Analysis of Climate Data of Khyber Pakhtunkhwa, Pakistan

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Abstract – *Weather information is important for food production plan, water resource management, and all activity plans in the nature. This information can be retrieved from largely available meteorological data base. In this study the trends, seasonality, and variations of climatic parameters; Minimum Temperature, Maximum Temperature, Relative Humidity at 8:00 am, and Relative Humidity at 5:00pm were examined. For this purposes five different weather stations located at different regions of Khyber Pakhtunkhwa, Pakistan were selected. The weather stations are located at Peshawar, Abbottabad, Dir, Swat, and Chitral. The past 32 years (January 1985 to December 2016) data were taken from Peshawar Meteorological Department for this study. Various statistical parameters; minimum, maximum, mean, standard deviation, coefficient of variation, and coefficient of skewness were calculated. Also to visualize the properties of climatic data various plots; line plots, box plots, and time series plots were drowned by using R-Statistics and R-Studio. From study it is observed that the trend of mean monthly minimum temperature for Peshawar weather station is increasing by 0.4 ℃ per year while for the rest of the stations are almost uniform. The seasonality of minimum temperature for all stations is uniformly periodical. Mean monthly maximum temperature are following slight increasing trend in all weather stations. Also the trends of mean monthly relative humidity at 8:00am and 5:00pm are following a slight increase in their nature.*

*Key Words***:** Meteorological Data, Seasonality, Trends, Variation, Weather Information

1. INTRODUCTION

The crop yields as well as economy of a country are highly affected by various changes occurs in the climate [1]. The increasing effects of global warming on the agriculture climate are posing huge problems for agricultural countries like Pakistan [2]. The occurrence of prolonged dry period or heavy rains at the critical stages of the crop growth and development may lead to significant reduction of crop yield [3]. Climatic data analyses are necessary for the better economic growth of a country because it plays a vital role in agriculture sector, hydrological activities, disaster warning systems, water resources, tourism, food production plan, ecosystem, wild life, and other natural activities [4]. To know about the trends, variations, and cyclic nature of data and to forecast the future weather conditions is one of the most scientifically and technologically challenging problem around the world in the last century. This is due to two factors; first, it is used for mainly human activities and secondly, due to opportunism created by various technological advances that directly related to this concrete research field, like the evolution of computation and the improvement systems.

Meteorological data contains huge hidden information, so the information retrieved can be transformed into usable knowledge. This useful knowledge can play important role in understanding the climate variability and climate prediction. In turn this understanding can be used to support many important sectors that are affected by climate like agriculture, vegetation, water resources, and tourism [5].

Through this study, hidden patterns inside largely available meteorological data can be retrieved. The increasing availability of climate data makes it important to find effective and accurate tools to analyze and extract hidden knowledge from this huge data. The basic patterns of weather are cyclic in nature influenced by the seasonal variations such as the revolution of earth, wind patterns, over the ocean and other parameters [6]. A time series is the chronologically arranged observations usually order in time. The aim of time series analysis is to describe the history of movements in time of some variable(s) at a particular site [7].

2. DATA AND METHODOLOGY

2.1 Study Area

Historical monthly weather data has been taken from Peshawar Meteorological Department for five weather stations of Khyber Pakhtunkhwa (KP), Pakistan as shown in Figure 1. The geographical locations of the selected weather stations are given in Table 1. Khyber Pakhtunkhwa formerly North West Frontier province (NWFP), is the northern most province of Pakistan. To the West and North it is bounded by Afghanistan, to the East and North by Northern areas, to South East by Punjab, and to South West by Baluchistan. Area of the province is 46296 square kilometers and population is 30523371. The terrain of the province consists of mountain ranges, undulating areas, and plain areas surrounded by hills. The climate varies with elevation. The hilly areas are cold in winter and cool in summer, and a temperature markedly rises towards South. The economy of province is essentially based on agriculture and about one third of the area is under irrigation. The rest of areas are dependent on rainfall. Wheat, maize, sugarcane and tobacco are the major crops of the province [8].
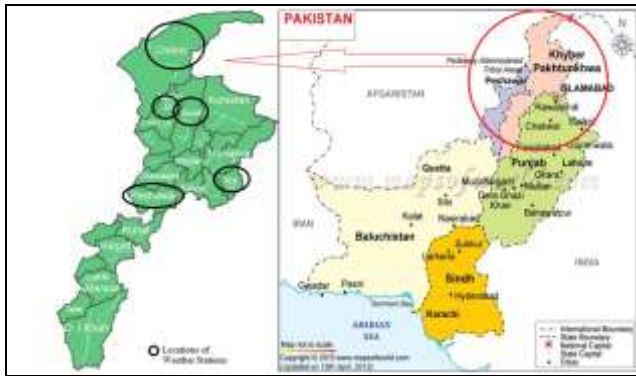
Figure -1: Map Showing Locations of Weather Stations

Table -1: Geographic locations of weather stations

S. #	Station Name	Latitude (N)	Longitude (E)	Elevation (masl)
1	Peshawar	34° 02'	71° 56'	327.0
2	Abbottabad	34° 44'	72° 21'	961.0
3	Dir	35° 12'	71° 51'	1375.0
4	Swat	34° 11'	73° 15'	1308.0
5	Chitral	35° 51'	71° 50'	1497.8

2.2 Data Analysis

For this study mean monthly data of four meteorological variables; minimum temperature, maximum temperature, relative humidity at 8:00am, and relative humidity at 5:00pm for five weather stations around KP for the period of January 1985 to December 2016 were collected. The geographical details of these five stations; Peshawar, Abbottabad, Dir, Swat, and Chitral are given in Table 1 and location map is shown in Figure 1.

The collected data were analyzed by using Micro Soft Excel 2010, R-Statistics 3.4.3, and R-Studio. For the collected data minimum values, maximum values, mean values, standard deviations, coefficient of variation, and coefficient of skewness were determined by using Microsoft Excel 2010.

Minimum Value
The lowest observation in a data set.

Maximum Value
The highest observation in a data set.

Mean
Mean is the average of the numbers; a central value for a set of number;

$$\mu = \frac{\sum_{i=1}^{N} X_i}{N}$$

Where, μ = Mean of a data set

X_i = Observed values

N = Number of observations

Standard Deviation

Represents that how much the observations are differ from the mean value;

$$\sigma = \sqrt{\frac{\sum_{i=1}^{N}(X_i - \bar{\mu})}{N}}$$

Where, σ = Standard deviation

μ = Mean of observations

N = Number of observation

Coefficient of Variation
It measures the relative variability of observations and is equal to the ratio of standard deviation to the mean and expressed in percentages;

$$CV = \frac{\sigma}{\mu} * 100$$

Where, CV = Coefficient of Variation (%)

σ = Standard deviation

μ = Mean

Coefficient of skewness
It shows the skewness of the data, either positive or negative;

$$S_k = \frac{Mean - Median}{Standard\ Deviation}$$

Statistical descriptions of all parameters are given in Tables 2, 3, 4, and 5.

R-Statistics and R-Studio

R is a language and environment for statistical computing and graphics. Its first version was released in 1993. R provides a wide variety of statistical; linear and nonlinear modeling, classical statistic tests, time series analysis classification, and clustering etc., and graphical techniques, and is highly extensible. One of R's strength is the ease with which well-designed publication quality plots can be produced, including mathematical symbols and formula where needed. R Studio is a free and open-source integrated development environment for R, a programming language for statistical computing and graphics and initially was released in 2011 [9].

Visual Description of Data through R-Statistic

Line Plots: The line plots of monthly data are shown in Figures 2, 3, 4, and 5.
Boxplots: These plots show the variation in monthly data as shown in Figures 6, 7, 8, and 9.
Time-Series Plots: These plots show the trends, seasonality, and irregularity of the cyclic data as shown in Figures 10, 11, 12, and 13.

Table -2: Statistical results of 32 years mean monthly minimum temperature (^{o}C)

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Peshawar												
Minimum	2.60	4.61	9.60	14.30	18.70	23.40	25.60	24.50	20.50	14.00	7.70	2.50
Maximum	7.30	11.30	15.40	19.60	26.00	27.40	27.60	27.10	24.60	19.60	12.60	7.50
Mean	4.46	7.26	11.99	16.90	22.09	25.64	26.69	25.88	23.15	16.67	10.15	5.62
S.D	1.19	1.38	1.50	1.51	1.91	1.01	0.53	0.58	1.00	1.42	1.04	1.21
CV	26.69	19.04	12.49	8.91	8.66	3.94	1.99	2.23	4.33	8.49	10.20	21.53
S$_k$	0.35	0.44	0.51	0.19	0.28	-0.20	-0.31	-0.23	-0.67	0.23	0.21	-0.48
Abbottabad												
Minimum	-2.20	0.00	3.30	7.30	9.80	15.90	18.10	17.30	13.20	7.50	3.10	-1.10
Maximum	3.90	6.10	9.20	13.40	18.50	20.30	21.20	19.80	17.70	12.30	7.90	4.20
Mean	0.62	2.43	6.25	10.46	14.49	18.11	19.47	18.90	15.91	10.38	5.65	2.29
S.D	1.29	1.30	1.31	1.44	1.88	1.02	0.74	0.55	1.20	1.11	1.03	1.17
CV	208.37	53.49	20.91	13.78	12.94	5.64	3.78	2.89	7.52	10.65	18.15	51.11
S$_k$	0.08	0.51	0.08	-0.27	0.18	-0.25	-0.20	-0.66	-0.60	-0.50	-0.04	-0.49
Dir												
Minimum	-7.20	-4.00	0.20	0.00	7.90	11.50	14.70	14.40	9.90	4.60	-0.20	-4.50
Maximum	0.50	4.00	5.70	9.30	14.30	19.20	21.60	21.00	16.50	9.30	4.40	2.10
Mean	-2.60	-0.63	3.02	7.20	11.27	15.17	17.93	13.65	13.65	7.13	2.30	-0.97
S.D	1.72	1.60	1.37	1.80	1.40	1.63	1.56	1.62	1.58	1.28	1.25	1.45
CV	-66.09	-254.0	45.39	24.93	12.43	10.73	8.38	9.03	11.56	17.92	54.39	-150.5
S$_k$	-0.84	0.64	-0.05	-2.40	0.28	0.18	-0.40	-0.21	-0.44	-0.09	-0.25	-0.06
Swat												
Minimum	-0.80	1.30	4.80	9.70	14.20	17.60	19.50	19.60	13.90	9.20	3.60	0.70
Maximum	3.90	7.70	10.20	14.30	20.40	23.30	24.40	23.50	20.60	15.90	8.70	4.70
Mean	1.72	4.02	7.92	12.15	16.63	20.28	22.23	21.43	17.77	11.74	6.08	2.82
S.D	1.06	1.27	1.42	1.06	1.46	1.24	1.09	1.03	1.64	1.70	1.31	1.16
CV	61.35	31.46	17.92	8.68	8.78	6.13	4.88	4.80	9.23	14.44	21.51	40.96
S$_k$	-0.30	0.39	-0.41	-0.14	0.31	0.13	-0.06	0.22	-0.56	0.56	0.05	-0.15
Chitral												
Minimum	-4.50	-7.50	1.60	5.50	8.50	13.20	14.00	13.10	9.00	2.60	0.70	-2.90
Maximum	1.10	4.80	6.60	9.50	14.70	19.10	21.50	20.20	15.20	9.10	5.10	2.30
Mean	-0.85	0.48	4.28	8.12	11.84	16.31	19.48	18.02	13.12	6.96	2.39	0.23
S.D	1.19	1.98	1.19	0.98	1.33	1.41	1.51	1.36	1.30	1.32	1.13	1.24
CV	-139.9	409.23	27.82	12.12	11.25	8.63	7.76	7.54	9.91	18.90	47.35	527.99
S$_k$	-1.01	-1.72	-0.09	-0.83	-0.15	0.00	-1.50	-1.60	-0.95	-1.29	0.40	-0.53

