GLOBE Trees

Seeing Trees in 2D and 3D

A Demonstration of Forest Extent and Tree Height

Purpose

Explain the different ways that scientists study forests from space, and why it is important to have multiple types of data.

Time

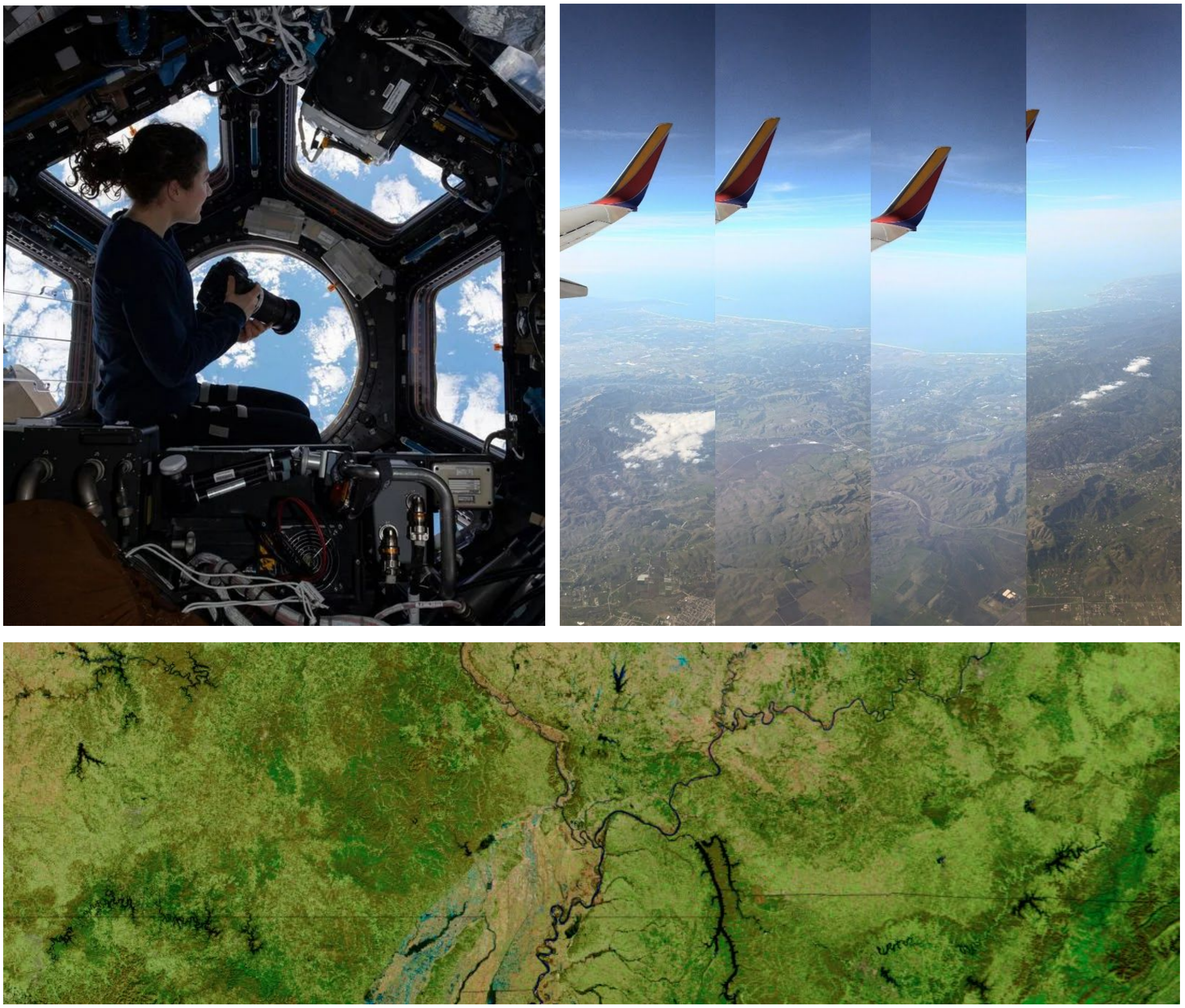
5 minutes

Materials

- LEGO, Duplo, Base Ten or other blocks of equal size (square prefered) in a variety of colors
- Adhesive (optional)
- Laser Pointer (optional)
- Printed images of satellite data
    - Antarctic Terrain
    - Sea Ice
    - Forested Coast
    - Crater Lake
- Videos showing how ICESat-2 and Landsat 8 collect data (open and right-click to download)
    - ICESat-2
    - Landsat 8

