Charleston Extreme Heat Initiatives Overview
Building toward a City Heat Plan

Janice Barnes, PhD
Climate Adaptation Partners
June 29, 2023
#SharingIsCaring

A Coalition Around Heat Research in Charleston, South Carolina

Climate Adaptation Partners
Charleston Medical District
City of Charleston Office of Sustainability and Resilience
City of Charleston GIS and Planning Teams
MUSC Office of Sustainability
Roper St. Francis Healthcare
Ralph H. Johnson VA Medical Center
Fernleaf Interactive
MUSC Office of Health Promotion
City of Charleston Wellness Committee
South Carolina Sea Grant
Carolinias Integrated Sciences Assessment
UNC Chapel Hill - SERCC
The Citadel James B. Near Center for Climate Studies
Southeast Regional Climate Center
North Carolina State University
Appalachian State
MUSC Arboretum
Charleston Resilience Network
Charleston Healthy Business Coalition
CAPA Strategies
NOAA NIHHIS Team
South Carolina Department of Health and Environmental Control
South Carolina Health Professionals for Climate Action
South Carolina Interfaith Power and Light
College of Charleston
Clemson University
South Carolina Aquarium
City of Charleston Planning
MUSC School of Nursing
MUSC Medical School
University of South Carolina
State of South Carolina Meteorology Team

Charleston Extreme Heat Initiatives Overview
NOAA US Eastern Region Climate Services: Heat Season Preparedness and City Pilots
June 29, 2023
Charleston Heat Research

1. CMD Heat Research
2. CISA Heat Research
3. HeatWatch Research
4. Expanding and Sharing Research
Charleston Heat Research

1. CMD Heat Research
   - Used LANDSAT to spatialize hot areas
   - Used FLIR and GPS to visualize materials that amplify heat
   - Hosted Heat Charrette at Charleston Medical District

2. CISA Heat Research
   - Janice Barnes, Climate Adaptation Partners
   - Leo Temko, Climate Adaptation Partners
   - Dennis Frazier, Charleston Medical District
   - Rick McMahon, Ralph Johnson VA Medical Center
   - Ken Hill, Roper St. Francis Hospital
   - Christine von Kolnitz, MUSC
   - Ray Huff, Clemson
   - Mark Wilbert, City of Charleston CRO (formerly)
   - Steve Hargett, Charleston Medical District (retired CFO MUSC)
   - Dr. Susan Johnson, MUSC Director, Office of Health Promotion, member of City Wellness Committee
   - Kirstin Dow, USC
   - Chip Konrad, UNC-Chapel Hill
   - City of Charleston
   - Fernleaf

3. HeatWatch Research

4. Expanding and Sharing Research

Charleston Extreme Heat Initiatives Overview
NOAA US Eastern Region Climate Services: Heat Season Preparedness and City Pilots
June 29, 2023
Charleston Vulnerabilities Assessment

Charleston Extreme Heat Initiatives Overview

NOAA US Eastern Region Climate Services: Heat Season Preparedness and City Pilots

June 29, 2023
Rising Waters

Charleston Extreme Heat Initiatives Overview
NOAA US Eastern Region Climate Services: Heat Season Preparedness and City Pilots
June 29, 2023
Upcoming Projects

+$2 billion @ CMD
MUSC Replacement Hospital
VA Bed Tower, Garage and Upgrades

+ USACE

+ City Projects

+ SC DoT

+ West Edge

Charleston Extreme Heat Initiatives Overview
NOAA US Eastern Region Climate Services: Heat Season Preparedness and City Pilots
June 29, 2023
Rising Heat

1961-1990 Baseline average 35 days
2025-2045 average 72 days

Source: US Climate Resilience Toolkit / Dr. Kirstin Dow / CISA

Charleston Extreme Heat Initiatives Overview
NOAA US Eastern Region Climate Services: Heat Season Preparedness and City Pilots
June 29, 2023
Heat is Deadly

In the south, heat is a given, but it’s getting hotter than it used to be.

Increased heat exposure impacts health.

Heat kills more people annually than any other weather hazard.

