Chapter 9

Earth's atmosphere and environment

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Radiation environment

Galactic cosmic radiation	
Flux at sunspot minimum:	~ 4 protons $cm^{-2} s^{-1}$ (isotropic)
Integrated yearly rate:	$\sim 1.3 \times 10^8$ protons cm^{-2}
Flux at sunspot maximum:	2.0 protons $cm^{-2} s^{-1}$ (isotropic)
Integrated yearly rate:	$\sim 7 \times 10^7$ protons cm^{-2}
Energy range:	40 MeV–10^{13} MeV; predominantly 10^3–10^7 MeV
Integrated dose (without shielding):	$\sim$4–10 rad yr^{-1}

Solar high energy particle radiation

Composition: predominantly protons (H^+) and alpha particles (He^{++}).

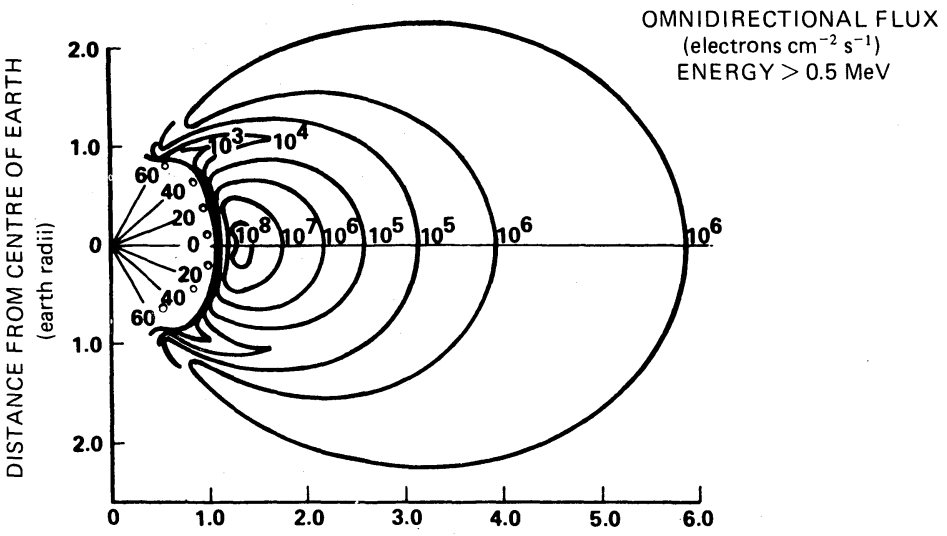
Integrated yearly flux at 1 AU:

Energy >30 MeV,	$N \approx 8 \times 10^9$ protons cm^{-2} near solar maximum
	$N \approx 5 \times 10^5$ protons cm^{-2} near solar minimum
Energy >100 MeV,	$N \approx 6 \times 10^8$ protons cm^{-2} near solar maximum
	$N \approx 5 \times 10^4$ protons cm^{-2} near solar minimum

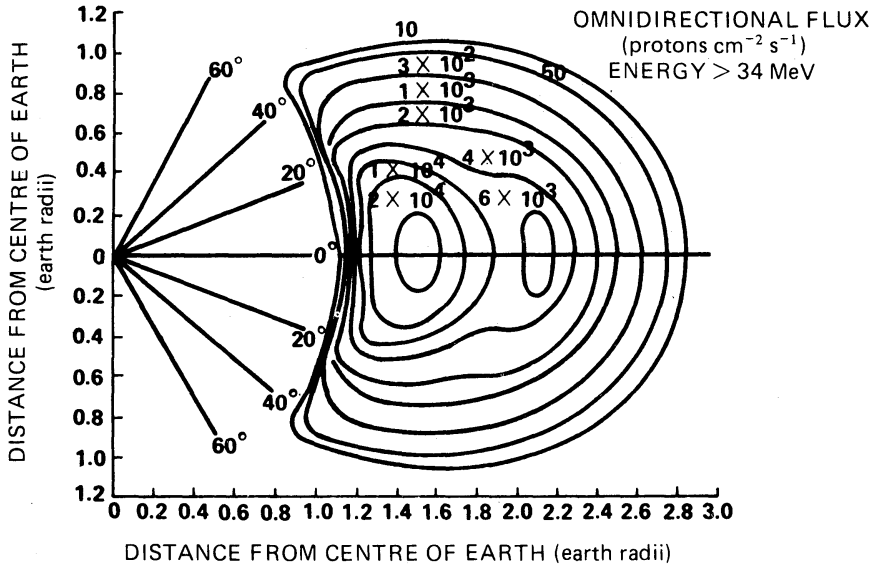
Maximum dosage with shielding of 5 g cm^{-2} (equivalent thickness): $\sim$200 rad per week (3 flares), skin dose at a point detector.

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Electron distribution in the Earth's field. (Published by Vette in August 1964.)