Background

When we think of satellite data, we often think of the "bird's-eye view" images that look similar to what astronauts aboard the ISS see when they look down at the Earth's surface or what someone would see looking from the window of a plane. However, not all satellite sensors work this way.



Top Left: Astronaut Christina Koch looking back at Earth from the ISS; Top Right: A view of Monterey Bay from a commercial aircraft; Bottom: A MODIS image of the Mississippi River from NASA's Terra satellite.

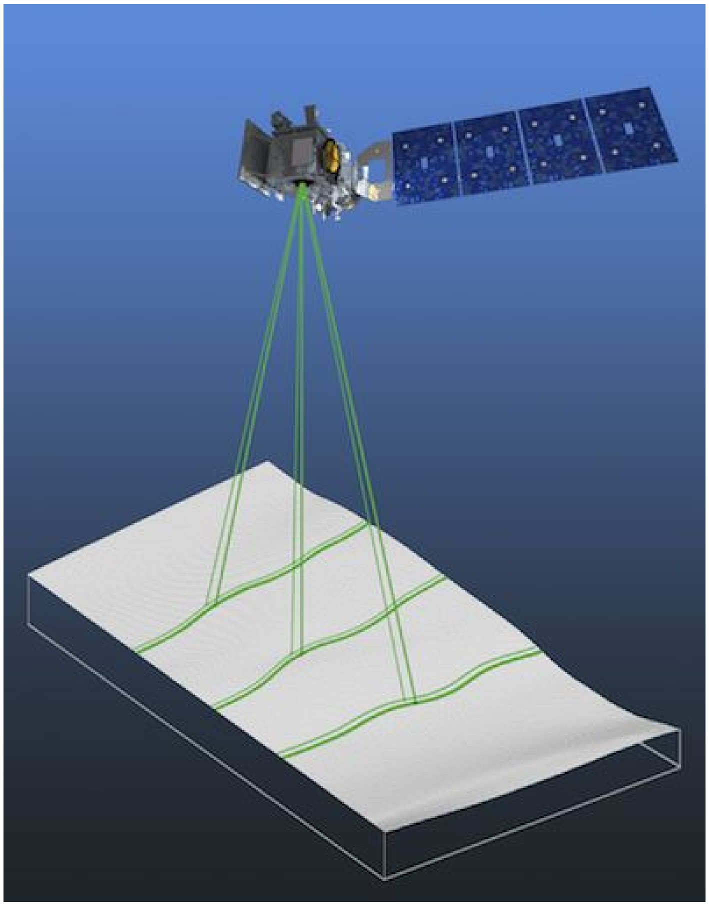
Satellite Basics

Read [NASA Knows! What is a satellite?]

Thousands of satellites orbit Earth, performing functions like sending data over long distances for near-instantaneous communication, allowing people to pinpoint their location using GPS, and collecting scientific data that can be used to forecast the weather and study the planet, sun, and other parts of the universe.

This scientific data is collected by sensors, or instruments, aboard the spacecraft. The instruments aboard Earth-observing satellites can generally be classified into two groups: passive or active.

Passive sensors detect phenomena such as light, heat, and vibrations. Our eyes and the cameras on our phones are passive sensors. A camera sensor measures the light that is reflected or given off of a surface and records it as a pixel, or picture element. From space, these instruments capture a 2D image of the sunlight reflected off Earth's surface and atmosphere, as well as light given off by things like artificial lighting and wildfires. The MODIS (Moderate Resolution Imaging Spectroradiometer) instruments aboard Aqua and Terra and the OLI (Operational Land Imager) instrument aboard Landsat 8 are passive sensors.