Table -3: Statistical results of 32 years mean monthly maximum temperature (^{o}C)

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Peshawar												
Minimum	15.50	15.80	21.60	26.90	32.40	29.70	35.00	33.30	32.47	25.50	23.60	18.20
Maximum	21.40	24.40	29.90	34.30	40.40	42.70	40.50	38.90	37.60	33.00	27.80	23.70
Mean	18.51	20.20	24.54	30.62	36.77	39.61	37.54	35.99	34.93	30.92	25.56	20.73
S.D	1.30	1.97	2.20	1.98	2.16	2.22	1.39	1.14	1.16	1.58	1.16	1.36
CV	7.02	9.75	8.96	6.45	5.88	5.60	3.71	3.16	3.31	5.12	4.53	6.57
S$_k$	0.05	0.31	0.88	0.13	-0.30	-2.87	0.33	0.32	-0.06	-1.63	-0.03	0.35
Abbottabad												
Minimum	9.90	10.30	15.10	19.80	22.00	29.10	27.80	27.20	26.60	21.00	18.10	12.90
Maximum	17.60	18.60	24.70	28.60	33.90	33.90	33.10	30.40	29.50	27.40	23.50	20.60
Mean	13.28	14.36	18.55	23.97	29.02	32.19	29.94	28.75	28.03	25.27	20.85	16.08
S.D	1.83	1.92	2.50	2.06	2.65	1.21	1.40	0.92	0.76	1.44	1.36	1.95
CV	13.80	13.39	13.47	8.58	9.14	3.77	4.68	3.20	2.71	5.71	6.53	12.14
S$_k$	0.30	0.32	0.81	0.14	-0.62	-0.76	0.69	0.09	0.11	-0.84	-0.05	0.26
Dir												
Minimum	8.40	9.10	13.50	19.40	23.90	29.70	30.60	27.80	28.10	21.10	16.10	11.20
Maximum	16.10	17.70	23.90	28.40	33.40	34.10	34.60	33.70	31.50	28.50	24.90	20.90
Mean	12.21	12.89	17.16	23.12	28.61	32.45	32.00	30.89	29.62	25.34	20.19	14.84
S.D	1.92	2.26	2.53	2.06	2.56	1.14	0.87	1.22	0.94	1.80	2.13	2.36
CV	15.69	17.54	14.72	8.89	8.94	3.51	2.71	3.96	3.18	7.11	10.55	15.90
S$_k$	0.09	0.48	0.84	0.41	-0.07	-0.63	0.75	-0.29	0.16	-0.65	0.26	0.79
Swat												
Minimum	11.80	12.90	17.20	22.40	28.50	33.10	32.60	30.00	28.30	24.20	18.80	13.50
Maximum	19.10	21.60	27.80	31.80	37.80	39.90	36.90	35.10	33.90	31.10	25.70	19.90
Mean	14.49	16.21	20.87	26.80	32.84	36.20	34.62	33.14	31.88	27.96	22.26	16.73
S.D	1.73	2.15	2.61	2.34	2.60	1.35	1.09	1.17	1.23	1.79	1.68	1.80
CV	11.93	13.30	12.49	8.72	7.92	3.72	3.14	3.53	3.85	6.42	7.53	10.76
S$_k$	0.62	0.80	0.91	0.25	0.04	0.08	0.41	-1.07	-0.89	0.10	-0.03	0.01
Chitral												
Minimum	5.60	8.30	12.60	19.60	23.80	30.30	33.90	31.70	29.00	21.60	16.20	8.60
Maximum	14.10	16.40	21.80	26.70	34.80	38.20	37.90	36.70	38.30	28.70	22.90	18.40
Mean	10.14	11.47	16.42	23.03	29.09	34.37	36.22	34.61	31.73	25.83	19.28	12.99
S.D	2.10	2.16	2.47	1.89	2.88	1.64	1.02	1.06	1.70	1.84	1.75	2.10
CV	20.71	18.87	15.02	8.19	9.89	4.77	2.81	3.06	5.36	7.11	9.07	16.13
S$_k$	0.08	0.50	0.58	-0.02	0.31	-0.33	-0.56	-0.98	1.66	-0.18	0.30	0.29

Table -4: Statistical results of 32 years mean monthly relative humidity (%) at 8:00am

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Peshawar												
Minimum	69.00	55.00	61.00	49.00	38.00	38.00	54.00	64.00	66.00	61.00	62.00	66.00
Maximum	90.00	87.00	87.00	82.00	65.00	66.00	82.00	85.00	85.07	87.00	89.00	92.00
Mean	80.05	77.04	75.48	67.01	51.86	52.29	69.40	77.05	75.94	75.38	77.87	79.81
S.D	4.67	7.99	6.57	7.67	7.62	6.74	7.05	4.98	4.06	7.23	5.78	5.78
CV	5.84	10.38	8.70	11.45	14.69	12.90	10.16	6.47	5.35	9.59	7.42	7.25
S_k	-0.07	-1.13	-0.36	-0.24	0.08	0.12	-0.49	-0.74	-0.10	-0.31	-0.37	-0.79
Abbottabad												
Minimum	56.00	54.00	53.00	50.00	35.00	42.00	65.00	68.00	62.00	50.00	43.00	39.00
Maximum	85.00	86.00	84.00	79.00	71.00	78.00	88.00	90.00	87.00	82.00	83.00	78.00
Mean	70.63	71.38	67.91	64.59	55.94	56.66	78.78	84.41	77.72	67.16	62.78	64.03
S.D	7.54	8.37	6.71	7.95	7.03	8.66	6.61	4.29	6.18	9.30	10.34	9.80
CV	10.68	11.72	9.88	12.30	12.57	15.29	8.39	5.09	7.95	13.85	16.47	15.30
S_k	-0.03	-0.29	0.25	-0.26	-0.66	0.40	-0.66	-1.83	-0.51	-0.06	-0.02	-0.69
Dir												
Minimum	75.00	76.00	77.00	56.00	44.00	41.00	61.00	74.00	74.00	71.00	62.00	55.00
Maximum	94.00	95.00	96.00	87.00	79.00	78.00	85.00	89.00	90.00	91.00	89.00	94.00
Mean	85.69	87.31	85.03	75.47	63.91	58.53	74.97	82.90	83.38	83.06	80.31	81.84
S.D	5.54	4.21	4.21	6.87	8.11	8.58	6.15	3.52	3.67	4.69	7.22	8.16
CV	6.46	4.82	4.95	9.11	12.69	14.66	8.20	4.25	4.40	5.65	8.99	10.02
S_k	-0.36	-0.54	-0.11	-1.00	-0.15	0.20	-0.35	-0.74	-0.53	-0.70	-0.91	-1.15
Swat												
Minimum	69.00	64.00	62.00	63.00	47.00	29.00	46.00	65.00	67.00	62.00	67.00	73.00
Maximum	89.00	89.00	82.00	86.00	74.00	76.00	88.00	92.00	92.00	91.00	91.00	89.00
Mean	81.34	79.31	75.84	70.94	60.87	59.10	77.19	83.53	81.31	78.16	78.94	80.09
S.D	4.45	4.61	5.05	5.95	6.15	10.23	8.44	5.48	6.91	7.44	5.07	4.10
CV	5.48	5.81	6.66	8.39	10.11	17.31	10.94	6.56	8.49	9.53	6.42	5.12
S_k	-0.72	-0.94	-1.08	0.92	-0.55	-0.78	-1.80	-1.25	-0.63	-0.61	-0.18	0.36
Chitral												
Minimum	46.00	43.00	56.00	52.00	40.00	21.00	49.00	68.00	75.00	51.00	39.00	45.00
Maximum	90.00	91.00	86.00	84.00	77.00	65.00	72.00	92.00	90.00	91.00	89.00	79.00
Mean	69.06	70.50	71.19	70.31	58.91	47.47	61.50	78.56	84.78	78.38	71.81	67.31
S.D	11.29	11.39	7.32	9.67	10.86	10.30	6.32	4.54	3.64	9.45	12.24	9.53
CV	16.35	16.16	10.28	13.75	18.44	21.70	10.28	5.78	4.30	12.05	17.04	14.16
S_k	-0.07	-0.25	-0.13	-0.37	-0.05	-0.52	-0.47	0.69	-0.65	-1.05	-0.93	-0.83

Table -5: Statistical results of 32 years mean monthly relative humidity (%) at 5:00pm

