UNIT III **WEATHER DYNAMICS** **Chp. 13-16**

Weather Dynamics
- The study of how the movement of water and air causes weather patterns

Weather
- The set of day-to-day environmental conditions

Climate
- A set of environmental conditions averaged over many years

- Eg; Central Canada has a climate consisting of hot summers and cold winters. In contrast, Newfoundland has a more temperate climate with less wide-ranging temperatures from summer to winter.

EARTH'S ENERGY BALANCE (p.504 - 507)

- The sun is our primary energy source and this energy is transferred to air, land and water
  - Particles that make up the air, land and water absorb the energy and this effects their movement which in turn determines weather patterns
  - Thus the sun is the ultimate cause of changing weather systems on a global scale

Kinetic Molecular Theory
- All matter is made up of particles that are in constant motion because they possess ***kinetic energy*** (energy of motion)

- The speed at which the particles of a substance move as well as the distance between the particles determine the physical state of the substance ie. both factors increase going from solids to liquids to gases

- *Temperature* is a measure of the average kinetic energy of the particles of a substance or how "hot" or "cold" something is
  - The greater the temperature, the greater the average kinetic energy and thus the faster the particles move

- *Heat (Thermal Energy)* is the total kinetic energy of all particles of a substance and is transferred from a warm object to a cooler one due to a difference in temperature

Types of Energy Transfer

Conduction
- The transfer of energy through a material by the collision of particles (particles that vibrate) that make up that material
- Occurs most easily in solids such as metals
- Also occurs to a lesser extent in rock, sand, soil and water

Convection and Advection
- The transfer of energy by the movement of particles in a fluid (particles that flow), including liquids (eg. water) and gases (eg. air)
- Convection = vertical transfer Advection = horizontal transfer

- <u>Convection</u> is the most important type of energy transfer to weather systems: involve movement of particles in oceans and the atmosphere

Radiation

- The transfer of energy by means of waves
- It can travel in a vacuum therefore no particles are required
- Electromagnetic spectrum = the set of waves that can travel from the sun through empty space (vacuum) to reach the earth

Reflection and Absorption of Radiant Energy

- The solar energy that reaches the earth is either reflected or absorbed depending on the *albedo* of the substance
    - 30% is reflected: 27% by clouds and particles in the atmosphere
      3% by Earth's surface
    - 70% is absorbed: 20% by clouds
      50% by water, land and ice

- the solar energy absorbed drives the water cycle and weather systems

Albedo:

- a measure of the percentage of light an object reflects

- High albedo:
    - objects that reflect a lot of light
    - snow, clouds and light-coloured areas (sand, pale rocks and deforested areas)

- Low albedo
    - Objects that absorb more light than they reflect
    - Dark surfaces such as asphalt, dark soil and dark forests

Heat Sinks

- An object that absorbs energy and becomes warmer
- Water and air are the earth's major heat sinks since they can hold a lot of heat
    - Eg: the oceans absorb solar energy which causes water to move and transfer energy into the ocean depths (convection)

- Soil and rock are poor heat sinks because heat is transferred (conducted) slowly

Heat Source

- Any warm body such as water or land in contact with colder air
- Recall that heat is transferred from a warm object to a cooler one

Heat Capacity

- A measure of how much heat is required to increase the temperature of a substance or how much heat is released as temperature decreases

    - Water and air have a high heat capacity since they are good heat sinks
    - Soil and rocks have low heat capacity since they are poor heat sinks

- This difference in heat capacity explains why a lake takes longer to heat up during the day than does land (takes more energy to increase the temperature of the water). However, the lake takes longer to cool off in the evening than does land because the water releases the energy more slowly.

