Chapter 3: Temperature

Elements of WAC (Basic Measurable Properties)

1. **Temperature of Air**
2. Humidity of Air
3. Cloud Cover (type and amount)
4. Precipitation (type and amount)
5. Air Pressure
6. Wind Speed and Direction

I. Air Temperature Data

Daily mean temperature

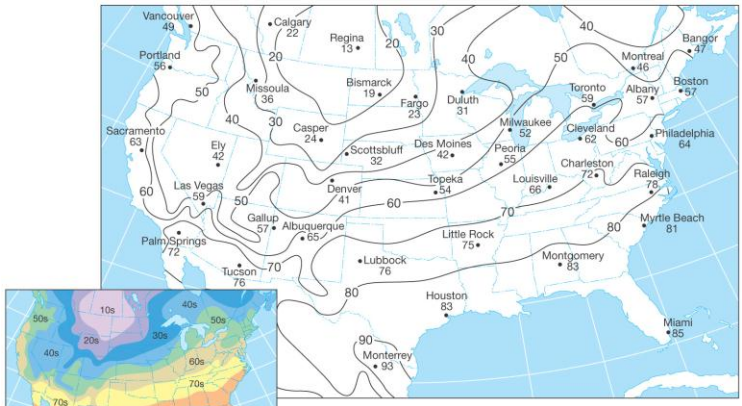
Daily temperature range

Monthly mean temperature

Annual mean temperature

Annual temperature range

Isotherms = lines that connect points on a map that have the same temperature



Temperature Gradient = temperature change per unit distance

II. Controls of temperature

Chapter 2 = Discussed variations in solar radiation

A. Differential Heating of Land and Water

B. Ocean Currents

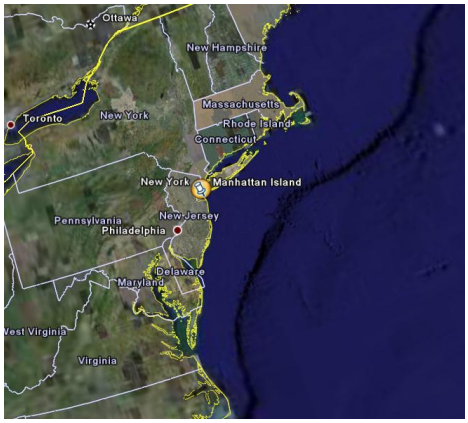
C. Altitude

D. Geographic Position

E. Cloud cover and Albedo

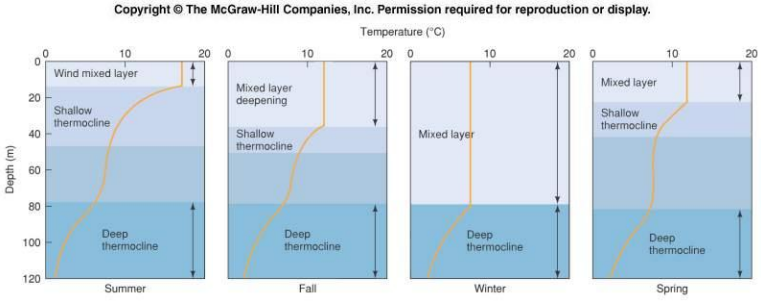
A. Differential Heating of Land and Water

- Atmosphere primarily heated from below
- Heating properties of various surfaces (soil, trees, water, ice, asphalt, concrete…)
- Land heats/cools quicker
- Land hotter/colder temps



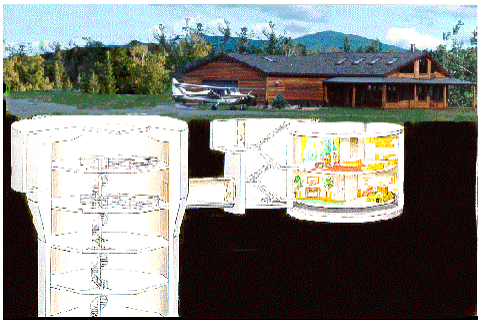
Why do land and water heat and cool differently?

1) Water is highly mobile, heats through convection



Why do land and water heat and cool differently?

