NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

MY NASA DATA

Mentoring and inquirY using NASA Data on Atmospheric and earth science for Teachers and Amateurs

Contrail Studies

Science Project: Contrail Studies

Web Id: P4

Purpose: Serious students, citizen scientists and regular weather watchers can use a camera and simple weather instruments to monitor and study contrails and to determine their possible environmental effects.

Age Range: 11 to adult

Time Required: Contrails can be observed, photographed and reported in only a few minutes a day. Scientific studies of contrails take more time and can provide important scientific information.

Image courtesy Forrest M. Mims III.

Background:

Contrails can spread into cirrus clouds that reduce sunlight during the day, thus causing a cooling effect. But contrails also trap heat during both the day and the night. It is not yet certain if the net result of these effects warms or cools the Earth, but most studies indicate that contrails have a net warming effect on our planet.

Scientists at NASA's Langley Research Center in Hampton, Virginia found that the increase in temperature over the United States from 1975 to 1994 closely matched the increase expected from the presence of contrails. Dr. Patrick Minnis is a senior research scientist at the Langley Research Center. He has measured a one percent per decade increase in cirrus cloud cover over the United States, which is likely due to contrails. Minnis estimates that cirrus clouds from contrails increased the temperatures of the lower atmosphere by anywhere from 0.36 to 0.54 degrees F per decade. Minnis's results show good agreement with weather service data, which reveal that the temperature of the surface and lower atmosphere rose by almost 0.5 degrees F per decade between 1975 and 1994. Reference.

An unprecedented opportunity to study the effect of contrails occurred during the 3 days following the terrorist attacks in New York and Washington on 11 September 2001. David Travis of the University of Wisconsin, Whitewater, found that during the virtual absence of contrails the difference in the high and low temperatures each day increased 1.1 degrees Celsius (2 degrees Fahrenheit) on each day. Reference.

The significance of all this is not fully established–which is where you come in. Observations and measurements of cirrus clouds by students, citizen scientists and weather observers might lead to new insights and discoveries that will be of serious interest to the professional scientists who study the impact of contrails on weather and climate.

Significance:

Contrails are often more difficult for satellites to detect than clouds, especially when they remain narrow and do not spread outward. Students, home weather station operators and citizen scientists can provide important scientific information by documenting the contrails they observe and reporting their findings. It is important simply to know the number of days contrails were present over a particular location in a given year.

Project Links:

- Contrail Education
- SCOOL: Observing Contrails
- SCOOL Cloud Chart: Contrails
- GLOBE Contrail Gallery
- GLOBE Contrail Resources

Real Time Data Source:

MODIS provides the best resolution satellite imagery that is freely available in near real-time through the MODIS Rapid Response System. Use the highest resolution images to look for contrails.

MY NASA DATA Source:

Because contrails are hard to detect in current satellite imagery, there is currently no standard source. A related parameter of interest in the LAS is Atmosphere, Clouds, Cloud Coverage, Monthly Cloud Coverage for Cirrus (ISCCP). Also Monthly Cloud Coverage for Cirrostratus (ISCCP) or Monthly High Cloud Coverage (ISCCP). Some of the clouds detected in these categories may in fact be contrails, or of contrail origin. The presence of high clouds also indicates possibly more favorable conditions for contrails to occur.

Project Ideas:

Serious students, citizen scientists and weather watchers in areas where persistent contrails are common can measure their effect on local temperature. This is best done by automatic home weather stations or data loggers that store temperature at preset or programmable intervals. You will need to devise a way of recording the presence of contrails at the Sun to make sense of the temperature data. A digital camera is ideal for this purpose. Even an inexpensive camera can be used.

1. Daily Contrail Observations. You can easily add contrail watching to a regular program of cloud observations (see Science Project 2: Cloud Studies, Science Project 1: Clouds for Kids). When contrails are visible, describe them as (1) short and transient, (2) long and persistent or (3) spreading. Be sure to note if cirrus clouds are present.

2. Special Contrail Observations. Spreading contrails have much more impact on sunlight and heat retention than other contrails. When you see spreading contrails, describe their coverage of the sky in terms of oktas (see Science Project 2: Cloud Studies, Project Idea 2).

3. Contrail Photographs. Contrail observations can be combined with sky photographs to provide a dynamic record of the presence and appearance of contrails. There simply is no better way to study contrails. Photography is an especially good method for recording spreading contrails and clusters of intersecting and parallel contrails.

4. Contrails and Satellite Images. Contrails are clearly visible in some satellite images. For example, this photograph from the International Space Station shows both narrow and spreading contrails over France south of Geneva, Switzerland. Far more contrails are visible in the image from NASA's Terra satellite. Comparing your ground reports and photographs of contrails with satellite imagery over your location would make for a fascinating science project.

