

The morphology of the topside  
ionosphere of Mars under different solar  
wind conditions: Results of a multi-  
instrument observing campaign by Mars  
Express in 2010

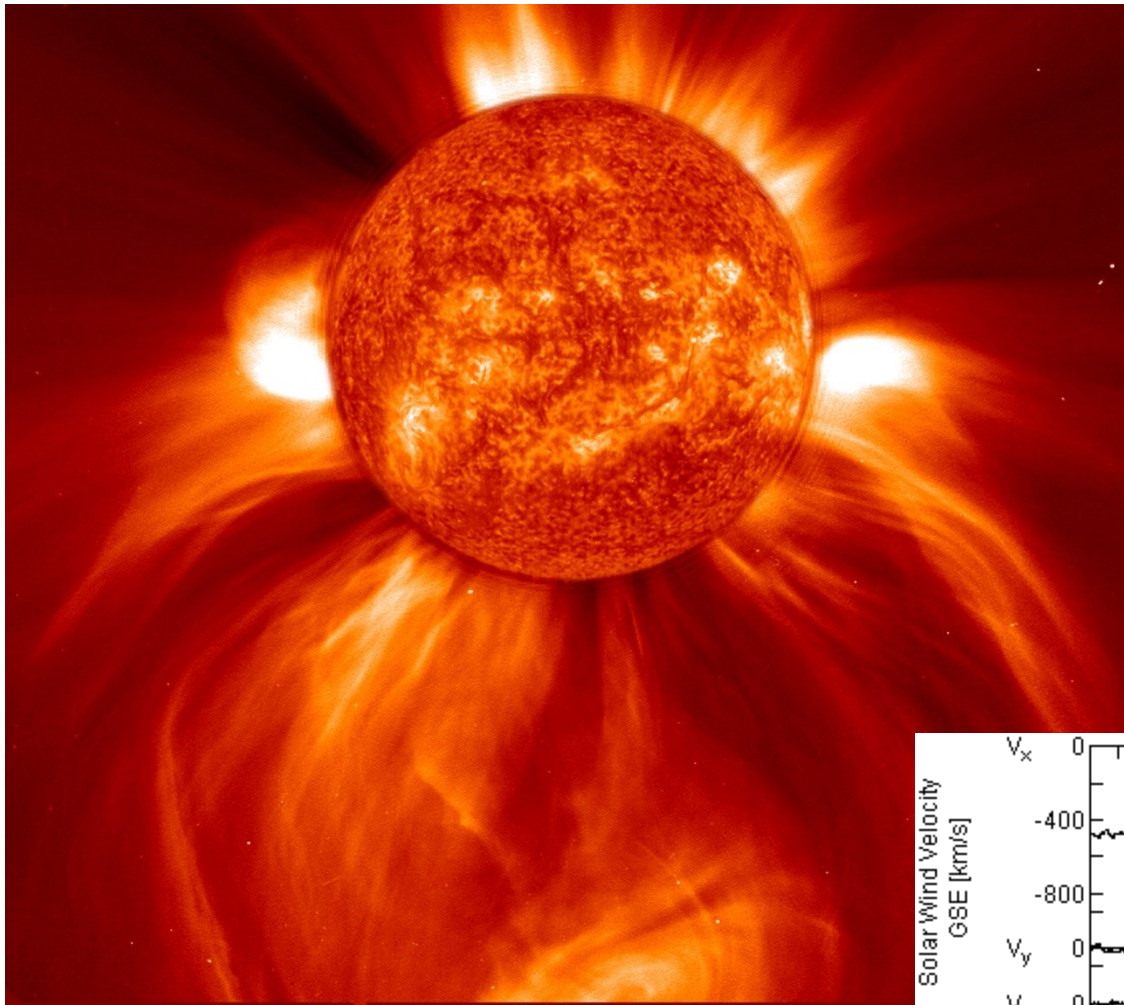
Paul Withers (withers@bu.edu)

Thanks to ISSI colleagues Matta, Lester, Andrews, Edberg, Nilsson, Opgenoorth, Dubinin,  
Fraenz, Kofman, Lei, Curry, Lillis, Morgan, Paetzold, Peter, Opitz, Witasse, Wild

AGU Chapman Conference, Yosemite CA

2014.02.13 17:45-18:00

# Solar wind



<http://lasp.colorado.edu/home/science/space-physics/space-plasma>  
(SOHO EIT and LASCO composite)

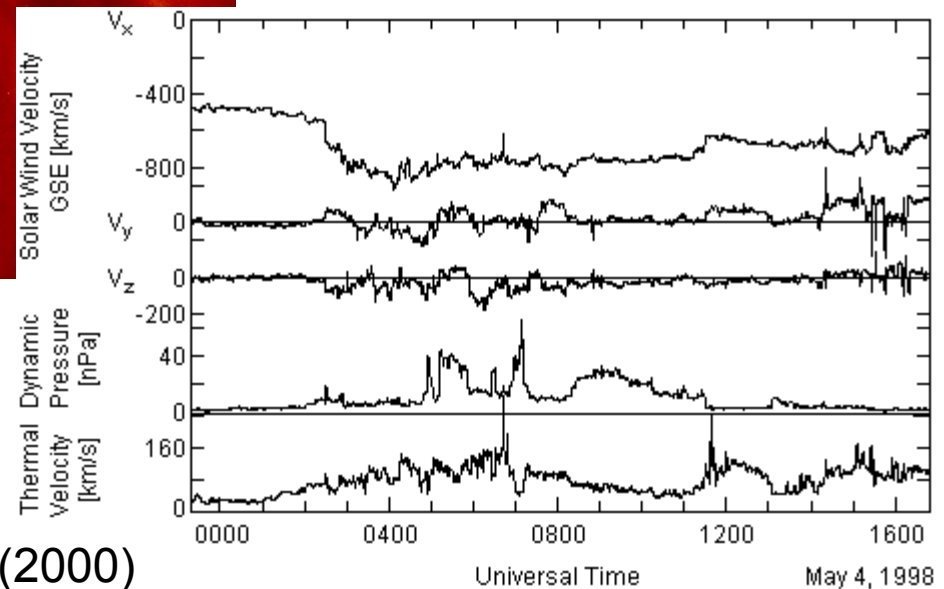


Fig 1b of Russell et al. (2000)  
(WIND data from 4 May 1998)

