Assessing the Effects of Local Cool Roof Policies on Urban Heat Islands

Comparative Analysis of Daytime and Nighttime UHI

07/30/2021

EPDM Roofing Association

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ICF

Research Objectives

- Compare the strength and significance of daytime and nighttime UHIs with results published in the Climate Central study

- Assess the probability of UHI being as prominent as indicated in the Climate Central study using alternate weather stations and summertime periods

Cities Selected for UHI Comparative Analysis

CZ3	CZ4	CZ5	CZ6
Las Vegas, Nevada	Portland, Oregon	Denver, Colorado	Minneapolis, Minnesota
San Diego, California	Louisville, Kentucky	Columbus, Ohio	
	Kansas City, Missouri	Buffalo, New York	
	Albuquerque, New Mexico		
	Washington, D.C.		
	Philadelphia, Pennsylvania		
	Baltimore, Maryland		

Portland, OR

Portland, Oregon – UHI

DAYTIME UHI IN PORTLAND

All data — Only positive data
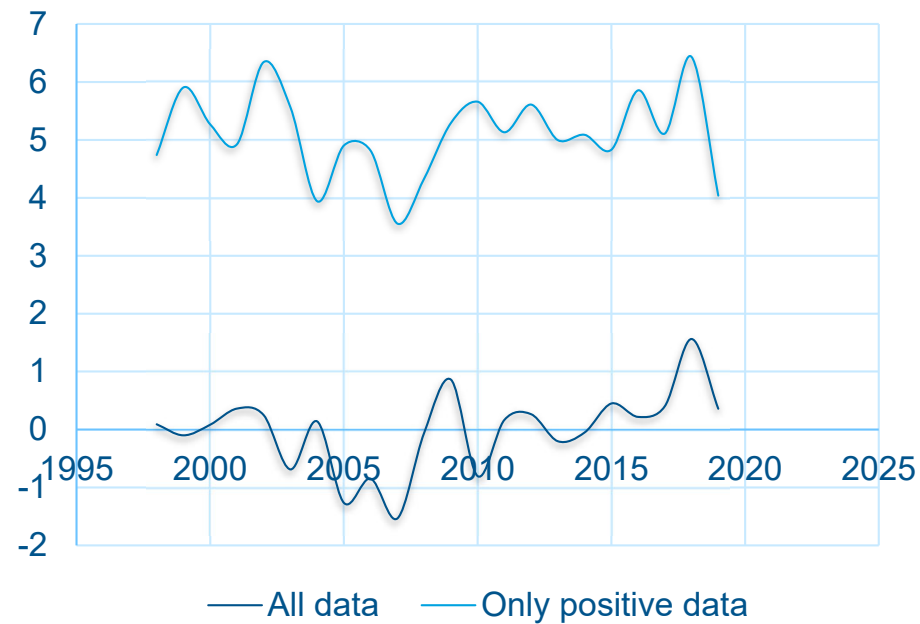
ICF 10-year Avg   -0.3   4.8

CC 10-year Avg = 4.8

NIGHTTIME UHI IN PORTLAND

All data — Only positive data
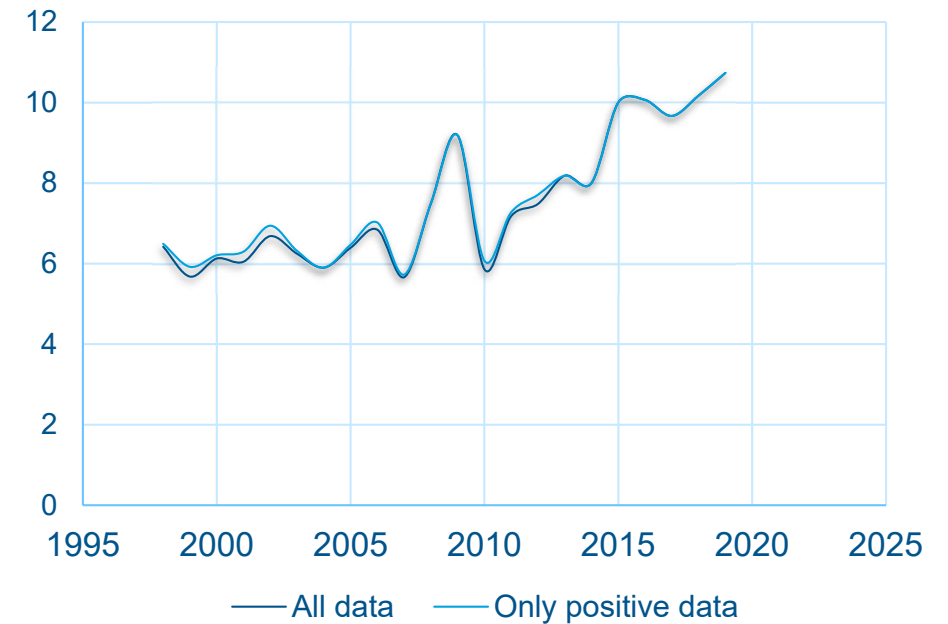
ICF 10-year Avg   7.0   7.1

CC 10-year Avg = 8.9

Las Vegas, NV

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Las Vegas, Nevada - Weather Station Locations
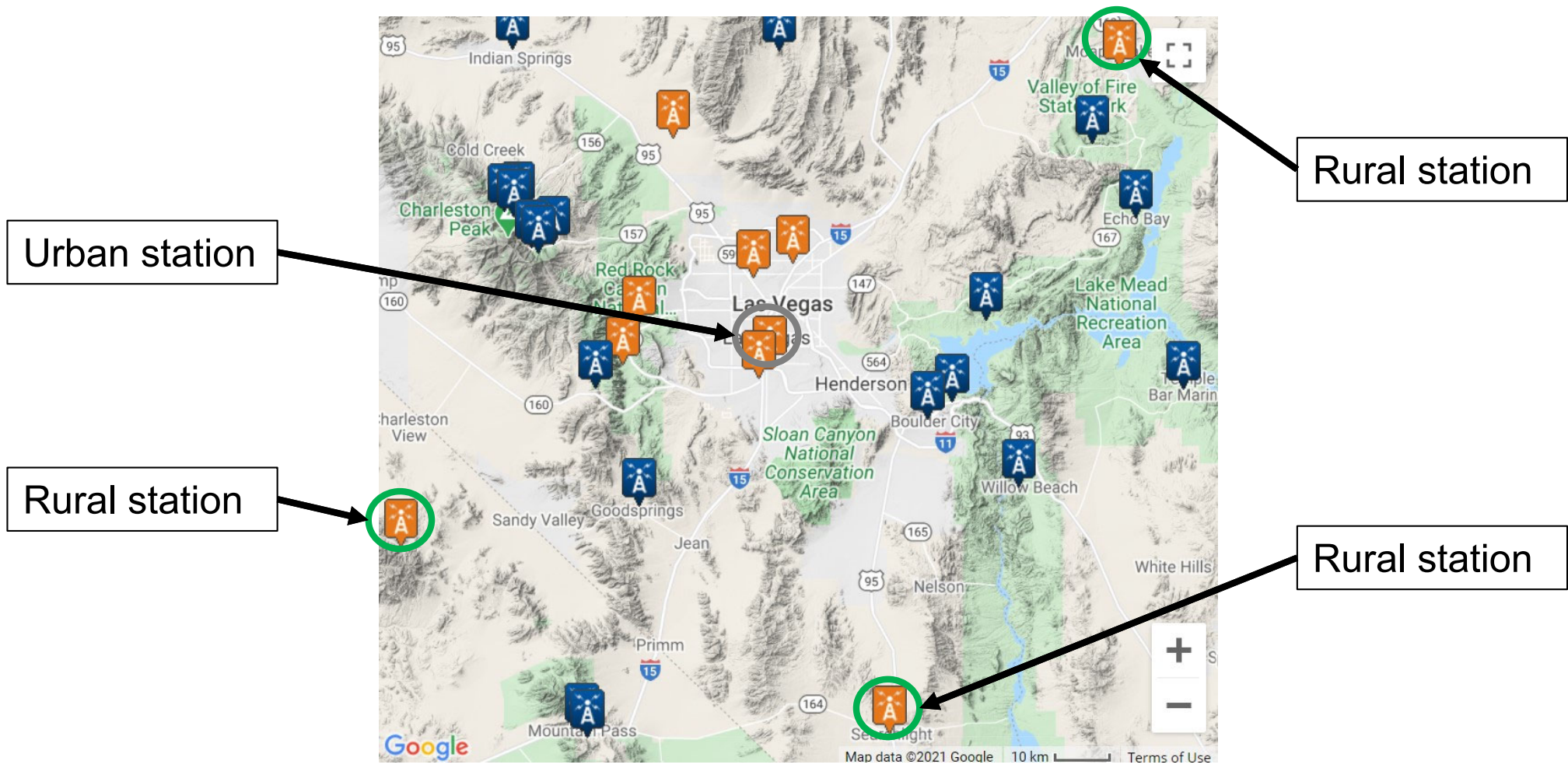
Rural station

Urban station

Rural station

Rural station

Las Vegas, Nevada – UHI – Climate Central Methods

DAYTIME UHI IN LAS VEGAS

Annual UHI
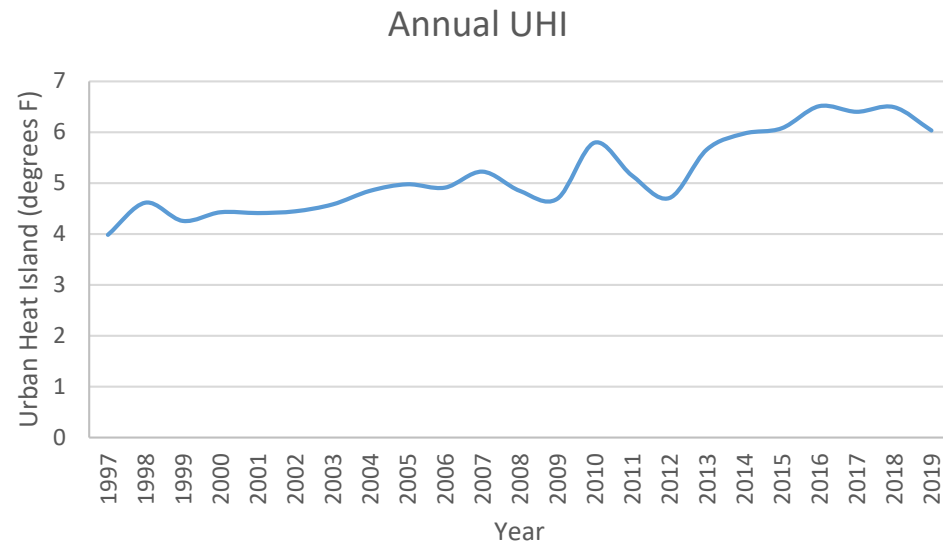
ICF	5.1
CC	7.3

10-year Average UHI

NIGHTTIME UHI IN LAS VEGAS

Annual UHI
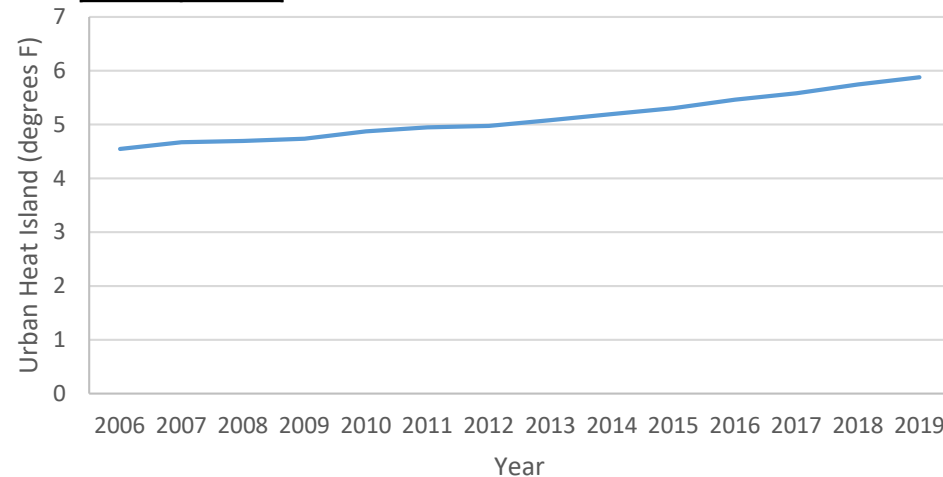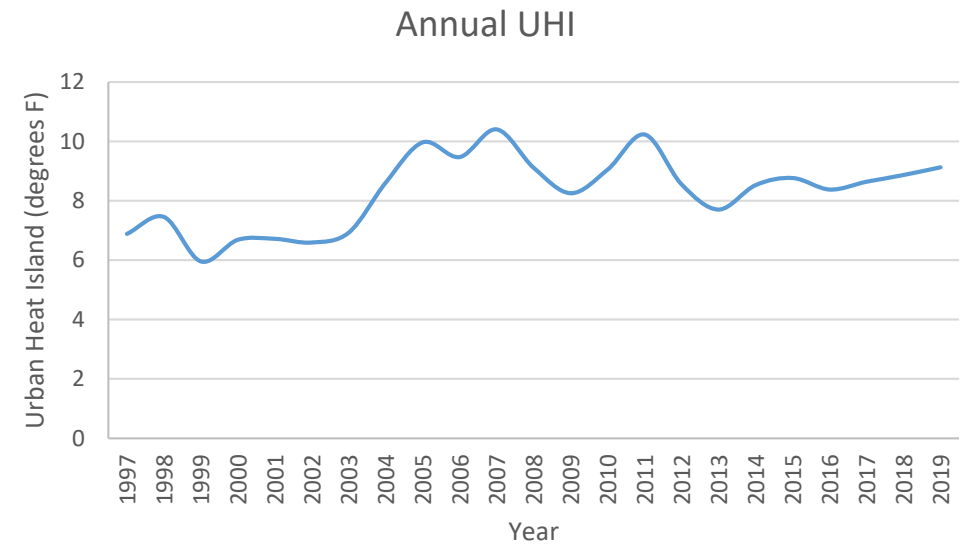
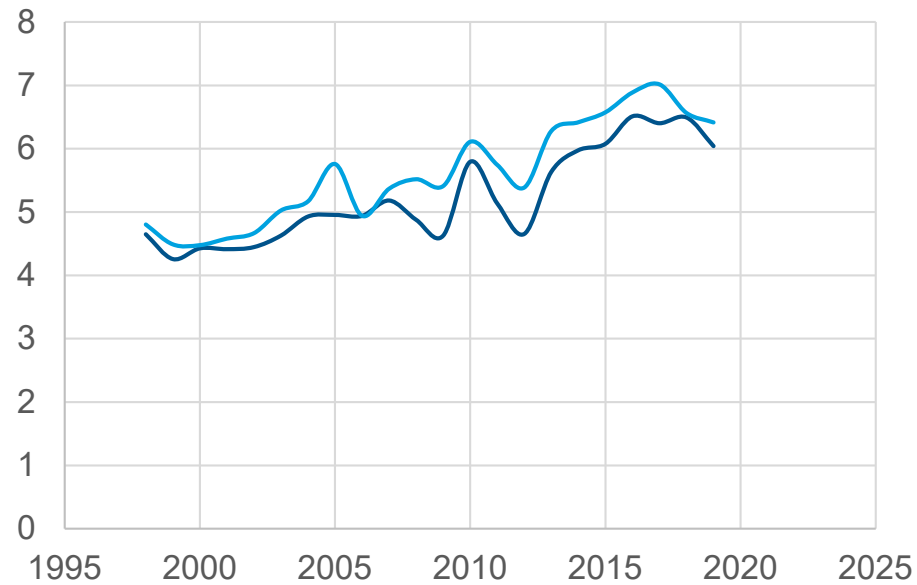| ICF	9.1
CC	10.3

10-year Average UHI
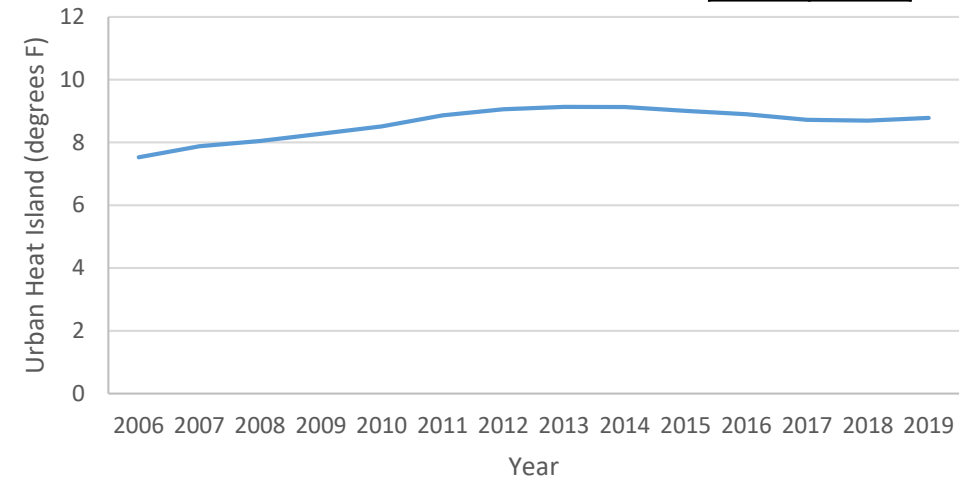
Las Vegas, Nevada – UHI – Deeper Dive

