🌎Thinking Like a Geoscientist

Instructor Lesson Prep

Objective: Prepare to guide students through an engaging exploration of the Earth System.

✅ **Review the Spheres**

- Geosphere, Atmosphere, Hydrosphere, Cryosphere, Biosphere
- Note that some resources may use different terms or omit spheres

✅ **Understand Key Cycles**

- Refresh the basics of the water cycle
- Focus on energy and matter movement through the system

✅ **Explore Cloud Formation**

- Review how clouds form and develop
- Connect their importance to the water cycle and Earth System
- Highlight their role in transporting water and energy

✅ **Latent Heat and Energy**

- Recall how water absorbs or releases energy during phase changes
- Be ready to explain how latent heat drives weather, climate, and Earth system processes

✅ **Long-Term Environmental Change**

- Consider how long-term environmental change influences each Earth System sphere
- Connect these changes to the water cycle, cryosphere, and global energy balance
- Be prepared to help students see real-world impacts

✅ **Anticipate Questions**

- Think about common areas of confusion
- Be ready to support students in making interdisciplinary links across spheres, cycles, and changes

💡 **Teaching Tip:** Use visuals, analogies, and real-world examples to make concepts like cloud formation, latent heat, and long-term environmental change engaging and relatable.

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💡 Student Learning Objectives

After completing this module, students should be able to:

- Describe the scientific method and make geoscientific observations, documenting them accurately.
- Recognize and interpret common imagery used in the geosciences.
- Classify the five major spheres (reservoirs) of the Earth System.
- Analyze key cycles that link the Earth System's spheres.
- Describe what clouds are and explain the mechanism of cloud formation.
- Describe and explain latent heat in the Earth System.
- Use Google Earth to explore and investigate the Earth System and the Cryosphere.

⛏️Lab Activities

- Activity A: Sketching Nature (~20 minutes)
- Activity B: Geoscience Spotlight (~50 minutes)
- Activity C: An Introduction to the Earth System (~30 minutes)
- Activity D: Imagery in the Geosciences (~20 minutes)
- Activity E: An Introduction to the Water Cycle (~15 minutes)
- Activity F: Cloud Formation (~25 minutes)
- Activity G: Using Google Earth to Explore Glaciers and Glacial Landforms (~30 minutes)

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Activity A: Sketching Nature (~20 minutes)

Materials: Timer, colored pencils or crayons, paper (with four squares labeled *Sounds*, *Sights*, *Smells*, and *Emotions*)

Overview: This short, creative activity helps students slow down and reconnect with the natural world through sensory memory and artistic expression. By sketching and reflecting on a past outdoor experience, students strengthen their observation skills, an essential part of fieldwork and scientific noticing.

Encourage students to approach this as both an artist and a scientist: observe carefully, remember deeply, and express what they notice without worrying about "perfect" drawings.

Step 1: Set the Stage (2 minutes)

Begin by explaining the purpose: "In science, observation is one of our most powerful tools. Today we'll practice it creatively, by sketching a memory of nature using all our senses."

Have students take out drawing materials (colored pencils, crayons, or markers) and a sheet of paper divided into four squares labeled (in lab):

- **Sounds**
- **Sights**
- **Smells**
- **Emotions**

Set your timer where everyone can see it.

Step 2: Guided Visualization (2 minutes)

Read this prompt slowly and calmly: "Take a moment to recall a time when you were outside in nature. Maybe it was a hike, a beach trip, your backyard, or a moment walking across campus.

Close your eyes and picture that place. What did you see? What sounds surrounded you? Could you smell rain, pine, salt, or soil?

How did that moment make you feel, peaceful, excited, curious, or calm?"

Pause for 10–15 seconds between phrases to let the image settle in their minds.

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Step 3: Sketching the Experience (8 minutes total — 2 minutes per square)

Explain the next part before starting the timer:

"You'll have 8 minutes total, 2 minutes per square, to draw or write what you remember for each sense.

Use color and shapes to capture the feeling as well as the details. Don't worry about drawing skill, focus on what stands out to you."

Then start the timer and give brief time reminders as you transition every 2 minutes:

- "Switch to *Sights*…"
- "Now move to *Smells*…"
- "And finally, *Emotions*…"

💡 ***Instructor Tip:***

- *Play gentle instrumental music or nature sounds to create a calm, reflective atmosphere.*

Step 4: Sharing and Reflection (8 minutes)

After the timer ends, invite students to share: "Turn to your group or a partner and show your sketches. Talk about what you noticed—did you focus on similar or different details?"

