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Effect of Lightning on Atmospheric Electric Field.

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ABSTRACT

The pattern of electrical charges in the atmosphere is known as atmospheric electricity. The movement of these charges in the earth's surface and ionosphere, taken together is known as global atmospheric electrical circuit. The origin of this circuit is thought to be thunderstorms which create lightning bolts. Lightening discharges huge amounts of atmospheric charges to the ground thus rapidly releasing the energy stored in the storm clouds. Hence there is a close correlation between the atmospheric electric field value and lightening. The study of the mechanism of global atmospheric electric circuit has advanced a lot in the past few decades. Huge advances have been made in the study of thunderstorm and lightening in relation to the global electric circuit. However, not many such studies have been done in the Kashmir valley. So, the authors have attempted to study the variations in the atmospheric electric field with different weather conditions. The atmospheric electric field was measured using an electric field mill. This instrument is installed in the University of Kashmir. In this paper authors discuss the effect of lightening on the atmospheric electric field which can help in the local lightning forecast.

Keywords: Atmospheric Electric Field, Electric Field Mill, Lightning, Thunderstorm.

I.INTRODUCTION

During earlier days lightening was regarded as a supernatural phenomenon and only from recent times has the mechanism of lightening has been studied and understood. Lightening is regarded as the most visible manifestation of the global electrical circuit's continuous action. It has been reported that lightning can strike at a rate of 100 times per second during storms. Lightning is defined as the process of momentary spontaneous electrostatic discharge of high current, initiated in the clouds [1].In simple terms lightning is a static electric discharge happening because of attraction between positive and negative charges in atmosphere [2]. The creation of lightening is a complicated process and the exact way a cloud builds up electrical charges leading to lightening is not understood completely. The basic cause of lightening is thought to be rapid motion of clouds. Small liquid water droplets are carried upto heights between 35,000 to 70,000 miles above the ground surface due to upward drift of clouds. Simultaneously hail and ice are being transported downwards from the upper parts of storm. When these upwards moving water particles and downwards moving ice particles collide, the water droplets freeze, thus releasing heat. This heat keeps the surface of hail and ice slightly warmer than its surrounding environment. When this graupel collides with additional water droplets and ice particles, a key process occurs involving electrical charge: negatively charged electrons are sheared off the rising particles and collect on the falling particles. The result is a storm cloud that is negatively charged at its base, and positively

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charged at the top. As the positive areas and negative areas grow more distinct within a cloud, an electric field is generated between the thunderstorm top and base. The farther apart these regions are, the stronger is the attraction between charges and stronger is the electric field. A huge amount of charge should be built up to overcome the atmosphere's insulating properties. Once the charge has been built up strong enough to overcome the insulating properties of atmosphere, current is discharged as a stroke of lightening. While all this is happening inside the storm, a positive charge starts to build up underneath the storm. This positive charge shadows the storm wherever it goes, and is responsible for cloud- to- ground lightening which is of the most importance to the humans and other life forms on earths surface [3]. However, the electric field within the storm is much stronger than the electric field between base of storm and earth's surface, so about 80% of the lightning strikes are inter cloud and intra cloud discharges [4].

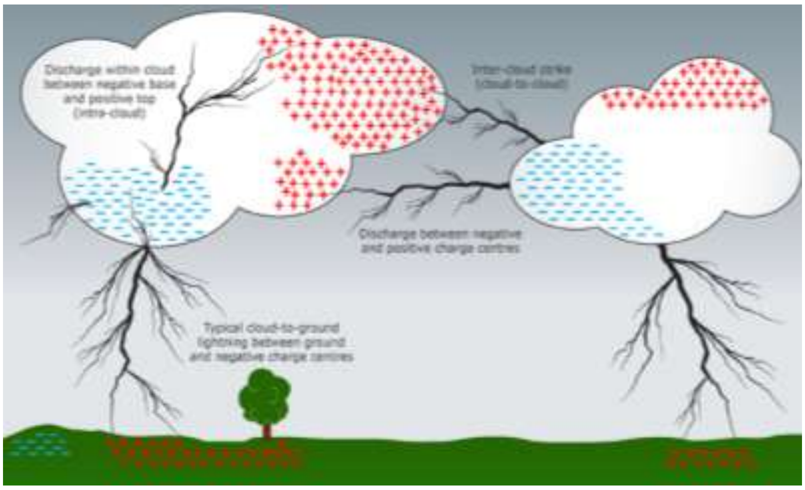

Figure 1 Types of lightning

However the atmosphere is not electrically active only during the thunderstorms. An electric field surrounds us at all times even during fair weather conditions. There is a potential gradient of 200kv to 500 kv between earth's surface and atmosphere with an approximate current of 1 kA flowing from atmosphere to ground during fair weather. Combined effects of all the thunderstorms occurring simultaneously all over the world are thought to be its reason. Observations of a continuous but unexplained electrification in the atmosphere during fair weather probably provided the motivation for the early research. Subsequently, the response of electrical atmospheric parameters to changes in meteorological parameters was also investigated. Formal studies of atmospheric electricity started as early as 1750, when Franklin hypothesized that electricity could be taken from clouds via a tall metal aerial with a sharp point. This was proved to be correct by dAlibard's and Lemonnier's experiments in 1752. Lord Kelvin (1860s) proposed that atmospheric positive charges explained the fair weather condition and later recognised the existence of atmospheric electric fields. Over the course of next century, using the ideas of Volta and Ronalds, several researchers contributed to the growing body of knowledge about atmospheric electric phenomena. Attempts were even made to predict weather using atmospheric electricity as a basis, for example, Beccaria said that if the recorded electricity is strong then the weather will be fair for several coming

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days whereas if electricity is small then fair weather will not last for long and it may rain or be cloudy soon. Lord Kelvin also thought atmospheric electricity to be a useful method for forecasting of weather. He established an observatory in Kew, London in 1861 where he continuously measured the atmospheric electricity using photographic recording [5]. The study of the mechanisms of lightning and thunderstorms has increased dramatically over the last 50 years. Now-a-days we have satellites to give us information about the location and time of occurrence of thunderstorms and lightening. The first satellite to observe lightening was launched in 1960s [6]. Subsequently, in the coming years three more detectors were launched in space, thus advancing our knowledge of lightning and thunderstorms. Worldwide, 16 million lightening strokes occur every year i.e. at any given point of time 2000 storms occur simultaneously. Lightning strikes are not distributed evenly. South America, Africa and South East Asia can be regarded as the three hotspots for tropical lightening activity. It is because a majority of lightening activity is concentrated over the continental regions of globe. In addition, extra tropical lightening is seen to play an important role in the summer season of northern hemisphere [7].

II.RESULTS AND DISCUSSION:

The present study was focused in the University Of Kashmir, Jammu and Kashmir where a Electric Field Mill was mounted on a rooftop in institutional premises of University of Kashmir. The data of lightening was obtained from the IMD website. The month of March in Kashmir valley is a time when a lot of lightening activity takes place. Figure 2 represents the electric field values on a clear day and figure 3 depicts the nature of variation in electric field when the Field Mill detects lightning activity in nearby regions.

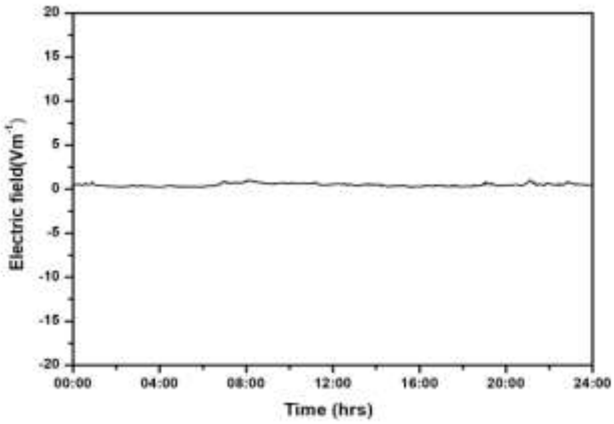

Figure 2 Electric field plot on a fair weather day on 25 March 2018

One can clearly see that the electric field value increases to 15 V/m during turbulent weather and during clear sky the electric field drops back to its normal value of 0.1 V/m. This happens because lightening strikes dump a huge value of charge in the earth's surface from the atmosphere resulting in the sharp peaks on the graph. Also, as is evident from the graph 5, the electric field increases to 0.5 V/m when clouds are passing over the field mill sensor.

