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Various Types of Lightning Electric Field Signatures Observed in Kathmandu, Nepal

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Abstract

Vertical electrical fields due to lightning in the sub-tropical thunderstorms over the rugged terrain were sensed, recorded, and measured at a hilly station of Kathmandu, Nepal. Various types of lightning electric field signatures have been observed, recorded and analyzed. From the records, the cloud-to-ground discharges were found to be 22.4% and cloud-to–cloud discharge were found to be 58.5% whereas, the unusual events counted 10.4% and rest of the events were found to be 8.7%. The lightning activity may be influenced by the hills and mountains due to which greater number of ground flashes and the density of positive ground flashes were relatively higher in Nepal than other geographical locations. Positive lightning flashes are mainly influenced by tall towers, high mountains, rugged hills and other tall structures. Hence, lightning activity is influenced by the high hills and mountains of Nepal.

Keywords: Nature of lightning; Lightning in rugged terrain; Lightning activities; Lightning in hilly and subtropical country.

Highlights

- Vertical electrical fields due to lightning measured in the subtropical region.
- Lightning occurring over the rugged terrain were sensed, recorded and analyzed.
- Various types of lightning activities have been recorded.
- Cloud-to-ground lightning discharges were 22.4%, Cloud-to-ground lightning discharges were 58.5%; the unusual lightning events were 10.4% and rest were 8.7%.
- Positive lightning flashes mainly occurred due to tall structures.

Introduction

The water on the earth's surface changes its phase, due to heat, in the presence of sunlight which results in the formation of thunderstorm cloud or cumulonimbus in the atmosphere. In the atmosphere, the temperature of the air has inverse relation with the altitude that is temperature decreases by increasing the altitude. As the height of the cloud increases, the water vapor changes in different phase and form snow crystal, ice crystal, etc. When the temperature difference is higher between the two layers of the cloud, they move faster. Due to the random motion of water molecules in the cloud, the electrification phenomena occur by the process of mutual contact, friction, etc. They produce large amount of charge in the cloud [1]. When some region of the atmosphere attains an electrical charge of sufficient amount, the lightning occurs. So, lightning is the electrical discharging phenomenon which a common natural activity in the atmosphere. On the process of lightning, huge energy is released in different form such as light, heat, sound etc. They produced several electromagnetic radiations of different wavelengths from zero to the order of GHz. Thus, it is an extremely complex electrical discharge and a complete theory of the flash does not exist [2]. In 2003, Barros and Lang described that the hydro meteorological processes occurring on the rugged terrain, the development of charge structure in the thundercloud, the waveforms of lightning flashes etc. are very much interested in the researchers on this field [3].

Rakov and Uman described that the thundercloud lightning shows a variety of different characteristics depending on the variability of the size of thunder cloud, which in turn depends on the latitude, topography, season and type of storm [4]. All lightning discharges can be categorized into two groups mainly cloud-to-cloud and cloud-to-ground discharges. The occurance of the cloud-to-cloud discharges is twice or thrice the cloud-to-ground discharges. The beautiful display of lightning is the lighted sparks produced during the lightning. The inter-cloud spark is never a straight line, but rather has numerous bends and branching. Normally, the spark channel is as long as several kilometers, sometimes dozens of kilometers. Bazelyan & Raizer stated that lightning discharge is initiated between two of the three charge centers from within a thunder cloud and can vaguely be divided into two categories:

- Cloud-to-ground discharges and
- Cloud discharges [5].

The lightning discharges which terminate at the ground are called cloud-to-ground discharges or simply ground discharges, and the discharges which do not reach the ground are in general called cloud discharges [6]. The cloud discharge includes cloud to cloud, cloud to air, inter-cloud, intra-cloud etc. According to Berger, the ground discharges are categorized in four parts. They are upward negative lightning, upward positive lightning, downward negative lightning, and downward positive lightning. According to Rakov and Uman, the downward negative lightning transports negative charges from the main negative charge center to ground and accounts for 90% of ground flashes. The other about 10% of ground flashes are downward positive lightning which transports positive charges from the main positive charge centre to ground. The upward lightning areisry rare, as opposed to the downward lightning, which occur due to the presence of tall structural objects of height more than one hundred fifty meters.

