

# Mars Upper Atmosphere Network

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Hermann Opgenoorth<sup>4</sup>, and the Mars Upper  
Atmosphere Network

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California, Berkeley, USA, 3-ESA, 4-IRF, Sweden

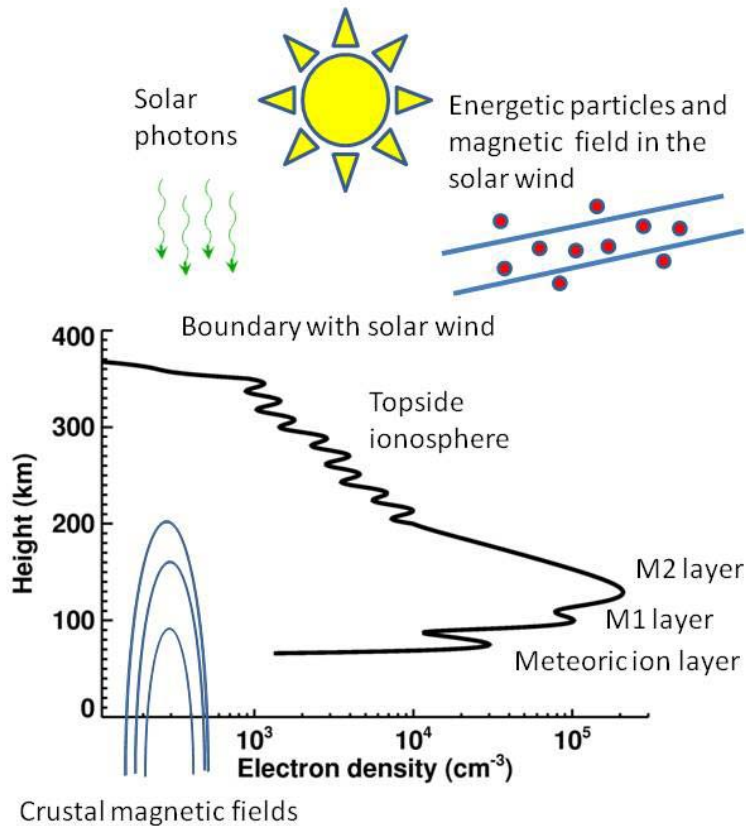
P-84

Tuesday 2010.10.05 16:00-18:00

5th Alfven Conference

Sapporo, Japan

# Mars



- The ionosphere and space environment of Mars form a unique plasma laboratory due to Mars's intense, small-scale crustal magnetic fields
- They are involved in many atmospheric loss processes



# Background

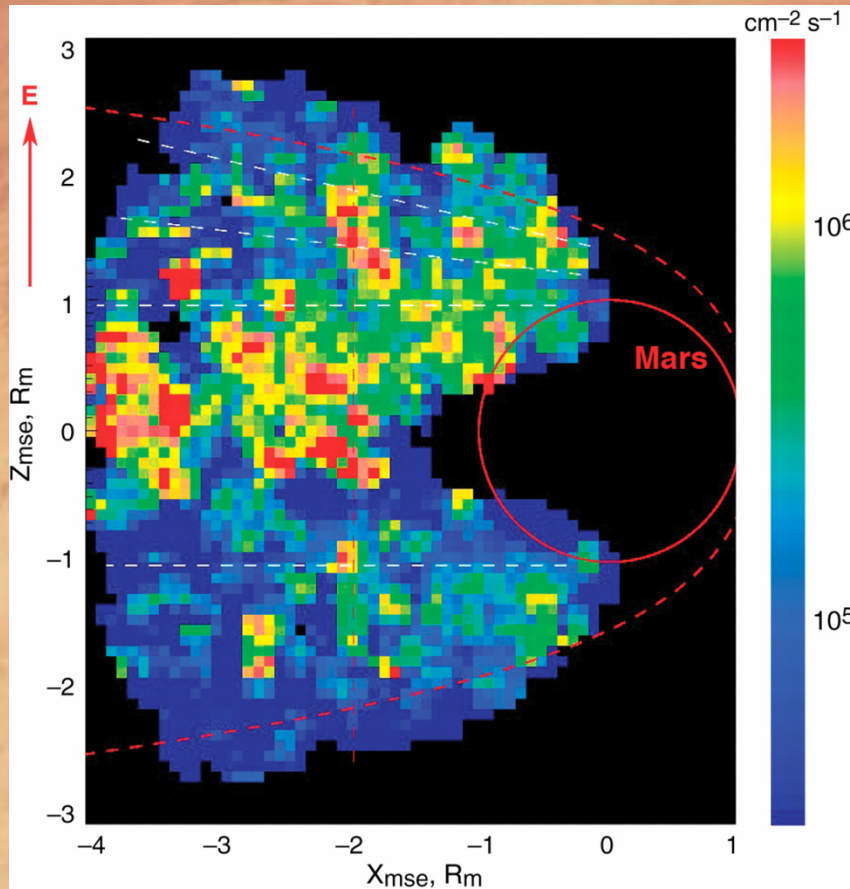
- Mars Express and other spacecraft obtain a wide range of measurements of the complex upper atmosphere, ionosphere, and space environment of Mars
- Collaborations that bring together instrument teams, modellers and others are powerful mechanisms for studying Mars with a broad range of tools, enabling discoveries that cannot be made by isolated groups
- This Network was created as a self-sustaining scientific enterprise in early 2009

# Participants

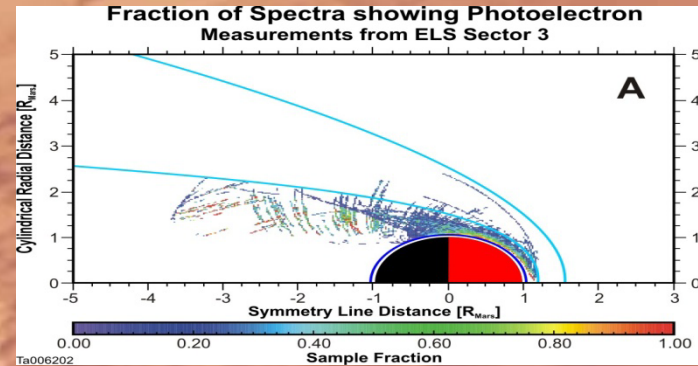
- Convened by Hermann Opgenoorth
- ESA (Olivier Witasse)
- BIRA, Belgium (Cyril Simon)
- LATMOS, France (Francois Leblanc)
- LMD, France (Jean-Yves Chaufray)
- University of Grenoble, France (Wlodek Kofman)
- Cologne University, Germany (Martin Paetzold, Kerstin Peter)
- Max Planck, Germany (Edik Dubinin, Markus Fraenz, Erling Nielsen)
- University of Rome, Italy (Roberto Orosei, Giovanni Picardi)
- IAA, Spain (Francisco Gonzalez-Galindo)
- IRF, Sweden (Stas Barabash, Niklas Edberg, Hermann Opgenoorth, Lisa Rosenqvist)
- University of Lancaster, UK (Mathew Beharrell)
- University of Leicester , UK (Ranvir Dhillon, Mark Lester, Steve Milan)
- Boston University, USA (Majd Matta, Paul Withers)
- University of California, Berkeley, USA (Dave Brain, Matt Fillingim, Rob Lillis)
- University of Iowa, USA (Firdevs Duru, Dave Morgan)



