A coordinated observation of GPS total electron content (TEC) and space-borne interferometric synthetic aperture radar (InSAR) has been conducted to reveal both the large- and small-scale plasma structures of daytime midlatitude sporadic-E (Es) regions. Both observations are used for the direct imaging of the plasma patches. GPS-TEC observations have shown a common frontal shape of Es elongated typically in the east-west (E-W) direction, while an interferogram derived from InSAR observation reveals the small-scale (fine) structure of Es. Small-scale patches are aligned in the E-W direction which is the same azimuthal direction of dominant large-scale frontal structure. We speculate that the Kelvin-Helmholtz instability with the vertical shear of meridional winds is considered to be the most likely candidate for the generation mechanism of the small-scale plasma patches aligned in the zonal direction.

**Method**

**Summary**

**Slant TEC**

**Fig. 1** Slant TEC time series (observed / model). Es leaves peculiar signature of pulse-like positive TEC enhancement in the slant TEC time series. By analyzing the slant TEC time series with the corresponding GPS data, small-scale structures can also be inferred with GPS-TEC observation.

**Vertical TEC anomaly**

**Fine Image 1**

**Rough Image**

**Fig. 3** Vertical TEC anomaly map at 01:44 UT derived from GPS Satellite 18 when ALOS acquired the SAR image (red framed region). ALOS was on a descending orbit and observed Es looking from the right side. Vertical TEC anomaly map shows a large-scale frontal structure which elongates over 250 km in the ENE-WSW direction. The SAR observation area corresponds to the eastern part of the frontal structure.

**Fig. 4** Interferogram derived from ALOS/PALSAR data (Path-frame: 32-220-2390). The phase changes are shown as slant range changes in centimeter. Beginning with pale blue, the color changes into purple and into yellow represent positive and negative slant range changes, respectively. In an enlarged image in (a), (i) a frontal patch (pointed by a slant arrow) and (ii) a chain of disc-shaped patches (pointed by short black arrows) are clearly seen.

**Discussion**

**Gradient-gravity instability**

In the present case, two plasma structures, i.e., the frontal patch and disc-shaped patches, are considered to be generated at the two nodes of K-H billows under the condition that the Richardson number is larger than 0.25, making the neutral atmosphere unstable to the K-H instability. Since the axes of K-H billows are perpendicular to the shear direction, two structures which are aligned in the ENE-WSW direction are suggested to be caused by a wind shear in the NNW-SSE direction. Thus the K-H instability with the vertical shear of meridional winds is considered to cause ion perturbations in the neutral atmosphere, forming two K-H billows aligned in the zonal direction.

Here’s the reference:


Acknowledgments

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