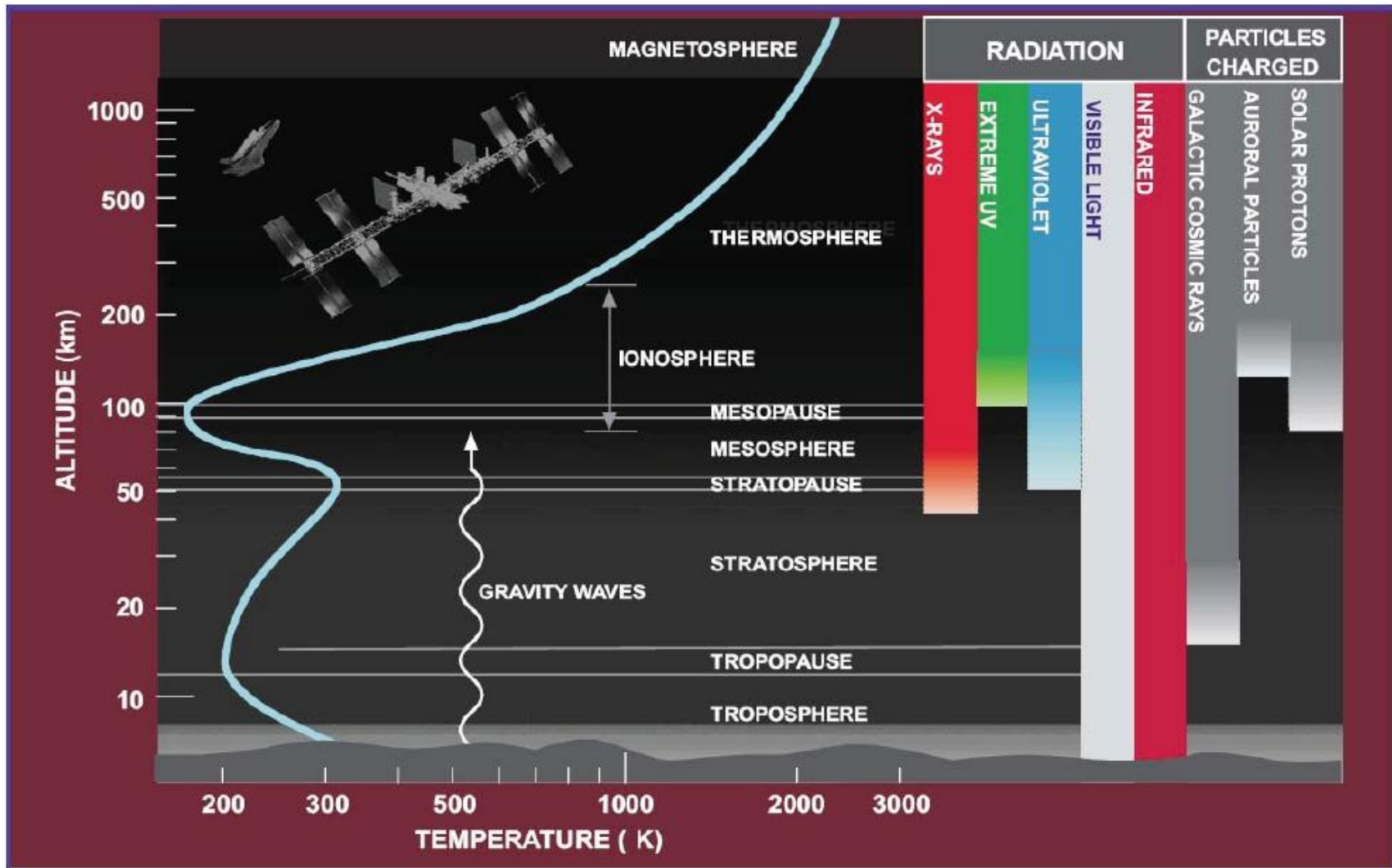