Characteristics of Isolated High-latitude Aurora

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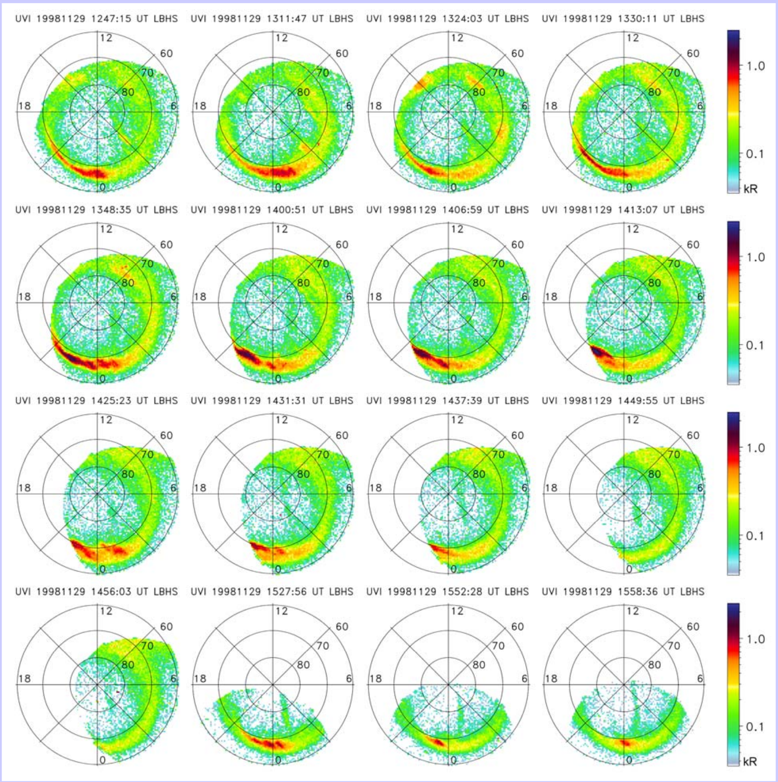
Introduction

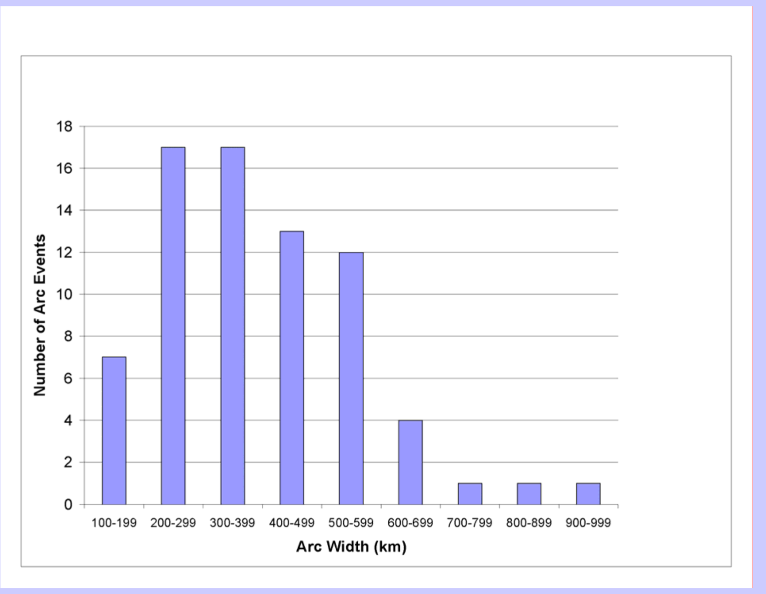
Transpolar arcs (TPAs) are often observed during northward interplanetary magnetic field (IMF). When transpolar arcs move in the dawn or dusk direction across the entire polar region in response to IMF B_y changes they form a "theta" aurora when the arc is aligned along the noon-midnight meridian. *Cumnock* [2005] selected events from a 4.5-year period when IMF B_z is northward for at least 2 hours before and at least 3 hours after a B_y sign change. For northward IMF and a B_y sign change theta aurora are almost always formed in the northern hemisphere, regardless of B_x and dipole tilt. This implies that theta aurorae form simultaneously in both hemispheres. Strongest UV emissions occur in the summer hemisphere and depend strongly on northward IMF B_z, IMF magnitude and solar wind speed. See also *Kullen et al.* [2008].

In the present study we analyze isolated arc events identified in the precipitating particle spectrograms measured by DMSP F13 SSJ/4. We consider only passes where the satellite track reaches at least 88 deg on the dayside and 86 deg magnetic latitude on the nightside of the magnetic pole. About 3,000 orbits out of approximately 15,000 total orbits during 1996-1998 are within this region. We then identify arc signatures which occur above 87 degrees magnetic latitude seen as the satellite moves in the dawn-to-dusk (dusk-to-dawn) direction in the Northern (Southern) hemisphere. This results in a total of 302 polar crossings in both the Northern and Southern hemispheres. Out of this number, a total of 73 polar crossings measure isolated arcs at high latitudes. As opposed to the previous studies, we select arc events first from DMSP data, without regard to IMF.

