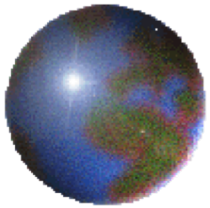
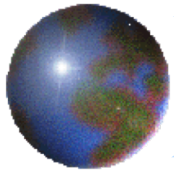


Lecture 2 – The Atmosphere

Announcements and updates

GEOG/ENST 2331

Ahrens: Chapter 1 (mainly)



Lecture outline

- **Atmospheric composition**
- Atmospheric state
- Atmospheric structure

From past midterms/final exams?

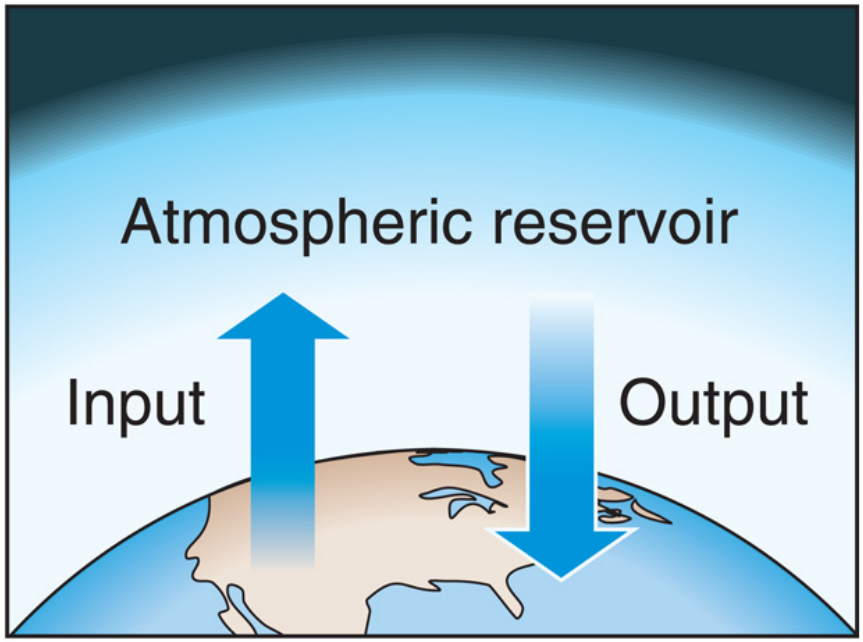
- What is the most influential greenhouse gas?

The Atmosphere

- A mixture of gas molecules, aerosols, and falling precipitation
  - *Aerosol*:
    - a suspended particle
    - microscopic
    - solid or liquid

Gases

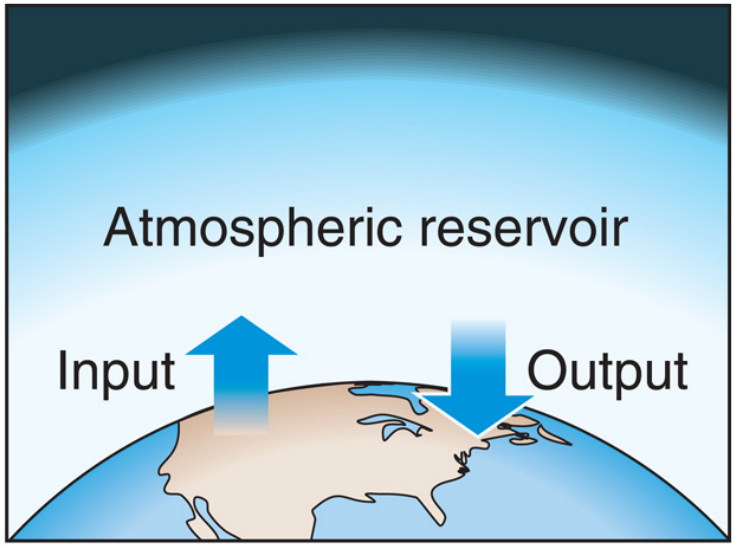
$$\text{Residence time} = \frac{\text{Mass in reservoir}}{\text{Mass flux}}$$



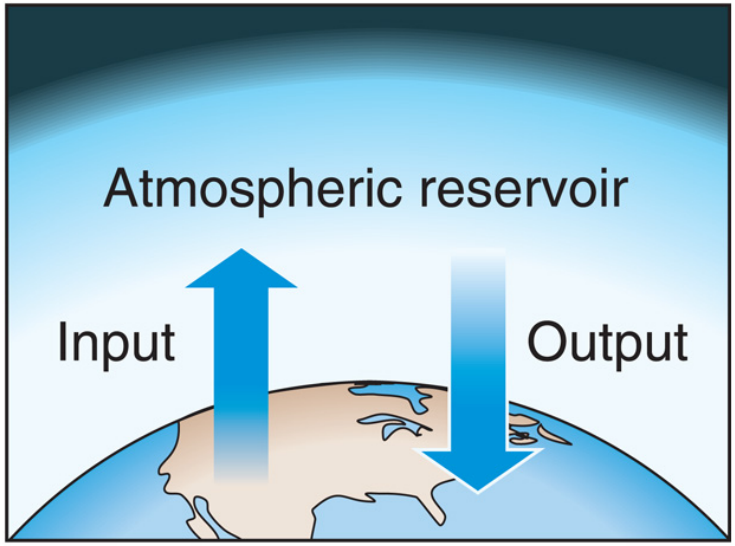
A&B: Fig. 1.2

Gases

- 'Permanent' Gases
  - Reservoir much larger than flux
- 'Variable' Gases
  - Reservoir similar to or smaller than flux



