From The Merman to the Weatherman:
The Evolution of Weather Prediction

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This curriculum unit is recommended for:
Science/Grade Seven

Keywords: weather, meteorology, mythology, hurricane, cultural ecology

Teaching Standards: See Appendix 1 for teaching standards addressed in this unit.

Synopsis: This curriculum unit investigates how weather forecasting has changed over the years. Students will begin by investigating weather myths and folk sayings in order to analyze whether these myths were rooted in science. Students will participate in cooperative learning groups while completing I-charts and reflective journaling activities to master the content presented. An important piece of this unit is the use of primary sources in the science classroom. Science instruction is often centered on text book like information text, but primary sources can be just as valuable as tools of learning and instruction. Students will analyze primary sources from two historical storms in order to understand the cultural, social, and economic impacts of these storms. Students should be able to make the connection that modern forecasting techniques were born not only for the curiosity of predicting the future, but out of necessity for keeping us safe and our cities secure. To that end, we'll explore the myriad of ways that early cultures ventured into meteorological prediction, ranging from observing merman as harbingers of bad weather to observing changes in animal behavior. Learning about modern forecasting technologies will come next in this unit with students making the connection that science has come a long way in the past several hundred years. The unit wraps up with a project where students will demonstrate that they understand how scientists have developed the field of meteorological forecasting over the years.

I plan to teach this unit during the coming year in to 140 students in seventh grade science

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Jennifer Thompson

Rationale

We are a weather obsessed society. Weather apps clutter our phones and the desktops of our computers. Even my alarm clock has a weather feature on it which collects a signal from a small receiver which I placed outside my bedroom window. Meteorologists somehow can talk about a snow storm for 36 hours straight and still have people tuning in to watch. Countless times a year in my classroom I hear: "Mrs. Thompson! Is it going to rain today? I have football practice!" Clearly, weather prediction is even important to 13 year olds. My students, who have always lived in a world where they can simply look up the weather forecast on the internet, have not even experienced the feeling of having to wait for the report on the television or for the arrival of the newspaper.

My students' natural interest, as well as misconceptions, about the Earth's weather is the source of my focus for this curriculum unit. I want my students to learn that although we as humans have always had this desire to know how our weather will change, we did not always have convenient ways to predict meteorological patterns. I want my students to begin to look up at the clouds and think about them as evidence of meteorological reality and then to consider about what those cloud observations mean. This is exactly how forecasting had to begin – people with a curiosity to look at the skies, find a pattern, and link that pattern to a meteorological even. For example, the saying, "Red sky at night, sailor's delight. Red sky in morning, sailors take warning," has been relied on heavily for those who make a living on the water. I know watermen on the Chesapeake Bay who still live by this saying. Although it is a good example of a prediction method which was established on recognizing the patterns of poor weather and sky color, it is based on loose, but sound, scientific reasoning. When a storm is on the way, the skies tend to have more debris and moisture within them due to the low pressure systems, which causes the sun's light to refract through the atmosphere and cause the red sky. My students need to know that even if an initial attempt at science may not be 100% successful, we continue to try by formulating more hypotheses, collecting more data and observations, and persevering until a satisfactory answer is found.

Whenever I try to explain to my students how people lived in the past, and what they believed, there is usually a chorus of giggles. With all of the technology available today, my students cannot imagine using animal behavioral patterns to predict winter. Looking to the color of the sky at dusk to predict rain coming seems absurd to a contemporary middle school student. My goal through this unit is to give students a comprehensive look at the historical contexts of forecasting, as well as how and why it

changed. Ultimately, the students will consider the technologies scientists use today, recognizing that even modern techniques are imperfect. I want these middle school students to learn that without these "silly myths and sayings" and without consistent weather observations across the globe, we would not be technologically where we are today in our ability to make meteorological predictions.

Student and School Background

This unit was designed to serve the students of James Martin Middle School, a Title 1 middle school located in Charlotte, NC. I teach approximately one third of our 400 seventh grade population. Our student demographic is very diverse including 69% African American, 20% Hispanic, 5% Asian, 4% Caucasian, and 2% other ethnicities. Approximately 80% of our students qualify for free and reduced meals. I teach multiple children who are considered homeless as well as many others who live with extended family members. Science classes are academically heterogeneously mixed. Within my classes I have multiple levels of ELL and LEP students as well as EC students and students with 504's. Only 15% of my students read on grade level. Science classes operate on a 90 minute block A-Day/B-Day schedule. I designed the activities and layout of this unit so that it is appropriate for all academic levels within my classes, and can be easily modified for different academic level and schedule differences.

Content Objectives

This unit is taught according to the North Carolina Essential Standards for Middle School. During the first or second quarter, depending on school location, a 9 week unit on weather is taught. Concentrated on here is standard 7E1.4 which states that students must predict weather conditions based on patterns and information obtained from weather data collected from direct observations and measurement; weather maps, satellite and radar; and clouds and associated elevations. It addresses the real life ways in which we predict weather, as well as the human consequences when this does not occur. The human consequences touches on standard 7E1.6 which states that students should be able to conclude that the good health of humans requires monitoring of the atmosphere, maintaining air quality, and stewardship. Students will also be reviewing standard 7E1.3, the formation of storms, during this unit.

To teach these standards the unit is broken up into four days. Day one addresses weather "myths", that is weather prediction in different cultural systems. Day two focuses on a historical storm, how it was predicted and the human impact of the storm (7E1.3, 7E1.6). Day three studies modern weather equipment and how it is used to predict the weather (7E1.4). Day four is a culminating project which has students think of days one through three has a complete history instead of three separate topics.

Background

The Evolution of Weather Prediction

Humans have always based their survival on looking to the future and prepare accordingly. The weather affects everything about our lives from how we dress when braving the elements, to when we plant and harvest our crops. Humans figured out quite early that the weather was a powerful force that required daily monitoring.

Early Weather Mythology and Prediction

Looking to the skies would be the logical place to start when observing the weather. One famous weather saying is: "Red sky at night, sailor's delight. Red sky in morning, sailors take warning." Shakespeare used a variation of this saying in his poem "Venus and Adonis": "Like a red morn that ever yet betokened/ Wreck to the seaman, tempest to the field/ Sorrow to the shepherds, woe unto the birds/ Gusts and foul flaws to herdmen and to herds." During high pressure systems it is common for there to be a higher concentration of dust particles. When the light shines and refracts through these dust particles an observer often sees a red sky. High pressure systems are characterized by cool, dry air. During sunrise, if there is a high concentration of water in the air, the sunlight will refract through the water droplets and the sky will appear a dark red. High humidity is a characteristic of a low pressure system, which usually brings stormy weather. [1]