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More than two hundred sixty years ago, the pioneer of research in lightning, Benjamin Franklin gave the idea that lightning discharge is electrical in nature. The systematic quest of lightning begun with two separate experiments performed in 1752. One of the experiments was 'The Sentry box' experiment proposed by Benjamin Franklin and carried out at Marly-la-Ville, France under the supervision of Thomas-Francois D'Alibard in May 1752. One month later another experiment, the famous "kite" experiment, was carried out by Benjamin Franklin himself at Philadelphia in June, 1752. Since then, many great advances on our knowledge of lightning phenomena have taken place, and then some significant work has been carried out in last century. According to Uman the development in the understanding of lightning was initiated by the use of lightning photography on a moving film or plate by Hoffert in England [7]. Berger, Uman etc. described that Pockels began the development of magnetic links by measuring the amplitudes of lightning current. Berger, Uman, Rakov and Uman further explained that a third branch of research was concerned with the measurement of electric fields, the first result being reported by Wilson in 1916. Berger, Nanevicz et al., described that various motivations for studying the electrical properties of lightning has existed and the complexity of the flash has continued to challenge the creativity of lightning experimenters and instrument designers to this day [8].

Baral and Mackerras found that the ratio of positive CG flashes to the total CG flashes was 0.28, this ratio was maximum in the post-monsoon with an average value of 0.38 and it is minimum during the pre-monsoon with value 0.26 [9]. Nepal is a hilly and subtropical country having unique topographical features. In the hilly and terrain topography, features of lightning activities are very interesting to the scientists and researchers. Nepal is a country of diversified topographical configuration with a varied altitude as low as 70 m to as high as 8848 m from the mean sea level. The northern part of Nepal is covered by the Himalayan peaks and the southern part is plain whereas much of the middle part of the country has been covered by hills. Such a topographical structure plays vital role in the meteorological changes. Monsoon is observed between June and August, with heavy rainfalls resulting in natural calamities such as landslides, floods and inundations. Apart from monsoon, winter rainfalls are also observed which generally are not so heavy. However, lightning has often been reported to have claimed life during the winter rainfalls and pre-monsoon period. The meteorological changes occurring in the Himalayan range is of much interest to the scientific community.

Methods of Measurement

The electric fields produced due to lightning radiations were measured and recorded from measuring station, which is situated at a height of about 1300 m from the sea level. The electric field of more than three thousand five hundred flashes within the mentioned period of March, 2015 to June, 2017, were measured. Waveforms of each flashes due to lightning radiation were recorded and have been analysed. The flat parallel plate antenna about the forty-five centimetre in diameter is set on the post of height of one hundred fifty centimetre which is placed on the building of height 12 m. The horizontal circular plate senses the vertical electric fields of the flashes. The circular plate is connected with buffer circuit via 60 cm long RG 58 coaxial cable whose capacitance of 100 pF/m so that the capacitance of the coaxial cable is 60 pF. The parallel plate antenna with buffer circuit is shown in the Figure 1. The output of the buffer is connected with the Pico-scope 6404D via co-axial cable. The signal captured by the antenna, passes through buffer circuit and pico-scope and finally storage on our PC. These stored signals of 500 ms window size and the sampling rate was more than 300 MS/seconds. All the voltage of the electric field signatures is in digitizer volts. The measurement of electric field described in this paper used in numerous experiments [10-23].

Data Analysis and Results

The vertical electric field radiation due to the lightning flash was measured and recorded. More than five thousand five hundred flashes within the mentioned period of March 2015 to June 2017 have been recorded. Among these recorded flashes, some saturated flashes, and some flashes of very less amplitude nearly to the noise level etc., were neglected. Thus, the total five thousand two hundred fifty-one flashes within this period have been taken and analysed. From this observation, some flashes were usual waveforms, and some were unusual waveforms. There were so many other waveforms IB pulses, PB pulses etc. that were observed which are expressed below in the Table 1 and the bar diagram of this observation is presented in Figure 2.

From the observation as in the Table 1, out of five thousand two hundred fifty-one flashes within this period have been taken in which 1176 flashes were ground flashes and 3072 flashes were cloud flashes. Similarly, 546 flashes were unusual events as mentioned in the paper published by Adhikari et al. and remaining 457 flashes were other events which includes preliminary breakdown pulses, isolated breakdown pulses multiple peaks etc. These distributions of all recorded flashes were mentioned in Table 2 expressed in percentage.

