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

Sun and Weather

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Introduction

Worthington Hooker School is a kindergarten through eighth grade New Haven Public School. Currently the fifth through eighth grades are located at a temporary site while a permanent location is secured for the third through eighth grades. Following extensive renovations during the 2005-2006 school year, Kindergarten through second grade will be relocated to the original, historic building at the intersection of Livingston and Canner Streets.

Worthington Hooker School is a neighborhood school for the East Rock community. The population of this area is composed of Yale faculty, graduate students, and other New Haven residents. The student population is largely drawn from the local community; when there are available slots, students from other neighborhoods in New Haven are allowed to enroll. For this reason, Worthington Hooker is ethnically, racially, and socioeconomically diverse.

Worthington Hooker School actively integrates arts into the school day. It is a HOT (Higher Order Thinking) School, which is funded through the Connecticut Commission for the Arts and encourages inclusion of the performing and visual arts in core classes of English, math, social studies and science.

The seventh and eighth grade science programs at Worthington Hooker School address the scientific disciplines of biology (reproduction, heredity, genetics, ecology, and evolution), earth science (rock cycle, erosion, earthquakes, plate tectonics, and fossilization), and space science (big bang theory, solar system dynamics, and asteroid impacts).

A prime motivation to write this curriculum unit on weather is to include more physical science and meteorology in the middle school science curriculum. Reviewing the outlined curriculum shows a deficiency in these areas.

In January 2005 The State of Connecticut released revised *Science Frameworks* . New Haven Public Schools is planning to prepare students for the next generation of CMTs (Connecticut Mastery Test)1.

This curriculum unit will explore several science content standards. The transformations of energy that drive weather will be explored. The sun is the ultimate source of this energy, but the dynamic interplay of weather is a result of how solar energy is moved around the earth by water. The unit will also explore the unequal distribution of energy on our planet, the nature of energy, temperature, pressure, the role water plays in transferring energy, and finally how proximity to large bodies of water impact meteorological phenomena.

Secondary students do not explicitly think about energy flow in the Earth's systems. This unit will help them to make the connection between solar energy and regularly observed meteorological phenomena. Energy to a middle school student may be a high sugar (and calorie) "Power Bar" candy bar, a high caffeine drink such as "Red Bull", or some form of chemical energy, such as oil. A middle school student may also say energy is the same as enthusiasm. There is much misunderstanding among secondary school students around the concept of energy.

Middle school students are generally familiar with the current weather forecast and can describe present meteorological conditions. Students typically cannot identify nor explain the mechanisms, which influence our weather.

Given sufficient motivation, students ask, "What causes weather?" There are many interesting phenomena to see in our daily skies and these are perfect for building enthusiasm for this unit.

Student questions may include:

> "Why is my breath sometimes visible?"
> "Why do thunderstorms form?"
> "How can it be nice today, but rainy (or snowy?) Tomorrow?"
> "What causes the wind to blow?"
> "How do I explain the dew (or frost) in the morning?"

This unit is to be integrated into a child's daily life. The principles we explore here are universal phenomena which students will be able to explore in and out of science class. Students can pose new questions, explore, and discover more about the world in which they live.

The Greek Philosopher Aristotle coined the term "Meteorology" around 340 B.C. in a text called *Meteorologica, which* included ideas on astronomy, geography, and chemistry. The origin of the term is the Greek *meteoros,* which means "high in the air". Despite his erroneous explanations (experiment-based science did not appear for another 2,000 years), these ideas stood undisputed2.

Subsequent technological and cultural changes permitted formal study of the physical world. In the late 1500's the thermometer was invented, followed by the barometer (a device for measuring air pressure) in 1643. In the late 1700's the hygrometer (a tool to measure water vapor) was invented, and the telegraph's invention in 1843 allowed observations to be sent across vast distances. Shortly thereafter, in 1869, isobars (lines of equal atmospheric pressure) appeared on weather maps. In the 1920's the Norwegians discovered air masses with different pressures, and therefore the existence of weather fronts. By the 1940's the use of weather balloons allowed us to take temperature, humidity, and pressure measurements and allowed for three-dimensional modeling of the atmosphere. Finally, in 1960, the first weather satellite *Tiros I* was launched3.

The unit also looks at how weather is affected by bodies of water and water vapor in the atmosphere. Heat transport, heat capacity, and the presence of the usually invisible air and water vapor are challenging concepts for middle school students!

