Inquiry-Based 5E Model
Climate Literacy Lesson

GONZAGA UNIVERSITY | Center for Climate, Society, and the Environment

Center for Climate, Society, and the Environment

Urban Heat Geographers

Grade Level: MS
Duration: 45 minutes

Lesson Overview: Students will collect their own data on urban heat in order to understand how different city design choices change temperatures.

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Disciplinary Area:
Earth and Human Activity

Key Concepts:
- The albedo effect
- Heat mapping
- Urban design

Key Lesson Information

Materials List

- Printed MS Exit Tickets (dependent on class size)
- Printed Hypothesis/Temperature Gradient handouts
- **If weather is inclement:** Laminated heat activity sheets (1/team, so about 1/every 3-4 students)
- **If weather is inclement:** Expo thin markers (2/team, so about 2/every 3-4 students)
- Thermal Cameras (1/team, so about 1/every 3-4 students)
- Phones (1/team, so about 1/every 3-4 students)

NGGS Performance Standards Addressed

ESS3.D – Global Climate Change	Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth's mean surface temperature (global warming). Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior and on applying that knowledge wisely in decisions and activities.

Key Vocabulary/Concepts List:

- **Albedo**: The albedo is the fraction of light a surface reflects.
- Heat and light: **light is one form of energy and can be radiated as heat energy.**
- **Urban Heat Island Effect**: Darker surfaces in cities like roofs and roads increase temperatures in cities compared to surrounding rural areas.

Big Questions:

- How does our physical environment affect the heat we feel?
- Why does city design matter to the global temperature increase?
- How do we collect data about temperature?

5E model part 1: Engage

Introduction and Background

In this lesson, we'll focus on how to collect data about temperature and how to apply that data to day-to-day life.

Have you ever stepped on a hot blacktop? What about worn a black tee shirt during a hot summer day? *(Allow students to reply with their experiences.)*

This is an expression of what's called **the albedo effect.** When light from the sun hits any surface, some of it is going to be absorbed while the rest is reflected. The reflected light, of course, is color! The absorbed light is a **form of energy** that is stored in the object or surface until it's radiated out as **heat.**

We're going to watch a short video to introduce us to other ways in which the albedo effect affects our daily lives! https://www.youtube.com/watch?v=nc9ywdt-u_k **(0:00-about 1:20)**

But how does this relate to the climate? Why would this be a problem for global climate change? *(Allow students to brainstorm reasons for 1-2 minutes)*

Example answers:

- Human beings need specific conditions to survive just like any other animal—heat can be dangerous!
- Cities make up a lot of the surface of the planet. If cities are heating, so is the planet.
- Quality of life: cities are where the majority of people live, so they should fit human needs as much as we can manage.

Connection: How does this relate to life in Spokane? **Show the local urban heat map.** Talk about life in the city versus outside it—why would cities trap more heat? Which parts of cities? Why?

5E model part 2: Explore

How does our school manage temperature?

Introduction to the activity, why they're doing it, what they will learn, and any ground rules for the activity.

Activity: Thermal Mapping!

Students will use thermal cameras to observe their school (ideally outside, weather conditions permitting) to collect data on what surfaces, objects, and areas of their school radiate more or less heat.

Essential Concepts

- Different surfaces reflect and absorb different amounts of energy
- Energy is radiated passively as heat. Some objects radiate electrical energy waste as heat.
- We can measure heat ourselves

Activity Setup

Split students into groups of 3-4. Walk students through the process of getting the app, installing it, plugging in and syncing the camera, and how to set the app up to show Fahrenheit measurements. Once the apps are functional, run the following quick activity to check that students understand what they're seeing:

- Pick a heat source in the room (computer, projector, ceiling light, etc.) and ask each group to observe what color it registers as
- Ask a different person from each group to read out what temperature it is
- Answer any questions this process raises as a group!

Activity Procedure

1. Students receive a temperature gradient handout. On it is a range from 0 degrees F to 100 degrees F. The objective is to note down the temperature of different surfaces or objects along the gradient.
2. First, this activity works best when you can go outside on a sunny day. If the weather isn't amenable to this, **see alternative activity below**.
3. **Data collection:**
    a. Show all students while still in a focused group what the boundaries of the observation area will be.
    b. Remind them that a shaded surface and a surface in the sun will have different temperature readings.
    c. They will note down *temperature, surface color, and a "best guess" at the surface material* (it may not be obvious, as something like painted concrete, cobblestones, or one kind of dirt vs another kind of dirt may be hard to distinguish precisely). That's their three-step checklist for every observation they make!
    d. Remind them to note down anything they think is weird or that they might have a question about.

    e. Be attentive to any technical problems—it will likely take some time to get oriented!
4. Tips for crowd control:
    a. Select observation area beforehand.
    b. Ask for teacher's help in selection.
    c. Teacher and fellows should be spread out and asking groups questions as they go—hopefully, this will successfully avoid sidetracking. If students do get distracted/distract their classmates on purpose, redirect them to why you're doing the activity: to collect actual data about how *their school* measures up in terms of climate management. **They are doing real science!**
5. Return to the classroom and make sure groups stay together!

Alternative Activity: Photographic Evidence

1. Pass out the laminated heat activity sheets. Point out that one of the photographs portrays a hotter outdoor environment, while the other is cooler. Both were taken on a hot day here in Spokane.
2. **Exploration:**
    a. The goal is for students to be able to match the colors of different surfaces on the images with the way their thermal cameras color-code different temperatures. They will use the thermal cameras to conceptualize of what colors generally mean what temperature ranges, and then write down their estimates.
    b. Each blank box should have a guess at what temperature that surface is. If any students are having trouble making the connection, ask them what in the room that they can point the camera at is a similar color? What temperature is the thermal camera telling you that object is?
3. *Optional:* **Math mini-activity:**
    a. If their math education allows, have them calculate an average temperature reading for each image. While making your way to different groups, as them: Which one is higher? Why is that?
4. Regroup as a full class and ask students to share their data with a neighboring team. *Optional*: Did they get the same average temperatures as the other group? Why? About how accurate do they think their temperature guesses were?

5E model part 3: Explain

Time to check in and recap!

Question Session

- In small groups, discuss any patterns they noticed in their data. Even obvious patterns matter! (1-3 minutes)
- Each group shares out their patterns. The whole class then discusses any consistent patterns across everyone's data. Why do those patterns exist? (1-2 minutes)
- Which of these surfaces is most common in their neighborhood? In their own yard? What about in other places in Spokane? Are there any patterns they themselves can come up with? (3-4 minutes)

Important Concept Check in: Vocabulary/Big Question

Key Vocabulary/Concepts List:

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Big Questions:

- How does our physical environment affect the heat we feel?
- Why does city design matter to the global temperature increase?
- How do we collect data about temperature?

