Direct entry and radial dependence of O^+ in the near-Earth plasma sheet

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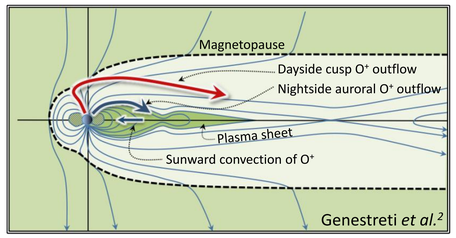
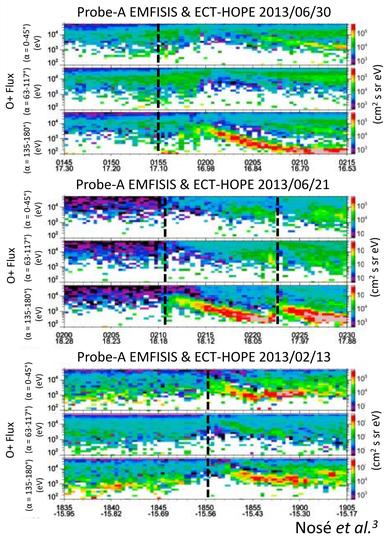
Introduction

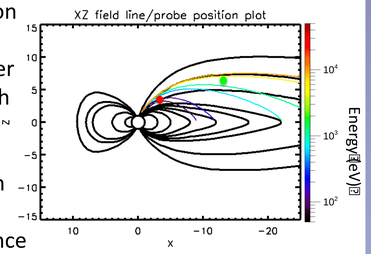


- Ionospheric O^+ outflow can be sourced from either the nightside auroral region or dayside cusp
- O^+ outflow sourced from the cusp flow over the polar cap and are convected through the lobes into the plasma sheet, while O^+ from the nightside aurora has direct access to the plasma sheet[1]



- Nightside auroral source ions exhibit temporal dispersions in energy consistent with time-of-flight from the ionosphere[1-3] (A 100 eV O^+ ion takes ≈18 min to reach 6.6R_E, while a 1 keV ion takes ≈6 min)
- Energy-dispersed O^+ flux enhancements following magnetic dipolarization events appear parallel or anti-parallel to magnetic field[3]

- Due to field line convection and ion trajectories, we expect to see slower, lower energy ions closer to earth and higher energy ions further down the tail
- Accordingly, the minimum energy of O^+ should increase with radial distance



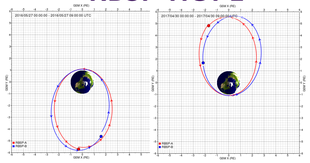
Research questions:

- Can we identify the sources of O^+ in the plasma sheet?

- How may the source contributions vary with radial distance?

