



## **Global Warming and Hurricanes: Is an Increase in the Number of Stronger Hurricanes an Indicator of Global Warming?**

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### **Objectives**

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#### **Course Description**

I teach four sections of 9th Grade Integrated Science; a survey course that integrates the concepts and ideas of Chemistry, Earth Science, and Physical Science. My classes are heterogeneously grouped, meaning that there are a wide-variety of skills and abilities in one classroom, and the range runs from students who are enrolled in the special-education program and are on Individualized Education Plans (IEPs) and students who are and/or could be in the gifted and talented program. The idea behind heterogeneous grouping is to create a diverse learning environment for all students and more importantly to help all students find success by allowing them opportunities to express their strengths in the classroom and in so doing each student helps each other with their weaknesses and their varying understanding of the content and/or activities. With a heterogeneously grouped classroom I must create activities that are catered to a variety of learning styles and ability levels. The school that I teach at has small class sizes, between 12-15 students, and the classroom is organized so that the students have mobile lab benches, which was designed specifically for laboratory investigations and for collaborative group-work. The classroom is also arranged in a way that allows for whole group discussions and for students to take notes during introductory lectures. I meet each section four times per week, 2 class periods are 60 minutes in length and 2 class periods are 70 minutes in length.

The Integrated Science course is designed around the scientific method and inquiry-based learning. The students learn how to use the scientific method as a way to organize and explore their curiosities about their world and about Science in general. The inquiry-based learning is an extension of the scientific method. It allows students to develop their knowledge and understanding of a topic by asking questions that will guide them to finding the answers. It's a skill that takes the entire year to develop fully, but is so important because they're not just passively receiving their education; they're taking an active role in it. All of their laboratory investigations require the students to ask the questions and develop the procedures, and determine what data they will need to collect and analyze to answer in order to answer the focus question. This is designed specifically with the Connecticut Academic Performance Test (CAPT) in mind, which is a test that all 10th grade students have to take and has students using their critical thinking skills to analyze laboratory scenarios and performance tasks, so the New Haven Academy 9th Grade Integrated Science curriculum allows students

to develop these critical thinking skills that will help them to successfully take the Science portion of the CAPT.

The 9th Grade Integrated Science course has a lot of content that gets covered throughout the year. After spending time covering the basics of Science such as the scientific method and measurement and conversions, we move into Chemistry where students learn about basic chemistry and chemical reactions. From chemistry we move on to physical sciences and energy, looking at energy sources and their role in global warming, and we finish the year with earth sciences, looking at weather patterns, earth's evolution, and human impacts on earth. These are just a sample of the many topics that get covered in the course. The course moves rather quickly, but in a way where there is a deliberate connection between all of the topics so that students can see that all of science is connected and that each part is equally important for understanding how the world works. The idea behind this survey course is to allow students to become exposed to the many concepts, theories, vocabulary, skills and techniques as a foundation for the remaining science courses that they will take throughout their high school career. The students at New Haven Academy are required to take at least three years of science, and this course is aimed at building the foundation that the students will need for their successful completion of their science career at New Haven Academy. Ultimately what I want the students to take away from this course is an ability to use the scientific method to design and conduct research about their world, organize and report results in a meaningful way, and make real world connections with their investigations of the content.

The goal of the New Haven Academy science curriculum is to develop scientifically responsible citizens who will use their knowledge and their understanding to become active agents of change in their community, to develop a curiosity that will allow them to seek information and consider multiple perspectives and make informed decisions, that will allow them to use the past and the present to make a better future for humankind.

### **School Philosophy**

New Haven Academy is an interdistrict magnet school in the New Haven Public School System. The magnet school is a school of choice, which has a specific theme designed to attract a variety of students from all facets of a community to create more racial, ethnic, and socioeconomic diversity within a school, so it's not just students from within the inner city, it's also students from suburban populations as well. The students come from all over the greater New Haven area, including Ansonia, East Haven, Hamden, New Haven, Shelton, and West Haven. New Haven Academy opened in September of 2003 and is graduating its first class this year. The school's mission is to "provide a rigorous education that prepares all students to succeed in college and become active citizens able to make informed decisions about their lives and their communities." <sup>1</sup> Our philosophy follows the idea of keeping class sizes small to allow for more personalized curricula. We also look for students to demonstrate learning in a variety of ways including, but not limited to, written laboratory research papers, oral presentations, and projects with a visual component that gets displayed and evaluated. The final project for my unit will require the students to collect scientific evidence to argue a debate topic relating to global warming and tropical cyclones and will write a final reflection paper on what they learned throughout the unit and describe their own belief system on the topics of the debates and explain and provide evidence as to why they have the opinion that they have about the topic of global warming and tropical cyclones.

The magnet theme is taken from the international organization, known as Facing History and Ourselves. It follows "a curriculum that engages adolescents in citizenship education and encourages adolescents and adults to examine profound ethical questions about history, decision-making, prejudice, and violence." <sup>2</sup>

Basically students analyze history and think about why certain events in history happened and reflect on how it was allowed to happen, and what could have been done differently by humans to prevent such events from taking place. More importantly it gets them to look at the history that they are currently making, and allows them to find ways of taking action so that their history can be healthier and/or more productive. We are also a member of the Coalition of Essential Schools (CES) founded by Ted Sizer, an organization guided by ten common principles, seeking "personalized, equitable and intellectually challenging schools." <sup>3</sup>

We ask our students to use five habits of mind as they learn and process new information.

1. The question of evidence: How do we know what we know?
2. The question of multiple perspectives: Who's speaking?
3. The search for connections and patterns: What causes what?
4. The idea of supposition: How might things have been different?
5. The question of why any of it matters: Who cares?

