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Does Lightning Always Strike the Tallest Objects

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ABSTRACT: Thunderstorms are classic weather events. Huge electrical forces are involved, producing millions of amperes and phenomenal voltages within microseconds of time. Though several proactive measures and safety tips are available ,still deaths due to lightning is very common in India. Most of the victims are farmers and children. Understanding lightning related casualties is more than just reporting numbers of deaths. Lightning safety education should emphasize planning to avoid the threats and knowing the safety actions to be taken. While teaching lightning safety to the public, a frequent question has been whether it is safe to find shelter under a tree or structure. Though generally it is perceived that lightning strikes only the tallest objects, but it is not always. In this paper, a typical case of lightning strike is discussed, where lightning had struck a neem tree surrounded by tall trees, buildings and a tower.

KEYWORDS: Cloud to ground lightning. Safety, Thunderstorms

I.INTRODUCTION

Lightning is a massive electrostatic discharge caused by the circulation of warm moisture-filled air through an unbalanced electric field in the atmosphere, accompanied by the loud sound of thunder. Lightning strikes 40–50 times a second worldwide, for a total of nearly 1.4 billion flashes per year. Lightning is not distributed evenly around the planet. About 70% of lightning occurs on land in the tropics, where most thunderstorms occur. During a thunderstorm the lightning flash/stroke discharge many current peaks varying from 10,000-200,000 Ampere occurring in a fraction of a second affecting an area of about 30m distance.[1] .The different type of lightning are Cloud-to-ground (CG), intra cloud, cloud to cloud and cloud to air. The majority of the lightning discharge is of the type Cloud to cloud lightning .[2]However the amount of current involved is small. The Cloud to Ground lightning accounts for 25% of lightning globally. Based on the polarity of the charge that is lowered to the ground, the cloud to ground lightning can be divided further into downward negative lightning, downward positive lightning, upward positive lightning, downward negative lightning and Bipolar lightning. The downward negative lightning discharge accounts for 90% of the cloud to ground discharge.[3].The different types cloud to ground lightning is shown in fig.1.

II.CLOUD TO GROUND LIGHTNING

During lightning, a flash between cloud and ground is initiated in the base of the cloud. The initiating discharge, the downward travelling spark is called the stepped leader. The stepped leader is a low luminosity travelling spark, which moves from cloud to the ground in rapid steps towards earth at a speed around 105 metres per second. The charge on the leader channel produces an electric field near the earth surface that is enhanced by objects projecting above the surface, such as towers, tress, tall buildings. When the leader is tens to hundreds of meters above ground the electric field becomes large enough to produce breakdown between the leader and one of the elevated objects. This involves one or more upward connecting leader starting from the ground or from grounded objects. One of these upward connecting leaders meets one of the branches of the downward propagating leader thus establishing a path between cloud and ground. A visible flash occurs when the stepped leader contacts the ground or any object. A small fraction of strikes to very tall structures occur in this way. A typical cloud to ground lightning is shown in fig.2.

