Planetary Ionospheres

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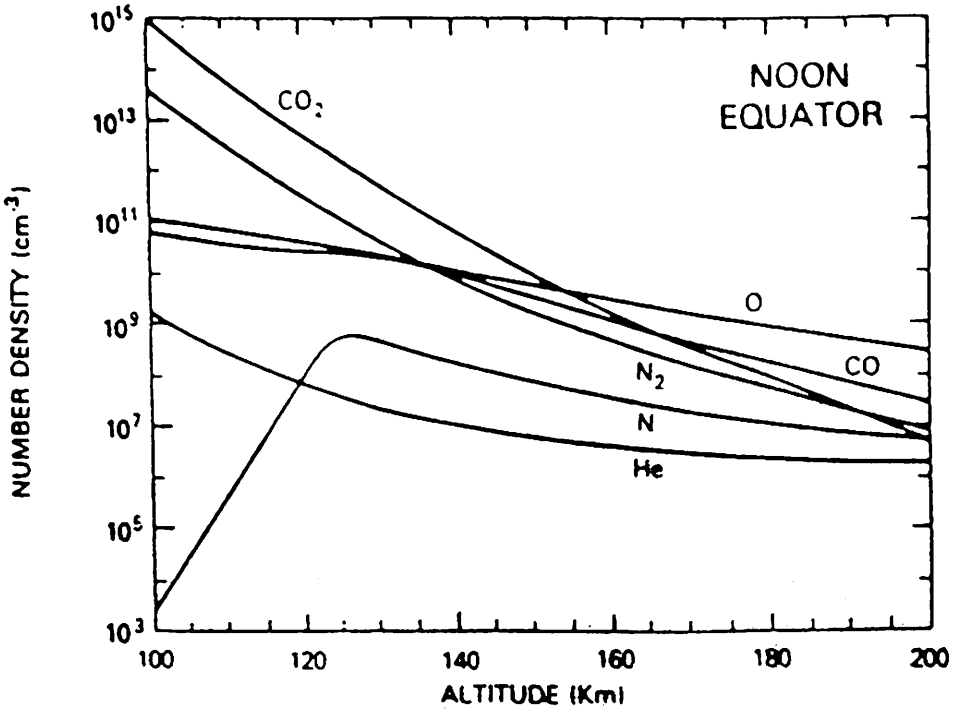
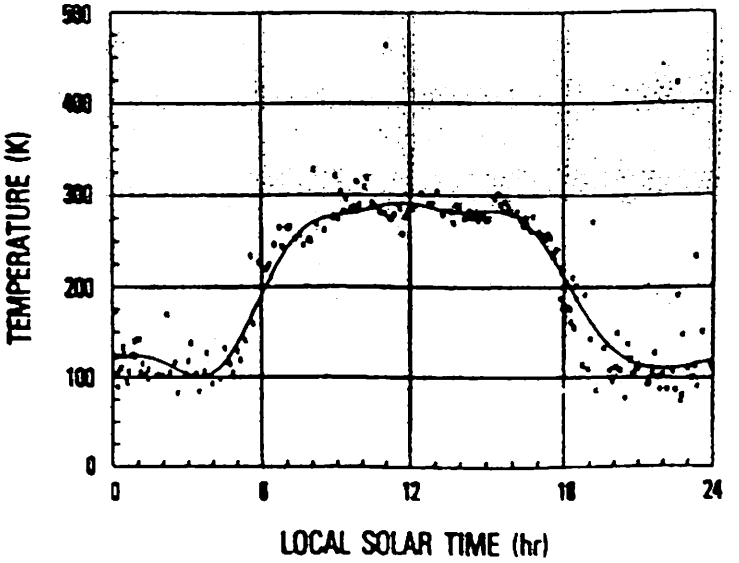
What is an ionosphere?

It is that region of the atmosphere (or gaseous envelope) surrounding a solar system body where there is a significant population of (low energy) free electrons and ions present.



VTS3 model densities as a function of altitude at noon and midnight at 0° latitude. Taken from



Kinetic temperatures of the exosphere of Venus versus local solar time inferred from scale heights of individual periapsis passes (point data) and from an empirical model (solid line).

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Venus Ion Chemistry.

$CO_2 + h\nu \rightarrow CO_2^+ + e$

$CO_2^+ + O \rightarrow O_2^+ + CO$

$CO_2^+ + O \rightarrow O^+ + CO_2$

$O + h\nu \rightarrow O^+ + e$

$O^+ + CO_2 \rightarrow O_2^+ + CO$

$O_2^+ + e \rightarrow O + O$

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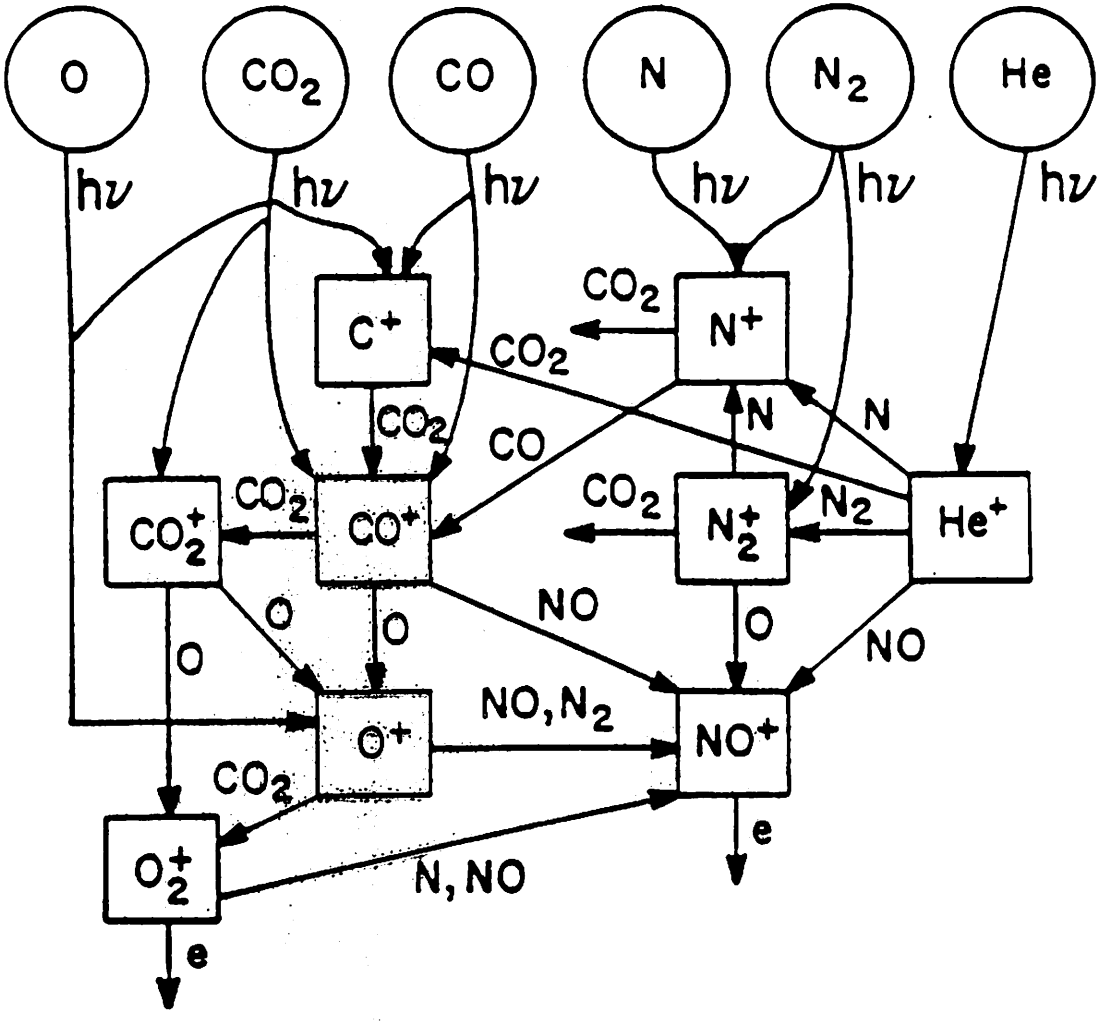

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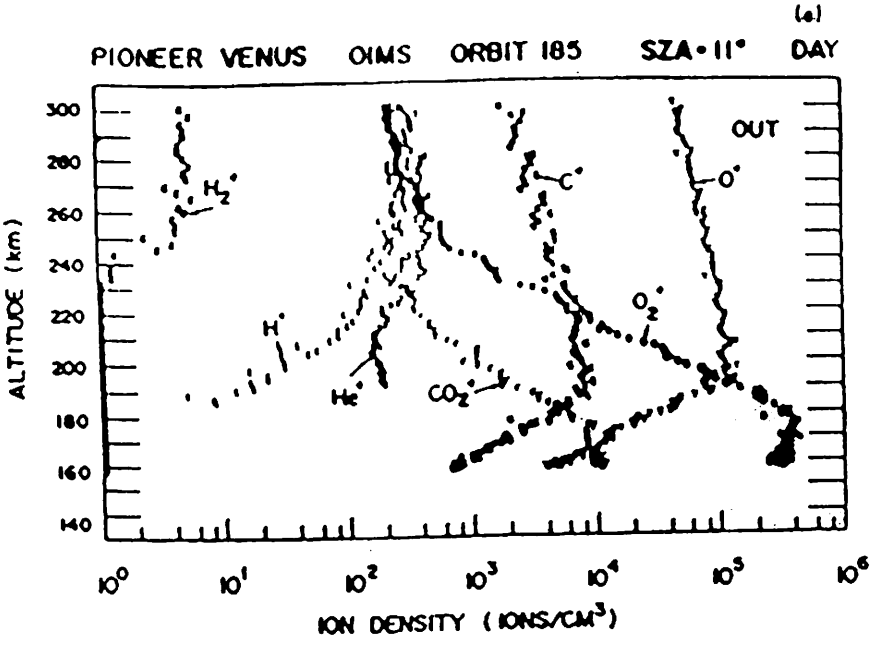
Simple Transport Equations.