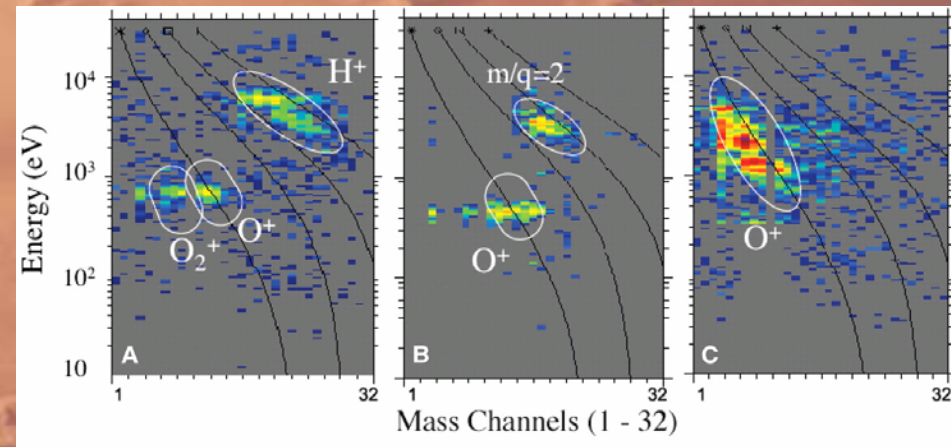
# MEX ASPERA (Energetic particles)



Escape fluxes of  $O^+$ ,  $O_2^+$ ,  $CO_2^+$

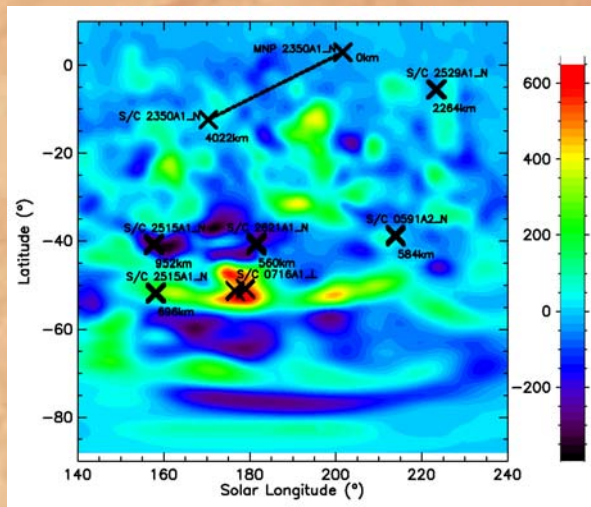
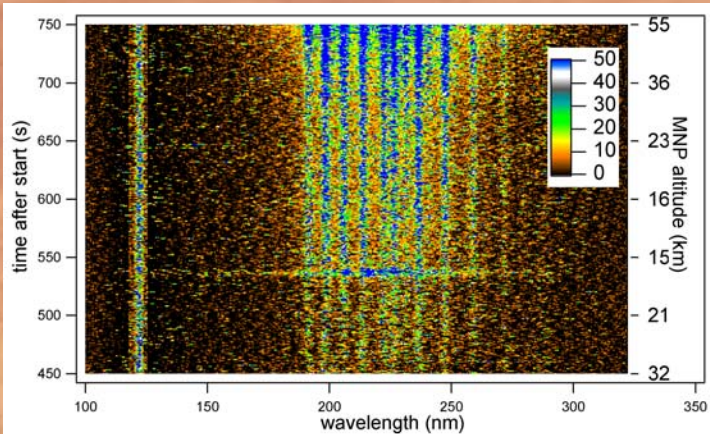


