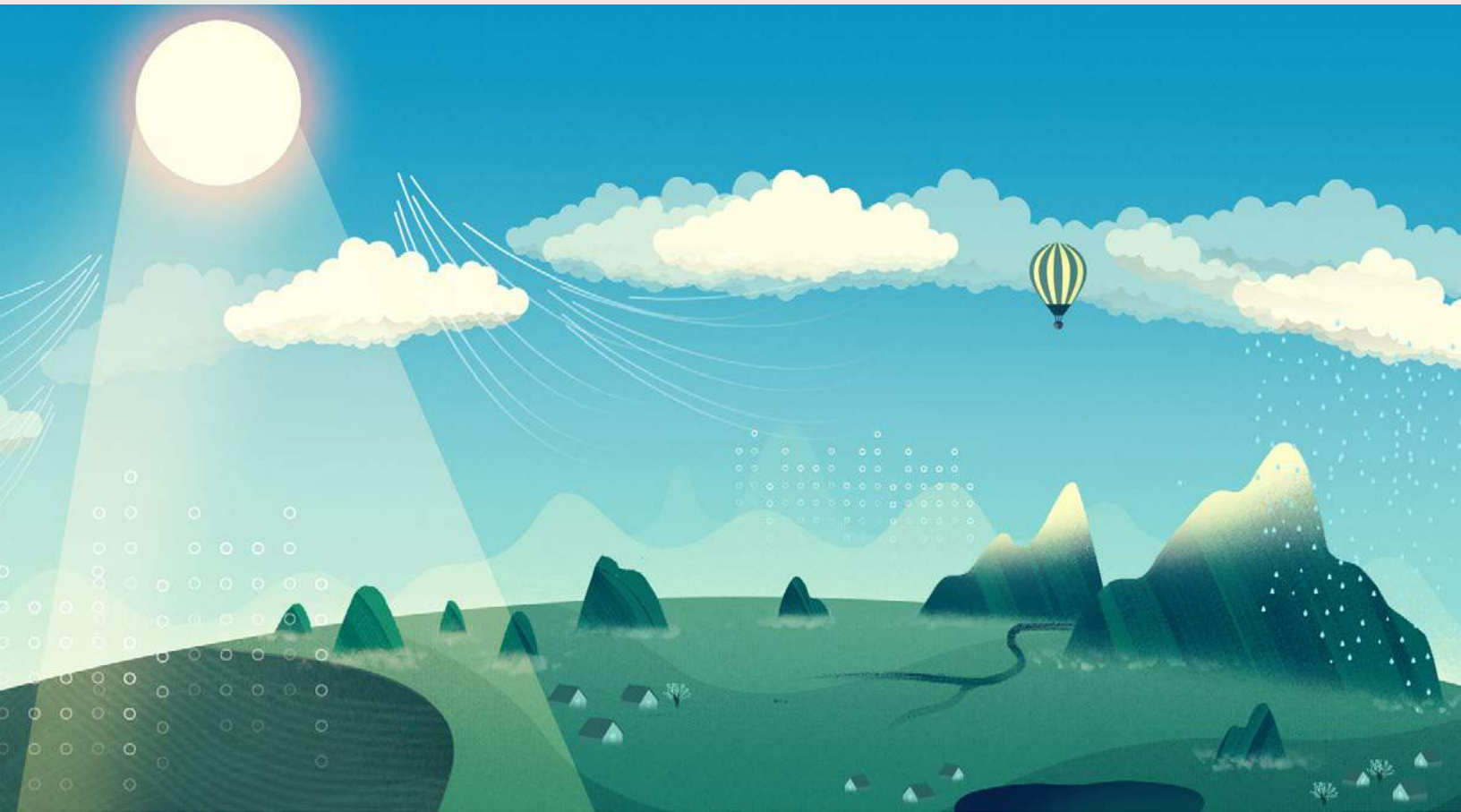
TINYBOP

WEATHER

HANDBOOK



At the beginning of every day, you probably check the weather. Maybe you look up the forecast. Maybe you read a thermometer. Or maybe you look at the sky and feel the air to see if it's sunny, warm, rainy, cold, windy, or cloudy that day. The **weather** is what it's like outside at a given time and place.

