

Lecture 1 Atmospheric Composition and Structure.

TABLE 1.1 Composition of the Atmosphere Near the Earth's Surface (EOM)

Permanent Gases			Variable Gases			
Gas	Symbol	Percent (by Volume) Dry Air	Gas (and Particles)	Symbol	Percent (by Volume)	Parts per Million (ppm)
Nitrogen	N ₂	78.08	Water vapor	H ₂ O	0 to 4	
Oxygen	O ₂	20.95	Carbon dioxide	CO ₂	0.036	360*
Argon	Ar	0.93	Methane	CH ₄	0.00017	1.7
Neon	Ne	0.0018	Nitrous oxide	N ₂ O	0.00003	0.3
Helium	He	0.0005	Ozone	O ₃	0.000004	0.04**
Hydrogen	H ₂	0.00006	Particles (dust, soot, etc.)		0.000001	0.01–0.15
Xenon	Xe	0.000009	Chlorofluorocarbons (CFCs)		0.00000002	0.0002

*For CO₂, 360 parts per million means that out of every million air molecules, 360 are CO₂ molecules.
 **Stratospheric values are about 5 to 12 ppm.

- Atmosphere primarily N₂, O₂, small quantities of other ‘permanent’ gases whose concentrations do not vary significantly over space or time. Trace permanent gases, except hydrogen (H), are inert.
- ‘Variable’ gases - concentrations vary with location, time due to exchange with sea, land surfaces, geological, biological and human activities.

Variable gases - H₂O and CO₂

- Moisture source: evaporation, plant transpiration. sink: precipitation
- Warm air can hold much more water vapor:
 - Tropics - Air is 2-4% water vapor by volume
 - Poles (winter), high altitudes - Under 0.1%
- CO₂ largely biological in origin, cycled through ocean, rocks.
- CO₂ has risen 30% from 280 ppm in 1800 to over 375 ppm today, mainly due to fossil fuel burning.
- CO₂ also outgassed in volcanic eruptions. This may have helped maintain CO₂ at several times current concentrations 50-100 million years ago.

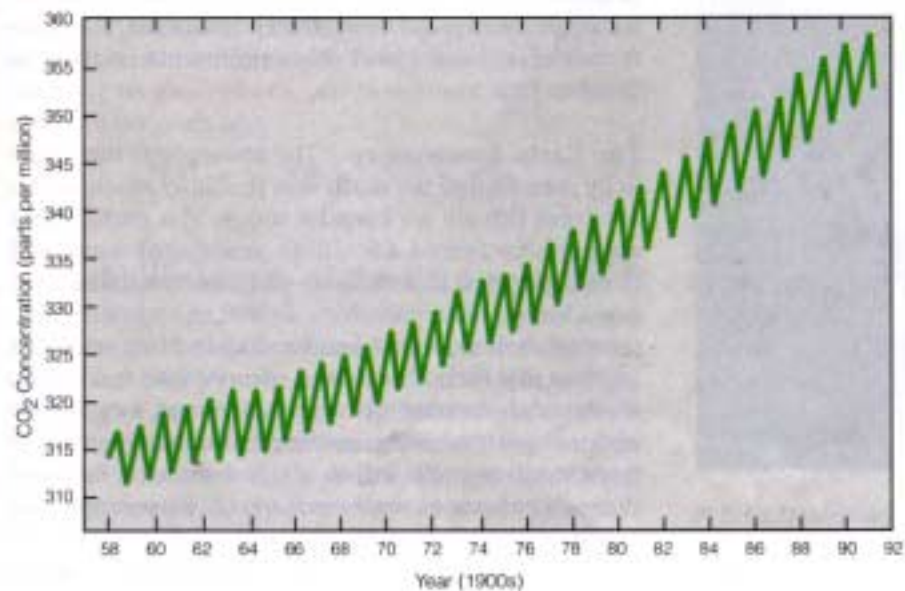
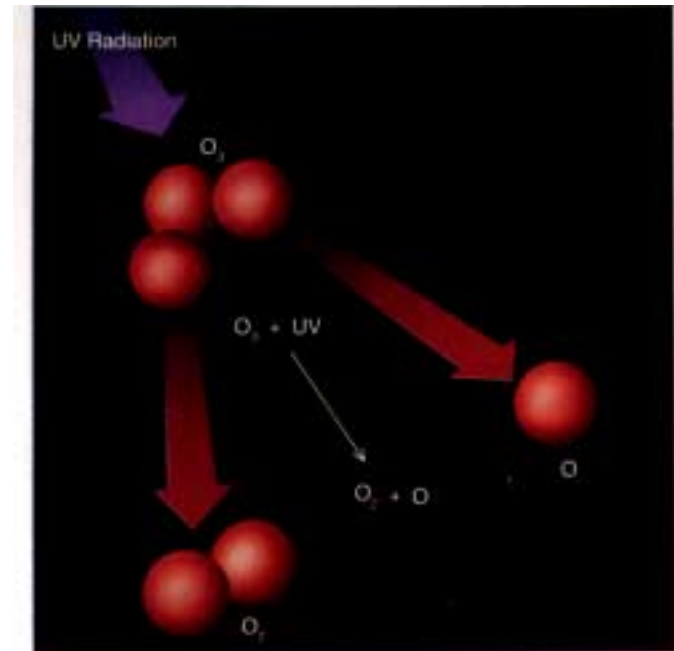


