National Aeronautics and Space Administration

NASA CONNECT™

Educational Product	
Educators	Grades 6-8

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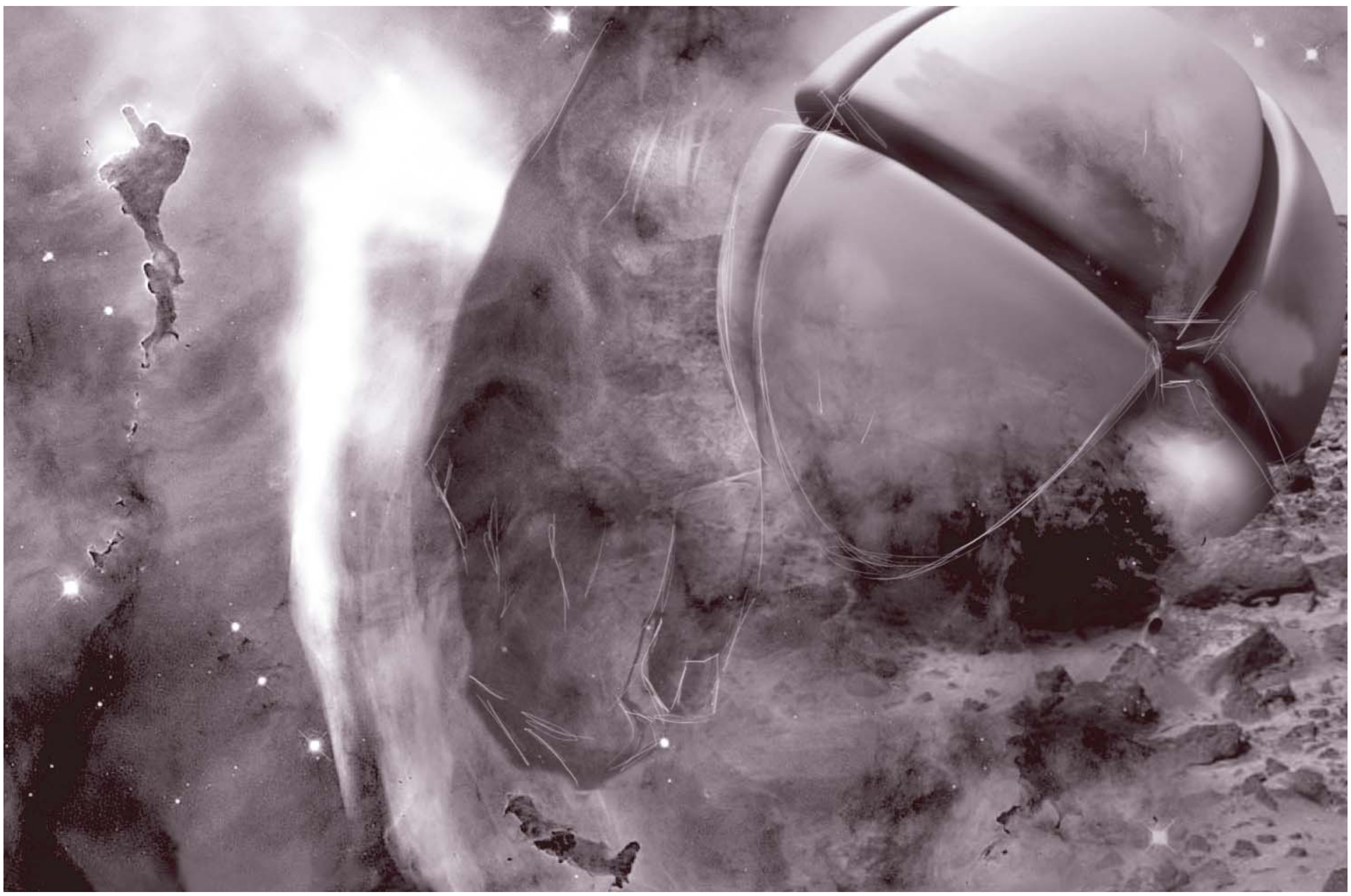
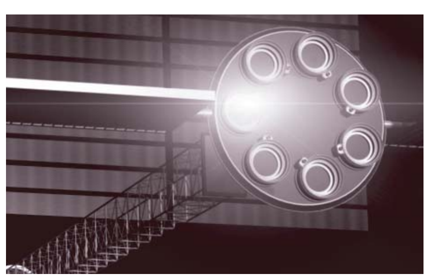
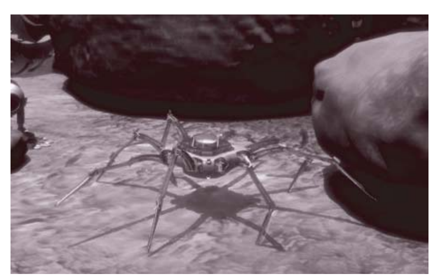
The "A" Train Express©

