Anomalous propagation of medium scale GWs along neutral winds

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- Azimuth of medium scale gravity waves (GWs) propagation in the thermosphere/ionosphere fundamentally depends on the daytime and day of year.
- Previous studies show that the GWs mostly propagate against the predominant direction of neutral winds in the ionosphere.
- Cases of anomalous propagation of GWs along the direction of neutral winds are analyzed.

Experimental

The analysis is based on measurements by multi-point and multi-frequency Doppler sounding network. The network is located in the western part of the Czechia and consists of at least three separated transmitter-receiver pairs at each frequency. Data at two different frequencies (3.59, 4.65 MHz) from the interval 9/2018-8/2019 are used in this analysis.

Maxima of spectral intensities for each transmitter signal are evaluated to obtain Doppler shifts as a function of time. A time resolution 30 s is used. The 90 min long time intervals of Doppler shift series are band-pass filtered to the 4–50 min period range.

Gravity waves propagation velocities, directions and periods are determined by cross-correlation and slowness search analysis. [1]

The HWM14 neutral wind model is used for comparison of neutral winds with the observed phase speeds of GWs. Azimuth difference ϕ between GW horizontal wind–rest frame velocities and velocities of neutral winds was calculated. [2]

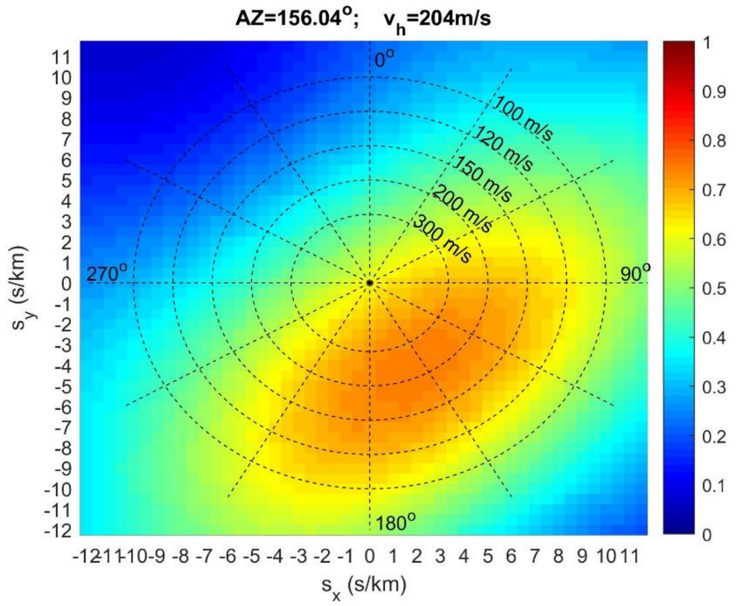

Fig. 1 Normalized energy map for various slowness components

Results

- two areas with anomalous wave propagation along the wind direction have been identified
- these cases are concentrated in the periods after the equinoxes
- both areas occurs around noon
- observed GWs periods are slightly shorter for cases with propagation along wind direction

Φ	T[min]	v_h [m/s]	v_{h0} [m/s]
< 60°	24.8	191	159
>= 60°	26.3	190	225

Tab. 1 Basic statistical values of GW parameters for group of cases with propagation along the wind (ϕ <60°) compared to the rest. T indicates the GWs period, v_h the horizontal velocity, and v_{h0} wind–rest frame horizontal velocity.

