CLIMATE OF DEHRA DUN

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Preface

Weather and climate affect all aspects of life. The importance of Meteorology and climatology for economic and social benefits of the society is being realized increasingly all over the world. Actions in the field of agriculture, aviation, energy, industry, Landscape and Urban ecosystem designs require climatological information for planning and successful execution of the projects with a view to derive maximum advantage out of the climatological information.

Apart from general weather information required by common man, hundreds of enquiries received by the , Meteorological Centre, India Meteorological Department from the general public, decision makers and the electronic and Print media are about current weather as well extreme weather conditions. Daily and weekly weather reports are prepared as a routine by the department. These summaries, however, do not readily provide answers to many of the general queries such as-"Was yesterday's rainfall a record?" or "When January was so cold or August so wet in the Past?" Capital cities by virtue of their large populace and greater awareness generate most of these queries. Climate features of Dehra Dun have been described in detail in this publication to answer these queries and for facilitating day to day decision making.

The booklet contains monthly summaries, divided into four seasons, describing the averages and extremes of temperature, rainfall, wind and humidity. Occurrences of different weather phenomena such as heavy rains, thunderstorms, hailstorms, dust storms, squalls and fog are described in detail to provide information as to how many of these phenomena occur on an average and what have been their highest occurrence in the past.

The three national festivals of India (Independence Day, Republic Day and Gandhi Jayanti) and state day of Uttarakhand (9th November) are celebrated in Dehra Dun. The averages and extremes of weather on these days are given to provide an idea of the weather conditions on these days.

My gratitude to Dr Krishna Kumar, Scientist E, National Data Centre, Pune for his valuable inputs.

I am thankful to Shri Abhinav Singh, Shri B.B. Lal, Shri Vishal Mani, Shri D.K. Verma, for their efforts in the compilation of data and shri Amit Pokhriyal for typing the script. My sincere thanks to the National Data centre, Pune, and Meteorological Centre, Lucknow for providing the required data.

Dehra Dun
09 January, 2012

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Foreword

Climate of a city plays an important role in its all round development. Dehra Dun the capital of Uttarakhand is lying in the foothills of Mussorie, Climatological Normals, extremes, diurnal variation and information during different seasons find wide application in different sectors.

It gives me great pleasure to present the booklet " Climate of Dehra Dun". It provides a summary of various climatological information pertaining to Dehra Dun to the users. I appreciate the efforts taken by the authors in bringing out this booklet. I am confident that the booklet will meet long standing demand of city planners, reserhers, farmers & tourists etc.

Dehra Dun
09 January, 2012

L. S. Rathore
Director General of Meteorology

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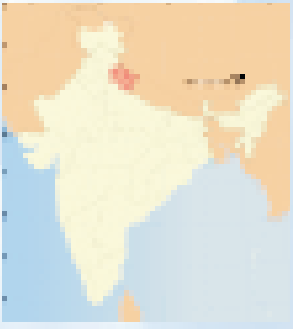
Geographical Location

Dehra Dun is the capital city of Himalayan state Uttarakhand. Dehra Dun is one of the oldest cities of India and became the capital city after the formation of the Uttarakhand state in the year 2000. Dehra Dun is famous for its picturesque landscape and pleasant climate and provides a gateway to the surrounding region. The capital once famous for Basmati rice, Litchi, tea gardens, Sal forests and water canals is fast deteriorating due to rapid unplanned development and expansion in the past decade. The landscape of the city has changed drastically and now basmati rice, Litchi, tea gardens, Sal forests and water canals are disappearing at a very fast pace and thereby also changing its microclimate. The land use land cover change along with development and encroachment in and around has also led to increased man-animal conflicts.

Dehra Dun is made up of two words Dehra and Doon where Dehra is derived from the word camp and Doon is a term for the valley that lies between the Himalayas and the Shivaliks.The night view of the city from nearby Mussoorie hills is quite beautiful. The coordinates of Dehra Dun are 30 degree 19' North and 78 degree 03' East. The observatory was established on 01January, 1967 in the Geodetic and Research Branch campus of the Survey of India.



Physiographic Setting

The Dehra Dun district is situated in the North West corner of the state. It is located between the latitudes 29 °58' N and 31°2' N and longitudes 77° 34' E and 78° 18'E. The district is located on the foothills of the Himalayas. The district is bordered by the Himalayan range to the north, the Shivaliks to the south the Ganges to the east and the Yamuna river to the west. The Dehra Dun district has varied physical geography from Himalayan Mountains to plains. Raiwala is the lowest point at 315 meters above sea level, and the highest point is within the Tuini hills, rising to 3700 meters above mean sea level. The famous hill station Mussoorie and Chakrata are part of the district and lie in the lesser Himalayan ranges. The district is bounded on the north and North West by the district of Uttarkashi and in the east by Tehri and Pauri districts. In the west it is bordered by Sirmaur district of Himachal Pradesh and to the south are Haridwar and Uttar Pradesh's Saharanpur disrtrict. Dehra Dun lies in the zone IV (High damage risk zone) as per the Earthquake hazard zoning of India.

Fig 1 : Location of Dehra Dun

CLIMATE OF DEHRA DUN

General Climate

Dehra Dun The capital of Uttarakhand lies on the foot hills of the Himalayas .The distance from the sea gives Dehra Dun an extreme type of continental climate with the prevalence of continental air during major parts of the year. The meteorological observatory was established on 01 January, 1967 in the Geodetic and Research Branch campus of the Survey of India. However, as far as, quantum of rain is concerned it is comparable to coastal stations of Maharashtra. Mainly during the three monsoon months of July, August and September does the air of oceanic origin penetrate to this region and causes increased humidity, cloudiness and rain. Most of the annual rainfall is received in the months from June to September with July and August being are rainiest. Dehra Dun is one of the rainiest capital cities of India. The rainfall and temperature variations within the city are quite considerable due to altitudinal variation and local orography with presence of high Mussoorie hills.

As per the India Meteorological Department classification, seasons in India are classified as Winter Season (January to February), Summer Season (March to May), Monsoon or South-West Season (June to September) and Post-monsoon Season (October-December).However, for the study of climate of Dehra Dun season are classified as

1. Winter Season (December to February)
2. Summer Season (March to May)
3. Monsoon or South-West Season (June to September)
4. Post-monsoon Season (October-November).

The summers in Dehra Dun are moderately hot and winters very cold. The temperature may rise up to about 41 degrees Celsius in summers with all time high of 43.9 degree Celsius, though the average temperature is around 35-36 degree Celsius. There are about 1-2 days of heat wave when the maximum temperature of a day rises to 4-6 degree Celsius above the normal values. Though the winters are not bitterly cold on most of the days, the temperatures may fall to 1-2 degree Celsius for a few days in winters when the cold winds from the nearby Himalayan Mountains makes the winters severe. The all time low minimum temperature for the city is -1.1 degree Celsius. The winters are also marked by mist and fog on few days especially during night and early in the mornings and rarely till forenoon with bright Sun shine during the day.

Data Used

A meteorological observatory is functioning at the Geodetic and Research Branch campus of the Survey of India since 01 January, 1867 and represents the city condition of Dehra Dun. Daily meteorological data of this observatory have been used to arrive at the climatology for Dehra Dun. The climatology of rainfall, temperature, humidity and wind described in the following sections are based on 40 years period of 1971-2010. The data in regard to maximum winds / squall are not available due to lack of Dynes PT instrument. Similarly the data about visibility is also not available. The extremes of rainfall described are from the year 1869 to 2010 and those of temperature from 1901-2010. The data on weather phenomena are for a 10 years period of 2001 to 2010. The normals are based on the period 1971 to 2010. There are some gaps in the data received from NDC, Pune, where ever possible gap filling has been done based on information available at the meteorological centre, Dehra Dun.

The annual march of maximum/ minimum temperatures and rainfall is given in Figure 2. It shows that the maximum temperatures are at their peak during the months of May and June. Though the temperatures start falling in the month of July, the fall is gradual till October. Both the maximum and the minimum temperatures decrease sharply from the month of October with January being the coldest month. The rainfall increases from the month of June with the onset of pre-monsoon rainfall activity. July and August are the rainiest months. Monsoon withdraws towards the end of September. The rainfall decreases drastically from the month of October with November being the driest month of the year.

Monthly means/ extremes of temperatures, number of days with heat wave/ cold wave, monthly total/ extremes rainfall and the average number of days with different weather phenomena are given in Table 1, 2, 3 and 4, respectively.

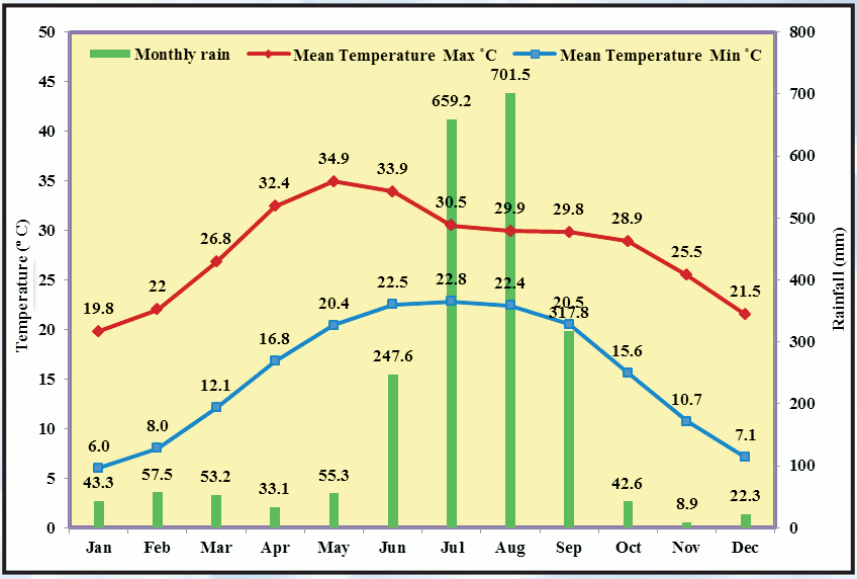


Fig 2 : Monthly Normal Maximum & Minimum Temperatures and Total Rainfall

Winter Season

The winter season in Dehra Dun starts from the month of December and lasts up to February. India celebrates its Republic Day during this season on 26 January to Commemorate the date on which the Constitution of India came into force in 1950 replacing the Government of India Act 1935 as the governing document of India. It is one of the three national holidays in India, and the functions take place at Governor House and Parade ground. New Year celebration is the other main attraction for this season as people expect snowfall in Mussoorie.

Though the winters are not bitterly cold on most of the days, the temperatures may fall to 1-2 degree Celsius for a few days in the season when the cold winds from the adjoining Himalayan mountains affect the region making the winters chilly. The winters are also marked by mist and fog and sometimes frost in the mornings with bright sunny days.

Temperature

The daily normal maximum and minimum temperatures for the season are given in Figure 3 below. The maximum temperatures register a gradual fall through the month of December. They fall from about 23 Deg. C in the beginning of the month to about 19 Deg. C towards the end. They continue to remain around 19 Degree Celsius till fourth week of January. They rise through the month of February and reach about 25 Deg. C by the end of the season.

The minimum temperatures also have a similar march through the season falling from about 8 Deg. C in the beginning of December to about 6 Deg. C by the end of the month. They remain around that value till the end of January. The minimum temperatures show an upward trend through the month of February. The minimum temperatures reach about 9 Deg. C by the end of the season.

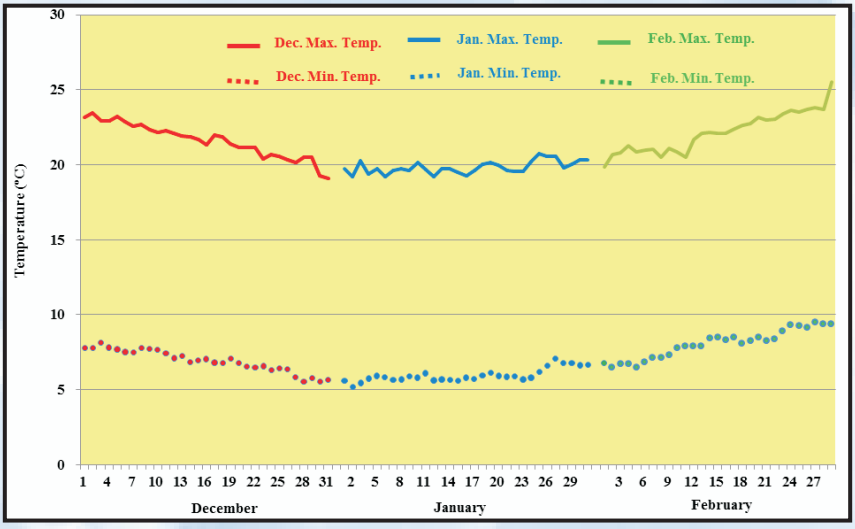


Fig 3 : Normal Maximum & Minimum Temperatures for Winter Season

Diurnal Variation of Temperature

The day temperatures show a diurnal variation of about 9 Degree Celsius during the Season. Figure 4 indicates the diurnal variation of temperature over Dehra Dun during first and second fortnights of December, January and February. Lowest temperatures are recorded around 07 hours IST during second fortnight of December and first fortnight of January when the Sun is at its southern most position, and around 07 hours IST during the rest of the season. A steep rise is experienced from 0800 hours IST to 1200 hours IST. However, they continue to rise till 1500 hours IST. The temperatures are lower by about 3 Degree Celsius at all the hours of a day during the coldest month of January than those recorded in the warmest period of the season-the second fortnight of February.

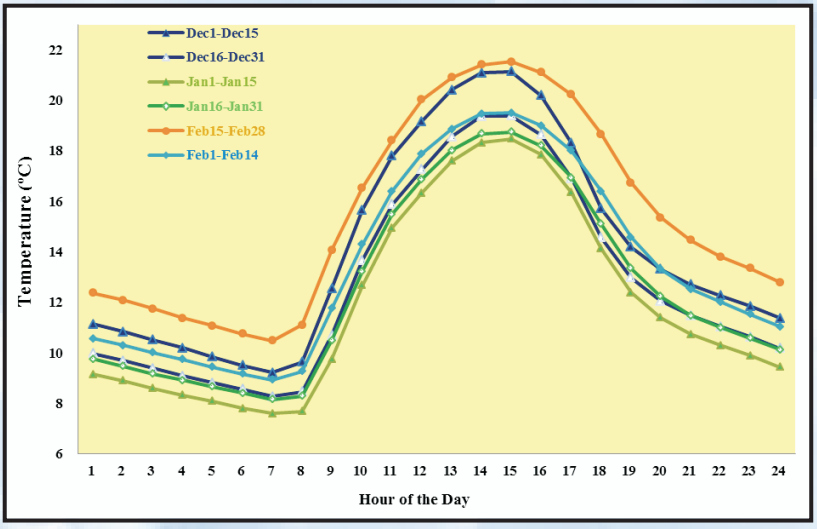


Fig 4 : Diurnal Variation of Temperatures during Winter Season

Extreme Temperature

The highest and lowest maximum temperatures recorded during the season (1971-2010) given in Figure 5 below indicates that maximum temperatures can have quite a large range during the season. The highest maximum temperatures in the month of December range around 22-27 Deg. C during most of the years. They range around 22 to 29 Deg. C during January and around 23-31 Deg. C during February. The highest maximum temperatures recorded during the period are 27.4 Deg. C for December (10 December, 2008), 28.6 Deg. C for January (24 January, 2009) and 31.2 Deg. C for February (25 February, 2006). These are also the all time record for these months since 1869. Quite low values of maximum temperatures can be recorded on individual days, particularly when the days remain foggy with no sunshine at all. The lowest maximum temperatures recorded in the city for different month during the season are 8.4 Deg. C (31 December, 2002), 8.9 Deg. C (20 January, 1997) and 10.7 Deg. C (13 February, 2007).

The maximum temperatures on few days remain very much below normal due to persistent fog/cloud and cold winds leading to cold day conditions (When maximum temperature is 16° C or below). Foggy conditions prevail during winter for few days leading to below normal maximum temperatures. The average number of cold days is 1.0 for December 2.9 for January and 1.1 for February. However, there is large inter annual variation. The highest number of cold days were 8 for December (1997), 8 for January (1981) and 4 for February (1972).