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Peshawar												
Minimum	35.00	25.00	27.00	25.00	19.00	20.00	29.00	43.00	41.00	34.00	44.00	43.00
Maximum	65.00	61.00	62.00	52.00	43.00	49.00	62.00	70.00	63.00	63.00	63.00	69.00
Mean	50.13	44.28	45.41	39.50	30.59	31.56	48.97	56.03	50.38	47.88	53.41	54.84
S.D	6.81	9.74	8.90	7.40	6.81	6.91	7.63	5.34	4.67	6.19	5.47	6.11
CV	13.59	21.99	19.59	18.74	22.26	21.89	15.58	9.52	9.27	12.94	10.24	11.14
S_k	0.18	-0.04	0.20	-0.04	0.19	0.51	-0.60	0.28	0.19	0.14	0.60	0.08
Abbottabad												
Minimum	39.00	31.00	33.00	29.00	20.00	24.00	42.00	57.00	41.00	35.00	34.00	31.00
Maximum	65.00	68.00	67.00	65.00	57.00	60.00	83.00	80.00	71.00	67.00	59.00	66.00
Mean	50.50	51.84	50.53	44.72	37.13	38.03	61.53	69.03	58.84	47.88	46.16	48.56
S.D	8.47	8.44	9.01	8.05	7.56	8.23	9.20	5.23	6.75	6.98	6.24	9.07
CV	16.77	16.29	17.83	17.99	20.36	21.64	14.95	7.57	11.48	14.58	13.53	18.67
S_k	0.18	-0.34	-0.40	0.46	0.71	0.75	-0.37	0.05	-0.58	0.29	0.35	-0.11
Dir												
Minimum	31.00	26.00	30.00	28.00	26.00	28.00	39.00	46.00	37.00	26.00	24.00	21.00
Maximum	75.00	72.00	62.00	61.00	54.00	53.00	64.00	68.00	60.00	60.00	60.00	83.00
Mean	48.19	48.91	46.13	42.75	39.28	38.16	51.81	56.42	49.13	41.63	41.16	47.09
S.D	11.34	10.62	8.89	8.22	7.69	6.79	5.72	5.27	5.56	8.15	9.39	13.59
CV	23.54	21.72	19.28	19.23	19.58	17.79	11.03	9.33	11.33	19.59	22.81	28.85
S_k	0.28	-0.06	-0.18	0.06	-0.10	0.50	0.00	-0.06	0.43	0.42	0.10	0.35
Swat												
Minimum	36.00	39.00	34.00	37.00	29.00	21.00	39.00	50.00	42.00	33.00	37.00	37.00
Maximum	72.00	67.00	61.00	64.00	50.00	54.00	68.00	73.00	65.00	65.00	63.00	68.00
Mean	53.41	54.38	50.09	46.61	38.70	38.20	55.10	60.34	53.97	47.34	49.50	53.50
S.D	12.58	8.08	8.43	6.93	6.64	7.30	7.09	6.40	5.97	6.98	6.22	9.21
CV	23.55	14.86	16.82	14.86	17.17	19.10	12.86	10.60	11.06	14.74	12.56	17.22
S_k	-1.94	-0.22	-0.63	0.73	-0.04	0.27	-0.74	0.21	-0.14	0.24	0.29	-0.20
Chitral												
Minimum	24.00	19.00	25.00	20.00	20.00	11.00	19.00	21.00	18.00	21.00	19.00	26.00
Maximum	66.00	64.00	54.00	51.00	47.00	41.00	39.00	53.00	52.00	56.00	54.00	57.00
Mean	40.38	41.72	40.34	36.31	31.78	23.09	27.31	32.13	30.59	34.03	37.47	40.66
S.D	10.34	10.77	7.71	7.48	7.21	6.36	4.93	7.00	6.96	8.34	10.07	10.42
CV	25.62	25.81	19.10	20.59	22.67	27.53	18.07	21.78	22.73	24.51	26.89	25.63
S_k	0.70	0.25	-0.13	-0.08	0.21	0.93	0.43	1.34	0.70	0.65	0.21	-1.46

