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RESEARCH ARTICLE

WEATHER PERTURBATIONS ASSOCIATED WITH THE TRANSIT OF TROPICAL CYCLONES IN THE COAST OF BANGLADESH

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ABSTRACT

During the transition of tropical cyclone in the coast of Bangladesh, it is normally observed that there is a noticeable perturbation of weather parameters around the cyclone landfall zone. Through this research the extent of perturbation is assessed. To make the inventory 4 recent cyclones were selected that had made landfall in Bangladesh coast. They are cyclone MORA, cyclone ROANU, cyclone KOMEN and cyclone MAHASEN. Weather parameters selected to check their perturbation are wind speed, temperature, dew point temperature, atmospheric pressure, relative humidity and precipitation. The dispersion of these parameters from their normal state was measured also in accordance of their distance from the landfall area. To perform the task a time scale of 15 days was selected for each cyclone. Middle 3 days window were considered as most affected weather, 6 days prior and after the event were considered as normal (prevailing) weather. The Synop (observed) data was downloaded from the Ogimet.com. The data was then processed and decoded by Synop decoder and then further analyzed in MS Excel. In case of atmospheric pressure perturbation the highest perturbation was found 5.8 mb low on average than prevailing pressure up to 50 km from cyclone landfall. Wind speed perturbation was highest in 50 to 100 km area. Perturbation of temperature was highest in 0 to 50 km (about 2.1 °C low on average). Perturbation of dew point temperature was found negligible and humidity perturbation was found highest 6.63% high on average up to 50 km of landfall. In case of precipitation perturbation highest was found in 0 to 50 km area of landfall (38.76 mm high on average than prevailing weather), however precipitation perturbation was irregular beyond 100 km of landfall. The most perturbed weather parameter was found atmospheric pressure and the least affected was dew point temperature.

KEYWORDS

Perturbation, Weather parameters, Cyclone, Synop data.

1. INTRODUCTION

Bangladesh is a maritime country. Almost every year it faces tropical cyclones in its coastal area. Tropical cyclones, hurricanes and typhoons are major natural disturbance that affect life, property and environment adversely around the world (Gallina et al., 2016; Poulos, 2010). These natural disasters generally form over Tropical Ocean and named according to their particular location (Puotinen, 2007). However, whatever the name of this disaster in different part of the world is, normally it is seen that during cyclone affected days a lowering of temperature, high wind speed, gust, extreme rainfall, high relative humidity, low atmospheric pressure etc. Different countries may experience it in different intensity due to their geographic location. For instance, a group researchers found that there is significant effect of tropical cyclone on extreme precipitation event along the coastal areas and apparent effects in inland areas of China (Zhang et al., 2018). But it is necessary to quantify how much perturbation of these weather parameters is occurred from their prevailing status due to transition of tropical cyclone. Here the perturbation means an unusual change, in the movement, quality or behavior of something (Collins Dictionary, 2019). The perturbation rate according to distance from the landfall area is also not known. Which parameter of weather is affected most and which parameter affected less by a cyclone is not examined in case of Bangladesh coast. So, an extensive study was badly needed to precisely identify how weather parameters are changing due to cyclone landfall and also the pattern of change according to distance from landfall zone and also how they are recovering after the cyclone transition. Alongside, this study will also help us to keep the record of the present status and in future it can be utilized to compare the perturbation pattern of weather of different time during cyclone transition in the coast.

The complete research work was based on available free SYNOP (observed) data where SYNOP stands for surface synoptic observations (FLDIGI, 2019). Anyone can use this free data for any related research aspect. Ogimet.com is a free platform for collecting synop data (Ogimet, 2019). There are some limitations of using this data such as narrow bandwidth to download data, data missing, bad data etc. But these are negligible. It can be easily overcome through careful interpretation of data. For this research downloaded Synop data were decoded in OADAL (Oceanographic and Atmospheric Data Analysis Laboratory) of Institute of Marine Sciences, University of Chittagong using data decoder program developed in OADAL. The objective of this research was generating

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fundamental information on perturbing effect of cyclone on weather parameters during the transition in the coast of Bangladesh and to make a record of present interaction status of cyclone with the prevailing weather, which can be used to compare in future.

2. MATERIALS AND METHOD

At the initial stage the weather parameters were selected for estimating their perturbation and those are wind speed, temperature, dew point temperature, relative humidity, pressure and precipitation. Four cyclones were selected for the analysis. And they are the latest cyclones named cyclone MORA, Cyclone ROANU, cyclone KOMEN, cyclone MAHASEN. Four stations were selected for every cyclone around the landfall area of the selected cyclones. Cyclone landfall areas were identified from their trajectory lines collected from local newspapers. Time scale around the cyclone landfall day was 15 days in total. The middle day is the landfall day. The previous and next day of the cyclone landfall day was considered as cyclone affected weather. That means total 72 hours were considered as cyclone affected weather. Other 12 days (First and last 6 days of the 15-day time scale) were considered as normal (prevailing) weather. The time scale is shown in figure 1.

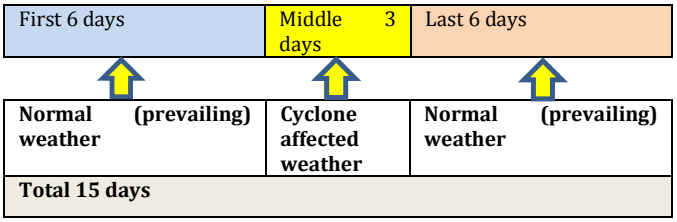

Figure 1: Time scale for data collection

2.1 Dates of cyclone affected days

Cyclone MORA affected days: 29 May 2017 to 31 May 2017
Cyclone ROANU affected days: 20 May 2016 to 22 May 2016
Cyclone KOMEN affected days: 29 July 2015 to 31 July 2015
Cyclone MAHASEN affected days: 15 May 2013 to 17 May 2013

Figure 2: Selected weather stations of Cyclone MORA (left) and ROANU (right) (Image source: Google Map)

Figure 3: Selected Weather stations for Cyclone Komen (left) and Mahasen (right) (Image source: Google Map)

The selected stations and their distance from the landfall epicenter are shown in table 1. Distance was estimated by measuring the distance between landfall area's latitude and longitude and selected weather station's latitude longitude.

Table 1: Selected stations for each cyclone and their distance from landfall epicenter.

Station	Distance from the landfall (km)
Cyclone MORA	
Kutubdia	32
Chittagong	40
Cox's Bazar	75
Maijdee court	118
Cyclone ROANU	
Chittagong	19
Kutubdia	72
Maijdee court	76
Cox's Bazar	125
Cyclone KOMEN	
Maijdee court	45
Chittagong	59
Bhola	65
Kutubdia	102
Cyclone MAHASEN	
Bhola	17
Potuakhali	31
Maijdee Court	98
Chittagong	125

Data was downloaded according to selected time and station from the Ogimet.com. There are WMO Indexes for every station to download the data station wise. By inputting the time lapse and other necessary information, observed data of specific time and station can be downloaded. Synop data was then decoded using Synop data decoder program developed in OADAL according to the data documentation found at data source. After decoding the downloaded data, the data was processed in MS Excel for further analysis. Processing includes sorting the data according to date from latest to oldest, keeping the data of cyclonic days and normal days side by side etc. Data processing made the whole data set fit for further analysis. Data those were missing and abnormal (very few) in the downloaded data set were collected from local newspaper of cyclone affected days. Every Parameter selected for each station was gone through the descriptive statistical analysis to find out how much perturbation is occurred during cyclone transition or whether any perturbation is occurred or not to that weather parameter.

Distance wise weather perturbation is also found out through comparing the mean, range, minimum and maximum value of any parameter among the selected stations. Perturbation of a particular parameter of weather is estimated from the descriptive statistics and by generating graphs and charts. Mean of a weather parameter during normal (prevailing) weather and cyclone affected weather at a particular station of a cyclone are compared. Comparisons of all the stations are then grouped distance wise (3 groups: 0 to 50 km, 50 to 100 km and beyond 100 km) from the cyclone landfall epicenter. Then Average of each group is estimated and compared with other groups. Thus, the perturbation pattern of that weather parameter and amount of perturbation is estimated. Minimum and maximum value of some parameter (wind speed, temperature) is also compared between normal and cyclone affected weather.

3. RESULT AND DISCUSSION

3.1 Atmospheric Pressure (mb)

3.1.1 Descriptive Statistics

Descriptive statistics of all selected stations of 4 cyclones for atmospheric pressure are given in table 2. Differences between mean value of normal and cyclonic weather are showing the average perturbation of atmospheric pressure of the respective station. These mean differences of atmospheric pressure at different station are then grouped distance wise from the landfall epicenter (0 to 50 km, 50 to 100 km and beyond 100 km) and then averaged to show the gradual decline of perturbing effect of cyclone with increasing distance. Ranges of atmospheric pressure of all stations are averaged to show the fluctuations during cyclone affected days and normal days.

Table 2: Descriptive statistics of Atmospheric Pressure (mb) at 4 selected stations for each cyclone.

Station	Distance from the landfall (km)	Normal (prevailing) Weather (12 days) (A)					Cyclone affected weather (3 days) (B)					Diff. Between Mean (A-B)
		Mean	SD(±)	Max	Min	Range	Mean	SD(±)	Max	Min	Range	
Cyclone MORA												
Kutubdia	32	1004	1.47	1007.4	1000	7.4	999.09	6.88	1007.3	978	29.9	4.91
Chittagong	40	1003.9	1.72	1009.8	999.3	10.5	997.8	1.19	1004.5	981.3	23.2	6.1
Cox's Bazar	75	1003.7	1.72	1006.8	998.5	8.3	999.2	7.31	1004.7	978.3	26.4	4.5
Maijdee court	118	1003.7	1.42	1007.1	999	8.1	999.8	3.85	1004.1	990.9	13.2	3.9
Cyclone ROANU												
Chittagong	19	1005	2.45	1009.8	1000.1	9.7	999.5	4.49	1005.6	988	17.6	5.5
Kutubdia	72	1005.2	2.33	1010.3	1000.2	10.1	1000	3.74	1006.2	990.6	15.6	5.2
Maijdee court	76	1004.7	2.26	1009.6	1000	9.6	999.2	4.52	1005.2	988.4	16.8	5.5
Cox's Bazar	125	1004.6	2.5	1009.4	1000	9.4	999.5	3.45	1005.4	993.1	12.3	5.1
Cyclone KOMEN												
Maijdee court	45	1002.2	3.26	1006.8	995.8	11	994	2.05	999.2	991.2	8	8.2
Chittagong	59	1002.4	3.64	1008	994.5	13.5	994.8	3.77	1000.9	988.9	12	7.9
Bhola	65	1001.4	3.56	1006.3	994.2	12.1	994.2	1.82	998.5	991	7.5	7.2
Kutubdia	102	999.9	3.75	1008.7	995	13.7	993.3	4.9	1001.2	986.3	14.9	6.6
Cyclone MAHASEN												
Bhola	17	1005	1.76	1008.2	1001.2	7	999	3.36	1007.9	997.1	10.8	6
Potuakhali	31	1004.1	1.82	1009.9	1000.4	9.5	1000	4.17	1007	993	14	4.1
Maijdee Court	98	1003.9	1.61	1006.6	1000.4	6.2	1000	4.006	1005.8	993.4	12.4	3.9
Chittagong	125	1005	1.76	1008.2	1001.2	7	1002	3.36	1007.9	997.1	10.8	3

From table 2, we can see that perturbation of atmospheric pressure is very high. Perturbation of atmospheric pressure up to 50 km is 5.80 mb on average and 5.70 up to 100 km and 4.65 beyond 100 km. The average minimum atmospheric pressure of all station during cyclone affected days is 989.2 mb and during normal days is 998.7 mb and the difference is 9.5 mb. The average fluctuation of atmospheric pressure during cyclone affected days is 15.33 mb and during normal days is 9.6 mb. A pictorial view of distance wise pressure perturbation during cyclone landfall is shown in figure 4.