# Magnetosphere

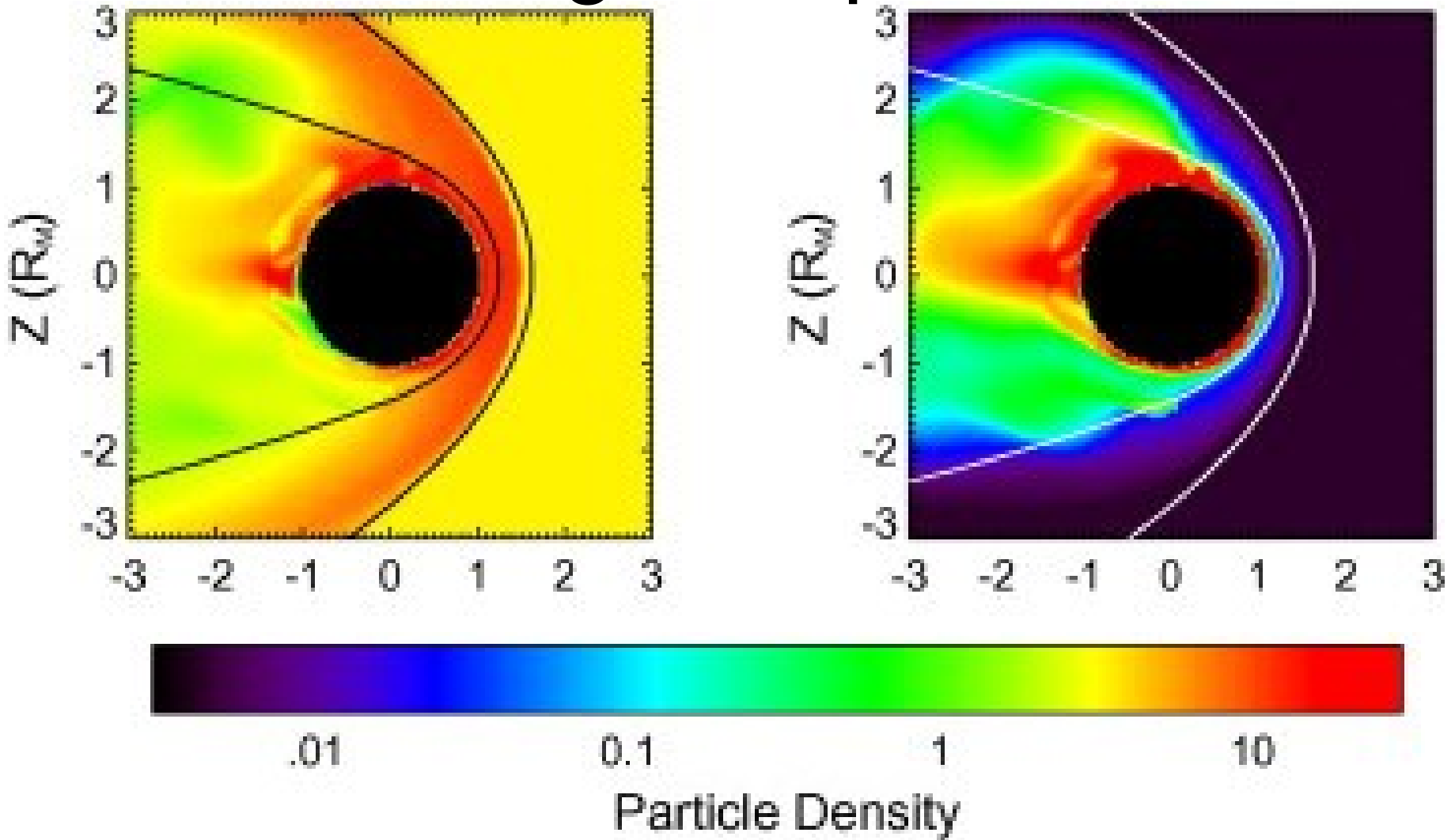


Fig 4 of Brain et al. (2010)

