Lesson 4: Are other parts of the world getting hotter?

MS Climate Unit

Previous Lesson….Where we've been: We investigated what changes in land use are happening and how changes in surface color affects temperatures in cities.

This Lesson….What we are doing now: This lesson explores whether other parts of the world are also changing and getting hotter.

Lesson Question	Phenomena	Lesson Performance Expectation(s)	What We Figure Out (CCCs & DCIs), *New Questions* and **Next Steps**
L4: Are other parts of the world getting hotter? (1.5-2 periods) *Building toward* ↓ *NGSS PEs: MS-ESS3-4*	Heat Wave Increases in US (1970-2000) Global surface temperature maps (mean period is annual Jan-Dec, time interval for beginning to end 2016, keep all other defaults) Global surface temperature map first half of 2016 Global temperature 1880-present Earth's albedo 2000-2011 Arctic albedo	**Analyze and interpret data…** of graphical displays about albedo, regional and world temperature change, and average global temperature over time to identify linear and nonlinear relationships.	Last time we came up with the idea that the heat generated by cities is caused by a change in something we called "albedo," which is a measure of how much light is reflected and is a function of characteristics of the surface, like color. *We're wondering:* • *Are temperatures increasing in other places?* • *Is the albedo changing there, too?* **We decide we should look at some data on temperature from around the world and find some data on albedo change.** When we look at the data together, we figure out: • Temperature is rising around the globe, and not just in cities. • The number of heat waves in the US shows a similar pattern: It's increasing in many places -- cities and rural areas, and in places that are growing as well as places where the population is going down. • The overall albedo is not changing around the globe, but it's changing a lot at the poles -- where there aren't any cities. • An increase in albedo itself can't be the only cause of why places are getting hotter. *Now we're thinking we need to answer the following questions:* • *Is this warming temperature a trend?* • *Is something happening to change the temperature?* **We decide we need to look at the world's temperature over time.**

Next Lesson….Where we're going: We are wanting to know what the world's temperature trend was in the past and whether temperatures have changed recently.

Getting Ready: Materials Preparation

Materials For Each Group

- N/A

Preparation of Materials (15 min.)

- Print Student Activity Sheet (1 per student)
- Post “Notice and Wonderings” chart from previous lesson.

Materials For Each Student

- Student Activity Sheet (1 per student)

Safety

- N/A

Getting Ready: Teacher Preparation

Background Knowledge

From 5th grade,

ESS2C: Roles of water in Earth's surface processes.
"Water is found almost everywhere on Earth: as vapor; as fog or clouds in the atmosphere; as rain or snow falling from clouds; as ice, snow, and running water on land and in the ocean; and as groundwater beneath the surface."

- Water in the form of clouds can be found everywhere across the globe.

ESS2D: Weather and climate.
Climate describes the ranges of an area's typical weather conditions and the extent to which those conditions vary over years to centuries.

- **Climate describes weather over many years.**
- **Climate can vary or change over time.**

Alternative Student Conceptions

Students may need a reminder of the distinction between weather and climate. They may also think that greenhouse gases in the atmosphere only make the Earth warmer or only keep out sunlight.

Linking Our Understanding to Scientific Terminology

- Albedo
- Global Mean Surface Temperature
- Temperature Anomaly

Learning Plan: Are other parts of the world getting hotter? (75 min)

1. (10 min) Begin with a Consensus Building Discussion [1] to help reorient students in the story line. Use the following prompts to help students articulate what they figured out in the last lesson.

Suggested Prompts:

- ➔ During our last two classes, we looked at how the surfaces in a place can make it warmer or cooler.
- ➔ What did we find out about the colors of surfaces and temperatures?
- ➔ What does this tell us about the amount of light reflected and temperature?
- ➔ What does this tell us about why growing cities are hotter?
- ➔ What did we decide that we should look at next?

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

- ➔ *We learned that darker surfaces are warmer than lighter-colored surfaces.*
- ➔ *This shows us that as cities grow in population, more plant surfaces are replaced with dark surfaces, and so the cities get hotter.*
- ➔ *We did an experiment that showed how light reflected on different colored surfaces raised the temperature to different levels.*
- ➔ *We decided to look if other parts of the world are getting hotter, too.*

2. (10 min) Albedo around the world

Have students look at the map that shows changes in albedo (reflectivity) around the world. Students look for patterns in the temperature changes. Have students work in groups of 3-4 to describe the relationship they observe between albedo and temperature changes.

Building Understandings Discussion: Review the title and map key as a class. Invite a group to share their explanation of patterns found in the data. Invite other students to respond (agree/disagree/add) to the explanation.

