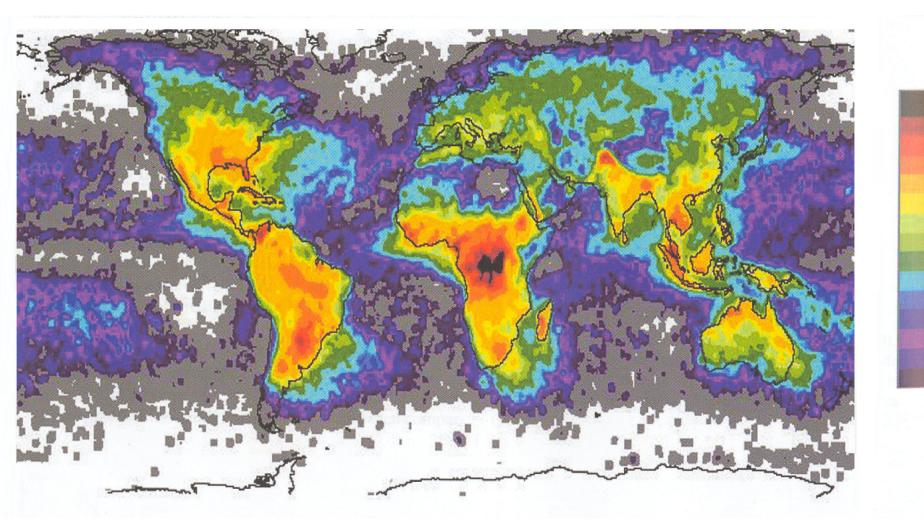# Atmospheric Electricity

Dr. Sunil D. Pawar
Indian Institute of Tropical Meteorology
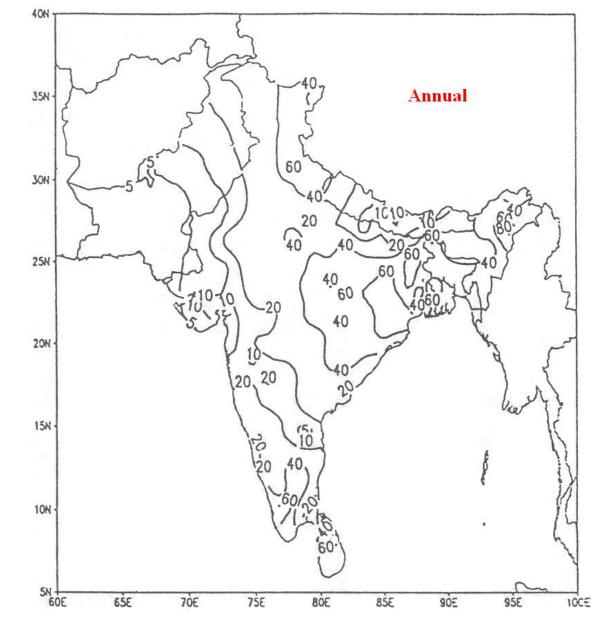**Pune 411 008 (India)**

Thunderstorm electrification
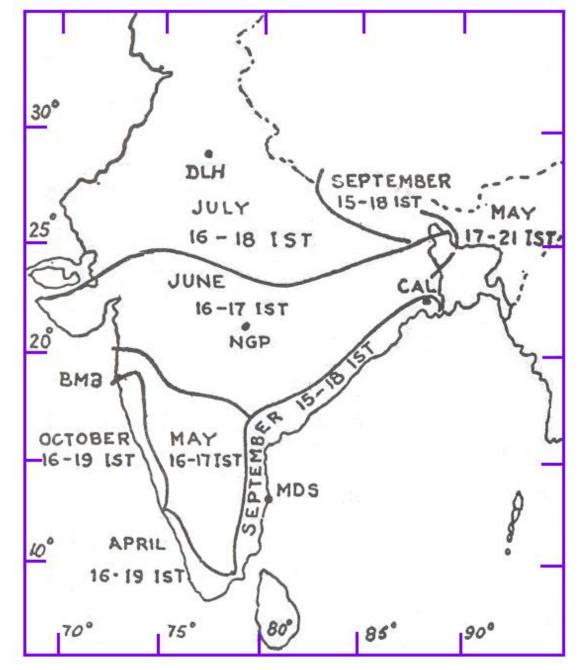
Geographical Distribution of Thunderstorms

➢ About 2000 thunderstorms are active at any time all over the globe.

➢ Major regions – South Americas, Africa, Asia. Comparatively negligible activity over oceans.

