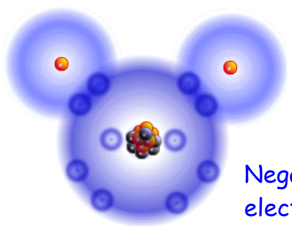
Energy-Atmosphere System Review
Exam 2: Wednesday, April 13, 2022

Atmospheric Moisture (L14, L15)

71% of surface area:
- Pacific Ocean and Southern Hemisphere
- 97% Oceans
- 3% Freshwater

Properties: Polar Molecule (Mickey Mouse)



Positive side where electrons rarely hang out

Negative side where electrons mostly hang out

Energy Transfer and Temperature

Specific Heat:
Energy required per kg to raise (or lower) the temperature of substance

Latent heat:
Heat released or absorbed/kg when something (water) changes state released: gas to liquid (condensation), liquid to solid (freezing), absorbed: solid to liquid (melting) or liquid to gas (evaporating)

Creates surface tension
- Makes solid float in liquid
- Creates hexagonal crystals: Pencil slices that create halos, sun dogs, sun pillars, etc.

High Heat Capacity: Energy transfer to change temperature

Energy to heat 1 kg 1 C° = Energy to lift 1 kg $\frac{1}{4}$ mile!

High Latent Heat: Energy transfer to change phase

Energy to melt 1 kg of ice to water (at 0°C) = Energy to lift 1 kg 20.7 miles!

⇒ Understand "Stone Soup" & "Fire & Ice"!

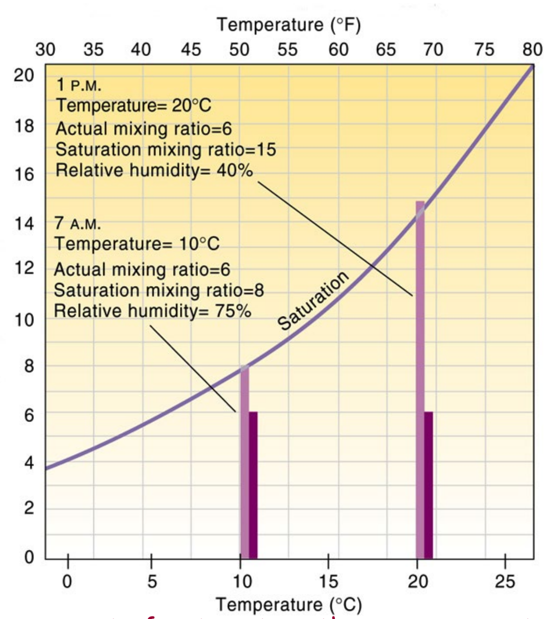
Water Vapor Content (L14)

Specific Humidity

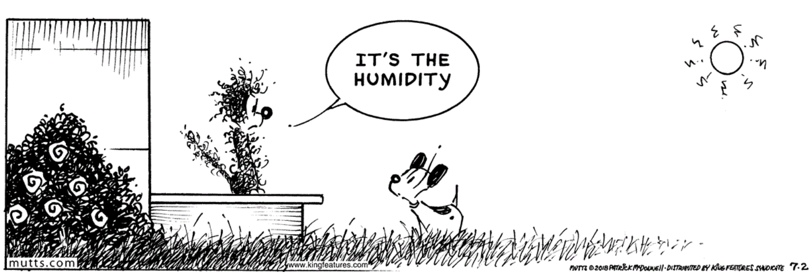
$$\frac{\text{mass of water vapor (g)}}{\text{mass of air (kg)}} = \text{amount of water present in air}$$

Relative Humidity (% of moisture air **can** hold)

$$\frac{\text{Specific Humidity}}{\text{Maximum at Current Temp.}} = \text{\% of water air } \textbf{can} \text{ hold}$$

