# Seasonal Distribution Of Wind In Iran

Mokhtar Karami, Mehdi Asadi

**Abstract**: In this study, an attempt has been made to evaluate long-term average variation and fluctuation of Seasonal wind in Iran. For this purpose, wind database network was initially formed over Iran. Then, data from the base of a 30-year period, the daily period of 1/01/1982 to 31/12/2012, was supposed as the basis of the present study, and a cell with dimensions of 15 × 15 km of the studied area was spread. In order to achieve the wind seasonal changes in Iran modern methods of spatial statistics such as, Moran global spatial autocorrelation, Moran Local insulin index and Hot spots, by using of programming in GIS environment, were accomplished. The results of this study showed that the spatial distribution of wind in Iran has the cluster pattern. In the meantime, based on Moran local index and Hot spots, wind patterns in the South, South-East, East, South West and North West, have spatial autocorrelation positive pattern, and parts of the Caspian Sea coast, north and center of the country have negative spatial autocorrelation. During the study period, a large part of the country (almost half of the total area) had a significant pattern or spatial autocorrelation.

**Index Terms**: Wind Seasonal, Spatial Autocorrelation, Local Moran, Global Moran, GIS, Hotspot, Iran.

## 1 INTRODUCTION

Result of the interaction of local factors and long-term circulation patterns, wind patterns each type and geographic reach will determine the pattern. Knowledge of the spatial distribution of wind in geographical areas will underlie the environmental planning and right policy. One of the important elements that have deniable effect on human activities and natural processes on climate, especially in the arid and semi-arid, is wind. The Horizontal movement of air is said wind that its speed of one meter per second, not less [4]. Wind which is produced by the deference between the pressures among the adjacent units that have same pressure, on the surface of the Earth which is assumed immobilized, is supposed as the factors that causes balance [6]. Five windy zones are seen in Iran, depending on the rise, peak and death patterns are produced in some parts of the country in the definite period of time, and culminate and disappear. These windy areas will vary on the issue of time and area of activity, intensity and wind direction and include: quiet zone, an area of low wind, wind zone, high windy zone, and extremely high windy zone. Unfortunately, research has ever been done about the wind spatial statistics in the country. But in the case of wind and wind resources surveys conducted under a few of them exist. Including wind energy potential survey in Kermanshah [14] Using data on wind direction and speed during three hours from the synoptic stations of Kermanshah, West Islamabad, Ravansar, Kangavar and Sarpolzahab during 1997 -2006 indicates that three stations Ravansar, Sarpolzahab and Kangavar have the potential for wind energy production. West Islamabad region in case of high wind turbines utilization is suitable to implement wind energy and Kermanshah doesn't have such potential.


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Potential of west regional wind energy was surveyed using Geographic Information System [34]. In this study, to measure wind potential, specified criteria (technical, environmental, economic and geographic) discuss with the same importance and significance. These studies have shown that the assumption of using turbines Gamesa G58, we can generate maximum 1897 MW wind power in the study area, which is considered as 26% of the electricity supply in the region in 2025. Entezari et al. (2012) using data of three-hour wind speed and continuity from synoptic stations of Sabzevar investigated wind energy potential and estimated electrical power generated by wind turbines. As well as overseas researches have been done in relation to spatial statistics as below [1]. Killeen et al (2007), who have examined have wet and dry spots in the Anode region [34]. Diffenbaugh and Giorgi (2008) examined the climate changes and Hot spots in the United States. They evaluated a few scenarios to identify climate changes of Hot spots in the United States. The results showed that modeling Hot spots in the structure of the GCM model was detected with high sensitivity [24]. Ohayon (2011) through using the parameters of the climatic average monthly temperature, Average maximum and minimum temperature over a period of 37 years in the Palestinian occupied territories in comparing the results of statistical spatial and traditional methods. His study showed that a temperature in the study area follows a complex pattern [9]. Del Río et al (2011) also used OLS (ordinary least square) method which is an optimal method for modeling spatial relations, in spatial statistics [28]. Jia et al (2011) using spatial statistics evaluated downscaling algorithm TRMM network based on NDVI and DEM on the basin of Qaidam of China. In this study, the global Moran index was used to analyze the pattern of NDVI index. The results showed that the downscaling of the six stations studied rainfall data using the algorithm according to the data values is different [29]. Chao-bing and Ning (2011) studied the Hot spots of heating islands China [15]. Allard and Soubeyrand (2012) in a study for Colmar area located in North East France for weather data and models of distribution of epidemiology of plant species benefited applied approach of spatial statistics and have identified sensitive areas to climatic changes [11]. De Lucena et al (2013) evaluated thermal fields in the metropolitan area of Rio de Janeiro, Brazil with Hot spot analysis [7]. Bajat et al (2014) in a study to analyzed the spatial temperature trend in Serbia (1961-2010). In this research, the average monthly temperature data of 64 synoptic stations was used and then the temperature ranges of linear trend were obtained, as well as ordinary least squares method. To search for spatial autocorrelation also the World

