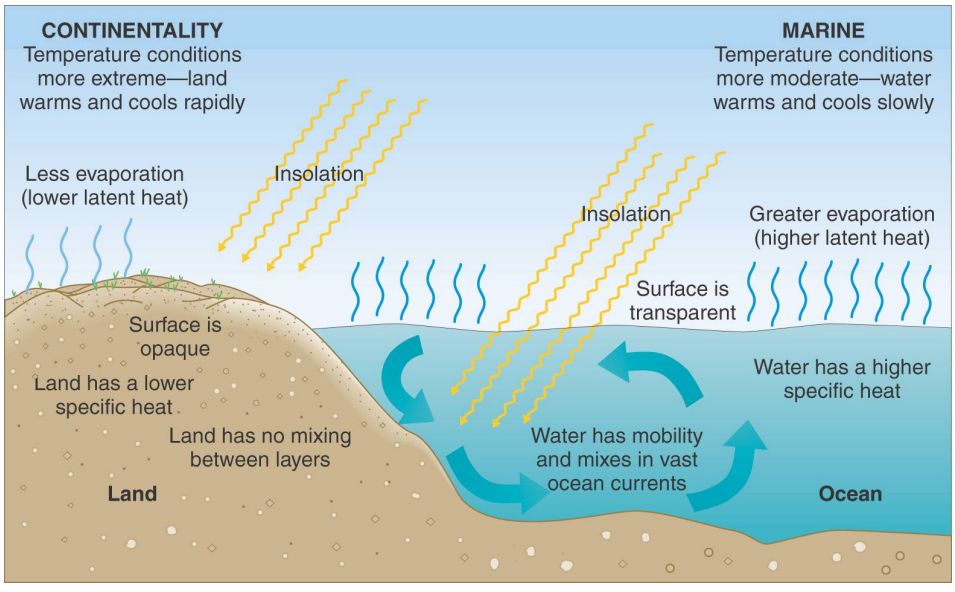
Energy-Atmosphere System Review
Aguado & Bert, Ch. 3, 4, 8, 15

Energy Balance & Temperatures (Ch. 3)

- Insolation
  - Absorption & Re-radiation by surface (Greenhouse)
    - Absorbs shortwave (visible), radiates longwave (IR)
- *Heat Capacity:*
  - Energy required to raise (or lower) the temperature of a substance
- *Latent heat:*
  - Heat released or absorbed when something (water) changes state
    - released: gas to liquid (condensation), liquid to solid (freezing)
    - absorbed: solid to liquid (melting) or liquid to gas (evaporating)
- *Heat transfer*
  - Conduction: Hot stuff heats neighbors (inefficient!)
  - Convection & Advection: Hot stuff moves
  - Radiation: Heat, itself moves
- 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