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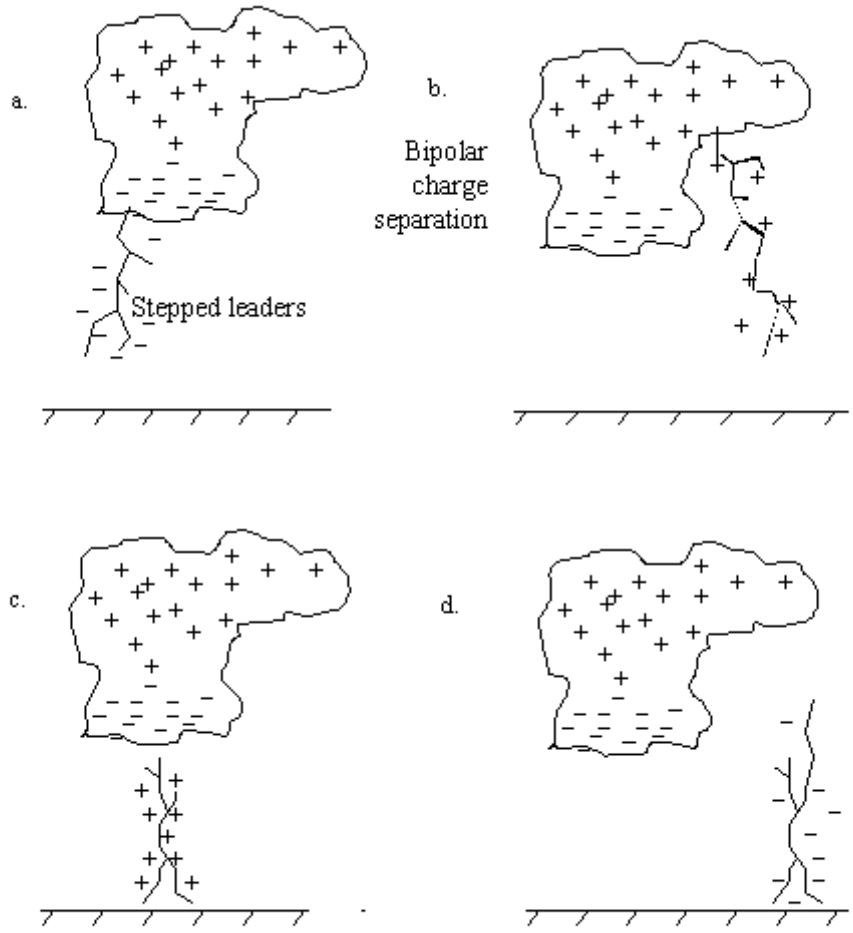

Fig 1. Cloud-to-Ground Lighting Flashes. The top left picture (a) demonstrates a negative CG flash, this type of negative CG flash accounts for ~90 % of all CG flashes. In (b) a positive Cg flash is depicted, this type of CG flash accounts for ~10 % of all CG flashes. Also possible are positive ground-to-cloud flashes (c) and negative ground-to-cloud flashes (d).

The lightning flash study on the Empire state building shows that most of the flashes to tall structures are initiated by the structure itself. The structure initiated flashes differ significantly from the usual cloud to ground flash. The flashes initiated by stepped leaders start at the building top and propagate upward to the cloud. The upward moving, stepped leaders from the object may well contact downward moving leaders from the clouds beneath or within the cloud. However the stepped leaders are not only initiated from the top but also from the lower level of structure. If the electric charge of the stepped leader emanating from the lower level is greater than one from the top of the structure, it may well propagate and contact the downward leader and thereby striking the structure at some lower level. This is the reason that lightning does not always hit the tallest object. A typical case of lightning strike where lightning had struck a smaller tree which is surrounded by buildings, tower and trees taller than the said tree is discussed here.

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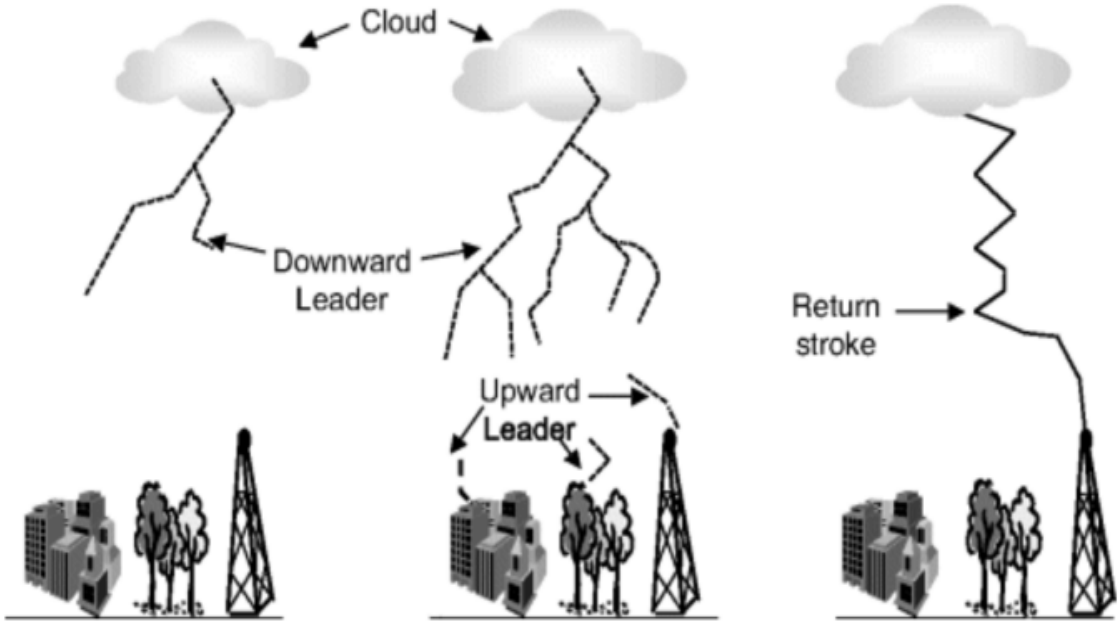

