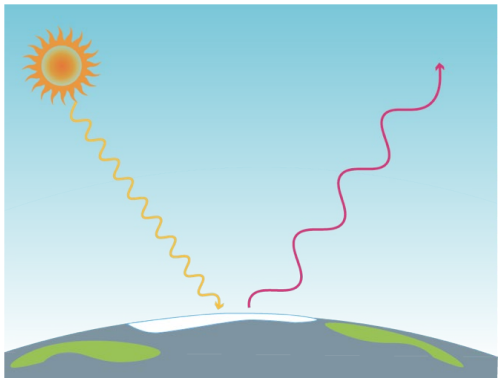
Earth's Energy Budget

Setting the Stage

Earth receives almost all of its energy from the Sun in the form of visible and ultraviolet radiation. The balance between the energy that is reaching the Earth from the Sun and the infrared energy that is flowing back into space from Earth is called Earth's energy budget. In this lesson, students explore Earth's energy budget by completing guided notes and constructing energy budget models.



Lesson Overview

- *Part 1 – (15 minutes) Earth's energy budget guided notes*
  Introduce students to Earth's energy budget with a Google Slides presentation. Students follow along with the presentation by completing guided notes.
- *Part 2 – (35 minutes) Construct a model of Earth's energy budget*
  Students construct a model of Earth's energy budget by cutting out and then arranging energy budget cutouts and text boxes on their desks.
- *Part 3 – (10 minutes) Update Summary Table*
  Students reflect on what they learned from the lesson and how it relates to the unit driving question.

Instructional Overview	
Grade Level	Middle/High School
Instructional Time	60 minutes
Standards Alignment	**NGSS Disciplinary Core Ideas:** • ESS2.D: Weather and Climate **NGSS Science and Engineering Practices:** • Developing and Using Models **NGSS Crosscutting Concepts:** • Systems and System Models • Energy and Matter
Unit Driving Question	• Why might the Arctic be warming twice as fast as the rest of the world?
Driving Question For	• How does Earth maintain the perfect balance of energy?

The materials were developed by CIRES Education and Outreach at CU Boulder with support from AGS 1554659 and OPP 1839104

This Lesson	
Learning Goals	• Identify and describe properties of longwave and shortwave energy • Create a model that represents Earth's energy budget
Materials	❑ Earth's Energy Budget PPT ❑ Earth's Energy Budget student worksheet (1 per student) ❑ Earth's Energy Budget cutouts (1 set per group of 2-3 students) ❑ Earth's Energy Budget Model worksheet (1 per student) ❑ Answer Key ❑ Scissors ❑ Tape ❑ Colored pencils (1 yellow and 1 red pencil per student) ❑ Summary Table (large butcher paper or digital copy, 1 per class) ❑ Initial ideas public record Optional: ❑ Earth's Energy Budget virtual cutouts ❑ Earth's Delicate Energy Balance video (0-2:48)
Material Preparation	❑ Cue and test web links ❑ Print student worksheets ❑ Review presenter notes in the Earth's Energy Budget PPT ❑ Display summary table and initial ideas public record.
Vocabulary	• Earth's energy budget - Balance between the energy reaching the Earth from the Sun and the energy flowing back into space from Earth • Wavelength - Distance from one wave crest (highest point) to an adjacent wave crest, or from one trough (lowest point) to an adjacent trough • Electromagnetic spectrum - term used to describe the range of different types of energy based on wavelength • Radiation - Emission of energy • Longwave energy - energy in the infrared to radio range, contains less energy than shortwave energy • Shortwave energy - energy in the visible to gamma ray range, contains a lot of energy

The materials were developed by CIRES Education and Outreach at CU Boulder
with support from AGS 1554659 and OPP 1839104

Part 1 - Earth's energy budget guided notes (10 minutes)

Refer to Part 1 slides included in the Earth's Energy Budget PPT. See PPT presenter notes for additional information.

1. Use the Energy Budget PPT to introduce students to Earth's energy budget
    a. Students follow along with the PPT by completing the guided notes on their student worksheets
    b. Take home points from PPT:
        i. Energy comes from the Sun in the form of shortwave radiation (mostly in the visible and ultraviolet spectrums)
        ii. Some of the Sun's energy is absorbed and later emitted by Earth as longwave energy (heat)
        iii. Balance of incoming energy from the Sun and outgoing energy emitted by Earth is called Earth's energy budget

Part 2 - Construct a model of Earth's energy budget (25 minutes)

Refer to Part 2 slides included in the Earth's Energy Budget PPT. See PPT presenter notes for additional information.

1. Distribute Earth's Energy Budget cutouts (1 set per group). Students should cut out parts and text boxes along dotted lines and arrange them on their desks. See Answer Key for example.

Teacher Tip:

- Scaffold instructions by demonstrating expectations -- cut out the two pieces representing Earth and tape them together. Instruct students to do the same. Students may use their guided notes to complete their models.
- While students are assembling their energy budget models, consider the following back-pocket questions:
    i. Does all shortwave energy pass through Earth's atmosphere and reach Earth?
    ii. What happens to shortwave energy once it reaches Earth? Is some of it reflected? Absorbed?
    iii. What happens to the longwave energy released by Earth? Where does it go?
    iv. Does all longwave energy pass through the atmosphere?

Optional: Construct Earth's energy budget model virtually

- Have students construct Earth's energy budget model using virtual "cutouts" -- modifying this Google Slides presentation.

The materials were developed by CIRES Education and Outreach at CU Boulder with support from AGS 1554659 and OPP 1839104

2. Distribute the "Earth's energy budget model worksheet" along with yellow and red colored pencils to students. Use student ideas to create a whole class model - complete under document camera (see Answer Key for example). Students use colored pencils to copy the whole class model on their model worksheet.

Teacher Note: Remind students that they will refer to and update the "Earth's energy budget model worksheet" with new information/concepts at the end of each class.

3. Display graphic of Earth's increasing temperatures to demonstrate that global temperatures are rising and that Earth's energy budget is imbalanced (see PPT). Refer to the PPT to pose the questions below about what is causing Earth's energy budget to be imbalanced, but do not provide students with answers (these questions will be answered in future lessons).
    a. Is there more shortwave energy (sunlight) reaching the Earth's surface?
    b. Is the Earth emitting (releasing) more longwave energy (heat)?
    c. What happens to the longwave energy (heat) after it has been released into the atmosphere?

Optional:
- Watch "Earth's Delicate Energy Balance" video from **0-2:48 minutes**. Do not watch beyond 2:48 as it gives away too much information about the unit driving question.

Part 3 - Update Summary Table (10 minutes)

Refer to Part 3 slides included in the Earth's Energy Budget PPT. See PPT presenter notes for additional information.

1. Students work in groups to reflect on their learning and how it relates back to the unit driving question, "Why might the Arctic be warming twice as fast as the rest of the world?"

2. Facilitate a discussion in which students come to a consensus about what they learned and how it helps them understand the unit driving question. Ideas/concepts agreed upon by the class should be included in the summary table (see Answer Key).
    a. Students record new summary table entries onto their own summary tables.

The materials were developed by CIRES Education and Outreach at CU Boulder with support from AGS 1554659 and OPP 1839104