

Planetary atmospheres and ionospheres...

How does a solar energetic
particle event disrupt the
ionosphere of Mars?

Paul Withers

withers@bu.edu

BU Astronomy Symposium

Boston, MA

2011.10.14

What's going on?

Katy Fallows – How does the lower ionosphere of Mars work?

Emphasis on working closely with spacecraft data

Zach Girazian – How does the main layer in the ionosphere of Mars work?

Desire models that promote physical understanding, not complicated black box

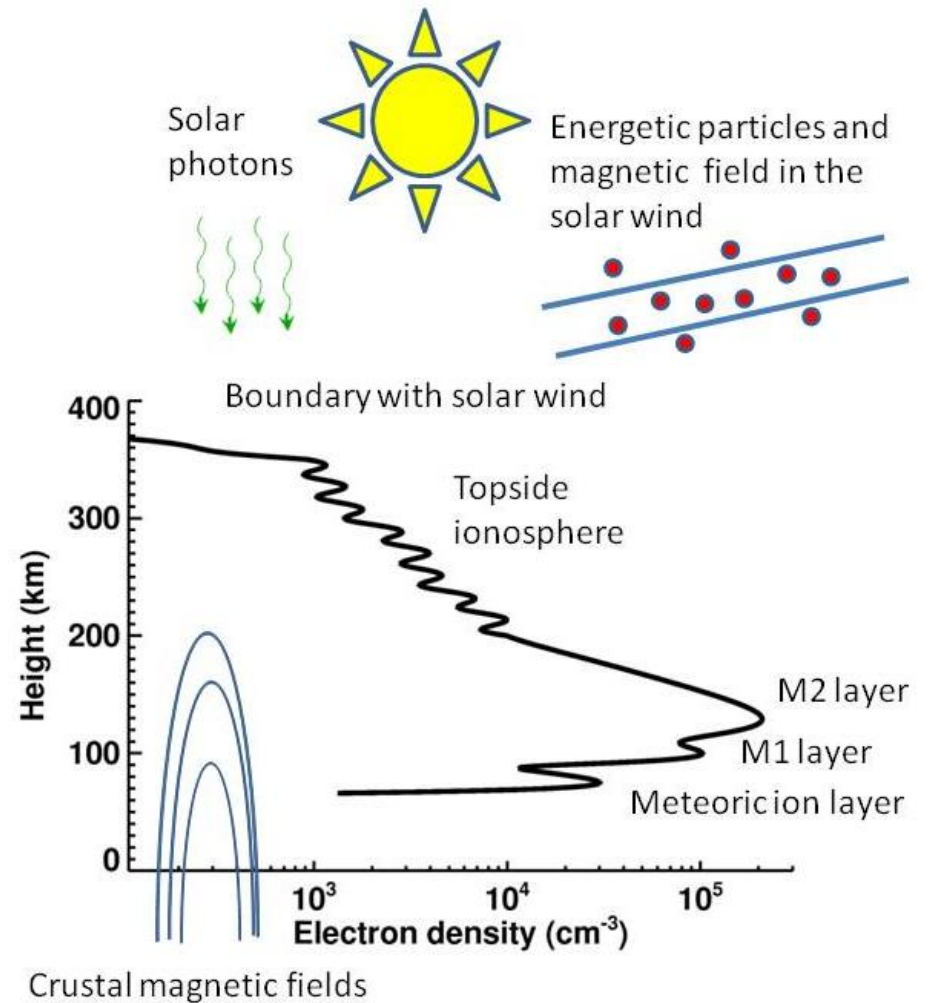
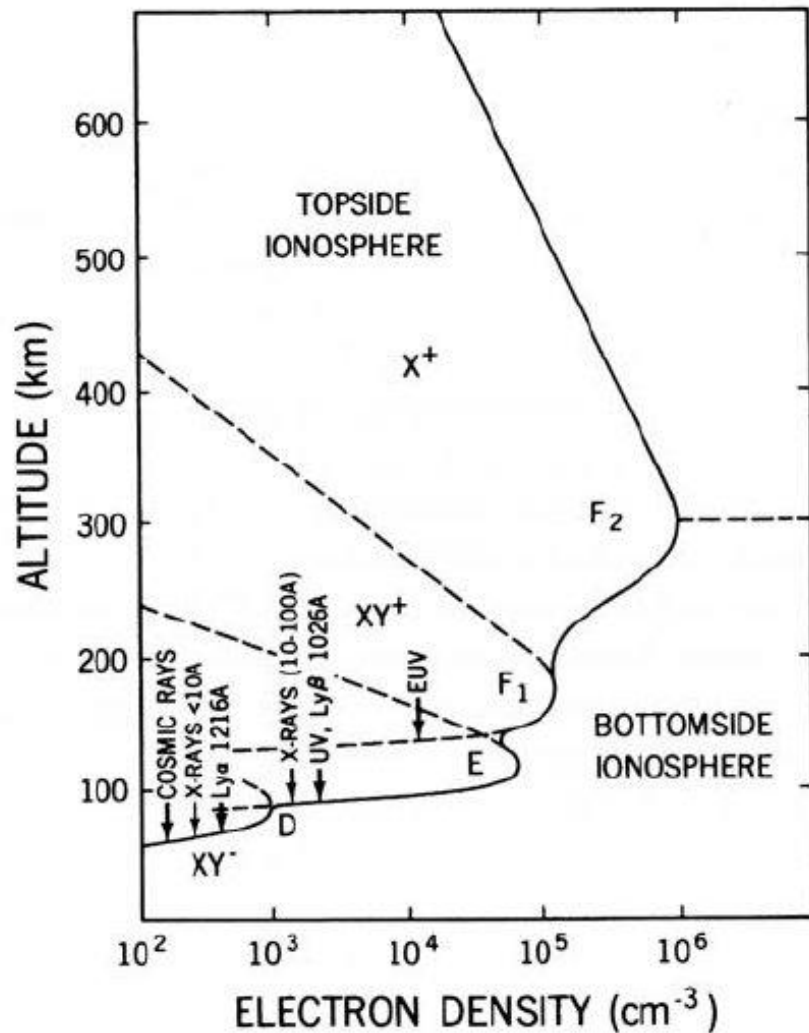
Majd Matta – Numerical simulations of the ionosphere of Mars

