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# Global Electric Circuit Parameters and their Variability Observed over Maitri, Antarctica (70°45' 53" S, 11° 44' 01" E)

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**ABSTRACT**

The Global Electric Circuit parameters are the consequences of the total global thunderstorms acting together at any time and they are composite signals from various electrical sources. Some of the results obtained from Maitri, Antarctica are presented here. During fair-weather condition the parameters are representing the global thunderstorm activity and to some extent they respond to the upper atmospheric electro dynamic phenomenon. The mean value of the potential gradient (77.7 V/m) and current density (2.13 pA/m$^2$) are well below the expected global mean of the respective parameters and the net conductivity; e.e4 x 10$^{-14}$ mhom$^{-1}$ is slightly at higher side.

**Keywords:** Conductivity, Conduction current, Potential Gradient, Global Lightning Flash numbers, Geomagnetic substorm.

## INTRODUCTION

Monitoring of the Global Electric Circuit parameters (GEC) has recently been shown be used as a tool to study the earth's climate and changes in it as it has direct implication with global lightning activity. It is also suggested that the global component of variation of fair weather electricity is subjected to special attention because of the physical integration of the electrical circuit gives a possibility to watch Solar-Terrestrial effects and secular changes in global climate (Williams 1994; Tinsley et al., 2000; Tripathi and Harrison, 2002). The physical correlation existing between the Solar originated disturbances on the climate changes suggests that an integrated approach in understanding the various electrodynamic processes at different regions of the atmosphere is required. Traditional Global Electric Circuit does not involve the upper atmospheric electro-dynamic process, whereas the New GEC model (Rycroft et al., 2000) treats the ionospheric and magnetospheric electrical parameter as passive system of the global electric circuit. Since the atmospheric electricity parameters couple the upper atmosphere and the earth the investigation of the GEC parameters is expected to provide a plausible mechanism to understand the influence of solar activity and weather related problems.

The Global Electric Circuit is formed by the total global thunderstorms acting together at any time charges the ionosphere to a potential of several kilo volts with respect to the Earth surface (Dolezalek, 1972). This potential differences generates a gradient of about 100-300 V/m close to the ground. With this electric field and the conductivity, in the order of $10^{-14}$ mho/m, caused by atmospheric molecular clusters ions formed by natural radioactive isotopes and cosmic rays, there flows a vertical current called the conduction current with the magnitude of about 2-3 $pA/m^2$. The conductivity of the atmosphere is bound to undergo spatial and temporal variations. This is well documented by Cobb and Wells (1970); Kamra (1972); Deshpande and Kamra (2002).

Though the global electric circuit is postulated since 1860 by Thomson Lord Kelvin, the global electric circuit concept by Wilson in 1920, no sufficient experimental measurement of the global electricity parameters is made. One of the major reasons for this is that the magnitude of the parameters is very low and it can easily be masked by anthropogenic disturbances. Hence monitoring sites are to be selected in such a way where the pollution is minimum and stable meteorological condition prevails. Antarctica is considered to be an ideal location to monitor the global variation of atmospheric electricity parameters as there is no anthropogenic inputs and in situ thunderstorm activity. Atmospheric electricity measurements over Polar Regions are expected to provide ample scope in understanding the solar originated disturbances over the GEC as the polar region atmosphere is directly coupled by geomagnetic field lines.

Interestingly a good amount of work from Antarctica shows the existence of correlation between the atmospheric electrical parameters and geomagnetic activity. During the disturbed conditions, the dawn-dusk potential difference of magnetospheric convection pattern was found to clearly influence the vertical fair-weather field as it intensified and presumably moved from its quiet time position to over balloon's height Mozer and Serlin (1969), Mozer (1971), Holzworth and Moser (1979) and Holzworth (1981). Measurements of vertical electric field at Syowa station showed that the vertical field increases in response to a magnetospheric substorm (Tanaka et al., 1977). The geomagnetic substorm signature over the air-Earth current was observed by Belova et al., (2001). The possible explanation given for this is the enhancement of vertical field at ground due to enhancement of ionospheric southward electric field during the substorm growth and expansion phase and redistribution of downward atmospheric electric current due to an increase in the atmospheric conductivity in the local D-region. More reports from Antarctica on the observation of the potential gradient show that there are significant changes in the electric field due to the IMF (Burns et al., 1998), Corney et al., (2003), Tinsley et al., (1998) and Reddell et al., (2004). All these studies emphasize the need of more measurements towards understanding the Solar-Terrestrial weather relationship and electric field induced changes in the climatology.

In most of the cases, mentioned above, there is measurement of either current or potential gradient. The uniqueness of this paper is that to presents the first results obtained from the measurement of the Conductivity, Electric field and conduction current obtained all together from Maitri, Indian Scientific base, Antarctica during the austral summer 2006-2007. The results are discussed in context with meteorological weather condition and fair weather GEC environment and its modulation during geomagnetic disturbances.

Measurements have been carried out by various groups from the location Amundsen-Scott base (Reddell et al., 2004), Tinsley et al., (1998), Vostoc (Corney et al., 2003). These stations are just below the polar cap region and most likely to be influenced by polar cap convection activity. Maitri is at the equator ward peripheral of the Auroral electrojet. During the geomagnetic quiet condition the station is under the influence of the Sq current system. During the geomagnetic stormy condition the station comes under the influence of the auroral electrojet which enables the field line currents to influence the upper space environment (Kalra et al., 1995, Gurubaran 2002, Girija Rajaram et al., 2002). Thus it is expected that during the quiet condition, the global electric circuit parameters are expected to provide the signatures of the global thunderstorm activity and during disturbed condition it might have the influence of the upper atmospheric current system which will alter the Vertical electric field and the current.

