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Ion upflows associated with pulsating auroras: Satellite and PFISR observations

Jun Liang (1), Eric Donovan (1), Johnathan Burchill (1), Ashton Reimer (2), Yangyang Shen (1), David Knudsen (1), Roger Varney (2), and Andrew Howarth (1)

(1) Univ. of Calgary, Physics & Astronomy, Calgary, Canada (liangj@ucalgary.ca), (2) SRI international, Melo Park, CA (roger.varney@sri.com)

Plasma outflows are recognized to play important roles in magnetospheric-ionosphere coupling processes and magnetospheric dynamics. For outflows to occur, ions have to be lifted up (aka “upflows”) first by an ambipolar electric field to the topside ionospheric altitudes, where they are then further accelerated by other processes such as wave heating to escape the Earth. It is well known that, the change of ionospheric electron temperature (Te) profile may modify the electron scale height and give rise to an ambipolar electric field that leads to ion upflows. In recent studies, based upon measurements from Swarm satellites and Poker Flat Incoherent Scatter Radar (PFISR) we have repeatedly identified strong Te enhancements in the upper F-region associated with pulsating auroras. In this study, we survey and investigate the ion upward flows associated with pulsating auroras based upon Swarm, e-POP, and PFISR observations, with the aid of optical measurements from THEMIS all-sky-imagers and/or e-POP fast auroral imager. We find a general trend of increasing ion upflows, on order of $\sim$100-400 m/s, in the upper F-region during pulsating auroral intervals. More importantly, when both pulsating and non-pulsating auroras pass over PFISR beams or are crossed by satellites in the same event, the upward flow velocities associated with pulsating auroras can often be larger than that associated with non-pulsating auroras, even though the latter may feature stronger optical auroral luminosity and field-aligned currents. This indicates that the pulsating auroras may acts as one special source of ion upflows in the upper F-region ionosphere. The ion upflow velocity during pulsating auroral intervals are found as positively correlated with the concurrent Te enhancement, yet on overall negatively correlated with the electron density. There is no noticeable correlation between the upward velocity and the field-aligned current density or the Poynting flux inferred from in-situ data. Based upon the above observations we explore possible candidate mechanisms that may drive the Te enhancement and ion upflows during pulsating auroral intervals.