Direct entry of O^+ into the near-Earth (6-12 R_E) plasma sheet

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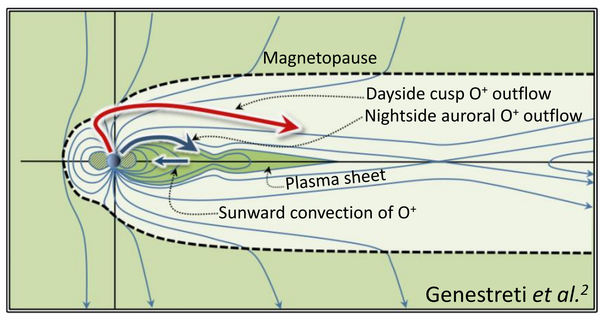
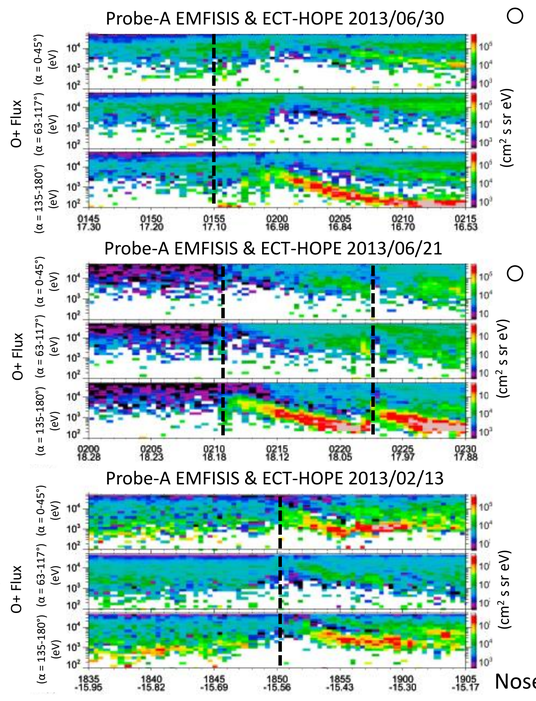
Background

O^+ Transport Mechanisms



- O^+ outflow is most commonly sourced from the nightside auroral region or dayside cusp
- Ionospheric O^+ outflow from the dayside cusp is convected through the lobes to the plasma sheet
- During reconnection, O^+ that was previously in the lobes' open field line is now on a closed field line within the plasma sheet[1]

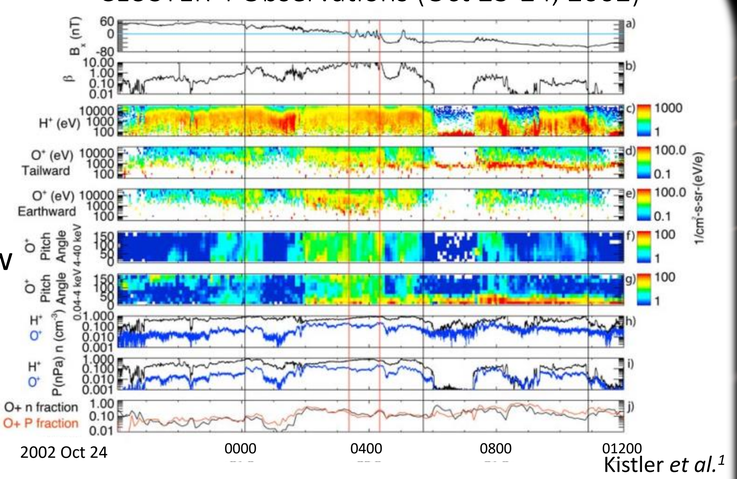
Nightside Aurora Source



- At <6.6R_E, energy-dispersed O+ flux enhancements following dipolarization events appear ∥ or anti-∥ to magnetic field[3]
- Energy-dispersed outflow is characteristic of a nightside auroral source of O^{+1-3}

Cusp Source

CLUSTER 4 Observations (Oct 23-24, 2002)



- In the region between 15-20 R_E, continuous O^+ outflow from the cusp/lobes to the plasma sheet is observed during stormy periods
- Ions are also accelerated at the boundary layer[1]