Class Discussion: Getting into the "Why"

First, we watch the second half of the video (linked above). Then, we look at the Urban Heat Map again now that we understand more about what it means.

Students will get the opportunity to explain/recap to the class why the map looks like this. Try to get students to engage with the actual pathway of energy from the sun all the way to radiating heat.

Questions re: the video to engage students further about the ties between this and climate change:

- Do you think Spokane is doing a good job of adapting to climate change? Why?
- What do you think will happen to the city if we didn't change anything about its design as the temperatures get hotter and hotter? What would that look like?

5E model part 4: Elaborate

Activity: Looking Closer at Spokane

You're the Urban Planner now! Student Problem Solving Activity

Students will break into their teams from before to discuss how they would improve the hottest areas of Spokane for 5-7 minutes. Afterwards, we'll discuss those ideas as a whole class!

5E model part 5: Evaluate

Expand: Relate the lesson more generally to students' lives

Discuss for remaining time the following:

- The other possible benefits of advocating for more greenery and fewer parking lots/denser development in their city
- Ways they can experience the outdoors safely in the summer
- What they can do in Spokane to advocate for change in their own lives

Exit Ticket:

1. Flip over their temperature worksheets. Fill out the information on the back:
    a. Three critical thinking questions on the board:
        i. Why is the albedo effect important to talking about the climate?
        ii. How is the albedo effect related to how we build cities?
        iii. Why is it important to collect data about temperature where we live?
    b. Put a check mark next to any statement that fits how you feel:
        i. I feel like I understand climate change and its effects better than I did before this lesson.
        ii. I feel like I am better equipped to talk about climate change and its effects than I was before this lesson.
        iii. I am concerned about how climate change is going to affect Spokane.
        iv. I feel optimistic about my ability to help climate change issues.
    c. What other questions do you still have? What do you wish we had talked more about?
2. Turn this in to one of the Climate Fellows to be entered into the binder!

By the end of this Lesson

Concepts Learned:

- Define the albedo effect
- Understand how light energy is reflected/absorbed/radiated as heat
- Describe the relationship between global climate change and the local effects on cities we live in
- Surface temperature is different from the temperature outside
- Use real scientific equipment to observe surface temperatures

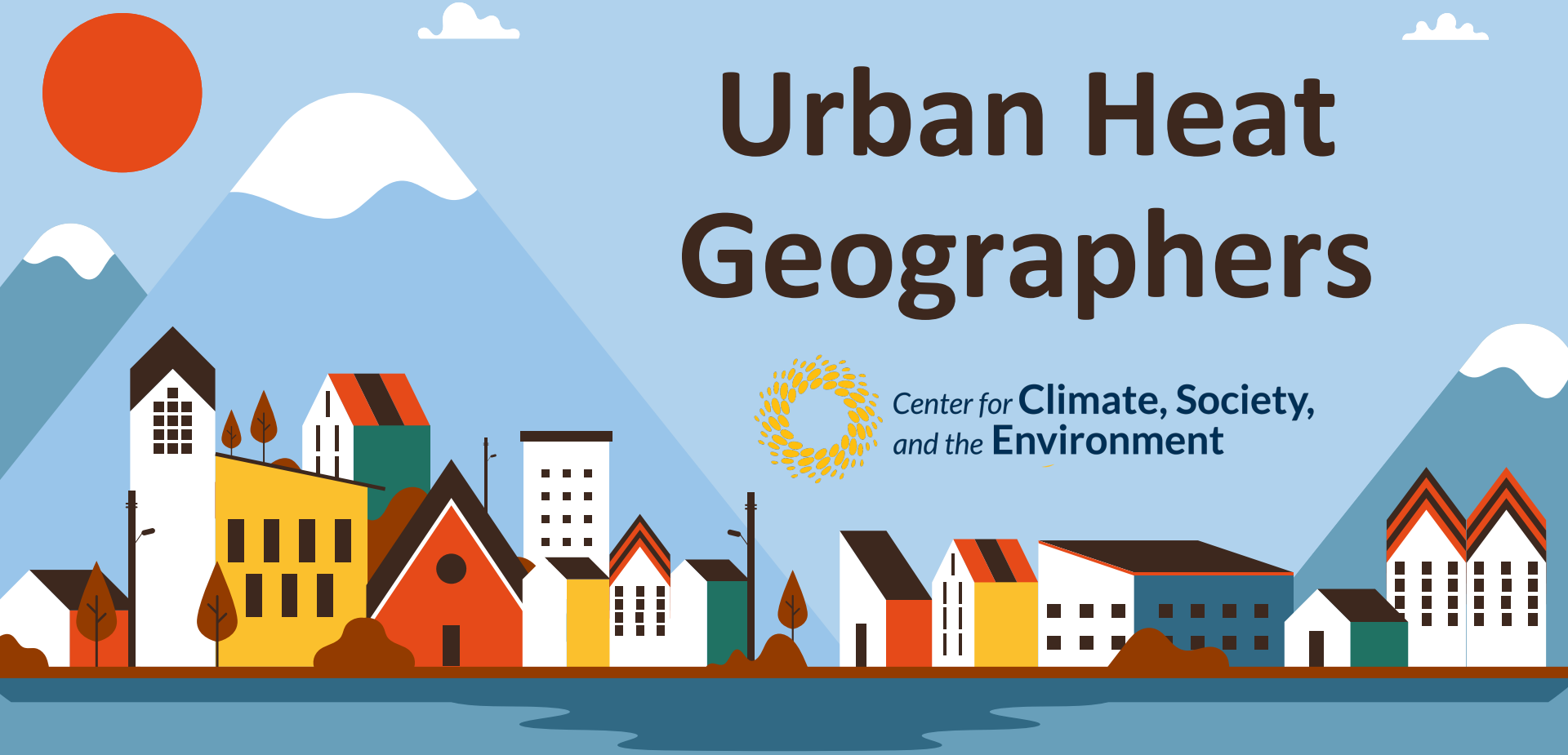
Connection/Evidence Gathered:

- Darker surfaces absorb and radiate more heat
- Shade creates cooler surfaces underneath, since something above the surface is reflecting energy away
- We can describe in both words and numbers the differences we see in surface temperatures
- Discussion on how Spokane could adapt to climate change to make life better for its citizens

Potential resources:

1. Other good videos include:
    a. https://www.youtube.com/watch?v=Y-bVwPRy_no: gets into city design in more detail.
    b. https://www.youtube.com/watch?v=PM101DvvG4Q: much longer, but gets into more potential solutions! The beginning is quite grim, so it's not for classroom use, but it could help instructors understand some proposed solutions better.

