Lesson 2: What makes cities hotter?
MS Climate Unit

Previous Lesson….Where we've been: We watched a short video and began to ask questions about why certain cities in Colorado are getting hotter.

	This Lesson….What we are doing now: This lesson explores reasons why temperatures in particular Colorado cities are rising.

Lesson Question	Phenomena	Lesson Performance Expectation(s)	What We Figure Out (CCCs & DCIs), *New Questions* and **Next Steps**
L2: What makes cities hotter? (1.5 periods) *Building toward* ↓ <u>NGSS PEs:</u> MS-ESS3-4	Climate Central report showing extreme heat by population NOAA National Centers for Environmental Information weather data NOAA Climate Data online Census of Population and Housing	**Analyze data…** Construct, analyze, and/or interpret graphical displays of data and/or large data sets to identify linear and nonlinear relationships among extreme heat, location, population and identify patterns across cities regarding temperature.	We decide that we want to start by comparing several cities in Colorado to see if we can find out what might be happening in the cities that are getting hotter. We have some initial ideas about what makes these cities different. We think these are bigger cities in Colorado, not small towns. They could be sunnier and get less rain. We also hear about climate change and global warming and think this may be the reason why temperatures are getting hotter. (Note: teacher is aware the class is going to look at this later in the unit but will direct students to first focus locally). *We are wondering what is special about these cities that is making them hotter:* ● *Is it because of the population of a city?* ● *Are these places just sunnier and dryer, making them hotter?* ● *Are things changing in these cities that could make them hotter?* We will look at data from the Climate Central report, the census, and NOAA data on temperature and precipitation for cities in Colorado to see if population or weather patterns explain why temperatures are getting hotter. We figure out that the hotter cities are not necessarily sunnier and dryer. The hotter cities have grown in population more than the other cities in Colorado, which is surprising! *We are wondering:* ● *How does population growth affect temperature in an area?* ● *What's changing in a city as it grows to make it hotter?* **We decide we need to investigate why growing cities are hotter than other places that are not developing.** *Note: Students may come up with other topics to research rather than the ones anticipated in this lesson. In that case, the students will have to take the research into their own hands.*

Next Lesson….Where we're going: We want to find out what changes in land use are happening and how changes in surface color affects temperatures in cities.

📋 Getting Ready: Materials Preparation

Materials For Each Group

- Printout of temperature data for Boulder, Pueblo, Greeley, Denver, and Fort Collins, Colorado (1) *(must be in color)*
- Printout of precipitation data for Boulder, Pueblo, Greeley, Denver, and Fort Collins, Colorado (1) *(must be in color)*
- Printout of population data for selected Colorado cities (1) *(must be in color)*

Preparation of Materials (15 min.)

- Look over data for temperature, precipitation, and population
- Print Data Sheet (data for temperature, precipitation, and population) for groups or class copies
- Print Student Activity Sheet (1 per student)

Materials For Each Student

- Student Activity Sheet (1 per student)

Safety

- N/A

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☁ Getting Ready: Teacher Preparation

Background Knowledge

Students have learned helpful information in previous grades before reaching middle school that will give them the background knowledge they need to brainstorm about this driving question.

<u>Kindergarten:</u> Students learned about weather patterns and they discussed how plants and animals could change the environment.

- **K-ESS2-1 Earth's Systems:** Use and share observations of local weather conditions to describe patterns over time.
- **K-ESS2-2 Earth's Systems:** Construct an argument supported by evidence for how plants and animals (including humans) can change the environment to meet their needs.

<u>Second Grade:</u> Students learned about fast and slow events that can impact the earth.

- **2-ESS1-1 Earth's Place in the Universe:** Use information from several sources to provide evidence that Earth events can occur quickly or slowly.

<u>Third Grade:</u> Students learned about typical weather patterns and learned about different climates that are possible worldwide.

- **3-ESS2-1 Earth's Systems:** Represent data in tables and graphical displays to describe typical weather conditions expected during a particular season.
- **3-ESS2-2 Earth's Systems:** Obtain and combine information to describe climates in different regions of the world.

