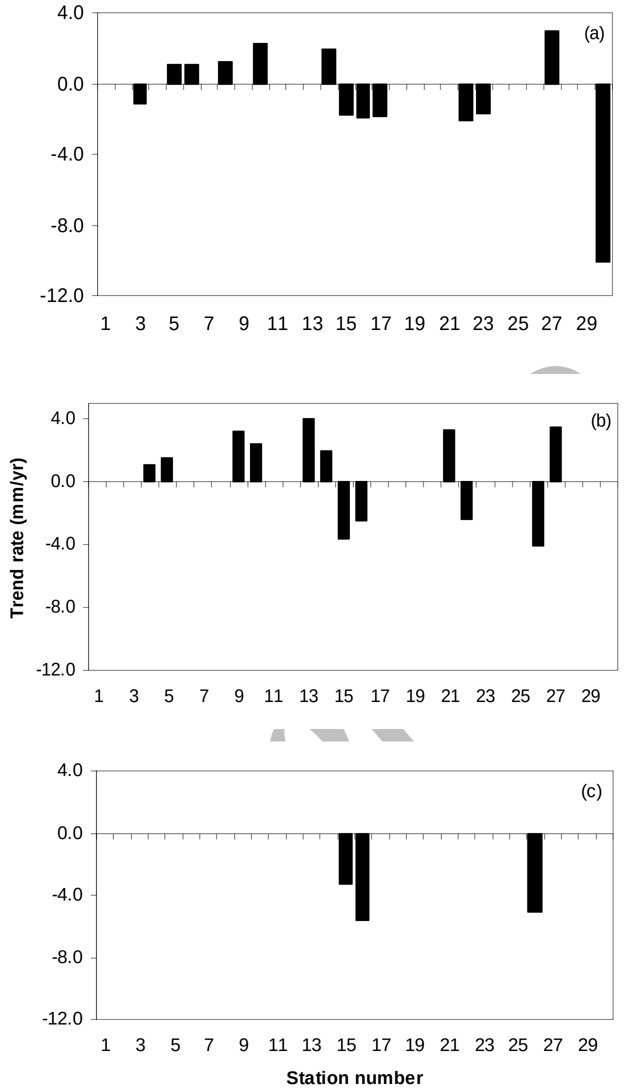

Figure 1. Significant trend rates for Iranian stations, using the entire record length (a), the last 40 years (b), and the last 30 years (c). For station number, see Table 1.

the trend value. Results of this research showed that both of these effects are probable. For example, in the Tabriz (station number 15) station, changing the length of recorded data from the entire period to the last 40 and then to the last 30 years resulted in a 108% and 84% decrease in the trend rate, respectively. And at the Zanjan (station number 17) station, the trend was significant when analyzing the entire period, but no trend was observed when analyzing the last 40 and 30 years. Khalili and Bazrafshan [6] investigated the annual rainfall trends of four Iranian stations (Esfahan, Tehran, Mashhad, and Bushehr station number 4, 11, 12 and 13) and observed no trends for a 108 year period, but we found significant trends for Esfahan and Bushehr in analyzing the last 40 years' data. Greenland and Kittel [3] showed that change in record length may

Table 1. Selected stations and line slopes (mm yr^{-1}) at different record lengths.