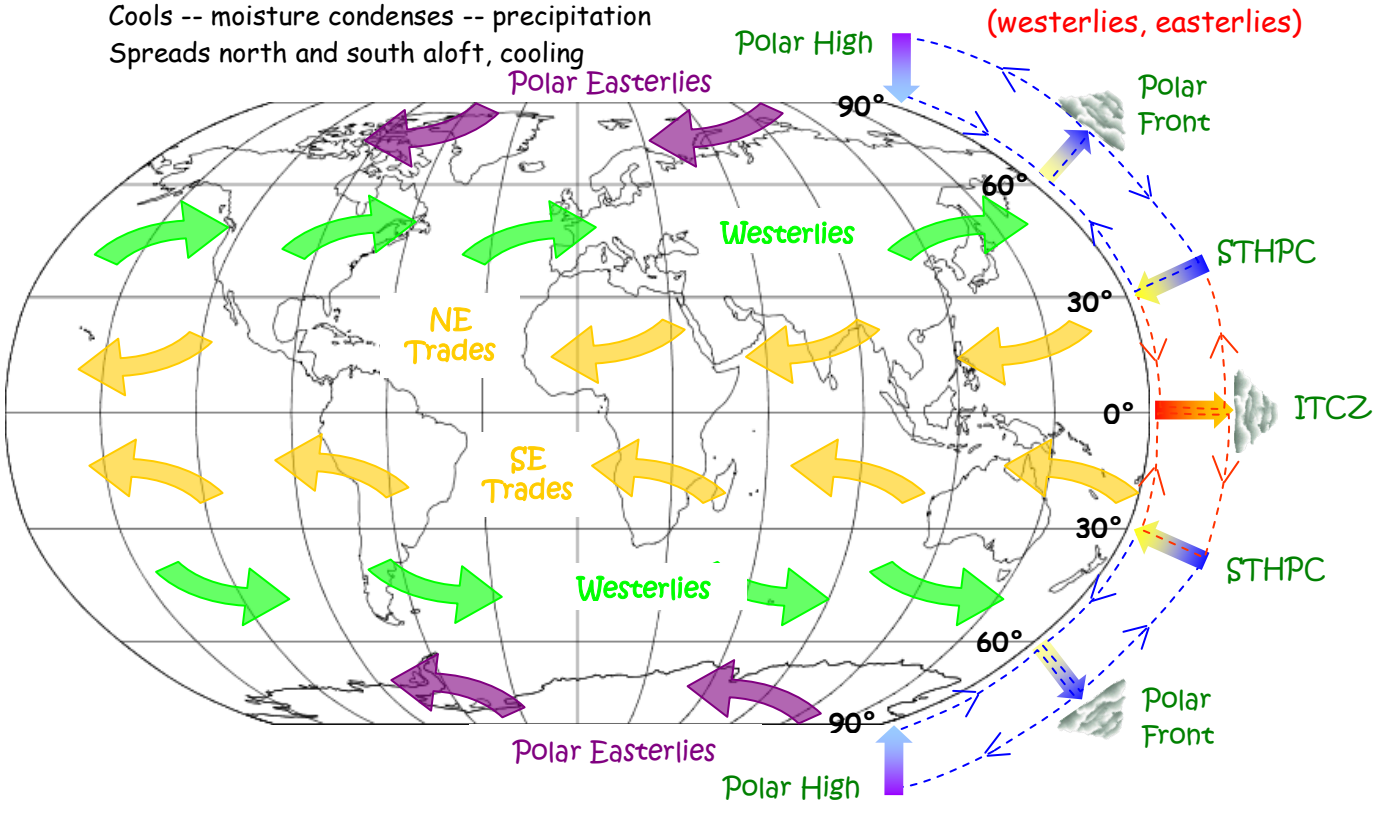
Regional Winds: (Ch. 4)

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

Global Scale (Hadley) Atmospheric Circulation (Ch. 8)

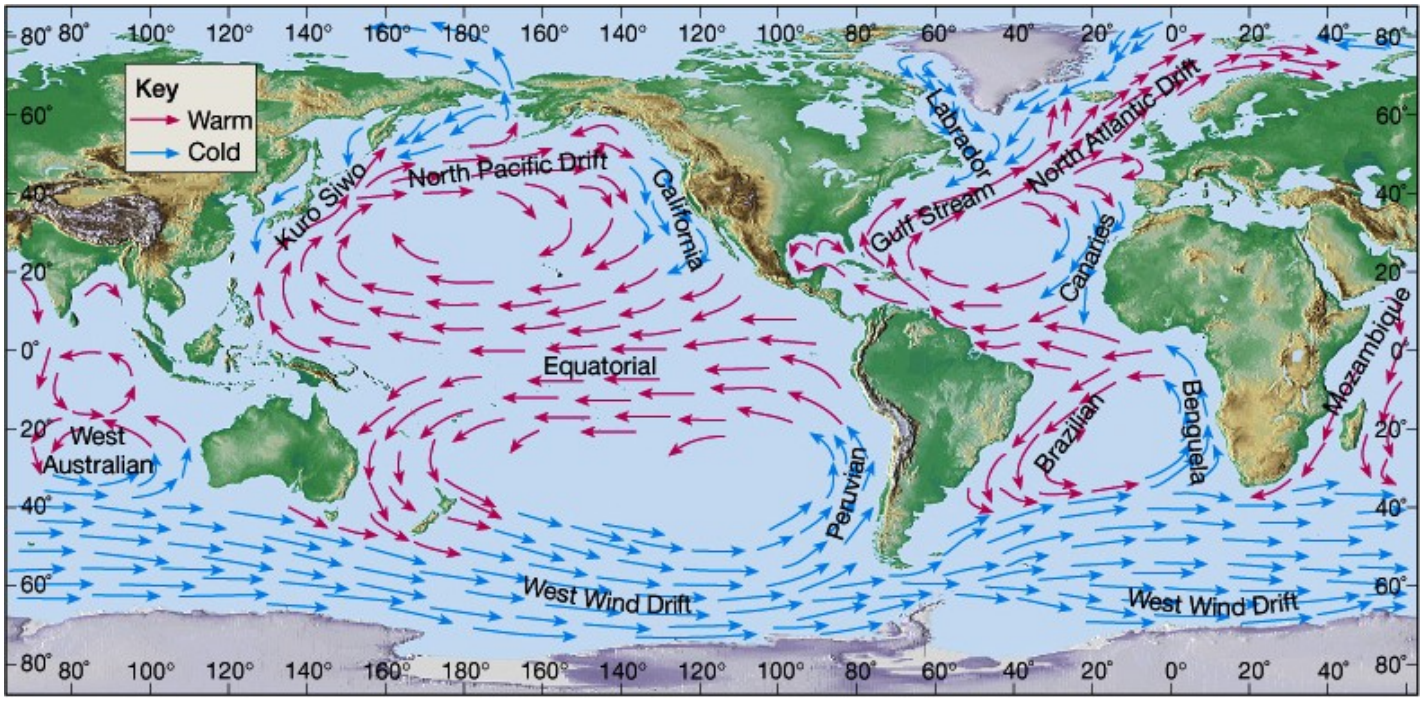
1. Air rises at ITCZ
   - Rising Air = Low Pressure
   - Cools -- moisture condenses -- precipitation
   - Spreads north and south aloft and continues cooling
2. Air sinks at about 30° N and S (STHPC)
   - Sinking Air = High Pressure
   - Dry since it lost moisture when rising
   - Spreads north and south, Coriolis deflection creates Trade Winds & Westerlies
3. Air Sinks at Poles (Polar High)
   - Moves southward (northward) & deflects right (left) along surface
   - Polar Easterlies
4. Convergence Zone at 60° N and S (Polar Front)
   - Rising Air = Low Pressure
   - Cools -- moisture condenses -- precipitation
   - Spreads north and south aloft, cooling

