Curriculum Units by Fellows of the Yale-New Haven Teachers Institute
2005 Volume IV: The Sun and Its Effects on Earth

Solar Effects on Global Warming

Curriculum Unit 05.04.08
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Introduction

The Sun plays a major role on planet Earth. Some scientists think that the Earth is getting hotter because the Sun is burning more brightly than it did about a thousand years ago. Other scientists have evidence that greenhouse gases, such as carbon dioxide, have contributed to the recent change in the Earth's temperature. Some speculate changes such as global warming may be due to changes in the Sun rather than to the release of greenhouse gases. Although some believe that the Sun may have some effects on global warming on Earth, no one knows for sure how much the effect is. There is not enough evidence produced as of yet to support exactly what role the Sun plays on global warming of the Earth. There is, however, evidence to suggest that the amount of green house gases have increased significantly.

The unit that I have written will be used to introduce children to the Sun and its effects on global warming. The intent of this unit is to ignite their interest so that they will study this subject further on their own. The unit is designed for children in grades 5-8 and will be taught for approximately ten days.

Because students are limited in their knowledge about the Sun, greenhouse effect, climate and global warming, this topic can be explored only to a somewhat limited extent. What I have tried to do is to incorporate four main ideas: 1) to study the Sun; 2) to examine the greenhouse effect to see if it is affecting Earth's climate; 3) to examine temperatures over time to see if global temperatures have any effects on weather patterns and 4) to examine whether a brighter Sun is also responsible for rising temperatures.

I think that many middle school teachers would agree that students are not exposed to these valuable concepts and will benefit if they learned more about them. Therefore, included in this unit are the following objectives; First, students will be able to gain content knowledge about the Sun and understand better its role and importance to Earth. Second, students will be able to use this knowledge to discuss the greenhouse effect and its role in global warming. And third, students will be able to use their knowledge to debate what effects the Sun has on global warming if any.

Several strategies are used in this unit. Learning packages are used with specific goals and objectives with guided instructions from the teacher. Whole group and small group discussions and individual activities are used with each lesson. Each lesson has a specific stated goal. Each lesson is guided by one of the main ideas

of this unit. The lessons have been constructed to have students 1) Discuss prior knowledge; 2) Explore by doing an activity; 3) Reflect by looking back at activity, analyze and discuss and 4) to come to some conclusions, communicate to others, identify next steps that lead to the next topic. Also included in this unit are teacher resources, student reading list and a bibliography.

The design of this unit has been guided by New Haven Public School Curriculum Science Standards grades 5-8. Specifically, Content Standard 4.0 Earth Science will be addressed. This standard states that students will develop an understanding of the structures, properties and dynamic processes of the earth, the solar system, the universe and the galaxy; they will be familiar with the origins, evolution, movements and interactions of these systems.

Lesson plans are used to address performance standards 4.2c which states that students will describe the features of our Sun and how it compares with other suns in the universe and performance standard 4.2d which states that students will describe other effects of the Sun's energy on our world such as weather and winds.

The Sun's Interior

Core

The Sun's interior is very hot. Its inner most part is called the core and it is a mass made up of glowing gas that produces energy. The core gives off a large amount of energy including all the Sun's light and heat. The Sun's mass is made up mostly of hydrogen, which is three times the amount of helium, and very small amounts of other chemical elements. In the core temperature and pressure are so tremendous that nuclear fusion causes hydrogen atoms to join together to form helium. The temperature inside the Sun core is about 15 million degrees Celsius.(1) The total mass of the helium produced by nuclear fusion is slightly less than the total mass of the hydrogen that goes into it. The change in mass occurs because some of the matter is converted into light and heat energy. The light and heat energy slowly move from the core of the Sun to its atmosphere and escape into space.