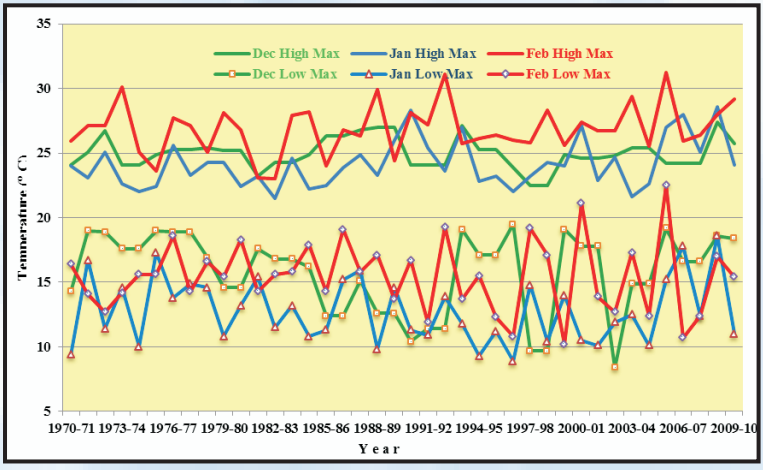


Fig 5 : Highest and Lowest Maximum Temperatures during Winter Season

During most of the years, the lowest minimum temperatures recorded are around 1-6 Deg. C during December, around 0-5 Deg. C during January and around 0-9 Deg. C during February (Figure 6). However, quite low temperatures have been recorded in some of the years. The all time record for lowest minimum temperature during the season is 0.0 Deg. C (31 December, 1954), -1.1 Deg. C (11 January, 1945) and -1.1 Deg. C (01 February, 1905). Such low temperatures are recorded when cold northerly winds from the frigid Himalayan mountains set in over the area after the passage of a western disturbance across northern parts of the country. The minimum temperatures can be quite high (14-16 Deg. C) on individual days during the season, particularly ahead of an approaching western disturbance, when warm moist air from south penetrates into the region and nights are cloudy allowing little nocturnal cooling. The highest minimum temperatures recorded in the city for different months during the season are 15.1 Deg. C (20 December, 2008), 14.2 Deg. C (27 January, 1994) and 16.3 Deg. C (26 February, 2006).

Low minimum temperatures lead to cold wave conditions (cold wave/ severe cold wave) in the region , when minimum temperatures are 4 Deg. C or much below their normal values (Annexure 1). The average number of days with cold wave conditions is 0.6 for December, 0.8 for January and 1.7 for February. Though there is large inter-annual variability, the coefficient of variation being 167%, 125% and 235%, for the months of December, January and February respectively. The highest number of days with cold wave / severe cold waves in any month has been 16 for February, 1972 (Table 2).

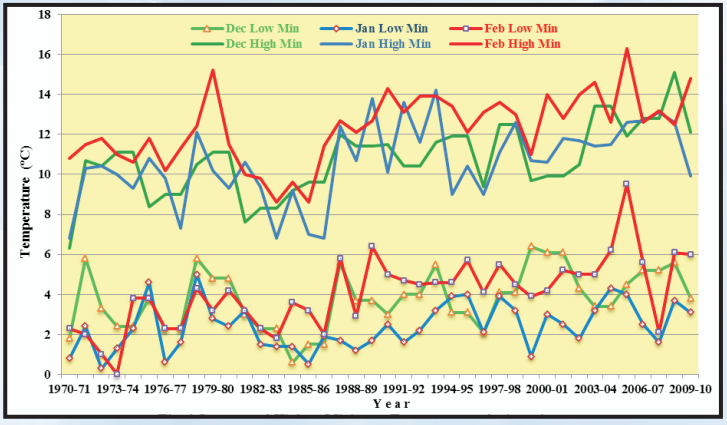


Fig 6 : Lowest and Highest Maximum Temperatures during Winter Season

The rise in temperatures on the approach of western disturbances is a relatively slow process whereas the fall is steeper as they move away. These rise/ fall are because of the change in the air mass on approach and in rear of these disturbances. The highest fall in the maximum and minimum temperatures are given in Table 5. The maximum temperature recorded on 10 February 1997 was 11.6° C lower than that on the previous day. The highest fall in maximum and minimum temperatures during different months is given in Table 5.

The probability of minimum temperatures to fall below 4 and 10 deg. C given in Figure 7 indicates very high probability (>90 %) of minimum temperatures to fall below 10 deg. C from first week of December to first week of February. It goes down to below 60 % towards the end of February. The probability of minimum temperatures to fall below 4 deg. C is around 20-30 % from end of December till first week of February. It is 5 to 15 % for rest of the period.

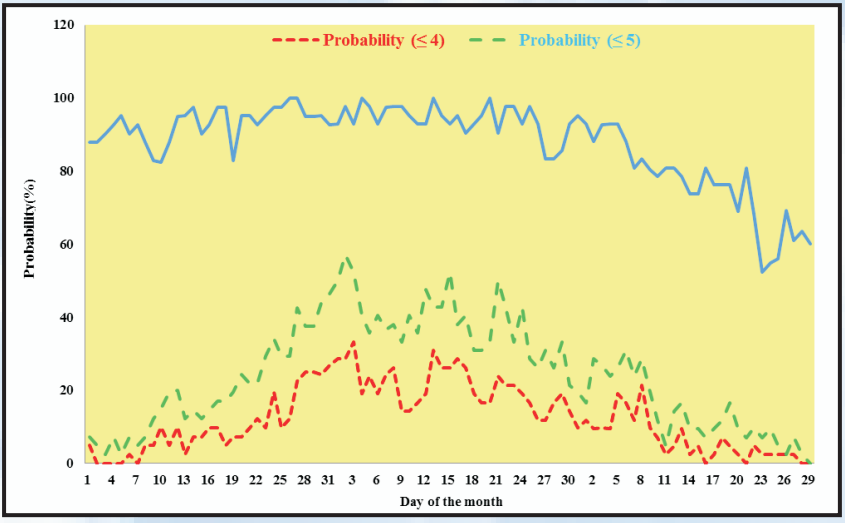


Fig 7 : Probability of Minimum Temperatures to fall below 4,5 and 10 °C during Winter Season

Humidity

The daily mean maximum and minimum Relative Humidity (RH) given in Figure 8 indicates that the maximum RH remains quite high all through the season due to relatively low temperatures. It exhibits a slight increasing trend in the first half of the season from about 80% in the beginning of December to about 87% by the second week of January. Gradual warming during the third week of February onwards caused the maximum RH to decrease. It falls to about 70% by the end of February. The minimum RH also shows a similar tendency during the season with a rise of about 5 % from the beginning of season to the first week of January and then a fall of about 20 % by the end of the season (28 February).

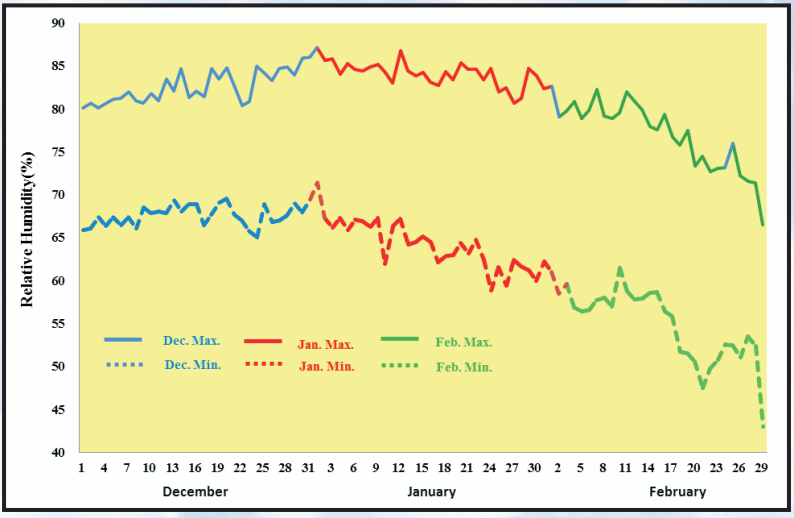


Fig 8 : Normal Maximum and Minimum Relative Humidity for Winter Season

Diurnal Variation of Relative Humidity

The diurnal variation of RH (Figure 9) indicates that the highest RH of about 82-88% is recorded at 0800 hrs IST during most of the season. It shows a sharp decline from 0800 to 1300 hrs IST with a gradual fall afterwards till 1500 hrs IST. It then registers a sharp increase reaching to 78-85% by 2200 hours in the night. The RH is highest during second half of December and whole of January at all hours of the day and the lowest in the second half of February.

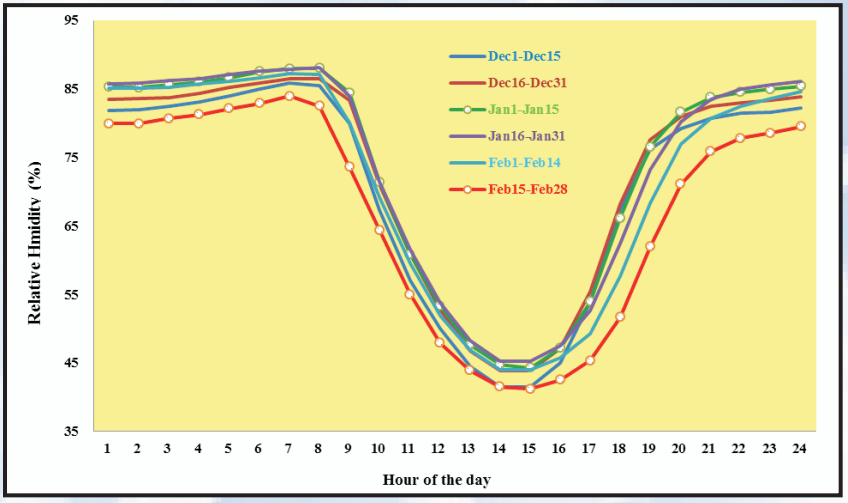


Fig 9 : Diurnal Variation of Relative Humidity during Winter Season

Rainfall

Winter contribution to total rainfall is about 5% for Dehra Dun with greater contribution by January and February months. Rainfall occurs in the association with eastward moving mid-latitude weather systems (known as Western Disturbances) which often penetrate Dehra Dun latitudes. Mean monthly rainfall is 22.3 mm, 43.3 mm and 57.5 mm for the months of December, January and February, respectively. The daily normal rainfall for each day (Figure 10) indicates that the rainfall activity increases as the season progresses. Average number of days of rain is also higher in February (3.8) than in January (3.3) and December (1.5). The probability of rainfall for each day in the season (Figure 11) indicates that the probability of rainfall increases from 5% in the beginning of December to 30% by the end of the season.

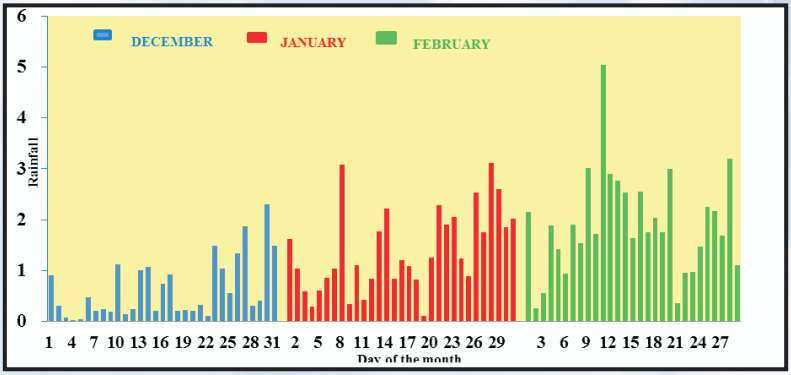


Fig 10 : Daily Normal Rainfall for Winter Season

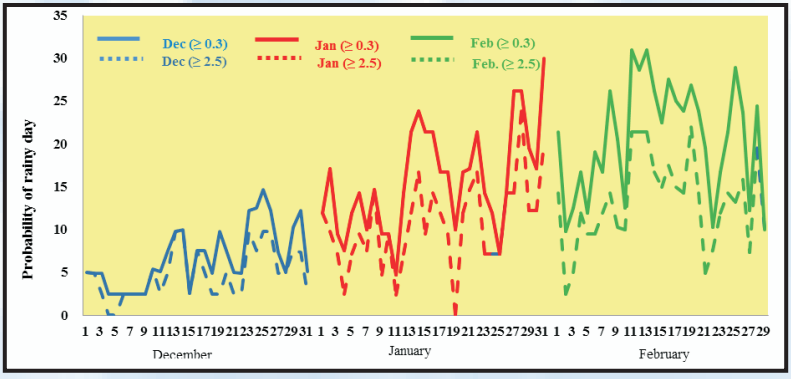


Fig 11 : Daily Probability of Rainfall for Winter Season

Heavy Rain

Heavy rains are normally not experienced during winter season. The heaviest 24 hours rainfall of winter months (1971-2010) in Figure 12 indicates that rainfall of 3-4 cm in 24 hours is not uncommon during the season. The all time records for heavy rainfall for the months of December, January and February are 108.5 mm (04 December, 1923), 79.5 mm (5 January, 1945) and 106.2 mm (5 February, 1949), respectively.

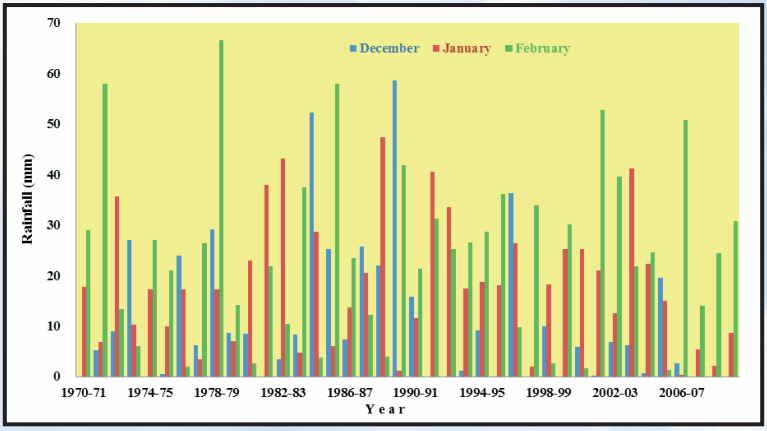


Fig 12 : Heaviest 24 Hours Rainfall for Winter Season

Thunderstorm and other Weather Phenomena

Thunderstorm activity is not very high during the season with an average of only 0.8, 2.0 and 3.4 days of thunderstorm during December, January and February, respectively. However, there is large inter-annual variation in the number of days with thunderstorms ranging from zero during some years to maximum of 2 in December (2003), 9 in January (2005) and 10 in February (2007). The diurnal variation of thunderstorms (Figure 13) indicates that the most preferred time is from mid-night to early morning (0600 h) with more than fifty percent occurring during this period. Other weather phenomena, except for fog, are not very common during the season (Table 4).

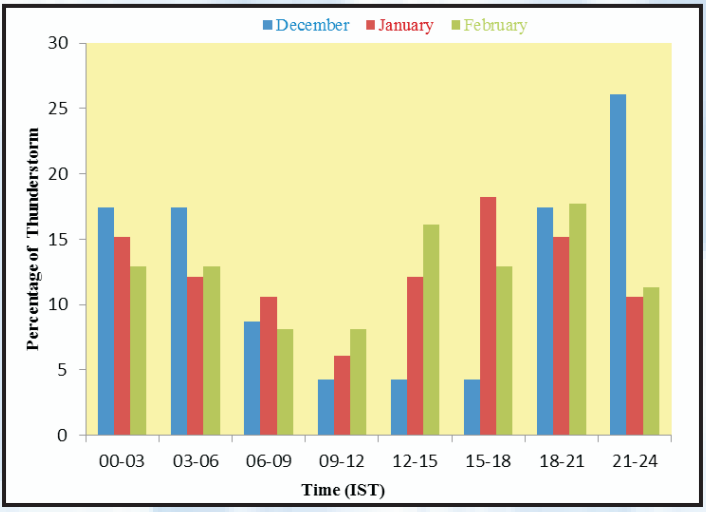


Fig 13 : Diurnal Variation of Thunderstorm during Winter Season

Fog

Poor visibility is one of the major weather phenomena of winter season. The prime reason for reduced visibility during the season is fog. Dense and prolonged fog during the season causes severe disruption of air, rail and road traffic. Fog generally sets in when the night temperatures drop after the passage of a WD. As the WDs give rainfall in the region, the moisture levels are high. Any drop in temperatures leads to the saturation of the air near the ground leading to Fog. The actual numbers of fog days for the period 2001 to 2010 are given in Figure 14. The highest numbers of days of fog in a year are 7 in January, 2003, while there was no fog in the year 2005 and 2007 and there was no fog in the month of February during the period of study. The instances of much longer duration of dense fog are rare in Dehra Dun.

