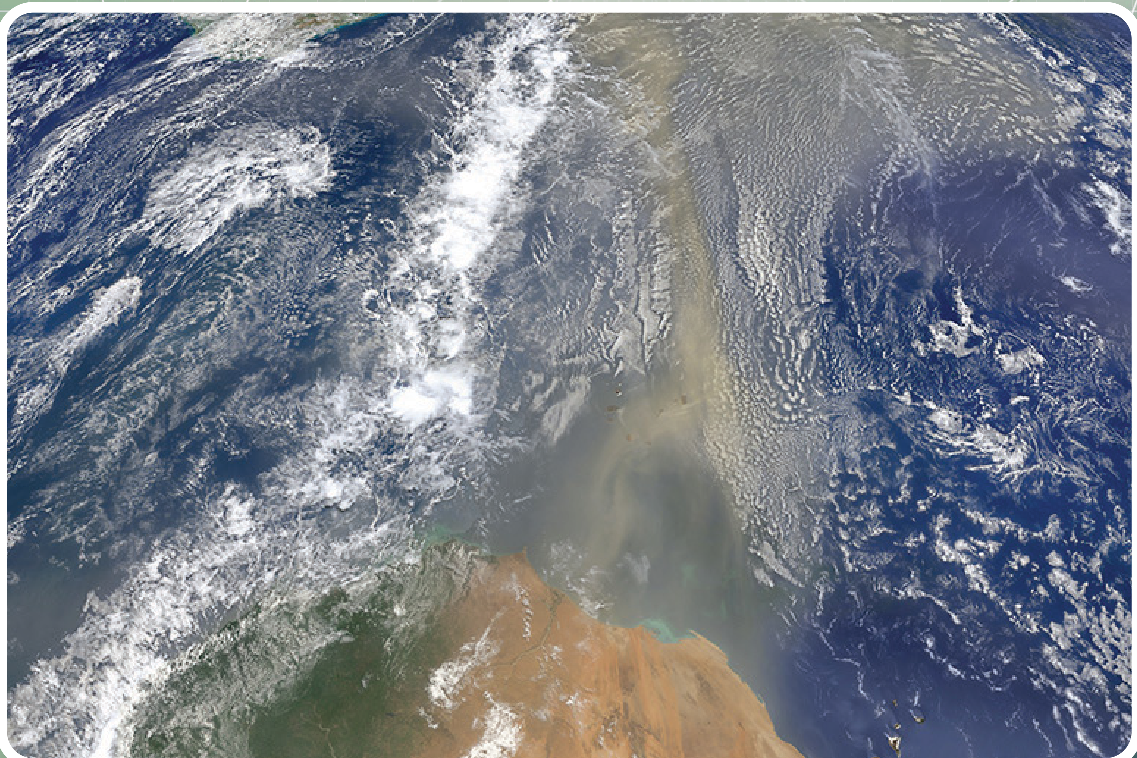
National Aeronautics and Space Administration

21CCLC NASA and GLOBE Investigation

Atmosphere Investigations

Facilitatior Guide and Student Science Research Journal



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GLOBE Protocols: Clouds and Surface Temperature

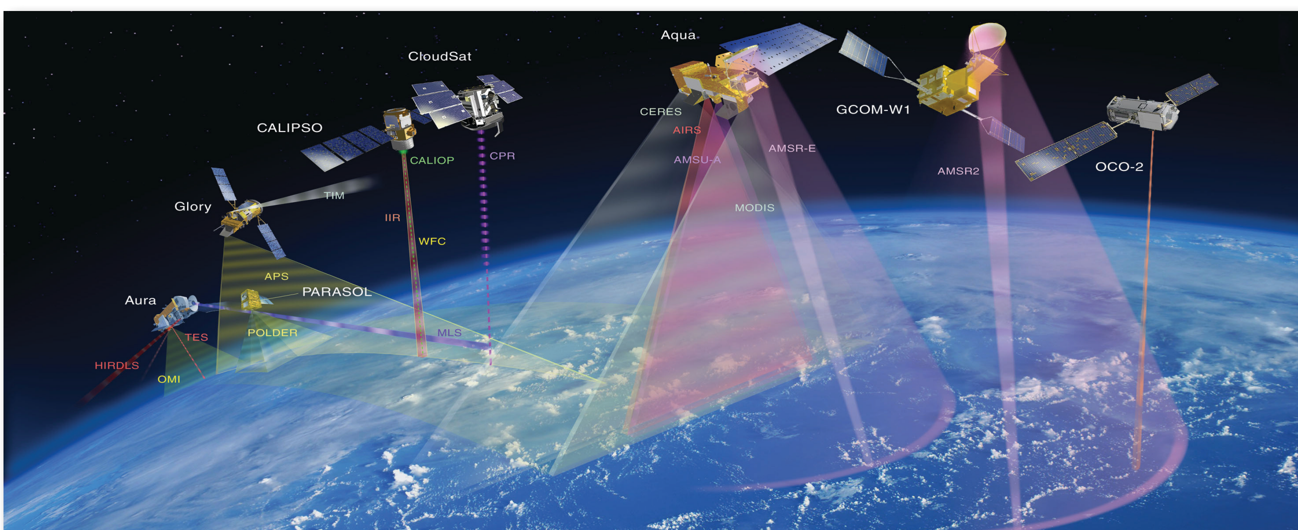
GLOBE: Global Learning and Observations to Benefit the Environment (GLOBE) is a hands-on international environmental science and education program. GLOBE links students, teachers, and the scientific research community in an effort to learn more about our environment through student data collection and observation.

GLOBE is a STEM based project that can benefit teachers and students in the following ways:

- GLOBE Learning Activities and Protocols are aligned with the Next Generation Science Standards (NGSS); independent evaluations show that GLOBE improves students' higher order thinking and science process skills.
- GLOBE activities are consistent with the U.S. Department of Education's priorities for international education by increasing knowledge and expertise about other regions, cultures, languages, and international issues.

The NASA Connection: Scientists at NASA Langley Research Center are currently studying the affect of clouds on the Energy Budget. The CERES satellite in addition to other satellites orbiting the Earth are gathering data to help our scientists answer this question. As a participant in the 21CCLC Middle School GLOBE Project, students have the opportunity to become a NASA Earth Observer by collecting data using the GLOBE cloud and surface temperature protocols. Ground based observations provide ground-truth, or validation, for the data that is being collected by our NASA satellites and can assist our scientists in finding answers to their questions.

Project Overview: You and your students will be carrying out a series of investigations that NASA and GLOBE have designed to enable students to gather data about the Earth and how it functions as a global system. Students will be using instruments and their own senses to observe the environment at sites located near their school. They will record the data they gather in their science research journals, and, if possible enter it into the GLOBE science database. Do not worry if you are not an experienced science educator. The learning materials provide a range of activities, from beginning activities to more complicated activities for the advanced level learner. Each learning activity includes the background information needed to successfully complete the activity.



There are four main components of this module: learning activities, student inquiry investigations using protocols, subject matter experts (SME) connections, and a culminating student presentation. Working as scientists, students will make observations, take measurements, record their data, formulate questions, test hypotheses, share their data, and develop theories to make sense of the data they collect. Students will conduct science investigations following GLOBE protocols to better understand how clouds impact Earth's energy system by collecting and analyzing GLOBE measurements of clouds and surface temperature.

NASA's Role in Studying Earth

***NASA uses the vantage point of space** to increase our understanding of our home planet, improve lives, and safeguard our future. NASA develops new ways to observe and study Earth's interconnected natural systems with long-term data records. The agency freely shares this unique knowledge and works with institutions around the world to gain new insights into how our planet is changing.*

Earth's changing environment impacts every aspect of life on our planet and climate change has profound implications for society. Studying Earth as a single complex system is essential to understanding the causes and consequences of climate change and other global environmental concerns. NASA addresses the issues of climate change and environmental sensitivity by answering the following **key science questions** through NASA's Earth Science programs:

- 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 benefits?

Clouds and Climate

One of the most interesting features of Earth, as seen from space, is the ever-changing distribution of clouds. They are as natural as anything we encounter in our daily lives. As they float above us, we hardly give their presence a second thought. And 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 the 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 the Earth and the amount of outgoing infrared radiation leaving the Earth. The Earth's climate also affects cloud formation. Both nature and human activities cause changes in the Earth's atmosphere. For example, a change in climate can increase or decrease the amount of heat that causes water to evaporate, or increased pollution can cause an increase in condensation nuclei. Clouds can form, change, or break up in seconds. Not knowing in advance which type of clouds will form makes it difficult to predict the future climate of the Earth. As you probably already have observed, different types of clouds normally exist simultaneously. What cloud combination will appear depends on factors such as current weather conditions at different levels of the atmosphere.

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 the Earth's surface and lower atmosphere emit (called thermal energy or longwave radiation). Cloud systems also 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.

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.

A critical question for 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.

Clouds Impact on Energy Balance

Depending on their characteristics and height in the atmosphere, clouds can influence the energy balance in different ways. Clouds can block a significant portion of the Sun's incoming radiation from reaching the Earth's surface, as anyone who has had a day at the beach interrupted by heavy clouds can tell you. Due to the shadowing effect of clouds, the Earth's surface tends to be cooler than it would otherwise be. Perhaps not as obvious to the casual observer, clouds also act like a radiative "blanket" by absorbing the thermal infrared radiation (a.k.a., heat) that the Earth's surface emits back toward space. As a result, the surface under the cloud doesn't cool as rapidly as it would if no clouds were present. ***The cloud's height in the atmosphere influences how effective is at trapping outgoing heat.*** A cloud that is higher in the atmosphere will emit less heat to space than an identical cloud at a lower altitude. Meanwhile, the clouds optical thickness (thickness in this case means how much light the cloud can intercept, rather than a specific physical thickness) is more important than its altitude in determining how much incoming solar energy the cloud reflects back to space.

Because of clouds' competing radiative effects (reflecting solar radiation cools the planet, while trapping outgoing heat warms the planet), ***predicting the impact of any particular cloud on the temperature of Earth's climate system is difficult***. In a global sense, the net effect of clouds depends on how much of the Earth's surface they cover, their thickness and altitude the size of the condensed particles, and the amount of water and ice they contain.

In general, low-altitude clouds(like stratus clouds) tend to be relatively thick optically, and they reflect a significant portion of the incoming solar radiation. They have little impact on emitted infrared radiation because these low, warm clouds have almost the same temperature as Earth's surface. With their relatively warm temperatures, these low-altitude clouds are typically composed of spherical water droplets, and their overall impact is to cool the planet. Conversely, high-altitude clouds (like cirrus clouds) are usually quite thin optically. They therefore reflect little solar radiation but still absorb some of the outgoing thermal radiation. These high-altitude clouds are composed mostly of ice crystals, with a wide variety of shapes and sizes, and their overall impact is to warm the planet.

Research on clouds and the climate indicates that overall, clouds' cooling effects are more powerful than their warming effects. But how the balance between clouds' cooling and warming influences might change in the future is still very uncertain.

How Does NASA Study Clouds Role on Earth's Climate?

NASA monitors Earth's vital signs from land, air, and space with 20 orbiting missions and several airborne and ground-based observation campaigns. The perspective from space is a unique one, providing a global view that is available in no other way. While the type of observations available limited scientists in the past, today's scientists use measurements collected from a number of perspectives.

Scientists require frequent observations (at least daily), over global scales (including remote ocean and land regions), and at wavelengths throughout the electromagnetic spectrum (visible, infrared, and microwave portions of the spectrum). Data from space-based instruments have become an integral tool for studying our global environment. Human eyes only see a small portion of the electromagnetic spectrum—a range of all possible frequencies of electromagnetic radiation. Instruments on orbiting satellites expand our ability to "see" into other portions of the electromagnetic spectrum, and thereby give us a broader and deeper view into our environment. Several NASA missions already provide unprecedented Earth observing capabilities that allow for global observations of the planet. For example, the Afternoon Constellation or "A-Train" is a grouping of satellites flying in very close proximity to one another that provide unprecedented ability to study clouds from space. One instrument called CERES, Cloud's and Earth's Radiant Energy System, measures cloud properties and measures solar reflected and Earth emitted radiation. This instrument flies on-board several satellites including Aqua, Terra, and NPP. Other satellites measure clouds in other ways with the CALIPSO and CloudSat satellites.

People have also been observing and keeping records of clouds for generations. Ground-based observations and measurements make significant contributions, particularly to temporal coverage, but are limited to mostly land areas. Satellite observations complement and extend the ground-based observations by providing increased spatial coverage and multiple observational capabilities.

For more information visit:

The Importance of Understanding Clouds: https://www.nasa.gov/pdf/135641main_clouds_trifold21.pdf

SNAPSHOT OF A NASA SCIENTIST

Dr. Yolanda Shea is a physical scientist at NASA Langley Research Center who studies Earth reflected sunlight to help understand how and why the Earth's climate is changing.

As a young girl, she was terrified of thunderstorms and would glue herself to the Weather Channel to make sure tornadoes weren't coming. Soon the meteorologists and cool maps ignited her interest in what was happening in the sky. Yolanda is a first generation American; both her parents immigrated to the United States from Trinidad. When she has time to relax she likes to play classical, folk, and bluegrass music on her violin. She loves weightlifting because it makes her feel powerful and she's almost reached her goal of dead-lifting half her bodyweight.

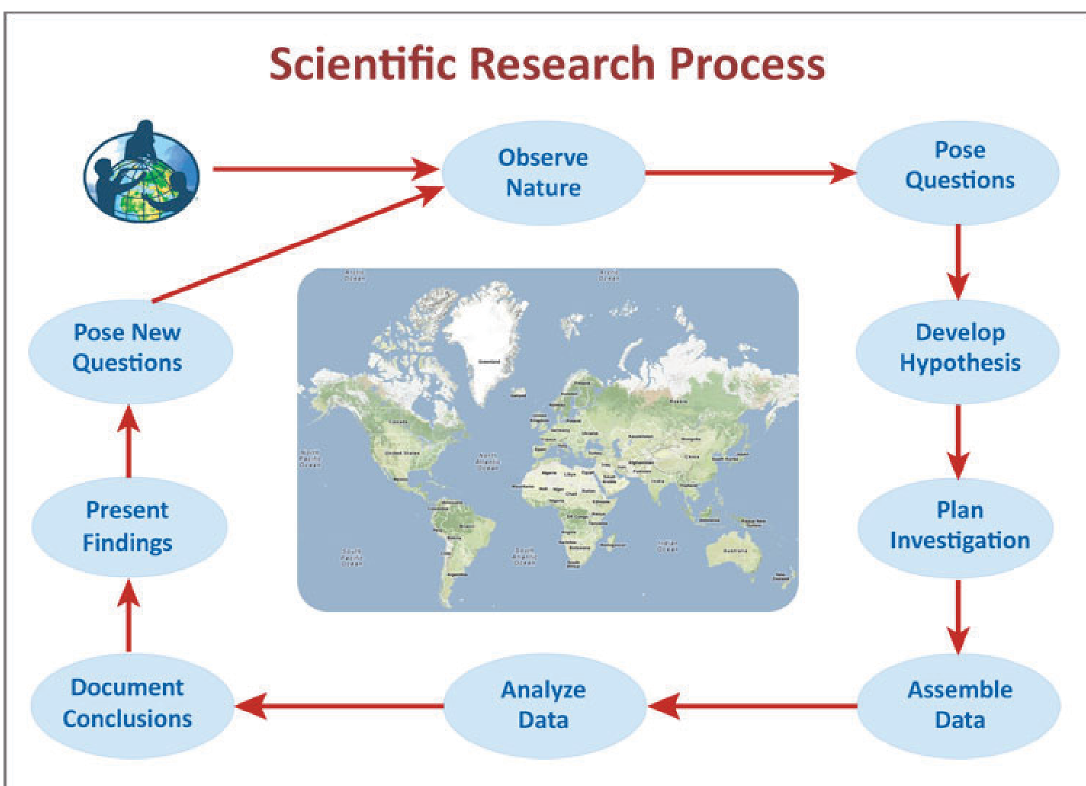
GLOBE and the Scientific Research Process

The GLOBE Program offers a wide range of opportunities for students to engage in scientific sense-making while they conduct their own inquiry-based science research using the data they collect and interaction with their peers and scientists who are applying their data to important research. This collaborative environment promotes a deeper understanding of scientific concepts and allows students to begin grappling with scientific ideas found in the world around them through manipulation of GLOBE data sets.

Questions are the key component to scientific research. For a question to be meaningful and relevant for a learner he/she must really care about the answer to it. Both learners and instructors can pose meaningful questions. However, for a question not generated by the learner to motivate genuine learning, it (the question) must be taken over and "owned" by the learner.

True scientific research does not always have to start with a clearly formulated question -- a premise that deviates from the standard "steps of the scientific method" view of student science research. Instructors and students have found that some of their most engaging learning activities arise only after some preliminary work (observations, collecting data, etc.) on a topic has been carried out, or as a by-product of trying to answer some other question. Questions may also occur quite spontaneously and unexpectedly in the course of reviewing work carried out to date.

The more general point then, is that a scientific investigation is not a "method" of doing science or any other subject in which the obligatory first stage in a fixed, linear sequence is that of students each formulating questions to investigate. Rather, it is an approach to the chosen themes and topics in which the posing of real questions is positively encouraged, whenever they occur and by whoever they are asked. Equally important as the hallmark of an inquiry approach is that all tentative answers are taken seriously and are investigated as rigorously as the circumstances permit. Below you will find a description of how you can describe the various parts of the scientific process with your students.



Observe Nature

Looking at the world around you is an important first step in scientific research. There are many ways to explore the world and to help identify the area you want to investigate. The most basic way we make observations is with our senses.

Pose Questions

After you have taken some time to observe the environment around you, identify research question(s) to be answered by your project.

A research question is one that does not have an immediately obvious answer and could have more than one answer or solution. Questions with yes or no answers are typically not good research questions; try to ask your research questions so that their answers help fill in gaps in the current understanding on your chosen topic. Questions that begin with "How does...?" and "What is...?" are often better than "Is there...?" It is also good if your research question addresses a problem that's significant and interesting to you and your community.

Develop Hypothesis

Science is about finding answers to our questions about the world around us. Part of finding the answer is to test a hypothesis. A hypothesis is a tentative statement that proposes a possible explanation to some phenomenon, even or scientific problem that can be tested by further investigation. A useful hypothesis is a ***testable, measurable*** statement. Then the rest of the scientific process helps us test if our hypothesis was correct or not.

What do you think will be the answer to your research question? That is your hypothesis. As you investigate and perhaps refine, your question you may also refine your hypothesis -- they go together.

Plan Investigation

How will you test your hypothesis and answer your research question?

- Develop a research plan with specific steps to complete your investigation, including who will be responsible for each task if you are working in a group.
- Determine the data you will need to collect to answer the question(s) you are asking. Decide which GLOBE measurement protocols you will use. If you need to take observations that are not covered by GLOBE protocols, write out the procedure you will follow, and specify the instrument(s) you will use.
- Decide what existing data you will need, where they can be obtained, and how you will get them.
- Identify the resources available to you such as measurement equipment and supplies.
- Identify what help you may need from others including your teacher, experienced scientists, and other adults and students. It often helps to have a mentor or coach when learning anything new.
- Plan your time. When and where will you take measurements? How will you get other data that you need?

Remember that the precision and accuracy of the data you use may affect the questions that can be answered. For instance, looking for a change of half a degree in temperature with a thermometer that is only accurate to ± 2 °C will only work if you average many measurements.

Assemble Data

Once you've developed a plan for conducting your investigation, you will need to start the investigation by assembling the data to be analyzed.

If you are taking measurements, be sure to keep records in an orderly fashion that will make it easy for you to use the data in analysis. Keeping a notebook of GLOBE data sheets is one way to do this. If your data were collected following GLOBE protocols, reporting your data to the GLOBE archive will guarantee that they are saved and can be viewed using GLOBE visualization tools.

Analyze Data

In studying Earth, data analysis often involves comparing data from different times and places and looking for patterns and different types of variations. Averages and extreme values are often useful to consider along with comparisons of how data from two different measurements vary.

- Think about what are the easiest ways to see what you are looking for in the data you have assembled -- maps, graphs, tables? If you are looking for spatial patterns, maps are useful. If you are looking for patterns over time for one place, a graph works well.
- Do you need to do any calculations as part of your analysis? Remember you can use spreadsheet programs if you have access to them. They can make it easier to do calculations on large amounts of data and generally provide the ability to graph data and results.
- Analyze your data and create tables, graphs, and charts to illustrate and summarize your discoveries Analysis should be focused on using the data to answer your stated research question(s).
- Can you answer your research questions from your data? Is your hypothesis confirmed or disproved? Remember that either result is valuable. Can you clearly state your reasoning and explain it to someone else? If you can't answer your question(s) with the data you have collected and the analysis you have performed, can you collect more data, do a different type of analysis, or revise your original questions? This is a point in your research project where talking to your teacher or mentor can help.

Document Conclusions

The key to documenting your conclusions is to clearly state the question(s) you investigated, how you did the investigation, and your results. Your discussion of how you did your investigation should describe:

- What measurements you took and when, where and how you took them
- What other data you used and where you obtained them
- What calculations you did

Generally you should show examples of the data you used (graphs, tables, maps) and the results of your analysis. In explaining your results you should describe your reasoning -- the thought process that you went through to get from the data to the conclusions.

Because research is an on-going process, you should share your thoughts about how this investigation could be improved, explain other approaches that might be taken that would lead to an answer to your question(s), and state what new questions you might ask as a follow-on to your research.

Present Findings

Sharing your findings with your peers and your community is a very important step in the scientific process. If you don't share your findings or your data with others then you have not completed the process of doing science. Science is about community, and the scientific community must present or write journal articles to share their research with others.

Pose New Questions

Think about what questions are still remaining after you conducted your investigation. Big science questions are seldom fully answered by just one investigation. Rather, subsequent investigations are needed to answer the remaining unanswered questions or new questions that were revealed by doing research.

You can also generate new research questions by hearing about what other students are doing.

21CCLC GLOBE Atmosphere Investigation: NASA's Big Question: How Do Clouds Affect Climate?

