Ups and Downs of Mars Surface

Suggested Grade Level: 3–9

Summary

- Students will learn how orbiting spacecraft measure the topography (surface elevations) of a planet.
- Students will construct a 2-D topographic profile on a graph.

Standards

- NM State Science Content Standards: Strand I, Scientific Thinking and Practice
- NM State Math Standards: Models and Numbers, measurements to Describe Physical World
- National Science Education Standards: Standard A, Scientific Inquiry; Standard E, Science and Technology; Standard G, History and Nature of Science

Background Information

Orbiter spacecraft missions are usually designed to acquire global information about a planet. A very useful data set to acquire is topographic or elevation information about the surface of the planet. In the case of Mars (just as in New Mexico) the topography is a clue to the geological process that formed the landscape and it is important to know where the valleys and mountains are and what they look like. It is also important to know the topography of a planet in order to choose flat, safe landing sites for future lander/rover missions. Most topographic information for other planets is acquired by using lasers from orbiting spacecraft. In some cases other instruments are used; radar is used to measure the topography of Venus and sonar is used to measure the topography of the Earth's ocean floors.

Topographic measurements usually produce elevation information along a straight line, which is plotted as a graph of location versus elevation called a topographic profile. Remember that a topographic profile just shows the topography along a single line. Profiles along other lines might give a very different view of the general topography of the surface. If many topographic profile lines are measured, the topography of an area can be illustrated as a topographic contour map. For Mars, the recent Mars Global Surveyor orbiter spacecraft has measured many topographic profiles using a laser altimeter. The MOLA (Mars Orbiter Laser Altimeter) profiles have widely spaced points of measurement (100 meters between points), but the vertical resolution of the measured elevation is in centimeters. That means that the elevation of the points is very well-known and high resolution, but the elevation between the points is unknown and difficult to extrapolate. This activity will allow your students to produce a sample topographic profile that is similar to those measured for Mars, but the points of measurement and vertical resolution of elevation will be in centimeters (or inches).

Materials

1. Graphing sheet included in this activity or your own graph paper
2. Sample topographic profile from Mars Orbiter Laser Altimeter (MOLA) included in this activity
3. Measuring tape included in this activity or your own measuring tapes
4. Washer, nut, or other weight taped to the end of one measuring tape
5. A plastic milk-type crate or cardboard box
6. Any number of blocks, small boxes, or books of different sizes and thicknesses

Preparation

1. Print the sample measuring tape included in this activity. Paste several photocopies together end-to-end at the 20 cm mark until the measuring tape is long enough to extend across the top of the crate or box.
2. Repeat #1 and produce another measuring tape that is long enough to extend downward from the top to the bottom of the crate or box.
3. If you do not want to use the tape included in this activity, other measuring tapes can be used; for example you can use string marked with a black line every 2 cm or 1 inch. Tape a heavy small washer or nut to the end of the measuring tape that will be used to measure from the top to the bottom of the crate or box.
4. Print the MOLA topographic profile included in this activity. Print the graphing sheet included in this activity and make one copy for each student team.
5. Collect large rectangular or square boxes or plastic milk crates for the number of student teams and collect a number of blocks, boxes or books of different sizes and thicknesses for each team to use in building the topography within their crate or box.
6. Younger students may need help to build their topography or the teacher may build the topography within several crates or boxes before the lesson.

Introduction for Students

You are going to examine high and low elevations (also called topography) in a way that is similar to a spacecraft orbiting another planet. Think about the location of the highest highs and lowest lows that you know. Mountains are highs and valleys or canyons are lows. In New Mexico, the highest high is Wheeler Peak in the northern part of the state and the lowest low is the Red Bluff Reservoir in the southern part of the state. If you walked in a straight line and measured the elevation at certain points between Wheeler Peak and Red Bluff Reservoir, you would produce what is called a topographic profile of the land along that line. How would you measure the elevation? How many times along that line would you stop to measure the elevation? You are going to produce a topographic profile of the highs and lows of a sample planetary landscape. How can the elevation of the surface of planets be measured? What do you think it will look like?