Be able to draw and explain this diagram … rising & subsiding air (pressure zones) and wind zones (westerlies, easterlies)



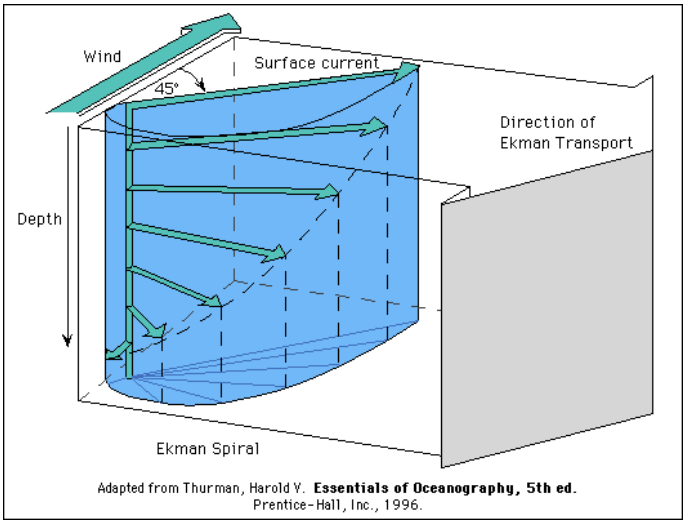
Ocean Surface Currents (Driven by Winds)

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



Adapted from Thurman, Harold V. **Essentials of Oceanography, 5th ed.** Prentice-Hall, Inc., 1996.

The Second Coming
William Butler Yeats

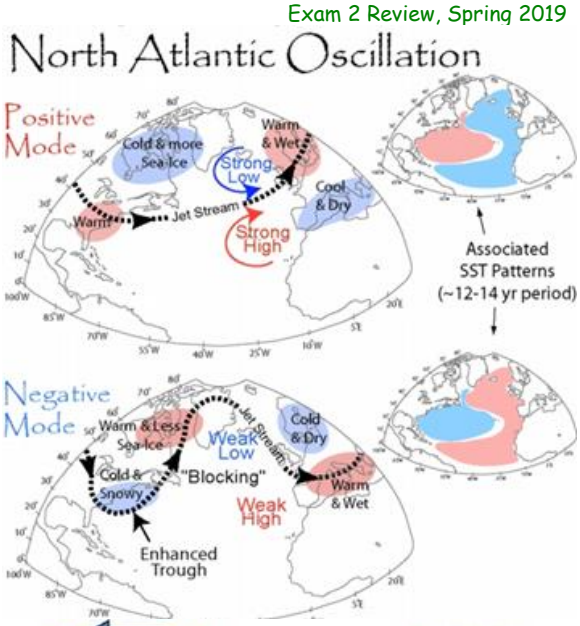
TURNING and turning in the widening gyre
The falcon cannot hear the falconer;
Things fall apart; the centre cannot hold;
Mere anarchy is loosed upon the world,
The blood-dimmed tide is loosed, and everywhere
The ceremony of innocence is drowned;
The best lack all conviction, while the worst
Are full of passionate intensity.

