



## Analysis of Air Humidity and Temperature for Post Lightning Circumstances

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### ABSTRACT

Lightning is a natural phenomenon that generates a high electric field during thunderstorm. It has been reported that lightning strikes amid storms can occur around 100 times per second. The atmospheric electric field is an imperative parameter during a thunderstorm. Therefore, monitoring the electric field and its parameters is the best way for local lightning forecast. The electric field monitoring data can validate the accuracy of weather prediction in a local area from meteorology department or by using equipment specially designed to measure this electric field that exists when the phenomenon of lightning occurs. In this paper, the relationship between lightning, air humidity and temperature is discussed to understand the post lightning effect on these electric parameters. Additionally, the characteristics of the parameters are observed and analysed.

*Keywords:* Lightning, humidity, temperature, atmospheric electric field

### INTRODUCTION

An atmospheric electric field is one of the most important parameters of a thunderstorm and every time a thunderstorm approaches, it is often accompanied by lightning whereby the

atmospheric electric field lights up (Bo, Bihua & Taichang, 2007). Typically, thunderstorms are linked to lightning whereby the latter generates electric discharge with high voltage. It is a transient discharge of static electricity which serves to re-create the electrostatic symmetry within a thunderstorm situation (Mohamed & Lee, 2006; Gan & Li, 2010; Oh, Pang & Chua, 2010). Atmospheric electric field is generated by the difference between ionosphere and ground that happens during fair weather in the order of 300kV (Price, 2002). During a thunderstorm, its strength near the ground can hit standards of 15 kV/m

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and shows quick varieties described by short pulses identified with lightning. The measurement of atmospheric electric field is known widely as an analytic instrument for many applications. By observing atmospheric electric field in the high intensity and high frequency ranges, it is possible to analyse the polarity, intensity and number of thunderstorm discharges (Xie, Zhang, Liu & Kai, 2011). Studies have shown that the expansion of atmospheric electric field in fair weather can be one of the indicators of presence of aerosol in the air or the atmosphere in general (Sheftel, Chernyshev & Chernysheva, 1994). Atmospheric electric field varieties are created because of the electric charge generation and the movement into a thunderstorm. During the thunderstorm and lightning, changes of magnitude and polarity of the atmospheric electric field occur. On cloud electric field estimations, it is possible to know the total thunderstorm duration, the distinctive thunderstorm stages and some lightning parameters, for example, lightning location and transfer charge (Aranguren, Delgadillo, Vargas, Perez & Torres, 2006). Lightning is just like a static electricity that happens because of the attraction between positive and negative charges in atmosphere (Srinivasan & Gu, 2006). During a thunderstorm, the moisture of air is changeable. The humidity and temperature are the indicators of moisture in the air (Lawrence, 2005). In this work, the relationship between humidity and temperature post lightning is examined.

## EXPERIMENT

The electric field is measured using Boltek EFM – 100 Electric Field Monitor. The electric field mill detects an electric field by repeatedly exposing and shielding a progression of sense electrodes to the air. The electric field data is displayed and graphed using the EFM – 100 display software, from the approach of lightning which gives a positive field reading, trailed by a field inversion to a negative field as the cloud moves overhead. Electric field mill utilises a mechanical chopper to shield and uncover a few sense plates to an electric field. An electric charge is attracted from ground to the plates through a sense resistor when the sense plates are presented at the electric field. The field charge streams back to ground, again through the sense resistor, when the sense plates are protected from the field. This moving charge delivered an electric current which is measured as an AC voltage over the sense resistor. The measure of the voltage corresponds with the span of the electric field connected to the plates. Charges that stream onto and off of the sense cathodes will build up a voltage over the resistor. Thus, the reading will be detected and displayed in a monitor. To measure the humidity and temperature, another equipment was used, Davis WeatherLink. This WeatherLink was mounted at the rooftop to give an accurate weather measurement. The weather data is then compared with electric field data to be analysed. Figure 1 shows the block diagram of the Boltek EFM-100 while Figure 2 shows the block diagram of WeatherLink that have been used in this work. The WeatherLink will measure the parameters of weather that can be captured around the weather station.