$H^+$  (left) and  $O^+$  (right) densities from Ma MHD model

“Typical” solar wind conditions, no crustal fields

# Ionosphere

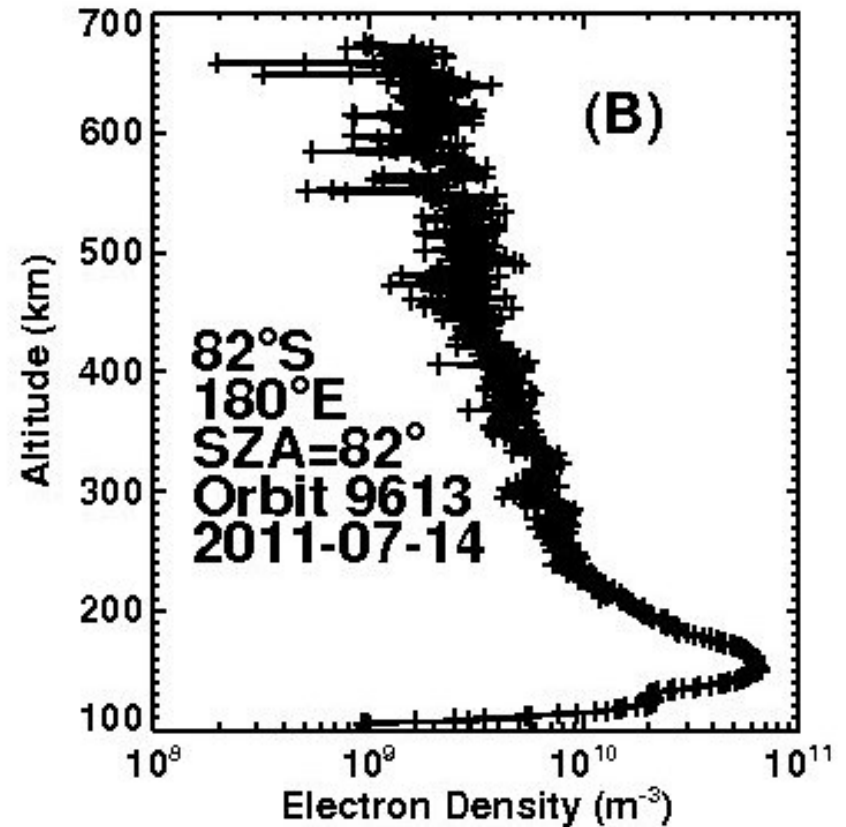
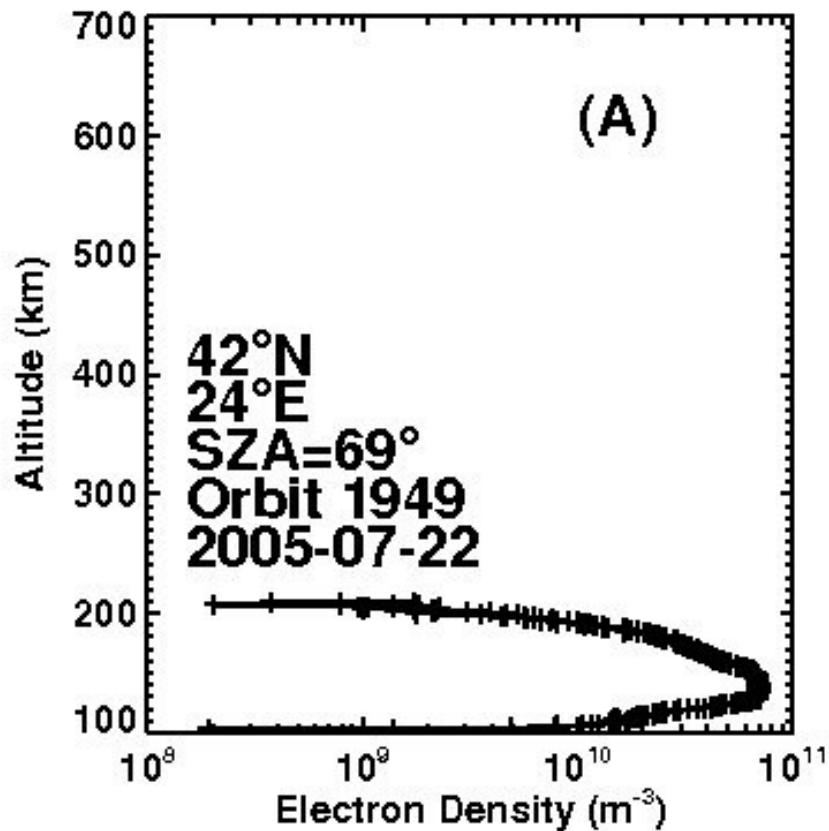
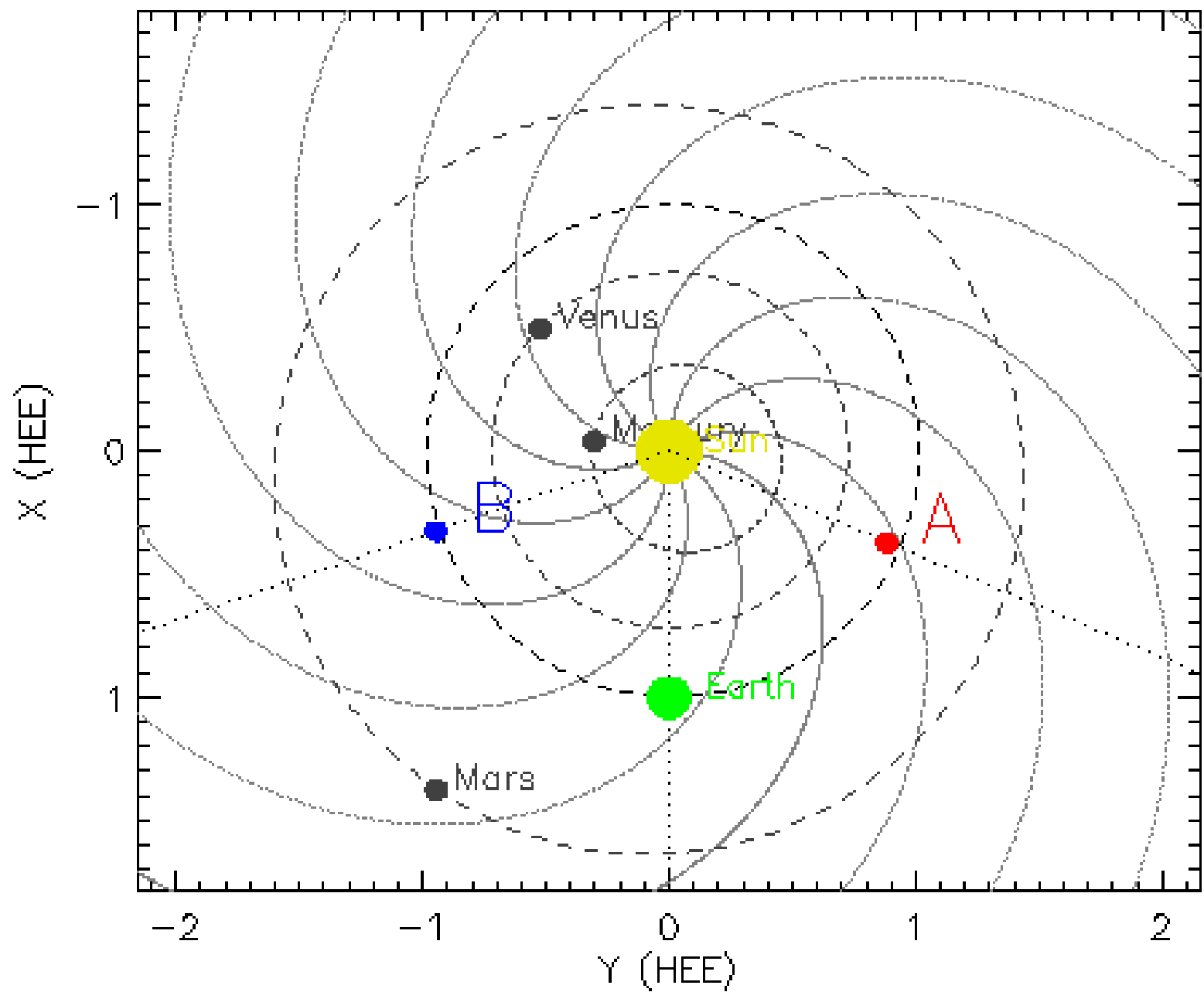


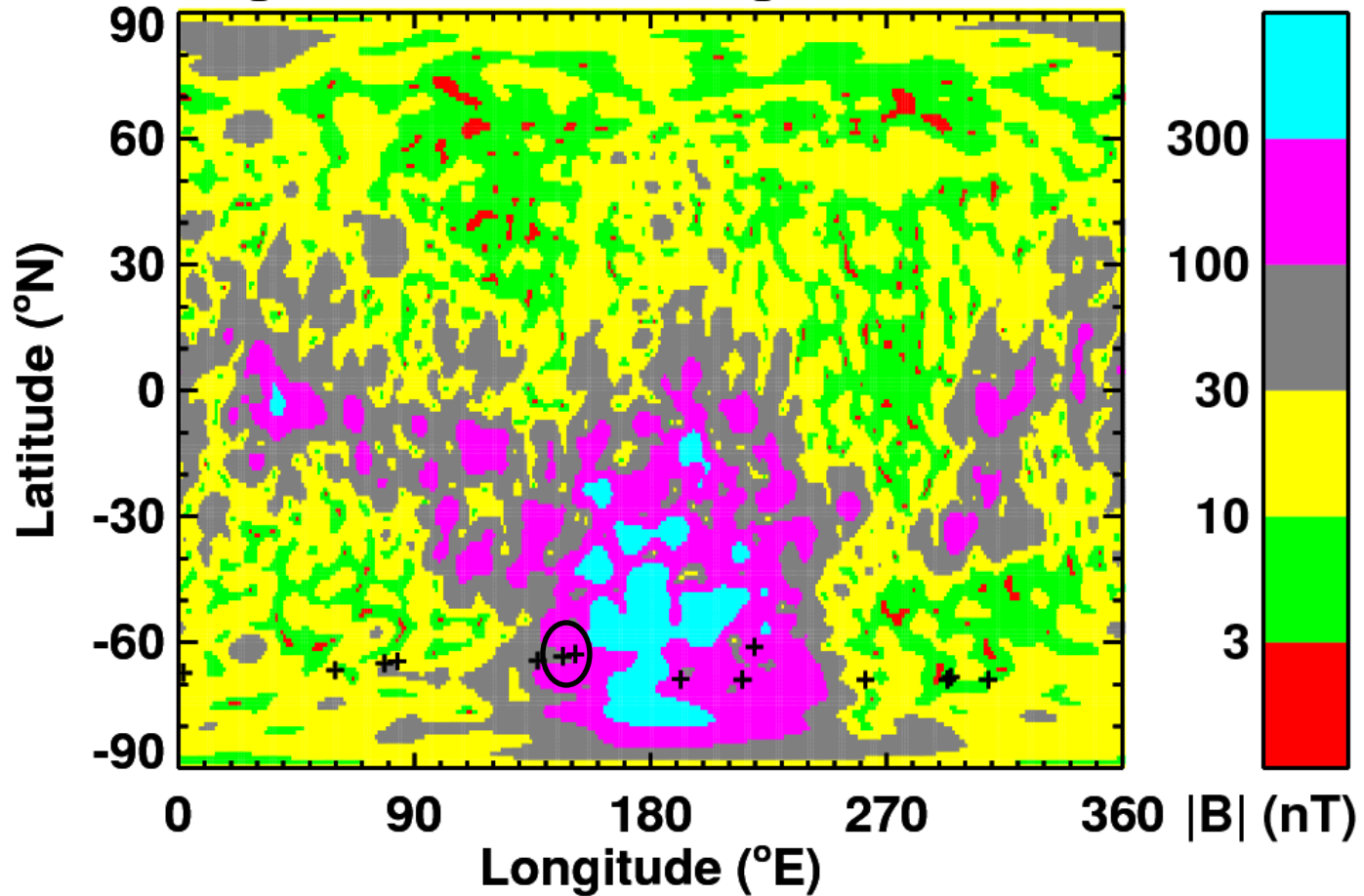
Fig 2 of Withers et al. (2012)  
Variations in the vertical extent of the ionosphere

