Meteorology

Meteorology: study of atmospheric phenomena
- from the ancient Greek meteor "high in the air"

Essential Questions:
- Compare and contrast weather and climate?
- Analyze how imbalances in the heating of the Earth's surface create weather?
- Describe how and where air masses form.

The Causes of Weather

Three main categories of "meteors" that meteorologists' study

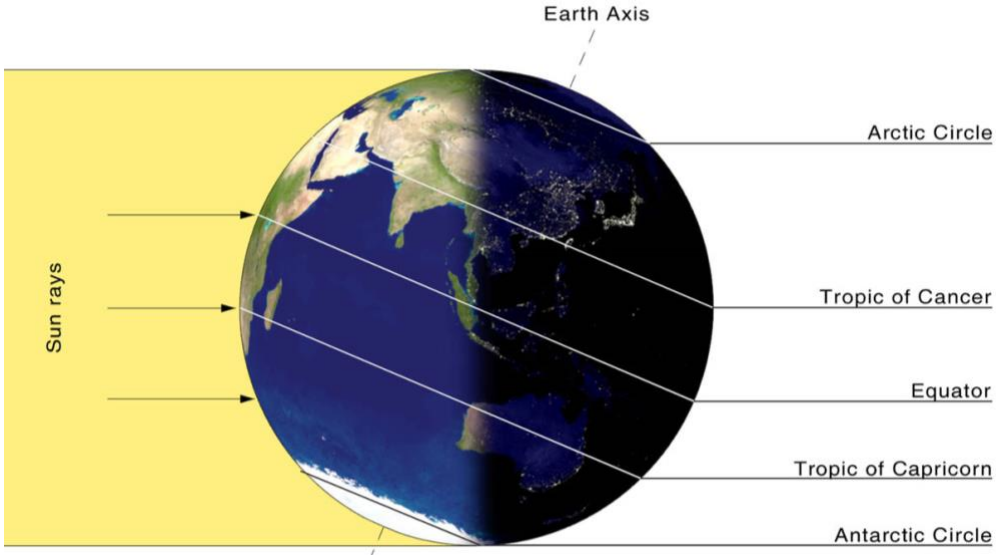
- "Hydrometeors" - precipitation
- "Lithometeors" - smoke, dust, haze(pollution particles)
  - Condensation nuclei
- "Electrometeors" - thunder and lightning

Weather: current state of the atmosphere
- short term variation in atmospheric conditions
- example:

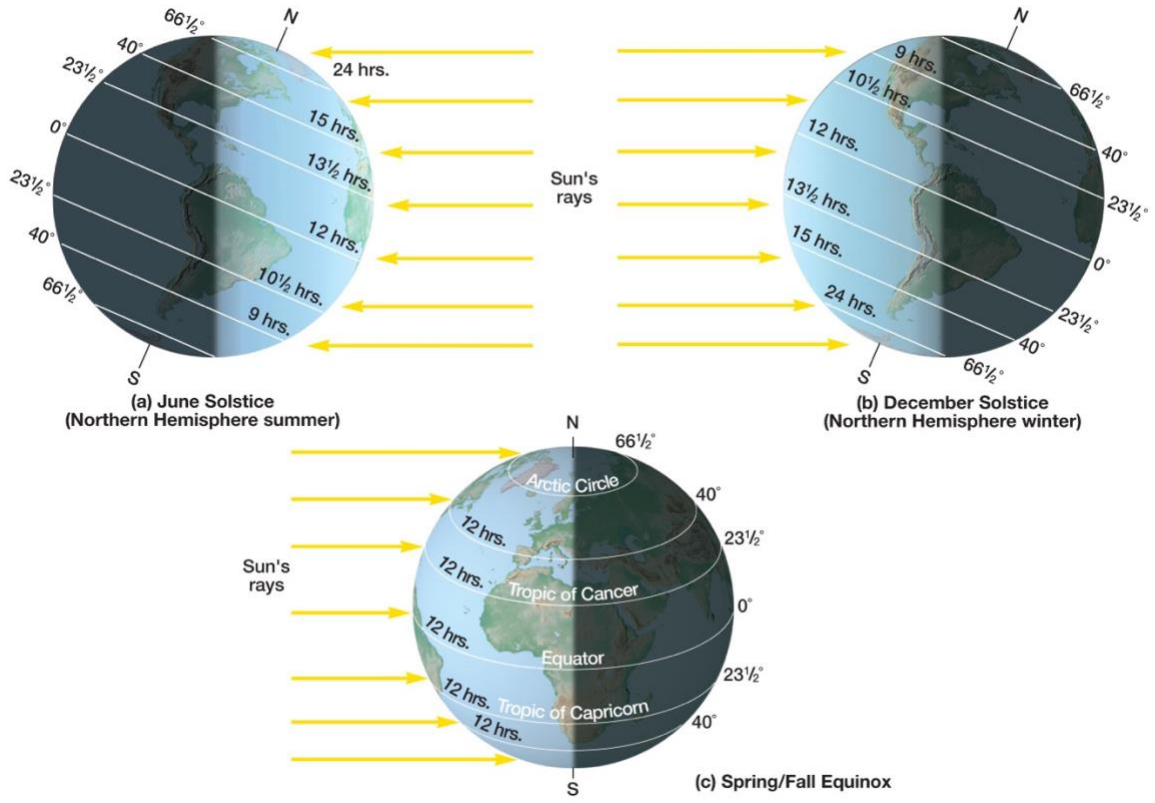
Climate: long term average of variations in weather for a particular area
- average weather over a 30 year period of time
- example: humid, continental zone, Ohio has a temperate climate with four seasons. Winters are cold and summers mild.

Imbalanced Heating

- Due to the Earth's angle (24.5º), different areas will get different amounts of solar radiation



- The solar radiation hitting the poles is spread out over a greater area
- This explains why the poles are never very warm



