International Journal of Environment and Climate Change

Volume 14, Issue 2, Page 488-518, 2024; Article no.IJECC.112206
ISSN: 2581-8627
(Past name: British Journal of Environment & Climate Change, Past ISSN: 2231–4784)

Change Point Detection of Temperature in Karnataka State in India During the Period 1979-2019

Seedari Ujwala Rani [a*], Pramod Kumar [b], Naveen P. Singh [c], S. K. Srivastava [c], Ranjit Kumar Paul [d], R. N. Padaria [b], Sirisha Tadigiri [e], M. Ravi Kishore [f] and N. Sri Vidya Rani [g]

[a] SAU- RARS, Chinthapalli, Acharya N.G. Ranga Agricultural University, Andhra Pradesh, India.
[b] ICAR- Indian Agricultural Research Institute, New Delhi, India.
[c] ICAR-National Institute of Agricultural Economics and Policy Research, New Delhi, India.
[d] ICAR-Indian Agricultural Statistical Research Institute, New Delhi, India.
[e] ICAR-Directorate of Floricultural Research, Regional Station, Vemagiri, Andhra Pradesh, India.
[f] SAU- DAATTC, Puttaparthi, Acharya N.G. Ranga Agricultural University, Andhra Pradesh, India.
[g] SAU-KVK, Vonipenta, Dr. Y.S.R. Horticultural University, Andhra Pradesh, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI:10.9734/IJECC/2024/v14i23964

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/112206

Original Research Article

Received: 01/12/2023
Accepted: 06/02/2024
Published: 12/02/2024

ABSTRACT

This paper deals with study of exposure of Karnataka state to climate change for a period 1979-2019. The Mann Whitney Pettit's homogeneity test (MWP) was analysed for 240 data sets for monthly data of minimum (MTmin) and maximum temperature (MT max) across ten agro climatic zones) to estimate the year of structural break or year of shift in mean monthly temperature from one level to next higher level during the forty years of study period i.e., 1979-2019. About 77 data sets were identified to show year of structural break The annual mean temperature recorded

**Corresponding author: E-mail: ujwala.aeco@gmail.com;*

anupward shift in all the agro climatic zones of Karnataka except in hilly zone. The break year was chosen based on its frequent occurrence in data sets of minimum and maximum temperature. It is observed to be 1998 for North Eastern Transition Zone and is 1997, 1994, 1996, 1995, 1996, 1999, 1999, 1999 and 1997 for North Eastern Dry Zone, Northern Dry Zone, Central Dry Zone, Eastern Dry Zone, Southern Dry Zone, Southern Transition Zone, Northern Transition Zone, Hilly Zone and Coastal Zone respectively. Therefore, it is a evidential picture reflecting the increase in temperatures across the zones. Researchers should develop crop varieties that are insensitive to temperature changes and should develop packages of practices which will mitigate adverse effect of fluctuations in climate parameters on crop productivity.

Keywords: Agro-climatic zones; break year; climate change; mitigate; shift; temperature.

1. INTRODUCTION

The emission of greenhouse gases disturbs the established energy balance of atmosphere which result in rising in temperature and increased erraticity of climatic parameters. The global annual mean surface temperature has increased by more than 1.5°C above the pre industrial level (IPCC, 2018). This increase in temperature has caused unprecedented changes across the human and natural systems [1,2]. In the process of gradual warming, the mean temperature shifted upward which amounts to climate change. At global level, though total precipitation has decreased across the African continent with increasing length of consecutive dry days and decreasing length of consecutive wet days, average rainfall intensity and extreme rainfall events have decreased in western central Africa [3]. In India, the last five decades experienced an increase in the frequency and magnitude of extreme rain events over central India, western India, north-eastern India, and southern India whereas, an increase in the frequency of severe droughts have been observed over south India, central Maharashtra, the Indo-Gangetic plains, north, and northwest India [4]. The vulnerability of a system is determined by concepts of exposure, sensitivity and adaptive capacity towards climate change [5-10].

Semi- arid region of peninsular India are vulnerable to drought and water stress due to uneven distribution of monsoon rainfall. The delay in monsoon or dry spells adds pressure on available water resources [11-14]. Even in such situations farmers in semi arid India continue to grow water intensive crops. Karnataka ranks second among drought effected states after Rajasthan with frequent occurrence of droughts once in five years.

The impact of climate shock creates unequal access to resources, food insecurity and incidence of poverty in country [15-20]. The risk associated with climate change calls for a broad spectrum of policy responses and strategies at the local, regional, national and global level to mitigate the effect of the same. It is, therefore, important to examine the extent of change and extremes in temperature across ten agro climatic zones of Karnataka.

2.MATERIALS AND METHODS

2.1 Study Location

There are 10 agro climatic zones in Karnataka which is classified by Department of Agriculture along with University of Agricultural sciences, Bangalore during the year 2010.There are five Agro Climatic Zones (ACZ) namely, ACZ-II, ACZ-III, ACZ-IV, ACZ-V, ACZ-VI with relatively low rainfall and more erratic distribution and are classified under Dry Zone. Similarly, along the eastern part of the Hill zones and to the west of the Dry zones there lies a region with relatively high rainfall with less erratic distribution and also a small portion of area in the north eastern part of the state were together identified as Transitional zones. This zone comprises three Agro Climatic Zones namely, ACZ-I, ACZ-VII, ACZ-VIII. The hill and coastal belts of Karnataka state are the two distinct Agro-climatic zones namely, ACZ-IX and ACZ--X and is together classified as Hill and Coastal Zone.

2.2 Data and Analysis

The daily observed data for minimum temperature (Min Temp) and maximum temperature (Max Temp) of 30 districts of Karnataka for a period of 1979 to 2019 were collected from the AICRPAM, CRIDA, Hyderabad. The daily weather data is aggregated for 12 months, 4 climatic seasons namely, Winter (January-February), Summer (March –May), South west monsoon (SWM) (June-September) and north east monsoon (NEM) (October –December) and annual by taking simple averages for analysis. Total 34 data sets i.e., 12 months, 4 seasons and 1 annual data set of temperature were computed for each agro climatic zones. Thus, 340 data sets were obtained for 10 agro climatic zones of Karnataka. About 240 data sets are obtained for Mann Whitney test after excluding seasonal data. As per the requirement of the objective, necessary analytical tools were used to evaluate the data. Non parametric test were used in the study because they are very less affected by the presence of outlier and other form of non normality. The statistical method try to analyse the exposure concepts of climate change for Karnataka. The shift points or change year of temperature is identified through Mann WhitneyPettit's homogeneity test.

2.3 Mann Whitney Pettit Method (MWP)Homogeneity Test

Mann Whitney Pettit Method is used to identify the sudden or abrupt change in climatologically trend [21]

$$\mathrm{Uk} = 2\sum_{t=0}^{n} \mathrm{mt} - \mathrm{k}(\mathrm{n}+1) \qquad (1)$$

Where M_i is the rank of the i^{th} observation when the values X_1, X_2... Xn in the series are arranged in the ascending order. Then the statistical change point (SCP) test statistic is defined as:

$$\mathrm{k} = \max|\mathrm{Uk}| \qquad (2)$$

A change point occurs in the series at which U_k attains a maximum value of K. A time series (X_1,X_2,...Xn) with length n is considered. Let t be taken as the time of the most expected change pointy. Two samples of (X_1,X_2,...Xt) and (X_{t-1},X_{t+2},..X_n) can be then obtained by dividing the time series at t time. The Ut index is derived in the following way

$$\text{Sign } (X_j - X_i) = 1 \text{ if } (X_j - X_i) > 0 \qquad (3)$$

$$\text{Sign } (X_j - X_i) = 0 \text{ if } (X_j - X_i) = 0 \qquad (4)$$

$$\text{Sign } (X_j - X_i) = -1 \text{ if } (X_j - X_i) < 0 \qquad (5)$$

Plotting the U_t value against 't' in a time series, no change point will result in a continuously increasing value of U_t. Nevertheless, if there is a presence of change point, then U_t will increase up to the level of the change point and then it will begin to decrease. The main significant change point t is considered as the point where the value of U_t remains highest.

$$K_t = \max U_t \qquad (6)$$

$$1<t<T$$

The estimated significant probability P(t) for a change point (Pettit, 1979) is given as

$$P=1-ep\ (-6k2t/n3-n2) \qquad (7)$$

The change point becomes statistically significant at 't' time with the significant level when probability P(t) surpasses (1-α).

The null hypothesis states that there is no shift or displacement in mean monthly temperature (MT min or MT max) data and the alternate hypothesis states that a certain data may be distinguished as a change point and mean monthly temperature data set is significantly displaced at the break point [22].

3.RESULTS AND DISCUSSION

Prior to analyzing the impact of climate change on environment and hydrological aspects, it is necessary to determine homogeneity of climate data which has great importance in climate change monitoring, weather forecasting, drought monitoring. The Pettit's test is a non parametric test that is used to identify the point at which the time series data takes a shift from one level to another. The break year is detected near the year when the estimated values exceed the critical value. The results obtained for ten agro climatic zones are presented in the form of figures in this section. A horizontal line in the figures is used to represent the critical value of test statistics at a 95 percent confidence level. If the estimated value is more than critical value, the null hypothesis of homogeneity cannot be rejected and it is consider as homogenous. Non homogeneity was found to vary for different months at different agro climatic zones {5-22} The following Table1 and 2 shows the results of change point detection across all the ten agro climatic zones in Karnataka.

Table 1. Results of the Pettit's homogeneity test and Break year of climate change across ACZ I-V for 1979-2019

	Minimum Temperature (°C)					Maximum Temperature (°C)				
	Mu$_1$ (°C)	Mu$_2$ (°C)	Shift value (°C)	Two tailed test (Þ-Value)	Break Year	Mu$_1$ (°C)	Mu$_2$ (°C)	Shift value (°C)	Two tailed test (Þ-Value)	Break Year
ACZ-I NETZ										
January	-	-	-	-	-	30.11	30.92	0.026	0.046	1999
August	21.81	22.11	0.013	0.023	1994	-	-			-
November	19.33	17.62	-0.088	0.035	1981	31.28	30.12	-0.037	<0.001	1998
December	-	-	-	-	-	29.16	30.38	0.041	0.000	1998
ACZ-II NEDZ										
January	-	-	-	-	-	31.28	32.16	0.028	0.000	1997
August	22.01	22.28	0.0122	0.031	1997	30.49	31.10	0.020	0.035	1994
November	18.29	18.50	0.011	0.008	1989	30.18	31.18	0.033	0.001	1998
December	-	-	-	-	-	29.30	30.41	0.037	0.000	1998
ACZ-III NDZ										
January	-	-	-	-	-	30.41	31.08	0.022	0.002	1997
February	-	-	-	-	-	32.70	33.35	0.019	0.016	2000
August	-	-	-	-	-	28.36	29.02	0.023	0.000	1994
November	-	-	-	-	-	29.98	30.70	0.024	0.001	1998
December	-	-	-	-	-	29.57	30.40	0.028	0.001	2000
ACZ-IV CDZ										
January	-	-	-	-	-	28.67	29.27	0.020	0.001	1997
July	20.36	20.65	0.014	0.019	1996	-	-	-	-	-
August	20.10	20.43	0.016	0.010	1997	-	-	-	-	-
ACZ-V EDZ										
January	-	-	-		-	29.06	29.66	0.020	0.017	2002
March	19.94	20.24	0.015	<0.001	1995	-	-	-	-	-
July	20.87	21.28	0.019	0.001	1996	-	-	-	-	-
August	20.58	21.00	0.020	0.000	1995	-	-	-	-	-
September	20.45	20.85	0.019	<0.0001	1997	-	-	-	-	-
October	19.96	20.32	0.018	0.037	1995	-	-	-	-	-
December	-	-	-	-	-	27.88	28.54	0.023	0.019	2001

Note: Mu1-Temperature value before break year; Mu2-Temperature value after break year; Shift Value =Mu2-Mu1/Mu1; (p values of the significant change points)

Table 2. Results of the Pettit's homogeneity test and Break year of climate change across ACZ (VI-X) for 1979-2019

