JOURNAL OF NATURE AND SPATIAL SCIENCES (2022) 2(1), 67–79

Available online at www.jonass.ir

Journal of Nature and Spatial Sciences

Journal homepage: www.jonass.ir

Research Article

Investigating temporal-spatial changes in the average temperature of the Abarku-Sirjan basin

Hamed Barzegaria[a], Amir Gandomkar [b,]*, Alireza Abbasi [c]

[a]*PhD student in climatology, Department of Geography, Najafabad Branch, Islamic Azad University, Najafabad, Iran*
[b]*Associate Professor, Department of Geography, Najafabad Branch, Islamic Azad University, Najafabad, Iran*
[c]*Assistant Professor, Department of Geography, Najafabad Branch, Islamic Azad University, Najafabad, Iran*

ARTICLE INFO

Article history:
Receive Date: 29 January 2022
Revise Date: 07 May 2022
Accept Date: 14 May 2022

Keywords:
Temperature, Trend, Abarku-Sirjan basin, Spatial statistics

ABSTRACT

Background and objective: Temporal-spatial changes in climate parameters, especially temperature, are considered one of the most obvious signs of climate change in a region. The aim of this study was to investigate the average temperature changes in the Abarku-Sirjan basin.
Materials and methods: In this regard, the daily analyzed data of ERA-Interim with a resolution of 0.25 * 0.25 degrees during the period 1979-2019 were used. According to the dimensions of the studied data, 338 points covered the whole basin. The trend of the studied data was examined using the Mann-Kendall test. Hot spots analysis was then performed on them.
Results and conclusion: The results showed that the temperature has an increasing trend in most months of the year. In April, May, August, and December; some parts of the basin have no trend and the rest of the basin has an increasing trend. In general, no decreasing trend has occurred in any part of the basin during the study period. Hot spot analysis also showed that the northwest of the basin has cold spots and the south of the basin has hot spots. In general, in the basin, hot spots are more frequent in the warm months of the year and cold spots are more prevalent in cold months of the year.

1. Introduction

Climate fluctuates on short time scales and changes on long time scales. Climate change is one of the important environmental issues and the most important challenge of the present century, which in recent years has attracted many researchers in various sciences and has been the subject of many studies. Climatic elements change in time and space. Temperature is one of the important parameters of climate change, whose change is the source of many environmental changes. Rising temperature is one of the signs of climate change that will cause many environmental changes in the long run.

These changes affect the lives of humans and other creatures. Due to the negative consequences of environmental changes, including changes in surface and groundwater and increasing desertification, the role of climate and especially temperature in this regard has been highlighted

* *Corresponding author.* Tel.: 09133254097
E-mail address: aagandomkar@gmail.com , ORCID: 0000-0002-9344-7607
Peer review under responsibility of Maybod Branch, Islamic Azad University

DOI: https://dx.doi.org/10.30495/jonass.2022.1951096.1022

(Jamali et al., 2018; Jamali et al., 2020). Having information on changes in climate parameters in different places helps to find the causes of these changes and adopt the necessary policies and programs. Due to the fact that Iran is a dry and water-scarce country, the increase in temperature creates many problems in it.

Therefore, the study of temperature and its changes in the country's catchments, including Abarku-Sirjan, seems necessary. Abarku-Sirjan basin is located in the hot and low altitude part of central Iran and is different from the rest of the country due to its low altitude and distance from moisture sources. The main objective of this research is to study the trend of temperature changes in this basin. The findings of the study can be used to estimate the climatic conditions of the basin and in future planning. The effects of temperature changes on the lives of humans and even other organisms have led to much research in this regard.

The results of extensive studies conducted at the national, regional, and global levels indicate an increase in temperature in many parts of the world and generally an increase in average air temperature. Stafford et al. (2000, 36) examined the night, day, and 24-hour temperatures of 25 stations in Alaska and found that the temperature had risen at all stations. Yue and Hoshinio (2003, 15) examined the monthly, seasonal, and annual temperature trends in Japan over the past 100 years and concluded that the annual temperature of 46 stations had increased with an amount of between 0.51 and 2.77 degrees. Giorgi and Lionello (2008, 90), in their study of Mediterranean climate change, found that the maximum heat is in summer. Capilla (2008, 275), identifying and analyzing time series in the Mediterranean, concluded that there are high variations in spring and summer temperature trends.

The results of Fischer et al.'s (2010, 1) study of temperature and precipitation trends and dryness patterns in the Zhujiang River Basin in southern China showed significant positive trends in annual temperatures and warm periods, while negative trends were observed in precipitation data and cold periods. Mamtimin et al. (2011, 1105) studying the trend of temperature changes in the climate of cold and hot deserts concluded that in hot deserts, increasing trends in summer and winter are observed and in cold deserts, a positive trend in winter and a negative trend in summer are observed. Sabziparvar et al. (2011, 27) examined the trend of changes in diurnal temperature in some arid climates of Iran in the last five decades and showed that 18% of stations had no significant trend but the rest of the stations had a negative trend in most months.

Varshavian et al. (2011) examined the trend of minimum, maximum, and mean daily temperature extremes in several climatic regions of Iran and showed that most stations have a significant increase in temperature extremes, especially in the minimum temperature. Birsan et al. (2014) studied the changes in annual temperature extremes in the Carpathians and concluded that the cold extreme parameters had a decreasing trend and the warm extreme parameters had an increasing trend. Gonçalves et al. (2014) examined the annual and seasonal trends of temperature and precipitation trends in the North-Western Mediterranean Basin by dynamical downscaling of climate scenarios at high resolution and predicted that the temperature would increase in all studied scenarios, especially during the summer and in high latitudes. Ghahari et al. (2015) examined the temperature trend of the Shiraz station applying the Mann-Kendall statistical method.