- This explains why we get more sunlight in the summer and less in the winter

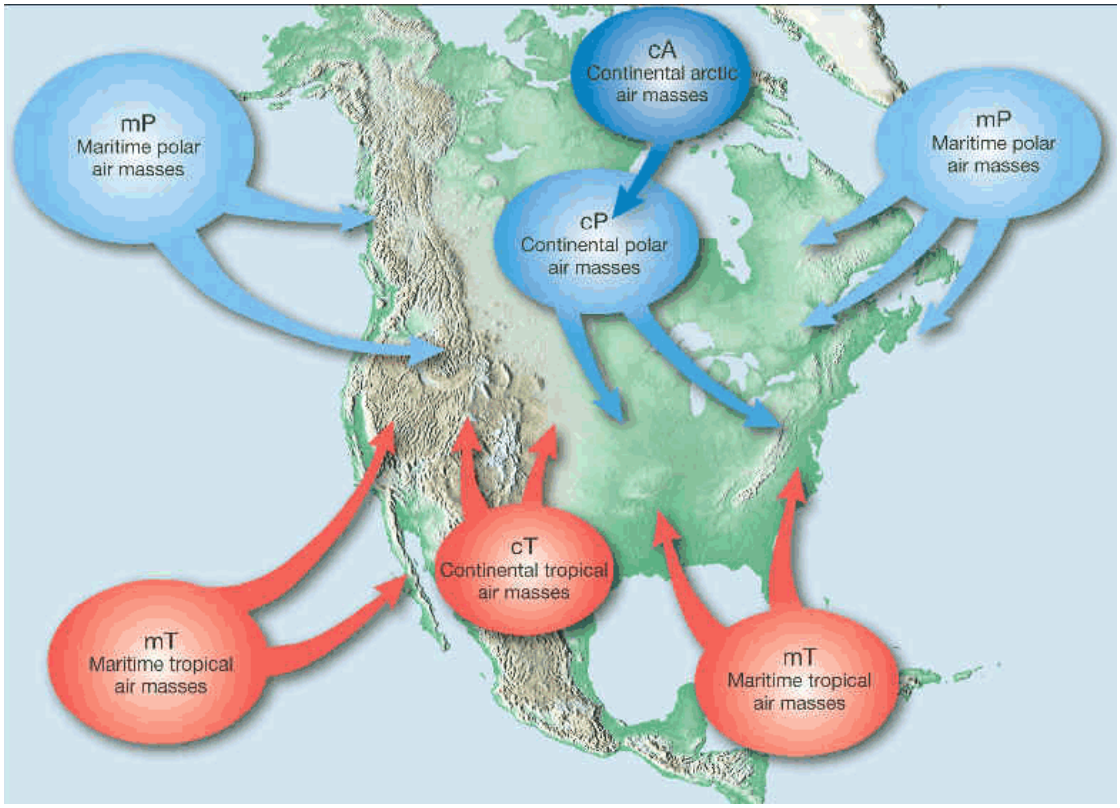
Redistribution of thermal energy

- Two things are always in motion to distribute heat energy on and around the Earth
    - Ocean currents
    - Air and wind

Air Masses

- **Air mass**: is a large volume of air that has the same characteristics, such as humidity and temperature
    - **Source area**: area over the air mass forms: land or water

- Five types of air masses influence the United States
    1. Continental Tropical: origin-land; hot and dry, from southwestern U.S. and Mexico
    2. Continental Polar: origin-land; cold and dry, from Canada
    3. Maritime Tropical: origin-ocean near the equator, hot and humid
    4. Maritime Polar: origin-ocean, cold and humid
    5. Artic: origin-above 60º North latitude, *very* cold and dry



Air masses do not stay in one place for long! As the air mass moves over land or water, it will take on some of the characteristics of the land or water.

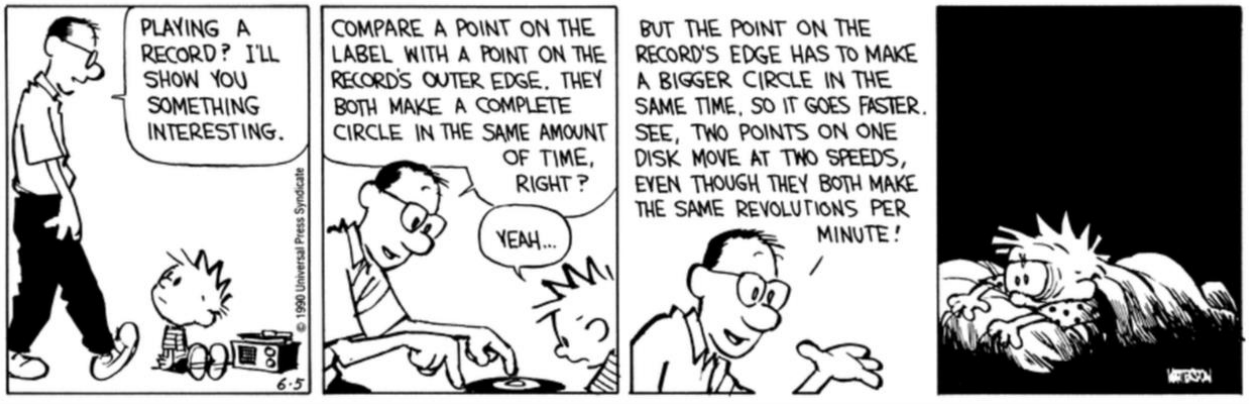
Example: Continental Polar (cold & dry) air moving over warmer Lake Erie water and creating lake-effect snows over Cleveland

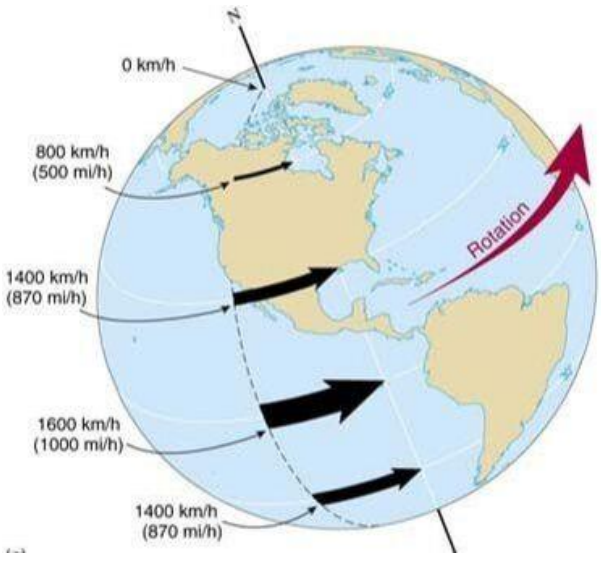
Weather Systems

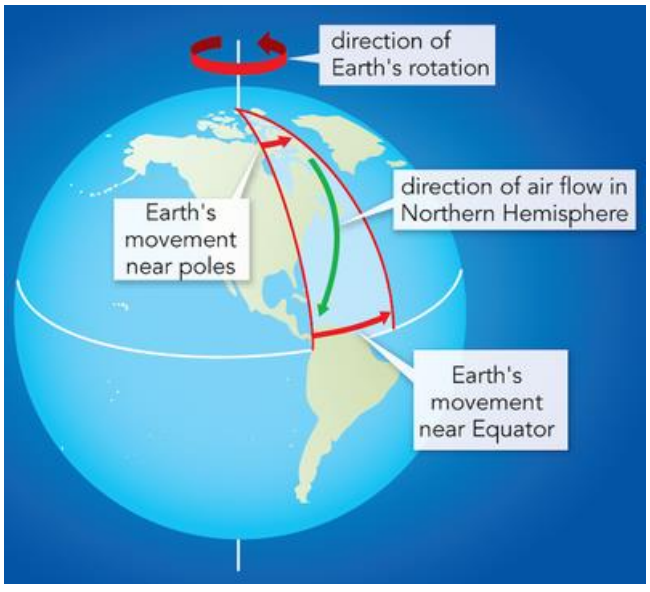
Essential Questions:

- Describe how the rotation of Earth affects the movement of air.
- Compare and contrast wind systems.
- What are the four types of fronts?
- Describe how and where air masses form.