➢ In India – maximum concentration in northeast India.

➢ Maximum activity in the afternoons.

A global map of total lightning flash density in km^{-2} yr^{-1} based on data from two satellite detectors, OTD (five years) and LIS (three years). Grey areas correspond to a flash density range 0.01-0.1 km^{-2} yr^{-1} and white areas to a flash density < 0.01 km^{-2} yr^{-1}. Courtesy of H.J. Christian, NASA/Marshall Space Flight Center.
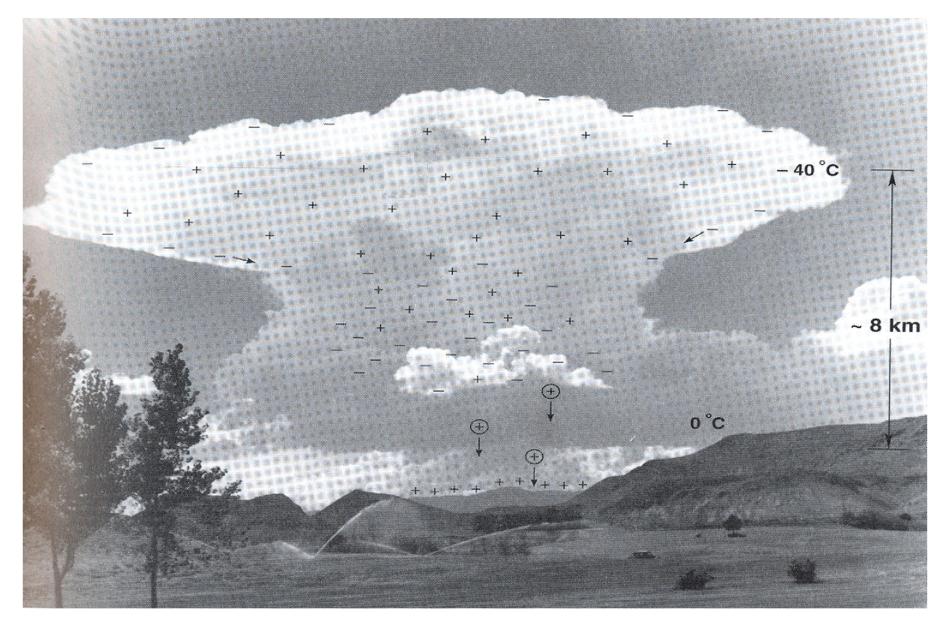
4

Mean annual number of thunderstorms in India and neighborhood
(After Pant and Rupa Kumar,1996).

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Month and timing of maximum thunderstorm activity.

Electrical structure of thunderclouds

➢ Positive charge above, Negative charge below, Positive charge pocket in the base.

➢ Positive dipole or a tripole structure.

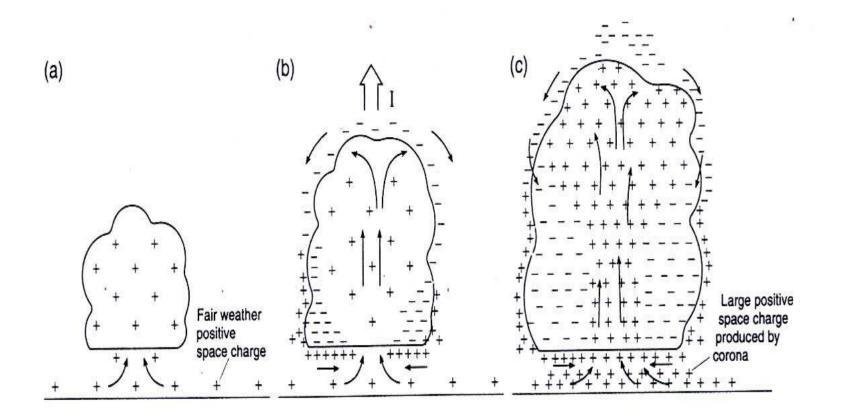➢ Currents flowing in and around thunderclouds.

