Surface Temperatures in Microclimates
Exploring with Infrared Thermometers

Objectives:
Students will be able to:

▪discern patterns in surface temperatures.

▪identify how colors relate to temperature.

▪use infra-red thermometers to measure surface temperature.

Author:
Ecology Explorers
Education team

Time:
50 min. class period

Grade Level:
6-9

Standards
AZ Science Strands
Inquiry, Investigation, Analysis, Communication, Nature of Science, Energy in the Earth System

NGSS-Core Ideas
Earth Systems; Weather and Climate; Biogeology; Human Impacts on Earth Systems; Ecosystem Dynamics, Functioning, and Resilience; Biodiversity & Humans; Energy Transfer

Practices:
Developing and Using Models, Investigations, Analyzing and interpreting data, Constructing explanations

Crosscutting Concepts
Patterns, and more

Specific NGSS Standards and links to other standards on page 3

Background:
Living in the desert has always been a challenge for people and other organisms. There is too little water and, in most cases, too much heat. As Phoenix has grown, the natural environment has been transformed from the native desert vegetation into a diverse assemblage of built materials, from buildings, to parking lots, to roadways. Concrete and asphalt increase mass density and heat-storage capacity. This in turn means that heat collected during the day is slowly radiated back into the environment at night. While both the city and the Sonoran Desert are hot during the day, the desert cools down much more quickly at night than the city. A high growth rate combined with clear, calm weather, low altitude with intense sun, and heat-absorbing surfaces explain our greater than normal urban warming (Brazel 2000). Scientists call this phenomenon the Urban Heat Island (UHI).

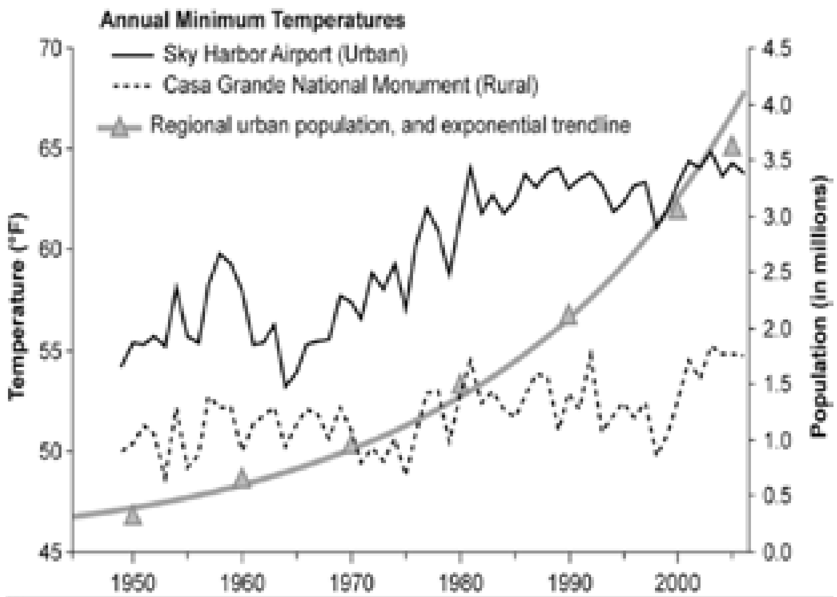

Figure 1 shows the average minimum temperature in the Phoenix metropolitan area has increased (along with its population) since 1945, as compared to a nearby rural location.

Some researchers have found that the density and diversity of plants moderate temperatures in neighborhoods (Stabler et al., 2005). Landscaping appears to be one way to mitigate the UHI effects. Designing the built environment with different materials is another approach. Roofs and pavements made with alternative materials and designs can absorb and retain less thermal energy than conventional materials under identical environmental conditions (Carlson & Golden 2008).

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Vocabulary:

Temperature - a measure of average heat or thermal energy

Microclimate - climate of a small, specific place within an area as contrasted with the climate of the entire area

Urban Heat Island - a metropolitan area which is significantly warmer than its surrounding rural areas, a night time phenomenon of increased temperatures in the Phoenix Metropolitan area

Thermometer - instrument to measure temperature

Infrared Thermometer - instrument to measure surface temperatures using infrared radiation (heat)

Advanced Preparation:

For background and to generate photos for this activity, you may wish to first conduct the Natural and Built lesson. Survey the school yard or study area for safety issues and to familiarize yourself with the variety of surfaces available to measure.

Materials:

- Photos of Built and Natural Environments (of schoolyard or from slideshow)
- Infrared (IR) thermometers (1 per group)
- Student Data Log Worksheet
- Clip boards (1 per student)

Recommended Procedure:

Engagement:

1) Introduction: Share photos of built and natural environments either taken by students in their school yard or from the slide show: "Natural and Built Pictures".

2) Ask students: Which environments do you predict stay cooler? Which are warmer?

3) Explore microclimates in your own schoolyard. Have students predict where they might find the hottest and the coolest temperatures. Record this prediction on the Student Worksheet: Surface Temperature Data Log and discuss students' reasoning.

Exploration:

4) Discuss and define temperature and thermometers. Have students think about the differences between a thermometer they use to measure body temperature and the IR thermometer—one needs to be next to the body to record temperature, the other can be further away.

