# NASA Applied Sciences Microlearning Training

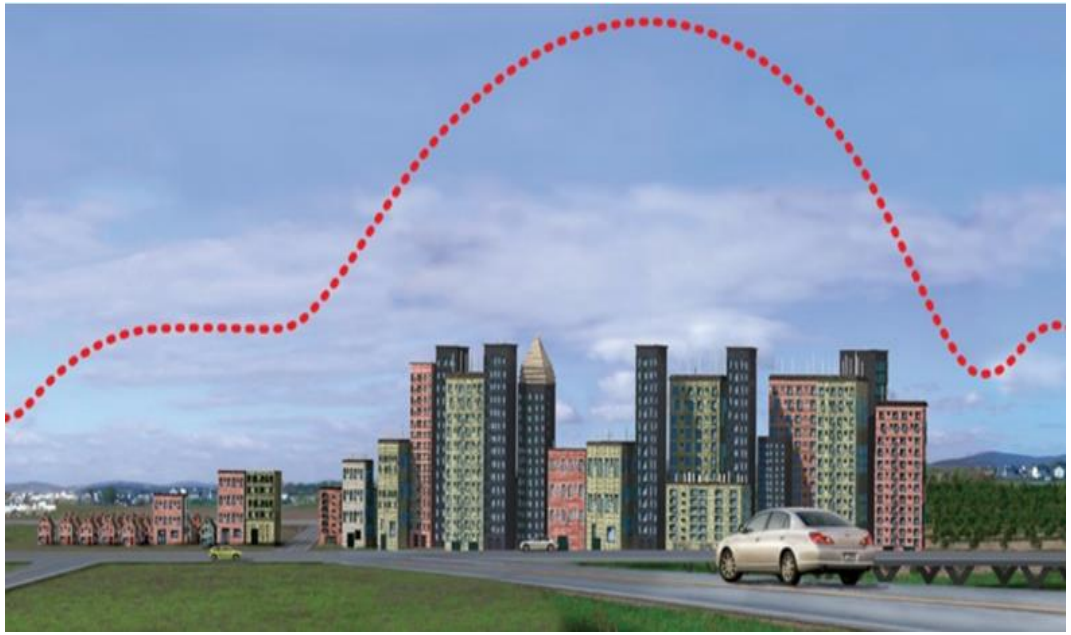
## Week 2

Part 1: Urban Heat Islands Case Study
Part 2: Urban Canopy Cover Case Study
Part 3: Urban Flooding Case Study

# Case Study: Urban Heat Islands

EARTH SCIENCE
APPLIED SCIENCES

Credit: NASA



Credit: Pikrepo

# Introduction to Urban Heat Islands Refresher

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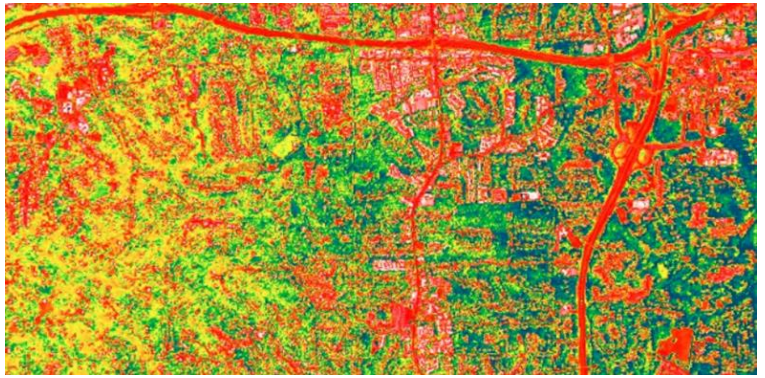
# What is an Urban Heat Island?

- Urban Heat Islands (UHI) are urban areas that experience higher temperatures than outlying areas. This difference in temperature is what constitutes an urban heat island, and it is caused by modifying land surfaces.
- There are two types of urban heat islands : Surface Urban Heat Islands and Atmospheric Urban Heat Islands
  - Surface Urban Heat Islands represents the temperature difference between impervious and natural surfaces
  - Atmospheric Urban Heat Islands refers to the effects on air from the surface of treetops/rooftops



Credit: NASA Goddard's Scientific Visualization Studio

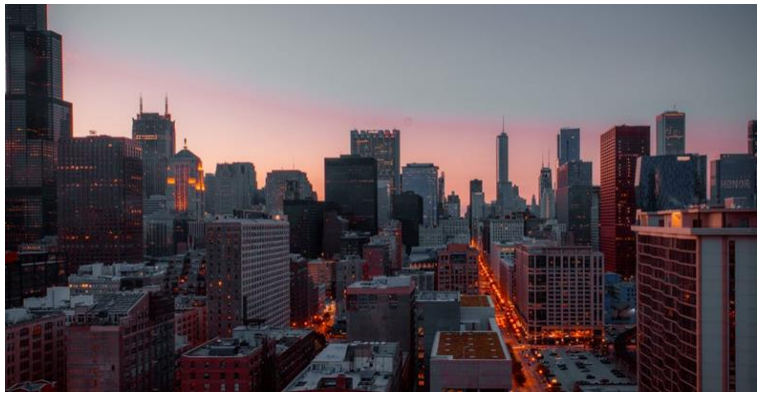


Photo by Bhargava Marripati from Pexels

# Case Study: Mobile Urban Development

Evaluating Urban Heat Islands and Flooding to Enhance Green Infrastructure Initiatives in Coastal Communities in Mobile, Alabama

