The spatial pattern changes of dust interior sources in Khuzestan province in recent decades

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Expanded Abstract

Introduction

Dusting phenomena are among the most serious environmental problems in certain areas of the world. Most of the dust in the atmosphere is due to the origin of fine particles, and these fine particles are more prevalent in the arid and semi-arid regions of the world. In general, a dust storm is a heavy wind that carries sand particles in the air and transfers them from one place to another. The diameter of the particles of these grains has a direct relation with the wind speed, so winds can transport coarser material faster and vice versa. In examining the scientific sources available in the field of dust, it can be concluded that so far there has been a lot of research in this regard. And in most of these studies, the transmission, publication, synoptic causes and the destructive effects of this phenomenon are expressed. In this research, we try to investigate and analyze the spatial pattern of dust and changes in spatial displacement of these patterns during different periods.

Materials & Methods

The purpose of this study was to investigate and analyze spatial Autocorrelation of Khuzestan province over recent decades. For this purpose, data collected from 20 synoptic stations on a daily basis from 1986 to 2016 were obtained from the country's Meteorological Organization

In order to investigate more accurate changes of dust, the spatial variations of dust cores were investigated and analyzed in six periods of 5 years (1990-86, 1995-1991, 2000-1996, 2005-2001, 2010-2006, 2016-2011) and three decades (1995-1986, 2005 1996, 2006, 2016-2006) were analyzed. In order to obtain a general view of the dusts of Khuzestan province, some descriptive characteristics of the dusts of Khuzestan province were first studied and analyzed. The Alexander's method was then used to identify the dominant mutations in the Khuzestan circle.

In order to investigate fluctuations of dust, Alexanderson statistical method was used. The SNHT test (Standard Normal Homogeneity Test) was developed by Alexanderson (1986) to detect a change in a series of rainfall data. The test is applied to a series of ratios that compare the observations of a measuring station with the average of several stations. The ratios are then standardized. The series of Xi corresponds here to the standardized ratios. In this method, the mean score of k in the first year is compared with that of n-k in the subsequent year, which yields T (K) (Alexanderson, 1997: 25-34):

$$T(K) = K \times \bar{Z}_1^2 + (n-K) \times \bar{Z}_2^2 \quad (1)$$

In this formula, $\bar{Z}_1^2$ and $\bar{Z}_2^2$ are calculated through the following formula:

$$\bar{Z}_1^2 = \frac{1}{K}\sum_{i=1}^{k}(Y_i - \bar{Y})/S \qquad \bar{Z}_2^2 = \frac{1}{n-K}\sum_{i=k+1}^{n}(Y_i - \bar{Y})/S \quad (2)$$

In this equation, Y_i is the value of annual set (from 1 to n), $\bar{Y}$ is the mean of set and S is standard deviation.

$$T_o = \max\big(T(K)\big) = \max(\bar{Z}_1^2 + (n-K)\bar{Z}_2^2 \qquad 1 \le k \le n-1 \quad (3)$$

If T_0 is greater than a particular critical value, then the null hypothesis is rejected for that significance level.

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In this study , in order to study and analyze the spatial pattern of dust in Khuzestan province, two indicators of Moran (I) and (GI*) have been used.

Index (GI*)

Then, in order to examine the spatial autocorrelation pattern of changes within a decade of dust, the hot spot analysis, Getis-Ord Gi, was employed. Analysis of hot spots calculates Getis-Ord Gi for all effects in the data. Z scores indicate in which section data are clustered in large or small quantities. In fact, this instrument considers every location in the light of its neighboring locations. If a location has high values, it is interesting and important; however, it may not be a statistically significant hot spots by itself. For a location to be considered a hot spot and also be statistically significant, both the location and its neighbors should contain high values. Local sum of a location and its neighbors is relatively compared to that of all the locations. When the local sum is significantly higher than the expected local sum, the Z score will be obtained. In fact, this instrument considers every location in relation to its neighboring locations.

$$\bar{x}_i = \frac{\sum_j x_i}{(n-1)} \quad (4)$$

$$s^2(i) = \frac{\sum_j x^2{}_j}{(n-1)} - [\bar{x}(i)]^2 \quad (5)$$

And Gi is calculated through the following formula:

$$Var(G_i) = \frac{W_i(n-1-W_i)}{(n-1)^2(n-2)}\left[\frac{s(i)}{\bar{x}(i)}\right]^2 \quad (6)$$

The values of G and G* are calculated through this statistical procedure W_i/ (n-1) and is standardized through calculating the second root of its variance.

$$G_i(d) = \frac{\sum_j w_{ij}(d)x_j - W_i\bar{x}(i)}{s(i)\{[((n-1)S_{1i}) - W_i^2]/(n-2)\}^{\frac{1}{2}}}, j \neq i \quad (7)$$

If we also consider the weight of i $w_{ii} \neq 0$, the standardized G* is calculated through the following formula.

$$G_i^*(d) = \frac{\sum_j w_{ij}(d)x_j - W_i^*\bar{x}}{s(i)\{[(nS_{1i}^*) - W_i^{*2}]/(n-2)\}^{\frac{1}{2}}}, j = i \quad (8)$$

In equations 7 and 8, $W_i^* = W_i + w_{ii}$, $S_{1i} = \sum_j w_{ij}^2$, where $j \neq i$ and $S_{1i}^* = \sum_j w_{ij}^2$, where $j=i$ and $\bar{x}$ and s^2 show the mean and variance of the model, respectively. The standardized values of G and G* are interpreted based on the table of Z scores.