Learning Progression Pacing Guide for Middle School Programs

Week	Steps of Learning Progression
Week 1 *Observe Nature and Pose Questions about Clouds*	Step 1: Project Introduction Video (10-15 minutes) Step 2: Introduction to GLOBE (5 minutes) Step 3: *What does a Scientist Do?* Activity (15-20 minutes) Step 4: *Observing, Describing and Identifying Clouds* Learning Activity Part 1, Part 2, and Part 3 (45-60 minutes) Step 5: Select Cloud Observation Location and begin Cloud Observations using *Cloud Observation Data Sheet* (20 minutes
Week 2 *Observe Nature and Pose Questions about Clouds*	Step 6: *Heating Things Up* Learning Activity (1.5 hours) Step 7: Continue Cloud Observations using *Cloud Observation Data Sheet* (15 minutes)
Week 3 *Observe Nature and Pose Questions about Clouds and Surface Temperature*	Step 8: *Surface Temperature Protocol Activity* (45 minutes) Step 9: Select sites and begin recording surface temperature measurements and cloud observations daily for comparison and analysis using the *Surface Temperature Measurements and Cloud Observation Data Sheet* (25 - 30 minutes) Step 10: *Cloudy vs Clear* MY NASA DATA Learning Activity (45 minutes)
Week 4 *Observe Nature and Pose Questions about Clouds and Surface Temperature*	Step 11: *What's Visual Opacity?* Learning Activity (60 minutes) Step 12: NOVA Video: *The Climate Wild Card* (20 - 25 minutes) Step 13: Continue to make Cloud Observations and record Surface Temperature Data using the *Surface Temperature Measurement and Cloud Observation Data Sheet* (20 minutes)
Week 5 *Pose Research Question, Develop a Hypothesis and Identify the Data*	Step 14: What does a NASA research question look like? (15 minutes) Step 15: The Science Research Process in Action (15 minutes) Step 16: *Looking at Your GLOBE Data Activity*: Part 1-3 (45 minutes) Step 17: Continue collecting data using the *Surface Temperature Measurement and Cloud Observation Data Sheet* (20 minutes)
Week 6 *Planning the Investigation and Identify the Data*	Step 18: *Looking at Your GLOBE Data Activity*: Part 4-7 (45 minutes) Step 19: Select Culminating Project (15 minutes) Step 20: Following the Steps of the Scientific Research Process (15 minutes) Step 21: Continue collecting data using the *Surface Temperature Measurement and Cloud Observation Data Sheet* (20 minutes)
Week 7 *Assemble and Analyze the Data, Document and Conclusion*	Step 22: Assemble Data (30-45 minutes) Step 23: Analyze Data to Develop Conclusion (30-45 minutes) Step 24: Continue collecting data using the *Surface Temperature Measurement and Cloud Observation Data Sheet* (20 minutes) Step 25: Begin working on the culminating project
Week 8 *Present Findings and Pose New Questions*	Step 26: Finalize the Culminating Project Step 27: Present Culminating Project to Peers and/or Community

Instructional Strategies for Teaching GLOBE Activities

Plan to teach GLOBE activities using scientific inquiry. Teachers should:

- Help students post worthwhile questions to research and investigate
- Use cooperative learning groups to carry out research
- Help students devise a plan or an approach for attacking the problem
- Make available the instruments and tools students need
- Encourage discourse and writing among students for understanding
- Require students to justify and explain their answers and results with evidence from their investigations

Meeting Student Needs: Not all students are ready to tackle the same problem—at the same level of sophistication—at the same time. Using a student-centered approach to learning means educators can more effectively deal with a wide range of students. GLOBE activities are inherently student-centered and will help effectively teach students of varying skills and ability levels. Students carrying out *GLOBE Protocols* and *Learning Activities* learn science by doing what scientists do while developing their natural curiosity. Students manipulate materials to test their ideas and make observations. They then analyze observations and present findings in a number of ways. This scientific inquiry approach to learning is accessible to all students. The following examples show the suitability of GLOBE activities to a differentiated student body.

Language Needs: GLOBE activities are hands-on. Students can participate regardless of their speaking skills. Many portions of the *Learning Activities*, and *Protocols*, will be available in the six United Nations languages (Arabic, Chinese, English, French, Russian, and Spanish). Some GLOBE countries translate the *Teacher's Guide* into other languages (e.g., Thai, German, Greek). There are also some countries that use GLOBE in the development of foreign language skills (such as English).

Special Needs: GLOBE *Protocols* and *Learning Activities* provide opportunities for authentic learning based on students' needs, interests, and talents. GLOBE *Protocols* and *Learning Activities* involve all students and help to create an environment where students become more active and involved learners. The opportunity GLOBE provides enables students to demonstrate and share their strengths.

Multiculturalism: GLOBE *Protocols* and *Learning Activities* are developed according to the scientific processes of an international body of scientists, incorporating the International System of Units (SI) accepted measurement values. They do not portray one specific group and allow for students of many cultural backgrounds to participate. Through GLOBE students learn about their local environment and compare that with measurements globally.

Cooperative Learning

Size and composition: The recommended group size for carrying out a GLOBE investigation is between three and five students. This allows each group member to benefit from the exchange of ideas. It also allows group members to actively observe and monitor each other to ensure the proper procedure is followed for the *Protocol* being investigated. The hands-on nature of the investigations allows students with a range of ability levels to help and support one another.

Assigning roles to students: Groups carrying out GLOBE investigations function effectively when specific responsibilities are placed on individual students. Each student is given a role that plays a part in the whole investigation. The investigation is successful and the data reported are reliable and accurate only if individuals carry their share of the group effort. The following roles are common to all the *Protocol* investigations:

Observers: Each GLOBE investigation requires individuals to make observations about specific scientific phenomenon. As a check for reliability and accuracy, three different individuals should make at least three observations. ***Recorder:*** The recorder documents the observations of the observers. This person writes the observers annotations on corresponding Protocol Data Work Sheets. ***Data Reporter:*** The Data Reporter is responsible for inputting data collected by the observers and documented by the recorder into the GLOBE database via the Internet.

Five Common Formats for Cooperative Learning

1. ***Student Teams-Achievement Divisions:*** *Require students to complete a common Work Sheet in groups of four or five, but to take individual tests. The team's score is the result of the individual student's improvement over past performance.*

2. ***Think-Pair-Share: Involves three steps:*** *Students first attempt to answer a question for themselves, then discuss their thoughts with partners, and finally share the combined effort with a small group or class.*

3. ***Jigsaw:*** *Uses teams of three to six. Each group member is given a piece of information and asked to teach it to the others. Students can also obtain their own information to share. Students are then tested individually.*

4. ***Team Accelerated Instruction:*** *Combines individualized instruction and cooperative learning. Students are assigned materials at their level and assisted by peers. Group points are obtained through high achievement or improvement on individual tests.*

5. ***Group Investigation:*** *Is a higher-level process in which students accept greater responsibility for their own learning. Small groups decide what to investigate, what contributions each member will make, and how to communicate what they have learned.*

Inquiry

- Learners who are engaged by scientifically oriented questions
- Learners who develop their own questions
- Learners who give priority to evidence, allowing them to develop and evaluate explanations that address scientifically oriented questions
- Learners who formulate explanations from evidence to address scientifically oriented questions
- Learners who communicate and justify their proposed explanations

Using Scientific Inquiry in the Classroom:

1. **Begin discussions with a series of questions:**
    - *What do you notice about...?*
    - *What do you observe about...?*
    - *Do you see any patterns...?*
    - *Describe similarities and/or differences about...?*
    - *Why does this work/look this way...?*
    - *What questions do you have or want to know about...?*
2. **List responses on the board or overhead:** Do not rephrase responses for students.
3. **Ask group members to comment** about the statements or ideas. Do they make sense? Can they come up with reasons or examples to show that the idea is or is not valid?
4. **Ask additional questions** that encourage learners to search deeper for patterns and to make generalizations.
5. **Do not correct mistakes** in the process used by learners. Ask if there are other ways to accomplish the group's goals.
6. **Do not quickly agree/disagree** with observations/statements. However, you may need to provide counter examples or point out implications of incorrect reasoning at some point.
7. **Provide examples** or suggest situations if students are having trouble with concepts. Ask, "What do you think about...?" or "What if...?"
8. **Do not provide answers** to questions asked of you; instead, ask questions.
9. **If the desired response/solution is achieved, do not immediately move on to something else. Ask if anyone else had alternative methods** for finding a solution. This helps learners see that most problems can be solved in a variety of ways.
10. **Be flexible** enough to deviate from a planned lesson focus to respond to new insights and unexpected directions proposed by the learners.

Using Science Research Journals to Develop Understanding

The primary student component of the 21CCLC GLOBE Middle School Module is a science research journal where students record their GLOBE experiences. Writing and learning through journals is a tool for connecting thought, feeling and action by combining reflective practice, critical thinking, and self-awareness. An essential for this connection is the individual experience of the learner where they create personal connections to the content; the journal provides a place to ponder the content, collect observations and data, and practice writing. Asking students to reflect on the "how" and "why" of a particular observation is an important activity that can lead to curiosity, more depth of understanding of content, and integration of facts from several disciplines.

The student journals are designed to correlate with the pacing guide and educator's instructional procedures. They were developed to include opportunities for students to periodically reflect on a series of guiding questions to assist them in making connections regarding the concepts being investigated. Throughout the science research journal they will work together to complete a series of learning activities, protocol investigations, and collection of data through cloud observations and surface temperature measurements.

Incorporating Inquiry Based Learning Skills in the Science Research Journal

As students work in their science journals, encourage them to incorporate various aspects of inquiry based learning and terminology by including words from the checklist below in class discussions. This will promote science literacy and critical thinking skills as they observe the world around them. Ask them specific questions regarding what they have observed, patterns they discovered, or predictions they might have based on previous results. The goal is to help them establish connections between what they are doing and their own personal learning.

☐ **Observing**	Looking/watching things with a purpose
☐ **Questioning**	Formulating questions based on observations
☐ **Sequencing**	Putting something in a certain order
☐ **Patterning**	Forming and following a set pattern
☐ **Counting**	Understanding quantity, one-to-one correspondence
☐ **Measuring**	Using standard and nonstandard units
☐ **Comparing**	Noting differences and similarities of things
☐ **Classifying**	Putting things into definite categories
☐ **Defining**	Developing and enhancing vocabulary
☐ **Communicating**	Describing and sharing information with others
☐ **Hypothesizing**	Making an informed guess
☐ **Predicting**	Thinking ahead about what might happen
☐ **Inferring**	Using reasoning to draw conclusions
☐ **Recording**	Writing or drawing gathered information
☐ **Reporting**	Using information and communicating it to others

Learner Outcomes for 21CCLC GLOBE Atmosphere Investigation

- Students will observe, describe, and identify the different cloud types using a cloud chart
- Students will learn the meteorological concepts of cloud heights, types, and cloud cover
- Students will gather cloud and surface temperature data
- Students will investigate the relationship between the percentages of cloud cover as it relates to differences in surface temperature
- Students will learn to draw inferences from observations and use them to make and test predictions
- Students will gain an understanding of how clouds affect the Earth's energy budget
- Students will learn to use an infrared thermometer and understand how different surfaces absorb and radiate energy
- Students will investigate the different rates of heating and cooling of certain materials on Earth in order to understand the heating dynamics that take place at the Earth's surface
- Students will design and conduct a scientific investigation
- Students will compare graphs, maps, and data tables as tools for data analysis
- Students will communicate procedures, descriptions, predictions, and cause-effect relationships based on evidence collected

Standards Alignment

21CCLC GLOBE Atmosphere Investigation and NGSS

GLOBE students learn science concepts by investigating and experiencing the world around them through hands-on activities. The hands-on approach of the GLOBE program allows students to actively experience science by doing real experiments and critically analyzing data. GLOBE investigations and learning activities require students to gather information through the senses (observing), exchange and discuss ideas (communicating), look at similarities and differences (comparing), sequence events (ordering), group objects or events by like characteristics (categorizing), recognize interactions, dependencies, and cause-and-effect relationships (relating), reason logically using observed evidence (inferring), and put knowledge to work to understand phenomenon and problems (applying).

NGSS Science Practices:

Practice 1:	**Asking questions and defining problems**
Practice 2:	**Developing and using models**
Practice 3:	**Planning and carrying out investigations**
Practice 4:	**Analyzing and interpreting data**
Practice 5:	**Using math and computational thinking**
Practice 6:	**Constructing explanations and designing solutions**
Practice 7:	**Engaging in argument from evidence**
Practice 8:	**Obtaining, evaluating, and communicating information.**

NGSS Disciplinary Core Ideas:

ESS2.D	**Weather and Climate**
ESS3.D	**Global and Climate Change**
PS3.A	**Definitions of Energy**
PS3.B	**Conservation of Energy and Energy Transfer**

NGSS Crosscutting Concepts:

- Patterns
- Cause and effect
- Systems and system models
- Energy and matter
- Stability and change

Instructional Procedures

GLOBE Atmosphere Investigation Materials List

- Facilitator Guide
- Introductory Video
- Student Science Research Journal
- Chart paper or board to post responses
- GLOBE Cloud Charts
- Hand-held Infrared Thermometers (IRT) one per group
- 5 plastic containers of the same size
- Equal amount samples of sand, soil, grass, and gravel or rocks
- Outside area in a sunny location (5 desk lamps or shop lights with 100-watt bulbs can be substituted)
- Stopwatch or timer
- Four outside locations with different surface materials where surface temperature observations can be completed
- Light colored construction paper or cardstock
- Glue Sticks or Clear Tape
- Scissors
- Copies of single line plots and double line plots from the Cloudy vs Clear Learning Activity
- Materials for What's Visual Opacity? Learning Activity
    1. Transparent items (cellophane, drinking glass or glass jar)
    2. Translucent items (wax paper, frosted contact paper, tracing paper, parchment paper, or tissue paper)
    3. Opaque Items (construction paper, cardboard, aluminum foil, cotton balls)
    4. Light source (small desk lamp, overhead light, natural light from the Sun)
    5. White paper
- NOVA Video: The Climate Wild Card
- Colored Pencils
- Calculators (optional)
- Materials for construction of students' culminating projects: (posters, construction paper, cardstock, graph paper, colored pencils, markers, notecards, photos, etc.)

GLOBE Atmosphere Investigation Checklist

Prior to Investigation:

1. Download and review the presentation slides for students.
2. Download, print and review the culminating project criteria and rubric. Make copies for each student.
3. Download, print and review the Facilitator Guide, *NASA GLOBE Atmosphere Investigation*.
4. Download and print a copy of the *NASA GLOBE Atmosphere Investigation* Student Science Research Journal for each individual student.
5. Download or bookmark the project introduction video and project slides.
6. Download and print enough media release forms for each individual student.
7. Gather and organize materials from the materials list for each learning activity.
8. Test your technology setup to make sure students can see and hear videos, slides, etc.
9. Identify locations outside for cloud observations and locations of four different surface material areas for surface temperature measurements.
10. Identify area inside of the classroom for students to complete the learning activities.

During the Investigation:

1. Distribute the media release forms to each participating student and set a due date for them to be returned.
2. Distribute the Student Science Research Journals to the students. Have them put their names and the date on the front of their journals.
3. Use the project introduction video to introduce the investigation to the students.
4. Use the Atmosphere Investigation project slides to guide students through the investigation following the steps provided in the learning progression, pacing guide found in the NASA GLOBE Atmosphere Investigation Facilitator Guide.
5. Encourage cooperation and group etiquette as the students work through the investigation.
6. Assist students in the completion of the different learning activities, encouraging them to ask questions and work together to find answers to their questions.
7. Make sure that all media release forms are collected from each participating student.

After the Investigation:

1. Guide students in selecting the format for their culminating project.
2. Assist students as they plan, design and construct their culminating project.
3. Provide students with materials necessary to complete their culminating project.
4. Encourage students as they present their culminating project to their peers and possibly to parents and/or members of the community.
5. Complete a culminating project rubric for each student or team of students.

Getting Started With the Investigation

You and your students can investigate the atmosphere at your own study site and cooperate with scientists and other students around the world to monitor the global environment. The atmosphere is one critical component of the global environment, and you can help compile a global database of atmospheric measurements that will aid in the long-term understanding of how the atmosphere is changing.

You should keep a permanent record of you GLOBE data as you conduct your investigations. The atmospheric data that students gather can be submitted to the GLOBE data server if internet access is available, but should also be recorded in their GLOBE Science Research Journals. As your local data set grows, you should engage students in looking at their data. Each protocol includes a Looking At the Data section, which outlines how to judge whether the data are reasonable and describes what scientists look for in data of this type. Most of them also contain a sample student investigation using data from the protocol. Review these sections for ideas on how to use GLOBE data for student learning about clouds and surface temperature. These can be found in the Appendix. At the end of the study students will be asked with a partner or in a small group to create a culminating project based on a science research question. This culminating project can be in the form of a science project display board, a PowerPoint presentation, a public service announcement, or another form of media that enables them to share their research question, the data they collected, an analysis of their data, and their conclusion.

Students' motivation to learn is peaked when they are given a sense of meaningfulness in regard to their studies. Because GLOBE links educators and students around the world, it fosters alliances among students and increases not only their environmental awareness but also their understanding of other cultures and their sense of a global community. GLOBE allows educators to put the concepts of authentic learning, student-scientist partnership, scientific inquiry, and standards-based pedagogy into practice on an unprecedented scale. The GLOBE website can supply an avenue for students to compare their data with that of other students around the world.

The GLOBE website can be accessed at www.globe.gov

GLOBE Protocols and Instrument Specifications

Throughout this project students will collect data on Clouds and Surface Temperature. Students should follow the GLOBE *Protocols* for data collection.

Cloud Cover/Type: Full protocol found at:

http://www.globe.gov/documents/348614/e83c12fl-38a7-404d-b032-b363f4ad4cd2

Cloud Chart: The GLOBE cloud chart displays at least one visual example of each of the 10 basic cloud types: cirrus, cirrostratus, cirrocumulus, altostratus, altocumulus, cumulus, nimbostratus, stratus, cumulonimbus, stratocumulus. Cloud cover will be visually estimated.

Contrail Chart: The GLOBE contrail chart displays at least one visual example of each of the 3 contrail types: short-lived, persistent, and persistent spreading. Contrail cover will be visually estimated.

The GLOBE cloud and contrail charts are available in multiple formats and in multiple languages and can be downloaded from the GLOBE website.

Surface Temperature: Full protocol found at:

http://www.globe.gov/documents/348614/7537c1bd-ce82-4279-8cc6-4dbe1f2cc5b5

Infrared Thermometer (IRT): The infrared thermometer should be a hand-held instrument. It must have an accuracy of ± 1 ^{O}C over a range of -32 ^{O}C to 72 ^{O}C.

Week One—Observe Nature and Pose Questions About Clouds

Instructional Procedure: Week One

Guiding Questions:

- What does a scientist do?
- Where on the school grounds would you see the most clouds? Where would you see the least?
- What are the four main types of clouds?
- How do the types of clouds in the sky change from day-to-day?

Materials Checklist:

- ❑ Introductory Video
- ❑ Student Science Research Journals
- ❑ Chart paper or board to post responses
- ❑ *Observing, Describing, and Identifying Clouds Learning Activity,* in Journal
- ❑ GLOBE *Cloud Charts*
- ❑ *Cloud Observation Data Sheets,* in Journals

Step 1: Show the Project Introduction Video to the class (Discuss as a class, introducing the idea that the students will be helping NASA scientists as they seek to answer a very important question that ultimately affects all of us.)

1. How are clouds affecting the Earth's energy budget?
2. What is happening to our overall climate?
3. *What changes are occurring and what can we do?*

Step 2: Using the first page of the Student Science Research Journal introduce students to the "What, Why, and How" they will be completing in the 21CCLC Atmospheric GLOBE Investigation. Discuss the two questions provided under the how section of the first page of the student journal.

4. What is the relationship between cloud cover and surface temperature in the area around your school?
5. How do clouds affect the Earth's energy budget?

Discuss students' predictions, posting their responses on a large piece of chart paper to be displayed in the classroom. Refer back to these as students develop their understanding through the different investigations.

Step 3: Have students complete the drawing of a scientist found on page 2 of their science journals. When students complete their drawings discuss the different type of scientists that they drew, what they were doing, and where they worked. It will also be interesting to consider the gender of the scientists and discuss whether or not males and females are equally capable of becoming a scientist.

Step 4: On the *Observing, Describing, and Identifying Clouds Learning Activity* page in the student journal, have students answer the question: "What do you already know about clouds?".

After answering the question and referring to the science background on the middle of the page, ask students the following questions: Where on the school grounds would you see the most clouds? Where would you see the least? What are things that need to be considered when selecting the best location for observing clouds?

Next have students go outside to sketch what they see in the sky. **Remind students that they should never look directly into the sun**. Prompt students to look for different types/shapes of clouds. As students begin the process of looking at clouds have them look for differences in the types of clouds they see. Have students sketch the different types of clouds that they see on page four of their science journal. They may or may not see four different types of clouds. *(Helpful Hint: If there are no clouds in the sky, it might be beneficial to show a picture of a cloudy sky for students to use as an example for this activity.)*

Once students have completed their sketches of the different types of clouds they see, in Part 2, have them compare their sketches to the official descriptions using the GLOBE Cloud Chart. Then in Part 3, as a class discuss the different types of clouds they identified and descriptive words that can be used to describe each type.

Step 5: Using the *Make Your Cloud Observation Data Sheet*, guide students through the process of making their first official cloud observation. The *Cloud Protocol* which contains additional information can be found in the Appendix. Encourage the students to use the GLOBE *Cloud Chart* as they complete their *Cloud Observation Data Sheet*.

Week Two—Observe Nature and Pose Questions About Clouds

Instructional Procedure: Week Two

Guiding Questions:

- How does the temperature of a surface area vary with surface color?
- How does surface temperature vary with different types of surface materials (e.g., asphalt, grass, leaves, water, bare soil)?

Materials Checklist:

- ❑ *Heating Things up Learning Activity,* in Journals
- ❑ Hand-held Infrared Thermometer (IRT) per group
- ❑ 5 plastic containers of the same size (per group)
- ❑ Sand
- ❑ Soil
- ❑ Grass
- ❑ Gravel or Rocks
- ❑ A sunny day (or 5 desk lamps or clip on shop lights with 100-watt bulbs)
- ❑ Stopwatch or timer
- ❑ *Cloud Observation Data Sheets,* in Journals
- ❑ GLOBE *Cloud Charts*

Step 6: Guide students through the completion of the *Heating Things Up Learning Activity* which is located in their student science research journal. This activity takes around 1 1/2 hours to complete, so it might be necessary to split it up between two class periods. In Part 1 of the activity students will be working in small groups as they explore the energy transfer of different Earth materials when they are heated up and cooled down. They will need to make sure that each container contains the same amount of material, recording their temperature measurements in Data Table 1 of their student science research journal. They can use an IRT or six thermometers for measuring the temperature of each material. If using the IRT, they will need to try to take the measurements of each container as close together in time as possible.

