



## Urban Heat Island Implementation Sequence

<b>Phenomenon:</b> Urban Heat Island	<b>Guiding Question:</b> What is the role of urban heat islands in Earth's energy balance?	<b>Contact:</b> Reach out to the <a href="#">My NASA Data Team</a> if you have questions.
<b>Grade Level:</b> 6-8		

**Further Investigation:** [My NASA Data Urban Heat Island main website](#) and the [My NASA Data main website](#)

**Revision Date:** 8-10-2023

**Note to Teachers:** The Urban Heat Island Implementation Sequence provides a series of lessons and activities for students to learn about the processes that create differences in surface temperatures, as well as how human activities have led to the creation of urban heat islands.

**Standards - These standards are supported by the activities in this guide but not completely covered.**

### Performance Expectations:

- MS-ESS2-1. Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.
- MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
- MS-PS3-4. Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample.
- MS-ESS3-5. Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.
- MS-ESS2-6: Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.

### Science and Engineering Practices:

- Constructing Explanations and Designing Solutions
- Analyzing and Interpreting Data

### Crosscutting Concepts:

- Cause and Effect
- Energy and Matter

**Disciplinary Core Ideas:** *DCIs are aligned to each activity below. Please note that the aligned activity may not fully address all components of the DCI.*



## Background Information and NASA Connection

### What Are Urban Heat Islands?

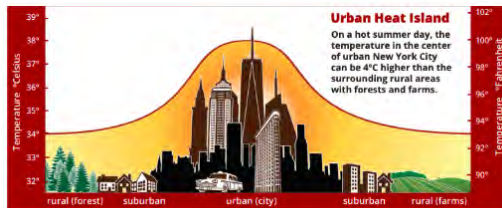
An urban heat island is a phenomenon that is best described when a city experiences much warmer temperatures than in nearby rural areas. The sun's heat and light reach the city and the country in the same way. The difference in temperature between urban and less-developed rural areas has to do with how well the surfaces in each environment absorb and hold heat.



### Where Do Urban Heat Islands Form?

The hottest places on Earth have a few traits in common. They are full of rock and stone, they do not have a lot of water, plants, or trees, and they are full of dark colors.

Cities are full of these rocky surfaces — asphalt, brick, and concrete — that absorb heat by day and release it at night. These materials are used to make the sidewalks, parking lots, roads, and basketball courts of urban areas. Urban heat islands form because humans replace cooler surfaces with rocky surfaces.



Credit: NASA



These hard and dark-colored surfaces contribute to the urban heat island effect in two ways. First, these surfaces have a low albedo, which increases the amount of energy from solar radiation they absorb. Second, these surfaces do not contain much water to evaporate, meaning that less of the absorbed energy evaporates water, and more goes into warming the surface and releasing energy by conduction, convection, or radiation. The combination of these factors means that cities and other highly developed areas are hotter than the plant-covered countryside.

### Why Does NASA Study This Phenomenon?

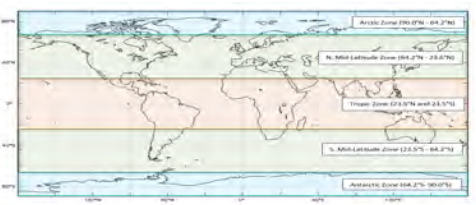
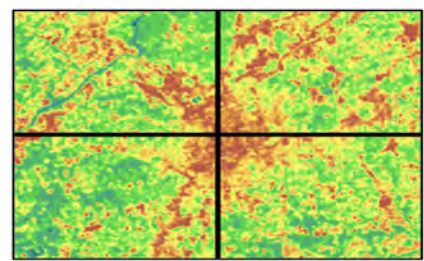
NASA analyzes surface temperature data from around the world to better understand the characteristics of cities that drive the development of urban heat islands.

Sources: [Basic Page for Urban Heat Islands](#) and [Lesson Plan Heating Things](#)

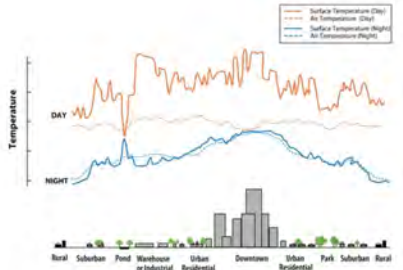
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Day 1			
Time	NGSS Disciplinary Core Ideas	Learning Objective	Activity / Assessment
30 min	<p><b>PS3.B: Conservation of Energy and Energy Transfer</b></p> <p>The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment. (MS-PS3-4)</p>	<p>I can analyze and compare the temperature of different surfaces.</p> 	<p><b>Mini Lesson: <a href="#">Analyzing Surface Temperature Differences</a></b></p> <p>Students observe the surface temperatures of a variety of surface types found in a suburban environment.</p>
Day 2			
Time	NGSS Disciplinary Core Idea	Learning Objective	Activity / Assessment
30 min	<p><b>ESS2.A: Earth's Materials and Systems</b></p> <p>All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms. (MS-ESS2-1)</p>	<p>I can identify which materials radiated and absorbed the most and least heat.</p> 	<p><b>Mini Lesson: <a href="#">A Mini Urban Heat Island</a></b></p> <p>Students explore the phenomenon of Urban Heat Island Effect.</p>

