Some Statistical Characteristics of Temperature Variations in Iran

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چکیده

سری زمانی دمای متوسط سالانه و فصلی شهرهای تبریز، تهران، اصفهان، و بوشهر در دوره آماری ۱۹۹۳-۱۹۵۱ بر اساس روش غیرپارامتری کندال تجزیه و تحلیل شد. نتایج بررسی هیچ نوع تغییر اقلیمی گسترده و بارزی را نشان نداد بلکه حاکی از نوسانات آب و هوایی کوتاه مدت در سراسر کشور بود. سری زمانی زمستان روند ضعیف سرمایش ولی سری‌های دیگر به ویژه سری تابستان روند افزایش نشان دادند.

Abstract

Mean annual and seasonsl temperature records of four stations for the 1951-93 period were analysed. The results did not show any dominant and widespread climatic change, but a climatic fluctuation over the country was of several. The colder season series was relatively stable and showed a trace cooling indication towards the end of study period, while the other seasons series indicated noticeable change and the second half of the study period became warmer.

Introduction

The climatic change of the planet earth has been the subject of many sutdies throug out the world. Most of these studies have been focoused on temperature. These studies indicate that the global mean air temperature has increased during c the last century (Jones and Sellers, 1990). Hansen and Lebedeff (1987) realized

that 0.6 in°rise annual temperature for the last century. Analysis of the annual growth of treses in Siberia also showed that the summer mean temperatures have increased during this century (Brifa et al, 1995).

The same results were achieved in the Mediterraninan region (Papadimitiou and Mahras, 1991; vecchio G. L and T. Nanni, 1995) and in the Middle East (Turkes-1995). Another study carried out by Harley (1980) substantiated the warming trend over the northern Iran during 1949-78.

about warming trend in the temperature of Iran, however, there it may be no scientific inverstigation so far has been carried out. Therefore, this study tries to find out whether there is a trend in the annual variations of temperature in Iran or therr are only short period random fluctations.

Data

This study has utilized mean annual and seasonal temperature series of stations Tabriz, Tehran, Isfahan, and Bushehr for the 1951 to 93 period. The data were obtatined from I. R. of Iran Meteorological Organization in the corrected form (Table 1).

the short- cut bartlet test (W M O, 1966) wad used to the homogeneity of the temperture series. For this purpose, the series of each station was divided into seven subperiods and their group variance was computed from the ratio s^2_{max}/s^2_{min}. If this amount was less than the critical valus at 5 percent significance level (see Table III- 2 of W. M. O. 1966)7 then the series was homogenous. The results showed that all series are6 homogeneous with the excepion of the fall season in Tehran and winter in Isfahan.

Table 1- Mean annual and seasonal tem perature

station	elevation	annual		spring		summer		fall		winter	
	m	$\bar{X}$	C.V.	$\bar{X}$	C.V.	$\bar{X}$	C.V.	$\bar{X}$	C.V.	$\bar{X}$	C.V.
Tabriz	1366	12.11	6.5	1634	6.3	24.1	3.9	7.22	17.5	8.7	234
Tehran	1110	16.44	4.3	21.75	5	28.1	3	11.7	10	6.16	26
Isfahan	1575	16.1	4.1	20.95	4.5	26.35	3.7	10.7	8.3	6.55	18.9
Bushehr	5	24.41	2.3	27.91	2.9	32.16	2.3	21.29	3.6	16.26	5.8

Results

Fluctuations

In order to visualize the nature of the temperature series, their temporal variations were graphed together and their smoothed line is drawn according to the nine year moving average of Gussian low- pass filter (WMO, 1966). The annual series of all stations show a wavey fluctuating pattern with different wave lengths indicating warming pattern in all station. The warming pattern is reltively apparent in stations Tehran and Isfahan. The smoothed curves indicate that 1980's and early 1990's have become warmer.