Diversification beyond Mars is planned

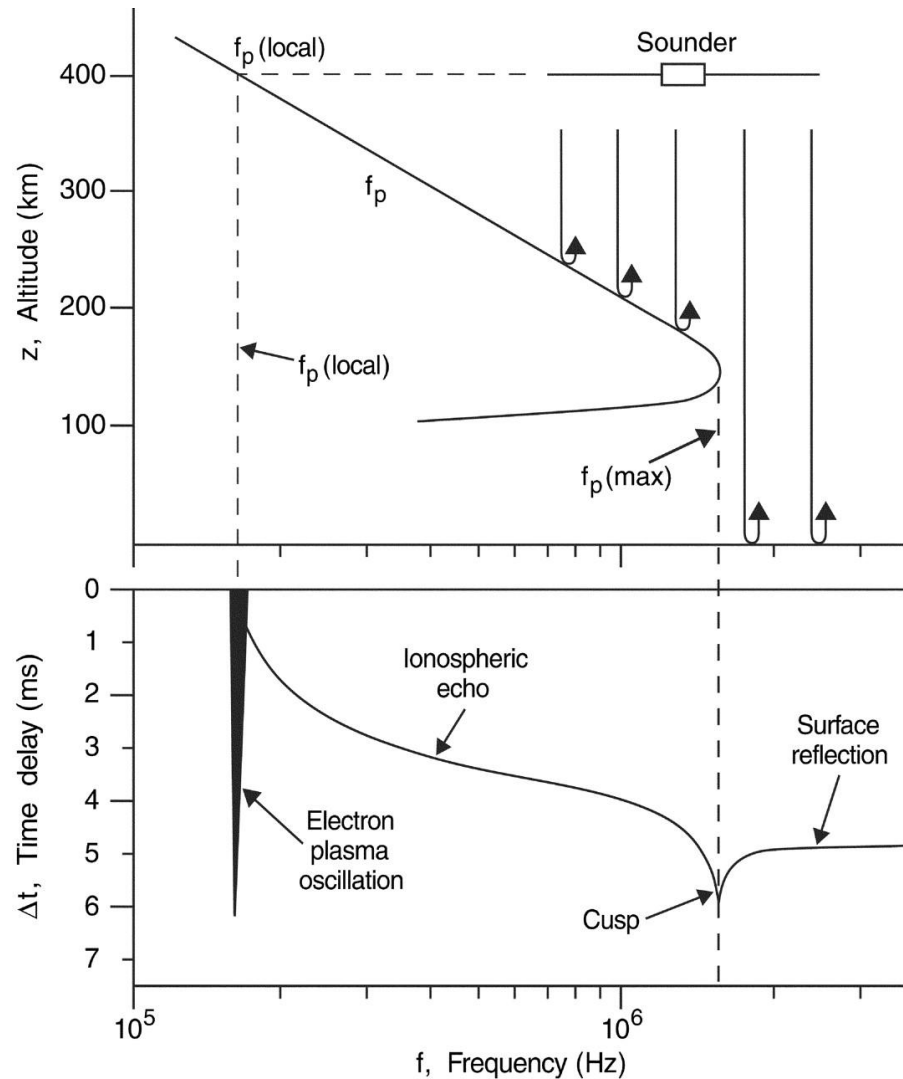
Rob Pratt – Response of the thermosphere of Mars to extreme events

