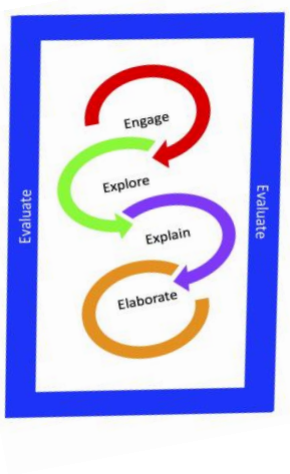
National Aeronautics and Space Administration

Educator Guide

Designing a Cloud Cover Estimator

NASA eClips™ Educator Guide - Our World: Designing a Cloud Cover Estimator allows students to think and act like engineers and scientists as they follow the five steps of the Design Process to successfully complete a team challenge. Within this work, students design, measure, build, test and re-design a cloud cover estimator. Once the design is built, students discuss ways to use this new tool.

NASA eClips Guides use the "Five E" constructivist model developed by Roger Bybee. Constructivism is an educational philosophy that promotes student-centered learning where students build their own understanding of new ideas. The 5E instructional model consists of five sequential stages for teaching and learning: Engage, Explore, Explain, Extend (or Elaborate), and Evaluate.



- The ENGAGE stage piques student interest and gets them personally involved in the lesson, while pre-assessing prior understanding.
- The EXPLORE stage gets students involved in the topic, providing them with the opportunity to build their own understanding.
- The EXPLAIN stage provides students with an opportunity to communicate what they have learned so far and understand what it means. This lesson introduces vocabulary in context and confronts misconceptions.
- The EXTEND stage allows students to use their new knowledge and continue to explore its implications.
- The EVALUATION stage is for both students and teachers to determine how much learning and understanding has taken place.

This NASA eClips™ Guides are designed to support existing curriculum.

The hyperlinks included in this document open PDFs or webpages and may perform differently based on the device being used. Links may have to be cut and pasted into a web browser to open. PDFs and other documents may need to be downloaded to view.

This document is based upon work supported by NASA under award No. NNX16AB91A. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Aeronautics and Space Administration (NASA).

Published January 2018

Designing a Cloud Cover Estimator

Grade Levels	Targeted Subjects	Teacher Preparation Time	Lesson Duration
3 – 5	Earth Science, Fractions, Engineering Design	30 minutes	Two 45-minute class meetings (adjust as needed)

National Standards

Science

Next Generation Science Standards (NGSS)

ESS2-4 - Earth's Systems

- Water changes its state as it moves through the multiple pathways of the hydrologic cycle.

ESS2.D: Weather and Climate

- Scientists record patterns of the weather across different times and areas so that they can make predictions about what kind of weather might happen next.

MS-ESS3-5

- Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.

Mathematics

Common Core

CCSS.MATH.CONTENT.5.MD.B.2 Represent and interpret data.
CCSS.MATH.CONTENT.4.MD.A.1 Solve problems involving measurement and conversion of measurements.

National Council of Teachers of Mathematics (NCTM)

Measurement

- Understand measurable attributes of objects and the units, systems, and processes of measurement
- Apply appropriate techniques, tools, and formulas to determine measurements**.**

Technology & Engineering

International Technology and Engineering Educator Association (ITEEA)

- Students will develop an understanding of the attributes of design.
- Students will develop an understanding of engineering design.
- Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.
- Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

Lesson Overview

Students think and act like engineers and scientists as they follow five steps of a Design Process to successfully complete a team challenge. Students view the NASA Spotlite Clouds video that corrects the misconception that: a cloud's only purpose is to produce precipitation. Within this work, students design, measure, build, test, and re-design a cloud cover estimator to measure the amount of cloud cover in the sky. Once the cloud cover estimator is built, students discuss the role clouds play in Earth's energy budget.

Instructional Objectives

Students will:

- Identify and describe the characteristics of the different types of clouds;
- Calculate the percent of cloud cover in the sky;
- Identify the role clouds play in Earth's energy budget; and
- Use an engineering design process to solve a problem.

