UDL Teacher Guide: Beginning Clouds

"Have you ever, looking up, seen a cloud like
to a Centaur, a Part, or a Wolf, or a Bull? "
—Aristophanes

Driving Question: Why are there clouds?

This unit explores the water cycle using models and simple hands-on investigations.

Introduction

Using the UDL approach, students explore the water cycle in multiple ways: from a fictional story to data collection with probes, and from hands-on inquiry investigations to computer models. Data collection using computer-based probes is displayed using smart graphs, allowing students to dissect elements of the graph for further understanding. Students are provided with scaffolded assistance to questions and offered choices for demonstrating what they have learned through text or drawings. Coaches offer prompts, hints, and models to engage students in the science content. Teacher resources allow the teacher to control the student scaffolding for their class and for individual students. Teachers can also access results of the multiple-choice section of the pre-test to make recommendations about which activities students should complete. While all the activities will provide learning opportunities for students, teachers can help students focus on areas they need to work on.

Technology

The technology used in the clouds unit is designed for students to discover the story told by the data as they investigate clouds. A humidity probe is used in the activity "Water Vapor" and a surface temperature probe is used in "Precipitation." The probes allow students to collect and view data in real time on smart graphs. Smart graphs allow students to analyze data in a meaningful and supported way. The graphing tools are the same, regardless of the activity.

The technology in UDL does not supplant the teacher. Instead, students are individually supported throughout the unit. One example of this support is that students can highlight the text and the computer will vocalize the words. Definitions for highlighted words (in blue) are also built into the program. If a student clicks on one of these words, a definition in the context of the unit pops up. A complete glossary for the unit can be found at the bottom of each page using the book icon. In some of the units you will also find three robot helpers. These robot "coaches" are there to help the student understand the material by asking them to make predictions, asking guided questions, and by clarifying or predicting what will happen next.

The teacher can manage certain features of the units for both the class and individual students. Once a class is set up the teacher can go to the UDL Portal Info page and click the "View a report on this class" icon. At the top of the report page there are two options, one that allows you to configure the parameters for students. This allows you to control the font size and set the initial scaffold level for students. The option on the class report page allows you to enable/disable activities within the units.

The default setting for lesson order when setting up your classes will be a sequenced order of lessons. When students enter the menu page they will complete the Pre-test. When they have

submitted the Pre-test they will be able to access the next lesson in the sequence. If you want to allow students to choose their own sequence you can set up your class so that once they have completed the Pre-test and Introduction they can move between lessons in whatever order they like. (A more detailed explanation can be found at http://udl.concord.org/share/teacher-guides/Dashboard.pdf)

Scaffolding in UDL Units

Scaffolding in education has traditionally been done by the teacher as a way to assist students as they are learning new skills or content. The scaffolding is done not to provide answers or do the work for them but as a way for the students to gain confidence and develop understanding of skills and concepts. The goal of scaffolding is that over time the level of assistance that a student needs will gradually be reduced until the minimal amount of support is needed and used. To use a cooking analogy: a chef will use a recipe the first few times he makes a dish. After he has made it several times, he may have the recipe out for reference and then after more time, it becomes so natural he no longer needs the recipe.

In the UDL units different levels of support are offered to students when answering questions. As with the cooking analogy, the scaffolding is intended to provide support for those students who need it with the goal that with time they will be able to work with minimal scaffolding. When scaffolding prompts are available they are accessed by clicking on the green question mark icon. Students may answer the open-ended question as presented. Or, if they are unable to do so, they can click on the question mark and access the first level of support. At this level they are given a hint that may lead them to the correct response. If the student is still unable to answer the question, they can click the question mark again for the answer with key words left out and they can fill in the blanks. If they need additional help, they receive a multiple-choice list. The final level of scaffolding offers the student a model response; they are given the answer and asked to provide their own ideas about the response.

Standards/Benchmarks

NSES Content Standard A: Science as Inquiry

- Abilities necessary to do scientific inquiry.
    - Identify questions that can be answered through scientific investigation.
    - Design and conduct a scientific investigation.
    - Use appropriate tools and techniques to gather, analyze, and interpret data.
    - Develop descriptions, explanations, predictions, and models using evidence.
    - Think critically and logically to make the relationships between evidence and explanations.
- Understandings about scientific inquiry.
    - Mathematics is important in all aspects of scientific inquiry.
    - Technology can be used to gather data enhances accuracy and allows scientists to analyze and quantify results of investigations.

NSES Content Standard D: Earth and Space Science (K-4)

- Earth materials are solid rocks and soils, water, and gases in the atmosphere.
- Weather changes from day to day and over seasons. Weather can be described by measurable quantities, such as temperature, wind direction and speed, and precipitation.
- The sun provides the light and heat necessary to maintain temperatures of the earth.