Land is rigid, heats through conduction



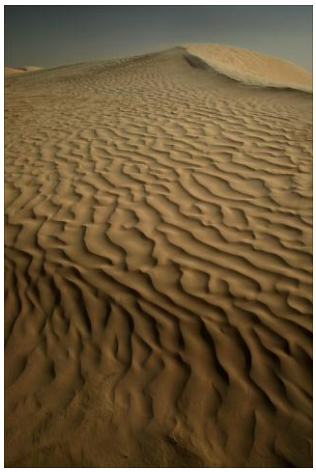
SILO

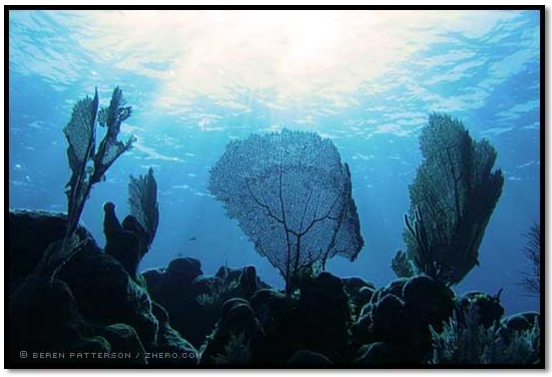
Climate constant/approx. 58 degree earth ambient temperature.

PriceOriginal Gov't cost for complex in 1958 $18 Million
(Present value is near $100 Million)

Why do land and water heat and cool differently?

2) Land surfaces are opaque, water is transparent





Why do land and water heat and cool differently?

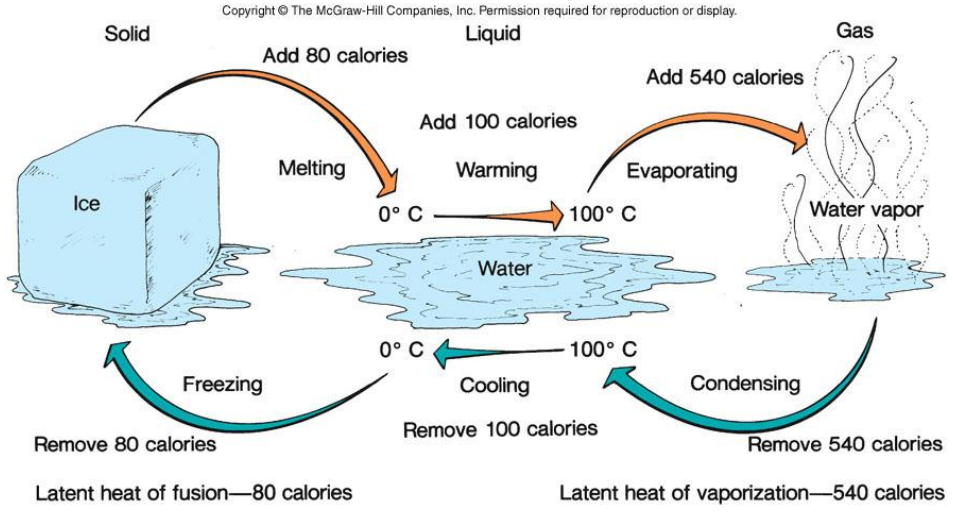
3) **Specific heat**: the amount of heat needed to raise the temperature of 1 gram of a substance 1°C

Specific Heat (at 25° C)

SUBSTANCE	CAL / GRAM °C	JOULE / GRAM °C
Air	0.24	1.01
Aluminum	0.22	0.90
Ethyl alcohol	0.59	2.45
Gold	0.03	0.13
Granite	0.19	0.80
Iron	0.11	0.45
Olive oil	0.47	2.00
Silver	0.06	0.24
Stainless steel	0.12	0.51
Water (liquid)	1.00	4.18
Wood	0.42	1.76

Why do land and water heat and cool differently?

