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AMBIENT TEMPERATURE TREND ANALYSIS FOR THE NORTH SAURASHTRA REGION IN VIEW OF CLIMATE CHANGE

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ABSTRACT

The paper emphasises the importance of Ambient temperature trend analysis, distinguishing between current climate variability and future changes in climate especially in understanding the agro-economic impact of climate change on Indian agriculture. The long-term change in maximum and minimum temperature has been evaluated by Mann–Kendall rank statistics and linear trend. The significantly increasing trend in maximum weekly temperature was observed in MSW 8, 14-15 and 18, which is initial, pegging and pod formation/development stages of *summer* groundnut in irrigated agriculture, respectively. Whereas significantly decreasing trend in maximum weekly temperature was observed in MSW 28, which is initial growing/establishment stage of *kharif* groundnut, cotton, pearl millet and sesame crops and MSW 37-39, which is pod development stage of *kharif* groundnut and grand growth stage of cotton crops in dry farming area of Saurashtra region. The weekly minimum temperature showed significantly increasing trend in MSW 44-45(Oct.-29 to Nov.-11), which is mid season of cotton and sowing stage of *rabi* season crops and 48th MSW, which is establishment stage of *rabi* season crops. This study may useful for management of *kharif*, *rabi* and *summer* season crops for agricultural community.

KEYWORDS: Ambient Temperature, Climate Variability, Grand Growth Stage, Agricultural Community

INTRODUCTION

In India, earlier work on long term trends of surface temperature showed a warming trend of 0.04 ^{0}C per decade. Due to such trend there has been a large-scale warming of the Earth's surface over the last hundred years or so (IPCC, 2007). This warming up of the Earth during the 20th century brought with it a decrease in the area of the world affected by exceptionally cool temperatures, and, to a lesser extent, an increase in the area affected by exceptionally warm temperatures (Jones et al., 1999; Parker and Horton, 1999; IPCC, 2001; 2007; Jones and Moberg, 2001; Vinnikov and Grody, 2003). Evaluation of trends in temperature showed decreasing minimum temperature trend during summer, monsoon and an increasing trend during winter season, whereas an increasing trend for maximum temperature was noticed which may have influence on rain fed agriculture production system in *kharif* and wheat production in *rabi.* Rao et al. (2011) reported that agriculture in eastern region are most affected by increased air temperature and major shift in cropping pattern are expected. Also area under *rabi* crops is likely to be reduced to suit cooler climate. He also reported that yield levels of some major pulses like pigeon pea in *kharif* and chickpea in *rabi* are to be decreased. Therefore the present investigation is planned to model the air temperature using time series analysis. This study will help the decision makers/ scientist's farmers to establish strategies and priorities in agriculture. The main aim of this work is to examine the general trend of maximum and minimum air temperature.

METHODS

The maximum and minimum temperature data of 30 years (1982-2011) of dry farming research station, Targhadia (Rajkot), Gujarat, India was collected for this study. It was converted to weekly series.

The Mann-Kendall statistic *S* is calculated as by Mann-Kendall test as

$$S = \sum_{i=1}^{n-1} \sum_{j=j+1}^{n} sgn(x_j - x_i)$$

The application of trend test is done to a time series x_i that is ranked from i = 1,2,…….n-1and x_j, which is ranked from j = i+1,2,……n. each of the data point x_i is taken as a reference point which is compared with the rest of the data points x_j so that,

$$Sgn(x_j - x_i) = \begin{matrix} +1, > (x_j - x_i) \\ 0, = (x_j - x_i) \\ -1, < (x_j - x_i) \end{matrix}$$

It has been documented that when n≥ 8, the statistic S is approximately normally distributed with the mean.

