



**GLOBE
Observer**



**4-H ACTIVITY GUIDE
GLOBE OBSERVER CITIZEN SCIENCE
EXPLORING CLOUDS**



United States
Department of
Agriculture

National Institute
of Food
and Agriculture

4-H National
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INTRODUCTION

The main focus of this 4-H Activity Guide is **citizen science**. Learning to observe and understand clouds is the science content of the guide, yet what distinguishes it from other cloud science education guides is that it is about youth doing citizen science.

Citizen science has been growing in both government and private circles over the last several years for good reason. It engages people of all ages in personal experiences of nature around them, while enabling them to make important contributions to professional science endeavors and at the same time connecting them with other citizen scientists across the world.

GUIDE OVERVIEW

Purpose: To provide opportunities for youth to become citizen scientists as they observe clouds and learn about them.

Target Audience: This guide provides opportunities for youth **ages 9-14** or in **grades 4-8**, but can be adapted to other age groups, to learn about clouds, collect cloud data and engage in citizen science through the GLOBE Observer program. The guide includes hands-on and interactive activities that can be used in a variety of educational settings, including camps, special interest programs, 4-H clubs, after-school programs, or school enrichment programs.

Learning Objectives:

Youth will:

- learn what clouds are and how they form;
- learn about the different types of clouds;
- identify a Clouds study site, take observations of the sky, and upload data to the GLOBE database;
- explain why cloud observations are important for understanding our changing Earth system;
- develop an understanding of the challenge of visually estimating the percentage of cloud cover and gain experience estimating cloud cover, evaluating the accuracy of estimates, and using fractions and percentages;
- become engaged in the process of science;
- become part of a worldwide community of learners and scientists.

National Standards: The Next Generation Science Standards (NGSS) provides a set of guidelines to help educators know what concepts and skills they should teach. GLOBE Observer citizen science aligns with the Next Generation Science Standards (NGSS) in multiple ways.

Through making and analyzing observations youth accomplish the following:

- learn science by engaging in practices that represent what scientists actually do
- experience discovery
- explore real-world connections

GUIDE OUTLINE

The core of this guide is citizen science: youth making observations of clouds with the GLOBE Observer app that is downloaded to a mobile device (at no cost to the users).

Activities 1-7 are citizen science activities that focus on aspects of clouds that are recorded by the app.

Activities 8-11 focus on general background and understanding of clouds and careers involving or relating to clouds.

Activity 1 - Becoming a Citizen Scientist (45-65 minutes total)

Part 1 - Who is a Citizen Scientist? (10-15 minutes)

Part 2 - Learn about the GLOBE Observer citizen science program. (8 minutes)

Part 3 - Observe Clouds Using the GLOBE Observer app (30-40 minutes)

Activity 2 - How Blue is the Sky? (20-30 minutes)

Activity 3 - Estimating Percentage of the Sky Covered by Clouds (20-30 minutes)

Activity 4 - Types of Clouds (30-40 minutes)

Activity 5 - Classifying Visual Opacity (Transparency) of Clouds (20-30 minutes)

Activity 6 - Citizen Science as a Community Activity (30-45 minutes)

Activity 7 - A Look at GLOBE Observer Cloud Data (15-20 minutes)

Activity 8 - All about Clouds (10-15 minutes)

Activity 9 - How are Clouds Formed? (20-30 minutes)

Activity 10 - How do Clouds Make Precipitation? (15-20 minutes)

Activity 11 - Careers Related to Clouds (15-20 minutes)

ABOUT THE 4-H / NASA PARTNERSHIP

The 4-H Program is the federal positive youth development program from the land-grant institution's Cooperative Extension Service and the National Institute of Food and Agriculture (NIFA) at USDA. There is a formal agreement between the two federal agencies, NIFA and NASA, to pursue collaboration related to youth in Science, Technology, Engineering, and Mathematics (STEM).

This 4-H Activity Guide is designed to support use of the GLOBE Observer. It was conceived as a joint project between 4-H National Headquarters at USDA-NIFA and NASA.

WHAT IS GLOBE?

The Global Learning and Observations to Benefit the Environment (GLOBE) Program (www.globe.gov) is an international hands-on environmental science and education program that provides youth and the public worldwide with opportunities to participate in data collection and the scientific process and to contribute meaningfully to our understanding of our shared environment and changing climate across the Earth system at local, regional, and global scales.

WHAT IS GLOBE OBSERVER?

GLOBE Observer was designed and is managed through a partnership between NASA and the GLOBE Program (<https://observer.globe.gov/>).

As part of GLOBE, GLOBE Observer provides broader access to the GLOBE Program through a smart phone app that is available to anyone in the 119 countries that partner with GLOBE. Citizen science data collected through GLOBE Observer is entered into the GLOBE database, where students, scientists, and citizen scientists can access it to support their research. Thus participation in GLOBE Observer strengthens science and education.

ABOUT CITIZEN SCIENCE AND 4-H

GLOBE Observer citizen science fits very well with the general philosophy and spirit of 4-H as hands-on and service-oriented learning, and its focus on community impact and environmental and ecological issues.

4-H seeks to:

- provide youth with experiences in which they learn by doing;
- improve youth science skills (scientific methods) and knowledge (content areas);
- increase awareness of opportunities to contribute to society using science skills;
- increase life skills (self-efficacy) among youth;
- provide youth with experiences in which they can see themselves in various professional futures.

In general, citizen science can be excellent for:

- learning to volunteer for a wider goal;
- linking studies to place and community issues;
- raising awareness of environmental issues;
- increasing education in science, technology, engineering and mathematics;
- developing new skills and insights;
- adapting to different types of learning.

Youth who participate in the activities included in this 4-H Activity Guide will:

- make their personal observations of clouds following a step-by-step protocol provided by the GLOBE Observer program;
- develop their awareness of clouds, how clouds form, and cloud types;
- consider their own and others' questions about clouds;
- identify and analyze patterns in clouds over time;

- share the data with each other and with GLOBE as part of a worldwide community of citizen scientists.

GLOBE Observer implementation is simple, easy to do, and adaptable to a wide variety of 4-H settings or methods of sharing including:

- 4-H clubs: school-based, afterschool, community or SPIN
- school enrichment programs
- special interest programs
- camping programs: residential experiences or summer day camps
- eXtension (extension.org) to facilitate communities of practice and as a vehicle for GLOBE Observer training
- 4-H extension specialists, educators, or volunteers as key promoters of GLOBE Observer use (or generally the use of citizen science) in 4-H
- county fairs, National Youth Science Day and other showcase type events
- 4-H competitions and skill-a-thons
- partnerships with agencies or other youth serving organizations

ABOUT THE IMPORTANCE OF CLOUDS AND OF 4-H YOUTH CLOUD OBSERVATIONS TO NASA'S WORK

4-H youth can play a key role in NASA's understanding of the changing Earth system as they make ground-based observations that will help scientists to improve the accuracy of their space-based observations.

One of the most interesting features of Earth, as seen from space, is the ever-changing distribution of clouds. As they float above us, we hardly give their presence a second thought. Yet clouds have an enormous influence on Earth's energy balance, climate, and weather. Studying clouds is a top priority among many atmospheric scientists because clouds are one of the greatest unknown factors in predicting changes in Earth's climate.

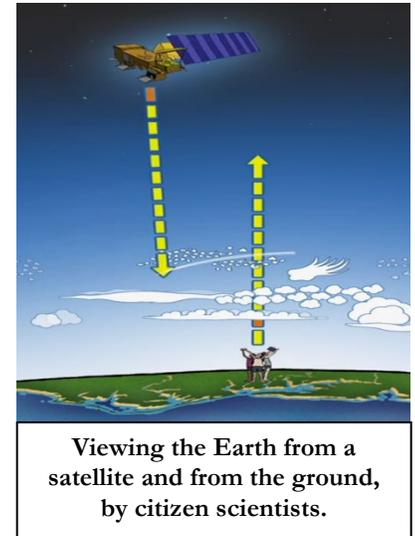
Climate is the weather at a particular place averaged over a long period of time, at least thirty years. Clouds can affect climate because they influence the amount of solar energy reaching Earth's surface and the amount of outgoing infrared radiation leaving the Earth.

Clouds are the key regulator of the planet's average temperature. Some clouds contribute to cooling because they reflect some of the Sun's energy (called solar energy or shortwave radiation) back to space. Other clouds contribute to warming because they act like a blanket and trap some of the energy that Earth's surface and lower atmosphere emit. Along with ocean currents and the movement of water vapor, cloud systems help spread the Sun's energy evenly over Earth's surface. Storms move across the planet and transport energy from warm areas near the equator to cold areas near the poles.

Clouds and Earth's atmosphere are enormously dynamic. Even small changes in the abundance or location of clouds could change the climate more than the anticipated changes caused by greenhouse gases, human-produced aerosols, or other factors associated with global change. In order for scientists to create increasingly realistic computer simulations of Earth's current and future climate, they need more accurate representations of the behavior of clouds. For this reason, clouds are an important area of study for NASA.

Satellites in space help us see clouds all around the world. Citizen scientists help NASA by providing ground observation of clouds. Scientists compare the ground observation data collected by citizen scientists with the data collected by satellites.

A critical question for all Earth scientists is this: Will an enhanced greenhouse effect produce changes in clouds that further influence global surface temperatures? The question is a tough one. The main uncertainties in global change predictions come from inadequate representation of clouds in climate models: the models do not yet have sophisticated enough descriptions of cloud processes, and scientists do not have enough cloud observations to verify the model predictions. GLOBE Observer citizen scientists' observations can contribute significantly to answering this question.



Using the GLOBE Observer app, youth can:

- understand how cloud climatology may be changing;
- provide ground-based data on clouds;
- identify qualitative aspects of clouds (such as cloud type clues) that automated sensors cannot;
- identify small features of clouds that are not visible from satellites.

The last three items are actions citizen scientists can take that cannot be done by satellites!

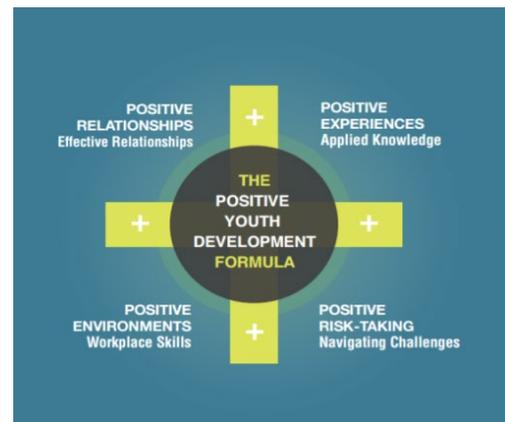
Clouds are part of the global Earth system that NASA is studying. NASA scientists seek to know:

- How is the global Earth system changing?
- What causes these changes in the Earth system?
- How will the Earth system change in the future?
- How can Earth system science provide societal benefit?

Clouds tell us about air temperature, water and wind, which helps us to predict weather. They also affect how much sunlight is reaching the ground and escaping back to space, which helps us to understand climate.

THE 4-H APPROACH TO LEARNING

4-H is the federal model for positive youth development (PYD) delivered through the land-grant institution's Cooperative Extension Service. PYD is an intentional, prosocial approach that engages youth within their communities in a manner that is productive and constructive. PYD recognizes, utilizes, and enhances youths' strengths and promotes positive outcomes by providing opportunities, fostering positive relationships, and providing the support needed to build on their leadership strengths.



Positive Relationships are connections between youth and adults, as well as peer relationships, that are founded upon trust, regard and reciprocity. They are a vital part of PYD as youth need to have a support system and inspirational role models in order to achieve their full potential.

Implementation Strategies:

- Youth and adults are accessible to one another for support, information and guidance.
- There is a sense of belonging and connectedness that is established between the youth and adult.
- There is consistency in the frequency of interactions between the youth and adults.
- Experiences that promote trust building and open communication are encouraged.
- The relationship is founded upon a high level of mutual respect between the youth and the adult.
- The relationship is a collaborative partnership where the youth and the adult decide on the learning pathway and goals together.

Positive Experiences are encounters undergone by youth that promote a wholesome lifestyle, address relevant issues and draw their interest. These experiences are important to establishing PYD because they lead to successful program implementation as the youth's needs are being met.

Implementation Strategies:

- Experiences are designed for frequency and duration that build learning over time.
- Experiences provide hands-on, real-world learning that takes place in the community and provides young people opportunities to develop relationships, skills and leadership.
- Experiences focus on contributions, as youth gain more by doing for themselves and others.
- Learning purpose, goals, and outcomes are determined in partnership by everyone involved.
- Experiences promote wellness by encouraging healthy choices, such as exercise, food and sleeping.
- Experiences are fun and learner-centered, built on youth interests, questions and their prior knowledge.
- Experiences help youth develop a growth mindset, approaching challenges with the intent to learn from them and thus develop skills as well as a deeper understanding.
- Experiences require active involvement that is authentic and direct.
- Experiences offer time for reflection both individually and with their peers.
- Experiences are driven by challenging real-world problems or questions.
- Experiences provide youth with the opportunity to demonstrate their learning through a public product, portfolio or action.

Positive Environments are settings with conditions that maximize youth growth, such as safety and (adherence to) values. It is necessary in order to have PYD as youth need to feel secure and comfortable in order to thrive in other facets of development.

Implementation Strategies:

- Environment is a space that is both physically and emotionally safe.
- Environment is welcoming and provides diverse learners access to the experience.
- Environment should be a space of respectful disagreement and opportunities to learn from failure.

- Environment places high expectations on the youth in terms of behavior.

Positive Risk Taking is a form of risk taking in which youth satisfy their desire to engage in behaviors that either generate uncertainty or have a novelty factor, while having a positive outcome. Positive risk taking is crucial in PYD as it stimulates brain development and helps strengthen decision making skills. Healthy risk taking is encouraged as long as the outcomes are not negative.

- Activities such as trying new foods, going on outdoor adventures (i.e. rock climbing, kayaking, tubing), or going to a theme park, are organized experiences, are exhilarating, and have an element of risk.
- Youth are encouraged to meet make new friends, as this is a form of positive risk taking.
- Dangerous risks are limited and instead supplemented with more appropriate risks.
- Adults serve as role models for youth and share their own experiences.

Learning and development are connected processes – both work together to help youth thrive. 4-H Educators need to be intentional about helping youth develop – to guide youth to articulate and reflect on the learning process so that they are learning how to learn and grow, as they learn and grow.

