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Three-way approach to test data homogeneity: An analysis of temperature and precipitation series over southwestern Islamic Republic of Iran

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ABSTRACT
The accuracy and reliability of trend analysis and model results in climate change studies vary according to the quality of data used. Non-climatic factors, such as relocation of station, change of instrument, etc. make data unrepresentative of the actual climate variation. This may influence the outcome of climatic and hydrological studies. Homogenization of climatic data is therefore, of major importance. The objective of the present study was to check the homogeneity of temperature and precipitation data of southwestern Iran to find a break in temperature and precipitation series. Three tests for homogeneity: The standard normal homogeneity test (SNHT), Pettitt's test, the standard normal homogeneity test by Alexandersson and Moberg were applied to analyse seasonal and annual temperature and precipitation series from 1960-2007 in southwestern part of Iran. Each test was evaluated separately and inhomogeneous stations were determined. The series were then grouped into three classes which were categorized as 'useful', 'doubtful' and 'suspect'. It was revealed by the homogeneity analysis that none of the series belonged to the class 'suspect', and therefore, it was concluded that the temperature and precipitation series are homogeneous.

INTRODUCTION

The quality and reliability of the data recorded at meteorological station depends on many factors. Inhomogeneous observation records may occur in the series because of the method used for data collection, the conditions around the observation site, reliability of the measurement, site relocation, etc. Homogeneous climate series may be defined as series only influenced by the variation in climate. Most of the long-term climatic time series have been affected by number of non-climatic factors which make the data unrepresentative of actual climate variations occurring over time (Peterson et al., 1998). For this reason the data taken from the observation stations should be tested for reliability and homogeneity prior to their use in research.

Climatologists across the world have proposed different methods for testing homogeneity of meteorological variables like precipitation and temperature (Modarres, 2008; Tomozeiu et al., 2005; Klingbjer & Moberg, 2003; Ducre – Rubitaille et al., 2003; Staudt et al., 2007). Freiwan and Kadioglu (2008) used annual, seasonal and monthly, maximum and minimum precipitation series to analyze climatic change in Jordan. They used SNHT and Pettitt's test for analysis of annual, seasonal and monthly precipitation series. Martinez et al. (2010) applied three location specific homogeneity tests - the SNHT, the Pettitt's test, the Buishand range test, to detect break year in annual maximum temperature and annual minimum temperature series of Spain. When two out of three tests reported the same year at a certain confidence level, that year was assumed as the break year. Karabörk et al. (2007) checked the homogeneity of 212 precipitation records in Turkey for the period 1973-2002 by the SNHT and Pettitt's test. Authors found that 43 out of 212 stations were inhomogeneous based on the criteria that station under investigation was considered inhomogeneous if at least one of the test reject the homogeneity. Gokturk et al. (2008) performed outlier trimming and homogeneity checking/correction on the monthly precipitation time series of various lengths from 267 stations in Turkey, by using the SNHT for homogeneity analysis. Tuomenvirta et al. (1999) used SNHT to test the reliability and homogeneity of the monthly maximum and minimum temperature series. Wijngaard et al. (2003) used the SNHT, Buishand test, Pettitt test and Von Neumann test for testing the homogeneity of daily precipitation and temperature series. Hanssen-Bauer and Forland (1994) applied homogeneity analysis on the 75-year long precipitation and temperature series of 165 stations in Norway by using the SNHT. Mihajlovic (2006) used the SNHT to test the homogeneity of monthly total precipitation series used in monitoring of meteorological drought over Pannonian part of Croatia. Thus, the SNHT and Pettitt's test have been regularly used by researchers to detect inhomogeneity and break year in the temperature and precipitation. These two tests along with standard normal homogeneity test by Alexandersson and Moberg have been used in the present study to test homogeneity of annual and seasonal temperature and precipitation series of southwestern part of Iran.