Moran Method was used. Their research results showed that the trend of temperature from all over Serbia follows the random pattern [8]. Robeson et al (2014) in a research using the function of K Ripely, evaluated the World Meteorological Stations and introduced the best type of this function. Since the time – place changes of precipitation is one of the most important applied climatically subjects [31], There are many studies that include studies [33, 16, 18, 30] as Indicators from hundreds of design templates and other selected pattern. Summing up the history of research shows that despite the high potential of spatial data analysis capabilities and analytical functions such as Hot spots analysis and cluster analysis and non-analysis in climatic studies in the country has not been mentioned. This approach using spatial analysis functions Spatial Statistics, focus identifying windy areas of the country.

## 2 Research Methodology

### 2.1 Preparation

In this study the data of 145 synoptic stations with a period of 30 years (1982-2012) were used. Figure 1 shows the distribution of the studied stations. In this study, the data point using Kriging interpolation method in ArcGIS 10.2.2 software mapping data was extended to the cells with dimensions of 15 × 15 km. To speed up the process of calculation, application programming capabilities GS + and Spss were used. Regarding that the information related to the wind has local correlation. Therefore, it can be obtained using Spatial Statistics wind model, and then through using the cluster and Outlier statistics and evaluating Hot spots analysis was done.

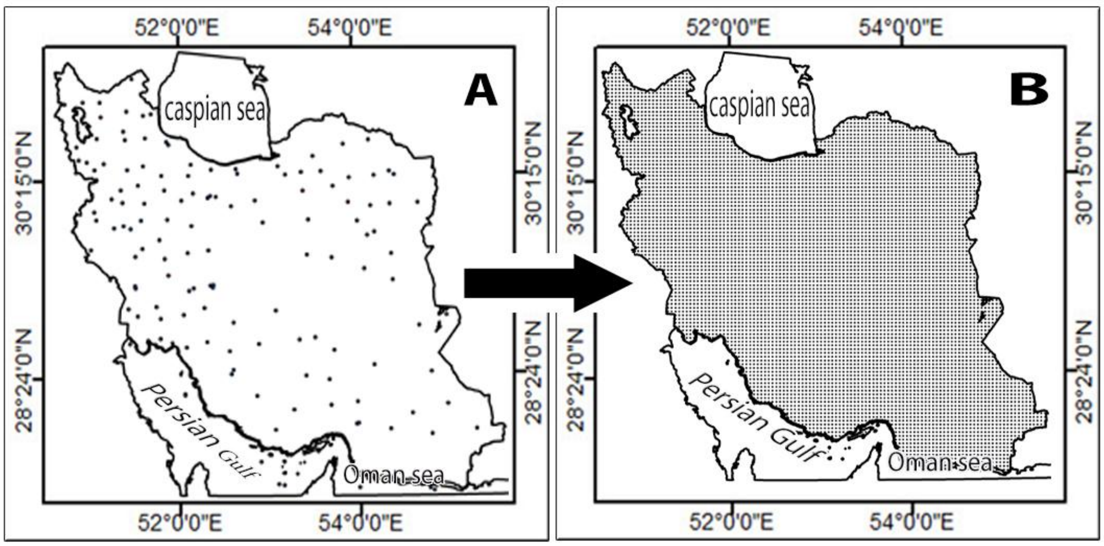


***Fig. 1.*** *Synoptic and climate stations (A) and 15 × 15 km cells (B).*

### 2.2 Spatial auto-correlation

To examine the prevailing pattern in Wind in Iran during the period under study it was used the modern spatial methods such as spatial autocorrelation (local Moran and global Moran) and Hot Spot. Recognition of patterns and discovery of existing process in spatial data are of importance [26, 27], because before any analysis of map in spatial statistics, it must engage in this prejudgment that how the data have been distributed in the space and what pattern and rule is used for distribution of data in the space [17]. In previous research analysis method of Moran local pattern has been used, for a better understanding of data and accurate decision making about the confidence level. In recent decades, a variety of scenarios concerning analysis of spatial data patterns have been expanded in spatial database. For this it can use Global Moran Index which is well known to Global Moran's I. This index obtains numerical statistics (z-score) through which it can measure degree of scattering in spatial data in the space [17, 3, 23, 5, 13]. Moran wind spatial autocorrelation is examines spatial autocorrelation based on dispersion area of two amounts and analyses, the considered characteristics of geographical condition in that area [12]. To calculate Moran index, firstly z-value and p-value is calculated, and in the next stage is considered the evaluation and significance of index.