Data Sets & Sample Events

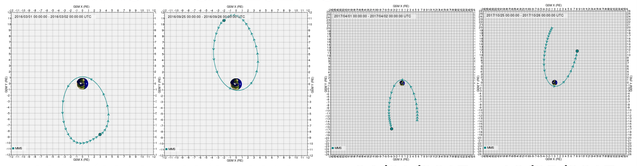
RBSP-HOPE



05/27/2016 to 04/30/2017

- Apogee 6 R_E

MMS-HPCA: 2016 & 2017 Tail Passes



03/01/2016 to 09/25/2016

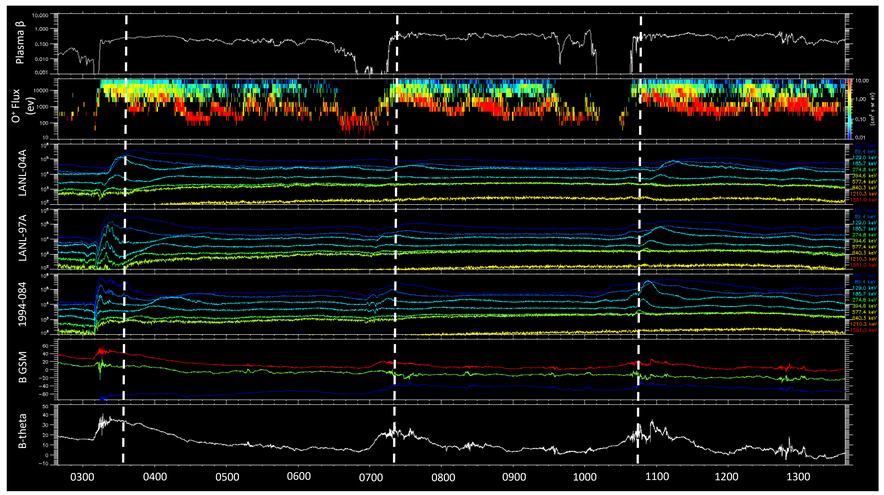
- Apogee 12 R_E

04/01/2017 to 10/25/2017

- Apogee 25 R_E

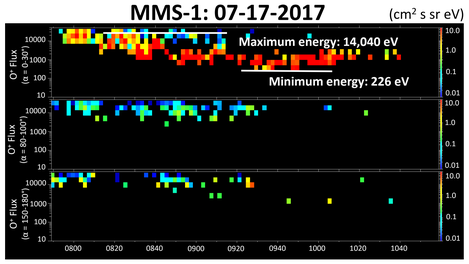
Method: (1) Look for characteristic O^+ injection/enhancement and any temporal dispersion. (2) If dispersion was observed, record maximum and minimum energy of O^+ and direction of flow by pitch angle (α). (3) Note if there was an injection observed by LANL-SOPA geosynchronous satellites within ≈30 min of observation by RBSP or MMS. (4) Identify if injection followed dipolarization event by checking for an increase in B-theta and Bz.

MMS-1: 05-16-2016



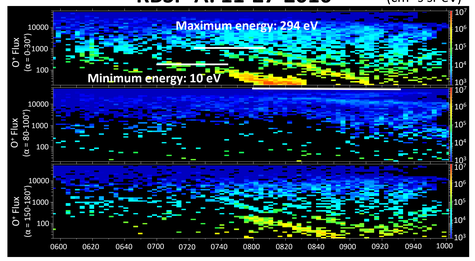
- O^+ flux enhancements all energy-dispersed, coincided with injections observed by LANL-SOPA instrument, and followed magnetic dipolarizations

MMS-1: 07-17-2017 (cm² s sr eV)



- Event shows an energy-dispersed O^+ enhancement with parallel flow

RBSP-A: 11-27-2016 $(cm^2\ s\ sr\ eV)^{-1}$

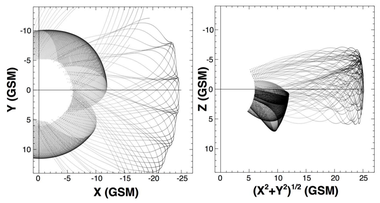


- Event has multiple energy-dispersed O^+ enhancements due to 'ion bounces' (assume lowest energy dispersion with parallel flow corresponds to most direct path to spacecraft)

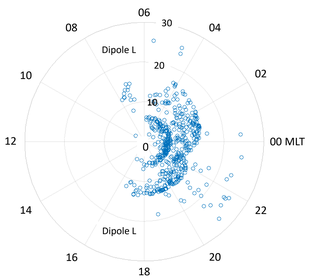
Results & Discussion

Data set	No. of events	% seen with LANL-SOPA	Avg. Max E (keV)	Avg. Min E (eV)
MMS 2016	298	61.07	11.232	284
MMS 2017	52	57.69	11.268	212
RBSP	171	52.05	1.28	14

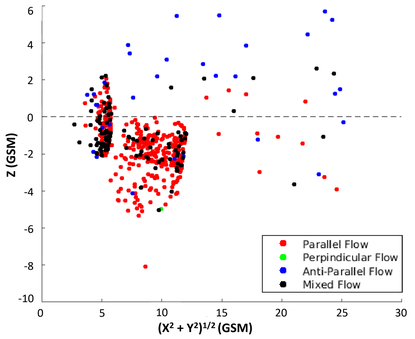
MMS 2016 & 2017 Tail Passes



Locations of Dispersed O^+ Signatures (MMS & RBSP)

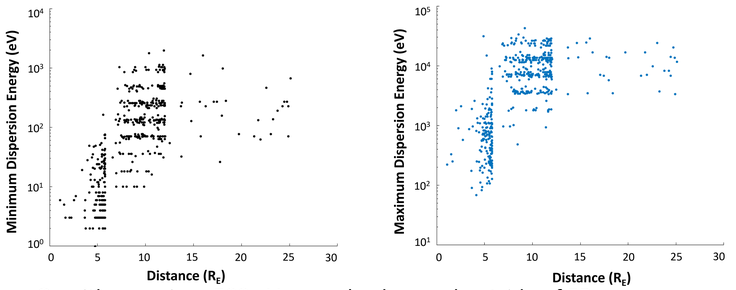


Flow Direction of O^+ (MMS & RBSP)



- Events at R_E>10 were uncommon and occurred mainly on the duskside
- Further investigations are needed to determine whether these results are real or due to distribution of data

- Majority of MMS events have unidirectional flow, while RBSP events have mostly bidirectional flow (in other RBSP studies, flow was seen to be unidirectionally anti-parallel in Northern hemisphere and parallel in Southern hemisphere)[3]



- O^+ with energies >500 eV are only observed outside of 5R_E
- Energies <10 eV only seen within L=6

Summary:

- Minimum energy of O^+ increases with radial distance, while range of maximum energy decreases with distance

- Observations are generally consistent with the expected results assuming a nightside auroral source

References & Acknowledgements

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