利用GITM模擬2024年5月母親節磁暴期間熱氣層中性風場與成分變化之分析

張麗妍[1](Li-Yan, Chang) 劉天祺[1](Tien-Chi Liu) 林映岑[1,2](Cissi Ying-tsen Lin)

[1]國立中央大學 太空科學與工程學系 [2]國立中央大學 太空科學與科技研究中心

[1] Department of Space Science and Engineering, National Central University

[2]Center for Astronautical Physics and Engineering, National Central University

摘　要

本研究以2024年5月母親節極端磁暴事件為研究對象，探討磁暴期間熱氣層中性風場與大氣成分之變化。研究將採用全球電離層－熱氣層模型(Global Ionosphere – Thermosphere Model, GITM)進行數值模擬，藉此釐清在極端磁暴條件下，非靜力平衡效應對於熱氣層垂直結構變化與能量傳輸之關鍵影響，分析不同能量沉積機制。研究將分析400–600 km高度範圍內之中性風場結構、全球O/N_2比值分布，以及其與電離層全電子含量(TEC)擾動之對應關係，並探討磁暴期間高緯度能量注入向中低緯度傳輸之物理過程，了解南、北半球的不對稱物理機制。為驗證模擬結果之合理性，研究將利用觀測資料進行比對分析。研究成果將有助於理解現有經驗模型在極端太空天氣事件下的預測限制，並為修正低軌衛星軌道阻力模型及提升太空天氣預報準確度，提供具體的物理依據與參考價值。

關鍵字：磁暴、GITM、熱氣層、中性風、O/N_2、TEC、太空天氣

Abstract

This study focuses on the extreme geomagnetic storm that occurred during the Mother's Day period in May 2024 and investigates variations in thermospheric neutral winds and atmospheric composition during the storm. Numerical simulations will be conducted using the Global Ionosphere–Thermosphere Model (GITM) to clarify the critical effects of nonhydrostatic processes on changes in the vertical structure of the thermosphere and on energy transport under extreme geomagnetic storm conditions, as well as to examine different energy deposition mechanisms.

The study will analyze the structure of neutral wind fields at altitudes between 400 and 600 km, the global distribution of the O/N_2 ratio, and their relationships with disturbances in ionospheric total electron content (TEC). It will also investigate the physical processes through which energy injected at high latitudes is transported toward middle and low latitudes during geomagnetic storms, with particular emphasis on the mechanisms responsible for interhemispheric asymmetries between the Northern and Southern Hemispheres.

To evaluate the reliability of the simulation results, comparisons with observational data will be conducted. The findings of this study are expected to improve our understanding of the limitations of existing empirical models in predicting thermospheric and ionospheric responses during extreme space weather events. Furthermore, the results will provide a physics-based foundation and valuable reference for improving orbital drag models for low-Earth-orbit satellites and enhancing the accuracy of space weather forecasting.

Key words : geomagnetic storm, GITM, thermosphere, neutral wind, O/N_2, TEC, space weather