Structure of a planetary atmosphere

Pressure in a planetary atmosphere

- Hydrostatic equilibrium and gas law

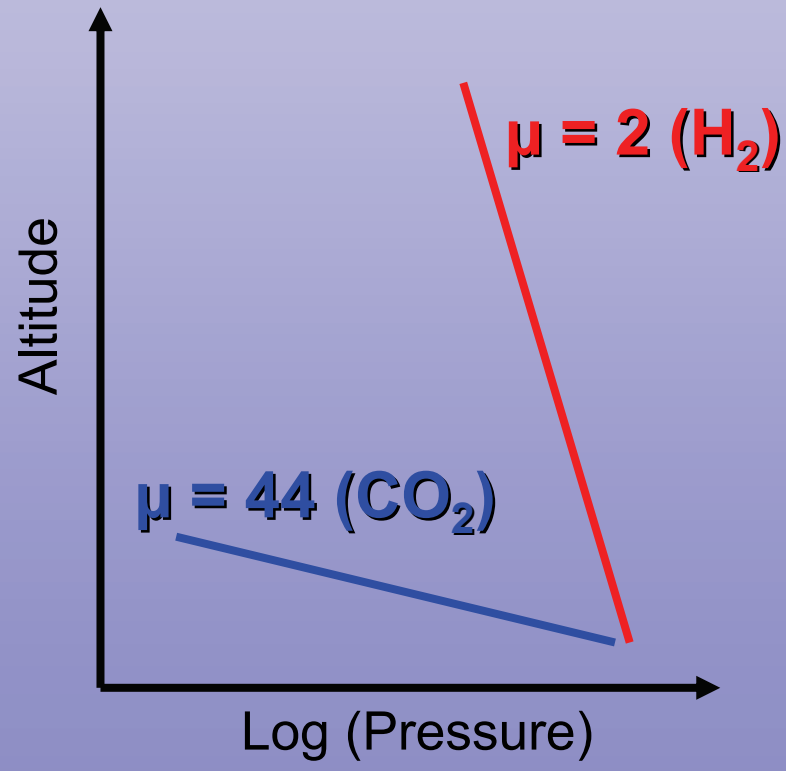
$$dP = -\rho g dz \;\&\; \rho = \frac{\mu P}{RT}$$