Wind is caused by forces, which result from air masses moving from higher to lower pressure4. Winds are also caused by the uneven heating of Earth's surface, the Coriolis effect, centripetal forces (seen as isobars around high air pressure regions), and friction5.

Because of Earth's rotation from West to East, winds are sent to the right (aerial view) in the Northern Hemisphere. In the case of high pressure systems, winds move clockwise and outward, away from the pressure center. In low pressure systems, they move counterclockwise and into the lower pressure region (from higher to lower pressure is the rule).

Additionally, the unit will explore the effect adding heat to objects has on their molecular motion. This is a very important idea, which not only helps to understand weather, but why global warming will cause sea level rise. Above 4 Celsius, water volume increases with increasing temperature.

Average temperatures are affected by latitude, location of land and water, ocean currents (such as the Gulf Stream) and elevation6.

The highest profile program for the New Haven Public School's Science Department is the Science Fair. The Science Fair was begun in 1993, and was awarded the "Presidential Award in Science, Mathematics and Engineering Mentoring" in 20017. It is held in March in Yale Commons, and hosts projects from most schools, grades K-12. The students are charged with designing an experiment, which is hypothesis driven and from which results can be deduced. This curriculum unit addresses many common physical phenomena, which are excellent springboard activities to engage student interest. From some of these activities students can develop more sophisticated science fair projects. Examples may include:

- Electrical explorations with photovoltaic solar cells
- Heat transfer experiments
- Field-based temperature readings of various locations, done over an extended time period
- Barometer or anemometer construction, calibration, and comparison with professional barometer or anemometer readings

The Unit

Weather is a topic for which students show interest. With this unit, middle school students will encounter the fundamental principles that cause the complex interplay of energy, water vapor, and pressure that results in our weather.

The goal in creating this unit is to help students engage with the physics of weather by participating in several classroom activities, making direct observations of the local weather and to connect with web-based observations of national and international weather.

In our six day "Sun and Weather" Yale New Haven Teachers Institute Curriculum Unit, the focus is on content standards8 which address:

- Energy
- Temperature
- The uneven heating of the Earth's surface
- Pressure
- Atmospheric water vapor
- Geographic location

The "Unit and Background" section will detail the necessary content for these six topics. Please refer to the "Lessons and Activities" for classroom applications.

Students

This unit is intended for middle school students between grades 6 and 8. The use of an easily observed and measured discipline such as meteorology encourages experimental design, direct observation and subsequent reinforcement of science content.

The unit has the objectives of demonstrating to students that:

- Solar radiation is not equally distributed on the surface of the Earth
- Energy can be described and measured in terms of molecular motion
- Temperature is the way we measure average molecular motion

- Pressure is the amount of force per unit area
- Air contains various amounts of water vapor
- Weather is strongly affected by the location of a place relative to large body of water

When working with middle school students, it is essential to keep their unique learning styles in mind. Lecture is generally ineffective. Brief introduction followed by minds- and hands-on activity, with science log book entries results in deeper learning. Student groups should follow up classroom activities with discussion and presentation of results.

This unit is broken down into six main topics, to be completed in approximately six class sessions of 45 minutes each. Each lesson is broken down into introduction, objective, materials, activity procedure, and wrap up with discussion.

Students benefit from concrete examples of scientific processes. For this reason, this unit includes numerous activities.

1. Radiational energy will be explored with an activity which relies on the temperature differences observed when objects are exposed to visible light and when they shaded. Extensions of this activity are to make use of photovoltaic solar cells for quantitative value collection, and changing the angle of the visible light source.

2. Temperature of gases will be changed and resulting volumes measured. Additionally Celsius temperature readings will be converted to Kelvin and Fahrenheit.

3. The uneven heating of the Earth will be investigated by placing thermometers in identical environments, but different materials (such as sand or soil and water). A heat source will be introduced (such as a classroom radiator or 100 watt incandescent light) and the change in temperature will be monitored over a classroom period and throughout the school day. Data will be collected and graphed. An extension is to evaluate uneven heating based on object color.

4. Pressure will be evaluated by using an anemometer (a wind gauge) and a current forecast, which shows low, and high pressure systems. Extensions include heating air in an Erlenmeyer flask with a balloon over the opening, massing a balloon before and after filling with air (or putting two balloons on the ends of a lever, such as a broom handle or meter stick with pivot point in the middle, and then filling one with air), making barometers with soda bottles, and when outdoors simply dropping light objects (such as leaves) to observe and make a rudimentary measurement of wind speed and direction.

