Unit 3 Lesson 3: Studying the Earth from the Moon

Challenge Guiding Question: How can we use experiments, models, and rehearsals here on Earth to understand other solar system objects and plan a successful mission to the Moon?

Unit Level Question: *What will it be like to live and work on the moon?*

Lesson Level Question: *What will it be like to study the Earth from the Moon?*

Lesson Summary: *First, students will consider images of the Earth from space and what evidence of Earth systems and changes they can see. Then, they will choose one change to the Earth that they could observe or measure from Earth, perform research, and share ideas about monitoring that change. Next, students will consider the Sun/Earth/Moon system as observed from the Moon, including a cultural storytelling component. Finally, they will record their findings in their MDLs.*

How to expedite this lesson: *After the "Engage" portion, skip to Part 2 of "Explore." Pre-select topics and resources for students to explore instead of allowing them to choose. For "Explain," provide feedback on students' work yourself rather than having them present to each other and get feedback. Complete the full "Elaborate" and "Evaluate" sections.*

Standards Information for each grade band can be found here:

- Elementary School (Grades 3-5) Standards Document *A2 ES Standards*
- Middle School (Grades 6-8) Standards Document *A2 MS Standards*
- High School (Grades 9-12) Standards Document *A2 HS Standards*

Materials Needed

Lesson Links	Materials Available from NESSP	Materials Provided by the Teacher
		(For Elaborate, Part 1--note that this activity is geared towards Middle and High School) Spherical objects (range of sizes if possible) Flashlight

Before The Lesson

- If your students are participating in the Student Challenge, review MO-6. https://nwessp.org/artemis-roads-ii-challenge-manual/
- The content and ideas from Unit 1, Lesson 3 (Looking at the Moon) and Unit 1, Lesson 4 (Comparing the Earth and the Moon) will be very useful to your students as they complete this lesson. If your students did not engage in these earlier lessons, you may wish to go back and review them and bring relevant portions of those lessons in now.
- If you need supplies for the ROADS Challenge, you can order your supplies through this link. https://nwessp.org/artemis-roads-ii-companion-course-sign-up/
- **Explore**: Decide if you will provide a limited choice of Earth System changes based on the content you want students to research (for example, if you want your students to choose something related to weather) OR if you will allow students free choice of topics.
- Decide if students will perform this task alone, with a partner or with their small group.
- **Elaborate**:Review the Teacher Guidance for Part 1 of Elaborate (supporting students in making Claims from Evidence)

Lesson Plan

Phase	Details	Materials/Prep
Engage (15 Min)	***Students will view images, videos, and animations of the Earth from space and consider the Earth systems and changes that they are seeing.*** **NOTE! The content and ideas from Unit 1, Lesson 3 (Looking at the Moon) and Unit 1, Lesson 4 (Comparing the Earth and the Moon) will be very useful to your students as they complete this lesson. If your students completed these lessons, you may ask them to review their MDL entries as directed below. If your students did not engage in these earlier lessons, you may wish to go back and review them and bring relevant portions of those lessons in now.** Display the first slide of the "Engage" slide deck (link in sidebar), which includes guiding questions. NOTE, if your students completed Unit 1, Lesson 4, this is where it may be helpful to review their MDL entries or other notes from this lesson). Allow students a few moments to consider the guiding questions on Slide 1 on their own before discussing with a partner. After partners have had a chance to discuss, ask them to share evidence from each of the four Earth systems. The purpose of this share-out is to ensure that students have a basic understanding of the four systems and what they entail. Students might say things like: ● I see plants/trees/vegetation (Bio) ● I see clouds and weather (Atmo / Hydro) ● I see oceans (Hydro) ● I see mountains and islands (Geo) Particularly observant students may also notice the Moon in this image, and attempt to discuss the systems on the moon based on their previous learning in Unit 1 Lessons 3 and 4. That's OK! Next, Display Slide 2. This image shows Earth at one moment in time. What could change if we took another image 5 minutes later? A day or year later? What about a million years later? Allow students to	U3 L3 Engage Spanish Version: A2 U3 L3 Enganches

<table>
<tr><td></td><td>discuss these ideas with a partner.

