Jurnal Teknologi

Full paper

Study of Lightning Fatalities in Malaysia from 2004 to 2012

N. A. Ahmad[a*], Nur Najihah Abu Bakar[a], Z. Adzis[a]

[a]*Institute of High Voltage & High Current, Faculty of Electrical Engineering, Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor, Malaysia*

*Corresponding author: azlinda@fke.utm.my

Article history

Received :21 February 2013
Received in revised form :
18 November 2013
Accepted :5 December 2013

Graphical abstract

Abstract

Lightning strike is an environmental phenomenon that dominates the factors of supplemental deaths as well as injury due to its extremely high current and voltage surge. Many fatalities caused by lightning have been reported whereby some were deaths and some were able to survive with injuries either on a short or long term effect with permanent injury. Since Malaysia is one of the countries in the world with very high lightning activities, a laudable statistics data about death and injuries is needed to increase public awareness on the dangers of lightning. This work manifests an overview, recent statistical data and analysis on lightning fatalities in Malaysia which includes the year, gender, age, status, month, state, activities and location of where the victim was hit by lightning. It describes the favorable image to illustrate the jeopardy of lightning to the public by employing case study and statistical analysis based on medical and newspaper report.

Keywords: Lightning; lightning fatalities statistical data; lightning injury mechanism

Abstrak

Panahan petir merupakan fenomena alam yang menyumbang kepada faktor utama kematian serta kecederaan akibat daripada renjatan jumlah arus dan voltan yang sangat besar. Kebanyakan mangsa panahan kilat dilaporkan meningggal dunia dan sebahagian lagi mengalami kecederaan teruk. Memandangkan Malaysia merupakan salah satu negara dengan aktiviti kilat yang tertinggi di antara negara-negara di seluruh dunia, statitik yang lengkap tentang kematian dan kecederaan adalah penting untuk meningkatkan kesedaran orang ramai mengenai bahaya kilat. Penyelidikan ini memberikan gambaran menyeluruh, data statistik terkini dan analisis mengenai kematian dan kecederaan yang disebabkan oleh kilat di Malaysia yang merangkumi tahun, jantina, umur, status, bulan, negeri, aktiviti dan lokasi di mana mangsa di panah kilat. Ia memberikan imej yang jelas untuk menggambarkan bahaya petir kepada orang ramai dengan menjalankan kajian kes dan menganalisis data statistik berdasarkan laporan perubatan dan penulisan di akhbar.

Kata kunci: Kilat; statistik kemalangan kilat mekanisma kecederaan kilat

1.0 INTRODUCTION

Lightning is usually related to electricity which occurs as when a charged cloud discharges to the ground. Lightning can cause severe electric injuries and may be seen as a result of an accident or in-deliberate attempts of injury. This damage to the human body is caused by a sudden flow of a large amount of electrical current in a range of several thousand amps to several hundred thousand amps.

There is an estimation of 25 million lightning flashes in the United States each year[14]. Documented lightning injuries in the United States shows the average of lightning fatalities is about 300 per year. Due to flaws in the reporting process of lightning-related occurrence, actual amount of lightning fatalities are likely to be much higher[1]. Malaysia likewise ranks as one of the highest countries with lightning injury in the world after Rwanda and Congo. Malaysia has an estimated 100 to 150 lightning deaths per year, according to a lightning researcher in the country[2]. Using 125 per year, an annual rate of 3.4 deaths per million people is obtained[2]. In comparison to United State that has 300 million people, the population in Malaysia is only 27 million. Thus it can be concluded that in the context of population size, Malaysia's lightning death and injuries rate is actually 10 times higher than United States.

2.0 GENERAL OVERVIEW OF LIGHTNING ACTIVITIES IN MALAYSIA WITH METEOROGICAL INFORMATION

The formation of lightning is influenced by environmental controls for instance, geographical variations[3]. Equator is one of the locations that tend to receive higher lightning flashes[4]. Since Malaysia is located at the equator, lightning flash develops nearly

every day due to the amount of sunshine received which consequently produces high vertical updrafts generating cold fronts and moist air[5].

The intensity of lightning is more critical due to the global warming and climate transformation[6]. It drives more warm and moist air due to the rise of sea surface temperature which is the main provocation for thunderstorm. The growing number of factories and released chemicals to the atmosphere in Malaysia leads to higher thunderstorm frequencies. In addition, deforestation and land clearing for development will worsen the 'heat islands' effect especially in urban regions and probably contribute to thunderstorm formation[7].