5. In order to observe atmospheric water vapor, we will create a weather system in a clear plastic box with a reservoir in the top for ice and a place inside for a warm mass. Water vapor will condense as liquid on the underside of the ice, simulating the hydrologic cycle.

6. The impact of geographic location (and heat capacity of water) will be explored by consultation with online

weather maps to make real-time predictions and comparisons of temperatures at various coastal regions (Pacific, Great Lakes, and Atlantic). With deeper understanding of how weather works, students may now make predictions for weather in regions around the country and world.

Students learn best by doing background reading and having access to high quality visuals (such as the WWW, posters, and videos). Discussion with peers is powerful as in this age group interpersonal communication is a startling effective way to have students learn new ideas.

In science courses we want to give students as many experiences with materials as possible. Hands-on activities without background information are usually not very effective at getting important concepts across. The activities used in this unit support the concepts being addressed.

The International System of Units (SI) is the preferred measurement to use in science. In this system, we measure:

Volume in liters,

Mass in grams (weight is technically mass x gravity, on Earth mass is synonymous with weight)

Length in meters, and

Temperature in Celsius, (with 0 C the temperature at which pure water freezes and 100 C the temperature at which the molecules have enough energy to begin to change state and go from liquid to gas. This is also called the boiling point).

Unit Plan and Background

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1. What is Energy?

Energy is the property of a system that allows it to do work. Work is defined as a force acting on matter, causing motion. Energy comes in many forms, such as kinetic (motion), radiant (such as light), potential (such as the energy in a rock at the top of a hill), chemical (such as unburned gasoline), electric (the transfer of electrons), and magnetic (for example iron ions or compounds).

The source of energy, which powers the Earth's weather, is the sun. The sun is a million times the size of Earth (the radius of the sun is 696,000 km, the radius of the earth is 12,756 km) and that provides more energy to the surface of our planet than any other source. Although the sun is very large, it has a relatively low overall density of 1.41 g/cm3. Pure water, for reference, has a density of 1g/cm3. Most of the sun's mass (94%) is located in the inner half of the sun's radius.

At one time, it was thought that the sun was releasing energy because it was behaving like a gas under pressure, and was heating up. It was also thought that the sun was burning, as in a chemical reaction9.

The source of this energy is a nuclear reaction. Unlike a nuclear power plant or nuclear weapon that derive energy from fission (or splitting of large atoms) a fusion reaction occurs in the sun between hydrogen nuclei, resulting in a helium atom.

In the middle 25% to 30% of the radius of the sun, the core, 600 million metric tons of hydrogen nuclei are fused each second to form helium. Each time this occurs, a large amount of energy is released as a portion of the mass of the four original hydrogen nuclei (0.7%) does not end up in the helium nucleus. This transformation of mass to energy was originally described by Einstein in his famous E=mc2 formula. This small amount of lost matter releases an enormous amount of energy. For each fusion reaction (the term which describes the uniting of atomic nuclei) there are 4.3 x 10-12 joules of energy released10.

Gamma ray photons are released in the core as a result of these thermonuclear reactions. The temperature in this region of the sun is 1.55 x 107Kelvin. (10 million Kelvin). The Kelvin temperature scale has the same incremental value as the Celsius scale, but is 273.15 degrees higher, as Kelvin starts at "absolute zero". Absolute zero is a value equal to -273.15 Celsius. The sun is 5,800 Kelvin at the surface. The temperature at the core is 10 million Kelvin, due to the tremendous pressure11.

The sun releases 3.9 x 1026 joules of energy per second, and will continue doing so for another six billion years.

Conduction, convection, and radiative diffusion are three ways energy is transferred from the core of the sun to the surface, where it leaves as radiant energy. Conduction is not an effective way to transfer energy in materials with low densities.

When the photons leave the core, they move via radiative diffusion from the 10 million Kelvin core towards the 5,800 Kelvin surface. When the photons are over 2/3 of the way to the surface, convection takes over, and the circulating band of solar fluid transfers this energy to the surface. This process takes an astonishing 170,000 years to complete! This is a rate 20 times slower than a snail travels! Once at the surface, the photons travel easily through space at the speed of light, and some of this energy will strike Earth eight minutes later12.

