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Forecasting Traveling Ionospheric Disturbance Propagation with TRIDENT

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1 Extended Abstract

Traveling Ionospheric Disturbances (TIDs) are driven by forcing from above, such as geomagnetic activity, and by forcing from lower atmospheric processes below, such as gravity waves. The wide range of drivers produce TIDs with a large range of scale sizes. . Orion Space Solutions is developing a unique instrument: a next-generation HF sounding system called the Traveling Ionospheric Disturbance Evaluation Tri-wave (TRIDENT) sensor. TRIDENT is an HF sounder that measures the horizontal and vertical propagation properties of TIDs, including wavelength, azimuth, period, and phase speed (similar to its predecessor, the TID Detector Build in Texas (TIDDBIT)) [1, 2]. It is made up of six sites: two transmitting sites and four receiver sites. Many TID studies use GNSS TEC data to extract TID characteristics, but this technique only gives horizontal characteristics. Using TRIDENT, we will be able to examine vertical propagation and horizontal propagation to identify TIDs.

In anticipation of TRIDENT deployment, we are developing a regional model that uses TRIDENT observations and climatological models to predict TID propagation. The modeled temperature profiles are used to calculate the acoustic buoyancy cut-off frequencies. This information can be used to identify the type of TID such as atmospheric gravity waves or acoustic waves and the propagation mode [4]. To characterize the TIDs, we use the ND-LSP spectral analysis method on TRIDENT observations[3]. This analysis gives the TID's k-vector, which can in some cases be used to determine its source and position in the future. Gravity waves from point sources can be geometrically constrained based on the period and horizontal wavelength. To develop this region model, we are using previous data from a similar system built at Orion, TIDDBIT. To do this, we focus on events with thunderstorm-driven TIDs because these are a convenient example of TIDs from a point source. Once the TRIDENT system is deployed, we will use this model to forecast TID propagation and determine the source of observed oscillations.

References

[1] Crowley, G., and F. S. Rodrigues (2012), Characteristics of traveling ionospheric disturbances observed by the TIDDBIT sounder, Radio Sci., 47, RS0L22, doi:10.1029/2011RS004959

[2] Vadas, S. L., and Crowley, G.(2010),Sources of the traveling ionospheric disturbances observed by the ionospheric TIDDBIT sounder near Wallops Island on 30 October 2007,J. Geophys. Res.,115, A07324, doi:10.1029/2009JA015053.

[3] Hughes, J., Collett, I., Newheart, A., Kelly, R., Wilson, W. J., Obenberger, K., Landry, R., Colman, J., & Malins, J. (2024). N-dimensional Lomb Scargle Periodogram analysis of traveling ionospheric disturbances using ionosonde data. In Frontiers in Astronomy and Space Sciences (Vol. 11). Frontiers Media SA. https://doi.org/10.3389/fspas.2024.1519436

[4] Jones, R. M., & Bedard, A. J. (2018). Atmospheric gravity wave ray tracing: Ordinary and extraordinary waves. In Journal of Atmospheric and Solar-Terrestrial Physics (Vol. 179, pp. 342–357). Elsevier BV. https://doi.org/10.1016/j.jastp.2018.08.014