The results showed that despite the lack of trends in the long run, after the onset of the cold phenomenon, the absolute minimum daily temperature of Shiraz is decreasing and the maximum annual absolute temperature of Shiraz is increasing. Aliabadi and Dadashi (2015: 86) investigated the patterns of spatial autocorrelation of Iran's maximum temperature. The results showed that the maximum temperature changes in Iran have a high cluster pattern. Yu and Li (2015) in a study examined the trend of temperature fluctuations in northern China during the period 1960-2011 and found that during the study period, significant changes in maximal temperature occurred, especially in stations within these regions. Asadi and Karami (2017, 64) studied temperature changes in Fars province using spatial statistics. Also, Jamali et al. (2022) studied temperature anomaly in Iran.

The results showed that the spatial-temporal changes in temperature in Fars province have a high cluster pattern. In another study, Mina et al. (2020, 485) examined the mean global temperature and suggested that the LTM observed in the climatic system should be controlled by two types of internal and external variables. Montazeri and Masoodian (2020, 35) studied the temporal-spatial behavior of the heat island of Isfahan. The results showed that the changes that the city has made in humidity, albedo, and composition of the atmosphere have played an important role in the formation of the heat island.

Tajik and Arbabi (2020: 109) studied the changes in Iran's extreme temperatures and found that Iran's temperature levels are increasing. Mirhoseini et al. (2021, 125) studied the trend of temperature changes in the eastern regions of Iran and found that the average temperature in most months and most stations has increased. Zarrin et al. (2021, 35) studied the temperature trend of Iran in different climatic zones and concluded that the temperature of Iran will increase by 0.05 degrees Celsius in future periods. Sabzevari et al. (2022, 41) studied the annual changes in Dezful rainfall using the Mann-Kendall test and concluded that Dezful rainfall had a decreasing trend. Studies on temperature show that the temperature does not change uniformly in all parts of the world, i.e., the temperature has increased in most parts of the world, but the intensity and time of temperature increase are not the same everywhere. Therefore, temperature changes and rising temperatures have become an issue that cannot be easily ignored and underestimated.

Due to the fact that temperature is a dominant climatic element among climatic elements, its change affects other elements as well. In Iran, due to the lack of monitoring stations in all areas and the existence of newly established stations, most areas do not have valid data, so gridded data is very useful in this regard. Therefore, the use of these data has become popular in recent years. The study literature showed that so far no study has been done on the temperature trend of the Abarku-Sirjan basin using gridded data and modern methods of spatial statistics. The present study has been conducted assuming an increase in temperature in the Abarku-Sirjan basin. To achieve more accurate and reliable results, the purpose of this study is to investigate the average temperature of Abarku-Sirjan basin using gridded data and modern methods of spatial statistics.

2. Data and methodology

Abarku-Sirjan basin is one of the sub-basins of Iran and is a subset of Iran’s Central Plateau catchment. The area of this basin is 57196 square kilometers and it is located from 28˚ 37' to 31˚ 92' north latitude and 52 ˚ 09' to 56 ˚ 27' east longitude (see Fig. 1)

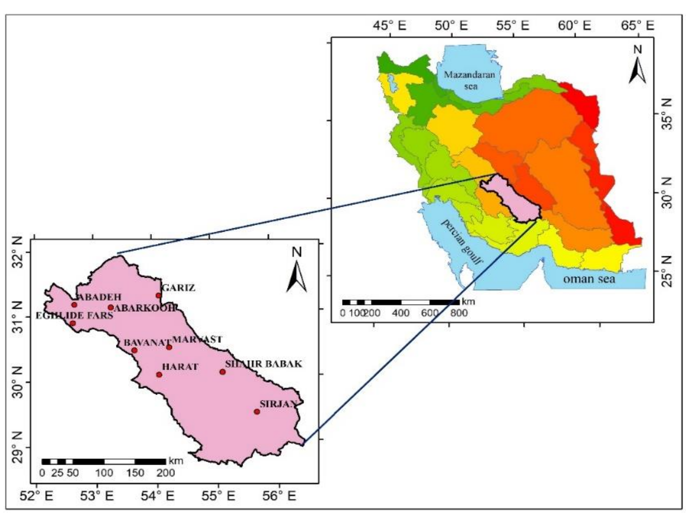


Fig. 1 - Location of Abarku-Sirjan basin in Iranian basins.

In this study, the daily analyzed data of ERA-Interim with a resolution of 0.25 * 0.25 degrees during the period 1979-2019 from the ECMWF site (European Centre for Medium-Range Weather Forecasts) have been used. According to the area of the Abarku-Sirjan basin region and the resolution of the studied data, 338 points covered the whole basin and were studied (Fig. 2). After extracting the data and preparing and formatting them, their process was examined by the Mann-Kendall test. Then hot spots analysis was performed on them and hot spots and cold spots were identified in three significant levels of 99, 95, and 90%.

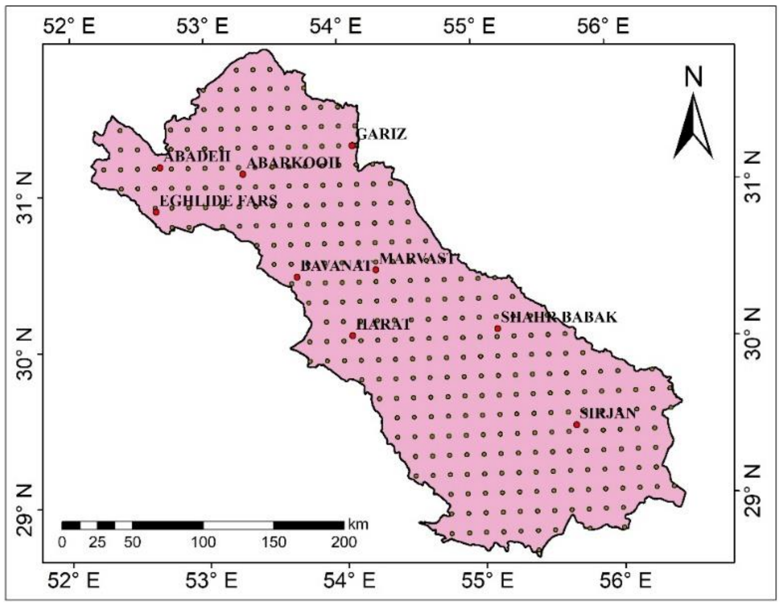


Fig. 2 - Dispersion of study points.