DAYTIME UHI IN LAS VEGAS

— All data — Only positive data

10-year Avg	5.1	5.6

CC 10-year Avg = 7.3

NIGHTTIME UHI IN LAS VEGAS
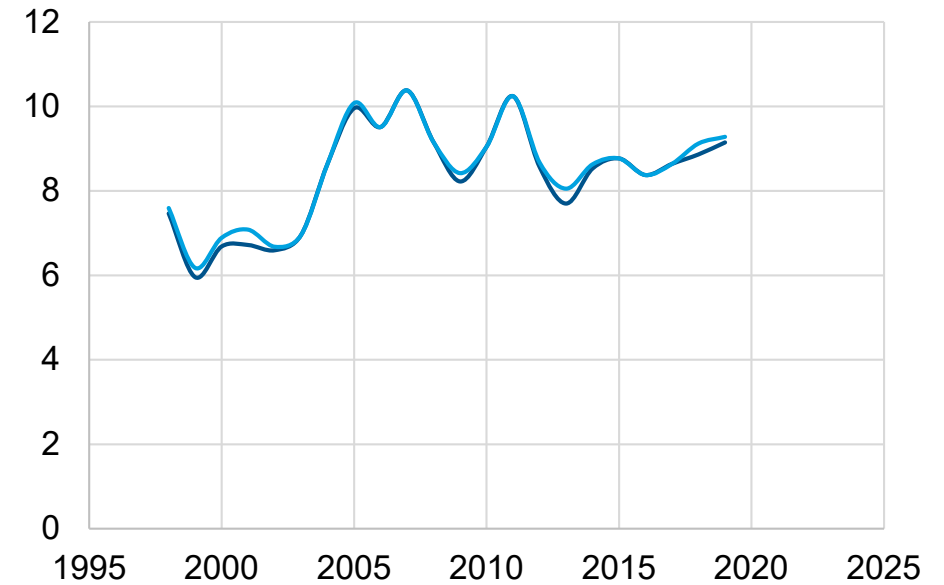
— All data — Only positive data
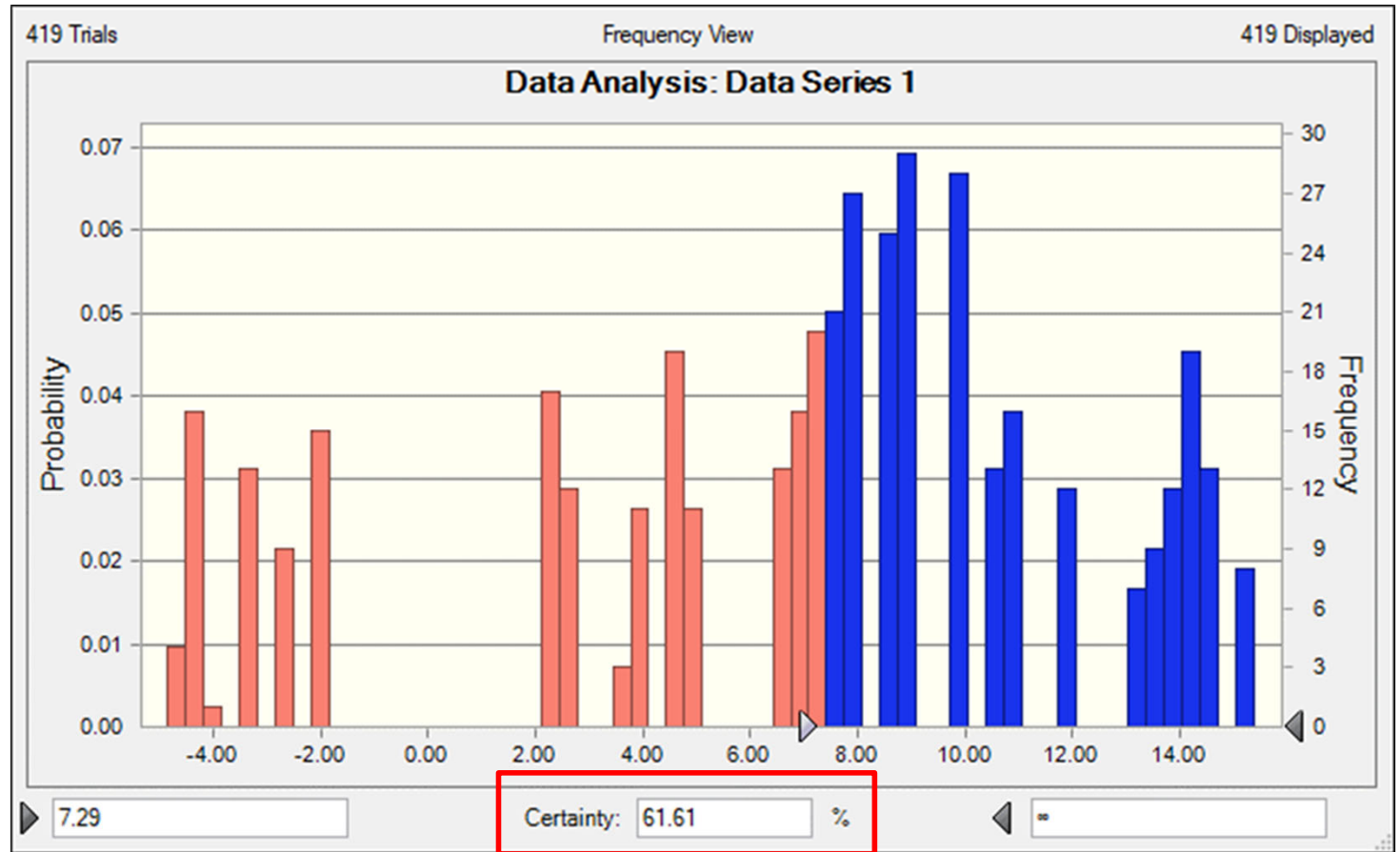
10-year Avg	9.1	9.2

CC 10-year Avg = 10.3

Las Vegas, Nevada – Daytime UHI – Simulated Probabilities

Scenario Number	Urban Weather Stations	Rural Weather Stations	Summer Month(s)
1	1	1	1
2	1	3	1
3	1	2	1 or more

- All simulated conditions produced roughly a 60% probability of UHI being as high as stated in the Climate Central study (7.3 °F)
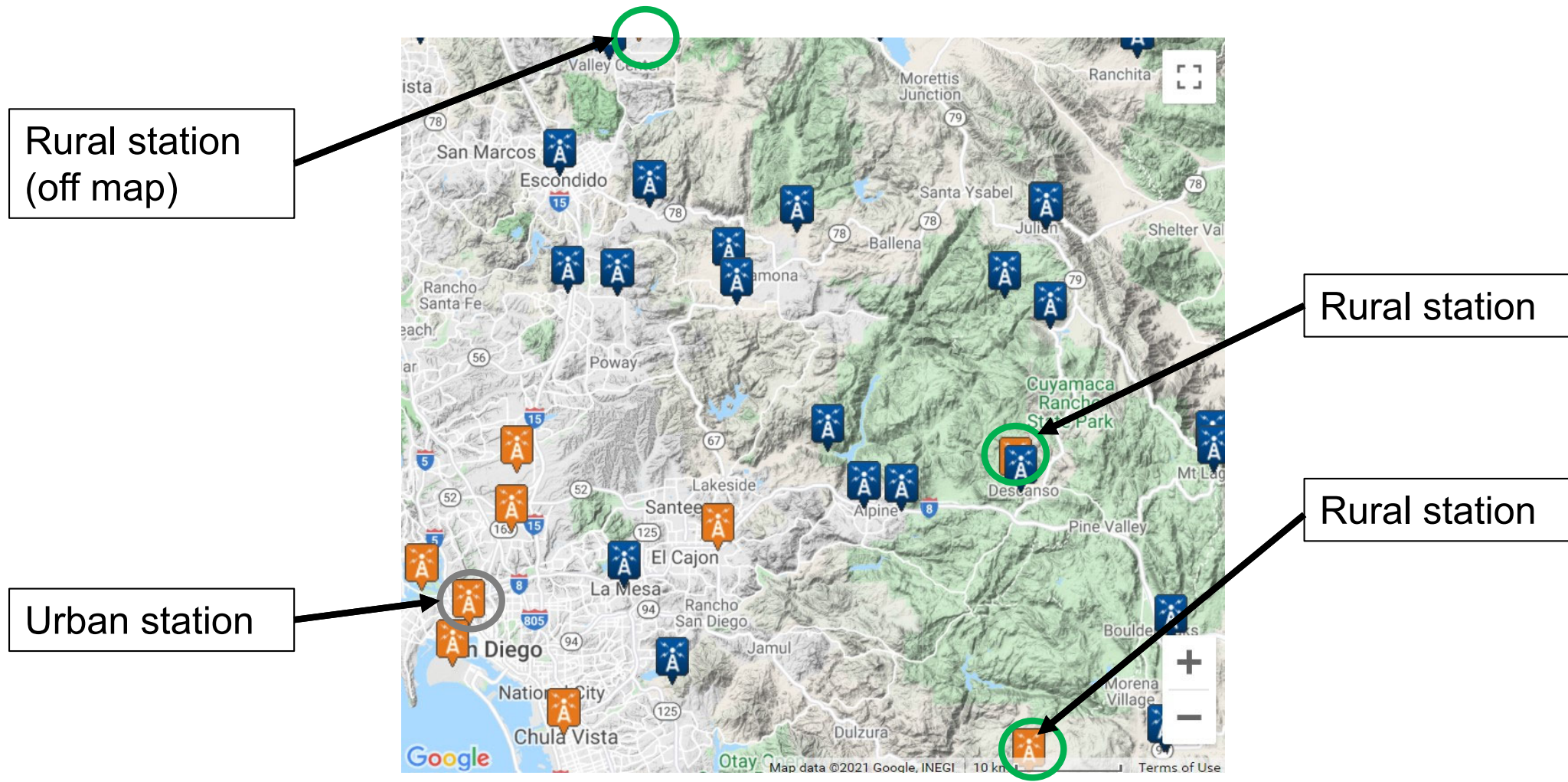

Results shown above are for scenario 1: one urban; one rural; and one summer month
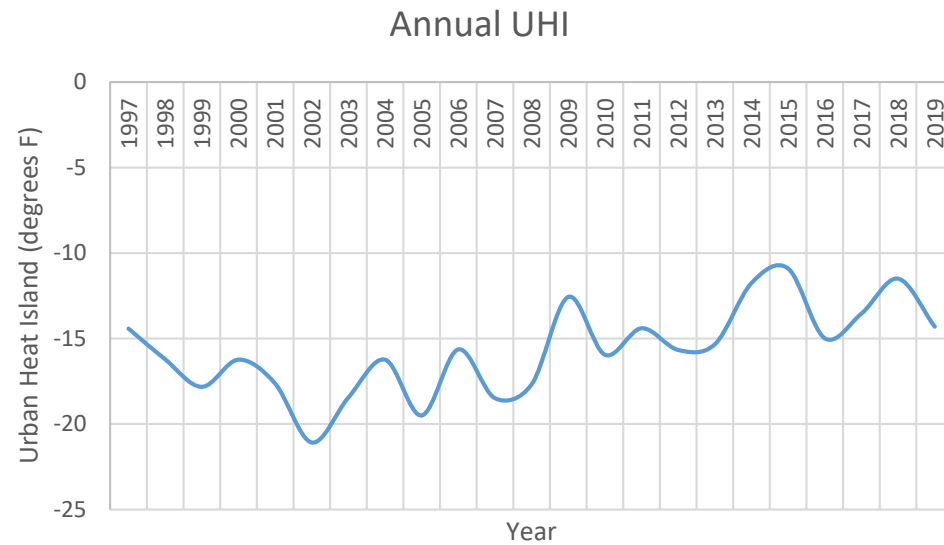
San Diego, CA

San Diego, California - Weather Station Locations

Rural station (off map)

Rural station

Rural station

Urban station

San Diego, California – UHI – Climate Central Methods

DAYTIME UHI IN SAN DIEGO

Annual UHI

ICF	-16.1
CC	-0.6

10-year Average UHI

NIGHTTIME UHI IN SAN DIEGO

Annual UHI
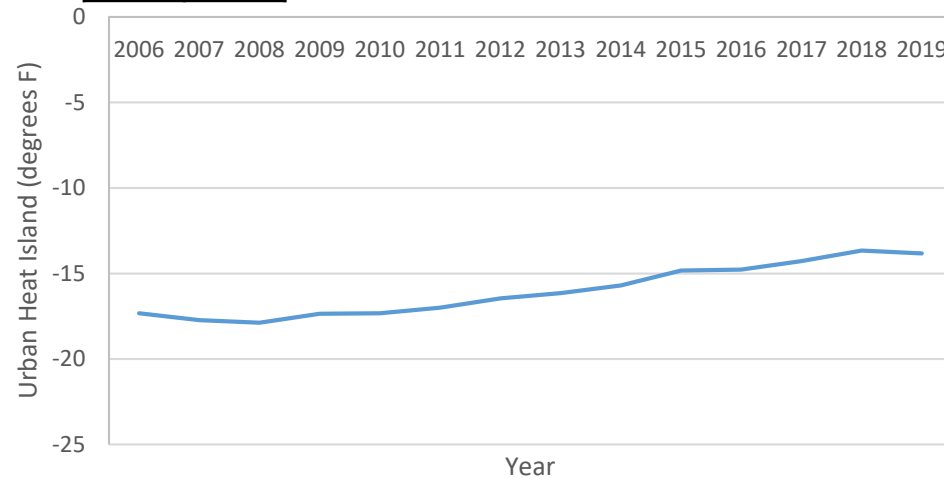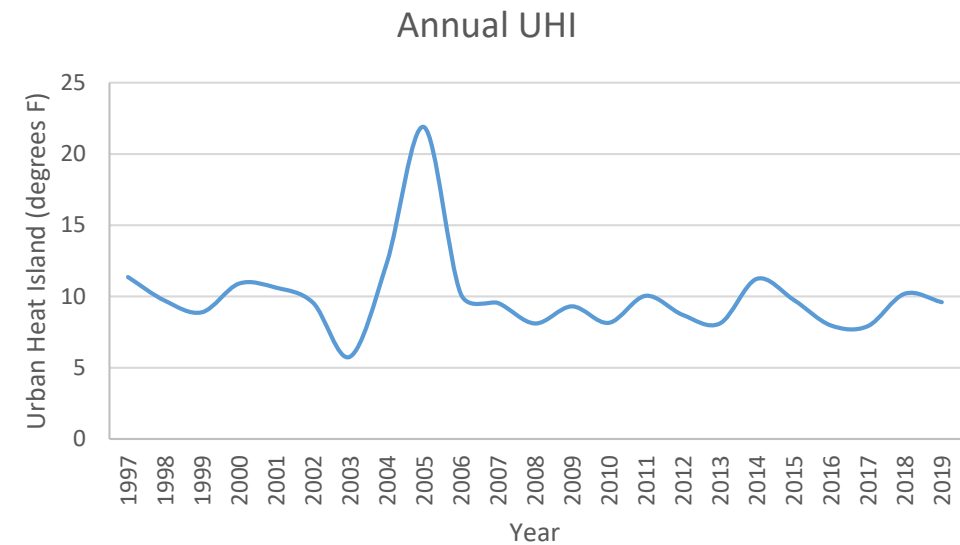
ICF	10.6
CC	7.1

10-year Average UHI
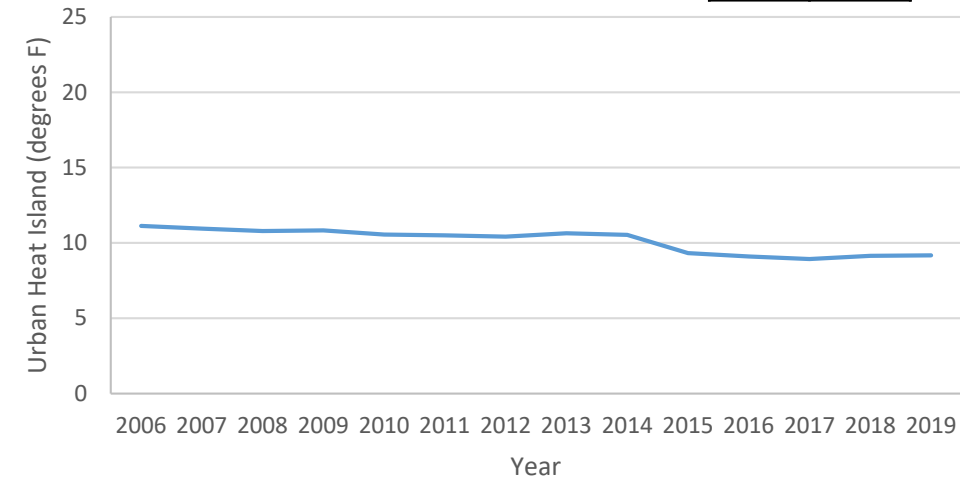
San Diego, California – UHI – Deeper Dive

DAYTIME UHI IN SAN DIEGO

All data — Only positive data
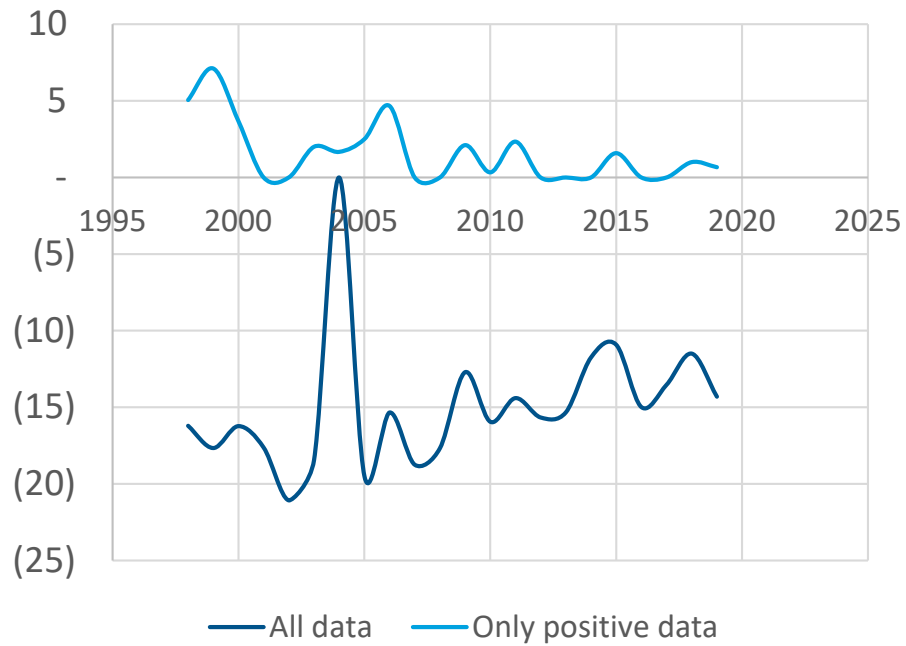
| 10-year Avg | -16.2 | 2.3 |

CC 10-year Avg = -0.6

NIGHTTIME UHI IN SAN DIEGO

All data — Only positive data
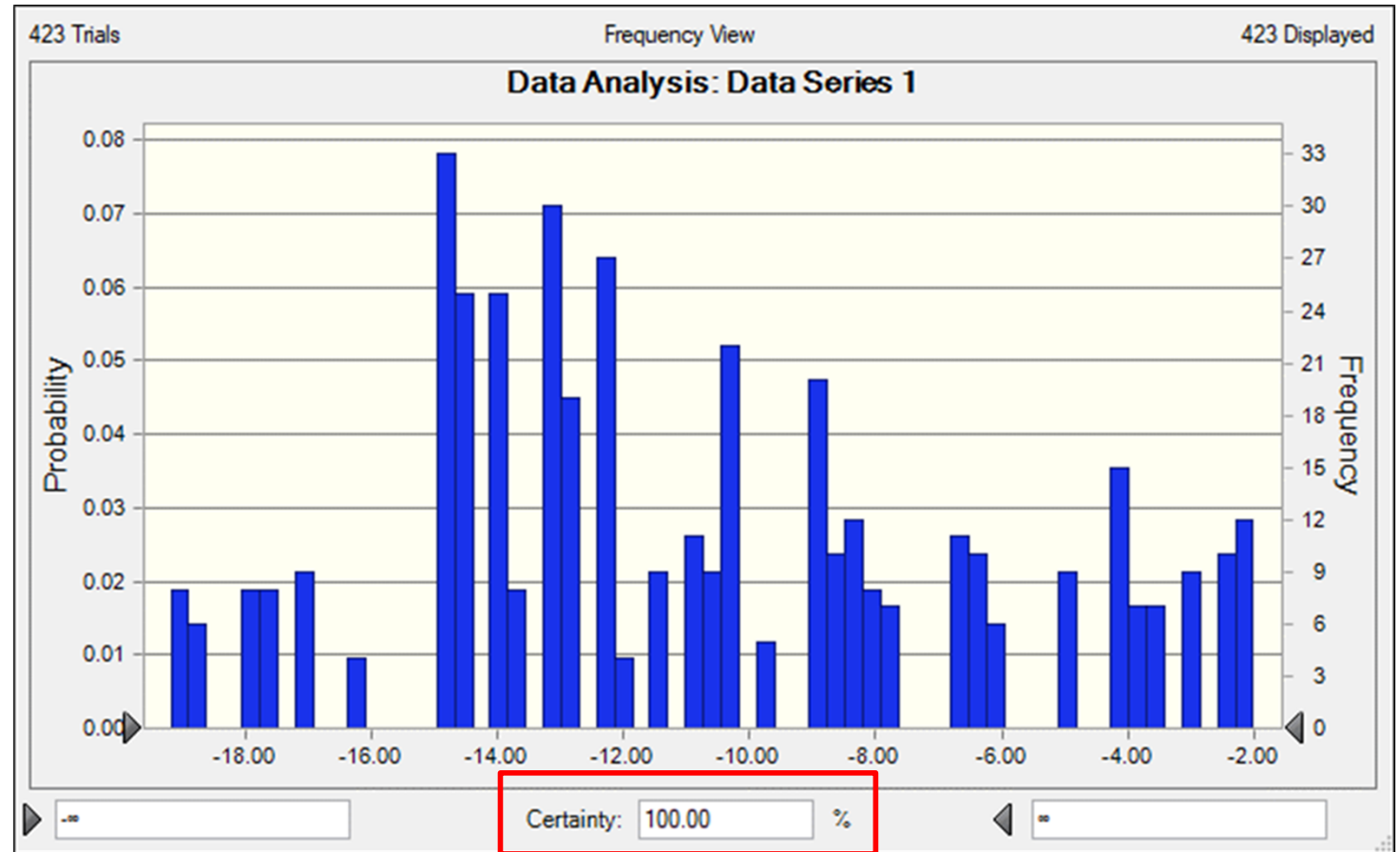
| 10-year Avg | 10.47 | 11.0 |

CC 10-year Avg = 7.1

San Diego, California – Daytime UHI – Simulated Probabilities

Scenario Number	Urban Weather Stations	Rural Weather Stations	Summer Month(s)
1	1	1	1
2	1	3	1
3	1	2	1 or more

