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Propagation of Lightning Through Thick Thunderclouds

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Introduction

- The phenomenon that is lightning, have sparked the interest of physicists and scientists for centuries. The journey to understanding this phenomenon of high-current electric discharge, can unlock the secret to other lightning related phenomenons. Lightning is a major source of interference in many types of radio communications. The effects of lightning on space crafts, nuclear power plants, and sophisticated military equipment, are problems of increasing concern. The purpose of this research is to study the propagation of lightning through optically thick thunderclouds by applying knowledge of cloud micro-physics, the physics of lightning, diffusion approximations, and an understanding of the scattering problem.

Research Objectives

- Simulation of lightning propagation, using a cylindrical shape to model the cloud.
- Study of the multiple scattering effect for propagation of radiation in random media.

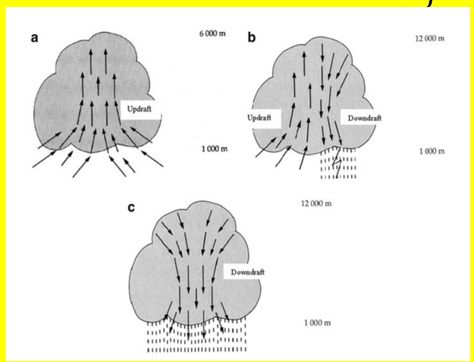
Method

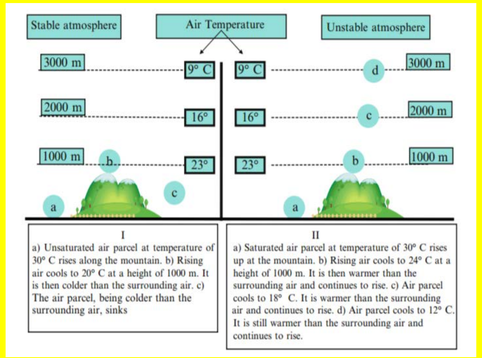
- The cloud was treated as a nuclear reactor in order to obtain forms that can be computable.
- Also, a one-speed Boltzmann transport theory using diffusion approximations is applied to examine the radiative transfer properties of lightning in optically thick thunder clouds.
- Lastly, the cloud is modeled geometrically, and the effects of multiple scattering are considered.

Formation of Thick Thunderclouds

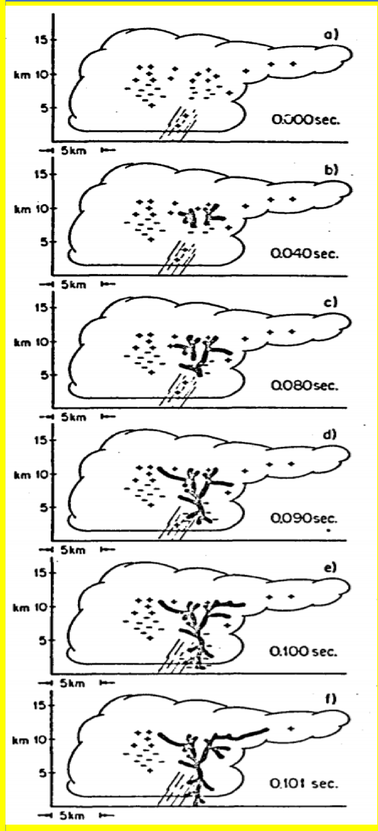
- There are three conditions that are necessary for the formation of a thundercloud: sunlight, moist air, and an unstable atmosphere (Cooray, 2014).

$$CAPE = \int_{Z_f}^{Z_e} g\,\frac{T_p(Z) - T_e(Z)}{T_e(Z)}\,dz$$





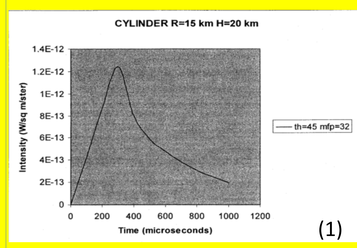
Propagation of Lightning



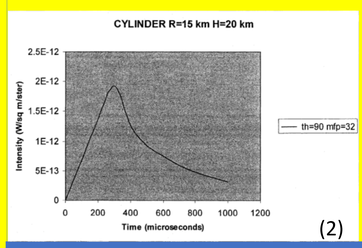
1. *Charge Distribution*
2. *Concentration of negative charges*: 6 to 8 km above the mean sea level (-10 to -20° C)
3. *Preliminary breakdown*: Location; occur between the distribution of + and – charges in the cloud.
4. *Stepped-leader*: Highly branched discharge that propagates horizontally and downward.
5. Electric field just above the surface becomes very large as Stepped-leader approaches the ground.
6. *Attachment process*: Upward discharge begin at the ground and connects with the leader channel at a junction point.
7. *Return stroke*: Begins when contact occurs at the junction point.
8. An intense positive wave of ionization propagates up the leader channel at about one third the speed of light.
9. The current carries the ground potential upward and effectively neutralizes most of the leader channel and a portion of the cloud charge.
10. *Dart leader*: A new leader produced by most cloud-to-ground flashes approximately 40 to 80 milliseconds after the return stroke (Krider, 1986).

Data Analysis/Results

$$I(\vec{r}, \hat{\Omega}, t) = \frac{2}{\pi V}\sum_{l=1}^{\infty}\sum_{m=1}^{\infty}\sum_{n=1}^{\infty}\left[\Psi_{lmn}(\vec{r}) - \frac{3D}{c}\hat{\Omega}\right.$$



(1)



(2)

- For simplicity, a cylindrical shape is used to model the cloud.
- The differential equation was solved. Data was obtained directly from its solution.
- The curve represents the intensity of the lightning over time.
- Observe that a change in the angle of observation from θ =45 to θ=90, results in a higher peak intensity in the propagation of radiation.

Future Research

- Analyze data recorded by LIS (lightning Imaging Sensor), a space-based lightning sensor aboard the EOS TRMM satellite. Perform a numerical analysis to help create a more realistic model.

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