**Anchor Coaching prompts:**

**After the video:**

* *What did you hear in the video about the causes of the precipitation?*
* *Where did all the moisture over CO come from?*
* *What had to happen to make that moisture turn into rain?*

**After sharing storm experiences:**

* *How do storms begin in the first place?*
* *What needs to happen so that rain or snow starts to fall?*
* *Why do some places get heavier precipitation but other places do not?*
* *Where does all the water come from before it falls as rain or snow?*

**After making model for Colorado Storm:**

* Point out common features/mechanisms that students were using across models, such as clouds, wind, air, precipitation, temperature differences.

**Sunny Day/Stormy Day (Lesson 2: Steps 1-3):**

**KEY PATTERN: The morning begins clear, clouds appear, and the storm occurs in the afternoon. The Sun’s energy warms water at/near the surface and causes it to evaporate. The heat and evaporated water traveled up from the ground. While there are several factors related to the difference between a sunny & stormy day, the available moisture in the atmosphere is an important one.**

Prompts:

* *What can we observe about weather by watching the sky over time?*
* *What would we see if we watched the sky on a day when a storm was forming?*
* *How can the video of the sky over time help us figure out more about clouds and storms?*
* *In the diagrams, we can see that the clouds are high above the ground. If you could somehow investigate the air up high compared to the air near the ground, what do you think you would see?*
* *What are some measurements you would want to take of the air from different altitudes? How might those measurements help us figure out how clouds start to form on a sunny day?*

**Weather Balloon Simulation (Lesson 3: Steps 1-3):**

**KEY PATTERN: Temperature is warmer near Earth’s surface and temperature decreases as the weather balloon moves higher into the atmosphere where clouds/storms form. *(Note: This pattern holds true in the troposphere.)***

Prompts:

* *If we were able to look closely at different altitudes, from near the surface to high in the sky, what temperature pattern would you expect to see?*
* *How do you think the results would compare if we measured temperature throughout a school day?*

**Temperature Graph (Lesson 3: Step 4):**

**KEY PATTERN:The surface is warmer than the air above it but that the two temperatures mirror each other as the Sun heats the Earth, and the Earth warms the air by conduction.**

Prompts:

* *Why do we think surface temperature is warmer than the air temperature above it?*
* *How is the warm air moving? Does this match our temperature pattern?*
* *More advanced question for students with prior knowledge of particles and temperature: What’s happening to the air molecules when they are heated near the surface?*

**Westview Middle School DATA SET**

Middle school students in Longmont, Colorado wanted to know how the ground temperature (surface temperature) compared to air temperature. They measured both temperatures over a school day. Their surface temperature data were measured on their school track and their air temperature thermometer was located on the school roof. The students agreed these two surfaces were the most similar, which is why they selected the school track for their surface temperature location. They measured both temperatures every hour during the school day. They also made observations of cloud cover.

**Make a Model of how sunlight warms the atmosphere (Lesson 3: Steps 5-6)**

**KEY PATTERNS: The surface is warmed by solar radiation. That heat conducts to the air, causing the air to warm and rise. The graph of surface and air temperatures provides evidence that the surface is always warmer than the air around it, which support this idea. The air temperature is lower at higher altitudes, which we learned in the weather balloon launch simulation. As warmed air rises through the atmosphere, it will begin to cool.**

Prompts:

* *Why do we think surface temperature is warmer than the air temperature above it?*
* *How is the warm air moving? Does this match our temperature pattern?*
* *What’s happening to the air molecules when they are heated near the surface?*

**Temperature & Humidity Graphs (Lesson 4: Steps 1-2)**

**AIR TEMP:**

* **Sunny pattern: Temperature gradually warms and then gradually cools on a sunny day**
* **Stormy pattern: Temperature gradually warms but then quickly cools in the afternoon**

**HUMIDITY:**

* **Sunny pattern: Humidity begins high but goes down during the day**
* **Stormy pattern: Humidity begins high and starts to go down, then it climbs really high, really quickly in the afternoon/early evening**

Prompts:

* *What patterns do you see in the data that indicate a storm?*
* *Why did it rain on one day and not the other?*
* *What were temperature and humidity like before, during and after the storm?*