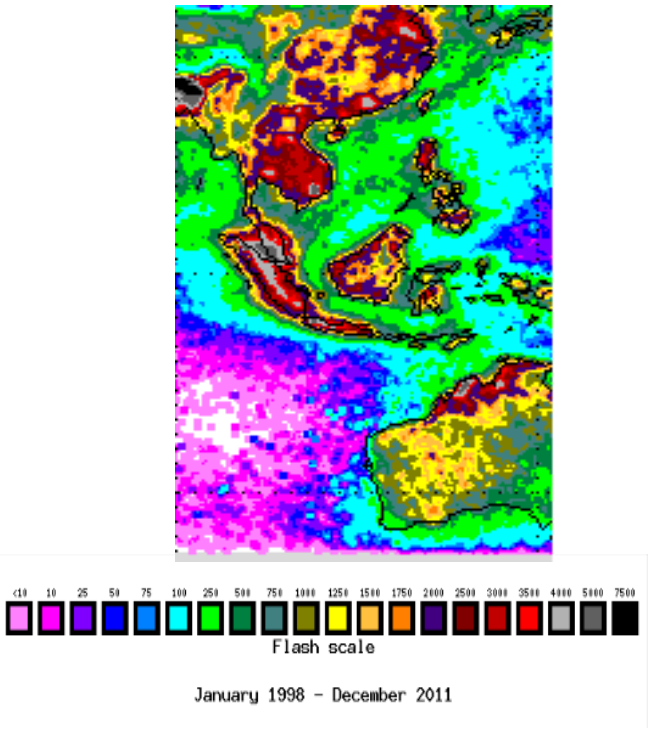

Figure 1 Lightning Isokeraunic level in Malaysia adapted from NASA[6]

With this serious situation, more lightning injury and death cases can be expected to occur in Malaysia. Figure 1 shows the density of lightning flashes in Peninsular Malaysia including Sabah and Sarawak. Based on the color of the flash scale given, Malaysia is in the range of 25 up to 4000 thunderstorm activities. The average number of thunderstorm days (TD) per year in Peninsular Malaysia is in the range of 159 to 293. In contrast, TD recorded by National Lightning Safety Institute (NLSI) of the US, Japan, Australia, Europe, and England show far fewer TD (below 70). Surprisingly, even the lightning capital of USA, Florida has only 90-110 TD[7].

3.0 LIGHTNING INJURY MECHANISM

Lightning injury may be accidental or non-accidental. Accidental lightning injury is usually related to lightning direct strike. However, non-accidental cases occur without us realizing it such as in Earth potential rise (EPR) case. Thinking of lightning injuries, it is assumed that most of the incidents are due to direct lightning strike. However, it has been shown in previous research that a direct strike lightning was responsible for only a small percentage of lightning-related injuries with the estimated frequency of about 3% to 5 %, compared to other causes[4].

Types of lightning injuries and deaths depend on many factors, such as intensity of the lightning current, time the current takes to go through our body, pathway involved and type of strike[8]. Obviously there are four main mechanisms of lightning injuries which may lead to death related cases such as direct strike, EPR, side splash and contact voltage[1].

3.1 Direct Strike

Injury caused by direct strike happens when the victim is directly hit by lightning. Head entry is the most common site[1] and exit pathway is through the soles of the feet because in most cases, the victim is usually standing thus earthed to the ground[8]. Figure 2 shows a picture of exit pathway (through the sole) when a person gets injured by direct strike.

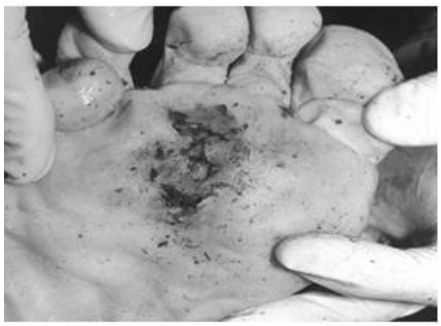

Figure 2 Exit pathway through feet during direct lightning strike adapted from[9]

For a given current path throughout human body, the danger depends mainly on the magnitude and duration of the current flow[2]. The rate of current directly enters the human body eagerly reaching up to thousands of Amperes and the standard rate of time is very short, that is 8/20 μs[5]. According to Fish *et al.*[10] a current of 20 mA might lead to human fatality since human body could not support the full strength of current flow when directly struck by lightning. Figure 3 illustrates the direct strike flash to human.