# Observational study of solar wind, magnetosphere, and ionosphere coupling using Mars Express

- March/April 2010
  - Earth and Mars on same branch of Parker spiral
- Solar wind data
  - WIND extrapolation, ASPERA
- Magnetospheric data
  - ASPERA
- Ionospheric data
  - Radio occultations, MARSIS local densities

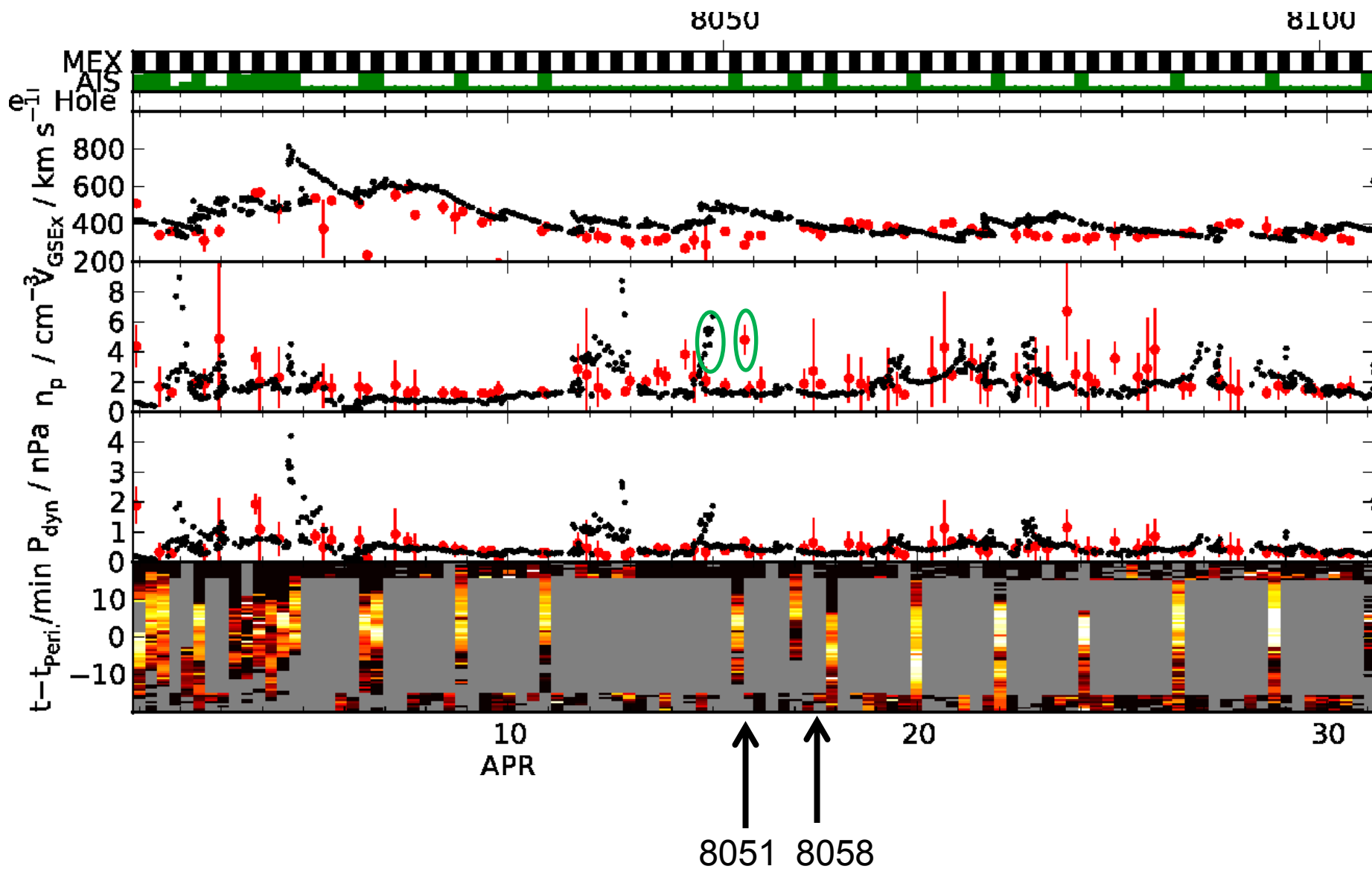


# Magnetic field strength at 150 km



Date and time (UTC)	Day of year	Latitude (°N)	Longitude (°E)	SZA (deg)	Orbit
2010-04-15T12:56:57.764	105	-63.74	145.46	89.39	8051
2010-04-17T13:55:00.771	107	-63.26	150.27	88.99	8058