In this work, both equipment were used to measure the atmospheric electric field, outside temperature and outside humidity. Lightning data was validated obtained from TNB Research and meteorology department for weather validation. The monitoring process a one year from October 2014 until September 2016. The Boltek EFM-100 and the WeatherLink was mounted at the rooftop of Faculty of Engineering, Universiti Putra Malaysia, Serdang.

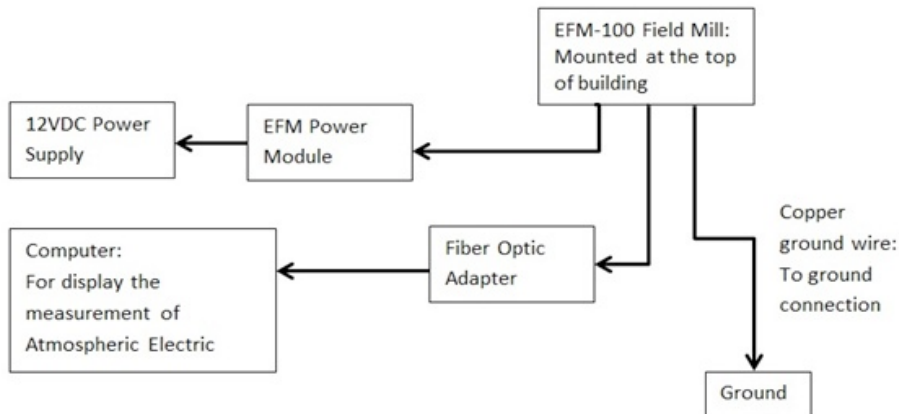


Figure 1. Block diagram of Boltek EFM-100

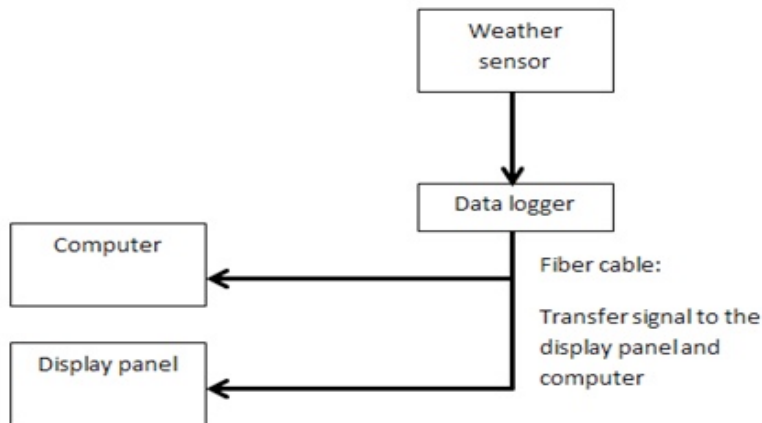


Figure 2. Block diagram of WeatherLink

## RESULT AND DISCUSSION

The monitoring process of atmospheric electric field and weather has been done continuously for one year starting from October 2014. By monitoring both the atmospheric electric field using Boltek EFM-100 field mill and parameters of the weather using WeatherLink, information regarding the validity of weather prediction in a native area, lightning forecast and the reliability of lightning protection validation can be observed, measured and analysed. This study had focused on Southwest Peninsular Malaysia where a field mill was mounted at the top of the building of Faculty Engineering, Universiti Putra Malaysia, coordinated at N 3.008543 latitude and E 101.720622 longitude. Data obtained was compared with real data from TNB Research for validation. Figure 3 and Figure 4 show the monthly average of electric field through the observation process. The Meteorology Department website indicates this area experiences southwest monsoon between May and October. The graph above shows average monthly rainfall during non-monsoon and monsoon periods. Figure 3 shows the monthly average for

December and January which is the intermediate period during non-southwest monsoon. Figure 4 shows when the southwest monsoon begins (May) and when it ends (October). The electric field curve shows that it has value in both regions, positive and negative. In theory, the earth is negatively charged and the ionosphere is positively charged which causes a constant flow of electricity. There is constantly some measure of limitless positive and negative, however, remaining positive, the atmosphere electric charge nearest to the surface of the negatively charged earth on a fine day. There is free electricity in the cloud and air caused by induction on earth and electromagnetics devices. Most of the experiment dealing with atmospheric electric field shown that there will always be free electricity in atmosphere, sometimes positive, sometimes negative.