The mean- Kendalk (WMO, 1966) statistical and graphical tests were used to test the randomness against trend characteristic of the series. First the statistical non parametric test was applied. For this purpose, series were reanked in ascending order, i. e, the lowest value renked 1 and the highest value, 43. Then the number of higher ranks counted after each calender year (n_i) was assigned to that year. The kendal value (t) was computed as follows:

$$t=\frac{4p}{N(N-1)}$$

where, $p=\Sigma n_i$ and N denotes the numbner of years studied. To substantiate the kendal value, the critical value (t_c) was computed as:

$$t_c=0+t_g\sqrt{\frac{4N+10}{9N(N-1)}}$$

where t_g was obtained from a two-way student Table at the 5 percent significance level by using df= (N-1) = 42. The critical value was computed as t_c= 2.021. if I lies within the range of tc, then the series shows no significant thend and the randomness is dominant. if t>tc, there is a positive trend and when t<tc, there exists a negative trend. The test results showed that all series except winter of Tehrna show non-random characteristics; the winter temperature series of Tehran

show non random characteristic; the winter temperature series of Tehran shows a random characteristic through the study period.

Mann-Kendall graphical rank statistic is used first to distinguish any probable trend and second, to localize the change pioints in the series (Sneyers-1990). This test is based on the computation of all U (d_i) $1 \leqslant i \leqslant N$: of the series, and all U' (d'_i) ot the series:

$$d_i = \Sigma n_i \quad d_i' = \Sigma n_i$$

where, n_i is the sum of smsller ranks before x_i in an ascending order of the series; n_i' is the sum of smaller ranks before $x_{i'}$, provided numberint the members of the seris begins from the end. The sequential representation of all the U (d_i) provides the normal distribution curve, in which the null hypothesis states: stable climate is charaterized by a simple random series. And similarly, the sequential representation of all the U' ($d_{i'}$) proviedes the retrogard series curve. The intersection of two curves between the critical values at a= .05 significance level, localizes the beginning of the change (Demaree, 1990). In this case when $\left| U(d_i) \right| > 1.96$, the null hypothesis is rejected and there is a trend in the series. If U (d_i)> 0 there is a warning trend, and if U (d_i)< 0 there is decrease. If U (d_i) lies between ± 1.96, then it localized the point of abrupt change towards warminq U (d_i)>0) or cooling (U (d_i)> 0).

The results of the annual series is presented in Figurd 2 and all series are summerized in Table2. According to Figure 2 the annual temperature series show a warming trend only in Isfahan. The temperature of Tehran has been warmed since 1977 (Table 2). Tabriz and Bushehr do not show significant variations. Stations Tabriz, Tehran and Isfahan had.The Table 2. Results of Mann-Kendal test. In each column T, is Trend and C is abrupt change I, is incerasing and D is

decreasing; The following are the change of year.

Station	annual	spring	summer	fall	winter
Tabviz		CI 56	CI 61	CI 61	
Tehran	CI 77	CI 73	TI	CI 82	
Isfahan	CI 76	CI 69	CI 83	CI 84	
Bushehr		CD 78		CI 76	

abrupt warmint since 1956, 1973 and 1969 respectively, but in Bushehr temperatures became colder since 1973. Tehran showed warming trend in summer, whereas Tabriz had abrupt warming in 1961 and Isfahan warmed since 1983; there was no significant variations in Bushehr. Fall series showed increasing trend in central stations of Tehran and Isfahan, but abrupt warming in the North and South. Winter temperature series did not have any significant variation, and randomness was do minant. In other words, winters were relatively stable through out thd study period.

In general, as Table 2 shows abrupt change is the do minant characteristic of temperature series. Isfahan shows warming trend in fall which, in turn, has affected the annual series. Tehran shows warming trend in summer and full seasons. Not any trend was seen in the North or South. Also, the colder season series are very irregular and random.

Persistence

The Persistence of the series was teste by computing the serial and r_3 autocorrelation coefficients r_1, r_2 was for all series (Jagannathan and Parthasarathy, 1993). The critical value r_c calculated from:

$$r_c=\frac{-1\pm z\sqrt{N-2}}{N-1}$$

where; z, is the standard score of the desired level of significance in the normal distribution whch was considered at a= .05 in this study, N , is the total

number of the years.

The results are shown in Table 3. In time series, except winter, r_1 (correlation of one year lag) is postive, indicating that the mean values are relatively similar and low frequency oscillations have occured, but the negative valuse of winters indicate high frequency oscillations and the existence of randomness. When r_1 is greater than the critical r_c and r_2 and r_3 are greater thean r^2_1 and r^3_1, respectively. theres is a Markov linear persistence and hence, warming trend. Therefore, in Tehran only summer series show an increasing trend, and in Bushehr spring and summer seasons series show warming trend.

