利用福衛七號電離層加值資料產品探討中低緯度電離層對磁暴效應的一致性響應

Recurrent Mid- and Low-Latitude Ionosphere Responses to Magnetic Storm Using Global Ionosphere Specification of COSMIC-2

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摘　要

本研究利用以福衛七號電離層掩星與地面接收機網觀測全電子含量基於卡爾曼濾波資料同化技術建立的全球電離層電子密度結構加值產品進行磁暴對電離層影響之研究。主要目的在探討中、低緯度電離層對於磁暴效應是否有一致性響應，並且探討此一致性響應是否有當地時間的相依性，當地時間的相依性與一致性響應可作為未來推測電離層在各種磁暴發生時間下各地電離層可能的受擾動情形。福衛七號電離層加值產品相對於目前國際上廣泛被使用的全球電離層圖有更多優勢，例如，全球電離層圖僅提供全電子含量，而加值產品卻可以提供各高度的電子密度分布，加值產品並具有較高的時空解析度，對於研究磁暴效應具有優勢，並且可以觀測到磁暴時由低緯度傳輸到中高緯度的電漿結構變化。我們基於這些優勢，利用疊加磁暴效應對於各當地時間的經度區域的影響，將2019-2022年中，15個小型磁暴、43個中大型磁暴進行疊加分析，以探討各磁暴時間相位時的中低緯度電離層響應。

關鍵字：電離層磁暴、無線電掩星、資料同化、福衛七號

Abstract

In this study, we present day-to-day variations of the ionosphere driven by the magnetic storm effects using the 3-D electron density outputs from the global ionosphere specification (GIS) built based on COSMIC-2 radio occultation observations and ground-based slant TECs. Previous studies of ionosphere responses to magnetic storms mainly using the global ionospheric maps (GIM) which is built by assuming ionosphere observations do not change much when they rotate with the Earth rotation along time. It is the assumption making ~200 ground-based GNSS stations provide sufficient data to fit to the spheric harmonic functions for the global TEC maps. However, this assumption may not be valid during storm period. Another weakness of using GIM is that the 2-D TEC maps only provide relatively coarse spatial resolutions due to sparse data from adopted ground-based GNSS receivers. On the other hand, with the global 3-D electron density output in time resolution of an hour or even shorter (20 mins) from GIS, we can re-exam the magnetic storm effects to mid- and low-latitudes. One of the important features seen by using COSMIC-GIS is the super plasma fountain effect that drives equatorial ionization anomaly to mid-latitude and further extend to high latitude through sub-auroral polarization stream (SAPS) electric field and featured by tongue of ionization (TOI) in the ionospheric with vertical structure revealed. Another important contribution from COSMIC-GIS is that it can be applied to revisit storm effects at various altitudes. In this report, an super epoch analysis is performed to study the general and recurrent ionosphere responses to the magnetic storms. We present the recurrent ionospheric storm features based on 15 minor and 43 moderate to severe magnetic storms (based on Dst) during 2019 to 2022.

Key words : Ionospheric Storm, Radio Occultation, Data Assimilation, FORMOSAT-7/COSMIC-2