Discrete Auroral Arcs Generated by Ionospheric Feedback Instability

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Currently, the hypothesis that discrete auroral arcs are produced by fluxes of magnetospheric electrons accelerated along the ambient magnetic field into the ionosphere by linear/non-linear mechanisms associated with magnetic field-aligned currents (FACs) carried by ultra-low-frequency (ULF) Alfvén waves is confirmed by a large number of experimental and theoretical works. This correlation arises from the fact that dispersive Alfvén waves have a component of the electric field parallel to the ambient magnetic field. This field can accelerate electrons into the ionosphere and produce some types of the discrete aurora. Two main questions studies of ULF waves and the discrete aurora seek to answer are: 1) What physical mechanism(s) generates the ULF waves? 2) What parameters of the coupled magnetosphere-ionosphere system define frequency, dynamics, and spatial structure of these waves? Ionospheric Feedback instability (IFI) is one of the most self-consistent physic models that aims to answer these two questions. The basic idea of IFI is that ULF waves can be generated due to the active interaction between FAC and ionospheric plasma under some favorable conditions, for example, large electric field and low plasma density in the ionosphere.

Our study uses a newly developed three-dimensional MHD model to investigate the discrete auroral arcs generated by IFI. The effects of Hall conductivity, convective nonlinearity in both ionosphere and magnetic field on the dynamics of discrete auroral arcs are studies through this model. It is found that our model can explain formation and spatial scales of homogeneous discrete auroral arcs, large-scale auroral folds, and small-scale curls in active aurora. Furthermore, the simulation results from the model successfully reproduce discrete auroral arcs with homogeneous/inhomogeneous structures. These numerical results are in good agreement with observed data during the substorm event on October 29 2008 in Alaska.