A mount of change

In order to assess the amount of change observed during the study period, the simple linear regression was comuted for the series with significant aburpt change or trend

(Table 4). The slope of change differs from $.023^c$ in Bushehr to. 04^c in summer series of Tehran. A ccordingly, the a mount of change during the study period varies from. 099^c in Bushehr to 1.72^c in Tehran. As a matter of fact, summers became warmer. Although winters did not show signifincant change or trend, but as a whole, weather has become relatively colder toward the end of the study period.

Table 3- Results of serial autocorrelations with lag times of 1,2,3 years.

station	lag number	snnual	spring	summer	fall	winter	r_c
Tabriz	1	.148	.06	.259	-.25	-.004	.275
	2	-.048	.11	.25	.15	-.1	
	3	-.11	-.09	.135	-.23	.14	
Tehran	1	.21	.13	.4	.19	-.06	
	2	.19	.17	.27	.21	-.04	
	3	.11	.13	.22	.08	.11	
Isfahan	1	.18	.41	.41	.266	-.009	
	2	.17	.06	.12	.33	.04	
	3	.25	.07	.16	.22	.12	
Bushehr	1	.26	.42	.54	.11	-.05	
	2	.16	.41	.45	.04	-.24	
	3	.27	.31	.38	.28	.1	

Table 4. regression Models of temperature change. t, is in C^0. t, is the amount of change during the peiod; y, is the ascending number of the year.

Discussion and Conclusions

The results of this study led to the following conclusions:

1- The colder season series show a stable condition with random fluctuations, although insignificantly and a trece of decrease is seen. This indicates that winter circulation system of the country i. e. the westerlies, have not changed significantly during the study period. Scillations are short with low amplitude indicationg the small amount of in terannual variability, which is the meterological characteristic of the westerlies. They assume different degress of zonal index and therefore bring

Table 4- regression Models of temperature change.

station	annual	spring	summer	fall	winter
Tabriz		t= 15.75+.0.25y Δt = 1.07	t= 23.3+.035y Δt = 1.5		
Tehran	t= 16.04+.0.024 Δt = 1.032	t= 20.9+.039y Δt = 1.67	t= 27.2+.04y Δt = 1.72	t= 10.9+.0338y Δt = 1.63	
Isfahan	t= 15.6+.0.23y Δt = .99	t= 20.12+..037y Δt = 1.6	t= 25.55+.0.35y Δt = 1.54	t= 9.79+.0.35y Δt = 1.5	
Bushehr		t= 27.4+.023y Δt = .99		t= 20.8+.023y Δt = .99	

different air masses to the area. On the other hand the urbanization effect is not an encouraging factor in winter, but in some cases due to smooth and surface high albedo, it lowers the amount of energy absorption and hence cools the at mosphere. It seems that the very trace decreasing trend is the result of urbanization.

-2 The other seasons, especially summer, have become warmer during the second half of the study period. During the warmer season, Iranis occupied by the A zores High which is a very stable and dominant system. This caused clear skys and intensive reaiation.

Under these circumstance, the urbanization process becomes a very important factor in climate warming. Despite the winter conditions, in this season Urban surfaces absorb much energy and get warmer. Therefore, the combination of high solar insolation through the clear skies and large a mount of surface radiation makes the weather very warmer. As a result, the ever expansion of urbanization, especially in Tehran, has caused the summer warming trend.

3- Temperature series were relatively stable in the northern and southeren stations. Because Iran is located in the transient region between temperate and tropical climatic realms; the southeren and northern parts of country more often experience weather systems from one climatic regim and show relatively a stable temperature regim; Wheresa, the central parts become under the influence of both regims frequently and therefore exhibit fluctuations.

4- Table 3 indicates warming trend of summer series in Tehran and Bushehr plus fall series of Bushehr. But the Mann-kendal U test confirms only summer series of Tehran.

