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Analysis of Atmosphere Electric Field Characteristics during Lightening

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Abstract: *Atmosphere Electric Field Characteristics during Lightening to be towards the Earth during a fair weather day. Moreover there is no negative inversion which further confirms to the set standards of the normalized weather conditions. Slight variations in the electric field are observed only during the morning and evening hours which might be influenced by the increased aerosols and suspended particulates in the atmosphere. This chapter establishes that there is a perfect harmony visible in the correlation graphs between AEF and different atmospheric parameters which confirm that the intensity of the AEF is essentially governed by these meteorological factors.*

Keywords: *Atmosphere Electric Field*

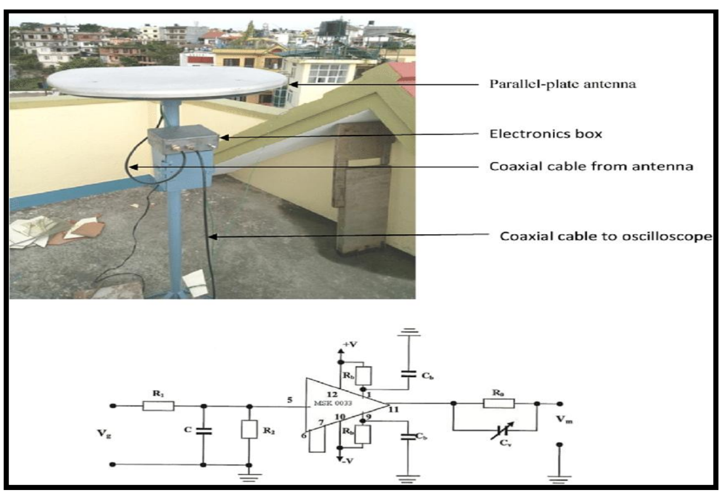
I. INTRODUCTION

Lightning is a high-energy luminous electrical discharge that occurs from inside, or even between dark clouds and also it's accompanied with sudden pressure fluctuations rippling in the earth environment. Finally, it seems to have a tremendous impact on human life and their facilities, and is a major concern specifically in the regions where precipitation and thunderstorms occur frequently. Although air is a poor conductor of electricity, there is no current flow between them. Positive charge accumulates on all objects below a thundercloud as it passes overhead [1]. When these positive charges are striving to meet the cloud's negative charge, they tend to accumulate at the top of the highest object in the vicinity. Lightning happens when the electrical potential difference between the +ve and -ve charges is high enough to transcend the resistance of air and force a conductive path between the cloud and the earth. It's probable that such a potential is as large around 100 million volts. In a few tens of milliseconds, a strong electrical discharge in the atmosphere heats the air to nearly 30,000°C [2-5]. This mechanism generates shock waves, whose propagation we hear as thunder. Thunder improves in approximately estimating range. Thunder (sound) travels one kilometer in three seconds, so the time (seconds) between seeing a lightning flash and hearing sound, separated by three, gives the slant range in kilometers. Further, the higher the pitch of sound of thunder, the closer is the lightning.