Urban Heat Geographers



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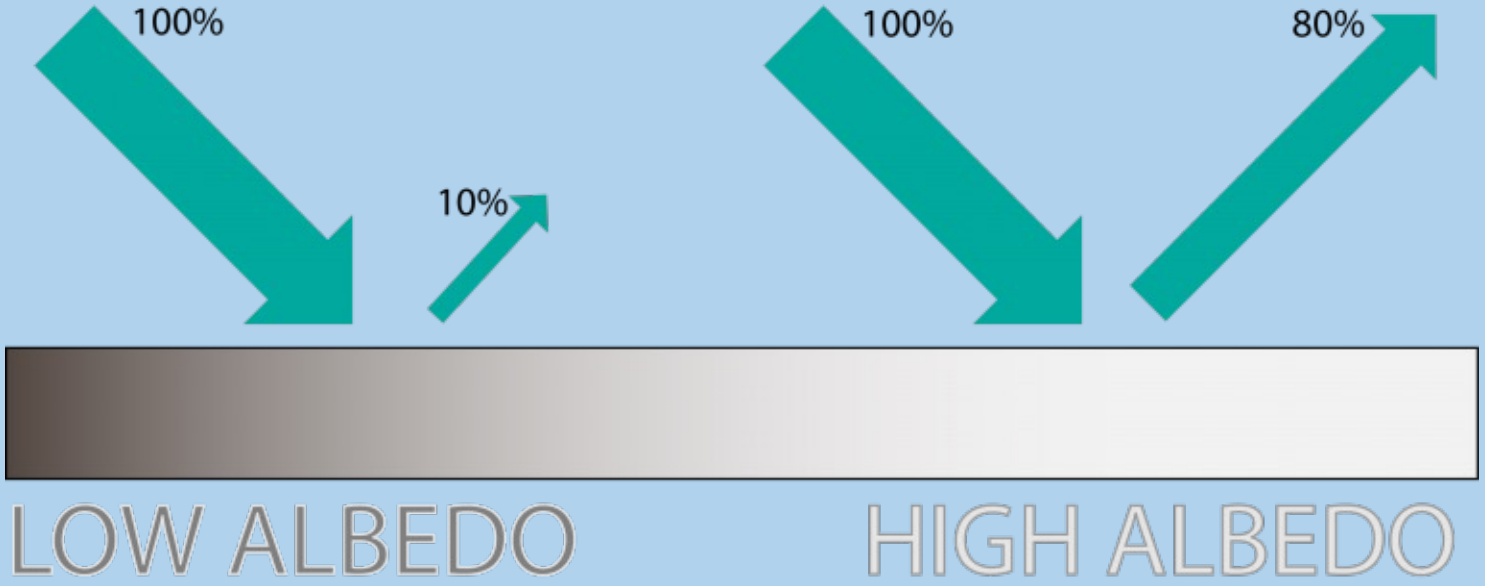
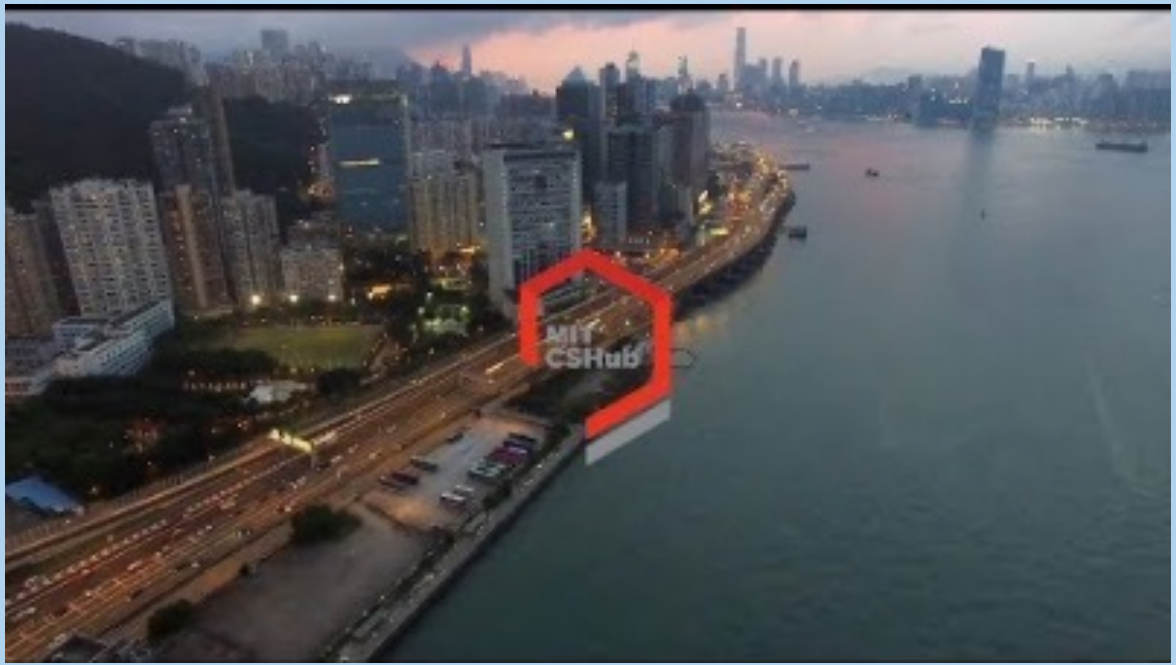
Have you ever stepped on a hot blacktop?