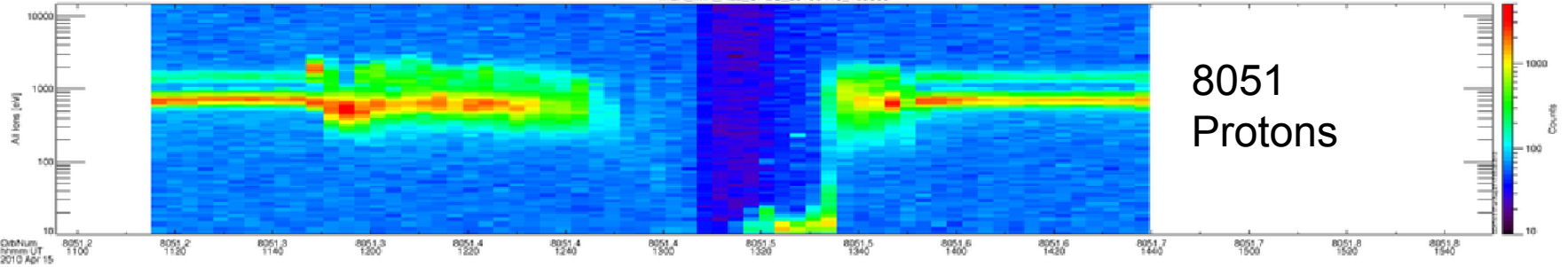
# Solar wind data



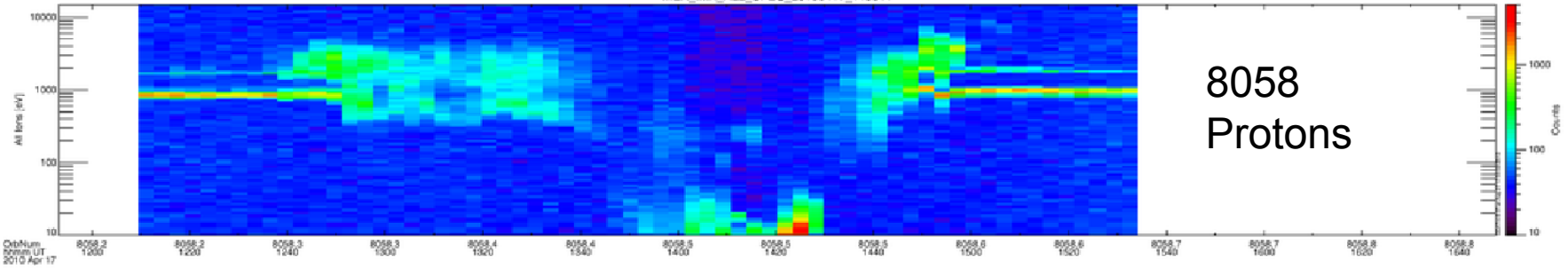


# Magnetospheric data

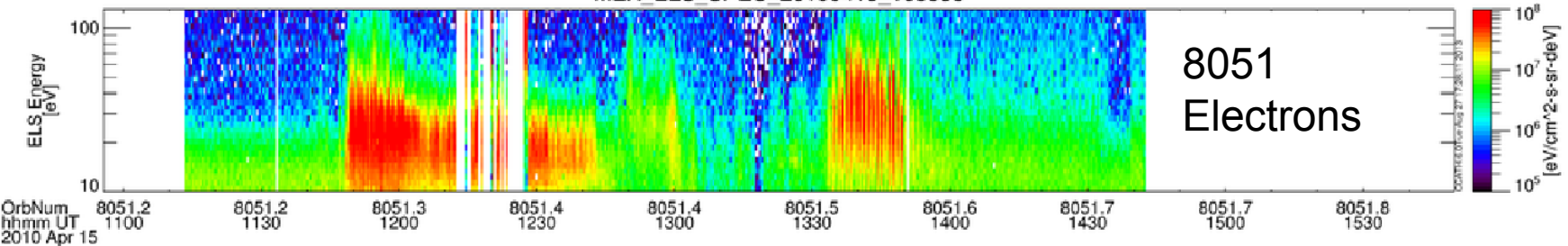
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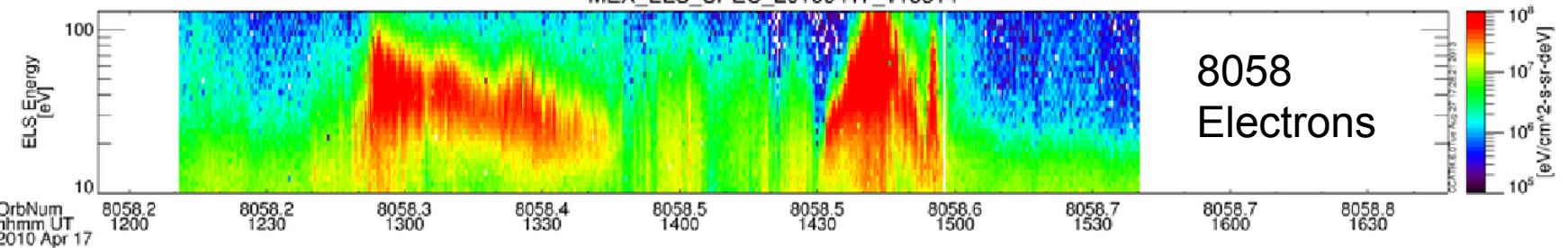
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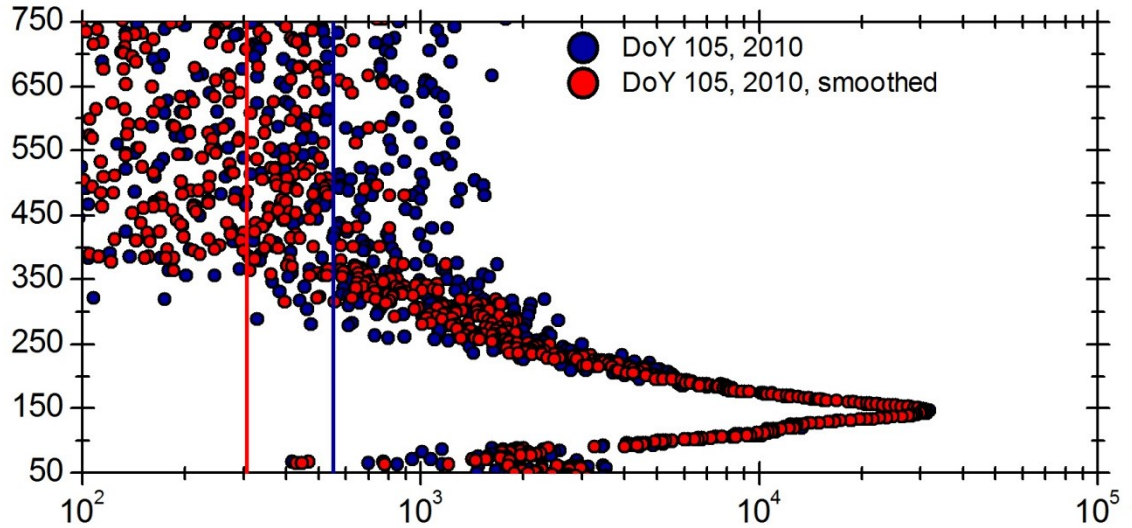
MEX\_ELS\_SPEC\_20100415\_105538



