Erosion and Landslides Teacher Guide

Lesson Overview: Students will investigate the effect of different types of soil on how quickly a landslide occurs and how much mass is moved. They will then relate that information to Tropical Rainfall Measurement Mission (TRMM)/Global Precipitation Measurement (GPM) data about rainfall and areas currently at risk of suffering a landslide.

Lesson is expected to take two 45-minute periods or one 90-minute block, with possible additional time needed for public service announcement project. (Could be given as homework.)

Learning Objectives:
- Students will be able to describe what a landslide is and the conditions that can create one.
- Students will look at how satellites are useful to collect precipitation data and predict risk areas for landslides.

National Standards:
ESS3.B - A variety of hazards result from natural processes (e.g., earthquakes, tsunamis, volcanic eruptions, severe weather, floods, coastal erosion). Mapping the history of natural hazards in a region, combined with an understanding of related geological forces can help forecast the locations and likelihoods of future events.

MS-ESS3-2. Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects. [Clarification Statement: Emphasis is on how some natural hazards, such as volcanic eruptions and severe weather, are preceded by phenomena that allow for reliable predictions, but others, such as earthquakes, occur suddenly and with no notice, and thus are not yet predictable. Examples of natural hazards can be taken from interior processes (such as earthquakes and volcanic eruptions), surface processes (such as mass wasting and tsunamis), or severe weather events (such as hurricanes, tornadoes, and floods). Examples of data can include the locations, magnitudes, and frequencies of the natural hazards. Examples of technologies can be global (such as satellite systems to monitor hurricanes or forest fires) or local (such as building basements in tornado-prone regions or reservoirs to mitigate droughts).]

From the Next Generation Science Standards, available at http://www.nextgenscience.org/.

Background Information:
"Landslides occur in all U.S. states and territories and can be caused by a variety of factors including earthquakes, storms, volcanic eruptions, fire and by human modification of land. Landslides can occur quickly, often with little notice and the best way to prepare is to stay informed about changes in and around your home that could signal that a landslide is likely to occur.

In a landslide, masses of rock, earth or debris move down a slope. Debris and mud flows are rivers of rock, earth, and other debris saturated with water. They develop when water rapidly accumulates in the ground, during heavy rainfall or rapid snowmelt, changing the earth into a flowing river of mud or "slurry." They can flow rapidly, striking with little or no warning at avalanche speeds. They also can travel several miles from their source, growing in size as they pick up trees, boulders, cars and other materials." (Text from http://www.ready.gov/landslides-debris-flow)

Other sources for background:

- USGS Landslide Hazards Program: http://landslides.usgs.gov/
- USGS Landslide Frequently Asked Questions: http://www.usgs.gov/faq/?q=taxonomy/term/9752
- Landslide Hazards video: http://www.youtube.com/watch?v=MVwSpGVfWVo
- Article about how satellites are used to help predict landslides: http://earthobservatory.nasa.gov/Features/LandslideWarning/
- How Stuff Works – How Landslides Work: http://science.howstuffworks.com/environmental/earth/geology/landslide.htm

Materials:

- Sand/soil/gravel
- Stream tables (or homemade ones from half-gallon cartons) – one per group
- Spray bottles –one per group
- Scales or balances (to measure water used by weight) or graduated cylinders (to measure water by volume) – one per group, or several to share between groups → if you don't have access to either, you can just use number of squirts, although it may be less precise
- Plastic bins or plastic sheeting to contain the water
- Wooden block or other way to prop up the stream tables

Engage: Using the *GPM Erosion and Landslides Lesson PowerPoint* (*slide 3*), give the students different types of soil, sand, and rocks, a tray (or cut open half-gallon milk carton), and a source of water. Challenge them to transport the sand and rocks from one end of the container to the other using as many different methods as they can. Students should record their methods and then share out to the class (blowing, pushing, running water, tipping the pan, etc.) Ask students to identify the processes they are demonstrating. Alternatively, this could be a thought experiment – showing the students the trays of soil, and asking them to think about how to move the soil around.