Coriolis Effect





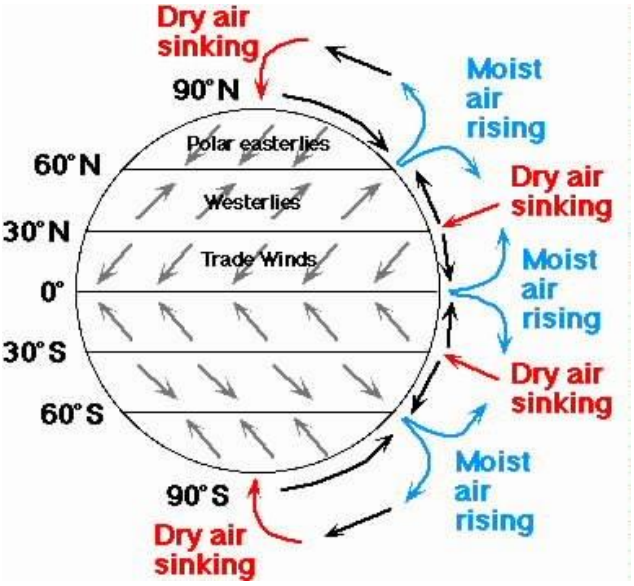


- The Earth rotates from EAST to West as it spins, this has an effect on the air, the air is deflected to the right in the northern hemisphere and to left in the southern hemisphere
- This Coriolis effect forms very specific and distinct global wind systems

Global Wind Systems

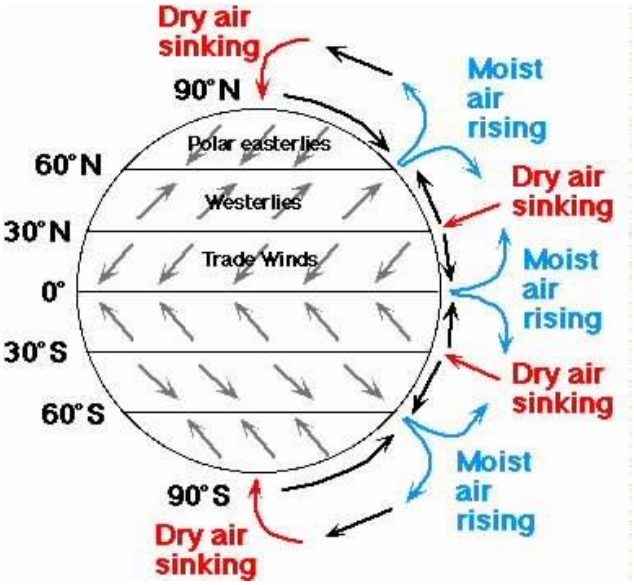
- There are three basic global wind systems in each hemisphere
  - Trade Winds
  - Prevailing Westerlies
  - Polar Easterlies

- **Tradewinds:** winds (in both hemispheres) flowing toward the equator between 30º and 0º latitude
  - Comes from the east
  - Northern hemisphere: winds flow from NE, therefore, are called northeast trade winds
    - deflected right by Coriolis effect
  - Southern hemisphere: winds flow from SE, therefore are called southeast trade winds
    - deflected left by Coriolis effect



  - Air sinks at 30º N&S, moves toward the equator in a westerly direction when it reaches the equator, it rises again and goes toward 30º N&S again… cycle complete!
    - *Itertropical convergence zone:* at the equator, 0º Lat
      - winds are calm
      - low pressure belt exists at equator
      - *doldrums:* another name for the ITCZ
    - *Horse latitudes*: high pressure- 30 º Lat N&S
      - Surface winds are weak
      - Sailors stranded here would throw their horses overboard when they couldn't feed or water them

- **Prevailing Westerlies:** winds (in both hemispheres) between 30º and 60º latitude
    - Comes from the west and blows east, hence the name
    - This wind is responsible for the weather patterns that move across the United States and Canada
    - The Coriolis effect deflects air towards the poles