The center of the sun is under extreme pressure - so much that the hydrogen and helium mixture (the two lightest elements) are 14 times the density of lead! The density of this region is 155 g/cm3, and under 3.4 x 1011 atmospheres of pressure!13 At sea level, there is one atmosphere of pressure, which is approximately 14.7 pounds per square inch (psi).

2. Temperature

Temperature is the relative measure of heat energy and a measure of the average speed with which particles in a material move around. This is important as it determines energy transfer from one region to another. There are vast temperature differences among the materials that make up our planet, as well as across regions of Earth. This is why being able to quantify these molecular motions is so useful to meteorologists.

Students usually need refreshing on the units of Fahrenheit, Celsius, and Kelvin. Some web sites offer online conversions14 and these are useful for students to use to check their work once they have mastered using the following formulas.

To convert Celsius to Fahrenheit: C x 9/5 +32

To convert Fahrenheit to Celsius: (F-32) x 5/9

To convert Celsius to Kelvin add 273.15 to the Celsius value

3. The uneven heating of the Earth's surface

Radiation is the mechanism by which energy is transferred from the sun to the Earth. Photons are the smallest unit of electromagnetic energy (light is an example of visible electromagnetic radiation), and do not require a medium to travel through. They travel through space. When these photons strike the surface of the Earth, they transfer their energy to the ground. In turn, the ground warms up the air. This is done through conduction over a very narrow layer (about 1 mm) above the surface.

Conduction is the direct transfer of energy without movement of the medium itself (in this case, air). This only happens across a very small distance because air is a very poor conductor.

Once the air in this gap has been heated, further transport of the heated air is done by convection. Convection in the atmosphere occurs when currents of air transfer heat in a flowing manner from one area to another.

The surface of Earth is composed of different materials (which do not heat evenly) and is a major driving force of weather.

The equatorial latitudes receive much more solar radiation during the entire year as this part of the Earth more directly faces the sun in our annual revolution. The Northern and Southern Hemispheres experience seasons as a result of the tilt of the Earth's axis. This differential in energy distribution sets up the subsequent flow of energy via convection of air and water.

Water has a very high specific heat (it takes more energy to raise the temperature of water than most other substances), it therefore has a high heat capacity and serves as a reservoir of heat. This makes water very important in the transfer of thermal energy from warmer to cooler regions.

The Gulf Stream is an example of one such current on the East Coast of the United States. It is one of the strongest ocean currents, and ferries energy from the tropics along the Eastern Seaboard, and across the Atlantic to Northern Europe!

In contrast, on the West Coast of the United States cold water is drawn south from Alaska to Mexico by the California Current. Kuroshio, or the Japan Current, carries warm water along the Eastern coast of Asia, and up to the north Pacific15.

4. Air Pressure

Air pressure results from the motion and number of air molecules over a geographic location.

As air molecules move about at an average of 1,090 mph, they push against what they strike. While individually this results in a small amount of pressure, collectively (a one inch square box holds 4 x 1023 air molecules) this pressure has dramatic effects16.

The lower temperatures that are associated with higher elevations are a result of fewer collisions of air molecules. With less contact (among fewer molecules) the temperature is lower16.

The significance of this in our study of weather is that differences in air pressure cause wind, as air will move from areas of high toward low pressure.

Air pressure is measured using three different scales: millibar, kilopascal (which is 1/10 a millibar (thus millibar=hectopascal), and inches of mercury (Hg). This is the conversion among these units:

1013.25 mb = 1013.25 hPa = 29.92 in. Hg18

5. Atmospheric water vapor

Water vapor in the atmosphere runs the water (or hydrologic) cycle. The hydrologic cycle is the process by which water changes state among liquid, solid, and gas. In order for this to occur, energy is lost or gained (please see "latent heat" in glossary). This is the primary means by which solar energy is transferred around the globe. 90% of the water in the atmosphere evaporated from surface water (oceans, rivers, lakes, and other bodies of water).

Plants also play a role in the transportation of water into the atmosphere. Plants draw water from the ground (via their roots) through their vasculature by selectively allowing water to evaporate off their leaves. This process is called transpiration, and is responsible for moving the remaining 10% of the water into the atmosphere19.

Sinking air does not produce clouds20. Clouds form when water vapor is cooled, and condenses around small particles of dust or smoke in the upper atmosphere. So you know the air mass is moving up when you see clouds forming!

