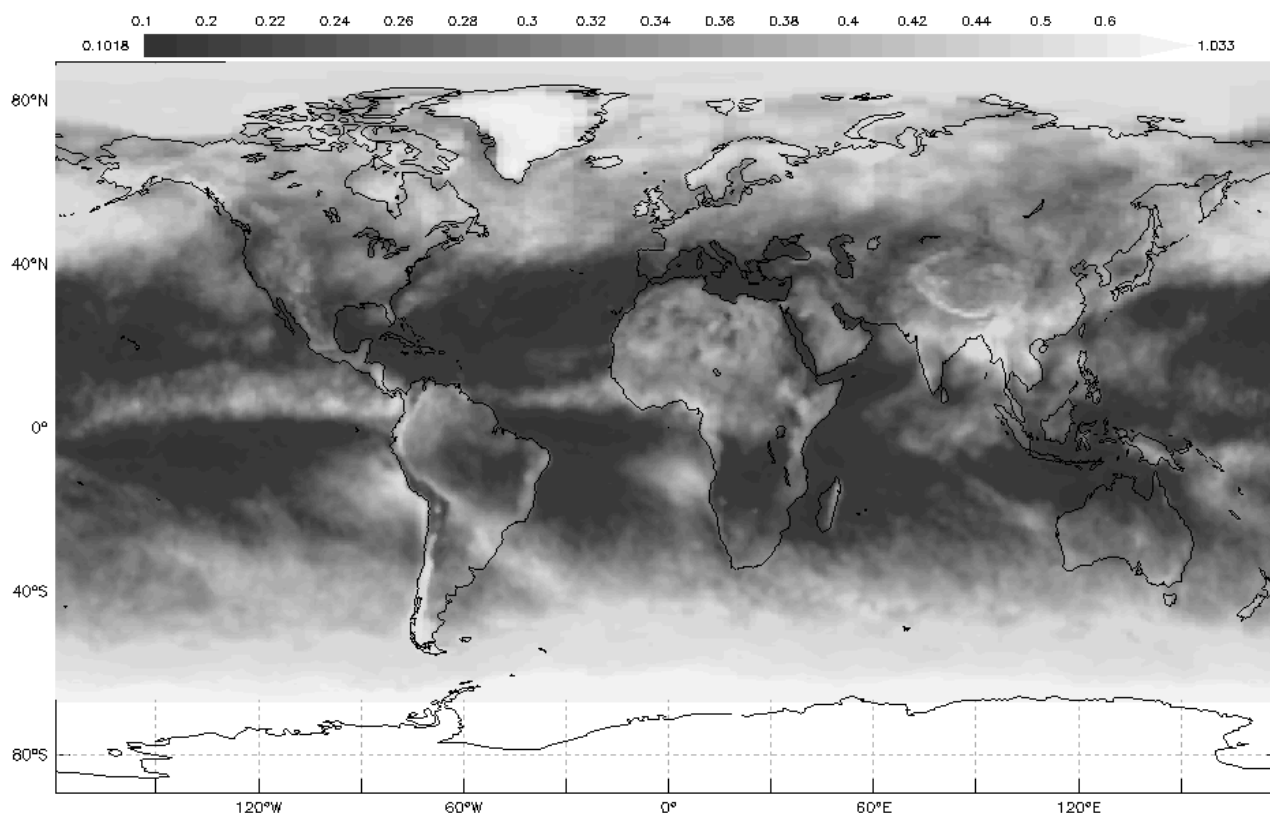


## My NASA Data - Lesson Plans

### Observing Solar Energy



### Overview

Students analyze map visualizations representing the amount of Sun’s energy received on Earth as indicated by the amount that is reflected to space, known as “albedo”. Engaging their prior knowledge of seasons and climate, students make inferences about the relative months that these data represent. This lesson includes a regional dataset of the Chicago, Illinois area. Students observe the map visualizations of the area, then compare them to a line graph of Earth’s absorption of the Sun’s radiation in 2018; this comparison helps students to understand how data may be represented in a variety of ways.

### Learning Objectives

- The students observe maps of global albedo in order to make inferences and explanations about the phenomenon.
- Students will analyze and discuss visualizations of global and regional solar radiation data collected in 2018.
- Students interpret the visualization models representing the same data sets to describe seasonal changes.

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## Why Does NASA Study This Phenomenon?

When sunlight reaches Earth's surface, some of it is absorbed and some is reflected. The relative amount (ratio) of light that a surface reflects compared to the total sunlight that falls on it is called albedo. Surfaces that reflect a lot of the light falling on them are bright, and they have a high albedo. Surfaces that do not reflect much light are dark, and they have a low albedo.