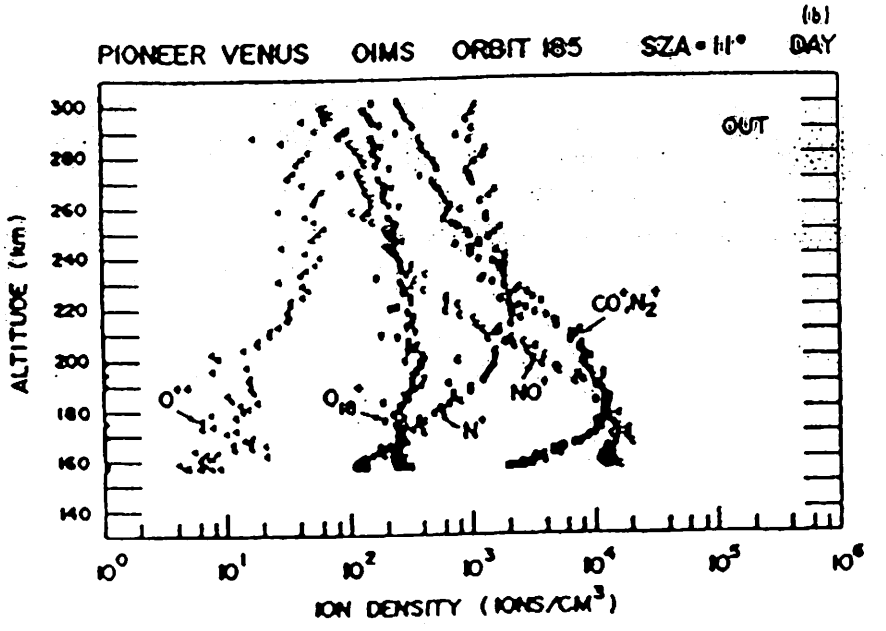
$$\frac{\partial n_i}{\partial t} + \nabla.\{n_i \vec{u}_i\} = q_i - l_i$$

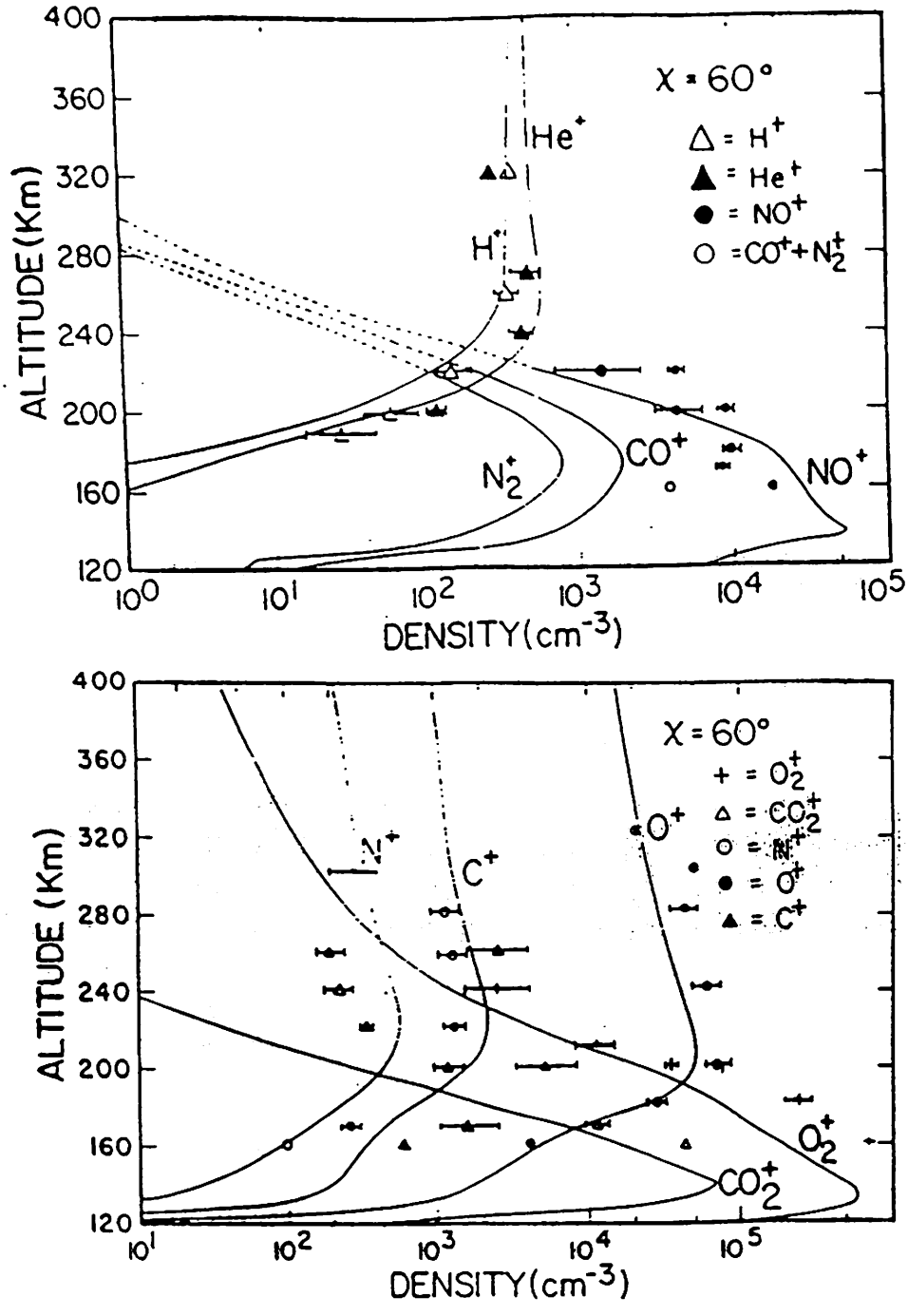
$$n_i m_i \left\{ \frac{\partial \vec{u}_i}{\partial t} + \vec{u}_i.\nabla \vec{u}_i \right\} + \nabla p_i - n_i \vec{F}_i =$$

$$\sum_t m_i n_i \nu_{it} \{\vec{u}_t - \vec{u}_i\}$$

$$\frac{\partial \{(3/2) n_i k T_i\}}{\partial t} - \nabla.\kappa \nabla T_i = E_{net}$$


(a)
PIONEER VENUS OIMS ORBIT 185 SZA = 11° DAY
OUT
ALTITUDE (km)
300
280
260
240
220
200
180
160
140
H_2^+
H^+
He^+
CO_2^+
C^+
O^+
O_2^+
10^0 10^1 10^2 10^3 10^4 10^5 10^6
ION DENSITY (IONS/CM^3)


(b)
PIONEER VENUS OIMS ORBIT 185 SZA = 11° DAY
OUT
ALTITUDE (km)
300
280
260
240
220
200
180
160
140
O^+
O_2^+
N^+
NO^+
$CO^+N_2^+$
10^0 10^1 10^2 10^3 10^4 10^5 10^6
ION DENSITY (IONS/CM^3)



Comparison of theoretical ion densities (solid) with the OIMS ion density measurements. Reasonable agreement was obtained except for the molecular ions N_2^+ and mass 28 ($CO^+ + N_2^+$) (after Nagy *et al.*, 1980).

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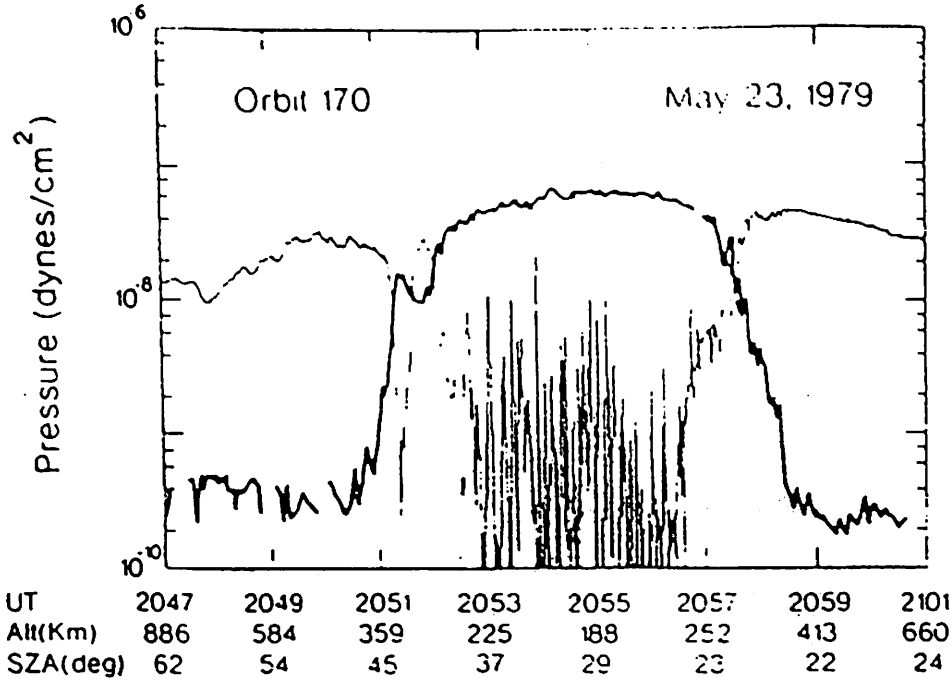

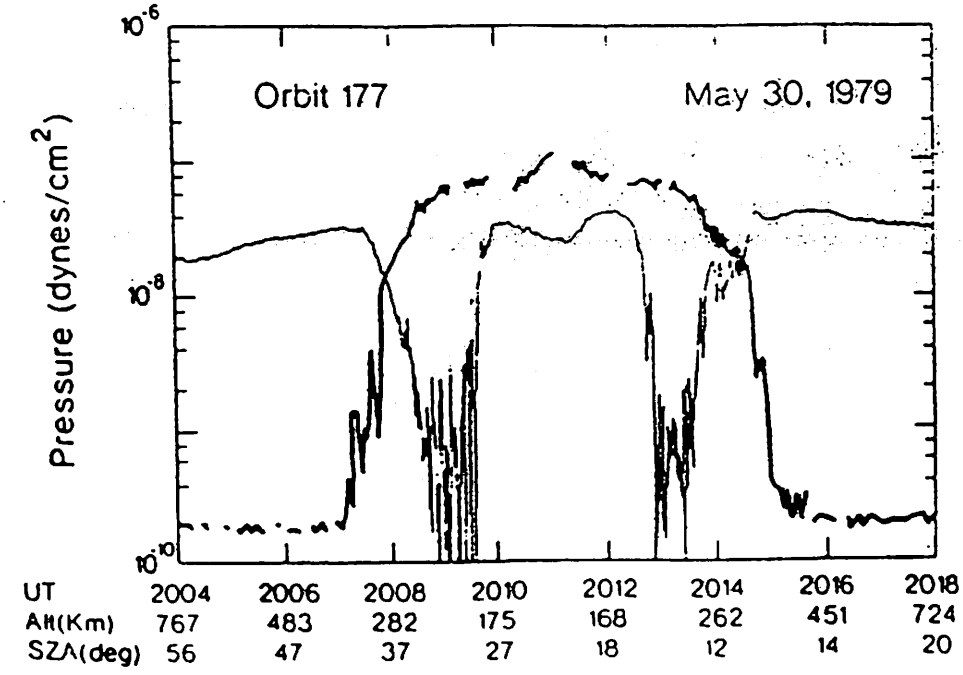

Two orbits which illustrate the pressure continuity across the ionopause, based on PVO measurements. The magnetic pressure outside the ionopause (light line) is in equilibrium with the plasma pressure (heavy line) of the underlying ionosphere (after Elphic *et al.*, 1980b).

