Observations of Poynting flux in the dayside cusp region at different altitudes

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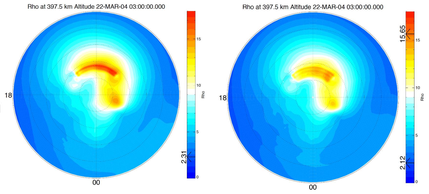
Abstract

The observations from Defense Meteorological Satellite Program (DMSP) satellites and Cluster satellites show that the cusp region may or may not have substantial Poynting flux and the quantitative results have strong altitude dependence. Our analysis of DMSP F15 satellites (~800km) data reveals that 49.6% of 1999 cusp crossing events observed a significant downward Poynting flux enhancement (S>10 mW/m2) . 84.2% of the crossings have a clear downward Poynting flux (S> 3 mW/m2), and only 4.2% of the crossings did not show a clear Poynting flux (S<1 mW/m2). In 49 Cluster (4~8 Re) cusp crossings, 41% observed significant downward Poynting flux enhancement. 71% showed a clear downward Poynting flux and 12% cases did not show a clear downward pointing flux. Interestingly, 26 (52%) out of the total 49 cases had a certain period with a significant upward Poynting flux in the cusp region. The relationships between Poynting flux and AE index, IMF conditions have also been analyzed.

motivation

- Correlation of Poynting flux and particle precipitation is very important at cusp region
- Influence on the thermosphere is different for different relative distributions of Poynting flux and particle precipitation
- Altitudinal dependence of the correlation need to be more specified
- Right fig shows same amount energy of PF and particle but at different location can have different influence on thermosphere [Cheng,2015]



Matched Non-matched

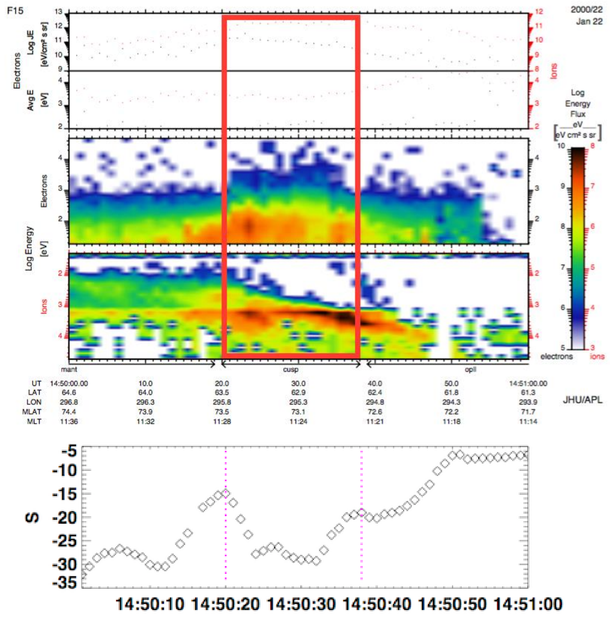
Methodology

Data
- DMSP F15 satellites : 2000-2004
  - Magnetic Field:SSM
  - Electric Field: IDM and RPA
- Background Magnetic field: IGRF Model
- Cluster satellites: Aug-Oct. 2004
  - Magnetic Field: FGM instrument
  - Electric Field: EFW instrument