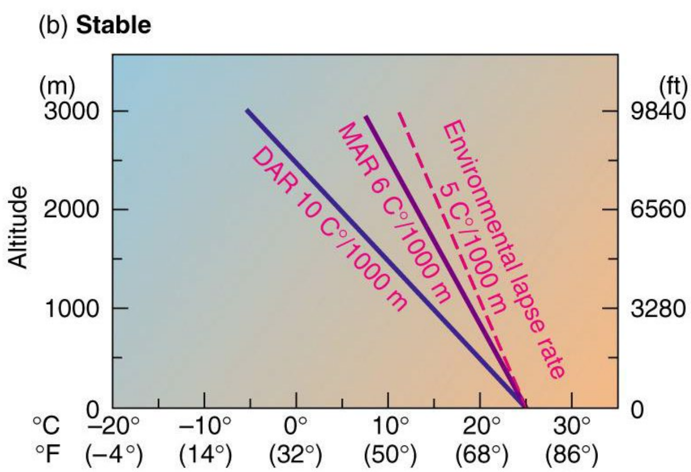


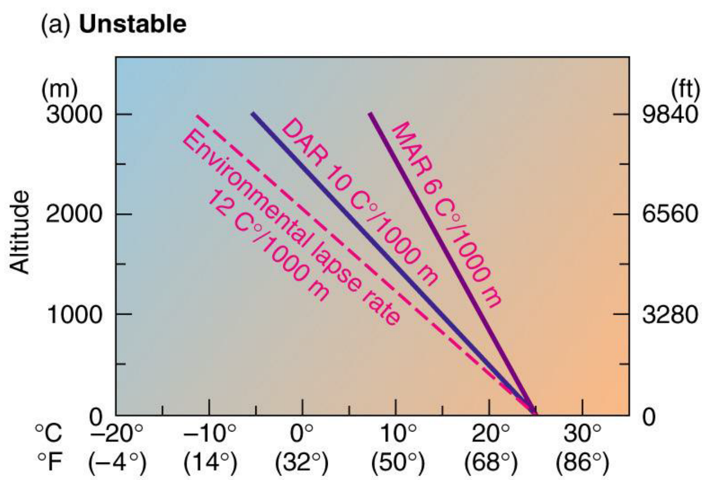
amount of water stays the same, amount air can hold changes

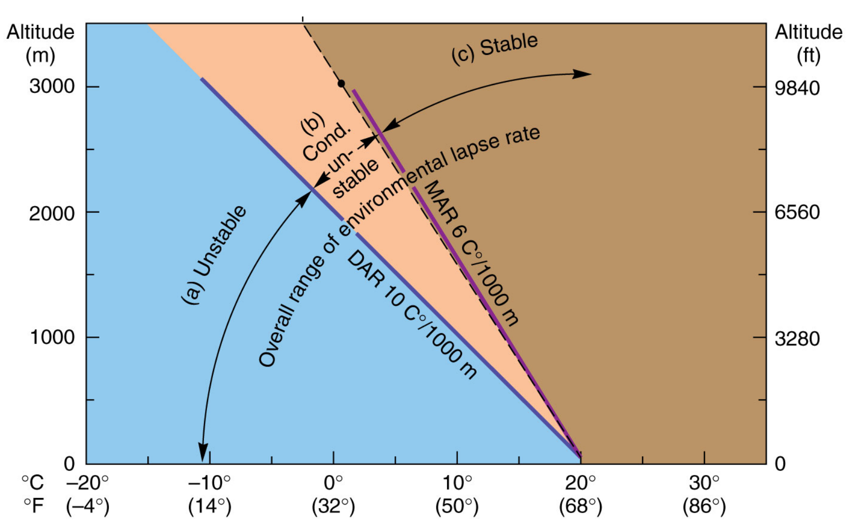


Atmospheric Stability (L14, JS Upper Air: The Parcel Theory, Stability/Instability)

1) Lapse Rates
   a) Environmental lapse rate (ELR)
      -environment's change in temperature with height
   b) Dry adiabatic lapse rate (DAR)
      - change in temperature with height of a dry parcel of air
      - dry parcels cool more quickly than moist parcels
   c) Moist adiabatic lapse rate (MAR)
      - change in temperature with height of a parcel in which water is condensing
      - moist parcels heated by latent heat & have higher heat capacity
         ⇒ cool more slowly than dry
2) Atmospheric Stability (L14)
   a) Stable conditions: parcel always cooler than environment
      - environmental lapse rate steeper (slower) than adiabatic rates
   b) Unstable conditions: parcel always warmer than environment
      - environmental lapse rate less steep (faster) than adiabatic rates
   c) Conditionally stable conditions:
      - dry air cools faster than surroundings,
      - moist air cools more slowly than surroundings

