The Influence of Solar Variability on the Ionospheres of Earth and Mars

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Interim CEDAR Postdoc Report

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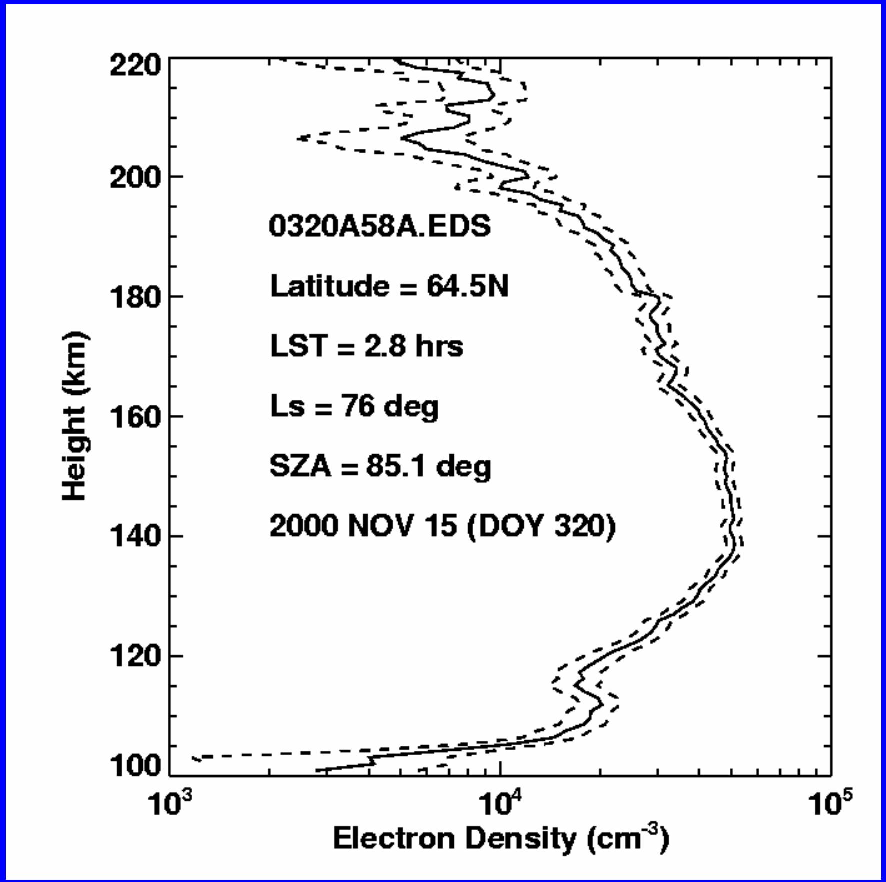
Introduction to Martian Ionosphere and MGS RS Data

MGS RS Data Coverage

60-85N, 60-70S
2-9, 12 hrs LST
70-180 deg Ls – over 2 yrs
70-87 deg SZA
Dec 98, Mar 99, May 99,
and Nov 00 – Jun 01