2.1. Mann-Kendall test

This test was first proposed by Mann (1945) and then developed by Kendall (1975) (Serrano, 1999, 85). This method is widely used in the analysis of the process of hydrological and meteorological series (Lettenmaier &Wallis 1994, 586). One of the strengths of this method is its suitability for time series that do not follow a specific statistical distribution. The low affectability of this method from the limit values observed in some time series is another advantage of using this method (Turgay & Ercan, 2005). This test is used to determine randomness and trend in series. If there is a trend, the data are non-random and equation (1) is used to determine the randomness of the data (Farajzadeh et al., 2010).

$$T = \frac{4P}{N(N-1)} - 1 \qquad (1)$$

Where T is the Mann-Kendall statistic and P is the total number of ranks larger than row ni which is placed after that and obtained by the following equation (2):

Hot spots use Getis-Ord G statistics for the effects on the data (Rogerson, 2006, 275). The z-score indicates the areas in which the data are clustered with high or low values. Hot spots are the ones when both the feature itself and its neighboring features are considered to be statistically significant. The z-score for the final output is obtained when the local sum of the feature and its neighbor is

$$p = \sum_{i-1}^{N-1} ni \quad (2)$$

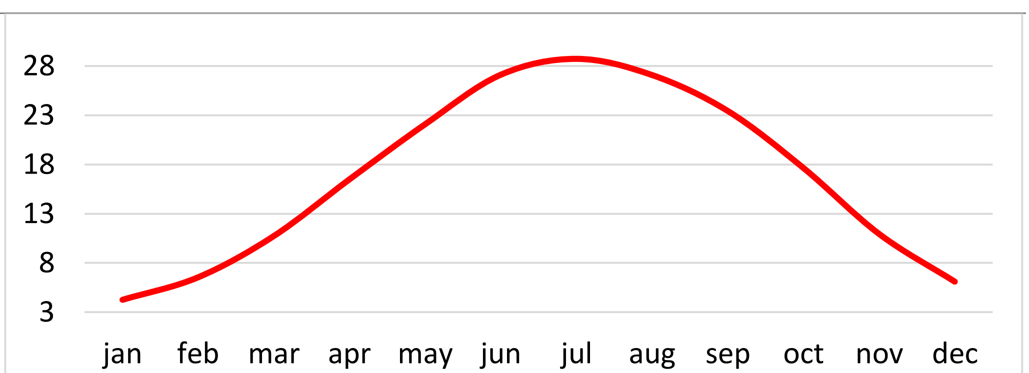
compared relative to the total sum of the features (Jacquez & Greiling, 2003, 2). Getis-Ord G statistics are calculated from Equation (3).

$$G_i = \frac{\sum_{j=1}^{n} w_{ij} xj - \overline{X \sum_{j=1}^{n} w_{ij}}}{S \sqrt{\frac{n \sum_{j=1}^{n} W_{ij}^2 - \left(\sum_{j=1}^{n} w_{ij}\right)^2}{n-1}}} \quad (3)$$

Where xj is the value of the attribute for feature j, wij is the spatial weight between feature i and j and n is the total number of features.

3. Discussion.

The average temperature of the Abarku-Sirjan basin during the study period shows that the average basin temperature is 16.76 ° C. Fig. 3 shows the trend of changes and the average monthly temperature in this basin. The highest temperature occurred in July and the lowest temperature occurred in January. During January, February, March, November, and December, the temperature is lower, and in other months, it is higher.



Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
4/26	6/54	10/73	16/49	22/08	27/11	28/72	27/07	23/43	17/64	10/94	6/1

Fig. 3 - Average temperature of the basin during the study period.

Fig. 4 shows the average zoning map of the basin temperature. According to this figure, the average temperature of the basin varies between 13 and 20 degrees Celsius. The southern parts of the basin have higher temperatures. The northwest of the basin, where Abadeh and Eqlid stations of Fars province are located, has the lowest temperature. Most of the basin has a temperature between 16.2 to 17.5 degrees Celsius.

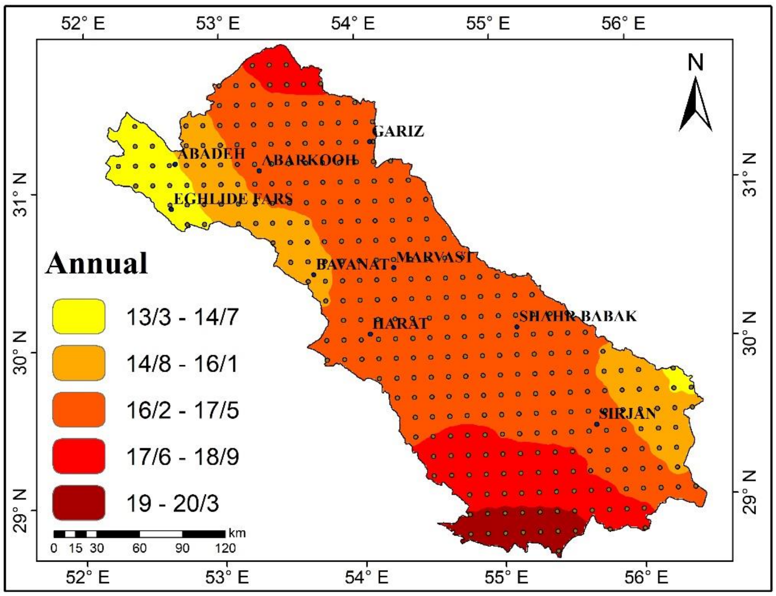


Fig. 4 - Zoning map of basin's medium temperature during the study period.