Figure 1.3 (EOM)
Measurements of CO₂ in parts per million (ppm) from 1958 through 1991 at Mauna Loa Observatory. Higher readings occur in winter when plants die and release CO₂ to the atmosphere. Lower readings occur in summer when more abundant vegetation absorbs CO₂ from the atmosphere.

Ozone (O_3)

- At the surface, naturally occurring O_3 concentrations are very low (0.02-0.05 ppm). However, O_3 is main constituent of photochemical smog, and causes lung, plant irritant at levels above 0.1 ppm.
- 97% of ozone in upper atmosphere, mainly at heights above 20 km, sunlight splits oxygen molecules (O_2) into O atoms, which recombine with O_2 molecules to produce 'lots of' (10+ ppm) O_3 .
- Here, it shields surface life by absorbing UV and splitting ('photodissociating') into $O_2 + O$
- Ozone is also destroyed by nitric oxide (high altitude jet planes). Chlorine (CFCs) also destroys ozone in extreme cold - Antarctic ozone hole.



EOM 1.10

Air pressure

- Supports weight of air column above.
- At surface -
Column 1 inch on side weighs 14.7 lb,
Column 1 cm on side weighs 1013 g,
⇒ Air pressure is $1013 \text{ g/cm}^2 = 1013 \text{ milli-bars (mb)}$.
- Air pressure decreases with height, reflecting smaller mass (weight) of overlying air column.
- Only 50% of the mass of molecules in the atmosphere is above 5.5 km, so pressure at 5.5 km is 50% that at surface, or about 500 mb.
- Only 1% of mass above 30 km, where pressure is 10 mb, 1% of surface pressure.

