Unit Four: Weather Dynamics

Weather Dynamics

- *the study of how the motion of water and air causes weather patterns.*
- *The main components of Earth that affects weather are*
  - *the atmosphere,*
  - *the land forms,*
  - *water in the forms (solid, liquid, and vapor).*

Weather vs. Climate

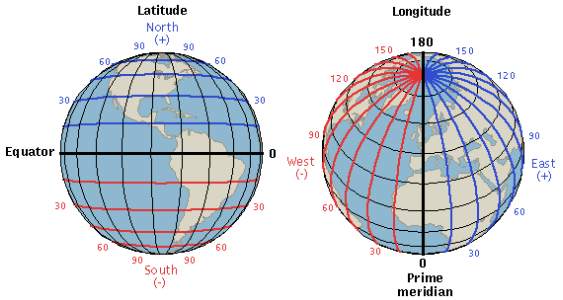
- **Weather -** is a set of environmental conditions encountered from day to day
  - the conditions of the atmosphere at any given period of time
    - *Eg. Today it is ……*
- ***Climate*** *– is a set of environmental conditions averaged over many years.*
  - *Eg. The climate in St. John's in January is cold, snowy, windy, with an average day time temperature of -5 ^{O}C (averaged from years of data)*

Global Geography

- **Longitude** - *the angle measured east or west from the 0° line, which passes through Greenwich, England.*
- **Latitude** - *the angle measured south or north of the equator.* (eg. Most of the Canada-US border is 49º N latitude)
- **Tropic of Cancer – 23.5^{O} N latitude** is the most northerly latitude reached by the sun's vertical rays.
- **Tropic of Capricorn** is the most southerly latitude reached by the sun's vertical rays.
- **Arctic Circle – 66.5^{O} N latitude**.
- **Antarctic Circle – 66.5^{O} S latitude**

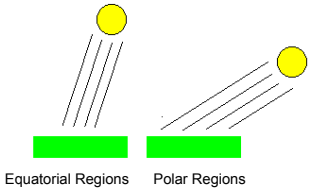
Global Geography

- **Equatorial Region** - *region located between the Tropic of Cancer and the Tropic of Capricorn.*
  - *Receives direct overhead sunlight at some point during the year*
- **Polar Regions** - *Region north of the Arctic Circle and the region south of the Antarctic Circle.*
  - *Receives 24 hours of darkness at some point during the year*
- **Mid-latitude Regions -** *Regions between the tropics and the polar regions.*



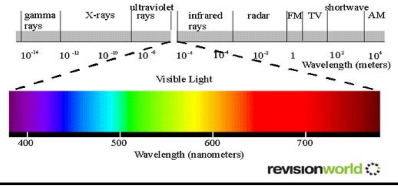
What causes Weather ??

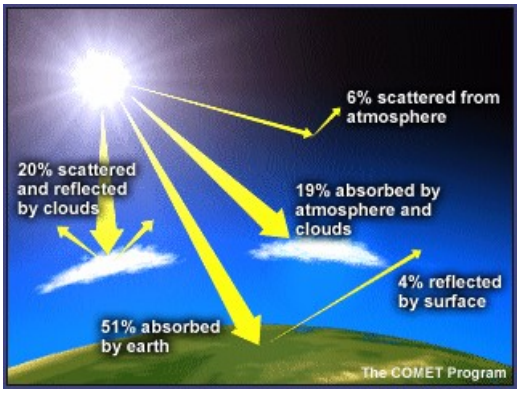
- Weather is caused by the unequal heating of the earth,its atmosphere, and its oceans
- Regions near the equator receive more direct sunlight than regions farther N or S
- Unequal heating creates global movements of air and water – this causes weather



Methods of heat transfer around the Earth

- **1. Radiation** - transfer of energy by waves
  - This is how energy is transferred from sun to earth
  - does not require a medium
  - Examples: visible light, microwaves, X-rays, infrared waves