E(S) = 0

The variance statistic is

$$Var(S) = \frac{n(n-1)(2n+5) - \sum_{i=1}^{m} t_i(i)(i-1)(2i+5)}{18}$$

Where t_i is considered as the number of ties up to sample i. the test statistics Z_c is computed as

Case Study

$$Z_c = \begin{matrix} \frac{S-1}{\sqrt{Var(S)}} \\ 0, S = 0 \\ \frac{S+1}{\sqrt{Var(S)}} \end{matrix}$$

Z_c here follows a standard normal distribution. A positive (negative) value of Z signifies an upward (downward) trend. A significance level α is also utilized for testing either an upward or down ward monotone trend (a two-tailed test). If Z_c appears than $Z_{\alpha/2}$ where α depicts the significance level, then the trend is considered as significant.

Sen's Slope Estimator Test

The magnitude of trend is predicted by the Sen's estimator. Here, the slope (T_i) of all data pairs is computed as (Sen, 1968)

$$T_i = \frac{(x_j - x_k)}{(j-k)} \text{ For I = 1, 2,……,N}$$

Where x_j and x_k are considered as data values at time j and k(j>k) correspondingly. The median of these N values of T_i is represented as Sen's estimator of slope which is given as:

$$Q_i = T_{\frac{N+1}{2}} \text{if N is odd}$$

$$Q_i = \frac{1}{2}\left(T_{\frac{N}{2}} + T_{\frac{N+2}{2}}\right) \text{If N is even}$$

Sen's estimator is computed as Q_{med}=T (N+1)/2 if N appears odd, and it is considered as Q_{med}= $[T_{n/2}+T_{(N+2)/2}]/2$ if N appears even. At the end, Q_{med} is computed by a two sided test at 100 (1-α) % confidence interval and then a true slope can be obtained by non-parametric test. Positive value of Q_i indicates an upward or increasing trend and a negative value of Q_i gives a downward or decreasing trend in the time series.

RESULTS AND DISCUSSIONS

Time series of maximum and minimum weekly temperature at Main Dry Farming Research Station for the period of 1982-2011 has been considered for trend analysis. The trend analysis of the weekly maximum and minimum temperature is given in Table 1 and 2 respectively. The weeks having trend of maximum and minimum temperature are shown in Figure 1-3 respectively. The MSW 8-10, 14-15, 18, and 28, 37-39 have shown the trend in maximum weekly temperature. Significantly increasing trend in maximum weekly temperature was observed in MSW 8, 14 and 15 whereas significantly decreasing in maximum weekly temperature was observed in MSW 28, 37-39. During MSW 9, 10 and 38, trend of maximum weekly temperature was observed but it was non-significant.

The 8th MSW is the initial stage of summer groundnut & sesame and harvesting stage of *rabi* crops i.e. gram, cumin and coriander. Increasing trend of maximum temperature is beneficial for rapid establishment and initial growth of summer groundnut and sesame crops. The 14th, 15th and 18th MSW are pegging, pod formation and development stages of summer groundnut as well as flowering and capsule/pod formation stages for summer sesame and green gram. Due to increasing trend of maximum temperature during these MSWs may decrease yield of summer groundnut and sesame crops because the reproductive stages of both crops coincides during MSW 14-15 and 18th. The 28th MSW is the initial stage of the *kharif* groundnut and cotton, whereas 37 and 39th MSW is pod development stage of groundnut and grand growth stage of the cotton crop. Decreasing trend of maximum temperature during initial stage of groundnut and cotton crops may cause negative effect on early crop growth. Decreasing trend of maximum temperature during 37 & 39th MSW may have positive effect on groundnut and cotton yield as these period coinsides with groundnut pod development stage and peak flowering and ball formation stages of cotton crop.

Minimum weekly temperature has shown the trend in MSW 3, 8, 9, 12, 13, 15-19, 21,32, 44-46, 48, 51 and 52. Minimum weekly temperature showed significantly increasing trend in MSW 3, 8, 9, 12, 13, 15, 19, 44, 45, 48, 51 and 52 whereas it showed increasing trend 16-18, 21, 32, 46 MSW but it was non-significant.