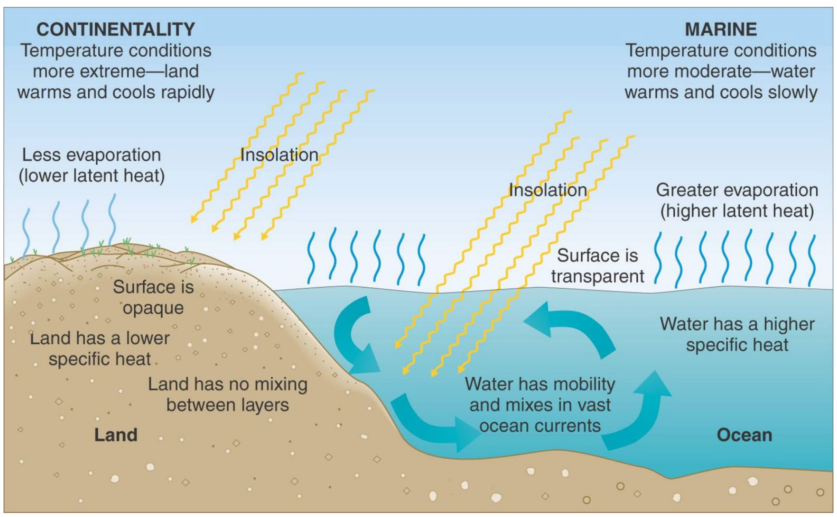




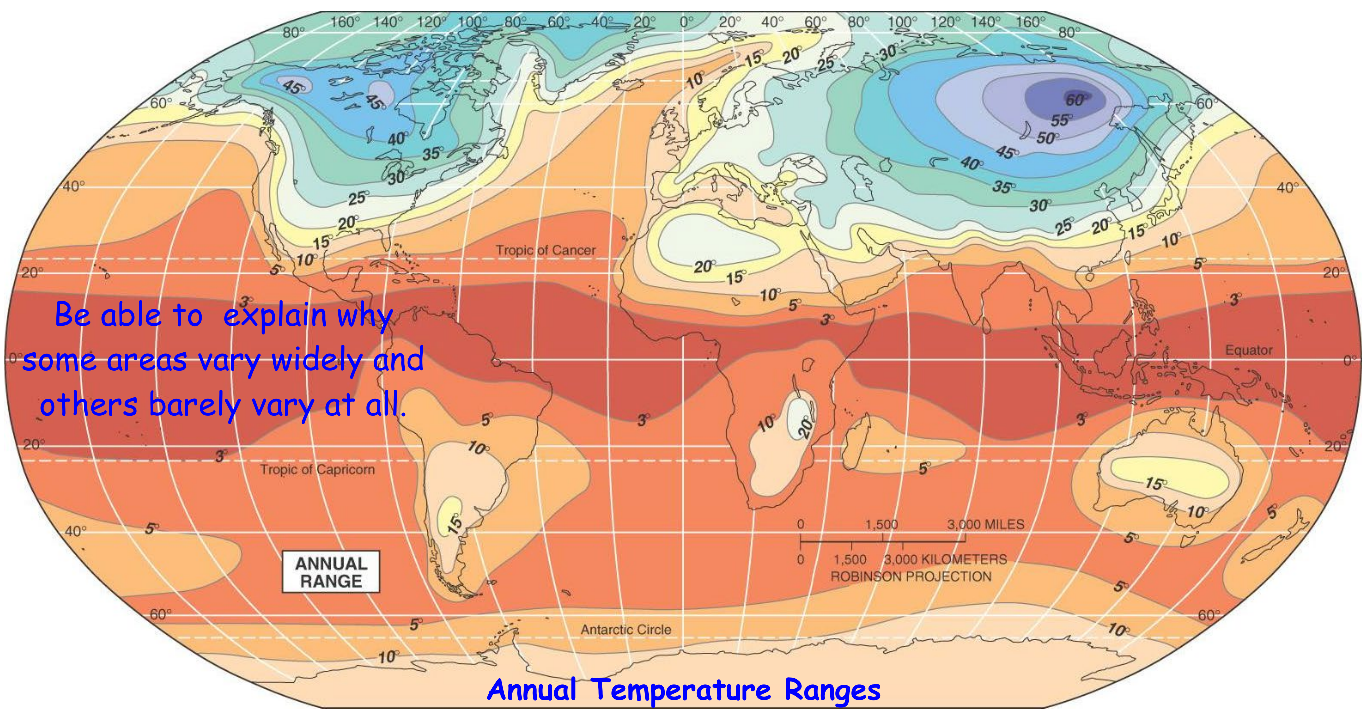


Energy Balance & Temperatures (L17)

- Insolation Variation
  - With Latitude & Season (sun angle!)
    - Equator, Tropics of Cancer & Capricorn, Arctic & Antarctic Circles
    - Tropics, Temperate Zones, Polar Zones
  - With Altitude
    - Normal Lapse Rate = 6.4 C°/km
  - Water
    - Humidity: humid air has higher heat capacity than dry air
    - Clouds reflect sunlight into space
    - Water vapor absorbs infrared radiation, so cooling earth warms the moist air
    - Moist ground conducts heat away from surface, keeping ground surface cooler
    - Lakes and oceans heat and cool much more slowly than land



Be able to explain this diagram. Why are beaches hotter than the water?