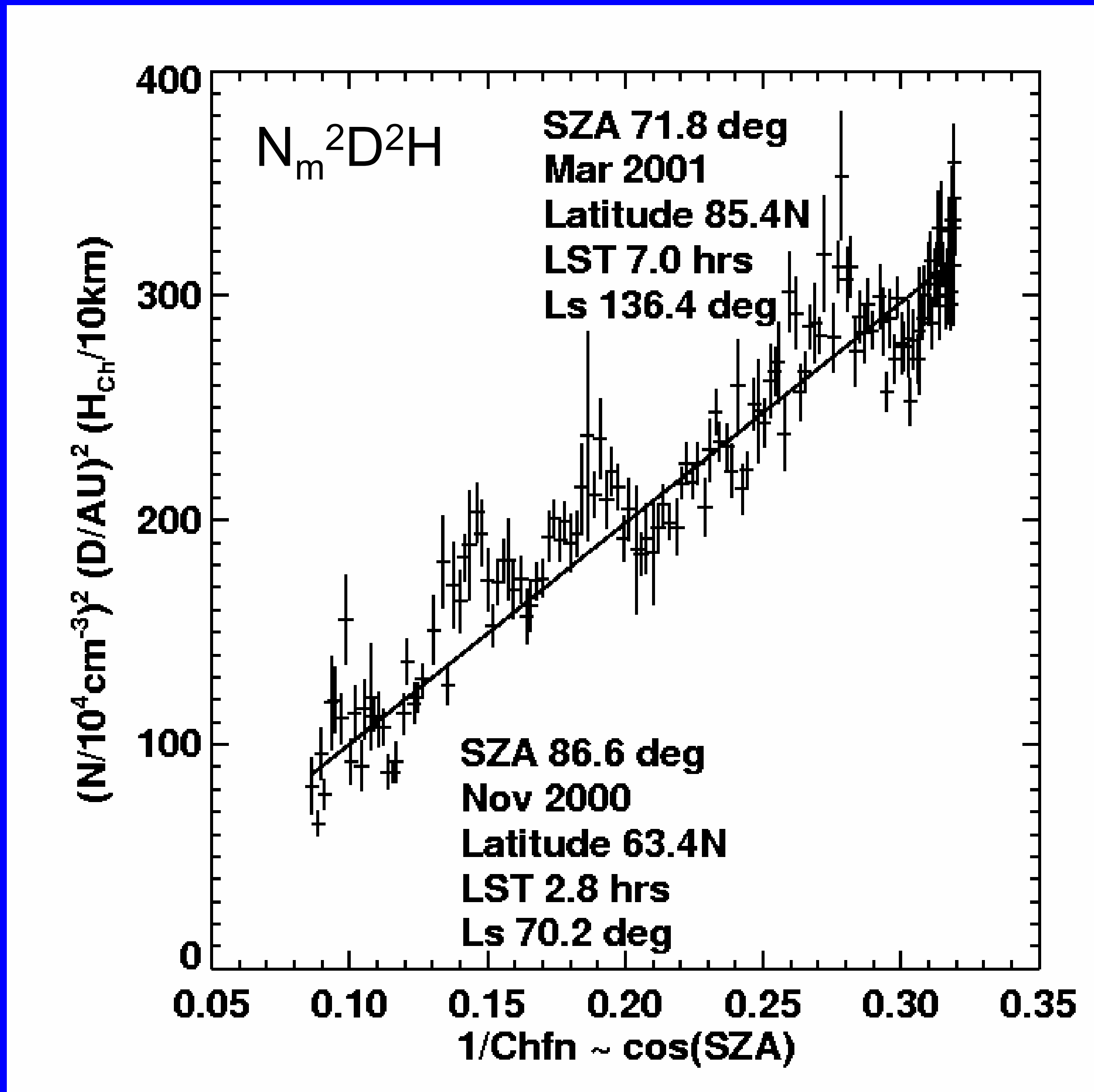


Simplified chemistry

CO_2 + hv -> CO_2^+ + e (fast)
CO_2^+ + O -> O_2^+ + CO (fast)
O_2^+ + e -> O + O (slow)

