Analyzing the Urban Heat Island Effect

Description:

The urban heat island (UHI) effect is a phenomenon closely linked to climate change that affects major cities, like New York City. Sometimes it can seem like New Yorkers are not being affected by climate change because we might not be experiencing direct impacts in this very moment. Although there are other parts of the world that are certainly more vulnerable to the climate crisis, the New York City Panel on Climate Change (NPCC) has shown that New Yorkers are in fact facing many of the impacts of climate change. Discussing UHI gives us an opportunity to explore an aspect of climate change that is specifically relevant to our local geographic location.

Objectives:

- Understand the main causes and impacts of the urban heat island effect
- Construct explanations and design solutions related to the urban heat island effect
- Develop or engineer using a systems thinking approach
- Consider the urban heat island effect on a local and global scale

Vocabulary:

Albedo, feedback loop, impervious, permeable, reflection, urban heat island effect

Materials:

- Poster paper
- Markers
- The Cool Neighborhoods NYC Report
- Computers, laptops, or tablets with internet access

Background Information:

The urban heat island effect describes why we experience higher temperatures in urban areas compared to surrounding suburban and rural areas. The NYC Mayor's Office of Resiliency defines UHI as "a regional elevation in air temperature that represents the difference between air temperatures in urban and built up areas and nearby rural areas."[1]

When an environment is made up of mostly dark, impervious, human-made materials, like cement and pavement, incoming solar radiation is absorbed and heat is trapped. This is due to the albedo effect. "Urban areas typically have surface materials, such as roofing and paving, which have a lower albedo than those in rural settings. As a result, built up communities generally reflect less and absorb more of the sun's energy. This absorbed heat increases surface temperatures and contributes to the formation of surface and atmospheric urban heat islands."[2] Permeability is another important factor; "As urban areas develop, changes occur in their landscape. Buildings, roads, and other infrastructure replace open land and vegetation. Surfaces that were once permeable and moist become impermeable and dry."[3]

Vegetative surfaces perform a service known as evapotranspiration, which helps to cool

[1] OneNYC Report: Cool Neighborhoods NYC
[2] EPA Reducing Urban Heat Islands: Compendium of Strategies
[3] EPA Learn about Urban Heat Islands

surrounding areas. “Trees and vegetation absorb water through their roots and emit it through their leaves—this movement of water is called ‘transpiration’… Evaporation, the conversion of water from a liquid to a gas, also occurs from the soil around vegetation and from trees and vegetation as they intercept rainfall on leaves and other surfaces. Together, these processes are referred to as evapotranspiration. Evapotranspiration cools the air by using heat from the air to evaporate water.”[4]

NYC parks, street trees, and green infrastructure increase evapotranspiration and lead to the cooling effect that we experience in microclimates throughout the City. For more information on the benefits of green infrastructure, see DEP’s Green Infrastructure module.

When a place has less vegetation, less heat is absorbed, causing surface temperatures to increase. According to the Environmental Protection Agency (EPA), “The annual mean air temperature of a city with 1 million people or more can be 1.8–5.4°F (1–3°C) warmer than its surroundings. In the evening, the difference can be as high as 22°F (12°C).”[5]

The following map from the Cool Neighborhoods NYC report displays thermal radiation in NYC and the UHI effect. Here you can see that the temperature of Central Park is significantly cooler than the rest of the city.

NYC Thermal Imagery

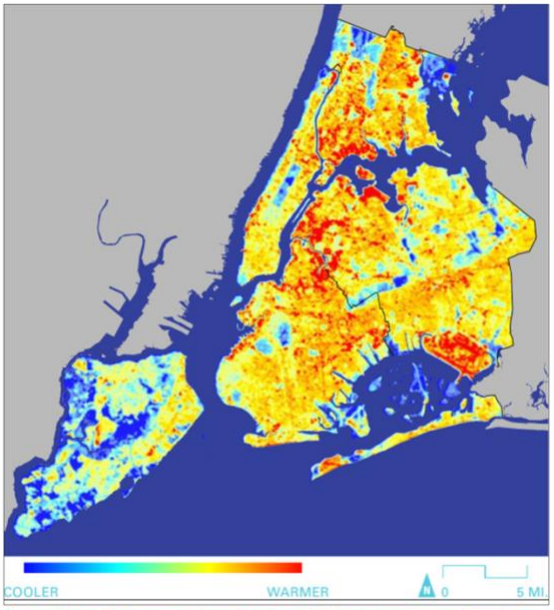

Figure 1: Some NYC communities experience higher temperatures than others. Variation in NYC’s densely built environment results in disparate neighborhood-level risks. Source: LANDSAT Thermal Data, 2009.