- All simulated conditions produced daytime UHIs lower than stated in Climate Central study

Results shown above are for scenario 1: one urban; one rural; and one summer month
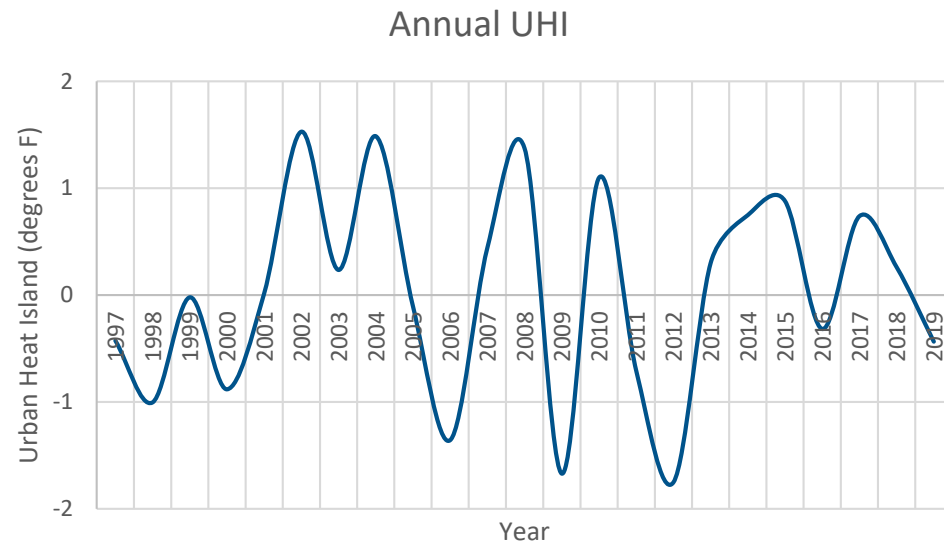
Louisville, KY

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Louisville, Kentucky - Weather Station Locations

Urban station

Rural station

Rural station

Rural station
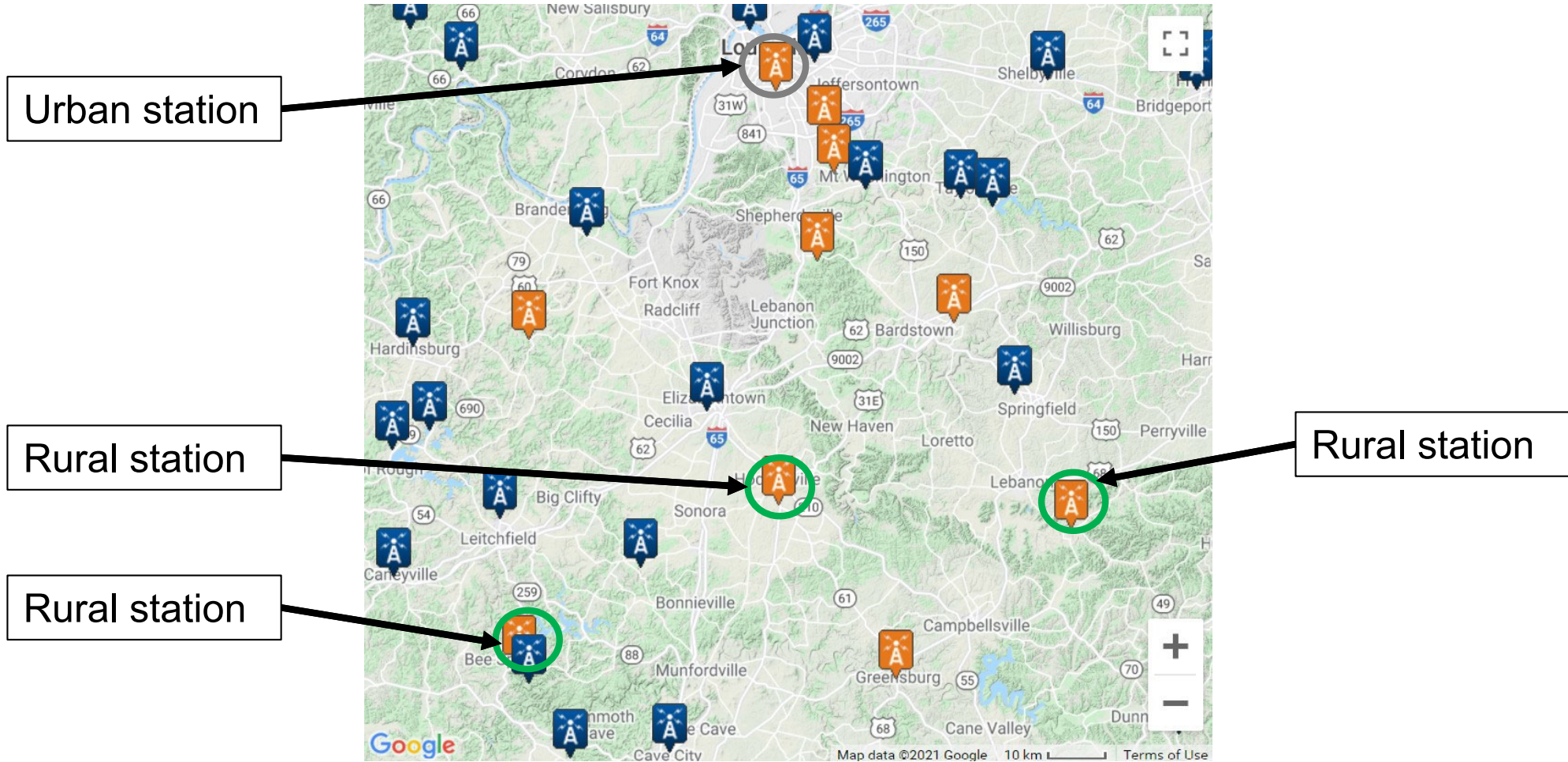
Louisville, Kentucky – UHI – Climate Central Methods

DAYTIME UHI IN LOUISVILLE
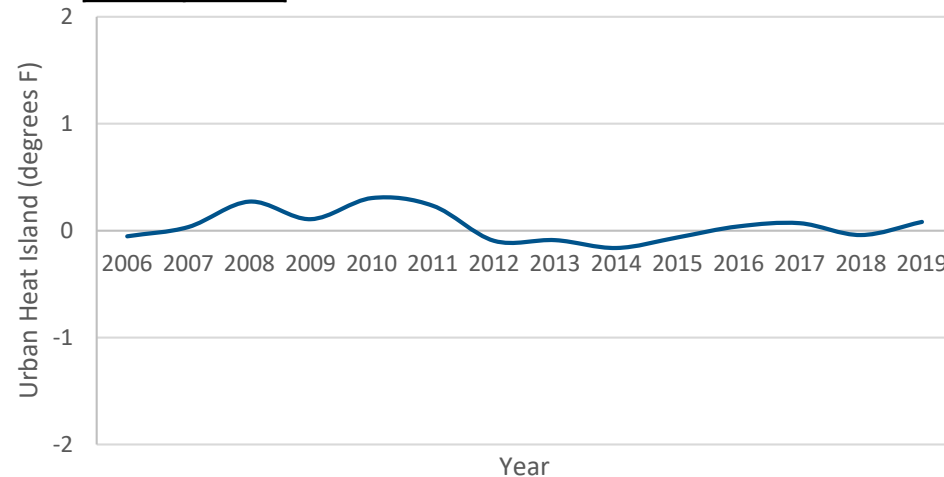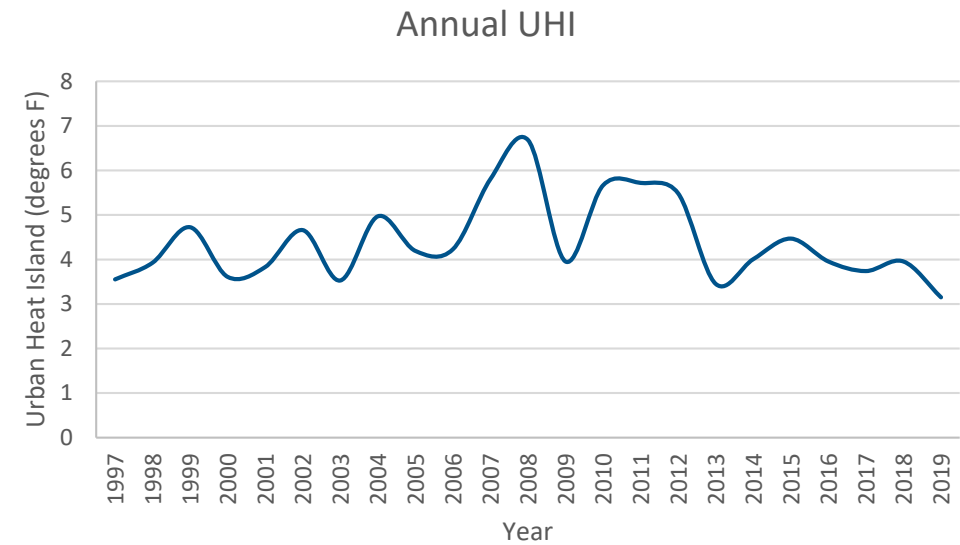
NIGHTTIME UHI IN LOUISVILLE
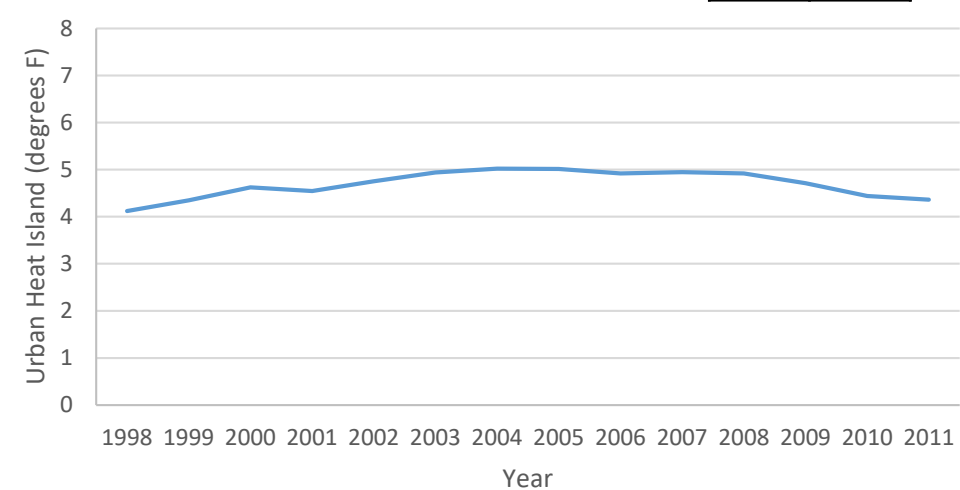
Louisville, Kentucky – UHI – Deeper Dive

DAYTIME UHI IN LOUISVILLE

— All data — Only positive data
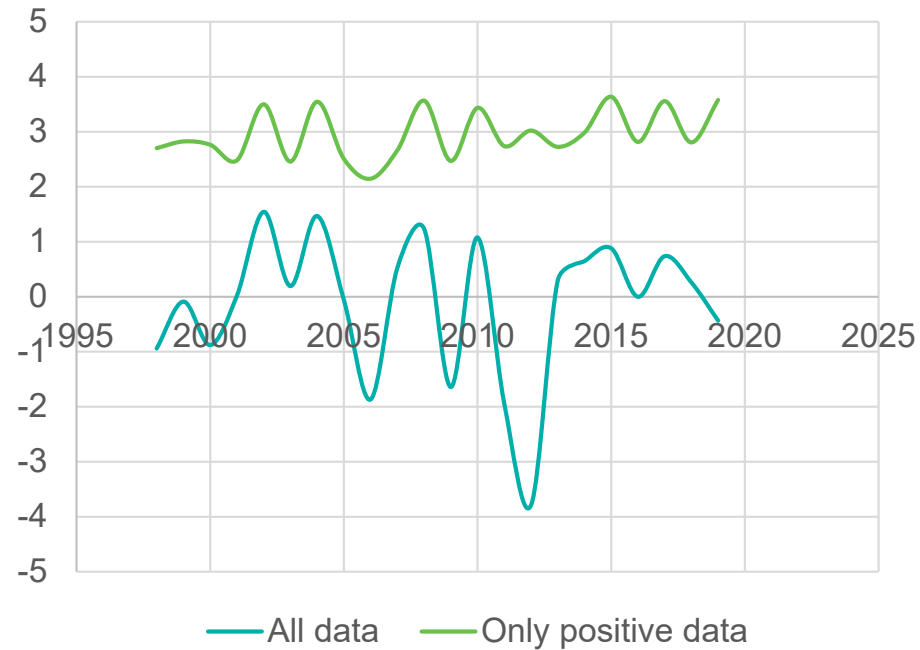
| 10-year Avg | -0.47 | 2.88 |

CC 10-year Avg = 4.8

NIGHTTIME UHI IN LOUISVILLE
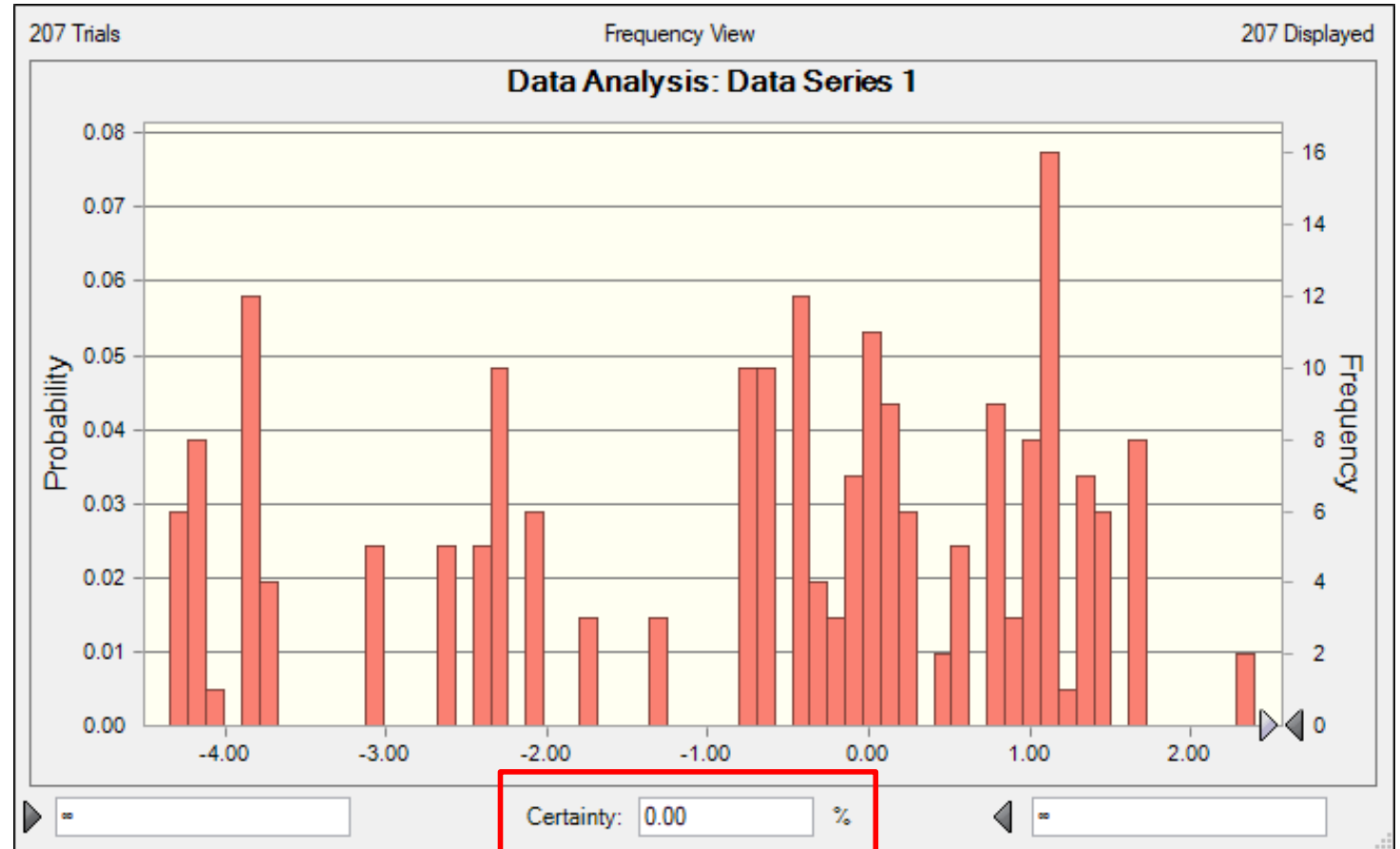
— All data — Only positive data
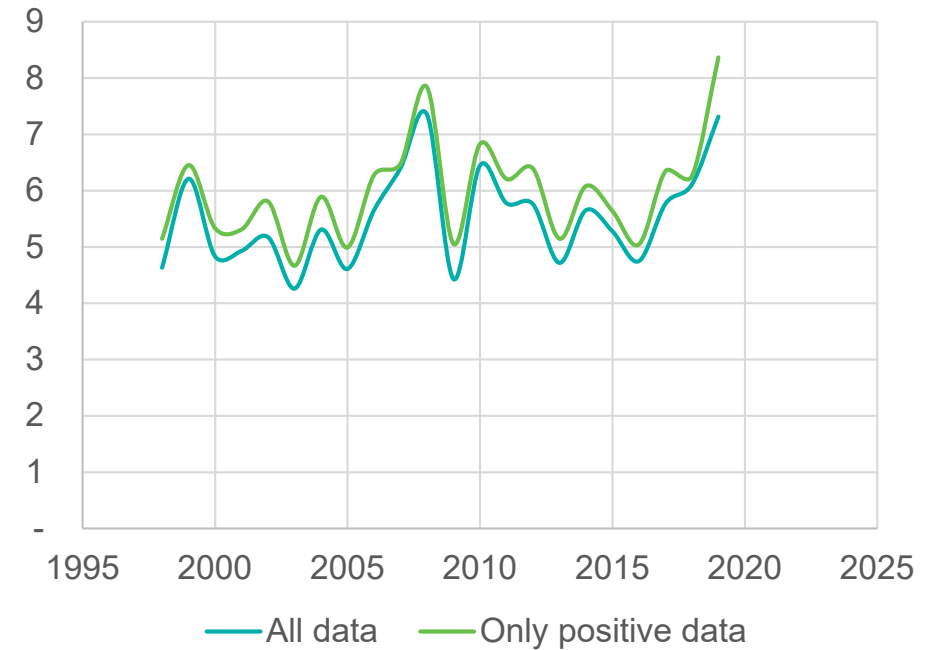
| 10-year Avg | 5.65 | 6.11 |

CC 10-year Avg = 7.0

Louisville, Kentucky – Daytime UHI – Simulated Probabilities

Scenario Number	Urban Weather Stations	Rural Weather Stations	Summer Month(s)
1	1	1	1
2	1	3	1
3	1	2	1 or more

- All simulated conditions produced daytime UHIs lower than 4.8°F stated in Climate Central study