The average temperature trend of Abarku-Sirjan basin area was studied and it was found that except for April, May, August, and December, the maps of which are presented in Fig. 5, other months only have an upward trend. In April, the northern areas and parts of the west and east of the basin have an increasing trend. Other parts of the basin have no trend. In this month, 37.05% of the basin area is covered by the upward trend zone and 62.94% by the non-trend zone Table 1. In May, the northern half of the basin has an increasing trend and covers 48.95% of the basin area. The southern half with an area of 29252.85 square kilometers is without trend and covers 51.04 percent of the basin area. In August, only a very small part of the northern basin showed an upward trend. This part with an area of 5728.55 square kilometers includes 9.99% of the basin area. Other parts of the basin, which cover about 90% of the basin area, do not have any trend. In December, the upward trend zone has expanded and it would cover more parts of the basin. This month, in the northern half of the basin, parts of the center and south of the basin have had an increasing trend. The increasing trend zone in this month with an area of 43886.6 square kilometers has covered 76.57 square kilometers of the basin area. The trendless zone with an area of 13422.44 square kilometers includes 23.42 percent of the basin area.

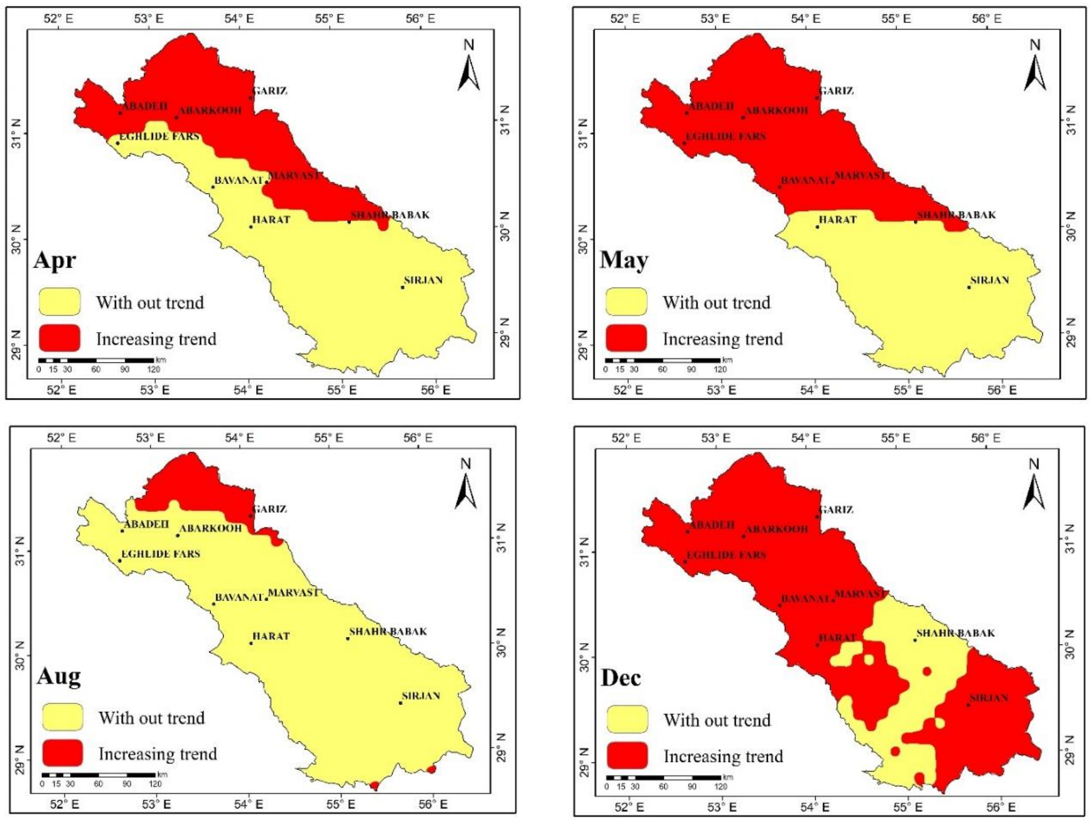


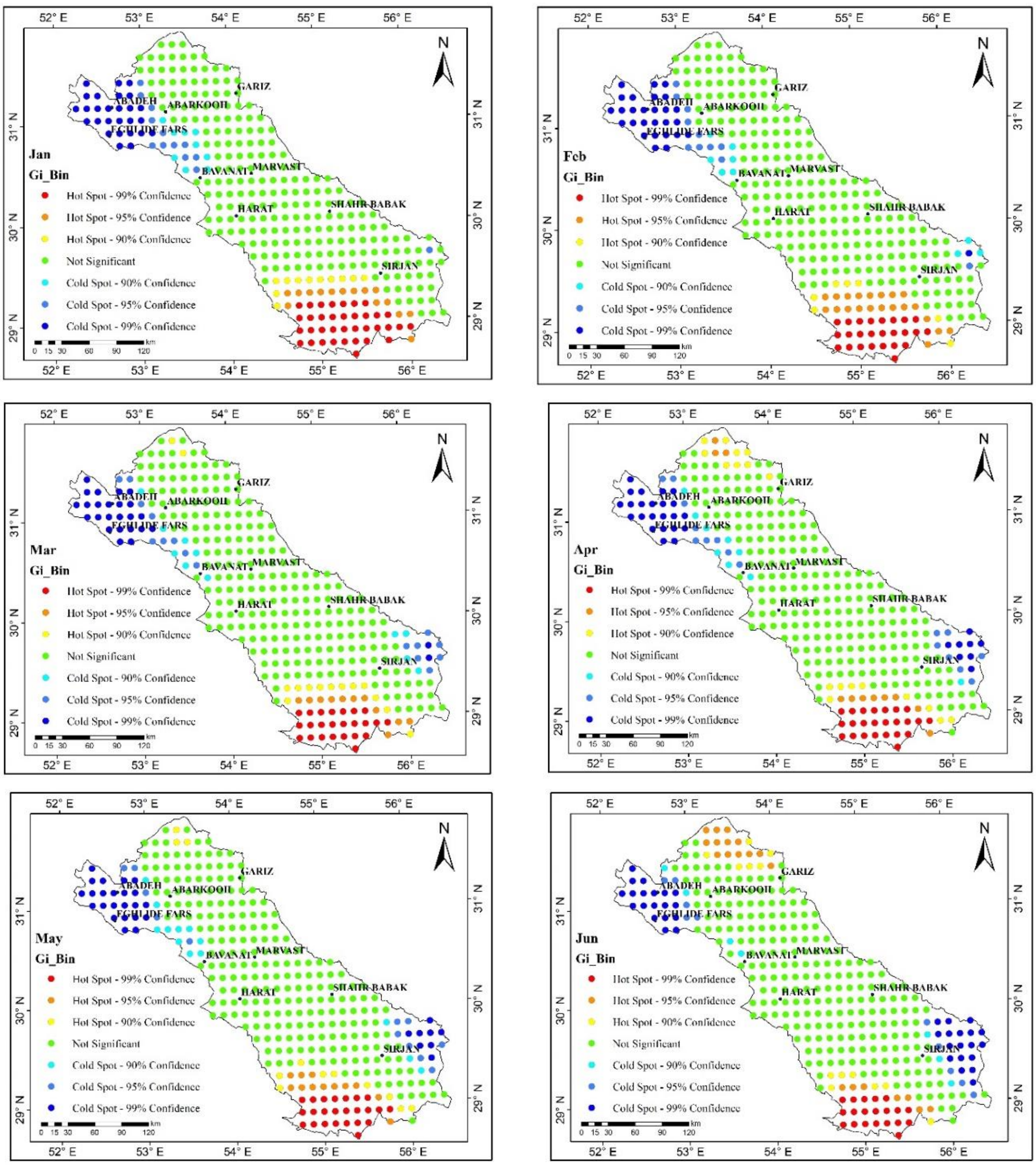
Fig. 5 - Average temperature trend of Abarku-Sirjan basin area.

Table 1- Area and percentage of areas covered by the average temperature trend.

Month	No trend		Increasing trend	
	Area (square kilometers)	Percentage of area	Area (square kilometers)	Percentage of area
April	36076.05	62.94	21234.9	37.05
May	29252.85	51.04	28060.06	48.95
August	51573.28	90.002	5728.55	9.99
December	13422.44	23.42	43886.6	76.57