3.1.2 Graphs of atmospheric pressure at selected stations for every cyclone

Graphs are given in figure 5 to 20 for understanding atmospheric pressure trend of 15 days around a cyclone. All the similar graphs in this paper are named following the format "Cyclone Name-Weather Parameter-Weather Station". Middle three-day time window is the cyclone affected days and marked in the box. Perturbation of atmospheric pressure on those days can be easily identified:

In the graph it is visible that most of the cyclones were cleared in 3-day time window that was considered in the research design as cyclone affected days.

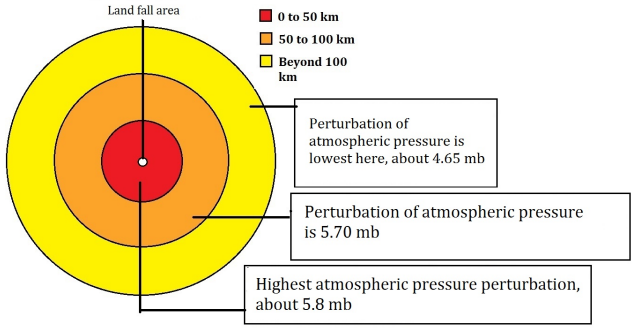

Figure 4: Perturbation of Atmospheric Pressure according to distance

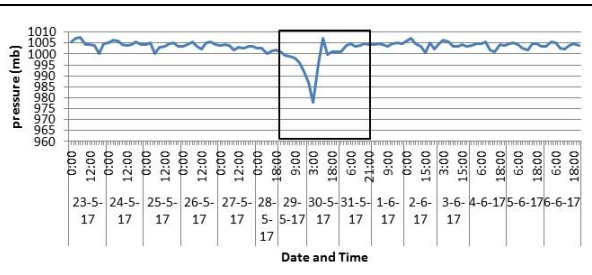

Figure 5: Cyclone MORA-Atmospheric pressure-Kutubdia

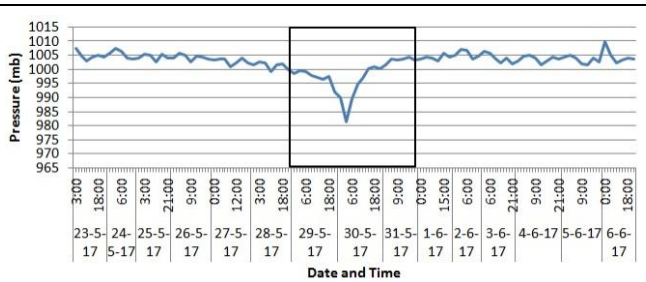

Figure 6: Cyclone MORA-Atmospheric Pressure-Chittagong

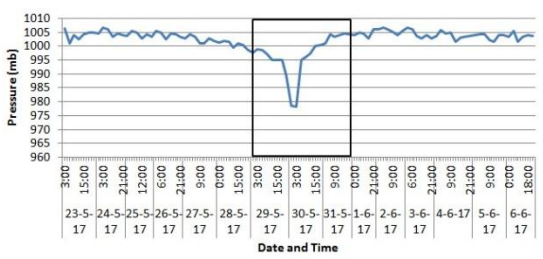

Figure 7: Cyclone MORA-Atmospheric Pressure-Cox's Bazar

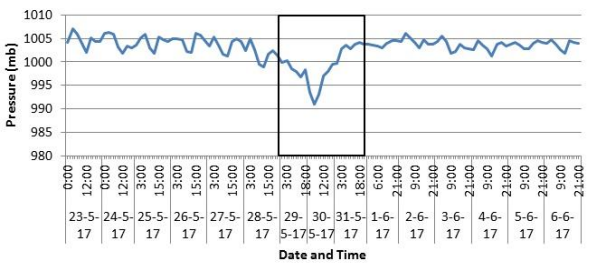

Figure 8: Cyclone MORA-Atmospheric Pressure-Maijdee court

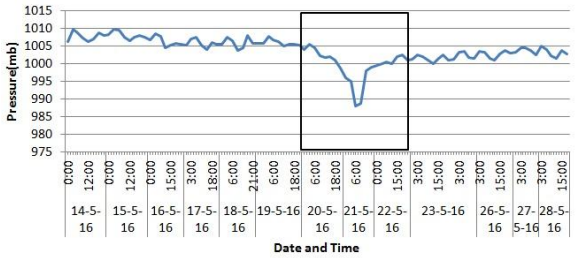

Figure 9: Cyclone ROANU-Atmospheric Pressure-Chittagong

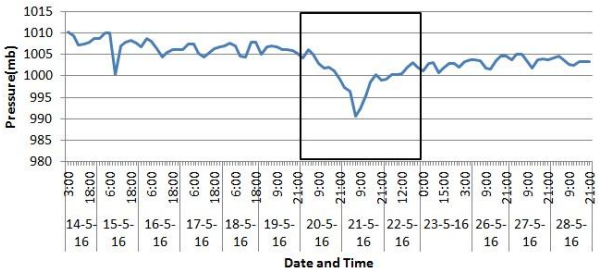

Figure 10: Cyclone ROANU-Atmospheric Pressure-Kutubdia

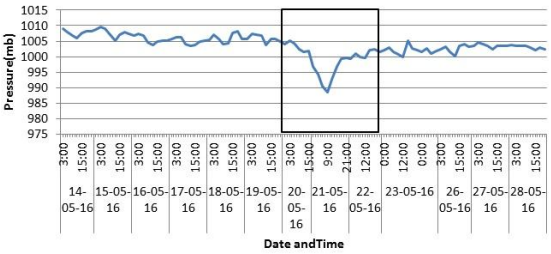

Figure 11: Cyclone ROANU-Atmospheric Pressure-Maijdee court

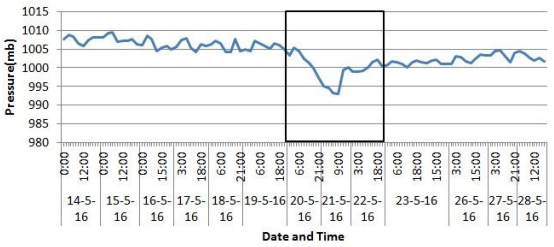

Figure 12: Cyclone ROANU-Atmospheric Pressure-Cox's Bazar

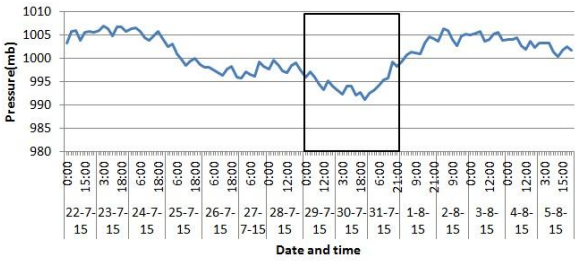

Figure 13: Cyclone KOMEN-Atmospheric Pressure-Maijdee court

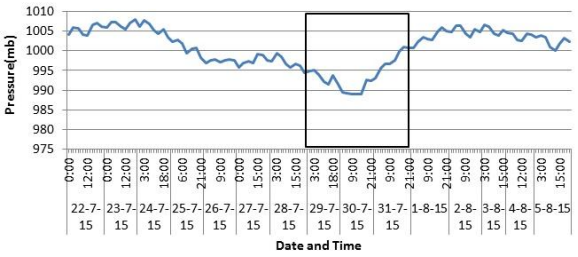

Figure 14: Cyclone KOMEN-Atmospheric Pressure-Chittagong

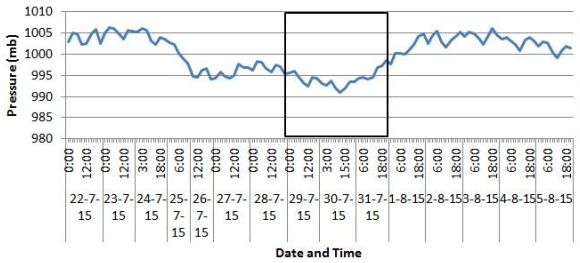

Figure 15: Cyclone KOMEN-Atmospheric Pressure-Bhola

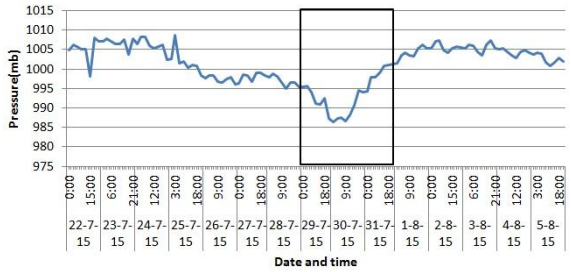

Figure 16: Cyclone KOMEN-Atmospheric Pressure-Kutubdia

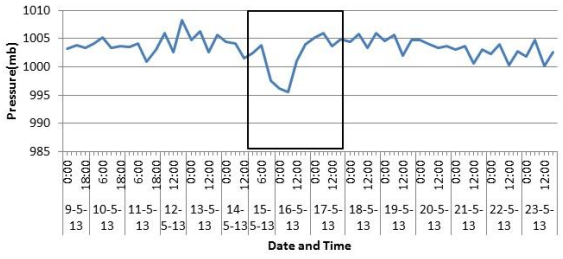

Figure 17: Cyclone MAHASEN-Atmospheric Pressure-Bhola

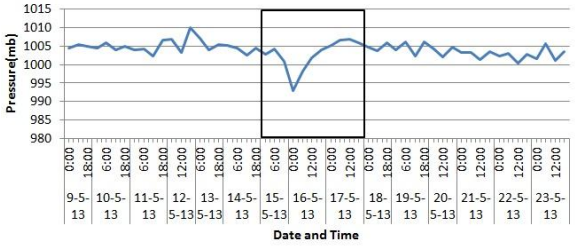

Figure 18: Cyclone MAHASEN-Atmospheric Pressure-Potuakhali

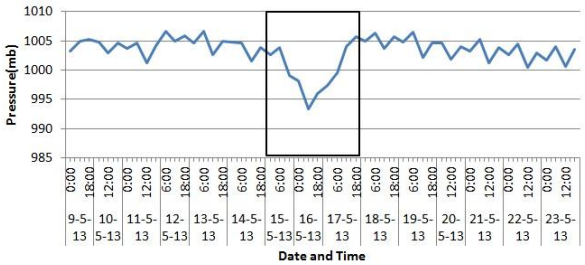

Figure 19: Cyclone MAHASEN-Atmospheric Pressure-Maijdee court

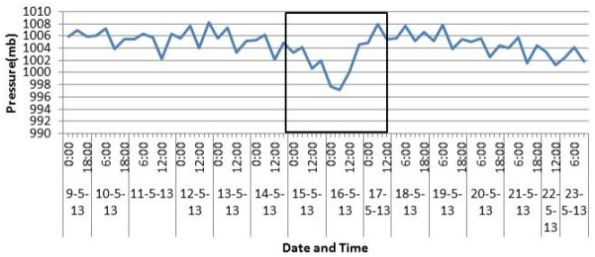

Figure 20: Cyclone MAHASEN-Atmospheric Pressure-Chittagong

3.2 Wind Speed (km/h)

3.2.1 Descriptive Statistics

Descriptive statistics of all selected stations of 4 cyclones for wind speed are given in table 3. Calculations to estimate the perturbation is same as before. Maximum wind speed during cyclone affected days of all stations are distance wise averaged to show the gradual decline of perturbing effect with the increase of distance from the landfall area

Table 3: Descriptive statistics of wind speed (km/h) at 4 selected stations for each cyclone.