Stories from sailors on the high seas may appear to be very eccentric. What starts out as a fisherman's tale can spin out of control from being told for centuries. But what happens when one particular story may actually have a bit of science behind it? Stories have been told about merman sightings in early Norse cultures. The story goes that if a merman is spotted then a storm is soon to follow. It has also been discovered that stories of these merman can be found in the ancient Norse text *The King's Mirror*. Within this text it says, "This monster is tall and of great size and rises straight out of the water. It has shoulders like a man's but no hands…But no one has ever observed it closely enough…Whenever the monster has shown itself, men have always been sure that a storm would follow." As scientists have researched to find if there is truth behind this myth, they have discovered that it is simply an optical illusion. Before a storm at sea develops there can often be pockets of warm air. This warm air mixes with the cooler air close to the ocean's surface. As these small masses of air mix, they act similar to a lens which refracts light and distorts what we see. Objects that are normally short, when viewed from the height of a Norse boat, will appear elongated, hence the sighting of the mermen. [2]

Humans, who have observed the behavioral changes in animals, before storms have often wondered if some creatures have a type of sixth sense to predict the weather. Dogs, for example, will often hide within their homes well before a storm strikes, while

many wild or feral animals seem to seek higher ground before hurricanes or floods wreak havoc on a town. It may seem like magic to some, but often times it is as simple as animals being able to sense changes in the length and temperature of the days, or perhaps even barometric pressure. One particular myth states that a cow will sit down when rain is coming to save a dry spot. Although scientists can say with some certainty that the cows are not saving a dry patch of grass, it has been shown that cows tend to lie down when they are cold, and stand up when they are warm. Birds may be a very accurate indicator of weather, as they experience the winds at a different level than we do. It is said that when birds fly high the weather is clear, and when they fly low then storms are brewing. This may be due to the Vitali organ, located in the middle ear of a bird, which is very sensitive to changes in barometric pressures.[3]

Plants and prediction: ferns, aspen, corn

Cultures initially relied on basic weather observations and the mythical interpretation of those observations. Although relying on animals, plants, and strange shapes in the sky might seem like outrageous claims to the modern person, this was the only way in which people used to be able to look ahead in the weather. Observers would notice a pattern in the weather. Maybe there was a major hurricane after that herd of animals, who normally dwell in the valley, moved up the mountain. Maybe that one winter there was 10 feet of snow after you thought you noticed a fuzzier caterpillar in your field that summer. Maybe there is even some science behind this – could the change in barometric pressure cause the animals to become restless and in turn move to higher ground with a different air pressure? Could the changes in temperature and humidity cause us to see creatures which did not exist? As humans noticed more patterns, we made more predictions. The first major essay that addressed weather observations and prediction was written by Aristotle around 340 BC. In his *Meteorological* he described theories about how clouds, wind, rain, hail, lightning, thunder and hurricanes were formed. Aristotle's claims, some very astute and many far from fact, were not widely challenged for centuries. [4]

The Next Stage of Prediction

By the 17th and 18th centuries scientist quickly realized that these mythological ways of studying, interpreting, and predicting the weather were not accurate enough. Weather instruments were needed. A few of these instruments had been designed in earlier years. For example, an instrument with the purpose of measuring the humidity in the air, a hygrometer, was designed by Nicholas Cusa in the mid-1400s. In 1592 Galileo Galilei invented a thermometer and Torricelli invented the barometer in 1643. Once these instruments were invented, and then fine-tuned over the next few hundred years, we were able to begin taking accurate data and correlating these data patterns with weather patterns. As communication became easier we did not only study data in our own cities and towns, but from different geographic locations from around the world. In the 1860s humans had weather stations set up around the world while scientists studied and

compiled weather data from across the globe. What a long way we had come from the days of believing the gods caused the wind to blow and the sun to shine. [5]

Modern Weather Equipment

We will soon move from stationary weather stations located around the globe, to weather stations which we could send up into the skies. These roaming weather stations, called radiosondes, are small boxes with a radio transmitter and a variety of weather equipment. A balloon carries the radiosondes to an altitude of approximately 30 kilometers where the balloon bursts and the radiosondes falls to the ground. While the balloon is lifting the wandering weather station it collects observational data on the temperature, moisture, and air pressure and sending the information back to a weather station on Earth's surface. The radiosondes were first used in the 1920's and only sent up sparingly. Today, we send radiosondes, also called weather balloons up into the atmosphere every 12 hours from hundreds of locations around the globe. With a twice-daily flow of more localized weather data, we can extract global weather patterns and form predictions as to how our weather will change. [6]

Even with new breakthroughs in weather equipment, we still needed to figure out how to predict those patterns before they happen. Two scientists believed that numbers were needed in order to make these accurate predictions. Vilhelm Bjerknes, and later Lewis Fry Richardson, dove into this idea in the late 1800s and early 1900s. Richardson was able to brilliantly use numbers and mathematical computations to create a 6 hour forecast for Munich, Germany. The challenge was that it took him weeks to create this forecast. He published his mathematical findings in *Weather Prediction by Numerical Processes* in 1922. In the mid-1900s a very early computer was designed and constructed at the Institute for Advanced Study in New Jersey. The idea was that this computer could facilitate the many calculations needed to make weather prediction using these equations more exact. This computer was successfully used in April of 1950 to make several accurate 24-hour forecasts in North America. These forecasts were being made on a regular basis just a few years later. Technology has made great strides since the successful 24-hour weather forecast of 1950. We have improved our predictions both in terms of length of forecast as well as accuracy. We have moved from predicting weather from looking up at the clouds, to predicting weather from looking down on them. We have satellites in orbit which can collect information about the temperature and moisture content of our atmosphere. Between satellite and weather balloon data we have assembled a comprehensive look at the weather and atmosphere from all around the globe even within desolated and uninhabited areas. [7]

Meteorological observers are continually improving the instruments and the interpreted mathematics used to predict our weather. It has become somewhat of a global effort, with websites that allow anyone to upload weather data from their home locations. We have even moved from making shorter forecasts, to predicting how the climate itself

will change. With this abundance of data, technology, and scientists able to interpret that information, we can better prepare ourselves for hurricanes, droughts, and that snow storm that is to come.

Historical Storms and Their Impacts

Galveston - 1900

On September 8, 1900 a category 4 hurricane slammed the town of Galveston, Texas. Galveston is a town located on a small island off the coast of southeast coast of Texas. The island measures 30 miles at its longest point and 3 miles at its widest. Situated within the island is Galveston Bay measuring about five hundred square miles. The hurricane took much of the island by surprise. A man by the name of Dr. Isaac Cline was the meteorologist on site. Meteorologists from Florida had warned Galveston and the surrounding areas that a hurricane was headed their way, but the exact location of landfall could not be determined. It was stated in reports of the storm that the normal "brick-dusk sky" was not present the night before the hurricane hit – even though that color pattern had been observed before other hurricanes in a similar geographic area. Cloud observations were taken and cirrus clouds, normally meaning a change in the approaching weather, were noted. Barometric pressure readings were taken and pressures began falling two days before the storm came ashore. Weather observers on the island also looked to the tide swells and began to worry about how quickly the water level was rising and flooding the lower parts of the island. Dr. Cline took the falling barometric pressure and high seas as a sign that this hurricane was going to strike his town. He warned the people as best he could. Those who could tried to seek higher ground and searched for more robust homes which might keep them safe. [8]