The Albedo Effect

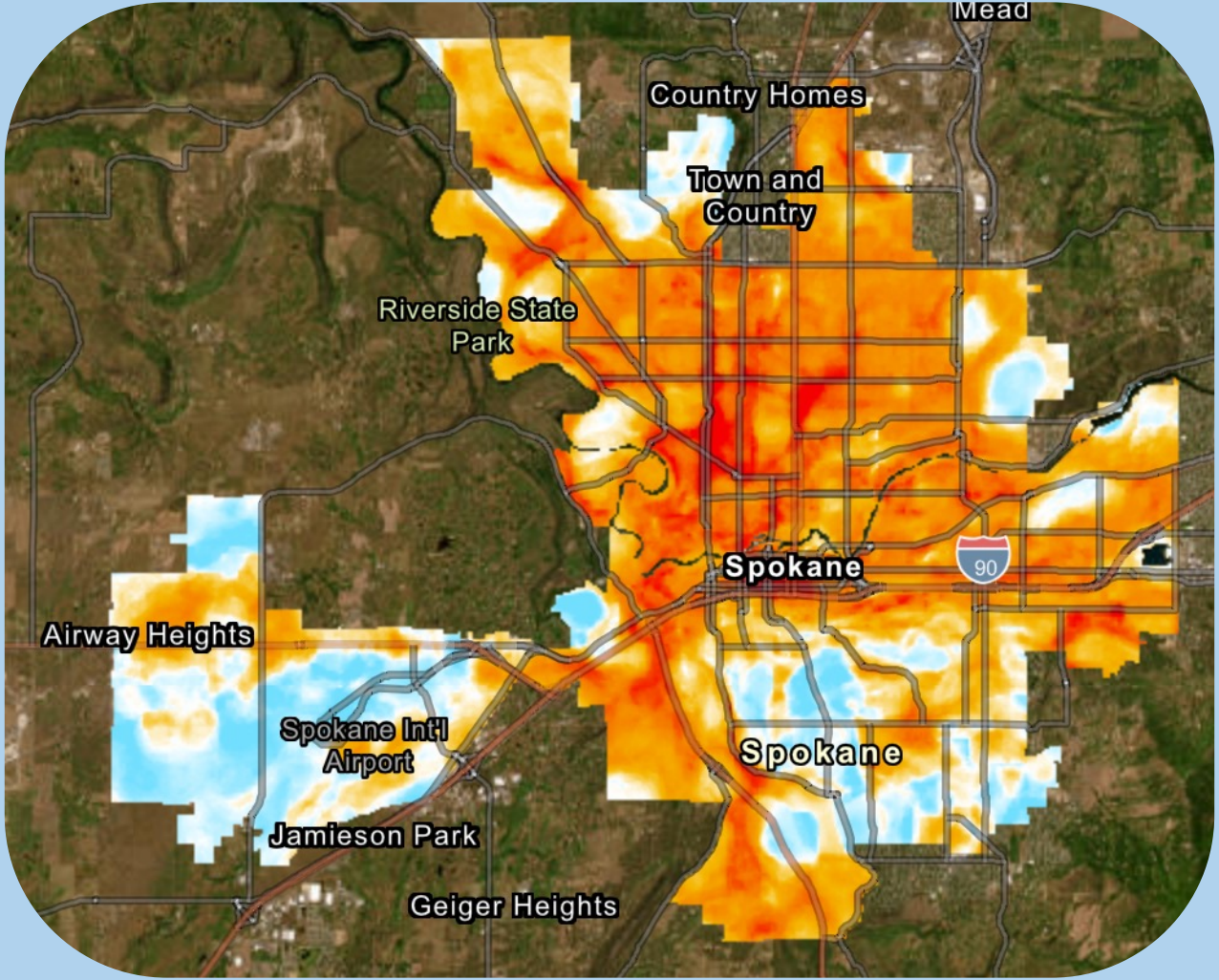


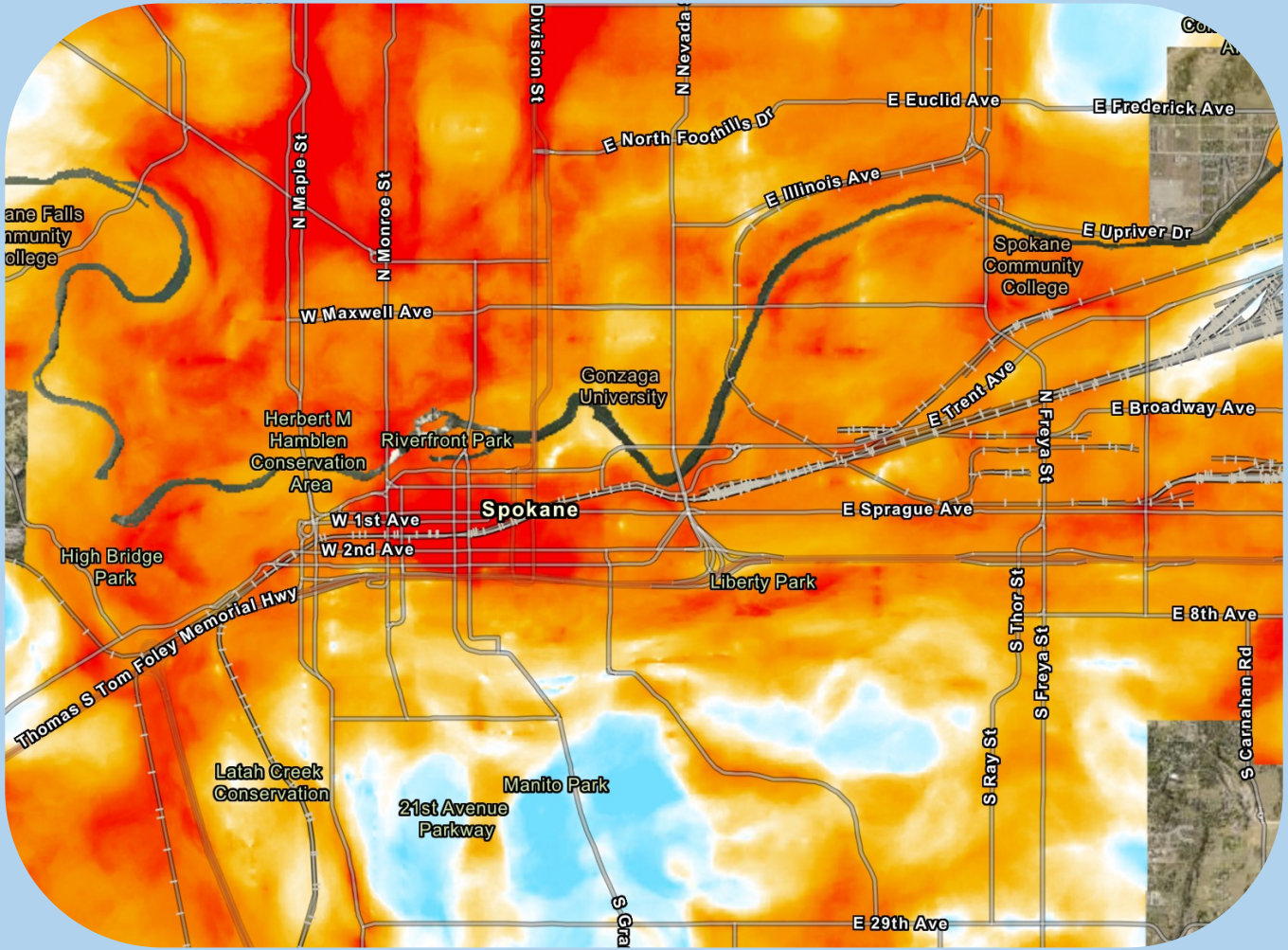
The Albedo Effect



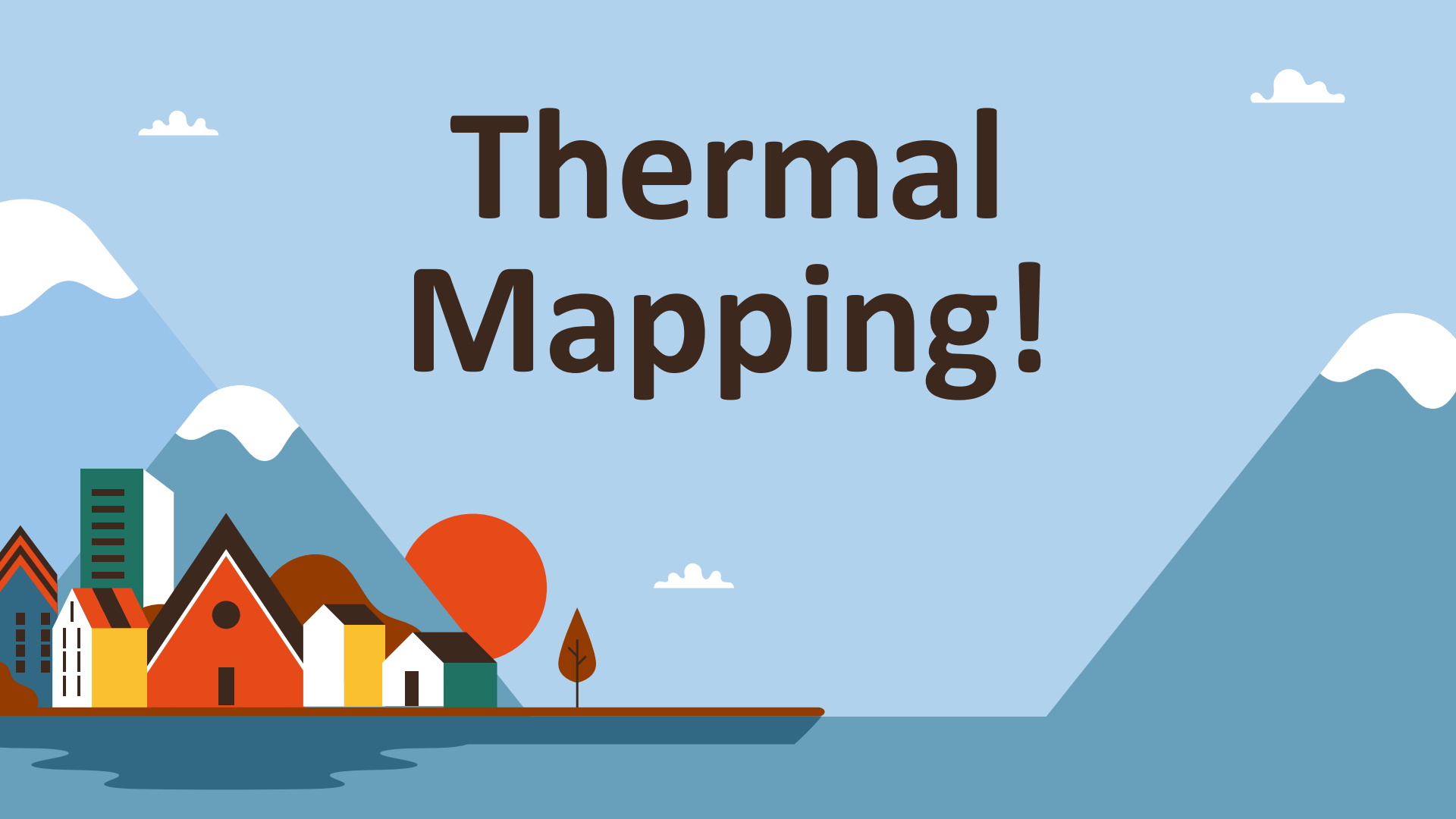
But how does this relate to the climate?

