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Preface: Recent advances in equatorial, low- and mid-latitude mesosphere, thermosphere and ionosphere studies

The Mesosphere-Thermosphere-Ionosphere (MTI) is a highly coupled system characterized by several neutral and electro dynamical processes. Spatio temporal features of the MTI region exhibit high degree of variability influenced by top-down and bottom-up forcing in addition to coupling between low, mid and high latitudes. Ever increasing reliability on the space based technologies and infrastructure in day-to-day life demands comprehensive knowledge of processes happening in the near Earth space environment. Continuous monitoring of the MTI region through ground and space-based equipment is essential to understand varied phenomena happening in this region and the impacts of forcing from above and below.

This special issue was organized in the framework of the scientific session C1.1 of the COSPAR assembly held in Athens, Greece during 16–24 July 2022, to present recent developments on the MTI system studies in a single publication. Submissions were open to all scientists having appropriate contributions. Following the conventional glory of the special issues related to the C1.1 sessions during the past several years, there was an immense response with 51 submissions. A rigorous review process has been carried out with all the manuscripts evaluated by a minimum of two reviewers and 35 papers have been accepted for publication, a compilation of which is presented in this special issue.

Articles in this special issue address diverse contemporary science questions related to MTI processes including among other things mesospheric characteristics, bottom-up forcing, complex interactions between irregular structures, geomagnetic storm and sub storm induced ionospheric perturbations, and machine learning techniques to characterize the ionospheric behaviour. Results in this special issue are based on observations from ground and satellite based experiments such as: regional and global networks of GNSS receivers, MST Radar, 205 MHz VHF radar, digisondes, oblique incidence sounders, networks of magnetometers, airglow photometers, imagers and spectrographs, and satellite based observations from IMAGE, GOES, RBSP-A and B, GOCE, TIMED, FORMOSAT-5, SWARM, AIRS, INSAT-3DR, MERRA-2, and COSMIC.

This issue is divided into four sections. Section 1 describes the long-term trends in the mesosphere and vertical coupling. Middle atmosphere dynamics and coupling processes are reviewed using three decades of Indian MST radar data and future scopes in these areas are presented. Seasonal, inter annual and long-term variations of the OH* (3–1) rotational temperatures are presented based on airglow observations for more than three decades. Interactions between mesospheric bore and front, quasi two-day wave (QTDW) amplification through interhemispheric coupling, cyclone generated gravity wave and thunderstorm induced acoustic gravity wave signatures in ionospheric TEC are also presented.

Section 2 deals with the night time ionospheric irregularities and medium scale travelling ionospheric disturbances (MSTIDs). Similarities and contrasts between the low- and mid-latitude irregularities and associated vertical drift variations are presented. Simultaneous observations of MSTIDs and plasma blobs in low- and mid-latitude regions, non-interacting electrified and non-electrified MSTIDs and plasma depletions, two-dimensional interaction between multiple bands of MSTIDs, seasonal and solar activity dependence of post-midnight TEC enhancements, role of gravity wave propagation angle in triggering the ionospheric irregularities, elevation angle and frequency dependence of ROTI and S4 index are also discussed.

Effects of geomagnetic storm and substorm induced perturbations on the ionospheric dynamics are discussed in Section 3. This includes storm time equatorward/poleward movement of the equatorial ionospheric anomaly, strong undulations in the post-noon F-layer peak height over the equator due to storm time wind reversal, the onset marking of recurring substorm activations using bursts of

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Pi1B pulsations, the thermosphere temperature gradient and zonal wind increase during X-class flares and O + ion flux enhancement after substorm onset.

Various deep learning techniques proposed for estimating regional ionospheric TEC are discussed in Section 4. These techniques include: a hybrid deep learning network based on Grapy Convolution Network (GCN) and Long Short-Term Memory (LSTM), a Bi-directional Long Short-Term Memory (Bi-LSTM) method, and a Weighted Least Square (WLS) analysis during storm conditions. Random Forest Method (RFM) and Minority Oversampling Technique (SMOTE) based Super Learner (SL) are presented to detect and classify ionospheric scintillations over low latitudes. Moreover, a machine learning based methodology to detect phase scintillation index using TEC measurements from geodetic receivers is also proposed.

Composite of variety of latest datasets from different platforms addressing diverse aspects of MTI phenomena signifies the quantum and novelty of the studies presented in this issue.

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