An Educator Guide with Activities in Mathematics, Science, and Technology







www.nasa.gov

NASA CONNECT™: *The "A" Train Express* is available in electronic format. Find a PDF version of the educator guide for NASA CONNECT™ at the NASA CONNECT™ web site: **http://connect.larc.nasa.gov**

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AIAA FOUNDATION
www.aiaa.org

ITEA International Technology Education Association
www.iteawww.org

AECC Aerospace Education Coordinating Committee
www.nasa.gov

Christopher Newport University
www.cnu.edu

NCTM
www.nctm.org

NSTA National Science Teachers Association
www.nsta.org

Knowitall.org
http://knowitall.org

NEC
NEC Foundation of America
www.nec.com

NASA CONNECT™

The "A" Train Express©

An Educator Guide with Activities in Mathematics, Science, and Technology

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AIAA FOUNDATION Registered users of NASA CONNECT™ may request an American Institute of Aeronautics and Astronautics (AIAA) classroom mentor. For more information or to request a mentor, e-mail **nasaconnect@aiaa.org**.

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Acknowledgments: Special thanks to CloudSat Outreach, CALIPSO Outreach, Chris Giersch, and The National Council of Teachers of Mathematics (NCTM).

Program Overview

SUMMARY AND OBJECTIVES

In NASA CONNECT™: *The "A" Train Express*, students will take a ride on the "A" Train Express. They will learn how weather affects everyone's daily lives. Students will see national and international scientists using satellite technology to help improve weather forecasting and our understanding of aerosols and clouds. They will also be introduced to two NASA satellite Earth Science missions, CALIPSO and CloudSat. By conducting inquiry-based and web activities, students will make connections between NASA research and the mathematics, science, and technology they learn in their classrooms.

STUDENT INVOLVEMENT

Inquiry-Based Questions

Host, Jennifer Pulley, and NASA scientists will pose inquiry-based questions throughout the program. These questions allow the students to investigate, discover, and critically think about the concepts being presented. When viewing a videotape or DVD version of NASA CONNECT™, educators should pause the program at the designated segments so students can answer and discuss the inquiry-based questions. During the program, Jennifer Pulley and NASA scientists and engineers will indicate the appropriate time to pause the tape or DVD. For more information about inquiry-based learning, visit the NASA CONNECT™ web site, **http://connect.larc.nasa.gov/**.

Teacher note: Please preview the program before introducing it to your students so that you will know where the pauses occur.

Hands-On Activity

The hands-on activities are teacher created and aligned with the National Council of Teachers of Mathematics (NCTM) Standards, the National Science Education Standards (NSES), and the International Technology Education Association (ITEA) Standards for Technological Literacy. There are two activities for this NASA CONNECT™ program, *Sizing Up the Clouds* and *Aerosols Protocol*. In *Sizing Up the Clouds*, students will set up simulated "clouds" to represent three cloud types and to estimate the "precipitation" contents of each cloud. In *Aerosols Protocol*, students will measure the atmosphere's optical thickness—how much of the Sun's light is scattered or absorbed by particles suspended in the air. This activity is part of the GLOBE program and can be downloaded from the GLOBE web site. To learn more about GLOBE, visit **http://www.globe.gov**.

