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Horizontal Shapes of Daytime Mid-latitude Sporadic-E Imaged by GPS Total Electron Content Observations in Japan

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Sporadic-E (Es) is a thin densely ionized plasma patch whose occurrence is highly unpredictable. Since the discovery of Es, its two-dimensional (2-D) horizontal shape has long remained ambiguous due to the lack of appropriate observation instruments. Here in our study, 2-D imaging of mid-latitude sporadic-E (Es) is performed by using a dense array of Global Navigation Satellite System (GNSS) receivers in Japan. We used Global Positioning System (GPS) satellites and the densely distributed GNSS receiver network to conduct GPS total electron content (TEC) observations and mapped positive TEC anomalies caused by Es. We analyzed over 70 Es occurrences over Japan to reveal morphological characteristics of daytime mid-latitude Es. Their horizontal shapes are characterized by frontal structure typically elongated in the east-west (E-W) direction by ~ 100 km with the north-south (N-S) width of 10-30 km. Frontal structures are often found to include smaller-scale structures, which are quasi-periodically located plasma patches. These small-scale patches indicate the operation of shear instability, e.g., Kelvin-Helmholtz (K-H) instability, in the horizontal structuring of daytime mid-latitude Es. In addition, frontal structures are observed to migrate mainly northward in the morning and southward in the afternoon with speeds of 30-100 m/s, which may reflect the directions and velocities of neutral winds controlled by the atmospheric tides.