MAGNETOSPHERE-IONOSPHERE COUPLING THROUGH PLASMA TURBULENCE AT HIGH-LATITUDE E-REGION ELECTROJET

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During periods of intense geomagnetic activity, electric currents penetrate from the Magnetosphere into the high-latitude Ionosphere where they close and dissipate a significant fraction of their energy. At the F-region ionosphere, strong electric fields mapped from the Magnetosphere cause cross-field plasma convection. At the E region, where electrons are magnetized while ions are demagnetized due to frequent collisions with the neutral atmosphere, strong electric fields form electrojets and excite plasma instabilities. These instabilities give rise to plasma density turbulence coupled to electrostatic field fluctuations. Plasma density turbulence induces nonlinear DC currents, while electrostatic field fluctuations often result in strong anomalous electron heating (AEH) observed by radars. The two coupled effects can modify the global ionospheric conductances, which is of importance for predictive modeling of Space Weather. Global MHD codes currently developed for such modeling use ionospheric conductances as their inner boundary conditions. These codes, however, often overestimate the values of cross-polar cap potentials. A possible reason is that the model conductances employed do not take into account the effects of E-region plasma instabilities. We argue that these effects are important and can explain the discrepancies.

In this talk, we will present results of our recent theoretical efforts of global energy flow, along with results of 2D and 3D fully kinetic, particle-in-cell (PIC), massively-parallel computer simulations. Theoretical analysis shows that the energy deposited to Ionosphere to excite plasma instabilities and anomalously heat plasma is provided by the work of the magnetospheric electric field on the nonlinear current. Our PIC simulations reproduce many of the observational characteristics of radar signals and provide information useful to accurately modeling plasma turbulence. As predicted by theory, the 3D simulations show the development of waves with a small component of the turbulent electric field parallel to the geomagnetic field. The parallel component is largely responsible for AEH. Comparison of results of the 2D and 3D simulations with the equal plasma parameters clearly shows the effect of AEH, as well as formation of strong nonlinear DC currents. Using these simulations along with the theoretical analysis allows one to quantify the effects of anomalous conductances and incorporate them in future global codes for more accurate predictions of Space Weather.