The homogeneity tests of time series may be classified in two groups as 'absolute method' and 'relative method'. In the first method the test is applied for each station separately. In the second method the neighboring (reference) stations are also used in the testing (Wijngaard et al., 2003). While both approaches are worthwhile and valid, they both have drawbacks. In some cases data only from individual stations is used, but this approach may be problematic because it is difficult to determine if change, or lack of changes result from non-climatic or climatic influences (Peterson et al., 1998). To overcome this problem, metadata support from station history information is essential for evaluating the breaks detected. Relative methods intend to isolate non-climatic influence. They assume that within a geographical region, climatic patterns will be identical and these observations from all sites within the region will reflect this identical pattern. The data collected at all sites within the same climatic region should highly correlate, have similar variability and differ only by scaling factors and random sampling variability. Problems arise when the inhomogeneities in the climate data series are caused by simultaneous changes in the observational network, such as simultaneous changes in the measuring technique, as relative tests become insensitive since all series are affected at the same time (Tuomenvirta et al., 1999; Wijngaard et al., 2003).

Absolute methods are represented by the SNHT and Pettitt's test while relative methods by the standard normal homogeneity test of Alexandersson and Moberg. SNHT developed by Alexandersson (1986) assumes a null hypothesis that the data values of testing variables are independent and identically distributed. Under the alternative hypothesis it assumes that a step-wise shift (a break) in the mean is present. Pettitt test (1979) developed by Pettitt is a nonparametric test capable of locating the period where a break is likely. The statistic is related to the Mann-Whitney statistic. The standard normal homogeneity test by Alexandersson and Moberg (1997) proposed the construction of ratio (difference) reference series, which is generally used in precipitation and temperature studies. The most usual approach to obtain adjustment factors is to calculate separate averages on the difference or ratio series for two sections defined by a breakpoint (Aguilar et al., 2003). When abrupt changes are identified in the time series, the obtained means are compared by calculating their ratio or difference and the obtained factor is applied to the inhomogeneous part. Sometimes the changes or breakpoints may be gradual. In such a case the inhomogeneous section is detrended, using the slope calculation on the difference or ratio time series.

In view of the above discussion, it was thought that tests representing both methods will make the homogeneity analysis more reliable. Another issue was that the data are collected from two different agencies (Islamic Republic of Iran Meteorological Organization (IRIMO) and Iranian Water Resources Management Organization) and therefore it becomes essential that the data are homogeneous and devoid of any breaks.

STUDY AREA

The study area under consideration includes southwestern part of Iran, particularly the states of Isfahan, Chaharmahal and Bakhtiari, Kohgiluyeh and Boyer-Ahmad, Lorestan and Khuzestan. The region spreads over 2,31,547 sq km which is about 14% of the country's geographical area. Area particulars are from 29′ 56″00 to 35′9″00 north latitudes, and 47′ 25″00 to 55′33″00 east longitudes. For the study, 20 precipitation stations and 20 Temperature stations operated by IRIMO and Iranian Water Resources Management Organization were considered (Fig.1) for testing of the homogeneity. For this purpose, seasonal and annual precipitation and temperature data covering the years between

1950 and 2007 were collected. This time range was determined by evaluating the records of stations and after incorporating missing data. In the study area no precipitation is recorded during summer season and therefore no analysis for summer precipitation is performed in the study.

METHODOLOGY

It has already been mentioned that three tests: Pettitt's test, the SNHT and standard normal homogeneity test by Alexandersson and Moberg have been used to analyze homogeneity of the temperature and precipitation data sets. Following sections outline in detail the methodology for performing these tests.