The *Weather* app lets you play and experiment with the atmospheric forces that make the weather: sun, air, and water. Create storms and clouds. Discover what happens in everyday and extreme weather events.

IN THE APP

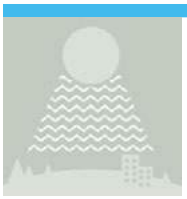
We encourage open play. Use the tool bar on the left to navigate through sun, air, and water scenes. Tap to view each scene individually or see how they all work together.

DIG IN

Tap and drag the sun, sky, clouds, water, land, and other elements in each scene.

Tap the white circles to see more detailed scenes.

As you explore *Weather*, think about how sun, air, and water interact.



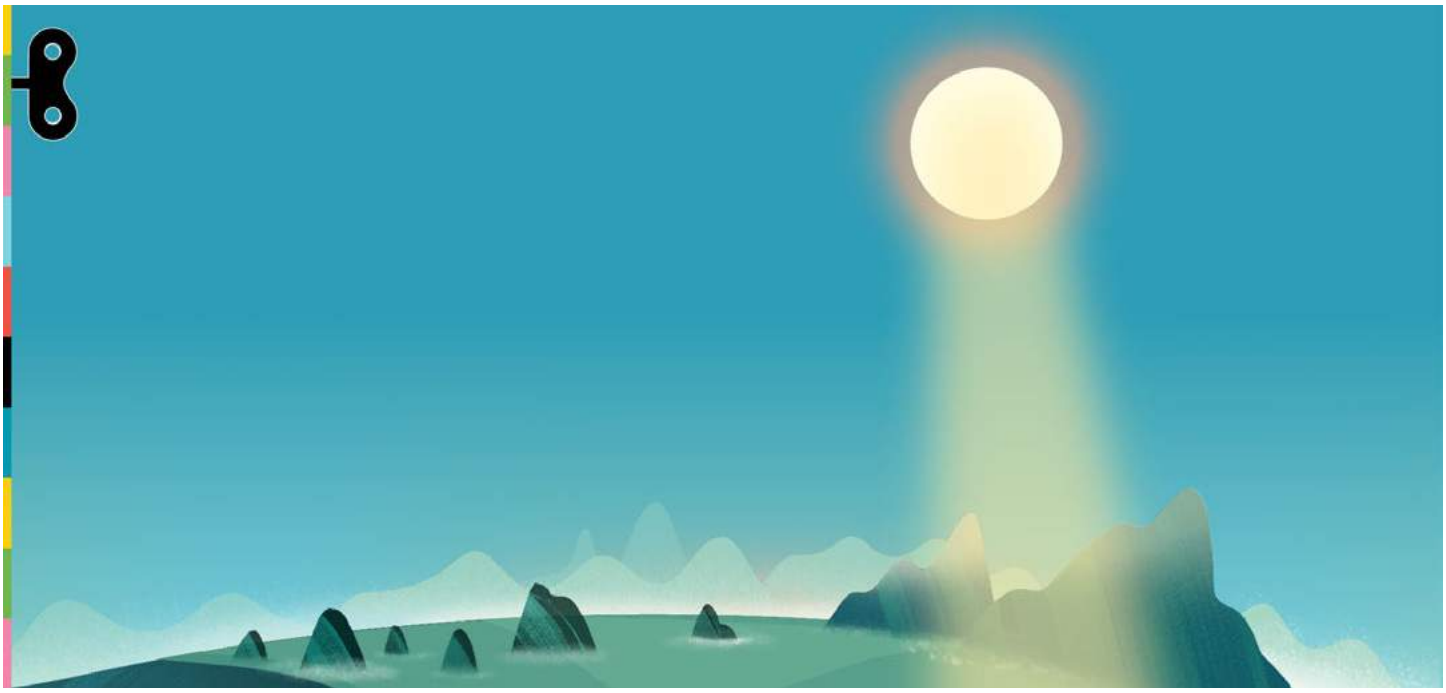
Sun & temperature

From 93 million miles (152 million kilometers) miles away, the sun sends energy to the Earth. This energy warms the Earth and its atmosphere. But the sun doesn't heat the Earth evenly.