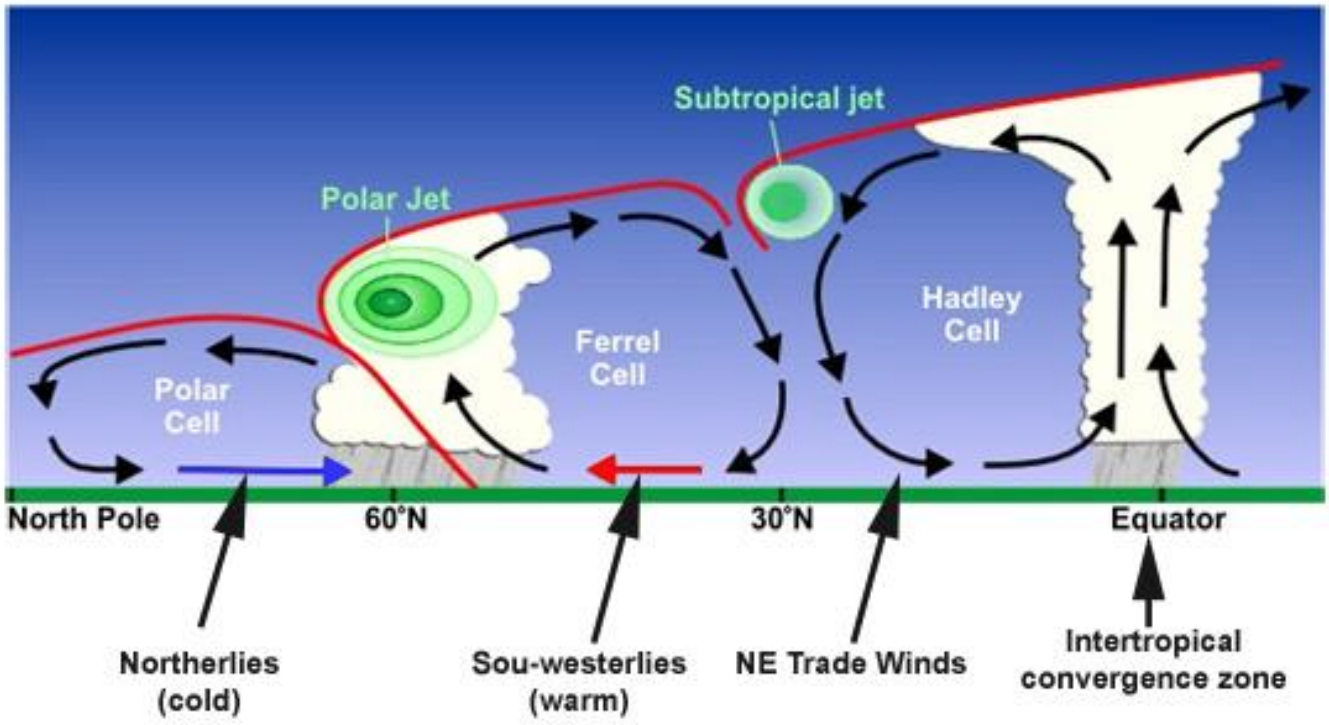


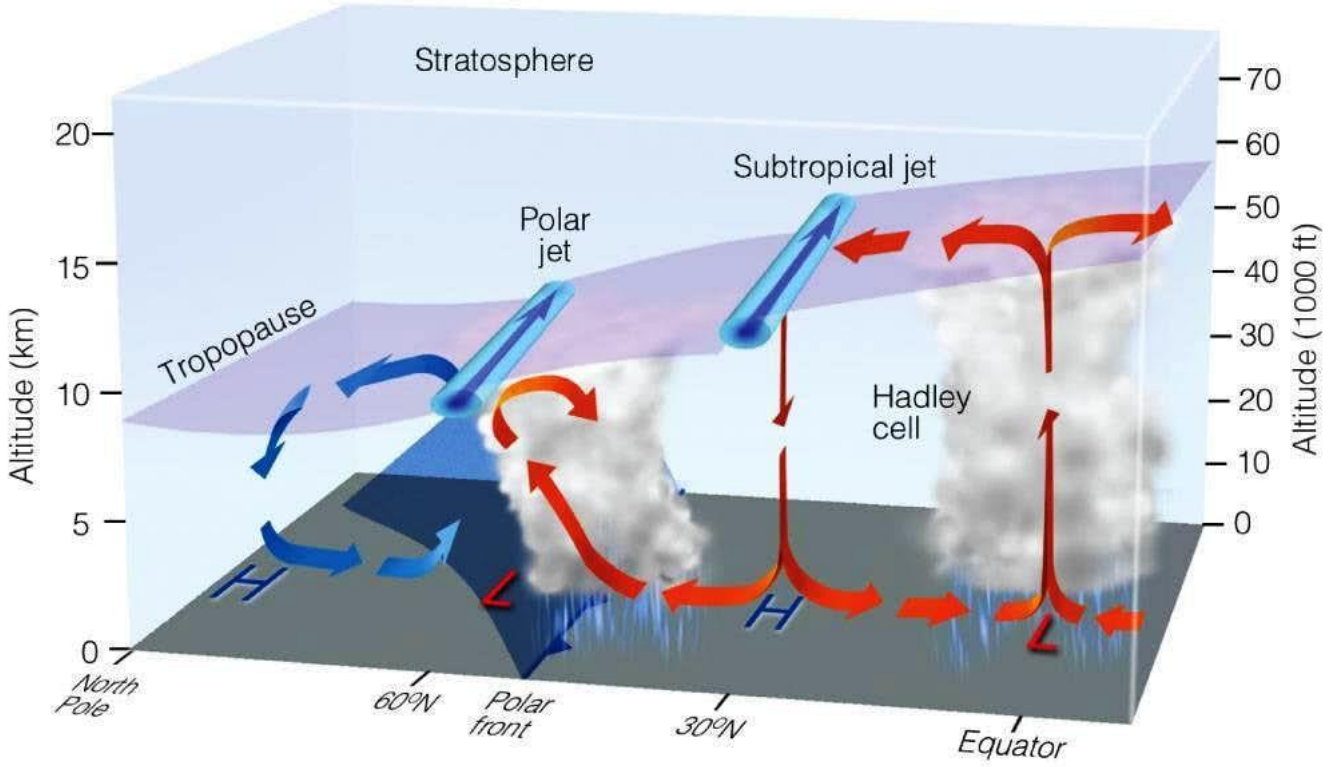
- **Polar Easterlies:** winds (in both hemispheres) between 60º and 90º latitude
    - Comes from the East and blows west
    - Created by polar high: descending cold air

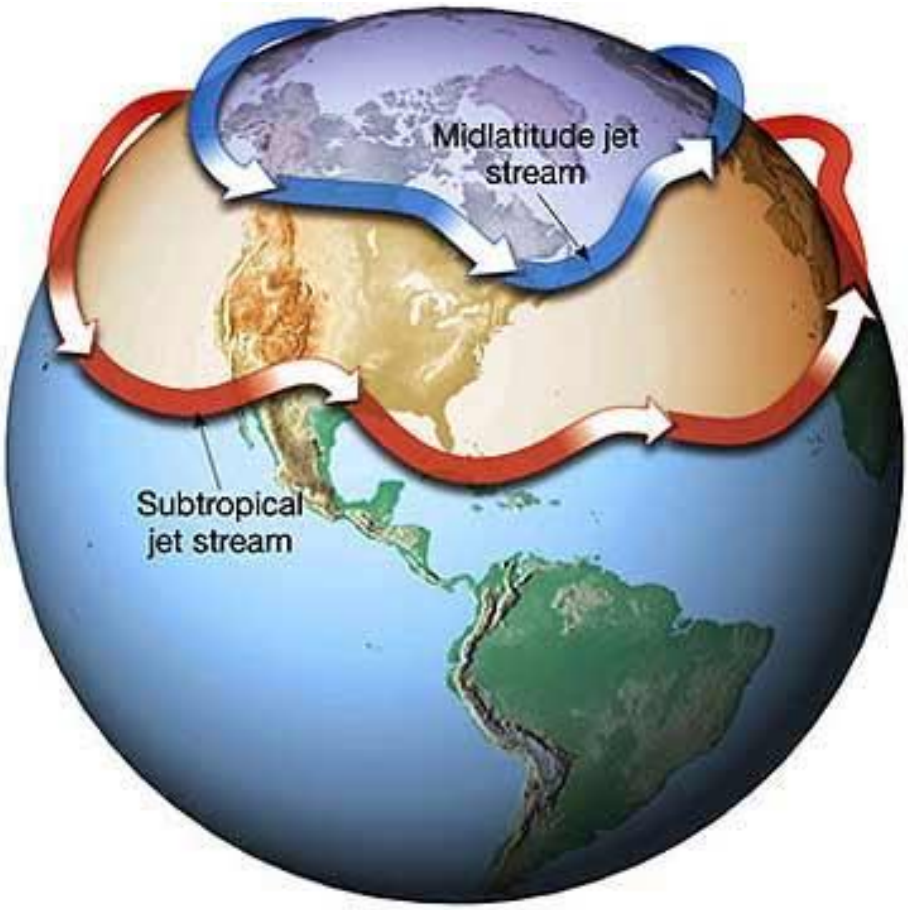
Jet Streams

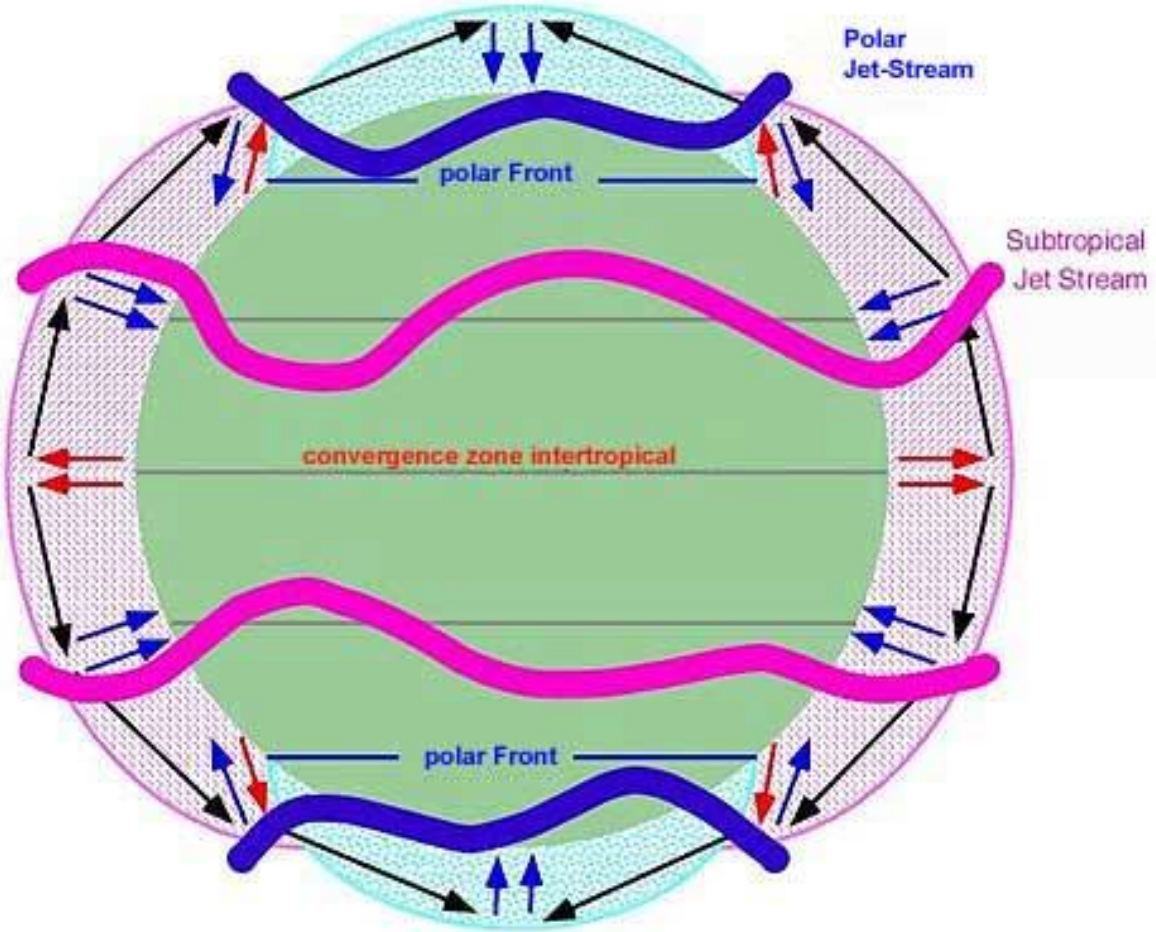
- **Jet Stream:** narrow bands of fast, high altitude westerly winds (which resemble jets of water)
    - Follow boundaries between hot and cold air and are strongest in the winter
    - Top speeds – normally between 80-140 mph, but up to 275 mph!!
    - Altitude – 4-8 miles
    - May have dramatic effect on weather, pushes air around the globe

