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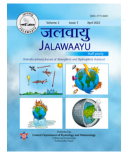

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Research Article

Meteorological Observation in the Central Kathmandu Valley using the First Automated Meteorological Observatory of Tri-Chandra Multiple Campus

Ram Hari Acharya*, Sunil Adhikary, Shiv Kumar Mahato, Narayan Prasad Gautam

Department of Meteorology, Tri-Chandra Multiple Campus, Sarswati Sadhan, Ghantaghar, Kathmandu, Nepal

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**Correspondence*
Ram Hari Acharya
E-mail: omaramhari@gmail.com,
ram.acharya@cdhm.tu.edu.np

Abstract: The main meteorological features of the central Kathmandu valley, Nepal were investigated by means of the dataset recorded by the automated meteorological observatory of Tri-Chandra Multiple Campus (1295m a.s.l. and 27.708217°N, and 85.315369°E) from May 2018 to April 2021. Initially, this observatory was installed for laboratory work with promoting clean energy resources by phasing out mercury instruments, since the onset of the coronavirus pandemic the growing importance of having resilience in the meteorological observation system has been more clearly demonstrated. Now, this automated real-time meteorological observatory becomes a backbone of our academic system, whereby students and teachers can have direct access to the data source and can self-analyze the prevailing atmospheric condition. As the detailed picture of the seasonal and diurnal cycle of meteorological parameters over the central Kathmandu valley, Ranipokhari premises, has been unavailable, this study tries to outline the

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prevailing surface air condition more precisely. The analysis was made on the basis of seasonal and diurnal variations of the weekly and monthly mean of meteorological parameters. The results confirmed that the surface heating by solar radiation mainly drives the variation in surface meteorological parameters. It was observed that the daily minimum temperature is recorded just before dawn and a maximum by mid-day with lagging to the daily solar maxima. In the time, the relative humidity was derived in a reverse cyclic pattern. During the summer monsoon and winter monsoon season, when the diurnal range of solar intensity became lower, also the temperature, relative humidity, and wind strength possessed smaller diurnal range. The seasonal rainfall distribution in central Kathmandu valley also agreed with the climatic normal, about 80% of the total annual rainfall is solely contributed by the summer monsoon season. Summer monsoon possesses some incoherent phase pattern of the diurnal cycle of mean rainfall with two comparable peaks, one as mid-night/nocturnal maxima and the other as late afternoon maxima. While, the early morning rainfall intensity tends to decrease and attains its minima around late morning, whereby the frequency of drizzle type of rainfall was most dominant.

1. Introduction

Determination of the prevailing surface air conditions of a place is crucial for understanding their influence on weather and climate. In recent years, researchers have been able to investigate atmospheric structures and mechanisms more precisely through their concerted effort. Timely and accurate meteorological measurements are always the critical requirements for measuring their success. Usually for many developing countries accurate and timely acquiring of meteorological data have challenges due to their sparse observation networks, particularly lack of real time automatic weather observatories. As real time data is the backbone for weather forecasting and warnings, the Department of Hydrology and Meteorology (DHM), government of Nepal started the installation of automatic weather stations (AWS) only after 2000 AD with their regular fund, still more challenges are facing for their regular operation (Karki, 2010). After the 1990s Pyramid Automatic Laboratory/Observatory the Glaciological Expedition in Nepal (GEN) project installed AWS in Khumbu region Nepal, the oldest one installed in 1994 (Ken'ichi et al., 1996). Most of the developed countries are replacing manual observation system, according to the goal set by the world meteorological organization (WMO). In Nepal, both the government and academic institutions are also installing the clean energy observatories. Tri-Chandra Multiple Campus, Department of Meteorology is operating its own automatic meteorological observatory since 2018. From the beginning it has been used as a strong academic tool for teaching and learning purpose. It is noteworthy that, since the onset of the coronavirus pandemic the importance of having resilience in the meteorological observation system for both educators and forecasters has been clearly demonstrated. Thus, during pandemic the automated real time meteorological observatory become a backbone of academic system of the universities and colleges, whereby students and teachers can have direct access to the data source from home and then self-analyze the atmospheric condition. Whereas a detailed picture of the seasonal and diurnal cycle of meteorological parameters over the central Kathmandu valley, Ranipokhari premises, has not been available. This study aims to analyze more precisely the prevailing surface air condition representing the central Kathmandu valley.

Some studies have made AWS based measurements of meteorological parameters on the seasonal and diurnal time scales outside of the valley, particularly in the high altitude region (Bollasina et al., 2002; Fujita et al., 1997; Karki, 2010; Khadka et al., 2021; Matthews et al., 2020; Tartari et al., 1998). Fujita et al. (1997) concluded that the variation of temperature and relative humidity (RH) during the summer monsoon season were more consistent with high value than that of other seasons due to thick clouds that dominate most of the parts of southern slope of the central Himalayas along with the advancement of monsoon system. In general, the daily pattern of air temperature is a minimum in the early morning hours just before dawn and a maximum at mid-day after the peak of solar and net radiation. This lagging of daily maxima to the solar maxima generally governed by the solar heating of ground surface and hence the corresponding warming of surrounding air. However, the diurnal variation of air temperature is not necessarily regular on individual days (Acharya et al., 2019; Bollasina et al., 2002; Pillai, 1998). In addition to this, other factors like evaporation, advection, convection, and conduction are also prime importance in determining the lagging of temperature with solar radiation (Adhikary et al., 2000, 2002; Foken & Napo, 2017; Lee et al., 2006). Because of very little cloud and the high solar elevation the pre-monsoon maxima were observed, particularly in May. As with high solar warming the wind gust strength is also generally increased. While, with the advancement of monsoon system during summer and winter the solar irradiation decreases and hence the wind speed is said to be relatively more stable (Fujita et al., 1997; Wu et al., 2018). The minimum solar intensity is observed during winter, when the sky is clear, but the sun elevation is low (Acharya et al., 2019; Adhikari, 2012; Adhikary et al., 2000; Adhikary & Ueno, 2020; Foken & Napo, 2017; Joshi et al., 2020; Oke, 2002; Pillai, 1998; Tartari et al., 1998).