**Bottle Model (Lesson 4: Step 3)**

**KEY PATTERNS: Both bottles experience warming, but only the wet sand bottle will form water droplets at the top of the bottle. The bottle with wet sand provides a source of humidity, which is necessary for storm formation. Condensation at the top of the bottle is evidence of a “storm” happening in the bottle model. The bottle with dry sand will not show condensation.**

Prompts:

* *What happened to the water at the surface before it traveled to the top of the bottle?*
* *What happened to the water at the top of the bottle?*
* *How did that water get up there? Why would it go up?*
* *Changing the amount of water in the system (humidity/moisture) was important. If a town is located far from an ocean or large body of water, where does the water come from?*

*• Using evidence from the bottle models what conditions are best for storms?*

**Mylar Balloon Investigation (Lesson 5: Step 1-2):**

**KEY PATTERN: As the air in the balloon is warmed, the balloon will expand and rise. When the air inside the balloon cools, it will sink again. If students are new to particle motion and thermal energy, they may be more uncertain about what’s happening in the balloon. You are steering them toward a basic understanding that warmed air molecules move more and are more spread apart, and vice versa for air molecules that have cooled.**

Prompts:

* *What is happening to the air inside the balloon?*
* *Why is the balloon rising and sinking?*

**Make a Thunderstorm simulation (Lesson 6: Step 1-2)**

**KEY PATTERN: Warm temperatures near the surface and colder temperatures higher in the atmosphere with high humidity are ideal conditions for thunderstorms.**

**• If there is less of a temperature difference between the two altitudes, weaker storms may still form.**

**• If there is low humidity, regardless of temperature, thunderstorms will not form.**

Prompts:

* *At what time of day would you expect a thunderstorm?*
* *Why doesn’t a big storm always form when humidity is present?*
* *What is different in the atmosphere on days when a big storm forms vs a smaller storm?*

**When did it Rain? (Lesson 6: Step 3)**

**KEY PATTERN: Looking at temperature and humidity data for two days allows students to identify the time that rain happened and explain their choice based on patterns in the data. On July 21st, just after noon there is a drop in temperature and a rise in humidity signifying an isolated storm. On July 22nd, there is no drop in temperature that correlates with a rise in humidity which means there was not a storm that day.**

Prompts:

* *What time of day would you expect an isolated storm to occur? Remember what is needed for air near the ground to rise into the atmosphere.*
* *What were conditions like leading up to the storm, and how did they change during and after the storm?*

**Cold Front Time-lapse video (Lesson 7: Step 1-2):**

**In the video you can see a few high-level cirrus clouds right after sunrise (starting at 20 sec.). Then mid-level clouds, lower and more uniform, form (starting at 27 sec.). Small, low-level cumulus clouds can be seen forming later (around 50 sec.). They grow into a cumulonimbus cloud that starts producing precipitation (about 1 min. 15 sec.). The cumulonimbus clouds change over the rest of the day, sometimes producing precipitation and sometimes not.**

Prompts:

* *How is the storm different in this video different from an isolated storm?*
* *Did the storm happen in the afternoon, like the one in our model?*
* *Did the storm last a short time (like a few hours) or did it last longer?*
* *How did the storm change the weather? What was the temperature like before, during and after the storm?*

**Examine a Weather Forecast of a Cold Front (Lesson 7: Step 3):**

**KEY PATTERN: The storm front moved through the area on Thursday, as indicated by rain. Students should notice an increase in cloud cover and a decrease in air temperature leading up to the front. There would also be an increase in humidity before the storm, and a decrease in humidity after the storm.**

Prompts:

* *What day do you think the storm front moved through the area?*
* *What was the air like before (Sat-Wed), during (Thurs) and after the front (Fri)?*
* *Do you think the humidity was high or low before, during and after the front?*
* *What kind of data would be useful to figure out more about this kind of storm?*

**Data analysis: Temperature, Humidity, and Wind Speed in a Cold Front (Lesson 8: Step 1-3):**

**KEY PATTERN: Students should notice a regular diurnal pattern before the front that gets disrupted. This diurnal pattern returns after the front, but it’s colder. This graph is different from the ones in the past, as it shows data collected over several days vs. just one day.**

Prompts:

