Water and the Atmosphere

Chapter 4: Weather

8th Grade

Lesson 1 (Water in the Atmosphere)

Water cycle – the continual movement of water among Earth's atmosphere, oceans, and land surface through evaporation, condensation, and precipitation

Evaporation – the process by which water molecules in liquid water escape into the air as water vapor

– When liquid water warms up, the particles move faster and faster. The fastest ones at the surface are going so fast they can break free into the air.

Condensation – the process by which molecules of water vapor in the air become liquid water as they cool

– When water vapor particles cool they move slower and clump together to form droplets of liquid water.

– When the water droplets become too large, gravity pulls them to the ground as **precipitation**.

Humidity – the amount of water vapor in a given volume of air

– Warm air can hold more water vapor than cool air. (When water vapor is cooled, condensation takes place in the air to form clouds and eventually precipitation.)

Relative humidity – the percentage of water vapor that is actually in the air compared to the maximum amount of water vapor that air can hold at a particular temperature

– 100% relative humidity means the air is saturated with water vapor. (The air is holding as much water vapor as it possibly can at that temperature.)

– 50% relative humidity means the air can hold twice as much water vapor than what it currently has at its current temperature.

Psychrometer – an instrument used to measure relative humidity, consisting of a wet-bulb thermometer and a dry-bulb thermometer

Lesson 2 (Clouds)

Clouds – form when water vapor rises, cools, and condenses to form water droplets or ice crystals on tiny particles in the air

– Tiny particles of dust or smoke must be in the air for clouds to form so the water has a surface to attach to.

Dew point – the temperature at which condensation of water vapor in the air begins

– Dew point above freezing – water droplets form (dew)

– Dew point below freezing – ice crystals form (frost)

Types of Clouds:

Cumulus – fluffy, white clouds, usually with flat bottoms, that look like rounded piles of cotton

– Short cumulus clouds indicate fair weather and are common on sunny days.

Cumulonimbus – towering cumulus clouds with flat tops and bottoms that often produce thunderstorms

Cirrus – thin, wispy, feathery clouds made mostly of ice crystals that form only at the **highest levels**

Cirrocumulus – high altitude clouds that look like rows of cotton balls overlapping each other like fish scales

– Often indicate that a storm is on its way.

Stratus – clouds that form in flat layers and often cover much of the sky and are a uniform dull, gray color

Nimbostratus – stratus clouds that have thickened and may produce drizzle, rain, or snow (but not thunderstorms)

Altocumulus, **Altostratus** – Middle-level clouds that are higher than regular cumulus and stratus clouds. (But lower than cirrus, which are the highest clouds.)

Fog – clouds that form at or near the ground

– Forms when the ground or a body of water is cooler than the air temperature.

– This cools the air just above the ground or water to the air's dew point and allows condensation to take place in the air.

Lesson 3 (Precipitation)

Precipitation – any form of water that falls from clouds and reaches Earth's surface

When cloud droplets become too large for the atmospheric conditions to hold them up, gravity pulls them to the ground.

Liquid precipitation comparison:

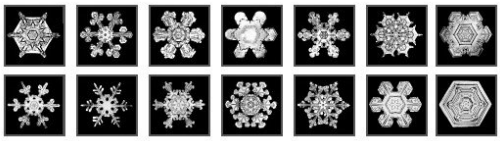
1. Cloud droplet – smallest (less than 0.02 *mm*)
2. Mist droplet – (0.02 – 0.05 *mm*)
3. Drizzle droplet – (0.05 – 0.5 *mm*)
4. Raindrop – (0.5 – 5 *mm*)

Freezing rain – falls as a liquid, then freezes when it hits or coats a very cold surface

Sleet – starts as liquid raindrops, but freezes on the way down as it passes through air that is below 0ºC (32ºF) to form ice particles smaller than 5 *mm*

Hail – a pellet of ice larger than 5 *mm*
- have layers (like an onion)
- form only in **cumulonimbus clouds**
- starts as an ice pellet that is pushed up through cold regions of the cloud by updrafts, adding a new layer of ice each time it is pushed up
- eventually becomes too heavy, then falls

Snow – forms when water vapor in a cloud is converted directly into ice crystals (was never a liquid)
- The type of snowflake that forms depends on the temperature and the amount of moisture in the cloud where they form.
- Many of the largest snowflakes are not individual snowflakes, but are bits of many broken snowflakes that have been frozen together.



Feathery star shapes form when the amount of moisture in the cloud is moderate.

Feathery star shapes usually form at warmer temperatures as well.

When its drier, plate-like shapes are more likely to form.

Plate-like shapes are more likely to form when it's very cold.

What basic shape do all snowflakes have in common? (6 sided or branched, or hexagonal)

The most intricate snowflake patterns are typically formed during _warm_ and _wet_ conditions.