An isolated thunderstorm in central New Mexico, with a rudimentary indication of how electric charge is thought to be distributed inside and around the thundercloud, as inferred from the remote and in *situ* observations. Adapted from Krehbiel (1986).
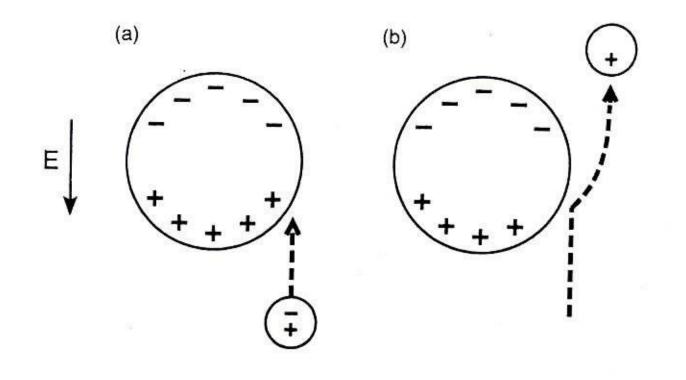
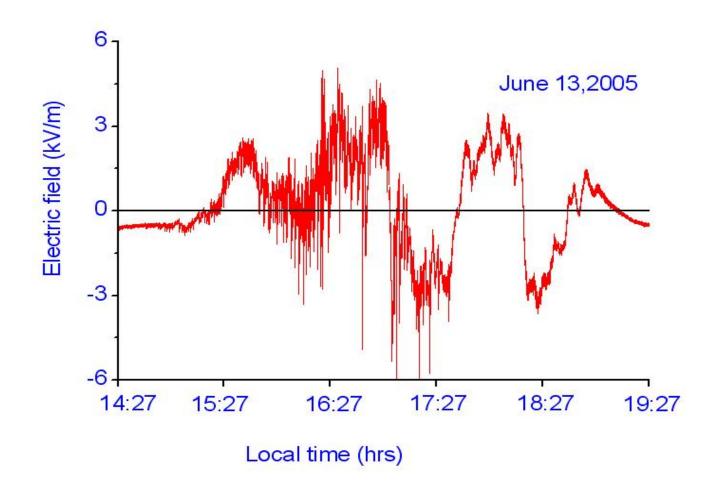# Charging Mechanisms

1. Convective

2. Inductive

3. Non inductive

Convective mechanism

Inductive mechanism
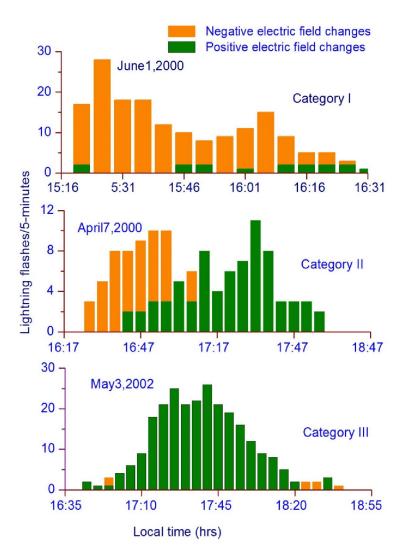
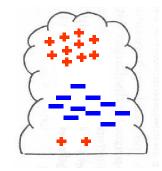# Electric field: Polarity and Magnitude

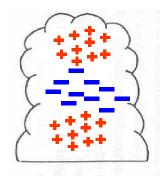# Electrical structure of Pune Thunderstorms
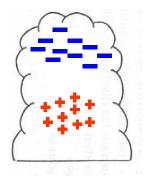
- Category I - Positive dipole (normal)

- Category II – Tripole

- Category III Negative dipole (inverted)

Pawar and Kamra JGR (Atmosphere) 2009

Types of Lightning

➢ About 100 discharges occur all over the globe and approximately 1/3rd of them strike the ground every second.

➢ 2/3 of the global lightning activity occurs in tropics.

  i)   **Intra-cloud discharges**

  ii) **Cloud-to-ground discharges**
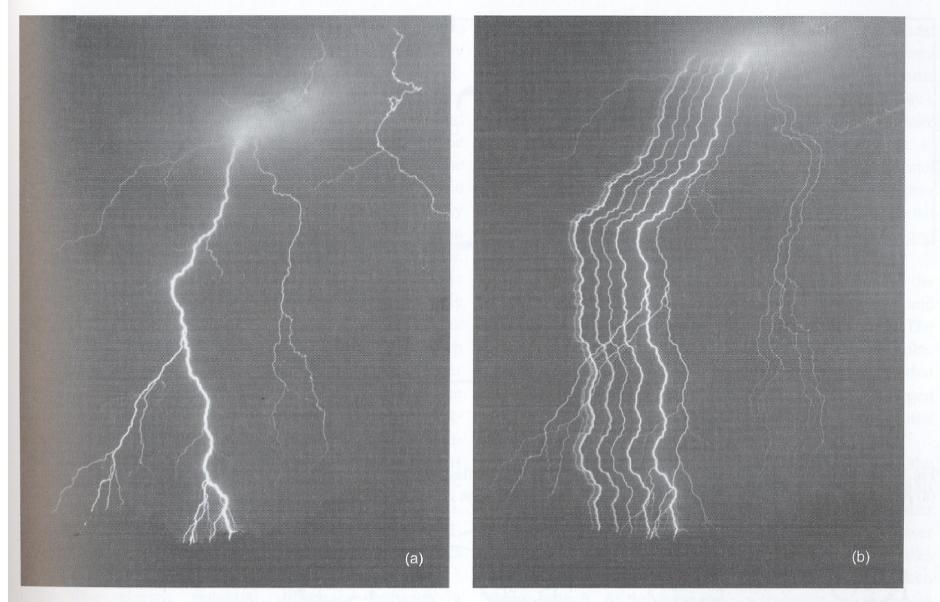
  iii) **Cloud-to-ionosphere discharges**