## **Unit Description**

The Global Warming and Tropical Cyclones Unit will be taught in conjunction with a larger theme in the 9th Grade Integrated Science Curriculum which focuses on Global Interdependence and the impacts of humans on their natural environment. This unit will be designed to have students enhancing their critical thinking skills, as they will explore the controversies surrounding global warming and the lasting effects of global warming on the environment. The unit will take approximately 6 weeks and will be taught in three parts, the first part will focus on learning about what Global Warming is and understanding our role as humans in Global Warming, the second will focus on understanding the Science behind the formation of Hurricanes/Tropical Cyclones, and finally the third part will focus on integrating the two concepts focusing on the question: Are Hurricanes affected by global warming? This question is not enough for a sufficient debate however. We're at the leading edge of this research at this point in time. Scientists don't have all of the evidence in yet. There is a lot of incomplete information out there for both sides of the argument, so the more important questions that the students will also be keeping in mind are: What do you believe (about the idea of global warming and its affect on the earth)? The other question is: How far are you willing to go if all of the evidence is still not in? Do you act without sufficient evidence and risk a major economic crisis? Or do you wait until it's possibly too late to avert ecological disaster? An analogy can be used here to help students to really think about the above questions. A person goes to the doctor and complains of chest pain and discomfort in the arms and jaw. The signs are pointing to a heart attack, but the doctor decides to run more tests to determine that it is really a heart attack, but the results of the test take too long and the patient dies before the results come back. When the results come back the doctor discovers that it really was a heart attack. At what point should the doctor have started treatment? Should the doctor really have done those extra tests or should the doctor have looked at the signs and symptoms and said, this patient is having a heart attack and something needs to be done for him/her immediately. The same case holds true for global warming; at what point do we stop speculating about global warming and finally start taking action? We can't wait until we see the effects that

cause us discomfort because that will be too late, and we may never see and/or feel that discomfort. Al Gore uses an analogy in *An Inconvenient Truth*, to help us understand the idea that we may not feel a difference before it becomes too late. The analogy is a frog put into a beaker of water on a hot plate. If the heat is slowly turned up to boiling, the frog adjusts its body temperature to the slowly and steadily rising temperature and does not notice the change, therefore boiling itself to death because it didn't realize what was happening to it. If, however, the temperature is increased too rapidly the frog can feel the difference and jumps out to safety. The problem right now with global warming is that we have not seen or felt much of a change, so we don't see a need to change our behaviors that could be resulting in global temperature change. Some guiding questions that the students will focus their research on is: Is global warming really happening? Is Carbon Dioxide (CO<sub>2</sub>) causing the global temperature to change? Are natural disasters affected?

## Rationale

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### Unit Overview

The unit that I'm teaching is called "Global Warming: How does it affect Hurricanes?" I chose this topic for two reasons; it fits in well with the 9th Grade Integrated Science curriculum that I teach and with the more recent release of Al Gore's documentary, *An Inconvenient Truth*, global warming is at the forefront of people's minds. I'm able to fit this in with the curriculum because the students are required to learn about global interdependence and the impacts of humans on their natural environment. As I mentioned above, the course that I teach integrates the topics of chemistry, physical, and earth sciences with a strong emphasis on connecting each topic with the next; at the beginning of the school year I teach the students about the basics of chemistry, which I connect to the atmosphere and greenhouse gases, because the atmosphere is a good place for students to apply their knowledge of atoms and molecules since there is a variety of elements making up the atmosphere. The chemical make-up of the atmosphere is what allows the earth's temperature to remain relatively constant and in a range that works for the organisms living on the planet. Global warming is a natural fit as we move on from the atmosphere and greenhouse gases. I use Al Gore's video as a way to understand the human role in global warming for the students and the reason why I chose to connect global warming to hurricanes is because in the video he mentions that one piece of evidence illustrating that global warming is really happening is that the numbers of category 4 and 5 hurricanes have been increasing over the past 30 years and he specifically states that they have doubled. However, Gore does not provide us with the Science behind this phenomenon. I want the students to investigate this statement and since one of our habits of mind is the question of evidence, how do we know what we know, it's important for the students to find out if the statement has any kind of validity and figure out how an increase in more intense storms could be considered evidence to global warming.

The Global Warming and Hurricanes unit will be about 6 weeks in length. It will be taught in three sections, a section on global warming, hurricanes, and finally a section that connects global warming to hurricanes. At the beginning of each section the students will explore the key vocabulary and we will develop questions that will help them to develop the necessary background information for understanding each topic. After learning about global warming and hurricanes, the end-of-unit assessment will have students debating the various issues that were addressed during the unit. They will use the questions from above and will form debate teams consisting of 3-4 students, depending upon the numbers of students in the class. The teams will spend time researching relevant information for both sides of the central debate question. It's essential that they

research both sides of their issue because when the actual debate day comes they won't know until 1 minute before their debate, whether they will be debating for or against the issue. They will be following a very specific debate protocol that is taken from my former cooperating teacher, Julianne Mueller-Northcott at Souhegan High School, in Amherst, NH. In the research and preparation for the debate the students will have the opportunity to develop their own focus questions for the research, but they will also be provided with the (above) list of focus questions so that they will be able to gather all of the relevant information for preparing a well-informed debate. They will spend a few periods on the research and debate preparation in class, and will be provided timelines and guidelines so that their class time will be structured and used wisely. They will be assigned homework to prepare an outline of their debate showing who will be assigned which roles and the specific information that will be included in the debate. I will read through each group's outline and provide them with feedback on the information that they gathered. After the research and preparation we will go over the debate protocol as a class and then the student groups will practice debating with each other using this protocol. As they practice I will listen and watch so as to provide each group feedback on their debate technique. After their practice day, the students will come dressed professionally and will be ready to give either side of the debate. After the debates, the students will write a final reflection on what they learned throughout the unit and describe their own belief system on the topics of the debates and explain and provide evidence as to why they have the opinion that they have about the topic of global warming and hurricanes.

