Atmospheric Electricity

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Bronze statue of Benjamin Franklin by Agnes Yarnall

"Now if the fire of electricity and that of lightning be the same . . . may not the knowledge of this power . . . be of use to mankind? . . ."

—FROM FRANKLIN'S AUTOBIOGRAPHICAL WRITINGS

History

Three phases of development in the atmospheric electricity

1.the early discoveries (1700-1785)

2.“the electrostatic period “ up to about (1885)

3.the modern period

The early discoveries

- E.N. Wall (1708) : The grand natural phenomena of lightening are a manifestation of static electricity.
- Franklin's Kite experiment.
- L.G. Lemonnier : Permanent electrical property of air.
- Beccaria : Discovered about electricity during clear sky & during thunderstorms.
- C.A.Coloumb : Concluded that air must be somewhat conducting.

Electrostatic period

- Earth surface is negatively charged with respect to atmosphere.

Modern phase

- Atmosphere posses a definite conductivity.
- The electric field has certain value.
- Thunderstorm electrification.
- Global electric circuit.
- Relationship between meteorology and atmospheric electricity.

1. Fair weather Electricity
2. Disturbed Weather Electricity
3. Global Electric Circuit

Origins and generation of ions In atmosphere

- Column (1785) : Air has a finite conductivity

- That Elster & Geitel (1899) & Wilson (1900) discovered of existence of ‘ions’ i.e. particles of approximately, molecular size carrying positive or negative charge.

- These ions are continuously being generated and destroyed by various processes in the atmosphere.

- Near to earth ‘s surface, the nature of the ions is very complex and they show large variations in the electrical properties

Source of atmospheric ionization

1 Galactic cosmic rays :

- They are main source of ionization over sea surface and 1-2 kilometres above land surface.
- Ionization rate between 1.5 to 2 ion-pairs/cm

2. Ground radioactivity:

- Ionization due toα, β, and γ radiations from earth surface.
- Ionization due to radioactive gases and their daughter products.
- Ionization rate vary up to 1-2 order.

Ionization of air

Cosmic rays	20%
From air	
α-rays	44%
β-rays	0.3%
γ-rays	1.5%
From soil	
α-rays	3%
β-rays	32%