Hot spot analysis was performed on the studied data. Hot spot analysis is calculated for all features in the data based on the Z score and shows which part of the data is clustered in low and high values. In other words, if there is a set of weighted features, this tool identifies high-value feature clusters (hot spots) and low-value clusters (cold spots). In this analysis, hot and cold spots are shown in three significance levels of 99, 95, and 90%, as well as points without a significant pattern. Fig. 6 shows the outputs of this analysis. Hot spots are shown at a 99% significance level in red and cold spots at a 99% significance level are shown in dark blue. In January, the frequency of hot spots is higher than cold spots. Hot spots are scattered in the southern parts and cold spots in the northwest of the basin.

The significance of these decreases towards the center of the basin to the extent that they lack a significant pattern in the center and the eastern half of the basin. During the months of February to September, the number of cold spots significantly exceeds the number of hot spots by 99%. In February, hot spots occurred in the south of the basin as in January, but cold spots appeared in the southeast corner of the basin in addition to the northwest of the basin. From March, the number of cold spots in the southeast of the basin has expanded so that they reach their peak in July and August. Since March, hot spots have appeared in the northeastern corner of the basin, and these spots, like cold spots in July and August, reach their maximum spread in this part of the basin. In other words, during the months of March to September, the northeast and southwest of the basin have hot spots and the northwest and southeast of the basin have cold spots. Since October, hot spots have been removed from the northeast of the basin, and in December, cold spots have been removed from the southeast of the basin. The frequency of spots indicates that warm spots are more frequent in January and October to December and cold spots are more frequent from February to September Table 2.