## EXPERIMENTAL SET UP

### Atmospheric Electrical Conductivity

Positive and negative polarities of atmospheric electrical conductivity were simultaneously measured with a pair of Gerdien condensers. The system is in use since 1905 after H. Gerdien. Its application is vast owing to the requirement of the measurement. In the present work, the Gerdien system used is U shape aspiration tube with a fan, two coaxial cylinders (condensers) with a shielding cylinder attached to the succession tube. The outer electrode is biased appropriately to measure the positive and negative ionic currents. The dimensions of the electrodes are as follows. The length of the central sensor is 0.2 m, and radius is .005m. The radius of the outer electrode is .05m and length is 0.45m. The flow rate of the air is 4m/s. Applied potential difference to the outer electrode is 36.7v (Dhanorkar et al., 1989). With these physical standard the apparatus constant the critical mobility ($\mu_c$) is calculated using the equation:

$$\mu_c = ku/V$$

k is the geometrical constant of the apparatus which can be obtained from the equation:

$$k = (a^2-b^2)\ln(a/b)/2L, \text{ where}$$

a-radius of the outer electrode in meter

b-radius of the inner electrode in meter

L-Length of the inner electrode in meter

V-Potential applied to the outer electrode.

u-flow rate of the air in m/s

The above physical size of the apparatus is selected so as the critical mobility should be more than of the order of $10^{-4}$ $m^2V^{-1}$ $m^{-1}$. This means the system is capable of sensing the ions having mobility more than $10^{-4}$ $m^2V^{-1}$ $m^{-1}$. Ions having less than this mobility are medium ions and large ions which do not contribute to atmospheric electrical conductivity. Elaborate theory on this aspect is discussed by K. L. Aplin (2000). The sensed ionic current is measured by two separate electrometers consisting AD 549 electrometer. The final conductivity is arrived from the equation (Mac Gorman and Rust, 1998)

$$\sigma_{\pm} = \varepsilon_o i_{\pm}/CV_{\pm}$$

where $\varepsilon_o$ is the permittivity of the air (8.85 x $10^{-12}$ $Fm^{-1}$), i-ionic current, C the capacitance of the apparatus 24 pF and V applied voltage. Few and Weinheimer (1986) pointed out that to obtain the current on the long wire, to account for the electric circuit using Ohm's law, only one polar conductivity should be accounted for as $\sigma = \sigma_+ = \sigma_-$. Various reports show that the positive conductivity and negative conductivity are not equal. This could be due to the difference in number density of positive ions and negative ions and also may be due to the difference in their mobility. Mohnen (1974) defined mean mobility for the positive ions as 1.3-1.6 $cm^2v^{-1}s_{-1}$ and 1.3-1.9 $cm^2v^{-1}s^{-1}$ for negative ions. We also, in the present work, have observed that there is difference in magnitude between the positive and negative conductivity. Hence the conductivity in the present is termed as net conductivity which is obtained from the equation:

$$\sigma = (\sigma_+ + \sigma_-)/2$$

**Atmospheric Current Density**

The atmospheric vertical current was monitored using long wire antenna (Kasemir, 1955), Ruhnke, 1969). Increased attention to its measurement is expressed in Global Atmospheric Electricity Measurement (GAEM) (Ruhnke and Michnowski 1991). Though there lays complication in using the effective area (Tammet, 1996) in this present work the effective area is obtained from the equation $A = hc/\varepsilon_o$ (Kasemir and Ruhnke, 1959). The long wire antenna senses the Maxwell current of the atmosphere. Freier (1979) presented a thunderstorm model which includes various electrical parameters at different stage of the atmosphere and the Maxwell current is termed as the sum of various currents.

$$J_M = J_E + J_L + J_C + \partial D/\partial t$$

As per his model in the fair-weather region, far away from the thunderstorm, only conduction current flows. In addition to this an appropriate RC time constant, in the order of 20-30 minutes we used, will consider only the conduction current part of the Maxwell current.

**Measurement of Potential Gradient**

It is commonly found that the measurement of the potential gradient is carried out using the mechanical field mill (Chalmers, 1967). The advantage in using the field mill is that it offers a more rapid time response and dynamic range (Chubb, 1990; MacGorman and Rust, 1998). At the same time it also has the disadvantages as the field mill is directly exposed to open atmosphere causing more heat or cold and it is to be prevented from precipitation. In the present study the vertical Potential Gradient (PG) was monitored using two different systems. One was the traditional field mill in which an electric motor rotates a grounded rotor and alternately exposes the sensing stator to the atmospheric electric field to generate an ac signal which can be easily amplified. The system was periodically calibrated to obtain the potential gradient. The second system we used to monitor the potential gradient was a Passive antenna system. The technical details and first results are presented by Paneerselvam et al.(2003).

**Validation of Data**

We have adopted various precautions in ensuring the quality of the data. The first precaution adopted here, to be free from errors, was to

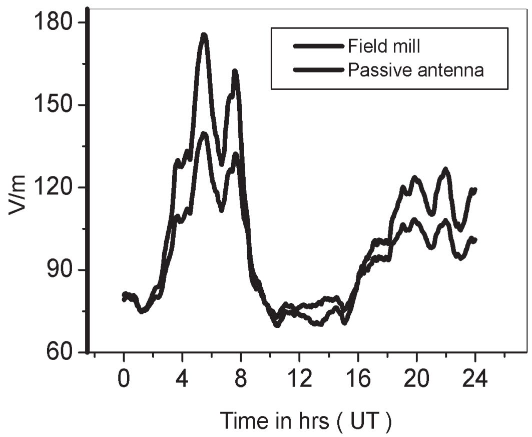


*Fig. 1: Comparison of the diurnal variation of potential gradient simultaneously monitored from field mill and passive antenna system*

monitor the potential gradient using two different systems, viz. the field mill and passive antenna. Any discrepancy can easily be brought out from the comparison of the PG obtained from those experiments. One such example is shown in Fig. 1 which shows the diurnal variation of potential gradient obtained from both the system simultaneously on 23 February 2007. A long term comparison of PG obtained from both the systems has also been carried out and found to be satisfactory. To know the possibility of error in the measured components, the parameters were verified using atmospheric electricity Ohm's law $j=\sigma E$. And the other two parameters were calculated from the following equation.

$$E_z = J_z/\sigma$$

and $$\sigma = J_z/E_z$$

The result is presented in Fig. 2a, 2b and 2c. There is fairly good agreement between the observed values and deduced values. However during the course of 24 hours the deviation varies from 20% to 50%. The maximum deviation is during night hours and minimum deviation is during day hours. The calculated value is more than the observed value for the current density and the calculated value is less than the observed value for the other two parameters. The measured conductivity is the consequences of the ionic current. The potential gradient will vary based on the sharp vertical gradients in the ion density in addition to the Earth-ionospheric potential difference. Whereas the observed current density is sensitive to the columnar conductivity. The major difference between the observed current density and calculated current density is that the observed current density is sensitive to the columnar conductivity. The calculated current density is obtained from the conductivity and the potential gradient. Both the parameters are sensitive to the surface conductivity. The same discussion is applicable for the differences in the deviation for the other two parameters.