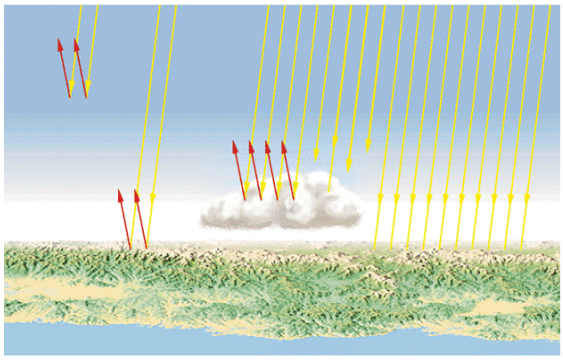


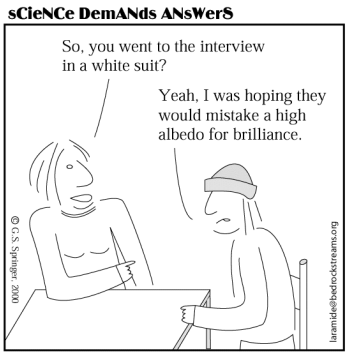
Heat transfer

- 2. **Conduction** - the transfer of energy through the collision of particles
  - Occurs most in solids, especially metals
  - Not an important factor in weather
- 3. **Convection** - the transfer of energy *vertically* by movement of particles in a fluid (water or atmosphere).
- 4. **Advection** - the transfer of energy *horizontally* by movement of particles in a fluid

The Energy of the Sun

- Some solar radiation that reaches earth gets reflected back into space.
  - The **albedo** (percentage of light reflected) of a material will determine how much radiation is reflected. Clean snow has a high albedo whereas black soil has a low albedo.
- Any material that absorbs energy and becomes warmer is called a **heat sink**.
  - The oceans are good heat sinks – they absorb heat and warm slowly (and cool slowly)
  - Soil and rock are poor heat sinks.



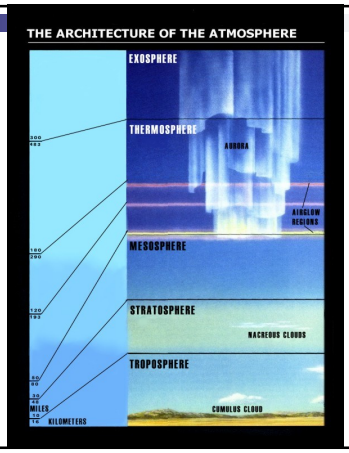


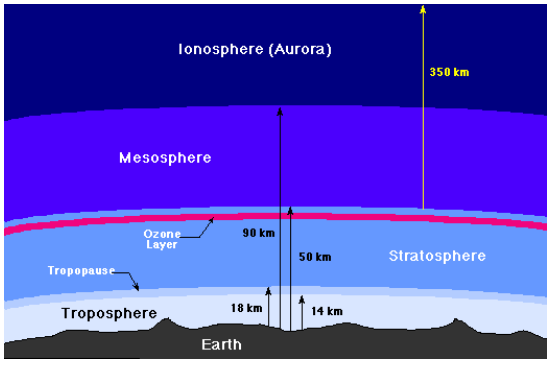
Specific Heat Capacity

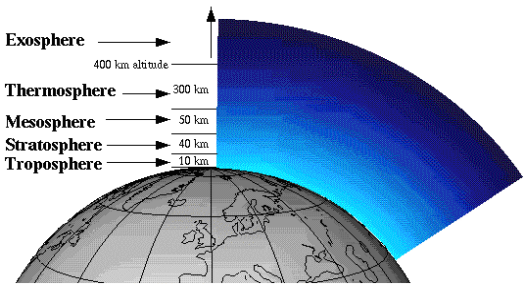
- *the measure of how much heat a substance requires to increase it's temperature one degree C, or how much energy it releases as it's temperature decreases by 1°C*
  - Figure 5 in your text shows the heat capacity of some common substances.
  - Substances with a high heat capacity are good heat sinks

The Atmosphere

- The atmosphere consists of air and moisture that surrounds the Earth. The common atmospheric gases are oxygen, nitrogen, carbon dioxide, and water vapor.
- The density of the atmosphere varies with height above sea level (most dense at sea level).
- **Altitude** *is the height (m or km) above sea level.*
- The atmosphere is thicker above the equator than it is above the poles. Warmer air takes up more space because warmer air expands.







