Curriculum Units by Fellows of the Yale-New Haven Teachers Institute
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Fueling Extreme Weather

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Introduction

Wexler-Grant Community School is a pre-kindergarten through eighth grade New Haven Public School. Wexler-Grant is primarily a neighborhood school for the Monterey Housing Development although recently it has had a huge influx of students from all over New Haven. The students are socioeconomically disadvantaged and the school provides both free breakfast and lunch for its students.

Racially my class is ninety eight percent Black and two percent Hispanic. My class is representative of the racial break up of the rest of the school. I teach a first grade class primarily composed of students that were recommended for retention last year, retained from second grade or have special educational needs. Additionally I have two children with extreme special needs in which their IEP's specified a small classroom environment so I was fortunate enough to have a small class size of fifteen students.

In my experience science in the lower elementary grades has been nearly ignored due to the intense focus on improving literacy proficiency. Particularly this year literacy training and improvement has made teaching science almost impossible as our new program from BEL Mondo requires a two hour uninterrupted block everyday. Even if science gets taught intermittently throughout the year without sustained attention to it my students cannot internalize the concepts and build on them. Due to these complications it is imperative that my science unit is directly related to the first grade weather standards and also be an integrated unit that can also be taught through literacy and incorporated over a prolonged and sustained period of time.

Being far below average as a class, even for my particular school, these students have little or no experience or background knowledge with science and only a few are proficient readers. It is absolutely necessary to have an integrated unit that utilizes all of my student's abilities and allows them many opportunities for hands on activities which cater to their various learning modalities. The structure for teaching each concept will follow a similar pattern to assist my students who need extra practice and routine. The unit will provide a pattern of being introduced to a concept, having a read aloud based on that topic, having a mini experiment or demonstration and then filling out an observation in their science journals with various supplemental materials in technology and film. Each concept must be explicitly introduced, explored and modeled before connecting it to the larger concept of weather.

Unit Goals

In order to address our science standards explicitly my first goal consists of creating the background knowledge needed for learning about how weather occurs. Firstly my students need to know that Earth is a planet and that the Sun is a star that provides a lot of energy in the form of heat. Focusing on heat as an energy source which fuels the weather will give students a sense of size and scale for each weather phenomena discussed. In learning about the ways that the sun's heat affects or powers the weather we will not only cover all types of "typical" weather but we will also explore extreme weather phenomena such as hurricanes, thunderstorms, lightning, tornadoes and heat waves.

Another goal of equal importance is introducing the scientific process as a way of thinking and exploring the natural world. Starting in Kindergarten each class must do a science fair project through which they are taught the scientific process. Thus my second goal is to steadily incorporate the scientific process into our approach to learning science so that many of the specific examples of extreme weather and observation lend themselves to being used for the science fair or at least give the students the tools to be able to do so.

Unit Overview

This unit is organized broadly into three parts. The first part focuses on introducing the concept of science as a way of looking at and studying nature. After setting up the framework that we will use as a class to explore and learn I will focus on the Sun as a hot star that has energy in the form of heat. I will create the analogy of the Sun as a light bulb to give the students a concrete sense of energy and then size when we consider how many light bulbs it takes to light up one room, then a school etc. The entire first section will focus on the concepts of the Sun, Earth, heat, energy, water and using the scientific process as a model for learning about nature. As a transition the second part will focus on how the solar energy from the Sun interacts with various processes on Earth which effect weather. We will focus on typical weather conditions for this section. The third and last section will focus on extreme weather and will be a series of four in-depth case studies of each phenomenon. The first case study will be on thunderstorms and then we will follow with hurricanes, tornadoes and heat waves. Each case study will be a complete cycle of the scientific process and will involve both making models and performing experiments.

Throughout the entire unit each concept will be taught in the same pattern and routine to help give extra assistance to those students who need more predictability and consistency. I will use visuals, movie clips, read alouds (whole group shared reading sessions) from content relevant books and hands-on models and experiments to make the abstract concepts more concrete. Each exploration will start with precursor information, such as vocabulary and visuals and film clips of the phenomena, being introduced from which we will form a scientific question and hypothesis. After having set up the framework I will continue the exploration in the literacy block through "read alouds" from both non-fiction and fiction books to explore what that phenomenon does. Then we will either create models and view movies or perform an experiment from which we can pull information and make observations. We will close each exploration with a conclusion and reflection piece in either writing or drawing as part of an ongoing science journal.