INTRODUCTION TO THE GLOBE PROGRAM and GLOBE OBSERVER

The Global Learning and Observations to Benefit the Environment (GLOBE) Program (www.globe.gov) is an international science and education program that provides youth and the public worldwide with opportunities to participate in data collection and the scientific process and to contribute meaningfully to our understanding of the Earth system at local, regional, and global scales. Announced by the U.S. Government on Earth Day in 1994, GLOBE launched its worldwide implementation in 1995.

GLOBE's strategic priorities are to:

- 1) improve student understanding of environmental and Earth system science across the curriculum;
- 2) contribute to scientific understanding of Earth as a system;
- 3) build and sustain a global community of students, teachers, scientists and citizens; and
- 4) engage the next generation of scientists and global citizens in activities to benefit the environment.

GLOBE provides age-appropriate, interdisciplinary activities and investigations about the atmosphere, biosphere, hydrosphere, and pedosphere (soil), which have been developed by the scientific community and validated by educators. GLOBE connects youth, educators, scientists, and citizens from different parts of the world to conduct authentic, hands-on science about their local environment and put it into a global perspective.

GLOBE is sponsored by U.S. National Aeronautics and Space Administration (NASA) with support from the National Science Foundation (NSF), the National Oceanic and Atmospheric Administration (NOAA) and the Department of State. Internationally GLOBE is implemented through government-to-government agreements with each Country Partner responsible for in-country activities. As the lead agency for GLOBE in the United States, NASA has the primary

responsibility for administering the Government-to-Government agreements, the management of the GLOBE Implementation Office and the data and information system that support the worldwide implementation.

GLOBE Observer provides broad, simplified access to GLOBE and to an international network of citizen scientists and scientists working together to learn more about our shared environment and changing climate. Citizen scientists are also providing data for student research and thus strengthening science education. The GLOBE Observer Program provides an application (app) for mobile devices, with modules including Clouds, Land Cover, and Mosquito Habitat Mapper. This 4-H Activity Guide supports the Cloud module in the app.

The GLOBE Observer Cloud app allows anyone in a country that has joined GLOBE to enter data about clouds directly into the GLOBE database. To participate, download the GLOBE Observer app and submit regular observations.

A simple process of registration is required to download the app. The app will guide users through the steps of taking a cloud observation. (*See Activity 1-Part 3*)

About the App:

<https://www.globe.gov/globe-data/data-entry/globe-observer>

Download for IOS via the App Store:

<https://itunes.apple.com/us/app/globe-observer/id1090456751?mt=8>

Download for Android via Google Play:

<https://play.google.com/store/apps/details?id=gov.nasa.globe.observer&hl=en>

More resources, information, and links to related programs can be found at the GLOBE Observer website: <http://observer.globe.gov>

If you are interested in collecting additional data such as temperature or water quality, you may choose to join GLOBE as an educator. Added benefits include support for educators, student accounts, a personalized space for your organization on the GLOBE web site, and the ability to collaborate with other educators in the GLOBE community. Learn more at:

<https://www.globe.gov/get-started/-educators/overview-and-benefits>

IMPORTANT TIPS FOR EDUCATORS

This guide provides instructions for several different activities. It is not required or necessary to complete all of the activities. As long as interest among the youth persists and time allows, use as many of the activities in this 4-H Activity Guide as you can. If you plan to use all of them, it is recommended that you use them in the order they appear in this guide. If you are unable to conduct all of the activities due to time constraints, it is strongly recommended that at a minimum, you implement *Activity 1 - Becoming A Citizen Scientist* because doing citizen science is the core of this guide.

- Before implementing any of this guide with youth, be sure to review the GLOBE Observer Cloud app and any of the activities you will implement, on your own.

4-H ACTIVITY GUIDE
GLOBE Observer Citizen Science – Exploring Clouds

A simple tutorial comes with the app. The app tutorial provides the basic information needed for its use.

Activities 4, 5, 8, 9, and 10 of this 4-H Activity Guide are about clouds themselves. More information and resources for learning and teaching about clouds are available through the Clouds training at this URL: <https://observer.globe.gov/training/clouds>

- Technical Requirement. All youth involved in this activity will need to have a mobile device with the GLOBE Observer app downloaded. The app can be downloaded at this URL: <https://observer.globe.gov/about/get-the-app>
- Youth Cloud Books. Youth can be encouraged to keep their own Cloud Books, which can be portfolios of impressions, observations, images and questions.
- Thinking Deeply. It is important to encourage youth to hypothesize when addressing questions and observations so they may start to think more deeply about clouds.
- Multiple-day Observations. It is recommended that youth make observations over several days at the same time and place. More can be learned this way, as youth will be able to investigate patterns in clouds over time.
- Sharing with Others. Provide opportunities for youth to share their experiences with others through presentations, displays, written stories or other methods.

4-H ACTIVITY GUIDE
GLOBE Observer Citizen Science – Exploring Clouds

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ACTIVITY 1 – BECOMING A CITIZEN SCIENTIST

Purpose:

- To introduce youth to citizen science and provide them an experience of being citizen scientists

Overview:

While participating in the three parts of this activity, youth will learn who citizen scientists are; gain background knowledge in citizen science; and make their own observations of clouds using the GLOBE Observer app.

Time Required: 40-60 minutes (10-30 minutes for each of three parts)

Part 1. Who is a Citizen Scientist?

Time Required: 10-15 minutes

Materials Needed:

- Marker
- Three (3) sheets of paper or pieces of poster board (approximately 8” X 14” or larger). Make three posters – one with the word TRUE on it, one with MAYBE on it, and the other with the word FALSE on it.
- Masking tape

Background Information:

There are several definitions of citizen science including the following:

- “In North America, citizen science typically refers to research collaborations between scientists and volunteers, particularly (but not exclusively) to expand opportunities for scientific data collection and to provide access to scientific information for community members. (Source: *Cornell University, Citizen Science Central*)
- “As a working definition, we offer the following: projects in which volunteers’ partner with scientists to answer real-world questions.”
(Source: <http://www.birds.cornell.edu/citscitoolkit/about/definition> Accessed on September 18, 2017)
- “There are various definitions for citizen science, but citizen science is mostly conceived as members of the public engaging in real-world research, sometimes in collaboration with scientists, sometimes not. True citizen science is not just an educational activity, but... contributes in original ways to our knowledge base...” (Source: *Martin Storksdieck, NASA GLOBE Observer for Afterschool Science, Year 1 Needs Assessment Report, 2017*)

There are currently thousands of citizen science projects around the world. Descriptions of some projects can be found on the websites listed below:

Case Studies in the Federal Crowdsourcing and Citizen Science Toolkit
<https://www.citizenscience.gov/toolkit/case-study/>

Wilson Center’s Federal Crowdsourcing and Citizen Science Catalog
<https://ccsinventory.wilsoncenter.org/>

SciStarter

<https://scistarter.com/>

What to Do:

1. Put the True, False & Maybe posters on the wall in three different locations.
2. Begin a discussion about citizen science. Ask for a show of hands in response to the following questions:
 - Who has heard the terms citizen science or citizen scientist?
 - Who thinks they know what a citizen scientist does?
 - Who has been involved in a citizen science project?
 - Who can describe or tell about a specific citizen science project?
3. Read the following statements to the group of youth and ask them to stand in front of the True, False, or Maybe posters based on their response to the statement. If space in the room does not allow youth to move around and stand in front of the signs, then you can have them raise their hand if they feel the statement is True, False or Maybe.
 - A citizen scientist works for NASA. *False*
 - A citizen scientist is an amateur scientist. *Maybe or True*
 - A citizen scientist has a degree in citizenship. *False*
 - A citizen scientist likes science. *Maybe*
 - A citizen scientist is a member of the general public who engages in scientific work.
True
 - A citizen scientist often works in collaboration with or under the direction of professional scientists and/or scientific institutions. *True*
 - I am a citizen scientist. *True*
 - A citizen scientist must be a US Citizen. *False*
 - A citizen scientist can live anywhere in the world. *True*

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GLOBE Observer Citizen Science – Exploring Clouds

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- A citizen scientist has as a science degree. *Maybe*
 - A citizen scientist is a teacher or professor at a university or college. *Maybe*
 - I can be a citizen scientist. *True*
 - Only adults can be citizen scientist. *False*
 - A citizen scientist serves their community. *True*
4. Continue the discussion about citizen science and review the true statements above. Refer to the Background Information section in this activity for more information. In the course of your discussion, ask the youth the following questions:
- What is citizen science?
 - Who is involved in it?
 - Why is it important?
 - Why is it important to be involved in citizen science projects?
 - Why might it be enjoyable to do?
5. Ask the youth to work in groups of three to five and develop a definition of a citizen science. Have groups share their definitions.
6. Arrive at a group definition based on the background information provided and thoughts shared by the youth.
7. Show the 3-minute video, GLOBE Observer Cloud Science
<https://youtu.be/TNc5qjj8ZZE>

Part 2. Learn about the GLOBE Observer Citizen Science Program

Time Required: 8-10 minutes

Materials Needed:

- Computer or tablet with Internet access to view two videos
 - GLOBE Observer – Your Observations video (1 minute)
<https://observer.globe.gov/about/citizen-science>
 - GLOBE Observer – Cloud Science video (3 minutes)
<https://youtu.be/TNc5qjj8ZZE>

Background Information:

GLOBE Observer is an international network of citizen scientists and scientists working together to learn more about our shared environments and changing climate.

The GLOBE Observer Program provides protocols for Clouds, Mosquito Habitat Mapper and Land Cover. The cloud observations help NASA scientists understand clouds from the ground and from space.

Clouds tell us about air temperature, water and wind, which helps us to predict weather. They also affect how much sunlight is reaching the ground and escaping back to space, which helps us to understand climate.

Clouds play an important role in transferring energy from the Sun to different parts of the Earth system. Since clouds can change rapidly, scientists need frequent observations from citizen scientists. Such observations are able to see change over time and help with interpretation of satellite cloud data.

What to Do:

1. Tell the youth about the GLOBE Observer Program using the background information above.
2. Show the video, GLOBE Observer - Your Observations.
<https://observer.globe.gov/about/citizen-science>
3. Show the video, GLOBE Observer – Cloud Science.
<https://youtu.be/TNc5qjj8ZZE>

Part 3. Observe Clouds Using the GLOBE Observer App

Note to Educator: It may be useful to tell youth about the three main types of clouds prior to utilizing the app. See background information and use the *GLOBE Cloud Identification Chart (Appendix A)*.

Though youth may not have all the background understanding they might need to make these observations, the authors of this guide strongly advise giving them the experience at this point. After they have completed some of the other activities, the youth might want to go out and make observations again.

In fact, multiple observations are encouraged so the youth can get a sense of cloud change over time and an opportunity to look for patterns in cloud appearances.

After youth make observations, have them talk about their experience as a citizen scientist and what it means to be involved in citizen science.

Time Required: 30-40 minutes

Materials Needed:

- Mobile devices for youth, with GLOBE Observer Cloud App downloaded
 - GLOBE *Cloud Identification Chart* for help in identifying types of clouds (*Appendix A*) and GLOBE *Observation Basics* for help in identifying cloud cover, sky color, sky visibility, and cloud opacity. (*Appendix B*)
- The GLOBE *Cloud Identification Chart* and the *Observation Basics* are also available at: <https://www.globe.gov/documents/348614/782194b1-b5c3-4416-b3aa-b4a208ea5812>

Background Information:

Below are the three main types of clouds and their descriptions.

- **Stratus** clouds are low, flat, gray clouds that look like sheets covering the sky. They are the closest clouds to the ground and can produce rain, drizzle, snow, or mist.
- **Cumulus** clouds are puffy and white-like cotton balls. They usually indicate fair weather. Sometimes they grow very large and become thunderheads or cumulonimbus (storm) clouds. As these clouds gather they create thunder and lightning and produce precipitation in the form of rain or hail.
- **Cirrus** clouds are thin, curly, wispy clouds located high in the sky. They are sometimes referred to as mares' tails.

Clouds are also grouped according to their position or height in the sky – low level clouds, mid-level clouds, and high clouds.

The GLOBE Observer app features the clouds in the list below. They are grouped according to the height of the cloud base.

High Clouds

- Contrails
- Cirrus
- Cirrocumulus
- Cirrostratus

Mid-level Clouds

- Altostratus
- Altocumulus

Low level Clouds (including rain or snow clouds)

- Fog/Stratus
- Stratocumulus
- Cumulus
- Nimbostratus
- Cumulonimbus

About the App:

<https://www.globe.gov/globe-data/data-entry/globe-observer>

Download for IOS via the App Store

4-H ACTIVITY GUIDE
GLOBE Observer Citizen Science – Exploring Clouds

<https://itunes.apple.com/us/app/globe-observer/id1090456751?mt=8>

Download for Android via Google Play

<https://play.google.com/store/apps/details?id=gov.nasa.globe.observer&hl=en>

To make a cloud observation, *the app will guide users* through the following:

1. Capture the date, time and location.
2. Identify whether the sky is clear, cloudy, or obscured (not visible because some atmospheric phenomenon is blocking your view of the sky and/or clouds).
3. Estimate what percent of the sky is covered.
4. Identify cloud/contrail types.
5. Classify cloud visual opacity (the ability of light to pass through a substance, which can be characterized as transparent, translucent, or opaque).
6. Record surface conditions.
7. Photograph the sky.
8. Send your observations to GLOBE.

If for some reason youth cannot submit their observations to GLOBE right away, the app will store the observations an indefinite period of time. Youth can submit their observations as soon as they can conveniently access the Internet.

ACTIVITY 2 - HOW BLUE IS THE SKY?

*Adapted from Elementary GLOBE by NASA Langley Research Center
(https://www.globe.gov/documents/348830/14328942/ElementaryGLOBE_AerosolsActivity2-Why_Not_So_Blue_ForGlobe.pdf/8bf8370f-4a74-4b02-9712-f476ae9d8a34)*

Note to Educator: After you have completed this activity, it is suggested that you take the youth outside to observe clouds again using the GLOBE Observer app. Have the youth consider how blue the sky is today in contrast to the last time they made observations.

Purpose:

- To help youth understand that aerosols in the atmosphere have an effect on sky conditions, including sky color and visibility
- To provide youth the opportunity to become more familiar with the classification categories for daytime sky color and visibility

Overview:

In this activity, youth will make a prediction about how drops of milk will affect color and visibility in cups of water. The water represents the atmosphere and the milk represents particles in the air called aerosols. The youth will observe a series of five (5) cups of water, each with increasing amounts of milk. They will observe and record how sky color and sky visibility change depending on the increased aerosols. Youth will discuss how increasing numbers of particles in the air (aerosols) in Earth’s atmosphere can affect the sky’s condition and appearance.

