

Precipitation and the Water Cycle

Lesson Overview:

This is an inquiry-based unit over the water cycle using precipitation measurements, hands on creation of instruments, demonstrations and student-led inquiry. Students will determine water availability, the water cycle's impact on our global water, and what role precipitation plays. Students will use precipitation data from NASA's TRMM (Tropical Rainfall Measuring Mission) mission and the Earth Observatory to determine precipitation and atmospheric water content.

Lesson Objectives:

Students will use all data collected and analyzed to develop a model showing the cycling of water through Earth's systems. Students will show understanding of the processes water molecules undergo in order to change phases throughout the water cycle, and the energy requirements for each of those processes. Data will be collected from hand-made rain gauges, TRMM data, water cycle investigations and classroom discussions.

Standards:

NGSS:

MS-ESS2-4: Earth's Systems

Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.

MS-PS1-4: Matter and Its Interactions

Develop a model that predicts and describes changes in particle motion, temperature, and the state of a pure substance when thermal energy is added or removed.

CCSS: ELA

RST.6-8.2: Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions.

Lesson created for middle school science, namely 6-8 grade students.

Background Information:

The Tropical Rainfall Measuring Mission (TRMM) is a NASA satellite that measures rainfall in the tropics and subtropics of the Earth. "These regions make up about two thirds of the total rainfall on Earth and are responsible for driving our weather and climate system" (TRMM). TRMM will also provide information about heat released during these water cycle processes. "Energy from the sun passes through the atmosphere to the ocean surface where much of it is absorbed and causes the liquid water there to become the gas we call water vapor" (TRMM). By using TRMM data, scientists hope to determine how the energy involved with rainfall interacts with other aspects of the global climate (TRMM). The Earth Observatory uses data from TRMM and the Moderate Resolution Imaging Spectroradiometer (MODIS) to show rainfall and water vapor, respectively.

Materials:

Computer with Google Earth and internet/printed maps of recent data

5 Gallon Bucket

2-cup measuring cup

Recommended: Sticky Notes

Rain Gauge materials

- Soda/water bottle or other plastic container
- Rulers
- Tape and scissors as needed
- Sharpie

Student record sheets

- Water Cycle:
https://pmm.nasa.gov/education/sites/default/files/lesson_plan_files/exploring-water-cycle/Exploring%20the%20Water%20Cycle%20SCS.pdf
- Student Data Record Sheet:
https://docs.google.com/document/d/1_Wsl1GGuNT8StuSj470CTp51kCEc31Q-wHqN7jHq_4/edit?usp=sharing
- Instructions for “Making a Rain Gauge”:
<https://www.theecologycenter.org/build-a-rain-gauge/>
- World Map: (For World Water Distribution without internet access)
https://docs.google.com/document/d/1gRuu0rTeG30ID8XpZVhPEd_iaW18DgpPePKqwdENEgo/edit?usp=sharing

Time Requirement:

Estimated time: 6-8 days(Class periods are based on a 50-minute class, adjust as necessary)

- Engage: 1 class period
- World Water Distribution: 1 class period
- Water Cycle: 1 class period
- Atmospheric water: 1 class period
- Rainfall patterns: 1-2 class periods (if students are new to Google Earth tools, they may need additional time to familiarize themselves with the tools. Additional class time needed to extend to global data sets. Teachers could look at local data first and then come back to this technology to extend to global patterns.)
- Rain Collection: **Weather Dependent.** 2 class periods (One class to design and build tools. One day to collect data after a weather event, discuss and compare collected data. Also to discuss discrepancies in data.)

Keywords/Vocabulary:

Precipitation	Crystallization	Cloud	Percolation
Condensation	Downhill Flow/ Surface Runoff	Atmospheric Water	
Transpiration	Thermal energy	Surface Water	
Ground Water	Atmosphere	Evaporation	

Engage (Requires observation of the weather):

Students will go outside either around their school or local natural area and observe all of the

sources of water. Ask them to record their observations in the student record sheet. (*Initial answers will be obvious-clouds, ground, a water source, etc. Have students think about water that is unseen-plants, animals, evaporated into the atmosphere, etc.*) Once inside, ask for students to create a model of all their ideas (Underground, above ground, in the atmosphere, etc. Teachers could do this best by using two methods-drawing and sticky notes. (Draw the ground and sky, have students use small sticky notes to write their sources.)

Explore:

World Water Distribution:

Using a 5 gallon bucket filled with water challenge the students with the following question: If this represents all of the Earth's water, what amount is usable by humans? After initial observations by students, have a volunteer remove 2 cups of water from the bucket. *This 2 cups represents the freshwater available, the remainder in the bucket represents the 97% salt water.*

Use the interactive map to show where useable water is located. One way to observe without internet is to download the map and color the different waters by useable and not.

<https://www.nationalgeographic.com/magazine/2010/04/>

Students would then discuss how water that is currently not useable would become useable.

This video explains how some water is usable, and how we use it

<https://pmm.nasa.gov/education/videos/show-me-water>

Water Cycle:

Students will watch the video "Water Cycle" <https://www.youtube.com/watch?v=iohKd5FWZOE> and fill out their student Water Cycle record sheets:

https://pmm.nasa.gov/education/sites/default/files/lesson_plan_files/exploring-water-cycle/Exploring%20the%20Water%20Cycle%20SCS.pdf

After completion discuss the additions and subtractions of thermal energy from the system to create the phase changes within the cycle.