The MSW 3rd is the flowering and grain filling stages of wheat, cumin, coriander and gram crops, the increasing trend in minimum temperature during MSW 3 may have ngetive impact on these *rabi* crops yield. The MSW 12-13th are the maturity/harvesting stage of wheat, garlic and onion, the increasing trend in minimum temperature during these period will help in grain & bulb development. It will also increase storage life of the bulb crops due to low moisture content. The MSW 15th is flowering and pod formation stages of summer groundnut, green gram and sesame crops. The increasing trend in minimum temperature during this period wills results in more/better flowering and healthy grain/pod developmet in summer groundnut, green gram and sesame crops. The MSW 44-45th (Oct. 29 to Nov. 11) is the mid-season of the cotton

crop and sowing time of *rabi* crops like wheat, cumin, coriander. The increasing trend in minimum temperature during this period may results in poor germination of the *rabi* crops. The increasing trend in minimum temperature during MSW 48th, which is initial stage of wheat, cumin, gram and coriander crops may cause negative effect on tillering in wheat crop and vegetative growth of gram, cumin and coriander. The MSW 50-51st are the The increasing trend in minimum temperature during MSW 50-51st which is growing stage of cumin, coriander, wheat and gram crops may cause negative impact on growth of *rabi* crops.

CONCLUSIONS

Thus, in long run the study of temperature trend analysis will be helpful for management of *kharif, rabi* and summer crops.

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APPENDICES

Table 1: Trend Statistic of Weekly Maximum Temperature

St. week	Test Z	Significant	Q	Qmin99	Qmax99	Qmin95	Qmax95	B	Bmin95	Bmax95
1	-1.53		-0.067	-0.157	0.057	-0.135	0.029	29.07	30.23	27.64
2	0.70		0.033	-0.084	0.163	-0.056	0.127	27.73	29.03	26.27
3	0.51		0.014	-0.124	0.125	-0.078	0.100	28.24	29.11	26.34
4	-0.54		-0.035	-0.196	0.100	-0.167	0.051	29.37	30.43	28.34
5	-0.39		-0.025	-0.178	0.111	-0.125	0.078	29.20	30.78	27.90
6	-0.20		-0.013	-0.149	0.128	-0.119	0.094	30.44	32.57	29.04
7	0.44		0.020	-0.100	0.137	-0.063	0.106	30.22	31.28	29.37
8	2.07	*	0.100	-0.048	0.221	0.006	0.191	29.70	31.09	28.29
9	1.87	+	0.069	-0.038	0.200	0.000	0.159	31.95	32.80	30.74
10	-1.72	+	-0.060	-0.167	0.040	-0.137	0.013	35.36	36.31	34.23
11	0.70		0.029	-0.071	0.152	-0.050	0.120	34.90	35.76	34.00
