Heat Islands

Overview

Global changes in the way we use the landscape, such as cutting down trees (deforestation), have led to an increased influx of carbon dioxide (CO_2) into the atmosphere and an increase in the temperature on Earth. Meanwhile, at the local or regional level, alterations in landscape use play a significant role in affecting local climate. For example, the transformation of natural landscape to an urban area can cause the air in urban areas to be 2 - 5°C (3.6 - 9°F) warmer than nearby rural areas. This local effect on temperature is referred to as Urban Heat Islands. While it's most noticeable when there is little wind, it has drastic consequences. For instance, it can cause prolonged heat waves and influence wind patterns and precipitation.

One reason for the formation of urban heat islands is the reduction in shade and moisture by paving or construction. Rural areas have more vegetation and open land than urban areas. The trees and other plants in these areas lower the surface temperatures through shading and evapotranspiration (a process by which plants release water to the surrounding air). Meanwhile, urban areas do not have large shaded areas and contain a lot of dry, non-porous surfaces like roofs, sidewalks, roads, and parking lots.

Yet another cause for the formation of urban heat islands depends on how heat from the Sun is absorbed and reflected back out towards space. Surfaces with light colors reflect a large portion of energy and remain cooler, while dark surfaces absorb a great deal of solar radiation and become warmer.

The alteration of the natural landscape from forests to paved roads and dark rooftops has changed the amount of heat absorbed in our cities and resulted in the urban heat island effect.

Materials

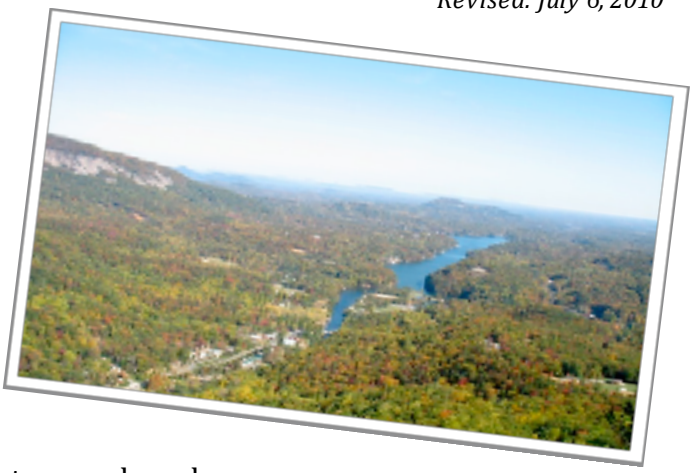
For the leader:

- ✓ Whiteboard or chart paper and a marker

For each group:

- ✓ *1 Pasco Spark unit*
- ✓ *1 Pasco Quad temperature sensor*
- ✓ *2 Pasco temperature probes*
- ✓ *Black or dark colored roofing shingle*
- ✓ *White or light colored roofing shingle*
- ✓ *Pens/Pencils/Markers*
- ✓ *Clipboard*

Draft Pilot Version
Revised: July 6, 2010



Motivating Question: How can human development influence climate?

Engage:	Students discuss their understanding of what influences the climate on Earth and on local scales	10 minutes
Explore:	Students will collect and share their data on how the color of a material impacts the amount of heat in an area	40 minutes
Make Sense:	They will discuss how urban heat islands are formed and strategies for combating the heat island effect.	10 minutes

Total: 60 minutes

Preparation (10 minutes)

1. Write the motivating question on the board or a large piece of paper:

   Q. How can human development influence climate?

2. Ensure that the PASCO Spark handheld devices are charged and ready to be used with the non-contact temperature sensors attached.

3. Gather materials needed for the second experiment, which begins in Step 8. Materials needed for each group include: a light source, roofing shingles (black and white), a quad temperature sensor, and 2 temperature probes.

Engage (10 minutes)

1. Ask the students to share their ideas on the following questions with the person next to them:

   Q. What affects the Earth's weather and climate?

   Q. Do you think these things would also affect the climate in our city? Are there any differences?

2. Have the students report out and share their ideas with the group.

Explore (40 minutes)

1. Explain to the students that they will be testing whether or not **color** can influence **heat absorption**.

2. Assign the students to 5 groups and distribute the following material to each group: a piece of a black roofing shingle, a piece

of a white roofing shingle, a Spark Handheld device with quad-temperature sensor and 2 fast-response temperature probes (white wires), and a light source.