5) Give each student group one IR thermometer and explain how to use it. (Safety is important—don't point at people's faces!!!).

6) Have the students brainstorm and write a list of surfaces in their environment (i.e. grass, concrete sidewalk, brick building, gravel, dirt, metal, etc.). This initial list is just a starting point. Students can write down more surfaces if they find them in the school yard.

7) Have the students go outside and record temperatures, colors and sun or shade on the different surfaces in their school yard.

Explanation:

9) As a class, review the data students have collected. Ask them what they noticed about their data. What were the hottest and coolest spots?

10) Discuss the following questions.

- What was the hottest temperature? - What kind of surface was it? What color was it? Was it in the sun?
- What was the coolest temperature? - What kind of surface was it? What color was it? Was it in the sun?
- What differences did the students find between the natural and built environment.

Expansion:

11) Summarize the most important factors involved in surface temperature: Ask students, what makes a surface hot or cold regardless of the sun? (e.g. light colors/dark colors, materials—metal, cloth, concrete, stone, living or non living). How does the sun affect these factors? Why does it matter if the object is vertical or horizontal?

12) Define microclimate and discuss how surface temperatures relate to microclimates. How would, then, colors and types of surfaces impact a microclimate?

Evaluation:

Students will conduct measurements, complete worksheets, and participate thoughtfully in discussion.

Extensions:

Students may average the temperatures from the same surfaces and make a bar graph with surface type on the x axis and average surface temperatures on the y axis.

Guide students to discuss why a bar graph may be a better way to communicate their results than a table.

Students follow the journal prompts on the Student Worksheet: Surface Temperature Journal Writing.

References:

Brazel, A., JN., N. Selover, R. Vose, and G. Heisler. 2000. The tale of two climates – Baltimore and Phoenix urban LTER sties. Climate Research. (15): 123-135.

Carlson, J. and J. Golden. 2008. Climate, Energy , and Urbanization. A Guide on Strategies, Materials and Technologies for Sustainable Development in the Desert. Prepared for The City of Phoenix By The National Center of Excellence on Sustainable Material and Renewable Technology (SMART) Innovations, Global Institute of Sustainability / Ira. A. Fulton School of Engineering / College of Design Arizona State University. 379pp

Stabler, L.B., C.A. Martin and A.J. Brazel. 2005. Microclimates in a desert city were related to land use and vegetation index. Urban Forestry & Urban Greening 3:137-147.

Standards:

Arizona Science Standards

S1-C1-GR5-PO2
S1-C2-GR5-8-PO1, PO4, PO5
S1-C2-GRHS-PO1, PO5
S1-C3-GR5-PO1, PO5
S1-C3-GR6-PO1, PO2
S1-C3-GR7-PO1, PO2, PO5
S1-C3-GR8-PO1, PO2, PO3
S1-C3-GRHS-PO1
S1-C4-GR5-PO1
S1-C4-GR6-7-PO2
S1-C4-GR8-PO3
S1-C4-GRHS-PO3
S2-C2-GR6-7-PO3
S2-C2-GR8-PO1
S6-C2-GR6-PO4
S6-C2-GRHS-PO9

NGSS Core Ideas

ESS2.A: Earth materials and systems
ESS2.D: Weather and climate
ESS2.E: Biogeology
ESS3.C: Human impacts on Earth systems
LS2.C: Ecosystem dynamics, functioning, and resilience
LS4.D: Biodiversity & Humans
PS3.B: Conservation of energy and energy transfer

NGSS Practices

Developing and Using Models
Investigations
Analyzing and interpreting data
Constructing explanations

NGSS Crosscutting Concepts

Patterns
Cause and effect
Scale, proportion and quantity
Systems & System Models
Energy

Common Core/ELA Literacy

RST7: Integrate content from diverse formats
WHST2: Write to convey ideas and information
WHST7: Research/investigate to answer question
SL1: Participate in collaborations and conversations
SL2: Integrate oral information
SL4: Present effectively to listeners

Common Core/Mathematics

Domains:
Number and Quantity
Measurement and Data
Math Practices:
2: Reason abstractly and quantitatively.

Student Worksheet (#1)
Surface Temperature Data Log

Instructions
As you brainstorm about identifying surfaces around your schoolyard to measure surface temperature, make entries in the "Surface" column below.

Before you take the actual surface temperature readings, predict the following:

the surface with the highest temperature reading____

the surface with the lowest temperature reading____

Surface i.e. grass, concrete, gravel...	**Color**	**Description of site** Is it in the sun or shade? Is it vertical or horizontal? Is it natural or built?	**Temperature (oF)**

Analyze your data:

the surface with the highest temperature reading____

the surface with the lowest temperatures reading____

Student Worksheet (#2)
Surface Temperature Journal Writing

Imagine and explain:

1) How might the high and low temperatures change during the day? The year?

2) How might this information be beneficial to you?

3) Do cities have microclimates?