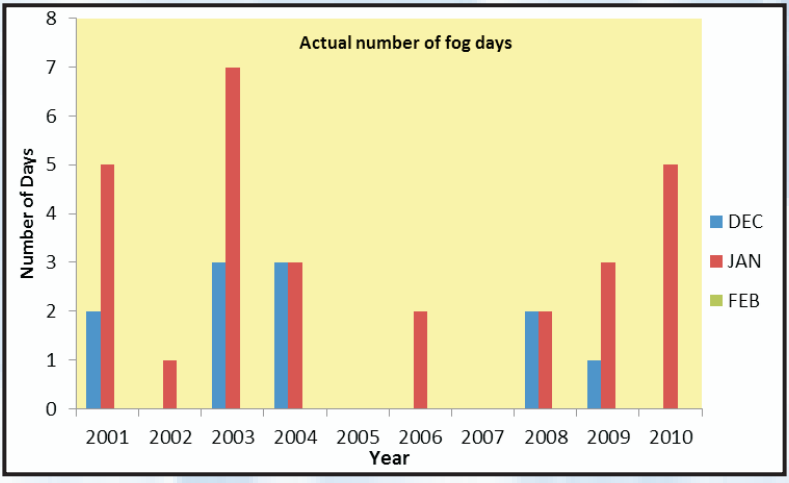


Fig 14 : Actual number of Fog days for the Winter Season

Visibility

Clear days, cold and comparitively dry winds lead to fewer fog days in Dehra Dun. On an averare there are hardly any days when the visibilty in Dehra Dun reduces below 1km or is more than 10 Km. The days with the visibility between 1-4 Km are 9 in December, 21 in January, and 7 in February . On many of the days i.e. 22 during December and February has the visibity range from 4-10km while visibility ranges between 4-10 Km for 10 days in the month of January.

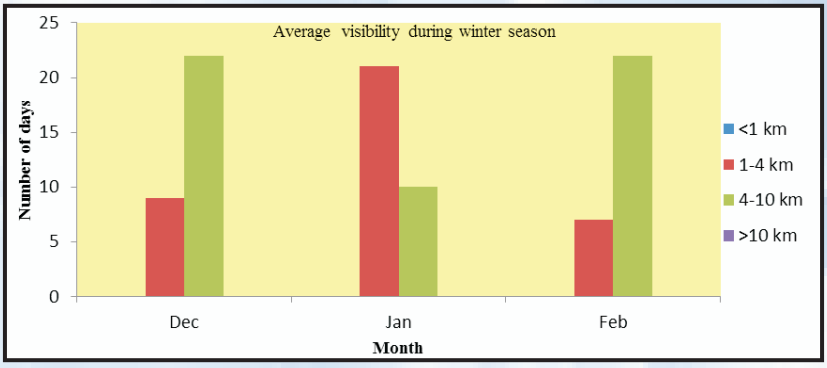


Fig 15 : Average Visibility during Winter Season

Wind

Winter is not a very windy season for Dehra Dun. Round the clock wind pattern and maximum wind could not be presented due to absence of Dynes PT instrument .The mean monthly wind roses for morning (0830 IST) and evening (1730 IST) show that the most prominent wind direction during the season is northeast in the morning and west to west-northwest in the evening. The frequencies of calm winds, both in the morning and evening are highest in the month of December and the lowest in February. Prominent wind speed varies between 1.8 to 3.6 Kmph during the season both in the morning and evening (Figure 16).

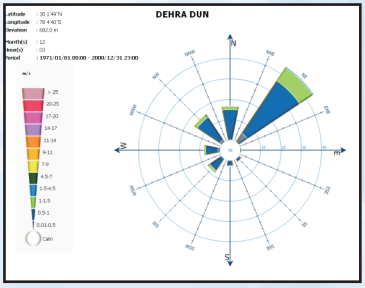


Fig 16(a) December (3 GMT)

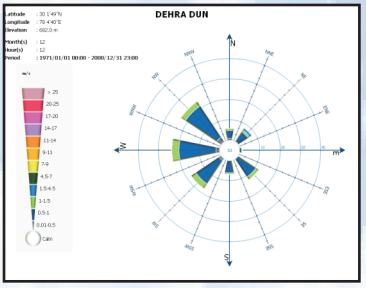


Fig 16(b) December (12 GMT)

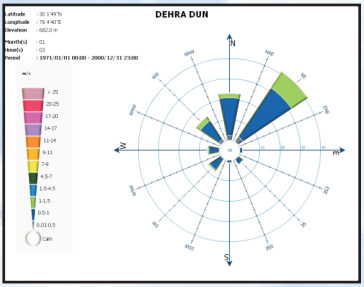


Fig 16(c) January (3 GMT)

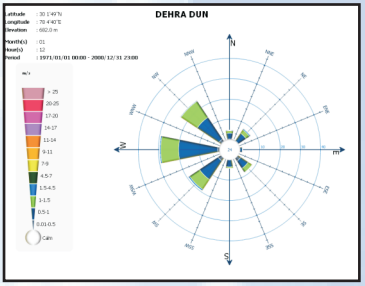


Fig 16(d) January (12 GMT)

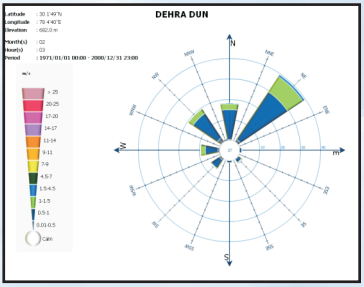


Fig 16(e) February (3 GMT)

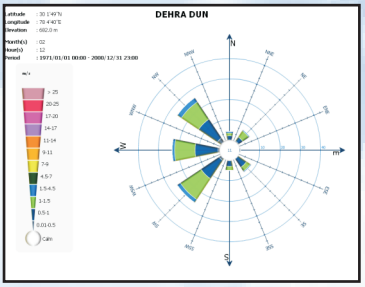


Fig 16(f) December (12 GMT)

Fig16 : Wind roses for Winter Season

Summer Season

The month of March, April and May constitute the summer season. The season is characterized by dry and hot weather in Dehra Dun. Increasing insolation and rise in temperatures with high incidence of convective weather phenomena (thunderstorms / duststorms, hailstorms and squalls) are the main weather features of the season. The WDs continue to affect through the season. Any incursion of moisture, and/ or operation of any trigger mechanism / orography create conditions conducive for explosive convective phenomena.

Daily Temperature

Continuous increase in temperatures is the main feature of the season. The daily normal temperatures for the season are given in Figure 17 below. The maximum temperatures register sharp increase from about 23 Deg. C in the beginning of March to about 35 Deg. C till the end of April. They continue to rise, though slowly, through the month of May reaching to around 36 Deg. C. The minimum temperatures also have a similar tendency rising from about 9 Deg. C in the beginning of March to about 21° C by the end of May.

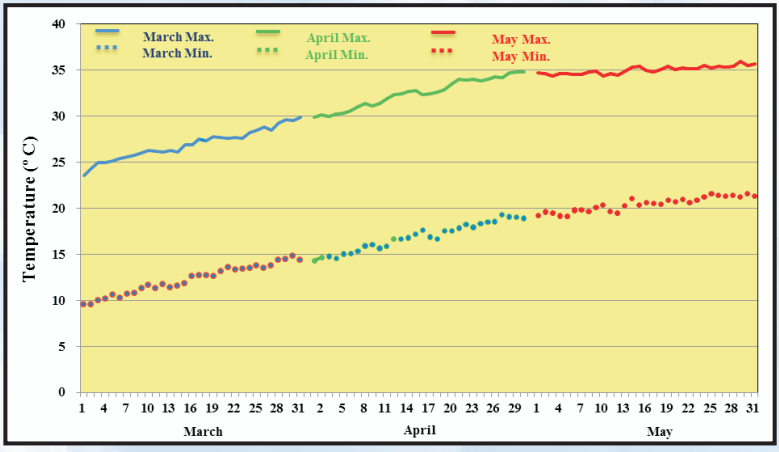


Fig 17 : Normal Maximum and Minimum Temperatures for Summer Season

Diurnal Variation of Temperature

The lowest temperatures during the day are recorded around 0700 hours IST in March, and around 0600 hours IST in April and May as the Sun starts rising earlier. The temperatures increase sharply from 0800 to 1300 hours IST and reach their peak values around 1500 hours. The decrease from afternoon to night is gradual compared to the winter season. The difference in temperatures of two fortnights of March and April is about 2-3 Deg. C at each hour of the day and about 1 Deg. C for those of May indicating the slower increase in temperatures through the month of May (Figure 18). The days in second half of the season (from 16 of April till the end of May) have 7-9 hours of temperatures in excess of 30 Deg. C.

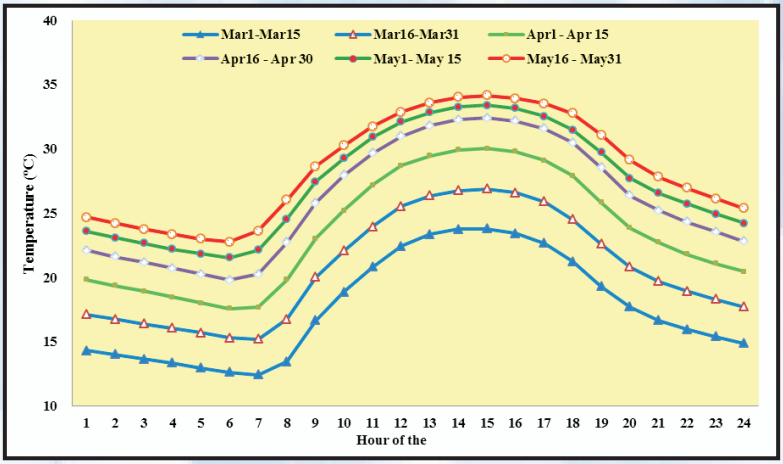


Fig 18 : Diurnal Variation of Temperatures during Summer Season

Extreme Temperature

The highest and the lowest maximum temperatures recorded during the season (1971-2010) given in Figure19 indicates that the highest maximum temperatures attained during most of the years is around 30-35 Deg. C during March, 35-37 Deg. C during April and 36-38 Deg. C during May. The highest maximum temperatures reached during the period have been 35.7 Deg. C in March (23 March, 2010), 40.8 Deg. C in April (30 April, 2009) and 42.8 Deg. C in May (05 May, 1988). However, the maximum temperature could remain significantly lower when persistent cloudiness and rainfall/ thunderstorm occur in the region in association with western disturbance. The thunderstorms / dust storms in the season are known to provide occasional relief from the oppressive heat. The maximum temperatures recorded during the period have been as low as 12.6 Deg. C for March (15 March, 1982), 13.4 Deg. C for April (03 April, 1997) and 23.1 Deg. C for May (06 May, 2000) indicating that the day-time temperatures on individual days could be quite cool and pleasant.

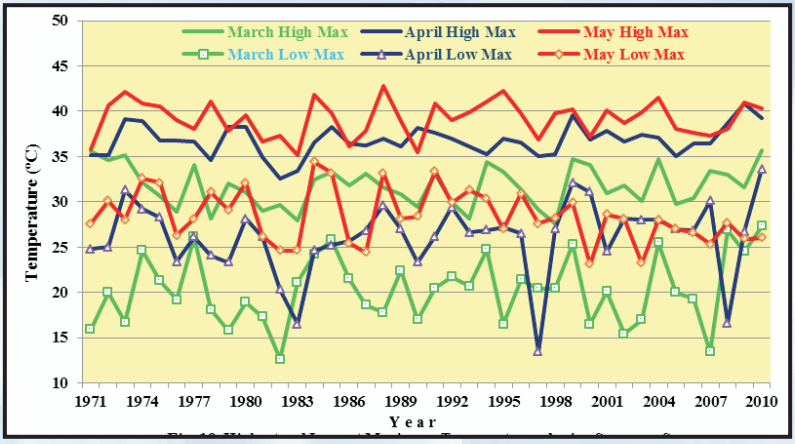


Fig 19 : Highest and Lowest Maximum Temperatures during Summer Season

The lowest and highest minimum temperatures (1971-2010) for different months given in Figure 22 indicates that the lowest minimum temperatures reach to about 08 Deg. C in March, 13 Deg. C in April and around 18 Deg. C in May during most of the years. However, they have fallen to as low as 2.4 (09 March, 1982), 7.2 (23 April, 1981) and 11.4 (16 May, 1982) Deg. C in the months of March, April and May, respectively during the study period. The highest minimum temperature on individual days could remain very high in excess of 20 Deg. C in March (very rarely), 25 Deg. C in April and May leading to very warm night conditions (Figure 20). The mean maximum/ minimum temperatures and extreme temperatures ever recorded during the season are given in Table 1.

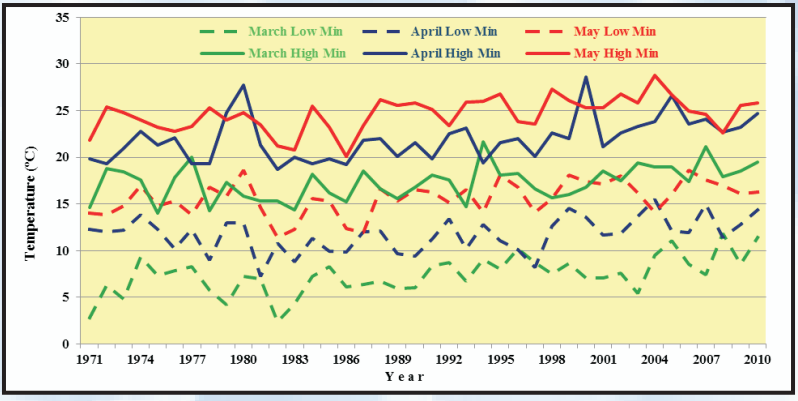


Fig 20 : Highest and Lowest Minimum Temperatures during Summer Season

The probability of maximum temperature exceeding 30°, 35° and 40° C given in Figure 21 indicates that the no such probability (35 and 40 degree Celsius) exists in the beginning of the season. The probability of temperatures exceeding ≥ 30 degree Celsius is 90% from mid April onwards .It is only after the first week of April that there is 60 % probability of the maximum temperatures exceeding 35° C. The probability of maximum temperatures exceeding 40° C does not exist in April. In May the probability of temperatures exceeding 40 degree Celsius are 5 -7 % only during second fortnight. The maximum temperatures on certain days remain 5° C or more, above normal. Such conditions are described as heat wave (Annexure I). Average numbers of heat waves are given in Table 2. The highest incidence of heat waves during the season is in the month of May (0.97) and the lowest in March (Nil). The highest number of days with heat wave has been 12 for June (1995) and 06 for May (1998).

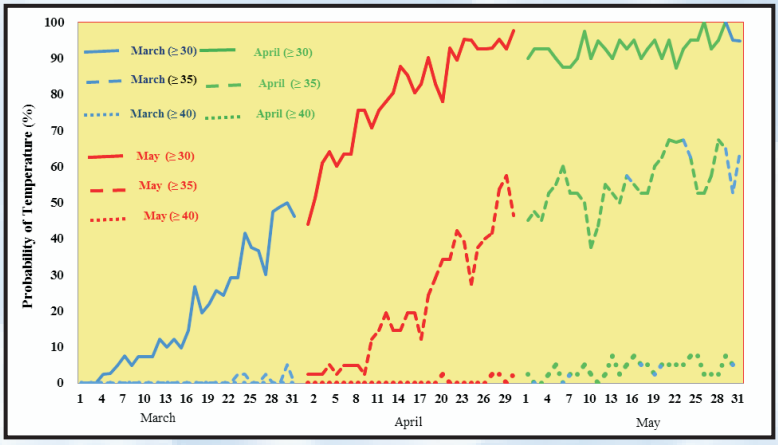


Fig 21 : Probability of Maximum Temperatures to exceed 30,35 and 40 °C during Summer Season

Humidity

The daily mean maximum and minimum RH (Figure 22) indicates that the maximum RH gradually falls through the month of March from about 70 % in the beginning to about 60 % towards end of the month. The fall is rapid in the middle of the season from around 58 % in the beginning of the April to about 50 % by the first week of May and it hovers around 55 % during rest of the season. Similar trend is observed in minimum RH, though the fall in first half of the season and rise in the second half are much gradual. Due to this, the range of daily RH is reduced from about 50% in the beginning of the season to about 33% in the first and last week of May.

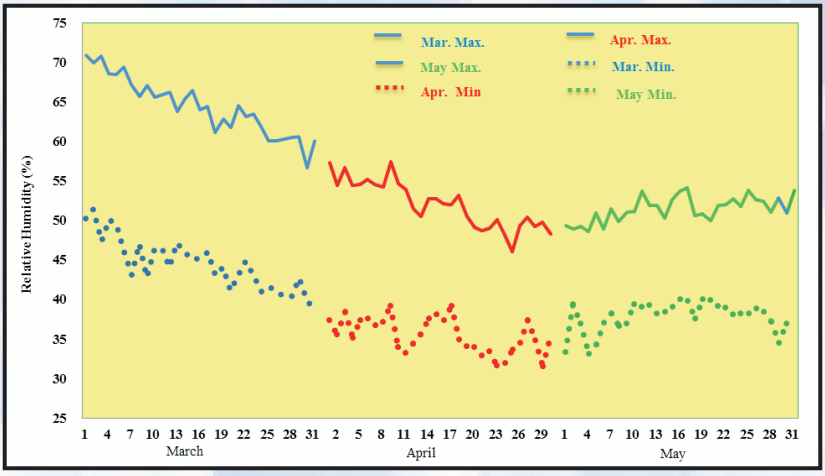


Fig 22 : Normal Maximum and Minimum Relative Humidity for Summer Season

Diurnal Variation of Relative Humidity

The air is quite dry in the season, particularly during the day hours. The minimum RH in the afternoon hours may fall to as low as 30 % on some of the days. The diurnal variation of RH (Figure 23) indicates that the highest RH is recorded around 0700 hours IST in the morning. This is an hour earlier than in the winter season. There is a steep fall from 0900 hours till 1300 hours and the RH reached its minimum around 1600 hours in the afternoon. The RH starts increasing from 1800 hours in the evening. The drop from morning to afternoon is about 40 % in March, and April and 30 % in May.