Pettitt's test

This test developed by Pettitt (1979) is a nonparametric test, which is useful for evaluating the occurrence of abrupt changes in climatic records (Sneyers, 1990; Tarhule and Woo, 1998; Smadi and Zghoul, 2006). One of the reasons for using this test is that it is more sensitive to breaks in the middle of the time series (Wijngaard et al., 2003). The statistic used for the Pettitt's test is computed as follows:

First step is to compute U_k statistic using following formula

$$U_k = 2 \sum_{i=0}^{n} m_i \text{ -k(n+1)} \tag{1}$$

Where m_i is the rank of the i-th observation when the values X_1, X_2 ….. X_n in the series are arranged in ascending order. Next step is to define statistical change point test (SCP) as follows:

$$\text{K} = \max_{1 \le k \le n} \left| U_k \right| \tag{2}$$

When U_k will attain maximum value of K in a series then a change point will occur in the series. The critical value is obtained by:

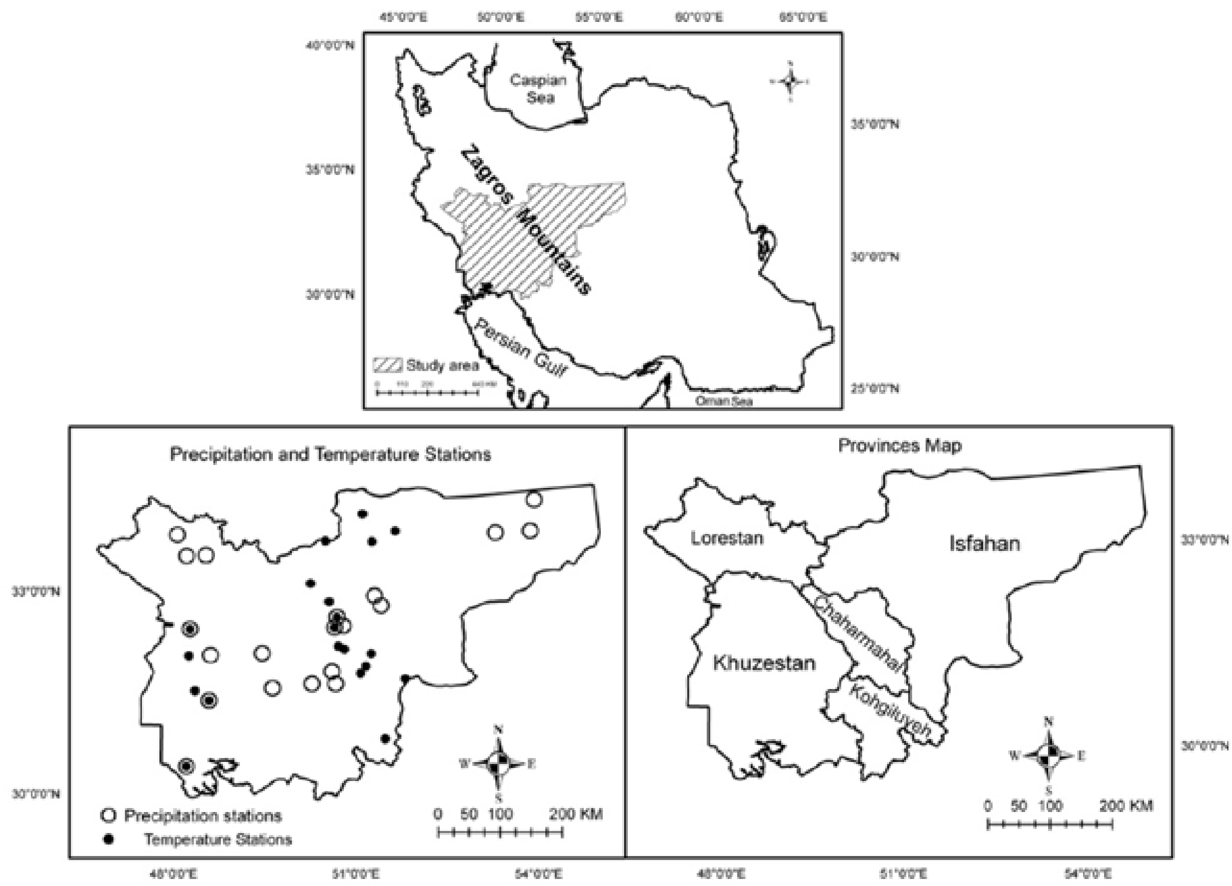

Figure 1. Location of the Study Area, Provinces Covered and Precipitation and Temperature Stations in the Southwestern part of Iran

$$K_a = [-1\ln\alpha\,(n^3+n^2)/6]^{1/2} \tag{3}$$

The standard normal homogeneity test (SNHT)

This test is devised by Alexandersson (1986) which makes use of ratios.

