# Chapter 1:The Earth and Its Atmosphere

- Overview of the Earth's atmosphere
  - The solar system
  - Composition of the atmosphere & greenhouse gases
  - The early atmosphere
- Vertical structure of the atmosphere
  - A brief look at air pressure and air density
  - Layers of the atmosphere
  - The radiosonde (weather balloon)
- Weather and climate
  - Meteorology- A brief history
  - Satellite's view of the weather
  - Weather & climate in our lives

## Solar System (p. 2, figure not to scale)

- 1st 4 planets are "small" and rocky:
  Mercury (looks like Earth's moon), Venus (covered with clouds; surface is hundreds of degrees hot),
  Earth (93 million miles from Sun, 8 min for light to travel to Earth), Mars
- Asteroid belt (not shown in figure)
- 4 "gas giants": Jupiter and Saturn, Uranus , Neptune (1st letters of last 3 spell SUN)
- Pluto: dwarf planet; rock, water ice, frozen methane

↙ Asteroid belt between Mars & Jupiter


## Remembering Order of Planets

- You can use the following sentence to help you remember the order of the "nine" planets:
  My very educated mother just showed us nine planets.
- Each word of the preceding sentence begins with the letter of the next planet as you go out from the Sun: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, Pluto
- As of August, 2006, Pluto was reclassified as one of several "dwarf planets" because a number of other small similar bodies have been identified beyond Neptune.

## Atmospheric Composition (pp. 2-8)

- Hydrogen: primary component of Sun & "gas giant" planets.
- Hydrogen almost certainly primary component of Earth's early atmosphere, but gravity on Earth & other inner planets not strong enough to prevent escape of hydrogen to space.
- Earth's current atmosphere probably developed from volcanic gases (outgassing from volcanoes)
- Earth's air: roughly 80% nitrogen ($N_2$) and 20% oxygen ($O_2$).
- Next most abundant gases are water vapor and argon (type of inert gas), each about 1% of atmosphere.
- Other gases present in minute amounts (much less than 1%: trace gases). Some are "greenhouse" gases which influence the Earth's temperature.

## Greenhouse gases (pp. 5-6; more in chap 2)

- The two most important greenhouse gases: water vapor ($H_20$, about 1% of atmosphere) and carbon dioxide ($CO_2$, about 0.04%). We'll say more in chapter 2.
- Amount of $CO_2$ has been steadily increasing due to burning. Graph below shows last 50 years. Also note annual cycle in $CO_2$ : lower in summer when plants absorb more $CO_2$, higher in winter when plants die and release $CO_2$.

Fig. 1.5, p. 6, $CO_2$ amount

Year: 1958 1965 1975 1985 1995 2005

## Greenhouse gases (cont)

- Other important greenhouse gases that are trace gases:
  - Methane (produced by plants & animals)
  - Nitrous oxide (laughing gas)
  - Ozone ($O_3$, i.e., 3 oxygen atoms)
  - Chlorofluorocarbons (CFCs)
- Chlorofluorocarbons (CFCs) also destroy ozone in stratosphere, which protects life from ultraviolet (UV) light. Without UV absorption, most plants and animals would die.
- If stratospheric ozone were compressed to sea level pressure, it would be a layer about 1/8 inch thick.
- Ozone in stratosphere helpful to life by absorbing UV but harmful near surface when breathed (main part of smog).
- Ozone amount recovering (Research published in 2006)
  http://www.sciencedaily.com/releases/2006/08/060830215811.htm

## Special Topic: Breath of Fresh Air (p. 4)

- You are constantly breathing history.
- Pick any historical person and key event in his or her life. Examples:
  - Archimedes shouting, "Eureka!"
  - Julius Caesar saying, "Veni, vidi, vici."
  - Cleopatra talking with Marc Anthony
  - Martin Luther King, Jr., saying, "I have a dream."
- Each breath you take may contain a molecule exhaled by that person at the chosen event.