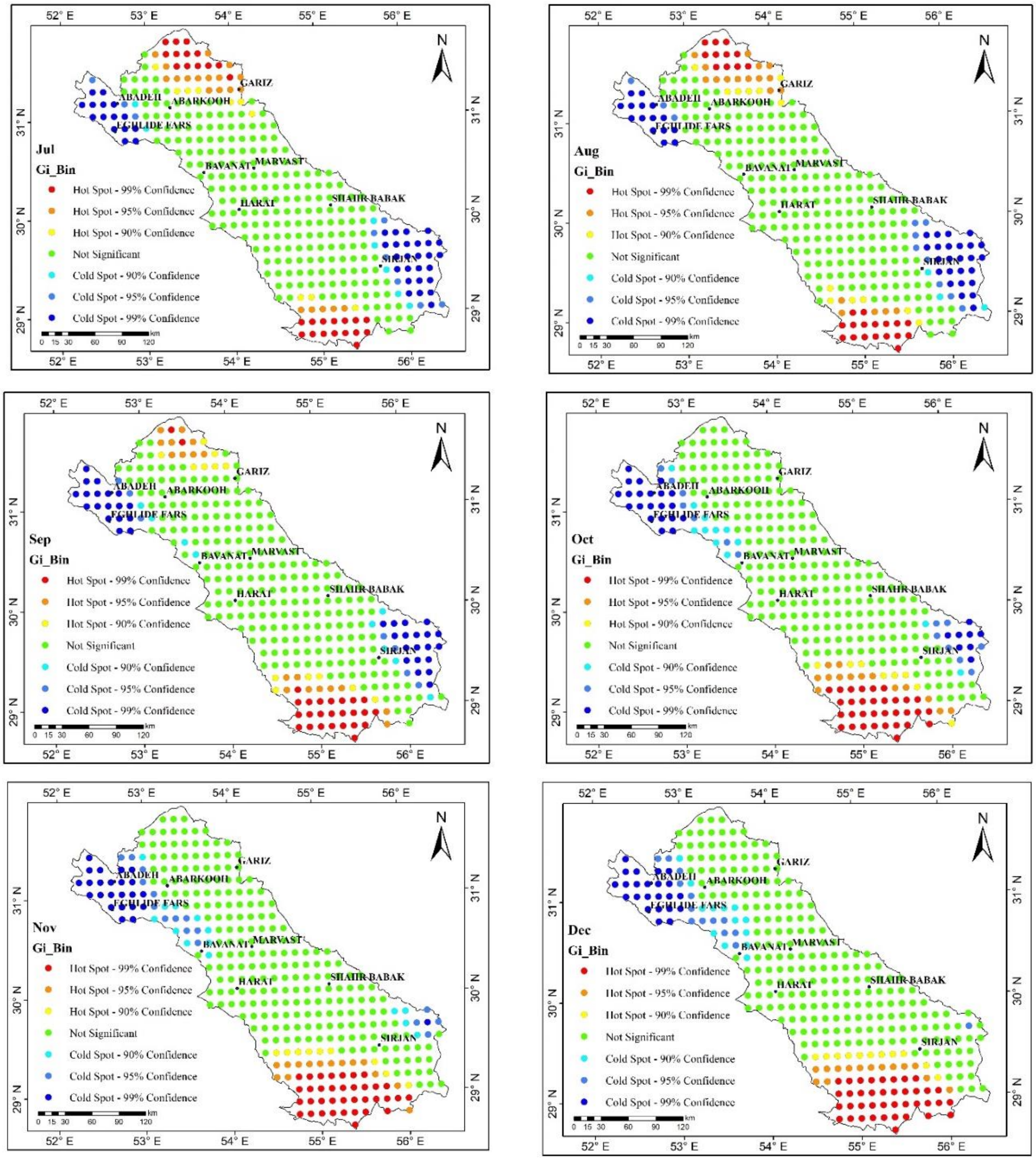


Fig. 6 - Distribution of Getis-Ord G statistics (HotSpot) in Abarku-Sirjan basin.

Table 2 - Number of Getis-Ord G statistics (Hot Spot).

Month	Cold temperature spot			No significant pattern	Hot temperature spot		
	level 99%	level 95%	level 90%		level 99%	level 95%	level 90%
January	27	13	9	227	36	15	11
February	28	21	9	237	25	11	7
March	26	11	11	236	24	16	14
April	31	16	9	229	24	11	18
May	31	12	13	234	24	12	12
June	37	10	7	231	20	20	13
July	41	9	7	223	28	20	10
August	40	11	3	224	28	19	13
September	37	7	9	228	26	18	13
October	29	14	12	229	32	14	8
November	24	16	14	225	36	14	9
December	23	14	13	224	39	14	11
Annual	30	14	12	230	26	11	15

Examination of hot spots on an annual scale shows that the northwest and southeast of the basin have cold spots and the south of the basin has hot spots (Fig. 7). Of course, the number of hot spots is more than the number of cold spots. Previous studies on temperature also show an increase in temperature in different places. Mirhoseini et al. (2021) stated that the temperature in the eastern regions of Iran is increasing. Zarrin et al. (2021) found that the temperature of different climatic zones of Iran increases by 0.05 degrees every year. Tajik and Arbabi (2020) concluded that temperature conditions and thermal events in Iran are increasing and similar results were found for China (He et al., 2021). In general, it can be concluded that the occurrence of temperature increase has been observed in all parts of Iran and the results of this study are consistent with the results of previous researchers.

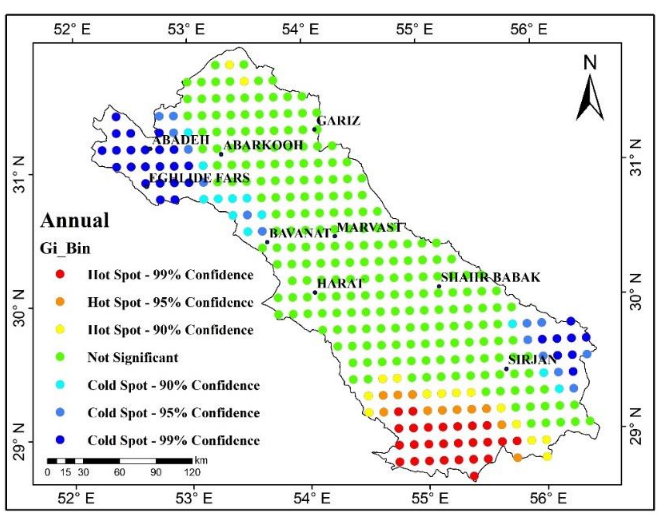


Fig.7 - Distribution of Getis-Ord G statistics (Hot Spot) in the annual scale of Abarku-Sirjan basin.