The Sun transports heat by two ways. The inner layer (center to 7/10 of the way out) is radiative. In the radiative zone, energy from the core slowly travels outward by the movement of radiation. This zone is so dense that the Sun's energy takes about 150,000 years to work its way through. The convection zone (the outer 3/10th up) has rising and falling plumes and materials that carry energy from the radiative zone to the surface. Some of this energy reaching the Earth energy is its main source of energy. There is enough hydrogen fuel in the core of the Sun to last for a total of 10 billion years and the Sun is now only about 5 billion years old.(2)

The Sun's Atmosphere

The Sun's atmosphere has three layers: 1) the photosphere, 2) the chromosphere, and 3) the corona. There are no sharp boundaries between the layers of the Sun.

Photosphere

The word photosphere comes from a Greek word with "photo" meaning light, so photosphere means the sphere that makes light. The photosphere is a visible outer layer of the Sun's atmosphere. In the photosphere, energy escapes from the interior and streams into the Sun's atmosphere and beyond. Sunspots are located in the photosphere. Sunspots are dark blemishes on the Sun's surface. They appear dark because they are much cooler than the area around them. Solar flares occur sometimes from the large sunspots. Solar flares are violent eruptive events on the Sun. These eruptions may cause a large quantity of particles and radiation to blast out into space. The eruptions can also cause disturbances that spread outward in the solar atmosphere. The energy from a solar flare is released from the intense magnetic field around a sunspot group.(3)

The Chromosphere

The word chromosphere comes from a Greek word chromo that means, 'color', so the chromosphere is the color sphere. It is the middle layer of the Sun's atmosphere located above the photosphere. It has great looping arcs of hot gases called prominences that erupt from the Sun. If you have ever seen the end of a total eclipse of the Sun, you can see a reddish glow just around the photosphere. Chromosphere has intense explosions gives off large amount of energy called solar flares that enter into space.

The Corona

The corona is the outer layer, which looks like a white halo around the Sun, can be seen during an eclipse. Corona means crown in Latin. The corona is the Sun's extended outer atmosphere. It sends out a stream of electrically charged particles called solar wind. The corona is much hotter than the surface of the Sun. It is so hot that it produces high energy light called X-rays. The corona is so hot, but it won't feel hot because it is not very dense. The corona contains very little thermal energy. The reason is that it is like a vacuum. Because of the corona's high temperature, the atoms there are moving at very high speeds. But because there are so few moving atoms in the corona, the total amount of energy these moving atoms have is low.(4)

Since the Earth's climate system is driven by energy from the Sun, the next section will discuss whether a brighter Sun is also responsible for rising temperatures.

Is A Brighter Sun Responsible for Rising Temperatures?

The Sun has a much higher surface temperature than any of the planets or moons. The Sun's spectrum shows that it has a temperature of 5800 Celsius. The high temperature on the Sun's surface causes it to emit a great amount of radiation, mostly at visible wavelengths. The Sun size also contributes to the large amount of radiation.

The Sun provides all the energy that drives our climate. Global warming is a gradual increase in the average temperature of the Earth. Some parts may actually get cooler. Some solar scientists are considering whether some part of global warming may be caused by periodic but small increases in the Sun's energy output. Some speculate that a 0.2% in the solar output could have the same affect as doubling the carbon dioxide in the

Earth's atmosphere.(5)

Issues such as whether the Sun might play a role in global warming have been and are still being debated. A few scientists for several decades have believed that weather patterns have been affected by the electrically charged particles that the Sun sprays out as solar winds. After decades of working on that theory, a 1999 study reported evidence that the Sun's magnetic field had strengthened greatly since the 1880s, which brought more attention to the question of whether increased solar activity the main cause of temperature rise. (6) However, many scientists dispute their finding.

Some believe that there is a strong correlation between the variations in solar irradiance and fluctuations in the Earth's temperature. The number of sunspots gets smaller and cooler when the Earth gets cooler. The opposite happens when the number of the sunspots gets larger, the Earth gets hotter. So important is the sun in climate change that half of the 1.5° F temperature increase since 1850 is directly attributable to changes in the sun. According to some NASA scientists, only one-quarter of a degree can be ascribed to other causes, such as greenhouse gases, through which human activities can theoretically exert some influence.(7) As the 21st century began, some experts thought it plausible that the Sun might have driven part of the previous century's warming.(8)

What Is the Greenhouse Effect and Is It Affecting Our Climate?