## **Section 1: Global Warming**

The unit will begin with the students generating a KWL chart about Global Warming, ultimately leading to their own exploration of their questions about global warming, allowing them to gain a general understanding of what global warming is. The way the chart works, is the students will generate a list of things that they already know about global warming. I'll ask them to write down at least two things that they know about global warming. As students share their responses, I will record them on a large piece of paper that will be displayed for the duration of the unit. After the students write down what they know about global warming, they will then be asked to write down their questions that they have about global warming. These questions will also be recorded and will be displayed next to the chart of things they already know, and will be used to guide them through the learning process of understanding global warming. They will explore these questions using their Science text, *Foundations of Physical Science with Earth and Space Science*, and other articles about global warming. In addition to exploring their questions using the text, I will also provide information in the form of lectures on Global Warming, specifically related to what it is and what causes it, i.e. greenhouse gases, long term climate change, and glacial cycles. Please refer to the section below, entitled "Content Background Information" for the specific information that will be included in these lectures. The students will also look into how humans play a role in global warming, by watching the Al Gore documentary, *An Inconvenient Truth*. We will use this movie as a basis for discussion about what they learned about Global Warming. There are a few articles that they will also read in conjunction with this video as a follow up to the evidence that Al Gore provides about global warming, the articles are taken from the University of Colorado, Boulder and focus on the Arctic Sea Ice Shrinking and the Antarctic Ice Shelf collapse. They will take all of the information gathered and have a discussion about their understanding of Global Warming and human impacts. The discussion will have a general focus question: Have humans impacted global warming? Not only will they look at the human impact on global warming, but they will also look at long term climate change not created by humans. The discussion will also be completely student-centered using a discussion protocol, which holds all students accountable for participating in the discussion. Throughout all the reading and class work, students will have a long term homework assignment to keep a daily log of their personal energy usage, in essence monitoring their daily CO<sub>2</sub> output. During week one, the students will monitor their "normal" energy usage, and during week two they will do everything in their power to conserve as much energy as possible,

and therefore monitor their "conserved" energy usage. They will need to collect information on all of the appliances that they use and keep track of the amount of time they use each appliance. In the end they will use an equation to calculate how much CO<sub>2</sub> they produced over the course of the two weeks and they will graph their results and see the difference between when they consciously make an effort to conserve energy and when they don't try to save energy. After the discussion and after fully monitoring their energy usage, students will finish filling out the "L" part of the KWL chart, and will then write a brief paper, answering the question "Have humans impacted global warming and what can we do to alleviate the problem? They will use points brought up from the discussion and from the multiple readings as evidence to support their ideas, they will also need to tie in what they learned from collecting the data on their own personal energy usage.

## **Section 2: Tropical Cyclones**

The next part of the unit will be a short informative session, only a few class periods long on the Science of hurricanes. As with the global warming section, the students will also create a KWL chart for tropical cyclones, i.e. hurricanes. Their questions generated about hurricanes will also guide them through understanding how hurricanes work. I will be teaching the students about what hurricanes are, how they form, and what causes them. They'll watch a short video as an introduction to the topic of hurricanes and I will also prepare several lectures on hurricanes and provide notesheets for the students to use for taking notes on the lecture. The information for the lecture will be gathered from *Natural Disasters*, Patrick L. Abbott, 4th Edition, 2004, McGraw-Hill from Chapter 11 entitled Hurricanes and the Coastline.

## **Section 3: Relating Global Warming to Tropical Cyclones**

The final part of the unit will be integrating the two topics of global warming and tropical cyclones. The students will explore the possibility of the intensity of hurricanes changing as a result of global warming. In the Scientific community there is disagreement over whether hurricanes are increasing in strength and numbers due to global warming. The students will read a number of different articles, from the National Oceanic and Atmospheric Administration, with varying arguments regarding hurricanes and global warming. The students will be provided a graphic organizer to help organize their thoughts and ideas as they read each of the articles. They will then use these articles and graphic organizers as a jumping off point for another student-centered discussion, following the same discussion protocol from the beginning of the unit. There will be one focus question for the discussion will focus on two questions: "Is an increasing number of category 4 and 5 hurricanes a result of global warming?" During this discussion students will take notes on each others comments, thoughts, and ideas.

## **Content Background Information**

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### **Global Warming**

Global Warming is defined as an increase in the average temperature on Earth (Miller 2002). There are many causes of global warming, ranging from natural causes to human induced causes. The greenhouse effect is actually a natural cause of global warming, defined as "a natural situation in which heat is retained in the Earth's atmosphere by carbon dioxide, methane, water vapor, and other gases (Miller 2002)." The greenhouse effect is actually a vital component to maintaining a relatively constant surface temperature on Earth and keeping temperatures in "a range suitable for life as we know it (Miller 2002)." Human activity, however, has



led to an increase in the amount of greenhouse gasses in the atmosphere. The students will look at the greenhouse effect, greenhouse gases, long vs. short term climate changes and finally they'll look at human activity. I believe that understanding the human activity aspect of global warming is highly important for the students to learn about because it's the one thing that we have control over, but I also see value in understanding the non-man-made causes of global warming so that we can distinguish the difference between the two types of causes. Human activity is the most prominently talked about cause of our current global warming trend, but because there is such great variety as to the causes of global warming over time, the subject of human activity and global warming is a topic of great debate and controversy and the reason being that there is no definitive piece of evidence linking human activity to the cause of global warming and that global warming is actually taking place. People have the most difficult time with the idea of global warming because they don't quite understand what global warming is and they're not experiencing immediate effects. Al Gore described it this way, he said that if you put a frog in a beaker of water on a hot plate and slowly turn up the heat, the frog adjusts to the slow temperature change and does not realize that it's getting too hot and will sit in the hot water until it boils to death unless someone rescues the frog. This same phenomenon is analogous to humans here on Earth. Global Warming is slowly turning up the burner of the hot plate, so humans are not seeing any drastic and lasting effects, so why should they make any changes? This is where the underlying debate question will become important for the students, should we do anything about global warming even if there is only a small amount of evidence. They will look at what global warming is and some of the causes of it, and they will analyze some of the arguments that Scientists are making for and against it and will look at some of the evidence and decide, is there enough information to make a decision that humans need to make changes in their daily habits.