Study from the high altitude station Tartari et al. (1998) and Bollasina et al. (2002) found that the RH reaches its maximum in the monsoon season with values close to saturation and during winter period it was the lowest, indicating the driest period. The diurnal range of RH is high during the pre-monsoon season, falls quickly in the monsoon period reaching its lowest values, then increases with the following two periods. There exists a direct relationship between the atmospheric moisture content with the monsoon patterns. Previous studies of surface and satellite observation focusing on the seasonal and diurnal cycle of precipitation have shown maximum summer precipitation followed from some considerable features of pre-monsoon events has large diurnal variations. The summer monsoon precipitation contribute to overall 80% of total annual precipitation in Kathmandu (DHM, 2017). The summer monsoon possesses some incoherent phase pattern of mean precipitation diurnal cycle with two comparable peaks, one as a nocturnal/mid-night maxima and other as late afternoon maxima. These precipitation characteristics are described for some parts of Nepal and neighboring countries (India and China) in general (Bollasina et al., 2002; Roy & Balling, 2007; Shrestha & Deshar, 2014; Yu et al., 2007). Furthermore, Bollasina et al. (2002) also highlights the frequency of light drizzle type of precipitation was highest during morning hours, while during the rest of the day more intense precipitation occurs with greater frequency.

2. Materials and Methods

The automatic meteorological observatory of Tri-Chandra Multiple Campus was installed at the roof top of the main administrative building at about the central east edge of Ranipokhari. The altitude and location are 1295m a.s.l. and 27.708217^{o}N, and 85.315369^{o}E coordinates respectively. This observatory was installed in 18th April 2018 and is shown in Figure 1. This is the first digital meteorological laboratory ever operating in the history of the Campus, located centrally in the Kathmandu valley. The station made continuous recording of air temperature (Tair), relative humidity (RH), wind speed (Ws), wind direction (Wd), downward short-wave radiation (DSR), and rainfall for every 30 minutes interval as per the required setting. All these records are visible online and retrieved online via HOBOlink web server. Measured variables for each sensor are listed in Table 1 with their calibration accuracy. All the meteorological parameters for the time frame of 01 May 2018 to 30 April 2021 were analyzed for this study.

For our analysis, as per the usual definition, we define four seasons, namely winter, pre-monsoon, summer monsoon and post-monsoon seasons for the months of December to February, March to May, June to September and October to November, respectively. The months with missing records of 10 days and more were eliminated for this analysis. The seasonal analysis was performed based on the weekly mean values of each parameter except for rainfall, which is cumulated for those 7 days. On the other hand, for the analysis of diurnal pattern/cycle, each parameter was first organized as hourly values, where except precipitation (cumulated) all are the mean values of instantaneous records. In order to produce clear picture of diurnal cycle, the analysis was conducted on the basis of monthly mean of hourly values. Due to some technical and mechanical problems there were some data gaps and all the gaps were considered without filling. Details on half hourly missing records of each parameter are tabulated in Table 2 by the years of 2018 to 2021. Analysis and plots of these parameters were performed using R-program (Team, 2020).

Table 1. The List of sensors with calibration accuracy. All the sensors were manufactured by ONESET C.C., USA

Parameter	Sensor and model	Accuracy
Wind Speed	Cup anemometer (S-WSB-M003) (..m)	±1.1ms^{-1}
Wind Direction	Wind vane (S-WDA-M003) (..m)	±5 degrees
Air Temperature	Temperature/RH sensor (S-THB-M00x) (2m)	±0.21^{o}C, ±2.5%
Relative Humidity	Temperature/RH sensor (S-THB-M00x) (2m)	±2.5%
Global Solar Irradiance	Pyranometer (S-LIB-M003) (..m)	±10.0 Wm^{-2}
Rainfall	Tipping bucket (S-RGB-M002) (1.5m)	±1.0%