Materials List

Per student

- Elementary Design Process Packet (https://nasaeclips.arc.nasa.gov/teachertoolbox/designpackets?r=elementary-design-packet)

Per team of 3-4

- cardboard cereal box
- construction paper
- string/yarn
- heavyweight clear plastic (vinyl or laminator film)
- markers/ crayons/ pencils
- tape or glue

Tools

- rulers
- scissors
- hole punch
- calculator

Background

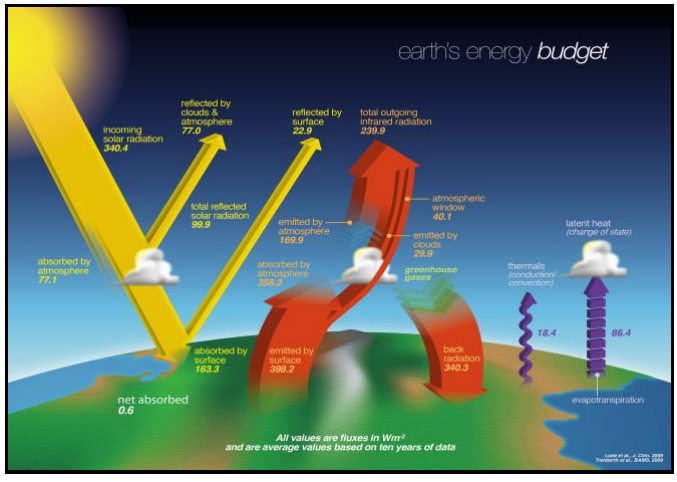
Clouds and Earth's Energy Budget

Our sun's solar energy reaches Earth as electromagnetic radiation. Clouds influence the amount of solar energy entering Earth's atmosphere and the radiated heat reflected back into space.

Once the energy reaches Earth, some of it is absorbed by the atmosphere, which includes being absorbed by clouds. Some of the energy reaches Earth's surface, and is absorbed by oceans and land. The amount of energy absorbed affects temperature. Low, thick clouds primarily reflect solar radiation and cool the surface of Earth during the day. At night, low clouds aid in reflecting outgoing infrared radiation emitted by the surface back to the ground and thus act as a warming agent. High, thin clouds primarily transmit incoming solar radiation; at the same time, they trap some of the outgoing energy emitted by Earth and radiate it back downward, thereby warming the surface of Earth. The energy that is not absorbed by Earth or its atmosphere is reflected back out to space.

Earth's energy budget creates a balanced system of incoming and outgoing energy. If more energy comes in than goes out, Earth's temperature increases. If too much energy is reflected back to space and not absorbed, Earth's temperature decreases.

Land, ocean, atmosphere and clouds absorb around 70% of the solar energy that reaches Earth, and 30% is reflected back into space.



The energy budget diagram shows our best understanding of how energy flows into and away from Earth. It is based on more than 100 years of work completed by many scientists. The most recent measurements that contribute to understanding Earth's energy budget come from *the Clouds and the Earth's Radiant Energy System* (CERES; http://ceres.larc.nasa.gov) satellite instrument. CERES provides high accuracy data of the radiation components (reflected solar and emitted infrared radiation fluxes).

This energy balance determines the climate of Earth. Our understanding of these energy flows will continue to evolve as scientists obtain a longer and longer record using new and better instruments (http://clarreo.larc.nasa.gov).

5E Inquiry Lesson Development

Engage

Engineering Design Challenge

1. Post this Design Challenge to engage students in this study.

   Design and build a cloud cover estimator that can be used to identify clouds and estimate cloud coverage as a fraction or percent.

2. Create a *Know-What do we need to know-Learn* (KWL) chart to help students analyze the challenge and determine what they need to do to complete the challenge.

   Guide the students to ask these questions:
   - What are clouds?
   - What do clouds do? What is their purpose?
   - Why does cloud cover matter?
   - How do you estimate cloud cover?
   - What is a fraction?
   - What is percent?
   - What does it mean to design something?

3. These questions will lay the groundwork for the **Explore** activities.

Explore
Clouds

1. These activities allow students to explore and seek answers for the questions generated in the **Engage** discussion around the topic of clouds.

Clouds:

1. Ask students what they know about clouds.

2. Show or ask students to view one of the following videos:
   - NASA eClips™ Spotlite video segment *Clouds* https://youtu.be/uGVTk7hz_7U
   - NASA eClips™ video segment *Our World: Cool Clouds* https://nasaeclips.arc.nasa.gov/video/ourworld/our-world-cool-clouds
   - NASA eClips™ video segment *Clouds and the Earth* http://nasaeclips.arc.nasa.gov/playlists/ourworld?v=our-world-monitoring-the-earths-climate-with-ceres

   The videos may be downloaded from https://nasaeclips.arc.nasa.gov/ web site. A captioned version is also available at the https://www.youtube.com/NASAeClips site. The videos may be streamed from either web site. When using the nasa.gov web site, click on the program playlist and scroll through the list beneath the video player to locate the appropriate segment.

