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Travelling ionospheric disturbances over Ukraine: results of three years of Doppler HF monitoring

Andriy Zalizovski*[1, 2, 3], Yuri Yampolski[1], Evgeny Mishin[4], Alexander Koloskov[1, 3], Andrii Sopin[1, 3], Sergei Kashcheyev[1], Volodymyr Lisachenko[1], Artem Reznychenko[1, 5]

(1) Institute of Radio Astronomy of NAS of Ukraine, Kharkov, Ukraine, zaliz@rian.kharkov.ua, yampol@rian.kharkov.ua, koloskov@rian.kharkov.ua, sopin@rian.kharkov.ua, kascheev@rian.kharkov.ua, lisachen@rian.kharkov.ua

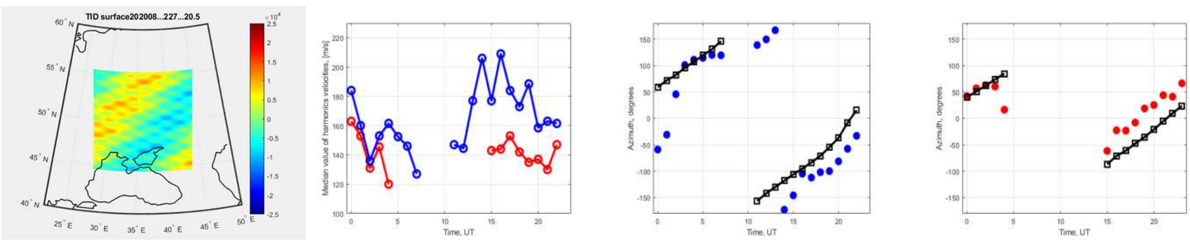
(2) Space Research Centre of Polish Academy of Sciences, Poland; e-mail: azalizovski@cbk.waw.pl

(3) National Antarctic Scientific Center of MES of Ukraine, Kyiv, Ukraine, alexander.koloskov@gmail.com

(4) Space Vehicles Directorate, Air Force Research Laboratory, Albuquerque, NM, United States, evgeny.mishin@us.af.mil

(5) National Technical University “KhPI”, Kharkiv, Ukraine, artem.reznychenko@gmail.com

Multiposition Doppler HF facility for monitoring travelling ionospheric disturbances (TID) over Ukraine is in operation since January 2018. As is well known, TID are the result of atmospheric gravity waves (AGW) propagating in the ionosphere. We report on the results of reconstruction of AGW/TID in the form of perfectly reflecting moving wave surface (Fig. 1 a) using the Doppler frequency shifts (DFS) of HF signals on quasi-vertical radio paths that measured at three spatially separated sites. We assumed that variations in surface height at three reflecting points are caused by the superposition of several harmonics of TID moving in arbitrary directions. It was also assumed that only one spatial harmonic of TID exists at each fixed frequency, which propagates in a certain fixed direction. Thus, we search for a solution as the superposition of plane waves with wave vectors calculated from cross-spectra of height variations estimated from DFS of HF signals reflected from three spatially separated points in the ionosphere. Data processing was performed on 2-hour time intervals with the time step of 1 hour. The main morphological results are as follows. The maximum in the histogram of the TID periods is observed at 30 minutes in summer and at 40 minutes in winter. The median values of the TID speed vary near 150 m/s during summer days and winter mornings, and near 160…200 m/s at winter afternoons and evenings (Fig. 1 b). In the diurnal cycle, the TID propagation direction rotates following the Sun both in winter and summer (Fig. 1 c, d). The main difference of propagation directions between winter and summer observed from 10 UT till midnight. As one can see, the TID propagation direction in winter is shifted anticlockwise from the direction on the sub-solar point, but at summer, it shifted clockwise. If the generally accepted hypothesis about the TID propagation against the wind direction were true, it is possible to estimate the dominant wind direction from TID observations. According this hypothesis, thermospheric winds at the height of observed TID in winter blow from the point delayed from the sub-solar point by several hours. At summer, winds turn and cross the direction from the hottest point. Thus, the summer winds demonstrate more geostrophic behavior. It might be explained by the relatively higher impact of horizontal temperature gradients on winds than that of ion drag at the summer time. We plan conducting a thorough analysis of these observations.



a) b) c) d)

Figure 1. a) An example of the restored TID as a moving reflecting surface for 19:30-21:30 UT 14 August 2020; b) diurnal variations of TID median speed values for summer (red) and winter (blue); c) diurnal variations of median values of TID propagation directions for Summer (blue dots); d) diurnal variations of median values of TID propagation directions for winter (red dots). Black markers and lines at the panels c)-d) show the median direction to the sub-solar point for the time of observations