## Pressure (pp. 9-10)

- Pressure = force / area
- Mean sea level pressure of air = 15 lb/sq in
  = 30 inches of mercury
  = 1013 millibars (mb) (units used on TV for hurricanes)
  = 1013 hectopascals (hPa) (metric system)
- If the surface pressure changes by a few percent, that is a BIG change.
  - Record high surface pressure:
    1084 mb in Siberia (1968), only 7% above average.
  - Record low surface pressure:
    870 mb in Typhoon Tip (1979), 14% below average.
- Because of small changes in surface pressure, pressure is measured to 5 digits of accuracy (to tenth of millibar) to follow weather changes.

## Example of pressure calculation

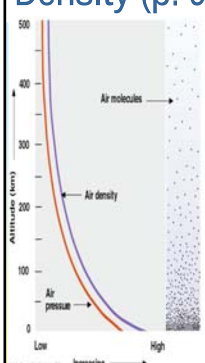
- How much pressure does someone exert when lying on a bed?
- Solution: Pressure = force /area, so
  consider someone who weighs about 150 lbs
  Area lying down ≈ 6 ft x 1ft = 72x12 ≈ 750 sq inches
- Therefore, pressure in lying on a bed =
  150 / 750 = 1/5 lb per square inch,
  which is very little.
- Let's test this!

## Bed of nails: This bed has 1 nail per sq inch. By the calculation in the last graphic, this is only 1/5 lb per nail, which is no problem.

## Air Pressure Decreases with Increasing Height

- Air is held to the Earth by gravity, i.e., it has weight.
- Pressure at any given height is due to the weight of the air that lies above that height.
- This is just like a human tower.
- Pressure on one's shoulders depends on the weight above.
- Person at the bottom experiences the greatest pressure.
- Air at the surface experiences the greatest pressure, and pressure decreases as you go up.

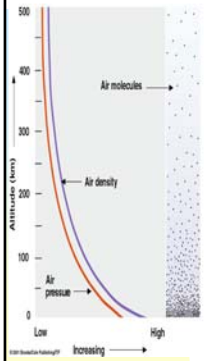

## Density (p. 9)




p. 10, fig. 1.8

- Density = mass/volume
- High density means lots of material (mass) in small volume
- Exponential decrease with height
- Density & pressure atop Mount Everest are about 30% of sea level values
- Air density near surface:
  about 1 kg/m$^3$ (2 lb / cubic yard)
- Density liquid water density is 1000 kg/m$^3$ (over 1700 lb / cubic yard), so liquid water is 1000 times denser than air.

## Why does density decrease with height?




p. 10, fig. 1.8

- Air, like any gas, is compressible.
- That is, you can squeeze it into a smaller volume, making it denser
- At the surface where the pressure is greatest, the compression is greatest, so the density is greatest
- As pressure decreases going up, compression decreases, so density decreases

## Atmospheric layers (p. 11, fig 1.10)

Layers determined by temperature structure.

**Layers & "tops"**

**Thermosphere**

**Mesopause 85 km**

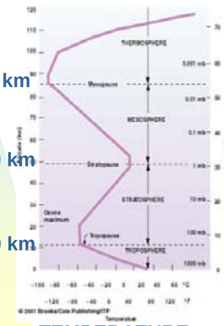
**Mesosphere**

**Stratopause 50 km**

**Stratosphere**

**Tropopause 10 km**

**Troposphere**



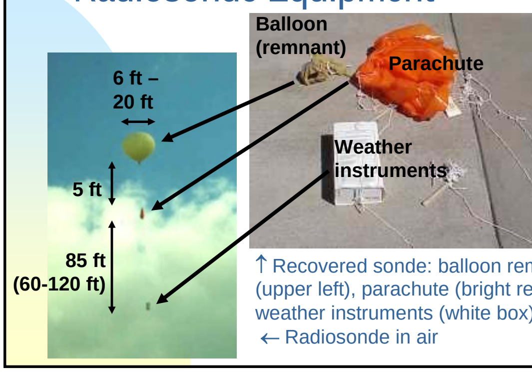
TEMPERATURE

- Hot top: oxygen absorbs sunlight
- Warm middle: ozone absorbs ultraviolet
- Warm surface: Ground absorbs sunlight

## Radiosonde: Weather balloon (p. 14, fig. 4)

- $75 - $100 for balloon and instruments
- Launched 1 hour before midnight and noon Greenwich Mean Time (now called UTC)
- Instrument package hangs 85' below balloon, measures temperature, pressure, & relative humidity
- Has a radio transmitter
- Winds: track balloon's radio
- Balloon pops over 15 mi up, parachutes down. Some are recovered.