Student's learning experience will extend outside of in-class time as homework assignments will require the students to find examples in their house of "heat making" devices, relate their own experiences about being in the sun and how it feels, observe and chart the weather and think about what they have heard or seen on television or in movies relating to the weather or phenomena.

The Unit

The Scientific Process

Science is the, "observation, identification, description, experimental investigation and theoretical explanation of phenomena (American Heritage Dictionary, 2001)." Science more broadly is, "knowledge gained through experience" and as such within my unit each example of extreme weather will be demonstrated through a model and experiment in which my students will apply the scientific process (American Heritage Dictionary, 2001). The scientific process is the lens scientists use to methodically study the world. It is a body of techniques for investigating phenomena and acquiring new knowledge. The scientific process is based on gathering observable, empirical and measurable evidence subject to specific principles of reasoning. This is done by the collection of data through observation and experimentation and the formulation and testing of hypotheses.

The scientific method as used in teaching elementary school can be broken up into six steps. First, a scientific question is proposed. Second, a hypothesis, or "educated guess", is suggested as a possible answer or outcome of the scientific question. Third, the methods or procedures and materials are clearly documented and measured in order to be able to repeat the process. Fourth the experiment is performed and careful observations are made. The fourth step should be repeated multiple times. Fifth, the data is compiled from the observations producing results. Sixth, a conclusion is made as to whether or not the data supports or rejects the hypothesis. The scientific process is paramount in teaching students critical thinking and methodical data collection. Students will be able to discover the underlying phenomena which fuel extreme weather through the scientific process.

The Sun

The sun is a huge bright star that provides the light for our planet creating the perception of night and day. There are many stars in our solar system, but our sun is the largest star which creates the illusion that in the daytime the other stars disappear. The light coming from our sun is so bright that it hides all of the other stars in the daytime. The sun is 4.5 billion years old and is a main sequence star that is about eight hundred and seventy thousand miles in diameter. More specifically it is a yellow dwarf star and is the center of our solar system. A stars color is dependent on how hot it is on its surface. Stars go through life phases and eventually burn out. The hottest stars are white and as they go through their life phases and slowly burn out they turn green, yellow, orange and then red. Our sun is about halfway through its life cycle and subsequently is yellow (Schoedler, 2002).

The sun has three main layers. These layers are: the photosphere, chromosphere and the corona. The photosphere is the part we can see and is mostly gas. In the center of the sun is a core. Inside the core is where the sun makes all of its energy. It takes hydrogen and through thermonuclear fusion changes it into helium. This fusion creates a lot of energy in the form of heat. The energy created by changing hydrogen into helium then travels to the surface of the sun through radiative diffusion, conduction and convection. This energy once transferred from the core of the sun to the surface leaves as radiant energy. The energy coming from the core of the sun makes the surface temperature about 10,000 degrees Fahrenheit (Schoedler, 2002).

Earth is the name of our planet and it is the third planet from the sun. The sun is a million times the size of

Earth and provides more energy than any other source. In fact if the sun were the size of a beach ball then the Earth would be smaller than a skittle (Van Rose, 1994). The sun's energy travels to the Earth both in the form of light, also known as radiation, and heat. The total combination of the sun's energy which it sends to the Earth is referred to as solar radiation. Sun's solar radiation only takes about eight minutes to travel to Earth and is so substantial that the human eye cannot directly stare at the sun (Schoedler, 2002). The sun's heat and light are an external source of energy for the Earth. That means the energy in the form of light and heat is what "fuels" the Earth.

The Sun's Energy

The solar radiation coming from the sun is what makes it look like a light bulb in the sky of Earth. The sun is very similar to a light bulb in terms of its energy. When a lamp is plugged into a light socket it is connected to an electrical fuel source. The electricity is a fueling energy, but it is not readily perceived. What is most readily apparent is the light given off from the light bulb. Likewise if the light bulb is left on for a long time its surface starts to get really hot thus giving off energy in the form of heat. In summation, the light bulb takes in energy in the form of electricity and then gives it off or transfers that energy into both light and heat. The Sun essentially does the same thing. Like the light bulb analogy the sun provides energy by creating light to illuminate our planet and heat to warm it up.