To calculate spatial autocorrelation, Global Moran Index is used equation 1:

$$I = \frac{n}{s_o} \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} W_{i,j} z_i z_j}{\sum_{i=1}^{n} Z_i^2} \quad (1)$$

The Global Moran's I statistic provides a measure of the degree of spatial autocorrelation based on both the locations of events and the values associated with the events at the same time. It indicates the degree of spatial concentration or dispersion for a given point pattern [22]. The index, □, is calculated as follows:

Where $z_i$ is the deviation of an attribute for feature □ from its mean $(x_i - \bar{X})$;$W_{i,j}$ is the spatial weight between features $i$ and $j$ ; $n$ is equal to the total number of features; finally, $S_o$ is the aggregate of all the spatial weights [5]. In general, if the amount of Moran index is close to +1, data will experience spatial autocorrelation, and if the amount of Moran index is close to -1, data will experience discrete pattern. Maps of clusters: a function which has been mentioned in analysis of pattern implies the general statistics which seek to give a response to this question "whether a significant spatial dispersion exists between the data or not?"; cluster maps help to identify where the clusters have been formed at the region under study and where are the borders in this region. In this study, cluster and outlier analysis (Anselin Local Moran's I) and Hot Spot Analysis have been used to study patterns and Spatial-Temporal variations in wind. The cluster and outlier analysis which is well known to Anselin Local Moran's I is regarded as an optimal pattern to display statistical distribution of phenomena in space [20, 21, 2, 19, 13]. To analyze cluster and outlier analysis (Anselin Local Moran's I) per any condition existing in layer, amount of local Moran index, Z-Value and P-Value which represent significance of index are calculated. Local Moran's I can be calculated based on:

$$I_i = \frac{x_i - \bar{x}}{s_i^2} \sum_{j=1, j\neq 1}^{n} w_{i,j} w_{i,j} (x_i - \bar{x}) \quad (2)$$

Where xi represents the characteristic of $i$, $\bar{x}$ represents mean of the given characteristic, and $w_{i,j}$ represents the spatial weight between features $i$ and $j$. Value of $s_i$ is calculated based on equation 3:

$$s_i^2 = \frac{\sum_{j=1, j\neq 1}^{n} w_{ij}}{n-1} - \bar{x}^2 \quad (3)$$

Where, $n$ equals to the number of all features. $z_{Ii}$ is calculated using equation below:

$$z_{I_i} = \frac{I_i}{\sqrt{V[I_i]}} \quad (4)$$

To calculate V [Ii], the equations 5 are used:

$$V[I_i] = E[I_i^2] - E[I_i]^2 \quad (5)$$

$$E[I_i] = -\frac{\sum_{j=1, j\neq 1}^{n}}{n-1} \quad (6)$$

Hot Spot Analysis uses (Getis-OrdGi*) for all the existing features in the data [25]. Z-value represents that where the data have been clustered with high or low values. Conceptual framework of this analysis works out in this way that if there is a high value, this will be an interesting point, yet this does not imply that a spot is hot. Hot Spot is called to a condition that the Feature and its neighborhood Features be significant. Z-value will be obtained for the final output when the local sum of the Feature and the Features in its adjacency are compared with the total sum of Features [20, 3, 19, 10]. The statistics (Getis-OrdGi*) is calculated using equation 7:

$$G_i^* = \frac{\sum_{j=1}^{n} w_{i,j} - x \sum_{j=1}^{n} w_{i,j}}{S \sqrt{\frac{[n \sum_{j=1}^{n} w_{i,j}^2 - (\sum_{j=1}^{n} w_{i,j})^2]}{n-1}}} \quad (7)$$

In equation above, $x_j$ represents the amount of characteristic for Feature $j$, $w_{i,j}$ represents spatial weight for the Features $i$, j, and $n$ represents total number of Features. To calculate $S$, equation below is used:

$$S = \sqrt{\frac{\sum_{i=1}^{n} x_j^2}{n} - (\bar{x})^2} \quad (8)$$

$$\bar{X} = \frac{\sum_{j=1}^{n} x_j}{n} \quad (9)$$

As $G_i^*$ is considered as a z-value, calculation of z has been avoided.