For this Mission Objective, we will consider what it will be like to study the Earth from space and what it will be like to observe the Earth from the Moon.</td><td></td></tr>
<tr><td>Explore
(90 - 135 Min)</td><td>Students will choose an Earth System change that might be observed from the Moon and research their topic.

<table><tr><td> 
</td><td>Part 1 of this section is geared towards Middle and High School. If you teach Elementary aged students, review Part 1 and decide if you will include it, briefly discuss it, or skip straight to Part 2.

Part 1: Measuring from Space (45 minutes)

Give students access to the “Out of this World Measurement” handout and ask them to first work individually to complete Part A. They can then join a partner or small group to discuss their answers to Part A, before each making a choice for Part B as well.

Discuss their thoughts as a whole class. Collect data (such as by making a tally sheet and having each student vote on which they think cannot be measured from space) to identify their most common answers. Then reveal that NASA can and does measure ALL of these things from space. This is a field called “remote sensing” and involves many kinds of satellites and technology, and often includes measuring more than what we could see with our eyes.

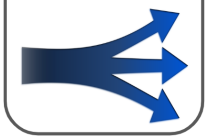
Give students access to the resources sheet “Out of this World Measurements, Explained” and ask them to explore two or three resources. They should focus on things that they thought could not be measured from space. It is up to you to decide if they should do this individually or with a partner. After they have explored, ask them to share what they learned with a student who explored a different resource.</td></tr></table>
Part 2: Observing the Earth from the Moon (90 minutes)

Note, if your students are engaged with Unit 1, Lesson 4, this is a good time to remind them about the four Earth spheres and some interactions. If your students did not engage with this lesson, consider going back to review parts of that lesson about the four Earth systems, particularly large-scale interactions.

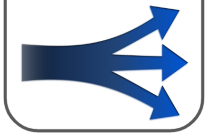
For this activity, students will choose a change to an Earth system that astronauts could observe from the Moon, perform research, and answer questions about their Earth observations. First, we will look at an</td><td>Part 1:
“Out of this World Measurement” handout (scroll down, MS and HS only)

“Out of this World Measurement, Explained” (scroll down, MS and HS only)</td></tr>
</table>

example.

Grade Level Adaptation 	**Choose one of these examples to share with the class.** **Elementary Example:** We are going to watch this short video several times. What is changing? What Earth Systems are involved? https://svs.gsfc.nasa.gov/12564 **Middle / High School Example:** We are going to watch this video, which was compiled from data over several years. Note the date. What is changing? What do you notice and wonder? What Earth Systems are involved? https://svs.gsfc.nasa.gov/5047 Green means net negative CO2 (absorbing more CO2 from the atmosphere). Purple means net positive CO2 (producing/releasing more CO2 to the atmosphere).

Now, students will choose a topic and do some research, including answering several prompts. If students have trouble picking a topic, you can provide some of the resources below to give them ideas. Students can work on this task individually or in pairs. They should take notes and make diagrams or electronic presentations to share later.

Grade Level Adaptation 	Numerous resources are organized below by grade band. Preview the resources and decide which will work best for your students. The prompts for each grade band also vary slightly.

Elementary	**Middle**	**High**
Some ideas could include: ● Volcanic eruptions ● Sea ice cover ● Landslides ● Wildfires	Some ideas could include: ● Any elementary idea ● Changes to glaciers ● Sea level rise ● Seasonal ground cover	Some ideas could include: ● Any middle or elementary school idea ● CO2 level ● Ozone layer