5. Contrails and Airports. On days when the atmosphere allows contrails to form, contrails are not produced until aircraft taking off from airports reach a certain altitude, usually above 7.5 km (24,600 feet) or higher. On some days cities with busy airports will be overlain by high contrails from planes passing by and surrounded by contrails produced by aircraft leaving and arriving at the airport. With perfect conditions and a clear sky, the airport might appear as if at the center of a wheel with radiating white spokes extending outward. If you live in the general vicinity of but not too close to a large airport, you can observe, record and photograph contrails related to the jet traffic at the airport.

6. Contrails and Weather. Why are contrails not visible all the time? The reason is that contrails form only when the temperature of the air is at or below -40 degrees Celsius (-40 degrees Fahrenheit) and the relative humidity is sufficiently high. So the presence of contrails high overhead provides clues about the temperature up there. Are contrails related to local weather? A good science project would involve comparing local weather patterns on days when contrails are and are not present.

7. Contrails and the Seasons. In some regions contrails occur throughout the year. In other areas they may tend to occur more during cooler months. What is the significance of this? Study the seasonal prevalence of contrails in your area to find out. Compare the presence of contrails with the temperature and other weather patterns. You may wish to explore the Appleman Chart activity to help understand this.

8. Contrails and Humidity. Water vapor in the atmosphere is commonly expressed in terms of the relative humidity, a measure of how much water vapor is present to the maximum amount the air can hold at a particular temperature. Warm air can contain far more water vapor than cool air, so 'relative humidity' does not represent the actual amount of water vapor in the air, but a relative measure of how much water vapor it could hold. In order for a contrail to form, the relative humidity must be very high at the aircraft altitude. Is this related to relative humidity near the ground? Collect data on relative humidity and contrail occurrence for at least 10 contrail days, and you will have the makings of a first class science project.

9. Contrails and Temperature. When spreading contrails block the sun, they can cause a temporary and measurable reduction in the temperature at the ground. The best way to study this is by means of a digital thermometer that automatically measures the temperature throughout the day at periodic intervals. The GLOBE program has several temperature protocols from which you can select. Some of these use commercial digital electronic weather stations made by Davis Instruments and Weather Hawk. The Onset Computer Corporation makes moderately priced, miniature temperature data loggers that are ideal for this project. Their Pendant loggers are especially good. No matter which instrument you select, it is important that the thermometer be kept from

direct sunlight as described in the GLOBE protocols.

10. Contrails and Sunlight. Contrails often block sunlight more effectively than ordinary cirrus clouds at the same altitude. As with temperature, the best way to measure this effect is to use an automatic instrument that records sunlight. The Onset Computer Corporation makes moderately priced, miniature light recording data loggers that are ideal for this project. An ideal choice is one of their light-sensing Pendant models. Note that it is necessary to place the light sensing data logger in full sunlight in order to measure the effect of contrails. Data loggers such as the Pendant record both temperature and light, and the temperature will be reduced when a contrail blocks the sun. But the direct sunlight temperature measurement will be higher than the air temperature in the shade. So, if you want to measure the impact of contrails on both light and temperature, it will be necessary to use two Pendants or a system that has a remote temperature sensor or otherwise provides shade for the temperature sensor and full sunlight for the light sensor.

Note: Mention of commercial products does not imply that they are endorsed by NASA.

Analysis Ideas:

Design an experiment to measure the temperature change that occurs when a contrail passes in front of the sun and shades the ground.

Related Projects:

The GLOBE Program.
The CERES S'COOL Project.

Questions:

1. Are contrails composed of droplets of water or ice crystals? How can you be sure?

2. Why are some contrails very short and others very long?

3. What causes some contrails to spread across the sky?

4. When the air where most passenger aircraft fly is moist and cold, would you expect more or fewer contrails?

Going Further:

Learning about contrails will teach you important facts about a manmade phenomenon that directly affects the environment in ways that remain to be fully understood.

Serious contrail watchers who want to make a difference should consider participating in S'COOL or GLOBE.

The web has many contrail sites. Enter 'contrails' in a search window and prepare to be surprised by the number of sites that appear. Some sites are excellent. But there are also many sites that claim contrails are actually 'chemtrails' intended to spread potentially dangerous chemicals or even diseases across cities and the countryside. Some chemtrail sites have excellent photographs of unusual contrail patterns across the sky. Do these sites describe real science? Or do they describe pseudoscience (false science)? How can you tell the difference?

Project ideas contributed by Forrest M. Mims III, Geronimo Creek Observatory, Texas