- Usually two per jet streams per hemisphere
    - **Polar jet stream**: separates polar easterlies from prevailing westerlies
    - **Subtropical jet stream**: where the trade winds meet the prevailing westerlies



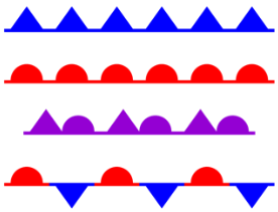



Midlatitude jet stream
Subtropical jet stream

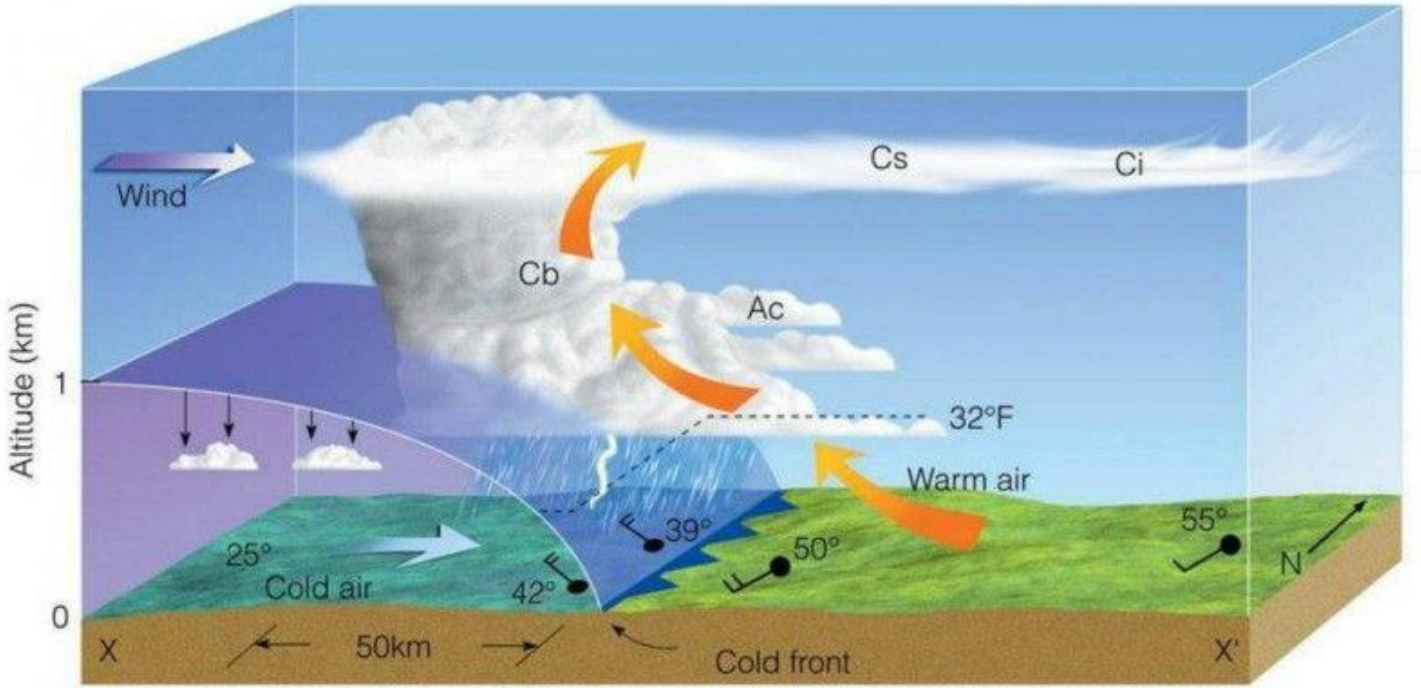

Polar Jet-Stream
polar Front
Subtropical Jet Stream
convergence zone intertropical
polar Front

Fronts

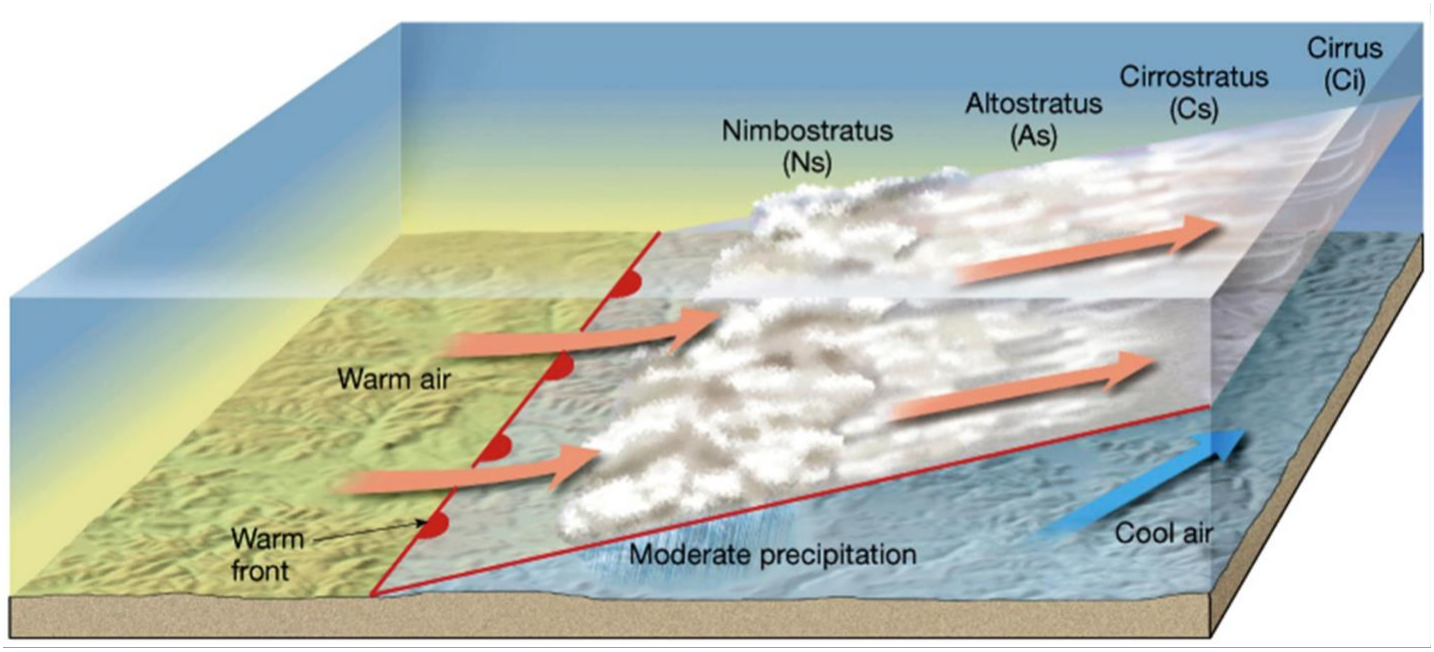
- **Front:** a narrow region separating two air masses of different densities.
  - Density differences are caused by changes in temp, press and humidity
  - Fronts form when air masses collide
  - Four types
    - Cold fronts
    - Warm fronts
    - Occluded fronts
    - Stationary fronts



