Multi-instrument observations of inner-magnetospheric density structures and dynamics

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Talk Outline

- Introduction
- What is the correlation between mid-latitude trough and plasmapause?
- What does the structure of ion outflows look like as a function of altitude?
- What is the potential opportunities of COSMIC GPS TEC to better understand MI coupling phenomenon?
- What is the global signature of SED TEC plumes?
- What is the storm aftermath response of the plasmasphere inside the plasmapause?
- Conclusion
**Plasmasphere-Ionosphere Coupling**

*Yizengaw et al., GRL, 2005*

Empirical Model estimation of Mid-latitude trough!

\[ \Lambda_T = 65.2^\circ - 2.1K_P - 0.5t \]

-15 \leq t < 9 \text{ hours}

*Moffett and Ouegan [1983]*
Filling the gap of understanding

Tomographic approach

Chain of GPS Receivers

Yizengaw and Moldwin, GRL, 2005
Application of Tomography to Low Earth Orbit (LEO) GPS data

- GPS_1
- Elevation angle
- Topside tomography raypath
- LEO Satellite
- Horizon of LEO
- Occultation geometry
- Ionosphere
- EARTH
Application of Tomography to LEO-GPS TEC

Reconstructed Electron Density \((x10^4 \text{ el/cm}^3)\)
FedSat pass b/n 22:10–22:35 UT on 14/12/03
FedSat-GPS Tomography

Reconstructed Electron Density ($\times 10^4$ el/cm$^2$)
For FedSat pass at 22:20 UT on October 29, 2003

Model electron density ($\times 10^4$ el/cm$^2$)
on 29 October 2003 at 22:20 UT

FedSat-GPS Tomography

Webb & Essex, 2004

Yizengaw et al., JGR, 2005

Oct. 29, 2003
(Day 302), 23:41 UT

280
240
200
160
120
80
40
0
-40
-80

80
100
120
140
160
180

GEOG. LONGITUDE (°E)

GEOG. LATITUDE (°N)

GPS TEC
TOPEX TEC

Percent Difference from Quiet Day

Image/FUV S1-13
SSC, UC Berkeley
View from 10000 LT
The presence of upward FAC sheets indicate the existence of precipitated electron in the cusp region where the ion outflows occurred.
Yizengaw et al., GRL, 2006b

First tomographic image of ionospheric outflows • Detailed analyses of the October 2005 Pakistan earthquake • China’s surface temperatures to increase despite decrease in insolation
Tomographic images of Ion outflows
Opportunities of COSMIC TEC

COSMIC GPS TEC data coverage

COS 1, 3, & 4 were at ~500 km
COS 2, 5, & 6 were at ~800 km

COSMIC GPS TEC on 349, 2006

04:59–05:15  03:46–04:31  09:03–09:11  04:20–05:12

UT

Geographic Longitude (°E)

Geographic Latitude (°N)

Local Time (hr)

TECU (x10^6 e/m²)
Plasmaspheric driving forces

- Corotational E-field (produced in the ionospheric E-layer and conveyed into the plasmasphere along the B-field), which is weak.

- Convection E-field (applied to the magnetosphere by its interaction with the solar wind), which is large.

- The two then superimposed and form SAPS E-field that creates a drift pattern, forming plasmaspheric plume.
SAPS effect on the ionosphere

How does this come down to the ionosphere?

(after J. Goldstein)
SAPS general effect on the ionosphere

Foster et al., GRL, 2002
SAPS global effect on the ionosphere

Over Europe;
Yizengaw et al., GRL, 2006a

Over North America

Yizengaw et al., JGR, 2007

Over Atlantic Ocean
Storm aftermath response of plasmasphere inside the plasmapause

- **JASON** orbits at ~ 1335 km altitude
- **Provide plasmaspheric GPS TEC**
What is the depletion mechanism of the plasmasphere inside the plasmapause?
Storm aftermath response of plasmasphere inside the plasmapause

Quiet time Ground based GPS TEC

Storm time Ground based GPS TEC

Percentage difference between disturbed and quiet time Ground based GPS TEC
Conclusion

• The preliminary tomographic reconstruction approach to the space-based GPS TEC reveals a more complete picture of field-aligned ion outflow emanating from the cusp region, indicating its important advantages to show the plasma transport between the ionosphere and magnetosphere.

• For the first time a statistical study using multi-instrument observations clearly demonstrate that the ionospheric signatures of plasmaspheric plumes, which were previously often observed over North America, can be viewed in various sectors of the globe.

• Although dumping of plasma into the ionosphere is thought to be responsible, the depletion mechanism of plasmasphere inside the plasmapause remains unclear. However, this needs more attention to clearly understand the evolution of plasmaspheric density as a function of L-shell, local time, and geomagnetic storm phase.
Thank you!