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ORGINAL ARTICLE

Trend Analysis of the average Monthly Temperature in Isfahan Province

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ABSTRACT
Climate Change as the most significant complication of this century is a serious threat against all begins on the earth. This alteration occurs in chronological and localized indicators. Many factors cooperate to form it. This research has been done for the purpose of analysis of trend of average temperature in Isfahan Province using Non parametric Mann-Kendall, s Test method on the basis of pixel. Thus monthly temperature data of 16 meteorology stations during a 15-year statistical period (1961-2010) have been used. An isothermal map with 2×2km pixel was prepared for every single year. So temperature rate on 6765 knot has been evaluated for every single year. The output represent rising and falling trend during months of year .The temperature has rising trend in Beyond fifty percent of Isfahan Province during June, October, July, November, August and December. In last average temperature has had rising trend since 50 year ago.
Key Word*: Isfahan Province, Temperature Change, Trend, Mann-Kendall, s.*

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INTRODUCTION

Planetary climate is changing and global heat is happening [1] .Alteration in climatic measurer particularly temperature and rain in different areas is result of this alteration. Various studies have done on climate and its changing as follows: Serrano and his colleagues (1991),didn't detect significant trend in annual rain series in an article named "Analysis of monthly rains trend in Iberian peninsula during 1921-1995" using total monthly and annual rain date in Iberian peninsula benefiting Mann-Kendall Test [13]. Gonzals Hidalgo and his colleagues (2001), have resulted :there is an irregularity in rain evolution and a downward trend has observed in rain during winter . They displayed these results in an article named" spatial distribution of seasonal trend of rain in eastern Mediterranean"[4] .Lisa and Julie (2009) have investigated climatic increases trend over Australia. The outcome represented that increases in temperature (particularly warm waves and number of warm nights), long dry courses, (have been diffuse during a year) and rain has increased significantly [7]. Santos and his colleagues (2010) searched tendency of increases in temperature and rain indices in Utah ,U.S. during statistic courses 1930-2007 benefiting meteorology date of 28 stations. They analyzed 20 indices related to increase in temperature and rain using R climdex1.0 soft ware for under discussion area. The result of above-mentioned analysis represented that air temperature has grown during late century, however rain trend has been less significant [11]. Schlunzen and his colleagues (2010) searched long term alteration and spatial temperature and rain differences around the metropolitan area of Hamburg .The result has shown that average temperature has increased significantly during statistical courses 1891-2007(0.07˚k), 1948-2007(0.19˚k) and 1978-2007(0.6˚k).The most significant increase in temperature is related to fall[12]. Zhi Li and his colleague (2010), resulted that prevention of compatibility and incompatibility effects should be kept on to improve tolerable ecology and agriculture posed accurately in an article named "distribution of timing and spatial trend of maximum rain and temperature events during 1961-2007 in Loess Plateau, China[17]. Luis and his colleagues (2010) considered seasonal rain regimes using 2670 centers during 1946-2005 in two 30-year periods (1946-1975) and (1976-2005) in an article named "seasonal rain alteration in Iberian peninsula [8]. Martinez and his colleagues (2010) evaluated daily and nightly temperature trend using 37 stations date in Catalonia, Spain during statistical courses 1975-2004.

They represented that annual temperature is increased 0.5˚c every decade (particularly in summer and spring) .It reaches 0.8-0.9˚c in summer [10] . Tabary and Hosseinzadeh have resulted that downward trend of annual rain is observed in 60 percent of stations and 95-99 percent of this tendency is significant. They displayed their achievement in an article named "Timing change of rain in Iran during 1966-2005 " using annual and seasonal rain data out of 41 stations by Mann- Kendall Method [14].

Under discussion Area

Isfahan is placed in central Iran. Its total area is about 106179 km, and it's located in northern temperate area between 30˚ 42′ N latitude and 34˚ 30′ from equator. It's also located between 49˚ 36′ E longitude and 55˚ 32′ from Greenwich Meridian. Generally Isfahan occupied 6.5 percent of total area in Iran from 4˚ 12′ latitude to 6˚ 4′ longitude.

DATA AND METHODOLOGY

In order to behavior measurement of average temperature factor, the long term temperature dates of 16 stations in Isfahan have been used. To evaluate if date are irregular or homogenous Run Test has been profited. This test was confirmed and an isothermal map whit 2×2km pixels was prepared for every single year. Hence amount of temperature on 6765 knot has been assessed in each year. Then using nonparametric Mann- Kendall test monthly temperature trend has been evaluated.