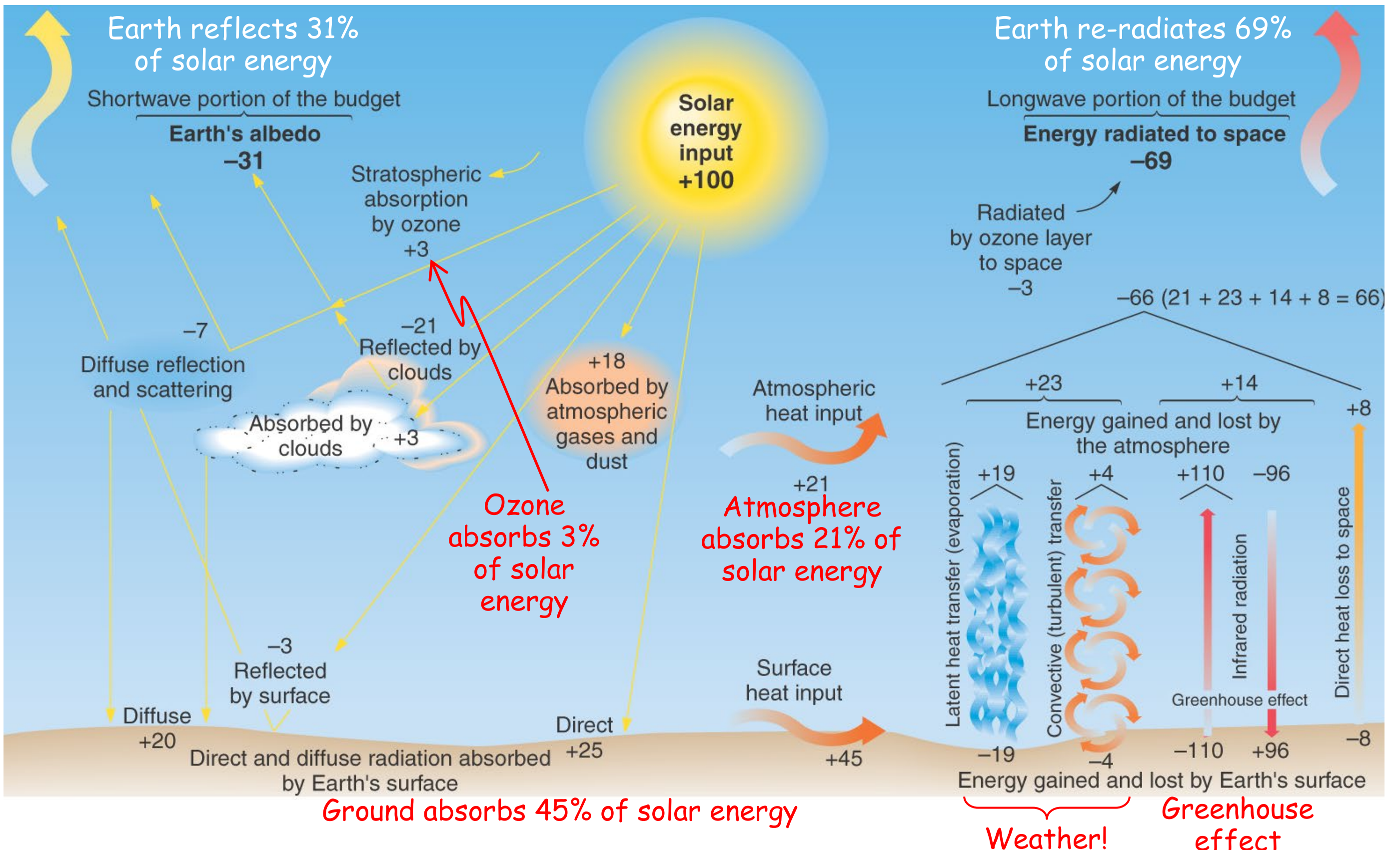


Be able to explain why some areas vary widely and others barely vary at all.

Annual Temperature Ranges

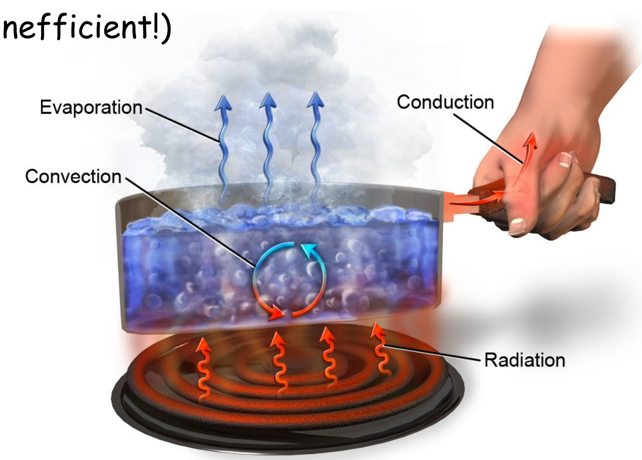
Insolation (L17, L19)

- Reflection
  - Albedo: Earth ~ 31
- Scattering
  - Blue sky & Daylight
    - Blue light is scattered … makes sky blue
    - Red goes straight … setting sun looks red
- Absorption by atmosphere
  - Absorbs most IR, almost all UV, X-ray
- Absorption & Re-radiation by surface (Greenhouse)
  - Absorbs shortwave (visible), radiates longwave (IR)



Heat transfer

- Conduction: Hot stuff heats neighbors (inefficient!)
- Convection & Advection: Hot stuff moves
- Radiation: Heat, itself moves



Regional Winds: (L19)

1. Land & Sea Breezes

Sea Breeze: (day) Insolation heats land, air rises, cooler air blows in from the sea.
Land Breeze: (night) Water cools more slowly than land, air rises, cooler air blows from land.

2. Up & Down Valley Breezes

Up-Valley Breeze: (day) Insolation heats air, air rises up mountain side.
Down-Valley Breeze: (night) Air in contact with mountain surface cools, sinks down the valley.