Squeak Laser Challenge Web Activity

The activity is aligned with the National Council of Teachers of Mathematics (NCTM) Standards, the National Science Education Standards (NSES), and the International Technology Education Association (ITEA) Standards for Technological Literacy. Students will measure, plot, and analyze data on laser beam intensity as a function of cloud and aerosol thickness. They will also use their data plot to determine an unknown thickness of a cloud or aerosol. To access the Squeak Laser Challenge Web Activity, go to the NASA CONNECT™ web site **http://connect.larc.nasa.gov**.

RESOURCES

Teacher and student resources support, enhance, and extend the NASA CONNECT™ program. Books, periodicals, pamphlets, and web sites provide teachers and students with background information and extensions. In addition to the resources listed in this educator guide, the NASA CONNECT™ web site **http://connect.larc.nasa.gov** offers online resources for teachers, students, and parents.

hands-on activity #1

SIZING UP THE CLOUDS

BACKGROUND

Clouds Are Not All Fluff!

Most of us see clouds as fluffy or wispy white things that break up the monotony of a blue sky or as gray blankets that cut off the sunshine and bring rain or snow. Actually, clouds play an important and very complex role in influencing our environment. Small changes in their abundance or distribution cause changes not only in weather and atmospheric circulation, but also in the way climate responds to greenhouse gases, such as the carbon dioxide from our automobiles and factories and from other sources of pollution. These factors can determine where and when more clouds are produced. We know very little about how that interactive feedback process works, however. Earth observing satellites have produced comprehensive pictures of global cloud cover, as well as how clouds either reflect or hold in radiant heat energy from the Sun. That heat energy is what drives the planet's climate and weather, but so far we do not understand how that energy is distributed throughout the atmosphere from cloud tops to Earth's surface. What we need is a tool, like radar, that can actually see into clouds. "Conventional" long radar waves are reflected from solid objects such as cars and airplanes but go right through or are absorbed by clouds, but when radar waves are only a few millimeters long, the water and ice in clouds reflect them. This kind of millimeter radar is used to track clouds and forecast weather. Ground-based weather radars typically view the horizon in all directions. They show position and movement of local clouds and precipitation but are not designed or positioned to examine clouds from top to bottom.

NASA's CloudSat mission will do just that. It will use radar in a unique way to discover more about the interiors of clouds. The CloudSat satellite will have a special downward-looking weather radar. It will look into clouds beneath it and view them from the top down. CloudSat will measure a cloud's thickness, as well as the altitudes of its base and top above the Earth. It will make vertical cloud profiles to identify the altitudes of liquid and ice water content. Other satellites will measure other things at the same time in the same location. We will then collect and compare the data from all sources to improve weather and climate prediction models. Results of the CloudSat mission can help the world's weather forecasters answer the following questions for a cloud of specific dimensions at a specific time and place:

- How much water and ice is the cloud expected to contain?
- How much of that water is likely to turn into precipitation?
- What fraction of the globe's cloud cover produces precipitation that reaches the ground?

To learn more about CloudSat, visit the CloudSat web site at **http://cloudsat.atmos.colostate.edu**.

INSTRUCTIONAL OBJECTIVES

The student will estimate the "precipitation" contents of three cloud types by using different scientific methods.

NATIONAL STANDARDS

NCTM Mathematical Standards

Numbers and Operations

- Understand numbers, ways to represent numbers, relationships among numbers, and number systems.
- Compute fluently and make reasonable estimates.

NSES Science Standards

Science as Inquiry

- Ability to do scientific inquiry

Earth and Space Science

- Structure of the Earth system

NASA RELEVANCE

CloudSat will be the first satellite to get the "inside" story on clouds (vertical cloud profiling) from space. This information will improve weather forecasting and will make predicting hazardous events, such as floods and tornadoes, more accurate.