MEX\_ELS\_SPEC\_20100417\_115314



# Ionospheric data

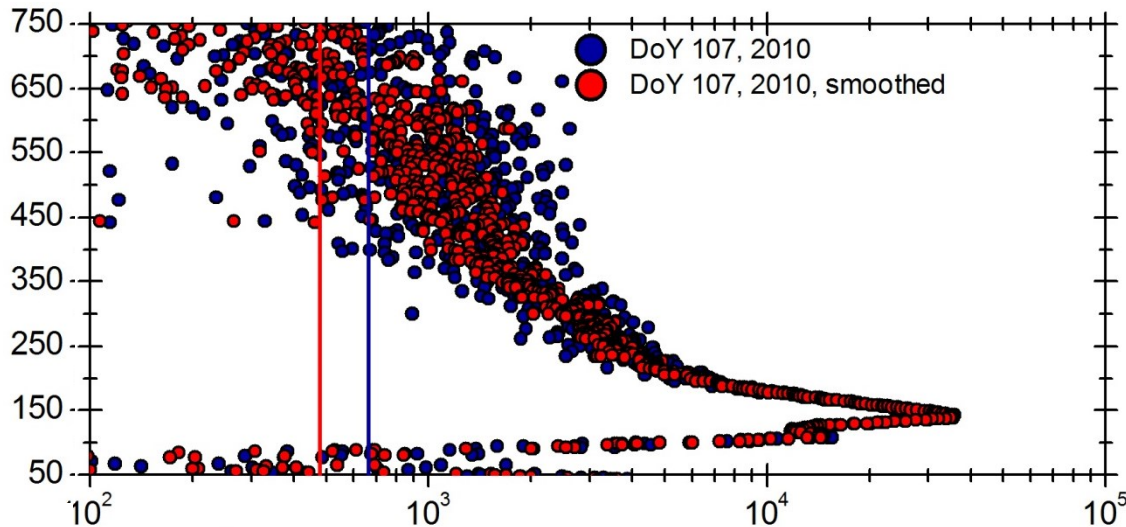


Orbit 8051

Blue – unsmoothed

Red – smoothed

Relatively small topside densities



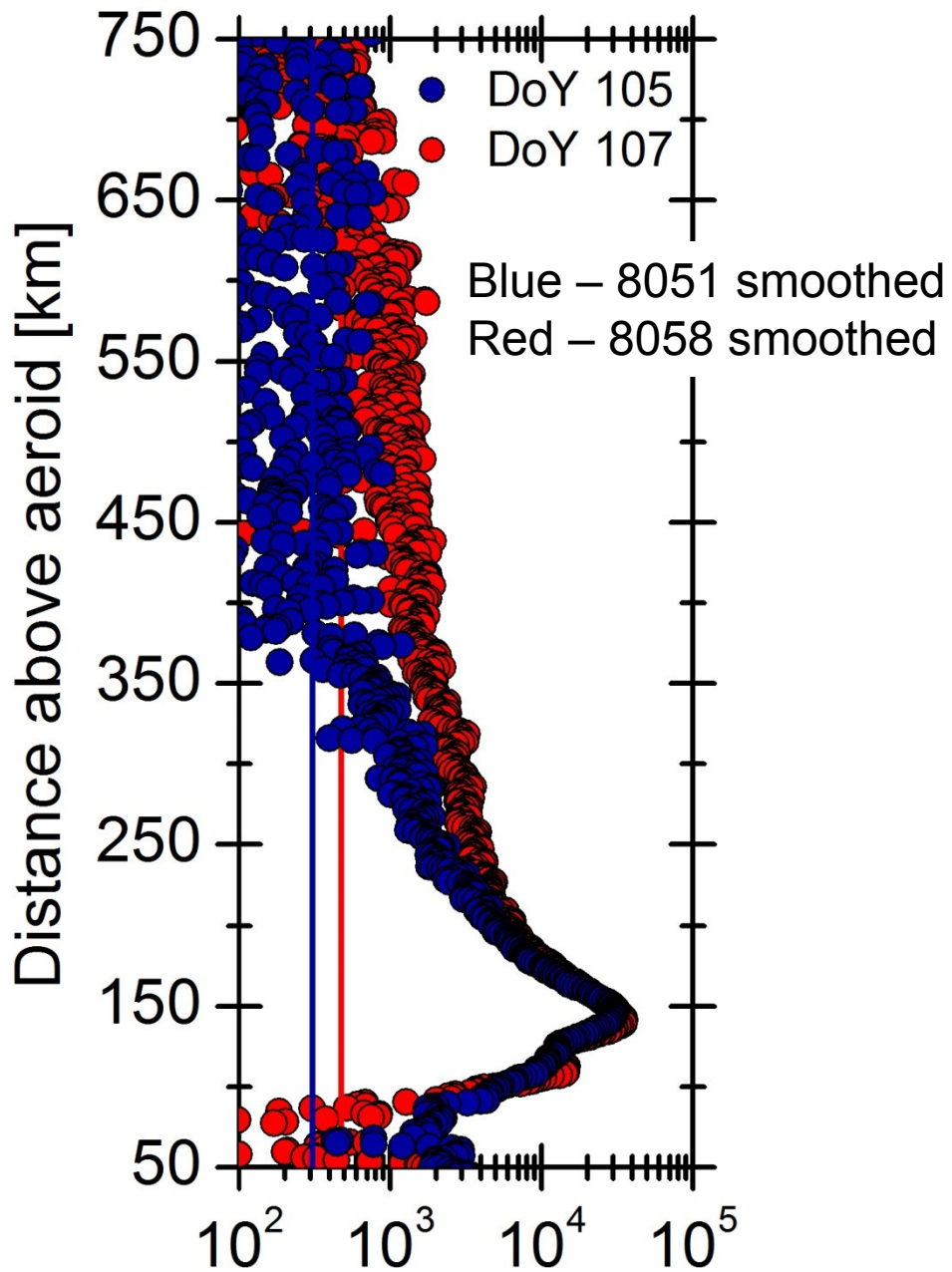
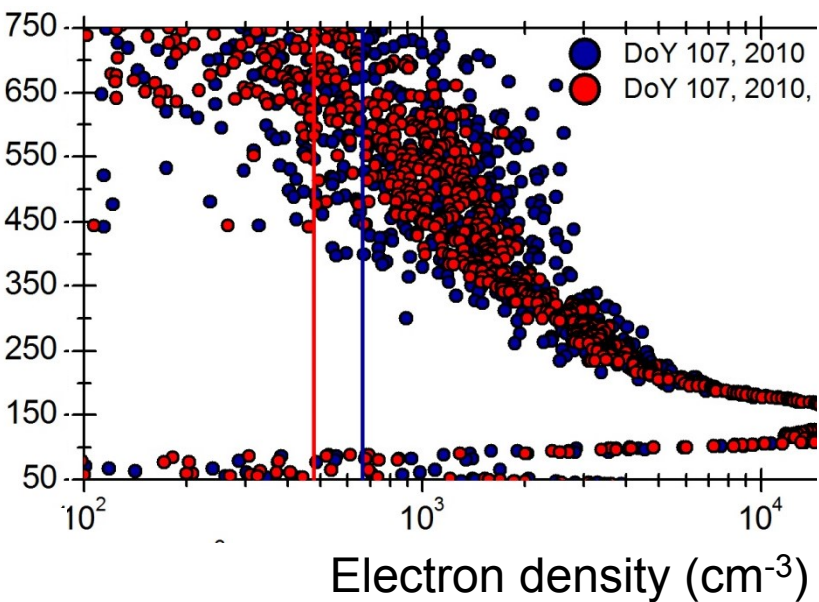
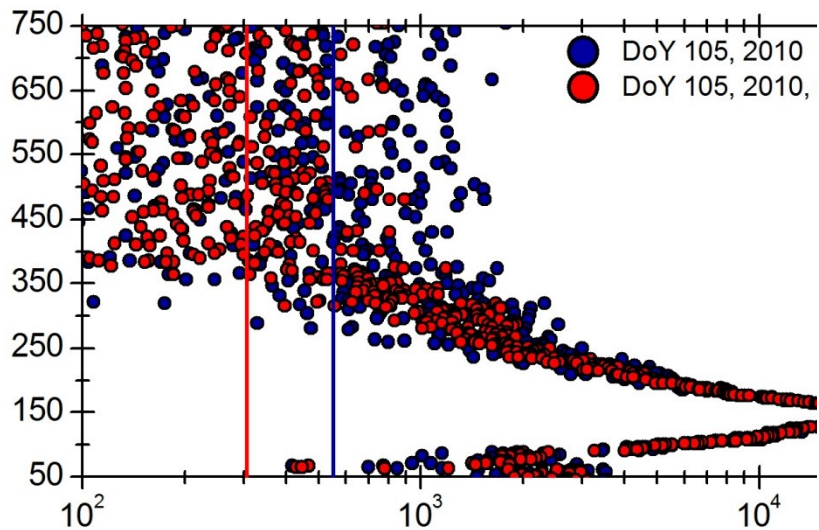
Orbit 8058

