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Equatorial electron acceleration and transport towards the inner magnetosphere by impulsive electric fields

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Although injections have long been studied observationally and via simulations, until recently those studies have been focused at geosynchronous orbit because of the plethora of satellites located there. These spatially limited observations led to the concept of an azimuthally wide injection boundary corresponding to the large-scale collapse of the magnetic field (dipolarization) and a particle source region near the inner edge of the plasma sheet. Recent observations, however, have demonstrated that particle acceleration occurs along with narrow, transient bursty bulk flows and dipolarization fronts farther downtail, suggesting an acceleration mechanism that can bring particles in from larger distances through a narrow slot in MLT. To understand the role of the transient electric fields associated with magnetotail fast flows on electron acceleration, we built an analytic model of particle guiding-center motion in prescribed electric fields to provide a realistic means of impulsively accelerating particles, opening up their Alfvén layers locally to transport plasma towards the inner magnetosphere. Representing the vortical nature of an earthward traveling flow burst, a localized, westward-directed transient electric field flanked on either side by eastward fields related to tailward flow is superimposed on a nominal steady-state electric field. We simulate particle spectra observed at multiple THEMIS spacecraft located throughout the magnetotail and fit the modeled spectra to observations, thus constraining properties of the electric field model. We find that a simple potential electric field model is capable of explaining the presence and properties of both geosynchronous and trans-geosynchronous ($L>6.6$) altitude injections. In particular, such a model can adequately describe the physics of both dispersed injections and depletions in energy flux in terms of convective fields associated with earthward flow channels and their return flow. The transient (impulsive), localized, and vortical nature of the earthward-propagating electric field pulse is what makes this model particularly effective.