



To Spread or Not To Spread

Purpose

- To help students identify contrails and learn to distinguish between the three types of contrails.
- To help students understand that contrails are human-made and that some contrails become clouds in the sky.

Overview

Students will explore the difference between the three types of contrails. Then they will make observations of contrails outside, record their observations, and then make follow-up observations 15 minutes later to see how the contrails they observed have changed.

Student Outcomes

Students will be able to: (1) identify the three types of contrails; (2) understand that contrails are created by jet airplanes; and (3) understand that some contrails become clouds.

Next Generation Science Standards

- DCI ESS-3A: Natural Resources
- Science Practice 1 Asking Questions
- Science Practice 3 Planning and Carrying Out Investigations
- Science Practice 8 Obtaining, Evaluating, and Communicating Information
- Crosscutting Concept 2 Cause and Effect
- Crosscutting Concept 6 Structure and Function

Geography Standards

- 14: How human actions modify the physical environment

Time

- Part 1: 30 minutes
- Part 2: 30 minutes

Level

Elementary (most appropriate for grades K-4)

Materials

Parts 1 and 2:

- *Elementary GLOBE* storybook *Do You Know That Clouds Have Names?*
- Small plastic cups for paint
- White tempera paint
- Paintbrushes (one per cup of paint)
- Water
- Glue sticks

For each student:

- Straw (cut in half)
- Blue construction paper
- Cut outs of jet airplanes (3 per student; use the handout at the end of the activity)
- Blue posterboard or cardstock (one per student, approximately 8x10")



Preparation

- Read the *Elementary GLOBE* storybook *Do You Know That Clouds Have Names?* – either read it to the class or have students read it to themselves. The book can be downloaded from www.globe.gov/elementaryglobe.
- Draw a vertical line on each sheet of posterboard or cardstock to divide it in half.
- Prepare cups of paint and water.
- Cut airplane stickers apart.

Teacher's Notes

Contrails are clouds that form when water vapor condenses and freezes around small dust-sized particles (aerosols) that are found in aircraft exhaust. Some of that water vapor comes from the air around the plane and some comes from aircraft exhaust. Contrails are all made of the same materials and are formed in the same way, but they exist for different lengths of time. Because of the differences in contrail “life-spans”, contrails can be divided into three groups: *short-lived*, *persistent non-spreading*, and *persistent spreading*.

1. *Short-lived contrails* look like short white lines following along behind the plane, disappearing almost as fast as the airplane goes across the sky. The air that the airplane is passing through has only a small amount of water vapor available to form a contrail. The ice particles that do form quickly evaporate again.



Figure 1. Short-lived contrail (Image: NASA)

2. *Persistent non-spreading contrails* look like long white lines that remain visible after the airplane has disappeared. This shows that the air where the airplane is flying has more moisture available than for short-lived contrails. Persistent contrails can be further divided into two classes: those that spread and those that don't. Persistent contrails look like long, narrow white chalk-lines across the sky.



Figure 2. Persistent, non-spreading contrail (Image: NASA)

3. *Persistent spreading contrails* initially look like long white lines. After some time they begin to look like they are turning into cirrocumulus or cirrus clouds. They last longer than short-lived or persistent non-spreading contrails.



Figure 3. Persistent, spreading contrail (Image: NASA)

Because contrails are formed at high altitudes where the winds are usually very strong, they will move away from the area where they originated.

Contrails are “human-induced” clouds because they are formed by water vapor coming from the air and jet planes that condenses on particles from airplane exhaust. Other types of clouds are also



formed by water vapor that condenses on particles which are present in the atmosphere due to many sources, such as from volcanoes or dust storms, not specifically from aircraft exhaust.

Contrails only form at very high altitudes (usually above 8000 m) where the air is extremely cold (less than -40 degrees C). Other clouds can form at a range of altitudes, from very close to the ground, such as fog, to very high off the ground, such as cirrus clouds.

