PREDICTION OF SEASONAL AND ANNUAL PRECIPITATION BY USING GEOGRAPHICAL INDICES

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ABSTRACT. – Prediction of seasonal and annual precipitation by using geographical indices. In this study, the daily precipitation observations of 428 weather stations across Iran were used. Statistic period of 40 years (1965-2004) was chosen. We used Kriging interpolation method to map of average daily precipitation with spatial resolution of 15kmx15km. As a result, mean monthly and seasonal precipitation were produced for more than 8000 point over Iran. The maps were plotted based on the Global Positioning System (GPS). The run-test was carried out to check validity and uniformity of the precipitation data. In this study, the effect of geographical factors (altitude, latitude, longitude) affecting the precipitation regime was verified. It is shown that that precipitation regime in northern sites are more exposed to local factors and seasonal precipitation than those of southern sites. Seasonal and annual regression equations are also presented. The results of this research can be applied in land–use, environmental plans projects and water resources management in case of lack or shortage of data and the places which rainfall data are not available.

Keywords: Precipitation regime, Prediction,Three-variable regression, Iran.

1. INTRODUCTION

Temporal-spatial variations of precipitation over different geographical areas have various effects on management and planning of water resources across a water basin and in a national scale. Precipitation as a very variable element and as a major element in water balance relations has been always of interest for climatologists and hydrologists. Assessment of precipitation regime has always been of interest for researchers and numerous works have been conducted in this subject in Iran and around the world.

Stafford et al. (2000) determined the 50 years trends of temperature and precipitation and showed that summer precipitation in most stations has increased. Romos (2001) analyzed distribution patterns of precipitation and its changes in Mediterranean regions and concluded that arid and hyper arid years were not reported over the period of study and most years were categorized as normal arid or normal humid years. Tarawneh, and Kadoglu (2003) studied the precipitation season in Jordan. They used harmony analysis methods and concluded that 90 percent of variability are appeared in the first and second harmonics.

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Bodri et al. (2005) studied the precipitation changes trend in Czech Republic from 1994 to 2001. They determined the variability of precipitation between two individual periods using the absolute difference method. The results revealed a total increase of precipitation variability over the study area. Tosic et al. (2005) studied Belgrade's precipitation time series and it showed that Belgrade's precipitation is under the influence of the Northern Atlantic Oscillation in winter, but during spring it is influenced by the oscillation of the Southern Atlantic. Qian and Lin (2005) analyzed the regional trend of precipitation indices in China. They observed a decreasing trend in the annual precipitation from the southern part of the north-east of China to the lower half of the Yellow River Valley and Yangtze River Valley.

Odekunle (2006) determined the begining and end of the precipitation season in Nigeria with the emphasis on the quantity and number of rainy days and found out that the number of rainy days gets more realistic dates for the beginning and ending of precipitation. Karagianndis et al. (2008) analyzed some characteristics of European countries rainfall. Using the harmonic analysis, they showed that the sum of the first and second harmonics describes the annual average of precipitation regime. Ashabokov et al. (2008) studied precipitation regime changes in Russia. The results showed that a noticeable increase in the intensity of the winter precipitation in the flat region is seen.

Asakereh (2008) studied annual precipitation of 232 synoptic and climatology stations of Iran during 1961 to 2003. He found that the statistical characteristics of precipitation have remarkably changed during 1986 to 2003.

Many other researchers have conducted such investigations. To avoid lengthy paper, the details are not described here. This research is aimed to determine the spatial factors influencing the precipitation regime in various regions of Iran using different harmonic analysis, Fourier and three-variable regression in the past 40 years.

2. MATERIALS AND METHODS

2.1 Data and Methods

Iran lays on the northern hemisphere between 25^0 about to $40^{0\prime}$N latitudes and between 44^0 to 63.5^0 eastern longitudes. The geographical location of Iran shows that the majority of the country is located in the sub-tropical arid region. Figure (1) illustrates the location of Iran in the world.

The geographical distribution of mean annual precipitation during the period of study (1965-2005) over the country is also illustared in Figure 2. In this study, the daily precipitation observations of 428 weather stations across Iran were used. Statistic period of 40 years (1965-2004) was chosen. We used Kriging interpolation method to maps of average daily precipitation with spatial resolution of 15km x 15 km. As a result, mean monthly and seasonal precipitation were produced for more than 8000 point over Iran. The maps were plotted based on the Global Positioning

System (GPS). The run-test was carried out to check validity and uniformity of the precipitation data.