Encourage discussion with guiding questions:

- Which sense was easiest to recall?
- Which was most surprising or vivid?
- How might these details help a scientist studying a landscape or ecosystem?

Wrap up with a brief whole-class reflection: "Observation isn't just about seeing—it's about sensing and feeling. By paying attention with all our senses, we deepen our connection to the natural world."

Optional Extension (5 minutes): If time allows, have students label one or two *scientific observations* they could make from their sketches (e.g., sound of a bird → species identification, smell of soil → humidity, color of light → time of day). This bridges creativity with scientific inquiry. Let them share their drawings with each other!

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Activity B: Geoscience Spotlight (~50 minutes)

Overview

In this activity, students will explore what science is, what scientists do, and why geoscience matters to society. Students will collaborate, discuss, and then focus on a real-world scientist's work through a *GeoScientist Spotlight* feature. The activity encourages critical thinking, discussion, and reflection, helping students see science as a dynamic process and scientists as people working for the public good.

Step 1: Small-Group Discussion – Defining Science & Scientists (10 minutes)

Instructions for Students:

1. Turn to your neighbor or form small groups of 2–3 students.
2. Discuss the following questions:
    a. **What is science?** What makes something scientific?
    b. **What do scientists do?** Consider what it looks like in practice, not just in theory.
3. Take notes on your ideas, you'll be sharing them with the class.

💡 ***Instructor Tips:***

- *Circulate and listen for interesting ideas or misconceptions.*
- *Encourage students to think beyond the textbook, including observation, experimentation, collaboration, and curiosity.*

Step 2: Sharing Ideas on "What is Science?" (10 minutes)

Instructions for Students: Each group shares one idea from their discussion about the first question.

Instructor Role:

- Facilitate discussion by highlighting connections, differences, and unique perspectives.
- Encourage productive discourse: ask follow-up questions like: "Why do you think that is important?" or "How does that example show science in action?"
- If needed, clarify that science is systematic, evidence-based, and aimed at understanding the natural world.

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Step 3: Sharing Ideas on "What Do Scientists Do?" (10 minutes)

Instructions for Students: Each group shares one example of what scientists do in their work.

Instructor Role:

- Facilitate discussion and draw connections between student ideas and real-world scientific work.
- Highlight examples of fieldwork, data analysis, modeling, and communicating findings.
- Reinforce the idea that science is for the good of society, emphasizing geoscience's role in addressing natural hazards, climate, water resources, and energy needs.
- Optional reference: AGI Critical Needs document for examples of societal benefits of geoscience.

Step 4: Scientist Spotlight – Dr. Naruki Hiranuma (20 minutes)

Instructions for Students:

1. Read the Scientist Spotlight on Dr. Naruki Hiranuma.
2. Work individually or in small groups to answer the associated questions.
    a. Questions could include:
        i. What research does Dr. Hiranuma focus on?
        ii. How does their work impact society or the environment?
        iii. What skills or approaches does Dr. Hiranuma use as a scientist?
3. Be prepared to share your observations or reflections with the class.

💡***Instructor Tips:***

- *Optionally, read the Spotlight aloud as a class to save time.*
- *Encourage students to connect Dr. Hiranuma's work to the earlier discussion about what scientists do.*
- *Ask reflective prompts like:*
    - *"How is this scientist's work similar or different from your ideas of what scientists do?"*
    - *"Why is this work important for society?"*

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Step 5: Wrap-Up Discussion (Optional, 2–3 minutes)

- Summarize key takeaways:
  - Science is systematic, evidence-based, and collaborative.
  - Scientists contribute to society in diverse ways—from research to policy guidance.
  - Geoscience has real-world applications that affect communities, resources, and the environment.

💡***Instructor Tip:***

- *Encourage students to reflect on how they might see themselves in a scientific role, even in everyday problem-solving or future careers.*

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Activity C: An Introduction to the Earth System (~30 minutes)

Introduction (10 minutes)

Begin by introducing the Earth as a dynamic system made up of five major spheres:

- Geosphere: the solid Earth, rocks, minerals, landforms, and the processes that shape them.
- Hydrosphere: all liquid water, oceans, rivers, lakes, and groundwater.
- Cryosphere: all frozen water, glaciers, ice caps, and sea ice.
- Atmosphere: the blanket of gases surrounding Earth, where weather and climate occur.
- Biosphere: all living things, from microorganisms to plants and animals, including humans (anthroposphere).