Energy is the "fuel" or property of a system that allows it to do work (White, 1995). Work is the ability to move something from one place to another. To move anything---that is, to do work---requires energy. Therefore energy and work require each other. Electricity is the energy used to allow the light bulb to do work. Likewise the energy coming from the sun provides fuel to do work here on Earth; such as generate earthquakes, hurricanes or even in the form of fossil fuels to drive cars. Fossil fuels are actually just stored solar energy from the sun via ancient photosynthesis. Forty seven percent of incoming solar radiation is directly converted to heat on Earth, another 23 percent is used to power the hydrologic cycle or water cycle and only about 30 percent of incoming solar radiation is reflected back to space (Abbott, 2004). The energy from the sun fuels most of Earths processes necessary for life as well as fuels all sorts of weather related phenomena.

The Planet Earth

The planet in which humans live on is called Earth. It is the third planet from the sun and the fifth largest planet in our solar system (Schoedler, 2002). Earth rotates around the sun once every year. The Earth is also always turning in its own rotation, like a top, which creates the perception of day and night. The Earth has four layers: the crust, the mantle, the outer core and the inner core. The crust is the outer most layer of Earth which consists of land and the ocean floor. The mantle is hotter and made of up of mostly molten rock. Under the mantle is the outer core which is mostly a mix of hot liquid iron and nickel. The very center of Earth is the inner core which is an iron rich solid mass. The Earth's layers are of varying densities where the densest are at the core and each layer outward is less dense (Abbott, 2004).

Earth is unique because it is the only planet that has life on it. Two major components make it possible to sustain life: water and the components of our atmosphere. Earth is a watery planet. About 71 percent of Earth's surface is covered by water (Van Rose, 1994). This enormous amount of water in reaction to solar radiation creates Earth's hydrologic cycle. Surrounding Earth is a veil of gas called the atmosphere. It extends out into space about 600 miles about the surface of the Earth. The Earth's atmosphere is divided into five layers: exosphere, thermosphere, mesosphere, stratosphere and troposphere (Abbott, 2004). The atmosphere is comprised of various gases the most abundant of which are nitrogen and oxygen (Abbott, 2004). The lowest layer of the atmosphere closest to Earth's crust is called the troposphere. The troposphere is where all weather related phenomena occur and will be the focus for this unit of study.

Heat and Water

Earth not only has a vast quantity of water, but water is an incredible molecule able to store potential energy. Water has an amazing ability to both absorb and release heat. Thus, the energy from the sun in the form of heat is very easily used by water. Energy is absorbed in water during evaporation and released during condensation. Energy is also absorbed in liquid water during melting and released during freezing. This process drives what is called the water or hydrologic cycle (Abbott, 2004). The hydrologic cycle has five steps that are continuously running. The five steps are: evaporation, condensation, precipitation, infiltration and then runoff (Schoedler, 2002). The major role that the sun plays in this cycle is it generates the energy necessary to create heat that causes water to evaporate. Water is heated up and evaporates, as the water rises it condenses turning back to liquid to make clouds. Then when the water droplets are big enough it rains. That falling rain water then infiltrates the land or returns to a water source (Van Rose, 1994). The sun heats the Earth unevenly and water makes it possible for heat to be moved around. The hydrologic cycle makes life possible on Earth and without the sun it would not have the fuel/ heat energy necessary to work (Van Rose, 1994).

Water and water vapor are also important because the solar radiation it absorbs goes into the air and water and transports that heat around our planet. Therefore water in the air can absorb the heat and take it from one place and drop it off in another place such as with the trade winds or jet streams (Abbott, 2004). Also the water near the equatorial regions absorbs the heat from the sun making the ocean warm and then transports that heat through convection to all the other parts of the ocean. If this heat transport is uninterrupted or falls within 'normal proportions' it helps prevent extreme ranges in temperatures on Earth. With the introduction of the hydrologic cycle students will also get the opportunity to go through the scientific process as they create and observe the water cycle with an in-class model. In doing this mini experiment students will also reconnect what they learned about energy by measuring the amount of energy needed to create precipitation. By measuring the amount of precipitation students will be able to see how much energy is used and then link that to the concept of the amount of energy given off by light bulbs. Throughout each experiment students will be asked to think of the energy used to fuel each phenomenon and translate that into watts to make a comparison of scale in relation to energy used to light city blocks.

