Bulletin of Environment, Pharmacology and Life Sciences
Bull. Env. Pharmacol. Life Sci., Vol 3 [6] May 2014: 260-264

Online ISSN 2277-1808
Journal's URL:http://www.bepls.com
CODEN: BEPLAD
Global Impact Factor 0.533
Universal Impact Factor 0.9804

ORIGINAL ARTICLE

Time-series analysis of temperature and relationship between atmospheric systems and recurring maximum temperatures-A case study of Isfahan city

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ABSTRACT

The environmental effect of temperature and the role in which the latter plays in micro-andmacro-models planning has attracted the attention of researchers. The aim of this paper is to study temperature variation for Isfahan during 1951–2005.The methodology involves using secondary data and descriptive statistics for data analysis and interpretation. Results show long-term oscillations of average temperature during the54-year, which peaked after1997 and temperature variability started to decrease after that period. The temperature data is shown to fit well with a quadratic curve, rather than a linear graph. Smoothed index of the curve shows increased in average temperature and the maximum and minimum temperature fluctuations occurring in fall and summer, respectively. The cumulative curves represent the normalized residual increase in average temperature from 1997 onwards. Analysis of daily maximum absolute temperature during hottest days in the analyzed period show above 40 °C in July. Analysis of synoptic surface maps and middle atmosphere level show that synchronous low and high pressure systems originating from North Africa and the north Latitude is the underlying cause of recurring hot days in Isfahan City.

***Key words**: Temperature variability, Isfahan, linear graph, smoothed index, seasonal changes.*

Received 11.02.2014 Revised 09.03.2014 Accepted 11.04. 2014

INTRODUCTION

The socio–economic and environmental effects of global warming exist because of certain fundamental issues such as climate change and extensive research has been conducted on global, regional, and local scales in this field. These previous studies indicate that there has been an average global temperature increase of 0.15 ± 0.45 °C over the past hundred years, and there has been an obvious increasing trend in the first decade of the twentieth century. Daily changes in air quality, air pollution standard index shows that this comparison is the range of urban air pollution in cities provides. Ecologists believe that long-term fluctuations in the average air temperature affect sensitive ecological systems, even if the fluctuations do not exceed 0.2–0.1 °C. Air quality standards for acceptable levels of pollutants in a certain set period of time and is produced in different countries with different methods [1,2].Although the range of annual and seasonal fluctuations is larger; it does not significantly affect the ecosystem. The process by which the ecosystem is balanced and protected against short-term effects of severe weather has been studied [3].Leite andPeixoto[4]application of autoregressive models in temperature changes using the longest time series have been.They study show that there are values of considerable variability in the annual and decade scales.Turkes et al [5] has mentioned in 1995 that the analyses show some noticeable variations and significant trends in the long term annual mean temperatures. In addition, research on the modeling of the mean annual air temperature [6] and a model used for estimating monthly and future trends in temperature [7] has been conducted.In their study, air temperature, an index of the density of heat and severity of climate and weather indicators in each geographical region has been considered. It has been found that the irregular solar energy received by the earth causes an instantaneous change in temperature and other meteorology parameters. In the few hours after sunrise, the heat energy received by consumers is directly related to the maximum temperature reached in the afternoon [8]. This paper seeks to determine whether there are notable trends in the temperature of Isfahan city over a period of several years. In order to achieve this goal, time series analysis of mean temperature data (54years) will be done and some patterns of variations will be tried to be determined.

MATERIALS AND METHODS

In this research the daily temperature data of Isfahan city from 1951 to 2005 recorded for analysis of temperature time series and determine of primary and secondary indicators [9] .To determine the prevailing weather systems during the hottest days of the year, the maximum temperatures attained at the meteorological stations KHoor, SHahreza, Kashan, Natanz, Ardestan, Daran, Naien, Golpayegan, Kabootarabad and the airport of Isfahan were studied. Isfahan station is located at a latitude of 32 °37' North and longitude of 51 ° 40' and at an altitude of 1550 meter from sea level, in south of Isfahan city.

For the preliminary analysis, the time series of temperature at Isfahan was organized in Excel software. The primary indicators including raw and smoothed indices (systematic variations reflecting in the views), the moving average index (a measure of the mean of the repeated observations, which reflected long-term fluctuations), and the variability index were calculated .which variability index is reflected in changes pattern from year to year and from the main observations divided by the moving average values in each year were calculated and expressed as percentages.