3. Katabatic Winds

Prevailing winds descend mountains (Chinook, Föen, etc.)
High pressure forces winds over mountains (Santa Ana)

4. Monsoons

Seasonal shifts in location of high and low pressure systems
Asian Monsoon and North American Monsoon

Ocean Surface Currents (Driven by Winds, L23)

1. Trade Winds Create Westward Currents

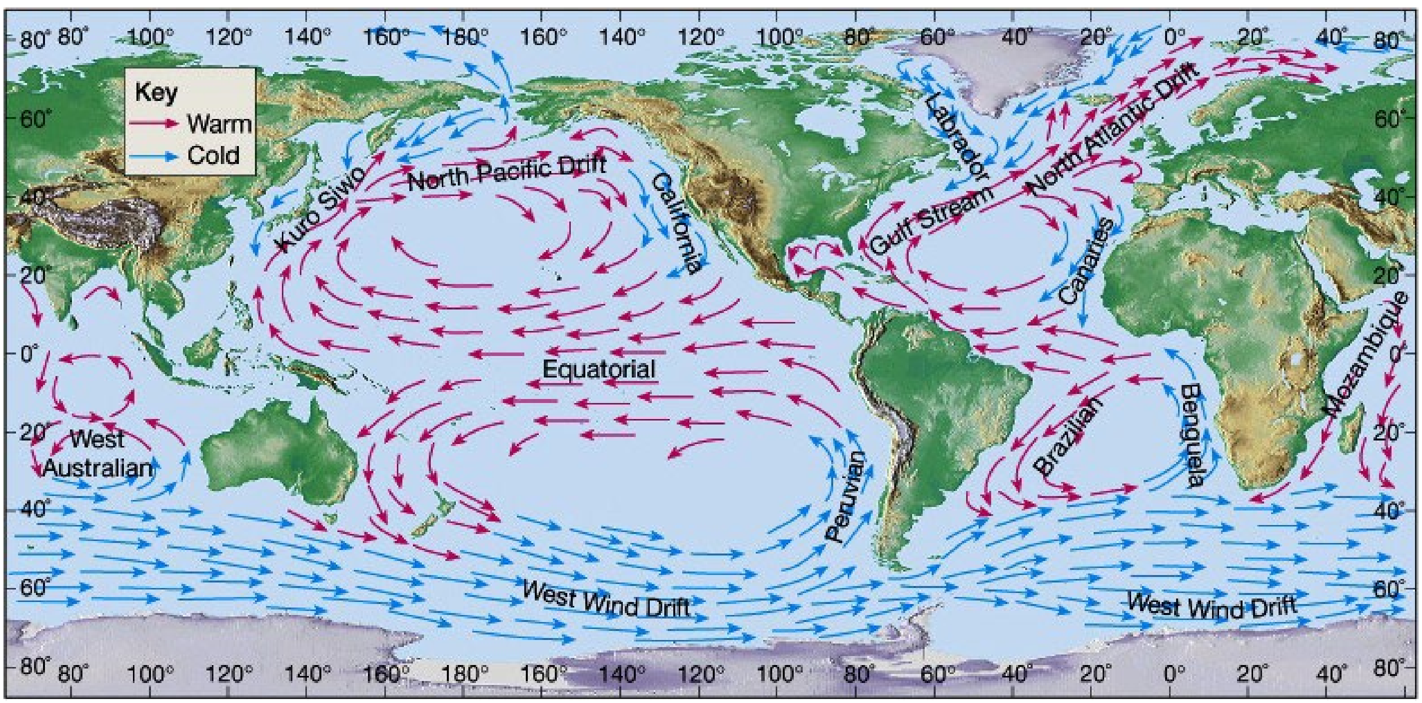
Eckman Spiral creates force perpendicular to wind

2. Continents Force Currents N & S

Eckman Spiral creates force perpendicular to surface current

3. Ocean Gyres Created by 1 and 2

Water "piles up" in centers of gyres due to Eckman Spiral



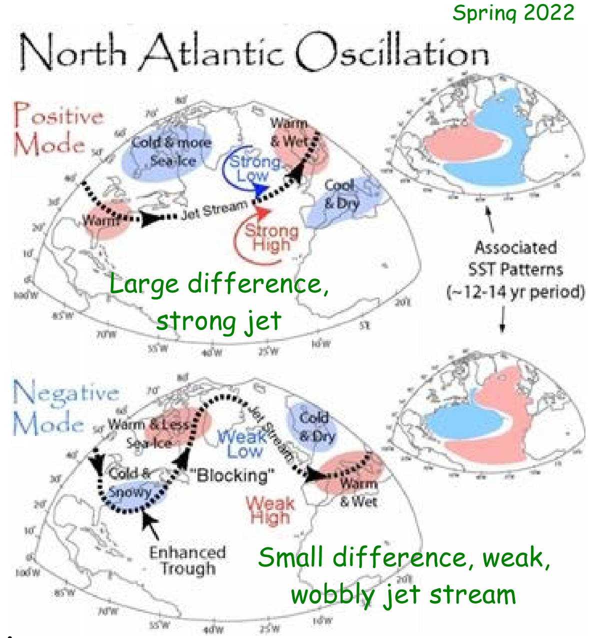
Eckman Transport (Gyres)

Net Transport of material perpendicular to wind
-- due to Coriolis force and friction
-- “piles up” water toward the centers of gyres … concentrates trash!

