ARM
CLIMATE RESEARCH FACILITY

# EDUCATION NEWS

## Aerosol in the Atmosphere: Part of Earth's Climate Balance

In this issue:



What comes to mind when you hear the word aerosol? Do you picture a can of spray paint or hair spray? Most people do, but to a climate scientist, the word aerosol means small particles suspended in the air, like dust, soot, or sea salt. These particles can be so small that you would need a microscope to see them. Most aerosols are smaller in diameter than a strand of hair!

*Courtesy Daniel Rosenfeld*

Aerosols come from many places in nature. In addition to blowing dust into the air, wind dries up water droplets from ocean spray leaving small salt particles behind. Large forest fires lift soot—the small dark particles in smoke—into the air. Even volcanoes produce aerosols, shooting ash and sulfur high into the atmosphere with their explosive eruptions. People can also create aerosols. When we drive cars, burn coal and gas to create electricity, and manufacture goods, we release small particles of soot, sulfur, and other material into the atmosphere.

### What's the big deal about aerosols?

On a hazy day, there are lots of aerosols in the atmosphere and you can't see very far into the distance. This "haze" comes from light that is bounced around by the aerosols in the air.

Energy gained from incoming sunlight and lost from the warm Earth into cold space determines the average temperature and climate of the Earth. This is called Earth's energy balance. Just like the view on a hazy day, aerosols in the atmosphere scatter sunlight back into space, cooling the Earth.

### About ARM:

*The Atmospheric Radiation Measurement (ARM) Climate Research Facility is a U.S. Department of Energy scientific user facility for the study of global climate change.*

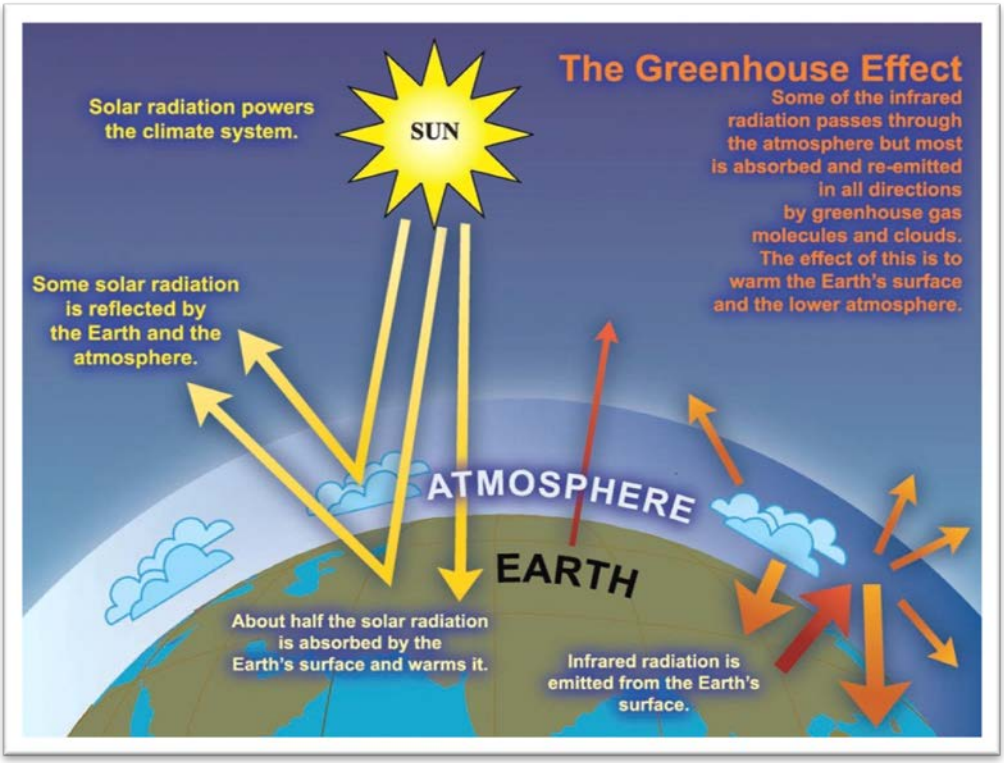
*As part of its outreach program, ARM provides education resources for students, teachers, and communities.*

**www.arm.gov**

U.S. DEPARTMENT OF ENERGY | Office of Science

To understand the climate of the Earth and what causes it to change, scientists keep track of all the elements of the atmosphere that scatter and absorb light and heat, including clouds, gases, and aerosols. Each of these elements shift the balance of energy by absorbing heat and light or reflecting sunlight back into space.