By mid-day on September 8th thick clouds and heavy rains moved in. The wind continually picked up speed without a break in these conditions. These winds reached hurricane speed by 5 pm. By 8pm the winds were in excess of 120 miles per hour. Sudden rises in water level were another deadly effect of the storm. The Galveston Hurricane was so powerful that after it tore through Galveston, it moved up through Oklahoma and Kansas as a tropical storm. It then continued up to the Great Lakes, swinging east, and continued back over to the northern Atlantic Ocean (9). Even with storm warnings being sent from Washington to the Gulf area for several days prior to the storm, they were not accurate enough to save the island. This change in the storm cost over 6,000 people their lives and caused an estimated damage of over $30 million, which would be close to $1 billion in today's currency. Even today, if you watch the weather and track a hurricane during the late summer and fall, you will notice that the forecaster gives a wide range of where the hurricane could travel. A 24-hour forecast would not be developed until 50 years after this historic storm struck Galveston. How different would history have been for this town had this storm occurred 50 years later? Even with the best weather prediction storms will still bring havoc to the most well-prepared towns, but

a death toll of 6,000 is a staggering number which we do not see when those forecasts are shared with the public.[9]

Galveston may have been leveled by the hurricane, but it did not dampen the spirit of the city. Clean-up and rebuilding started the next day. Within the first week both telegraph and water service was restored to the island. Within the second week new telephone lines were being laid. By the third week, freight was being shipped back into the harbor. It was obvious that this storm was not going to shut down Galveston. A major multi-year project was planned: the raising of the city. The entire city was raised anywhere from a few inches to 11 feet. Engineers dredged sand from the channel to use in the raising. Every remaining building or home had to be jacked up bit by bit while the land was raised. Within ten years most of this project was complete. A massive sea wall was also built. It took almost 60 years for 10 miles of a sea wall to be built. It is estimated that it cost Galveston $16 million to complete the raising and sea wall projects. This money was thought to be well spent. Several comparable hurricanes have struck Galveston since, and those homes and buildings behind the sea wall have survived well.[10]

Ocean City, Maryland – 1933

The hurricane which struck Ocean City Maryland in 1933, also called the Chesapeake-Potomac hurricane, forever changed the landscape of the seaside resort town. The hurricane developed in the Atlantic Ocean and grew to be a category 4 hurricane. Residents of towns from North Carolina to Maryland were warned of the impending storm and many were able to evacuate in time. The storm first made landfall in North Carolina on August 23, 1933. The storm quickly weakened into a tropical storm as the eye passed over Virginia, and the storm continued on to Washington DC, passing Maryland along the way. The storm caused such severe flooding in the Chesapeake Bay region that it took 80 years, until Hurricane Sandy, for those records to be broken. An estimated total of 2 square miles of beaches along the Maryland coast were eroded away into the ocean. Economic damages were high: $7 million in crop damages, $3 million in fishing/boating, and $10 million in other property damages, totally more than $500 million in today's currency. [11]

When the hurricane hit in 1933, Ocean City Maryland was still a relatively young resort town. A storm of this magnitude could have easily caused irreversible damage, but instead the citizens were able to capitalize off of this storm. Some have been reported saying that they were even "tickled" by the main result.[12] The storm left a lasting geographic change – it created the Ocean City inlet. Ocean City had been part of a peninsula which incorporated not only Ocean City, but also Assateague to the south and the Delaware beaches to the north. To the east of the peninsula was the Atlantic Ocean, and the Assawoman Bay lied to the west. Fishermen wanted to dock their boats in the calmer waters of the bay, as well as deliver their catch to customers. Fishermen had used manpower, rollers, and even donkeys to haul their ships across low lying land to get from

the ocean to the bay. It was a dangerous task where many men lost their lives. The town was in the process of presenting a costly half-million dollar construction project to cut a passageway so that these fishermen could enter the bay easily. But the storm of 1933 solved their problem for them. Due to the many days of rain built up in the back-bay, the water surged through and created a break in the land. A new passageway from the ocean to the bay had just been created.[13]

Teaching Strategies

Journals

There are as many different ways in which to use journals in the classroom as there are teachers. The general purpose of a journal is to provide a record of what a student has experienced within the classroom. Ideally, journals promote higher level thinking skills such as analyzing, interpreting, collaborating and researching within the content area. An effective journal can blend together writing, data, and visuals to allow students to experience all angles of the science in which they are studying. For example, within a science lab a teacher might request that a student record their data findings, illustrate their laboratory set up, and summarize their conclusions. The teacher can communicate back to their students through their journals. This not only allows the teacher to keep up on a student's knowledge and progress, but also to create a relationship with the student that may normally be hard to reach.[14]

An effective journal does have some minimal components. There should be a summary of the journal requirements as well as a rubric in an easy to locate spot within the journal. If the students are clear on what is expected, it is easier for them to be successful. It is helpful if there is table of contents should be written by the student at the front of their journal. Some teachers are more regimented about what to include in journals. They will instruct students on what labs to include on what pages. Other teachers simply request that students place into their journals what they deem to be important, and write a minimum number of pages of reflection per week within their journal. Whatever the set-up of the journal, the educator must remember that the purpose of a journal is not to simply store notes. It is a tool that should allow students to create a framework in which to think more profoundly about the content and to apply what they are learning within the particular content area.[15]

The purpose of using journals within this unit is to reinforce content knowledge and promote inquiry. On day one, for example, students will start with a quote in their journal about what a meteorologist does and reflect on it. Students will then complete the weather myth stations and build on the quote and reflection in their journal. Each day, students will wrap up with a reflection as to what they learned about weather prediction and its purpose, as well as reflect on how well their group functioned as a cohesive unit. For example, day one's reflection will be, "How do you think our society in America

would be different if we still believed in the weather myths you learned today?" Each day's journal entries will be similar to day one, with a reflective warm up, content focused center, and a reflective conclusion for the day. After each day I will write a note down within each student's journal. This could be a simple note such as, "Great thought!" or could go into more detail about encouraging the student to write a bit more. With this set up my hope is that my students have a central place for them to demonstrate their mastery of weather prediction as well as think higher about the implications of what they have learned. With the daily feedback from myself I am hoping that not only will the journal interaction build more rapport with my students, but also encourage them to work harder as they know someone cares and is watching.

Primary Sources

Primary sources are considered to be text or non-text sources which are first hand resources from the time period being studied. Primary sources can include news articles, interviews, photographs, and many other items left behind in the past for us to discover in the future. The purpose of looking at these resources is to provide the reader or observer a first-hand look at the past without it being distorted by the interpretation of someone not present at that time. Most teachers, especially science teachers, rely entirely on secondary sources which are simply a summary of a topic or even. The benefits to using primary sources appropriately in the classroom are endless. Not only can they transfer information, but they can give students an engaging, emotional connection with an event that transpired years before they were born.[16] Using primary sources allows students to discover new knowledge for themselves as if they were truly observing an event for the first time. Science teachers tend to concentrate on the facts of the concept being taught, but so much of that can be introduced and taught through the rich history of science.