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Day 3			
Time	NGSS Disciplinary Core Idea	Learning Objective	Activity / Assessment
30 min	<p><b>ESS3.D: Global Climate Change</b></p> <p>Human activities, such as the release of greenhouse gasses from burning fossil fuels, are major factors in the current rise in Earth’s mean surface temperature (global warming). Reducing the level... decisions and activities. (MS-ESS3-5)</p>	<p>I can analyze surface air temperature anomalies to identify change with respect to different latitudes across the world.</p> 	<p><b>Mini Lesson: <a href="#">Analyzing Surface Air Temperatures by Latitude</a></b></p> <p>Students observe global surface air temperature anomalies from 1880 to 2017 through a visualization. After acquiring background knowledge on latitude zones and anomalies, they draw conclusions about which latitudes had air temperature anomalies.</p>
Day 4			
Time	NGSS Disciplinary Core Idea	Learning Target	Activity / Assessment
30 min	<p><b>ESS3.C: Human Impacts on Earth Systems</b></p> <p>Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth’s environments can have different impacts (negative and positive) for different living things. (MS-ESS3-3)</p>	<p>I can analyze geospatial images of Atlanta, Georgia, to explore the relationship between surface temperature and vegetation.</p> 	<p><b>Mini Lesson: <a href="#">Relationship Between Surface Temperature and Vegetation</a></b></p> <p>Students analyze Landsat images of Atlanta, Georgia to explore the relationship between surface temperature and vegetation.</p>

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Day 5			
Time	NGSS Disciplinary Core Idea	Learning Target	Activity / Assessment
30 min	<p><b>ESS3.D: Global Climate Change</b>                      Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities.(HS-ESS3-6)</p>	<p>I can describe the pattern between population density and the location of urban heat islands.</p> 	<p><b>Interactive: <a href="#">Human Impact and the Creation of Urban Heat Islands</a></b>                      Students will identify and describe the relationship between land cover classification and surface temperature as it relates to the urban heat island effect.</p>

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Additional Resources (Page 1 of 5)			
Time	NGSS Disciplinary Core Idea	Learning Target	Activity / Assessment
1 week	<p><b>ESS3.C: Human Impacts on Earth Systems</b></p> <p>The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources.</p>	<p>I can Identify how climate has been altered before and after an event in different parts of the world by observing and analyzing different satellite images.</p>	<p><b>Unit:</b> <a href="#">Urban Surface Temperatures and the Urban Heat Island Effects</a></p> <p>This unit plan called “Urban Surface Temperatures and the Urban Heat Island Effects“ has the purpose to educate students how climate is changing in urban settings and produce mitigation solutions for city environmental concerns through the use of groundbreaking technology and authentic science learning experiences.</p>
30 min	<p><b>ESS2.A: Earth’s Materials and Systems</b></p> <p>All Earth processes are the result of energy flowing and matter cycling within and among the planet’s systems. This energy is derived from the sun and Earth’s hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth’s materials and living organisms.(MS-ESS2-1)</p>	<p>I can identify any trends and differences seen in a line graph.</p>	<p><b>Mini Lesson:</b><a href="#">Surface and Air Temperatures Throughout the Day</a></p> <p>Students will analyze a line graph that shows how the surface temperature and air temperature values change over the course of 24 hours.</p>

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Additional Resources (Page 2 of 5)			
Time	NGSS Disciplinary Core Idea	Learning Target	Activity / Assessment
15 min	<p><b>ESS3.D: Global Climate Change</b>                      Human activities, such as the release of greenhouse gasses 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. (MS-ESS3-5)</p>	<p>I can identify and explain which community (rural, suburban, urban) has the highest and lowest surface temperatures.</p>	<p><b>Mini Lesson:</b>  <a href="#">Interpreting a Graph of Surface Temperature of Urban Areas</a>                      Students interpret a graph of surface temperatures taken from city districts and other types of communities.</p>
15 min	<p><b>ESS2.A: Earth’s Materials and Systems</b>                      All Earth processes are the result of energy flowing and matter cycling within and among the planet’s systems. This energy is derived from the sun and Earth’s hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth’s materials and living organisms.(MS-ESS2-1)</p>	<p>I can analyze and explain trends seen on a graph.</p>	<p><b>Mini Lesson:</b> <a href="#">Global Air Temperatures Graph</a>                      Students analyze a graph that illustrates the change in global surface temperature relative to 1951-1980 average temperatures.</p>

