Factors Controlling TID Occurrence and Characteristics in Antarctic Peninsula Region

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Abstract

Ionospheric HF sounding observations made during 2015-2017 in Antarctic Peninsula region are analyzed with the emphasis on the travelling ionospheric disturbances phenomenon. Drake Passage in Antarctica generates severe tropospheric disturbances making it a good candidate for studying tropospheric-ionospheric interaction and propagation of the weather disturbances from the ground level to the ionospheric heights. Disturbances in the ionosphere also affect the propagation of the HF radio waves. By measuring the parameters of the ionospherically reflected HF signal it is possible to monitor and to measure the characteristics of TIDs. A dedicated HF sounding system was installed at Palmer and Vernadsky station in 2015 making it possible to collect significant amount of data. Wavelet analysis (i.e., continuous wavelet transform) is used to determine the presence and characteristics of the observed disturbances. The occurrence of the TIDs is directly related to the background ionospheric plasma density, which in turn is controlled by the solar terminator and also affected by the presence of the Weddell Sea Anomaly. Disturbances observed during the nighttime in the Antarctic summer are characterized by longer time periods (30-140 min) in comparison to those observed during the daytime in the winter (10-50 min). Although the observations were made during the solar minimum conditions, the number and intensity of the disturbance observations increased significantly during the geomagnetically active (Kp > 3) conditions. A comparison of the ionospheric disturbance occurrence during geomagnetically quiet times with the wavevane variations in the tropospheric parameters (ground level pressure and wind speed) and also oscillations in the geomagnetic field strength is made. Several cases with the supposed correlation between the variations detected at different regions of the Earth atmosphere are found and presented as the possible evidence of the troposphere-ionosphere-magnetosphere interaction.

TID observations in Antarctic Peninsula region

Antarctic Peninsula is the region of peculiar geophysical characteristics. Palmer station is located in high latitudes geographically ~65 deg South, but in midlatitudes geomagnetically, ~51 deg.

Bistatic HF System

- Three-channel HF receive system based on software-defined radio built and installed at Palmer Station to measure parameters of HF signals reflected from ionosphere.
- Transmitter is installed at Vernadsky station (50 km due south).
- Raw data (decimated IQ samples) shipped by sea to Boston College

System Characteristics and Diagram

- Operating frequency: 2-10 MHz
- Radiated power: < 50 W
- Operating system: Linux real-time system
- Input Rx Impedance: 50 Ohm
- Output sample rate: 100 Hz
- Equipment type: compatible standard
- Operational period: 24/7

Left panels show daily variations in the TID periods and plasma density changes over the month of August 2016. During this period the difference between daytime and nighttime plasma densities is the largest, and TIDs are concentrated in the interval of the maximum density. Note the widening of the high plasma density interval from beginning to the end of the month. The right panels show characteristic TID parameters observed from December 2015 to March 2016.

Parameter Value Comments
- Operating frequency: 2-10 MHz appropriate for the location
- Radiated power: < 50 W
- Output sample rate: 100 Hz
- Equipment type: compatible standard
- Operating system: Linux real-time system

Example of TID events presumably generated by the disturbances in the troposphere (left) and magnetosphere (right). All the plots show the full day of observations (24 hours or 1440 minutes). On Sep 10, 2016 the disturbance observed in the surface level pressure measurements (from 5 to 10 UT) corresponds to the TID event observed with the HF system, but it is not visible in the ground-based magnetic field measurements. On Sep 30, 2016 a very strong disturbance in the RMF 8z (around 10 UT) has its signature in the ground magnetic field data and ionospheric HF measurements. Note that the periods of RMF 8z and magnetic field are same, but the TID period is twice shorter.

Summary

The measured TID wavelengths and periods allow classifying them as MFTIDs. Overall the observed climatology of ionospheric disturbances in Antarctic Peninsula region vary significantly through the analyzed period and is mainly controlled by background plasma density distribution, which in turn strongly depends on the solar activity and season. During the Antarctic summer period, disturbances are present mainly during the night time and morning hours, when background plasma density is at minimum (Weddell Sea Anomaly). During the winter, the TID events are almost exclusively observed during the daytime. The periods of the TID events also significantly differ between different seasons. Summer time TIDs have much longer periods (30-140 min) compared to the winter time ones (50-90 min). This is probably also should be attributed to the higher plasma densities observed in the summer time. Geomagnetic disturbances are also shown to produce the TIDs, which typically have larger amplitudes than quiet time ones. For some events, investigating their correlation with the surface atmospheric pressure and interplanetary field makes it possible revealing their sources in the troposphere or magnetosphere.

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