	Minimum Temperature (°C)					Maximum Temperature (°C)				
	Mu_1 (°C)	Mu_2 (°C)	Shift value (°C)	Two tailed test (Þ-Value)	Break Year	Mu_1 (°C)	Mu_2 (°C)	Shift value (°C)	Two tailed test (Þ-Value)	Break Year
ACZ-VI SDZ										
January	-	-	-	-	-	28.65	29.23	0.020	0.000	1997
February	-	-	-	-	-	30.94	31.54	0.019	0.017	2002
April	20.68	21.15	0.022	0.018	1997	-	-			-
July	19.65	20.01	0.018	0.002	1996	-	-			-
August	19.49	19.90	0.021	0.001	1996	26.74	27.24	0.018	0.039	1992
September	19.39	19.73	0.017	0.004	1996	-	-			-
October	19.14	19.52	0.019	0.011	1996	28.37	29.01	0.022	0.030	2007
December	-	-	-	-	-	27.91	28.50	0.0211	0.043	2002
ACZ-VII STZ										
January	-	-	-	-	-	29.63	30.31	0.022	<0.0001	1997
February	-	-	-	-	-	31.08	31.86	0.025	0.000	2000
March	-	-	-	-	-	32.86	33.32	0.013	0.030	2001
August	-	-	-	-	-	26.18	26.80	0.023	0.004	1992
November	-	-	-	-	-	28.99	29.60	0.021	0.012	1999
December						29.08	29.70	0.021	0.005	2000
ACZ-VIII NTZ										
January	-	-	-	-	-	30.83	31.43	0.091	0.009	2002
February	-	-	-	-	-	32.42	33.12	0.021	0.008	2000
August	-	-	-	-	-	27.85	28.57	0.025	<0.0001	1994
November	18.83	19.18	0.018	0.046	1989	30.63	31.34	0.023	0.001	1999
December	29.56	30.40	0.028	0.694 NS	2000	30.24	31.05	0.026	<0.0001	1999
ACZ-IX HZ										
January	16.63	15.78	-0.051	0.000	2005	29.21	28.08	-0.038	<0.0001	1993
February	17.50	16.68	-0.046	0.000	2003	30.17	28.96	-0.040	<0.0001	1999
March	19.14	18.39	-0.039	<0.0001	1999	31.51	29.98	-0.048	<0.0001	1999
April	20.44	19.61	-0.040	<0.0001	2003	32.03	30.44	-0.049	<0.0001	1999
May	20.80	19.85	-0.045	<0.0001	2003	31.50	29.74	-0.055	<0.0001	1998
June	20.08	19.28	-0.039	<0.0001	2003	28.34	27.21	-0.039	<0.0001	2000
July	19.69	19.05	-0.032	<0.0001	2003	27.11	26.21	-0.033	0.001	2002

	Minimum Temperature (°C)					Maximum Temperature (°C)				
	Mu_1 (°C)	**Mu_2 (°C)**	**Shift value (°C)**	**Two tailed test (Þ-Value)**	**Break Year**	**Mu_1 (°C)**	**Mu_2 (°C)**	**Shift value (°C)**	**Two tailed test (Þ-Value)**	**Break Year**
August	19.61	19.08	-0.027	0.000	1999	26.99	26.38	-0.022	0.004	1996
September	19.51	18.95	-0.028	0.000	2000	28.08	27.17	-0.032	0.000	1997
October	19.36	18.78	-0.029	<0.0001	1999	28.73	27.70	-0.035	<0.0001	1997
November	18.37	17.77	-0.032	0.019	2001	28.54	27.63	-0.031	<0.0001	2003
December	17.14	16.51	-0.036	0.010	1999	28.74	27.67	-0.037	<0.0001	1995
ACZ-X CZ										
January	-	-	-	-	-	30.27	30.95	0.022	<0.0001	1997
February	-	-	-	-	-	31.47	32.32	0.027	0.001	2000
March	-	-	-	-	-	33.20	33.69	0.014	0.012	2000
August	-	-	-	-	-	26.67	27.34	0.025	0.001	1993
November	-	-	-	-	-	29.88	30.51	0.021	0.003	1999
December	-	-	-	-	-	29.91	30.56	0.021	0.000	2000

Note: Mu1-Temperature value before break year; Mu2-Temperature value after break year; Shift Value =Mu2-Mu1/Mu1; (p values of the significant change points)

3.1 Shift in Mean Temperature in North Eastern Transition Zone during 1979-2019

There is an upward shift in mean minimum temperature of August from 21.81 to 22.11°C in 1994 which implies that temperature increased by 0.3 percent in that year (Fig. 1). The mean minimum temperature of November shifted downwards in the year 1981 from 19.33 to 17.62°C. The mean maximum temperature of January has recorded a shift during the year 1999 from 30.11 to 30.92°C (Fig. 2) while shift of mean temperature of November was 30.12 to 31.28°C. The mean temperature of December shifted from 29.16 to 30.38°C in 1998. The shift in annual mean temperature was observed between the year 1994 and 1998.

3.2 Shift in Mean Temperature in North Eastern Dry Zone During 1979-2019

There is a upward shift in the year 1997 of mean minimum temperature of August from 22.01 to 22.28°C (Fig. 3) while that of November was in year 1989 from 18.29 to 18.50°C. The mean maximum temperature of January month recorded a shift in the year 1997 from 31.28 to 32.16°C. The shift of temperature from 30.49 to 31.10°C occurred for the mean temperature of August month in the 1994. The maximum temperature of November month shifted from 30.18 to 31.18°C and of December month shifted from 29.30 to 30.41°C in the year 1998 (Fig. 4). There is upward shift of mean maximum temperatures was observed to have taken place during the period 1994 to 1998 in North Eastern Dry Zone of Karnataka.

3.3 Shift in mean temperature in Northern dry zone during 1979-2019

There was no shift in monthly mean minimum temperature in Northern Dry zone during 1979 to 2019. There is an upward shift during the year 1997 in mean maximum temperature of January month from 30.41 to 31.08 °C (Fig. 5). There is an upward shift in the year 2000 for the mean temperature of February and December months from 32.70 to 33.35 °C and 29.57 to 30.40°C, respectively. The maximum temperature of August and November shifted in the years 1994 and 1998 from 28.36 to 29.02 °C and from 29.98 to 30.70°C, respectively. The shift of maximum temperature of various months of Northern Dry Zone of Karnataka was observed during the period 1994 to 2000.

3.4 Shift in Mean Temperature in Central Dry Zone during 1979-2019

The upward shift from 20.36 to 20.65°C took place in the year 1996 in mean minimum temperature of July month. (Fig. 6) where as the shift from 20.10 to 20.43°C was recorded in in the year 1997 for the mean minimum temperature of August month. The upward shift of maximum temperature January month occurred (Fig. 7) from 28.67 to 29.27 °C in the year 1997. The shift in temperature in Central dry zone identified between 1996 to 1997.

3.5 Shift in Mean temperature in Eastern Dry Zone during 1979-2019

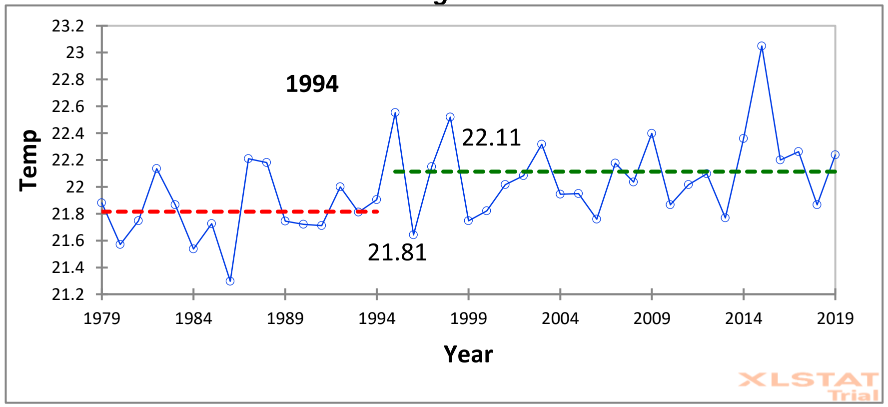
The shift in mean minimum temperature has occurred more frequently rather than shift in mean maximum temperatures. There is an upward shift during the year 1995 in the mean minimum temperature of March, August and October from 19.94 to 20.24°C, 20.58 to 21.00°C, 19.96 to 20.32°C, respectively (Fig. 8). The shift of temperature of July month was from 20.87 to 21.28°C in the year 1996, while that of September was observed in the year 1997 from 20.45 to 20.85°C. The shift of maximum temperatures of January and December months took place (Fig. 9) from 29.06 to 29.66°C and 27.88 to 28.54°C, during the years 2000 and 2001, respectively.

3.6 Shift in Mean Temperature in Southern Dry Zone During 1979-2019

The southern Dry zone recorded larger shifts in monthly mean minimum and maximum temperatures. The upward shift was observed in the year 1997 in mean minimum temperature of April month and the shift was (Fig. 10) from 20.68 to 21.15°C. The mean temperatures of July, August, September and October months took place in the year 1996 and the shift was from 19.65 to 20.01°C, 19.49 to 19.90 °C, 19.39 to 19.73°C, 19.14 to 19.52 °C, respectively. The shift in maximum temperature of January (28.65 to 29.23°C), February (30.94 to 31.54°C), August (26.74 to 27.24 °C), October (28.37 to 29.01 °C) and December (27.91 to 28.50 °C) months was observed to have taken place in the years 1997, 2002, 1992, 2007 and 2002, respectively (Fig. 11).

ACZ -1: Graphical results obtained through Pettit's homogeneity test of NETZ

August



November

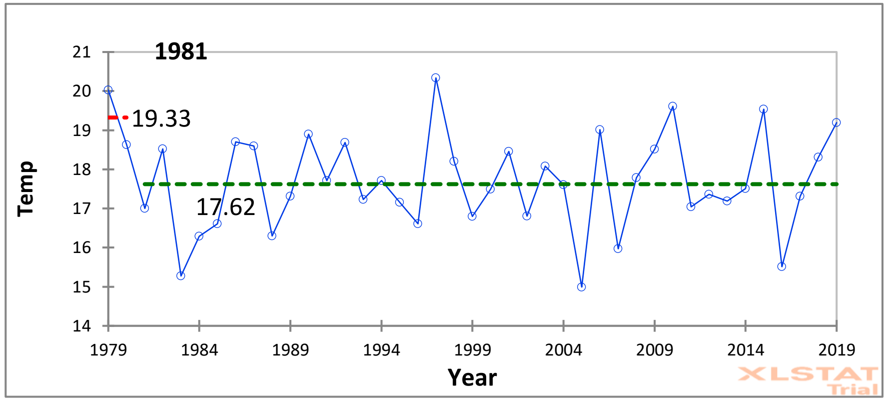


Fig. 1. Shift in monthly mean minimum temperature of NETZ

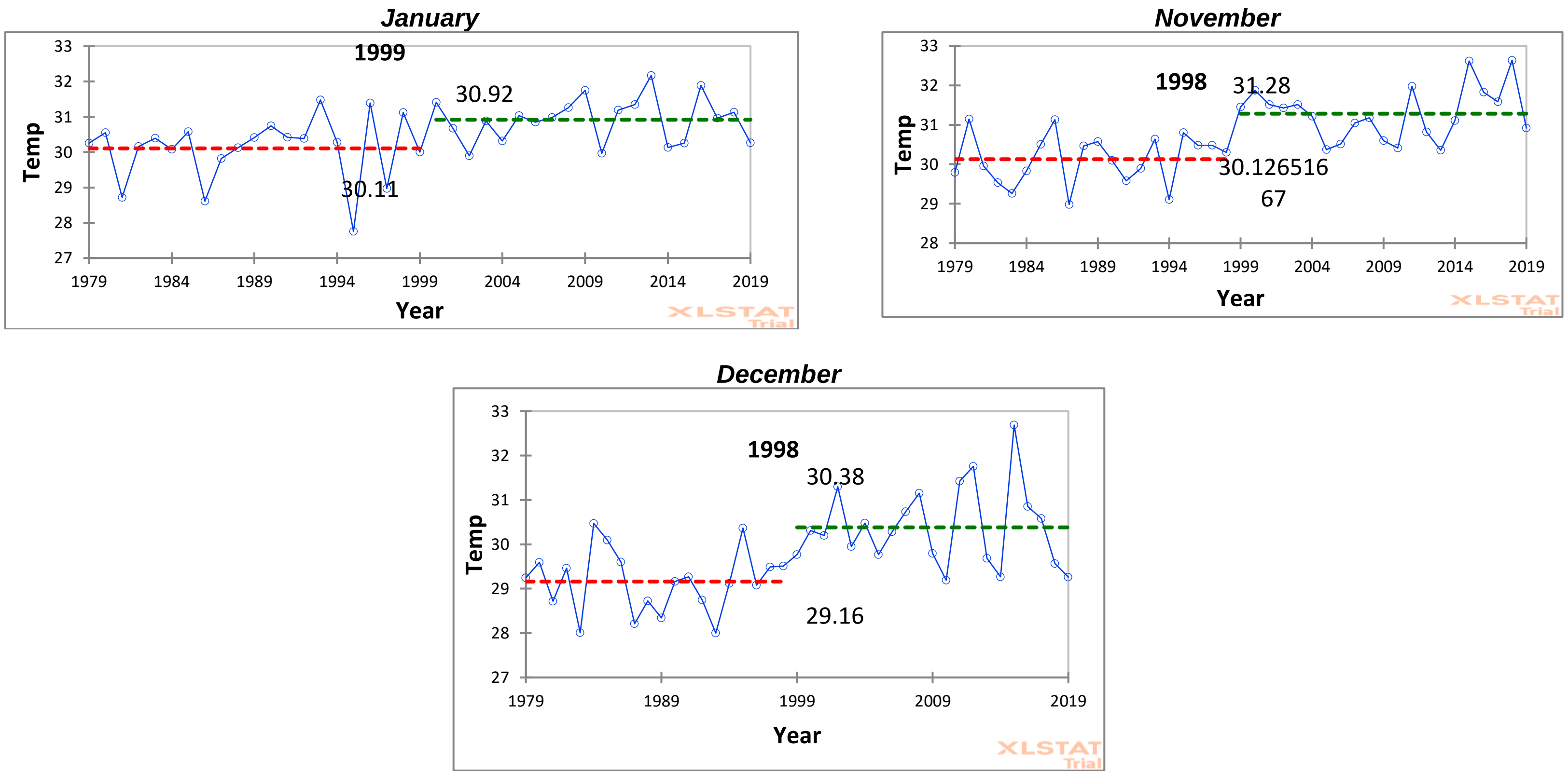
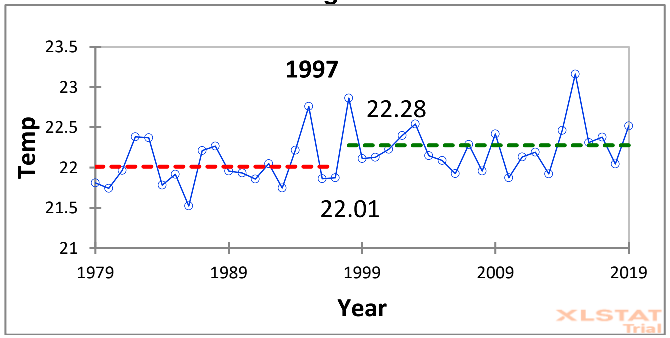


