Investigations of Magnetosphere-Ionosphere-Thermosphere System Under Varying Space Weather Conditions

A THESIS

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DECLARATION

I, **Mr. Diptiranjan Rout**, S/o Mr. Ananta Charan Rout, resident of RN-014, PRL student hostel campus, Thaltej, Ahmedabad 380059, hereby declare that the research work incorporated in the present thesis entitled, **"Investigations of Magnetosphere-Ionosphere-Thermosphere System Under Varying Space Weather Conditions"** is my own work and is original. This work (in part or in full) has not been submitted to any University for the award of a Degree or a Diploma. I have properly acknowledged the material collected from secondary sources wherever required and I have run my entire thesis on the antiplagiarism software namely,"iThenticate". I solely own the responsibility for the originality of the entire content.

Date:

Diptiranjan Rout

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CERTIFICATE

I feel great pleasure in certifying that the thesis entitled, **"Investigations of Magnetosphere-Ionosphere-Thermosphere System Under Varying Space Weather Conditions"** by Mr. Diptiranjan Rout under my guidance. He has completed the following requirements as per Ph.D regulations of the University.

(a) Course work as per the university rules.

(b) Residential requirements of the university.

(c) Regularly submitted six monthly progress reports.

(d) Presented his work in the departmental committee.

(e) Published minimum of one research papers in a referred research journal.

I recommend the submission of thesis.

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Countersigned by

Head of the Department

Dedicated to

My parents

for their unconditional love and sacrifices

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ABSTRACT

The interaction between the solar wind and the Earth's magnetosphere decides the energy input into the terrestrial plasma environment and this, in turn, controls the magnetosphere-ionosphere (MI) coupling processes. The solar wind-magnetosphere interaction drives the magnetospheric plasma convection from the high to low latitude ionosphere through the prompt penetration (PP) electric field. This PP electric field modifies the ionospheric dynamo electric field, driven by tidal winds over low latitudes. Therefore, the origin, strength and efficiency of the PP electric field depend on the solar wind (interplanetary), magnetospheric and ionospheric conditions. The present thesis work comprises of various aspects of the effects of PP electric field on the global ionosphere, in general, and low latitude ionosphere, in particular.

Chapter 1 of this thesis work introduces the background physics that is required to understand the results discussed in chapters 3-6. In order to address the impacts of different types of prompt penetration electric fields on the global ionosphere, data from various measurement techniques are adopted. Further, the analyses techniques used in the investigations are also discussed in **Chapter 2**.

Chapter 3 brings out different types of prompt electric field perturbations on equatorial ionosphere during a geomagnetic storm based on coordinated digisonde and OI 630.0 nm airglow observations from Thumba (TVM). It is shown that although, traditionally, these prompt electric field perturbations are classified under one category (Disturbance-Polar current Type 2 or DP2) during long duration events, these might constitute phenomenologically different processes that include the electric field perturbations due to substorm and pseudo-breakup. In fact, for the first time, signatures of substorm and pseudo-breakup induced electric field perturbations in 630.0 nm nightglow emission intensities over equatorial region are also brought out in this chapter.

In **Chapter 4**, the responses of the global ionospheric electric field associated with the passage of the ICME sheath region have been investigated using Incoherent scatter radar measurements of Jicamarca and Arecibo along with the variations of EEJ strength over India. This investigation shows that ICME can be geoeffective in terms of PP electric field perturbations even if variation in ring current indices suggest absence of a typical geomagnetic storm.

In **Chapter 5**, a total of 43 CIR-induced geomagnetic storms during the deep solar minimum of solar cycle 23 (2006-2010) are studied. The daytime ionospheric effects are investigated by using the EEJ strength over Jicamarca as the signature of geoeffectiveness during these CIR events. It is found that PP electric field perturbations affect equatorial ionosphere when the average solar wind azimuthal angle is below 6 degree at the first Lagrangian point (L1) of the Sun-Earth system. Therefore, this result, for the first time, provides a method to forecast the geoeffectiveness of CIR events based on the observations from the L1 point.

Chapter 6 brings out a new type of PP electric field disturbance which is driven by changes in solar wind density alone. The density-driven electric field has not only enhanced the high-latitude ionospheric convection pattern but also enhanced the EEJ strength and the peak height of the F layer (hmF2) over the Indian dip equatorial sector. It is suggested that this type of electric field originates in the magnetosphere and is phenomenologically different from conventional PP electric fields.

Chapter 7 brings out the scope of the thesis.

Keywords: CME, CIR, Geomagnetic storm, Magnetospheric substorm, Pseudo-breakup, Magnetosphere-Ionosphere coupling, Prompt penetration electric field, Space weather, 630.0 nm airglow, Geoeffectiveness

LIST OF PUBLICATIONS

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