The first cause of global warming is the greenhouse effect, which is "the buildup of heat beneath substances such as glass, water vapor, and carbon dioxide that allow incoming short-wavelength solar radiation to pass through, but block the return of long-wavelength solar radiation [...]" (Abbott 2004)." The greenhouse effect is actually quite important because it actually keeps the temperature on earth relatively constant and is what sustains life on the planet, that is, if the greenhouse gases remain in the proper proportions. The greenhouse gases, specifically carbon dioxide, methane, nitrous oxide, ozone, water vapor, and chlorofluorocarbons, prevent the reradiated infrared wavelengths from escaping out of the earth's atmosphere, thus causing the earth to heat up. The more greenhouse gases in the atmosphere, the more heat that stays inside of the earth's atmosphere that won't escape back into space, which ultimately causes the earth to get hotter. Carbon Dioxide is often blamed as the culprit of global warming, but it's heat absorbing potential is a lot smaller than the other gases mentioned above. For instance, methane has a heat absorbing ability of 21 times more than that of Carbon Dioxide and ozone's heat absorbing ability is 2,000 times greater than Carbon Dioxide, so then why is Carbon Dioxide often blamed for global warming? First of all there's a lot more CO<sub>2</sub> in the atmosphere than the other greenhouse gases. Since there is such a high amount of CO<sub>2</sub> in the atmosphere therefore causing increased temperatures, this has led to more water vapor in the atmosphere, which is also a greenhouse gas. Secondly, sixty percent of the earth's warming due to the greenhouse effect is caused by humans releasing Carbon Dioxide into the atmosphere. CO<sub>2</sub> is naturally cycled in the environment, through the process of photosynthesis, plants take in CO<sub>2</sub> which aids in the process of tissue production, when they die the unused CO<sub>2</sub> is returned to the atmosphere. Humans have significantly changed this cycle by burning wood and burning fossil fuels. This has caused a dramatic increase in the amount of CO<sub>2</sub> in the atmosphere because when wood and fossil fuels are burned, it causes chemical reactions to take place that end up releasing excess CO<sub>2</sub> into the atmosphere. Fossil fuels were formed when organic-rich decaying plant materials were buried beneath sediments and the pressure of the ever increasing buildup of sediments above, caused the material to transform into the coal, oil, and natural gas that we use to power and heat our homes,

and run our cars, etc. According to Abbott author of, *Natural Disasters*, the CO<sub>2</sub> concentration in 1800 was 280 parts per million (ppm), but by 2000 the amount had increased by greater than 30 percent to 370 ppm, and 70 percent of that increase came after the year 1950. So while there are other gases that have the ability to trap more of the reradiated infrared wavelengths of light, Carbon Dioxide is the gas that we have significantly increased over the last several decades.

Global climate change is something that has occurred since the beginning of the earth, so it's important for students to understand that not only is global warming and climate change something that humans can impact, but there are also natural phenomena that can cause the earth to warm and/or cool. Abbott tells us that the Earth's climate is dependent upon a balance between the heat that comes into the Earth's atmosphere and the heat that leaves the Earth's atmosphere. The Earth is divided into three temperature zones which are described as frigid, temperate, and torrid and these zones are all dictated by latitude. Looking at the Earth's climate history, the climate has gone through many irregular changes throughout time. There have been times when the Frigid Zone's temperature became dominant over most of the Earth's surface, typically known as an Ice Age, while there have been other points in history where warmer temperatures from the Torrid Zone dominated the Earth. Three Hundred Sixty Million years ago, was one such period of time when the Earth's climate was in a cold state, known as the Late Paleozoic Ice Age, which lasted for 100 million years. The reason for this Ice Age was due to changes in the sizes, shapes, and orientations of the oceans and the continents. There had to be a huge land mass at one of the poles, which would gather the snow to create massive ice sheets. Ocean water circulation was also an important factor. Water at the equator always receives more solar energy than the water at the poles, if there were no continents, then the water would flow in an east-west pathway because of the earth's spin. "The geologic record shows that Ice Ages are favored when oceanic circulation is more longitudinal (north-south) than latitudinal (east-west) (Abbott 2004)." North-South continental alignment causes ocean water to circulate longitudinally and propels the warm equatorial water to each of the poles, and because warm water evaporates much better than cool water, this allows clouds to form over the poles and dumps massive amounts of snow on to the land masses at the poles and causes the formation of glaciers. The Late Paleozoic Ice Age most likely ended because the Southern Portion of Pangaea broke apart causing the circulation of the ocean waters to change, the warm waters stayed near the equator, while the cold water circulated at the poles, thus preventing the needed evaporation and cloud formation at the poles to create the snow necessary to maintain the glaciers. This was an example of the opposite of global warming, and that global climate change can take place without the humans. There have also been times in the geologic time scale that indicate a warming period of the Earth. One such event occurred during the Late Paleocene Torrid Age, which was about 65-55 million years ago. During this warming event there came to be less of a difference between the temperatures of the waters at the equators and the poles. When the temperatures in these areas become less diverse, meaning without extremely cold water, there is no longer a sinking action of the colder more dense water in the polar regions which causes the temperature at the surface and in the depths to be more uniform, which means that ocean circulation would be slow-moving. With slow-moving surface waters, also come changes in the atmospheric temperatures, worldwide there was little temperature difference which caused more peaceful weather, meaning that the world-climate was without extremes. The reason for the torrid-dominated temperatures of the world was because of a several factors, the first being that at the equator there was mainly oceans, which meant that the ocean was absorbing more of the sun's energy. The second reason was that warmer oceans caused more snow and ice to melt and exposed more land, while snow and ice reflect sun rays, the land absorbs it. The third factor was probably that in the North Atlantic Ocean lava was escaping at fault lines as the ocean was opening up in this area, which caused a release of profuse amounts of gas, which would have increased the amounts of greenhouse gases in the atmosphere, thus causing a warming effect throughout the entire earth.