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# Background: Mobile Urban Development

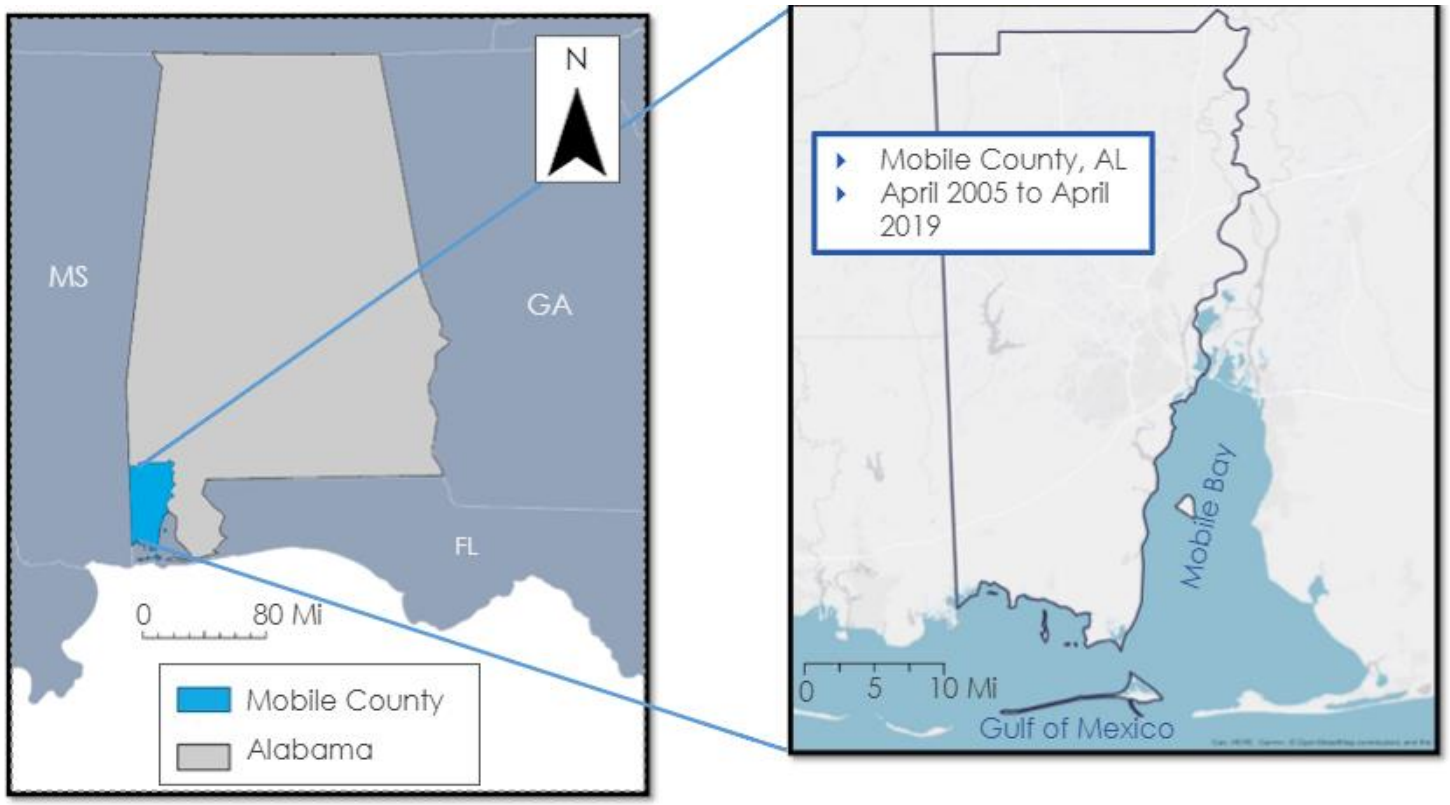
- In learning more about Urban Heat Islands, we will take a closer look at NASA's DEVELOP project conducted in 2019 by four DEVELOP interns; Lydia Stanley, Arman Bajracharya, Kelly Dunn, and Filoteo Gomez-Martinez.
- They utilized satellite Earth observations to assess locations in Mobile County, Alabama, that are vulnerable to the urban heat island effect (UHI) and flood impacts.
- Their project objectives were  to study and provide information on UHIs and flooding risk to develop mitigation strategies for reducing such threats.
- Landsat 8 OLI, Landsat 8 TIRS, Landsat 5 Tm, Sentinel -1 C-SAR, Sentinel 2-MSI, STRM, and Terra MODIS satellite imagery were used in collecting land coverage data.
- Partnership with the Groundwork Mobile County and other local entities.