Latent Heat

- A measure of the attraction between particles in a substance
- Eg: when changing state from a solid to a liquid to a gas attractions must be overcome

a) Latent Heat of Fusion (Melting)
   - The amount of energy that must be absorbed by a substance in order to melt

b) Latent Heat of Vaporization (evaporation)
   - The amount of energy that must be absorbed by a substance in order to evaporate

THE HYDROSPHERE AND THE WATER CYCLE (p.522 - 524)

Hydrosphere

- All of the earth's water including salt water, fresh water and ice.
- 70%of the planet's surface is covered by water
    - 97.5% = salt water   2.5% = fresh water

- it is because there is so much water that the earth's weather systems are greatly affected by water in its 3 physical states, by the changing of water from one state to another and by the energy involved in these changes

The Water Cycle

- the means by which heat energy is transferred between the hydrosphere and the atmosphere
- the processes involved include evaporation (l → g), condensation (g → l), sublimation (s → g or g → s), precipitation, percolation and runoff

Steps:

1. Solar energy causes *evaporation* from bodies of water and from plant leaves (*transpiration*) as well as *sublimation* of ice.

2. The water vapor (gas) rises and as pressure and temperature decrease with increasing altitude, the vapor undergoes *condensation* to form fog, mist and clouds and/or *sublimation* into ice crystals

3. *Precipitation* falls to the surface in the form of rain, snow, etc.

4. Water seeps into the ground (*percolation*), and enters bodies of water as runoff from land.

The Cycle Continues!

Assign: p.507, 1-8; p.524, 1-4

<u>CLOUDS AND FOG</u> (p.530 – 534)

Cloud: *a visible aggregate of minute particles of water and/or ice in the air*

Cloud Formation

- Warm air is less dense then cold air and rises into the atmosphere
- When water in the warm air absorbs energy the water molecules move more quickly and change from liquid to a gas (evaporation)
- These molecules rise with the warm air
- When the water vapor reaches higher elevations where pressure and temperatures are lower the molecules lose energy and change from gas to liquid (condense into clouds)

Three Main Categories of Clouds

1. Convective Clouds
    - Produced where air near the ground absorbs energy from warm surfaces (bodies of water or land), water vapor rises with the warmed air, cools and condenses to form clouds

2. Frontal clouds
    - Form where the leading edge (front) of a large, moving air mass meets another air mass with a different temperature
    - The warm air is pushed upward, water vapor rises with it, cools and condenses to form clouds

3. Orographic clouds
    - Form where air moves up a mountain (*orographic lifting),* water vapor rises with it, cools and condenses to form clouds

Types of Clouds

- 2 general shapes:

1. *Cumulus* ('heap')
    - Billowing, rounded shape that tend to grow vertically
    - Indicate unstable weather
    - Usually form as a result of convection currents, orographic lifting or when a cold air front pushes into a warm air mass

2. *Stratus* ('stretched out')
    - Flattened, layered shape that tend to grow horizontally
    - Indicate stable weather
    - Form where a front of a warm air mass overruns a cold air mass

Clouds are further classified according to their altitudes in the atmosphere:

a) Low-level clouds = cumulus and stratus

b) Medium-level clouds = given the prefix 'alto' (higher) Eg. altostratus and altocumulus

c) High-level clouds = cirrus

d) Rain-holding clouds = nimbus Eg. cumulonimbus and nimbostratus

Fog: *A cloud that forms near the ground*

Fog Formation

- Fog, like other types of clouds, forms because of a change in temperature
- In general, it occurs when water vapor within warm air is cooled and condenses into fog near the surface

- *How fog can form:*

1. On clear nights when energy radiates upward from the surface but isn't reflected back to Earth because there are no clouds then air near the ground cools and water vapor within it condenses into fog

2. When warm air passes over snow cover

3. When moist sea air drifts over a cold current or a seashore

4. When moist air rises up the sides of mountains during orographic lifting

Assign: p. 534, 1,2 & 4

<u>PRECIPITATION </u>(p.556-557)