Nick Ferreri – Resurrecting ancient Mars data

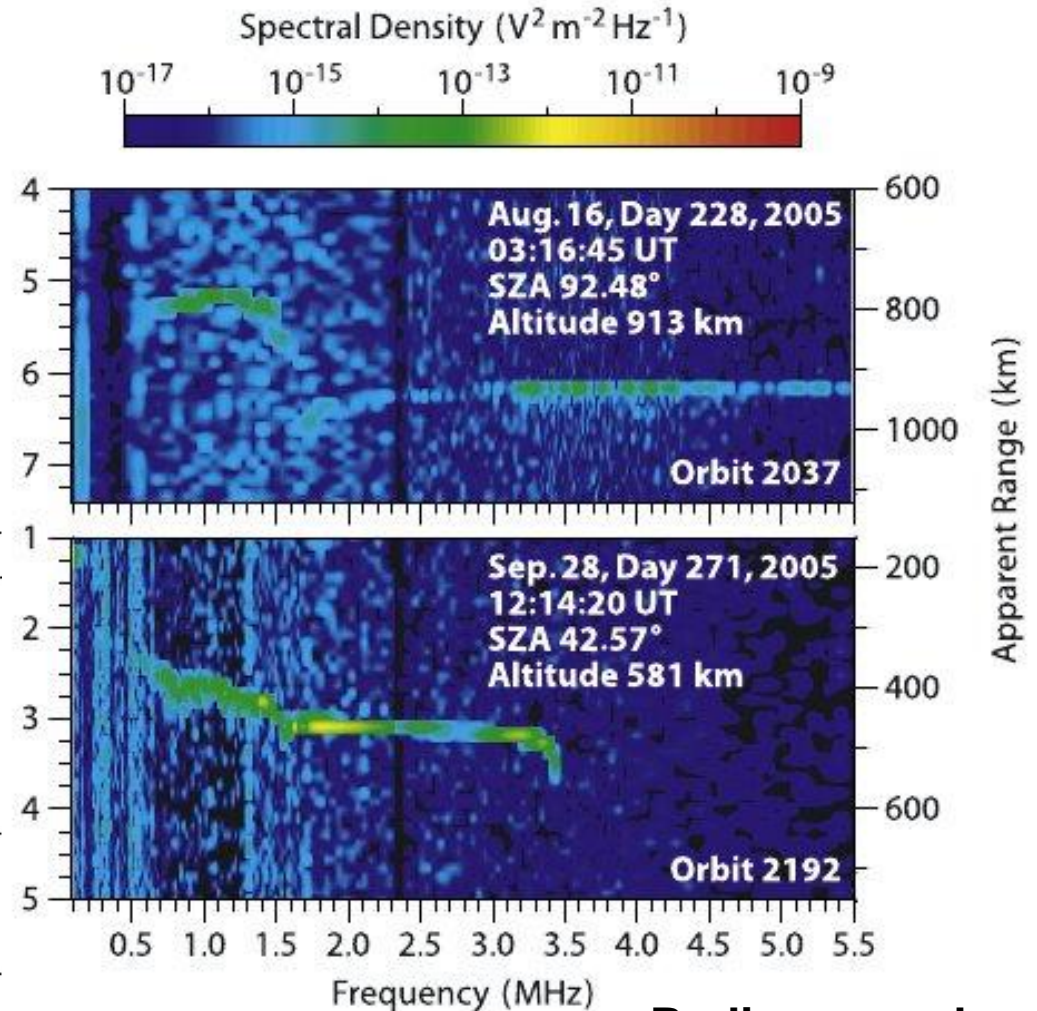
Ionospheres of Earth and Mars



The problem: MARSIS gets blacked out occasionally



Gurnett et al. (2005)

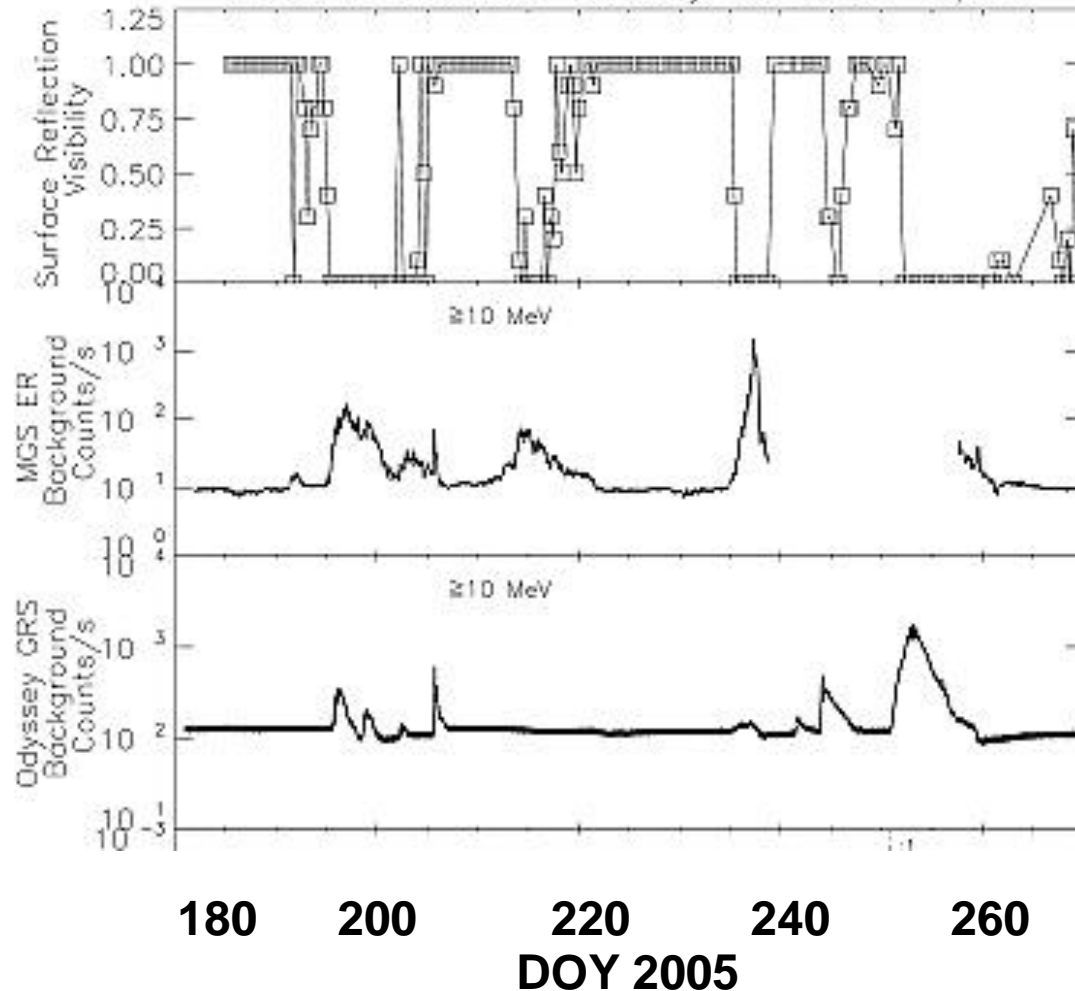


Morgan et al. (2006)