• Hurricanes • Deforestation • Floods • Light pollution at night https://earthobservatory.nasa.gov/blogs/eokids/ The side bar has a whole list to choose from. https://climate.nasa.gov/images-of-change/ (Click on the "waffle" in the upper right to see a list of all of the photo comparisons and choose a few. After you choose one, click on the blue arrow under the photos to get more information.) Interaction cards from Unit 1, Lesson 4 (Which are large enough to be observed or measured from space?)	(plants) • Snowpack amounts • Ocean currents • Plate tectonics (very long term!) https://earthobservatory.nasa.gov/blogs/eokids/ The side bar has a whole list to choose from. https://svs.gsfc.nasa.gov/Gallery/index.html (Choose from all Earth visualizations here) https://climate.nasa.gov/images-of-change/ (Click on the "waffle" in the upper right to see a list of all of the photo comparisons and choose a few. After you choose, one click on the blue arrow under the photos to get more information.)	https://svs.gsfc.nasa.gov/Gallery/index.html (Choose from all Earth visualizations here) https://climate.nasa.gov/images-of-change/ (Click on the "waffle" in the upper right to see a list of all of the photo comparisons and choose a few. After you choose one, click on the blue arrow under the photos to get more information.)	
PROMPTS: • What is your Earth System change? • Which Earth systems are involved? • What is the time scale of the change (days/ weeks/ months/ years/etc)? • What would the change look like from the Moon? • What question scientists might want to know about your change. In other words, what is still unknown about this kind of change?	PROMPTS: • What is your Earth System change? • Which Earth systems are involved? • What kinds of forces and energy are involved in the change and cause / effect relationships? If possible, include effects in all four Earth systems. • What is the time scale of the change (days/ weeks/ months/ years/etc)? Is it a one-time event or a cycle? • What would the change	PROMPTS: • What is your Earth System change? • Which Earth systems are involved? • What kinds of forces and energy are involved in the change and cause / effect relationships? If possible, include effects in all four Earth systems. • What is the time scale of the change (days/ weeks/ months/ years/etc)? Is it a one-time event or a cycle? • What would the change	

<table>
<tr>
<td></td>
<td>
<table>
<tr>
<td>Feel free to include a series of labeled drawings or a comic-strip with your explanation.</td>
<td>look like from the Moon?
• What question scientists might want to know about your change. In other words, what is still unknown about this kind of change?

Feel free to include a series of labeled drawings or a comic-strip with your explanation.</td>
<td>look like from the Moon?
• What question scientists might want to know about your change. In other words, what is still unknown about this kind of change?

Feel free to include a series of labeled drawings or a comic-strip with your explanation.</td>
</tr>
</table>
Circulate as students work and check in with their progress on choosing a phenomenon to observe and answer the prompts.
</td>
<td></td>
</tr>
<tr>
<td>Explain
(45 Min)</td>
<td>Students will share the results of their research and understanding of the Earth systems they will observe from space, give and receive feedback, and discuss how all of the changes studied impact the four Earth systems.

After students have had a chance to research the Earth systems that they will observe or measure from the Moon and answer the reflection questions, allow each student, pair, or group to work with another student, pair, or group to discuss the change they observed.</td>
<td></td>
</tr>
<tr>
<td>Elaborate
(60 - 120 Min)</td>
<td>Students will “zoom out” from thinking about the Earth to consider the Sun/Earth/Moon system and how this system impacts what people on the Moon will see and the scientific and possible cultural explanations of these phenomena.

<table>
<tr>
<td>Grade Level Adaptation
  </td>
<td>The Elaborate section of this lesson has two parts. Part 1 involves students understanding the Earth/Moon/Sun model by thinking deeply about what this system will look like from the Moon. This section is geared towards Middle and High School students.

If you teach Elementary age students, you can choose to skip Part 1 entirely or briefly discuss it with students, but spend most of the time focusing on Part 2.</td>
</tr>
</table>
Part 1: Sun/Earth/Moon System Claims (60 min)

NOTE: If your students completed Unit 1, Lesson 3, now is a good time to revisit the “Explore” and “Explain” portions of the lesson for reminders about how the Sun/Earth/Moon system looks (as viewed from Earth). In this part of the lesson, you will ask students to consider what the Sun/Earth/Moon system</td>
<td>Part 1

Various spherical objects for students to use to model the Sun/Earth/Moon system.