- Water that reaches the ground in either liquid or solid form
- Occurs when air reaches it's saturation point and the water vapor in the air condenses to form liquid droplets. When many droplets join together they become heavy enough to fall to the surface
  - The type of precipitation that reaches the surface depends on the temperature in the atmosphere, and, more importantly, the temperature near the ground

  - Liquid forms: drizzle, rain and dew
  - Solid forms: snow, ice pellets (sleet), hail, frost and freezing rain

Assign: p. 557, 1-4 & 6

<u>HUMIDITY</u> (P.558 – 561)

- A measure of the amount of water vapor in the atmosphere
- It affects the weather and how comfortable we feel

- Low humidity = Evaporation can occur from bodies of water

- High humidity = Evaporation cannot occur;
  Condensation can occur producing clouds &/or fog

Relative Humidity

- A measure of the amount of water vapor in the air as a percentage of the maximum amount the air can hold at that temperature
- Warm air can hold more moisture than cold air.
  - *Figure 1 (p.558)* shows the maximum concentration of water vapor in dry air (in g/kg) at different temperatures to give 100% humidity = *saturated air*

Calculations involving relative humidity:

Example 1: If the concentration of water vapor at 0^oC is 1.9g/kg of dry air, what is the relative humidity?

$$\text{Relative humidity} = \frac{\text{concentration}}{\text{Maximum concentration}} \times 100$$

Example 2: Determine the concentration of water vapor in air at 20^oC when the relative humidity is 50%

Determining Relative Humidity

- A *psychrometer* is used (*Figure 3, p.560)*
  - A set of 2 thermometers: a regular dry-bulb thermometer and a wet-bulb thermometer, the bulb of which is surrounded by moist gauze
  - In dry air, moisture will evaporate from the wet-bulb thermometer and its temperature will drop
  - The lower wet-bulb temperature is compared to the air temperature from the dry-bulb and the relative humidity is determined (*Table 1, p.560)*
  - When the air is saturated (100% humidity) both thermometers will have the same temperature reading; if not saturated, the wet-bulb will have a lower reading than the dry-bulb

Example 3: The air temperature in a classroom is 22^0C and the wet-bulb temperature is 17^oC. Determine the relative humidity of the room.

Effects of Humidity

Humidity affects personal comfort levels:

a) High humidity
   - Normally, when a person perspires, evaporation of perspiration removes heat from the body and cools it down
   - Perspiration cannot easily evaporate when humidity is high so the person can feel uncomfortably hot

b) Low humidity
   - Evaporation occurs quickly because the air can hold a lot more moisture, so the skin can become uncomfortably dry

Assign: p. 561. 1, 4, 6, 8

THE ATMOSPHERE (P.510-514)

- The blanket of air and moisture that surrounds the earth.
- It's most dense at sea level and decreases as height above sea level decreases
- Near Earth's surface, the atmosphere consists of 78% N_2, 21% O_2 and 1% other gases (Ar, CO_2, H_2O, ozone, etc)

Atmospheric Layers

- Differ in altitude (elevations, heights above sea level), temperature, composition and pressure
- All layers are thicker above the equator than above the poles because air above the equator is warmer and therefore it expands and takes up more space than the cold air above the poles

1. <u>Troposphere</u>

- Altitude: 8 to 16 km above the surface
- Contains most of the atmosphere's moisture and is responsible for most of our weather systems
- As altitude increases, temperature decreases
- by about 6^{o}C for every 1000m rise
- *temperature gradient = change in temperature over a distance*
  = - 6^{o}C per 1000m for this layer

- The *tropopause* is a thin boundary zone at the top of the troposphere
  - Contains more ozone than the rest of the troposphere therefore the temperature is higher in this zone (since ozone absorbs UV radiation from the sun)

2. <u>Stratosphere</u>

- Altitude: 12 to 15 km above the surface
- Contains the most ozone (the ozone layer) which protects the earth from the damaging affects of UV radiation from the sun
- As altitude increases, temperature increases because of the large amount of ozone

