Farley-Buneman Turbulence in 3D

Meers M. Oppenheim[(1)], Yakov S. Dimant[(1)], and Lars P. Dyrud[(2)]
(1) Center for Space Physics, Boston University, 725 Commonwealth Ave., Boston, MA, 02215, USA
(2) Center for Remote Sensing, Fairfax, VA, USA

In the E-region ionosphere, turbulent processes driven by strong ambient DC electric fields create plasma density irregularities responsible for type 1 radar echoes. These irregularities affect ionospheric conductivity, temperatures, and radio wave propagation and reflectivity. As a result they have been studied experimentally and theoretically for five decades. In the last decade, numerical simulations became an important tool in exploring the nonlinear behavior of E-region instabilities. However, these simulations were limited to 2-D and meshes resolving typically around 4096 (64x64) cells. Having improved the method of parallel processing of our Particle-In-Cell (PIC) code, EPPIC, we can now take advantage of supercomputers with thousands of processors to run simulations with enormous meshes in 2-D or 3-D (up to 8092x8092 in 2D or 512x512x512 in 3-D).

In this talk we will discuss, some recent 3D simulations showing the saturated amplitude of the waves; wave heating due to turbulence; coupling between linearly growing modes and damped modes; the evolution of the system from dominance by shorter (1m-5m) to longer (10m-80m) wavelength modes; and the propagation of the dominant modes at phase velocities that lie below the linearly predicted phase velocity and close to but slightly above the acoustic velocity. These simulations reproduce many of the observational characteristics of type 1 waves. As predicted by theory, these 3-D simulations show the development of modes with a small component parallel to the geomagnetic field. Nevertheless, 2-D and 3-D runs develop similar spectral features. We also can quantify the 3-D wave-driven electron heating, a phenomena clearly observed by radars. These simulations provide information useful in accurately modeling FB turbulence and demonstrate the significant progress we have made simulating the electrojet.