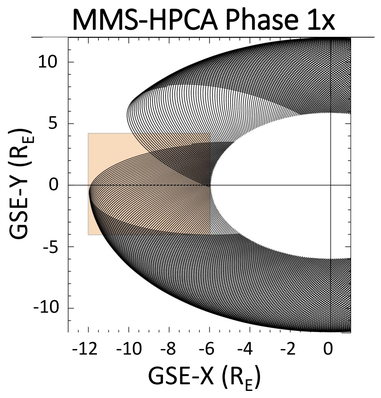
In this work, we investigate whether the auroral or cusp source dominates in the 6-12 R_E region

Select Event

Magnetospheric Multiscale Mission (MMS)

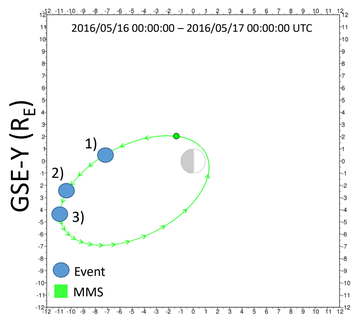
- Data acquisition period: 05/01/2016 to 09/26/2016
  - First tail passage (apogee at 12 R_E)
- HPCA: Hot Plasma Composition Analyzer
  - Detects ions with energies from 1 eV to 40 keV by determining mass from velocity
- EIS: Energetic Ion Spectrometer
  - Measures particles with energies greater than 40 keV

MMS-HPCA Phase 1x



May 16, 2016: Kp: 2.5 (Quiet)

MMS Constellation Orbit

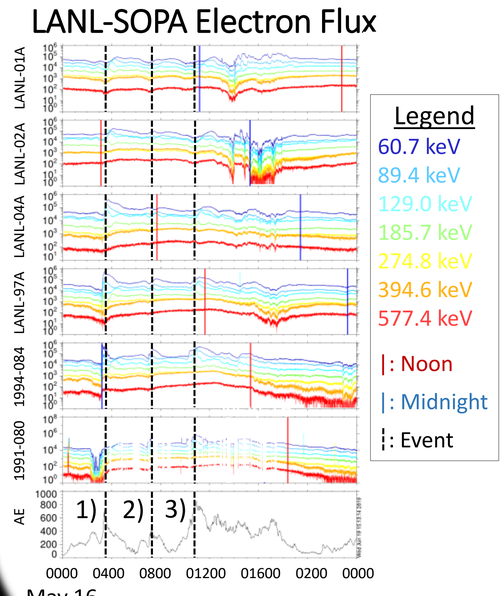


Orbit: 0-12 R_E

Los Alamos National Lab (LANL) Geosynchronous Satellites

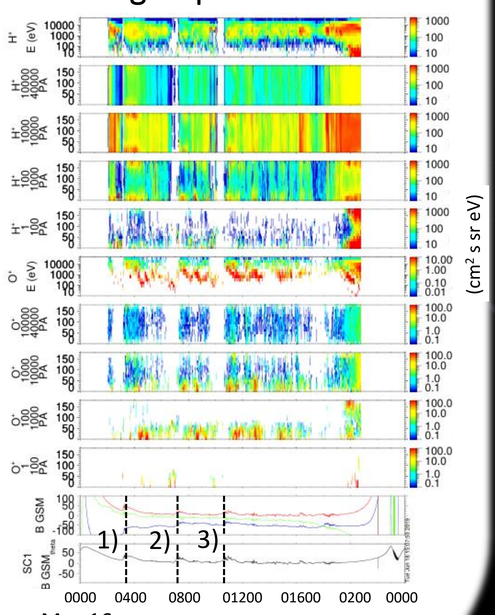
- SOPA: Synchronous Orbit Particle Analyzers

LANL-SOPA Electron Flux



Legend
60.7 keV
89.4 keV
129.0 keV
185.7 keV
274.8 keV
394.6 keV
577.4 keV
|: Noon
|: Midnight
¦: Event