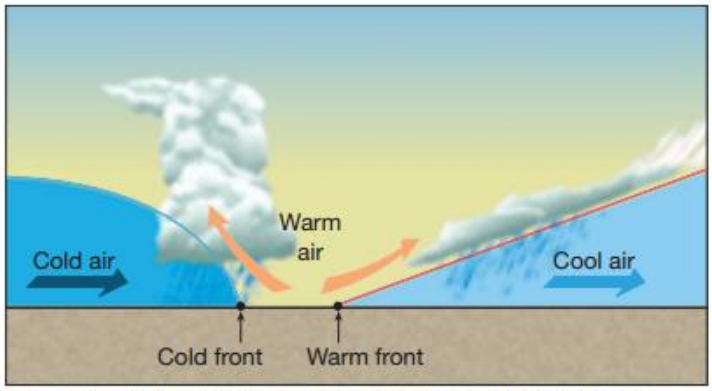
- **Cold Front:** cold, dense air pushes warmer air up steeply.
  - As the warm air rises, it begins to cool and thereby lose its moisture, creating clouds, showers, and thunderstorms are all associated with cold fronts
  - Symbol: solid blue line with blue triangles pointing in the direction of the fronts motion – blue icicles!



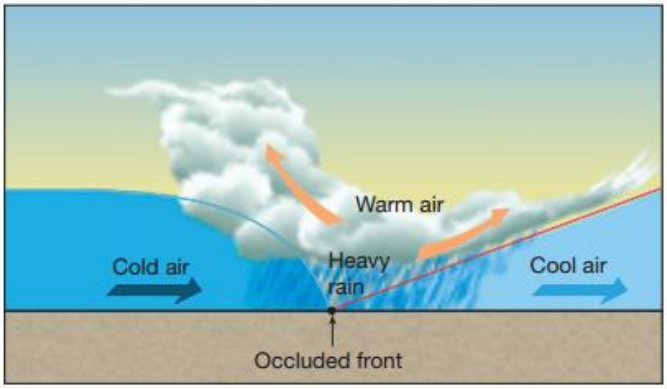
- **Warm Front:** advancing warm air displaces cold air and move up slowly.
  - The air ahead of a warm front moves slowly and because of less friction for the warm air it can gradually overtake and being less dense, push up over the cold air
  - Cloudiness and precipitation
  - Symbol: solid red line with semicircles pointing in the direction of the front's motion



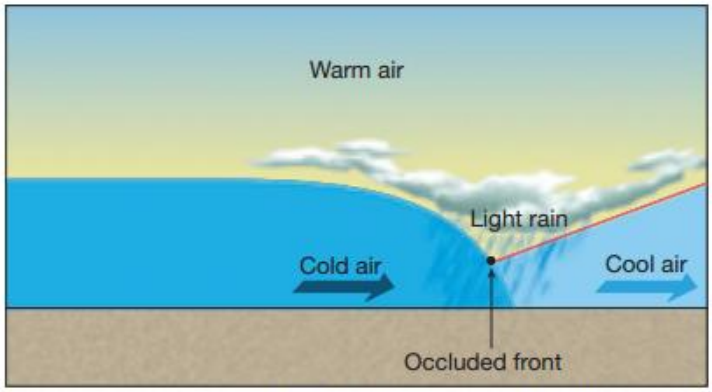
- **Occluded Front:** a warm front that gets wedged in between two cold fronts
  - A fast moving cold front slams into a warm front pushing it into and up over the cold air in front of the warm front.
  - Large zone of precipitation on both sides of the front
  - Precipitation continues until "cutoff" warm air mass runs out of moisture
  - Symbol: purple alternating semicircles/icicles



A A cold front moves toward a warm front, forcing warm air aloft.

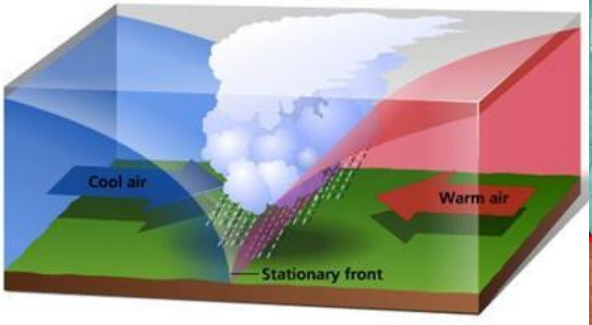


B A cold front merges with the warm front to form an occluded front that drops heavy rains.



C Because occluded fronts often move slowly, light precipitation can fall for several days.

- **Stationary Front:** two air masses meet and neither advances
  - Weather is very similar to that of a warm front
  - Symbol: blue icicles alternate with red semicircles

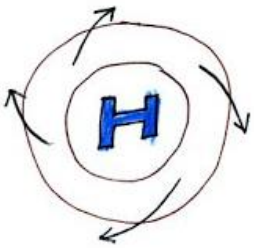


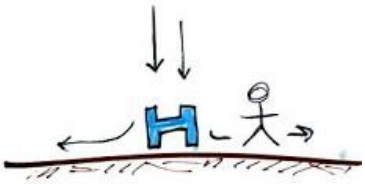
Pressure Systems

- **Rising air is associated with low pressure and sinking air is associated with high pressure**
- **Rising and sinking air combined with the Coriolis effect result in *rotating* high and low pressure systems**

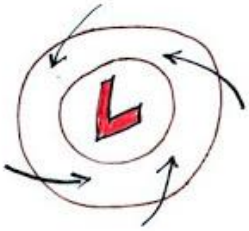
- **Low pressure system**
  - **As air rises, it creates space beneath it that is usually filled in by dense colder air**
  - **Low pressure systems pull air into the Earth's surface as air rises**
  - **Clouds and precipitation**
  - **Rotates counter-clockwise in northern hemisphere**
  - **On a map it is represented as a red "L"**
  - **"L" for lousy weather day**