Blue – unsmoothed

Red – smoothed

Relatively large topside densities

Electron density ( $\text{cm}^{-3}$ )



# Summary

## Orbit 8051 – Compression

Solar wind dynamic  
pressure relatively high

Magnetosphere relatively  
compressed and  
magnetosheath densities  
relatively enhanced

Ionopause detected by  
MARSIS

Relatively low densities in  
topside ionosphere

## Orbit 8058 – Relaxation

Solar wind dynamic  
pressure relatively low

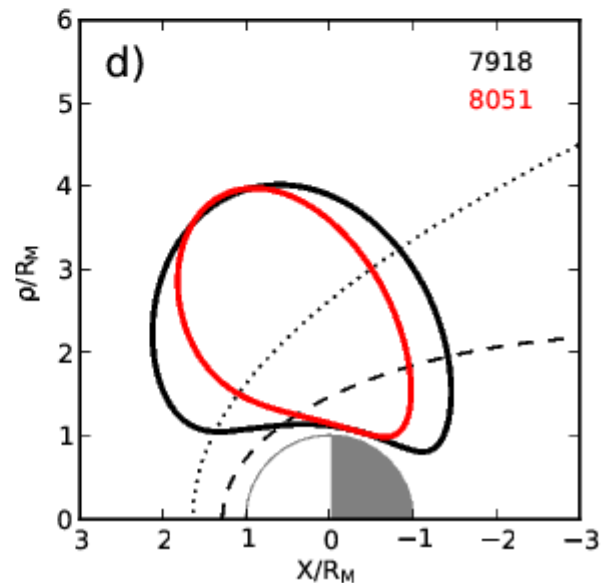
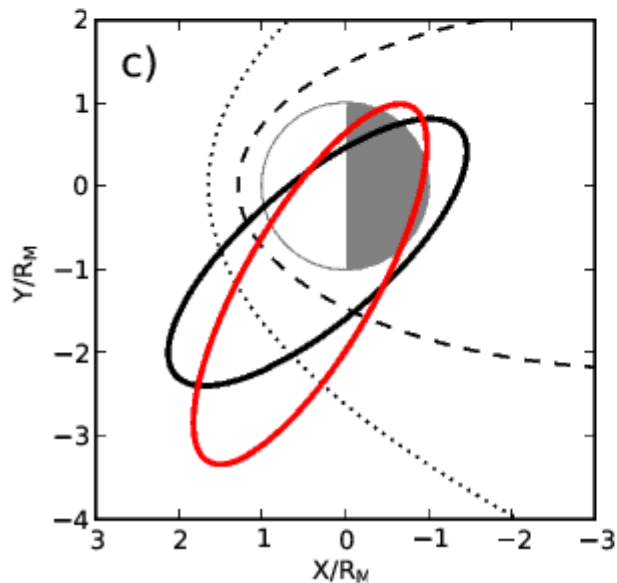
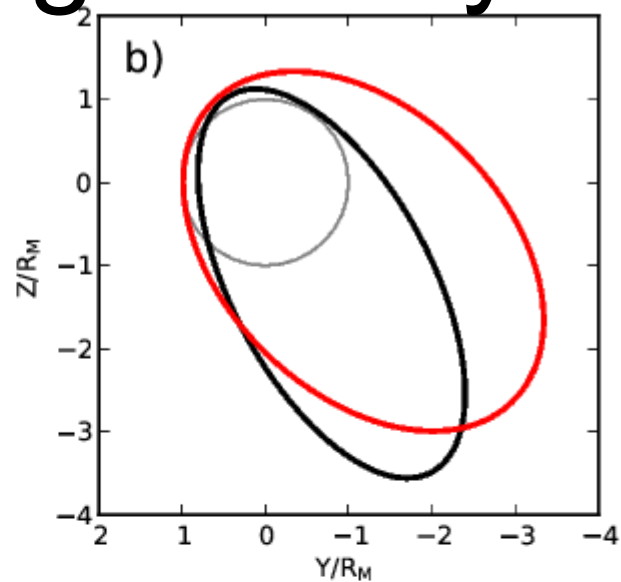
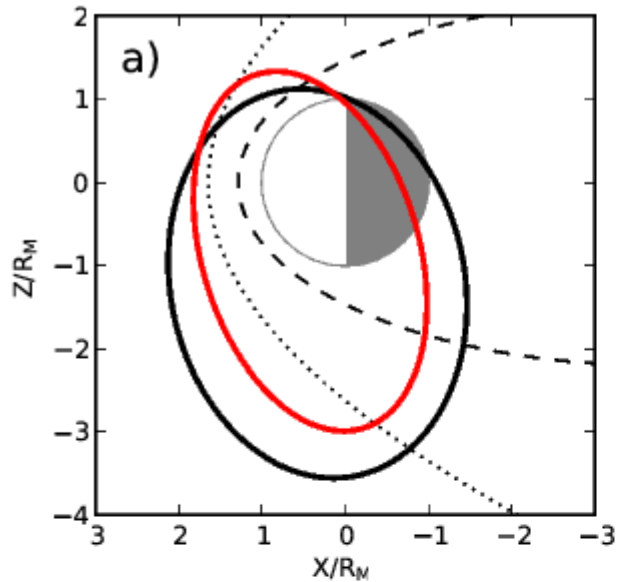
Magnetosphere relatively  
relaxed and magnetosheath  
densities relatively  
diminished

Ionopause not detected by  
MARSIS (orbits 8056, 8059)

