UNDERSTANDING THE NATURAL HAZARD OF LIGHTNING

The Science and Extent of the problem

Advisory - December 2019

ACLENet
Lightning and Electromagnetics Network

THE REPUBLIC OF UGANDA

INTRODUCTION

Lightning is a natural hazard, a natural phenomenon of extreme weather with harmful effects on humans and the environment. Natural hazards are classified into two broad categories, the geophysical and biological, and lightning falls in the former. Understanding the nature of any hazard helps us to reduce its effects. This is called mitigation.

ACLENet, the African Centers for Lightning and Electromagnetic Network, is dedicated to reducing deaths, injuries and property damage from lightning across Africa. Part of their work is to help the general public to understand the natural hazard of Lightning. ACLENet has organized a pool of internationally recognized research advisers and lightning protection experts who are proud to be volunteering their time and expertise for the public good in Africa.

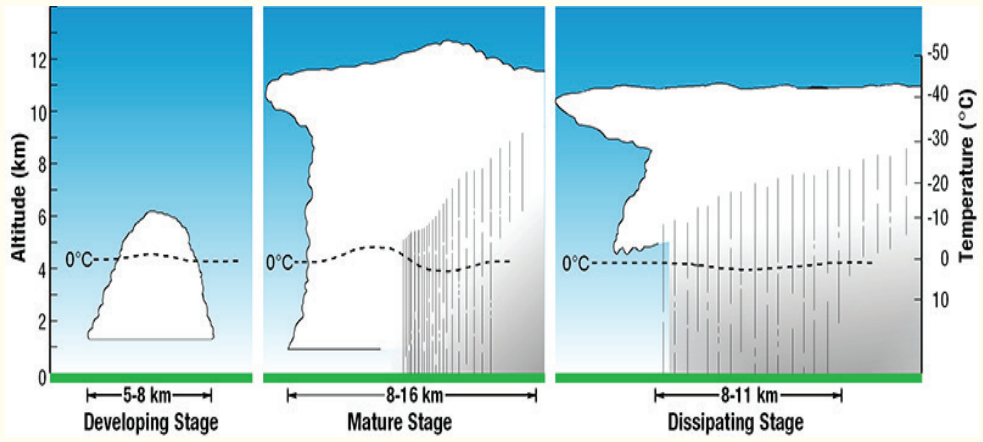
Lightning causes damage to people and animals but also to buildings. If it hits an electrical transmission tower, it may knock out electricity to everyone downstream from the damage and it may cause uncounted 'down time' loss as we wait for replacement parts to arrive and the damage to be repaired. Banks may lose data, businesses lose customers, food is damaged, and many other impacts. According to internet sources, lightning is responsible for more than 65% of all over-voltage surge damage in South Africa. Cloud-to-ground lightning flashes cause all of these damages. Note that there are also several times as many in-cloud flashes that do not reach the earth.

In this edition, we cover what, how, when, and where of lightning.

1. ***What is the nature of lightning?***
2. ***Where is lightning likely to occur?***
3. ***When is lightning likely to occur?***
4. ***How is lightning propagated?***

1. *What is the nature of the lightning hazard*?

Thunderstorms have three stages in their life cycle:



Source: https://www.nssl.noaa.gov/education/svrwx101/thunderstorms/

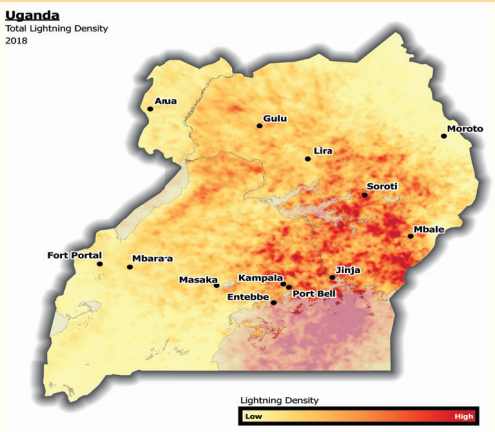
As thunderstorms build up, lightning does not travel in a straight line like a bullet. It is a massive electrical discharge with many streams (currents) each trying to find the path of least resistance to the ground – more like a ball of fire thrown at you. Figures 1 and 2 show these multiple paths to ground.