- Barometric law

$$P(z) = P_0 e^{-\int \frac{dz'}{H(z')}}$$

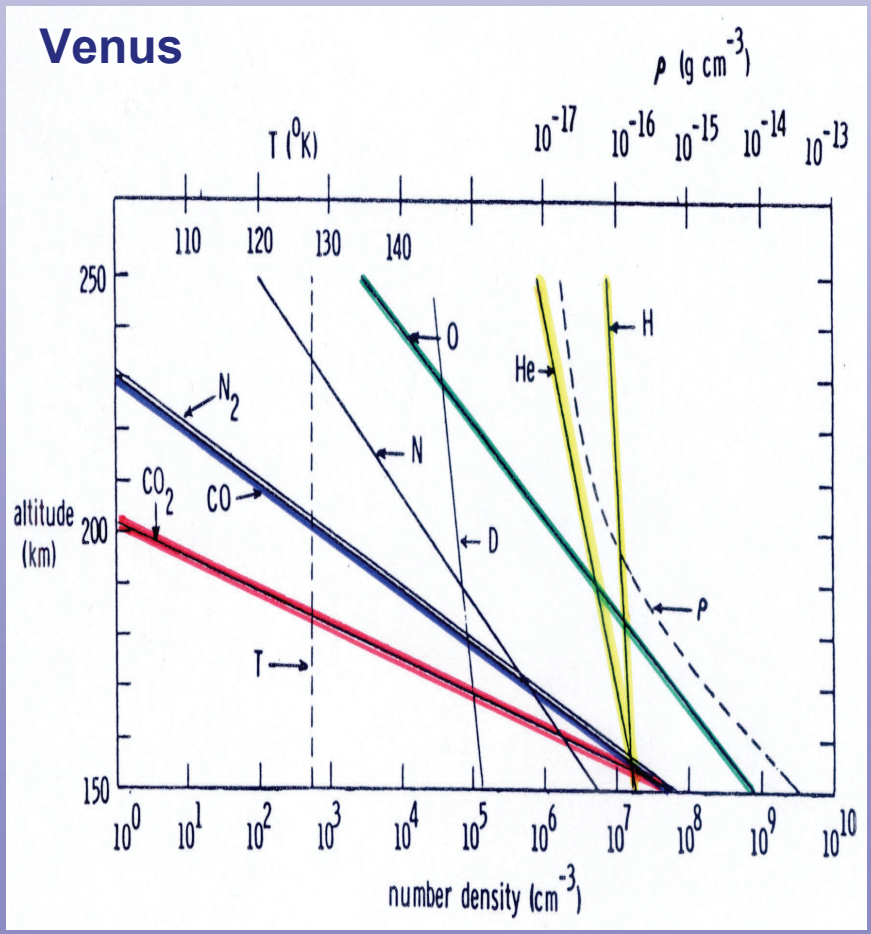
- Scale height

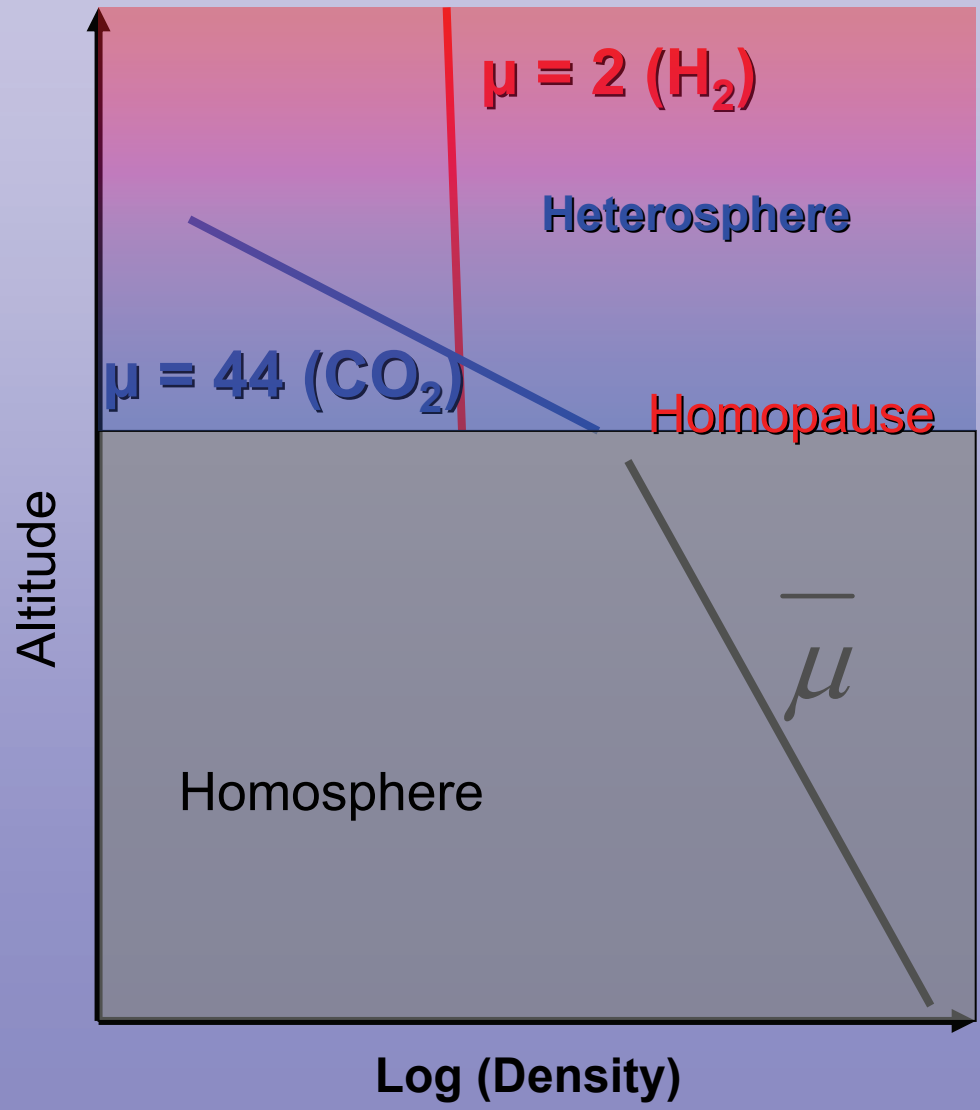
$$H(z) = \frac{RT(z)}{\mu g}$$



Density in a planetary atmosphere

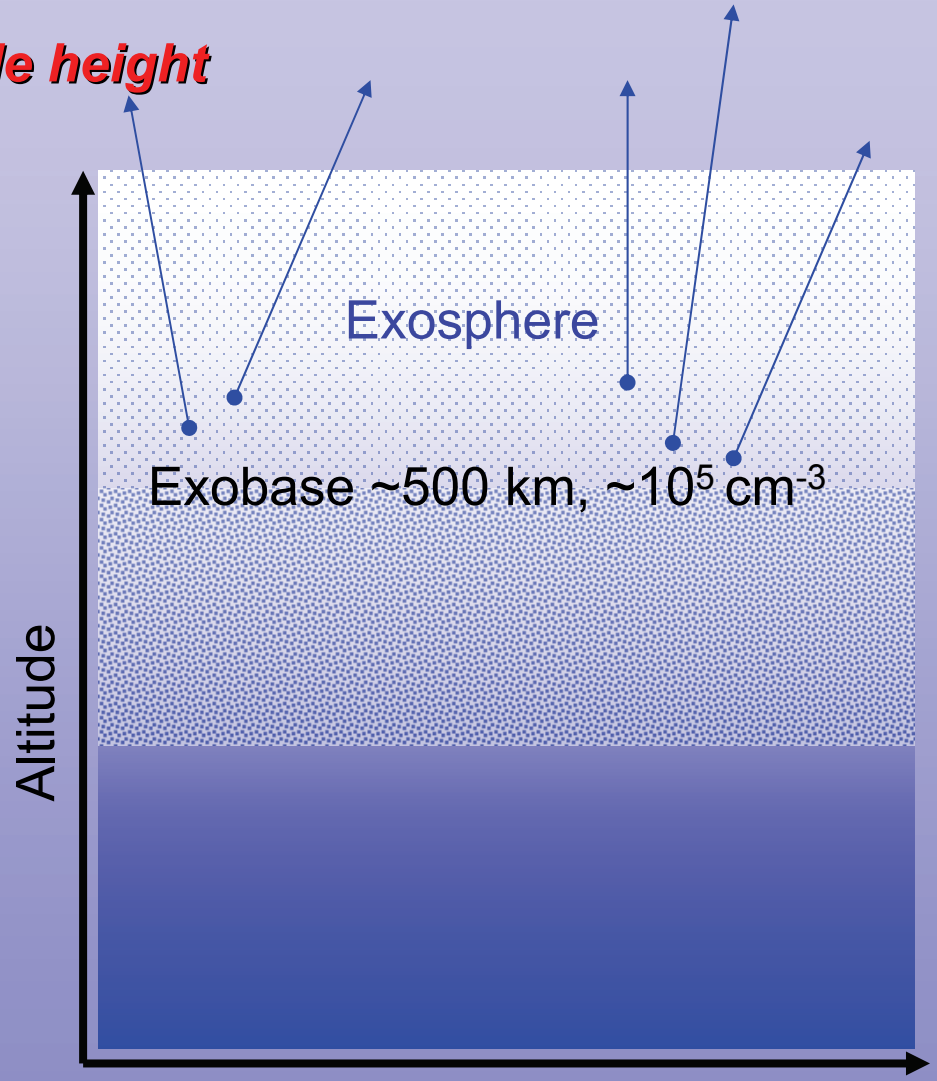
- Homopause: eddy mixing ~ molecular diffusion (z~ 130 km)
- Homo- and heterosphere
- Hydrogen-helium coronas