Charleston Extreme Heat Initiatives Overview
NOAA US Eastern Region Climate Services: Heat Season Preparedness and City Pilots
June 29, 2023
Investment Service Life

Near Term

Mid Term

Long Term

USACE Storm Surge Barrier Installed

Charleston SLR / 2070 Target

Charleston Extreme Heat Initiatives Overview

NOAA US Eastern Region Climate Services: Heat Season Preparedness and City Pilots

June 29, 2023
Surface Temperature

Landsat 8 Operational Land Imager (OLI)

NDVI
• Band 4: Red
• Band 5: Near Infrared

Land Surface Temperature
• Band 10: Thermal Infrared Sensor (TIRS1)

Charleston Extreme Heat Initiatives Overview
NOAA US Eastern Region Climate Services: Heat Season Preparedness and City Pilots
June 29, 2023
### FLIR ONE Gen 3

**Outputs**
- Relative comparison
- Surface temperature
- Accuracy of +/- 5%
- Range -20°C to +120°C

**Limitations**
- Single Surface only
- Battery Life / Circuit Impact
- Image Registration

### ArcGIS Collector + Bad Elf GPS Pro

**Outputs**
- Geolocated survey points
- Custom web-enabled app
- Web-hosted geospatial layer ready for GIS processing

**Limitations**
- 2.5m Stationary Accuracy
- Environmental obstructions can limit accuracy

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**Charleston Extreme Heat Initiatives Overview**

NOAA US Eastern Region Climate Services: Heat Season Preparedness and City Pilots

June 29, 2023
Surface Temperature Points

<table>
<thead>
<tr>
<th>27 AUGUST 2020</th>
<th>12 am</th>
<th>6 am</th>
<th>12 pm</th>
<th>6 pm</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEMPERATURE deg. f (high)</td>
<td>75</td>
<td>88</td>
<td>91</td>
<td>90</td>
</tr>
<tr>
<td>WIND mph (direction)</td>
<td>1 (nne)</td>
<td>2 (w)</td>
<td>9 (w)</td>
<td>8 (ssw)</td>
</tr>
<tr>
<td>HUMIDITY %</td>
<td>94</td>
<td>82</td>
<td>63</td>
<td>80</td>
</tr>
</tbody>
</table>

Charleston Extreme Heat Initiatives Overview
NOAA US Eastern Region Climate Services: Heat Season Preparedness and City Pilots
June 29, 2023
Charleston Extreme Heat Initiatives Overview
NOAA US Eastern Region Climate Services: Heat Season Preparedness and City Pilots
June 29, 2023
Charleston Extreme Heat Initiatives Overview
NOAA US Eastern Region Climate Services: Heat Season Preparedness and City Pilots
June 29, 2023
Urban Farm

Charleston Extreme Heat Initiatives Overview
NOAA US Eastern Region Climate Services: Heat Season Preparedness and City Pilots
June 29, 2023
Bee Street

Charleston Extreme Heat Initiatives Overview
NOAA US Eastern Region Climate Services: Heat Season Preparedness and City Pilots
June 29, 2023
Material Type / Temperature Distribution

- Artificial Turf
- Asphalt
- Asphalt: Painted
- Brick
- Concrete: Bare
- Fabric: Dark
- Gravel
- Layered Planting
- Low Planting / Groundcover
- Manicured Grass
- Mulch
- Paver: Pervious
- Paver: Rubber
- Plastic / Manmade
- Steel / Aluminum
- Stone
- Water
- Wood: Bare

~40 degree surface temperature differential

Charleston Extreme Heat Initiatives Overview
NOAA US Eastern Region Climate Services: Heat Season Preparedness and City Pilots
June 29, 2023
Vulnerability to Extreme Heat

Key Indicators for the Medical District area:
- Highly developed (more than 70%)
- Sensitive populations (54% households with members 65+ or under 18)
- Low tree canopy (less than 6% area with significant coverage)
- Moderate Socioeconomic Status vulnerability (CDC)

Note: Does not consider populations served within the Medical District
CISA Heat Research: Measuring Personal Temperature Exposure & WBGT

Thermochron or Hydrochron iButton

GPS and Heart Rate Data at the Individual Level

Hand-held device that estimates wet bulb globe thermometer

Three Groups of Outdoor Workers

WBGT Pilot Sites

Charleston Extreme Heat Initiatives Overview
NOAA US Eastern Region Climate Services: Heat Season Preparedness and City Pilots
June 29, 2023
Charleston Heat Research

1. CMD Heat Research
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3. HeatWatch Research
4. Expanding and Sharing Research

**Charleston Extreme Heat Initiatives Overview**

NOAA US Eastern Region Climate Services: Heat Season Preparedness and City Pilots
June 29, 2023

**1. CMD Heat Research**

Used ibuttons and GPS-enabled watches to monitor participant heart rate during workhours across four weeks.