Water vapor plays a very important role in transferring energy around the globe. As we have discovered, there is an uneven distribution of thermal energy, and water vapor in the atmosphere, along with oceanic water currents, play an important role in distributing this energy.

6. Geographic location

Oceanic and atmospheric currents serve as distribution networks for energy around our planet. The geographic location therefore will play a very important role in the kind of weather experienced. Locations which are near large bodies of water will experience cooling or warming, depending on the relative temperature of the water to the land. If the location is served by a cold current (such as the California) the land near the sea will be cooler. The inland locations can be much warmer, as they receive less influence from the large thermal mass. Conversely, in times when the inland areas are very cold, the coastal areas can have their temperature moderated by the presence of a large body of water. This can be an ocean, or large lake, such as the Great Lakes21.

Our location at the coast of Long Island Sound makes teaching this portion of the standard fun! In coastal Connecticut we regularly have different weather from those who live further inland. Crops can be planted a full two weeks earlier closer to the coast due to the high heat capacity of the water in Long Island Sound.

Glossary

Air – the combination of gasses (mostly nitrogen and oxygen) that compose the atmosphere above Earth's surface

Atmospheric pressure - force applied by the atmosphere over the surface of the earth, varies with weight of air, and decreases with increasing height

Atmosphere - gases that make up the thin envelope around Earth, about the relative thickness of a sheet of paper placed on a basketball

Atmospheric water vapor – gaseous form of water released to the atmosphere

Barometer - an instrument used to measure atmospheric pressure

Barometric Pressure- atmospheric pressure as given by a barometer

Carbon Dioxide - gas molecule containing one carbon and two oxygen atoms, important greenhouse gas

Climate - average weather over a long time period

Condensation - the process of vapor changing state to liquid

Density - mass per unit volume

Energy - ability or capacity to do work

Energy Flow - the movement of energy from one area to another (higher to lower is the usual flow)

Evaporation - change of state from liquid to gas, requires energy

Force - application of energy to an object causing it to accelerate

Freezing - change of state from liquid to solid, gives up energy

Gas - state of matter where molecules are moving freely about, can be compressed.

Gravity - universal, invisible force of attraction between two bodies

Greenhouse Gas – gases that trap heat, such as CO_2, Methane, water vapor

Heat - energy in the process of being transferred from one body to another because of temperature difference between them.

Heat Transport - the movement of thermal energy

High Pressure Region - center of air mass with higher pressure than surrounding air masses

Humidity - water vapor in the air

Hygrometer - tool used to measure humidity

Isobar - line on a weather map that links areas of equal pressure

Joule - SI unit of energy

Latent Heat - heat released or absorbed to change from one form of a substance to another. As water changes state. Ice to water gives up 80 cal/g whereas water to vapor requires 600 cal/g to change state!

Liquid - state of matter where molecules are sliding past one another, not compressible.

Low Pressure Region - center of air mass with lower pressure than surrounding air masses

Mass - amount of matter in an object

Molecule - atoms combined, such as O2, H2O, CO2

Partial pressure = the pressure of the individual components of a mixture of gases. Add to get total pressure.

Power - energy (work) per unit time (watts)

Pressure - force per unit area

Saturated: evaporation rate = condensation rate

Solar Energy - radiation from the sun

Solid - state of matter where molecules are in a fixed arrangement

Specific Heat - amount of energy that needs to be supplied (or taken away) from one gram of a substance to change its temperature by one degree. Water has a specific heat of 1 cal/g, ice has 0.5 cal/g, and air has 0.33 cal/g

Sub-saturated: evaporation rate > condensation rate

Supersaturated: evaporation rate condensation rate

Temperature - measure of average speed of atoms and molecules

Telegraph - communication system using wires

Thermonuclear Fusion – lighter nuclei come together to form heavier nuclei under conditions of extreme pressure and heat. E.g., the formation of helium from hydrogen in the Sun's core.

Vapor pressure - partial pressure of water vapor

Volume - the space that something occupies

Water Content - the amount of water vapor in the air

Weather - the current atmospheric conditions

Weight – The force applied by gravity on a body. It is the product of mass and the acceleration due to gravity.

Wind - movement of air along a planet's surface

Work - product of force times distance

Individual Lesson Plans

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1. Energy Lesson and Activity

Introduction

The purpose of this activity is to have students make direct observations on the transmission of energy through space.

