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The Changes of Precipitation Frequency Distribution in Iran

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Abstract:

In this study, annual precipitation of 232 synoptic and climatology stations of Iran during 1961 to 2003 has been analyzed. The precipitation was mapped based on Kriging method. Then a gamma distribution function was employed for every map's pixel. Finally, the shape and scale parameters of distribution were analyzed and explained.

Since 1961, three phases of precipitation have occurred in Iran. The first phase took place during 1961 to 1967 with high asymmetry of precipitation distribution in some places and low scale parameters almost all over the country. The second phase happened in 1968 and continued to 1986; this phase is characterized by its high frequency of precipitation of extreme aridity and humidity in the mid-areas of the country extending from West to East. The third phase started in 1986. At this time, the rain fall occurred around the long-term average, but the range was lower compared to the previous phase. In this phase, the shape and scale parameters even in the moist parts of the country had remarkably changed.

Key words: Precipitation, Distribution

Introduction

In many studies of climate change, it is often assumed that only the mean (or so called "location" in an asymmetric distribution) would change, while the shape of distribution remains unchanged. It is extremely important to know that frequency ofclimate variable would be changed with changing the mean.

It was shown, however, by Mearn et.al(1984), Katz(1991) and Katz and Brown (1992) , that the relative frequency of events depends to changes in the standard deviation. In other word, a change in a climate variable that possibly skewed in shape will also result in a change in shape of distribution.

As it is clear, the idea of using probability distribution could be a good way to evaluate climate change. In the present study, the frequency distribution of precipitation will be analyzed all over Iran to identify its temporal-spatial changes.

Methodology

Generally total precipitation may show a variety of shapes, from an exponential to a positively skewed, or close to normal distribution shape in arid regions. Variability of precipitation is high with low amount of annual precipitation in some years and high in others. The frequency distribution of annual rainfall in arid regions will thus present an asymmetric shape with a long tail to the right.

The Gamma distribution provides a reasonably good fit to precipitation data. It has been widely used by many experts (Vinnikov et. al 1990; Wilks and Eggleston 1992; Juras 1994, Ropolewsi and Halpert 1996). The Gamma parameters even can be obtained from even relatively short- term records. The probability density function for distribution can be presented by the following equation:

$$f(x) = \frac{b^{a}}{\Gamma(a)} x^{a-1} e^{-Bx}$$

Where x – the random variable, i.e precipitation over interested period a - the shape parameter of the distribution expressing the extend of the symmetry around the mode. b - The reciprocal of the scale parameter of the distribution in above equation. It scales the precipitation amounts at respective frequencies and shows the distribution of extreme events (see fig 1). $\Gamma(a)$ -is the Gamma function, which is defined as:

$$\Gamma(a) = \int_{0}^{\aleph} y^{a-1} e^{-y} dy \qquad ; a > 0$$

According to Wilks (1990), the parameters of Gamma distribution function can be estimated by method of moments as follow:

$$a = \frac{s^{2}}{\bar{x}}$$

$$b = \frac{\bar{x}^{2}}{s^{2}}$$

Where s is standard deviation and $\bar{x}$ is average of variable. If the Gamma function is fitted properly to a variable, a *and* b are perfect shape and scale parameters respectively.