A great diagram to explain the hydrologic cycle is: http://ga.water.usgs.gov/edu/watercycle.html

Vocabulary

Before specifically focusing on typical weather some basic concepts need to be individually introduced and understood.

Vocabulary: precipitation

Precipitation is the deposition of moisture from the atmosphere onto the earth's surface. Precipitation develops in two stages. Firstly, cloud droplets grow through condensation. In warmer clouds (-10 degrees Celsius) the larger droplets get larger by collision and fusion with the smaller ones. In colder clouds, super-cooled water droplets freeze on impact with the ice and they aggregate or stick to larger ice crystals. Most precipitation begins in the form of ice crystals and develops into snow flakes, but if the atmosphere where it falls is warm it melts and becomes rain (Mayhew, 2004).

Vocabulary: clouds

Clouds are a visible, dense mass of suspended water droplets suspended in the air. Clouds generally form when air is forced to rise: at a front, over mountains or because of convection (Mayhew, 2004). When the warm air is forced to rise, at a front or over mountains, the drop in temperature causes the air to condense. As a mini demonstration students will observe a cloud forming apparatus. During this demonstration varying amounts of dust, serving as nuclei for the water vapor, will be used inside the chamber to see how it affects the cloud formation. (The cloud forming apparatus is made of a glass flask, rubber bulb and inlet tube. Manipulating the rubber bulb causes condensation and the perception of clouds)

Vocabulary: atmospheric pressure

Atmospheric pressure is the force exerted by the atmosphere as a result of gravitational attraction exerted on the air lying above a particular point. The attraction exerted on the air is measured by the weight per unit of area. The atmospheric pressure decreases as you move further away from the earth. Air pressure is easily measured by a barometer (Mayhew, 2004).

Vocabulary: lightning

Lightning is an emission of electricity from cloud to cloud, cloud to ground, or ground to cloud, accompanied by a flash of light. It is the result of variations of electrical charge on droplets within the cloud and on the earth's surface (Mayhew, 2004). During the buildup of tall clouds, such as in thunderstorms, charged particles separate. An abundance of positive charges accumulate on top of the cloud and an excess of negative charges dominate down low. The charge imbalance comes about when the freezing and shattering of super cooled water drops initiate charge separations that are then distributed by updrafts and downdrafts within a thundercloud which occurs during the early stage of a thunderstorms development. It is then during the mature stage that lightning takes place (Abbott, 2004).

There are four steps in creating a lightning bolt: the initiation, stepped leader, connection and return stroke. During the initiation charge separation in cloud builds up static electricity. The stepped leader is when negative charges move in dimly visible stream downward in intermittent steps. A connection is made when the leader nears the ground or another cloud and then a positive discharge leaps up, completing the attachment. Lastly a return stroke is when the connected path flashes bright as charges exchange between cloud and ground in several events all which occur in about half a second (Abbott, 2004).

Vocabulary: relative humidity

Relative humidity is the amount of water vapor in the atmosphere. More precisely it is the mass of water vapor per unit volume of air. Relative humidity is expressed as the percentage of water vapor in the air compared to the amount that it can hold at the same temperature and pressure (Mayhew, 2004).

Vocabulary: wind

Wind is defined as air in motion. Winds generally blow from high pressure to low pressure areas. The larger the difference between pressures areas, the stronger the wind is. Wind happens when warm air moves up and cooler air moves in to replace it or cold air falls and spreads along the ground (Abbott, 2004).

Vocabulary: Coriolis Effect

The Coriolis Effect is when moving objects experience the Earth move out from beneath them. In the Northern hemisphere, bodies move toward their right-hand sides, while in the Southern Hemisphere, they move toward their left. This is due to the fact that the Earth is spinning more rapidly at the equator at about 1670km per hour and only about 432km per hour at its poles (Abbott, 2004). Therefore if a body starts at the equator and moves north towards the pole it will veer to the right as it's speed becomes faster than that of the Earth's rotation. (See hurricane section following for more in-depth explanation and example of the Coriolis Effect).

Vocabulary: convection

Convection is a process of heat transfer. During convection hot material rises upward due to its lower density while cooler material above sinks because of its higher density (Abbott, 2004). More specifically in liquids and gases the molecules move about more freely spaced. When heated up, they also move further apart. A heated liquid or gas therefore expands and rises, while a cooled liquid or gas contracts and sinks. This movement which is known as convection spreads the heat around (Macaulay, 1988).

