

Ionospheric Feedback Instability in the Alfvén Resonator at High Latitudes: 3D Modeling

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We present results from a numerical study of physical processes responsible for the generation of small-scale, intense electromagnetic structures in the ultra-low-frequency range frequently observed in the close vicinity of bright discrete auroral arcs. In particular, our research is focused on the role of the ionosphere in generating these structures. A significant body of observations demonstrate that small-scale electromagnetic waves with frequencies below 1 Hz are detected at high latitudes where the large-scale, downward magnetic field-aligned current (FAC) interact with the ionosphere. Some theoretical studies suggest that these waves can be generated by the ionospheric feedback instability (IFI) inside the ionospheric Alfvén resonator (IAR). The ionospheric feedback instability occurs when the magnetic field-aligned currents change the conductivity in the ionosphere by precipitating and removing electrons from it and the variations in the conductivity positively “feed back” on the structure and amplitude of the FACs increasing their magnitude. The ionospheric Alfvén resonator is the region in the low-altitude magnetosphere bounded by the strong gradient in the Alfvén speed at high altitude and the conducting bottom of the ionosphere (ionospheric E-region) at low altitude.

To study ULF waves in this region we use a numerical three dimensional model developed from reduced two-fluid MHD equations describing shear Alfvén waves in the ionosphere and magnetosphere of the earth. The active ionospheric feedback on structure and amplitude of magnetic FACs that interact with the ionosphere is implemented through the two dimensional ionospheric boundary conditions. These boundary conditions include the effects of both the Pederson and Hall conductivities, and link the parallel current density with the plasma density and the perpendicular electric field in the ionosphere. Simulations show a good agreement with the observed data, and suggest that both IAR and IFI plays important role in the electromagnetic coupling between the ionosphere and magnetosphere at high latitudes.