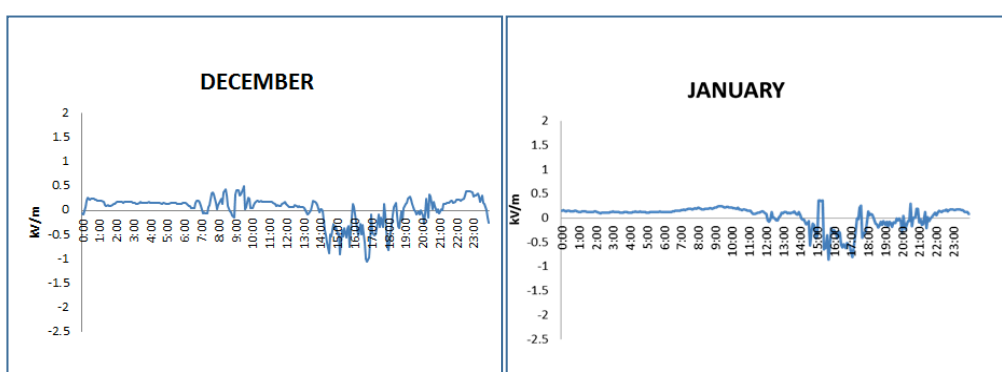


Figure 3. Monthly average electric field data curve during off the southwest monsoon

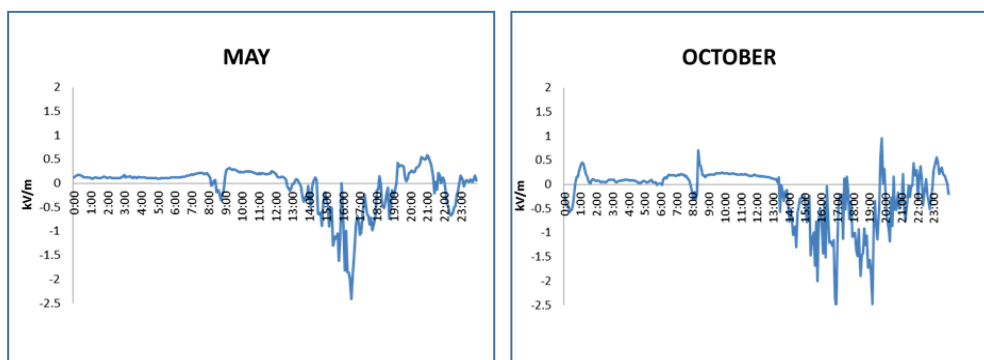


Figure 4. Monthly average electric field data curve during the southwest monsoon

From the graphs, it can be seen that rainfall and thunderstorm occur in the evenings. In the morning until noon, a flat line showed that no lightning was detected during this period. Fluctuation of the curve shows that lightning which occurs frequently and the radius of the field mill mounted point was around 50km. The trends of electric field was studied and recognised. It rains daily between 1600 until 1800. According to the Meteorology Department, it sometimes rains during the night and sometimes thunderstorm can be heard and lightning strikes can be

observed. During a thunderstorm, the electric field can reach up to 20kV/m. In this condition, the weather is disturbed, the vertical electric field can change from negative to positive value (Watt, 1960). Figure 5 shows the output of electric field, outside temperature and outside humidity during sunny days. In the mornings, humidity and temperature is stable. When the sun rises, temperature increases and humidity decreases until evening whereby temperature drops and humidity increases. The reading is stable until end of the day.