Radio wave absorption
Excess plasma at
low-ish altitudes

Happens during solar energetic particle (SEP) events

Surface reflection visibility with solar inputs



“High” means surface reflection is visible

“Low” means it is not visible

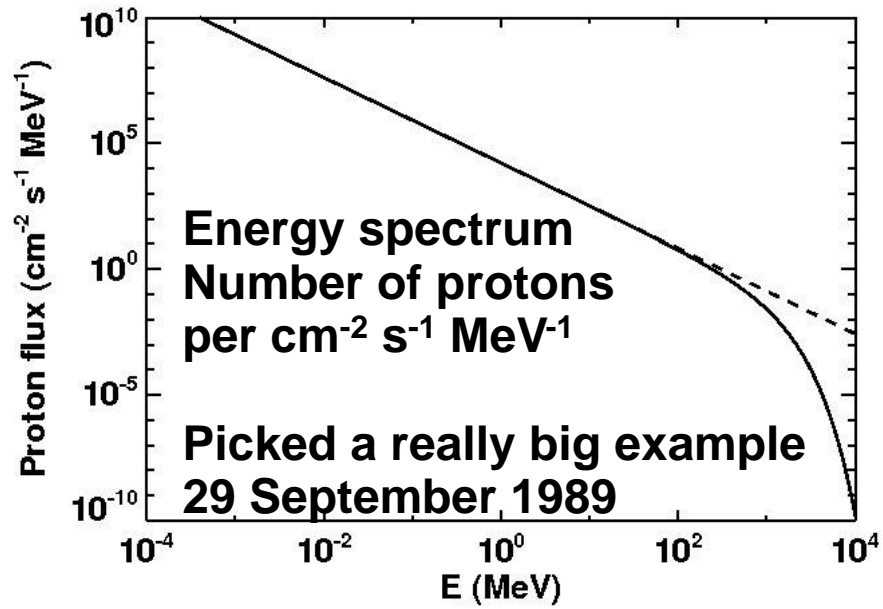
Proxy for energetic particle flux at Mars

Another proxy for the same thing

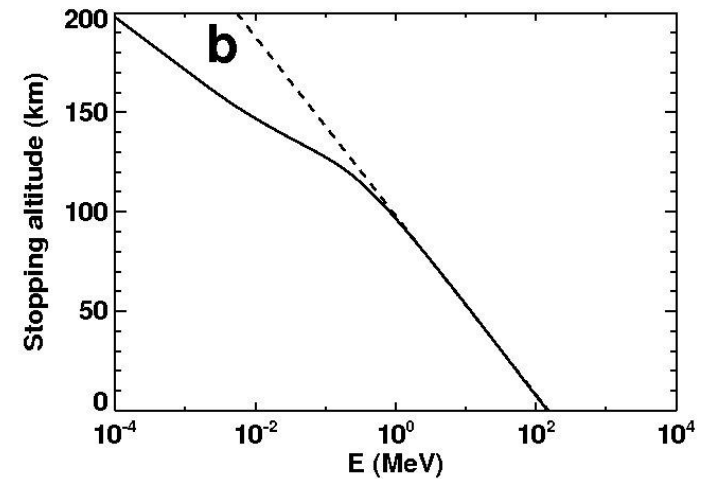
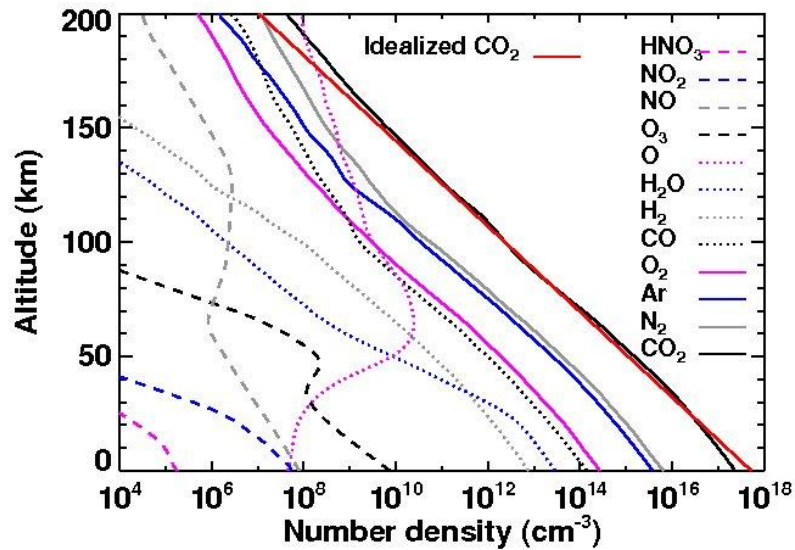
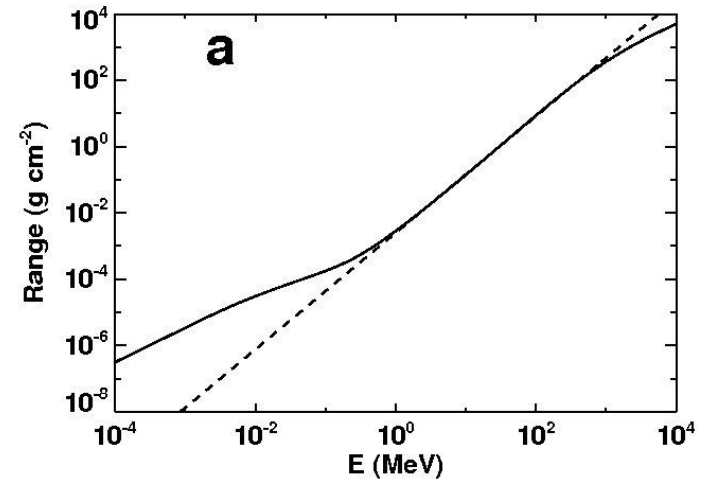
Hypothesis: SEP events cause sufficient plasma enhancement at low altitudes to account for MARSIS blackouts

But this has never been simulated...