Objective

To observe the effects of radiant energy

Materials

Thermometers (2 per student pair)

Access to sunlight, or incandescent light bulb, or other radiant heat sources

Activity procedure

The procedure is to have student pairs take two thermometers and place one under a light source, or in the sunlight, and shade the other, but keep them in an area with the same conditions. This will reveal differences in temperature that can be compared across the class when all groups have completed the activity.

If there is access to photovoltaic cells, this activity could be made into a data-collecting laboratory. Another extension is to explore the rate of temperature change if the angle of light is changed, simulating the effect that occurs in the Northern and Southern Hemispheres.

Wrap up with discussion

Students will record data individually in their laboratory notebooks. As they finish their experimentation, they will add their data to a class list, either via computer with data projection, or to a table on the chalkboard.

Students will review their results, as well of the results of their fellow researchers. They will be guided to question the procedures, and make conclusions based on the available data.

2. Temperature Lesson and Activity

Introduction

This lesson will help students understand some properties of air.

Objective

To perform volume and mass calculations.

To perform temperature conversions.

Materials

Balloons

1 Liter soda bottles

Stockpots for hot and cold water

Ice

Activity procedure

The procedure is to place a balloon over a soda bottle and then place the bottle in a bucket of hot water and leave it there for several minutes to observe changes in the volume of the gas. Students will take the temperature of the water and convert it to Fahrenheit and Kelvin. Students will measure the diameter of the balloon.

After students have written down their observations, they may then immerse their bottle and balloon apparatus into the ice water (and this could be cooled even further with the addition of salt). Again, students will write down their measurements and observations.

Wrap up with discussion

Students will record data individually in their laboratory notebooks. As they finish their experimentation, they will add their data to a class list, either via computer with data projection, or to a table on the chalkboard.

Students will review their results, as well of the results of their fellow researchers. They will be guided to question the procedures, and make conclusions based on the available data.

Students need to be reminded that the amount of gas has not changed, simply the temperature and subsequently the volume.

3. Uneven Heating Lesson and Activity

Introduction

One major influence of our weather is the fact that different materials absorb energy at different rates.

Objective

To experience the fact that different materials have different heat capacities.

Materials

Thermometers (2 per student pair)

Access to sunlight, or incandescent light bulb, or other heat sources such a classroom radiator or heat exchange

Coffee containers of soil, sand, and water

Activity procedure

Suspend thermometers inside two samples of material, such as soil or sand and water. As in the activity for energy, students will place these containers near a light source and take periodic temperature readings.

As well as seeing how different substances respond to the introduction of heat, it is useful for students to see the effect of color on heat absorption. Students will be given dark and light colored construction paper and can design experiments to discover what effect the background colors have.

Wrap up with discussion

These data are to be graphed manually on graph paper, or using a computer and a graphing program such as Excel. Experimental data will reveal that water is much more slow to gain heat, and is also slower to lose heat. This *heat capacity* of water will be explored in more detail in the water vapor and geographic location units.

4. Pressure Lesson and Activity

Introduction

Students typically have a difficult time realizing that air has mass.

Objective

To determine that air has mass by conducting experiments.

Materials

Balloons

Triple beam or electronic balance, with precision of 0.01g

Activity procedure

The introductory activity is to determine the mass a balloon on a triple-beam balance and then inflate it and mass it again22.

Students can construct a barometer using a soda bottle23.

Another activity is to attach a sandwich bag to the mouth of a jar with a rubber band and then pull or push the bag in and out of the jar and ask students to explain which situation had higher or lower air pressure.

A simple wind activity: stand parallel to the wind and toss leaves, or some other very light objects, directly in front of you and see how far they go.

To demonstrate the expansion of air when it is heated, a balloon can be attached to an Erlenmeyer flask and placed on a hot plate. As the air inside the flask heats up, it will expand and inflate the balloon.

Another activity (easily given as a take-home assignment) would be to construct an anemometer. Students could measure wind speeds at different locations, at different times, and connect their data with air masses that are moving in or out of the area (by using the web or newspapers).

As an extension, it would be interesting to use the Internet to obtain local weather conditions and explore the shifting of winds at the end of the day along the coast ("the sea breeze").

Wrap up with discussion

Discuss results of massing balloon and lever activity. Students should have discovered that air has mass.

Other discussions will depend on activities chosen.

