

## The Rainfall Activity and Temperature Distribution over KPK during the Winter Season (January to March) 2010

Syed Mushtaq Ali Shah<sup>1</sup>, Alam Zeb<sup>1</sup>, Shahzad Mahmood<sup>1</sup>

### Abstract

*In this report, changes in the rainfall activity, minimum, maximum and mean temperatures have been studied on monthly as well as on seasonal basis during the winter season (January-March) 2010 in Khyber Pakhtoonkhwa of Pakistan. The data was collected from 11 meteorological observatories located in Khyber Pakhtoonkhwa. By comparing the monthly data of rainfall, minimum, maximum and mean temperatures for the winter months of the year 2010 with the climatic normal values of 1971-2000, it has been found that the rainfall was moderately below normal during the month of January, largely above normal during February and largely below normal during the month of March. As a whole, seasonal rainfall remained normal during the winter season across the region due to the large scale global circulations. Consequently, scanty rainfall distribution during the season resulted in a bad crop conditions.*

*As a whole, the minimum and maximum temperature remained slightly above normal during the winter season throughout the region. Consequently the mean temperature also remained slightly above normal during the study period across the region. The possible reason for this may be abnormal approach of western disturbance, position Tibetan high pressure system or frequent changes in El Nino and La Nina conditions.*

### Introduction

During winter months, the western and northern parts of the country experience cloudiness and rainfall / snowfall is association with weather systems commonly known as “Western Disturbance” (WD). It is one of the most important weather systems that can cause adverse weather conditions over the region. It usually originates over the Mediterranean Sea / Black Sea area as an extra-tropical frontal system, but its frontal characteristics are lost while moving eastward to Pakistan across Iran / Afghanistan. However, even then an intense Western Disturbance is capable of producing wide spread heavy rainfall / snowfall over northern mountains region due to supply of moisture from the Arabian Sea.

The winter rains generally are wide spread. The northern and western areas of the province receive comparatively higher rainfall during the season. The study has been conducted to find the significant change in rainfall, minimum, maximum and mean temperature during the winter season 2010.

### Methods & Materials

The study examines the data for 30 years normal period (1970–2000) over three month’s period for January to March, 2010 of Khyber Pakhtoonkhwa. The mean monthly rainfall, minimum, maximum, mean temperatures and snowfall data (Tables 1 to 5) for the months January through March was collected from the 11 meteorological observatories (Chitral, Drosh, Dir, Saidu Sharif, Balakot, Kakul, Cherat, Peshawar, Kohat, Bannu and D.I.Khan) located in the Khyber Pakhtoonkhwa and used for the analysis. Percentage departures of the rainfall and departures of minimum, maximum and mean temperatures were calculated for each month as well as for the season as a whole and then the changes in the parameters were shown graphically.

The climatic normal value for the Bannu meteorological observatory was calculated on the basis of available data for 14 years (1997-2009). The data of Parachinar was found unreliable; therefore it was not included in the analysis.

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<sup>1</sup> Pakistan Meteorological Department

## Results and Discussion

### Monthly Features of Rainfall and Temperature Distribution

#### January, 2010:

During the month, weather remained dry except for the last week of the month. The region received good rainfall along with the snowfall (Table- 5) over the hilly areas of the province, under the influence of Western Disturbance.

The rainfall was in large excess at one meteorological station (Chitral), normal at two stations (Drosh and D.I. Khan); moderate deficit in four stations (Dir, Saidu Sharif, Peshawar and Bannu); large deficit in (Balakot, Kakul, Cherat and Kohat).

As a whole, the rainfall was at moderate deficit at a number of places across the region during the month. The heaviest amount of rainfall was recorded 78.0 mm on 29th January, 2010 at Dir. Figure 1 shows normal and actual whereas Figure 2 illustrates percentage departures from the normal.

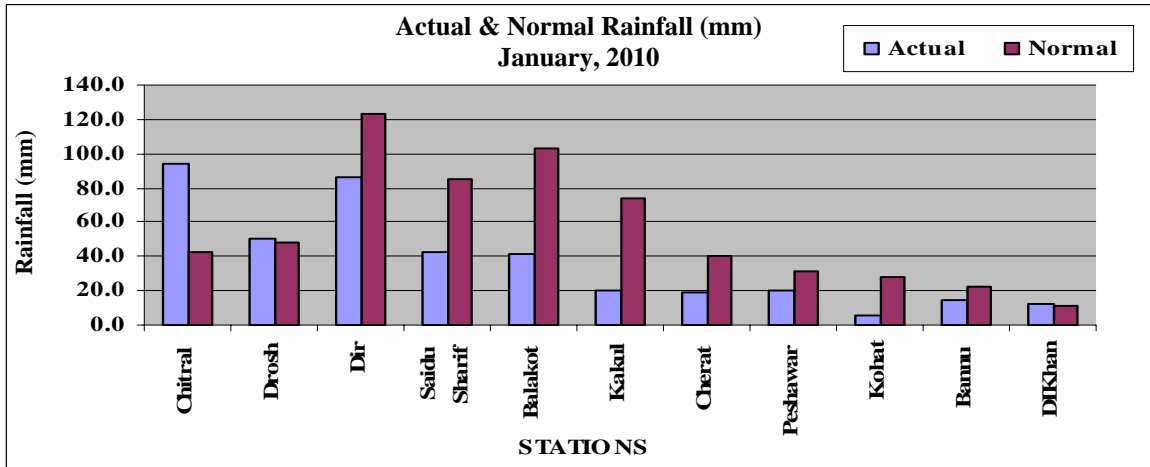


Figure - 01

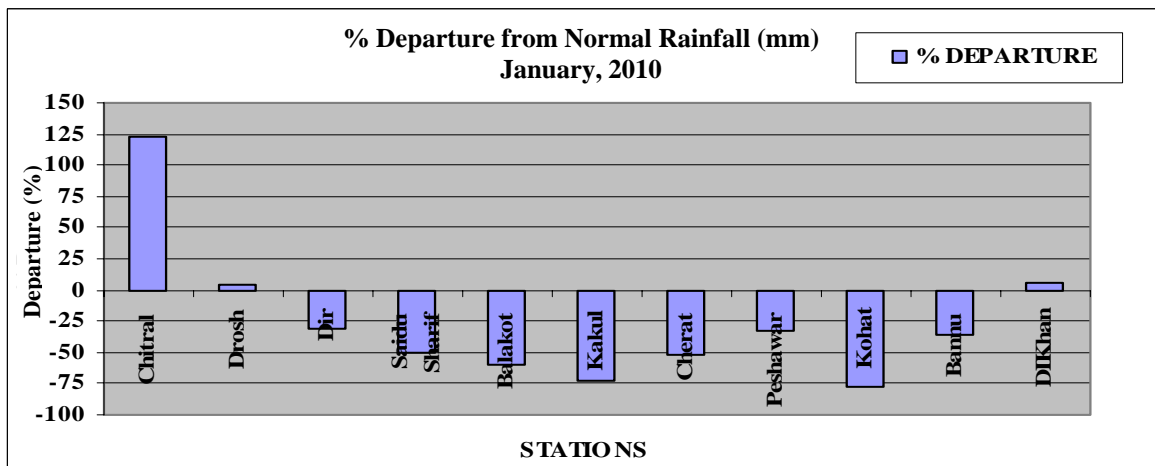


Figure - 02

February, 2010:

The Western Disturbance remained active during the month of February. Moderate to heavy rains associated with snow over hilly areas were reported from various meteorological observatories.

The rainfall was in large excess at eight meteorological stations (Chitral, Drosh, Dir, Saidu Sharif, Balakot, Kakul, Cherat and Peshawar); slight excess at one station, Kohat and large deficit at two stations (Bannu and D.I Khan).As a whole, the rainfall was at large excess throughout the region during the month. The heaviest amount of rainfall was recorded 92.0 mm on 9th February, 2010 at Balakot. Figure 3 shows normal and actual whereas Figure 4 illustrates percentage departures from the normal.

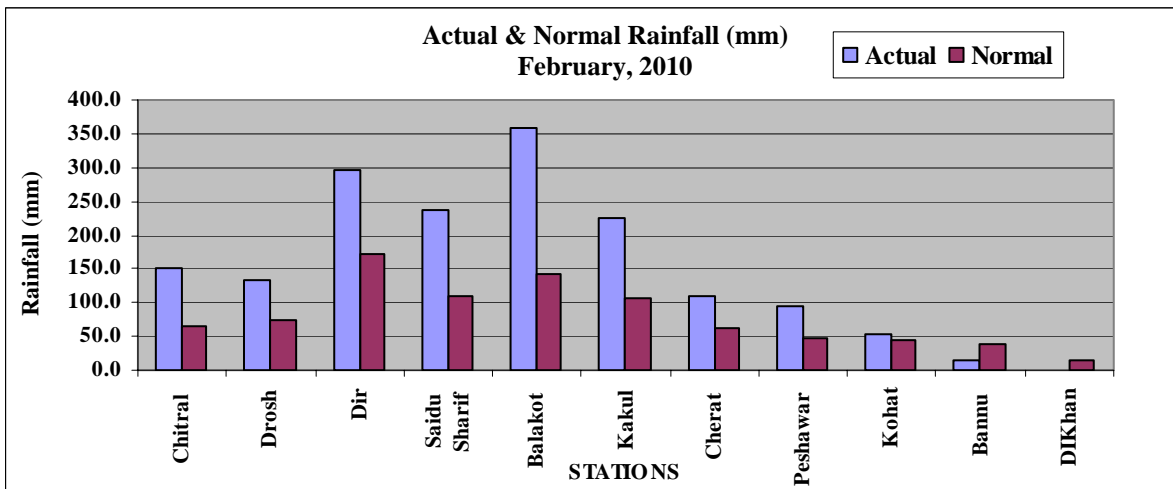


Figure- 03

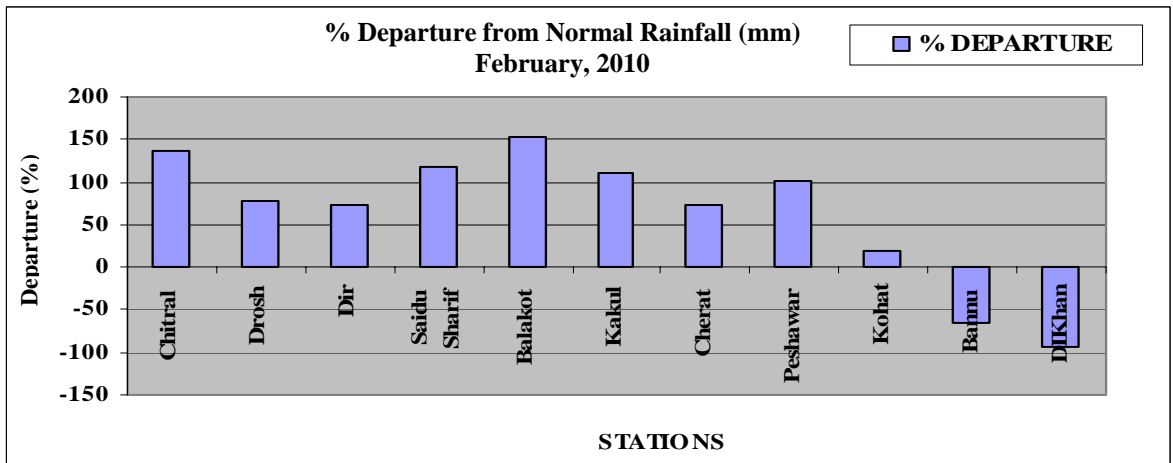


Figure-04

March, 2010:

The Western Disturbance remained passive during the month of March and the weather remained dry especially in 2nd and 3rd week of the month at all parts of the province. During the month rainfall was normal at one station (D.I Khan); moderate deficit at two meteorological stations

(Balakot and Bannu); and large deficit at eight stations (Chitral, Drosh, Dir, Saidu Sharif, Kakul, Cherat, Peshawar and Kohat). As a whole, the rainfall was large in deficit during the month throughout the region. The heaviest amount of rainfall was recorded 37.0 mm on 1st March, 2010 at Dir. Figure 5 shows normal and actual, whereas Figure 6 illustrates percentage departures from the normal.