3. <u>Mesosphere</u> ('meso' = middle)

- Altitude: 50 to 80 km above the surface
- Extremely low temperatures and low density

4. <u>Thermosphere</u>

- Altitude: 80 to 500 km
- Low density but higher temperatures than the mesosphere because particles have higher energy due to the fact that they absorb the highest energy electromagnetic waves from the sun.
- Also called the *ionosphere* because particles become electrically-charged ions as they absorb the high energy radiation to produce *auroras*

5. <u>Exosphere</u>

- Altitude: 500 km to ….
- Thin, outermost layer with few particles
- 'Space'

Importance of the Atmosphere

- It supports life on the planet in 2 major ways:

a) Major gases: O_2, N_2 and CO_2 and ozone
   - Oxygen for cellular respiration, Nitrogen for protein production, carbon dioxide for photosynthesis and ozone for protection against UV radiation

b) Physical factors
   - important in the water cycle, providing fresh water for living things
   - helps keep the average global temperature within a life-supporting range
     - it contains gases such as CO_2 which trap heat energy radiated from the ground (greenhouse effect)
     - it circulates air (wind) to maintain a constant balance of energy around the world

Atmospheric (Air) Pressure

- the pressure the air exerts as gravity pulls it toward the center of the earth
- it is greatest at sea level, where particles are closest together (density is highest) and decreases with increasing altitude
- at any particular altitude the air pressure also depends on whether air is rising (lowering air pressure) or falling (increasing air pressure)

Pressure gradient
- a measure of the amount the air pressure changes across a set distance
- can be vertical or horizontal

a) Vertical (Figure 4a, p.512)
- Shows that the pressure decreases rapidly with increasing altitude

b) Horizontal (Figure 4b, p.512)
- Shows horizontal pressure gradients using lines of equal air pressure = **isobars**
- Isobars close together = high pressure gradient; indicates strong winds
- Isobars farther apart = low pressure gradient; indicates lower wind speeds

- Isobars are used on weather maps to indicate low and high pressure systems as well as the direction and speed of winds

Measuring Atmospheric Pressure

- Units = kilopascals (kPa)   1kPa = 1000 Pa   Ground level = 100 kPa

- **Aneroid Barometer** ('without liquid') Figure 5, p.512
- The most common instrument used to measure air pressure
- It consists of a sealed metal container with expandable sides.
- As air pressure decreases, the container expands
- As air pressure increases, the container contracts
- This movement causes a needle to move as well; the amount of movement is calibrated against a scale that indicates how much the pressure has changed

Assign: p. 513, 2-7 & 9.

<u>GLOBAL GEOGRAPHY</u> **(p.502 – 503)**

Longitude
- The angle measured east or west from the 0^o line (runs through Greenwich, England)
- Vertical lines that run north to south

Latitude
- The angle measured north or south of the 0^o line (the equator)
- Horizontal lines that run east to west

Northern Hemisphere
- North of the equator
- Contains 2 important latitudes:
  - *Tropic of Cancer* = 23.5^oN latitude
  - *Arctic Circle* = 66.5^oN latitude

Southern Hemisphere
- South of the equator
- Contains 2 important latitudes
  - *Tropic of Capricorn* = 23.5^oS latitude
  - *Antarctic Circle* = 66.5^oS latitude

Tropics
- Large equatorial region between the Tropic of Cancer and the Tropic of Capricorn

Polar Regions
- North of Arctic Circle and South of Antarctic circle

Mid-latitudes
- Between the tropics and polar regions
- Most of Canada is in this area

<u>SEASONS AND THE ANGLE OF THE SUN</u> **(p.508- 509)**

- Earth *revolves* (orbits) the sun elliptically and *rotates* (spins) around an internal axis that is tilted at an angle of 23.5^0 with respect to its plane of orbit around the sun.