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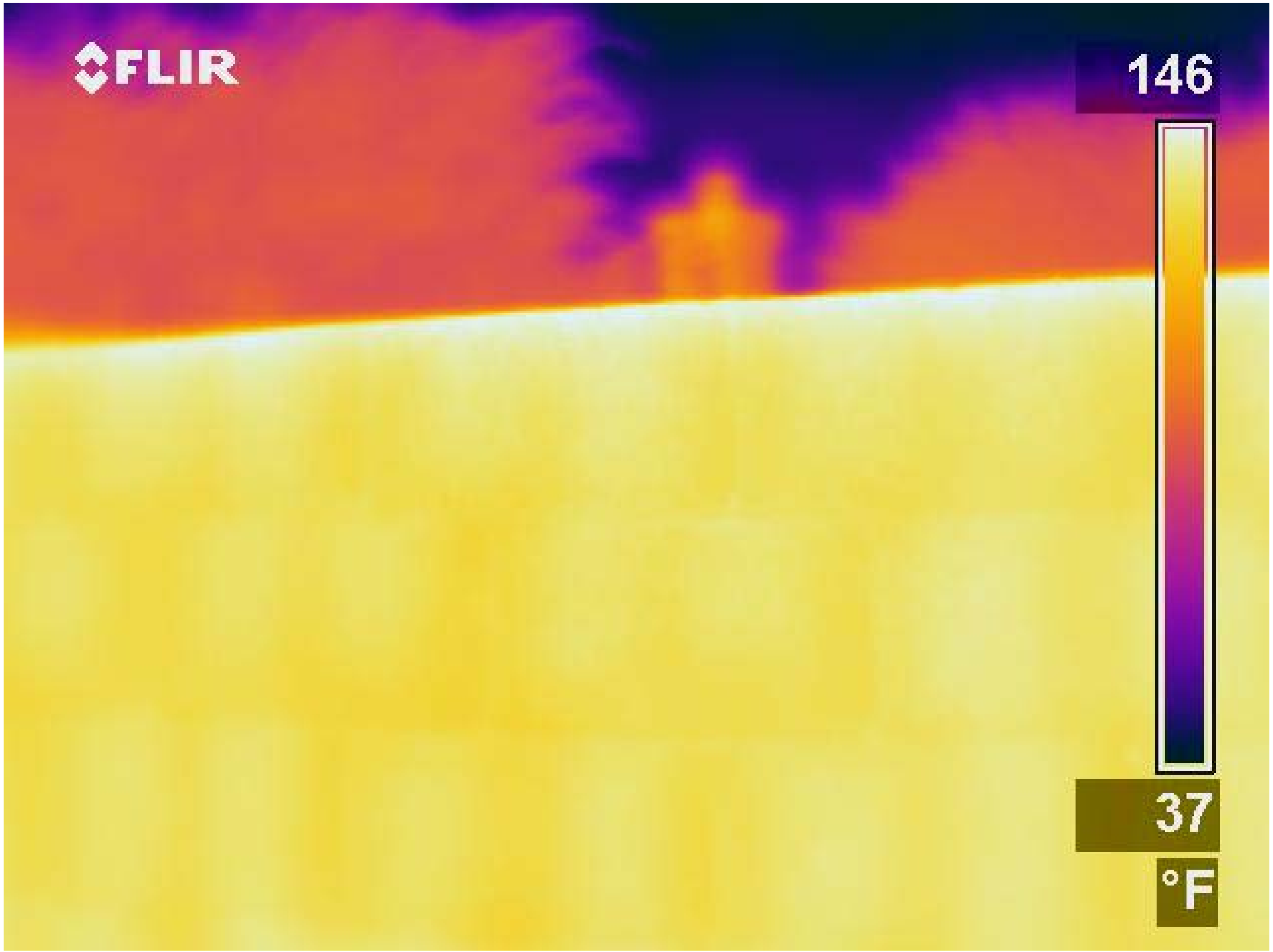