When choosing resources for a lesson, no matter the content, primary sources should not be your only source the students use, as the students need background knowledge to understand the primary sources in which they are investigating. When choosing primary sources be sure to evaluate the age-appropriateness of the selection. Although we all want to challenge our students, the last thing we want to do is choose something so challenging that our students give up so easily. It is important to also understand the purpose to which you are using these sources. In this unit, the purpose is to teach science history, so the vocabulary will be easily understood by my students. If you are focusing on vocabulary development, then a more challenging selection would be appropriate. If this is the first time in which students are using primary sources, it can be helpful for students to work in small groups while evaluating these sources.[17] Students may have to be taught how to look at a primary source. Even if students will be dedicating most of their time to analyzing the primary source within small groups, an introduction by the teacher can be helpful. As a class, have students answer questions such as who created this primary source? When was it created? And where does your eye go?[18]

Within this unit plan, students will be studying a famous storm and analyzing the impact that storm had on the populations of that town through a selection of primary sources. Students will look at a first-hand account of the storm, a selection of photographs, and a newspaper report. Students will, within their cooperative learning groups, complete an I-chart to organize the information obtained about the hurricane (see I-Chart section and Cooperative Learning Group section below).

Stations

Stations, also called centers, at their most basic form, are multiple activities that are located around the classroom to allow students to work independent of the teacher. These activities could be reading a text, interpreting a photo, completing a mini-lab analysis, watching a video, or any number of other tasks. Sometimes a teacher may want to have multiple stations set up and have students visit each station in an organized manner. Other times a teacher may instruct students to only visit the stations in which they need information from resulting in a more fluid dynamic of the activity. Ideally, stations will allow students to foster a sense of independence and self-accountability. Students must rely on themselves and their group members to be successful at the tasks. As with any classroom activity, the stations should not be given to students to complete with no introduction or wrap-up from the teacher. The teacher must be clear in the purpose of these stations with their students. Once students have completed the stations, the teacher must evaluate whether or not students received what he or she had intended to from the activity.

Stations within this unit will be used on day one when studying weather myths and on day three when studying modern weather equipment. Day one, for example, will have multiple stations set up for students to read and interpret weather mythology and folklore. Students will read about a weather myth and look at an illustrative representation if available. The student must then summarize the information, compare it to how they think we predict the weather in modern times, and reflect on how you think our lives would be different if we still predicted or viewed the weather in such a manner. By using this particular variety of questions to focus on with each station, the tasks are not to simply reiterate the information in which they read. Students will start out with a basic summary to get them started, but then use those stations to delve deeper into the information. By allowing students to work in stations, instead of at their desks silently on the same work, they will have to rely on their group members to be successful. It will allow me to bounce between groups to check on comprehension and peek into their own views on weather.

I-Charts

An information chart, or I-chart, is a chart designed to help organize students while they are utilizing multiple resources to answer questions. The teacher will choose four to five questions they want the student to answer. Students will answer these questions using each of the sources provided to them. Successful I-charts use a variety of sources. Text sources of various length, videos, photographs, music, news articles, textbook selections are all appropriate examples of sources within an I-chart. Logistically, these charts are set up with the questions being asked along the columns at the top of the chart. To the right of the last column, there is a column left where students can record a question that they come up with while they are reading the source. Each source has a dedicated row along the left. The first row needs to be left available for students to record the background knowledge about the question before evaluating any of the sources.

An I-chart is used on the second day of this unit to help students analyze and organize multiple sources when looking at a historic storm. Students will be evaluating multiple primary sources (see above Primary Sources section) as well as modern text about the Galveston hurricane of 1900 or the Ocean City hurricane of 1933. Students will be using five sources within their I-chart. Their first source will be a text-book like summary of the hurricane. This will help students have background knowledge of the storm and be better prepared to understand the primary sources, a benefit discussed in the primary sources section from above. The next three sources will be primary sources: one will be a personal account of a survivor, one will be a collection of photographs or a video and one will be a news report. The last source will be a secondary historical account of how each city developed after the hurricane. Included within the I-chart will be "questions that lead to more observations and reflections" (2) by the students. A copy of the specific I-chart and details as to sample student responses can be found in the activities section below.

Cooperative Learning Groups

Cooperative learning groups go beyond simply placing students in groups and telling them to work together. Every teacher knows that unless carefully thought out and purposefully introduced to the students, many group assignments have a tendency to fail. One student will do all of the work, other students will sit and do no work, and quite often group members even begin to wander to join other groups. Cooperative learning includes purposefully placing students into groups so that while working together they can achieve a common goal (6). Within these groups students can successfully depend on one another, hold each other and themselves accountable, and build interpersonal relationships and group skills through face-to-face interactions (6). While watching a successful cooperative learning group, teachers should see their students as active learners. Students will be keeping each other on track, rather than relying on a teacher to nag them to get their work done. All students should be participating and contributing to the group's discussion. You should hear positive interactions among the students. At the end of the activity, students need time to debrief and self-reflect about their group

process[19]. These types of groups mimic how collaboration occurs in science. Meteorology does not rely on a single person, but instead relies on many scientists and, as the students will learn, even amateurs collecting and interpreting data, sharing those results, and offering help and support to others around the globe.

During this unit, students will be placed into groups to include a variety of academic levels within each group. These groups will work together for the entirety of this unit. Each student in the group will be assigned a job: group leader, materials manager, and time keeper. The group leader will be responsible for reviewing directions with the group and leading the discussion/keeping it on topic. The materials manager will be responsible for collecting and returning all supplies to the proper station or to the teacher. The time keeper will be responsible for keeping track of the time, keeping the group on topic, and ensuring that the group finishes on time. Although students within the group will remain the same, the jobs will rotate each day. Groups will begin by looking at and analyzing weather myths, will move onto analyzing primary sources from a historical storm, and wrap up with a project summarizing what they have learned. Throughout each daily activity students will need to rely on one another and respect each other's opinions and contributions to be successful as a group.

Classroom Activities

As stated above, this unit was designed to take 4 days on a 90 minute block schedule. Day one will cover an introduction to weather myths. Day two will cover two major historic storms. Day three will consist of modern weather prediction techniques. Day four will cover reflecting on how we got from the myth to the modern and why we made those changes.

Day One

Objective: Students will be able to analyze weather myths and sayings for scientific accuracy. (NCES 7.E.1.5)

Essential Question: What would our lives be like if we had to rely on these "primitive" ways of weather forecasting? How have past weather myths helped us to develop the modern weather technologies we use today?

Warm Up: Students will read and reflect on the quote below. Students will be given a copy of the quote to paste into their journal. The teacher will read the quote aloud to the students. Students will then have sixty seconds to write down everything that they think of or feel when the quote was read. Their pencils should not stop for the sixty seconds that they are writing and reflecting. The teacher will lead students in a five minute class discussion about the reflections the students wrote in their journal.