Brainstorm with your neighbor!

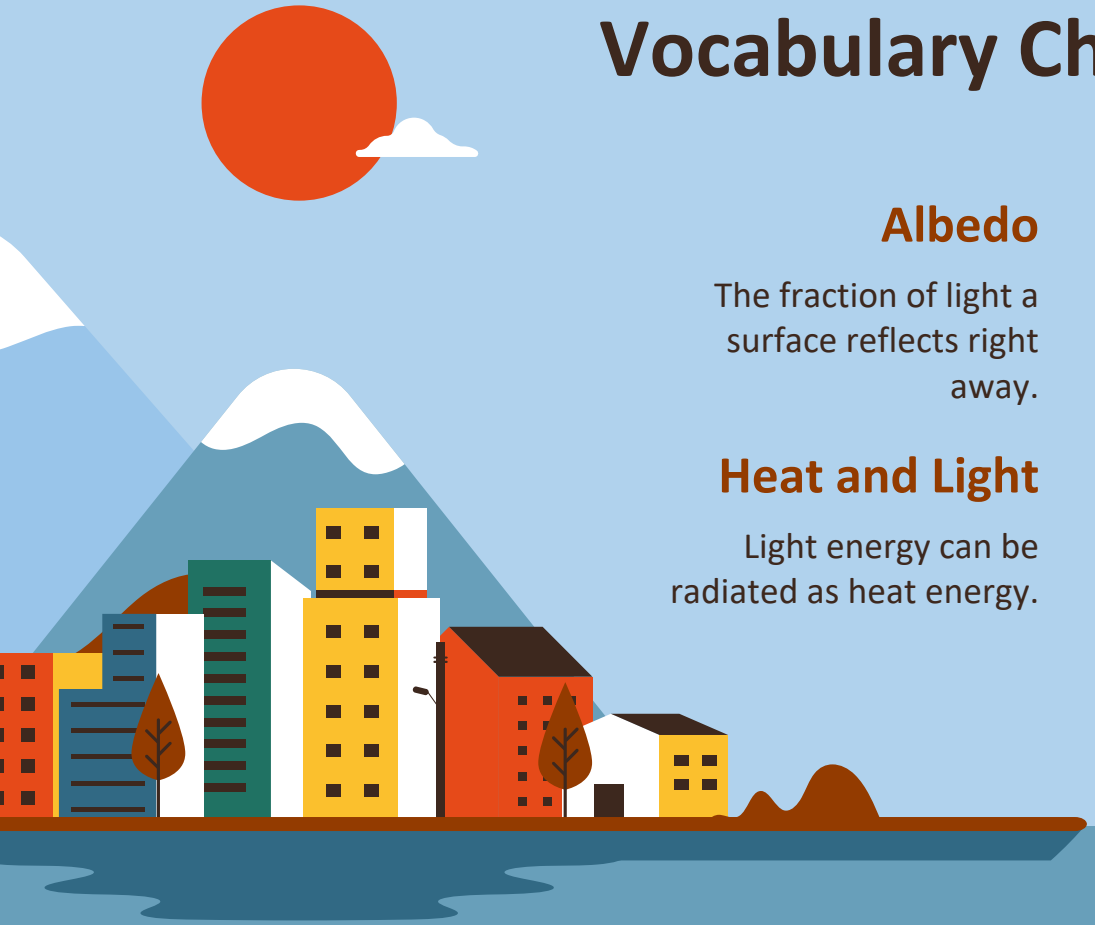

Mead
Country Homes
Town and Country
Riverside State Park
Spokane
90
Airway Heights
Spokane Int'l Airport
Spokane
Jamieson Park
Geiger Heights