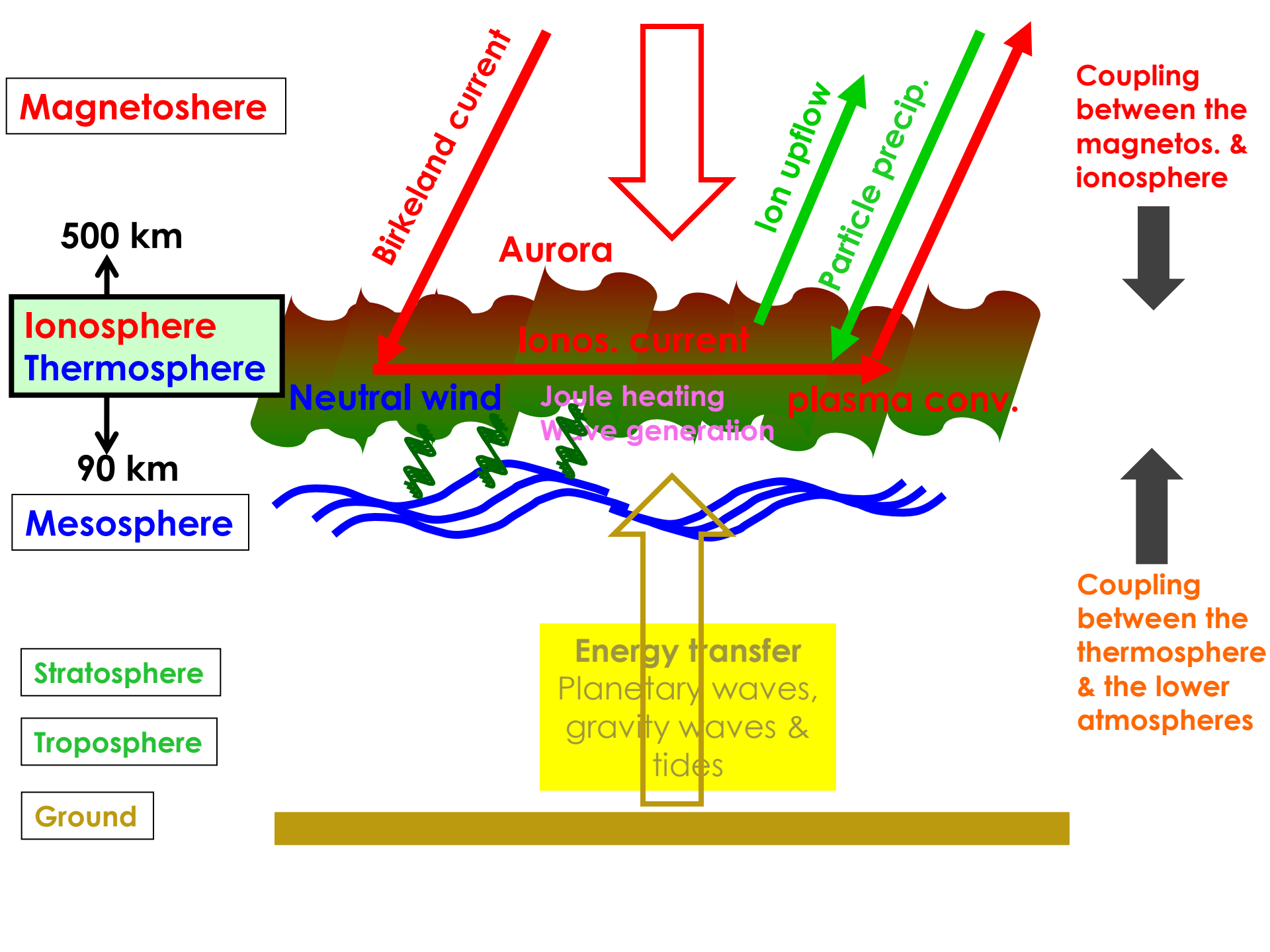# Agenda Week 34