Step 7: Complete the Cloud Observation using the *Cloud Observation Data Sheet*. Remind students to use the GLOBE *Cloud Chart* to assist them in completing their cloud observations.

Week Three—Observe Nature and Pose Questions About Clouds and Surface Temperature

Instructional Procedure: Week Three

Guiding Questions:

- How does the surface temperature vary depending on whether the surface is in the sun or in the shade?
- Does it matter whether the shade is from a tree, a shrub, or a cloud?

Materials Checklist:

- ❑ *Surface Temperature Learning Activity,* in Journals
- ❑ Hand-held Infrared Thermometer (IRT) per group
- ❑ Identify four locations outside with different surface material
- ❑ *Surface Temperature and Cloud Observation Data Sheet,* in Journals
- ❑ GLOBE *Cloud Chart*
- ❑ *Cloudy vs Clear Learning Activity,* in Journals
- ❑ Light colored construction paper or cardstock
- ❑ Glue sticks or clear tape
- ❑ Scissors
- ❑ Single line plots and double line plot for *Cloudy vs Clear Learning Activity* (one set per student)

Step 8: Guide students through the completion of the *Surface Temperature Learning Activity* in their science research journal. As a class you will be identifying four different surface areas outside of your school for surface temperature measurement Locations that are in direct sunlight as much as is possible. These four locations will need to have four different surface materials for comparison (e.g., asphalt, grass, soil, sand, and concrete) and be located in close proximity to the cloud observation location. See the *Surface Temperature Protocol* in the Appendix for additional information. Once the four locations have been selected the students will sketch the different surface areas in their science research journals and predict the surface temperatures from coolest to warmest.

Step 9: Once the surface temperature locations have been selected the students will work in small groups to complete the *Surface Temperature Measurements and Cloud Observation Data Sheet* in their journals. Remind them to continue to use the GLOBE *Cloud Chart* as they make their cloud observations. See the *Surface Temperature Protocol* in the Appendix for additional information.

Step 10: *Cloudy vs Clear Learning Activity* students will be examining a line plot that uses authentic NASA data to compare temperature on a cloudy vs clear day. They will practice drawing conclusions based on the graphed data that they observe. In the completion of the activity they will be constructing a Cloudy vs Clear Foldable. Provide each student with a set of the single line plots for cutting out and gluing in their foldable. They will first analyze the temperature differences using two single line plots and draw representative cloud scenes. Next provide students with a copy of the double line plot to cut out and place in their foldable. They will examine the double line plot of the same set of data to see how much easier the data is to visualize using a double line plot instead of two separate single line plots. Once they have constructed their foldable, this should be taped in their science research journal on the designated page.

Week Four—Observe Nature and Pose Questions About Clouds and Surface Temperature

Instructional Procedure: Week Four

Guiding Questions:

- What affect do clouds have on the Earth's energy coming from the Sun?
- What is the relationship between clouds and precipitation?
- How do clouds affect the balance of the Earth's energy budget?

Materials Checklist:

- ❑ *What's Visual Opacity? Learning Activity,* in Journals
- ❑ Materials for *What's Visual Opacity?*
  - ❑ Transparent items (cellophane, drinking glass or glass jar, bottle full of water)
  - ❑ Translucent items (wax paper, frosted contact paper, tracing paper, parchment paper, tissue paper)
  - ❑ Opaque items (construction paper, cardboard, aluminum foil, cotton balls)
  - ❑ Light source (small desk lamp, overhead light, natural light from the Sun)
  - ❑ White paper
- ❑ NOVA Video: ***The Climate Wild Card*** (found online at: http://www.pbs.org/wgbh/nova/labs/video_popup/3/23/)
- ❑ *The Wild Card Activity Sheet,* in Journals
- ❑ *Surface Temperature Measurement and Cloud Observation Data Sheet*, in Journals
- ❑ Infrared Thermometer (IRT) per group
- ❑ GLOBE *Cloud Chart*

Step 11: Guide students through the completion of the *What's Visual Opacity? Learning Activity,* which is located in their science research journals. Each group will need materials to investigate translucent, transparent, and opaque items. After student investigate the materials and sort them, lead them through the discussion questions asking them to predict what these properties mean for clouds. The activity will require at least two class periods to complete, allow 15-20 minutes for students to discuss and record their responses. The Looking at the Science section can be done in a later class and goes well with the Climate Wild card video.

Step 12: Show the NOVA Video ***The Climate Wild Card***. After watching the video divide the class into small groups and have each group discuss one of the reflection questions within their group. Give students 5 minutes to brainstorm their answers and then regroup as a class to discuss each question. Follow-up with the flow chart that shows a chain reaction of events that might occur as a result of an increase in the percentage of absorbing clouds.

Step 13: Have students work within a small group to complete the *Surface Temperature Measurement and Cloud Observation Data Sheet.* Remind them to continue using the GLOBE *Cloud Chart* as they complete their cloud observations.

Week Five—Pose Research Question, Develop a Hypothesis and Identify the Data

Instructional Procedure: Week Five

Guiding Questions:

- What are things that you should consider when identifying a good research question?
- What are the parts that make up a science investigation?
- How might the steps of a scientific investigation occur in a different order, based on the investigation being conducted?

Materials Checklist:

- ❑ Student Science Research Journals
- ❑ *What Does a NASA Research Question Look Like? Learning Activity*, in Journals
- ❑ *The Science Research Process in Action*, in Journals
- ❑ *Looking at Your GLOBE Data*, in Journals
- ❑ Colored pencils
- ❑ Calculators (optional)

Step 14: Complete the *What Does a NASA Research Question Look Like? Learning Activity,* discuss as a class and use the research question rubric to analyze the two questions that are provided. Emphasize that a good science research question is one that can be answered through the process of investigating or analyzing data that has already been collected by other scientists.

Step 15: During *The Science Research Process in Action*, as a class, discuss the investigations and learning activities that they have been working on during the last few weeks. Discuss NASA's Big Question: "How do clouds affect the Earth's Energy Budget?". Have them consider the two possible research questions that are presented for them to use as their research question. Based on the question that they select, they will work with a partner to develop a hypothesis for what they think is the answer to their research question.

Step 16: The activity, *Looking at Your GLOBE Data*, will guide students through the process of assembling and analyzing data. They will have the opportunity to take a closer look at the surface temperature data they have collected and compare that with the amount of cloud cover that was present. If calculators are available they can be used for calculating surface temperature averages.

Step 17: Have students work within a small group to complete the *Surface Temperature Measurement and Cloud Observation Data Sheet.* Remind them to continue using the GLOBE *Cloud Chart* as they complete their cloud observations.

Week Six—Planning the Investigation and Identify the Data

Instructional Procedure: Week Six

Guiding Questions:

- How did the surface type affect the surface temperature collected at each of your four sites?
- What types of relationships can be found between the percentage of cloud cover and the overall global surface temperature?

Materials Checklist:

- ❑ Student Science Research Journals
- ❑ *Looking at Your GLOBE Data*, in Journals
- ❑ *Selecting Your Culminating Project*, in Journals
- ❑ *Following the Steps of the Scientific Research Process*, in Journals
- ❑ Colored pencils

Step 18: Students complete parts 4 through 7 of the *Looking at Your GLOBE Data Learning Activity*. In this component of the activity, they will be constructing a graph of their data and comparing what they discovered with GLOBE data sets. They will examine two images of surface temperature for January 2007 and July 2007. They will identify three locations on the global image and compare those locations for the months of January and July. Next, they will compare the global surface temperature images with corresponding images that show cloud fraction (percentage of sky covered by clouds).

Step 19: In *Selecting Your Culminating Project*, students are presented with three formats to choose from for their culminating project (science project poster, public service announcement video, or a PowerPoint presentation). The ultimate goal will be for the students to develop a project that incorporates the science research process demonstrating what they have learned. This project can be completed with a partner or a small group (team of 3-4 people). If completing a team project it will be important to ensure that each student has a specific role in the development process of the project.

Step 20: *Following the Steps of the Scientific Research Process* will reinforce the various components of the research process. It will guide students through identifying each of the steps they have completed as they have worked through the various investigations. By working through the activity they will develop the framework to be used in their culminating project.

Step 21: Have students work within a small group to complete the *Surface Temperature Measurement and Cloud Observation Data Sheet*. Remind them to continue using the GLOBE *Cloud Chart* as they complete their cloud observations.

Week Seven—Assemble and Analyze the Data, Document, and Conclusion

Instructional Procedure: Week Seven

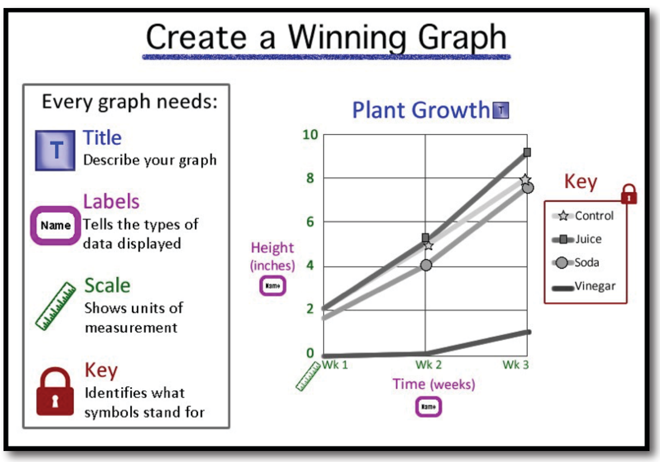
Guiding Questions:

- What types of information will you need to include when creating a graph of your data?
- What relationship do you observe within the data that you collected?

Materials Checklist:

- ❑ Student Science Research Journals
- ❑ *Following the Steps of the Scientific Research Process*, in Journals
- ❑ *Assemble Your Data* and *Analyze your Data*, in Journals
- ❑ Colored pencils
- ❑ Completed Data Sheets from all Cloud Observations and Surface Temperature measurements, in Journals
- ❑ Any materials that will be used in the construction of students culminating projects (posters, construction paper, cardstock, graph paper, colored pencils, markers, notecards, photos, etc)

Step 22: Continue completing the components of *Following the Steps of the Scientific Research Process* as students assemble and analyze the data they have collected. It will be important to guide them in the construction of their graph to ensure that they include all of the necessary components. See example of components of a graph below.



Step 23: While analyzing data to develop a conclusion, students will need to examine their data to see if they can identify any relationships, patterns, or cause-effects. They will write their conclusion based on what they observe, referring back to the hypothesis that they developed and deciding whether or not it is supported by their data. They will also include any new questions that they would like to investigate in the future related to what they discovered in their investigation. The components of the science process that they have completed in their science research journals can be used as their rough drafts in preparation for what they will include on their culminating project.

Step 24: Provide students with opportunity to work on their culminating project. Provide feedback along the way to guide them toward successful completion of their project. Encourage them to incorporate neatness and accuracy.

Step 25: Have students work within a small group to complete the *Surface Temperature Measurement and Cloud Observation Data Sheet.* Remind them to continue using the GLOBE *Cloud Chart* as they complete their cloud observations.

Week Eight— Present Findings and Pose New Questions

Instructional Procedure: Week Eight

Guiding Questions:

- Why is it important for scientists to present their work?
- What have you learned about clouds and/or climate?
- What have you learned about science?

Materials Checklist:

- ❑ Student Science Research Journals
- ❑ Data Sheets from all Cloud Observations and Surface Temperature Measurements
- ❑ Any materials that will be used in the construction of students culminating projects (posters, construction paper, cardstock, graph paper, colored pencils, markers, notecards, photos, etc)

Step 26: Provide students with the opportunity to finalize their projects. Continue to provide feedback along the way to guide them toward a successful completion of their project. All of the students should feel very proud of what they have accomplished and have the opportunity to share this with others in a manner that will positively present the results of their investigations. Encourage them to incorporate neatness and accuracy. Upon conclusion of project, have students complete the Week 8 journal reflection.

Step 27: PRESENTATION DAY *(Provide students with the following ideas to consider while making a presentation.)*

Points to remember when presenting:

- Make eye contact
- Speak clearly
- Smile
- Discuss your project rather than read it
- Identify your main points
- Refer to your graph for visualization
- Have your science research journal available
- Feel proud of what you have accomplished

21CCLC NASA/GLOBE Atmosphere Investigation Culminating Project Ideas

Choice 1: Science Project Poster

With a partner or a small group:

- Identify the research question
- Develop a title for your project
- Use steps of the science research process to guide the components of your poster
- Identify visuals and the data you will include on the poster
- Draft content to be included on the poster
- Present the draft to your instructor
- Make necessary edits to the draft
- Create graphic components
- Write a conclusion from analysis of the data
- Show a rough draft of the poster to the instructor for feedback
- Construct the poster
- Present the final poster to peers for a critique
- Optional: present final poster at Culminating Project Community Night

Choice 2: Public Service Announcement

With a partner or in a small group:

- Identify the research question
- Develop a Public Service Announcement (PSA) message
- Identify visuals and sounds to use in the PSA
- Draft a storyboard and script
- Present the PSA draft to the instructor for review
- Make necessary edits to the draft
- Film and edit the PSA
- Show a rough cut to teacher for feedback
- Present final PSA to peers for a critique
- Optional: present final PSA at Culminating Project Community Night

Choice 3: PowerPoint Presentation

With a partner or a small group:

- Identify the research question
- Use steps of the science research process to guide the components of your PowerPoint
- Develop an outline for the PowerPoint
- Identify images and data to be included
- Draft content to accompany images
- Present the PowerPoint draft to the instructor
- Make necessary edits to the draft
- Show the edited PowerPoint to the instructor for feedback
- Present the final PowerPoint to peers
- Optional: present the final PowerPoint at Culminating Project Community Night.

GLOBE Atmosphere Investigation Culminating Project Rubric

Category	Exemplary 5 points	Proficient 3 points	Novice 1 point	Not Included 0 points
Research Question	Clearly stated a research question that could be answered using data collected during the process of the atmosphere investigation.	Provided a research question from the atmosphere investigation that related to the data that was collected.	Referred to a question that was not necessarily answerable with the data that was collected.	Did not provide a research question for the investigation.
Hypothesis Developed	Fully developed the hypothesis proposing a possible explanation of the research question in a format that is testable and measurable.	Provided a hypothesis as a possible explanation of the research question that was not clearly testable or measurable.	Developed a hypothesis that did not provide an explanation of a possible answer for the research question and was not testable or measurable.	Did not provide a hypothesis for the atmosphere investigation.
Detailed Procedure	Clearly summarized and detailed the steps of the investigation process providing enough detail that the atmosphere investigation could be replicated.	Provided steps for the investigation that could be followed but would not allow for accurate replication of the atmosphere investigation.	Steps given were unclear and contained gaps that would not allow for the atmosphere investigation to be replicated.	Did not provide a procedure for the atmosphere investigation.
Data Assembled	Data was selected and assembled in a graphical visualization that could be used as evidence to answer the research question.	Data was selected that could be used to provide an answer to the research question, but was not provided in a graphical format.	Data was selected but could not be used to provide an answer to the research question.	Did not assemble data from the atmosphere investigation.
Data Analyzed	Data was analyzed as evidence to support a clear explanation/argument of the answer to the research question.	Data was analyzed providing an answer to the research question that was not clearly evident from the data.	Data was examined but was not related to the research question as a possible explanation.	Did not analyze data from the atmosphere investigation.
Conclusion Summarized	Results of the atmosphere investigation were summarized with supporting evidence from data collected during the investigation as it related to the hypothesis and new questions were provided for further investigation.	Results of the investigation were summarized with supporting evidence from the data that was collected during the investigation but no reference to the hypothesis was given and questions for further investigation were not provided.	Results of the investigation were summarized but not supported by evidence from the data collected during the investigation, no reference to the hypothesis was given and questions for further investigation were not provided.	Did not provide a conclusion for the atmosphere investigation.

Team Name: ________________________ **Final Team Score:** ____________________

Appendix

Relevant Links

- **The GLOBE Program:**

  http://www.globe.gov

- **GLOBE Cloud Protocol:**

  http://www.globe.gov/documents/348614/e83c12f1-38a7-404d-b032-b363f4ad4cd2

- **GLOBE Surface Temperature Protocol:**

  http://www.globe.gov/documents/348614/7537c1bd-ce82-4279-8cc6-4dbe1f2cc5b5

- **Cloudy vs Clear Learning Activity Graphs:**

  http://mynasadata.larc.nasa.gov/docs/L122compgraph.pdf

- **NOVA Climate Wild Card video:**

  http://www.pbs.org/wgbh/nova/labs/video_popup/3/23/

Optional Extensions

- **Watch SciGirls, *SkyGirls:***

  http://pbskids.org/video/?guid=47624166-a7d0-49e9-bfc3-57f9f4c734cd

- **Cloud in a Bottle demonstration:**

  http://nasawavelength.org/resource/nw-000-000-002-395/

- **Watch NASA eClips *Real World: Monitoring Earth's Energy Budget with CERES:***

  https://www.youtube.com/watch?v=D_Qmue54W14

- **NASA Earth's Energy Budget Poster & Resources:**

  http://science-edu.larc.nasa.gov/energy_budget/

- **MY NASA Data: Circle the Earth - Explore Surface Types on a Journey around Earth Activity**

  http://nasawavelength.org/resource/nw-000-000-002-181/

NASA GLOBE Atmosphere Investigation

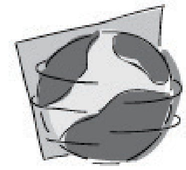
Student Science Research Journal

Student Name: ______________________________

Date: ______________________________

Week One—Observe Nature and Pose Questions About Clouds

Student Introduction: What, Why, and How



WHAT: Scientists are investigating the atmosphere; they want to understand and be able to predict the weather and climate for the different regions of the world. One of the questions that NASA scientists are currently studying is "How do clouds and surface temperature affect the Earth's Energy Budget?"

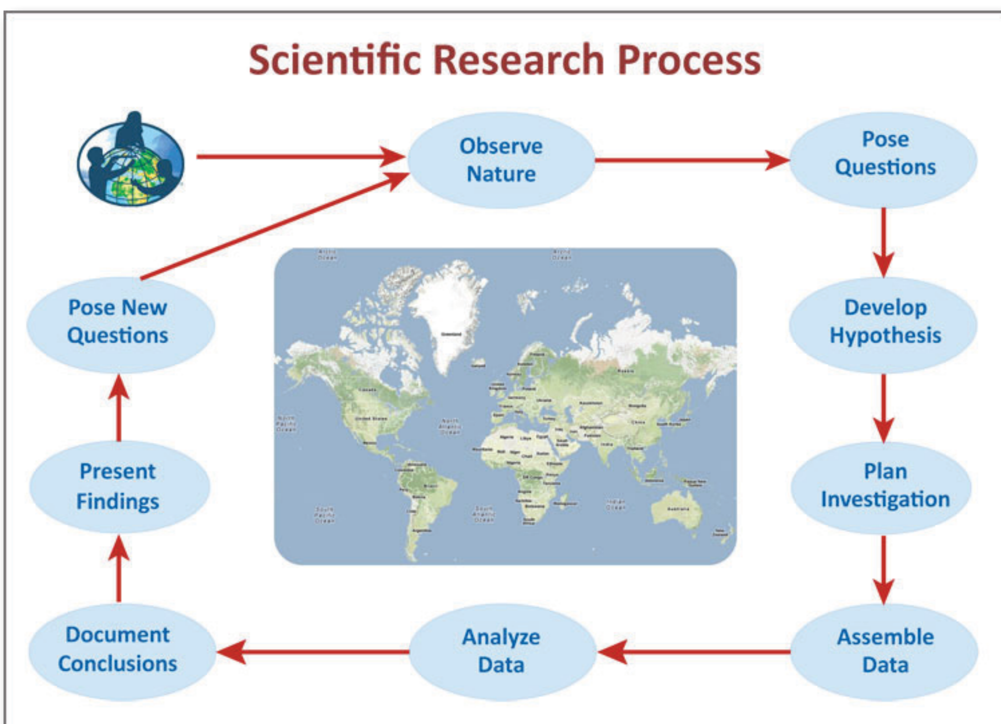
WHY: Each of the different characteristics of the atmosphere affects us and our environment. What we wear and what we can do outside today depend on the weather. Is it raining? Sunny? Cloudy? What is the temperature outside? How do clouds affect our temperature? Do different surfaces on Earth heat up differently? How we build our homes and schools, what crops we grow, what animals and plants naturally live around us depend on climate. All of these are questions that you will be exploring as you become a GLOBE scientist.

Your task as a GLOBE scientist is to explore the region around your school and determine how the energy coming from the Sun is being affected by clouds. You will be using the scientific research process as you conduct a series of investigations during which you will collect data to find the answer to your question.

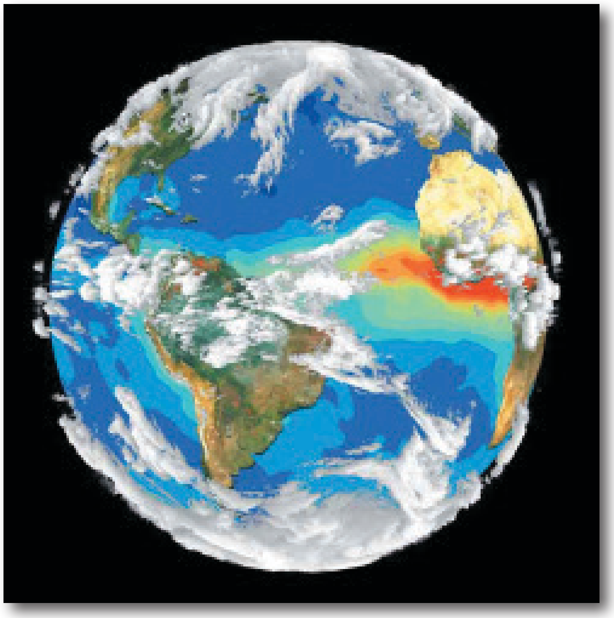
HOW: Collecting Data Using the Scientific Research Process

1. **What is the relationship between cloud cover and surface temperature in the area around your school?**
2. **How do clouds affect the Earth's Energy Budget?**

Make sure to record your observations and measurements as accurately as possible in your science journal.



Step 1: Project Introduction



Why are clouds so important?