Nonparametric Mann-Kendall, s test

This test displays trend of some decades. It is used by hydrologists and researchers to evaluate meteorology –hydrology variables behavior such as rain, temperature and stream current. First Mann displayed this test in 1945 and then it was expanded by Kendall as statistical test. To have linear trend or not, isn't the purpose of this test. It's used to evaluate if timing series have statistical significant tendency. (Mann, 1945; Kendall, 1975; Yue and Wang, 2004)[9] ,[6] ,[16] .Now a day this test is used by world meteorology organization to detect trend. Evaluation of Mann-Kendall test includes some steps: A) first difference of observations (rain, temperature and other climatic factors) is computed based on S statistic

$$S=\sum_{k=1}^{n-1}\sum_{j=k+1}^{n}\operatorname{sgn}(x_j-x_k) \quad (1)$$

j>i

n: number of total observations.

X_j, X_k: amount of jth and kth of series.

Result of above function display sign of series as follows:

$$\operatorname{sgn}(x)=\begin{cases}+1 \text{ if } (x_j-x_k)>0\\ 0 \text{ if } (x_j-x_k)=0\\ -1 \text{ if } (x_j-x_k)<0\end{cases} \quad (2)$$

B) After determination of sign, variance of every observation is computed by below formula. When number of observation exceeds 10(n>10).

$$V(s)=\sqrt{\frac{n(n-1)(2n+5}{18}} \quad (3)$$

C) Z Value is computed in next step.

$$Z=\begin{cases}\frac{S-1}{\sqrt{V(s)}} \text{ if } & S>0\\ 0 \text{ if } & S=0\\ \frac{S+1}{\sqrt{V(s)}} \text{ if } & S<0\end{cases} \quad (4)$$

D) Assumption test: Null hypothesis indicated that it's irregular and no trend. It means that Z isn't significant statistically. (For instance there isn't heat and coldness: Null hypothesis is accepted. $-Z_{a/2} < Z < Z_{a/2}$ Or dry and wet period) If (relation Ship 5) Amount of $Z_{a/2}$ is standard deviation (Z of table). Rival hypothesis indicates that it $-Z_{a/2}$ $Z <$ or $Z > Z_{a/2}$ trended. It means that Z is significant statistically. If Rival hypothesis is accepted (Gun1998)[5] :

$$|Z| \leq Z_{a/2} \quad (5)$$

In some stations temperature has positive trend (heat) and some other station negative trend (coldness) is observed. In addition some months are humid some ones dry. Hence in these situations hypotheses are chosen mutual (two-sided). (Fu and his colleagues, 2004; Xu and his colleagues2007, 2010)[3] , [15] . In

this project significance level is considered a= 0.05. Considering that this test is mutual, amount of Z equals 1.96.

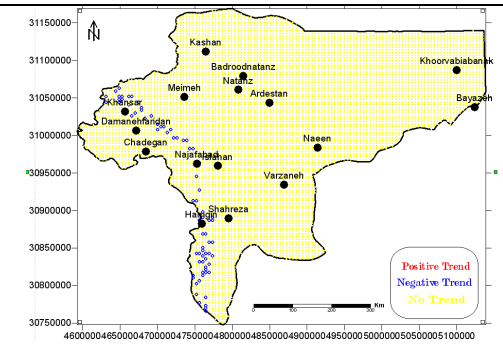
DISCUSSION

Considering whole time series around under discussion area, it is determined that average temperature hasn't changed in late 50years. Positive and negative change trends are as I will mention below:

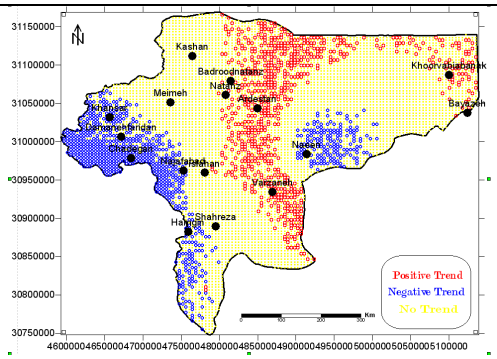
Time series of temperature have had both positive and negative trends during January but their ranges were worthless against no trend plots so that 12.3 percent of province is included negative trend and 10.9 percent has positive trend. However 76.8 percent of total area is no trend areas with positive trend are located in west of province and some parts around Nain. Negative trend has covered some areas from north to center and even eastern south. (Fig.2A). a major part of province is no trend in February and March and just 1.1 percent in February (Fig.2B) and 0.2 percent in March, negative trend is observed. (Fig.2C). In April just negative trend is noticed and most parts of province are no trend. In 3.6 percent of small parts of north and center with 242 pixels included Ardestan and Varzaneh, negative trend is observed. (Fig.2D).

