Substorm imaging at 450 MHz with the electronically steerable Poker Flat ISR

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A substorm represents an impulsive release of magnetotail energy into the high-latitude ionosphere. The role of the ionosphere in governing the rate and timing of substorm energy release remains an active area of debate within the space science community. Auroral imagery has long been considered the only diagnostic capable of providing a simultaneous space-time representation of this physics. But recent experiments with the 450-MHz electronically steerable Poker Flat Incoherent Scatter Radar (PFISR) have demonstrated an analogous capability to provide volumetric imaging of ionospheric state parameters. Using pulse-by-pulse steering, a dense grid of beam positions, and a judicious use of multiple frequency channels, PFISR can provide three-dimensional reconstructions of density, temperature, and flow fields at a time-cadence that is short compared to physical time scales of the coupled magnetosphere-ionosphere system (specifically, <1-min cadence for full state parameters, and <15-s cadence for uncorrected plasma density fields) and over a significant regional volume (100x100 km horizontal x 400 km vertical).Coherent backscatter, arising from plasma turbulence, is also a commonly observed feature at 450 MHz during substorms, providing an additional dimension of information about the plasma state and its drivers.

This talk considers substorm remote sensing through the coupled perspective of PFISR and collocated optical systems. We draw from several case studies, and use a variety of contextual diagnostics to identify the position of PFISR with respect to the substorm onset point. We report initial efforts to assimilate optical and radar imagery through the use of first-principles physical modeling of the coupled magnetosphere-ionosphere system. This approach provides a means of accessing additional state parameters not directly observed by either diagnostic, such as ion composition or species-specific ion upflow rates.