We define a new standardized series of ratios $\{z_i\}$ according to

$$z_i = (q_i - \bar{q}) / S_q \tag{4}$$

Where $\bar{q}$ is the arithmetic mean value of the ratio (q_i) and S_q is the sample standard deviation of this series. This new series $\{z_i\}$ thus has exactly zero mean value and unit standard deviation. Now we may define our hypotheses, H_0, the null hypothesis, and H_1, the alternative hypothesis, as

$$H_0 \quad Z\varepsilon\, \mathrm{N}(0,1), \forall i$$

$$H_1 : \begin{cases} \text{For some } 1 \le \nu < n \text{ and } \mu_1 \ne \mu_2 \text{ we have} \\ Z \in \mathrm{N}(\mu_1, 1) \text{ for } i \le \nu \\ Z \in \mathrm{N}(\mu_2, 1) \text{ for } i > \nu \end{cases} \tag{5}$$

Here $Z \in (0,1)$ means that the Z has a normal distribution with zero mean value and unit standard deviation. Thus we have assumed that the sequence of ratios can be described by a normal distribution and that the possible break is one single break and that it consists only of a shift of the mean level. In equation (2), 0, μ_1 and μ_2 are mean values of normal distributions which all have unit standard deviation. Then we obtain:

$$\underset{\mu 1.\mu 2,\nu}{Max}\ \frac{(2\pi)^{-n/2} e^{-1/2}(\sum_{i=1}^{\vee}(z_i-u_1)^2+\sum_{i=\vee+1}^{n}(z_{i-\mu_2})^2)}{(2\pi)^{-n/2} e^{-1/2}\sum_{i=1}^{n} z_i^2} > C \tag{6}$$

By differentiation the maximum of the numerator is found for $\mu_1 = z_1$ and $\mu_2 = z_2$ where

$$\overline{z_1} = \frac{1}{\vee}\sum_{i=1}^{\vee} z_i \tag{7}$$

$$\overline{z_2} = \frac{1}{n-\vee}\sum_{i=\vee+1}^{n} zi$$

Inserting in equation (6) gives, after some calculations

$$\underset{1\le\vee<n}{Max}[\vee\bar{z}_1^2 + (n-\vee)\bar{z}_2^2] > 2 \ \text{In c} = c' \tag{8}$$

Here we prefer to use equation (8) which give us our test statistic T_o as

$$T_{o=\underset{1\le\vee<n}{Max}}\{T_\vee\} = \underset{1\le\vee<n}{Max}[\vee\bar{z}_1^2 + (n-\vee)\bar{z}_2^2] \tag{9}$$

Hence, after having standardized the sequence of ratios, we only have to compute the accumulated sums of this sequence from which the arithmetic mean values z_1 and z_2 and thus $T_\vee$ and T_o, can be calculated. Thus we obtain:

1. T_o If T_o is larger than a certain critical level the series should be classified as non-homogeneous at a certain level, e.g. With 95 per cent confidence.
2. The year which is the most probable for break, More precisely it is the last year with the former mean level.
3. q_1 and $\overline{q_2}$ The mean values of the sequences of the ratios before and after the possible break. The ratio q_2/q_1 will then give a measure of the relative change of the measurement.