        (sprites, elves, blue jets)

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Polarity of Charge

- ➢ **Cloud-to-ground discharges mostly bring negative charge to ground – negative discharges.**

- ➢ **Positive discharges not uncommon, involve more energy and, perhaps, initiate cloud-to-ionosphere discharge.**

Structure of cloud-to-ground discharges

i) **Stepped leader**

ii) **Return stroke**

iii) **Dart leader**

    (a) Strokes – up to 26 observed

    (b) Streamers from ground objects

    (c) Junction process

    (d) Continuing currents – 100-200A   for ~ 100s.

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A lightning flash that appears to have at least seven (perhaps as many as 10) separate ground strike points: (a) still-camera photograph, (b) moving-camera photograph. Some of the strike points are associated with separate branches of the same stroke while others are associated with the fact that different strokes may take different paths to ground. The first and the second strokes exhibit unconnected branches. The second and the third strokes, second and third from the right on the streaked photograph, are brighter than the first stroke, on the far right. Adapted from Hendry (1993).
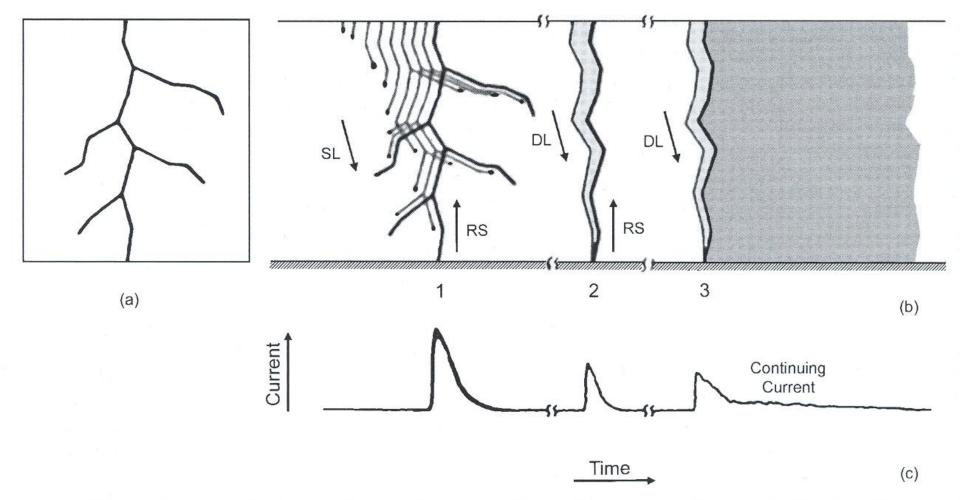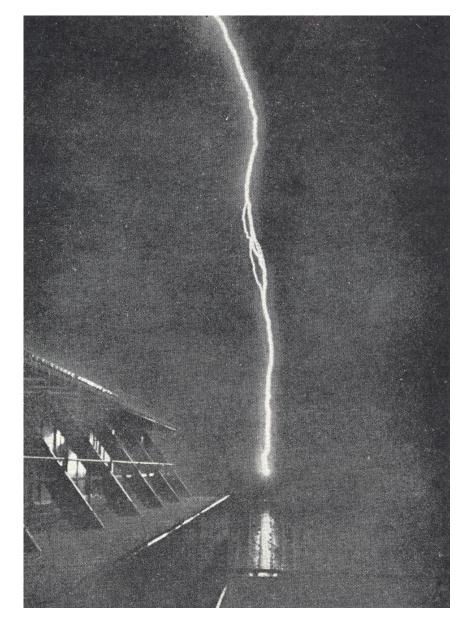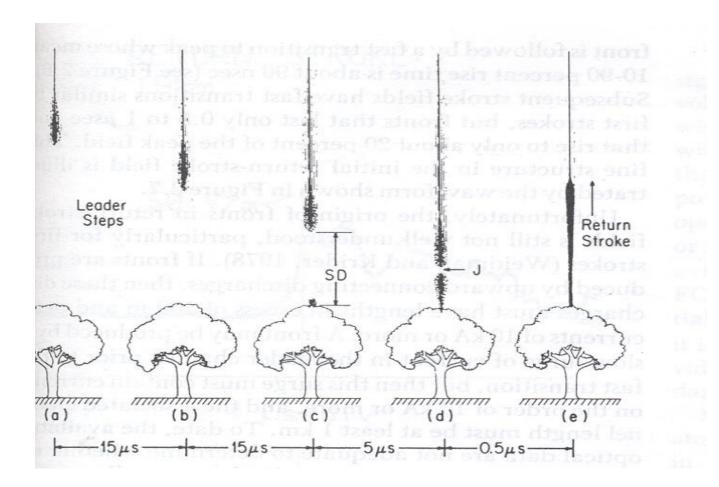
(a)