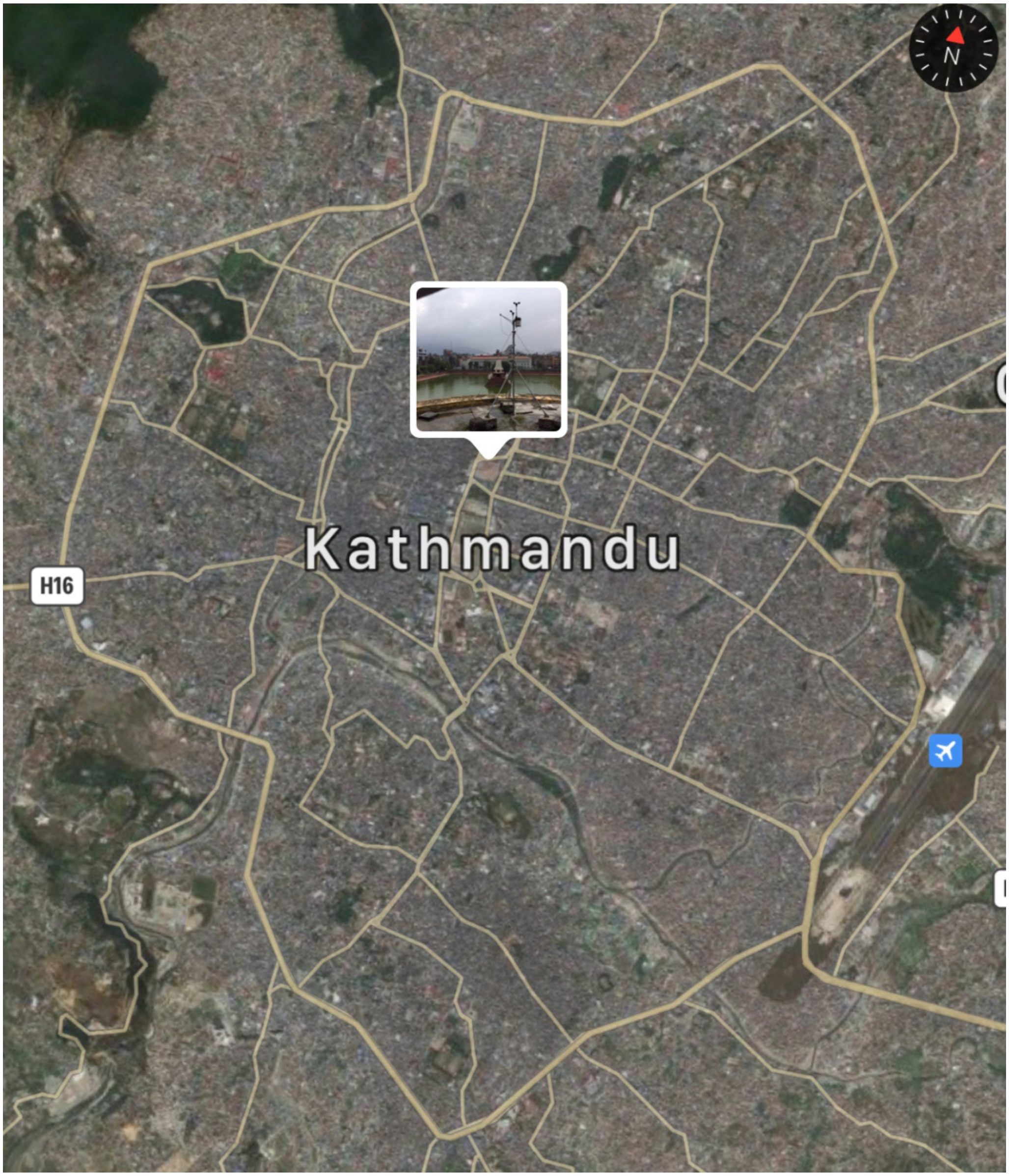

Figure 1. Automated meteorological observatory of Tri-Chandra Multiple Campus (1295m a.s.l., 27.708217°N, 85.315369°E), at roof top of the main administrative building, Sarswati Sadhan, Kathmandu, Nepal.

Table 2. Yearly percentage of missing half hourly records of different parameters

Parameters	2018	2019	2020	2021	Total
Wind Speed (ms^{-1})	0	1.76	6.41	20.16	4.93
Wind Guest Speed (ms^{-1})	0	1.76	6.41	20.16	4.93
Relative Humidity (%)	0	1.76	6.41	20.12	4.93
Wind direction (degree)	0	1.76	6.41	20.21	4.94
Downward short-wave radiation (Wm^{-2})	0	1.76	6.43	20.21	4.94
Air Temperature (^{o}C)	0	1.76	6.41	20.12	4.93
Rainfall (mm)	0	1.76	6.41	20.21	4.94

3. Results and Discussion

3.1 Seasonal variation in surface meteorological parameters on weekly mean basis

3.1.1 Temperature

Figure 2(a) shows the variation of air temperature in weekly mean basis. Variation of the temperature seems to be highly characterized by the changes in earth-sun geometry. It is clear that the temperature changes seem to be more consistent during the summer monsoon season particularly from second week of June along with the increasing influence of monsoon system.

This consistency might be due to the persistent thick cloud cover during summer monsoon season. Similar pattern was indicated in Fujita et al., (1997) and Bollasina et al., (2002) using some meteorological observations from southern slope of the Himalayas. High range of temperature fluctuation observed during post monsoon and winter months. The maximum weekly mean values were recorded with the months of summer monsoon season and minimum during winter. The primary highest value was found for second week of June 2019 (26.04 ^{o}C) which is 1.2 ^{o}C above the recorded average with the first week of August as the secondary maxima of 24.6 ^{o}C in average. During this monsoon period the weekly mean temperature records were not found below 21 ^{o}C. However during winter it was confined below 17.5 ^{o}C. Figure also revealed that the lowest temperature records of about 10 ^{o}C were observed for the last week of December to first week of January.

