Theme: ANTARCTIC GEOMAGNETISM

Project Title:

1) Storm-Substorm relationship using ground based measurements
2) Application of Global Positioning Systems (GPS) for Crustal deformation, Glaciology and Atmospheric studies

Project Summary:

The geomagnetic storm and substorm is the major mechanisms by which solar wind energy enters the earth's upper atmosphere. The field aligned currents (FAC) generated at the high latitude regions are closed through auroral electrojets and can be monitored by operating Magnetometers and Riometers at high latitudes. Substorms are a nighttime phenomena in high latitudes, through which charged particles are pushed inside the magnetosphere.

The geomagnetic storm is caused by the intensification of equatorial ring currents at a distance of several earth radii from the surface of the earth. The main phase of a geomagnetic storm is characterised by injection of energetic particles inside the magnetosphere from the distant tail region. This injection is thought to be caused by the induced electric fields that are generated during the expansion phase of the substorm (Kamide 1979, Akasofu 1968).

The magnetic data recorded at the Antarctic station can be analysed to identify the various stages of the substorms. The ground geomagnetic data recorded at the chain of magnetic observatories in India by IIG can be used to monitor the dynamics of the geomagnetic storms. Thus, the combined data from Antarctic station together with the data from the Indian magnetic observatories will be used to investigate the relationship between the storms and substorms.

Comparison of Y, X, Z variations in the magnetic field and the Riometer absorption patterns at MAI with the IMF variations and the Interplanetary solar wind parameters measured by the WIND satellite during 1999 show good agreement between the Magnetometer and the Riometer variations and the southward component of the IMF, its
intensity, the speed of the solar wind, and the ion dynamic pressure of the solar wind. Work is currently on to place these correlations on a quantitative footing.

The Proton Precession Magnetometer at MAI has indicated a drop of about 120 nT per year (as of 2003) in the Total Magnetic Field Intensity, as compared to the global average drop of 30 nT per year. Study of high-latitude stations in both northern and southern hemispheres has shown that this rapid decline is confined to a narrow horseshoe shaped belt in the Antarctic region, encompassing MAITRI. The rate of decline falls as one moves away in the poleward or the equatorward direction. GUBBINS (1989), defined these areas as ‘Regions of Reverse Magnetic Flux’ and continuous monitoring of the F value as well as efforts at modeling the decline will be useful in future.

The study of global electric circuit (GEC) provides a platform for understanding the solar-terrestrial relationship and associating changes in surface weather with the solar output. Continuous measurements of atmospheric electrical parameters, namely, the air-Earth current, the surface vertical electric field and the electrical conductivity, are considered useful in any study aiming towards understanding the near-Earth electrical environment.

The electrical measurements from Antarctica would provide an opportunity to examine the processes contributing to the generation and maintenance of the GEC, inspite of strong winds and frequent bad weather. Using the continuous measurements of atmospheric electrical parameters and the geomagnetic field variations, the problems related to the contributions from terrestrial and extraterrestrial sources to the modulation of the GEC can be addressed, namely, the interaction of solar wind with the geomagnetic field resulting in a potential drop across the polar caps, auroral effects, solar flares, solar magnetic sector boundary crossings, etc.

The satellite based navigation and surveying technique **Global Positioning System (GPS)** is a widely used tool to acquire measurements for earth sciences as well as Atmospheric sciences. As a consequence of earthquake and plate tectonics, this space geodetic technique has a major impact on the study of problems of regional and
local tectonics by making accurate measurements of the positions of point marks attached to earth. The aim of these types of observations are to determine the changes in the position of points on earths surface, determining the strain accumulation in the region, caused by seismic activities in the earths crust. Apart from this study, GPS has an important role to understand the ice shelf dynamics and the repeated GPS measurements at an interval of time helps to determine the ice velocity very precisely. Since the Antarctic Plate is enriched by divergent plate boundaries, broken by numerous large structures and Ice mass, this precise geodetic measurement can shed light on the deformation occurring in Antarctica.

GPS will also provide an opportunity to investigate many an important dynamic processes in the ionosphere, troposphere system. The main parameter involved in the modeling of the ionospheric error is the Total Electron Content (TEC). The TEC, measured in electrons per square meter, is the number of free electrons integrated along the path from the GPS receiver to the observed satellite. The estimation of TEC from GPS data will allow a detailed study of the ionosphere and will also allow the accurate determination of plasmaspheric contribution to TEC. The measurements will also be useful in the analysis of magneto-ionospheric coupling, scintillation etc. The tropospheric error is the effect of the neutral atmosphere on GPS signals. This error contains a dry and wet component. Assuming that the earth’s atmosphere is in hydrostatic equilibrium, the dry component only depends on the atmospheric pressure at the surface. For geodetics, the tropospheric effect is a disturbance that has to be removed from the measurements. But for meteorologists, this effect is an interesting signal that can give relevant information concerning the small-scale and short-term variations in the water vapor content.

Scientific Aims & Objectives:

- To find out the statistical occurrence of storms and substorms with intensification of auroral electrojet currents.
- To workout a phenomenological relationship between the strength of a storm with the strength of the strength/occurrence frequency of the substorms.
• To identify global signature in the atmospheric electrical parameters and distinguish atmospheric, ionospheric and magnetospheric signatures.

• To identify polar cap signals in the high latitude measurements and to evaluate the electrical response of the atmosphere to magnetospheric influences.

• To ascertain influences of solar magnetic sector boundary crossing and understand the underlying physical mechanisms.

• To study the Decline in Total Magnetic Field ‘F’ observed over the last few decades in southern hemisphere, especially over Antarctic continent.

• To setup 20 semi permanent stations in the Schirmarchar Oasis and rocky outcrops in the vicinity of Maitri station, to measure crustal displacement and to estimate the strain field.

• To monitor the Glacier movement to the south of Schirmarchar Oasis and to study the ice-shelf dynamics

• To study the effect of intense atmospheric disturbances on the repeatability of baseline.

• To monitor the ionospheric TEC, scintillation and tropospheric water vapor content.

Importance of the proposed project:

MAITRI is one of the very few geomagnetic observatories functioning in Antarctica and Southern Hemisphere, it will be very useful to convert it into a full–fledged Magnetic Observatory, by measuring Absolute values of H and Z, and if possible Declination and Inclination.

In view of the rapidly declining Total Field (F) (100-120 nT/yr) at MAITRI and its surroundings, it will be important to monitor the total field on a continuous basis.