Benchmarks for Science Literacy—AAAS

- 1B Scientific Inquiry
  - Scientific investigations may take many different forms, including observing what things are like or what is happening somewhere, collecting specimens for analysis, and doing experiments. Investigations can focus on physical, biological, and social questions.
  - Scientists do not pay much attention to claims about something they know about works unless the claims are backed up with evidence that can be confirmed and with logical argument.
- 4B The Earth
  - When liquid water disappears, it turns into a gas (vapor) in the air and can reappear as a liquid when cooled, or as a solid if cooled below the freezing point of water. Clouds and fog are made of tiny droplets of water.
- 4D The Structure of Matter
  - Heating and cooling cause changes in the properties of materials. Many kinds of changes occur faster under hotter conditions.

Alaska state standards (http://udl.concord.org/share/teacher-guides/TG_Clouds_Beginning-AK-Standards.pdf)

California state standards (http://udl.concord.org/share/teacher-guides/TG_Clouds_Beginning-CA-Standards.pdf)

Learning Goals

The general learning goals that are addressed in this unit relating to scientific process are present in all activities. Refer to each activity for more specific content goals.

Students investigate clouds while:

- making explanations and predictions from evidence and drawing logical conclusions;
- identifying variables that can affect the outcome of an experiment and learning which variables must be controlled to isolate the affect of another variable;
- designing and conducting a scientific investigation;
- gaining skills and confidence in using scientific measurement tools, models and graphs to represent and analyze data;
- valuing accuracy and precision in scientific investigation.

Background Information

Weather is one of the most visible and most easily observed parts of the natural world. In addition to affecting the non-living parts of the environment, it also controls much of the activity of the living world. We also know that other planets in our solar system have their own weather that affects them.

Clouds are one part of weather that we can see around us. Clouds are formed when water vapor in the air condenses and may best be described as *visible aggregates of minute droplets of water or tiny crystals of ice.* They change shape and form as part of a continual process we call weather.

To understand clouds we first need to understand the phase changes that water goes through. Water exists on earth as a solid (ice), a liquid (water), and a gas (vapor). If we start with fresh water that has been cooled below 0 degrees Celsius (32°F), the movement of molecules slows until a solid is formed. If we reverse the process and reheat the water, it will become a liquid

again. Water enters the air through **evaporation**. This can happen at almost any temperature. In any given quantity of water, individual molecules are moving at different speeds. Low energy/low temperature molecules move slowly; high energy/high temperature ones move quickly. Even though the average temperature of the liquid may be below boiling, some molecules build up enough speed as a result of random collisions to break free from the liquid's surface and enter the surrounding air. This process is reversed as the molecules of water in the air are cooled; they slow down and collect. We call this process **condensation**. We can see this on the outside of a cold glass of soda on a warm day. Water vapor in the air collects on the outside of the glass, making droplets that make the glass wet.

Before the beginning of the 19th century there were no generally accepted names for the clouds we regularly see. Luke Howard, an English naturalist, developed and published a classification for clouds in 1803. His system of classification became the basis for the system we use today.

Today we classify clouds based on two criteria: *form* and *height*. We have three basic cloud forms, which are then broken down by height. **Cirrus** clouds are high, white, and thin. They are separated or detached, often looking like thin wispy fibers or feathery. **Cumulus** clouds form globular individual masses. Usually they form with a flat base and then rise in large dome-like structures some describe as looking like heads of cauliflower. **Stratus** clouds form sheets or layers that cover the sky. There may be some small breaks, though they generally form one continuous cloud mass.

The second aspect of the classification is height. Three levels are defined as high, middle, and low. **High** clouds are those that have a base above 6000 meters (20,000 feet). **Middle** clouds occupy heights from 2000 to 6000 meters. **Low** clouds form below 2000 meters (6500 feet). These heights are not hard and fast, and may vary somewhat by season and latitude.

To understand clouds and their formation we also need to understand how the water cycle works. The water cycle is the set of processes that move water in and around the planet earth. In its simplest form the cycle is water evaporating, then condensing in the atmosphere, and then falling again to the ground. The energy for this movement comes from the energy from the sun. As water is heated or as air moves over it, water molecules enter the atmosphere as vapor. In addition some water enters the air through transpiration and a result of burning various fuels by humans. Once the vapor enters the air the water moves as the result of the rising of heated air, cooling air, and wind currents. As the water moves and is cooled the molecules begin to condense. As they condense, if there is enough water, they become visible in the form of clouds. These clouds may or may not result in precipitation. The forms of precipitation vary depending on temperature. If the air near the ground is warm enough, the water may fall as rain. If the air is colder, the water may fall as snow. In addition to these common forms of precipitation other forms include mist, drizzle, sleet, glaze, rime, hail, and graupel. Each is defined by its state and the size of the droplet.

Reference: Lutgen, F. K., & Tarbuck, E. J. (2001). *The Atmosphere* (8th ed.). New Jersey: Prentice Hall.