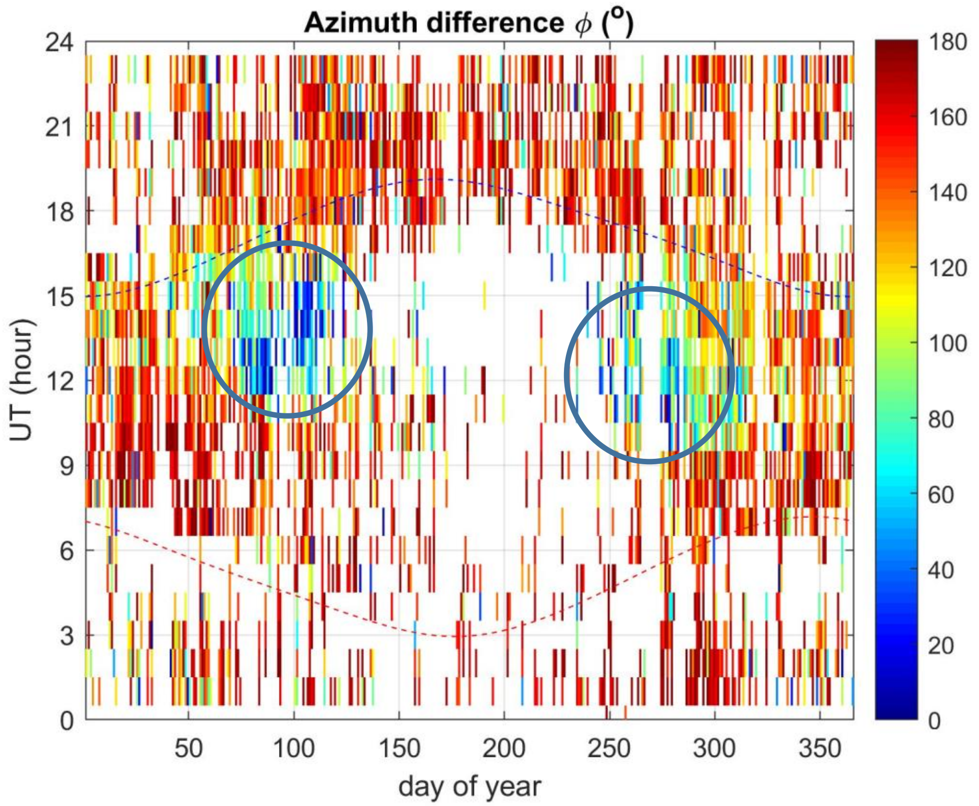

Fig. 2 Azimuth difference ϕ between GW horizontal velocities and velocities of neutral winds. Dashed lines indicate times of sunrise and sunset.