Station	Distance from the landfall (km)	Normal (prevailing) Weather (12 days) (A)					Cyclone affected weather (3 days) (B)					Difference between Mean (B-A)
		Mean	SD(±)	Max	Min	Range	Mean	SD(±)	Max	Min	Range	
Cyclone MORA												
Kutubdia	32	6.2	2.2	18.5	1.8	16.6	14.7	16.4	74	3.7	70.3	8.5
Chittagong	40	11.7	8.9	37	0	37	23.1	18.6	83.3	3.7	79.6	6.9
Cox's Bazar	75	3.3	4.8	18.5	0	18.5	14.1	15.5	55.6	0	55.6	10.8
Maijdee court	118	4.11	4.9	22.2	0	22.2	6.4	5.4	14.8	0	14.8	2.29
Cyclone ROANU												
Chittagong	19	15	7.54	33	0	33	17.5	11.24	48.1	5.5	42.6	2.5
Kutubdia	72	8.83	7.74	22	2	20	15	12.11	52	2	50	6.2
Maijdee court	76	8	3.9	17	0	17	12	15.45	56	0	56	4
Cox's Bazar	125	3.02	4.23	15	0	15	5.4	11.93	37	0	37	2.38
Cyclone KOMEN												
Maijdee court	45	7.14	6.62	22	0	22	19	14	69	7	62	11.86
Chittagong	59	10.8	5.39	29	0	29	15	7.5	34	0	34	4.2
Bhola	65	1.62	2.11	9.2	0	9.2	12	12.88	56	0	56	10.38
Kutubdia	102	6.7	4.47	18	0	18	16	7.7	35	5.5	29.5	9.3
Cyclone MAHASEN												
Bhola	17	2	2.26	7.4	0	7.4	11.8	17.92	55.5	0	55.5	9.8
Potuakhali	31	4.03	2.90	11	0	11	9.6	15.92	55.6	0	55.6	5.57
Maijdee Court	98	6.9	3.91	14	0	14	16.4	19.12	67	5.5	61.5	9.5
Chittagong	125	9.9	5.38	25	0	25	14.6	11.3	33.3	0	33.3	4.7

From table 3, at every station average wind speed during cyclone is higher than normal weather and with the increase of distance of weather station from landfall area, the difference of average wind speed between normal and cyclonic day is also decreased. The average wind speed difference between mean wind speed of normal and cyclonic days is 7.51 km/h up to 50 km from landfall area, 7.58 km/h up to 100 km/h and 4.66 km/h beyond 100 km/h. In case of maximum wind speed the nearer the station to the landfall area higher the maximum wind speed. Average maximum wind speeds up to 50 km of landfall is 60.15 km/h and 53.43 km/h up to 100 km and 30.03 km/h beyond 100 km of landfall. A pictorial view of maximum wind speed and perturbation of average wind speed according to distance is given in figure 21.

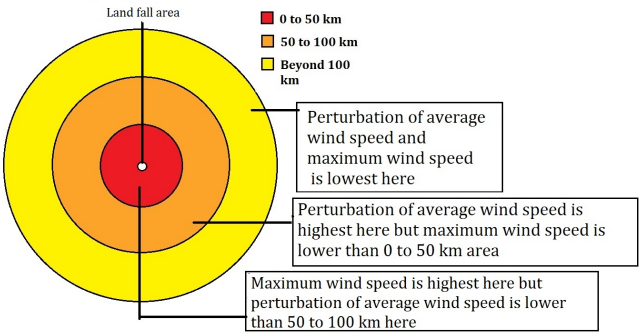

Figure 21: Perturbation of wind speed according to distance

3.2.2 Graphs of wind speed at selected stations for every cyclone

Graphs are given in figure 22 to 37 for showing the wind speed trend of 15 days around a cyclone. Middle three-day time window is the cyclone affected days and marked in the box.