4. Conclusion.

Iran has an arid to semi-arid climate and due to its various forms of roughness, its climate is different from other Middle Eastern countries and it has a diverse climate. This condition is due to not only the variety of roughness, but also atmospheric currents on a global and synoptic scale. Abarku-Sirjan basin area is located in the south and center of the country, between the end of the Zagros Mountains and the central mountain range of Iran. In this basin, all rivers and canals flow toward the deserts of Sirjan, Qavavieh, and Abarku. Sirjan, Shahrbabak, Khatunabad, Harat, and Marvast regions of Kerman province are located in this basin.

The results of examining the average temperature trend of this basin showed that the temperature in this basin has only an increasing trend and during the period 1979-2019, there was no decreasing trend in the average temperature of this basin. In January, February, March, June, July, September, October, November, and on an annual basis, the whole basin has an increasing trend. In April, May, August, and December, in addition to the upward trend zone, zones with no trend are also observed in the basin. The results of the hot spots study also showed that cold spots appear in the northwest of the basin and hot spots in the south in all months. Of course, in the warm months of the year, cold spots have been observed in the southeast of the basin and hot spots in the northeast.

In general, during the warm months of the year, hot spots and during the cold months of the year, cold spots are more frequent. Due to global warming and rising temperatures in most parts of the world, it seems that the Abarku-Sirjan basin has not been unaffected by these changes and has had an increasing trend during the study period. This basin is spread along the northwest and southeast and its north and south are surrounded by plains and mountains of central Iran and the northern slopes of the southern Zagros. This basin is different in terms of the climate from the rest of the country due to its low altitude and distance from moisture sources.

Due to the location of this basin which is situated in the hot and low altitude part of central Iran, which has a low altitude and is far from moisture sources in the north and south of the country, it can be said that the increasing trends observed in this basin are due to the effects of the geographical location, environmental conditions, and distance from moisture sources. According to the obtained results, the research hypothesis of the increase in the temperature of the basin is confirmed. Climate change and global warming have been confirmed in all parts of the world, according to the fourth report of the Intergovernmental Panel on climate change. The most obvious sign of climate change in an area is rising temperatures and temperature changes. Temperature changes affect other climatic elements and elements of an ecosystem, so it is very important and has become one of the World's hot topics.

In the Abarku-Sirjan basin, an increase in temperature increases evaporation, decreases soil moisture, and increases the occurrence of dust, resulting in the intensification of dry and desert conditions in the basin and affecting the ecosystem of the basin. Considering that studying the trend of climate change is the first step in recognizing and studying climate change, in this study, the average temperature trend of the Abarku-Sirjan basin and how it changes based on gridded data and modern methods of spatial statistics were studied. It is suggested that in future studies, other parameters of this basin be studied to better understand the climate change that has occurred in this basin.

Declarations

Funding Information (Private funding by authors)

Conflict of Interest /Competing interests (None)

Availability of Data and Material (Data are available when requested)

Consent to Publish (Authors consent to publishing)

Authors Contributions (All co-authors contributed to the manuscript)

Code availability (Not applicable)

REFERENCES

Aliabadi, K & Dadashi Roudbari, A. A. (2015) Assessing changes patterns of spatial autocorrelation of maximum temperature of Iran, *Geographical studies of arid regions*, *6*(21), 86-104. http://journals.hsu.ac.ir/jarhs/article-1-718-fa.html

Asadi, M & Karami, M,. (2017). Representation of Temperature Variability in Fars Province Using Spatial Statistics, *Quarterly Journal of Geographical Research*, *32*(1), 124, 64-75. https://doi.org/10.18869/acadpub.geores.32.1.64

Birsan, M. V., Dumitrescu, A., Micu, D. M., & Cheval, S. (2014). Changes in annual temperature extremes in the Carpathians since AD 1961. *Natural Hazards*, *74*(3), 1899-1910. https://doi.org/10.1007/s11069-014-1290-5

Capilla, C. (2008). Time series analysis and identification of trends in a Mediterranean urban area. *Global and Planetary Change*, *63*(2-3), 275-281. https://doi.org/10.1016/j.gloplacha.2007.10.001

FarajZadeh, V., & Nowrozi, M. (2010, April). The study of climate change in Sistan and Baluchistan by Mann-Kendall. In *the proceedings of the 4th international conference of geographers of the Islamic world, Zahedan*.

Fischer, T., Gemmer, M., Lüliu, L., & Buda, S. (2011). Temperature and precipitation trends and dryness/wetness pattern in the Zhujiang River Basin, South China, 1961–2007. *Quaternary International*, *244*(2), 138-148. https://doi.org/10.1016/j.quaint.2010.08.010

Ghahari, Gh, Gandomkar, A, Najafpour, B & Nejabat, M. (2015). Investigating temperature changes in Shiraz synoptic station by Mann-Kendall statistical method. Quarterly *Journal of Natural Geography*, 8(27), 105 -118. https://dorl.net/dor/20.1001.1.20085656.1394.8.27.8.5

Giorgi, F & Lionello, P. (2008). Climate Chang Projections For The Mediterran Region, *Global And Change*, 63, 90-104. https://doi.org/10.1016/j.gloplacha.2007.09.005

Gonçalves, M., Barrera-Escoda, A., Guerreiro, D., Baldasano, J. M., & Cunillera, J. (2014). Seasonal to yearly assessment of temperature and precipitation trends in the North Western Mediterranean Basin by dynamical downscaling of climate scenarios at high resolution (1971–2050). *Climatic change, 122(1), 243-256.* https://doi.org/10.1007/s10584-013-0994-y

