R005-19
Zoom meeting C ：11/1 PM2 (15:45-18:15)
16:00〜16:15

3-D imaging of daytime mid-latitude sporadic E over Japan with ground-based GNSS data

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Sporadic-E (Es) is electron density inhomogeneities manifested in the ionospheric E-region (˜100 km), exhibiting a high correlation of occurrence with intense trans-ionospheric signal scintillation. Due to the characteristics of its thin-layer (˜2 km) and small contributions (˜1 TECU) in total electron content (TEC), the three-dimensional (3-D) imaging of Es structure is challenging. This paper presents a novel two-step computerized ionospheric tomography (CIT) technique to reconstruct the 3-D structures of mid-latitude daytime Es based on TEC measurements from ground-based Global Navigation Satellite System (GNSS). To facilitate digital CIT at a high spatiotemporal resolution, we have adopted TEC measurements from a dense receiver network, GEONET, which contains more than 1000 receivers over Japan.

In the first step, we reconstruct a more accurate F-region structure on a coarse grid, by using a multiplicative algebraic reconstruction technique (MART) from a smooth background calibrated by empirical orthogonal functions (EOFs). In the second step, on a fine grid and using singular value decomposition (SVD), the 3-D Es structure is estimated based on the residuals of electron density in the E-region covering 80˜180 km in altitude. To vertically constrain the solution, we use time-dependent EOFs generated from a Chapman model function tuned to manually scaled Es observations from a network of four ionosondes over Japan. In step-1 (step-2), the resolution is set to 1 ° (0.4 °) in horizontal, 20 km (1 km) in altitude, and 15 min (1 min) in time. Three event days of daytime sporadic-E are investigated. Results from simulation and real observations show that the technique can reconstruct Es structure with a high degree of fidelity, specifically during strong Es (foEs $>$20 MHz). From the 2-D horizontal slices at the height of maximum Es, the size, shape, and migration of this fine structure Es are obtained and found in good agreement with earlier results. The east-west (E-W) aligned frontal structures of daytime Es are observed to span over several hundred kilometers, last for ˜30 min, and migrate northwestward in the morning and southwestward in the afternoon. The simultaneous analyses of reconstructed Es and zonal wind data from MU radar, further support the Es wind shear theory: at mid-latitudes, the presence, direction, and magnitude of wind shear play a role in Es morphology. For the first time, CIT based on ground-based GNSS TEC is shown to reproduce the Es-layer altitude time variation.