Guide students through Question #1, asking them to match each listed item to its "home" sphere. Encourage quick reasoning, what clues help them decide? Use this as a springboard to expand on what each sphere includes and how they overlap. This discussion will naturally lead into Question #2, which dives deeper into the defining characteristics of each sphere.

Visual Connections (5 minutes)

Next, invite students to draw or sketch simple representations for each sphere in Question #3. They can do this individually or while contributing to a shared discussion for Questions 1 & 2. Encourage creativity, these drawings don't need to be perfect, just expressive of what each sphere represents. *Optional: share examples on the board or screen to spark ideas.*

Exploring Interactions (5 minutes)

Have students work independently or in small groups on Questions #4 and #5, where they investigate how these spheres interact to drive Earth's processes and changes. Encourage them to think of real-world examples, like rainfall (atmosphere → hydrosphere → geosphere) or volcanic eruptions (geosphere → atmosphere → biosphere).

Class Discussion & Reflection (10 minutes)

Bring the class back together to discuss how Earth changes over time. Ask guiding questions:

- Which processes seem fast, and which seem slow?
- Does "slow" always mean unimportant?

Challenge students to rethink their sense of scale and time, comparing events like an earthquake (seconds) versus mountain building (millions of years). Highlight how rates of change shape both landscapes and ecosystems.

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Activity D: Imagery in the Geosciences (~20 minutes)

Goal: Help students recognize and interpret different types of Earth imagery, satellite, aerial, digital elevation models (DEMs), and topographic maps, used by geoscientists to study our planet.

Part 1: Satellite Images (5 minutes)

Prompt: Consider the image below. Which type of image could this be? Select your choice from the list below. *Hint: this image was taken by NASA.*

- Digital Elevation Model
- Aerial Image
- Topographic Map
- Satellite Image

Instructions for Students: Take one minute to quietly observe the image, look for color, texture, patterns, and scale. Discuss in pairs: What clues suggest this might be a satellite image? Then, write a brief explanation of your choice.

💡 ***Instructor Tips:***

- *Ask guiding questions: "What makes this perspective unique?" "Can you see vegetation, clouds, or large-scale features?"*
- *Emphasize that satellite images capture broad-scale patterns, often from hundreds of kilometers above Earth's surface.*

Part 2: Aerial Images (5 minutes)

Prompt: Examine the next image. Which type of image could this be? *Note, this image was taken by Prof. B as she flew over eastern California!*

- Digital Elevation Model
- Aerial Image
- Topographic Map
- Satellite Image

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Instructions for Students: Observe carefully, look at the scale, shadows, and detail. How does it differ from the satellite image? Share your reasoning with a partner and note one visual feature that helped you decide.

💡 ***Instructor Tips:***

- *Highlight that aerial images are taken from planes or drones at lower altitudes, offering finer detail of landforms, vegetation, and human structures.*
- *Encourage students to compare perspectives: "What details can you see here that weren't visible in the satellite view?"*

Part 3: Digital Elevation Models (5 minutes)

Prompt: Now look at the third image. Which type of image could this be? *Note, this is a computer model of Mount Hood, a volcano, in Oregon!*

- Digital Elevation Model
- Aerial Image
- Topographic Map
- Satellite Image

Instructions for Students: Identify the key visual cues, color gradients, shaded relief, or 3D textures. Discuss what kind of information this image conveys about the land's shape or elevation.

💡 ***Instructor Tips:***

- *Explain that DEMs represent elevation data in digital form, often using color or shading to show height differences.*
- *Ask: "How might this data be used in geology, hydrology, or hazard mapping?"*

Part 4: Topographic Maps (5 minutes)

Prompt: Examine the final image. Which type of image could this be? *Note, this map is of Mount Hood, a volcano, in Oregon and was published by the United States Geological Survey (USGS)*

- Digital Elevation Model
- Aerial Image
- Topographic Map
- Satellite Image

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Instructions for Students: Look for contour lines, labels, and symbols. Use those features to confirm it's a topographic map. Explain how this type of map represents elevation and landscape shape differently than a DEM.

💡 ***Instructor Tips:***

- *Reinforce that topographic maps are interpretive representations, not photographs.*
- *Consider showing how contour spacing indicates slope steepness, linking it to previous imagery types.*

Wrap-Up (Optional, 1–2 minutes if time allows):

Ask the class:

- "Which imagery type do you think is most useful for studying landscape change, and why?"
- "How could combining different types of imagery give scientists a more complete understanding of Earth's surface?"