Greenhouse Effect

The greenhouse effect is the rise in temperature of the Earth because certain gases in the atmosphere, such as, water vapor, carbon dioxide, nitrous oxide, and methane, trap energy from the Sun. Without these gases, heat would escape back into space and the Earth's temperature would be too cold for human life to exist. In the greenhouse effect, sunlight warms the Earth's surface and helps to regulate the temperature of the planet. The Earth in turn emits infrared radiation once heated. A great deal of the radiation is absorbed by atmospheric gases, which help to raise the average temperature of the surface. Some infrared radiation penetrates the atmosphere and leaks into space. In a state of equilibrium, the rate at which the Earth loses energy to space in this way is equal to the rate at which it absorbs energy from the Sun.

The Earth's surface temperature has risen by about 1 degree Fahrenheit in the past century, with an increase in warming during the past two decades. Many scientists say that there is evidence that most of the warming over the last 50 years is attributed to human activities.(9) They say that human activities have changed the chemical composition of the atmosphere through the buildup of greenhouse gases. These greenhouse gases consist mainly of carbon dioxide, methane, and nitrous oxide, which have heat trapping properties. Scientists have evidence that atmospheric concentrations of carbon dioxide have increased by approximately 30%, methane concentrations have more than doubled, and nitrous oxide concentrations have risen by about 15%.

This buildup of greenhouse gases is mostly caused by human activity. The rise in carbon dioxide caused by widespread combustion of fossil fuels, such as coal, oil and natural gas may have long-term effects on climatic changes. Fossil fuels burned to run cars and trucks, heat homes and businesses, and power factories are responsible for approximately 98% of U.S. carbon dioxide emissions, 24% of methane emissions, and 18% of nitrous oxide emissions. Also, increased agriculture, deforestation, landfills, industrial production, and mining have contributed a great deal of emissions. The US emits about one-fifth of total greenhouse gases. What is

important is figuring out to what extent the human activities is facilitating the accumulation of green house gases The major greenhouse gases emitted by human activity remain in the atmosphere from decades to centuries. The increases in greenhouse gases have enhanced the heat-trapping capability of the earth's atmosphere.(11)

Several scientists speculate that an increase in atmospheric concentrations of other trace gases such as chlorofluorocarbons (Freons), nitrous oxide, and methane due to human activity may aggravate greenhouse conditions. They fear that significant changes in climate patterns will be seen by the turn of the century. Such global warming would cause polar ice caps and mountain glaciers to melt resulting in higher coastal waters.(12)

The Intergovernmental Panel on Climate Change (IPCC) stated that humans influence climate and that the observed warming trend is not likely to have natural origins. The

IPCC has been established by the World Meteorological Organization (WMO) who is the United Nations system's authoritative voice on the state and behavior of the Earth's atmosphere, its interaction with the oceans, the climate it produces and the resulting distributions of water resources(13) and the United Nations Environment Programme (UNEP) who provide leadership and encourage partnership in caring for the environment by inspiring, informing, and enabling nations and peoples to improve their quality of life without compromising that of future generations.(14) The IPCC assesses scientific, technical and socio-economic information relevant for the understanding of climate change, its potential impacts and options for adaptation and mitigation.

Scientists believe levels of greenhouse gases in the atmosphere are rising, but to what extent are undetermined. They feel that increase in temperature may include natural variability. Scientists seem more comfortable about their projections on issues of global temperature and precipitation change, average sea level rise and less certain about local temperature and precipitation changes, as well as, other weather patterns.

IPCC cautions that warmer temperatures can lead to more storms, such as hurricanes. They admit that they do not have all the answers to global warming. They know that human activities causes global warming, but there is a lot of uncertainty about how much warming? How fast it will occur? To what are the potential adverse and beneficial effects? The next session will discuss Is the Greenhouse Effect Affecting Our Climate?