Model ingredients



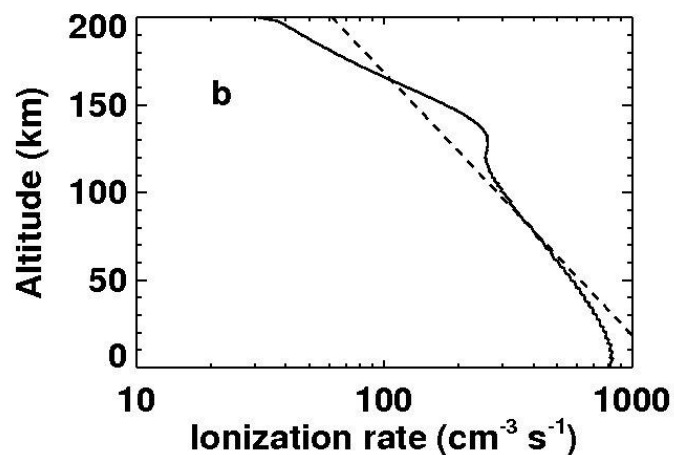
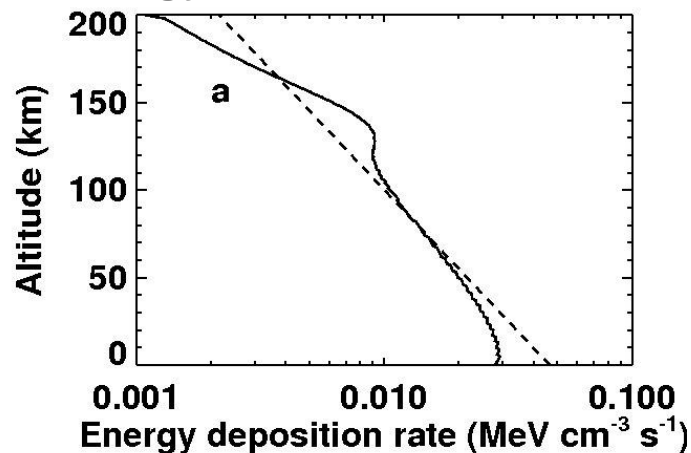
“Range” – How many g cm^{-2} of CO_2 stops a proton of some energy



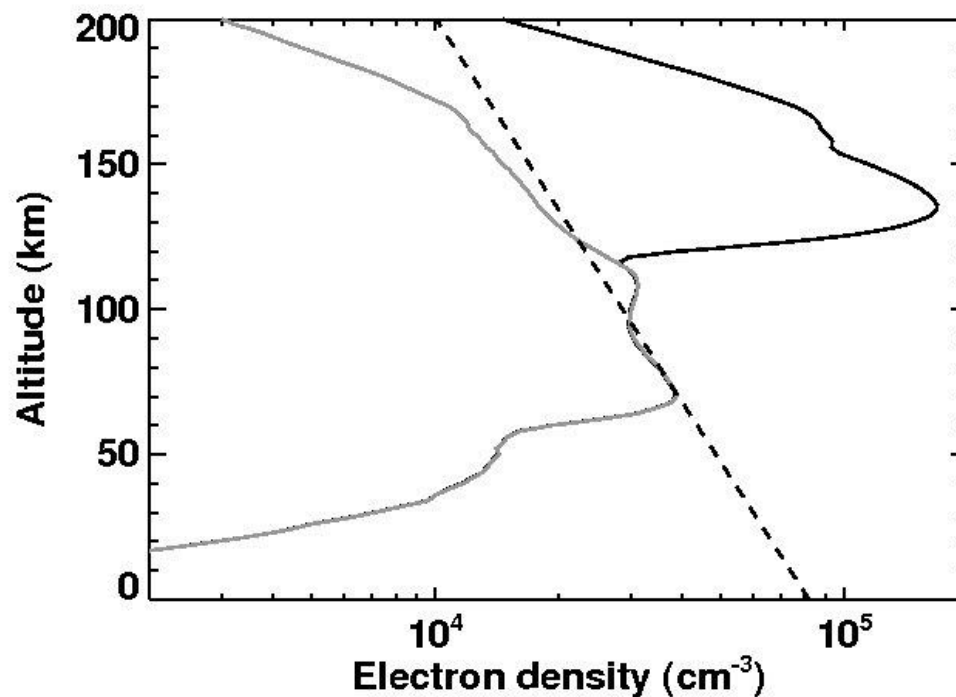
Altitude at which a proton of some energy is stopped

Model results

Make an assumption for how energy is deposited



Make another one for associated ionization rate, then get colleagues in India to produce ionospheric densities