Explore: Play a short video (length 0:19) of the La Conchita, California landslide from 2005 (*slide 4*). Have students brainstorm what they know about landslides, whether they've ever seen one and what they think causes the debris to suddenly go down a slope (*slide 5*), before revealing a definition and factors involved in landslides (*slide 6 & 7*). Using the *GPM Erosion and Landslides Lab Instructions and Student Capture Sheet*, students will simulate landslides in trays with different types of soil. In brief, they will spray each tray with a squirt bottle until a landslide begins and record data about how many squirts and the amount of water it took (*slide 8*). Some important reminders: students should NOT move the tray once the spraying starts, or the data between groups will be inconsistent. (If it happens, you can talk about how an earthquake can set off a landslide, especially if it's rained a lot recently.) Also, make sure you talk to students about the need to standardize what is considered a landslide. Making lines on the containers at a standard distance from the top will help (see Teacher Notes below), but it's important that students understand that if any part of the soil moves below that line, a landslide has occurred, even if some soil is still sticking above the line. Alternatively, you could get small toy houses to set on the slope, and when they have moved past the line, consider a landslide to have occurred. If students do not all use the same methodology, it can result in very inconsistent data and outliers. Optionally, students could also measure the amount of material moved. Each group will report back to the class about results, and compare the data for different types of soil (*slide 9*).

Explain: Students will relate the lab activity to data collected by TRMM (and soon the GPM satellite), and look at how they gather data about rainfall and use that to predict areas at risk of a landslide. First, a bit about why we study landslides. Show students a map of where landslides occur (*slide 10*) and point out how widespread they are, and they type of damage they can cause, both in terms of property and human life (*slide 11*).

Ask students to think about how we might be able to predict landslides and how we might get that data (*slide 12*). They should think about the experiment they just did, and how precipitation and soil type made a difference in when the landslides occurred. They may also think about the steepness of the slope and how quickly the rain is falling (not just overall quantity), although these were not variables in the experiment.

In terms of how to get the data, especially about rainfall, try to get students to think about how we measure rain – the primary three methods for collecting rainfall data are gauges, radar, and satellites. They may have seen rain gauges, or you might bring one in to show them. The U.S. has a good rain gauge and radar network, but there are still limitations and it doesn't cover everywhere. There are relatively few gauges compared to the land area of Earth, especially in remote areas and developing regions, and they don't work over the ocean (not relevant to landslides, but to the use of satellites to measure rain). Radar can be expensive, and still has a relatively limited range, and is affected by land features such as mountains. Satellites such as TRMM and GPM can provide a near real-time picture of rainfall. A short video about GPM titled "For Good Measure" (length 2:01) could be shown at this point, available at http://gpm.nasa.gov/education/videos/for-good-measure. For information about an example of a citizen science program collecting nation-wide rain gauge data, visit http://www.cocorahs.org/.

The next slide (*slide 13)* discusses landslide risk in the United States, but it is static data, without current precipitation information. To get that information, especially where rain gauge or radar data is unavailable, we can use the TRMM satellite (soon GPM) to know where rain is falling (*slide 14).* For more information about TRMM's mission, go to http://trmm.gsfc.nasa.gov/overview_dir/background.html. For an article about how TRMM is used to predict landslides, go to http://earthobservatory.nasa.gov/Features/LandslideWarning/. Satellites can provide data about many of the factors that will determine when a landslide will occur, allowing modeling and prediction of landslides (*slide 15).* Satellite data represented in the images on the slide are:

- TRMM (and soon GPM) for precipitation - http://pmm.nasa.gov/ (upper left)
- Aqua (and soon SMAP) for soil moisture - http://aqua.nasa.gov and http://smap.jpl.nasa.gov/ (upper right)
- SRTM for topography - http://www2.jpl.nasa.gov/srtm/ (lower left)
- MODIS for land cover http://modis.gsfc.nasa.gov/ (lower right)

The data can be combined to show areas of the globe that are current at risk for landslides (*slide 16).* For the most recent data, go to http://trmm.gsfc.nasa.gov/publications_dir/potential_landslide.html. To show students the power of satellites, *slide 17* has a 3-D image of Hurricane Sandy taken using radar (an animated version is at http://www.youtube.com/watch?v=erg_Ek_VIfA), as well as microwave data showing rainfall accumulation. To show how GPM will improve TRMM's measurements, *slide 18* has an image of the constellation of satellites that will be coordinated by the GPM core satellite. (More at http://ppm.nasa.goc/GPM.) An animation of how the paths of the various satellites overlap, allowing for precipitation readings every three hours, is available at http://pmm.nasa.gov/video-gallery/global-precipitation-measurement-constellation or http://svs.gsfc.nasa.gov/goto?3971.