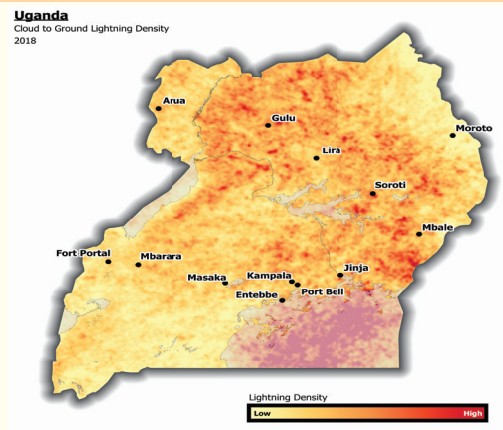
Photograph of cloud-to-ground lightning (©Ronald L. Holle).

Photograph of in-cloud lightning (©Ronald L. Holle).

2. *Prevalence of the lightning hazard (Where is lightning likely to occur?)*

Lightning strikes the earth more than 8 million times per day but is not evenly distributed. Lightning strikes are more common in tropical and subtropical areas like Africa than in arctic or temperate areas. Lightning is the most prevalent natural hazard that most people encounter in the world – nearly everyone has seen lightning and many know someone who has been injured or killed by it.



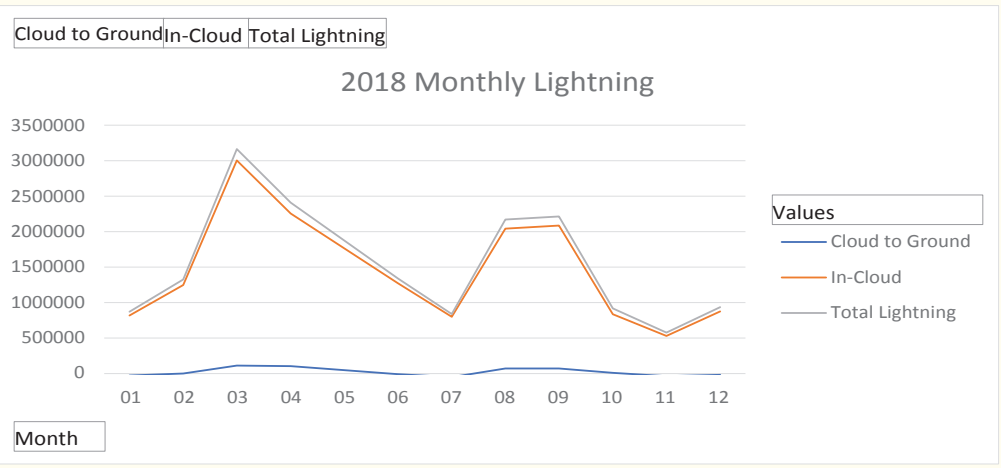


Two maps of Uganda: On the left it shows Total Lightning (TL) density for 2018, and on the right it shows Cloud to Ground (CG) lightning density for 2018. (*Courtesy of*, Earth Networks Inc.). The CG lightning density map is most important because it highlights the kind that is hazardous to humans, property and infrastructure. Further breakdown shows that CG was only 5.96% of TL in 2018 over Uganda, while Intra-Cloud (IC) was 94.04%. It is clear that hazardous lightning reached every corner of Uganda and Lake Victoria received the highest number of strokes followed by north, east, central, and west in that order.

3. When is lightning likely to occur?

Total lightning detection in Numbers: 2018 over Uganda

Month	CG	IC	Total	%CG	%IC
January	53343	830954	884297	6.03%	93.97%
February	76971	1254429	1331400	5.78%	94.22%
March	160609	2989126	3149735	5.10%	94.90%
April	155294	2249649	2404943	6.46%	93.54%
May	113177	1763437	1876614	6.03%	93.97%
June	69035	1278062	1347097	5.12%	94.88%
July	37872	811901	849773	4.46%	95.54%
August	128940	2037828	2166768	5.95%	94.05%
September	128767	2083457	2212224	5.82%	94.18%
October	82599	847737	930336	8.88%	91.12%
November	47226	544924	592150	7.98%	92.02%
December	60212	886085	946297	6.36%	93.64%
Annual Total	**1114045**	**17577589**	**18691634**		



Lightning in Uganda is most frequent over Lake Victoria, where nearly all activity occurs at night. It is also frequent over the eastern, northern, and northwest regions. Although less often, lightning occurs over all of the country, including the southwestern portion. The two times of year with the most lightning over Uganda are centered on March and August-September. Lightning is somewhat less frequent during the adjacent months to these times; nevertheless, there is activity all year. These two maximum times are when the equatorial trough, also called the Intertropical Convergence Zone, passes over Uganda. These lightning maxima coincide with the two rainy seasons.