Typical Profile

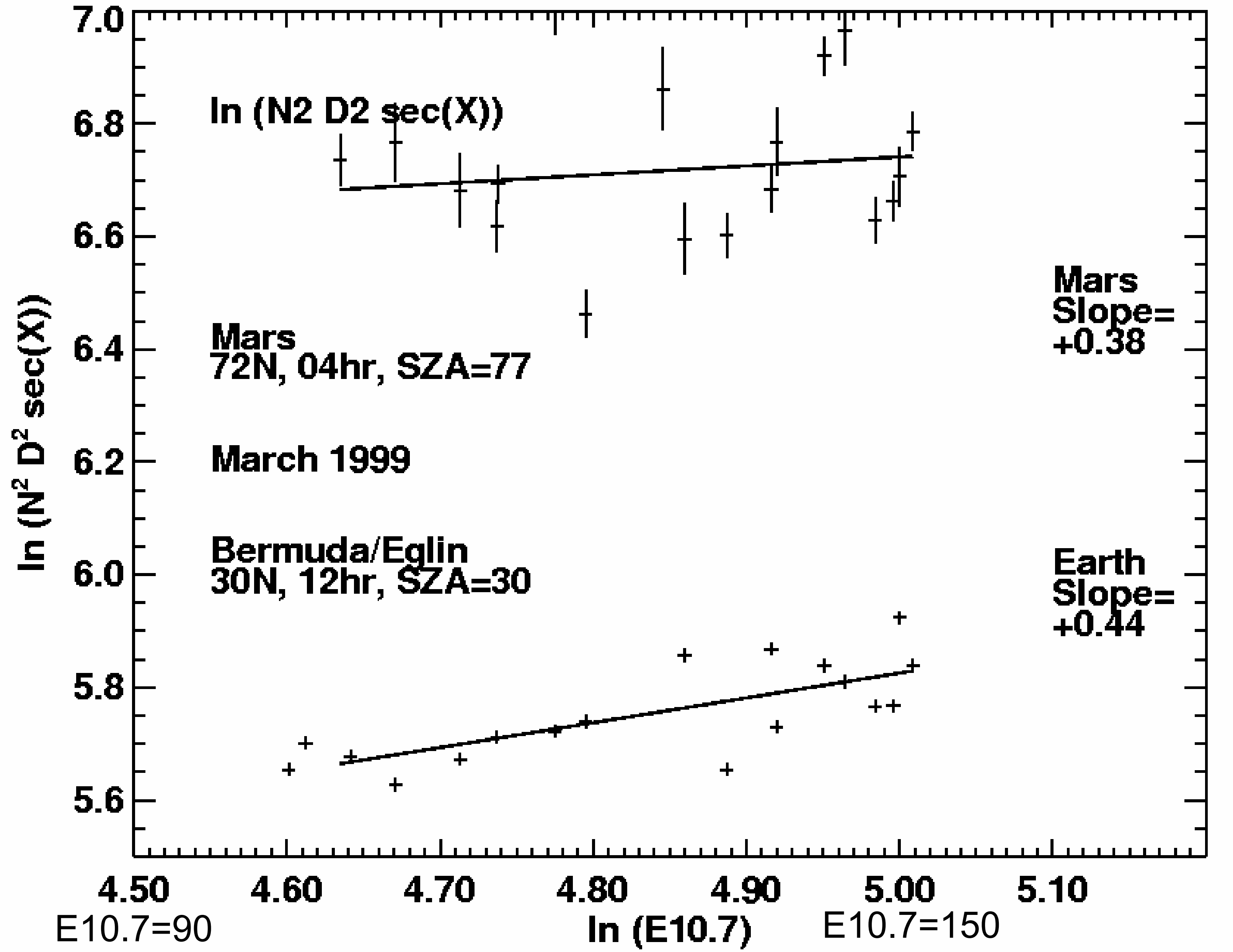
Primary peak, well fit by alpha-Chapman function, 130-150 km, (4-14) x 1E4 cm^{-3}
Secondary feature (ledge, peak, etc) of variable significance, 110-120 km
Primary peak mainly from 30.38 nm (Helium) flux, secondary peak from few nm X-rays
Wavy topside with H decreasing as altitude increases



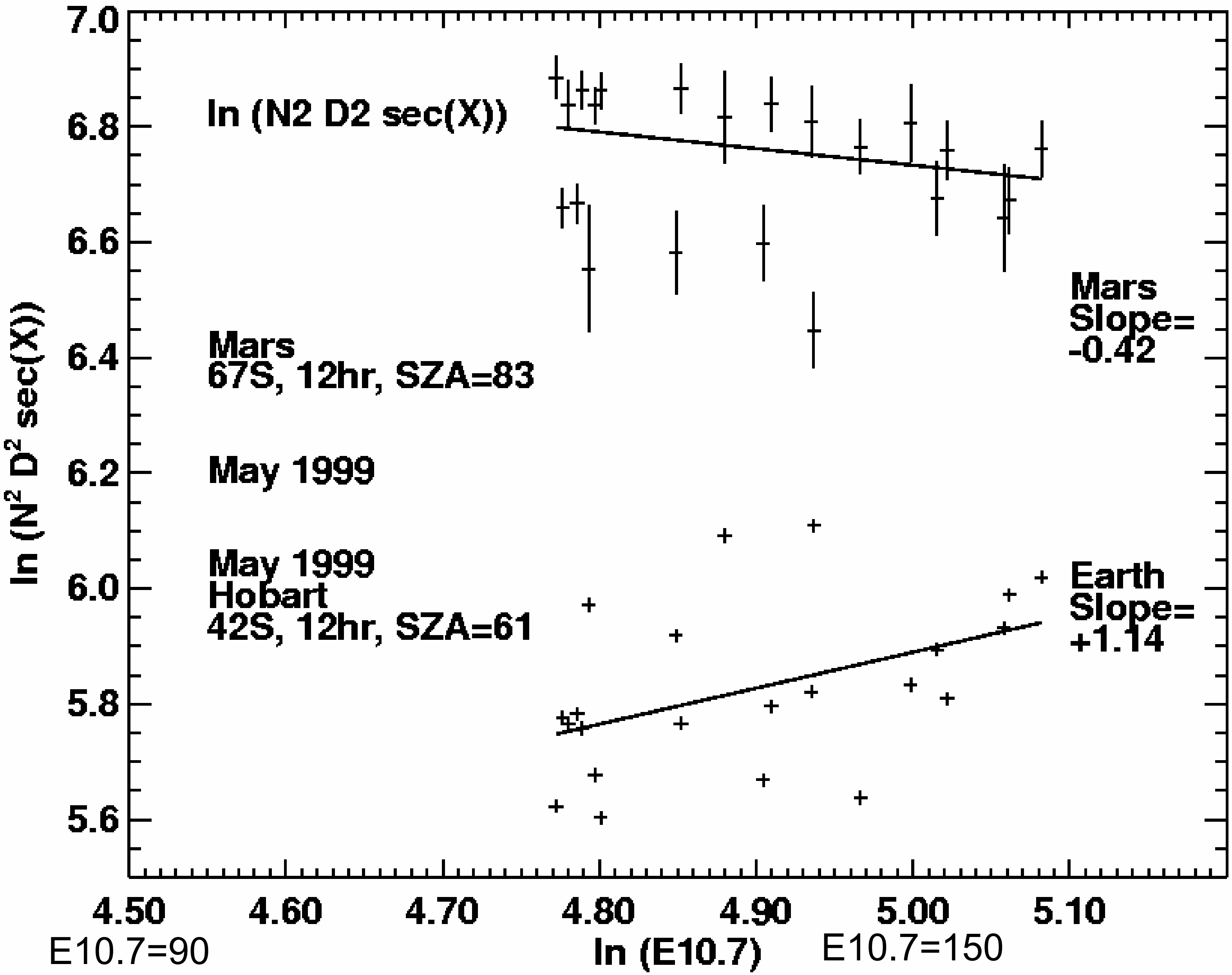
$N_m{}^2D^2H$
SZA 71.8 deg
Mar 2001
Latitude 85.4N
LST 7.0 hrs
Ls 136.4 deg
SZA 86.6 deg
Nov 2000
Latitude 63.4N
LST 2.8 hrs
Ls 70.2 deg
$(N/10^4 cm^{-3})^2 (D/AU)^2 (H_{Ch}/10km)$
1/Chfn ~ cos(SZA)
0
100
200
300
400
0.05
0.10
0.15
0.20
0.25
0.30
0.35