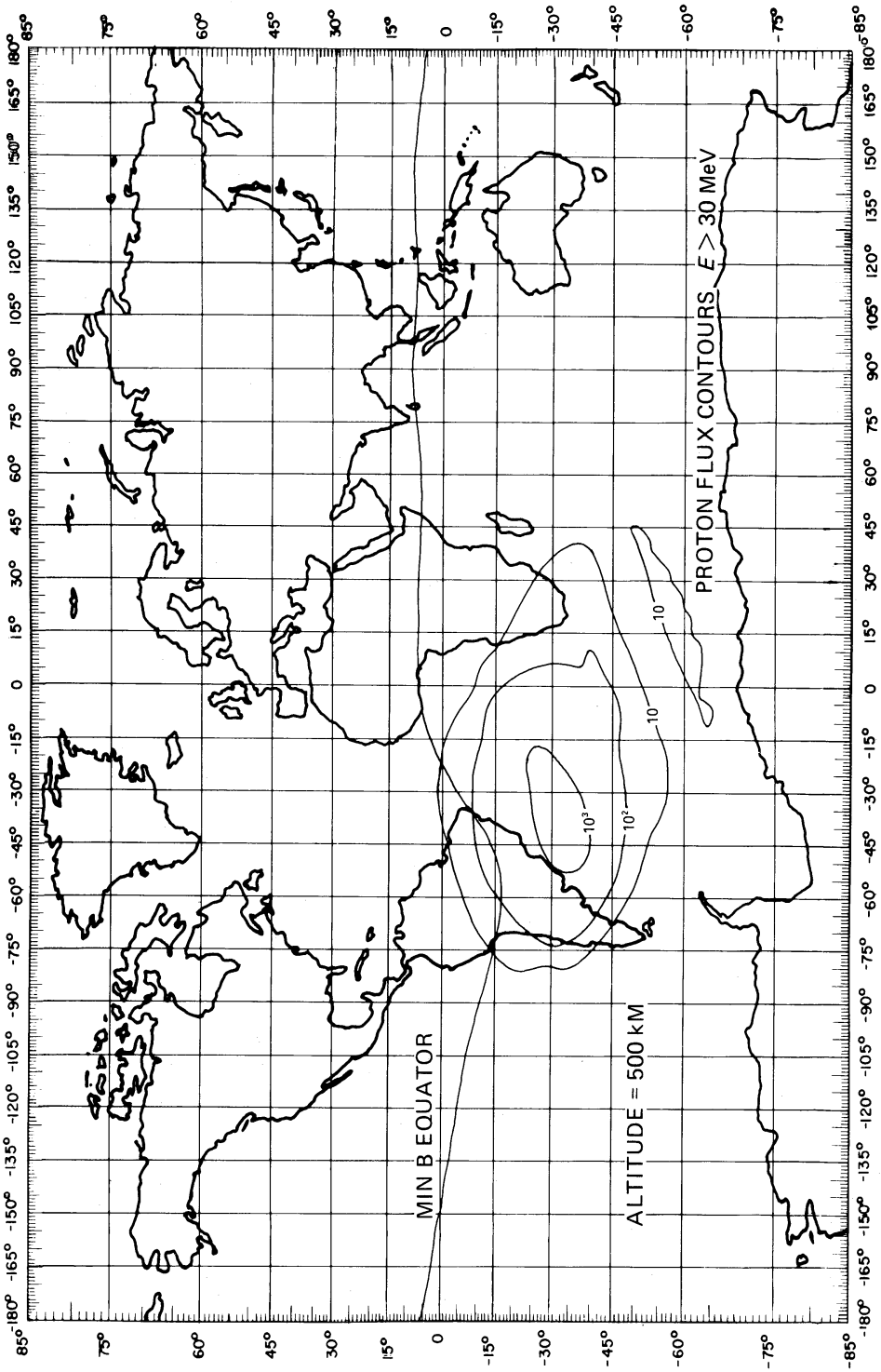
Proton distribution in the Earth's field. (Published by Vette in September 1963.)



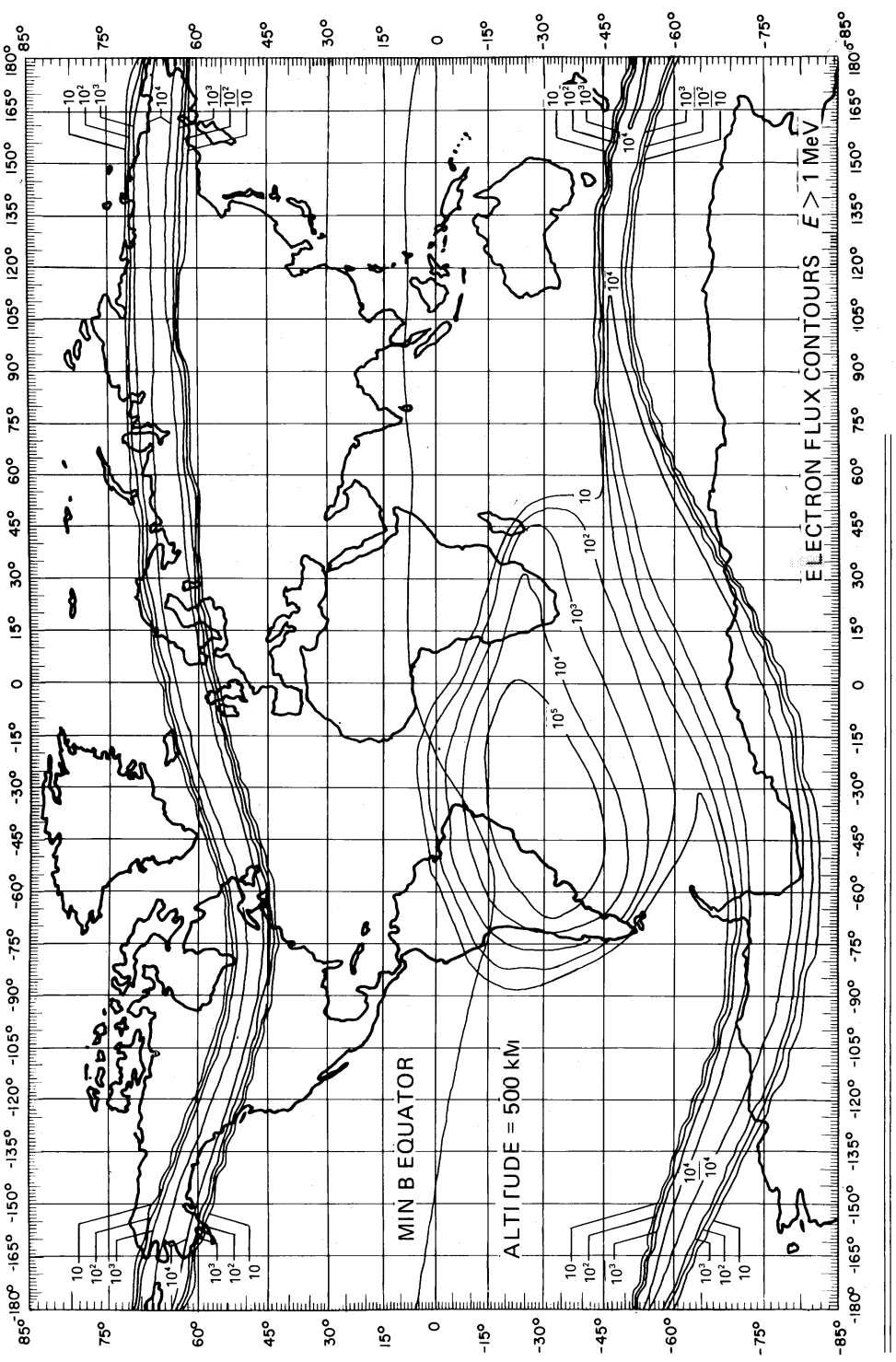
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Trapped radiation (*cont.*)

