Coupling Study of Mid-latitude *E*- and *F*-region Irregularities over Japan

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Various types of plasma instabilities have been studied in the mid-latitude ionosphere *E*- and *F*-region. Field Aligned Irregularities (FAIs) in both regions is one of them. The *E*-region FAI (E-FAI) is caused by the polarization electric field in the electronic density perturbation of the Sporadic *E* layer. The *F*-region FAI (F-FAI) is generated by the polarization electric field at the wall of the Traveling Ionosphere Disturbances (TID). In the ionosphere, conductance parallel to the geomagnetic filed is so high that such polarization electric fields are easily mapped along the field line for several hundred kilometers. Because of these characteristics, electromagnetic coupling is expected between the *E*- and *F*-region. We studied ionospheric *E*- and *F*-region coupling process from the FERIX (*F*- and *E*- Region Ionosphere Coupling Study) campaign in 2004, and from statistical comparison of radar observation of E-FAI and the GPS-TEC perturbation over Shigaraki in 2005.

During the FERIX campaign, we used the MU radar and LTPR (Lower Thermosphere Profiler Radar) located in Sakata, Yamagata for simultaneous observations of *F*- and *E*-region FAIs, respectively (Fig. 1). We successfully found the coupling of E-FAI and F-FAI that occurred along the same magnetic field lines (Fig.2). The horizontal structures of E-FAI, F-FAI and TID are all aligned from northwest to southeast, and propagated to the west at the same speed. From the statistical analysis, the coupling was often detected when the TID had a northwest-southeast wavefront structure.

From these results, we found several direct evidences of electromagnetic coupling between the *E*- and the *F*-regions. When the coupling is observed, northwest-southeast aligned structures were often seen in both regions. This is consistent with the theoretical study by Cosgrove *et al.* [2004]. On the other hand, when the *E*- and *F*-regions don't couple, the QP structures of E-FAI seem to occur only by the gravity wave or Kelvin-Helmholtz instability in the neutral atmosphere.

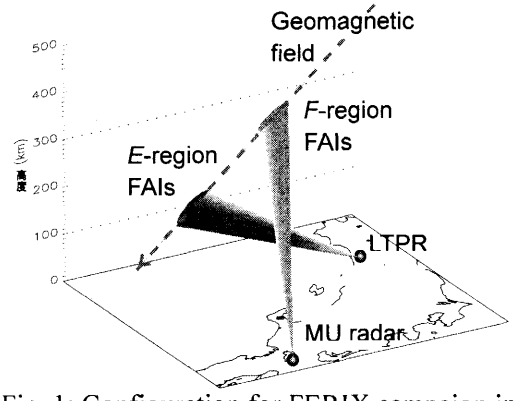

Fig. 1: Configuration for FERIX campaign in 2004. The MU radar and LTPR observe F- and E-region FAI echoes, respectively, along the same geomagnetic field line.

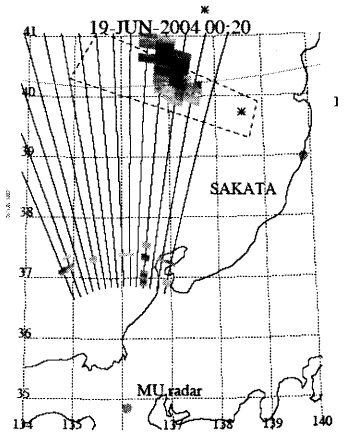

Fig. 2: Horizontal distribution of echoed from F-FAI (shade) and E-FAI (dots). F-FAI echoes are mapped down to 100km altitude along the geomagnetic field.

REFERENCE

Cosgrove, R. B., R. T. Tsunoda, S. Fukao and M. Yamamoto, Coupling of the Perkins instability and the sporadic E layer instability derived from physical arguments, J. Geophys. Res., 109, A06301, doi:10.1029/2003JA010295, 2004.