Preface

The Equatorial Ionosphere Thermosphere is a closely coupled system manifesting a variety of associated large scale processes like the Equatorial Electrojet (EEJ), the Equatorial Ionization Anomaly (EIA) and the Equatorial Spread F (ESF). The development and variability of these and various other phenomena are the result of the complex electrodynamical as well as neutral dynamical processes that operate in this region. The E-region dynamo electric field is the driving force that, together with the thermospheric winds, controls the daytime processes leading to the development of EEJ and EIA. Another manifestation of the variability in electric fields and neutral winds is the formation of an additional stratification above the F2 peak, known as the F3 layer.

The structure and the dynamics of the nighttime ionosphere are controlled by the F-region dynamo that becomes active towards the sunset hours (due to the decay of the E-region conductivity after sunset). The PreReversal Enhancement (PRE) electric field, which is the immediate result of the activation of the F-region dynamo, is responsible for the resurgence of the post sunset EIA as well as for the destabilization of the nocturnal equatorial ionosphere. The resulting development of the plasma structures is grouped under the generic name, ESF. The presence of ESF irregularities can affect the trans-ionospheric radio wave propagation involved in the use of GPS and communication satellites in space application systems. This necessitates a better prediction capability of ESF.

There are three aspects which must be addressed to, while studying the phenomena of ESF. The first one is the triggering of the primary plasma instability leading to ESF, the second one is the duration of ESF once it gets triggered and third aspect is its intensity. Both the aspect of triggering and sustenance largely depend on the background Ionosphere Thermosphere conditions. The background Ionosphere/Thermosphere conditions favoring the generation of ESF are broadly understood and parameterized, but the missing parameter in this parameterization is the nature and intensity of the density perturbations required to initiate the plasma instability. The first observational evidence, from the Indian longitude sector, for the presence of gravity wave like seed perturbations leading to the generation of ESF is presented in this thesis. The results from this study will take us one step closer towards understanding the enigmatic day-to-day variability of ESF occurrence better.

Further, the duration of ESF is found to depend on the post sunset vertical drift ($V_z$) and the magnetic activity index, $K_p$ during different seasons as well as under varying solar
activity conditions. Thus, knowing the level of $K_p$ and $V_z$, one could make a reasonable estimate of the ESF duration. Also, the duration of the L-band scintillations over the anomaly crest regions is found to depend on the ESF duration over the magnetic equator during the equinoxes of low and moderate solar activity. The study thus underlines the importance to predict the duration of ESF at the equatorial location to get a handle on the prediction of the duration of L-band scintillations over the anomaly region.

The forcings brought about by the neutral dynamical and electrodynamical coupling of the high latitude-low latitude upper atmosphere determines the response of the Equatorial Ionosphere Thermosphere System (EITS) to the enhanced geomagnetic activity. In this context, the response of the EITS to the geomagnetic storms of January and August 2005 is studied in detail through a case study approach. This study points towards the important role played by the disturbance electric fields (prompt penetration and disturbance dynamo) in modulating the electron density distribution and the generation of plasma density irregularities in the EITS. The study also highlights the importance of electrodynamics in the formation of F3 layer.

The general features of the F3 layer occurrence over the magnetic equatorial location of Trivandrum (8.5°N, 76.5°E, dip latitude 0.5°N) under varying magnetic activity levels over a solar cycle are studied. This study brings out that the F3 layer occurrence over Trivandrum is very weak and rare compared to other equatorial locations. Also, the study for the first time, reports the unusual F3 layer occurrence at dawn and dusk over Trivandrum on two magnetically disturbed days. The Sheffield University Plasmasphere Ionosphere Model (SUPIM) is used to qualitatively reproduce the observed dawn F3 layer. The upward ExB drift of the ionospheric peak estimated from the real height analysis using POLAN is used in the model calculations. The study indicates that an additional source, such as the eastward prompt penetration electric field, is favorable for distinct F3 layer to occur at Trivandrum.

The results from these investigations are presented in this thesis, comprising of seven chapters. A brief introduction to the various phenomena of the EITS is presented in Chapter 1. The experimental techniques used to probe the EITS and the methodology adopted for the analysis is described in detail in Chapter 2. The results from the studies carried out are presented in the subsequent Chapters 3-6. The summary and conclusions of the work presented in each chapter, along with the possible direction for future studies is presented in Chapter 7.