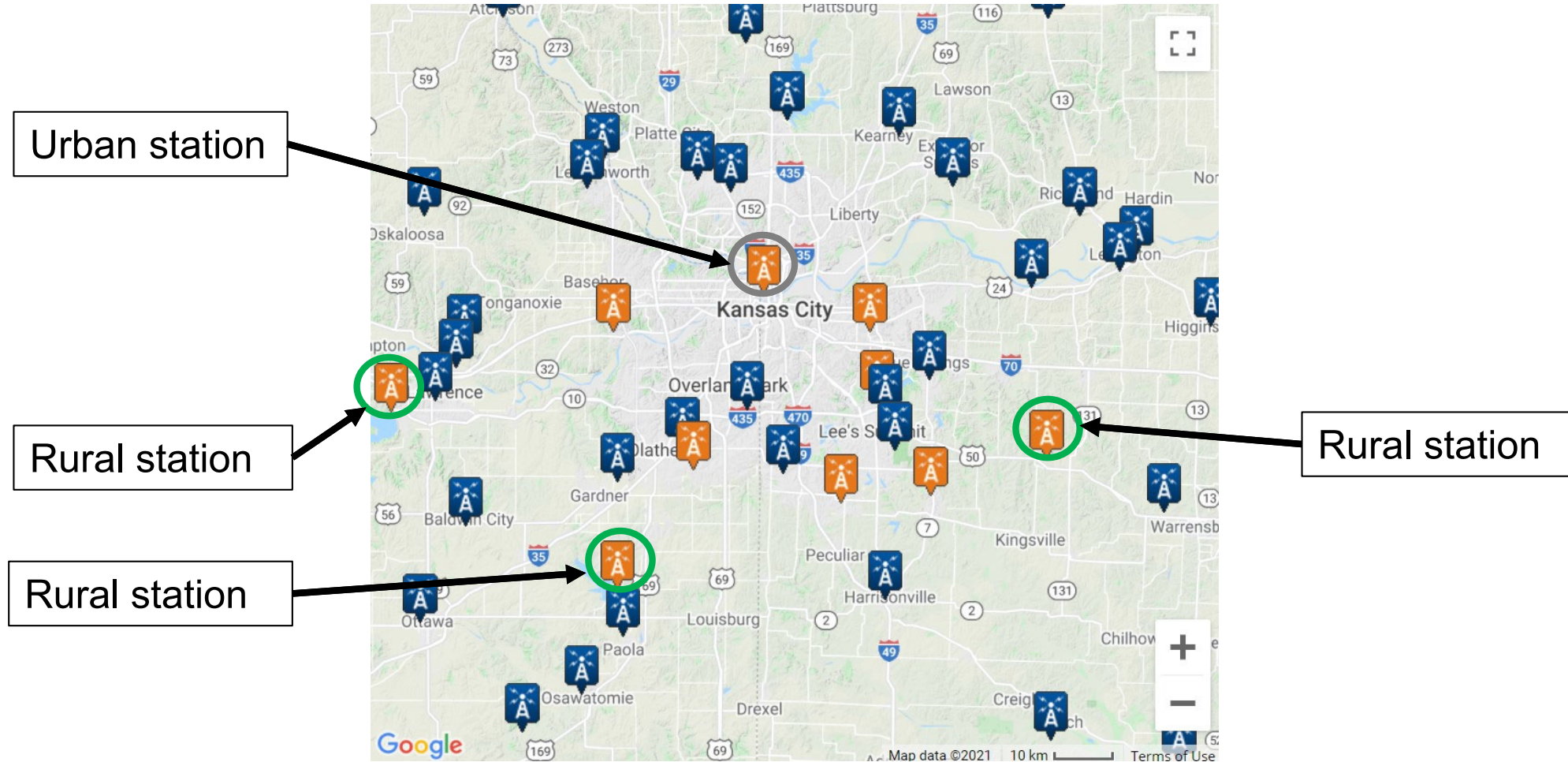Results shown above are for scenario 1: one urban; one rural; and one summer month

Kansas City, MO

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7/30/2021   21

Kansas City, Missouri - Weather Station Locations

Urban station

Rural station

Rural station

Rural station

Kansas City, Missouri – UHI – Climate Central Methods

DAYTIME UHI IN KANSAS CITY

Annual UHI
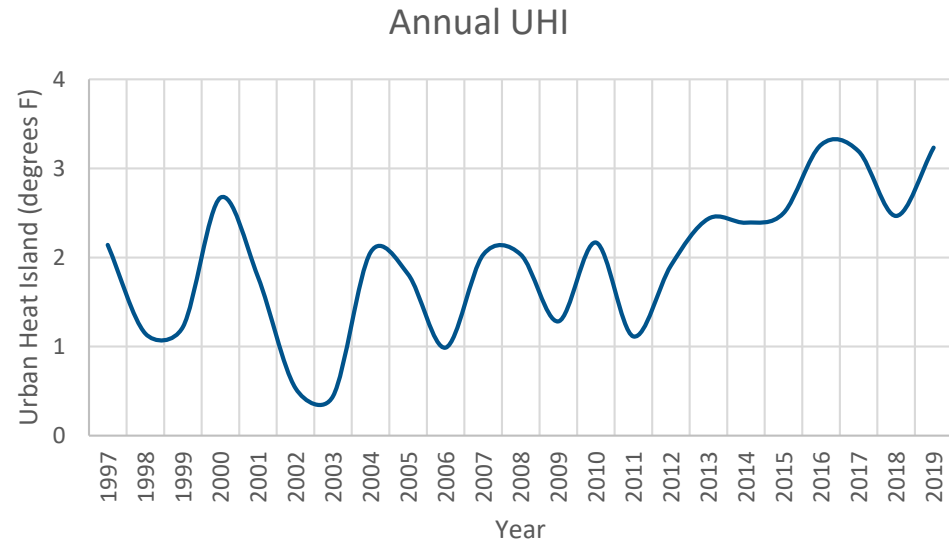
ICF	1.8
CC	4.6

10-year Average UHI

NIGHTTIME UHI IN KANSAS CITY

Annual UHI
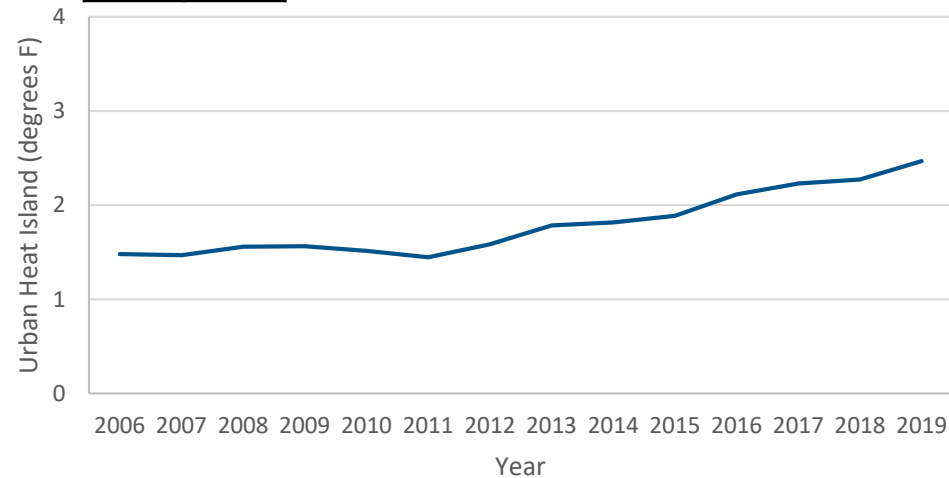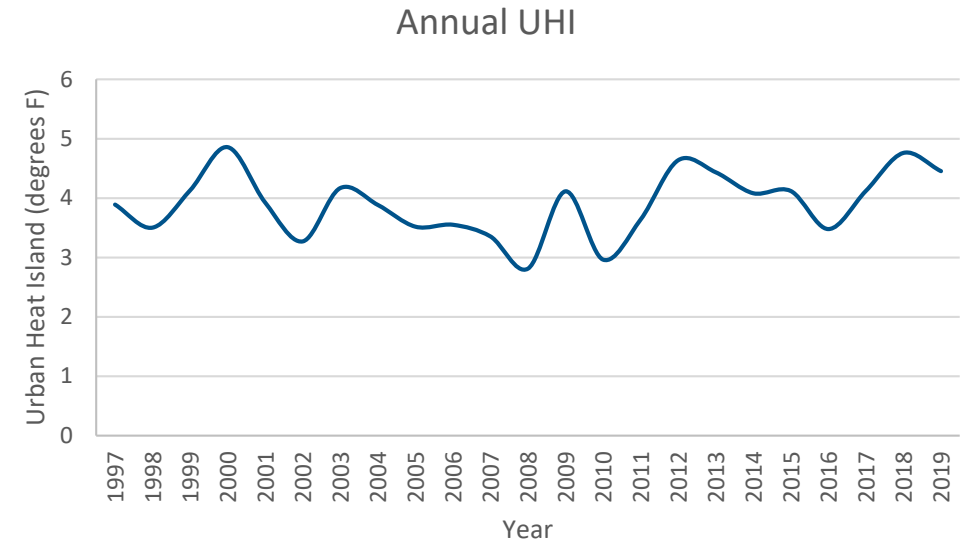
ICF	3.7
CC	5.6

10-year Average UHI
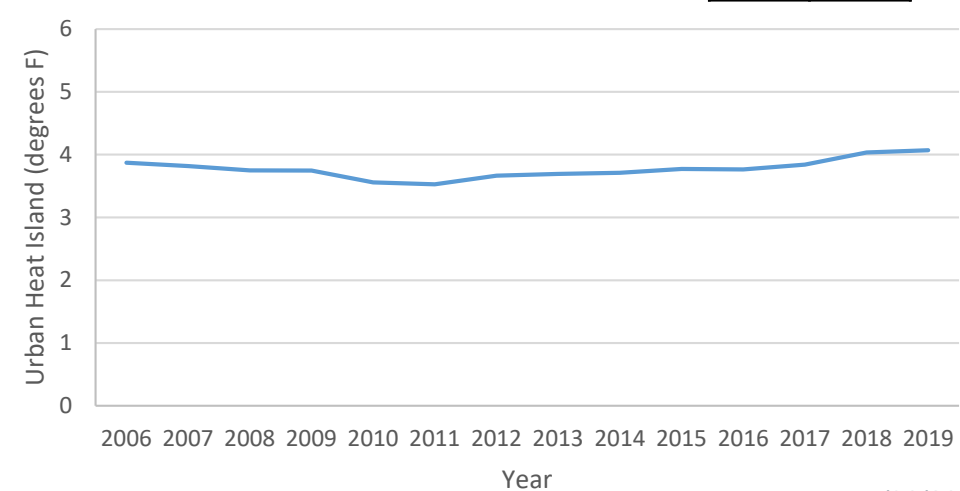
Kansas City, Missouri – UHI – Deeper Dive

DAYTIME UHI IN KANSAS CITY
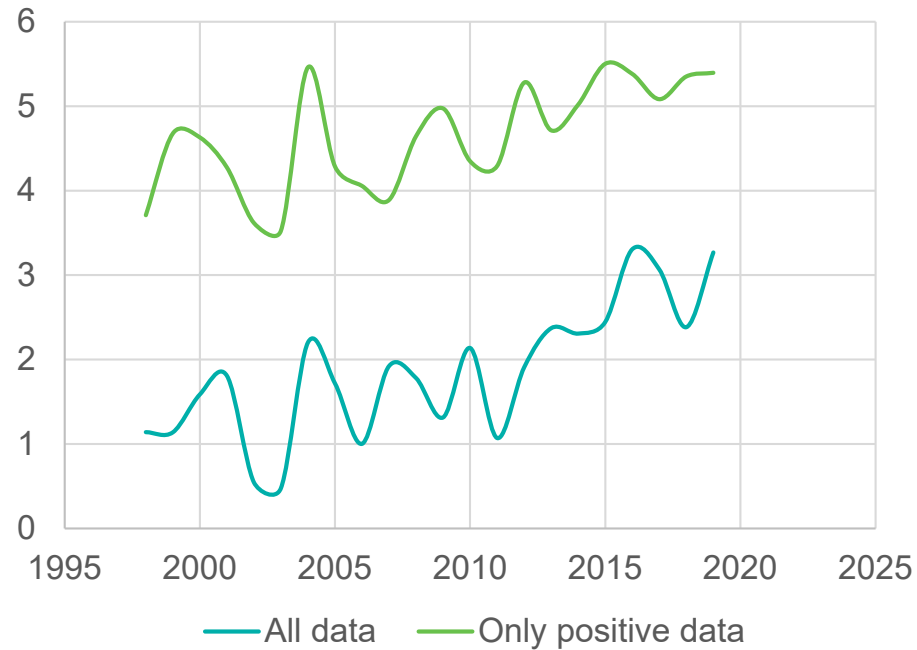
10-year Avg	1.74	4.59

CC 10-year Avg = 4.6

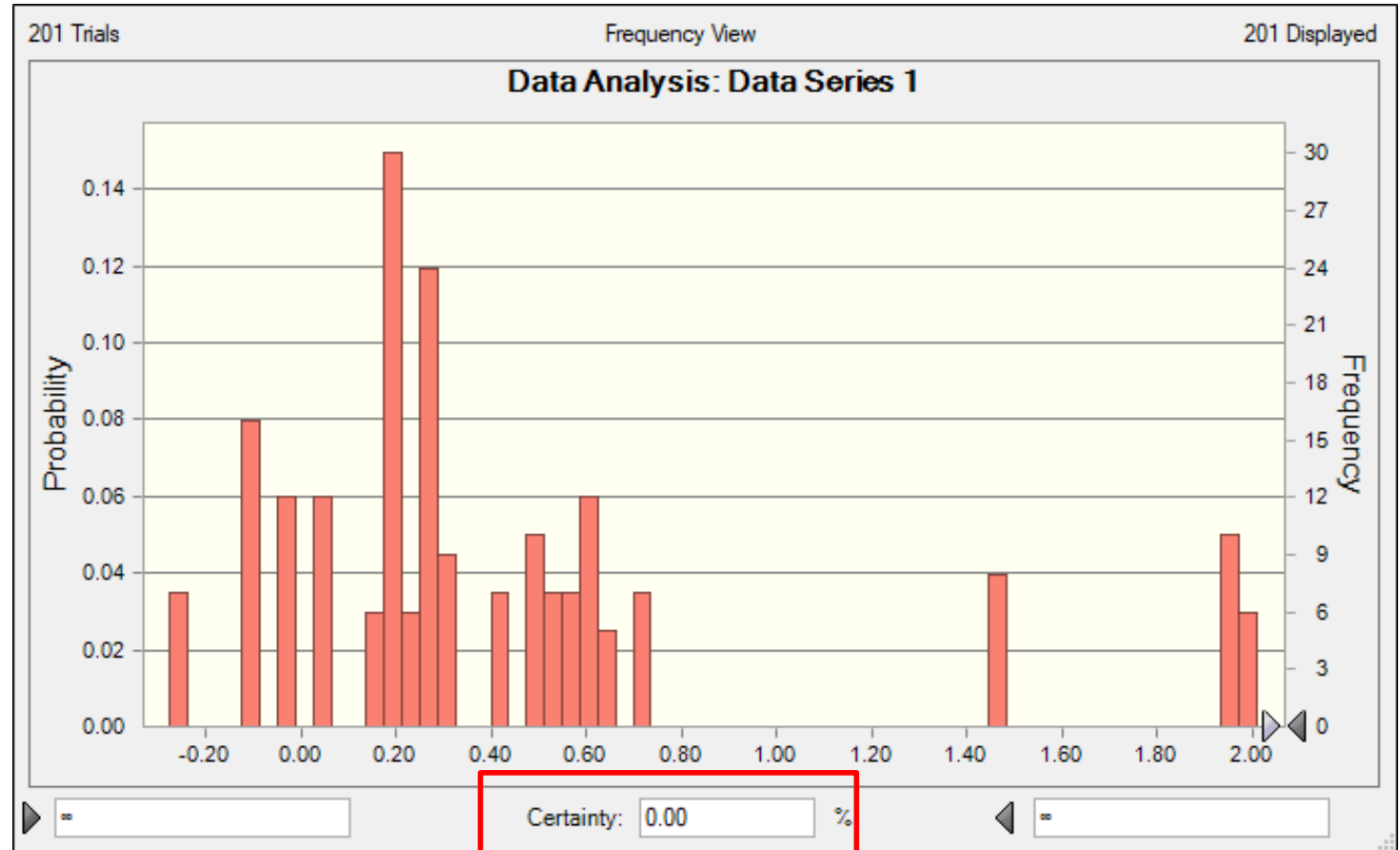### NIGHTTIME UHI IN KANSAS CITY
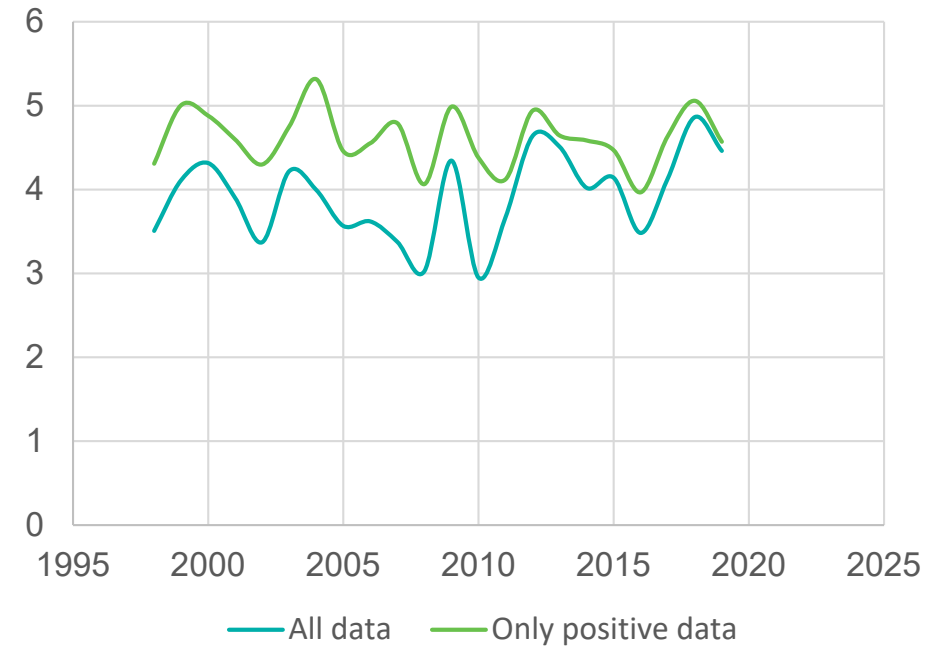
10-year Avg	3.77	4.63

CC 10-year Avg = 5.6

Kansas City, Missouri – Daytime UHI – Simulated Probabilities

Scenario Number	Urban Weather Stations	Rural Weather Stations	Summer Month(s)
1	1	1	1
2	1	3	1
3	1	2	1 or more

- All simulated conditions produced daytime UHIs lower than 4.6°F stated in Climate Central study

Results shown above are for scenario 1: one urban; one rural; and one summer month

Albuquerque, NM

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Albuquerque, New Mexico - Weather Station Locations

Rural station

Urban station

Rural station

Rural station
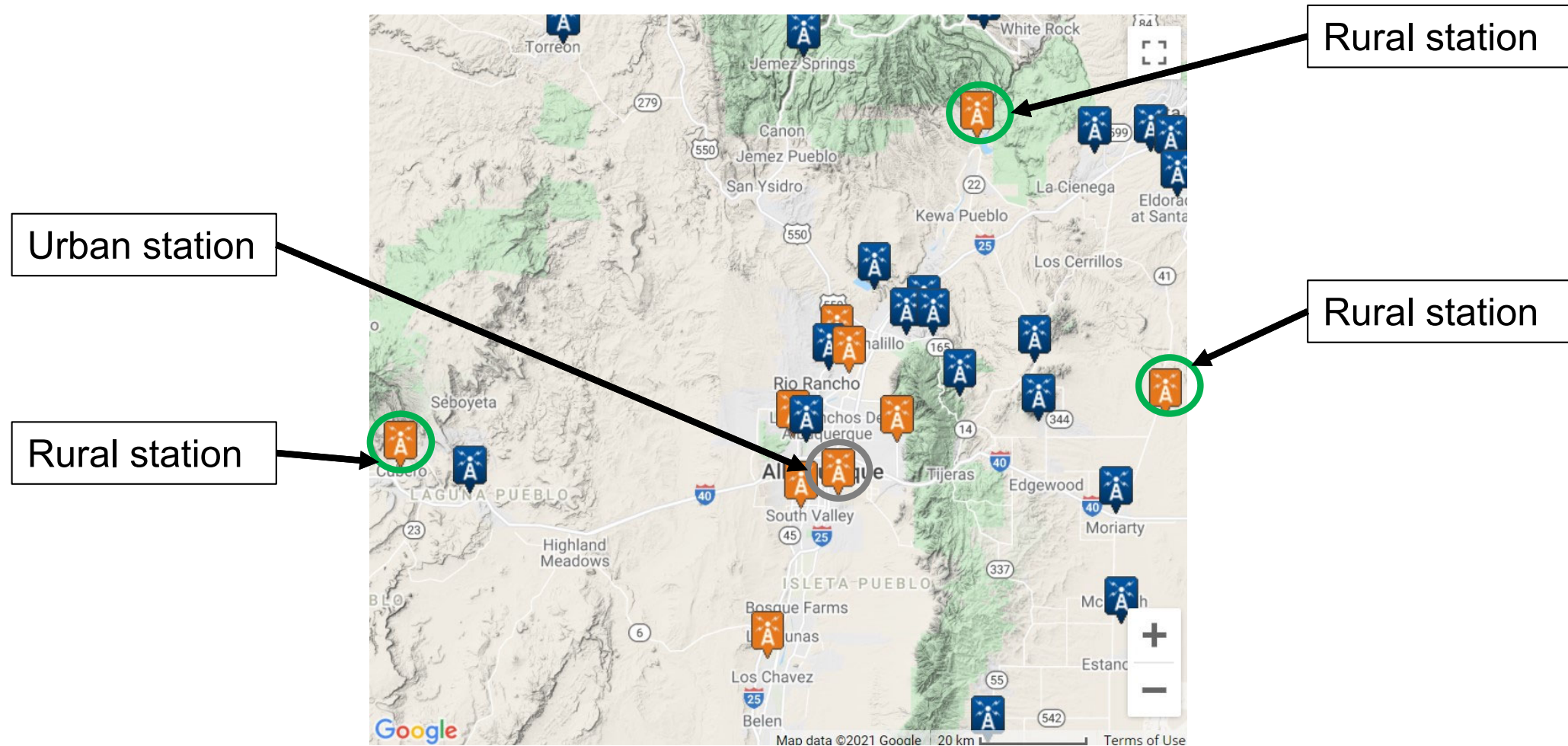
Albuquerque, New Mexico – UHI – Climate Central Methods