Vocabulary: fronts

Fronts are the border zone between two air masses which contrast, usually in temperature. A warm front marks the leading edge of a sector of warm air and a cold front denotes the influx of cold air (Mayhew, 2004).

Typical Weather Phenomena

After exploring the necessary components of our solar system, planet and sun and basic concepts in introducing weather students will spend the transitional part of the unit focusing on typical weather phenomena.

The solar energy that the Earth receives from the Sun is the basic fuel of our changing weather as the Sun is a heat engine that drives the circulation or movement of our atmosphere. Weather is created by a mixture of heat, water and air within the troposphere. The short-term changes of atmospheric conditions are what we refer to as weather. Examples of 'typical' weather conditions include cloudy, rainy, snowy, windy and just plain sunny. Each type of weather varies in its combination of temperature, water vapor content and movement. During this section students will make ongoing observations of the weather. They will chart the weather each day throughout the unit in correspondence with first grade district weather standards. In preparation for the next part of the unit students will discuss and learn how much energy it takes to cause precipitation, wind and other weather phenomena (Abbott, 2004).

Extreme weather: thunder storms

Water evaporated into the Earth's atmosphere by solar heating, is a large factor in fueling extreme weather. If there is enough evaporated water in the air thunderstorms can occur. A thunderstorm is a tall buoyant cloud of moist air that generates lightning and thunder and usually it is accompanied by rain, gusty winds and sometimes hail (Abbott, 2004).

It develops when warm air is forced to rise rapidly. This is usually caused at fronts where a warm air front is forced up by a cold front or by warm winds just blowing up a mountain slope. This creates a strong updraft forcing warm air to rise quickly where it is then cooled off by the rising and expanding. The subsequent drop in temperature causes the water vapor in the air to condense into droplets and clouds. The process of condensation then produces enormous amounts of latent heat release which creates a feedback loop as the heat given off fuels the updraft of warm air thus making it rise faster and feed the cycle (Abbott, 2004).

Most thunderstorms form on sunny days late in the afternoon because the temperature of the ground surface and lower troposphere are the highest (Abbott, 2004). A thunderstorm can be broken up into three stages of development: the early stage, the mature stage and the dissipating stage. During the early stage the thundercloud begins with an initial updraft of warm moist air which then condenses. The early stage is characterized by rising cumulus clouds. The mature stage is marked by both strong updrafts of warm moist air and downdrafts of cool, dry air descending rapidly side by side. When the amount of ice crystals and water drops becomes too heavy for the updrafts to support precipitation begins making the mature stage the most violent stage of the thunderstorm. During this stage rain is heavy, thunder and lightning are powerful and the cloud-mass top commonly spreads out as an icy cap (Abbott, 2004). The last stage is the dissipating stage which is when downdrafts drag in so much cool, dry air that it overpowers the updrafts of warm moist air which fuels the thunderstorm. When the downdrafts dominate the cloud mass shrinks and the tall thundercloud mass evaporates in the surrounding dry air (Abbott, 2004).

A thunderstorm can cause both thunder and lightning however so the name is a misnomer. Lightning occurs during a thunderstorm when liquid and ice particles above the freezing level collide, and build up an electrical field in the clouds. Lightning is similar to the static electricity created by dragging your shoes along a carpet and then touching a doorknob and getting shocked. The spark from that electrical interaction is like the lightning caused by thunderstorms. Just like your body is interacting with the door knob the thundercloud interacts electrically with the ground (Hone, 2006). The abundance of negative charges in the bottom of the clouds creates buildup of positive charges on the ground because the opposite charges attract each other. Lightning can more from cloud to earth, earth to cloud or cloud to cloud. Lightning moves as speeds over six thousand miles per second and can have multiple strokes occurring within seconds of each other (White, 1995). The electrical discharge of lightning can briefly create temperatures as high as 55,000 degrees Fahrenheit. The high temperatures of lightning, flash heat the surrounding air causing it to expand explosively. It is this explosive expansion of heating of air that produces the sound waves called thunder (Abbott, 2004). During this section students will perform mini experiments both with static electricity and a heat engine so they can see convection at work.

It is estimated that at any given moment, nearly two thousand thunderstorms are in progress over the earth's surface. In the United States thunderstorms are most common in Florida, Texas and areas east of the Rocky Mountains as thunderstorms need both warm moist air and an updraft associated with either colliding fronts or mountain topography. The Gulf of Mexico provides a lot of warm moist air that also aided from the Atlantic makes Florida the most susceptible to thunderstorms. Texas has a consistent updraft initiated by the topography of the Balcones Escarpment fault zone. Likewise areas east of the Rocky Mountains are also susceptible to thunderstorms because of the topography which aides in updrafts. The frequency of thunderstorms and their potential for violence makes them, and more specifically their side effects, one of nature's great killers and destroyers. Thunderstorms can cause flash floods because of the precipitation and can also develop into tornadoes (Abbott, 2004). In order to measure the energy needed to "fuel" a thunderstorm students will take the average amount of precipitation generated by a thunderstorm and calculate the amount of energy needed to turn that amount of water vapor into water. (It takes 2.25 million J/kg to convert water vapor into liquid water)

Extreme weather: tornadoes

Tornadoes are a destructive rotating storm under a funnel-shaped cloud which advances over the land along a narrow path. This storm is generated by powerful updrafts. The rotating wind speeds can exceed 300 miles per hour and the core can be up to 200 meters across. Tornadoes have the highest wind speeds of any weather phenomenon. A typical duration of the storm is only about 20 minutes. Tornadoes can be more intense than the biggest hurricanes but as a whole are far less destructive because of their relatively short duration and comparatively small size (Abbott, 2004).

The Great Plains region of the central United States is where 70 percent of the tornadoes occur on Earth. In the central US several conditions typically occur simultaneously making it more susceptible to tornadoes. First, there is a low-altitude, northerly flow of warm tropical air from the Gulf of Mexico which is humid and may have ground temperatures that exceed 75 degrees Fahrenheit. Next, a mid-altitude, cold dry air mass is simultaneously moving down from Canada or out from the Rocky Mountains at speeds around 50mph. Lastly, high-altitude jet-stream winds race East at speeds in excess of 150mph. These three different air masses, all moving in different directions set up the conditions which create a spin on a thundercloud (Abbott, 2004).

Tornadoes start like a thunderstorm with warm moist upwellings. Colliding fronts or other wind shear cause a horizontal rotating tube. Then thunderstorm warps tube into a vertical position. Air is drawn into low pressure zone at the base of updraft which tightens and strengthens the tube. When wind shear tilts storm updraft and precipitation-enhanced down draft then don't compete on the backside of the storm. This creates a situation where there are better conditions for updraft and convergence into a tornado. More specifically the corkscrew motion is enhanced by the vertical air movements of warm air rising on the leading side and cool air descending on the trailing side (Abbott, 2004).

Although tornadoes may grow out from some thunderclouds, most large thunderclouds do not spin off tornadoes. The exact cause is still not completely understood but sometimes wind shear tilts the thundercloud mass and it grows into a supercell thunderstorm as opposed to a single-cell thunderstorm. A single cell thunderstorm is where warm moist air rises vertically, forming precipitation that falls down through the cloud, cooling it down. A supercell thunderstorm is a tilted thunderstorm that has precipitation on the leading side with tornadoes on the trailing side (Abbott, 2004).

The tilt is the main component allowing the warm air to rise in the middle of the cloud while most of the rain falls in the forward flank of the storm with the associated precipitation downdraft. But on the rear the downdrafts are cooler, drier air. It is between the front updraft and trailing downdraft that tornadoes usually form (Abbott, 2004). Once the air is rotating the core pulls into a tighter spiral and gets the "ice skater" effect where the speed dramatically increases as the size of the rotation gets smaller and tighter (Abbott, 2004). Students can measure the energy used to fuel tornadoes by converting the wind speed into watts to gauge how the latent heat release has fueled the destructive tornado.

Extreme weather: hurricanes

A hurricane also known as a cyclone or typhoon is a disturbance about 650km across, spinning about a central area of very low pressure, with winds over 74 miles per hour. The violent winds are accompanied by towering clouds, some 4000m high and by torrential rain in which 6 inches may fall in a few hours (Mayhew, 2004). They are heat engines that convert solar heating of the tropical ocean into winds and waves. Because they can generate incredible wind speeds over the ocean they can push massive volumes of seawater onshore as surges that temporarily raise sea level over 20 feet; and their heavy rains can cause dangerous floods and other destruction as a result (Abbott, 2004).

Hurricanes are storms of the tropics, as the heat builds up in the tropics during long hot summers hurricanes are one way of transferring that heat to the mid-latitudes. Several conditions need to occur for a hurricane to develop. First, seawater should be at least 80 degrees Fahrenheit in the upper 60 meters of the ocean. This usually occurs late summer, early fall as it takes a while for the oceans to heat up over summer. Also as the ocean temperature increases the amount of water vapor that the air can hold increases dramatically. Next, the air must be unstable, warm and humid (it must have large water vapor content). Lastly, the upper-level winds should be weak and preferably blowing in the same direction the developing storm is moving. These conditions are compounded by the Coriolis effect (Abbott, 2004).

The Coriolis Effect is how the shape and rotation of the Earth influences the movement of the air. This is because the Earth is spinning more rapidly at the equator at about 1670 km per hour and as it moves towards the poles the rotation is slower moving at 432km per hour. Air moving away from the equator, going north in the Northern Hemisphere moves faster east than surrounding air and pushes east. Whereas air moving toward equator, going south in the Northern Hemisphere moves slower east than surrounding air and therefore pushes west. Thus the air is deflecting to the right and therefore instead of reaching the poles, the warm rising air from the equator is deflected so far east that it cools before getting to subtropical latitudes. The Coriolis Effect causes the equator pole convection cell to break up (Abbott, 2004).

A hurricane develops through four stages: a tropical disturbance, tropical depression, tropical storm and tropical cyclone or hurricane. It begins with a low pressure zone that draws weak surface winds, also called a tropical disturbance. Then as surface winds increase and flow more efficiently around and into the center of the storm it becomes a tropical depression at which point it gets an identifying number. When the sustained wind speeds exceeds 39mph but is still less than 74 mph it receive an identifying name and is considered a tropical storm. It matures to a hurricane when the surface winds consistently exceed 74mph (Abbott, 2004).

Hurricanes are easily identified by the "eye". The upwelling of warm moist air spirals forming a cylinder. As increasing amounts of wind blow faster into the center it becomes difficult for all winds to reach the center. The result is a spiraling upward cylindrical wind mass near the center of the storm, in the eye wall. When surface wind speeds reach about 74 mph none of the wind reaches the center of the storm resulting in a calm clear area known as the eye. Inside the eye, air sinks. The cool air sinks into the center of the core on top. As the air descends, it warms and absorbs moisture, leaving the core clear and cloud free to form the "eye" of the hurricane (Abbott, 2004).

The massive destructive effects of the hurricane are due to the combination of three major factors. First, they form in warm tropics (low latitudes) as warm upwellings and pressure lows. Next, the moist air spirals in (Coriolis effect) to pressure lows. Last, the condensation of water and latent heat release boost upwelling and thus draw in air faster creating a crucial feedback. The size of the hurricane, fueled by the latent heat release if further fed by the rotation of the Earth and the Coriolis effect to create the most destructive extreme weather phenomenon (Abbott, 2004).

A hurricane acts as a heat engine transferring heat from the warm, moist air above tropical seas into the core of the hurricane. As air rises into the hurricane, latent heat is released in enormous quantities. The average hurricane generates energy at a rate 200 times greater than our capacity to generate electricity worldwide (Abbott, 2004).

To put the size and scale into perspective we will again explore how much energy is used to fuel an average hurricane. Although the students will not be able to calculate the formulas the analogy to a light bulb will serve as a comparison. [The amount of latent heat energy used to fuel one average hurricane by looking at the volume of rain per day which is 21 billion m^3 per day. In order to create that much precipitation it would take 600 calories per gallon which would equal 2.5 million J/kg.] Overall the energy release is 600 trillion watts or 15 times the heat coming out of the Earth!

Extreme weather: heat waves

Although not always immediately thought of in terms of extreme weather, heat waves are very devastating phenomena that are a direct result of the sun's solar radiation in combination with a lack of precipitation (Abbott, 2004). The heat wave is an invisible, silent killer that causes destruction in a number of ways. Heat waves not only kill elderly and young purely due to temperatures but long lasting bouts without precipitation also known as droughts can change the geography of entire regions killing the life supporting vegetation. The combination of dry and hot can also spark fires in dry vegetation and quickly grow out of control consuming homes and lives.