Time Required: 20-30 minutes

Materials Needed:

Each group of three to five youth need the items listed below:

- Five small (5-8 ounce) plastic cups
- About 2 Tablespoons of milk
- Pitcher of water
- Piece of blue paper
- Eye dropper
- Spoon or plastic coffee stirrer
- Five identical stickers (colored dot or colored star)
- “Why (Not) So Blue?” Sky Color and Visibility Activity Sheet (*Appendix C*)
- GLOBE *Observation Basics* (*Appendix B*)

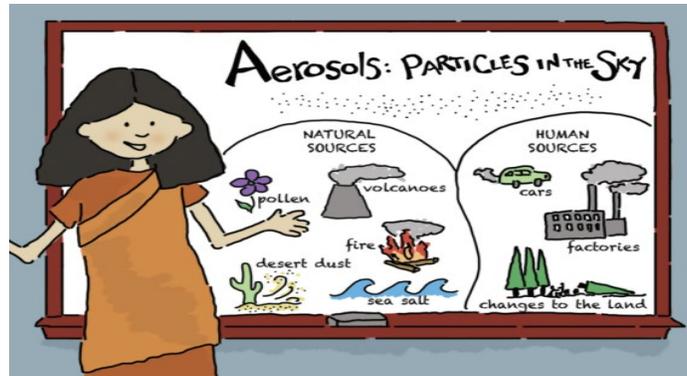
Background Information:

The number and kinds of particles (aerosols) in our atmosphere affect our sky conditions. An aerosol can be liquid or solid, mists or droplets, or tiny particles or material, such as ash. Aerosols can be anthropogenic (man-made) or naturally occurring. Man-made examples of aerosols include smoke from clearing land via burning. Naturally occurring examples of aerosols include ash from volcanic eruptions or from wildfires, pollen from plants, or dust blowing off deserts such as the Sahara.

When sunlight enters the atmosphere, it encounters air molecules (nitrogen, oxygen, water vapor, carbon dioxide, and other trace gases) as well as other small particles, known as aerosols.

Air molecules and aerosols both scatter the light. The color blue is scattered most effectively, causing the sky's blue color. A perfectly clear sky will be deep blue in color and very clear in visibility.

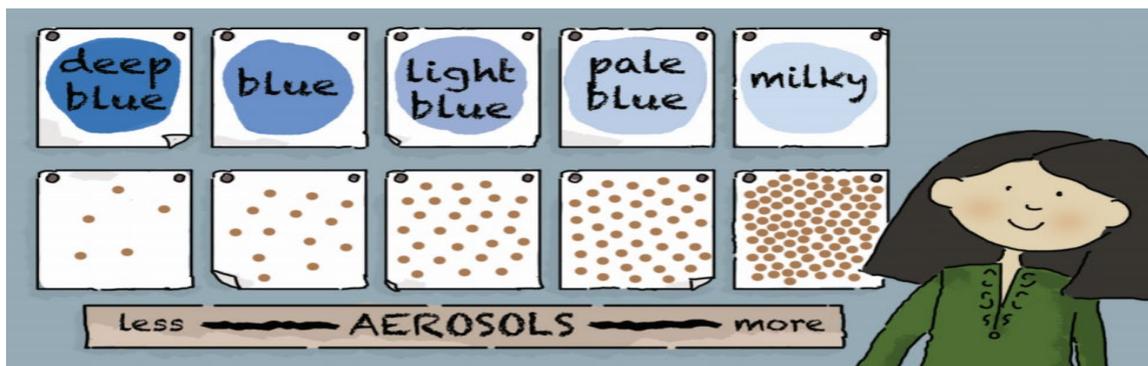
In large enough concentrations, aerosols can change the appearance of the sky, affecting color and visibility. When many aerosols are suspended in the atmosphere, the color will look pale or milky, and the visibility will become extremely hazy. Other atmospheric conditions can impact color and visibility.



High relative humidity can also make the sky appear more milky. Visibility can also be impacted by fog. Some atmospheric conditions may even make the sky obscured, such as when there is a high level of ash from a forest fire.

In this activity, drops of milk dispersed into a cup of water represent tiny particles of aerosols dispersed into the Earth's atmosphere. Because the numbers and concentrations of aerosols in the atmosphere can and do change, we observe these different sky conditions in the natural environment. Each group will do an experiment to demonstrate these different types of conditions. The number and kinds of aerosols in the atmosphere affects our sky conditions.

Most aerosols are too small to see but we can observe their impacts by observing and categorizing sky color and visibility. A low number of aerosols in the atmosphere relates to unusually clear visibility and a deep blue sky color. Visibility is extremely hazy and sky color is milky when there are a lot of aerosols present in the atmosphere.



The five sky color categories and the five sky visibility categories are listed below:

Sky Color Categories: Deep Blue, Blue, Light Blue, Pale Blue, and Milky

Visibility Categories: Unusually Clear, Clear, Somewhat Hazy, Very Hazy, and Extremely Hazy

Note: Refer to the GLOBE *Observation Basics* sheet located in *Appendix B* for pictures of sky colors and visibility.

What to Do:

1. Have youth watch the video, Earth Minute: My Name is Aerosol.
<https://www.youtube.com/watch?v=4eh6IKahbok>
2. Organize youth into groups of two to five (2-5) each.
3. Talk with the youth about aerosols and what they are. Explain that the numbers of aerosols in our atmosphere affects our sky conditions and that although most aerosols are too small to see, we can observe their impacts by observing and categorizing sky color and visibility.
4. Review the sky color and visibility categories in the Background Information and refer to the GLOBE *Observation Basics* (*Appendix B*). Tell youth that they are going to do an experiment to help them become more familiar with the five classification categories for both daytime sky color and visibility.
5. Describe the activity to the youth and tell them that they will be placing increasing amounts of milk in each cup of water.
6. Ask the youth to make a prediction. Have one person in the group record their prediction on the “Why (Not) So Blue? Color and Visibility” Activity Sheet (*Appendix C*).
 - What will happen to color and visibility as we increase the milk content?
 - Ask them why they made this prediction.
7. **Experiment Setup:** Each group of youth will do the following:
 - Place five small clear plastic cups in a straight line across the middle of a piece of blue paper.
 - Fill each cup with 1.5-2 inches of water or about half full.
 - Starting with the second cup from the left, add increasing drops of milk to the cups as you move to the right of the paper. (no drops in the first cup, small drop in the second cup, 2 drops in the third cup, 3 drops in the fourth cup, and 5 drops in the fifth cup).
 - Using a stirring utensil, mix well to achieve an even consistency.

Once you have set up the five plastic cups with their respective concentrations of milk, you should have an increase of milky water as you move from left to right on the blue paper starting with clear water in the first cup.
 - To best view the visibility parameter, have them view the cup from the top as well as the side. Look through the cup (liquid) and compare the different cups side by side.

Observation:

- Have each person in the group observe the paper and liquid color paper with the cups.

- Youth should start with the first cup (clean, clear water) and work their way toward the right (most milk in the cup). To best observe the sky color, have youth view the cups from the top. Look straight down into the cup to view the new color of the blue paper at the bottom of the cup as the consistency changes from left to right. Have someone record what they see on the activity sheet.
- Next, youth should observe each cup from the side, looking through each cup of liquid and comparing the different cups side by side to assess visibility through the cup. Have the youth record what they see. If needed, place a common object, such as a sticker behind each cup.

Discuss with the group the following questions:

- Is there a pattern that they observe? (*The more aerosols that are present, the more milky the sky color becomes and visibility decreases*)
- What does the water and drops of milk represent in each cup? (*water represents the atmosphere and the milk represents the aerosols or particles in the air*)
- In this activity, how does the increase of milk affect the water's color and visibility? (*more milk makes it milky or cloudy in color and reduces visibility*)
- What do you think would happen if we added 10 drops of milk to one of the cups?
- The cup of water represents our atmosphere. What are some examples of these conditions in real life?
- What factors could cause changes in sky visibility? (*high humidity, fog, and atmospheric conditions such as high levels of ash from a forest fire*)

ACTIVITY 3 - ESTIMATING PERCENTAGE OF THE SKY COVERED BY CLOUDS

*Modified from GLOBE Atmosphere Learning Activity - Estimating Cloud Cover: A Simulation
(<https://www.globe.gov/documents/348614/d58984c8-381c-4783-ad30-221fc381d619>)*

Note to Educator: After you have completed this activity, it is suggested that you take the youth outside to observe clouds again using the GLOBE Observer app. Have the youth consider the percentage of the sky covered by clouds today as compared to the last time they made an observation.

Purpose:

- To give youth practice in accurately estimating the percent of the sky that is covered by clouds

Overview:

Youth will make estimations of cloud cover percentage by using construction paper or through an online practice website.

Time Required: 30-40 minutes

Materials Needed:

Note: This activity can be done with paper or by using the interactive “Cloud Cover Practice” website listed as an optional activity. (Of course, access to computers, tablets or mobile devices will be needed if you plan to use the website. Adobe Flash Player is required.)

Advanced Preparation – Cut the blue construction paper in half horizontally.

- Blue construction paper (five ½ sheets per person)
- White copy paper (one to two pieces per person)
- Marker
- Glue stick
- Cloud cover categories and pictures on GLOBE *Observation Basics (Appendix B)*

Background Information:

Cloud cover is the percentage of the sky which is obscured by clouds when observed from a particular location. Our estimation of cloud cover is subjective, but scientifically important. Meteorologists and climate scientists must have accurate cloud cover observations to correctly account for the amount of solar radiation which is reflected or absorbed before sunlight reaches Earth’s surface, and the amount of radiation coming from Earth’s surface and lower atmosphere which is reflected or absorbed before it can escape to space.

There are five categories for amount of cloud cover. They are:

- Few (less than 10%)
- Isolated (10-25%)
- Scattered (25-50%)
- Broken (50-90%)
- Overcast (greater than 90%)

Note: Refer to GLOBE *Observation Basics (Appendix B)* for photos.

When observing cloud cover, include contrails (line-shaped clouds produced by aircraft engine exhaust, composed primarily of water in the form of crystals). Estimate the total cover of the whole sky. It may be helpful to divide the sky in four quadrants (North, South, East, and West) and estimate cloud cover in each, then take the average to get the whole sky value.

What to Do:

1. Ask the youth if they know what cloud cover is and why it is important to determine cloud cover.
2. Provide an overview of cloud cover and the five categories of cloud cover by name and percentage. Refer to the Background Information section and to the cloud cover pictures in the GLOBE *Observation Basics* sheet (*Appendix B*).
3. Give each person a sheet of white paper, a piece of blue construction paper, a marker and a glue stick.
4. Tell the youth that the white paper represents clouds and can be torn into several pieces.
5. Have youth make a sample of each type of cloud cover representing the percentage of clouds in the sky, by using the glue stick to attach the white pieces of paper onto the blue paper. Have youth label each sheet with the type cloud cover it represents.
6. Discuss the difference between each type of cloud cover.

Cloud Cover Youth Project Samples:



Optional Activity:

Cloud Cover Practice Website – Have youth go to the Cloud Cover Practice website available at the following link (requires Adobe Flash):

<https://zebrazapps.com/embed/#/ff5f29880f0042c5b884e3fc67ea97f0>

This interactive web-based tool allows you to calibrate your eye by practicing cloud cover estimation using images on the computer. This can be very helpful when the youth begin their cloud observations and data entry on the GLOBE Observer – Clouds app.

ACTIVITY 4 - TYPES OF CLOUDS

Note to Educator: For younger children, educators might consider focusing only on the three main types of clouds (stratus, cumulus, cirrus) rather than all nine types. After completing this activity, it is suggested that educators take the youth outside to observe clouds again using the GLOBE Observer app. Have youth reflect on how their experiences in observing clouds and their skills in identifying clouds has changed since they first started using the app.

Purpose:

- To give youth an opportunity to develop their skills at identifying cloud types

Overview:

Youth work with photographs of clouds to sort them into high, middle, and low-level clouds and to learn to identify cloud types.

Time Required: 20-30 minutes

Materials Needed:

Advanced Preparation – Print on paper or cardstock, cut apart, and collate the sets of cloud levels, cloud pictures, types of clouds, and cloud description cards.

Each group of three to five youth need the items listed below:

- GLOBE *Observing Cloud Type (Appendix D)*
Also available at: <https://www.globe.gov/documents/348614/50bab4c6-d6b6-451c-84e3-2877d382f4ac>
- GLOBE *Cloud Identification Chart (Appendix A)*
Also available at: <https://www.globe.gov/documents/348614/782194b1-b5c3-4416-b3aa-b4a208ea5812>
- Set of cloud level cards (low-level clouds, mid-level clouds, and high clouds) (*Appendix E*)
- Set of cloud pictures (*Appendix F*) *Note:* the cloud pictures in Appendix F can be printed or shown using the Cloud Pictures Slide Show (PowerPoint) available at: <http://go.rutgers.edu/sl9pgiak>
- Set of types of clouds (*Appendix G*)
- Cloud type description card (*Appendix H*)

Background Information:

Clouds are masses of water and ice particles suspended in the atmosphere. At any given time, about two-thirds of Earth’s surface is covered by clouds.

Clouds help make the weather and affect Earth’s climate. They are a major component of the Earth system as they reflect, absorb, and scatter sunlight and infrared emissions from Earth. This affects how energy passes through the atmosphere. Clouds can change rapidly. Different types of clouds have different effects, and the amount of cloud cover is also important.

Characteristics of clouds are dictated by the atmospheric elements available, including the amount of water vapor, the temperatures at that height, the wind, and the interplay of other air masses. Colder clouds are found higher in the atmosphere with warmer ones closer to the surface.

Clouds take different shapes depending on the amount of water vapor available and the speed and direction of the moving air. Clouds are classified according to how they are formed.

Note: Refer to GLOBE *Cloud Identification Chart (Appendix A)* and GLOBE *Observation Basics (Appendix B)* for photos and more information.

Below are the three main types and their descriptions.

- **Stratus** clouds are low, flat, gray clouds that look like sheets covering the sky. They are the closest clouds to the ground and can produce rain, drizzle, snow, or mist. Such clouds with precipitation are distinguished as nimbostratus.
- **Cumulus** clouds are puffy and white-like cotton balls. They usually indicate fair weather. Sometimes they grow very large and become thunderheads (cumulonimbus). As these clouds gather they create thunder and lightning and produce precipitation in the form of rain and hail.
- **Cirrus** clouds are thin, curly, wispy clouds located high in the sky. They are sometimes referred to as mares' tails.