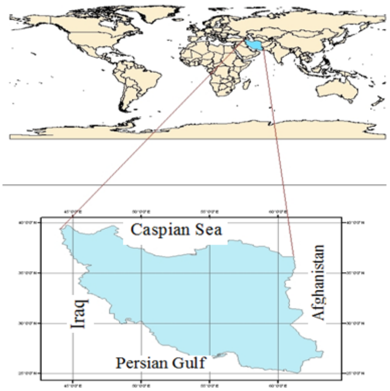

Fig. 1 ***Geographical location of Iran***

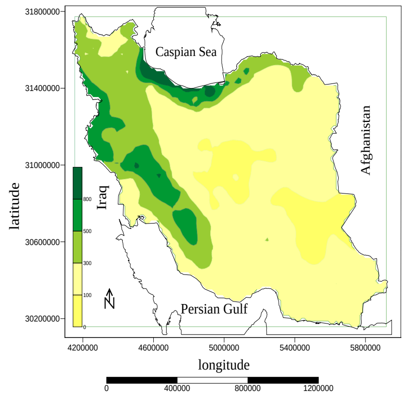

Fig. 2 ***Mean annual precipitation over Iran*** **(1965-2004)**

The annual range of precipitation in Iran is 1657 mm which shows its large variability compared to the annual mean of 253 mm. The statistical details of annual and seasonal precipitation are shown in Table 1.

Table 1. ***Seasonal and annual statistics of precipitation over Iran***

Precipitation	Min (mm)	Max (mm)	Range (mm)	Avg (mm)	SD (mm)	V	CV
Winter	27	456	428.6	115.7	72.5	5252	0.6
Spring	13.5	319	305	73	50	2552	0.7
Summer	0	321	321	11.5	25.8	665	2.2
Autumn	4.5	267	763	53.4	61	3738	1.1
Annual	47	1704	1657	253	178	31859	0.7

Avg: Average SD: Standard Deviation V: Variance CV: Coefficient of Variation

To characterize the effects of geographical factors affecting the precipitation regime, the standard correlation and three-variable regression approach were employed (Eqs. 1-3). These equations show the relationship between precipitation and geographical factors (longitude, latitude, and altitude).

$$r_{xy} = \frac{\sum (X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{(X_i - \bar{X})^2}\sqrt{(Y_i - \bar{Y})^2}} \quad (1)$$

$$r_{xy.z} = \frac{r_{xy} - r_{xz} r_{yz}}{\sqrt{1 - r_{xz}^2}\sqrt{1 - r_{yz}^2}} \quad (2)$$

$$\hat{y} = a + b_1 X_1 + b_2 X_2 + b_3 X_3 \quad (3)$$

Where, (r) is the correlation coefficient between independent variable (X) and dependent variable (Y).

3. RESULTS AND DISCUSSION

The standard correlation, regression equations and three-variable correlation coefficients with geographical factors were calculated for the annual and seasonal precipitations (Table 2). The presented regression equations show the linear relationship between P and the geographical factors at each study sites.

As seen in Table 2, the highest correlation coefficient (r) belongs to the longitude (λ). This shows that the longitude has an important role in the variation of the annual precipitation. The negative sign of the correlation coefficient means the higher the longitude the lower the precipitation (i.e. precipitation decreases from west to the east).

By contrast, the latitude (φ) shows positive correlation with the annual precipitation. Its positive sign means that the higher the latitude the more the annual precipitation. Compared to the mentioned geographical factors, the altitude (H) has the least effect on the annual precipitation. In spring, the value of the three-variable correlation is about 0.79 which is larger than the other seasons (Table 2). It means that about 79 percent of the precipitation variations can be explained by geographical factors.

Based on the standard correlation coefficient (0.43), the effect of the (φ) is more than (λ) and (*H*). As shown in Tab. 2, during spring the altitude (*H*) has the highest positive effect (0.15) on precipitation than other seasons.

The occurrence of higher correlation between P and H in spring months can be explained by stronger convection, particularly in mountain regions of the country. The largest effect of (λ) is observed for winter precipitation (r = -0.6) as a result of intensifying the Mediterranean frontal system over Iran. The negative sign of *r* in winter (r = -0.6) highlights this fact that the precipitation rate reduces as the frontal systems move eastward (Table 2). It is reminded that the presence of subtropical high pressure belt (SHPB) during the warm seasons would reduce the possibility of rainfall event in most area of the country.