Lesson 4 (Air Masses)

Air mass – a huge body of air that has similar **temperature**, **humidity**, and **pressure** throughout

Cold dense air has a higher pressure because the particles are closer together and hit things more often. (Warm, less dense air has a lower pressure.)

Tropical air mass – a warm air mass that forms in the tropics and has low pressure

Polar air mass – a cold air mass that forms north of 50º north latitude and south of 50º south latitude (have higher pressure)

Maritime air mass – an air mass that forms over oceans and is humid due to evaporated water

Continental air mass – a dry air mass that forms over land

Types of Air Masses: (classified according to temperature and humidity)

1. **maritime tropical** – warm, humid air mass that comes from the South Pacific, South Atlantic, or Gulf of Mexico toward the U.S.
2. **continental tropical** – hot, dry air mass that forms mostly in summer over dry areas of the Southwest and Northern Mexico
   - bring hot, dry weather to the Midwest as they travel northeast
3. **maritime polar** – cool, humid air mass that forms over the North Pacific and North Atlantic oceans
   - affect the West Coast more than the East Coast with fog, rain, and cool weather
4. **continental polar** – cool, dry air mass that forms over northern Canada and Alaska
   - bring bitterly cold weather with very low humidity in winter
   - In summer, they develop storms when they move south and collide with a maritime tropical air mass moving north.

Prevailing westerlies and **jet streams** usually push air masses from west to east. (This is why most of our "weather" comes from the west, southwest, of northwest.)

Front – the boundary where unlike air masses meet, but do not mix
- Storms often develop along fronts as two air masses collide and the less dense air mass is pushed upward.

Types of Fronts:

Cold fronts – where a fast-moving cold air mass overtakes a slow-moving warm air mass
- The denser cold air slides under the warm air, pushing the warm air upward.
- As the warm air rises, water vapor condenses, and clouds form.
- Since cold fronts move quickly, rapid changes in weather can take place.

Warm fronts – where a fast-moving warm air mass overtakes a slow-moving cold air mass
- The warm air mass slides over top of the cold air mass, water vapor condenses, and clouds form.
- Since warm fronts move more slowly, the weather may be cloudy, rainy, or snowy for many days.

Stationary fronts – where cold and warm air masses meet, but neither one can move the other
- Where the air masses meet, water vapor condenses, clouds form, and may result in clouds or precipitation for many days as the front is stalled.

Occluded fronts – where a warm air mass is caught between two cooler air masses
- The warm air is pushed upward, clouds form, and precipitation may result.

Weather maps:

L = area of relatively low air pressure that often **results in precipitation**

H = area of relatively high air pressure that usually **results in clear skies**

Cyclone – a swirling center of low air pressure (called "lows" on a weather map)
- As air masses collide, mountains or strong winds (jet stream) can distort, or bend the boundary along the front.
- The air along the front begins to swirl and can cause a low-pressure center to form.
- As warm air at the center of a cyclone rises, the pressure decreases even more.
- Cooler, higher pressure air rushes into this area, creating the swirling action.
- Cyclones have winds that swirl **inward** and **upward** toward the center. (Counterclockwise as viewed from above in the Northern Hemisphere)
- Cyclones bring clouds, winds, and precipitation.

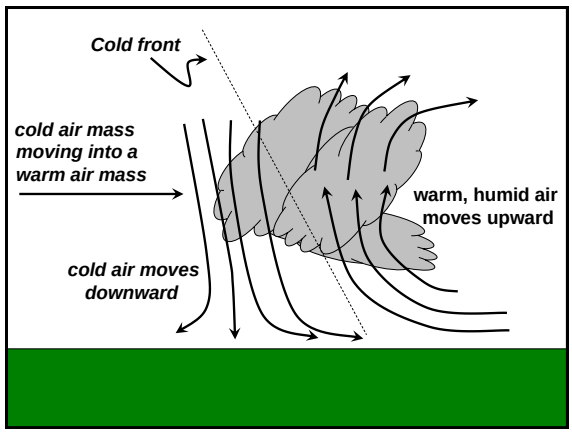
Anticyclone – a high pressure center of dry air (called "highs" on a weather map)
- Winds spiral **outward** and **downward** from the center, moving towards areas of lower pressure.
- They spin clockwise, as viewed from above in the Northern Hemisphere.
- Cool air moves down from above to take the place of the air that spiraled out of that area.
- The descending air usually causes dry, clear weather.

Lesson 5 (Storms)

Storm – a violent disturbance in the atmosphere
- Storms may or may not involve precipitation.
- Storms involve sudden changes in air pressure that cause sudden changes in air movement.