Multiyear Oscillations (L25, L26)

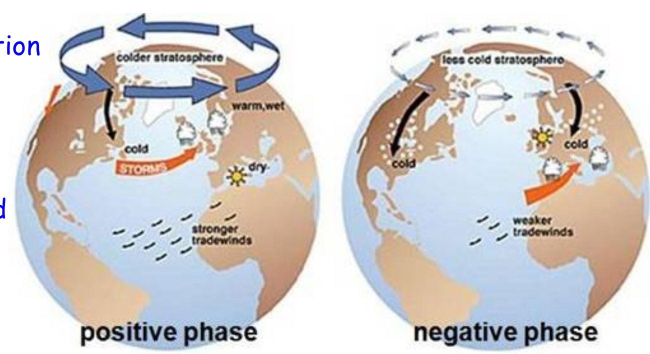
Know names and conditions

1. NAO (Currently Positive)
   North Atlantic Oscillation
   Pressure difference between Azores & Iceland
2. AO (Currently Positive)
   Arctic Oscillation
   Pressure over Arctic vs. Mid-latitudes
3. PNA (Currently Negative)
   Pacific North-American Pattern
   Pressure difference across N. America
4. **ENSO (Currently La Niña)**
   El Niño Southern Oscillation
   - **Temperature of eastern Pacific (off Peru)**
   - **Pressure difference between Tahiti & Darwin**



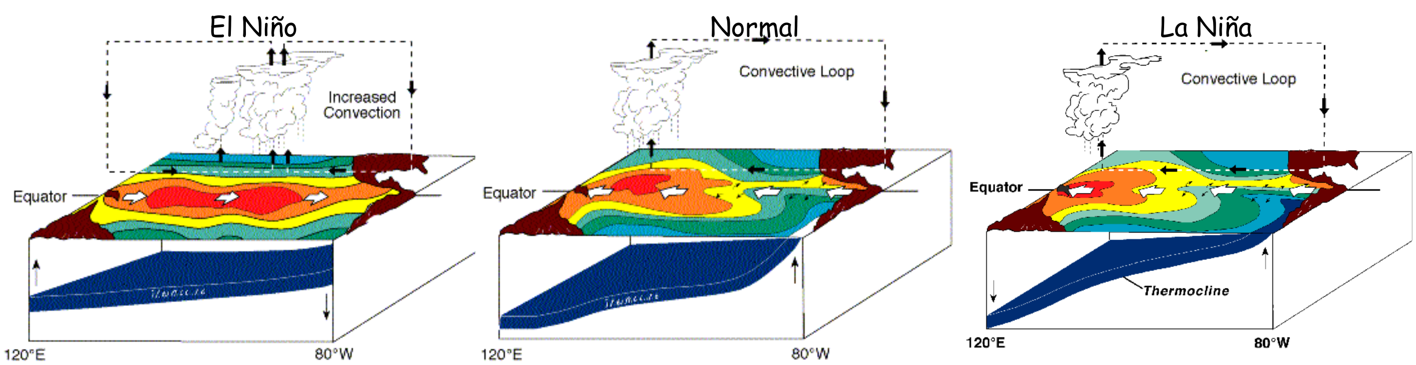
Arctic Oscillation

Deep low in arctic keeps cold north.



Moderate low in arctic allows cold to flow south.

ENSO: Know these diagrams of El Niño, La Niña, and Normal conditions in the Pacific Ocean



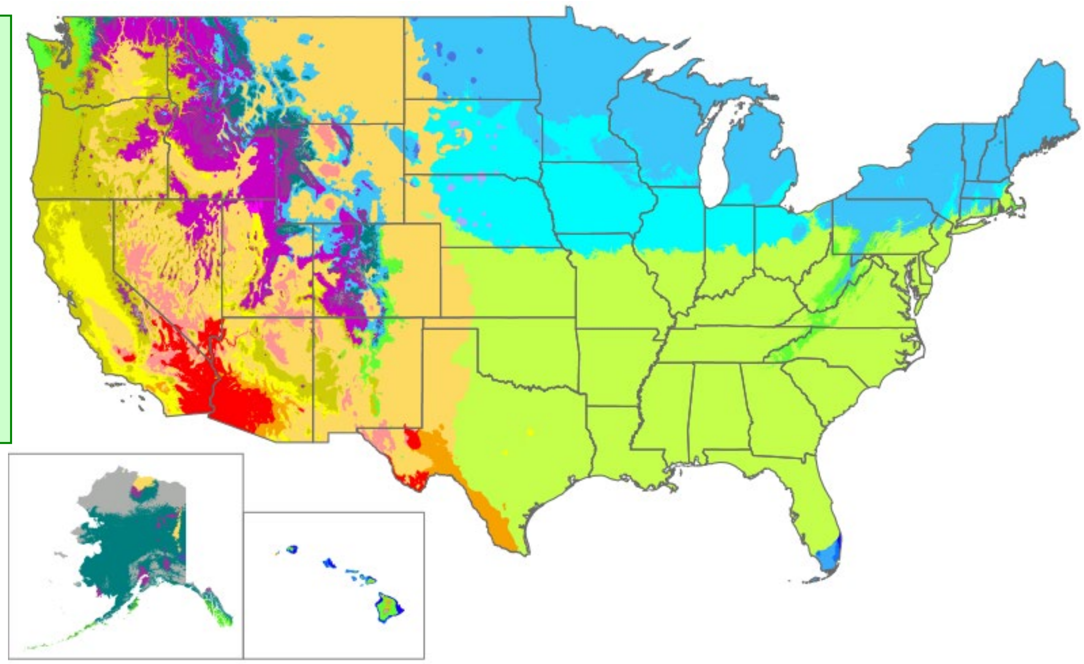
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/daily_ao_index/teleconnections.shtml