The final reason for the warming was because the warm waters became extremely dense, which is opposite of the current state of the ocean, where the cold waters are more dense. The change in density happened because of the higher evaporation rate of the ocean waters, leaving more salt in the warm waters, which increased the water's density. Warm water was able to sink to the bottom of the ocean, and this caused the methane hydrates at the bottom of the ocean floor to melt and get released. Methane has a heat trapping ability of 21 times more than Carbon Dioxide, so releasing the Methane from the ocean floor caused a drastic increase in the greenhouse effect thus changing the temperature on earth and life on earth. Today on our current ocean floors there is still large amounts of these methane hydrates. Climate change is nothing new to the earth. It has undergone many changes over the course of its history and happens naturally without the help of humans, however, humans can and do play a significant role. Climate change usually takes place in 10s of 1000's of years, the climate change that we are currently seeing is happening at a much faster rate.

There are also shorter term climate changes that take place such as El Nino. El Nino is a phenomenon that occurs because of the weakening of the trade winds. Normally there is a low pressure system that remains over Indonesia, but when the trade winds weaken, it causes the low to move over into the Pacific Basin, causing the warm waters to move toward South and Central America. When this happens, the currents get reversed and the winds from the west blow the surface water to the east, causing the Americas to receive a large amount of warm ocean water that easily evaporates. When water evaporates more freely, more clouds are produced and the atmospheric pressure is lowered, causing the warm moist air to flow in an easterly direction towards the Americas and heavier rains in areas that are not used to getting rain. Not only do the coastal areas of the Americas receive heavier rains but because the jet stream flows differently in an El Nino, the southeastern United States is also hit with more rain. The number of hurricanes is reduced because the normally moist areas of the West Pacific Ocean, Indian Ocean, and Africa dry up due to the weakening of the trade winds, the winds enter the Central Pacific Ocean from both sides, and the warm water and moist air spread into Eastern Pacific causing a weaker North Atlantic Hurricane season. The weaker trade winds are unable to transport the cyclones to the west. The jet stream also flows in between the Atlantic and Caribbean breaking apart major storm systems.

It's important that the students understand that there are many causes to global climate change, and that global climate change can and does happen without humans, however it is important for students to understand that while global climate change does occur naturally it happens at a rate of 10s of 1000s of years. When we compare that time scale to the climate change that is currently taking place, it's evident that our climate change is happening at a much quicker rate, and it's due mainly to the fact that humans are releasing Carbon Dioxide into the atmosphere in excess quantities. So I want students to be able to compare the difference between the warming during the Late Paleocene period and the warming that is occurring now.

## **Hurricanes**

A hurricane is a large cyclonic storm that occurs in warm tropical waters with sustained winds of greater than 74mph, the reason why 74mph makes a hurricane a hurricane, is that at this speed the winds are no longer able to reach the center of the storm, thus creating the hurricane's eye (Abbott 2004). A hurricane is often referred to as a heat engine. They work by the process of convection, which "is a process of heat transfer where hot material at depth rises upward due to its lower density while cooler material above sinks because of its higher density (Abbott 2004)." Basically a hurricane is able to take the heat energy from the ocean and change it to winds and waves. The energy of a hurricane has the ability to generate winds greater than 150mph, push seawater onshore to heights of 20ft or more and produce heavy rains leading to floods far from the coastal shores.

In order for a hurricane to form several criteria must be met, first within the top 200ft of the ocean's surface, the water temperature must be at least 80°F. The second criterion is the air above the water must be warm, humid, and unstable. Finally there should be weak upper level winds blowing in the same direction of the developing storm. A hurricane begins as a tropical disturbance, where a low pressure zone draws in groups of "poorly organized" thunderstorms (Abbott 2004). From that point a tropical depression begins to form "as surface winds strengthen and flow more efficiently around and into the growing storm [ . . . ] (Abbott 2004)." In the Northern Hemisphere the storm rotates in a counterclockwise direction around the core. At this central core the surface winds converge and this core "acts like a chimney" pushing warm, moist air up toward the stratosphere. As the air rises it begins to cool and reaches the dew point temperature, causing condensation of the water vapor and a large amount of latent heat to be released. This heat release warms the air within the core, thus "causing stronger updrafts," increasing the rate of upward movement of the warm, moist air from below (Abbott 2004). The tropical depression grows in strength as the converging winds gain speed as they continually spiral up into the core and it becomes a tropical storm when the converging winds sustain speeds between 39 and 74mph. The tropical storm develops into a hurricane when the surface winds remain above 74mph. A hurricane's strength is dependent upon "the speed that the surface winds can flow into the central core, race up its sides, and easily flow out and away in the upper atmosphere. The path that the hurricane follows is due to the trade winds and Coriolis Effect. Trade winds push the hurricanes toward the west. While the Coriolis Effect causes hurricanes to curve to the right, in the Northern Hemisphere. Abbot explains that "[i]f the Earth's surface were as smooth as a billiard ball and solar energy were received equally over its surface, then the atmosphere would be rather still[,] however this is not the case, Earth's surface is not smooth and further more it does not receive equal solar radiation (Abbott 2004). The earth rotates rapidly, causing warm and cold air masses to move around the earth's surface. At different latitudes the velocity of the rotation of the earth's surface varies, at the equator it moves a 1,037mph and at the poles it moves at 0mph (Abbott 2004). These changes in velocity at different latitudes cause bodies to follow curved paths as they move across the latitudes. This is known as the Coriolis Effect, so hurricanes located in the Northern Hemisphere will always follow a path that curves to the right, while hurricanes in the Southern Hemisphere will always follow a path that curves to the left.