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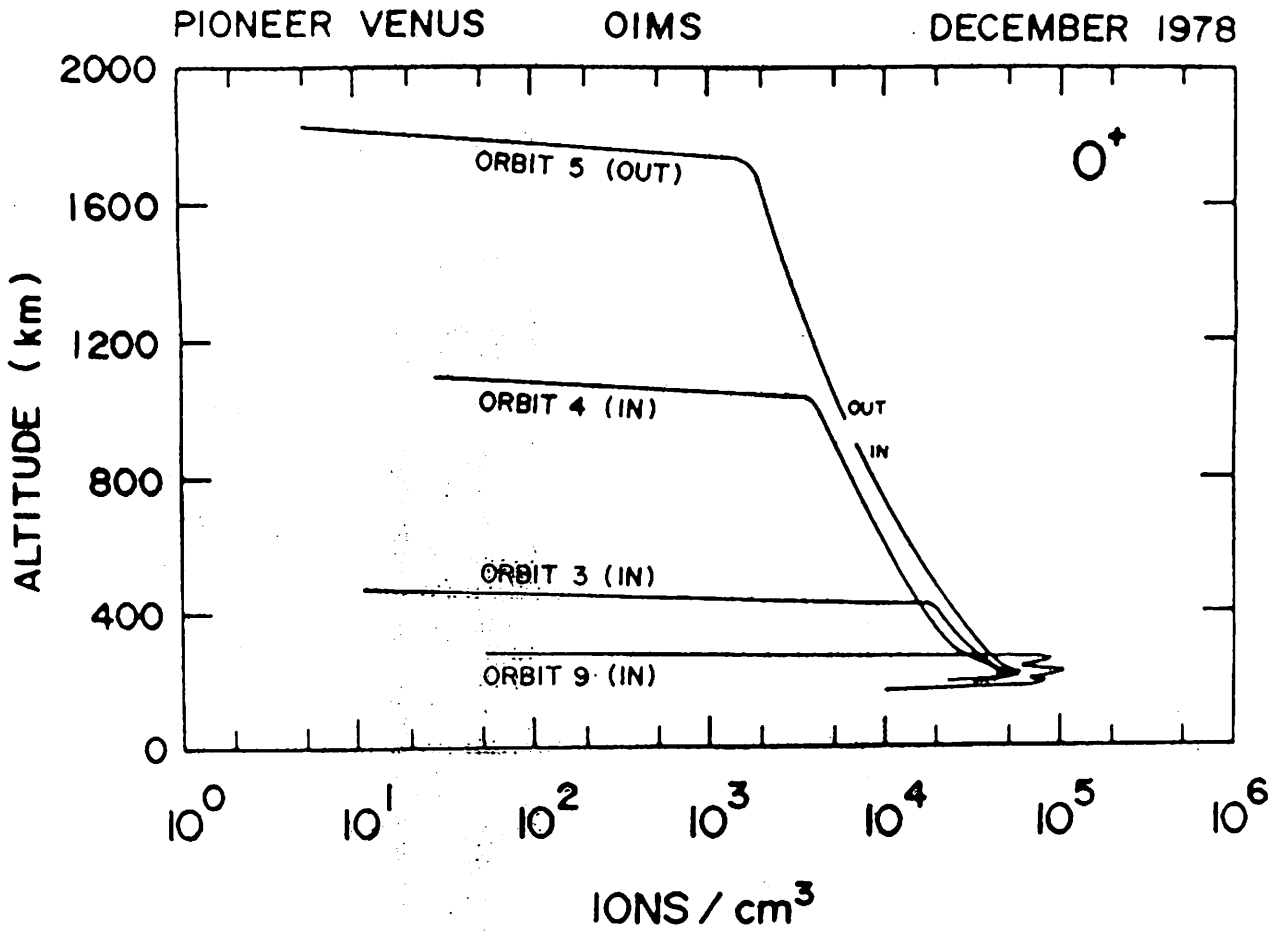
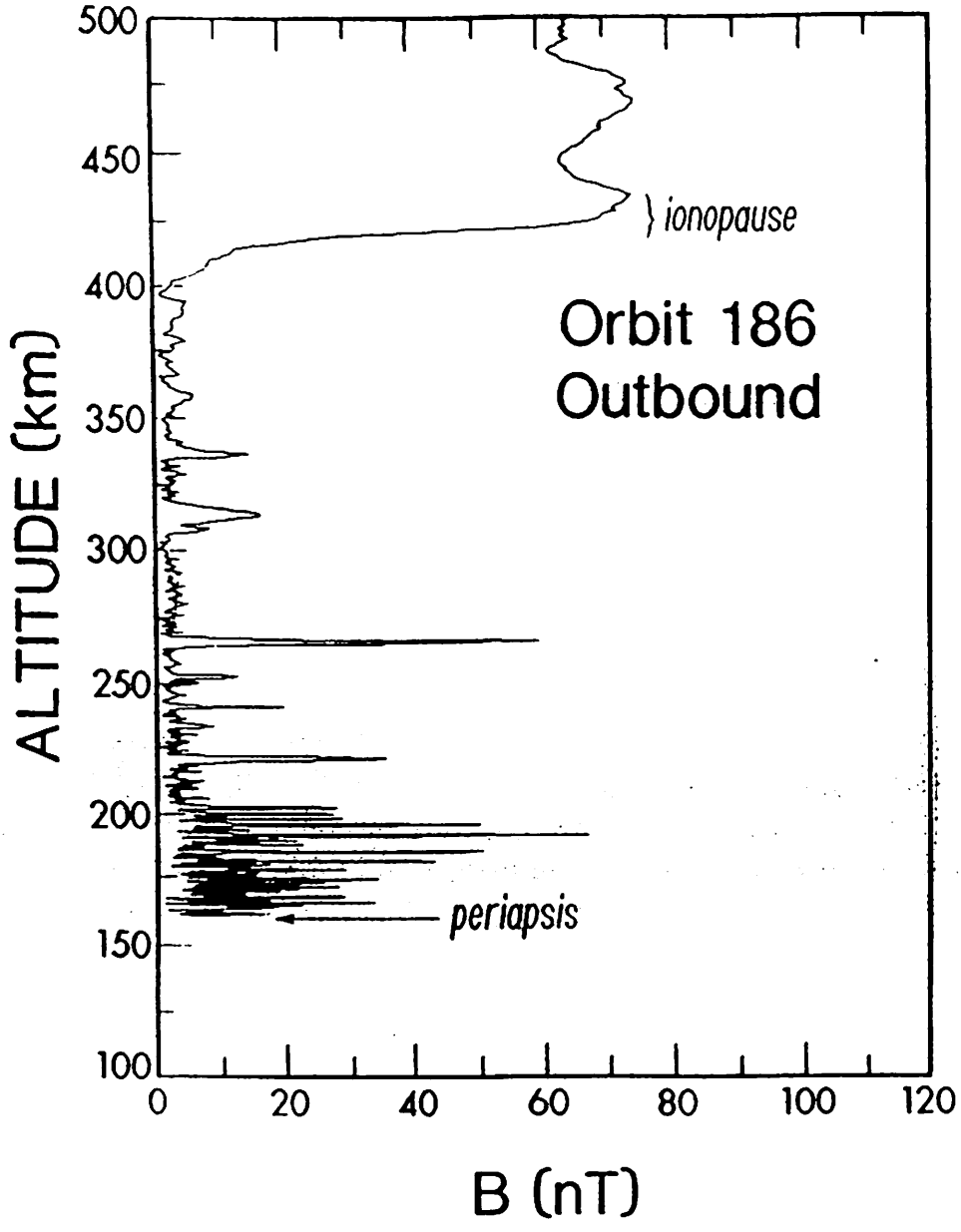
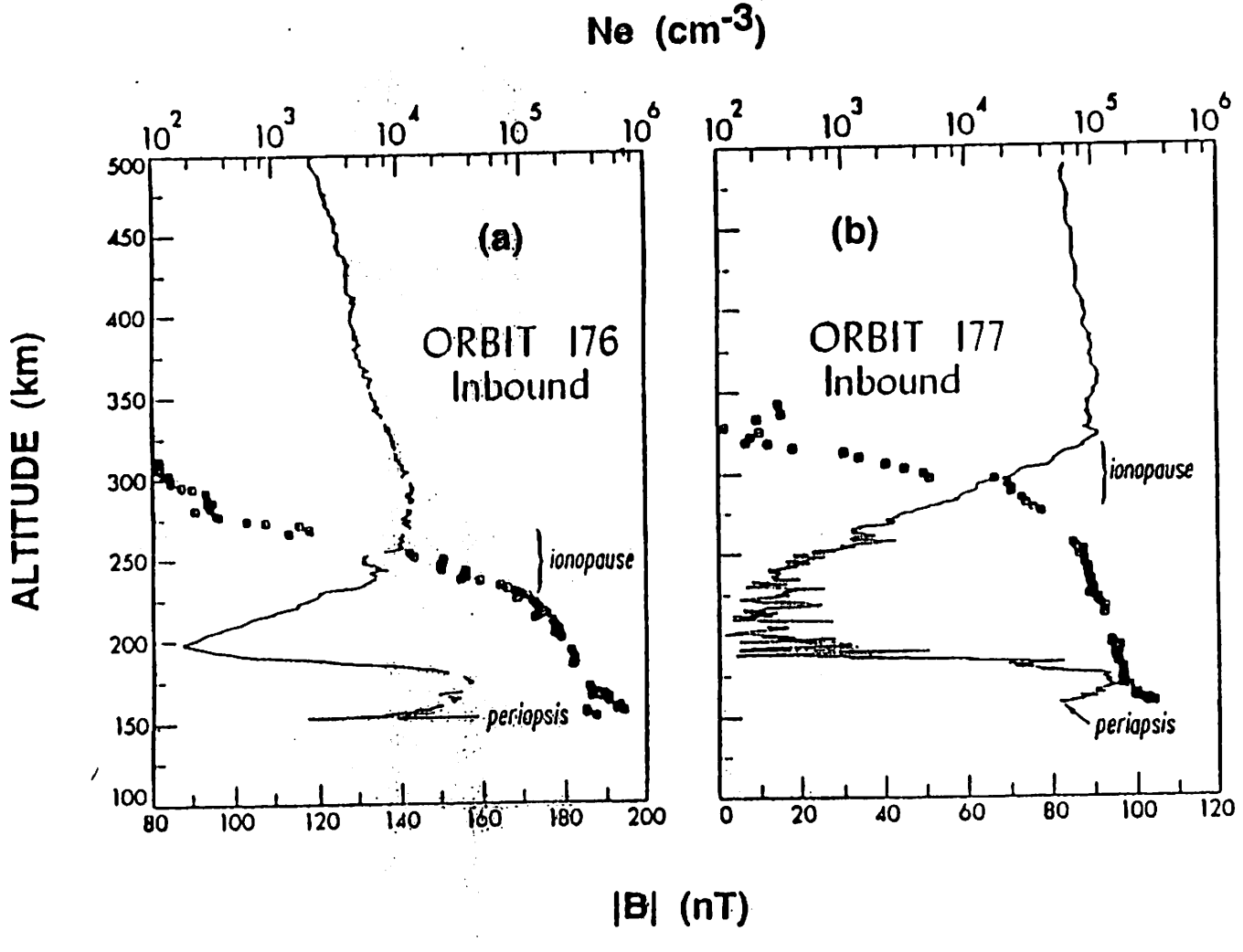


Altitude profiles of O^+ measured by the orbiter ion mass spectrometer on Pioneer Venus on four different days, indicating the extreme variability of the ionopause height [from *Taylor et al.*, 1979*a*].