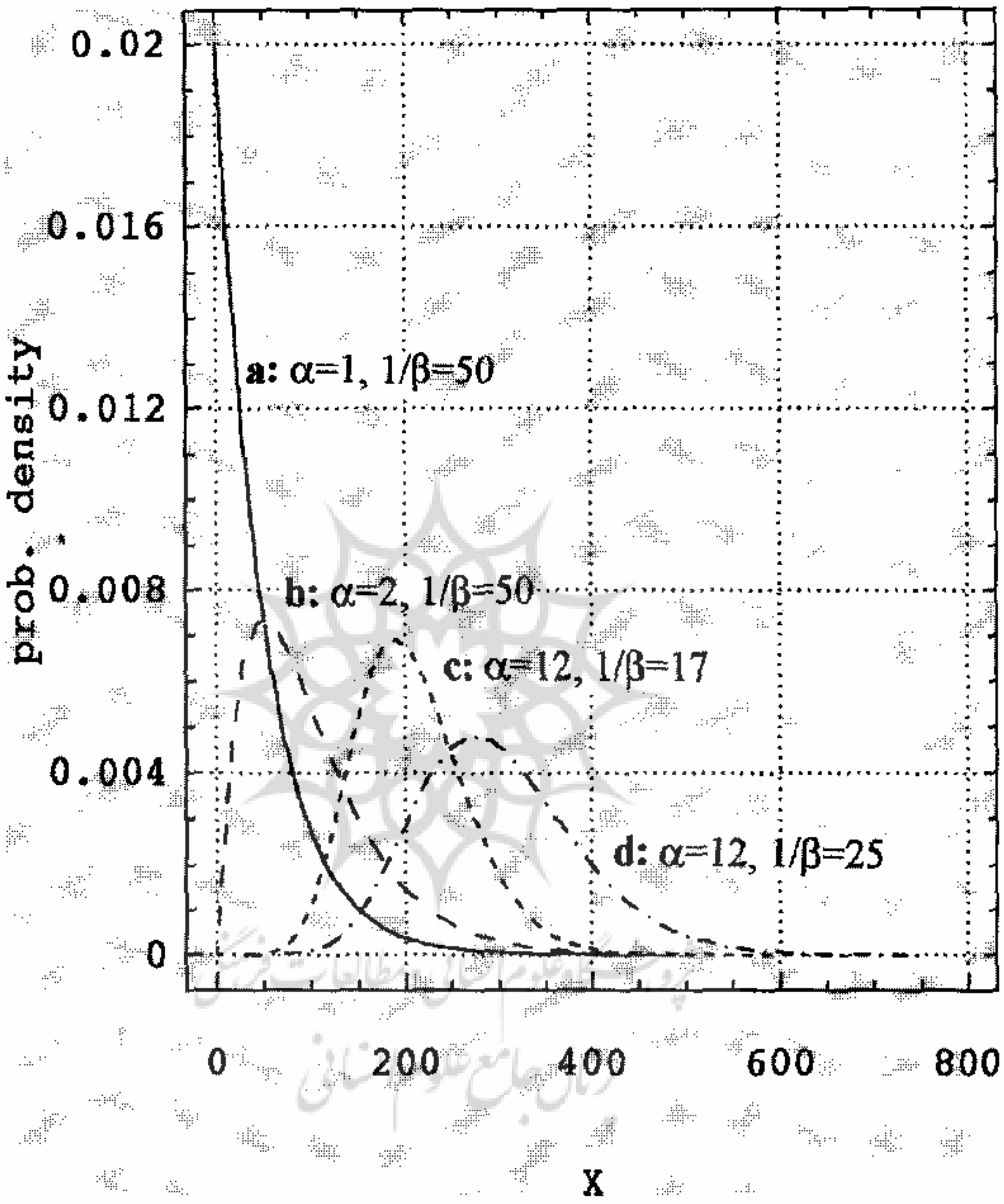

Fig1: Gamma distribution probability density. A: $\alpha=1,1/\beta=50$, b: $\alpha=2,1/\beta=50$ c: $\alpha=12,1/\beta=17$;d: $\alpha=12,1/\beta=25$

Data Base

The database of the present study consists of monthly precipitation values at 232 synoptic and climatology stations from Islamic Republic of Iran Meteorological Organization (IRIMO) network for all over Iran mainland during 1961 to 2003(43 years).

The station choice was based on the desire to have a widespread and availability of data. These stations are presented in Fig 1. They have collected 92940 data points of monthly precipitation over 43 years. After the data had been filed in a Surfer /Win worksheet, monthly precipitation maps were prepared in order to establish annual maps based on straightforward algebraic averaging for all the maps. The maps have delineated based on Kriging technique and by 14×14 KM pixel size as Masoodian (2003) had offered. The Gamma distribution fitted to all pixels was provided. The goodness of fit has proved by Kolmogorov – Smirnov test for most of the pixels.