Omni-directional flux in protons $cm^{-2}\ s^{-1}$. (Adapted from Stassinopoulos, E. G., *World Maps of Constant B, L, and Flux Contours*, NASA SP-3054, 1970.)



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Omni-directional flux in electrons $cm^{-2}\ s^{-1}$. (Adapted from Stassinopoulos, E. G., *World Maps of Constant B, L, and Flux Contours*, NASA SP-3054, 1970.)

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Solar irradiance (1 AU)

Visible and infrared radiation

Radiant energy distribution:

approximated by that from a 5800 K blackbody

Fraction of solar radiation:

Above 7000 Å = 53.12%
Above 4000 Å ~ 91.28%
3000 Å–30 000 Å = 96.62%

Ultraviolet and X-ray radiation

Fraction of solar radiation:

Below 4000 Å = 8.72%
Below 3000 Å = 1.21%
Below 2000 Å = 0.008% (variable)
Below 1000 Å = 10^{-4}% (variable)

Principal line emission fluxes at 1.0 AU:

Lyman Alpha H I (1215.67 Å): 51.0×10^{-4} W m^{-2}
He II (303.8 Å): 2.5×10^{-4} W m^{-2}
H I (1025.72 Å): 0.60×10^{-4} W m^{-2}
C III (977 Å): 0.50×10^{-4} W m^{-2}

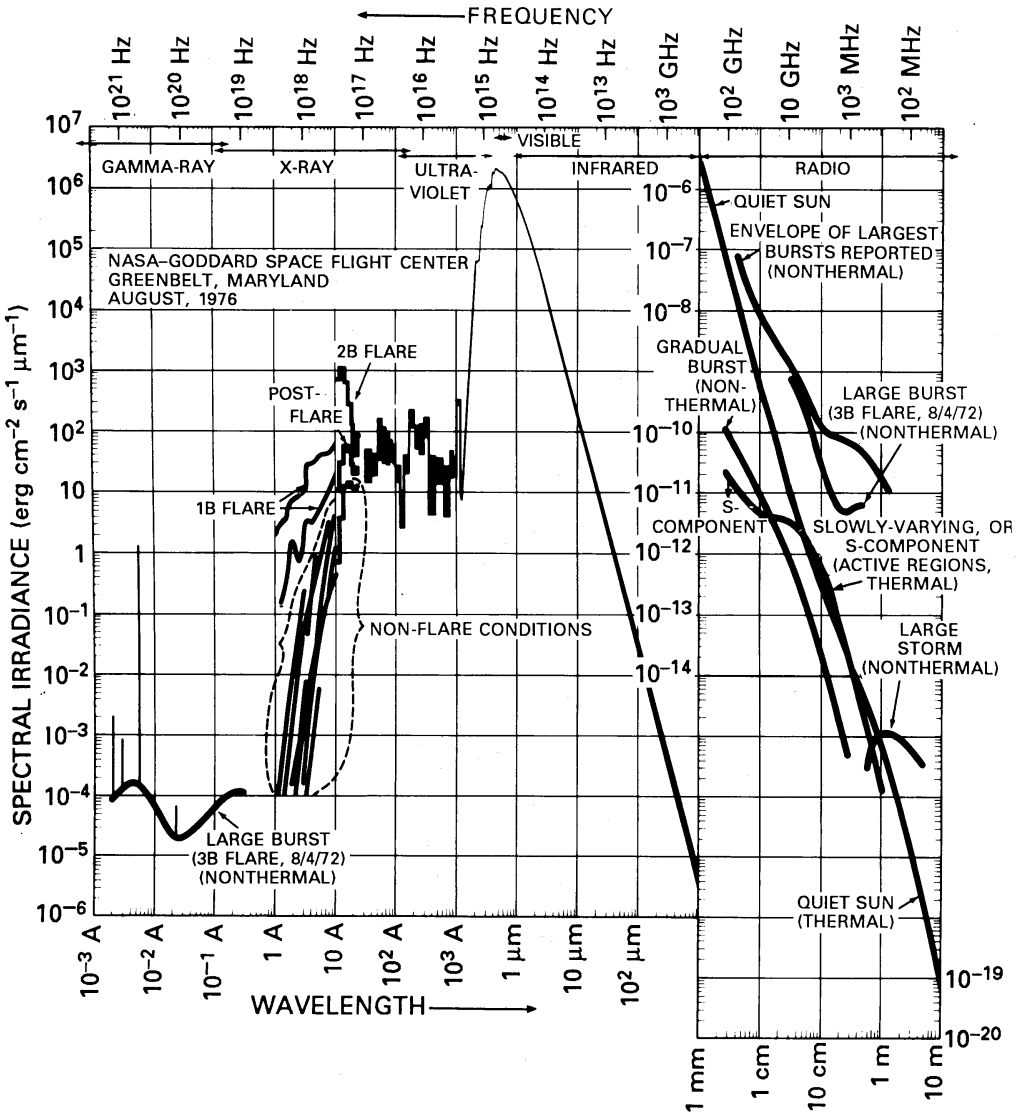
X-ray flux (W m^{-2}):