Measurement tools (ruler, tape measure, etc)

Flashlights

Claims/Evidence/Reasoning Template (scroll down)
Spanish Version:</td>
</tr>
</table>

	will look like when viewed from the Moon. If your students did not complete Unit 1, Lesson 3, now is a good time to review resources in the lesson related to Moon phases and how the Moon looks when viewed from the Earth and why. SAY: When people spend long periods of time on the Moon, they will have a chance to observe patterns of the Earth and Sun. You are going to work with a partner (or small group) to explore one or more of these questions about what it will be like to observe things from the Moon. Prepare to make a claim about at least one of these questions. We have some spherical objects here for you to use as a model to help you consider these ideas. 1. How big will the Earth look from the Moon? How big will the Sun look from the Moon? 2. How fast and in which direction will the Earth move across the sky when viewed by astronauts from the Moon? 3. Predict how often astronauts will see the same spot on the Earth from the Moon (for example, your hometown). Does the frequency change or stay the same? 4. Are there places on Earth that astronauts won't be able to see from the Moon? 5. Does the Earth appear to have phases from the Moon? If so, describe them and the pattern they take. Allow students to select the question that interests them most, or assign questions to students. Then, provide the "Claims/Evidence/Reasoning" template and make sure students review and ask questions about the template. Students may wish to create diagrams or use spherical objects and/or flashlights to model the Earth/Moon/Sun system. What they pay attention to, model, and measure will vary based on which question they are exploring. Circulate as students work, asking guiding questions and making sure that they can explain their evidence and reasoning for their claims. Teacher guidance on the questions above are provided in the handouts section. If students finish early, ask them to consider the following question and add new evidence to their claim: "NEXT LEVEL" PROMPT: NASA's base on the Moon will be located near the South Pole of the Moon. Does that change anything about your claim or evidence? (Same claims are "No, this changes nothing because…" or "Yes this changes (something / everything) because…" After students have made their claims, group all students who had the same question to compare and contrast their claim/evidence/reasoning work. They may have areas of disagreement or want to update their answers based on this discussion. Then, group students who had different questions so that they can take turns explaining their claims to each other.	

	 *NOTE: If your students completed Unit 1, Lesson 3, now is a good time to revisit the "Elaborate" portion of the lesson for reminders about cultural stories about the Moon (as viewed from Earth). In this part of the lesson, we will turn that around and create our own stories about the Earth (as viewed from the Moon). If your students did not complete Unit 1, Lesson 3, now is a good time to review resources in the "Elaborate" portion of that lesson, including the Padlet of Moon stories and calendars.* **Part 2: Culturally Responsive Storytelling (60 min)** Cultural connections. Imagine that people have been living on the Moon for a very long period of time. They understand the science of the changes they observe on Earth, but still like creating stories and calendars to describe and explain what they see. Craft a story or calendar that Moon-dwelllers might create to explain the Earth System change you described in Explore/Explain (or, for Middle/High school, the Sun/Earth/Moon system question that you chose in this portion of the lesson). Be as creative as you'd like to be! Importance of stories and storytelling: https://quileutenation.org/stories-and-tales/ You can share this example with your students: A2 U3 L3 Culturally Responsive Storytelling - Sun Example. The example is about the Sun, but your students might benefit from seeing this example if they are unsure about completing this task combining science and creativity! Students can create slides like this example, a poster or drawing, or just a narrative story. After students have completed their stories, allow them to share in pairs, small groups, or as a whole group. (Whole group sharing will take the longest, pair sharing will take the shortest amount of time.)	
Evaluate (30 Min)	***Students will reflect on the lesson and record their ideas in their MDL.*** In their MDLs, students should include both their answers to the prompts from the Explore (Part 2) section as well as their story about observing the Earth from the Moon from the Elaborate (Part 2) section.  Middle and High School students should also include their final Claim / Evidence / Reasoning about the Earth/Moon/Sun system question that they chose.	

Extend (Optional)	**(Middle School / High School):** This option is for students who completed the Part 1 of the Elaborate section (Sun/Earth/Moon system claims). Update your Claims/Evidence/Reasoning considering the following prompt: The Moon base will probably be located near the south pole of the Moon. Does that change any of your answers? How would things look differently if the base was on the equator of the Moon, facing Earth? What about if it was on the side of the Moon facing away from Earth?	