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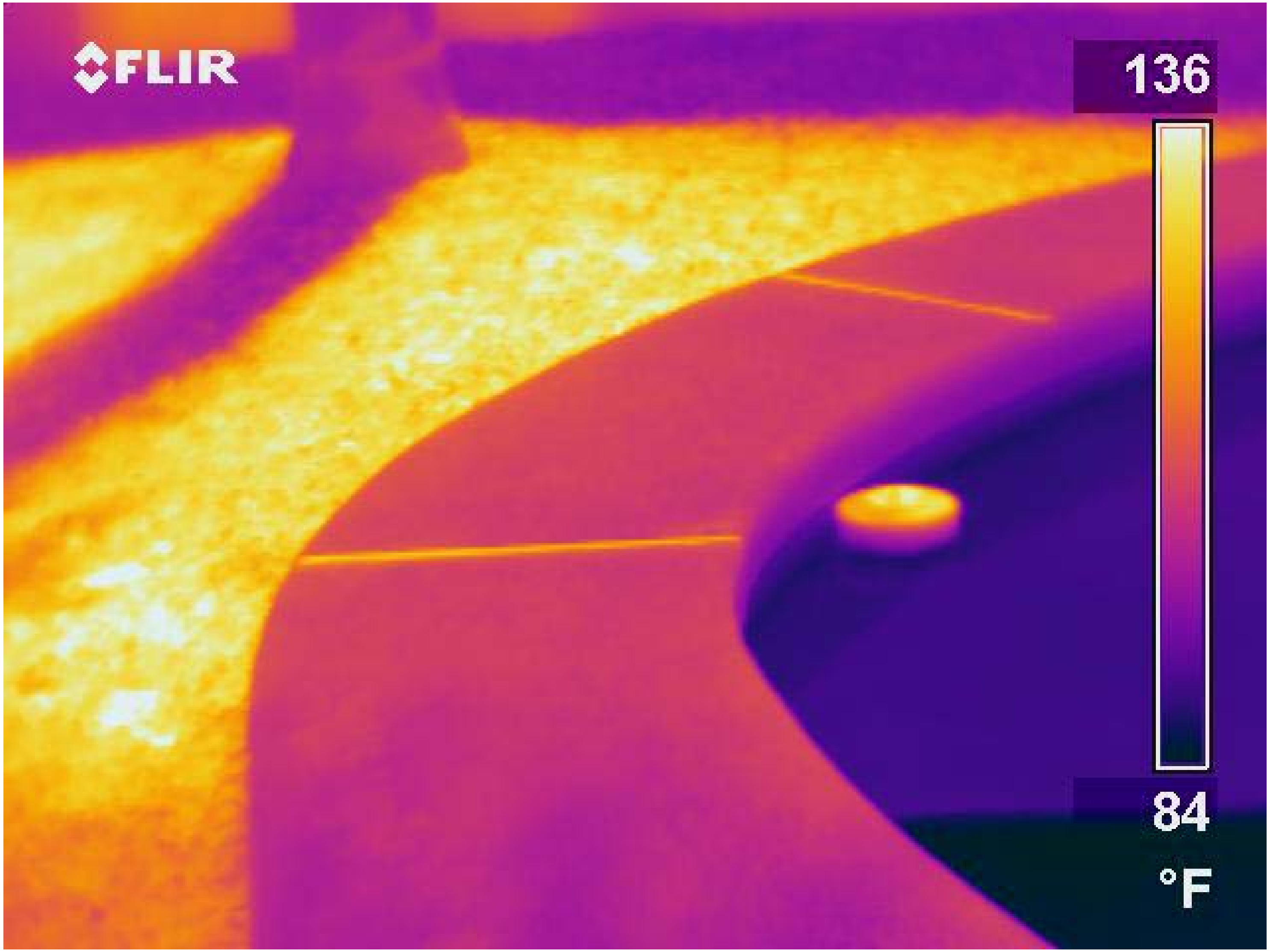

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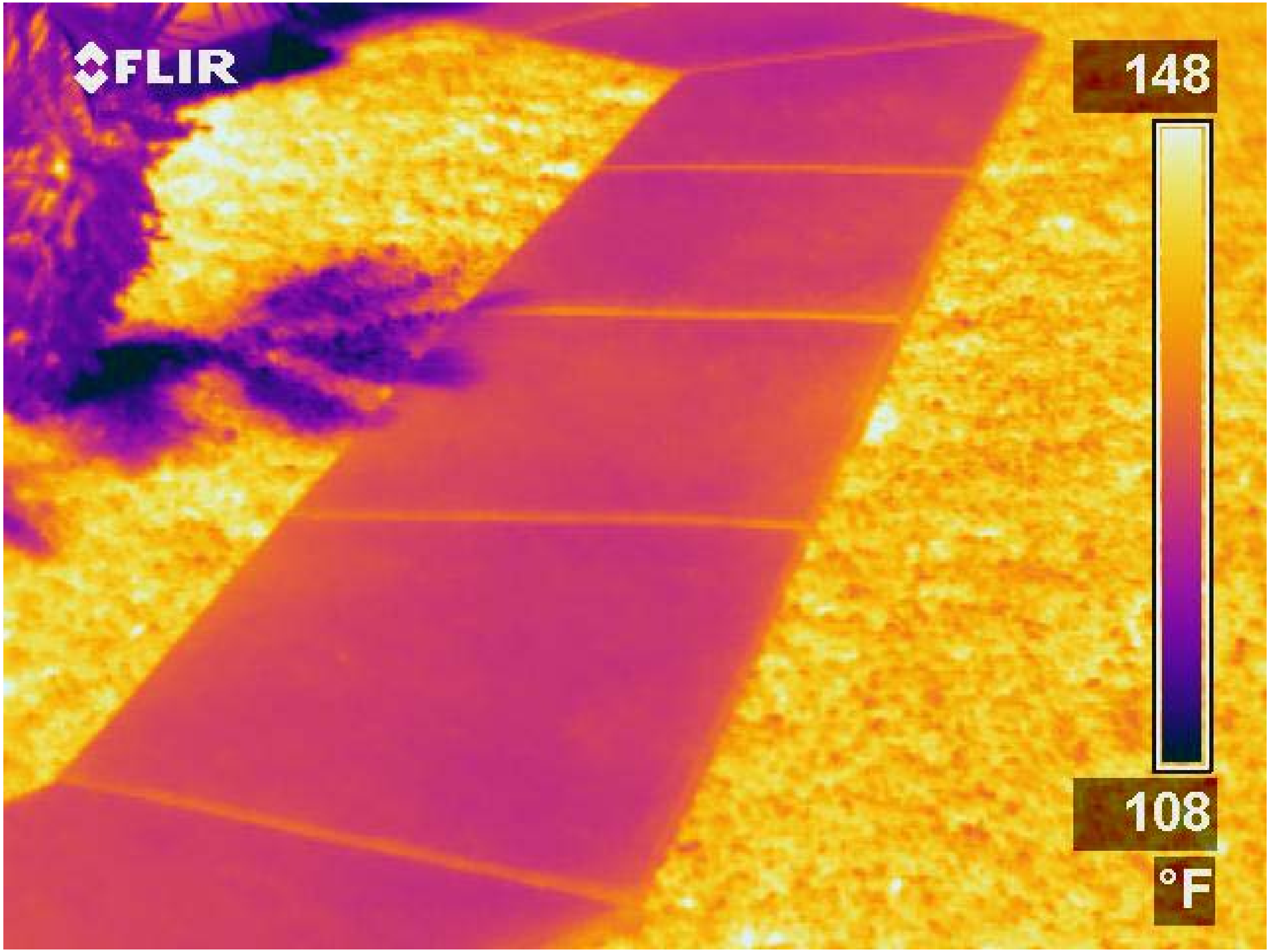

