

## LESSON 4

# Aerosols & Clouds

### INTRODUCTION & BACKGROUND

#### ***What are aerosols?***

**Aerosols** – incredibly small particles suspended in air – are a vital ingredient in cloud formation. Aerosol particles range in size from about “10 nm (1 nanometer is a billionth of a meter) to around 100 micrometers (1 micrometer is a millionth of a meter)” (NASA, 2005). Aerosols provide substrates, or surfaces, upon which water molecules condense, grow into drops and eventually fall as rain. Students who are familiar with the water cycle may know that water vapor condenses into liquid water droplets, but the concept of aerosols may be new.

Aerosols can be classified either by source – industrial pollution, fires, desert storms, volcanic eruptions, sea spray or products from living things (pollen, spores, etc...) or by composition – carbon-based, sulfur-based, or mineral-based.

#### ***How do aerosols affect climate and clouds?***

Aerosols affect climate. Aerosols can scatter incoming sunlight, resulting in cooling of the ground below. Conversely, aerosols can absorb energy from sunlight and warm layers of air. In addition, aerosols can prevent clouds from forming thick enough to cool the Earth below. Atmospheric systems are complex. It is difficult for scientists to predict the effects of aerosols on climate because aerosols are transitory – the particles do not remain suspended in the atmosphere for long periods of time. NASA scientists estimate that aerosol particles are in the atmosphere for only a few days before rain washes them away (2005).

Aerosols affect cloud formation. Without aerosols, rain clouds would not form. As water molecules condense on aerosol particles and form tiny droplets, they

join together and form larger and larger drops, until they are heavy enough to fall as rain. The concentration of aerosol particles affects the size of rain drops. The overall amount of water is the same; the size of rain drops and duration of clouds varies. For example, with a high concentration of aerosol particles, the water is spread out over a greater area and the rain drops that form are smaller than they would be if there were fewer aerosol particles. Smaller drops of water are not as heavy as large drops, so they are more likely to remain in the clouds. (See Figures 5a, 5b, p. 5, NASA Fact Sheet: *Aerosols: More Than Meets the Eye* for pictures of how aerosols affect rain drop size).

#### ***How do scientists study aerosols?***

Scientists study aerosols using both satellites (such as NASA’s TERRA and CALIPSO satellites) and instruments called “sun photometers.” Data from sun photometers are typically more precise than satellite data. The researchers on board *Ocean Watch* will measure the amount of solar energy passing through the atmosphere using a sun photometer. The photometer on *Ocean Watch* measures sunlight in six different color bands from violet to red. The amount of sunlight that reaches the Earth is affected by the concentration of aerosols in the atmosphere. The higher the concentration of aerosols, the more light is scattered, resulting in less sunlight reaching the meter. Scientists will compare data from satellites and the photometer on *Ocean Watch* to evaluate the accuracy of the satellite data. This process is called “**ground-truthing**.” Ground-truthing is important when interpreting satellite data because some conditions, like snow on the ground, can look like cloud cover from a satellite image.



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**ACTIVITY MISSION****Time: 45 min.**

Students will gain a deeper understanding of the atmospheric observations being made during the *Around the Americas* expedition by the researchers on *Ocean Watch* as they experiment with creating clouds in plastic syringes and soda pop bottles. To determine the effect of aerosols on cloud formation, students will vary both aerosol concentration (particle amount) and composition (match smoke, chalk dust, ash, salt). Student groups will work together to compare results, with each group supervising the procedure of one bottle. (Or, if time permits, each group may test each variable). Students will investigate the following questions: How do clouds form? How does the amount of atmospheric aerosol effect cloud formation? (The question, “How do aerosols vary daily, among locations, globally?” can be addressed with a companion activity).

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**CONCEPTS**

- Aerosols are very small particles suspended in air.
- Aerosols are essential for cloud formation.
- The concentration of aerosols in the air affects weather and climate.

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**LEARNING OBJECTIVES**

- Students will be able to demonstrate their knowledge of aerosols and clouds by defining terms.
- Students will be able to demonstrate their comprehension of aerosols and clouds by interpreting experimental data.

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**STANDARDS & PRINCIPLES****U.S.:** 1.6, 12.1-8**Canada:** 311-9, 210-6, 211-1, 211-2, 211-3, 211-4, 211-5**Ocean Literacy Principles:** 3a-b

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**PRE-DELIVERY PREP****Supplies Needing a Day or More to Prepare**

- 2-L dry plastic soda pop bottles with caps – Empty, rinse and remove labels.
- Fireplace ash
- Paper funnels for chalk, ash, salt: Roll a piece of paper into a funnel and secure with tape. Trim edges as necessary, leaving enough of an edge to fold over if material is pre-filled and stored. Pre-fill with fireplace ash, chalk and/or salt and fold top and bottom to store. Or, have students spoon ash, chalk or salt into the funnel during class.