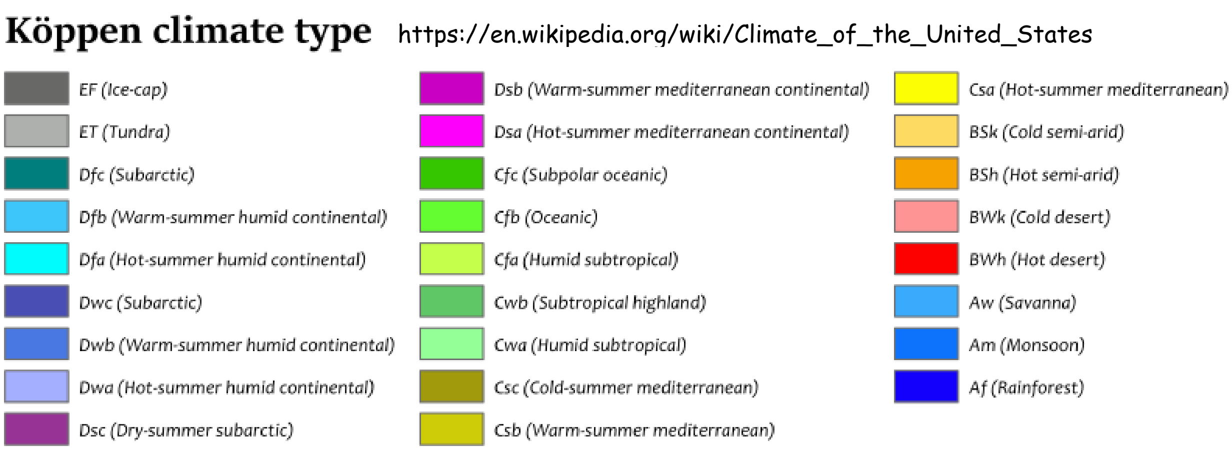
Earth's Climates (L21, L22)

1) Controlling Factors
    a) Insolation – time of day, season, latitude, humidity
    b) Temperature – latitude, altitude, continentality
    c) Air Pressure – Hadley zones (e.g. two rainy seasons ⇒ equatorial … ITCZ)
    d) Air Masses & Precipitation – maritime, continental, tropical, polar
2) Köppen Classification
    a) Thermal units (A, C, D, E) + Arid (B) + Highland (H)
    b) Precipitation:
        f: moist all year, m: monsoon, w: dry winter, s: dry summer
    c) Seasonal Temperature Variations
        a: hot summers (>22°C), b: mild summers (<22°C),
        c: mild winters (1 – 4 months < 10°C), d: cold winters (<-3°C)