12	1.43		0.059	-0.051	0.171	-0.023	0.135	35.97	37.39	34.32
13	1.24		0.056	-0.069	0.190	-0.041	0.165	37.14	38.91	34.82
14	2.23	*	0.092	-0.020	0.200	0.014	0.173	36.72	38.45	35.68
15	2.70	**	0.083	0.004	0.163	0.031	0.144	37.03	38.07	36.10
16	0.60		0.033	-0.058	0.137	-0.041	0.107	38.43	39.40	37.20
17	0.99		0.023	-0.045	0.074	-0.020	0.056	40.00	40.56	39.61
18	2.57	*	0.078	0.000	0.129	0.021	0.118	39.62	40.35	38.80
19	0.32		0.009	-0.075	0.086	-0.048	0.064	40.77	41.38	39.82
20	-0.95		-0.024	-0.102	0.064	-0.089	0.036	41.36	42.27	40.46
21	-1.01		-0.025	-0.106	0.058	-0.088	0.034	41.13	42.04	40.72
22	-0.60		-0.011	-0.088	0.050	-0.060	0.029	40.41	41.16	39.89
23	-1.33		-0.040	-0.125	`	-0.100	0.022	40.46	41.40	39.70
24	0.39		0.011	-0.105	0.100	-0.064	0.073	38.32	39.28	37.40
25	0.80		0.033	-0.100	0.175	-0.068	0.132	36.53	37.62	34.73
26	-1.46		-0.060	-0.147	0.059	-0.129	0.023	37.02	38.08	35.65
27	-1.53		-0.067	-0.157	0.057	-0.135	0.029	29.07	30.23	27.64
28	-2.64	**	-0.093	-0.175	0.000	-0.154	-0.029	34.69	35.72	33.78
29	1.16		0.053	-0.100	0.150	-0.050	0.113	31.95	33.10	31.25
30	-0.36		-0.015	-0.125	0.125	-0.085	0.094	31.83	32.65	30.40
31	-0.31		-0.015	-0.141	0.084	-0.100	0.066	31.93	33.00	30.10
32	-1.06		-0.050	-0.153	0.063	-0.126	0.040	31.90	32.78	30.46
33	0.44		0.013	-0.106	0.093	-0.066	0.072	31.19	32.36	30.41
34	0.83		0.025	-0.062	0.117	-0.034	0.094	31.30	32.34	30.40
35	-0.43		-0.017	-0.100	0.070	-0.072	0.050	32.10	32.99	31.20
36	-0.63		-0.018	-0.115	0.074	-0.090	0.050	33.22	33.90	32.09
37	-2.30	*	-0.061	-0.150	0.011	-0.129	-0.008	34.16	34.92	33.61
38	-1.94	+	-0.058	-0.150	0.017	-0.130	0.000	34.67	35.96	34.00
39	-1.99	*	-0.092	-0.209	0.020	-0.170	-0.006	35.32	36.63	34.00
40	-1.31		-0.063	-0.181	0.073	-0.158	0.034	36.35	37.50	35.19
41	-1.04		-0.047	-0.144	0.091	-0.117	0.054	36.52	38.04	34.77
42	0.82		0.025	-0.091	0.101	-0.062	0.083	35.13	37.06	34.18
43	0.56		0.016	-0.090	0.121	-0.053	0.100	34.82	36.16	33.30
44	-0.20		-0.004	-0.076	0.078	-0.057	0.055	34.83	35.80	34.03
45	0.95		0.025	-0.050	0.100	-0.033	0.080	33.90	34.60	33.10
46	-0.65		-0.019	-0.087	0.064	-0.065	0.042	33.88	34.23	32.77
47	0.00		0.000	-0.088	0.077	-0.064	0.062	32.30	33.24	31.60
48	-0.03		0.000	-0.090	0.062	-0.063	0.050	31.30	32.23	30.80
49	0.70		0.022	-0.087	0.107	-0.055	0.080	31.08	31.96	30.32
50	-0.07		0.000	-0.119	0.132	-0.092	0.100	30.10	31.96	29.40
51	-0.15		-0.004	-0.089	0.115	-0.062	0.077	30.27	31.18	29.25
52	0.66		0.018	-0.087	0.130	-0.059	0.099	28.33	29.51	26.71