> Imagine a rotating sphere that is 8,000 miles in diameter, has a bumpy surface, is surrounded by 40-km-deep mixture of different gases whose concentrations vary both spatially and over time, and is heated, along with its surrounding gases by a nuclear reactor 150 million km away. Imagine also that this sphere is revolving around the nuclear reactor and that some locations are heated more during one part of the revolution and other locations are heated during another part of the revolution. And imagine that this mixture of gases continually receives inputs from the surface below, generally calmly but sometimes through violent and highly localized injections. Then, imagine that after watching the gaseous mixture you are expected to predict its state at one location on the sphere one, two or more days into the future. This is essentially the task encountered day by day of a weather forecaster.[20]

Activity: Students will rotate through five stations. Each station should take between ten and fifteen minutes to complete, depending on reading ability of the group of students. The teacher should assign groups to the students. Students should be working in these same groups for all four days of the unit. Guidelines for jobs within the student groups can be found within the "Cooperative Learning Groups" section above. Station one will focus on weather prediction based on sky colors, station two on the Norse mermen, station three on animal behavior used for prediction, station four on plants used for prediction, and station five on folk sayings. Links to all sources can be found in appendix two.

Daily Reflection: Students will reflect on how well their group worked together, as well as the content they learned in day one's activity. Students will fill out the reflection sheet found in appendix two. This consists of a scale from 1 to 5 of how well their group worked together as well as a space for personal reflection. At the bottom of their reflection students will answer the following question: "Do you believe that these weather myths and sayings you learned about today were necessary in order for us to get to where we are today? Or were they silly? Explain your answer." All daily reflections will be similar and can all be found in appendix two.

Day Two

Objective: Students will be able to analyze and reflect on two major historical storms (Galveston in 1900 and Ocean City in 1933) through primary sources. Students will make conclusions as to how past historic weather events have given us modern weather technologies. (NCES 7E1.4 & 7E1.6)

Essential Question: How do weather events affect the development of cultures such as their technologies and cities?

Warm Up: We've all heard about a hurricane on the news. How far in advance do you think we start to hear about a hurricane headed our way? What types of information about the approaching hurricane is the meteorologist able to give you?

Lesson: The class will be divided into two large groups for this activity. One half will be studying the Galveston hurricane of 1900 and the other half will be studying the Ocean City Maryland hurricane of 1933. The Galveston group will be analyzing two pieces of informational text: one on the characteristics of the storm and one on the rebuilding of Galveston after the storm. This group will also be looking at three primary sources: photos, a news article, and a personal account of the storm. The Ocean City group will also be analyzing two pieces of informational text: one on the characteristics of the storm and one on the impact of geographical changes on the economy of Ocean City. The group will also be looking at three primary sources: a video and two news articles. Links to all sources can be found within appendix four. Before venturing out on their own, students must be introduced on how to "read" primary sources. For each of the three primary sources students will need to answer the questions listed below. These questions can be projected or posted in the room while the students answer them in their journals. The teacher may want to guide students through these questions, depending on level of experience of the students.

1. Who created this primary source?
2. When was it created?
3. Where does your eye first go?
4. What do you see that you didn't expect?
5. What powerful words/visuals and ideas are expressed?
6. What feelings and thoughts does the primary source trigger in you?
7. What questions does it raise?

Within the Galveston group and the Ocean City MD group, students will be placed into pairs so they can have conversations about their sources as they work through their assignment. Each student will be completing an I-chart. Copies of the I-chart can be found in appendix four. Once the I-chart is complete, each pair in the Galveston group will be matched up with a pair from the Ocean City MD group. This will result in groups of four with representation from each storm. Students will then interview the opposite pair on their storm using questions that address both facts about the storms and students' reflection and perception about the storms. The interview sheet can be found in appendix four. Both the I-chart and interview will be pasted into the students' journals so they can be used as a reference later.

Daily Reflection: Students will reflect on how their group performed and what they learned today. At the bottom of their reflection students will answer the following question: "Weather prediction is not perfect – do we give up and move on? Or try again?

Explain your answer." Once complete, these will be placed into the next page in their journals. The reflection sheet and question can be found in appendix two.

Day Three

Objective: Students will be able to describe the uses of modern weather equipment such as weather balloons, satellites, and Doppler radar. (NCES 7E1.5)

Essential Question: How does modern day weather forecasting equipment affect our daily lives?

Warm Up: We have come a long way since weather prediction in 1900 and 1933. What advancements do you think we have made to make forecasting since the times of the storms which we learned about yesterday?

Activity: Students will rotate through five stations that address modern meteorological technologies. Each station should take between ten and fifteen minutes to complete, depending on reading ability of the group of students. Students should be in the same groups as they have been in for the prior two activities. Station one will focus on satellites, station two will focus on weather balloons, station three will focus on hurricane hunters, station four will focus on Doppler radar and station five will focus on personal weather stations. Stations and their questions, along with links to all reading passages, can be found in appendix five. The teacher may want to shorten or modify reading passages based on student reading levels.

Daily Reflection: Students will reflect on how their group performed and what they learned today. At the bottom of their reflection students will answer the following question: "Choose one of the five weather technologies you read about today. Explain what would have happened if this technology had been available during the Galveston hurricane of 1900. Would the impact of the storm have been different? Explain." Once complete, these will be placed into the next page in their journals. The reflection sheet and question can be found in appendix two.

Day Four

Objective: Students will be able to explain the advancements meteorologists have made in the field of forecasting and how those technologies have affected our lives. (NCES 7E1.5 & 7E1.6)

Essential Question: How have the advancements in the field of weather forecasting impacted human lives over the past century?

Warm Up: What information is needed to predict the weekend's weather forecast? What types of technology might be used? Use the information you learned yesterday as well as information we have learned in past lessons about weather patterns.

Activity: Day four's activity will give students a chance to share what they have learned. The activity should show that students understand how all of weather history connects from the primitive ways of weather prediction through our modern weather equipment. Students will create a newspaper layout. Within this newspaper layout students will need to include the following sections: historic prediction, past storms, modern technology, and weather prediction of the future. Within the historic prediction students will need to include a paragraph on one of the early forecasting techniques studied on day one. Within the past storms section students will need to include a paragraph on one of the storms we studied, or another past storm which interests them. Within the modern technology section students will write a paragraph on one of the modern technologies studied on day three. Within the weather prediction of the future section, students will write a paragraph on where they see the future of forecasting. This could be a new technology that they would invent, or comments on the areas in which we need improvement. The layout of the newspaper will be up to the student.

Daily Reflection: Students will reflect on how their group performed and what they learned today. At the bottom of their reflection students will answer the following question: "Summarize what you have learned during the activities during the last four days. Be sure to include what you learned about how weather prediction has evolved and how it has impacted humans." Once complete, these will be placed into the next page in their journals. The reflection sheet and question can be found in appendix two.

Appendix 1: Implementing Teaching Standards

This unit incorporates the North Carolina Essential Standards for seventh grade science. It covers three standards within the weather unit. All three of these standards will be incorporated simultaneously throughout the unit, relying on each other for the successful completion of each day of the unit.

7.E.1.3 Explain the relationship between the movement of air masses, high and low pressure systems, frontal boundaries to storms (including thunderstorms, hurricanes, and tornadoes) and other weather conditions that may result.