## 3 Results and Discussion

### 3.1 Analysis of pattern of Seasonal variations of wind

Outputs of Global Moran's Wind spatial autocorrelation have been represented in table 1. In general, if Moran index be close to +1, data will have spatial autocorrelation and clustering pattern, and if the Moran index be close to -1, data will be discrete. According to Global Moran, null hypothesis has been grounded on this point that there is no spatial clustering between values of the element associated to geographical Features. Yet, when the p-value is so small and the calculated z-value is so large, it can reject the null hypothesis. If Moran index be greater than 0, data will represent a type of spatial clustering. If Moran index be less than 0, geographical Features under the study will have a scattered pattern. As shown in table 1, Global Moran index for the four periods under study will be above 0.95. This point represents that Seasonal wind at the country at seasons under study at level 95% and 99% indicate a high clustering pattern, concerning Global Moran index. Nonetheless, the highest Global Moran index with the value (0.970272) has associated to seasons. Z-value for seasons under study is high ranging from 257 to 261. Hence, to sum up, based on Global Moran index, it can deduce that wind changes during these seasons at country follow high clustering pattern. Hence, with regard to high z-value and low p-value, it can reject null hypothesis based on lack of spatial autocorrelation among data at seasons under study. If it was supposed spreading wind in a normal way at seasons under study, Global Moran index will be equal to -0.000139.

***TABLE 1***

*OUTPUT OF MORAN (MORAN'S I) STATISTICS DURING SEASONS*

| SEASONS | MORAN INDEX | EXPECTED MORAN INDEX | VARIANCE | Z-SCORE | P-VALUE | CONCEPTUALIZATION OF SPATIAL RELATIONSHIPS | DISTANCE METHOD |
|---|---|---|---|---|---|---|---|
| SPRING | 0.970272 | -0.000139 | 0.000014 | 261.759344 | 0 | INVERSE-DISTANCE | EUCLIDEAN |
| SUMMER | 0.954033 | -0.000139 | 0.000014 | 587.385013 | 0 | INVERSE-DISTANCE | EUCLIDEAN |
| AUTUMN | 0.961615 | -0.000139 | 0.000014 | 259.468540 | 0 | INVERSE-DISTANCE | EUCLIDEAN |
| WINTER | 0.966913 | -0.000139 | 0.000014 | 260.851890 | 0 | INVERSE-DISTANCE | EUCLIDEAN |

As observed, spatial autocorrelation of Global Moran index just specifies the type of pattern. For this reason, local Moran during the seasons under study has been used to display the spatial distribution pattern of wind in Iran. The results indicate that whether the Features have been distributed in random, scattered or clustering in the space. If I value be positive, this will imply that the considered condition has been dominated by the similar Features. Hence, the considered Feature is a part of that cluster. If I-value be negative, this will imply that the considered Feature has been enclosed by the dissimilar Features. This Feature is called Outliers. The value of this statistics has been calculated in the framework with the standard score, and p-value can be analyzed. In this statistics, HH represents clusters with positive spatial autocorrelation at 99% confidence level, LL represents clusters with negative spatial autocorrelation at 99% confidence level, HL represents Outliers in which a high value has been enclosed via low values, and LH represents single-cells in which the condition enjoys a low value, enclosed via high values. Figure 2 represents the variations during decades with spatial autocorrelation in the clustering pattern of wind during the seasons under study (1982-2012). In all seasons of the year in most parts of the country, low-wind and high- wind patterns are prevailed in the cluster pattern. This status equally is 53.74% distributed all around the country in spring (Figure 2). In the season 27.60 percent of the country, often in areas of the South, South East and West, on behalf of synoptic stations of Sistan and balouchestan, Kerman, Hormozgan, Lorestan and south east of Kurdestan, have the cluster pattern with high value (positive spatial autocorrelation) is dominant (Figure 2). In this period of the year the wind pattern or quantities with low value (negative spatial autocorrelation) that represent low wind pattern. With 26.14 percent in the northern region that extends towards the center of the country have been distributed (Table 2). Wind values with high positive spatial autocorrelation in the summer than in the spring, about 3.14 percent and also changed in terms of location (because of the 120-day winds, windy pattern in the East has taken on the role of color) and parts of the West, South East Kurdistan and Kerman from windy to non-correlation pattern has changed. While that of the spring wind pattern has shifted to the West as well as the beam penetrates into the country. In the fall, because the 120-day wind of Sistan has subsided windy patterns also have covered less area than in summer and about 3.21 percent compared to summer have been decrease. Low wind cluster pattern for a strip in the center and north of the country is limited and parts of the North West region have become high windy region which due to the existence and development of westerly winds in the area. In winter through development of western wind all over the country the high windy pattern has been increased and has increased to 6.43 percent compared to the fall. And the North-West part of the country where the westerly winds of the area has become windy and low wind area is moved to the East. And about 0.02 percent of its area has been decreased compared to fall higher than in the fall is reduced and has reached to the amount of 27.29.