# Abstract: Mobile Urban Development

- Mobile County is located in the southwestern corner of Alabama and neighbors the Gulf of Mexico. Mobile has mild-subtropical weather with hot and humid summer months and an average of 66 inches of annual precipitation. (NASA DEVELOP)
- Previous storm surges have impacted areas that are too small for redevelopment or within the floodplain leaving overgrown vacant lots and brownfield sites. (NASA DEVELOP)
- The Groundwork Mobile County (GWMC) and other local entities partnered to complete a study using NASA Earth observations and ancillary datasets to locate communities with UHI impacts between 2005 and 2019. (NASA DEVELOP)


Source: Google Earth

# Visual Analysis: Mobile Urban Development




Source: NASA DEVELOP

# Conclusions: Mobile Urban Development

- Mobile, Alabama is susceptible to intense flooding and the urban heat island (UHI) effect. UHI poses health risks among individuals living in urban communities.
- The potential of flooding does not pose a high threat to the county in upland areas of dense vegetation. Flood risk was identified based on elevation data for 3 low-lying locations; these areas of concern are the Mobile basin area, Bayou La Batre, and Dauphin Island.
- The project will serve as a guiding force for Mobile County by providing Urban Heat Assessments, Flood Extent Analysis's Socioeconomic and Demographic Risk Evaluation (SDRE) and Impervious Surface Evaluations .

# Takeaways

## Urban Heat Island (UHI)

## Case Study: Mobile Urban Development

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# Case Study: Urban Tree Canopy

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# Introduction to Tree Canopy

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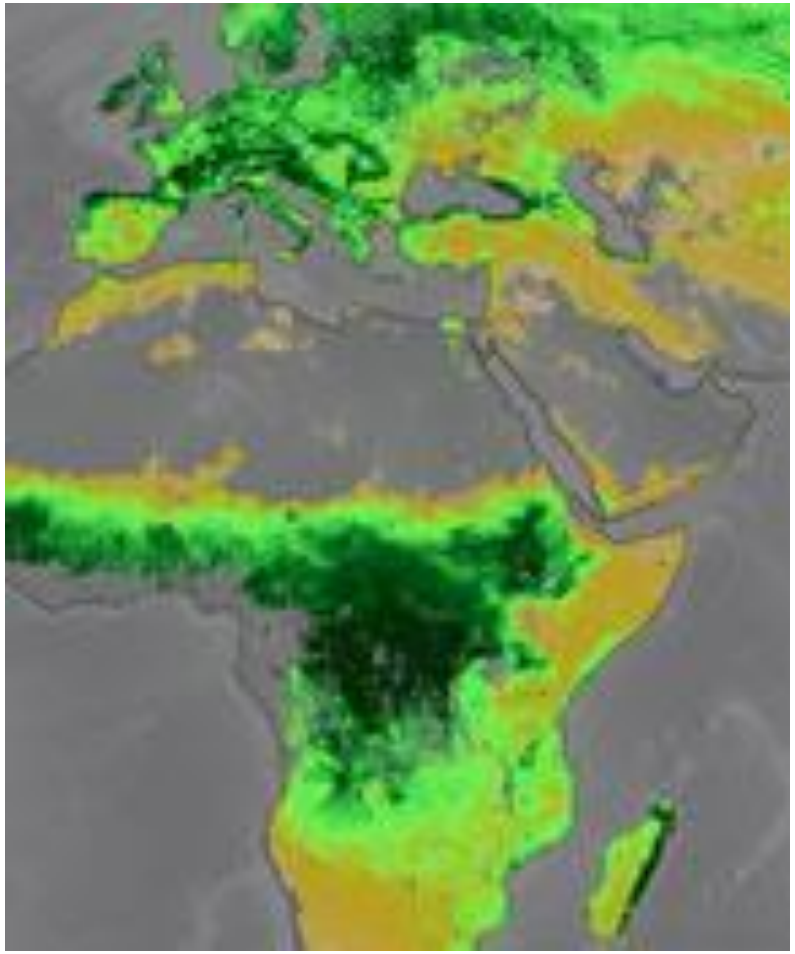
# What is tree canopy?