PREPARING FOR THE ACTIVITY

Student Materials

- Student Observation Data Sheet
- pencil or pen
- calculator

Teacher Materials for Cloud Demo

- 3 nontransparent paper or Sytrofoam® cups with lids, each a different size (such as 12, 14, and 16 ounces)
- 1 beaker or cup of any convenient size and material
- X-acto® or box knife
- 3 1 and 1/2-in. x 2-in. Post-it® notes
- transparent tape or masking tape
- 1 marker pen
- 1 postal type scale (or kitchen scale) with at least 16-ounce capacity
- 1 small, narrow-beam flashlight (Mini Maglite® works great.)
- 1 transparent measuring cup, calibrated in ounces, with measuring capacity of at least 16 ounces
- 2 14-ounce bags of M&Ms® (Similar small candies, pebbles, or beans, can be used instead.)
- 2 small plastic bags (sandwich size)

Setup for Cloud Demo

1. Cut a 3/4-in. diameter hole in the center bottom of each cup. Cover the hole with a 1 and 1/2-in. x 2-in. Post-it®. (See Figure 1.)

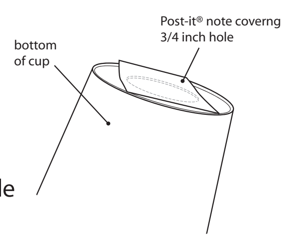


Figure 1

2. Place about 1 ounce (volume) of M&Ms® in one of the plastic bags. Gathering the candies into one corner of the bag, twist the bag tightly and tie the excess bag material in a knot. Cut off the excess to make a compact bundle. Repeat to make a second bundle of M&Ms®. (Because these bundles will not fall through the 3/4-in. hole, they will represent the portion of a cloud's moisture that may not be converted to precipitation.) (See Figure 2.)

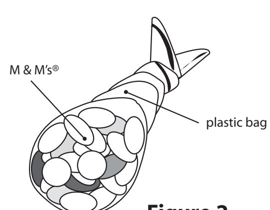
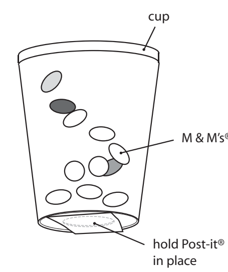


Figure 2

3. Holding Post-its® in place, fill cups in this way:
   - Select any cup, and pour it about 1/2 full of M&Ms®; next, add one of the M&M® bundles to make it 2/3 full; then add more loose M&Ms® to fill the cup about 3/4 full.
   - Select another cup and fill it about 1/3 full of M&Ms®.
   - Select the third cup and fill it about 1/4 full of M&Ms®; drop in the other bundle of M&Ms®; then add more loose M&Ms® to make the cup 1/2 full. (See Figure 3.)

Figure 3



4. Put lids securely on cups. To hold them firmly, tape the joint with transparent tape or masking tape. (See Figure 4.)
5. Invert the cups.
6. With a marker, mark the three cups as "Type X", "Type Y", and "Type Z."
7. Below the X, Y, and Z designations, mark the actual capacities; for example, "12 oz," "14 oz," and "16 oz."
8. Put a few ounces of M&Ms® into the beaker.

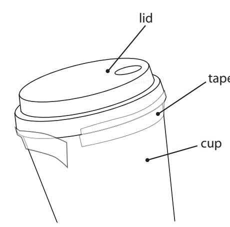


Figure 4

On a table where all the group members can view them, place the three inverted cup "clouds." Place the measuring cup, postal scale, flashlight, and beaker on the same table.

Teacher Note: *Students should work in groups for this activity. Some teachers may wish each group to have its own setup. Keep in mind that multiple setups will require more materials and longer preparation time.*

Time for Activity

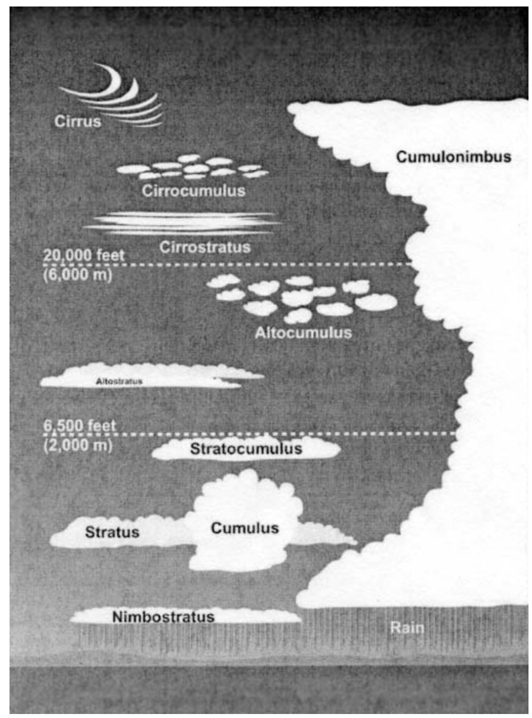
- 60 minutes (watching the video and discussing the inquiry-based questions)
- 15 minutes (preparation time)
- 60 minutes (the activity)

