Detection of SuperDARN-Observed Medium Scale Traveling Ionospheric Disturbances in the Southern Hemisphere

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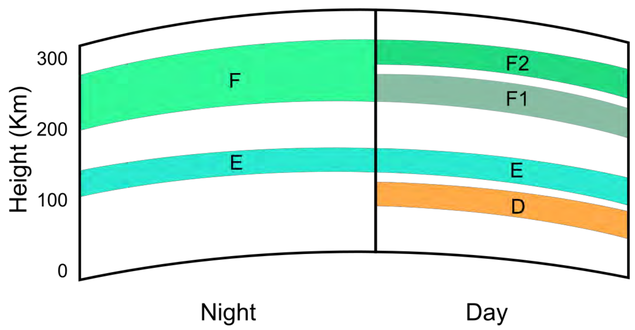
Abstract

Traveling Ionospheric Disturbances are quasi-periodic variations in the plasma that exist in the upper atmosphere and they impact the propagation of radio waves. Medium Scale Traveling Ionospheric Disturbances (MSTIDs) are defined as TIDs which travel at 100-250 m/s and have periods within the 1 hour range. Previously, most of the existing research has focused on MSTIDs in the Northern Hemisphere. This project seeks to determine whether there is enough data available to recognize seasonal trends in MSTID occurrence in the Southern Hemisphere. Currently, we have found some success in applying the PyDARN MUSIC algorithm to identify periods of high and low MSTID activity in the southern hemisphere in SuperDARN and have had success in replicating an existing study on the Falkland Islands radar. Going forward, we hope to refine the techniques which were originally used to identify MSTIDs in the Northern Hemisphere for use on the Southern Hemisphere in order to gain a better understanding of their climatology.

The Ionosphere

- The ionosphere is a region of Earth's upper atmosphere that contains a high concentration of positive ions and free electrons
- located 48 to 965 km (30 to 600 miles) above the Earth's surface
- plays a critical role in radio wave propagation
- main layers of the ionosphere are the D, E, F regions
- F regions being further divided into the F1 and F2 sections
- Electron density is dependent on the amount of ultraviolent and x-ray energy received by the sun.
- Medium (MF, 300kHz to 3 MHz) and high (HF, 3 MHz to 30MHz) frequency radio waves can be refracted back to earth by the ionosphere
- This allows for over-the-horizon (OTH) communication
- OTH communication allows amateur radio operators to communicate around the entire world



IonosphereLayers-NPS.gif: Naval Postgraduate School derivative work: Phirosiberia, CC BY-SA 3.0 , via Wikipedia Commons

SuperDARN Radar Network

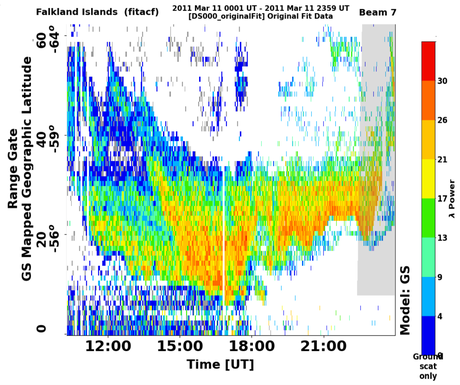
- Radars are devices which send out radio waves and listen for a return
- They have applications in scientific measurement, air traffic control, military operations, navigation, and predicting weather conditions
- Due to the ionosphere's effect on radio wave propagation one can use radar data in order to make conclusions about various ionospheric phenomena
- One network designed for measuring ionospheric conditions is the Super Dual Auroral Network (SuperDARN)
- SuperDARN radars point in the direction of the poles because that is the region where the terrestrial magnetic field lines enter/leave the Earth and associated auroral phenomena occur.
- The SuperDARN network is used by many different scientists who interested in studying the ionosphere and its connection to space and the neutral atmosphere.

Blackstone SuperDARN radar

SuperDARN Radar, Blackstone, Virginia Google Earth 2008

TIDs & MSTIDs

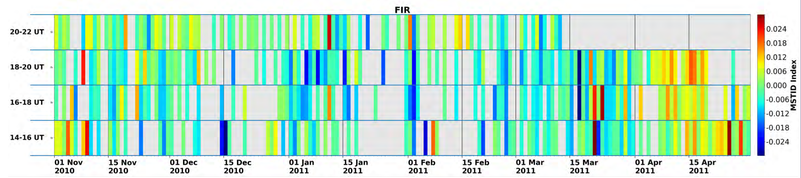
- Traveling Ionospheric Disturbances (TIDs) are quasi-periodic variations in the plasma that exists in the upper atmosphere
- TIDs have various properties like propagation speed, direction of travel and period
- Medium Scale Traveling Ionospheric Disturbances (MSTIDs) are defined as TIDs which travel at 100-250 m/s and have periods of less than an hour



Southern Hemisphere MSTIDs

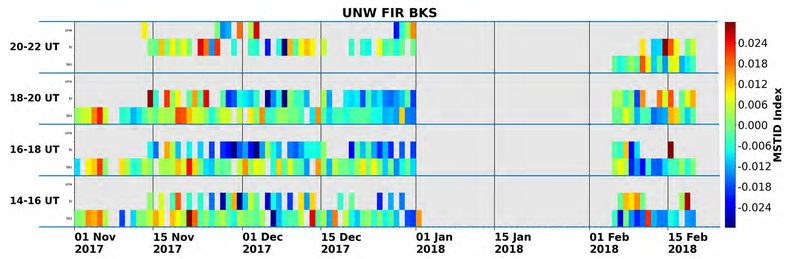
- Existing research has been successful in identifying and measuring the characteristics of MSTIDs using Falkland island radar data between 2010 and 2011 (Grocott)
- We were able to replicate the results of this study by using a different MSTID detection algorithm from (Frissell 2016)

Falkland Islands Radar Climatology Plot November 2010 – May 2011



- For the Falkland Islands radar the data for more current years is either unreliable or unavailable
- Some success is found in looking at more current radar data also using the detection algorithm from (Frissell 2016)

Climatology Plot for Unwin, Falkland Islands and Buckland Park Radar November 2017 – May 2018



References

Grocott, Adrian, et al. "Characteristics of medium-scale traveling ionospheric disturbances observed near the Antarctic Peninsula by HF radar." *Journal of Geophysical Research: Space Physics* 118.9 (2013): 5830-5841.

Frissell, N. A., et al. "Climatology of medium-scale traveling ionospheric disturbances observed by the midlatitude Blackstone SuperDARN radar." *Journal of Geophysical Research: Space Physics* 119.9 (2014): 7679-7697.

Frissell, Nathaniel A., et al. "Sources and characteristics of medium-scale traveling ionospheric disturbances observed by high-frequency radars in the North American sector." *Journal of Geophysical Research:* Space Physics 121.4 (2016): 3722-3739.

Acknowledgements

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