3.1.2 Relative Humidity

The relative humidity (RH) remained at high value, more than 80%, during the monsoon season from late June to the mid-September. Like as temperature, the variation of RH (Figure 2(b)) was more consistent with high value with the advancement of monsoon system. It is clear that RH increasing gradually from second week of May and attained its maximum by July-August (80-90%). Even if the lower RH was observed during winter season the minimum records were found by the second week of March to first week of April (<50%), when temperature reached to maximum value. These results of pre-monsoon minima was in contrast to some of the high altitude measurements of winter minima (Bollasina et al., 2002; Tartari et al., 1998).

3.1.3 Wind speed and direction

The variation of weekly mean wind speed and wind gusts is depicted in Figure 2(c). The wind gust speed represents for the maximum of horizontal wind speed. Wind seems to be relatively stable during the winter monsoon and summer monsoon period and it was noticed that, the gusts speed during the monsoon period were dominated by the prevailing wind speed of pre-monsoon and post-monsoon seasons. During monsoon season the decreased in surface heating rate may cause the strength of surface gusts to reduce (Fujita et al., 1997; Wu et al., 2018). With the end of the prevailing monsoon system the wind strength gets resumed within late October, and then after it tends to decrease rapidly and minimum values were observed during December-January (<0.6 ms^{-1}). Again it plumed gradually and attending the mean peak value of 1.07 ms^{-1} by the 3rd week of May with mean gust speed greater than 3 ms^{-1}. The West-Northwest (WNW) wind was most dominant throughout the study period in central valley with high frequency of mean wind speed of 2-4ms^{-1}.

3.1.4 Global radiation

The available mean weekly downward shortwave radiation or solar radiation is presented in Figure 2(d). It is clear that the monsoon system highly characterized the variation of the solar radiation that strikes the surface. Generally, from pre-monsoon to the early monsoon season, there are clear skies. By the pre-monsoon, the down-welling shortwave radiation attained maximum value of 252Wm^{-2}, in the month of May. After this, the maximum value was observed with the onset of the monsoon, in the 2nd week of June. Then after it tends to decreased gradually and reached winter minima below 100Wm^{-2} by the first two weeks of January. Similar trends were highlighted by Acharya et al.,(2019) and Joshi et al.,(2020).

3.1.5 Rainfall

The annual total rainfall record of 2019 was 1158mm which was slightly higher than the observed rainfall in 2020 (1141mm). For these years 80.77% and 80.78% of total annual rainfall were contributed by the monsoon system, respectively. So, it is clear that almost 80% of the total annual rainfall in the central valley was solely contributed by monsoon system. This result satisfies the distribution of climatological normal precipitation over Nepal (DHM, 2017). However the winter and pre-monsoon season contribute to about 7% and 12% of the total rainfall respectively. As the station was fully operated is in operation since May 2018, the recorded monsoon rainfall was 802.8mm in the first year with 71 percentages of rainy days in total (Table 3). From Table (3) it is obvious that the rainy events during summer monsoon period were decreasing continuously for these three years but, the rainfall intensity seems to be increasing. Figure 2(e) shows the weekly mean of daily total rainfall and weekly total rainy days. It is clear that very little rainfall was recorded in the beginning of the pre-monsoon season with low rain-events however, towards the end of the season mean weekly rainfall increased significantly reaching as high as 10mm by the last week of May. Especially the pre-monsoon precipitation of central valley was characterized by local convective system and hence found low depth of precipitation even more events were recorded. Heavy rainfall of seven days mean was observed by the second week of July (16 – 27 mm per week) and the monthly total rainfall of July exceed 300mm contributed by 21 days of rainfall in average. It is noteworthy that there were 11 events in total with all 7 days having rainfall, among these 5 events were found during July, 3 during August, and 2 during September. It is pointed out that there were very little rainfall at the early week of post-monsoon and latter no records were found for the study period. During winter season there were only 4 weekly events were in record, average rainfall depth for this events were in the range of 2-6mm.