**2. CISA Heat Research**

Used wet bulb globe temperature (WBGT) device to measure temperature, humidity and wind speed at designated areas across a number of days.

**3. HeatWatch Research**

PI: Dr. Kirstin Dow, USC
Stafford Mullin
Grant Farmer
Dr. Jen Runkle, NC State
Dr. Maggie Sugg, Appalachian State

MUSC
Dr. Jerry Reves, MUSC
Robin Smith, MUSC Arboretum and Grounds
Major Dorothy Simmons, MUSC Public Safety
Christine Von Kolnitz, Director of MUSC Sustainability and Recycling

The Citadel
Dr. Scott Curtis, The Citadel James B Near Center for Climate Studies
Jonathan Lewellyn, The Citadel Grounds

Climate Adaptation Partners
Janice Barnes
Leo Temko

**4. Expanding and Sharing Research**

PI: Dr. Kirstin Dow, USC
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Climate Adaptation Partners
Janice Barnes
Leo Temko
Local Heat-health Monitoring in Outdoor Workers: Results from a Participatory Sensing Study in Charleston, SC

Jennifer Runkle, PhD, MSPH  jrrunkle@ncsu.edu  Maggie Sugg, PhD  kovachmm@appstate.edu
Measuring **Heat Index** Exposure

Heat Index → Takes into account temperature + relative humidity

Often measured at *weather stations* at airports or removed from city centers

Charleston Extreme Heat Initiatives Overview

NOAA US Eastern Region Climate Services: Heat Season Preparedness and City Pilots

June 29, 2023
Continuous Monitoring of Personal Heat Index in an Occupationally Exposed Population

3 groups of participants
8,500 observations

Examine exposure misclassification relative to HeatWatch and Weather Station

- Quantity heat exposure metrics (intensity, frequency, and duration) and health effects
- Compare individual experienced temperatures with data from UHI campaign in Charleston

Charleston Extreme Heat Initiatives Overview
NOAA US Eastern Region Climate Services: Heat Season Preparedness and City Pilots
June 29, 2023
Key Messages

We observed that on average, worker's personal ambient temperature experience was higher than that recorded at the local weather station. This was especially true for maximum temperature (the highest temperature recorded for a given day).
We observed on average worker’s **personal heat index experience** was higher than the local weather station. However, these differences between worker and weather station heat index values were not as high as the temperature.
Key Messages

Personal temperatures and heat index values were highest for grounds workers, particularly at MUSC.
We also noted that the **average recorded heat index values for CB and MG were 85°F or higher.**

According to the National Institute for Occupational Safety and Health (NIOSH), **heightened heat prevention measures should be triggered for workers.**

Temperatures modelled based on observations from hydrochron temperature and humidity sensors worn by volunteers July 18-31, 2021
Key Messages

We noted that workers were shifting their workday to include more work outdoors in the earlier parts of the workday.
There are a number of ways workers can protect themselves from extreme heat including:

**Leadership**

1. **Limit time in the heat and/or increase recovery time** in a cool environment
2. **Reduce energy expenditure** demands of the job to generally cooler times of the day
3. **Conduct trainings** about heat stress and how to recognize the signs/symptoms at work
4. **Increase rest breaks and shorten work periods** during extreme heat periods
5. Develop and use **heat acclimatization plan** at work
6. Implement a **buddy system** where workers observe each other for signs of heat intolerance
7. Require workers to conduct **self-monitoring**

**Personal**

1. **Increase physical fitness** outside of work
2. Drink water frequently

---

**NIOSH Recommendations**

From: Local Heat-health Monitoring in Outdoor Workers: Results from a Participatory Sensing Study in Charleston, SC (Runkle and Sugg, 2022)

https://www.cdc.gov/niosh/docs/2016-106/
Charleston Heat Research

1. **CMD Heat Research**
   - Used ibuttons and gps-enabled watches to monitor participant heart rate during workhours across four weeks.

2. **CISA Heat Research**
   - Used wet bulb globe temperature (WBGT) device to measure temperature, humidity and wind speed at designated areas across a number of days.