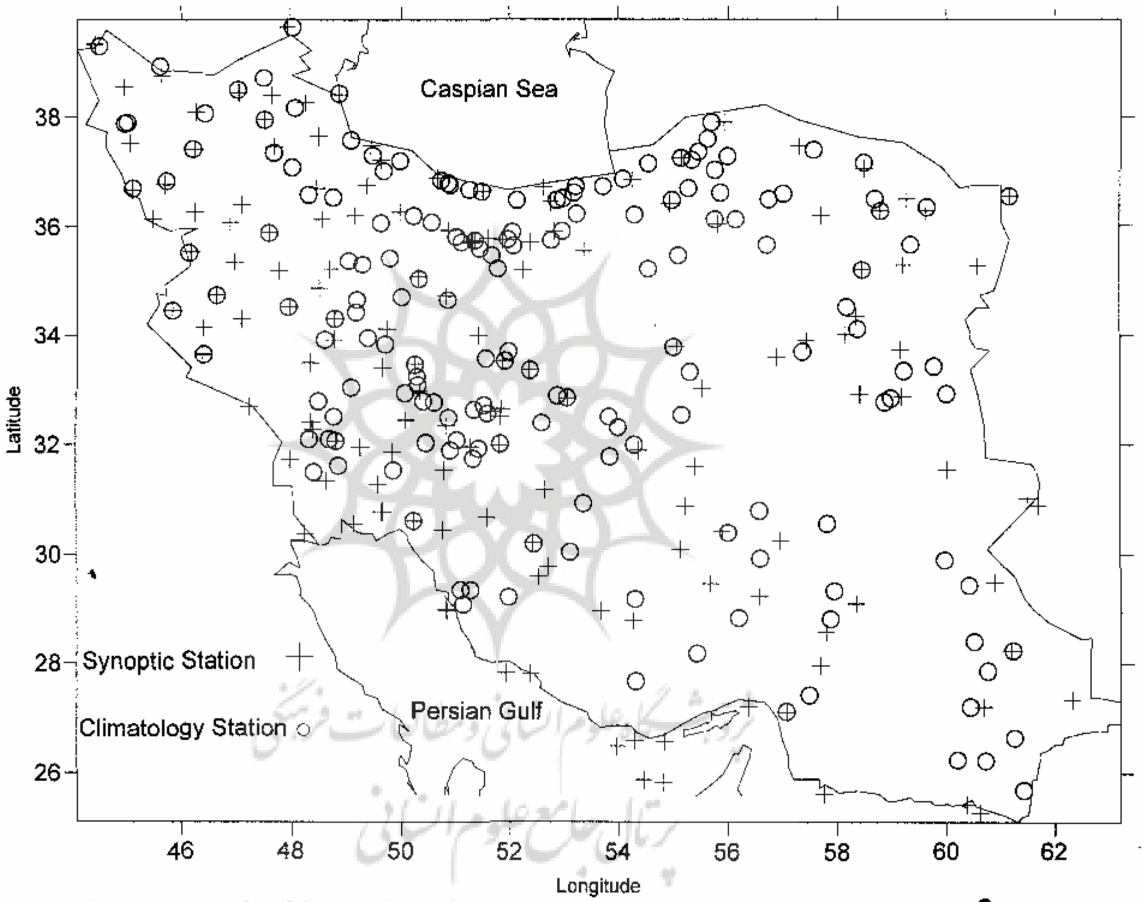

Fig 2: Network of Synoptic and Climatology stations over considered area S

Results

Annual precipitation of Iran is shown in Fig 3 in order to identify the annual precipitation phases. This precipitation amounts have been calculated from the precipitation maps of Iran. As it is presented, there are three phases since 1961 in precipitation of Iran. The first phase covers 1961 to 1967 that shows a fluctuation below total average. The second phase characterized by high range of precipitation around long-term average started in 1968 and lasted to 1986. The third phase has begun since 1986 around long –term average with a lower range in comparison with the previous phase.