Lecture 1

- Thermal structure : Thermosphere, Stratosphere, Mesosphere, Thermosphere
- Particle and momentum fluxes
- Continuity equation
- Pressure: Thermodynamic & bulk
- Aerostatic equation
- Pressure gradient force
- Temperature – thermal velocity – random
- Ideal gas law
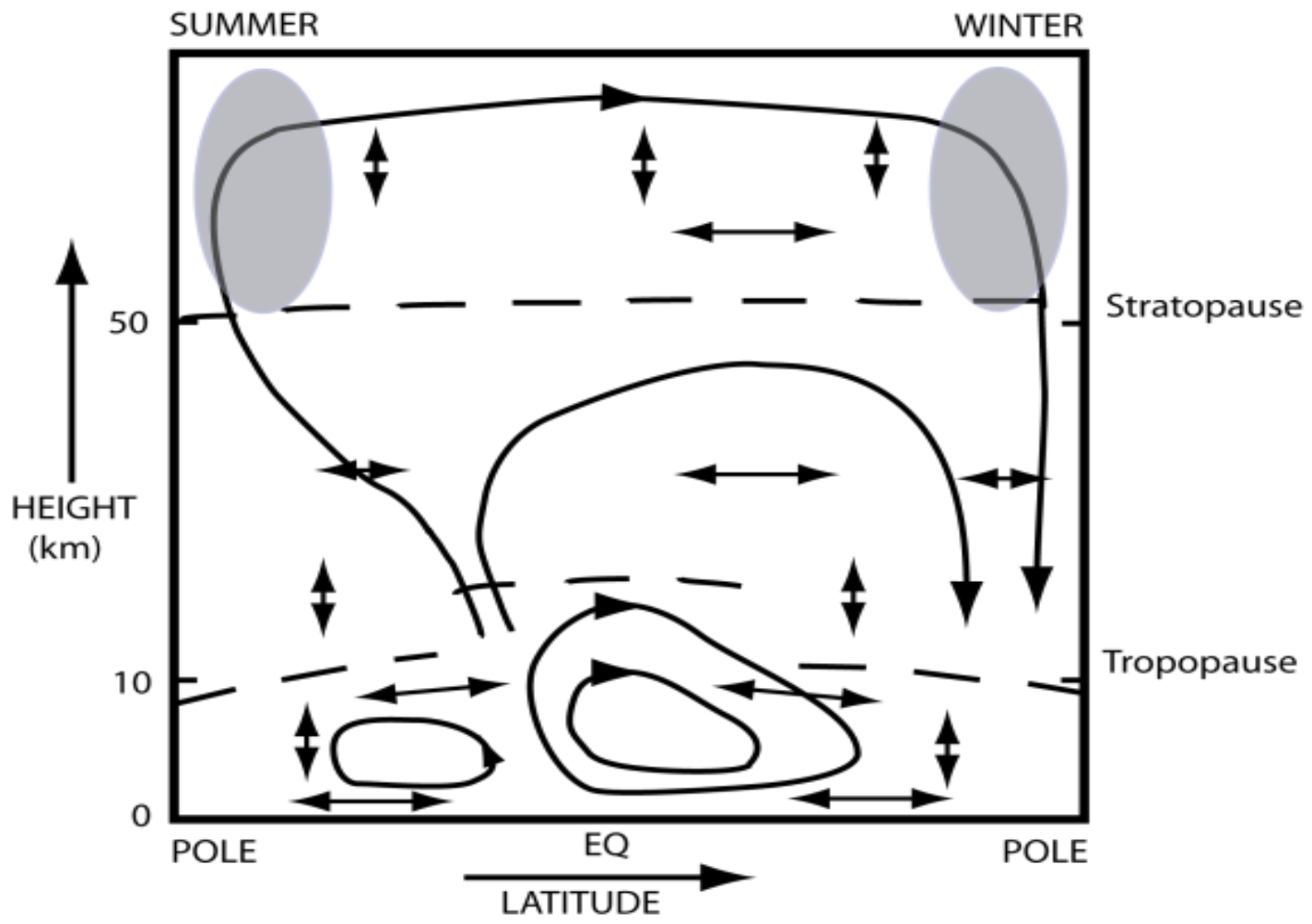- Adiabatic process – Adiabatic lapse rate