Division St
N Nevada
E Euclid Ave
E Frederick Ave
E North Foothills Dr
N Maple St
N Monroe St
E Illinois Ave
E Upriver Dr
Spokane Community College
W Maxwell Ave
Gonzaga University
E Trent Ave
E Broadway Ave
N Freya St
Herbert M Hamblen Conservation Area
Riverfront Park
Spokane
W 1st Ave
W 2nd Ave
E Sprague Ave
High Bridge Park
Liberty Park
E 8th Ave
S Thor St
S Freya St
S Carnahan Rd
Thomas S Tom Foley Memorial Hwy
S Ray St
Latah Creek Conservation
Manito Park
21st Avenue Parkway
E 29th Ave

Thermal Mapping!



Vocabulary Check-in



Albedo

The fraction of light a surface reflects right away.

Heat and Light

Light energy can be radiated as heat energy.

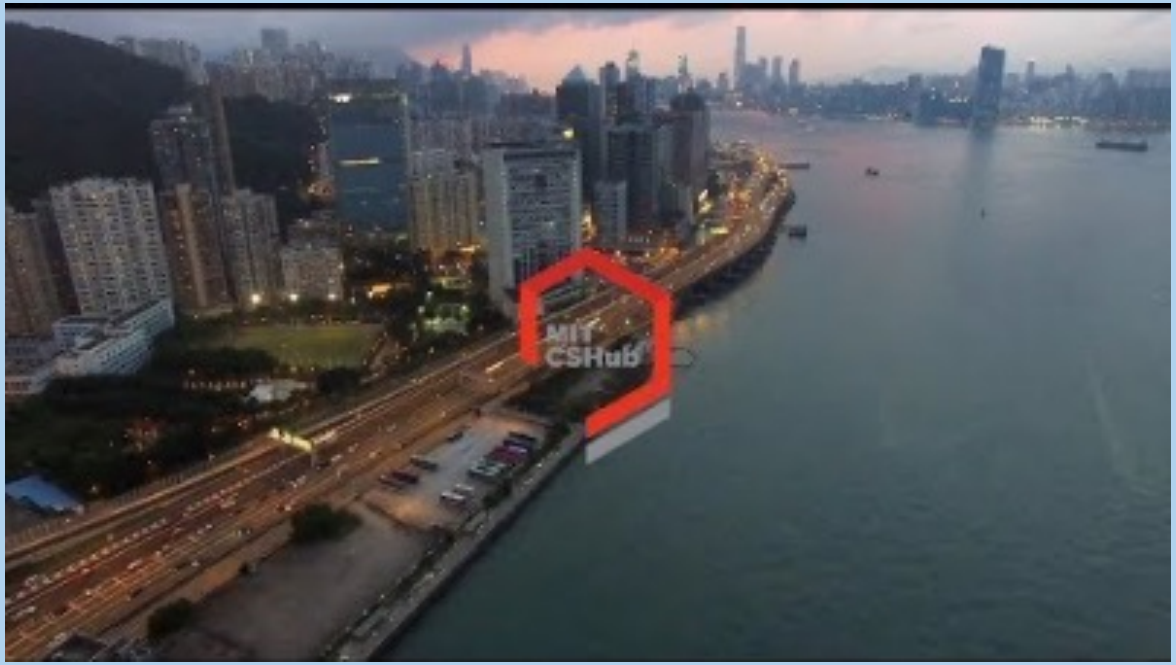
Heat Islands

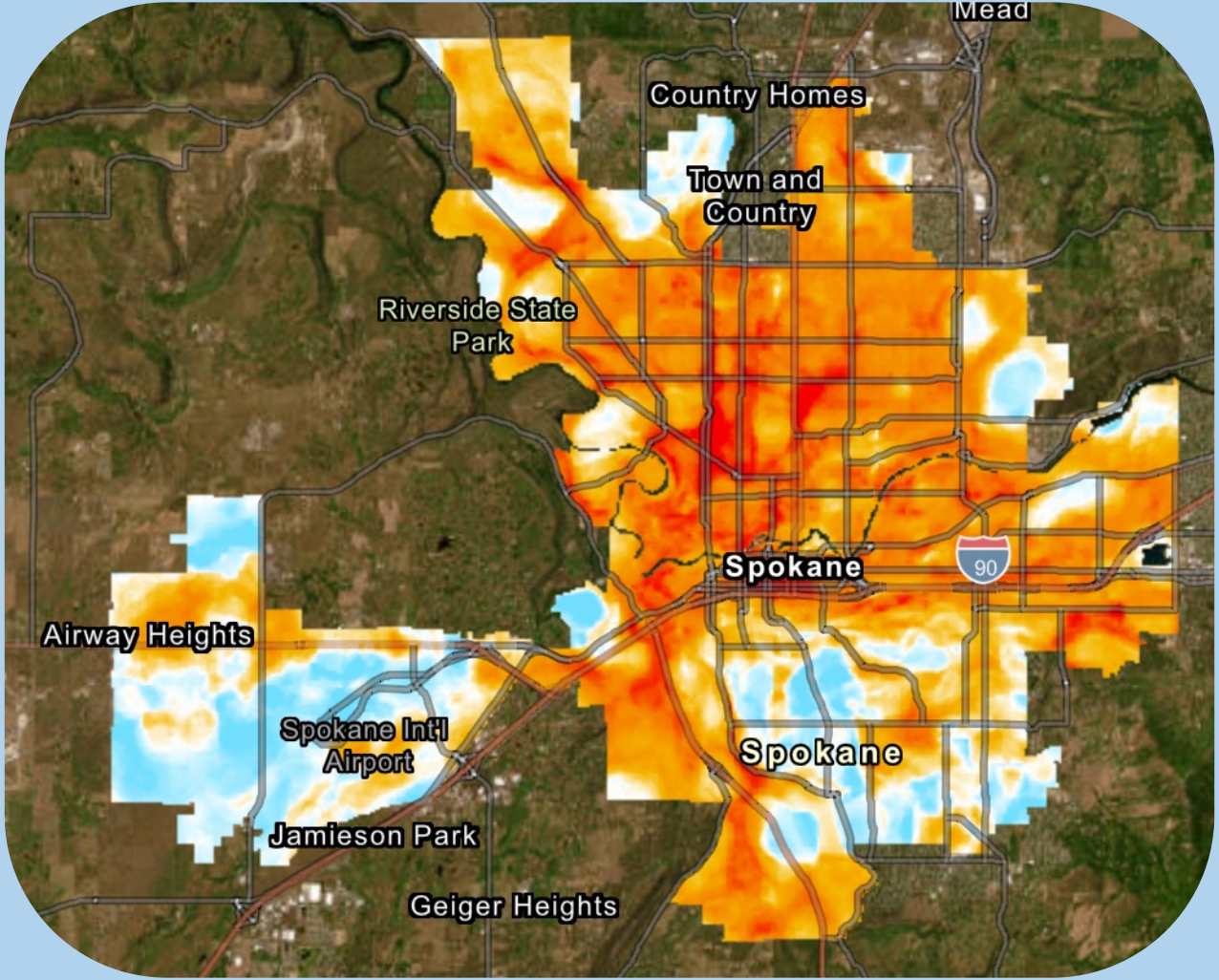
High-albedo areas that become much hotter than their surroundings.