3. Have the students place the black and white shingles side by side at an equal distance to the light source and then place one temperature probe on each piece of the shingles. To ensure the temperature probes touch the shingles, use a small piece of scotch tape an inch or two above the probe. Do not tape the probe end.
4. Have the students turn on the Spark Handheld device and measure the initial temperature of each shingle.
5. After recording their initial temperatures, have the students turn the light on.
6. Ask the students to form a hypothesis based upon their results with the non-contact temperature sensors (if they did the microclimates lesson) about whether the black or white shingles will get warmer or if the temperatures will remain the same as long as they are the same distance from the light source.
7. After approximately 5 minutes, have the students record the temperature reading from both probes.
8. While waiting to take the reading, introduce the concept of microclimates:

   ✓ There can be small differences in temperature even in areas like the schoolyard. These differences reflect different microclimates.

   ✓ The term microclimate can be used to describe differences in small areas of just a few square meters or much larger areas a few kilometers apart.

   ✓ Factors that contribute to microclimates in a small area like a school yard include the presence or absence of shade (from trees or buildings) and the type of material an object is made of (dirt, asphalt, concrete, metal), and whether there is vegetation.

   ✓ Shaded areas are generally cooler because much of the solar radiation is unable to reach the ground. Ground materials like asphalt and concrete absorb solar energy readily and dark paving will typically be warmer than light color paving because dark colors absorb more heat.

Experiment setup for the Heat Islands activity

Instructor's Notes

Help the students understand that in urban areas where surfaces like asphalt and concrete are abundant, temperatures will be higher due to greater absorption of solar energy.

If they are having difficulty understanding what it means to absorb something, explain that the dark colors are like a sponge that takes up the heat more than light colors.

9. Have the students determine the change in temperature for both shingles by subtracting their initial reading from their final reading.

10. Ask the students the following:

    Q. Did the black or white roofing shingle become warmer under the light source (the sun) or were the temperatures the same? How did this compare to your hypothesis?

11. Introduce the concept of absorption. Ensure that the students understand that dark colors absorb more heat than light colors do. The heat that is not absorbed is reflected back up away from the surface. As a result, the light colors reflect more heat and remain cooler.

Make Sense (10 minutes)

1. Ask the students the following question:

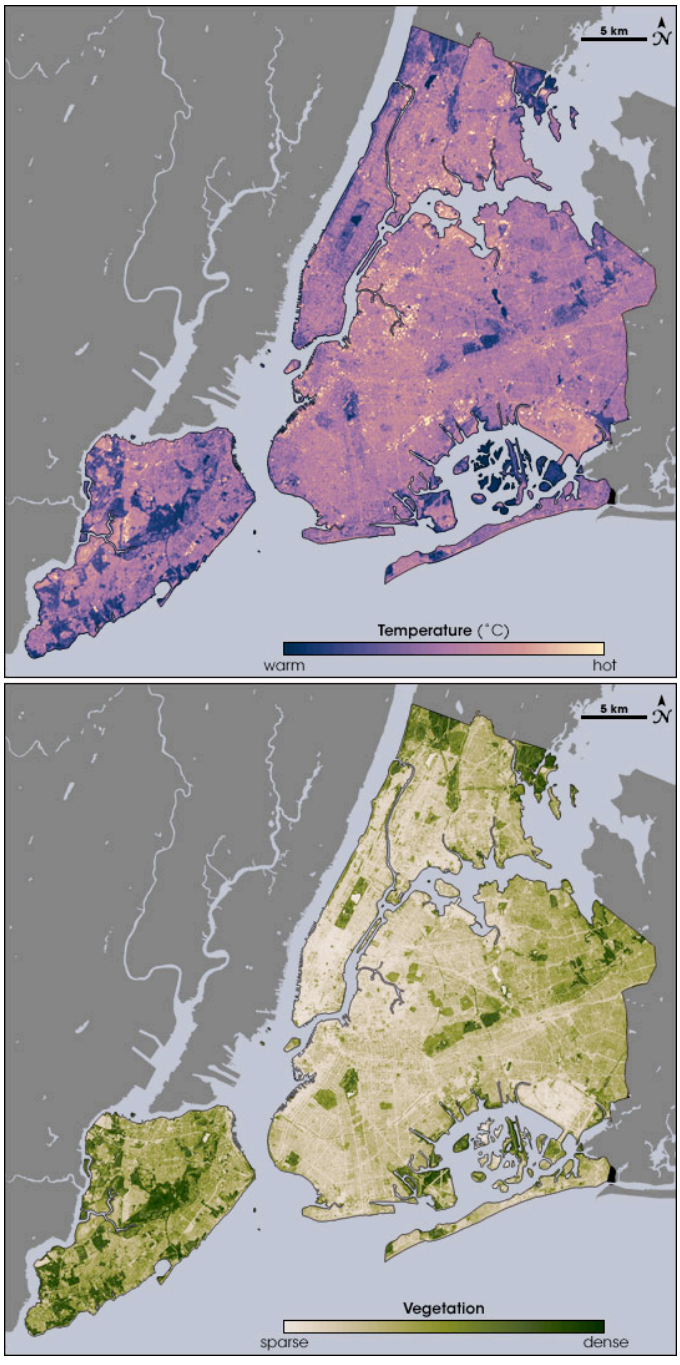
    Q: Based on all of your results, would you predict that urban (city) or rural (farm) areas would be warmer? Why?