Is the Greenhouse Effect Affecting Our Climate?

Global surface temperatures have increased since the late 19 th century. This section will address whether global temperatures have any effects on weather pattern.

The United States National Climatic Data Center shows evidence that global mean surface temperatures have increased 0.5-1.degrees Fahrenheit since the late 19th century. The 20th century's warmest years occurred in the last 15 years of the century with 1998 being the warmest year on record. However, this does not mean that all areas have warmed up. Some areas such as southeastern U.S. have cooled over the last century. The recent warmth has been greatest over North America. Increasing concentrations of greenhouse gases are likely to speed up the rate of climate change. Scientists speculate that the average global surface temperature could rise 0.6-2.5 degrees Celsius in the next fifty years, and 1.4-5.8 degrees Celsius) in the next century, with a great deal of regional variation.(15)

An enhanced greenhouse is expected to cause cooling in higher parts of the atmosphere because of the increased blanketing effect in the lower atmosphere holds in more heat, allowing less to reach the upper atmosphere. (16)

The IPCC has concluded that greenhouse gases will continue to rise over the 21st century. This will impact the lives of mankind both positively and negatively. The more gases are emitted, the higher the tendency for earth to warm. The IPCC predicts that the greater and faster the warming, the more the adverse effects will dominate and the greater the possibility of large-scale and possibly irreversible impacts.(17)

The next section discusses the greenhouse effect on Venus to see what could happen if Earth has a run away greenhouse effect.

A Runaway Greenhouse Effect on Venus

Much like Venus the Earth is heating up due to the increase in carbon dioxide. The heating up of the planet contributes to the greenhouse effect. This occurrence contributes to raising the surface temperature about 35 degrees Celsius and is responsible for much of the polar ice caps melting to water. To make matters worst, there is some evidence that carbon dioxide that is currently heating up the surface temperature is still increasing due to the increase of pollutants.(18) The same effect is responsible for making Venus the hottest planet in the solar system. The thick atmosphere on Venus traps the absorbed solar energy and raises its average surface temperature. Earth and Venus have some common traits, such as: they are near each other in the Solar System, and have similar sizes, density, and composition. By studying the greenhouse effect on Venus, we can increase our knowledge and understanding so that we may prevent a runaway greenhouse effect on Earth.(19)

Sunlight that comes to the surface of the Earth is mostly in the visible part of the spectrum. The reflection of light from the surface tends to produce light of longer wavelength called infrared radiation (IR). Infrared radiation actually produced by cool surface radiation is radiated from a hot surface like a hot piece of metal. The molecule structures of certain gases like carbon dioxide, water vapor and many others have the property that they are essentially transparent to visible light but absorb IR radiation very strongly. These compounds are called greenhouse gases. They are called greenhouse gases because when they are present in a planetary atmosphere they absorb the scattered IR radiation and raise the temperature of the atmosphere by trapping solar energy.(20)

Most planets have some type of greenhouse gases on it except for Mercury which has no atmosphere. The greenhouse effect is responsible for planets being warmer than they would be otherwise. The greenhouse effect alone does not account for the conditions that we find on Venus, but under certain conditions it is believed the greenhouse effect became unstable. For example, the Earth has enormous amounts of two greenhouse gases: water vapor and carbon dioxide. However, most of the water and carbon dioxide are not in the Earth's atmosphere. The water is mostly in the oceans, and the carbon dioxide is mostly bound chemically in rocks made from compounds that chemists call carbonates, such as, limestone.(21)

If we increased the effectiveness of greenhouse heating of the Earth's atmosphere, by increasing the amount of solar radiation falling on it, or by increasing the concentration of greenhouse gases in the atmosphere by

burning fossil fuels to produce water vapor and carbon dioxide (by- products of burning), then we would expect the temperature to rise in the atmosphere assuming no other effects intervened. This would be a greenhouse effect. In real life the atmosphere is complicated to control.(22)