Ionization profile

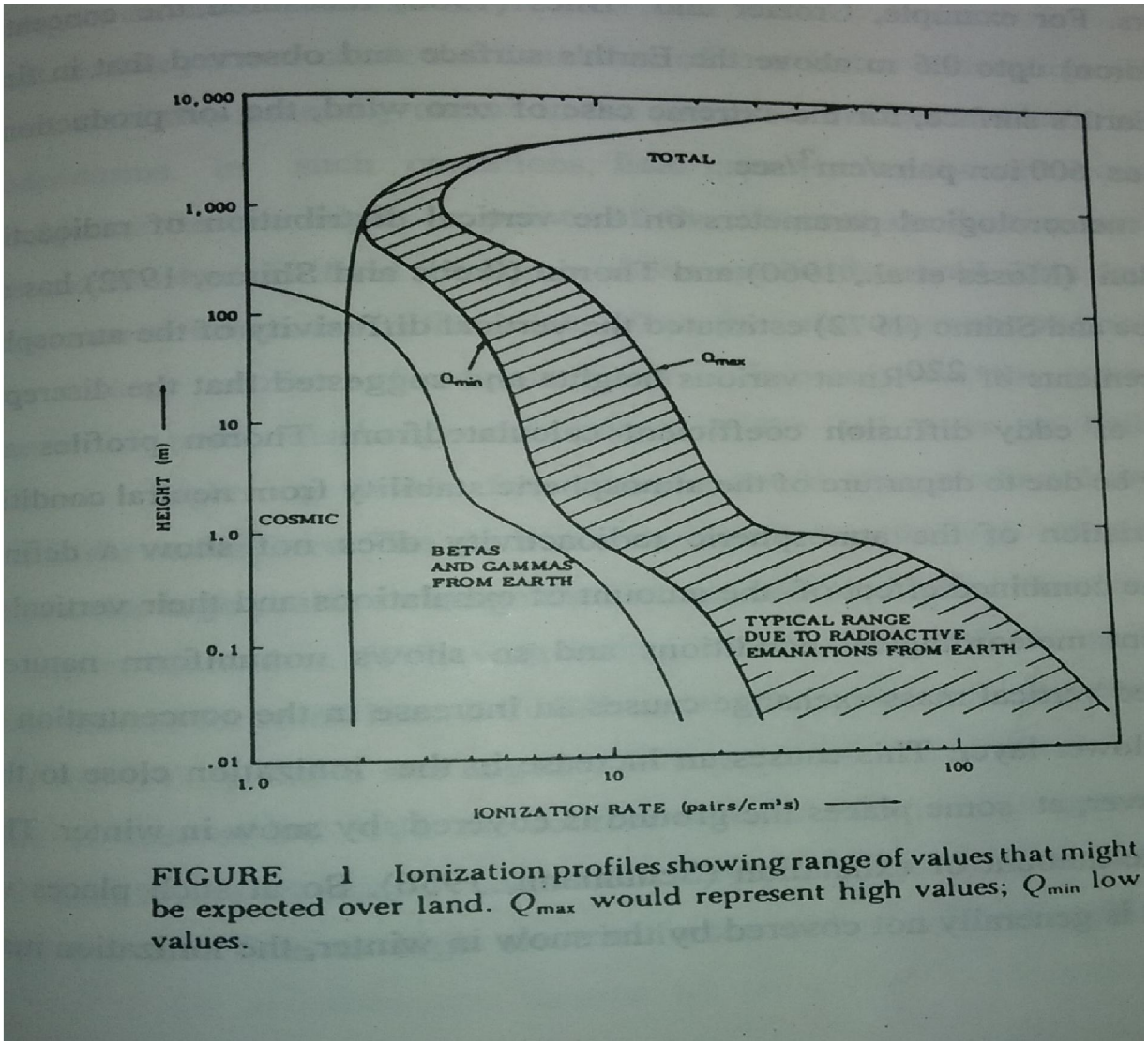