Photoelectron measurements

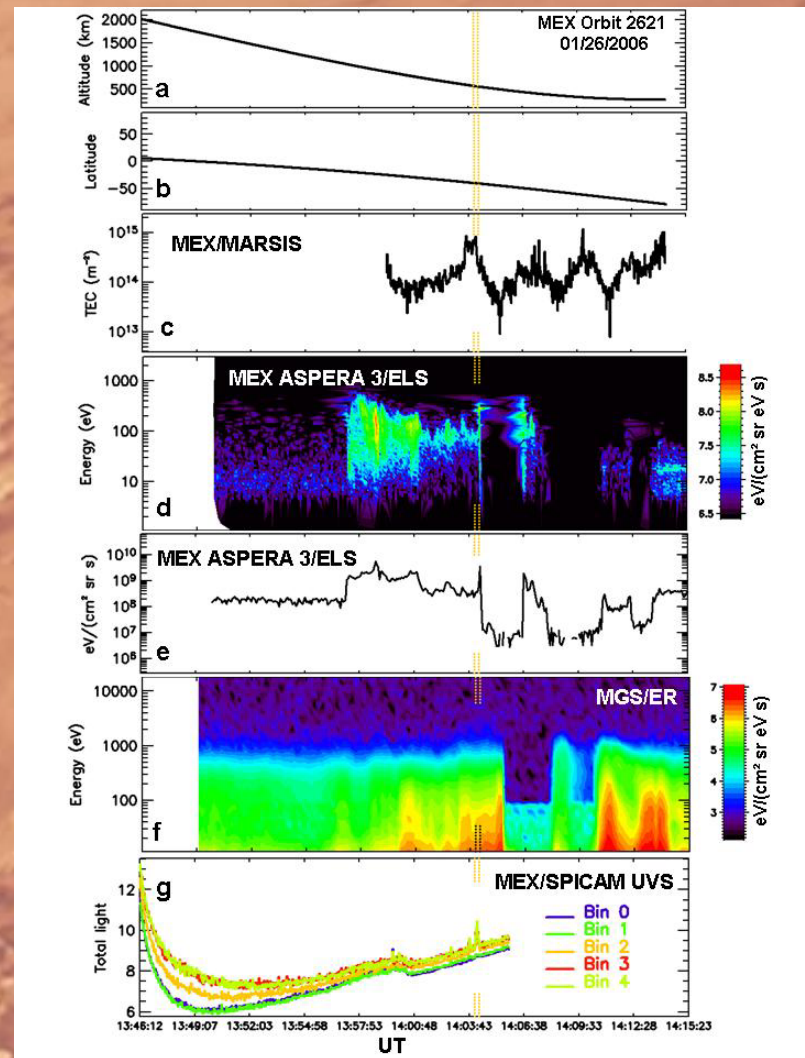


Three example energy spectra

# MEX SPICAM (UV spectrometer)



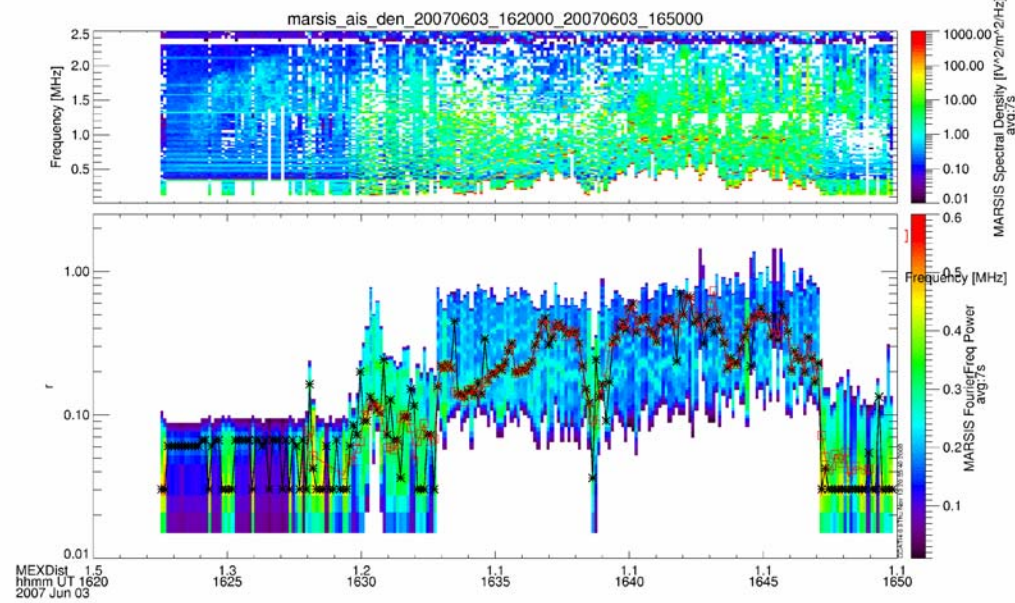
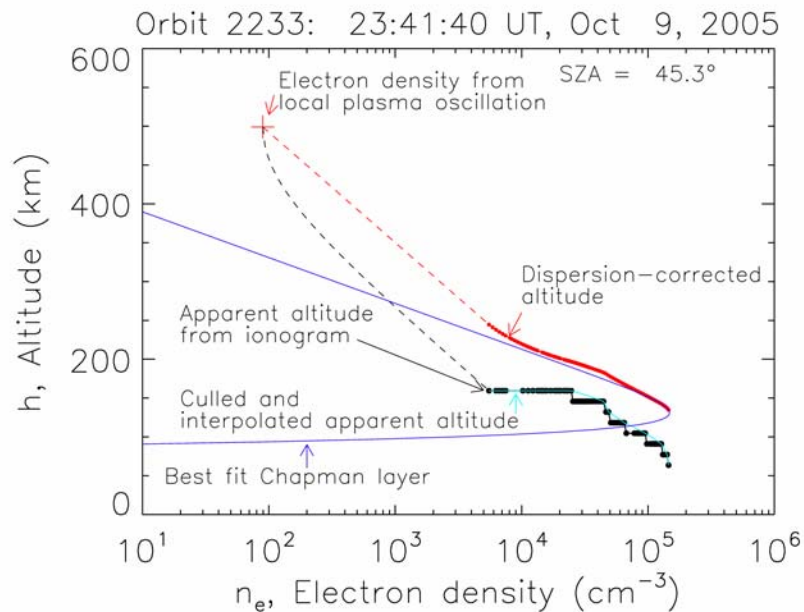
Observations of aurora at magnetic cusps



Observational context



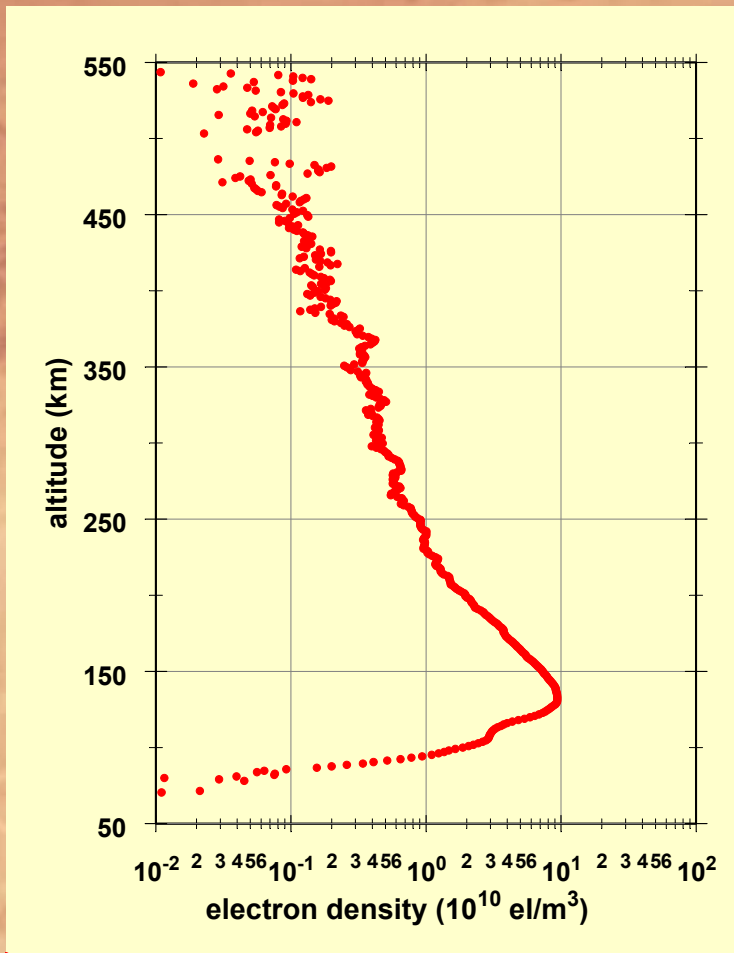
# MEX MARSIS (Radar sounder)