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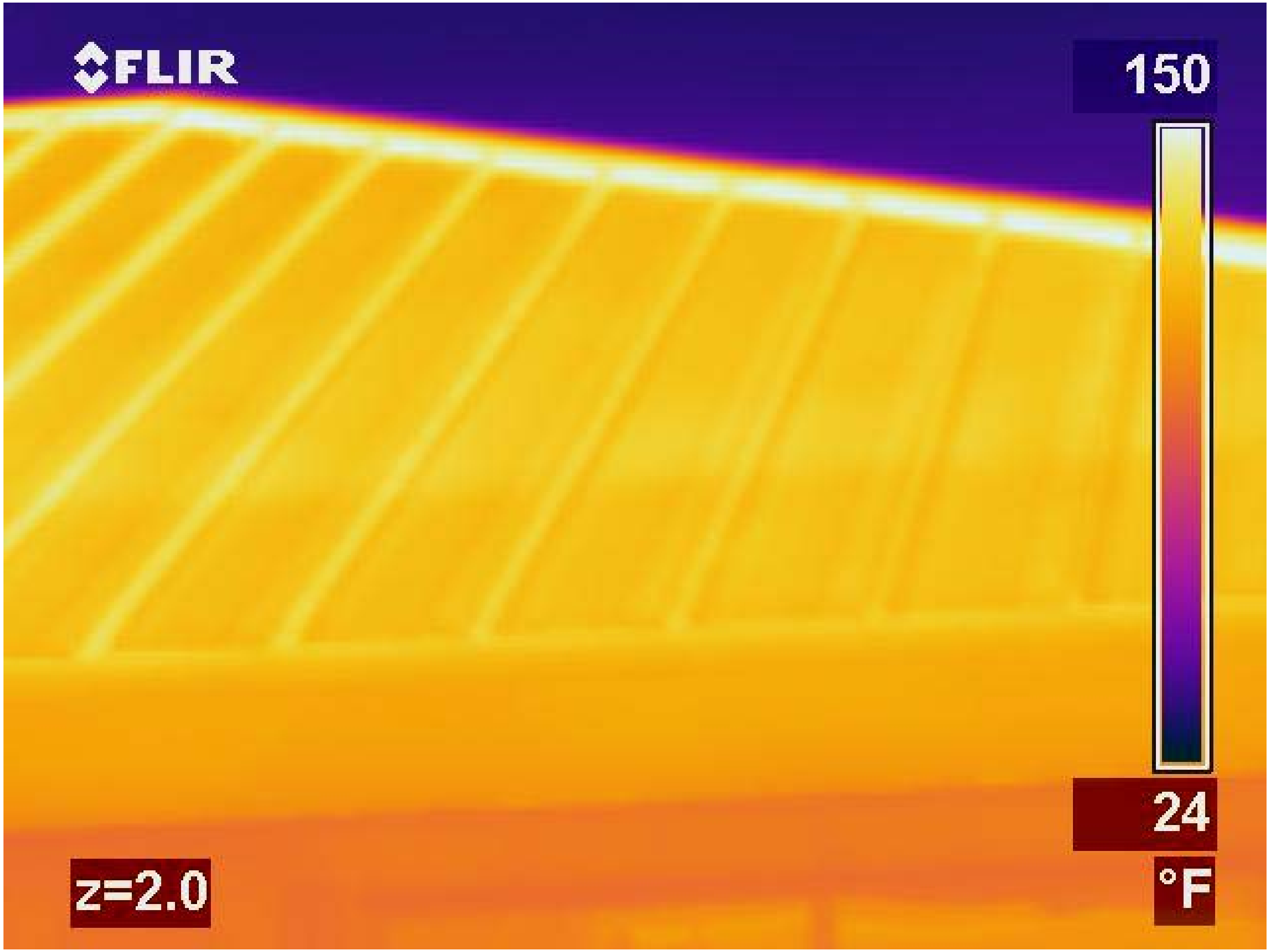

