Research at Boston University on the upper atmosphere of Mars

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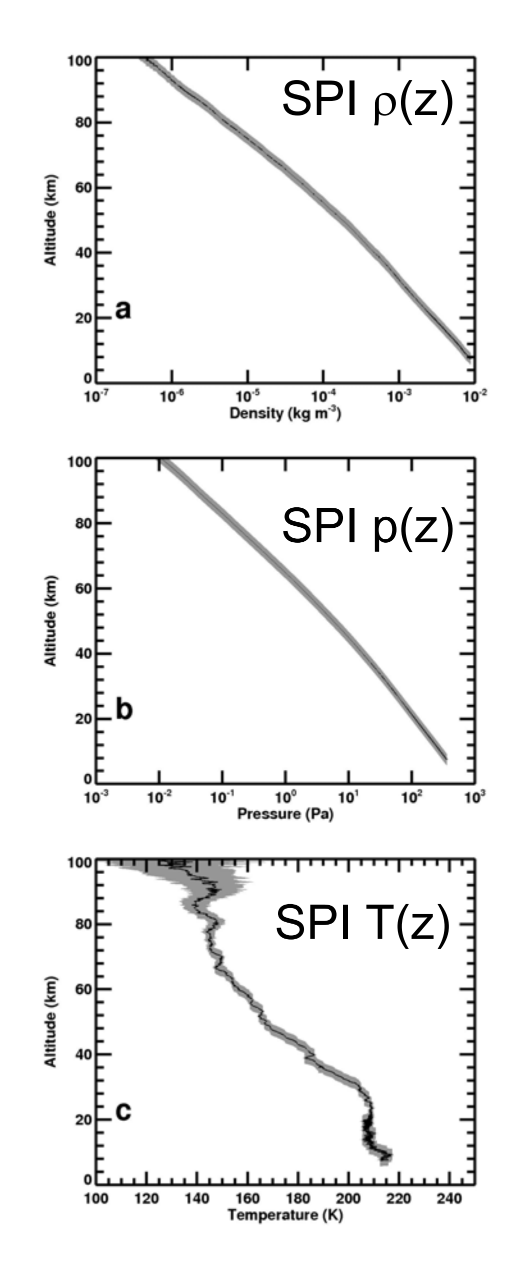
People

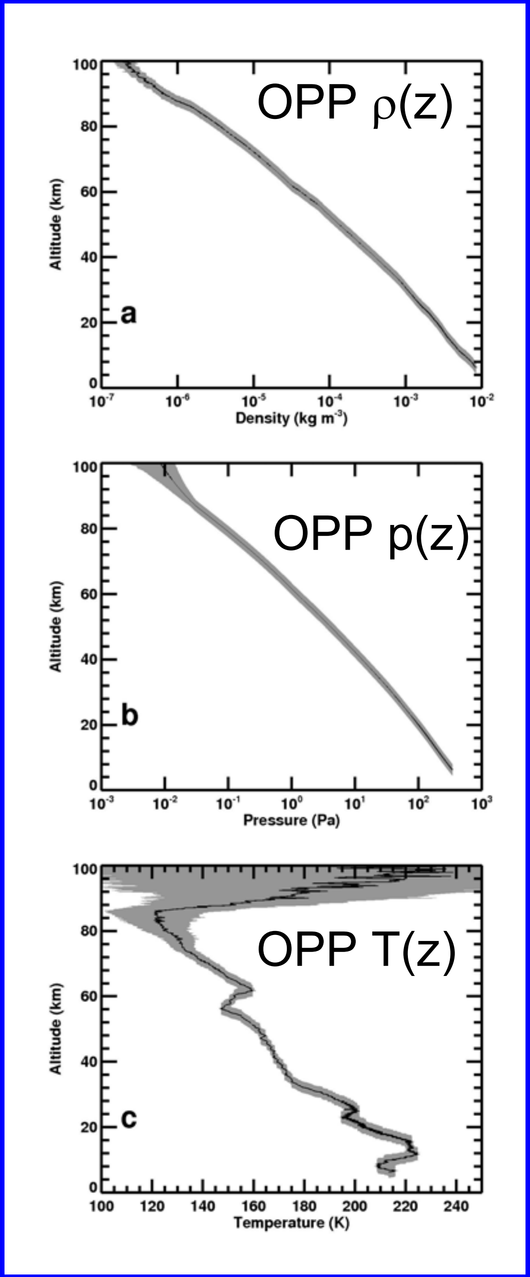
- Michael Mendillo
  - Professor, research on ionospheres, lots of terrestrial experience
- Paul Withers
  - Postdoc, data analysis for atmospheres and ionospheres, some modelling experience, some mission experience
- Majd Matta
  - Graduate student, has looked at comparative modelling of planetary ionospheres, will soon be introducing twisted magnetic fields into existing model of the martian ionosphere
- Other postdocs in our group collaborate on Mars occasionally
- About four undergraduate research assistants