* *What day do we expect the front to move into South Riding, Virginia? How long will the front be in the area? How can you tell?*
* *What do we think the wiggly up and down line means?*
* *How do the ups and downs relate to the temperature ups and downs on our sunny day/stormy day graph?*
* *How is this storm similar to or different from the isolated storm?*
* *If you collected weather data at your school, what types of weather events would you likely observe?*

**Density tank demonstration (Lesson 9: Step 1&2):**

**KEY PATTERN: Air in the atmosphere behaves as a fluid. The density tank models the interaction of air masses of different temperatures. The cold fluid is more dense and pushes the warm fluid up above it.**

Prompts:

* *What happened to the warm fluid? What happened to the cold fluid? Why did this happen?*
* *What would happen to the warm air ahead of the front and the cold air behind the front when the come together?*
* *How could the density tank help explain precipitation along a front?*

**Interactive Reading: Investigating Air Masses and Fronts (Lesson 9: Steps 4-5):**

KEY PATTERN: Student’s read about the phenomenon of a cold front to clarify how frontal weather systems are different from isolated storms. They are also introduced to different types of weather maps and symbols for three different types of fronts (cold front, warm front, and stationary front). Students create a diagram to show two different ways that moisture becomes available: in an isolated storm through convection, and in a cold front through the interaction of two air masses.

Prompts:

* *What do the different symbols mean?*
* *What information does the map show?*
* *What type of air mass was over Freedom High School before the front moved in? What type of air mass was over Freedom High School after the front moved in?*
* *What happened as the cold air mass moved into the warm air mass at Freedom High School?*

**Tracking a cold front over four days (Lesson 9: Step 6):**

KEY PATTERN: Using four days of data temperature and precipitation data, students observe the front moving east and the changing location of the warm and cold air masses. Students should use temperature data to back up their decision about the location of air masses. Students notice that some locations along the front had precipitation while other locations did not.

Prompts:

* *How can we use temperature to figure out the kind of air over a region?*
* *Where do we think the cold air mass comes from? Why?*
* *Where do we think the warm air mass comes from? Why?*
* *If we predicted the weather for the next day, which direction would the front move?*
* *Let’s use our model to figure out why some locations along the front had precipitation while others did not.*

**Remember Air Pressure? (Lesson 10: Step 1):**

KEY PATTERN: Sinking air in an area of high pressure is more dense than rising air in an area of low pressure. In an area of high pressure, the movement of air vertically down causes the horizontal movement of air away from the center of high pressure. In an area of low pressure, the movement of air vertically upward causes the horizontal movement of air towards the center of low pressure.

Prompts:

* *What happens to air when there is high pressure? Where does it go?*
* *The circles you drew show how air moved at the ground level. Why was the circle bigger for the air under high pressure?*
* *If air at an area of low pressure is rising, why would these arrows move toward it?*
* *If air at an area of high pressure is sinking, why would these other arrows move away from it?*

**Analyze Pressure Data over a Region (Lesson 10: Step 2):**

KEY PATTERN: Air moves from an area of high pressure towards areas of lower pressure. The center of the low pressure area is located along and to the north end of the cold front. The center of the high pressure area is near the upper left corner of the map.

Prompts:

* *The front is moving from the west (left side of the map) to the east (right side of the map). The arrows on the cold front point in the direction it is moving. Using the barometric pressure measurements, why might the front move in this direction?*

**Pressure data (WIS/WIM) (Lesson 10: Step 3):**

KEY PATTERN: Air pressure begins to drop as the cold front moves into South Riding, with the lowest pressure along the front. After the front passes through the area, the pressure begins to rise again.

Prompts:

* *If we go back to Freedom High School in Virginia and were expecting a cold front to come through, how would we expect pressure to change before, during, and after the front?*

**Observing patterns in storm movement (Lesson 12: Steps 1-5):**

KEY PATTERN: In the video of North American, two storm fronts pass through, moving from the west towards the east. The white areas are places with more water vapor (moisture) in the air, which indicate where precipitation is happening.

In the NASA video of precipitation across the Earth, there are two key patterns:

* Precipitation near the equator moves from east to west.
* Precipitation in the midlatitudes moves from west to east

Prompts:

* *What patterns do you notice as storms move across North America?*
* *How could understanding patterns of storm movement be helpful to people and communities?*
* *What patterns do you notice about how precipitation moves around the world?*
* *What questions do you have about those patterns?*

**Patterns in annual temperatures (Lesson 13: Step 1):**

KEY PATTERN: Temperatures are warmer at the equator and cooler at the poles. Temperature follows a pattern of warmer bands in the middle (and around the equator) and cooler bands toward the poles.