	1–8 Å	8–20 Å	20–200 Å
Sunspot min	1×10^{-8}	1×10^{-7}	$\sim 1 \times 10^{-4}$
Sunspot max	3×10^{-6}	2×10^{-5}	$\sim 1 \times 10^{-3}$
Flare activity (large flares)	1×10^{-4}	5×10^{-4}	$\sim 1 \times 10^{-2}$

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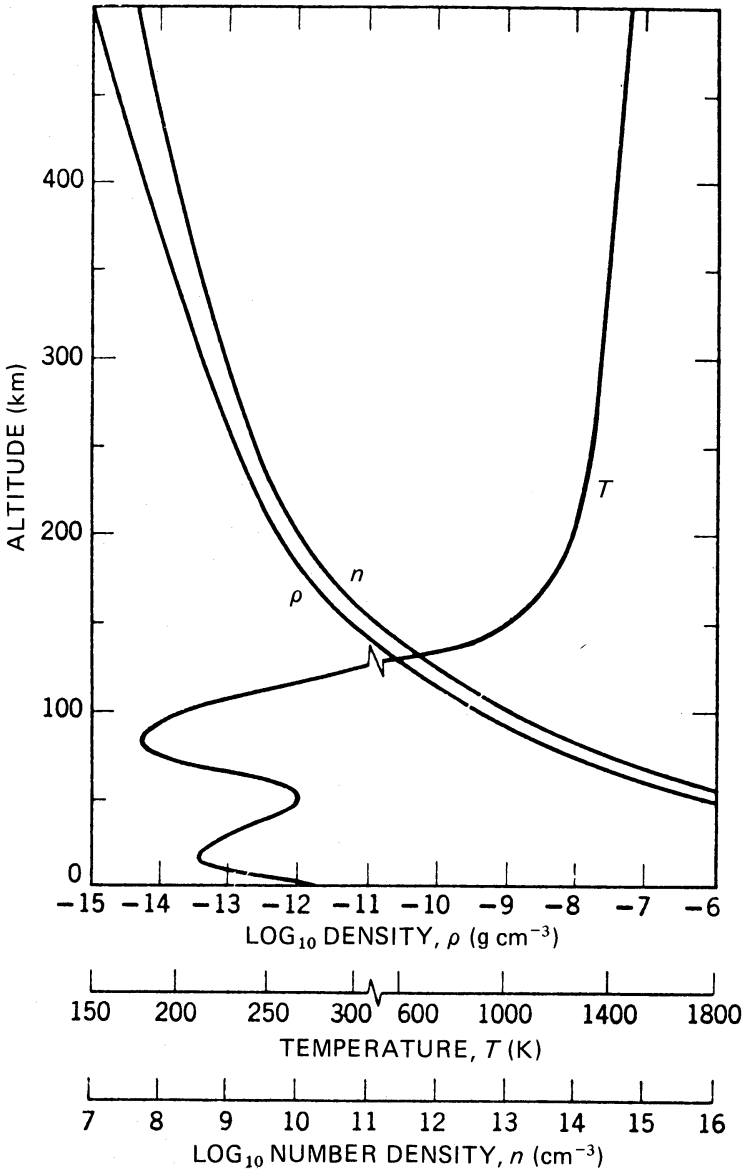
The solar spectrum

The solar spectral irradiance from radio waves to gamma-rays. (Courtesy H. Malitson and the National Space Science Data Center.)