(a)



(b)

A&B: Fig. 1.2

Permanent Gases

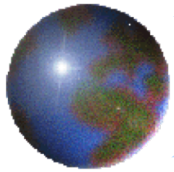
Gas	Symbol	ppmv	Residence Time (in years)
Nitrogen	N_2	780 840	14 000 000
Oxygen	O_2	209 460	4 500
Argon	Ar	9 300	Forever
Neon	Ne	18	Forever
Helium	He	5	2 000 000
Xenon	Xe	0.09	Forever

From Ahrens: Table 1.1

Variable Gases

Constituent	Symbol	ppmv	Residence Time (in years)
Water vapour	H_2O	0 - 40 000	0.026 (9.5 days)
Carbon dioxide	CO_2	410	Multiple timescales
Methane	CH_4	1.8	8.4
Nitrous oxide	N_2O	0.314	120
Ozone	O_3	0.04	0.25 (91 days)
Aerosols		0.01 – 0.15	Up to 0.04 (14 days)

From Ahrens: Table 1.1



Section outline

- Atmospheric composition
- **Atmospheric state**
  - **Describing the atmosphere**
- Atmospheric structure

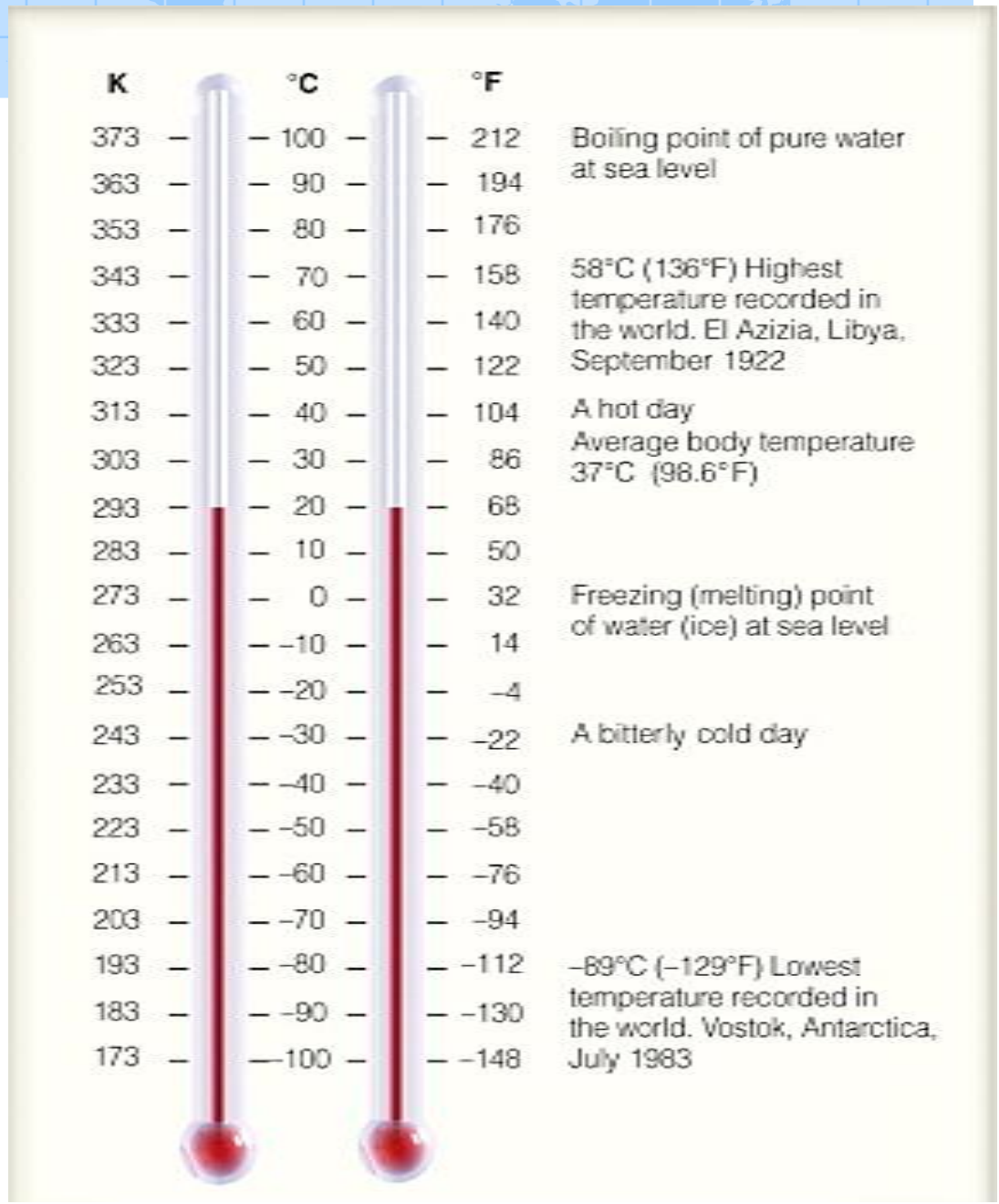
Temperature (T)

- Temperature is a measure of the average speed of air molecules.
- Absolute zero: the temperature, in Kelvin, where molecules do not move
  - Absolute zero (0 K = -273°C)

Other scales: Fahrenheit, Celsius, Rømer, others

Measuring T

- Thermometer
  - Mercury, alcohol
  - Electrical
  - Historical: Wine!



