Lesson 3.2
Making Sense of Where Raindrops Form
Lesson Overview

Students build on the understanding they gained in Lesson 3.1 of where water vapor condenses in the atmosphere and why it condenses there. Students begin by predicting which areas of the atmosphere in a Sim landscape will have the most condensation. They use *The Earth System* Simulation to collect data on where and at what temperatures water vapor condenses in the atmosphere. They then graph their data set in *The Earth System* Data Tool to look for patterns, concluding that more condensation occurs high in the atmosphere because it is colder there. Finally, students reflect on where raindrops form in the atmosphere and why. The purpose of this lesson is to provide evidence that water vapor must move high up in the atmosphere for condensation to occur and create rain.

**Anchor Phenomenon:** One side of Ferris Island has a water shortage and the other does not.

**Predicted Phenomenon:** The amount of condensation in different parts of the atmosphere

**Students learn:**

- Water vapor condenses as it moves higher, to where the atmosphere is colder.
- When liquid water evaporates, water molecules do not disappear; they change to water vapor.
- Scientists and engineers graph data to help them visualize and recognize patterns.
Students gather data about where water vapor condenses in the atmosphere using *The Earth System* Simulation.

**Instructional Guide**

1. **Introduce the purpose of Sim investigation.** Explain that students will be gathering and analyzing data from the Sim to see if the data supports the ideas students discussed about where water vapor condenses.

2. **Focus on analyzing data.** Explain that collecting and analyzing data is an important practice in science.

   Scientists and engineers collect and analyze data, which are observations or measurements recorded in an investigation. Analyzing data helps scientists and engineers figure out patterns that help them explain why things happen. They might have an idea about how something works, but collecting and analyzing data provides evidence they can use to support their ideas.

3. **Project The Earth System Simulation.** Project the Student Apps Page and select *The Earth System* and then the Simulation. Choose any landscape. In Analyze, highlight

   - the Atmosphere Window, which only shows molecules that are in the atmosphere
   - the Air Temperature and Height measurements

   Explain to students when they move the window to the different heights listed in the data table, they should move it to where there are the most molecules at that height.

4. **Introduce notebook page 52.** Have students turn to page 52, Investigating Where Water Vapor Condenses, in the Investigation Notebook. Review the instructions and demonstrate each step using your projected Sim.

   Your goal is to use the Sim to investigate where water vapor condenses, then answer the questions.

   - Step 1: Choose any landscape.
• Step 2: In RUN, check that Wind is OFF and the Water Molecules toggle is ON. Make sure these settings are applied in your projected Sim, then let the Sim run for a few moments.

• Step 3: Observe where condensation is happening in the atmosphere.

• Step 4: Press ANALYZE, then replay to make further observations. Use the slider to scroll to just before rain begins to fall. Place the Atmosphere Window at 2 km above the lake or ocean. Record temperature and water molecule data in the table below.

Point out the table listing the different heights students should test. Explain that 2 km is the first height listed in the table, so they will test that one first. Have students tell you what data they would record for temperature and water molecules, based on your projected Sim.

• Step 5: Repeat Step 4 for each height listed in the table below. Students should repeat the steps for different heights in the atmosphere using the same landscape.

5. Designate pairs and distribute digital devices. Distribute one digital device to each pair of students and direct them to The Earth System Simulation. As needed, remind students of the Guidelines for Using Apps.

6. Pairs work in the Sim and collect data. Circulate and provide assistance as needed. Prompt students to switch “drivers” after they collect the first two sets of data.

7. Have students set their digital devices aside.

Teacher Support

Rationale

Pedagogical Goals: Collecting Data in the Sim
The previous lesson introduced students to the idea that water vapor is more likely to condense high up in the atmosphere because it is cold there. In this lesson, students collect data in the Sim to collect both visual support and quantitative evidence for this phenomenon.

Background

Technology Note: Inaccuracies of the Sim
It is important to remind students that The Earth System Simulation is a model, which makes it a useful learning tool but not entirely accurate. An inaccuracy that is especially prominent in this lesson is that the numbers of water molecules in the simulated atmosphere is much lower than the number of water molecules in the real atmosphere. However, the ratio of water vapor to liquid water at different heights in the atmosphere is roughly accurate. This is why the data students collect is still useful for learning about patterns of condensation in the atmosphere.
Possible Responses

The Earth System Simulation

What students should do and notice:
Students should choose any landscape and let the Sim run with Wind off. With the Water Molecules toggle off, students should observe where in the atmosphere they see rain forming. In Analyze, with the Water Molecules toggle on, students should use the Atmosphere Window to measure the amount of water vapor and liquid water in different parts of the atmosphere. Students should measure above the center of the body of water at the heights indicated on the notebook page. Students should notice that the temperature of the air decreases as height in the atmosphere increases. Condensation occurs at low temperatures high in the atmosphere, and rain only occurs where there is a high density of water vapor.

Below is an example of the data that students might collect. There is no single correct set of values for these measurements. Generally, students should notice the amount of water vapor decreasing and the amount of liquid water increasing as the height in the atmosphere increases and temperature decreases.

Row 1
2 km / 10.0°C / 9 / 0
Row 2
3 km / 5.0°C / 10 / 0

Row 3
4 km / 0.0°C / 3 / 9

Row 4
5 km / -5.0°C / 4 / 12
Investigating Where Water Vapor Condenses

Use the Sim to investigate where water vapor condenses, then complete the table below.