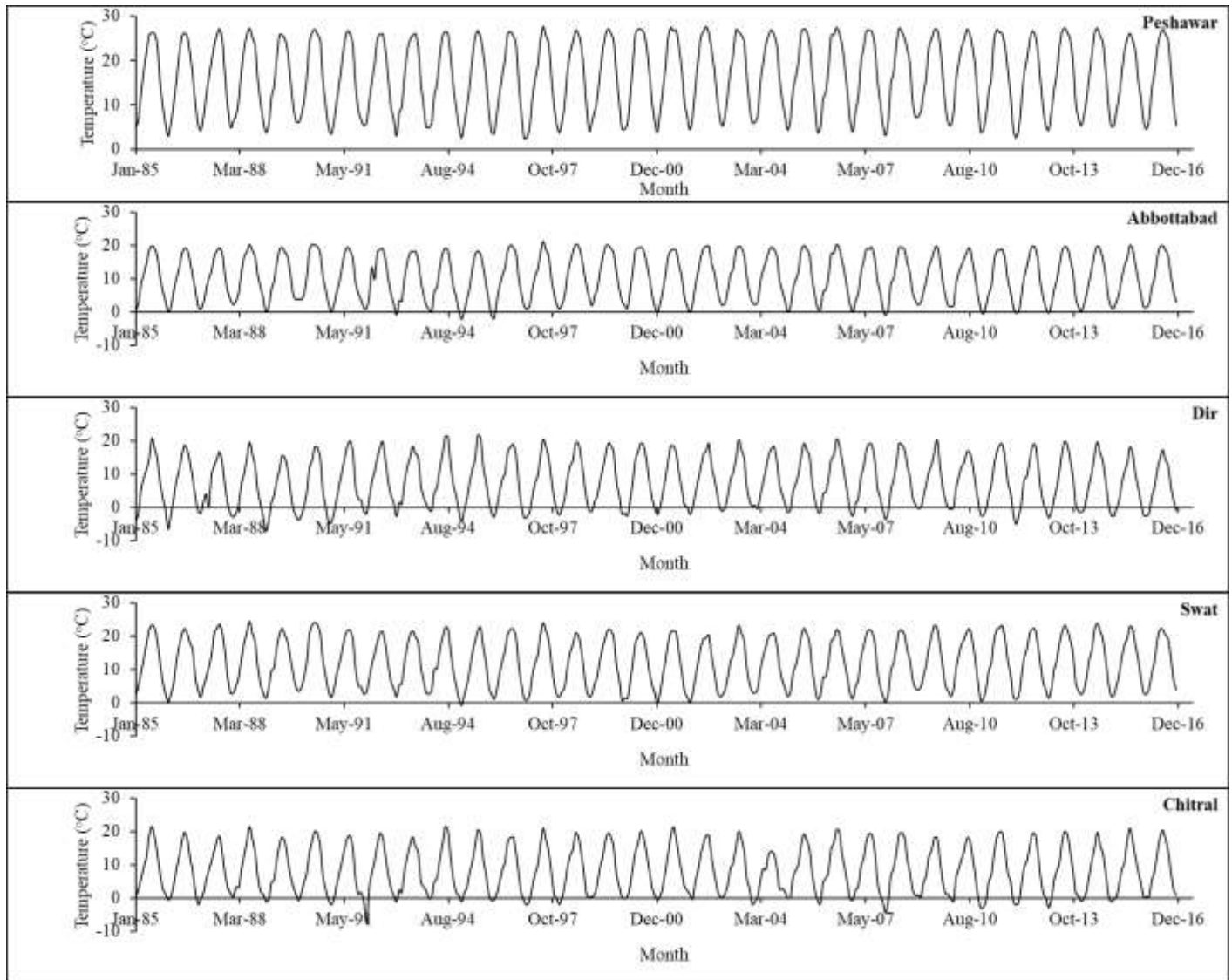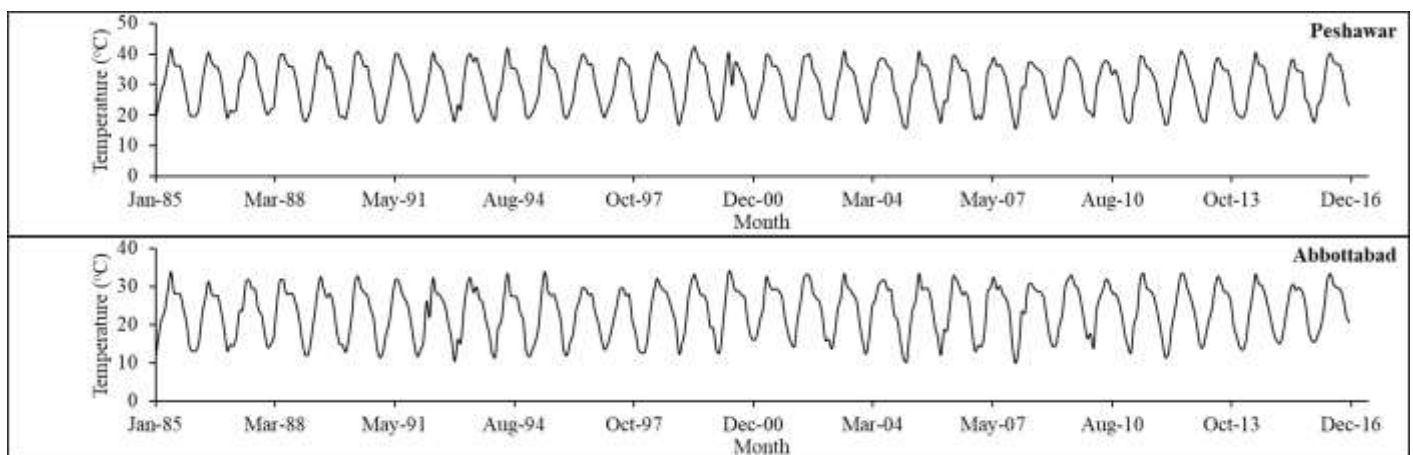**Figure -2:** Mean monthly minimum temperature (1985 to 2016)
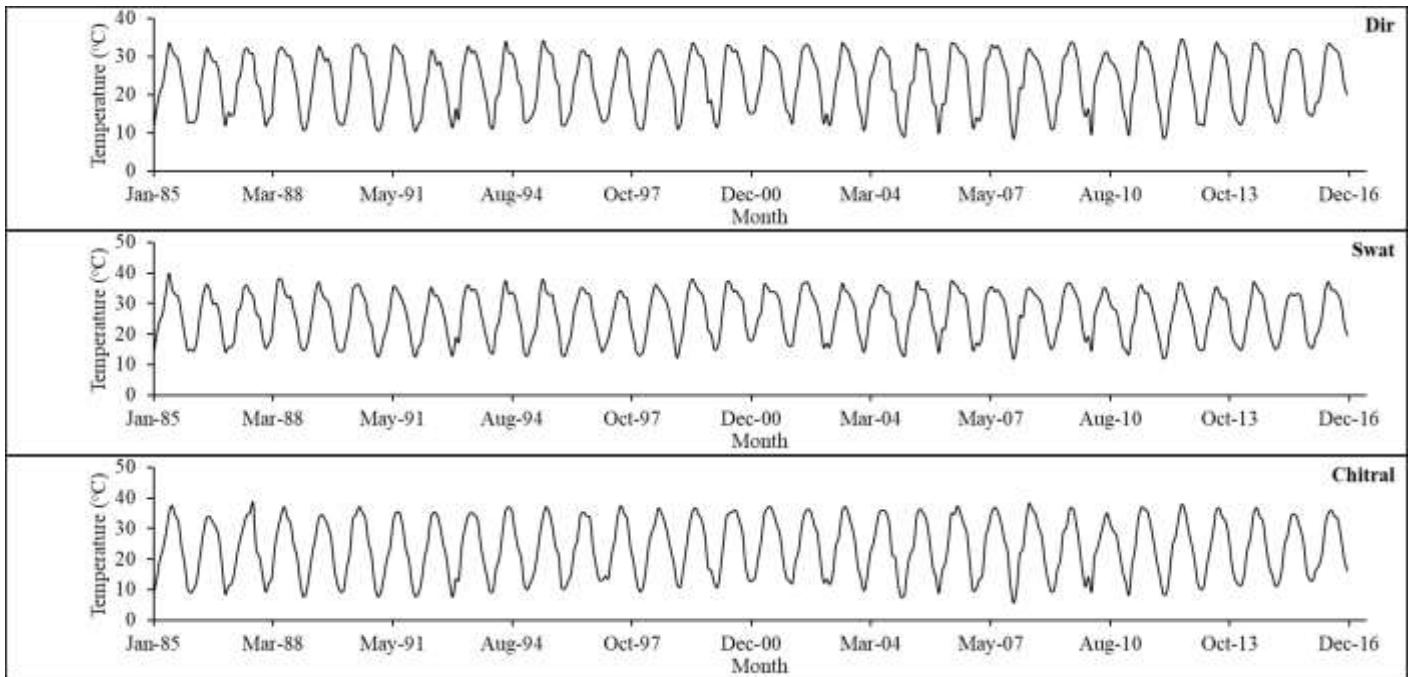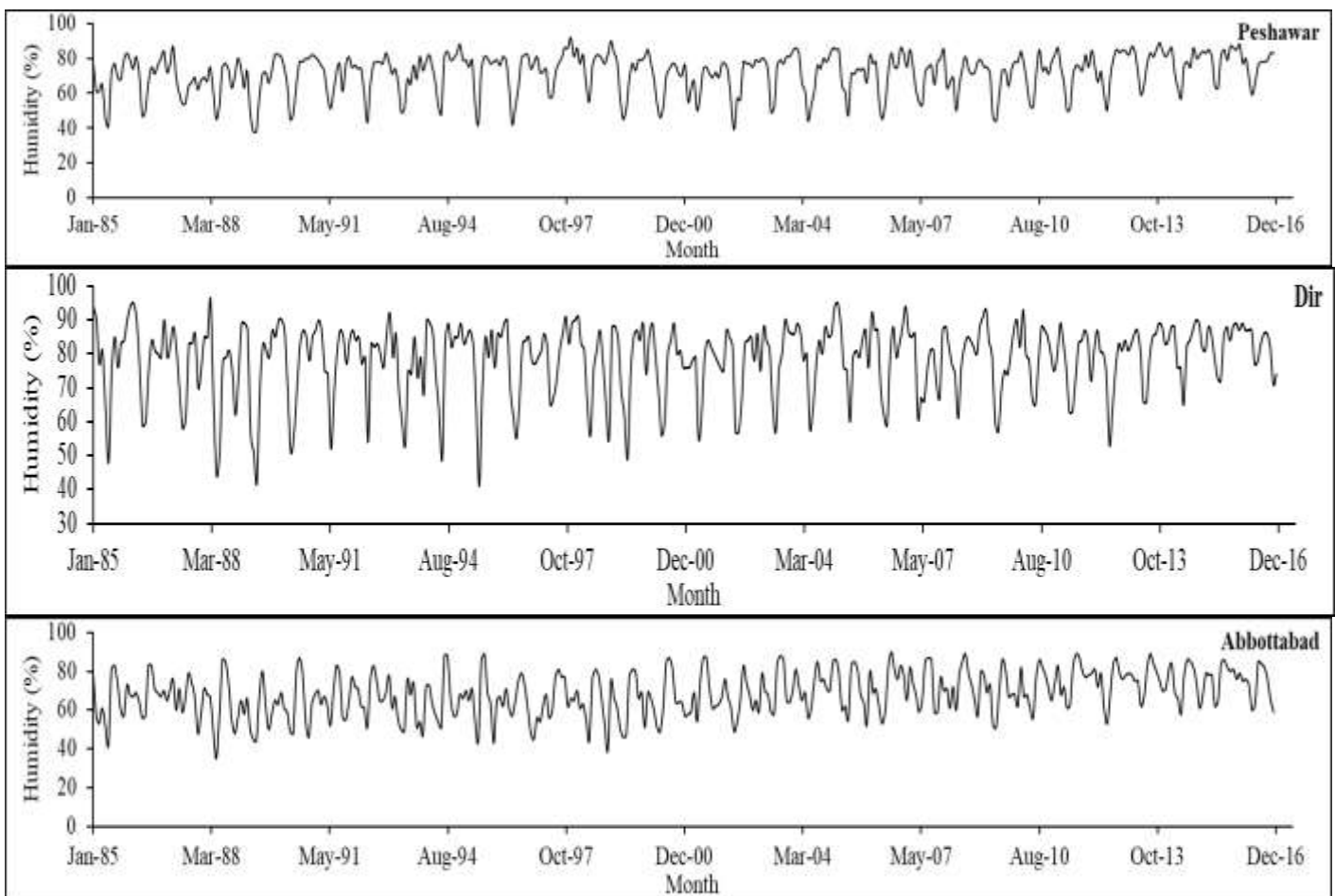
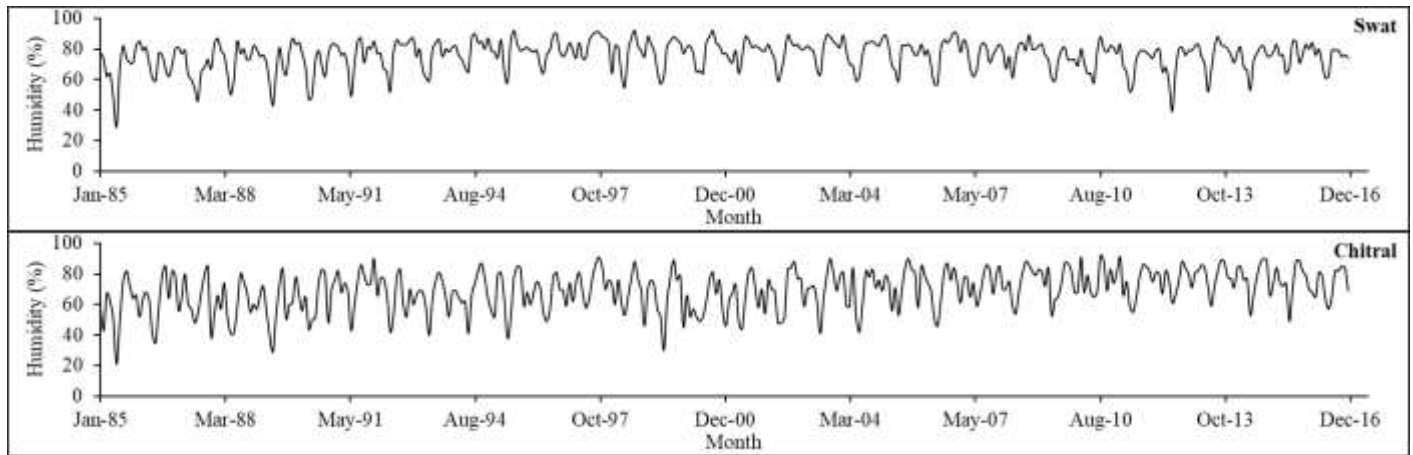**Figure -3:** Mean monthly maximum temperature (1985 to 2016)