Ahrens: Fig. 3.2

Origin of temperature scales

- Check text – page 62 – 63

  Chapter 2

- Origins of temperature scales

Temperature scales require points of reference

Examples

Pressure (P)

- Pressure: Force per unit area
  - Surface pressure results from the weight of the air above.
  - Higher in the atmosphere there is less total air above and hence pressure decreases with height.

Pressure units

SI: pascal (1 Pa = 1 N / 1 m^2)

1 hPa = 100 Pa

American: bar (force of 100 000 N on 1 m^2)

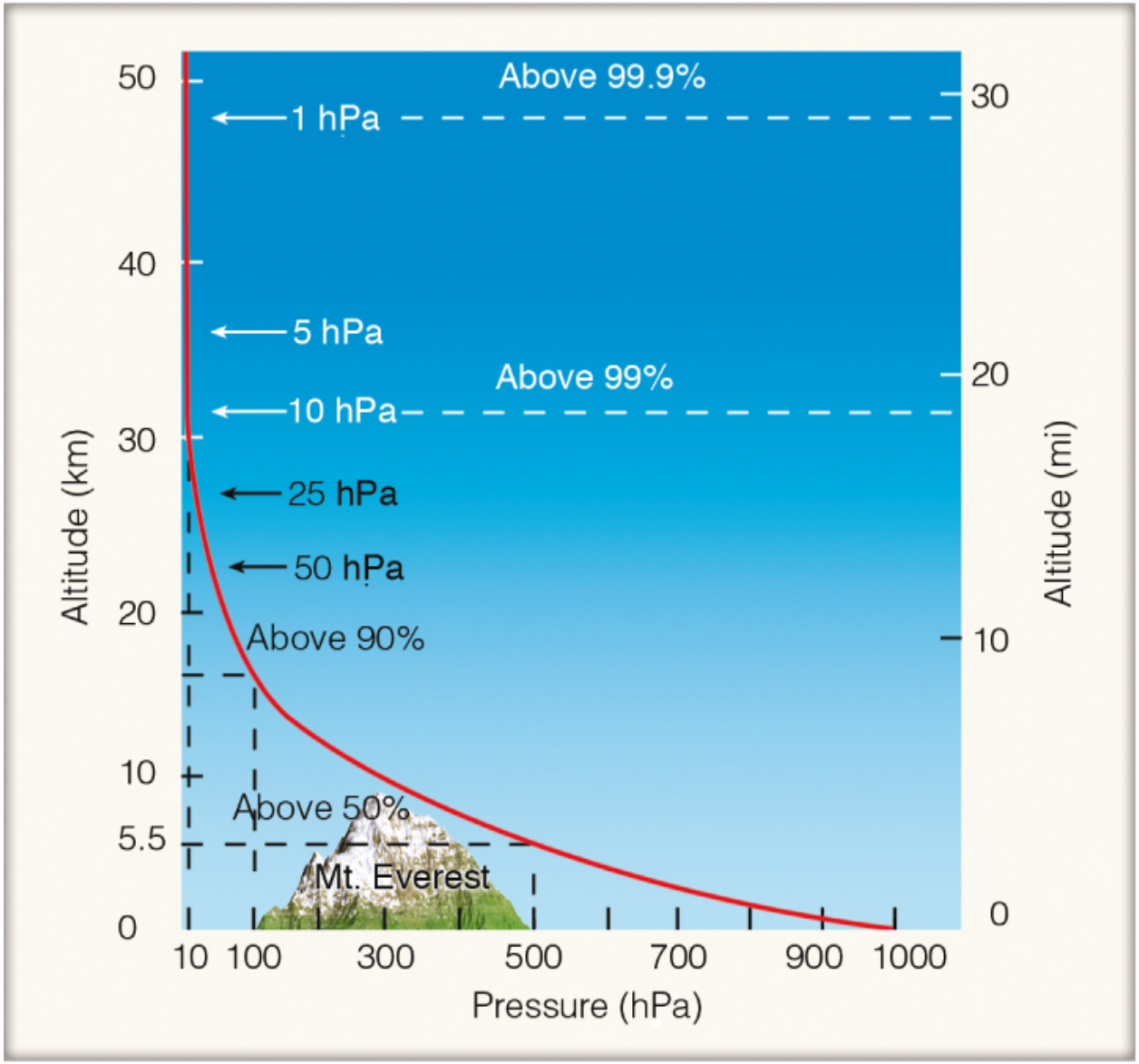
1 bar = 100 000 Pa = 1000 hPa

1 hPa = 1 millibar (mb)

Standard pressure (one *atmosphere*):