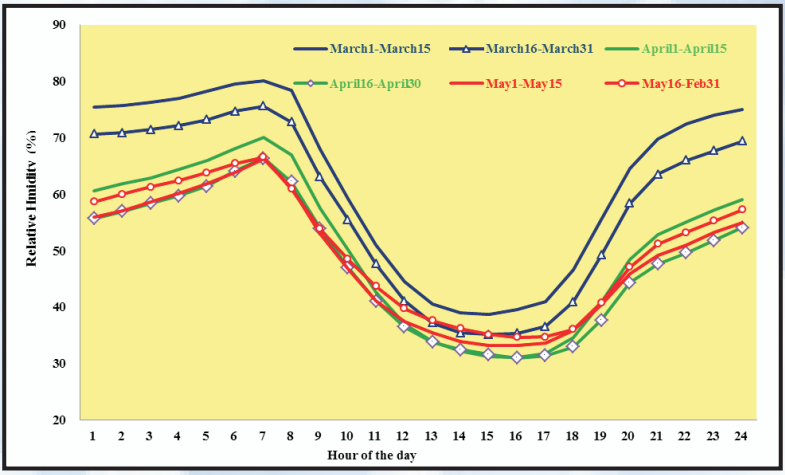


Fig 23 : Diurnal Variation of Relative Humidity for Summer Season

Rainfall

Like winters, the summer season contributes about 7 percent rainfall to the annual total for Dehra Dun. Most of the rainfall is caused by the eastward moving western disturbances and is associated with thunderstorms on most of the days. On some occasions thunderstorms are also induced by thermal convection / orography when incursion of moisture takes place from the Arabian Sea in association with the southwesterly winds. April is the driest month of the season while March and May receives about 55 mm of rainfall. The daily normal rainfall for the season (Figure 24) indicates a decrease in April and increase from the second fortnight of May.

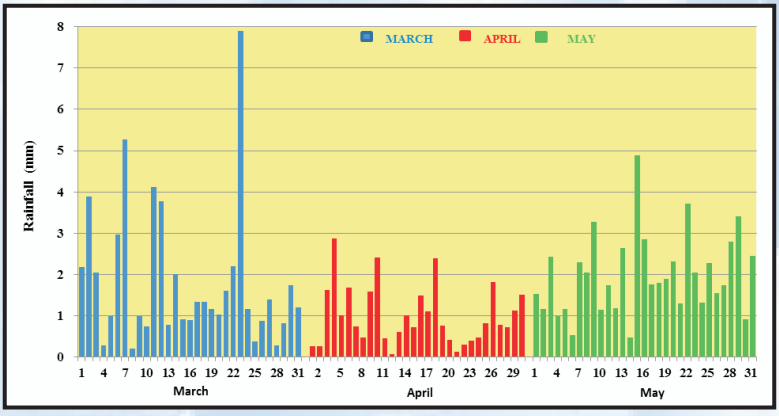


Fig 24 : Daily Normal Rainfall for Summer Season

Average numbers of days with rain are 3.5 for March, 2.4 for April and 4.2 for May. The probability of rainfall for each day in the season (Figure 25) indicates that the probability of rainfall for each day is around 15% in April and around 20 % in March and 25 % in May.

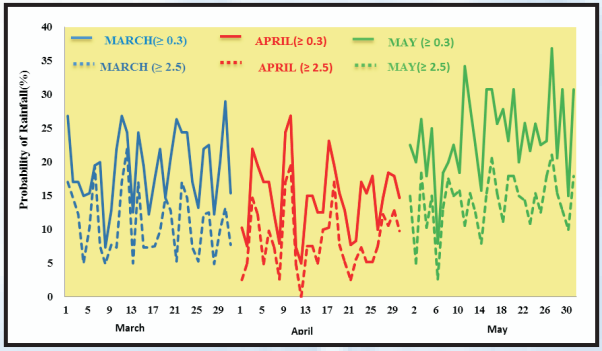


Fig 25 : Daily Probability of Rainfall for Summer Season

Like the winter season, summers also do not normally experience heavy rains. The heaviest 24 hours rainfall during different months of the season (Figure 26) indicates that the most frequently occurring heaviest 24 hours rain of the season is 2-3 cm. The all time record of heavy rainfall for March, April and May, have been 122.0 mm (26 March, 1967), 43.5 mm (02 April, 1965) and 79.3 mm (28 May, 1940), respectively.

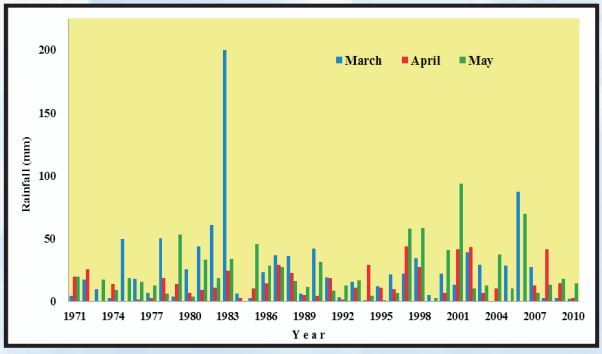


Fig 26 : Heaviest 24 Hours Rainfall for Summer Season

Thunderstorm and other Weather Phenomena

The summer season is characterized by severe weather phenomena such as dust storm, thunderstorm, hail and squall. These phenomena are associated with tall cumulonimbus clouds which form in the field of upper air divergence ahead of the eastward moving troughs in middle and upper tropospheric westerlies. Thermal convection / orographic lifting also cause thunderstorms in afternoon / evening when sufficient moisture is available in the atmosphere. The severe downdraft from the Cumulonimbus clouds result in convective dust storm / squall. For the last10 years (2001-2010) period for which the data was analyzed, the average numbers of thunderstorms during the season were 4.3 in March, 4.8 in April and 9.4 in May. The diurnal variation of thunderstorms (Figure 27) indicates that afternoon/ evening (1500-2100 h) and late night are the most preferred time for occurrence of thunderstorms with about fifty percent of the thunderstorms occurring during these periods. The average numbers of weather phenomena during the season are given in Table 4.

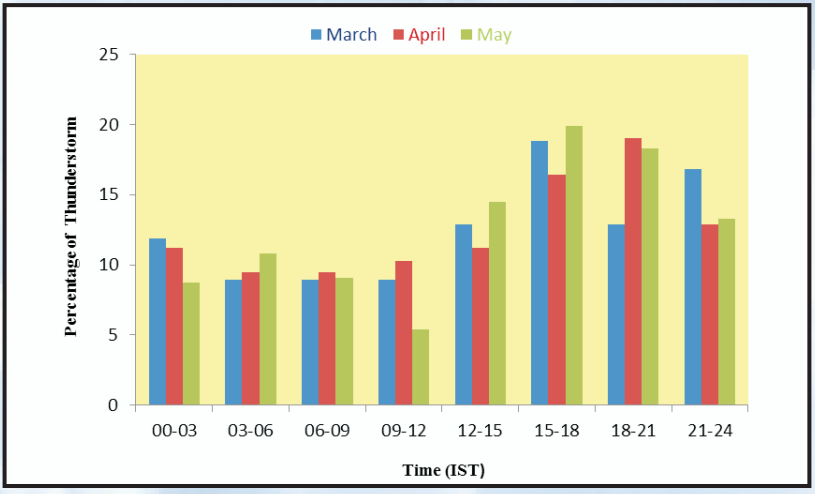


Fig 27 : Diurnal Variation of Thunderstorm Summer Season

Wind

Increased insolation and, on occasions, steep pressure gradient over northwest India makes summer a relatively windy season for Dehra Dun. In fact, it is the windiest season for Dehra Dun.

The mean monthly wind roses for morning (0830 IST) and evening (1730 IST) given in Figure 28 indicates that for the month of March in the morning (0830 IST) most prominent wind direction is northeast and in the evening (1730 IST) northwest. Where as in the month of April, most prominent wind direction is northwest in the morning and southwest in the evening whereas in the month of May both morning and evening wind directions are south easterly. During the entire season in the morning prominent wind speed is 1.8-3.6 kmph where as in the evening prominent wind speed is 3.6-5.4 kmph. The frequencies of calm winds, both in the morning and evening are highest in the month of March and the lowest in May.

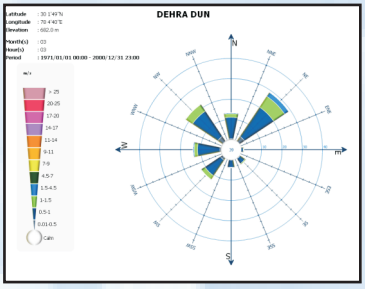


Fig 28 (a) March (3 GMT)

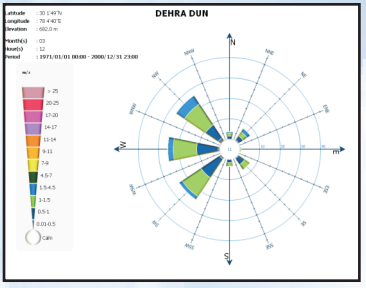


Fig 28 (b) March (12 GMT)

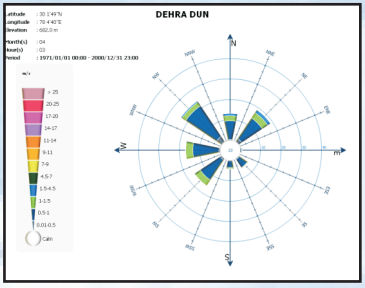


Fig 28 (c) April (3 GMT)

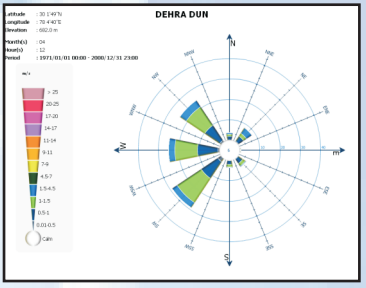


Fig 28 (d) April (12 GMT)

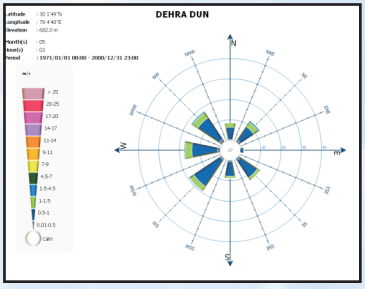


Fig 28 (e) May (3 GMT)

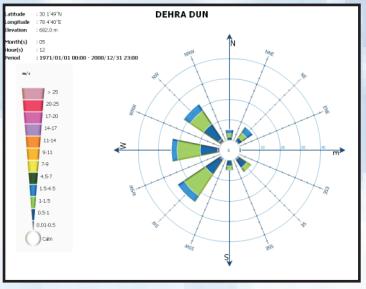


Fig 28 (f) May (12 GMT)

Fig 28 : Wind Roses for Summer Season

Monsoon Season

This is the main rainy season for most parts of India including Dehra Dun. Frequent rainfall / thunderstorms, occasional heavy rains, and the relief from the oppressive heat of the previous season are the characteristic features of the season. India celebrates its Independence Day every year on 15 August during this season.

Onset & Withdrawal of Monsoon

The southwest monsoon sets in over mainland of the country (Kerala) around 1st June. It takes about a month for the monsoon to travel through the peninsula and central parts of the country before it reaches Dehra Dun. The average date of onset of southwest monsoon over Dehra Dun is 28th June. There is large dispersal in the dates of onset of monsoon over Dehra Dun. It has set in over Dehra Dun as early as 10th June (2000) and as late as 29th July (1983). The Dates of onset of southwest monsoon over Dehra Dun from 1971 to 2011 are given in Figure 29 below. The southwest monsoon affects Dehra Dun for three months; and it withdraws around 26th September. However there is a large scatter in the dates of withdrawal also. The earliest withdrawal has been on 11 September 1982 and the farthest delay on 12 October, 1975.

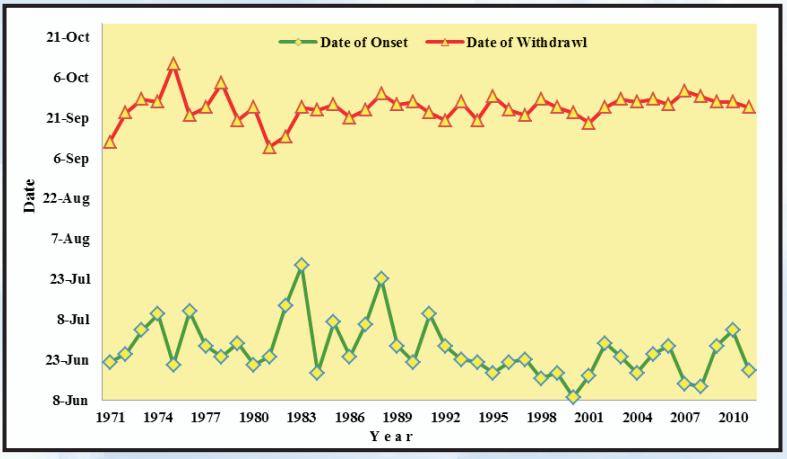


Fig 29 : Dates of Onset and Withdrawl of Southwest Monsoon over Dehra Dun

Rainfall

Monsoon is the rainy season for Dehra Dun. Though the monsoon sets in towards the end of June only, the pre-monsoon showers start from middle of June. With this, the daily normal rainfall picks up and reaches to about 10 mm per day. July and August is the rainiest period with daily normal rainfall of 15 to 30 mm. During September, there is a gradual decrease and the rainfall decreases sharply after 19th September. The daily normal rainfall represented in Figure 30 indicates that it does not increase or decrease constantly. This indicates the fluctuating behavior of rainfall over the region which is governed by the migratory monsoon systems and oscillation of the monsoon trough. July and August are the rainiest months which together contributes about 61 % to the total seasonal rainfall of 2242 mm.

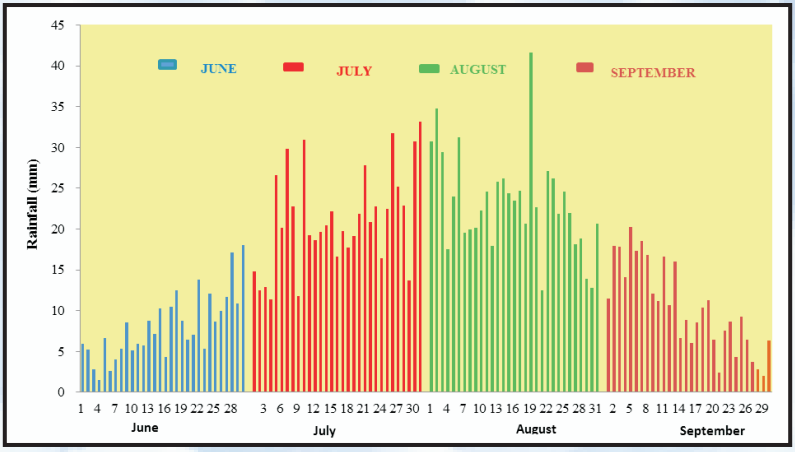


Fig 30 : Daily Normal Rainfall for Monsoon Season

The daily probability of rainfall increases from about 1-20% in the beginning of June to 40% by the end of the month (Figure 31). It further increases to 50-60% from 10th July to 20th August. It decreases sharply and falls about 10-20% by the end of the season. Average numbers of rainy days are 10 for June, 20 for July, 21 for August and 12 for September. However, there is a large inter-annual variability in the number of rainy days. They have ranged from 4 to 22 in June, 10 to 28 in July, 15 to 28 in August and 2 to 21 in September.

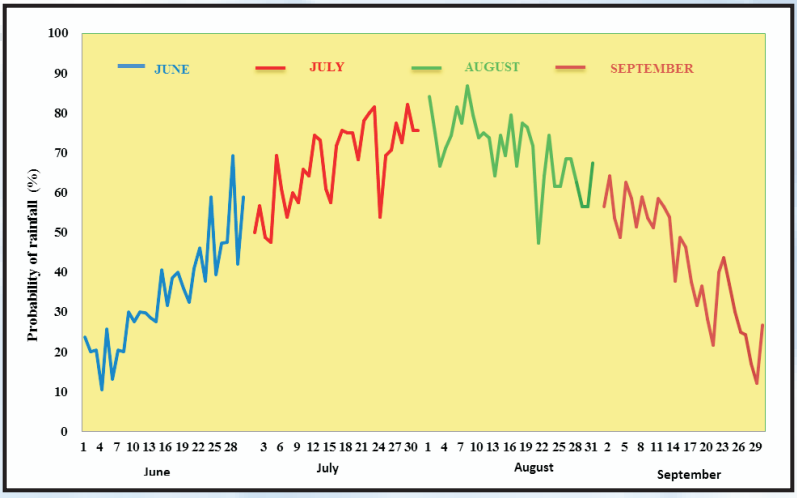


Fig 31 : Daily Probability of Rainfall during Monsoon Season

The daily probability of rainfall increases from about 1-20% in the beginning of June to 40% by the end of the month (Figure 31). It further increases to 50-60% from 10th July to 20th August. It decreases sharply and falls about 10-20% by the end of the season. Average numbers of rainy days are 10 for June, 20 for July, 21 for August and 12 for September. However, there is a large inter-annual variability in the number of rainy days. They have ranged from 4 to 22 in June, 10 to 28 in July, 15 to 28 in August and 2 to 21 in September.

