Celebrate With SATELLITES

An International Polar Year partnership to study Earth's materials

Mikell Lynne Hedley, Kevin Czajkowski, Janet Struble, Terri Benko, Brad Shellito, Scott Sheridan, and Mandy Munroe Stasiuk

Partnerships between scientists, teachers, and students have shown to be one of the most effective forms of science instruction (Wormstead, Becker, and Congalton 2002). Students and Teachers Exploring Local Landscapes to Investigate the Earth From Space (SATELLITES) is one such collaboration that uses the International Polar Year (IPY) as its underlying theme. This year's IPY—the fourth in history—is a collaborative, international effort to research the Earth's polar regions from March 2007 to March 2009 (see "A history of the IPY," p. 33).

The SATELLITES program uses geospatial technologies to study surface temperatures of Earth's materials, such as sand, soil, grass, and water. Data are collected using Global Learning and Observations to Benefit the Environment (GLOBE) protocols, which are then used in research projects that are a part of the IPY. Students collect data, conduct field campaigns, design inquiry-based research projects, and attend and present at a SATELLLITES science conference. One student activity, "Heating Things Up," is included in this article to help introduce students to the factors that affect Earth's surface temperature.

You and your students are encouraged to join our partnership! This article describes the program, activity, and ways to get involved.

About SATELLITES

Since it began in 2000, the SATELLITES partnership has built a community of learners that is beneficial to teachers, students, and scientists around the world (Hedley and Struble 2004). This collaborative program studies Earth using the geospatial technologies of remote sensing, global positioning systems (GPS), and geographic information systems (GIS).

Through a five-day Teacher Institute, teachers are trained in GLOBE's surface temperature and cloud protocols, which use Earth's energy budget (Figure 1) as their underlying science concept. Earth's energy budget is a measure of the amount of energy entering and leaving the Earth-atmosphere system in the form of radiative energy, sensible, and latent heat. The amount going in must equal the amount going out, or Earth would continually heat up or cool down. At the Institute, teachers learn how to measure Earth's materials with infrared thermometers (IRTs), how to model data-collection methods, and the overall process for students (Figure 2).

Teachers take what they learn back to the classroom, and train students to collect surface temperature and atmospheric field data according to these protocols. This involves a field campaign in which students collect data locally during a given time frame, while other students collect data in their locations as a means of comparison. Students then enter their data on the GLOBE website (see "On the web"), which can be accessed by students, teachers, and scientists everywhere (Figure 3). GLOBE's focus is to involve these groups in the study of global climate change and other environmental issues (see "More on GLOBE," p. 30).

Get involved!

We would like to get you and your students actively involved with our research and the use of geospatial technologies. To become a part of the SATELLITES program, you must attend one of our free Teacher Institutes. If you would like to learn more about the SATELLITES program or attend one of our 2009 workshops, please contact Mikell Lynne Hedley at *mikell.hedley@utoledo.edu.*

Information about participating in GLOBE can be found online (see "On the web"), along with access to extensive data collected by students in 110 participating countries around the world.

As part of the SATELLITES program, the data students collect is used to develop an inquiry-based research project. Teachers are encouraged to help students brainstorm practical ideas. This helps students arrive at a question they are able to answer using their present skill level, available data or experimental procedures, and time limitations. Since the teachers themselves have done this in the Institute, they can better guide students in coming up with a question and how they will answer it. International Science and Engineering Fair rules are used in the research project.

FIGURE 1

The energy budget.

This drawing illustrates the dynamics of the heating and cooling of Earth—this is one way to introduce the energy budget to your students.