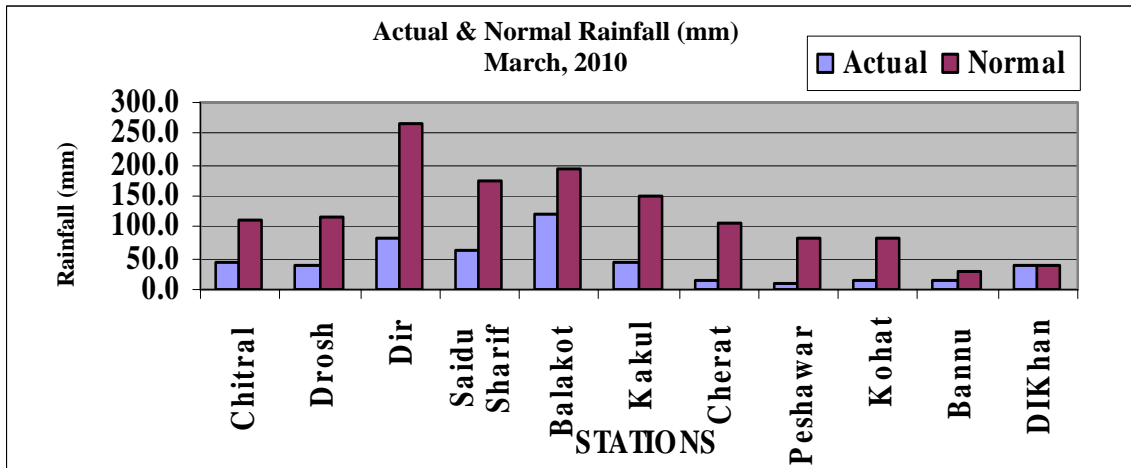


Figure-05

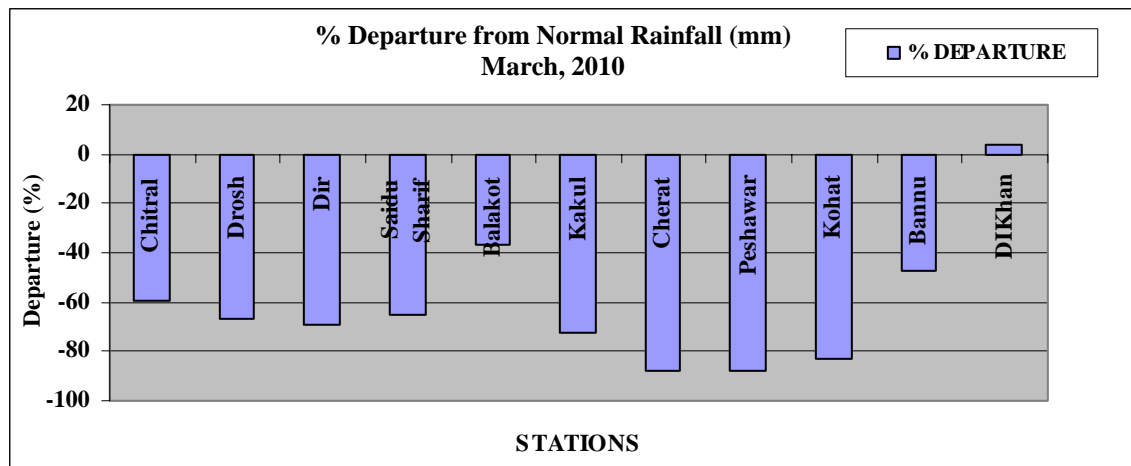


Figure- 06

Seasonal Rainfall (January to March, 2010):

Rainfall in January remained below normal almost in all parts of the region. However, good precipitation was reported at the end of the month. This is due to the prevailing of blocking HIGH over Pakistan in January, which caused deficient rainfall over KPK; consequently mean temperature of the month remained above normal. The highest amount of rainfall reported 94 mm at Chitral followed by 86 mm at Dir. Western Disturbance remained active during the month of February, which caused sufficient precipitation over the region; as a result mean temperature of the month remained normal. The highest amount of rainfall was recorded 357 mm at Balakot followed by 297 mm at Dir. March is normally the wettest month of the season, however, this

year Western Disturbance remained passive during the month, which caused largely below normal precipitation over the province, and thus mean temperature of the month remained appreciably above normal due to clearer skies. Highest amount of rainfall reported in this month was 122 mm in Balakot.

During the season, rainfall was in moderate excess at one meteorological observing station (Chitral); slight excess at one station (Balakot); normal at two stations (Drosh and Saidu Sharif) and in slight deficit at four stations (Dir, Kakul, Peshawar and D.I. Khan); moderate deficit at one station (Cherat) and in large deficit at two stations (Kohat and Bannu). As a whole, Precipitation was normal across the region during the winter season.

The heaviest amount of rainfall was recorded 521.0 mm at Balakot followed by 464 mm at Dir during the season. The mean monthly rainfall data with normal and percentage departures from the normal are shown in Figures 07 & 08.

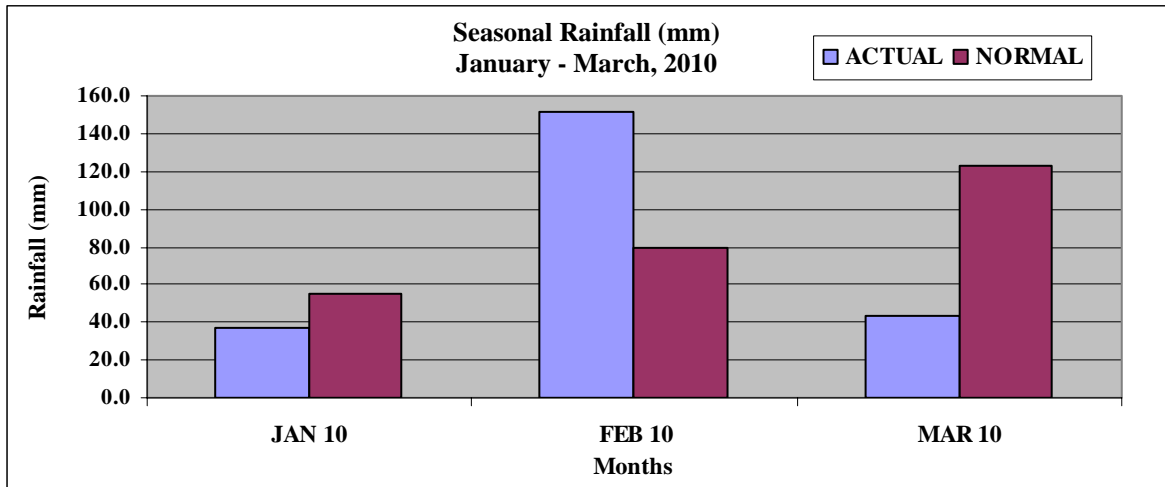


Figure-07

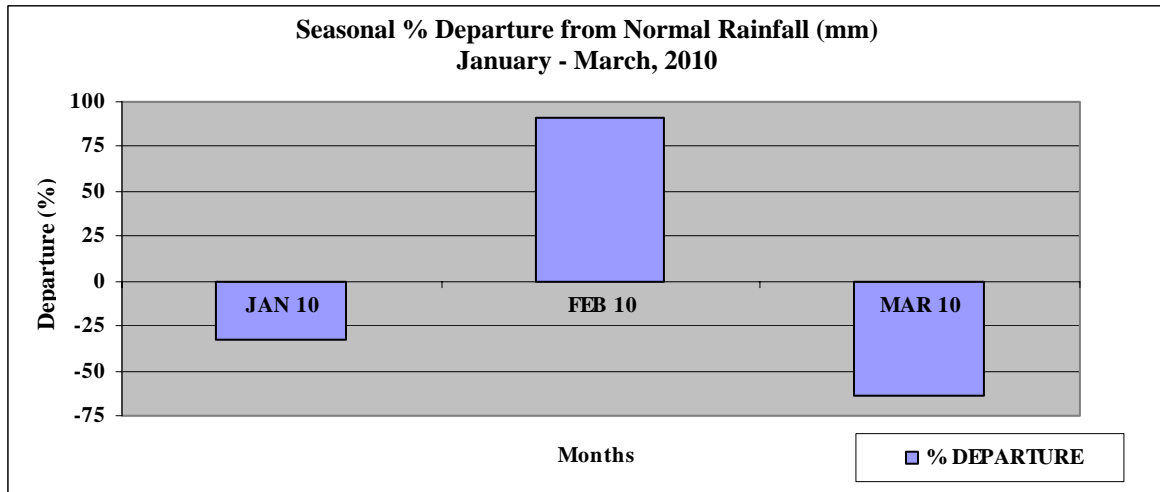


Figure - 08

**Monthly Features of Minimum Temperature Distribution**

January, 2010:

During the month, minimum temperature remained normal at eight meteorological stations (Chitral, Saidu Sharif, Balakot, Kakul, Peshawar, Kohat, Bannu and D.I Khan); slightly above normal at three stations (Drosh, Dir and Cherat). As a whole, it remained normal almost at all places of the region during the month. The month's lowest minimum temperature was  $-4.7^{\circ}\text{C}$  recorded at Chitral on 31st January, 2010. Figure 09 shows normal & actual, whereas figure 10 illustrates departures from the normal.