NASA scientists use data from multiple satellites to analyze albedo and its effect on weather and climate. In this My NASA Data Lesson, Observing Solar Energy, students observe different visualizations to identify patterns of average albedo values as they change from one month to another in 2018. GLOBE and My NASA Data enable educators and students to connect with NASA scientists and access the satellite data to answer their own questions related to atmospheric interactions.

For seventeen years, scientists have been examining albedo with a series of space-based sensors known as [Clouds and the Earth's Radiant Energy System](#), or CERES. The instruments use scanning radiometers to measure both the shortwave solar energy reflected by Earth (known as albedo) and the longwave thermal energy emitted by it. The first CERES went into space in 1997 on the [Tropical Rainfall Measuring Mission](#), and three more have gone up on [Terra](#), [Aqua](#), and [Suomi-NPP](#). CERES FM5 is currently flying on the Suomi NPP satellite mission, and CERES FM6 will fly on the [JPSS-1 spacecraft](#).

### Essential Questions

1. How is Earth affected by the change in the Sun's energy?
2. What factors affect the amount of the Sun's energy absorbed? Reflected?

### Cross-Curricular Connections

National Geography Standards:

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

### Materials Required

#### Per Group:

Part 1:

- Set 1: 2018 World Map of Albedo (Jan, Jul, Oct)

Part 2:

- Set 2: 2018 Map of Albedo in the Greater Chicago, Illinois Area (Jul, Oct., Dec)
- Graph 2018 Albedo Values for the Chicago, Illinois Area

Per Class:

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- OPTIONAL: Globe/s, styrofoam balls, and flashlights to help facilitate understanding of the role of Earth's tilt

## Technology Requirements

- Internet Required
- Teacher computer/projector only

## Teacher Background Information

The energy coming from the Sun to Earth's surface is called *solar energy*. Every day, the Sun radiates an enormous amount of energy. Most of it is in the form of radiation from the "visible" wavelengths, that is, those responsible for the light detected by our eyes. Visible radiation and radiation with shorter wavelengths, such as ultraviolet radiation are labeled "shortwave." The temperature of the Sun's radiating surface, or photosphere, is more than 5500°C (9900°F).

Not all of the Sun's energy comes to Earth. The Sun's energy is emitted in all directions, with only a small fraction being in the direction of Earth. The amount of solar energy a place on Earth receives depends on several conditions. Mostly, it depends on latitude (as it relates to the season of the year, the angle of the Sun, and the amount of daylight hours), but it also depends on the clearness or cloudiness of the sky.

Energy returns to space from the Earth System in two ways: reflection and emission. Part of the solar energy that comes to Earth is reflected to space in the same, short wavelengths in which it came to Earth. The fraction of solar energy that is reflected to space is called the *albedo*.

Different parts of Earth have different albedos. For example, ocean surfaces and rainforests have low albedos, which means that they reflect only a small portion of the Sun's energy. Deserts, ice, and clouds, however, have high albedos; they reflect a large portion of the Sun's energy. Over the whole surface of Earth, about 30 percent of incoming solar energy is reflected to space. The average albedo for Earth is about 0.3. The albedo values can also be more localized, which is controlled by the amount of Sun's light reflected from a particular place and time. The albedo value can depend on the local surface that may change seasonally such as gardens and forests. It also depends on events that change more quickly such as ones that affect clouds and snow patterns.

## Prerequisites Student Knowledge

- Energy from the Sun is responsible for heating land, air, and water of Earth
- Names and locations of continents
- General knowledge of the difference between absorption and reflection

## Student Misconception

- The thermal energy of an object is not related to the material the object is made of (Herrmann-Abell & DeBoer, 2009).
- Energy is not transferred from one object to another unless those objects are in direct contact with each other. ? ? ? ? ?