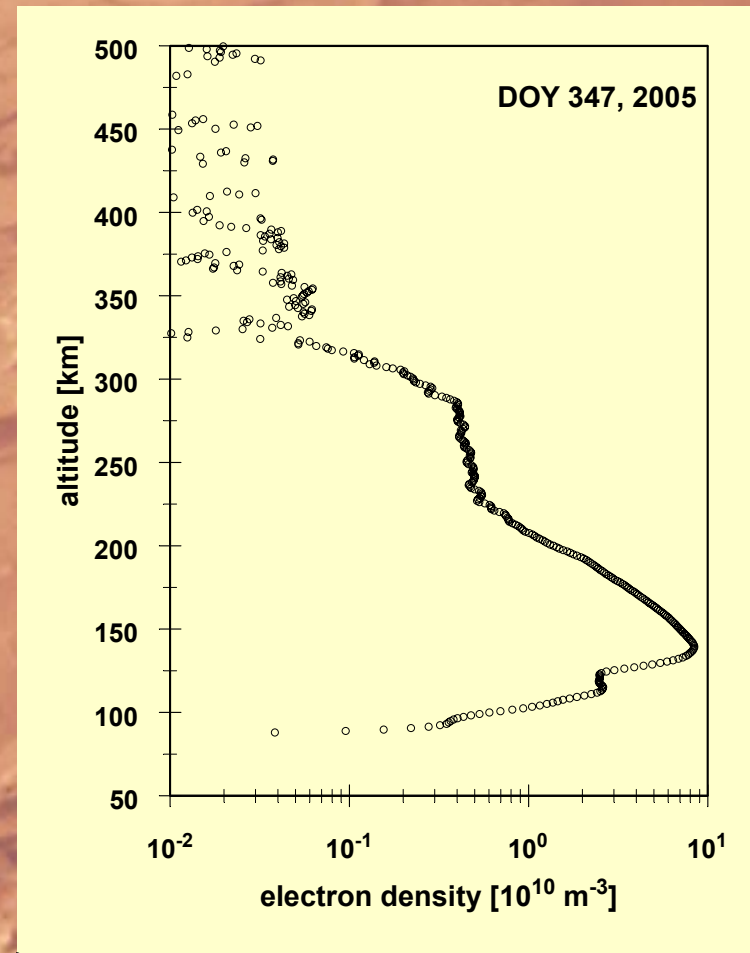
Many topside ionospheric profiles

Local measurements of plasma density and magnetic field strength

# MEX MaRS (Radio science)



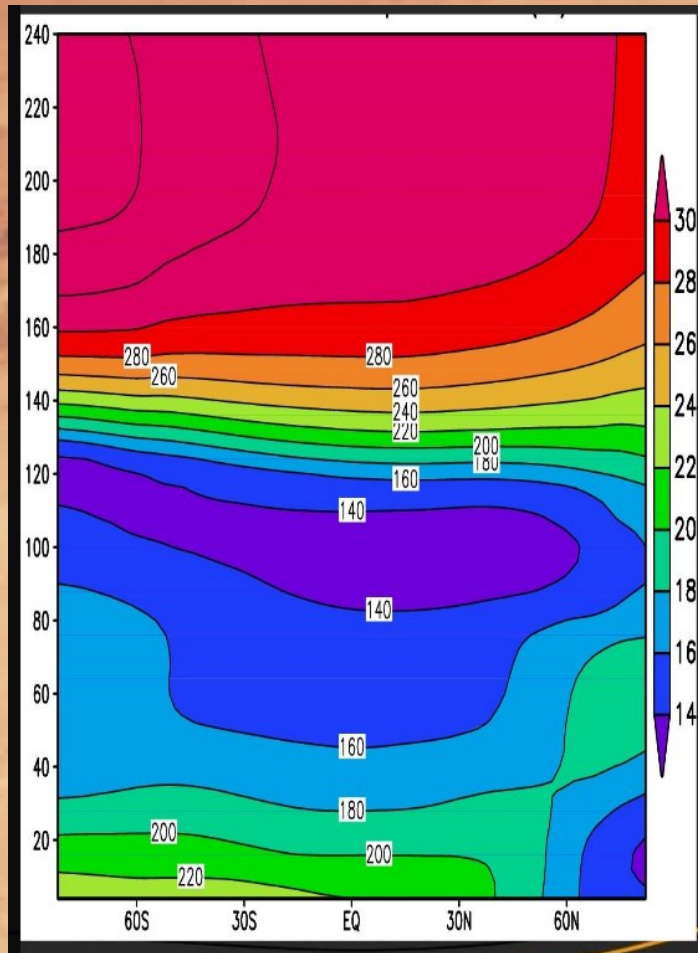
High resolution profiles of entire ionosphere