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Activity E: An Introduction to the Water Cycle (~15 minutes)

Instructor Overview

This short activity helps students think beyond the "basic" water cycle diagram and see water as a dynamic connector across the Earth's systems. Students will consider how water moves through the geosphere, hydrosphere, atmosphere, biosphere, and cryosphere, and how those movements vary across environments, especially in polar regions.

Encourage students to draw on real-world observations, rain, rivers, snowmelt, humidity, or ice, to make the cycle more tangible.

Introduction to Students (2 minutes)

Start with a short framing statement to connect big ideas:

"Energy and matter constantly move through Earth's systems, linking the spheres together through powerful natural cycles. These cycles keep our planet dynamic and ever-changing. Over this course, we'll explore several, like the Water (Hydrologic) and Rock cycles, as well as biogeochemical cycles such as Carbon, Nitrogen, Sulfur, and Phosphorus.

Today, we'll focus on the Water Cycle, a familiar yet surprisingly complex story of how water moves through Earth's spheres, shaping everything from weather patterns to life itself."

Then transition with:

"Let's think about how water connects it all, where it travels, how it transforms, and what that means for our planet."

Critical Thinking Activity (13 minutes total)

Question 1: Water's Path Through the Spheres (≈5 minutes)

Prompt to Students: "How does the water cycle weave its way through Earth's different spheres? Think about where water shows up, how it moves, and which parts of the Earth System it touches. Write down the spheres you identify, then explain how water connects to each one. What role does it play, and what kinds of changes or interactions does it cause?"

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Instructor Tips:

- *Encourage them to use vivid examples: "When it rains, which spheres are interacting?" "What happens when groundwater flows into the ocean?"*
- *If time allows, sketch a simple Earth System diagram on the board and have students label sphere-to-sphere connections with arrows.*

Question 2: The Polar Water Cycle (≈4 minutes)

Prompt to Students: "Now, imagine the water cycle at Earth's poles over many years. How might melting ice, shifting snowfall, and warming temperatures change the way water moves through this frozen world?"

💡 ***Instructor Tips:***

- *Invite brief discussion: "What happens when the cryosphere shrinks? How does that affect the hydrosphere or atmosphere?"*
- *Highlight feedback loops, like how melting ice changes reflectivity (albedo), leading to further warming.*
- *If visuals are available, show a short NASA animation or image of Arctic ice retreat to spark discussion.*

Question 3: Measuring Water in Motion (≈4 minutes)

Prompt to Students: "Imagine you are a scientist studying the Polar Regions. How would you measure changes in ice, snow, and water over time? What tools, observations, or experiments could you use to track the water cycle in this frozen world?"

💡 ***Instructor Tips:***

- *Guide students toward scientific reasoning: satellites, ice cores, GPS, temperature sensors, and long-term observation networks.*
- *Ask: "What kinds of data would tell you water is moving or changing? How could you tell if a glacier is melting faster than before?"*

Wrap-Up (Optional, 1 minute)

Bring the class back together and ask: "So, what makes the water cycle such a powerful connector across Earth's systems?" Emphasize that water links all the spheres, moving energy, shaping landscapes, and sustaining life. This concept of connection will carry forward into future labs on the Rock Cycle and biogeochemical cycles.

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Activity F: Cloud Formation (~45 minutes; 20 minute guided discussion + 25 minute experiment and wrap-up)

Instructor Overview

This lab helps students connect what they *see,* like clouds forming or fog rolling in, to the scientific processes behind it. Through short guided questions and a hands-on demonstration, students will explore phase changes, latent heat, and how clouds form from invisible gases to visible droplets.

Part 1: Concept Warm-Up (20 minutes total)

Use the following questions as an interactive discussion or a short think-pair-share. Students can record their answers or discuss before you reveal explanations.

(5 minutes)

1. **What would you expect clouds to be composed of?**
    a. Water drops
    b. Water vapor
    c. Ice crystals
    d. All of the above *correct answer*

Guide students to see that clouds can include all three, tiny water droplets, water vapor, and ice crystals depending on altitude and temperature.

(5 minutes)

2. **What term describes when a gas changes into a liquid?**
    a. Condensation *correct answer*
    b. Vaporization
    c. Sublimation

Reinforce that condensation is key to cloud formation, this is where water vapor becomes visible as droplets.

3. **What happens when air cools or becomes saturated with water vapor and can't hold any more moisture?**
    a. Condensation *correct answer*
    b. Vaporization

   c. Sublimation

Tie this to dew point and why clouds often form when warm, moist air rises and cools.