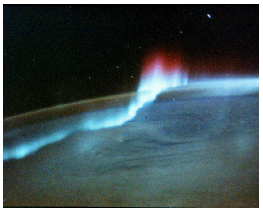
Six layers of the Atmosphere

- **1. Troposphere** - the layer closest to the Earth's surface.
  - Thickness of 8 km at the poles and up to 16 km at the equator.
  - Most of our weather occurs in this layer.
  - Temperature decreases with altitude
- **2. Tropopause** – the transition layer between the troposphere and stratosphere
- **3. Stratosphere -** a dry layer located between 12 km and 50 km above the Earth's surface.
  - This layer contains **high concentrations of ozone** - protects the Earth from harmful ultraviolet rays given off by the sun.
  - The ozone also cause the stratosphere to be warmer.

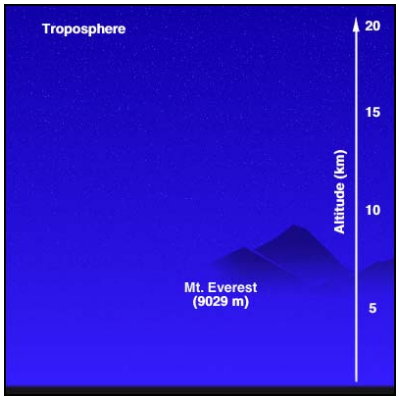
Atmosphere (continued)

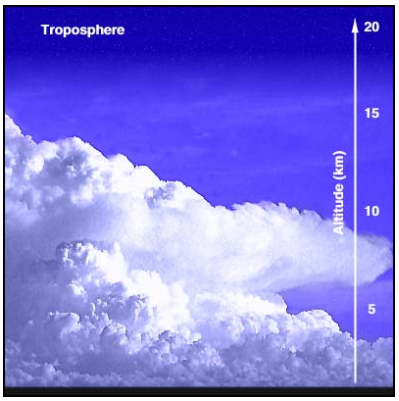
- **4. Mesosphere -** the middle layer
  - extends from 50 km to 80 km.
  - This layer has low concentrations of gases and low temperatures.
- **5. Thermosphere -** extends from 80 km to 500 km.
  - X-rays (from the sun) are absorbed, producing higher temperatures.
  - particles in this layer can become electrically charged to produce the northern lights (*aurora borealis*) and southern lights.
- **6. Exosphere -** the thin outer part of our atmosphere.
  - very few particles (mainly hydrogen) in this layer.

The *auroras* occur in the Thermosphere



Aurora Link





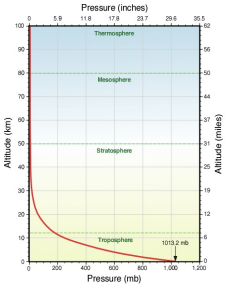
Gradients

- **Temperature Gradient -** The change in temperature over a distance. The troposphere has a vertical temperature gradient of –6 C per 1000 m

Pressure Gradient

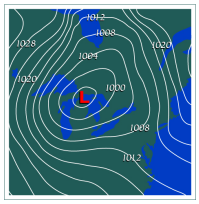
- **–** the change in atmospheric pressure across a set distance.
  - vertical gradient

  (pressure decreases with altitude)



Horizontal gradient

(between points on the earth's surface)



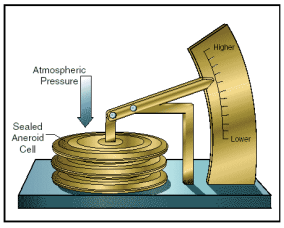
- *Isobars:* lines representing areas of equal pressure
- Maps of pressure are drawn using *Isobars*
- *If i*sobars close together = high pressure gradient (area of high wind speed)
- If isobars far apart = low pressure gradient (area of low wind speed)

Atmospheric Pressure

- **Atmospheric Pressure**
  - the pressure the air exerts as gravity pulls it toward the Earth.
  - greatest at sea level where the air molecules are closer together.
  - generally decreases with altitude
  - measured in kilopascals. (See text p.512)
  - The average atmospheric pressure at sea level is 100kPa.