'Altitude' profile of magnetic field magnitude from a PVO orbit during which small-scale ionospheric field structures were observed. (From Elphic *et al.*, 1980.)



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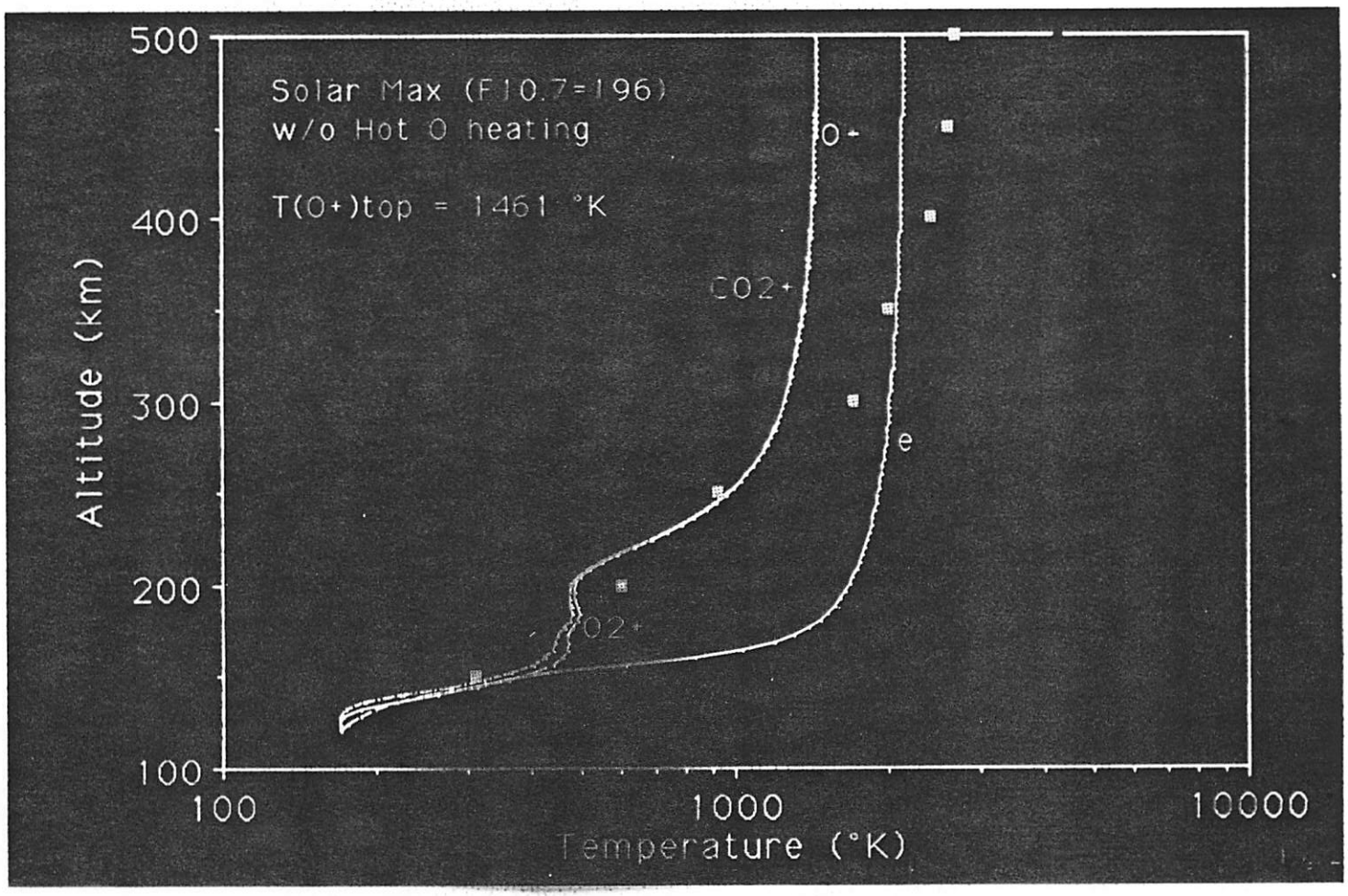
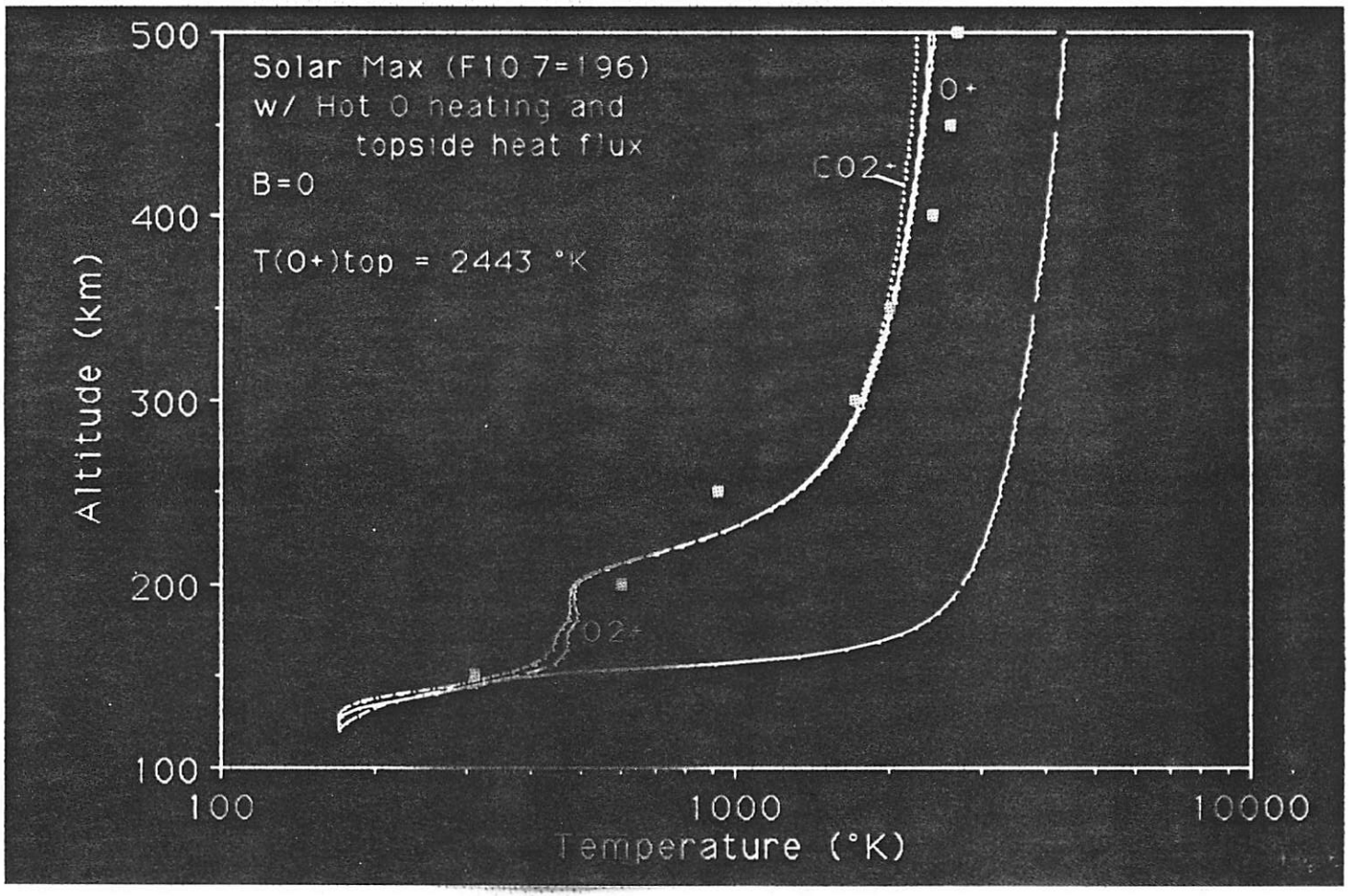
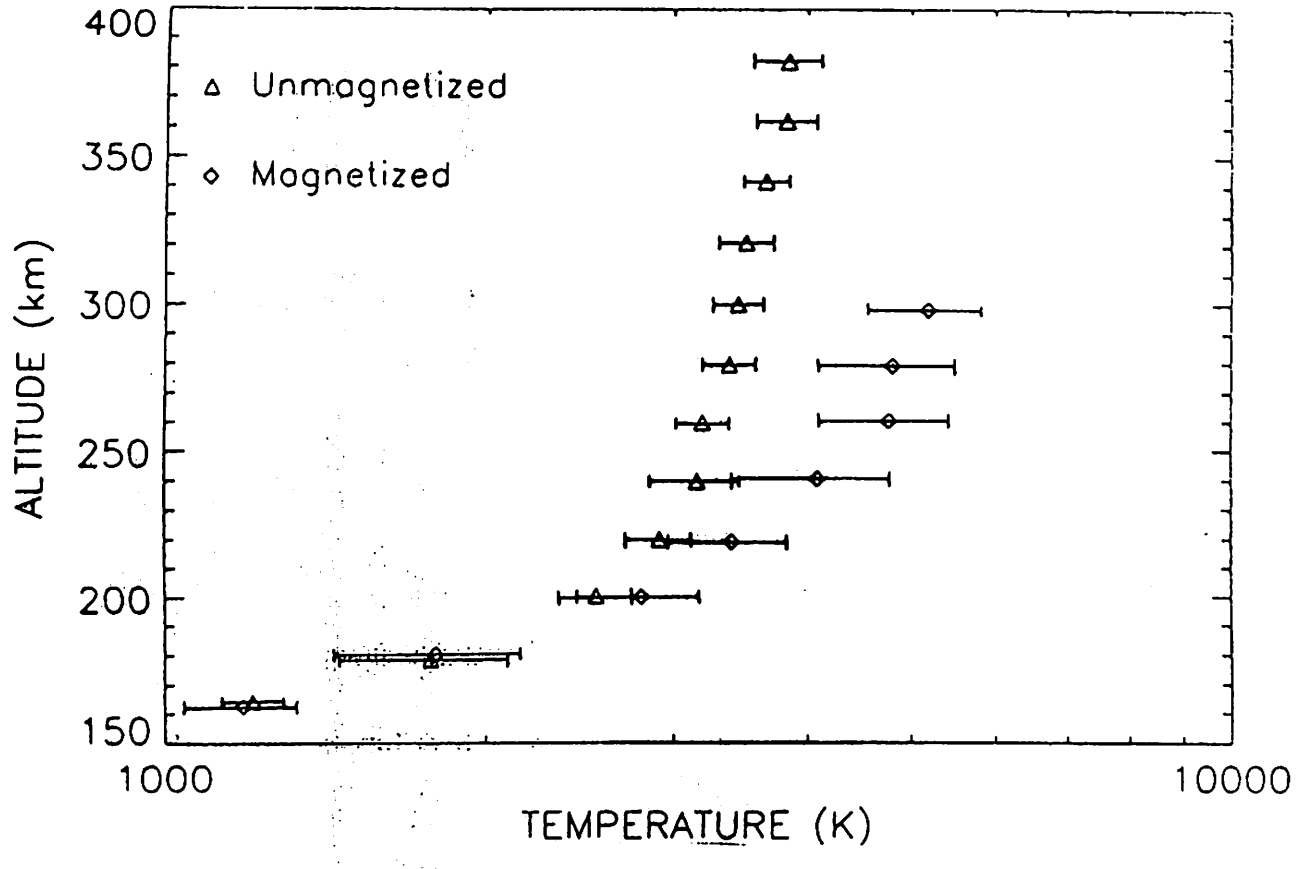
Venus Multiion Energetics