THE ACTIVITY

Brief Description

In this activity, you will set up three simulated "clouds" to represent three cloud types. Students will use different methods to estimate the "precipitation" contents of each cloud type. Each method is roughly analogous to methods actually used in weather forecasting. Finally, the "precipitation" from each cloud will be released, and the students will compare their estimates to what is actually experienced on the "ground." In addition to gaining an appreciation of weather forecasting issues and technologies, students will practice math skills, including estimation, percentages, ratios, and averages.

Lesson Description



ENGAGE

View the NASA CONNECT™: *The "A" Train Express* program and answer all inquiry-based questions.

Teacher led discussion: Read the following text to your students and have them try and answer the inquiry-based questions. Remember, these questions are very difficult, and students aren't expected to know all the answers.

Forecasting the weather is a tricky business. In spite of weather satellite images, ground-based weather radar, all sorts of high-tech atmospheric measurement devices, and computer programs to analyze all the data, forecasts of local weather and climate trends are still far from 100 percent accurate.

So, why is predicting the weather so difficult?

Well, take clouds. Can you look at the sky and predict whether the clouds you see are going to produce any rain right where you are standing? The sky over your town can be covered with thick clouds for days, but they may never release enough moisture to even wet the sidewalks. Big, fluffy, juicy-looking clouds can rise up from the horizon…and then just disappear.

What fraction of the globe's cloud cover do you think actually produces precipitation that reaches the ground? Give up?

Here's a more basic question: For a cloud of specific type and dimensions, at a given location and time, how could you tell

- *What proportion of it is likely to be liquid water and ice?*
- *How much of that water and ice is likely to turn into precipitation?*

Don't know that one either? Neither do weather experts! These are difficult questions. The following activity will give you a first-hand look at why.

EXPLORE

Test Your Forecasting Skills

As you know, clouds occur in a variety of types, such as cirrus, cumulus, cumulonimbus, and so on, depending on their altitude, moisture content, winds, and other atmospheric conditions.

Your teacher will hand out the Student Observation Data Sheet to each student.

The three cups your teacher has prepared represent three different make-believe cloud types (not actual or specific cloud types) that we will call Type X, Type Y, and Type Z. These make-believe cloud types all produce precipitation in the form of small candies (or other small objects your teacher chose to use). The objective is to estimate, as closely as possible, how much precipitation each cloud type produces. You will observe the clouds in several different ways to make your estimates.

Method 1: Satellite Image and Weather Radar View

Currently, meteorologists estimate the precipitation content of clouds by viewing satellite photos of cloud coverage in their areas. They might also look at cloud images on the screen of ground-based weather radar as the radar sweeps around the horizon.

Those views are not so different from the view you have as you look at these cup "clouds."

As you examine the "clouds," do your best to estimate how many ounces (volume, not weight) of "precipitation" each cloud type contains. Record your estimate on the Student Observation Data Sheet as "Satellite Image and Weather Radar View." Note that each cup is labeled with its volume (not weight) capacity. The "ounce" unit can be confusing because it is used to measure both volume (how much space something takes up) and weight.

It's difficult, of course, to make this kind of precipitation estimate without knowing more about what's inside the clouds. Currently, the amount of water in real clouds cannot be estimated closer than a factor of two; that is, the cloud could have twice as much water or half as much water as estimated. So predicting how much of it will change into precipitation is a lot like the kind of speculating you've just done.

Method 2: Cloud Profiling Radar (CPR) View

CloudSat is a research satellite. Its mission is to gather information that will allow more accurate estimates of cloud precipitation content and other characteristics related to climate and weather. The CloudSat satellite will use a special Cloud Profiling Radar (CPR). The CPR can tell a lot about moisture content and air current activity within the cloud. For now, let's see what a CPR view might do to improve our estimates.