THE STANDARD NORMAL HOMOGENEITY TEST (ALEXANDERSSON AND MOBERG)

This test was developed by Alexandersson and Moberg (1997) which is a useful technique to detect and estimate gradual changes of the mean value in a candidate series compared with a homogeneous reference series. The test is described as follows:
We will use Y to denote our candidate series and Y_i to denote a specific value (e.g. annual accumulated precipitation or mean temperature). Furthermore, x_j will denote one of the surrounding reference sites (the jth of total of k)and X_{ji} a specific value from that site. To detect relative non-homogeneities, we form ratios or differences according to

$$Q = Y_i \left\{ \left[\sum_{j=1}^{k} \rho_j^2 X_{ji}\, \bar{Y}\big/\bar{X} \right] \sum_{j=1}^{k} \rho_j^2 \right\} \tag{10}$$

In these equation ρ_j denotes the correlation coefficient between the candidate site and a surrounding station. This coefficient must be positive. Bars denote mean values which have been incorporated for normalizing reasons. The normalizing is important because it allows us to use different sets of neighbouring stations at different years, including shorter and non-complete records, when we calculate reference values. The normalizing also causes Q-values to fluctuate around 1 for equation (10). It is necessary that mean values of Y and x_j are calculated for one common time period for all j=1,….,k. Otherwise the size of non-homogeneities may be underestimated or missed by the test . The correlation coefficient ρ_j need not for algebraic reasons be estimated from the same common time period, but it seems reasonable to use one common period for all stations.

The standard normal homogeneity tests are applied to the standardized series

$$Z_i = (Q_{i-\overline{Q}}) / \sigma Q \quad (11)$$

We use (n-1) weighted standard deviations. This is important to mention because it influences the test statistic and the critical levels.

A single shift of the mean level at the candidate site Y can be expressed formally with a null hypothesis (H_0) and an alternative hypothesis (H_1) as :

$$H_0 : Z_i \in \mathrm{N}(0,1) \qquad i \in \{1,....n\}$$

$$H_1 \quad \begin{array}{ll} Z_i \in \mathrm{N}(Z_i \in \mathrm{N}(\mu_1, 1) & i \in \{1,....a\} \\ Z_i \in \mathrm{N}\,(\mu_2\,,\,1) & i \in \{a+1,....n\} \end{array} \quad (12)$$

Where N denotes the normal distribution with its parameters (mean values and standard deviation). The null hypothesis, which is the ideal case with a homogeneous record from the candidate site, follows directly from the standardization in equation (11), except that we have added the assumption that we can use the normal distribution.

The alternative hypothesis says that at same unknown time the mean value changes abruptly. The standard deviation is assumed not to change at this point. This is a simplification, and in fact it should, as a rule be slightly less than one for the series before and after the year with a possible break.

Based upon the two hypotheses we can derive a test quantity, i.e. a quantity that is the most effective one to separate H_0 from H_1.This is usually done by forming a likelihood ratio, i.e. the ratio of the probability that H_1 is correct , give the observed series { z_i }, to the probability that H_0 is correct. After some calculations (Alexandersson, 1986) we obtain the test statistic as:

$$T^s_{\max} = \max_{1 \le a \le n-1} \{ T^s_a \} = \max_{1 \le a \le n-1} \{ a\bar{z}_1^{-2} + (n-a)\bar{z}_2^{-2} \quad (13)$$

Where $\bar{z}_1$ and $\bar{z}_2$ are the arithmetic averages of the { z_i } sequence before and after the shift. The value of a, corresponding to this maximum, is then the year most probable for the break, or more precisely the last year at the old level $\bar{z}_1$. If $T^s_{\max}$ is above a certain critical level we say that the null hypothesis of homogeneity can be rejected at the corresponding significance level. If it is above the 95 per cent significance level there is risk, at most 5 per cent, that we are wrong when we reject the null hypothesis. The two levels of the ratios or differences before and after the possible break are then;

$$\overline{q_1} = \sigma Q^{\bar{z}_1} + \overline{Q} \quad (14)$$

$$\overline{q_2} = \sigma Q^{\bar{z}_2} + \overline{Q} \quad (15)$$

Which are reverse uses of equation (11). If one intends to correct data for the period {1,…., a} then the values within this period should be corrected by $\overline{q_2} / \overline{q_1}$ in the ratio case (equation 10) and by $\overline{q_2} - \overline{q_1}$ in the difference case (equation 11). If data contains only one shift, then we obtain a homogenized series where all data refer to the present measuring situation.