  - The seasons are determined by the position of the earth as it revolves around the sun combined with the tilt of the earth on its axis

  - Earth's rotation on its axis causes day and night

- The beginning of each season is marked by **solstices** and **equinoxes**:

Solstice*:* ' Sun stands still' ie. does not move any further north or south
Summer: day of maximum daylight hours
Winter: day of minimum daylight hours

Equinox: ' Equal night' ie. day and night are of equal length

<u>Progression of the Seasons:</u>

- The following outline important dates for the Northern Hemisphere (the opposite occurs in the Southern Hemisphere)

Summer Solstice
- June 21, the first day of summer
- N.H. is at its maximum tilt toward the sun so it is the maximum daylight period
- Sun is over the Tropic of Cancer (N.H.) so sun's rays are hitting N.H. most directly, therefore the sun's rays have their maximum intensity since they are concentrated over a smaller surface area

Autumnal Equinox
- September 23, the first day of fall
- Sun is directly over the equator
- The sun is above the horizon for 12 hours and below the horizon for 12 hours

Winter Solstice
- December 21, the first day of winter
- N.H. is at its maximum tilt away form the sun is it is the minimum daylight period
- Sun is over the Tropic of Capricorn (S.H.) so sun's rays are hitting N.H. at a steep angle, therefore the sun's rays have their minimum intensity since they are spread over a larger surface area

Vernal Equinox
- March 21, the first day of spring
- Sun is directly over the equator
- The sun is above the horizon for 12 hours and below the horizon for 12 hours

Assign: p. 509, 1-4

<u>PREVAILING WINDS</u>

Wind: a movement of air in the atmosphere

Local or Regional Winds: occur in fairly small areas

Prevailing Winds: major wind patterns that affect large areas

<u>The Coriolis Effect</u>
- An apparent change in the direction of a moving object within a rotating coordinate system.
  - The earth's rotation creates an apparent force ("Coriolis force") that deflects moving air to the right of its initial direction in the Northern Hemisphere and to the left of its initial direction in the Southern Hemisphere.
  - The effect is proportional to wind speed; that is, deflection increases as wind strengthens.
- When viewed from a point above the North Pole, Earth rotates eastward or counterclockwise
- Objects in motion in the N.H. appear to move to the right

<u>Major Wind Patterns and how they are created:</u>

- They are due to a combination of convection currents and earth's rotation.

1. *The Trade Winds*:

- Occur between the equator and 30^o latitude.

- The sun heats up air at the equator causing the hot air to rise, leaving behind an area of low pressure.
- This rising air moves northward, cools, becomes more dense and falls around 30^o latitude.
- This air moves back towards the equator (low pressure area) producing the trade winds.
- This air movement twists to the right in the northern hemisphere to form the *northeast trade winds*. (They twist left in the southern hemisphere - *southeast trade winds)*

2. Mid-latitude Westerlies

- Occur between 30^o and 60^o latitude

- At 30^o latitude some of the warm air from the equatorial convection current meets cold polar air, creating low pressure around 60^0 latitude. The surface air moving north twists to the right in the northern hemisphere (left in Southern hemisphere) to form the *mid latitude westerlies.*

3. Polar Easterlies

- Occur between 60^0 latitude and the poles

- 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 *easterlies.*

4. Jet Streams

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

Summary: Air pressure gradients, or the difference between regions of high and low air pressure, impel air in the direction of lowest pressure, creating wind. The larger the air pressure gradient, the greater the wind speed. The Coriolis effect also affects wind speed and direction.

Effects of Prevailing Winds

- Distribute large amounts of solar energy from the equator.
- Return cooler air to the equator.
- Carry moisture
- Cool falling air is dry, creating desert like conditions around 30^o latitude.
- At 60^o mixed systems rise creating unsettling conditions.