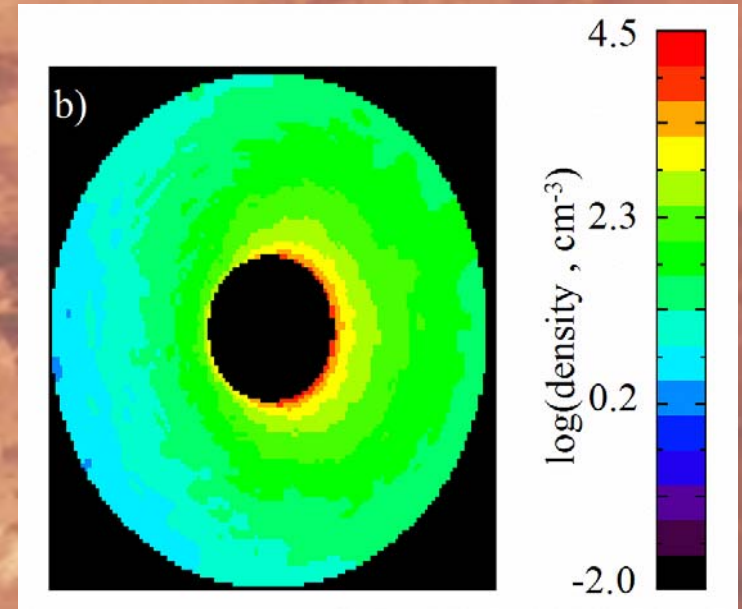
Variable ionopause



# Thermosphere/exosphere simulations



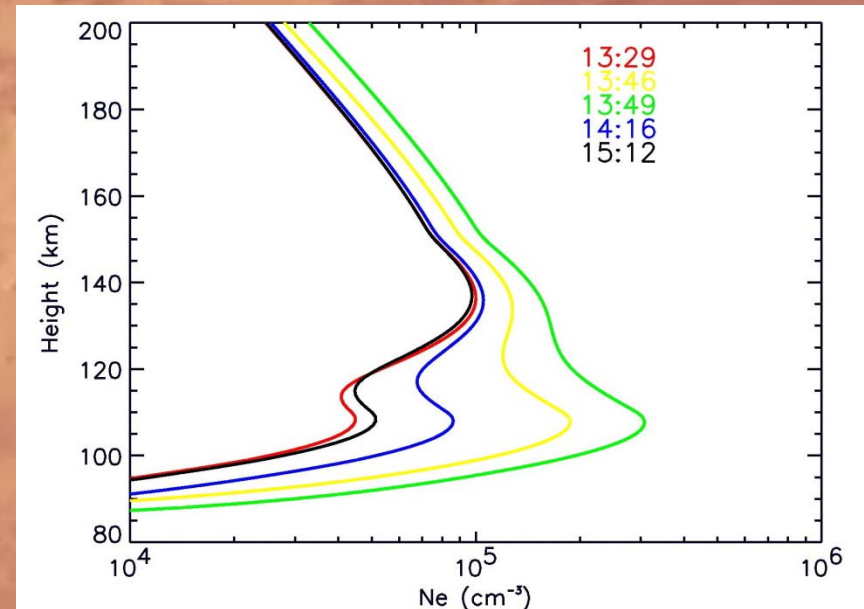
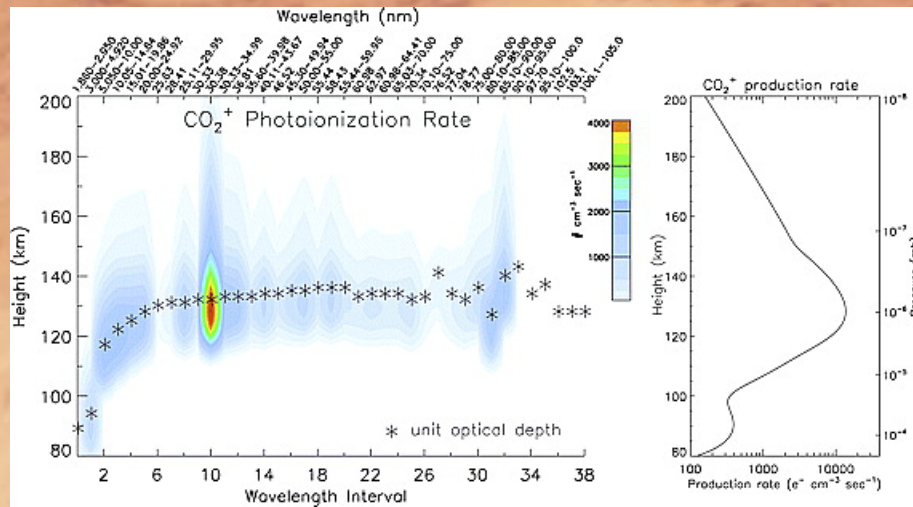
Temperatures from general circulation model



Hot oxygen densities in equatorial plane at solar maximum

# Ionospheric simulations

Peak of solar flare at  
13:49 on 15 April 2001

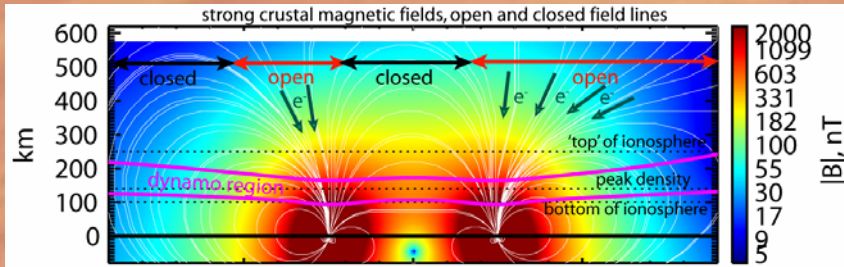


1-D simulations with ion photochemistry  
and ion transport

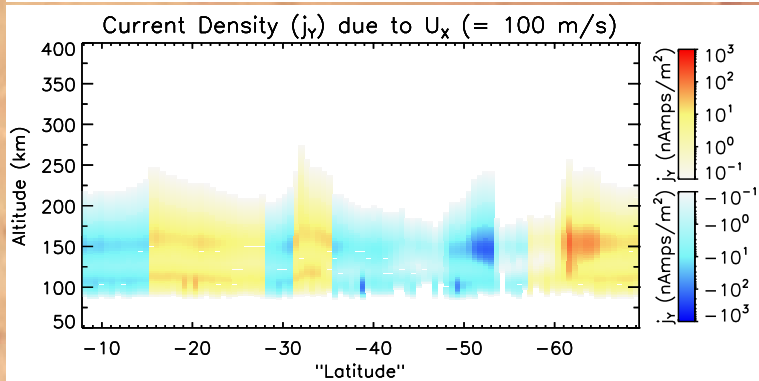
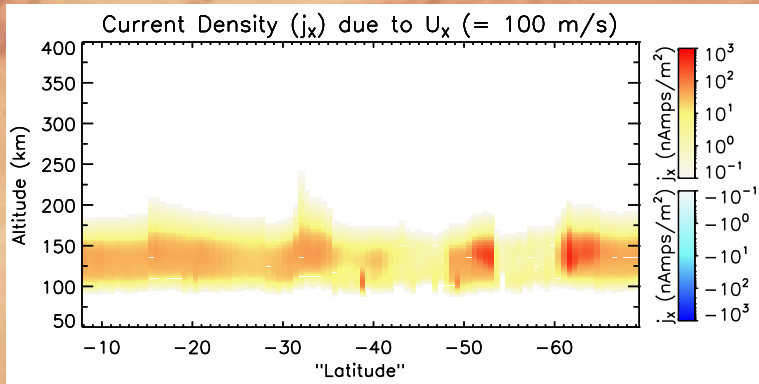
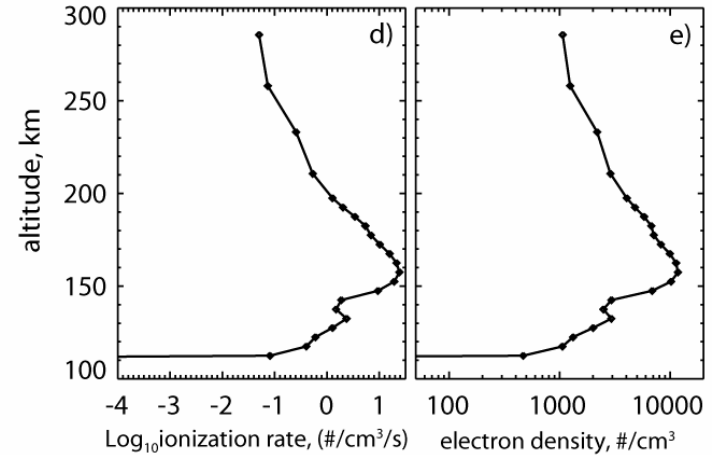
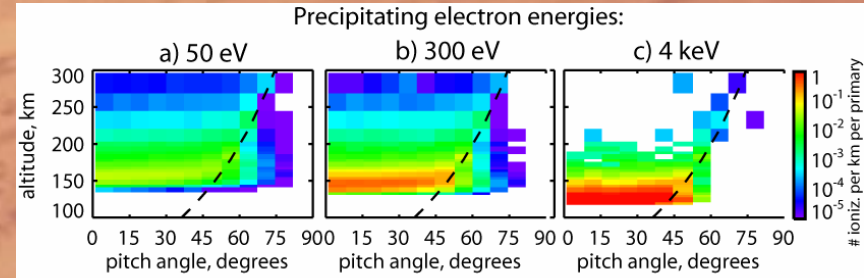
Simulating ionospheric response to a  
solar flare using time-dependent solar  
irradiance