No.	Station	A.R.L.[a]	Elevation (m)	M.A.R.[b]	B		
					total	40	30
1	Yazd	47	1230	61.9	0.014	0.325	-0.369
2	Bam	44	1066.9	64.2	-0.107	0.11	0.475
3	Zahedan	48	1370	93.7	-1.161**	-0.363	0.406
4	Esfahan[c]	49	1550.4	121.6	-0.08	1.061*	-0.338
5	Abadan	50	6.6	155.3	1.045*	1.496*	-0.326
6	Shahrood	49	1345.3	156.9	1.048*	0.581	-1.367
7	Birjand	43	1491	173.1	0.083	0.492	0.085
8	Sabzevar	46	977.6	189.2	1.252*	1.298	-1.202
9	Bandar Abas	44	10	192.6	1.873	3.224*	1.522
10	Ahvaz	41	22.5	228.9	2.234*	2.394*	0.054
11	Tehran (Mehrabad)[d]	50	1190.8	229.2	0.531	0.701	-1.123
12	Mashhad[e]	50	999.2	257.1	0.666	1.02	-1.151
13	Bushehr[f]	48	19.6	275.5	-0.662	4.013**	3.396
14	Torbate Heydarieh	41	1450.8	278.8	1.925*	1.997*	0.92
15	Tabriz	50	1361	293.0	-1.765*	-3.676**	-3.255*
16	Khoy	41	1103	295.5	-1.947*	-2.501*	-5.583**
17	Zanjan	45	1370	315.6	-1.832*	-1.61	-2.135
18	Ghazvin	42	1278.3	315.9	1.386	0.934	-0.201
19	Shahre Kord	44	2061.4	323.2	0.695	-0.449	-1.253
20	Hamedan	50	1679.7	335.9	-0.674	0.648	-0.694
21	Shiraz	48	1488	345.5	-0.78	3.286**	2.519
22	Arak	44	1708	347.8	-2.079*	-2.415*	-2.057
23	Oroomieh	49	1313	348.8	-1.676*	-1.453	-2.027
24	Kermanshah	49	1322	450.8	0.714	-1.622	-3.27
25	Khorramabad	48	1125	517.6	-0.092	0.454	-3.385
26	Gorgan	48	13.3	605.0	-2.422	-4.038**	-5.108**
27	Babolsar	50	-21	881.5	2.931*	3.453*	-1.005
28	Ramsar	45	-20	1209.7	-4.108	-4.619	-3.131
29	Rasht	44	36.7	1356.5	0.744	1.792	-4.159
30	Bandar Anzali	49	-26.2	1869.4	-10.094**	-2.514	-8.964

* Significant at 5% ** significant at 1%.

[a] Available Record Length.

[b] Mean Annual Rainfall (mm).

[c-f] 0.102, 0.096, 0.050, and 0.094 mm yr^{-1}, respectively, corresponding to 108,108,108, and 124 years, respectively, adapted from Khalili and Bazrafshan [6].

change the trend behavior. One of the reasons for this behavior could be the presence of extreme events over different data period lengths.

CONCLUSION

Since rainfall is the most important source of water for all agricultural requirements, information about rainfall trends is valuable to policy makers. Trend analysis for 30 Iranian synoptic stations with equal or less than 50 years of recorded data was conducted. The results showed that an overall significant trend (based on a regression line slope) was derived only for a few stations. Seven and 6 stations showed negative and positive significant trends, respectively, for the entire record length of the stations. Changing the record length to the last 40 years, modified these numbers to four and 8, respectively. Over a 30 year period, we found only three stations that showed negative trends. By the results, the trend was insensitive to mean annual rainfall, but its behavior was anomalous for different record lengths.

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بررسی روند بارندگی سالانه در ایران

ب. قهرمان و ص. تقوائیان

چکیده

در این تحقیق، وجود روند در بارندگی سالانه ایران مورد بررسی قرار گرفته است. آمار بارندگی سالانه ۳۰ ایستگاه سینوپتیک ــ با پراکنش مناسب ــ در ایران با طول دوره آماری برابر یا کمتر از ۵۰ سال (مختوم به سال ۲۰۰۰) جمع آوری شده و روند بارندگی سالانه آنها با استفاده از آزمون شیب خط رگرسیون (باران سالانه به عنوان متغیر وابسته و زمان به عنوان متغیر مستقل) مورد بررسی قرار گرفت. نتایج نشان داد با در نظر گرفتن کل طول دورهٔ آماری در سطح ۹۵٪ هفت ایستگاه روند منفی و شش ایستگاه روند مثبت داشتند. با تغییر طول دورهٔ آماری به آخرین ۴۰ سال، در سطح ۹۵٪ هشت ایستگاه روند مثبت و چهار ایستگاه روند منفی داشتند. با کاهش طول دورهٔ آماری به آخرین ۳۰ سال، در ایستگاه های کمتری روند مشاهده شد. نتایج نشان داد که در تمام حالات، روند به میزان بارندگی سالانه بستگی ندارد اما در مورد طول دورهٔ آماری، روند رفتار متفاوتی را نشان داد.