This could be the main reason for the lowest (0.26) three-variable correlation coefficient which observed in summer (Table 2). As seen, altitude (H) in summer months has negative impact the rainfall, because adequate humidity is not available in high lands.

Table 2. ***Seasonal and annual regression statistics between P and geographical factors***

Precipitation (P)	Geographical factors	Standard Correlation	Three-variable Regression equation	Three-variable Correlation(r)
Winter	λ	-0.6	P=815.7 – 9.5λ -5.8 φ+ 0.008 H	0.53
	φ	-0.27		
	H	-0.07		
Spring	λ	-0.42	P =104.5 – 4.6λ +6.3 φ+ 0.012 H	0.79
	φ	0.43		
	H	0.15		
Summer	λ	-0.04	P =28.5 – 0.22λ +1.8 φ- 0.005 H	0.26
	φ	0.24		
	H	-0.12		
Autumn	λ	-0.5	P =347 - 6.9 λ +2.8 φ - 0.006H	0.58
	φ	0.15		
	H	-0.07		
Annual	λ	-0.53	P =1233.8 - 21.2λ +5 φ+ 0.008 H	0.6
	φ	0.09		
	H	0.03		

With the exception of winter, in other seasons, the correlation between (φ) and P is positive (the higher the latitude, the more rainfall). This can be explained by the significant rainy days in coastal regions of the Caspian Sea throughout the year. During winter, the correlation between P and (φ) has the opposite sign (r = -0.27). This is due to the entrance of moist winter Mediterranean frontal system to the lower latitudes of Iran. In general, spring rainfall was more sensitive to all geographical factors than other seasons.

4. CONCLUSIONS

In this research, the effect of the geographical factors on annual and seasonal precipitation was also determined. The results suggest different precipitation regimes throughout the year. In general, the dominant regime of the country is winter precipitation regime. Main reason for this can be the large sale synoptic systems originated from Mediterranean and North Atlantic sources which are determinant in winter months (November-March). The findings of this research highlights that Iran's precipitation regime tends to be more concentrated in one specific season. The seasonal (intra-annual) and local precipitation regimes are also associated with significant fluctuations which mainly originated from the second and third harmonics variances in the last decades. The geographical factors showed various effects on local precipitation over Iran. The results highlighted that the first harmonic is able to describe the large scale systematic precipitation for all decades (not shown in the paper). By contrast, the second harmonic explained stronger contribution for convective and local precipitation. Analysis of precipitation variances for the third harmonic revealed that the northern latitudes are more sensitive to the local geographical factors than the southern latitudes. This study showed that the geographical factors have dominant influence on spatial and temporal precipitation variability over Iran. Identification of these variations in local and meso-scale is an important key point for water resources management and weather forecasters.

More studies need to be carried out on the precipitation variations and geographical factors affecting these variations. To evaluate the role of geographical factors on precipitation variations in more details, comparison over longer period of time is suggested.

REFERENCES

1. Asakereh H (2008) The Changes of Precipitation Frequency Distribution in Iran. Journal of Humanities (The University of Isfahan, Iran) 30(2): 81-90.
2. Ashabokov B A, Bischokov R M and Derkach D V (2008) Study of changes in the regime of atmospheric precipitation in the Central Northern Caucasus. Meteorologiya and Gidrologiya NO. 2:98-102.
3. Bodri L, Cermak V and Kresl M (2005) Trend in precipitation variability: Prague (the Czech Republic). Climatic Change 72:151-170.
4. Karagianndis A F, Bloutsos A A, Mahers P and Sachsamanoglou Ch (2008) Some statistical characteristics of precipitation in Europe. Theor Appl Climatol 91: 193-204.
5. Odekunle T O (2006) Determining rainy season onset and retreat over Nigeria from precipitation amount and number of rainy days. Theor Appl Climato 83:193-201.
6. Qian W and Lin X (2005) Regional trends in recent precipitation indices China. Meteorol Atmos Phys 90:193-207.
7. Romos M C (2001) Rainfall distribution patterns and their change over time in a Mediterranean area. Theor Appl Climatol 69:163-170.
8. Stafford J M, Wendle G and Curtis J (2000) Temperature and precipitation of Alaska: 50 year trend analysis. Theor Appl Climatol 67:33-44.
9. Tarawneh Q and Kadoglu M (2003) An analysis of precipitation climatology in Jordan. Theor Appl Climatol 74:123-136 DOI 10.1007/s00704-002-0705-5.
10. Tosic I and Unkasevic M (2005) Analysis of precipitation series for Belgrade. Theor Appl Climatol 80:67-77.