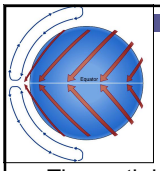
Measuring Pressure

- Aneroid barometer
  - A device used to measure air pressure

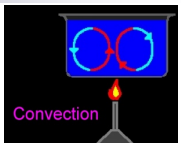


Wind

- the movement of air in the atmosphere from a region of higher pressure to an area of lower pressure
- Major wind patterns on the earth are called prevailing winds
- Winds are also affected by the Earth's rotation



What causes winds?



- The earth is unevenly heated
  - Regions near the equator receive more direct rays from the sun than regions further North or South
- Air near the equator becomes warmed, expands and becomes less dense – its pressure decreases – this warm air rises
- Cooler air from N and S, which is more dense, moves toward the equator
- The rising air cools and moves north and south. This completes a convection current.

Major Prevailing Winds

- **1. The Trade Winds**
  - Hot air at the equator rises, creating a region of low pressure.
  - This rising air moves north and southward, cools, becomes more dense, and sinks at around 30^0 N and S
  - This sinking air moves back towards the equator, producing the trade winds.
  - The trade winds twist to the right in the northern hemisphere to form the northeast trade winds (they twist left in the southern hemisphere - southeast trade winds)

Major Prevailing Winds

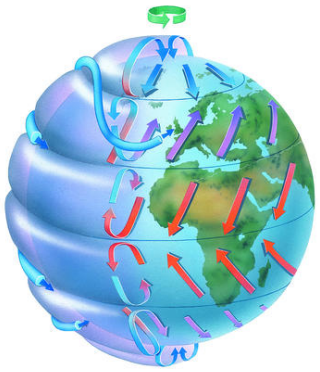
- **2. Polar Easterlies -** near the poles , the air is cold and dense.
- This air sinks and moves toward the equator.
- The Earth's rotation cause this air mass to twist to the right in the northern hemisphere (left in South) causing the **polar easterlies.**

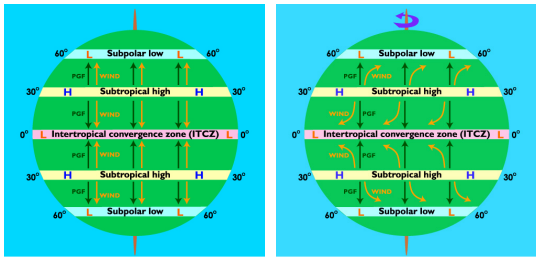
Major Prevailing Winds

- **3. Mid-latitude Westerlies -** At 30^0 N latitude, some of the sinking equatorial air moves northward
- This air meets the cold polar air and a low pressure forms around 60^0 latitude.
- The surface air moving north twists to the right in the northern hemisphere to form the mid latitude south-westerlies.
- A similar pattern occurs in the southern hemisphere

Jet Streams

- High altitude, fast moving, winds in the troposphere
- Generally flow from west to east over the mid-latitudes.
- The jet streams separate cold polar air to its north from warmer air to its south.





The Hydrosphere

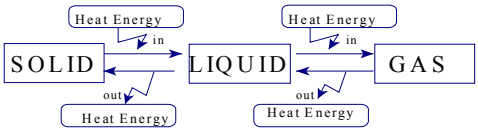
- Made up of both fresh and salt water
- Approximately 70% of the Earth's surface is water.
- Only 2.5 % of all water is fresh.
- Most of this 2.5% consists of water frozen in glaciers and in the ice caps.