(5 minutes)

4. **What term describes when a liquid changes into a gas?**
   a. Condensation
   b. Vaporization *correct answer*
   c. Sublimation
5. **Evaporation is a surface phenomenon, whereas boiling is a bulk phenomenon. What term is applied to both?**
   a. Condensation
   b. Vaporization *correct answer*
   c. Deposition

Use this to help students distinguish between localized (evaporation) and widespread (boiling) energy processes.

(5 minutes)

6. **Can geoscientists measure the weight of gas (water vapor)?**
   a. How might they do that? *Prompt discussion on using digital scales, barometers, or spectrometers to measure changes in pressure, mass, or gas content.*
7. **What is dry ice? (Hint: its temperature is below –100°F / –78.5°C!)**
   a. Frozen water
   b. Frozen carbon dioxide *correct answer*
   c. Frozen helium
   d. Frozen hydrogen

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Part 2: Making a Cloud Experiment (25 minutes total)

Goal: To recreate the formation of clouds through sublimation and vaporization, and to observe how phase changes involve the absorption of latent heat.

Materials *(to reduce time, provide prepared items in the table below to each group, or complete the demo yourself in front of the class)*

Quantity	Item
1	Pair of Gloves
1	Permanent marker
1	50 mL Plastic Falcon Tube
1	250 mL Beaker
1	~400 g Dry Ice (solid form of carbon dioxide)
1	400 mL Water (Activation Solution)
1	Digital Scale

Observation Note:
*The "white smoke" you see is **carbon dioxide gas** mixed with condensed water vapor, essentially an artificial cloud!*
Eventually, sublimation slows because part of the water freezes, forming a thin layer of ice that insulates the remaining dry ice and stops the reaction.

💡 ***Instructor Tips***

- *Encourage students to predict what will happen before Step 5.*
- *Use a projected timer or have one student time the intervals while others record data. After data collection, discuss how latent heat drives weather, connecting this experiment to storm energy and atmospheric processes.*
- *Reinforce phase change vocabulary throughout the discussion (sublimation, condensation, deposition, vaporization).*

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Activity G: Exploring Glacial Landforms with Google Earth (~30 minutes)

Instructor Overview

In this lab, students will explore glacial landscapes through the lens of Google Earth, a free interactive tool that allows us to "fly" over Earth's surface and recognize patterns shaped by glaciers. Students will learn to spot common glacial features, such as U-shaped valleys, cirques, moraines, and drumlins, and connect them to the processes that created them.

By the end of the activity, students should be able to describe how glaciers sculpt the land and how these frozen forces continue to shape our planet today.

Step 1: Getting Started (5 minutes)

- Go to **Google Earth** using Google Chrome. *Phones can work in a pinch, but laptops, tablets, or lab computers are best.*
- Locate the gear icon (⚙️) in the upper right corner, that's your Settings.
- Scroll down to Formats and Units and set Units of Measurement to Feet and Miles. *Note - If you'd prefer students use Meters and Kilometers, that's OK too.*
- Scroll to the bottom and click **"Done"** to save your changes.

Instructor Tip: *Project Google Earth on the screen and demonstrate zooming, rotating, and switching between 2D and 3D. This helps students orient themselves and feel comfortable before independent work.*

Step 2: Explore the Tools (5 minutes)

Take a few minutes to explore these essential tools before diving into the questions.

- **2D / 3D View:** Tilt the map to reveal terrain shape.
- **Ruler Tool:** Measure distances, like valley widths or glacier lengths.
- **Pins:** Mark locations of interesting landforms.
- **Timelapse Layer:** See how glaciers retreat or advance over time.
- **Gridlines & Coordinates:** Show latitude and longitude for precision.

💡 *Encourage students to freely explore glaciated regions such as the Alps, Alaska Range, Patagonia, the Himalayas, or the Canadian Rockies.*

Step 3: Guided Exploration & Questions (15 minutes)

Students answer the 12 guiding questions as they explore glacial landscapes. Each pair or small group can tackle a few, then discuss as a class. Question #12, can lead into a broader class discussion on long term environmental change.

Step 4: Wrap-Up & Discussion (5 minutes)

Bring students back together to share findings. Highlight how these visual observations connect to real geologic processes.

Suggested discussion prompts:

- Which glacial features were easiest and hardest to identify?
- What surprised you about glacier scale or landscape change?
- How can satellite tools like Google Earth support geoscientific research?

💡***Instructor Tips***

- *Encourage collaboration, students can split up regions and compare notes.*
- *Use projected examples to model what to look for before independent work.*
- *Remind students to take screenshots or drop pins of their best examples for later reflection or reports.*