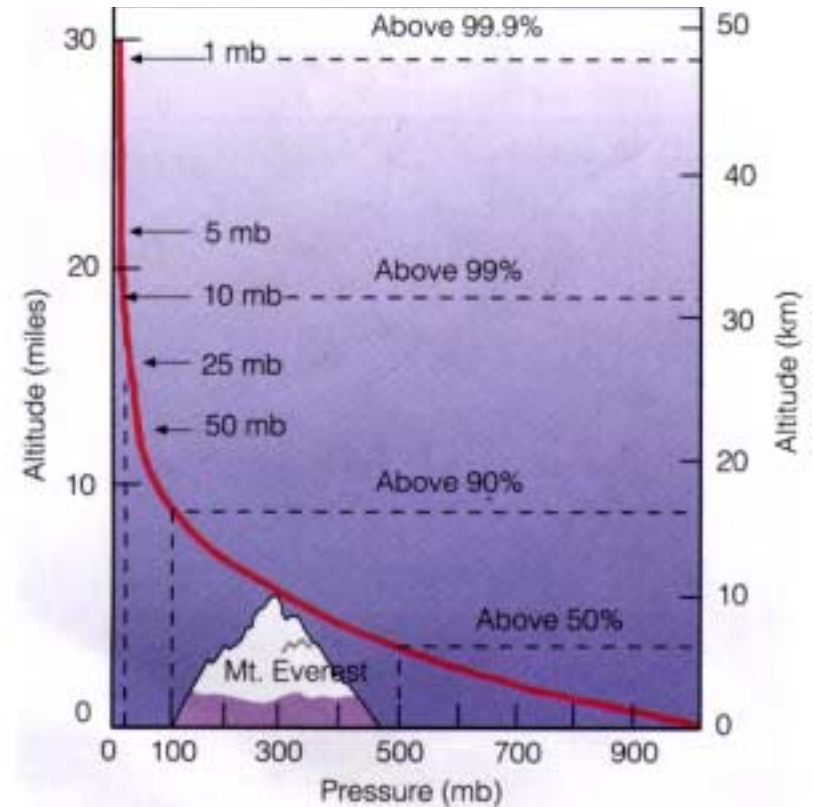
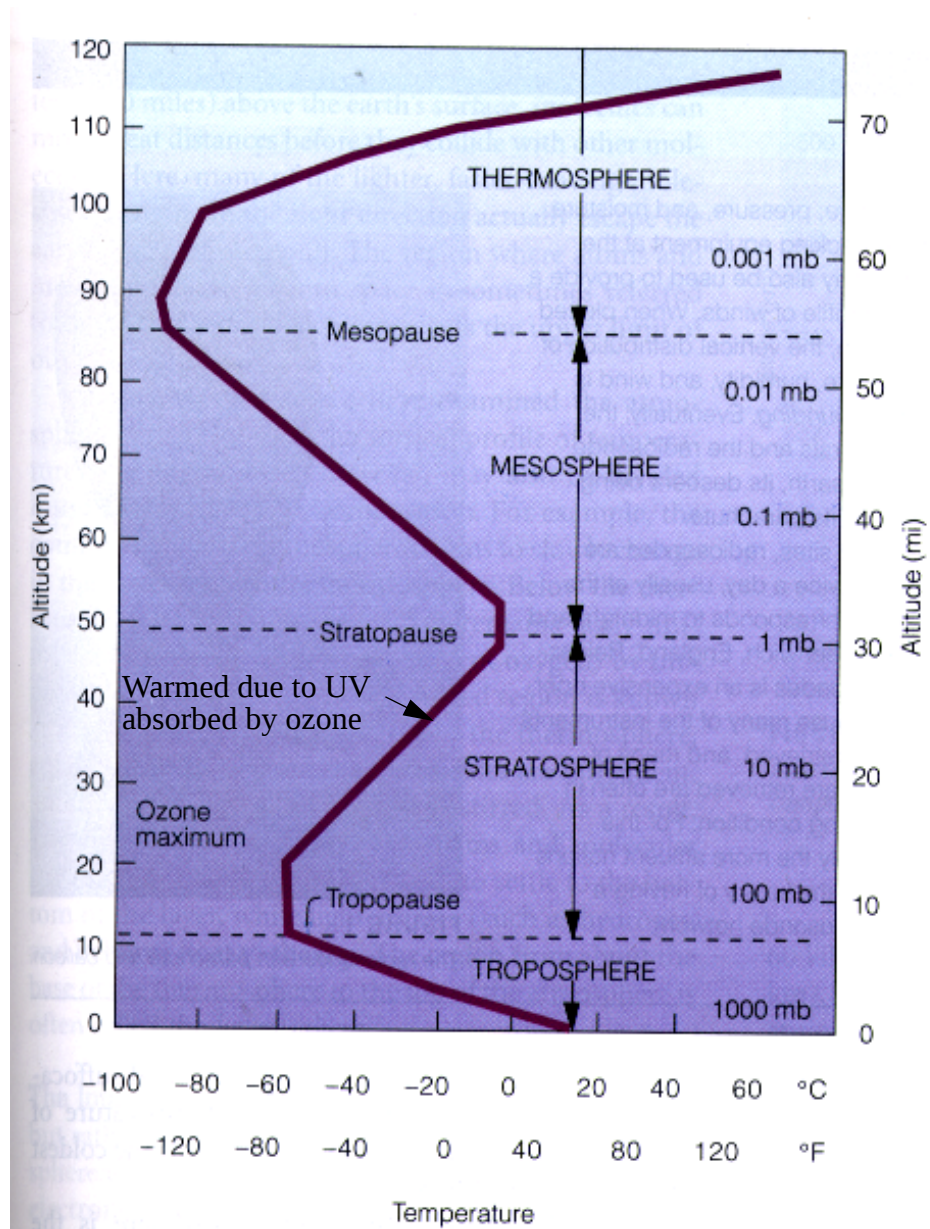


Figure 1.6 (EOM)

Atmospheric pressure decreases rapidly with height. Climbing to an altitude of only 5.5 km, where the pressure is 500 mb, would put you above one-half of the atmosphere's molecules.