5. Atmospheric Water Vapor Lesson and Activity

Introduction

The goal of this lesson is to simulate the hydrologic cycle.

Objective

To make direct observations of a simulated evaporation, condensation, precipitation system.

Materials

Plastic shoebox with lid
Mass that can be heated (such as a brick)

Ice

Activity procedure

This system can be modeled by using a clear box (about the size of a shoe box), a warm mass (such as a rock, soil or sand) and a cup of ice placed in a hole in the top of the box. As the vapor condenses, it will drop back down onto the warm mass, and evaporate once again.

A simple activity is to calculate the dew point by using a can with ice and a thermometer.

For an extension, students could use the system modeling software STELLA to more carefully recreate this dynamic24.

Wrap up with discussion

Discuss observations and elicit student explanations for the condensation under the ice, and precipitation from this condensation.

Discuss with students why earthenware pots are used to keep water cool (they allow for evaporation and therefore cooler water).

6. Geographic Proximity to Water Lesson and Activity

Introduction

This lesson allows the instructor and students to explore myriad geographic regions, and make connections among the physical science concepts explored as part of the entire unit.

Objective

To recognize that oceans and other large bodies of water have dramatic impact on weather.

Materials

Internet access

Activity procedure

The activity to explore this would be to consult temperature maps of the region during weather events where the influence of heating from the water is evident.

Students will choose areas that are near oceans or large bodies of water, and make predictions about the weather and temperature conditions over a 24 hour period. Possible specific locations include the Pacific Coast, Great Lakes, Gulf of Mexico, Atlantic Coast, and then areas inland from these regions. Students then go online and gather real-time data on their chosen locations.

An extension is to encourage students to make predictions and gather information on locations from around the globe.

Wrap up with discussion

Discuss findings with students. What patterns emerge?

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Teacher Reading List

C. Ahrens, *Meteorology Today,* (Brooks/Cole, 2003)

W. Freedman and W. Kaufmann, *Universe,* (W.H. Freeman, New York, 2005)

S. Smith and B. Ford, *Project Earth Science: Meteorology* (NSTA Press, 2001)

S. Smith, *Project Earth Science: Astronomy* , (NSTA Press, 2001)

Various Authors, *The Science Teacher,* 72, 2, (2005)

http://www.aoml.noaa.gov/hrd/tcfaq/tcfaqHED.html

http://www.edgcm.org/EdGCMCooperative/Downloads.php

http://www.nasa.gov/vision/earth/everydaylife/climate_class.html

Appendix - Standards (State of Connecticut, 2005)1

V. Energy in the Earth's Systems: How do external and internal sources of energy affect the Earth's systems?

6.3 - Variations in the amount of the sun's energy hitting the Earth's surface affect daily and seasonal weather patterns.

Local and regional weather are affected by the amount of solar energy these areas receive and by their proximity to a large body of water.

C 7. Describe the effect of heating on the movement of molecules in solids, liquids and gases.

C 8. Explain how local weather conditions are related to the temperature, pressure and water content of the atmosphere and the proximity to a large body of water.

C 9. Explain how the uneven heating of the Earth's surface causes winds.

I. SCIENTIFIC INQUIRY

Scientific inquiry is a thoughtful and coordinated attempt to search out, describe, explain and predict natural phenomena.

II. SCIENTIFIC LITERACY

Scientific literacy also includes the ability to search for and assess the relevance and credibility of scientific information found in various print and electronic media.

III. SCIENTIFIC NUMERACY

Scientific numeracy includes the ability to use mathematical operations and procedures to calculate, analyze and present scientific data and ideas

The following numeracy performance items serve as a selection rubric for minds-on classroom activities.

C INQ.1 Identify questions that can be answered through scientific investigation.

C INQ.2 Read, interpret and examine the credibility of scientific claims in different sources of information.

C INQ.3 Design and conduct appropriate types of scientific investigations to answer different questions.

C INQ.4 Identify independent and dependent variables, and those variables that are kept constant, when designing an experiment.

C INQ.5 Use appropriate tools and techniques to make observations and gather data.

C INQ.6 Use mathematical operations to analyze and interpret data.

C INQ.7 Identify and present relationships between variables in appropriate graphs.

C INQ.8 Draw conclusions and identify sources of error.

C INQ.9 Provide explanations to investigated problems or questions.

C INQ.10 Communicate about science in different formats, using relevant science vocabulary, supporting evidence and clear logic.