Although students will have been formally taught this content prior to this unit taking place, it will be reviewed within their study of two famous hurricanes on day 2 of the unit. Students will be analyzing informational text within an I-chart.

7.E.1.4 Predict weather conditions and patterns based on information obtained from:

- Weather data collected from direct observations and measurement (wind speed and direction, air temperature, humidity, and air pressure)
- Weather maps, satellites, and radar
- Cloud shapes and types and associated elevations

This is the standard in which this unit centers the most closely around.

Students will be looking at myth and folk based weather predictions (cloud shapes, wind speed, sky colors) on day one. On day three students will be analyzing modern weather technologies such as satellites and radar. Students should be able to demonstrate that they understand how we came from the more basic means of weather prediction to the more advanced means of weather prediction, and that both can be valid means of predicting.

7.E.1.6 Conclude that the good health of humans requires: monitoring the atmosphere, maintaining air quality, and stewardship

Day two begins to address this standard when students can conclude that monitoring of the atmosphere and weather is a critical piece of human survival. Once students are familiar with the background knowledge of storms and meteorological forecasting, they move into covering this standard in more depth on day four. During their final project students should be able to demonstrate that we rely on weather forecasting (monitoring of the atmosphere) to do everything from plant our crops and the proper time to building our cities resistant to the winds and rains of hurricanes.

Appendix 2: Weather Myths and Sayings Stations (Day 1)

Station One

Read the passage on the colors of the sunrise and sunset and what they mean for the weather.[21] Answer the questions below in complete sentences in your journal. Remember to restate the question in your answer!

Analysis Questions:
1. What are two groups of people mentioned in the article that relied on weather prediction? Why did they need to rely on predicting the weather?
2. What, in meteorological terms, does a red sky at night mean? (Why does it occur?)
3. What, in meteorological terms, does a red sky at dawn mean? (Why does it occur?)
4. What is one additional fact you learned about in this text?
5. Do you think we could still rely on the color of the sunrise and sunset to predict the weather in modern times? Explain your answer.

Station Two

Read the passage below on the legend of the Norse mermen.[22] Answer the questions below in complete sentences in your journal. Remember to restate the question in your answer!

Analysis Questions:
1. What type of weather was the sighting of a merman supposed to predict?
2. Scientists later figured out why these mermen were spotted before a storm. Explain why this optical illusion may become visible before a storm occurs?
3. What is one additional fact you learned about in the above text?
4. Why do you think sailors created stories such as ones of mermen sightings?
5. Do you think we could still rely on the sighting of mermen to predict the weather in modern times? Explain your answer.

Station Three

Read the passage below which explains how the behavior of animals has been used by some as a weather forecasting tool.[23] Answer the questions below in complete sentences in your journal. Remember to restate the question in your answer!

Analysis Questions:
1. How could a farmer use his or her cows to predict how to prepare their crops? (Think about the type of weather that cows can predict.)
2. According to the text, what do ants do in order to prepare for a storm?
3. You wake up and look out your window. You notice that the birds are flying quite low today. According to the text, what type of weather would you predict for today?
4. The text states that frogs croak differently depending on whether or not a storm is on

the way. Design a short experiment that you could conduct to test this theory.
5. Do you think we could still rely on the behavior of animals to predict the weather in modern times? Explain your answer.

Station Four

Read the passage below which explains how plants have been used by some as an indicator of future weather and seasonal patterns.[24] Answer the questions below in complete sentences in your journal. Remember to restate the question in your answer!

Analysis Questions:
1. Why did humans many years ago look to plants to predict weather patterns?
2. Imagine you are out camping in the forest. You wonder if it is going to rain tomorrow – but you do not have any phone/internet/television/radio to check the weather. At least you have your trusty pinecone! According to the passage, how could you use this pinecone to predict if there will be rain tomorrow?
3. Explain what the pimpernel flower does when the humidity in the air changes.
4. The last saying discussed in the text was, "A year of snow, fruit will grow." Design an experiment where you could test to see if this saying was true.
5. Do you think we could still rely on plants to predict the weather in modern times? Explain your answer.

Station Five

Read the following poem, and then answer the questions below in complete sentences in your journal.[25] Remember to restate the question in your answer!

Analysis Questions:
1. According to the text, what are clouds going to look like if we are to expect showers in the forecast?
2. According to the text, what type of weather would bring an abundant growth of hay?
3. According to the text, what is the consequence of no snow or rain in February?
4. Reading through the poem, what is your favorite weather saying? Explain the type of weather it would be used to predict.
5. Do you think we could still rely on some of the sayings in this text to predict the weather in modern times? Explain your answer. (Imagine what the morning weather forecast would sound like!)

Appendix 3: Student Reflection Sheets (Day 1 – 4)

Day One Reflection Sheet

Rate yourself and your group on a scale of 1 to 5 on the questions below. Consider 5 to be "always" and 1 to be "never".

1. I contributed fairly to my group: _____
2. My other group members equally contributed to my group: _____
3. What did we do well today that we should continue to do tomorrow?
4. What do we need to work on to make tomorrow even better?

Do you believe that these weather myths and sayings you learned about today were necessary in order for us to get to where we are today? Or were they silly? Explain your answer.

Day Two Reflection Sheet

Rate yourself and your group on a scale of 1 to 5 on the questions below. Consider 5 to be "always" and 1 to be "never."

1. I contributed fairly to my group: _____
2. My other group members equally contributed to my group: _____
3. What did we do well today that we should continue to do tomorrow?
4. What do we need to work on to make tomorrow even better?

Weather prediction is not perfect – do we give up and move on? Or try again? Explain your answer.

Day Three Reflection Sheet

Rate yourself and your group on a scale of 1 to 5 on the questions below. Consider 5 to be "always" and 1 to be "never."

1. I contributed fairly to my group: _____
2. My other group members equally contributed to my group: _____
3. What did we do well today that we should continue to do tomorrow?
4. What do we need to work on to make tomorrow even better?

Choose one of the five weather technologies you read about today. Explain what would have happened if this technology had been available during the Galveston hurricane of 1900. Would the impact of the storm have been different? Explain.

Day Four Reflection Sheet

Rate yourself and your group on a scale of 1 to 5 on the questions below. Consider 5 to be "always" and 1 to be "never."

1. I contributed fairly to my group: _____
2. My other group members equally contributed to my group: _____
3. What did we do well today that we should continue to do in future classes?
4. What do we need to work on to make future classes even better?

Summarize what you have learned during the activities during the last four days. Be sure to include what you learned about how weather prediction has evolved and how it has impacted humans.

Appendix 4: I-chart and I-chart Interview (Day 2)

Note: Formatting for the chart works best when it can be oriented in landscape and spaces added to allow students room to write their responses.

Galveston Hurricane of 1900				
	What was the geographical impact of the storm?	What was the human impact of the storm?	What were the long term consequences of the hurricane?	Questions created while analyzing the source
Pre-reading: Brain storm answers to questions				
Storm Summary[26]				
Photos[27]				
News Article[28]				
Personal Account[29]				
Rebuilding[30]				

Post I-Chart Interview Questions:

These are questions to be asked towards the Galveston group by the Ocean City MD group.