Fig. 2. Shift in monthly mean maximum temperature of NETZ

ACZ –II:Graphical results obtained through Pettit's homogeneity test of NEDZ

August



November

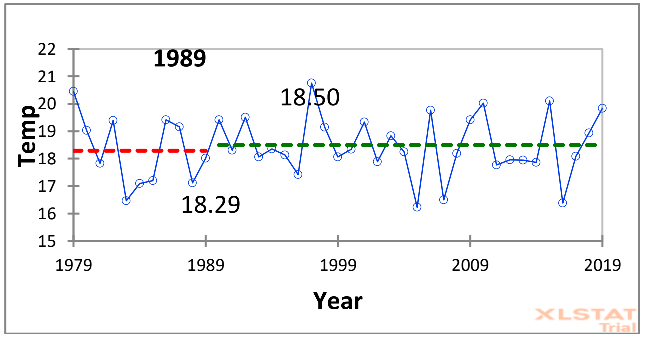
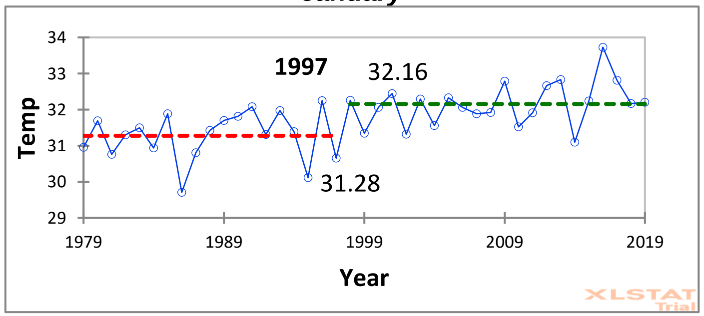
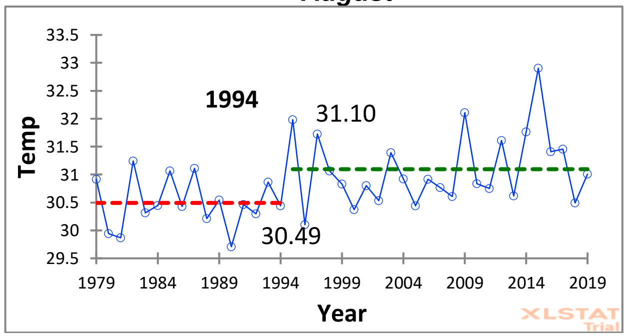


Fig. 3. Shift in monthly mean Minimum temperature of NEDZ

January



August



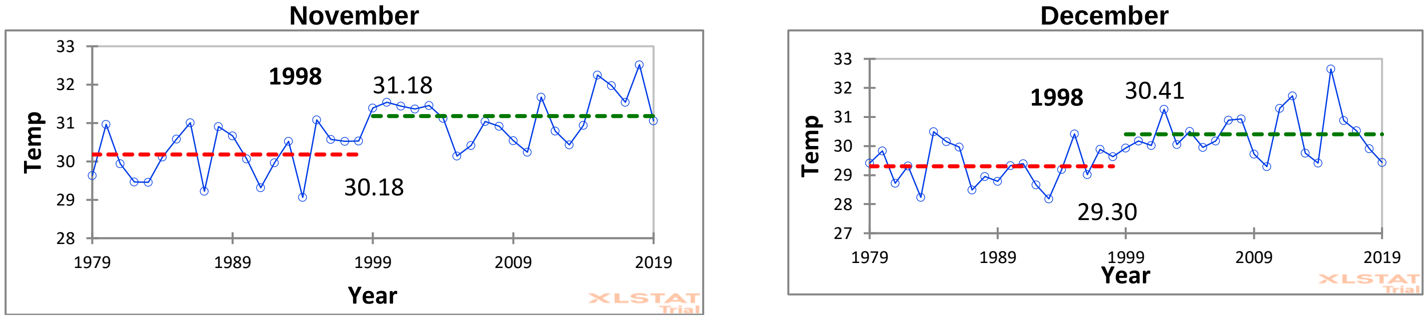
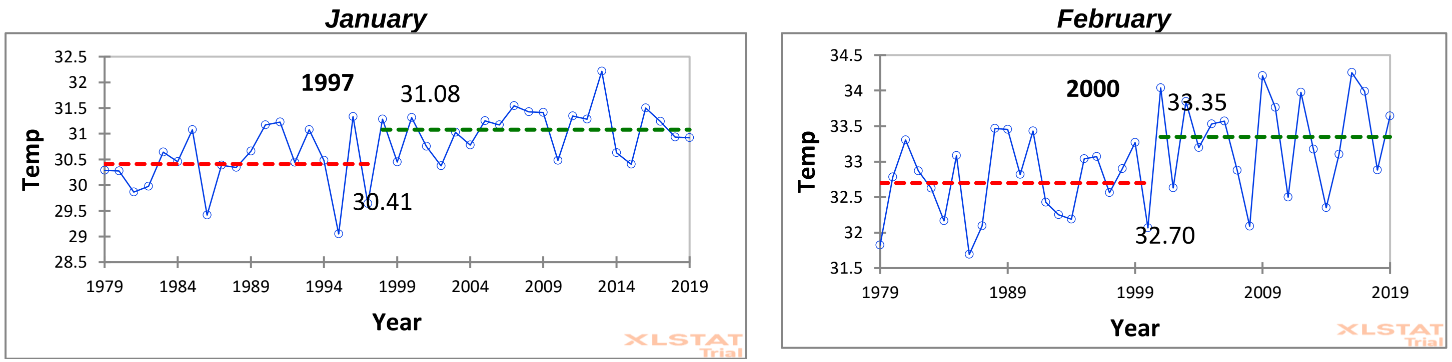


Fig. 4. Shift in monthly mean maximum temperature of NEDZ

ACZ- III:Graphical results obtained through Pettit's homogeneity test of NDZ



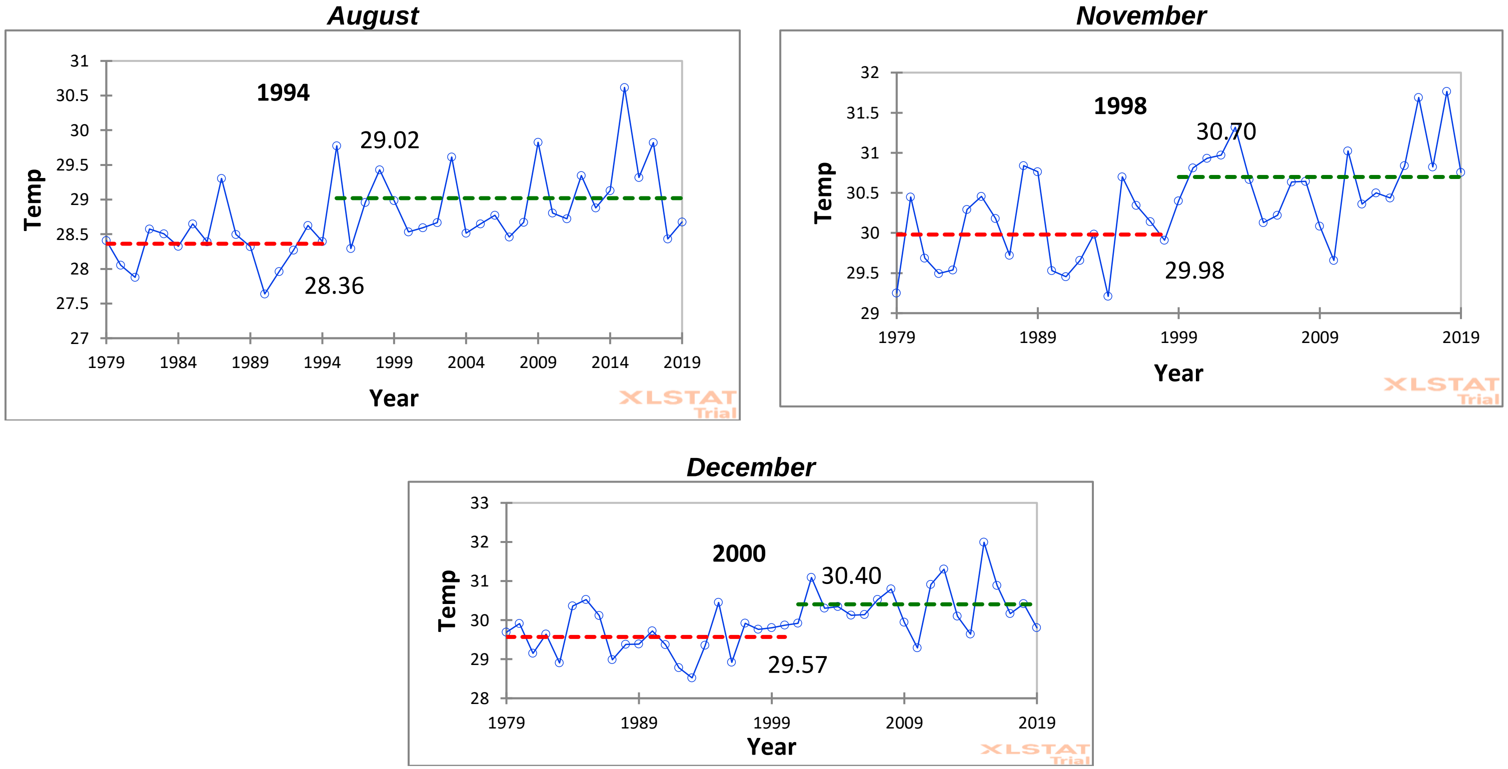
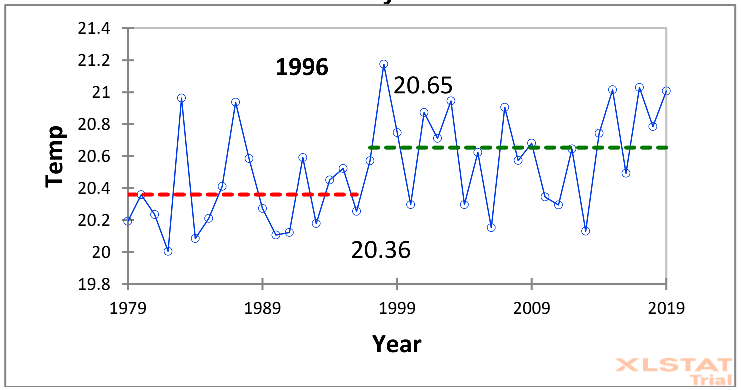


Fig. 5. Shift in monthly mean maximum temperature of NDZ

ACZ- IV: Graphical results obtained through Pettit's homogeneity test of CDZ

July



August

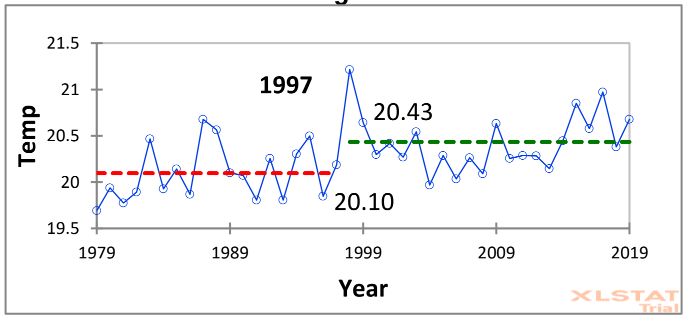


Fig. 6. Shift in monthly mean minimum temperature of CDZ

January

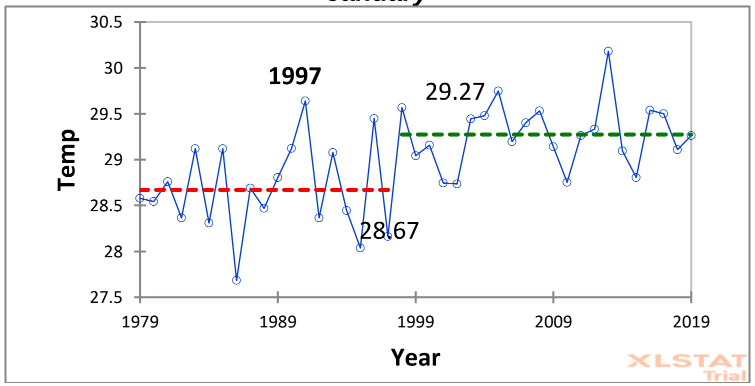
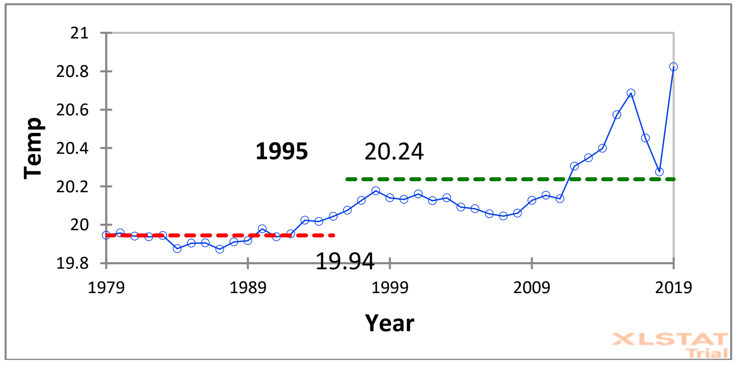


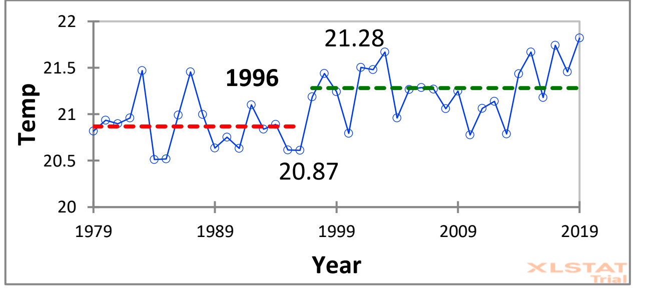
Fig. 7. Shift in monthly mean maximum temperature of CDZ

ACZ-V: Graphical results obtained through Pettit's homogeneity test of EDZ

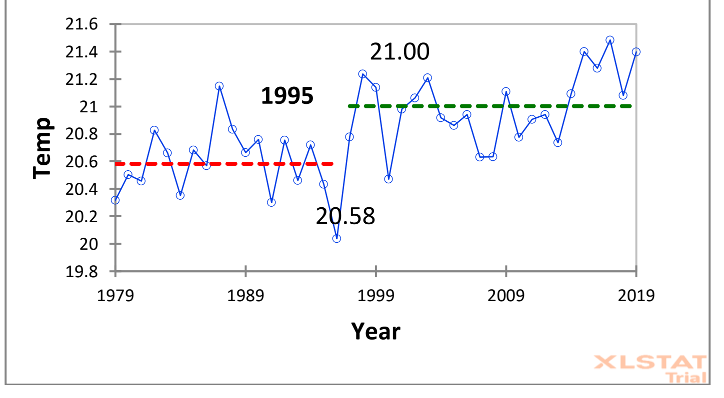
March



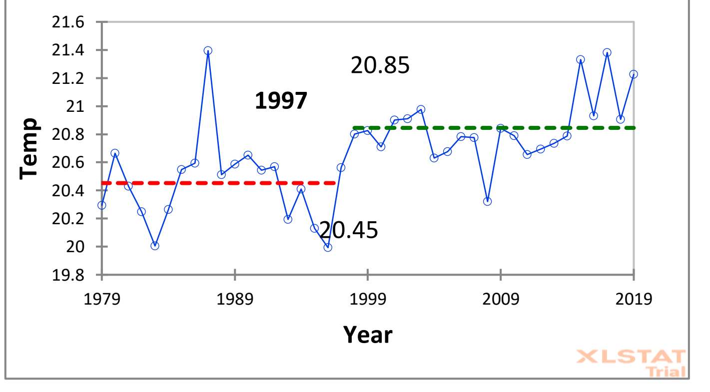
July



August



September



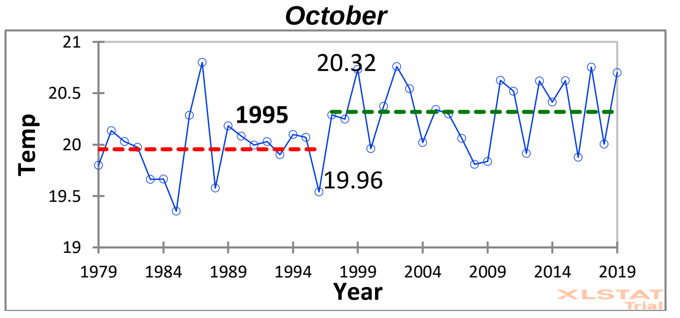


Fig. 8. Shift in monthly mean minimum temperature of EDZ

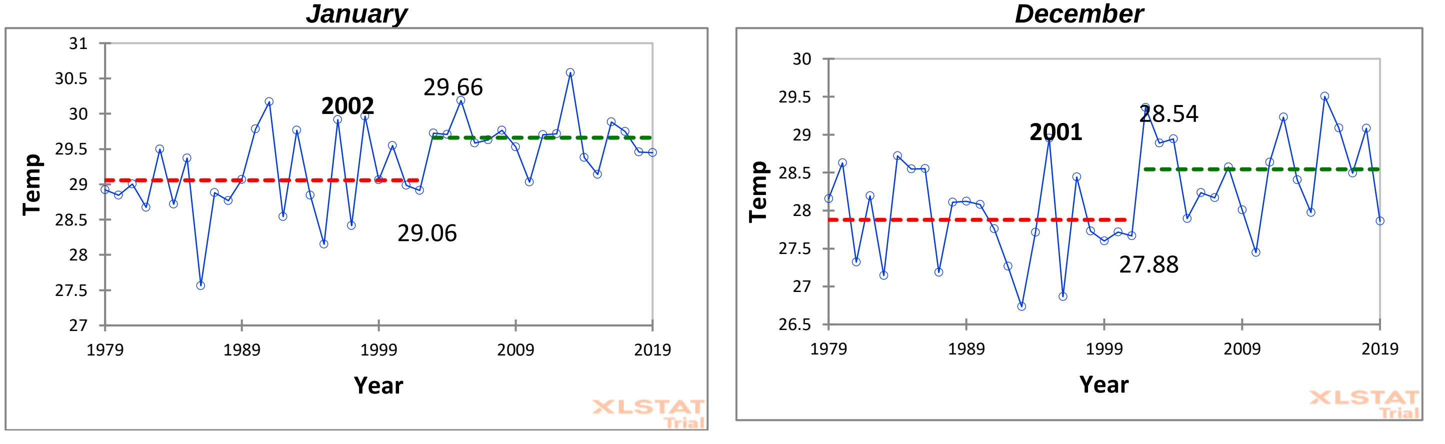
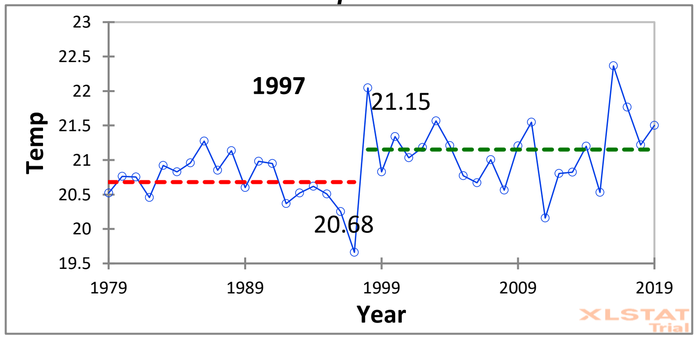


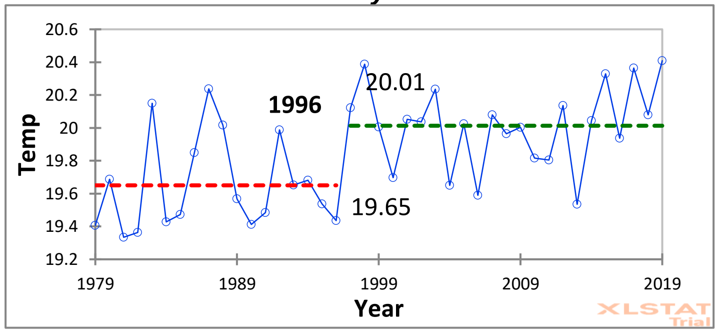
Fig. 9. Shift in monthly mean maximum temperature of EDZ

ACZ-VI: Graphical results obtained through Pettit's homogeneity test of SDZ

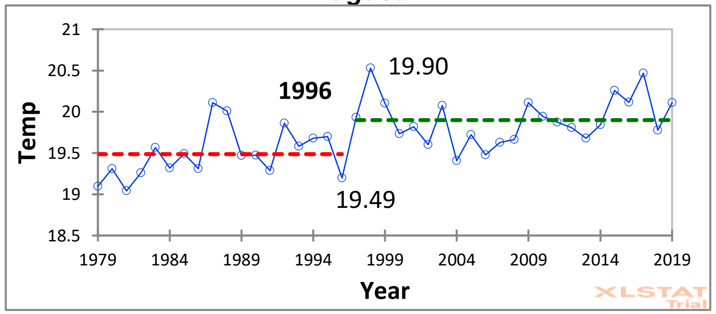
April



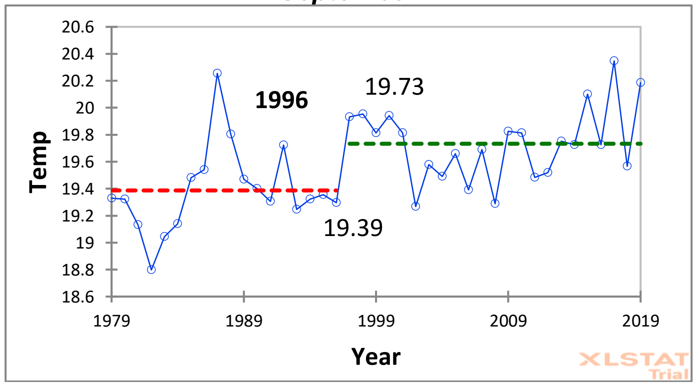
July



August



September



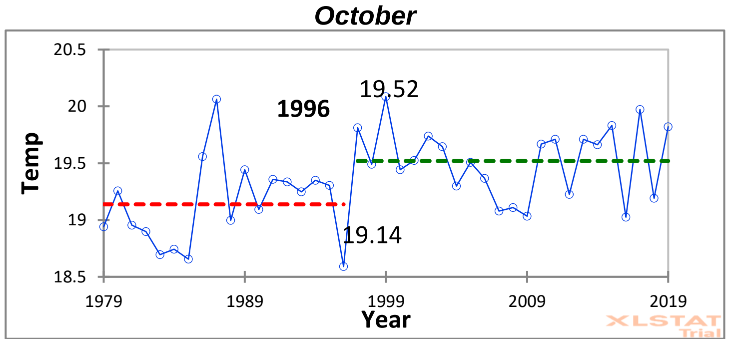
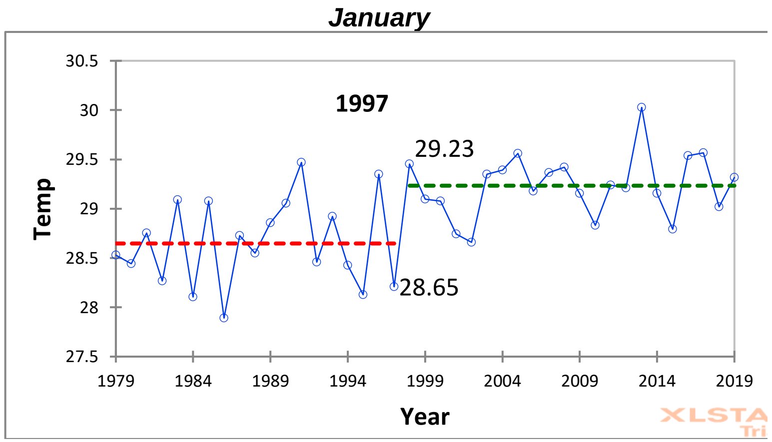
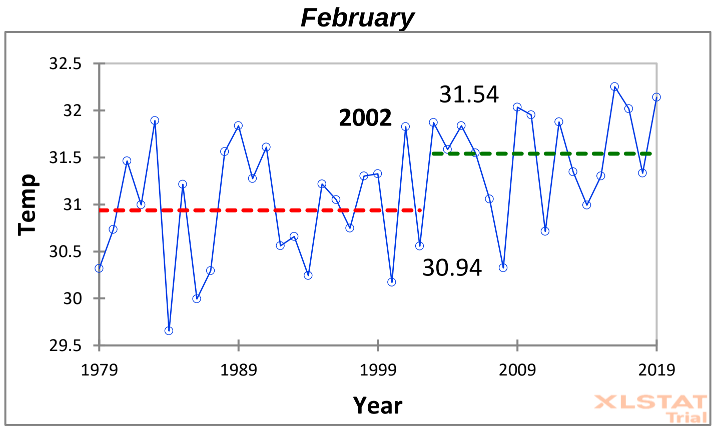


Fig. 10. Shift in monthly mean minimum temperature of SDZ





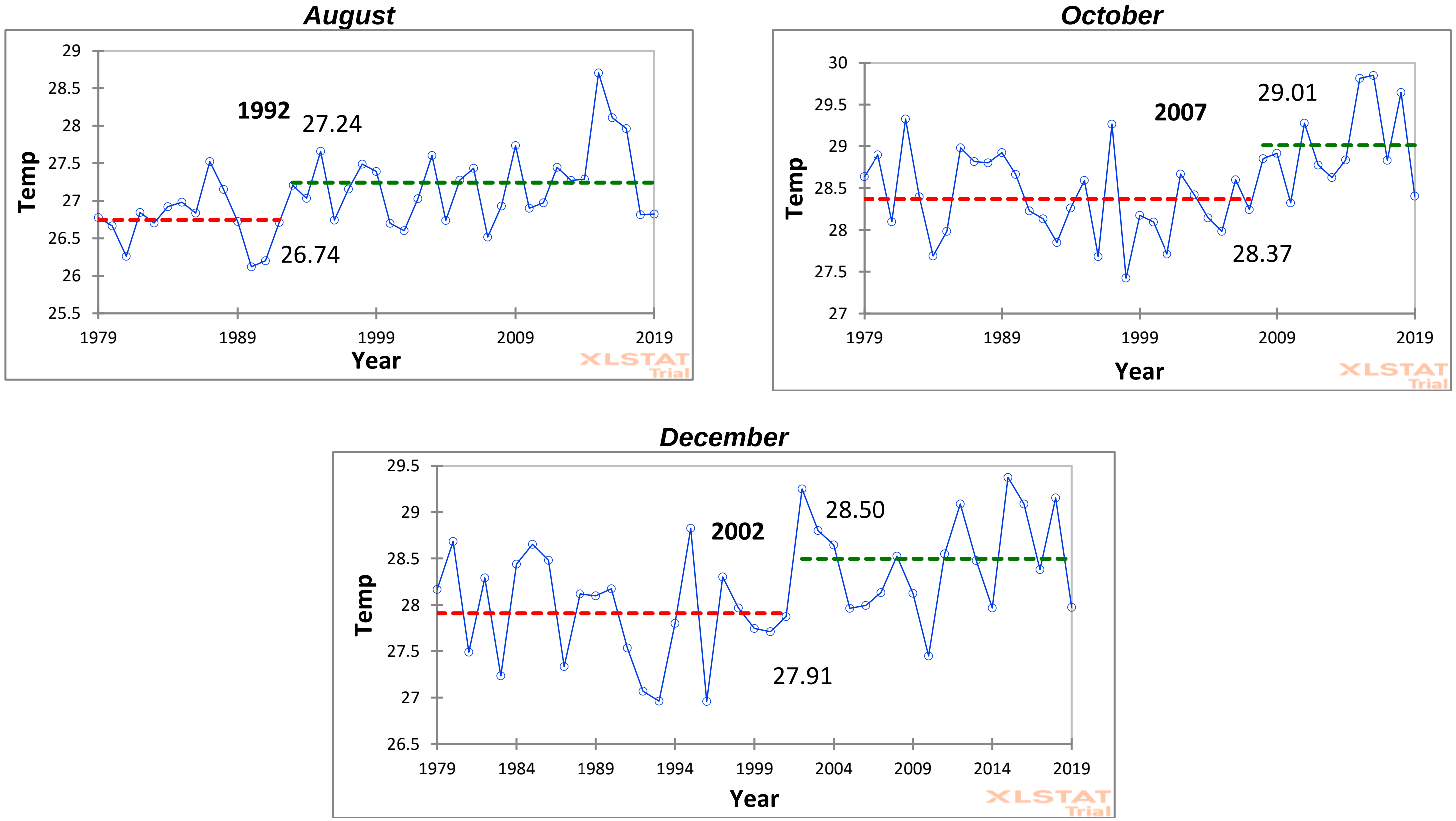
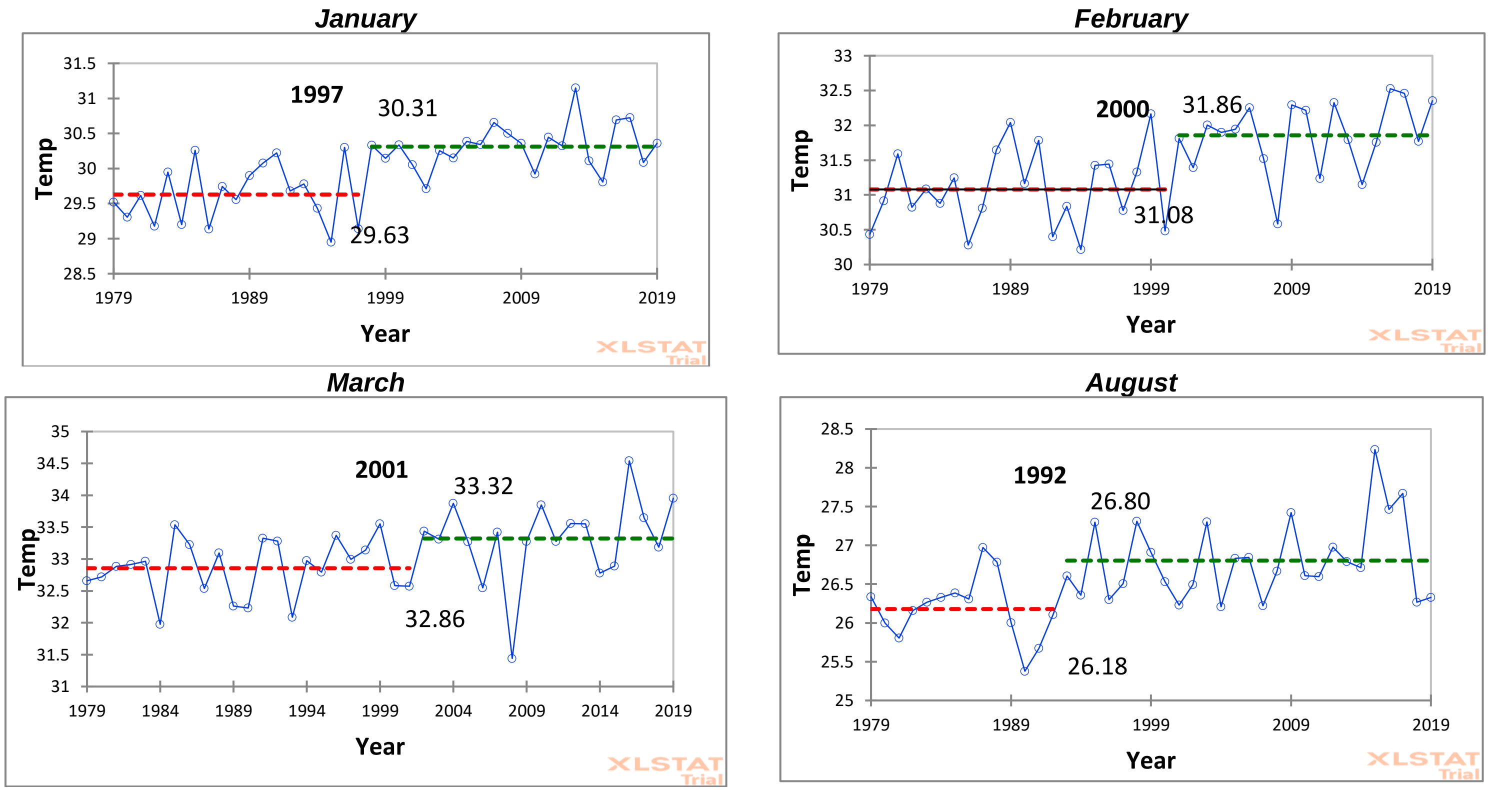


Fig. 11. Shift in monthly mean maximum temperature of SDZ

ACZ-VII: Graphical results obtained through Pettit's homogeneity test of STZ



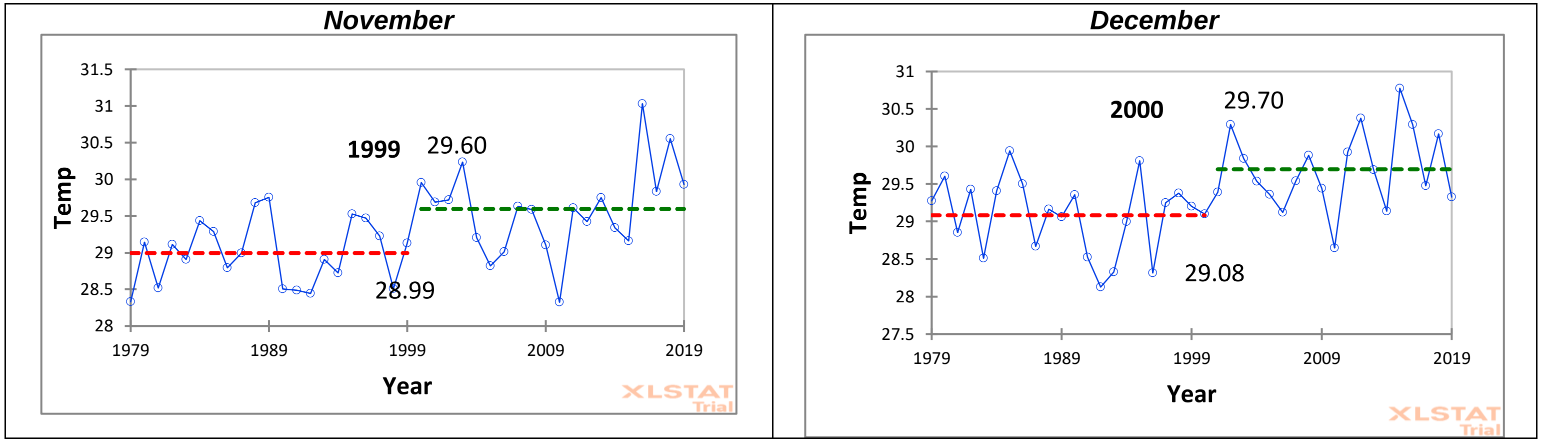


Fig. 12. Shift in monthly mean maximum temperature of STZ

ACZ-VIII: Graphical results obtained through Pettit's homogeneity test of NTZ

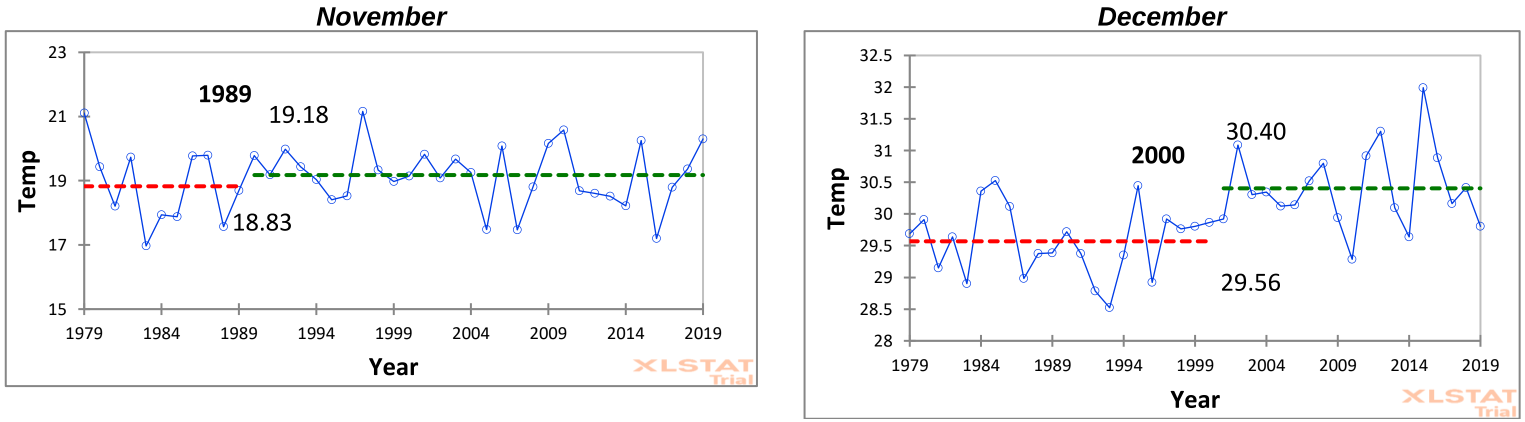


Fig. 13. Shift in monthly mean minimum temperature of NTZ

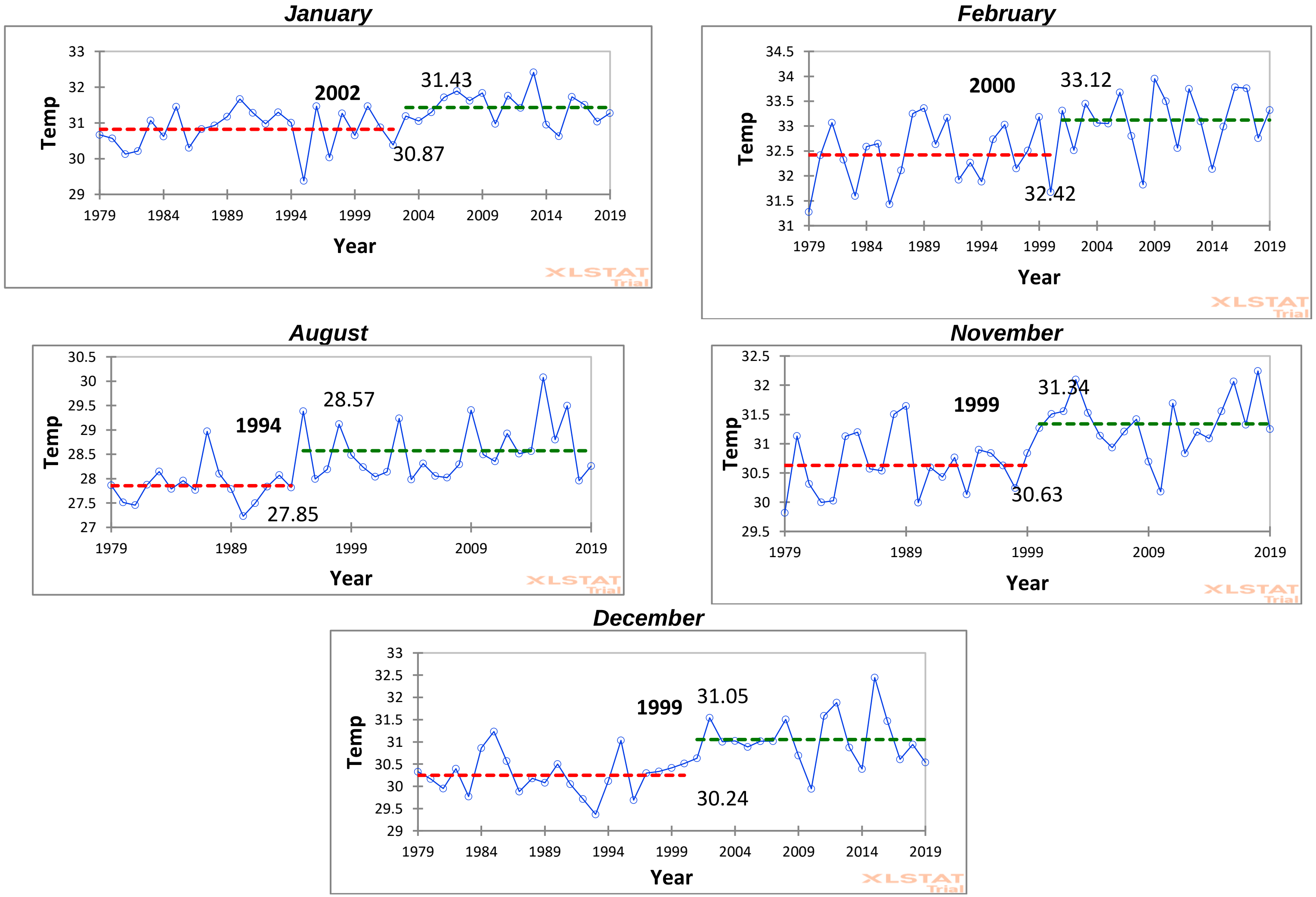
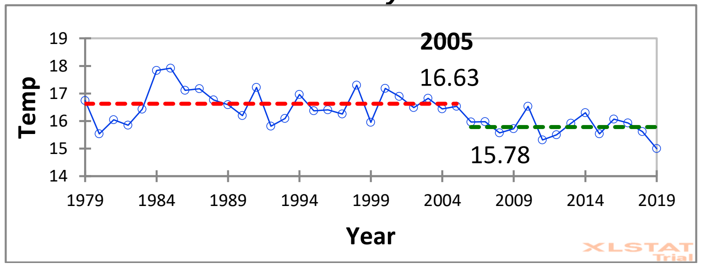


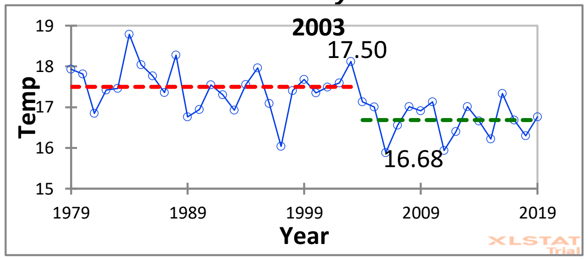
Fig. 14. Shift in monthly mean maximum Temperature of NTZ

ACZ-IX: Graphical results obtained through Pettit's homogeneity test of HZ

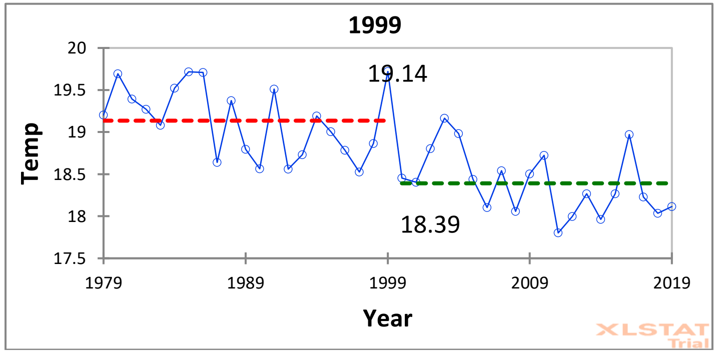
January



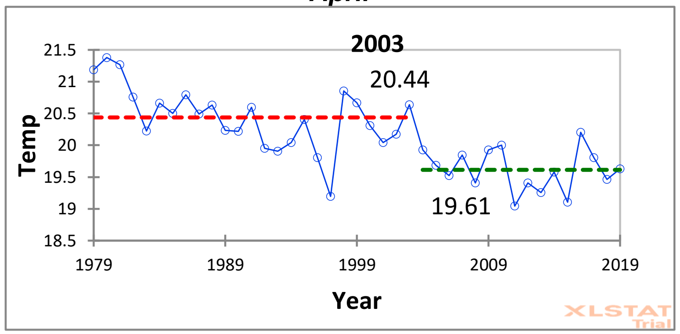
February

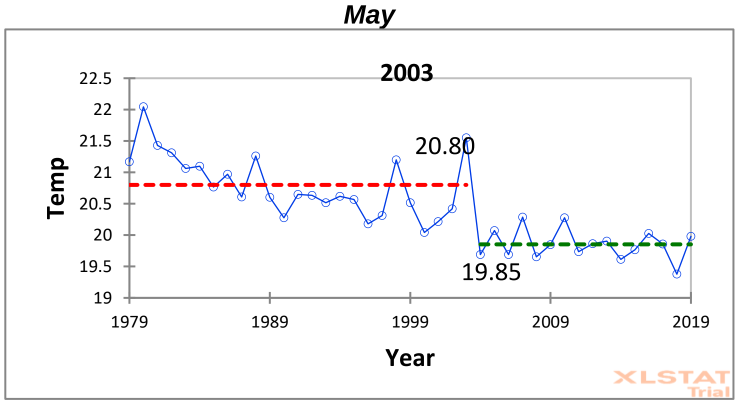


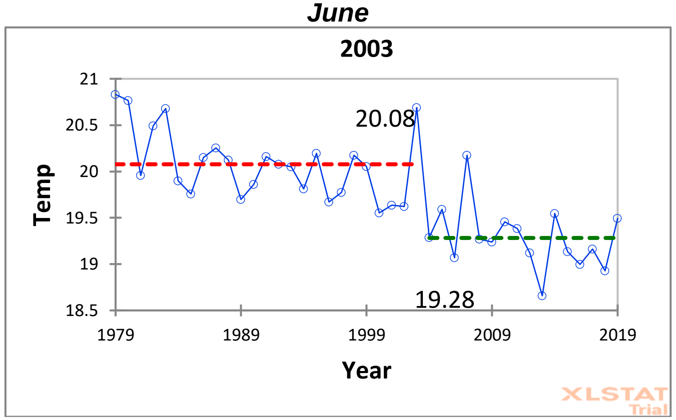
March

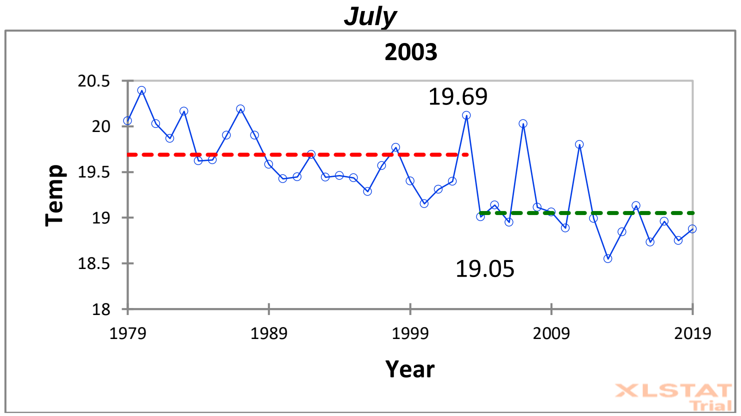


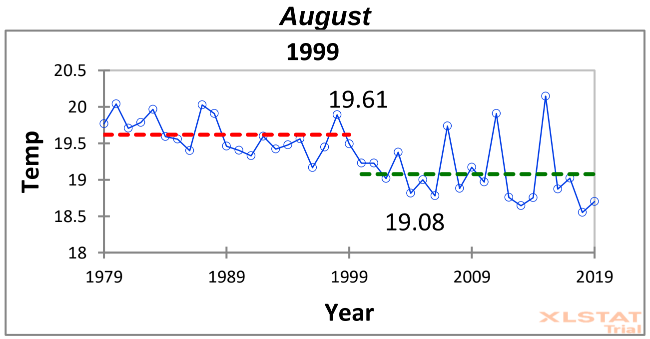
April




May
2003
20.80
19.85
Temp
Year
22.5
22
21.5
21
20.5
20
19.5
19
1979
1989
1999
2009
2019


June
2003
20.08
19.28
Temp
Year
21
20.5
20
19.5
19
18.5
1979
1989
1999
2009
2019


July
2003
19.69
19.05
Temp
Year
20.5
20
19.5
19
18.5
18
1979
1989
1999
2009
2019


August
1999
19.61
19.08
Temp
Year
20.5
20
19.5
19
18.5
18
1979
1989
1999
2009
2019

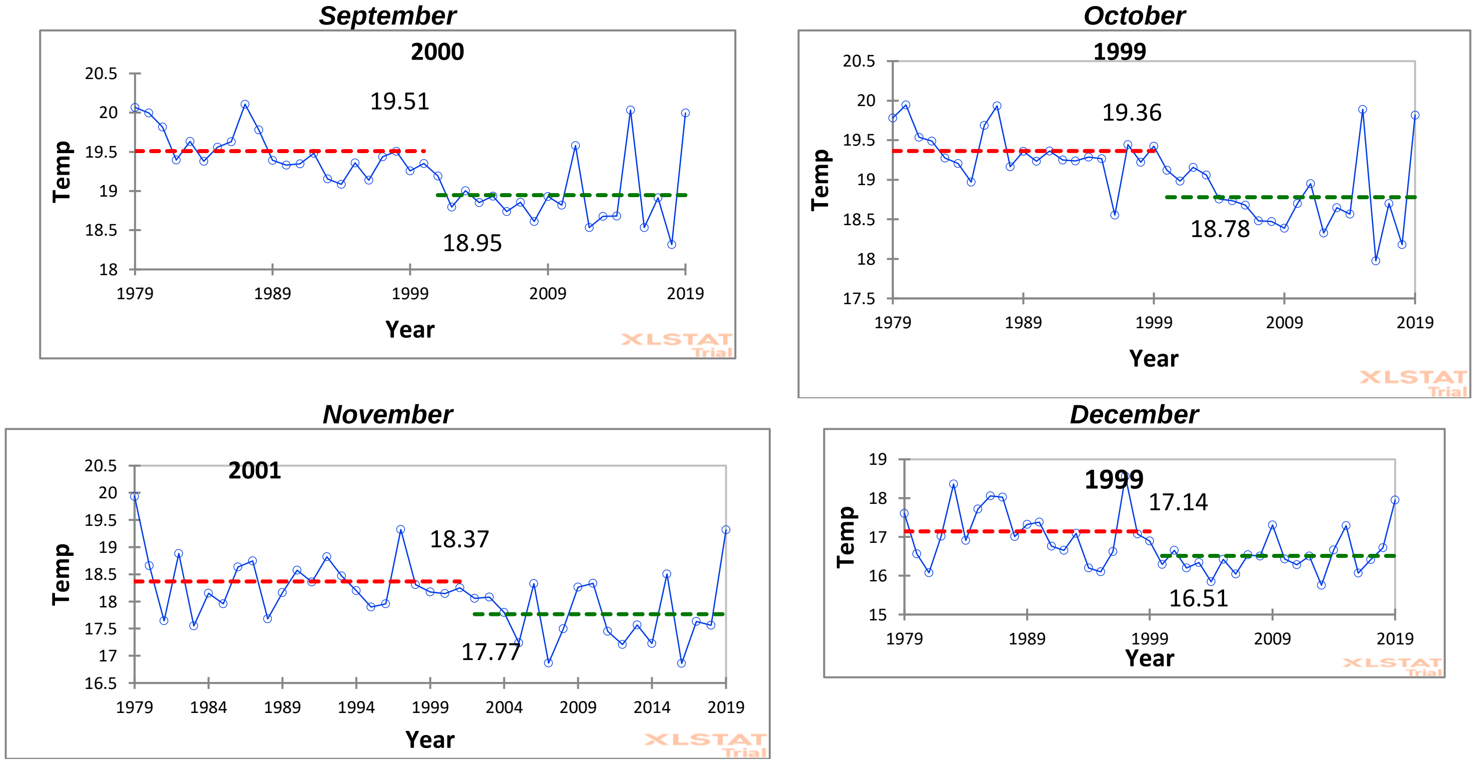
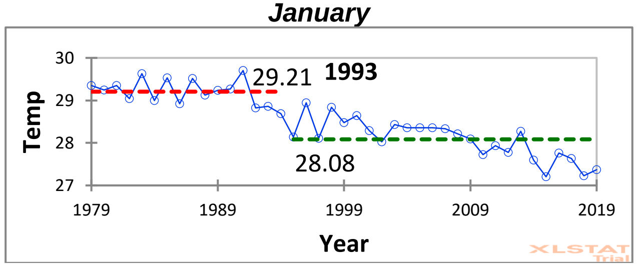
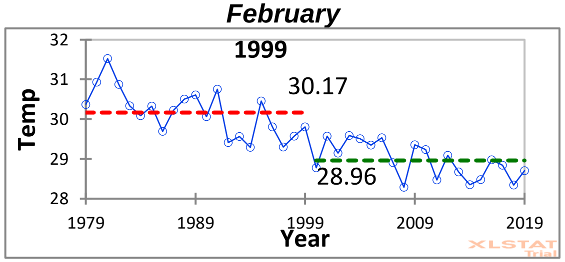
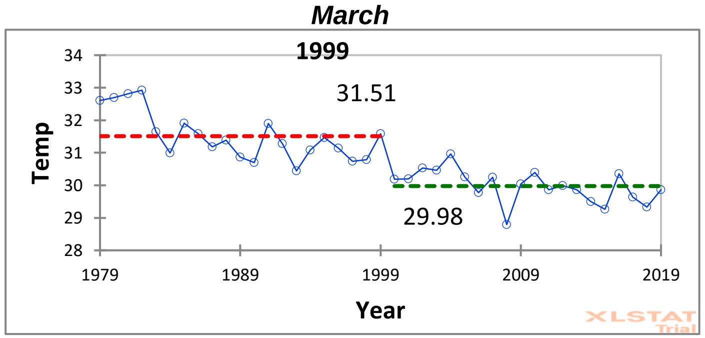
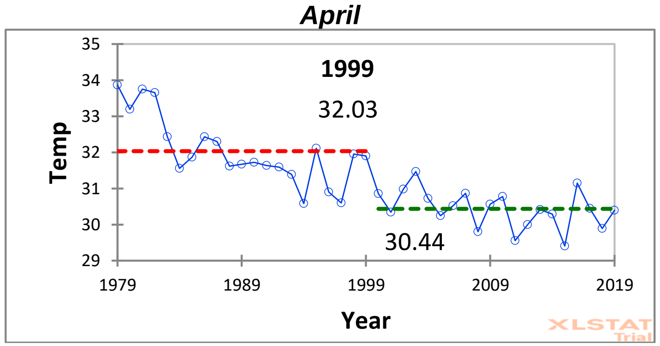


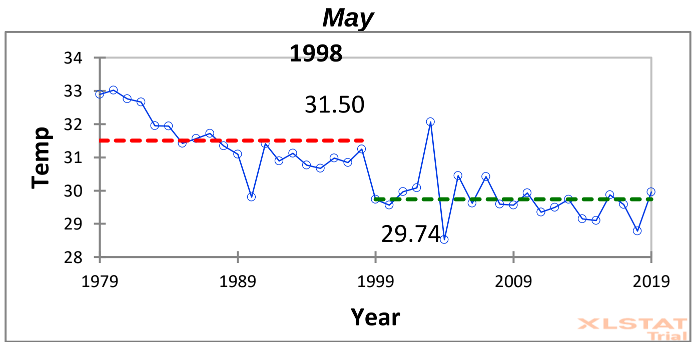
Fig. 15. Shift in monthly mean minimum Temperature of HZ

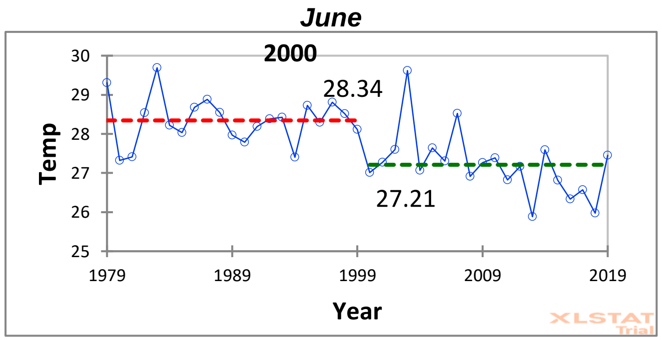

January
Temp
29.21
1993
28.08
Year
1979
1989
1999
2009
2019


February
1999
30.17
28.96
Temp
Year


March
1999
31.51
29.98
Temp
Year


April
1999
32.03
30.44
Temp
Year


May
1998
31.50
29.74
Temp
Year


June
2000
28.34
27.21
Temp
Year

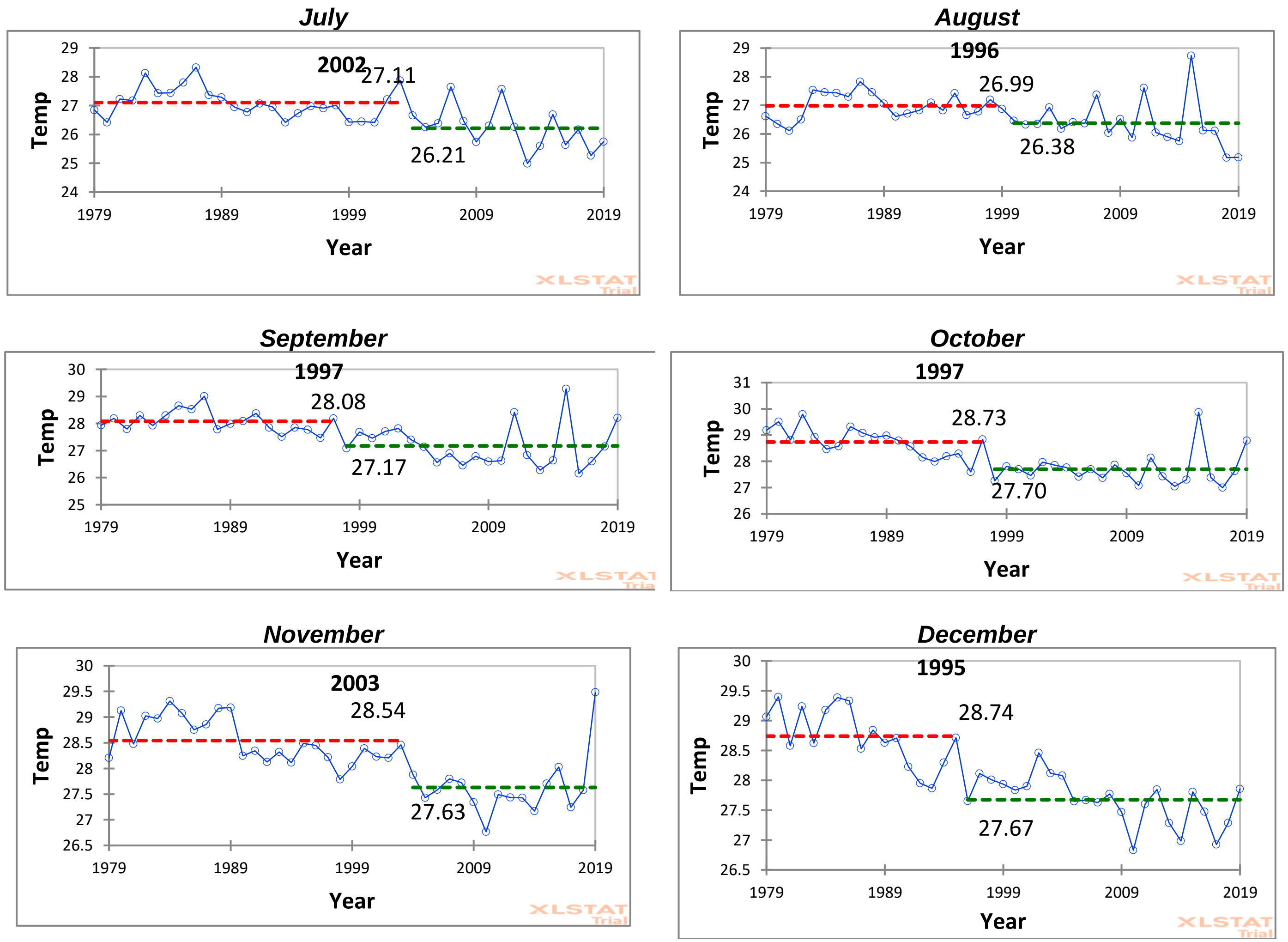
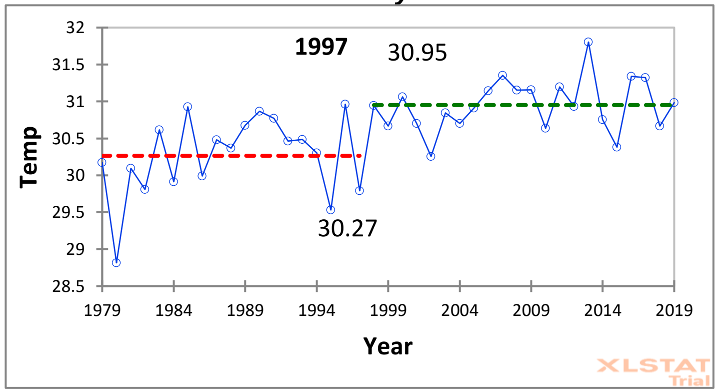


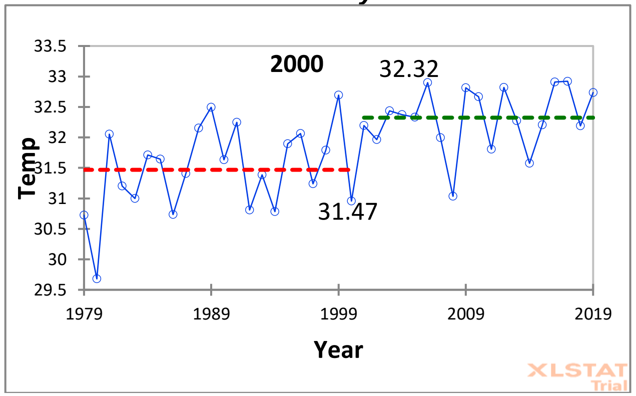
Fig. 16. Shift in monthly mean maximum temperature of HZ

ACZ- X: Graphical results obtained through Pettit's homogeneity test of CZ

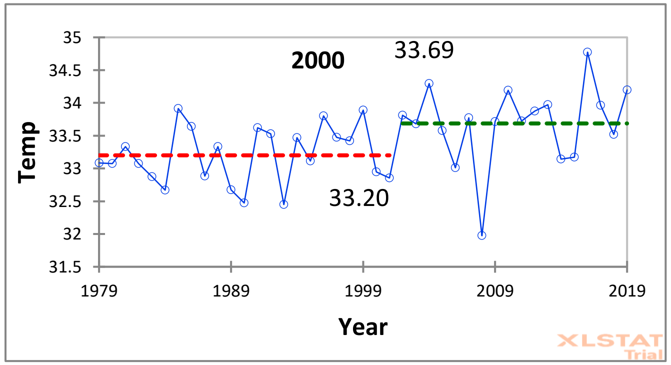
January



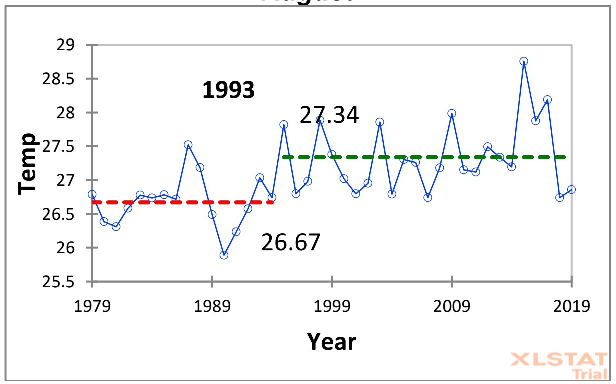
February

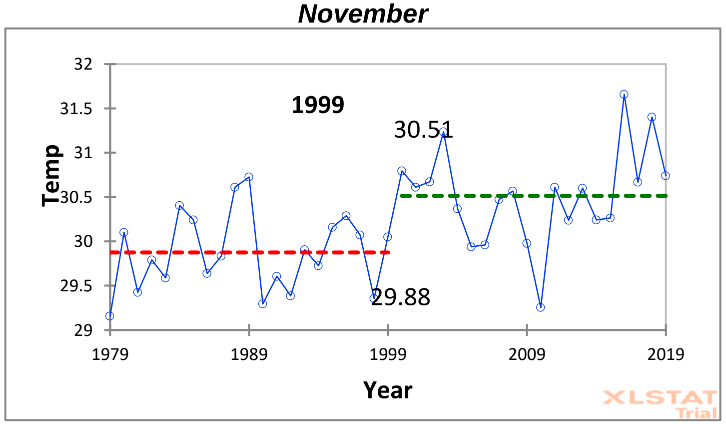


March



August





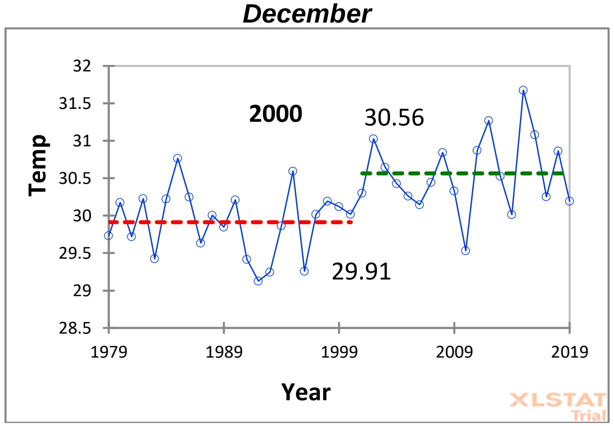


Fig. 17. Shift in monthly mean maximum temperature in CZ

3.7 Shift in Mean Temperature of Southern Transition Zone During 1979-2019

There are no shifts in mean monthly minimum temperature in Southern Transition Zone during the year 1979 to 2019. The shift in mean maximum temperature of January (from 29.63 to 30.31°C) and February (29.08 to 29.70 °C) was observed to have taken place during the years 1997 and 2000, respectively (Fig. 12). The shift in mean maximum temperatures of March (from 32.86 to 33.32°C), August (26.18 to 26.80°C) and Novermber (28.99 to 29.60°C) was observed to have taken place in the years 2001, 1992 and 1999, respectively.

3.8 Shift in mean Temperature of Northern Transition Zone During 1979-2019

The shift in mean minimum temperature of November (from 18.83 to 19.18°C) and December (from 29.56 to 30.40°C) was observed in the years 1989 and (Fig. 13) December, respectively. The shift in maximum temperature of January and February was observed during the year 2000 (Fig. 14) from 30.87 to 31.43°C and 32.42 to 33.12°C, respectively. The upward shift of mean temperature of August took place in the year 1994 from 27.85 to 28.57°C. During the year 1999 the upward shift ws observed in mean maximum temperatures of November (from 30.63 to 31.34 °C) and December (30.24 to 31.05 °C.

3.9 Shift in Mean Temperature in Hilly Zone During 1979-2019

There is a downward shift in both minimum and maximum temperatures in all the months. The downward shift of minimum temperature in (Fig. 15) of January month was recorded in the year 2005. The downward shift of minimum temperature of February, April, May, June and July was observed to have taken place in the year 2003.The downward shift of maximum temperature of all the months was recorded (Fig. 16) in different years.

3.10 Shift in Mean Temperature in Coastal Zone During 1979-2019

The upward shift of mean maximum temperature of coastal zone was observed. There is an upward shift from 30.27 to 30.95 °C in (Fig. 17)January 1997. The upward shift in temperatures of February (from 31.47 to 32.32°C), March (33.20 to 33.69°C) and and December (29.91 to 30.56°C) occurred during the year 2000.

4.CONCLUSION

The upward shift in mean temperature was experienced between 1994 and 1999 across different agro-climatic zones of Karnataka except in Hilly zone. Researchers should develop crop varieties that are insensitive to temperature changes.The scientist should develop packages of practices which will mitigate adverse effect of fluctuations in climate parameters on crop productivity. The state is surrounded by rivers Krishna in the north, Cauvery in the south and Tungabhadra in the central part. Therefore, there is a great need and scope for development of irrigation sources. Investment should be made in creating micro irrigation and water harvesting structures like checkdams, farm ponds which helps the farmers to increase crop production. There is a need for government programs to educate farmers and provide them with more localized information on climate forecasts, climate change and droughts.

ACKNOWLEDGEMENT

This paper is a part of the Ph.D. research work of the author. The authors are thankful to ICAR-IARI to carry out the research work and extend their gratitude to SAU-ANGRAU for granting study leave.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Onoz, B, Bayazit M. Block bootstrap for Mann–Kendall trend test of serially dependent data. Hydrological Processes. 2012;26(23):3552-3560
2. Panda A, Sahu N. Trend analysis of seasonal rainfall and temperature pattern in Kalahandi, Bolangir and Koraput districts of Odisha, India. Atmospheric Science Letters, 2019;20(10):e932.
3. Aguilar E, Barry AA, Brunet M, Ekang L, Fernandes A, Massoukina M, Mbah J,

Mhanda A, Nascimento DJD, Peterson TC, Umba OT, Tomou M, Zhang X. Changes in temperature and precipitation extremes in western central Africa, Guinea Conakry and Zimbabwe, 1955–2006, Journal of Geophysical Research. 2009;114: D02115.

4. Sharma S, Mujumdar P. Increasing frequency and spatial extent of concurrent meteorological droughts and heatwaves in India. Scientific reports. 2017;*7*(1): 1-9.
5. Prabhakar AK, Singh KK, Lohani AK, Chandniha SK. Long term rainfall variability assessment using modified Mann-Kendall test over Champua watershed, Odisha. J. Agrometeorol. 2017;17(2):288-289.
6. Rani SU, Kiran LP, NaikBN, RaniN, Mahendra SB. Application of Non-Parametric Statistical Tools in Analysing the Climate Data through XLSTAT. Contemporary Perspective on Science, Technology and Research BP international Publisher. 2023;1:1-12
7. Ujwala RaniS, P Singh N, Kumar P, Padaria RN, Paul RK. Trend Analysis of Temperature and Rainfall across Agro Climatic Zones of Karnataka-A Semi Arid State in India. International Journal of Environment and Climate Change. 202111(10):67-78.
8. Tabari H, Talaee PH. Temporal variability of precipitation over Iran: 1966–2005. Journal of Hydrology. 2011;396(3-4):313-320.
9. Varadan RJ, Kumar P, Jha GK, PalS, Singh R. An exploratory study on occurrence and impact of climate change on agriculture in Tamil Nadu, India. Theoretical and Applied Climatology. 2017;127(3):993-1010.
10. Waghaye AM, Rajwade YA, Randhe R. D, Kumari N. Trend analysis and change point detection of rainfall of Andhra Pradesh and Telangana, India. Journal of Agro Meteorology. 2018;20(2):160-163.
11. Asgher, S, Ahmad M, Kumar N, Kumari M. Trend Analysis of Temperature and Rainfall using Mann Kendall Test and Sen's Slope Estimator in Bhaderwah Tehsil of Doda District.Research Journal of Agricultural Sciences. 2021;12(3):1021–1026.
12. BonfilsS. Trend analysis of the mean annual temperature in Rwanda during the last fifty two years. Journal of Environmental Protection.2012;3:538-551.
13. Deb S,Sil BS. Trend analysis of climatic variables for the subtropical region of Assam and its neighbouring states in NE India.Indian Journal of Geo Marine Sciences. 2020;1359-1371
14. Dhorde AG, Zarenistanak M. Three-way approach to test data homogeneity: An analysis of temperature and precipitation series over south-western Islamic Republic of Iran. Journal of Indian Geophysics. Union. 2013;17(3):233-242.
15. Gadedjisso-Tossou A, Adjegan KI, Kablan, AKM. Rainfall and Temperature Trend Analysis by Mann–Kendall Test and Significance for Rainfed Cereal Yields in Northern Togo. Sci. 2021;3(1):17.
16. Kothawale DR, Revadekar,JV,Rupa Kumar K. Recent trends in pre-monsoon daily temperature extremes over India. Journal of Earth System Science. 2010;119(1):51-65.
17. Lanzante JR. Resistant, robust and non-parametric techniques for the analysis of climate data: Theory and examples, including applications to historical radiosonde station data. International Journal of Climatology: A Journal of the Royal Meteorological Society. 1996; 16(11):1197-1226.
18. MartinezMD, SerraC, Burgueño A, Lana X. Time trends of daily maximum and minimum temperatures in Catalonia (ne Spain) for the period 1975–2004. International Journal of Climatology: A Journal of the Royal Meteorological Society. 2010;30(2):267-290.
19. Modarres R, da Silva VDPR. Rainfall trends in arid and semi-arid regions of Iran. Journal of arid Environments. 2007;70(2):344-355.
20. Mohamed MAH, El-Mahdy MES. Evaluation of climate change impact on extreme temperature variability in the Blue Nile Basin, Ethiopia. Geoscientific Instrumentation, Methods and Data Systems. 2021;10(1):45-54.
21. Pettitt AN. A non-parametric approach to the change-point problem. Journal of the Royal Statistical Society: Series C (Applied Statistics). 1979;28(2):126-135.

22. Gholami H, Moradi Y, Lotfirad M, Gandomi MA., Bazgir N, Shokrian Hajibehzad M. Detection of abrupt shift and non-parametric analyses of trends in runoff time series in the Dez river basin. Water Supply, 2022;22 (2):1216-1230.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/112206