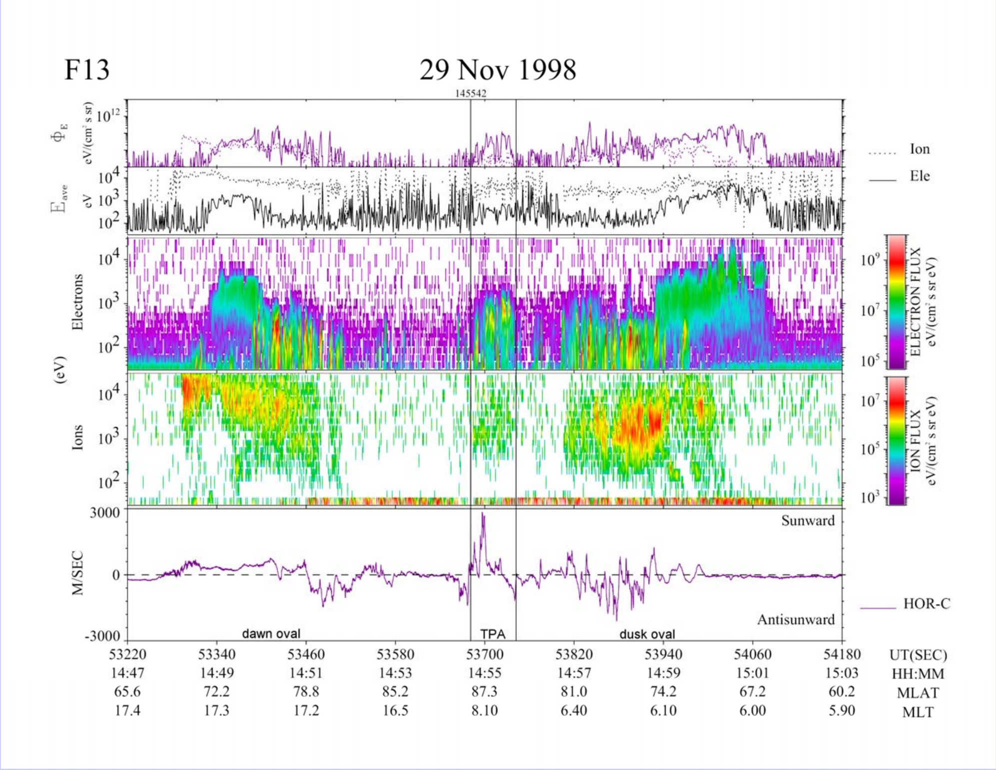
Observations



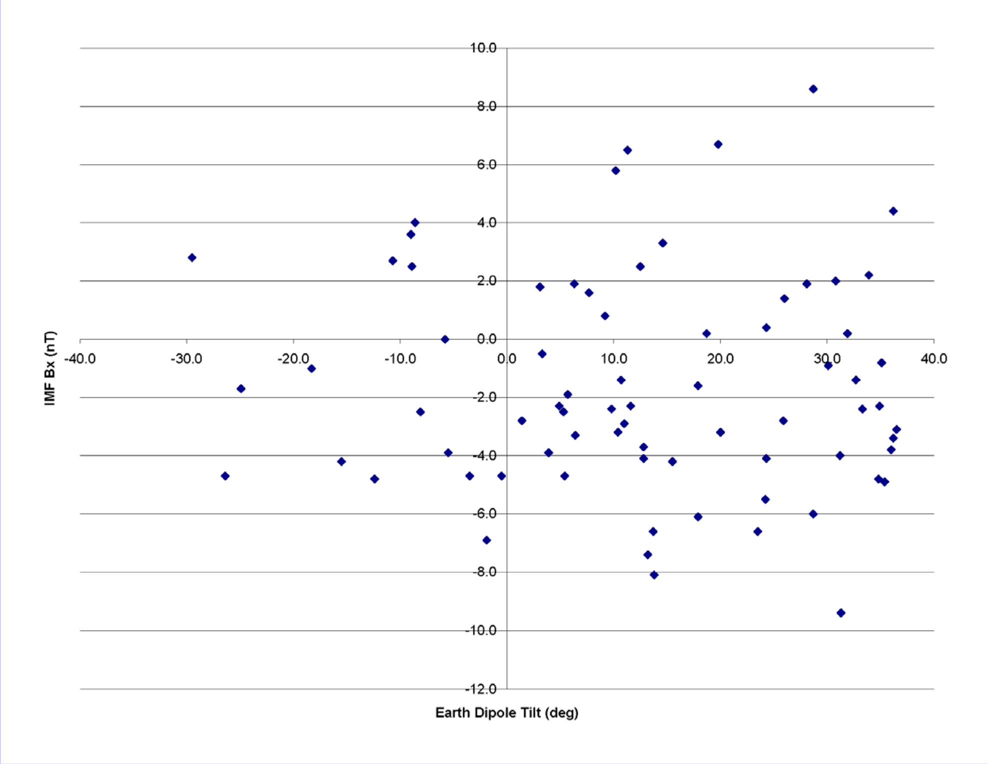
Polar UVI global auroral images from 29 November 1998. Example of a dawnside originating transpolar arc during Northward IMF, B_y increasing in value, positive B_x.