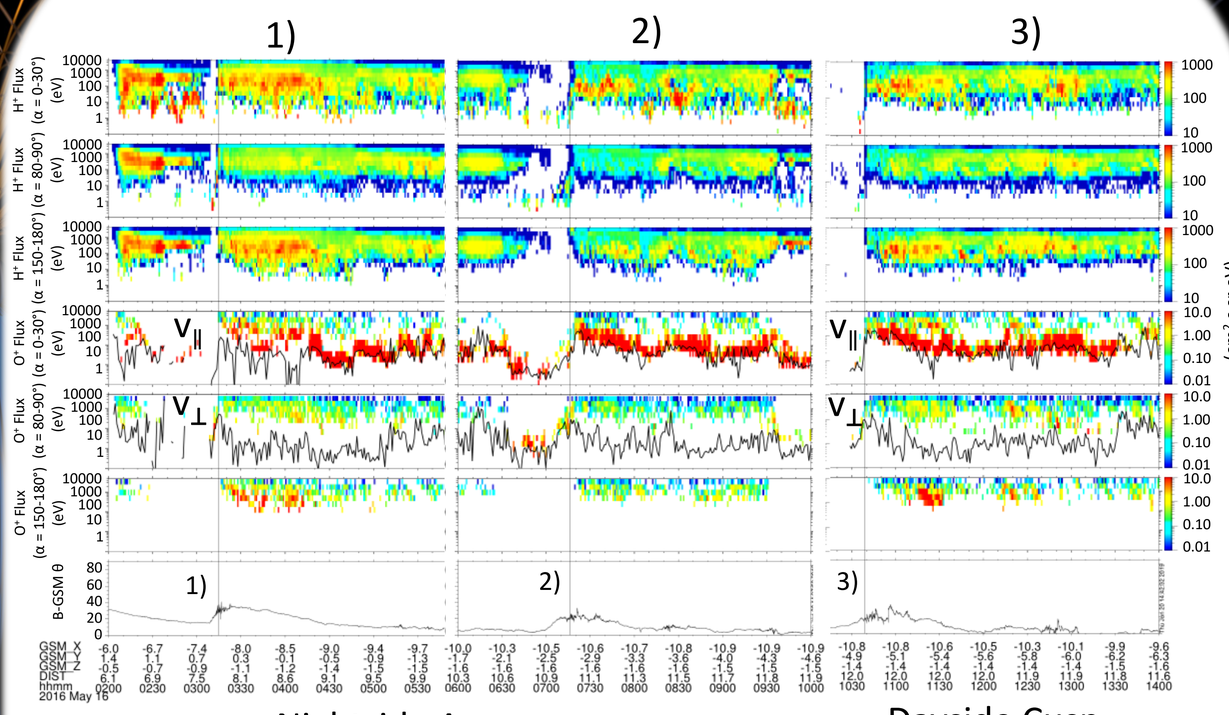
Pitch Angle Spectra for H^+ and O^+



Dipolarization events accompany ion/electron flux enhancements

Preliminary Results

May 16, 2016



Origin of O^+:

Nightside Aurora

- Events 2 & 3 (between 11-12R_E) both exhibit dispersive O^+ outflow
- Following event 1, there are several bursts of time-dispersed O^+

Dayside Cusp

- Prior to event 1, there is very little O^+ within lobes
- As spacecraft moves into the boundary layer and exits into the lobe preceding event 2, there are low-energy ions present
- Before event 3, there are low-energy O^+ populations in boundary layer but not the lobe

- Ion velocity is predominantly parallel except for just after dipolarization events, where an increase in $v_\perp$ can be observed
- Event 1 (≈7.6 RE) shows bidirectional field-aligned H^+ & O^+ shortly after onset, which are likely equatorial ions accelerated down the field line

Conclusions:

I. **After dipolarization, signatures of nightside auroral outflow are observed near the 12 R_E region**

II. **Tailward streaming, low-energy (100 eV) ions in the boundary layer are also observed. Whether this indicates the cusp as a strong plasma sheet O^+ source is not clear**

References & Acknowledgements

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4. "Cusp as a source for oxygen in the plasma sheet during geomagnetic storms," Kistler *et al.*, *J. Geophys. Res.*, **2010**, *115*(A), 03209.
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Background image by Greg Shirah, "Magnetic field print resolution still", *NASA Scientific Visualization Studio*, 2011.