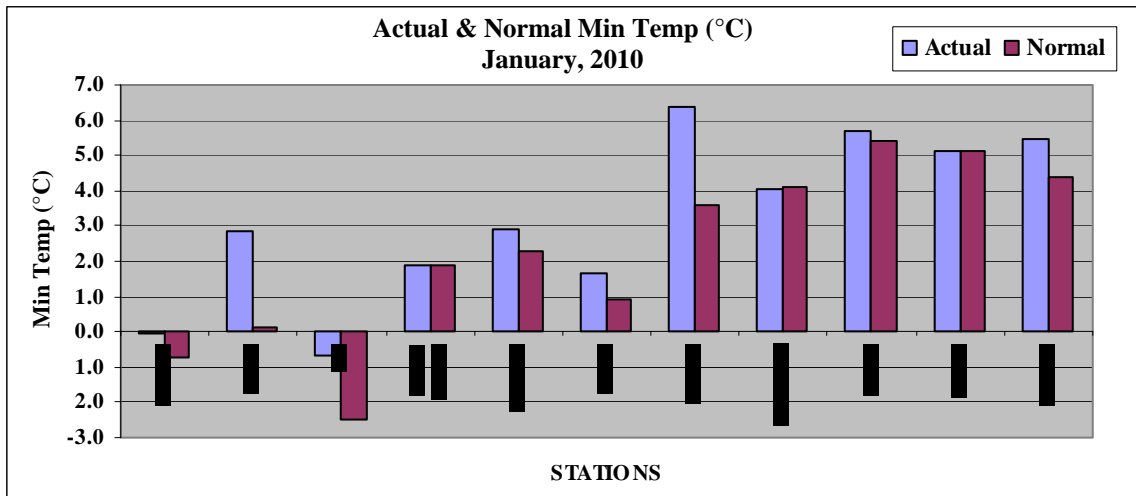


Figure - 09

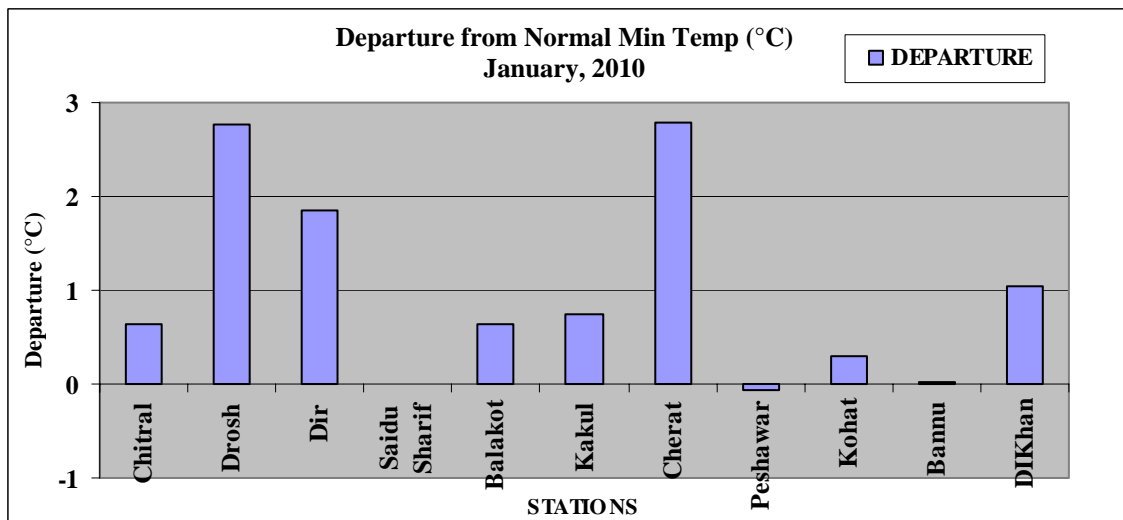


Figure-10

February, 2010:

During the month, minimum temperature remained slightly above normal at two stations (Peshawar and D.I. Khan), normal at nine stations (Chitral, Drosh, Dir, Saidu Sharif, Balakot, Kakul, Cherat, Kohat and Bannu). As a whole, it remained normal almost at all places of the region during the month. The month's lowest minimum temperature was  $-7.0^{\circ}\text{C}$  recorded at Chitral on 2nd February, 2010. Figure 11 shows normal & actual, whereas figure 12 illustrates departures from the normal.

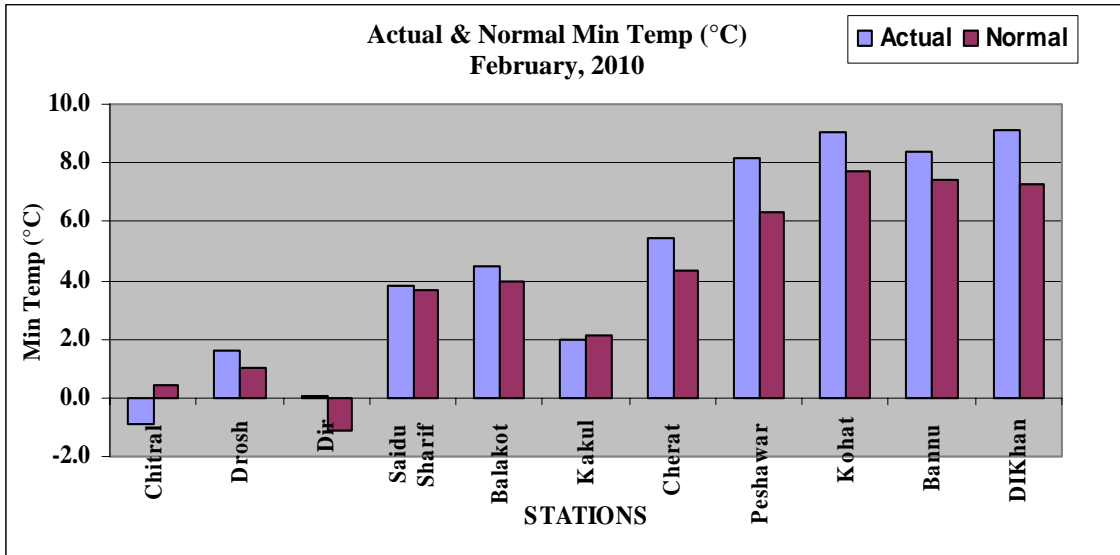


Figure- 11

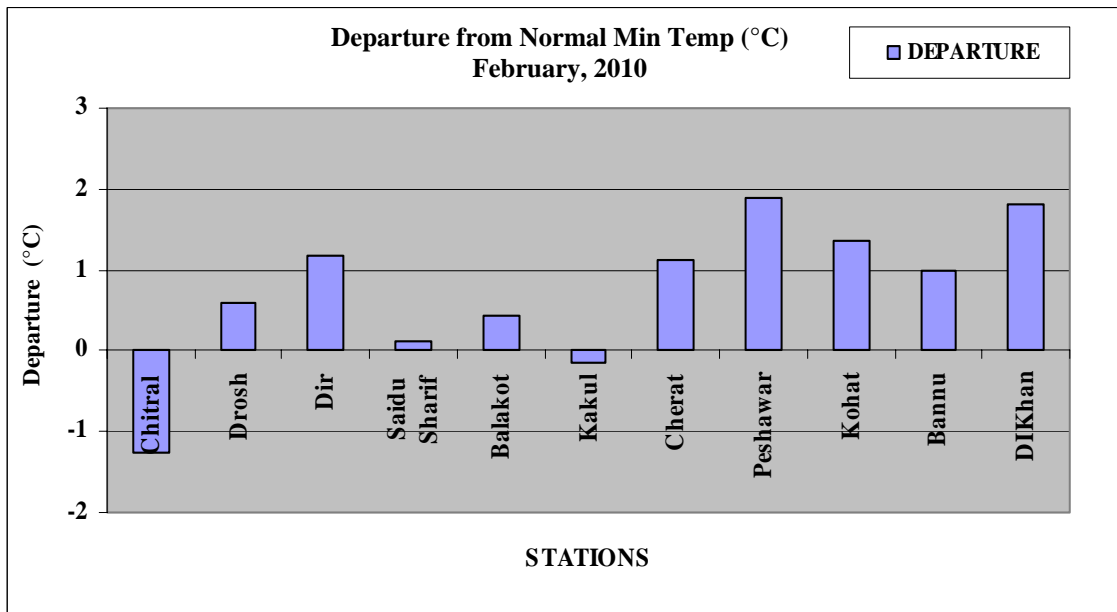


Figure- 12

March, 2010:

During the month, minimum temperature remained markedly above normal at one station (Cherat); appreciably above normal at five stations (Drosh, Peshawar, Kohat, Bannu and D.I.Khan) and slightly above normal at five stations (Chitral, Dir, Saidu Sharif, Balakot and Kakul). As a whole, it remained appreciably above normal at a number of places across the region during the month. The month's lowest minimum temperature was recorded 1.0 °C at Dir on 2nd March, 2010. Figure 13 shows normal & actual, whereas figure 14 illustrates departures from the normal.

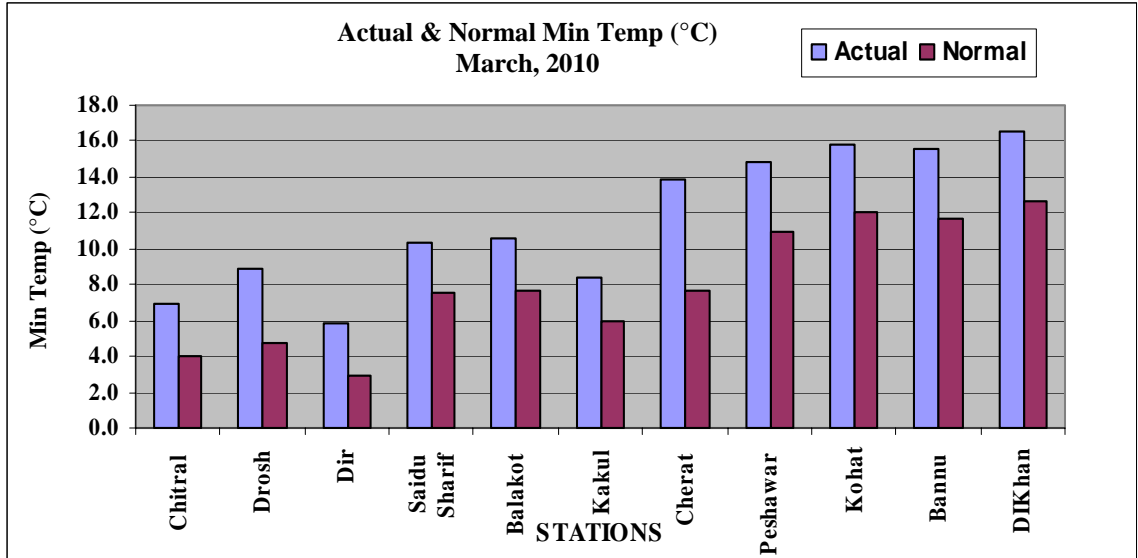


Figure-13

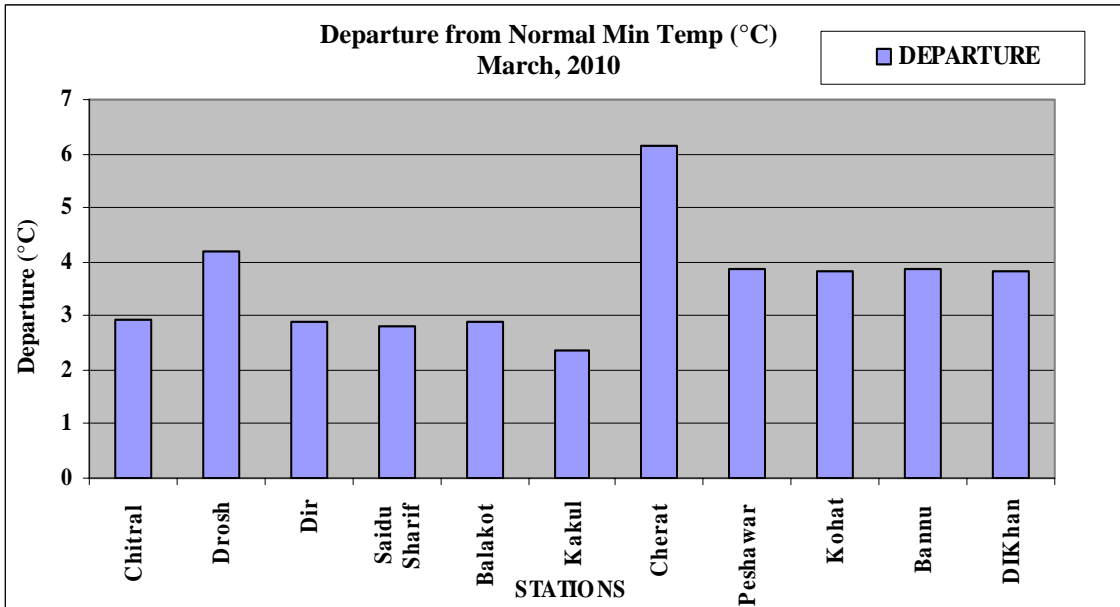


Figure-14



**Seasonal Minimum Temperature (January-March, 2010):**

January is the coldest month of the region; however the mean monthly minimum temperature remained normal to above normal in most parts of the region. In February it remained normal where as during the month of March it remained above normal at all places.

During the season, minimum temperature remained normal at four stations (Chitral, Saidu Sharif, Balakot and Kakul), slightly above normal at seven stations (Drosh, Dir, Cherat, Peshawar, Kohat, Bannu and D.I. Khan). As a whole, it remained slightly above normal almost at all places across the region during the season. The season’s lowest minimum temperature of the season was -7.0 °C recorded at Chitral on 2nd February, 2010. Mean monthly minimum temperatures with normal & departures are shown in Figures 15 & 16.

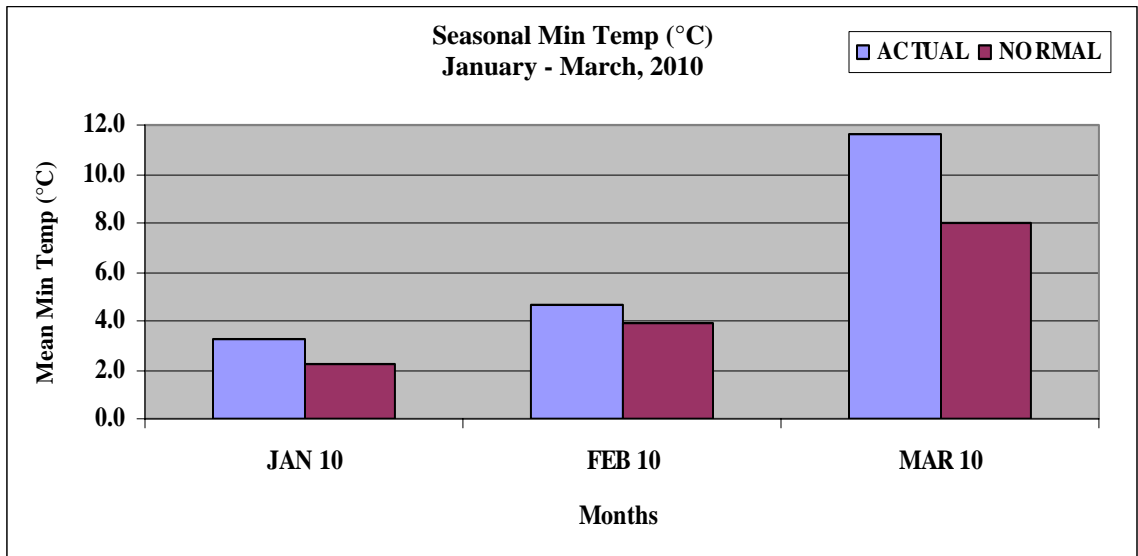


Figure- 15

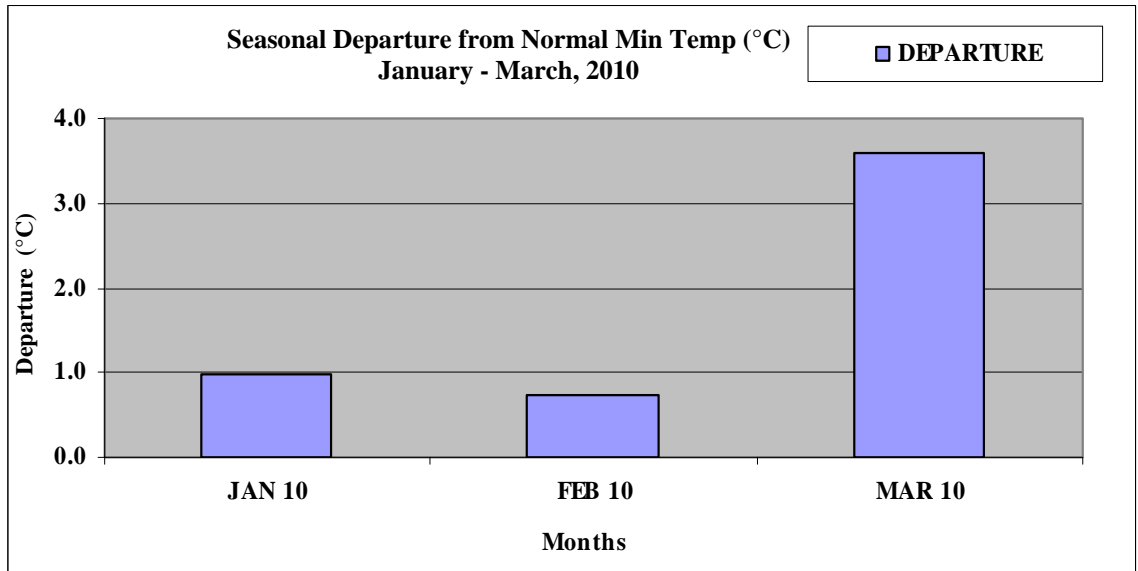


Figure- 16

**Monthly Features of Maximum Temperature Distribution**

January, 2010:

During the month, maximum temperature remained appreciably above normal at six stations (Chitral, Dir, Saidu Sharif, Balakot, Kakul and Cherat) and slightly above normal at four stations (Drosh, Peshawar, Kohat, and Bannu ); and slightly below normal at one station, D.I Khan. As a whole, it remained slightly above normal during the month throughout the region. The month’s highest maximum temperature was 25.3 °C recorded at Peshawar on 24th January, 2010. Figure 17 shows normal & actual, whereas figure 18 illustrates departures from the normal.

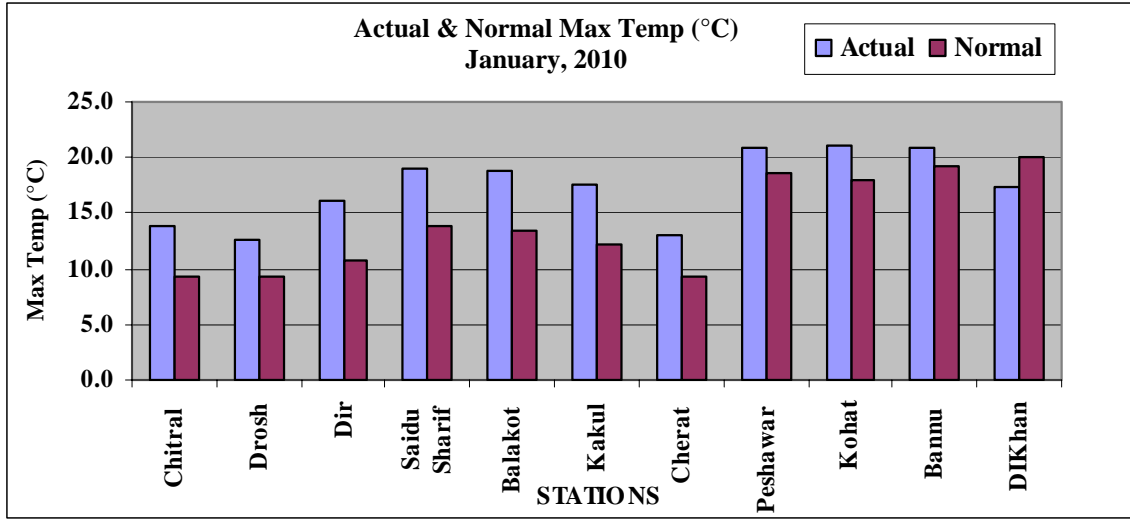


Figure-17

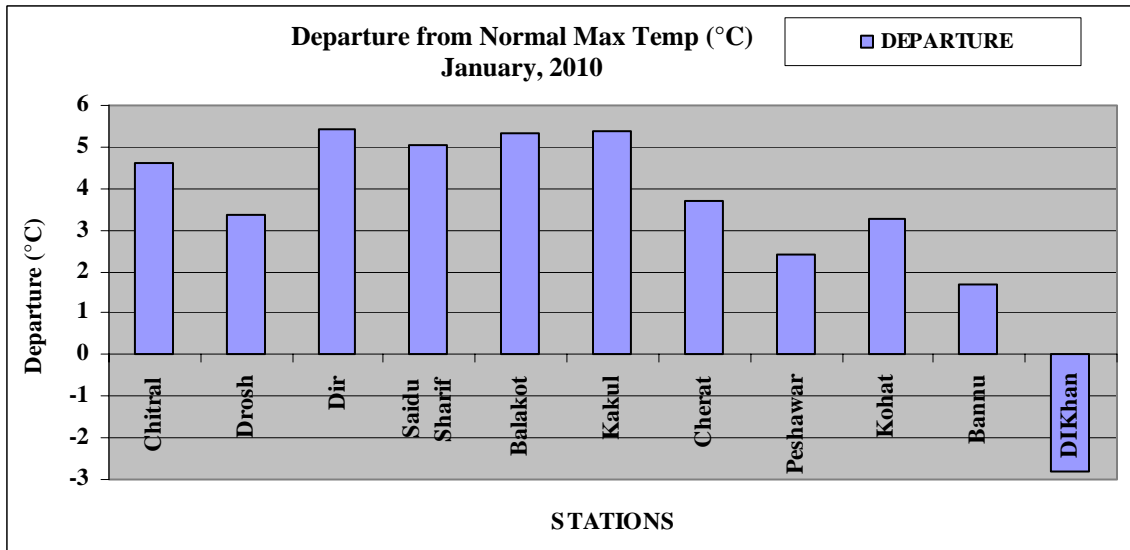


Figure-18

February, 2010:

During the month, maximum temperature remained normal at eight stations (Chitral, Saidu Sharif, Balakot, Kakul, Cherat, Peshawar, Bannu and D.I. Khan) and slightly below normal at three stations (Drosh, Dir and Kohat). As a whole, it remained normal in the area during the month. The month's highest maximum temperature was 28.0 °C recorded at D.I Khan on 22nd February, 2010. Figure 19 shows normal & actual, whereas figure 20 illustrates departures from the normal.

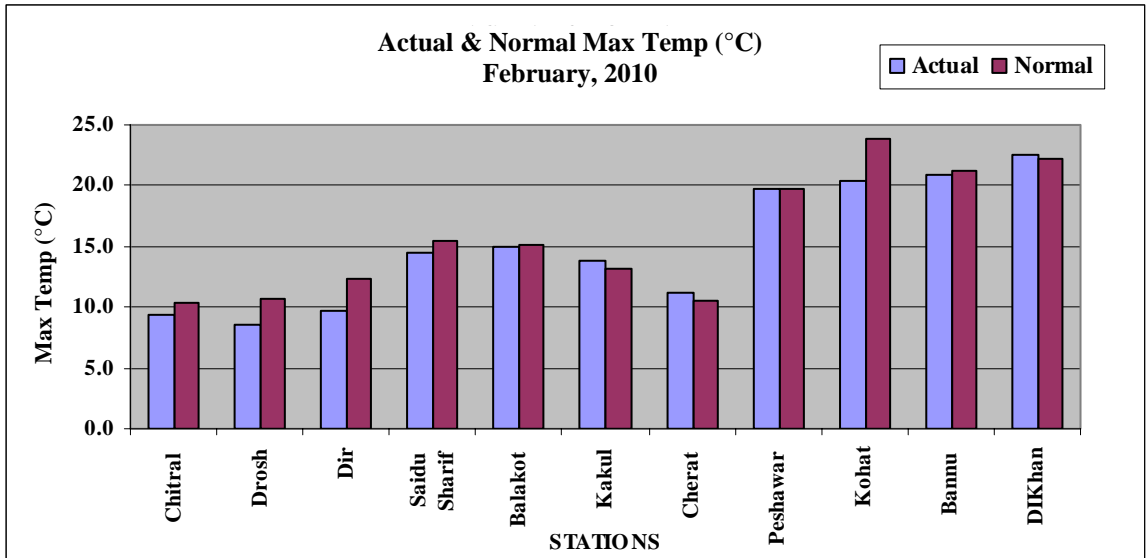


Figure-19

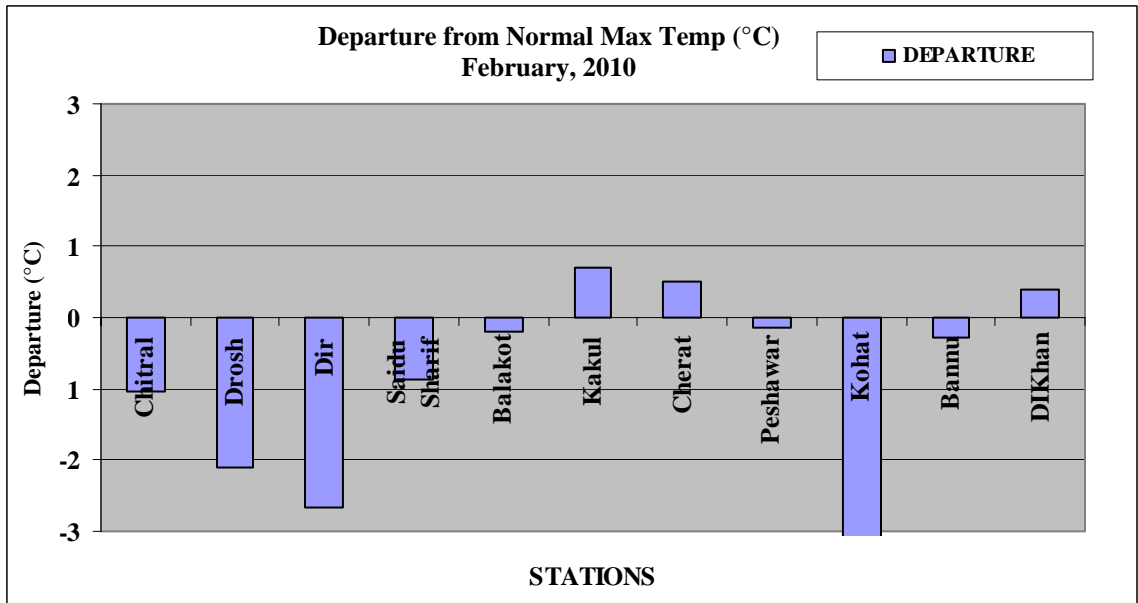


Figure-20

March, 2010:

During the month, maximum temperature remained markedly above normal at seven stations (Chitral, Dir, Saidu Sharif, Balakot, Kakul, Cherat and Peshawar), appreciably above normal at two stations (Drosh and D.I.Khan), slightly above normal at one station (Bannu) and normal at one station (Kohat). As a whole, it remained appreciably above normal throughout the region during the month. The month's highest maximum temperature was recorded 37.0°C at D.I Khan on 24th March, 2010. Figure 21 shows normal & actual, whereas figure 22 illustrates departures from the normal.

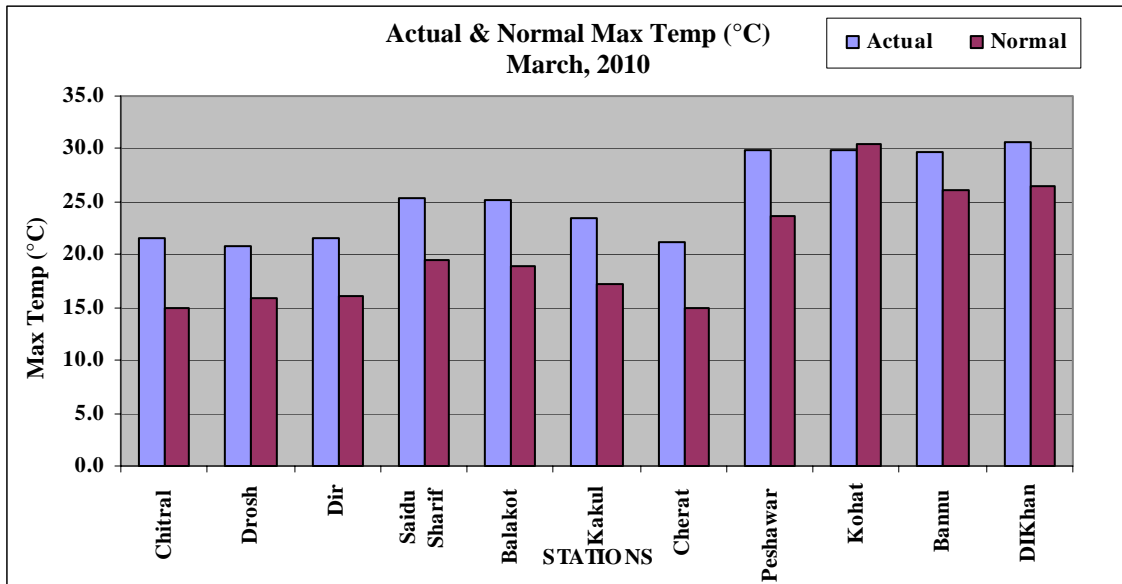


Figure-21

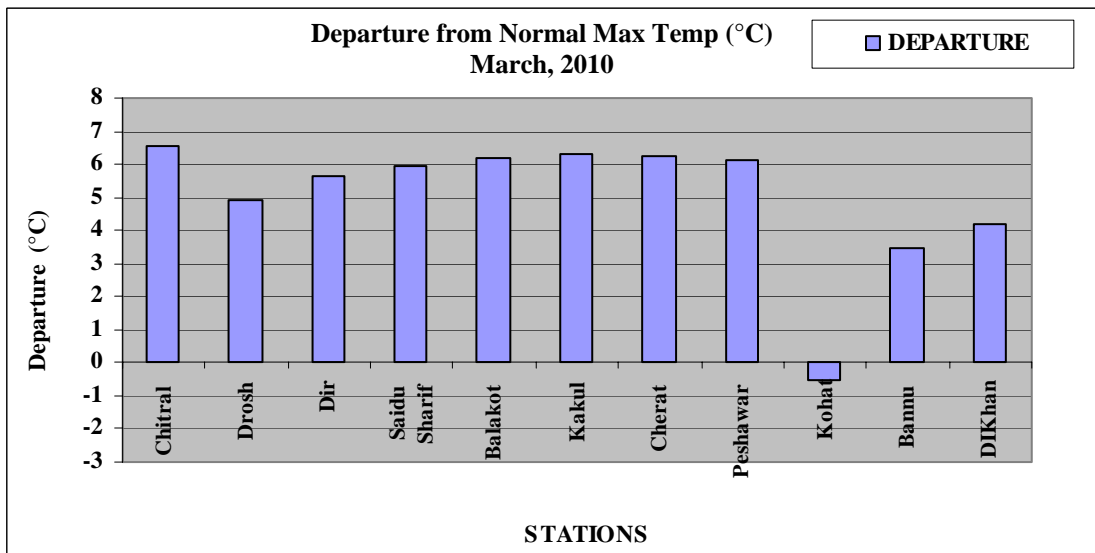


Figure-22

Seasonal Maximum Temperature (January-March, 2010):

During the month of January, maximum temperature remained above normal in most parts of the region except D.I Khan where it remained below normal due to foggy weather during the day time. Maximum temperature remained normal in all parts except at few places (Drosh, Dir and Kohat); where it remained below normal during the month of February. In the month of March, it remained above normal in the region except for Kohat where it remained normal.

