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Study of Nighttime Mid-latitude E-F Coupling in Geomagnetic Conjugate Regions Using a Double-thin-shell Model and Multi-source Data

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Geomagnetic conjugate mid-latitude nighttime ionospheres are frequently simultaneously populated with electrified nighttime medium-scale traveling ionospheric disturbances (MSTIDs). Earlier observations and theoretical analysis have underscored the ionosphere E-F coupling and the postulation of coupled conjugate hemispheres, playing a pivotal role in the formation of electrified MSTIDs. Due to the limited observation area, resolution, and methods, comparing the temporal relationship between the occurrence of Es and MSTIDs is difficult, and thus the causal relationship in the E-F and interhemispheric coupling is not yet fully understood. Therefore, a comprehensive analysis of the interhemispheric coupled ionosphere is required to deepen our understanding of MSTIDs.

In this paper, the conjugate MSTIDs are studied to elucidate the causes and effects of E-F coupling in the interhemispheric coupled ionosphere. The hemisphere-coupled ionospheres over Japan and Australia are observed and analyzed using total electron content (TEC) measurements, supplemented with multi-source observations from ionosondes, ICON (neutral wind), COSMIC (electron density) and Swarm (magnetic field). The double-thin-shell model, which parameterize the integrated three-dimensional density perturbations, has proven to be an effective tool to analyze the E-F coupling [1], and was therefore introduced to analyze the ionospheric responses in E and F regions during the nighttime coupling processes. Two different event days of nighttime mid-latitude MSTIDs on 29 July 2019 and 26 December 2019, were analyzed in detail. The results and conclusions obtained from this work are listed below.

- For the first time, observation results provide the evidence that the F-region conjugate irregularities in both hemispheres are mainly driven by the Es layers in the summer hemisphere during the interhemispheric coupling process.
- The sporadic and blanketing E layers with small amplitudes in the winter hemisphere were observed to show intensity reduction or even dissipation after the interhemispheric coupling.
- Thermospheric winds play an important role in the MSTID generation and development.
- A combination of thermospheric winds and non-equipotential magnetic field lines leads to the asymmetry in the amplitude of hemispheric conjugate MSTIDs and the slower growth rate of MSTID structures in the winter hemisphere.

References

[1] W. Fu, T. Yokoyama, N. Ssessanga, M. Yamamoto, and P. Liu, "On Using a Double-thin-shell Approach and TEC Perturbation Component to Sound Night-time Mid-latitude E–F Coupling," *Earth, Planets and Space*, **74**, 83, June 2022, pp. 1–17, doi:10.1186/s40623-022-01639-w.