Table 2: Trend Statistic of Weekly Minimum Temperature

St. week	Test Z	Significant	Q	Qmin99	Qmax99	Qmin95	Qmax95	B	Bmin95	Bmax95
1	0.56		0.018	-0.100	0.156	-0.067	0.120	10.53	12.27	9.16
2	1.29		0.059	-0.059	0.200	-0.031	0.150	9.77	11.36	8.60
3	1.99	*	0.085	-0.027	0.188	0.000	0.156	9.53	11.10	8.12
4	0.71		0.027	-0.096	0.160	-0.064	0.130	11.22	12.64	9.38
5	0.53		0.016	-0.076	0.125	-0.060	0.093	11.47	12.18	10.13
6	0.71		0.035	-0.128	0.150	-0.069	0.126	12.20	13.51	11.09
7	1.36		0.057	-0.059	0.133	-0.028	0.112	12.07	13.36	11.64
8	2.26	*	0.088	-0.025	0.208	0.018	0.178	12.54	13.80	11.44
9	2.28	*	0.067	-0.012	0.139	0.006	0.125	14.13	14.89	13.12
10	0.05		0.000	-0.118	0.120	-0.086	0.087	16.00	17.43	14.53
11	0.56		0.017	-0.051	0.104	-0.035	0.088	17.22	18.02	16.45
12	2.06	*	0.071	-0.038	0.175	0.003	0.157	17.79	18.65	16.34
13	2.40	*	0.100	-0.012	0.200	0.029	0.170	17.93	19.07	16.82
14	1.14		0.033	-0.050	0.117	-0.025	0.096	19.87	20.55	18.92
15	2.23	*	0.038	-0.007	0.094	0.005	0.079	20.82	21.40	20.30
16	1.79	+	0.045	-0.024	0.118	-0.004	0.100	21.59	22.23	20.40
17	1.96	+	0.029	-0.014	0.072	0.000	0.063	22.67	23.00	22.21
18	1.72	+	0.038	-0.016	0.075	-0.004	0.067	23.11	23.60	22.69
19	2.30	*	0.041	-0.006	0.097	0.006	0.086	23.98	24.38	23.36
20	1.57		0.031	-0.029	0.084	-0.011	0.069	24.46	24.98	23.90
21	1.72	+	0.033	-0.018	0.088	-0.005	0.072	25.13	25.56	24.67
22	1.06		0.015	-0.029	0.050	-0.014	0.040	25.59	25.89	25.18
23	-1.17		-0.019	-0.072	0.034	-0.057	0.018	26.37	26.93	25.87
24	-1.26		-0.018	-0.052	0.017	-0.043	0.008	26.34	26.56	25.88
25	1.01		0.013	-0.033	0.079	-0.020	0.065	25.86	26.42	24.78
26	0.49		0.008	-0.046	0.050	-0.035	0.041	25.63	26.30	25.23
27	-0.85		-0.017	-0.063	0.025	-0.050	0.014	25.45	25.95	24.98
28	-0.41		-0.006	-0.049	0.040	-0.038	0.032	25.24	25.78	24.61
29	1.55		0.015	-0.017	0.050	-0.004	0.042	24.63	25.03	24.27
30	1.01		0.015	-0.026	0.050	-0.015	0.043	24.38	24.92	24.07
31	-0.29		-0.001	-0.050	0.042	-0.040	0.032	24.41	24.94	24.08
32	1.83	+	0.022	-0.012	0.055	0.000	0.046	24.02	24.30	23.70
33	0.38		0.005	-0.029	0.040	-0.021	0.033	24.01	24.45	23.54
34	-0.44		-0.006	-0.056	0.032	-0.045	0.020	24.04	24.55	23.74
35	0.34		0.006	-0.040	0.047	-0.026	0.036	23.64	24.10	23.30
36	0.95		0.020	-0.050	0.076	-0.033	0.064	23.06	24.03	22.42
37	1.31		0.030	-0.030	0.087	-0.014	0.070	22.58	23.27	21.86
38	1.02		0.025	-0.035	0.089	-0.024	0.073	22.83	23.77	22.11
39	-0.07		0.000	-0.083	0.077	-0.058	0.060	23.20	24.01	22.68
40	-0.24		-0.005	-0.067	0.082	-0.047	0.060	23.02	23.48	22.08
41	1.28		0.031	-0.043	0.108	-0.022	0.096	21.35	21.86	20.44
42	0.34		0.017	-0.086	0.113	-0.067	0.075	20.85	21.60	19.80
43	0.41		0.009	-0.082	0.125	-0.056	0.100	18.98	20.03	18.00
44	2.26	*	0.075	-0.009	0.150	0.010	0.138	17.53	18.63	16.82
45	3.27	**	0.117	0.032	0.222	0.050	0.194	16.52	17.60	15.22
46	1.68	+	0.084	-0.045	0.197	-0.009	0.165	15.95	17.18	14.78
47	0.60		0.023	-0.075	0.126	-0.050	0.100	15.43	16.55	14.09
48	1.99	*	0.067	-0.025	0.173	0.000	0.148	13.67	14.50	12.60
49	1.16		0.062	-0.055	0.222	-0.028	0.168	13.19	14.22	12.09
50	0.00		0.000	-0.121	0.181	-0.095	0.131	13.30	14.55	11.10
51	2.16	*	0.095	-0.025	0.216	0.011	0.178	12.02	13.12	10.85
52	2.21	*	0.095	-0.019	0.206	0.015	0.178	10.41	11.50	9.17