From the observed data, the cloud – to – ground discharges were 18.2% in 2015, 28.2% only in 2016, and 26.5% in 2017. Hence in the average, 22.4% was cloud – to – ground discharges within the mentioned period. The example of cloud – to – ground flash is shown in the Figure 3. About 14.6 percent of unusual events were found in 2015, six percentage were found in 2016 and only 4.2% were found in 2017. The example of unusual flash is shown in the Figure 4. Similarly, cloud discharges were 53.3% in 2015, 62.8% in 2016 and sixty-eight percentage in 2017. So, the average percentage 58.5% were cloud discharges on the mentioned period. The remaining discharges of other events were 8.7% in average found accordingly as mentioned in the Table 2. The example of cloud flash is also shown in the Figure 5.

Discussion

As described by Uman in the thunderstorm, there are three regions, the upper positive charge regions from which positive ground flashes are probably initiated; the centre negative charge region from which

Parameters\ Years	2015	2016	2017	Total
RS (CGS)	526	407	243	1176
Unusual	422	86	38	546
Cloud (CC)	1542	906	624	3072
Others	402	43	12	457
Total	2892	1442	917	5251

Table 1: Different flashes observed and recorded in the different year.

Parameters	2015	2016	2017	Total
RS (CGS)	$\frac{526}{2892} = 18.2\%$	$\frac{407}{1442} = 28.2\%$	$\frac{243}{917} = 26.5\%$	$\frac{1176}{5251} = 22.4\%$
Unusual	$\frac{422}{2892} = 14.6\%$	-------	$\frac{38}{917} = 4.2\%$	$\frac{546}{5251} = 10.4\%$
Cloud (CC)	$\frac{1542}{2892} = 53.3\%$	$\frac{906}{1442} = 62.8\%$	$\frac{624}{917} = 68.0\%$	$\frac{3072}{5251} = 58.5\%$
Others	$\frac{402}{2892} = 13.9\%$	$\frac{43}{1442} = 3.0\%$	$\frac{12}{917} = 1.3\%$	$\frac{4557}{5251} = 8.7\%$
Total	2892	1442	917	5251

Table 2 Different flashes observed and recorded yearly expressed in percentage.

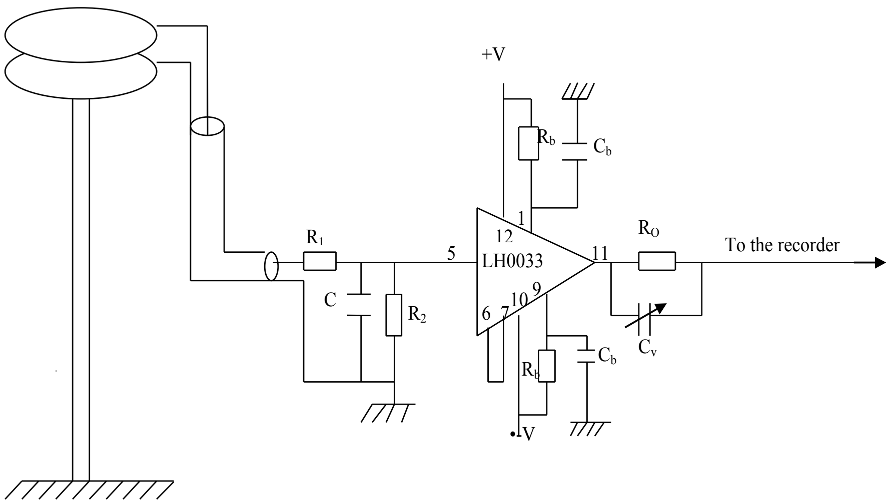

Figure 1: The flat-plate antenna with buffer circuit used to measure the electric field.