This insert was made possible by funding from LUDWICK FAMILY FOUNDATION

Real-time accurate lightning detection using ground-based sensors was developed in the late 1970s in the United States. There are regional networks in over 50 countries in addition to several global networks. These systems use triangulation from measured angles and the GPS times from multiple antennas. Spherical trigonometry and sophisticated statistical methods are used to determine locations to within 200 meters in the most advanced networks. Space-based lightning detection uses optical emissions from flashes, but no satellite routinely covers Uganda at present. Data from lightning detection networks have been used in the United States and many other nations for 35 years by meteorological agencies, forest fire interests, power utilities, aviation, mining, space launch facilities, and insurance adjusters. One of the products resulting from lightning detection technology is stroke density. This is used in risk calculation of lightning injury or damage to determine the lightning protection level required.

It has been determined that most lightning strikes happen during rainfall in the afternoon and evening hours but they can occur year-round and at all hours. (https://www.nssl.noaa.gov/education/svrwx101/thunderstorms/)

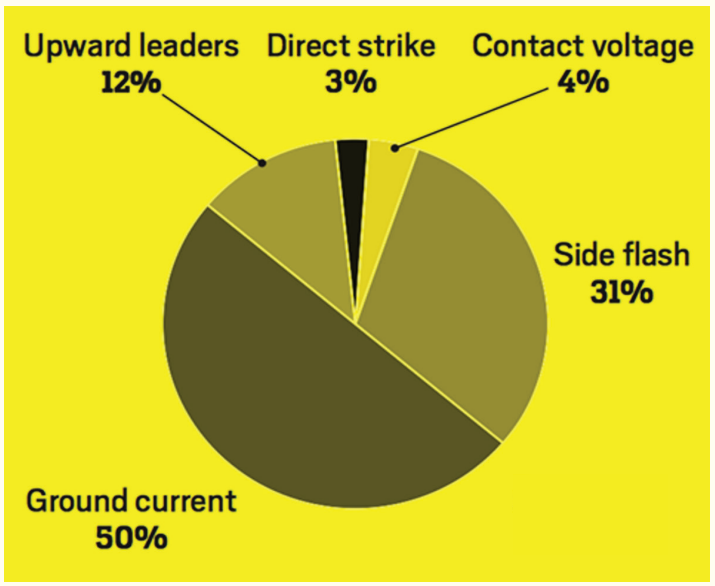
4. *How is lightning propagated?*

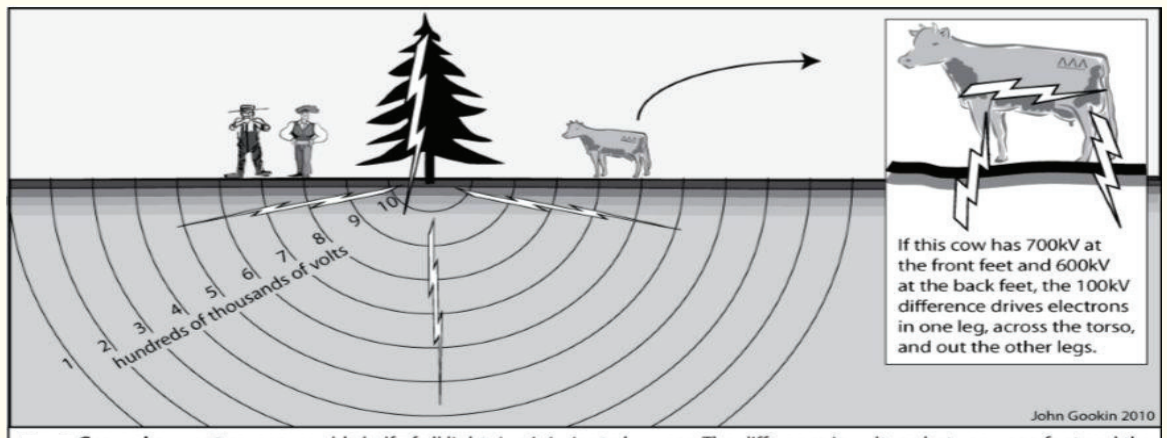
(Including Mechanisms of Injury)

Most people think of lightning only as direct strikes. However, scientists have found five mechanisms or different ways in which lightning kills/ injures people and animals. Direct strike is the least frequent and ground current is the most frequent.