During the season, maximum temperature remained appreciably above normal at two stations (Balakot and Kakul), slightly above normal at seven stations (Chitral, Drosh, Dir, Saidu Sharif, Cherat, Peshawar, and Bannu) and normal at two stations (Kohat and D.I Khan). As a whole, it remained slightly above normal across the region during the month.

The season’s highest maximum temperature was 37.0 °C recorded at D.I Khan on 24th March, 2010. Mean monthly maximum temperatures with normal & departures are shown in Figures 23 & 24.

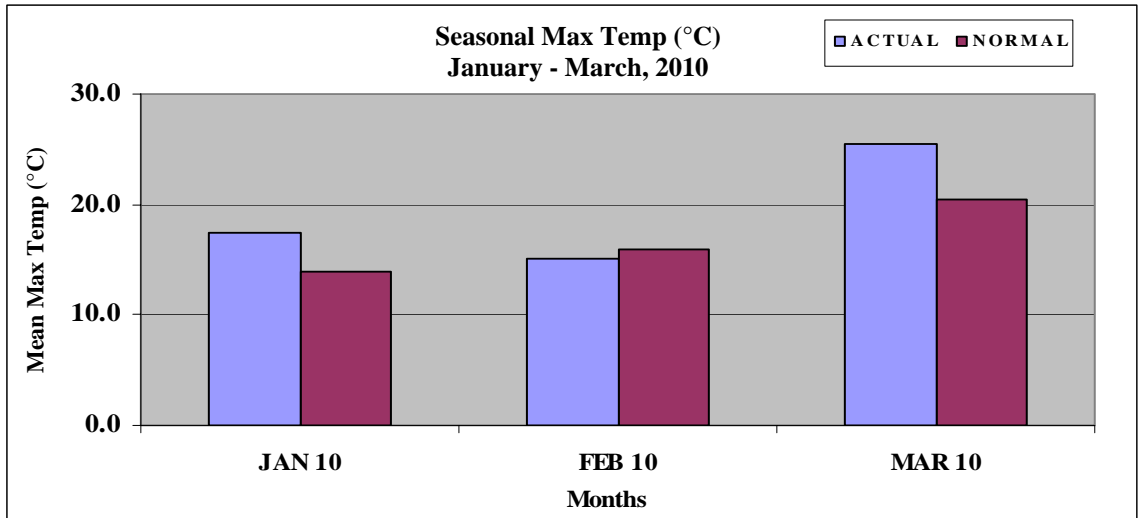


Figure- 23

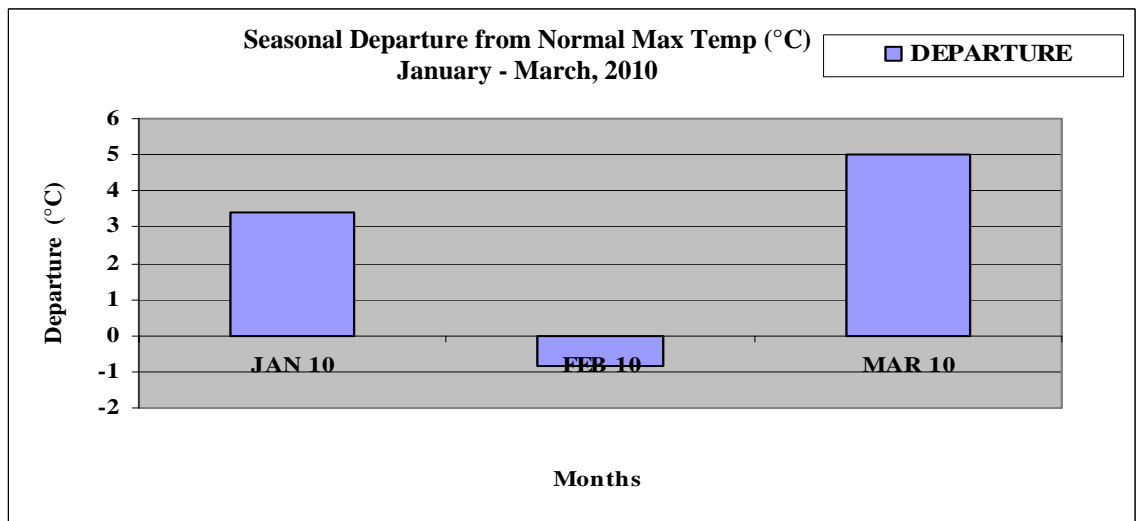


Figure - 24

**Monthly Features of Mean Temperature Distribution**

January, 2010:

During the month, mean temperature remained slightly above normal at seven observing stations (Chitral, Drosh, Dir, Saidu Sharif, Kakul, Cherat and Kohat) and remained normal at four stations (Balakot, Peshawar, Bannu and D.I.Khan). As a whole, it remained slightly above normal at a number of places across the region during the month. Figure 25 shows normal and actual whereas figure 26 illustrates departures from the normal.

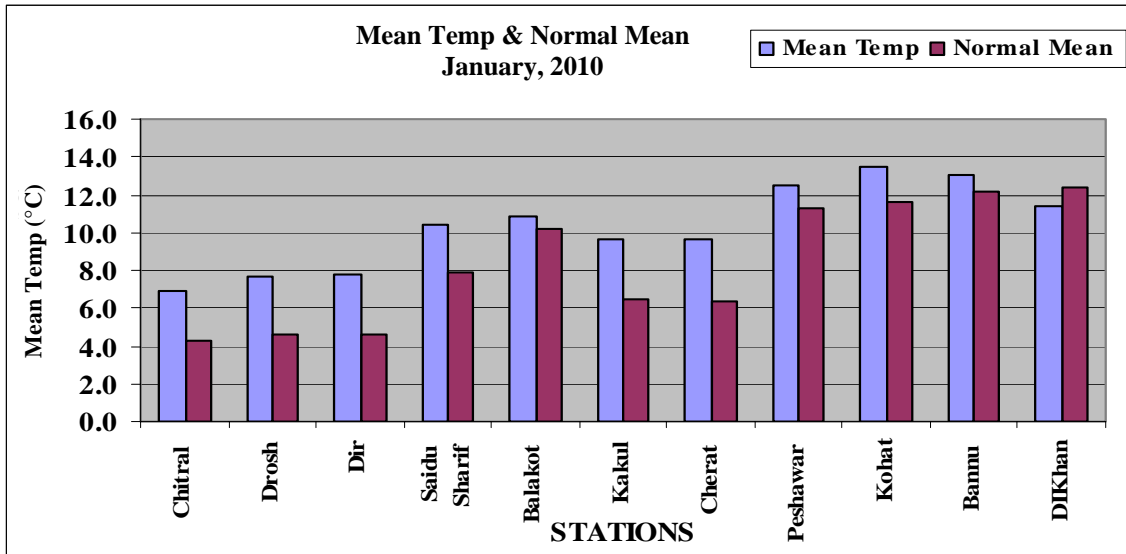


Figure-25

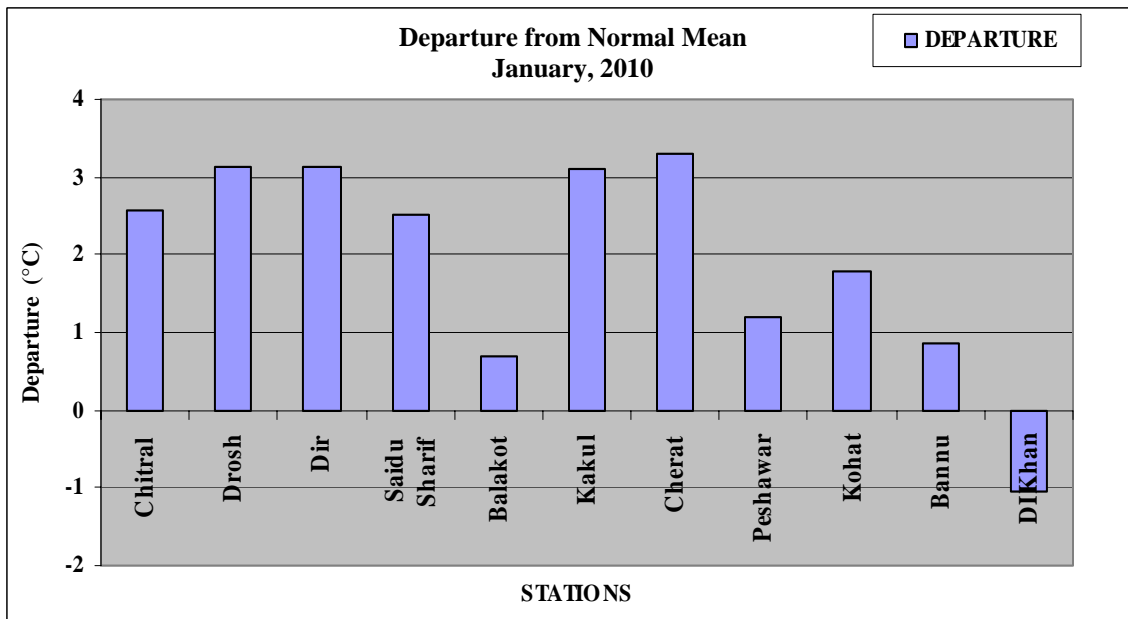


Figure- 26

February, 2010:

During the month, mean temperature remained normal at all observing stations (Chitral, Drosh, Dir, Saidu Sharif, Balakot, Kakul, Cherat, Kohat, Peshawar, Bannu and D.I Khan).As a whole, it also remained normal throughout the region during the month. Figure 27 shows normal and actual whereas figure 28 illustrates departures from the normal.