Pretend the light from the little flashlight is the CPR beam.

Teacher note: *The teacher will now remove the Post-it® cover from each cloud.*

Without touching the clouds, each group takes a turn using the CPR (flashlight) beam to peer into the hole of each cloud to observe the level of candies inside it. From your CPR observation, make a new estimate of how many ounces of precipitation each cloud type contains and record it on your Student Observation Data Sheet as "CPR View."

Method 3: Moisture Content Data From Other Sources

CloudSat will orbit in close formation with four other Earth observing satellites that gather different data on the same cloud in different ways. The data from all of them will be combined. This constellation of satellites is nicknamed the "A" Train.

In our example, the postal scale will represent the "A" Train group, and its weight report will represent the "total moisture content" data of a single cloud, as combined from all "A" Train sources. Choose one person from the class to weigh each cloud on the scale, one at a time, and announce the weight, in ounces, to the whole class. Record the weights on your Student Observation Data Sheet as "Moisture Content Data From Other Sources." Remember, weight ounces do not equal volume ounces.

Method 4: Revised Precipitation Estimate From Moisture Content Data

Can you use this "A" Train data to refine your CloudSat volume estimates?
(Your teacher will review the concepts of ratios if you have trouble.)

Math Review: Ratios of exact weight can now be set up among the three cloud types. These exact weight ratios can be compared to ratios of guessed volumes. Volume guesses can be improved by adjusting them to match weight ratios.

For example, suppose your CloudSat volume estimates for the three clouds were
• X Type = 2 ounces
• Y Type = 4 ounces
• Z Type = 6 ounces
or $X_V = 2$, $Y_V = 4$, and $Z_V = 6$, where V = volume.

And the weights were actually
• X Type = 4 ounces
• Y Type = 5 ounces
• Z Type = 8 ounces
or $X_W = 4$, $Y_W = 5$, $Z_W = 8$, where W = weight.

You see now that Z_W (8 ounces) weighs twice as much as X_W (4 ounces), but you had estimated Z_V (6 ounces) to have 3 times the volume of X_V (2 ounces). You must decide now whether to revise your volume estimate for Z_V down to 4 or your volume estimate of X_V up to 3. Or, you could split the difference and say the volume of X_V is 2.5 and $Z_V = 5$. As for Y_W, you see that the weight ratio of Y_W:X_W is 5:4 or that Y_W weighs 1.25 times (5 / 4 = 1.25) more than X_W. Multiply whatever your revised volume estimate is for X_V times 1.25 to get your revised estimate for Y_V.

Note your revised volume estimates on a separate line on your Student Observation Data Sheet (p.13) as "Revised Precipitation Estimate From Moisture Content Data."

Method 5: Checking in With the Ground

CloudSat's data will ultimately be compared with simultaneous measurements from many sources, including ground stations, so scientists can learn as much as possible about each cloud studied. The actual precipitation coming out of the clouds can then be compared with the data observed in the clouds. In our example, we can make ground station measurements of all three clouds right now.

Choose one person (maybe your teacher) to take each cloud, in turn, and invert it over the measuring cup, shaking and jiggling the cloud until no more "rain" (candies) can be shaken out. This person then reads, aloud to the class, the volume level from the measuring cup.

Record these readings on your Student Observation Data Sheet as "Precipitation recorded by ground station."

EXPLAIN

Journal Write: Working in your groups, answer the following questions in your journals.

1. How do these data compare with your estimates?
2. How do your estimates compare with other group estimates?
3. What factors might cause differences?
4. If you had another X, Y, or Z cloud type of a different size, could the data you've collected help you predict a more accurate precipitation forecast for it? How would you go about it?

Discuss the answers to these questions with your teacher and peers.

EXTEND

Select one group *(maybe the group that had the best estimated values from the activity, or perhaps your teacher can make a new set)* to create another set of experimental cloud types (X, Y, and Z). This time, the selected group should use different size cups. The remaining groups should repeat the experiment by using the new experimental cloud types.