Procedure

1. Students build a simulated mountain, mesa, and valley topography with blocks, small boxes, or books inside a crate or cardboard box.

2. Tape the long measuring tape across the top of the crate or box.

3. The topographic measuring tool is a second measuring tape with a weight on the end.

4. Students drop the weight to touch the surface, at intervals of every 2 cm (or every 1 inch), moving across the top measuring tape from one side of the box to the other.

5. Students record the distance from the spacecraft (the measuring tape across the top of the box) to the landscape at each measurement point on a piece of paper and locate the point on the graphing sheet.

6. Students connect the points and compare their depiction of the topography with the real topography that they have just measured.

Process/Closure

Discuss the differences between the real topography and their graphed depiction. What would happen if you increased the number of data points recorded? What would happen if you decreased the number of data points? Spacecraft do not drop down measuring tapes. They use instruments that bounce a signal off the surface of the planet; this signal can be produced by radar, sonar, or laser instruments. Mars Global Surveyor has produced a very detailed global topography data set with its MOLA instrument (Mars Orbiting Laser Altimeter). Where would you choose to land a lander/rover mission in the topographic area you just measured? This is a two-dimensional profile (or slice) through a three-dimensional object. How would you re-create the three-dimensional shape?

Extension/Enrichment

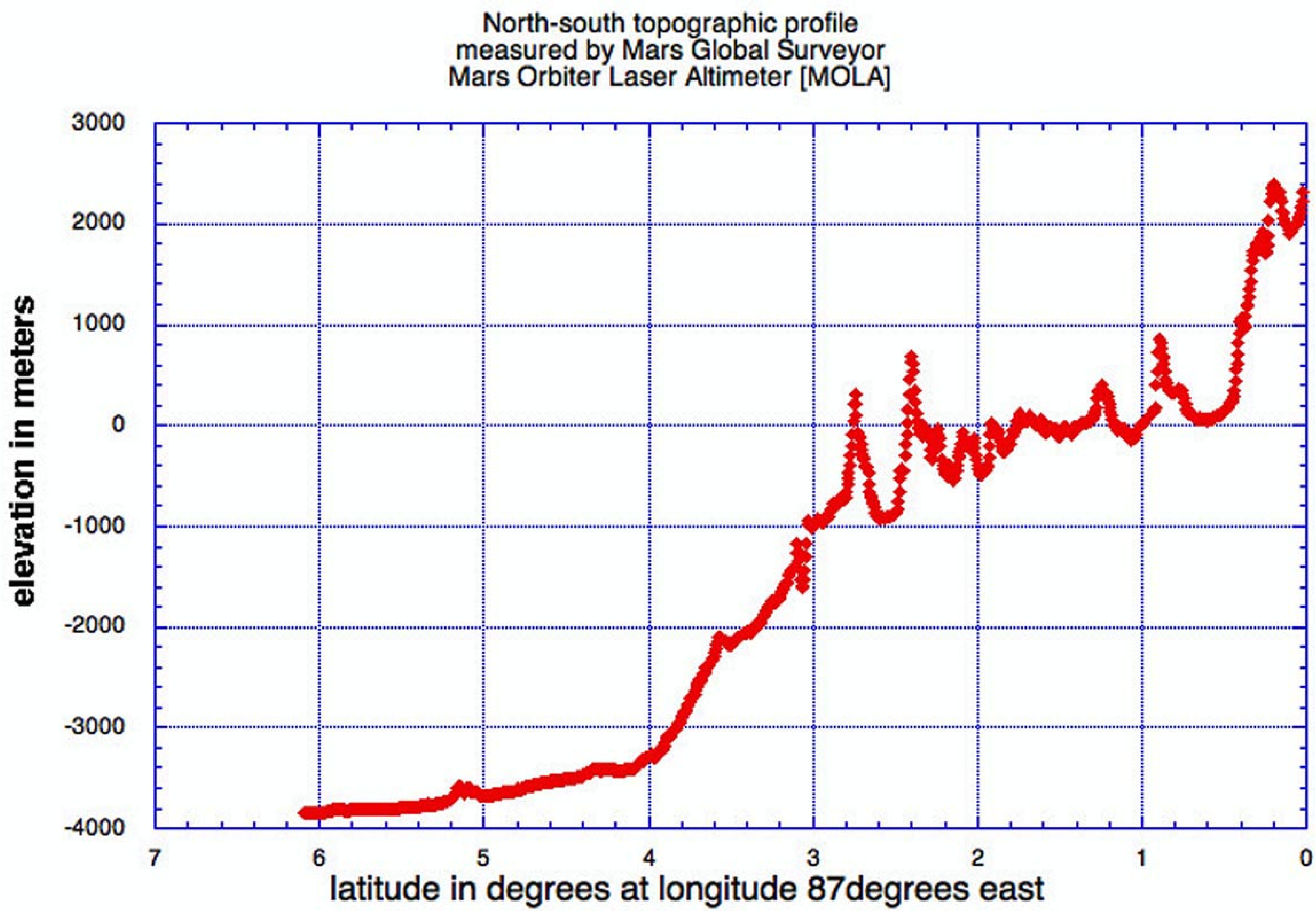
Look at the topographic profile from Mars included in this activity for comparison. This profile is one of the many MOLA topographic profiles (Mars Orbiting Laser Altimeter). The profile is from the Mars Global Surveyor spacecraft and an instrument called a Laser Altimeter that measured the topography of Mars as the spacecraft orbited the planet.