Clouds are also grouped according to their position or height in the sky – low level clouds, mid-level clouds, and high clouds.

The GLOBE Observer app features the clouds in the list below grouped according to the height of the cloud base.

High Clouds

- Contrails
- Cirrus
- Cirrocumulus
- Cirrostratus

Mid-level Clouds

- Altostratus
- Altocumulus

Low level Clouds (including rain or snow clouds)

- Fog/Stratus
- Stratocumulus
- Cumulus
- Nimbostratus
- Cumulonimbus

Introduction:

Did you know that clouds take different shapes depending on the amount of water vapor available and the speed and direction of the moving air? Clouds are classified according to how they are formed. There are three main types of clouds: Stratus, Cumulus, and Cirrus.

What to Do:

1. Provide an overview of cloud classifications including the three main types of clouds utilizing the Background Information.
2. Divide the youth into groups of three to five.
3. Give each group a copy of GLOBE *Observing Cloud Type (Appendix D)*, GLOBE *Cloud Identification Chart (Appendix A)*, and the cloud type descriptions (*Appendix H*) pages.
4. Give each group a set of cloud levels (*Appendix E*), a set of cloud pictures (*Appendix F*), and a set of the types of clouds cards (*Appendix G*).
5. Have the groups sort and group the photos by height (level) – low attitude or close to the ground, high in the sky, or medium attitude.
6. Have the groups sort and group the photos by type of cloud.
7. Have groups match the name with each cloud picture.
8. Discuss the difference between each type of cloud. Why is it helpful to be able to identify cloud types?
9. Review the cloud types and names.

Optional Activities:

- If youth have access to computers and the Internet, they can practice identifying clouds with the GLOBE Cloud Identification Key (requires Adobe Flash). This online interactive resource is available at:
<https://zebrazapps.com/embed/#/e7ac1eeb4717444183a36606035ecfd7> (20-30 minutes)
- Have groups visit the Cloud Type Practice website to practice their cloud classification skills website available at:
<http://www.pbs.org/wgbh/nova/labs/lab/cloud/research/classification>
This interactive web-based tool asks a series of questions to help you narrow down the type of cloud you are observing. This can be very helpful when the youth begin their cloud observations and data entry on the GLOBE Observer – Clouds app. (20-30 minutes)
- Using cotton balls or chalk on a large sheet of blue construction paper, have youth make examples of the three types of clouds – cirrus, cumulus, and stratus. (20-30 minutes)
- Have youth bring photographs of clouds and have the group look at them and identify the cloud type. Discuss with the youth when and where the photos were taken. Photos can be included in the cloud books made by the youth. (20-30 minutes)

ACTIVITY 5 - CLASSIFYING VISUAL OPACITY (TRANSPARENCY) OF CLOUDS

*Adapted from NASA S'COOL Program, Langley Research Center
(<https://scool.larc.nasa.gov/opacity.html>)*

Note to Educator: After you have completed this activity, it is suggested that you take the youth outside to observe clouds again using the GLOBE Observer app. Have youth consider the visual opacity (transparency) of the clouds today as compared to the last time they made an observation. Also have them reflect on how their experiences and skills in observing and classifying the visual opacity of clouds has changed since they first started using the app.

Purpose:

- To enable youth to learn the difference between transparent, translucent, and opaque

Overview:

Youth will learn about visual opacity or transparency of clouds and the differences among transparent, translucent and opaque.

Time Required: 20-30 minutes

Materials Needed:

Each group of three to five youth need the items listed below:

- Cloud pictures (actual or computer images to share with the group) (see *Appendix E*)
- Flashlights
- White construction paper (one piece per person)
- Clear plastic wrap (one piece approximately 6" X 6" per person)
- Gray and/or blue tissue paper (one piece approximately 6" X 6" per person)
- S'COOL Observing Cloud Visual Opacity (*Appendix I*)

Optional:

- Computer access
- Internet access

Background Information:

If clouds are present, we need some information on their opacity, or how much sunlight passes through the clouds. We use opacity rather than thickness because it means something a little different. When studying the radiative effects of clouds, we are interested in how much sunlight they let through, not so much how much vertical space they take up. We use three somewhat subjective categories to describe this: Transparent Cloud Opacity, Translucent Cloud Opacity, and Opaque Cloud Opacity. Refer to the *S'COOL Cloud Opacity page* for visual examples of different types of opacity: https://scool.larc.nasa.gov/opacity_examples.html

Transparent – light passes through and things on the other side can be seen clearly. This describes thin clouds through which light shows through.

Translucent – some light passes through, but things on the other side can't be seen clearly. These clouds are medium thickness and look milky/whitish in appearance.

Opaque – little to no light passes through. This describes thick clouds which do not allow light to pass directly, although light can diffuse through them. These clouds typically look gray or dark.

What to Do:

1. Divide youth into groups of three to five each.
2. Show youth pictures of clouds. Discuss the fact that the darker the cloud, as a general rule the less sunlight passing through.
3. Have youth use flashlights in a darkened room to explore the different amounts of light that come through construction paper, tissue paper, and clear plastic wrap.
4. Introduce the terms opaque cloud opacity, translucent cloud opacity, and transparent cloud opacity, and compare those terms to the amount of light that comes through construction paper, tissue paper, and clear plastic wrap.
5. Have youth create a "stained glass" project to visually show the difference between opaque, translucent and transparent clouds.
6. Have youth cut out the shape of one large cloud using all of a 9 x 12 piece of white construction paper.
7. Have youth cut out two smaller cloud shapes within the larger cloud.
8. Have youth cut a piece of tissue paper and a piece of clear plastic wrap slightly larger than each of the shapes.
9. Have youth tape the tissue paper to the back to the construction paper to fill one of the empty cloud spaces and the clear plastic wrap to fill the other one.
10. Tell the youth to write the types of visual opacity next to each cloud shape.

The construction paper will illustrate opaque clouds; the tissue paper will illustrate translucent clouds; and the clear plastic wrap will illustrate transparent clouds.

Optional Activity:

SciGirls Cloud Clues Activity (Visual Opacity) - This hands-on learning activity explores designing an experiment to categorize the opacity of different materials, extending the concept to real life and how the differing opacity of clouds can affect surface temperature. This activity is available at:

<https://observer.globe.gov/documents/19589576/20846667/scigirls2015+cloudclues.pdf/3c87e51b-1b12-4309-9285-ca68280ea4fe>

ACTIVITY 6 - CITIZEN SCIENCE AS A COMMUNITY ACTIVITY

Purpose:

- For youth to experience and recognize the community aspects of citizen science

Overview:

Science is a process of discovery that allows us to link isolated facts into coherent and comprehensive understandings of the natural world. It is a collection of observations intended to make sense of the world, and it moves in the direction of greater accuracy and understanding. As a process that takes place over time and that involves multitudes of people it is a community endeavor.

A key aspect of science is that scientists provide checks on each other's work. Even when one makes observations with an electronic device such as a mobile phone, results of observations can vary among observers. Variations may be due to slight differences in the instruments themselves or to observers' differences in perspective. Observers' reports may emphasize different aspects of the experience.

In this activity, youth will compare their experiences of making cloud observations.

Time Required: 30-45 minutes

Materials Needed:

- Same as for Activity 1, Part 3

What to Do:

1. Conduct Activity 1, Part 3, **Observe Clouds Using the GLOBE Observer App.**
Have youth make notes on the data they observe, so they will be able to compare their specific observations with other observations.
2. Have youth group into pairs and compare their observations. Have them note how their observations were similar and how different, and why that might have been.
3. Hold a class discussion: Why might one want to collaborate with another person when making observations? Do they feel they could come up with better answers by sharing and discussing?

ACTIVITY 7 – A LOOK AT GLOBE OBSERVER CLOUD DATA

Purpose:

- For youth to gain an awareness that GLOBE Observer citizen scientists from around the world are making and submitting observations
- To give youth an experience of studying patterns in their group’s observations, if multiple observations are made over time

Overview:

Youth will observe citizen-collected cloud observations on the GLOBE Observer website.

Time Required: 15-20 minutes

Materials Needed:

- Computers for youth with access to Internet

Background Information:

Clouds and the Earth's atmosphere are enormously dynamic. Even small changes in the abundance or location of clouds could change the climate more than the anticipated changes caused by greenhouse gases, human-produced aerosols, or other factors associated with global change. In order for scientists to create increasingly realistic computer simulations of Earth’s current and future climate, they need more accurate representations of the behavior of clouds. For this reason, clouds are an important area of study for NASA.

Satellites in space help us see clouds all around the world. Citizen scientists help NASA by providing ground observations of clouds. Scientists compare the ground observation data with the data collected by satellites.

What to Do:

With youth on computers, have them do the following:

1. Go to: observer.globe.gov
2. Click on “See the Data” (in band below green band near top of page).

A window will appear asking if you would like to share your location. Sharing is optional.

3. Select “Atmosphere” protocol at left; then, “Clouds,” and under Clouds, select the first three options: “Cloud Cover,” “Cloud Types,” and “Cloud Color.”
4. Click on “Submit” in the window with green background near top of page.
5. See that Cloud data have been submitted from across the globe. Different kinds of dots will appear. Clicking on “Legends” at lower right will provide information about what the different dots indicate.
6. Use the menus to change to different dates, and see how patterns of observation vary over time.

NOTE: *Activities 8-10 deal with a basic understanding of clouds. Activity 11 focuses on careers related to clouds.*

ACTIVITY 8 - ALL ABOUT CLOUDS

Purpose:

- To provide an opportunity for youth to develop a basic understanding of clouds

Overview:

Youth will learn what clouds are, what they do, and how clouds are formed.

Time Required: 10-15 minutes

Materials Needed: None

Background Information:

Clouds are masses of water and ice particles suspended in the atmosphere. At any given time, about two-thirds of Earth's surface is covered by clouds. Clouds play an important role in transferring energy from the Sun to different parts of the Earth. They help make the weather, and they profoundly affect Earth's climate.

NASA scientists need observations of clouds both from above (from space taken by satellites) and below (the ground). Since clouds change rapidly, scientists need frequent observations, and citizen scientists such as youth involved in 4-H programs can contribute important data.

What to Do:

Ask youth what questions they have about clouds, and list those where everyone in the group can see them. If any of the following questions are not included, add them to the list. Then as a group, brainstorm and discuss possible responses to the list of questions about clouds.

- What are clouds? *Clouds are visible masses of condensed water droplets and ice particles suspended in the atmosphere.*
- What do clouds do? *One of the most interesting features of Earth, as seen from space, is the ever-changing distribution of clouds. Clouds have an enormous influence on Earth's energy balance, climate, and weather. Clouds are the key regulator of the planet's average temperature. Some clouds contribute to cooling because they reflect some of the Sun's energy. Other clouds contribute to warming because they act like a blanket and trap some of the thermal energy Earth's surface and lower atmosphere emit.*
- Where do they come from? *Clouds are formed when water vapor in the atmosphere condenses into collections of tiny particles of water and/or ice that together are large enough to be visible.*
- What ingredients are needed to make a cloud? *The two required ingredients are water vapor and aerosols under the right environmental conditions.*

GLOBE Observer Citizen Science – Exploring Clouds

- Why don't clouds look the same? *Clouds are formed by different conditions in the atmosphere, and those conditions are never the same, so clouds take different shapes and have different properties.*
- Why are there sometimes clouds in the sky that don't rain? *Clouds have to contain enough moisture that it can fall to the ground before evaporating in order to produce rain.*
- How do I study clouds if I can't reach them? *People can learn a lot by observing clouds from the ground over time. Scientists study clouds with instruments on airplanes and on satellites, and that information is also available to explore.*
- Why is it important to study clouds? *Clouds tell us about air temperature, water and wind, which helps us to predict weather. They also affect how much sunlight is reaching the ground and escaping back to space, which helps us to understand climate.*

ACTIVITY 9 - HOW ARE CLOUDS FORMED?

Note to Educator: You can demonstrate this cloud activity to the entire group or you can allow each group of two-three youth to conduct the activity.

Purpose:

- To give youth an experience of making a cloud

Overview:

Youth will make their own cloud in a jar.

Time Required: 20-30 minutes

Materials Needed:

Each group of two or three youth need the items listed below:

- Sink or access to water
- Pint or quart size glass canning jar
- Small glass bowl to cover the jar
- Stove and teapot or a hot water pot
- Hot pad or pot holder
- Hot water (bubbling, almost ready to boil)
- Ice
- Can of air freshener or hairspray
- Safety glasses or goggles

Note to Educator: Tell youth that “aerosol spray” such as a spray can of hairspray or air freshener contains some liquid particles and that “aerosols” in relation to the atmosphere include particulate matter from many natural and human sources. As the youth learned in Activity 2, the number and kinds of particles (aerosols) in our atmosphere affect our sky conditions. An aerosol can be liquid or solid, mists or droplets, or tiny particles or material, such as ash. Aerosols can be anthropogenic (man-made) or naturally occurring. Man-made examples of aerosols include smoke from clearing land via burning or from burning of fossil fuels. Naturally occurring examples of aerosols include ash from volcanic eruptions or from wildfires, pollen from plants, or dust blowing off deserts.

Background Information:

A cloud is a large collection of small water droplets or ice crystals. The droplets are so small and light that they can float in the air. All air contains water, but near the ground it is usually in the form of an invisible gas called water vapor. When warm air rises, it expands and cools. Cool air can't hold as much water vapor as warm air, so some of the vapor condenses onto tiny pieces of dust or other particles that are floating in the air. Tiny water droplets form around these aerosol particles. When billions of such droplets come together they become a visible cloud.

There are a number of ways that the atmosphere can reach the conditions to form clouds; these involve either a drop in temperature or an increase in the water content of an air mass or both.

One common way that clouds form is when air is heated by the Sun. As air rises, it slowly cools and when it reaches the saturation point, the water condenses thus forming a cloud.

Clouds are constantly changing and moving under the influences of gravity, wind, and the processes of evaporation and condensation.

Introduction:

Clouds are interesting and mysterious. They come in a variety of shapes, sizes and colors. What are clouds made of? How do they form?

What to Do:

Note: Use caution when dealing with hot liquids and containers.

1. Divide youth into groups of two or three each.
2. Introduce this activity about clouds and ask youth the questions listed in this activity's Introduction.
3. Have youth put on safety glasses or goggles.
4. Warm up the glass jar by rinsing it with warm water from a faucet.
5. Pour 1-2 inches of hot water into the glass jar.
6. Fill a small glass bowl with ice and place the bowl on top of the glass jar.
7. Add a quick spray of air freshener or hairspray to the middle of the jar. Lift the ice bowl, spray, and quickly replace the bowl. (Try to spray the aerosol into the middle of the jar. If you hit the side of the jar, a cloud might not form.)
8. A cloud will form inside the jar as soon as you place the bowl of ice on top.
9. Lift the bowl of ice and release the cloud. Be sure to use your senses of sight and touch when the cloud leaves the jar.

Discussion:

1. What did you observe? What happened? Why do you think this happened?

Clouds in the atmosphere form in a very similar way as our cloud in the jar. First, clouds need water vapor. This was provided as the hot water evaporated into the jar. Next, clouds need cooling. As the water vapor rises, the air in the atmosphere is cooler. This causes the water vapor to condense. The last thing a cloud needs to form is a surface to condense upon. Small particles called cloud condensation nuclei fill this role. In the atmosphere, these particles could be dust, smoke, air pollution, soot, sea salt, sulfate, or something else. In this cloud formation experiment, the aerosol spray served as the cloud condensation nuclei.

2. When you removed the bowl of ice from the jar, what happened?
3. When the cloud was released from the jar, what did the cloud look like? What did it feel like?

Optional Activities:

- [Investigating the Earth System. Activity Two: Cloud Formation](https://www.nasa.gov/pdf/62317main_ICSClouds.pdf) (For Grades 5-8)
https://www.nasa.gov/pdf/62317main_ICSClouds.pdf (Pages 5-6)

GLOBE Observer Citizen Science – Exploring Clouds

Note to Educator: The “Create a Cloud in a Jar” activity entails youth using matches and incense sticks. Educators will vary on their levels of comfort with this aspect of the activity.

- S’Cool. Create a Cloud in a Jar (For Grades 9-12). *This activity involves the use of matches.*
https://scool.larc.nasa.gov/cgi-bin/view_lessonplan.cgi?id=88
- Contrail Formation Tutorial - In this tutorial, youth can explore the physics of contrail formation in the atmosphere and develop the ability to recognize the several types of contrails that form under varying atmospheric conditions. Practice classifying the type and abundance of contrails. The tutorial (requires Adobe Flash) is available at:
<https://zebrazapps.com/embed/#/699134bfa0b74d53a382f21e8d375024>

ACTIVITY 10 – HOW DO CLOUDS MAKE PRECIPITATION?

Adapted from various locations including KidSpot Things to Do website:

<http://www.kidspot.com.au/things-to-do/activities/rain-cloud-in-a-jar-science-experiment>

Notes to Educator:

- This activity does *not* reproduce the actual phenomenon of how clouds make rain. It only approximates that phenomenon to help youth better understand how precipitation can happen.
- You can demonstrate this activity to the entire group or have each group of three to five youth do the activity.

Purpose:

- To give youth an experience of visualizing how clouds make rain

Overview:

Youth learn how clouds make precipitation and observe clouds making rain in a jar.

Time Required: 15-20 minutes

Materials Needed:

Each group of three to five youth need the items listed below:

- Clear plastic cup, glass or jar
- Shaving cream
- Blue food coloring
- Eye dropper or plastic pipette
- Water
- Tray or pan to hold plastic cup, glass or jar

Background Information:

When warm, wet air rises, it cools, and water vapor condenses to form clouds. A cloud is made up of small drops of water or ice crystals, depending on its height and how cold the surrounding air is. Height and temperature also determine whether any “precipitation” that results will be rain or hail associated with thunderstorms or snow, sleet or freezing rain associated with winter weather.

In order for rain to form, water vapor needs a “condensation nucleus”, which can be particles of dust or pollen in the atmosphere. When the condensing droplets that form the cloud get large and heavy enough to overcome the upward motion of convection, rain or some other form of precipitation begins to fall from the clouds.

What to Do:

1. Have youth watch the “Making of a Cloud” video:
The Making of a Cloud. <https://www.youtube.com/watch?v=UZEETyzql0Q>
Also see: Precipitation Education. <https://pmm.nasa.gov/education/water-cycle>
2. Divide the youth into groups of three to five each.

GLOBE Observer Citizen Science – Exploring Clouds

3. Ask the youth if they know how clouds make rain or other types of precipitation (snow, sleet or hail).
4. Fill a clear plastic cup, jar or glass three quarters full with tap water.
5. Place the plastic cup, jar or glass on a tray or in a pan to prevent spills.
6. Use shaving cream to create a cloud on top of the water.
7. Using an eye dropper or pipette, insert 10-12 drops of food coloring into the shaving cream (cloud). Ask the youth to predict what might happen.
8. Discuss with the youth how precipitation is formed in clouds. Tell the youth that water droplets and ice crystals are high in the sky in the clouds. As more and more vapor condenses and droplets or ice crystals become larger, they will fall from the sky. The force of gravity on them overcomes the upward air motions.
9. Observe the shaving cream cloud and discuss what happens in this simple model. The shaving cream can hold only some food coloring. When the food coloring becomes too much (somewhat like cloud droplets or crystals becoming too heavy), it falls down into the water, much like rain or snow falls from clouds.

ACTIVITY 11 - CAREERS THAT INVOLVE UNDERSTANDING CLOUDS

Note to Educator:

- This activity is most appropriate for youth, ages 12-14 (grades 7-8) and older.
- After you have completed this activity, it is suggested that you take the youth outside to observe clouds again using the GLOBE Observer app.

Purpose:

- To provide an opportunity for youth to explore careers related to clouds

Overview:

Youth will learn about the wide variety of careers that involve the study and/or understanding of clouds.

Time Required: 15-20 minutes

Materials Needed:

Advanced Preparation – Print, cut, and collate a set of job title cards and job description cards for each group.

Each group of three to five youth need the items listed below:

- Set of job title cards (*Appendix J*)
- Set of job description cards (*Appendix K*)

Introduction:

There are a variety of careers involving the study of clouds. Everything from scientists to technicians to educators. Can you name a job related to clouds or a career that might involve knowledge and understanding of clouds?

What to Do:

1. Introduce the activity.
2. Divide the youth into groups of three to five.
3. Distribute a set of job descriptions and a set of job titles to each group.
4. Ask the youth to read aloud all of the job titles and job descriptions and then work as a group to match the job title with the description.
5. Have individuals in each group read aloud the cards they matched and check for accuracy.
6. Discuss the careers on the list below. Ask if anyone knows someone who has this type of job, or if they might be interested in learning more about this career option.
7. Tell the youth that some scientists study the clouds of other planets. Ask them if they knew that those clouds are made of different substances than Earth's clouds.

Careers Related to Clouds:

Atmospheric Chemist – a person who studies the chemical composition of the atmosphere.

Atmospheric Physicist – a person who studies processes such as the heating and cooling of the atmosphere.

Atmospheric Scientist – a person who studies the physics and chemistry of clouds, gases, and aerosols (airborne particles) that surround the planetary bodies of the solar system. Atmospheric science education at the college and university level has grown in recent years. Atmospheric scientists may work in the following areas: field research, laboratory studies, and/or computer analysis and modeling.

Climatologist – a person who studies weather variations over long-term periods such as months, years, or centuries. Their work may include collecting and analyzing past records of region specific temperatures or rainfall.

Cloud Physicist – a person who studies the formation and evolution of clouds and precipitation.

Communications/Public Affairs Specialist – a person who is responsible for sharing and/or distributing the work and research findings of an agency or organization.

Computer Scientist – a person who helps meteorologists design computer models of atmospheric processes.

Data Analysis and Modeling Specialist – a person who examines the data produced by experiments and develops the theoretical models to interpret the data. The result is an improvement of our understanding of atmospheric motions and chemistry, climate change, and weather forecasting. This area requires experience in computer science, mathematics, chemistry, physics, and meteorology.

Information and Technology Specialist – A person who has an in-depth knowledge of design theory for operation and operating practices who is responsible for information technology equipment, software, telecommunications, networking, and security.

Instrumentation and Data Acquisition Manager – a person who works with the design and operation of instrument systems that measure the Earth’s atmosphere from space, from within the atmosphere, and from the ground. This area requires a background in electronics, optics, computer science, or radiative transfer.

Meteorologist – a person who studies the atmosphere. They use scientific principles to explain, understand, observe or forecast the earth’s atmospheric phenomena and/or how the atmosphere affects the Earth and life on the planet. They can have many different jobs including weather forecasting, atmospheric research, teaching, etc.

Physical Meteorologist – a person who studies the chemical and physical properties of the atmosphere such as light transmission and radio and sound waves. They may also study factors that affect cloud formation or other atmospheric phenomena.

Research Meteorologist – a person who often works closely with chemists, physicists, oceanographers, hydrologists, and researchers in other branches of environmental science to better understand complex weather phenomena such as tornadoes, hurricanes, snowstorms, etc.

Science and Operations Officer - A person responsible for a variety of duties including creating and assigning new training to infusing new technology into operations as well as overall management of operations.

Resources for this Activity:

- Video: Why the World Needs Meteorologists (Runs about five minutes)
<https://youtu.be/QECIYoiaFY>
- American Meteorological Society Career Guide
<https://www.ametsoc.org/ams/index.cfm/education-careers/career-guides-tools/>

Optional Activities:

- Invite a guest speaker to your meeting or program to talk about a career related to clouds or about the speaker's involvement in citizen science.

- Encourage youth to research careers related to clouds. Have them select one career and prepare a public presentation or a poster on that career for the group.

4-H ACTIVITY GUIDE
GLOBE Observer Citizen Science – Exploring Clouds

EVALUATION

Please complete this evaluation to help us document the impact of this 4-H Activity Guide. The evaluation can be completed on-line at: https://rutgers.ca1.qualtrics.com/jfe/form/SV_7Vhk4ue15LCVWyp or you can print and mail or email to the address at the bottom of this page.

Today's Date:

Title of Person Completing:

Which activities did you use? (*circle all that apply*):

Activity 1 – Becoming a Citizen Scientist

Activity 2 – How Blue is the Sky?

Activity 3 – Estimating Percentage of the Sky Covered By Clouds

Activity 4 – Types of Clouds

Activity 5 – Classifying Visual Opacity (Transparency) of Clouds

Activity 6 – Citizen Science in Communities

Activity 7 – A Look at GLOBE Observer Cloud Data

Activity 8 – All About

Clouds

Activity 9 – How are Clouds Formed?

Activity 10 – How do Clouds Make Precipitation?

Activity 11 – Careers Related to Clouds

Grade (*circle all that apply*):

Grade 4

Grade 5

Grade 6

Grade 7

Grade 8

Other (please specify) _____

OR Age (*circle all that apply*): 10 yrs.

11 yrs.

12 yrs.

13 yrs.

14 yrs.

Other (please specify) _____

Delivery Setting (*circle all that apply*):

Club

Camp

Afterschool

School Enrichment Program

Workshop Other (please specify) _____

Number of Participants:

____ Male

____ Female

____ Not Identified

____ Total

Please answer the following questions about curriculum:

	Agree	Somewhat Agree	Disagree
The activities addressed the stated objectives.			
The activities provided a valuable learning experience for my youth.			
The activity overall met my expectations.			

Please evaluate the learning experience:

	A lot	Somewhat	A little or not at all
Youth learned about citizen science.			
Youth learned how to observe clouds.			
Youth learned about clouds.			

4-H ACTIVITY GUIDE
GLOBE Observer Citizen Science – Exploring Clouds

Youth are interested in citizen science.			
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Thank you for completing this evaluation. Please return by email or U.S. Mail.

Jeannette Rea Keywood, State 4-H Agent, 1636 Delaware Avenue, Cape May, New Jersey 08204
 reakeywood@njaes.rutgers.edu

APPENDICES

Activity	Appendix	Title
Activity 1- Part 3 Activity 4	A	GLOBE Cloud Identification Chart
Activity 1-Part 3 Activity 2	B	GLOBE Observation Basics
Activity 2	C	Why (Not) So Blue? Sky Color and Visibility Activity Sheet
Activity 3	B	GLOBE Observation Basics
Activity 4	D	Observing Cloud Type
Activity 4	E	Cloud Level Cards
Activity 4	F	Cloud Pictures
Activity 4	G	Types of Clouds
Activity 4	H	Cloud Type Descriptions
Activity 5	I	S'COOL Observing Cloud Visual Opacity
Activity 11	J	Cloud Career/Job Title Cards
Activity 11	K	Cloud Career/Job Description Cards



THE **GLOBE** PROGRAM

Cloud Identification Chart



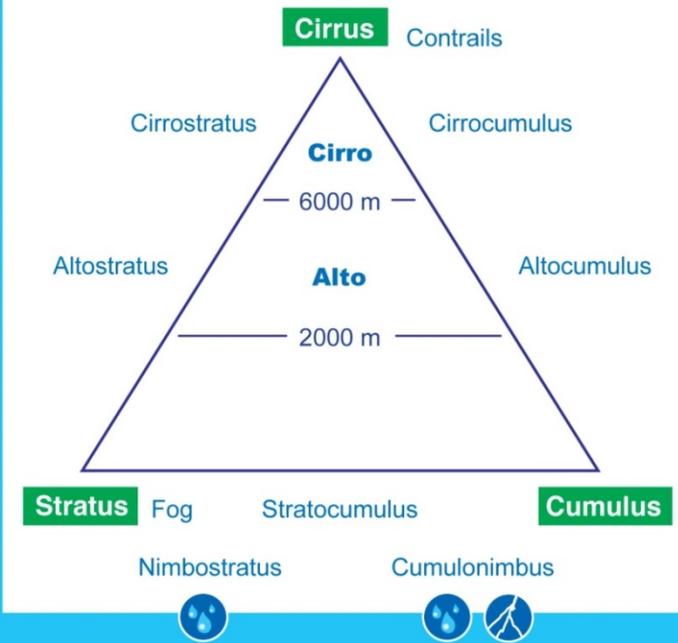
Contrails			
	Short-lived	Persistent Non-Spreading	Persistent Spreading
Cirrus			
	Cirrus	Cirrocumulus	Cirrostratus
Altostratus			<div style="border: 2px solid blue; padding: 10px; text-align: center;"> <p>CONVECTIVE CLOUDS</p>   <p>Cumulonimbus  </p>  <p>Cumulus</p> </div>
	Altostratus	Altostratus	
Stratus			
	Stratus	Stratocumulus	
Nimbostratus			
	Nimbostratus 	Fog	



Observation Basics



Cloud Type



Sky Color

Deep Blue Blue Light Blue
 Pale Blue Milky

Sky Visibility

Unusually Clear Clear
 Somewhat Hazy Very Hazy
 Extremely Hazy

Cloud Cover

Few (<10%) Isolated (10-25%)
 Scattered (25-50%) Broken (50-90%)
 Overcast (>90%)

Cloud Opacity

Transparent Translucent Opaque

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Why (Not) So Blue? Color and Visibility Activity Sheet

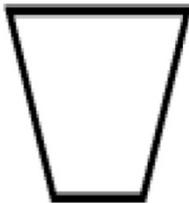
Prediction

When I add drops of milk to the water, this is what I think will happen:



When I add drops of milk to the water, this is what I see:

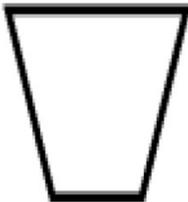
No Milk



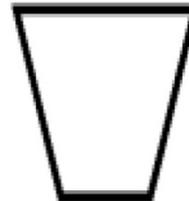
3 Drops of Milk



Less than 1 Drop
of Milk



2 Drops of Milk



5 Drops of Milk



Observing Cloud Type

<https://www.globe.gov/documents/348614/50bab4c6-d6b6-451c-84e3-2877d382f4ac>

Observing Cloud Type

There are five descriptive terms for the various types of clouds:

CIRRO or high clouds

ALTO or middle clouds

CUMULUS or white puffy clouds

STRATUS or layered clouds

NIMBUS or clouds from which precipitation is falling

The following ten types of clouds, named using the above terms, are to be used when reporting the cloud type for your area:



High Clouds

Cirrus

These clouds look like white delicate feathers. They are generally white wispy forms. They contain ice crystals.



Cirrocumulus

These clouds are thin white layers with a texture giving them the look of patches of cotton or ripples without shadows. They contain primarily ice crystals and perhaps some very cold water droplets.

Observing Cloud Type

<https://www.globe.gov/documents/348614/50bab4c6-d6b6-451c-84e3-2877d382f4ac>

***Cirrostratus***

These clouds are a thin, almost transparent, whitish layer made up of ice crystals. They may totally or partly cover the sky and can create a halo appearance around the sun.

**Contrails*****Short-lived Contrail***

Note the short line of cloud above the lightpole. The airplane is barely visible in this photo but is at the front of the contrail

***Persistent Contrails***

These are very distinct contrails, and show a range from persistent non-spreading on the right to persistent spreading on the left. The most likely explanation for this photo is that all three airplanes followed about the same path, but that the winds high in the atmosphere are blowing from right to left, moving the older contrails to the left. The spreading of the left-most contrail indicates there is a fair amount of water vapor in the upper atmosphere.

Observing Cloud Type

<https://www.globe.gov/documents/348614/50bab4c6-d6b6-451c-84e3-2877d382f4ac>



Persistent, Spreading Contrails

This photo shows persistent, spreading contrails in an area of high air traffic. As above, it is likely that the planes are mostly following a similar path, but the contrails are being spread out by the wind. Note that all the contrails in this photo appear as wide or wider than those above, indicating that the presence of abundant water vapor in the atmosphere is allowing the contrails to spread. Also note the cloud near the middle of the photo, which looks like a regular cirrus cloud, but whose position makes it likely that this cloud actually originated from a contrail.



Middle Clouds

Altostratus

These clouds form a bluish or grayish veil that totally or partially covers the sky. The light of the sun can be seen through them but there is no halo effect.



Altostratus

These clouds look like waves of the sea with white and gray coloring and shadows. They contain mostly water droplets and perhaps some ice crystals.

Observing Cloud Type

<https://www.globe.gov/documents/348614/50bab4c6-d6b6-451c-84e3-2877d382f4ac>



Low Clouds

Stratus

These clouds are gray and lie very close to the surface of the Earth. They usually look like a sheet layer but sometimes are found in patches. They rarely produce precipitation.



Stratocumulus

These clouds are a gray or whitish color. The bases of these clouds tend to be more round than flat. They can be formed from old stratus clouds or from cumulus clouds that are spreading out. Their tops also tend to be mostly flat.

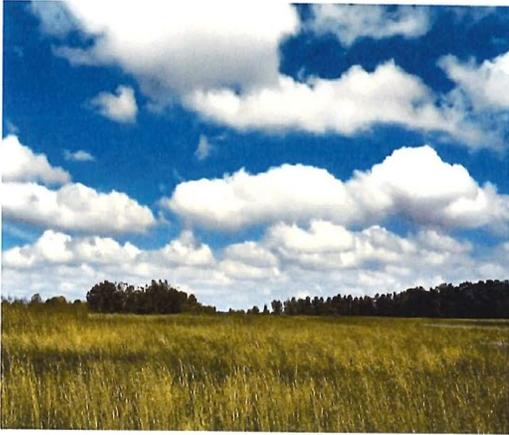


Nimbostratus

This is a very dark and gray-colored cloud layer that blots out the light of the sun. It is massive and has a continuous fall of precipitation.

Observing Cloud Type

<https://www.globe.gov/documents/348614/50bab4c6-d6b6-451c-84e3-2877d382f4ac>

***Cumulus***

These clouds have a flat base and a dense, mound-shaped top that resembles a large cauliflower. Where the sun hits these clouds they are a brilliant white. The base tends to be a darker gray. They generally do not produce precipitation.

***Cumulonimbus***

These are large, heavy, and dense clouds. They have a generally flat, dark surface with very tall and large tops like the shape of a massive mountain or anvil. These clouds are often associated with lightning, thunder and sometimes hail. They may also produce tornados.

High Clouds	High Clouds
Mid-Level Clouds	Mid-Level Clouds
Low Level Clouds	Low Level Clouds

APPENDIX F
Cloud Pictures

<http://go.rutgers.edu/sl9pgiak>

Photo #2

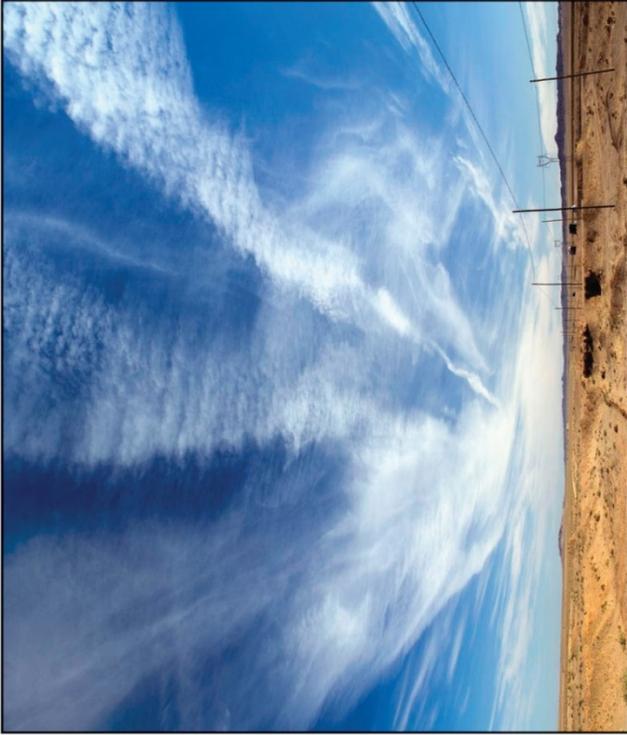


Photo #4

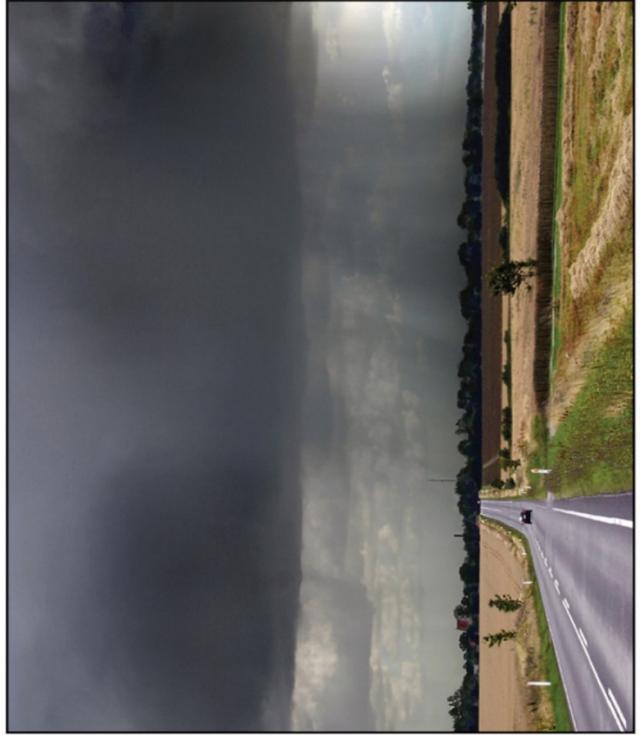
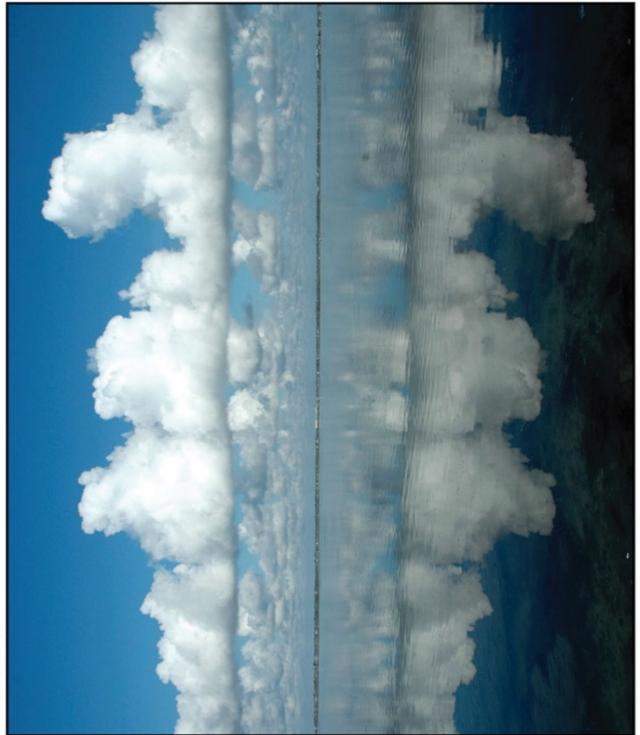


Photo #1



Photo #3



APPENDIX F
Cloud Pictures

<http://go.rutgers.edu/sl9pgiak>

Photo #6



Photo #8

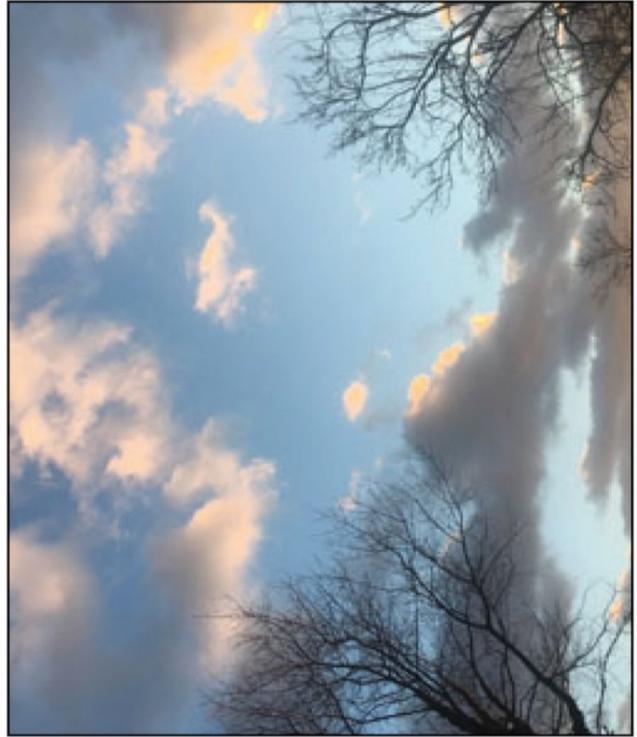


Photo #5



Photo #7

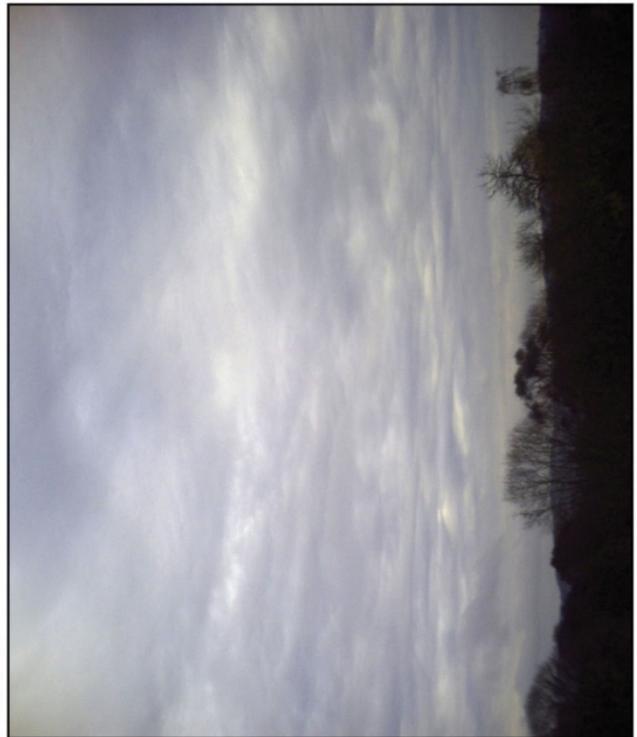


Photo #10



Photo #12

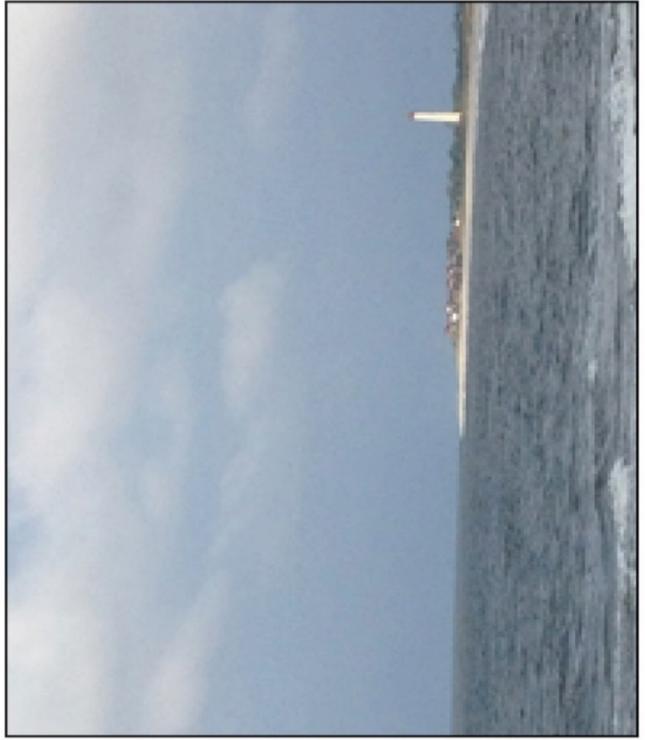


Photo #9



Photo #11

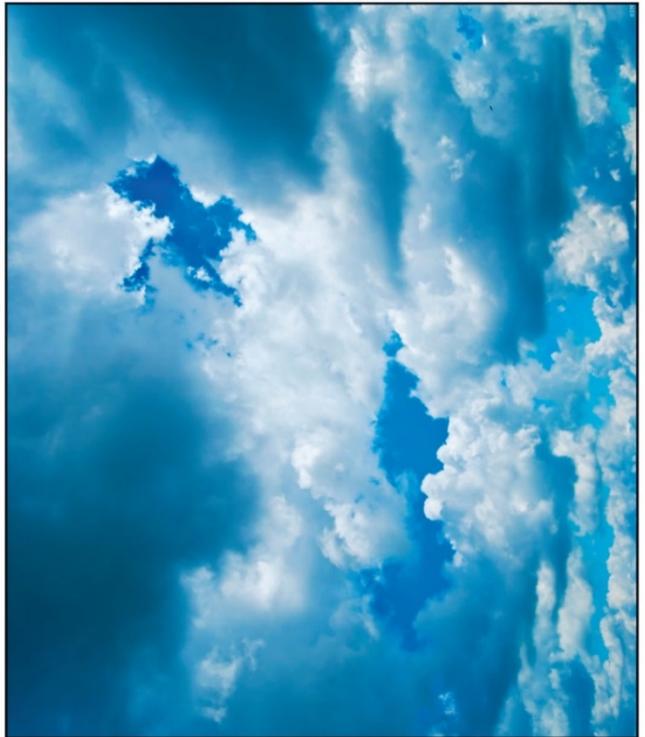


Photo #14

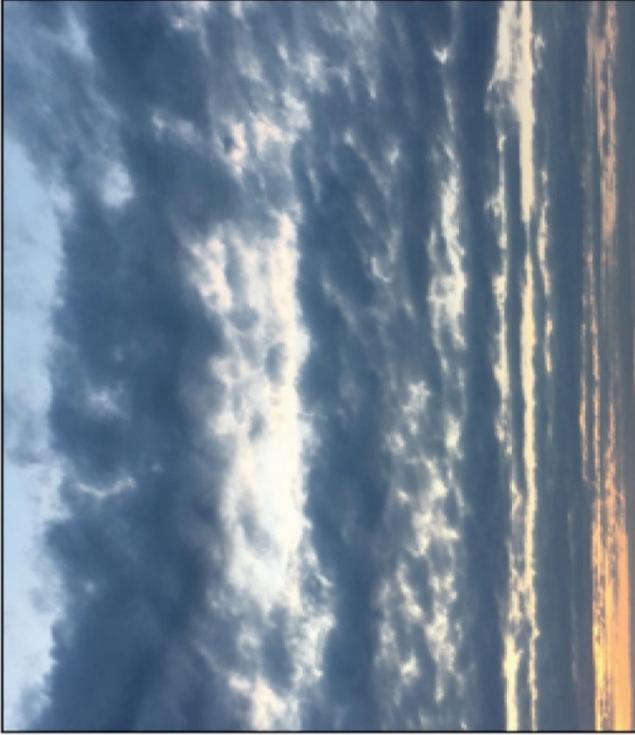


Photo #16

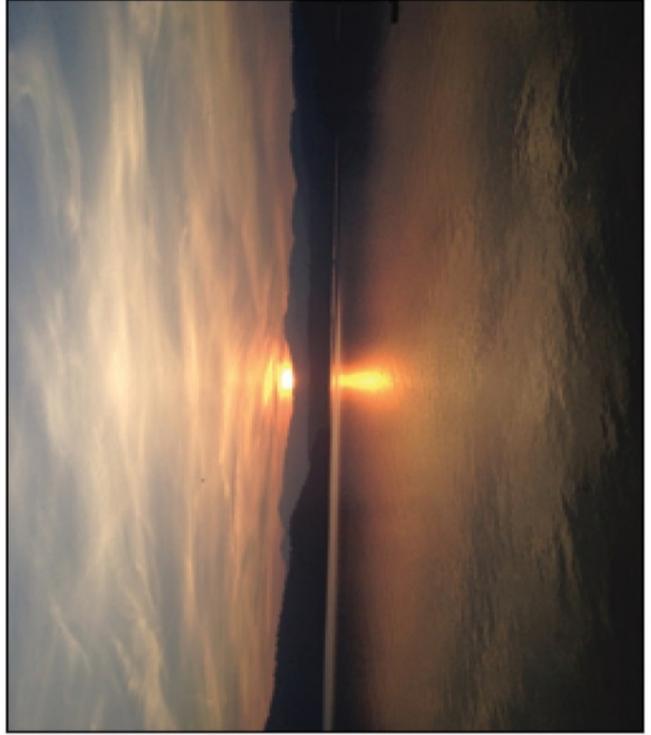
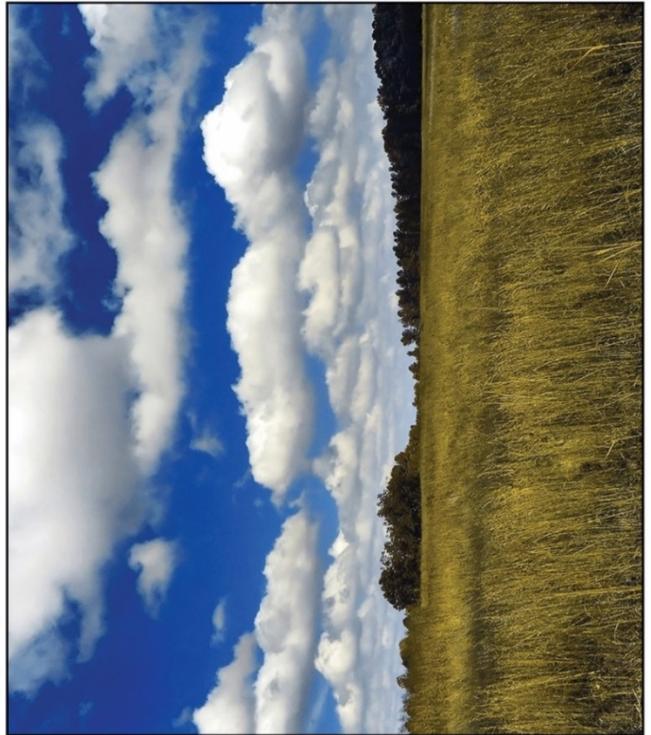


Photo #13



Photo #15



APPENDIX F
Cloud Pictures
<http://go.rutgers.edu/sl9pgiak>

Photo #18

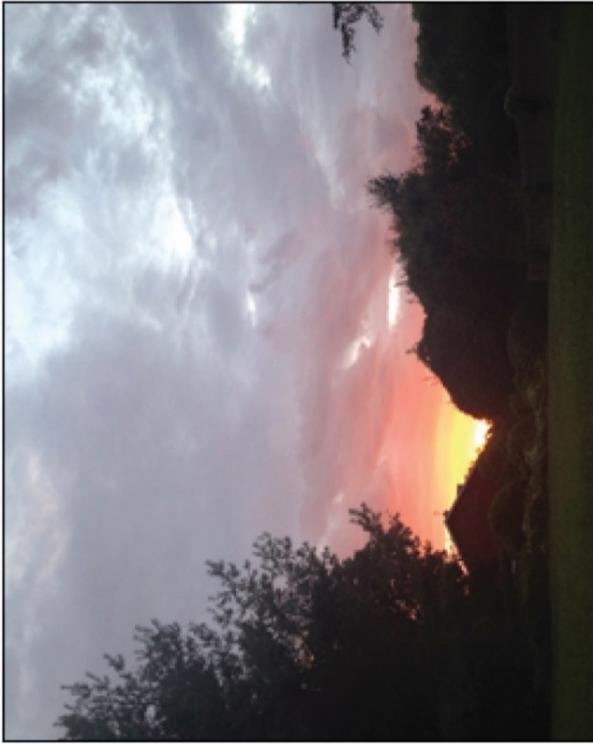


Photo #20

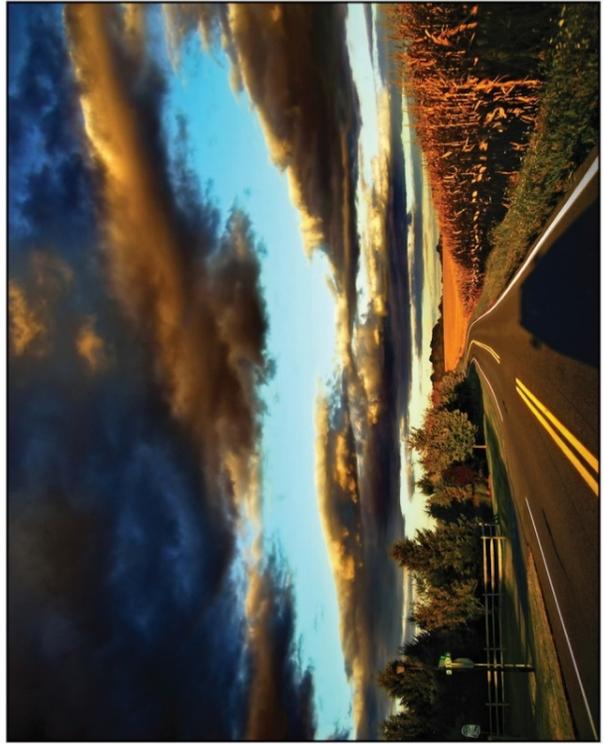


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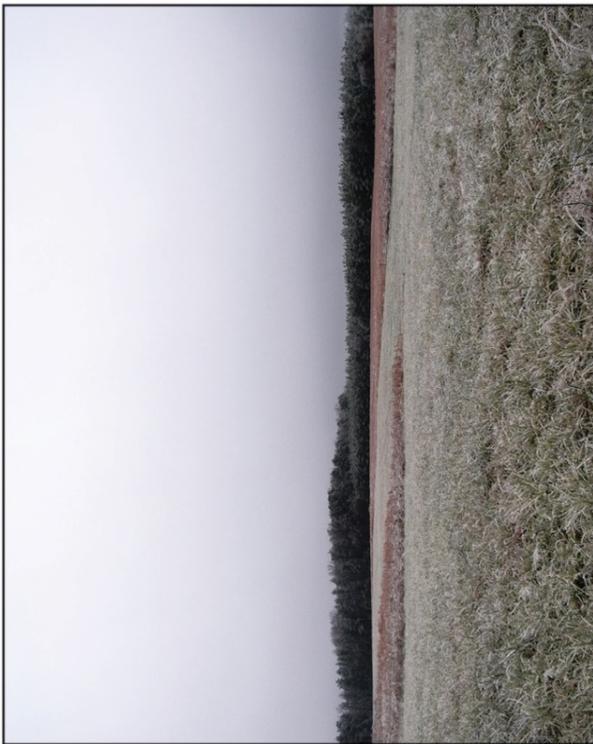


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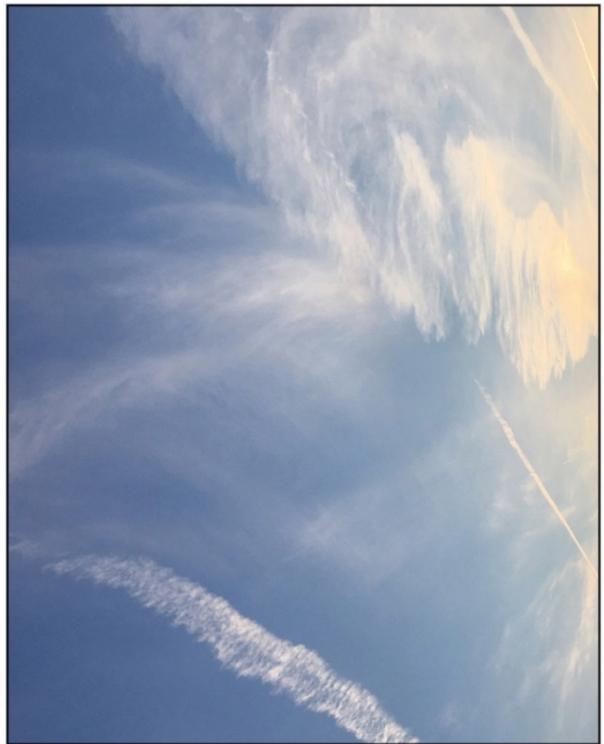