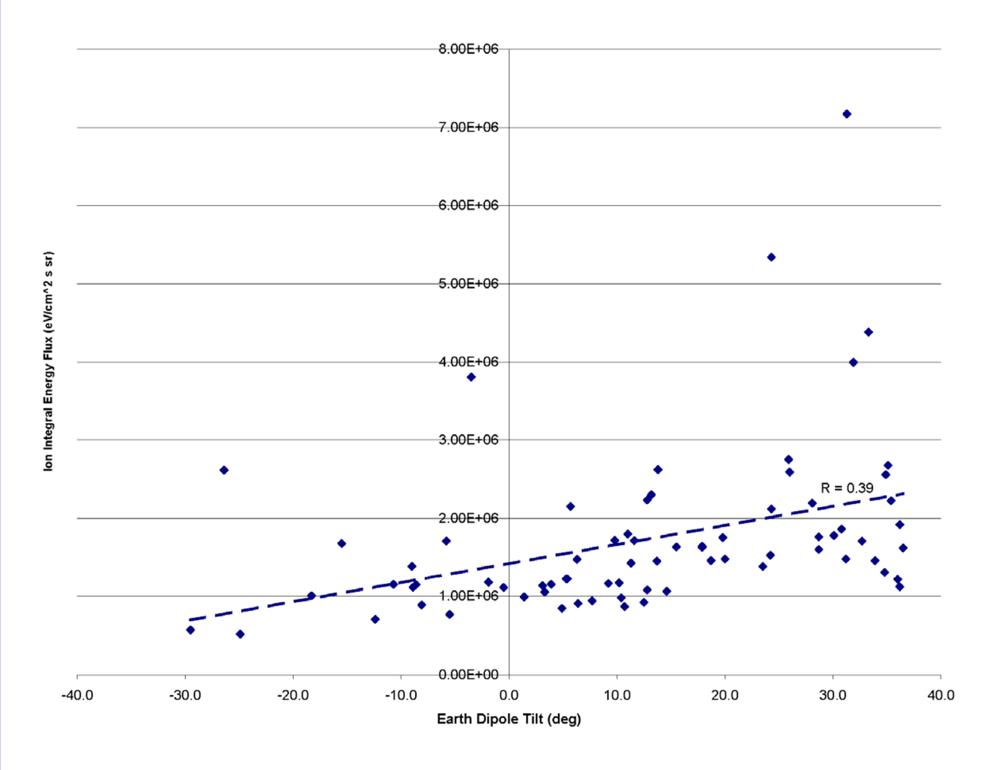
Statistical results: Characteristic arc width. Arc widths (measured along the DMSP satellite track) range between 100 and 950 km and have a characteristic arc width where the highest numbers of arcs have a width of 200-400 km. We find that there is no correlation between arc width and dipole tilt, particle energy flux or with IMF parameters (B_x, B_y, B_z, $v_{sw}B^2$) even after separating cases by dipole tilt.



