7. Conclusions and suggestions for future work

7.1 Overview of the studies completed

- Fairweather monthly / long term means of potential gradient, Maxwell current and Air-Earth conduction current density diurnal variations observed at Tirunelveli, a low latitude station in India and Maitri, a high latitude station in Antarctica, proved that the low latitude continental station Tirunelveli is also suitable for the measurement of atmospheric electrical parameters.

- The Passive wire antenna sensor have been designed and put in operation at Tirunelveli and Maitri, Antarctica, proves to be successful in the measurement of atmospheric potential (Electric field), which is first hand and new technique adopted.

- Mean diurnal variation of potential gradient, conduction current density and total air conductivity have been measured and analyzed for the period 1996 to 2005. Atmospheric electrical parameters were found to be largely dependent on routine meteorological parameters.

- Surface atmospheric electrical parameters were found to be sensitive to convective clouds, fog, rain and snow. The variations of electrical parameters will always be in the positive side, and goes to well in negative side at about 3 hours before the onset of a blizzard at the measuring site. Hence at high latitude station Maitri, it may perhaps be used as a tool for forecasting the onset of blizzards.
• Ohm’s Law is in good agreement with the measured atmospheric electrical parameters like current density, conductivity and electric field at Maitri during fairweather days.

• Diurnal variability of surface Conduction current, electric field and conductivity measurements on fairweather days were most likely to be dominated by global sources and follow the famous Carnegies curve with a minimum at about 4:00 UT and a maximum at about 19:00 UT.

• Separation of different atmospheric currents carried out during this course of study using the data collected with different instruments like Field mill, Passive antenna, Maxell antenna and long wire antenna at high latitude station Maitri, Antarctica.

• Influence of geomagnetic storms and sub- storms on atmospheric electricity at high latitude auroral station was studied. Different atmospheric electrical generators and their contributions to the atmospheric electrical parameters were identified and separated using mathematical techniques.

7.2 Summary and future work

The Maxwell wire antenna, Gerdian conductivity meter and passive wire antenna instruments have been proven capable of measuring the atmospheric currents, conductivity and potential respectively during this study. The absolute values of potential gradient from both the passive wire antenna, and the commercially-
purchased field mill were reliable under all atmospheric conditions, and showed high level of accuracy, resolution and thermal stability. With the different instruments for measuring different atmospheric electrical parameters, the comparison work carried out and has good correlation. Apart from the above suggested research work, modeling, and the interaction of atmospheric electricity with climate may be undertaken in near future.

A key scientific question to be answered is whether the effect of space charge (both ionic and charged aerosol) can be effectively incorporated in the vertical profile model. The departure from an otherwise fair-weather model would allow modeling of surface atmospheric electrical parameters during disturbed weather, and quantitatively investigate the influence of space charge and turbulent current density on surface potential and conduction current, allowing the observed non-Carnegie diurnal variations to be replicated. A coupled boundary layer-atmospheric electrical model that simulates convectively-driven changes to the aerosol and ionization rate profiles would allow more accurate determination of surface/columnar sources of potential gradient and conduction current variability. By modeling and compensating for these local effects, including space charge, it may be possible to retrieve global signals from polluted sites such as the Tirunelveli on a daily basis during all seasons, not just from fair-weather monthly / long term means as demonstrated by this study.

The sensors must be capable of continuous measurements of all atmospheric electrical parameters during any weather conditions. An instrument capable of continuously measuring the true total conductivity would be useful for the local meteorological studies and their influence on atmospheric electricity. With such
measurements, it would be possible to quantify the Ohmic fulfillment in terms of absolute values, not just significant correlations.

Measurement of atmospheric electrical vertical profiles (not just surface measurements) would be useful for model accuracy assessment and development, including the possibility of directly determining the columnar resistance (and therefore ionospheric potential using measured conduction current). This will be possible if inexpensive balloon-borne atmospheric electrical sensors capable of operating in the conditions except during the ascent (extreme cold, high and low humidity, cloud etc) are developed. Continuous, long term measurements of atmospheric electrical parameters at a low-pollution site would offer a useful comparison with those of the Maitri, and may serve as a reference source for “realtime” variability of the global circuit, without the need to average over several days to be confident of a Carnegie-like diurnal cycle. Using times of JC or PG correlation between two clean-air sites (preferably displaced by many degrees longitude so their local diurnal variations are not in phase) it may be possible to observe sub-diurnal variations of the global circuit. The continuation of atmospheric electrical measurements both at Tirunelveli and Maitri sites will eventually allow investigation of inter-annual and decadal changes to both local and global sources of variability; vital if the effect of climate change on the global electric circuit is to be studied. A key benefit of atmospheric electrical measurements even when they are not giving global-circuit data, is the additional insight provided into cloud and atmospheric physical processes. More investigation into the effect of local meteorological conditions on conduction current, conductivity and potential gradient will enable a more quantitative use of atmospheric electrical measurements for
meteorological research in areas such as now casting, aerosol studies, convective clouds and boundary-layer processes. Measurement of short-period (order of minutes) variability in conduction current due to the passage of convective cloud is now possible using the geometrical method, as the requirement for ~1000s measurement lag using the more traditional "matching circuit" method is not required.