3. Lead the students in a discussion of what they learned about the purpose of clouds. Compare their responses to the list created prior to viewing the video. Emphasize to students that the video talks about how clouds play a role in moderating Earth's temperature. Students may need to research the different types of clouds and their altitude in the atmosphere. See sample chart below.

Clouds		
High Clouds	Mid Clouds	Low Clouds
•**Cirrus** •**Cirrostratus** •**Cirrocumulus**	•**Altostratus** •**Altocumulus** •**Nimbostratus**	•**Cumulus** •**Stratus** •**Cumulonimbus** •**Stratocumulus**

4. Provide students with these links if they need more information about cloud types:
   Do You Know That Clouds Have Names?: Elementary GLOBE provides an in-depth exploration of cloud types through this storybook. https://www.globe.gov/documents/348830/350460/ElementaryGLOBE_Clouds_en.pdf

Cloud ID Chart https://scool.larc.nasa.gov/printables-guides-CloudChart.html
Cloud Cover Math
https://scool.larc.nasa.gov/lesson_plans/SoiActivityCloudCoverage.pdf
Online Cloud Chart https://scool.larc.nasa.gov/cldchart.html

Explain

Discuss Clouds and Earth's Energy Budget

Energy Budget and Cloud Cover

1. Facilitate a discussion to help students EXPLAIN what they have learned from the EXPLORE activities. Ask students what they have learned about clouds and how this relates to Earth's Energy Budget.

2. Share this information about why NASA studies clouds.

Why Does NASA Study Clouds? NASA studies clouds to better understand Earth's weather. Currently there are several satellites in space used to study clouds. CERES, Clouds and the Earth's Radiant Energy System, is an instrument on several NASA satellites orbiting Earth. It measures the amount of energy reflected and given off by clouds at different heights. Climate forecasts made by computers use the data collected by CERES.

By studying clouds on Earth, NASA can learn about clouds on other planets. Mars has clouds that are like clouds on Earth. Other planets have clouds that are different than Earth's. One example is Jupiter, which has clouds made out of a gas called ammonia.

Understanding clouds is also important because the observations help improve and validate models of Earth's climate, and improve climate predictions. Scientists are gaining new insights into how clouds control atmospheric and surface temperature, atmospheric humidity, and atmospheric and oceanic circulation and precipitation patterns, all of which affect our daily lives in fundamental ways.

Complete articles can be found at the following links:
https://www.nasa.gov/audience/forstudents/k-4/stories/nasa-knows/what-are-clouds-k4.html

https://www.nasa.gov/audience/foreducators/5-8/features/F_Head_in_the_Clouds.html

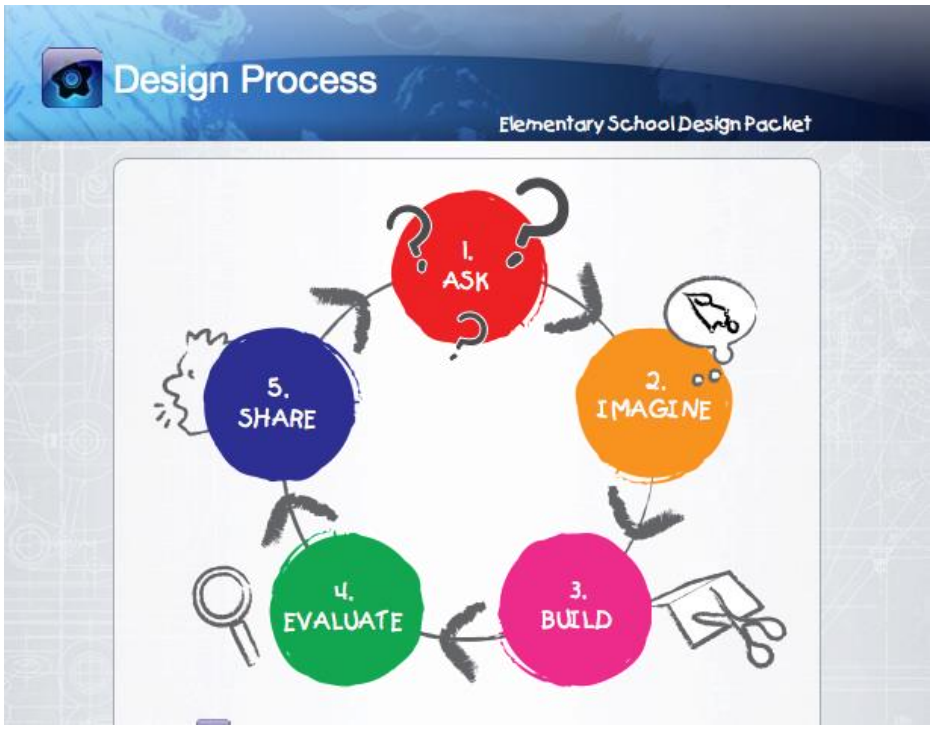
https://www.nasa.gov/pdf/135641main_clouds_trifold21.pdf