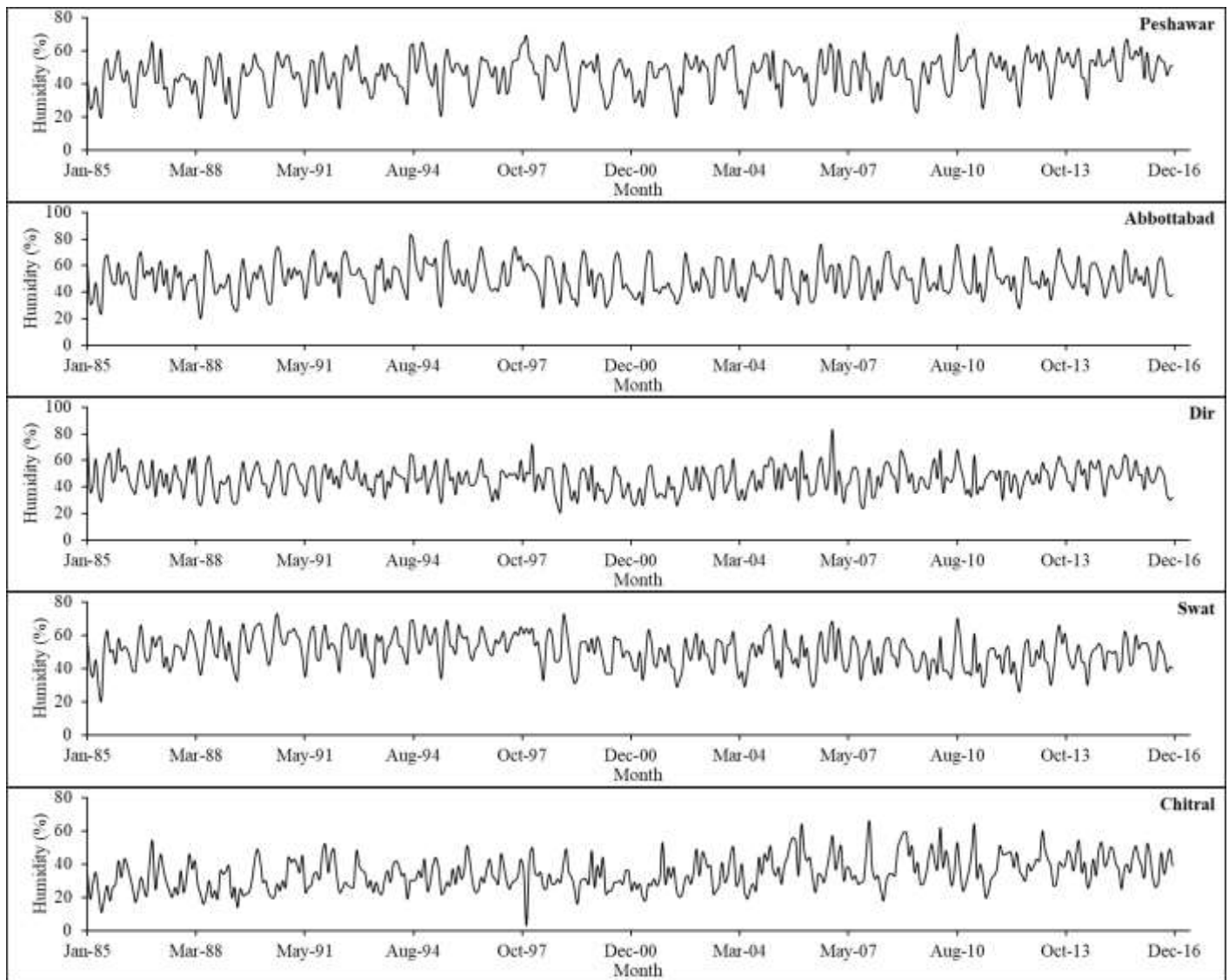**Figure -4:** Mean monthly relative humidity at 8:00am (1985 to 2016)

Figure -5: Mean monthly relative humidity at 5:00pm (1985 to 2016)
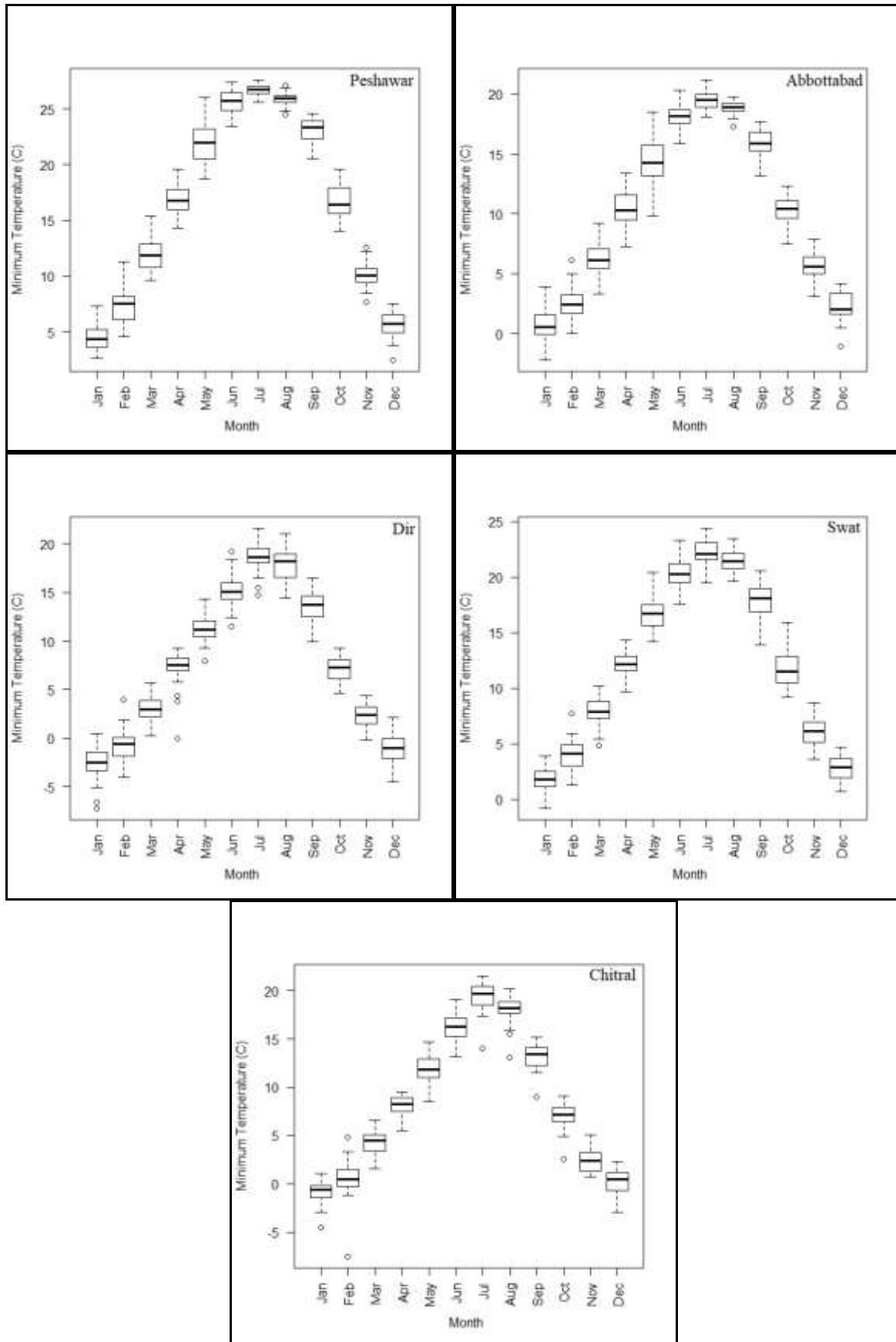
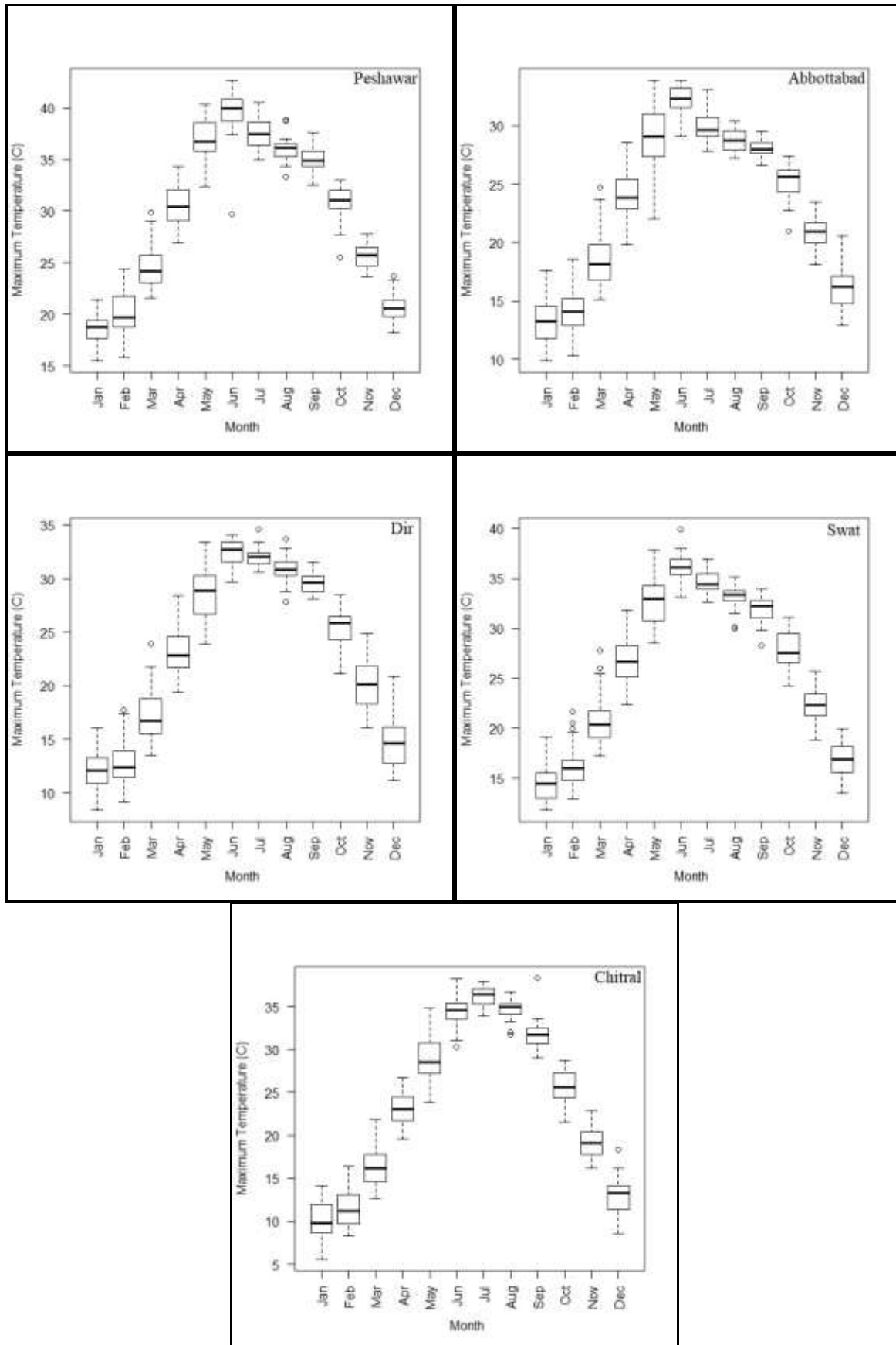**Figure -6:** Monthly variations in mean monthly minimum temperature (1985 to 2016)