Assign: p.519, 1-3

MAJOR OCEAN CURRENTS (p.525 – 527)

- *Figure 1,p.525* shows the major ocean currents of the world

<u>Causes of Ocean Currents;</u>

1. ***Convection currents***
   - Water at the equator absorbs the intense, direct rays of the sun and becomes heated
     - This warm water is less dense than cold water and moves away from the equator towards the poles. The warm water is replaced by cold water from below (originating from the polar regions). This starts a convection current.

2. ***Prevailing winds and the Coriolis effect***
   - Ocean currents tend to follow the prevailing winds blowing at the surface

3. ***Earth's rotation***
   - Because of Earth's eastward rotation currents on the *west sides* of oceans tend to be narrow and fast moving and those on the *east sides* of oceans are wide and slow moving

4. ***Shapes of the Continents***
   - Where currents encounter a landmass they are deflected away from the path produced by the prevailing winds. Exception: Antarctic Circumpolar Current

5. ***Heat Capacity of water***
   - Oceans act as huge heat sinks so they heat up slowly and, once heated, cool down slowly

6. ***Amount of salt***
   - When seawater evaporates, the salt left behind makes the remaining water more dense. This dense seawater sinks and creates a deep water current.

<u>Effects of Ocean Currents:</u>

1. ***Creation of rain forests***
   - Warm currents heat the air above them which increases the air's ability to carry moisture
   - Creates rain forests on the *east side* of continents
   - Eg: Brazilian rain forest of eastern South America

2. ***Creation of deserts***
   - Cool currents cool the air above them which decreases the ability of the air to hold moisture
   - Creates deserts on the *west side* of continents
   - Eg: desert area in Peru of western South America

3. ***Moderation of temperature***
   - A coastal area will tend to have cooler summers and milder winters than an inland location at the same latitude due to the moderating affect of a large body of water ie. it prevents the extremes in temperature
   - Eg. St.John's is warmer in winter than Ottawa because of the warm moist air brought northward by the Gulf Stream

Assign: p.527, 1-3, 5 & 7

WEATHER FORECASTING **(p. 542 - 543)**

Meteorology: the study of the atmosphere and weather forecasting

Studied by ***meteorologists***

WEATHER FORECASTING TECHNOLOGY (p. 567 – 570)

1. Weather Satellite
   - An orbiting spacecraft that regularly gathers weather-related data and images and relays them to weather stations on the ground

   - *High-orbit satellites*
     - Orbit about 36,000 km above the equator
     - Provide images that show cloud cover, earth's physical features & amount of infrared radiation from the atmosphere

   - *Low-orbit satellites*
     - Orbit about 1000 km above the poles
     - Gather data that is used to detect changes in air temperature and water vapor at different levels of the atmosphere, as well as global wind patterns

2. Weather Balloons
   - Helium-filled balloons that are launched 2 or more times per day from weather stations across North America
   - Carry instruments that collect data on temperature, pressure, humidity and ice-crystals
   - Can also be used to determine speed and direction of winds

3. Ground-Based Technology
   - Instruments used at weather stations

Instrument	**Weather factor measured**
Thermometer	Current minimum & maximum temperatures
Anemometer	Wind speed & direction
Aneroid barometer	Atmospheric pressure
Rain Gauge	Rainfall
Hydrometer	Relative humidity

4. Computer Technology
   - Data from satellites, weather balloons and ground-based instruments are gathered, stored and analyzed by computer software
   - Computers linked to satellite communication systems allows info to be sent around the world

Weather System: a set of temperature, wind, pressure and moisture conditions for a certain region, that moves as a unit over a period of days

NORTH AMERICAN WEATHER SYSTEMS (p. 546 – 549)

- In the mid-latitude regions of North America weather is difficult to forecast because it changes so often (because in this region cold air form the north meets warm air from the south)
- It's easier to forecast near the equator (usually hot and humid) and near the North Pole (usually cool and dry).