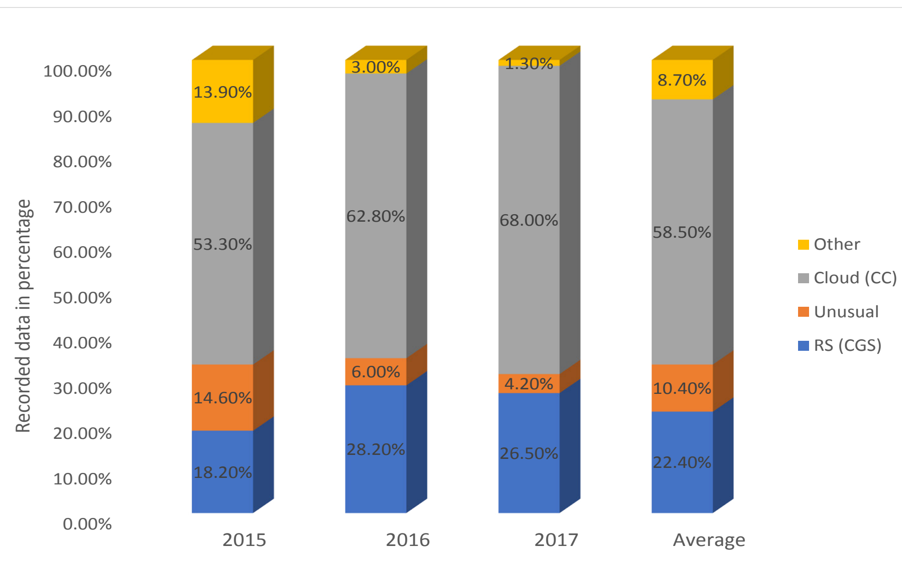

Figure 2: Observed data expressed in bar diagram.

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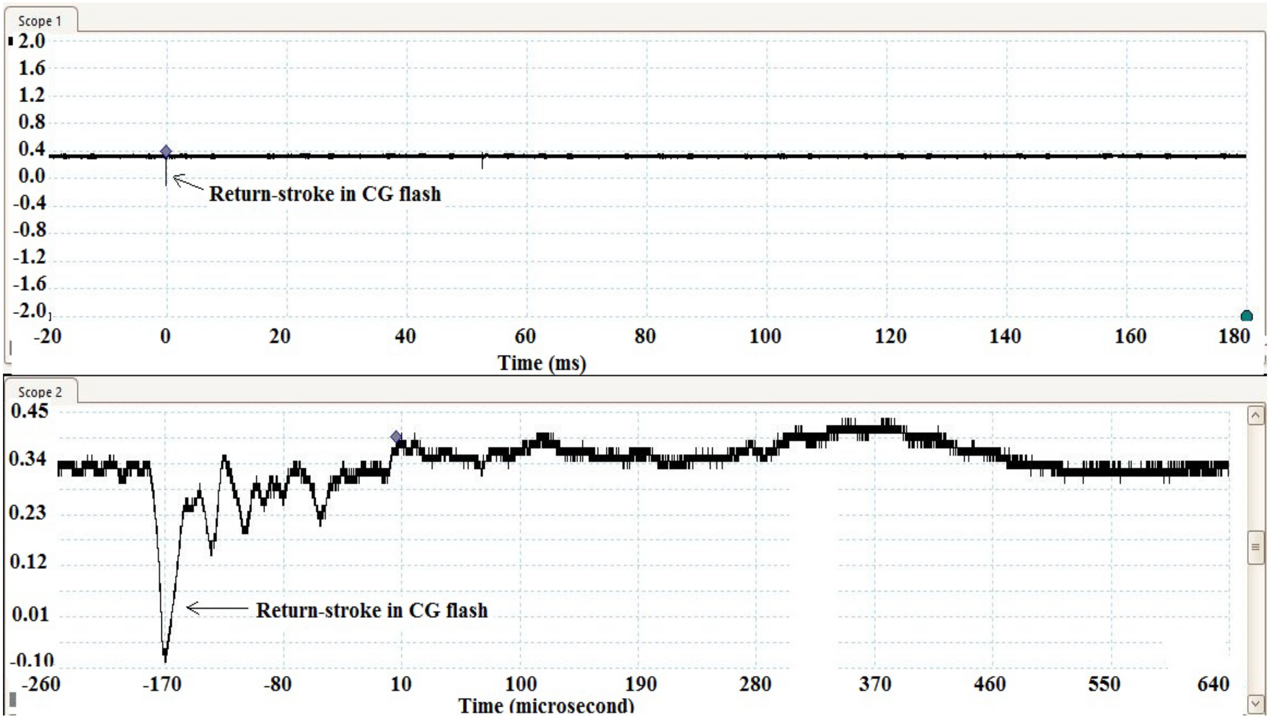

Figure 3: An example of a CG flash recorded on the 30th March 2015 (Flash no – 20150330 - 0030) (1) Scope1 shows the whole flash. (2) The zoomed signature of the return stroke is in inset.