There will be climograph & city matching & explanations

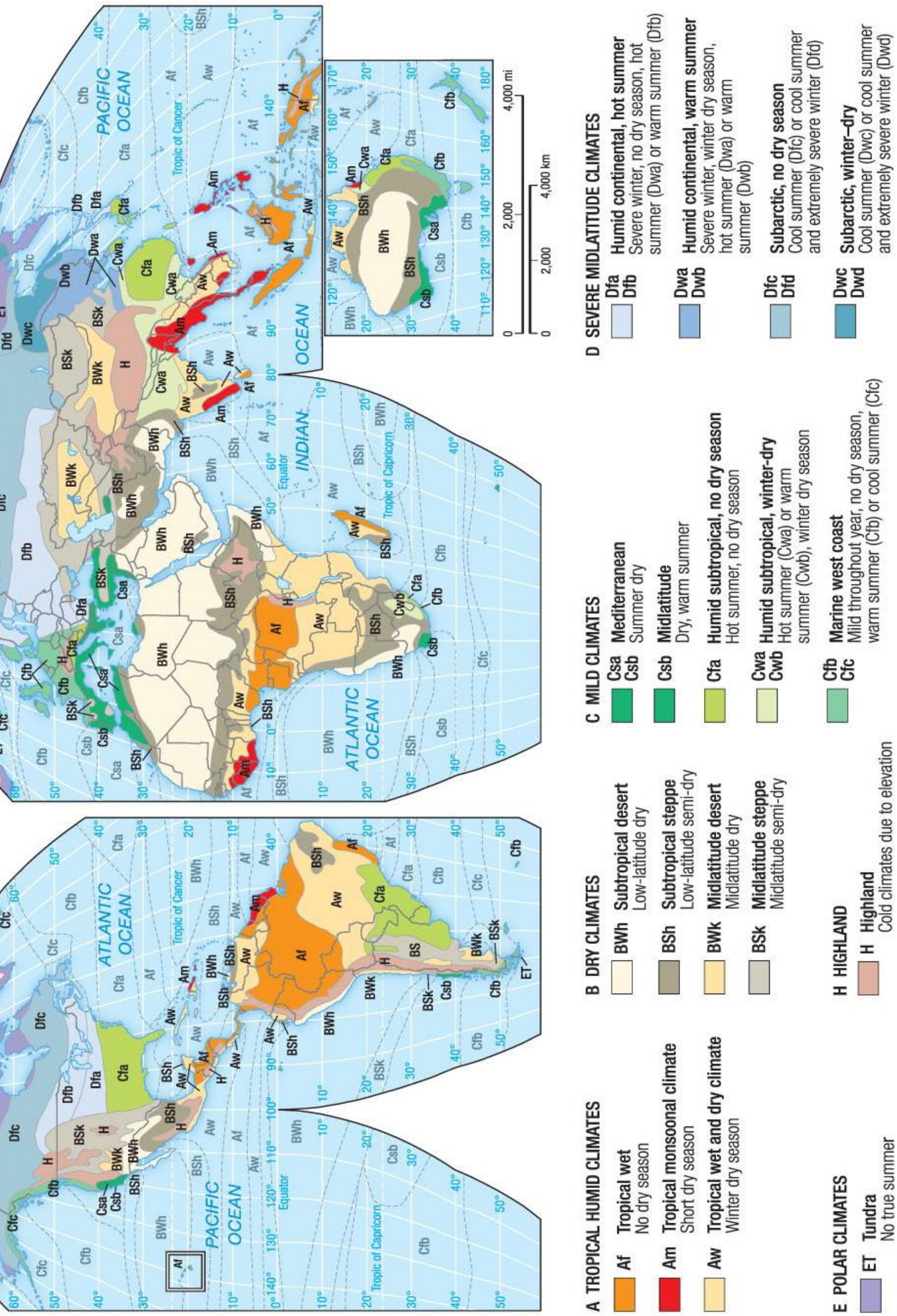
Know the Köppen Climate type of Canton, NY, your North America project city & your Climate Symposium city and be able to explain why it is so classified.





*Isotherm used to distinguish temperate (C) and continental (D) climates is -3°C

Data sources: Köppen types calculated from data from PRISM Climate Group, Oregon State University, http://prism.oregonstate.edu; Outline map from US Census Bureau


A TROPICAL HUMID CLIMATES
Af Tropical wet
No dry season
Am Tropical monsoonal climate
Short dry season
Aw Tropical wet and dry climate
Winter dry season
B DRY CLIMATES
BWh Subtropical desert
Low-latitude dry
BSh Subtropical steppe
Low-latitude semi-dry
BWk Midlatitude desert
Midlatitude dry
BSk Midlatitude steppe
Midlatitude semi-dry
C MILD CLIMATES
Csa Csb Mediterranean
Summer dry
Csb Midlatitude
Dry, warm summer
Cfa Humid subtropical, no dry season
Hot summer, no dry season
Cwa Cwb Humid subtropical, winter-dry
Hot summer (Cwa) or warm summer (Cwb), winter dry season
Cfb Cfc Marine west coast
Mild throughout year, no dry season, warm summer (Cfb) or cool summer (Cfc)
D SEVERE MIDLATITUDE CLIMATES
Dfa Dfb Humid continental, hot summer
Severe winter, no dry season, hot summer (Dwa) or warm summer (Dfb)
Dwa Dwb Humid continental, warm summer
Severe winter, winter dry season, hot summer (Dwa) or warm summer (Dwb)
Dfc Dfd Subarctic, no dry season
Cool summer (Dfc) or cool summer and extremely severe winter (Dfd)
Dwc Dwd Subarctic, winter–dry
Cool summer (Dwc) or cool summer and extremely severe winter (Dwd)
E POLAR CLIMATES
ET Tundra
No true summer
EF Polar ice cap
Perennial ice
H HIGHLAND
H Highland
Cold climates due to elevation
ARCTIC OCEAN
PACIFIC OCEAN
ATLANTIC OCEAN
INDIAN OCEAN
Equator
Tropic of Cancer
Tropic of Capricorn
Arctic Circle
0 2,000 4,000 mi
0 2,000 4,000 km