Dry and hot weather in the central United States and Canada are commonly associated with high-pressure atmospheric conditions. What can make heat waves especially difficult is its combination of both high maximum and high minimum temperatures. The surface air mass may not cool much at night because of high humidity (water vapor content in the air) which contains the heat. Heat stroke is dangerous as it happens as the heat is prolonged and bodies become weak and fail (Abbott, 2004).

Classroom Activities

Activity 1: hydrological cycle

After exploring the three states of water and having a demonstration on each we will begin learning about the hydrologic cycle. In order to observe atmospheric water vapor, we will create a weather system in a clear glass container with section in the top for ice and a place inside for water and a hot plate underneath it for heating up the water. The water will warm up and rise as steam in this case. It will collect on the top of the container. Water vapor will condense as liquid on the underside of the ice, simulating the hydrologic cycle as it precipitates back down. Students will make observations of the process at least 3 times. They will draw pictures and label them before making a comparison to the larger world outside.

Activity 2: uneven heating of the Earth

In discussing the transfer of energy in the form of light and heat from the sun to the Earth we will then learn about thermometers and how to read them. Following that mini lesson we will perform a mini experiment in which we place thermometers in 4 different areas outside. One thermometer will be on one side of a tub of water that is exposed to the sunlight, the second will be in the other side of the tub of water not exposed to sunlight and two other thermometers will be in the soil. Again with one thermometer in the soil exposed to sunlight and the other not exposed to sunlight.

Students will follow the scientific process and make a hypothesis as to which will absorb the most heat and how that might change from morning to night. Students will check the thermometers in the morning when they arrive and at the end of the day. They will record any change they see and repeat the process over 3 days. Students will have discussions about the weather observed on each day and which thermometer had the highest temperature as well as had the largest difference between morning and afternoon.

The point of this mini experiment is to firstly see constant flux of heat absorption and also how unevenly materials are heated. Data will be collected and graphed before coming to a conclusion. After the conclusion of the mini experiment students will discuss how they feel in the direct sunlight when they wear different colored clothing and decide based on their observations whether or not it makes a difference in how they perceive the temperature. They will write a reflection journal on any connections they make to the experiment.

Activity 3: transferring electrical energy

This is a precursor activity to explaining the phenomena of lightning. It will take place during the second of three parts of the unit when we discuss "What is weather?" During this mini experiment students will have a balloon filled with air. They will rub the balloon on a soft piece of fleece material to create an electrical charge. The lights will then be turned off and they will touch either a table or the ground to watch the spark that results from the exchange of electrical charge. They will record their observations in a notebook and repeat process 3 times. A follow up reflection and comparison writing response will be presented after they have learned about lightning and watched a few movie clips of the phenomenon.

Activity 4: spinning tornado

Following the introduction of the extreme weather example of tornadoes we will have a demonstration by making our own tornado in a bottle. Using two 2 liter bottles taped together containing so aluminum squares, colored water and oil we will spin the bottles and flip them upside down to observe the funnel rotation.

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5 Hone, E. *Teaching Elementary Science* , Harcourt. University of Michigan. MI, 2006. Gives great child friendly explanations for larger scientific concepts.

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Implementing District Standards

Power content standard 1.1: The sun appears to move across the sky in the same way every day, but its path changes gradually over the seasons.

During the first third of the unit students will learn about and explore both the sun and Earth. In learning about the sun and how it unevenly heats the Earth we will cover both the rotation and revolution of the Earth.

Expected performances A 10: Describe the changes in the length and direction of shadows during the day. A 11: Describe the apparent movement of the sun across the sky during the day.

We will create a model of the sun and the Earth and using a flashlight will make observations of where the sun hits as the Earth rotates. We will repeat the process with making the model of the Earth evolve around the sun.

Expected performances A 17: Estimate, measure and compare the size and weight of different objects and organisms using standard and nonstandard measuring tools.

Throughout the unit students will be using the scientific process as a means for exploring the extreme weather examples. In doing so and keeping with scientific inquiry students will use various methods of measuring in collecting their data and making comparisons.