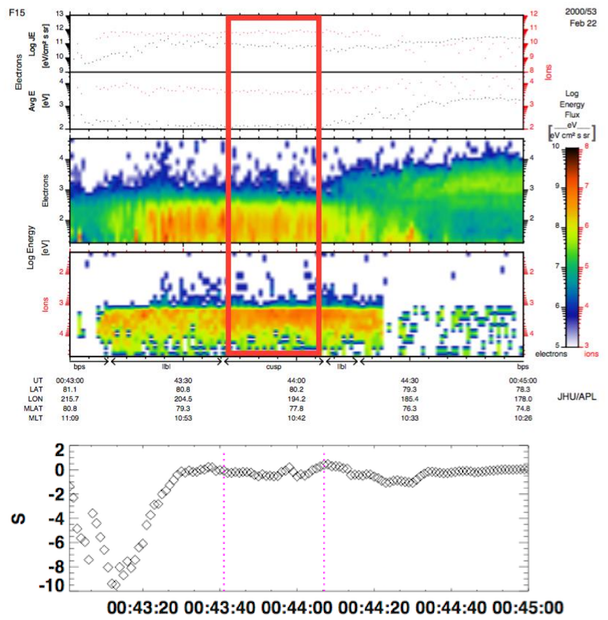
1) Poynting flux :
   $S = E \times dB/\mu 0$
2) Electric field
   estimated from ion drift speed
   Measurements $E = -v \times B$
3) Magnetic perturbation
   dB = measured magnetic field - background field
   For DMSP F15 satellites: background magnetic field from IGRF Model
   For Cluster satellites: background field from 3rd order polyfit.
4) Mapping Poynting flux to certain altitudes (300km)
   Poynting flux at the Cluster satellite altitudes has been calculated and mapped to 300 km using the relationship Si = Scl *Bi /Bcl. Bcl and Pcl are magnetic field and Poynting flux computed at Cluster
   [**T. Živkovic´**,2015]

DMSP Observations

With significant Poynting flux



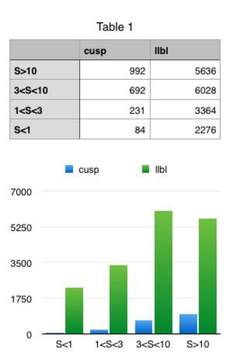
Without clear Poynting flux

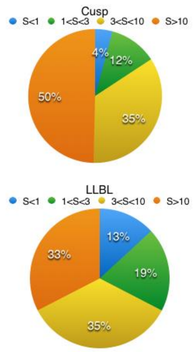


- Above is a typical DMSP cusp/LLBL crossing event.
- We use the JHU/APL's Auroral Particles and Imagery- Dayside Boundaries to identify all cusp and LLBL crossing locations.
- Typically, the cusp region shows a clear enhancement of 1K eV ion flux and 100 eV electron flux.
- The bottom panels are the Poynting flux of corresponding periods. Left one shows a significant downward Poynting flux (S>10) in the cusp. In comparison, the Right one shows no clear Poynting flux (S<1) in the cusp region, but it shows a clear Poynting flux(S>3) in the LLBL region.

Table 1

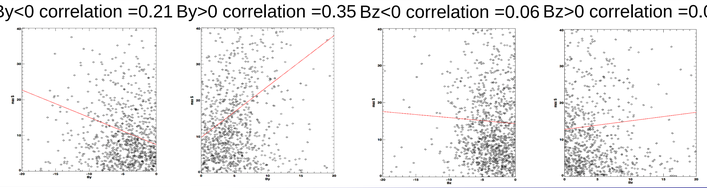
	cusp	llbl
S>10	992	5636
3<S<10	692	6028
1<S<3	231	3364
S<1	84	2276