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Who is studying the clouds?

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Step 2: What is GLOBE?

G : ______________________

L : ______________________

O : ______________________

B : ______________________

E : ______________________

The GLOBE Program

NASA Scientists NEED YOU!

Step 3: What Does a Scientist Do?

Draw a picture of a scientist in action. Consider the following: Where does your scientist work? What does your scientist do? What are some characteristics of your scientist? Write down any additional information regarding your scientist below.

Step 4: Observing, Describing, and Identifying Clouds

What do you already know about clouds?

Accurate weather forecasting starts with careful and consistent observations. The human eye represents one of the best weather instruments. Much of what we know about the weather is a result of human observation. Although being able to identify clouds is useful in itself, observing clouds on a regular basis and keeping track of the weather associated with certain kinds of clouds will enable you to make the connection between cloud types and weather. Recognizing cloud types can help you predict the kind of weather to expect in the near future.

Part 1: What do you see? Draw a picture of the clouds you see in the sky.

Draw a picture of the different types of clouds you see in the boxes below. Under each picture use words to describe the characteristics of each cloud.

Part 2: Compare Your Descriptions to the Official Descriptions Using the GLOBE Cloud Chart.

With a partner or small group use the GLOBE Cloud Chart to try to identify the different clouds that you sketched on the previous page.

Part 3: As a class, discuss the different types of clouds that you observed.

Based on your observations one person from your group should volunteer to draw one of your cloud sketches on the board and record the words your group used to describe the cloud.

As a class, work together to determine the “official” names for each of the different types of clouds that you observed.

Using the chart, determine what the four main types of clouds are and record those below. Write descriptive words for each of the different types.

Step 5: Cloud Observation

Clouds Measurement Data Sheet

School Name: ______________________________ *Study Site:* ____________________

Observer Names: ____

Date: Year ________ *Month* ________ *Day* ________ *Universal Time (hour:min):* ____________________

Sky conditions (check one):

❑ **Clear** *(no clouds visible)*

❑ **Clouds visible** *(1% to 100% covered by clouds or contrails)*

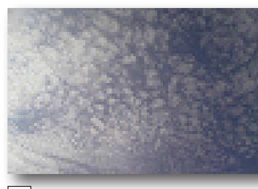
❑ **Obscured** *(More than 25% of the sky is not visible)*

Note: selecting ***Obscured*** will prevent data entry on clouds and contrails; therefore skip the cloud type and cover and the contrail type and cover sections and proceed to the Obscured section. If clouds and contrails are visible in non-obscured areas of the sky, these data can be entered in the Metadata field.

If clouds are visible select all cloud types seen:

High (in the sky):
(Check all types seen)

❑ Cirrus

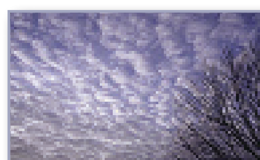


❑ Cirrocumulus

❑ Cirrostratus

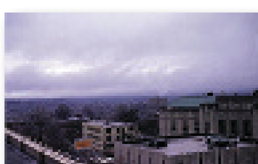
Middle (of the sky):
(Check all types seen)

❑ Altostratus

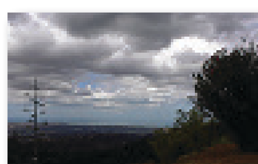


❑ Altocumulus

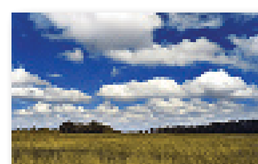
Low (in the sky):
(Check all types seen)



❑ Stratus

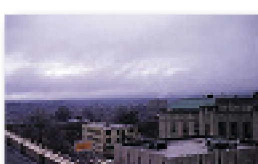


❑ Stratocumulus

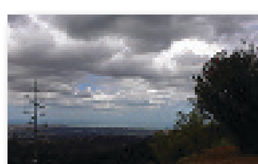


❑ Cumulus

Rain or snow producing clouds:
(Check all types seen)



❑ Nimbostratus

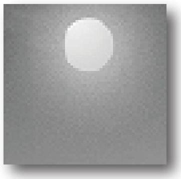


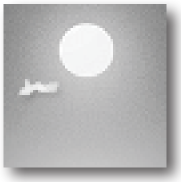
❑ Cumulonimbus

GLOBE Atmosphere Investigations

Study Site: ____________________ *Date:* ____________ *Time (UT):*____________________

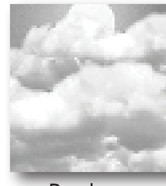
What percent of the sky is covered by clouds? (Check one): Three-quarters or More of the Sky is Visible: Cloud Cover (Check one)


No Clouds
❏ 0%


Clear
❏ >0 to 10%


Isolated
❏ 10 to 25%


Scattered
❏ 25 to 50%


Broken
❏ 50 to 90%

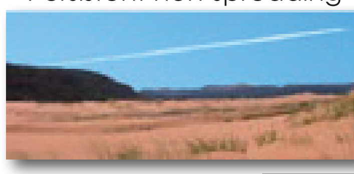

Overcast
❏ >90%

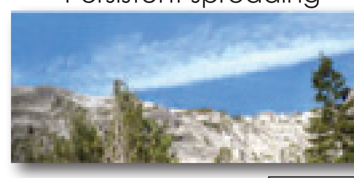
Are there contrails in the sky? (Check one): ❏ **No contrails** ❏ **Contrails are visible**

If contrails are visible, record the number of each type seen:

Short-lived

Number observed ☐

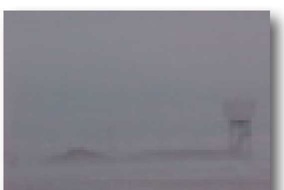
Persistent non-spreading

Number observed ☐

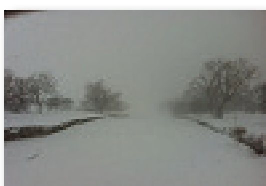
Persistent spreading

Number observed ☐

What percent of the sky is covered by contrails? (Check one):

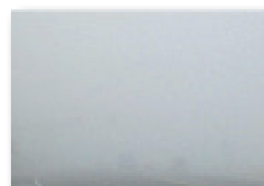
❏ 0 to 10% ❏ 10 to 25% ❏ 25 to 50% ❏ >50%

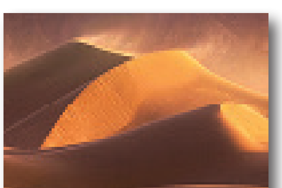
If you selected "obscured" (>25% of the sky is not visible) (check all that apply):

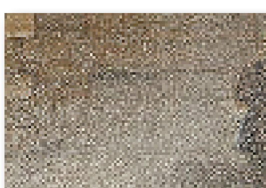

❏ Blowing snow


❏ Heavy snow


❏ Heavy rain


❏ Fog

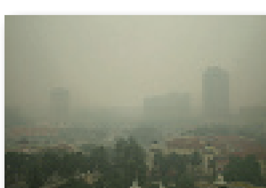

❏ Sand


❏ Spray


❏ Volcanic ash


❏ Smoke


❏ Dust


❏ Haze

Comments:

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Week One Science Journal Reflections

What have you learned?

What would you like to know more about?

Week Two—Observe Nature and Pose Questions About Clouds

Step 6: Heating Things Up Learning Activity

Imagine that you are at the beach and you are barefooted. What surfaces would you want to walk on and why? Why are some surfaces cool to your touch? Why are some hot to your touch? Where did the hot surfaces get their energy? Today you will investigate what happens to air and different Earth materials when they are exposed to the Sun.

Description of task:

Working in small groups you will explore the energy transfer of different Earth materials when they are heated up and cooled down. You will be recording your data in a chart which you will use to graph the changes in temperatures that occur over a 15-minute period of heating the Earth material up and a 15-minute period of the Earth material cooling down.

What to Do Part 1:

1. Make sure that each container has about the same amount of material. If it is a sunny day you will be completing the activity outside, but if not, desk lamps will be used to simulate the Sun's energy.
2. Once you have your containers set up, place a thermometer in each container.
3. For each Earth material, designate a recorder that will record the temperatures and a person that will measure the temperatures in degrees Celsius.
4. Record the beginning temperature of each material. Start the timer and the timekeeper should tell the student taking the measurements when they should measure the temperature with the Infrared Thermometer (IRT) or read the thermometers. If you are using one IRT, try to take the measurements as close together in time as possible.
5. Record the temperature of the Earth material in the Sun or under the light every 3 minutes for a total of 15 minutes. After 15 minutes, the Earth materials are shaded or the lights are turned off. Measure the temperature every 3 minutes for the next 15 minutes during the cooling down phase. Record your data in the Data Table Sheet that is provided on the next page.
6. Share your data with the class by having one person from your group record your data on the board or the piece of chart paper that is provided by your instructor.

Data Table Sheet 1

	Temperatures °C				
Time	**Bare Soil**	**Grass**	**Gravel/Rocks**	**Sand**	**Water**
Beginning					
3 minutes					
6 minutes					
9 minutes					
12 minutes					
15 minutes					
	Shaded or turn off lights				
18 minutes					
21 minutes					
24 minutes					
27 minutes					
30 minutes					

Now look at the data and discuss the following questions within your group, record your answers below each question:

1. **Does each material in the containers start at the same temperature?**

2. **How can you compare them to see which one had the most change in temperature?**

3. **How would you describe the change that occurs over time?**

Part 2: As a class, fill in the changes in temperature in the data table below.

Data Table Sheet 2

	Change in Temperatures °C				
Time	**Bare Soil**	**Grass**	**Gravel/Rocks**	**Sand**	**Water**
Beginning					
3 minutes					
6 minutes					
9 minutes					
12 minutes					
15 minutes					
	Shaded or turn off lights				
18 minutes					
21 minutes					
24 minutes					
27 minutes					
30 minutes					

Going Further: One way scientists analyze their data is by graphing the data. In order to look at what is happening with each material, you will graph the data of all materials on one graph. Each material's data will be graphed in a different color. Use colored pencils to identify the different materials.

Using the graph that you have constructed, answer the following questions:

1. **Did all of the Earth materials heat up at the same rate? Explain the evidence you use to support your answer:**

2. **Did all of the Earth materials cool down at the same rate? Explain the evidence that you use to support your answer:**

3. **Which Earth material heated up the fastest? How do you know this?**

4. **Did each Earth material receive the same amount of energy? How do you know this?**

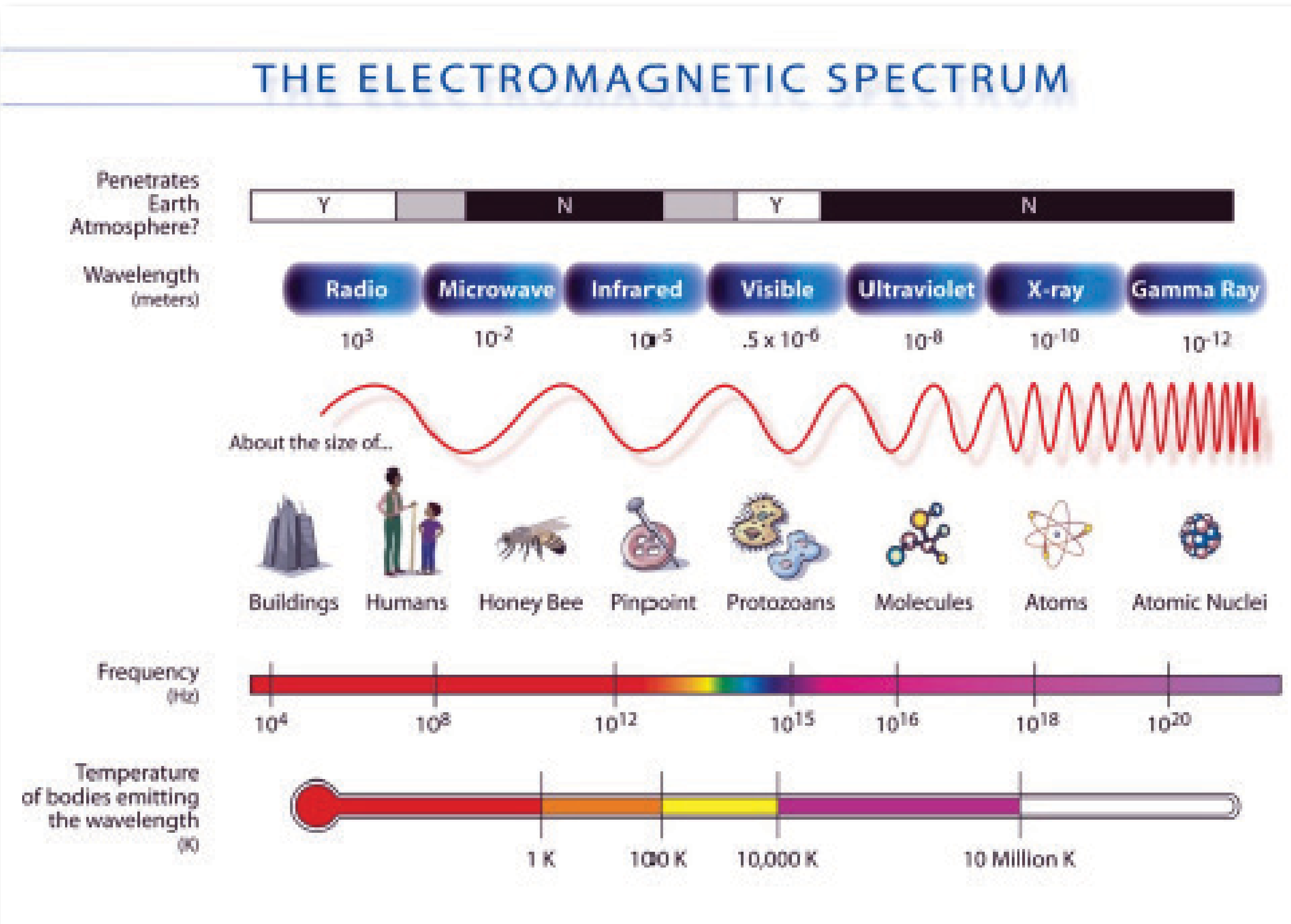
5. **Which Earth material cooled down the fastest? How do you know this?**

6. **Did each Earth material receive the same amount of energy? How do you know this?**

The Science Behind the Investigation

What you should find from this investigation is that water is the slowest to heat up and the slowest to cool down. All of the materials received the same amount of energy. So why do you think water increased so little? For water, it takes five times more heat energy to raise the temperature of an equal amount of dry soil or sand one degree. When the same amount of energy is absorbed equally by all of the Earth materials, the temperature of the solid Earth materials will increase faster and greater than water. In addition, water is a liquid that mixes. The energy for water is mixed throughout its volume while only the very surface of solids is heated.

The energy that comes from the Sun is radiant energy that travels in waves through space. This energy makes up the electromagnetic spectrum. Some waves that you may be familiar with are visible light (which we can see), radio waves (listening to radio stations in your car), and microwaves (like your microwave oven that can heat up things). When the energy hits a molecule or atom such as molecules of sand or water, the molecule gains energy. The gain in energy makes the molecule vibrate or move faster. We say the molecule absorbed the energy. This molecular movement is what we call heat. The more molecules move, the more heat is produced.



Step 7: Cloud Observation

Clouds Measurement Data Sheet

School Name: ____________________ *Study Site:* ____________________

Observer Names: ____

Date: Year ________ *Month* ____________ *Day* __________ *Universal Time (hour:min):* ____________

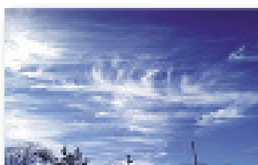
Sky conditions (check one):

- ❑ **Clear** *(no clouds visible)*
- ❑ **Clouds visible** *(1% to 100% covered by clouds or contrails)*
- ❑ **Obscured** *(More than 25% of the sky is not visible)*

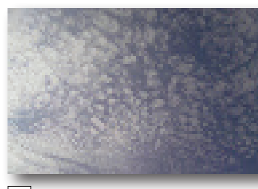
Note: selecting ***Obscured*** will prevent data entry on clouds and contrails; therefore skip the cloud type and cover and the contrail type and cover sections and proceed to the Obscured section. If clouds and contrails are visible in non-obscured areas of the sky, these data can be entered in the Metadata field.

If clouds are visible select all cloud types seen:

High (in the sky):
(Check all types seen)



❑ Cirrus

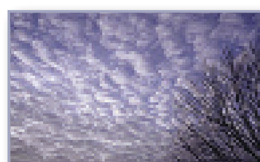


❑ Cirrocumulus

❑ Cirrostratus

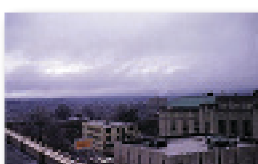
Middle (of the sky):
(Check all types seen)

❑ Altostratus

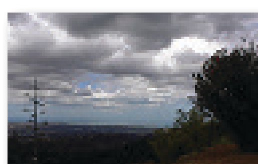


❑ Altocumulus

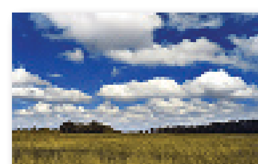
Low (in the sky):
(Check all types seen)



❑ Stratus

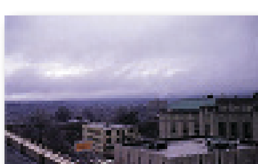


❑ Stratocumulus

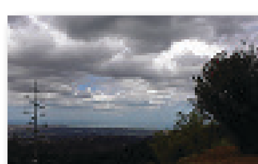


❑ Cumulus

Rain or snow producing clouds:
(Check all types seen)



❑ Nimbostratus

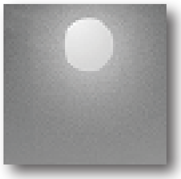


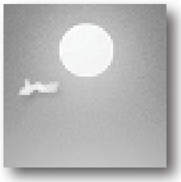
❑ Cumulonimbus

GLOBE Atmosphere Investigations

Study Site: ______________________ *Date:* ______________ *Time (UT):*______________________

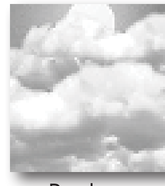
What percent of the sky is covered by clouds? (Check one): Three-quarters or More of the Sky is Visible: Cloud Cover (Check one)


No Clouds
❑ 0%


Clear
❑>0 to 10%


Isolated
❑10 to 25%


Scattered
❑25 to 50%


Broken
❑50 to 90%

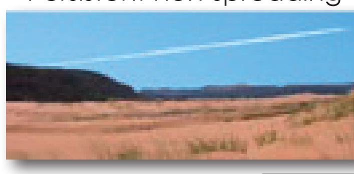

Overcast
❑ >90%

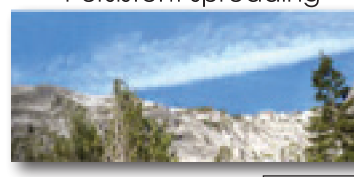
Are there contrails in the sky? (Check one): ❑ **No contrails** ❑ **Contrails are visible**

If contrails are visible, record the number of each type seen:

Short-lived

Number observed ☐

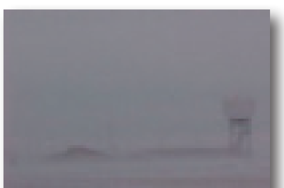
Persistent non-spreading

Number observed ☐

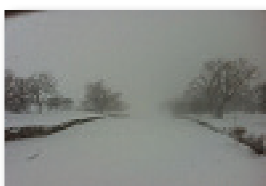
Persistent spreading

Number observed ☐

What percent of the sky is covered by contrails? (Check one):

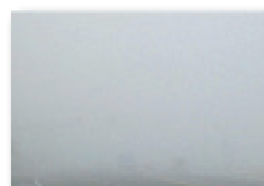
❑ 0 to 10% ❑ 10 to 25% ❑ 25 to 50% ❑ >50%

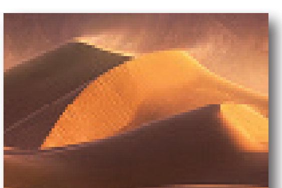
If you selected "obscured" (>25% of the sky is not visible) (check all that apply):

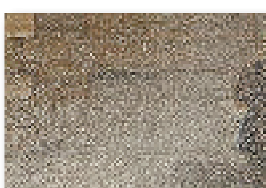

❑ Blowing snow

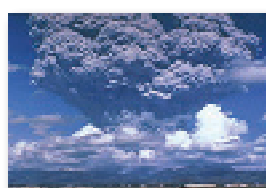

❑ Heavy snow


❑ Heavy rain


❑ Fog

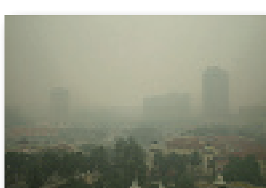

❑ Sand


❑ Spray


❑ Volcanic ash


❑ Smoke


❑ Dust


❑ Haze

Comments:

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Clouds Measurement Data Sheet

School Name: ____ *Study Site:* ________________________

Observer Names: ____

Date: Year ________ *Month* _____________ *Day* ___________ *Universal Time (hour:min):* ___________

Sky conditions (check one):

❑ **Clear** *(no clouds visible)*

❑ **Clouds visible** *(1% to 100% covered by clouds or contrails)*

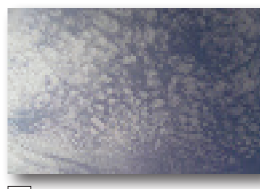
❑ **Obscured** *(More than 25% of the sky is not visible)*

Note: selecting ***Obscured*** will prevent data entry on clouds and contrails; therefore skip the cloud type and cover and the contrail type and cover sections and proceed to the Obscured section. If clouds and contrails are visible in non-obscured areas of the sky, these data can be entered in the Metadata field.