(b)

(c)

Diagram showing the luminosity of a three-stroke ground flash and the corresponding current at the channel base:
(a) still-camera image, (b) streak-camera image, and (c) channel-base current.
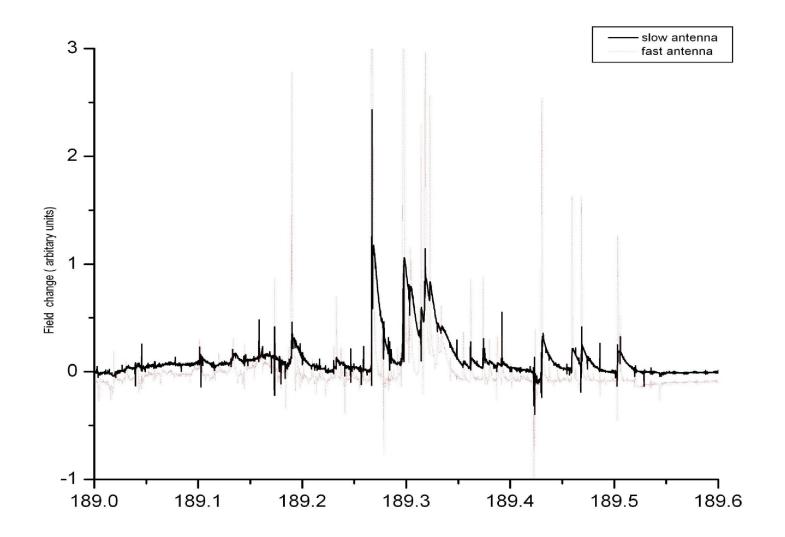
Lightning stroke to chimney pot showing meeting point between downward leader and upward streamer.
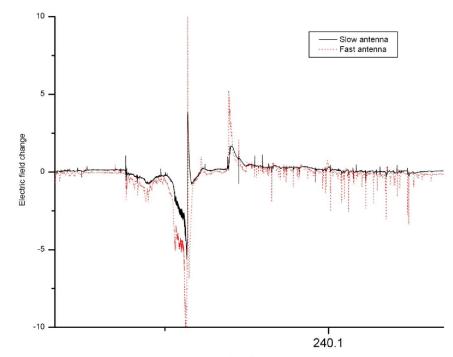
Cloud-to-Ground lightning discharge
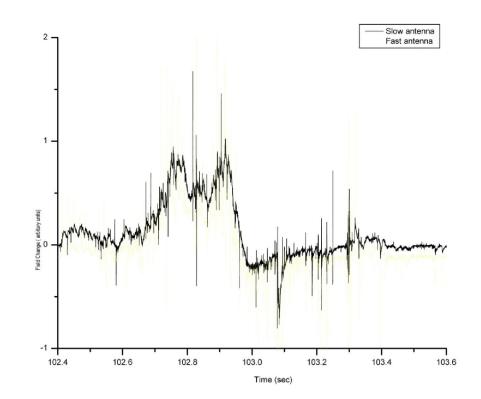
Electric Field change

CG Discharge

IC Discharge

Gross features of discharges

- ❑   **Currents flowing in a discharge 20,000 to 200,000 amp.**

- ❑   **Charge destroyed in a single discharge ~ 20 C.**

- ❑   **Electrical moment destroyed in a single discharge ~ 100 C km.**

- ❑   **Energy of a flash - $10^9 – 10^{10}$ J.**

Thank You