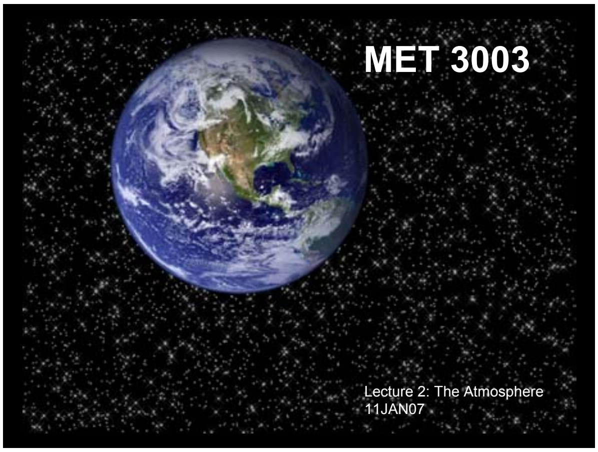
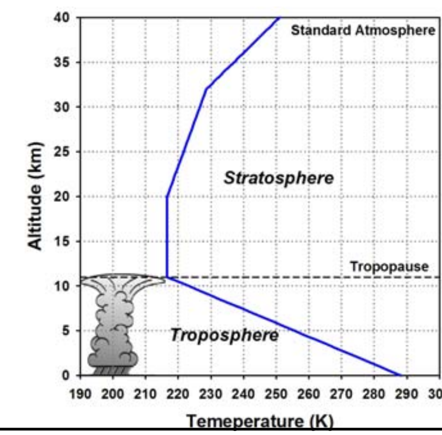


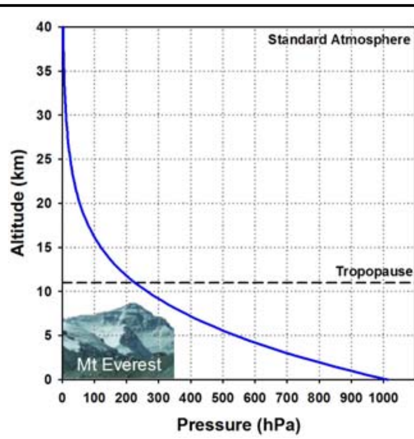
SI Units of Measurement

- Length: meters (m) or kilometers (km)
- Weight: kilograms (kg), grams (g), or tonne = 1000 kg.
- Factoids:
  - A cubic meter of air weighs about 1.2 kg
  - A cubic meter of water weighs 1000 kg
- Time: seconds (s)
- Temperature: Celsius (^oC) or Kelvin (K)
  - T K = T^{o}C + 273.16

Standard Atmosphere

- Used in aeronautics and elsewhere
- Surface temperature is 288.16K, or 15^{o}C
- Decreases 6.5^{o}C per km up to 11 km
  - Nearly all weather happens in this layer, called the ***Troposphere***
- At 11 k, the temperature is 216.65K, or -56.5^{o}C
- From 11 to 20 km the temperature is constant
- Above 20 km temperature varies in ways that we will talk about later.
- Since pressure is the weight of air above, it is possible to calculate the pressure





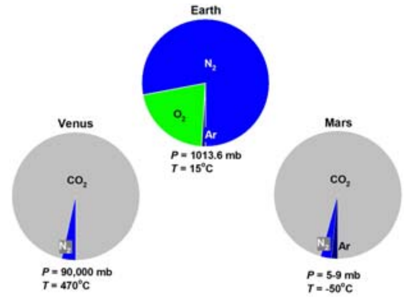
HISTORY of the ATMOSPHERE

- Original atmosphere composition (4.5 Byr ago) was probably like the sun or the atmospheres of the gas giant planets—Mostly H_2 and He
- Present atmosphere is deficient in He, Ne, Xe & Kr
- First atmosphere lost when the Moon was formed as a result of impact by a Mars-sized object, or maybe it just evaporated to space.
- Second atmosphere formed by outgassing from the solid Earth, largely through volcanoes
- Vented gasses are 85 % H_2O, 10% CO_2, some H_2S and SO_2 , N_2….
- CO_2 dissolves in water and plants convert it to O_2,
- A third atmosphere?

More About Atmospheric Chemistry

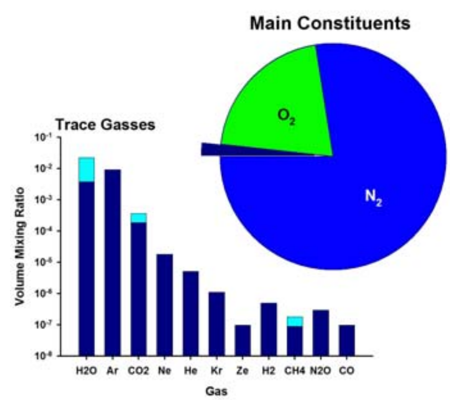
- SO_2, H_2S, etc in volcanic emissions (and air pollution) oxidize quickly and form sulfate compounds in the solid Earth.
- Argon and Helium in the modern atmosphere are the result of radioactive decay in the crust---ie of Potassium-40 to Argon-40.
- Carbon dioxide is increasing 0.4 ppm annually as a result of humans burning fossil fuels,
  - Reaching 375→500 ppm in 2100.
  - Preindustrial level was 280 ppm in early 1800s.