Out of This World Measurements

Many surprising things can be observed or measured from space. Remember, satellites orbit the Earth outside of the atmosphere. Sort the list below into things you think CAN be measured from space and things you think CANNOT be measured from space by writing the number of each choice in one of the boxes below.

1. Air temperature	2. Water temperature (in the ocean)	3. Carbon Dioxide in the atmosphere	4. Wind speed
5. Humidity (how much water is in the atmosphere)	6. Sea level	7. Amount of photosynthesis	8. Wind direction
9. Soil Moisture (how much water is in soil)	10. Salinity (how much salt is in the ocean)	11. Wave height (in the ocean)	12. Percent Cloud Cover
13. Surface temperature (of the soil)	14. State of precipitation (solid or liquid)	15. Moisture content of clouds	16. Cloud Thickness
17. Barometric air pressure	18. Amount of precipitation (inches)	19. Amount of solar energy reaching Earth	20. Cloud Type
21. Gravity	22. Snow depth on the ground	23. Lightning strikes	24. Air pollution

Part A: List each of the numbers in one of these options		**Part B: Choose one thing that you are pretty sure CAN be measured from space and one thing that you are pretty sure cannot be measured from space. List the number in the blank and explain your thinking below.**	
CAN be measured from space	**CANNOT be measured from space**	**I think that _____ can be measured from space because:**	**I think that _____ cannot be measured from space because:**

Out of this World Measurements, Explained

Here are some NASA resources that explain how many of these are measured from space.

1. Air temperature	2. Water temperature (in the ocean) https://www.youtube.com/watch?v=q_xPsKRuoEc	3. Carbon Dioxide in the atmosphere NASA Space Missions Pinpoint Sources of CO2 Emissions on Earth	4. Wind speed https://www.youtube.com/watch?v=HPSv1vUZ3bc
5. Humidity (how much water is in the atmosphere) https://science.nasa.gov/technology/technology-highlights/cubesat-mission-demonstrate-innovative-method-mapping-soil-moisture-and-snow-space#:~:text=Space%2Dbased%20methods%20to%20measure,it%20reflects%20from%20the%20soil.	6. Sea level https://www.youtube.com/watch?v=Jy2oZ2xX_zY How does NASA study sea-level change?	7. Amount of photosynthesis NASA | Seeing Photosynth…	8. Wind direction https://www.youtube.com/watch?v=HPSv1vUZ3bc
9. Soil Moisture (how much water is in soil) https://www.youtube.com/watch?v=-7_YdsNb2w4 https://svs.gsfc.nasa.gov/30177	10. Salinity (how much salt is in the ocean) https://www.youtube.com/watch?v=5xQP_B18vMw	11. Wave height (in the ocean) Ocean Waves | PO.DAAC	12. Percent Cloud Cover Cloud Fraction
13. Surface temperature (of the soil) New Studies Increase Confidence in NASA's Measure of Earth's Temperature	14. State of precipitation (solid or liquid) NASA Understanding Earth - What's Up With Precipitation?	15. Moisture content of clouds	16. Cloud Thickness
17. Barometric air pressure https://education.nationalgeographic.org/resource/atmospheric-pressure/	18. Amount of precipitation (inches) https://www.youtube.com/watch?v=wwEhG-rYLcQ	19. Amount of solar energy reaching Earth Four decades and counting: New NASA instrument continues	20. Cloud Type Why Does NASA Have Its Head in the Clouds?.

	The Global Precipitation Measurement Mission (GPM).	measuring solar energy input to Earth	
21. Gravity Grace - Earth Missions - NASA Jet Propulsion Laboratory	22. Snow depth on the ground NASA Scientist Discovers New Means to Measure Snow Depth from Space	23. Lightning strikes https://www.youtube.com/watch?v=KRTJyDkb0EU	24. Air pollution https://www.youtube.com/watch?v=sRtxHfVvbKs

Elaborate, Part 1 (TEACHER GUIDANCE)

- Provide the least amount of guidance and support that still allows students to make progress.
- If students make claims or partial claims, ask what evidence supports their claim or why they think their claim is true.
- Resist the urge to declare certain claims right or wrong. Focus on whether students have evidence and reasoning to support their claims.