## Data Selection

During the fair-weather days the atmospheric current and potential gradient are expected to follow the trend of global thunderstorm activity. The fair-weather condition is generally defined as the days with no precipitation (snowfall/rain) wind speed less than 10ms$^{-1}$, high clouds are less than 3 octas throughout the day (Deshpande, 2001). Since the

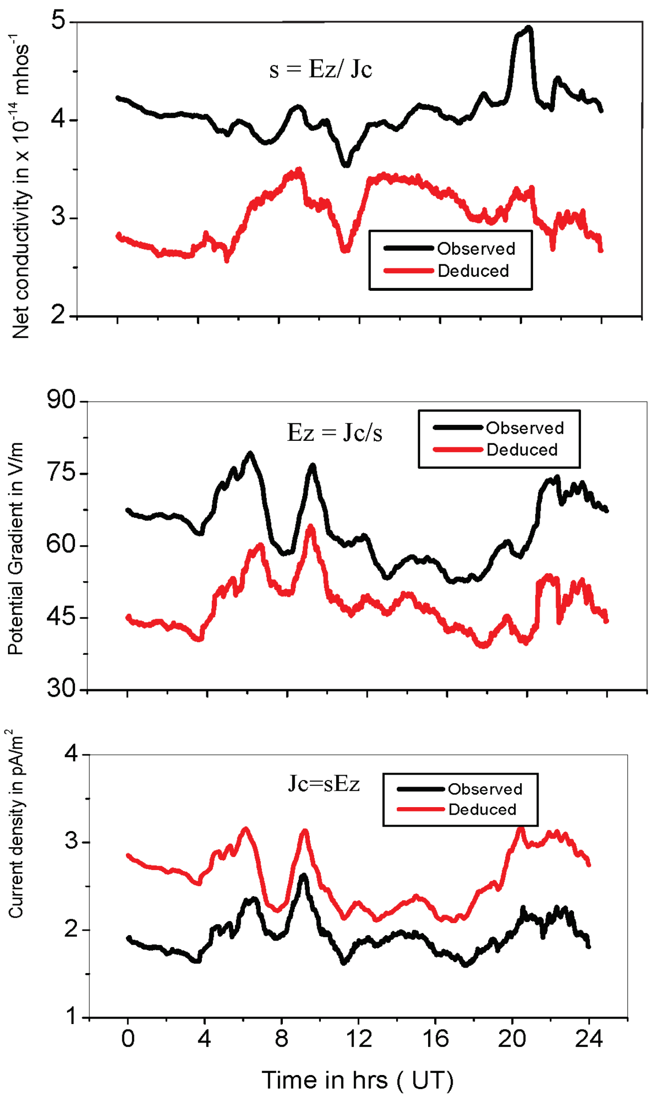


*Fig. 2: Comparison of the diurnal variation of the observed and calculated atmospheric parameters for the day 4.2.07*

continent is free from thunder clouds and anthropogenic pollution the conditions for the fair-weather days are relaxed from the cloud condition and the limit for the winds velocity. Visual observation showed that strong wind with drifting snow/sand alone distorts the regular and smooth variation of the measured parameters. Hence in the present work data sets are selected by omitting large and rapid fluctuations due to weather conditions like strong wind with drifting snow/sand, fog and low cloud conditions which used to disturb the smooth recording of the parameters.

## RESULTS

### Conductivity

The diurnal variation of the net conductivity displayed various patterns during the observation period whose mean variations are depicted in Figures 3a and 3b. They were two prominent peaks during post and

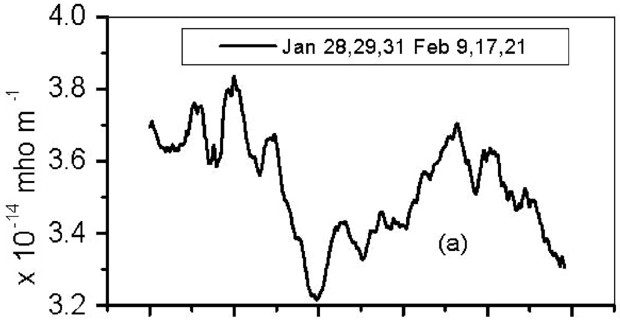


*Fig. 3a: Diurnal variation of net conductivity for a few selected days*

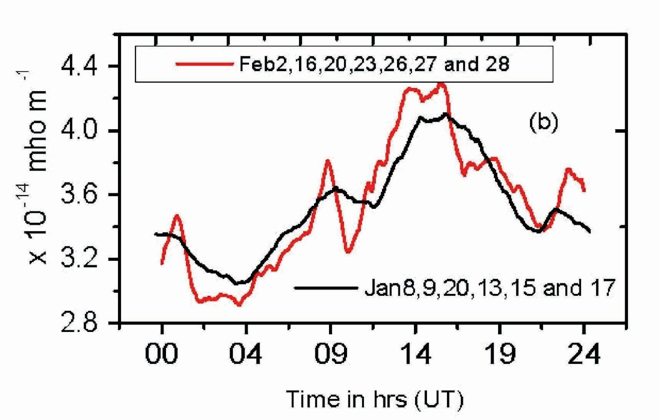


*Fig. 3b: Diurnal variation of net conductivity for a few selected days*

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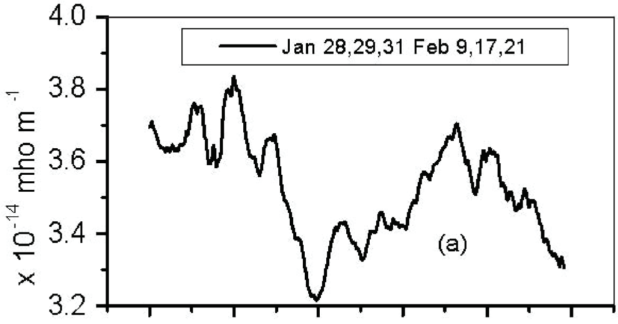


*Fig. 3a: Diurnal variation of net conductivity for a few selected days*

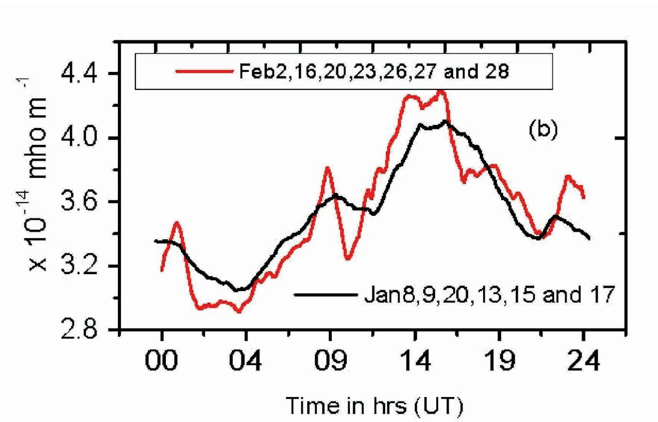


*Fig. 3b: Diurnal variation of net conductivity for a few selected days*

pre mid night hours and a minimum during noon hours. This pattern was observed on days January 28, 29, 31, February 9, 17 and 21. The other pattern was just the opposite to the former one. It displayed a peak around noon hours. They days were January 8, 9, 13, 15, 17, 20, February 2, 16, 20, 23, 26 and 27.