## Procedure

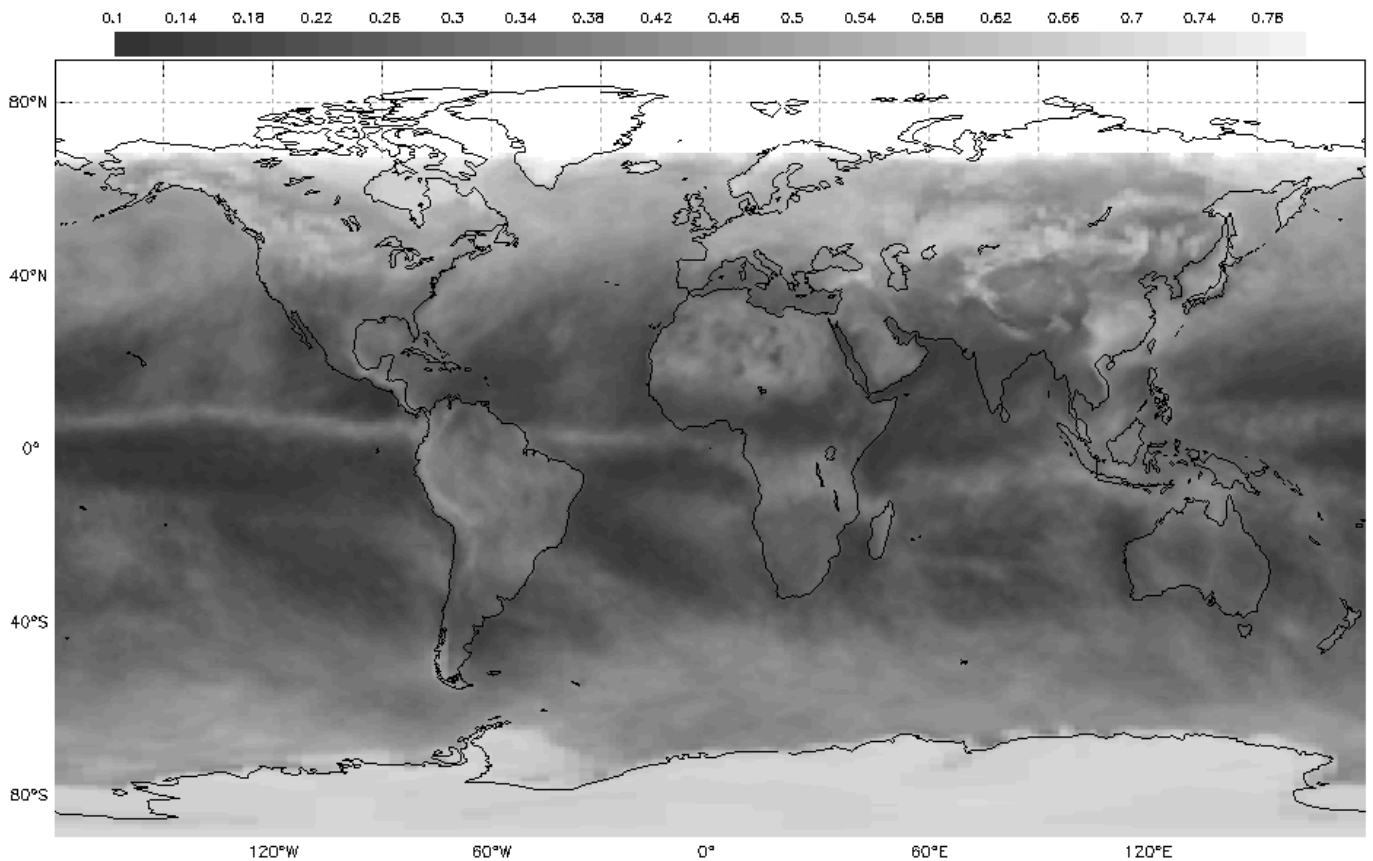
### Part 1: Global Comparisons of Albedo

A. Explain that students will be observing maps that show the Sun's energy absorbed by Earth or reflected back to space. Now show the Youtube video [link](#), show until 1:15.

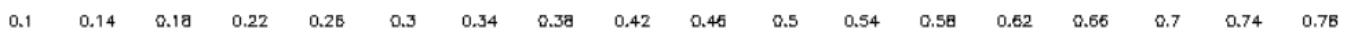
1. What is albedo?
2. What happens when Sun's light reaches the Earth?
3. What affects this absorption or reflection?
4. What are natural surfaces on Earth that have a high albedo? Low?
5. If the Earth was completely covered in ice, its albedo would be about 0.8. What would this mean; how would this affect our planet?
6. On the other hand, how would the Earth be affected if it was covered by a dark green forest canopy?
7. What types of changes in the Earth System affect global albedo?
8. How do scientists measure albedo values?
9. Predict the Earth's average albedo.

### Part 2: Global Albedo Observations and Comparisons

A. Hand out and/or display the Set 1A: World Map of Albedo (January 2018) without showing or mentioning the month that this image was collected.



3. Briefly describe what the map is showing a range of values. Take a look at the legend's scale at the top of the map; ask students to identify the lowest value of the range and its color: 0.1, black and the highest value of the range: 0.78, white. Also have students identify the units: Since the albedo is a ratio of incoming light to the light reflected at the surface, it is a quantity that has no units (dimensionless). This shows how much of the Sun's energy is reflected into space. Some of the land, water, or air in the Sun's path, is not heated by this energy.