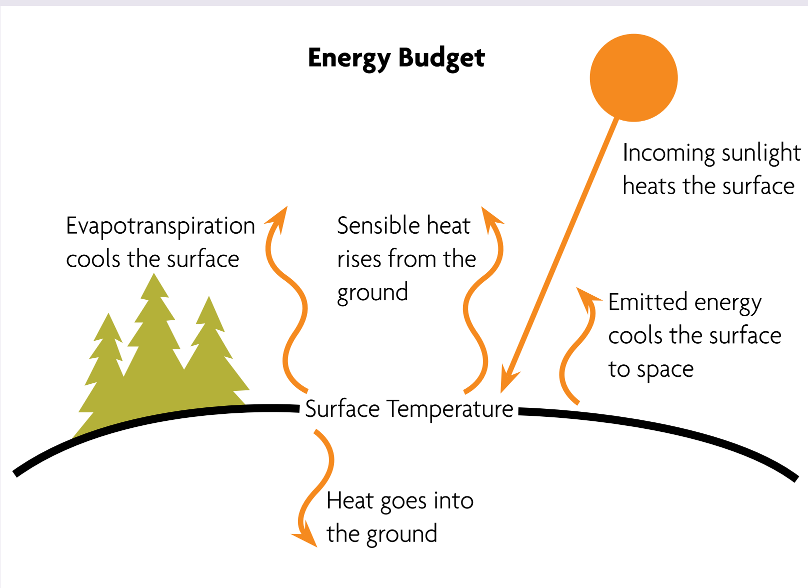

IMAGE COURTESY OF KEVIN CZAJKOWSKI

Student research projects are presented at the annual SATELLITES science conference. This conference brings together the students, teachers, parents, and scientists who have worked together throughout the year. At the conference, students present their projects in person or by video to the judges. Winning students receive medals and ribbons and their schools receive trophies. Some of the winning projects in 2008 had the following titles:

- Take Me Out to the Ball Game (middle school)
- When It's Hot, It's Hot (middle school)
- The Big Stinky Time Bomb (middle school)
- How Clouds Affect Global Warming (high school)
- Global Warming—True or False? (high school)

During the IPY, the conference has included a presentation by a NASA scientist actively involved in IPY research. The IPY theme was chosen to help students understand how the events that happen at the poles have a ripple effect on their own location's weather and surface conditions. This IPY is seeking student involvement in research activities, unlike the previous three.

Students have the opportunity to submit their research projects to GLOBE for inclusion in GLOBE Learning Expeditions. This is a weeklong event that hosts scientists, teachers, students, and other partners from around the world—allowing students to present their projects to the international science community. In 2008, a SATELLITES student project was one of five chosen from the United States to be presented at the South African conference.

On the ground

The SATELLITES program uses geospatial technologies—GPS, GIS, and remote sensing—to set up study areas, collect surface temperatures, and portray student data in a visual manner. Students pick both a grassy test area and a paved area such as a parking lot and use their GPS units to pinpoint the exact latitude and longitude of each site—information that is necessary for students to compare their data with other locations. The grassy test area is used to check surface temperatures of natural materials, and the parking lot is used to measure the temperature of human-made materials. Students can observe and compare the difference in surface temperature of these two areas.

Once the study sites have been allocated, students use an IRT—a handheld device that takes the temperature of Earth in much the same way as satellites do—to take surface temperatures. (**Safety note:** Use of IRT controls, adjustments, or performance of procedures other than those specified here may result in hazardous radiation exposure.) Students hold the

CAUTION

FIGURE 2

A prize-winning project: Arctic ice vs. Erie ice.

This teacher project used the decrease in Lake Erie ice cover to predict the decrease in Arctic ice cover over a number of years. This particular project was developed by two teachers in a 2007 Teachers' Institute.

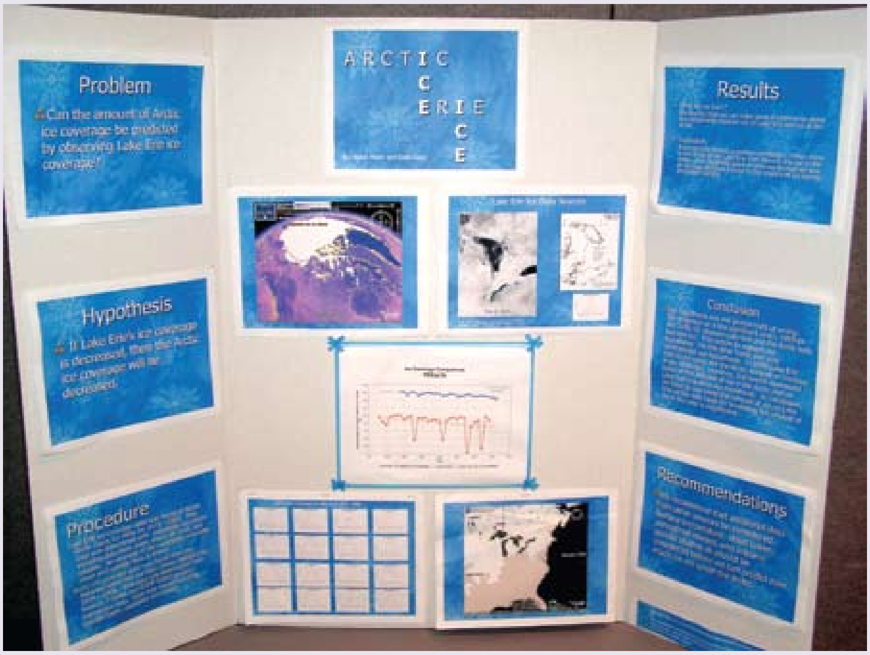

FIGURE 3

Participating schools.