Earth would have a *runaway* greenhouse effect if the rising temperature approached the boiling point of water, because then the oceans would begin to convert to water vapor, the water vapor would increase the effectiveness of heat trapping and accelerate the greenhouse effect, which would cause the temperature to rise further, thus causing the oceans to evaporate faster, etc. This is a runaway effect because it is a positive feedback loop. However, once the oceans are gone, the atmosphere would finally stabilize at a much higher temperature and at much higher density because all the water would now be in the atmosphere.(23)

This scenario can be taken further. Suppose the above runaway raised the temperature so high that chemical reactions called sublimation begin to occur. This would drive the carbon dioxide from the rocks into the atmosphere a few hundred degrees Celsius. Then another runaway would occur as the carbon dioxide feeding into the atmosphere would accelerate the heating, which would accelerate the transfer of carbon dioxide from the rocks to the atmosphere. It is easy to see the devastation in this scenario.(24) The atmosphere would stabilize at a still higher temperature and pressure after all the carbon dioxide had been driven from the rocks.

In fact, it is believed that if this sequence were to take place on the Earth, the resulting temperature and pressure of the atmosphere left behind would not be very different from that for present-day Venus. Earth's atmospheric temperature would be hundreds of degrees Celsius and the pressure would be maybe 100 times greater than it is today. (25)

In the case of Venus, it is believed that the initial solar heating kept oceans from forming, or kept them from staying around if they did form, and the subsequent lack of rainfall and failure of plant life to evolve kept the carbon dioxide in the atmosphere rather than binding it in the rocks as is the case for the Earth; causing Venus to have an environmental disaster for an atmosphere.(26)

The scenario of the runaway greenhouse effect on Venus should make us extremely concerned about processes such as burning of fossil fuels in large volumes that might have the potential to trigger a runaway greenhouse effect and produce on the Earth atmospheric conditions such as those found on Venus.

Since the Sun is by far the largest supplier of energy to the Earth's surface, any change in the radiative output of the Sun also affects the energy balance of the Earth's surface and atmosphere, so that at some level it influences our climate, too. But how strongly does the Sun vary and to what extent does it influence the Earth's climate? One of the most important ways to find a definitive answer to the question of the solar effects on global warming is to determine its weight relative to that of the man-made greenhouse gases.(27) Most scientist think that greenhouse gases from fossil fuels have contributed to the warming of the planet in past decades, but do not rule out that a brighter Sun is also responsible for rising temperatures. To determine the Sun's role in global warming, magnetic zones or sunspots on the Sun's surface are measured for energy output of the sun. More evidence will need to be sought after before it can be determined whether greenhouse gases causes global warming alone or does the Sun also has an effect on global warming.

What Can Be Done to Decrease Green House Gases?

It is the responsibility for all people and nation throughout the world to help do their parts in stabilizing greenhouse gases on Earth. On a national level, a national renewable energy portfolio standard would help make available the renewable energy technology as well as provide incentives to develop the next generation of clean energy technology.

We must make personal choices to make a difference. Instead of driving a car, we may choose to walk, bike or carpool whenever possible. At home we can turn off the lights or consider unplugging electronic devices that do not need to be on. Everyone should try to be as energy efficient as possible. Have student government association to ask schools to buy renewable energy from their utility company whenever possible.