Average temperature has had positive trend since first month of fall so that negative trend has just covered small areas in province. The most extended upward trend had been in June, October, July, November and August so that during this month's 73.6, 62.2, 57.2, 55.3 and 55.3 percent of total area in order, have been under domination of upward trend. Average temperature was no trend in June like April. Only positive trend was observed during two above – mentioned months. Of course positive trend has occupied more parts of province. (Fig.2F)Areas with negative trend are increased since June until September but after that negative trend includes lesser parts of province, so that it reaches 0.2 percent in December.

Table(2):change in average temperature trend during different months

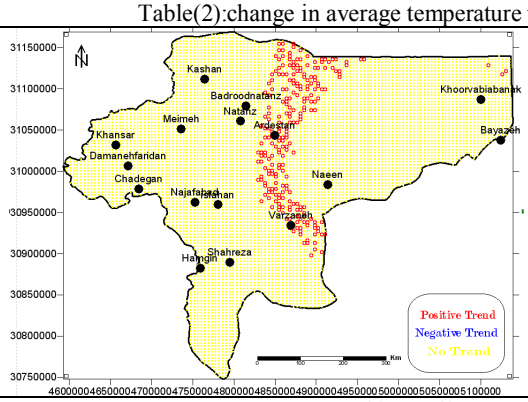


B) Average temperature trend in February

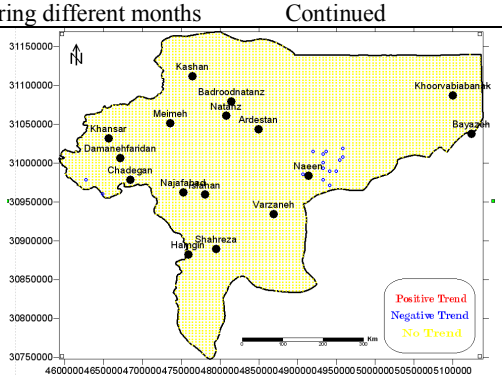


A) Average temperature trend in January

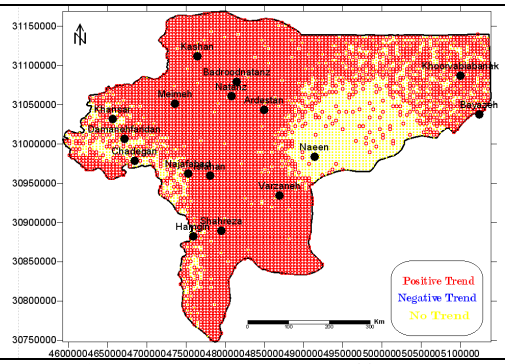
Table(2):change in average temperature trend during different months Continued