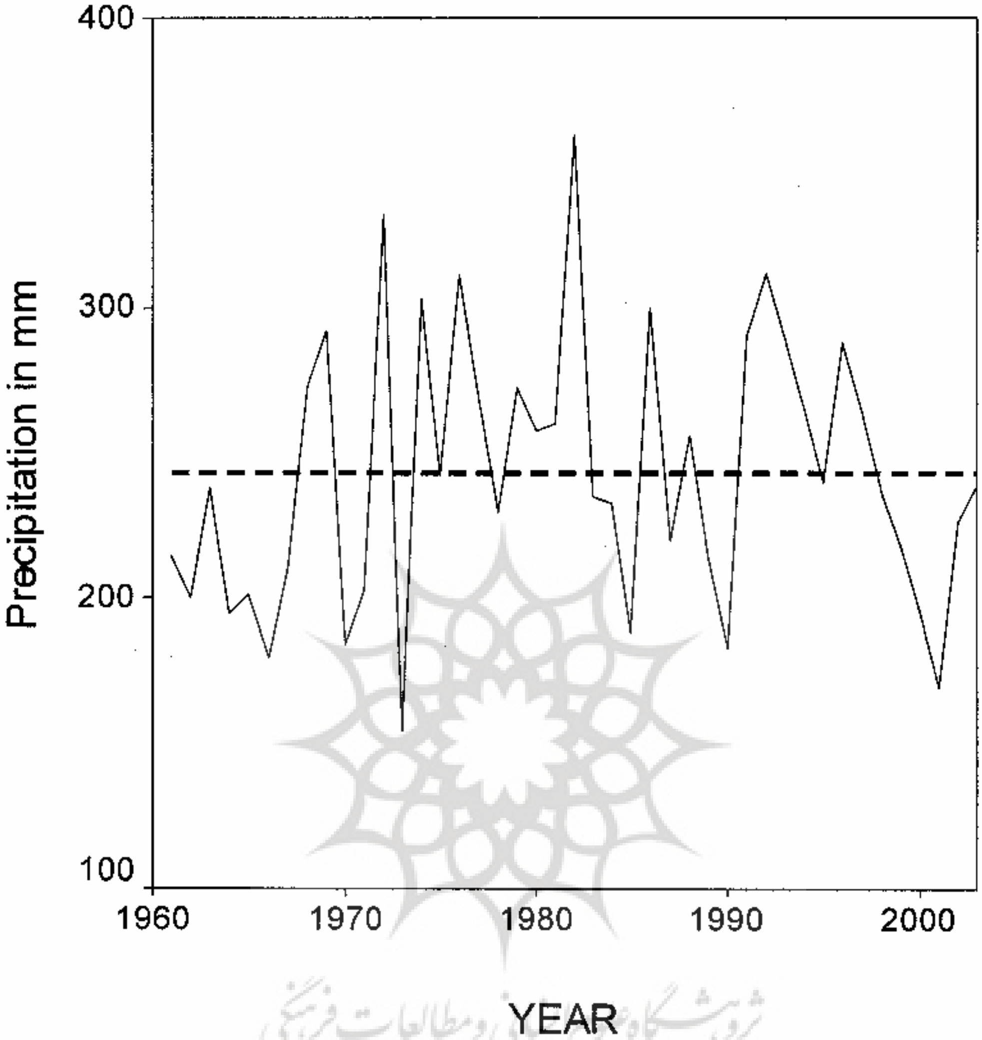

fig.3: Time series of annual precipitation of Iran during 1961-2003

Based on this information, it is possible to provide three maps containing shape and scale of precipitation for these three phases. The spatial distributions of the shape and scale parameter of the Gamma distribution for the three consecutive periods are presented in Figs 4 to 6.