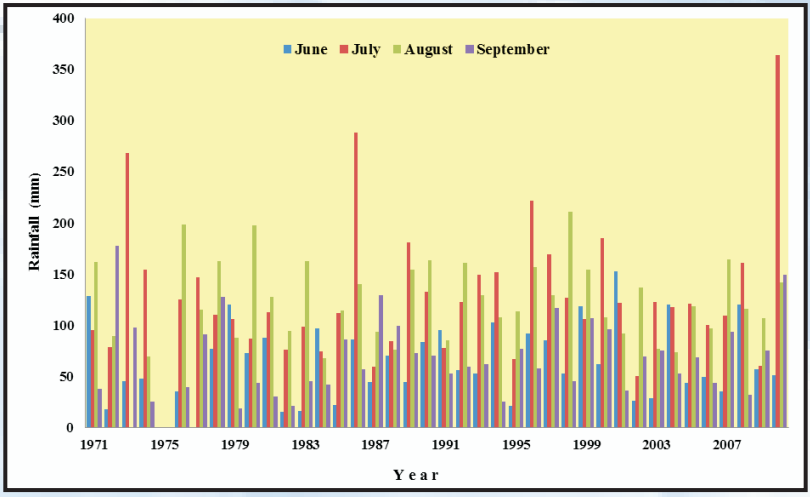


Fig 32 : Heaviest 24 Hours Rainfall for the Monsoon Season

Thunderstorm and other Weather Phenomena

The severe weather phenomena of summer season dust storm, thunderstorm and hail continue to occur during the month of June. However, the frequency of these phenomena, except thunderstorms, falls down drastically from July onwards. For the 10 years (2001-2010) Period for which the data was analyzed, the average numbers of thunderstorms during the season were 12.4 in June, 14.4 in July, 14.4 in August and 10.9 in September. The diurnal variation of thunderstorms (Figure 33) shows that afternoon (1200-1800 h) and night (1800-2100) are the most preferred time for occurrence of thunderstorms during June to September with 45-63 % of the thunderstorms occurring during these periods. The average numbers of weather phenomena during the season are given in Table 4.

The thunderstorms, on many occasions, are associated with dust storms and squalls. As the atmosphere becomes more stable with the progress of the season, their occurrence decreases. For the month of June, the highest fall in 24 hours has been 7.9° C in maximum temperature on 01 June, 1986 and 8.9° C in minimum temperature on 09 June, 1973 (Table 6).

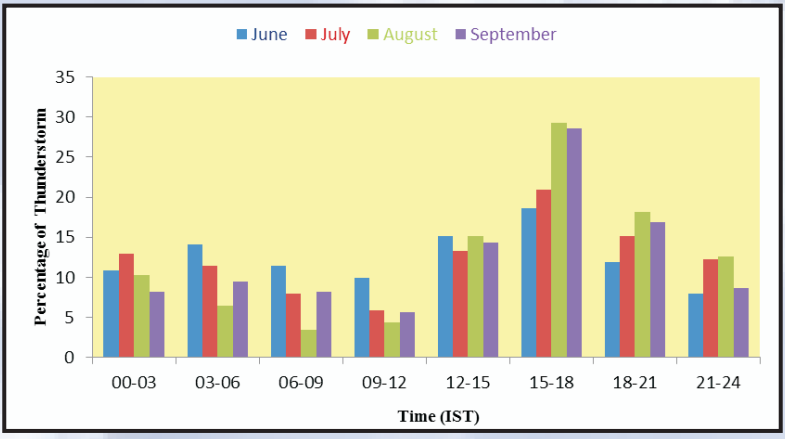


Fig 33 : Diurnal Variation of Thunderstorm during Monsoon Season

Temperature

The season begins on a not so warm note with daily normal maximum temperatures around 36 Deg. C in the beginning of June (Figure 34). They start falling after the first week of June and the drop is very steep from middle of June as pre-monsoon showers cool the atmosphere. They continue to drop further reaching around 30 Deg. C till the end of the season. A slight warming is noticed in the second half of September as the monsoon withdraws from the region. The minimum temperatures, however, do not show any drop and are around 22 Deg. C till the first week of September. The slow decrease continues from second week of September and they reach around19 Deg. C by end of the season.

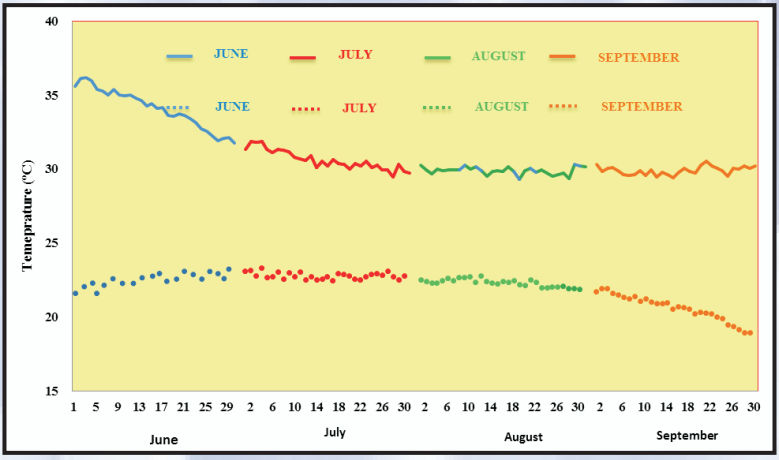


Fig 34 : Normal Maximum and Minimum Temperatures during Monsoon Season

Diurnal Variation of Temperature

The Diurnal Variation in Temperatures given in Figure 35 indicates that the lowest temperatures in the day are realized around 0600 IST during all the months of the season. The highest temperatures in the day are realized around 1500 IST all through the season. Monsoon is the season of least diurnal variation in temperatures. The figure indicates a decrease in the range of temperature as the monsoon approaches. It decreases from 9 Deg. C during the first half of June to 6 Deg. C in the second half and further to 5 Deg. C in the first half of July and it remains around 5 Deg. C till end of August and is about 6 Deg. C in the first half of September. The diurnal range increases to 7 Deg. C in the second half of September with the withdrawal of monsoon. The rise in temperatures during the day is much steeper in the first half of June and the second half of September. Increased rainfall activity during the rest of the season keeps the range lower. The peak hour temperatures during the two months period of mid-July to mid-September are about 5 degree cooler than those of the first fortnight of June.

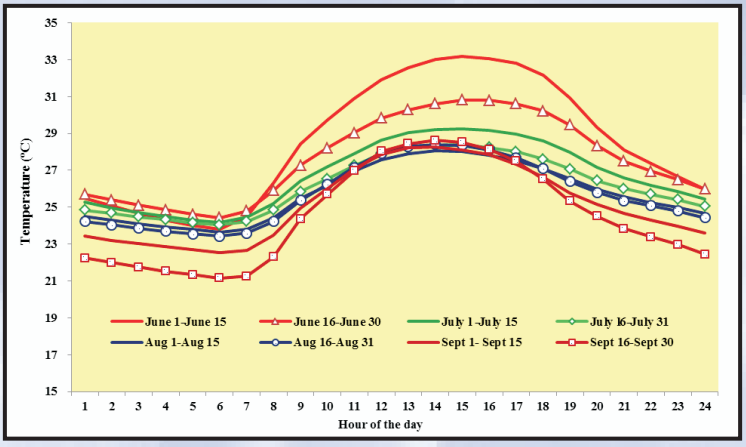


Fig 35 : Diurnal Variation of Temperatures during Monsoon Season

Extreme Temperature

The highest and lowest maximum temperatures recorded in the month of June-September during 1971-2010 given in Figure 36 indicate that highest maximum temperatures during June reach 39 to 42 Deg. C during quite a many years. It reached 43.7 Deg. C in the year 1995 However, the maximum temperature during 2000 was only 33.6 Deg. C (13 June, 2000). Highest maximum temperatures attained during July are more variable mostly ranging between 34 and 36 Deg. C. They have reached 39.1 Deg. C during 1982 (05 July). These temperatures, during most of the years have ranged between 32 and 34 Deg. C during August and September. However, the weather on individual days could become very pleasant with quite low maximum temperature. This normally happens on the days of widespread rains in the region. The lowest maximum temperatures recorded during different months have been 22.2 Deg. C (15 June, 1976), 23.8 Deg. C (29 July, 1989), 22.4 Deg. C (28 August, 1989) and 18.6 Deg. C (17 September, 2002).

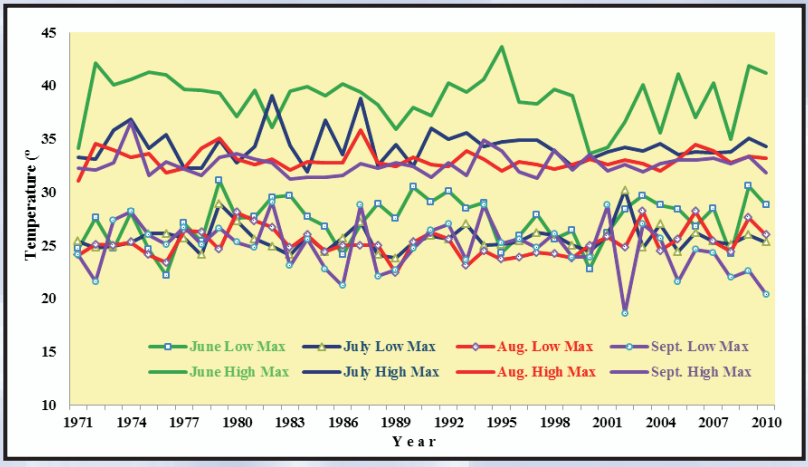


Fig 36 : Highest and Lowest Maximum Temperature during Monsoon Season

The lowest and highest minimum temperatures for the season given in Figure 37 indicates that the most frequently occurring lowest minimum temperature is between 18 and 20 Deg. C during the season. However, minimum temperatures occasionally fall below 18 Deg. C, particularly in the months of June and September. The lowest minimum temperature ever recorded in the season have been 13.1 (01 June, 1986), 12.8 (15 July, 1982), 12.4 (03 August, 1971) and 12.8 Deg. C (22 September, 1982). Persistent widespread rains and the consequent cooling of the atmosphere results in these abnormally low minimum temperatures. However, the minimum temperatures could remain significantly high on certain days. This normally happens due to either cloudy nights or the dust suspended in the atmosphere allowing little nocturnal cooling. The highest minimum temperatures have exceeded 25 Deg. C almost every year during the month of June, many in July, occasionally during August and never in September during the last 40 years. The extreme temperatures for each month are given in Table 1.

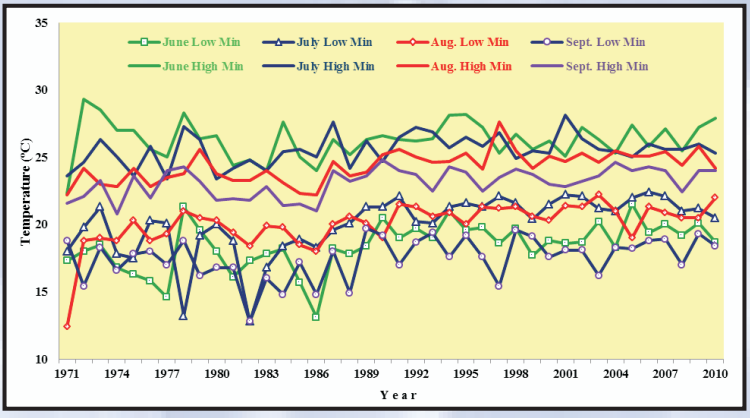


Fig 37 : Lowest and Highest Minimum Temperature during Monsoon Season

The probability of maximum temperatures to exceed 30, 35 and 40° C during Monsoon season given in Figure 38 indicates that the probability of maximum temperatures to exceed 30° C is above 95% till middle of June It starts falling from middle of June due to the beginning of the pre-monsoon showers. It further drops from July to the end of August and the fall is due to the onset of monsoon, while the probability to exceed 30° C varies from 60-70% during September. The probability of maximum temperatures to exceed 35° C is above 50% till middle of June. It falls to around 10% by the end of June. There is a steep fall to almost 0% by the second week of July and remains so till the end of the season. The probability of maximum temperatures to exceed 40° C is quite low and varies from 10-15 % in the first week of June and then falls close to 0% during the rest of the season.

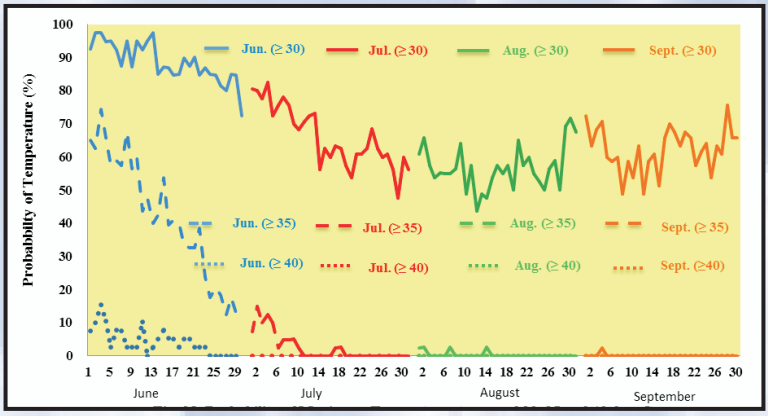


Fig 38 : Probability of Maximum Temperatures to exceed 30, 35 and 40 °C

Humuduty

The daily mean maximum and minimum Relative Humidity (RH) given in Figure 39 indicates that the maximum RH is quite low in the beginning of the season (55%) due to mostly dry weather conditions in first half of June. It exhibits a sharp increase in the second half of June and reaches to about 83% by the end of the month as the wet season begins. It continues to rise and reaches to 90% by the third week of July. It starts falling from third week of August and reaches around 75% in the last week of September. The daily mean minimum RH also shows a similar trend rising from 40% in the beginning of the season to about 80% by the third week of July. The fall in the end of the season is much steeper from 80% in the second week of September to about 60% by the end of the season.

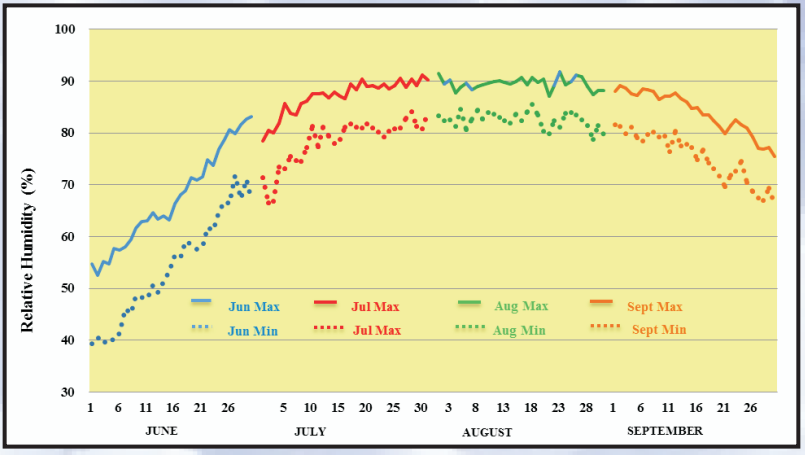


Fig 39 : Normal Maximum and Minimum Relative Humidity for the Monsoon Season

Diurnal Variation of Relative Humidity

The diurnal variation of RH (Figure 40) indicates that the highest RH is recorded at 0700 IST in the season. It declines from 0800 to 1300 hrs IST with a gradual fall afterwards till 1500 hrs IST. The lowest RH at the hours is recorded in the first fortnight of June; and the highest in the second fortnight of August. The decrease in RH from morning to afternoon is the steepest during the second fortnight of September indicating large diurnal variation.