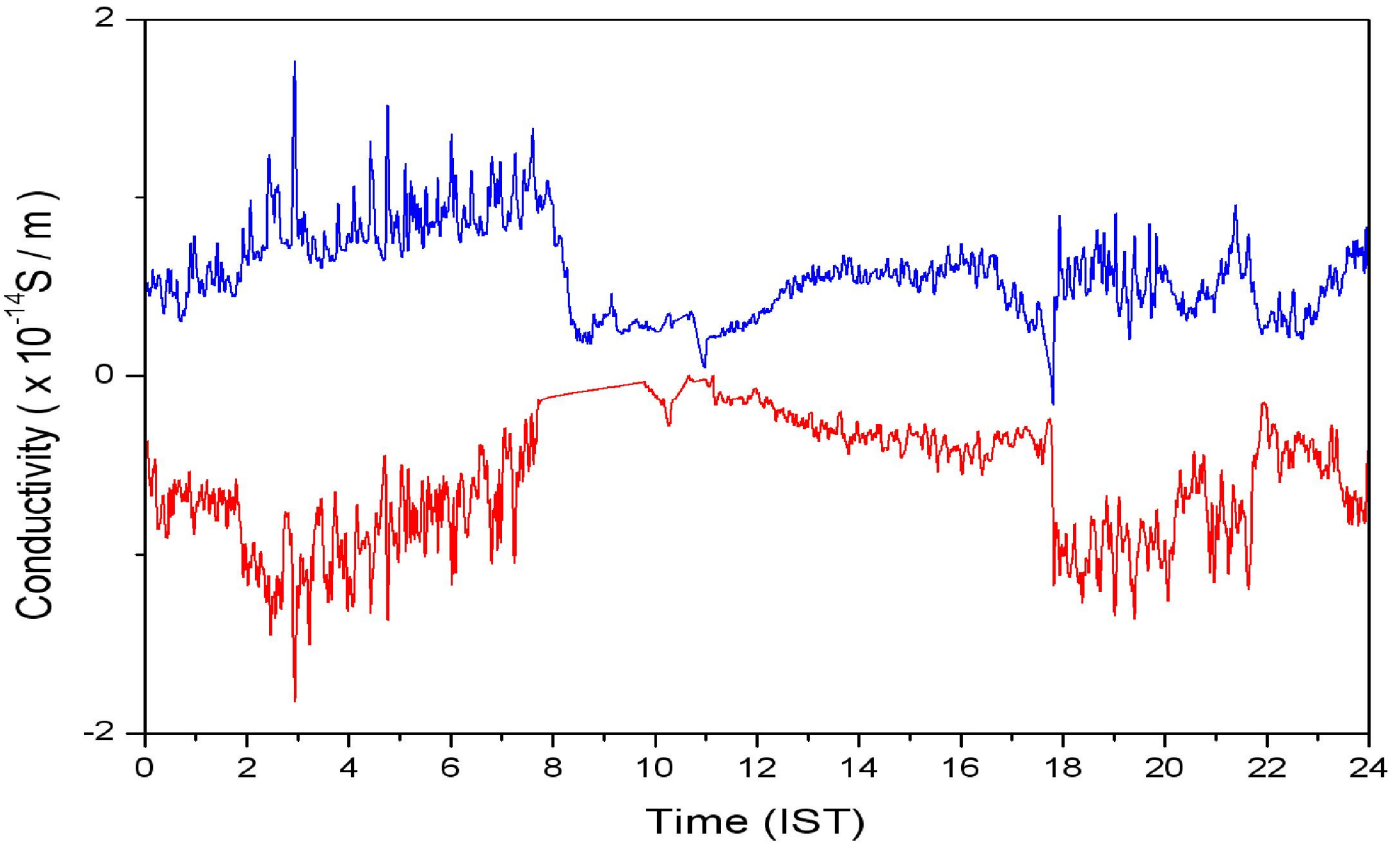


