THREE-DIMENSIONAL SIMULATION OF THE COUPLED PERKINS AND ES LAYER INSTABILITIES IN THE NIGHTTIME MIDLATITUDE IONOSPHERE

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Plasma density structures and associated irregularities in the nighttime midlatitude ionosphere are frequently observed as frontal structures elongated from northwest to southeast (NW-SE) in the northern hemisphere. The frontal structures and the coupling process between the E and F regions are studied with a three-dimensional numerical model which can simulate two instability mechanisms: Perkins instability in the F region and sporadic-E (Es)-layer instability in the E region. The fastest growth of the coupled instability occurs when the unstable conditions on NW-SE perturbation are satisfied in both regions. The perturbation of F-region integrated conductivity grows much faster than the isolated Perkins instability. The meridional component of a rotational wind shear blows an existing Es layer southward, and the F-region structure follows the E-region drift velocity. NW-SE structure in the E region can be formed from random perturbation regardless of the F-region condition. When the F region is unstable on the NW-SE perturbation, however, the NW-SE structure is formed in both regions with a common scale length. We conclude that (1) the Es-layer instability plays a major role in seeding NW-SE structure in the F region, and the Perkins instability is required to amplify its perturbation, (2) the rotational wind shear in the E region produces southwestward phase propagation of the NW-SE structure in both the E and F regions, and (3) the coupling process has a significant effect on the scale of the Es-layer perturbation rather than the growth rate of the Es-layer instability.

MSTID, QP echoes, Perkins instability

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