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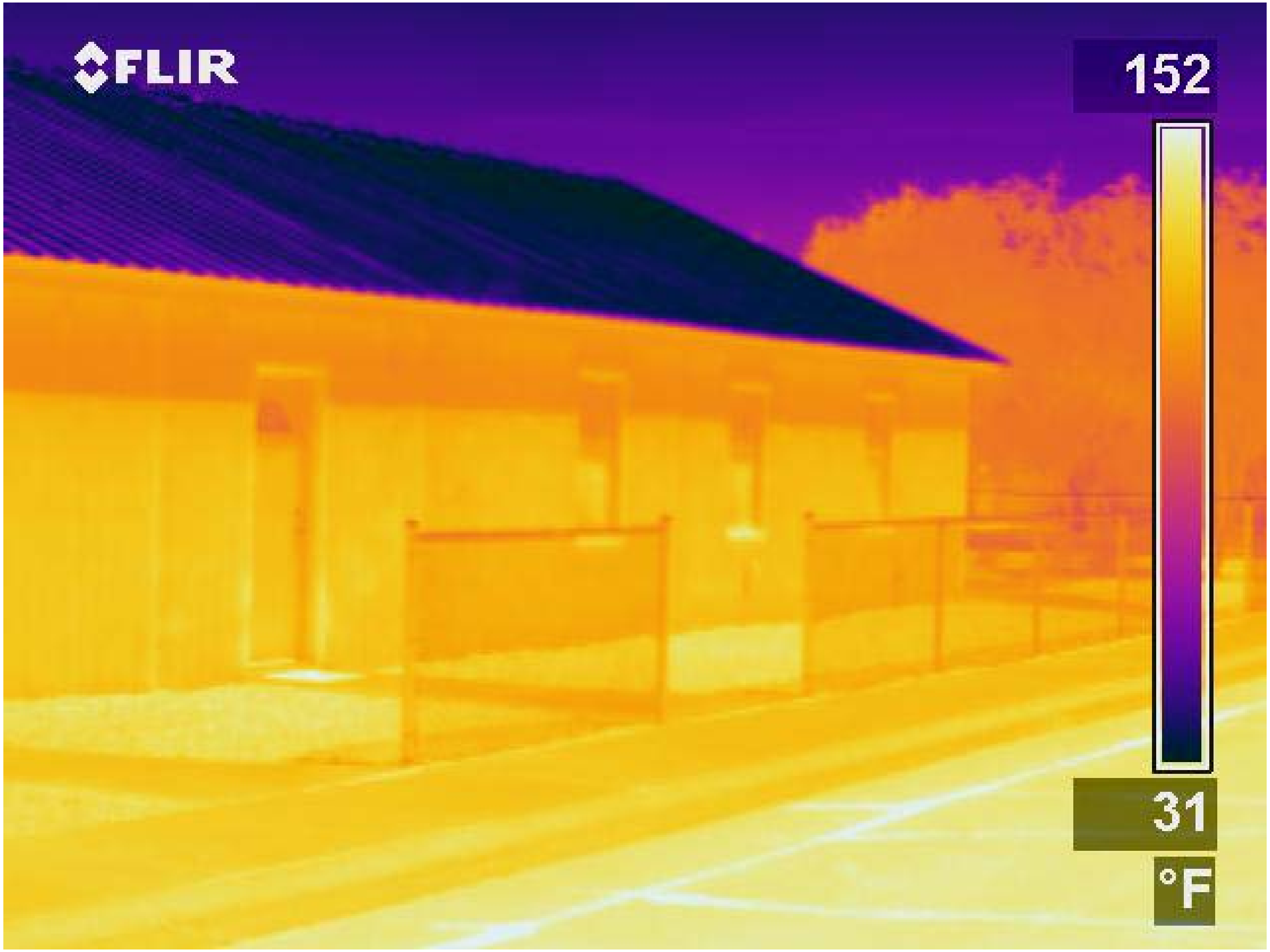