Index Moran (I)

Moran's I is a global measure of spatial autocorrelation statistic designed to test the dependence of dust values on neighboring values. Moran's I is calculated from the following formula:

$$I = \frac{n}{S_0}\frac{\sum_{i=1}^n\sum_{j=1}^n w_{i,i} z_i z_j}{\sum_{i=1}^n z_i^2} \quad (9)$$

where z_i is the deviation of dust for point i from its long-term mean ($x_i - \bar{x}$), w_{ij} is the spatial weight between points i and j, n is the total number of points, and so is the sum of all the spatial weights:

$$S_0 = \sum_{i=1}^{n}\sum_{j=1}^{n} w_{i,i} \quad (10)$$

The score statistic z_i is computed by the following formula:

$$z_i = \frac{I - E[I]}{\sqrt{V[I]}} \quad (11)$$

where $E[I]$ and $V[I]$ are computed as:

$$E[I] = -1/\,(n-1)\ ) \quad (12)$$

$$V[I] = E[I_1^2] - E[I_1^2] \quad (13)$$

The values of Moran's I vary from 1 for the perfect positive correlation and clustering to -1 for the perfect negative correlation and dispersion. The high similarity of dust in neighboring areas results in the positive spatial autocorrelation. The negative autocorrelation describes patterns in which neighboring areas differ and random patterns exhibit no spatial autocorrelation.

Discussion of Results

The results of the frequency distribution of dust in different periods showed that in the first period (1986-1986), the core of the occurrence of the summits was observed in the central parts of Khuzestan province and south, while during the second period core events, it is formed in the form of spots in northern parts of the province. In the third period (1996-1996), the core of dusts is almost the same as in the first period, with the exception that during this period the severity of the events has decreased. Distribution of dust events in the fourth period (2001-2005) has almost reached the same level as the second period, with the exception that the aggregate core has tended to be closer to the border areas of Iran and Iraq. In the fifth period (2006-2010) and the sixth period (2011-2016), the frequency of the occurrence of storms in comparison to previous periods, in addition to being increased, has been observed more in the border areas of Iran and Iraq. The results of spatial pattern changes in the dusts of Khuzestan province showed that the positive spatial Autocorrelation pattern on the districts of the province was more dispersed in the first three periods more sporadically, especially in central parts, southern parts and insignificant parts of Northern Province. Since the third period, the spatial variations of the dust patterns of Khuzestan province have been quite evident. The status of the spatial autocorrelation pattern of dust on the annual scale is approximately the same as the pattern governing the dust of the fifth and sixth periods. In the annual scale, the pattern of the dusty areas of the province in the border areas and parts of Ahwaz has formed a high cluster pattern and the southeastern regions and parts of the north of the province, have a low cluster pattern (negative spatial autocorrelation pattern). As a result of recent periods, the pattern of positive spatial Autocorrelation patterns is more concentrated in the border areas of Iran and Iraq and southern parts of Khuzestan province. The low cluster pattern (negative spatial Autocorrelation pattern) is more focused along the Zagros Mountains and the southeastern provinces of the province.

Conclusions

The dusty phenomenon is one of the most important climatic events in many parts of the world, especially in countries in the dry and dry land, especially in the subtropical regions. In this study, the spatial pattern core of dust the Khuzestan province has been investigated. Then, the spatial autocorrelation pattern was used from two indicators of the Hot Spot Index (GI *) and Moran (I) or Moran Index. The results of this study showed that the dust of Khuzestan province were more severe in the western and southern parts of the country. On the other hand, since the third period, the incident has increased dramatically over recent periods. The results of the analysis of spatial autocorrelations hotspot indicates that during the first three core dust for spots in parts of central, northern (part of Safiabad) and parts of South and West Khuzestan province scattered. The low cluster pattern (negative spatial autocorrelations pattern) is further concentrated along the Zagros Mountains and the southeastern provinces of the province. So, we can say that as far as recent periods are farther away from the border regions, the severity of positive spatial mapping patterns is reduced and, in spite of the severity of the spatial autocorrelations pattern, is increased.

Keywords: dust, index of Alexanderson, hotspot index, Moran index, spatial Autocorrelation.