3. **HeatWatch Research**
   - PI: Dr. Kirstin Dow, USC
   - Stafford Mullin
   - Grant Farmer
   - Dr. Jen Runkle, NC State
   - Dr. Maggie Sugg, Appalachian State

4. **Expanding and Sharing Research**
   - PI: Dr. Chip Konrad, UNC Chapel Hill
   - Jordan Clark
   - Stafford Mullin
   - Grant Farmer
   - Student Volunteers
Patterns of Heat Stress Across the Landscape and Its Measurement using Wet Bulb Globe Temperature

Dr. Chip Konrad

Director of the NOAA Southeast Regional Climate Center
Carolina Integrated Science and Assessments Program (CISA)
Professor, Department of Geography
University of North Carolina at Chapel Hill
Measures of Heat Stress

1. Air temperature
2. Humidity
3. Wind speed
4. Solar Radiation

Heat Index

Wet-Bulb Globe Temperature (WBGT)
HEAT SEASON DATA COLLECTION

WBGT THRESHOLDS: High School Athletics Associations

Many states have developed requirements for high school sports practice

<table>
<thead>
<tr>
<th>Heat Category</th>
<th>WBGT Index (F)</th>
<th>Activity Guidelines</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Flag</td>
<td>Under 82</td>
<td>Normal activities</td>
</tr>
<tr>
<td>Low (Green Flag)</td>
<td>82-86.9</td>
<td>Three (3) separate four (4) minute rest breaks per hour of activity</td>
</tr>
<tr>
<td>Moderate (Yellow Flag)</td>
<td>87-89.9</td>
<td>Maximum two (2) hour activity time. Four (4) separate four (4) minute rest breaks per hour of activity. For football, student-athletes are restricted to helmet, shoulder pads and shorts during activity.</td>
</tr>
<tr>
<td>High (Red Flag)</td>
<td>90-91.9</td>
<td>Maximum one (1) hour activity time. Five (5) separate four (4) minute rest breaks. No protective equipment permitted. No conditioning activities permitted.</td>
</tr>
<tr>
<td>Extreme (Black Flag)</td>
<td>Over 92</td>
<td>No outdoor activities</td>
</tr>
</tbody>
</table>

Source: Georgia, South Carolina, and Florida High School Athletics Association

Charleston Extreme Heat Initiatives Overview

NOAA US Eastern Region Climate Services: Heat Season Preparedness and City Pilots
June 29, 2023
## Heat Season Data Collection

### WBGT Thresholds: United States Military

<table>
<thead>
<tr>
<th>Heat Category</th>
<th>WBGT Index (F)</th>
<th>Activity Guidelines</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Flag</td>
<td>Under 80</td>
<td>Normal Activities</td>
</tr>
<tr>
<td>Low (Green Flag)</td>
<td>80-84.9</td>
<td>Discretion required in planning heavy exercise for unseasoned personnel. This is a marginal heat stress limit for all personnel.</td>
</tr>
<tr>
<td>Moderate (Yellow Flag)</td>
<td>85-87.9</td>
<td>Strenuous exercise and activity should be curtailed for new and unacclimated personnel during first 3 weeks of heat exposure.</td>
</tr>
<tr>
<td>High (Red Flag)</td>
<td>88-89.9</td>
<td>Strenuous exercise curtailed for all personnel with less than 12 weeks training in hot weather.</td>
</tr>
<tr>
<td>Extreme (Black Flag)</td>
<td>Over 90</td>
<td>Physical training and strenuous exercise suspended for all personnel</td>
</tr>
</tbody>
</table>

Source: U.S Military Heat Stress Index

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**Charleston Extreme Heat Initiatives Overview**

NOAA US Eastern Region Climate Services: Heat Season Preparedness and City Pilots

June 29, 2023
### WBGT Activity Guidelines and Rest/Break Guidelines for Athletes

<table>
<thead>
<tr>
<th>Heat Category</th>
<th>WBGT Index (F)</th>
<th>Activity Guidelines</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Flag</td>
<td>Under 71</td>
<td>All activities allowed, but be alert for prodromes of heat-related illness in prolonged events</td>
</tr>
<tr>
<td>Low (Green Flag)</td>
<td>71-74.9</td>
<td>All activities allowed, but be alert for prodromes of heat-related illness in prolonged events</td>
</tr>
<tr>
<td>Moderate (Yellow Flag)</td>
<td>75-78.9</td>
<td>Longer rest periods in the shade, enforce drinking every 15 minutes</td>
</tr>
<tr>
<td>High (Red Flag)</td>
<td>79-84.9</td>
<td>Stop activity of unacclimatized persons and other persons with high risk; limit activities of all others (disallow long-distance races, cut down further duration of other activities)</td>
</tr>
<tr>
<td>Extreme (Black Flag)</td>
<td>Over 85</td>
<td>Cancel all athletic activities</td>
</tr>
</tbody>
</table>

Source: American Academy of Pediatrics
Local patterns of heat stress (WBGT) across a landscape

1. Surface type
   Asphalt/concrete is hottest, especially if it is dark colored. Artificial turf is hotter, but natural grass is hot.