Atmospheric Water:

Students will use NASA's Earth Observatory to analyze the interactive maps of water vapor concentration in the atmosphere and different factors such as time of year, land mass surface temperature and rainfall. Students will work with their groups to write a statement citing evidence from the interactive maps on how atmospheric water vapor, rainfall and temperature are linked. Utilize the CER rubric for citing evidence to support a claim, found here:

<https://drive.google.com/file/d/0B2Im-XdKLBCBT3IPT1FCXzNNZDA/view?usp=sharing>

World/Local Rainfall Amounts:

Students will work with the TRMM data corresponding to Google Earth here:

https://trmm.gsfc.nasa.gov/affinity/download_kmz.html. This allows local and global data collection. They also can retrieve data from the TRMM website about other patterns of precipitation that are monitored here: <https://trmm.gsfc.nasa.gov>

If internet connection is not available, teachers can print pictures of recent data.

Students will be asked to make three observations of local rainfall amounts from the last 30 days. Record these in the student record sheet.

Class will discuss what factors affect these rainfall amounts. At this point they may compare the normal data to data from TRMM's Extreme Event Archives or Rain Averages and Anomalies to

compare normal rainfall amounts to extreme changes. (Data can be found here: <https://trmm.gsfc.nasa.gov>)

Discussion about rainfall being the primary source of freshwater. Ask students which part of the water cycle they believe to be the main way we can obtain available water. *Student Mastery shows understanding that rainfall refills freshwater sources.*

STEM Activity: Rain Collection:

Students will work together to design a rain gauge. (At this point gauges will not be accurate. The goal is not to have a perfect instrument but to understand the design behind measuring rain.) Students will collect rain measurement data. Record this data on their student record sheet. They can compare their data through a digital graph, or class graph (Google Forms to gather data shows real-time answers). *If a rain event will occur that students can measure, the data could be used to compare against the satellite data from the TRMM satellite.*

Students will discuss with their partner/groups, and the class, differences in measurement between types of gauges and what inaccuracies exist. How can we lessen inaccuracies? Show the video “For Good Measure” which explains why scientists use satellites to measure rainfall. <https://pmm.nasa.gov/education/videos/for-good-measure>

Explain:

Students will be able to explain how water changes form due to thermal energy changes and what forms we find it in.

Students will explain how knowing precipitation amounts is important, and explain the differences between rain gauges here on earth, and the TRMM satellite information. *Mastery would explain how rainfall can predict climate change through the water cycle process.*

Evaluate:

Formative Assessment:

Throughout the lesson students will be able to complete Mastery of each topic. Also, teachers could evaluate the student’s understanding of the phases of the water cycle currently being talked about.

Students should be able to meet rubric requirements for citing evidence to support claims. Students will be able to explain how water changes phase based on thermal energy.

Summative Assessment:

Students will develop a model of the water cycle showing each of the phases of water in the perspective locations. Students will also include where thermal energy enters and leaves the system causing such phase changes. *Mastery of concept is achieved when students can show each of the precipitation processes, the energy involved and all sources of water that play a role in the water cycle.*

Elaborate/Extend:

Use the TRMM data to predict droughts and areas of impact by flooding from above average rainfall. Students can predict and evaluate the effect on local ecosystems due to these changes in precipitation.

Students could design an instrument that can measure snowfall.

If rainfall is the primary source to refill freshwater bodies, how can we conserve and protect that source, in order to best protect our global water? (Students can create designs for protecting rainfall and water sources that collect it)

Math Extension:

The Number System: Using positive and negative quantities to quantify changes in physical quantities. Observing the changes in rainfall amounts over a 30 day period and then averaging the rainfall as well as quantifying those changes would include this math standard.

ELA Extension:

Water Cycle:

Have students create a comic strip with water as the main character. Mastery of concept shows the steps of the cycle with correct vocabulary and thermal energy requirements for the changes in steps.

TRMM Data:

Students can write a script for a local weather station about possible flooded/drought areas portrayed on the TRMM extreme events data map.

Resources:

Lessons adapted from:

- Exploring the Water Cycle:
https://pmm.nasa.gov/education/sites/default/files/lesson_plan_files/exploring-water-cycle/Exploring%20the%20Water%20Cycle_Teacher%20Guide_rev2_2019.pdf
- Measuring Precipitation:
https://pmm.nasa.gov/education/sites/default/files/lesson_plan_files/Measuring%20Precipitation/Measuring%20Precipitation%20TG.pdf
- Earth's Water:
https://pmm.nasa.gov/education/sites/default/files/lesson_plan_files/earths%20water/Earth%27s%20Water%20TG.pdf
- How to Build a Rain Gauge. November 8, 2014. The Ecology Center. Retrieved from
<https://www.theecologycenter.org/build-a-rain-gauge/>

TRMM Resources: <https://trmm.gsfc.nasa.gov>

TRMM Information: https://trmm.gsfc.nasa.gov/overview_dir/why-ms.html

TRMM Connection to Google Earth: https://trmm.gsfc.nasa.gov/affinity/download_kmz.html

Rainfall Maps (Extention/no internet access):

<http://www.waterandclimatechange.eu/rainfall/average-monthly-1985-1999>

The Earth Observatory. (n.d.). NASA. Retrieved from

https://earthobservatory.nasa.gov/global-maps/MYDAL2_M_SKY_WV