Statistical study of MSTIDs parameters using SuperDARN ground backscatter data

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We present statistical characteristics of medium-scale traveling ionospheric disturbances (MSTIDs) revealed from the data of two mid-latitude SuperDARN HF radars: Hokkaido (43.53N, 143.61E) and Ekaterinburg (56.42N, 58.53E). We elaborated an automated technique (Oinats et al., 2012; Oinats et al., 2013) where we used a cross-correlation analysis of minimum range corresponding to ground backscatter skip distance to determine main MSTID parameters such as azimuth, apparent horizontal velocity, period and wavelength. Datasets collected by Hokkaido and Ekaterinburg radars cover a long period from the late 2006 until 2014 and during 2013 accordingly. This allows us to study diurnal and seasonal dependences of predominant MSTIDs propagation direction as well as its solar and geomagnetic activity dependence. In addition, comparison of the results for two spatially separated radars allows us to study dependence of predominant MSTIDs propagation direction from geographic location.

For illustration, Figure 1 shows diurnal and seasonal dependences of the occurrence rate of calculated MSTID azimuth for entire operational history of SuperDARN Hokkaido radar. As one can see from Figure 1a, there are four dominant MSTID propagation directions: northeast ($\sim 35^{o}$), southeastern ($\sim 120^{o}$), southwestern ($\sim 205^{o}$), and northwest ($\sim 295^{o}$). The relative occurrence rate for these directions is two (or more) times higher than the background rate. There is a distinct diurnal dependence of the four dominant MSTID groups. Azimuths corresponding to the northeast peak are typical of the morning hours (4-6 LT). Southeast azimuths prevail in the daytime (8-13 LT). Southwest azimuths are typical mostly at night and in the evening (16-2 LT). Northwest azimuths are typical of daytime and in the evening (12-17 LT).

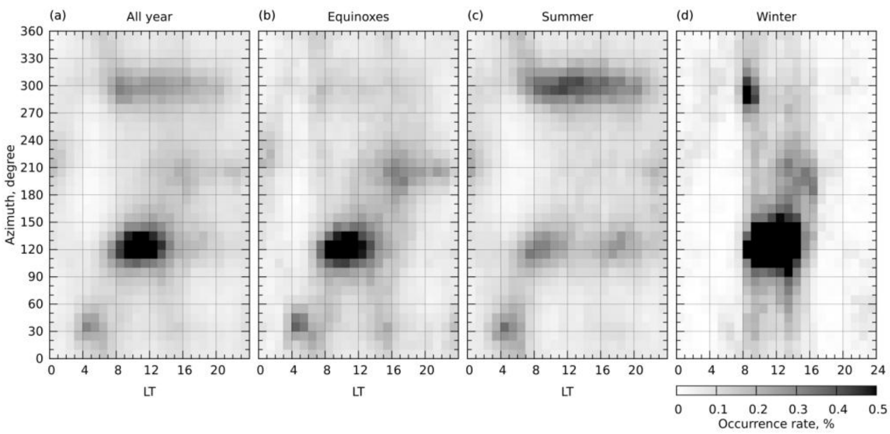

Figure 1. Local time occurrence rate of calculated TIDs azimuths calculated using SuperDARN Hokkaido radar data for 2007-2013. For entire year (a), equinoxes (b), summer (c), and winter (d).

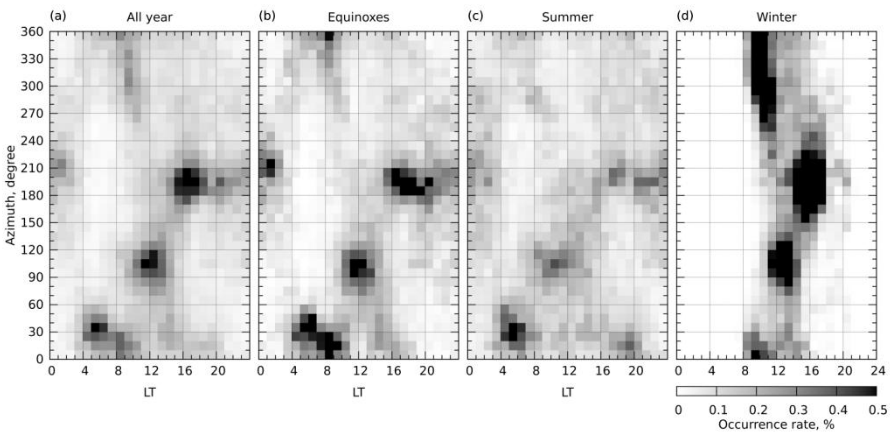

Figure 2. The same as on Figure 1 but for SuperDARN Ekaterinburg radar data for 2013.

Figures 1b-d show MSTID azimuth occurrence rate local time distributions for three seasons: equinox (March, April, September and October), summer (May, June, July and August) and winter (November, December, January and February). The daytime southward directions are most typical of winter. Nighttime southwestward are typical of summer and equinox. The morning northeastward are observed mainly in summer and equinox. The evening northwestward are typical of summer.

Obtained statistical results for SuperDARN Hokkaido radar agree well with the earlier studies by other researchers (see, for example, Kotake et al., 2007 and Otsuka et al., 2011). However, there are also several differences. According to Figure 1c, northwestward MSTIDs are typical of summer daytime. Other studies do not indicate this. Explanation of the difference requires a further investigation. The possible reason of appearing of northwestward direction during summer daytime is a mixing the E and F2 layer echoes in the Hokkaido radar data.

Figure 2 shows similar diurnal and seasonal dependences of the occurrence rate of calculated MSTID azimuth for SuperDARN Ekaterinburg radar for 2013. As we can see the distributions for two radars are very close to each other except the rate maximums for Ekaterinburg radar are shifted to lower azimuth values and to greater local time hours. Shift in local time can be explained by that fact that registration region of Hokkaido radar is located mainly to the east from the radar site in different timezone. The azimuth shift might be explained by different direction of geomagnetic field lines in the registration regions for these two radars.

The common feature for distributions for two radars is that MSTID propagation direction changes clockwise during the day from the northeast (~30^{o}) in the morning, to the southeast (~100^{o}) at 9-12 LT and to the southwest (~210^{o}) at 17 LT. This behavior was indicated earlier and is well explained by the filtering properties of the neutral wind. To check this we calculated similar occurrence rate distribution for the azimuth which is opposite to neutral wind propagation direction at heights of the HF wave reflection from the ionospheric layer using Horizontal Wind Model (HWM07). We found a good agreement between distributions for MSTID azimuth and for the azimuth which is opposite to the neutral wind propagation direction for both radars.

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