Question	Some Sample Claims	Some Potential Sources of Evidence	Guiding Questions for Students
1. How big will the Earth look from the Moon? How big will the Sun look from the Moon?	The Earth will look (some description of size) from the Moon because…. The Sun will look (some description of size) from the Moon because…	Measurements of the size of the Sun, Earth and Moon and the distances between them. How the Sun/Earth/Moon system looks from the Earth. Evidence from modeling or diagrams. Mathematical calculations involving scale factor.	How would you describe how big the Sun and Moon look from Earth? How could we measure this? Do the Sun and the Moon appear the same size from Earth, or different sizes? (Yes. Evidence = Solar Eclipses when the Moon almost perfectly obscures the Sun.) Are the Sun and the Moon the same size in reality? (No, the Sun is much larger.) How could you model this using spheres to represent the Sun, Moon and Earth? What could you observe or measure?
2. How fast and in which direction will the Earth move across the sky when viewed by astronauts from the Moon?	The Earth won't move across the sky when viewed from the Moon because… The Earth will move (description of movement might be left to right, back and forth, in a circle) across the sky in (some measurement of duration, like Earth hours, Earth days, Earth years, etc) when viewed from the Moon because…	Model of the Earth/Moon/Sun system (diagram, physical models, etc)	How could you model this using spheres to represent the Sun, Moon and Earth? What could you observe or measure? How would you model and describe how fast and what direction the Moon moves across the sky when viewed from Earth? How could this help us answer the question? What is the difference between rotate and revolve? What kinds of movement of the Sun, Earth, and Moon are most important for figuring this claim out?
3. Predict how often astronauts	Astronauts will see my home town every ((some	Model of the Earth/Moon/Sun system (diagram, physical	How could you model this using spheres to represent the

will see the same spot on the Earth from the Moon (for example, your hometown). Does the frequency change or stay the same?	measurement of duration, like Earth hours, Earth days, Earth years, etc) when viewed from the Moon because…. Astronauts will not see my hometown at all when viewed from the Moon because…. Astronauts will see my hometown when viewed from the Moon but I the frequency will vary because….	models, etc).	Sun, Moon and Earth? What could you observe or measure? What is the difference between rotate and revolve? What kinds of movement of the Sun, Earth, and Moon are most important for figuring this claim out? What have previous astronauts seen and documented from the Moon?
4. Are there places on Earth that astronauts won't be able to see from the Moon?	Astronauts will be able to see every point on the Earth from the Moon because… Astronauts will only be able to see (describe parts of Earth that you will be able to see) from the Moon because…	Model of the Earth/Moon/Sun system (diagram, physical models, etc)	What have previous astronauts seen and documented from the Moon? How could you model this using spheres to represent the Sun, Moon and Earth? What could you observe or measure?
5. Does the Earth appear to have phases from the Moon? If so, describe them and the pattern they take.	The Earth does NOT appear to have phases from the Moon because…. The Earth does have phases from the moon that take the pattern (describe the pattern they take, including some measure of duration) because…	Photos or videos of the Earth taken from the Moon (like the famous Earthrise photo) Model of the Earth/Moon/Sun system (diagram, physical models, etc) Comparison to how Moon phases work	What have previous astronauts seen and documented from the Moon? (Note, this answers the yes/no claim, but does not provide evidence to explain why) What causes Moon phases (when viewed from Earth? How can we model Moon phases to help us understand Earth phases? How could you model this using spheres to represent the Sun, Moon and Earth? What could you observe or measure? (They may also need a light source.)

Elaborate**: Claims/Evidence/Reasoning Planning Template** **Name:**_____

Use this template to plan your Claims/Evidence/Reasoning statement before you begin to write.

My **claim** is:

Explanation:	Labeled drawings to explain your claim.

The **evidence** that supports this claim is:

Evidence	Source of Evidence	The **reasoning** that explains why the evidence supports the claim is: