Three-Dimensional Nonlinear Simulations of the Gradient Drift Instability in the High-Latitude Ionosphere

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ABSTRACT. Nonlinear three-dimensional (3-D) simulations of the gradient drift instability (GDI) are presented for a two-dimensional equilibrium density gradient representing a polar cap plasma patch. The overall evolution of structuring of the plasma patch is influenced markedly by the effects caused by dynamics parallel to the geomagnetic field. The long wavelengths ($kL_n \leq 1$) are strongly stabilized in the 3-D case, and the nonlinear state is dominated by smaller mesoscales ($kL_n \gg 1$) (where k and L_n are the mode number and density gradient scale length, respectively). The results provide an interpretation to the observations at the high-latitude ionosphere indicating a generation of mesoscale irregularities associated with the polar cap patches when the interplanetary magnetic field (IMF) B_z is southward and antisunward convection prevails over the polar cap. The polar cap patches are observed to convect to large distances ($\sim$3000 km) undergoing structuring while maintaining their distinct identity. Thus we suggest here that the inclusion of three-dimensional effects is key to a successful interpretation of high-latitude irregularities, as well as a prerequisite for a credible simulation of these processes.

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