If clouds are visible select all cloud types seen:

High (in the sky):
(Check all types seen)

❑ Cirrus

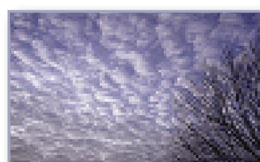


❑ Cirrocumulus

❑ Cirrostratus

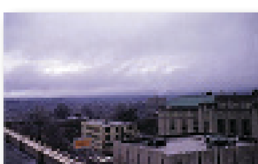
Middle (of the sky):
(Check all types seen)

❑ Altostratus

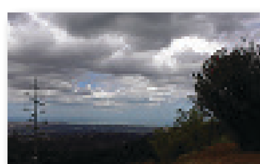


❑ Altocumulus

Low (in the sky):
(Check all types seen)



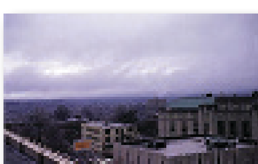
❑ Stratus



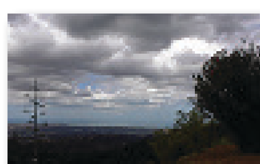
❑ Stratocumulus

❑ Cumulus

Rain or snow producing clouds:
(Check all types seen)



❑ Nimbostratus



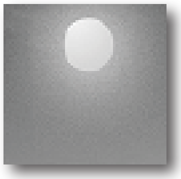
❑ Cumulonimbus

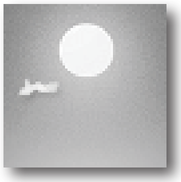
GLOBE Atmosphere Investigations

Week Two

Study Site: ______________________ *Date:* ______________ *Time (UT):*_______________________

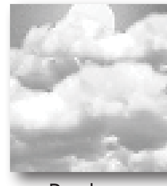
What percent of the sky is covered by clouds? (Check one): Three-quarters or More of the Sky is Visible: Cloud Cover (Check one)


No Clouds
❑ 0%


Clear
❑>0 to 10%


Isolated
❑10 to 25%


Scattered
❑25 to 50%


Broken
❑50 to 90%


Overcast
❑ >90%

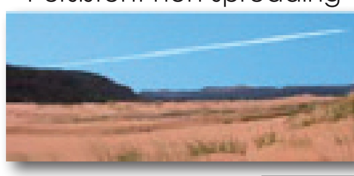
Are there contrails in the sky? (Check one): ❑ **No contrails** ❑ **Contrails are visible**

If contrails are visible, record the number of each type seen:

Short-lived

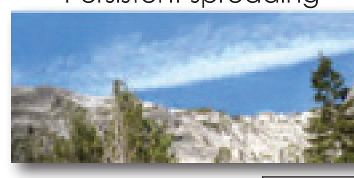
Number observed ☐

Persistent non-spreading



Number observed ☐

Persistent spreading

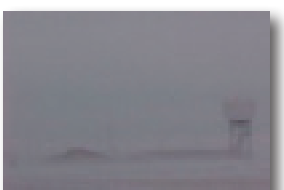


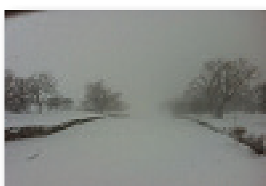
Number observed ☐

What percent of the sky is covered by contrails? (Check one):

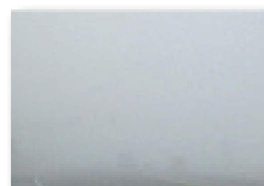
❑ 0 to 10% ❑ 10 to 25% ❑ 25 to 50% ❑ >50%

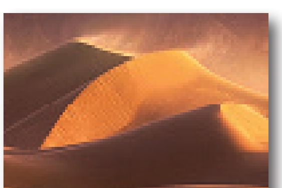
If you selected "obscured" (>25% of the sky is not visible) (check all that apply):

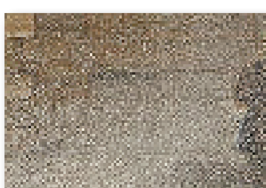

❑ Blowing snow

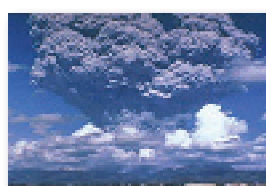

❑ Heavy snow


❑ Heavy rain


❑ Fog

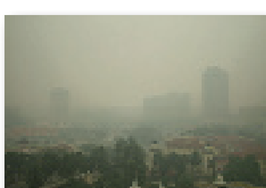

❑ Sand


❑ Spray


❑ Volcanic ash


❑ Smoke


❑ Dust


❑ Haze

Comments:

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Week Two Science Journal Reflections

What have you learned?

What would you like to know more about?

Week Three—Observe Nature and Pose Questions About Clouds and Surface Temperature

Step 8: Surface Temperature

Surface temperature is measured with a hand-held Infrared Thermometer (IRT). The instrument is pointed at the ground to take surface temperature readings.

With a partner, brainstorm answers to the following question thinking back to the activity you did with different Earth materials that heated and cooled at different rates.

How might the surface temperature of the different surfaces around the outside of your school be different?

Consider the following question as you and your classmates select four different surface areas for your surface temperature sites:

What factors do you need to consider as you select your sites to ensure that the only variable affecting the surface temperature being collected is the type of ground cover?

As a class identify four different surface areas outside of your school as surface temperature study sites remembering to consider what you have learned regarding heating and cooling of different Earth materials. Sketch the different site surfaces in the spaces provided on the next page and predict the order of surface temperatures from coolest to warmest.

Step 9: Surface Temperature Measurements and Cloud Observation Surface Temperature Data Sheet

School Name: ______________________________*Study Site:*________________

*Observer Names:*____

Date: Year _________ *Month* ___________ *Day* __________*Universal Time (hour:min):*__________

Surface Temperature:

Site's overall surface condition (Check one): ❑ Wet ❑ Dry ❑ Snow

Sample	Temperature (°C)	Snow Depth (mm)
1		❑ Zero Trace ❑ (<10 mm) ❑ Measurable ❑ (>10 mm) ______ mm
2		❑ Zero Trace ❑ (<10 mm) ❑ Measurable ❑ (>10 mm) ______ mm
3		❑ Zero Trace ❑ (<10 mm) ❑ Measurable ❑ (>10 mm) ______ mm
4		❑ Zero Trace ❑ (<10 mm) ❑ Measurable ❑ (>10 mm) ______ mm

Sky conditions (check one):

❑ **Clear** *(no clouds visible)*

❑ **Clouds visible** *(1% to 100% covered by clouds or contrails)*

❑ **Obscured** *(More than 25% of the sky is not visible)*

Sketch the sky below:

Comments:

____

____

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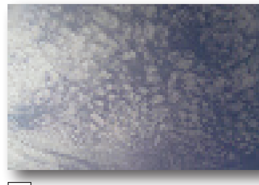
Study Site: ______________________ *Date:* ____________ *Time (UT):*______________________

If clouds are visible select all cloud types seen:

High (in the sky):
(Check all types seen)

☐ Cirrus

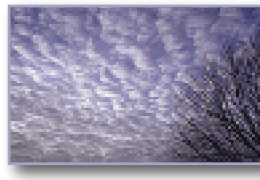


☐ Cirrocumulus

☐ Cirrostratus

Middle (of the sky):
(Check all types seen)

☐ Altostratus



☐ Altocumulus

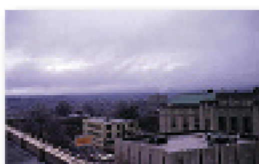
Low (in the sky):
(Check all types seen)

☐ Stratus

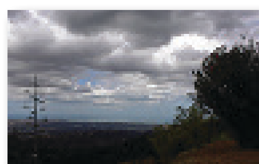
☐ Stratocumulus

☐ Cumulus

Rain or snow producing clouds:
(Check all types seen)



☐ Nimbostratus

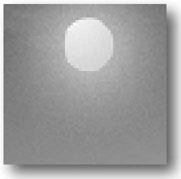


☐ Cumulonimbus

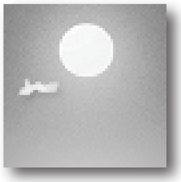
GLOBE Atmosphere Investigations

Study Site: ______________________ *Date:* ______________ *Time (UT):*______________________

What percent of the sky is covered by clouds? (Check one): Three-quarters or More of the Sky is Visible: Cloud Cover (Check one)



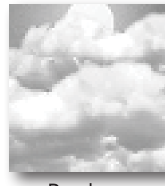
No Clouds
❑ 0%



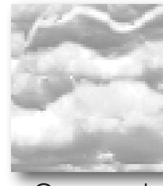
Clear
❑>0 to 10%

Isolated
❑10 to 25%

Scattered
❑25 to 50%



Broken
❑50 to 90%



Overcast
❑ >90%

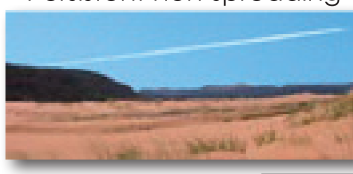
Are there contrails in the sky? (Check one): ❑ **No contrails** ❑ **Contrails are visible**

If contrails are visible, record the number of each type seen:

Short-lived

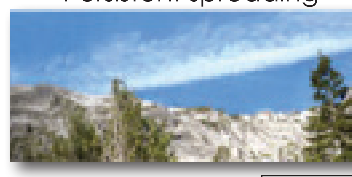
Number observed ☐

Persistent non-spreading



Number observed ☐

Persistent spreading

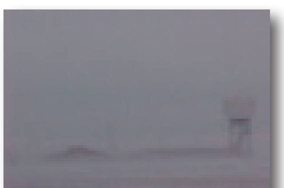


Number observed ☐

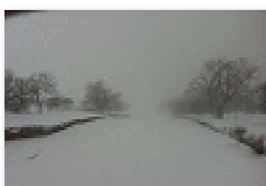
What percent of the sky is covered by contrails? (Check one):

❑ 0 to 10% ❑ 10 to 25% ❑ 25 to 50% ❑ >50%

If you selected "obscured" (>25% of the sky is not visible) (check all that apply):

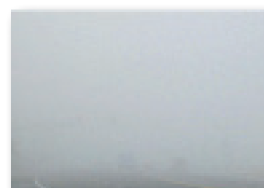


❑ Blowing snow

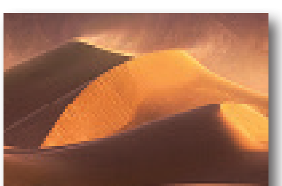


❑ Heavy snow

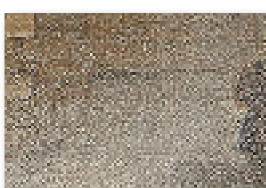
❑ Heavy rain



❑ Fog



❑ Sand

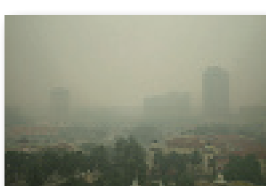


❑ Spray

❑ Volcanic ash

❑ Smoke

❑ Dust



❑ Haze

Comments:

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Surface Temperature Measurements and Cloud Observation Surface Temperature Data Sheet

School Name: ______________________________ *Study Site:* ____________

Observer Names: ______________________________

Date: Year ________ *Month* __________ *Day* ________ *Universal Time (hour:min):* ________

Surface Temperature:

Site's overall surface condition (Check one): ❑ Wet ❑ Dry ❑ Snow

Sample	Temperature (°C)	Snow Depth (mm)
1		❑ Zero Trace ❑ (<10 mm) ❑ Measurable ❑ (>10 mm) ______ mm
2		❑ Zero Trace ❑ (<10 mm) ❑ Measurable ❑ (>10 mm) ______ mm
3		❑ Zero Trace ❑ (<10 mm) ❑ Measurable ❑ (>10 mm) ______ mm
4		❑ Zero Trace ❑ (<10 mm) ❑ Measurable ❑ (>10 mm) ______ mm

Sky conditions (check one):

❑ **Clear** *(no clouds visible)*

❑ **Clouds visible** *(1% to 100% covered by clouds or contrails)*

❑ **Obscured** *(More than 25% of the sky is not visible)*

Sketch the sky below:

Comments:

____

____

____

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____

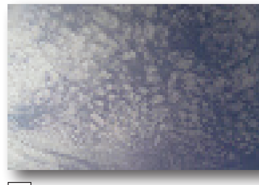
GLOBE Atmosphere Investigations

Study Site: ______________________ *Date:* _____________ *Time (UT):*______________________

If clouds are visible select all cloud types seen:

High (in the sky):
(Check all types seen)

❑ Cirrus

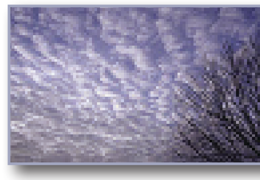


❑ Cirrocumulus

❑ Cirrostratus

Middle (of the sky):
(Check all types seen)

❑ Altostratus



❑ Altocumulus

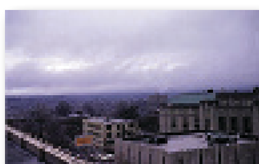
Low (in the sky):
(Check all types seen)

❑ Stratus

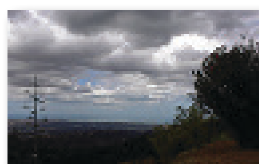
❑ Stratocumulus

❑ Cumulus

Rain or snow producing clouds:
(Check all types seen)



❑ Nimbostratus

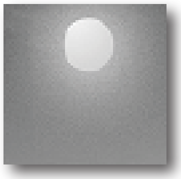


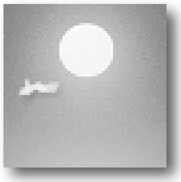
❑ Cumulonimbus

GLOBE Atmosphere Investigations

Study Site: ____________________ *Date:* ______________ *Time (UT):*____________________

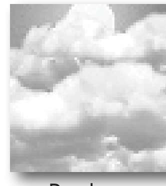
What percent of the sky is covered by clouds? (Check one): Three-quarters or More of the Sky is Visible: Cloud Cover (Check one)


No Clouds
❑ 0%


Clear
❑ >0 to 10%


Isolated
❑ 10 to 25%


Scattered
❑ 25 to 50%


Broken
❑ 50 to 90%

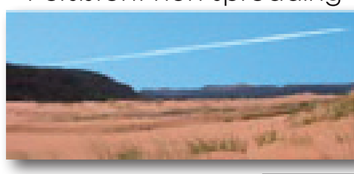

Overcast
❑ >90%

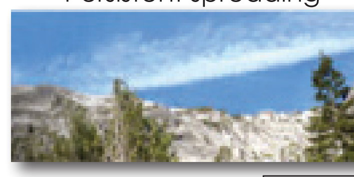
Are there contrails in the sky? (Check one): ❑ No contrails ❑ Contrails are visible

If contrails are visible, record the number of each type seen:

Short-lived

Number observed ☐

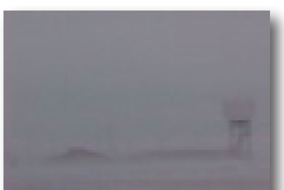
Persistent non-spreading

Number observed ☐

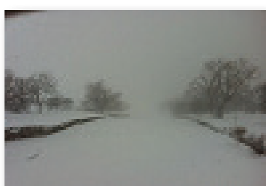
Persistent spreading

Number observed ☐

What percent of the sky is covered by contrails? (Check one):

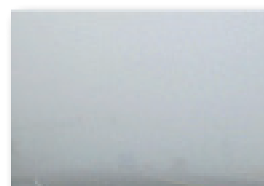
❑ 0 to 10% ❑ 10 to 25% ❑ 25 to 50% ❑ >50%

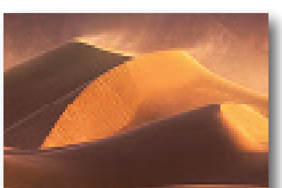
If you selected "obscured" (>25% of the sky is not visible) (check all that apply):

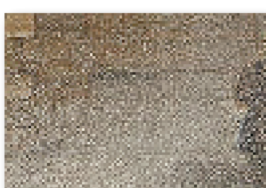

❑ Blowing snow

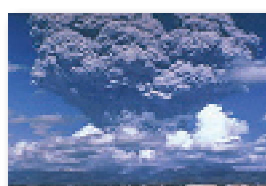

❑ Heavy snow


❑ Heavy rain


❑ Fog

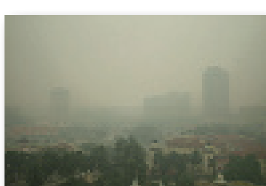

❑ Sand


❑ Spray


❑ Volcanic ash


❑ Smoke


❑ Dust


❑ Haze

Comments:

____

____

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Step 10: Cloudy vs Clear MY NASA DATA Activity

Description of task:

You will be examining a line plot using authentic NASA data to compare temperature on a cloudy vs clear day. You will practice drawing conclusions based on graphed data of cloudy vs. clear sky observations.

What to do:

1. **Cut out the two single-line plots and glue them in your foldable as demonstrated by your teacher**
2. **Identify the titles of the graphs. Is it easy to compare the two separate line plots?**

____

____

3. **Examine the double-line plot that your teacher gives you and glue it in your foldable. With a partner discuss similarities and differences between the single and double line plots, make a list of these on your foldable. Which one is easier to use to make a comparison between the cloudy and clear data?**

____

4. **Identify 2 locations on the plot that are similar in cloudy and clear sky conditions.**

____

5. **Find the month with the biggest difference in cloudy and clear sky conditions.**

____

6. **Which line has the higher amount of energy from the sun throughout the year?**

____________________ **Why?** ____________________

7. **What other things might affect how much of the Sun's energy reaches the Earth's surface?**

____

8. **During what season is it most cloudy in China?** ____________________
9. **In the space below write a summary of how temperature is affected by clouds.**

____

____

____

10. **On the front of your foldable, sketch a picture of a cloudy sky on the left fold and a clear sky on the right fold.**

Attach your foldable Cloudy vs Clear in the space below:

Week Three Science Journal Reflections

What have you learned?

What would you like to know more about?

Week Four—Observe Nature and Pose Questions About Clouds and Surface Temperature

Step 11: What's Visual Opacity? Activity

Clouds play an important role in maintaining the Earth's temperature.

Materials have lots of different properties. One is called *visual opacity*, which means how much light passes through the material. There are three different ways to describe visual opacity:

- ***Transparent:*** light passes through the material/object, things on the other side can be seen clearly (example: plastic wrap).
- ***Translucent:*** light passes through the materials/object; things on the other side can't be seen clearly (example: wax paper).
- ***Opaque:*** little or no light passes through the materials/object (example: paper bag).

Investigate

Come up with a way to test the visual opacity of different everyday items. Describe your test. You can draw your setup if you need.

Describe:

____

____

____

____

____

____

Draw:

Now test your materials and sort them based on your observations. List your results below.

Transparent	Translucent	Opaque

Predict

One of the ways they regulate the amount of light (energy) coming from the sun is their opacity. The terms transparent, translucent, and opaque describe how much light gets through a cloud and helps us understand why clouds make shadows.

How do you think an opaque cloud will impact surface temperature?

____

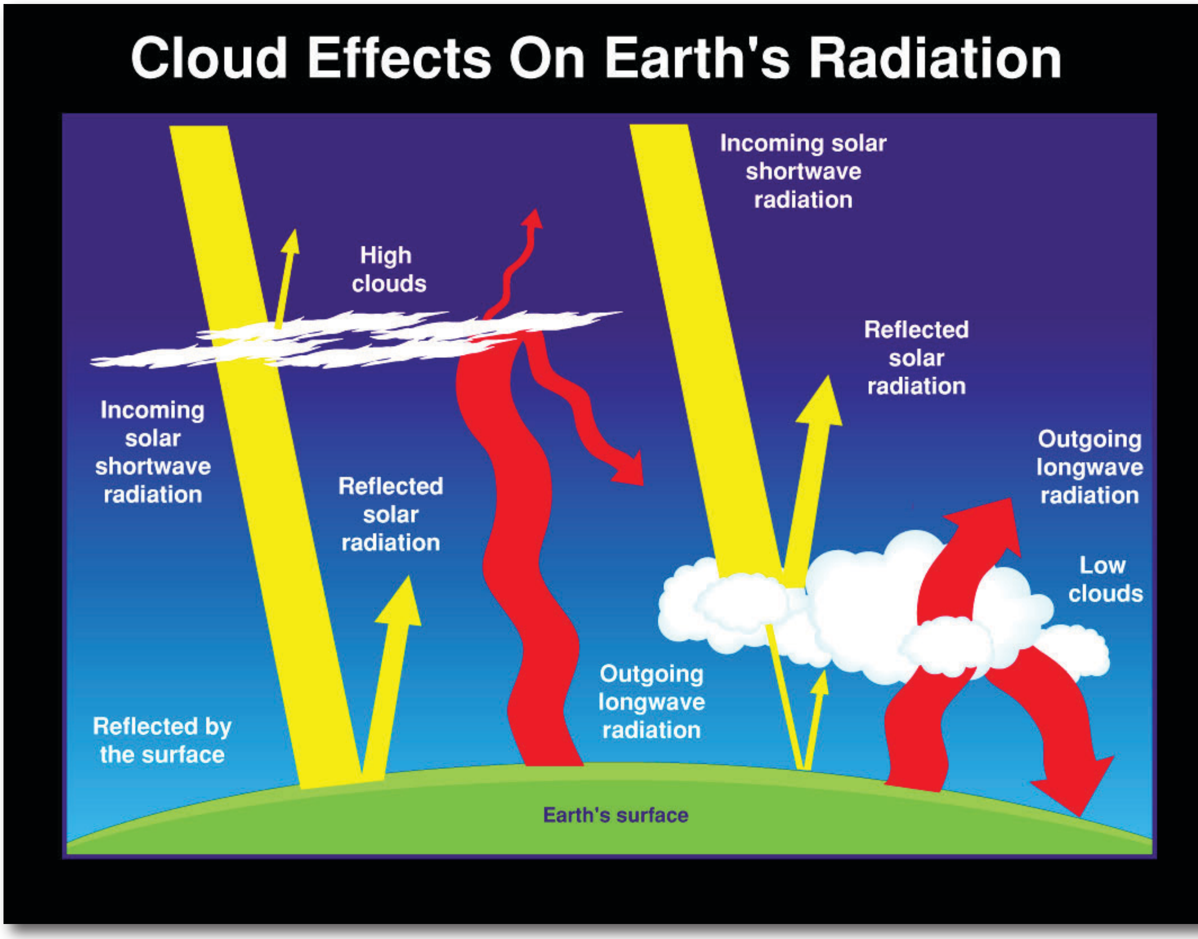
____

How do you think a transparent cloud will impact surface temperature?

____

____

Looking at the Science: The Earth's Radiation Budget is a concept used for understanding how much energy the Earth gets from the Sun and how much energy the Earth-system radiates back to outer space. It is this exchange of energy that powers and drives Earth's weather and climate systems. If the Earth system (earth surface, atmosphere, oceans and ice mass) retains more solar energy than it radiates back to space, the Earth will warm. If the Earth-system radiates more energy to space than it receives from the Sun, the Earth will cool. Scientists think of the *Radiation Budget* in terms of a see-saw or balance. If the Earth retains more energy from the Sun, the Earth warms and emits more infrared energy. This brings the Earth's Energy Budget into balance. If the Earth emits more of this energy than it absorbs, the Earth cools. As it cools, the Earth emits less energy. This change also brings the Energy/Radiation Budget back into balance.