1013.5 hPa = 1013.5 mb

Pressure and height

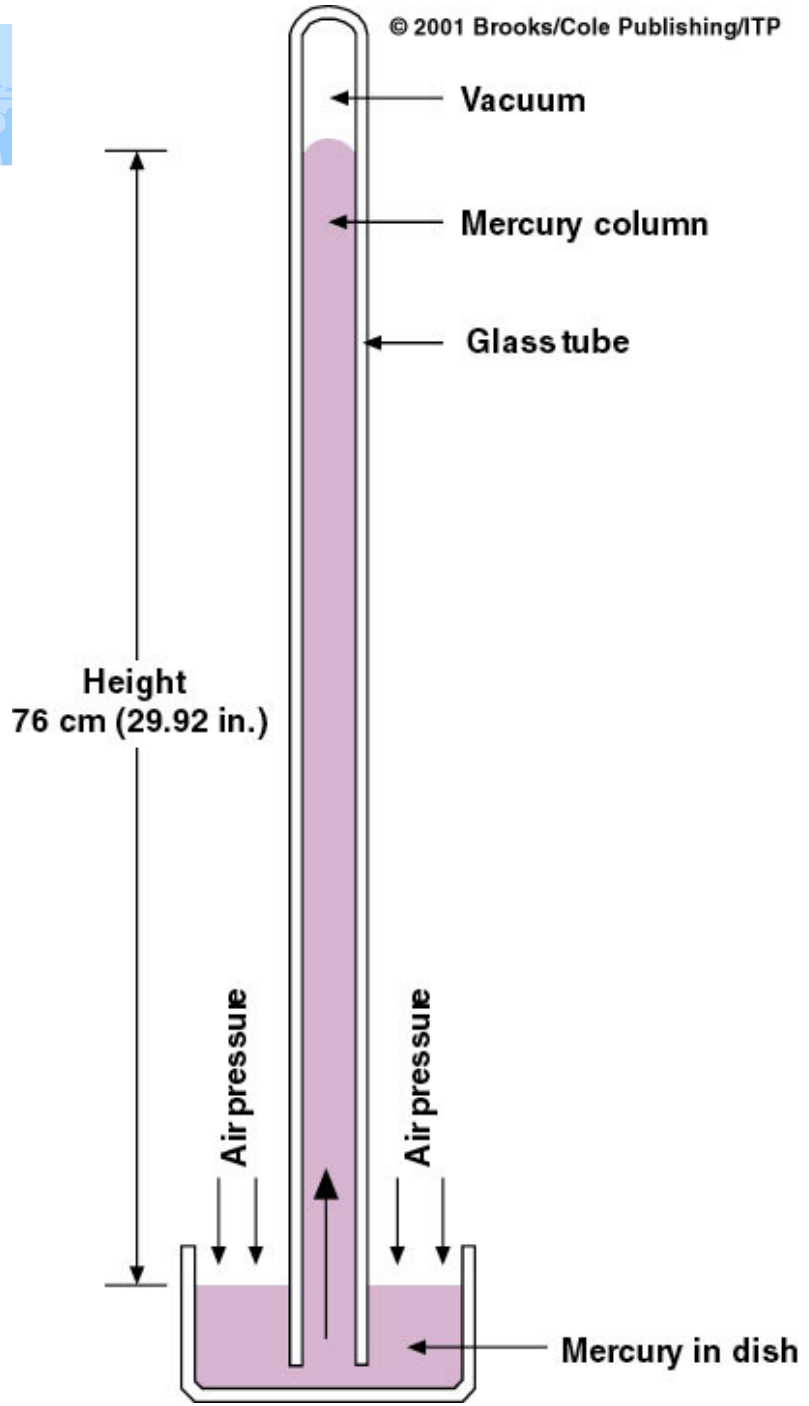


Ahrens: Fig. 1.9

Measuring P

Mercury barometer

Ahrens: Fig. 8.6

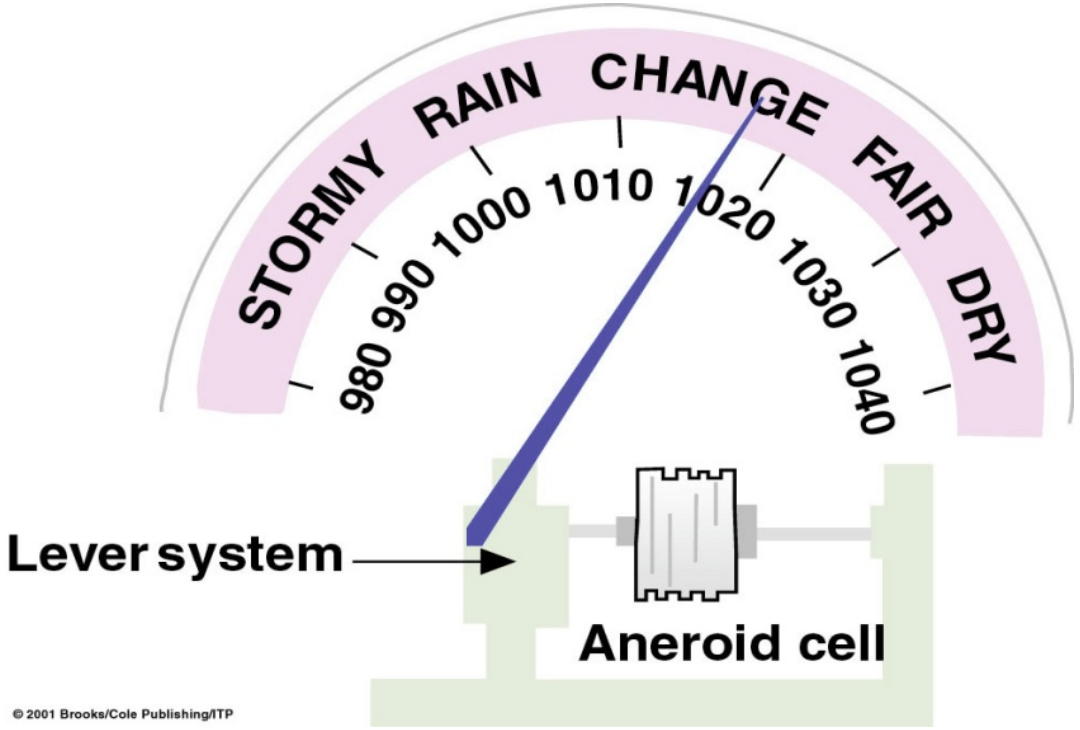


Measuring pressure

Aneroid barometer

- variation of volume of a partially evacuated container

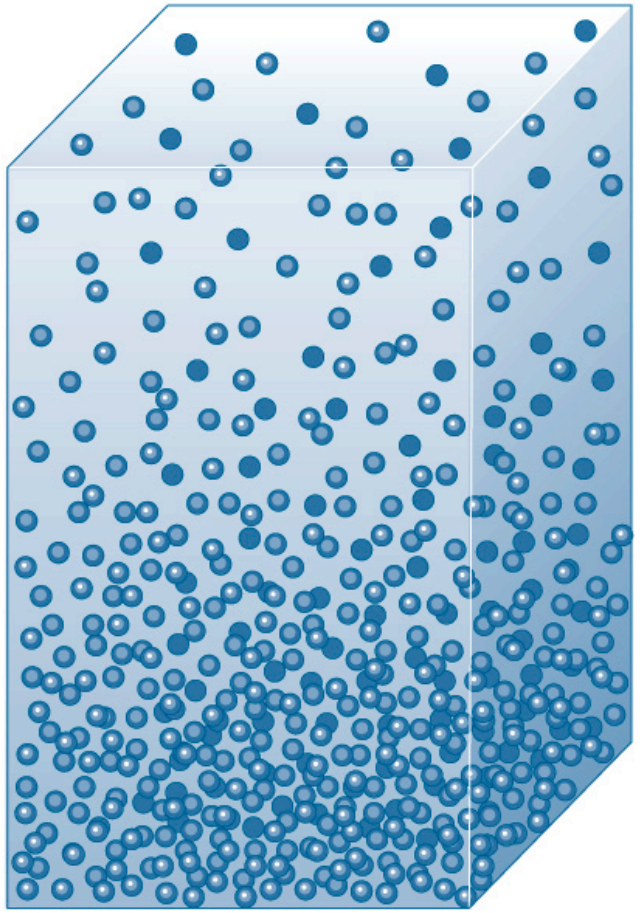
Ahrens: Fig. 8.7



Density (ρ)