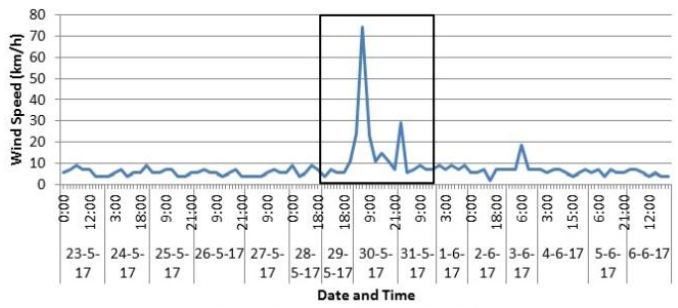

Figure 22: Cyclone MORA-Wind Speed-Kutubdia

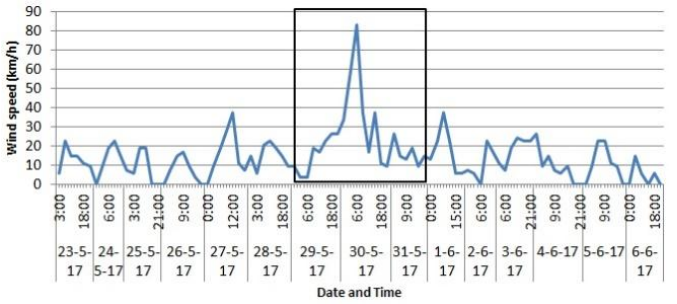

Figure 23: Cyclone MORA-Wind Speed-Chittagong

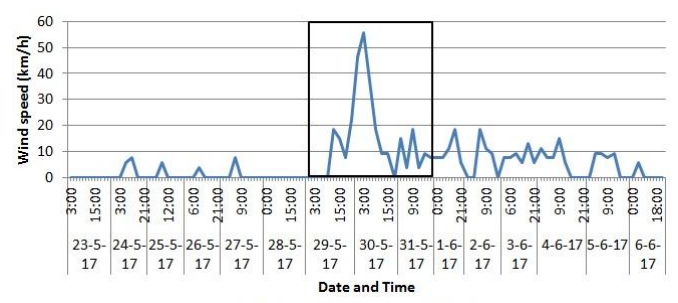

Figure 24: Cyclone MORA-Wind Speed-Cox's Bazar

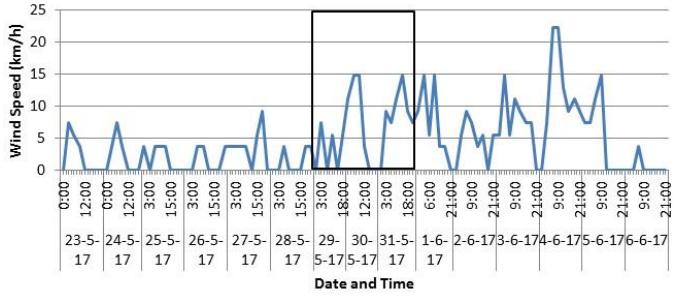

Figure 25: Cyclone MORA-Wind Speed-Maijdee court

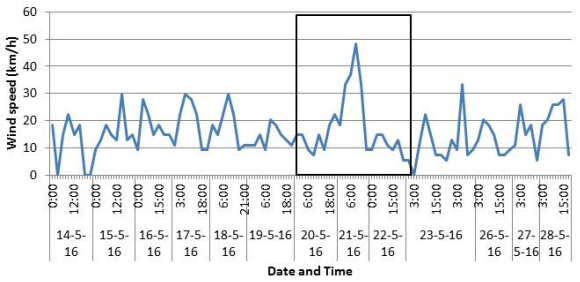

Figure 26: Cyclone ROANU-Wind Speed-Chittagong

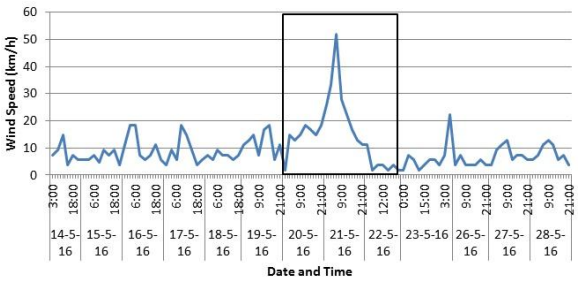

Figure 27: Cyclone ROANU-Wind Speed-Kutubdia

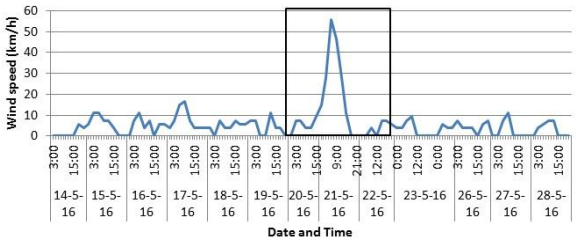

Figure 28: Cyclone ROANU-Wind Speed-Maijdee court

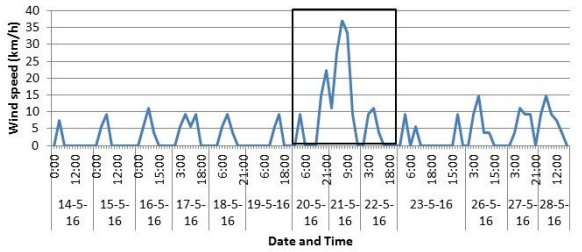

Figure 29: Cyclone ROANU-Wind Speed-Cox's Bazar

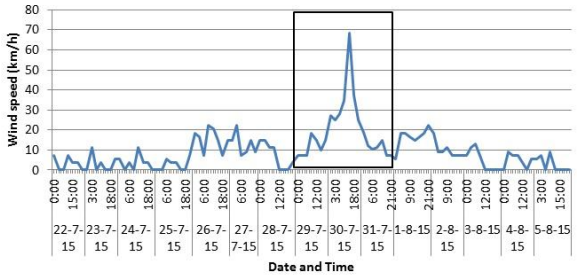

Figure 30: Cyclone KOMEN-Wind Speed-Maijdee court

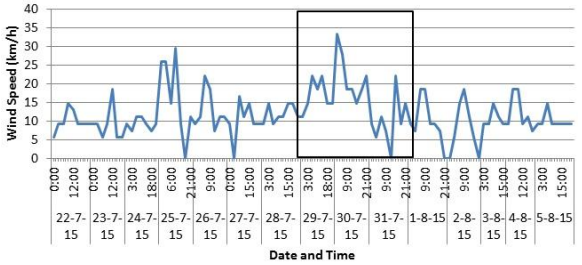

Figure 31: Cyclone KOMEN-Wind Speed-Chittagong

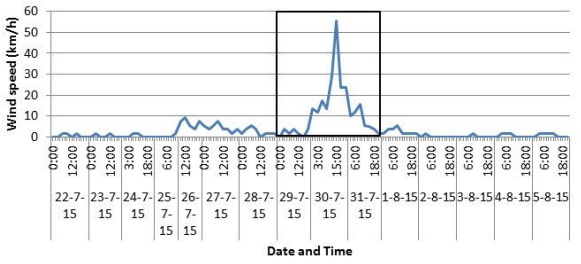

Figure 32: Cyclone KOMEN-Wind Speed-Bhola

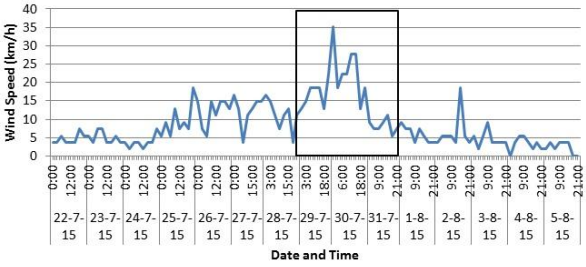

Figure 33: Cyclone KOMEN-Wind Speed-Kutubdia

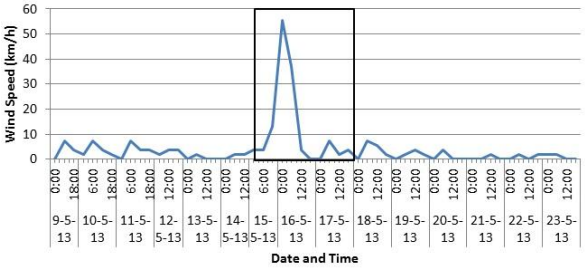

Figure 34: Cyclone MAHASEN-Wind Speed-Bhola

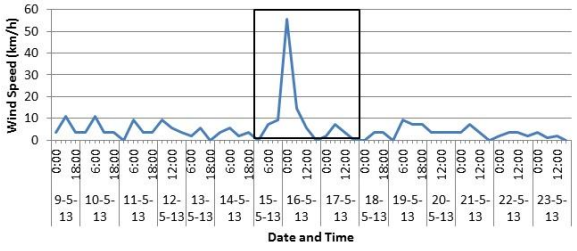

Figure 35: Cyclone MAHASEN-Wind Speed-Potuakhali

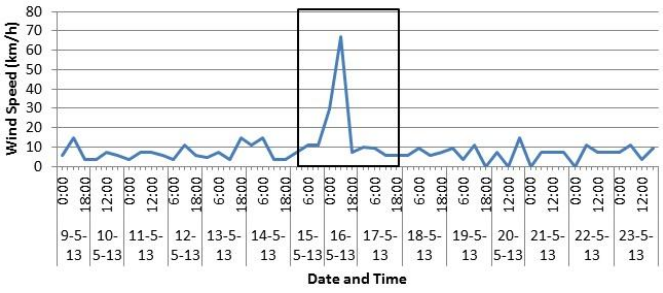

Figure 36: Cyclone MAHASEN-Wind Speed-Maijdee court

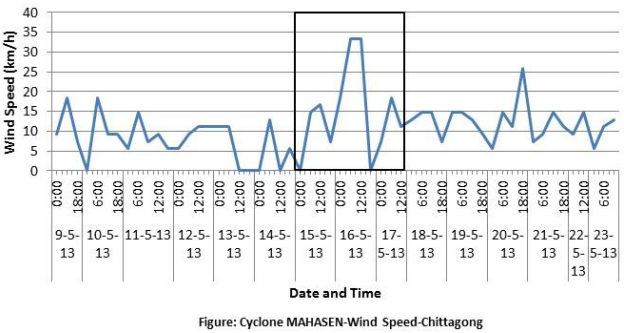

Figure 37: Cyclone MAHASEN-Wind Speed-Chittagong

3.3 Temperature (°C)

3.3.1 Descriptive Statistics

Descriptive statistics of all selected stations of 4 cyclones for temperature are given in table 4. Calculations to estimate the perturbation is same as before. Maximum and minimum temperature of both normal and cyclonic weather of all the station are averaged here and subtracted to find out the maximum and minimum temperature perturbation.

Table 4: Descriptive statistics of Temperature (°C) at 4 selected stations for each cyclone.

Station	Distance from the landfall (km)	Normal (prevailing) Weather (12 days) (A)					Cyclone affected weather (3 days) (B)					Difference Between Mean (A-B)
		Mean	SD(±)	Max	Min	Range	Mean	SD(±)	Max	Min	Range	
Cyclone MORA												
Kutubdia	32	29.9	2.59	34.3	23.5	10.8	27.6	1.92	32	24.5	9	2.3
Chittagong	40	29.6	3.23	35	22.6	12.4	27.6	1.77	31.2	25.4	5.8	2
Cox's Bazar	75	29.9	3.16	35.7	23.2	12.5	28	1.37	31.8	26	5.8	1.9
Maijdee court	118	30.4	0.36	37	24.4	12.6	28.6	2.92	34	25	9	1.8
Cyclone ROANU												
Chittagong	19	29.6	2.79	34.4	24.5	9.9	26.4	1.39	29.8	24.8	5	3.2
Kutubdia	72	29.6	2.49	34.5	25.2	9.3	26.8	1.18	29.5	24	5.5	2.8
Maijdee court	76	29.4	2.99	35	24	11	26.8	2.05	31	24	7	2.6
Cox's Bazar	125	29	2.59	34.3	24.2	10.1	26.8	1.97	32.2	24.4	7.8	2.2
Cyclone KOMEN												
Maijdee court	45	28.1	2.58	33.6	24.2	9.4	25.5	1.12	28.4	24	4.4	2.6
Chittagong	59	27.2	2.04	32	24.5	7.5	25.5	0.97	28.8	24.2	4.6	1.7
Bhola	65	27.3	1.73	32.6	24.8	7.8	25.7	1.43	28.2	23.4	4.8	1.6
Kutubdia	102	26.8	1.85	31.6	24.3	7.3	25.5	0.81	27.2	24	3.2	1.3
Cyclone MAHASEN												
Bhola	17	28.1	2.79	33.2	24	9.2	26.1	2.77	30.8	22.7	8.1	2
Potuakhali	31	28.5	2.87	33.7	24	9.7	26.2	3.26	32.2	22.5	9.7	2.3
Maijdee Court	98	28.1	2.71	33.8	24.4	9.4	26.7	2.81	31.2	23.2	8	1.4
Chittagong	125	28.1	2.26	33.4	23.8	9.6	26.9	2.31	31.7	24	7.7	1.2

From table 4, at every station average temperature during cyclone is lower than normal weather and with the increase of distance of weather station from landfall area, the difference of average temperature between normal and cyclonic day is also decreased. That means perturbation of temperature decrease with the increase of distance between weather station and landfall area. The average difference of mean temperature between normal (prevailing) and cyclonic weather is 2.1 ◦c within 50 km around landfall area and 2 ◦c within 100 km around landfall area and 1.63 ◦c beyond 100 km around landfall area. That means comparatively the remote area from landfall epicenter of cyclone shows lower perturbation of temperature. On the other hand Maximum temperature during normal (prevailing) days is 3.25 ◦c higher than cyclonic days on an average. Surprisingly minimum temperature of normal days is 1.8 ◦c lesser than cyclonic days on average. That means fluctuation of temperature during cyclonic days is lesser than normal days. A pictorial view of temperature perturbation according to the distance of weather station from landfall area is given in figure 38.

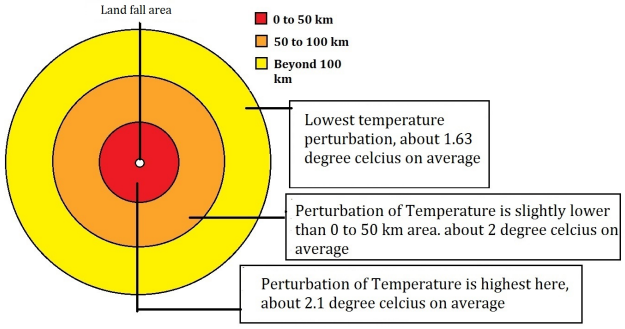

Figure 38: Perturbation of temperature according to distance

3.3.2 Graphs of temperature at selected stations for every cyclone

Graphs are given in figure 39 to 54 for showing the temperature trend of 15 days around a cyclone. Middle three-day time window is the cyclone affected days and marked in the box.