***TABLE 2***

*Percent of the area under coverage of pattern derived from Anselin Local Moran's I*

| TYPE OF SEASONAL WIND PATTERN | SPRING | SUMMER | AUTUMN | WINTER |
|---|---|---|---|---|
| HIGH CLUSTERING PATTERN (HH) | 27.60 | 24.46 | 21.25 | 27.68 |
| LOW CLUSTERING PATTERN (LL) | 26.14 | 27.28 | 27.31 | 27.29 |
| WITHOUT PATTERN | 46.26 | 48.26 | 51.44 | 45.03 |

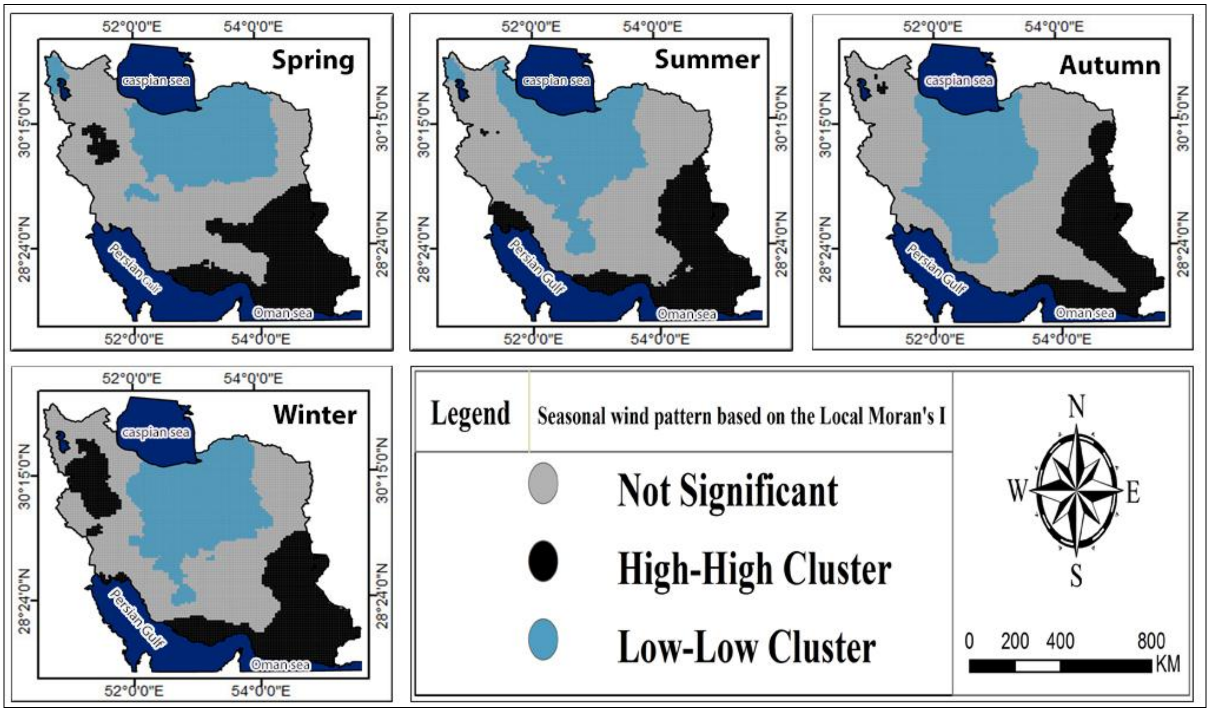


***Fig. 2.*** *the results from scattering of Anselin Local Moran's I for Seasonal distribution of wind in Iran.*

With regard to what mentioned above, those areas of country with positive and negative spatial autocorrelation were specified, yet Hot spots index or GI* have been used to assure from the areas with clusters with high and low value, that the results have been represented in figure 3 and table 3. Statistic GI* which is calculated for existing condition in the data is a z-value. For positive Z score, the more score is greater, high values have been clustered to a large extent, developing Hot spot. For negative score, the more score is small, there will be lower amounts, indicating cold spots. As shown in figure 3, In the spring, parts of the South, South East, East, Central and West part of the country On behalf of the synoptic stations in Sistan and Baluchestan, Kerman, Hormozgan, Yazd, Fars and Lorestan and southern East parts of Kurdistan have windy patterns (at a significance level of 99%), which are distributed around 30.40 percent of the studied area (Table 3). In this season of the year, (at a significant level of 99%) south coast, East and West coasts of the Caspian Sea, Central and West of the country is covered with an area of about 26.30 percent (Figure 3). In the summer the wind pattern (at a significance level of 99%) has penetrated toward west and within the country. But 3.07 percent was subtracted from that value compared to spring but the high windy pattern at 99% penetrated toward the North East of the studied area so that 2.07 percent was added to the that area. In the western regions also windy pattern is slightly colored. In fall the North West regions have gone out of the low wind pattern and have changed to high windy pattern and against the pattern of the low windy at 99%, with an area of over 26.33 percent (Table 3), of the country to the West and inside the country has been completed (Figure 3). In the winter through spreading the western wind in the country, the high windy patterns at 99 and 95 % it was spread behind the dam of Zagrose mountain and North West of the country. Also the low patterns wind from the inside and the West part of the Country has regressed to the North and East (31.68), and the windy patterns have been replaced. Overall in this season the high windy patterns with 31.05 percent of the local area have had many changes (Figure 3).

***TABLE 3***
*Percent of the regions under coverage of Hot Spot Analysis (Getis-Ord Gi*)*

| Type of Seasonal wind pattern | Spring | Summer | Autumn | Winter |
|---|---|---|---|---|
| Very low pattern (negative spatial autocorrelation at 99% ) | 30.40 | 32.47 | 32.08 | 31.05 |
| low pattern (negative spatial autocorrelation at 95% ) | 5.17 | 5.16 | 6.28 | 5.22 |
| average low pattern (negative spatial autocorrelation at 90%) | 2.90 | 2.21 | 4.60 | 2.26 |
| Lack of a significant pattern | 24.86 | 27.74 | 23.96 | 23.33 |
| Average full pattern (positive spatial autocorrelation at 90%) | 2.37 | 1.96 | 2.24 | 2.21 |
| full pattern(positive spatial autocorrelation at 95% ) | 4.04 | 3.72 | 4.51 | 4.25 |
| full pattern(positive spatial autocorrelation at 99% ) | 30.26 | 27.19 | 26.33 | 31.68 |