Venus Multiion Energetics





Average electron temperature values for orbits with SZA between 0 and 30°, grouped according to ionospheric magnetic field conditions (horizontal bars indicate the standard deviations).

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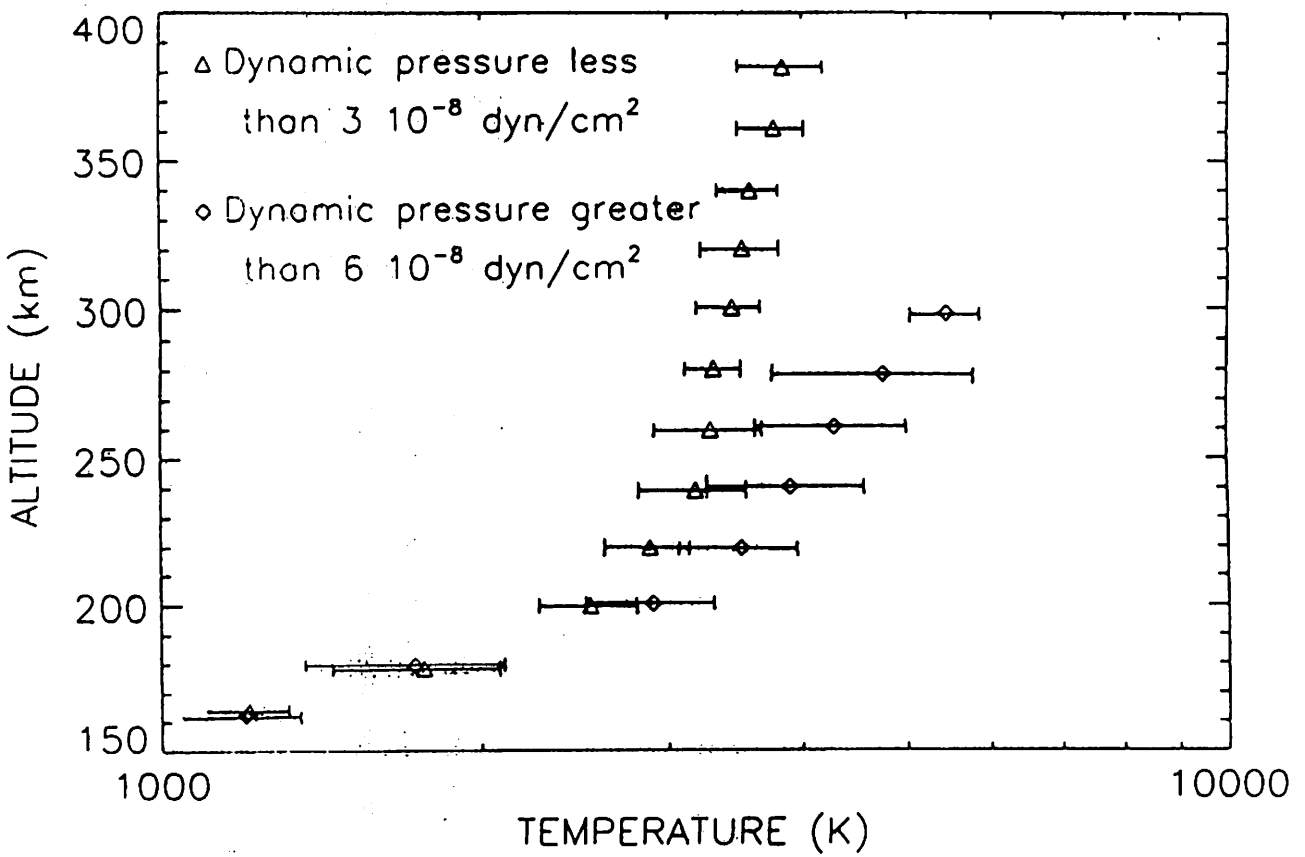
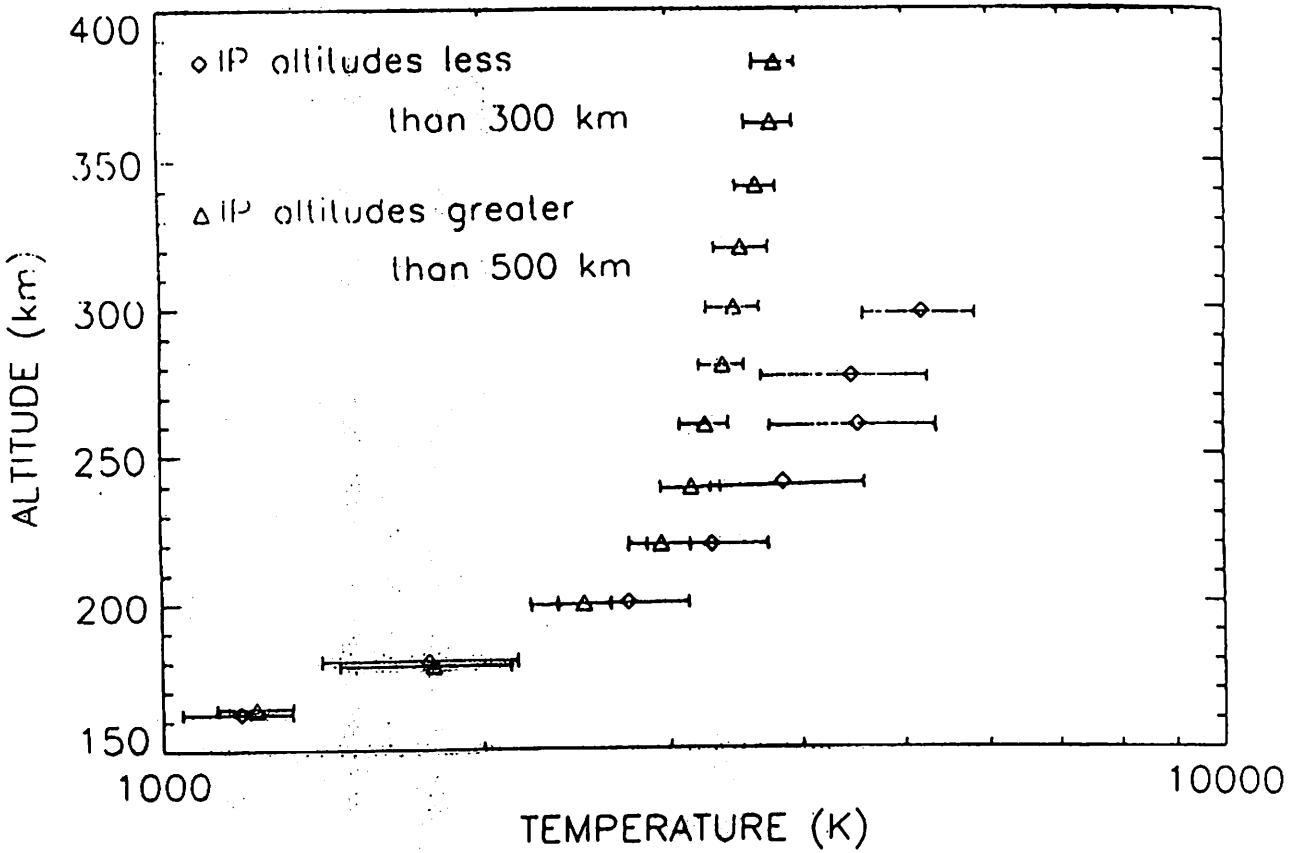


Average electron temperature values for orbits with SZA between 0 and 30°, grouped according to the unperturbed solar wind dynamic pressure (horizontal bars indicate the standard deviations).



Average electron temperature values for orbits with SZA between 0 and 30°, grouped according to the ionopause height (horizontal bars indicate the standard deviations).