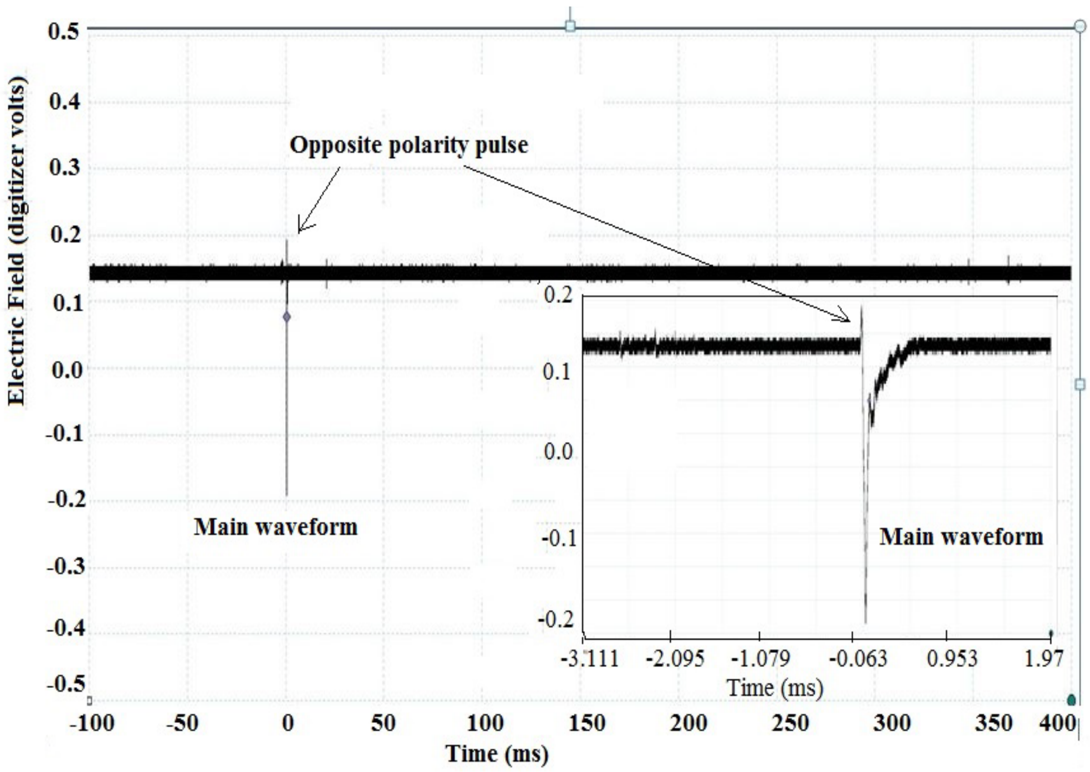

Figure 4: The unusual lightning electric field signatures and expanded the waveform in the in-set.