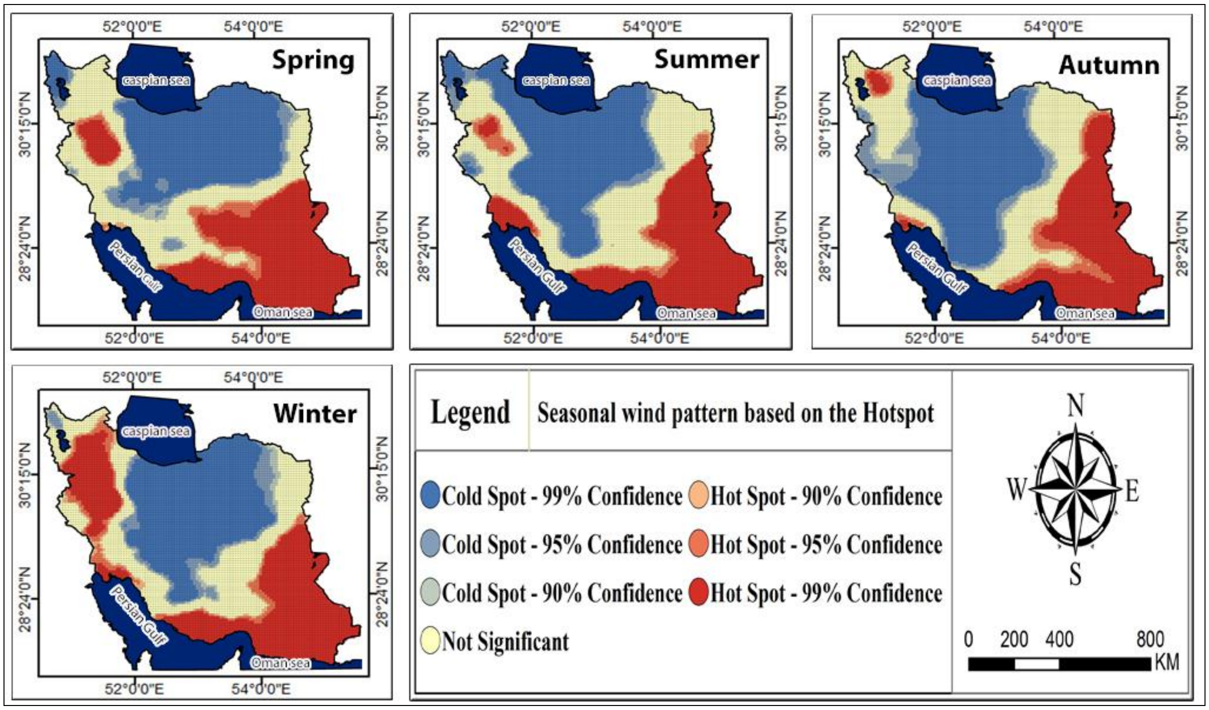


***Fig. 3.*** *The results from scattering of Hot Spot Analysis (Getis-Ord Gi*) for Seasonal distribution of wind in Iran*

## 4 CONCLUSION

Wind is the most important climatic element in identifying the climate type of each region. Changes in amount and pattern of wind are indication of climate change. Variability and variation are of a particular important in wind related studies, having a major role in climate predictions. Based on both indices, southern East, East, South, Central and Western on behalf of stations Sistan and Baluchestan, Kerman, Fars, Yazd, South Khorasan, Ahvaz, Lorestan, Kurdestan, had a significant role in shaping high windy patterns, with high cluster pattern, so that these areas of the country had positive spatial autocorrelation. However, that negative spatial autocorrelation areas or in other words low windy patterns are limited to the Caspian Sea coast, north and central part of the country (central area). In general, in the winter the maximum area of high wind sample with the amount of 31.68 (due to complete expansion of western winds) and in the fall since the western winds haven't started their activities the lowest amount of (26.33) have the high wind sample. Also a large area of the country have a significant pattern in all four seasons of studied period, or in the other word had statistically significant spatial autocorrelation. The results of this study indicated that wind patterns form under influence of local factors and atmospheric elements in a long-term, yet they play a different role, so that geographical arrangement of wind patterns is formed via local agents especially altitudes and mountains; this is in a way that role of extrinsic factors must not be ignored in formation of wind patterns, because the external factors play a major role in determination of wind regime and wind temporal variations. Looking into wind clusters at the country, it can observe that