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The ionospheric feedback instability in a collisional height-resolved ionosphere

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The ionospheric feedback instability (IFI) is often considered as a mechanism for the generation and amplification of inertial scale Alfven waves at high latitudes. The significance of these waves is that they contain parallel electric fields large enough to accelerate electrons to energies that can produce aurora and ion outflow observed by numerous satellites and rockets. Free energy for the IFI is available in the form of large scale convection electric fields and/or transverse electric fields of Alfven waves incident on the ionosphere. Standing waves that have been observed and attributed to the IFI have boundaries defined by the bottom layer of the ionosphere and an altitude that may extend to the Alfven speed maximum at approximately 1 Earth radii. These waves have frequencies on the order of Hz and carry field-aligned currents that interact with and close through the E-region ionosphere. In spite of four decades of research, conclusions about the IFI remain based on an E-layer that is represented by an unrealistic height-integrated conducting boundary. In this presentation, a 2D numerical model of the IFI is considered that resolves the vertical structure of the ionosphere for altitudes above 100 km. The model includes realistic plasma, neutral, and temperature profiles, and accounts for an externally applied transverse convection electric field. Using the model, it is demonstrated that the IFI is completely suppressed by collisions with neutrals when the E-layer is resolved. Wave currents entering the ionosphere are found to follow a complex closed path through the E-layer rather than being aligned along the geomagnetic field, as predicted when a height-integrated boundary condition is used. Initially vertical current structures become non-uniformly stretched in the transverse direction because of vertical shear in the transverse ion flow velocity through the E-layer. This leads to suppression of the IFI. The simulation results show that in oder to accurately model the IFI making use of a height-integrated boundary, the thickness of the plasma slab used to calculate the boundary parameters should not exceed the transverse spatial scale of interest. For the IAR at Earth, this translates to a few hundred meters, which is two orders of magnitude smaller than the E-layer thickness. The significance of the results of the study presented is discussed in the context of satellite observations of waves attributed to the IFI. Potential relevance to other planetary magnetospheres is also discussed.