Indian Journal of Fundamental and Applied Life Sciences ISSN: 2231– 6345 (Online)
An Open Access, Online International Journal Available at www.cibtech.org/sp.ed/jls/2015/03/jls.htm
2015 Vol. 5 (S3), pp. 1502-1512/Tabatabaie et al.
Research Article

KHUZESTAN PROVINCE DUST MODELING USING NONPARAMETRIC METHODS

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ABSTRACT
In Khuzestan province, the occurrence of dust has had higher intensity and persistence, due to closeness to huge deserts like south of Iraq and Arabia, also drought conditions in the recent years. The purpose of the present study was to analyze the procedure and modeling of Khuzestan's dust phenomenon changing, based on Mann-Kendall and Sense-Estimator nonparametric methods in two periods of the year include warm period (spring and summer) and cold (autumn and winter)., the data from 9 synoptic stations across the province were used in order to perform the steps of the research, in a way that the data covered the whole areas of province. Results of the stations analysis showed that for warm period, most of the northern parts have an increasing trend in spring and in summer the province's positive procedure dominance is even higher compared to spring. The situation is also changed in the cold period. In autumn, the South East has a reduced negative trend which moves to northern parts of the province in winter. Controlling the final models and use of the remaining series showed that Sense Statistic has a high capability to estimate the changing dust phenomenon in Khuzestan provinces.

Keywords: *Procedure Analysis, Modeling, Dust, Zoning, Khuzestan*

INTRODUCTION
Dust is a weather phenomenon that leaves inappropriate environmental impacts. The existence or non-existence of humidity is one of the most important conditions of dust creation, alongside with unstable weather; in a way that it creates rain, storm and thunderstorms, if the unstable weather has humidity and it creates dust, if the weather doesn't have humidity (Zolfaghari and Abedzadeh, 2004). Climate studies on dusty days have indicated that Iran's central holes have the highest frequency of dust days with more than 150 days, and then South West and West areas which are in the vicinity of the great deserts of Iraq, Saudi Arabia, Syria, etc (Alijani, 1998). The dust can in fact be a reaction to changes in land cover where the role of human activities should be considered in addition to the geographical environmental conditions (Raeespour, 2007). Most of the dust created in the atmosphere is due to particles which have a higher frequency in the arid and semiarid regions of the world. Effects of dust may persist up to a distance of 4000 km from the main source and cause damages in health, agriculture, industry, transport and communication systems fields (Raeespour, 2007). One of the main characteristics of the dust system is sight reduction. Moreover, it creates damages to health problems such as respiratory problems and infecting the human environment. It also creates disturbances in the country's air transportation system. Medical studies have showed that eyesight problems and respiratory diseases such as asthma and infectious diseases are the most important effects of dust storms (Marjani, 1994). West and south-west of the country are the regions that experience this phenomenon, yearly. The purpose of the present study was to analyze the procedure of dust phenomenon and provide a model to changing of Khuzestan's dust phenomenon, based on Mann-Kendall and Sense-Estimator nonparametric methods in two periods of the year include warm period (spring and summer) and cold period (autumn and winter). Dust storms as one of the most important atmospheric pollutions and environmental hazards have attracted the attention of researchers and each of them has investigated an aspect of the phenomenon. One of the early works in this field which can be pointed out is Romanov research done in 1961; he investigated the dust storms in Central Asia and Kazakhstan and concluded that most of these storms occur in the warm period of the year. Wai and Shaavinshi (2001) are among those who studied the reasons of dust storms occurrence and their effects on the climate of China; they have considered the global warming zone in Mongolia and