up and down wind clusters are not the same, indicating effect of General Atmospheric Circulation. Thus, in general, the wind patterns are developed and influenced under two systems: 1- Local influencing factors (geographical arrangement of wind patterns), 2- External influencing factors (regime of wind patterns).

## 5 REFERENCES

[1] A, Entezari, A, Amirahmadi, A, Borzooyi, A, Erfani, "Wind energy potential evaluation and assessing the possibility of wind plant construction in Sabzevar," dry areas geographical studies periodical, third year, No. 9 & 10, pp 33-46, 2012.

[2] A, Getis, and J, Aldstadt, "Constructing the spatial weights matrix using a local statistic," Geogr Anal 36 (2), pp 90-104, 2004.

[3] A, Getis, and J. K, Ord, "the analysis of spatial association by use of distance statistics," Geogr Anal 24 (3), pp 189-206, 1992.

[4] A, Masoudian, "weather of Iran," Mashhad Sharia publications. First printing, Mashhad, 2011.

[5] A, Mitchell, "The ESRI guide to GIS analysis," volume 2: spatial measurements and statistics. ESRI, Redlands [CA], 2005.

[6] A, Stine Godar, "Climatology," translator A h Rajaee, Niknami publication, 2006.

[7] A. J, De Lucena, O. C, Rotunno Filho, J. R, de Almeida França, L, de Faria Peres, and L. N. R, Xavier, "Urban climate and clues of heat island events in the metropolitan area of Rio de Janeiro," Theoretical and applied climatology, 111(3-4), pp 497-511, 2013.

[8] B, Bajat, D, Blagojević, M, Kilibarda, J, Luković, and I, Tošić, "spatial analysis of the temperature trends in Serbia during the period 1961–2010," Theoretical and Applied Climatology, pp 1-13, 2014.

[9] B, Ohayon, “Statistical Analysis of Temperature Changes in Israel: An Application of Change Point Detection and Estimation Techniques,” 2011.

[10] C, Zhang, L, Luo, W, Xu, and V, Ledwith, “Use of local Moran’s I and GIS to identify pollution Hot spots of Pb in urban soils of Galway, Ireland,” Sci Total Environ 398 (1-3), pp 212-221, 2008.