According to concept, an atmospheric electric field is a measurable key factor observing the intensity of the lightening at any given point in space and time. In fair weather, the atmospheric electric field near the earth's surface ranges from 100 to 300 V/m. It is a positive field that travels from the atmosphere to the earth [6-8]. Poor weather occurs simultaneously in all places around the world in which there is no thunderstorm activity. According to the conductivity theory of the global electric field, at thunderstorm locations, this field reverses direction and rises thousands of volts per meter. It has been observed that the electric field exhibits a sudden bipolar peak at the time of a flash at very specific times to a lightning strike. Electric field fluctuations are known as sluggish (or static) or rapid (dynamic) in statistical experiments and changes in both are associated with the lightning mechanism. Sluggish electric field antennas effectively reverse field changes over duration of a lightning discharge, including data on the discharge edge leader process, and continued flow. Strong electric field antennas analyze discharge portions on a quicker timeframe and return shifts on a microsecond time scale [9-10]. An Electric Field Mill (EFM) is an electronic circuit which measures the intensity of the static atmospheric electric field at the instrument's location. It functions by revealing a transmitter component as well as an unidentified response to the electric field simultaneously. When heated to an unidentified analog, the sensor element becomes activated by the external electric field and then discharged. Charge amplifiers convert the sensor element's induced charge to a voltage that is proportional to the external electric field [11]. Variations in the electric field are shown in both clear and cloudy weather. A comprehensive review will show distinct changes in the electric field before and after a strike. Since modifications prior to a strike help in prediction, a study in Brazil explores a technique of lightning warning systems based on electric field variations. Electric field data obtained from an EFM has been used in a simulation experiment, and the results compared with lightning data collected from the Brasil DAT data repository. The characteristics of an electric field that can predict a lightning strike also include reversal of electrostatic field polarity and an increase in field magnitude [13]. While lightning location systems are considered to be more accurate, EFMs have the potential to enable to detect the development of a thunderstorm directly over the area of concern, enabling them to predict. even first strikes. According to the Brazilian simulation outcome, the field threshold for precise warning signals becomes 0.9kV/m for a range of 10km, with the fair weather value of field being 300V/m. Preliminary Breakdown (PB) is a dynamic electrical process that happens within the cloud prior to lightning and occurs even before the cloud initiates [14-15]. Meteorological conditions have been discovered to have an effect on these electrical pulses. A bipolar pulse train with a normal duration of a few milliseconds is used to identify the PB process in electric field records. The time interval between the preliminary breakdown and the first return stroke is referred to as the actually stepped leader duration. An assessment of lightning strikes in Florida reveals that approximately 29 percent of the strikes had a detectable PB pulse train. When the signal-to-noise ratio was increased through filtering, the percentage rose to 47 percent. Detestability was also affected by location. They discovered that at higher latitudes, a greater proportion of flashes had visible PB pulse trains than at lower latitudes. Other factors influencing PB pulse detestability include storm type, distance, and first return stroke peak current. The observations here validate the arithmetic and geometric means of PB pulse duration as 3.6ms and 2.1ms, respectively, which are close to Nag and Rakov's findings. The ratio of the strongest PB pulse peak to the first return stroke pulse peak ranges from 0.05 to 0.9 for 93 of 104 flashes (excluding 11 saturated records), with an arithmetic mean of 0.26 and a geometric mean of 0.20. Another Malaysian study discovered a preliminary break-down signature in more than 95 percent of the flashes observed. The polarity of the characteristic pulses was found to be the same as that of the first return stroke.

II. METHODOLOGY

Around 80% of the recorded flashes were discovered to be consistent with the BIL model. A proposed model of Clarence and Malan explain the phenomenology of lightning. A BIL model can be studied from an experiment of parallel plate antenna which captures the vertical component of the atmospheric electric field by using the buffer circuit, GPS, DSO, data logging system. The waveform describes the initial breakdown (B) stage, which lasts milliseconds, and the intermediate stage (I), which lasts several hundred milliseconds.



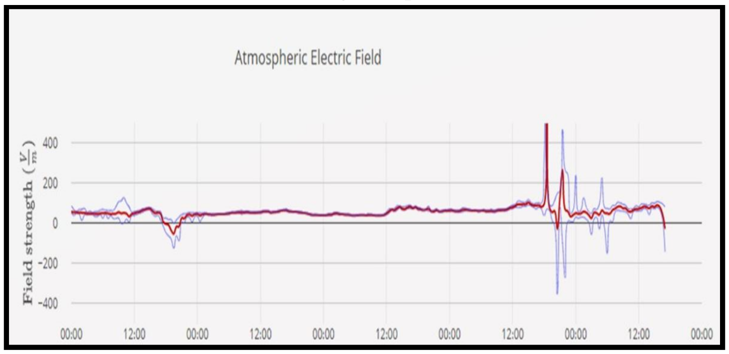
The final stage is the stepped leader (L), which lasts a few milliseconds. The stepped leader stage concludes with a very intense return stroke, which is the perceived lightning flash as charges flow from the ground to the clouds through the lightning channel. The most prevalent method for analyzing electric field variations is to investigate them in either the static or dynamic domains, but not both at the same time. However, a different technique was used in a Polish experiment: frequency domain analysis. This spectral analysis is intended to aid in the correct identification of lightning-related electrical processes such as preliminary breakdown, stepped leader, ongoing current, and other separate electrical processes. A rapid change in the electric field caused by lightning strikes result in a high level of power spectral activity. When slow field changes are represented by low frequency components, preliminary breakdown and return stroke are represented by faster components. The particulars of their experiment demonstrate the importance of determining the components of preliminary breakdown in order to improve existing detection systems [16] . In this experiment, they suggested using a narrow STFT window for preliminary breakdown or return stroke analysis. We used the Short-Time Fourier Transform to identify the different lightning stroke components such as preliminary breakdown (PB), return stroke (RS), and continuing current (CC) in the power spectrum density analysis of lightning electric fields (STFT). The parameters for lightning detection can be divided into two groups: those concerned with determining the precise time and location of a strike, and those concerned with physical parameters such as lightning current, electric field, amplitude, polarity, and strike type.