# Electron transport models



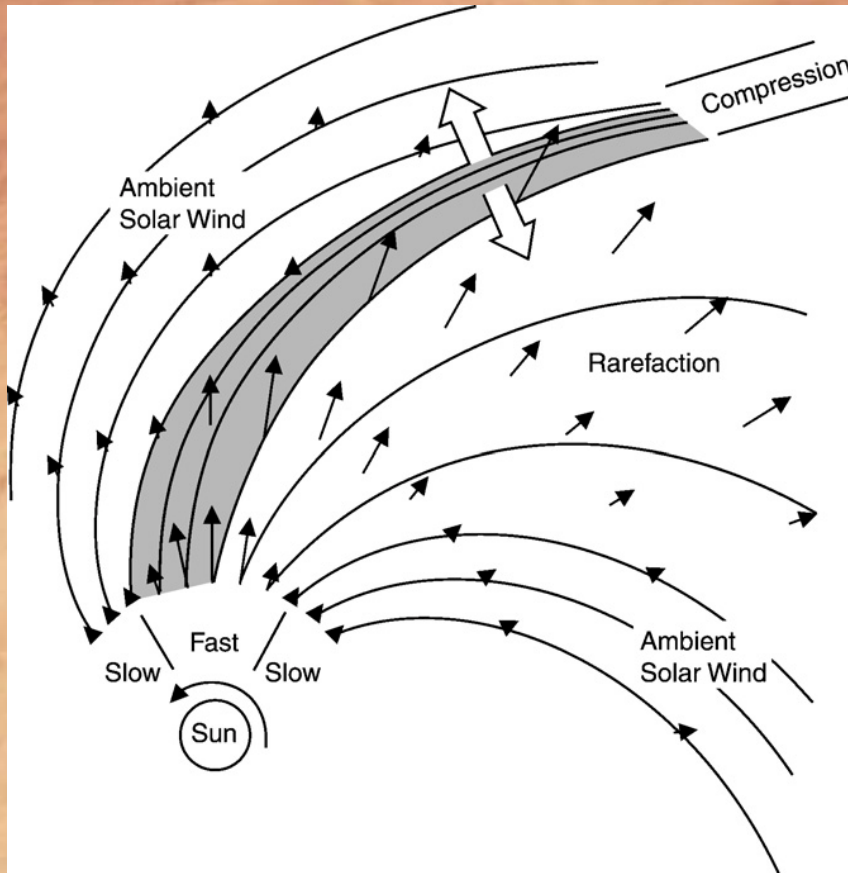
Complex dynamo region predicted



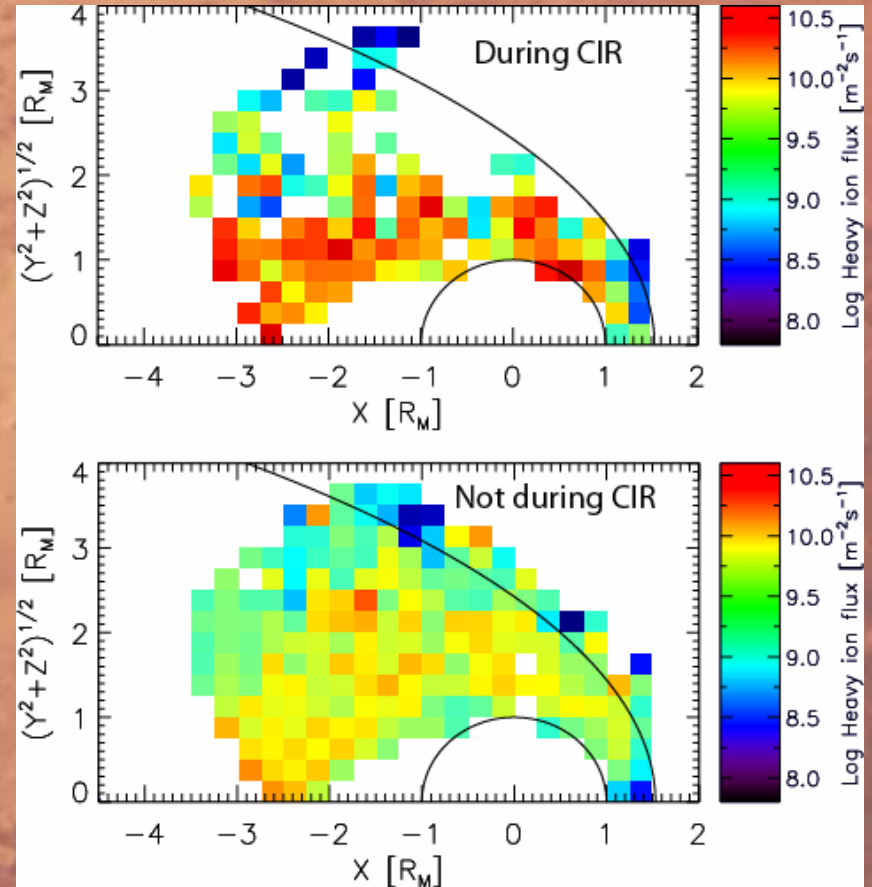
Formation of nightside ionosphere due to precipitating electrons