## Radiosonde Equipment




↑ Recovered sonde: balloon remnant (upper left), parachute (bright red), weather instruments (white box)
← Radiosonde in air

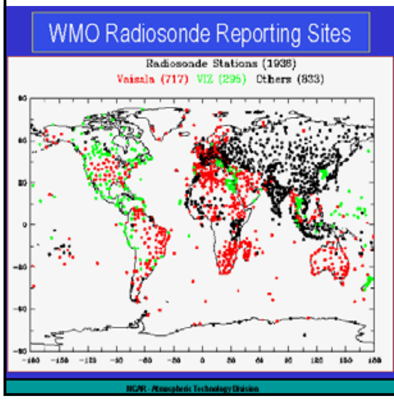
## Radiosonde launches by NWS at FSU

- Latex balloon inflated by tying it to nozzle in upper picture. Helium used for safety instead of hydrogen.
- Ceiling opened in inflation room to release balloon through cylinder in roof of Love Bldg (lower picture).
- Radiosondes launched at 7 am/pm Eastern Standard Time, 8 am/pm EDT (1 hr before noon and midnight Coordinated Universal Time).

## Radiosonde launches by NWS at FSU

- Balloon tracked automatically by dish antenna inside white sphere on roof of Love Bldg.
- Antenna's tilt angle (azimuth) and azimuth (CW angle from north) adjusts to maximize strength of received signal.
- Tracking the balloon as it rises is the basis from which wind speed & direction is computed at various heights.

## Worldwide Radiosonde Network



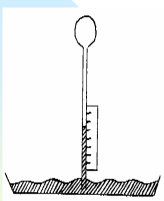

Rough numbers:

- US: 108 sites
- Canada: 34 sites
- Mexico: 15 sites
- World: 1936 sites
- 2 launches/day at most places
- Different colors of dots on map denote different companies that make the radiosonde equipment

## Weather and Climate (pp. 16-17)

- Weather: condition of atmosphere at any particular time or place
- Climate: weather statistics
- Climatological normals: average over last 30 years (current period used is 1971-2000)

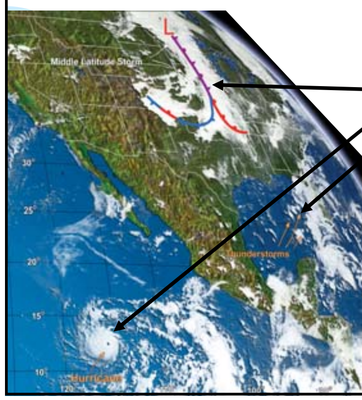
## Western History of Meteorology (p. 17)



Galileo's thermometer. Barometer looks similar.

- ca. 340 BC: Aristotle wrote Meteorologica (meteoros = lifted up, in air)
- 1597: Galileo invents thermometer
- 1643: Toricelli (student of Galileo): invents barometer
- 1843: Morse invented telegraph
- 1940's: Radiosondes & radar
- 1950: 1st computer weather forecast
- 1960: 1st weather satellite (TIROS)
- 1990's:Doppler radar network (NEXRAD)

## Storms of all sizes (p. 20, fig. 1.13)




Largest to smallest:
Mid-latitude storm
Hurricane
Thunderstorm
Tornado (too small to see on satellite picture)

## Weather in Our Lives (pp. 20-24)

Approximate deaths per year in the United States due to:

- Heat waves 300 to 1000
- Cold spells 150
- Floods 150 (p. 23, col. 1, "Weather Watch")
- Lightning 90 (Web search, NASA site)
- Various winds 90
- Tornadoes 70
- Tropical cyclones 25
- For more information, see http://www-das.uwyo.edu/~geerts/cwx/notes/chap03/nat_hazard.html (The hyphen after www is part of the address.)
- For information about severe weather (and safety in general) in Florida, see http://www.FloridaDisaster.org