1. Which was the most impactful primary source which you analyzed? Why?
2. What do you think the most important human impact of the 1900 Galveston hurricane was that you read about in your sources?
3. How did the long term consequences of the storm shape the modern city of Galveston?

Ocean City Maryland Hurricane of 1933				
	What was the geographical impact of the storm?	What was the human impact of the storm?	What were the long term consequences of the hurricane?	Questions created while analyzing the source
Pre-reading: Brain storm answers to questions				
Storm Summary[31]				
Video: "Hurricane of August 23rd" [32]				
News Article[33]				
News Article[34]				
Rebuilding[35]				

Post I-Chart Interview Questions:

These are questions to be asked towards the Ocean City MD group by the Galveston group.

1. Which was the most impactful primary source which you analyzed? Why?
2. What do you think the most important human impact of the 1933 Ocean City, MD hurricane was that you read about in your sources?
3. How did the long term consequences of the storm shape the modern city of Ocean City, MD?

Appendix 5: Modern Meteorological Technologies Stations (Day 3)

Station One

Read the passage at your station about weather satellites.[36] Answer the questions below in complete sentences in your journal.

Analysis Questions:
1. Why were weather forecasts inaccurate several decades ago?
2. What do satellites allow meteorologists to see?
3. When was the first weather satellite launched? What did it carry?
4. What are the two types of satellites and where would you find each type? (Hint: It has to do with where/how they orbit the Earth.)
5. Do you think forecasters would be able to accurately predict an impending storm without data from satellites? Explain.

Station Two

Read the passage at your station about weather balloons.[37] Answer the questions below in complete sentences in your journal.

Analysis Questions:
1. What type of data do weather balloons collect?
2. What does the National Weather Service use this data for?
3. What is the highest altitude the weather balloon reaches? What happens when the balloon reaches this altitude?
4. If you were to find a weather balloon, what other components would you find with it?
5. The article mentions that only 20% of weather balloons are returned. It also mentions that more education of the public about weather balloons may ensure that more are returned. How could we make the public more aware of what to do when they find a weather balloon?

Station Three

Read the passage at your station about hurricane hunters.[38] Watch the video clip set up at the computer as well.[39] Answer the questions below in complete sentences in your journal.

Analysis Questions:
1. Who are the hurricane hunters? What do they do?
2. During a flight, where specifically do the hurricane hunters fly?
3. What types of data do the hurricane hunters collect about the storms which they fly into?
4. While watching the video, what would you be thinking or feeling if you were on a

plane with the hurricane hunters?
5. Using evidence from the article and the video, how do the hurricane hunters help meteorologists? What would be a consequence if we did not have the hurricane hunters?

Station Four

Read the passage at your station about Doppler radar.[40] Answer the questions below in complete sentences in your journal.

Analysis Questions:
1. Describe what the Doppler radar weather station looks like in the picture in the article.
2. What weather phenomena (events) does the Doppler radar measure and detect?
3. How is Doppler radar able to detect the possible formation of a tornado?
4. What data would the Doppler radar in our area have collected yesterday? Today?
5. How would storm prediction be different without the use of Doppler radar? What would be the disadvantages of not having Doppler radar?

Station Five

Read the passage at your station about personal weather stations.[41] Answer the questions below in complete sentences in your journal.

Analysis Questions:
1. What is a personal weather station?
2. What types of data does a personal weather station collect?
3. What does a hygrometer measure?
4. What does an anemometer measure?
5. If you installed a personal weather station at your home, what happens with the data you collect? How does this benefit the local community?

Teacher and Student Resources

1933 Chesapeake-Potomac Hurricane. n.d. http://en.wikipedia.org/wiki/1933_Chesapeake%E2%80%93Potomac_hurricane (accessed October 29, 2014).
A resource for teachers and students describing the rebuilding of Ocean City MD.

AccuRite. n.d. *What is a weather station?* Accessed October 2013, 2014. http://www.acurite.com/what-is-a-weather-station.
A resource for students describing what a personal weather station is, the date it collects and the different types of stations.

Baltimore Sun. n.d. *1933 Storm Photo Gallery.* Accessed October 31, 2014. http://www.baltimoresun.com/news/maryland/eastern-shore/bal-1933storm-pg-photogallery.html.
A resource for students which is a slide show of photographs from Ocean City after the 1933 hit.

Bean, Elaine. *How 1933 hurricane carved a lifeline for Md. beach resort.* August 22, 2013. http://www.usatoday.com/story/travel/destinations/2013/08/22/ocean-city-inlet-hurricane-1933/2686973/ (accessed October 29, 2014).
A resource for teachers and students describing how the Chesapeake Potomac hurricane changed the region.

CuriousVideos. 2011. *Flying through a Hurricane Eye Wall.* July 31. Accessed October 31, 2014. https://www.youtube.com/watch?v=a-SnxC-BkPo.
A resource for students which shows a behind the scenes look of missions flown aboard a hurricane hunter's plane.

European Space Agency. 2011. *Weather studies from space.* Accessed October 31, 2014. http://www.esa.int/esaKIDSen/SEMXUKXJD1E_UsefulSpace_0.html.
A resouce for students which describes how satellites collect weather data and how we use it to improve our forecasting.

Fingon, Joan C, and Shallon D Fingon. "Using science journals to encourage all students to write." *Science Scope*, 2008: 41 - 45.
A resource for teachers which gives examples of how to use journals to incorporate literacy and writing into the science classroom.

Graham, Steve, Claire Parkinson, and Mous Chahine. *Weather Forecasting Through the Ages.* n.d. http://earthobservatory.nasa.gov/Features/WxForecasting/printall.php (accessed September 23, 2014).
A resource for teachers which gives background on weather forecasting from the days of mythology through modern times.

History Channel. *1900 Galveston Hurricane.* n.d. http://www.history.com/topics/1900-galveston-hurricane (accessed October 29, 2014).
A resource for students which gives an overview of the meteorological characteristics and impact of the 1900 Galveston hurricane.

Laurel. *Poetic Weather Forecasting.* March 7, 2012. http://unfetteredwood.blogspot.com/2012/03/poetic-weather-forecasting.html (accessed October 25, 2014).
A resource for students with lists folk weather sayings.

Library of Congress. *Everyday Mysteries.* October 2, 2014. http://www.loc.gov/rr/scitech/mysteries/weather-sailor.html (accessed October 28, 2014).
A resource for teachers and students which describes the science behind a weather folk saying.

Library of Congress. *Using Primary Sources.* n.d. http://www.loc.gov/teachers/usingprimarysources (accessed September 16, 2014).
A resource for teachers which describes how to use primary source in the classroom, including how to introduce them to students who have not used them before.

MDHS Library Department. *Ocean City: The Great Hurricane of 1933.* July 24, 2013. http://www.mdhs.org/underbelly/2013/07/24/ocean-city-the-great-hurricane-of-1933/ (accessed October 28, 2014).
A resource for students which includes a video taken during the hurricane of 1933.