DAYTIME UHI IN ALBUQUERQUE

Annual UHI
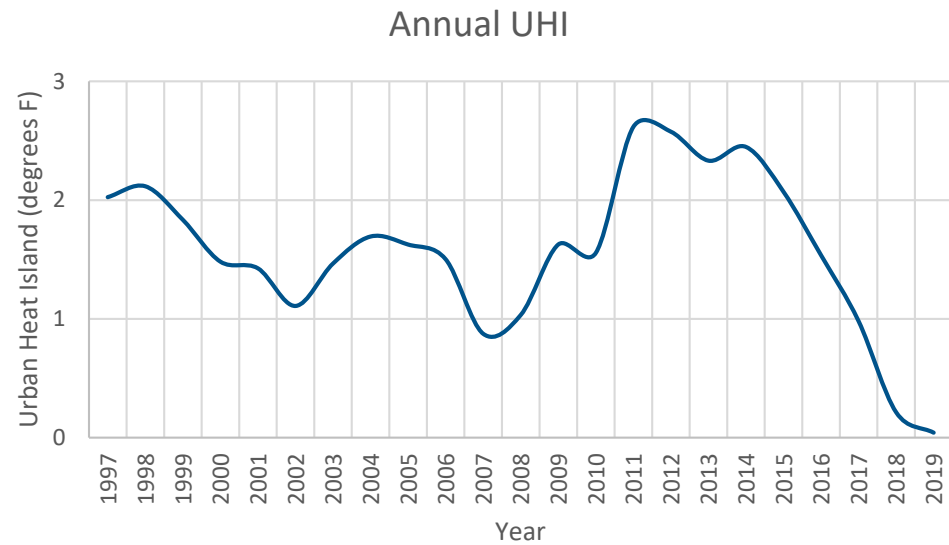
ICF	1.7
CC	5.9

10-year Average UHI

NIGHTTIME UHI IN ALBUQUERQUE

Annual UHI
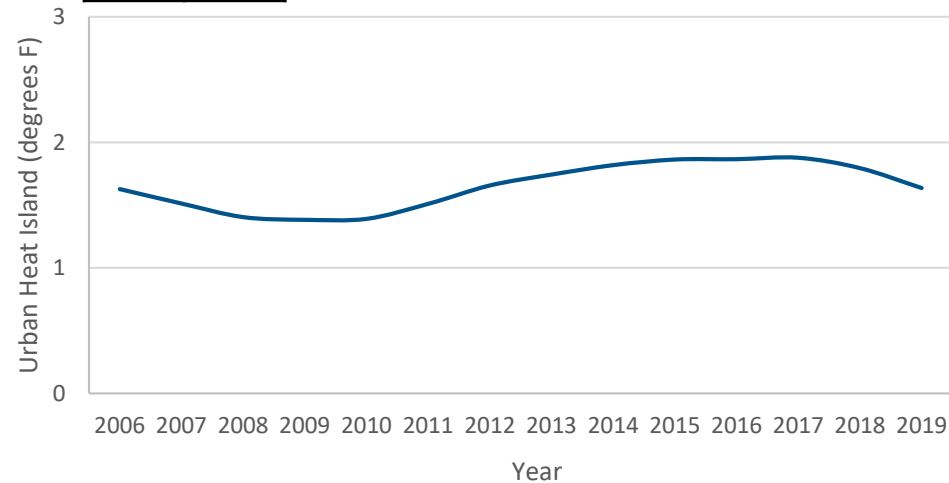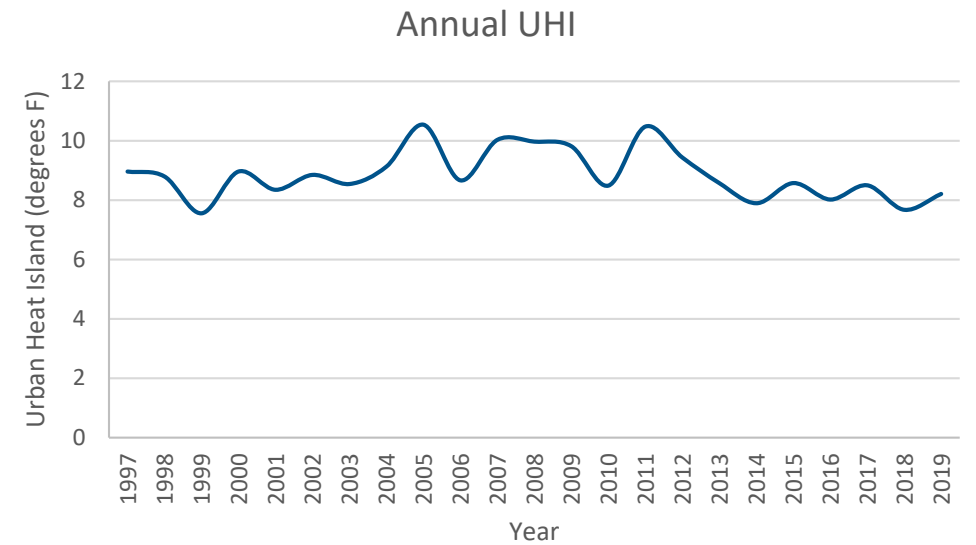
ICF	9.5
CC	9.7

10-year Average UHI
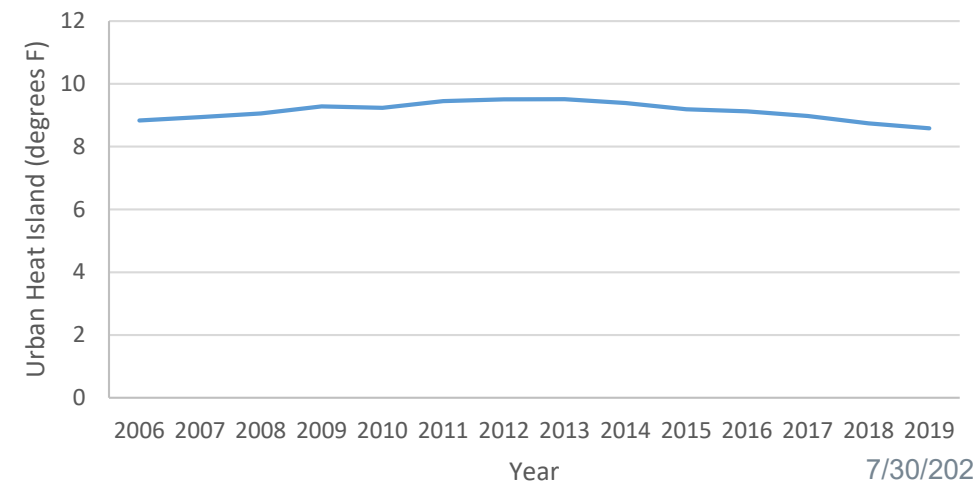
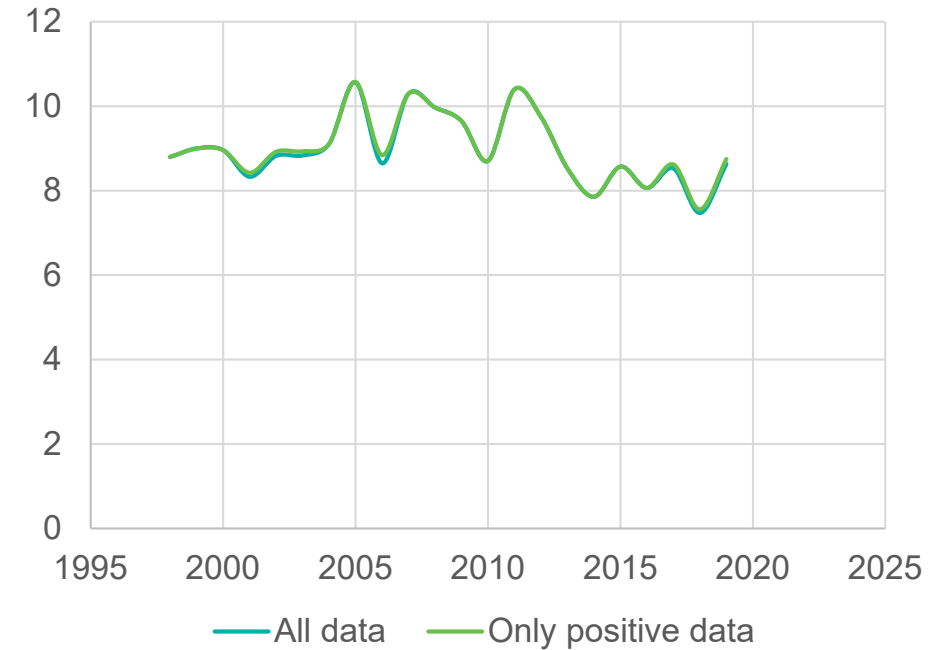# Albuquerque, New Mexico – UHI – Deeper Dive

DAYTIME UHI IN ALBUQUERQUE

| 10-year Avg | 1.57 | 3.02 |

CC 10-year Avg = 5.9

NIGHTTIME UHI IN ALBUQUERQUE
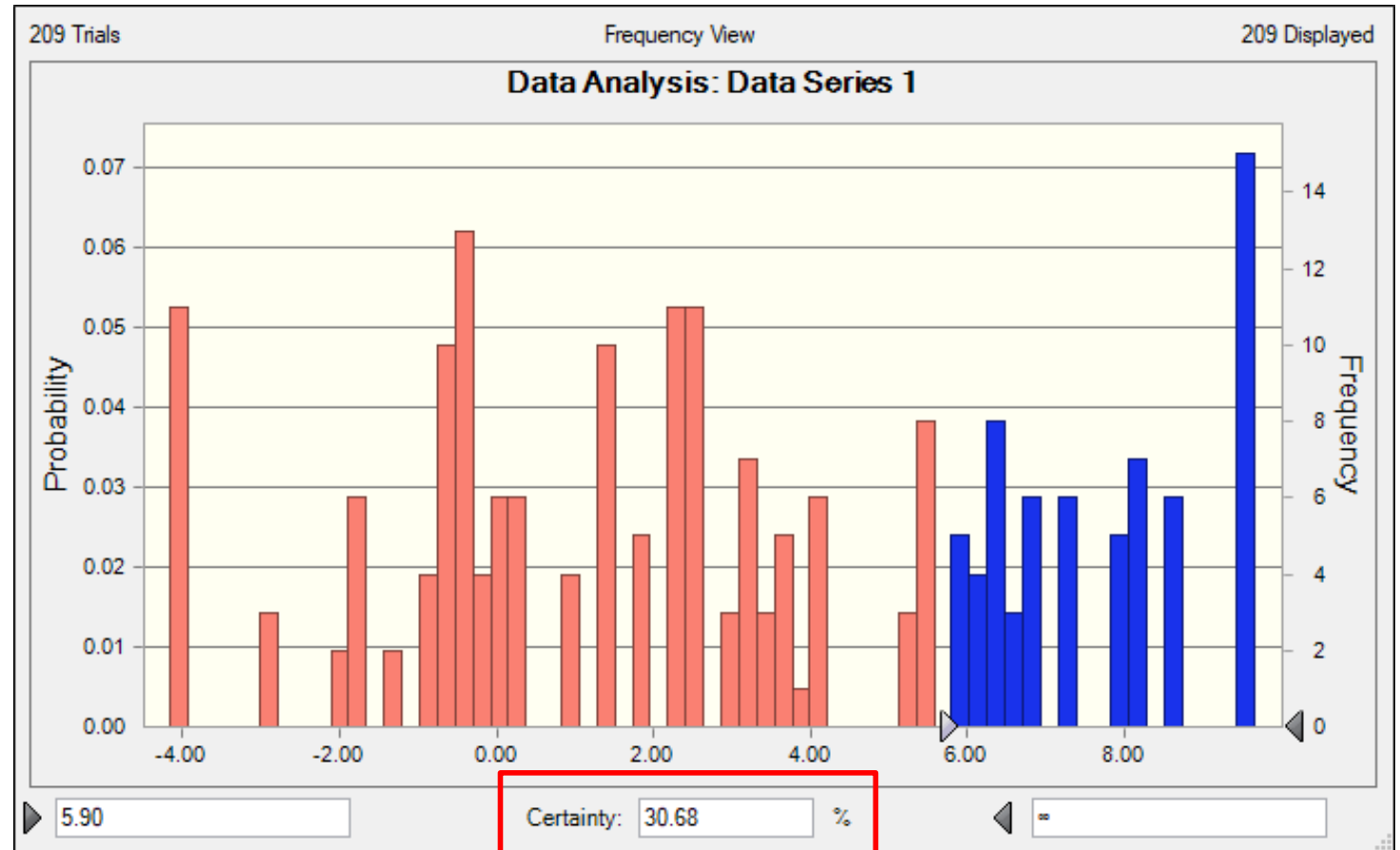

| 10-year Avg | 9.56 | 9.58 |

CC 10-year Avg = 9.7

Albuquerque, New Mexico – Daytime UHI – Simulated Probabilities

Scenario Number	Urban Weather Stations	Rural Weather Stations	Summer Month(s)
1	1	1	1
2	1	3	1
3	1	2	1 or more

- 31% probability that conditions produce a daytime UHI of 5.9°F (as stated in Climate Central study) or greater

Results shown above are for scenario 1: one urban; one rural; and one summer month

Washington, DC

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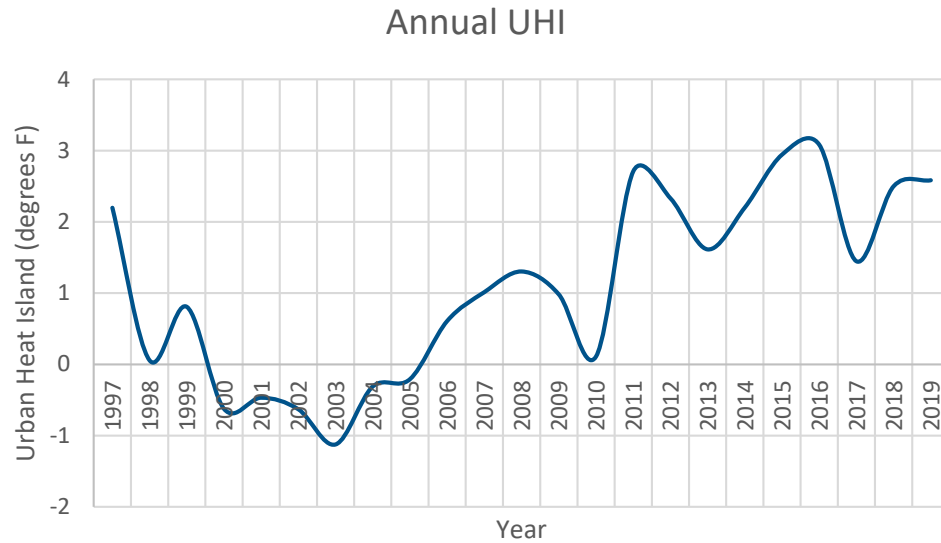# Washington, DC - Weather Station Locations
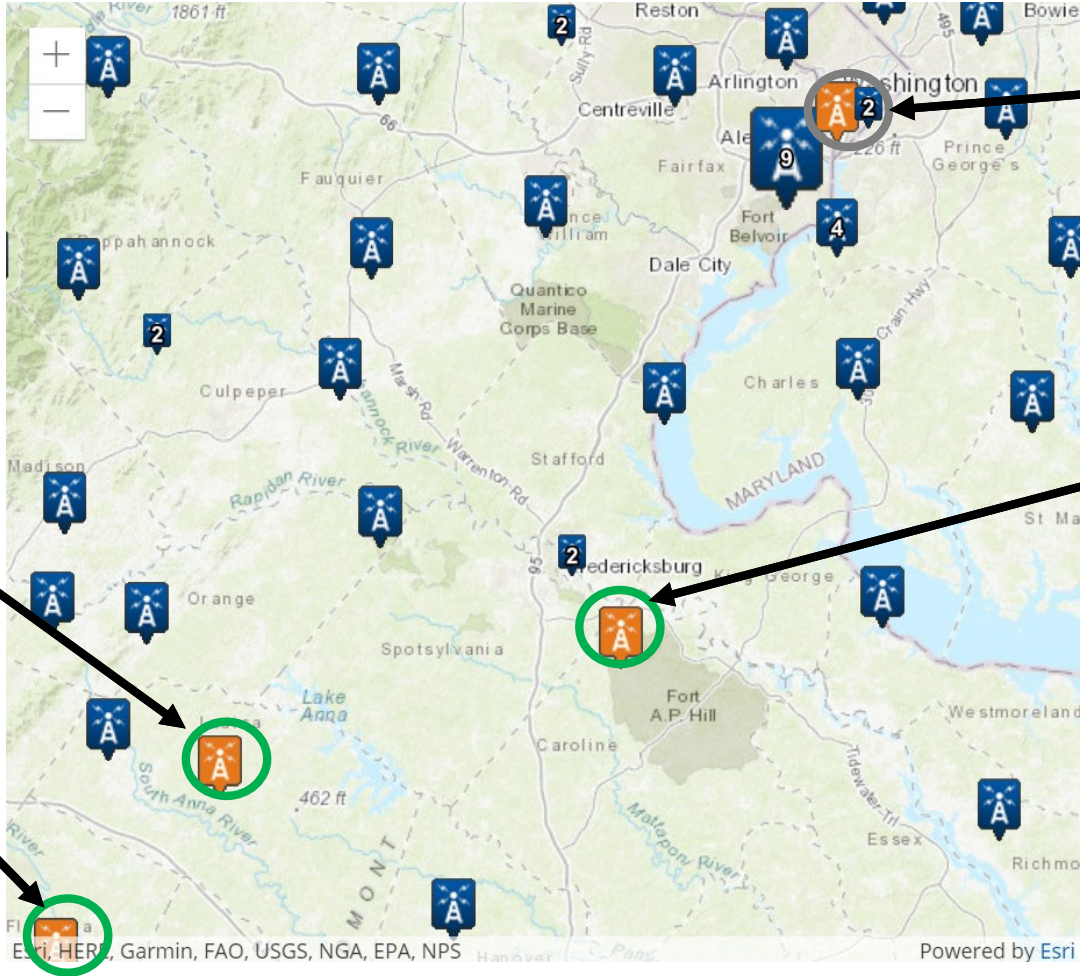
Urban station