Photo #22



Photo #24

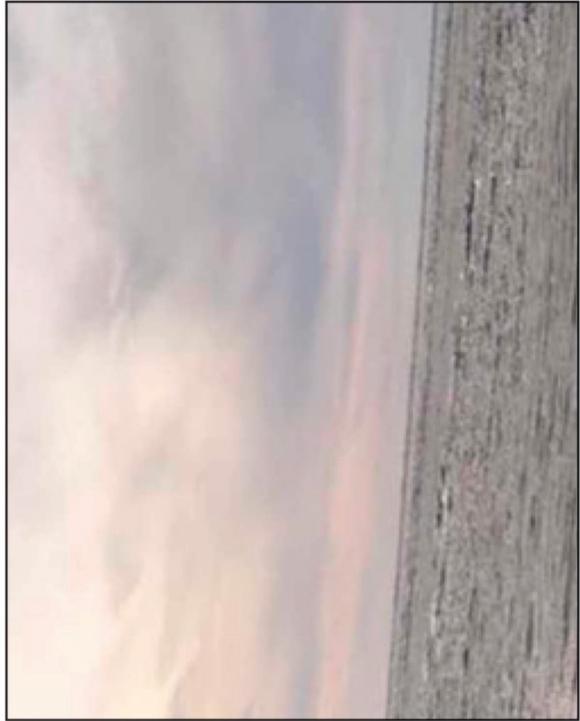


Photo #21



Photo #23



<http://go.rutgers.edu/sl9pgiak>

Photo #26



Photo #28

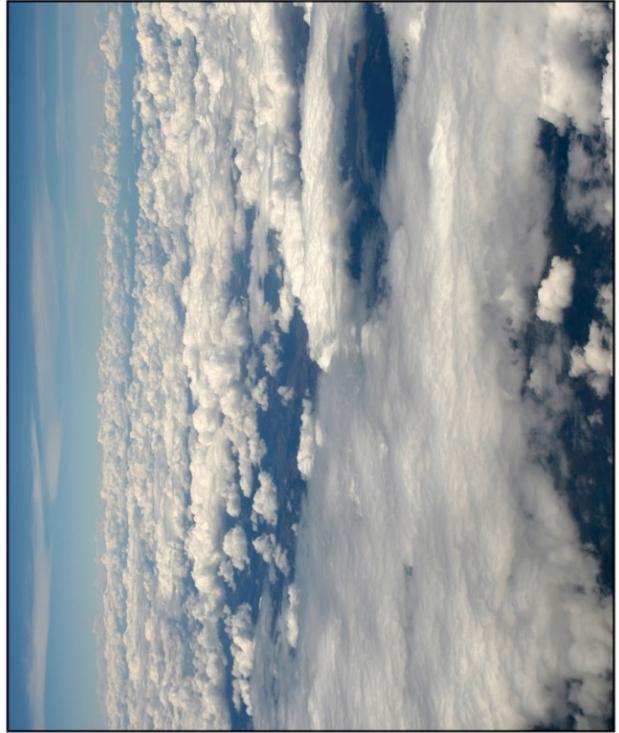
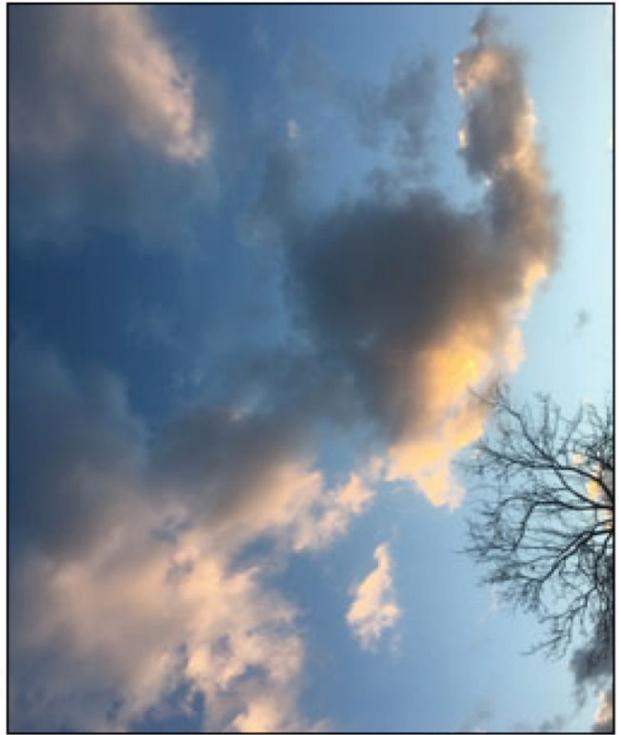


Photo #25



Photo #27



APPENDIX F
Cloud Pictures

<http://go.rutgers.edu/sl9pgiak>

Photo #30

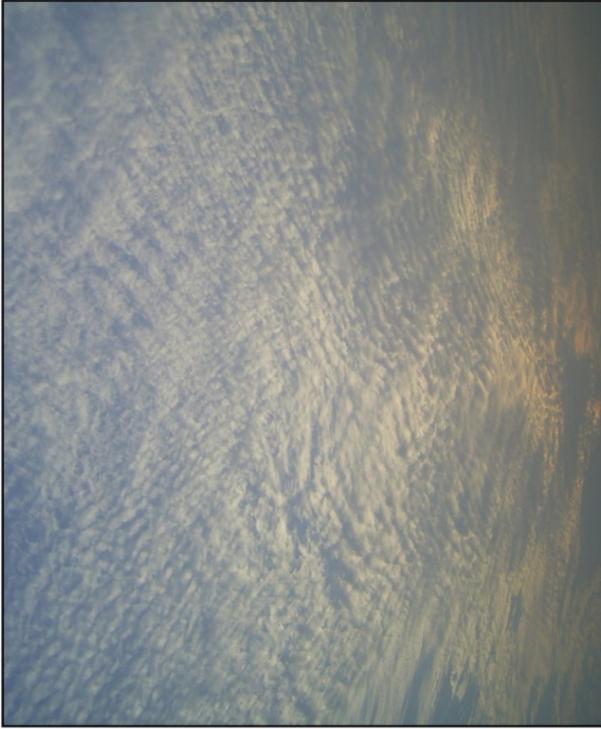


Photo #29

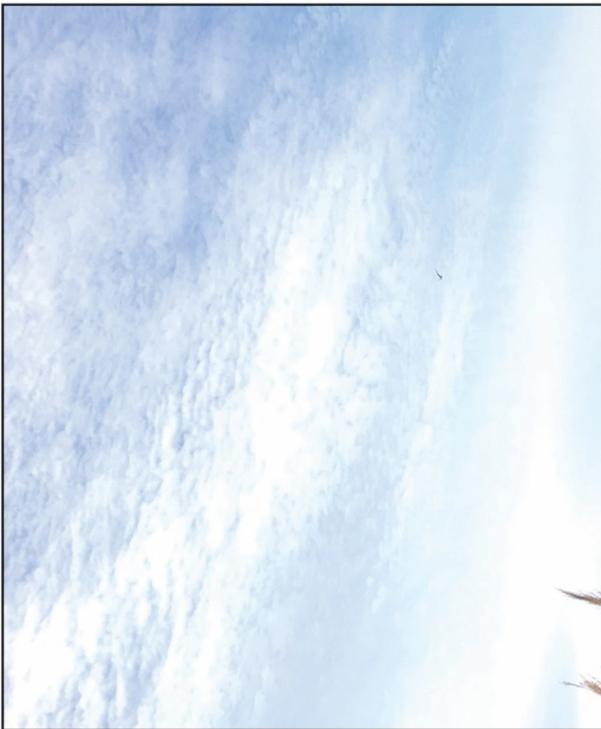


Photo #31



Cloud Identification Key

Please note that often clouds seen in the sky are a combination of different types. Many views of the sky will have more than one cloud type and not every cloud will be exactly typical of its type.

Photo 1: Cirrus

Photo 2: Cirrus and Persistent Spreading Contrails

Photo 3: Cumulus

Photo 4: Nimbostratus

Photo 5: Altocumulus

Photo 6: Cirrus

Photo 7: Altostratus

Photo 8: Cumulus – Stratocumulus clouds are forming at the bottom of the picture.

Photo 9: Persistent Spreading Contrails

Photo 10: Altocumulus

Photo 11: Cumulus

Photo 12: Stratus

Photo 13: Nimbostratus

Photo 14: Altocumulus

Photo 15: Cumulus

Photo 16: Cirrus

Photo 17: Nimbostratus

Photo 18: Stratocumulus

Photo 19: Persistent Spreading Contrails and Cirrus

Photo 20: Stratocumulus

Photo 21: Cirrostratus

Photo 22: Cumulus

Photo 23: Shelf Cloud – Shelf clouds are not a GLOBE cloud type.

Cloud Pictures

<http://go.rutgers.edu/sl9pgiak>

Photo 24: Stratus

Photo 25: Cirrocumulus

Photo 26: Cumulus

Photo 27: Cumulus

Photo 28: Stratocumulus

Photo 29: Cirrus

Photo 30: Cirrocumulus

Photo 31: Persistent Contrails

Photo Credits: Jeannette Allen (Photos 1, 3, 4, 6, 9); Bidgee (from Wikipedia) (Photo 5); Amy Chan (Photo 2); The Great Cloudwatcher (Photo 7); Jeannette Rea Keywood (Photos 8, 10, 12, 14, 16, 18, 19, 22-26, 27, 29); PiccoloNamek (Photo 15, 17); Nicholas A. Tonelli (Photo 20); Jupiter Plymouth (Photo 21); Muhammad Mahdi Karim (Photo 28); Typhoonchaser (Photo 30); Carol Clark (Photo 31)

APPENDIX G
Types of Clouds

Contrails	Cirrus
Cirrocumulus	Cirrostratus
Altostratus	Alto cumulus
Fog	Stratus
Stratocumulus	Cumulus

APPENDIX H
Cloud Type Descriptions

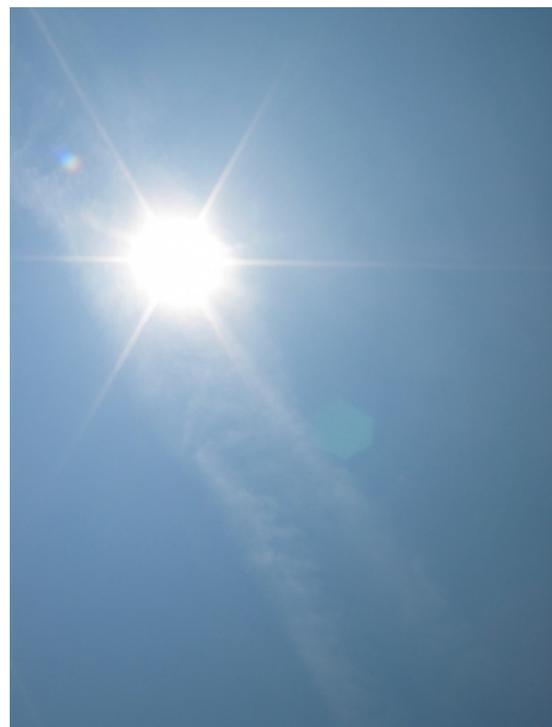
<ul style="list-style-type: none"> • Stratus clouds are low, flat, gray clouds that look like sheets covering the sky. They can produce rain, snow, drizzle or mist. • Cumulus clouds are puffy and white-like cotton balls. They usually indicate fair weather. Sometimes they grow very large and become thunderheads. • Cirrus clouds are thin, curly, wispy clouds located high in the sky. They are sometimes referred to as mares' tails. 	<ul style="list-style-type: none"> • Stratus clouds are low, flat, gray clouds that look like sheets covering the sky. They can produce rain, snow, drizzle or mist. • Cumulus clouds are puffy and white-like cotton balls. They usually indicate fair weather. Sometimes they grow very large and become thunderheads. • Cirrus clouds are thin, curly, wispy clouds located high in the sky. They are sometimes referred to as mares' tails.
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Observing Cloud Visual Opacity: Some Examples

Photos by student interns in the summer 2007 SPHERE program: Jon Doughty, Amy Lankey, and Matt Page.

Transparent Cloud Examples

Note the milky blue-white appearance of all these clouds.



Translucent Cloud Examples

These clouds are much more definitely white, with only a little bit of gray.



S'COOL Observing Cloud Visual Opacity

Opaque Cloud Examples

These clouds are predominantly gray, especially on the undersides.



Source: S'COOL (Students' Cloud Observation On-Line) New Users, NASA Langley Research Center
https://scool.larc.nasa.gov/opacity_examples.html

Cloud Related Career/Job Titles

Atmospheric Chemist	Atmospheric Physicist
Atmospheric Scientist	Climatologist
Cloud Physicist	Communications/Public Affairs Specialist
Computer Scientist	Data Analysis and Modeling Specialist
Information and Technology Specialist	Instrumentation and Data Acquisition Manager
Meteorologist	Physical Meteorologist

Cloud Related Career/Job Titles

<p>Research Meteorologist</p>	<p>Science and Operations Officer</p>
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Cloud Related Career/Job Description Cards

<p>A person who studies the chemical composition of the atmosphere.</p>	<p>A person who studies processes such as the heating and cooling of the atmosphere.</p>
<p>A person who studies the physics and chemistry of clouds, gases, and aerosols (airborne particles) that surround the planetary bodies of the solar system.</p>	<p>A person who examines the data produced by experiments and develops the theoretical models to interpret the data.</p>

Cloud Related Career/Job Description Cards

<p>A person who has an in-depth knowledge of design theory for operation and operating practices who is responsible for information technology equipment, software, telecommunications, networking, and security.</p>	<p>A person responsible for a variety of duties including creating and assigning new training to infusing new technology into operations as well as overall management of operations.</p>
<p>A person who studies the formation and evolution of clouds and precipitation.</p>	<p>A person who is responsible for sharing and/or distributing the work and research findings of the agency or organization.</p>

<p>A person who works with the design and operation of instrument systems that measure the Earth's atmosphere from space, from within the atmosphere, and from the ground.</p>	<p>A person who studies the atmosphere. They use scientific principles to explain, understand, observe or forecast the earth's atmospheric phenomena and/or how the atmosphere affects the earth and life on the planet. They can have many different jobs including weather forecasting, atmospheric research, teaching, etc.</p>
<p>A person who studies the chemical and physical properties of the atmosphere such as light transmission and radio and sound waves. They may also study factors that affect cloud formation or other atmospheric phenomena.</p>	<p>A person who often works closely with chemists, physicists, oceanographers, hydrologists, and researchers in other branches of environmental science to better understand complex weather phenomena such as tornadoes, hurricanes, snowstorms, etc.</p>

<p>A person who helps meteorologists design computer models of atmospheric processes.</p>	<p>A person who studies weather variations over long-term periods such as months, years, or centuries. Their work may include collecting and analyzing past records of region specific temperatures or rainfall.</p>
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PURPOSE

This guide provides opportunities for youth ages 9-14 or in grades 4-8, and can be adapted to other age groups, to learn about clouds, collect cloud data and engage in citizen science through the *GLOBE Observer* program. The guide includes hands-on and interactive activities that can be used in a variety of educational settings, including camps, special interest programs, 4-H clubs, after-school programs, or school enrichment programs.

4-H & NASA PARTNERSHIP

The 4-H Program is the federal positive youth development program from the land-grant institution's Cooperative Extension Service and the National Institute of Food and Agriculture (NIFA) at USDA. There is a formal agreement between the two federal agencies, NIFA and NASA, to pursue collaboration related to youth in Science, Technology, Engineering, and Mathematics (STEM).

This 4-H Activity Guide is designed to support use of the *GLOBE Observer*. It was conceived as a joint project between 4-H National Headquarters at USDA-NIFA and NASA Goddard Space Center.