FIGURE 1 Ionization profiles showing range of values that might be expected over land. Q_{max} would represent high values; Q_{min} low values.

Atmospheric conductivity

- $\lambda = nek$
- n – number of small ions
- e – electronic charge
- k - mobility of small ion
- Mobility is a velocity acquired by small ions in unit electric field.

Diurnal variation of conductivity



Potential gradient/Electric field

- The ratio of the force acting on the body to the charge on the body is known as" electric intensity" or the "electric field strength", often abbreviated to "field".
- $E = F/q$

- $E = -\text{grad } V$
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- $Er = -\partial V/\partial r$

Electric field

- **In most of the phenomenon of atmospheric electricity , the equi-potentials are horizontal and the fields are vertical ; at the horizontal surface of the conducting earth the field must always be vertical, whatever may be its direction higher up.**
- **In normal fine weather condition the potential V increases with height.**
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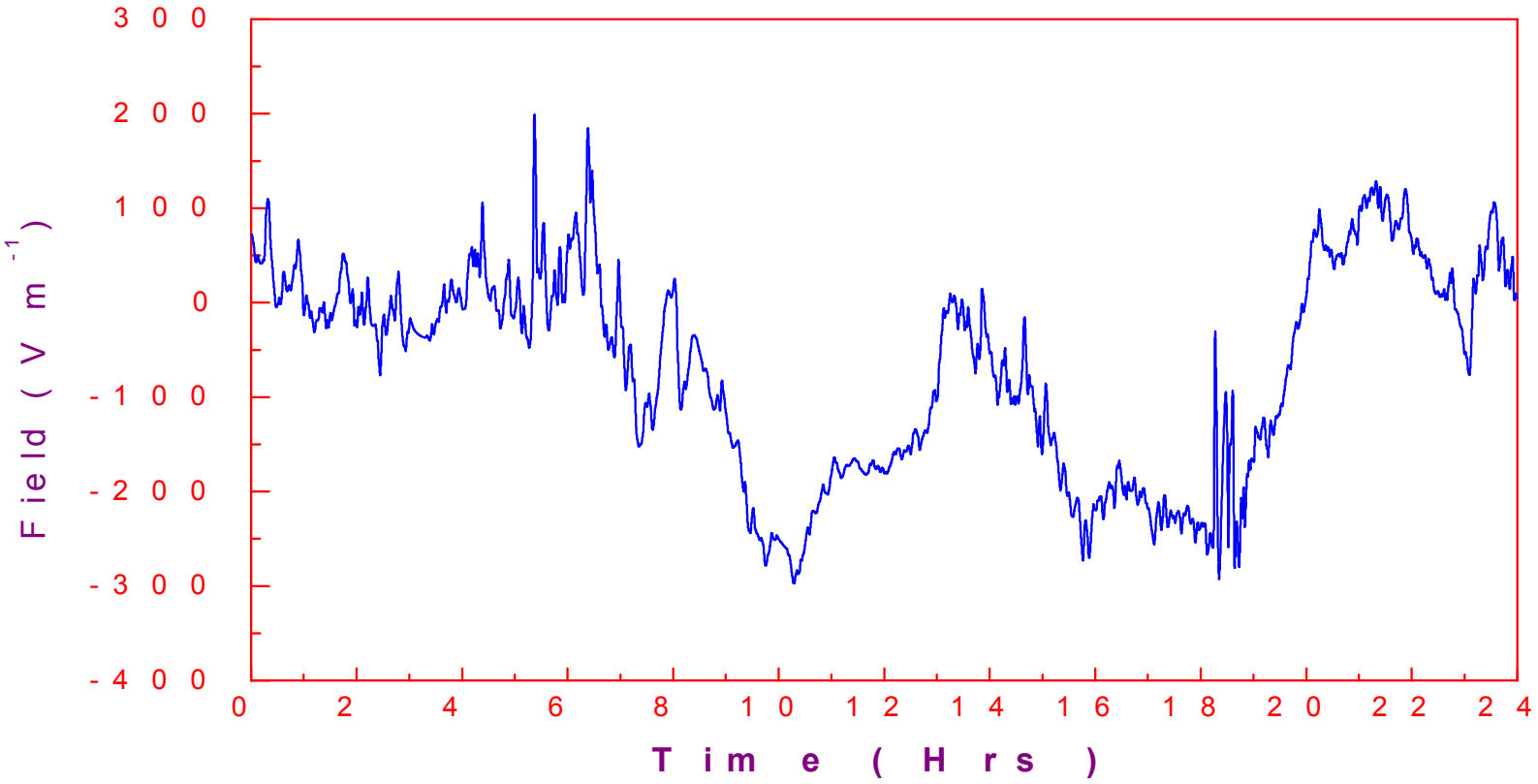
Electric field

Sign convention for field :

- The field is a vector and as such, has a direction but not of necessity, a sign until some convention of sign is laid down. If we take the fairly obvious convention that height is measured positively upwards, then, in fine weather ,$\partial V/\partial h$ is positive and so E is negative.