Ionospheric currents due to neutral winds and complex magnetic field morphology

# Atmospheric escape



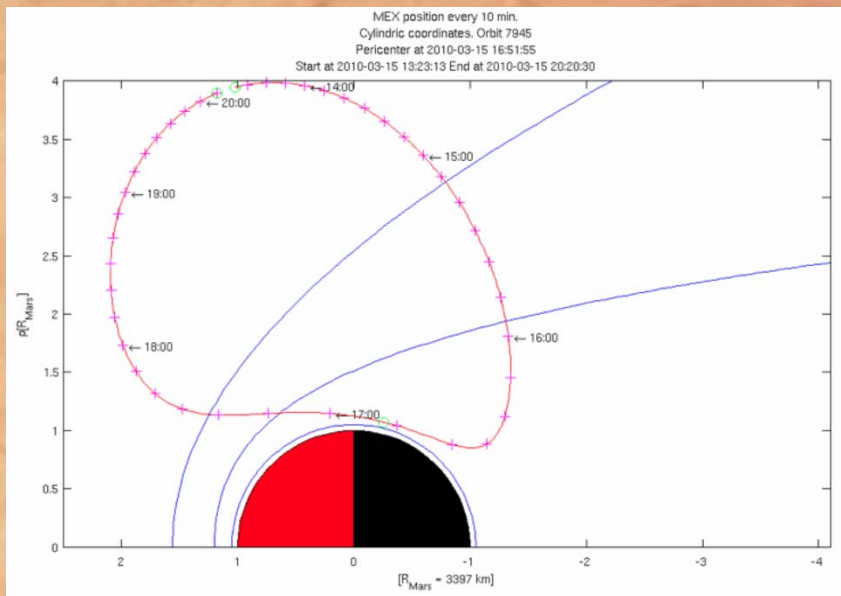
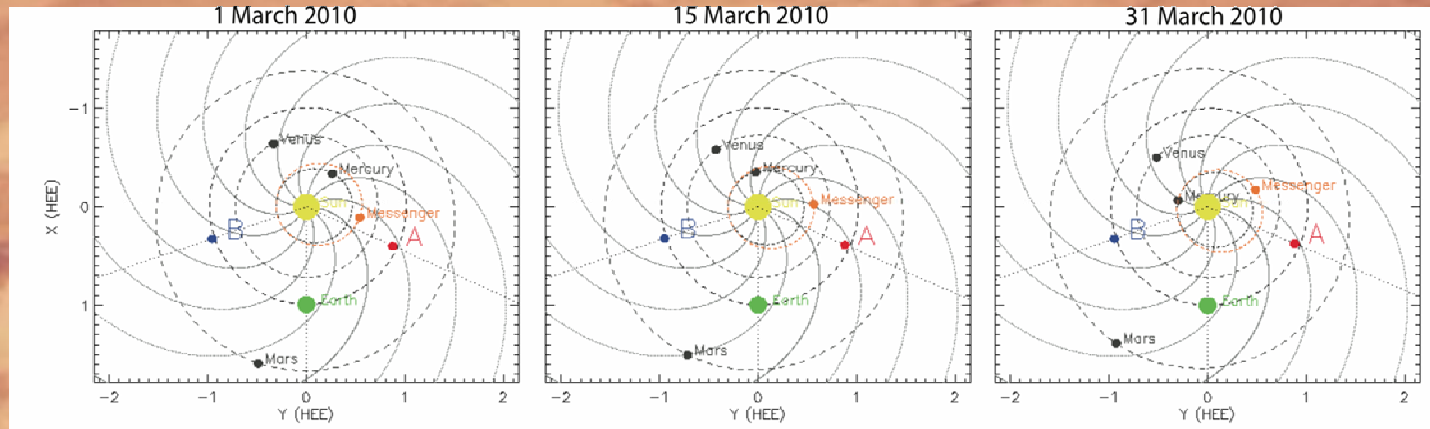
Corotating interaction region (CIR)  
in solar wind



Heavy ion escape flux doubles during CIRs



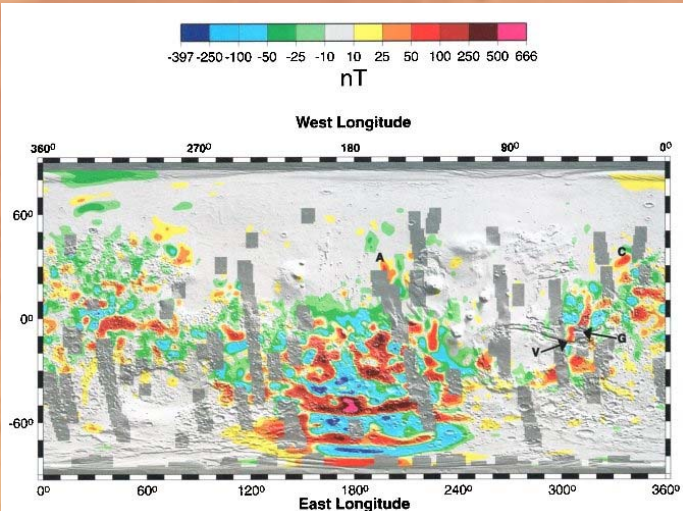
# MEX Campaign – March 2010



Earth and Mars on same arm of Parker spiral

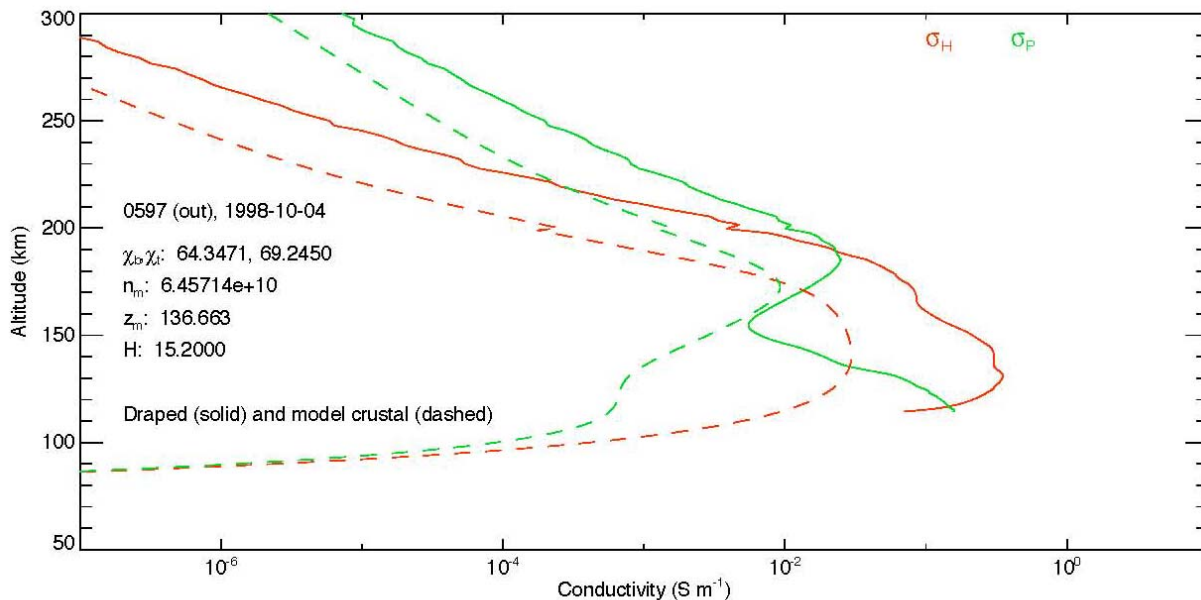
Extensive and coordinated MEX observations of upper atmosphere, ionosphere and space environment are planned

# Focus - Electrodynamics



Crustal magnetic fields at 200 km altitude

Field strength, local field direction, and topology (connection with solar wind) vary over short distances, which creates complexity.

