Project Details

ROSES ID: NNH06ZDA001N
Selection Year: 2007
Program Element: Focused Science Topic

Topic: Investigate the Global Distribution, Sources and Effects of Large Electron Density Gradients at Middle and Low Latitudes

Project Title:
Modeling Large Scale Electron Density Gradients in the Low- to Mid-Latitude Ionosphere

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Summary:
A three-year program is proposed to develop a comprehensive modeling capability to study and understand the onset and evolution of large scale electron density structures in the low- to mid-latitude ionosphere. In particular we intend to address a number of critical science questions associated with this phenomenon:

- What physical processes control the spatial and temporal scales of large scale electron density gradient structures?

- What mechanisms trigger large scale density depletions? Gravity waves? Bottomside F region turbulence?

- What mechanisms suppress large scale density depletions? E region conductivity? Meridional neutral winds?

- What physical processes control the day-to-day variability of low-latitude ionospheric structures?

- What is the relation between equatorial spread F bubbles and large scale depletions that develop during storm-times?

These questions will be addressed using a newly developed two-dimensional equatorial spread F code NRLESF2 and an upgraded version of the three-dimensional NRL ionosphere model SAMI3. We will also use the coupled SAMI3/RCM model to investigate storm-time generation of large scale density gradients in the low- to mid-latitude ionosphere. To our knowledge, SAMI3 is the only comprehensive 3D ionosphere model capable of addressing the onset and evolution of large scale electron density gradients in the low- to mid-latitude ionosphere. The unique features of the code are (1) a non-orthogonal, nonuniform fixed grid that can highly resolve the post-sunset ionosphere on relevant spatial scales (e.g., 10s km zonally and few km in the altitude range 200 - 800 km), (2) a 2nd order, semi-implicit temporal scheme that can model the development of instabilities, and (3) the ability to resolve sharp gradients using a high-order spatial interpolation scheme (e.g., typically 8th order) using the distribution function method and the partial donor cell method as a flux limiter. Additionally, preliminary results from the newly developed model NRLESF2 show multiple bifurcations, secondary structure development, density `bite-outs' of over three orders of magnitude, and high speed flows within low density channels (few km/s). These results are consistent with radar observations and have not been reported in previous simulation studies of equatorial spread F.

The investigation of large scale electron density gradient structures in the low- to mid-latitude ionosphere is a Focused Science Topic in the NASA Living with a Star Targeted Research and Technology program. The proposed program directly addresses the following goals of this Focus Science Topic: (1) to develop models with the appropriate spatial and temporal resolution to simulate the relevant physical processes, and (2) to improve the characterization of the global distribution, dynamics, and lifetimes of large gradient features.

Publication References:

Summary: no summary

Reference: Huba, J. D.; Joyce, G.; Krall, J.; (2008), Three-dimensional equatorial spread F modeling, Geophysical Research Letters, Volume 35, Issue 10, CiteID L10102, doi: 10.1029/2008GL033509

Summary: no summary

Reference: Hagan, M. E.; Maute, A.; Roble, R. G.; Richmond, A. D.; Immel, T. J.; England, S. L.; (2007), Connections between deep tropical clouds and the Earth's ionosphere, Geophysical Research Letters, Volume 34, Issue 20, CiteID L20109, doi: 10.1029/2007GL030142