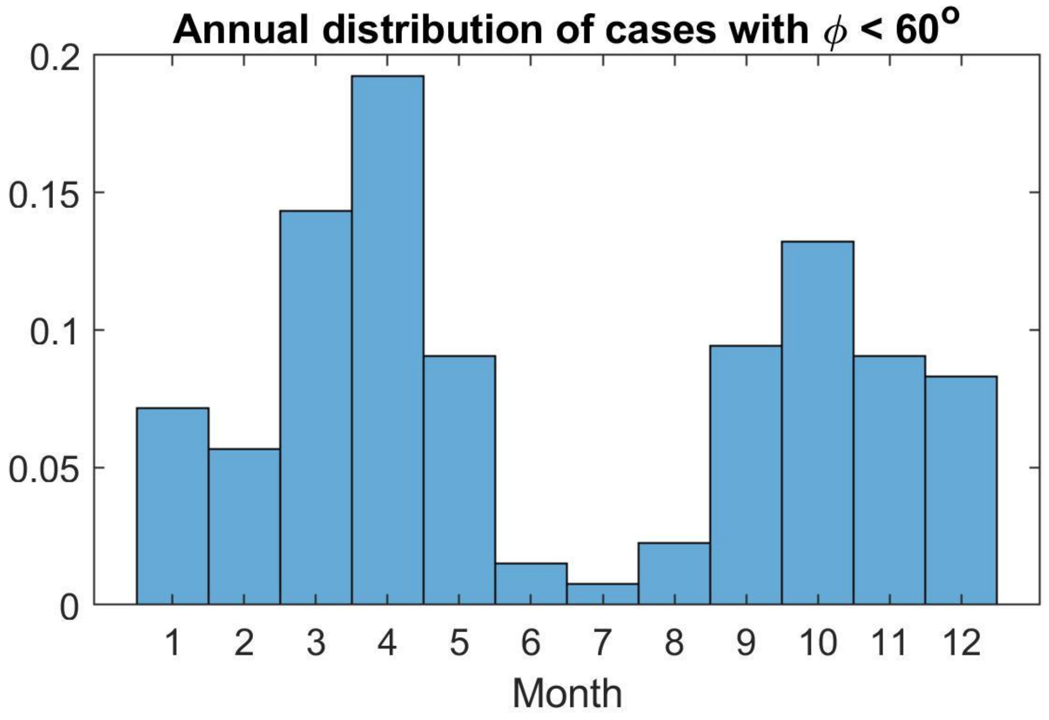

Fig. 3 Annual distribution of cases with small azimuth difference between GWs and neutral winds velocities (ϕ<60°) . The maxima occur shortly after the equinoxes.

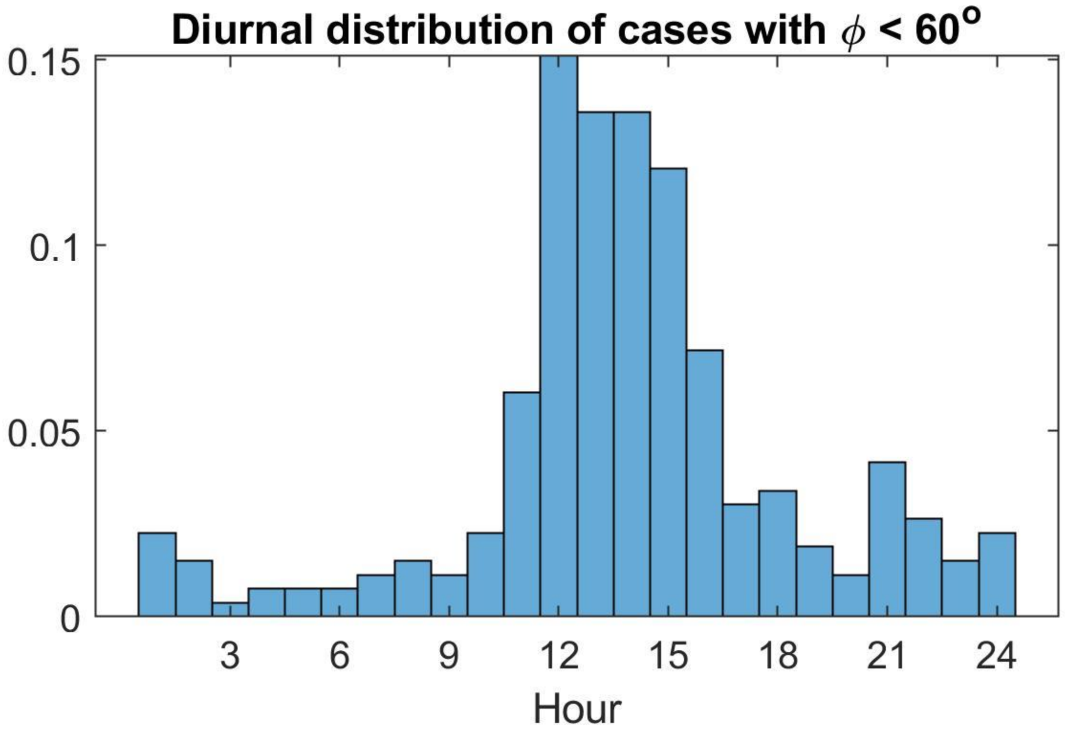

Fig. 4 Diurnal distribution of cases with small azimuth difference between GWs and neutral winds velocities (ϕ<60°) . The maximum occurs around noon.

References

[1] Chum, J., & Podolská, K. (2018). 3D analysis of GW propagation in the ionosphere*. Geophysical Research Letters, 45, 11,562–11,571.* https://doi.org/10.1029/2018GL079695

[2] Chum, J., Podolská, K., Rusz, J. *et al.* Statistical investigation of gravity wave characteristics in the ionosphere. *Earth Planets Space* 73**,** 60 (2021). https://doi.org/10.1186/s40623-021-01379-3