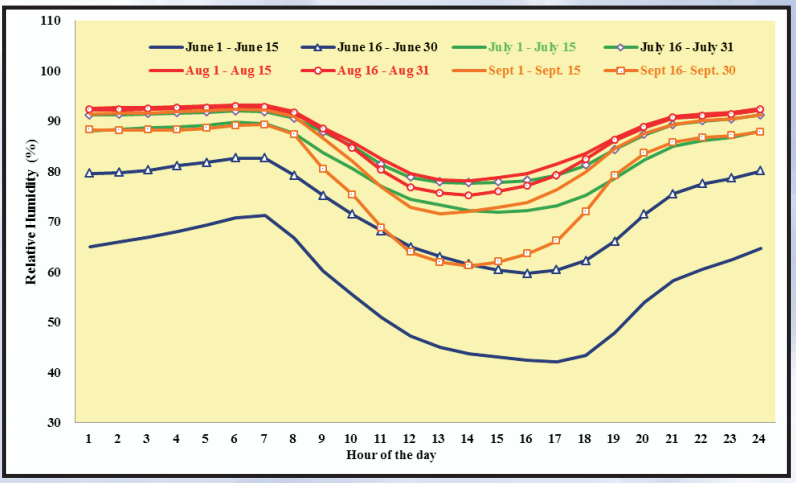


Fig 40 : Diurnal Variation of Relative Humidity during Monsoon Season

Wind

The average wind speed decreases in the monsoon season compared to the summer season. This decrease continues as the season progresses. The average winds are the strongest in June and fall progressively till the end of August. They again increase in the first fortnight of September before falling to their lowest values in the second fortnight of September.

During Monsoon season average wind speed in the morning and evening is 1.8-3.6 kmph for Dehra Dun.

The mean monthly wind roses for morning (0830 IST) and evening (1730 IST) given in Figure 41 indicates that for the month of June in the morning (0830 IST) most prominent wind direction is northeast and in the evening (1730 IST) southeast, in the month of July & August, most prominent wind direction is southeast in the morning and northwest in the evening and in the month of September most prominent wind direction is northeast and northwest in the evening. During the whole season both in the morning and evening prominent wind speed is 1.8-3.6 kmph. The frequencies of calm winds, both in the morning and evening are highest in the month of August and the lowest in June.

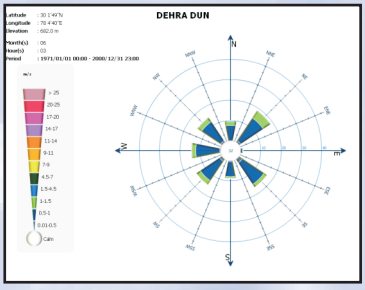


Fig 41 (a) June (3 GMT)

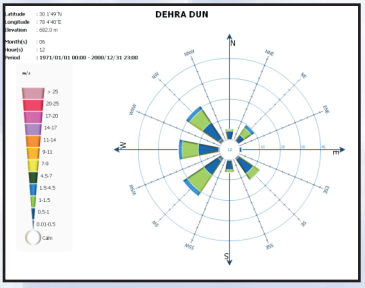


Fig 41 (b) June (12 GMT)

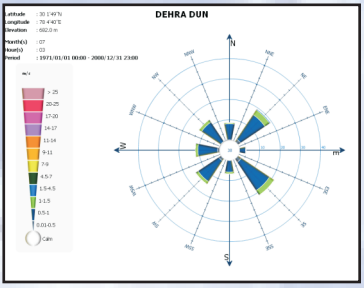


Fig 41 (c) July (3 GMT)

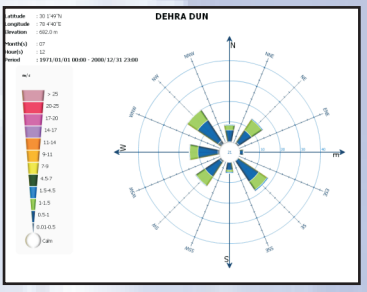


Fig 41 (d) July (12 GMT)

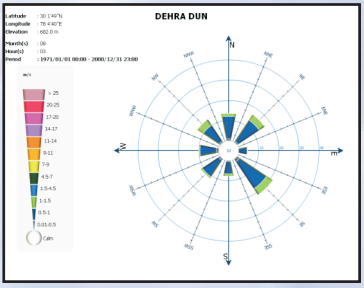


Fig 41 (e) August (3 GMT)

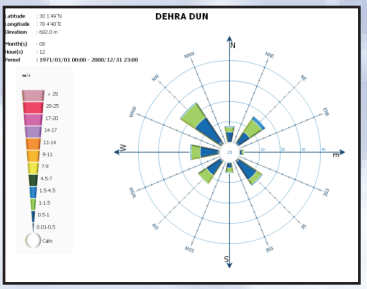


Fig 41 (f) August (12 GMT)

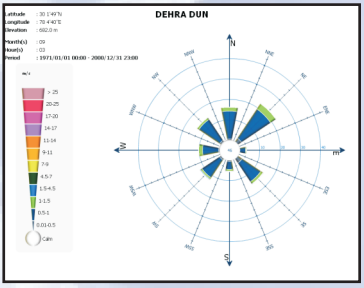


Fig 41 (e) September (3 GMT)

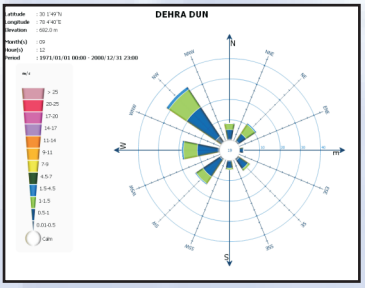


Fig 41 (f) September (12 GMT)

Fig 41 : Wind roses for the Monsoon Season

Post Monsoon Season

The post monsoon season (October-November) is a transit season between monsoon and winters. The season is characterized by generally dry and pleasant weather with a constant decrease in both day and night temperatures. With the retreat of southwest monsoon from the region in the latter half of September, weather becomes fairly dry.

Temperature

The season is marked by decreasing temperatures (Figure 42) due to continued south ward march of the sun. The mean maximum temperatures fall from 30° C in the beginning of October to 24° C towards end of the season. The mean minimum temperatures fall from 18° C in the beginning of the season to 8° C by its end. The decrease in both maximum and minimum temperatures is relatively smooth through the season.

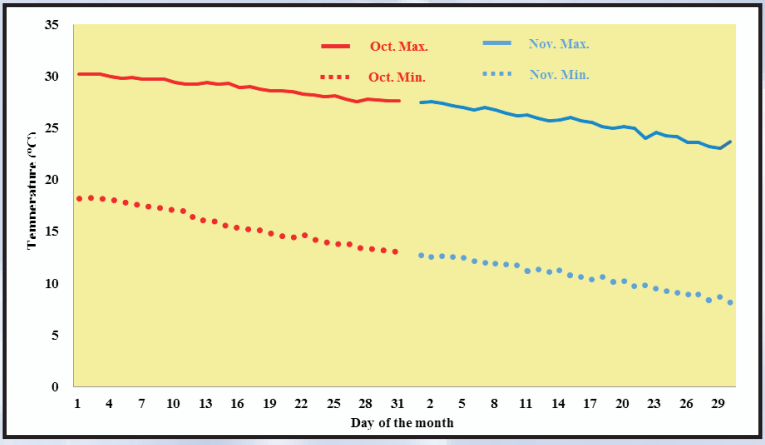


Fig 42 : Normal Maximum and Minimum Temperatures for Post-Monsoon Season

Diurnal Variation of Temperature

The diurnal variation of temperatures in the season (Figure 43) is similar to many other months in the year with lowest temperatures in the day occurring around 0700 IST. A sharp increase is noticed from 0800 to 1300 IST before they peak around 1400 IST. The fall in temperatures from afternoon to evening becomes steeper as the season progresses. The drop in temperatures from 1700 IST to mid night is about 7° C.

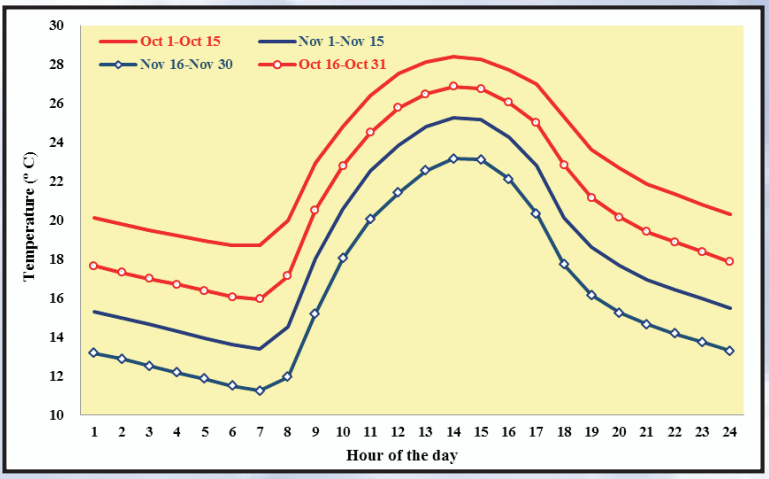


Fig 43 : Diurnal Variation of Temperatures for Post-Monsoon Season

Extreme Temperature

The highest maximum and lowest maximum temperatures recorded in the month of October and November during 1971-2010 given in Figure 44 show that highest maximum temperatures during October are realized between 30-32° C and those during November between 27 and 29° C. However, they have touched 33.3° C in 2009 (02 October) during October. It reached only up to 19.9° C in October,(17, 1986) by persistent rainfall activity with total monthly rainfall of 164.5 mm (against a normal 43 mm) and 8 numbers of days with rain. The maximum temperature on 3 November, 2001 reached 30.5° C, and is a step closer to the all time record for the month. The maximum temperature also remain quite low on individual days (19.9 ° C on 17 October, 1986 and 15.8° C on 29 November, 1980).

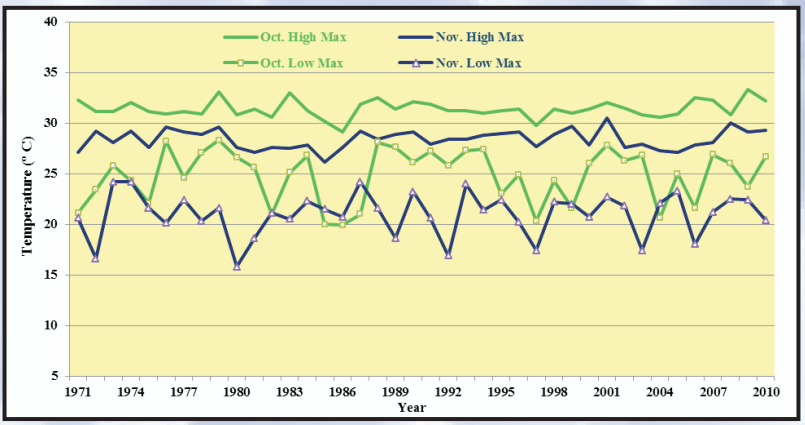


Fig 44 : Highest and Lowest Maximum Temperatures during Post-Monsoon Season

The lowest and highest minimum temperature for the two months given in Figure 45 indicates that the most frequently occurring lowest minimum temperature is 10-12° C during October and 6-8° C during November. However, minimum temperatures have reached as low as 8.4° C on 24 October, 1983 and 4.1° C on 27 November, 1985. The minimum temperatures also remain significantly high on certain days.

The highest minimum temperatures during the study period have been 23.6° C on 03 October, 1998 and 19.5° C on 20 November, 1995. Like the winter season, the high minimum temperatures are caused by cloudy nights and warm air incursion ahead of an approaching western disturbance; and the significantly low minimum temperatures are caused by cold northerly winds from the adjoining Himalayan ranges after the passage of a western disturbance.

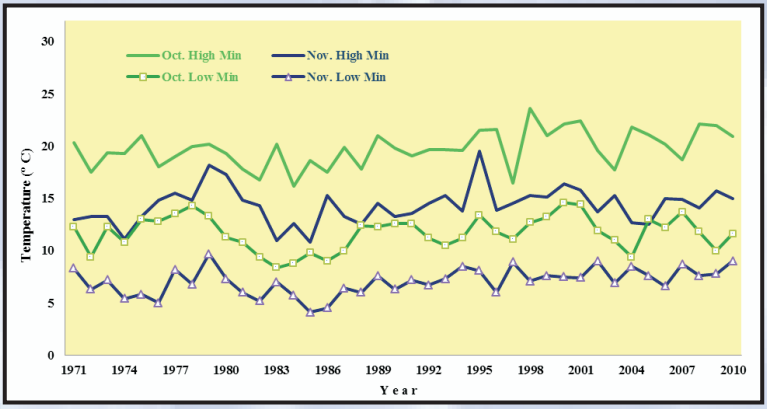


Fig 45 : Lowest and Highest Minimum Temperatures during Post-Monsoon Season

The probability of maximum temperature to exceed 30 Deg. C (Figure 46) is greater than 60% till the first week of October. It falls to around 30% in the middle of the month and falls to around less than 0 % by the end of the month and remains so till the end of November. The probability of the minimum temperature to fall below 10 Deg. C is below 5 % during the second fortnight of October and it rises to 20% by end of first fortnight of November and reaches to 80% by the end of November.

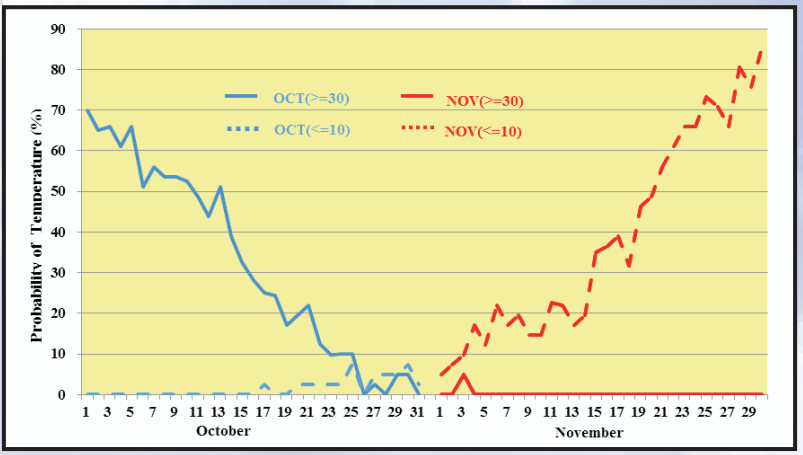


Fig 46 : Probability if Maximum Temperature to exceed 30 °C and of Minimum Temperature to fall below 10 °C during Post-Monsoon Season

Relative Humidity

Though the weather becomes dry in the season, the maximum RH continues to remain high as the fall in temperatures compensate for the decrease in atmospheric water vapour content. Large changes in RH are not experienced with the progress of the season. The maximum RH is around 75% throughout the season except towards the end of November when it becomes 80% (Figure 47). The minimum RH is around 60-65% during the season.

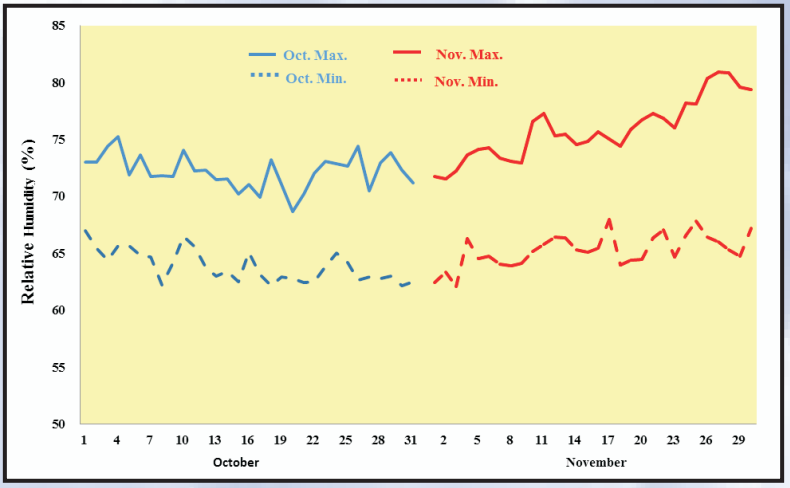


Fig 47 : Normal Maximum and Minimum Relative Humidity for Post-Monsoon Season

Diurnal Variation of Relative Humodity

The RH has the maxima around 0700 IST and minima around 1400 IST (Figure 48). The steepest fall in RH from morning to noon; and the steepest rise from afternoon to night is experienced in this season indicating that the diurnal range of RH is the highest in this season.

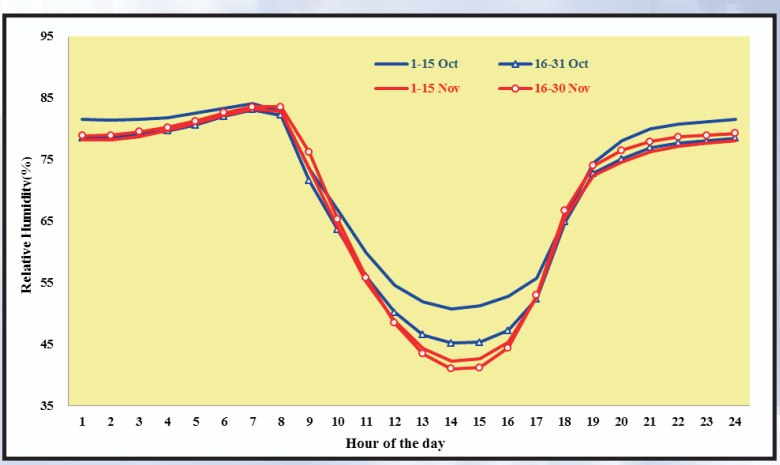


Fig 48 : Diurnal Variation of Relative Humidity during Post-Monsoon Season

Rainfall

Southwest monsoon withdraws from northwest India during the second half of September and from Dehra Dun around last week of September. However, the season is not completely devoid of rain/ thundershower activity as they occur in association with eastward moving mid- latitude weather systems and the westward moving tropical disturbances which cause incursion of moisture in the northern India. The daily normal rainfall is around 1-2 mm during the first fortnight of October (Figure 49).