**Hard-to-Obtain Materials**

- None

## SAFETY GUIDELINES

### Safety Procedures

- Supervise matches at all times.
- Use these plastic syringes only for educational purposes.

### Hazardous Materials

- Matches

### Safety Concerns for Students

- Some steps of the procedure require the cooperation of all members in each group. Practicing the steps before adding chemicals may reduce chalk/ash/salt particles being blown into the air.
- Teachers may wish to light matches.

## SUMMARY OF SUPPLIES

### Durable Supplies

ITEM	DESCRIPTION	QUANTITY
Part A:		
Syringe (no needle)	Plastic (60 mL or as large as possible)	1/group
Dropper bottle or container of water and dropper/pipet		1/group
Plastic pieces (ex: extra lids) (optional)	For sizing water drops	1/group
Part B:		
Plastic soda pop bottles	2-L	1 bottle/group of 2-3 students
Container of water		1/group of 2-3 students
Graduated cylinder/beaker or teaspoon (25 mL)		1/group of 2-3 students
Scoop	(Optional)	1 each for chalk, ash, salt/group
Clock in room or stopwatch	So students can measure seconds	1 clock/room or 1 stopwatch/group



### Consumable Supplies

ITEM	DESCRIPTION	QUANTITY
Wooden matches		1 large box
Warm water		
Black construction paper	4.5" x 6" (11.4 cm x 15.2 cm) rectangles	1/group
Tape		Approx. 2 in. (5 cm)/bottle
Chalk dust	(optional)	At least 2 tsp (2 mL)
Ash from fireplace	(optional)	At least 2 tsp (2 mL)
Salt	(optional) table salt	At least 2 tsp (2 mL)
Paper funnel	Rolled together, secured with tape	1 each for chalk, ash, salt

### PROCESS & PROCEDURE

#### Suggested order of activities:

Pre-instruction activity: Part A: Mini-clouds in a Syringe;

Post-instruction activity: Part B: Cloud in a Bottle, and Extensions

#### Part A: Mini-clouds in a Syringe – for small groups

1. Pull the plunger out of the syringe. (Keep it for Step 4.)
2. Add  $\frac{1}{4}$  drop of water into the syringe. (If you're not sure how much this is, put one drop of water onto the desk or a small piece of plastic – squeeze the dropper bottle or pipette normally. Note the size of this drop and the amount of pressure you used on the dropper bottle or pipette. Now try to create a drop that is half of a half of the droplet you just made.)
3. Cover the tip of the syringe with your thumb.
4. Put the plunger into the syringe. Hold the syringe so the tip (and your thumb) points up.
5. Select a place on the table near its edge. Put the plunger down against the table. Use the weight of your body to press it down. (As the plunger moves toward the tip, it compresses the volume of air inside the syringe.)

6. While keeping the plunger compressed, quickly drag the syringe off the table.  
(The high pressure inside the syringe will push the plunger back.)
7. Remove your thumb from the tip of the syringe and gently depress the plunger.  
(A fine mist of cloud appears.)
8. Collect syringes and re-use for educational purposes.

**Part B: Cloud in a Bottle General Experimental Procedure** – for small groups

Each student group will test one variable, share data and form conclusions.  
A description of the general experimental procedure and each variable condition:

1. Follow the instructions for your variable (see below).
2. For each trial...
  - a. Squeeze the bottle near the base. Hold for 5–10\* seconds and then release.  
(\*All trials should use the same amount of time.)
  - b. Repeat Step a (above) five times.
  - c. Observe the inside of the bottle for clouds. (Students may find it useful to tape a piece of black paper behind the bottle to detect cloud formation)
    - Do you see a cloud inside the bottle?
    - How quickly did it form? How thick is it?(Use an appropriate rating method for your students – a 1–5 scale of cloudiness, percent or uniform descriptive words)
  - d. Record your results. Clean the bottle (removing as much water as possible) and repeat the procedure.
3. Run three trials and average your results.
4. Compare results of all variables with class.

**Variables**

*No Water*

1. The bottle should be empty and dry.
2. Do not add anything to the bottle.
3. Replace the cap on the bottle.
4. Complete Steps 2–3 of the Experimental Procedure.