Talk about what size features you would be able to distinguish from orbit. How many data points would you need in order to distinguish the true size and shape of a feature? Could you measure your house? Your school? The convention center? (New Mexico landmarks) The Albuquerque Volcanoes? Mount Taylor? or Sierra Blanca? The Sandia Mountains, the Sangre de Cristos, or the Sacramento Mountains?

Look at a relief map of New Mexico. For older students, relate this activity to topographic contour maps and discuss the vertical exaggeration used to construct most topographic maps and models of real landscape.

Credits

This activity was adapted by Kathy Jones, Albuquerque Public Schools, from the activity How High Are the Mountains? (http://mars.jpl.nasa.gov/classroom/ teachers.html).


North-south topographic profile
measured by Mars Global Surveyor
Mars Orbiter Laser Altimeter [MOLA]
elevation in meters
3000
2000
1000
0
-1000
-2000
-3000
-4000
7
6
5
4
3
2
1
0
latitude in degrees at longitude 87degrees east

Graphing Sheet: The Ups and Downs of the Mars Surface

Name(s) ____________________ Date ___________

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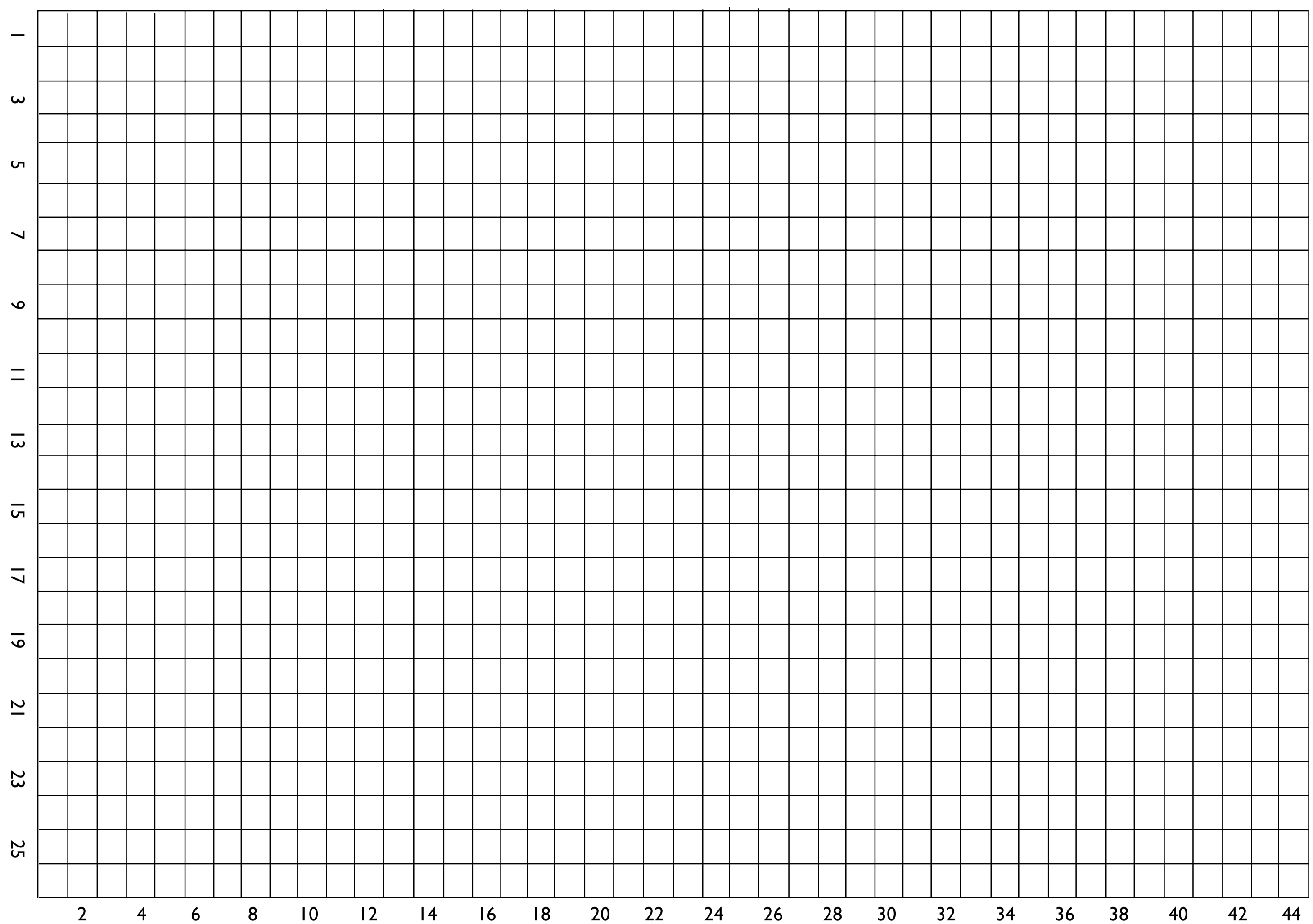

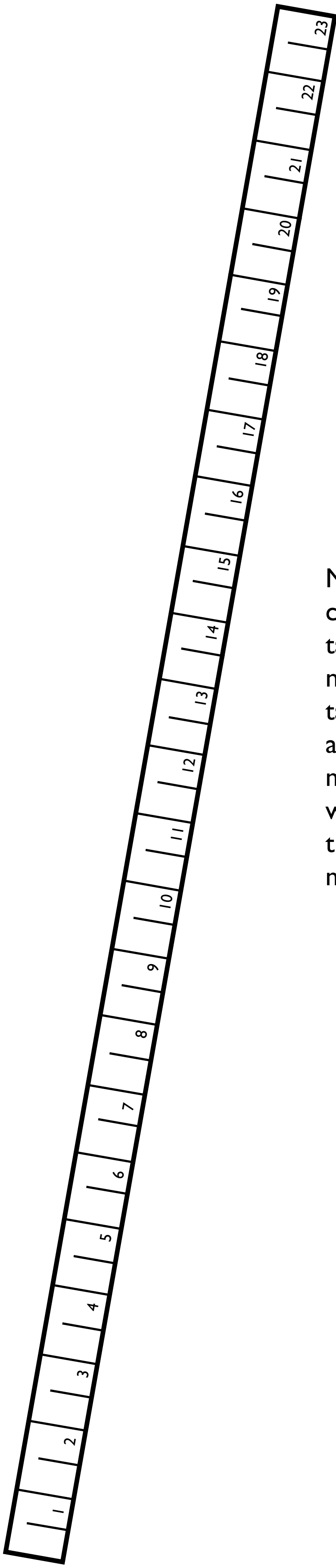

Make multiple copies of this tape: you will need one long tape on the box and another to measure; tape a washer or nut to the end of the measuring tape.