The changes in asymmetry of the distribution occurred in all three phases more or less. The first period shows a high shape parameter (fig 4 A) in the northwest, southeast of Caspian Sea and it is increased in the east of the country. It refers to extending asymmetry of precipitation distribution in those places. The lowering scale parameters almost all over the country during this period (fig4 B) refer to not covering events with extreme precipitation amounts (see fig 3). As it can be seen, the highest scale parameter took place where the high shape parameters happened. It can be expressed because of the lowering precipitation during this phase.

In

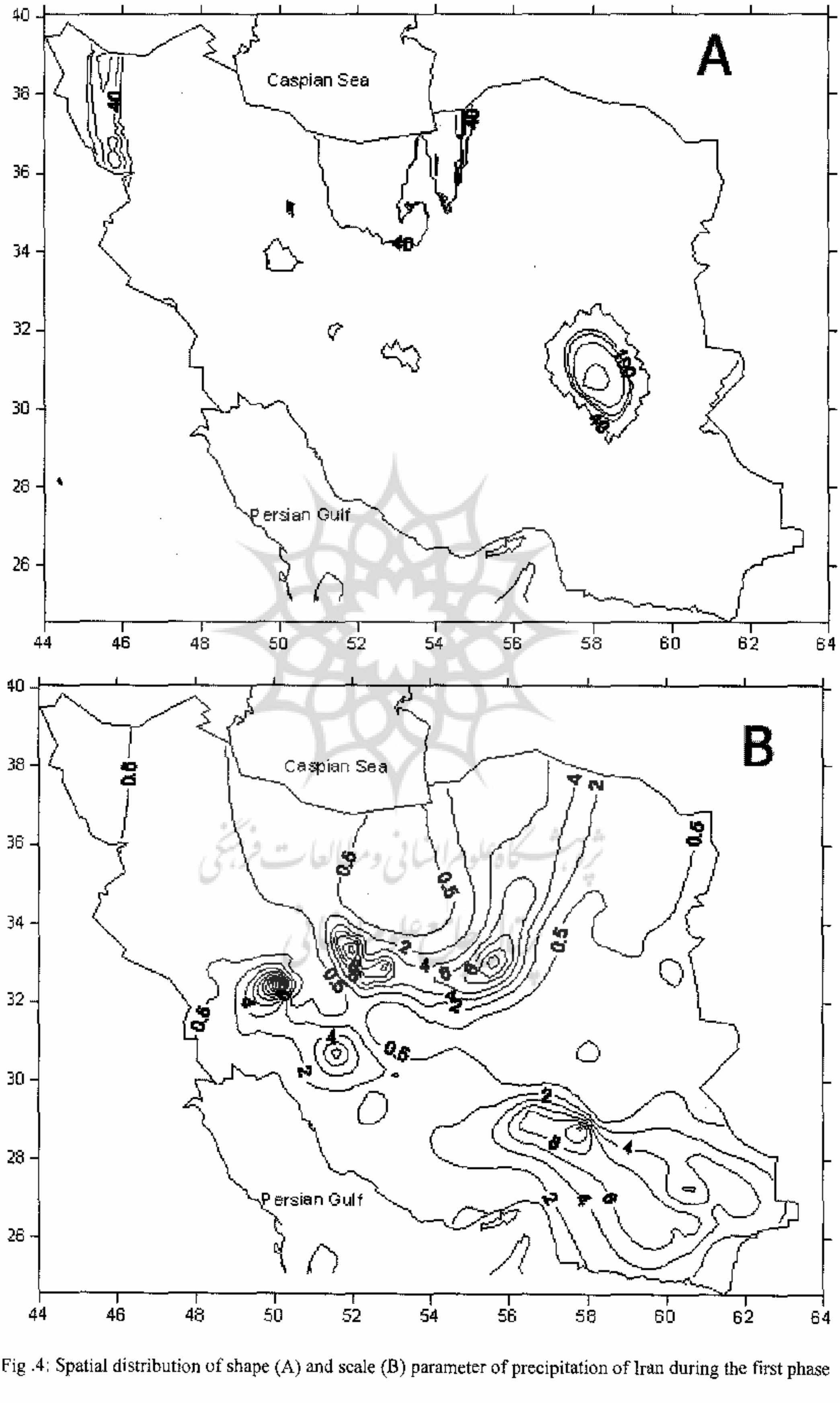

Fig .4: Spatial distribution of shape (A) and scale (B) parameter of precipitation of Iran during the first phase spite of the increase of precipitation during the second period, it is characterized by a positive in the shape parameter and a shift toward the east in northern part of country and to the west in eastern parts. Another characteristic is the rising of the shape parameter in southwest (Fig5A). There is a decrease in b value (so a decrease in scale parameter) which implies the high fluctuation in those places shown in Fig 5. This is a sign of increasing in extreme dry-wet spells frequency in the middle of Iran. It happened across west to east.

The third period characterized by the elevation in positive parameter that happens even in northern part of Iran where the moist part of the country is located. However, the dry part of Iran in east shifted its scale toward the west. Also southwest of Iran experienced a big scale parameter.

Conclusion

The stochastic methods have been widely employed to describe climate change characters. One of the most important methods is fitting a probability density function to climatic variable and explaining its parameters. In the present study, the Gamma distribution has been utilized to describe frequency distribution change of precipitation of Iran through interpretation of shape and scale parameters.

Based on Annual precipitation all over Iran three precipitation phases have been detected. The first phase happened during 1961 to 1967 with high shape parameter and extending asymmetry of precipitation distribution in some places and lowering scale parameters almost all over the country. The second phase happened in 1968 and continued to 1986. It shows an increase in extreme dry-wet spells frequency in the middle of Iran west to east. The third phase has started since 1986 around long –term average with a lower range in comparison with the previous phase.

The third period is characterized by the elevation in shape parameter that happens even in moist parts of the country and the decrease of the scale parameter.