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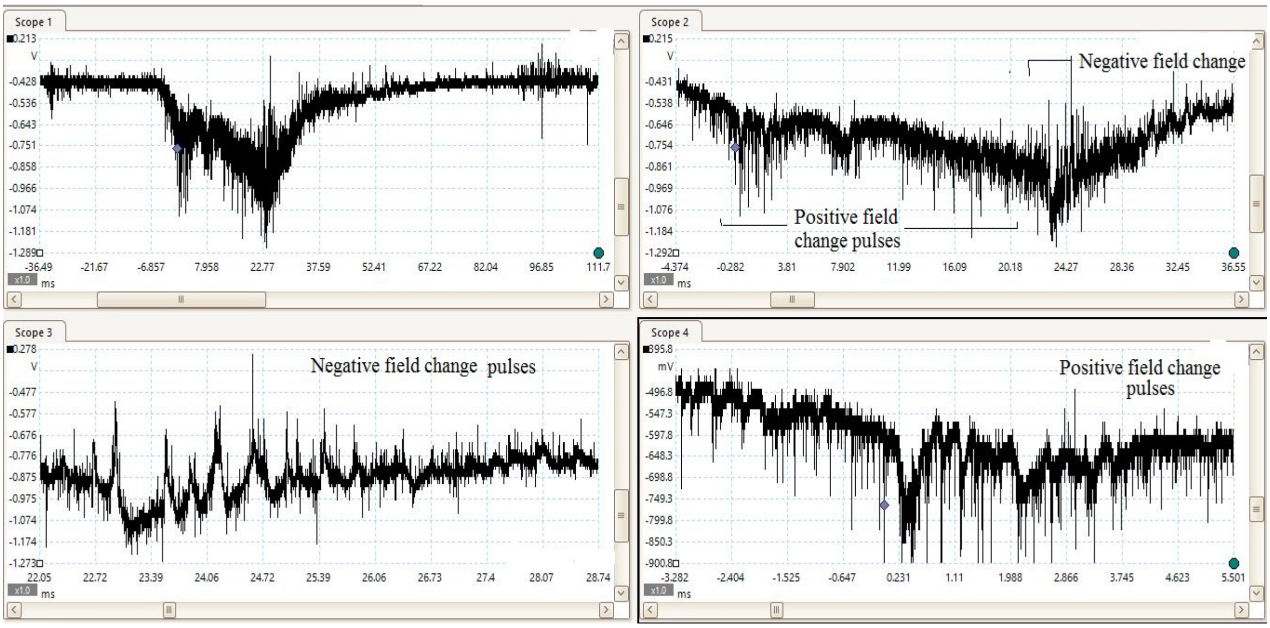

Figure 5: (1) The cloud flashes in first (Number 20150612-0132). (2) +ve and –ve field change pulses in second (3) The expanded form of –ve field change pulses in third and (4) The expanded form of +ve field change pulses in fourth.

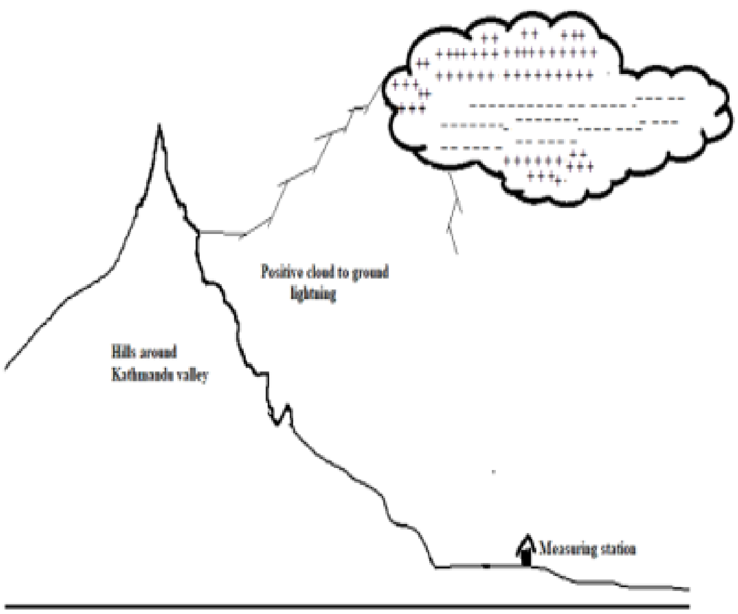

Figure 6: The cloud structure as well as positive lightning occurs in the hill and top of the mountain.

negative ground flashes are initiated and some positive charge pocket remains in the bottom part of the thundercloud. The lower positive charge pocket as mentioned by Nag and Rakov plays an important role [24]. Excess number of this positive charge in the pocket converts the negative CG flash to an intra-cloud flash. The cloud flashes occur between the different clouds or inside the same cloud or cloud to air discharges. As mentioned already in the charge structure, the cloud flashes forms between the boundary of negative charge and upper positive charge. Only few cloud flashes form between the positive charge pocket and negative charge. For each cloud flashes, they have different form of wave signatures but have some similar features. Similarly, the unusual waveforms are also found in the observation of the mentioned time. From the charge structure as mentioned, the hills and mountains may be near to positive charge which influenced and greater number of positive ground flashes as shown in Figure 6.

