Correlation between Poynting flux and soft electron precipitation in the dayside polar cap boundary regions

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**ABSTRACT:**
DMSP spacecraft have observed signatures of enhanced electromagnetic (Poynting flux) and kinetic (soft electron precipitation) energy deposition in the polar cap boundary regions, including the cusp. With strict criteria of region identification, the correlation between these energy inputs has been investigated in detail. The two different energy sources are coincident in some cases, but a clear displacement can also be identified in others, depending on the location and conditions. The consequence of the energy displacement has been simulated in the Global Ionosphere-Thermosphere Model (GITM) through comparing different cases. These results will help to specify the horizontal distribution of energy inputs in the ionosphere-thermosphere modeling.

**MOTIVATION:**
- The Earth’s Cusp is a special region with open magnetic field lines. Poynting flux and particle precipitation have been observed in this region.
- Simulations have shown that both Poynting flux and soft electron precipitation in the cusp have strong impacts on the neutral dynamics. Figures on the right show the percentage difference of neutral density at 400 km after adding in a Poynting flux of 75 mW/m\(^2\) (left) and soft electron precipitation of 100 eV, 2 mW/m\(^2\) (right) in the cusp, respectively.
- In simulations, Poynting flux and soft electron precipitation are usually added in at the same time and same location. But in reality, what’s the correlation between them?

**DMSP OBSERVATIONS: CORRELATION**

**Match Case, July 24\(^{th}\), 2004**
- We searched cusp and/or lower-latitude boundary layer (LLBL) crossings during storm periods in 2004 and 2005. DMSP particle data plots are generated by the Online Spectrogram Viewer developed by JHU/APL. Data from the magnetometer and ion drift meter have been used to calculate the Poynting flux.
- In the July 24\(^{th}\), 2004 event (left), Poynting flux enhancement matched very well with particle precipitation. While, in the April 13\(^{th}\), 2005 event (right), particle precipitation and Poynting flux enhancement were not coincident, and ~1° displacement between them in magnetic latitude can be identified.
- 24 similar cusp/LLBL crossings have been identified. In 2/3 of them, Poynting flux and soft electron precipitation are collocated, while in the others they are not.

**Non-match Case, April 13\(^{th}\), 2005**
- Percentage difference in neutral density @ 400 km altitude between runs with and without additional energy, including Poynting flux (PF, 20 mW/m\(^2\)) and soft electron precipitation (SEP, 150 eV, 1 mW/m\(^2\)), is shown for different situations.
- With Poynting flux only, the neutral density enhancement can be as large as 11.5%, as shown by (a).
- The difference between (b) and (a) represents the significance of soft electron precipitation, the peak of neutral density enhancement increases from 11.5% to ~20%.
- In (c)/(d), the location of soft electron precipitation is poleward/equatorward of Poynting flux. The magnitude of the maximum neutral density enhancement is similar (~16%), but the distribution changes slightly when the location of soft electron precipitation moves.

**SUMMARY**
- Both match and non-match cases have been identified from DMSP observations.
- So far we have found more match cases than non-match cases, but more events are needed for a statistically reliable conclusion.
- In GITM simulations, the peak of neutral density enhancement changes from 11.5% to ~20% when adding in the soft electron precipitation on top of Poynting flux around the cusp. The peak value changes to ~16% when a displacement between Poynting flux and soft electron precipitation has been applied.