Phase Changes of Water

- **Evaporation -** *process of changing a liquid to a gas.*
  - *Requires energy (endothermic)*
- **Sublimation -** *process of changing a solid to a gas (endothermic),*
  or gas to solid (exothermic)
- **Condensation -** *process of changing a gas to a liquid.*
  - Releases energy (exothermic)

Phase Changes of Water

- **Freezing** – change of state from liquid to solid (exothermic)
- **Melting or Fusion** – change of state from solid to liquid (endothermic)



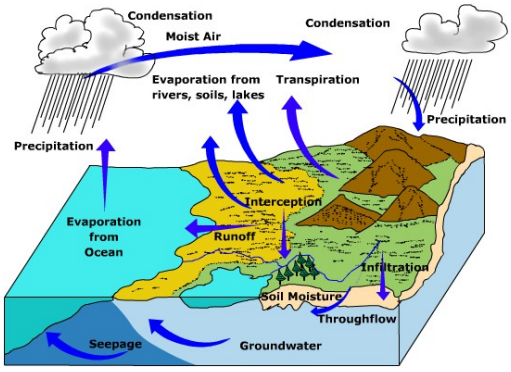
The Water Cycle

Radiant energy from the sun causes water to evaporate or ice to sublimate.

- Transpiration (evaporation of water from plants) adds to the formation of water vapor.
- The water vapor rises , cools, and condenses into fog, mist, and clouds.
- Water returns to the earth as precipitation (rain, snow, sleet etc.)

Water cycle

- Water runs off into streams, rivers, etc. that run into lakes and oceans.
- Some water percolates into the ground.
- This process continuously repeats.

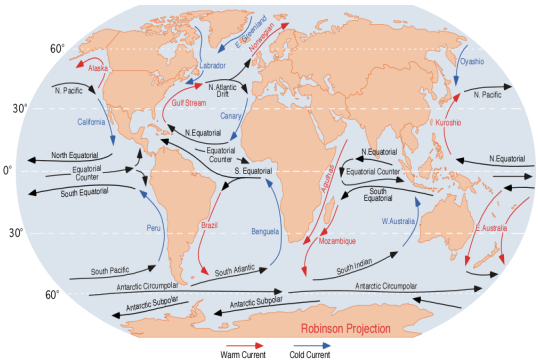


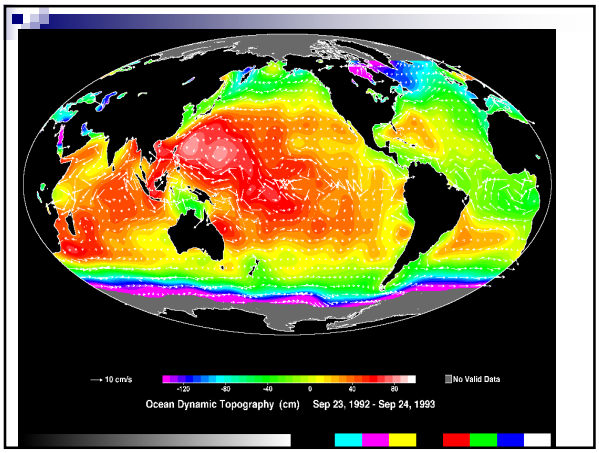
Major Ocean Currents

- The oceans have an important effect on weather dynamics.
- 1. Water's high heat capacity will affect temperature changes in a given area.
- 2. ocean currents act as conveyer belts to transport energy around the world.
- 3. the direction of the major ocean currents are similar to the directions of the major winds.

Causes of Ocean Currents

- 1. Solar heating of the oceans near the equator set up convection currents.
- 2. The continents will redirect water movement along its edge.
- 3. Earth's eastward rotation affects ocean currents. Currents on the east side of oceans tend to be fast, those on the west side of oceans tend to be wider and slower.
- 4. The salt content affects ocean currents. As water evaporates, sea water becomes saltier and sinks, setting up convection currents.





Clouds and Fog

- Solar energy heats up water causing evaporation.
- This mixture of water vapor and heated air rises in the atmosphere.
- As the moist air rises, air pressure and temperature lowers, causing condensation to occur.
- If the temperature drops low enough ice crystals will form.