Active sensors produce a signal and measure the return signal. This is similar to how animals, like bats and dolphins, use echolocation. They produce a sound and listen for the sound to bounce off objects in their environment. Sonar (sound), radar (radio waves), and LiDAR (light) are all different forms of active remote sensing. The ATLAS (Advanced Topographic Laser Altimeter System) instrument is an active sensor aboard the Ice, Cloud, and land Elevation Satellite-2 or ICESat-2. The satellite fires 10,000 times each second, sending hundreds of trillions of photons to the ground in six beams of green light. The roundtrip of individual laser photons from ICESat-2 to Earth's surface and back is timed to the billionth of a second to precisely measure elevation of Earth features like, but not limited to ice sheets, sea ice, bodies of water, mountains, and trees.
More on active vs. passive sensors.

Together, different types of measurements provide a more robust dataset for scientists to work from. You can help provide yet another type of data by measuring trees with the GLOBE Observer app. Using the Trees tool, you can contribute height estimates, photos, and notes about individual trees.
Find more resources related to using the Trees tool.

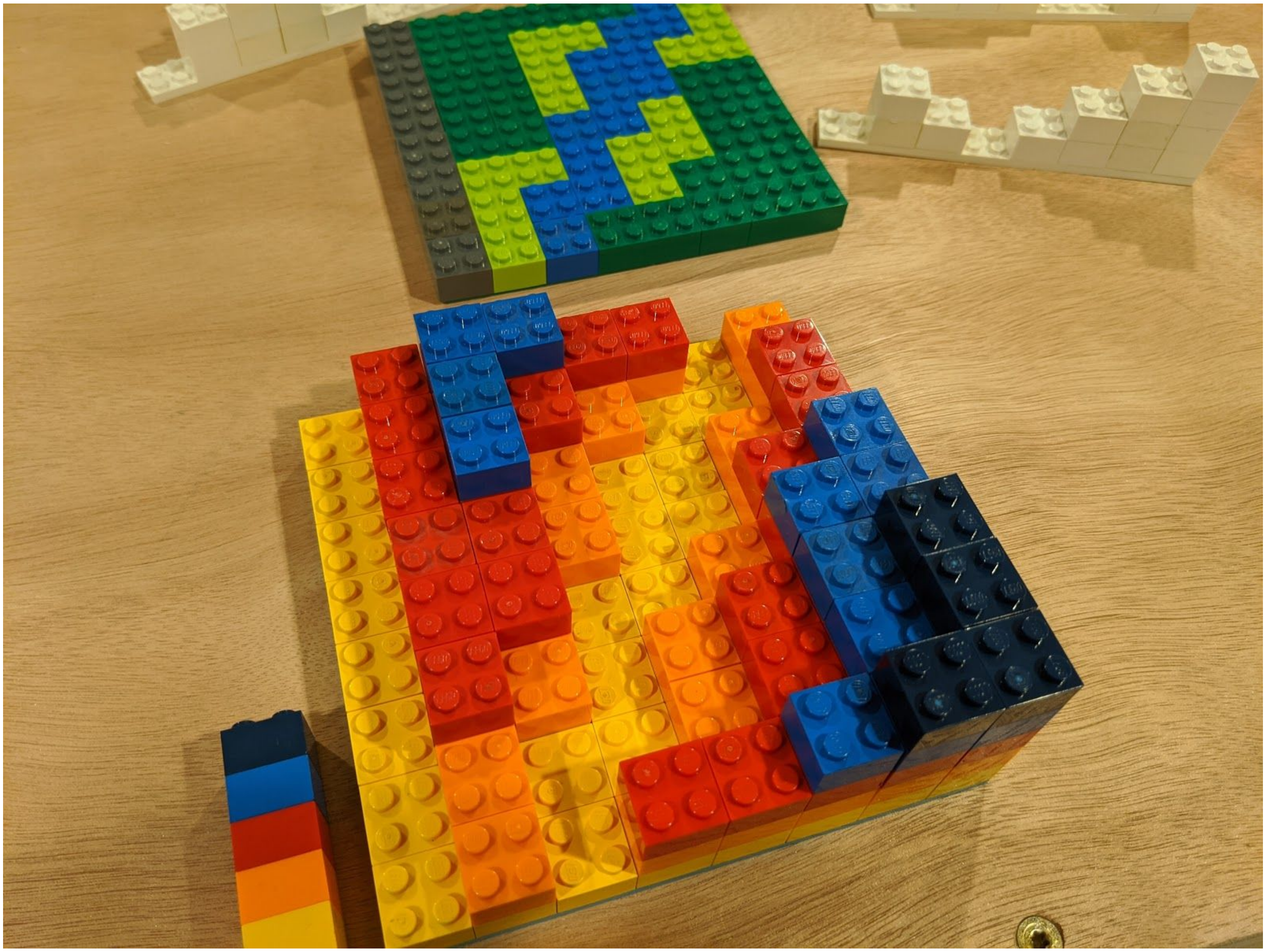
Preparation

Scene

You will be constructing two models to compare ICESat-2 and Landsat 8 data. They will both represent the same area, but in different ways. You may choose to base your models off of a real place or make up a scene. Whichever option you choose, you will want to make sure that the scene includes different elevations. For our example below, we made up a scene that includes a river winding through a forest with a road on one edge. The road and river are the same elevation, while the forest grows taller the farther it is from the river.

Size