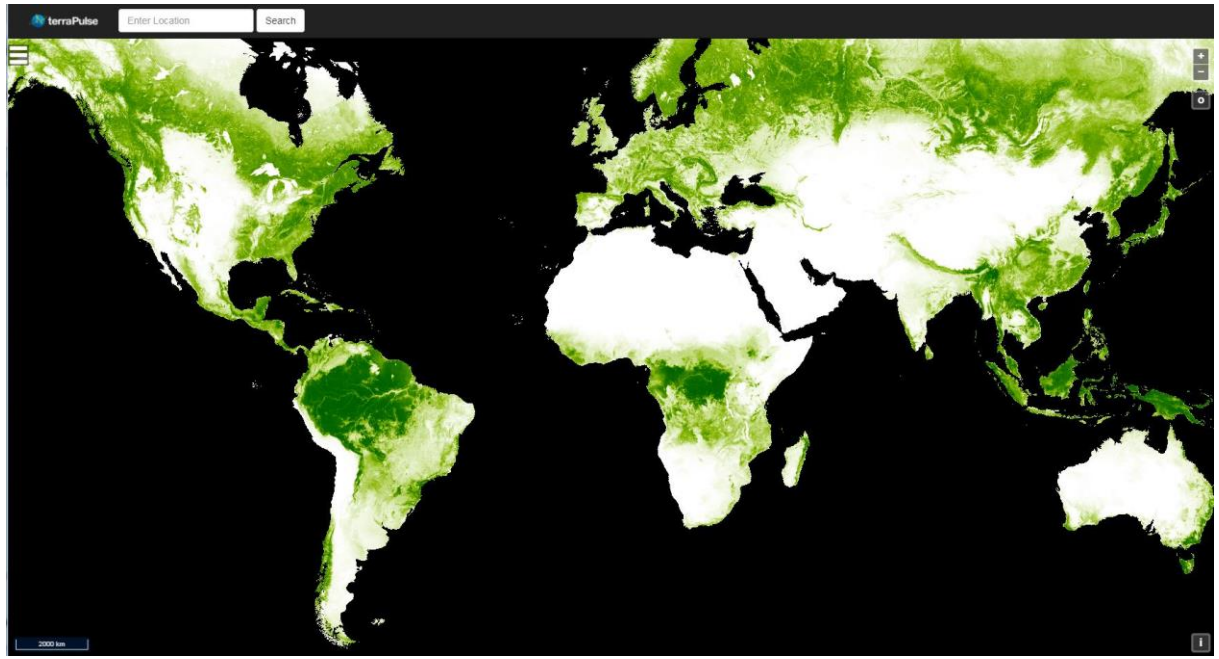
- Urban Tree Canopy (UTC) refers to the layer of tree leaves, branches, and stems that provide tree coverage of the ground when viewed from above. (USDA)
- The Urban Tree Canopy Assessment approach and protocols were invented by the U.S. Forest Service in 2006 to map and quantify landcover for Baltimore City. (USDA)
- Evapotranspiration (ET) – The combination of water surface evaporation, soil moisture evaporation, and plant transpiration, wherein water is transported through a plant from its roots and into the surrounding air through the plant's leaves. (Asheville Urban Development)
- Leaf Area Index (LAI) – LAI is defined as the one-sided green leaf area per unit ground area in broadleaf canopies and as half the total needle surface area per unit ground area in coniferous canopies. (NASA)



Source: NASA

# What are the benefits of tree canopy?

- As more people move to cities and as these cities develop, cautiousness on maintaining environmental protections against the rapid growth of urban heat islands are important measures to consider in protecting the lives of those who live in the cities.
- Tree canopy has been a building block in mitigating urban heat islands.
- Trees provide several services for resilience to the UHI effect and can contribute to the cooling of urban microclimates due to shading, reflectance rates, and evapotranspiration (Georgi & Zafiriadis, 2006; Qiu et al, 2013) & (Asheville Urban Development).

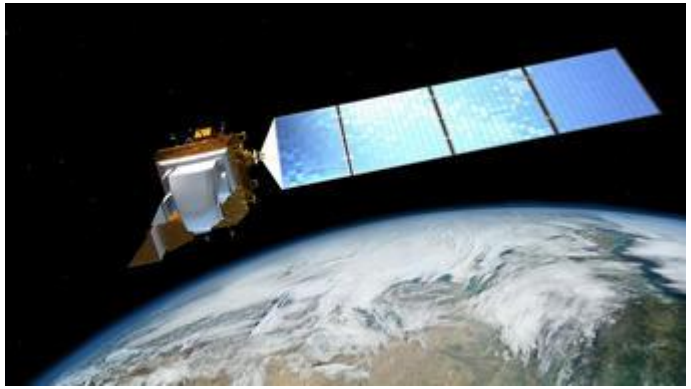



Source: NASA

# How tree canopy is measured and applied?

- There are a few metrics in which tree canopy is analyzed, most commonly using Lidar and Landsat satellite.
- Canopy height measures how far above the ground the top of the canopy is. Lidar can be used to determine both of these variables. (ESRI)
- Landsat 5 Thematic Mapper (TM) and Landsat 8 Operational Land Imager (OLI) are used in measuring heat, land surface temperature, tree cover, etc.
- Obtaining Landsat and other Earth observations data from NASA's Distributed Active Archive Centers (DAACs) using tools like NASA Worldview can help supply the data products needed in studying the effects of tree canopies in urban communities.
- Collecting real time data, using resources such as GLOBE which is an open source platform in allowing that allows citizen scientists and scientists to retrieve and upload real time data sets.

Source: USGS



Source: USGS

# Case Study: Asheville Urban Development

Using NASA Earth Observations to Quantify the Impact of Urban Tree Canopy Cover on Urban Heat and Identify Community Vulnerability in Asheville, North Carolina