- Density = Mass / Volume
- Units: kg/m^3

- Surface: $\rho = 1.2\ kg/m^3$
- 150 km: $\rho = 3.6 \times 10^{-9}\ kg/m^3$



A&B: Figure 1-8

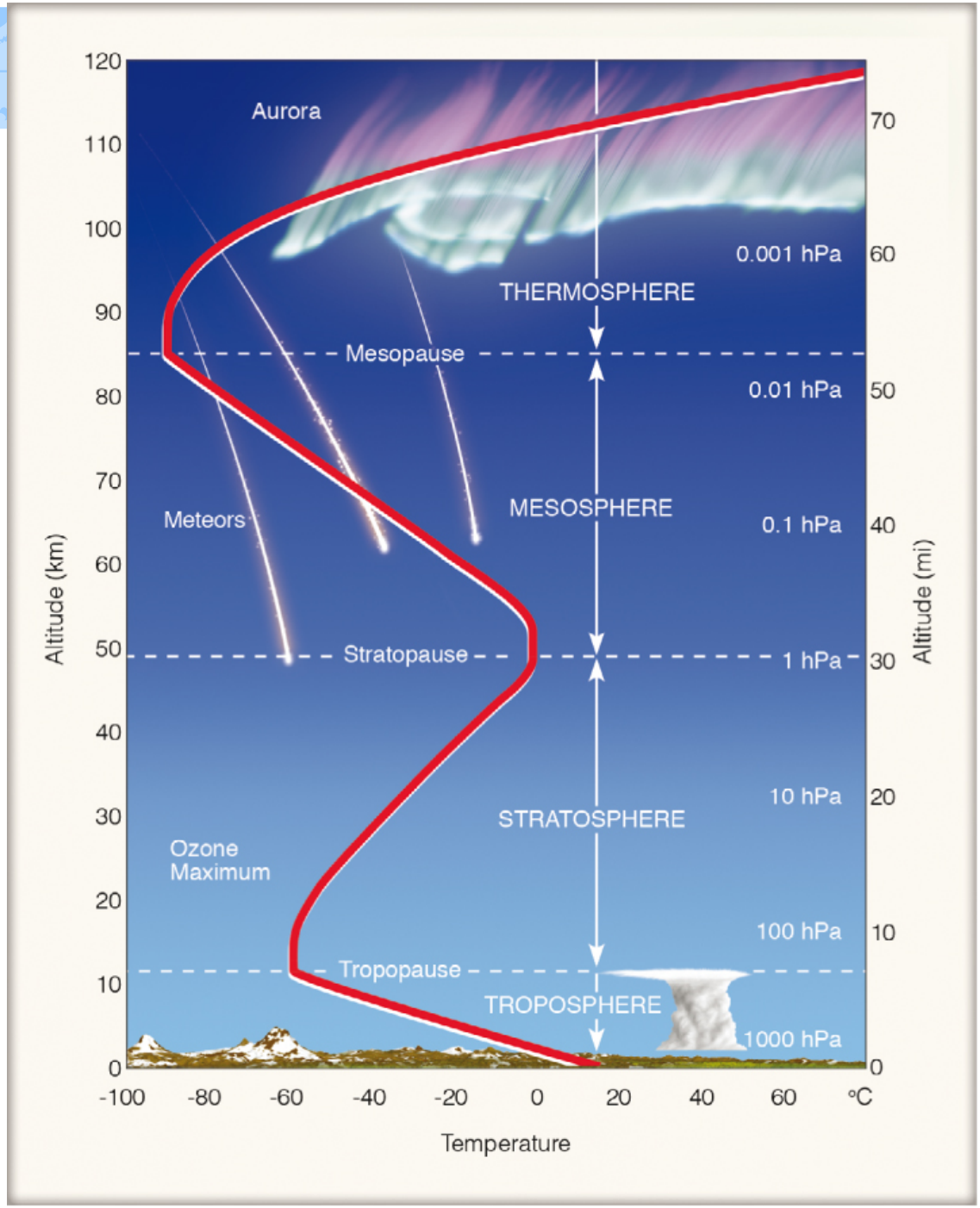
Ideal Gas Law

- Pressure, density and temperature of air are related by the Ideal Gas Law
  - $P = \rho TC$, or $\rho = \dfrac{P}{TC}$
  - For typical air, $C = 287$ [N m kg^{-1} K^{-1}]

Section outline

- Atmospheric composition
- Atmospheric state
- **Atmospheric structure**
  - **Vertical structure**
  - **Temperature profile**