This map shows the location of some of the schools that are currently involved in the collection of surface temperature and atmospheric data as part of GLOBE and the SATELLITES field campaign. Finding Earth's surface temperature at various locations and on different types of surfaces gives students a good picture of how the temperature of Earth is affected by various conditions.

instrument in their hand with their arm extended and press the lever on the instrument. The IRT gives nearly instantaneous observations using the long-wave radiation emitted by the surface and records the temperature on its display panel. (**Note:** Participants of the SATELLITES Teacher Institute receive a free GPS unit, IRT, and GIS software.)

Several factors can affect surface temperature, such as

- atmospheric conditions;
- percentage of cloud and contrail (or vapor) cover;
- types of clouds at various heights;
- amount of snow cover;
- precipitation; and
- any obscuring factors, such as smoke, volcanic ash, or haze.

These are all noted with the surface temperatures as part of the data. Data is collected for 10 consecutive school days in the weeks between the Monday after Thanksgiving and the beginning of most schools' winter breaks. GIS software can be used to map data-collection areas and compare data.

Students enter their surface temperature and atmospheric data on the GLOBE website, which scientists and students can then use in inquiry-based science projects.

More on GLOBE.

GLOBE is a worldwide hands-on, primary and secondary school–based science and education program. The program promotes and supports students, teachers, and scientists to collaborate on inquiry-based investigations of the environment and Earth system. The program works in close partnership with NASA and National Science Foundation Earth System Science Projects to research the dynamics of Earth's environment.

Announced in 1994 by then Vice President Al Gore, GLOBE began operations on Earth Day 1995. Today, the international GLOBE network has grown to include representatives from 110 participating countries and 138 U.S. partners coordinating GLOBE activities in their local and regional communities. Due to their efforts, there are more than 40,000 GLOBE-trained teachers representing over 20,000 schools around the world. GLOBE students have contributed more than 18 million measurements to the GLOBE database for use in their inquiry-based science projects.

GLOBE brings together students, teachers, and scientists through the GLOBE Schools Network in support of student learning and research. Parents and other community members often work with teachers to help students obtain data on days when schools are not open.

ADAPTED FROM THE GLOBE WEBSITE: *WWW.GLOBE.GOV/FSL/HTML/ABOUTGLOBE.CGI?INTRO&LANG=EN.*

In the past, students' work has been used to ground-truth NASA's Moderate Resolution Imaging Spectroradiometer (MODIS) satellite data (Ault et al. 2006). Ground-truthing is done to compare the data obtained from remote sensing with the data taken at the actual location. It is an important method used to calibrate a remote-sensing instrument. MODIS is the key instrument on the Terra and Aqua satellites (see "On the web"). Terra passes north to south over the equator in the morning, and Aqua passes south to north over the equator in the afternoon. These two satellites give a good picture of the entire Earth every one to two days. Students' data was used to ground-truth the MODIS data recorded by the Aqua and Terra satellites, primarily to help verify snow and cloud data. In this case, ground-truthing was needed because the spectral reflectance—the proportion of incident light that is reflected from a surface at any given wavelength of the visible spectrum—of snow and clouds is very similar, and the satellite data sometimes misreads snow and clouds.

In the classroom

Understanding the factors that affect Earth surface temperatures involves information about how Earth is heated and cooled, how energy flows from the Sun, and what variables affect the amount of energy that enters and leaves Earth. Heating Things Up is an example activity that can be used in the classroom to introduce these concepts to students (Figure 4). Janet Struble, a teacher with over 20 years of inquiry-based science experience, developed the activity.

Conclusion

The entire SATELLITES program emphasizes the importance of students doing science and not just reading about it. The collaboration with scientists and teachers makes science come alive, and the program is suitable for many ages and grade levels. The use of GLOBE protocols, which have been developed by scientists and educators, enables even third-grade students to learn correct data collection.

Through this project, students can use data they collect to answer their own science inquiries. And because data have been collected by students around the world, students everywhere are able to collaborate with one another. The use of geospatial technology tools opens up a world of new possibilities for the types of data students can use in answering the questions they have about the world, especially those related to the IPY.

The IPY theme provides the opportunity for students to study what happens in their own locality and how it is affected by global climate change. The comparison of data from the present time to that in years past introduces students to the idea that Earth is warming up. It

FIGURE 4

Heating Things Up lesson.

Purpose

To investigate the different rates of heating and cooling of certain materials on Earth in order to understand the heating dynamics that take place in Earth's atmosphere.