1. Which type of clouds do you see represented in the diagram?

2. How do the low level clouds interact with the solar radiation that is coming from the Sun toward Earth's surface?

3. The high level clouds?

4. Based on the diagram, what affect do clouds have on the Earth's energy coming from the Sun?

5. What affect do clouds have on the energy that is being reflected from the Earth's surface back toward the atmosphere?

Step 12: NOVA Connection: *The Climate Wild Card*

After watching the NOVA Video: *The Climate Wild Card,* reflect on the questions below that NASA scientists are working hard to answer.

- **How will clouds respond as the planet warms?**

- **Could we see an increase in reflecting clouds, which would help to slow the global warming trend?**

- **Or will there be an increase in absorbing clouds, which could dramatically speed up the warming?**

- **How would this warming affect the polar regions and in turn affect coastal areas?**

As a class brainstorm how the polar regions and coastal areas might be affected if there is an increase in absorbing clouds. Fill in the chain of events below that might occur if the percentage of absorbing clouds increase.

Percentage of Absorbing Clouds Increase

↓

Warming of Atmosphere ______________________________

↓

Ice at the Polar Regions ______________________________

↓

Sea Level ______________________________

↓

Coastal Areas ______________________________

↓

This would result in the following impacts on humans:

____

____

Step 13: Surface Temperature Measurement and Cloud Observation Data Sheet

School Name: ______________________________ *Study Site:* ____________________

Observer Names: ____

Date: Year ________ *Month* __________ *Day* _________ *Universal Time (hour:min):* __________

Surface Temperature:

Site's overall surface condition (Check one): ❑ Wet ❑ Dry ❑ Snow

Sample	Temperature (°C)	Snow Depth (mm)
1		❑ Zero Trace ❑ (<10 mm) ❑ Measurable ❑ (>10 mm) ______ mm
2		❑ Zero Trace ❑ (<10 mm) ❑ Measurable ❑ (>10 mm) ______ mm
3		❑ Zero Trace ❑ (<10 mm) ❑ Measurable ❑ (>10 mm) ______ mm
4		❑ Zero Trace ❑ (<10 mm) ❑ Measurable ❑ (>10 mm) ______ mm

Sky conditions (check one):

❑ **Clear** *(no clouds visible)*

❑ **Clouds visible** *(1% to 100% covered by clouds or contrails)*

❑ **Obscured** *(More than 25% of the sky is not visible)*

Sketch the sky below:

Comments:

____

____

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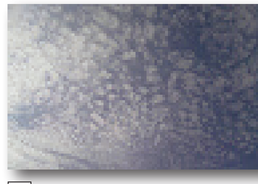
Study Site: ______________________ *Date:* _____________ *Time (UT):*______________________

If clouds are visible select all cloud types seen:

High (in the sky):
(Check all types seen)

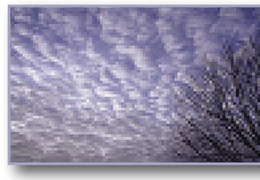

☐ Cirrus


☐ Cirrocumulus


☐ Cirrostratus

Middle (of the sky):
(Check all types seen)


☐ Altostratus


☐ Altocumulus

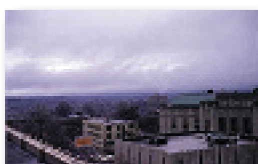
Low (in the sky):
(Check all types seen)

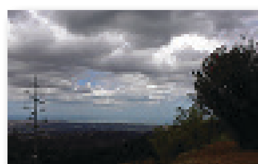

☐ Stratus


☐ Stratocumulus


☐ Cumulus

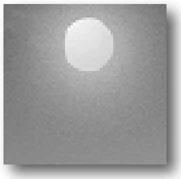
Rain or snow producing clouds:
(Check all types seen)

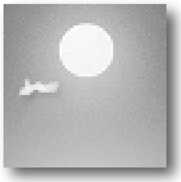

☐ Nimbostratus


☐ Cumulonimbus

Study Site: ____________________ *Date:* ______________ *Time (UT):*____________________

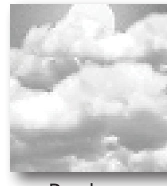
What percent of the sky is covered by clouds? (Check one): Three-quarters or More of the Sky is Visible: Cloud Cover (Check one)


No Clouds
❑ 0%


Clear
❑>0 to 10%


Isolated
❑10 to 25%


Scattered
❑25 to 50%


Broken
❑50 to 90%

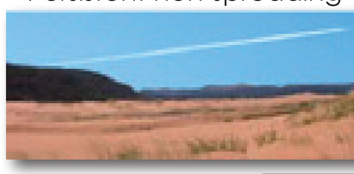

Overcast
❑ >90%

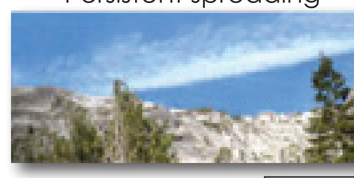
Are there contrails in the sky? (Check one): ❑ **No contrails** ❑ **Contrails are visible**

If contrails are visible, record the number of each type seen:

Short-lived

Number observed ______

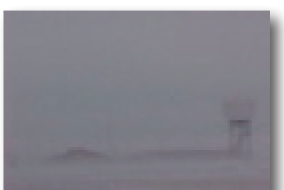
Persistent non-spreading

Number observed ______

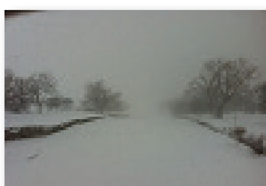
Persistent spreading

Number observed ______

What percent of the sky is covered by contrails? (Check one):

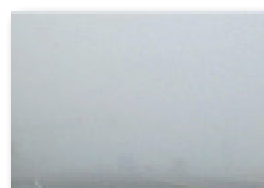
❑ 0 to 10% ❑ 10 to 25% ❑ 25 to 50% ❑ >50%

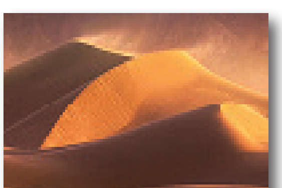
If you selected "obscured" (>25% of the sky is not visible) (check all that apply):

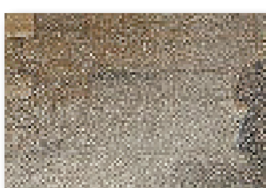

❑ Blowing snow

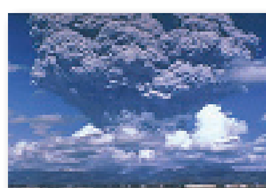

❑ Heavy snow


❑ Heavy rain


❑ Fog

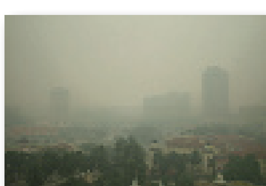

❑ Sand


❑ Spray


❑ Volcanic ash


❑ Smoke


❑ Dust


❑ Haze

Comments:

____

____

____

Surface Temperature Measurement and Cloud Observation Data Sheet

School Name: ____ *Study Site:* ____________________

Observer Names: ____

Date: Year ________ *Month* __________ *Day* _________ *Universal Time (hour:min):* __________

Surface Temperature:

Site's overall surface condition (Check one): ❑ Wet ❑ Dry ❑ Snow

Sample	Temperature (°C)	Snow Depth (mm)
1		❑ Zero Trace ❑ (<10 mm) ❑ Measurable ❑ (>10 mm) ______ mm
2		❑ Zero Trace ❑ (<10 mm) ❑ Measurable ❑ (>10 mm) ______ mm
3		❑ Zero Trace ❑ (<10 mm) ❑ Measurable ❑ (>10 mm) ______ mm
4		❑ Zero Trace ❑ (<10 mm) ❑ Measurable ❑ (>10 mm) ______ mm

Sky conditions (check one):

❑ **Clear** *(no clouds visible)*

❑ **Clouds visible** *(1% to 100% covered by clouds or contrails)*

❑ **Obscured** *(More than 25% of the sky is not visible)*

Sketch the sky below:

Comments:

____

____

____

____

____

____

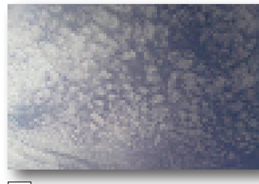
____

Study Site: ______________________ *Date:* _____________ *Time (UT):*______________________

If clouds are visible select all cloud types seen:

High (in the sky):
(Check all types seen)

❑ Cirrus

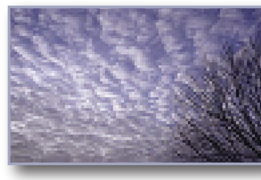


❑ Cirrocumulus

❑ Cirrostratus

Middle (of the sky):
(Check all types seen)

❑ Altostratus



❑ Altocumulus

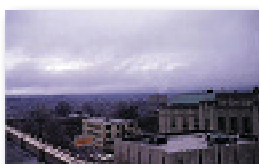
Low (in the sky):
(Check all types seen)

❑ Stratus

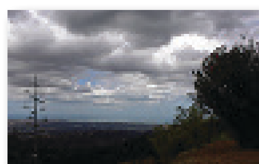
❑ Stratocumulus

❑ Cumulus

Rain or snow producing clouds:
(Check all types seen)



❑ Nimbostratus

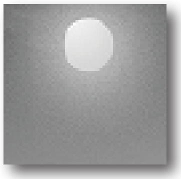


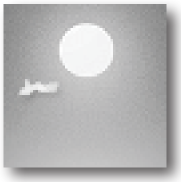
❑ Cumulonimbus

GLOBE Atmosphere Investigations

Study Site: ____________________ *Date:* ____________ *Time (UT):*____________________

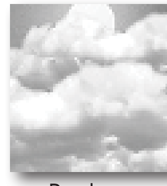
What percent of the sky is covered by clouds? (Check one): Three-quarters or More of the Sky is Visible: Cloud Cover (Check one)


No Clouds
❑ 0%


Clear
❑>0 to 10%


Isolated
❑10 to 25%


Scattered
❑25 to 50%


Broken
❑50 to 90%

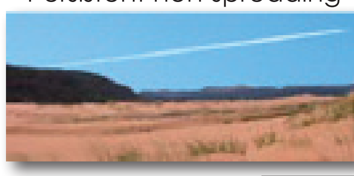

Overcast
❑ >90%

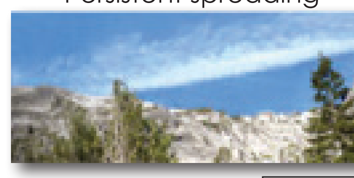
Are there contrails in the sky? (Check one): ❑ **No contrails** ❑ **Contrails are visible**

If contrails are visible, record the number of each type seen:

Short-lived

Number observed ☐

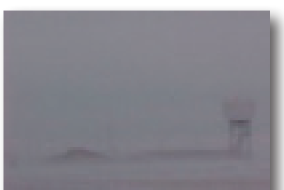
Persistent non-spreading

Number observed ☐

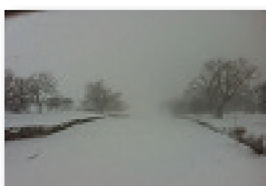
Persistent spreading

Number observed ☐

What percent of the sky is covered by contrails? (Check one):

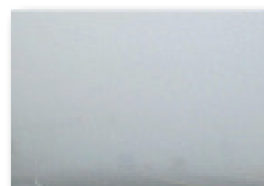
❑0 to 10% ❑10 to 25% ❑25 to 50% ❑>50%

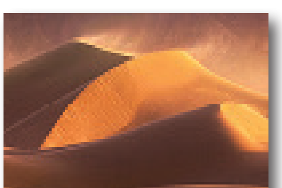
If you selected "obscured" (>25% of the sky is not visible) (check all that apply):

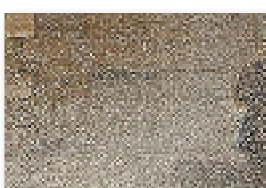

❑ Blowing snow

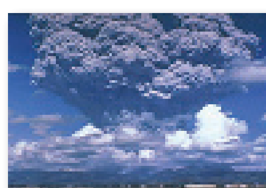

❑ Heavy snow

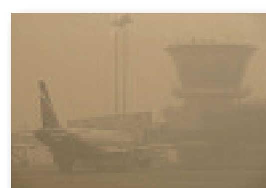

❑ Heavy rain


❑ Fog

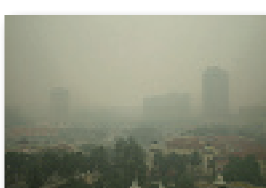

❑ Sand


❑ Spray


❑ Volcanic ash


❑ Smoke


❑ Dust


❑ Haze

Comments:

____

____

____

Week Four Science Journal Reflections

What have you learned?

What would you like to know more about?

Week Five—Pose Research Question, Develop a Hypothesis and Identify the Data

Step 14: What Does a NASA Science Research Question Look Like?

As you can see from the previous activities, scientists asking questions and finding answers is extremely important to all of us. All factors of our daily lives are affected by the answers that NASA scientists are seeking. Everything we know about Earth and the world around us has been a result of someone, somewhere, asking a question and setting out to find an answer. It is natural human curiosity that has often resulted in the most important discoveries.

So what makes a "GOOD" science research question?

A good research question is a question that is worth answering. It poses a problem that can be answered through scientific investigation or the examination of data that has been collected. Simple yes or no questions may have important practical significance, but they do not make good research questions. A good science research question requires more than looking something up in a book or on the Internet. The answer does not simply depend on one or two missing facts. A good research question should force you to evaluate evidence and compare different possible answers.

Use the Research Question Characteristics Rubric below to identify which of the following questions are "GOOD" science research questions.

1. **Is there a relationship between today's clouds and tomorrow's weather?**
2. **How reliable is a prediction of tomorrow's weather based on today's cloud observations?**

Research Question Characteristics	Points (0 or 1)
The answer is not immediately obvious	
There could be more than one answer - the answer is not just yes or no	
Encourages a new or different view of phenomena	
Narrow in focus so that the necessary research can be done	
Clear enough for other people to understand	
Tests an accepted explanation	
Goes beyond existing explanations	
Possible to answer in the time available to you	
Possible to answer with measurement equipment and techniques available to you	
Any data required from others is available or can be obtained through collaboration	
Will sustain your interest for the time required to complete the research	
Tests your assumptions about the phenomena	
Completes or adapts an existing explanation	
Total Points	

Step 15: The Science Research Process In Action

The NASA big question: ***How do clouds affect the Earth's energy budget?***

Your science research question: How do clouds affect the surface temperature? OR ***What is the relationship between cloud cover and surface temperature in the area around your school?***

Reflect back on what you have learned through your investigations and respond to the following question.

What have you learned about the relationship between clouds and Earth's surface temperature?

Developing a Hypothesis: Science is about finding answers to our questions about the world around us. Part of finding the answer is to test a hypothesis. A hypothesis is a tentative statement that proposes a possible explanation to some phenomenon, event, or scientific problem that can be tested by further investigation. A useful hypothesis is a testable, measurable statement. Following the other steps in the scientific process helps us test to see if our hypothesis was correct or not. Over the next couple of weeks you will be compiling and analyzing the data that you have collected to find the answer to your science research question. What do you think will be the answer to your research question? That is your hypothesis.

Hypothesis:

Now that you have your hypothesis you need to assemble your data to be analyzed. Over the past several weeks you have been recording your GLOBE data, now it is time to put it all together so that you can begin to look for patterns and any cause-effect relationships that might exist. In the next activity, *Looking at Your GLOBE Data,* you will practice looking at data, graphic data and analyzing data.

Step 16: Looking at Your GLOBE Data Learning Activity

Part 1: Sketch, label, and describe the four surface areas that you have gathered data for during your investigation.

Location #1:

Location #2:

Location #3:

Location #4:

Describe how the four locations are similar.

Describe how the four locations are different.

Part 2: Copy the surface temperature data that you have collected over the past two weeks in the data chart below.

Surface Temperature/Sky Conditions Data

Sample Site	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Average
1											
2											
3											
4											
Sky Condition											N/A

Part 3: Describe how your predictions of the surface temperatures of these two locations compared with the observations and measurements that you collected.

Use the data chart to answer the following questions related to your data:

1. **Which location had the highest average surface temperature?**

____

2. **What is the explanation for why that location had the highest average surface temperature?**

____

____

____

3. **Do you think the average surface temperature for the four locations you selected would be different during a different season? ____________________ Why or why not?**

____

____

____

____

Step 17: Surface Temperature Measurement and Cloud Observation Data Sheet

School Name: ______________________________ *Study Site:* ____________________

Observer Names: ____

Date: Year __________ *Month* ____________ *Day* __________ *Universal Time (hour:min):* __________

Surface Temperature:

Site's overall surface condition (Check one): ❑ Wet ❑ Dry ❑ Snow

Sample	Temperature (°C)	Snow Depth (mm)
1		❑ Zero Trace ❑ (<10 mm) ❑ Measurable ❑ (>10 mm) ______ mm
2		❑ Zero Trace ❑ (<10 mm) ❑ Measurable ❑ (>10 mm) ______ mm
3		❑ Zero Trace ❑ (<10 mm) ❑ Measurable ❑ (>10 mm) ______ mm
4		❑ Zero Trace ❑ (<10 mm) ❑ Measurable ❑ (>10 mm) ______ mm

Sky conditions (check one):

❑ **Clear** *(no clouds visible)*

❑ **Clouds visible** *(1% to 100% covered by clouds or contrails)*

❑ **Obscured** *(More than 25% of the sky is not visible)*

Sketch the sky below:

Comments:

____

____

____

____

____

____

____

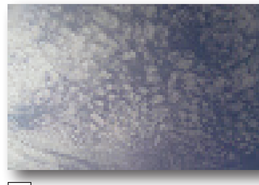
GLOBE Atmosphere Investigations

Study Site: ______________________________ *Date:* __________________ *Time (UT):*_______________________________

If clouds are visible select all cloud types seen:

High (in the sky):
(Check all types seen)

❑ Cirrus

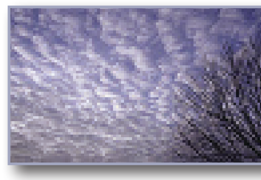


❑ Cirrocumulus

❑ Cirrostratus

Middle (of the sky):
(Check all types seen)

❑ Altostratus



❑ Altocumulus

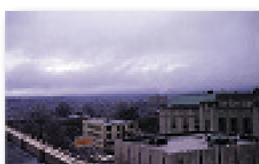
Low (in the sky):
(Check all types seen)

❑ Stratus

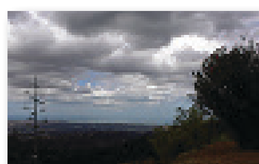
❑ Stratocumulus

❑ Cumulus

Rain or snow producing clouds:
(Check all types seen)



❑ Nimbostratus



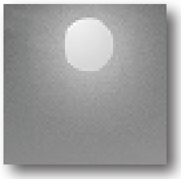
❑ Cumulonimbus

GLOBE Atmosphere Investigations

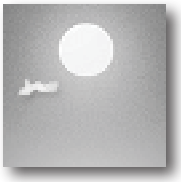
Week Five

Study Site: ____________________________ *Date:* __________________ *Time (UT):*_____________________________

What percent of the sky is covered by clouds? (Check one): Three-quarters or More of the Sky is Visible: Cloud Cover (Check one)



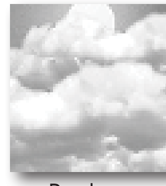
No Clouds
❑ 0%



Clear
❑ >0 to 10%

Isolated
❑ 10 to 25%

Scattered
❑ 25 to 50%



Broken
❑ 50 to 90%

Overcast
❑ >90%

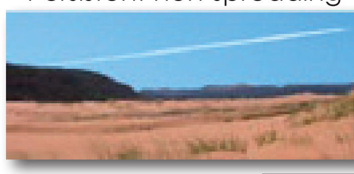
Are there contrails in the sky? (Check one): ❑ **No contrails** ❑ **Contrails are visible**

If contrails are visible, record the number of each type seen:

Short-lived

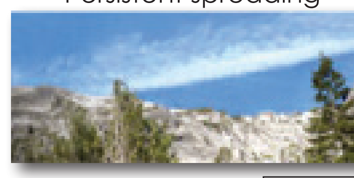
Number observed ☐

Persistent non-spreading



Number observed ☐

Persistent spreading

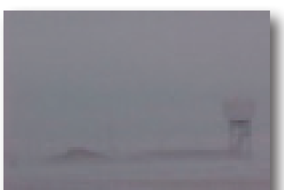


Number observed ☐

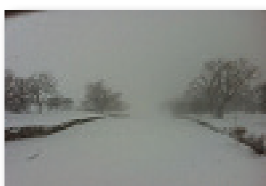
What percent of the sky is covered by contrails? (Check one):

❑ 0 to 10% ❑ 10 to 25% ❑ 25 to 50% ❑ >50%

If you selected "obscured" (>25% of the sky is not visible) (check all that apply):

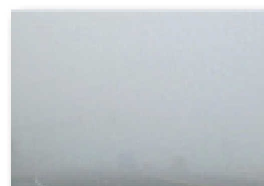


❑ Blowing snow

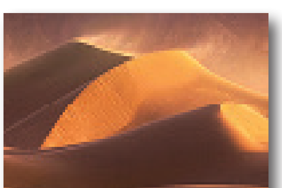


❑ Heavy snow

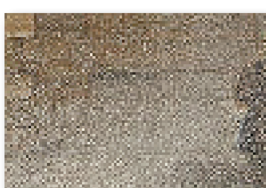
❑ Heavy rain



❑ Fog



❑ Sand

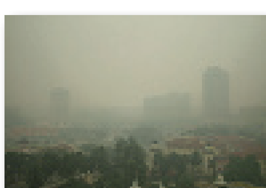


❑ Spray

❑ Volcanic ash

❑ Smoke

❑ Dust



❑ Haze

Comments:

____

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Week Five Science Journal Reflections

What have you learned?

What would you like to know more about?

Week Six—Planning the Investigation and Identify the Data

Step 18: Part 4: Graphing Your Data (Continue from Step 16)

Select the two locations from your data chart in **Part 2** that have the highest and lowest average surface temperatures and graph them on the grid below. You will use different colors to represent the different locations (purple for the highest surface temperature and green for the lowest surface temperature). Remember to provide appropriate labels/scales and a title for your graph. You should plot the ten days across the X-axis (horizontal) and the temperature in °C on the Y-axis (vertical).