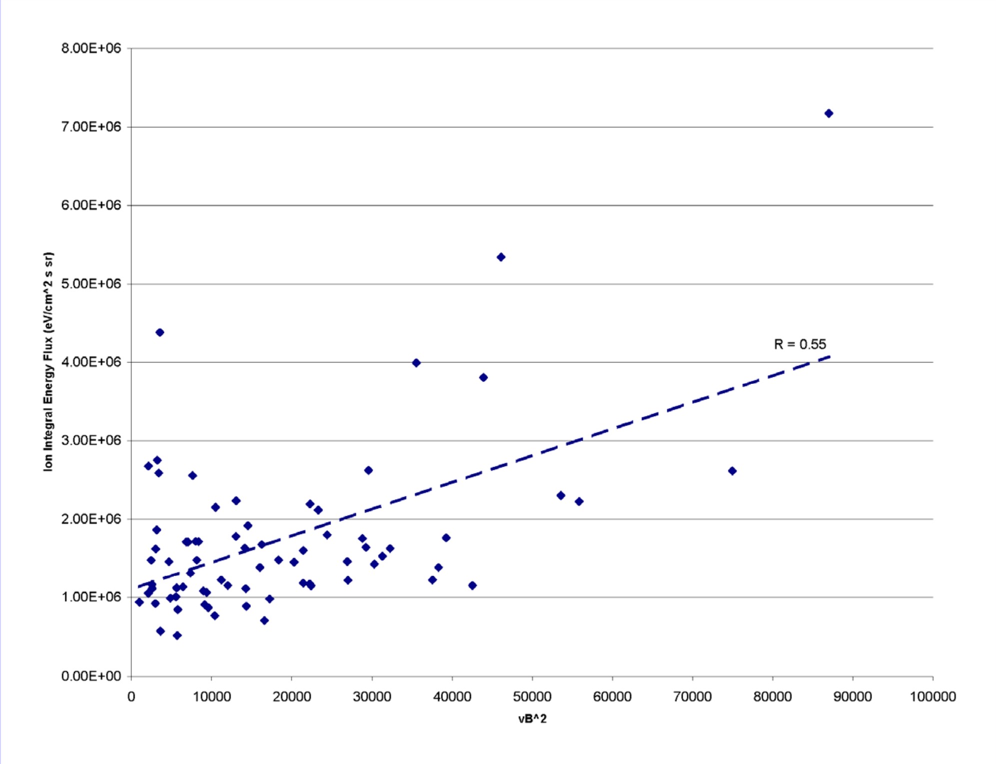
DMSP F13 satellite Northern hemisphere pass during the TPA event; same time as the 12th plot in the Polar UVI figure. The particles are boundary plasma sheet-like and are normally associated with closed field lines. The arc is surrounded on both dawn and dusk sides by regions void of particles, which are associated with open field lines. The integral energy flux associated with the high-latitude arc region is about the same as those seen in the auroral oval for the electrons, and lower for the ions. Averaged across the arc the cross-track plasma flows are only about 340 m/s and are part of a very structured ionospheric flow pattern, typical of plasma flow in the dark winter hemisphere.



Distribution of events: IMF B_x vs. Earth dipole tilt. The lower right quadrant is that in which both B_x (negative) and dipole tilt (positive, toward the Sun) are such that the IMF and Earth's magnetic field lines are more likely to be anti-parallel resulting in lobe reconnection [*Crooker*, 1979]. *Cumnock* [2005] found that theta aurora were just as likely to form for the least favored IMF-dipole tilt configuration as for the most favored, however, these theta formed during stable northward IMF and changing B_y, thus anti-parallel merging may be less important.



Statistical results: Ion integral energy flux vs. dipole tilt (r = 0.39). We see a weak positive correlation between arc energy flux (averaged over the arc) and dipole tilt where the largest energy fluxes are associated with larger positive dipole tilt. The electron energy flux and maximum ion and electron energies have weaker correlations than the ion flux with dipole tilt.



Statistical results: Ion integral energy flux vs. $v_{sw}B^2$ (r = 0.55). Both ion energy flux (averaged over the arc) and the arc-aligned (cross-satellite track component) horizontal plasma drift are positively correlated with $v_{sw}B^2$. Plasma flow associated with the arcs varies and can be approximately equally assigned to three categories (1) sunward, (2) sunward on the duskside and anti-sunward on the dawn side, and (3) the reverse of case 2.

Previous Results:

- For steady northward IMF and a *By* sign change, theta aurora are almost always formed in the northern hemisphere, regardless of *Bx* and dipole tilt [*Cumnock*, 2005].
- Generally, the strongest UV emissions measured in the theta aurora occur in the summer hemisphere.

New Results:

- Most of the 73 isolated arc events identified occur during northward IMF conditions and changing B_y (42 events follow a positive B_y sign change).
- The highest electron and ion integral energy fluxes measured in the arcs occur in the summer hemisphere. There is a weak positive correlation between particle energy and dipole tilt.
- Strongest (positive) correlations for energy fluxes were found with "magnetic energy flux" in the solar wind ($v_{sw}B^2$) and the arc-aligned (cross-satellite track component) horizontal plasma drift in the ionosphere.
- Small-scale arcs are embedded in the large-scale convection pattern in either sunward flow regions or very weak flow (reduced anti-sunward flow). The convection associated with the thin arcs is localized and has little influence on the large-scale convection.
- All types of convection patterns are seen during these events (dominant one-cell, 2-, 3- and 4-cell; e.g., *Cumnock et al.*, 1995). The largest group (32) is dominant 1-cell patterns; 15 are 3-cell, 13 are 4-cell, 10 are very structured, only three are 2-cell. For most of the events (61) negative potential cells dominate.

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