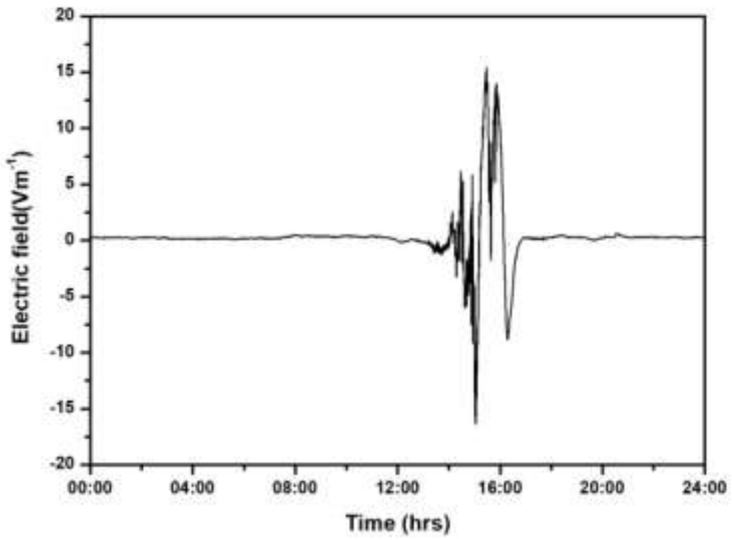

Figure 3: Electric field plot on a rainy day on 6 April 2018

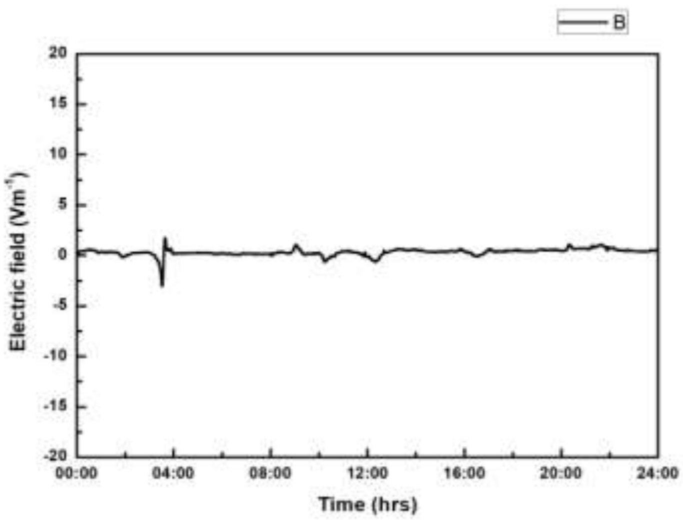

Figure 4 variation in electric field during thunderclouds (21 March 2018)

The clouds are charged electrically thus the atmospheric electric field increases in value when thunderclouds approach the electric field sensor (William and Heckman, 1993). When the clouds are overhead the Mill, the field direction reverses (03:45 hrs) to a negative value which again bounces back to its initial value when the clouds have passed from the site. By carefully studying the atmospheric electric field during thunderstorm regions, it is possible to determine the number, polarity and intensity of thunderstorm discharges (Xie, Zhang, Liu, Kai, 2011).

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As can be seen from the graph, electric field has values both in positive and negative regions. This happens because the earth is negatively charged while as the ionosphere is positively charged, thus causing a constant flow of electricity from ionosphere to the earth surface on a fine day. There is free electricity in the clouds and air caused by induction on earth surface and electromagnetic devices (S. Sakinah et al, 2017).

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