4. Draw two boxes on the board - one shaded in black, the other in white. Ask students what effect does the color have on the temperature.



Absorbs light = Warmer, absorbs Sun's energy



Reflects light = Cooler, reflects Sun's energy

5. Look more closely at the Set 1A (without revealing the month) World Map of Albedo. Select different values of the high, medium, and low values of albedo. Ask students which continents have the highest values of albedo.

6. Now, compare the Set 1A image to the Set 1B: World Map of Albedo World Map of Albedo without showing or mentioning the month that this image was collected. Select different values of the high, medium, and low values of albedo. Ask students which continents have the highest values of albedo. Ask students to predict the season that they believe this image captures. Have students explain the

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evidence that they have to support the claim.

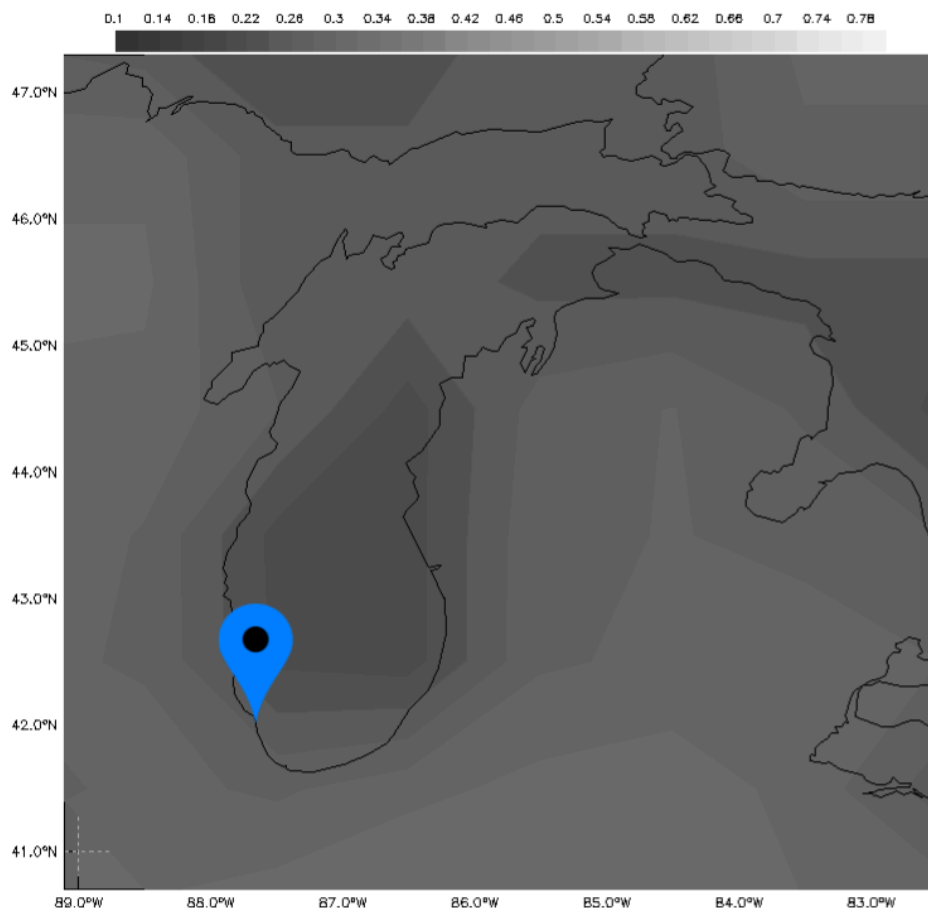
7. Repeat Step 6 with Set 1C: World Map of Albedo World Map of Albedo without showing or mentioning the month that this image was collected.

### Part 3: Chicago, Illinois Comparisons of Albedo

To bring in a more regional context to this lesson, students compare the images of the Greater Chicago Region (Set 2) and related graph. Let's take a deeper look at albedo by comparing satellite images albedo values representing the Chicago, Illinois region.