<u>Fourth Grade:</u> Students learned about how energy is used and how it impacts the environment and analyzed how to mitigate the effects of natural earth processes on humans.

Alternative Student Conceptions

Students may come into this unit with some common misconceptions:

- Fires can cause long-term warming over time in one isolated location
- One or two high data points can prove that something (in this case, fires or sunshine) caused the warming in that area
- Weather and climate are the same
- One hot day is enough evidence to prove that climate change is happening
- Earth's natural warming and cooling patterns provide enough evidence to prove that climate change isn't happening
- If there are less plants, CO2 cannot be used for photosynthesis, and that alone can cause a single area (i.e. one city) to experience higher temperatures

Linking Our Understanding to Scientific Terminology

Key Vocabulary:

- Pattern
- Global warming
- Climate change
- Population growth
- Average
- Phenomenon

- **4-ESS3-1 Earth and Human Activity:** Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.
- **4-ESS3-2 Earth and Human Activity:** Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.

Fifth Grade: Students analyzed and developed a model to describe how different realms of the earth interact.

- **5-ESS2-1 Earth's Systems:** Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.

Lesson 2: What makes cities hotter?   (60 min)

Teacher Supports & Notes

1. (10 min) Begin with a Consensus Building Discussion [1] to help remind students what they discussed in the last class. Students should engage in a think-pair-share discussion format at first, and then discuss the questions as a whole class. Use the following prompts to help students articulate what they figured out in the last lesson.

Suggested Prompts:
➔ What did we wonder about last class? (refer to "Driving Questions Board")
➔ We had some ideas about how to investigate our questions. What were our ideas?
➔ Which questions did we decide were the most important to investigate first?

Listen for *student responses* [2] that refer to what we figured out last time, such as:

➔ *We figured out that there are three cities in Colorado that are experiencing higher temperatures on average than other cities.*
➔ *We asked three main questions: Why these cities? Is this really a pattern? What's causing the pattern?*

2. (15 min) Next, shift to a Sharing Initial Ideas Discussion [3]. Students should engage in a think-pair-share discussion format at first, and then discuss the questions as a whole class. Use the following prompts to guide students to articulate what they think they should focus on in today's lesson.

Suggested Prompts:
➔ What do you think is causing these cities to get hotter?
➔ What kinds of data would we need to help us decide what's causing the cities to get hotter?
➔ What can we look for in the data in order to determine whether that phenomenon is causing the cities to get hotter?
➔ How can we figure out if a pattern or correlation between two variables is there? How do we know if it is going up or down?

Listen for *student responses* and ideas about how to determine what these three cities have in common, what is causing the rising temperatures, and how we can determine what's causing it:
➔ *Is it because of the population that these cities are so hot?*
➔ *Is stuff happening like fires that could make it hotter?*
➔ *Is it that these places are just sunnier?*
➔ *We can look at graphs showing us information about fires, population, and sun and we can see if they're the causes of the cities getting hotter.*
➔ *We can look at whether there are more fires over the past 50-100 years, whether there was more sunshine over the past 50-100 years, and whether there were more people moving to these cities over the past 50-100 years.*

Strategies for this Consensus Building Discussion

1: The goal of this discussion is to put students in the driver's seat. Use the prompts to help students recall and restate what we as a class figured out in the last lesson. Their ideas should motivate what we are going to need to do next, in this lesson.

Additional Guidance

2: If students struggle to recall the previous lesson, prompt them to consider what phenomena they examined or what activities they engaged in. Refer to the three cities that saw the largest rises in temperatures. Ask them what their questions and ideas were.

Strategies for this Initial Ideas Discussion

3: In this discussion, students should lay out the path for the activities they will engage in today. Use the prompts to ensure that students do this heavy lifting to generate ideas. Gently guide them toward the topics for which we have data to analyze: fires, population growth, and sunshine.