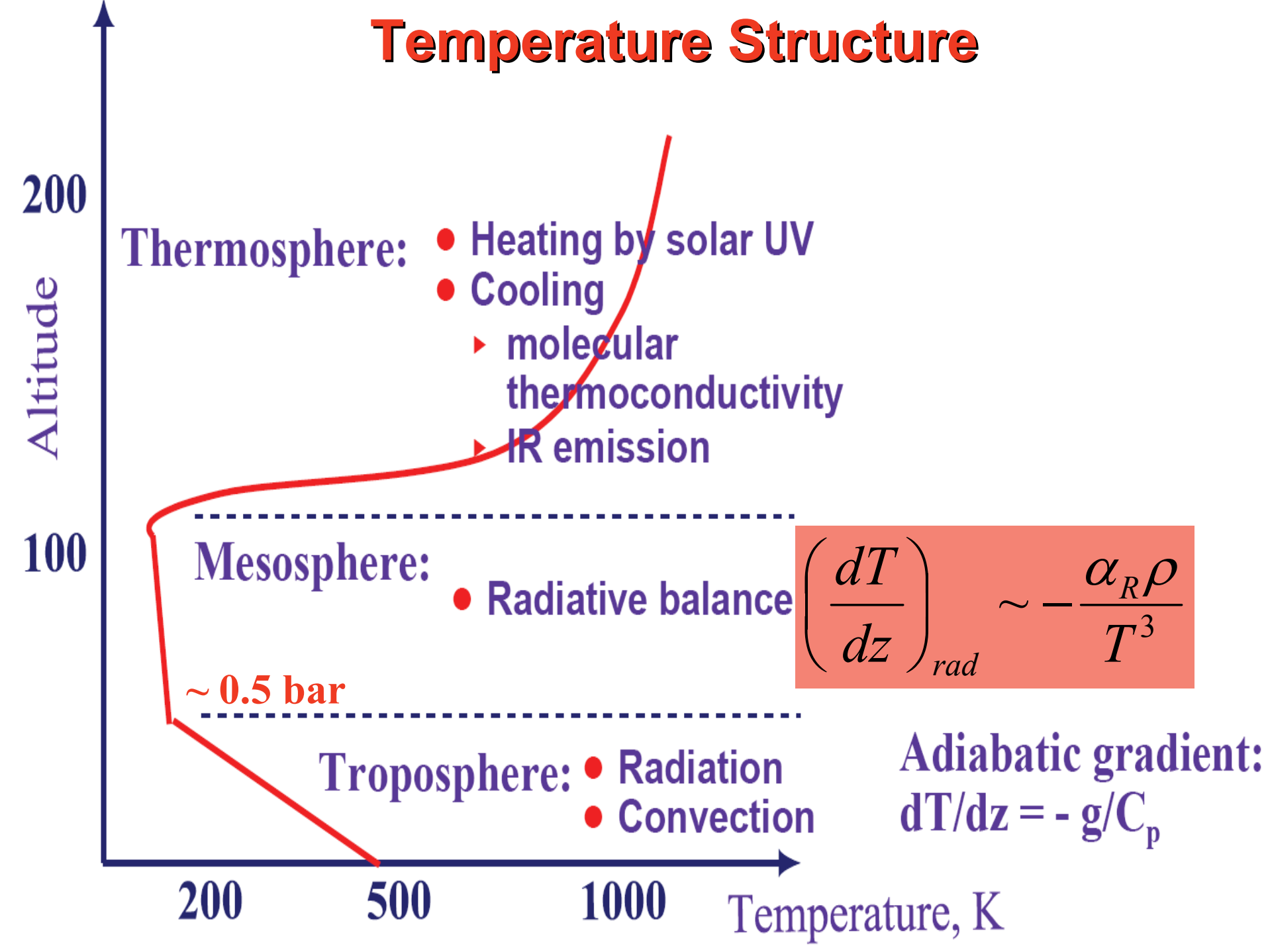


Exosphere and escape processes

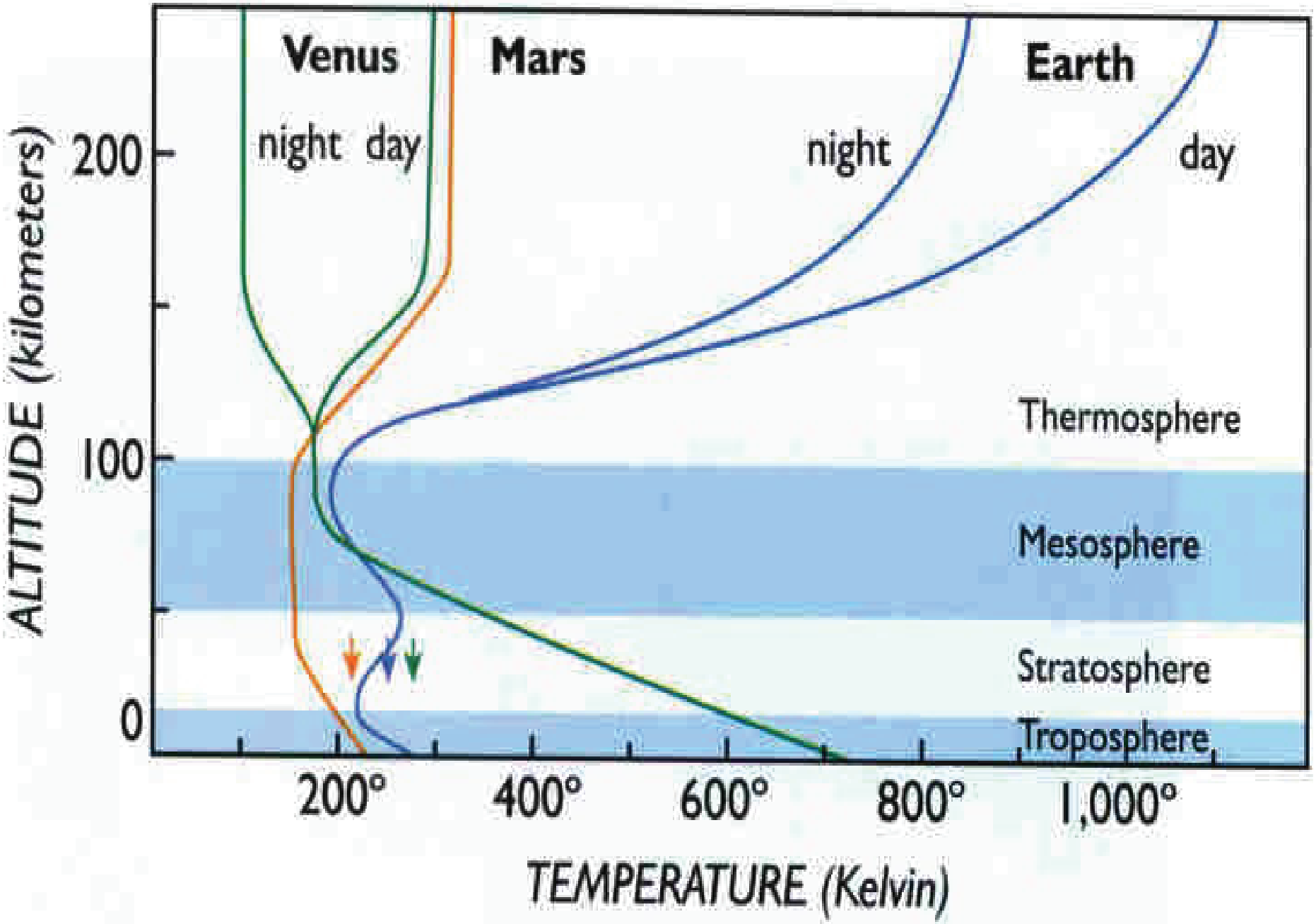
- **Exosphere:** ***free path > scale height***
- **Thermal (Jeans) escape**
- **Non-thermal escape**
  - ***dissociation***
  - ***charge exchange***
  - ***sputtering***
  - ***acceleration by electric field***
  - ***sweeping by solar wind***
- **Hydrodynamic escape**
- **Impact escape**