Because any change in global cloud cover may contribute to long-term changes in Earth's climate, it's important to study contrails. Contrails, especially persistent contrails, represent a human-caused increase in the Earth's cloudiness, and may affect climate. In general, contrails contribute to climate warming because they don't block incoming solar radiation like other clouds and they help hold heat in the atmosphere.

Scientists are most interested in persistent contrails because they form long-lasting and sometimes extensive clouds that would not normally have formed in the atmosphere. Persistent contrails can last for hours to days, and spread over thousands of square kilometers, becoming indistinguishable from naturally occurring cirrus or cirrocumulus clouds.

Scientists are concerned about contrails because predicted increases in air-traffic could result in a continued increase in cloud cover. Knowing when and where contrails form is key to determining their contribution to cirrus cloud cover and their effect on the energy balance. Thus, collecting information on short-lived contrails is also of interest.

Note: in this activity, the use of paint is an analogy of what happens in the formation of contrails. Please explain to students that they are not really modelling the same processes that occur in the atmosphere during the formation of contrails.

What To Do and How To Do It

Part 1:

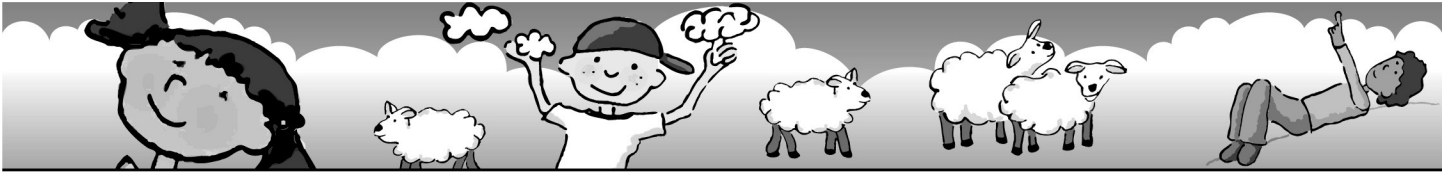
(This section works well as a center where students rotate to this and other activities.)

1. Provide students with three cups of paint, a paintbrush in each cup, and a piece of blue construction paper (the inexpensive, absorbent paper works best). Label and fill the cups using the following ratios (paint:water)
 - Cup A (Short-lived contrails) - put in white paint and thin it with water (1:6)
 - Cup B (Persistent non-spreading contrails) - fill it with thick white paint (1:0)
 - Cup C (Persistent spreading contrails) - put in white paint and thin it with water (1:3)
2. Give three airplane stickers to each student and have them evenly space the stickers down the side of their construction paper. You may also photocopy the images of airplanes provided in this packet and have the students tape or glue the airplane to their paper. The airplane should appear to be flying off the paper.



Figure 4: Making paint contrails on blue paper

3. Model for the students how to paint the three types of contrails on their paper:
 - **Short-lived contrails:** dip the brush into cup "A". Start by the airplane tail and make a line across the paper. Watch it. Blow on it with a straw so it dries faster. The line will slowly go away.
 - **Persistent non-spreading contrails:** dip the brush into cup "B" being sure to stir the brush well. Then make a line across the page. Start by the airplane tail. This line will remain white and



distinct even after blowing on it with a straw to dry it.

- **Persistent spreading contrails:** dip the brush into cup “C”. Start by the airplane tail and make a line across the paper. The line will spread out, but the line will remain even after blowing on it with a straw to dry it.
4. Emphasize that all contrails, like clouds, eventually disappear from the sky.
 5. Have the students do these steps on their own after seeing them modeled by the teacher. They might want to label the three contrails to help them remember which type each one is.

Part 2:

After your students have experimented with the three types of contrails, take them outside to make observations on a day when contrails are present in the sky.

1. Give each student a piece of heavy cardstock or poster board in a size that is workable for their grade level. Draw a vertical line down the center of the paper before passing it out. Draw a version of Figure 5 (below) on the board or chart paper to demonstrate what students need to do.