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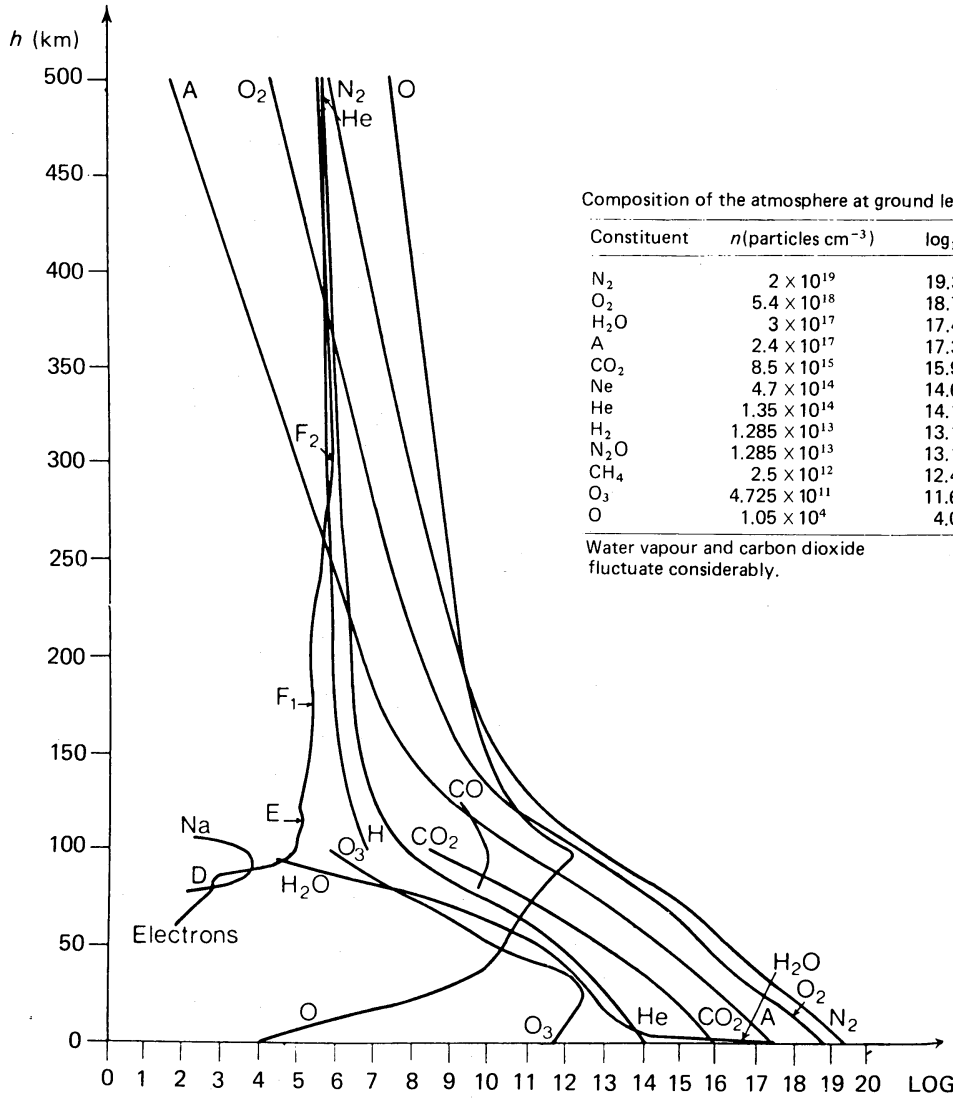
(COSPAR International Reference Atmosphere, 1961.)



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Altitude variation of atmospheric constituents

Variation with altitude of the various constituents of the atmosphere. The horizontal scale is the logarithm of the particle density n in particles cm^{-3}. (Adapted from Pecker, J., *Space Observatories*, D. Reidel Publishing Company, Dordrecht, 1970.)