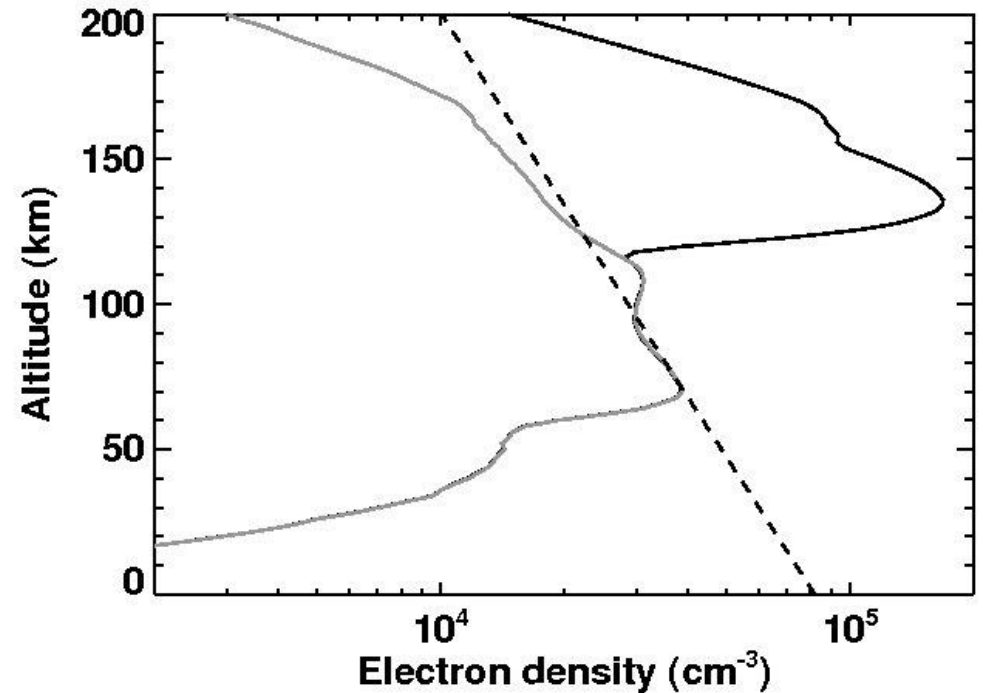
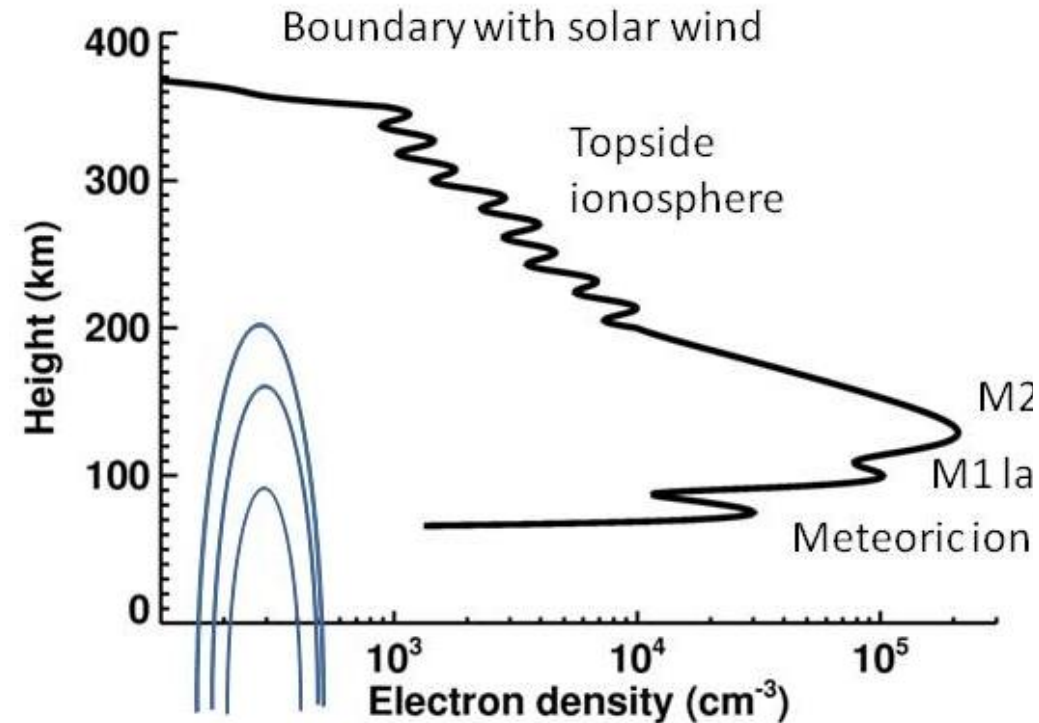


Black line – $N(z)$ for SEP and photons
Grey line – $N(z)$ for SEP only

Dashed line – Simple analytical prediction for the grey line
Pretty good, huh?

Ask me about the wacky chemistry below 70 km altitude...