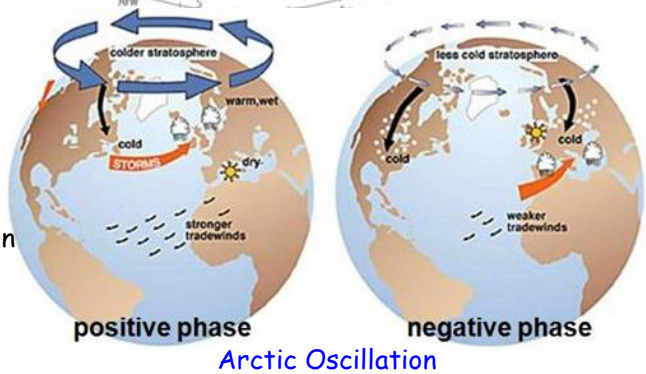
Surely some revelation is at hand;
Surely the Second Coming is at hand.
The Second Coming! Hardly are those words out
When a vast image out of Spiritus Mundi
Troubles my sight: somewhere in sands of the desert
A shape with lion body and the head of a man,
A gaze blank and pitiless as the sun,
Is moving its slow thighs, while all about it
Reel shadows of the indignant desert birds.
The darkness drops again; but now I know
That twenty centuries of stony sleep
Were vexed to nightmare by a rocking cradle,
And what rough beast, its hour come round at last,
Slouches towards Bethlehem to be born?

Multiyear Oscillations

For each, know
- current conditions (March)
- possible effects on northeastern US

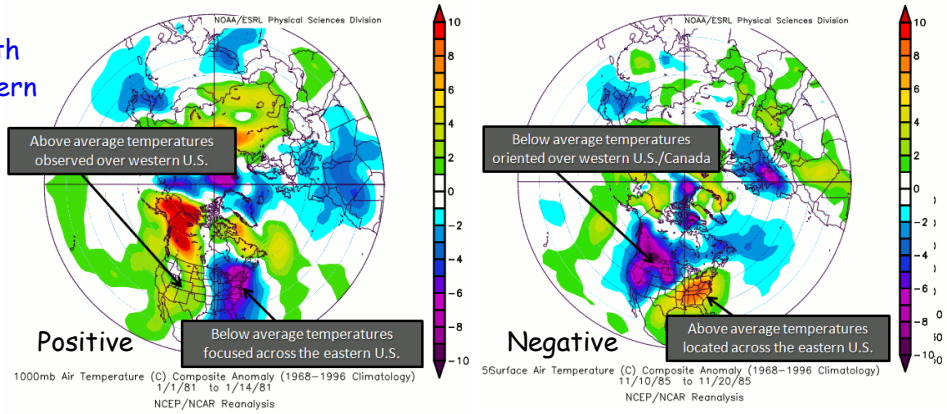
1. NAO (Currently Positive)
   - North Atlantic Oscillation
   - Pressure difference between Azores & Iceland
   - Positive warms eastern US
2. AO (Currently Positive)
   - Arctic Oscillation
   - Pressure over Arctic
   - Positive warms Eastern US
3. PNA (Currently Positive)
   - Pacific North-American Pattern
   - Pressure difference across N. America
   - Positive cools eastern US
4. ENSO (Currently weak El Niño)
   - El Niño Southern Oscillation
     - Temperature of eastern pacific (off Peru)
     - Pressure difference between Tahiti & Darwin
   - El Niño can cool eastern US
   - Currently on El Niño alert!