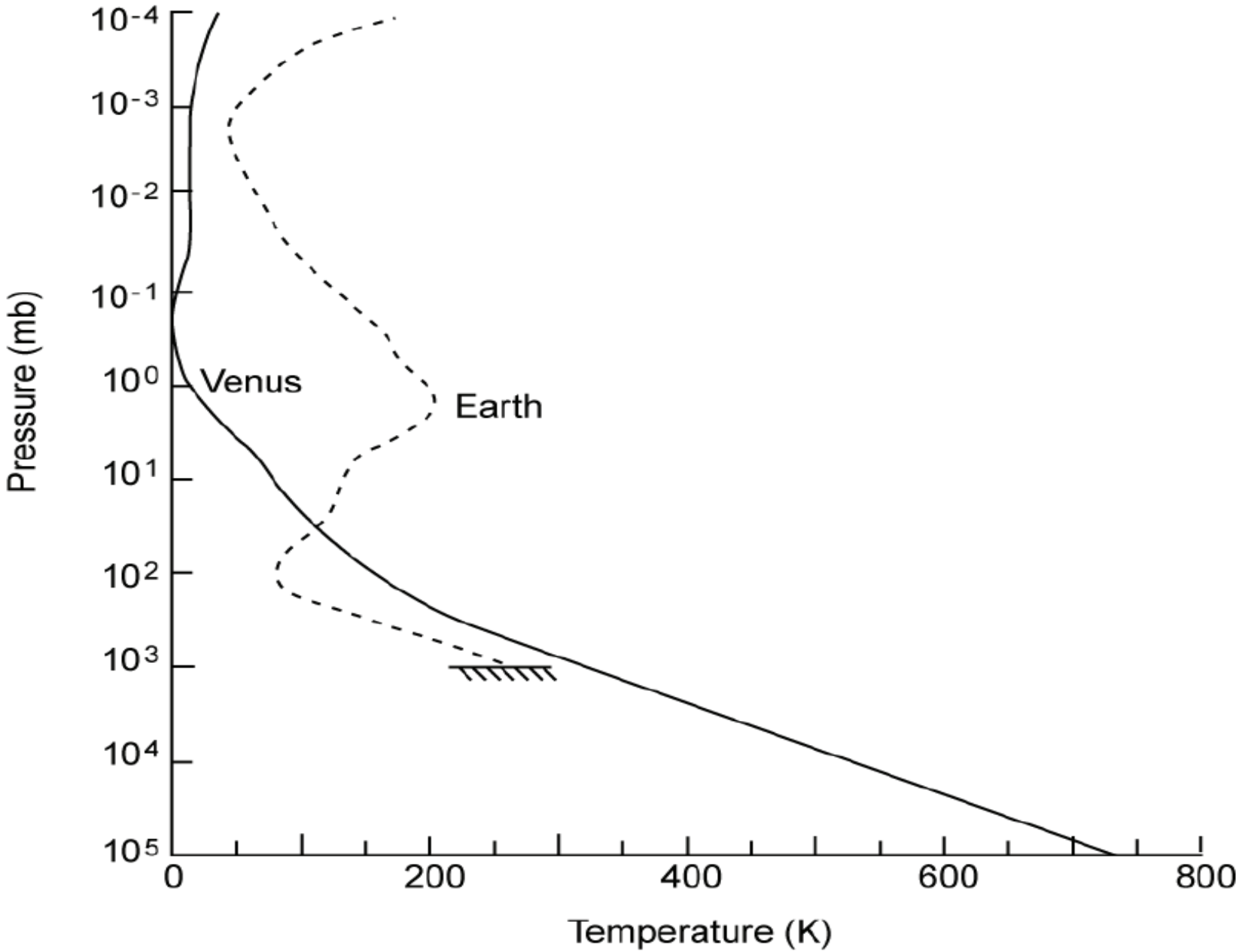
Temperature Structure



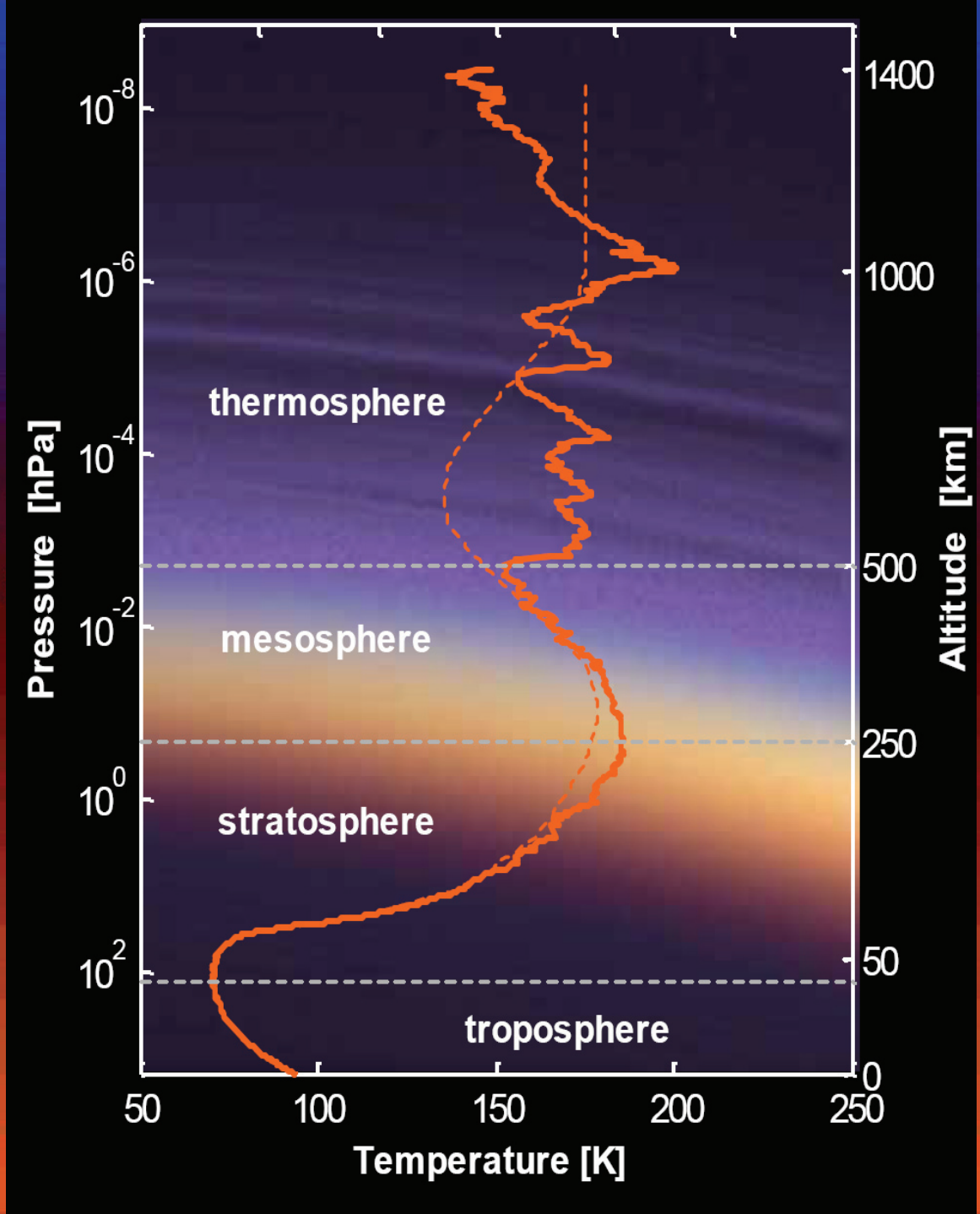
Temperatures on terrestrial planets

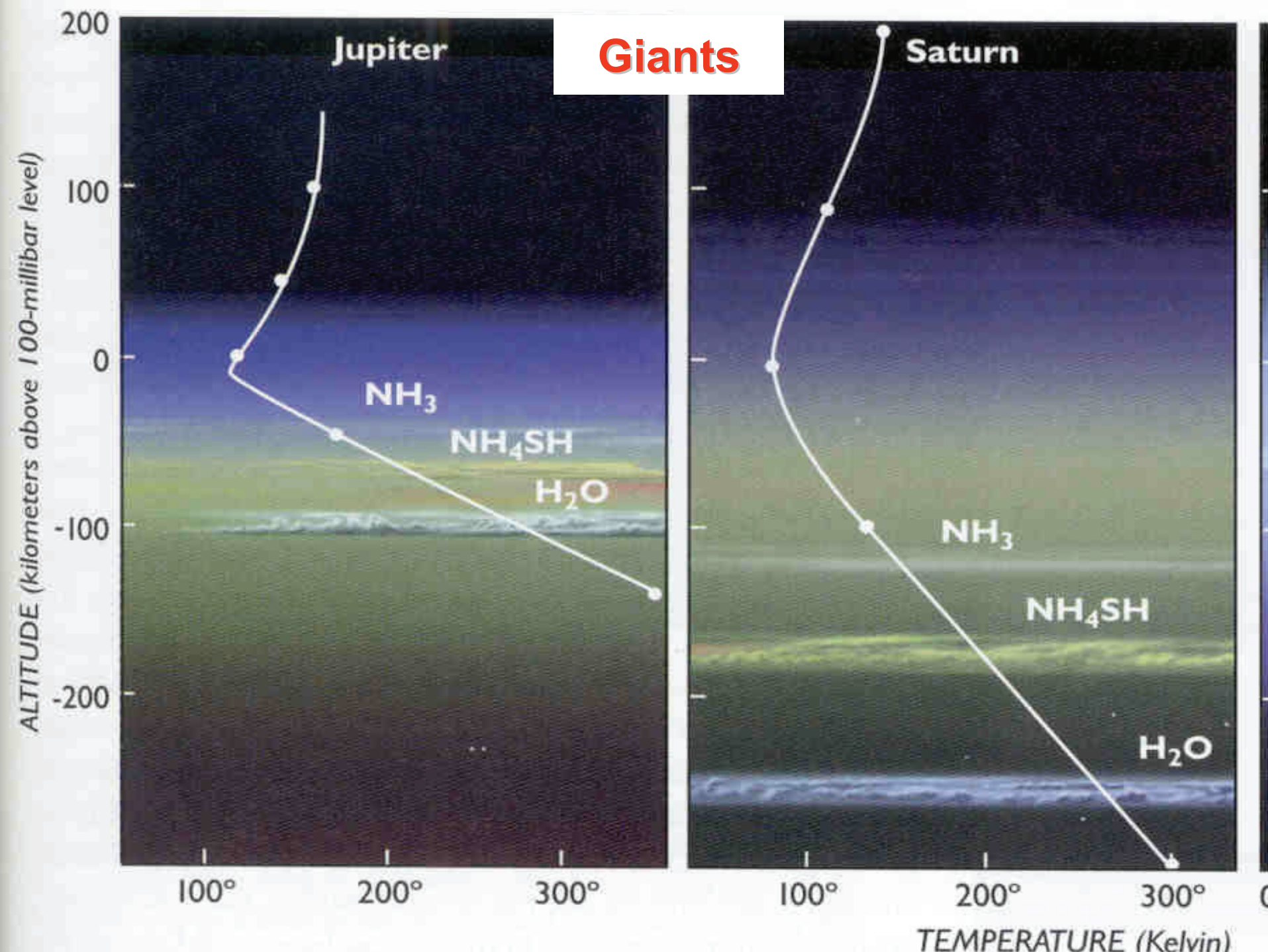


Temperatures on Earth and Venus

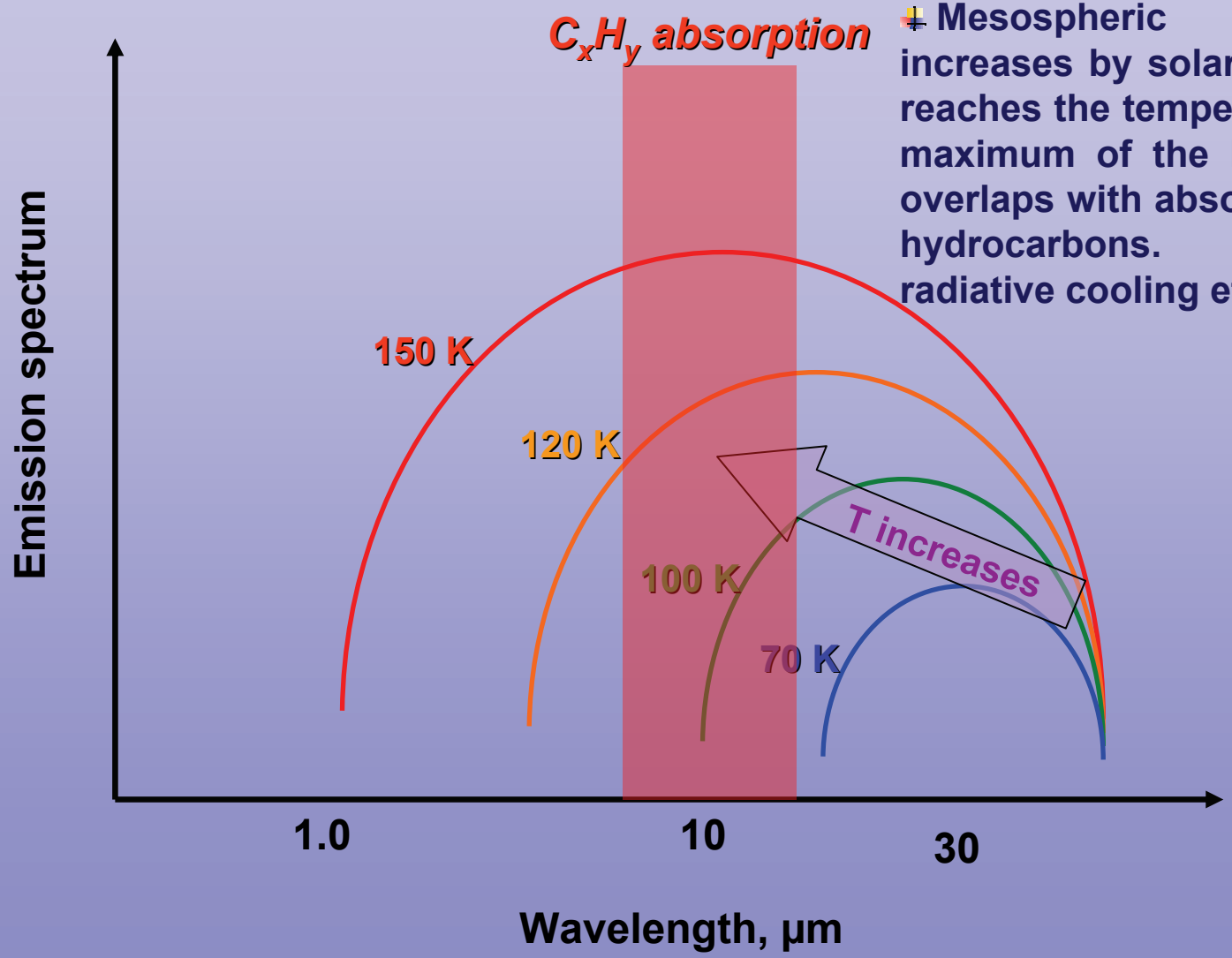


Titan


thermosphere
mesosphere