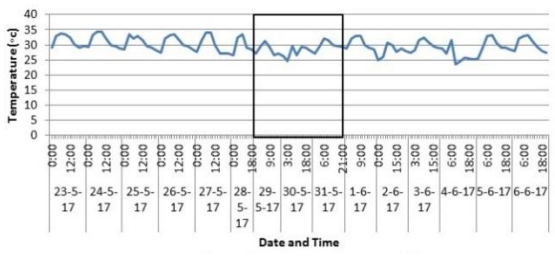

Figure 39: Cyclone MORA-Temperature-Kutubdia

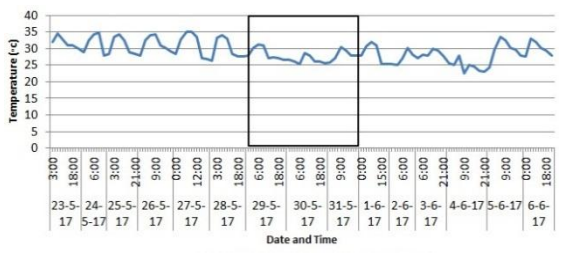

Figure 40: Cyclone MORA-Temperature-Chittagong

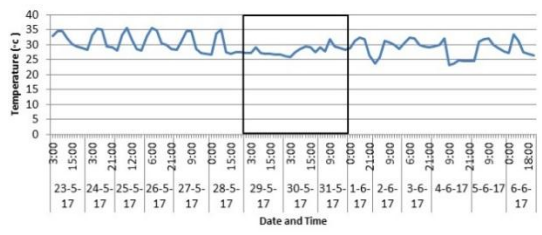

Figure 41: Cyclone MORA-Temperature-Cox's Bazar

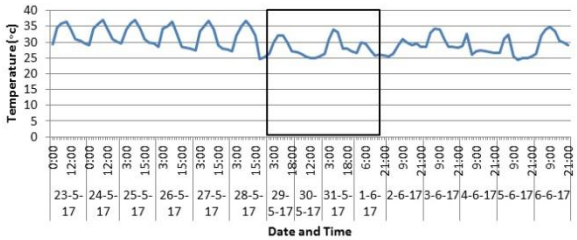

Figure 42: Cyclone MORA-Temperature-Maijdee court

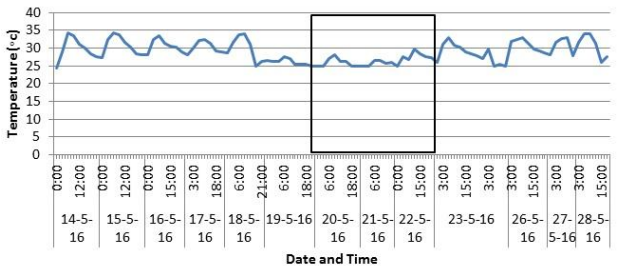

Figure 43: Cyclone ROANU-Temperature-Chittagong

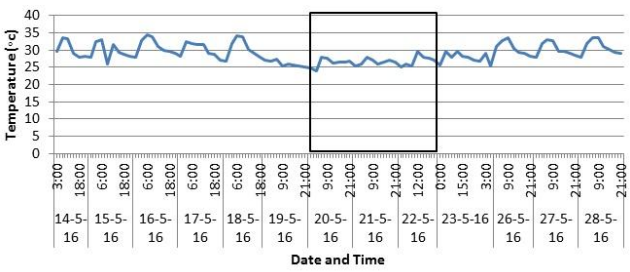

Figure 44: Cyclone ROANU-Temperature-Kutubdia

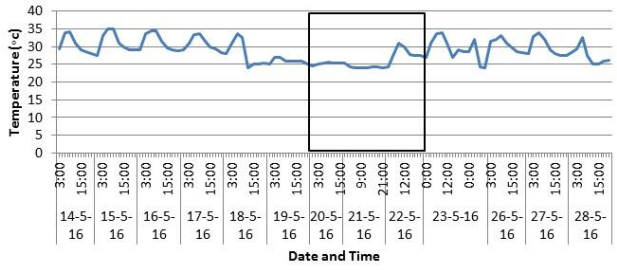

Figure 45: Cyclone ROANU-Temperature-Maijdee court

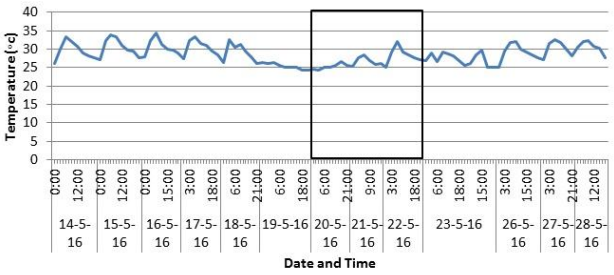

Figure 46: Cyclone ROANU-Temperature-Cox's Bazar

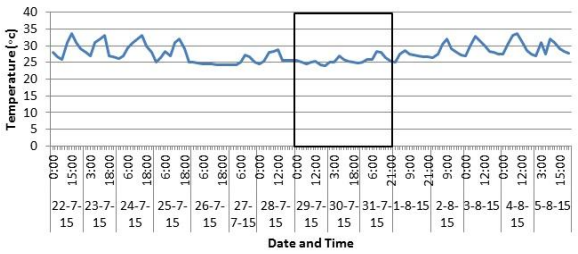

Figure 47: Cyclone KOMEN-Temperature-Maijdee court

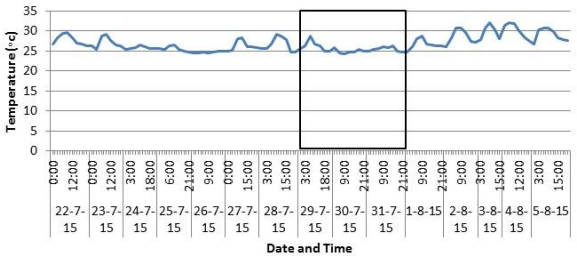

Figure 48: Cyclone KOMEN-Temperature-Chittagong

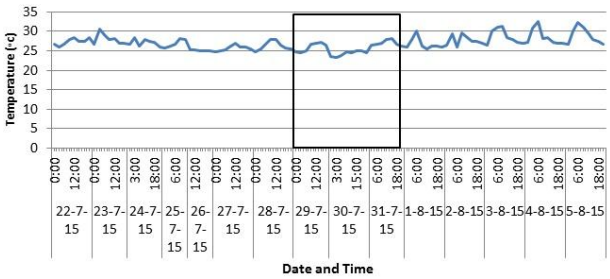

Figure 49: Cyclone KOMEN-Temperature-Bhola

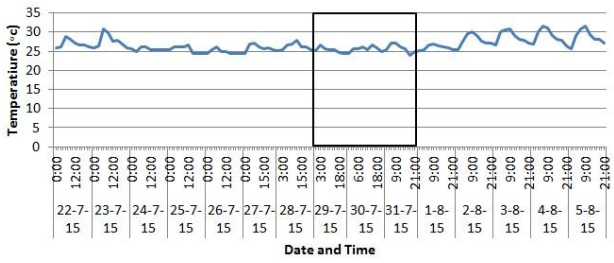

Figure 50: Cyclone KOMEN-Temperature-Kutubdia

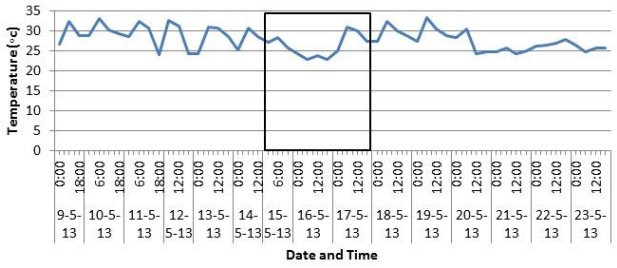

Figure 51: Cyclone MAHASEN-Temperature-Bhola

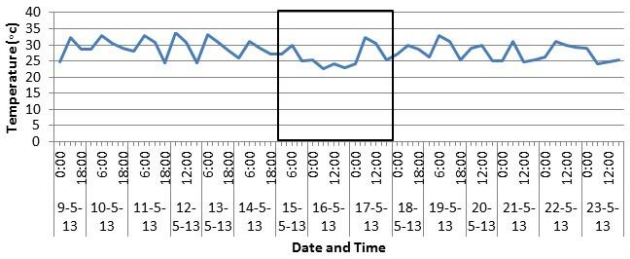

Figure 52: Cyclone MAHASEN-Temperature-Potuakhali

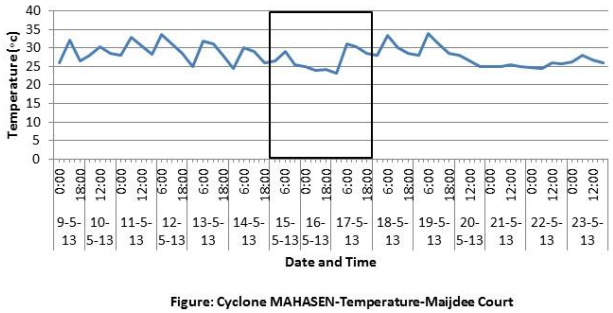

Figure 53: Cyclone MAHASEN-Temperature-Maijdee court

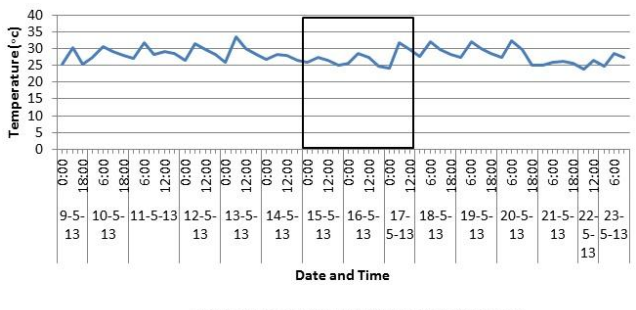

Figure 54: Cyclone MAHASEN-Temperature-Chittagong

3.4 Dew Point Temperature (°C)

3.4.1 Descriptive Statistics

Descriptive statistics of all selected stations of 4 cyclones for dew point temperature are given in table 5. Calculations to estimate the perturbation is same as before

Table 5: Descriptive statistics of Dew Point Temperature (°C) at 4 selected stations for each cyclone

Station	Distance from the landfall (km)	Normal (prevailing) Weather (12 days) (A)					Cyclone affected weather (3 days) (B)					Difference Between Mean (A-B)
		Mean	SD(±)	Max	Min	Range	Mean	SD(±)	Max	Min	Range	
Cyclone MORA												
Kutubdia	32	26.1	1.51	28	22	6	26.0	1.09	28	24	4	0.1
Chittagong	40	26.1	2.13	34	21	13	25.3	0.77	27	24	3	0.8
Cox's Bazar	75	25.7	1.57	28	21	7	25.5	1.36	28	23	5	0.2
Maijdee court	118	26.5	1.73	28	24	4	25.5	1.21	28	24	4	1.0
Cyclone ROANU												
Chittagong	19	25.5	1.25	28	21	7	24.6	0.91	26	23	3	0.9
Kutubdia	72	25.5	1.19	28	23	5	24.4	1.03	27	23	4	1.1
Maijdee court	76	26	1.21	28	23	5	24.7	1.09	27	23	4	1.3
Cox's Bazar	125	25.5	1.12	28	22	6	24.7	0.95	27	23	4	0.8
Cyclone KOMEN												
Maijdee court	45	25.6	1.17	28	23	5	24.7	0.6	26	23.7	2.3	0.9
Chittagong	59	25.3	0.92	28	24	4	23.9	0.73	25	23	2	1.4
Bhola	65	25.8	0.90	27.9	24	3.9	24.8	0.92	26	23	3	1.0
Kutubdia	102	25	0.85	26	22	4	24.4	0.79	25	22	3	0.6
Cyclone MAHASEN												
Bhola	17	25.4	1.54	28	22	6	24.4	1.50	27	22	5	1.0
Potuakhali	31	26.1	1.57	28	22	6	24.5	1.64	27	22.5	4.5	1.6
Maijdee Court	98	25.2	1.41	27	21	6	24.1	1.19	26	22	4	1.1
Chittagong	125	25.3	1.26	28	23	5	25	1.30	27	23	4	0.3

From table 5, it is visible that there is very small perturbation in dew point temperature during cyclone affected days. Though the perturbation is small, but it is significant. Difference between mean dew point temperature of normal and cyclonic weather is minimal. According to distance of weather station from landfall area, the change of average dew point temperature is 0.88 ◦c up to 50 km, 1.01 ◦c up to 100 km and 0.675 ◦c beyond 100 km. A pictorial view of dew point temperature perturbation according to the distance of weather station from landfall area is given in figure 55.

3.4.2 Graphs of dew point temperature at selected stations for every cyclone

Graphs are given in figure 56 to 71 for showing the dew point temperature trend of 15 days around a cyclone. Middle three-day time window is the cyclone affected days and marked in the box.