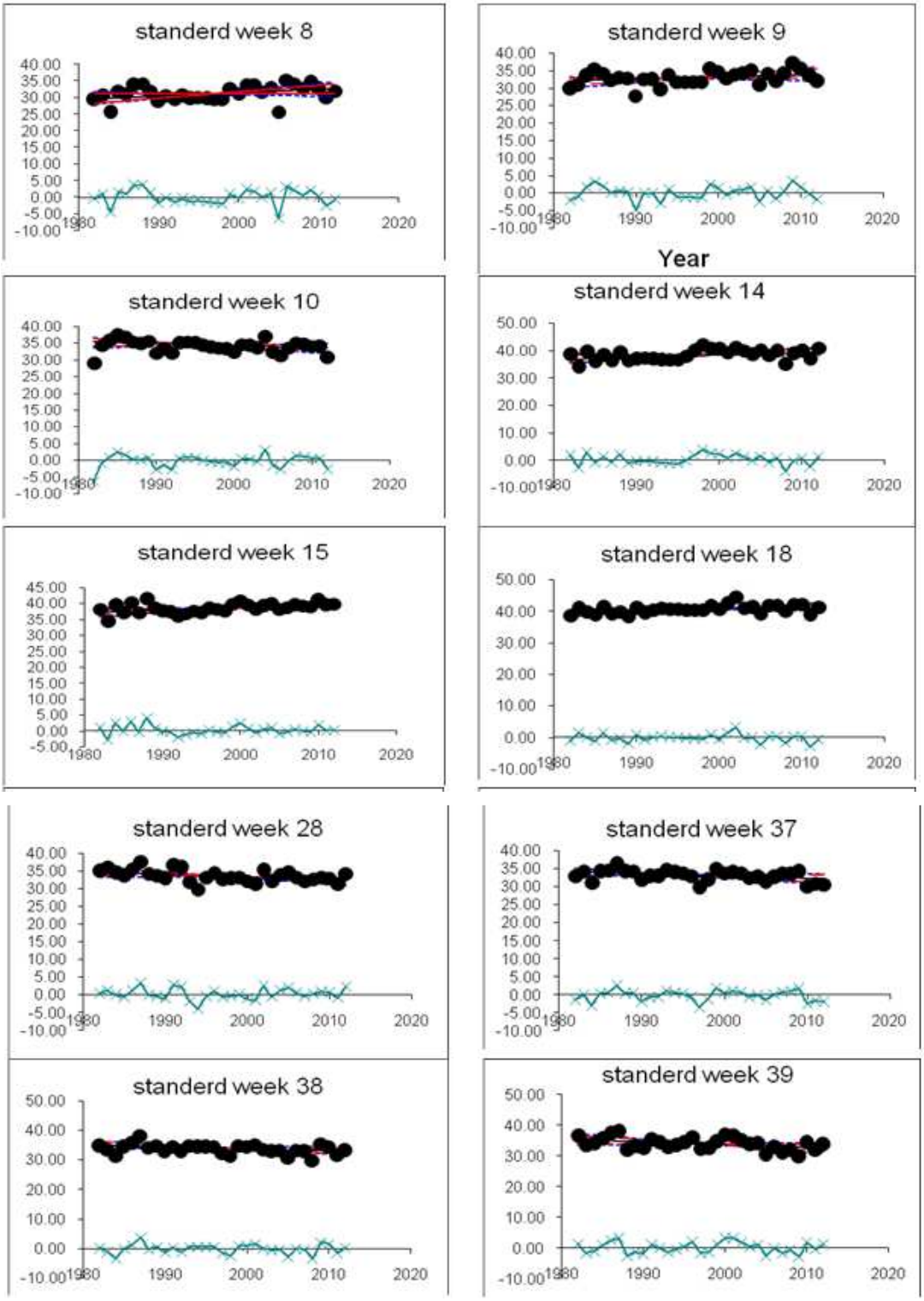

Figure 1: Trend of Maximum Temperature in Different Weeks

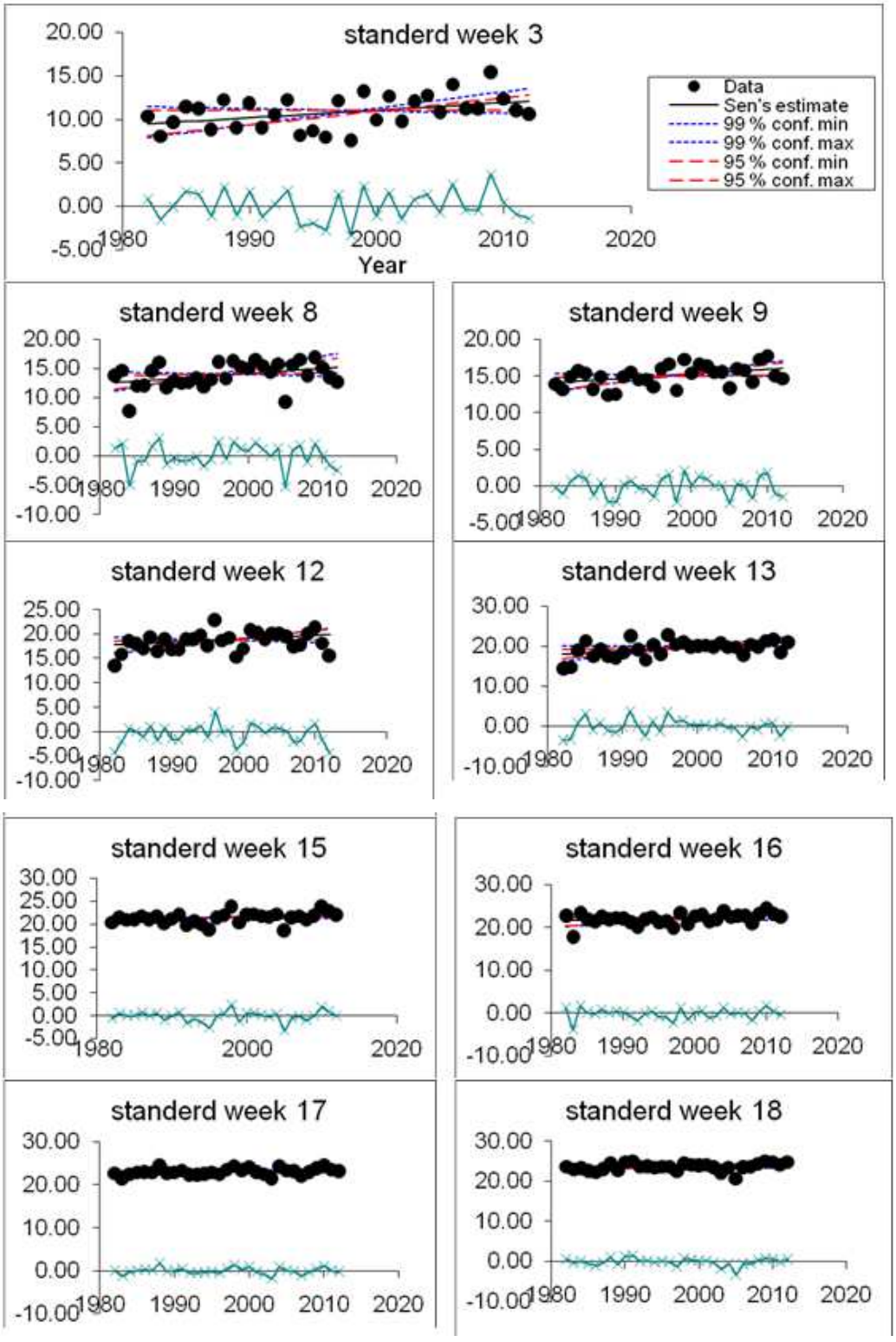

Figure 2: Trend of Minimum Temperature in Different Weeks (Upto MSW 18)