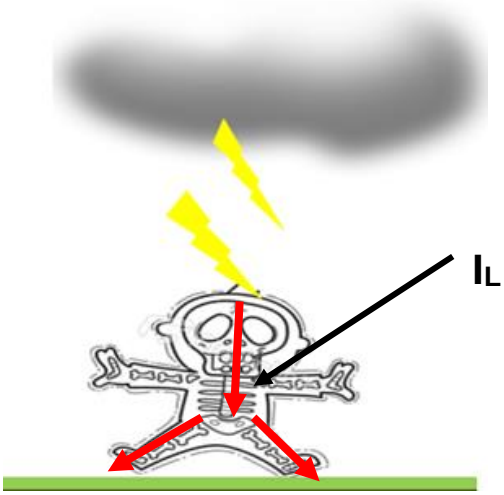

Figure 3 Illustration of lightning direct strike through human body. Arrows show the division of lightning current, I_L through human body

3.2 Slide Splash

Side splash can be explained when a flash of lightning hits a nearby object such as a tree and travels partly down through the object before jumping to a nearby victim. Side splash is also able to occur from one person to another[4]. This kind of lightning mechanism injury splashes the lightning from tall object onto nearby object in order to reach the ground. Current divides itself between the two paths in inverse proportion to their resistances. Resistance of the jump path and additional path is separated from the path to earth from the stricken object[11]. This is the most common lightning injury phenomenon that occurs in real life. The lightning is deviated to the victim from another tall object as illustrated in Figure 4. Portion of lightning current (I_{L2}) is directed to the victim after striking the tree.

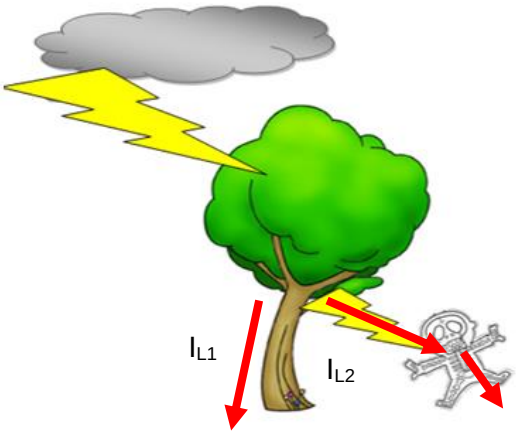

Figure 4 Illustration of side splash lightning strike mechanism

3.3 Contact Voltage

Besides direct strike and side splash another main cause of lightning injury is contact voltage. It occurs when a person is holding or touching something that can be categorize as metal such as weapon, umbrella and telephones poles. More often lightning will strike this metal object, driving high current throughout the body of the victim due to the least resistance[8]. A voltage development is established on that object from the strike point to the ground, and the person in contact with the object is subjected to the voltage between their contact point and the earth[11]. In the electrical field, electricity obligates a complete path (circuit) to flow and proceed. It can be observed either from theory or practical that there is no hazard shock without two contact points on the body for current to enter and exit.

3.4 Earth Potential Rise (EPR)

When lightning strikes into the earth and travels through it, voltages are established in the ground before being directed towards people walking or standing nearby the location where EPR is active[1]. The voltage between one leg and the other may differ especially if the strike is from the side of the standing person. The difference in voltage drives current into the body. EPR strikes are less severe since the strength of the lightning current has been weakened by travelling through the ground[4]. However, for both legs usually it will show severe burns similar to that shown in Figure 2.

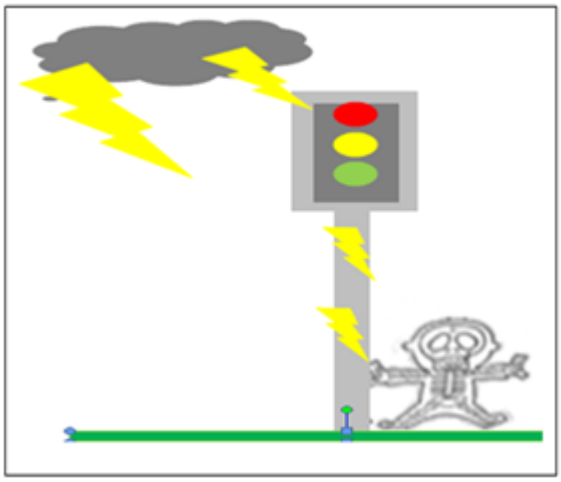

Figure 5 Illustration of situation of the contact voltage mechanism when victim is touching metal object before getting shocked. Lightning current will flow from metal to the victim's body in order to find the shortest way to the ground.