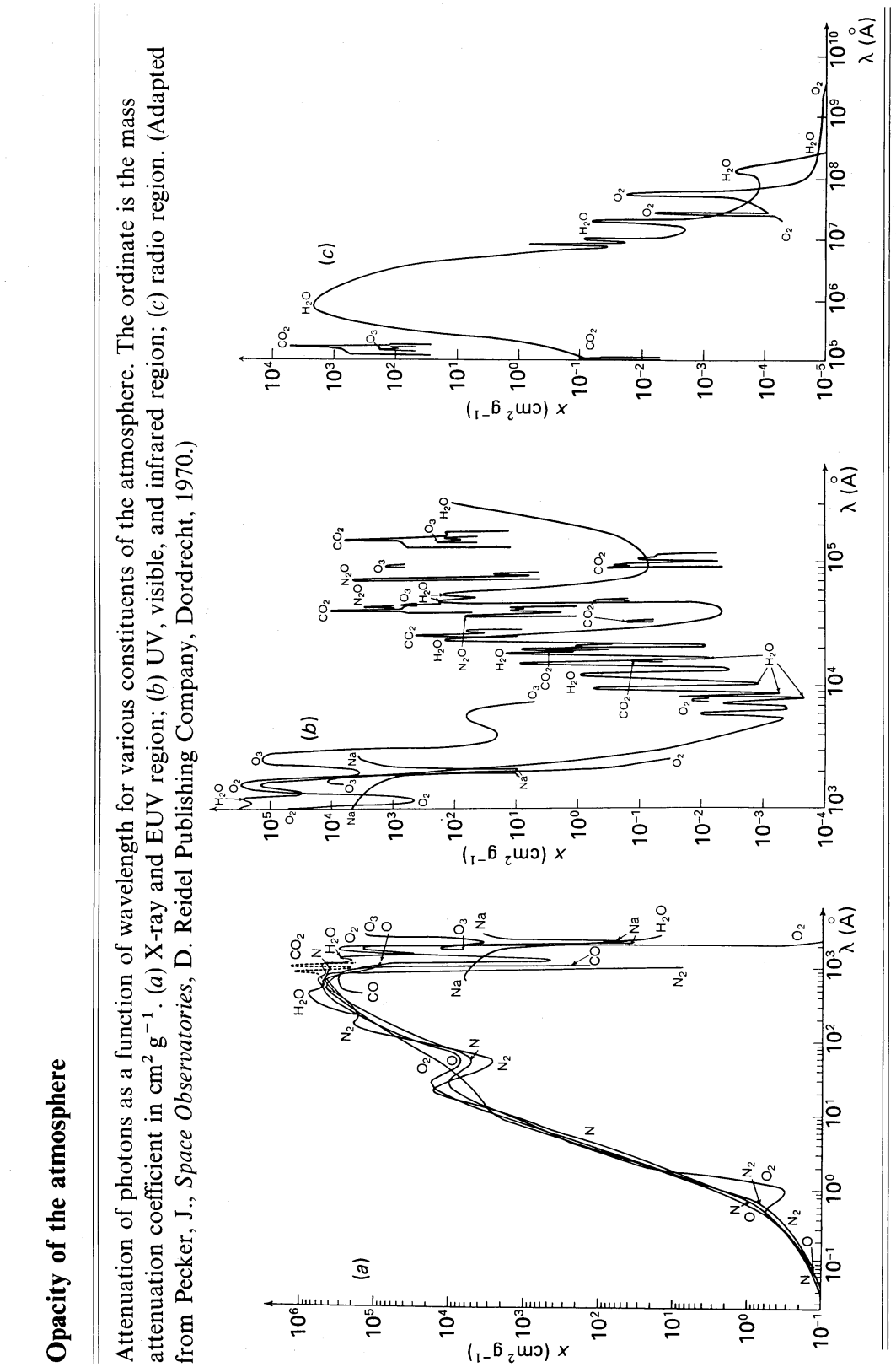


Composition of the atmosphere at ground level

Constituent	n(particles cm^{-3})	$\log_{10} n$
N_2	2×10^{19}	19.3
O_2	5.4×10^{18}	18.73
H_2O	3×10^{17}	17.48
A	2.4×10^{17}	17.38
CO_2	8.5×10^{15}	15.93
Ne	4.7×10^{14}	14.67
He	1.35×10^{14}	14.13
H_2	1.285×10^{13}	13.11
N_2O	1.285×10^{13}	13.11
CH_4	2.5×10^{12}	12.4
O_3	4.725×10^{11}	11.675
O	1.05×10^{4}	4.025

Water vapour and carbon dioxide fluctuate considerably.

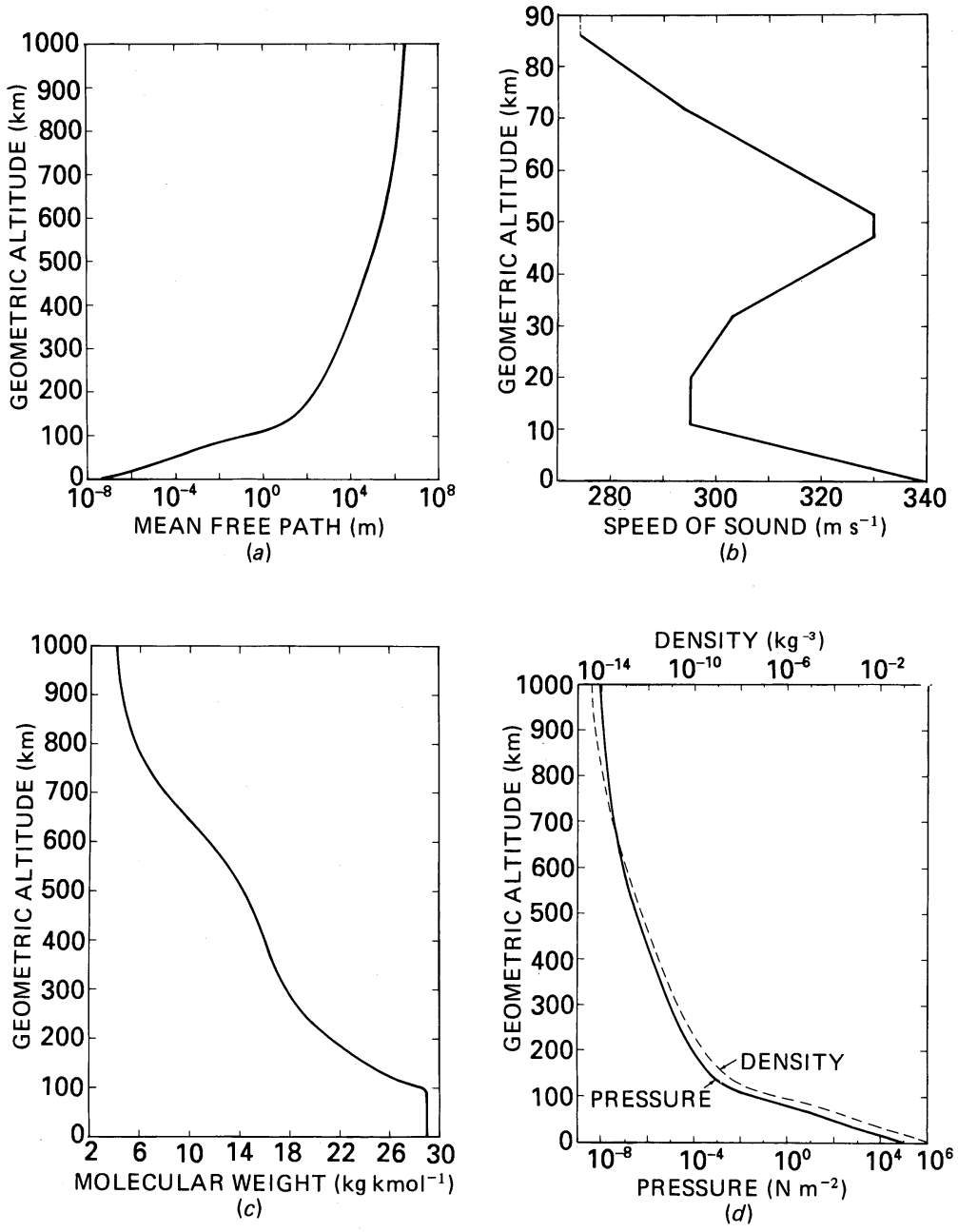
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Attenuation of photons as a function of wavelength for various constituents of the atmosphere. The ordinate is the mass attenuation coefficient in $cm^2\ g^{-1}$. (*a*) X-ray and EUV region; (*b*) UV, visible, and infrared region; (*c*) radio region. (Adapted from Pecker, J., *Space Observatories*, D. Reidel Publishing Company, Dordrecht, 1970.)