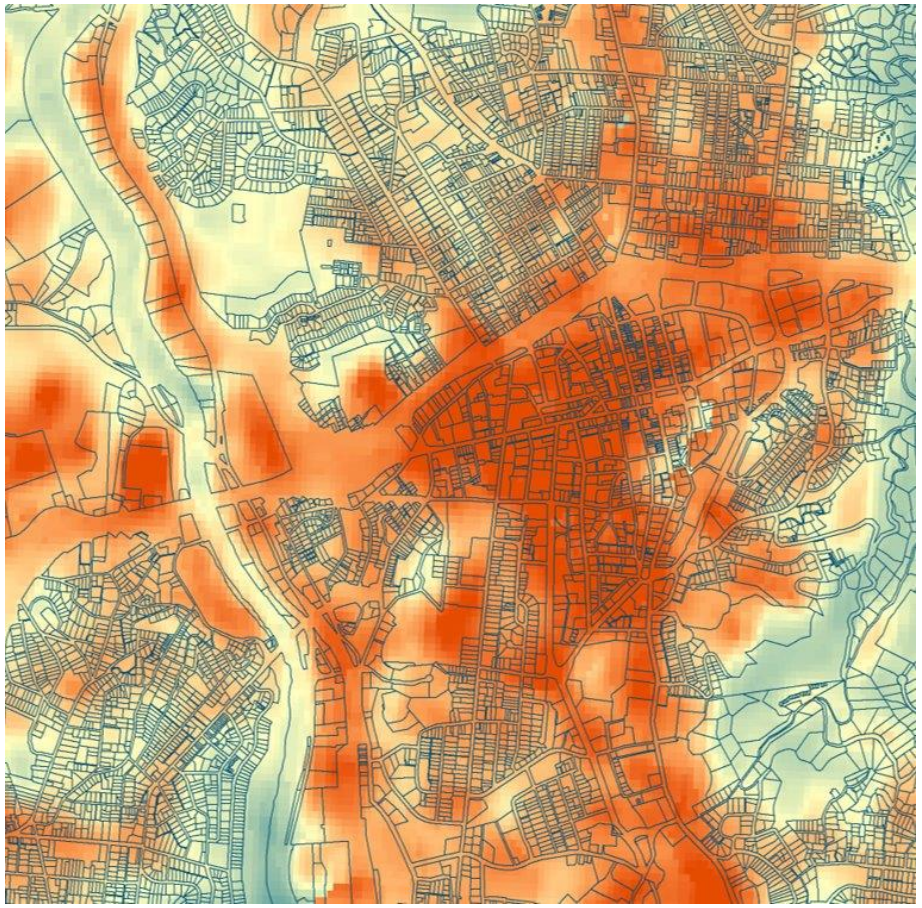
EARTH SCIENCE
APPLIED SCIENCES

# Background: DEVELOP's Asheville Urban Development

- In learning more about Tree Canopy, we will take a closer look at NASA's DEVELOP project conducted in 2019 by three DEVELOP interns; Darcy Gray (Project Lead), Amiya Kalra, and Amy Kennedy.
- They studied methods in mitigating the Urban Heat Island effect in Asheville, North Carolina by analyzing tree canopies, heat vulnerability, socioeconomic data, and land surface temperature.
- Their project objectives were to study land surface temperature and tree canopy data from years 1984 to 2019, using statistical models in determining land coverage changes in Asheville, North Carolina, and measuring the heat vulnerability index, temperatures, tree cover, and socioeconomic data.
- Landsat 5 and 8 satellite imagery was used in collecting land coverage data.
- Partnership with the City of Asheville, Urban Forestry Commission.