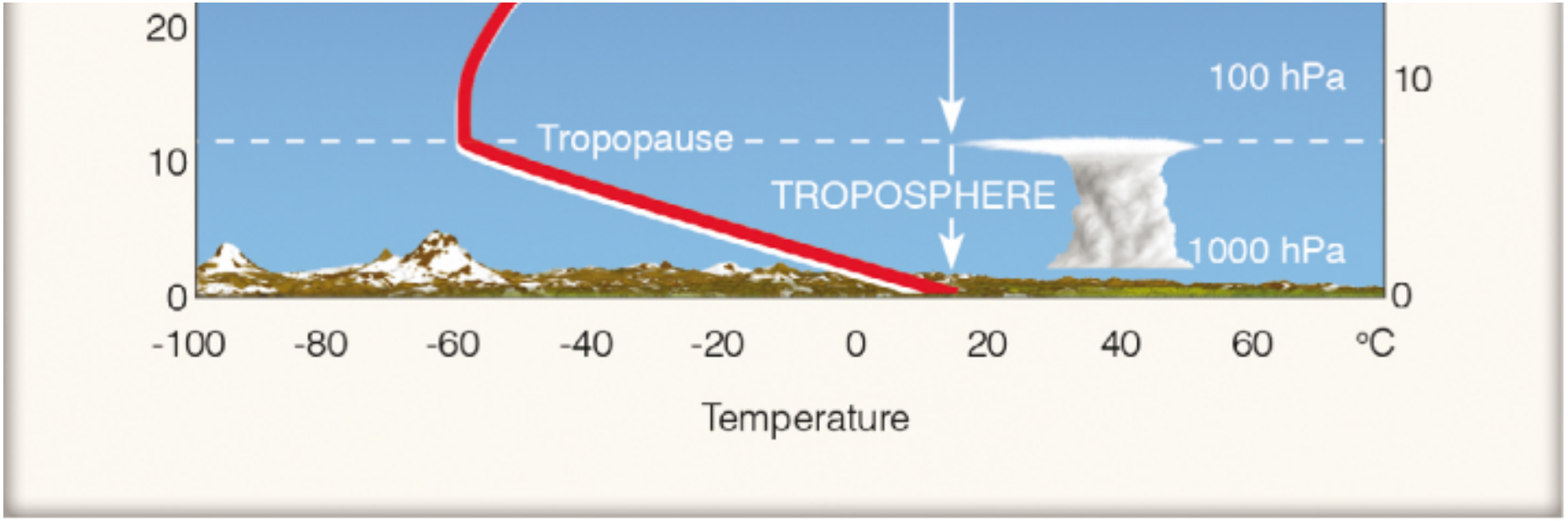
Thermal Layers of the Atmosphere

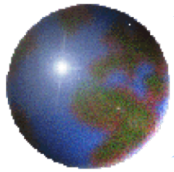


Ahrens: Fig. 1.11

Troposphere

- Heated from below
- Top boundary called the *tropopause*





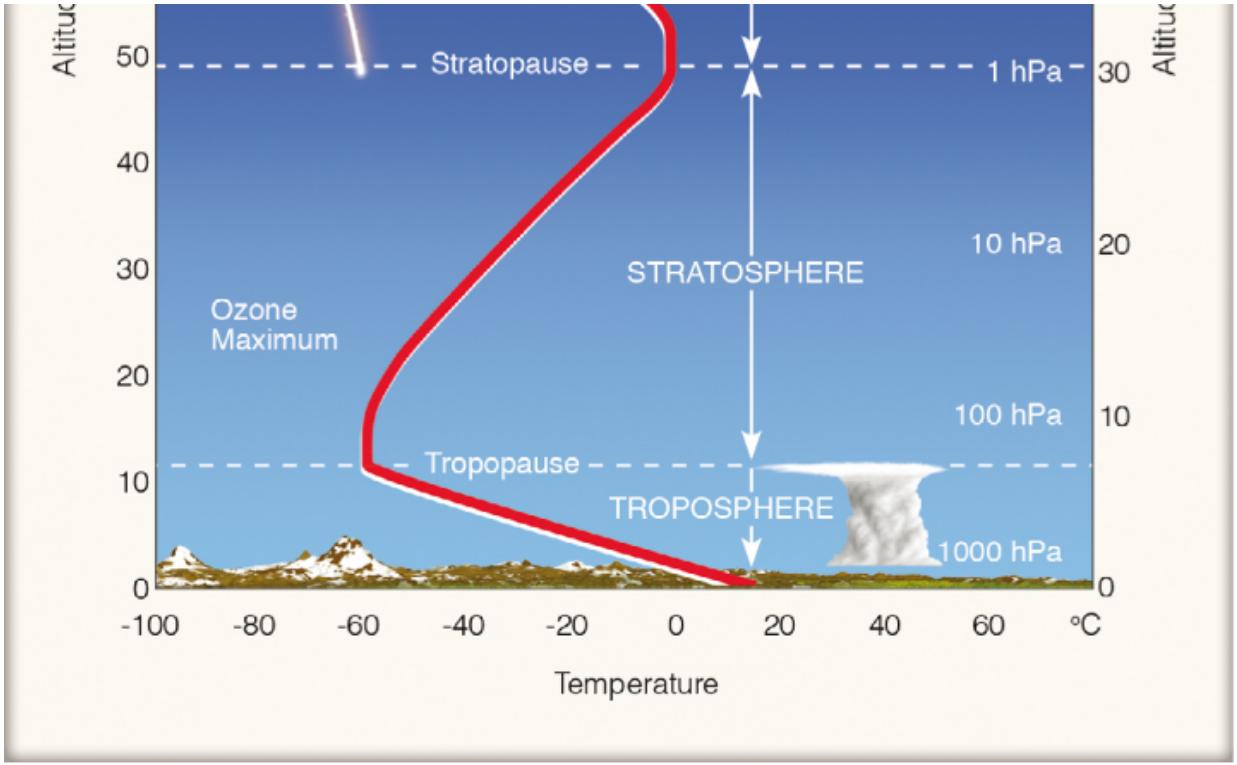
Troposphere

- Well-mixed vertically.
- Averages 11 km thick.
- Contains 80% of the mass of the atmosphere.
- All of our weather occurs in this part of the atmosphere.