For example, records show that more carbon dioxide in the atmosphere absorbs heat, warming the Earth. It is relatively easy to measure this because the amount of carbon dioxide in the atmosphere changes slowly and mixes well throughout the atmosphere. Therefore, measurements of carbon dioxide made anywhere are a good indication of the change in carbon dioxide throughout the Earth's atmosphere.




It is much more difficult, however, to measure how changes in aerosols will impact the climate. Aerosols in the atmosphere both reflect and absorb sunlight, either cooling or heating the Earth depending on what they are made of—soot, dust, salt, and sulfur. Aerosols can also change cloud reflectivity by providing more particles for cloud water droplets to form on, reflecting more sunlight back into space and cooling the Earth. This effect also depends on what type and how many aerosols are in the atmosphere, as well as the altitude of the clouds. Because the number and type of aerosols changes quickly and regionally, it is difficult to know how many aerosols of each type exist around the Earth at any given time.

## The Two-Column Aerosol Project

To better measure the impact of aerosols on the climate, the Atmospheric Radiation Measurement (ARM) Climate Research Facility is pulling out all the stops for the Two-Column Aerosol Project (TCAP). Starting in July 2012 and lasting a year, the ARM Facility's portable observatory, called the ARM Mobile Facility, is operating dozens of instruments for measuring aerosols, clouds, light, heat, and the state of the weather at Cape Cod National Seashore in Massachusetts.

*Shown in Germany during a precipitation study, this is a typical setup of the ARM Mobile Facility instruments and shelters. The Mobile Facility is operating at Cape Cod National Seashore from July 2012 to June 2013 for an aerosol study.*

Similar scientific instruments on board a research aircraft will take measurements above the mobile facility and out over the ocean for several days a week in July 2012 and February 2013. The measurements obtained during this field campaign will be used to compare the impacts of aerosols during summer and winter, during polluted and clean times, and in different weather conditions.

*The G-1 plane carries an assortment of probes for measuring clouds and aerosols in the sky.*

A special focus of the TCAP campaign is to observe the details of how chemical reactions change aerosols over time, and whether that makes it easier or harder to form cloud droplets. Cape Cod's unique geography—a long isolated coastal spit downwind of major metropolitan areas—makes it an ideal location to capture these details. This information will help scientists improve the computer models that predict the impact of aerosols on Earth's climate.

## TCAP Educational Outreach

Throughout the campaign, a Cape Cod National Seashore Education Ranger is collaborating with ARM staff to coordinate teacher resources and student activities that will correspond to the research being conducted by TCAP scientists. This effort is intended to provide students with hands-on experience in physical science, Earth and space science, math, and critical thinking skills used by research scientists.

### Definitions

- **Aerosols:** Particles in the atmosphere. There are an abundance of naturally occurring aerosols in the Earth's atmosphere, e.g., dust and salt from sea spray. Pollution also contributes aerosols for cloud formation.
- **Atmosphere:** The air surrounding and bound to the Earth by gravity.
- **Cloud droplets:** The small drops of water that make up a liquid cloud. These cloud droplets are quite small—often a few thousandths of a millimeter!
- **Earth's energy balance:** The heat that the Earth absorbs from the sun minus the heat emitted from the Earth back into space.
- **Haze:** Aerosols in the atmosphere that reduce visibility.