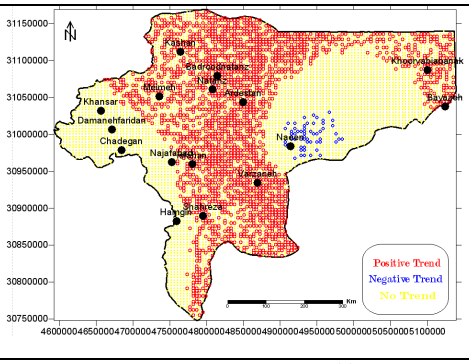
D) Average temperature trend in April



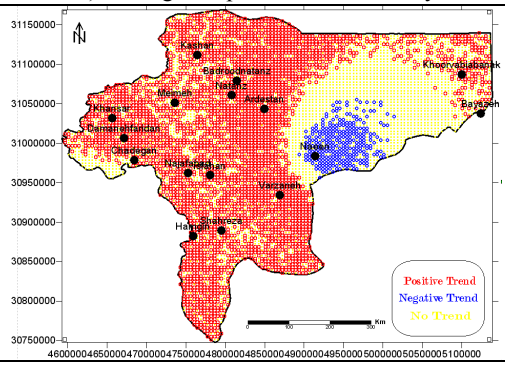
C) Average temperature trend in March



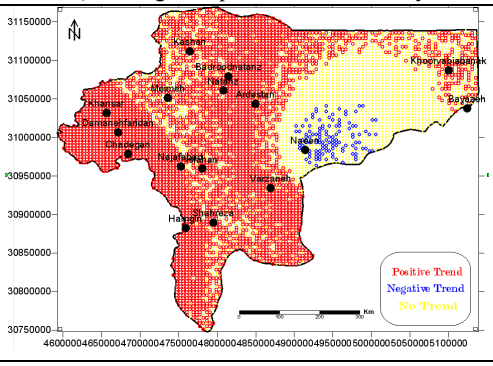
F) Average temperature trend in Juny



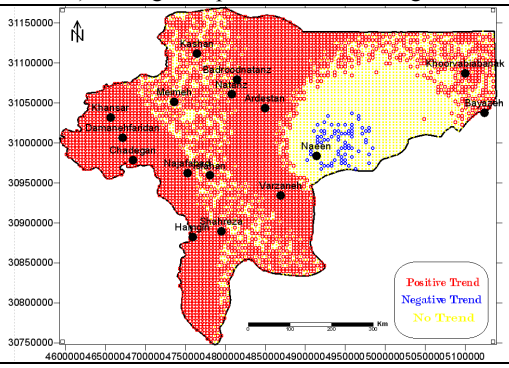
E) Average temperature trend in May



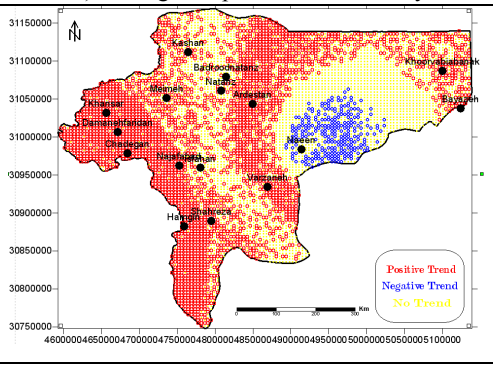
H) Average temperature trend in August



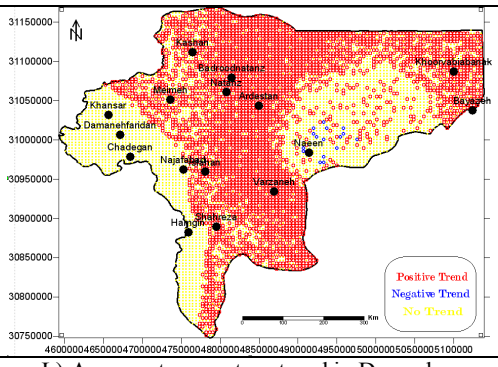
G) Average temperature trend in July



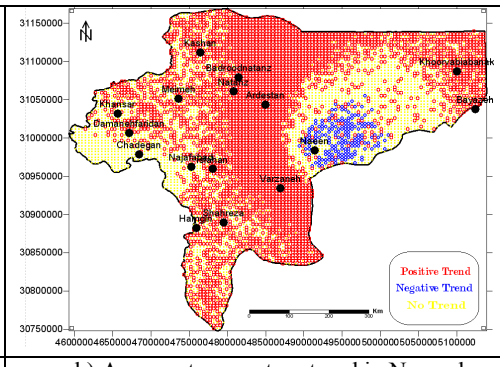
J) Average temperature trend in October



I) Average temperature trend in September



L) Average temperature trend in December



k) Average temperature trend in November

RESULT

It can be mentioned that upward trend of temperature trend in Isfahan is followed by specific regularity according its position. So that positive trend can be assigned to a vast area. Particularly upward trend is seen during warm months more, and it covers most part of province (western areas).Finally it's worthy to say: warm months with higher temperature have gotten warmer during recent 50 years than other

months of year. Hence increase in temperature will result in inconvenient effects on other measures such as effect on timing and spatial features of rain and early melting of snow during cold months. Above-mentioned effects themselves cause climate change and disadvantageous consequence on bio-ecology.

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