## Potential Gradient and Current Density

The diurnal variation of the potential gradient and current density display various trend over the season of austral summer. In order to study their diurnal characteristics they have been averaged for every ten days and 30 minutes smoothed curve is considered to study the diurnal

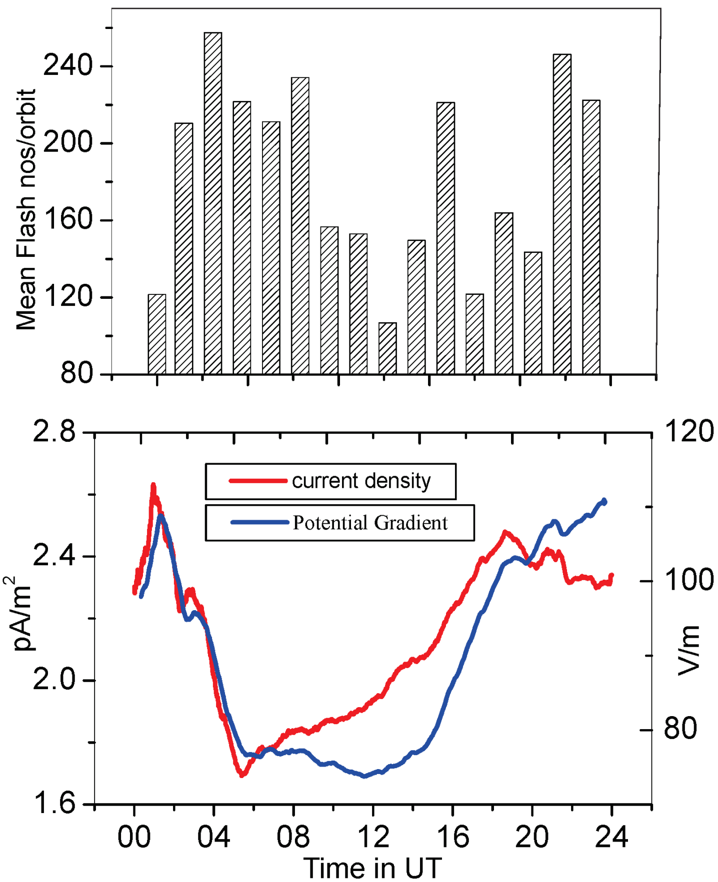


*Fig. 4a: Mean Diurnal variation of potential gradient and current density for the days 17-31 Dec, 2006*

pattern. They are presented in Figures 4a-e. The top panel of each figure represents the mean global lightning flash numbers for those corresponding days. Figure 4a shows the mean diurnal variation for the days from December 17 to 31 Figure 6 b is from January 12 to 15. Figure 6 c shows for the first ten days of February, followed by 8 days mean from February 13 to 20 (Fig.4d) and last eight days of February in the Figure 4e. The first common signature found with all the above figures is that

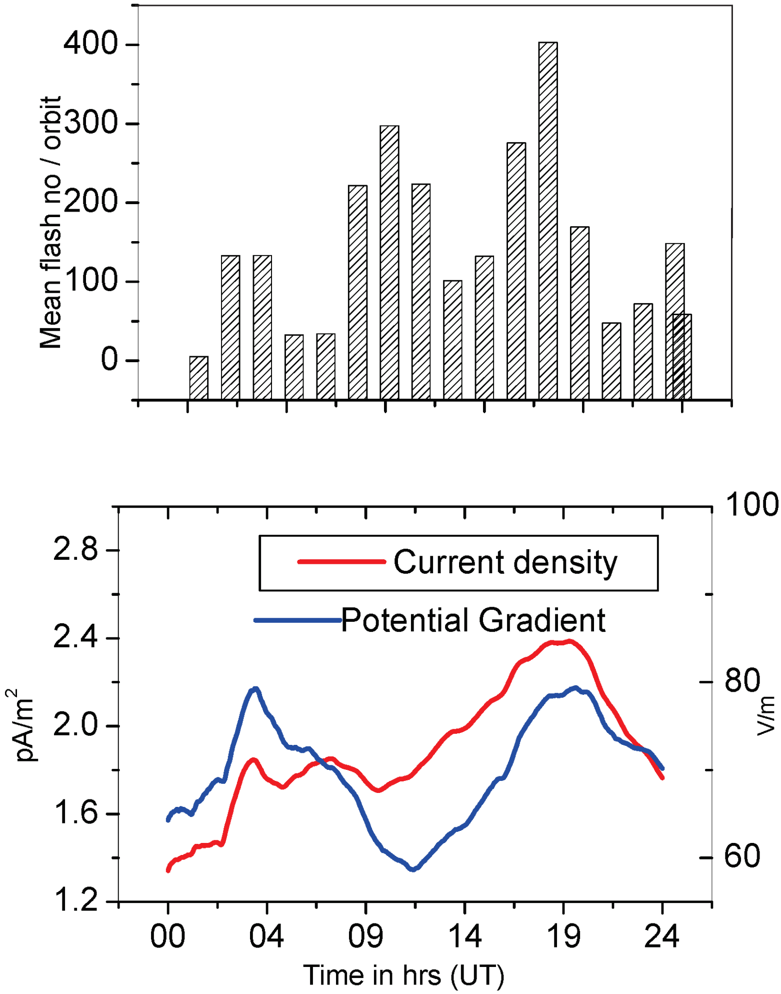


*Fig. 4b: Mean Diurnal variation of potential gradient and current density for the days 12-15 Jan, 2007*