Fig 2: Representation of cloud to Ground Lightning.

III.CASE STUDY

In April 13 2015 in Gudiyatham, Vellore district of Tamilnadu, few people were playing cricket in a ground.As it had started raining they found shelter under a neem tree.[3]. The lightning had struck the neem tree and one student was dead and six others were injured. The authors had visited this place and the topological survey map of the location is shown below. As shown in fig .3. the Neem tree is surrounded by tower on one side, palm tree on the other side and the third side by distribution line and the fourth side by a building. The neem tree (point of the strike) is surrounded by almost in all sides by trees and buildings which are taller than the neem tree. In spite of this lightning had struck the tree. The topological survey of the place is shown in fig.3.

IV. DISCUSSIONS

A typical cloud to ground lightning strike can be over five kilometres long. But it is not necessary that the clouds over few kilometres alone can cause a lightning flash. In this case, if the cloud is over few kilometres long, then it should have hit the tower, which is four times the height of the Neem tree. Whereas it had struck the Neem tree, which is shorter than the surrounding trees and buildings. So the probability of lightning strike not only depends on the height of the object but also highly on the space charge distribution and position of cloud. From this case study, our observation is that the low lying clouds moving into the gap between the objects should have provided proper space charge distribution, such that the stepped leader initiated from the Neem tree would have met the downward stepped leader from the cloud, thereby causing a flash.

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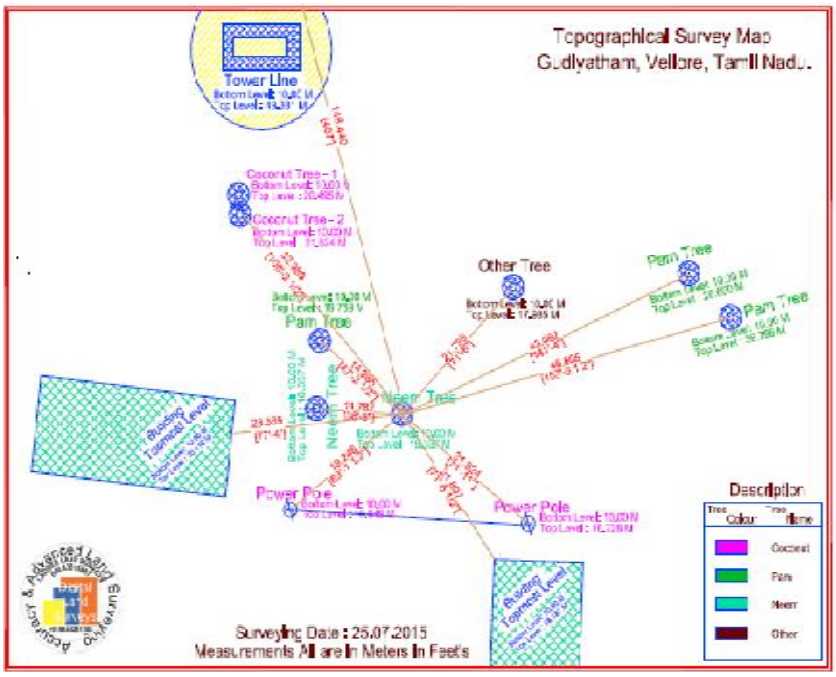

V.CONCLUSION

The general belief is that lightning strikes only the tallest objects. But it is not always true. Though lightning can preferentially strike the tall objects, but it is not always the case. No place is safe when there is lightning and thunderstorm. It is evident from this study that lightning can strike anywhere. The point of strike depends on the height of the cloud, the direction of movement of clouds which determines the space charge distribution. So it is not safe to find shelter under any tree or object at all.

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