Urban Heat Island Effect

Because of darker surfaces like roads and roofs packed densely, cities become big heat islands!

The Albedo Effect




Mead
Country Homes
Town and Country
Riverside State Park
Spokane
90
Airway Heights
Spokane Int'l Airport
Spokane
Jamieson Park
Geiger Heights

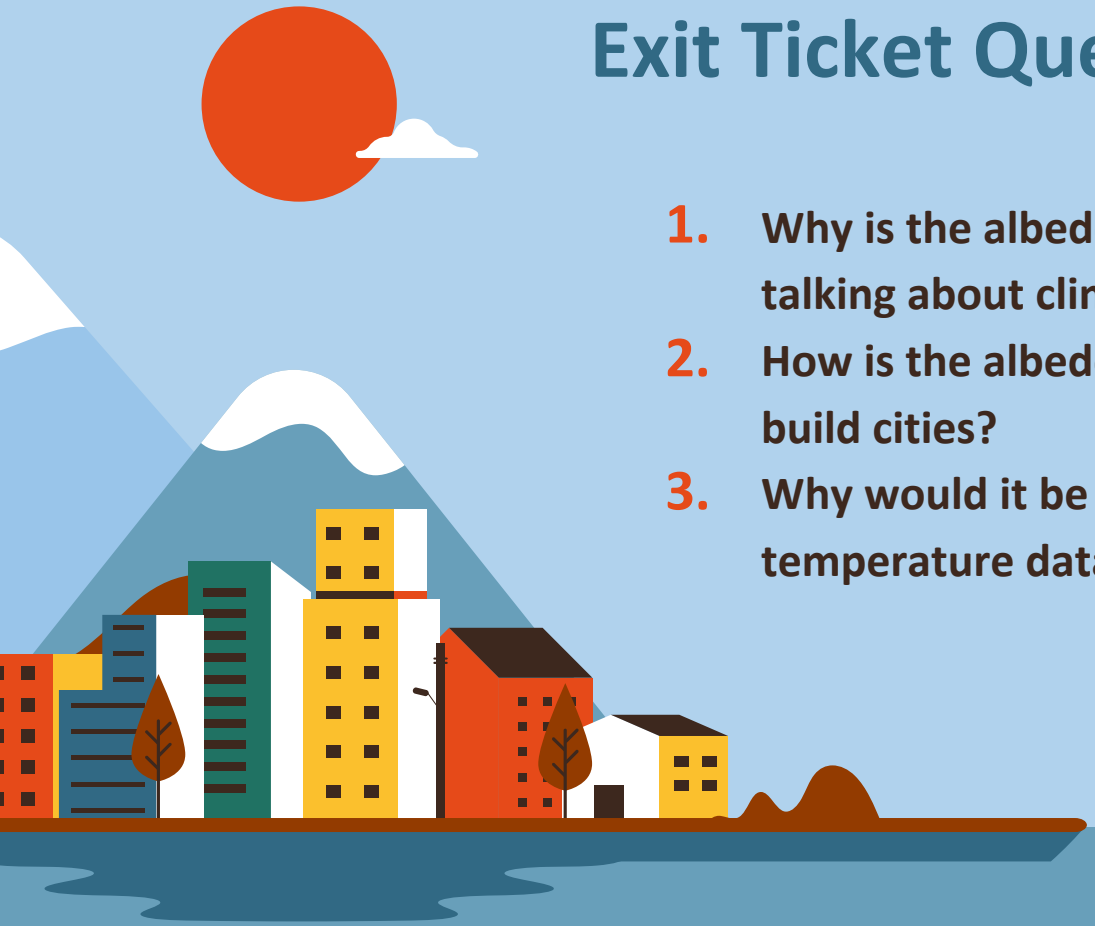
Discuss with your neighbors:

- Do you think Spokane is doing a good job of adapting to climate change? Why?
- What do you think will happen if a city doesn't change anything about its design as temperatures get hotter and hotter?

What would *you* change about Spokane?

Exit Ticket Questions

1. Why is the albedo effect important when we're talking about climate change?
2. How is the albedo effect important to how we build cities?
3. Why would it be important to collect temperature data about the cities we live in?