Part 5: Use a blue colored pencil to circle the points on the graph for days with clear skies, an orange colored pencil to circle points on the graph for days with clouds visible and a red colored pencil to circle points on the graph for days with obscured skies. Based on the data does there appear to be a pattern/relationship between the surface temperature and clouds in the sky? ________________________________

Explain:

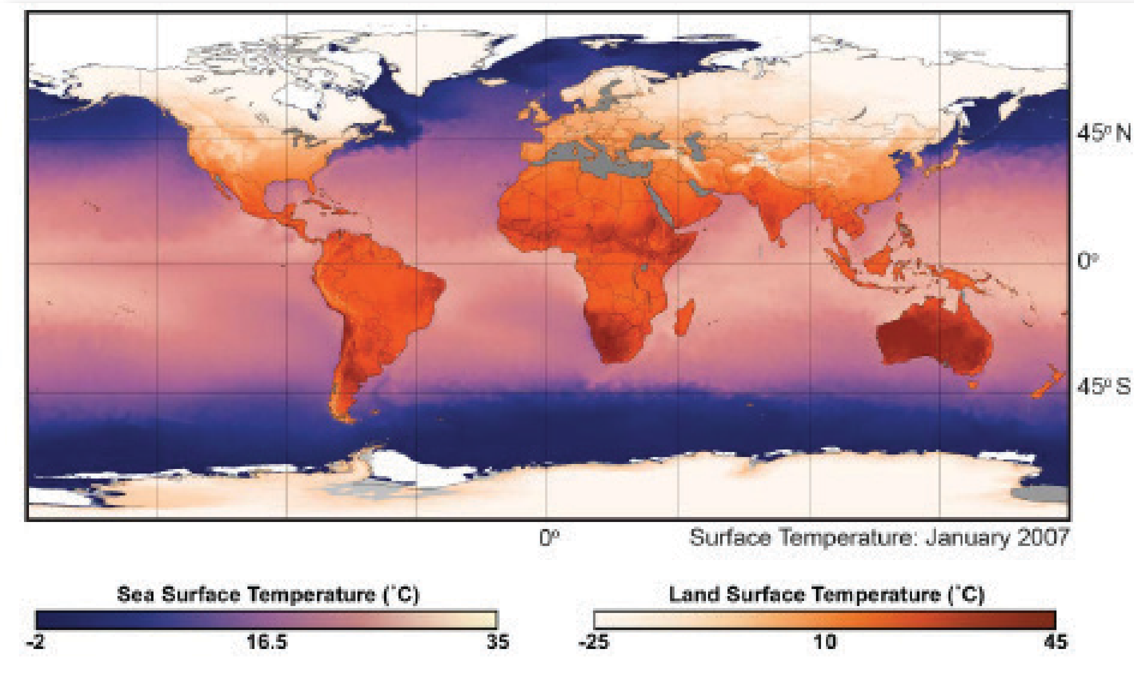
____

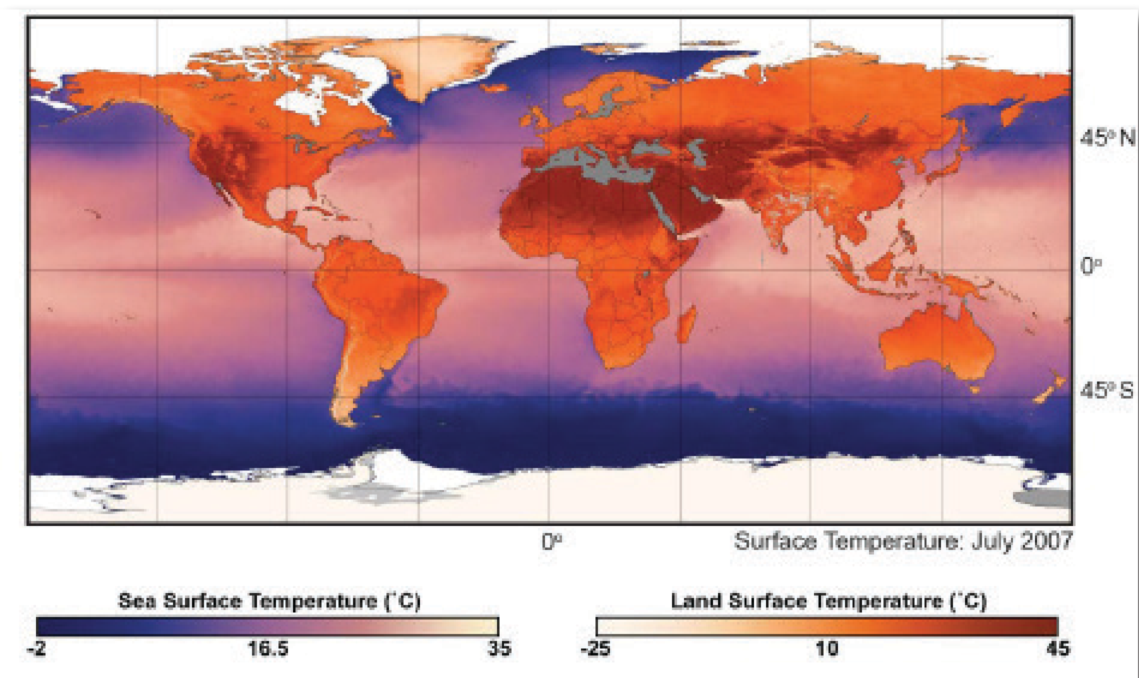
____

____

Part 6: Looking at GLOBE data

Work with a partner to examine the satellite images below to view surface temperature at a global scale. Pick a particular location in the first image and compare that to the surface temperature of the same point in the second image. Do this for three different locations and record your observations on the next page.





Estimated Latitude/Longitude of the Locations Selected:

Location #1: ______________________________

Northern or Southern Hemisphere: ______________________________

Location #2: ______________________________

Northern or Southern Hemisphere: ______________________________

Location #3: ______________________________

Northern or Southern Hemisphere: ______________________________

What similarities and or differences did you observe between the three locations that you selected on the two images for the months of January and July?

Similarities:

____

____

____

Differences:

____

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____

On the next page you will observe two satellite images that show cloud fraction (the fraction of sky hidden by visible clouds) for the months of January and July in 2007. Compare the images of cloud fraction with the images of surface temperature for these same two months. Examine the same three locations that you selected previously and see how the percentage of cloud cover compares to the surface temperature.

Describe what you observe:

Location #1: ______________________________

____

Location #2: ______________________________

____

Location #3: ______________________________

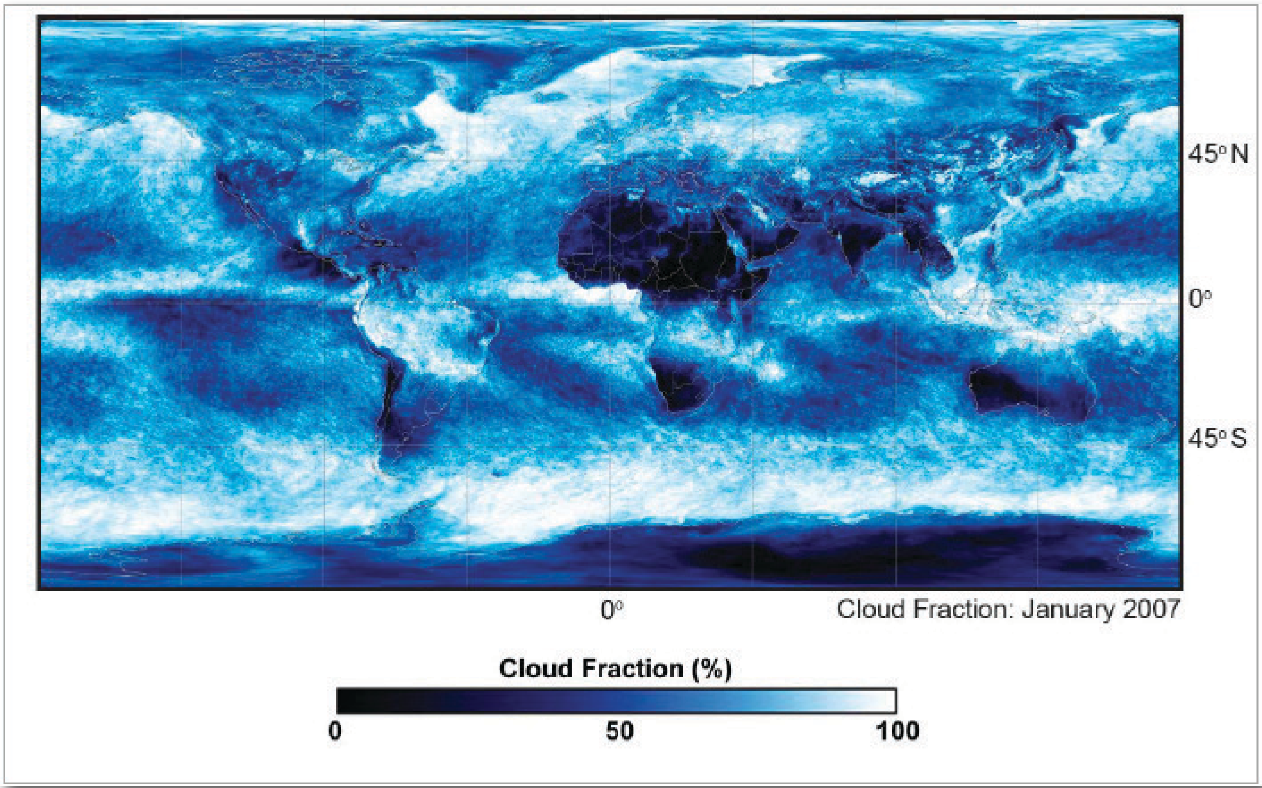
____

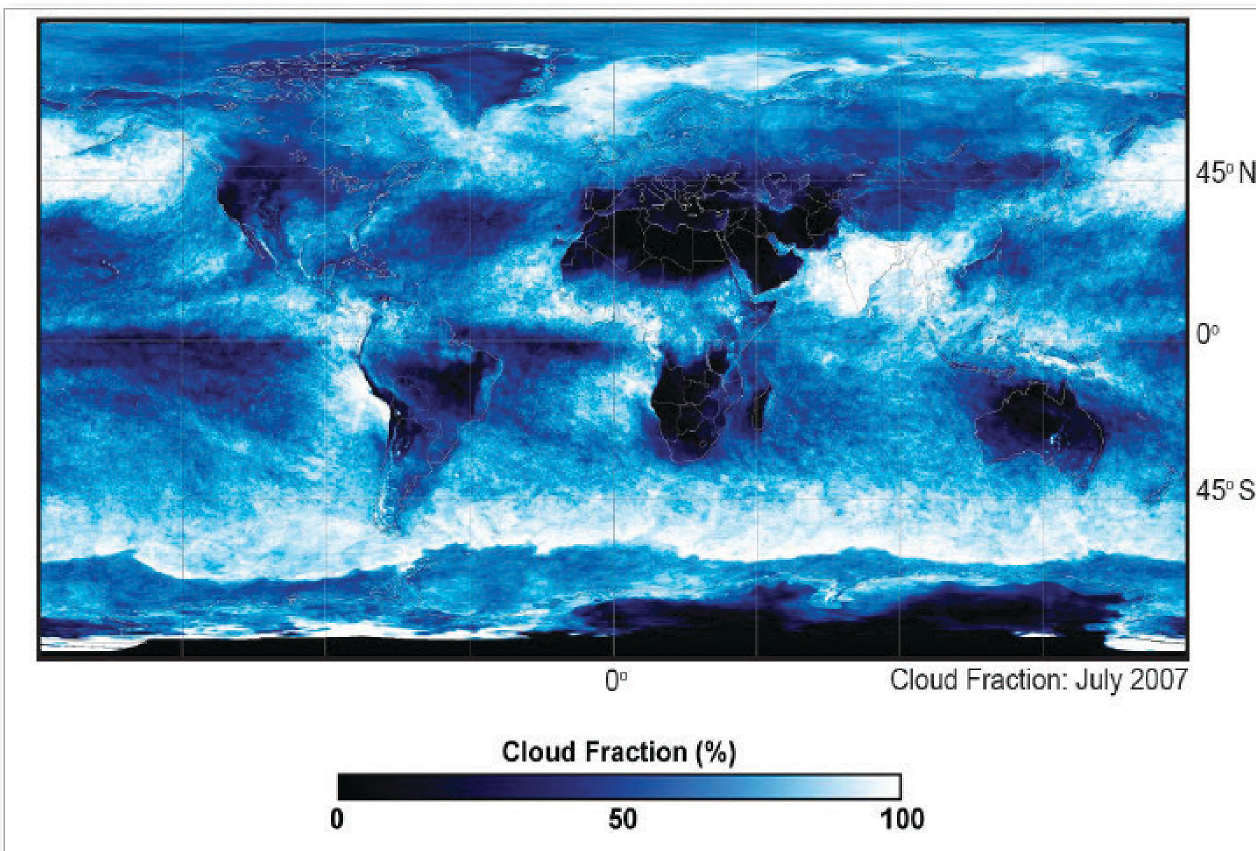
Does there appear to be a relationship between the surface temperature and the cloud fraction for the months of January and July, 2007? Why or why not?

____

____

____


45° N
0°
45° S
0°
Cloud Fraction: January 2007
Cloud Fraction (%)
0
50
100


45° N
0°
45° S
0°
Cloud Fraction: July 2007
Cloud Fraction (%)
0
50
100

Step 19: Selecting Your Culminating Project

Choice 1: Science Project Poster

With a partner or a small group:

- Identify the research question
- Develop a title for your project
- Use steps of the science research process to guide the components of your poster
- Identify visuals and the data you will include on the poster
- Draft content to be included on the poster
- Present the draft to your instructor
- Make necessary edits to the draft
- Create graphic components
- Write a conclusion from analysis of the data
- Show a rough draft of the poster to the instructor for feedback
- Construct the poster
- Present the final poster to peers for a critique
- Optional: present final poster at Culminating Project Community Night

Choice 2: Public Service Announcement

With a partner or in a small group:

- Identify the research question
- Develop a Public Service Announcement (PSA) message
- Identify visuals and sounds to use in the PSA
- Draft a storyboard and script
- Present the PSA draft to the instructor for review
- Make necessary edits to the draft
- Film and edit the PSA
- Show a rough cut to teacher for feedback
- Present final PSA to peers for a critique
- Optional: present final PSA at Culminating Project Community Night

Choice 3: PowerPoint

With a partner or a small group:

- Identify the research question
- Use steps of the science research process to guide the components of your PowerPoint
- Develop an outline for the PowerPoint
- Identify images and data to be included
- Draft content to accompany images
- Present the PowerPoint draft to the instructor
- Make necessary edits to the draft
- Show the edited PowerPoint to the instructor for feedback
- Present the final PowerPoint to peers
- Optional: present the final PowerPoint at Culminating Project Community Night.

Step 20: Following the Steps of the Scientific Research Process

Atmospheric GLOBE Investigation Culminating Project

As you work to complete your culminating project complete the following:

Scientific Research Question: ______________________________

____

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____

Hypothesis: ______________________________

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Summarize the steps of your investigation (*what did you do to find the answer to your question?*):

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Step 21: Surface Temperature Measurement and Cloud Observation Data Sheet

School Name: ______________________________*Study Site:*__________________

Observer Names: ____

Date: Year _________ *Month* ___________ *Day* __________*Universal Time (hour:min):*__________

Surface Temperature:

Site's overall surface condition (Check one): ❑ Wet ❑ Dry ❑ Snow

Sample	Temperature (°C)	Snow Depth (mm)
1		❑ Zero Trace ❑ (<10 mm) ❑ Measurable ❑ (>10 mm) ______ mm
2		❑ Zero Trace ❑ (<10 mm) ❑ Measurable ❑ (>10 mm) ______ mm
3		❑ Zero Trace ❑ (<10 mm) ❑ Measurable ❑ (>10 mm) ______ mm
4		❑ Zero Trace ❑ (<10 mm) ❑ Measurable ❑ (>10 mm) ______ mm

Sky conditions (check one):

❑ **Clear** *(no clouds visible)*

❑ **Clouds visible** *(1% to 100% covered by clouds or contrails)*

❑ **Obscured** *(More than 25% of the sky is not visible)*

Sketch the sky below:

Comments:

____

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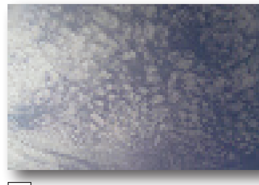
GLOBE Atmosphere Investigations

Study Site: ______________________ *Date:* _____________ *Time (UT):*______________________

If clouds are visible select all cloud types seen:

High (in the sky):
(Check all types seen)

❑ Cirrus

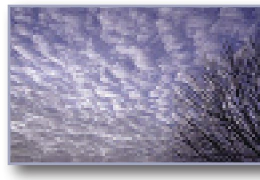


❑ Cirrocumulus

❑ Cirrostratus

Middle (of the sky):
(Check all types seen)

❑ Altostratus



❑ Altocumulus

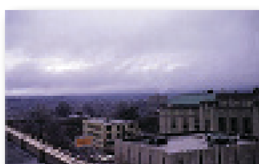
Low (in the sky):
(Check all types seen)

❑ Stratus

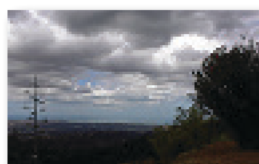
❑ Stratocumulus

❑ Cumulus

Rain or snow producing clouds:
(Check all types seen)



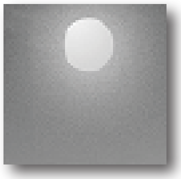
❑ Nimbostratus

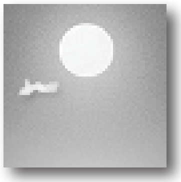


❑ Cumulonimbus

Study Site: ________________________ *Date:* _______________ *Time (UT):*_________________________

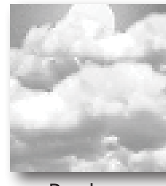
What percent of the sky is covered by clouds? (Check one): Three-quarters or More of the Sky is Visible: Cloud Cover (Check one)


No Clouds
❑ 0%


Clear
❑>0 to 10%


Isolated
❑10 to 25%


Scattered
❑25 to 50%


Broken
❑50 to 90%

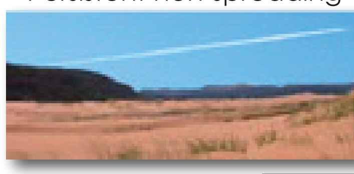

Overcast
❑ >90%

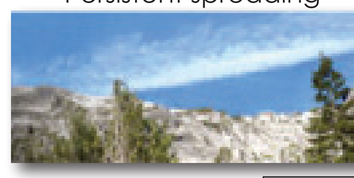
Are there contrails in the sky? (Check one): ❑ **No contrails** ❑ **Contrails are visible**

If contrails are visible, record the number of each type seen:

Short-lived

Number observed ☐

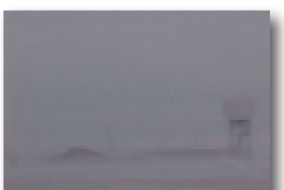
Persistent non-spreading

Number observed ☐

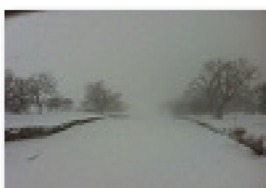
Persistent spreading

Number observed ☐

What percent of the sky is covered by contrails? (Check one):

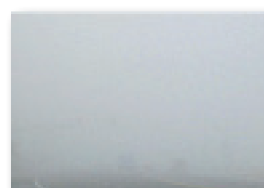
❑ 0 to 10% ❑ 10 to 25% ❑ 25 to 50% ❑ >50%

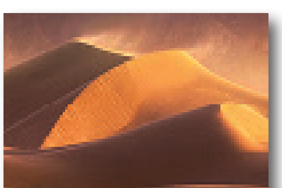
If you selected "obscured" (>25% of the sky is not visible) (check all that apply):

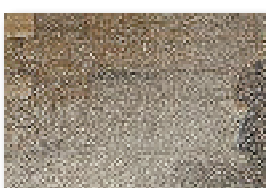

❑ Blowing snow

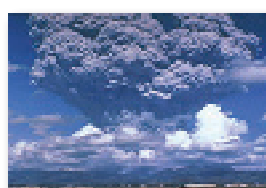

❑ Heavy snow


❑ Heavy rain


❑ Fog

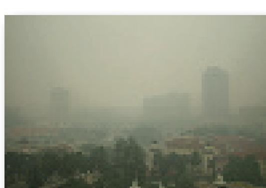

❑ Sand


❑ Spray


❑ Volcanic ash


❑ Smoke


❑ Dust


❑ Haze

Comments:

____

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____

Week Six Science Journal Reflections

What have you learned?

What would you like to know more about?

Week Seven—Assemble and Analyze the Data, Document, and Conclusion

Step 22: Assemble Your Data

(Continuing the development of your science research project)

Describe the data you will use to show the results of your investigation:

____

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____

Components to consider for your graph: *(Depending on the data you have selected to use for your project, consider the following components and fill in the information that you will use to complete your graph.)*

Title:____

What variable will you plot on the X-Axis? ____

____

Range of numbers needed:____

____

Scale:____

Units of measurement: ____

Use the grid below to create a rough draft of the graph of your data:

Step 23: Analyze Your Data

In conclusion: As you develop your conclusion refer back to your hypothesis as it relates to your research question and state whether or not it was supported by your data. You should also include any new questions that you might have as a result of your findings.