Rural station

Rural station

Rural station

Washington, DC – UHI – Climate Central Methods

DAYTIME UHI IN WASHINGTON, DC

Annual UHI

ICF	1.0
CC	4.7

10-year Average UHI

NIGHTTIME UHI IN WASHINGTON, DC

Annual UHI
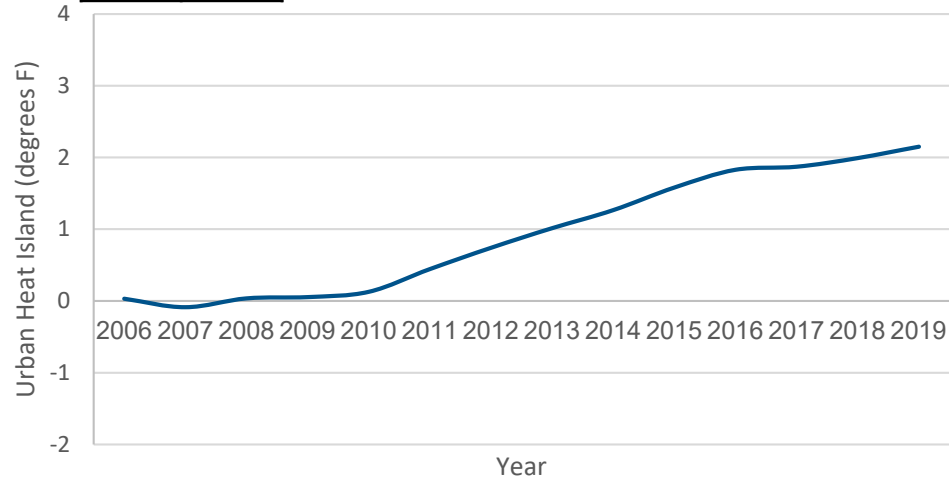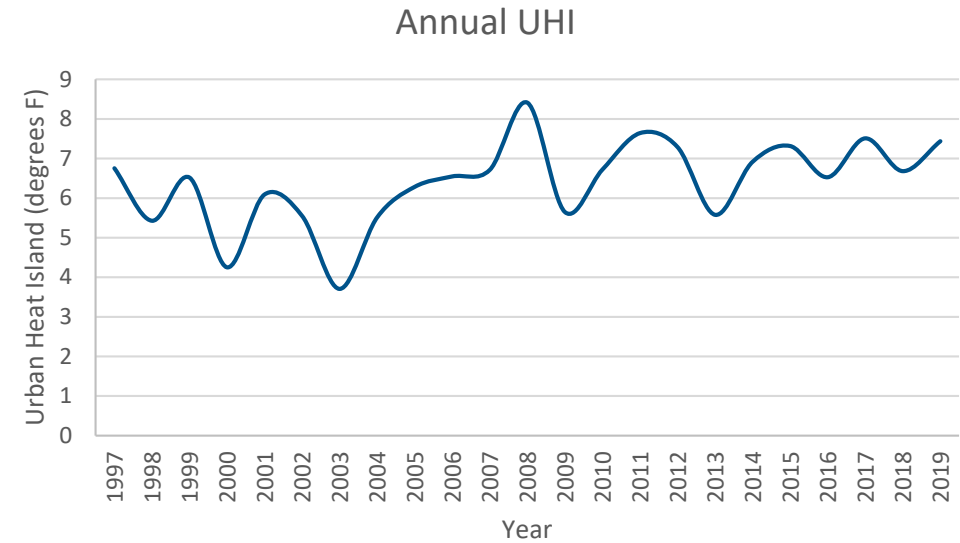
ICF	6.6
CC	7.1

10-year Average UHI

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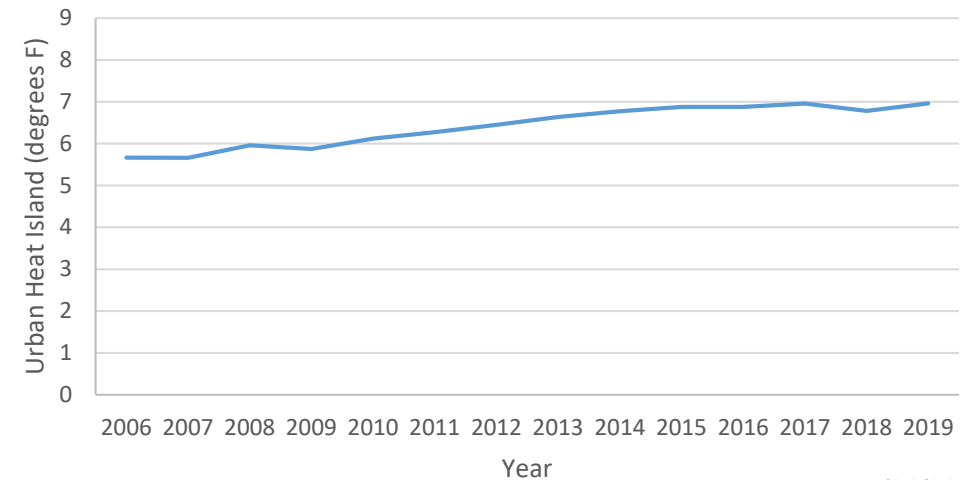
Washington, DC – UHI – Deeper Dive

DAYTIME UHI IN WASHINGTON, DC

10-year Avg   1.0   3.2

CC 10-year Avg = 4.7

NIGHTTIME UHI IN WASHINGTON, DC
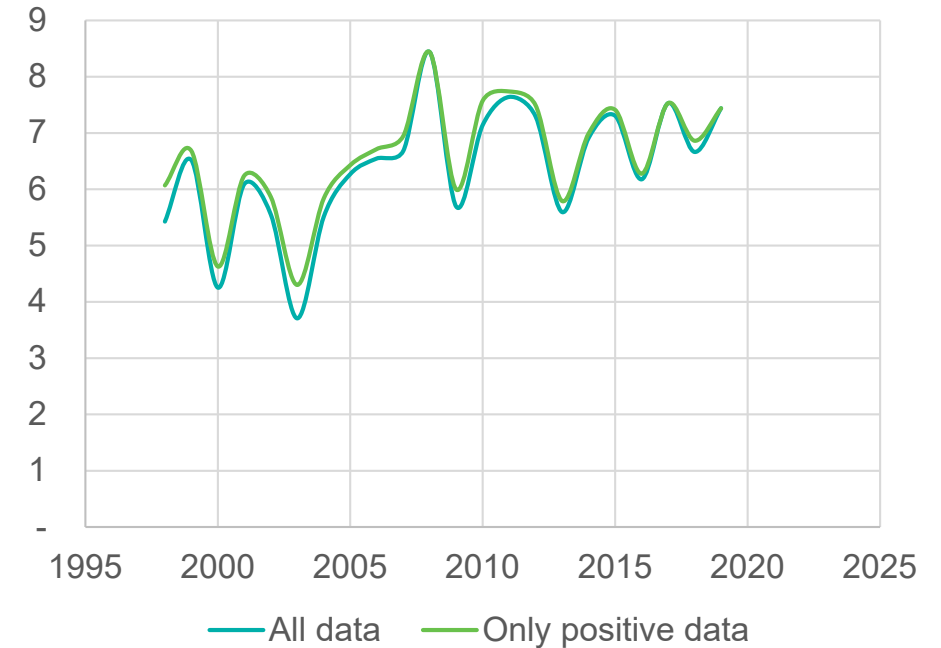
10-year Avg   6.6   6.9

CC 10-year Avg = 7.1

Washington, DC – Daytime UHI – Simulated Probabilities

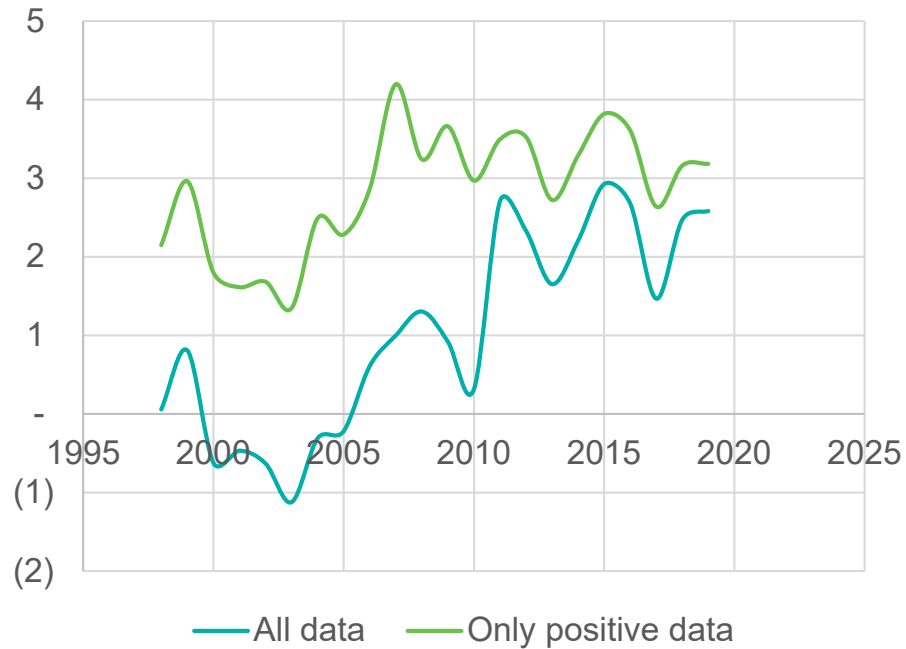| Scenario Number	Urban Weather Stations	Rural Weather Stations	Summer Month(s)
1	1	1	1
2	1	3	1
3	1	2	1 or more

- 16% probability that conditions produce a daytime UHI of 4.7°F (as stated in Climate Central study) or greater
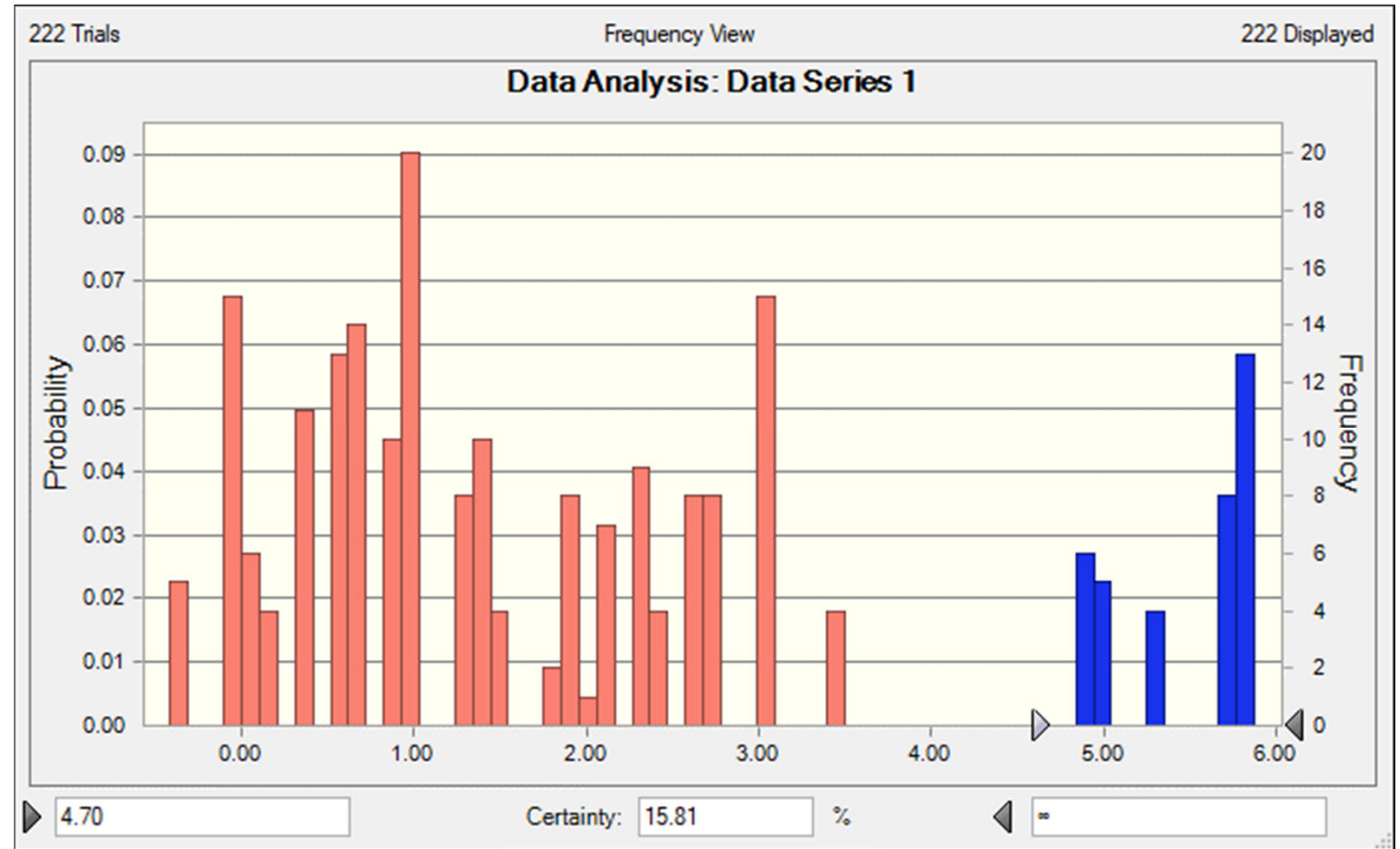
Results shown above are for scenario 1: one urban; one rural; and one summer month

Philadelphia, PA

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Philadelphia, PA - Weather Station Locations

Rural station

Rural station

Rural station (not pictured due to NOAA map display error)

Urban station (not pictured due to NOAA map display error)
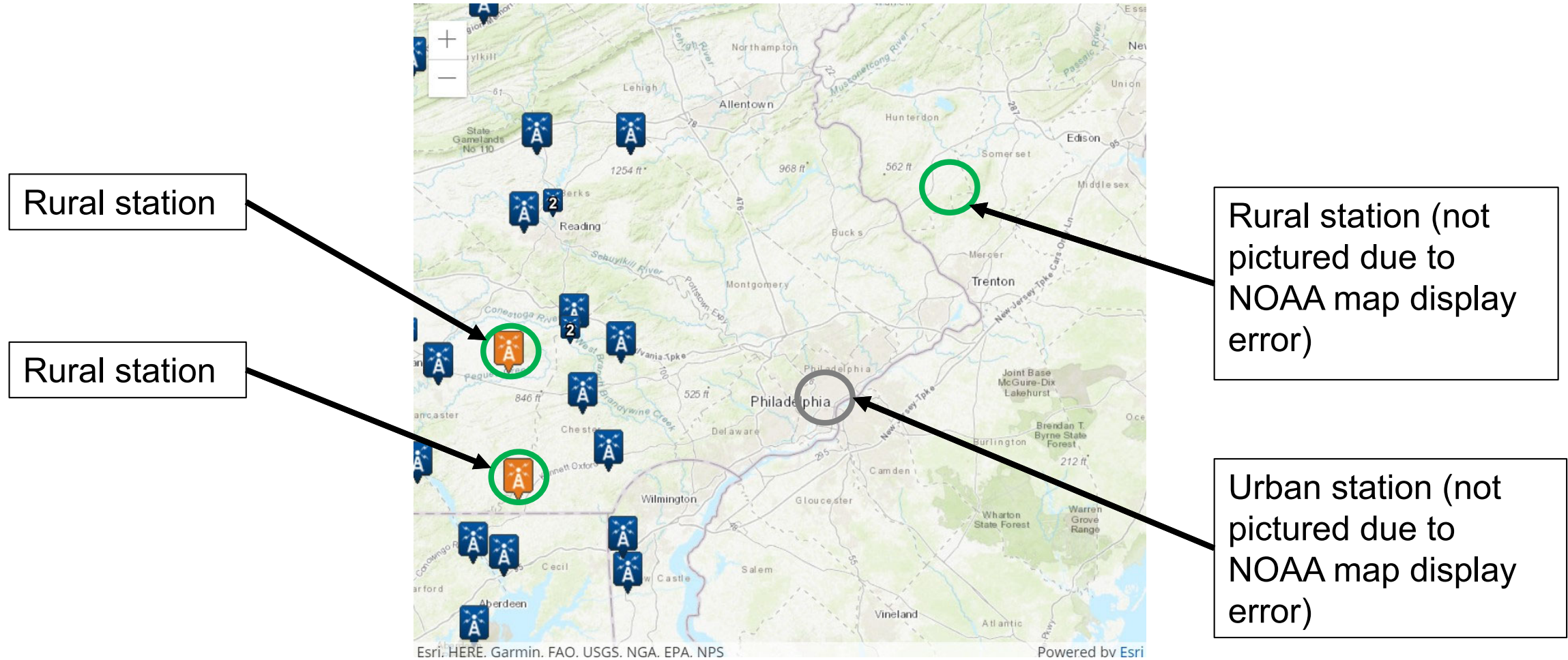
Philadelphia, PA – UHI – Climate Central Methods

DAYTIME UHI IN PHILADELPHIA, PA

Annual UHI

ICF	3.4
CC	3.8

10-year Average UHI

NIGHTTIME UHI IN PHILADELPHIA, PA

Annual UHI
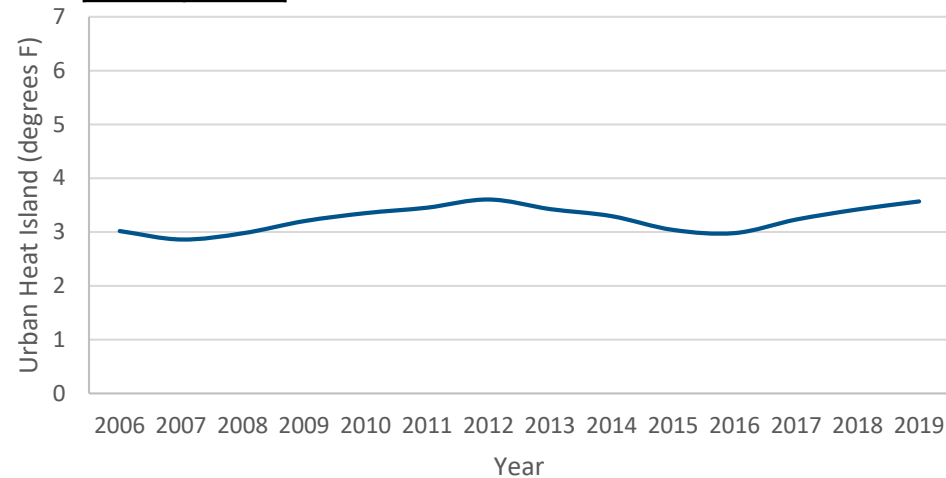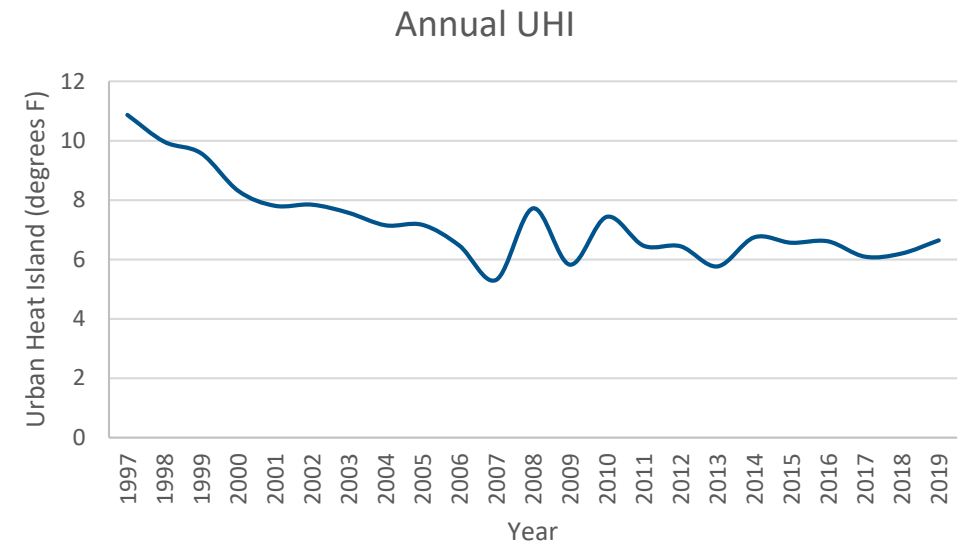
ICF	6.6
CC	6.0

