Our Place in Space

Cosmic Rays

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GRADE LEVEL(S): 3-5

SUBJECT AREA(S): science, math, solar power, visible light, ultraviolet (UV), infrared (IR), energy, Watt, atmospheric conditions

ACTIVITY LENGTH: 1-2 weeks, 3 hours of class time

DESCRIPTION:

Using a map of school buildings, students will pick four areas to monitor over the year using wireless weather stations and the Solar Power Meter. In a following lesson, students will use an online sun photometer simulator to learn how changing sun angle and atmosphere conditions lead to different voltage readouts from a photometer. With these new tools, the students will then conduct seasonal evaluation of the solar radiation around the school (Oct, Jan, April). They will learn to graph and predict areas of high or low solar radiation around the campus.

LEARNING GOAL(S): Students will learn how the sun affects their school by measuring the temperature at different locations around the building in the fall, winter, and spring. They will learn how to measure solar energy and look for trends in temperature and solar power over the year. These trends will then be used to investigate how energy reaches Earth from the Sun.

NEXT GENERATION SCIENCE STANDARDS:

3-ESS2-1

- Represent data in tables and graphical displays to describe typical weather conditions expected during a particular season.

3-EES2-2

- Obtain and combine information to describe climates in different regions of the world.

4-PS3-2

- Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents

5-ESS1-2

- Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky

COMMON CORE:

SCI.03.07 – Identify daily and seasonal weather changes
SCI.03.08 – Identify and trace the movement of objects in the sky
SCI.03.09 – Identify a cycle in our solar system
SCI.04.09 – Describe examples of energy transfer
SCI.05.04 – Describe the Earth's place in the solar system and the patterns of movement of objects within the solar system
SCI.05.05 – Identify natural objects outside the Earth

STUDENT BACKGROUND: Prior knowledge of sunlight - visible light, ultraviolet, infrared

EDUCATOR BACKGROUND: Basic understanding of the different types of energy from the sun

- http://solar.physics.montana.edu/YPOP/Spotlight/Tour/tour03.html
- http://en.wikipedia.org/wiki/Electromagnetic_spectrum
- http://www.nasa.gov/mission_pages/sunearth/news/light-wavelengths.html#.VCJCo7tWrHI

MATERIALS LIST:

- Ambient Weather TM-206 Solar Power Meter
- Pyranometer kits - http://www.instesre.org/getPyranometer.htm or http://www.vernier.com/products/sensors/solar-radiation-sensors/pyr-bta/
- Data collection unit - U12-006
- HOBO Temperature attachment
- Protractors
- Compasses
- Wood blocks at different angles
- Instead of the above pyranometer and temperature collection equipment, you can use Vernier pyranometers, temperature probes, and a LabQuest.

VOCABULARY:

- Energy
- Watts
- Photo meter
- Pyranometer
- Thermometer

- Atmospheric conditions
- Sun angle
- Particle size

Activity 1: Measurements

TIME NEEDED: 1 hour

MATERIALS:

- Solar Power Meter
- Data logger or Vernier LabQuest
- HOBO Temperature attachment or Vernier temperature probes
- Protractor
- Compasses
- Wood blocks at different angles

GUIDING QUESTIONS:

- What type of data can we record about the Sun's energy?
- What can we do with this data?

ACTIVITY PLAN:

- If you previously conducted the Cosmic Ray Detector activity, review by asking the students to share what they observed in the cloud chamber. Start a 'question wall' with post-it notes for questions that the students have that may not be answered that day. Have students share out a question from someone else that also interests them.
- Explain that cosmic rays can be measured with the photometer.
- Take the class in small groups to test the photo meter and the temperature attachment

Photo meter activities

- Record the watts/m^2 in different rooms, outside, in the shade, etc.
- Review student compass skills and have them record the direction of the sun at that moment
- Using a protractor and blocks, ask the students to record which angle the photo meter needs to be held at for the maximum watts/m^2

Thermometer activities

- Ask the students to record the location and time for each 'event'
- Possible 'events' include in the sun, shade, refrigerator, freezer, hands, soil, water, etc.
- Back in the classroom, connect the data logger to the computer to graph the temperature changes and label the 'events'

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Activity 2: Class Data Collection Project - Session 1

TIME NEEDED: 1 hour for project set up, 30 minutes one week later for results

MATERIALS:

- Pyranometer kit - http://www.instesre.org/getPyranometer.htm
- Solar Power Meter
- Data logger
- HOBO Temperature attachment
- Computer
- Website - http://calipsooutreach.hamptonu.edu/sunphoto-sim/sunphotometer.html
- Website - http://earth.nullschool.net/
- Instead of the above pyranometer and temperature collection equipment, you can use Vernier pyranometers, temperature probes, and a LabQuest.