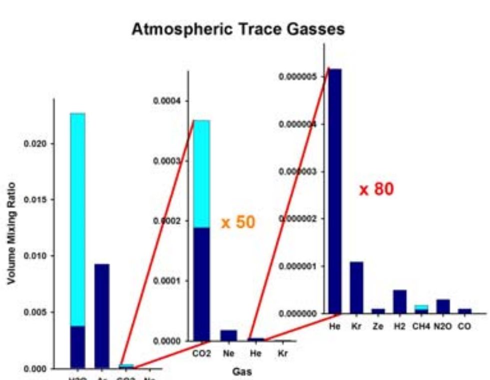
Earth's Atmosphere in Comparison With Other Planets

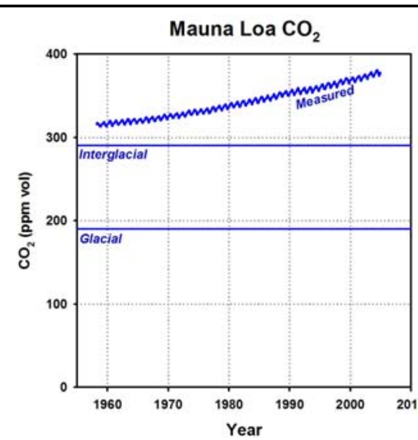


Atmospheric Composition

Component		Molecular Weight	Fraction by Volume
Nitrogen	N_2	28.02	0.7808
Oxygen	O_2	32.00	0.2095
Argon	Ar	39.94	0.0097
Water	H_2O	18.02	0 to 0.04
Carbon Dioxide	CO_2	44.01	0.000374
Neon	Ne	20.01	1.82×10^{-5}
Helium	He	4.00	5.2×10^{-6}
Krypton	Kr	83.7	1.1×10^{-6}
Xenon	Xe	131.29	1.0×10^{-7}
Hydrogen	H_2	2.02	5.0×10^{-7}
Methane	CH_4	16.04	1.8×10^{-7}
Nitrous Oxide	N_2O	44.01	3.0×10^{-7}
Carbon Monoxide	CO	28.01	1.0×10^{-7}







Ozone and Sunlight

Formation by UV radiation

$$O_2 + UV \rightarrow 2O \quad (0.1\mu m \le \lambda \le 0.2\mu m)$$

$$O_2 + O \rightleftharpoons O_3 + UV \quad (0.2\mu m \le \lambda \le 0.4\mu m)$$

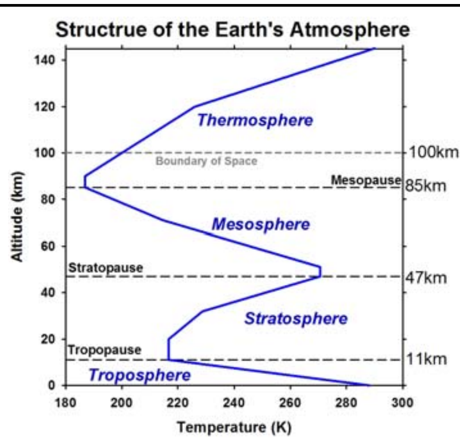
Destruction by Chlorine, or Hydrogen, or...

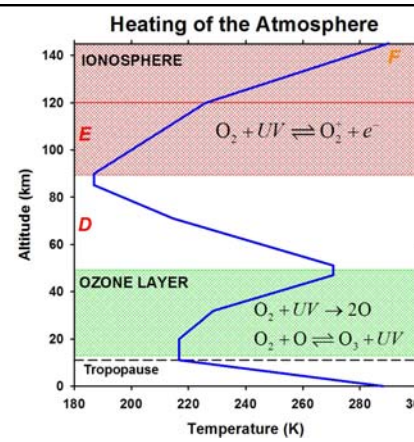
$$O_3 + Cl \rightarrow O_2 + ClO$$

$$ClO + O \rightarrow O_2 + Cl$$

Structure of the Atmosphere

- **Troposphere:** Lowest 10 (mid-lat) to 16 km (tropics) . Where the weather happens. Tropopause is top boundary, above 75% of the atmosphere
- **Lapse rate:** Temperature decrease with height in the Troposphere, standard = 6.5° C per kilometer in the troposphere.
- **Inversion:** Negative lapse rate, temperature increases.
- **Stratosphere:** Temperature constant at –50 to –80°C then increases with height to 45-50 km where it is about –5°C. Warmed by O_3 absorption (30-60 km) of solar UV. Stratopause is top boundary, above 99% of the atmosphere
- **Mesosphere:** Temperature decreases with height reaching < -80°C. Mesopause is top boundary, above 99.9% of the atmosphere at 85 km.
- **Thermosphere:** Above the mesosphere. Temperature increases greatly because air absorbs sunlight, but radiates inefficiently.
- **Boundary of Space:** 100 km
- **Ionosphere:** Overlaps Meosphere and thermosphere. Reflects AM radio at night but during the day extends lower (100 km → 60 km) and absorbs most AM radio energy.
- **Ozonzosphere (Ozone layer):** 10-50 km, produced by sunlight breaking up oxygen Protects us from solar UV.





Summary

- **For next time look over the posted lecture notes on gas laws.**
- Be familiar with basic SI units
- Know the quantitative characteristics of the standard atmosphere in the troposphere and lower stratosphere.
- Be familiar with the chemical history of the Earth's early atmosphere
- Be able to compare the composition of Earth's atmosphere with that of Mars and Venus.
- Be able to describe the composition of the Earth's atmosphere including percentages of the most abundant gases (to He & Ne)
- Be able to name the two most important greenhouse gasses
- Know the chemistry of ozone
- Know the variation of carbon dioxide over time and the reason for it.
- Be able to draw an explain the the Atmosphere's thermal structure below 150 km, including the ***"spheres" & "pauses."***
- Know the definitions of ***Lapse Rate*** and and ***Inversion***
- Be able to explain how the ionosphere and ozonosphere cause the observed vertical variations of temperature.