

Study of ionospheric irregularity in the midlatitude E- and F-regions
with rocket and radar observations in Japan

Mamoru Yamamoto

Research Institute for Sustainable Humanosphere (RISH)

Kyoto University

Uji, Kyoto 611-011, Japan

We have studied field-aligned irregularities (FAIs) in the mid-latitude ionosphere with rocket and radar experiments. From MU radar observations, we found quasi-periodic (QP) structures in the E-region FAIs. The FAIs in the F-region were also found that they have wavelike structures called “plumes”. Activities of FAIs in both regions are known high in summer nighttime. However, periodicities of the QP echoes are in the range of 5—10 minutes while those of the F-region FAIs are longer. We have conducted experiments in Japan in order to reveal generation mechanism of these phenomena, and interactions between them.

For the mechanism of the QP echoes and associated behavior of the nighttime sporadic-E (Es) layers, we have conducted observation campaign SEEK (Sporadic-E Experiment over Kyushu) for two times; the first (SEEK-1) in 1996 and the second (SEEK-2) in 2002. The campaigns were conducted over Kyushu (southern part of Japan) with four (two for each) sounding rockets and network of ground-based observations, i.e., radars and optical instruments. From SEEK-1 and SEEK-2, we confirmed that the QP echoes are associated with Es layers at around 105 km. Accumulation of the Es-layer plasma is well explained by the shear of the neutral wind. Spatial modulations of the Es layers are enhanced by the motion of the neutral atmosphere, and then QP echoes start to appear. Wind-driven FAI mechanism is effective at both upper and lower sides of the Es layers. Spatial inhomogeneity of the Es layers induces polarization electric field that can reach 5—10 mV m⁻¹. Plasma density in the upper E-region is modulated by the polarization electric field. We found that the QP echoes are the phenomenon that reflects coupling processes between the E-region plasma and the neutral atmosphere.

The intense polarization electric field induced in the E-region can easily map to the F-region along the geomagnetic field. Electromagnetic coupling between E- and F-region ionosphere became the next research topic. In 2004, we conducted an observation campaign named FERIX (F- and E-Region Ionosphere Coupling Study). We located a portable VHF radar in north of Japan for observations of the E-region FAIs. From the MU radar we simultaneously observed F-region FAIs. FAI echoes in E- and F-regions appeared in the areas that were well connected by the geomagnetic field, and showed similar motion to the southwest. We found the first clear evidence that FAIs in both regions are closely coupled in the midlatitude.