cooling of lands in north China as the main causes of dust storms creation in the country, especially in the Trim Basin. Couts (1987) studied the two-dimensional analysis of the dynamics and microphysics of dust storms in the Sahara desert. Serd (1960) stated that one of the meteorological phenomenons during dust storms is the Vaykov phenomenon. Nehsert *et al.,* (2002) investigated dust storms in Mongolia during the period 1937 to 1999. Orlovoski (1962) performed a study on temporal-spatial distribution of dust and sand storms in Turkistan. Diane (1986) used synoptic analysis and classification of prevailing weather conditions in Palestine and concluded that there are significant differences between the patterns of these seasonal routes. Brazel and Nickling (1988) classified atmospheric circulations based on Arizona dust storms and identified four major types of weather. Fuling *et al.*, (2002) presented a model of development of severe dust storms in northwest China. Hyme (2003) studied the main source and temporal-spatial characteristic of dust storms in Middle East. He used cluster analysis to identify four main areas of dust with the highest storm frequency. Marjani (1994) used synoptic maps to investigate severe winds of over 15 meters per second in Khorasan and also presented five classifications to the factors influencing the occurrence of dust storms in the region by performing a synoptic and topographic survey on Khorasan. Hemati (1995) investigated the frequency of dust storms occurring in the South and West regions of the country. Salari (1996) with studying vertical distribution of dust believed that the resulted dust which is mostly made of the colloidal particles is less often a function of barrier and is more depend on the continuity and strength of the wind. Among the preliminary studies on climate prediction, one can point pout the work of Alijani and Ramadan (2001) who used the Box-Jencks model to predict the droughts and wet periods of the province. Alijani (2005), presented the temporal and spatial zoning map of dust along side with investigating the causes of dust in Iran. Kaviani (2007) has considered the weather instability as main cause of the dust storms in deserts. Raeespour (2007) has investigated the statistical analysis and synoptic Dust storms in Khuzestan. Heidari (2007) concluded that closed Cyclones in Iraq and Saudi Arabia are the reason behind dust storms in Kermanshah, after studying a sample of dust-generating system in the province. Tavosi *et al.,* (2010) analyzed synoptic weather systems affecting the dust in Khuzestan in two warm and cold periods throughout the year and concluded that in cold period westerly winds and the influence of the polar front and low-pressure heating surfaces of earth in warm period of the year are the main cause of the mentioned phenomena in the province.

MATERIALS AND METHODS

Khuzestan province is located in southwest part of the country in the geographic range of 29 degrees 56 minutes and 33 degrees 5 minutes of north latitude and 47 degrees 42 minutes and 50 degrees 22 minutes of east latitude. The area of the province is 67 thousand square kilometers. The height changing range of province varies from about zero to 4,000 meters which divides the province into two parts of plain with the area of about 41,000 km and mountainous with the area of about 26,000 square kilometers (Hoghoughi, 1996).

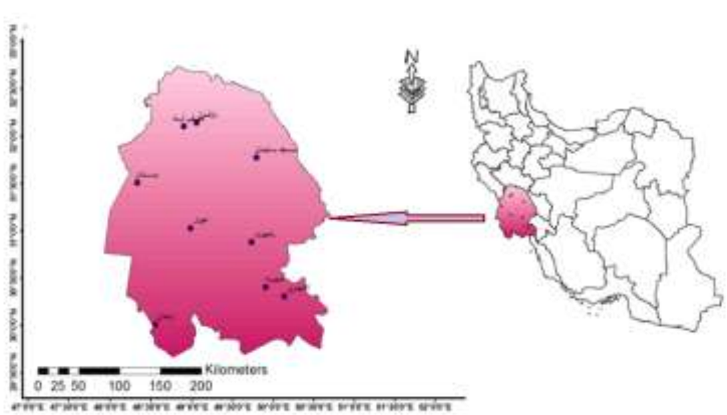

Figure 1: The stations studied in Khuzestan province and country

Khuzestan province is composed of diverse climates, due to the high height differences in different regions and the existence of Persian Gulf, which the vast majority of them are made of the plain areas of arid and semi-arid desert climates and changes to dry and weak semi-dry and semi-humid in the heights (Ghasemi and Sepaskhah, 2003). In Khuzestan province, the occurrence of dust has gotten higher with more intensity and persistence, due to closeness to huge deserts like south of Iraq and Arabia and also the drought conditions of recent years.

In the present, the monthly rainfall data from 9 synoptic stations within the scope of Khuzestan were used, so that the whole area of province was covered. The characteristics of the stations have been shown in Table 1. The data series of warm period i.e Spring and summer (April to September) and cold period (October to March) were created in monthly and quarterly scales in order to perform the present study. The Data Tester software was used for preparation and quality control of data, Minitab 14 to normalize the data and Arc GIS 9.3 for zoning the calculated values, after creating the databank.

