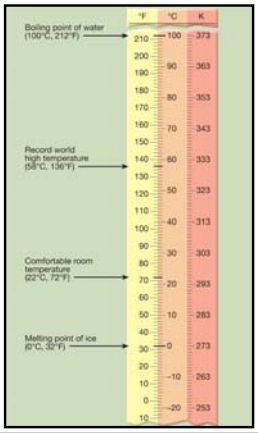
MET3003

Lecture 6: Temperature
29Jan07

Temperature

- One of the most basic weather elements---along with wind. You can feel it.
- Measured with thermometers or various electronic sensors
- Plays a vital role in weather analysis (of course), agriculture, power generation, medicine, athletics….
- **Warmest ever:** El Azizia, Lybia 58ºC (136ºF), 13 SEP 1923
- **Coldest ever:** Vostok, Antarctica -89ºC (-129ºF), 21 JUL 1983. Note: Antarctica record high is 58 ºF (14 ºC) at Esperanza
- Difference = 147ºC.
- Climatological temperature records:
  - Current Temperature, right now
  - Daily maximum and minimum
  - Daily mean: Average of max & min, or of hourly measurements
  - Monthly mean: Average of daily means
  - Yearly mean: Average of monthly means
  - Daily, monthly, annual temperature range: Difference between maximum and minimum



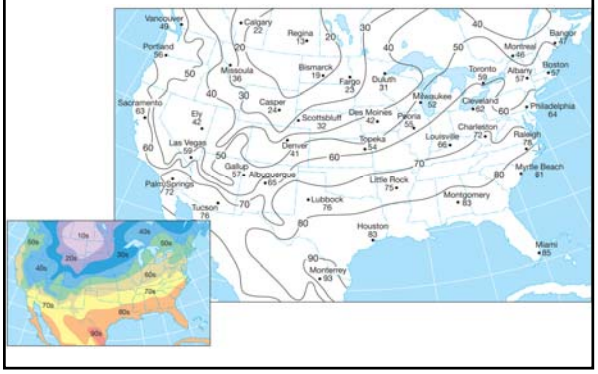
Temperature Scales

ºF = 1.8ºC + 32, or

ºC= (ºF – 32)/1.8

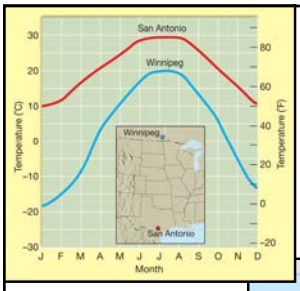
K = ºC + 273.16

Temperature is shown on maps with ***Isotherms,*** lines of constant temperature.

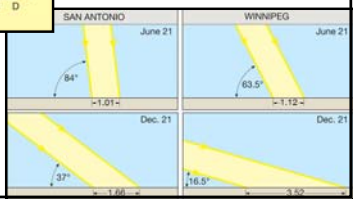


What Controls Temperature?

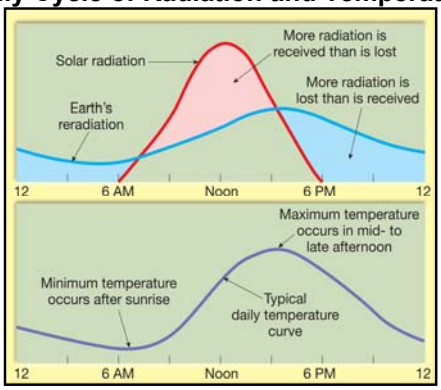
- Solar radiation, i.e. latitude & season
- Different responses between land & water surfaces
- Ocean currents
- Geographic setting
- Cloud cover and albedo



Latitude, Sunlight & Temperature

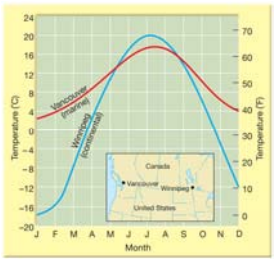


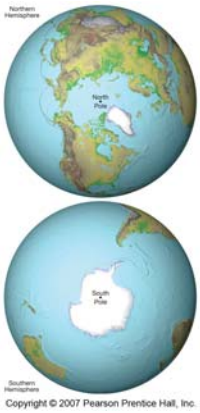
Daily Cycle of Radiation and Temperature



Water Heats or Cools More Slowly than Land

- Heat convects and advects in water
- EM radiation can penetrate into water, but not land
- The specific heat (number of Joules needed to warm 1 kg 1°C) of water is larger than for most other substances
- Evaporation absorbs heat