### **Connecting Global Warming to Hurricanes**

There is disagreement in the scientific community over whether the increase in the number of more intense hurricanes is a result of global warming. However, naturally since warm water is a key and necessary ingredient to forming a hurricane, common sense would tell us that even warmer water would yield stronger hurricanes. The problem is that the warmer water may not necessarily be the result of global warming, and even if it is, Scientists still are not sure about the idea that an increase in the number of more intense hurricane is truly an indicator of global warming. The students will be looking at both sides to this argument, and because the students must research the reason, I need to have a strong understanding of what both sides are to this argument. An article in the American Meteorological Society journal, entitled, *Hurricanes and Global Warming* , looks at the 2004 hurricane season to help to bring light to the idea of the disagreement.

Some prominent scientists proposed that the intense 2004 hurricane season and its considerable impacts, particularly in Florida, could be linked to global warming resulting from the emissions of greenhouse gases into the atmosphere. But the current state of climate science does not support so close a linkage.

The scientists agree that because a hurricane acts as a heat engine, which works by transferring energy from a warm region to an area of cooler temperatures. So a hurricane is able to take the heat energy from the warm waters and transfer it to the cooler air above it thus increasing the wind velocity and moisture content of the hurricane. In this sense global warming does play a role because it has increased the surface temperatures of the water. However Scientists are having difficulties buying this as an explanation because the current models are showing mixed results. Some models show that there is no theoretical foundation for evidence to support a change in the numbers of higher intensity hurricanes, while other models do show that if you increase the temperature of water that the intensity of the hurricane does increase. This inconsistency in the models is preventing Scientists from definitively saying that increased hurricane intensity indicates global warming. There are qualitative observations that suggest that tropical cyclones need "thermodynamical and dynamical" factors to fuel the intensity of hurricanes.

*Since 1995 there has been an increase in the number of [ . . . ] major hurricanes (categories 3, 4, and 5) in the Atlantic. But the changes in the last decade in these [parameters] are not so large as to clearly indicate that anything is going on other than the multidecadal variability that has been well documented since at least 1900.*

As I mentioned above, warmer waters may not necessarily be the result of global warming, and from the above quote from the *Hurricanes and Global Warming* article, there is some controversy as to whether warmer ocean waters and more intense hurricanes is due to something other than global warming. The ocean goes through periods of warm and cold temperatures that can last between 20 and 30 years, known as multidecadal oscillations. During these periods of time the ocean temperatures will remain at a warm or cool state for decades. If the ocean is in a warm state, then there will be an increase in the numbers of higher intensity hurricanes, and if the ocean is in a cool state, then there will be fewer hurricanes. The Atlantic Ocean, within the last few years has entered into a warm oscillation period, so until Scientists are able to collect more data, which will need to happen over the course of several decades, they can't say with certainty that the increase in hurricane intensity is not due to the multidecadal oscillations and that global warming is the definitive cause. What this means is that there are no trends yet to suggest that there is a significant increase in stronger hurricanes due to greenhouse gases and global warming. Recent history has helped in showing the weak trend, but it could also very well indicate the multidecadal oscillations. In the '70s, '80's, and early '90s there was relatively very little hurricane activity, while compared to the 40s, 50s, and 60s there was a lot more hurricane activity especially in Florida which was hit with 11 hurricanes from 1944-1950 (Pielke 2005). The other evidence that is out there is that in a global sense over a span of several recent decades there has not been an increase in the frequency of tropical cyclones.

In the grand scheme of the Earth's history, global warming has just begun and Scientists have just recently begun recording data on it, so the students will run across very little distinctive evidence indicating whether global warming has caused an increase in the numbers of more intense hurricanes, especially since the recorded measurements of the increase in Carbon Dioxide is no longer than a decadal oscillation, so determining if global warming is really the cause will only happen over a period of several more decades. Scientists have however developed theoretical predictions of future hurricane activity, based on simulated hurricane activity; one such study was done looking at a 1% increase in CO<sub>2</sub> per year for the next 80 years. These simulated models compare the present day hurricane intensities to the future and the prediction is that the Earth will have more Category 5 hurricanes in 80 years (Knutson 2004). We can't however rule out another possibility which is that global warming could send the earth into a permanent state of El Nino conditions

which would therefore contradict all arguments that increased numbers of more intense hurricanes is an indicator of global warming, because as it was already mentioned in the "Content Background Information" in the section on global warming, the El Nino phenomenon actually produces fewer hurricanes.

The trends in tropical cyclone intensity is a lot more complicated, there are a lot of things that need to be taken into consideration such as, maximum potential energy, average intensity, average storm lifetime, maximum storm lifetime, accumulated cyclone energy, etc. Because of these varying factors affecting hurricane strength and intensity, it's difficult for Scientists to say with certainty that hurricanes are getting stronger.

This research that the students will be conducting should lead them to truly question Al Gore's statement in *An Inconvenient Truth*, that evidence to global warming is that the numbers of higher intensity hurricanes has doubled over the past 30 years. Mr. Gore failed to talk about other factors that could potentially influence hurricane intensity, the most important one being the multidecadal oscillations of the oceans' temperatures. This evidence, I would hope would lead the students to look for other pieces of evidence to suggest that global warming really is occurring.

## Lesson Plans and Activities

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### Lesson Plan 1: Global Warming and Carbon Dioxide

*Essential Question:*

- Can we observe if Carbon Dioxide really causes temperatures to increase?

*Instructional Objectives:*

- 1) Students will use inquiry to discover if and how Carbon Dioxide affects temperature
- 2) Students will use the Scientific Method as a means of discovering the effects of Carbon Dioxide on temperature.
- 3) Students will analyze the limitations of laboratory investigations and try to figure out a way to yield more meaningful results.
- 4) Students will develop skills in analyzing graphs.

*Supportive Vocabulary:*

- 1) Global Warming
- 2) Greenhouse Gases
- 3) Carbon Dioxide
- 4) Greenhouse effect

*Background:*

Before beginning their Scientific Inquiry, the students will be given a journal prompt on the chalkboard: What do you know about global warming and carbon dioxide? The students are given about 5 minutes or so to write down their responses to the journal prompt. After the time is up, the students will share their responses and I will chart their responses on a KWL chart. The students will have access to this information as we move through the unit on global warming and they will be able to observe how their thoughts have evolved through the process of learning about global warming. We will also go over the supportive vocabulary before the students begin their scientific investigation.