Most clouds exist in the troposphere. Occasionally, violent updrafts penetrate cloud tops into the stratosphere. The flattened top of this cumulonimbus cloud is in the stratosphere.

Stratosphere

- Heated from above
- Top boundary is the *stratopause*

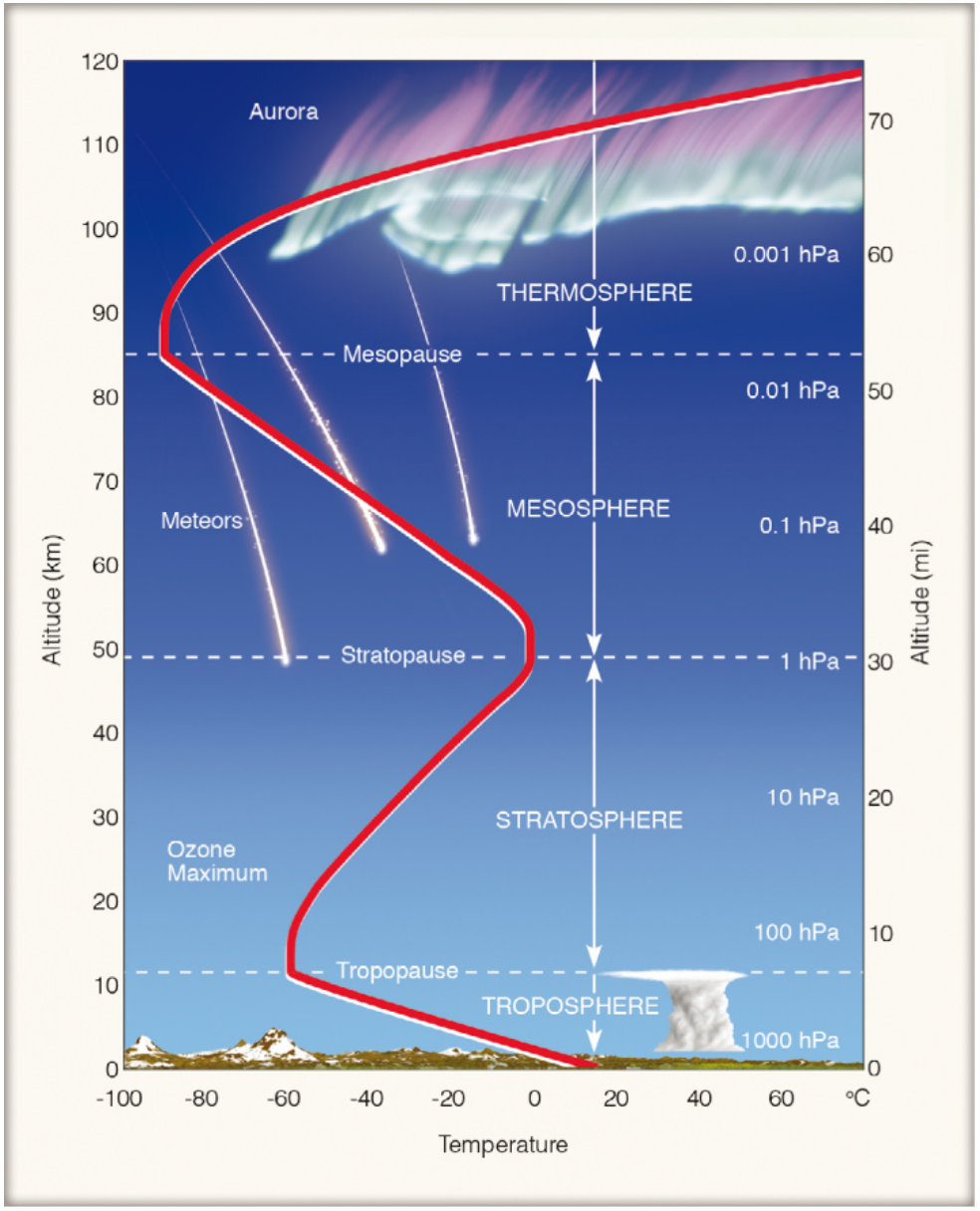


Stratosphere

- Warm air over cold air is very *stable*
  - Very little vertical mixing
- 11-50 km in height
- 20% of mass of atmosphere
- Heated by absorption of UV by ozone
  - Ozone peaks at 25 km (ozone layer)