Because the Earth is round, the sun reaches different parts at different angles. The poles never receive direct sunlight and sometimes don't receive any sunlight at all, while the equator gets lots of direct sunlight. Plus, different surfaces on the Earth, water and land, warm and cool at different rates. Water absorbs heat slowly and releases it slowly. Land warms up and cools down more quickly.

These differences in heating are important: they influence the movement of air and water from one place to another, which makes weather happen.

Temperature is a familiar way to measure how warm or cold it is in a certain place using a thermometer. If the **thermometer** says it's 32° Fahrenheit or 0° Celsius, it's cold out! That's the temperature water freezes at.



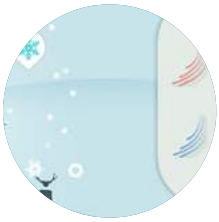
IN THE APP

Tap the sun. Drag the sun over land and water.

The sun warms land quickly and water slowly. Land cools quickly after the sun moves away. Water cools slowly after the sun moves away.

Tap the dog, window, or table.

These are scenes you might also see around your home. Observe what happens in each as the temperature changes.



Drag warm or cold air into the scene.

Observe what changes as the air gets warmer or colder.

DISCUSSION QUESTIONS

How might you tell if it's warm or cold outside without checking the temperature?

What kinds of things do you do outside on a hot day?

What do you do on a cold day?

Air & wind

The layer of air that wraps around the Earth is called the **atmosphere**. It's up to 62 miles (100 kilometers) thick. Compared to the Earth, which is 7,915 miles (12,742 kilometers) in diameter, that's pretty thin. But the atmosphere plays a big role: it's mostly made up of nitrogen and oxygen that we need to live and breathe.

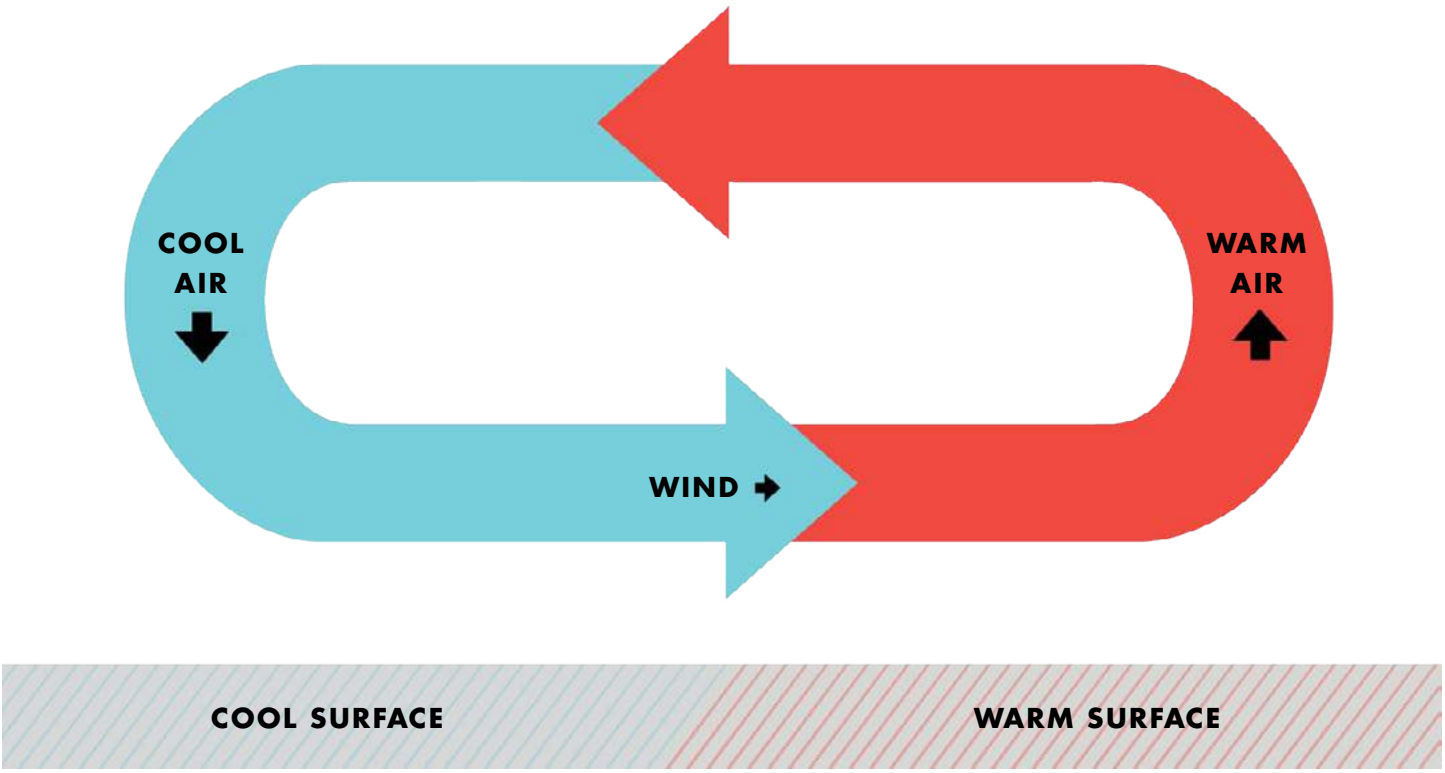
Pilots who spend a lot of time up in the atmosphere think of it as an ocean of air. While air is made up of particles too small for your eyes to see, it takes up space, moves, and has weight — just like water in the ocean.

