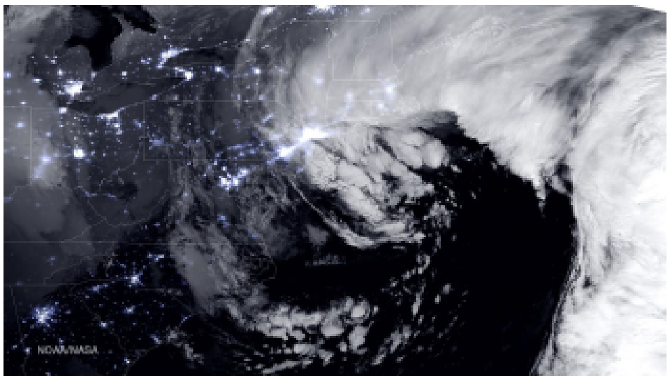
The Blizzard of 2015

1. In January 2015, New York City did something it had never done before. It shut down the subway system because of the weather forecast.



This satellite image shows the blizzard at its peak intensity on Jan. 27, 2015.

2. A powerful storm was moving toward Canada and the central and eastern United States. In response, six U.S. states declared a snow emergency, and four states banned all travel except emergency vehicles. Thousands of flights were cancelled, as were many schools around the region.

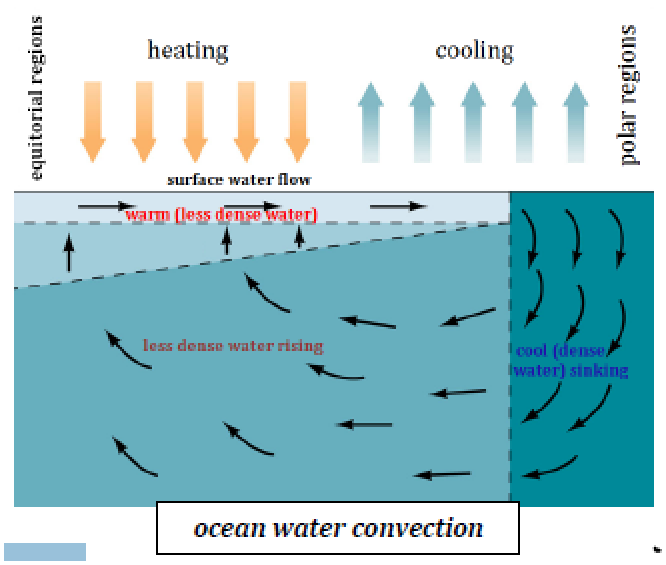
3. The decision to shut down New York City's subway was controversial because more than 4 million people use the subway every day. People became angry because the storm ended up dropping much less snow in New York City than had been predicted.

4. This blizzard showed how difficult weather forecasting can be. Some news outlets called the difference between the forecast and the actual snow amounts in New York City one of the most famous

forecasting “busts” of the 21st century. 5. However, many forecasters and other scientists have said that overall, the forecasting was pretty good. Models showed that there was going to be an extremely powerful storm—and there was. The problem came down to the storm’s exact path. For example, forecasting for central Massachusetts was spoton, with the region receiving record-breaking amounts of snow. However, forecasters predicted that New York City would fall within the western boundary of the storm. In the end, the city was outside the storm’s western boundary. **Weather and Climate** 6. The blizzard of 2015 was one kind of weather event. **<u>Weather</u>** is the conditions of the atmosphere in a particular place at a particular time. Temperature, humidity, wind speed, air pressure, and precipitation are all parts of weather. **<u>Climate</u>** is an average of the weather in a location over 30 years or more. The uneven heating of Earth’s surfaces, along with the cycling of water around the planet, are major drivers of weather and climate on Earth. 7. Weather and climate on Earth are very complex, influenced by a variety of different factors. However, the fundamental cause is that heat always seeks equilibrium. It does this by transferring from warmer substances to cooler substances until the two substances are the same temperature. Because the sun heats Earth unevenly,	

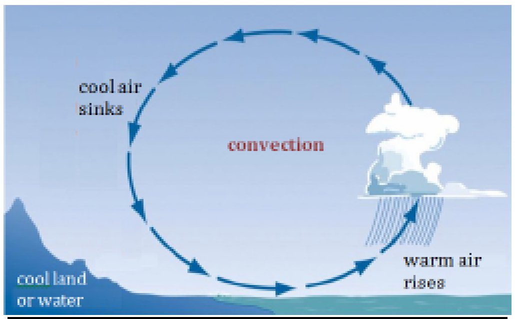
heat is constantly transferred from warmer locations to cooler locations seeking equilibrium. This transfer of heat around the planet regulates Earth's climate. Without it, regions near the equator would be much hotter, while regions near the poles would be much colder.

8. Ocean currents are one way that heat is transferred around the planet. Deep ocean currents transfer heat through a form of heat transfer called convection, where warmer, less-dense fluid rises, allowing cooler, denser fluid to take its place. Ocean currents push warm and cold water to different parts of the planet. Cold, dense water in the oceans sinks deep and spreads out all around the world. The sinking water is replaced by the warm, less-dense water near the surface that moves to the north.

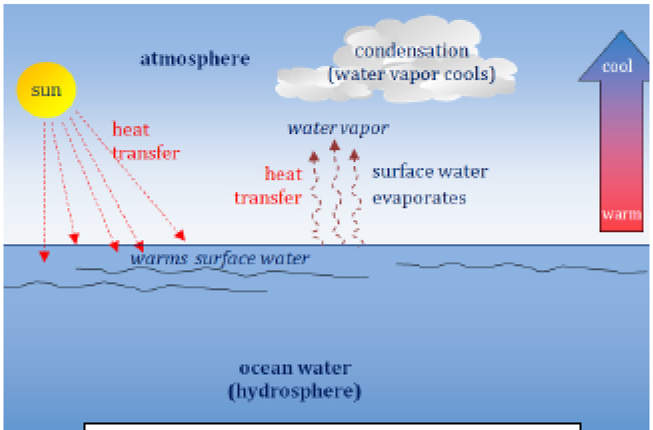


Transferring Heat

9. Wind is also caused by convection. **<u>Wind</u>** is moving air, and it occurs as a result of heat being transferred from the

sun to Earth's surface and then from the surface to the air above it. When air is heated, its molecules spread out. This decreases the density of the air, causing it to rise. At the same time, cooler, denser air sinks.  *Heat is transferred through convection currents in the air.* 10. Because of interactions between the hydrosphere and the atmosphere, the water cycle also plays a role in transferring heat around the planet. Remember that molecules of water vapor carry thermal energy (heat). As those molecules spread out into the atmosphere, they begin to transfer some of that energy into the atmosphere, which is cooler. This transfer of heat causes the water vapor to cool off, condensing back into liquid water and forming clouds. 11. The condensation transfers heat to the atmosphere, which warms the cooler air. This causes the warmed air to rise, making space for more humid, warm air from the ocean below. 12. As this cycle of heat transfer between the ocean and the atmosphere continues, more moist, warm air is drawn upward, and more heat is transferred from the ocean to the atmosphere. That heat is then transferred to colder parts of the	

planet by wind.



Heat is transferred between the ocean and the atmosphere.

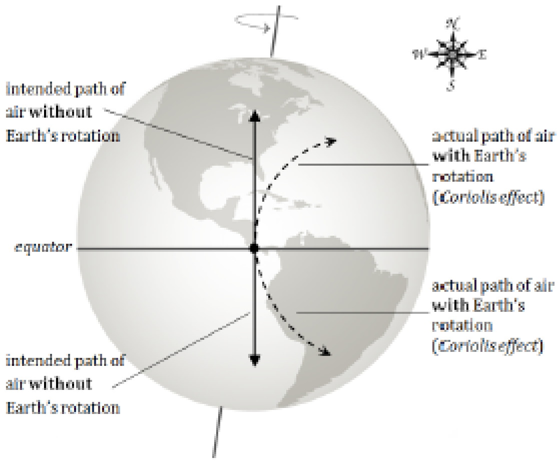
Moving Air

13. Wind moves from high-pressure to low-pressure areas, similar to how high-pressure air rushes from the mouth of an inflated balloon when you let go.

14. In addition to transferring heat and moving storms across the planet, wind is also the primary driver of surface ocean currents. However, air and surface ocean currents don’t move in a straight line between the equator and the poles. Instead, they are affected by Earth’s rotation.

15. As Earth rotates around its axis, the movement causes air to move in curved paths. This is called the Coriolis effect. In the Northern Hemisphere, warm air around the equator rises and flows toward the North Pole. Because of the Coriolis effect, the warm air is pushed to the right (northeast), where it begins to cool. As it cools, it increases in pressure as its density increases. This causes some of the air to move lower in the

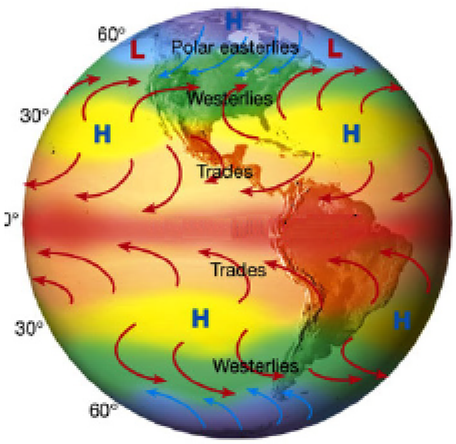
atmosphere, where it blows from the northeast to the southwest, back toward the equator.



16. A similar wind pattern happens in the Southern Hemisphere but opposite. Because of the Coriolis effect, the warm air is pushed southeast, where it begins to cool. As it cools, it increases in pressure as its density increases. This causes the air to move lower in the atmosphere, where it blows from the southeast toward the northwest, back toward the equator. These winds in both hemispheres are the trade winds.

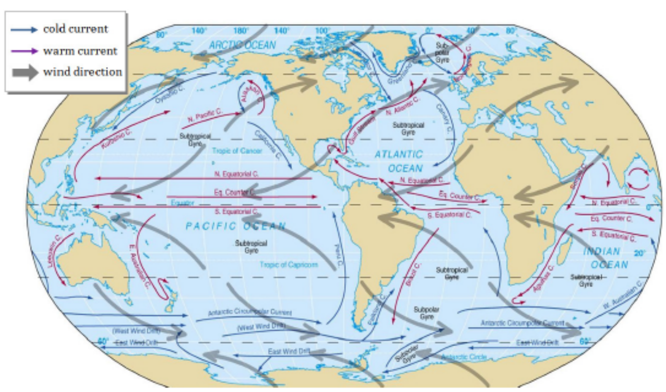
17. Not all of the warm air lowers in the atmosphere, however. The remaining air continues toward the poles. These winds in both hemispheres are called the westerlies.

18. These global winds, both the trade winds and the westerlies, also push against the ocean's surface. This creates surface ocean currents that move to the right in the Northern Hemisphere in a clockwise spiral and to the left in the Southern Hemisphere in a counter-clockwise spiral.



prevailing global wind patterns

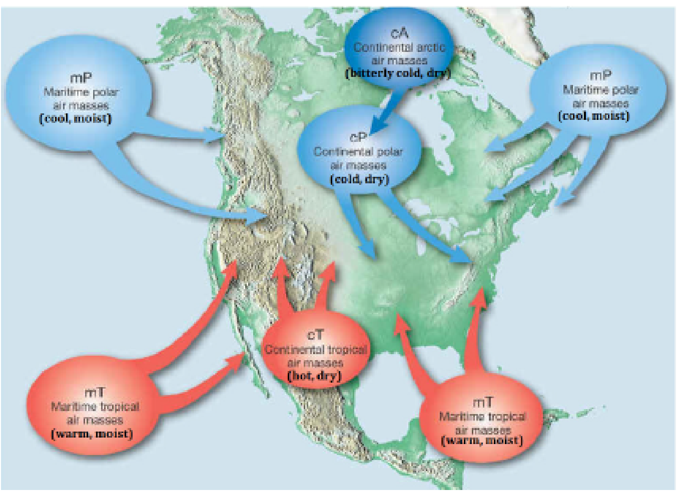
19. The ocean currents are also affected by the outlines of Earth's continents as they transport heat from the equator to the poles.



Air Masses

20. Earth's surface also interacts with air as heat and moisture are exchanged between the two. When a large mass of air remains over part of Earth for many days, it begins to take on the characteristics of the surface below it because heat and moisture are transferred between the surface and the atmosphere. These large bodies of air are called **air masses**, and the entire body of air has a similar temperature and humidity throughout.

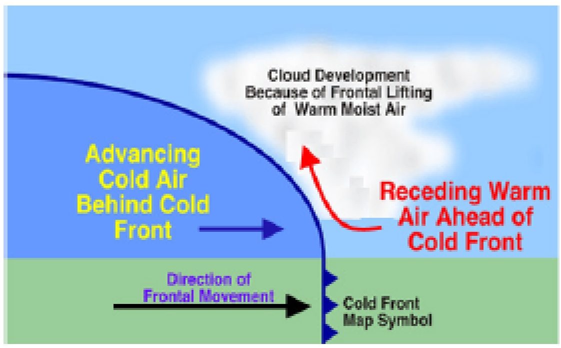
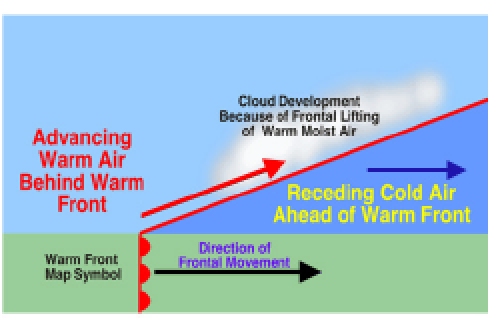
21. Scientists classify air masses into one of five categories based on the temperature of the air mass and how much moisture it has. The first part of an air mass's category tells whether the air mass formed over land or water. Continental air masses are marked with a "c" and they form over land. Because of this, the air is dry. In contrast, maritime air masses ("m") form over oceans. These air masses are full of water vapor that has evaporated from the water below.

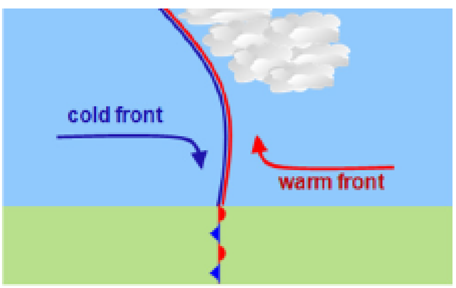


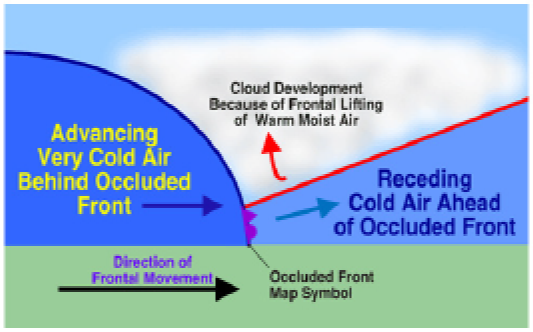
22. The second part of an air mass's category tells where the air mass formed relative to the equator. Tropical air masses ("T") form near the equator, where the air is warmed as heat transfers from the land or water. Polar air masses ("P") form in higher latitudes, where the air becomes cool because heat transfers from the air to the colder land or water. In the winter, Arctic air masses ("A") form near the North and South poles.

23. Air masses move with the global wind patterns. At the same time, the air masses move around the planet in an effort to redistribute the heat. The cold air

masses move south toward warmer temperatures, while warm air masses move north toward cooler temperatures. However, the surface features of the land can cause an air mass to change its path. For example, air masses are often deflected when they collide with mountains. 24. As air masses move, they carry with them their temperature and moisture. However, as an air mass moves over Earth's surface, the changing characteristics of the surface can change the air mass. For example, when a continental polar air mass moves over warm water, heat and moisture from the warm water will transfer from the water's surface to the air nearest the surface. 25. As air masses move, they can also collide with other air masses. The boundary between two air masses is called a **<u>front</u>**. When a front passes over a location, the weather in that location will change. Remember that warm air rises and cold air sinks. This behavior is true for air masses as well, and it is what causes the different kinds of fronts. 26. For example, a cold front occurs when a cold air mass replaces a warm air mass. When a cold air mass collides with a warm air mass, the cold air mass will sink underneath the warm air mass, pushing the warm air upwards. This happens very quickly because the cold air mass is so much denser than the warm air mass. As a result, it pushes the warm air up into the atmosphere, where the warm air quickly loses heat to the atmosphere. This causes the water vapor	

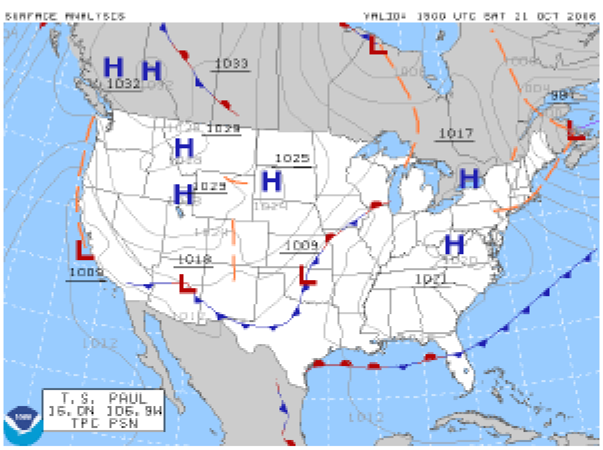
in the atmosphere to cool off and condense, forming clouds and precipitation. Because of this, cold fronts often produce powerful storms. They are represented on a weather map by a solid blue line with triangles pointing in the direction of its movement. Temperatures in front of the cold front are warmer than temperatures behind it.  27. When a warm air mass replaces a cold air mass, it is called a warm front. When this happens, the warm air mass gradually moves over the cold air mass. Because this occurs much more slowly than a cold front, there aren't usually strong storms associated with warm fronts. Instead, light rain or snow is more common, followed by milder temperatures. Warm fronts are represented on a weather map by a solid red line with semi-circles pointing in the direction of its movement. Temperatures in front of the warm front are cooler than temperatures behind it.  	

28. Sometimes when a warm air mass collides with a cold air mass, neither mass is powerful enough to move the other. The cold air mass pushes against the warm air mass, but the warm air mass pushes back equally. The result is a stationary front. This can result in clouds that can remain for days at a time. Eventually the front will either break apart or begin moving again. It turns into a warm front if the warm air moves forward, pushing the cold air. It turns into a cold front if the cold air mass moves forward instead.  29. The last kind of front is called an occluded front. This occurs when a cold front follows right behind a warm front. The warm front occurs when a warm air mass replaces a cold air mass. When another cold air mass pushes into the warm air mass, it is usually moving faster than the warm air mass. Because of this, the second cold air mass runs into the cool air that was ahead of the warm front. The warm air is pushed up, and precipitation often occurs. An occluded front is represented with a purple line with half triangles and half semicircles along it pointing in the direction that the front is moving.	

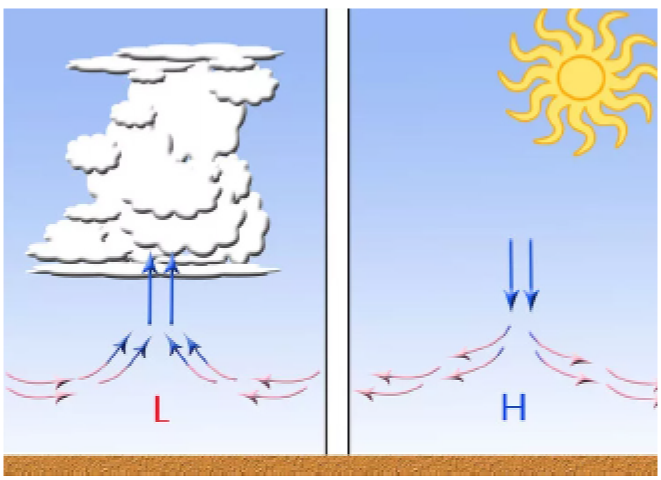


High and Low Pressure Systems

30. Weather maps also often indicate high and low pressure systems. A high pressure system is noted with a blue “H,” and a low pressure system is noted with a red “L.”



31. A **high pressure system** has higher pressure at its center. Because of this, it is characterized by sunny and clear skies. This can be understood by thinking about heat transfer and the water cycle. The air in a high pressure system sinks down from above because air always moves from high pressure areas to low pressure areas. As it moves lower in the atmosphere, it becomes warmer and drier. The winds in a high pressure system blow clockwise in the northern hemisphere and counterclockwise in the southern hemisphere because of Earth’s

rotation and the Coriolis effect. 32. A **<u>low pressure system</u>** has lower pressure at its center than the areas around it. It is characterized by clouds and precipitation. This is because warm air near Earth's surface rises into the atmosphere. As it moves upward, it cools and condenses, forming clouds and precipitation. Winds in a low pressure system move opposite from a high pressure system. They move counterclockwise in the northern hemisphere and clockwise in the southern hemisphere.  **Complex Interactions** 33. Scientists called meteorologists use powerful supercomputers to gather information about weather conditions around the planet. Because weather conditions in one location are affected by conditions in distant regions, there are thousands of weather stations positioned around the world, constantly gathering data about the weather. Weather stations include temperature sensors, wind gauges, and rain collectors. As a result of all of these stations, more than one	

million weather-related observations are made every single day. 34. Those calculations all feed into supercomputers that perform millions of calculations every second in an effort to predict weather conditions over time. It is these predictions that most weather channels and meteorologists around the country use in their weather forecasts. 35. And yet, despite the many weather stations around the world, weather forecasting remains an inexact science, as was shown in New York during the 2015 blizzard. A sudden storm can catch even the most diligent forecaster off guard. This is because even a small change to any one variable can have dramatic effects on Earth's weather. Forecasters have to predict how exactly the sun will heat each part of Earth's surface, how that heat will influence the water cycle, how differences in air pressure will affect wind patterns, and how the planet's rotation will affect the movement of air and water.	

QUESTIONS OR WONDERS