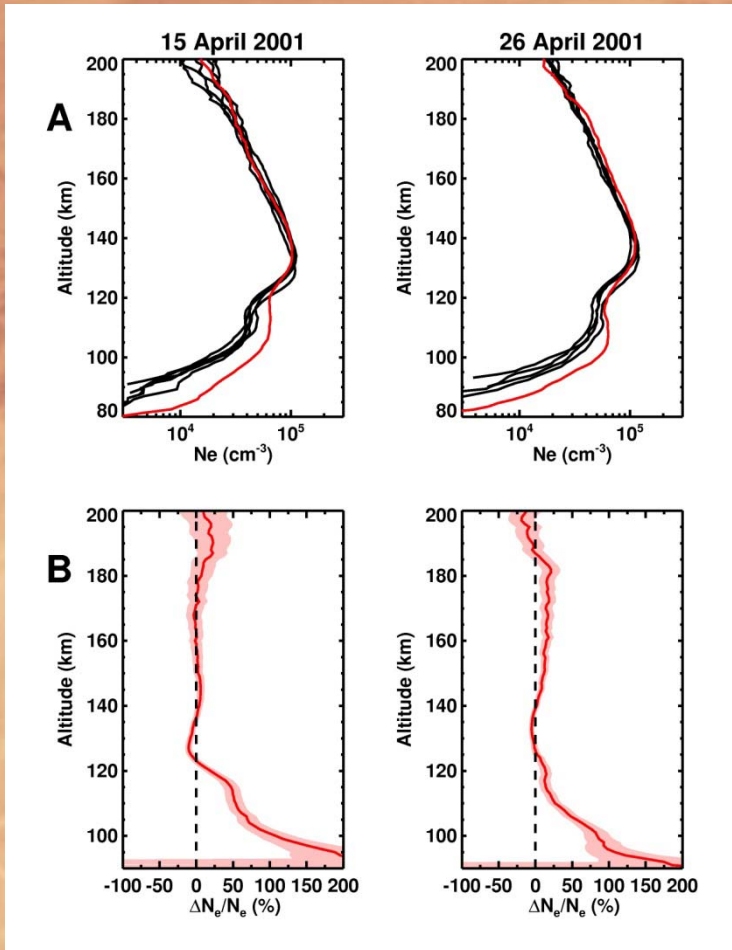


Hall (red) and Pedersen (green) conductivities change between strong field regions (dashed lines) and weak field regions (solid lines)

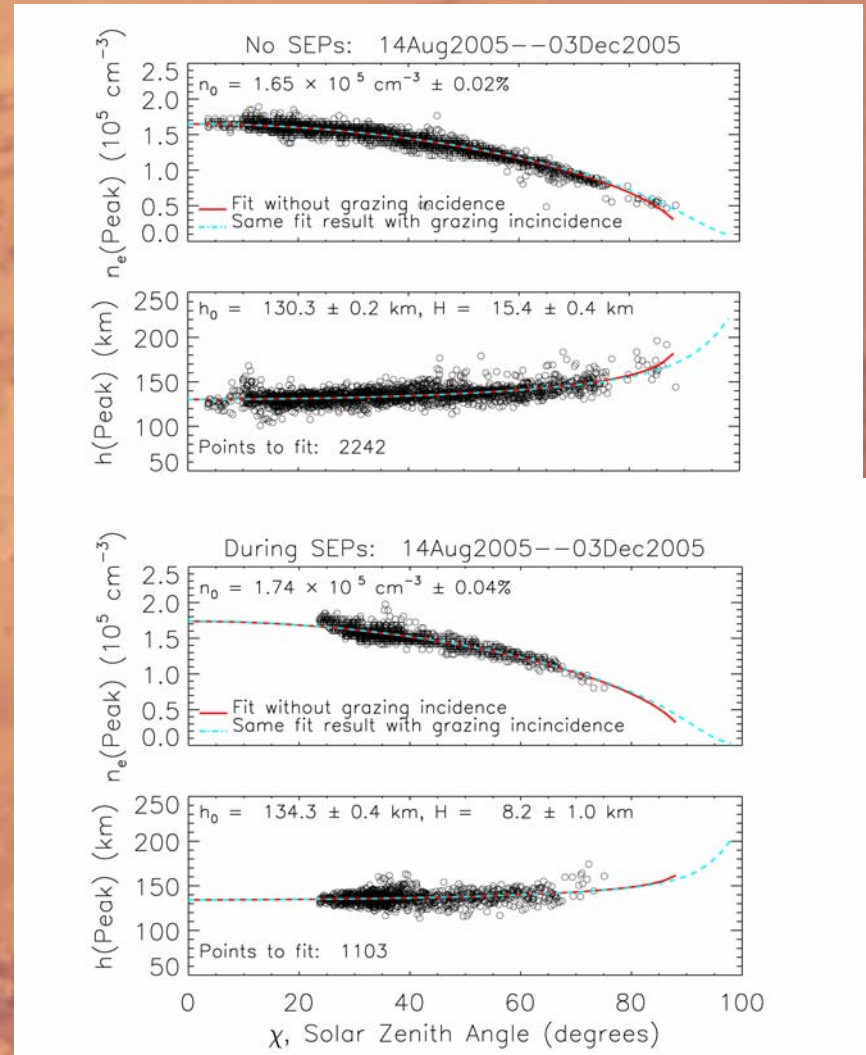
Variable ionospheric conductivity leads to variable ionospheric currents and field aligned currents.



# Focus – Solar variations



Ionospheric profiles shortly after a solar flare show enhanced electron densities below 120 km



Ionospheric properties change during solar energetic particle (SEP) events

# For more information

- This is an open network, other participants are welcome
- Please contact Hermann Opgenoorth ([opg@irfu.se](mailto:opg@irfu.se)) or Olivier Witasse ([owitasse@rssd.esa.int](mailto:owitasse@rssd.esa.int))