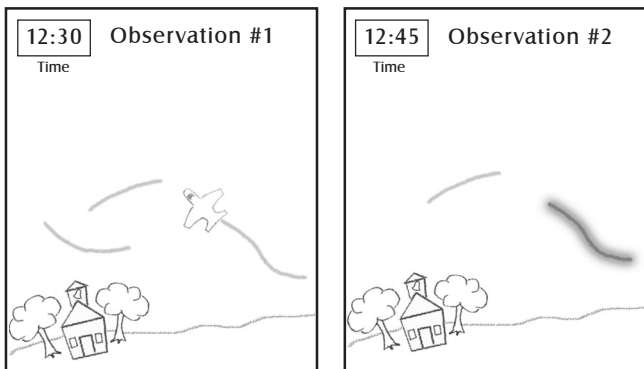


Figure 5: Example of contrail observations. Note that contrails will appear high in the sky when they are directly overhead and others will appear close to the horizon if they are at a distance.

2. In order to be sure they understand where contrails are in the sky, have them draw small buildings or trees at the bottom of the picture to show the horizon. This provides perspective to help students see that contrails aren't found

directly above a house or a tree but are much higher in the sky.

3. Take your students outside to observe and discuss the contrails they see. Just before going outside, have students record what time it is on their piece of posterboard or cardstock.
4. Inside or outside, give students the same three cups of white paint. Ask them to create the contrail(s) on the left half of the board that they observed. See Figure 5.
5. Have your students make a hypothesis of what they think will happen to the contrails 10 minutes after they made their initial observations.
6. After 10 minutes, have students observe the contrails they saw before. On the right half of their paper, have them paint what the contrails look like now. Their drawings should be different than the original; this will help them understand that contrails change over time.
7. Have the students share their observations and findings with the class.

Adaptations for Younger and Older Students

Younger students: Have your students clear off their desks. After discussing the three types of contrails with your students, give each student a bit of shaving cream and have them create the three types on their desks or on construction paper.

Further Investigations

- **Literacy Activity for Older Students:** Write an acrostic poem with the whole class using “contrails.” You may need to guide your students in this process. Hang the finished student work in your classroom for others to see.
- **Literacy Activity for Younger Students:** Do an interactive writing activity with them, making a “Predictable Chart” about contrails. Begin by writing the word CONTRAILS at the top of a large piece of chart paper. Next, model the first



sentence for the class both verbally and in writing. An example might be: They are long. (Mrs. Hall) After your sentence let other children dictate a sentence to you using the same “predictable” pattern. Some examples from the children might be: They are white. (Kristen) They are high in the sky. (David) Be sure to put their name after the sentence in (parentheses). This way each child can contribute to the chart and also have some ownership in the activity. Continue this process until every child has a sentence on the chart. Then reread your chart for everyone to hear. If you want to continue this activity further, write the child’s thought on a sentence strip, have them cut it apart, glue it on a piece of construction paper in the correct order along with their name, and have them draw a picture of their sentence. Display these on a bulletin board or assemble them into a class book for your classroom. For more information, check out the book *Predictable Charts* by Dorothy Hall and Elaine Williams.

- **GLOBE Cloud Protocols:** Start making cloud observations as a class to submit to GLOBE. See the *GLOBE Teacher’s Guide* (www.globe.gov) for more information on the Cloud Protocols , formulating a research question, and collecting cloud data. Also, see the *GLOBE Observer Clouds App* (observer.globe.gov), which guides students through the process of taking cloud observations using a smartphone or tablet.

- **Contrail Study:** Conduct a scientific investigation concerning contrails. You and your students can investigate questions such as: How many contrails are there on different days of the week? How does wind direction/temperature affect the type of contrails we see in the sky? How do breezes at ground level relate to the direction of cloud movement aloft? Or build up a count of the amount of contrails your class sees in different seasons to determine how seasons affect them. This last one might be the easiest to implement with early elementary students but it also takes a long time.
- **Contrail Calendar:** Keep a calendar or chart for your class to record contrail observations over a certain period of time.

The To Spread or Not to Spread Learning Activity has been adapted with permission from an activity by GLOBE in Alabama, Huntsville, AL.

Elementary

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Do You Know That Clouds Have Names?

Airplane Stickers