Period	Height	Latitude	Longitude	Station
1951-2005	6/6	30 22	48 15	Abadan
1985-2005	320/5	31 56	49 17	Masjed Soleyman
1955-2005	22/5	31 20	48 40	Ahvaz
1961-2005	143	32 24	48 23	Dezful
1987-2005	82/9	32 16	48 25	Safiabad
1983-2005	34/9	30 46	49 39	Omidiyeh
1984-2005	27	30 48	49 40	Aghajari
1986-2005	7/8	31 43	48 00	Bostan
1987-2005	150/5	31 16	49 36	Ramhormuz

Figure 2: Stations Characteristics

The procedure tests are classified into two categories of parametric and non-parametric. The default of the parameter tests is that the data are random and outcomes of a normal distribution. However, the assumption of normality of the data doesn't exist in the non-parametric tests. Therefore, using non-parametric tests seems more prudent, when we are not sure about the normality of the data. However, some researchers have shown that the difference between two methods is meaningless about most elements (Vinikov 2002). Here, for doing the temperature test we assumed that temperature is a linear function of time. Therefore, the changing model will be as follows:

Temperature = α + Q

It is clear that a positive value for Q indicates an increase in temperature with time and a negative value indicates a decrease in temperature with time. The assumption of procedure existence is not confirmed for Q=0. But since the value of Q is unknown it can be obtained an estimation of Q with 95 percent certainty by the following equation (Batacharia *et al.*, 1977):

$$Q = \frac{Xi' - Xi}{i' - i}$$

If the high and low limits of Q which are obtained in this way are both positive the assumption of procedure existence is not rejected for temperature. If the high and low limits of Q are both negative, the assumption of procedure existence is proved and if the high and low limits of Q have different marks the assumption of procedure existence is not confirmed (Masoudian, 2003).

RESULTS AND DISCUSSION

Research Findings

The occurrence of dust storms is one the climate characteristics of Khuzestan province. This area is almost constantly being affected by this phenomenon due to its proximity to the vast expanse of deserts.

In terms of synopsis, westerly winds migratory systems, cyclones and the influence along its front polar, play an important role in the creation and development of dust storms In Khuzestan by creating instability in the Arabic desert land adjacent to the area during the cold period of the year. In the warm period of the year which is the case study of this research, the establishment of a center of low pressure on the Persian Gulf and its surroundings (Embayment of Persian Gulf) is the main cause of dust storms in Khuzestan. In order to analyze the phenomenon of dust the Z value was first calculated by the Man Kendal statistics so that a general trend is determined for the stations. After determining the Z value and trend using the Man Kendal statistic, its extent and direction were calculated based on nonparametric Sense-Estimator statistics, for a final comparison between the tests and the final model validation. After determining dust's trend of time series, the slope equations for each of the stations were extracted for estimations in coming years by calculating Q and B values with upper and lower boundaries. According to the results of dust phenomenon trend of time series alternations in Abadan station and generally given the annual scale, the procedure exists in %90 confidence level and the changes are decreasing which its reason can be considered proximity to the waters of the Persian Gulf and non- proximity with the desert in south of Iraq. In Abadan station for cold period, only February in winter, April in spring and November and December in the autumn didn't have significant trend and in the other months the phenomenon of dust had a significant trend which was decreasing. In Abadan station, the significantly of dust phenomenon occurrence was increased from cold period to warm period. There was a decreasing trend in the warm period of June and September at a confidence level of %99. In Abadan, the further we go from spring to summer, the frequency and intensity of the phenomenon of dust decreases which causes the sultry summer weather and not allowing the completion of dust systems. Ahvaz station situation is different. From Man Kendall's statistics point of view, Ahvaz has a confidence level of 95 percent in the spring in April (39/2) and May (3.2) with an increasing trend direction. But according to Sense statistics, in addition April and May months, September too due to both upper and lower bounds having the same direction, has a procedure of 95% level confidence with an increasing direction. In the cold period of the year, in winter, there was no special trend seen except in February. But in the autumn in the months of October and November there was a trend at a %95 level with an increasing direction; and no trend at all in December. There was no significant trend in Dezful station during the warm period (spring and summer) of the year; only a weak decreasing trend in late summer in September, according to Man Kendall statistics. In the cold period of the year in winter in late March, there was only a 95 percent decreasing trend and another one in late autumn in December. Omidiyeh stations in South-East part of the province, due to the distance and the having the same width with Abadan station, did not have any significant trend in any month and only had an upward trend in mid-autumn at %95 level in its data series. Aghajari station also, because of taking advantage from Omidiyeh station, had no significant trend in the warm period of the year in the data series; but the situation changed for this station in the cold period of the year; meaning given the agreement between the upper and lower bounds there was a trend at the %95 level with a decreasing direction in February in winter and in October and November in autumn. Man Kendall statistics showed the existence of a trend in Masjed Soleyman station in spring months. April (88.2) with a confidence level of 99% and June (18.02) with a confidence level of 95 percent had an increasing trend. But Sense statistics and checking the upper and lower bounds showed that in addition to the two mentioned months, May and September had an increasing trend with the confidence level of 95 percent. There was no significant tend observed in Masjed Soleyman in none of the cold seasons and the discordance between the upper and lower bounds was a confirmation for data sets of the cold period of this station. Masjed Soleyman station had an increasing trend with a confidence level of 95 percent on an annual basis. The two tests showed same results about Bostan station. In Bostan station there was an increasing trend in the beginning of spring in April (2.15) and no trend in other months. According to Man Kendall statistics, there was a decreasing trend in Ramhormuz station on June (52/2) and September (97/1) at a 95% level; while Sense statistics and checking upper bounds in both confidence levels of 95 and 99 showed no trends in Ramhormuz station data sets. According to Kendall statistic Safiabad station had an increasing trend at 95 percent in early summer in July (2.31); but according to Sense statistics in addition to July, there was also a trend at 95%observed in April. The results of calculations using nonparametric, Man Kendall and Sense statistics are shown in Tables 2-10.