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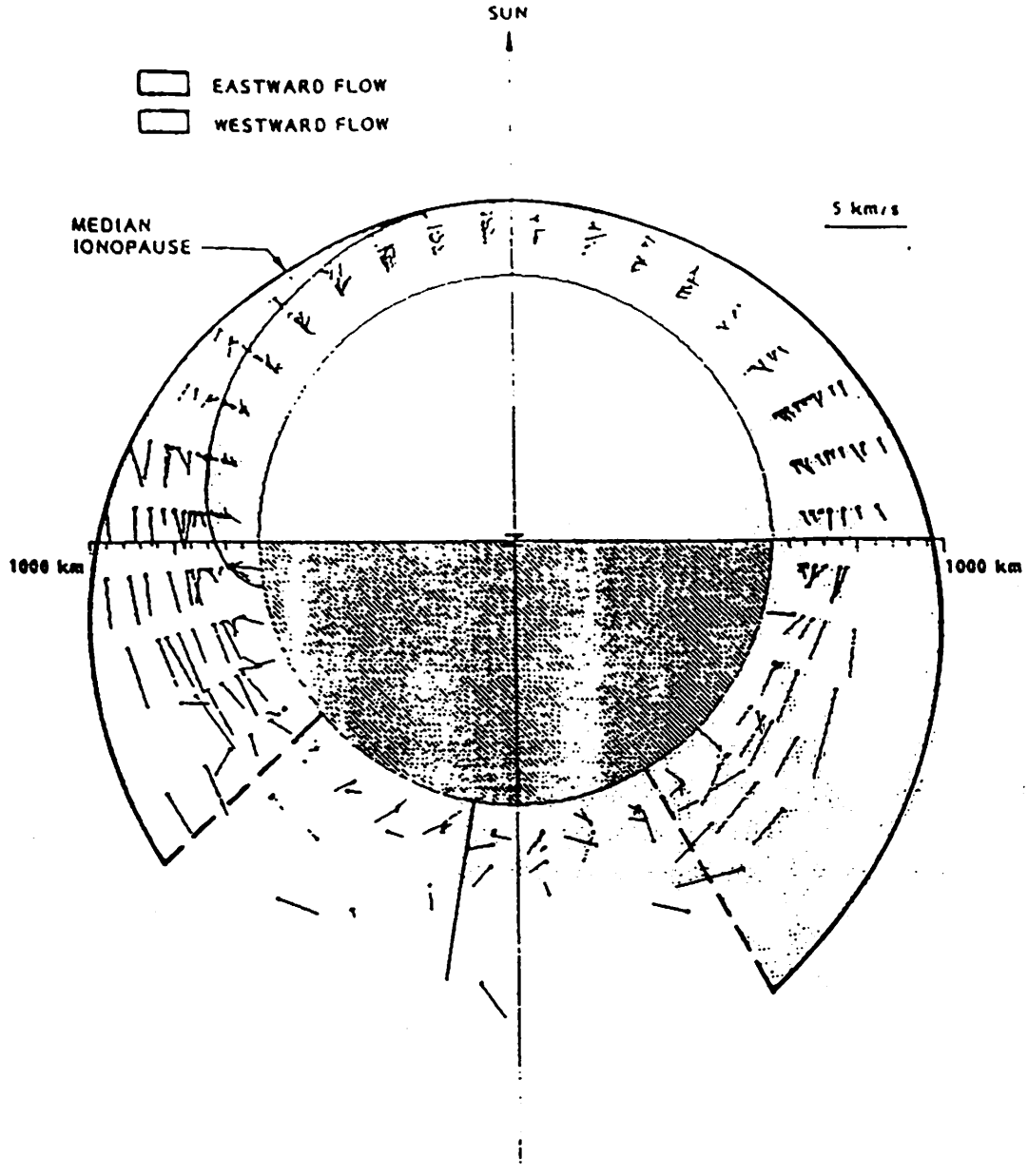
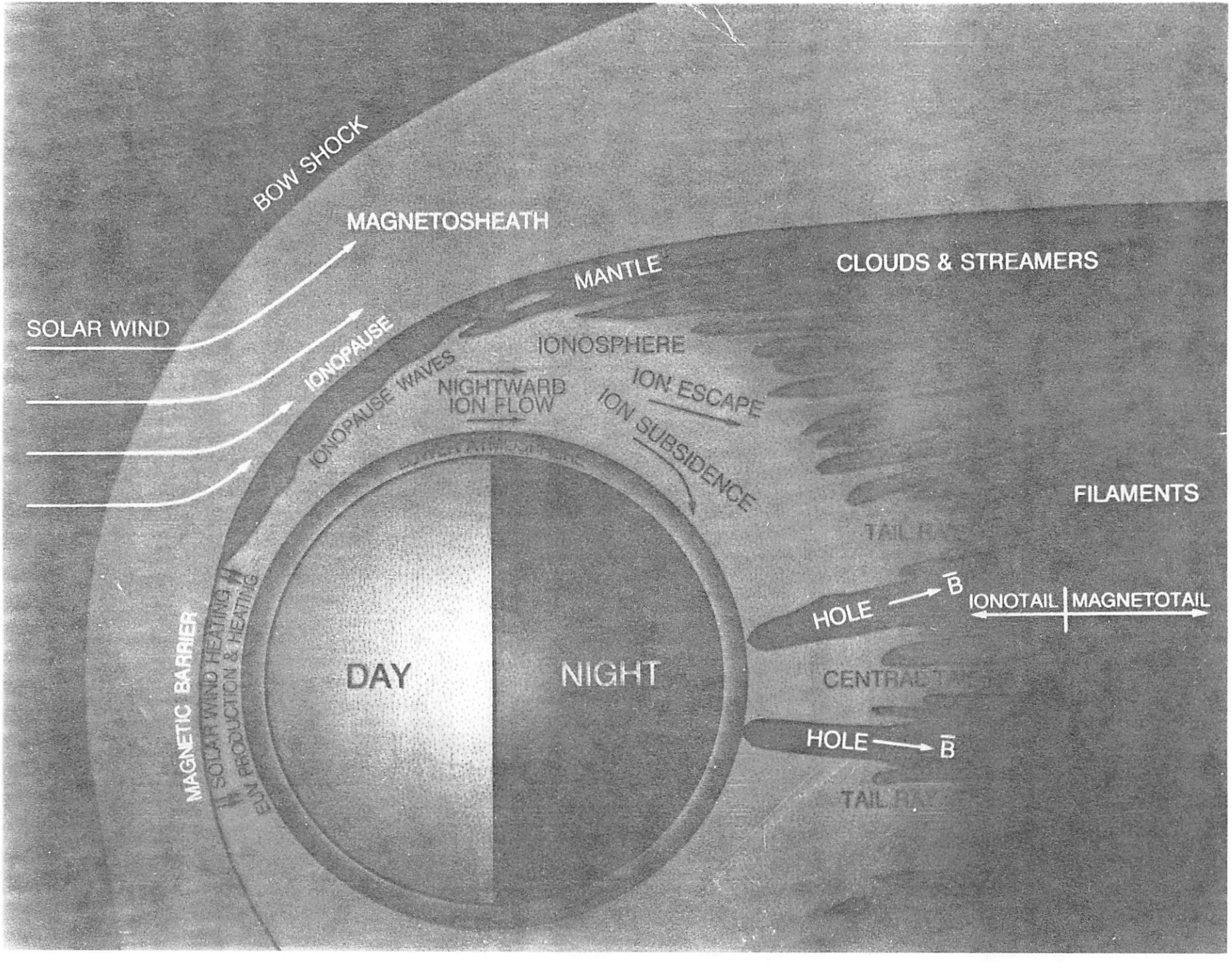


Anti-Sunward O^+ velocity averages at 10° intervals in longitude. The altitude scale has been exaggerated by a factor of four relative to the planetary radius. The shaded area is approximately defined by the median altitude of the ionopause, with the nightward boundary near the point where the velocities become chaotic. The light and dark shading denote regions where the velocity is predominantly westward and eastward, respectively.


BOW SHOCK
MAGNETOSHEATH
MANTLE
CLOUDS & STREAMERS
SOLAR WIND
IONOPAUSE
IONOPAUSE WAVES
IONOSPHERE
NIGHTWARD ION FLOW
ION ESCAPE
ION SUBSIDENCE
FILAMENTS
MAGNETIC BARRIER
SOLAR WIND HEATING
EUV PRODUCTION & HEATING
DAY
NIGHT
HOLE
B
IONOTAIL
MAGNETOTAIL
HOLE
B

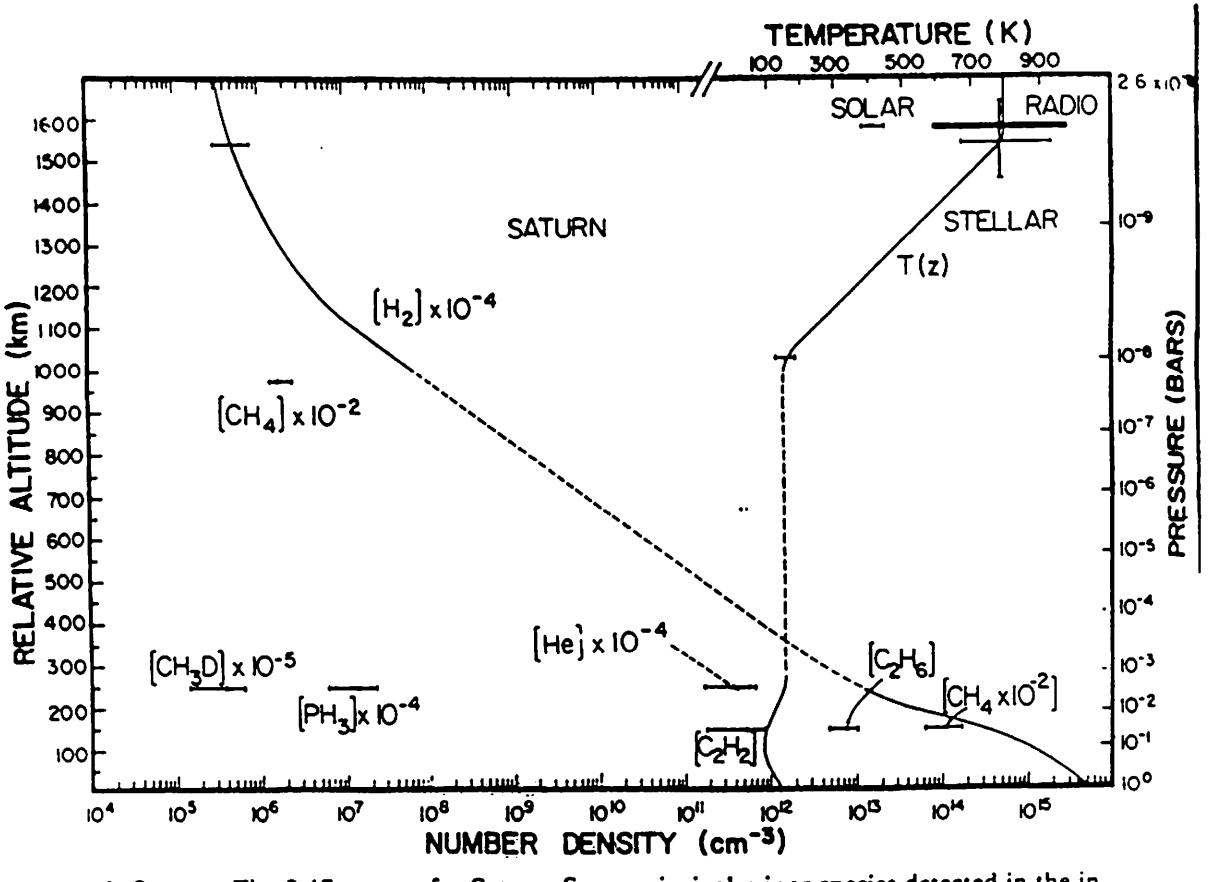
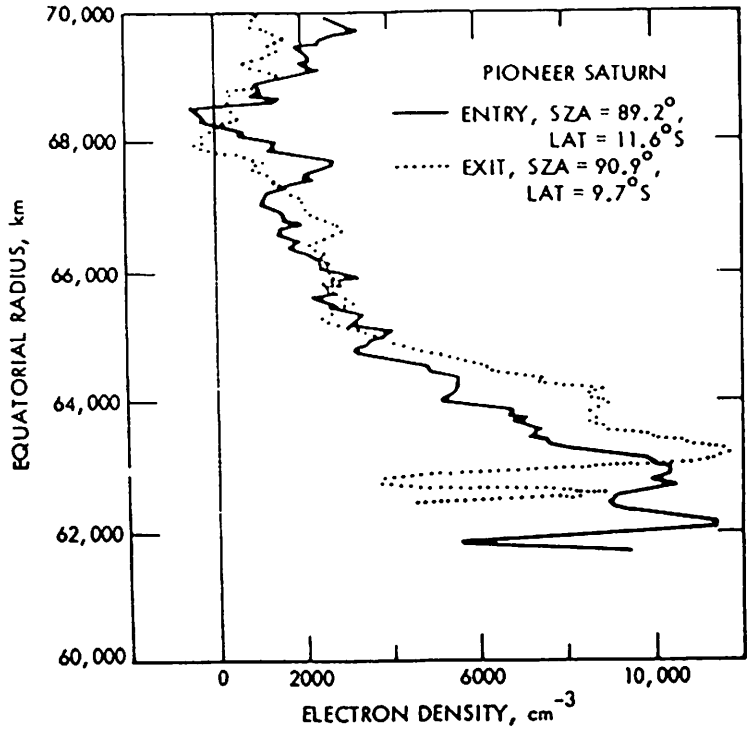
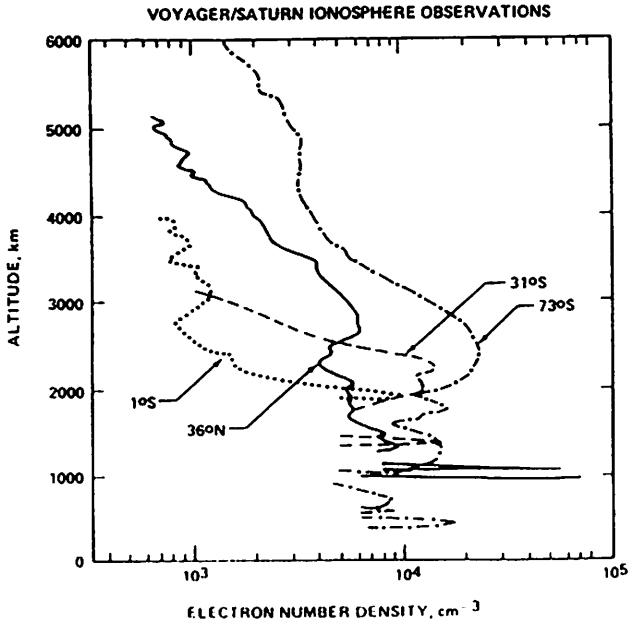