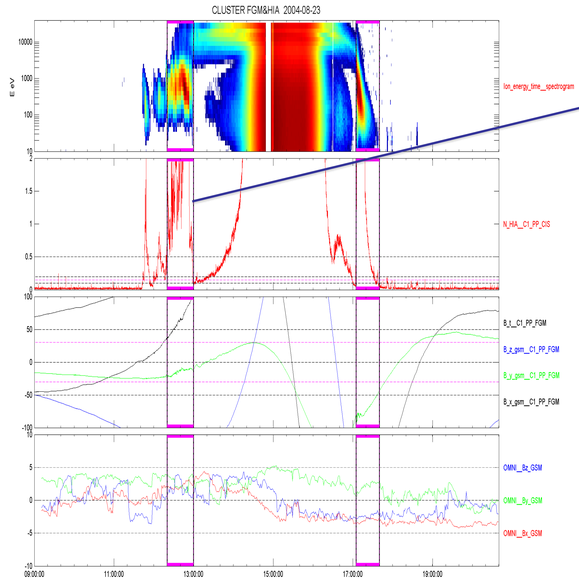


- Statistic results of Poynting flux in the cusp & LLBL from DMSP 2000-2004
- The maximum downward Poynting flux in the cusp or LLBL has been analyzed.
- Half cases show a significant Poynting flux enhancement (S>10) in the cusp region
- Comparison between cusp and LLBL reveals that the cusp region has a higher chance (50%>33%) to observe significant downward Poynting flux (S>10).
- LLBL region has a larger chance to observe no-clear Poynting flux(S<1) than the cusp region (13%>4%)
- No clear correlation of PF with IMF By or Bz has been identified.

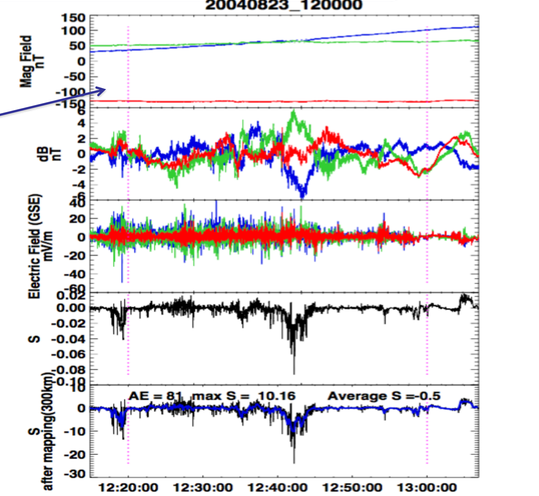
By<0 correlation =0.21 By>0 correlation =0.35 Bz<0 correlation =0.06 Bz>0 correlation =0.08



Cluster Observations

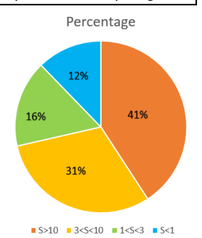


- Example of cusp crossing case from Cluster observation
- The rectangle box indicates the cusp crossings
- Typically, the plasma density increases and the 1K eV ion flux enhancement appears when Cluster satellites pass the cusp region



- the magnetic field (1st panel) and electric field (3rd panel) of Cluster measurement in the cusp (from 12:20-13:00)
- dB (2nd panel) is magnetic perturbation, which is calculated by subtracting the background magnetic field (3rd order polyfit).
- The 4th panel shows Poynting flux. And bottom panel shows the Poynting flux after mapping to 300 km altitude.
- The bottom panel shows Cluster observed clear Poynting flux (S>3) enhancement around 12:40-12:45.
- Poynting flux is highly fluctuating. Black line is the original data with time resolution of 1/22 s and blue line is the time average in 1 s.

	Numbers	Percentage
S>10	20	41%
3<S<10	15	31%
1<S<3	8	16%
S<1	6	12%



- Our statistic study of 49 Cluster cusp crossing cases show: 41% showed significant Poynting flux(S>10); 71% showed clear Poynting flux enhancement(S>3); and 12% did not show substantial downward Poynting flux(S<1).
- Meanwhile, 26 cases(52%) have certain period of significant upward Poynting flux in the cusp region, which has not been shown in the DMSP observations.

Conclusion

- At DMSP altitudes, half cases show a significant Poynting flux enhancement (S>10) in the cusp region, 85% cases show a clear Poynting flux(S>3) and only 4% case show no-clear Poynting flux (S<1) in the cusp region
- At DMSP altitudes, the chance to observe significant Poynting flux in cusp region is higher than in LLBL region.
- It also has a higher chance to observe significant Poynting flux at DMSP altitudes than at Cluster altitudes.
- At Cluster altitudes(4~8Re), it also shows significant upward Poynting flux in the cusp region (52%), which has not been observed in the DMSP measurements.