Listen for understanding and confusion around the patterns:

- ➔ *The blue means more reflective surface and so temperatures should not be as warm.*
- ➔ *The red means less reflective surface so temperatures should be warmer.*
- ➔ *Why is the Arctic less reflective and Antarctica more reflective surface since they're both polar regions?*
- ➔ *Northern and central US is more reflective while the southern US has a less reflective surface cover.*

3. (10 min) Temperature in other parts of the US

Give students the map that shows the changes in heat wave duration around the continental US. Students look for patterns in the temperature changes. Have students work in groups of 3-4 to formulate an explanation of the patterns they see.

Building Understandings Discussion: Review the title and map key as a class. Invite a group to share their explanation of patterns

Teacher Supports & Notes

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.

found in the data. Invite other students to respond (agree/disagree/add) to the explanation.

Listen for understanding and confusion around the patterns:

- ➔ *Areas without large populations/cities (e.g. western states) have longer heat waves than areas with large populations/cities (e.g. east and west coast states) This is a little confusing since there are more land use changes in populated areas than less populated areas.*
- ➔ *We learned yesterday that as more people move to a city plant surfaces are replaced by dark surfaces, which increases temperatures.*

4. (20 min) Temperature in other parts around the world

Have students look at the map that shows the changes in the global mean surface temperatures and average global temperatures. Students look for patterns in the temperature changes. Have students work in groups of 3-4 to formulate an explanation of the patterns they see.

Building Understandings Discussion: Review the title and map key as a class. Invite a group to share their explanation of patterns found in the data. Invite other students to respond (agree/disagree/add) to the explanation.

Have students look at the graph of the land-ocean temperature index. Review the title and axis labels as a class. Students should work in groups of 3-4 to formulate an explanation of the patterns they see.

<u>Listen for understanding and confusion around the patterns:</u>

- ➔ *The Arctic is warming above normal but there isn't a lot of land use changes or people living there. Since the world as a whole has been getting warmer, the snow in the Arctic has been melting, which exposes darker dirt and rock underneath, which absorbs more light and heat than snow.*
- ➔ *Why is Antarctica cooling?*
- ➔ *Most of the world looks to be increasing in temperature.*
- ➔ *Why isn't the area around the equator the warmest?*
- ➔ *Global temperatures have been rising above normal since the 1970s.*
- ➔ *Global temperatures rising the fastest since 2010.*
- ➔ *I wonder what global temperatures were like before 1880?*
- ➔ *I wonder what global temperatures will be like in the future?*

5. (15 min) Draw and explain a model of what we know so far.

Invite students to draw a model to explain what we have figured out so far about temperatures in other parts of the world. In their models, students should include how the different changes we have seen affect each other, and include evidence we have seen for these changes. Encourage students to record questions that come up as they are drawing and writing.

Ask students:

- ➔ Are temperatures in other areas of the world getting hotter, too? Do you think changes in population or surface coverage is causing this to happen, like in the cities, or do you think there may be other reasons? How do you know?

Listen for:

- ➔ *Temperatures in other parts of the world are getting warmer.*
- ➔ *Some areas that are getting warmer are also areas that have more reflection, which doesn't make sense (e.g. the area in the US with increased heat wave duration have more reflectivity)*
- ➔ *Areas that are normally the coldest are warming the most (e.g. the Arctic is warming at a greater rate even though there is much less population or land use changes there and it's usually more snow and ice covered so it's more reflective and should not be warming as much).*

6. (10 min) What have we figured out? What should we do next?

Have students reflect on what we have learned about temperatures in other parts of the world.

Suggested Prompts:

- ➔ What is happening with temperature and heat waves in the rest of Colorado and the lower 48 states?
- ➔ What is happening with temperature in other parts of the world?
- ➔ What does this tell us?

Listen for *student responses* such as:

- ➔ *It seems like other areas without growing cities or many land use changes are also experiencing increases in temperatures.*
- ➔ *This shows us that temperature increases are happening on a world scale and something else besides increases in population and land use changes is causing this to happen.*

7. Ask students to brainstorm what we should do next in our investigation.

Suggested Prompts:

- ➔ What do we need to figure out next?
- ➔ How can we figure this out?

Listen for *student responses* such as:

- ➔ *We need to know if warming temperatures are a pattern.*
- ➔ *We should look at data to find out what temperatures were like in the past.*

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 Earth's systems.

Building Toward Common Core Standard(s)

ELA/Literacy -
RST.6-8.1: Cite specific textual evidence to support analysis of science and technical texts. (MS-ESS3-4)
WHST.6-8.1: Write arguments focused on discipline content. (MS-ESS3-4)
WHST.6-8.9: Draw evidence from informational texts to support analysis, reflection, and research. (MS-ESS3-4)

Mathematics -
6.RP.A.1: Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. *(MS-ESS3-4)*
7.RP.A.2: Recognize and represent proportional relationships between quantities. *(MS-ESS3-4)*
6.EE.B.6: Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set. *(MS-ESS3-4)*
7.EE.B.4: Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities. *(MS-ESS3-4)*