The time series was determined by a sequence of observations conducted frequently in equal intervals each having four components: process, periodic, seasonal, and irregular. The process is, long-term changes or the natural process of time series in long-term. The net effect of the periodic component measure that it tends to vary with time. On the other hand, the seasonal component occurs regularly over the course of a one-year period. However, the random (irregular) component does not have a predictable frequency of occurrence. So after the primary indices calculation, secondary components were derived from the original data. To calculate the seasonal indices for differentiation between seasons, April, May, and June were considered as the spring season; July, August, and September were considered to be summer; October, November, and December were considered to be the fall season; and January, February, and March were considered to be winter. The component model was employed to calculate the following product:

$$Y = T \times C \times S \times I \qquad (1)$$

Here Y represents the index time seriesandT, C, S, and I represent process, periodic, seasonal, and irregular components, respectively. Using Equations (2) to (4), the values of the least squares method were calculated as follows:

$$Y = a + bX \qquad (2)$$

$$b = \frac{n\sum x_i \sum y_i - \sum xi \sum y_i}{n\sum x_i^2 - (\sum x_i)^2} \qquad (3)$$

$$a = \overline{y} - b\overline{x} \qquad (4)$$

The periodic component is defined as alternating increases and decreases in a period. Each cycle has a different length and intensity. We noted a reduction in the time series with different cycle lengths and severity of temperature changes. In order to extract the cyclical component, the observations were analyzed without the seasonal component. Therefore, Equation (5), which is a general equation for this case, is given as

$$y_i = T \times C \times I \qquad (5)$$

If the process component is removed, the remaining equation, which is a product of the cyclic component and the random component,can be presented as a percentage.

$$\times I = \frac{Y_I}{T} = \frac{T \times C \times I}{T} \text{C} \qquad (6)$$

Similarly, the seasonal component can be obtained by eliminating the random component in the averaging method (Equation 7).In Table2,the first column represents the average seasonal of temperature, the second column gives the quarters moving average, the third column shows the central moving average and the last column represents the seasonal component multiplied by the random component.

$$S \times I = \frac{Yt}{T \times C} = \frac{T \times C \times S \times I}{T \times C} \qquad (7)$$

Results and Discussion

The statistical profile of the mean annual temperature is described in Table1. A comparison of the mean annual temperature curve to a normalized curve shows that the data distribution is close to normal (Figure 1). The data indicated on the bisector of the first quarter is normally distributed (Figure 2).

Table 1: Statistical profile of the mean annual temperature for the period 1951–2005

Elongation	Tilt	Domain	Diffraction	Minimize	Max	Average	Number
0.005	−0.376	4.2	0.746	21.1	25.3	23.41	55
0.634	0.322	-	0.836	-	-	0.116	**Error**

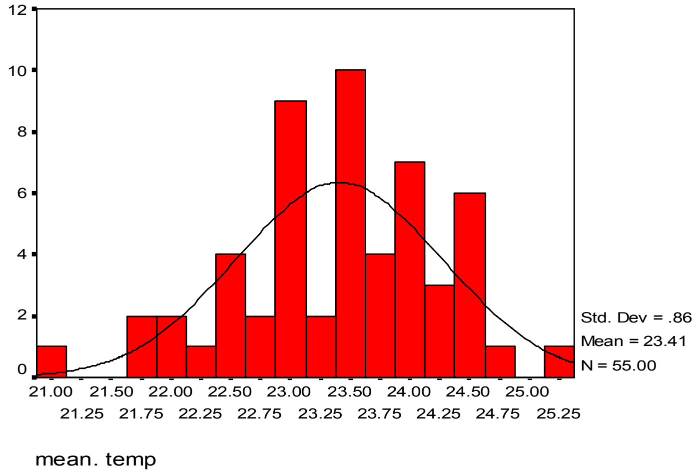

Fig1: Mean annual temperature curve compared with normalized curve

Table 2: How to calculate the moving average component and the variability of the Temperature

Component of variability	Observations for the average 5-year average	Total hits for average 5-year	The annual average temperature	year
-	-	-	24.3	1951
-	-	-	24	1952
99	24. 4	120.2	23.8	1953
98	23.98	119.9	23. 5	1954
104.15	23.62	118.1	24. 6	1955
				...
100.41	24.5	122.5	24.6	1999
99.11	24.7	123.6	24.5	2000
102.35	24.72	123.6	25.3	2001
100.41	24.6	123	24.7	2002
99.59	24.6	123	24.5	2003

