CHAPTER VII

SUMMARY OF THE RESEARCH WORK AND
SCOPE OF FUTURE WORK

7.1 Introduction

The upper atmosphere has a major influence on space weather and Earth-space communications. In the early days of upper atmosphere research, ground based radio probing was the most useful technique for studying ionospheric processes. During the space era, it has become possible to measure directly solar radiations at the top of the atmosphere that are screened from reaching the surface of the Earth, to measure the structure and composition of the upper atmosphere directly with \textit{in situ} sensors, to conduct plasma experiments in space and to carry out remote sensing of the atmosphere from space. This recent dominance of space research methods in ionospheric research is becoming less marked as satellite opportunities diminish and greater emphasis is placed on studies of the ionosphere using new types of ground-based instrumentation. In this thesis, the signature of solar activity on the terrestrial environment is investigated.

7.2 Summary of the Thesis

Chapter I provide a review on solar activity, terrestrial atmosphere and various ionospheric processes. This chapter discusses in detail about sun, its different layers and various solar types of activity with in it. It also gives an elaborate view about neutral atmosphere, ionosphere and ionospheric processes in detail.

Chapter II describes the instruments and various observations used for the study. This gives detailed explanations about each instrument including ground based observations like ionosonde, HF radar and various satellites including CHAPMP, GUVI etc.
Chapter III presents an investigation on the response of equatorial and low latitude ionosphere to geomagnetic storms. A case of drastic effects of an eastward prompt penetration and a westward oversielding electric field successively affecting the daytime equatorial ionosphere during the space weather event occurred on 24 November 2001 is presented in one of the study. It discusses about the highest EEJ strength observed during the November month for the entire solar cycle and latitudinal variation of the F-region electron density, and Sporadic E using CHAMP satellite and ionosonde respectively.

Another study brings out unusual equatorial and low latitude ionospheric response to the geomagnetic disturbances of November 08 - 10, 2004. The interesting aspect that has emerged is the significant modulation of electron density in the EIA region by storm induced changes in O/N2 rather than purely by the expected disturbance induced changes in fountain effect.

Chapter IV presents an investigation of the effect of changes in solar flux during solar flare events and found that the UV flux enhancement depends on both flare intensity and its position on the solar disk while the X-ray flux enhancement depends only on the intensity. The study brings out a new result, that the E region response to flare events is directly related to the X-ray flux enhancement. Moreover, it is revealed that the E region response does not show any limb effect confirming that it is being controlled by the X-ray flux which also does not exhibit limb effect. It is also seen that the Total Electron Content (TEC) enhancement increases from equator to low latitude during summer whereas, during winter and equinoxes TEC enhancement decreases from equator to low latitudes.

The chapter V deals with the investigation of short period fluctuations in the F region vertical drift during magnetically quiet and disturbed periods and it is found that during disturbed conditions, F region vertical drift fluctuations are associated with IMF variations; whereas during quiet days it is controlled by gravity waves.

The Chapter VI presents post sunset electrodynamics of the equatorial F layer during counter electrojet days vis-à-vis normal electrojet days for magnetically quiet periods. This chapter explains how the counter electrojet related westward electric field during pre sunset hours is controlling the post sunset F region vertical drift. The
interesting observation is that, even though the magnetic field came back to the normal level before the sunset, the PRE showed a clear-cut signature of the reversed electric field.

7.3 Scope for Future work

Space weather issues are important since they affect artificial satellites and Astronauts. Each geomagnetic storm is unique in its own kind. In this thesis two storms have been analyzed using satellite data and ionosonde data. Since temporal resolution of ionosonde is 15 minute, it will be accurate if ground based instruments such as Radars having high temporal resolutions can be used for ionospheric parameter analysis. Systematic study of geomagnetic storms is necessary for the prediction of space weather events. More such storm events occurring under different conditions need to be taken up so that a more comprehensive understanding on storm time ionospheric response is arrived at. Only such an understanding will lead to full proof of space weather predictions.

Solar flare studies in this thesis utilize SOHO/GOES satellites and GPS receiver. GPS TEC data was not available for all the flare days and for all longitudes and hence the number of evens is limited in the GPS TEC related flare study. Nevertheless interesting results on ionospheric response to flare events have been obtained. The upper atmospheric neutral density response to solar flares is an interesting line of research that can be taken up in continuation of the present work. Although a few studies have been published on this aspect, a detailed study needs to be taken up so that the upper atmospheric neutral density response to flares is well understood.

This thesis utilizes multi frequency HF Radar for vertical drift measurements. HF Radar is having some limitations. Main limitations of the present radar system are (i) only three frequencies are available and (ii) the manual changing of the frequency settings. Full automation and increasing the frequency band of the radar to 2 - 7 MHz will facilitate round the clock sounding of the ionosphere and investigation of the complete picture of ionospheric plasma motion. The increase in number of frequencies also will enhance both the probing altitude and the height resolution; and hence will give better picture of plasma drift vortex and height gradients. Some data
sets used in the thesis are spread F days. So the vertical drift measurement after the
onset time of spread may not be correct. So a systematic study of $V_d$ on spread F days
may be useful for prediction of Spread F. Investigation of the role of lower
atmospheric dynamics on the upper atmosphere is also important in understanding the
behavior of upper atmosphere.