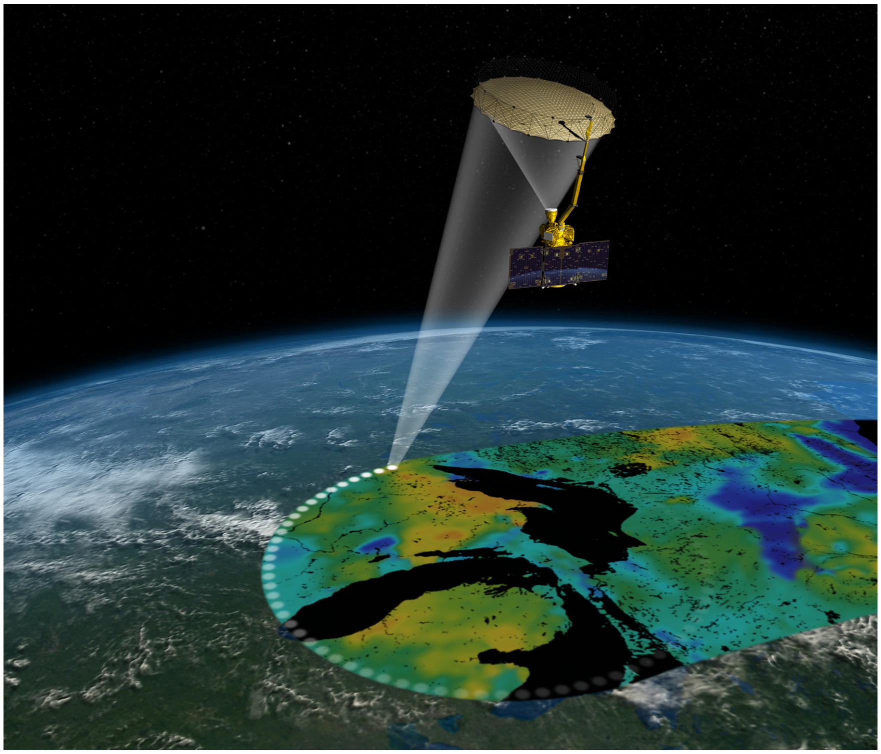
This activity was developed by SSSA for the 2015/16 AGI Earth Science Week Kit

Learning Activity: Soil Moisture



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Soil Moisture

Soil moisture is the water stored in the soil and is affected by precipitation, temperature, soil characteristics, and more. These same factors help determine the type of biome present, and the suitability of land for growing crops. The health of our crops relies upon an adequate supply of moisture and soil nutrients, among other things. As moisture availability declines, the normal function and growth of plants are disrupted, and crop yields are reduced. And, as our climate changes, moisture availability is becoming more variable.

Soil Moisture Activity

Upper Elementary & Middle School

Where is the water in soil? Solids, liquids, and gasses, the three phases of matter, are always present in soil. Small mineral and organic particles comprise the solid fraction, and there are spaces (pores) between the solid particles. Some pores are large, and others are very small. Air and water, the gas and liquid phases, exist in the pores. The size of the soil particles and pores affects how much water a soil can hold, and how that water moves through the soil.

Sponges also contain solid material and pores of different sizes. This activity uses sponges to observe the basic properties about how soils hold water, and then observes the water holding capacity of some soils.

The students will determine the mass and volume of dry sponges and make observations about the pores in the sponges. The sponges will be saturated and allowed to drain, then weighed again. Students will then squeeze all the water they can out of the sponge, and the sponge will be weighed again. Students will use these data to calculate the gravimetric and volumetric water content of the sponges. Students will look for connections between the characteristics of the sponges and how much water they hold after drainage by gravity, and after being squeezed.

If the sponges have different pore sizes, sponges with larger pores will allow water to drain more freely, and will hold less water against gravity. If a sponge has small pores and more fibers, water held to the fibers cannot be squeezed from the sponge, and so the sponge will retain more water than a sponge with a larger pore matrix.

Materials Needed

- Sponges with different pore sizes
- Dry soil materials: sand (play sand or sand from a beach or dune), topsoil (from a lawn or garden), cat litter
- Trays or baking dishes to hold water and wet sponges
- 250-ml clear beaker or similar container
- Balance (0.1 g sensitivity, at least 400 g capacity)
- Ruler
- Computer with internet access

In the next step, students will measure out a set volume of different dry soils into containers, then determine the weight of the soil, and make observations on the soil properties. Students will determine the bulk density of the soil, which is the dry mass of soil per unit of volume. Then students will add water until the soil is just saturated. After weighing, students will determine the amount (mass and volume) of water in each soil at saturation, and make any observations about changes in the volume of soil upon wetting.

Students will look for connections between the soil properties and bulk density and the water the soils hold at saturation. Soils with lesser bulk densities (such as clays) generally have smaller pores, so water moves into them more slowly, and at saturation, they will hold more water than soils with greater bulk densities (such as sands), which often have larger pores. But a few big pores do not hold as much water as a multitude of small ones. Cat litter is often made with a special kind of clay that expands slightly when water is added. The cat litter particles may appear larger than sand particles, but are actually aggregates composed of maybe millions of individual particles. Because they are so very small, they have a tremendous amount of surface area, and hold tightly to water.