GUIDING QUESTIONS:

- What variables can we test?
- Which tested variables are dependent and which are independent?
- What do we predict that the data will look like over a week/month?
- What do we predict will differ/be the same as data collected in fall, winter, spring, summer?

ACTIVITY PLAN:

- Review how the pyranometer and thermometer work with the data logger by connecting the unit to a computer.

Go Outside

- Take the class outside to the location that the equipment will be installed for one week.
- Using the solar photo meter, protractor, and a table, ask the students to record the angle the photo meter needs to be held at for the maximum watts/m^2
- Ask the class to look around and brainstorm what in the environment may affect the photometer or temperature readings (clouds, trees, rain, wind, etc).
- Set the data logger to record once an hour for one week

Demonstrations

- Back in the classroom demonstrate the CALIPSO Sun Photometer Simulator (http://calipsooutreach.hamptonu.edu/sunphoto-sim/sunphotometer.html)
  - What conditions create the highest and lowest readings with the virtual photometer?
  - What conditions in our region could affect the photometer readings?
- Show the class the Earth NullSchool site and allow them to explore the wind speeds and TPW (Total Precipitable Water) data representations.
  - How does TPW affect our solar data readings?

Experiment at Home

- Ask the students to run an experiment with water, light, and milk at home. They should shine a flashlight through a glass of water and then observe changes in the light passing through the glass as milk is added to the water. Have them record their observations to report back to the class.
    - How does pollution affect the photometer readings?

Record Measurements and Observations

- Over the week, have the students record the daily max/min temperature, wind and rain fall from an online weather site as well as their observations about the sky conditions.
- The following week have the students report back about the water/milk experiment.
    - What did they observe when they shone the flashlight through the water?
    - Did anything change with the light beam from the flashlight as they started adding milk?
    - Review how the visible light spectrum has different size wavelengths and that the more particles there are in the atmosphere or water, the more the smaller wavelength are scattered - example - red/orange sunsets
    - Background - http://scifun.chem.wisc.edu/homeexpts/bluesky.html

Data Analysis

- Draw a graph on the board with the days on the x axis and temperature on the y axis
    - Ask a student to come up for each day that they recorded data and have them label the high and low temperature for that day.
- Instruct the students to write down on a piece of paper what day they think they 'collected' the most solar energy.
- Connect the data logger to the computer and graph the data
    - One graph with temperature
    - One graph with solar power
- Have the student work in groups to label the graphs with data they recorded over the week from the weather station (i.e. this day was cloudy, this day was rainy, etc)
- Print a copy of the graphs together so the students can view any trends between temperature and solar energy. Ask students where they see data pieces that are not what they expected and have them make predictions as to why this occurred. One useful, commonly confusing example, is a day where it was cooler than usual but had high levels of solar energy recorded.

Activities 3 & 4: Class Data Collection Project - Session 2 & 3

TIME NEEDED: 2 hours over a week (January/February and May/June)

MATERIALS:

- Pyranometer kit - http://www.instesre.org/getPyranometer.htm
- Solar Power Meter
- Data logger
- HOBO Temperature attachment
- Computer

- Again, the Vernier LabQuest equipment can be substituted for the pyranometer and temperature sensor kits

GUIDING QUESTIONS:

- What do we predict that the data will look like over a week/month?
- What do we predict will differ/be the same as data collected in fall?

ACTIVITY PLAN:

- Review how the pyranometer and thermometer work with the data logger by connecting the unit to a computer.
- Set the data logger to record once an hour for one week.
- Over the week, have the students record the daily max/min temperature, humidity, wind and rain fall from an online weather site.

Graph the Data

- After one week connect the data logger to the computer and graph the data:
  - One graph with temperature
  - One graph with solar power
- Have the student work in groups to label the graphs with data they recorded over the week from the weather station (i.e. this day was cloudy, this day was rainy, etc.)
- Print a copy of the graphs together so the students can view any trends between temperature and solar energy. Use areas where there are inverse relationships (i.e. high solar power with lower temperatures) to start a discussion of the conversion of the sun's light energy into heat and how weather conditions, seasonality, and energy absorption of different materials can affect this process. Students often struggle in the understanding that the sun delivers energy as light, which is converted into heat upon absorption.

Session 4 – Reflection

- Ask the class what they would change or add if they had a chance to repeat this experiment. Before opening the discussion, have them also write what this change/addition would tell us.

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