On *slide 19*, you'll find a link to a video called "Too Much, Too Little" (length 4:44) explaining why we need to use satellites to measure precipitation and leading in to the societal impacts of landslides.

Evaluate: To apply their new knowledge, students will create a public service announcement for one of the areas currently in danger of a landslide, giving both data from the experiment and from TRMM/GPM or other sources, as well as recommendations for preparations to make in case of a landslide (*slide 20). (See end of this *Teacher Guide* for a sample rubric.) A video from the USGS (length 6:13) introduces the hazards of landslides before students begin their research (*slide 21).*

Resources for research: (*slide 22)*

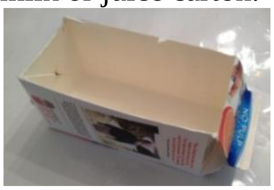
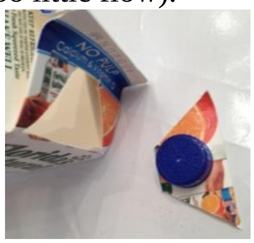
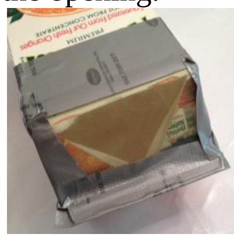
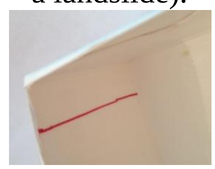
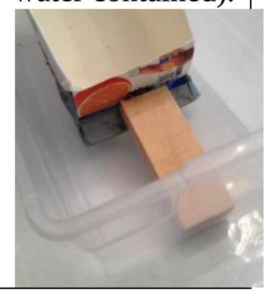
- USGS Landslides Hazards Program: http://landslides.usgs.gov/
- Most current data from TRMM about landslide hazards locations: http://trmm.gsfc.nasa.gov/publications_dir/potential_landslide.html
- Landslide Hazards – A National Threat: http://pubs.usgs.gov/fs/2005/3156/2005-3156.pdf
- Preparation for Landslides: http://www.ready.gov/landslides-debris-flow

Elaborate/Extend:

- Meet a scientist who studies landslides (*slide 25*). As part of the Faces of GPM video series, Dr. Dalia Kirschbaum discusses her role with GPM, how she became a scientist, and how remotely sensed satellite data can be used to study and evaluate natural hazards such as landslides. Link to video (length 3:04): http://gpm.nasa.gov/education/videos/faces-gpm-dr-dalia-kirschbaum-gpm-applications-scientist
- Discuss what else besides type of soil might have an impact on landslides – for example earthquakes, volcanic activity, deforestation, human building of roads and structures, etc. Students could do research on one particular factor and create a poster or presentation to share the information with the class.
- Students could design and carry out experiments to test other variables affecting landslides, such as differences in the angle of the slope, mixtures of soil types, the rate of precipitation, etc. and the effect they have on the speed and mass moved during a landslide.
- With some lead time, a landslide tray could be seeded with quick-growing grass, to compare landslide risk in areas with vegetation versus areas without (such as after a fire). This could be an excellent class demonstration, after they have completed their own experiments.
- Students could design ways to prevent a house or other building from being damaged by a landslide, and build models to test which is most effective.
- Students could read and respond to an article about how TRMM is used to predict landslides, http://earthobservatory.nasa.gov/Features/LandslideWarning/.
- If students are interested in more detail about the instruments on GPM, see the notes with the image of the satellite on *slide 26*. For more about the core observatory and instruments, see http://pmm.nasa.gov/GPM/flight-project/spacecraft-and-instruments
- If you wish to discuss landslides on other celestial bodies, *slide 27* and *slide 28* have examples. Interesting discussion points could be about what the condition would need to be without rainfall. For more about the Mars Reconnaissance Orbiter, see http://mars.jpl.nasa.gov/mro/. The article pictured can be found at http://www.bbc.co.uk/news/science-environment-19011011.

