

SuperDARN Hokkaido radar observations of nighttime medium-scale traveling ionospheric disturbances and sporadic E irregularities

T. Ogawa¹, N. Nishitani¹, Y. Otsuka¹, K. Shiokawa¹, and T. Tsugawa²

¹Solar-Terrestrial Environment Laboratory, Nagoya University, 3-13 Honohara, Toyokawa, Aichi 442-8507, Japan (Email: ogawa@stelab.nagoya-u.ac.jp)

²National Institute of Information and Communications Technology, 4-2-1 Nukui-Kita, Koganei, Tokyo 184-8795, Japan

The mid-latitude SuperDARN Hokkaido HF radar at Rikubetsu in Hokkaido, Japan (43.5°N, 143.6°E; 36.5°N geomagnetic) can cover a wide area to the northeast of Hokkaido, and is very suitable for the studies of high- and mid-latitude ionospheric disturbances. In this paper, we focus on radar echoes from nighttime medium-scale traveling ionospheric disturbances (MSTIDs) in the F region and decameter-scale field-aligned irregularities (FAIs) in sporadic E (Es) layers appearing near the radar site. To investigate the MSTID and Es-FAI characteristics, HF radar data are compared with data from a 630-nm all-sky imager at Rikubetsu and GEONET (GPS Earth Observation Network), consisting of about 1200 GPS receivers distributed in Japan, that provides an ionospheric total electron content (TEC) map over Japan every 30 s.

Some features, including new ones, revealed by the Hokkaido radar, GEONET and airglow observations are as follows: (1) radar echoes from nighttime MSTIDs are mostly due to F region FAIs and partly due to ground (sea) scatter. (2) These MSTIDs, maybe generated at high-latitudes, propagate southwestward from Kamchatka at about 100 m/s and then are observed with the all-sky imager and GEONET. (3) Some MSTIDs propagate from Kamchatka to the southwest of Japan through Hokkaido over 5500 km or more. Such a feature is consistent with previous observations over Japan using GEONET and all-sky imagers. (4) The radar can also observe nighttime and daytime coherent echoes from Es-FAIs also to the northeast of Hokkaido. (5) In some cases it observes echoes simultaneously from MSTIDs in the F region and Es-FAIs. MSTID-associated echoes during the night can be closely related to Es-FAI echoes, suggesting a strong electrical coupling between the E and F regions along the geomagnetic field. The existence of such coupling has been recently found over the central Japan by means of the 46.5-MHz MU radar and all-sky imager at Shigaraki (34.9°N, 136.1°E) and GEONET. (6) Peculiar quasi-periodic (QP) echoes from nighttime Es-FAIs were first found by the MU radar. First examples of MSTID-associated QP echoes from Es-FAIs detected by the Hokkaido radar are also shown. (7) Interestingly the Hokkaido radar acts as a vertical-incidence ionosonde when very strong Es layers appear in summer. Multiple Es reflection echoes observed with the radar are strongest on the central HF radar beams (beams 6, 7, 8 and 9) having low antenna gains in the vertical.