stratosphere
troposphere
Pressure [hPa]
Altitude [km]
Temperature [K]
10^-8
10^-6
10^-4
10^-2
10^0
10^2
1400
1000
500
250
50
0
50
100
150
200
250


Giants
Jupiter
Saturn
200
100
0
-100
-200
ALTITUDE (kilometers above 100-millibar level)
NH_3
NH_4SH
H_2O
100°
200°
300°
TEMPERATURE (Kelvin)

Mesospheric "thermostat" on Giants

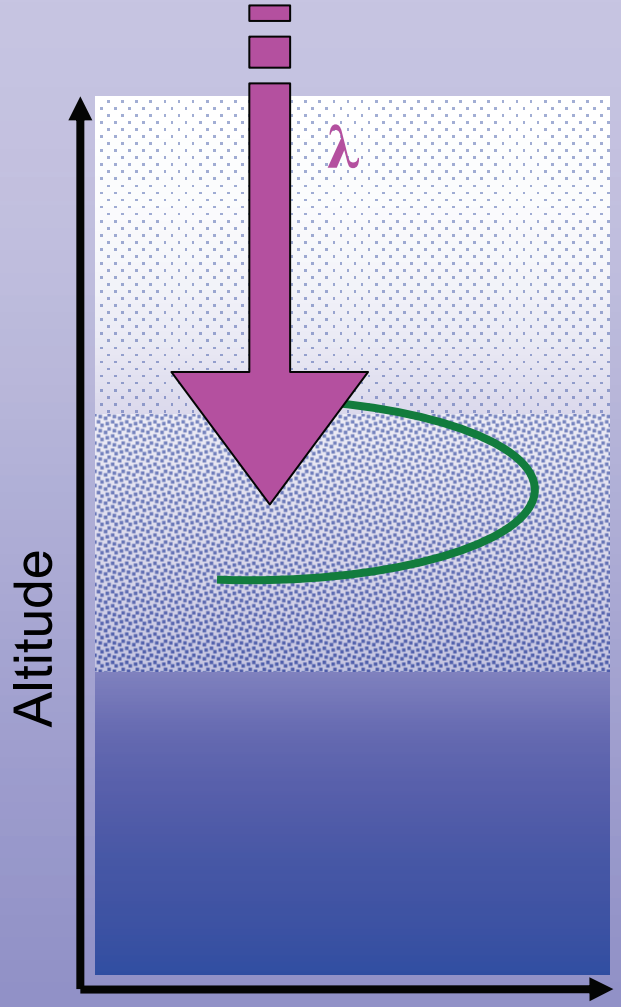


- Mesospheric temperature increases by solar heating until it reaches the temperature,for which maximum of the Planck function overlaps with absorption bands of hydrocarbons. This makes radiative cooling efficient.