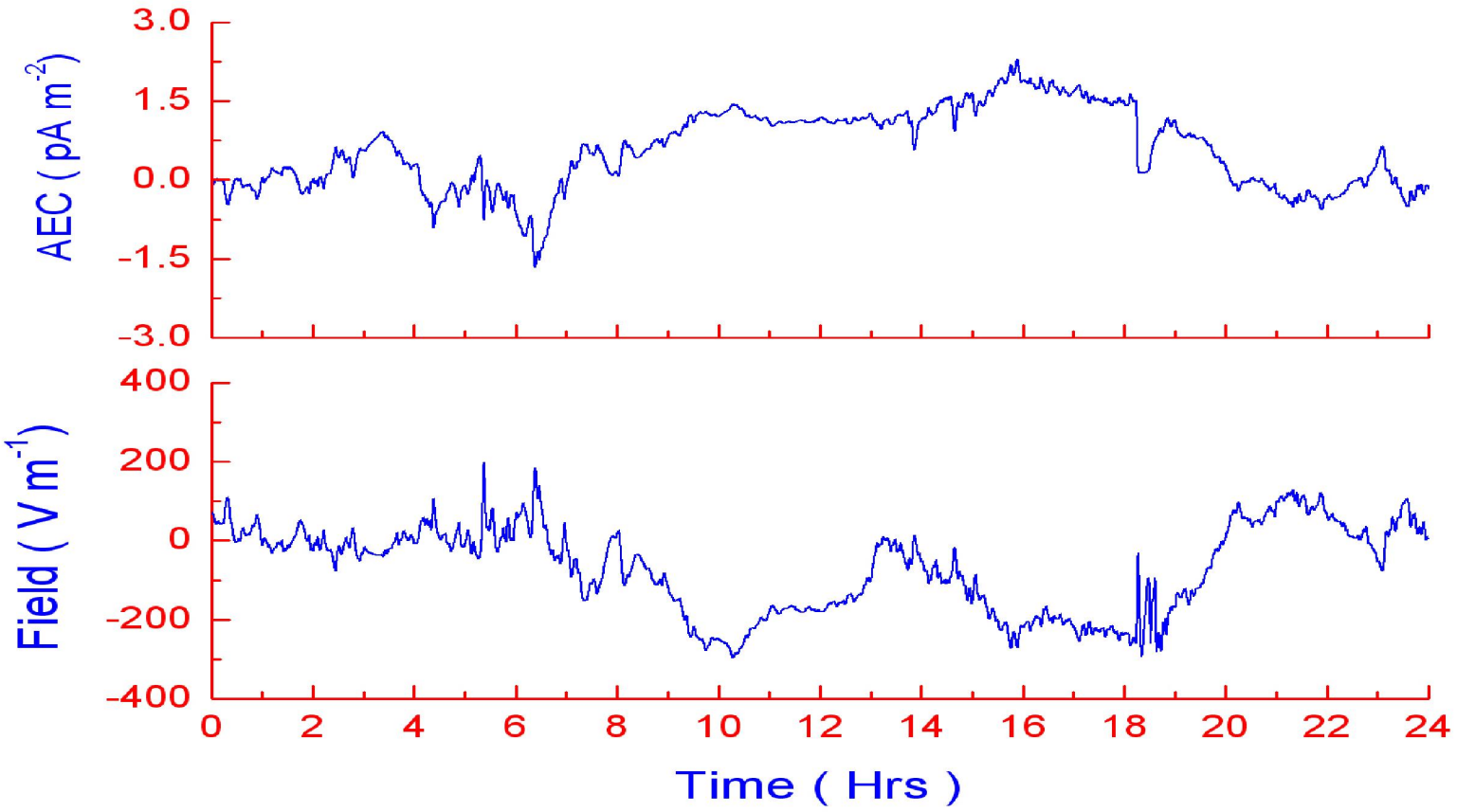
Diurnal variation of fair weather Electric Field



Air-Earth Current

- Electric charge transported from atmosphere to earth surface.
- Typical value is about 1pAmp/m^2
- It is summation of conduction current , convection currents and displacement current.
- Conduction current = E λ
- Convection current = ρ V
- Displacement current = € dE/dt