Table 2: Results of nonparametric statistics at 95 and 99 percent of Abadan station

Time series	Test Z	Signific.	Q	Qmin99	Qmax99	Qmin95	Qmax95	B
JAN.	-2.57422	*	-0.02941	-0.07692	0	-0.06667	0	2.264706
FEB.	-1.0181		0	-0.08187	0.032633	-0.06403	0	3
MAR.	-2.42831	*	-0.08696	-0.18623	0	-0.16207	0	7.826087
APR.	-1.11654		-0.03846	-0.14286	0.047614	-0.11717	0.022621	8.038462
MAY	-1.6761	+	-0.0625	-0.17857	0.032521	-0.14815	0	11.625
JUNE	-3.28326	**	-0.19048	-0.32415	-0.04	-0.28571	-0.06506	20.19048
JULY	-2.29181	*	-0.12766	-0.28109	0	-0.24259	0	18.42553
AUG.	-2.02338	*	-0.11111	-0.27027	0.02439	-0.22222	0	12.77778
SEP.	-2.67548	**	-0.09091	-0.18182	0	-0.15778	-0.02044	8.545455
OCT.	-2.02695	*	-0.04651	-0.11111	0	-0.09302	0	5.093023
NOV.	0.731709		0	-0.0276	0.057143	0	0.045554	2
DEC.	-1.10121		0	-0.04566	0	-0.02743	0	1
ANNUAL	-3.19549	**	-0.93617	-1.68133	-0.20077	-1.46672	-0.36364	105.3617

Table 3: Results of nonparametric statistics at 95 and 99 percent of Ahvaz Station

Time series	Test Z	Signific.	Q	Qmin99	Qmax99	Qmin95	Qmax95	B
JAN.	0.805834		0	0	0.043478	0	0.031706	1
FEB.	1.912828	+	0.047619	0	0.142857	0	0.121212	1
MAR.	1.536364		0.045455	-0.02941	0.142857	0	0.121212	2.909091
APR.	2.39925	*	0.117647	0	0.25	0	0.21875	3.470588
MAY	2.377103	*	0.12932	0	0.272727	0	0.239966	4.154961
JUNE	0.561878		0.032563	-0.125	0.23077	-0.08333	0.1875	9.706933
JULY	1.451281		0.10961	-0.07417	0.318361	-0.03068	0.271363	7.588589
AUG.	1.075985		0.033333	-0.06873	0.156963	-0.02773	0.128008	5.366667
SEP.	1.34747		0.041667	-0.03226	0.15	0	0.133333	3.833333
OCT.	2.393682	*	0.054805	0	0.166667	0	0.128503	1.725976
NOV.	2.016871	*	0.052632	0	0.112761	0	0.096774	1.421053
DEC.	0.882517		0	0	0.07682	0	0.05722	1
ANNUAL	2.362274	*	0.8	-0.09354	2	0.171429	1.698167	35.2

Table 3: Results of nonparametric statistics at 95 and 99 percent of Dezful Station

Time series	Test Z	Signific.	Q	Qmin99	Qmax99	Qmin95	Qmax95	B
JAN.	0.805834		0	0	0.043478	0	0.031706	1
FEB.	1.912828	+	0.047619	0	0.142857	0	0.121212	1
MAR.	1.536364		0.045455	-0.02941	0.142857	0	0.121212	2.909091
APR.	2.39925	*	0.117647	0	0.25	0	0.21875	3.470588
MAY	2.377103	*	0.12932	0	0.272727	0	0.239966	4.154961
JUNE	0.561878		0.032563	-0.125	0.23077	-0.08333	0.1875	9.706933
JULY	1.451281		0.10961	-0.07417	0.318361	-0.03068	0.271363	7.588589
AUG.	1.075985		0.033333	-0.06873	0.156963	-0.02773	0.128008	5.366667
SEP.	1.34747		0.041667	-0.03226	0.15	0	0.133333	3.833333
OCT.	2.393682	*	0.054805	0	0.166667	0	0.128503	1.725976
NOV.	2.016871	*	0.052632	0	0.112761	0	0.096774	1.421053
DEC.	0.882517		0	0	0.07682	0	0.05722	1
ANNUAL	2.362274	*	0.8	-0.09354	2	0.171429	1.698167	35.2