Air Masses

- The bases of weather systems in N.A.
- Large bodies of air in which temperature and moisture content at a specific altitude are fairly uniform
- Vary in size, from 100 km across to 1000 km across
- Most form where air above surface is fairly still for days or weeks and air takes on the moisture and temperature properties of the surface
- Help maintain Earth's energy balance ie. Convection and prevailing winds move warm, tropical air northward and cold, polar air southward.

THE 6 NORTH AMERICAN AIR MASSES

Air Masses	**Temperature**	**Moisture Content**	**Where they form**	**Direction they move**
Maritime Polar (West Coast)	Cool	moist	Over North Pacific Ocean	Northwest to southeast
Maritime Polar (East Coast)	Cool	moist	Over North Atlantic Ocean	Northeast to southwest
Continental Polar	Cold	dry	Over mid-polar Regions of N.A.	North to south
Maritime Tropical (West Coast)	warm	moist	Over South Pacific Ocean	Southwest to northeast
Maritime Tropical (East Coast)	warm	moist	Over South Atlantic Ocean	Southeast to northwest
Continental Tropical	warm	dry	Over mid-southern U.S. & northern Mexico	South to north

Low-Pressure Systems: *tend to bring cloudy skies and stormy weather*

Front: the boundary between a cold air mass and a warm air mass

Warm front: the leading edge of a warm air mass

Cold front: the leading edge of a cold air mass

Occluded front: forms when a cold front catches up with a warm front; the warm air is lifted above the earth's surface and is cut off (occluded) from the cooler air below

Stationary front: occurs when the boundary between warm and cold air masses remains still for some time

FORMATION OF A LOW-PRESSURE SYSTEM (STORM)

A front forms between a cold air mass and a warm air mass

⇓

Fast-flowing air in the jet stream pulls air up out of both air masses, creating a low-pressure system near the ground.

⇓

The low-pressure area pulls in air near the surface

⇓

The rising air swirls in a counter-clockwise direction (Coriolis effect)

⇓

The warm front rises over the cold air mass, carrying moisture with it and the cold front pushes under the warm air mass, causing warm, moist air to rise steeply.

⇓

A region of precipitation forms in front of the warm front as the jet stream continues to pull air away. Cumulonimbus clouds form and bring precipitation

⇓

An occluded front forms as the warm front is caught by the cold front, cutting it off from the cooler air below (in the low-pressure system)

⇓

The storm ends as upper air flow no longer pulls air away from the low-pressure area and a stationary front forms

Cyclogenesis: the process of forming a cyclone

Cyclone: a low-pressure system that rotates counterclockwise (in the Northern Hemisphere) and usually brings cloudy, stormy weather

Anticyclone: a high-pressure system that rotates clockwise (in the Northern Hemisphere) and usually brings clear skies

Warm high-pressure systems:

- form at 30^0 latitude, when air in the equatorial convection currents that are heading northward becomes colder and more dense and move downward, toward the surface.

Cold high-pressure systems:

- occur in central Canada and the Arctic regions, especially in winter, from the cold, dry, descending Arctic air

<u>REGIONAL WEATHER</u> (p. 553- 556)

Thermals **= thermal updrafts**

- Local convection currents set up during the day

<u>Steps:</u>

On a clear, sunny day, solar energy warms the land
⇓
land absorbs the energy and converts it into heat, which warms the nearby air
⇓
warm air expands, becomes less dense and rises
⇓
rising warm air is replaced by cooler, denser air
⇓
sets up a convection current

Sea Breeze**:**

- a convection thermal that flows from a large body of water toward the land

<u>Steps:</u>

In early morning, solar energy warms the land faster than the water
⇓
Warm air above land rises and moves out over the water
⇓
warm air is replaced by cooler air from above the water
⇓
sets up a convection current

Land Breeze**:**

- a convection thermal that flows from the land toward a large body of water

<u>Steps:</u>

As the sun sets, the land cools down faster than the water
⇓
Warmer air above water rises and moves in over the land
⇓
warm air is replaced by cooler air from above the land
⇓
sets up a convection current

Lake-Effect Snow:

- When an air mass moves across a large body of water it picks up moisture. In winter the air above the land is colder than the air above the water, therefore when the air blows onshore the colder air temperature causes the moisture to change to snow.

