My NASA Data - Lesson Plans

Earth’s Energy Budget-Seasonal Cycles

Grade Band

- 9-12

Lesson Duration

- 90 minutes

Sphere(s)

- Atmosphere
- Hydrosphere
- Earth as a System

Phenomenon

- Changing Air Temperatures
- Flow of Energy and Matter

Science and Engineering Practices

- Asking Questions and Defining Problems
- Developing and Using Models
- Analyzing and Interpreting Data

NGSS Crosscutting Concepts

- Cause and Effect
- Systems and System Models
- Stability and Change

NGSS Performance Expectation

- **HS-ESS2-4**: Use a model to describe how variations in the flow of energy into and out of Earth’s systems result in changes in climate.
- **HS-ESS2-5**: Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.

Related Resources
Striking a Solar Balance
The NASA Earth's Energy Budget Poster
Data Literacy Cubes Page

Student Handout(s)
- Student Sheets

Teacher Resource(s)
- Teacher Sheets

Key Vocabulary
- solar radiation
- net radiation
- absorb
- Top of the Atmosphere
- Longwave Radiation
- Shortwave Radiation

Purpose
Students move through a series of short activities to explore and evaluate global solar radiation data from NASA satellites. In this process, students make qualitative and quantitative observations about seasonal variations in net energy input to the Earth system.

Learning Objectives
- Use evidence to create an explanation.
- Observe the seasonal changes to explain the phenomenon of Earth’s tilt and incoming solar energy.

NASA Phenomenon Connection
The Sun’s radiation and its interactions with different parts of the Earth system (atmosphere, biosphere, geosphere, hydrosphere) is the foundation of the global climate system. These interactions are key components of global climate models, which are developed by scientists and mathematicians to predict future changes to the climate. Using GLOBE and My NASA Data educators and students can access NASA satellite data to examine a variety of Earth system interactions. In this lesson, Earth’s Energy Budget-Seasonal Cycles, students move through a series of short activities to explore and evaluate Net Radiative Flux data from NASA satellites. In this process, students make qualitative and quantitative observations about seasonal variations in net energy input to the Earth system during the year of 2015.

Essential Questions
• How does energy flow in and among the spheres within the Earth System?
• What does it mean that the atmosphere is in a "dynamic balance?"
• How do changes in one part of the Earth system affect other parts of the system?

Cross-Curricular Connections

National Geography Standards:

1. How to use maps and other geographic representations, tools, and technologies to acquire, process, and report information from a spatial perspective.

7. The physical processes that shape the patterns of Earth's surface.

STEM Career Connections

• Atmospheric and Space Scientists - Investigate weather and climate-related phenomena to prepare weather reports and forecasts for the public
• Computer and Information Scientists - Conduct research in the field of computer and information science
• Remote Sensing Scientists and Technologists - Research a variety of topics using techniques that allow the study of an object or phenomena without making contact directly with the object such as analyzing geological and geographical data. They typically work with aerial or satellite pictures.

Materials Required

Per Student:

• StudentDatasheet

Per Group

• Student Pages: Monthly TOA All-Sky Net Radiative Flux for Jan & March 2015 - July 2015

Prerequisites Student Knowledge

• Locating given geographical locations using latitude and longitude and a world map
• Seasons and Earth’s tilt

Student Misconception

• “Where earth's axis of rotation points, with respect to a point in space, changes during the year.”
• “The angle between the earth's axis and the plane of the earth's orbit around the sun changes throughout the year.”
• “The orientation of earth's axis of rotation with respect to the sun does not change during the year.”
• “The intensity of sunlight at a place does not change from day to day during the year.”
• “The amount of time the sun is above the horizon at a given place does not change from day to day.”

Credit: AAAS Science Links

Procedure

Part 1:

1. Display Student Page Monthly TOA All-Sky Net Radiative Flux for January 2015. Do not share the date of the image with students.

2. Have students brainstorm, journal, and share three qualitative and three quantitative observations. Possible answers may include, but not be limited to the following: (NOTE: It is hard to differentiate in the grayscale image; you may wish to project the colored image for whole class to view if color printer is unavailable).