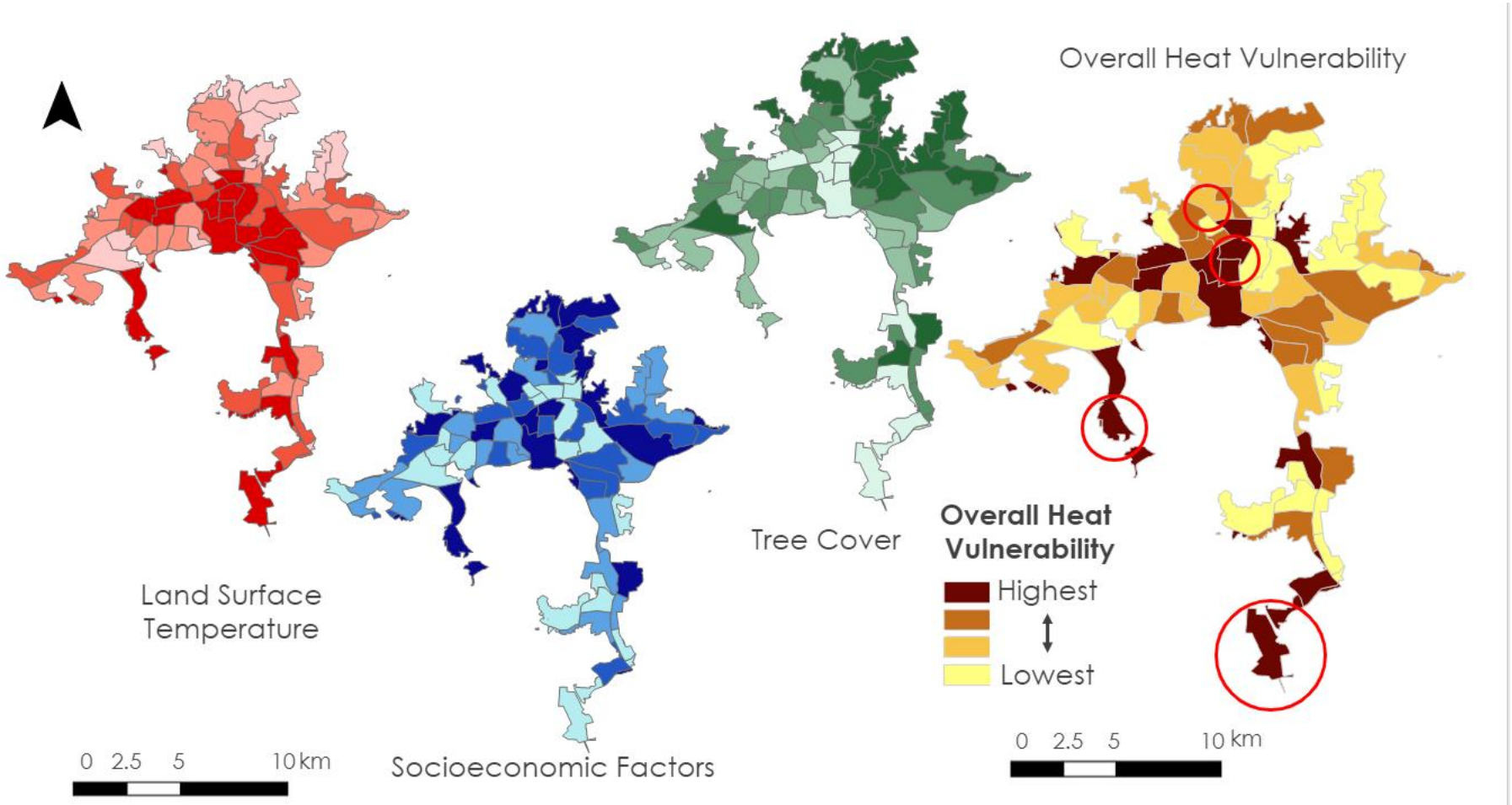
# Abstract: Asheville Urban Development

- Asheville, North Carolina has had a population growth of approximately 10 percent over the past decade, while the city's tree canopy cover has simultaneously decreased by 6.4 percent. (NASA DEVELOP)
- A well-known benefit of urban tree cover is the mitigation of the effects of urban heat islands through factors including shade and evapotranspiration. (NASA DEVELOP)
- The Asheville Urban Development team partnered with the Urban Forestry Commission to complete a study using NASA Earth observations and ancillary datasets to explore relationships between changes in land surface temperature and tree cover over the last 10 years. (NASA DEVELOP)



Source: NASA DEVELOP

# Visual Analysis: Asheville Urban Development

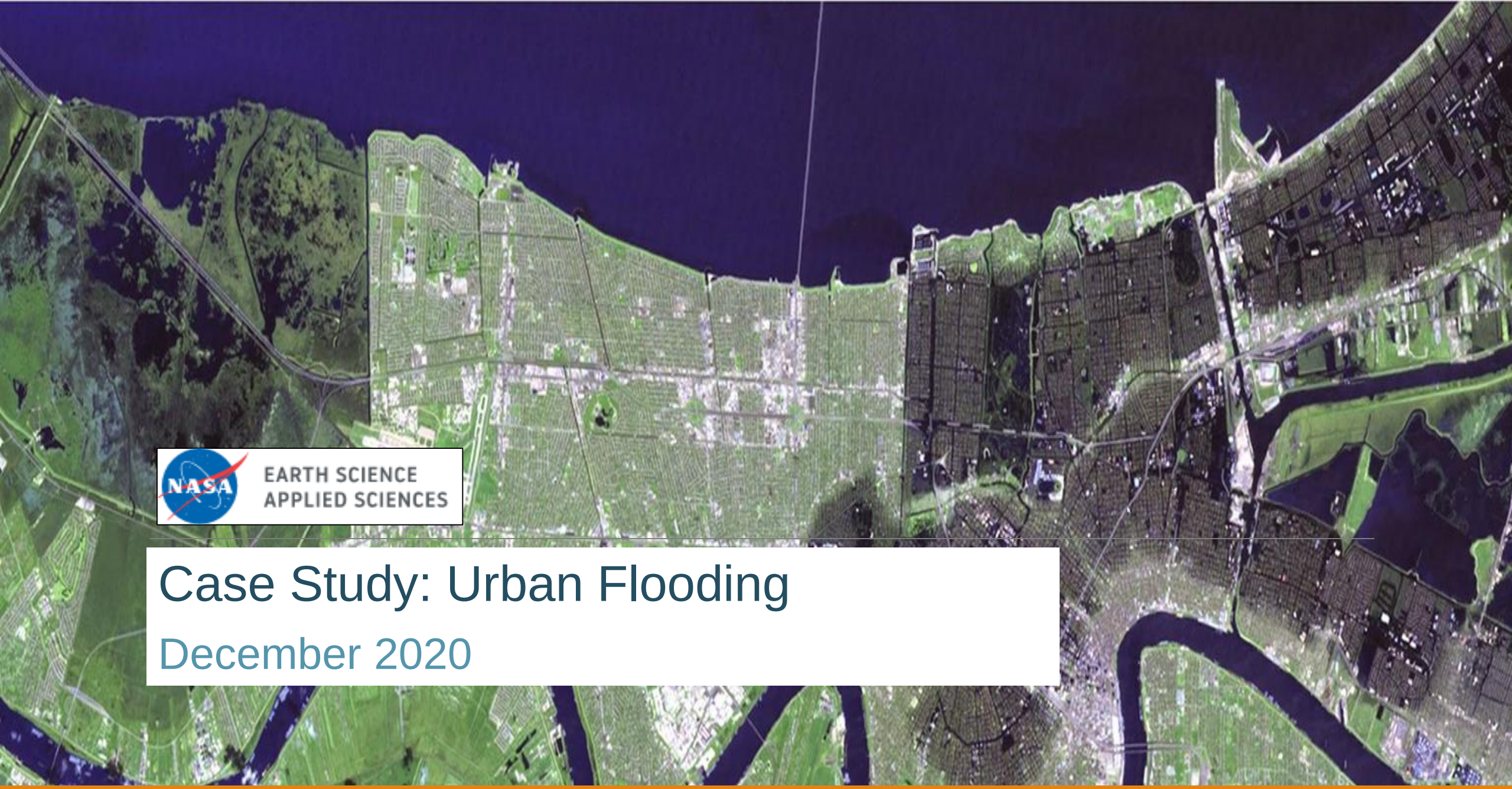



Source: [NASA DEVELOP]