Lake-effect snow – an event that explains why cities in upstate New York get an immense amount of snow.
- In the fall, the land cools more rapidly than the water in the Great Lakes.
- As cold, dry air moves from the NW across the lakes, it is warmed by the water and picks up a great amount of water vapor.
- As the warming air reaches the other side of the lake, it rises and cools again.
- As warm air cools, condensation, cloud formation, and precipitation (snow) falls.
- This ongoing process continues throughout the winter.

Thunderstorms:
- form in large cumulonimbus clouds, also known as "thunderheads"
- form when warm, humid air rises rapidly on hot humid afternoons, or when air is forced upward along a cold front
- Within the thunderhead are strong upward and downward winds (updrafts and downdrafts).



Lightning – a sudden spark, or energy discharge, caused when electrical charges jump between parts of a cloud, from one cloud to a nearby cloud, or between a cloud and the ground

Fulgurite – a tube-like figure left after lightning strikes sandy ground, melts the sand grains, and fuses them together

Calculating Thunderstorm Distance:

Count the seconds between seeing the lightning and hearing the thunder, then divide by 5 for miles. (Divide by 3 for kilometers.)

Tropical disturbance – a low pressure area over warm ocean water

– When a tropical disturbance intensifies, or becomes more severe, it becomes a tropical storm.

Tropical storm – a mild cyclone that forms in a low pressure area over warm ocean water

– When a tropical storm intensifies, it becomes a hurricane.

Hurricane – a tropical cyclone that has winds of about 119 *km/hr* to 320 *km/hr*. (75 - 200 *mph*)

– As warm, humid air rises and forms thick clouds, cooler air rushes in to take its place.

– Winds spiral inward at very high speeds to the area of lowest pressure at the center.

– The lower the air pressure at the center of the storm, the faster the winds move.

– Hurricanes last longer than most storms (usually a week or more) but lose strength as they hit land due to the lack of warm, moist air that fuels them.

Eye – the name given for the center of a hurricane

– Winds are strongest near the eye, but are calm in the eye.

Storm surge – a "dome" of water that sweeps across the coast where a hurricane lands

– The area covered by a hurricane has a raised water level (up to 6 meters high) due to the low pressure and high winds.

Typhoon – a hurricane in the Western Pacific

How Tornadoes Form:

1. Tornadoes form in the same clouds that bring thunderstorms (cumulonimbus).
2. Warm, moist air flows in at the bottom of a cumulonimbus cloud and moves upward.
3. This forms a low-pressure area in the cloud.
4. The rising warm air begins to rotate within the cloud as it meets winds blowing at different directions in the cloud.
5. Downdrafts bring the rotating air to the ground to form a funnel.
6. Updrafts can tilt the rotating funnel and cause it to spin even faster (up to 500 *km/h*r or 300 *mph*).
7. The extreme low pressure inside a tornado sucks up dust and other objects into the funnel.

Fujita scale – rates tornadoes by the amount of damage they cause, from light damage (F0) to extreme damage (F5).

tornado watch – conditions are right to form tornadoes

tornado warning – a tornado has been actually spotted of detected on radar

water spout – a tornado that touches down over a lake or ocean

Lesson 6 (Predicting the Weather)

Meteorologist – a scientist who studies and tries to predict the weather

Barometer – an instrument used to measure changes in air pressure

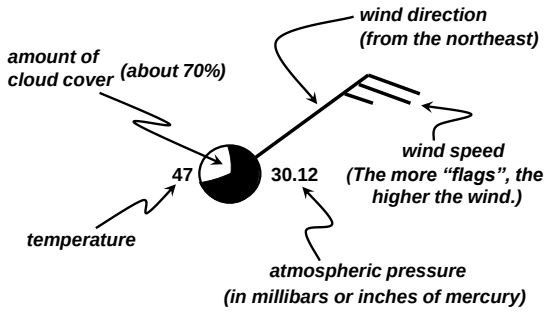
Anemometer – an instrument that measures wind speed

Reading the Weather:

– If a barometer reading shows falling air pressure – rain or snow is possible.

– On a warm afternoon, cumulus clouds growing taller and larger may become cumulonimbus clouds.(may produce thunderstorms)

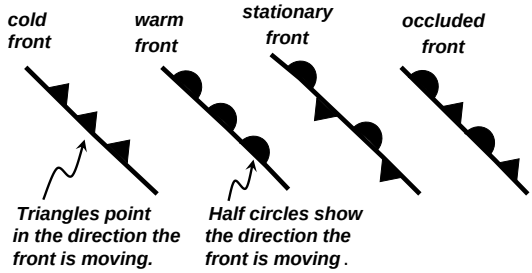
National Weather Service map symbols:



isobar – a curved line on a weather map that joins places that have the same air pressure

– Numbers on the isobar represent pressure readings.

isotherm – a line on a weather map that joins places that have the same temperature.



Color bands on a weather map represent different temperature ranges and usually include a key.

Predicted temperatures are often plotted as high and low temperature (example: 78/51)