Table 3: Results of nonparametric statistics at 95 and 99 percent of Omidiyeh Station

Time series	Test Z	Signific.	Q	Qmin99	Qmax99	Qmin95	Qmax95	B
JAN.	0.805834		0	0	0.043478	0	0.031706	1
FEB.	1.912828	+	0.047619	0	0.142857	0	0.121212	1
MAR.	1.536364		0.045455	-0.02941	0.142857	0	0.121212	2.909091
APR.	2.39925	*	0.117647	0	0.25	0	0.21875	3.470588
MAY	2.377103	*	0.12932	0	0.272727	0	0.239966	4.154961
JUNE	0.561878		0.032563	-0.125	0.23077	-0.08333	0.1875	9.706933
JULY	1.451281		0.10961	-0.07417	0.318361	-0.03068	0.271363	7.588589
AUG.	1.075985		0.033333	-0.06873	0.156963	-0.02773	0.128008	5.366667
SEP.	1.34747		0.041667	-0.03226	0.15	0	0.133333	3.833333
OCT.	2.393682	*	0.054805	0	0.166667	0	0.128503	1.725976
NOV.	2.016871	*	0.052632	0	0.112761	0	0.096774	1.421053
DEC.	0.882517		0	0	0.07682	0	0.05722	1
ANNUAL	2.362274	*	0.8	-0.09354	2	0.171429	1.698167	35.2

Table 3: Results of nonparametric statistics at 95 and 99 percent of Aghajari Station

Time series	Test Z	Signific.	Q	Qmin99	Qmax99	Qmin95	Qmax95	B
JAN.	0.805834		0	0	0.043478	0	0.031706	1
FEB.	1.912828	+	0.047619	0	0.142857	0	0.121212	1
MAR.	1.536364		0.045455	-0.02941	0.142857	0	0.121212	2.909091
APR.	2.39925	*	0.117647	0	0.25	0	0.21875	3.470588
MAY	2.377103	*	0.12932	0	0.272727	0	0.239966	4.154961
JUNE	0.561878		0.032563	-0.125	0.23077	-0.08333	0.1875	9.706933
JULY	1.451281		0.10961	-0.07417	0.318361	-0.03068	0.271363	7.588589
AUG.	1.075985		0.033333	-0.06873	0.156963	-0.02773	0.128008	5.366667
SEP.	1.34747		0.041667	-0.03226	0.15	0	0.133333	3.833333
OCT.	2.393682	*	0.054805	0	0.166667	0	0.128503	1.725976
NOV.	2.016871	*	0.052632	0	0.112761	0	0.096774	1.421053
DEC.	0.882517		0	0	0.07682	0	0.05722	1
ANNUAL	2.362274	*	0.8	-0.09354	2	0.171429	1.698167	35.2

Table 3: Results of nonparametric statistics at 95 and 99 percent of Masjed Soleyman Station

Time series	Test Z	Signific.	Q	Qmin99	Qmax99	Qmin95	Qmax95	B
JAN.	0.805834		0	0	0.043478	0	0.031706	1
FEB.	1.912828	+	0.047619	0	0.142857	0	0.121212	1
MAR.	1.536364		0.045455	-0.02941	0.142857	0	0.121212	2.909091
APR.	2.39925	*	0.117647	0	0.25	0	0.21875	3.470588
MAY	2.377103	*	0.12932	0	0.272727	0	0.239966	4.154961
JUNE	0.561878		0.032563	-0.125	0.23077	-0.08333	0.1875	9.706933
JULY	1.451281		0.10961	-0.07417	0.318361	-0.03068	0.271363	7.588589
AUG.	1.075985		0.033333	-0.06873	0.156963	-0.02773	0.128008	5.366667
SEP.	1.34747		0.041667	-0.03226	0.15	0	0.133333	3.833333
OCT.	2.393682	*	0.054805	0	0.166667	0	0.128503	1.725976
NOV.	2.016871	*	0.052632	0	0.112761	0	0.096774	1.421053
DEC.	0.882517		0	0	0.07682	0	0.05722	1
ANNUAL	2.362274	*	0.8	-0.09354	2	0.171429	1.698167	35.2

Table 3: Results of nonparametric statistics at 95 and 99 percent of Bostan Station

Time series	Test Z	Signific.	Q	Qmin99	Qmax99	Qmin95	Qmax95	B
JAN.	0.805834		0	0	0.043478	0	0.031706	1
FEB.	1.912828	+	0.047619	0	0.142857	0	0.121212	1
MAR.	1.536364		0.045455	-0.02941	0.142857	0	0.121212	2.909091
APR.	2.39925	*	0.117647	0	0.25	0	0.21875	3.470588
MAY	2.377103	*	0.12932	0	0.272727	0	0.239966	4.154961
JUNE	0.561878		0.032563	-0.125	0.23077	-0.08333	0.1875	9.706933
JULY	1.451281		0.10961	-0.07417	0.318361	-0.03068	0.271363	7.588589
AUG.	1.075985		0.033333	-0.06873	0.156963	-0.02773	0.128008	5.366667
SEP.	1.34747		0.041667	-0.03226	0.15	0	0.133333	3.833333
OCT.	2.393682	*	0.054805	0	0.166667	0	0.128503	1.725976
NOV.	2.016871	*	0.052632	0	0.112761	0	0.096774	1.421053
DEC.	0.882517		0	0	0.07682	0	0.05722	1
ANNUAL	2.362274	*	0.8	-0.09354	2	0.171429	1.698167	35.2

Table 3: Results of nonparametric statistics at 95 and 99 percent of Ramhormuz Station

Time series	Test Z	Signific.	Q	Qmin99	Qmax99	Qmin95	Qmax95	B
JAN.	0.805834		0	0	0.043478	0	0.031706	1
FEB.	1.912828	+	0.047619	0	0.142857	0	0.121212	1
MAR.	1.536364		0.045455	-0.02941	0.142857	0	0.121212	2.909091
APR.	2.39925	*	0.117647	0	0.25	0	0.21875	3.470588
MAY	2.377103	*	0.12932	0	0.272727	0	0.239966	4.154961
JUNE	0.561878		0.032563	-0.125	0.23077	-0.08333	0.1875	9.706933
JULY	1.451281		0.10961	-0.07417	0.318361	-0.03068	0.271363	7.588589
AUG.	1.075985		0.033333	-0.06873	0.156963	-0.02773	0.128008	5.366667
SEP.	1.34747		0.041667	-0.03226	0.15	0	0.133333	3.833333
OCT.	2.393682	*	0.054805	0	0.166667	0	0.128503	1.725976
NOV.	2.016871	*	0.052632	0	0.112761	0	0.096774	1.421053
DEC.	0.882517		0	0	0.07682	0	0.05722	1
ANNUAL	2.362274	*	0.8	-0.09354	2	0.171429	1.698167	35.2

Indian Journal of Fundamental and Applied Life Sciences ISSN: 2231– 6345 (Online)
An Open Access, Online International Journal Available at www.cibtech.org/sp.ed/jls/2015/03/jls.htm
2015 Vol. 5 (S3), pp. 1502-1512/Tabatabaie et al.
Research Article

Table 3: Results of nonparametric statistics at 95 and 99 percent of Safiabad Station

Time series	Test Z	Signific.	Q	Qmin99	Qmax99	Qmin95	Qmax95	B
JAN.	0.805834		0	0	0.043478	0	0.031706	1
FEB.	1.912828	+	0.047619	0	0.142857	0	0.121212	1
MAR.	1.536364		0.045455	-0.02941	0.142857	0	0.121212	2.909091
APR.	2.39925	*	0.117647	0	0.25	0	0.21875	3.470588
MAY	2.377103	*	0.12932	0	0.272727	0	0.239966	4.154961
JUNE	0.561878		0.032563	-0.125	0.23077	-0.08333	0.1875	9.706933
JULY	1.451281		0.10961	-0.07417	0.318361	-0.03068	0.271363	7.588589
AUG.	1.075985		0.033333	-0.06873	0.156963	-0.02773	0.128008	5.366667
SEP.	1.34747		0.041667	-0.03226	0.15	0	0.133333	3.833333
OCT.	2.393682	*	0.054805	0	0.166667	0	0.128503	1.725976
NOV.	2.016871	*	0.052632	0	0.112761	0	0.096774	1.421053
DEC.	0.882517		0	0	0.07682	0	0.05722	1
ANNUAL	2.362274	*	0.8	-0.09354	2	0.171429	1.698167	35.2

After doing the calculations related to the trend and determining the trend value the province-wide zoning was done, based on the absence of occurrence of significant dust trends. Generally, the South West parts of the province have a decreasing trend in the spring while the south part of the province has no trend and the northern part has an increasing trend. Ramhormuz is the only station which has a decreasing trend in its central part. The situation alters in summer. Abadan, Aghajari and Ramhormuz stations have same negative decreasing trend. Instead, the increasing trend range gets higher compared to spring and takes over the central part of the province.