Lecture 2

- Barometric equation
- Molecular diffusion
- Eddy diffusion
- Maxwellian distribution function

The Earth's Atmosphere

Magnetoshere

500 km

Ionosphere
Thermosphere

90 km

Mesosphere

Stratosphere

Troposphere

Ground

Birkeland current

Aurora

Ion upflow

Particle precip.

Coupling between the magnetos. & ionosphere

Ionos. current

Neutral wind   **Joule heating**
                     Wave generation   **plasma conv.**

Coupling between the thermosphere & the lower atmospheres

Energy transfer
Planetary waves, gravity waves & tides

Quantity	Temperature	Composition	Vertical Transport	Gravitational Binding	Thermal Plasma

Interplanetary Space

Height, km

100 000

Thermosphere — Hydrogen-sphere (Geocorona) — Effusosphere — Exosphere — Plasmapause

10 000 — Plasmasphere (Protonosphere)

Heterosphere — Exobase

1000 — F-Region

Diffusosphere

Mesopause — Homopause — Turbopause — Barosphere — E-Region

100 — D-Region

Mesosphere

Stratopause

Stratosphere

Tropopause — Homosphere — Turbosphere

10

Troposphere

0

Fig. 2.13. Classification and nomenclature of the terrestrial atmosphere

1. ATOMIC PARAMETERS

Parameter	Symbol	Gas type						unit
		H	He	O	N_2	O_2	Ar	
Particle radius	r	$1 - 3 \cdot 10^{-10}$						m
Mass number	$\mathcal{M}$	1	4	16	28	32	40	
Particle mass	m	$= m_u \, \mathcal{M} = 1.66 \cdot 10^{-27} \mathcal{M}$ [1]						kg
Degrees of freedom	f	3	3	3	5	5	3	

[1] m_u = atomic mass unit

2. GAS KINETIC PARAMETERS

Parameter	Symbol	Height		Unit
		0 km (300 K; N_2)	300 km ($T_\infty = 1000$ K; O)	
Particle density	n	$2 \cdot 10^{25}$ [1]	10^{15}	$1/m^3$
Random velocity	$\vec{c}$	470 [2]	1100 [2]	m/s
Collision frequency	ν	$6 \cdot 10^9$	0.4	1/s
Mean free path	l	$8 \cdot 10^{-8}$	3000	m

(1) For normal conditions (0°C, 101 kPa) the *total* particle number density $n \simeq 2.69 \cdot 10^{25} \, m^{-3}$ (*Loschmidt number*); (2) Mean absolute value