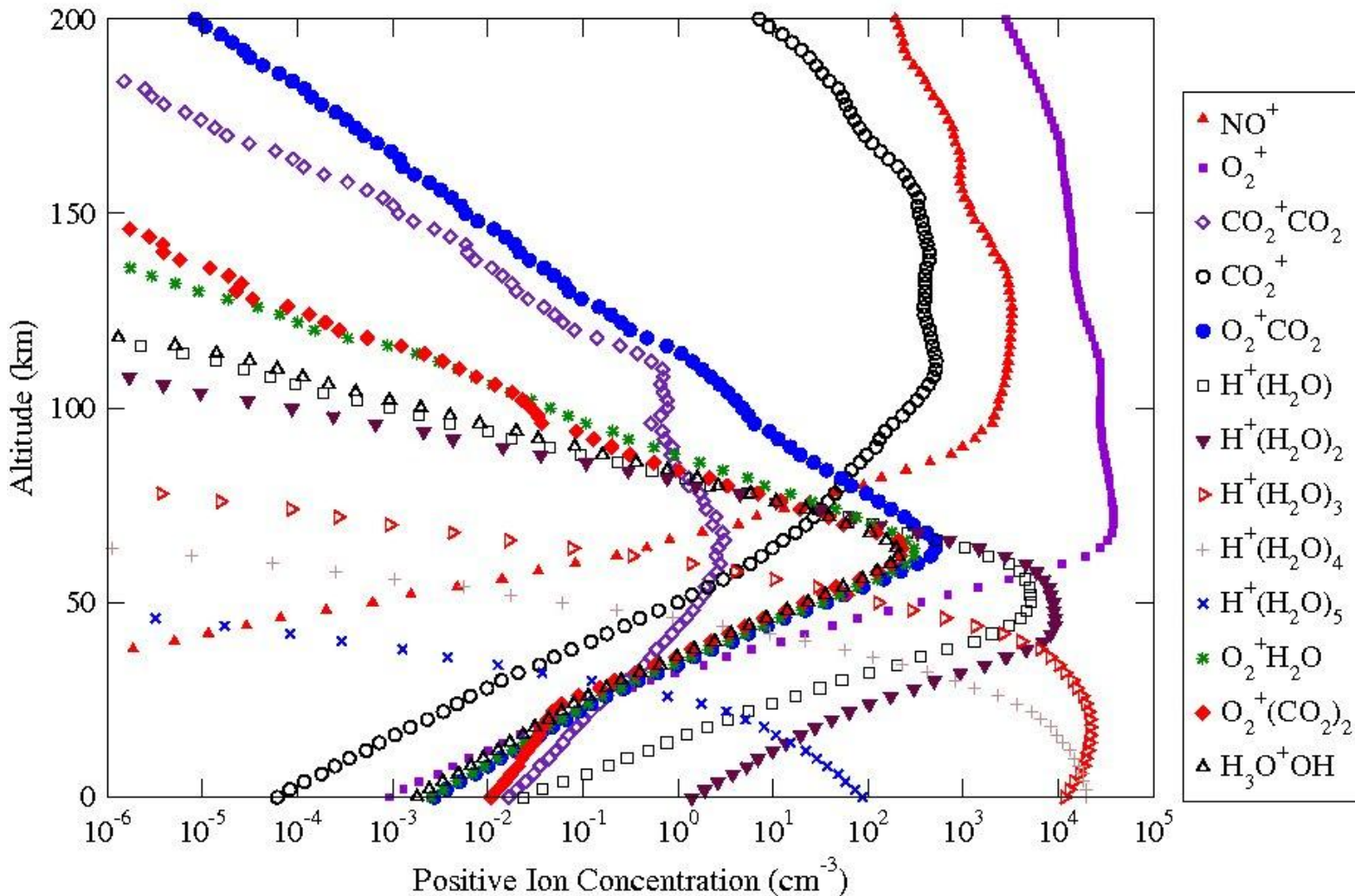
Major ionospheric changes



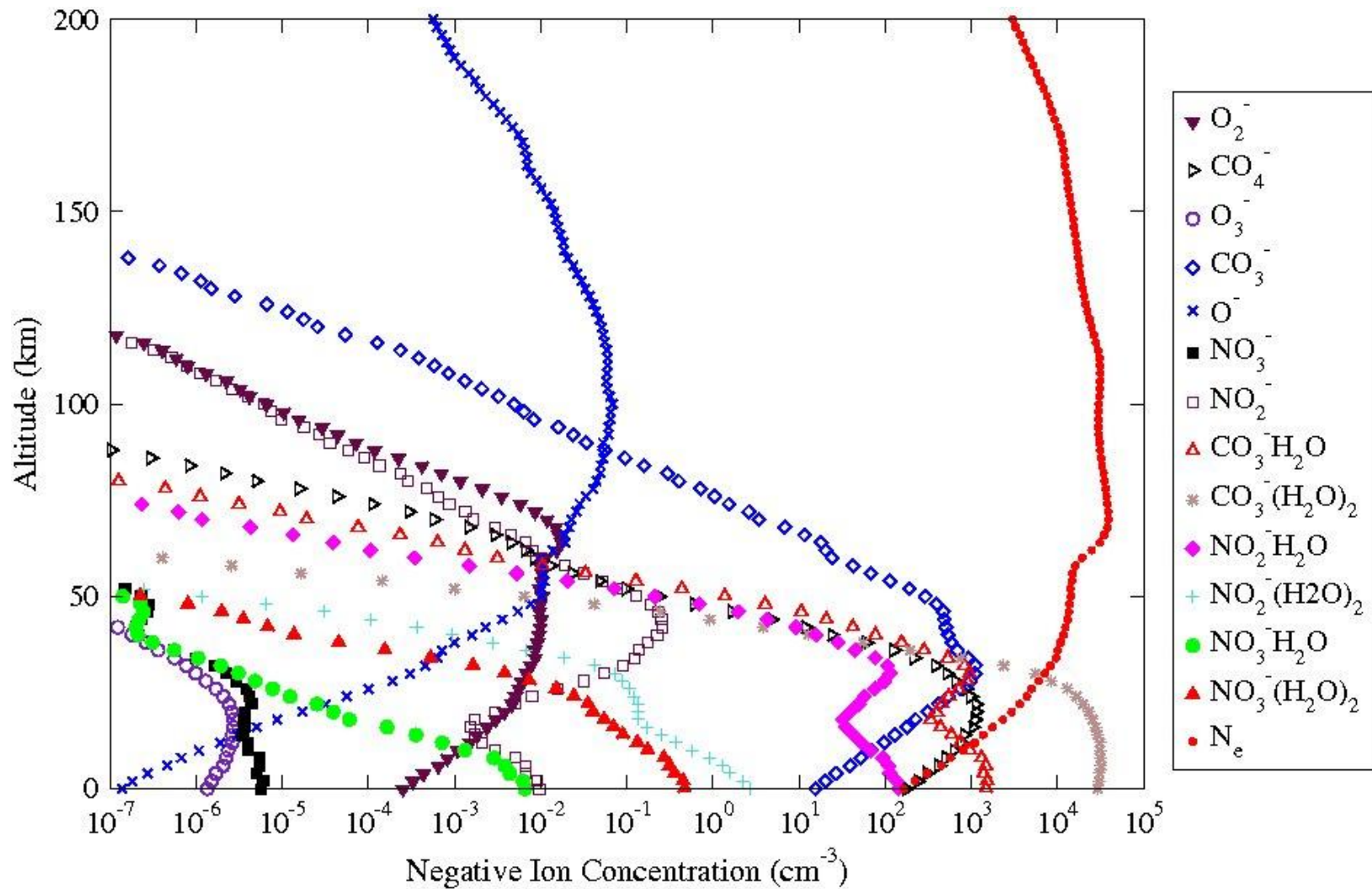
- A – Unusually large electron densities at 70-100 km**
Should be visible in radio occultation observations ?
- B – Increase in total electron content (TEC)**
Is visible in MARSIS TEC observations !
- C – Tremendous radio wave absorption**
Sufficient to black out MARSIS surface reflections !