10-year Average UHI
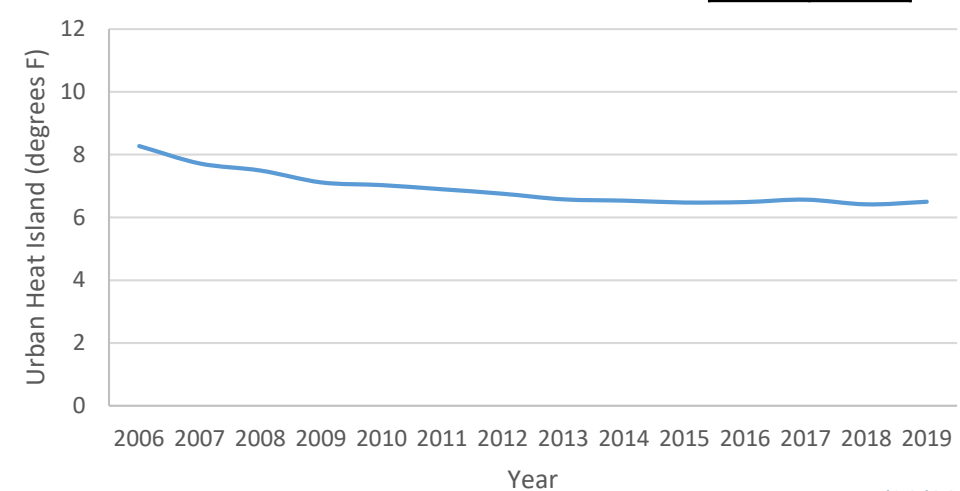
Philadelphia, PA – UHI – Deeper Dive

DAYTIME UHI IN PHILADELPHIA, PA
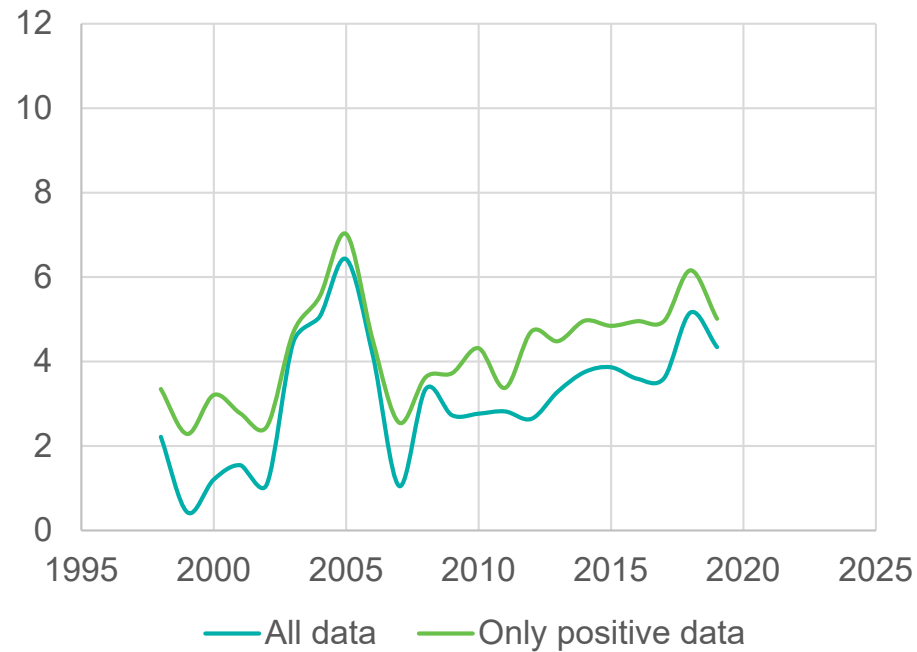
10-year Avg	3.4	4.4

CC 10-year Avg = 3.8

NIGHTTIME UHI IN PHILADELPHIA, PA
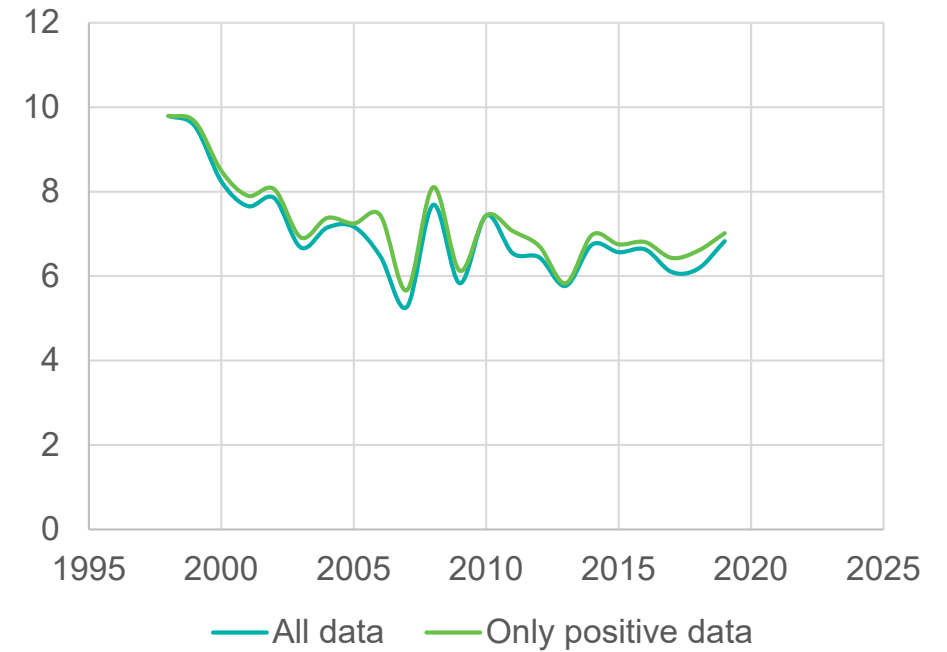
10-year Avg	6.6	6.9

CC 10-year Avg = 6.0

Philadelphia, PA – Daytime UHI – Simulated Probabilities

Scenario Number	Urban Weather Stations	Rural Weather Stations	Summer Month(s)
1	1	1	1
2	1	3	1
3	1	2	1 or more

- 15% probability that conditions produce a daytime UHI of 3.8°F (as stated in Climate Central study) or greater
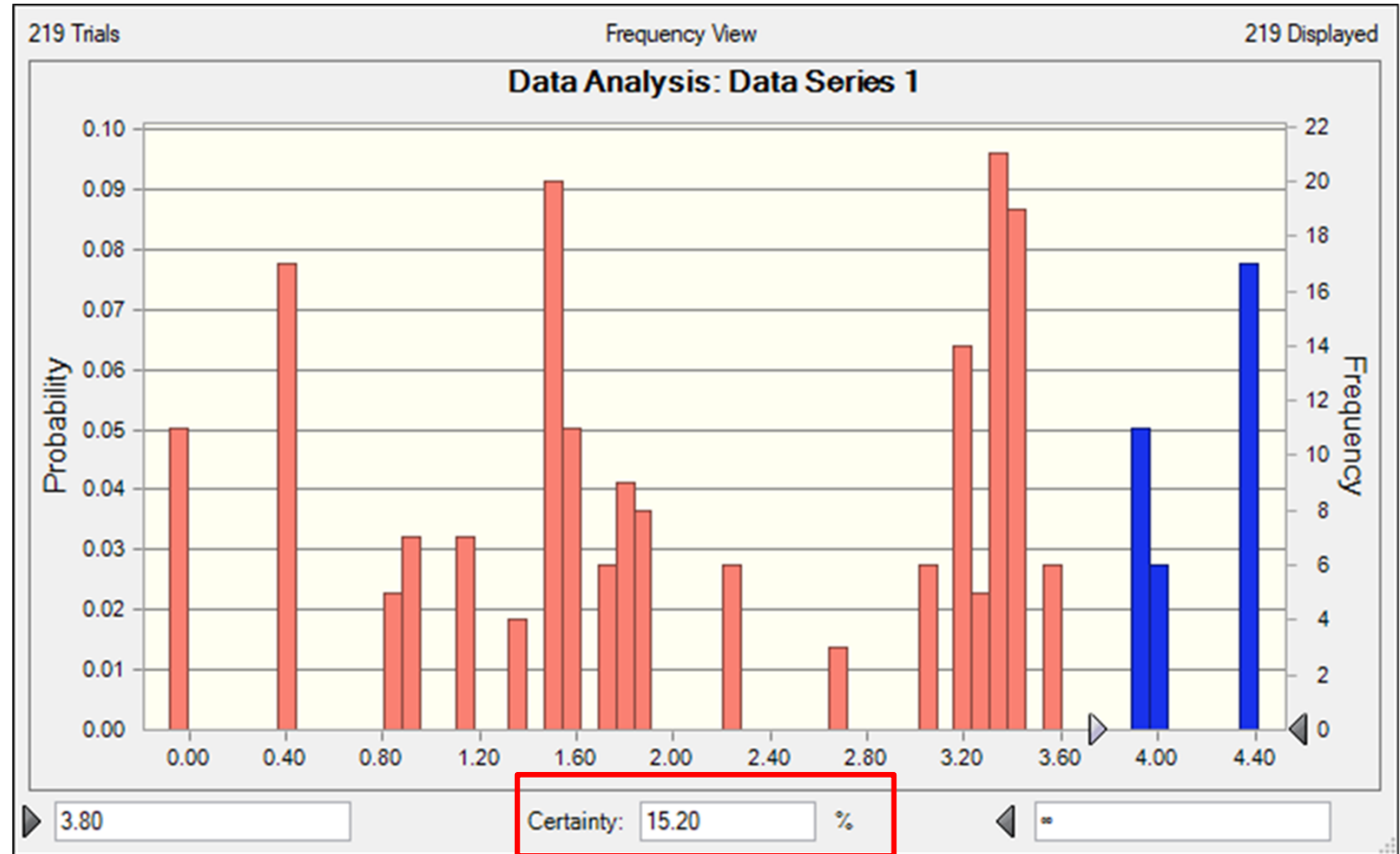
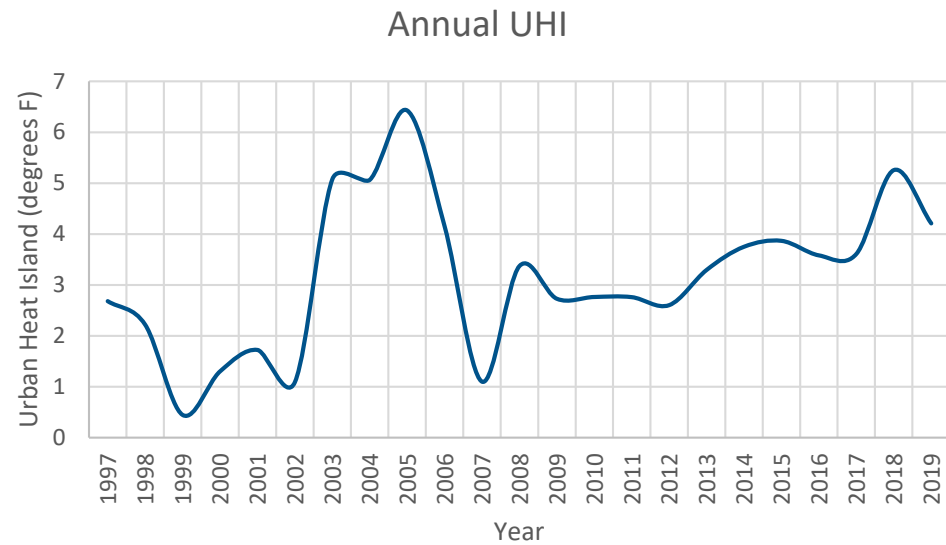Results shown above are for scenario 1: one urban; one rural; and one summer month

# Baltimore, MD

Baltimore, MD - Weather Station Locations

Rural station

Urban station

Rural station

Rural station
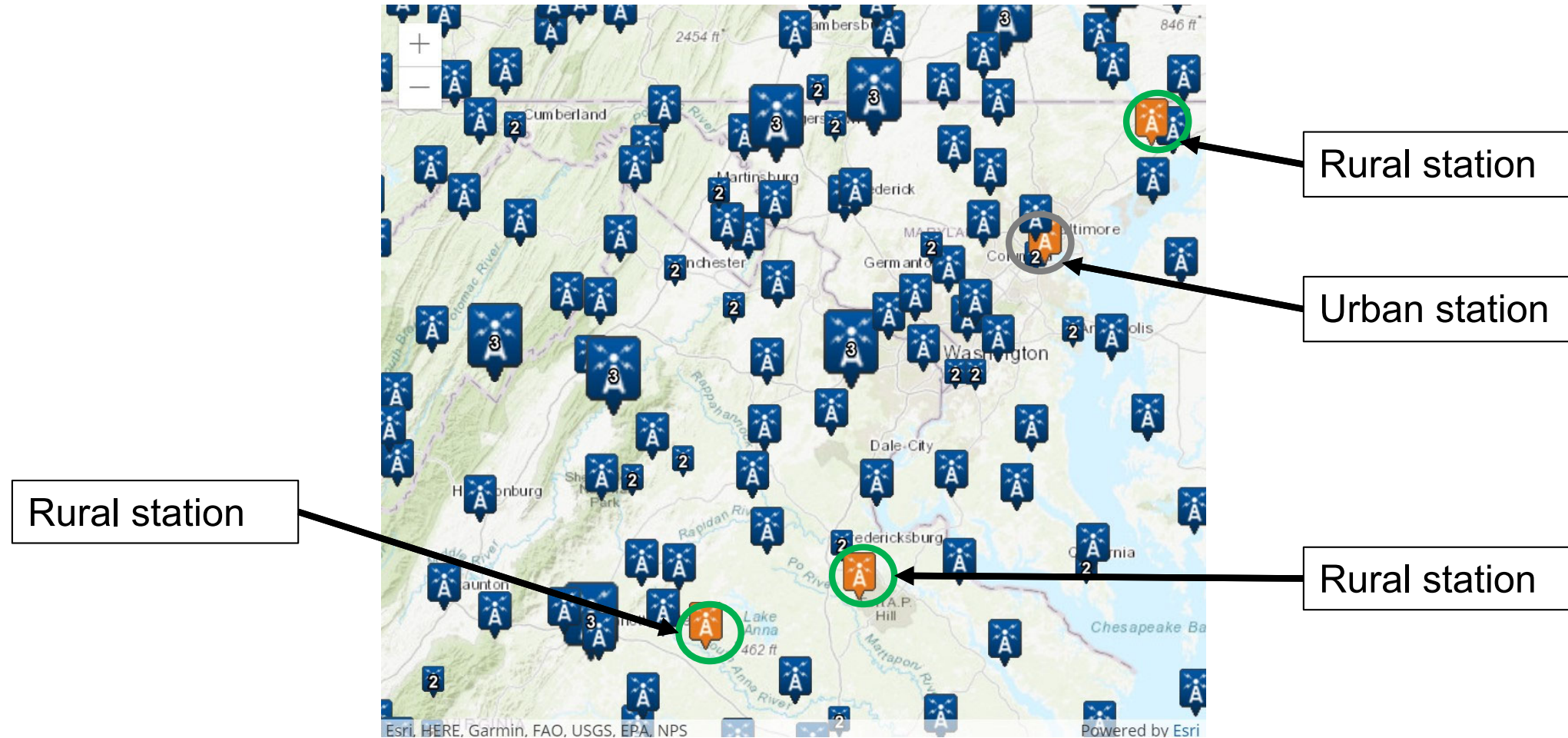
Baltimore, MD – UHI – Climate Central Methods

DAYTIME UHI IN BALTIMORE, MD
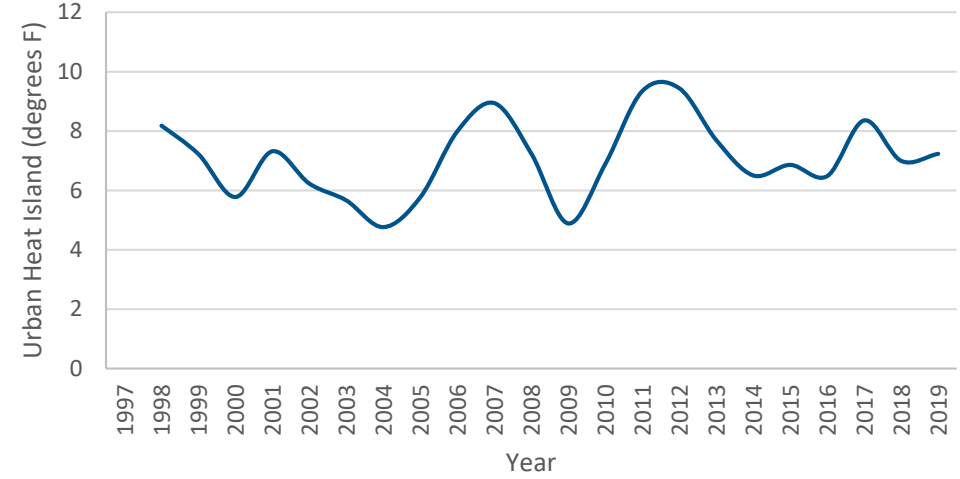
NIGHTTIME UHI IN BALTIMORE, MD

Baltimore, MD – UHI – Deeper Dive

DAYTIME UHI IN BALTIMORE, MD
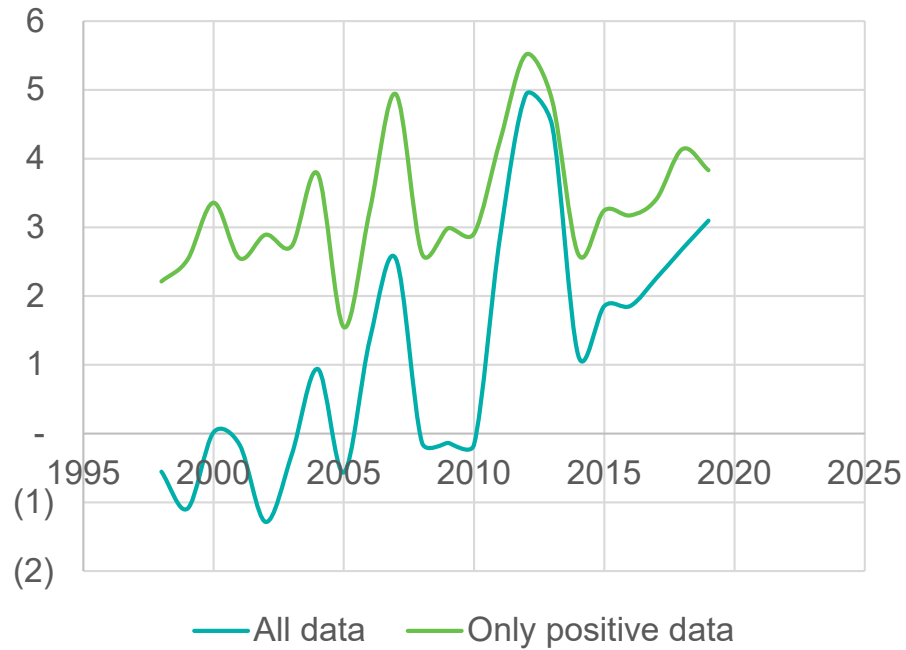
| 10-year Avg | 1.6 | 3.7 |
| CC 10-year Avg = | 2.7 | |

NIGHTTIME UHI IN BALTIMORE, MD

| 10-year Avg | 7.5 | 7.7 |
| CC 10-year Avg = | 4.0 | |

Denver, CO

Denver, CO - Weather Station Locations

Urban station (not shown due to NOAA map error)