Then the sum to minimize is:

$$S = \sum_{i=1}^{a} (z_i - \mu_l)^2 + \sum_{i=a+1}^{n} (z_i - \mu_2)^2 \quad (16)$$

The ordinary operations $\partial S / \partial \mu_1 = 0$ and $\partial S / \partial \mu_2 = 0$ give $\mu_1 = \bar{z}_1$ and $\mu_2 = \bar{z}_2$ so that

$$Min(s) = \max_{1 \le a \le n-1} \{ a z_1^{-2} + (n-a) z_2^{-2} \} \quad (17)$$

This coincidence is a consequence of using the normal distribution with a common standard deviation.

We would like to mention that it is more approiate and rigorous to use a simple t-test if we know that a series being studied has one , and only one possible risk for break. We can use the Q-series directly and calulate

$$t = \frac{\bar{q}_1 - \bar{q}_2}{\sqrt{\dfrac{\sigma_1^2}{A} + \dfrac{\sigma_2^2}{n-A}}} \quad (18)$$

Classification of the results of homogeneity tests

After testing the homogeneity of all the selected stations for temperature and rainfall the results of all the three tests were evaluated. The results were classified following Schonwiese and Rapp (1997) and

Wijngaard et al. (2003). This classification was based on number of tests rejecting the null hypothesis. Three categories were identified:

Class1: 'useful'- one or zero test reject the null hypothesis.

Class 2: 'doubtful'- two tests reject the null hypothesis.

Class 3: 'suspect'- three tests reject the null hypothesis.

The qualitative interpretation of the categories is as follows:

Class1: 'useful'. No clear signal of an inhomogeneity in the series is apparent. Hence inhomogeneities that may be present in the series are sufficiently small with respect to the inter-annual standard deviation of testing variable series that they will largely escape detection. The series seem to be sufficiently homogeneous for trend analysis and variability analysis.

Class 2: 'doubtful'. Indications are present of an inhomogeneity of a magnitude that exceeds the level expressed by the inter-annual standard deviation of testing variable series. The results of trend analysis and variability analysis should be regarded very critically from perspective of the existence of possible inhomogeneities.

Class 3: 'suspect'. It is likely that an inhomogeneity is present that exceeds the level expressed by the inter-annual standard deviation of testing variable series. Marginal results of trend and variability analysis should be regarded as spurious. Only very large trends may be related to a climatic signal.

It can be inferred from the above discussion that series falling in class 3 labelled 'suspect' cannot be taken as reliable. Therefore, these series should not be used for further statistical analysis like trend analysis.

RESULTS AND DISCUSSION

Homogeneity of precipitation series

Table 1 lists the inhomogeneous precipitation stations and comparative test statistics calculated by the three techniques. It is clear from the table that amongst the annual series only one series (Ahwaz) is detected inhomogeneous by two tests and two series (Abadan and Zaghehe Khorremebad) are found to be inhomogeneous by single test. The autumn series of Sadabasspour is detected for inhomogeneity by two tests, and the series represented by Khorremebad is not homogeneous according to only one test.

Table 1. Comparison of results of precipitation series analysis at 95% significance level

Series/Station	standard normal homogeneity test by Alexandersson and Moberg		standard normal homogeneity test		Pettitt's test		Classification
	T-test	Break Point	P value	Break Point	P value	Break Point	
Annual							
Abadan					0.014	1973	Class1
Ahwaz			0.037	1966	0.045	1966	Class 2
Zaghehe Khorremebad	2.9669	1969					Class1
Autumn							
Khorremebad	2.3044	1994					Class1
Sadabasspour			0.657	2004	0.813	1983	Class 2
Spring							
Anarak	2.2410	1991					Class1
Winter							
Abadan			0.031	1971	0.010	1971	Class 2
Kelishadorokh					0.049	1990	Class1
Jandagh	-2.8261	1999					Class1
Barez	-3.0343	2005					Class1

The spring series are by and large homogeneous as only one station (Anarak) records inhomogeneity in its series but falls in class one which can be regarded as useful. Out of the four stations recording inhomogeneity in winter series, three (Kelishadorokh, Jandagh and Barez) fall in class one and only one (Abadan) falls in class two. Thus, out of twenty stations analyzed for homogeneity for annual and seasonal precipitation series not a single station was categorized as class 3 or 'doubtful'. Therefore, according to the results the precipitation data series of these stations seem to be sufficiently homogeneous for trend analysis.