Effects Of Ocean Currents

- water's high heat capacity causes it to warm up and cool down slowly
- the coastal areas of some northern countries can be warmed by a current which has picked up heat at the equator, losing that heat slowly as it travels north.
- air above a cold current will be dry, helping to create desert like conditions on nearby land
  - (e.g. Atacama Desert of Peru)
- air above warmer waters will be moist, forming clouds and large amounts of precipitation
  - (e.g. Brazil's rain forests)

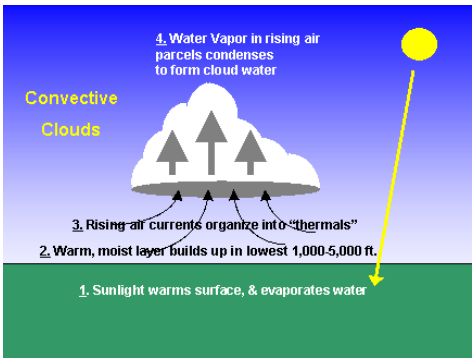
Formation of Clouds

- air containing water vapour is cooled below a critical temperature - the dew point
- the resulting moisture condenses into droplets on microscopic dust particles in the atmosphere
- air is normally cooled by expansion as it rises (temperature is cooler and air pressure is lower)

Three categories of Clouds

1. **Convective Clouds –**

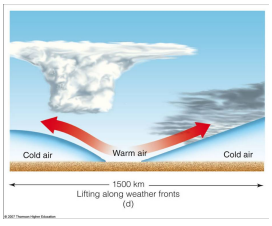
- air near the ground absorbs energy from heated surfaces and rises in the atmosphere.
- The air cools, water vapor condenses, forming clouds.
  - Temperature at which condensation occurs is called the **dew point**



Three categories of Clouds

2. Frontal Clouds

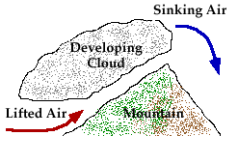
- Form where the leading edge, or front, of a large mass of air meets another mass of air at a different temperature.
- Warm air contains more water vapor and will be pushed up by a cold air mass.
- The rising warm air will cool and water vapor condenses to form clouds.



Three Categories of Clouds

3. Orographic Clouds

- Form when air moves up a mountain, expands at the lower pressure, and cools.
- Clouds are formed when water vapor in this air cools and condenses

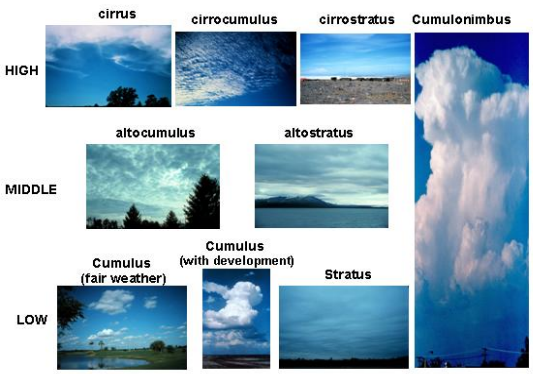


Fog

- Fog is actually a cloud at ground level.
- Air near the ground cools (especially on clear nights) and water vapor condenses into fog.
- **Fog may also be formed when:**
  - When warm air passes over a snow-covered ground or moist sea air drifts over a cold current (or seashore).
  - When warm air rises up the sides of a mountains during orographic lifting.

Classification of Clouds

- By shape
  - - **cumulus** = puffy; they grow vertically
  - **- stratus** - flattened; they grow horizontally
- By altitude:
  - **Cirrus** = high-level clouds **Alto** = mid-level clouds
    Low level clouds - no prefix
- **Nimbus** clouds = rain-bearing clouds
- Cloud names:
  - eg. Cumulonimbus = puffy rain clouds
  - Altostratus = Mid-level flattened clouds



- http://www.srh.weather.gov/jetstream/synoptic/precip.htm