Advanced Preparation

Before starting this unit send out a call to parents in your class to begin collecting and saving one- or two-liter clear plastic bottles. Depending on the size of your class you may need 6-8 bottles.

Unit Overview

Activity Title	Activity Length	Materials	Overview
Pre-test	20 minutes	▪ Computer with Internet access	The pre-test allows students to demonstrate what they know about topics related to clouds and how they are formed. Students complete the pre-test and are then given access to the rest of the activities in the unit.
Introduction	60 minutes: 15 minutes to construct cloud wheel 30 minutes to make cloud observations 15 minutes to make sky drawing	▪ Cloud map (http://udl.concord.org/artwork/cloud_34/cloud_map/cloud_map.pdf) ▪ Cloud wheel (http://udl.concord.org/artwork/cloud_34/cloud_wheel/cloud_wheel.pdf) ▪ Brad (paper fastener) ▪ Computer with Internet access	Students construct a Cloud Wheel and then use it to explore clouds that they see outside their classroom. They use their observations to make a drawing of the clouds/sky they observe.
Wondering About Clouds	Two-three 30-minute sessions	▪ Computer with Internet access ▪ Printout of story (optional) (http://udl.concord.org/share/teacher-guides/Clouds_34_v5.pdf)	Students read the story "Wondering About Clouds." The story tells about the adventures of siblings Margaret and Eduardo who learn about clouds and the water cycle with the help of Elvira.
Globe Toss	30 minutes	▪ Computer with Internet access ▪ Soft globe that can be tossed ▪ Paper and pencil ▪ Data chart (http://udl.concord.org/artwork/cloud_34/toss_chart/globe_toss_chart.pdf)	Students use a globe, which is tossed between them. Students keep a record of 100 tosses, noting each time where the right thumb is touching (land or water).
Water Cycle	30-40 minutes	▪ Computer with Internet access ▪ Earphones (optional)	Students learn about the water cycle through listening to the "Water Cycle Song," which is embedded in the

			activity. They write and use the drawing tools to explain their new understandings.
Precipitation	40 minutes	▪ Computer with Internet access ▪ Surface temperature sensor ▪ 2 clear plastic cups ▪ Ice ▪ Warm water	Students investigate how water in clouds forms rain or snow, by modeling the process using warm and cold cups to show what happens when the atmosphere is warmed or cooled.
Water Vapor	45-60 minutes (Or can be done in two 30-minute sessions.)	▪ Computer with Internet access ▪ Humidity sensor ▪ Warm water ▪ Cold water ▪ Plastic wrap ▪ 2 plastic bowls ▪ Plastic bag	Students explore how water moves into the air. The humidity sensor is used to measure the humidity above bowls containing warm and cool water.
Cloud in a Bottle	30 minutes (This activity can be done with one or two groups of students at a time **or** as a whole class demonstration with the students writing their observations as the demonstration progresses.)	▪ Computer with Internet access ▪ 1 or 2-liter clear plastic bottle with cap ▪ Clear plastic wrap ▪ Rubber band ▪ Ice cubes ▪ Scissors (for teacher use) ▪ Warm water ▪ Wooden matches	Students help build and then observe a cloud chamber. Students write about their observations and explain how the cloud in the bottle is like a real cloud.
Wrapping Up	Ongoing	▪ Computer with Internet access	Students can visit and revisit "Wrapping Up" during their completion of the unit activities. In Wrapping Up they have the opportunity to review and clarify their thinking.
Post-test	20 minutes	▪ Computer with Internet access	Students complete the post-test, which contains the same set of question from the pre-test as well as student feedback questions.

Unit Activities

Pre-test


Time: 20 minutes


Materials: computer with Internet access

This unit begins with a short pre-test. The pre-test allows students to share what they already know about the learning goals. Students must complete the pre-test and press the "Submit" button before proceeding to any activity. The post-test at the end of the unit contains the same set of questions. Based on students' responses to the multiple-choice questions teachers are able to make recommendations about which activities each student should complete.

Introduction

The driving question "Why are there clouds?" is introduced. In this unit students explore the water cycle. Students use a **cloud map** to describe any clouds they see outside the classroom window; they record what the clouds look like and where they are in the sky. They then build a **cloud wheel** that the students use to indentify the cloud types.


Time:
60 minutes in three sessions (15 minutes to build cloud wheel, 30 minutes to make observation, 15 minutes to make drawings of observations)


Standard/Benchmarks:

NSES Content Standard A: Science as Inquiry

- Abilities necessary to do scientific inquiry.
    - Identify questions that can be answered through scientific investigation.
    - Design and conduct a scientific investigation.
    - Use appropriate tools and techniques to gather, analyze, and interpret data.
    - Develop descriptions, explanations, predictions, and models using evidence.
    - Think critically and logically to make the relationships between evidence and explanations.

