Characterizing ionospheric irregularities with GEONET

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Ionospheric irregularities disrupt the propagation of radio waves in the frequency range below a few GHz, a band used by navigation and communication systems such as Global Navigation Satellite System (GNSS). Detailed understanding of the irregularity characteristics is helpful to estimate potential degradation of the performance of radio systems. Dense GNSS network can work as two-dimensional array to provide the spatial structure of the irregularities. With high spatial resolution vertical total electron content (VTEC), we propose a spatial fluctuation of total electron content (TEC), SFT parameter, to identify and analyze ionospheric irregularities by using the world’s densest GNSS Earth Observation Network (GEONET) of Japan. The data used in this study are carrier phase of the dual frequency GNSS signals from more than 1300 GNSS receivers of GEONET. VTEC is derived by assuming that it is identical in a grid of 0.1˚× 0.1˚ in longitude and latitude, and removing a quantity of inter-frequency hardware bias mixed with integer ambiguity. SFT is defined as the spatial dispersion of TEC within a specific area at a given time. The size of the specific area for SFT calculation is chosen as 0.8˚× 0.8˚ in longitude and latitude, which corresponds to approximately 77 km×95 km at 400 km height 35˚N of Japan. An SFT map is generated by sliding window to show the spatial variation of the ionospheric irregularities in two dimensions. The map can be used to obtain the size, shape, orientation and intensity distribution of the irregularity structures. Case studies are carried out for three strong irregularity events on 12 February 2000, 20 March 2001 and 10 November 2004. The irregularities are found to be anisotropic branching structures, which elongate in north-south direction when first seen at lower latitudes. The structures can move and deviate from their previous orientations, and eventually drift perpendicular to their orientations. Such analyses of SFT maps with GEONET observation successfully provide a new perspective of irregularity morphology and evolution.

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