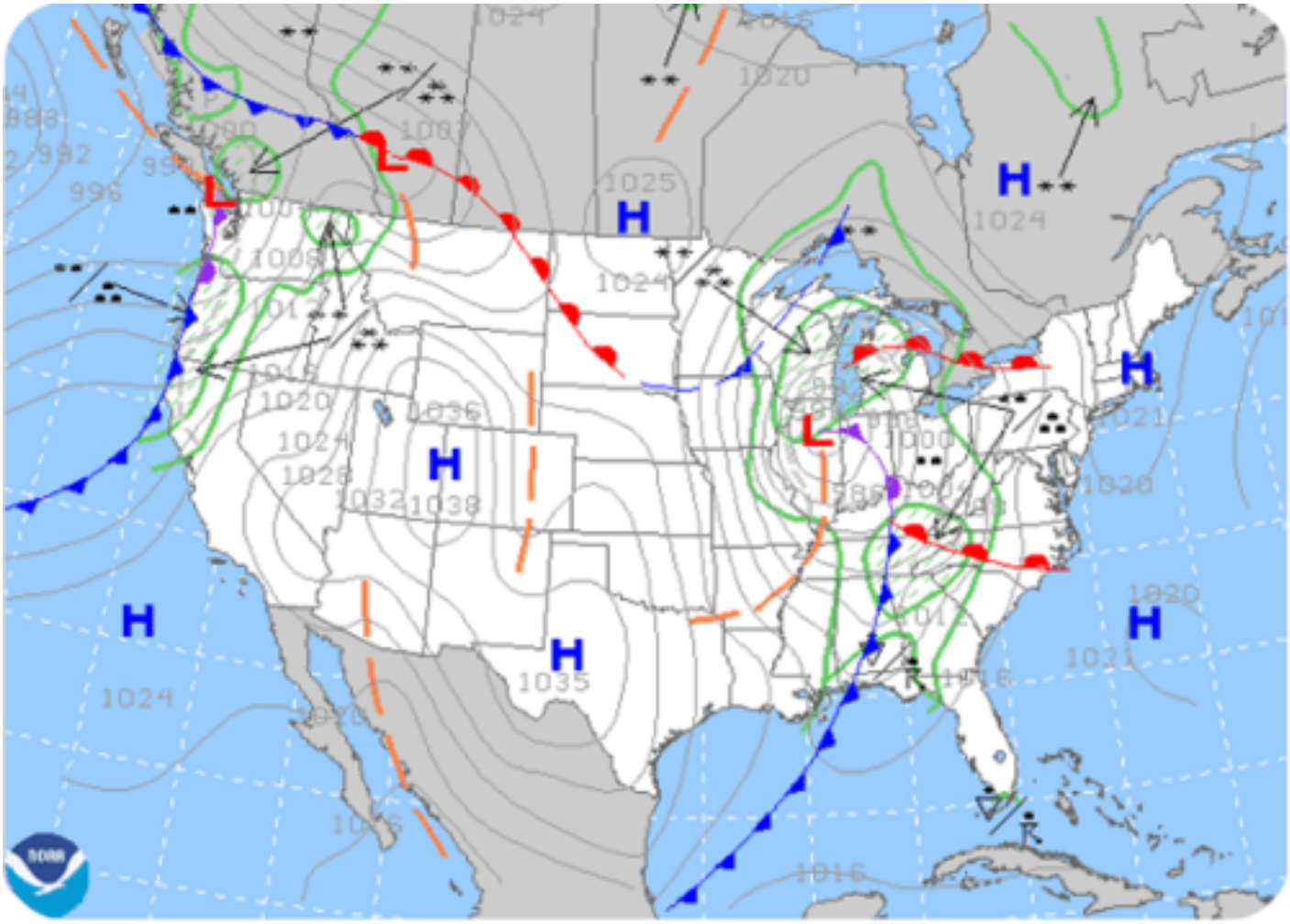
- **High pressure system**
  - **In a high pressure system, air is sinking… so when it finally hits the surface it spreads out pushing everything away**
  - **Fair weather**
  - **Clear skies**
  - **Rotates clock-wise in northern hemisphere**
  - **On a map it is represented as a blue "H"**
  - **"H" for "Good 'H'air Day!!**





https://www.youtube.com/watch?v=aiYyCurh_SU





Key: *L = low-pressure center* *H = high-pressure center*

warm front *cold front*

1008 *isobar*

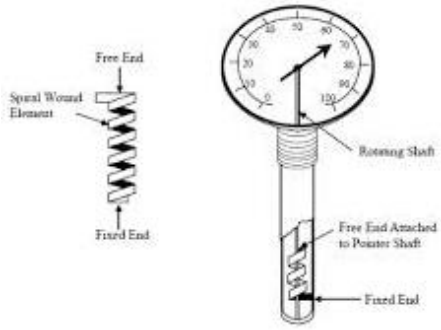
Gathering Weather Data

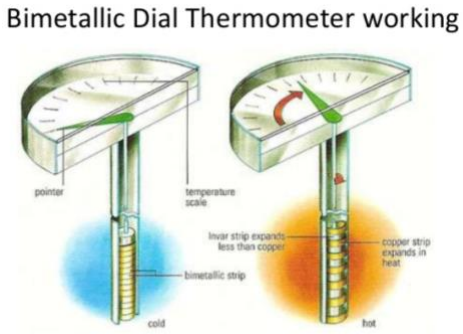
Essential Questions:

- Describe the technology and instruments used to collect weather data.

Surface Weather Data

- Surface Data Instruments
  - Thermometers: measures temperature
    - Liquid in glass types use alcohol that expands when heated
    - Bimetallic strip types: two different metals that expand at different rates when heated; usually has a dial with a pointer



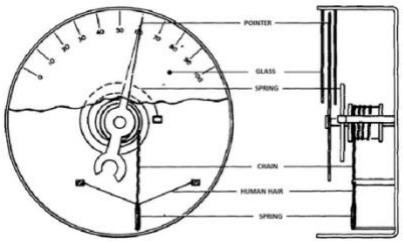


  - Barometers: measures air pressure
    - Aneroid barometer: sealed metal chamber that is flexible that expands or contracts with pressure

https://www.youtube.com/watch?v=ieq-kRxdLaw
watch first 2:06 sec

- Anemometer: measures wind speed
  - Cupped arms move as the wind blows
    - anemometer with wind vane
    - wind vane: shows wind direction

- Hygrometer: measures relative humidity



  - sling psychrometer: uses wet and dry bulb thermometers and determines how fast the water evaporates from the wet bulb

Upper Level Data

- While surface data is important, the weather that we experience is caused by changes that take place in the upper atmosphere!
- To make accurate forecasts, meteorologists gather data up to 30,000 meters

  - Radiosonde: used to gather upper atmospheric data
    - Contains weather sensors that can transmit data to meteorologists
    - Measures: temp, air pressure, humidity, wind speed and direction
    - Go as high as 23 miles, 125k feet
    - The instruments come back to earth via a parachute

Weather Observation Systems

- Weather Radar: Radar pinpoints where rain is falling at any given moment
  - radio detecting and ranging
  - works by bouncing radio waves off rain drops

- Doppler Radar: change in pitch or frequency that occurs due to the relative motion of a wave
  - Tracks movement of precipitation caused by wind
  - Ability to measure wind speed is an advantage over other radar systems

- Weather satellites: uses cameras to take images of Earth
  - Infrared imagery: can measure temperature differences
  - Visible-light imagery: tracks clouds
  - Water-vapor imagery: measures water vapor in atmosphere

Weather Analysis and Prediction

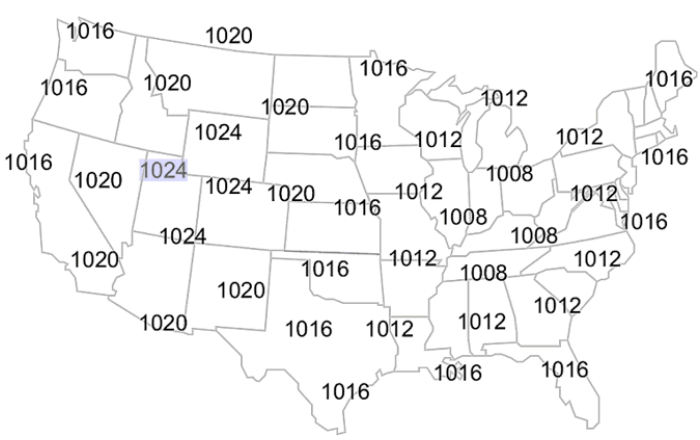
Essential Questions:

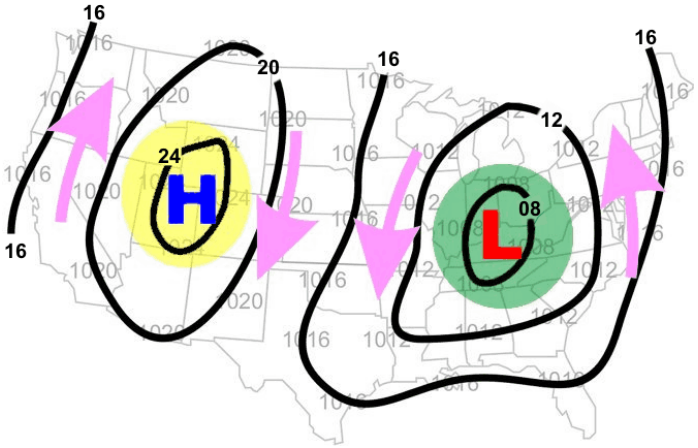
- What information is on a basic surface weather map?
- How do digital and analog forecasting differ?
- Describe the problems with long term forecasts.

Surface weather Analysis

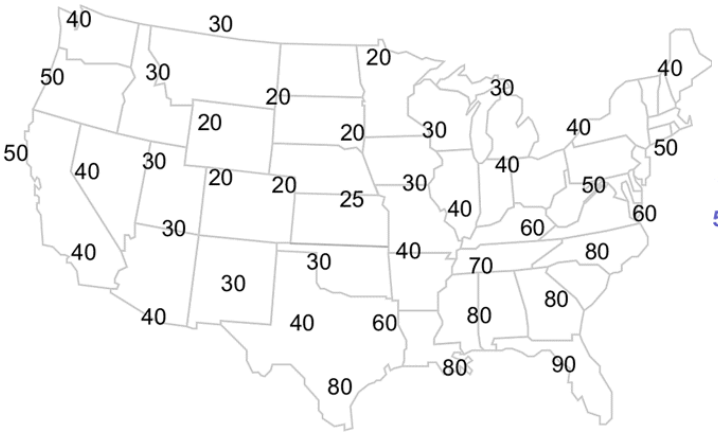
- Station models: record of weather data for a particular site at a particular time
  - Symbols are used to represent weather data
  - Allow a large amount of data can fit into a small space
  - Uniform way to communicate weather data

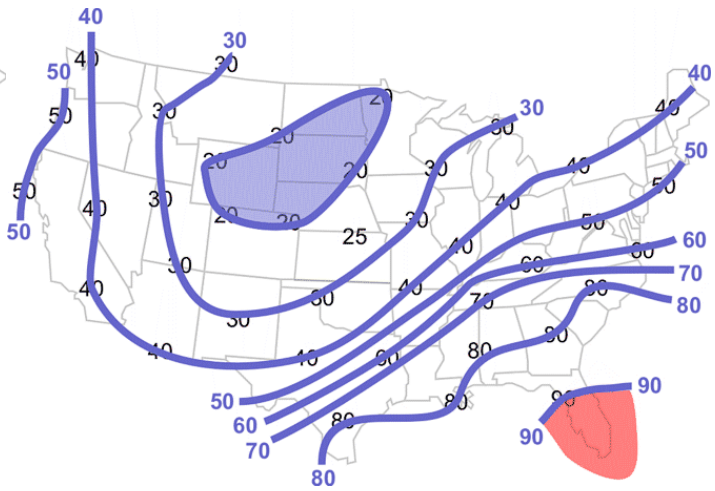
- Isobars: lines of equal pressure on a map





  - The closer the isobars the faster the wind speed
  - The further apart the slower the wind speed
- Isotherms: lines of equal temperature on a map





https://www.youtube.com/watch?v=N5rJ1yWk4IU Recap of isobars and isotherms and fronts 8:40

https://www.youtube.com/watch?v=jw-0pfOG8TM How to draw isolines 18:57

Cloud Symbols

Low Clouds
- Stratus
- Cumulus humilis
- Stratocumulus

Middle Level
- Altocumulus
- Altostratus

High Level
- Cirrus
- Cirrostratus
- Cirrocumulus

Vertically Developed
- Cumulus congestus
- Cumulonimbus

Present Weather Symbols

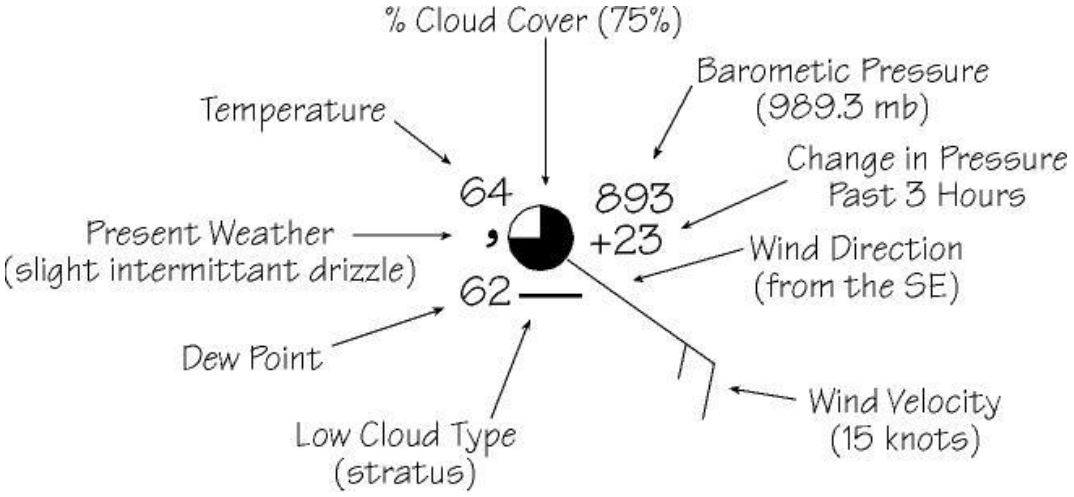
- Fog
- Rain
- Drizzle
- Snow
- Freezing rain
- Freezing drizzle
- Hail
- Sleet
- Drifting snow
- Dust storm
- Thunderstorm
- Haze
- Funnel cloud
- Dust devil

Cloud Cover (%)

- Zero
- 10
- 25
- 40
- 50
- 60
- 75
- 90
- 100
- Sky obscured

Wind Velocity (mph)

- calm
- calm, sky obscured
- 1-2
- 5 (+ or -)
- 10
- 25
- 50
- 75
- 100
- 145



- Types of Forecasts
  - Digital forecasts: created by applying physical properties and mathematics to atmospheric variables and then making a prediction about how these variables will change over time
    - Super computers
    - Main method used to predict weather
  - Analog forecasts: weather forecast that compares current weather patterns to patterns that occurred in the past.
    - Disadvantage is it is difficulty in finding the same weather pattern from the past
    - Useful for seasonal forecasts
  - Short-term forecasts are most reliable
    - 1-3 day forecast is usually accurate
  - Long-term forecasts are less reliable
    - > than 5 day forecasts are unreliable