Chinook Winds: ('snow eater')

- On the west side of the Rockies orographic lifting causes water vapor in the air to condense into clouds, snow and rain. A lot of energy is released during this phase change so that the air is warmed
- The air that sinks on the east side is warm and dry producing the warm, dry chinooks

Assign: p. 549, 1-4, & 6; p.555, 1-3, Case Study, p.550 (Weather Maps- p.683)

EXTREME WEATHER Chapter 15

Thunderstorms and Tornadoes (p.584 –588)

Thunderstorms:
- A storm with lightning, thunder, heavy rain and sometimes hail
- Results from the uplift of air and moisture high into the troposphere

Tornadoes:
- Form in the most severe thunderstorms
- Fast rising air begins spinning, forming a funnel of air and moisture. As it rises it turns to the right due to the Coriolis Effect.
- Travel at speeds of up to 100 km/h

Floods and Droughts (p.589 – 591)

Floods:
- Excess of water from rain, rivers, or oceans that form over land that cannot soak up any more water

- 2 Types:

  Broadside – cover a large land area; seasonal, predictable floods
  (eg. Monsoon Flooding)

  Flash - quick onset; difficult to predict
  (eg. Badger, NL)

Drought:
- occur whenever precipitation is very low over a long time period
- common in areas at or near 30^{o} latitude (high pressure areas)
- eg. Dust Bowl of 1930's in the prairies

Hurricane, Typhoons and Tropical Cyclones (p. 594 – 597)

- All are cyclones: massive high-energy low pressure systems which have resulted from the large amounts of energy from hot, tropical marine air masses spinning off of equatorial ocean areas.

- The names are different due to the regions in which they are found.
  - Hurricanes: eg. Atlantic Ocean
  - Typhoons: eg. Pacific Ocean
  - Tropical Cyclone: eg. Indian Ocean

Blizzards and Ice Storms (p. 598 – 603)

Blizzards:
- Severe snow storms with strong winds (> 55 km/h) and low temperatures
- Can develop when a warm moisture-laden air mass moves northward and meets a cold Arctic air mass, under a strong jet stream.

Ice Storms:
- Freezing rain that lasts for several hours
- Can occur when a warm air mass meets a cold air mass and the cold air mass pushes the warm one upward.
    - The moisture in the warm condenses into clouds and ice crystals. As ice crystals fall through air mass they melt to form rain.
    - The raindrops fall through cold air mass, cool and then freeze instantly when they hit a cold object on the ground

Extreme Heat and Cold (p. 604 – 607)

Heat Wave
- A period of more than 3 days at or above 32°C
- Can occur when southern continental air masses produce long term warm, high pressure systems as they fall over regions in central Canada.
- Often exaggerated over cities where it may produce a "temperature inversion" which traps warm air and pollution over these regions preventing normal convection from occurring.
- Can feel hotter with high humidity

- Humidex Scale: combines the temperature and relative humidity to give a temperature indicating how it feels to humans

Extreme Cold
- Can occur when large polar air masses may be drawn southward by advection bringing much cooler than normal temperatures.
- Can feel colder with high winds

- Wind chill factor: takes into account the cooling effect of wind to indicate what the temperature would feel like with the wind

El Nino and La Nina (p. 612 – 615)
- Major changes in the seasonal weather systems in the South Pacific resulting from the changes in the ocean convection currents

El Nino:
- Caused by high surface water temperatures and water levels in the western Pacific
- May result in warm temperatures in Canada

La NIna:
- Caused by low surface water temperatures in the eastern Pacific
- May result in colder temperature in Canada