Recommendations of the International Climate Change Taskforce states that global problems requires global solutions. The taskforce recommends that a long-term objective be establish to prevent global average temperatures from rising more than 2 degrees Celsius above the pre-industrial level, to limit the extent and magnitude of climate-change impacts.(28)

They recommend that a global framework be adopted that builds on the work of others, and enables all countries to be a part of the action on climate change at the global level. The task force suggests that G8 governments increase their spending on research, development and demonstration of advanced technologies for energy-efficient and low-and zero-carbon energy supply by 2010.(29)

The International Climate Change Taskforce recommends that G8 and other major economies pursue technology agreements that will lead to large emissions reductions, and food crops biofuels. They advocate for a culturally and ecologically sensitive land preserve and protection for biodiversity.(30)

The taskforce recommends that all developed countries introduce mandatory cap-and- trade systems for carbon emissions, and construct them to allow for future integration into a single global market. In addition, The International Climate Change Taskforce recommends that developed countries keep existing commitments to provide greater financial and technical assistance to help less well developed countries. They stated that governments committed to action on climate change should raise public awareness of the problems and build public support for climate policies and make a long-term investment in effective climate communication activities.(31)

Lesson Plans

Lesson Plan I

Content Standard 1:0 Scientific Inquiry: Student will develop abilities necessary to do scientific inquiry by being able to pose a question, state a hypothesis, develop an investigation, observe and document the process and record and determine results.

Initiating the Lesson: Features of the Sun

Objective : Students will recall and learn features of the Sun. They will develop descriptions, explanations, predictions and models using evidence.

Discuss: Ask students what they know about the Sun. Write down all ideas on the blackboard. Working in cooperative learning groups of three to four students, have them draw the Sun and label as many features as they know.

Explore: After that, have students compare their drawings with each other. Have them compared their drawing to their prior knowledge. Student's observations on what they have learned are to be recorded in their portfolio. Give students a picture of the Sun and discuss its features.

Apply: Give students a picture of the Sun with no labels and have them to label each part.

Lesson Plan II: Is A Brighter Sun Responsible for Rising Temperatures?

Content Standard 4.0- Earth Science: Students will develop an understanding of the structures, properties and dynamic processes of the earth, the solar system, the universe and the galaxy; they will be familiar with the origins, evolution, movements and interactions of these systems.

Objective : Students will describe other effects of the sun's energy on our world such as weather and wind.

Discuss : Ask students what they know about global warming. Record their answers on large sheet of paper that is in front of the class for everyone to see. Give them basic knowledge about what global warming is and how it differs from the greenhouse effect.

Materials needed : Two-liter plastic pop bottles (each group should have two bottles), soil, thermometers for each bottle, plastic wrap, student journals, stop watches, a computer with a spreadsheet (use excel)

Teaching Time : Three class periods

Part I: One Class Period

Apply: The class will be divided into groups of two. Each group will be given two plastic bottles with the tops cut off of them. Students will place 10 centimeters of soil in the bottom of each bottle with a thermometer taped inside. Secure thermometer with tape at the top and bottom. Put plastic wrap on one bottle and leave the other bottle open.

Reflect: Ask the students what they feel the bottles represent. Have student record ideas in their journal.

Part II: Second Class Period

Students will be placed bottles under two heat lamps. They will record temperatures inside each bottle every ten minutes for sixty minutes in their journals. They should use stop watches to record the time.

Part III: Third Class Period

Each group of students will be assigned a computer with Microsoft Excel spreadsheets. They will create a chart with their data. A class discussion will take place on what they feel the data represents and how it applies to our atmosphere.

Source : This lesson has been adapted from:http://portfolio.edu/mundyn/tip2/new

Lesson Plan III: Average Global Temperatures

Content Standard 4.0 - Earth Science: Students will develop an understanding of the structures, properties and dynamic processes of the Earth, the solar system, the universe and the galaxy; they will be familiar with the origins, evolution, movements and interactions of these systems.

Objective: Students will use Appendix B to analyze the data to answer the following questions;

1) Are there any trends in changes of average global temperatures?
2) Has there been an increase in average global temperature?
3) Has the rate of change increased or decreased?
4) What was significant about the 1990's decade?

Lesson Plan IV: Greenhouse Effect

Content Standard 4.0- Earth Science: Students will develop an understanding of the structures, properties and dynamic processes of the Earth, the solar system, the universe and the galaxy; they will be familiar with the origins, evolution, movements and interactions of these systems.