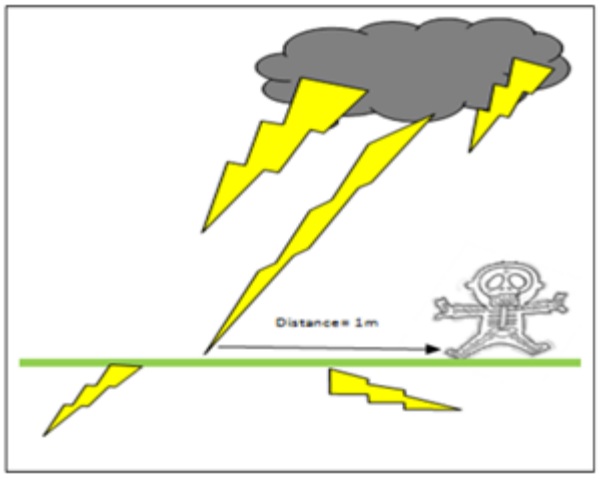

Figure 6 Illustration of earth potential rise (EPR)

■3.0 STATISTICAL DATA OF LIGHTNING FATALITIES IN MALAYSIA

Malaysian government is pressing for citizens to report lightning injuries as well as death. Unfortunately reliable statistics data on lightning fatalities in Malaysia is often difficult to accumulate. Apart from the completeness of medical facilities in each state of this country, some victim do not seek treatment at the time of the injury resulting to medical data sources even more unreliable[7]. In fact, deaths are regularly better reported than injuries since it is mandatory[12]. Average of the lightning injuries was estimated about ten times the quantity of deaths[13].

Table 1 Summary of lightning fatalities data from 2004 to 2012

Year	Month												
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
2004					7								7
2006				6	2						3	1	12
2007	3										1		4
2008	1			2	1	1					2		7
2009					11					4		2	17
2010				4	2			2	1				9
2011	1	1	1			3	2	12	5	1	3	1	29
2012	6												6

In this study, a statistical data of lightning fatalities in Malaysia for the year 2004, 2006, 2007, 2008, 2009, 2010, 2011 and early 2012 is presented. Table 1 shows that, in general, the number of lightning fatalities in this country is increasing yearly. Although the number of cases is small in 2004, 2008 and 2010, the actual number may be considered larger because sometimes most survivors do not require a hospital admission and this may affect statistical database which relies on the report.

On the other hand, it appears that the number of male victim is higher than that of female as shown in Figure 7. In 2006 and 2011, there were only two female victims recorded. Other than that, all the cases were dominated by male victims; the highest was in 2011, with 28 cases. This result is similar to the data presented by Holle[2] where the male ratio predominated over female ratio. This could be due to a reason that males are usually more exposed outdoor activities compared to females. Moreover when lightning strikes either direct or indirectly, many victims will get involved due to multi-point grounds terminations[5]. As shown in Figure 8, majority of lightning victims aged between 31-50 years old (38%), followed by those aged between 16-30 years which contribute to approximately 32 % of the cases. It can be seen that both groups are dominating the number of lightning incidents in Malaysia which could be due to the fact that both groups are more exposed to the outdoor activities as depicted in Figure 9.