4) **Evaporation**: from water is greater than from land, energy goes toward evaporation instead of heating



Marine –vs- Continental Locations

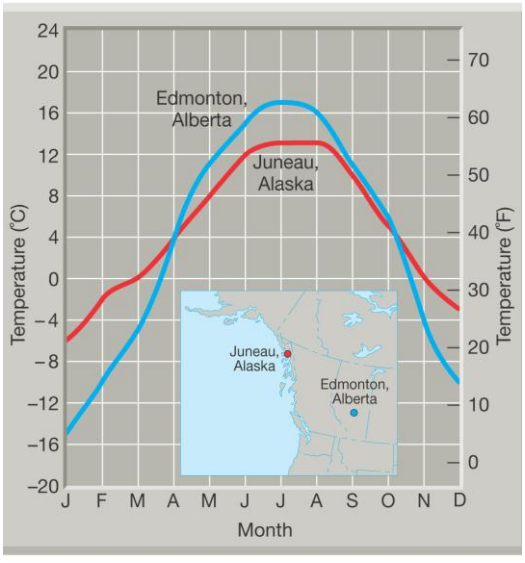
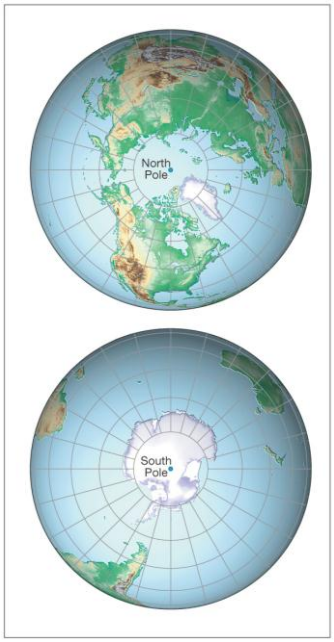


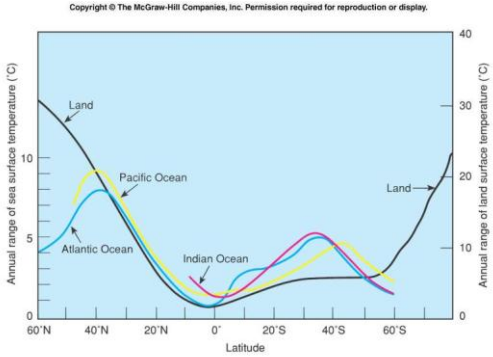
TABLE 3-1 Variation in mean annual temperature range (°C) with latitude

Latitude	Northern Hemisphere	Southern Hemisphere
0	0	0
15	3	4
30	13	7
45	23	6
60	30	11
75	32	26
90	40	31

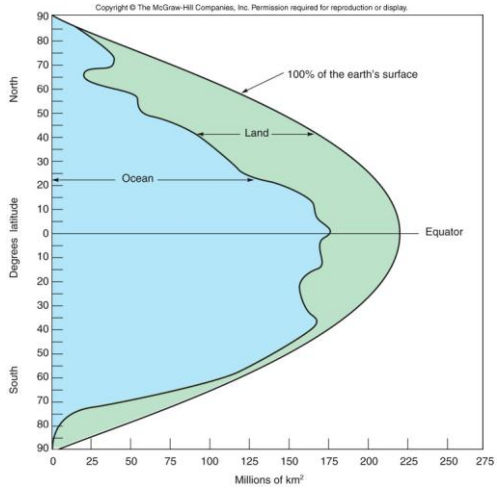
- In general temperature range increases with latitude
- Southern Hemisphere?



Distribution of Water



Distribution of Land



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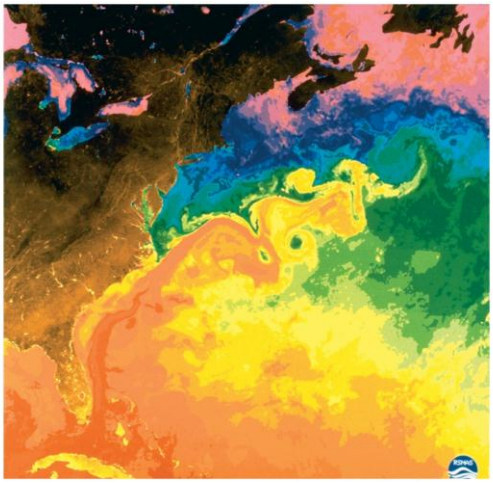
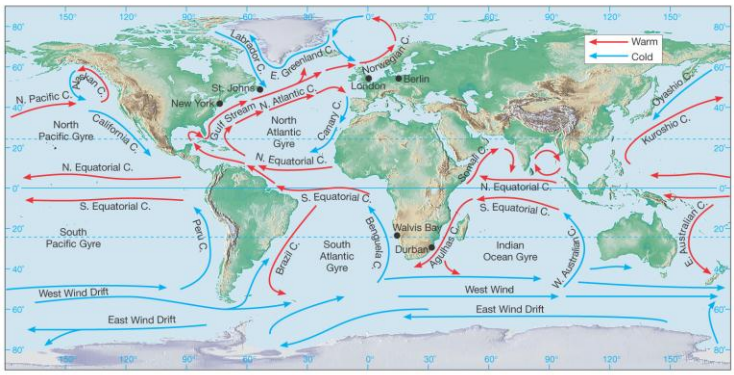
B. Ocean Currents