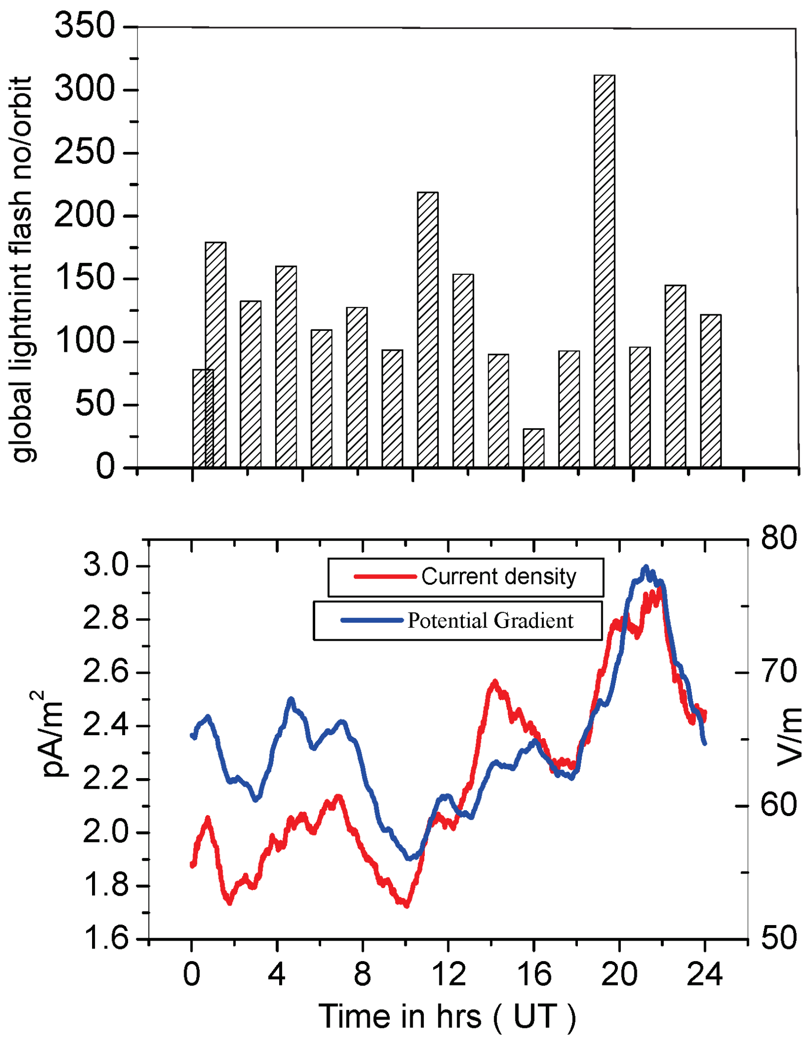


*Fig. 4c: Mean Diurnal variation of potential gradient and current density for the days 1-10 Feb, 2007*

the parameters, the potential gradient and current density, are exhibiting identical trend except for a small deviation from each other for short periods. Secondly, the diurnal variation of the potential gradient and current density is that in majority cases there are two prominent peaks, one during the post mid night hours and the other during the after noon and pre-mid night hours. The noon hours shows a depression.

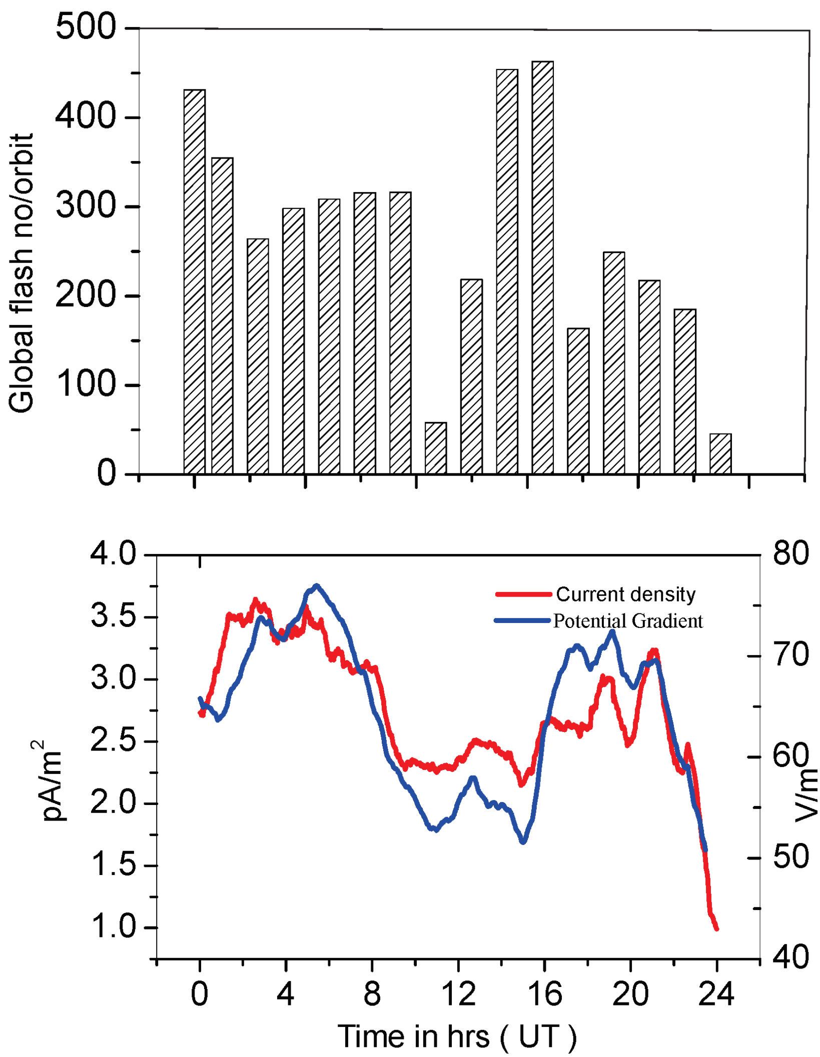


*Fig. 4d: Mean Diurnal variation of potential gradient and current density for the days 13-20 Feb, 2007*

## Discussion and Conductivity

The atmospheric conductivity is directly proportional to the net ion density (n) and it is also subject to the ion mobility (μ) i.e. $\sigma = \mu n$. The ions in the atmosphere are generally categorized into small ions, intermediate ions and large ions. The atmospheric electrical conductivity is controlled by the small ions due to their smaller size and so the

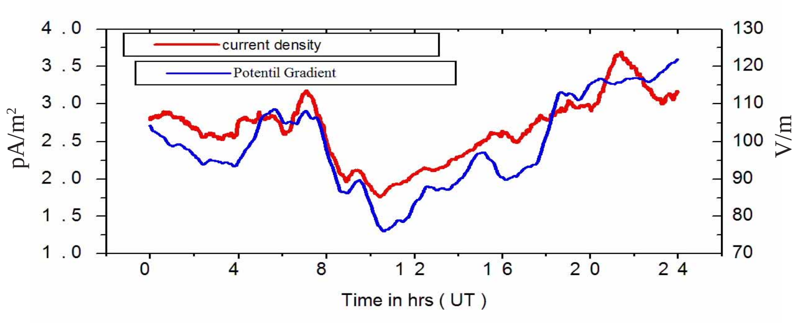


*Fig. 4e: Mean Diurnal variation of potential gradient and current density for the days 21-28 Feb, 2007*