Relatively high densities in  
topside ionosphere

# Backup

# MEX orbit geometry



# Solar wind-magnetosphere

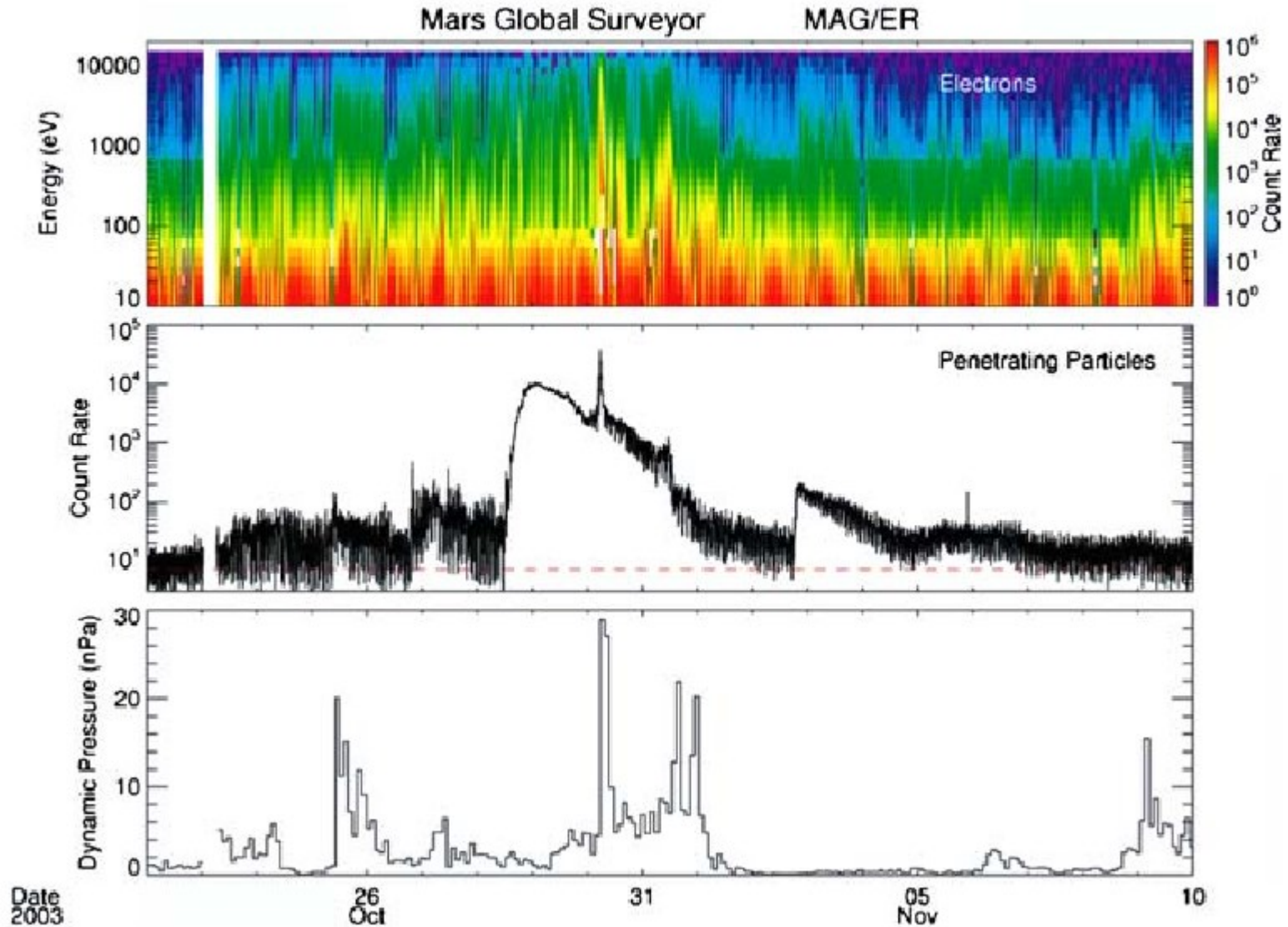


Fig 17 of Brain (2006)  
Halloween 2003 solar events

# Solar wind-ionosphere

Surface reflection visibility with solar inputs

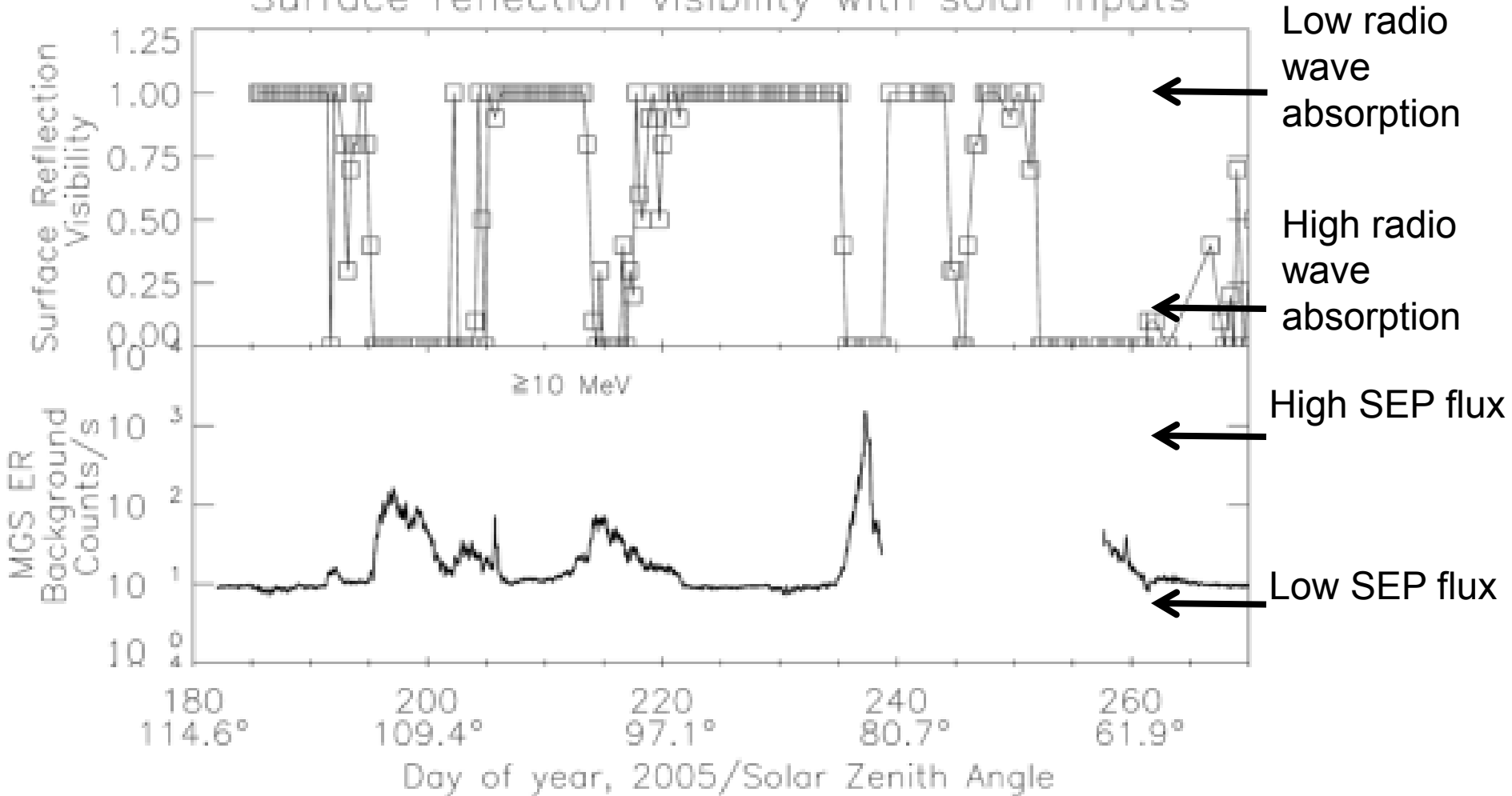


Fig 2 of Morgan et al. (2006)

Strong ionospheric attenuation seen by MARSIS topside radar sounder in SEP events  
Implication – enhanced plasma densities at “low”(?) altitudes during SEP events