Questions for further research:

Step 24: Surface Temperature Measurement and Cloud Observation Data Sheet

School Name: ____*Study Site:*____________________________

Observer Names: ____

Date: Year __________ *Month* ______________ *Day* ____________*Universal Time (hour:min):*_____________

Surface Temperature:

Site's overall surface condition (Check one): ❑ Wet ❑ Dry ❑ Snow

Sample	Temperature (°C)	Snow Depth (mm)
1		❑ Zero Trace ❑ (<10 mm) ❑ Measurable ❑ (>10 mm) _______ mm
2		❑ Zero Trace ❑ (<10 mm) ❑ Measurable ❑ (>10 mm) _______ mm
3		❑ Zero Trace ❑ (<10 mm) ❑ Measurable ❑ (>10 mm) _______ mm
4		❑ Zero Trace ❑ (<10 mm) ❑ Measurable ❑ (>10 mm) _______ mm

Sky conditions (check one):

❑ **Clear** *(no clouds visible)*

❑ **Clouds visible** *(1% to 100% covered by clouds or contrails)*

❑ **Obscured** *(More than 25% of the sky is not visible)*

Sketch the sky below:

Comments:

____

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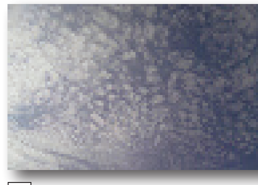
GLOBE Atmosphere Investigations

Study Site: ______________________ *Date:* ____________ *Time (UT):*______________________

If clouds are visible select all cloud types seen:

High (in the sky):
(Check all types seen)

☐ Cirrus

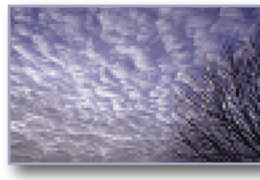


☐ Cirrocumulus

☐ Cirrostratus

Middle (of the sky):
(Check all types seen)

☐ Altostratus



☐ Altocumulus

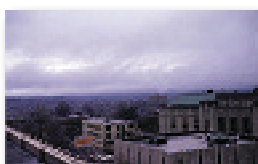
Low (in the sky):
(Check all types seen)

☐ Stratus

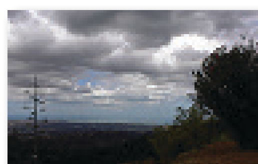
☐ Stratocumulus

☐ Cumulus

Rain or snow producing clouds:
(Check all types seen)



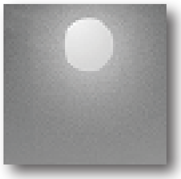
☐ Nimbostratus

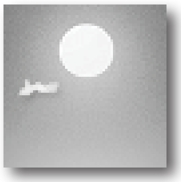


☐ Cumulonimbus

Study Site: ____________________ *Date:* ____________ *Time (UT):*____________________

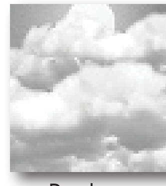
What percent of the sky is covered by clouds? (Check one): Three-quarters or More of the Sky is Visible: Cloud Cover (Check one)


No Clouds
❑ 0%


Clear
❑>0 to 10%


Isolated
❑10 to 25%


Scattered
❑25 to 50%


Broken
❑50 to 90%

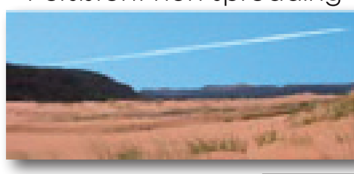

Overcast
❑ >90%

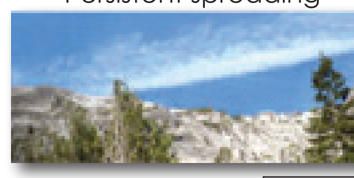
Are there contrails in the sky? (Check one): ❑ **No contrails** ❑ **Contrails are visible**

If contrails are visible, record the number of each type seen:

Short-lived

Number observed ☐

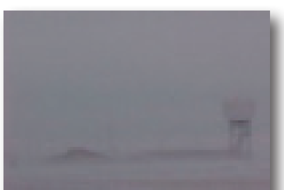
Persistent non-spreading

Number observed ☐

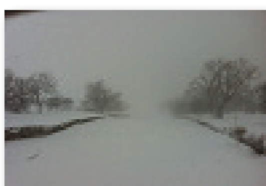
Persistent spreading

Number observed ☐

What percent of the sky is covered by contrails? (Check one):

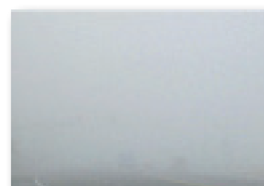
❑ 0 to 10% ❑ 10 to 25% ❑ 25 to 50% ❑ >50%

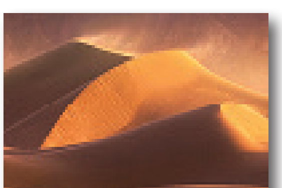
If you selected "obscured" (>25% of the sky is not visible) (check all that apply):

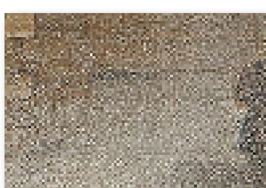

❑ Blowing snow


❑ Heavy snow


❑ Heavy rain


❑ Fog

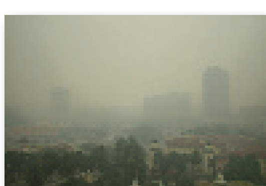

❑ Sand


❑ Spray


❑ Volcanic ash


❑ Smoke


❑ Dust


❑ Haze

Comments:

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Week Seven Science Journal Reflections

What have you learned?

What would you like to know more about?

Week Eight—Present Findings and Pose New Questions

Step 25: Surface Temperature Measurement and Cloud Observation Data Sheet

School Name: ______________________________ *Study Site:* ________________

Observer Names: ____

Date: Year ________ *Month* __________ *Day* _________ *Universal Time (hour:min):* __________

Surface Temperature:

Site's overall surface condition (Check one): ❑ Wet ❑ Dry ❑ Snow

Sample	Temperature (°C)	Snow Depth (mm)
1		❑ Zero Trace ❑ (<10 mm) ❑ Measurable ❑ (>10 mm) ______ mm
2		❑ Zero Trace ❑ (<10 mm) ❑ Measurable ❑ (>10 mm) ______ mm
3		❑ Zero Trace ❑ (<10 mm) ❑ Measurable ❑ (>10 mm) ______ mm
4		❑ Zero Trace ❑ (<10 mm) ❑ Measurable ❑ (>10 mm) ______ mm

Sky conditions (check one):

❑ **Clear** *(no clouds visible)*

❑ **Clouds visible** *(1% to 100% covered by clouds or contrails)*

❑ **Obscured** *(More than 25% of the sky is not visible)*

Sketch the sky below:

Comments:

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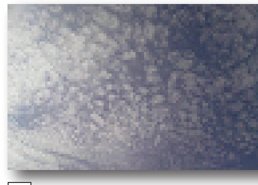
Study Site: ______________________ *Date:* ____________ *Time (UT):*______________________

If clouds are visible select all cloud types seen:

High (in the sky):
(Check all types seen)

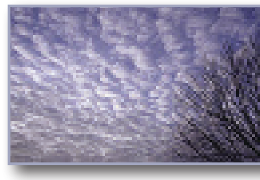

❑ Cirrus


❑ Cirrocumulus


❑ Cirrostratus

Middle (of the sky):
(Check all types seen)


❑ Altostratus


❑ Altocumulus

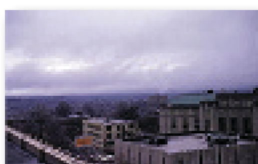
Low (in the sky):
(Check all types seen)

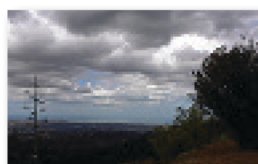

❑ Stratus


❑ Stratocumulus


❑ Cumulus

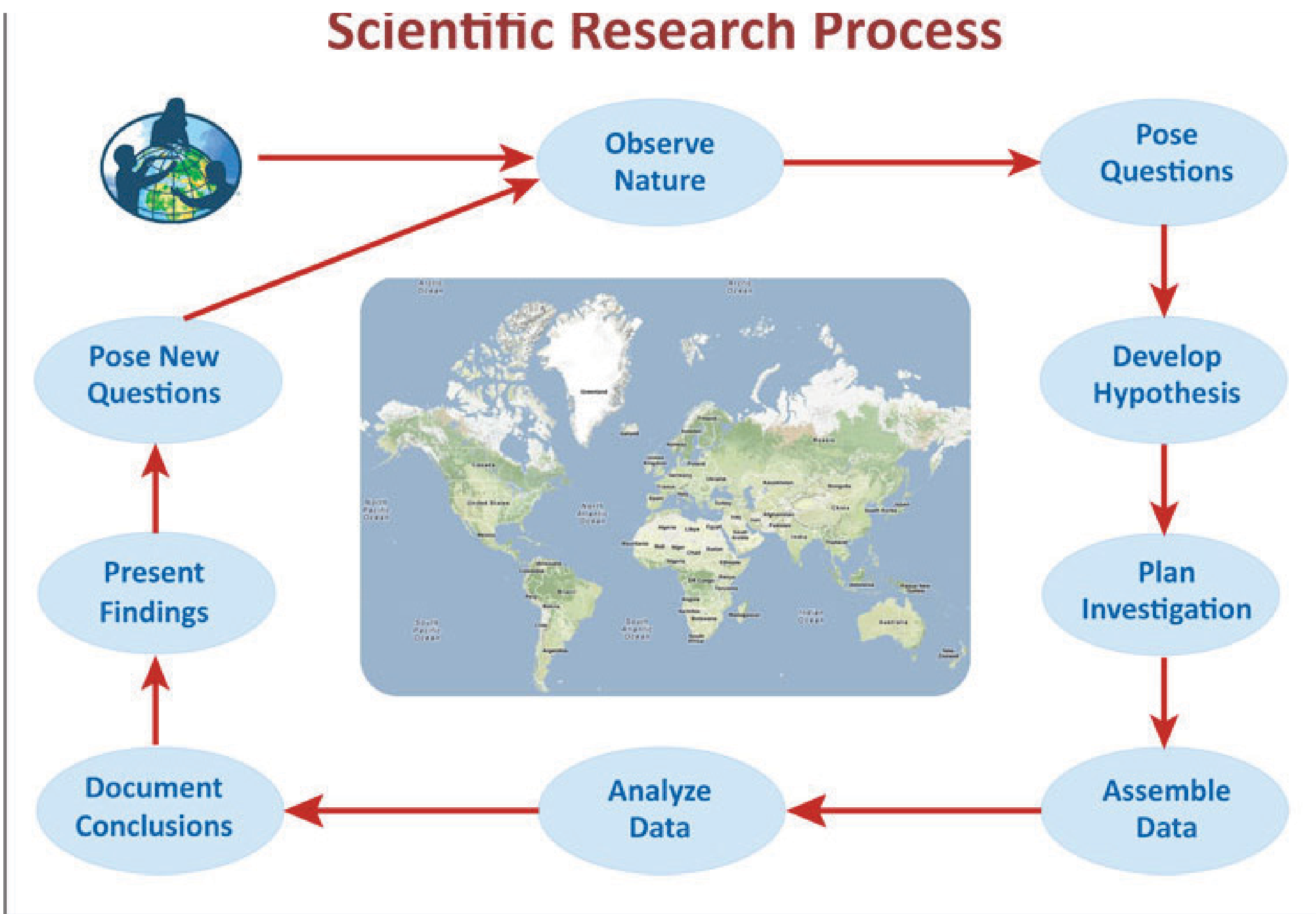
Rain or snow producing clouds:
(Check all types seen)


❑ Nimbostratus


❑ Cumulonimbus

Step 26: Finalizing the Culminating Project

Putting the final touches on your culminating project is very important. You want to make sure that it provides the audience with a clear visualization of your investigation and the data that you collected. As you finalize your project refer back to the Science Research Process as a guide and use the Culminating Project Rubric to ensure that you include all of the key components.



GLOBE Atmosphere Investigation Culminating Project Rubric

Category	Exemplary 5 points	Proficient 3 points	Novice 1 point	Not Included 0 points
Research Question	Clearly stated a research question that could be answered using data collected during the process of the atmosphere investigation.	Provided a research question from the atmosphere investigation that related to the data that was collected.	Referred to a question that was not necessarily answerable with the data that was collected.	Did not provide a research question for the investigation.
Hypothesis Developed	Fully developed the hypothesis proposing a possible explanation of the research question in a format that is testable and measurable.	Provided a hypothesis as a possible explanation of the research question that was not clearly testable or measurable.	Developed a hypothesis that did not provide an explanation of a possible answer for the research question and was not testable or measurable.	Did not provide a hypothesis for the atmosphere investigation.
Detailed Procedure	Clearly summarized and detailed the steps of the investigation process providing enough detail that the atmosphere investigation could be replicated.	Provided steps for the investigation that could be followed but would not allow for accurate replication of the atmosphere investigation.	Steps given were unclear and contained gaps that would not allow for the atmosphere investigation to be replicated.	Did not provide a procedure for the atmosphere investigation.
Data Assembled	Data was selected and assembled in a graphical visualization that could be used as evidence to answer the research question.	Data was selected that could be used to provide an answer to the research question, but was not provided in a graphical format.	Data was selected but could not be used to provide an answer to the research question.	Did not assemble data from the atmosphere investigation.
Data Analyzed	Data was analyzed as evidence to support a clear explanation/ argument of the answer to the research question.	Data was analyzed providing an answer to the research question that was not clearly evident from the data.	Data was examined but was not related to the research question as a possible explanation.	Did not analyze data from the atmosphere investigation.
Conclusion Summarized	Results of the atmosphere investigation were summarized with supporting evidence from data collected during the investigation as it related to the hypothesis and new questions were provided for further investigation.	Results of the investigation were summarized with supporting evidence from the data that was collected during the investigation but no reference to the hypothesis was given and questions for further investigation were not provided.	Results of the investigation were summarized but not supported by evidence from the data collected during the investigation, no reference to the hypothesis was given and questions for further investigation were not provided.	Did not provide a conclusion for the atmosphere investigation.

Step 27: Present Culminating Project

You will have the opportunity to present your project to your peers and possibly to other members of your community. Below you will see a list of items to remember when making a presentation.

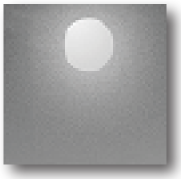
Points to Remember When Presenting:

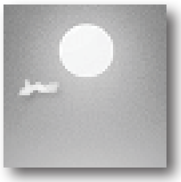
- Make eye contact
- Speak clearly
- Smile
- Discuss your project rather than read it
- Identify your main points
- Refer to your graph for visualization
- Have your science research journal available
- Feel proud of what you have accomplished

You might also consider sharing your project with members of the GLOBE Community through submission to the Virtual Science Symposia. (http://www.globe.gov/news-events/globe-events/virtual-conferences)

Study Site: ____________________ *Date:* ____________ *Time (UT):*____________________

What percent of the sky is covered by clouds? (Check one): Three-quarters or More of the Sky is Visible: Cloud Cover (Check one)


No Clouds
❑ 0%


Clear
❑>0 to 10%


Isolated
❑10 to 25%


Scattered
❑25 to 50%


Broken
❑50 to 90%

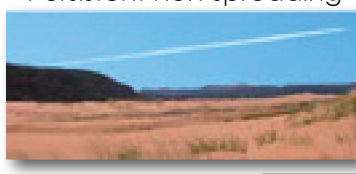

Overcast
❑ >90%

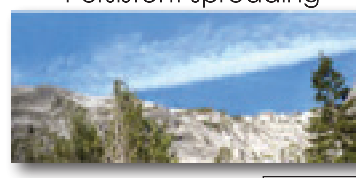
Are there contrails in the sky? (Check one): ❑ **No contrails** ❑ **Contrails are visible**

If contrails are visible, record the number of each type seen:

Short-lived

Number observed ☐

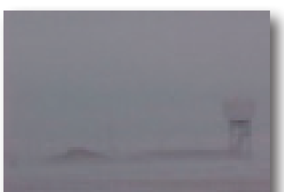
Persistent non-spreading

Number observed ☐

Persistent spreading

Number observed ☐

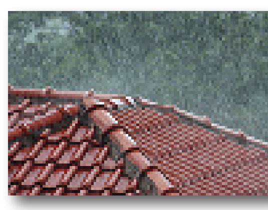
What percent of the sky is covered by contrails? (Check one):

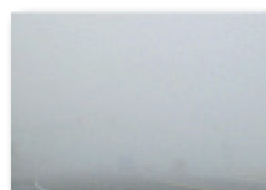
❑ 0 to 10% ❑ 10 to 25% ❑ 25 to 50% ❑ >50%

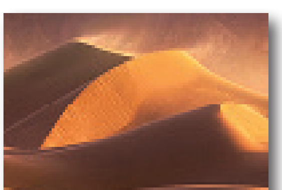
If you selected "obscured" (>25% of the sky is not visible) (check all that apply):

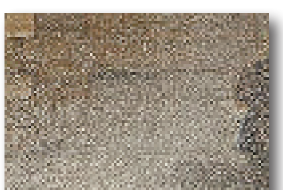

❑ Blowing snow


❑ Heavy snow

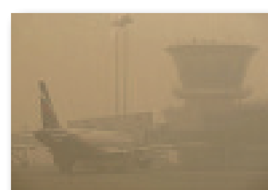

❑ Heavy rain


❑ Fog


❑ Sand


❑ Spray


❑ Volcanic ash


❑ Smoke


❑ Dust


❑ Haze

Comments:

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Surface Temperature Measurement and Cloud Observation Data Sheet

School Name: ______________________________ *Study Site:* ________________

Observer Names: ____

Date: Year _________ *Month* ___________ *Day* __________ *Universal Time (hour:min):* ___________

Surface Temperature:

Site's overall surface condition (Check one): ❑ Wet ❑ Dry ❑ Snow

Sample	Temperature (°C)	Snow Depth (mm)
1		❑ Zero Trace ❑ (<10 mm) ❑ Measurable ❑ (>10 mm) ______ mm
2		❑ Zero Trace ❑ (<10 mm) ❑ Measurable ❑ (>10 mm) ______ mm
3		❑ Zero Trace ❑ (<10 mm) ❑ Measurable ❑ (>10 mm) ______ mm
4		❑ Zero Trace ❑ (<10 mm) ❑ Measurable ❑ (>10 mm) ______ mm

Sky conditions (check one):

❑ **Clear** *(no clouds visible)*

❑ **Clouds visible** *(1% to 100% covered by clouds or contrails)*

❑ **Obscured** *(More than 25% of the sky is not visible)*

Sketch the sky below:

Comments:

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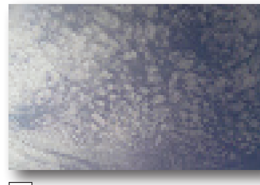
Study Site: ______________________ Date: ____________ Time (UT):______________________

If clouds are visible select all cloud types seen:

High (in the sky):
(Check all types seen)

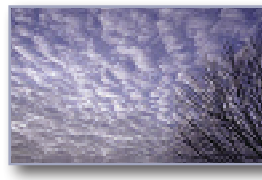

☐ Cirrus


☐ Cirrocumulus


☐ Cirrostratus

Middle (of the sky):
(Check all types seen)


☐ Altostratus


☐ Altocumulus

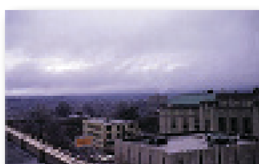
Low (in the sky):
(Check all types seen)

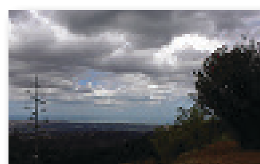

☐ Stratus


☐ Stratocumulus


☐ Cumulus

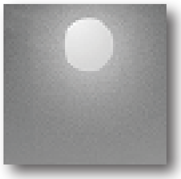
Rain or snow producing clouds:
(Check all types seen)

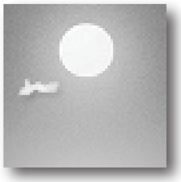

☐ Nimbostratus


☐ Cumulonimbus

Study Site: ______________________ *Date:* ______________ *Time (UT):*_______________________

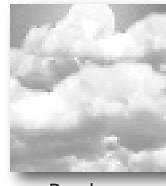
What percent of the sky is covered by clouds? (Check one): Three-quarters or More of the Sky is Visible: Cloud Cover (Check one)


No Clouds
❑ 0%


Clear
❑>0 to 10%


Isolated
❑10 to 25%


Scattered
❑25 to 50%


Broken
❑50 to 90%

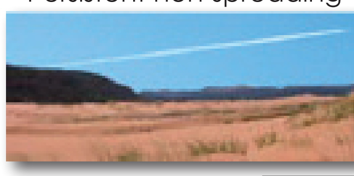

Overcast
❑ >90%

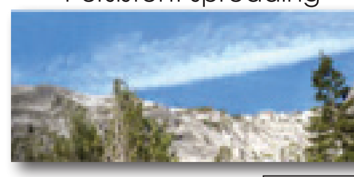
Are there contrails in the sky? (Check one): ❑ **No contrails** ❑ **Contrails are visible**

If contrails are visible, record the number of each type seen:

Short-lived

Number observed ☐

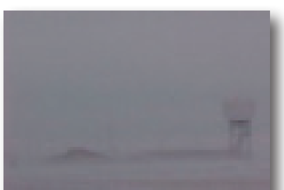
Persistent non-spreading

Number observed ☐

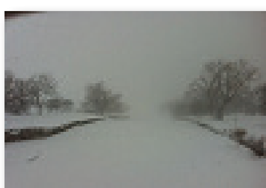
Persistent spreading

Number observed ☐

What percent of the sky is covered by contrails? (Check one):

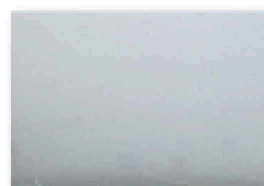
❑ 0 to 10% ❑ 10 to 25% ❑ 25 to 50% ❑ >50%

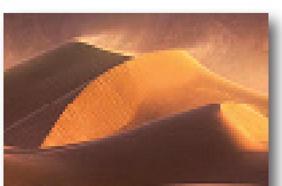
If you selected "obscured" (>25% of the sky is not visible) (check all that apply):

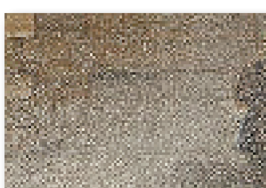

❑ Blowing snow

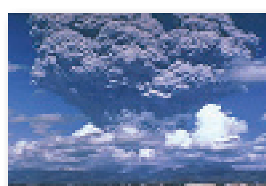

❑ Heavy snow


❑ Heavy rain


❑ Fog

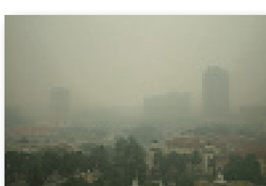

❑ Sand


❑ Spray


❑ Volcanic ash


❑ Smoke


❑ Dust


❑ Haze

Comments:

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Week Eight Science Journal Reflections

What have you learned?

What would you like to know more about?

National Aeronautics and Space Administration

Langley Research Center
1 NASA Drive
Hampton, Virginia 236665

www.nasa gov

NP-2016-08-831-LaRC