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Guide Lites

Mapping Earth's Surface with ICESat-2

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Mapping Earth's Surface with ICESat-2

Ice comes in many forms here on Earth, like mountain glaciers and frozen lakes, but most of it is found near the North Pole and South Pole. With temperatures on our planet warming up, many of these icy areas are melting.

ICESat-2 is a satellite mission that will measure the height of Earth's ice-covered regions to track melting and other changes. From space, the satellite will also take the height of other features of our planet, including trees and shrubs, lakes and buildings.

The sole instrument on ICESat-2 will be the Advanced Topographic Laser Altimeter System (ATLAS). The ATLAS laser will emit visible, green laser pulses at a wavelength of 532 nm. This new technology allows the satellite to take measurements every 70 cm along its track.

The ATLAS laser will improve the elevation estimates in sloped areas, as well as rough land surfaces such as crevasses. The ICESat-2 instrument will also improve the ability to estimate the height difference between the polar oceans and sea ice. See Figure 1.

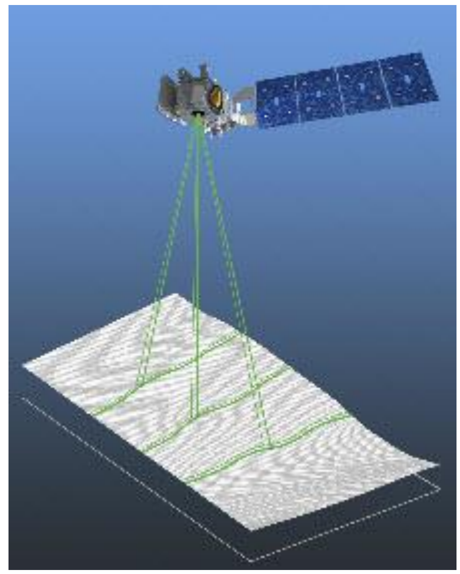

Figure 1
Image credit: NASA ICESat-2

Objective: To understand how a satellite in space can accurately measure Earth's surface.

Materials:

- Small boxes (one per group) – may be shoeboxes or small plastic boxes less than 16 cm deep
- Modeling clay
- Small rocks, foam, or blocks
- New sharpened pencils
- Permanent markers (fine to medium point)
- Heavy duty aluminum foil
- Centimeter rulers
- Masking tape

Optional:

- Sonar distance meters
- Handheld depth finders
- Computer probes to measure distance
- Retractable depth finders
- Colored plastic tablecloth
- Assorted books and small boxes

Engage:
To learn about NASA's ICESat-2 mission and how it will help scientists more accurately measure the height of Earth's ice covered regions, watch the NASA eClips video, *Launchpad: ICESat-2 - Next Generation Technology*, which can be viewed or downloaded from: http://www.nasa.gov/audience/foreducators/nasaeclips/search.html?terms=%22Next%20generation%20technology%22&category=0000&disp=grid.

This segment may also be viewed in high definition at the following direct YouTube link: https://www.youtube.com/watch?v=g3qmgopJt_8&list=PLD7BEC5371B22BDD9&index=3.

Explore:
Collect measurements of simulated landforms to understand how NASA uses satellites like ICESat-2 to measure elevation.

1. In groups of 2 to 3, use clay, blocks, foam, small rocks, and other available materials to create a model of a section of Earth's surface in the bottom of a small box, such as a shoebox. Include several different landforms, such as mountains, rivers, rolling hills, etc. For example you could use the clay to create a rolling landscape and add a rock to represent a mountain. **Teacher Note:** If a plastic box is used, cover the outside of the box with foil before creating the landscape.
2. Cut a piece of heavy duty foil large enough to fit over the top of the box.
3. On the foil, use a permanent marker to draw a grid that will fit over the box. Make each of the grid squares 2 cm by 2 cm. Label the columns with letters and the rows with numbers to create coordinates for each square on the grid. Create a paper grid or use graph paper to match the foil grid. Students will use the paper grid to record measurements. See Figure 2.

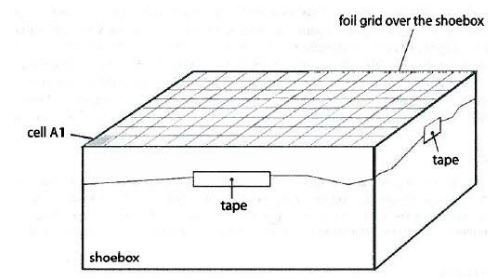

Figure 2
Image credit: NASA

4. Secure and tape the foil grid over the top of the shoebox, completely covering the box and hiding the surface below. Tape the edges of the foil tightly over the shoe box to prevent sagging and align the grid so the corner of square A1 is over the corner of the box as seen in Figure 2.
5. Trade boxes with a different group. Do not attempt to look inside the boxes.
6. Each group's mission is to make a map of the environment without looking inside the boxes.
7. Using a centimeter ruler and a permanent marker, mark off centimeter and half centimeter units on a newly sharpened pencil. Label the whole centimeter marks with the appropriate numbers for easy data collection. Begin measuring from the top of the pencil so your first labeled mark near the eraser is 1 cm and so on. **Teacher Note:** By calibrating the measuring tool (pencil with the centimeter markings) from the eraser to the point, the smaller numbers will actually represent valleys and the higher numbers will represent mountains. Students may need additional explanations to understand how the data points correlate to elevation on a map.
8. Choose a square on the foil and carefully poke the pencil through the foil grid. Slowly push the pencil straight down until the pencil gently touches the surface. Read the number closest to the foil top and record the measurement in the appropriate square on the paper copy of your coordinate grid. *(Example: A3 – 5 cm; B6 – 11 cm).* These numbers represent elevation, or ground height of the section.
9. Continue taking measurements in 50 different squares on the grid. Choose your squares wisely because you have only 50 choices to help you determine what the entire surface looks like. Do not look through the holes.
10. After recording the elevations of 50 squares, each member of the group should choose one row. Use the data points in the row to create a line graph. Use the location for the x-coordinate and the

elevation for the y-coordinate. Each line graph represents a profile map of that section. When compared, the individual profiles make up a surface map. Based on the profiles you have created, use different color pencils or crayons to predict what the entire landscape will look like.

Explain

Create a 3-D surface map, or topographical map, from the elevation measurements collected.

1. Using Microsoft Excel, or a similar spreadsheet program, input data into the appropriate coordinates in a spreadsheet. Excel has an option in the charts function that creates a 3-D surface map. Highlight the Excel cells and insert a surface chart. The resulting graph will be a surface map that represents the data points collected. See Figure 3. **Teacher Note:** Ask the students to compare the charts to the landscape maps. How accurate are the maps? How much more information can be learned from a 3-D map instead of a 2-D profile?

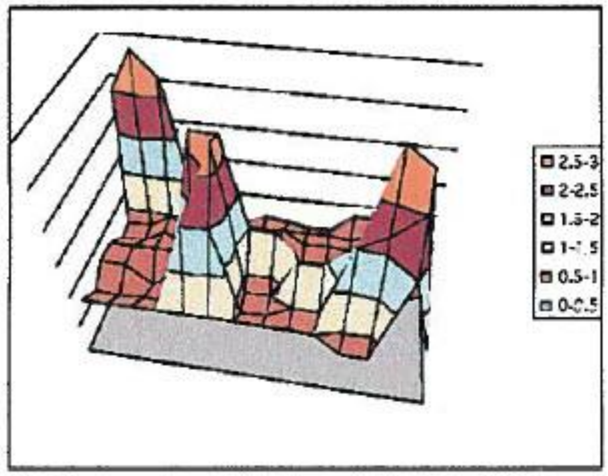

Figure 3
Image credit: NASA

2. Now carefully remove the foil lid from the box to be used later in the activity. Compare maps to the actual landscape. **Teacher Note:** Students may wish to take digital images of the landforms for comparison.

3. Discuss ways to make the maps more accurate. (*Answers may include: have a more accurate measuring device; take more measurements of the surface.)* **Teacher Note:** Students may record responses in STEM notebooks.

4. Replace the lid on the box. Take additional measurements in grid squares that were previously unmeasured. Determine how the accuracy of the map changes when more data points are identified.

Extend

Design a system that will collect the most accurate elevation measurements for a large area.

1. Using books, small boxes, etc., create “landforms” on the classroom floor. Cover with a colored plastic tablecloth. This area will be the simulated surface for the activity.

2. Learn about the steps of the design process used by engineers. **Teacher Note:** A graphic of the design process and an open-ended design packet may be found on the NASA eClips™ web site: www.nasa.gov/nasaeclips. The direct link to the Elementary Design Packet is: http://www.nasa.gov/pdf/324205main_Design_Packet_I.pdf . The direct link to the Secondary Design Packet is: http://www.nasa.gov/pdf/324206main_Design_Packet_II.pdf .

3. Using the design process, engineer or design a system to measure the height of the simulated surface based on the following criteria:

    a. The system must accurately measure the elevation of the surface.

b. Accuracy in the design must include a method to keep the tool a specific distance from the surface; a method of determining where the measurements are taken, similar to the coordinate grid system used in the shoebox activity; and a means of analyzing and interpreting the data so the most accurate map of the surface is made.

c. Tools including the following may be used in the design: computer probes; an ultrasonic distance measuring tool (like the kind found at a home improvement store); a handheld portable depth finder (similar to those found at a sporting goods store); or a retractable depth measurement tape.

d. If a measuring tool is calibrated so the lowest numbers are at the bottom, as found on a ruler or meter stick, the data will create a "negative" map. High numbers would indicate lowest surfaces while low numbers indicate highest surfaces. **Teacher Note:** Caution students to use care when analyzing data so their final map reflects the actual topography. If using pre-marked tools, students may need to subtract each measurement from the depth of the box and record the answers as the data points.

e. A topographical map of the surface must be created using the data collected.

4. **Teacher Note:** Ask students to determine if the designed tool or protocol can be used to go back and measure the original surface in the box both with and without the lid. Would modifications be needed? Ask students to redesign the tool as needed and share ideas.

5. As a group, compare the process you have just completed to what you learned about ICESat-2. You may want to visit the ICESat-2 web site at http://science.nasa.gov/missions/icesat-ii/ or watch other NASA eClips™ videos about ICESat-2. The videos can be found at:

   Our World: ICESat-2 – What Is Ice?
   http://www.nasa.gov/audience/foreducators/nasaeclips/search.html?terms=%22What%20Is%20Ice%22&category=1000&disp=grid

   Real World: ICESat-2 and Earth's Cryosphere
   http://www.nasa.gov/audience/foreducators/nasaeclips/search.html?terms=%22ICESat-2%20and%20Earth's%20Cryosphere%22&category=0100&disp=grid

   With your group, answer the following questions to guide your thinking:

   a. Why is collecting data about Earth's landforms important? *(Answers may include: understanding Earth's cryosphere offers insight into the past, present and future behavior of Earth as a whole; to determine the rate of change in Earth's ice features and how these changes impact Earth; Earth's polar regions are the most sensitive to climate change, etc.)*

   b. How will ICESat-2 enable scientists to collect more accurate data? *(Answers may include: ICESat helped scientists build maps of the shape of the ice sheets, the thickness of sea ice and the height of forests across the globe. The ICESat-2 lasers use a smaller beam that takes measurements every 70 cm, making data more accurate and precise. The laser splits into 6 beams allowing measurement of a wider area at one time than with a single beam, etc.)*