# Conclusions: Asheville Urban Development

- Urban developments such as tree canopies have been effective in mitigating increased land surface temperatures.
- The urban heat island effect are more amplified and present in under-resourced communities where they lack tree cover in which more solar energy is released, increasing land surface temperatures in the area.
- Urban heat is a climate change environmental risk and poses health risks among individuals living in urban communities.
- The project will serve as a guide for the City of Asheville, Urban Forestry Commission to continue to expand green infrastructure projects in urban communities.

Source: Asheville GreenWorks




# Case Study: Urban Flooding

## December 2020

Image Source: https://earthobservatory.nasa.gov/images/15445/hurricane-katrina-floods-new-orleans

# Introduction to Urban Flooding Refresher

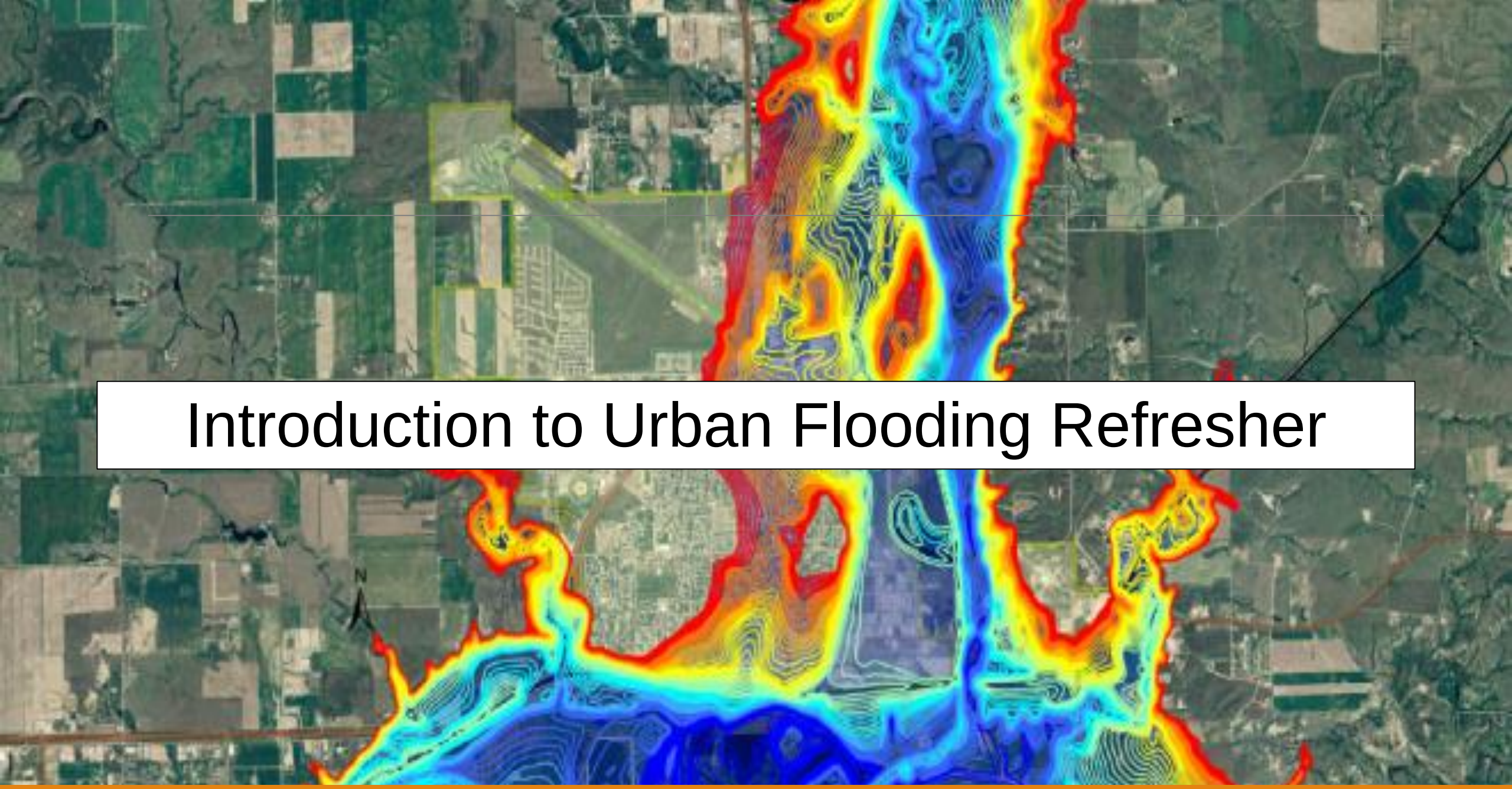


Image Source: https://appliedsciences.nasa.gov/join-mission/training/english/monitoring-urban-floods-using-remote-sensing

# Introduction to Urban Flooding

**How is Urban Flooding caused?:**

- Urban Flooding occurs from both natural causes and human-error.