Overview

Working in small groups, students will explore the energy transfer of different Earth materials when they are heated up and cooled down. Students graph the changes in temperatures that occur over a 15-minute period of heating the Earth material up and a 15-minute period of the Earth material cooling down. Class time: two periods; level: middle and secondary.

Science concepts

Earth and Space Sciences:

- The atmosphere is composed of different gases and aerosols.
- The Sun is the major source of energy for changes in the atmosphere.
- The Sun is the major source of energy for Earth's surface processes.
- The Sun is the source of energy that heats Earth, including the atmosphere.
- The Sun heats Earth's surface.
- That heat is transferred to the atmosphere from the surface by conduction and convection.

Physical Sciences:

- Matter exists in three different states: solid, liquid, and gas.
- Heat transfer occurs by radiation, conduction, or convection.
- Light and radiation interact with matter.
- The Sun is a major source of energy on Earth's surface.
- Energy is transferred in many ways.
- Heat moves from warmer objects to cooler objects.
- Energy is conserved.
- Temperature is a measure of the kinetic energy of molecules and atoms.
- Materials heat up and cool down at different rates.

Science-inquiry abilities

- Use infrared thermometer (IRT) or regular thermometers.
- Design and conduct scientific investigations. (**Note:** After conducting this particular activity, students can change variables [e.g., time, types of materials, and types of heating method] and conduct their own investigations.)
- Use appropriate mathematics to analyze data.
- Communicate results and explanations.

Materials and tools

- five plastic containers of the same shape and volume
- handheld IRT or five thermometers
- sand
- soil
- grass
- water
- gravel or rocks
- a sunny day, five desk lamps, or clip-on shop lights with 100 W light bulbs
- stopwatch or timer

Preparation

Put equal amounts of each Earth material in separate containers.

Teacher preparation

Heat is a difficult concept for students to understand. It is not a substance but a form of energy (the movement of energy). So what does the temperature tell us about the amount of heat in the substance? The thermometer does not measure the amount of heat but the level of average molecular kinetic energy. This distinction is hard for even adults to understand. The big ideas of this activity are that

- heat is the movement of energy;
- energy has many forms; and
- energy can move from one place to another by radiation, conduction, or convection.

One form of energy is the motion of molecules (atoms): kinetic energy. Temperature can be used to compare the molecular kinetic energy of different substances; the movement of this energy is measured as heat.

FIGURE 4 (CONT.)

Heating Things Up lesson.

Procedure

1. Ask students to think about a hot, sunny day at the beach: "You are barefoot. What surfaces would you walk on, and why? Why are some surfaces cool to your touch? Why are some hot to your touch? From where did the hot surfaces get their energy?"
2. Tell students that today they are going to investigate what happens to Earth materials when they are exposed to the Sun.
3. A higher degree of inquiry can be achieved by having students develop an experiment that will answer the question, "Do different Earth materials heat up and cool down at the same rate?" Include the materials listed; other Earth materials could be added. Steps 4–7 offer an example. The amount of help students will need in developing these experiments will depend on their grade level. SATELLITES is open to grades 4–12.
4. Ask each group to record the temperature change of each Earth material. If it is a sunny day, this activity can be done outside. If not, desk lamps or shop lights can be used to simulate the Sun's energy.
5. If using thermometers, place them in the Earth material.
6. Record the beginning temperature of each material with the IRT. Turn on the lamps, and then record the temperature every 3 minutes for a total of 15 minutes. Enter the values on the attached data table. (**Safety note:** Use care with lamps, as the 100 W bulbs can become hot.) CAUTION
7. After 15 minutes, turn off the lamps (or shade the containers if outside) and measure the temperature every 3 minutes for the next 15 minutes.
8. Have students examine the data, graph it, and then interpret the graphs.
9. Use the following questions for class discussion or as an individual assignment:
   - Did all the Earth materials heat up at the same rate? Explain the evidence for your answer.
   - Did all the Earth materials cool down at the same rate? Explain the evidence for your answer.
   - Which Earth material heated up the fastest? How do you know this? Explain why this may have happened.
   - Which Earth material cooled down the fastest? How do you know this? Explain why this may have happened.
   - Did each Earth material receive the same amount of energy? How do you know?

TABLE 1.

Data table sheet.