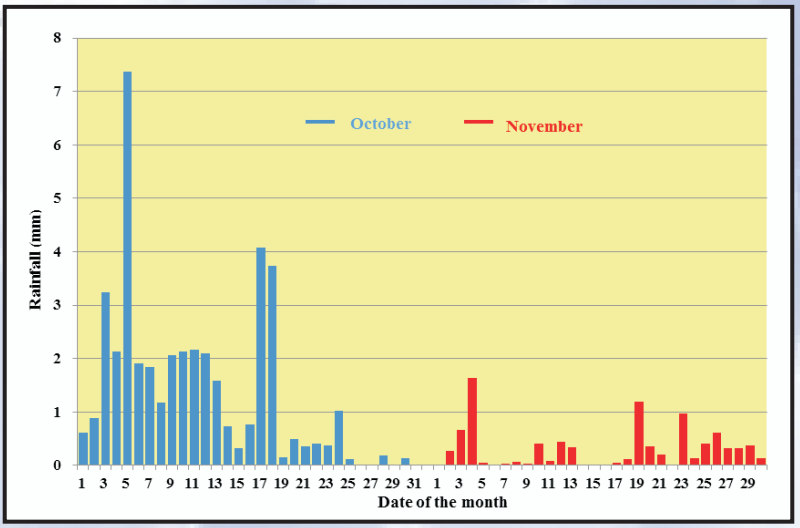


Fig 49 :Daily Normal Rainfall for the Post-Monsoon Season

Subsequently there is a decrease and the normal rainfall is less than 0.5 mm per day on most of the days. The average monthly total rainfall is 42.0 mm for October and 9.0 mm for November.

The probability of rainfall for individual days shows large fluctuations indicating uncertain behaviors of rainfall in the season (Figure 50). There is a decrease from 10-15% in the beginning of October around 5 % during November. The marginal increase is noticed in the second half of November. Average number of rainy days is 2.2(3.2) in October and 0.7(1.3) in November.

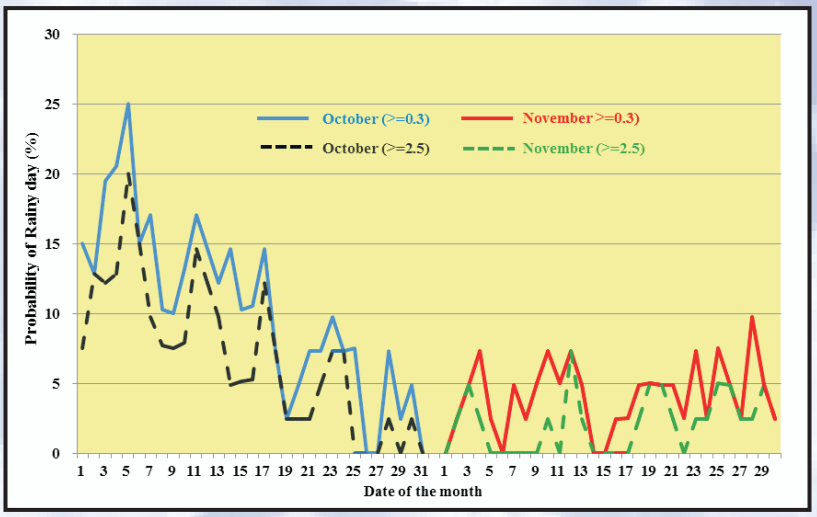


Fig 50 :Daily Probability of Rainfall during Post-Monsoon Season

Heavy Rainfall

Generally, heavy rains are not experienced during the season. The heaviest rainfall of 24 hours during October and November for the period 1971-2010 given in Figure 51 indicates that it is less than 1 cm in majority of years. However, a 24 hour rainfall amount of 1-2 cm is not uncommon. During the above 40 years period there has been four occasions of heavy rainfall for the month of October (78.0 mm on 5th October 1973, 66.8 mm on 09th October, 1985, 123.9 mm on 18th October, 1998 and 110.3 mm on 5th October 2009) and nil for November. The all time records for heavy rainfall are 137.4 mm for October (09th October, 1956) and 78.7 mm for November (19th November, 1911).

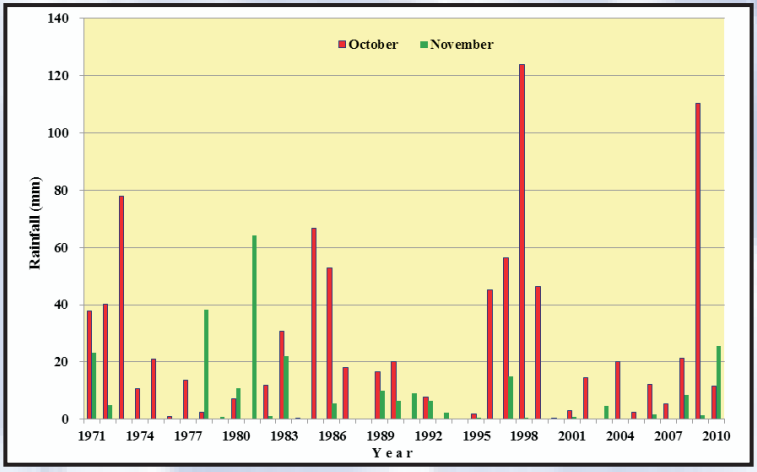


Fig 51 : Heaviest 24-Hours Rainfall for the Post-Monsoon Season

Thunderstorm and other Weather Phenomena

As the normal rainfall activity is less, thunderstorm activity is also not very pronounced during the season. The average number of thunderstorms is 2.3 for October and 0.6 for November. The most preferred time for occurrence of thunderstorms is from noon to evening (1200-2100 IST) for October during which more than 50% of the thunderstorms occurred. For the month of November, the most preferred time for thunderstorms is 0000 to 0300 IST and from noon to evening (1200-2100 IST. The secondary maxima for the month are from 1200 to 1800 IST (Figure 52).

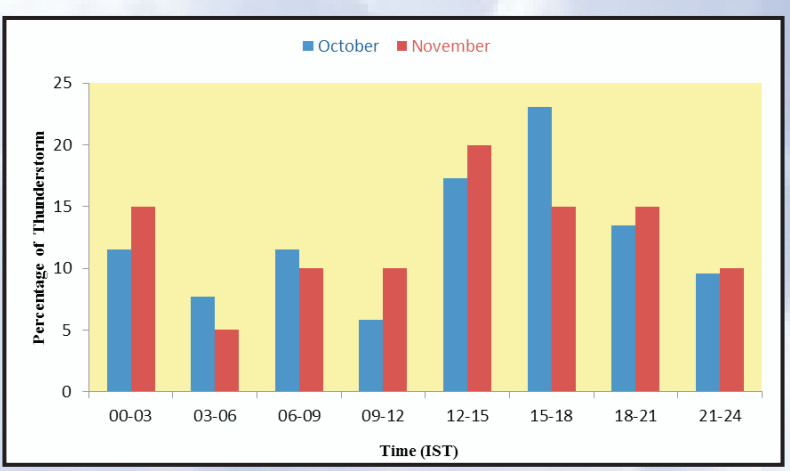


Fig 52 : Diurnal Variation of Thunderstorm during Post-Monsoon Season

Wind

Winds generally are not very strong during the season. The mean monthly wind roses for morning (0830 IST) and evening (1730 IST) given in Figure 53 indicates that during the entire season in the morning (0830 IST) most prominent wind direction is northeast and in the evening (1730 IST) is Northwest while in the month of July & August, the most prominent wind direction is southeast in the morning and northwest in the evening. In the month of September most prominent wind direction is northeast in the morning and northwest in the evening. In both the months the prominent wind speed in the morning as well as in the evening is 1.8-3.6 kmph. The frequencies of calm winds both in the morning and evening are highest in the month of November and the lowest in October.

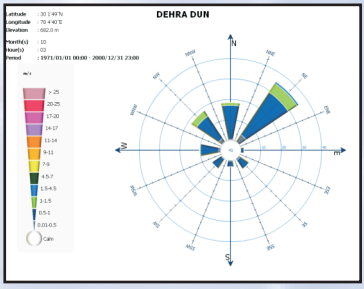


Fig 53 (a) October (3 GMT)

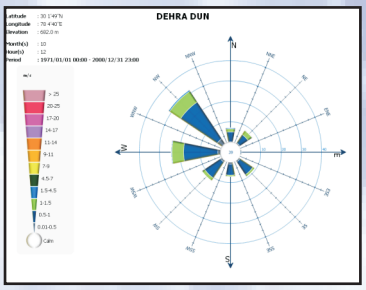


Fig 53 (b) October (12 GMT)

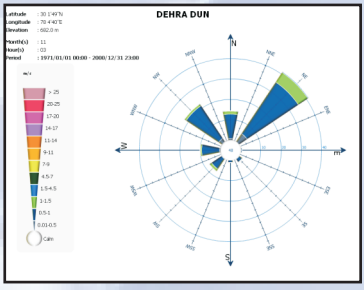


Fig 53 (a) November (3 GMT)

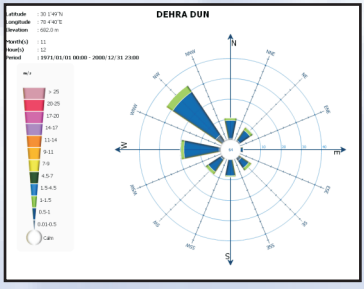


Fig 53 (b) November (12 GMT)

Fig 53 : Wind Roses of the Post-Monsoon Season

Weather on National Festival and State Days

The Independence Day (15 August), Republic Day (26 January) and Gandhi Jayanti (02 October) are the National Festivals of India which are celebrated with great patriotic fervor all over the country. The main functions on these days are held in the State capital – Dehra Dun. The general weather conditions of these days are described in the following section.

Independence Day

Independence Day of India is celebrated on 15th August every year to commemorate its independence from British rule and its birth as an independent nation in 1947. Flag-hoisting ceremonies are conducted all over the state. The main event takes place at the parade ground in Dehra Dun where the Chief Minister hoists the national flag. The Chief Minister pays his tribute to the leaders of the freedom struggle of India and meets the freedom fighters from the state and distributes awards to sports personalities and best officers and / workers of the state government . Presence of large number of school children adds colors to these celebrations. Partly cloudy to cloudy conditions with moderate temperatures and high probability of rain are the main weather features of Dehra Dun on the Independence Day. The maximum / minimum temperature and rainfall of 15 August for the last 40 years (1971-2010) given in Figure 54 indicates that during most of the years, the maximum temperature on independence range between 29° and 31° C. However it has been as high as 32.9° C in 1984 and as low as 24.7 C in 1971. The minimum temperatures range between 20° and 22° C during most of the years. The lowest minimum temperature recorded during the period has been 19.7° C (1986) and the highest 25.1° C (2005). The probability of rainfall is around 80% as the rainfall was recorded in Dehra Dun on 33 years on 15th August, out of the last 40 years, the highest being 128 mm recorded on 15th August, 1981.

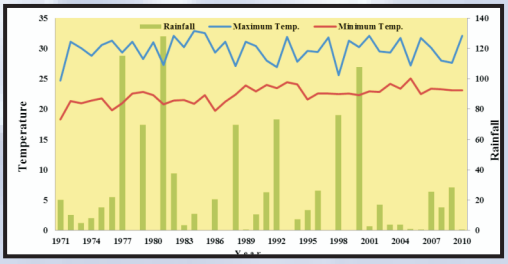


Fig 54 : Maximum and Minimum Temperatures and Rainfall of Dehra Dun on Independence Day

Diurnal Variation of Temperature on Independence Day

The diurnal variation of temperature on the Independence Day is given in Figure 55. The green line indicates the average temperature of different hours of the day. The red and blue lines indicate how the highest and the lowest temperatures, respectively, are recorded at different hours of the day. The figure indicates that on an average, the lowest temperature of about 24° C is recorded around 0600 IST in the morning. The temperature increases at a rate of about 1° C per hour from about 24° C at 0800 IST to 28° C at 1200 IST. It remains around 28° C till 1800 IST in the evening. It then gradually falls to around 25° C by mid night. Temperatures in excess of 30° C have also been recorded on the Independence Day from late forenoon (1100 IST) to the evening (1800 IST). However, pleasant low temperatures (less than 25° C) have been realized all through the Independence Day in certain years.

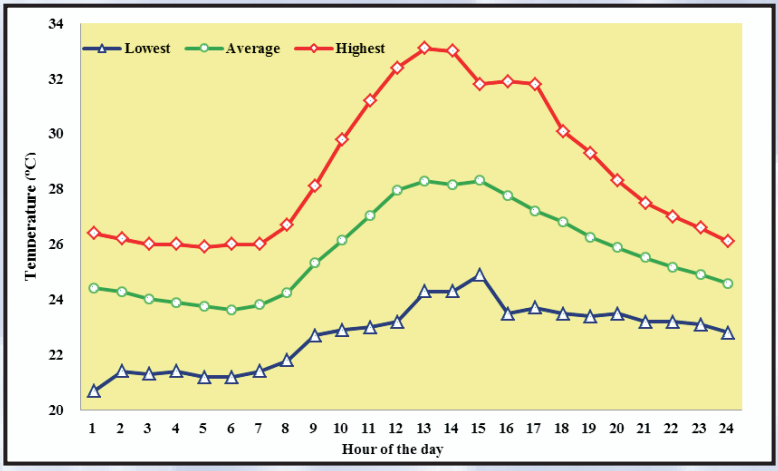


Fig 55 : Diurnal Variation of Temperatures on Independence Day

Republic Day

The Republic Day, celebrated on January 26th every year, is one of India's most important national events. It was on this day in 1950 that the constitution of India came into force and India became a Sovereign, Democratic and Republic state. To mark the importance of this occasion, every year a parade is held in the capital, Dehra Dun.

Different regiments of police march past in all their finery and official decorations. The Governor of Uttarakhand, who is the Chief of the State, takes the salute. Also parts of the parade are children who won the National Bravery Award for the year. The parade also includes other vibrant displays and traditionally ends with a fly past by Indian Air Force jets.

The weather of the Republic Day is marked by cold morning and pleasant warm afternoons. The minimum temperatures during most of the years range between 5 and 10° C (Figure 56). The lowest minimum temperature during the last 40 years has been 1.4° C in 1974 and the highest 11.4 in 2009. Incidence of rain is not very common as rainfall has been recorded only on 5 years during the last 40 years, with a highest amount of 22.8 mm in 2000.

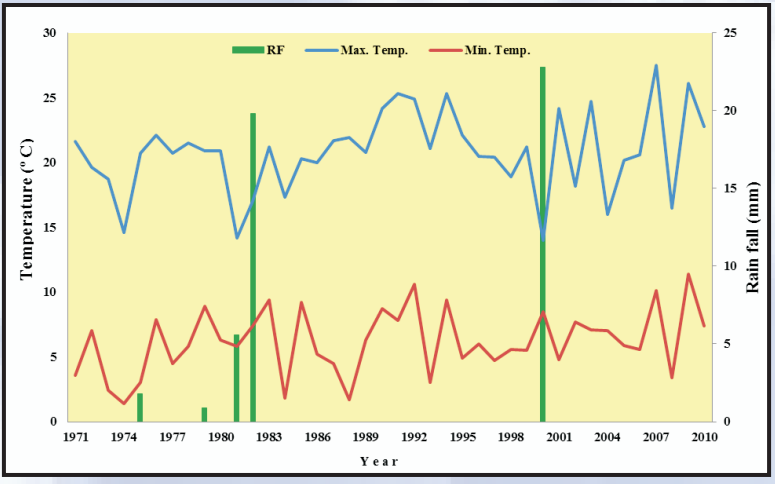


Fig 56 : Maximum and Minimum Temperatures and Rainfall of Dehra Dun on Republic Day

Diurnal Variation of Temperature on Republic Day

The diurnal variation of temperature on the Republic Day is given in Figure 57. The green line indicates the average temperature of different hours of the day. The red and blue lines show the highest and lowest temperatures, respectively, recorded at different hours of the day. The figure shows that the average temperatures are around 10° C till 0800 IST in the morning. The temperatures then increase rapidly to about 16° C by 1100 IST and further to 18° C by 1300 IST. And remain around 18° C till 1600 hrs in the afternoon. The evenings cool down rapidly with temperatures falling to 13° C by 2000 IST and to 11° C by mid-night. The Republic Day during certain years have been quite mild with temperatures reaching to about 15° C by 0900 IST and in excess of 20° C from 1100 IST in the forenoon to 1800 IST in the evening. However, quite low temperatures have been recorded in the past all through the day. On 26th January 1971 the day temperatures remained between 4.8 and 13.6° C from 0700 to 1300 hours IST during which the main function of the Republic Day was held.