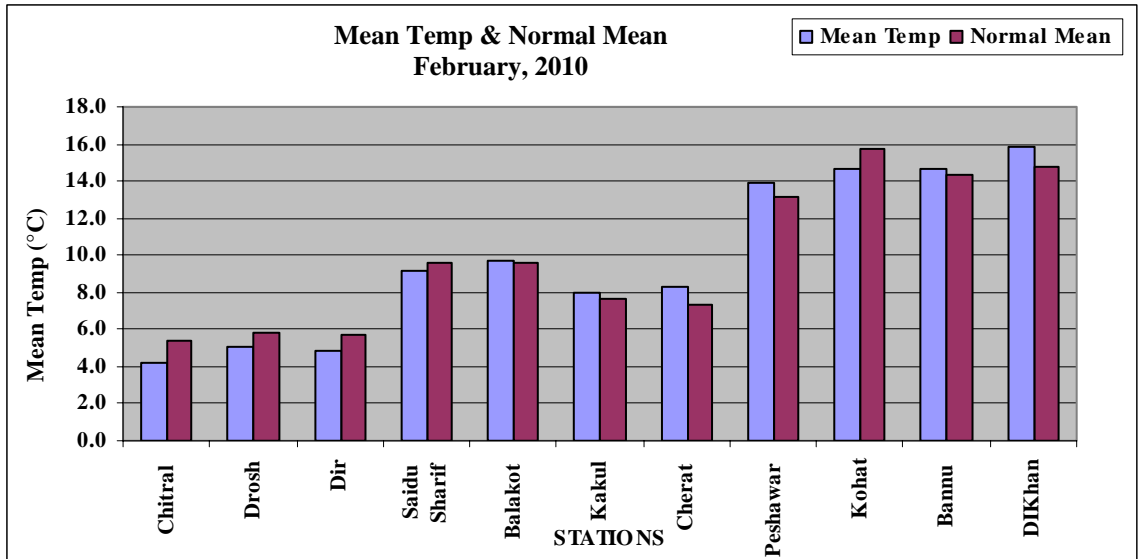


Figure- 27

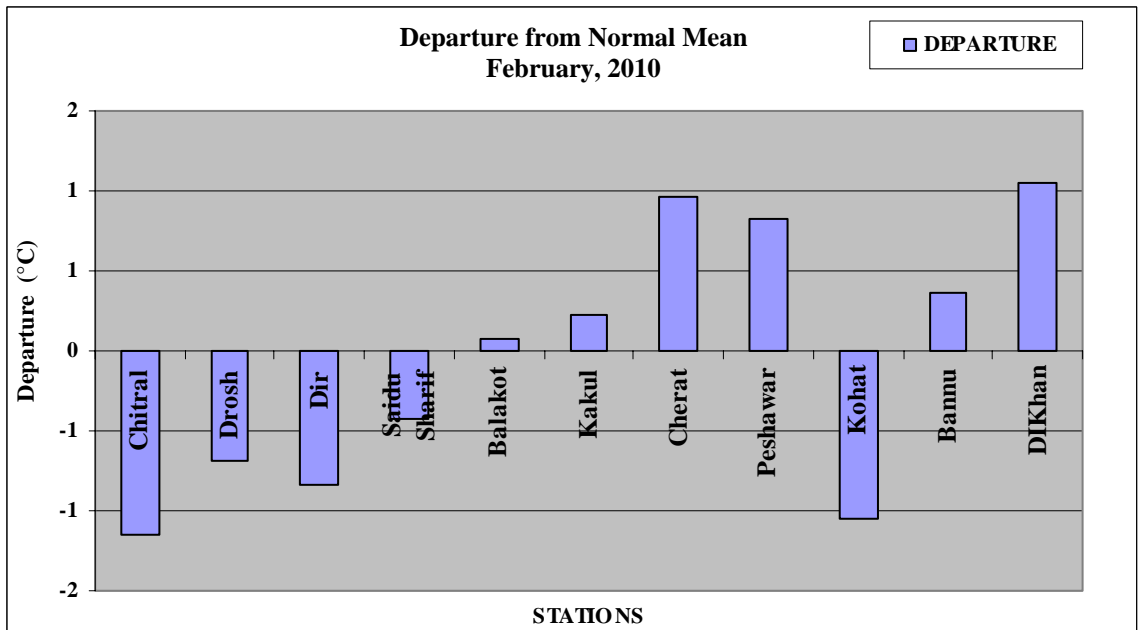


Figure- 28

March, 2010:

During the month, mean temperature remained slightly above normal at one station, Kohat; appreciably above normal at nine observing stations (Chitral, Drosh, Dir, Saidu Sharif, Balakot, Kakul, Peshawar, Bannu and D.I.Khan) and markedly above normal at one station (Cherat). As a whole, it remained appreciably above normal throughout the region during the month. Figure 29 shows normal and actual whereas figure 30 illustrates departures from the normal.

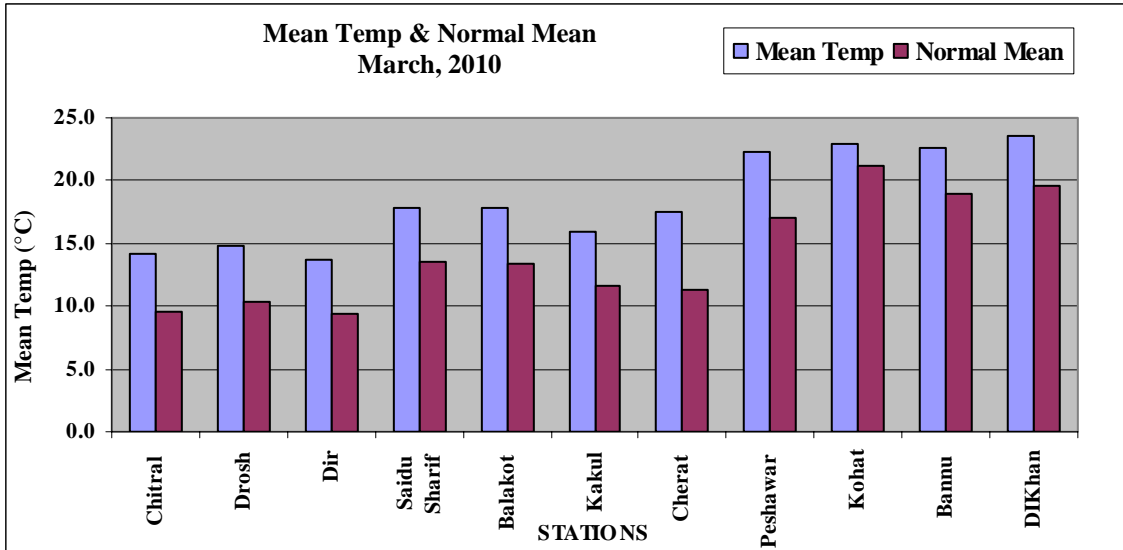


Figure-29

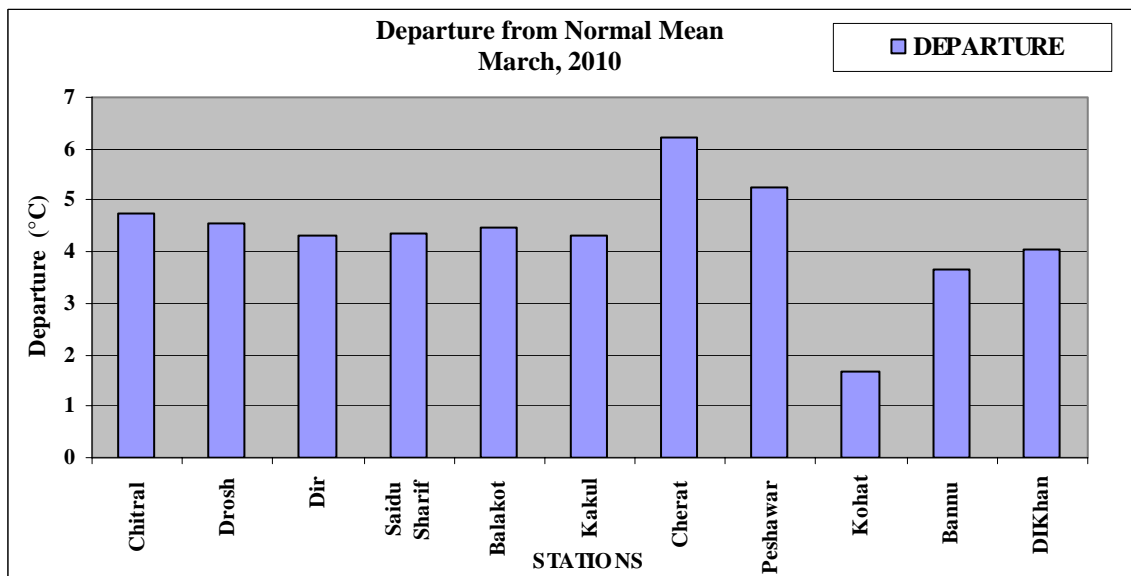


Figure-30



**Seasonal Mean Temperature (January-March, 2010):**

A blocking HIGH prevailed over Pakistan in January, which caused deficient rainfall over KPK; consequently mean monthly temperature of the month remained above normal throughout the province. Western Disturbance remained active during the month of February, which caused sufficient precipitation over the region; as a result mean temperature of the month remained normal at all parts of the region. March is normally the wettest month of the season, however, this year Western Disturbance remained passive during the month, which caused largely below normal precipitation over the province and thus mean temperature of the month remained appreciably above normal due to clearer skies.

During the season, mean temperature remained normal at two Meteorological stations (Kohat and D.I Khan), slightly above normal at nine observing stations (Chitral, Drosh, Dir, Saidu Sharif, Balakot, Kakul, Cherat, Peshawar and Bannu). As a whole, it remained slightly above normal throughout the region during the season. Figure 31 shows normal and actual whereas figure 32 illustrates departures from the normal.