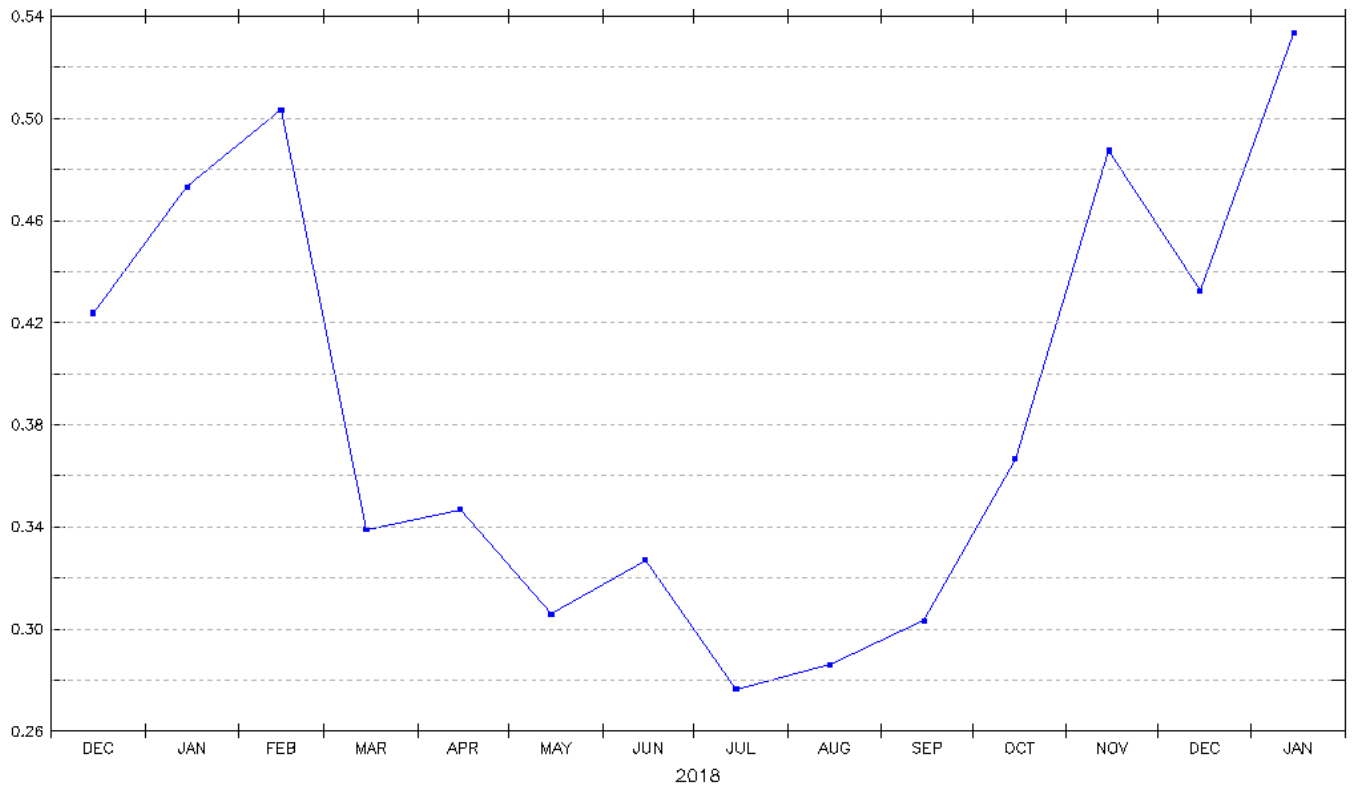
1. Brainstorm with the class what they know about the urban environment of Chicago. What kinds of materials do you find in cities as opposed to the rural areas, and parks?
2. Ask students to predict the albedo values of the most common materials, such as asphalt, steel, and brick. These are often very dark colors with lower albedo values—like black, brown and grey. How would these dark materials affect Chicago?
3. Distribute Set 2A: Map of Albedo in the Greater Chicago, Illinois Area without showing or mentioning the month that this image was collected. Identify Chicago's location by the question mark icon. Students analyze the data visualization and describe the different values of high, medium, and low values of albedo and areas. What are the possible effects of these values?

#### SET 2A: 2018 Map of Albedo in the Greater Chicago, Illinois Area Monthly Albedo Measured from Space (dimensionless)



4. Next, students compare these areas with the other images (Set 2B & C) from the set. Analyze for high, mid-range, and low values.

5. Disseminate Graph 2018 Albedo Values for Chicago, Illinois Area to students. Review key features of the graph with the students (i.e., title, X and Y axes labels, the scale of the axes, units, etc.)



6. Explore the data on the graph with students. Ask for students to identify the month with the highest absorption of Sun's radiation and lowest albedo. Lowest absorptions of Sun's radiation and the highest albedo.

7. Finally, have students put Set 2 in chronological order based on what they have learned about albedo.

### Exit Ticket

Have students complete an exit ticket answering the following question. What evidence is there that albedo changes throughout the year?