The models can be any size you would like as long as they are equal size. Choose an appropriate size given the amount of blocks that you have, the space you have for the demonstration, how big the audience will be, and how portable it needs to be.

Glue
Because this is more of a demonstration, we recommend glueing the blocks together. You can find both temporary and permanent adhesives for this purpose.

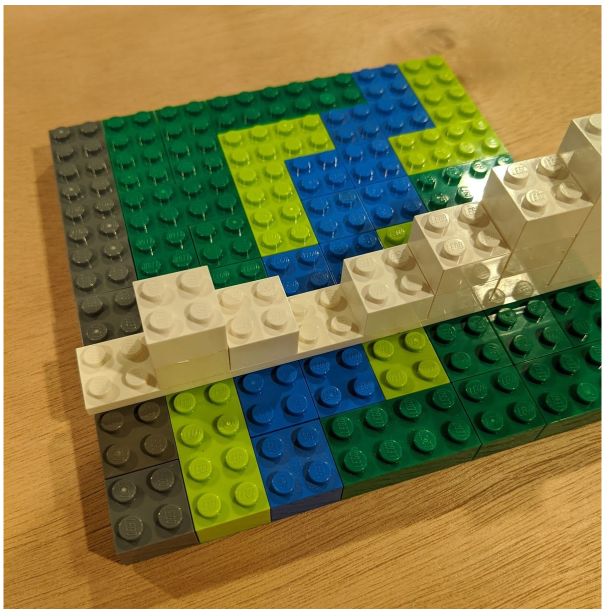


One model shows a 2D representation of a forest, while the other shows a 3D representation of the same forest. A small stack of blocks shows the color scale for the 3D model.

Model 1: Landsat 8
Landsat 8 collects color data using a sensor that works like a camera. Each block represents a pixel of Landsat data. The colors represent the different types of land cover (for a block activity related to land cover, see Lego Land Cover). We represented trees with green, water with blue, and pavement with gray.

Model 2: ICESat-2

ICESat-2 collects elevation data by measuring the amount of time it takes for laser light to bounce off the surface of the Earth and return to the satellite. In this model, the blocks no longer represent pixels, they represent the elevation calculated based on when individual photons return to the sensor. The laser has a longer "round trip" when bouncing off of lower elevations and a shorter one while bouncing off of higher elevations. We chose to represent ICESat-2 data using a color scale that changes with elevation. We avoided more natural colors in order to prevent confusion, since ICESat-2 does not collect color data. You may also choose to use only one color or entirely random colors. We also made sure that, even though there were two different colors of trees, elevation did not directly correspond with the color. Even though the lighter green trees near the river were generally shorter, that wasn't always the case, thus reinforcing the need for both types of data.