Layers of the Atmosphere



The Outer Atmosphere

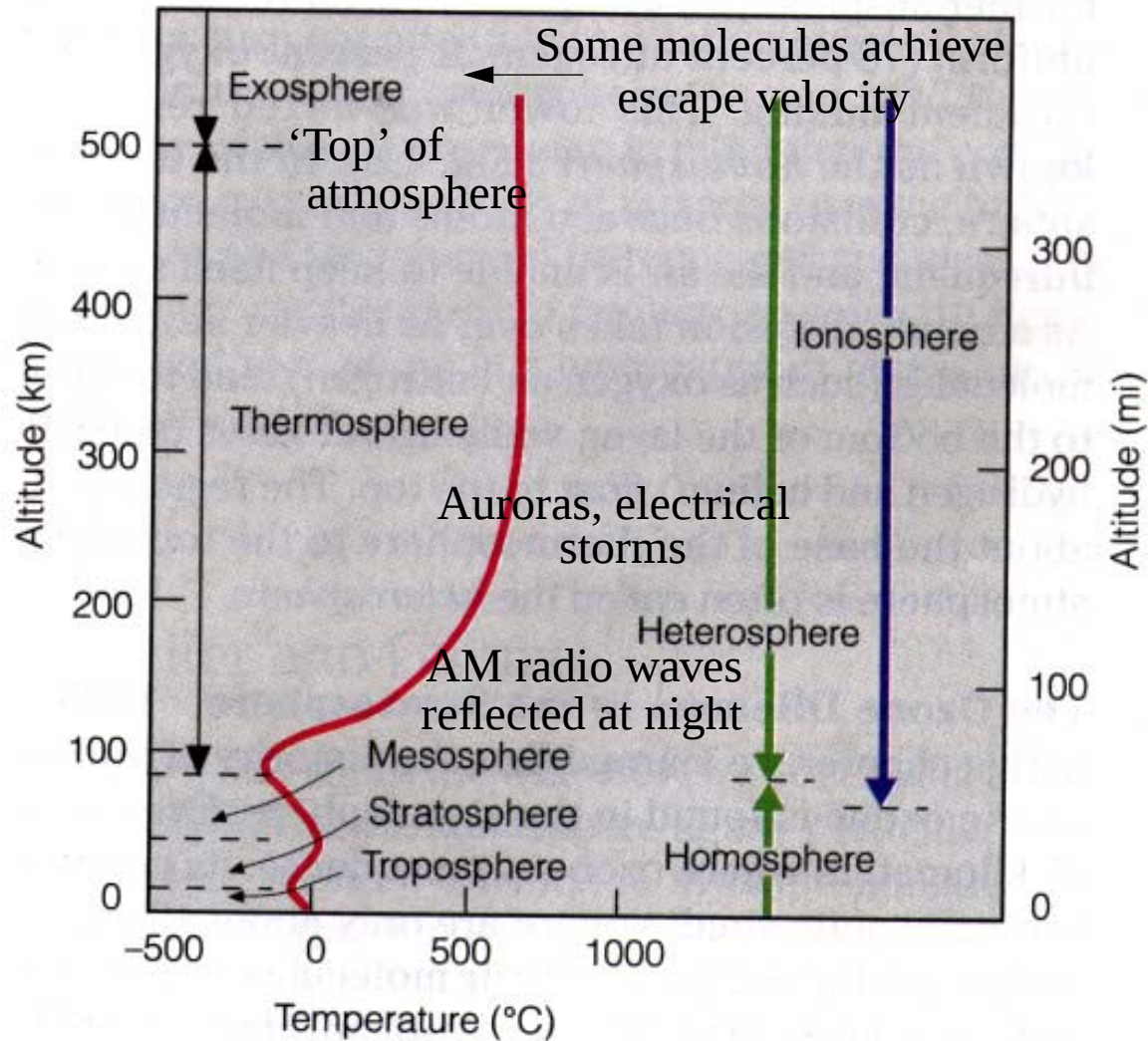


Figure 1.8 (EOM)

Layers of the atmosphere based on temperature (red line), composition (green line), and electrical properties (blue line).