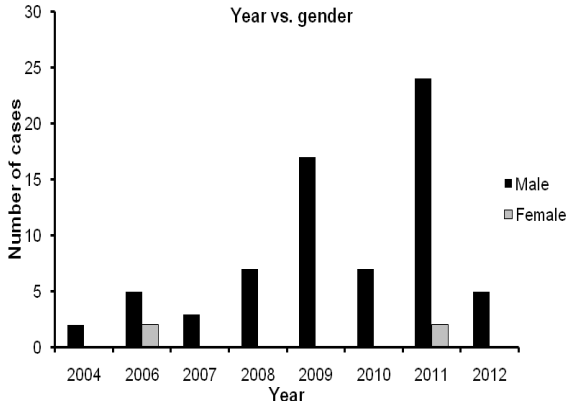

Figure 7 Chart showing year of lightning incident vs. gender

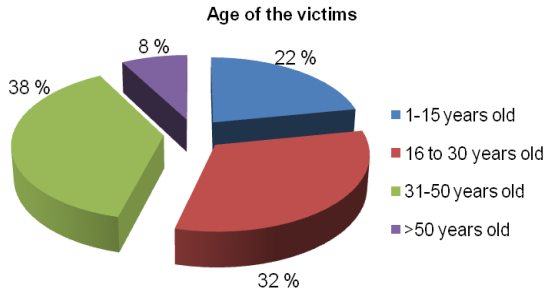

Figure 8 Summary of the casualties affected by the lightning incident according to age

Taking shelter during outside activities contribute to the highest percentage with 29 % as shown in Figure 9. Most of the victims were foreigners including Indonesian and Bangladeshi working in construction sites. Others such as riding motorbike, chatting outside, selling, and archery training dominate 19 % of the total cases. Fishing also has the large scale number of fatalities (17 %). This is probably due to the sea geographical condition which tends to generate higher density of moist air that will lead to the large lightning flash in the area.

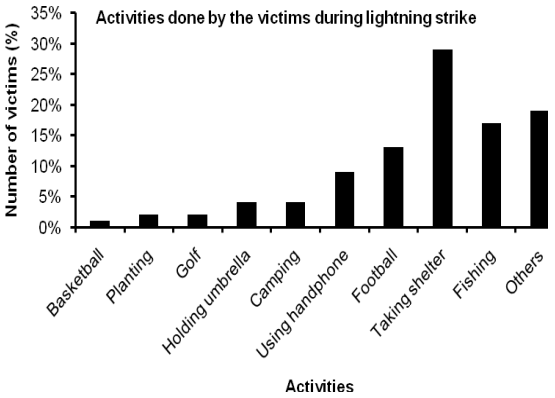

Figure 9 Summary of activities done by the victims during lightning incident

One of the significant factors of lightning fatalities is the location of lightning strike. Obviously, lightning is prone to strike to an open place or field. Figure 10 shows that most of the fatalities occur at the field (53%) followed by sea which accounts for about 20 %. Only 3 % of the cases happened when victims were standing under a tree. Direct strike often occurs to people who are standing in the open area because lightning tend to hit highest object at the area. However this is not necessary true since lightning only ''sees'' objects about 30 to 50 meters from its tip. There is also ample photo documentation of lightning striking halfway down flagpoles, in narrow mountain gullies, or at the bottom of the space shuttle gantry[13].