mobility (more than 1 x $10^{-4}$ $m^2v^{-1}s^{-1}$) (Dhanorkar and Kamra, 1997, Aplin, 2000). It can also be clearly explained from the equation that the conductivity can vary owing to the density of ion number and its mobility. In a given location and time the ion density is the net reaction of the production and destruction of ions. The loss can take place chiefly by attachment ions with aerosol pollution number concentrations (Horrak et al., 2002). This will be insignificant in places like Antarctica. However, another common source to deplete the ion concentration is the electrode effect (Hoppel and Gathman, 1971, Tuomi 1981, 1982, Hoppel et al., 1986; Israelsson et al., 1991) in which the ions are transported upward due to the increased updrafts after the enhancement of solar energy during the morning hours. The stable atmospheric condition during night hours causes more accumulation of radon and hence the conductivity is expected to be more during the morning hours. This phenomenon is very common over the land surface and the variation can be called as continental type. Interestingly Aumento (2001) made a study on the Radon tides on an active Volcanic Island in which he showed the radon emanation, one of the major ionizing source at the surface level, andshowed two prominent peaks one at dawn hours and the other at the sunset hours. He has also showed a close correlation between the sun's elevation angle and the emanation of the radon gas. From this it can clearly be said from our study that the ground based ionizing source dominates in the Maitri location.

It was also observed that there is another pattern of diurnal variation which is just opposite to the continental pattern. In this pattern there is a maximum around noon hours and minimum during the pre mid-night and post mid-night hours (For example the days 8, 9, 13, 15, 17 and 20 in January and 2, 16, 20, 23, 26 and 27 in February as is shown in Fig. 4b). One such possible source could be from the upper atmosphere which includes the cosmic ray ionization and geomagnetic activity. Since the observation was carried out in polar region, both the sources are expected to play major role in the atmospheric electricity parameters. To explain the observation we are using the geomagnetic activity and its influence on the potential gradient, which is discussed in section above.

## Potential Gradient and Current Density

The vertical atmospheric potential gradient and vertical current are the well studied atmospheric phenomena. A common global diurnal variation results from a diurnal variation of the ionospheric potential which modulates the vertical air-earth conduction current in the absence of local effects (Mulheisen, 1977). Takaji and Iwata (1980) observed that the characteristics of the Potential Gradient regularly alter with the season. The electric field in winter has the same diurnal pattern as that observed at globally representative stations. It exhibits in summer a pattern depending on the variation of the local conductivity. Dolezalek (1972) found a diurnal maximum at 16UT. Deshpande (2001) observed at Maitri (Antarctica), a maximum around 12 UT. Williams and Satori (2004) reported large current contributions from South American shower clouds around 20 UT. All the above studies indicate that the maximum is during the universal afternoon hours.

## Global Maximum and Minimum

The Carnegie curve which is considered to be the representation of global thunderstorm activity is having a minimum around 0300 UT and maximum at about 1900 UT. Comparing this curve with our observation it is found that our curve is strongly deviating from it, particularly during post midnight hours. Our observation are in agreement with the maximum of the afternoon hours. However, the occurrence of another maximum around the post mid night hours and the minimum close to the noon hours have no relevance with the Carnegie curve. In Figure 4a and 4b, the maximum was found to be around 1900 UT. In Figure 4c and 6e the maximum was around 2100 UT. In Figure 4b, a prominent maximum was seen around 1500 UT. It is to be considered here that the Carnegie curve is the mean diurnal variation of potential gradient, from about 100 days, spread over a few years (Seven expeditions), whereas the present investigations deals with a very limited days. Hence it will be appropriate to compare the diurnal variation with the global lightning activity corresponding to the same period. For this the LIS data from onboard TRMM satellite is plotted in the upper panel of the respective electricity parameters from Figures 4c to 4e.

All the above reports clearly suggest that there can be maximum potential gradient or conduction current during the universal afternoon hours. The variability on the timings is obvious as the thunder storm all over the globe is not uniform. The peak activity may vary by a few minutes to hours and one global thunder storm region may be more active than the other on a particular day and thus there can be variability in their contribution to the global electric circuit.

While the maximum of the potential gradient and current density show an unambiguous feature of the global thunderstorm activity, the minimum, which is expected around 0300 UT, appears to have shifted to pre noon hours. It is intriguing to note a maximum around 0200 UT on most of the days during which the global thunderstorm activity is expected to be minimum. During these hours there is a sharp decrease in the conductivity observed. The cause for the decrease in the conductivity and increase in the potential gradient and current clearly indicates that the parameters obey the atmospheric Ohm's law. Initially it appeared that the depletion of the space charge near the ground, due to electrode effect, modifies the potential gradient and current density. On examination of the global thunderstorm activity, using LIS data, there is clear indication that the enhancement of the potential gradient and current density is due to the global thunderstorm activity.

## Geomagnetic Field and Potential Gradient

The years 2006 and 2007 were the solar minimum years. We have selected three magnetically disturbed days based upon the maximum $\sum$Kp for the month of Dec 2006 was 33-, for January 2007 30+ and for February 29-. One of the most severe storms recorded in this decade on 29 Oct 2003 was with $\sum$Kp -58. Comparing to this the disturbance we consider is not very severe. The simultaneous monitoring of geomagnetic field variation at this laboratory also showed disturbances around the

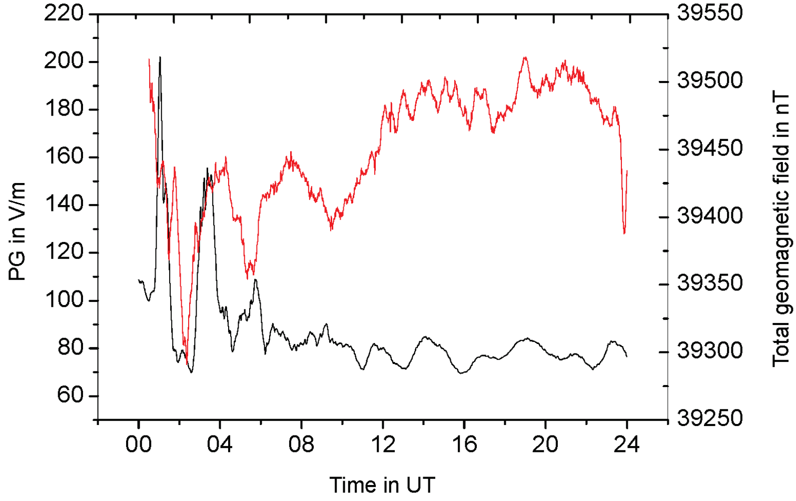


*Fig. 5a: Diurnal variation of potential gradient and total geomagnetic field observed on Dec 19, 2006*