2. Degree of shade
   Surfaces that have been shaded most of day are the coolest. (e.g. north side of quad)

3. Openness of landscape
   Closed (lots of trees/buildings nearby) - Hottest (lowest wind speeds)
   Open (few trees/buildings) – Coolest (highest wind speeds)
Charleston Extreme Heat Initiatives Overview

NOAA US Eastern Region Climate Services: Heat Season Preparedness and City Pilots

June 29, 2023
Charleston Heat Research

Lead Organization(s)
- City of Charleston, Climate Adaptation Partners

Partner Organizations
- Medical University of South Carolina Arboretum
- Citadel James B. Neale Center for Climate Studies
- Charleston Resilience Network (Over 120 organizations)
- Charleston Medical District
- South Carolina Interfaith Power and Light
- Carolinas Integrated Sciences and Assessments
- Medical University of South Carolina Institute for Air Quality Studies
- Medical University of South Carolina Office of Health Promotion
- Medical University of South Carolina Sustainability Office
- National Weather Service Charleston

HeatWatch Research

Used car-mounted devices to measure temperature and humidity on one representative day

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June 29, 2023
Charleston Extreme Heat Initiatives Overview
NOAA US Eastern Region Climate Services: Heat Season Preparedness and City Pilots
June 29, 2023
Charleston HeatWatch

Driving Team
Simon and Darla Ghanat
Lyndsey and Matthew Davis
Susan and Greg Lovelace
Catherine Parker and Ben Stone
Deidre Ragan and Aidan Ragan Fillippa
Will McCloud
Grant Farmer
Rebecca Starkey
Al Harpring
Scott Curtis
Bonnie Ertel
Darcy Everett
Christine von Kolnitz
Pamela Ferguson
Andrea Forgacs
Kweku Brown
Emma Larsen

FLIR Team
Shawn McKay
Amanda Mushal
Stewart Weinberg
Starr Hazard

Charleston Extreme Heat Initiatives Overview
NOAA US Eastern Region Climate Services: Heat Season Preparedness and City Pilots
June 29, 2023
Charleston HeatWatch

Coverage Area
NOAA Funding for 100 SM
10 Traverses @10 SM / Traverse

Initial Charleston screening excluding water and wetlands ~69 SM
Remainder for North Charleston adjoining area

Data Collection
July 31, 2021
Morning, Afternoon, Evening Traverses

Volunteers
10 Driving Teams
3 FLIR Teams
1 Coordinating Team

Charleston Extreme Heat Initiatives Overview
NOAA US Eastern Region Climate Services: Heat Season Preparedness and City Pilots
June 29, 2023
Charleston Area Heat Watch Context

Life Expectancy at Birth

Grid: 1 Square Mile

CHS HeatWatch Study Area

CHS Life Expectancy at Birth

CDC Life Expectancy (census tract)

- 85 yr - 93 yr
- 75 yr - 84 yr
- 65 yr - 74 yr
- 50 yr - 64 yr
- 20 yr - 49 yr
- 10 yr - 19 yr
- no data

IMAGE CREDIT: Climate Adaptation Partners
HeatWatch Results

Charleston Extreme Heat Initiatives Overview
NOAA US Eastern Region Climate Services: Heat Season Preparedness and City Pilots
June 29, 2023

- 27 Volunteers
- 10 Routes
- 57,948 Measurements
- 95.9° Max Temperature
- 11.8° Temperature Differential
Charleston Extreme Heat Initiatives Overview
NOAA US Eastern Region Climate Services: Heat Season Preparedness and City Pilots
June 29, 2023
HeatWatch Summary

1. More effect of density of development
2. Peninsula was far warmer
3. Conserved Forest was cooler and offered a bigger impact on cooling than water bodies
4. No effect of swampy areas versus regular forest

Open Science Forum
https://osf.io/b41fy/

City of Charleston GIS Team
https://www.charleston-sc.gov/2513/HeatWatch-Charleston-2021
HeatWatch Summary