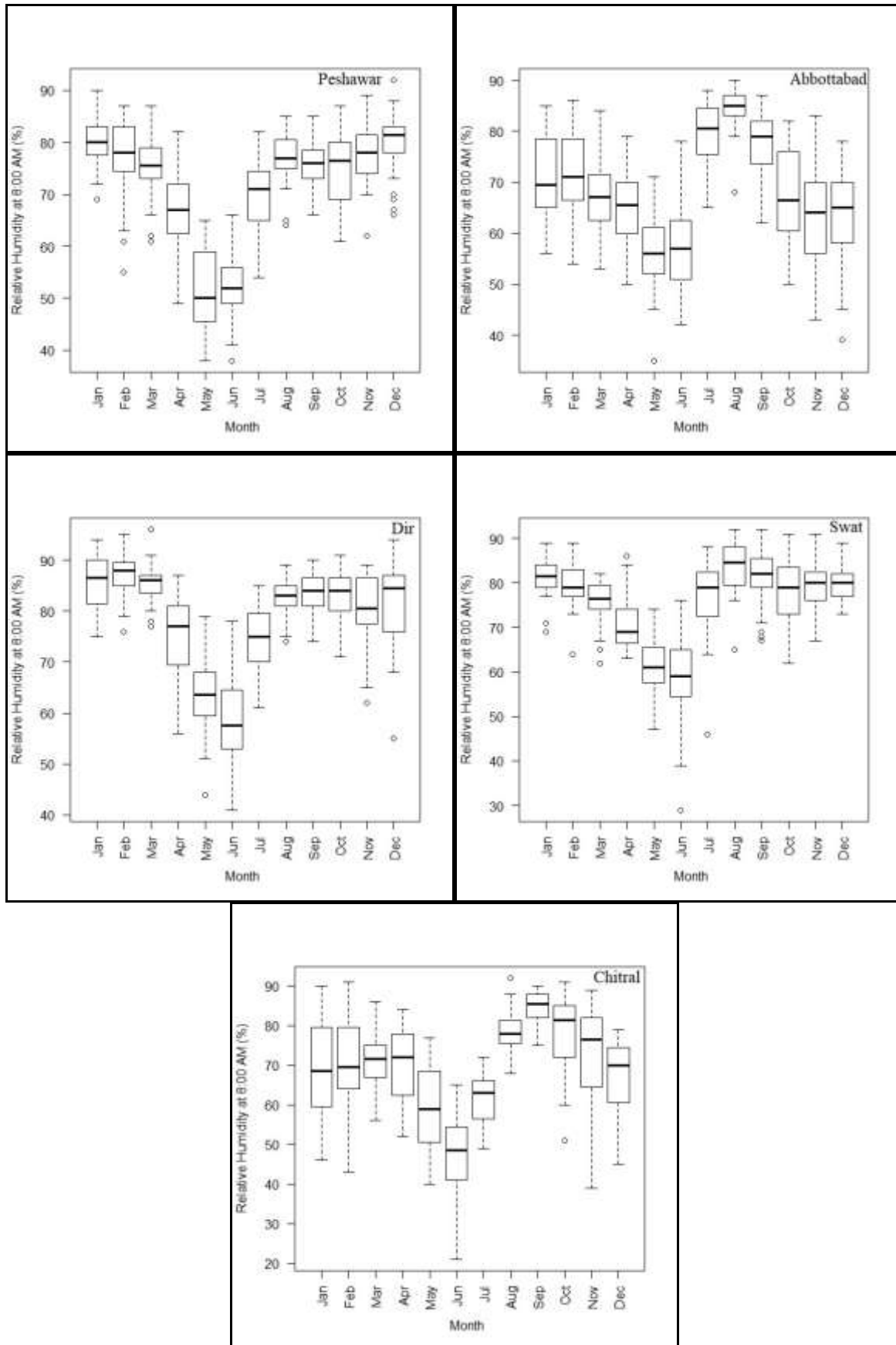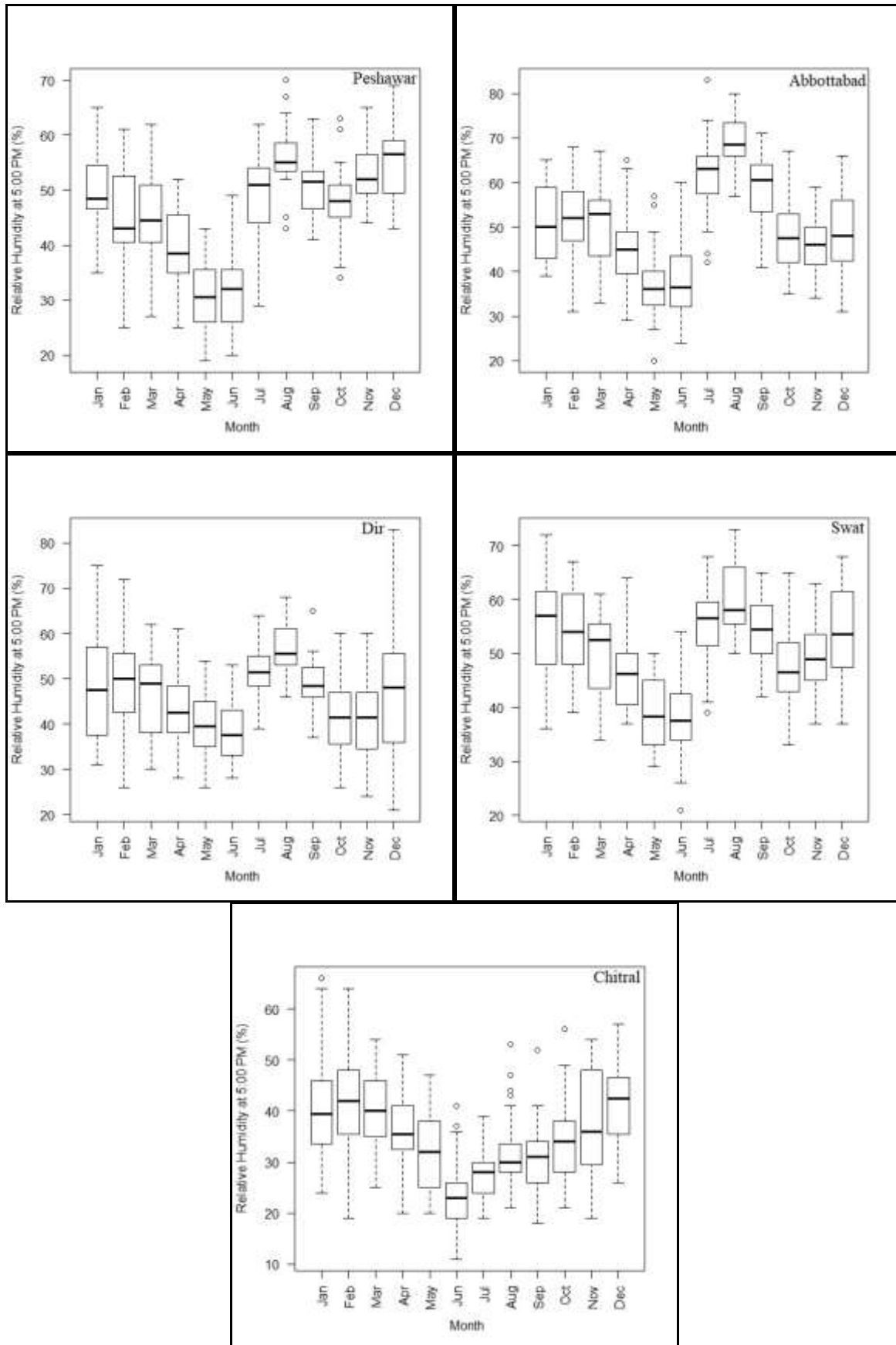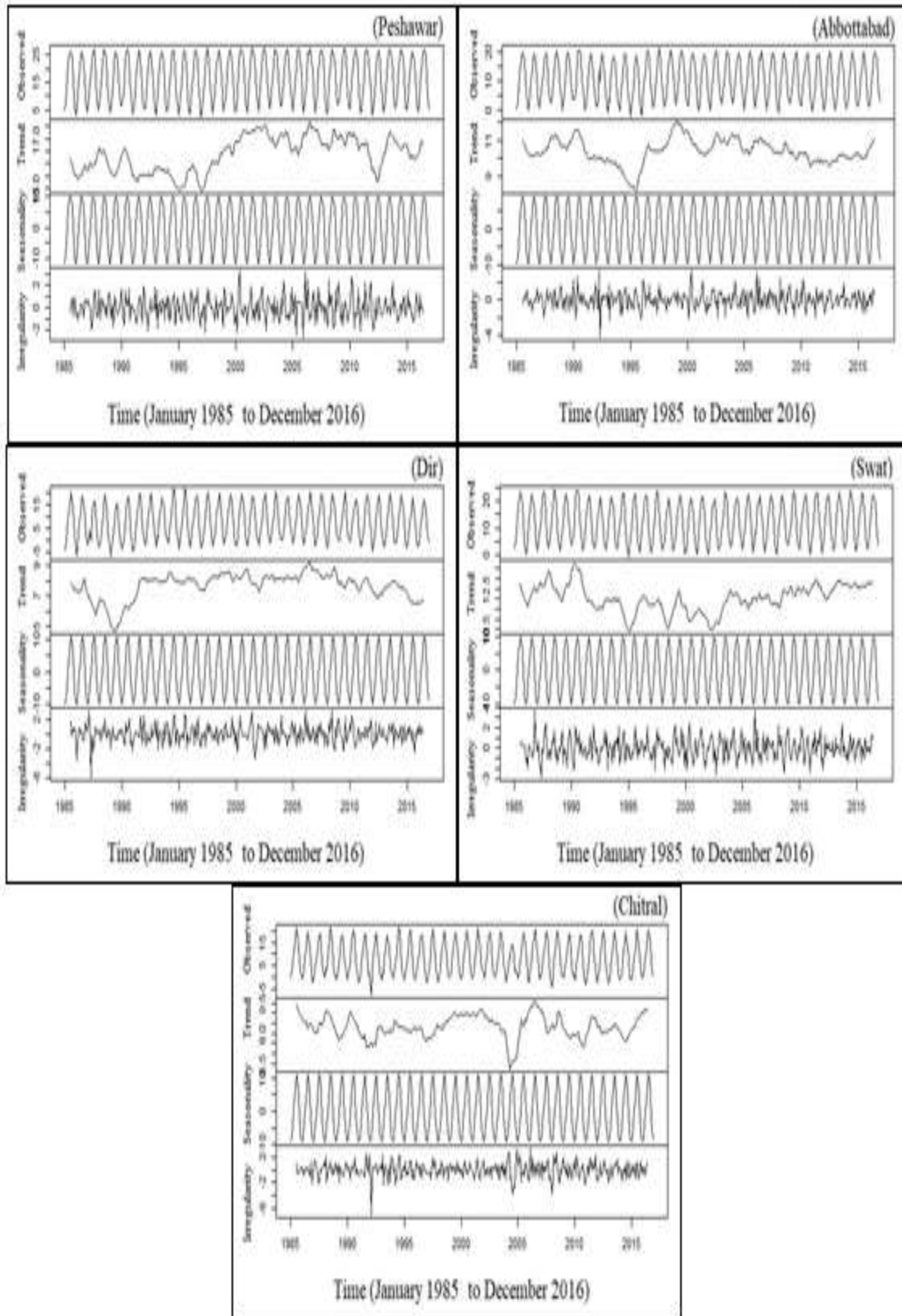Figure 7: Monthly variations in mean monthly maximum temperature (1985 to 2016)

Figure -8: Monthly variations in mean monthly relative humidity at 8:00am (1985 to 2016)

Figure -9: Monthly variations in mean monthly relative humidity at 5:00pm (1985 to 2016)

Figure -10: Time series Analysis of mean monthly minimum temperature (1985 to 2016)
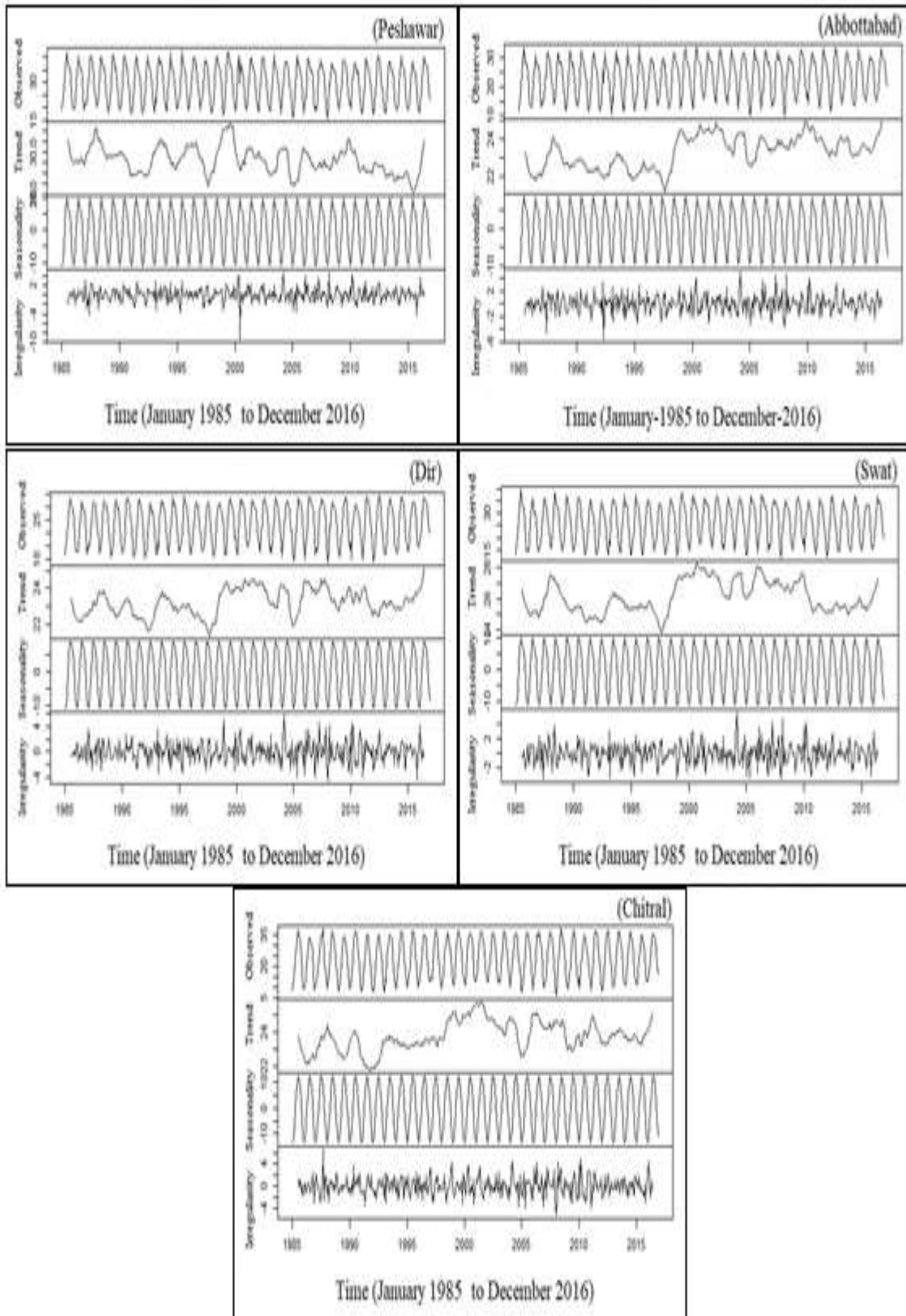
Figure -11: Time series analysis of mean monthly maximum temperature (1985 to 2016)
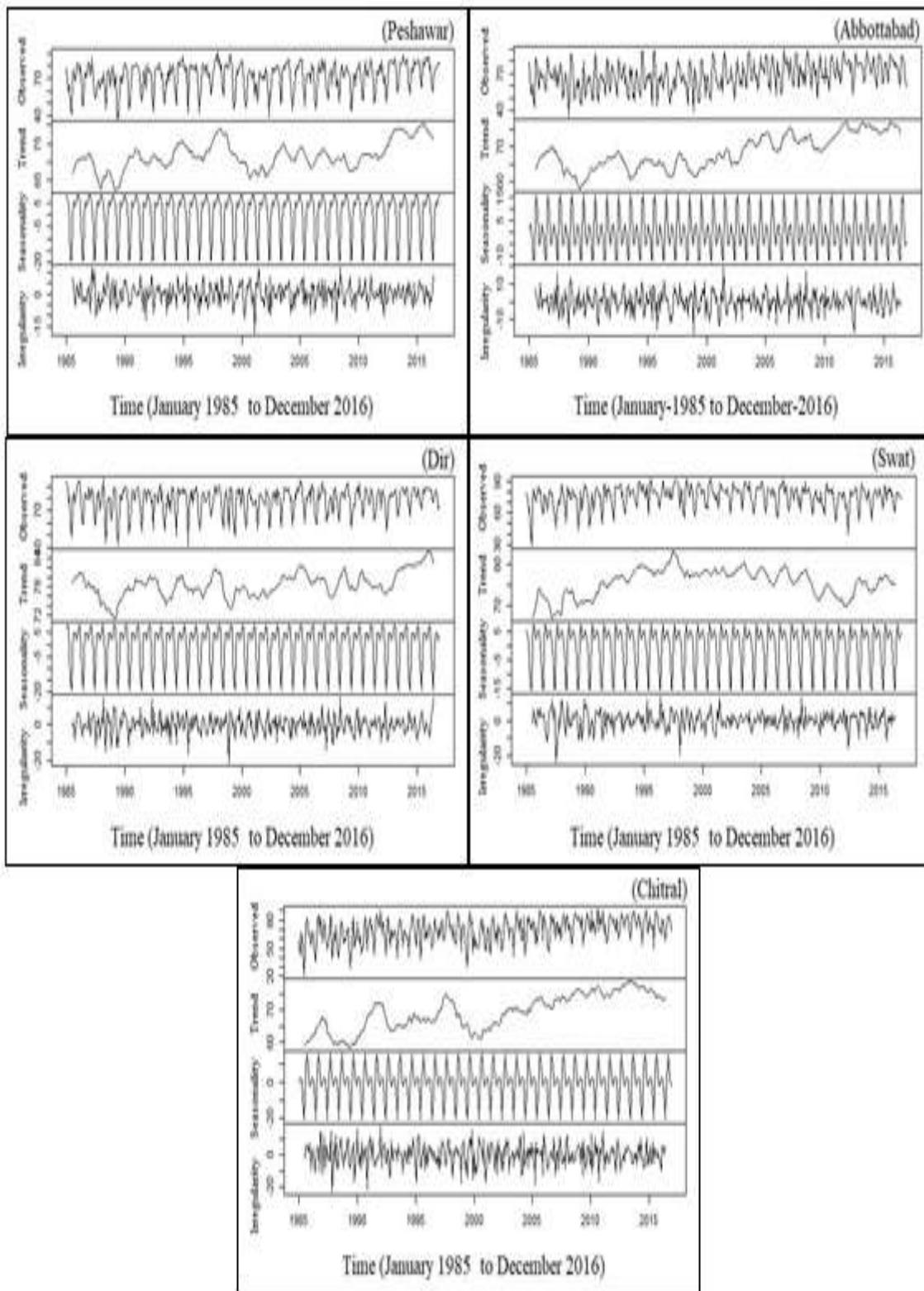
Figure -12: Time series analysis of mean monthly relative humidity at 8:00am (1985 to 2016)
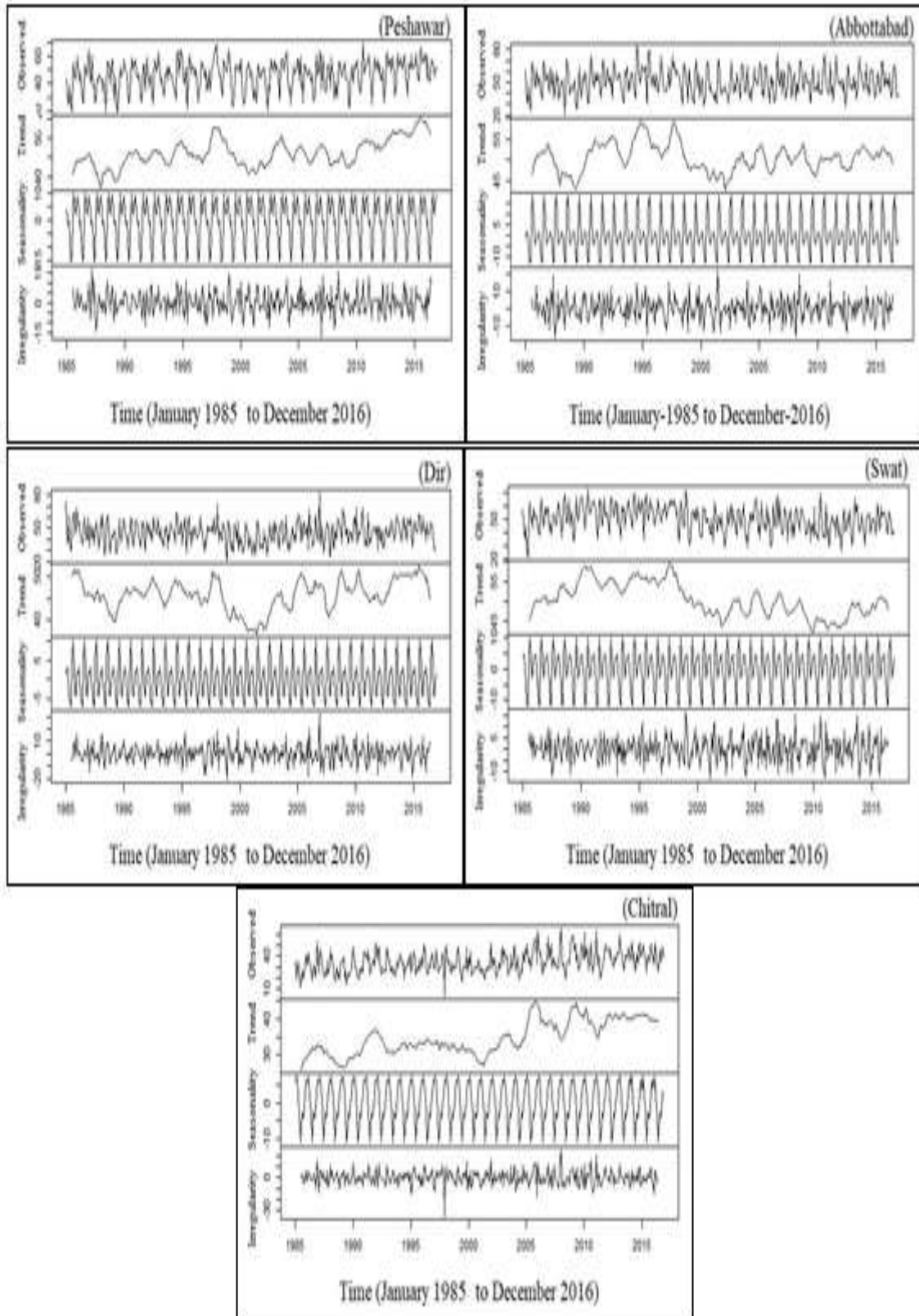
Figure -13: Time series analysis of mean monthly relative humidity at 5:00pm (1985 to 2016)

3. RESULTS AND DISCUSSIONS

The collected data was explored by using MS Excel 2010 for recovering hidden relationship that exists in the recorded data. Also the data were cleaned up by filling the missing values with the mean values. The statistical parameters; minimum value, maximum value, mean, standard deviation, coefficient of variation, and coefficient of skewness for all meteorological variables were calculated to understand the trend and periodicity of the weather data as given in Table 2, 3, 4, and 5. Also to visualize the trends, variations, and seasonality of the collected data different plots; line plots, box plots, and time series plots were plotted as shown in Figures 2 to 13.

Peshawar Weather Station

Lowest mean monthly minimum temperature 2.50 °C was recorded in December 1996 while highest mean monthly minimum temperature 27.60 °C was recorded in July 1997 and mean varies between 4.46 °C and 26.69 °C. Lowest mean monthly maximum temperature 15.50 °C was recorded in January 2008 and highest mean monthly maximum temperature 42.70 °C was recorded in June 1995 with mean variation of 18.51 °C to 39.61 °C. The lowest and highest mean monthly relative humidity at 8:00 am was 38% (May 1989) and 92% (December 1997) respectively with mean variation of 51.86% to 80.05%. Similarly lowest and highest mean monthly relative humidity at 5:00 pm was recorded 19% and 70% at May 1988 and August 2010 respectively with mean variation of 30.59% and 56.03%.

Abbottabad Weather Station

Lowest mean monthly minimum temperature -2.20 °C was recorded in January 1995 while highest mean monthly minimum temperature 21.20 °C was recorded in July 1997 and mean varies between 0.62 °C and 19.47 °C. Lowest mean monthly maximum temperature 9.90 °C was recorded in January 2008 and highest mean monthly maximum temperature 33.90 °C was recorded in June 1987 and May 2000 with mean variation of 13.28 °C to 29.94 °C. The lowest and highest mean monthly relative humidity at 8:00 am was 35% in May 1988 and 90.00% in August 2006 respectively with mean variation of 55.94% to 84.41%. Similarly lowest and highest mean monthly relative humidity at 5:00 pm was recorded 20% and 83% at May 1988 and July 1994 respectively with mean variation of 37.13% and 69.03%.

Dir Weather Station

Lowest mean monthly minimum temperature -7.20 °C was recorded in January 1989 while highest mean monthly minimum temperature 21.60 °C was recorded in July 1995 and mean varies between -2.60 °C and 18.65 °C. Lowest mean monthly maximum temperature 8.40 °C was recorded in January 2008 and highest mean monthly maximum temperature 34.60 °C was recorded in July 2012 with mean

variation of 12.21 °C to 32.45 °C. The lowest mean monthly relative humidity at 8:00 am was 41% in June 1995 and highest was 94% in January 1985, January 1986, January 2005 and December 2006, with mean variation of 58.53% to 85.69%. Similarly lowest and highest mean monthly relative humidity at 5:00 pm was recorded 21% and 83% at December 1998 and December 2006 respectively with mean variation of 38.16% and 56.42%.

Swat Weather Station

Lowest mean monthly minimum temperature -0.80 °C was recorded in January 1995 while highest mean monthly minimum temperature 24.40 °C was recorded in July 1988 and mean varies between 1.70 °C and 22.23 °C. Lowest mean monthly maximum temperature 11.80 °C was recorded in January 2008 and highest mean monthly maximum temperature 39.90 °C was recorded in June 1985 with mean variation of 14.49 °C to 36.20 °C. The lowest and highest mean monthly relative humidity at 8:00 am was 29% in June 1985 and 92.00% in August 1995, September 1998, and September 2000 respectively with mean variation of 59.10% to 83.53%. Similarly lowest and highest mean monthly relative humidity at 5:00 pm was recorded 21% and 73% at June 1985 and August 2010 respectively with mean variation of 38.20% and 60.34%.

Chitral Weather Station

Lowest mean monthly minimum temperature -7.50 °C was recorded in February 1992 while highest mean monthly minimum temperature 21.50 °C was recorded in July 1985 and mean varies between -0.85 °C and 19.48 °C. Lowest mean monthly maximum temperature 5.60 °C was recorded in January 2008 and highest mean monthly maximum temperature 38.30 °C was recorded in September 1987 with mean variation of 10.14 °C to 36.22 °C. The lowest and highest mean monthly relative humidity at 8:00 am was 21% in June 1985 and 92% in August 2010 respectively with mean variation of 47.47% to 84.78%. Similarly lowest and highest mean monthly relative humidity at 5:00pm was recorded 11% and 64% in June 1985 and February 2011 respectively with mean variation of 23.09% and 41.72%.

The basic patterns of weather data are cyclic in nature. Figures 10, 11, 12, and 13 show the trend, seasonality and irregularity for all metrological variables in five weather stations. From these figures it is visualized that the trend of mean monthly minimum temperature for Peshawar weather station is slightly increasing while for the rest of the stations are almost uniform. The seasonality of minimum temperature for all stations is uniformly periodical. Mean monthly maximum temperature are following slight increasing trend in all weather stations. Also the trends of mean monthly relative humidity at 8:00am and 5:00pm are following a slight increase in their nature.

4. CONCLUSION

This research work reports a detailed survey analysis of past climatic data collected from Peshawar Meteorological department, KP Pakistan. The past 32 years (January 1985 to December 2016) of data were collected for five different meteorological weather stations located at Peshawar, Abbottabad, Dir, Swat, and Chitral. The data of meteorological variables; minimum temperature, maximum temperature, relative humidity at 8:00am and relative humidity at 5:00pm were collected. The statistical parameters; minimum, maximum, mean, standard deviation, coefficient of variation, and coefficient of skewness were calculated for these parameters. Also for visualizing trends, seasonality, and periodicity of these parameters different plots; line, box, and time series were plotted. From study it is observed that the trend of mean monthly minimum temperature for Peshawar weather station is increasing by 0.4 ^{o}C per year while for the rest of the stations are almost uniform. The seasonality of minimum temperature for all stations is uniformly periodical. Mean monthly maximum temperature are following slight increasing trend in all weather stations. Also the trends of mean monthly relative humidity at 8:00am and 5:00pm are following a slight increase in their nature. The trends and seasonality of the data can be extended to the future for further investigations and prediction.

ACKNOWLEDGEMENT

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