SEMINAR

專題演講

國立中央大學 太空科學與工程學系

Department of Space Science and Engineering, National Central University

Time

Tuesday, October 1, 2024
7:00-8:00

Place

國鼎圖書資料館

309 教室
Room 309,
Kwoh-Ting Library and Archives complex

Thermospheric Neutral Density Data Assimilation Based on Whole Atmosphere Model

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Space weather disturbances lead to significant changes in the neutral density and have a substantial impact on the thermosphere-ionosphere system due to the interaction between neutral particles and plasma, which subsequently affect communication and navigation systems. However, we still lack the ability to reliably predict the dynamic density of the upper atmosphere. The Iterative Driver Estimation and Assimilation (IDEA) data assimilation technique was employed with the Whole Atmosphere Model (WAM) to enhance neutral density specification in the upper thermosphere. Results show that WAM ingesting the accelerometer estimates of neutral density from the Challenging Mini-Satellite Payload (CHAMP) satellite effectively captured the thermospheric neutral density at the CHAMP's altitude. Furthermore, data assimilation outputs were also validated against an independent neutral density data set from the Global Ultraviolet Imager (GUVI) limb-scan airglow observations aboard the Thermosphere Ionosphere Mesosphere Energetics and Dynamics (TIMED) satellite, and the strong agreement within 270-320 km altitude supports the use of GUVI data set in the IDEA system. An experiment was conducted in which WAM ingested GUVI-derived neutral density at 300 km, and IDEA-GUVI data assimilation outputs closely matched both GUVI and CHAMP observations throughout the storm period. Given the limited spatial and temporal coverage of satellite measurements, High Accuracy Satellite Drag Model (HASDM) empirical neutral densities are employed for robust, global-scale, and long-term data integration into the IDEA scheme. Results show that the IDEA-HASDM effectively eliminated the model bias and brought the model density into the agreement with CHAMP during the quiet time. For the future transition from a nowcasting to a forecasting system, we also experimented the IDEA with using solar and Joule heating scale factor as the estimators, allowing the model to ingest the observed solar wind drivers. Well agreement between IDEA and CHAMP shows that the two scale factors can equally be integrated in the IDEA system.

This dissertation demonstrated the utility of the IDEA scheme based on WAM during the quiet time and under the extremely disturbed condition and that using various data sources, such as neutral density estimates from accelerometers and airglow limb scan measurement and global empirical neutral density database. The improvement made to WAM can further enhance our understanding of the thermosphere-ionosphere coupling, bolster the whole atmosphere nowcasting and forecasting capability, and improve the accuracy of LEO satellite orbit determination.