[11] D, Allard, S, and Soubeyrand, “Skew-normality for climatic data and dispersal models for plant epidemiology: when application fields drive spatial statistics,” Spatial Statistics, 1, pp 50-64, 2012.

[12] D, Griffith, “spatial Autocorrelation: A Primer. Resource Publication in Geography,” Association of American geographers, 1987.

[13] D, Wheeler, and A, Paéz, “Geographically Weighted Regression,” In Fischer MM, Getis A (eds) Handbook of applied spatial analysis. Springer, Berlin, Heidelberg and New York, pp 461-486, 2009.

[14] H, Mohammadi, J, Rostami, T, Nima, and F. S, Aliakbar “Wind energy potential in Kermanshah province,” natural geography researches, 44th year, No. 2, pp 19-23, 2012.

[15] H. L. M. D, Chao-bing, L. I, Ning, “A review on the Hot Spotissues of urban heat island effect,” Journal of Meteorology and Environment, 4, 011, 2011.

[16] I, Ageena, N, Macdonald, and A. P, Morse, “Variability of maximum and mean average temperature across Libya (1945–2009),” Theoretical and Applied Climatology, pp 1-15, 2013.

[17] J, Illian, A, Penttinen, H, Stoyan, and D, Stoyan, “Statistical Analysis and Modelling of Spatial Point Patterns,” John Wiley and Sons, Chichester, 2008.

[18] J, Nemec, C, Gruber, B, Chimani, and I, Auer, “Trends in extreme temperature indices in Austria based on a new homogenized dataset,” International Journal of Climatology, 33(6), pp 1538-1550, 2013.

[19] J. K, Ord, and A, Getis, “Local spatial autocorrelation statistics: distributional issues and an application,” Geogr Anal 27(4), pp 287-306, 1995.

[20] L, Anselin, “Local indicators of spatial association: LISA,” Geogr Anal, 27(2), pp 93-115, 1995.

[21] L, Anselin, I, Syabri, and Y, Kho, “GeoDa: an introduction to spatial data analysis. In Fischer MM, Getis A (Eds) Handbook of applied spatial analysis,” Springer, Berlin, Heidelberg and New York, pp 73-89, 2009.

[22] L. M, Scott, and M. V, Janikas, “spatial statistics in ArcGIS,” In Handbook of applied spatial analysis, Springer Berlin Heidelberg, pp 27-41, 2010.

[23] N, Levine, “spatial statistics and GIS: software tools to quantify spatial patterns,” JAm Plann Assoc 62(3), pp 381-391, 1996.

[24] N. S, Diffenbaugh, F, Giorgi, and J. S, Pal, “Climate change Hot spots in the United States,” Geophysical Research Letters, 35(16), 2008.

[25] P. A, Rogerson, “Statistics Methods for Geographers: students Guide, SAGE Publications,” Los Angeles, California, 2006.

[26] P. J, Diggle, “Statistical Analysis of Spatial Point Patterns,” Arnold, London, second edition, 2003.

[27] R, Waagepetersenand, and T, Schweder, “Likelihood-based inference for clustered line transect data,” Journal of Agricultural, Biological, and Environ- mental Statistics, 11 pp 264–279, 2006.

[28] S, Del Río, L, Herrero, C, Pinto-Gomes, and A, Penas, “Spatial analysis of mean temperature trends in Spain over the period 1961–2006,” Global and Planetary Change, 78(1), pp 65-75, 2011.

[29] S, Jia, W, Zhu, A, Lű, and T, Yan “a statistical spatial downscaling algorithm of TRMM precipitation based on NDVI and DEM in the Qaidam Basin of China,” Remote sensing of Environment, 115(12), pp 3069-3079, 2011.

[30] S, Kim, and V. P, Singh, “Modeling daily soil temperature using data-driven models and spatial distribution,” Theoretical and Applied Climatology, pp1-15, 2014.

[31] S. M, Robeson, a, Li, and C, Huang, “Point-pattern analysis on the sphere,” Spatial Statistics, 2014.

[32] T. J, Killeen, M, Douglas, T, Consiglio, P. M, Jorgensen, and J, Mejia “Dry spots and wet spots in the Andean Hot spot,” Journal of Biogeography, 34(8), pp 1357-1373, 2007.

[33] V, Homar, C, Ramis, R, Romero, and S, Alonso, “Recent trends in temperature and precipitation over the Balearic Islands (Spain),” Clim Change 98, pp 199–211, 2010.

[34] Y, Noorollahi, S. m, Ashraf, and M, Zamani, “Wind power energy potential in west using GIS,” Moshaveran and Eghtesad-e Shaygan Co, 2010.