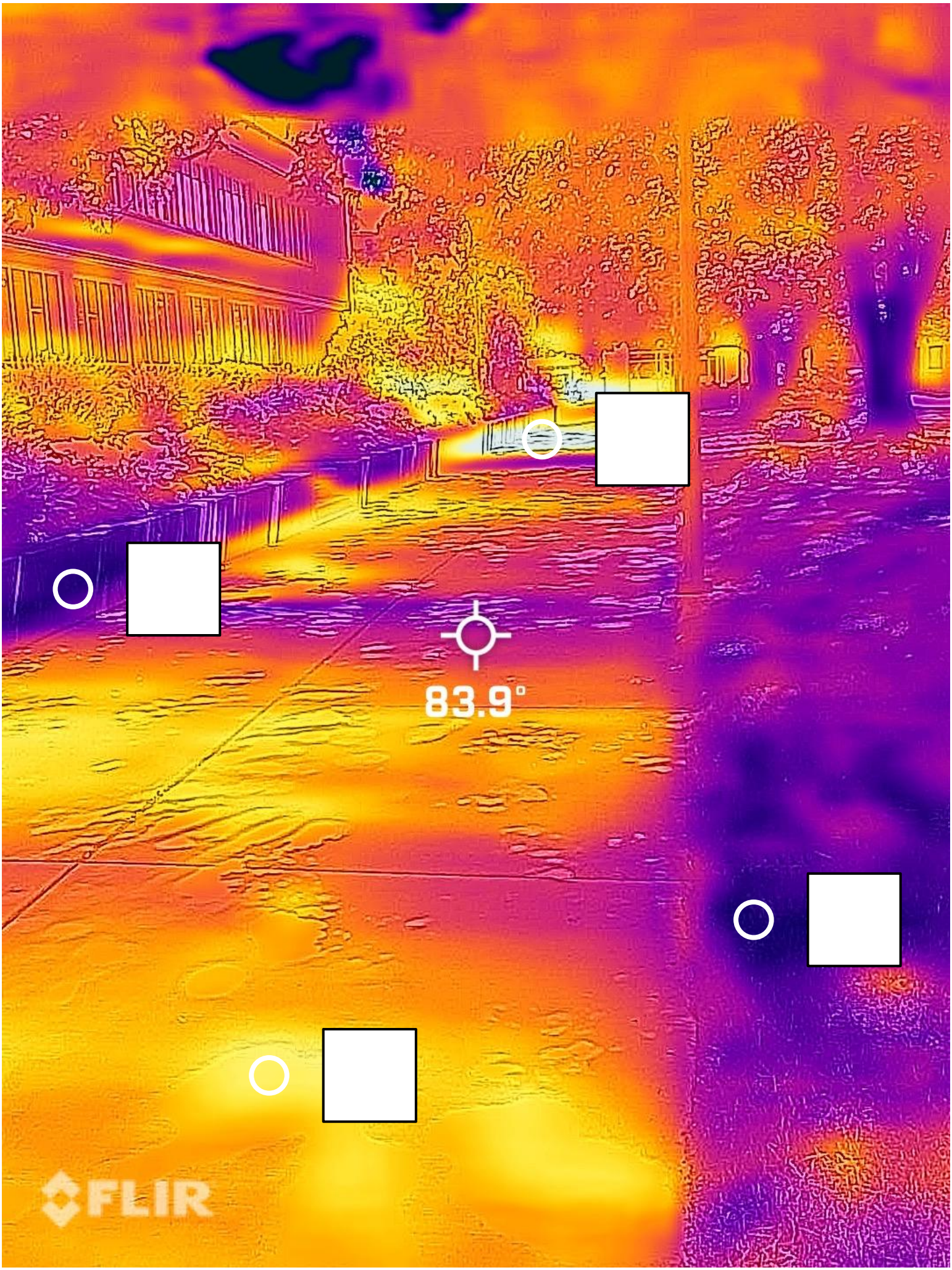


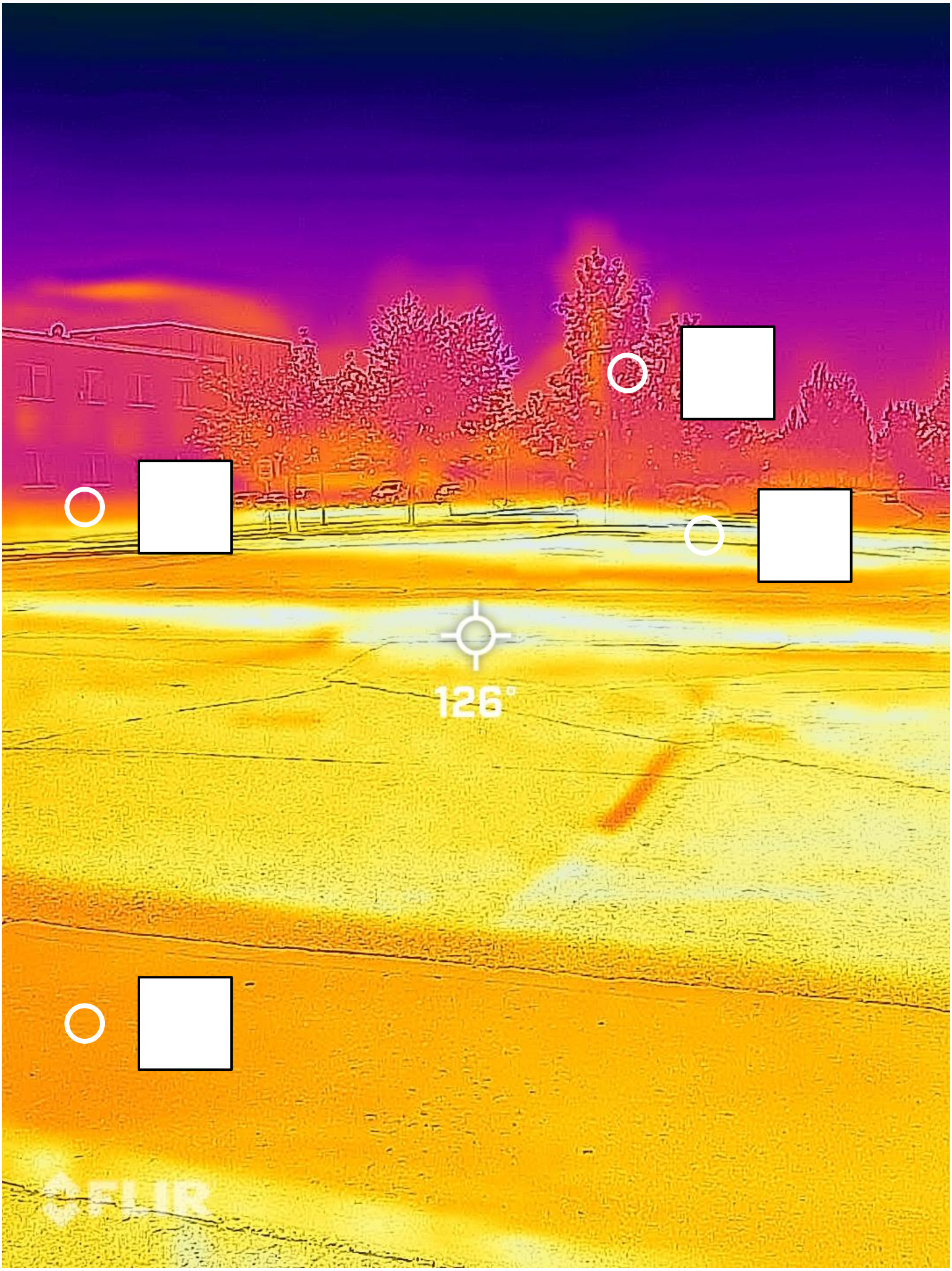
Temperature Gradient

0° F **100° F**

For every observation, place it on the gradient and note down:

- Your best guess for the numerical temperature
- Where you found it
- What material it was
- Whether or not it was in the shade


83.9°
FLIR


126°