Theory and Observations

- $N_m^2 D^2 H \sec(SZA) = F_{1AU} / (alpha.e)$
- Mars: $d\ln(N_m^2) / d\ln(F10.7) = 0.7\text{-}0.8$, not 1
- Earth, E region: $N_m^2 = k \times (F10.7 + 40)$
  Titheridge, 1997
- F10.7=120: $d\ln(N_m^2) / d\ln(F10.7) = 0.75$
- Examine some data near opposition…



ln (N2 D2 sec(X))
Mars
72N, 04hr, SZA=77
March 1999
Bermuda/Eglin
30N, 12hr, SZA=30
Mars
Slope=
+0.38
Earth
Slope=
+0.44
$\ln (N^2\ D^2\ sec(X))$
7.0
6.8
6.6
6.4
6.2
6.0
5.8
5.6
4.50
4.60
4.70
4.80
4.90
5.00
5.10
E10.7=90
ln (E10.7)
E10.7=150



ln (N2 D2 sec(X))
Mars
67S, 12hr, SZA=83
May 1999
May 1999
Hobart
42S, 12hr, SZA=61
Mars
Slope=
-0.42
Earth
Slope=
+1.14
7.0
6.8
6.6
6.4
6.2
6.0
5.8
5.6
ln (N^2 D^2 sec(X))
4.50
4.60
4.70
4.80
4.90
5.00
5.10
ln (E10.7)
E10.7=90
E10.7=150

Current Work

- Does Mars N_m respond to changes in F10.7 (measured at Earth) with lead/lag time matching solar rotation? If so, can the Mars ionosphere be a monitor of farside solar activity?
- Tides cause zonal variations in neutral density and scale height. How do embedded ionospheric layers respond on Mars and Earth?

Dear Dr. Mendillo:

I am pleased to inform you that the National Science Foundation has awarded support for your research entitled "CEDAR Post-Doc: Photo-Chemistry and Neutral-Plasma Coupling at Earth and Mars." My congratulations to you on this award to your institution.

COMPARATIVE AERONOMY: Photo-Chemistry and Neutral-Plasma Coupling at Earth and Mars

Goal: To compare the ionospheres of Earth and Mars using data and theory in order to better understand the basic physical processes that are common to both.

1) Test Chapman theory for dependence of peak electron density on F10.7, solar distance, SZA for Earth and Mars
2) Study effects of flares and CMEs on simultaneous observations of ionospheres of Earth and Mars
3) Examine effects of waves and tides in martian atmosphere on ionosphere and compare to predictions from Earth-based models