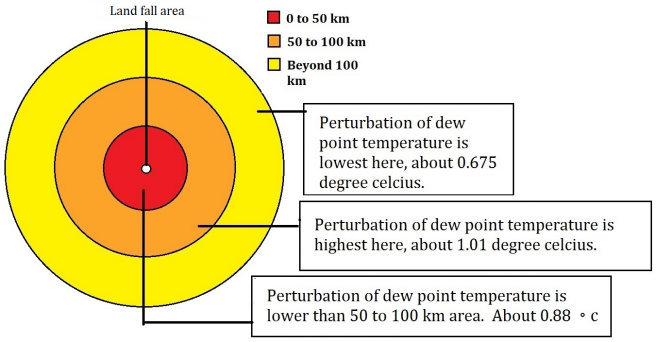

Figure 55: Perturbation of dew point temperature according to distance

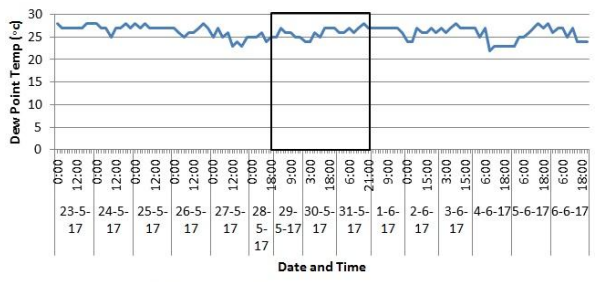

Figure 56: Cyclone MORA-Dew Point Temperature-Kutubdia

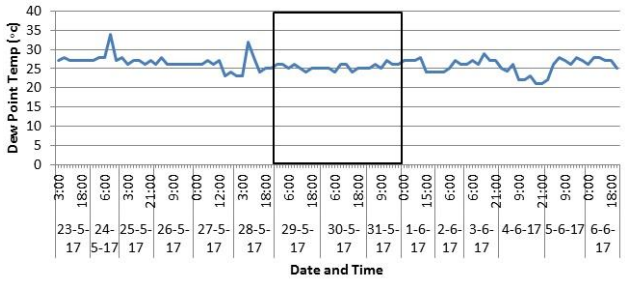

Figure 57: Cyclone MORA-Dew Point Temperature-Chittagong

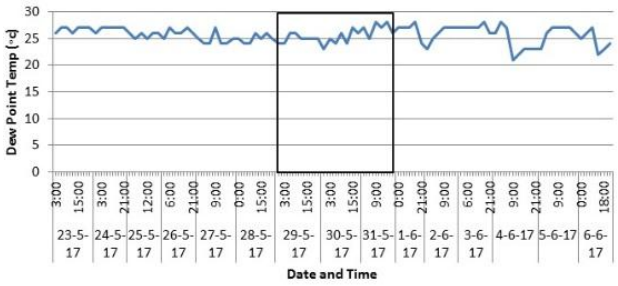

Figure 58: Cyclone MORA-Dew Point Temperature-Cox's Bazar

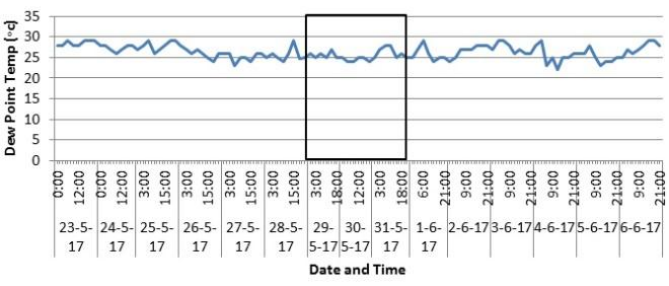

Figure 59: Cyclone MORA-Dew Point Temperature-Maijdee court

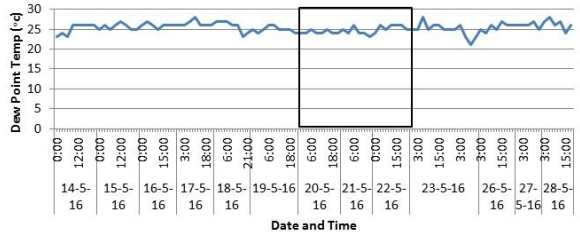

Figure 60: Cyclone ROANU-Dew Point Temperature-Chittagong

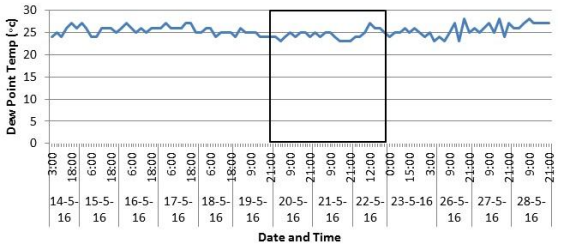

Figure 61: Cyclone ROANU- Dew Point Temperature-Kutubdia

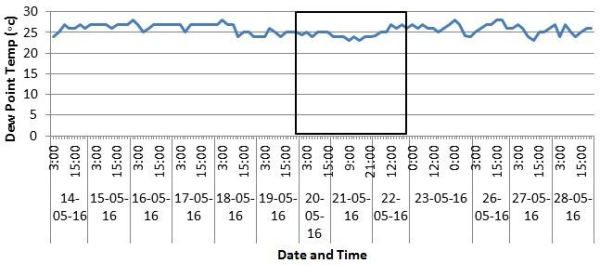

Figure 62: Cyclone ROANU-Dew Point Temperature-Maijdee court

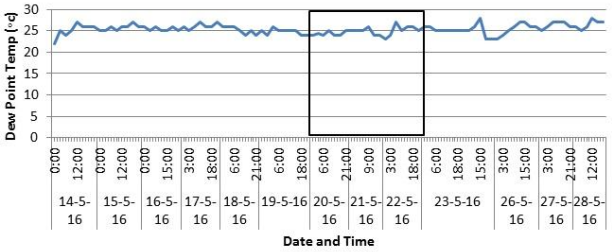

Figure 63: Cyclone ROANU-Dew Point Temperature-Cox's Bazar

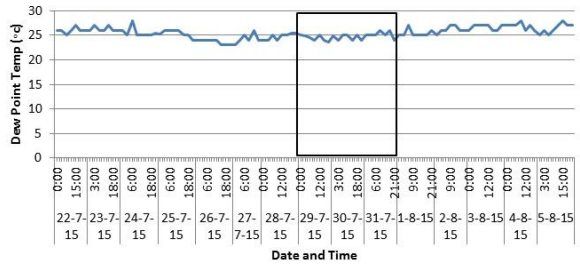

Figure 64: Cyclone KOMEN-Dew Point Temperature-Maijdee court

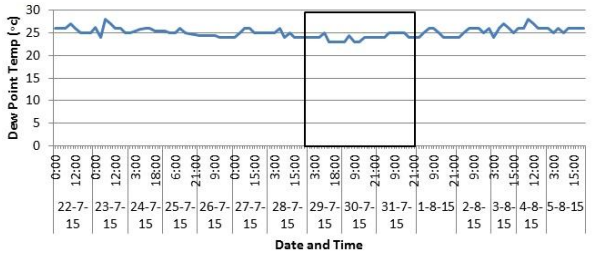

Figure 65: Cyclone KOMEN-Dew Point Temperature-Chittagong

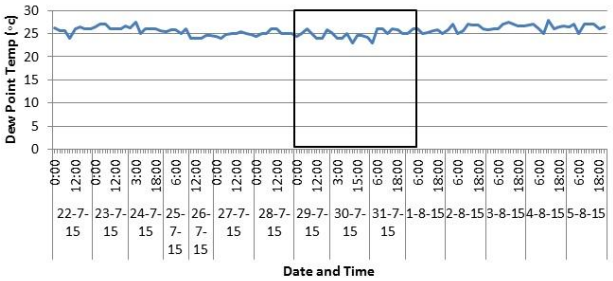

Figure 66: Cyclone KOMEN-Dew Point Temperature-Bhola

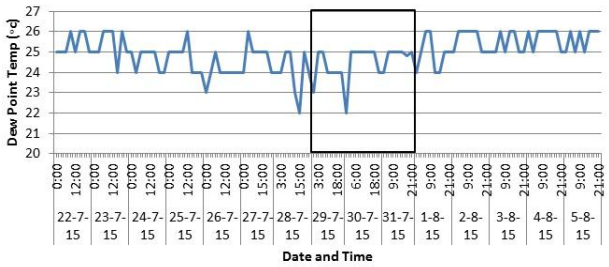

Figure 67: Cyclone KOMEN-Dew Point Temperature-Kutubdia

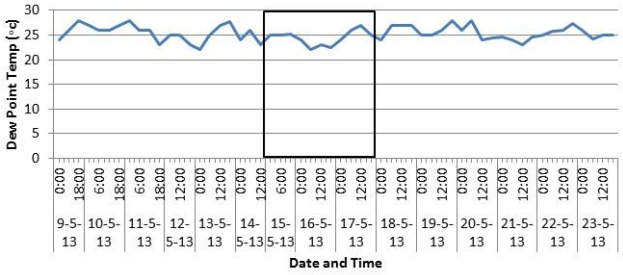

Figure 68: Cyclone MAHASEN-Dew Point Temperature-Bhola

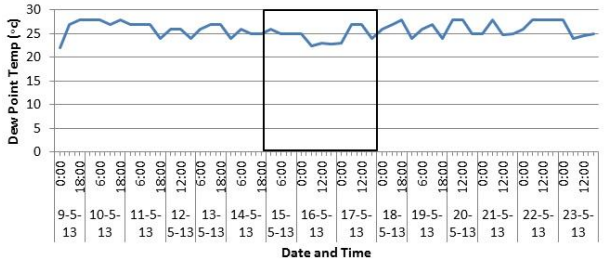

Figure 69: Cyclone MAHASEN-Dew Point Temperature-Potuakhali

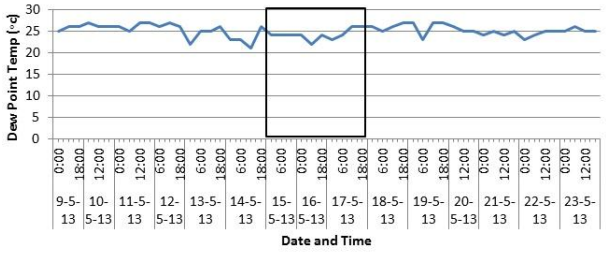

Figure 70: Cyclone MAHASEN-Dew Point Temperature-Maijdee court

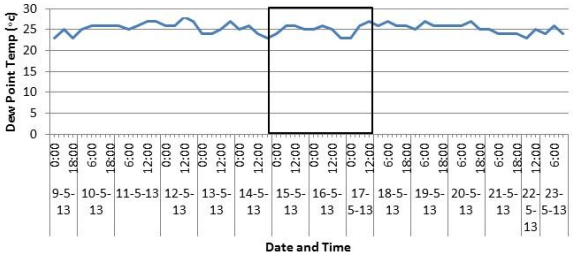

Figure 71: Cyclone MAHASEN-Dew Point Temperature-Chittagong

3.5 Relative Humidity (%)

3.5.1 Descriptive Statistics

Descriptive statistics of all selected stations of 4 cyclones for relative humidity are given in table 6. Calculations to estimate the perturbation is same as before

Table 6: Descriptive statistics of Relative Humidity (%) at 4 selected stations for each cyclone

Station	Distance from the landfall (km)	Normal (prevailing) Weather (12 days) (A)					Cyclone affected weather (3 days) (B)					Difference Between Mean (B-A)
		Mean	SD (±)	Max	Min	Range	Mean	SD (±)	Max	Min	Range	
Cyclone MORA												
Kutubdia	32	80.9	10.33	97.1	58.5	38.6	86.4	6.65	97	73	24	5.5
Chittagong	40	82.4	10.16	97.1	55	41.9	87.2	7.32	96.4	69.6	26.8	4.8
Cox's Bazar	75	79.3	11.14	95.8	52.7	43.14	86.6	5.25	95.4	72.7	22.69	7.3
Maijdee court	118	81.2	14.01	100	48	52	85.3	10.2	100	65.8	34.2	4.1
Cyclone ROANU												
Chittagong	19	79.6	10.22	97	52	45	90.4	5.51	100	78	22	13.8
Kutubdia	72	79.5	10.85	97	56.4	40.6	88.4	5.14	97	78	19	8.9
Maijdee court	76	82.9	12.29	100	58.1	41.9	94.1	7.35	100	70.5	29.5	11.2
Cox's Bazar	125	81.9	10.87	100	57.6	42.4	88.9	7.78	100	73.6	26.4	7
Cyclone KOMEN												
Maijdee court	45	87	9.84	100	62.2	37.8	95	4.41	100	83.7	16.3	8
Chittagong	59	89.9	8.26	100	70.7	29.3	91.3	5.33	100	75.3	24.7	1.4
Bhola	65	91.7	6.98	98.3	65.5	32.8	94.3	4.71	99.4	81.1	18.3	2.6
Kutubdia	102	89.9	7.52	98.2	71.3	26.9	93.7	3.75	100	86.5	13.5	3.8
Cyclone MAHASEN												
Bhola	17	86.5	10.9	98.8	62.3	36.5	90.7	7.59	98.2	75.6	22.6	4.2
Potuakhali	31	87.7	10.3	100	64.2	35.8	91.2	9.83	100	74.1	25.9	3.5
Maijdee Court	98	85.4	12.31	100	53.3	46.7	86.4	10.7	98.8	65.6	33.1	1
Chittagong	125	85.5	8.81	100	58	42	89.9	7.71	100	71.8	28.13	4.4

From table 6, it is found that perturbation of relative humidity is 6.63% on average up to 50 km from landfall area, 5.4% up to 100 km and 4.82 % beyond 100 km. That means perturbation of relative humidity is higher when the distance is shorter from landfall area of cyclone. Relative humidity highly fluctuates during normal weather. It ranges from 57.23% to 92.45% on average but during cyclonic days relative humidity is fluctuate less and it is 74.68% to 98.88%. That means Cyclonic weather shows higher minimum relative humidity than normal weather. The difference between average minimum relative humidity is 17.45% combining all the station.

A Pictorial view of relative humidity perturbation according to distance from the landfall area is shown in figure 72.

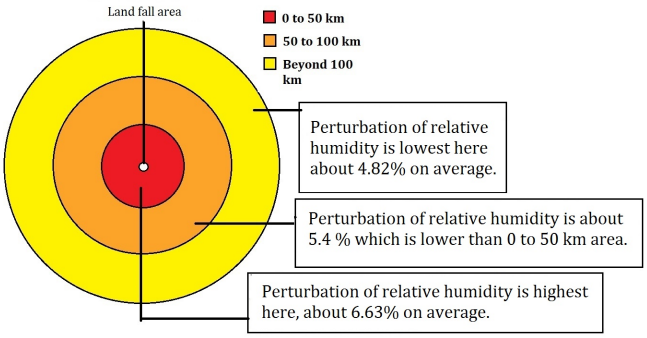

Figure 72: Perturbation of relative humidity according to distance

3.5.2 Graphs of relative humidity at selected stations for every cyclone

Graphs are given in figure 73 to 88 for showing the relative humidity trend of 15 days around a cyclone. Middle three-day time window is the cyclone affected days and marked in the box.