Extend

Design, Build and Test Cloud Coverage Estimator

1. Explain that students will work in teams to solve a design problem. Show students the graphic of the engineering design process found on page 2 of the Elementary School Design Packet. Inform students that they are being asked to use the engineering design process to solve this challenge:

   Design and build a cloud cover estimator that can be used to identify clouds and estimate cloud coverage as a fraction or percent.



   Caution: Remind students to follow all classroom safety rules, including safe use of scissors.

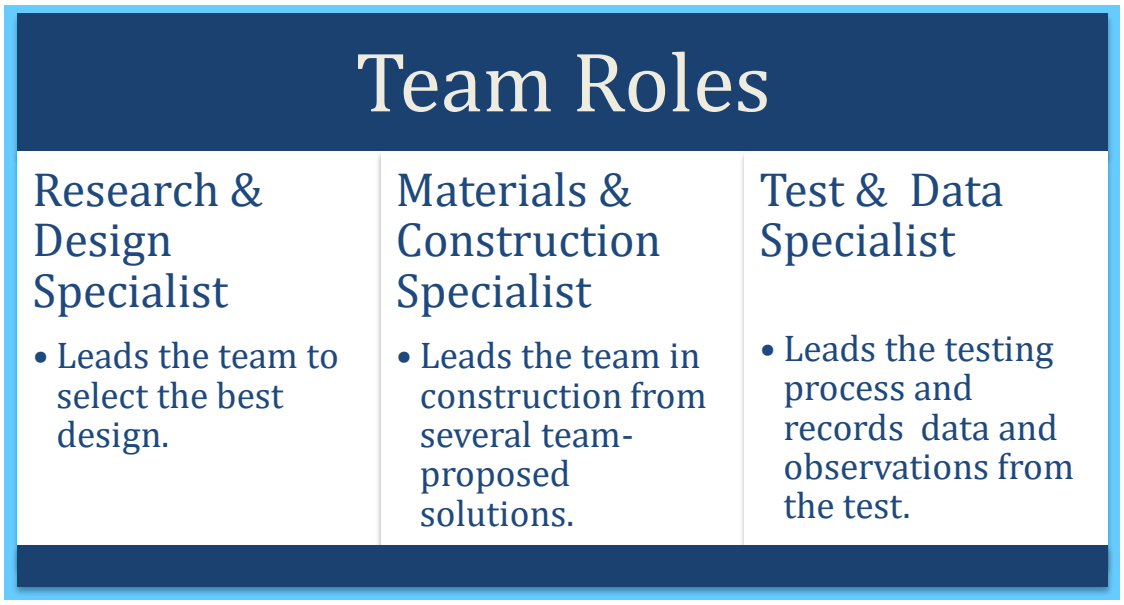
2. Explain to your students that the first step in the design process is to **ASK** all the questions they can think of about the challenge. That will help them understand the purpose and function for the end product and any limitations they may need to follow. Through the **ASK** step, students identify the design challenge criteria (conditions that must be met to solve the problem) and constraints (things that might limit the final solution). Their responses can be recorded on page 3 of the Design Packet.

   Student questions might include:
   a. What materials are available?
      Give teams of students the list of materials on page 2 of this guide.
   b. Are there any limitations for how to build the cloud cover estimator?
      1. The cloud cover estimator must:
         a. have a viewing opening that measures in length between 13 cm and 18 cm, and width between 7 cm and 11 cm;

b. have a way to measure the amount of cloud cover in the sky. A grid may be drawn on the plastic that covers the opening;
c. include a removable "lens cover" for the viewer. This can be used to remind students not to look directly at the sun.

2. Include a list of different types of clouds;
3. show or tell the location of where different types of clouds are located in the sky; and
4. be portable and easy to carry and hold.

c. What are the guidelines that all teams must follow?
Suggested guidelines should be established BEFORE students begin the challenge. These might include:
1. Teams may request additional materials from the teacher.
2. Students must work in teams to complete the challenge.
3. Each team member must take responsibility for a role in the challenge. Possible roles and responsibilities are listed in the Team Roles chart.