EVALUATE

Each group should develop a method of determining its level of improvement in estimating the precipitation content of each cloud. In other words, did your group's estimation skills improve in the second activity? How much? Did the class collectively improve its estimation skills?

Teacher note: *Points may be assigned for this process or corrections can be made.*

Student handout

Student Observation Data Sheet

Measurement Method	Cloud Type X	Cloud Type Y	Cloud Type Z
1.			
2.			
3.			
4.			
5.			

Hands-On Activity 2:

Aerosols Protocol

BACKGROUND

Aerosols Protocol, an activity designed by GLOBE, is a worldwide, hands-on, primary and secondary school-based education and science program.

For students, GLOBE provides the opportunity to learn by doing the following:

- Taking scientifically valid measurements in the fields of atmosphere, hydrology, soils, and land cover/phenology—depending upon their local curricula
- Reporting data through the Internet
- Creating maps and graphs on the free, interactive web site to analyze data sets
- Collaborating with scientists and other GLOBE students around the world

For teachers, GLOBE provides assistance through

- Training at professional development workshops
- Teacher's Guide "how-to" videos and other materials
- Continuing support from a help desk, scientists, and partners
- Contact with other teachers, students, and scientists worldwide

To learn more about GLOBE and how to join, please visit GLOBE's web site at **http://www.globe.gov**.

The purpose of the Aerosols Protocol is to measure the atmosphere's aerosol optical thickness (how much of the Sun's light is scattered or absorbed by particles suspended in the air). Upon completion of this activity, students will understand the concept that the atmosphere prevents all of the Sun's light from reaching Earth's surface and what causes hazy skies.

The teacher guide for the protocol can be accessed from the GLOBE web site.

- Go to **http://www.globe.gov/fsl/welcome.html**.
- Click on Protocols *(left-hand side of the screen)*.
- Under Atmosphere/Climate, click on "Aerosols."

All GLOBE protocols can be downloaded in PDF format. If you do not have Adobe Acrobat Reader on your computer, you can download it at **http://www.adobe.com/products/acrobat/readstep2.html**.

INSTRUCTIONAL OBJECTIVES

The student will measure the aerosol optical thickness of the atmosphere

NATIONAL STANDARDS

NCTM Mathematical Standards

Numbers and Operations

- Understand numbers, ways to represent numbers, relationships among numbers, and number systems

Algebra

- Understanding patterns, relations, and functions

NSES Science Standards

Science as Inquiry

- Ability to do scientific inquiry

Earth and Space Science

- Structure of the Earth system
- Earth in the solar system

ITEA Standards for Technological Literacy

Standard 5: Students will develop an understanding of the effects of technology on the environment.

NASA RELEVANCE

The CALIPSO satellite will use lidar *(light detection and ranging)* to provide vertical, curtain-like images of the atmosphere on a global scale. The lidar technique is similar to radar in operation, but lidar uses short pulses of laser light instead of radio waves to probe the atmosphere. The lidar data from CALIPSO will allow scientists to determine precisely the altitudes of clouds and aerosol layers and the extent of layer overlap, to identify the composition of clouds and to estimate the abundance and sizes of aerosols.

Resources

WEB SITES

CloudSat Outreach

http://cloudsat.atmos.colostate.edu

CALIPSO Outreach

http://calipsooutreach.hamptonu.edu/

GLOBE

http://www.globe.gov

The CERES S'COOL Project

http://scool.larc.nasa.gov

Exploring the Environment™

http://cotf.edu/ete/

Earth Science Explorer

http://www.cotf.edu/ete/modules/msese/explorer.html

Teaching Earth Science

http://earth.nasa.gov/education

Dr. Art's Guide to Planet Earth

http://www.planetguide.net

Figure This!
This site offers online mathematics challenges that middle school students can do at home with their families to emphasize the importance of a high-quality mathematics education for all.
http://www.figurethis.org

Engineer Girl
This site highlights the National Academy of Engineering's Celebration of Women in Engineering project. The project brings national attention to the opportunity that engineering represents to people of all ages, but particularly to women and girls.
http://www.engineergirl.org

NCTM (National Council of Teachers of Mathematics)
http://www.nctm.org