Examples of structural parameters

	Venus	Earth	Titan	Jupiter	Saturn
g, m/s^2	8.87	9.78	1.35	~25	~10
μ	~44	29	28	~4	~4
Scale height, km	5-16	8.5	30-40	18	35
Lapse rate, K/km	8	8	~1	1.9	0.84

Formation of a planetary ionosphere



- Single gas
- Monochromatic radiation

Electron density $\frac{\partial n}{\partial t} = Q - an^2$

Chapman layer

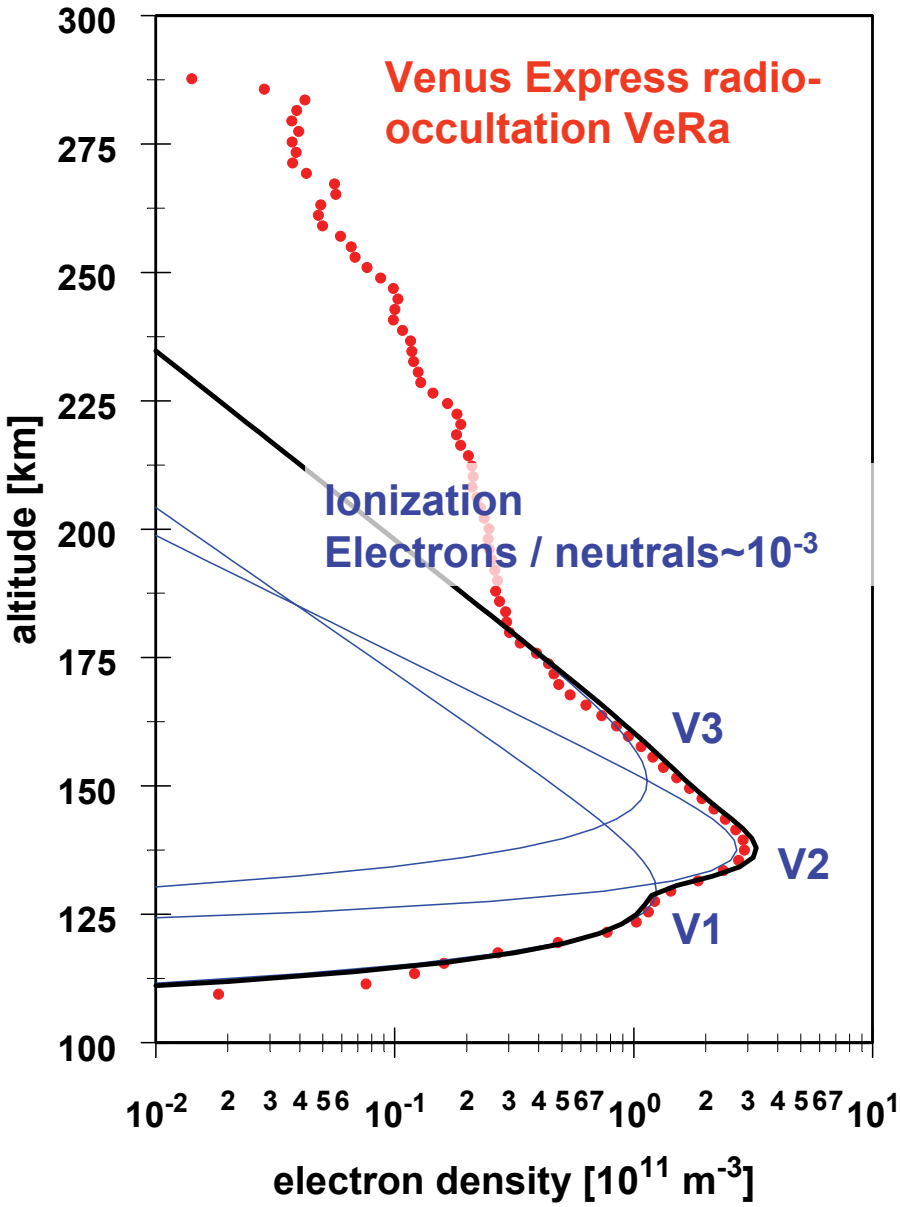
- Parabolic distribution of e^- density