Neutral Atmosphere – Data Analysis

- Entry ρ, p, T profiles from accelerometers
- Aerobraking ρ measurements from accelerometers
- UV occultation ρ, p, T profiles from SPICAM

Entry ρ, p, T profiles from accelerometers





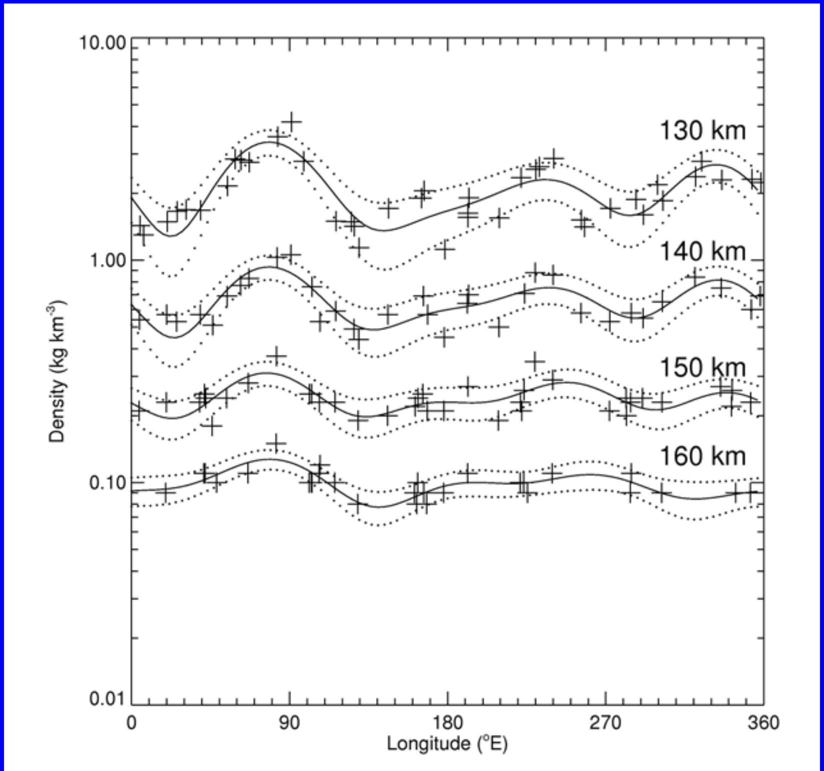
Sparse measurements

Excellent vertical range
Excellent vertical resolution

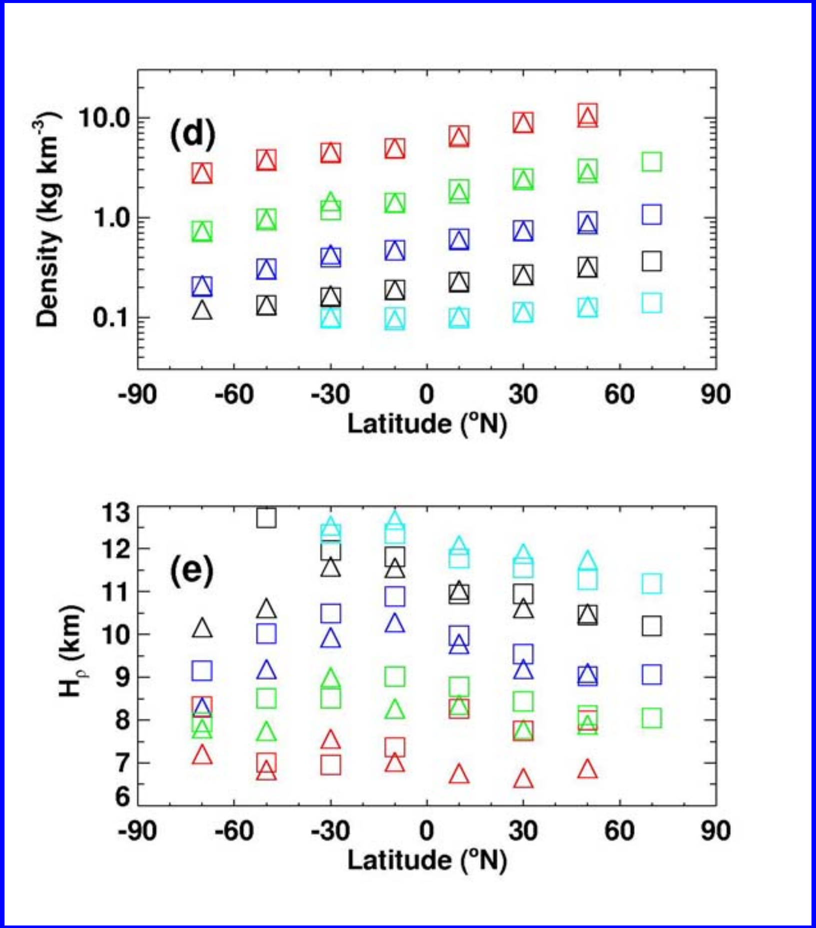
BU has tools to derive atmospheric profiles from measured accelerations. PDS