- Transfer of heat by ocean currents (and wind) equalizes the latitudinal energy imbalances
- Example: **Gulf Stream**
- 500 Times the discharge of the Amazon River

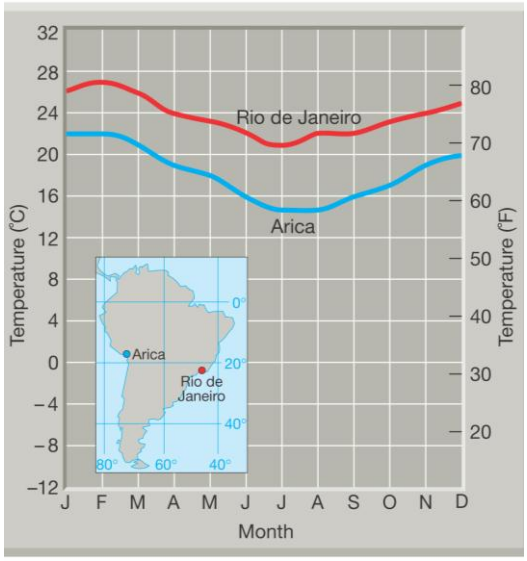


B. Ocean Currents

- Warm currents move toward the poles
- Cool current move toward the equator



Arica, Chile –vs- Rio de Janeiro, Brazil

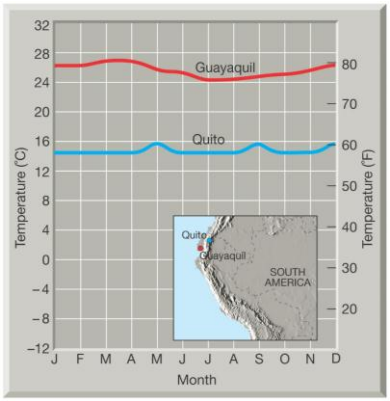


C. Altitude

- Temperature decreases with altitude
- Normal Lapse Rate **6.5°C/km**

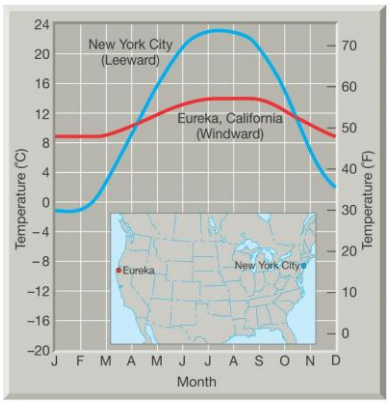
C. Altitude

- Expect 18.2°C difference based on the normal lapse rate
- Actual difference = 12.2°C
- **Thinner Atmosphere**
  - Less reflection/absorption
  - More solar energy striking the surface
  - Rapid heating and cooling

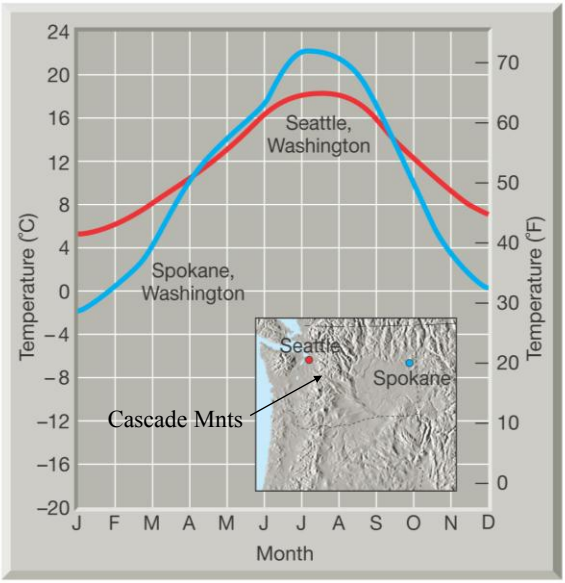


D. Geographic Position

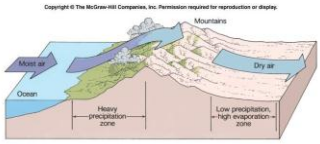
- **Windward** coastal locations receive full moderating influence of the ocean.
- **Leeward** locations (wind blows from land to ocean) reduce the moderating effect of water



Seattle -vs- Spokane

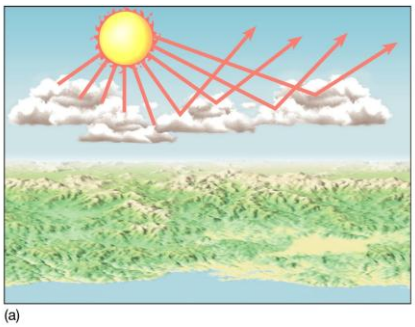


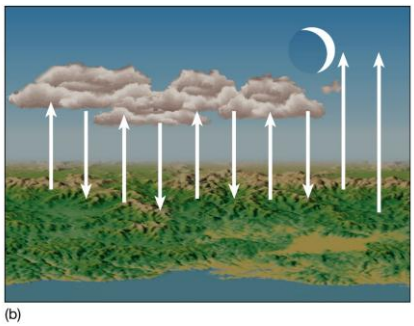
topographic effect



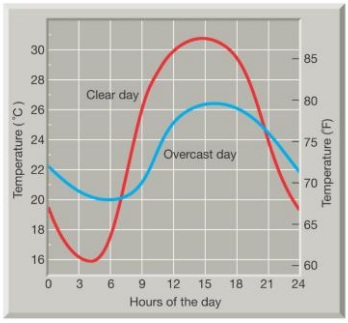
E. Cloud Cover and Albedo

- Daylight hours clouds reflect solar radiation back to space
- At night clouds retard heat loss


(a)

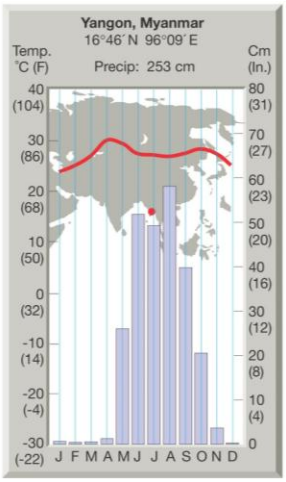

(b)

E. Cloud Cover and Albedo



Peoria, Illinois

July (~8°F difference)



Highest surface temperatures in April

Monsoon clouds reduce solar radiation

III. World Distribution of Temperatures

-Latitudinal Effects

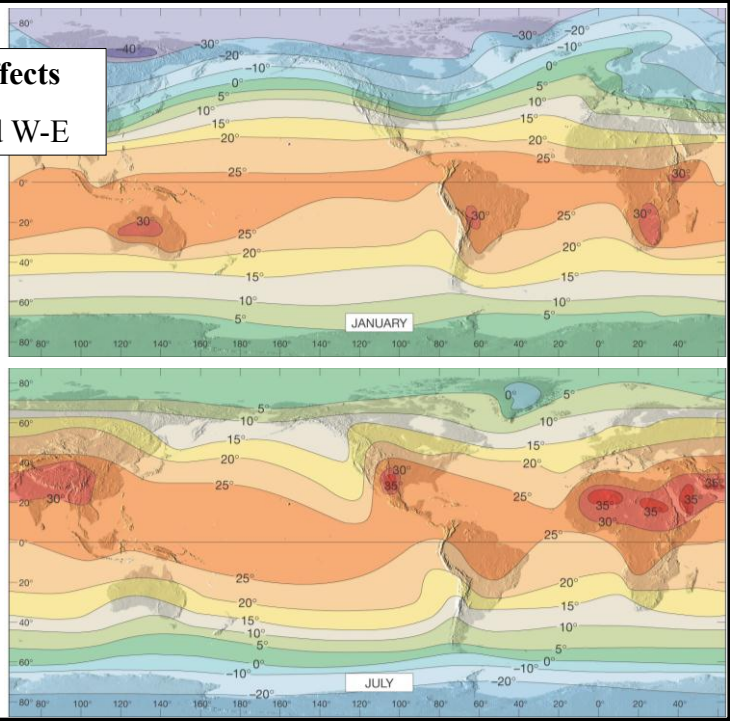
-Seasonal Migration of Sun Angle

-Land and Water Differential Heating

-Ocean Currents

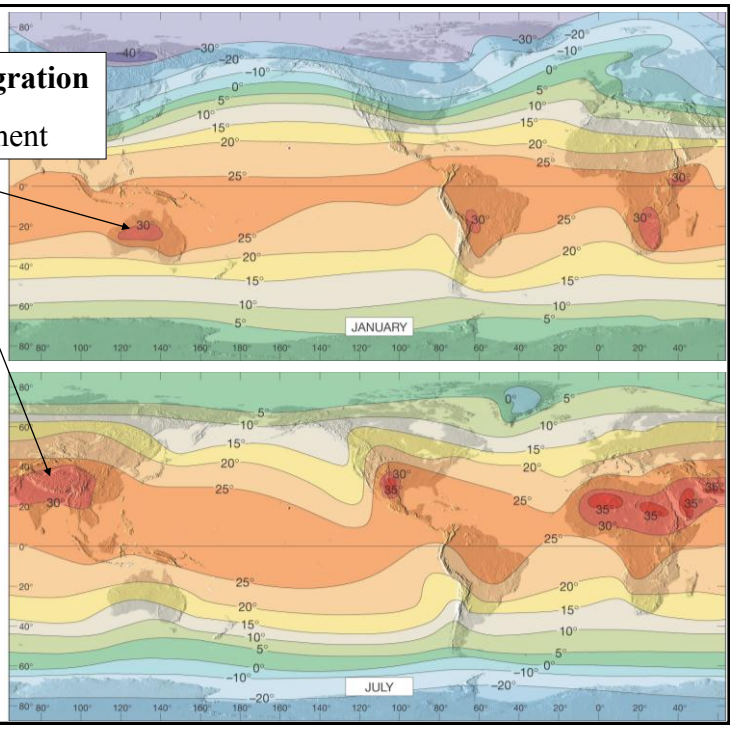
Latitudinal Effects

Isotherms trend W-E



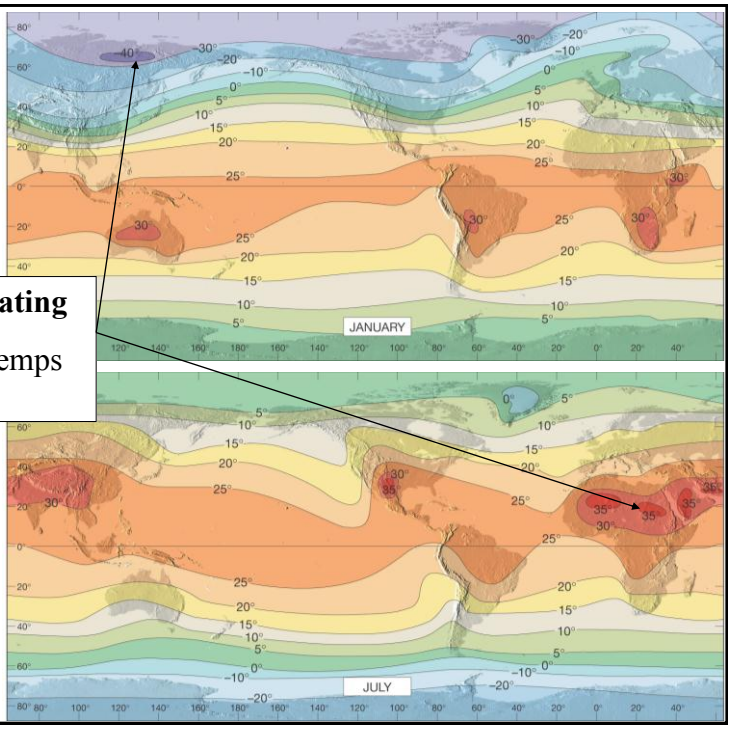
Sun Angle Migration

Hotspot movement



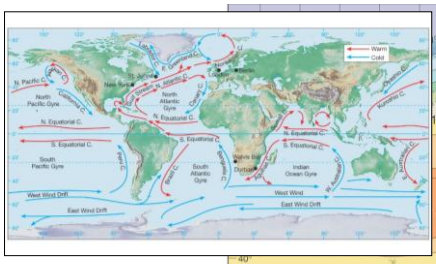
Differential Heating

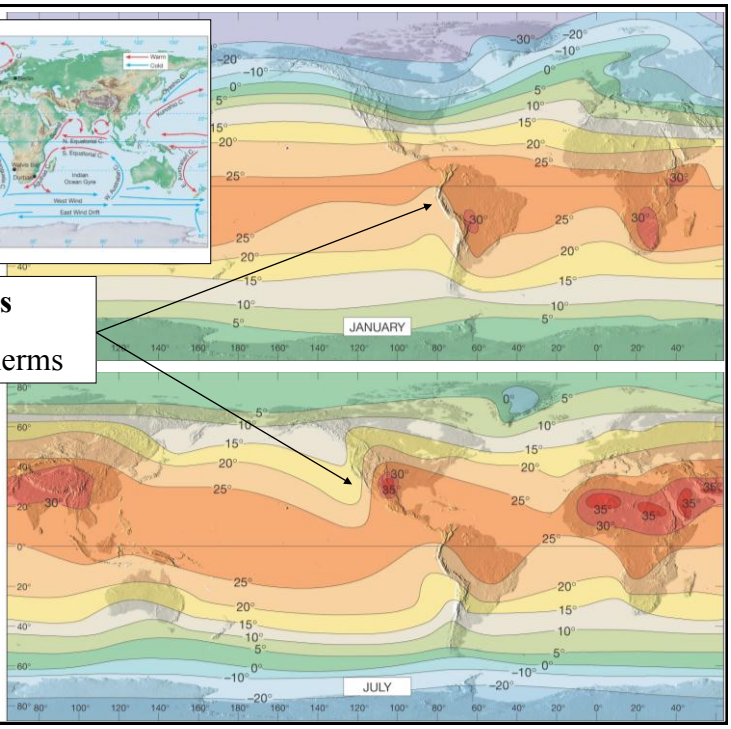
hottest/coldest temps over land



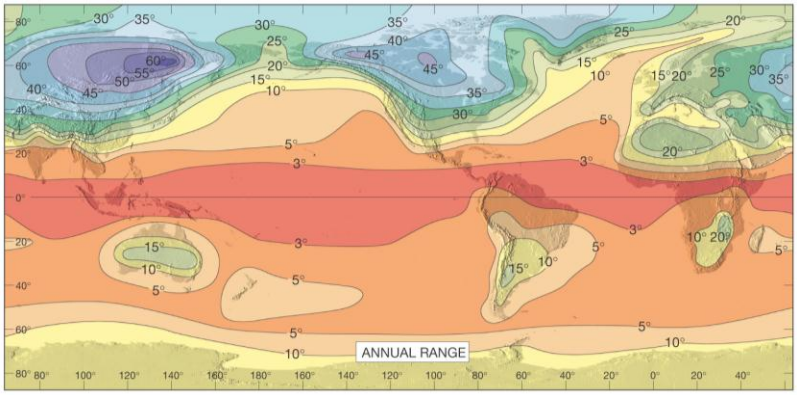
Ocean Currents

bending of isotherms





World Distribution of Temperature Range

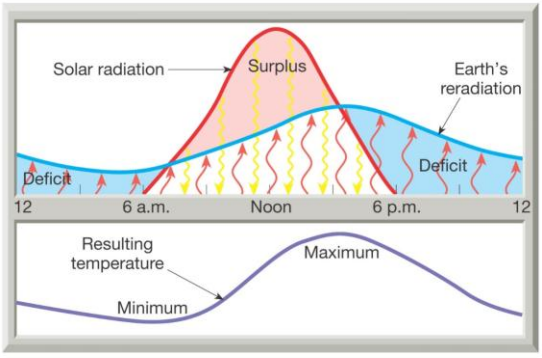


Equator –vs- Poles

Land –vs- Water

N.H. Land –vs- S.H. Land

Daily Variations in Air Temperature



Maximum solar radiation at noon

Minimum temperatures occur just before sunrise

Temperature maximum lags solar maximum

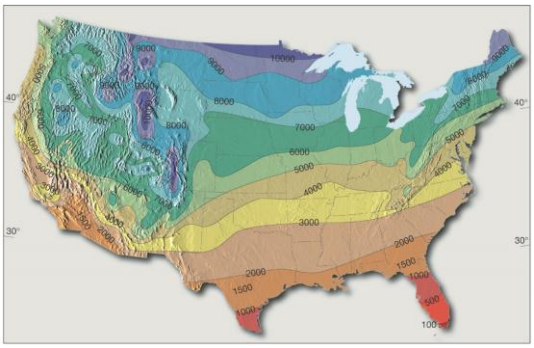
VII. Practical Applications of Temperature Data

A. Heating degree-days: measure of energy demand and consumption

B. Cooling degree-days

C. Growing degree-days: measure of crop maturity

D. Temperature and comfort



The Urban Heat Island

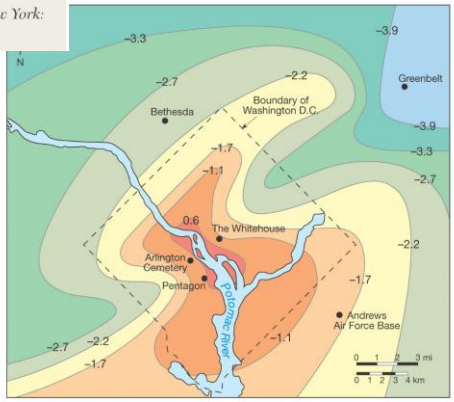
- Cities are hotter than surrounding rural communities
- Concrete and asphalt absorb more solar radiation than vegetation and soil
- Engineered runoff reduces the evaporation effect, more heat for temperature increase
- Waste heat: home heating, power generation, combustion (industry and transportation)
- Increased pollutants (absorb outgoing radiation)

Table 3-A Average temperatures (° C) for suburban Philadelphia Airport and downtown Philadelphia (10-year averages).

	Airport	Downtown
Annual mean	12.8	13.6
Mean June max	27.8	28.2
Mean December max	6.4	6.7
Mean June min	16.5	17.7
Mean December min	- 2.1	- 0.4

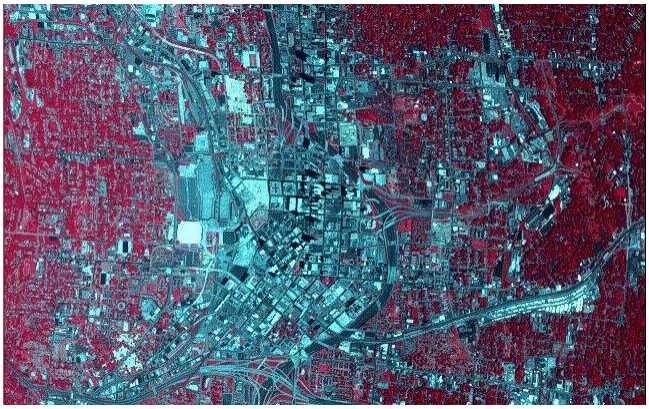
Source: After H. Neuberger and J. Cahir, Principles of Climatology *(New York: Holt, Rinehart and Winston, 1969), 128.*

Philadelphia



In many cities the air temperature is, on average, 0.5 to 0.8 ^{o}C higher than the surrounding non-urban areas. In winter the average temperature difference is even greater, between 1.1 and 1.6 °C.

Atlanta



10m spatial resolution

Trees and other vegetation appear red in the color image.

Buildings, streets appear white or blue-green.