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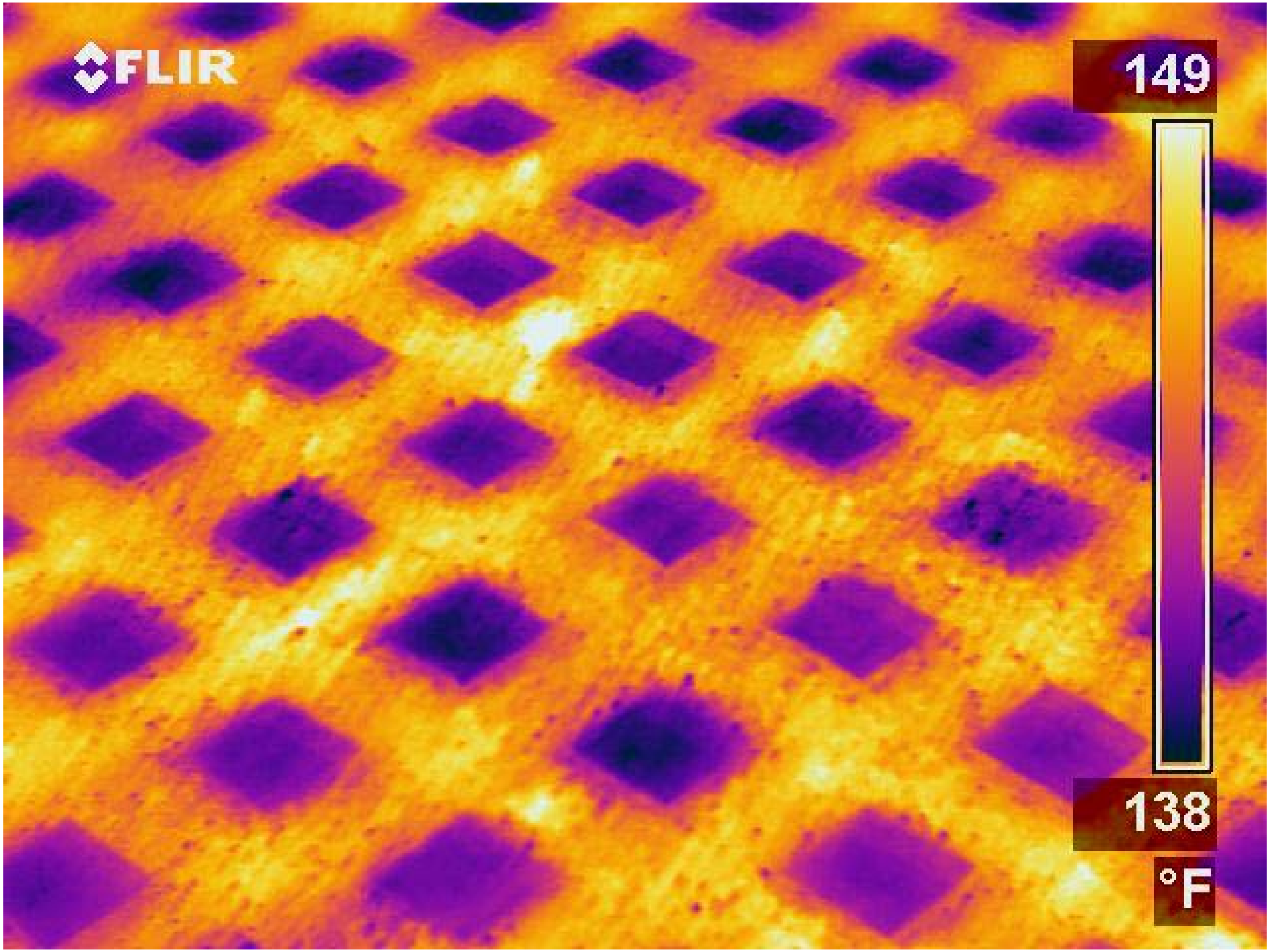

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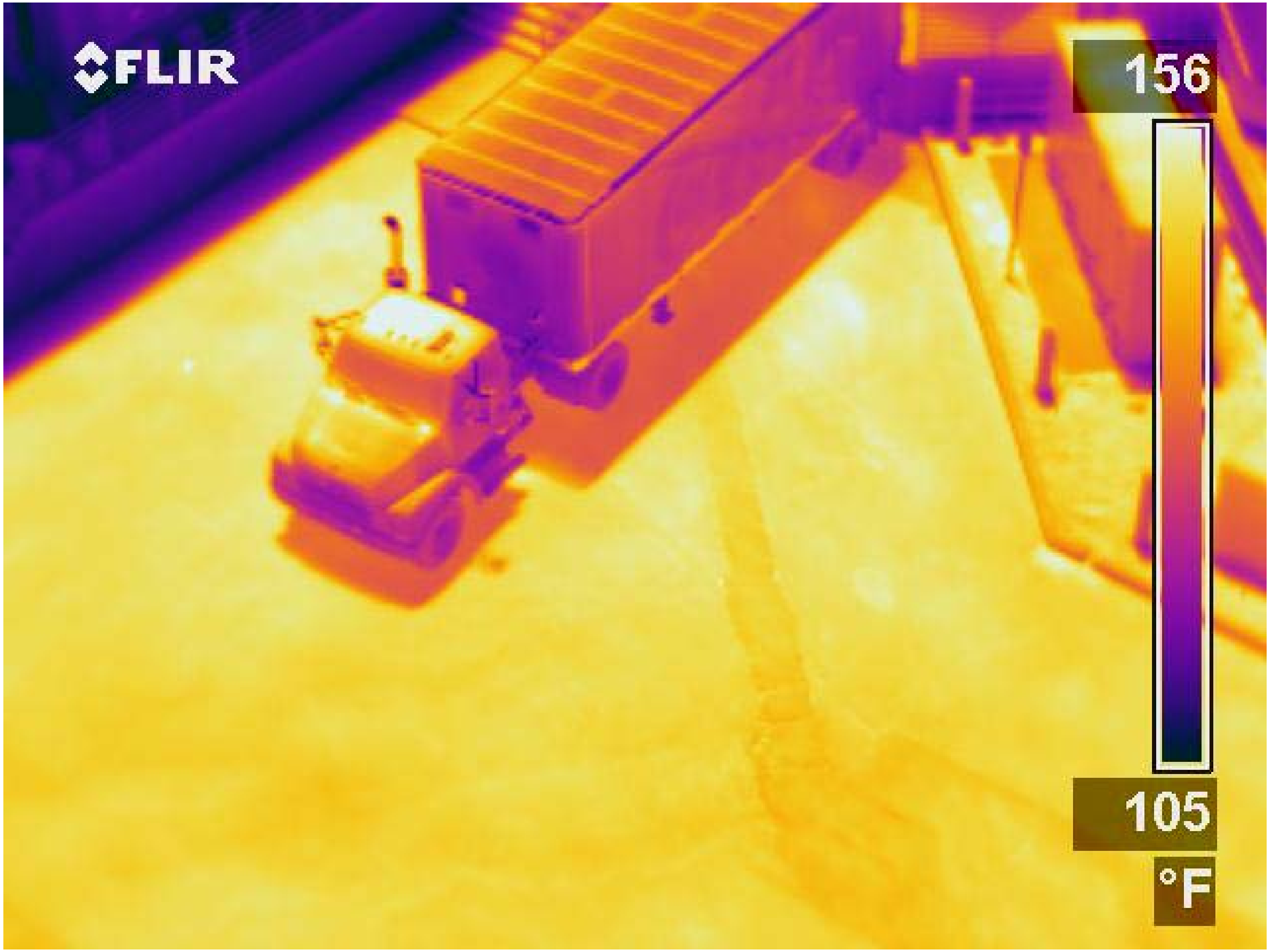