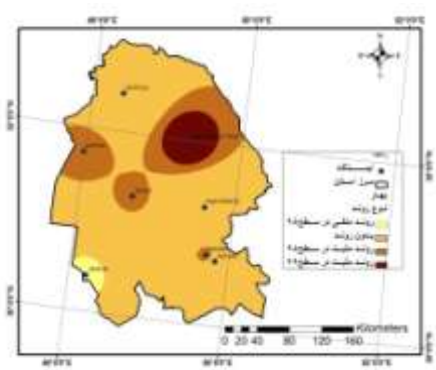

Figure 3: Spring Trend Zoning

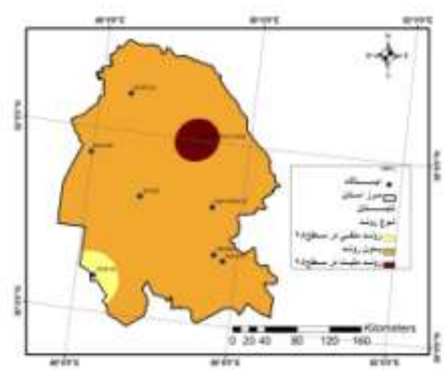

Figure 4: Summer Trend Zoning

Figure 5: Autumn Trend Zoning

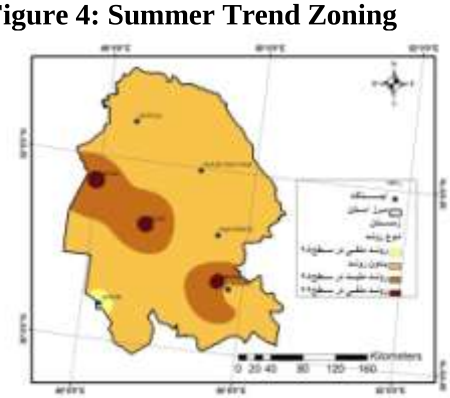

Figure 6: Winter Trend Zoning

There is not any trend observed in other parts of the province except for the Safiabad station. The increasing trend gets limited in autumn in the northern parts of the province and takes over Ahvaz and

Masjed Soleyman stations as an island. The decreasing trend range gets higher in autumn in South and South-East parts of the province. In terms of trend range, autumn and winter are similar. The difference is that in the winter Safiabad and Dezful have a decreasing trend in the number of days in the dust in their range. According to the maps of trend zones, generally, the further we go from cold period of the year to the warm period the positive increasing trend of dominated areas increases. Figures 2-5 show the zoning of the dust phenomenon in different seasons of the year. Two examples of trend slope diagrams for Ahvaz and Abadan stations with upper and lower boundaries which obtained by Sense test at 95 and 99 certainty levels, have been shown in Figure 7 and 8.

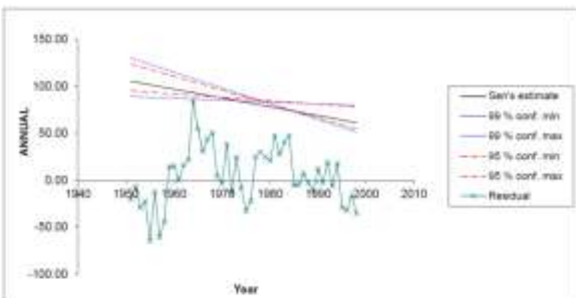

Figure 7: Abadan dust trend slope diagram

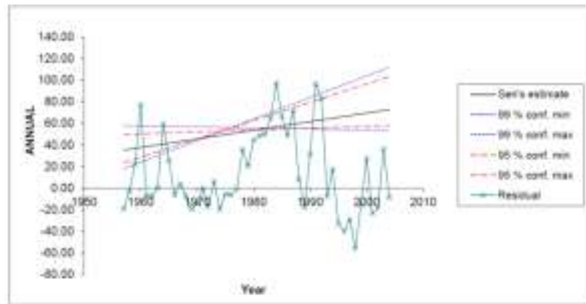

Figure 8: Ahvaz dust trend slope diagram

After determining and analyzing the trend of the stations on monthly, seasonal and annual scales and determining the values of Q and B which are the main components of the equation model, the slope equations were designated for dust storms forecast of Khuzestan province, for the scales that had a significant trend. The mentioned equations are shown in Table 11. With replacing the base year and the year of the forecast **the d**ust phenomena can be predicted for the province in future.