Therfore, irrespective of this little discrepancy of the methods, there is no

dominant and widespread persistent warming trend in Iran. But on the other hand, the temper ature series show an incrieasing trend after the abrupt changing point This means that in most of the stations there is a warming trend durint the second half of the study period.

These findings indicate that there is not a do minant and widespresd warming trend in the countury and what is happening is a climatic fluctuation adn random variability. As a whole, the second half of the study period showed warming pattern.

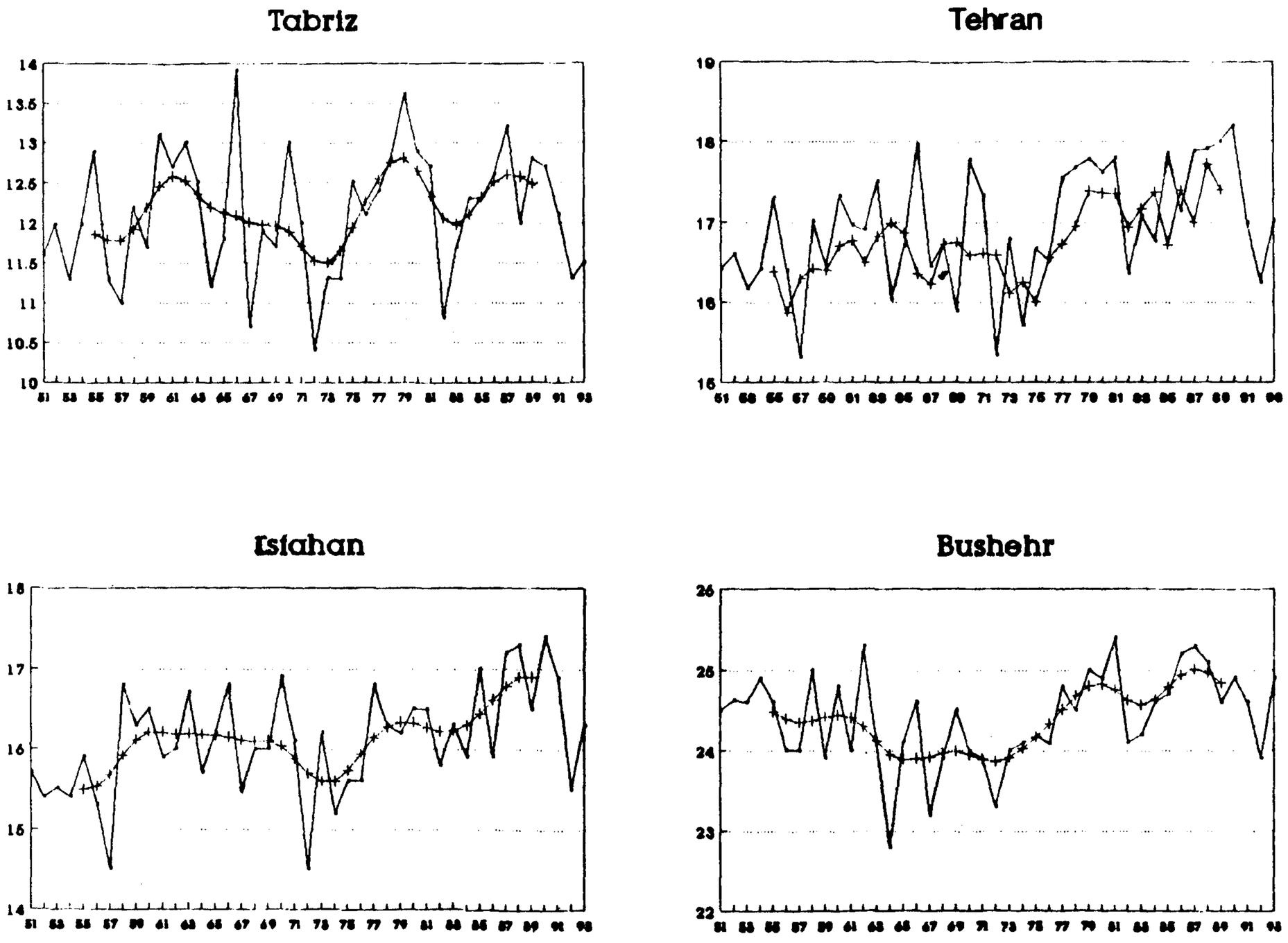

Figure1. Time series of annual mean temperatures in degrees celsius (smooth line) with 9-year running mean