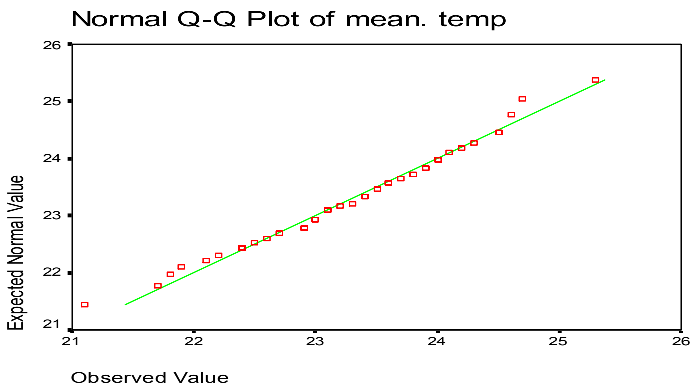

Fig 2: Distribution of data

Table 2 shows that the maximum absolute temperature above 40 °C occurred for 94 days: these included 14 days in 1997, 20 days in 2003, 15 days in 2001, and 12 days in 2005. The hottest days occurred in July. Figure 3 shows the prevailing weather systems at ground level during the hottest days of July in 2005. It is noted that the central heating system and low pressure originated from the Indian Ocean. The map covers the countries of India, Pakistan, and a part of Afghanistan, Iran, and Saudi Arabia. Figure 4 shows the weather systems for the same time period at the level of the middle atmosphere. The cell next to the tropical high pressure cell spans 5950 Geopotential meters with the central value of the tabs on North Africa, Iran Afghanistan, apartofPakistan, and China. Next to the tropical high pressure cell is the dominance of concurrent middle level atmospheric pressure and low temperature of the warmest days in the southern Indian Ocean to the East to the center–south of Iran. The findings [5] also show that variations and significant trends in the long term annual mean temperatures.

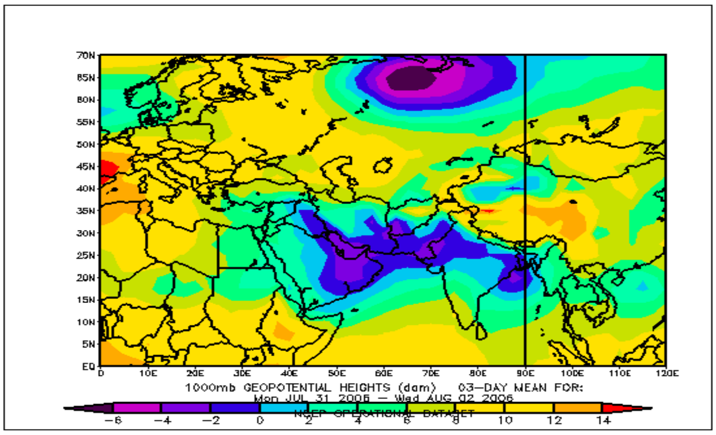

Fig 3: Map synoptic ground level from July 31, 2005 to August 14,2005

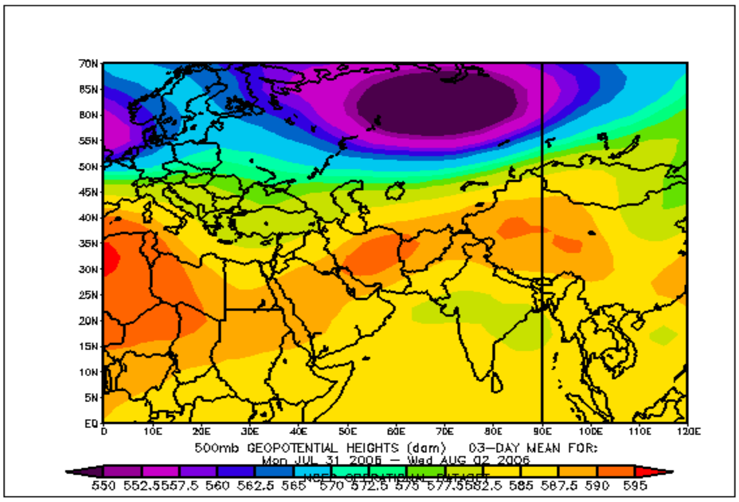

Fig 4: Map of synoptic middle atmospheric level from 31 Julyto 14August2005

CONCLUSION

The results of this study show that the average temperature over the 54-year period was 23.2 °C.The lowest annual average temperature 21.1 °C in 1973 and the highest annual average temperature 25.4 °C in 2002 were recorded in other years, and fluctuated periodically around the long-term mean. However, the degree of temperature variability decreased after 1997. The smoothed index showed an average temperature increase of 2 degrees. The variation in the data was not linear, but fitted well with a quadratic curve. Seasonal changes in the index indicated amplitudes of fluctuations in summer (with temperatures between 37 and 33 °C), spring (between 33 and 5.25 °C), fall (between 15 and 33 °C), and winter (between 15 °C and 8 °C). The lowest temperature fluctuations were observed in summer and the highest fluctuations were observed in autumn. The cumulative curves represented the normalized residual increase in the average temperature from 1997 onwards. During this period, the average temperature was above the normal line in 21 cases and was below the normal line in 34 cases.

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