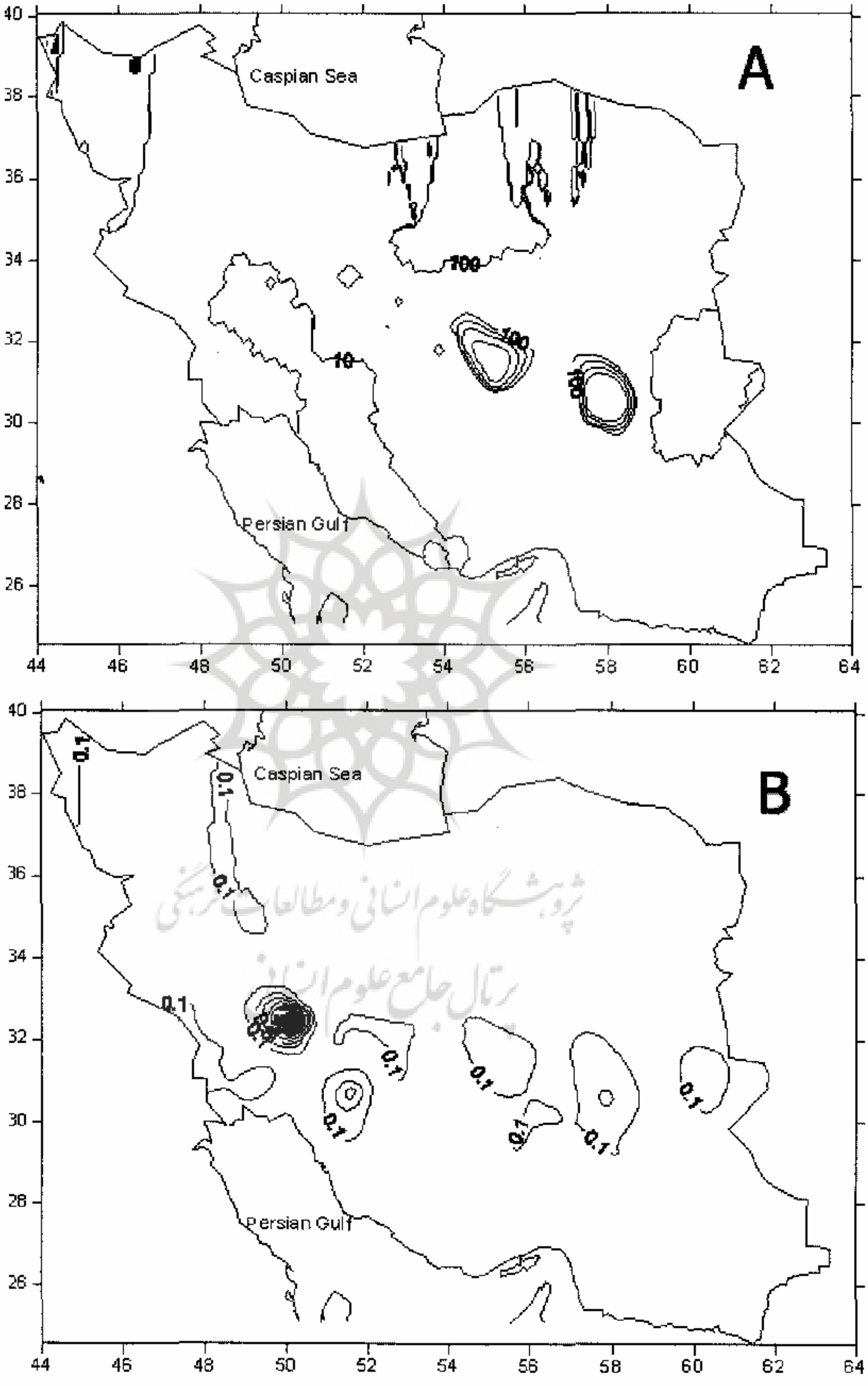

Fig .5: Spatial distribution of shape (A) and scale (B) parameter of precipitation of Iran during the second phase

