Moisture and Clouds

NASA SUMMER OF INNOVATION

UNIT
Earth and Space Science—Weather

GRADE LEVELS
4 – 6

CONNECTION TO CURRICULUM
Science and Mathematics

TEACHER PREPARATION TIME
1 hour

LESSON TIME NEEDED
3 hours Complexity: moderate

LESSON THEME

This lesson has two activities: develop a basic understanding of the relationship between cloud type and the form of precipitation and the relationship between the amount of water in the atmosphere available for precipitation and the actual precipitation observed by satellite.

OBJECTIVES

Students will

- Use MY NASA DATA to obtain precipitation and cloud type data
- Create graphs of data within MY NASA DATA
- Compare different cloud types
- Compare precipitation and cloud type data
- Qualitatively describe graphs of the precipitation and cloud type data
- Examine global moisture and precipitation
- Examine seasonal changes in precipitation
- Practice finding data using Internet resources

NATIONAL STANDARDS

National Science Education Standards (NSTA)
Science as Inquiry
- Understanding of scientific concepts
- An appreciation of “how we know” what we know about science

Earth and Space Science Standards
- Properties of Earth materials

Common Core State Standards for Mathematics (NCTM)
Geometry
- Graph points on the coordinate plane to solve real-world and mathematical problems

Operations and Algebraic Thinking
- Analyze patterns and relationships

National Geographic Society
The World in Spatial Terms
- How to use maps and other geographic representations, tools, and technologies to acquire, process, and report information from a spatial perspective
- How to analyze the spatial organization of people, places, and environments on the Earth’s surface

MANAGEMENT

Activity 1—Does cloud type affect rainfall?

You will need to discuss basic information about the atmosphere and water in the atmosphere and clouds. You will need access to computers with the Internet and graphing utility software (e.g., Microsoft Excel) for some of the extension exercises. For best understanding of global and seasonal climate, compare data for different months of the year at various locations. It is recommended that you assign a certain month to 12 groups, or ask each student to examine a particular month for different years. The data you will use for this lesson is from the International Satellite Cloud Climatology Project (ISCCP) and the NOAA Climate Diagnostics Center Merged Analysis of Precipitation (GPCP). These two acronyms are defined in the Science Glossary and have links to more information (Web sites for the projects). It is important to discuss the terms listed in the Vocabulary section prior to beginning the Procedure. Assessments can be generated from student Procedure participation and responses to the Questions and Extensions sections. The opportunity, afforded by using the data and exercises, may be expanded to help teach students the nature of science and technology and the methods used by scientists.

Activity 2—How much water is available in the atmosphere for precipitation?

You will need to discuss the Earth's water budget or cycle and have a familiarity with Internet access and computer use. Students will need access to computers with the Internet or you will need to print materials and use an overhead projector (or computer projector) to show students the materials needed to complete the activity. It is strongly suggested that the teacher practice accessing data and creating graphs prior to introducing the lesson to the class.

CONTENT RESEARCH

Clouds are the source of precipitation. If you look up to the sky on any given day, there can be many different types of clouds. We see clouds even when there is no rain. How can this be? The type of cloud determines what types of precipitation could fall from it. The two cloud types that produce rainfall are cumulonimbus and nimbostratus (see the Links section for more information). Scientists have studied the physical properties of clouds and have developed instruments onboard satellites to characterize the types of clouds. Some satellites have instruments that allow them to measure rainfall as well.

For Activity 1, students will hypothesize what types of clouds they believe will create the most precipitation (rainfall) over Nashville, Tennessee. Students will use cloud coverage data that represents what percentage of the sky is covered by a certain type of cloud (cirrus, stratus, cumulus, see the Cloud ID Form by Dr. Tina Cartwright). They will then compare the cloud coverage data to precipitation data provided by the National Weather Service's Climate Prediction Center.

Water is one of Earth's most unique and valuable resources. Thus, the distribution of water on Earth is a very important factor in the evaluation of global climate and its impact on life. For decades, scientists have observed, measured, and studied the water budget of Earth by examining water from oceans, lakes, rivers, and glaciers. The atmosphere also plays an important role in the water budget by the processes of evaporation and precipitation, therefore, scientists also collect data from satellites on atmospheric water vapor, cloud water, rainfall, and snowfall.

In Activity 2, you will use historical satellite data to examine precipitable water—a measure of the water available in the atmosphere from evaporation (in the form of water vapor). You will then compare precipitable water (which is expressed as a depth in centimeters) to the observed precipitation (which is expressed as a rate in millimeters per day).

Water plays a major role in life on Earth. In fact, the surface of the Earth is about 70 percent water. Most of the water is salty, leaving a small portion for land, animal, and human use. Much of this water is located beneath the ground, while other water is found in rivers, lakes, ponds, etc. It is from these latter sources that the water

cycle begins, but let us not forget that water is also found in the air as water vapor and clouds. Additionally, the more water vapor that is in the air, usually the more clouds there are. This water vapor condenses to form water droplets that eventually fall out of the cloud as precipitation. Precipitation has many different forms such as rain, snow, hail, sleet, or ice. For people living in the southern United States, rainfall is the most common form of precipitation.