Students may come up with additional sources of data. If time permits, you can allow them to look for additional data. However, make sure that fires, population growth, and sunshine are part of the data that groups analyze.

➔ *We will be able to determine whether the pattern or correlation is going up or down by looking at the data and if there's more or less fires happening, more or less days of sun happening, or more or less people moving there over the last 50-100 years.*

3. (25 Minutes) Hand out the datasets for population, temperature and precipitation to each team of 3 or 4 students and hand a Student Activity Sheet to each student[4]. They will work in teams but each of them will complete their own Student Activity Sheet. They are looking for patterns and trying to figure out whether there is evidence for their hypotheses about the cause of the rising temperatures in Greeley, and Fort Collins, Colorado.

Suggested Prompts (Ask Groups While Circling the Room):
➔ What patterns in the data should you be looking for, given your hypothesis about what's causing the temperatures to rise more in these three cities?
➔ Do you see the patterns you expect to see? If so, how does that support your hypothesis? If not, what does that tell you about that phenomenon and the rising temperatures in the three cities?
➔ There's a lot of "noise" in the data: what can you do to help you see the pattern in the data? How can you be convinced there's a pattern, and that the numbers are not random?

Listen for *student responses* as they do their data analysis:
➔ *We see an upward pattern for population growth in these cities. They appear to be growing faster than some of the other cities on the list. That could be contributing to the rising temperatures.*
➔ *Temperatures have changed in most places, getting warmer.*
➔ *Precipitation is generally a small amount each year.*

4. (5 min) When students have completed the data analysis bring them back together as a whole group, having team members sit close to one another. In this Building Understandings Discussion, use the following prompts to help students debrief what they learned with their data analysis.

Suggested Prompts:
➔ Did you see any patterns? If so, what patterns did you see? If not, what does that tell you about that phenomenon and the rising temperatures in the three cities?
➔ (For GT Students: What does the line of best fit tell you?) Are the patterns upward or downward? If not, what can you conclude about that phenomenon and the rising temperatures in the three cities?

Listen for *student responses* as they do their data analysis:

➔ *We saw an upward pattern for population growth in these three cities. That could be contributing to the rising temperatures.*
➔ *A majority of cities had an increase in their maximum temperatures.*
➔ *Precipitation has increased slightly for most cities.*

Differentiation Strategies and Alternate Activities

4: Depending on your students' level of understanding, you may want to go over how to read the graphs before they start their independent work:
- How do you know what you're looking at? (Title of the graph, x- and y-axes, numbers on axes)
- What do the different axes represent?
- What do the data points represent?

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5. (5 min) Ask students to brainstorm what our next steps should be in our investigations.[5]

Suggested Prompts:
➔   What questions from our Driving Questions Board can we answer now?
➔   What new questions arose from our investigation today that we might need to add to the Board?
➔   What should make sure to do in our next class?
➔   What do we need to investigate next time we meet for science?

Listen for *student responses* such as:

➔   *We figured out that these cities are growing faster than others, and we think this might have something to do with the heat.*
➔   *Why does population growth matter for heat?*
➔   *What's changing in a city as it grows?*

Formative Assessment Opportunities

5: Ask students to complete an exit slip restating what they figured out in this lesson and/or what they think we should do in the next lesson.

🏴 **Alignment With Standards**

Building Toward Target NGSS PE

- **MS-ESS3-4:** Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact

Building Toward Common Core Standard(s)

ELA/Literacy -
W.6.7: Conduct short research projects to answer a question, drawing on several sources and refocusing the inquiry when appropriate.

W.7.7: Conduct short research projects to answer a question, drawing on several sources and generating additional related, focused questions for further research and investigation.

W.8.7: Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.

WHST.6-8.9: Draw evidence from informational texts to support analysis, reflection, and research.

Mathematics –
8.SP.A.1: Construct and interpret scatter plots for bivariate measurement data to investigate patterns of association between two quantities. Describe patterns such as clustering, outliers, positive or negative association, linear association, and nonlinear association.

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