Objectives: 1) Students will define global warming and greenhouse effect; 2) understand that carbon dioxide is a gas that creates a greenhouse effect and contribute to global warming

Apply : Students will describe what it is like to be in a greenhouse. Explain that the earth's atmosphere contain gases that produce same greenhouse effect for the Earth.

Demonstration: Place a layer of newspaper on a table, measure 3 grams of baking soda and add to 1000ml Erlenmeyer flask, pour 50 ml of vinegar into the flask, let reaction continue until the bubbling has stopped, set up a lamp on your lab table, place one thermometer directly on the newspaper, place a small thermometer under a beaker that is turned upside down on the table, pour the gas of the flask into a second beaker, and set it on newspaper right side up arrange the two beakers and the thermometers under the lamp, all three at equal distance from the lamp and turn it on, record the temperature of each thermometer in the data table (See Appendix C).

Discuss:

1. What are greenhouse gases?
2. Where does greenhouse gas come from?
3. Is the greenhouse effect a bad thing for the Earth?
4. How does the greenhouse lead to global warming
5. Compare the greenhouse effect on Venus to the greenhouse effect on Earth.

Write essay about what could happen if Earth has a greenhouse effect like what happened on Venus.

Lesson Plan V: Defend Your Decision

Content Standard 4.0- Earth Science : Students will develop an understanding of the structures, properties and dynamic processes of the Earth, the solar system, the universe and the galaxy; they will be familiar with the origins, evolution, movements and interactions of these systems.

Discuss: What causes global warming? Is it the greenhouse effect or the solar effect on global warming on Earth or both? Support your answer with evidence. What is your conclusion?

Tips

Search materials that are available to you.

Describe how the Sun produces energy.

Make a list of human activities that you think contribute to global warming.

Appendices

Appendix A: Vocabulary Word List

Convection Zone : The region in a star where convection is the dominant transport.

Source: Universe: Stars and Galaxies (Chapter 8)

Core (of the Earth): The iron-rich inner region of the Earth's interior.

Source: Universe: Stars and Galaxies (Chapter 8)

Corona (of the Sun): The Sun's outer atmosphere, which has a high temperature and a low density.

Source: Universe: Stars and Galaxies (Chapter 8)

Degree Celsius : A basic unit of temperature , designated by the symbol *?C* and used on a scale where water freezes at 0 *? and boils 100?.*

Source: Universe: Stars and Galaxies (Chapter 5)

Eclipse : The cutting off of part or all the light from one celestial object by another.

Source: Universe: Stars and Galaxies (Chapter 3)

Chromosphere: A layer in the atmosphere of the sun between the photosphere and the Corona.

Source: Universe: Stars and Galaxies (Chapter 8)

Global Warming: The upward trend of the Earth's average temperature caused by increased amounts of greenhouse gases in the atmosphere.

Source: Universe: Stars and Galaxies (Chapter 8)

Greenhouse effect: The trapping of infrared radiation near a planet's atmosphere

Source: Universe: Stars and Galaxies (Chapter 8)

Photophere: The region in the solar atmosphere from which most of the visible light escapes into space.

Source: Universe: Stars and Galaxies (Chapter 18)

Prominence : Flamelike protrusions seen near the limb of the Sun and extending into the solar corona.

Source: Universe: Stars and Galaxies (Chapter 18)

Radiative Zone: A region within a star where radiative diffusion is the dominant mode of energy transport.

Source: Universe: Stars and Galaxies (Chapter 18)

Solar Flare: A sudden, temporary, temporary outburst of light from an extended region of the solar surface.

Source: Universe: Stars and Galaxies (Chapter 18)

Sunspot: A temporary cool region in the solar photosphere.

Source: Universe: Stars and Galaxies (Chapter 18)

Sunspot Cycle: The semi-regular 11-year period with which the number of sunspots is highest or lowest.