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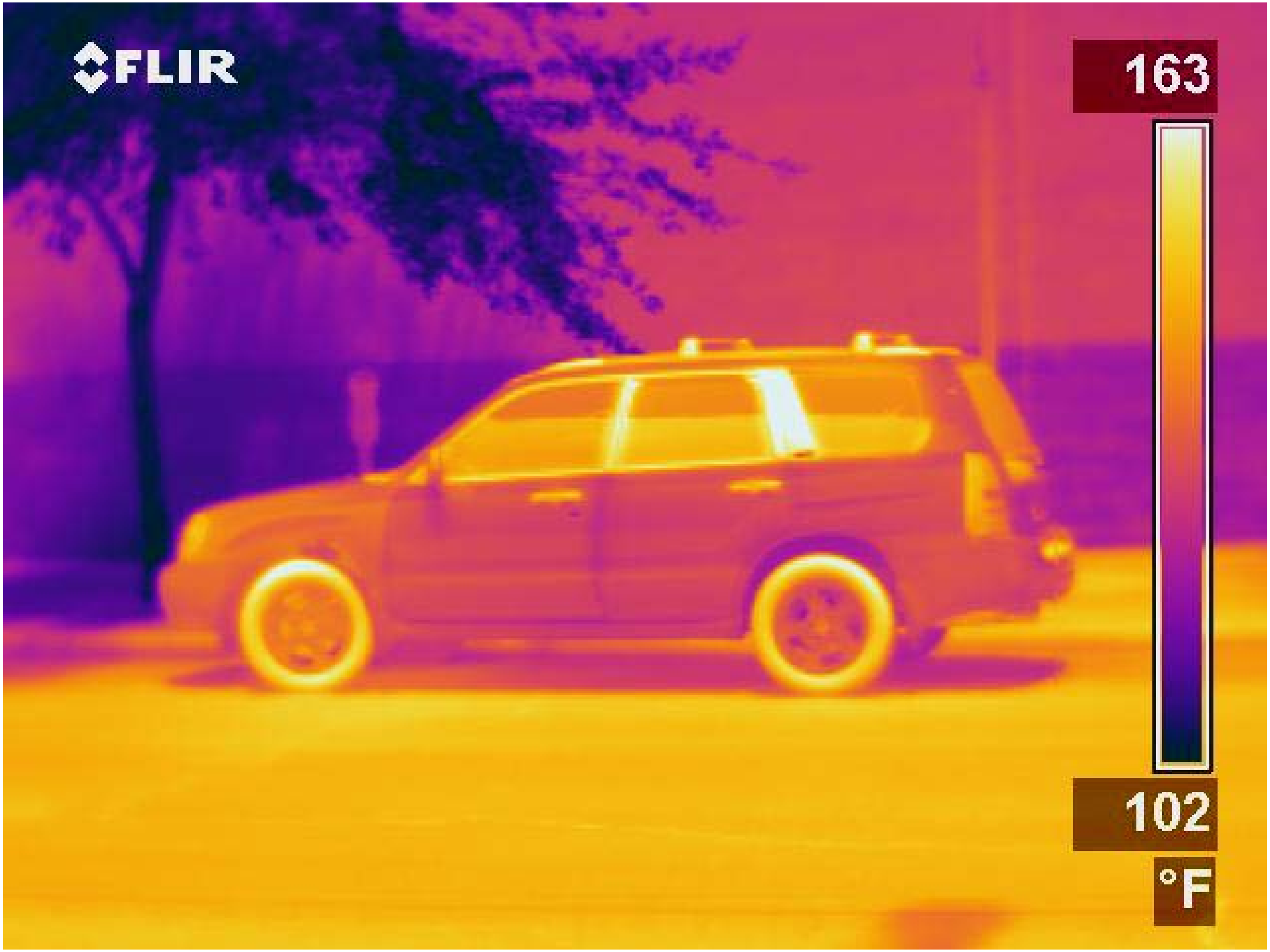

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