Homogeneity of temperature series

Table 2 shows the list of inhomogeneous temperature stations and comparative test statistics calculated by the three methods.

The results for annual series indicate that the inhomogeneous structure is generally observed between 1991 and 1997 and in 1983. Further, it can be seen that the inhomogeneous structure was detected at 2 stations in 1991 and at one station in 1995 by standard normal homogeneity test by Alexandersson and Moberg. SNHT detected break point in 1993 and 1995 at two stations each and in 1996 and 1997 at one station each. According to Pettitt's test the break occurred in 1983 at one station, 1993 at two stations and 1996 at one station. Overall, the table indicates that annual series of 8 stations were found to be inhomogeneous either by one or two tests, with all stations falling in Class 1 and 2. The autumn series of 3 stations was found to be inhomogeneous by standard normal homogeneity test by Alexandersson and Moberg with the break points in the year 1980, 1995 and 2005. Four stations had inhomogeneity according to SNHT with two stations showing break point in 1986 and the other two indicating break point in 1970 and 2003. Pettitt's test detected inhomogeneity in five stations. For two stations break point occurred in the year 1986, whereas for other three stations break point occurred in the year 1980, 1982 and 1983. Like annual series in autumn series not a single station was felled under class 3. In the spring series nine stations were detected with inhomogeneity. Standard normal homogeneity test by Alexandersson and Moberg indicated inhomogeneity in the series of 3 stations with break points in the years 1969, 1991 and 1997. Six stations, according to SNHT had inhomogeneity. Break point occurred in the year 1997 for three stations and one station each in the years 1972, 1983 and 1995. Inhomogeneous structure was revealed by the Pettitt's test in 4 stations with break points in 1983, 1994, 1995 and 1997. During summer season 9 stations indicated inhomogeneity, out of which inhomogeneity at two stations was reported by standard normal homogeneity test by Alexandersson and Moberg with breaks in the years 1990 and 1994. SNHT reported inhomogeneous structure in 4 stations and indicated break points in the years 1981, 1983, 1995 and 1997. Pettitt's test revealed that summer series was not homogeneous at 5 stations. The test indicated break points in the years 1983, 1985, 1994, 1995 and 1997. Temperature series of 4 stations was not homogeneous according to the standard normal homogeneity test by Alexandersson and Moberg, and had break points in the years 1975, 1980, 1990 and 1996. SNHT indicated winter series of 3 stations was not homogeneous and had breaks in the years 1976, 1993 and 1998. Pettitt's indicated inhomogeneity in 4 stations with 3 stations having break point in the year 1993 and 1 in the year 1971.

Putting together the annual and seasonal series, 41 series were reported inhomogeneous either by one or two tests. This also reveals that the inhomogeneous series belong to class 1 or 2. Out of the 41 series 23 belong to class 1 i.e. 'useful' and remaining 18 belong to class 2 i.e. 'doubtful'. This also reveals that none of the series belong to class 3 which is 'suspect'. Thus, it can be deduced from the findings that the temperature as well as precipitation series of the stations under study are sufficiently homogeneous, and therefore, these series can be considered for further climatic analysis

CONCLUSION

In this study, homogeneity tests were applied for the precipitation and temperature series of meteorology stations operated by Iranian Meteorological Organization and Iranian Water Resources Management Company from southwestern part of Iran. Since the data were obtained from two different agencies it was essential to test the data for homogeneity. For this purpose, 20 temperature stations and 20 precipitation stations having observations between 1950 and 2007 were analyzed