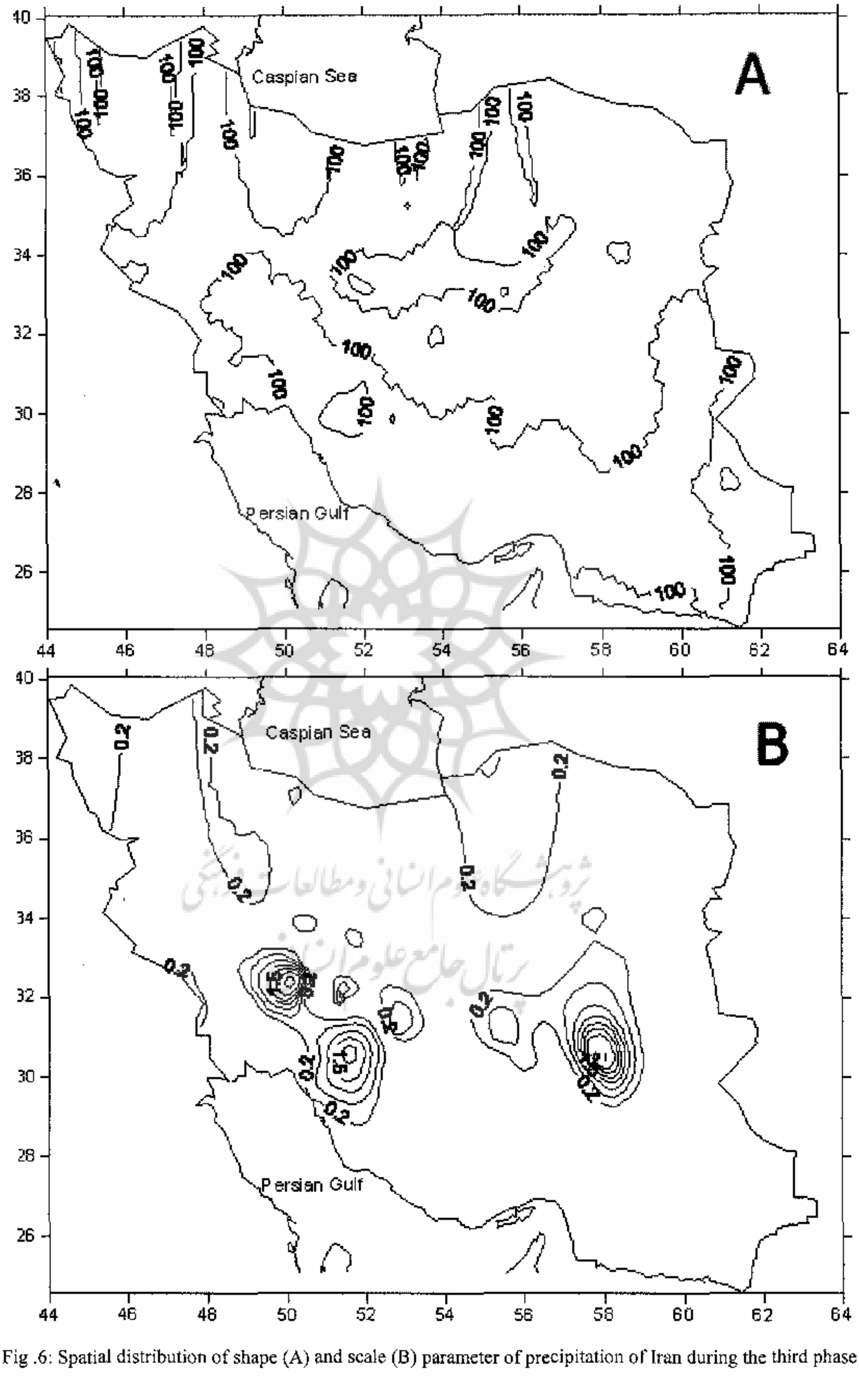

Fig .6: Spatial distribution of shape (A) and scale (B) parameter of precipitation of Iran during the third phase

Reference

1-Juras, J., 1994: Some Common Features of Probability Distributions for Precipitation. Theor.Appl.Climatol.,49,69-76.

2-Katz, R.W., 1991: Towards a Statistical Paradigm for Climate Change. 7th Conference on Applied Climatology, American Meteorological Society, Boston.

3-Katz, R.W.,Brown,B.G.,1992:Extreme Events in a Changing Climate : Variability is More Important than Averages .Climate Change ,21(3),289-302

4-Masoodian,Abolfazl(2003): On Precipitation Mapping in Iran, EGS-AGU-EUG joint Assembly,Nice,France, 6-11 April 2003. Available on www.ui.ac.ir/red/RCGSSS

5-Mearns, L.O., Katz,R.W., Schneider,S.H., 1984: Extreme High- Temperature Events: Changes in Their Probabilities With Changes in Mean Temperature. J.climate Appl.Meteor., 23, 1601-1613

6-Ropelewski,C.F.,Halpert,M.C.,1996:Quantifying Southern Oscillation- Precipitation Relationships.J.Climate,9,1043-1059

7-Vinnikov, K.Ya., Groisman, P.Ya., Lugina, K.M., 1990: Empirical Data on Contemporary Global Climate Changes (Temperature and Precipitation) . J. Climate. 3, 662-677

8-Wilks, D.S., 1990: Maximum Likelihood Estimation for Gamma Distribution Using Data Containing Zeros. J. Climate, 3, 1495-1501

9- Wilks, D.S., Eggleston, K.L., 1992 : Estimating Monthly and Seasonal Precipitation Distributions Using the 30-and 90-Day Outlooks . J. Climate, 5(3), 252-259