**Did you know?**
Each day during TCAP, trained local assistants are launching weather balloons four times a day from the ARM Mobile Facility site. As each balloon rises through the air, a sensor tied to the balloon records measurements of temperature, pressure, wind, and humidity. These data provide researchers with a record of the environment in which to consider all the other measurements. Weather balloons like this are launched from 70 other locations across North America each day—one of which is located nearby in Chatham, Massachusetts.

### ABOUT ARM EDUCATIONAL OUTREACH

The goal of ARM Educational Outreach is to develop basic science awareness and increase critical thinking skills focusing on environmental science and climate change for K-12 students. Resources for students and teachers are available at:
**education.arm.gov**

*Try our social media channels!*

**Related Activity:** Making Clouds

**Grade Level:** 6th–8th

**Objective:** Investigate what conditions must be present for clouds to form.

**Materials:**

Each student or group of students will need the following:

- 1 liter (or larger) clear glass jar with lid (large-mouth jars work best)
- Ice cubes or crushed ice
- Hot water
  **Caution:** Even very warm water will do. Do not use water that is hot enough to burn your skin.
- Matches (NOTE: **To be used under adult supervision**)
- Can of aerosol spray (air freshener is suggested)
- Black construction paper
- Safety goggles
- Flashlight (optional)

**Preparation**

- Before the lesson begins, discuss cloud formation with the class to determine the students' ideas on how clouds form. Ask students what they think a cloud is made of, and then ask them how it forms. This information can be input on a chart or on a document camera to be revisited in the future.
- Be sure that all materials are either centrally located or already distributed to the students. Perhaps the students could bring clear glass jars, such as mayonnaise jars, pickle jars, canning jars, etc., from home. The jars do not have to be the same shape, but clear glass works best. The larger the mouth of the jar, the better the experiment.

**Safety Tip: VERY IMPORTANT!**

Depending on the students, the teacher may choose to light all matches for them to reduce the risk of accidents and the temptation for horseplay. Be careful: Flames and aerosol cans are an explosive combination. Holding a lighted match in front of an aerosol can makes a very effective flame thrower. Students **must never** have access to both the matches and the aerosol at the same time. If, in the teacher's opinion, this represents too great a risk for his or her students, it is strongly recommended that the aerosol not be used at all. *The important points of this activity can still be made using only smoke.*

Each trial in this experiment (Control and Match) will be conducted three times. The final trial is done once with an aerosol. This will make a total of seven trials.

**Procedure:**

1. Fill the jar with hot water. Do not use water that is hot enough to burn your skin.
2. Pour out most of the hot water, but leave about 2 centimeters of water in the bottom of the jar. Hold the black paper upright or prop it up against some books behind the jar.
3. Turn the lid of the jar upside down and fill it with ice. Now place the upside-down lid on the jar. Observe the jar for 3 minutes. If you have a flashlight, darken the room, and shine the flashlight on the jar while you observe it. Record your observations in the table, under "Control."
4. Pour the water out of the jar and repeat steps (1) and (2). Record additional observations.
5. Prepare the lid so that you can immediately cover the mouth of the jar during the next step.
6. Move all loose papers away from the jar, put on your safety goggles, then strike a match and drop the burning match into the jar. Cover the mouth of the jar immediately (with the ice-filled lid). Record your observations in the table, in the box marked "Match." Be extremely careful with the matches as they may still be very hot.
7. Pour out the water in the jar and repeat steps (5) and (6). Record your observations in the table, under "Match."
8. Spray a very small amount of the aerosol in the jar and immediately cover the mouth of the jar with the ice-filled lid.
9. Observe what happens in the jar for three minutes and record your observations in the table in the box marked "Aerosol."

**Questions**

1. In all the trials of this experiment, the jar contained water vapor and cooled air. Where did each come from?
2. Did a cloud form the first time you put the lid over the mouth of the jar? How about the second and third times?
3. Define *aerosol*.
4. Based on the definition of aerosol, would you classify smoke as an aerosol?
5. Based on your observations and your answers, what is the other condition besides moisture and cool air necessary for cloud formation?

For the full lesson plan, visit:
http://education.arm.gov/teacherslounge/lessons/Making-Clouds-Gr-6-8.pdf