Optional Model 3: ICEsat-2 Swath

Because ICESat-2 is using laser beams, the satellite collects data in narrow lines, called swaths. Each of ICESat-2's six beams has a 56 ft. swath. Landsat 8, on the other hand, has a 115 mile swath, and each OLI pixel is 49 ft. wide. Depending on the swath size, satellites need to orbit Earth for different amounts of time in order to capture a complete image of the globe. Landsat-8 observes the same place every 16 days, while ICESat-2 observes the same place every 91 days. We created rows of blocks that are just one block wide in order to represent one ICESat-2 swath. This can be placed directly over Model 1 to transition to talking about Model 2.

Steps

Below is a suggested order in which to present the models and information, along with an example script for talking to a family. Feel free to present the models in whatever way feels most comfortable.

1. Invite your audience to come examine the models. Explain that they both represent satellite data. Bring their attention to Model 1.
    a. *Take a look at this model here. This model represents Landsat 8 data. Landsat captures images of the Earth much like how the camera on your phone captures pictures. Each block represents a pixel. Pixels are the tiny blocks of color that make up a picture. What do you think the different colors represent?*
2. Shift attention to Model 2 and discuss the similarities and differences.
    a. *Now let's look at this model. Do you think it represents the same place? It sure does, but what's different about it?*
    b. *That's right, this model is 3D. It shows how tall the features that we noticed in the other model are. This model represents ICESat-2 data. ICESat-2 measures how tall things are*

using a laser. The satellite shines a laser at the surface of the Earth and measures how long it takes for the laser photons to bounce off Earth and come back to the satellite.

   c. *Can you point to a place where it would probably take a longer amount of time for the laser light to get back to the satellite? That's right, the river and road are further from the satellite, so it would take longer.*

3. Now discuss why scientists need both types of data to study forests.
   a. *Do you think one of these models is better than the other? Scientists actually need both types of data to study the health of forests. They want to know how much of Earth is covered by forests AND how tall those forests are.*
   b. *What are some of the reasons why a scientist might want to know about how healthy a forest is? That's right, they produce oxygen and shade, animals live in them, and they also play an important role in the carbon cycle.*
      - *Certain animals might prefer to live in taller trees, so it's good to know how tall a forest is.*
      - *Taller trees often provide more shade. That's why areas of our city with more mature trees feel cooler.*
      - *Trees are always absorbing and releasing carbon throughout their lives. Healthy trees absorb more carbon than they release and use it to grow, while unhealthy trees release more carbon than they absorb as they decompose. We can use the area that a forest covers and its height to estimate how much mass is in the forest, this can help us understand how much carbon is being stored in trees.*
4. Wrap-up and invite the audience to contribute their own tree height data.
   a. *So we just talked about why scientists want to study the health of forests, and why it is important for them to have different kinds of data. It turns out, you can provide them another type of data by submitting observations of trees using your phone. The Trees tool within the GLOBE Observer app allows you to contribute height estimates, photos, and notes about individual trees to a global database.*
   b. *Be sure to join our team, so that we can work together to study trees in our community.*

Glossary

Opposites

Extent/Area Data - the amount of land that a forest covers

Elevation/Height Data - how tall a forest is (when combined with area, mass can be calculated)

Passive Sensor - a sensor that detects phenomena like sound, heat, light, etc.

Active Sensor - a sensor that produces a signal and measures the return signal

Additional Vocabulary

Satellite - a natural or artificial body that orbits another. When we talk about satellites, we are usually talking about human-made machines that orbit Earth. The moon is an example of a natural satellite.

Instrument - the sensors aboard a satellite that collect data

Pixel - the smallest element of a picture

Photon - an individual light particle

Swath - the amount of ground a satellite sensor covers

Orbit - the path that a satellite follows (polar orbit, geostationary orbit, low Earth orbit, etc.)

Carbon Cycle - Carbon is the backbone of life on Earth. We are made of carbon, we eat carbon, and our civilizations—our economies, our homes, our means of transport—are built on carbon. We need carbon, but that need is also entwined with one of the most serious problems facing us today: global climate change. Keep reading on Earth Observatory.