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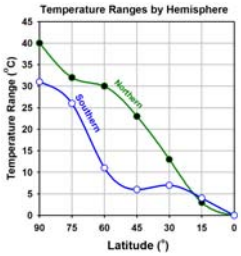
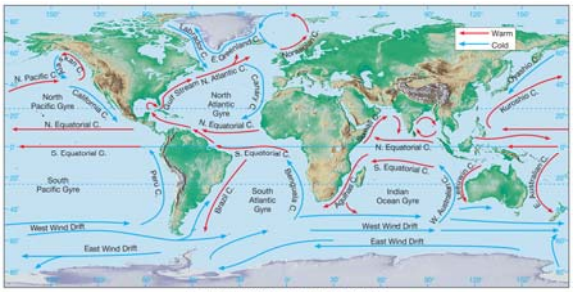
Oceans cover 81% of the Southern Hemisphere, but only 61% of the Northern Hemisphere



So annual temperature ranges in the Southern Hemisphere are less

Ocean Surface Currents



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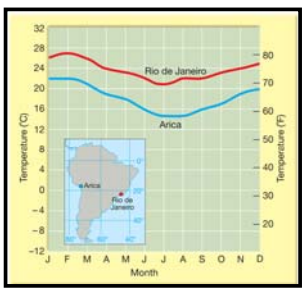
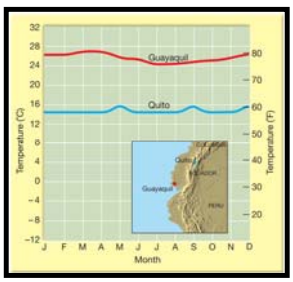
Effect of Ocean Currents

- Caused by winds blowing over the ocean surface.
  - From W in mid latitudes
  - From E in tropics
- Rio de Janeiro
  - Warmed by the Brazilian Current
- Arica (Chile)
  - Cooled by the Peruvian Current
- Generally:
  - East coasts warmed by poleward flowing currents
  - West coasts cooled by equatorward flowing currents
- Net poleward transport of heat

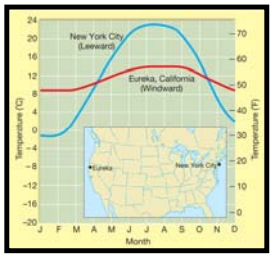


Effect of Altitude



- Normal lapse rate 6.5°C per km
- But because the mountains absorb sunlight, mountain temperatures don't decrease that fast
- Because the optical path is shorter more solar heating and more nighttime cooling

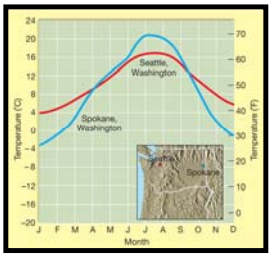
Windward and Leeward Coasts



- Winds blow from the west in middle latitudes
- Pacific Ocean water with cool currents upwind
- Atlantic ocean with warm currents downwind
- Lead to warmer winters and cooler summers in Eureka.

Geographic Position Relative to Mountains

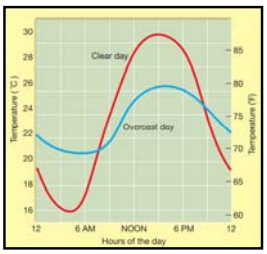
- Mountains act as barriers to upwind influences
- Block temperature and rainfall
- Spokane is actually colder in winter because of artic blasts from Alberta and Saskat-chewan that blow down the east side of the mountains

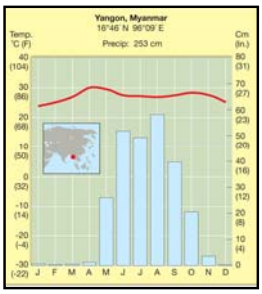


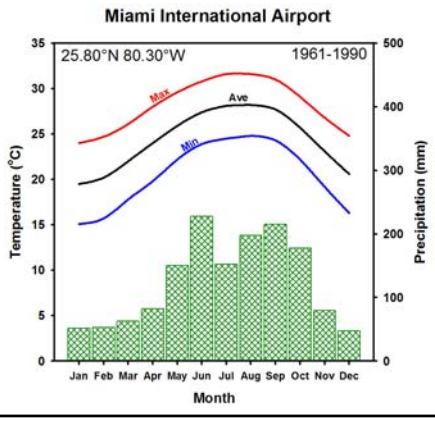
Clouds and Rainfall

- Clouds reflect sunlight
- They also trap IR radiation at night
- Leading to a smaller daily temperature range
- Rain wets the surface
  - Evaporative cooling
  - Cool downdrafts
  - Increases specific heat

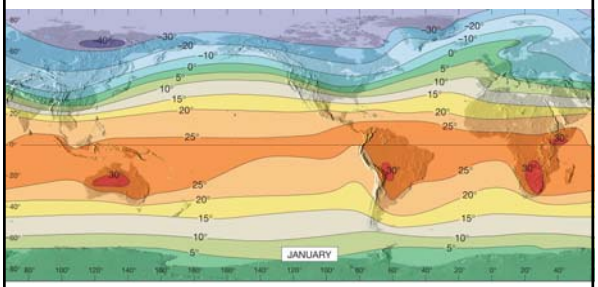
Examples of Cloud/Rainfall Effect



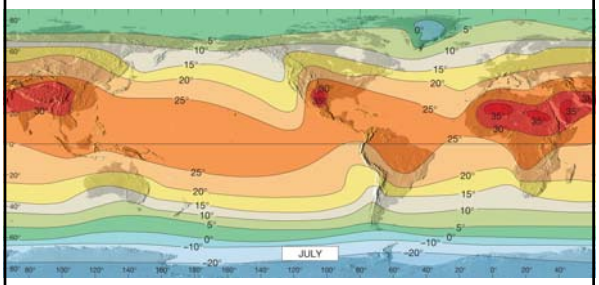




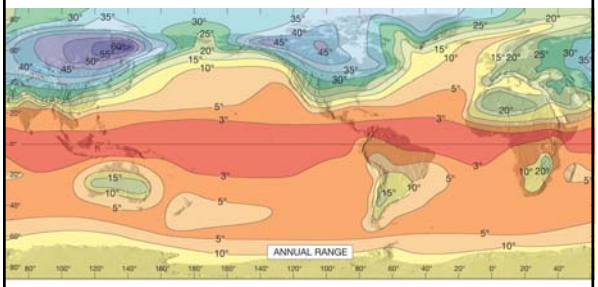
January Mean Temperatures



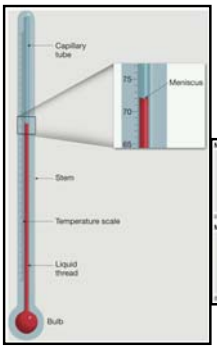
July Mean Temperatures



Global Annual Temperature Ranges

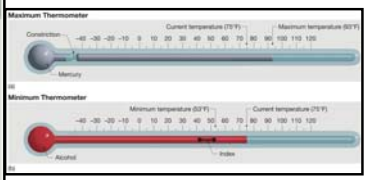


Measuring Temperature



Liquid-in-glass Thermometer

Maximum Thermometer



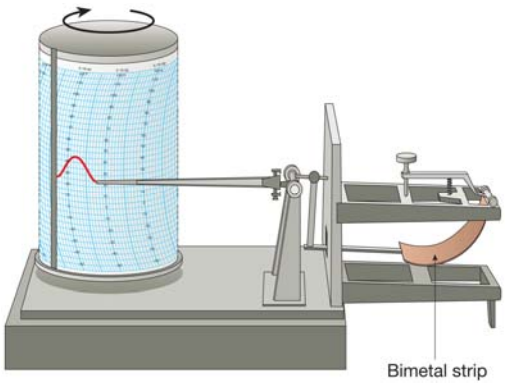
Minimum Thermometer

Instrument Shelters

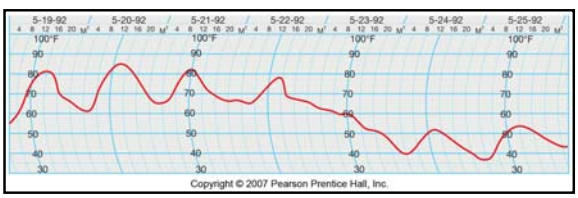
Traditional Shelter

Shelter for Electronic Sensors

Thermograph

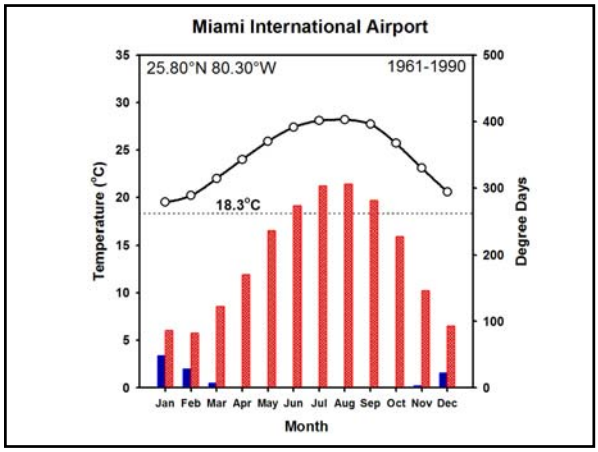


Daily March of Temperatures



Concept of Degree-Days

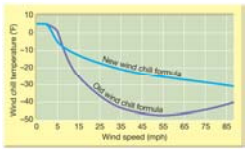
- Total days with temperature above a base temperature (or zero temperature) times the number of degrees that temperature is **above** the base on each day.
- For example, ***Cooling Degree Days*** where the base is 65 F.
  - Five days with temperatures of 63, 66, 70 75, and 61.
  - Cooling degree days = 2 + 0 + 0 +0 + 4 = 6
- ***Heating Degree Days*** work the same way with the same base but it's days with temperature **below** the 65 F threshold.
  - For the temperatures above, heating degree days = 0 + 1 + 5 + 10 + 0 =16
- In agriculture the concept of **Growing Degree Days** is used to estimate time when a crop will be ready for harvest.
  - Corn: Base temp = 50. Degree-days to harvest = 2200
  - Peas: Base temp = 40. Degree-days to harvest = 1200-1400
  - Corn growing degree days for above temperatures = 13+16+20+25+11=85
  - Thus. temperature records (and rainfall) allow one to estimate whether or not a crop will grow in a locale, ideal planting time and expected harvest times.

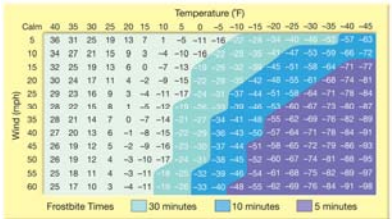


Temperature and Human Comfort

- Normal room temperature = 20-25°C
- Normal human body temperature = 37 °C.
- Humans generate heat through metabolism of carbohydrates and fats at a rate of 88W at rest and as much as 1060 W (12 x resting) for fit person working hard.
- Heat is dissipated through conduction, convection, and radiation. Mostly by evaporation of sweat.
- At the hard-working rate evaporation of sweat = 1.5 kg per hour.
  - This same hard working human has a surface area of 2.5 m^2
  - To maintain temperature he needs to radiate 400 W m^{-2}
  - A bit more than the average net IR radiation from the Earth's surface, 390 W m^{-2}
- Heat dissipation works best when there is forced convection---i.e wind.
- Wind chill "feels like temperature" takes into account the cooling effect of winds and is always less than actual.
  - $T_{wc}(^oC) = 13.12 + 0.631T - (11.37 - 0.396T)V^{0.16}$
    for V in km per hour

Wind-Chill Factor





Medical Effects

- Hyperthermia: Body temp > 38°C (100.4°F). Potentially lethal when core temp reaches 41°C (106°F). Body cooks (crock pot is more like 160°F).
- Frostbite: Freezing of peripheral tissues (nose, ears, fingers, toes). Leads to gangrene and death through septicemia if dead tissues are not amputated
- Hypothermia: Temperature drops below 26°C (79°F). Death occurs through ventricular fibrillation.
- Metabolic rate increases (decreases) 6% for each 1°C increase in temperature, leading to metabolic run-away.

Summary

- Be able to work with Celsius, Fahrenheit & Kelvin temperatures
- Understand Daily, Monthly, and Annual mean temperatures and ranges
- Understand the typical daily cycle of temperature
- Understand how the following factors control temperature at localities
  - Soar Radiation
  - Land & Water Surfaces
  - Altitude and Geographic Settings in General
  - Ocean Currents
  - Clouds and Albedo
- Understand the factors that control the global distributions of temperature in winter and summer
- Know how temperature is measured with
  - Mercury-in-glass thermometer
  - Maximum and minimum thermometers
  - Thermograph
- Understand and be able to calculate Heating, Cooling, and Growing Degree days
- Know how heat affects human comfort, including definitions of
  - Wind Chill
  - Hypothermia and Hyperthermia
  - Frostbite

FOR NEXT TIME READ CHAPTER 4. HOMEWORK IS DUE MONDAY 05FEB