Morgan, Denise N, and Timothy V Rasinski. "The Power and Potential of Primary Sources." *The Reading Teacher*, 2012: 584 - 594.
A resource for teachers which details ways to incorporate primary sources into the classroom.

Musbach, Joan W. "Using Primary Sources in the Secondary Classroom." *OAH Magazine of History*, 2001: 30 - 32.
A resource for students which details ways to use primary sources in middle and high school grades. Includes tips for how to use these sources successfully to enhance learning of content.

National Earth Science Teacher Association. n.d. *Chasing the Storm.* Accessed October 31, 2014. http://www.windows2universe.org/earth/Atmosphere/hurricane/hunters.html.
A source for students which describes the hurricane hunter division of the USAF including the data the planes and equipment collect.

NOAA. *It's a Bird! It's a Plane! No...It's a NOAA Weather Balloon!* n.d. http://www.noaa.gov/features/02_monitoring/balloon.html (accessed October 30, 2014).
A resource for students which describes what a weather balloon is and the types of data they collect.

NOAA History. *Galveston Storm of 1900.* n.d. http://www.history.noaa.gov/stories_tales/cline2.html (accessed September 13, 2014).
A resource for teachers which gives details about the 1900 Galveston hurricane including details of the storm and how the town was affected.

Ohio State University Extension. "Can Plants Predict the Weather?" *Trumpet Vine,* 2008: 5 - 6.
A resource for teachers and students which names and describes plants whose shape or other characteristics change depending on the current weather conditions.

SkyMet Weather Service. *6 Animals That Can Help Predict the Weather.* April 29, 2013. http://www.skymetweather.com/content/2013/04/lifestyle-and-culture/6-animals-that-can-help-predict-weather/ (accessed October 28, 2014).
A resource for teachers and students which lists animals whose behaviors change depending on the current weather conditions. This source also details any scientific research behind these animal predictors.

Silver, Debbie. "What is cooperative learning?" *Debbie Silver.* n.d. www.debbiesilver.com (accessed September 14, 2014).
A resource for teachers which discusses ways to use cooperative learning in the classroom, such as jobs to give students and ways to rotate through groups.

The City of Galveston. *The 1900 Storm: Galveston Texas.* 2014. http://www.1900storm.com/nightofhorrors/ (accessed October 29, 2014).
A resource for students which contains personal accounts and quotes from citizens who lived through the 1900 Galveston hurricane.

The City of Galveston. *The 1900 Storm: Galveston Texas.* 2014. http://www.1900storm.com/rebuilding/ (accessed October 29, 2014).

A resource for teachers and students which discusses how the town of Galveston was rebuild after the 1900 hurricane and how well the rebuilding plan has protected them from hurricanes since.

The Sourcerous Finfolk. n.d. http://www.orkneyjar.com/folklore/finfolk/index.html (accessed October 29, 2014).
A resource for teachers and students which discusses the Norse merman folktale and the scientific evidence behind the tale.

The Weather Channel. *Hurricane: The Galveston Hurricane of 1900.* n.d. http://www.weather.com/outlook/weather-news/hurricanes/articles/hurricane-historical-hurricanes-galveston_2010-05-27 (accessed October 28, 2014).
A resource for students which contains photos from 1900 and the aftermath of the hurricane in Galveston.

Towndrow, Phillip Alexander, Tan Aik Ling, and A M Venthan. "Promoting Inquiry Through Science Reflective Journal Writing." *Eurasia Journal of Mathematics, Science and Technology Education*, 2008: 279 - 283.
A resource for teachers which shares ideas with teachers on how to use journals within the science class to promote higher level thinking.

Williams, C. Arthur. "5000 Is Now Estimated." *The Houston Daily Post*, September 12, 1900.
A primary resource for students which gives an account of the 1900 Galveston hurricane.

WTVY. 2011. *A brief explanation of how Doppler radar works.* April 26. Accessed October 31, 2014. http://4warnwxteam.com/2011/04/26/a-brief-explanation-of-how-doppler-radar-works/.
A resource for students which describes how Doppler radar works as well as the purpose and the data which it reports.

Notes

[1] Library of Congress. *Everyday Mysteries.* October 2, 2014. http://www.loc.gov/rr/scitech/mysteries/weather-sailor.html (accessed October 28, 2014).

[2] *The Sourcerous Finfolk.* n.d. http://www.orkneyjar.com/folklore/finfolk/index.html (accessed October 29, 2014).

[3] SkyMet Weather Service. *6 Animals That Can Help Predict the Weather.* April 29, 2013. http://www.skymetweather.com/content/2013/04/lifestyle-and-culture/6-animals-that-can-help-predict-weather/ (accessed October 28, 2014).

[4] Graham, Steve, Claire Parkinson, and Mous Chahine. *Weather Forecasting Through the Ages.* n.d. http://earthobservatory.nasa.gov/Features/WxForecasting/printall.php (accessed September 23, 2014).

[5] Graham, Steve, Claire Parkinson, and Mous Chahine. *Weather Forecasting Through the Ages.* n.d. http://earthobservatory.nasa.gov/Features/WxForecasting/printall.php (accessed September 23, 2014).

[6] Graham, Steve, Claire Parkinson, and Mous Chahine. *Weather Forecasting Through the Ages.* n.d. http://earthobservatory.nasa.gov/Features/WxForecasting/printall.php (accessed September 23, 2014).

[7] Graham, Steve, Claire Parkinson, and Mous Chahine. *Weather Forecasting Through the Ages.* n.d. http://earthobservatory.nasa.gov/Features/WxForecasting/printall.php (accessed September 23, 2014).

[8] NOAA History. *Galveston Storm of 1900.* n.d. http://www.history.noaa.gov/stories_tales/cline2.html (accessed September 13, 2014).

[9] NOAA History. *Galveston Storm of 1900.* n.d. http://www.history.noaa.gov/stories_tales/cline2.html (accessed September 13, 2014).

[10] The City of Galveston. *The 1900 Storm: Galveston Texas.* 2014. http://www.1900storm.com/rebuilding/ (accessed October 29, 2014).

[11] *1933 Chesapeake-Potomac Hurricane.* n.d. http://en.wikipedia.org/wiki/1933_Chesapeake%E2%80%93Potomac_hurricane (accessed October 29, 2014).

[12] Bean, Elaine. *How 1933 hurricane carved a lifeline for Md. beach resort.* August 22, 2013. http://www.usatoday.com/story/travel/destinations/2013/08/22/ocean-city-inlet-hurricane-1933/2686973/ (accessed October 29, 2014).

[13] Bean, Elaine. *How 1933 hurricane carved a lifeline for Md. beach resort.* August 22, 2013. http://www.usatoday.com/story/travel/destinations/2013/08/22/ocean-city-inlet-hurricane-1933/2686973/ (accessed October 29, 2014).

[14] Towndrow, Phillip Alexander, Tan Aik Ling, and A M Venthan. "Promoting Inquiry Through Science Reflective Journal Writing." *Eurasia Journal of Mathematics, Science and Technology Education*, 2008: 279 - 283.

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