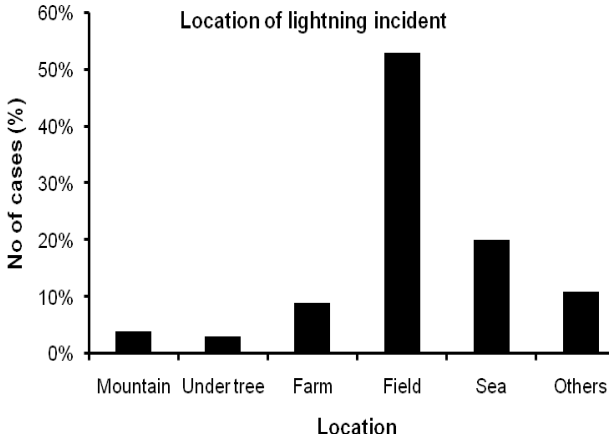

Figure 10 Location of lightning incidents

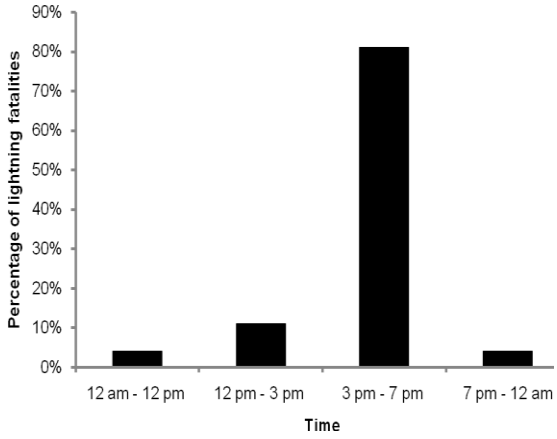

Figure 11 Time of lightning incidents

Figure 11 indicates the time victims were struck by lightning. In most of the cases, lightning incidents happened in the evening between 3.00 pm to 7.00 pm. During this time, Malaysia usually experiences heavy rain followed by thunderstorm especially during the monsoon transition. However, slight rain may also cause lightning activities. Sometimes lightning can also strike during a perfectly blue sky. It is estimated that approximately 10% of lightning strikes take place where there is no rain falling in the area of the strike[1]. Waiting to see or hear the first stroke of lightning means that we have been at risk of a direct lightning strike for 30 minutes or more. Based on previous study, 60 % of injuries and fatalities occur after a storm has passed.

4.0 CONCLUSION

Lightning fatalities has become major incidents in Malaysia causing injuries and deaths. Most lightning statistics in Malaysia are based on medical record and newspaper reports. However, a good and comprehensive statistical data is still not available because many cases that occur were left unreported especially for lightning injuries since it is not compulsory. Based on our collected data from 2004 to January 2012, it was found that lightning incident victims are higher in males than female. In addition, the largest age group being hit by lightning is within 30–50 years old. This could be due to the reason that males especially within that age are actively involved in outdoor activities as compared to female. It was also found that in most cases, lightning incidents happened when victims were standing under a shelter (29%) such as tree, bus stand or food stall and approximately 50% cases happened on field. Furthermore, we have recorded that 80% of lightning incidents happened in the evening between 3.00 pm to 7.00 pm which could be due to the fact that Malaysia usually experienced heavy rain followed by thunderstorm in the evening especially during the monsoon transition (June to December).

Acknowledgement

This project was fully supported by Universiti Teknologi Malaysia, GUP grant no. 06J72.

References

[1] M. O'Keefe Gatewood, R.D. Zane. 2004. Lightning Injuries. *Emerg. Med. Clin. N. Am.* 22: 369–403.
[2] Ronald L. Holle. 2010. Annual Rates of Lightning Fatalities by Country. Proc. 21st International Lightning Detection Conference. 19-20 April 2010. Orlando Florida, USA.
[3] Cooray, V. 2003. The Lightning Flash. *IET Power and Energy Series.* 34.
[4] N. R. Misbah, Ab Kadir MZA, C. Gomes. 2011. Modelling and Analysis of Different Aspect of Mechanisms in Lightning Injury. In: Proc. 4th International Conference on Modelling, Simulation and Applied optimization (ICMSAO).
[5] Ab Kadir MZA, Cooper MA, Chandima G. 2010. An Overview of the Global Statistics on Lightning Fatalities. In Proceedings of the 30th International Conference on Lightning Protection.
[6] Lightning and Atmospheric electricity Research. [Online] Available: http://www.thunder.nsstc.nasa.gov.
[7] Andrew, S., Elizabeth, T. 2009. Land of Lightning. [Online] Available: http://thestar.com.my.
[8] Seidl, S. 2006. Pathological Features of Death from Lightning Strike. *Forensic Pathology Reviews*. 4(1): 3–23.
[9] Odell, M. 1997. The Human Body As an Electric Circuit. *Journal of Clinical Forensic Medicine*. 4(1): 1–6.
[10] Fish, M. R., Geddes, L. A. 2009. Conduction of Electrical Current to and Through the Human Body. *A Review. Journal of Plastic Surgery*. 9.
[11] Cooper, M. A., Holle, R. L. 2008. Andrews, A. Distribution of Lightning Injury Mechanisms. In: Proc 20th International Lightning Detection Conference. 22–23.
[12] Lopez, R. E., Holle, R. L., Heitkamp, T. A., Boyson, M., Cherington, M., Langford, K. 2003. The Underreporting of Lightning Injuries and Deaths in Colorado. *Bulletin of the American Meteorological Society*. 74(11): 2171–2178.
[13] Cooper, M. A., Holle, R. L. How to use Public Education to Change Lightning Safety Standards (And Save Lives and Injuries). In: Proc. 14th Symposium on Education, Proceedings, American Meteorological Society, San Diego, U.S.
[14] Huffines, G. R., Orville, R. E. 1999. Lightning Ground flash Density and Thunderstorm Duration in the Contiguous United States. *Journal of Applied Meteorology*. 38–1013.