Project Details

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Program Element: Focused Science Topic

Topic: Causes and Consequences of Hemispherical Asymmetries in the M-I-T System

Project Title:
Hemispheric asymmetries of the electrodynamic environment in the middle and high-latitude ionosphere

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Summary:
Hemispheric asymmetries in the ionosphere arise naturally from seasonal differences in the behavior of the plasma and neutral gases and from the offset between the geomagnetic and geographic poles in each hemisphere. Hemispheric asymmetries also arise from the interaction of the geomagnetic field with the solar wind, which is dependent on the orientation of the interplanetary magnetic field with respect to the geomagnetic field. These hemispheric asymmetries appear in the plasma density and electrodynamic environment of the high and middle latitude ionosphere either directly due to changes in the ionospheric conductance and neutral winds that are dependent on solar zenith angle, or indirectly by mapping of electric potentials, modified by field-aligned potential drops, between the ionosphere and the magnetosphere.
We propose to investigate hemispheric asymmetries in the middle and high-latitude ionosphere by focusing on three main questions
1) How are hemispheric differences in the electric field and associated plasma motions in the auroral zones related to hemispheric differences in the energetic particle precipitation that influence the ionospheric conductance and indicate the presence of field-aligned potential drops?
2) How do hemispheric differences in the ionospheric conductance at middle latitudes affect the current closure associated with penetration electric fields equatorward of the auroral zone?
3) How do interhemispheric differences in the plasma convection pattern and geographical offsets in the magnetic poles combine to produce interhemispheric differences in the plasma density distribution?
Addressing these questions will require the identification of hemispheric differences in the ionosphere with respect to their connection to the equatorial plane of the magnetosphere and the condition of the external drivers and ionospheric conductance. Publicly available data from the Defense Meteorological Satellite Program will be used in this study to describe the plasma motion, the particle precipitation, and the field-aligned current density in each hemisphere. Regional measurements of total electron content (TEC) from sites distributed in mid-latitude and high-latitude regions in each hemisphere, will be utilized to illustrate the differences in the plasma density distribution. An open source magnetic field model, including nominal magnetospheric current systems, will be utilized to collocate observations along the same magnetic flux tube in the ionosphere and the equatorial plane of the magnetosphere.
Our investigation will focus on identifying systematic variations in the ionospheric potential distribution across the auroral zone in each hemisphere that are related to systematic variations in the average energy and energy flux of the precipitating particles. This will establish the degree to which interhemispheric differences in ionospheric potential distributions may be accounted for by field-aligned potential drops. We will also examine the sub-auroral penetration electric field and the TEC in each hemisphere associated with storm time evolution of the high latitude convection pattern in order to examine the influence of ionospheric conductance on the region-1 and region-2 field-aligned current systems. In addition, comparing TEC measurements in the northern and southern polar, auroral and mid-latitude regions will quantify changes in the ionospheric plasma density attributable to transport and geographical offsets with respect to the magnetic poles.
This work will provide observational insights that will advance our understanding of interhemispheric asymmetries in ionospheric electrodynamics. However, we expect that our results will be integrated with other focus team activities to provide a complete link between ionospheric asymmetries and the dynamics of the ionospheric-magnetosphere-solar wind interaction.

Publication References:

Summary: Blah

Reference: Valladares, C. E., Chen, Y.-J., Hairston, M., Chau, J. L., & Dhanya, R. (2023). Observation of scintillation enhancements and large-scale structures within the equatorial ionization anomaly during a sudden stratospheric warming event. Journal of Geophysical Research: Space Physics, 128, e2022JA030985. https://doi.org/10.1029/2022JA030985

- **Investigation Type:** Other Investigations
- Blah

Summary: Blah

Reference: Heelis, R. A., Chen, Y.-J., Depew, M. D., Harding, B. J., Immel, T. J., Wu, Y.-J., et al. (2022). Topside plasma flows in the equatorial ionosphere and their relationships to F-region winds near 250 km. Journal of Geophysical Research: Space Physics, 127, e2022JA030415. https://doi.org/10.1029/2022JA030415

- **Investigation Type:** Other Investigations
- Blah