Fig. 2.18. Same as Fig. 2.17, except for Saturn. Some principal minor species detected in the infrared in the lower atmosphere are also indicated. (After Festou and Atreya 1982; Atreya et al. 1984)



Pioneer radio occultation profiles of Saturn



Voyager radio occultation profiles of Saturn

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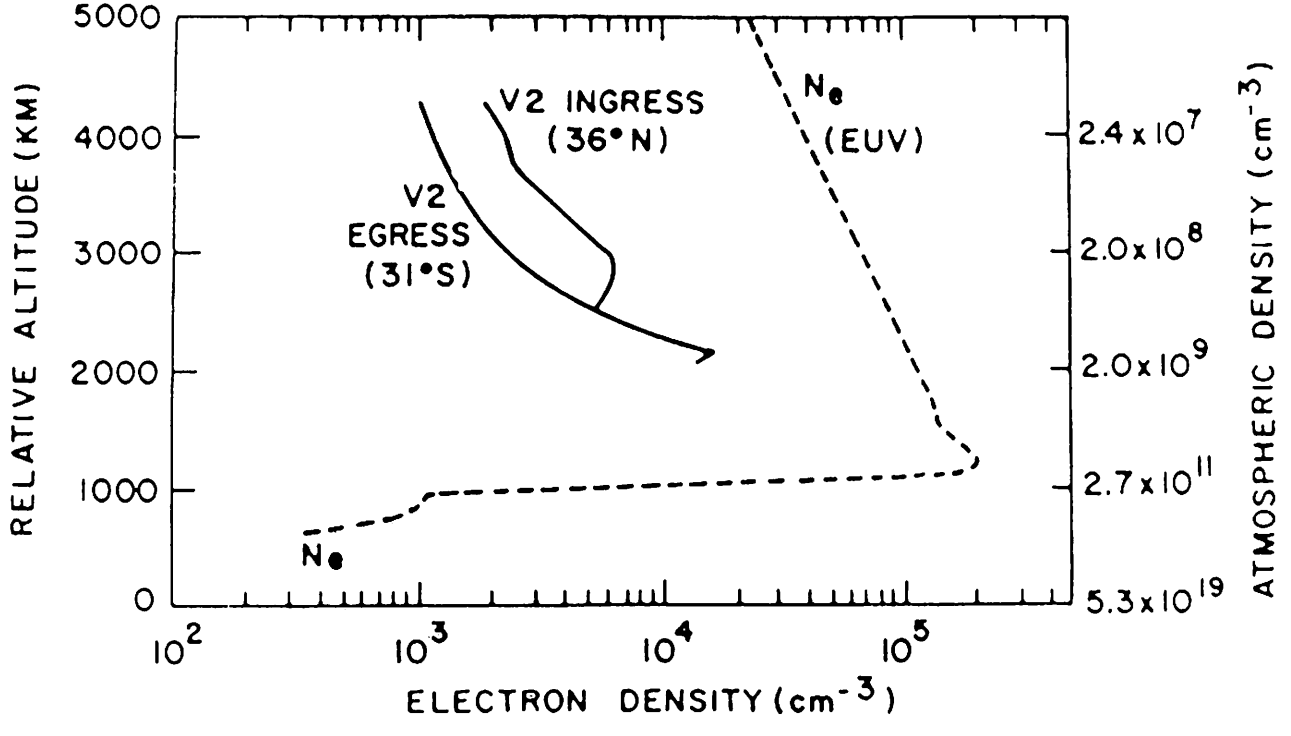


Fig. 13. Comparison of pre-Voyager model calculations of the Saturnian ionosphere with measured mid-latitude profiles of the ionosphere (from /34/).

PHOTO CHEMISTRY OF THE OUTER PLANETS

$$
\begin{aligned}
H_2 + h\nu &\rightarrow H + H \\
&\rightarrow H_2^+ + e \\
&\rightarrow H^+ + H + e
\end{aligned}
$$

$$
H + h\nu \rightarrow H^+ + e
$$

$$
\begin{aligned}
H_2^+ + H_2 &\rightarrow H_3^+ + H \\
H_3^+ + e &\rightarrow H_2 + H
\end{aligned}
$$

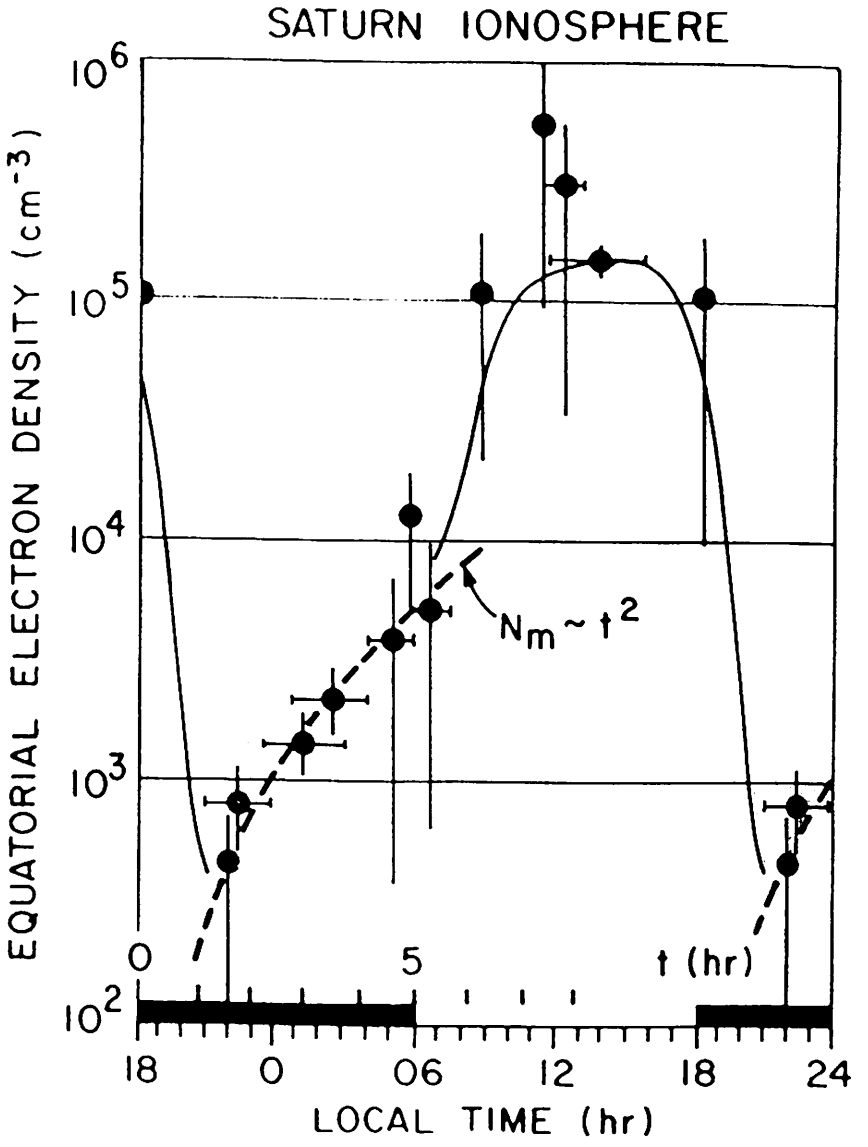
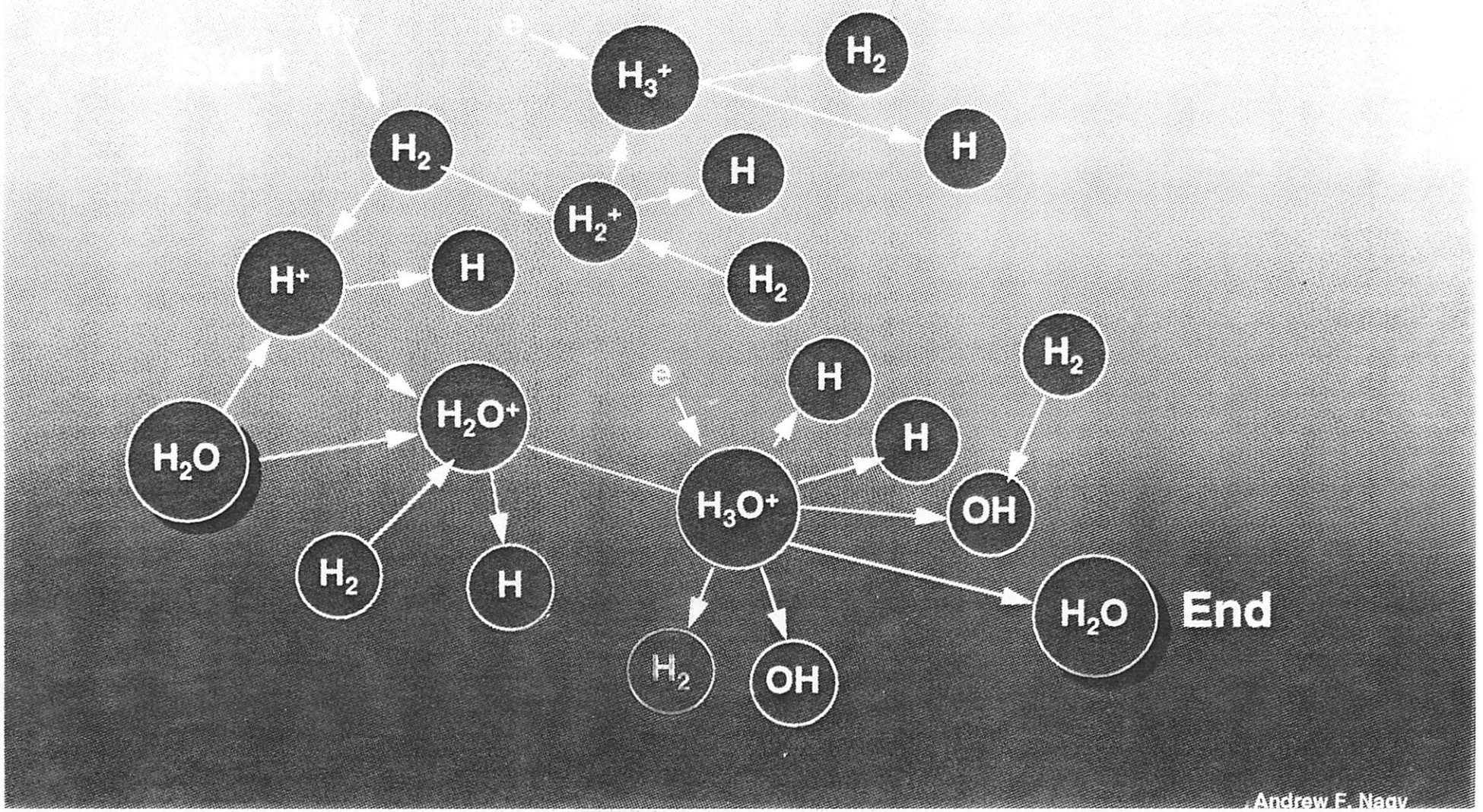