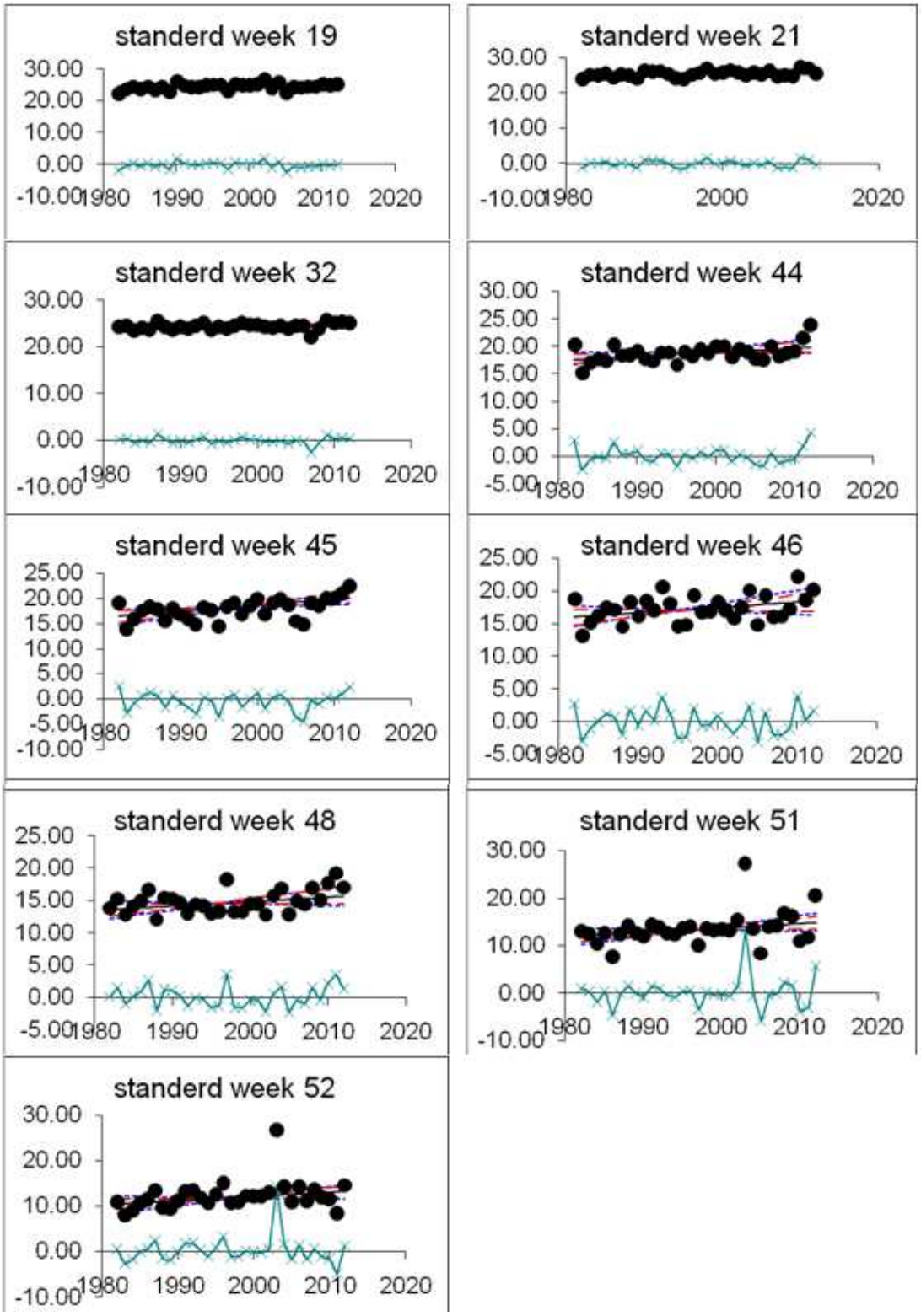

Figure 3: Trend of Minimum Temperature in Different Weeks (Upto MSW 52)