They will focus their scientific investigation on trying to find a way to observe if Carbon Dioxide can really affect temperature. They will be given a list of materials that they will be able to use for the investigation. It's up to them how they want to set up the lab so they can collect data to try to observe if Carbon Dioxide can affect the temperature. They already have the background that they will need for creating the carbon dioxide necessary for the experiment. Their list of materials will include 2 liter Soda Bottles with caps, Baking Soda, Vinegar, thermometers, timers, balance, beaker, graduated cylinder, heat lamps, and water. They will use their skills in the scientific method to develop a scientific experiment that will allow them to determine if carbon dioxide does have an effect on temperature. When I conducted the lab myself there was a minimal temperature difference between the two atmospheres. Despite the fact that the lab did not yield the results that I was hoping for, I still see value in having the students conduct the investigation. First of all it's an opportunity for them to enhance their skill in the Scientific Method and use prior knowledge from past topics to create the lab. Secondly it's an opportunity for them to analyze the limitations of the experiment, why didn't the experiment yield the results that they had been expecting to see? Students should think about the fact that the atmospheres may not have been an accurate representation of our own atmosphere; the simulated atmosphere may not have been thick enough, etc. What could they do differently to create and experiment that will yield the expected results, what conditions do they need to change, what variables could have been misrepresented? Finally, they will see that there is a lot of trial and error that goes along with Science and that it takes time and patience to investigate and understand the world around us.

Although their experiment didn't yield the expected results and the purpose was to see if they could observe if Carbon Dioxide had an effect on Temperature, they will still have the opportunity to see that CO<sub>2</sub> affects temperature. It just won't be hands-on. They will analyze the graph of Atmospheric Carbon Dioxide Concentration and Temperature Change, taken from *An Inconvenient Truth* and using this graph they can interpret what it means and analyze the relationship between Carbon Dioxide and Temperature.

They will use the information collected from this lab and from the analysis of the Atmospheric Carbon Dioxide Concentration and Temperature Change graph as a starting point for their two-week homework assignment, which is to keep track of their own personal electricity usage as a way to determine and calculate the amount

of Carbon Dioxide that they are personally responsible for emitting into the atmosphere. A more detailed explanation of this particular homework assignment can be found in the Unit Overview under Section 1: Global Warming.

*Assessment:*

The students will be required to write a lab report, complete with introduction, materials and methods, data and results and conclusions. I will be looking for them to discuss what their data means, describe the expected results, and provide an analysis for the difference in their own results and their expected results and an analysis of the graph of atmospheric carbon dioxide concentration and temperature change.

**Lesson Plan 2: *An Inconvenient Truth***

*Essential Question:*

Is there validity to the points that Al Gore raises in the documentary, *An Inconvenient Truth* ?

*Instructional Objectives:*

- 1) To analyze the points that Al Gore brings up about global warming in *An Inconvenient Truth* .
- 2) To read articles that will help further understand and investigate Al Gore's points.
- 3) To develop their own opinion about global warming after reading and discussing several articles and Al Gore's documentary.

*Background:*

After several lectures on the background information on what global warming is and the causes of global warming, not just the human causes, but the natural causes as well, student will watch *An Inconvenient Truth* , and read several articles on the human causes of global warming. I think it's important to stress the human causes of global warming, because those are the things that we can control to help alleviate the problem of global warming. There are a few articles that they will also read in conjunction with this video as a follow up to the evidence that Al Gore provides about global warming, the articles are taken from the University of Colorado, Boulder and focus on the Arctic Sea Ice Shrinking and the Antarctic Ice Shelf collapse. They will also read two newspaper articles, one taken from The Washington Post, entitled Undeniable Global Warming and the other taken from the New York Times, called Poorest Nations Will Bear Brunt as World Warms. They will take all of the information gathered and have a discussion about their understanding of Global Warming and human impacts. The discussion will have a general focus question: How have humans impacted global warming? The discussion will also be completely student-centered using a discussion protocol, which holds all students accountable for participating in the discussion. The way the protocol works, is students are given certain point values for participating in certain ways in the discussion. For instance: If the student makes a comment s/he will receive 1pt, if the student asks a question s/he will receive between 3-5 pts (depending on type of question), if the student refers to the text s/he will receive 2 pts, and if the student builds off of another student's comment s/he will receive 2pts. The students are required to earn a specific amount of points as a minimum so the entire class can't earn points until everyone has earned the minimum point value,



so they have to listen to each other and actually follow the conversation and hold each other accountable for listening to each other and participating in the conversation.

*Assessment:*

Students will be video taped during the discussion and I'll be looking for them to demonstrate an understanding of the readings and the video with the comments that they make and the questions that they ask throughout the discussion.

### **Lesson Plan 3: Connecting Global Warming to Hurricanes**

*Essential Questions:*

- 1) Are Hurricanes affected by global warming?
- 2) What do you believe about the idea of global warming and its affect on the earth?
- 3) How far are you willing to go if all of the evidence is still not in; do you act without sufficient evidence and risk a major economic crisis or wait until it's too late?

Guiding questions for the students to focus their research on is:

- 1) Is global warming really happening,
- 2) Is Carbon Dioxide (CO<sub>2</sub>) causing the global temperature to change?
- 3) Are natural disasters affected?

*Instructional Objectives*

- 1) Students will learn how to research multiple perspectives on the varying issues of the topic of global warming and hurricanes.
- 2) Students will take a stand on whether they believe that humans should do something to fix the problem of global warming even if there is limited evidence to suggest global warming exists and is changing the world in which we live.