Backup

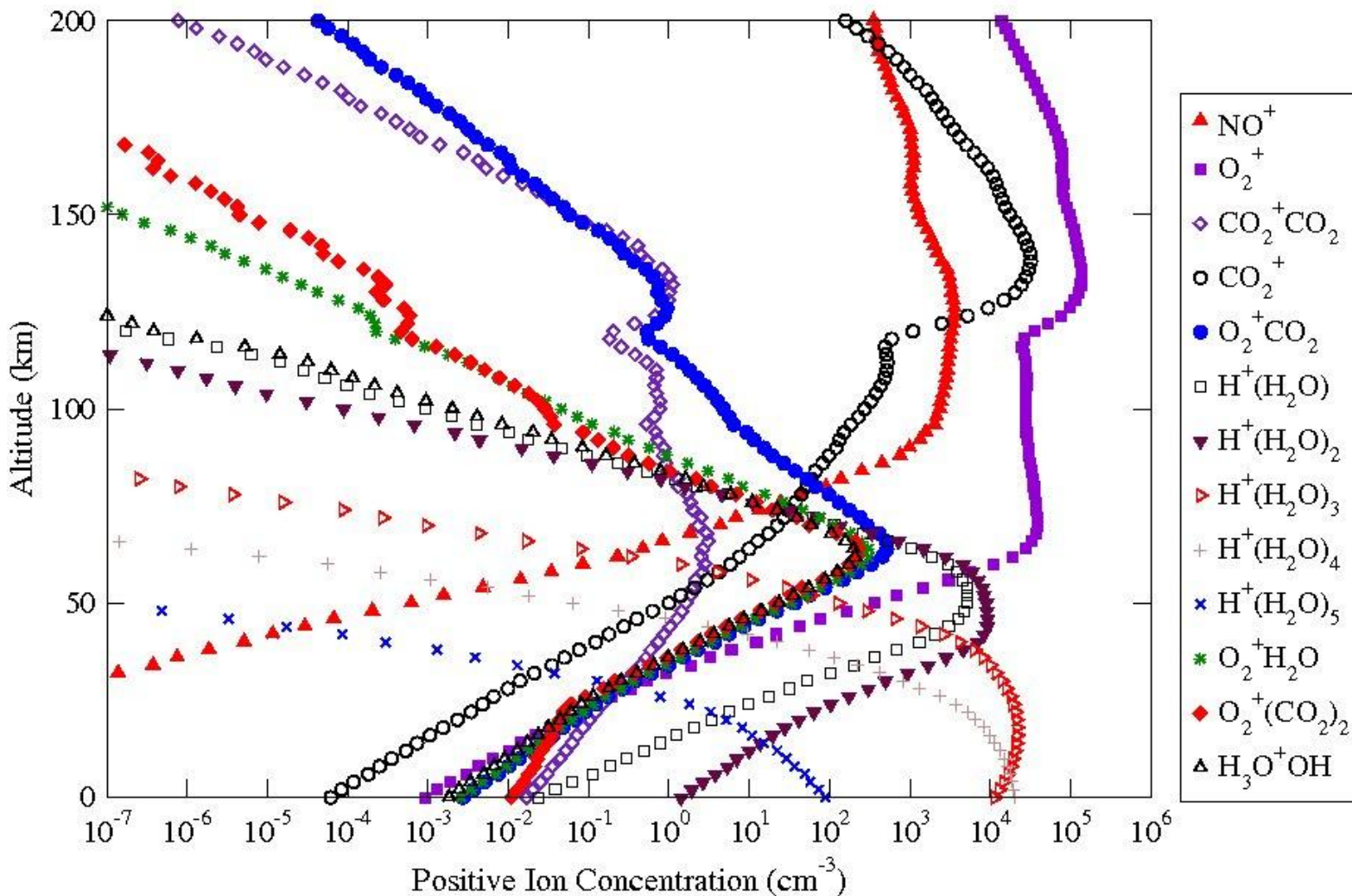
SEP only, positive ions



SEP only, negative ions



SEP and photons, positive ions



SEP and photons, negative ions