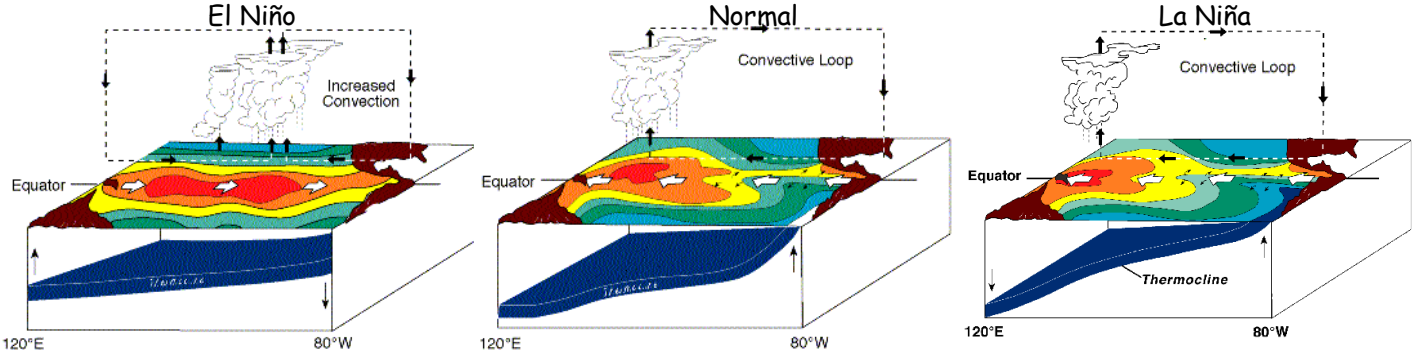


Arctic Oscillation

Pacific-North America Pattern



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



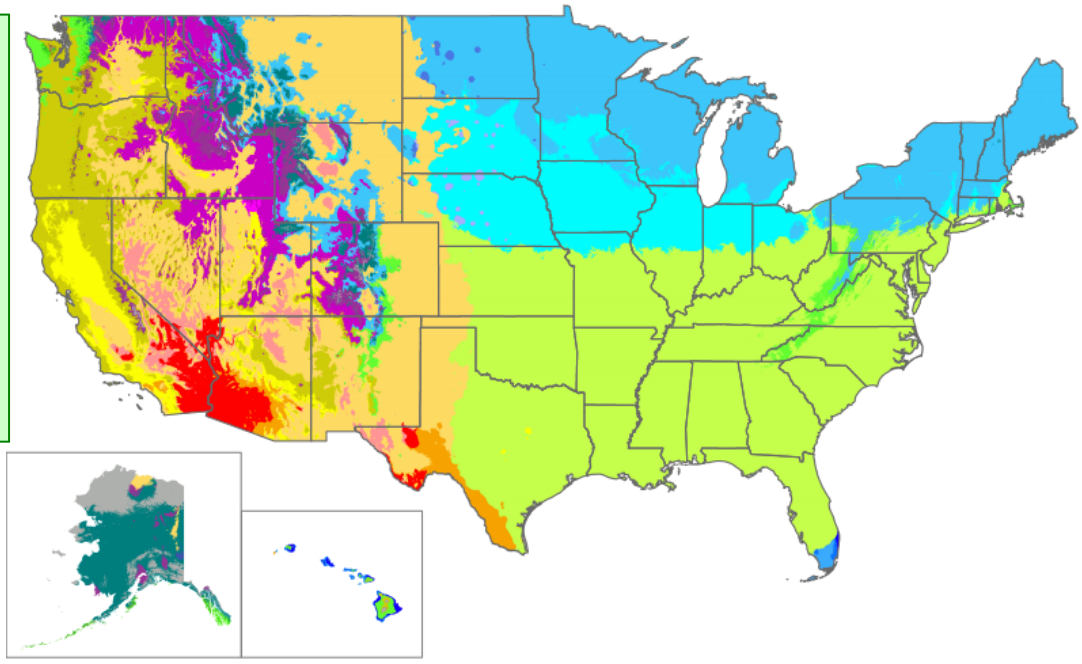
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/daily_ao_index/teleconnections.shtml

Earth's Climates (Ch. 15)

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.