Teacher Notes:

Steps to make a home-made stream/landslide table:

1. Cut out one side of a half-gallon milk or juice carton. 	2. Cut out enough of the top to allow water to flow out (the existing spout allows too little flow). 	3. Tape mesh or cheesecloth over the opening. 	4. Make a mark with permanent marker 2 cm from the top (to give students a reference for what constitutes a landslide). 	5. Use a block of wood inside a plastic bin to prop up the carton (and keep the draining water contained). 

Any sort of scrap wood, cut to identical lengths for each group, will work as a spacer. Shims (as for under a bookcase) are especially easy to cut. With a plastic shoebox-size outer container and half-gallon carton as pictured, 15 centimeters is a good length. A steep angle will help the landslide occur more quickly, as will making sure the soil is wet before placing in the bin, and using a relatively large spray bottle (such as old spray cleaner bottles, rinsed out well, or inexpensive spray bottles from a hardware store or home center). Having a large bin with the sand/soil already wet, ready to scoop a cup's worth into the carton (after emptying the saturated sand/soil) will make it easy to reset between classes. Having a relatively thin layer of sand/soil (only about a centimeter deep) will also help make the landslide occur quickly, and be obvious and dramatic.

→ Sample data, using the set-up pictured above with one cup of sand/soil, 15 cm wooden prop:

- Potting soil: 17 sprays to first movement, 24 sprays to landslide, 12 mL of water used
- Sandbox Sand: 19 sprays to first movement, 26 sprays to landslide, 16 mL of water used

Additional Resources:

The story of Holland Island demonstrates human impact issues related to erosion, if not landslides directly. http://www.washingtonpost.com/wp-dyn/content/gallery/2010/10/24/GA2010102401657.html

Animations of landslides:
http://highered.mcgraw-hill.com/sites/0072402466/student_view0/chapter9/animations_and_movies.html#
http://higheredbcs.wiley.com/legacy/college/strahler/0471238007/animations/ch15_animations/animation1.html

Rubric Erosion and Landslides Public Service Announcement

	Advanced (4)	Proficient (3)	Partially Proficient (2)	Basic (1)	Points
Content					
Landslide description	• Includes a definition of a landslide, including what may cause a landslide to occur	• Includes a definition, but lacks details or has minor errors in content	• Definition is attempted, but with major errors in content	• Minimal attempt or not included	x 1 =
Landslide experiment	• Experiment is clearly described, including data and any errors or areas of future experimentation	• Experiment is described, but lacks details or data, or has minor errors in content	• Description is attempted, but missing many details or with major errors in content	• Minimal attempt or not included	x 2 =
Areas currently at risk/landslide preparedness	• Includes a description of data from TRMM/GPM about areas of the world that are currently at high risk of landslides • Includes tips about how to prepare for a landslide	• Includes description and data, but lacks details or has minor errors in content	• Description is attempted, but missing many details or with major errors in content	• Minimal attempt or not included	x 2 =
Presentation					
Visuals	• Includes a diagram or visual aid that helps explain what a landslide is or how to prepare • If not drawn by student, includes citation of the source	• Includes a diagram or visual, but may not be most effective to convey content • If not drawn by student, includes citation of the source	• Includes a diagram or visual, but citation is missing	• No diagram or visual included	x 1 =
Neatness	• Neatly drawn and/or written • Very few errors in grammar or spelling • Makes the viewer/reader say "wow, that's great!"	• Neatly drawn and/or written • Very few errors in grammar or spelling	• Shows a lack of effort to be neat, or many distracting errors in grammar or spelling	• Shows poor effort at neatness and/or excessive errors in grammar or spelling	x 1 =

Rubric Pts	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7 or less
% Grade	100	98	96	94	92	90	88	86	84	82	80	78	76	74	72	70	68	66	64	62	60	50