Vocabulary:
Atmospheric Column: A vertical pillar defined by a unit area on Earth's surface and bounded by the top of the atmosphere that is used to quantify an atmospheric parameter such as pressure, ozone, or precipitable water. See image illustrating atmospheric pressure.
Precipitable Water: The amount of water in the form of vapor (gas) that is in a column of atmosphere. Under the right conditions, this water vapor can condense into liquid water and turn into clouds or precipitation. Precipitable water has units of centimeters, so one must imagine condensing all the moisture in the column of air into a small layer of water and then measuring its height.
Precipitation: Water that falls from clouds to the ground. This can be in the form of rain, snow, sleet, hail, etc.
Troposphere: The bottom layer of the atmosphere extending from the surface to an altitude between 8 kilometers (at poles) and 14 kilometers (in tropics); most weather occurs in this layer.
Cloud Coverage: Cloud coverage, also called cloud fraction or cloud cover, describes the amount of clouds in the sky. It can be measured as a percentage (0 to 100) or as a fraction (0 to 1.0).
Cloud Opacity: A parameter that characterizes the reduction of light or energy through a cloud due to interactions with its water, ice, or particle content. See definition for optical depth.
Global Precipitation Climatology Project (GPCP): An international activity of the Global Energy and Water Experiment, part of the World Climate Research Program, to provide long-term global precipitation estimates. The bulk of the data used in GPCP products are based on data from the international constellation of meteorological satellites. Where possible, mostly in land areas, analyses of rain gauge data are combined with the satellite data.
International Satellite Cloud Climatology Project (ISCCP): Established in 1982 as part of the World Climate Research Programme (WCRP) to collect and analyze the global distribution of clouds, their properties, and their diurnal, seasonal, and interannual variations.

LESSON ACTIVITIES

Activity 1—Does cloud type affect rainfall?
The purpose of this activity is to explore the relationship between the amount of water in the atmosphere available for precipitation and the actual precipitation observed by satellite.
http://mynasadata.larc.nasa.gov/preview_lesson.php?&passid=49

Activity 2—How much water is available in the atmosphere for precipitation?
The purpose of this activity is to have students explore the relationship between the amount of water in the atmosphere available for precipitation and the actual precipitation observed by satellite.
http://mynasadata.larc.nasa.gov/preview_lesson.php?&passid=39

ADDITIONAL RESOURCES

Our World: What Is a Cloud?
This NASA video segment describes the different types of clouds and cloud formation. The relationship between clouds and weather on Earth is demonstrated.
http://www.nasa.gov/audience/foreducators/nasaeclips/search.html?terms=clouds

Our World: Cloud Inspection
Find out why scientists and meteorologists study clouds and what tools they use to collect data about the effect of clouds on Earth's climate. Learn to tell the difference between cirrus, stratus, and cumulus clouds.
http://www.nasa.gov/audience/foreducators/nasaeclips/search.html?terms=clouds

DISCUSSION QUESTIONS

Activity 1—Does cloud type affect rainfall?

-Have you ever noticed clouds in the sky? *Answers will vary.*
-Have you ever wondered if the different shapes of clouds affect what types of weather you get? *Answers will vary.*
-Describe the shapes of the clouds you see during a thunderstorm? *Students should describe a large puffy tall cloud that sometimes has a flat top—a cumulonimbus cloud.*
-What types of clouds do you see when it rains for a day or days? *Answers should be that the sky is covered with gray or dark clouds—stratus clouds.*

Activity 2—How much water is available in the atmosphere for precipitation?

-Do you think you need to have a certain amount of water in the air before you get some sort of precipitation? *Answers will vary.*
-How much water do you think is in the atmosphere? *Answers will vary.*

ASSESSMENT ACTIVITIES

Activity 1—Does cloud type affect rainfall?

Below are the assessment questions provided in the activity. The answers will vary.
-Compare the two graphs and list ways in which they are similar or different.
-Describe any pattern that you see in both graphs.
-What is the range of cloud cover that has the most precipitation? What is the range of cloud cover that has the least precipitation?
-Describe any seasonal changes that occur. For example, during which months do the dry and wet seasons occur?

Activity 2—How much water is available in the atmosphere for precipitation?

Below are the assessment questions provided in the activity. The answers will vary.
-Compare the values for lower and upper atmospheric precipitable water. Which layer of the atmosphere contains the most water vapor? Why?
-For a particular month, do you notice a comparable pattern in the color contours between precipitable water and precipitation rate? What region of the Earth has the most precipitation and precipitable water?
-Given the season for your monthly data, are the results what you would expect? As a class, discuss the seasonal changes in precipitation throughout a particular year.
-Can you draw any conclusions about the weather patterns and climate for different regions of the globe?

ENRICHMENT

Activity 1—Does cloud type affect rainfall?

-Compare precipitation to cloud opacity (variable name and cloud optical depth). Answer the questions found in the Questions section. The outputs are provided in the Links section.
-Instruct the students to choose different locations around the world. Allow them to hypothesize about what they would expect to see in different locations. Allow them to compare the same variables (precipitation and cloud coverage). Ask the students to report on whether their hypothesis was correct.

Activity 2—How much water is available in the atmosphere for precipitation?

-Instead of examining a global map, select a particular region to study. Return to the Live Access Server and use the Select Region drop down menu. Instead of Full Region, select a different option. Discuss the resulting graphs.

-Examine a particular location on Earth, perhaps your location. Return to the Live Access Server and again Click on the Compare Two tab. Select a Time Series and Overlay Plot. Enter your desired latitude and longitude. You can then compare any two of the three variables. You may also click back to a single data set to obtain all three variables individually in an ASCII file output. These can then be input to a spreadsheet to allow exploration of all three variables at once. You might want to add Lower and Upper Troposphere and Precipitable Water to obtain the total water vapor available in the atmospheric column and compare this with precipitation.