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Study of Atmospheric Electric Field Using EFM 100 and Its Initial Results

Shaista Afreen[1], Gowher Bashir Vakil[1], Nissar Ahmed[1].

[1]*Department of Physics, University of Kashmir, Srinagar, 190006, (India)*

ABSTRACT

Study of atmospheric electric field enhances our understanding of the complex processes that are responsible for defining the climate of any region. Knowledge and understanding of atmospheric electric field and its correlations with other weather parameters like humidity, temperature, aerosol can also be very useful in prediction/projection of various extreme weather related events like, lightening, thunder storm, cloudburst etc. Advance warning on the basis of such studies can help in guarding life and property from extreme weather related events.

As far as the study of atmospheric electric filed over the state of Jammu and Kashmir is considered, only few studies have been made at High altitude Laboratory at Gulmarg, during 70's and 80's. However during last thirty years no such studies have been carried in any part of the state. In the present study, the author reports installation/commissioning and study of atmospheric electric field using Field Mill Setup (EFM-100) procured from Boltek Corporation and installed at University of Kashmir. Studies related to variation of Atmospheric electric field and lightening events detected by EFM-100 under various weather conditions (Fair, Cloudy and Rainy) have also been presented in the current research paper.

Keywords: Atmospheric electric field, Electric field mill , Fair weather, Global electric circuit.

I.INTRODUCTION

Atmospheric electric field is part of global electric circuit which is generated by the thunderstorm discharges creating a potential difference of approximately 260-280 kV between ground and ionosphere in the regions of fair weather. Potential gradient has the capability to reflect changes in global electric circuit if measured at pollution free sites such as oceans, mountain peaks etc during fair weather. Abundant availability of historical and contemporary data for different latitudes can help in improving our understanding of global electric circuit, so an analysis of atmospheric electricity and of local factors which control the potential gradient at many locations around the world is required. Although quite a large number of measurements have been made on the atmospheric electric field since a long time using a variety of measurement technologies, yet there are comparatively very less data on potential gradient measurements under the conditions when snow was both present and absent from the ground at a station.

Scientific studies have shown that Atmospheric Electric Field is regulated by variations in the climatic conditions such as rainfall etc. which produces a vertical electric field in normal weather conditions [1]. The atmospheric electric field is one of the diagnostic tools for many applications. If the electric field measurements

have sufficiently high time resolution, it can be possible to study the number, intensity and polarity of the thunderstorm discharges and this can prove to be very useful for the improvement of the global electric circuit model [2]. Observation of the atmospheric electric field during fair weather has always been important for the researchers who are studying the global electric circuit or local effects (Tammet and Israelsson, 2001) [3]. Weather phenomena in space affect the ionosphere which causes disturbances in the Global Atmospheric Electric Circuit and these disturbances can be monitored by analysing the variations in the electric field during fair weather (Rycroft et al., 2012) [4]. Investigations into the relation between atmospheric electric field with meteorological factors and aerosols can help predict the amount of pollution or meteorological parameter variation. Electric field variations can be used as a tool for weather modification as was stated by Kauffman and Ruiz-Columbie´ (2005) [5], or electric field as scavenging mechanism as suggested by Tammet et al. (2001) [3] or for microbe control in the air as said by Yao, et al. (2005) [6]. Furthermore as the atmospheric electric processes modify the aerosol- cloud microphysics, they can help us in studying the global aerosol profiles and better our understanding of the aerosol-cloud interactions. Atmospheric electric field varies strongly just before the occurrence of an earthquake as was suggested by Rulenko (2000) [7]. So knowing the behaviour of atmospheric electric field in different metrological conditions we can use the global electric circuit as a short term precursor of seismic activity.

II.INSTRUMENTATION

To have a comprehensive approach to the problem an electric field mill EFM 100 is being used. The field mill is a simple and established technique for measurement and long term monitoring of the vertical electric field of the atmosphere at a place from which the PG can be directly derived (John Chubb, 2014) [8]. Environmentally durable field mills are available which are able to operate in rain and snow. For our present study the experimental setup consisting of an Electric Field Mill EFM 100 is installed in the educational premises of university of Kashmir on the roof top of a building, at a height of 10 feet above the ground and is connected through interfacing and cables to the computational and recording facility in our laboratory. It is to be mentioned here that the equipment has been manufactured by the Boltek Corporation, Canada.

Figure 1 Electric Field Mill as installed in the University of Kashmir.

The electric field mill works on the basic principle that an electric field which terminates on an earthed metal plate induces an electric charge on it. In the electric field mill an earthed metal plate is alternately shielded and exposed from the atmospheric vertical electric field using a mechanical chopper. When the metal plate is exposed to the electric field an induced charge develops on it and the opposite polarity charge flows to the ground through a sense resistor. When the metal plate is then shielded from the field, the excess charge on the plate is neutralised by the charges that are drawn to the plate from ground, again through a sense resistor (Ferro et al, 2011) [9]. Hence when plate is alternately exposed and shielded, This moving charge shows as an electric current which is measured as an AC voltage across the sense resistor. The size of the produced AC voltage is proportional to the size of the electric field applied to the plates and the exposed area of the plates while as the direction of the current depends on the direction of the electric field. This voltage is amplified and fed into an analog switch along with an out of phase version of the signal. The activity of the mill is being continuously recorded by the computer, every day, through suitable software as raw data which is being analysed.

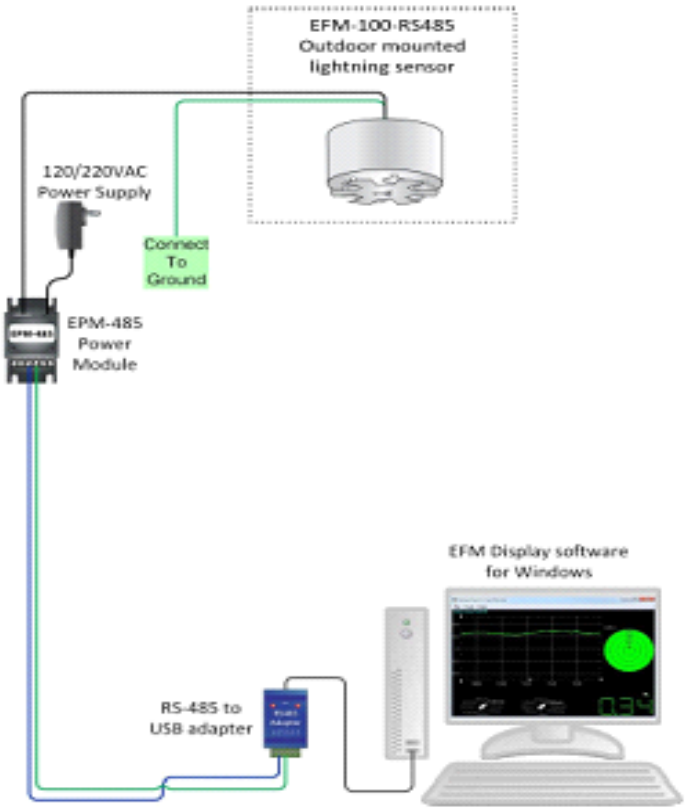

Figure 2 Block Diagram of Electric Field Mill.

III.OBSERVATIONAL RESULTS

The continuous recording of data started from 26th of February 2018, after proper installation. In this paper, some initial results have been presented to see the short term response of electric field mill when mounted on the roof top and is being exposed to open sky. Some plots have been sketched on a very basic level to show the variation of atmospheric electric field with the time if the day. Here two different graphs have been sketched to compare and understand the variation in electric field pattern under normal and turbulent weather conditions.

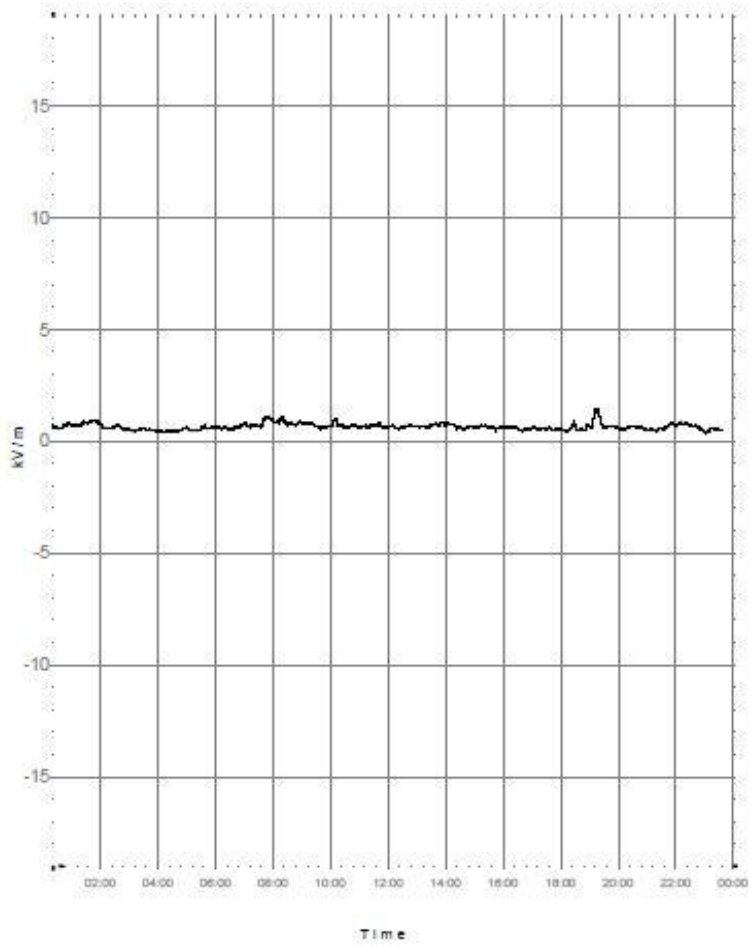

Figure 3 Plot of Atmospheric Electric Field as was observed on 27th February 2018

Figure 3 shows the 24 hour (00:00 to 23:59 UT) variation in atmospheric electric field on 27th February 2018. One can clearly see the very dormant nature of electric field with the value of electric field lying between 0.4 to 1.1 kV/m for most of the time. This is the approximate state of the AEF under normal weather conditions although the data has been gathered for a very short span of time.

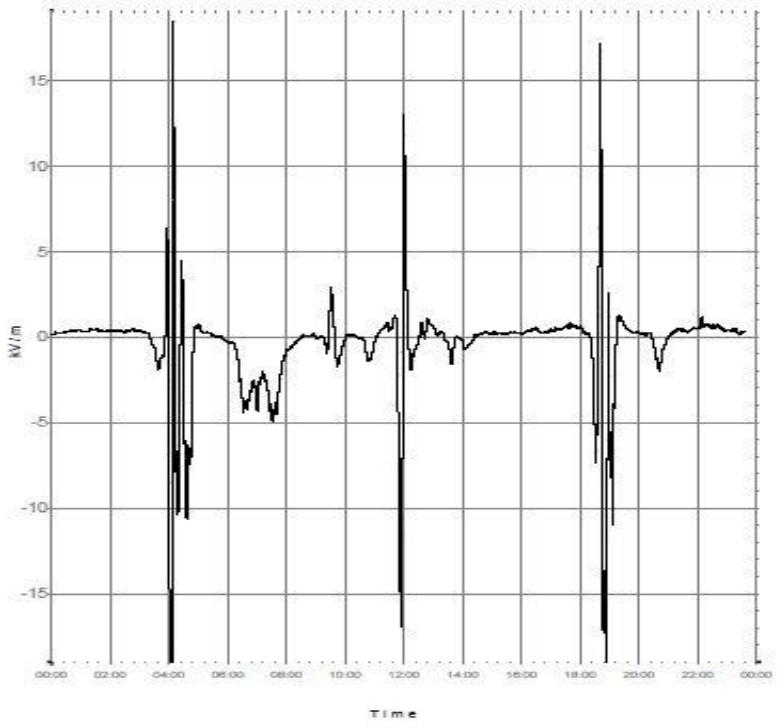

Figure 4 Plot of Atmospheric Electric Field as was observed on 2nd March 2018

Figure 4 represents the observation of electric field on 2nd march 2018. Heavy rainfall was recorded on this day at UT 04:00, 12:00 and at around 19:00 followed by some heavy lightening activities. The drastic variations in the values of electric field at these times can be seen clearly from the figure, with the values of electric field ranging between -20 to +20 kV/m. This can possibly be attributed to the lightening events taking place, during those hours in close by regions.

IV.CONCLUSION

The authors in this paper have presented the variations in measurements of atmospheric electric field as measured by the electric field mill, set up for the first time in Kashmir valley. Although the measurements have been taken for just a couple of days but one can clearly see the variations in the electric field arising due to different weather conditions. This leaves an impression about the variation of the atmospheric electric field in different conditions of the climate, normal as well as turbulent.

V.ACKNOWLEDGEMENTS:

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