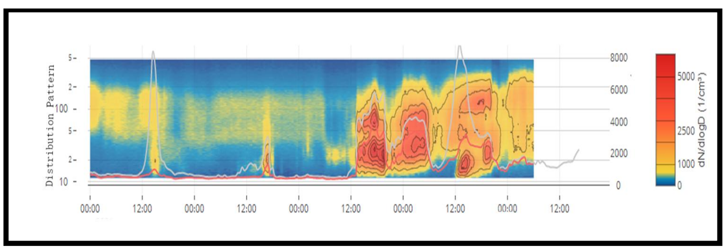
III. LIGHTNING DATASETS

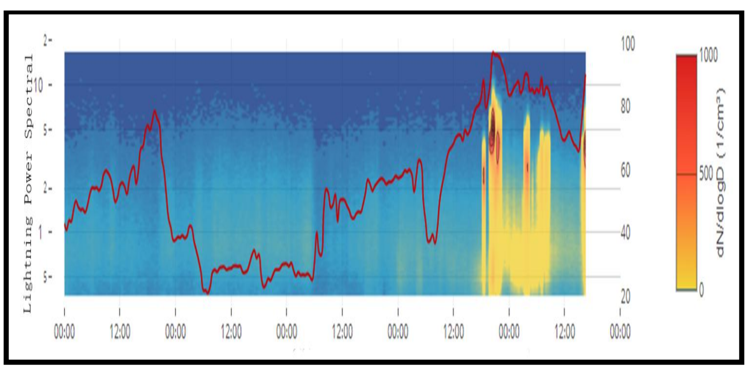
Sonnblick Observatory, Austria, provided the electric field measurement values. Sonnblick Observatory is situated in the Austrian Central Alps at an elevation of 3106 m a.s.l. at the top of the mountain "Hoher Sonnblick." It is centered at the alpine main divide, and is a distinct climatological boundary. It is also found in the “Nationalpark Hohe Tauern,” which comprises 1856 km^2 of the Austrian Alps on the frontier of the provinces of Salzburg, Carinthia, and Tyrol. The nearest villages are Heiligenblut (10 km away) to the south and Rauris (10 km away) to the north (20 km away). The accessible infrastructure from gold mining operations was a significant factor for the creation of the Sonnblick Observatory in 1886. Sonnblick analysis is currently being conducted in the research program ENVISON. It has a large surveillance network and several scientific programs that address three major topics (the environment, the cryosphere, and the biosphere). Sonnblick is renowned for its long-term temperature monitoring and research on glacier transitions. Sonnblick Observatory, one of Austria's largest meteorological observatories, is exclusively devoted to the collection of data of global scientific significance after a thunderstorm and prior to a lightning strike [17]. The initial weather station has become an interdisciplinary research center thanks to its location at the main peak of the Alps at over 3,100 meters above sea level in a nearly free atmosphere, as well as the ZAMG technicians' year-round support. Electric Field measurements were taken at two Electric Field Mills in Sonnblick and Kolm from March 29 to April 2, 2016 Local Time. Lightning is accompanied by localized changes in the electric fields of the atmosphere. Changes in ambient electric fields can also be detected at the ground a few minutes before a strike in cloud-to-ground strike areas. A great deal of study has also been conducted on the electrostatic shifts that occur in the area above ground prior to lightning. With the aid of COMSOL Multiphysics simulations, we analyze the effects of lightning electric fields on/underground in this work. Horizontal and vertical voltage gradient, electric field, polarisation, and other profiles are studied. Experiments were carried out using a general model of lightning electric fields generated from data obtained by Electric Field Mills (EFMs) from three different locations around the world: Kennedy Space Centre (KSC), Florida (using GHRC datasets), and Sonnblick Observatory, Austria. Sandstone was used as the base model for land in COMSOL simulations of the global electric circuit. Previously, similar works of literature only dealt with lightning electric fields above level. This study is the first step toward creating a high-level simulation of the effects of atmospheric electric fields on/below ground [18]. The outcomes of this simulation work will assist with lightning forecasting and preparedness by opening up new avenues for voltage-based prediction methods at field. It is also a medium for comprehending phenomena such as fulgurites, the corona effect, and so on. It also assists in the construction of buried cables and more efficient grounding schemes.

