Diagnostics of Ionospheric Disturbances over the Antarctic Peninsula using GNSS TEC Measurements and Coherent HF Ionospheric Sounding

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ABSTRACT

Plasma irregularities over the Antarctic Peninsula represent special interest to the ionospheric community due to several reasons. This area has been identified as a hot spot of AGW activity and is controlled by several geophysical factors. Firstly, while the Antarctic Peninsula region is at the middle geomagnetic latitudes, it is strongly influenced by the disturbances from the auroral latitudes produced by Lorentz forcing and Joule Heating. Secondly, the Antarctic Peninsula is one of the most meteorologically active (i.e. associated with cyclones, convective plumes, enhanced zonal winds, orographic waves, etc.) regions of the Earth, which makes it a very good candidate for studying tropospheric-ionospheric interaction and propagation of the weather disturbances from the ground level to the ionospheric heights. And thirdly, this area is associated with the "Weddell Sea anomaly", manifesting itself in the inversion of the summer daily trend of the electron density (maximum during the nighttime, minimum during the daytime).

At the Ukrainian Antarctic station "Akademik Vernadsky" (UAS) (U.K. Faraday base until 1996) the vertical ionospheric sounding has been carried out for more than 50 years. Routine total electron content (TEC) measurements made using L-band signals of the global navigation satellite system (GNSS) began in 2009 (permanent GPS station VNAD: 65.25º S, 64.25º W). Together with the observations from PALM (64.78º S, 64.05º W) and DUPT (64.81º S, 62.82º W) GNSS ground stations these data make it possible reconstructing characteristics of ionospheric irregularities. The parameters of the travelling ionospheric disturbances (TIDs), such as velocity and propagation direction, can be calculated using a "dynamic approach" to the problem of GNSS diagnostics of TIDs proposed by *Galushko et al.* [1]. The application of this technique to the large database of TEC measurements from these three stations makes it possible assessing the diurnal variations of the disturbance parameters and determining their characteristic features.

In January - March of 2004 trial measurements of TID parameters were performed on HF radiolink between UAS and "Ak. Arcktowski" (Poland) Antarctic stations [2]. It was shown that TID characteristics, such as period, propagation direction and velocity can be obtained

with the help of the frequency-and-angular (FAS) HF sounding technique [3]. For further study of TID characteristics a new data-acquisition system for bistatic coherent HF sounding of the ionosphere was installed in 2015. HF transmitter operating at frequencies from 2 to 6 MHz was deployed at the UAS and receiving system was deployed at the U.S. Antarctic station "Palmer" establishing approximately 53 km long radiolink. Variations of the parameters of ionospherically reflected HF signal on this quasi-vertical radio path will be used for computing TID characteristics and comparison with the measurements made using GNSS signals.

This work presents preliminary results of the diagnostics of travelling ionospheric disturbances over the Antarctic Peninsula that have been obtained with the two types of observations. The comparison of variations of Doppler frequency shifts (DFS) of the probe HF signal received at Palmer station with the dynamics of TEC variations is presented. Quasi-periodic changes associated with the propagation of TIDs are registered simultaneously in both types of data (Figure 1). The current status of the work on the reconstruction of the temporal and spatial characteristics of TIDs, aimed at establishing their diurnal and seasonal behavior patterns, and also at the identification of their origins is discussed.

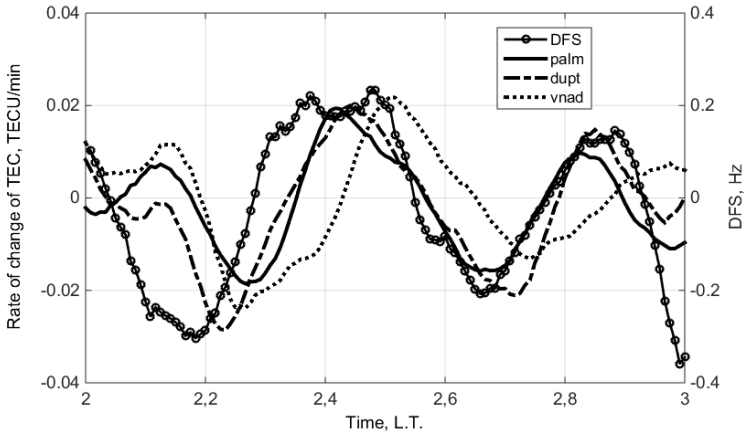

Figure 1. Variations of DFS of HF signal (frequency 4.4785 MHz) recorded at Palmer station on 2015.11.13 2:00-3:00 LT and the rate of change of detrended TEC records for GPS satellite PRN03 obtained at stations PALM, DUPT, and VNAD. Note the strikingly close periods of the variations observed with the two methods and time shift between TEC observations at different stations.

Key words: Ionosphere, GNSS diagnostic, Travelling ionospheric disturbances, Doppler frequency shift.

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