He, S., Wang, D., Li, Y., Zhao, P., Lan, H., Chen, W., ... & Chen, X. (2021). Social-ecological system resilience of debris flow alluvial fans in the Awang basin, China. *Journal of Environmental Management*, *286*, 112230. https://doi.org/10.1016/j.jenvman.2021.112230

Jacquez, G. M & Greiling, D. A. (2003). Local clustering in breast, lung and colorectal cancer in Long Island, New York. *International Journal of Health Geographics* . 2(3). https://doi.org/10.1186/1476-072X-2-3

Jamali, A. A., Kalkhajeh, R. G., Randhir, T. O., & He, S. (2022). Modeling relationship between land surface temperature anomaly and environmental factors using GEE and Giovanni. *Journal of Environmental Management*, *302*, 113970. https://doi.org/10.1016/j.jenvman.2021.113970

Jamali, A. A., Naeeni, M. A. M., & Zarei, G. (2020). Assessing the expansion of saline lands through vegetation and wetland loss using remote sensing and GIS. *Remote Sensing Applications: Society and Environment*, *20*, 100428. https://doi.org/10.1016/j.rsase.2020.100428

Jamali, A. A., Zarekia, S., & Randhir, T. O. (2018). Risk assessment of sand dune disaster in relation to geomorphic properties and vulnerability in the Saduq-Yazd Erg. *Applied Ecology and Environmental Research*, *16*(1), 579-590. https://doi.org/10.15666/aeer/1601_579590

Lettenmaier,D.P. Wood ,E.F. & Wallis, J. R. (1994). Hydro-climatological Trends in the Continental United States, 1948-88. *Journal Climate*, 7, 586-607. https://doi.org/10.1175/1520-0442(1994)007<0586:HCTITC>2.0.CO;2

Mamtimin, B, Et-Tantawi, A, M. M, Schaefer, D. Meixner, F. X & Domroes, M. (2011). Recent trends of temperature change under hot and cold desert climates : Comparing the Sahara (Libya) and Central Asia (Xinjiang, China), *Journal of and Environments*, 75, 1105-1113. https://doi.org/10.1016/j.jaridenv.2011.06.007

Mina, Q, Naimingb, Y & Shujie, Y. (2020). Understanding long-term memory in global mean temperature: An attribution study based on model simulations, *ATMOSPHERIC AND OCEANIC SCIENCE LETTERS*, *13*(5), 485–492. https://doi.org/10.1080/16742834.2020.1778418

Mirhoseini, H., Gandomkar, A., Afrous, A., & Abbassi, A. (2021). Investigation of changes in temperature series in the eastern regions of Iran in order to study regional changes. *Geography (Regional Planning)*, *12*(1), 125-141. https://dorl.net/dor/20.1001.1.22286462.1400.11.2.7.7

Montazeri, M., & Masoodian, S. A. (2020). Tempo-spatial behavior of surface urban heat island of Isfahan metropolitan area. *Journal of the Indian Society of Remote Sensing*, *48*(2), 263-270. https://doi.org/10.1007/s12524-019-01059-6

Rogerson, P.A. (2006). Statistics Methods for Geographers: students Guide. *SAGE Publications.* Los Angeles. California.

Sabzevari, Y, Eslamian, S & Moradalivand, K. (2022). Monitoring annual precipitation changes in Dezful plain with statistical analysis and time series, *Journal of Nature and Spatial Sciences*, *2*(1). 41-54. https://dx.doi.org/10.30495/jonass.2022.1955278.1036

Sabziparvar, A. A, Mirgaloybayat, R, & Ghyami Shamami, F. (2011). Evaluation Of The Possible Changes In Diurnal Temperature Range (Dtr) Trend In Some Arid Climates Of Iran Since Last Five Decades . *Iranian Physics Research*, *11*(1), 27-37.

Serrano, A., Mateos, V. L., & Garcia, J. A. (1999). Trend analysis of monthly precipitation over the Iberian Peninsula for the period 1921–1995. *Physics and Chemistry of the Earth, Part B: Hydrology, Oceans and Atmosphere*, *24*(1-2), 85-90. https://doi.org/10.1016/S1464-1909(98)00016-1

Stafford, J. M., Wendler, G., & Curtis, J. (2000). Temperature and precipitation of Alaska: 50 year trend analysis. *Theoretical and Applied Climatology*, *67*(1), 33-44. https://doi.org/10.1007/s007040070014

Tajik, A., & Arbabi Sabzevari, A. (2020). Investigation of Spatial Variations of extreme temperature in Iran. *Physical Geography Quarterly*, *13*(49), 109-124. https://dorl.net/dor/20.1001.1.20085656.1399.13.49.7.3

Turgay, P. & Ercan K. (2005). Trend Analysis in Turkish Precipitation data. *Hydrological processes published onlineinwiley Interscience*. https://doi.org/10.1002/hyp.5993

Varshavian, V., Khalili, A., Ghahreman, N., & Hajjam, S. (2011). Trend analysis of minimum, maximum, and mean daily temperature extremes in several climatic regions of Iran. *Journal of the Earth and Space Physics, 37*(1).

Yu, Z., & Li, X. (2015). Recent trends in daily temperature extremes over northeastern China (1960–2011). *Quaternary International*, *380*, 35-48. https://doi.org/10.1016/j.quaint.2014.09.010

Yue, S., & Hashino, M. (2003). Temperature trends in Japan: 1900–1996. *Theoretical and Applied Climatology*, *75*(1), 15-27. https://doi.org/10.1007/s00704-002-0717-1

Zarrin, A, Dadashi Roudbari, A. A & Salehabadi, N. (2021). Projected temperature anomalies and trends in different climate zones in Iran based on CMIP6, *Iranian Journal of Geophysics*, *2*(1), 35-54. https://dx.doi.org/10.30499/ijg.2020.249997.1292