Table below summarizes the different mechanisms lightning is propagated to harm people and property.

Ground current	Current spreads radially through the ground from point of first contact.
Side flash	Also called a side splash; a part of the lightning that has hit a tree, tower, or other structure jumps across to a person or object close by.
Upward Leaders	Opposite electrical charge is induced in anything close to a strong electric field (like a thunderstorm).
Contact Voltage	Lightning strikes at a distance, such as a wire fence or telephone line, and is conducted along to a person, animal or building to cause damage
Direct strike	Direct energy flow from cloud to strike point on ground





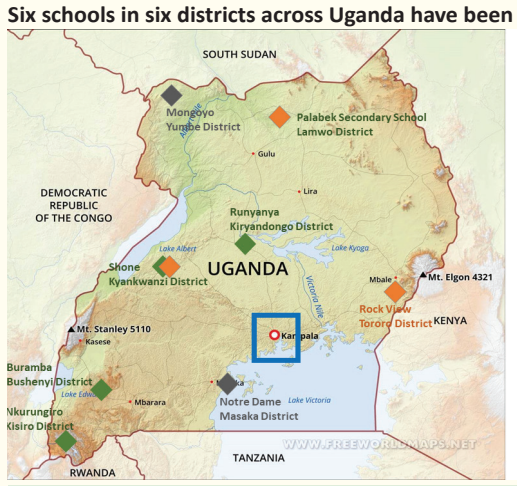
Ground current causes roughly half of all lightning injuries to humans. The difference in voltage between one foot and the other drives current through us. In this simplified illustration the cow has a 100kV (100,000 volts) differential, one farmer has a 50kV differential, and the other farmer has her feet together so her voltage difference is close to zero.

5. *Way forward*

The International Electrotechnical Commission (IEC) is an international standards organization that prepares and publishes international standards for all electrical, electronic and related technologies – collectively known as "electro technology". IEC 62305 is the code that elaborately stipulates how lightning protection should be carried out. IEC 62305-compliant design and installation of lightning protection is the answer to prepare for the natural hazard of lightning.

Left photo: Classroom building at Runyanya School where 18 children died and 38 hospitalized with lightning injuries in June 2011. Right photo: Close-up showing IEC compliant arrester installed by ACLENet and existing non-compliant multipronged rod commonly found on many Uganda schools that ACLENet staff have surveyed.

Six schools in six districts across Uganda have been protected by IEC-62305 compliant design and installation.



Status of school projects

- Completed with DEHN-Africa
- Completed, funded by Ludwick Family Foundation
- Pending
  Notre Dame: Kisoboka Trust
  Mongoyo: materials donated, delivery pending funds for import fees.

Large urban area of Kampala and Entebbe where schools are more likely to be protected from lightning

Completed Schools

1. Runyanya Primary School in Kiryandongo Distict
2. Nkurungiro Primary School in Kisoro District
3. Buramba Primary School in Bushenyi
4. Shone Primary School in Kyankwanzi District
5. Palabek Secondary School in Lamwo District
6. Rock View Primary School in Tororo Didtrict

STATEMENT FROM MINISTER FOR DISASTER PREPAREDNESS AND REFUGEES GOVERNMENT OF UGANDA

In Uganda, lightning has appeared like a natural disaster with no solution possible until ACLENet appeared on stage. According to the UN Office for Disaster Risk Reduction, there is no such thing as a 'natural disaster' -- there are only 'natural hazards'. The natural hazard of lightning, which has claimed many lives in our schools and even outside, can be mitigated through ACLENet.

I commend the many efforts ACLENet is employing to address the natural hazard of lightning. These include installing world class Lightning Protection Systems on some schools across Uganda funded by donations and grants, public seminars on lightning safety, newspaper inserts, and TV programs and appearances.

The Ministry of Disaster Preparedness promises to extend moral and all kinds of support to ACLENet and the pool of international volunteers mobilized through their networks.

A team put together this advisory to help the Ugandan public face the lightning hazard with the right information while avoiding the misinformation and misrepresentation.

Eng. Hillary Onek
Hon. Minister for Disaster Preparedness & refugees

Prof. Emerita Mary Ann Cooper,
President of ACLENet

Mr. Richard Tushemereirwe,
Vice President of ACLENet

Earth Networks

This insert was made possible by funding from the LUDWICK FAMILY FOUNDATION