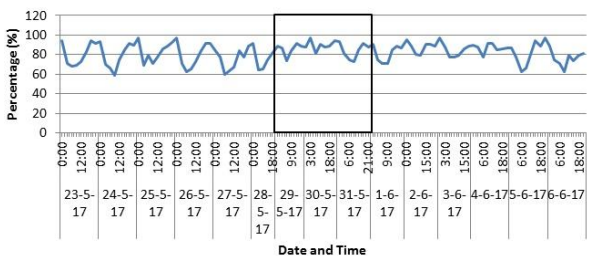

Figure 73: Cyclone MORA-Relative Humidity-Kutubdia

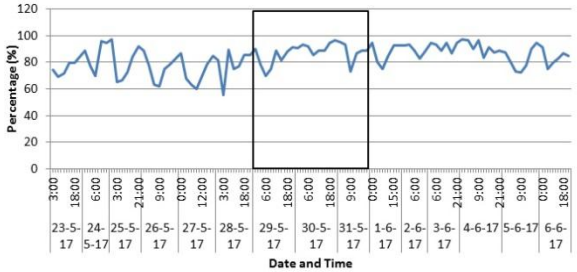

Figure 74: Cyclone MORA-Relative Humidity-Chittagong

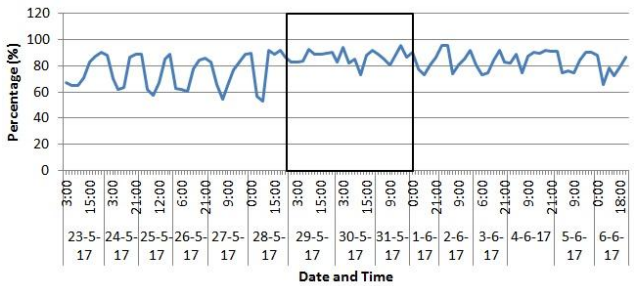

Figure 75: Cyclone MORA-Relative Humidity-Cox's Bazar

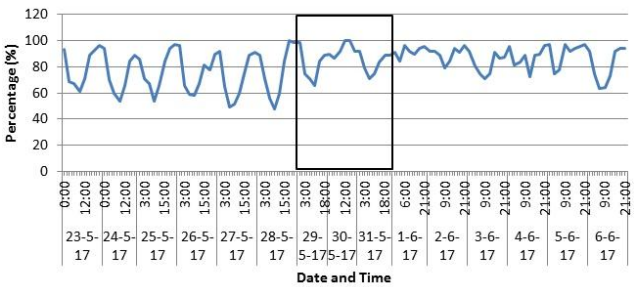

Figure 76: Cyclone MORA-Relative Humidity-Maijdee court

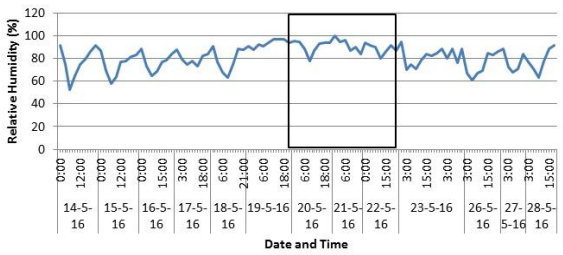

Figure 77: Cyclone ROANU-Relative Humidity-Chittagong

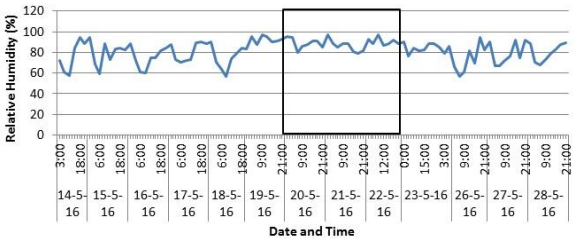

Figure 78: Cyclone ROANU-Relative Humidity-Kutubdia

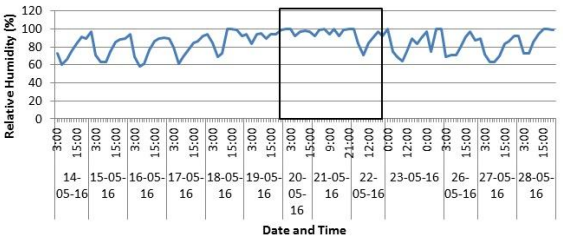

Figure 79: Cyclone ROANU-Relative Humidity-Maijdee court

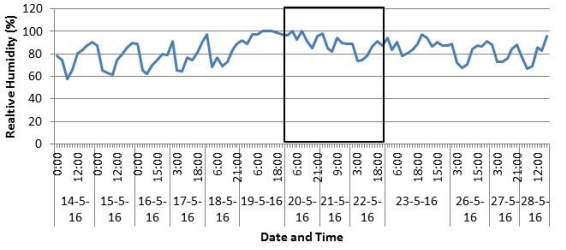

Figure 80: Cyclone ROANU-Relative Humidity-Cox's Bazar

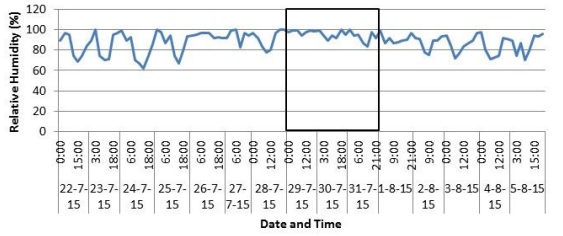

Figure 81: Cyclone KOMEN-Relative Humidity-Maijdee court

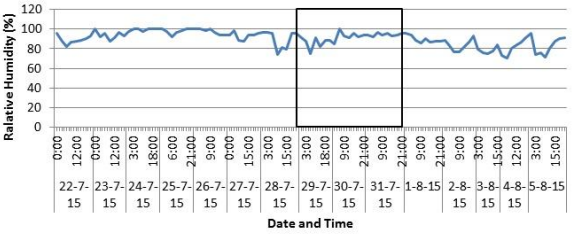

Figure 82: Cyclone KOMEN-Relative Humidity-Chittagong

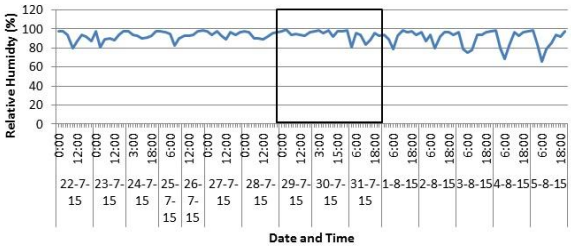

Figure 83: Cyclone KOMEN-Relative Humidity-Bhola

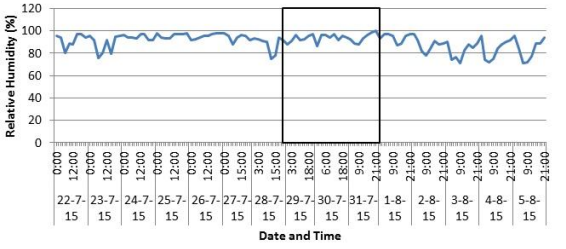

Figure 84: Cyclone KOMEN-Relative Humidity-Kutubdia

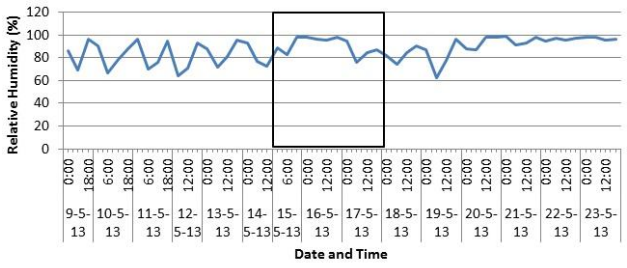

Figure 85: Cyclone MAHASEN-Relative Humidity-Bhola

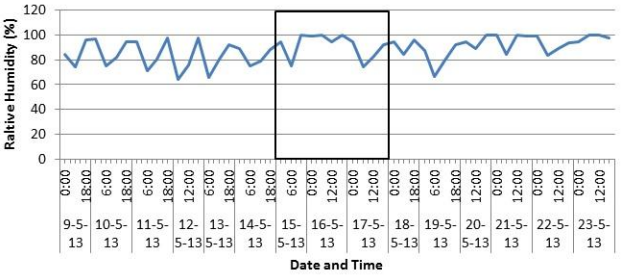

Figure 86: Cyclone MAHASEN-Relative Humidity-Potuakhali

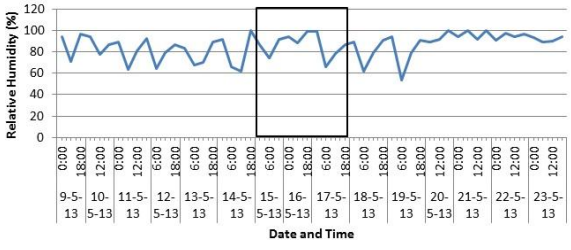

Figure 87: Cyclone MAHASEN-Relative Humidity-Maijdee court

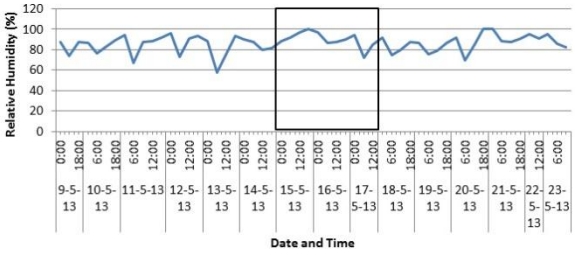

Figure 88: Cyclone MAHASEN-Relative Humidity-Chittagong

3.6 Precipitation (mm)

3.6.1 Descriptive Statistics

Descriptive statistics of all selected stations of 4 cyclones for precipitation are given in table 7. Calculations to estimate the perturbation are same as before.

Table 7: Descriptive statistics of Precipitation (mm) at 4 selected stations for each cyclone.

Station	Distance from the landfall (km)	Normal (prevailing) Weather (12 days) (A)					Cyclone affected weather (3 days) (B)					Difference between Mean (B-A)
		Mean	SD(±)	Max	Min	Range	Mean	SD(±)	Max	Min	Range	
Cyclone MORA												
Kutubdia	32	6.41	13.47	41	0	41	47.7	56.09	112	9	103	41.29
Chittagong	40	21.8	25.83	90.4	0	90.4	82.5	74.5	153	4.6	148.4	60.7
Cox's Bazar	75	5.66	11.69	47	0	37	22	18.24	43	10	33	16.34
Maijdee court	118	15.9	31.26	102	0	102	24.3	39.5	70	0	70	8.4
Cyclone ROANU												
Chittagong	19	3.66	7.87	26	0	26	33	32.7	69	5	64	29.34
Kutubdia	72	4.42	8.25	29	0	29	56.6	32.62	76	19	57	52.22
Maijdee court	76	10.8	18.47	54	0	54	73	37.4	98	30	68	62.2
Cox's Bazar	125	12	4.91	53	0	53	78.6	37.5	116	41	75	66.6
Cyclone KOMEN												
Maijdee court	45	44.4	42.58	131	0	131	30.6	14.4	39	14	25	-13.8
Chittagong	59	79.3	119.8	319	0	319	91.2	52.4	141	36	105	11.9
Bhola	65	28	29.5	95	0	95	33.2	16.5	52	20.	31.4	5.2
Kutubdia	102	76.2	101.2	272	0	272	62.3	35.6	100	29	71	-13.9
Cyclone MAHASEN												
Bhola	17	19	39.72	137	0	137	50.5	45.28	97.7	7.4	90.3	31.5
Potuakhali	31	12.3	17.89	44	0	44	122	75.40	198	47	51	109.7
Maijdee Court	98	12	19.03	50	0	50	31.4	24.76	58	9	49	19.4
Chittagong	125	22.4	29.39	90	0	90	19.1	17.94	35.6	0	35.6	-3.3

From table 7, among 16 stations, 3 stations shows higher mean precipitation during normal days. But Other 13 stations shows higher mean precipitation during cyclone affected days and it is 38.76 mm higher up to 50 km on average from the landfall area, 27.87 mm up to 100 km of landfall area. Beyond 100 km of landfall area precipitation pattern is irregular and here some time it shows higher precipitation in normal days and sometimes higher during cyclone affected days.

A pictorial view of perturbation of precipitation pattern during cyclone transition in Bangladesh coast according to distance is given in figure 89.

3.6.2 Graphs of precipitation at selected stations for every cyclone

Graphs are given in figure 90 to 105 for showing the precipitation trend of 15 days around a cyclone. Middle three-day time window is the cyclone affected days and marked in the box.