- Natural Causes:
  - Higher Levels of Precipitation/Flash Floods
  - River Floods and Overbank Flow
  - Coastal Flood

- Human Causes:
  - Drainage and Sewage Systems at Over-Capacity
  - Improper Management/Care towards Drainage Systems
  - Concretization causing Lower Water Permeability

References: https://appliedsciences.nasa.gov/join-mission/training/english/monitoring-urban-floods-using-remote-sensing

# Introduction to Urban Flooding

**What are the effects of Urban Flooding?**

- Consequences of Urban Flooding include:
  - Building, Assets, and Utility Damages
  - Losses in Income from Industries
  - Increases in Unemployment
  - Halts in Transportation Systems
  - Hazardous to Human Lives

References: https://appliedsciences.nasa.gov/join-mission/training/english/monitoring-urban-floods-using-remote-sensing

# Introduction to Urban Flooding

**Why is Urban Flooding Important?**

- Urbanization developing at an incredibly fast and unstable pace increases the likelihood to face more drastic effects of Urban Flood disasters.
- The growth in population within urban areas makes it more difficult to handle Urban Flooding disasters.
- UN Sustainable Development Goals deem that it is necessary to strategize the reduction of urban disasters and disaster-related deaths.

References: https://appliedsciences.nasa.gov/join-mission/training/english/monitoring-urban-floods-using-remote-sensing

# Case Study: New Orleans Urban Development

Image Source: https://develop.larc.nasa.gov/2018/summer/images/2018Sum_AL_NewOrleansUrban.jpg

# New Orleans Urban Development

***"Utilizing Earth Observations to Assist Groundwork New Orleans in Reducing Flood Vulnerability in the New Orleans, Louisiana, Metropolitan Area."***

Background

- Because of rising sea levels and land subsidence, flooding in New Orleans, Louisiana became more frequent and intense.
- As such, Groundwork New Orleans (GWNO) focuses on supporting green infrastructure in order to make the city more resilient to disasters.
- However, the initial site selection and assessment practices were expensive, and took a lot of time.

References: https://develop.larc.nasa.gov/2018/summer/NewOrleansUrban.html

# New Orleans Urban Development

Improving GWNO's Green Infrastructure Implementation Process

- Plans on improvement were determined using NASA and ESA Earth Observation Data from the following satellites:
  - Landsat 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS)
  - Sentinel-2 Multispectral Instrument (MSI),
  - Sentinel-1 C-Band Synthetic Aperture Radar (C-SAR)
  - Terra Moderate Resolution Imaging Spectroradiometer (MODIS) imagery from 2013 to 2018

References: https://develop.larc.nasa.gov/2018/summer/NewOrleansUrban.html

# New Orleans Urban Development

Improving GWNO's Green Infrastructure Implementation Process cont.

- How the Remote Sensing Data was gathered and used:
  - Due to the Atlantic hurricane season, the data was geared towards Summer months.
  - Areas of high surface runoff and flood vulnerability were mapped out with remote sensing and geospatial analysis.
  - Methodologies to determine these areas included using Land Classification, Normalized Difference Vegetation Index (NDVI), Normalized Difference Flood Index (NDFI), and Land Surface Temperature (LST) Assessment.

References: https://develop.larc.nasa.gov/2018/summer/NewOrleansUrban.html

# New Orleans Urban Development

Study Results and Conclusion

- As determined by the Land Cover Classification and NDVI methodologies, green space decreased between 2013 and 2017.
- From 2016 to 2017, Flood extend analysis had an increasing trend.
- The eastern areas of New Orleans were more likely to have a risk of flooding.
- Areas with lower permeability have an increased land surface temperature compared to areas of green space.

References: https://develop.larc.nasa.gov/2018/summer/NewOrleansUrban.html

# New Orleans Urban Development

End Products to Aid in Green Structure Implementation

- Urban Tree Canopy Assessment
  - Allows users to identify areas with low tree coverage, and provides information on the difference their current tree planting project has on decreasing flood vulnerability in New Orleans.
- Gray Infrastructure and Impervious Surface Cover Analysis
  - Shows areas with an increased risk of surface runoff and flooding based on impervious land cover, and includes an annual analysis of New Orlean's urban growth to learn about grey infrastructure's impact on land modification.

References: https://develop.larc.nasa.gov/2018/summer/NewOrleansUrban.html

# New Orleans Urban Development

End Products to Aid in Green Structure Implementation cont.

- Flood Extent Analysis
  - Contains storm water surface coverage suitability maps and flood classification maps to help in identifying flooded lands, as well as displaying areas of shallow water in short vegetation lands.
- Surface Heat Assessment
  - An annual and seasonal analysis of urban surface temperature to learn how communities and storm water threats are affected by temperature. It helps identify the correlation between urban cover areas and surface temperature as time goes on.

References: https://develop.larc.nasa.gov/2018/summer/NewOrleansUrban.html

# Takeaways

Urban Flooding: How, What, and Why

Case Study: New Orleans Urban Development Background, Process, and Results