Comparing EISCAT cusp observations with in-situ drivers during active Poleward Moving Auroral Form Event

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Outline

- Introduction and motivation
  - The cusp and PMAFs
  - Upwelling/Neutral upwelling discussion
  - Description of RENU2 campaign event
- EISCAT Data
  - Time history/overview
  - Calculation of Ambipolar field
- In-situ Data from RENU2
  - Characterizing the drivers
- Comparison to electrodynamic model
Open field lines allow direct entry of solar wind particles into ionosphere

Collection of thin, wispy arcs which convect poleward as a general group

Highly structured spatially, temporally
Introduction

PMAF frames – Evolution of one PMAF

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Neutral Upwelling

CHAMP
400 km, polar orbit

Deceleration spikes in cusp region

Observed in conjunction with small-scale currents

RENU2 Goal: Fully characterize the conditions during a PMAF event to better understand the driving mechanism behind neutral upwelling in the cusp

25 Sep. 2000

Lühr et al [2004]

Particle precipitation, waves

Joule heating

Thermosphere

Ionosphere

100 km

600 km
Upwelling Processes

**Type I**
Large scale Poynting Flux and joule heating cause ion scale height increase

**Type II**
Soft electron precipitation heats the ambient ionosphere and causes electron scale height increase

Upwelling of ions transfers momentum to neutral thermosphere
Neutral Gas Density

- Neutral Upwelling

Density "bump" ≈10%
Not large enough to register in statistical surveys

Average of OI 630.0 nm emissions acquired by the UiO ASI (67 min.)

Solid black line ≈ PMAF orientation
EISCAT
PMAFs are clearly visible in the electron density and temperature plots (top two plots).

Ion temperature enhancements also visible.

Some weak upwelling signatures throughout.

UiO All-Sky Imager (ASI) at KHO real-time monitor:
- O I 630.0 nm
- Mapped to MLAT (at 250 km)
Ambipolar field

Ambipolar field more effectively driven by $T_e$ enhancements

At high altitudes $\text{Grad}(T_e)$ is small, so the density term dominates [Cohen et al, 2015]

\[ E_a = \frac{-1}{e n_e} \nabla (k_B n_e T_e) = \frac{-k_B}{e} \left[ \nabla T_e + T_e \frac{\nabla n_e}{n_e} \right] \]
Ambipolar field – preflight
Ambipolar Field
Launch profile

Trajectory east of nominal (within margin)

Actually improved coverage of event!
In-situ drivers – electron precipitation

RENU 2 Electron Data

Energy (keV)

Characteristic Energy

$mW/m^2$

Particle

Poynting

$T_e (eV)$

Flight time (sec)

MAIN

SUB
Comparisons

Ionization Count

Electron Temperature

Plasma Number Density

Ion Velocity

Ion Drift (ms⁻¹)

Electron Temperature (K)

Te

07:37:55-07:39:56

07:39:56-07:41:58

Ne

07:37:55-07:39:56

07:39:56-07:41:58

Modeling

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Conclusions

• PMAFs are highly structured both temporally and spatially and present an ideal event type for cross-scale coupling studies

• Ionospheric response to PMAF drivers shows two time scales: rapid, localized temperature enhancements and more widespread, integrated heating effects

• Modeling this type of response based only on electron precipitation shows similar behavior to observed; inclusion of Poynting flux data should bring this closer
Questions?

- GRL Special issue this winter on RENU2 results

- AGU Special Session — SA016: Observation and modeling of high latitude thermosphere phenomena driven by magnetospheric forcing.