*Water Only*

1. Use the plastic funnel to add 50 mL (10 tsp) water to the bottle, without getting water on the sides of the bottle.
2. Put on the cap and carefully swirl the bottle for 15 sec.
3. Complete Steps 2–3 of the Experimental Procedure.



### *Water and Smoke Particles*

1. Use a plastic funnel to add 50 mL (10 tsp) water to the bottle, without getting water on the sides of the bottle.
2. Put on the cap and carefully swirl the bottle for 15 sec. Remove the cap.
3. Light a match and place it in the opening of the bottle. Do not drop it into the bottle.
4. Squeeze the bottle (blowing out the match), and let go of the bottle quickly to draw the smoke into the bottle.
5. Remove the match and replace the cap.
6. Complete Steps 2–3 of the Experimental Procedure.

### *Water and Chalk Particles*

1. Use a plastic funnel to add 50 mL (10 tsp) water to the bottle, without getting water on the sides of the bottle.
2. Put on the cap and carefully swirl the bottle for 15 sec. Remove the cap.
3. Squeeze and hold the bottle, and place the paper funnel on the opening of the bottle.
4. Put a pinch/tiny scoop of chalk dust into the paper funnel and quickly let go of the bottle to draw the particles into the bottle.
5. Remove the paper funnel and replace the cap.
6. Complete Steps 2–3 of the Experimental Procedure.

### *Water and Ash Particles*

Observe the ashes. Are the particles uniform in size? How do the particles compare to the chalk, salt or smoke particles? If more than one size is present, roughly estimate the quantity of each type of ash particle size in a scoop of ash.

1. Use a plastic funnel to add 50 mL (10 tsp) water to the bottle, without getting water on the sides of the bottle.
2. Put on the cap and carefully swirl the bottle for 15 sec. Remove the cap.
3. Squeeze and hold the bottle, and place the paper funnel on the opening of the bottle.
4. Put a pinch/tiny scoop of fireplace ash into the paper funnel and quickly let go of the bottle to draw the particles into the bottle.
5. Remove the paper funnel and replace the cap.
6. Complete Steps 2–3 of the Experimental Procedure.

### *Water and Salt Particles*

1. Use a plastic funnel to add 50 mL (10 tsp) water to the bottle, without getting water on the sides of the bottle.
2. Put on the cap and carefully swirl the bottle for 15 sec.
3. Squeeze and hold the bottle, and place the paper funnel on the opening of the bottle.

4. Put a pinch/tiny scoop of salt into the paper funnel and quickly let go of the bottle to draw the particles into the bottle.
5. Remove the paper funnel and replace the cap.
6. Complete Steps 2–3 of the Experimental Procedure.

### Clean Up

- Contents of bottles (except for ashes) can be rinsed down the sink with large amounts of water.
- Ash particles: pour liquid through a strainer. Collect ashes and add to compost or dispose in trash.
- Plastic bottles in good condition can be rinsed and re-used for other science activities (NOT FOR FOOD USE).

### Notes:

*Misconception Alert: Adults and students may associate the term “aerosols” with aerosol cans that use CFCs (chlorofluorocarbons) as a propellant. The use of CFCs as an aerosol propellant was banned in 1978 to prevent further accumulation in the upper atmosphere and protect the thinning upper ozone layer, which protects the Earth from harmful ultraviolet radiation. More information about non-CFC propellant products, including recycling methods, can be found at the Consumer Aerosol Products Council: “The Environment.” Home Page - Consumer Aerosol Products Council - CAPCO. 06 Mar. 2009 <<http://www.nocfcs.org/environment/home.htm>>.*

## K-5 ADAPTIONS

Perform Part B as a class demonstration. Use the variation (smoke, ash, chalk, salt) that is most appropriate for your region or current events.

Focus on cloud formation, identification and the role of clouds in the water cycle using additional exercises. There are some excellent activities developed by one of the collaborators of the *Around the Americas* program, the NASA Students’ Cloud Observations On-Line (S’COOL) program:

“S’COOL - For Teachers - Resources.” Education Resources from the Science Directorate at NASA Langley Research Center. 06 Mar. 2009  
<<http://science-edu.larc.nasa.gov/SCOOOL/ForTeachers-resources.html>>.

U.S.G.S. (United States Geological Survey). Water Science for Schools: The Water Cycle – Water cycle diagrams in English, French, Spanish, Portuguese, and other languages

“The Water Cycle, from USGS Water Science for Schools. Diagram available in 60 languages.” USGS Georgia Water Science Center. 06 Mar. 2009  
<<http://ga.water.usgs.gov/edu/watercycle.html>>.