Procedures:

Soil Moisture: The Sponge Model Experiment

1. Measure the length (L), width (W), and height (H) of each sponge. Calculate its volume (V), V = L x W x H.
2. Weigh each dry sponge and record its mass.
3. Record observations about the sizes and types of pores visible in each sponge. Are they large or small, round or irregular, separate or connected,.
4. Submerse each sponge in a water-filled dish until it becomes very wet. Press on the sponge while it is under the water to remove some of the air, then release the sponge to let water flow back into it.
5. Lift and hold the sponge above the dish until the water stops draining.
6. Record the mass, length, width, height, and volume of the wet sponge.
7. Record observations about changes in the volume of the sponges when wetted, and if water can be seen in pores and the size of those pores.
8. The gravimetric water content is the mass of water in the sponge relative to its mass. Determine the gravimetric water content (g/g) = (mass of wet sponge – mass of dry sponge)/(mass of dry sponge).

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9. The volumetric water content is the volume of water in the sponge relative to the total volume of the sponge. The density of water is 1 g/cm^3, so the mass of water is equal to its volume. Determine the volumetric water content (cm^3/ cm^3) = (volume of water)/(volume of dry sponge).
10. Now squeeze as much of the water out of the sponge as you can. Repeat Steps 6-9.
11. Compare the gravimetric and volumetric water content of the sponges. Do the size and shape of the sponges or of the pores in the sponge make a difference? Why?

Soil Moisture: Soils Experiment

12. Weigh each container and record its mass.
13. If the containers are not graduated, add 50 g of water to the container and use a waterproof marker to record the water level on the outside of the container. Empty the water and dry the container.
14. Add 50 cm^3 (ml) of each soil material to a separate container. Gently tap the container on the bottom 10 times, and if needed, add additional soil to restore the soil to the 50 cm^3 level.
15. Weigh each container plus soil and record the mass. Determine the mass of the soil = (mass of container + soil) – (mass of container).
16. The bulk density is a property that describes the dry mass of soil in a given volume, and is useful for comparing and understanding soil characteristics. For each soil, calculate the bulk density = (mass of soil)/(50 cm^3, the volume of soil).

17. Record observations about any pores visible in the soil materials, just as you did for each sponge.
18. Slowly add water to each container in 5 ml increments until the water is just visible at the soil surface. Make sure the soil is wet all the way to the bottom of the container. It may be necessary to wait several minutes before adding the next increment of water, especially with the cat litter.
19. Record the volume of the soil in the container (if the soil swells when wetted, its volume will increase).
20. Weigh each container and record its mass.
21. For each container determine the mass of water added = (mass of container + soil + water) – (mass of container + soil).
22. Determine the gravimetric water content (g/g) = (mass of water added)/(mass of soil).
23. The density of water is 1 g/cm^3, so the mass of water equals its volume. Determine the volumetric water content (cm^3/ cm^3) = (volume of water)/(50 cm^3, initial volume of soil).
24. Compare the gravimetric and volumetric water content of the soils. Is there any relation with the bulk density? Why or why not?

Soil Moisture Sampling

Middle and High School

Calling all student scientists! Soil scientists and agronomists use gravimetric methods and in-situ instrumentation to monitor soil moisture at the field scale in cropped lands. Other scientists look at a bigger picture, using Earth-observing satellites to survey the planet for soil moisture changes. These data will assist soil scientists, hydrologists, and climatologists in forecasting potential changes in moisture availability. NASA recently launched a satellite called Soil Moisture Active Passive (SMAP) to monitor the water in the top 5 cm of soil. (http://smap.jpl.nasa.gov/) The SMAP mission team needs help and is partnering with GLOBE to get students involved in collecting ground truth measurements. These student-provided measurements will help scientists calibrate satellite information and interpret the data.

The GLOBE program **(www.globe.gov/web/smap/overview)** has partnered with SMAP team to elicit the assistance of students in ground-truthing (*in-situ*) the data collected from SMAP. The GLOBE Gravimetric & Volumetric Soil Moisture Protocols will assist scientists by collecting data at a small/local scale in order to validate the SMAP satellite data. Visit the website to learn how you and your students can participate using their easily implemented protocol.

Links to the sponge model of soil:

http://www.doctordirt.org/teachingresources/sponge/

From GLOBE: Soils as Sponges: How Much Moisture Does Soil Hold?

http://www.globe.gov/documents/352961/e4a90c9f-2a5a-43ef-b7b6-108ec4a06e76

From GLOBE: Gravimetric & Volumetric Soil Moisture Protocols

https://www.globe.gov/documents/10157/8818947/grav.pdf

SSSA Web Resources:

Soils4Teachers—http://www.soils4teachers.org/

Soils4Kids—http://www.soils4kids.org/