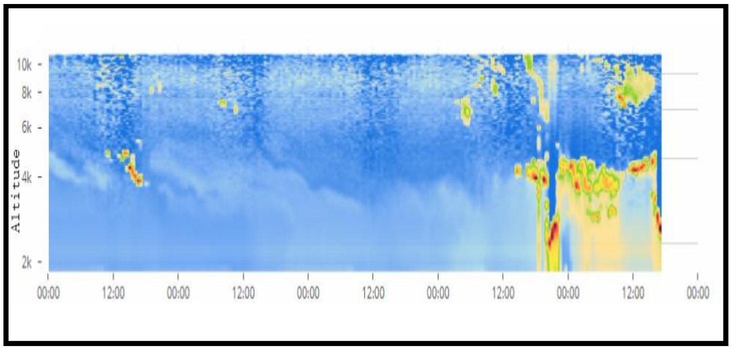
IV. RESULTS AND DISCUSSION

The most significant control of instantaneous changes in IMF components on the convection pattern and its associated ionospheric potential difference is expected to occur in the closest region where a direct interaction (VSW × B) is possible (magnetic daytime) Similarly, during the next course (~09:40–11:30 UT), the gradual changes in the IMF-BZ maximum of 15 nT significantly enhance the ionospheric potential difference. In addition, a sudden peak signature in the AE and AL indices around ~09:45 UT suggests that the aurora geomagnetic field responded to the shock front. This effect is significantly recorded on ΔH as a strong negative phase, and it depicts the westward motion of the electro jet overhead of measuring site; in other words, the westward electro jet indicates the position of the convection pattern over the station, In this scenario, it is expected that an intense horizontal electric field exists at the ionosphere altitude, which may produce electrical perturbations through downward mapping. On account of this downward mapping, PG values for Vostok and Dome C are substantially increased 2.2 times than that of the average values (reference curves) at 10:30 UT, whereas Maitri PG increased up to 1.8 times to that of the average. This source of the ionospheric electric field is manifested in the atmospheric electric field (PG) with different weights depending on measurement locations with respect to the magnetosphere convection cell [19]. It is noted that the three observatories were significantly influenced by solar wind-magnetosphere interaction. The recovery phase of the PG values at 10:45 UT infers that the ionosphere potential is being weakened, and this effect is also consistent with the DFM records by recovery of the ΔH and ΔZ components. A long recovery phase of PG reached well below the ambient values (reference curve). This negative phase, a lesser amplitude than the reference curve at a given UT hour, infers the phase reversal of the superposing downward ionosphere electric field, which may be caused by the polarity changes in the magnetosphere electric field. This strong penetration of the electric field from the interaction of the solar wind and Earth's magnetic field is observed from the polar cap to subauroral latitude. In addition, the weather is also favorable during the course of measurements at all the three stations. Hence, the attenuation ratio for downward mapping due to local weather factors is almost negligible. In the third interval, PG enhancement is observed at about 11:30 UT at Vostok and Dome C, which is associated with the third magnetic perturbation observed over two stations.









This particular dataset was used because of the presence of lightning strikes during the considered interval. The parallel plate antenna for atmospheric electric field at Sonnblick Observatory makes measurement, when the field is below 500 V/m and 2 measurements / second when the field is above. Lightning characteristics and their statistical information supported by accurate analysis pave way for a good lightning detection system. The study of electric field data from geographically diverse countries Austria and gives an insight into how this analysis can be used on a global basis. The EFM of Sonnblick Observatory readings in the Sonnblick data, shows a peak buildup of about 6000V/m preceded by a drop in value due to a reversal of electric field that is characteristic of a lightning electric field prior to the strike [20].The data from the National Centre for Earth Science Studies, Trivandrum on dates 8/10/2011, 25/10/2011 and 30/10/2011. 8th October is a representative day of fair weather, and it can be seen that the electric field values are confined to less than 500V/m. NCESS data for 30/10/2011- thunderstorm with lightning flash midnight and the fields can be clearly seen to have risen till 2500 V/m.NCESS equipment only measures the magnitude blinding us on the polarity. And on 30th October 2011, electric field buildup to about 5000V/m was observed and a lightning had occurred in agreement with their lightning incident Electric field measurements and their analysis assist the meteorologists in predicting the very difficult first stroke. The experimental datasets from both the regions were found to be consistent with the literature study. Such a comparison of data from two very diverse places points out the observed similarities in the behavior of electric field prior to lightning and it helps to formulate a general mechanism to effectively predict lightning. Also, this research work will be a first step towards formulating a standard model of atmospheric electric field characteristics prior to lightning strike for other research and early warning systems. recordings. Due to lack of polarity measuring devices in the Trivandrum Centre, the dip before the peak could not be identified as the reversal of polarity which is a characteristic of electric field variations. However, the magnitude variations are clearly visible. The build up and flip in polarity of electric field prior to strike is a key parameter that can be used effectively in lightning detection. whenever a charge separation occurs over or nearby an EFM, or whenever a mature thunderstorm approaches the area of concern, there is a reversal of electric field polarity which is accompanied by an increase in magnitude. This means that the electric field becomes a large negative value before a lightning strike.

V. CONCLUSION

Atmospheric Electric Field under Perturbed Weather Conditions, examines the behaviour of atmospheric electric field under the influence of various indicators of perturbed weather like rainfall, precipitation, humidity, gust and wind velocity. There has been an attempt to establish a correlation between the intensity of these factors and that of the atmospheric electric field. The comparative graphs illustrating the correlation between these factors and the changing patterns of the atmospheric electric field demonstrate a high interdependence between these phenomena and the intensity of atmospheric electric field. This chapter also aims at exploring the propensity of developing the behavioral patterns of the atmospheric electric field when it is affected by climatic turbulences, which can be further taken as a contrasting reference to the behavioral graphs of atmospheric electric field during a clear weather so that any forthcoming natural disasters may be forecast well in advance and precautionary decisions may be taken.

REFERENCES

[1]. S Twomey, Atmospheric Aerosols, Elsevier Scientific Publishing Co., 1997.

DOI: 10.48175/568

[2]. S. Changnon, R. Changnon, R. Fosse, D. Hoganson, R. Roth, J. Tostsch, Effect of recent weather extremes on the insurance industry: Major implications for the atmospheric sciences, Bull. Am. Meteorol. Soc. 78, 425 – 435, 1997.

[3]. E. A. Bering, A. A. Few and J. R. Benbrook, "The Global Electric Circuit," Physics Today, Vol. 51, No. 10, 1998, pp. 24-30. doi:10.1063/1.882422.

[4]. Stolzenburg M, Rust W D and Marshall T C 1998 Electrical structure in thunderstorm convective regions 2: Isolated storms; J. Geophys. Res. 103 14,079–14,096.

[5]. S. Changnon, Evaluation of weather catastrophe data for use in climate change investigation, clim. Chang., 38,435-445, 1998.

[6]. K. Kumkel, R. Pielke, S. Changnon, Temporal fluctuations in weather and climate extremes that causes economic and human health impacts; A review: Bull. Am. Meteorol. Soc., 80, 1998.

[7]. J N Chubb, Experience with electrostatic instruments with no earthing of the ratationg chopper paper presented at 'Electrostatics 1999' Conference in Cambridge, March 29-31, 1999.

[8]. C G Deshpande and A K Karma, The atmospheric electric field and conductivity measurements during the XVI India Antarctica expedition, Technical publication, No. 14 pp. 1 to 36, Sixteenth Indian Expedition to Antarctica Scientific report, 2000.

[9]. M J Rycroft, S Israelsson, C Price, The global atmospheric electric circuit solar activity and climate change, Journal of atmospheric and solar- Terrestrial physics 62, 1563-1576, 2000.

[10]. E. Belova, S. Kirkwood and H. Tammet, The effect of magnetic sub storms on near ground atmospheric current, Ann. Geophysicae, 18, 1623 – 1629, 2000.

[11]. P. Stauning, High voltage power grid disturbances during geomagnetic storms, Proceedings of the second Solar cycle and space weather euro- conference, 24, 2001.

[12]. Gurevich A.V., K. P. Zybin, Runway breakdown and electric discharges in thunderstorms, UFN, 171, No. 11, 1177-1199, 2001.

[13]. P. Stauning, High-voltage power grid disturbances during geomagnetic storms, Proceedings of the Second Solar Cycle and Space Weather Euro-conference, 24, 2001.

[14]. Glavatovic Branislav and Cavelis Marin, Possible new phenomenon in the atmospheric electric field intensity variation that is caused by the strong earthquake occurrences, Montenegro Seismological Observatory, Montenegro, Podgoria. 2001.

[15]. R G Harrison and K L Aplin, Mid 19th century smoke concentration nearLondon, Atmos, Environ, 36 4037, 2002.

[16]. Harold Kirkham, On the measurement of stationary electric field in air, Jet propulsion laboratory, California institute of technology, Pasadena, California, 2002.

[17]. Tsurutani, B.T., Gonzalez, W.D., Lakhina, G.S. and Alex, S., J. Geophys. Res., 108 (A7), 1268, 2003.

[18]. B. T. Tsurutani, W. D. Gonzaliz, G. S. Lakhina and S. Alex, J. Geophysics, Res. 108(A7), 1268, 2003.

[19]. Rakov V A and Uman M A, Lightning physics and effects, Cambridge University Press, 2003.

[20]. R. Latha, Diurnal variation of surface electric field at a tropical station in different seasons, a study of plausible influences, Earth planets space 55. 677-685, 2003