City of Charleston GIS Team
https://www.charleston-sc.gov/2513/HeatWatch-Charleston-2021

Charleston Extreme Heat Initiative Overview
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Charleston Heat Research

1. CMD Heat Research
2. CISA Heat Research
3. HeatWatch Research
4. Expanding and Sharing Research

City of Charleston Resilience, GIS, and Planning Departments
Climate Adaptation Partners
University of South Carolina
The Citadel James B. Near Center for Climate Studies
South Carolina Sea Grant
UNC-Chapel Hill
MUSC Sustainability, Office of Health Promotion, Nursing, Epidemiology, Emergency Department, and Arboretum
National Weather Service Charleston
State of South Carolina Meteorology Office
NOAA NIHHS and Pilot Research Team
City of Miami
City of Phoenix
City of Las Vegas
Drexel University
City of Philadelphia
City of Columbus

Charleston Extreme Heat Initiatives Overview
NOAA US Eastern Region Climate Services: Heat Season Preparedness and City Pilots
June 29, 2023

Expanding and Sharing Research
NOAA Pilot Project
Journal Publications
Philly & Columbia HeatWatch
Charleston Extreme Heat Initiatives Overview

NOAA US Eastern Region Climate Services: Heat Season Preparedness and City Pilots

June 29, 2023
Why is the NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION (NOAA) sponsoring this work?

• Extreme heat is the number one weather related killer in the United States

• Heat-related health impacts likely will increase with climate change

• Informed by Climate and Equity Roundtable Events, NOAA is working with four communities to understand heat health impacts and address community needs (in Charleston, Miami, Las Vegas, Phoenix)

RESOURCES:

• National Integrated Heat Health Information System (NIHHIS)

• Interagency resource: Heat.gov
Charleston Extreme Heat Initiatives Overview
NOAA US Eastern Region Climate Services: Heat Season Preparedness and City Pilots
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HEAT SEASON DATA COLLECTION

Charleston Extreme Heat Initiatives Overview
NOAA US Eastern Region Climate Services: Heat Season Preparedness and City Pilots
June 29, 2023
Near to the CMD, Gadsden Green is in a hot part of Charleston.

We hoped to better understand heat impacts by:

**Phase 1 (LEARN):**
- recording hot temperatures in the community
- identifying materials that make heat feel worse
- talking about how heat affects health

**Phase 2 (ACT):**
- identifying resources to help cope with heat
- finding solutions to help cool the environment

**Charleston Extreme Heat Initiatives Overview**
NOAA US Eastern Region Climate Services: Heat Season Preparedness and City Pilots
June 29, 2023

Note that dark red parcels indicate CHA properties. These are not heat indicators.
HEAT SEASON DATA COLLECTION

Charleston Extreme Heat Initiatives Overview

NOAA US Eastern Region Climate Services: Heat Season Preparedness and City Pilots
June 29, 2023

Figure 2: Gadsden Green Land Cover
ENVIRONMENTAL CONDITIONS DURING OBSERVATION

Atmospheric Readings were collected in Gadsden Green during the 09/04/2022 study

- 6am – 8am
  - 115 Observations
  - Average Air Temperature: 78° F
  - Average Relative Humidity: 90%
  - Average Heat Index: 87° F

- 2pm – 4pm
  - 140 Observations
  - Average Air Temperature: 89° F
  - Average Relative Humidity: 65%
  - Average Heat Index: 104° F

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NOAA US Eastern Region Climate Services: Heat Season Preparedness and City Pilots
June 29, 2023
HEAT SEASON DATA COLLECTION

COLLECTION SITE

Data Collection focused on Gadsden Green and Gadsden Green Extension

- Four Kestrel WBGT Locations
- FLIR imagery focused on:

<table>
<thead>
<tr>
<th>landscape</th>
<th>buildings</th>
</tr>
</thead>
<tbody>
<tr>
<td>asphalt (roads)</td>
<td>clay tile (roofs)</td>
</tr>
<tr>
<td>concrete (sidewalks)</td>
<td>shingles (roofs)</td>
</tr>
<tr>
<td>grass (lawns)</td>
<td>painted brick (walls)</td>
</tr>
<tr>
<td>bare earth (dirt)</td>
<td>unpainted brick (walls)</td>
</tr>
<tr>
<td>sand (playgrounds)</td>
<td>metal (windows / doors)</td>
</tr>
<tr>
<td>mulch (plant areas)</td>
<td>glass (windows)</td>
</tr>
<tr>
<td>rubber (play surfaces)</td>
<td>wood (benches / fences)</td>
</tr>
</tbody>
</table>