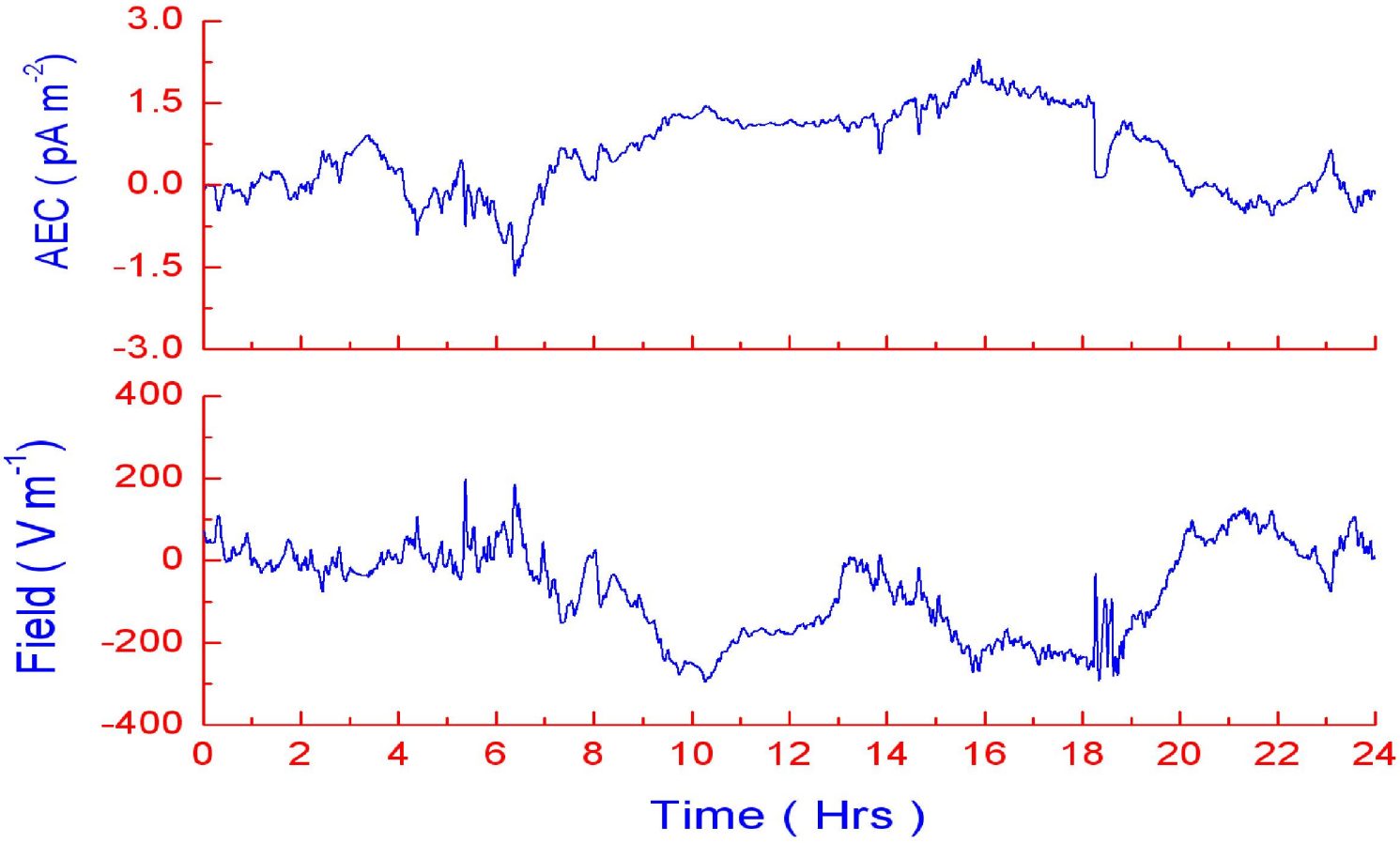
Diurnal variation of Air-Earth current



Ohms law

- $i = E \lambda$
- E – Electric field
- λ - air conductivity

Air -Earth Current



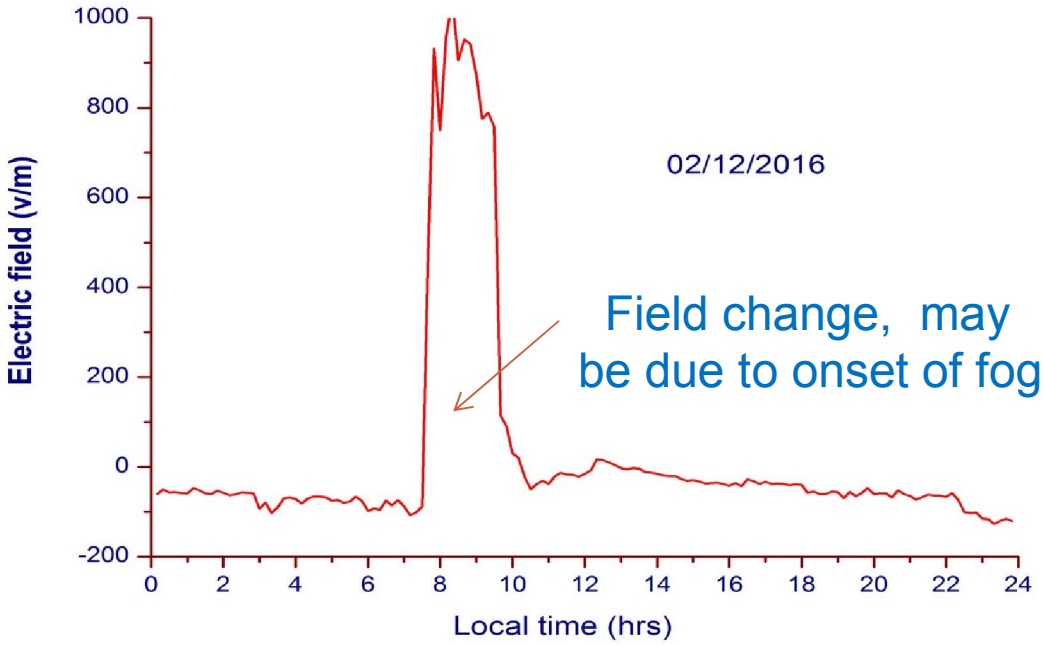
Effect of fog on Atmospheric electric field

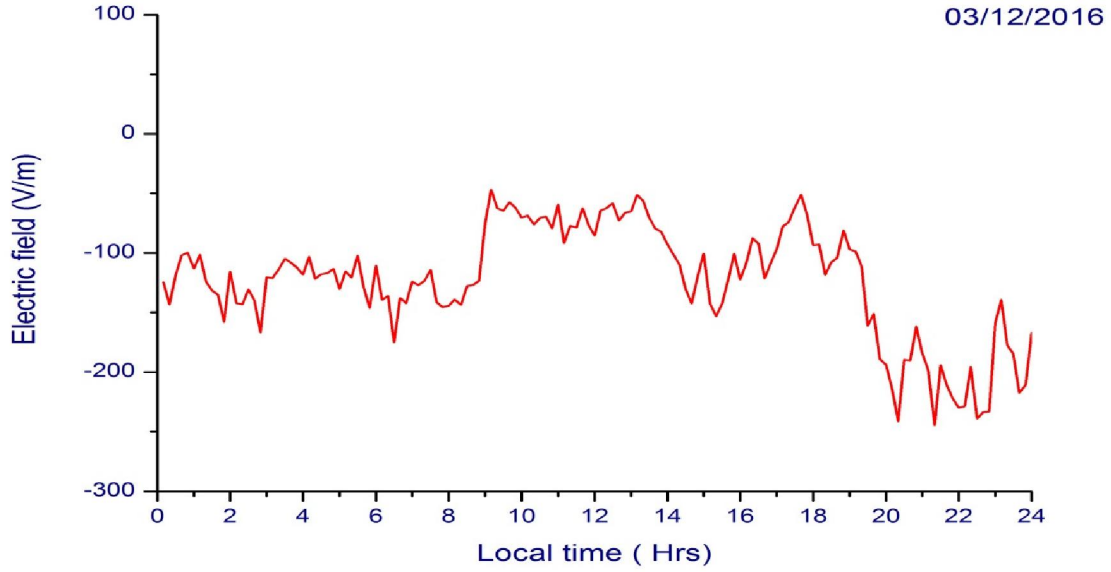
- Atmospheric electric parameters show significant variations, few hours before the formation of fog becomes visible. The same is true for the dissipation of fog.

- Earlier measurements by Deshapande et al (2004) show increase in atmospheric electric field and decrease in air conductivity during widesprade fogs.

- Kamra et al. [1997] and Pawar et al (2009) show an inverse relation between conductivity and relative humidity.

Diurnal variation of electric field





1. Data is being analysed to study the effect of fog onset on atmospheric electric field.
2. Diurnal variation of electric filed on a foggy day does not match with typical diurnal variation of electric field on a fair weather day.

Effect of aerosols on electrical properties of atmosphere.

- Air conductivity decreases with decrease in aerosol concentration.
- Electric field increases with increase in aerosol concentration.