*Background Information :*

The students will be participating in a debate on two issues the first and foremost issue, is the one of global warming and its effect on hurricanes, that debate is really the starting point for the main debate question

which is, how far are you willing to go with the limited evidence of global warming? Should we as humans make changes in our daily lives and routines? Should we risk an economic crisis or wait until it's too late? Is our use of fossil fuels really to blame? Do we really need to find alternative forms of energy? Is Carbon Dioxide really to blame and are we really adding excess carbon dioxide into the atmosphere that is causing the earth to warm at a much faster rate than it is supposed to? All of these questions should be questions that the students are prepared to answer during their debate. The debate will follow a very specific protocol. The first section of the debate is the briefs: First affirmative (introduction), First negative (introduction), Second affirmative (body), Second negative (body), Last affirmative (conclusion), Last negative (conclusion). The second section of the debate is the rebuttal: First negative controls a minute of questions and then the First affirmative controls a minute of questions; rotation continues through panel until rebuttal is finished or becomes circular. The final part of the debate is the summation: Affirmative panel selects the most effective speaker to sum up the strengths of their case and the weaknesses of the opposition and finally the negative panel sums up.

*Assessment:*

The rest of the class observing the debate will have tally sheets keeping note of the logical points made by each team and making comments on each team member. The class will decide which team won the debate and will have reasons for why this team was the overall winner of the debate.

## Implementing District Standards

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Strand III: Global Interdependence

9.8: The use of resources by human populations may affect the quality of the environment.

The students will be looking at how humans can play a role in global warming.

## Annotated Bibliography

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Abbott, P. *Natural Disasters*, 4th Edition, McGraw-Hill, Boston, Chapter 11, 2004.

Great source of background information on the Science of hurricanes.

Knutson, T., R. Tuleya, Impact of CO<sub>2</sub>-Induced Warming on Simulated Hurricane Intensity and Precipitation: Sensitivity to the Choice of Climate Model and Convective Parameterization *Journal of Climate* v.17, no 18, 3477-3494, Sept 15, 2004.

Provides predictions of hurricane intensity in 100 years.

Miller, K., J. Levine, *Biology*, Prentice Hall, Upper Saddle River, NJ, 2002

Information on global warming and the greenhouse effect.

Pielke, R.A., C. Landsea, M. Mayfield, R. Pasche, Hurricanes and Global Warming, *American Meteorological Society*, 1571-1575, <http://www.aoml.noaa.gov/hrd/Landsea/pielkeetalBAMS05.pdf>, November 2005.

Website provides arguments against the idea that global warming is causing hurricanes to increase in intensity.

An Inconvenient Truth, Dir. Davis Guggenheim, Perf. Al Gore, DVD, Paramount, 2006.

Provides some arguments and evidence about Global Warming.

## Student Reading List

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Hsu, T. *Foundations of Physical Science, with Earth and Space Science*, 1st Edition, Cambridge Physics Outlet, Peabody, MA, pp. 480-83, 506, 2003.

Resource for the fundamentals of global warming and for understanding human impacts on global warming, with minimal information of hurricanes and how they work.

Oreskes, Naomi. "Undeniable Global Warming." *Washington Post* 26 Dec. 2004, sec. B: 07.

An article explaining global warming and its effects.

Revkin, Andrew C. "Poorest Nations Will Bear Brunt as World Warms." *New York Times* 1 Apr. 2007. 1 July 2007 <http://select.nytimes.com/>>.

Demonstrates how different areas of the world are affected differently by global warming, and that there are varying effects of global warming.

Scambos, Ted. "Antarctic Ice Shelf Collapses in Largest Event of Last 30 Years." *University of Colorado At Boulder*. 18 Mar. 2002. Office of News Services, University of Colorado. 15 Apr. 2007 <http://www.colorado.edu/news/releases/2002/131.html>>.

A website describing in greater detail about the collapse of the Antarctic Ice Shelf Collapse as was mentioned in *An Inconvenient Truth*.

Serreze, Mark. "Arctic Sea Ice Shrinking, Greenland Ice Sheet Melting, According to Study." *University of Colorado At Boulder*. 07 Dec. 2002. Office of News Services, Colorado University. 15 Apr. 2007 <http://www.colorado.edu/news/releases/2002/541.html>>.

A website with research and evidence on global warming, helpful in reiterating the point of the Arctic Sea Shelf melting in *An Inconvenient Truth*.

## Classroom Resources

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"A Paleo Perspective... ..on Global Warming." NOAA Satellite and Information Service. 16 Nov. 2006. NOAA Paleoclimatology. 1 Apr. 2007

<http://www.ncdc.noaa.gov/paleo/globalwarming/what.html>>.

Good resource on explaining what global warming is and how the greenhouse effect plays a role in global warming.

"A Paleo Perspective... ..on Global Warming." NOAA Satellite and Information Service. 10 Nov. 2006. NOAA Paleoclimatology. 1 Apr. 2007

<http://www.ncdc.noaa.gov/paleo/globalwarming/end.html>>.

Good resource on analyzing the human role in global warming.

"Global Warming and Hurricanes." NOAA Research. 2005. Geophysical Fluid Dynamics Laboratory. 1 Apr. 2007 [http://www.oar.noaa.gov/spotlite/archive/spot\\_gfdl.html](http://www.oar.noaa.gov/spotlite/archive/spot_gfdl.html)>.

Website that provides arguments for the idea of global warming causing stronger, more intense hurricanes.

Hsu, T. *Foundations of Physical Science, with Earth and Space Science*, 1st Edition, Cambridge Physics Outlet, Peabody, MA, pp. 480-83, 506, 2003.

Resource for the fundamentals of global warming and for understanding human impacts on global warming, with minimal information of hurricanes and how they work.

## Endnotes

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1. A description of NHA's mission taken from the NHA website: [newhavenacademy.org](http://newhavenacademy.org)
2. A description of FHAO taken from New Haven Academy's mission statement.
3. A description of CES taken from the CES website under "About the Coalition of Essential Schools." Website: [essentialschools.org](http://essentialschools.org)

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