Conclusion

Hence, the density of positive ground flashes is relatively higher and the high hills and mountains influenced the lightning activity. From the total records, the cloud-to-ground discharges were found to be 22.4% and cloud flashes were 58.5% whereas the unusual waveform events were counted 10.4% and rest of the events were found to be 8.7%.

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References

1. Malan DJ (1963) Physics of lightning. Engilish Universities Press Ltd: UK.
2. Sharma S (2007) Electromagnetic fields radiated by lightning in tropical and temperate regions.
3. Barros A, Lang T (2003) Monitoring the monsoon in the Himalayas: Observation in Central Nepal. Mon Weather Rev 131: 1408-1427.
4. Rakov V, Uman MA (2003) Lightning: Physics and effects. New York: Cambridge Univ press: USA.
5. Bazelyan E, Raizer Y (2000) Lightning Physics and Lightning Protection. Institute of Physics Publishing Dirac House UK.
6. Berger K (1977) The earth flash, in Lightning. Physics of lightning, New York: Academic press: USA.
7. Uman MA (1987) The lightning discharge. New York: Dover Edition: USA.
8. Nanevicz JE, Vance EF, Hamm JM (1987) Observation of Lightning in the frequency and time domains. Gardner R. Ed. Lightning Electromagnetics 7: 267-286.
9. Baral K, Mackerras D (1993) Positive cloud-to-ground lightning discharges in Kathmandu Thunderstorms. J Geophys Res 98: 10331-10340.
10. Galvan A, Fernando M (2000) Operative characteristics of a parallel-plate antenna to measure vertical electric fields from lightning flashes, Uppsala University, Sweden.
11. Adhikari PB, Sharma SR, Baral KN (2016) Features of Positive Ground Flashes Observed in Kathmandu Nepal. J Atmos Sol-Terr Phy 145: 106-113.
12. Sharma SR, Cooray V, Fernando M (2008 A) Isolated breakdown activity in Swedish lightning. J Atmos Sol-Terr Phy 70: 1213-1221.
13. Sharma SR, Fernando M, Cooray V (2008 B) Narrow positive bipolar radiation from lightning observed in Sri Lanka. J Atmos Sol-Terr Phy 70: 1251-1260.
14. Adhikari PB, Sharma SR, Baral KN, Rakov VA (2017) Unusual lightning electric field waveforms observed in Kathmandu, Nepal, and Uppsala, Sweden. J Atmos Sol-Terr Phy 164: 172-184.
15. Adhikari PB (2017) Features of ground flashes before and after the massive earthquake observed from Kathmandu, Nepal. J Nepal Phys Soc 4: 11-22.
16. Johari D, Cooray V, Rahman M, Hettiarachchi P, Ismail MM (2017) Characteristics of leader pulses in positive ground flashes in Sweden. Electr Pow Syst Res 153: 3-9.
17. Adhikar PB, Bhandari B (2017) Computation of electric field from lightning discharges. Intl J Sci Eng Res 8: 147.
18. Adhikari PB, Sharma SR, Baral KN (2017) Features of electric field pulses of cloud flashes observed in Kathmandu, Nepal. Intl J Hydra Res Group 1: 9-16.
19. Baharudin ZA, Fernando M, Ahmad NA, Makela JS, Rahman M, et al. (2012) Electric field changes generated by the preliminary breakdown for the negative cloud-to-ground lightning flashes in Malaysia and Sweden. J Atmos Sol-Terr Phy 84: 15-24.
20. Adhikari PB (2017) Analyzing the components of lightning electric field. Golden-Gate J Sci Technol 3: 22-26.
21. Adhikari PB (2018) Time varying electric and magnetic fields from lightning discharge. Intl J Electrical and Electronic Sci 5: 50-55.
22. Adhikari PB, Bhandari B (2018) Jefimenko equations in computation of electromagnetic fields for lightning discharges. Intl J Sci Eng Res 9: 1678-1687.
23. Ahmad NA, Fernando M, Baharudin ZA, Cooray V, Ahmad H, et al. (2010) The characteristics of narrow bipolar pulses in Malaysia. J Atmos Sol-Terr Phy 72: 530-540.
24. Nag A, Rakov V (2009) Some inferences on the role of lower positive charge region in facilitating different types of lightning. Geophys Res Lett 36: L05815.