Source: Universe: Stars and Galaxies (Chapter 18)

Appendix B: Average Global Temperatures (Degrees Celsius)

Year - Temperature

1959 - 15.04

1960 - 14.98

1961 - 15.10

1962 - 15.10

1963 - 15.10

1964 - 14.78

1965 - 14.88

1966 - 14.95

1967 - 14.99

1968 - 14.93

1969 - 15.05

1970 - 15.02

1971 - 14.93

1972 - 15.00

1973 - 15.11

1974 - 14.92

1975 - 14.92

1976 - 14.84

1977 - 15.11

1978 - 15.06

1979 - 15.09

1980 - 15.18

1982 - 15.08

1983 - 15.24

1984 - 15.11

1985 - 15.09

1986 - 15.16

1987 - 15.27

1988 - 15.28

1989 - 15.22

1990 - 15.38

1991 - 15.36

1992 - 15.36

1993 - 15.14

1994 - 15.23

1995 - 15.39

1996 - 15.27

1997 - 15.50

Appendix C: Data Table

(table available in print form)

Source: http://www.n.j.f.btinternet.co.uk/Y7science/globalwarm/averagetemps.html

Appendix D: Science 5-8: New Haven Public School Content Standard for Scientific Inquiry and Earth Science

Content Standard 1.0: Scientific Inquiry

Students will develop abilities necessary to do scientific inquiry by being able to pose a question, state a hypothesis, develop an investigation, observe and document the process and record and determine results.

Content Standard 4.0: Earth Science

Students will develop an understanding of the structures, properties and dynamic processes of the earth, the solar system, the universe and the galaxy; they will be familiar with the origins, evolution, movements and interactions of these systems.

Teacher Resources

Intergovernmental Panel on Climate Change (IPCC) Website

Environmental Protection Agency on Global Warming

Books:

Buchdahl, J. Global Climate Change Student Information Guide

Christianson, G.E. Greenhouse: The 200-Year Story of Global Warming, Penquin Books, 1999.

Freedman, Roger A. & Kaufmann III, Universe: Stars and Galaxies, 7th Ed., W.H. Freeman and Company, New York, 2002

End Notes

1. Science Explorer: Astronomy, Jay M. Pasachoff, Ph.D, Prentice Hall, Inc., Upper Saddle River, N.J., pp. 56-57.

2. Science Explorer: Astronomy, Jay M. Pasachoff, Ph.D, Prentice Hall, Inc., Upper Saddle River, N.J., pp. 57.

3. Freedman, Roger A. & Kaufmann III, Universe: Stars and Galaxies, 7th Ed., W.H. Freeman and Company, New York, 2002, p. 412.

4. Freedman, Roger A. & Kaufmann III, Universe: Stars and Galaxies, 7th Ed., W.H. Freeman and Company, New York, 2002, pp. 403-404.

5. Scientists blame sun for global warming, Stanford Solar Center, http://solar-center.stanford.edu/sun-on-earth/glob-warm.html, p.1

6. Blame Sun for Global Warming, Stanford Solar Center, http://solar-center.stanford.edu/sun-on-earth/glob-warm.html, p.1

7. Blame the Sun for global warming, http://www.enterstageright.com/archieve/articles/0798globalwarm.htm

8. Blame Sun for Global Warming, Stanford Solar Center, http://solar-center.stanford.edu/sun-on-earth/glob-warm.html, p.1

9. U.S. Environment Protection Agency, Global Warming-Climate, http://yosemite.epa.gov/OAR/globalwarming.nsf/content/climate.html

10. http://yosemite.epa.gov/OAR/globalwarming.nsf/content/climate.html pp. 1-2

11. http://yosemite.epa.gov/OAR/globalwarming.nsf/content/climate.html p.1

12. http://www.crystalinks.com/greenhouseeffect.html

13. http://www.wmo.ch/menuframe.html

14. http://www.unep.org/Documents.Multilingual/Default.asp?DocumentID=43

15. http://yosemite.epa.gov/OAR/globalwarming.nsf/content/climate.html, p.2

16. http://www.greenfacts.org/studies/climate_change/level_1.htm

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