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Additional Resources (Page 3 of 5)			
Time	NGSS Disciplinary Core Idea	Learning Target	Activity / Assessment
>90min	<p><b>ESS3.C: Human Impacts on Earth Systems</b>                      Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things. (MS-ESS3-3)</p>	I can analyze surface temperature data to use as evidence to explain the urban heat island effect.	<p><b>Story Map:</b> <a href="#">Creation of Urban Heat Islands Story Map</a>                      Students explore the <i>urban heat island effect</i> using land surface temperature and vegetation data. Students will investigate the processes that create differences in surface temperatures, as well as how human activities have led to the creation of urban heat islands.</p>
30 min	<p><b>ESS3.C: Human Impacts on Earth Systems</b>                      Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.(MS-ESS3-3)</p>	I can analyze how surface (skin) temperatures vary among a community and determine what factors contribute to this variation.	<p><b>Interactive:</b> <a href="#">Patterns in Earth's Surface Temperature</a>                      Using interactive maps of surface (skin) temperature and land cover classification in Austin, Texas, students will analyze how surface (skin) temperatures vary across a community and determine what factors contribute to this variation. Upon completion of this lesson, students will be able to describe how human activity alters the local environment.</p>



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Additional Resources (Page 4 of 5)			
Time	NGSS Disciplinary Core Idea	Learning Target	Activity / Assessment
30 min	<p><b>ETS1.B: Developing Possible Solutions</b>                      There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem.(MS-ETS1-2)</p>	<p>I can describe the advantages and disadvantages of using two different satellites to study the urban heat island effect.</p>	<p><b>Interactive:</b> <a href="#">Exploring the Tradeoffs of Surface Temperature Models</a>                      Using interactive maps that compare surface (skin) temperature data between MODIS and Landsat 8 satellites, students will learn about and describe the different characteristics of satellite data. Students will also describe the advantages and disadvantages of using two different satellites to study a phenomenon such as the Urban Heat Island Effect.</p>
15 min	<p><b>PS4.C: Information Technologies and Instrumentation</b>                      Digitized signals (sent as wave pulses) are a more reliable way to encode and transmit information. (MS-PS4-3)</p>	<p>I can create a false color image by using a color key and a data table.</p>	<p><b>Interactive:</b> <a href="#">Creating Images from Numbers</a>                      Scientific data are often represented by assigning ranges of numbers to specific colors. The colors are then used to make false color images which allow us to see patterns more easily. Students will make a false-color image using a set of numbers.</p>
30 min	<p><b>PS4.C: Information Technologies and Instrumentation</b>                      Digitized signals (sent as wave pulses) are a more reliable way to encode and transmit information. (MS-PS4-3)</p>	<p>I can create an array table and determine the color of a pixel in a grid.</p>	<p><b>Interactive:</b> <a href="#">Creating and Interpreting Images as Models</a>                      Information from satellites is often used to display information about objects. This information can include how things appear, as well as their contents. Explore how pixel data sequences can be used to create an image and interpret it.</p>

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Additional Resources (Page 5 of 5)			
Time	NGSS Disciplinary Core Idea	Learning Target	Activity / Assessment
90 min	<p><b>ESS2.A: Earth's Materials and Systems</b></p> <p>All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms. (MS-ESS2-1)</p>	<p>I can analyze data that I collected on the energy transfer of different Earth materials.</p>	<p><b>Lesson Plan: <a href="#">Heating Things Up</a></b> Working in small groups, students will explore the energy transfer of different earth materials when they are heated up and cooled down. The students graph the changes in temperatures that occur over a 15-minute period of heating the earth material up and a 15-minute period of the earth material cooling down.</p>
90 min	<p><b>ETS1.A: Defining and Delimiting Engineering Problems</b></p> <p>The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions. (MS-ETS1-1)</p>	<p>I can design a map showing where trees should be placed in the parking lot of the Huntsville Madison Square Mall.</p>	<p><b>Lesson Plan: <a href="#">What's Hot at the Mall?</a></b> In this investigation, "What's Hot at the Mall," students examine how shopping malls change natural environments. Studying NASA thermal images of a mall and its immediate surroundings introduces students to urban deforestation and to the formation of urban heat islands. Studying malls from an environmental perspective demonstrates the usefulness of geography in daily life and offers opportunities for direct observation and fieldwork. This investigation is modified from NASA's Mission Geography's Module 3: Human footprints on Earth as seen by NASA scientists for grades 5-8.</p>