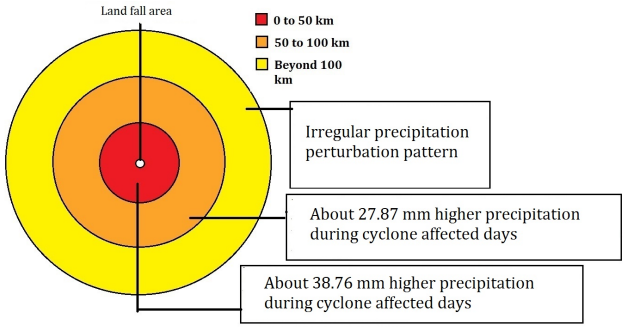

Figure 89: Perturbation of precipitation pattern according to distance

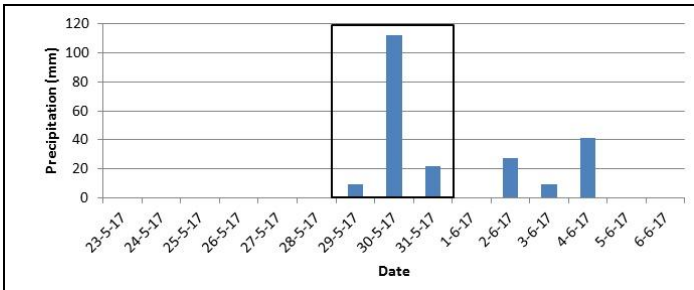

Figure 90: Cyclone MORA-Precipitation-Kutubdia

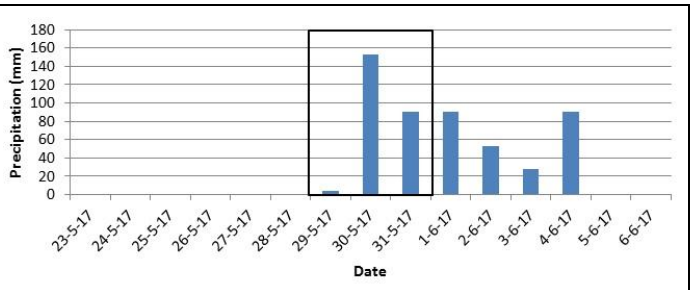

Figure 91: Cyclone MORA-Precipitation-Chittagong

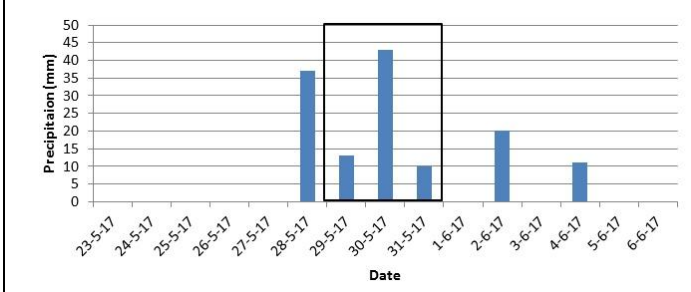

Figure 92: Cyclone MORA-Precipitation-Cox's Bazar

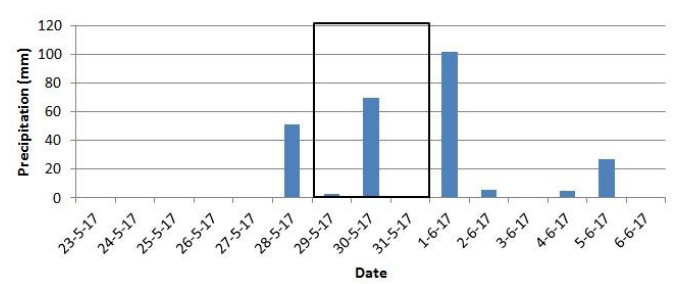

Figure 93: Cyclone MORA-Precipitation-Maijdee court

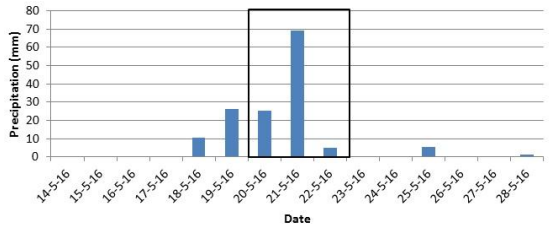

Figure 94: Cyclone ROANU-Precipitation-Chittagong

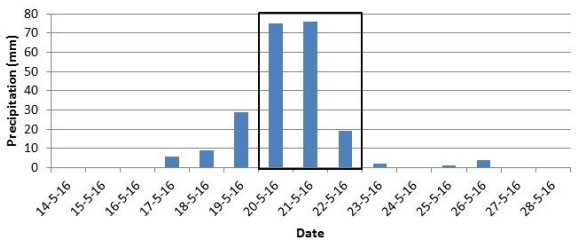

Figure 95: Cyclone ROANU-Precipitation-Kutubdia

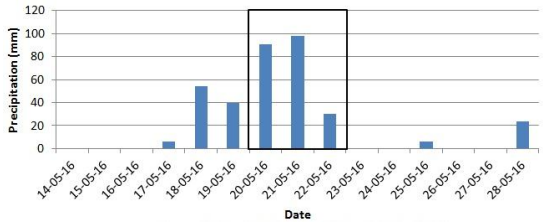

Figure 96: Cyclone ROANU-Precipitation-Maijdee court

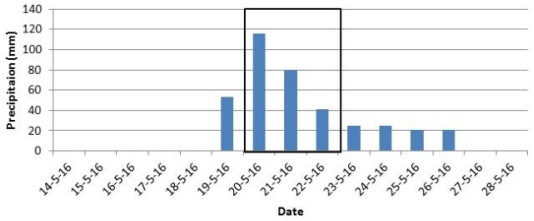

Figure 97: Cyclone ROANU-Precipitation-Cox's Bazar

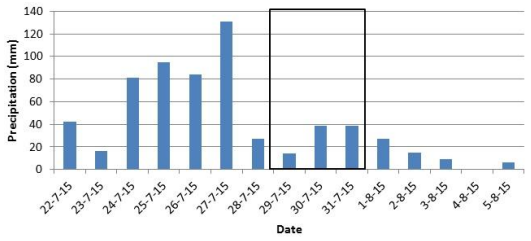

Figure 98: Cyclone KOMEN-Precipitation-Maijdee court

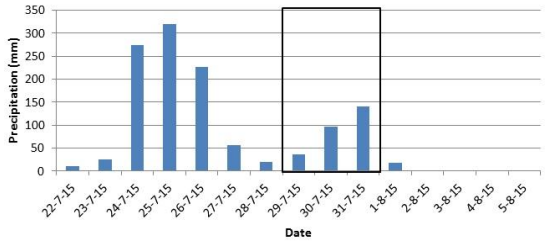

Figure 99: Cyclone KOMEN-Precipitation-Chittagong

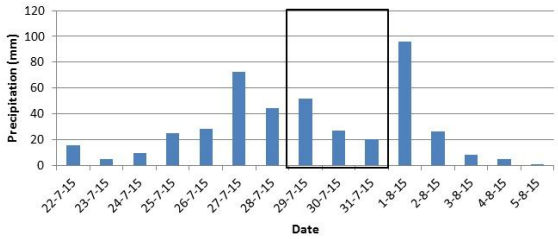

Figure 100: Cyclone KOMEN-Precipitation-Bhola

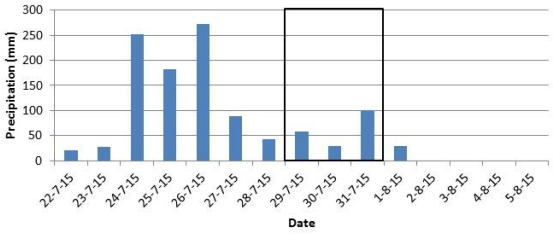

Figure 101: Cyclone KOMEN-Precipitation-Kutubdia

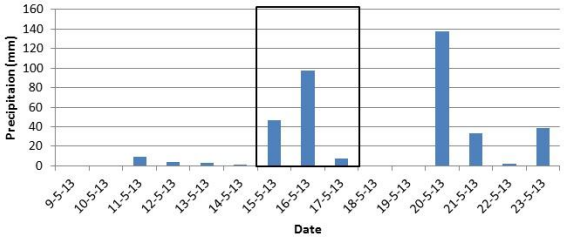

Figure 102: Cyclone MAHASEN-Precipitation-Bhola

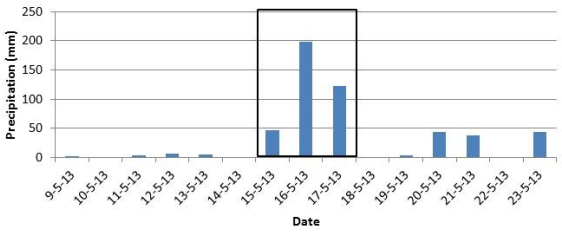

Figure 103: Cyclone MAHASEN-Precipitation-Potuakhali

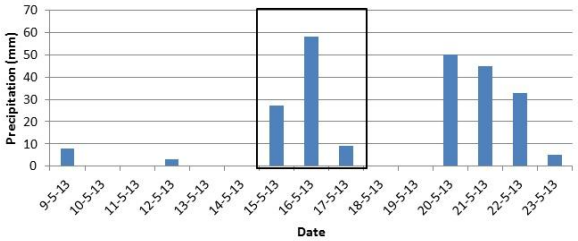

Figure 104: Cyclone MAHASEN-Precipitation-Maijdee court

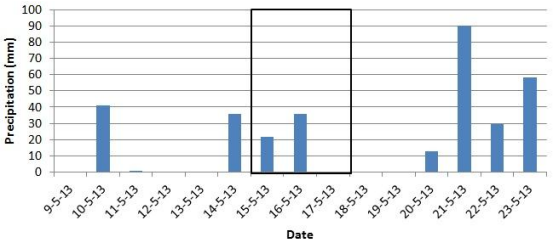

Figure 105: Cyclone MAHASEN-Precipitation-Chittagong

3.7 Average Perturbation of different Weather Parameters (Combining 4 respective stations for each cyclone)

A combined average result of perturbed weather parameters is shown in table 8 without considering distance from cyclone landfall epicenter.

Table 8: Combined average result of perturbed weather parameters without considering distance from cyclone landfall epicenter

Cyclone Name	Atm. Pressure (Average) mb	Wind Speed (Average) km/h	Temperature (Average) °C	Dew Point Temperature (Average) °C	Relative Humidity (Average) %	Precipitation (Average) mm
MORA	4.85	7.12	2	0.53	5.43	31.68

ROANU	4.05	3.77	2.7	1.03	10.23	52.59
KOMEN	7.47	8.93	1.8	0.98	3.95	11.2
MAHASEN	4.25	7.39	1.73	4	3.275	40.98

From the above discussion it is clearly appeared that during the transition of tropical cyclone in the cost of Bangladesh, the normal (prevailing) weather parameters get perturbed. Among different weather parameter some affected more and some less. The most affected weather parameters are Atmospheric pressure, wind speed, precipitation and temperature. Comparatively less affected parameters are relative humidity and dew point temperature. In the result and discussion section we have found the estimation of perturbation of every selected weather parameters. The perturbation of atmospheric pressure is found highest 5.8 mb on average of 3 days cyclone affected weather against 12 days normal (prevailing) weather. It seems that 5.8 mb is very low, but it is a difference of average. So, a small difference of average can affect our weather greatly. In case of other parameters, the comment is same.

4. CONCLUSION

The most important weather parameters have been analyzed through this research. Although some other weather parameters have been excluded from the analysis but those parameters do not have so much effect on the final output. Six parameters those are discussed in this paper are the most important weather parameters that bother human being and the environment mostly. Atmospheric, pressure, wind speed, temperature, dew point temperature, relative humidity and precipitation are closely interlinked. Change in one parameter can affect the other. So study of these parameters was useful. There were many limitations those had to be overcome to complete the research. After downloading bulk of data the main challenge was to decode them. With the help of Synop data decoder developed in Oceanographic and Atmospheric Data Analysis Laboratory of Institute of Marine Sciences the challenge is overcome. Careful analysis of data and discarding the bad data was another challenging job. As the huge amount of data had to be analyzed, it required high end computer to perform the task smoothly. However, the study was based on freely available Synop (observed) data. This kind of research becomes very costly when the data is not freely available. The information generated here is not only helped us to understand the perturbation pattern of weather during cyclone transition in the coast but also made a record of recent mode of perturbation. At the end, the corresponding author likes to declare that there is no conflict of interest and no funding was taken from any organization.

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