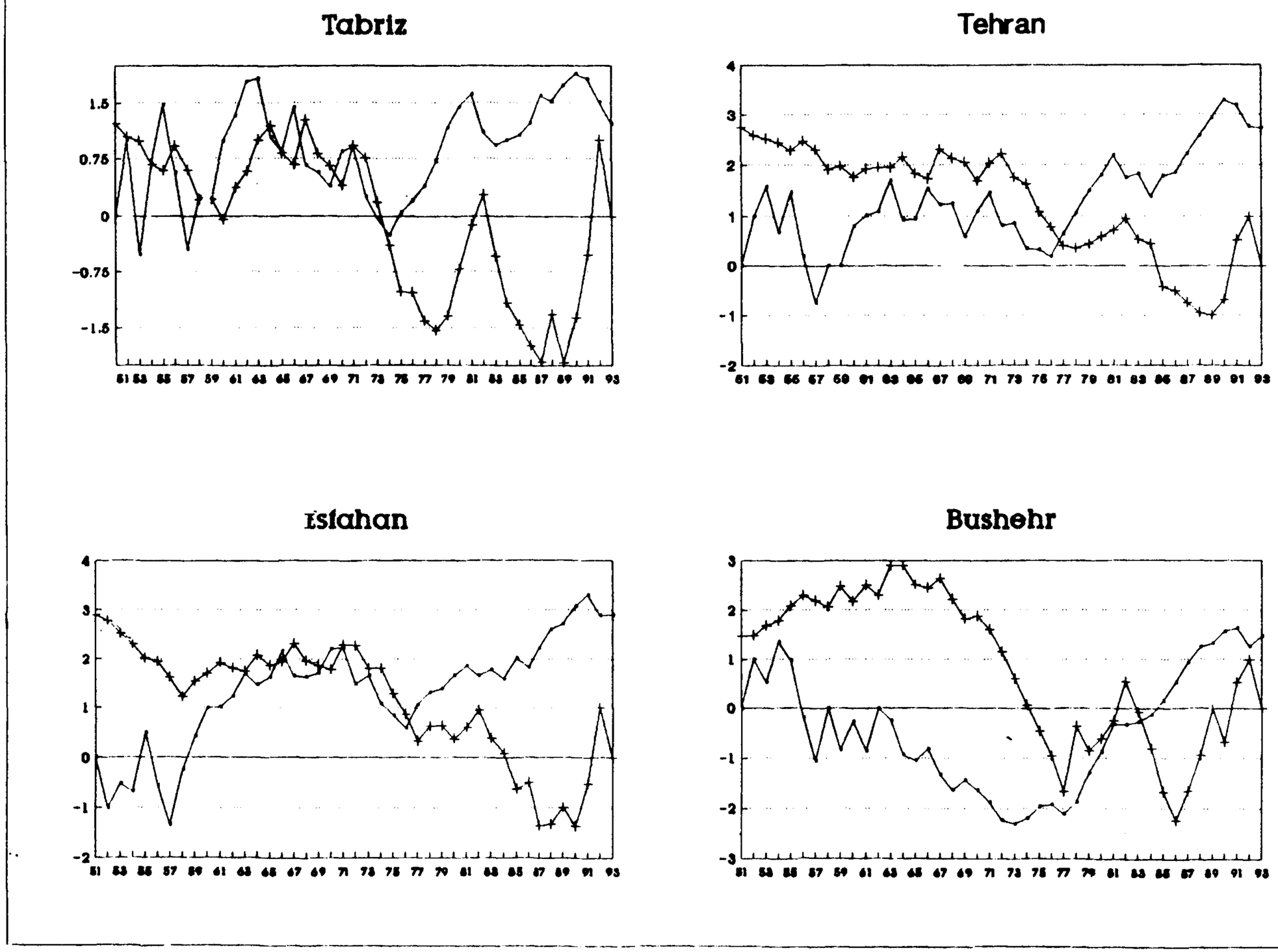

Figure 2. Sequential values of the statistics U (smooth line) and U' (marked line) for annual mean temperatures.

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