   Qualitative: e.g., 1.) There appears to be a balance of incoming and outgoing radiation at the Equator and at the northern edge of Antarctica. 2.) Antarctica is mostly losing energy by radiation. 3.) Greenland is losing energy by less radiation that its surrounding environments at its same latitude.

   Quantitative: e.g., 1.) Around 10°N, there is a balance whereby there is an apparent balance between absorbing and reflecting energy. 2) The Southern Hemisphere falls mostly in the
range of 30 - 162.5 W/m². 3) The Northern Hemisphere falls mostly in the range of -30 to -207.1 W/m²

3. Direct students to observe the color legend and its values. **It is important to note that the ranges vary among all plots, meaning that the minimum and maximum values may be different and represented by different colors on the color bar.**

![Color legend image]

a. What could the false colors represent? units of measurement?

b. What time of year do you think this image represents? Why?

**Part 2:**

1. Again, review the Monthly TOA All-Sky Net Flux but tell students that this is an image captured by NASA satellites showing Atmospheric Radiation in January 2015.

   a. Knowing this date, how does this support or reject your ideas from earlier? **Answers will vary.**

2. Explain that places in white represent areas where the amount of incoming and outgoing energy are in balance. (NOTE: It is hard to differentiate in the grayscale image; you may wish to project the colored image for the whole class to view if a color printer is unavailable).

   a. Places where more energy comes into the Earth System then goes out (positive net radiation) are red/dark gray. Places where more energy goes out then comes in (negative net radiation) are blue/white.

3. Distribute the Student Sheet. Allow students to work in teams or independently to answer the following questions:

   1. What systems are absorbing energy? atmosphere, land surfaces and oceans

   2. Where do you think more heat is being given off? What evidence do you have to support this?

   3. Where do you think there is more heat absorbed? What evidence do you have to support this claim?

   4. Now, distribute compare with the image from March 2015.
a. What do you notice? *The red color is beginning to spread north, meaning that more solar energy is being absorbed in the Northern Hemisphere. The white areas are becoming more varied in location meaning that there is a balance of absorption and release.*

b. Where is energy being released than absorbed? *the Southern Ocean and Antarctica.*

**Part 3:**

1. Post the following questions for students to consider as they watch an animation:
   a.) How does net radiation vary over the year at key months in the solar cycle?
   b.) What are the key months where you see the most change?

2. Show Animation of Earth Net Radiative Flux and then review students’ answers.

   ![Net Radiation Map](image.png)

   a.) The maps and animation illustrate how net radiation varies over the year at key months in the solar cycle. In June, the tilt in Earth’s rotational axis has its strongest influence on the amount of sunlight reaching the ground in each hemisphere. One hemisphere is tipped its farthest away from the Sun, and other is tipped toward it. Net radiation is strongly positive across the Northern Hemisphere in June and strongly negative across the Southern Hemisphere. In December, the pattern reverses.

3. Play the following video
Earth's Energy Budget-Seasonal Cycles of Net Radiative Flux

Using the additional images provided, compare the monthly changes.

<table>
<thead>
<tr>
<th>Month</th>
<th>Qualitative</th>
<th>Quantitative</th>
</tr>
</thead>
</table>
| January | 1. There appears to be a balance of incoming and outgoing radiation at the Equator and at the northern edge of Antarctica.  
2. Antarctica is mostly losing radiation.  
3. Greenland is losing less radiation that its surrounding environs at its same latitude. |
|         | 4. Around 50°N, there is a balance where there is an apparent balance among absorbing and reflecting energy.  
5. The Southern Hemisphere falls mostly in the range of 10 - 150 W/m².  
6. The Northern Hemisphere falls mostly in the range of 10 - 150 W/m². |  |
| February|                                                                           |                                       |
| March   |                                                                           |                                       |
| April   |                                                                           |                                       |
| May     |                                                                           |                                       |
| June    |                                                                           |                                       |
| July    |                                                                           |                                       |

Part 4:

Discuss whether the patterns students observe are consistent with your earlier observations.

1. Using the additional images provided on the Student Pages, compare the monthly changes.  
Note: The only Student Page with an unlabelled date is January 2015.

2. Discuss whether the patterns students observe are consistent with your earlier observations.