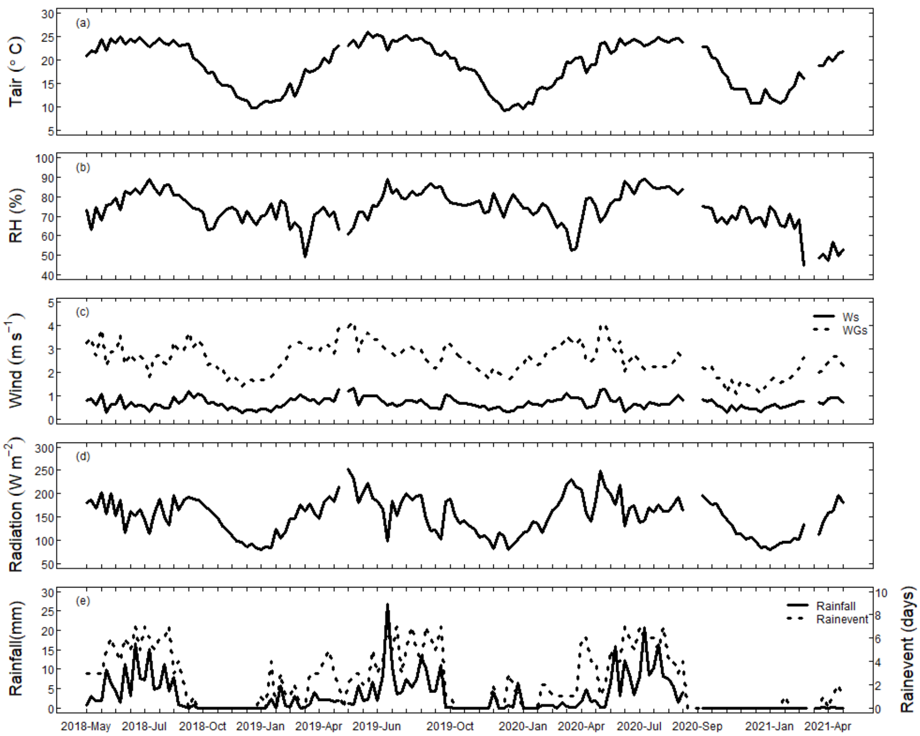

Figure 2. Seasonal variation of weekly mean meteorological parameters (a) air temperature(Tair), (b) relative humidity (RH), (c) wind speed (Ws) and wind gust speed (WGs), (d) global radiation, and (e) total rainfall with number of rainy days during the period from May 2018 to April 2021 at the automatic weather laboratory of Tri-Chandra Multiple Campus. The ticks along x-axis are maintained at an interval of 3 weeks.

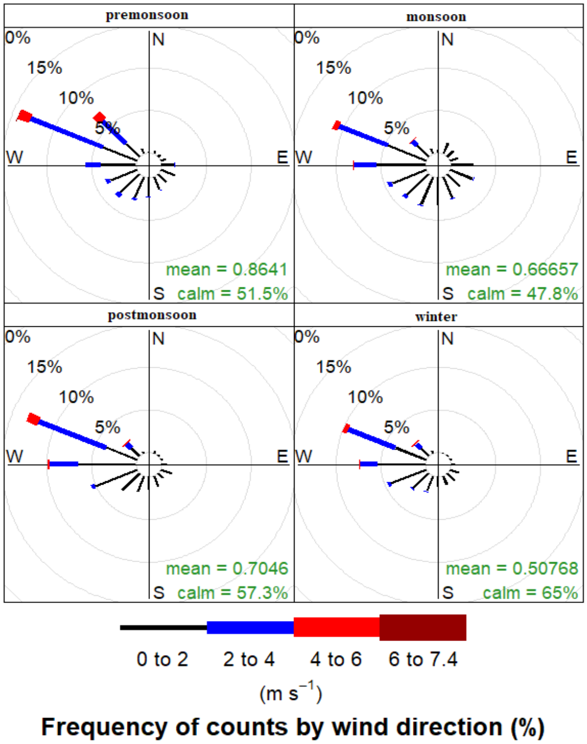

Figure 3. Seasonal variation of the wind recorded during the period from May 2018 to April 2021 at the automatic weather laboratory of Tri-Chandra Multiple Campus.

Table 3. Total monsoon precipitation (mm) and percentage of days with precipitation for each summer monsoon seasons (June-September)

	2018	2019	2020
Total Rain (mm)	802.8	935.6	928
% of days with Rain	71	70	64

3.2 Diurnal variation in surface meteorological parameters on weekly mean basis

The diurnal variation of meteorological parameters in Figure (4) and Figure (5) presents the clear picture of prevailing surface air condition in the central valley. These diurnal signals for different seasons are symptomatic of a typical diurnal cycle driven by solar heating that is characterized by a convective daytime boundary layer and a stable nocturnal boundary layer. The diurnal variation of all the parameters possessed significant monthly cycles and described below in detail.

3.2.1 Temperature

The diurnal variation in temperature has been following the daily cycle of surplus surface heating (Figure 4 (a, d) and Figure 5 (a, d)). Figure 4(a), the monthly mean of daily temperature cycle, clearly shows that the daily temperature with a minimum just before dawn and a maximum observed at mid-day after the peak of solar and net radiation. This lagging of daily maxima to the solar maxima generally governed by the solar heating of surface and hence the corresponding warming of surrounding air (Acharya et al., 2019; Bollasina et al., 2002; Fujita et al., 1997; Pillai, 1998). The air temperature maxima were generally observed between 13:00 to 14:00 Nepal Standard Time (NST) and minima between 05:00 to 06:00 NST on average (Figure 5(a)). While, these records seems to be slightly different for some months (Figure 4(a)), more especially for the months of November to February the minima was observed between 06:00 to 07:00 NST. And the mean monthly maxima were observed between 12:00 to 13:00 NST. From Figure 4(a) it is also evident that there is a greater range of air temperature during winter with 10°C and above but, it was around only 6°C during the monsoon period even if it displays a much higher value of diurnal cycle than the winter as well as other seasons. This lower diurnal range in those monthly mean values was due to less water vapor concentration and low cloudiness in the dry winter atmosphere compared to the wet season. More particularly, in average of 2018 to 2021 the July month possess the lowest mean monthly range (*26.8°C - 21.6°C*) with no lags in air temperature maxima to the solar radiation and that during December and January it was around 11°C and 10°C with recorded monthly minima of 6.9 °C and 6°C respectively between 06:00 to 07:00 NST. Maximum rain events during July might be the cause of no lagging in air temperature with respect the maximum solar insolation.