F(y) =Q*(year –first data year) +B

Table 11: Trend Slope Equations to estimate the dust in the warm period of the year for the scales with a significant trend

Trend equation for estimation	Scale	Station	Trend equation for estimation	Scale	Station
F(y)=0/115*(y –fd.y) +12/90	Sept	Dezful	F(y)= -0/063*(y –fd.y) +11/63	May	
F(y)=0/306*(y –fd.y) +1	April		F(y)=-0/19*(y –fd.y) +20/19	June	
F(y)=0/477*(y –fd.y) +2/45	May	Masjed	F(y)= -0/128*(y –fd.y) +18/43	July	Abadan
F(y)=0/5*(y –fd.y) +4	June	Soleyman	F(y)= -0/111*(y –fd.y) +12/78	August	
F(y)=0/174*(y –fd.y) +0/61	Sept		F(y)=-0/091*(y –fd.y) +8/55	Sept	
F(y)=2/8*(y –fd.y) +23	Annual		F(y)=-0/936*(y –fd.y) +105/36	Annual	
F(y)= -0/6*(y –fd.y) +10/2	June	Ramhormuz	F(y)=0/118*(y –fd.y) +3/47	April	
F(y)= -0/2*(y –fd.y) +4	Sept		F(y)=0/129*(y –fd.y) +4/15	May	Ahvaz
F(y)=0/231*(y –fd.y) +0/54	April	Safiabad	F(y)=0/8*(y –fd.y) +35/2	Annual	
F(y)=0/667*(y –fd.y) +3/33	July		F(y)=0/333*(y –fd.y) +1	April	Bostan

Table 11: Trend Slope Equations to estimate the dust in the cold period of the year for the scales with a significant trend

Trend equation for estimation	Scale	Station	Trend equation for estimation	Scale	Station
F(y)=-0.1*(y –fd.y) +8.87	March	Dezful	F(y)= -1.29*(y –fd.y) +2.26	January	
F(y)=-0.02*(y –fd.y) +2	Dec		F(y)=-.087*(y –fd.y) +7.83	March	Abadan
			F(y)= -.047*(y –fd.y) +5.09	October	
F(y)=0/048*(y –fd.y) +1	Feb	Ahvaz	F(y)= -.083*(y –fd.y) +2.46	Februar y	Aghajari
F(y)=0/055*(y –fd.y) +1.73	Oct		F(y)=-0.1*(y –fd.y) +2.50	October	
F(y)=0.53*(y –fd.y) +1.42	Nov		F(y)=-0/05*(y –fd.y) +1.53	Novem ber	

Conclusion

The dust phenomenon of Khuzestan province was modeled and analyzed for two warm (spring and summer) and cold (autumn and winter) periods of the year in the form of 9 synoptic stations. Some of the results of the present study are as following:

- In the warm period of the year, the low pressure on the Persian Gulf is the cause of dust storms in the province.
- The results of Khuzestan's trend analysis indicated that most of the areas have an increasing trend in spring in the warm period, but only North West has an increasing trend in summer. The situation was different in the cold period. In autumn, the South East had a decreasing negative trend which moved to the northern parts of the province in winter.
- In seasonal terms, South West of the province has a decreasing trend and the northern parts have a positive increasing trend in spring. In the summer, the decreasing trend range is lower and the positive trend range increases in the northern parts of the zone.
- Changes trend in Abadan stations in both spring and summer is decreasing and negative; which is due to it being located on the coast of Persian Gulf and relatively high humidity due to the evaporation of surface water in the area.
- Masjed Soleyman, Bostan and Ahvaz stations have a positive increasing trend in spring and no trend at all in summer in their series.
- Ramhormuz station had a decreasing trend throughout the whole year according to both Sense and Kendall statistics.
- Aghajari, Omidiyeh and Dezful stations had no significant trends in two seasons of the year according to the nonparametric Sense and Man Kendall statistics.
- The use of nonparametric statistics of Sense and Man Kendall showed same results on the existence of a trend and the only difference was the level of confidence in the data set.
- Checking the final models and using the remained series showed that the Sense statistics has a high potential in estimating dust alternations in Khuzestan province.

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