	Temperatures (°C)				
Time (min.)	Bare soil	Grass	Gravel or rocks	Sand	Water
Beginning					
3					
6					
9					
12					
15					
Shaded or turn off lights.					
18					
21					
24					
27					
30					

(**Note:** This lesson is just one example of the ways in which science content and geospatial technologies are related through the SATELLITES program.)

raises their awareness of the problems of climate change and what their part might be in the solution to this global problem. ■

Mikell Lynne Hedley (mikell.hedley@utoledo.edu) *is a research scientist and SATELLITES education coordinator; Kevin Czajkowski* (kevin.czajkowski@utoledo.edu) *is director of OhioView, an associate professor of geography, and director of the Geographic Information Science and Applied Geomatics (GISAG) Lab; Janet Struble* (janet.struble@utoledo.edu) *is program coordinator for UToledo.UTeach. UTouch the Future (UT3); and Terri Benko* (breadnbalance@gmail.com) *is a senior researcher, all at The University of Toledo in Ohio. Brad Shellito* (bashellito@ysu.edu) *is an assistant professor of geography at Youngstown State University in Youngstown, Ohio; Scott Sheridan* (ssherid1@kent.edu) *is an associate professor of geography and graduate coordinator; and Mandy Munroe Stasiuk* (mmunrost@kent.edu) *is an associate professor of geography, both at Kent State University in Kent, Ohio.*

On the web

GLOBE: *www.globe.gov*
MODIS: *http://modis.gsfc.nasa.gov/about*
History of IPY websites:
www.nas.edu/history/igy
http://classic.ipy.org/development/history.htm
www.arctic.noaa.gov/aro/ipy-1/History.htm
www.ipy.org/index.php?/ipy/history
www.ipy.gov/Default.aspx?tabid=70

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Hedley, M.L., and J.L. Struble. 2004. A community of learners. *The Science Teacher* 71(5): 46–47.

Wormstead S.J., M.L. Becker, and R.G. Congalton. 2002. Tools for successful student-teacher-scientist partnerships. *Journal of Science Education and Technology* 11(3): 277–287.

A history of the IPY.

Over the last 125 years, there have been four IPYs. The first was the brainchild of an Australian explorer and naval officer, Karl Weyprecht. Weyprecht was a scientist and a co-commander of the Austro-Hungarian Polar Expedition of 1872–74. He was convinced that the solutions to fundamental problems of meteorology and geophysics could be found at the North and South poles and that it would take the combined efforts of many nations to solve these problems. In all, 12 countries participated in this first IPY, spanning the years 1882–83. Fifteen expeditions were conducted: 13 to the Arctic and 2 to the Antarctic. Perhaps even more important than the advances in science and geographical information was the fact that this first IPY set a precedent for international scientists to work together to solve problems. Unfortunately, Weyprecht died in 1881 before the first IPY took place.

The second IPY (1932–33) with the theme of "Jet Stream," was proposed and promoted by the International Meteorological Organization. The Jet Stream—fast flowing air currents in the tropopause—had recently been discovered, and 40 nations joined in the effort to investigate the global implications for meteorology, magnetism, atmospheric science, and the study of ionospheric phenomena. Forty permanent research stations were established in the Arctic during this IPY, and the second Byrd Antarctic expedition, sponsored by the United States, established a winter-long meteorological station—the first research station on the Antarctic coast.

The third international polar year (1957–58) was named the "International Geophysical Year" (IGY), and celebrated the 75th anniversary of the first polar year and the 25th anniversary of the second. This IPY was established by physicists Sidney Chapman, James Van Allen, and Lloyd Berkner. The year's research centered on advances in understanding the upper atmosphere. During this year, the Van Allen Radiation Belt that encircles Earth was discovered, the first artificial satellites were launched, continental drift was confirmed, and the total size of the Antarctic ice mass was determined. Sixty-seven countries were involved in the research carried out during the IGY, with 65 stations in Antarctica maintained by 12 nations. One of the most memorable accomplishments that followed from this year was the setting aside of an entire continent for peaceful scientific exploration under the Antarctic Treaty of 1961.

The fourth International Polar Year (2007–09) was organized by the International Meteorological Organization and the International Council for Science. It is unique in a number of ways. Unlike the previous Polar Years, this "year" lasts two years instead of one. This was done so that the time period would cover a complete summer and winter season at both the Arctic and the Antarctic and give equal coverage to both regions. Over 60 countries are involved in 200 research projects in this IPY. The largest difference in this IPY is the breadth of topics under research and the active inclusion of the public, students, and their teachers in the program. This year focuses on research of the atmosphere, ice, land, oceans, space, and, for the first time, people of the polar region. It comes at a time in our history when climate change has led to an unprecedented focus on Earth's polar regions and their effects on the rest of the planet.

More information on the history of these four IPYs can be found on a number of websites (see "On the web").