3.2.2 Relative Humidity

The diurnal variation of relative humidity (Figure 4(b) and Figure 5(b)) seems to be more similar but in inverse cyclic pattern with respect to the diurnal cycle of temperature. The maximum diurnal RH peak values were maintained just before the dawn when the air temperature was recorded minimum and RH minima at mid-day with maximum air temperature throughout the study period. Same as temperature, the range of RH cycle was small during the monsoon period, that is the variation between the maximum and minimum daily records are closed than that were observed in other seasons. The maximum diurnal variation or range of monthly mean RH during summer monsoon season was confined between 94-75%, while during winter it was 88-44%. Tartari et al. (1998) and Bollasina et al. (2002) also found the similar patterns of diurnal RH cycle.

3.2.3 Wind speed and direction

As can be seen from Figure 4(c) and Figure 5(c), strong wind gusts generally prevailed during the daytime and reached maximum between 13:00 to 16:00 NST when the air is most subject to terrestrial heating and vertical motion(Wu et al., 2018). It shows that, during pre-monsoon season winds were generally strongest and the maximum monthly mean diurnal gusts speed reached around 8ms^{-1} with 17ms^{-1} of instantaneous hourly maxima. These pre-monsoon high gusts events were generally observed between

15:00 to 16:00 NST. These high gust periods can be attributed to the strong thermal circulation in the valley associated with high daytime surface temperature followed by strong night time cooling. With the end of monsoon season the wind speed tends to increase and attained it's secondary maxima by October-November, where the monthly mean diurnal value peak at about 7ms^{-1} with instantaneous value peaks around 11ms^{-1} around 13:00 NST. By grouping together wind gust profiles from non-monsoon seasons, it can be seen that the wind was generally weaker during summer monsoon season than in other seasons by the day hours. Which maintain maximum monthly mean diurnal value below 6ms^{-1} during July and August along with none of any instantaneous hourly maxima reached to 10ms^{-1} and these maxima were blowing from West-Northwest (WNW). Another lowest monthly mean diurnal peak was maintained by the months of December and January with about 10ms^{-1} as hourly maxima between 13:00 to 15:00 NST, while nights were totally seemed to be calm, even no single records reached to 1ms^{-1}.

In general, the observed wind speeds were low during night to morning and maximum by the afternoon and evening throughout the study period. Further investigation revealed that, except the monsoon period, high speed wind (>1ms^{-1}) generally began blowing after sunrise and stopped by the late evening. From night time to early morning the considerably high wind speed were prevailed throughout the whole monsoon period as compared to the other seasonal frame with the variable wind direction of 170 to 220 degree.

3.2.4 Global radiation

From the Figure 4(d), the diurnal variation of downward short wave radiation (DSR) possessed significant monthly cycles. The downward short wave radiation (DSR) peaked around the mid-day between 11:00 to 12:00 NST, then after it started to decrease in general (Figure 5 (d)). The amplitude of monthly mean DSR cycle attained peak value twice a year, one during April, and another after the monsoon period in October as primary and secondary maxima respectively. The primary maxima were observed between 627 Wm^{-2} to 782 Wm^{-2} during the study period and for the secondary maxima it varies from 573 Wm^{-2} to 660 Wm^{-2}. The primary maxima was maintained between 11:00 to 12:00 NST while, the secondary maxima was observed between 12:00 to 13:00 NST. It is noteworthy that, during July the DSR maxima hardly reached around 500 Wm^{-2} within the peak hours 13:00 to 14:00 NST. The declining of DSR value during core monsoon period was due to maximum number of rainy events, even exceeding 25 days in July with thick cloud cover. During January as the solar elevation become low the smallest peak value of DSR cycle of about 363 Wm^{-2} in average was observed by this study period.

3.2.5 Rainfall

Figure 4(e) shows the variation of diurnal cycle of precipitation with number of rain events on monthly mean basis. It is found that summer precipitation over the central Kathmandu valley has large diurnal variations followed from some considerable features of pre-monsoon events. The post-monsoon features of diurnal cycles were generally negligible. During the pre-monsoon the precipitation revealed an afternoon to evening maxima, while the winter with morning maxima. It is possible to point out that summer monsoon possess some incoherent phase pattern of diurnal cycle of mean precipitation with two comparable peaks, one as mid-night/nocturnal maxima and other as late afternoon maxima. By the early morning, rainfall intensity tends to decrease and attained its minima around late morning (09: 00 to 10:00 NST), illustrated by Figure 4(e) and 5(e). Where, Figure 5(e) exhibit only the monsoon period rain features. Similar rainfall features were also highlighted by Bollasina et al. (2002), Roy & Balling (2007), Shrestha and Deshar (2014), and Yu et al. (2007). During the late afternoon precipitation maxima may usually cause by maximum instability in the lower surface layer also called the boundary layer due to surface solar heating that propelled the moisture convection. The underlining mechanisms behind the nocturnal maximum may results from the diurnal variation of local circulation and the associated deep convection in the central valley. These types of scientific reasons were also described in Bollasina et al. (2002), Oke (2002), Foken & Napo (2017), Yu et al. (2004). Additional research work is needed for detail understanding of the mechanism behind mid-night maximum rainfall.