1. Choose any landscape.
2. In RUN, check that Wind is OFF and the Water Molecules toggle is ON.
3. Observe where condensation is happening in the atmosphere.
4. Press ANALYZE, then replay to make further observations.
   - Use the slider to scroll to just before rain begins to fall.
   - Place the Atmosphere Window at 2 km above the lake or ocean.
   - Record temperature and water molecule data in the table below.
5. Repeat Step 4 for each height listed in the table below.

<table>
<thead>
<tr>
<th>Height in the atmosphere</th>
<th>Temperature</th>
<th>Water vapor (# of molecules)</th>
<th>Liquid water (# of molecules)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 km</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 km</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 km</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 km</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Analyzing Data About Where Water Vapor Condenses

Answer the following questions using the data table on the previous page.

How does temperature change as you get higher in the atmosphere?
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

How do the amounts of molecules in water vapor and liquid water change as you move from 3.0 to 4.0 kilometers in the atmosphere?
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

Where does water vapor condense most? Why do you think more condensation is happening there than in other areas of the atmosphere?
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
Students gather data about where water vapor condenses in the atmosphere using *The Earth System* Simulation.

**Instructional Guide**

1. **Introduce the purpose of Sim investigation.** Explain that students will be gathering and analyzing data from the Sim to see if the data supports the ideas students discussed about where water vapor condenses.

2. **Focus on analyzing data.** Explain that collecting and analyzing data is an important practice in science.

   Los científicos y los ingenieros recolectan y analizan datos, los cuales son observaciones o mediciones apuntadas en una investigación. Analizar datos ayuda a los científicos y a los ingenieros a identificar patrones que les ayudan a explicar por qué suceden las cosas. Ellos podrían tener una idea acerca de cómo funciona algo, pero recolectar y analizar datos proporciona evidencia que pueden usar para respaldar sus ideas.

3. **Project The Earth System Simulation.** Project the Student Apps Page and select *The Earth System* and then the Simulation. Choose any landscape. In Analyze, highlight

   - the Atmosphere Window, which only shows molecules that are in the atmosphere
   - the Air Temperature and Height measurements

   Explain to students when they move the window to the different heights listed in the data table, they should move it to where there are the most molecules at that height.

4. **Introduce notebook page 52.** Have students turn to page 52, Investigating Where Water Vapor Condenses, in the Investigation Notebook. Review the instructions and demonstrate each step using your projected Sim.

   Su objetivo es usar la Simulación para investigar en dónde se condensa el vapor de agua, luego responder las preguntas.
Point out the table listing the different heights students should test. Explain that 2 km is the first height listed in the table, so they will test that one first. Have students tell you what data they would record for temperature and water molecules, based on your projected Sim.

- **Step 5:** Repeat Step 4 for each height listed in the table below. Students should repeat the steps for different heights in the atmosphere using the same landscape.

5. **Designate pairs and distribute digital devices.** Distribute one digital device to each pair of students and direct them to *The Earth System Simulation*. As needed, remind students of the Guidelines for Using Apps.

6. **Pairs work in the Sim and collect data.** Circulate and provide assistance as needed. Prompt students to switch “drivers” after they collect the first two sets of data.

7. **Have students set their digital devices aside.**

**Teacher Support**

**Rationale**

**Pedagogical Goals: Collecting Data in the Sim**

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Possible Responses

_The Earth System Simulation_

**What students should do and notice:**
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**Row 1**
2 km / 10.0°C / 9 / 0
<table>
<thead>
<tr>
<th>Row</th>
<th>Distance</th>
<th>Temperature</th>
<th>Time 1</th>
<th>Time 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>3 km</td>
<td>5.0°C</td>
<td>10 / 0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>4 km</td>
<td>0.0°C</td>
<td>3 / 9</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>5 km</td>
<td>-5.0°C</td>
<td>4 / 12</td>
<td></td>
</tr>
</tbody>
</table>
Investigar dónde se condensa el vapor de agua

Usa la simulación para investigar dónde se condensa el vapor de agua, luego completa la tabla debajo.

1. Elige cualquier paisaje.
2. En la opción RUN (accionar), chequée que Wind (el viento) esté OFF (apagado) y que el interruptor de Water Molecules (moléculas de agua) esté ON (encendido).
3. Observa en qué parte de la atmósfera está ocurriendo la condensación.
4. Oprime ANALYZE (analizar) y luego vuelve a repetir la simulación para hacer observaciones adicionales.
   • Usa la barra de ajuste para desplazarte hasta el punto justo antes de que la lluvia empiece a caer.
   • Coloca la ventana Atmosphere (atmósfera) a 2 km por encima del lago o del océano.
   • Apunta los datos sobre temperatura y moléculas de agua en la tabla debajo.
5. Repite el paso 4 para cada altura indicada en la tabla debajo.

<table>
<thead>
<tr>
<th>Altura en la atmósfera</th>
<th>Temperatura</th>
<th>Vapor de agua (número de moléculas)</th>
<th>Agua líquida (número de moléculas)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 km</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 km</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 km</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 km</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Analizar datos sobre dónde se condensa el vapor de agua

Responde las preguntas siguientes usando la tabla de datos en la página anterior.

¿Cómo cambia la temperatura a medida que llegas más alto en la atmósfera?
___________________________________________________________________
___________________________________________________________________

¿Cómo cambian las cantidades de moléculas de agua en el vapor de agua y en el agua líquida a medida que te mueves de 3.0 a 4.0 kilómetros en la atmósfera?
___________________________________________________________________
___________________________________________________________________

¿En dónde se condensa más el vapor de agua? ¿Por qué crees que está ocurriendo más condensación ahí que en otras áreas de la atmósfera?
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________