The weight of air pushing down on the Earth is called **air pressure**. At sea level, a column of air above one square inch weighs about 14.7 pounds (6.7 kilograms).

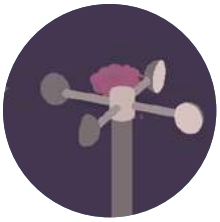
Air's pressure changes as its temperature changes. When air is warm, air particles move quickly and away from each other, making the air less dense and lighter. It rises up into the sky and creates a **low pressure** area. As air rises, it expands, cools, and forms clouds and stormy weather.

When air is cool, air particles move slowly and closer to each other, making the air more dense and heavy. It sinks and presses down on the Earth, which creates a **high pressure** area, with clear, pleasant weather.

A **barometer** is a tool used to measure air pressure. If a barometer indicates that pressure is rising, expect clear weather ahead. If it indicates falling pressure, expect poor weather.



Air moves from high pressure areas to low pressure areas. As the sun heats the Earth's surface, the surface warms the air above it. As air warms, it expands and becomes less dense and lighter. The warm air rises. Then cooler dense, heavy air moves in to take its place. We feel the moving air as **wind**.



We can measure the speed of wind with an **anemometer**. Wind blows the top of the anemometer, and as it spins, a device calculates its speed and converts it to wind speed. We can measure the direction of wind with a **wind vane**. A wind vane also spins, and points to the direction the wind is coming from.

Sometimes we can also see the effects of wind. It can pick up dust, dirt, or your hair or hat. In powerful storms, like hurricanes and tornadoes, wind can break branches, destroy homes, toss cars in the air, or create swelling ocean waves.

IN THE APP

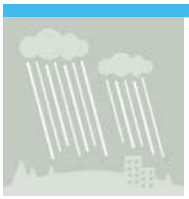
Drag the sun.

Air rises after the sun warms it. Swipe anywhere to create more wind.

DISCUSSION QUESTIONS

What creates wind?

How can you tell how windy it is outside?



Water & precipitation

There is always water in the air, sometimes more and sometimes less. Water moves from the Earth's surface, into the air, and back down to the surface, then up again and down again. This process is called the **water cycle**. The water cycle happens in three stages: evaporation, condensation, and precipitation.

When the sun warms water on the surface of the Earth, it evaporates. In **evaporation**, water turns into a gas (water vapor). This warm, moist air rises. (Bonus fact: warm air can hold more water than cool air. As it takes in more water, it becomes even less dense, which gives it even more lift.)

Air cools as it rises and the water vapor condenses. In **condensation**, water vapor turns back into liquid water. The water collects and forms clouds. If the temperature is above freezing, the clouds are made of water droplets. If it's below freezing, they're made of ice crystals.

As the liquid water droplets or ice crystals in clouds bump into each other in the cloud, they grow into raindrops or snowflakes. Eventually they become too big and heavy to float. The water falls back to the Earth, in **precipitation**, and collects in lakes, rivers or streams, or seeps into the ground.

A **rain gauge** measures how much rain or precipitation has fallen. The simplest rain gauge is a clear tube with height markings.

Rain (liquid water) and snow (frozen crystals) are two common types of precipitation. But precipitation can also be sleet, snow that melts and refreezes as it falls; freezing rain, frozen precipitation that melts as it falls but freezes when it hits cold surfaces, or hail, frozen chunks of ice formed inside a cloud.

From evaporation to condensation to precipitation, and back to evaporation again, the water cycle repeats. Whether water falls to the Earth as snow or rain, hail or sleet, eventually, it evaporates into the air again. The amount of water in the air at a given time is called **humidity**.

While you can't usually see water in the air, sometimes you can feel it. Dry air feels dry because it pulls sweat off your skin. Humid air feels sticky because it can't absorb any more water so sweat stays on your skin. You can also measure humidity with a **hygrometer**.

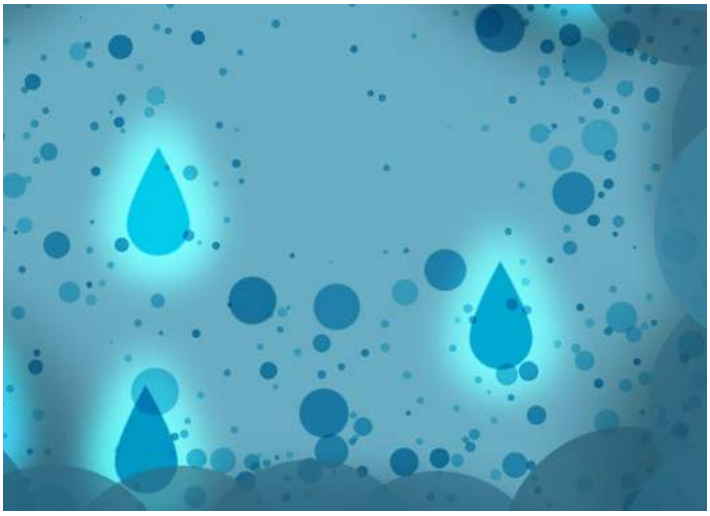
IN THE APP

Tap the water and land.

Water vapor rises into the air.

Tap the cloud.

Water falls from the sky as precipitation.



DISCUSSION QUESTIONS

What happens to water after it evaporates into the air? After it condenses?

Is the air where you live humid or dry? Does the humidity change?

What do you think happens to a cloud after it has produced lots of rain or snow?

Clouds

Clouds are the result of **condensation** in the water cycle. **Clouds** are collections of tiny water droplets or ice crystals that float in the sky before falling to the Earth again. Water that condenses into a cloud doesn't stay a cloud forever. It will become rain, snow, vapor, groundwater, or part of a lake, river, or ocean. It may even become part of you, if you drink it.

During the day, clouds reflect the sun's light back into space. At night, they radiate heat released by the Earth's surface back to the ground. This can make cloudy days cool and cloudy nights warm.

TYPES OF CLOUDS

A cloud's shape can tell us how it was formed, which can also give us clues for describing and predicting the weather.

There are three main types of clouds:

STRATUS

Stratus clouds are flat sheets of clouds, usually made of water droplets (instead of ice crystals), that form when air cools. They can sit very low in the sky and produce light to moderate rain or snow that can last all day. Fog is a type of stratus cloud that touches the ground.

CUMULUS

Cumulus clouds look like giant piles of cotton. They're made of either water droplets or ice crystals, depending on air temperature, and they are usually flat on the bottom and puffy on the top. They form from rising moist, warm air. You usually see them on sunny days, but they can turn into tall, dark cumulonimbus clouds that produce thunderstorms.

CIRRUS

Cirrus clouds look wispy and curly. They're usually made of ice crystals, and sit high in the sky on a clear day. They often signal changing weather and might tell you that a storm is moving your way.

IN THE APP

Swipe or tap to create clouds.

Different clouds form at different altitudes. Stratus clouds sit low in the sky while cirrus clouds sit high in the sky.

DISCUSSION QUESTIONS

If you could touch a cloud, what would it feel like?

What kind of weather would you expect if you saw cumulus clouds? Cirrus clouds?

Storms

Storms form when warm air rises quickly, taking a lot of water with it.

THUNDERSTORMS

Thunderstorms are the most common type of storms. They're created when warm, wet air rises over cold air. The water in the warm air cools and condenses into a thick, tall cumulonimbus cloud. When water condenses, it releases energy. This energy powers the thunderstorm, which releases rain or sometimes hail and creates lightning and thunder, the sound you hear when lightning crackles through the air.

Lightning is created as particles of ice and water bounce around in a thunderstorm cloud. As the particles collide, they transfer electricity to each other. An electric charge builds up until it is released as a bolt of lightning from one cloud to the other, into the air, or toward the Earth.

A severe spinning thunderstorm is called a **supercell**. Supercells can create rain, hail, lightning, and tornadoes.

BLIZZARDS

Blizzards are large snowstorms. Just like a thunderstorm, warm, wet air rises over cold air. But the air must be very cold, below freezing, to allow snowflakes to form and hold as they fall to the ground.

TORNADOES

A tornado is a column of fast, spinning wind, 200 to 500 yards (180 to 450 meters) wide, that reaches from a cloud and touches the ground. The average tornado travels 10 to 20 miles (16 to 32 kilometers) per hour over about five miles (eight kilometers). The winds in a tornado can be as fast as 100 to 300 miles per hour (160 to 480 kilometers per hour).

Tornadoes are a product of supercells. The supercell grows from rising warm, moist air, forming a cumulonimbus cloud. If the cloud gets caught in a column of spinning air, it starts to spin, too. Scientists don't know exactly how air starts spinning. It may be that air rotates as a result of winds blowing at different speeds and directions at different altitudes. But once the cloud starts spinning, it creates a funnel cloud. The funnel cloud can get bent down by rain or hail. And when it touches the ground, it becomes a tornado.

Tornadoes are so powerful that they destroy most measuring instruments. Instead, a Fujita scale estimates tornado wind speeds by measuring the amount of damage done by a tornado. For example, in an EF0, wind tears away loose branches and shingles and reaches about 65 to 85 miles per hour (100 to 103 kilometers per hour). An EF3 overturns train cars and removes the top stories of homes when winds reach about 136 to 165 miles per hour (219 to 266 kilometers per hour).

HAIL

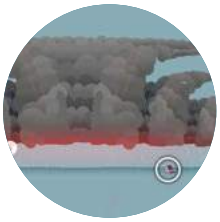
Thunderstorms, supercells, and tornadoes can also create hail: small balls of ice that can fall from the sky, even on a warm day. In a cumulonimbus cloud, an ice chunk moves up and down, growing as it collects more frozen layers. Like rain and snow, when the hail gets too heavy to stay in the cloud, it falls.

HURRICANES

A hurricane, or typhoon or cyclone, is an intense, spinning storm with strong winds and heavy rain. They are slower but much bigger storms than tornadoes. They can travel thousands of miles and last for days.

Hurricanes begin over tropical waters. Heat from the water fuels them and the turning of the Earth helps them spin. They spin counterclockwise in the northern hemisphere and clockwise in the southern hemisphere. Hurricanes lose their strength when they blow over cooler land or water and lose heat.

Hurricanes are measured with a Saffir-Simpson Hurricane Wind Scale. It's the reverse of the Fujita scale; it estimates the damage a hurricane will do based on its actual wind speed. In a category one hurricane, winds reach 74 to 95 miles per hour (119 to 152 kilometers per hour). Roofs and large tree branches will be damaged. In a category five hurricane, winds travel faster than157 miles per hour (253 kilometers per hour) and can leave places uninhabitable for weeks to months.



IN THE APP

Tap and swipe to create hurricanes and tornadoes.

Observe warm, moist air traveling upwards. The strength of the storm you create will affect the amount of damage done.

DISCUSSION QUESTIONS

What kinds of storms occur near where you live?

What signs would you look for to predict a storm?

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