Further examination revealed that over 50% of the hourly events in monsoon season were of drizzle type rainfall (<1mm/hr) throughout the day and that on average, 80% of the hourly rainfall events were of below 5mm and 96% of occurrence was of below 10mm. Thus, about 4% of the hourly rainfall events were heavy rain showers. It was found that on June 8, 2020 the instantaneous maximum rainfall records exceeded 35mm/hour between 00:00 to 03:00 NST with peak records of 42mm/hrs, which was the highest in records during the study period. The controlling mechanisms behind this extreme require more studies for the detail investigation. Between 07:00 to 13:00 NST frequencies of drizzle was dominant (about 60% of the events), when there was only 29% of rainfall events with rainfall of 1-5mm were recorded. It was true that between 13:00 and 18:00 NST when the frequency of drizzle (< 1mm) dropped to 48%, the frequency of hourly monsoon rainfall between 1 to 5mm and >10mm raised to 35% and 6% respectively in response to the thermal convective activities. Furthermore, high intensity rainfall events from 18:00 to 23:00 NST were lower than the events recorded before 18:00 NST but considerably higher than the late morning observations. Bollasina et al. (2002) also described the similar precipitation characteristics. With the mid night the sporadic heavy events were increasing along with the moderate rainfall intensity (1-5mm/hrs). Where, frequency of the moderate rainfall intensities in average were appeared to be higher as compared to the other timestamps.

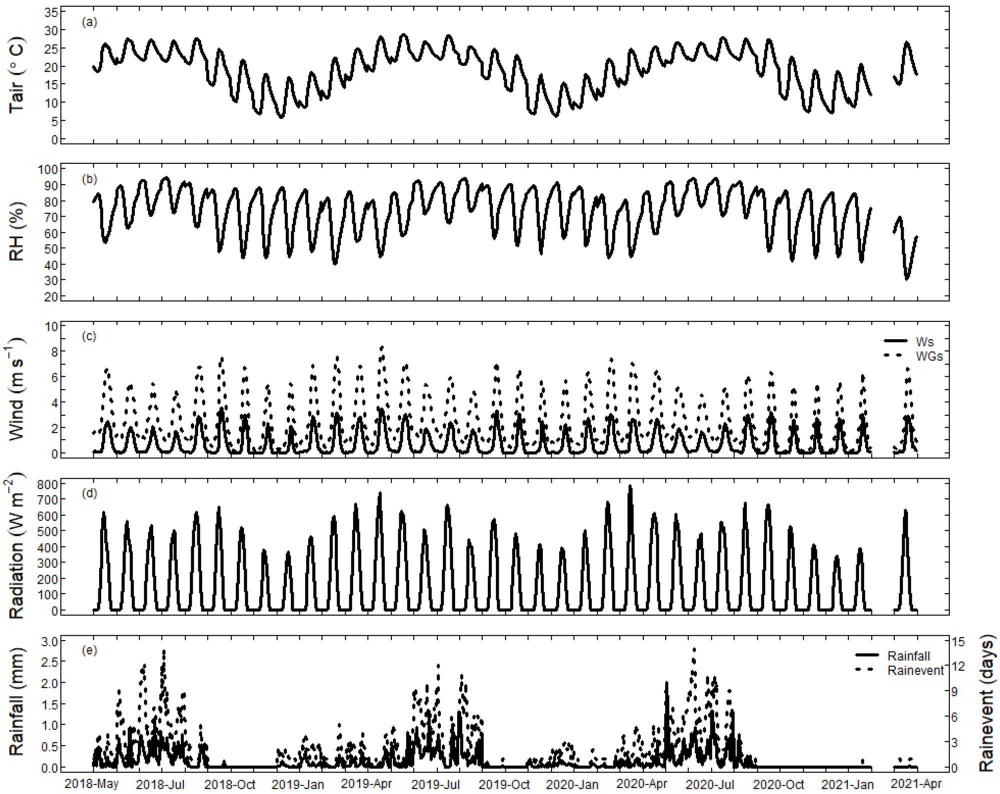

Figure 4. Diurnal variation of Monthly mean meteorological parameters (a) air temperature (Tair), (b) relative humidity (RH), (c) wind speed (Ws) and wind gust speed (WGs), (d) global radiation, and (e) total rainfall with number of rainy days during the period from May 2018 to April 2021 at the automatic weather laboratory of Tri-Chandra Multiple Campus.