Benchmarks for Science Literacy—AAAS

- 1B Scientific Inquiry
    - Scientific investigations may take many different forms, including observing what things are like or what is happening somewhere, collecting specimens for

analysis, and doing experiments. Investigations can focus on physical, biological, and social questions.
- Scientists do not pay much attention to claims about something they know about works unless the claims are backed up with evidence that can be confirmed and with logical argument.

Alaska state standards (http://udl.concord.org/share/teacher-guides/TG_Clouds_Beginning-AK-Standards.pdf)

California state standards (http://udl.concord.org/share/teacher-guides/TG_Clouds_Beginning-CA-Standards.pdf)

Materials:

- Cloud map (pdf file)
- Cloud wheel (pdf file)
- Brad (brass fastener)
- Computer with Internet access

Advanced Preparation:
The cloud map and cloud wheel should be downloaded and printed. If possible, the cloud map and cloud wheel should be printed in color. The cloud map can be laminated for repeated use by students. If the cloud wheel can be printed on card stock, it will hold up better.

Student Activity:
Students begin by using the cloud map to describe clouds outside the classroom window. Talk with students about how they can describe the height of the clouds. This may be difficult for some younger students who just see them as being high.

After writing their descriptions of the clouds, students build a cloud wheel. With the cloud wheel they will make observations of clouds when they go outside.

When they have completed their observations they are asked to draw the clouds they saw and identify them. There are follow-up questions that ask students to begin making predictions about cloud types.

Wondering About Clouds — *Story*

Discovery Question: Where does water go?

Siblings Margaret and Eduardo visit the beach and begin to wonder about the clouds they observe. A friendly stranger, Elvira, flies them up to the clouds where they learn about the water cycle. Students answer short questions about the story in words or drawings.

Time: two or three-30 minute sessions (or chapters can be read as time allows)

Standards/Benchmarks:

NSES Content Standard A: Science as Inquiry

- Abilities necessary to do scientific inquiry.
    - Think critically and logically to make the relationships between evidence and explanations.

Benchmarks for Science Literacy—AAAS

- 1B Scientific Inquiry
    - Scientific investigations may take many different forms, including observing what things are like or what is happening somewhere, collecting specimens for analysis, and doing experiments. Investigations can focus on physical, biological, and social questions.

Alaska state standards (http://udl.concord.org/share/teacher-guides/TG_Clouds_Beginning-AK-Standards.pdf)

California state standards (http://udl.concord.org/share/teacher-guides/TG_Clouds_Beginning-CA-Standards.pdf)

Materials:

- computer with Internet access (story can be downloaded and students can read the chapters and write summaries and later type them into the answer spaces in the unit)

Student Activity:

Students read a story about siblings Margaret and Eduardo. On a visit to the beach, they begin to wonder about the clouds they observe. A friendly stranger, Elvira, flies them up to the clouds where they learn about the water cycle. Students answer short questions about the story in words or drawings.

Scaffolding is available using the "robot" helpers, which provide prompts to help students understand the story.

Teacher Notes:

It is important that you take some time while the students are reading the story to talk about how what the characters are doing is imaginary, but the concepts related to clouds and the water cycle are real.

Globe Toss — *Math*

Discovery Question: How much water is on the earth?

In this activity, students determine how much of the earth's surface is water.

Time: 30-45 minutes

Standards/Benchmarks:

NSES Content Standard A: Science as Inquiry

- Abilities necessary to scientific inquiry.
    - Identify questions that can be answered through scientific investigation.
    - Design and conduct a scientific investigation.
    - Use appropriate tools and techniques to gather, analyze, and interpret data.
    - Develop descriptions, explanations, predictions, and models using evidence.
    - Think critically and logically to make the relationships between evidence and explanations.
- Understandings about scientific inquiry.
    - Mathematics is important in all aspects of scientific inquiry.
    - Technology can be used to gather data enhances accuracy and allows scientists to analyze and quantify results of investigations.

Benchmarks for Science Literacy—AAAS

- 1B Scientific Inquiry
    - Scientific investigations may take many different forms, including observing what things are like or what is happening somewhere, collecting specimens for analysis, and doing experiments. Investigations can focus on physical, biological, and social questions.
    - Scientists do not pay much attention to claims about something they know about works unless the claims are backed up with evidence that can be confirmed and with logical argument.

Alaska state standards (http://udl.concord.org/share/teacher-guides/TG_Clouds_Beginning-AK-Standards.pdf)

California state standards (http://udl.concord.org/share/teacher-guides/TG_Clouds_Beginning-CA-Standards.pdf)

Materials:

- soft globe that can be tossed (if possible, have one globe for each group of students)
- paper (or download a printable t-chart for data collection) and pencil
- Computer with Internet access

Note: A variety of soft globes are available for purchase online. You may also be able to purchase one at a local toy store. The globe needs to be large enough that students have to catch it using both hands when tossed.

PDF of chart is available at
http://udl.concord.org/artwork/cloud_34/toss_chart/globe_toss_chart.pdf

Student Activity:

Note:
If you have access to the school gym or other room without a lot of furniture these would be good locations for doing this activity.

Engage:
Students begin by make a prediction about how much of the earth's surface is covered with water. They are shown a grid with 100 squares and are asked to color blue the number of squares that would be covered with water and brown the number of squares that would be dry land. They take a snapshot for their lab book.

Explore:
Students toss the globe back and forth to each other. With each toss they record where their right thumb is when the globe is caught (either land or water). Each group should toss and catch the globe 100 times. Then using the data they collected as a group they record their results on a 100-square grid, marking water squares blue and land squares brown. They take a snapshot of their grid.

Students now combine their data with the other groups in the class to make comparisons.

Explain:
Students use their lab books and make comparisons between their prediction and the results from the globe toss.

Elaborate:
Then they are guided through the process of converting their data into a percentage, which is recorded.

Discussion:
Lead the whole class in a discussion using the questions below to start the conversation. Allow students time to clarify their ideas and encourage them to explain their thinking

"Since there seems to be so much water covering the surface of the earth, why should be worried about keeping it clean?"

"Is the water on the surface the only water on the Earth? Where else might you find water?"

Water Cycle *Movie*

Discovery Question: Where on earth does the water go?

In this activity students explore water moving around the earth and how clouds are part of water's journey. They use drawing tools to make pictures showing the parts of the water cycle. In addition, they learn the "Water Cycle Song" by watching movie sections.

 **Time:** 30-40 minutes

 **Standards/Benchmarks:**

NSES Content Standard A: Science as Inquiry

- Abilities necessary to do scientific inquiry.
    - Identify questions that can be answered through scientific investigation.
    - Design and conduct a scientific investigation.
    - Use appropriate tools and techniques to gather, analyze, and interpret data.
    - Develop descriptions, explanations, predictions, and models using evidence.

- Think critically and logically to make the relationships between evidence and explanations.

NSES Content Standard D: Earth and Space Science (K-4)

- Earth materials are solid rocks and soils, water, and gases in the atmosphere.
- by measurable quantities, such as temperature, wind direction and speed, and precipitation.
- The sun provides the light and heat necessary to maintain temperatures of the earth.

Benchmarks for Science Literacy—AAAS

- 1B Scientific Inquiry
  - Scientific investigations may take many different forms, including observing what things are like or what is happening somewhere, collecting specimens for analysis, and doing experiments. Investigations can focus on physical, biological, and social questions.
- 4B The Earth
  - When liquid water disappears, it turns into a gas (vapor) in the air and can reappear as a liquid when cooled, or as a solid if cooled below the freezing point of water. Clouds and fog are made of tiny droplets of water.

Alaska state standards (http://udl.concord.org/share/teacher-guides/TG_Clouds_Beginning-AK-Standards.pdf)

California state standards (http://udl.concord.org/share/teacher-guides/TG_Clouds_Beginning-CA-Standards.pdf)

Materials: computer with Internet access

Student Activity:
Students use the drawing tools to show understanding about the water cycle. Then they watch and use the information from the "Water Cycle Movie" to refine their understandings about the water cycle.

Engage:
The water cycle is introduced using drawing tools. Students are asked to place water in one of its solid forms (snow) where it would be found in a picture showing land, ocean, clouds, mountains, lakes, and streams. They take a snapshot of the drawing. When the snapshot is taken they are asked to describe what the picture shows. They repeat this process by placing liquid water where it is found and water vapor where it is found.

Explore:
The "Water Cycle Song" movie is shown in four sections. Each section focuses on one part of the water cycle. The first part shows precipitation in the form of rain. The next section shows water evaporating from the ocean. The third section of the song shows condensation of the water vapor through cooling to form clouds. The final section explains the main way that water makes its way from the land back to the ocean. With each section of the movie/song students are asked clarifying questions about what is happening to the water.

Explain:
Using what they learned from the Water Cycle Song movie, students answer questions about the movement of water in the water cycle. They then write a story that explains how a water

droplet falling on your roof travels to the ocean or a lake. Then using the drawing tool (with background) they show the path water takes as it moves through the water cycle.

Elaborate:
Using the drawing tool students show the path water takes as it moves in through the water cycle. They start with an image of land, water, and air.

Discussion:
Lead the whole class in a discussion using the questions below to start the conversation. Allow students time to clarify their ideas and encourage them to explain their thinking.

"Is snow the only form that solid water is found?"

"Do clouds stay in just one place? If not, what causes them to move?"

Quick Check for Understanding: Ask students to think about water moving in their local environment. Help them make connections between area lakes, creeks, and streams. For example, you could ask them to start with their neighborhood creek and follow its path to the ocean.

Precipitation ***Hands-on (temperature sensor)***

Discovery Question: How are rain and snow made?

In this activity, students investigate how water in clouds forms rain or snow.

Time: 40 minutes

Standards/Benchmarks:

NSES Content Standard A: Science as Inquiry

- Abilities necessary to scientific inquiry.
  - Identify questions that can be answered through scientific investigation.
  - Design and conduct a scientific investigation.
  - Use appropriate tools and techniques to gather, analyze, and interpret data.
  - Develop descriptions, explanations, predictions, and models using evidence.
  - Think critically and logically to make the relationships between evidence and explanations.
- Understandings about scientific inquiry.
  - Mathematics is important in all aspects of scientific inquiry.
  - Technology can be used to gather data enhances accuracy and allows scientists to analyze and quantify results of investigations.

NSES Content Standard D: Earth and Space Science (K-4)

- Earth materials are solid rocks and soils, water, and gases in the atmosphere.
- Weather changes from day to day and over seasons. Weather can be described by measurable quantities, such as temperature, wind direction and speed, and precipitation.

Benchmarks for Science Literacy—AAAS

- 1B Scientific Inquiry
  - Scientific investigations may take many different forms, including observing what things are like or what is happening somewhere, collecting specimens for analysis, and doing experiments. Investigations can focus on physical, biological, and social questions.
  - Scientists do not pay much attention to claims about something they know about works unless the claims are backed up with evidence that can be confirmed and with logical argument.
- 4B The Earth
  - When liquid water disappears, it turns into a gas (vapor) in the air and can reappear as a liquid when cooled, or as a solid if cooled below the freezing point of water. Clouds and fog are made of tiny droplets of water.
- 4D The Structure of Matter
  - Heating and cooling cause changes in the properties of materials. Many kinds of changes occur faster under hotter conditions.

Alaska state standards (http://udl.concord.org/share/teacher-guides/TG_Clouds_Beginning-AK-Standards.pdf)

California state standards (http://udl.concord.org/share/teacher-guides/TG_Clouds_Beginning-CA-Standards.pdf)

Materials:

- computer with Internet access
- external temperature sensor
- 2 clear plastic cups (8-9 ounce)
- ice
- warm water
- cold water

Safety Note:
The temperature of the warm water should not exceed 40 degrees Celsius. Severe burns may result.

Engage:
Students begin by thinking about whether there is water in the air even if they can't see it. Then they are asked to define precipitation and make a list of types of precipitation.

Explore:
Students explore a graph that shows temperature changes when a student measured their thumb temperature. They are asked to label several points that correspond to a specific event. They can check their responses. When they are finished they take a snapshot.

Next they set up an investigation using two cups, one with warm water and one with water and ice cubes. They measure and graph the air temperature first. Then they switch to the warm water graph and measure the temperature of the outside of the cup. Finally they switch to the cold water graph and measure the temperature of the outside of the cup with the ice water.

Explain:
Students are now given a chance to use the data they collected to explain when and where they expect to see condensation form. They are asked to think about places where they have seen condensation.

Elaborate:
Students are asked to think about what would form on the surface of a cup of water placed in a freezer. This final question completes the activity.

Teacher Notes:
Since there are several forms of frozen precipitation that students may have observed it would be a great opportunity to invite a meteorologist into the class to talk about all the forms of frozen precipitation.

Water Vapor *Computer model & Hands-on (humidity sensor)*

Discovery Question: Where does the water in the air come from?

In this activity, students investigate how water gets into the air and creates clouds. Students use the humidity sensor to collect data.

Time: 60 minutes (can be completed in two 30-minute sessions)

Standards/Benchmarks:

NSES Content Standard A: Science as Inquiry

- Abilities necessary to do scientific inquiry.
  - Identify questions that can be answered through scientific investigation.
  - Design and conduct a scientific investigation.
  - Use appropriate tools and techniques to gather, analyze, and interpret data.
  - Develop descriptions, explanations, predictions, and models using evidence.
  - Think critically and logically to make the relationships between evidence and explanations.
- Understandings about scientific inquiry.
  - Mathematics is important in all aspects of scientific inquiry.
  - Technology can be used to gather data enhances accuracy and allows scientists to analyze and quantify results of investigations.

NSES Content Standard D: Earth and Space Science (K-4)

- Earth materials are solid rocks and soils, water, and gases in the atmosphere.
- Weather changes from day to day and over seasons. Weather can be described by measurable quantities, such as temperature, wind direction and speed, and precipitation.

Benchmarks for Science Literacy—AAAS

- 1B Scientific Inquiry

    - Scientific investigations may take many different forms, including observing what things are like or what is happening somewhere, collecting specimens for analysis, and doing experiments. Investigations can focus on physical, biological, and social questions.
    - Scientists do not pay much attention to claims about something they know about works unless the claims are backed up with evidence that can be confirmed and with logical argument.
- 4B The Earth
    - When liquid water disappears, it turns into a gas (vapor) in the air and can reappear as a liquid when cooled, or as a solid if cooled below the freezing point of water. Clouds and fog are made of tiny droplets of water.
- 4D The Structure of Matter
    - Heating and cooling cause changes in the properties of materials. Many kinds of changes occur faster under hotter conditions.

Alaska state standards (http://udl.concord.org/share/teacher-guides/TG_Clouds_Beginning-AK-Standards.pdf)

California state standards (http://udl.concord.org/share/teacher-guides/TG_Clouds_Beginning-CA-Standards.pdf)

Materials:

- computer with Internet access
- humidity sensor
- cold water
- warm water
- plastic wrap
- two plastic bowls
- plastic bag (a small sandwich bag will work)

Safety Note: Warm water should not exceed 40 degrees Celsius. Severe burns may result.

Student Activity:
Technical hints are provided for connecting the sensor and the data collection graph.

Engage:
Students begin by looking at satellite weather images showing cloud cover over the United States. They are asked to think about where the clouds in the images come from and what they are made of. They are given the explanation that the water is vapor that has moved into the air. Then using the humidity sensor and a plastic bag they first measure the humidity in the bag. The data is graphed and students can take a snapshot of the graph. They are then asked to breathe into the bag and take a second humidity measurement.

Explore:
In this piece of the investigation, students set up two plastic bowls, one with warm water and one with cold water. A piece of plastic wrap is placed over each bowl. They use the humidity sensor to measure the humidity in the classroom air, above the cold water, and above the warm water. A graph is created showing the various humidity readings. In addition to the quantitative measurements from the sensors, they also observe the changes to the plastic above the two bowls.

Explain:
Students are asked to explain their observations by responding to questions about where the water droplets on the plastic wrap come from. They also observe and explain what happened to the water that has condensed on the plastic.

Elaborate:
Finally, using the drawing tools and picture showing the ocean and clouds, students show the path of a water droplet moving from water to the clouds.

Cloud in a Bottle — *Hands-on*

Discovery Question: What are clouds made of?

In this activity, students create a cloud in a bottle. This is a simple model that shows how vapor collects around a nucleus to form droplets.

 **Time:** 30 minutes

 **Standards/Benchmarks:**

NSES Content Standard A: Science as Inquiry

- Abilities necessary to do scientific inquiry.
  - Identify questions that can be answered through scientific investigation.
  - Design and conduct a scientific investigation.
  - Use appropriate tools and techniques to gather, analyze, and interpret data.
  - Develop descriptions, explanations, predictions, and models using evidence.
  - Think critically and logically to make the relationships between evidence and explanations.

NSES Content Standard D: Earth and Space Science (K-4)

- Earth materials are solid rocks and soils, water, and gases in the atmosphere.
- Weather changes from day to day and over seasons. Weather can be described by measurable quantities, such as temperature, wind direction and speed, and precipitation.

Benchmarks for Science Literacy—AAAS

- 1B Scientific Inquiry
  - Scientific investigations may take many different forms, including observing what things are like or what is happening somewhere, collecting specimens for analysis, and doing experiments. Investigations can focus on physical, biological, and social questions.
  - Scientists do not pay much attention to claims about something they know about works unless the claims are backed up with evidence that can be confirmed and with logical argument.
- 4B The Earth
  - When liquid water disappears, it turns into a gas (vapor) in the air and can reappear as a liquid when cooled, or as a solid if cooled below the freezing point of water. Clouds and fog are made of tiny droplets of water.
- 4D The Structure of Matter

- Heating and cooling cause changes in the properties of materials. Many kinds of changes occur faster under hotter conditions.

Alaska state standards (http://udl.concord.org/share/teacher-guides/TG_Clouds_Beginning-AK-Standards.pdf)

California state standards (http://udl.concord.org/share/teacher-guides/TG_Clouds_Beginning-CA-Standards.pdf)

Materials:

- 1- or 2-liter clear plastic bottle with cap
- clear plastic wrap
- ice cube
- scissors
- warm water
- wooden matches
- rubber bands

Safety Note: Only the teacher should light and hold the match over the bottle. Severe burns may result.

Advanced Preparation:
The teacher needs to collect several clear plastic bottles. The top 1/3 of the bottle needs to be cut off prior to beginning the activity. Both pieces of the bottle should be retained.

Student Activity:
Models are one of the tools that scientists use to understand processes that may be difficult to observe in real time. In this activity students use a physical model to understand what clouds are made of.

Engage:
Students begin by thinking about what clouds are made of and how they form. They answer two questions to share their thinking.

Explore:
Students, with the teacher's help, fill the bottom of the bottle about a third full of warm water. The teacher lights a wooden match, blows it out, and drops it into the bottle. The students place a piece of plastic wrap over the top of the bottle. The plastic is secured to the side of the bottle with a rubber band. An ice cube is placed on top of the plastic. Students then observe the model and watch for a cloud to form. Using the drawing tools students draw and label their observations.

Explain:
Students start by explaining how they think clouds are formed based on their observations of the model. They are asked to list different forms of precipitation to help them clarify their thinking about what happens to the water vapor that has entered the air. Snow is included as a form of precipitation and students are asked to draw what they think a snowflake looks like.

Elaborate:
Students are asked to think about a time that they have walked through fog. They are asked to explain what the air feels like in the fog. This gives students an opportunity to make a connection to clouds being made of water vapor.


Teacher Notes:
This model may be affected by factors outside the teacher's control. Humidity and temperature of the classroom may make the cloud harder for students to see.

One way to extend this activity is to read the book "Snowflake Bentley" that tells the story of the man who took the first photographs of individual snowflakes. (Martin, Jacqueline Briggs. *Snowflake Bentley*. Houghton Mifflin, 1998. ISBN: 0395861624. 40 pages.)

Wrapping Up

Driving Question: Why are there clouds?


Time: Ongoing


Materials: computer with Internet access

Having completed the investigations in this unit, students review what they have learned about clouds and respond to the discovery question for each activity with text, drawings, snapshots, or data they have collected. Students can revisit any activity except the pre-test. When students are ready, they need to input a password to access the post-test.

The password is: **clouds**

Post-test


Time: 20 minutes


Materials: computer with Internet access

In the post-test, students have an opportunity to rethink their answers to the same set of questions from the pre-test. Once students open the post-test, they will not be able to return to previous activities.

Note: When the students finish the post-test, a box comes up saying they have finished and should tell the teacher. At that moment, their data is *not yet saved*. They must close the unit for the data to be saved. The student cannot just walk away. Students can close the unit by going to the File menu and selecting Exit, or simply clicking the red circle (upper left) to close it.

Additional Resources

Vocabulary

Analogy: comparison between two situations or things that are alike in some ways but different in others.

Atmosphere: the layer of air that surrounds the earth. It is made up of a mixture of gases, including nitrogen, oxygen, carbon dioxide, and water vapor.

Atom: a very small piece of matter. Several atoms joined together are called **molecules.**

Average: the middle of a set of values. To calculate it, add up the values and divide by how many there are.

Cloud: water in the air in the form of tiny water droplets or ice crystals.

Cloud cover: the proportion of the sky that is filled in with clouds, usually expressed as a percent.

Computer model: a program that runs on a computer and imitates the real world in some way.

Condensation: the process of changing from a gas to a liquid, for example, water changing from water vapor into a liquid.

Condense(d): to change from a gas to a liquid, for example, water changing from water vapor into a liquid.

Cycle: something that repeats over and over again, like traveling around in a circle or swinging back and forth.

Energy: a property of materials that can be used to heat things. It can take many forms, such as motion, electrical or chemical energy. The total amount of energy in a system doesn't change.

Estimate: to make a careful guess of the numerical value of something.

Evaporate: to change from a liquid to a gas, for example, water changing from a liquid into water vapor.

Evaporation: the process of changing from a liquid to a gas, for example, water changing from a liquid into water vapor.

Evidence: what you observe or measure to support an idea.

Fog: a cloud near the ground.

Freezing: the process of changing from a liquid to a solid.

Gas: a state in which matter has no definite shape or volume, for example, air.

Grid: a square pattern of lines.

Heat: a form of energy that consists of wiggling or motion of molecules. The faster the molecules wiggle, the hotter the material.

Humid: a state when a lot of water vapor is in the air.

Humidity: a measure of the amount of water vapor in the air. It is measured as the percentage relative to the maximum amount of water vapor the air can hold at that temperature.

Hypothesis: a prediction or careful guess about how something will work.

Ice: water in its state as a solid. Ice is a crystal.

Kinetic energy: the energy of motion. If an object is not moving, its kinetic energy is zero.

Liquid: a state in which matter has a definite volume but no definite shape, for example, drinking water.

Matter: anything that takes up space. Solid, liquid, and gas are all states of matter.

Melting: the process of changing from a solid to a liquid.

Moist: air that is very humid.

Molecule: a group of atoms that are joined together.

Monitor: to observe something carefully over a period of time.

Outlier: in a collection of measurements, an outlier is one that is very different from the others.

Percent: "out of 100" or "compared to 100." For example, if 30 kids in a class of 100 have brown hair, then 30 percent have brown hair.

Potential energy: stored-up energy, such as a stretched rubber band, chemical energy in a battery, or a car at the top of a hill.

Precipitation: any form of water that falls on the earth. It includes rain (water droplets), snow (ice crystals), sleet (frozen water droplets), and hail (big frozen water droplets).

Predict: to make a careful guess about how something will happen.

Prediction: a careful guess about how something will happen.

Relative humidity: a measure of the amount of water vapor in the air compared to the maximum the air can hold at that temperature.

Solid: a state in which matter has a definite volume and shape, for example, earth.

Temperature: the measure of how fast molecules in a material are wiggling or vibrating.

Water cycle: the continuous movement of water on, above, and below the surface of the earth.

Water vapor: water in its state as a gas.