Prompts:

* *How might temperature cause air to move in different ways on a global scale?*
* *Why is it hotter at the equator than other places on Earth?*

**Energy Angles (Lesson 13: Step 2-3):**

KEY PATTERN: As the angle of light increases, the light spreads out and covers more of the surface. But the amount of light hitting the surface does not change. Thus, it is hotter where the heat is more concentrated and cooler where the heat is more spread out.

Prompts:

* *Was there any difference in the amount of light coming from the flashlight? Did it change or stay the same?*
* *So what happened when you tilted the clipboard?*
* *If you were standing in one of the squares on the clipboard, within which one do you think you would feel the most heat? Why?*

**Temperature & latitude sorting activity (Lesson 13: Step 4):**

KEY PATTERN: Seasonal differences (fluctuations from cold to warmer temperatures) are stronger at higher latitude (further from the equator). At or near the equator, there is usually no seasonal difference in temperature. Temperatures are warmer at low latitude (close to the equator) than at high latitude (far from the equator). The graphs introduce seasonal shifts in temperature, which is NOT part of this unit. If you have already taught seasons in your class, this is a good place to have students make connections. If you have not taught seasons in your class, ask students to focus on the range of temperatures, focusing on where warmer and cooler temperatures are and not the seasonal shifts within the year.

Prompts:

* *Compare your matches with someone else’s. Do they match? Discuss any differences.*
* *So, we know that the Earth is unevenly heated, causing some places to be warmer than others. How does uneven heating relate to air movement in the tropics?*

**Develop a model of air moving in the Tropics (Lesson 14: Step 1):**

KEY PATTERN: Warm air at the equator is rising. At 30°N and 30°S cooler air is sinking. This model is to gather students initial ideas about air movement in the tropics before exploring further.

Prompts:

* *Where might air be rising from Earth’s surface to the atmosphere and why?*
* *Where might air be sinking from the atmosphere to Earth’s surface and why?*

**Convection demonstration & articulate metaphor (Lesson 14: step 2-3):**

KEY PATTERN: Convection is observed, with warm, red food coloring rising and then sinking back down. The blue food coloring is pulled horizontally across the bottom of the container towards the warm, low pressure area. The movement along the bottom of the tank represents air movement, or winds, across the Earth’s surface.

* The water in the tank represents air. This model uses water to simulate air because both air and water are fluids, so they behave similarly, but water can be seen.
* The red food coloring represents air at the equator.
* The blue food coloring represents air at 30°N and 30°S.
* The cup full of hot water represents solar radiation.
* The bottom of the tank represents Earth’s surface.

Prompts:

* *Why does your analogy work? For example, why is red coloring a good choice to represent air at the equator?*
* *What will happen when the warm cup of water is added?*

**How and Why Air Moves in the Tropics (Lesson 14: Steps 4-5):**

KEY PATTERN: Air moves from high to low pressure. The horizontal movement of cool air across the surface is winds. Warm air rises from the equator and sinks again as it cools near 30°N and 30°S. This model should relate to what we learned by observing the convection tank.

Prompts:

* *What happened to air at the surface of the Earth when it received direct heat?*
* *What happened to the pressure where the warm air rose?*
* *Why would the air move from the cool location to the warm location?*

**Record an Explanation for Storm Movement Where You Live and in the Philippines (Lesson 15: Step 3):**

KEY PATTERN: Use these key patterns to interpret how storms move where you live and in the Philippines:

* In the tropics, air moves across Earth’s surface towards the equator due to convection.
* In the tropics, air moves across Earth’s surface east to west due to the Earth’s rotation.
* In the midlatitudes, air moves across Earth’s surface toward the poles due to convection.
* In the midlatitudes, air moves across Earth’s surface west to east due to the Earth’s rotation.

Prompts:

* ***Where is it likely that storms originate where we live?***
* ***Why is being able to anticipate where storms come from important for communities?***
* ***How can we use our understanding of weather to prepare for the impacts of storms?***