archive of Spirit and Opportunity results was produced by BU.

PHX data are coming

Aerobraking ρ measurements from accelerometers



Thermal tides cause dependence on longitude



Density as function of latitude and altitude

Non-vertical profiles of density

It is hard to derive p, T from density

BU has tools to derive densities from measured accelerations

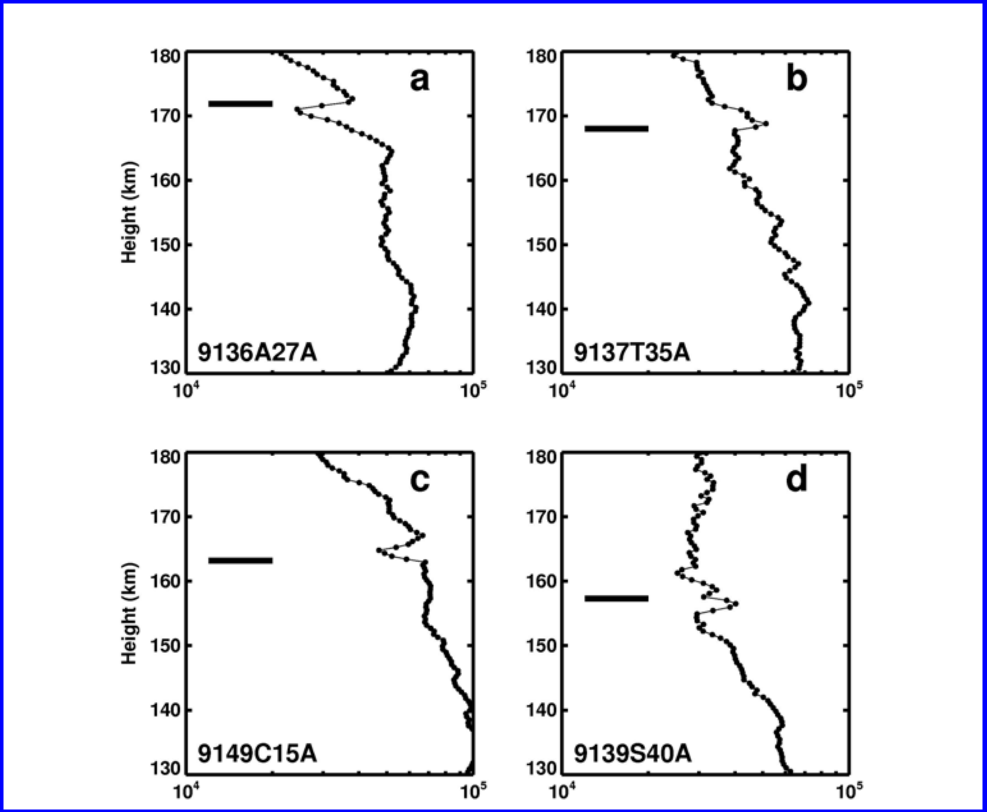
UV occultation ρ, p, T profiles from SPICAM

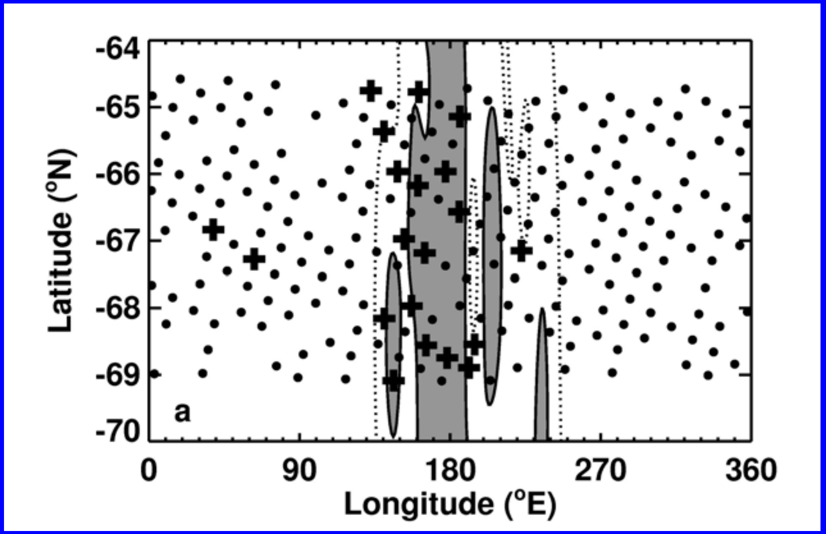
- Compare to aerobraking accelerometer measurements
- Study thermal tides in ρ, p and T datasets
- Study thermal tides over 20 km to 120 km range, extend 100 km to 150 km range provided by aerobraking downwards

Ionosphere – Data Analysis

- Main data sources are Ne(z) profiles from radio occultations by MGS and MEX
- Effects of magnetic fields
- Effects of solar flares
- Effects of meteors

Effects of magnetic fields





Some MGS Ne(z) profiles contain unusual "biteouts"

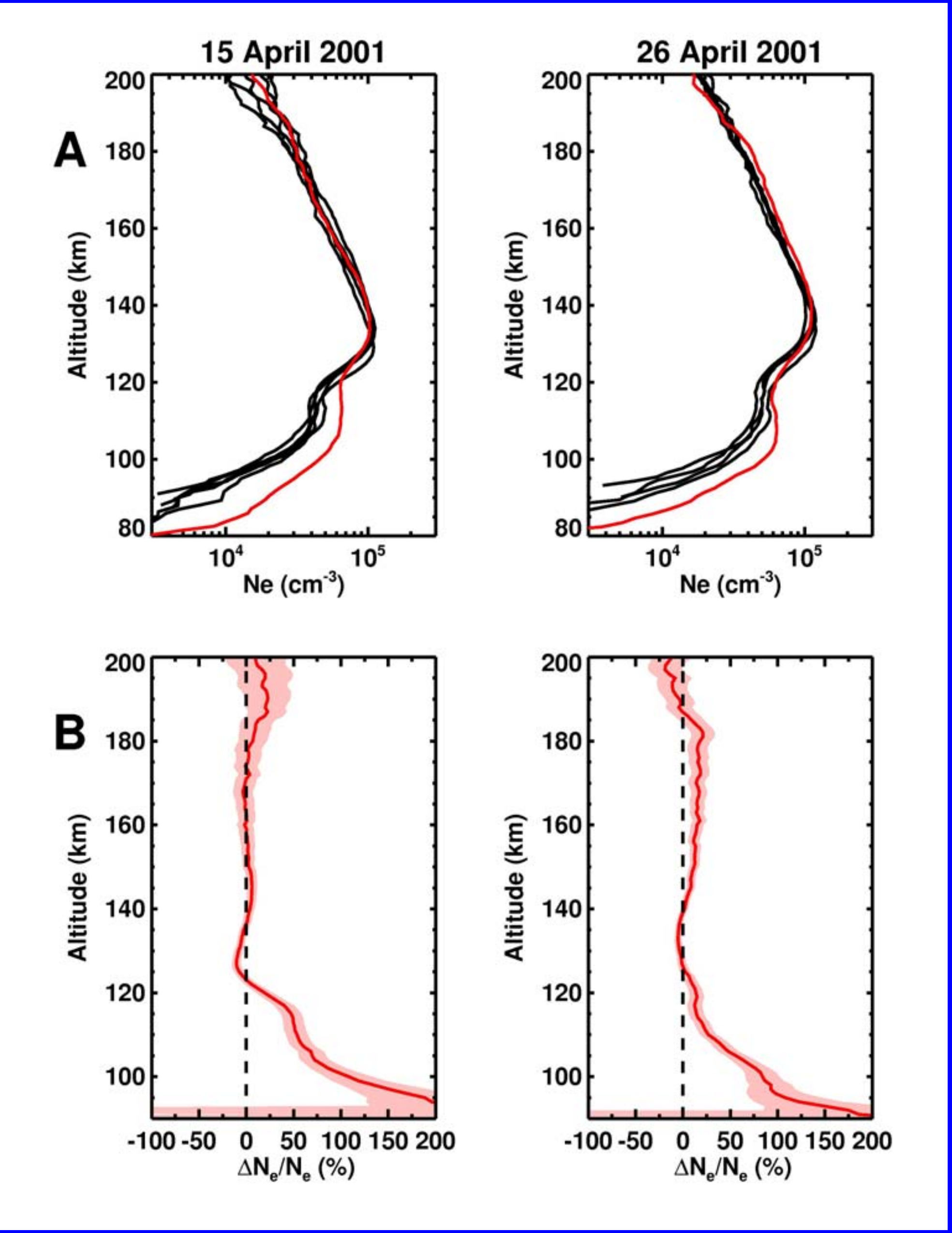
Real vertical structure or aliasing of horizontal structure?

Anomalous profiles located above strong crustal magnetic fields

MEX RS starting to see waviness in its profiles over strong fields

MARSIS sees lots of things above strong fields

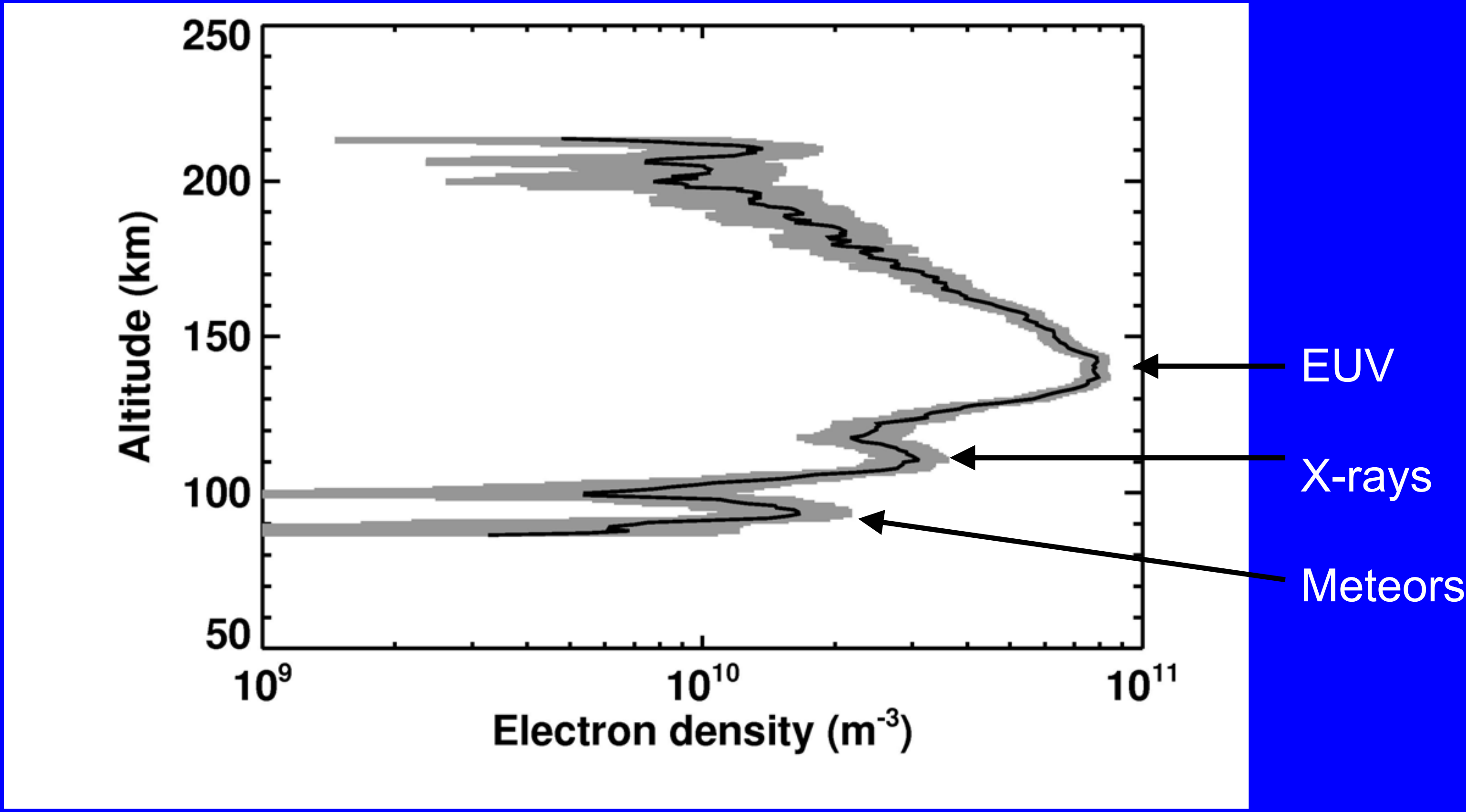
Effects of solar flares



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

Relative increase in Ne increases as altitude decreases due to hardening of solar spectrum in flare

Effects of meteors

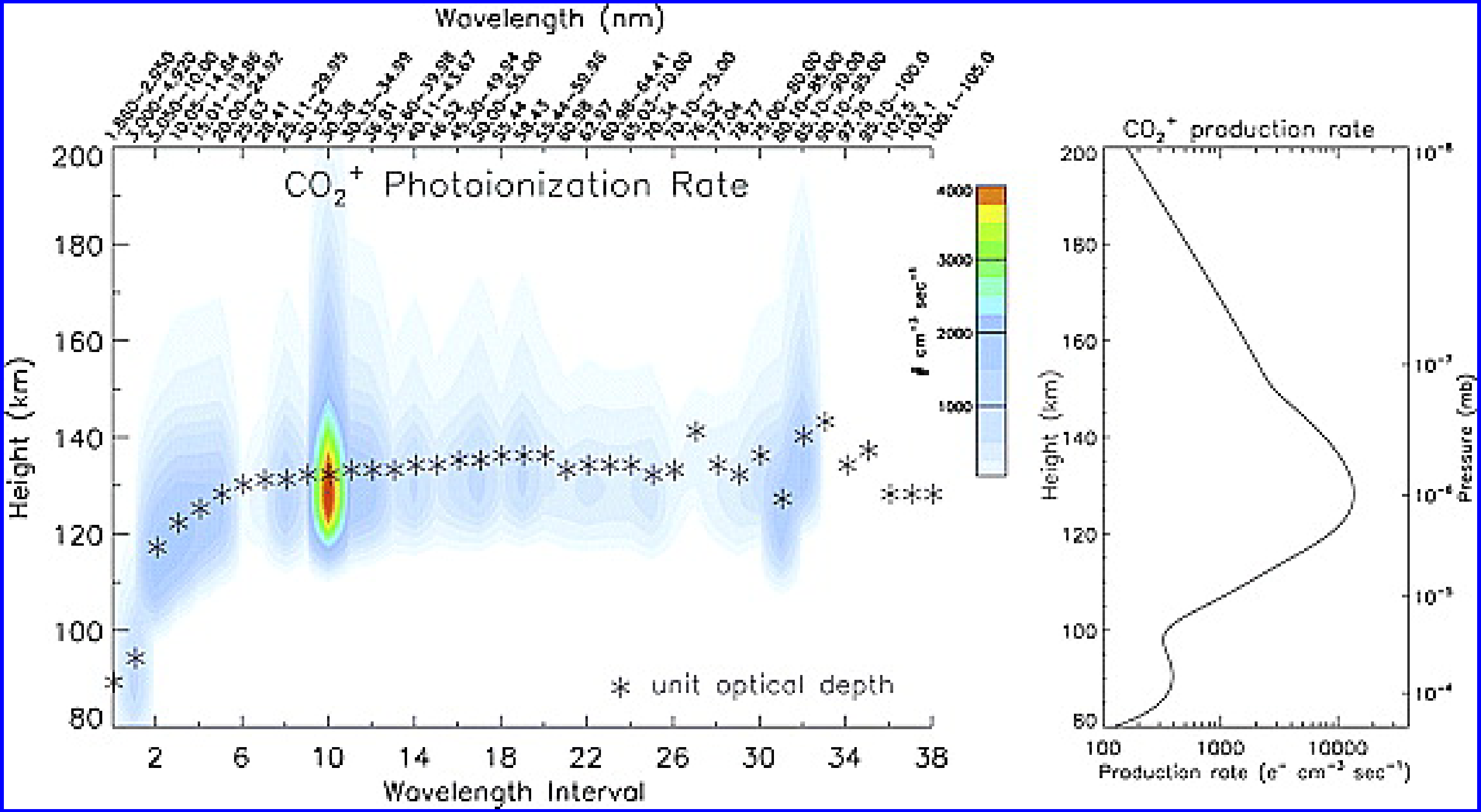


Observed in MGS and MEX profiles
Characterize altitude, electron density, width of meteoric layer and how these properties depend on (e.g.) solar zenith angle, etc.
Occurrence rate depends on season –
controlled by atmospheric dynamics or meteor showers?

Ionosphere – Theory

- Basic ionospheric model
- Effects of magnetic fields on currents, electric fields, and plasma densities
- Response of ionosphere to solar flares

Basic ionospheric model



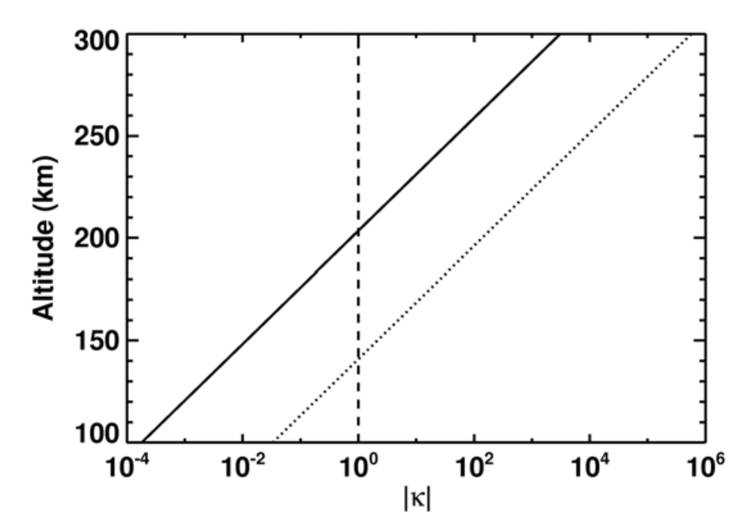
1D model, includes photochemistry and transport

Challenges include: neutral composition, solar irradiance, electron-impact ionization

Effects of magnetic fields on currents, electric fields, and plasma densities

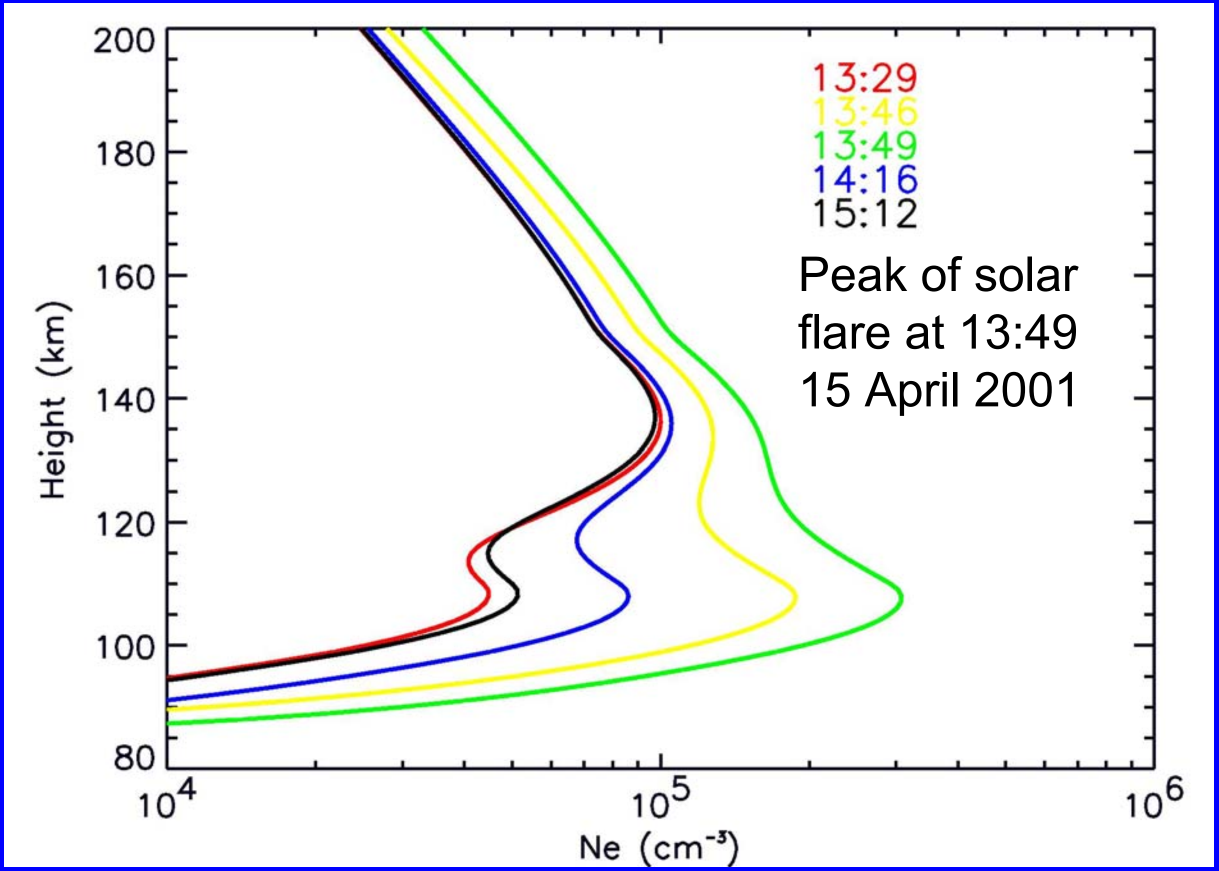
$$\underline{J} = \underline{Q} + \underline{\underline{S}}\,\underline{E}' \text{ and } \underline{J} = \underline{\underline{\sigma}}\,\underline{E}'$$

- Typical theories have one of
  - Very strong magnetic field
  - Very weak magnetic field
  - Empirical model of electric field
- Mars has none of these



K = ratio of gyrofreq to collision freq
Ions = solid, el = dashed, B=100 nT

Response of ionosphere to solar flares



Time-varying solar irradiance needed
Accurate electron-impact ionization and solar irradiance very important

Future Directions

- Comparison of SPICAM and aerobraking accelerometer measurements, including tides
- Continue looking at meteoric layers. Simulations of meteoric layers are needed, but hard
- Continue simulations of solar flares
- Investigate MARSIS dataset