UHI can have major impacts on the environment and public health, with especially intensified effects during heat waves. According to the EPA, these impacts include “increasing summertime peak energy demand, air conditioning costs, air pollution and greenhouse gas emissions, heat-related illness and mortality, and water pollution.”[5] These impacts are closely linked to climate change as energy systems shift. Here we can notice a positive feedback loop. Increased urban heat island effect increases carbon emissions which intensifies climate change and causes more frequent and intensified UHIs.

Method:

Part 1:

- Introduce students to the concept of the urban heat island effect. Refer to the resources cited in this lesson for background information.

[4] EPA Reducing Urban Heat Islands: Compendium of Strategies Trees and Vegetation

[5] EPA Heat Island Effect

- Ask students to examine surface temperature maps and vegetation maps of NYC, like the surface temperature map in Cool Neighborhoods NYC shown above, NYC Department of Health's (DOH) Vegetative Cover Map and NASA's Landsat temperature and vegetation maps. Discuss the correlation between vegetation and surface temperature. How do these maps and concepts connect to UHI? Ask students to predict where UHI might be most extreme based on these maps and discuss why these patterns exist in various pockets across NYC.
- Then, explore DOH's Heat Vulnerability Index. Notice how different neighborhoods are more vulnerable to higher temperatures than others. Discuss why that is as a class.
- Use the Cool Neighborhoods NYC report to share information with your class on the impacts UHI has on communities throughout NYC and the City's strategies for addressing UHI.

Part 2:

- Ask students to imagine that the City of New York gave your class a piece of land or an existing plot and instructed them to design a new way to use this space to decrease NYC's UHI effect as much as possible. How would they approach this project?
- As the educator, you can decide how specific or broad to get with this prompt. You may choose to specify how much land is available, what resources they have to develop it, and where in NYC the land exists. Consider assigning students real-world spaces for them to redesign using Google Maps and Google Earth. These site assignments could be located near your school, or in different boroughs and neighborhoods throughout NYC. Alternatively, you might choose to use this activity as an opportunity to let your students be imaginative and creative by providing no additional details with the prompt.
- In their notebooks, have students draw their designs and label the various features that work to mitigate heat.
- Afterwards, form small groups and have students present their designs to each other.
- Then, instruct the groups to design one larger site together on poster paper by integrating ideas from each group members' original designs.
- Optional: once the designs are selected and illustrated, have students make dioramas to display their designs using recycled household materials. What features are highlighted in the dioramas? Students might choose to create blueprints for their new designs, to provide more details on how their sites should be created.
- Display these creations around the room, allow students to view and discuss each other's work.

Discussion:

- Why did you choose some features for your designs over others? What considerations did you make when creating your designs?
- How does the UHI effect shift from daytime to nighttime?
- How is UHI connected to climate change? Employ a systems thinking approach to discuss the various aspects of human and Earth systems that connect to UHI.

Extension:

- Consider presenting a similar prompt for students, but bigger in scale: You were given the task of designing a new city with the

primary goal being to minimize urban heat island effect in the city. What would your city look like? What materials would you use to build this city? How would it differ from present-day New York City?

- Read the Cool Neighborhoods NYC report, which outlines Mayor de Blasio's "citywide effort to tackle extreme heat," and discuss the strategies listed for addressing UHI. Do any of these strategies overlap with the designs presented in this lesson's projects? Could you envision your designs being added to the next iteration of the Cool Neighborhoods NYC program?
- Check out New York State Department of Environmental Conservation's Effects of Street Trees on Urban Heat Islands article and discuss how trees might impact UHI.
- Use the NYC Street Tree Map to see where trees are planted around the city. Consider how "urban forests" or street trees might alter UHI locally, and provide additional benefits to our urban environment.
- Tour your school neighborhood as a class and consider locations that could benefit from additional vegetation, based on your previous discussions on UHI. Look through NYC Parks Street Tree Planting options, and then utilize the website's options to "Request a Free Tree", "Plant A Tree on Your Own" or "Plant a Tree as Required by NYC Department of Buildings."

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