3. Ask students to **IMAGINE** possible solutions. Students should complete Step 2 on page 4 of the Design Packet, *Brainstorming Solutions*. Encourage the use of illustrations and diagrams to help students document the engineering design process.

4. The student taking the role of the *Research and Design Specialist* guides the team to select the best idea. Encourage students to identify how the plan addresses the criteria and constraints for the cloud cover estimator.
Some guiding questions for teams:
-How can you estimate cloud coverage?
-What is the length and width of the viewing opening?
- How might you use the plastic to help estimate cloud coverage?
-If you have trouble remembering the types of clouds, what can you add to your design to help you?

5. Use step 3 on page 5 of the Design Packet to guide students through the **BUILD** step. The student taking the role of the *Materials and Construction Specialist* gathers materials based on the team's plan. Monitor teams for participation of all members and check for understanding of the instructional objectives and design process.

6. The student taking the role of the *Test and Data Specialist* leads the team as they **EVALUATE** their design. These are steps 4A, 4B and 4C of the engineering design process found on page 6 of the Design Packet. Discuss what kind of data will be collected and the best method for recording that data. A sample data collection sheet is in this guide.

7. Before students test their cloud cover estimator discuss and develop a set of rules for testing. Some rules might include:
   a. Remain in the designated area on the school grounds.
   b. **Safety Precaution: Protect your eyes by not looking directly at the sun.**
   c. Stand in one place while using the cloud cover estimator. (If you are walking while looking up, you could trip.)

8. Guide students to think about changes they might include in a new version of the Cloud Cover Estimator.
   What other materials might they use? Why would they make the changes? Have them complete the **EVALUATE** steps 4D, 4E, and 4F on page 6 of the Design Packet.

Evaluate

Cloud Coverage Estimator Redesign and Sharing

1. For formative assessment, review student entries for each step in the design process before proceeding to the next step. For example, the teacher could review the IMAGINE entries before students proceed to the BUILD step.

2. Guide students to compete the final step of the design process found on page 7 of the Design Packet, step 5: SHARE.

3. Students could use digital resources such as cameras and multimedia presentation programs (PowerPoint, Keynote, Prezi, Canva, Camtasia) to explain their ideas and what they learned during this design challenge.

4. Have students submit their design logs/notebooks and use the Design Challenge Evaluation Rubric on page 8 of the Design Packet to evaluate student understanding of the design process.

5. Ask students to explain how their Cloud Cover Estimator could be useful to meteorologists or atmospheric scientists.

6. Ask students to discuss and compare their recorded cloud cover estimator data and how this data would be useful to:
   - understand Earth's energy budget
   - predict the weather
   - understand the importance of NASA's missions of CloudSat or CERES.

Cloud Cover Estimator Data Collection

Team Members: _____

Date: _____ Time: _____ Location: _____

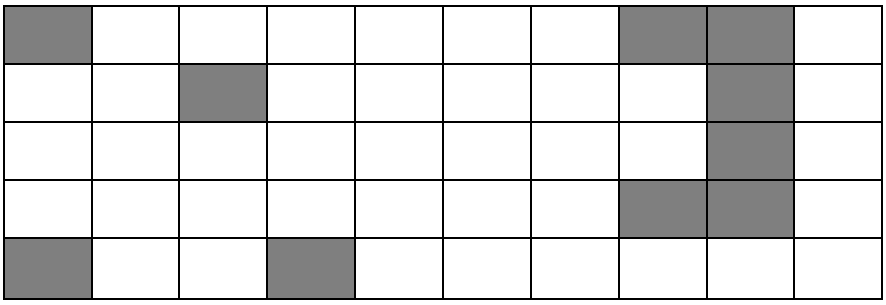
Caution: Remember to never look directly at the sun!

Use your Cloud Cover Estimator to:

1. Identify the types of clouds by drawing examples in the area of sky your team is assigned.

2. Identify where each type of cloud can be found in the atmosphere (high-, mid-, or low-level).

High	
Mid	
Low	



3. Calculate the fraction of clouds in the area of sky your team is assigned.

Example:

There are 50 cells on this grid.
There are 10 dark gray cells that represent the clouds seen through the viewing window of the Cloud Cover Estimator.
$\frac{10}{50} = \frac{1}{5}$ of this area of sky contains clouds

To find the percent of cloud coverage
1. Divide the numerator by the denominator.
2. Then multiply the result by 100 to get the percent.

10 ÷50 = 0.2
0.2 x 100 = 20%

This area of the sky has estimated cloud coverage of 20%.