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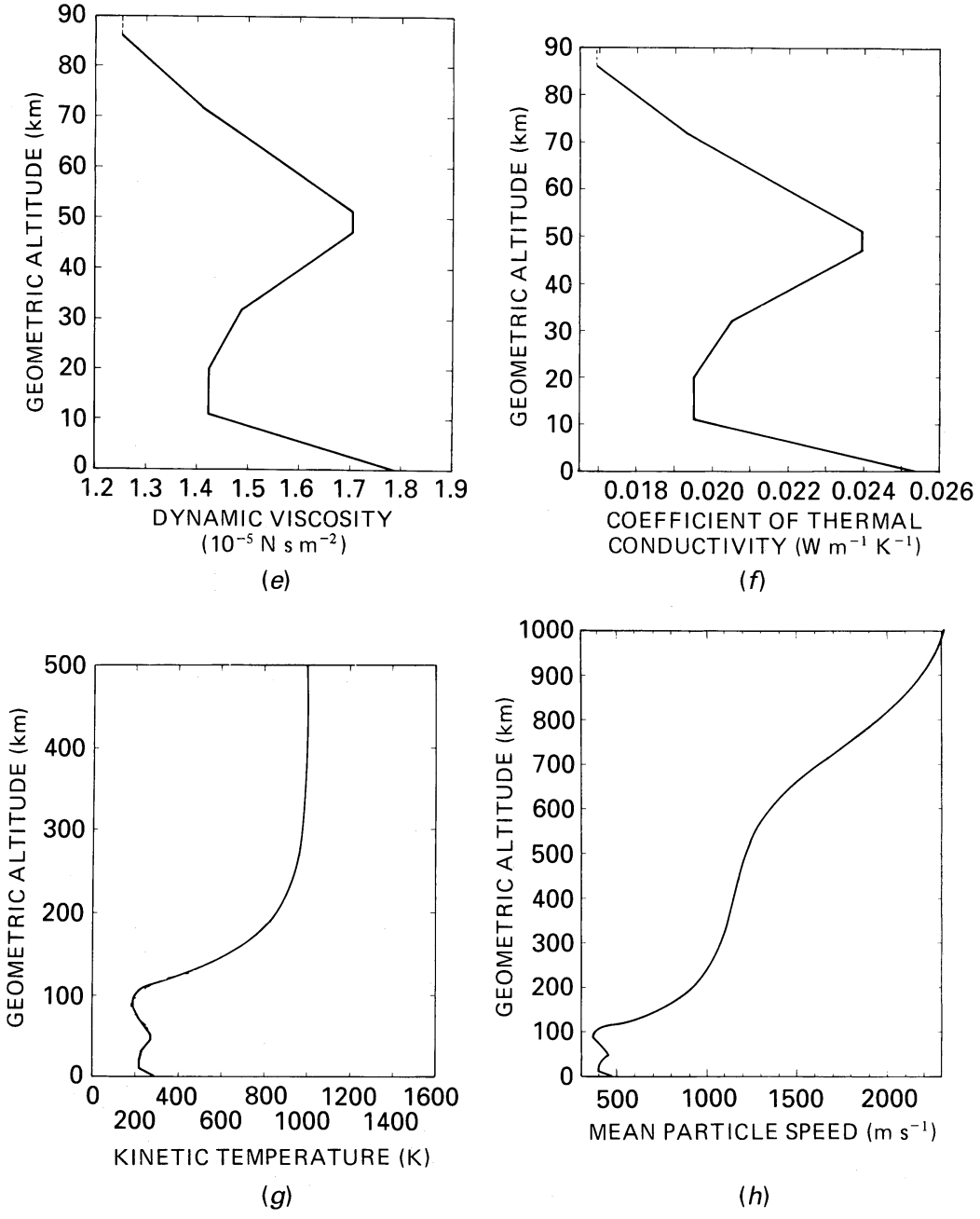
(*a*) Mean free path as a function of geometric altitude. (*b*) Speed of sound as a function of geometric altitude. (*c*) Mean molecular weight as a function of geometric altitude. (*d*) Total pressure and mass density as a function of geometric altitude.



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US standard atmosphere, 1976 (*cont.*)