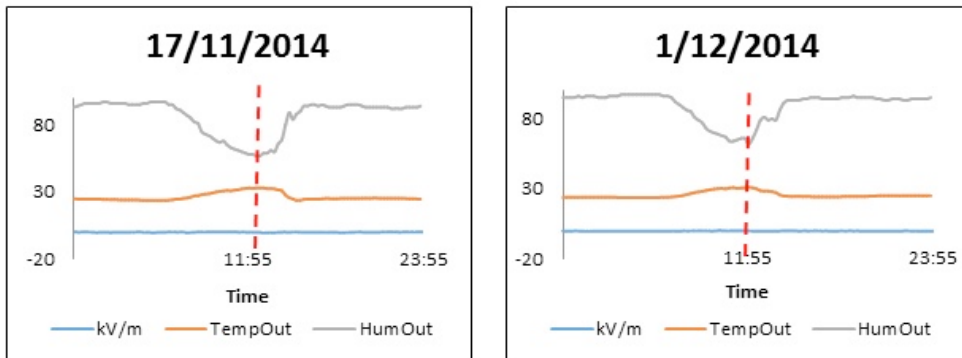


Figure 5. Data curve of electric field, outside humidity and outside temperature during sunny days

During sunny days, the electric field around the field mill is below 200V/m. The electric field is ordinarily down coordinated, and in fair weather and in unpolluted air, the strength near the ground surface is between 100-200 V/m (Xie, Zhang, Liu & Kai, 2011). It will reach a peak point between 12pm and 2pm, temperature at the maximum and humidity at the minimum reading because of the vertical position of the sun which is at the peak. The curve will be flat again. Results of the experiment show that output is almost same as theoretically principle of humidity and temperature which is the humidity will be vice versa from the temperature curve. In short, when humidity reaches the minimum reading, the temperature should record maximum reading. Figure 6 shows relative humidity and temperature as per the Comet Meteorology Education.

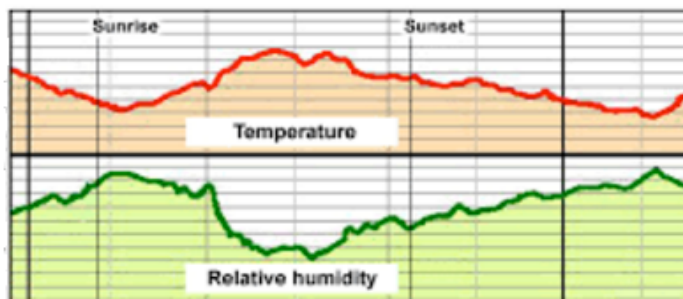


Figure 6. Illustration of relative humidity and temperature

When thunderstorm begins, the field mill will detect lightning signs. Usually, lightning strikes first, before the weather changes from sunny to cloudy. So, it can function as a lightning alarm system. Figure 6 shows the data curve of electric field, humidity and temperature in one graph when lightning was detected and thunderstorm occurred. In the morning, the curve is flat until thunderstorms are detected. During a thunderstorm, humidity and temperature fluctuate. Even when a thunderstorm clears, the reading changes because of the post rain situation.

