PROPAGATION AND ATTENUATION OF MEDIUM SCALE TIDS IN THE IONOSPHERE, FOCUS ON 3D INVESTIGATION

Chum Jaroslav[1], Fagre Mariano[2], Podolská Kateřina[1], Rusz Jan[1], Baše Jiří[1]

[1]*Institute of Atmospheric Physics of the Czech academy of Sciences, Czech Republic,* [2]*Facultad de Ciencias Exactas y Tecnología, Universidad Nacional de Tucumán, Argentina*

Abstract:

Doppler sounding technique is suitable for monitoring of ionospheric perturbations on the time scales from ~20 s to ~60 min. A multi-point continuous Doppler sounding is currently performed in Tucumán, Argentina. Examples of ionospheric perturbations (travelling ionospheric disturbances, equatorial spread F, co-seismic disturbances and solar effects) observed by this system in Argentina are presented. Main focus is, however, on multi-point and multi-frequency observations in Czechia, Europe, which allows the 3D analysis of wave propagation. An upgrade to the multi-frequency system is anticipated in the near future in Tucumán.

Phase velocities (3D vectors) and attenuation of medium scale travelling ionospheric disturbances (TIDs) associated with gravity waves (GWs) are studied using multi-point and multi-frequency continuous Doppler sounding in the Czech Republic. The observed phase velocities of TIDs are determined from phase shifts between the signals reflecting from the ionosphere at different locations that are separated both horizontally and vertically. The reflection heights are determined from a nearby ionospheric sounder located in Průhonice. Wind-rest frame (intrinsic) velocities are calculated by subtracting the neutral wind velocities, obtained by HWM-14 wind model, from the observed GW velocities. Attenuation of TIDs/GWs with height was estimated comparing the Doppler shifts observed at different altitudes, assuming that Doppler shifts are mainly determined by wave amplitudes (oscillation velocities). A statistical analysis was performed over two one-year periods: a) from July 2014 to June 2015 representing solar maximum b) from September 2018 to August 2019 representing solar minimum.

The results show that the distribution of elevation angles of wave vectors in the wind–rest frame is significantly narrower than in the Earth frame (observed elevations). Typical periods of the analyzed GWs were 10 - 25 min, usual wavelengths 100 – 300 km and velocities 100 – 250 m/s. Diurnal and seasonal dependence of propagation directions was observed.

It is shown that the attenuation of GWs in the ionosphere increased with height. It was on average smaller at the lower heights than at higher altitudes (roughly above 200 km). This is consistent with the idea that mainly viscous damping and losses due to thermal conductivity are responsible for the attenuation. Possible values of molecular viscosity at highly rarefied air are discussed.

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