Fig. 14. Profile of the diurnal variation of $N_m F_2$ in the Saturnian ionosphere (from /18/)

Hydrogen Ion Chemistry with Water



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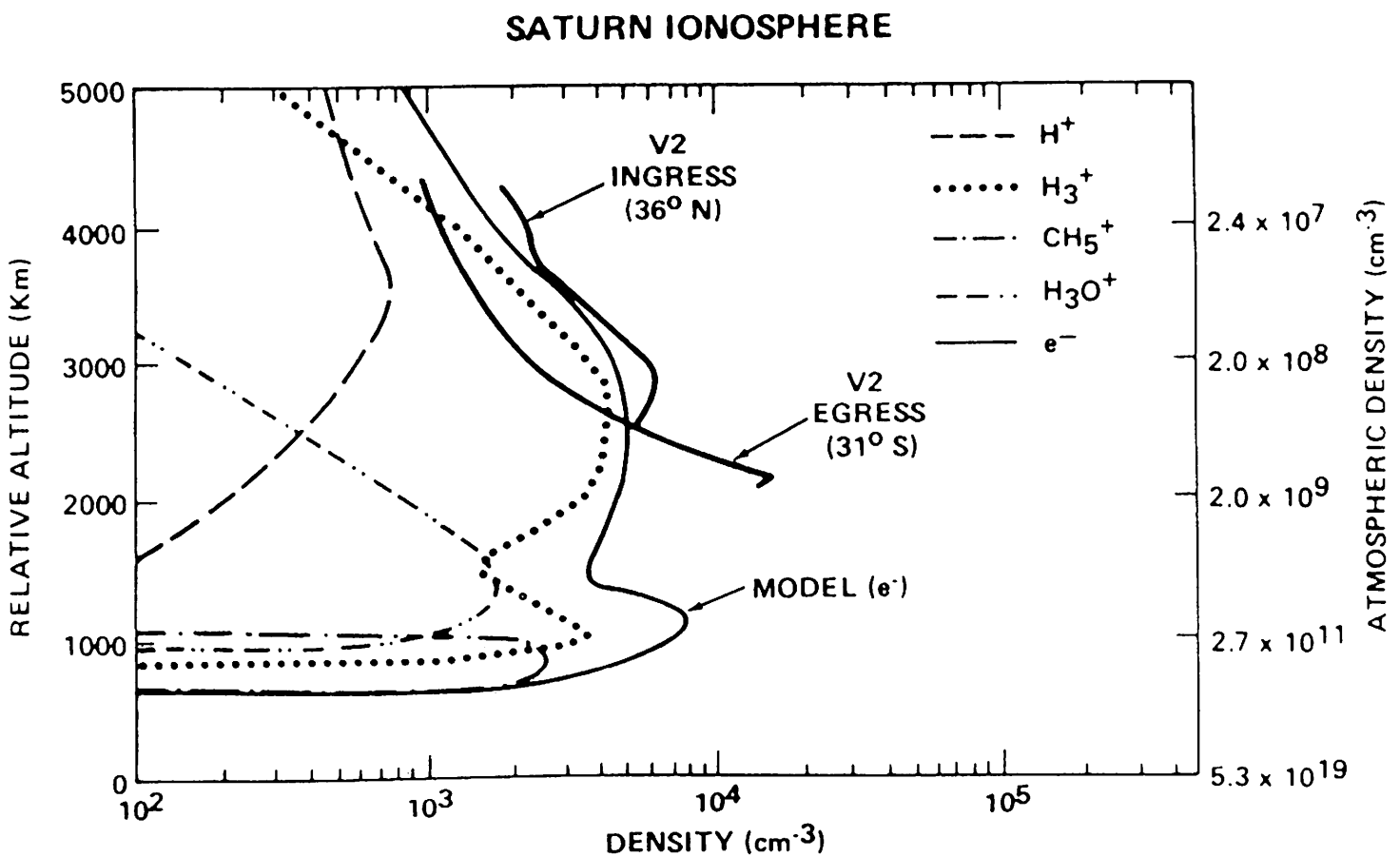

Fig. 16. Model ionospheric profile of Saturn illustrating the effects of H_2O influx from the rings on the ionospheric composition and structure and including particle ionization sources due to "electroglow" processes.

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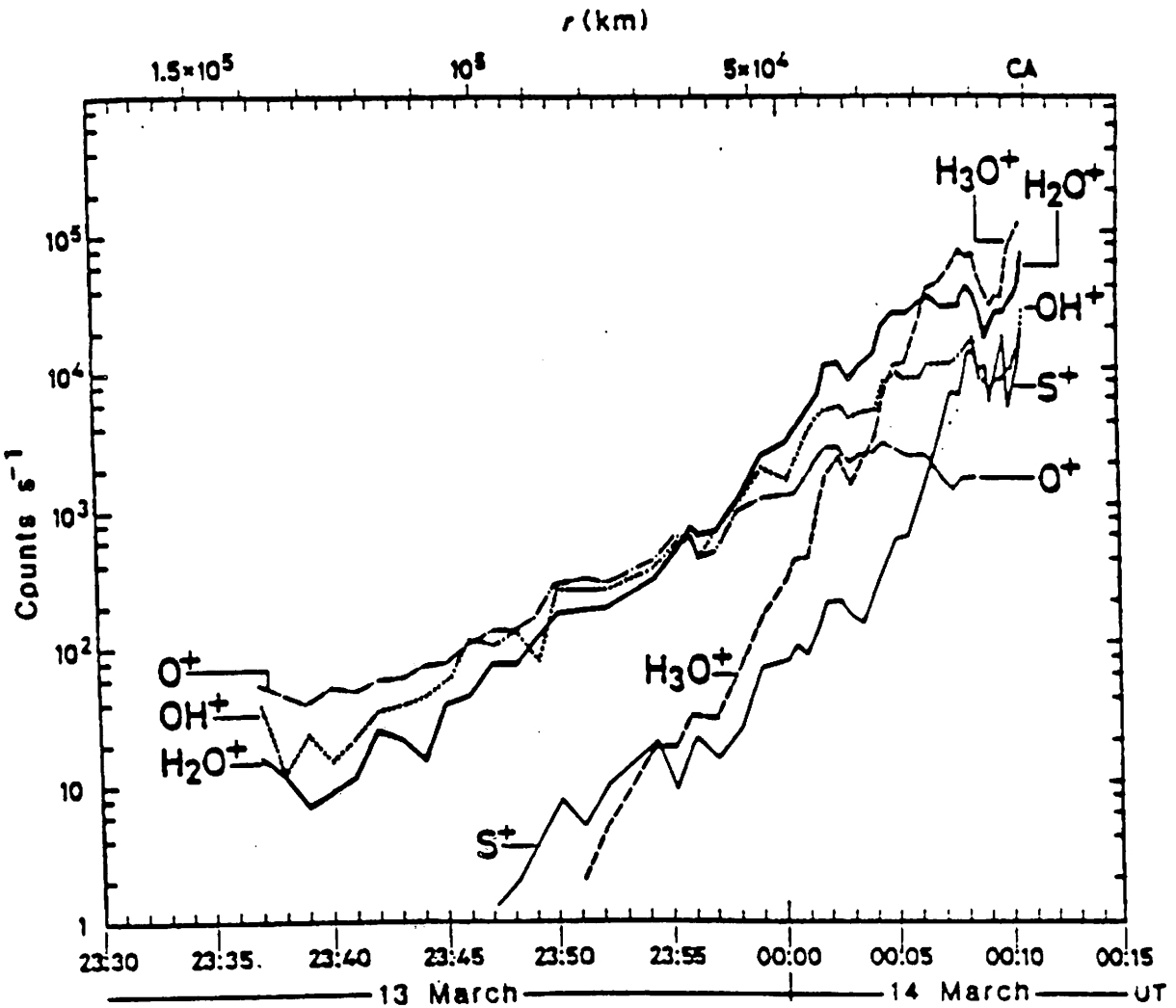

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