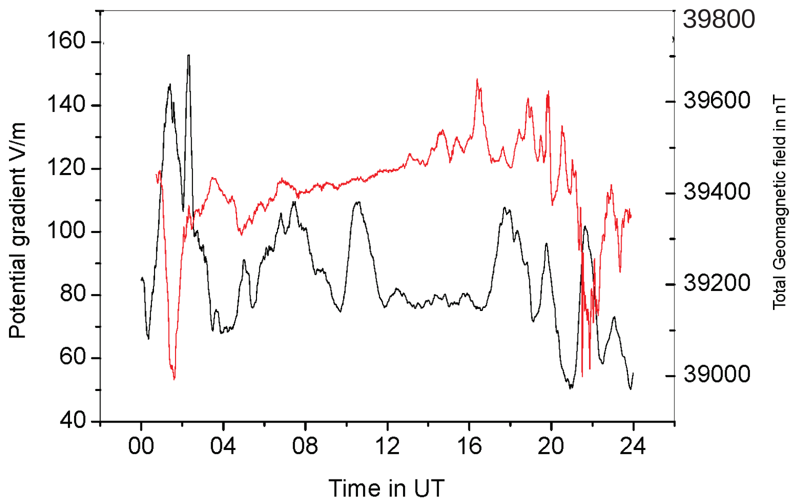


*Fig. 5b: Diurnal variation of potential gradient and total geomagnetic field observed on Dec 20th, 2006*

same period. Figure 5a shows the diurnal variation of the atmospheric potential gradient and total geomagnetic field observed on 19 December 2006. In the beginning, when there was a sharp decrease in the total field, a sharp increase in the PG was observed. Afterwards the disturbance appeared to have identical variation to each other. Similarly Figure 5b depicts the diurnal variation of the geomagnetic field disturbed during the post mid night and pre mid night hours on 20 December 2006. Figure 6 shows another significant geomagnetic disturbance on 28 February 2007 with ∑Kp 30+, the season's maximum, on which the potential gradient and current density is compared. In Figure 5b all the three atmospheric electricity parameters are compared with the total geomagnetic field. In all the above comparison it was found that the potential gradient has significantly increased during the geomagnetic disturbed condition. Similar variation was also observed with the current density. The variation of the atmospheric conductivity showed opposite trend to that of the potential gradient and the current density which can be explained from atmospheric Ohm's law.

The geographical location of Maitri is unique from geomagnetic studies point of view. Under quiet geomagnetic conditions, the stations is under the influence of the mid-latitude ionospheric Sq current system. As the magnetic disturbances grow due to the enhanced solar wind-

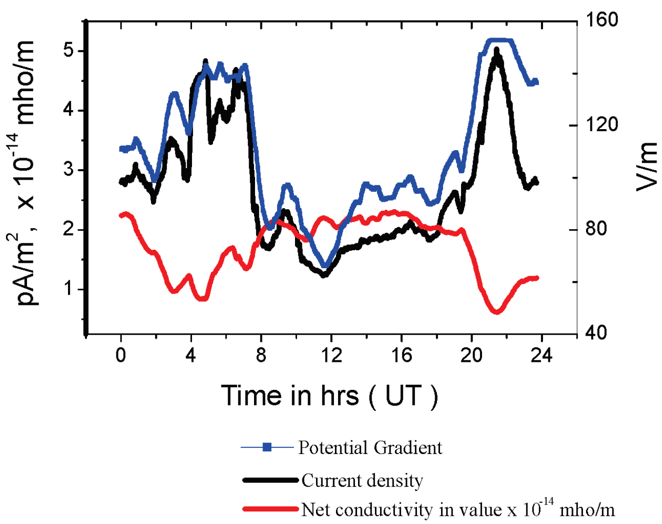


*Fig. 6: Daily mean value of Conductivity and potential gradient*

magnetospheric interaction, the atmosphere over Maitri comes increasingly under the auroral oval. Many important processes occur on the night side of the Earth wherein the geomagnetic field is stretched from a long tail by the streaming charged particle flow from the Sun. The field lines forming the tail are energized whenever the interplanetary magnetic field (IMF) turns southward as this favors magnetic field reconnection on the dayside of the earth. The energy extracted from the solar wind may be dissipated in the ionosphere through the directly driven process leading to an enhancement of the convection driven auroral electrojet in the

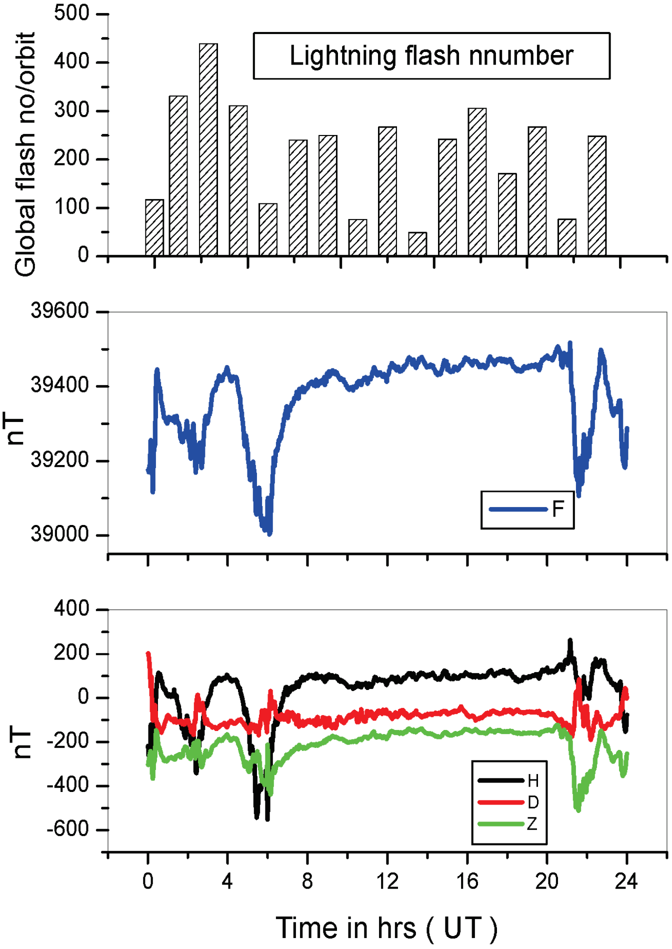


*Fig. 7: Diurnal variation of H, D and Z components (bottom), Total field (middle panel) and global lightning flash number for 28 February 2007*

dawn and dusk sectors (Rostoker, 1999). The energetic charged particles precipitating from the Earth's inner and outer magnetospheric radiation belts interacts with the middle atmosphere by increasing the ionization directly or via bremmstrahlung radiation, by altering its chemistry (Jackman et al., 1995) or by affecting the nucleation by the electro freezing of droplets from clouds, thereby influencing the dynamics of storm and atmosphere (Tinsley and Heelis, 1993; Tinsley 1996, 2000). Freier (1961) and Lobodin and Paramanov (1972) reported auroral effects on vertical electric field measured on the ground. In general, they reported a decrease in the electric field that later recovers to pre auroral condition. Figure, 7 depicts the geomagnetic variation in the total field F, H, D and Z component and global flash numbers per orbit. The global lightning flash number was close to normal values. There was no any severe enhancement during these hours. Hence, we infer that this could have caused the variation on the surface measurement of the potential gradient and current density. Since the parameters obey Ohm's law, the changes in the conductivity might be caused by the upper atmospheric electrodynamic process.