$$n \sim 1 - 0.25 \cdot (z - z_{\max})^2$$

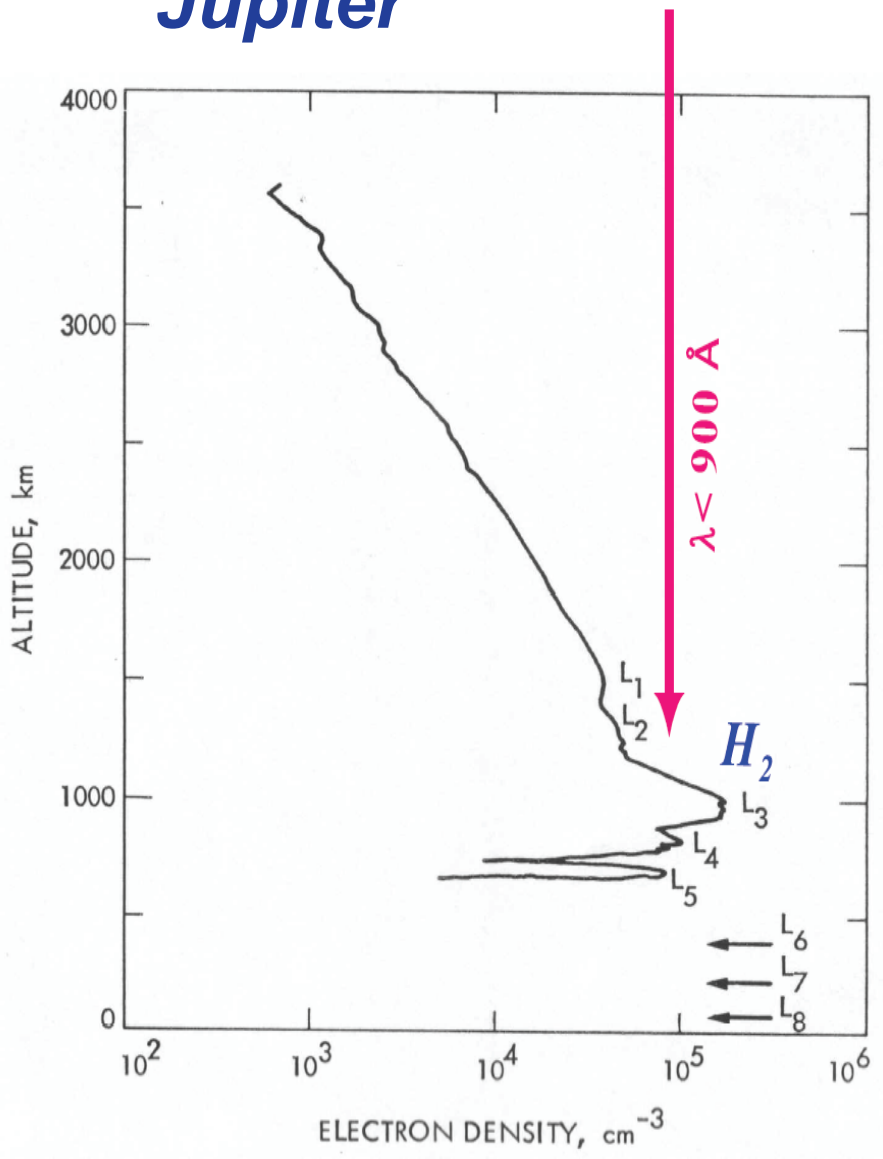
- Variation with solar angle

$$n_{\max} \sim \sqrt{\mu}$$

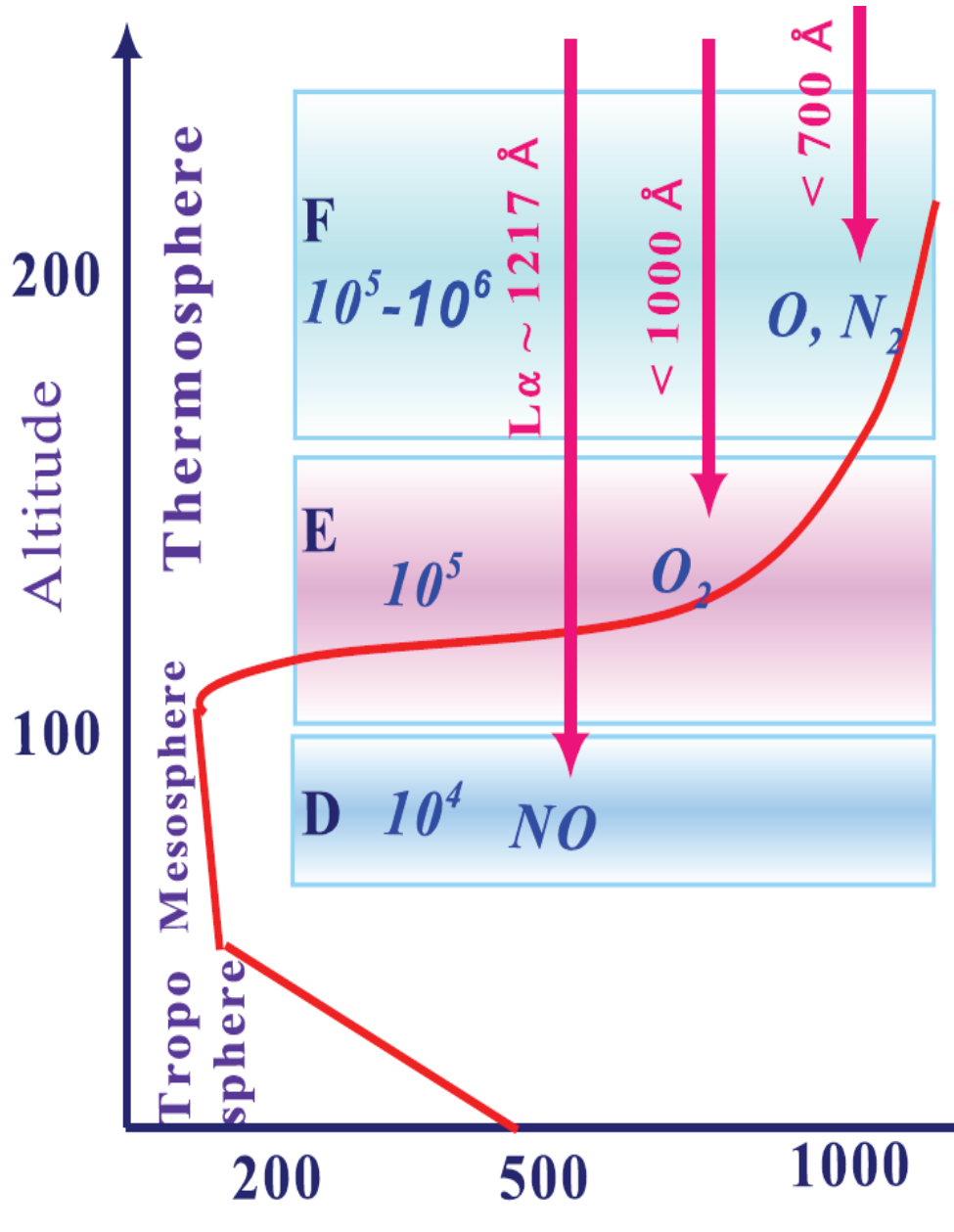
Structure of ionospheres



Jupiter



Ionosphere of the Earth



Reasons for distinct ionospheric regions

- Spectral dependence of penetration depth of solar radiation
- Composition changes with height
- Dependence of recombination physics on density