Study of electromagnetic coupling of midlatitude ionosphere *E* and *F* regions with VHF radars and GPS-TEC observations

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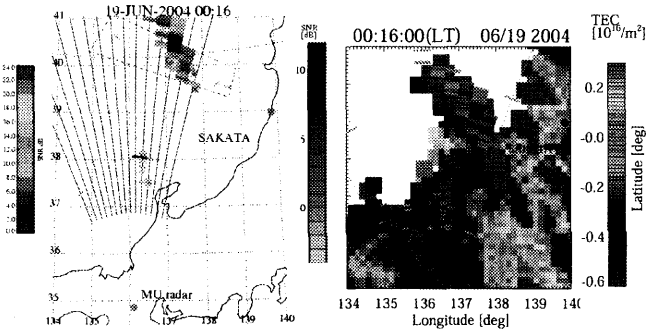
Various types of plasma instabilities have been studied in the mid-latitude ionosphere *E*- and *F*-region. FAIs (Field Aligned Irregularities) in both regions is one of them. The *E*-region FAIs (*E*-FAIs) are assumed to be caused by the polarization electric field in the electronic density perturbation of the *Es* layer. The *F*-region FAIs (*F*-FAIs) are thought to be generated by the polarization electric field at the wall of the TIDs (Traveling Ionosphere Disturbances). 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 the *F*-region. In this research, we discussed such *E-F* coupling process from the results of FERIX (*F*- and *E*-Region Ionosphere Coupling Study) campaign in 2004 and statistical comparison of radar observation of *E*-FAIs and the GPS-TEC perturbation over Shigaraki in 2005.

During the FERIX campaign, using the MU radar for *F*-FAIs observation and LTPR (Lower Thermosphere Profiler Radar) for *E*-FAIs observation, we succeeded to observe the coupling of *E*-FAIs and *F*-FAIs that occurred simultaneously along the same magnetic field lines. We also found that the horizontal structures of *E*-FAIs, *F*-FAIs and TIDs are all aligned from northwest to southeast, and propagated to the west at the same speed. Fig1 is a significant example of such result. Fig1(a) shows the comparison of *E*-FAIs (color dot) and *F*-FAIs (gray contour). The spatial structures of *E*-FAIs were determined by the LTPR interferometry and those of *F*-FAIs were determined by the 16 beams observation technique of the MU radar. The coordinates of *F*-FAIs were arranged from altitude 300km to 100km along the field line in order to compare with *E*-FAIs. Fig1(b) shows the comparison of *F*-FAIs and perturbation TEC (color contour), both of which were arranged to altitude 300 km. At that time, we can see all structures are aligned NW to SE.



(a) (b)

Fig1

During the continuous observation in 2005, data from the experiment were compared with GPS-TEC data from the GEONET for statistical study for the *E*- and *F*-region coupling processes. At first, we determined the position where the *E*-FAIs echoes were often observed with LTPR, and mapped them to the *F*-region (300 km altitude) along the field line. Perturbation of the GPS-TEC (pTEC) at that point was compared with *E*-FAIs activity determined from the LTPR echo power. Within 64 samples, in 34 cases, there were clear correlations between the *E*-FAIs occurrence and large fluctuation of pTEC. Fig2 is a typical example of clear correlation. We investigated the *F*-region plasma structure such as azimuth-dependent structure of MSTIDs (Medium-Scale Traveling Ionospheric Disturbance) of such case. The result showed that the angle distribution of pTEC horizontal structure for the case had a prominent angle distribution of about -50 to –20 (Fig3). We discussed that this shows developed MSTIDs exist when *E*- and *F*-region coupling occurred.

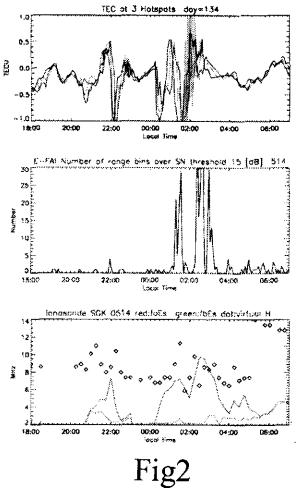


Fig2

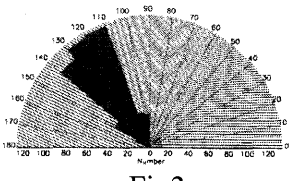


Fig3

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.