Charleston Extreme Heat Initiatives Overview
NOAA US Eastern Region Climate Services: Heat Season Preparedness and City Pilots
June 29, 2023
HEAT SEASON DATA COLLECTION

FLIR IMAGES FROM GADSDEN GREEN

- 223 FLIR Images Analyzed
- 13 Distinct Material Types were Captured
- 488 Unique Temperature Readings
- FLIR teams captured morning and afternoon images to match the WBGT observation periods
- FLIR teams captured sunny and shaded surfaces
- Temperatures reported are typically AVERAGES estimated across contiguous surface areas

Charleston Extreme Heat Initiatives Overview

NOAA US Eastern Region Climate Services: Heat Season Preparedness and City Pilots
June 29, 2023
SURFACE TEMPERATURES IN GADSDEN GREEN

This is a summary of temperature AVERAGES of various materials in Gadsden Green, including:

- temperature **averages** captured in the morning (blue line) and afternoon (red line)
- surfaces in **(sun)** and in **(shade)**

What does this tell us?
HEAT SEASON DATA COLLECTION

SURFACE TEMPERATURES IN GADSDEN GREEN

Notice how the **average temperatures** of some materials observed in the **afternoon** vary significantly.

This diagram reinforces how important shade is to cooling. Shaded materials are significantly cooler than unshaded. **Average material temperatures** varied as much as **24 degrees** between sun and shade.

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Charleston Extreme Heat Initiatives Overview
NOAA US Eastern Region Climate Services: Heat Season Preparedness and City Pilots
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SURFACE TEMPERATURES IN GADSDEN GREEN

The next two images illustrate the surface temperature differences in sunny and shaded conditions.

This image of an exposed stoop in Gadsden Green shows grass, concrete, and brick in direct sun.

Note the temperature differences between the lighter-colored concrete and darker-colored concrete.

IMAGE CREDIT: The Citadel / CAP
HEAT SEASON DATA COLLECTION

SURFACE TEMPERATURES IN GADSDEN GREEN

This is a “Box and Whisker” plot showing the distribution of afternoon surface temperature averages that provides another way to look at the data.

Box and Whisker plots show where most of the collected temperatures fall (the box) as well as the highs and lows (the whiskers).

This illustrates how temperature values are clustered (showing trends and important deviations of those trends).

Charleston Extreme Heat Initiatives Overview
NOAA US Eastern Region Climate Services: Heat Season Preparedness and City Pilots
June 29, 2023
SURFACE TEMPERATURES IN GADSDEN GREEN

This image is from Gadsden Green and includes the two different roof types:

- The blue and red painted brick buildings have dark-colored clay-tile roofs.
- The green painted brick building has a dark-colored asphalt-shingle roof.

Note that the clay tile roof has a temperature of 120° and the asphalt shingle roof is much warmer at 139°
It’s important to note that there can be significant variation between similar materials as well. This image shows two asphalt shingle roofs (one lighter and one darker)
SURFACE TEMPERATURES IN GADSDEN GREEN

It’s important to note that there can be significant variation between similar materials as well. This image shows two asphalt shingle roofs (one lighter and one darker)

Note that the darker colored asphalt shingle roof is significantly warmer than the lighter asphalt shingle roof.
SURFACE TEMPERATURES IN GADSDEN GREEN

This image, from the Gadsden Green Extension playground, includes many different surface materials: healthy grass, wood chips / mulch, steel, and plastic.

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HEAT SEASON DATA COLLECTION

SURFACE TEMPERATURES IN GADSDEN GREEN

Note that the wood chips / mulch areas are significantly warmer than the grass areas.

The hottest surfaces in this area are the plastic and steel surfaces.

But there is also another important principle illustrated by this image.