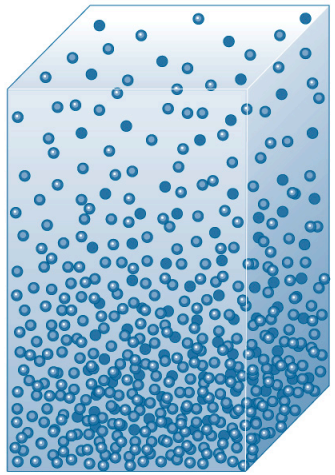
Mesosphere

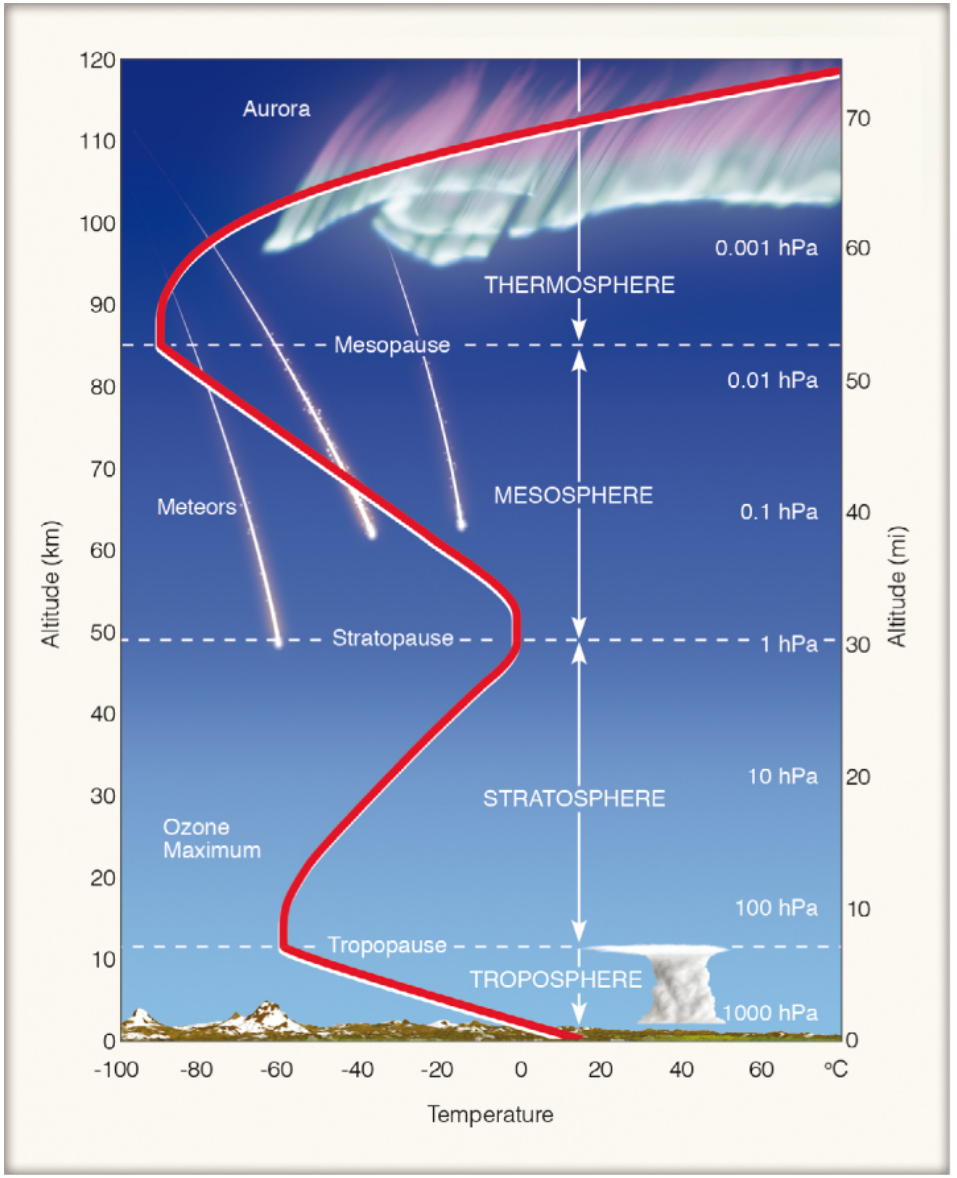
- 50-85 km
- 99.9% of the *rest* of the atmosphere (by mass)
- No ozone layer; heated from below
- Well-mixed vertically

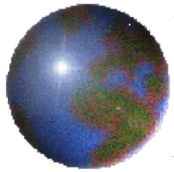


Thermosphere

- Above 85 km
  - No defined upper threshold
- Temperatures can reach 1500°C
- Heated by O_2 absorbing solar radiation







Next lecture

- Energy and radiation
- Ahrens: Chapter 2