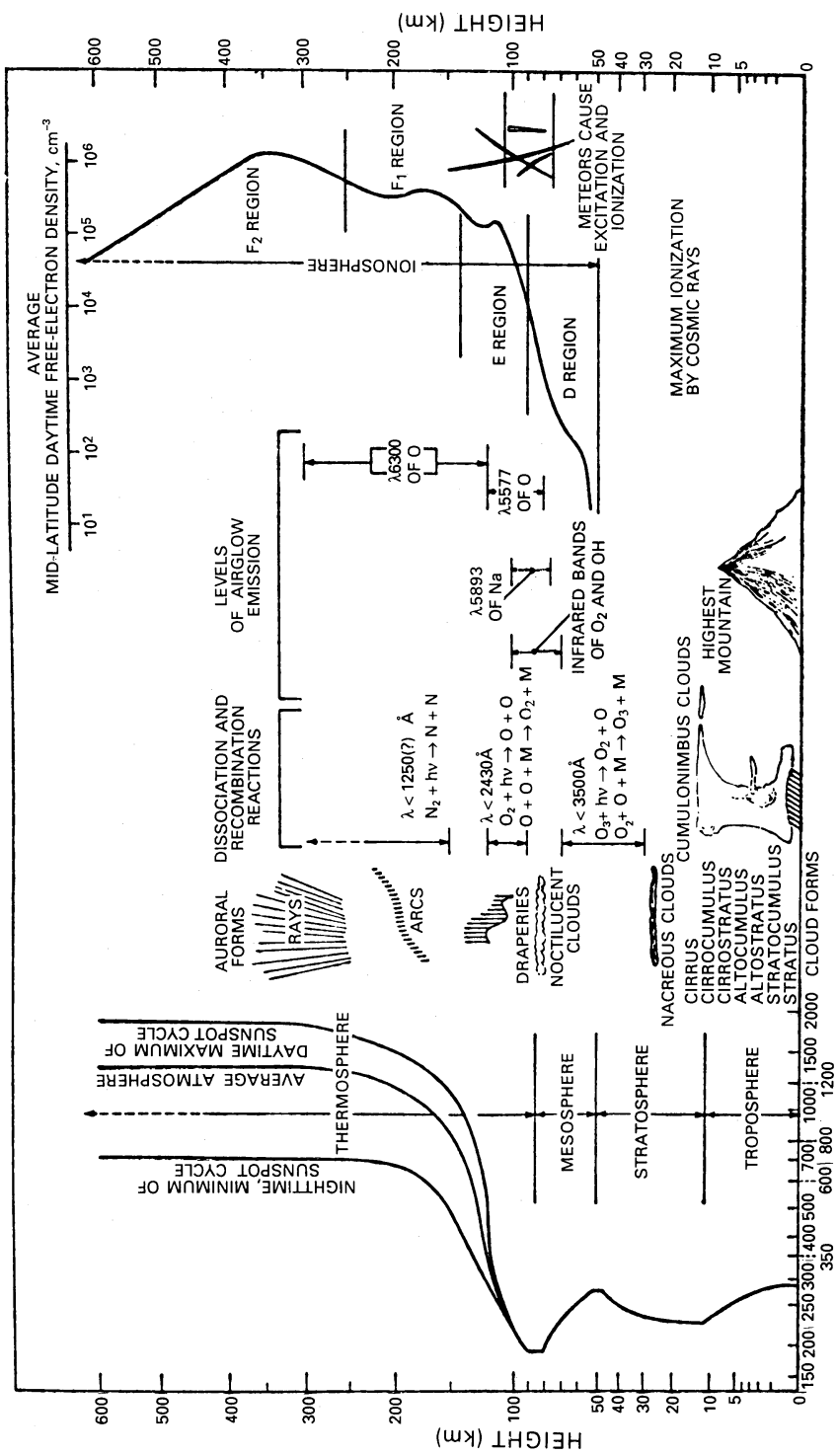
(*e*) Dynamic viscosity as a function of geometric altitude. (*f*) Coefficient of thermal conductivity as a function of geometric altitude. (*g*) Kinetic temperature as a function of geometric altitude. (*h*) Mean air-particle speed as a function of geometric altitude.



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Structure of the upper atmosphere

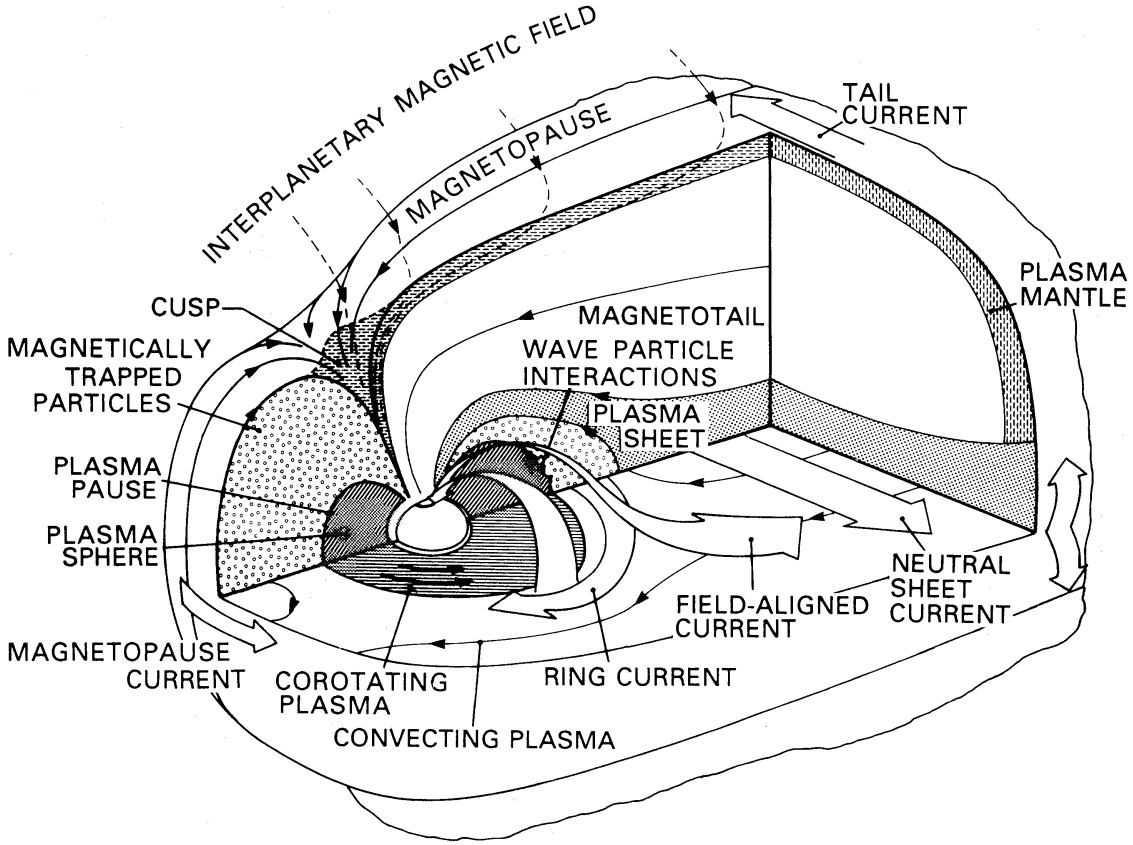
(Adapted from Harris, M. F. in *American Institute of Physics Handbook*, D. E. Gray, ed., McGraw-Hill Book Company, 1972.)



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Earth's magnetosphere

Schematic view of the Earth's magnetosphere.



(From NASA)

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