The radiant heat emitted by the plastic is significantly increasing the surface temperature of the adjacent wood chips / mulch by nearly 20°.
HEAT SEASON DATA COLLECTION

WBGT IN GADSDEN GREEN

Collection Period:
- September 4, 2022
- ~6-8 am and 2-4 pm
- Locations informed by community input

Counts (minute averages):
- ~120 am & ~120 pm

Analysis Process:
- Examine WBGT time series
- Examine WBGT components
- Compare published WBGT health "flag" thresholds

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Community Involvement

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OUTDOOR TEMPERATURE READINGS

Also: considering wind direction and cooling effect

Playground
Alway St.
Paired Open
Paired Tree

*Flags are U.S. military standard

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Sharing Research
Providing Open Access GIS resources for knowledge sharing

NOAA
• HeatWatch ArcGIS Resource

Open Science Framework
• https://osf.io/b4tfy

City of Charleston
• HeatWatch
• Tree Canopy Tools App
• Street Tree Canopy Storymap

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Journal of Biometeorology

Sugg, M.M., Runkle, J.D., Dow, K., Barnes, J., Pearce, J., Bossak, B., Curtis, S.

Individually experienced heat index in a coastal Southeastern US city among an occupationally exposed population.

https://doi.org/10.1007/s00484-022-02309-y

Advances in Environmental Engineering

Larsen E, Ghanat S, Curtis S.


*Adv Environ Eng Res* **2022**;3(2):9

Frontiers in Climate

Barnes, J. and Dow, K.

Water AND Heat: Intervening in Adaptation Hazard Bias

*Frontiers in Climate*, 29, June 2022
https://doi.org/10.3389/fclim.2022.868017

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Starting Research on Health Outcomes from Temperature (HOT)

Retrospective Study

designed to produce a statewide temperature dose response curve. Temperature would be the variable of interest and death the outcome

Prospective Study

compares temperature and air quality with morbidity and mortality in Charleston - clinical data gathered from MUSC, Roper and Regional EMS and temperature and air quality from sensors and weather department

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Collecting Existing Extreme Heat Resources

Charleston Extreme Heat Initiatives Overview

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Charleston Extreme Heat Initiatives Overview
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Outcomes to Date

Collaborative growth and progress on complementary activities

CMD introduced heat into its draft resilience strategy and to its respective masterplanning teams

MUSC declared July 2021, 2022, and 2023 Heat Awareness Month

City of Charleston added extreme heat to the Charleston Comprehensive Plan

https://www.charleston-sc.gov/DocumentCenter/View/31227/Final-City-Plan-Adopted-October-12-2021

Charleston Tourist Bureau plans heat risk training for guides and new hydration stations

South Carolina’s Draft Strategic Statewide Resilience and Risk Reduction Plan includes images of Heat Mapping from Charleston and Columbia Heat Watch activities (to be finalized in July 2023)

https://scor.sc.gov/sites/scor/files/Documents/5.%20Draft%20Other%20Hazards%20Vulnerability%206.5.23.pdf

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Get Involved
Motivating Local Action to Address Climate Impacts and Build Resilience

Increase Awareness
Increase Coping Capacity
Increase Mitigation
Increase Adaptation

Proclamations Help!

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Statewide Disaster Funding 2015-2021

$1.42 B
FEMA storm-related disaster recovery and mitigation project total funds* 2015-2020. Of this $1.19B is federal obligation. The balance is match funding.

$451.4 M
HUD Community Development Block Grant (CDBG) storm-related disaster recovery and mitigation grant totals as of August 2021.

$1.87 B
Total FEMA + HUD storm-related disaster recovery and mitigation project values 2015 – August 2021 (excluding Wildfire and BioHazard).

*This excludes FEMA’s Individual Assistance (IA), Individuals and Households (IHP), Housing Assistance (HA), and Other Needs Assistance (ON) programs.

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NOTE: These data were compiled in a 2021 federal disaster recovery funding study by The Nature Conservancy, Southern Environmental Law Center, and Climate Adaptation Partners. The results of that study are forthcoming.
Possible Additional NOAA Collaborations

• increasing research resources, to expand **Heat Health Disparities** research, including **better understanding of energy insecurity** across South Carolina

• linking NOAA/NIHHIS and our campaigns to FEMA/HUD disaster recovery investments to **integrate heat resilience into recovery investments**, such as green and other infrastructure

• deepening collaboration across the RISAs(CAPs) and other research teams working to support the integration of climate information into decision making, sharing lessons and pilot work, and extending the research investments

• along with SCOR, **engaging counties and municipalities across the State** to better integrate heat risk awareness and heat reduction strategies in planned investments

• **shared indicators and reporting to value heat** in disaster preparedness and recovery planning

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Charleston Extreme Heat Initiatives Overview
Building toward a City Heat Plan

Janice Barnes, PhD
Climate Adaptation Partners
June 29, 2023