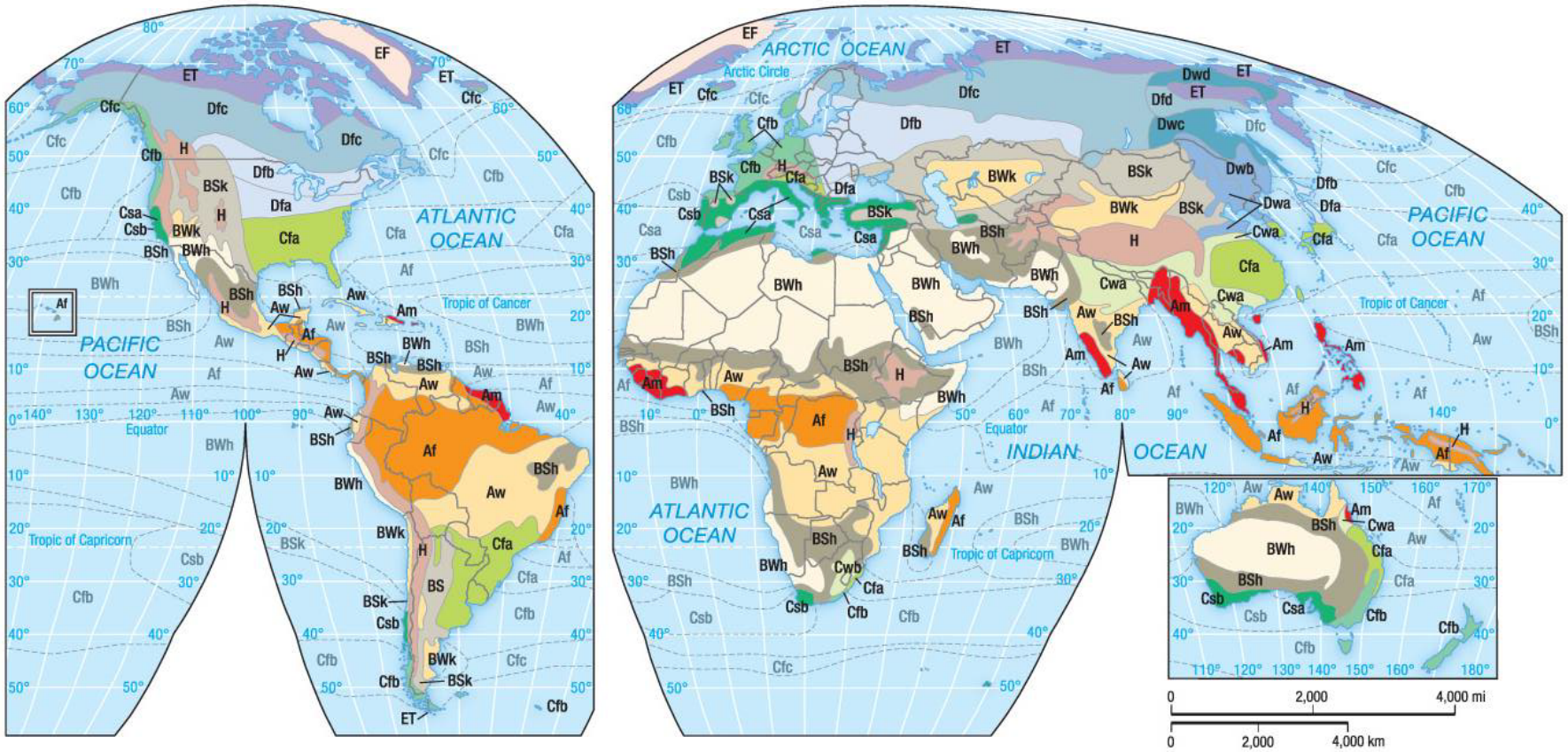


Köppen climate type https://en.wikipedia.org/wiki/Climate_of_the_United_States

EF (Ice-cap)	Dsb (Warm-summer mediterranean continental)	Csa (Hot-summer mediterranean)
ET (Tundra)	Dsa (Hot-summer mediterranean continental)	BSk (Cold semi-arid)
Dfc (Subarctic)	Cfc (Subpolar oceanic)	BSh (Hot semi-arid)
Dfb (Warm-summer humid continental)	Cfb (Oceanic)	BWk (Cold desert)
Dfa (Hot-summer humid continental)	Cfa (Humid subtropical)	BWh (Hot desert)
Dwc (Subarctic)	Cwb (Subtropical highland)	Aw (Savanna)
Dwb (Warm-summer humid continental)	Cwa (Humid subtropical)	Am (Monsoon)
Dwa (Hot-summer humid continental)	Csc (Cold-summer mediterranean)	Af (Rainforest)
Dsc (Dry-summer subarctic)	Csb (Warm-summer mediterranean)	

*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