Geophysical Research Abstracts
Vol. 14, EGU2012-4766, 2012
EGU General Assembly 2012

Cluster multi-point study of the acceleration potential pattern and electrodynamics of an auroral surge and its associated horn arc

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We present results from Cluster crossings through the acceleration region of an auroral surge and connected surge horn in the southern hemisphere during an extended time period of moderate substorm activity. The four spacecraft crossed different magnetic local time (MLT) sectors of the surge and horn, with lag times of 2-10 min between the spacecraft. The Cluster data are used to infer the acceleration potential patterns of the horn and of the double arc system (surge and horn) at the front of the surge and deeper into the surge. The horn is a typical Inverted-V arc with a parallel potential drop ranging between 4 and 6 kV along its extent. The pattern derived at the surge front consists of two U-potential structures, with acceleration potentials of 6-8 kV and 4-6 kV for the surge and horn, respectively. In between the two structures is a region of low density polar cap plasma not associated with any field-aligned currents. A similar pattern is derived for the region deeper into the surge, but here the two potential structures are more integrated. The Cluster data are also used to address how the field-aligned currents at different MLT sectors of the surge close in the ionosphere. The Cluster multi-point data allow close in time estimates of the degree of latitudinal closure of the surge system at various MLT sectors. Significant net upward currents are derived for the horn and for the surge, whereas the R1/R2 currents at the surge front are roughly balanced. The net upward current of the horn is proposed to be fed by the divergence of a westward Pedersen current, driven by a westward electric field in the arc, and possibly by an oppositely directed electrojet, equatorward of the horn, having some similarities to recent results by Marghitu et al. (2009). The net upward surge current is proposed to be fed by the divergence of a westward electrojet, driven by the equatorward electric fields poleward of the surge as well as by localized downward currents adjacent to the surge.