2. Introduce the concept of Urban heat islands:

    ✓ The air temperature in urban areas can be 2 - 5°C (3.6 - 9°F) warmer than nearby rural areas. This is known as the heat island effect.

    ✓ Many rural areas have a higher albedo than urban areas. There are more trees in rural areas, which shade the ground, preventing radiation from the Sun from being absorbed. Meanwhile, dark rooftops and pavement absorb more radiation, which traps more heat in urban areas.

    ✓ Trees and vegetation also keep areas cool by aiding in evaporation of water through transpiration. Evaporation can utilize much of the heat energy that would otherwise be absorbed.



These images show how areas with lots of vegetation remain cooler on the hottest days.

- ✓ Urban heat island can increase the magnitude and duration of a heat wave and influence the weather by changing wind patterns, clouds, and precipitation.

3. Ask if the students can suggest any ways to help decrease the effect of heat islands. You may want to discuss with them that many cities are trying to fight urban heat islands by planting more trees, painting roofs white, and actually putting trees on top of roofs.

Extension Activity

Relating Local Climate Changes to Global Climate Change

1. Explain that understanding local, regional, and global solar reflection and absorbance is critical in predicting how the climate might change on a global scale. In this activity, students consider how humans can have an impact on local climate by changing the one environmental factor, albedo, or the amount that heat is reflected. Ask students if they think these changes might also be seen on regional or global scales?

2. Lead a discussion about how rapid melting of the glaciers and sea ice at the Poles is enhancing the warming of our planet by decreasing the Earth's albedo. Use the following questions as prompts:

   Q. Where is most of the white (snow/ice) on Earth is found?

   Q. What would happen to the albedo of the Earth if the ice and snow continued to melt? (hint: think about what would happen if the Earth was wearing a black shirt)

Parts of this activity were adapted from Feeling the Heat, A Windows to the Universe activity by Lisa Gardiner.

Investigating Heat Islands

Group Name: _____

Date: _____

Use the table below to record the starting and ending temperatures during your heat island experiment. (Don't forget the units.)

After recording your measurements, calculate the difference between the two (end minus start) to see how the temperature has changed for each piece of paper.

	Starting Temperature	Ending Temperature	Difference
White Paper			
Black Paper			

Elapsed Time: _____

If you wish, you can try the experiment again using different colored paper, other surfaces, or materials.

	Starting Temperature	Ending Temperature	Difference

Elapsed Time: _____

Synthesis #1

How did the color affect the temperature change you observed?

Synthesis #2

How would the results have been different if you left the light off? What do you think you would see if you used different colors or materials in your test?

Page 13 - Other Factors: Vegetation

What, if any, relationships do you see between the two? Why do you think this is?

Page 15 - Other Factors: Development

What, if any, relationships do you see between the land use and temperature? Where are temperatures warmer? Cooler? How does this relate to the measurements you made earlier or to any other factors?