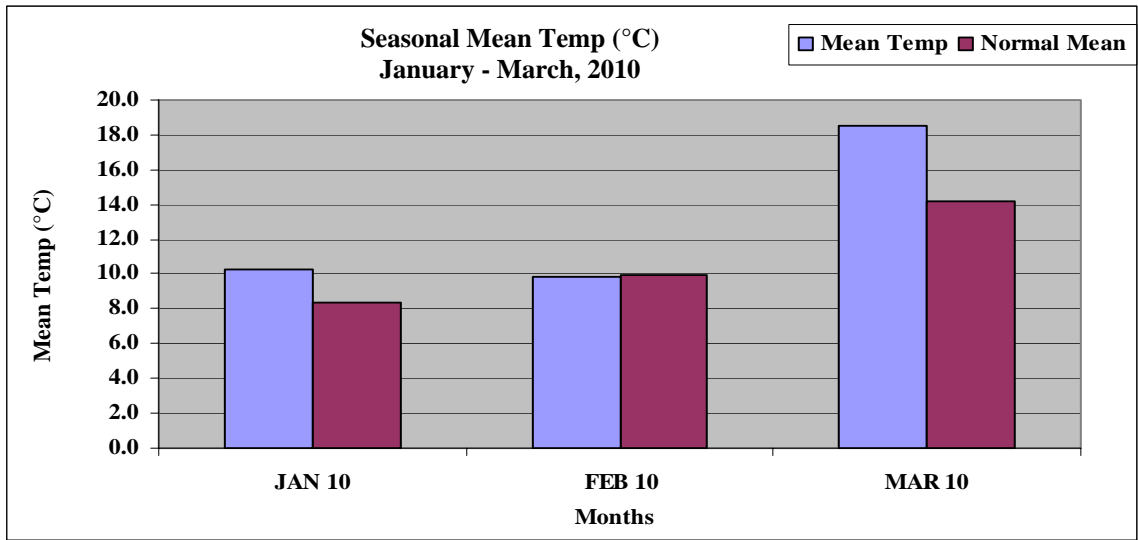


Figure-31

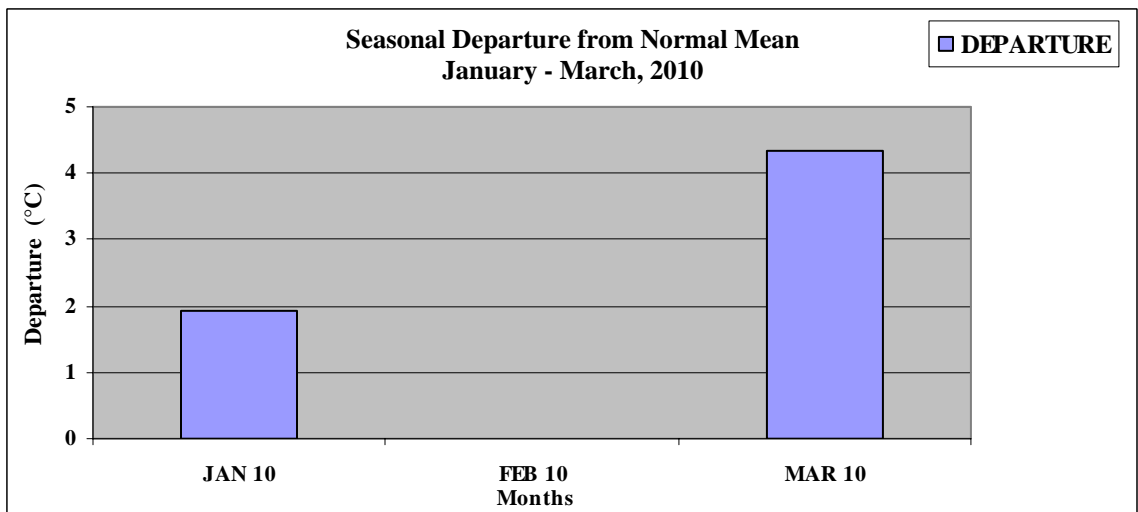


Figure-32

## **Conclusion**

During the month of January moderate deficit precipitation occurred in the region causing slightly increase in the mean temperature during the month. As a result the month was remained fairly warmer than normal.

During the month of February the rainfall was largely above normal throughout the region causing no change in the mean temperature during the month. As a result the month mean temperature remained normal.

During the month of March large deficit precipitation occurred in the region causing rise in the temperature during the month. As a result the month remained significantly warmer than normal.

During the winter season Khyber Pakhtoonkhwa received normal precipitation as a whole due to extra ordinary rainfall in the month of February and mean temperature remained slightly above normal during the study period across the region, causing insignificant change in the mean temperature.

The possible reasons of this abnormal behavior of temperature and rainfall over the region may be attributed to possible frequent changes in El Nino and La Nina conditions of South Pacific Ocean which remain unstable during the season of study. The position of high pressure system in the northwest Himalaya and the abnormal approach of secondary and primary western disturbance.

To find out the behaviour of these global climate systems another detailed study is required.

## **Recommendations**

It is recommended that further study is required to correlate the regional weather parameters in more detail with that of the global parameters for good prediction of winter climate condition.

## **References:**

**Lutgens, F.K. and Edward J. Tarbuck, 2004.** The Atmosphere, an introduction to Meteorology, Prentice Hall, USA.

**Shamshad, K.M., 1988.** The Meteorology of Pakistan, Royal Book Company, Karachi, Pakistan,

**Table 1:** Station Wise Rain Fall (mm) for each month & Season as a whole (January - March, 2010)

Stations	Jan-10			Feb-10			Mar-10			Season (Jan - Mar)		
	Actual	Normal	Dep %	Actual	Normal	Dep %	Actual	Normal	Dep %	Actual	Normal	Dep %
Chitral	94.2	42.2	123	150.6	63.8	136	45.3	110.7	-59	290.1	216.7	34
Drosh	50.9	48.6	5	131.9	74.4	77	38.6	115.6	-67	221.4	238.6	-7
Dir	86.0	123.4	-30	297.0	171.5	73	81.0	264.4	-69	464.0	559.3	-17
Saidu Sharif	42.4	84.6	-50	238.0	109.1	118	61.1	174.9	-65	341.5	368.6	-7
Balakot	41.2	103.5	-60	357.4	141.4	153	121.9	192.7	-37	520.5	437.6	19
Kakul	20.2	73.4	-72	223.8	106.7	110	42.2	151.9	-72	286.2	332.0	-14
Cherat	19.5	40.0	-51	109.3	63.4	72	12.7	105.1	-88	141.5	208.5	-32
Peshawar	20.6	30.8	-33	94.7	47.1	101	10.0	83.3	-88	125.3	161.2	-22
Kohat	6.0	27.7	-78	52.0	43.7	19	14.0	82.2	-83	72.0	153.6	-53
Bannu	14.2	22.0	-35	13.4	39.3	-66	15.0	28.3	-47	42.6	89.6	-52
D.I.Khan	12.0	11.4	5	1.0	15.0	-93	38.8	37.4	4	51.8	63.8	-19

**Table 2:** Station Wise Minimum Temperature (°C) for each month & Season as a whole (January - March, 2010)

Stations	Jan-10			Feb-10			Mar-10			Season (Jan - Mar)		
	Actual	Normal	Dep	Actual	Normal	Dep	Actual	Normal	Dep	Actual	Normal	Dep
Chitral	-0.1	-0.7	1	-0.9	0.4	-1	6.9	4.0	3	2.0	1.2	1
Drosh	2.9	0.1	3	1.6	1.0	1	8.9	4.7	4	4.5	1.9	3
Dir	-0.6	-2.5	2	0.1	-1.1	1	5.8	2.9	3	1.7	-0.2	2
Saidu Sharif	1.9	1.9	0	3.8	3.7	0	10.3	7.5	3	5.3	4.4	1
Balakot	2.9	2.3	1	4.4	4.0	0	10.6	7.7	3	6.0	4.7	1
Kakul	1.6	0.9	1	2.0	2.1	0	8.4	6.0	2	4.0	3.0	1
Cherat	6.4	3.6	3	5.4	4.3	1	13.8	7.7	6	8.5	5.2	3
Peshawar	4.0	4.1	0	8.2	6.3	2	14.9	11.0	4	9.0	7.1	2
Kohat	5.7	5.4	0	9.1	7.7	1	15.8	12.0	4	10.2	8.4	2
Bannu	5.1	5.1	0	8.4	7.4	1	15.6	11.7	4	9.7	8.1	2
D.I.Khan	5.4	4.4	1	9.1	7.3	2	16.5	12.7	4	10.4	8.1	2

**Table 3: Station Wise Maximum Temperature (°C) for each month & Season as a whole (January - March, 2010)**

Stations	Jan-10			Feb-10			Mar-10			Season (Jan-Mar)		
	Actual	Normal	Dep	Actual	Normal	Dep	Actual	Normal	Dep	Actual	Normal	Dep
Chitral	13.8	9.2	5	9.4	10.4	-1	21.6	15.0	7	14.9	11.5	3
Drosh	12.6	9.2	3	8.6	10.7	-2	20.8	15.9	5	14.0	11.9	2
Dir	16.1	10.7	5	9.6	12.3	-3	21.6	16.0	6	15.8	13.0	3
Saidu Sharif	18.9	13.9	5	14.5	15.4	-1	25.4	19.4	6	19.6	16.2	3
Balakot	18.8	13.5	5	14.9	15.1	0	25.2	19.0	6	19.6	15.9	4
Kakul	17.6	12.2	5	13.9	13.2	1	23.5	17.2	6	18.3	14.2	4
Cherat	13.0	9.3	4	11.1	10.6	1	21.2	15.0	6	15.1	11.6	3
Peshawar	20.9	18.5	2	19.7	19.8	0	29.8	23.7	6	23.5	20.7	3
Kohat	21.2	17.9	3	20.3	23.8	-3	29.9	30.4	-1	23.8	24.0	0
Bannu	20.9	19.2	2	20.9	21.2	0	29.7	26.2	3	23.8	22.2	2
D.I.Khan	17.3	20.1	-3	22.6	22.2	0	30.7	26.5	4	23.5	22.9	1

**Table 4: Station Wise Mean Temperature (°C) for Each Month (January - March, 2010)**

Stations	Jan-10			Feb-10			Mar-10			Season (Jan - Mar)		
	Mean	Normal	Dep	Mean	Normal	Dep	Mean	Normal	Dep	Mean	Normal	Dep
Chitral	6.9	4.3	3	4.2	5.4	-1	14.2	9.5	5	8.5	6.4	2
Drosh	7.7	4.6	3	5.1	5.8	-1	14.8	10.3	5	9.2	6.9	2
Dir	7.7	4.6	3	4.9	5.7	-1	13.7	9.4	4	8.8	6.6	2
Saidu Sharif	10.4	7.9	3	9.2	9.6	0	17.8	13.5	4	12.5	10.3	2
Balakot	10.9	10.2	1	9.7	9.6	0	17.9	13.4	4	12.8	11.1	2
Kakul	9.6	6.5	3	7.9	7.7	0	15.9	11.6	4	11.2	8.6	3
Cherat	9.7	6.4	3	8.3	7.3	1	17.5	11.3	6	11.8	8.3	3
Peshawar	12.5	11.3	1	13.9	13.1	1	22.4	17.1	5	16.3	13.8	2
Kohat	13.4	11.7	2	14.7	15.8	-1	22.9	21.2	2	17.0	16.2	1
Bannu	13.0	12.2	1	14.7	14.3	0	22.6	19.0	4	16.8	15.1	2
D.I.Khan	11.4	12.4	-1	15.9	14.8	1	23.6	19.6	4	16.9	15.6	1

**Table 5: Station wise Snow Fall for Winter Season January- March 2010**

S. NO	STATION	JANUARY	FEBRUARY	MARCH	TOTAL SNOW FALL (INCH)
1	CHITRAL	15.0	13.3		28.3
2	TIMERGARA		10.0		10.0
3	DIR	2.5	32.0		34.5
4	MIRKHANI		1.0		1.0
5	KALAM	30.0	138.5	7.0	175.5
6	DROSH	14.0	11.5		255
7	SKARDU		11.2	7.5	17.7
8	BUNJI		1.1		
9	ASTORE		8.5	6.0	14.5
10	SAIDU SHARIF		8.5		8.5
11	KAKUL		5.0		5.0
12	BALAKOT		1.0		1.0
13	PARACHINAR		4.0		4.0
14	MUREE		25.0		25.0