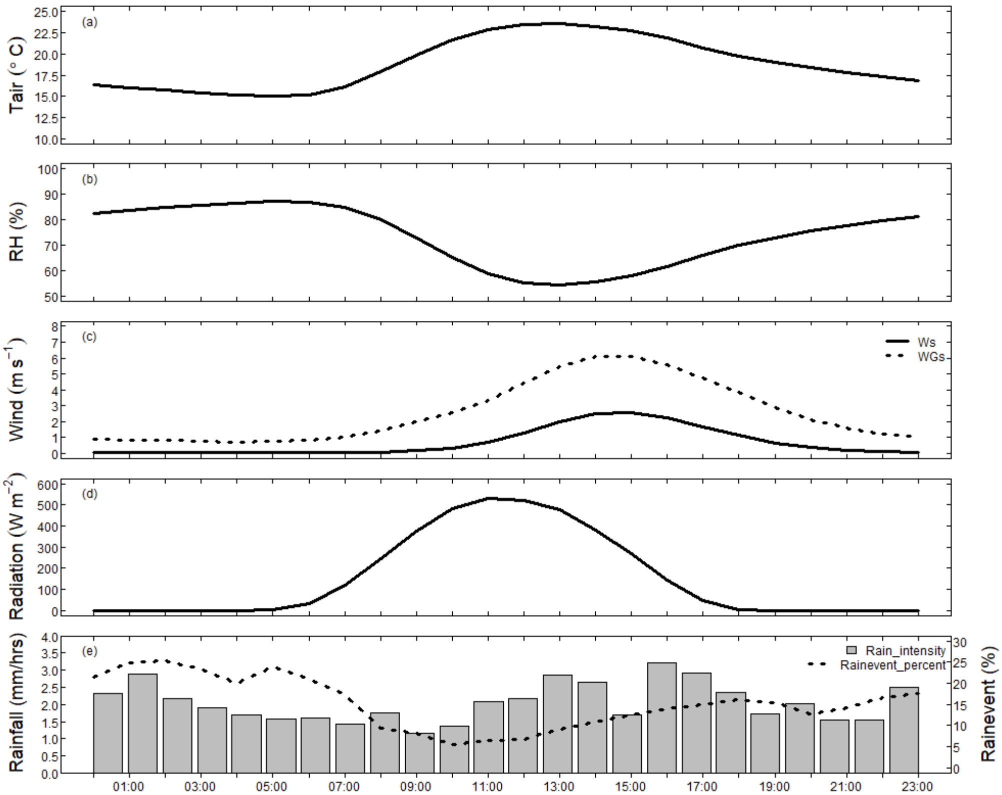

Figure 5. Diurnal average of meteorological parameters (a) air temperature (Tair), (b) relative humidity (RH), (c) wind speed (Ws) and wind gust speed (WGs), (d) global radiation, and (e) average monsoon rainfall with rainy events recorded during the period from May 2018 to April 2021 by the automatic weather laboratory of Tri-Chandra Multiple Campus.

5. Conclusion and Summary

The present study on meteorological parameters observed from May 2018 to April 2021 at roof-top automatic laboratory of Tri-Chandra Multiple Campus located in the central Kathmandu valley, Nepal provides clear pictures of prevailing surface air condition for understanding and working with the automatic observation system. The performance of the observatory is almost good, along with the errors and missing records the observed full datasets were handled more accurately and scientifically. The main results are summarized as follows:

1. The seasonal variation of weekly mean temperature and relative humidity shows that, the variation seem to be more consistent during the summer monsoon season particularly from second week of June due to the persistent thick cloud cover with the increasing influence of monsoon system.

2. The daily minimum temperature is recorded just before the dawn and a maximum by the mid-day with lagging of daily solar maxima. The relative humidity possess similar but inverse cyclic pattern with respect to the diurnal temperature cycle. The diurnal range of temperature and relative humidity is higher around 10^{o}C during winter but, it is small during the summer monsoon around only 6^{o}C in average.

3. Wind seems to be relatively stable during the winter monsoon and summer monsoon period as with decreasing of surface heating rate as compared to pre-monsoon. During the pre-monsoon season wind is generally strongest and the maximum monthly mean diurnal gusts speed reached around 8ms^{-1}. The maximum gusts speed is observed between 13:00 to 16:00 NST while, nights are generally calm. Mostly, the prevailing high speed wind was blowing from WSW to WNW toward the central valley.

4. The downward short wave radiation (DSR) peaked around the mid-day between 11:00 to 12:00 NST in general, then after it starts to decrease. The amplitude of monthly mean DSR cycle attained peak value twice a year, one between 627 Wm^{-2} to 782 Wm^{-2} during April (11:00 to 12:00 NST), and another is observed between 573 Wm^{-2} to 660 Wm^{-2} after the monsoon period in October (12:00 to 13:00 NST) as primary and secondary maxima respectively. During the core monsoon time (July) the DSR maxima hardly reached around 500 Wm^{-2} in the central valley.

5. The seasonal rainfall distribution in central Kathmandu valley also agree with the climatic normal, about 80% of the total annual rainfall is solely contributed by the summer monsoon season. Summer monsoon possess some incoherent phase pattern of diurnal cycle of mean precipitation with two comparable peaks, one as mid-night/nocturnal maxima and other as late afternoon maxima. While, the early morning rainfall intensity tends to decrease and attained its minima around late morning, when the frequency of drizzle type of rainfall was most dominant.

The results presented in this paper cannot be considered as a complete representation of recent climate features of the central Kathmandu valley, neither can a comparison be made with the nearest meteorological observatories available in the valley. For this reason a data exchange is planned between the Department of Hydrology and Meteorology, government of Nepal to increase numbers of automatic observatories and to make a long-term series of observations with promoting the clean energy resources in both the institutions. With the onset of the coronavirus pandemic the growing importance of having resilience in the meteorological observation system has been more clearly demonstrated. Thus, this automated real time meteorological observatory becomes a backbone of our academic system. The meteorological data set recorded by this observatory is a valuable tool for the academic purpose including thesis and research work for the respective institutes, departments, and schools under similar disciplines.

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