3. MACROSCOPIC STATE PARAMETERS

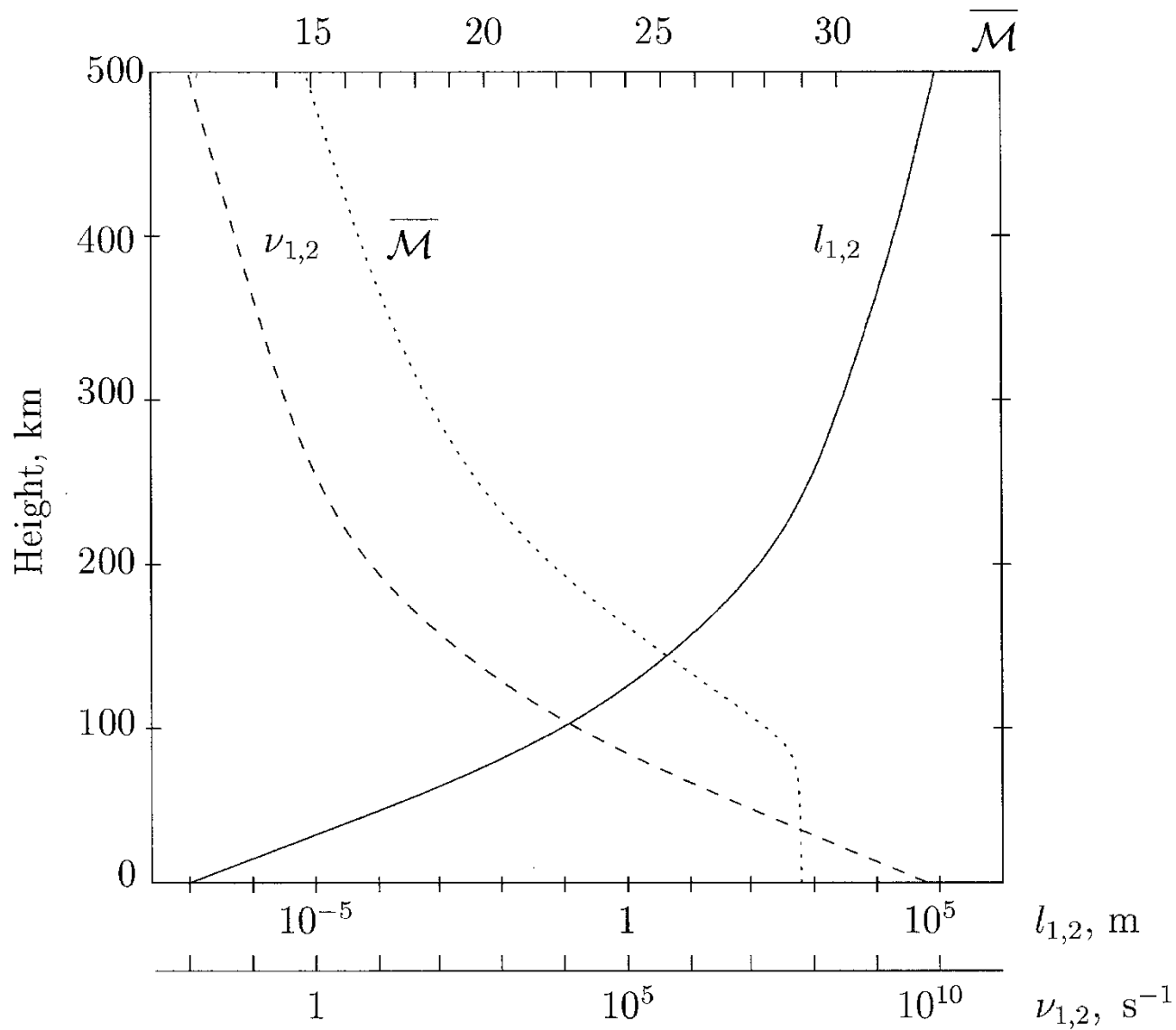| Parameter	Symbol	Gas kinetic meaning	Height		Unit
			0 km	300 km	
Chemical Composition		n_i/n	78% N_2 21% O_2 1% Ar	78% O 21% N_2 1% O_2	
Mass Density	ρ	$\sum_i m_i n_i$	1.3	$2 \cdot 10^{-11}$	kg/m^3
Flow velocity	$\vec{u}$	$\langle \vec{v} \rangle$	0 - 50	0 - 1000	m/s
Temperature	T	$(2/3k)m\,\overline{c^2}/2$	200 - 320	600 - 2500	K
Pressure	p	$n\,m\,\overline{c^2}/3$	10^5	10^{-5}	Pa

Fig. 2.10. Height profiles of the collision frequency ($\nu_{1,2}$), the mean free path ($l_{1,2}$) and the mean mass number ($\overline{\mathcal{M}}$) in the terrestrial atmosphere

Particle number density, m^{-3}