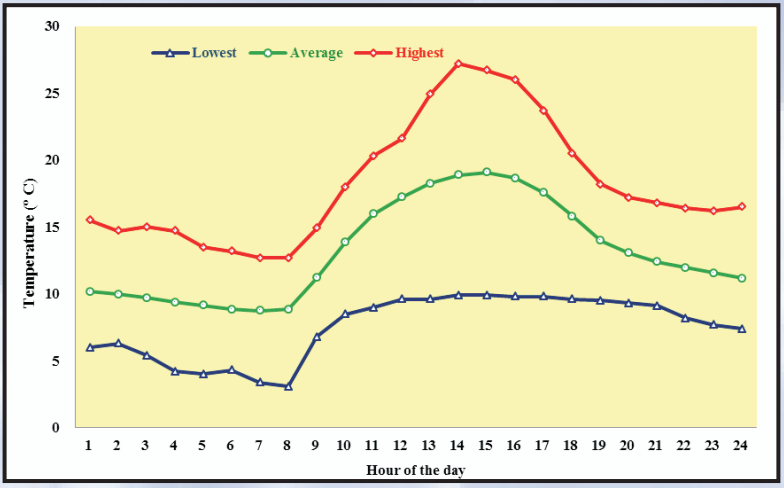


Fig 57 : Diurnal Variation of Temperatures on Republic Day

Gandhi Jayanti

Gandhi Jayanti is celebrated every year on 2nd October to mark the birthday of Mahatma Gandhi, the apostle of peace and the Father of the Nation. Gandhi Jayanti is observed all over the country, both in government and non-government forums.

Generally dry weather, pleasant mornings and warm afternoons are main weather characteristics of weather in Dehra Dun on Gandhi Jayanti. The Temperatures and rainfall of Gandhi Jayanti Day (Figure 58) indicates that the minimum temperature during most of the last 40 years has ranged between 17 and 20° C. The lowest minimum temperature recorded during the period was 13.9° C (1982) and the highest was 22.4° (2001). The maximum temperature most frequently is between 30 and 32° C. The highest and lowest maximum temperatures realized on Gandhi Jayanti during the last 40 years in Dehra Dun have been 33.3° (2009) and 25.6° (1998), respectively. The reason for this pleasantly low maximum temperature on Gandhi Jayanti 1998 was that a rainfall of 10.1 mm was recorded in Dehra Dun on this day. Otherwise, the incidence of rainfall on this day is not very common in Dehra Dun. During the last 40 years there have been 07 days when rainfall was recorded in the city (Figure 58).

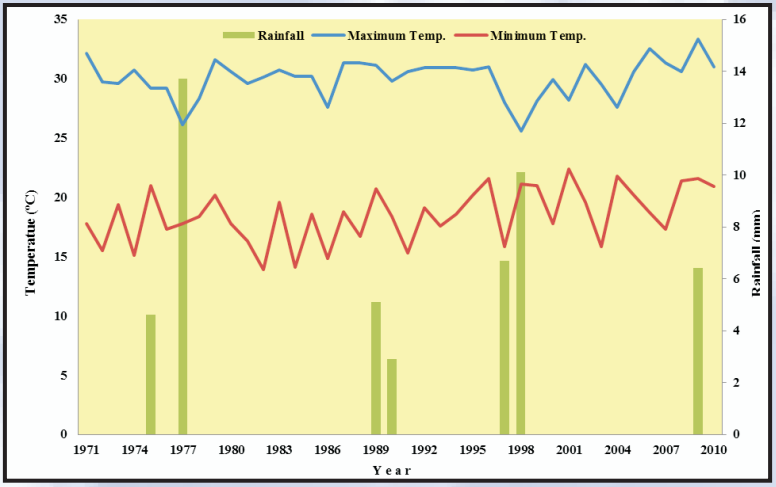


Fig 58 : Maximum and Minimum Temperatures and Rainfall of Dehra Dun on Gandhi Jayanti

Diurnal Variation of Temperature on Republic Day

The Diurnal Variation of Temperature on Gandhi Jayanti is given in Figure 59. The green line indicates the average temperature of different hours of the day. The red and blue lines indicate the highest and lowest temperatures, respectively, recorded at different hours of the day. The figure shows that on an average, the lowest temperature of about 20° C is recorded around 0600 and 0700 IST in the morning. The temperatures then increase rapidly to about 25° C by 1000 IST. It rises further and remains around 29° C in the afternoon from 1300 to 1500 IST. The evening cools down slowly with temperatures falling to 21° C by mid-night.

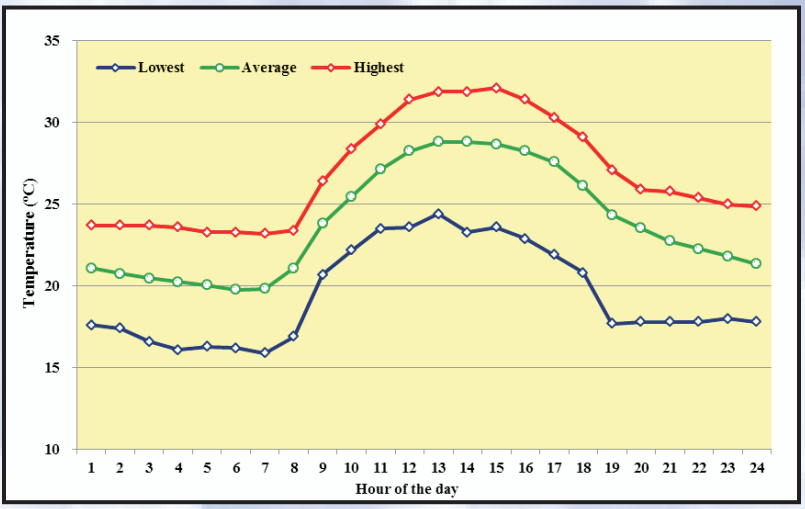


Fig 59 : Diurnal Variation of Temperatures on Gandhi Jayanti

State Day

The Uttarakhand was earlier part of Uttar Pradesh and became an independent state in the year 2000. Every year on 09 November Uttarakhand day is celebrated in Dehra Dun and throughout the state with great fervor and enthusiasm. The unfurling of National flag and march past by Uttarakhand police, Uttarakhand home guards and NCC cadets are part of the celebrations. Cultural programmes by various troupes display the cultural ethos of the mountain state. November is the driest month of the year with cool mornings and warm and sunny days with very good visibility. The temperature and rainfall on the state day are depicted in the figure 60. The maximum temperatures generally range around 25-27° C. The highest and lowest maximum temperatures realized on Uttarakhand state day during last 40 years have been 29.1° C (1971) and 17.4° C (1997) respectively. The lowest minimum temperatures ranged between 10-12° C. The lowest minimum temperature recorded during the past 40 years on the state day was 7.7° C (1985) and the highest minimum temperature was 15° C (1979). During the last 40 years there were only 03 years when light rainfall was recorded in Dehra Dun city on 9th November.

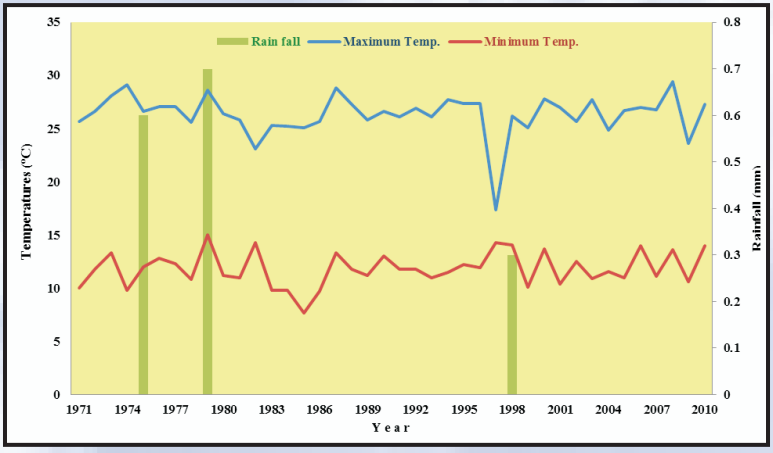


Fig 60 : Maximum and Minimum Temperatures and Rainfall on State Day

Diurnal Variation of Temperature on State Day

The diurnal variation of temperatures on the Uttarakhand day is given in the Figure 61. The green line indicates the average temperature of different hours of the day. The red and blue lines indicate the highest and lowest temperatures, respectively, recorded at different hours of the day. The figure shows that on an average, the lowest temperature of about 13° C is recorded around 0700 IST in the morning. The temperatures then increase rapidly to about 23° C by 1100 IST. It rises further and remains around 24° C in the afternoon from 1200 to 1600 IST. The evening cools down slowly with temperatures falling to 15° C by mid-night. The state Day during certain years have been quite mild with temperatures reaching to about 20 ° C by 9000 IST and in excess of 26° C from 1100 IST in the forenoon to 1600 IST in the evening. However, low temperatures have been recorded in the past all through the day. On 9 November 1997 the day temperatures remained between 14 to 17 ° C throughout the day.

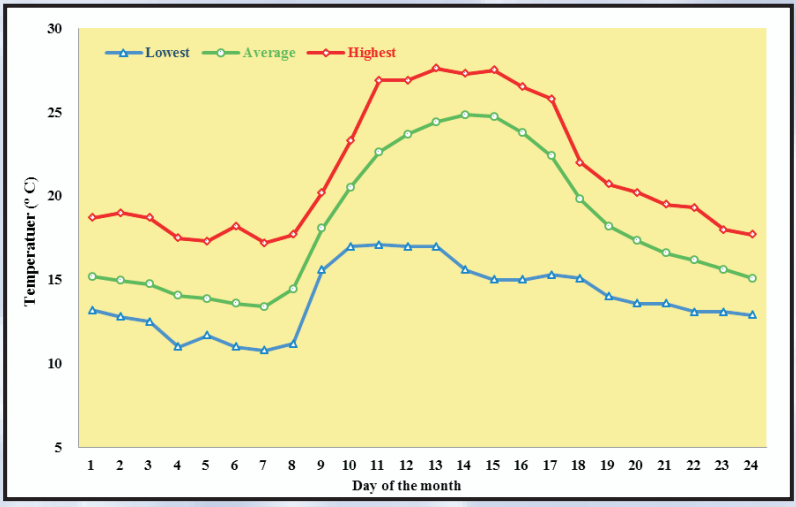


Fig 61 : Diurnal Variation of Temperatures on State Day

Tables

Month	Maximum Temperature (°C)			Minimum Temperature (°C)		
	Mean	Highest ever	Date and Year	Mean	Lowest ever	Date and Year
January	19.8	28.6	24,2009	6	-1.1	11,1945
February	22.1	31.2	25,2006	8	-1.1	01,1905
March	26.8	37.2	28,1892	12.2	2.2	06,1945
April	32.4	40.8	30,2009	16.9	7.2	23,1981
May	34.9	42.8	18,1944	20.5	11.3	15,1982
June	33.9	43.9	04,1902	22.5	13.1	01,1986
July	30.6	40.6	01,1931	22.9	13.2	17,1978
August	29.9	37.2	05,1949	22.4	18.0	04,1986
September	29.9	36.6	04,1974	20.5	14.3	30,1982
October	28.9	36.1	02,1901	15.7	8.4	24,1983
November	25.6	30.6	01,1952	10.7	2.8	30,1938
December	21.6	27.4	10,2008	7.1	0	31,1954

Table 1: Averages and Extremes of temperature over Dehra Dun

Month	Average number of days with		Maximum number of days with cold wave/severe cold wave	
	Cold wave	Severe Cold wave	Number	Year
December	**0.6**	0.08	10	1986
January	**0.8**	0.05	5	1984
February	**1.7**	0.2	8	1972

Month	Average Number of days with		Maximum number of days with heat/severe heat waves	
	Heat wave	Severe Heat wave	Number	Year
April	**0.05**	**0.00**	**2**	**2009**
May	**0.90**	**0.05**	**6**	**1988**
June	**0.97**	**0.32**	**12**	**1995**

Table 2: Averages and maximum number of days with cold wave/heat in Dehra Dun

Tables

Month	Monthly Total (mm)	Heaviest in 24 hours		Total in wettest month	
		Rainfall (mm)	Date & year	Rainfall (mm)	Year
January	43.3	79.5	05,1945	229.9	1911
February	57.5	106.2	05,1949	212.9	1961
March	53.2	122.0	26,1967	198.0	1967
April	31.1	43.5	02,1965	111.1	1997
May	55.3	79.3	28,1940	193.0	1933
June	247.6	188.0	28,1925	963.5	1966
July	659.2	487.0	25,1966	1256.7	1973
August	701.5	332.2	22,1951	1637.8	1885
September	317.8	212.6	03,1924	1014.0	1924
October	42.6	137.4	09,1956	325.4	1955
November	8.9	78.7	19,1911	115.6	1911
December	22.3	108.5	04,1923	150.1	1929

Table 3: Averages and Extremes of Rainfall over Dehra Dun

Average Number of days with different weather phenomena in Dehra Dun from 1971-2010

Month	Weather phenomena					
	Rain	Hail	Thunder	Squall	Dust Storm	Fog
January	4.8	0.2	2.0	0.0	0.0	0.3
February	5.9	0.4	3.4	0.0	0.0	0.2
March	5.9	0.4	4.3	0.0	0.0	0.0
April	4.5	0.4	4.8	0.0	0.2	0.0
May	7.2	0.7	9.4	0.0	0.3	0.0
June	13.6	0.1	12.4	0.0	0.3	0.0
July	24.5	0.0	14.4	0.0	0.1	0.0
August	25.3	0.0	14.4	0.0	0.0	0.0
September	16.1	0.0	10.9	0.0	0.0	0.1
October	3.1	0.2	2.3	0.0	0.0	0.0
November	1.3	0.0	0.6	0.0	0.0	0.0
December	2.2	0.1	0.8	0.0	0.0	0.5
Annual	114.4	2.5	79.7	0.0	0.9	1.1

Table 4: Average number of days with different phenomena

Squall * Data not available.

Tables

Month	Maximum Temperature		Minimum Temperature	
	Temperature fall	Date, Year	Temperature fall	Date, Year
December	10.2	31, 2002	6.5	24, 2005
January	10.7	11,1992 & 28,1999	6.4	13,1973
February	11.6	10,1997 6.1	11,1997	

Table 5: Highest magnitude of fall in temperatures (ºC) in 24 hours in Winter Season

Month	Maximum Temperature		Minimum Temperature	
	Temperature fall	Date, Year	Temperature fall	Date, Year
March	11.6	18, 1995	9.7	27, 1977
April	11.6	3, 1997	8.2	25, 1987
May	11.9	25, 2003	7.8	17,1993
June	7.9	1,1986	8.9	09, 1973

Table 6: Highest magnitude of fall in temperatures (ºC) in 24 hours in Summer Season

Criteria for Heat Wave, Cold Wave and Rainfall

Heat Wave

a) When normal maximum temperature of a station is less than or equal to 40° C

Heat Wave	:	Departure from normal is 5 °C to 6° C
Severe Heat Wave	:	Departure from normal is 7 °C or more

b) When normal maximum temperature of a station is more than 40° C

Heat Wave	:	Departure from normal is 4 °C to 5° C
Severe Heat Wave	:	Departure from normal is 6 °C or more

c) When actual maximum temperature remains 45° C or more irrespective of normal maximum temperature, heat wave should be declared.

Note: Heat wave need not be considered till maximum temperature of a station reaches at least 40° C for Plains and at least 30° C for Hilly regions.

Cold Wave

Wind chill factor plays an important role and brings down the actual minimum temperature depending upon the wind speed. The actual minimum temperature of a station is reduced to "Wind chill effective minimum temperature (WCTn)" as per WMO technical note No. 124 (The assessment of human bio-climate: A limited review of physical parameters, 1972).

For declaring "Cold Wave" and "Cold Day" WCTn is used. If WCTn is 10 ° C or less, then only the conditions for cold wave should be considered.

a) When normal minimum temperature is equal to 10° C or more

Cold Wave	:	Departure from normal is -5 °C to -6° C
Severe Cold Wave	:	Departure from normal is -7 ° C or less

b) When normal minimum temperature is less than 10° C

Cold Wave	:	Departure from normal is -4 °C to -5° C
Severe Cold Wave	:	Departure from normal is -6 ° C or less

c) When WCTn is 0° C or less, Cold wave is declared irrespective of normal minimum temperature of the station. However, this criterion is not applicable for those stations whose normal minimum temperature is below 0° C.