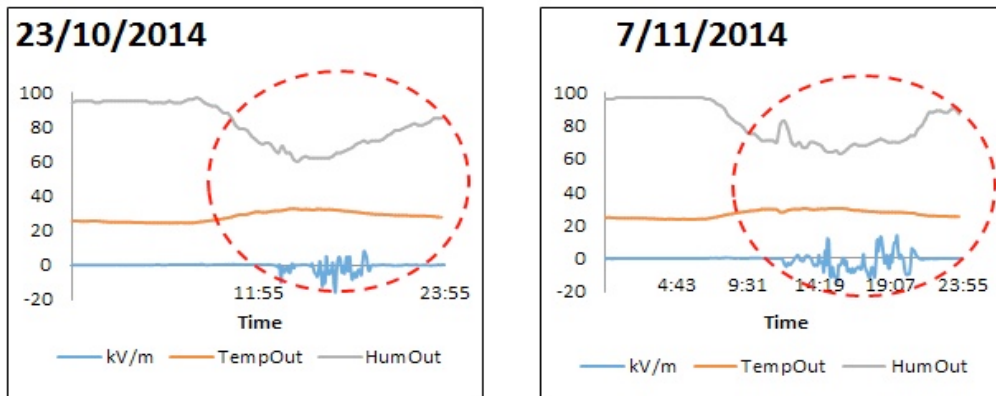


Figure 7. Data curve of electric field, outside temperature and outside humidity when lightning detected

From the field observation, at noon, humidity starts to decrease while temperature increases slightly. When a thunderstorm occurs, humidity increases slowly and temperature decreases slightly because rainfall makes the area cooler and more humid. This situation is unlike during a sunny day. As long as thunderstorms and lightning keep occurring, humidity and temperature will fluctuate until the weather normalises. When a thunderstorm dissipates, the humidity increases slowly and the temperature decreases slightly because of the reservoir of rain in this area. By studying the post lightning situation, important information can be obtained for safety alerts, and prepare for any eventualities.

## CONCLUSION

The atmospheric electric field and its trend was studied. The variation of an atmospheric electric field near the ground showed the reading of the electric field to be quite high. The strength of an electric field during a thunderstorm is much higher compared with during sunny and cloudy days where humidity and temperature fluctuate.

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## REFERENCES

- Aranguren, D., Delgadillo, A., Vargas, M., Pérez, E., & Torres, H., (2006). Estimation Of Lightning Electrostatic Parameters Based On Atmospheric Electric Field Measurements And Genetic Algorithms. In *19th International Lightning Detection Conference 24-25 April*. Tucson, Arizona, USA
- Bo, Y., Bihua, Z., & Taichang, G. (2007, October). Research on distribution of electric field near ground during thunderstorm process. In *2007 International Symposium on Electromagnetic Compatibility* (pp. 267-270). IEEE.
- Gan, P. Y., & Li, Z. (2008). An econometric study on long-term energy outlook and the implications of renewable energy utilization in Malaysia. *Energy Policy*, 36(2), 890-899.
- Lawrence, M. G. (2005). The relationship between relative humidity and the dewpoint temperature in moist air: A simple conversion and applications. *Bulletin of the American Meteorological Society*, 86(2), 225-233.
- Mohamed, A. R., & Lee, K. T. (2006). Energy for sustainable development in Malaysia: Energy policy and alternative energy. *Energy Policy*, 34(15), 2388-2397.
- Oh, T. H., Pang, S. Y., & Chua, S. C. (2010). Energy Policy and Alternative Energy In Malaysia: Issues and Challenges for Sustainable Growth. *Renewable and Sustainable Energy Reviews*, 14, 1241–1252.
- Price, C., (2002). *Lightning and Atmospheric Electricity*. Encyclopaedia of Global Environmental Change, T. Nunn, Ed. Chichester, U.K, Wiley, 502-503.
- Sheftel, V. M., Chernyshev, A. K., & Chernysheva, S. P. (1994). Air conductivity and atmospheric electric field as an indicator of anthropogenic atmospheric pollution. *Journal of Geophysical Research: Atmospheres*, 99(D5), 10793-10795.
- Srinivasan, K., & Gu, J. (2006, May). Lightning as atmospheric electricity. In *2006 Canadian Conference on Electrical and Computer Engineering* (pp. 2258-2261). IEEE.
- Watt, A. D., (1960). ELF Electric Field From Thunderstorms. *Journal of Research of the National Bureau of Standards-D Radio Propagation*, 64D(5), 425-433.
- Xie, Y., Zhang, T., Liu, X., Kai, X., (2011). Electric Characteristic of Atmosphere in Yuxi Region and Its Application of the CG Lightning Warning. In *Pacific International Conference on Lightning Warning*, IEEE.