**Absolute Value of the Atmospheric Electricity Parameters**

The mean fair weather atmospheric electricity parameters were obtained for 34 days from the months January and February 2007. Figure 8 shows the relationship between the potential gradient, lightning flash numbers and the conductivity. There is positive correlation between the global thunderstorm activity and the potential gradient, suggesting that the PG monitored over here is the true representation of global thunderstorm activity. The increasing trend in the potential gradient and lightning flash numbers indicate that the excursion of the global thunderstorm activity towards southern hemisphere, where there used to be the least thunderstorm activity had come to an end and it is advancing Towards the northern hemisphere. The mean value of the observed and calculated parameters are presented in Table 1. The season's mean potential gradient we obtained was 77.7 V/m which is far lower than the mean global potential gradient 130 v/m, (Markson, 1978). Such low values were also reported from different stations as shown in Table 2. The decreased value for the PG is also an indication that the southern hemisphere summer does not produce sufficient number of severe thunderstorm activity. By comparing the northern and southern hemisphere

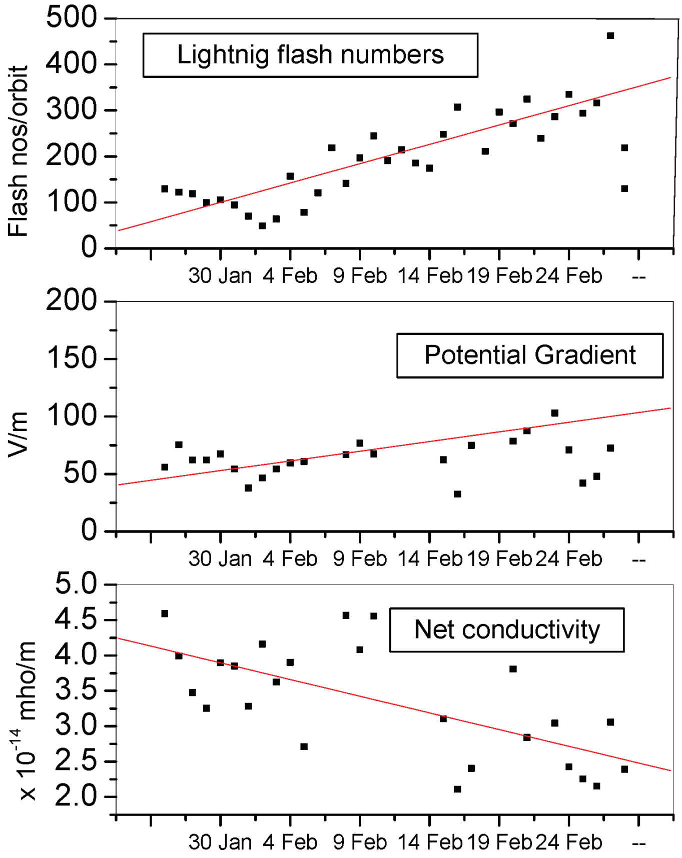


*Fig. 8: Relationship between the global lightning activity, conductivity and potential gradient*

PG data, Alderman and Williams (1996) found a maximum in PG in June/July, consistent with the maximum in lightning occurrence.

**TABLE 1:**

| **Parameter** | **Value** |
|---|---|
| Air-Earth current density | 2.13 $pA/m^2$ |
| Vertical potential gradient ( Field mill) | 77.7 V/m |
| Vertical potential gradient (passive antenna) | 72.7 V/m |
| Positive conductivity | 3.89 x $10^{-14}$ mho/m |
| Negative conductivity | 2.78 $^{-14}$ mho/m |
| Net conductivity | 3.34 x$10^{-14}$ mho/m |
| Air-Earth current density calculated using Ohm' law ( $Jz=Ez\sigma$) | 2.47 $pA/m^2$ |

**TABLE 2:**

| Station name | Year of observation | Mean PG V/m |
|---|---|---|
| McMurdo Sound | 1902-1903 | 93 |
| Triieste | 1902-1905 | 73 |
| Davos | 1908-1910 | 64 |
| Cape Evans | 1911-1912 | 87 |
| Upasala | 1912-1914 | 70 |
| Scoresby Sound | 1932-1933 | 71 |
| Fair Bank | 1932-1933 | 97 |

## CONCLUSIONS

There are several salient features in the present work and the first to be mentioned here is that we monitored all the global atmospheric electricity parameters simultaneously.

The concept "Electricity parameters are not the representative of thunderstorm activity if they are not following Carnegie pattern" has to be reviewed. It may be appropriate for the summer vernal solstice and equinox, but may not be suitable for autumn solstice. Since the sun is over the southern hemisphere where there is majority of ocean there can be no sufficient convection activity to generate large number of thunderstorm activity.

We could clearly observe that the current density and potential gradient are lower than the mean global values. The cause for the reduced magnitude is that the northern hemisphere, which is the major contributor to the global thunderstorm activity, is undergoing the winter season. This fact is also established by showing the increasing trend of the potential gradient and decreasing conductivity as the measuring site moves from the southern hemisphere winter to equinox. This clearly suggests that the monitored parameters truly represent the global variation.

We have been undergoing the minimum phase of the solar activity due to which we were not able to have enough severity of geomagnetic disturbances. However, a couple of cases that were available appear to have strong influence over the atmospheric electricity parameter. During geomagnetically quiet conditions the variation of the atmospheric current density and potential gradient is displaying the signature of global thunderstorm variability. When the station comes under the influence of geomagnetic activity, i.e. during the equator ward shift of the auroral electrojet, the global variation of the atmospheric electricity is strongly influenced. It is interesting to note that the conductivity is also strongly influenced by the geomagnetic activity which suggests that the Planetary Boundary Layer's electrical environment is also significantly altered during the geomagnetic disturbances.

The large variability in the conductivity suggests that the ionization due to the rock and soil might be containing a large quantity of radioactive elements which will emanate radon gas.

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