Table 2. Comparison of results of temperature series analysis at 95% significance level

Series/Station	standard normal homogeneity test by Alexandersson and Moberg		standard normal homogeneity test (SNHT)		Pettitt's test		classification
	T-test	Break Point	P value	BreakPoint	P value	Break Point	
Annual							
Abadan			< 0.0001	1995	< 0.0001	1993	Class 2
Ahwaz			< 0.0001	1993	< 0.0001	1983	Class 2
Dezful	-3.9074	1991	0.000	1995			Class1
Hamidiyeh	-3.5307	1995					Class1
Abyaneh			0.032	1996			Class1
Jangalbani badroud natanz			0.003	1997	0.003	1996	Class 2
Emam gheis			0.010	1993	0.005	1993	Class 2
Sad e zayandeh rood	3.0749	1991					Class1
Autumn							
Dezful	-2.3308	1995					Class1
Abyaneh	3.5426	2005					Class1
Emam gheis			0.022	1986			Class1
Share kord			0.050	2003	< 0.0001	1983	Class 2
Solgaun			0.010	1986	0.032	1986	Class 2
Yasoug					0.049	1982	Class1
Sarab handeh	-2.3136	1980			0.012	1986	Class 2
Pol zamankhan			0.000	1970	0.010	1980	Class 2
Spring							
Ahwaz	6.8481	1969					Class1
Dezful			0.002	1972			Class1
Haft tapeh	-4.3767	1997					Class1
Hamidiyeh			< 0.0001	1995	< 0.0001	1994	Class 2
Faridan damaneh			0.004	1997	0.009	1995	Class 2
Share kord			0.002	1983	0.000	1983	Class 2
Hamgin	3.5308	1991					Class1
Sarab handeh			0.018	1997	0.024	1997	Class 2
Adl dozak			0.002	1997			Class1
Summer							
Abadan			< 0.0001	1995	< 0.0001	1985	Class 2
Ahwaz	-3.8916	1994					Class1
Haft tapeh			0.017	1981			Class1
Hamidiyeh					< 0.0001	1994	Class1
Jangalbani badroud	3.5974	1990					Class1
Faridan damaneh					0.009	1995	Class1
Share kord			0.002	1983	0.000	1983	Class 2
Sarab handeh					0.024	1997	Class1
Adl dozak			0.002	1997			Class1
Winter							
Ahwaz					0.008	1993	Class1
Hamidiyeh	3.1362	1996	0.046	1998			Class 2
Emam gheis					0.038	1993	Class1
Faridan damaneh	-3.8049	1990	0.011	1993			Class 2
Yasoug					0.047	1993	Class1
Pol zamankhan	3.6226	1975			0.042	1971	Class 2
Sadzayandeh rood	-3.2193	1980	0.046	1976			Class 2

to detect inhomogeneity. Three tests, SNHT, standard normal homogeneity test by Alexandersson and Moberg and Pettitt's test were applied. The result for precipitation series indicated that from the annual and seasonal precipitation series only 3 out of 20 stations belonged to class 2 or doubtful and other stations belonged to the class 1 or useful. In annual temperature it was found that 4 stations out of 20 stations belonged to class 2 or doubtful and other stations were in the class 1 or useful. The homogeneity of autumn temperature series indicated that 2 stations belonged to class 2 (doubtful) and other stations belonged to class 1 (useful). The spring temperature series of 4 stations out of 20 qualified for class 2 (doubtful) and other stations for class 1 (useful). In summer series 2 stations were found to be falling under class 2 (doubtful) and other stations under class 1 (useful). The analysis of winter temperature series depicted that the series of 4 stations was found to be doubtful (class 2) and other stations as useful (class 1). In the precipitation and temperature data series we did not find any Class 3 or suspect stations. The study showed that all the three tests are very sensitive to inhomogeneity in the series and can be effectively used for temperature as well as precipitation data. The three-way approach, is therefore, in a way robust approach to test and confirm homogeneity in data series.

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