Rural station

Rural station

Rural station
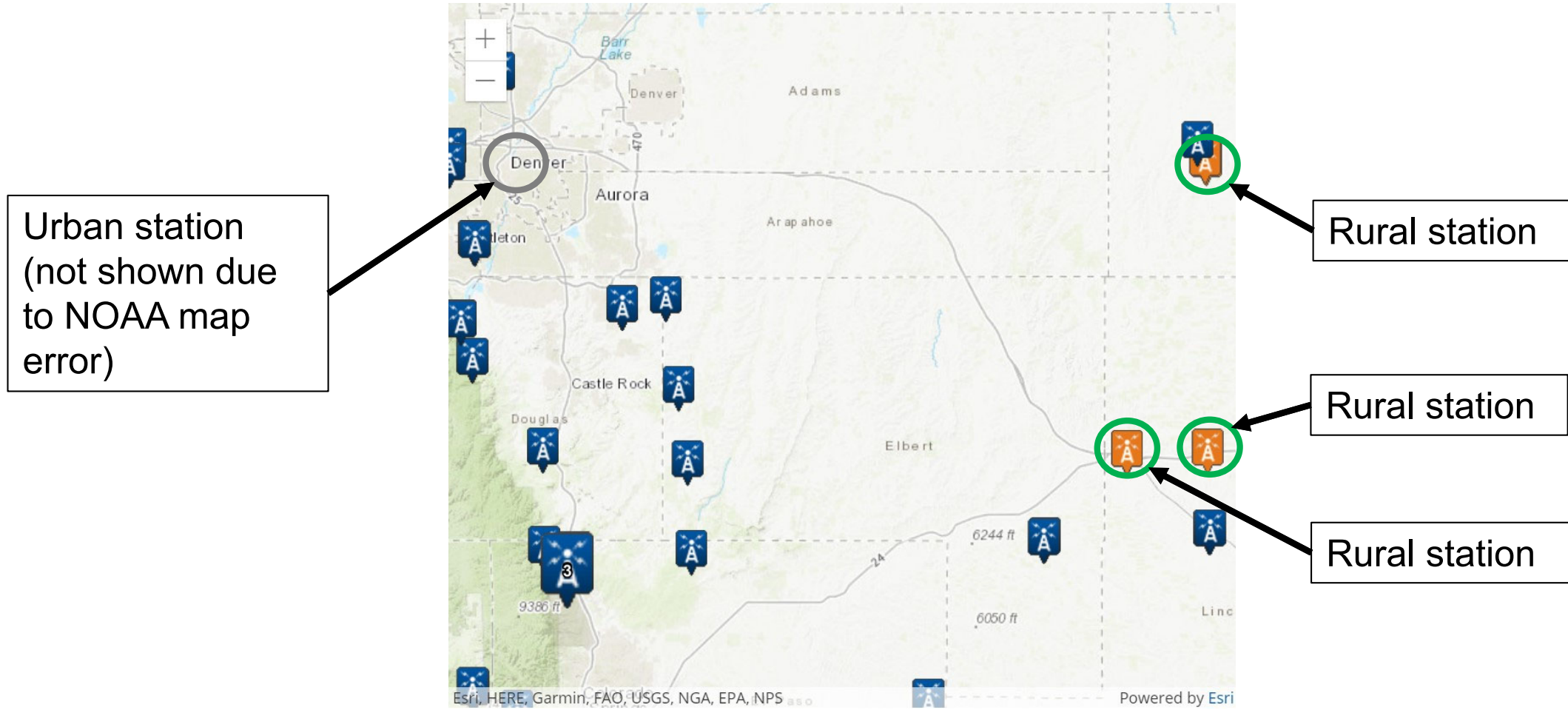
Denver, CO – UHI – Climate Central Methods

DAYTIME UHI IN DENVER, CO

Annual UHI
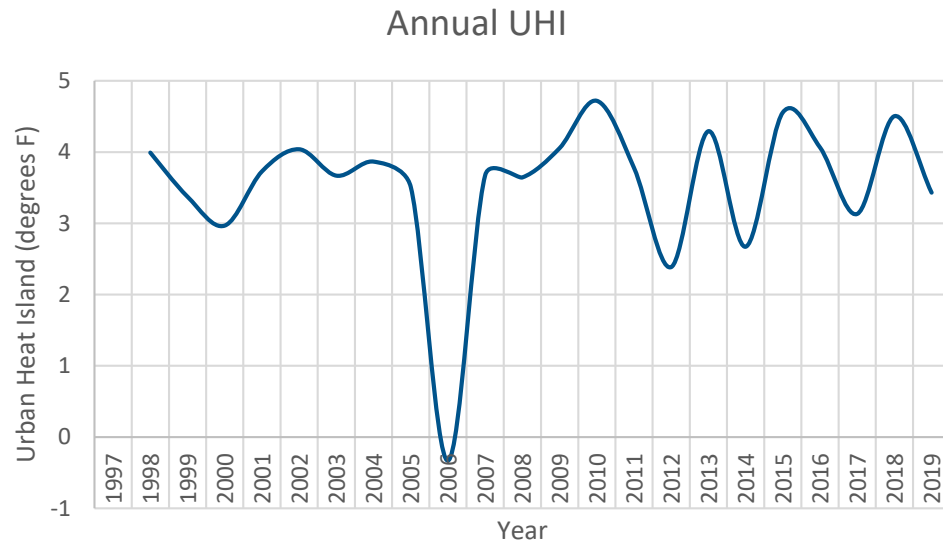
ICF	3.4
CC	4.9

10-Year Average

NIGHTTIME UHI IN DENVER, CO

Annual UHI

ICF	3.5
CC	5.6

Annual UHI
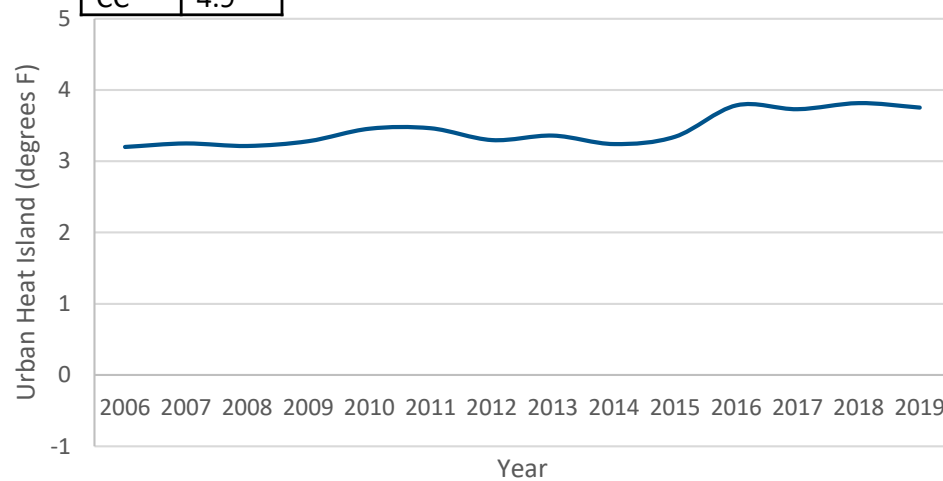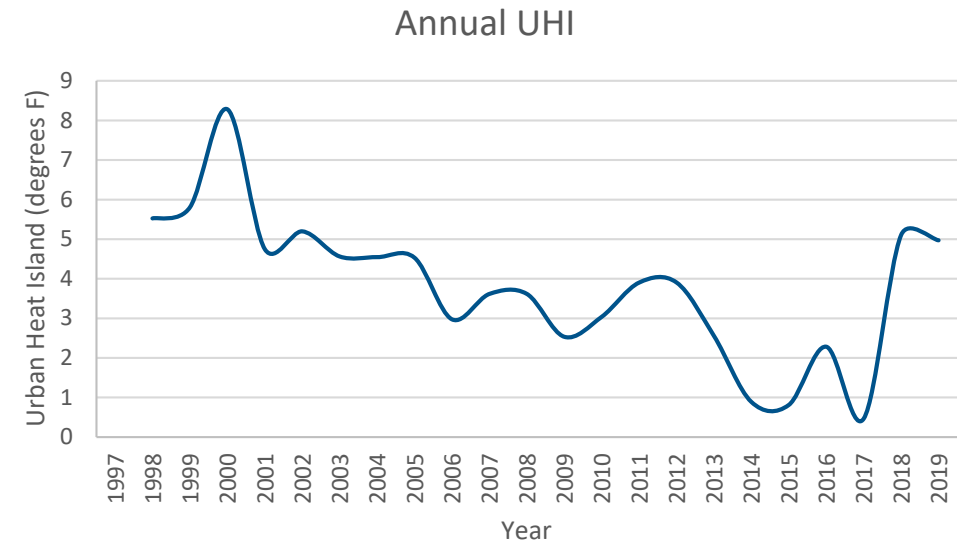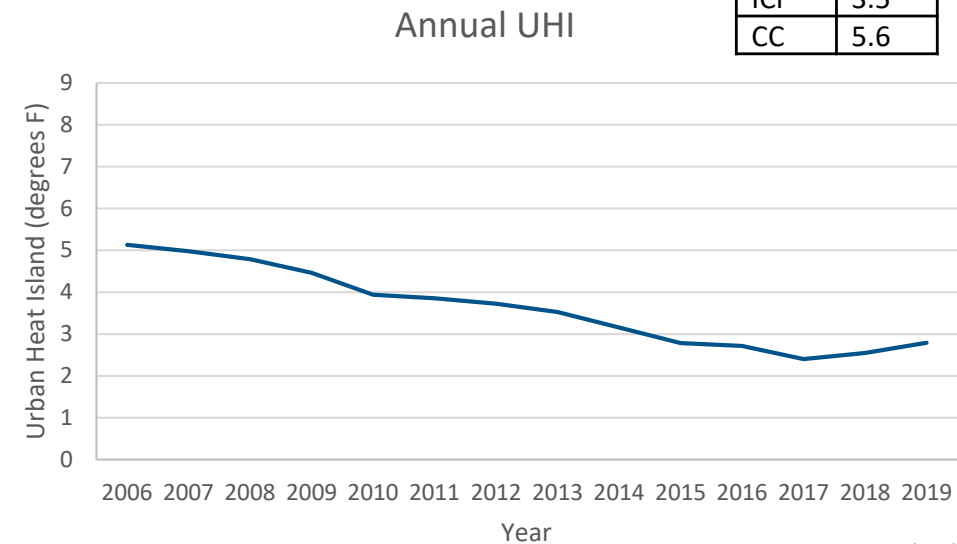
Denver, CO – UHI – Deeper Dive

DAYTIME UHI IN DENVER, CO

10-year Avg   3.4   4.7

CC 10-year Avg =   4.9

NIGHTTIME UHI IN DENVER, CO

10-year Avg   3.6   4.5

CC 10-year Avg =   5.6

Columbus, OH

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Columbus, OH - Weather Station Locations
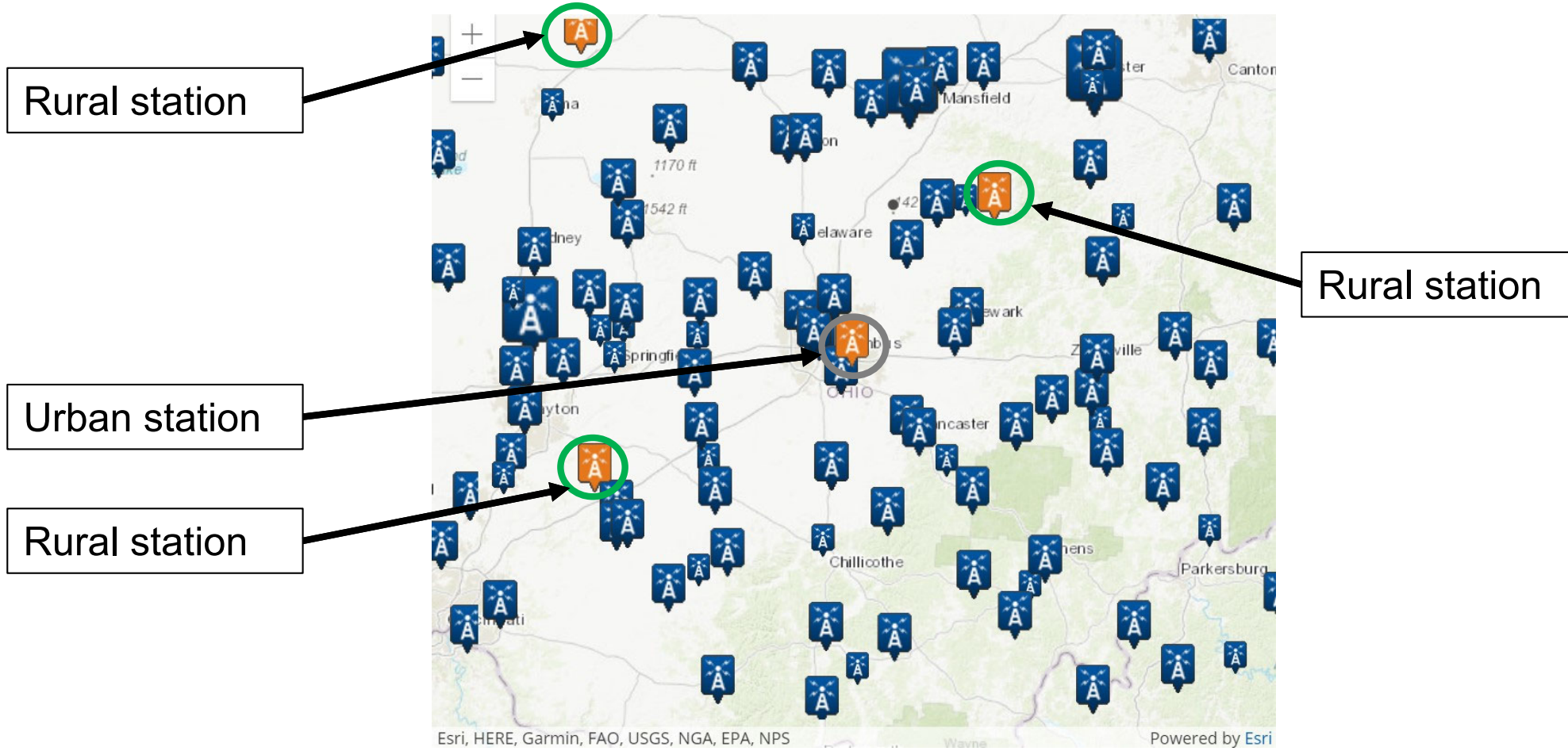
Rural station

Rural station

Urban station

Rural station

Columbus, OH – UHI – Climate Central Methods
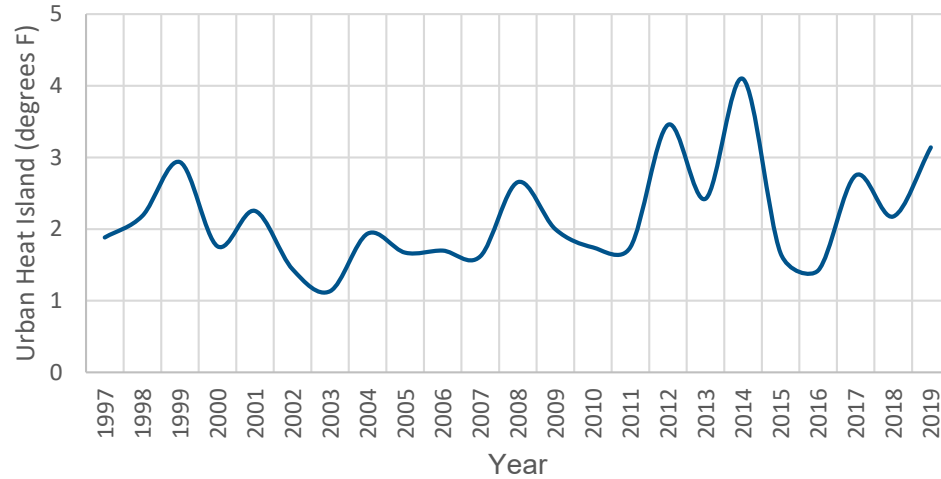
DAYTIME UHI IN COLUMBUS, OH

Annual UHI
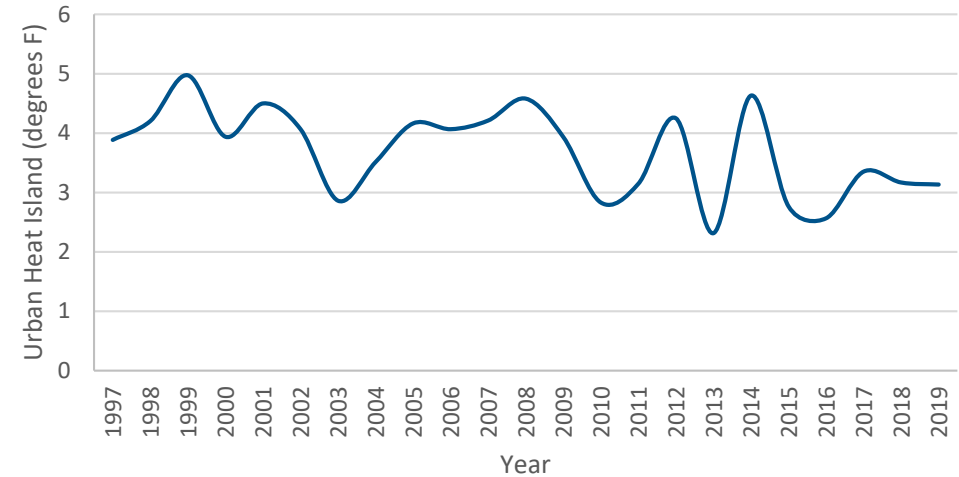
ICF	2.1
CC	4.4

10-Year Average

NIGHTTIME UHI IN COLUMBUS, OH

Annual UHI
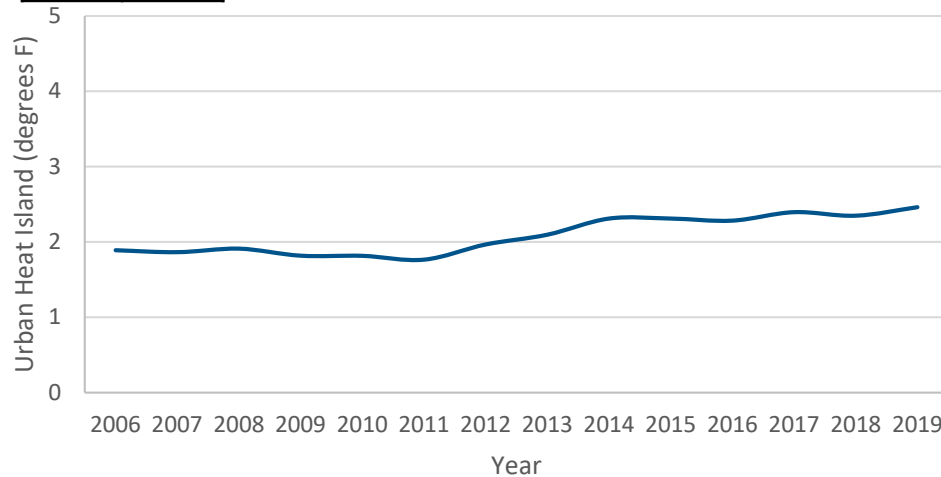
10-Year Average

ICF	3.7
CC	5.2
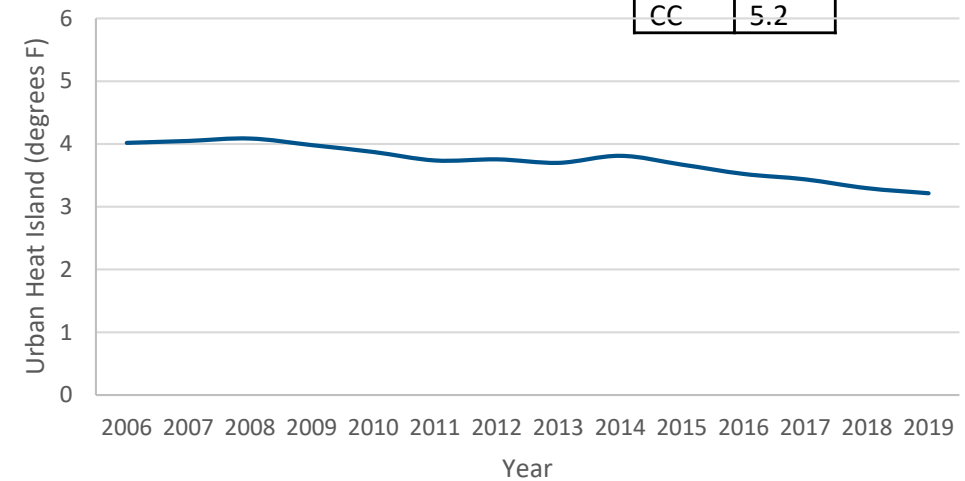
Columbus, OH – UHI – Deeper Dive

DAYTIME UHI IN COLUMBUS, OH

—All data —Only positive data

10-year Avg   2.1   3.0

CC 10-year Avg = 4.4

NIGHTTIME UHI IN COLUMBUS, OH

—All data —Only positive data
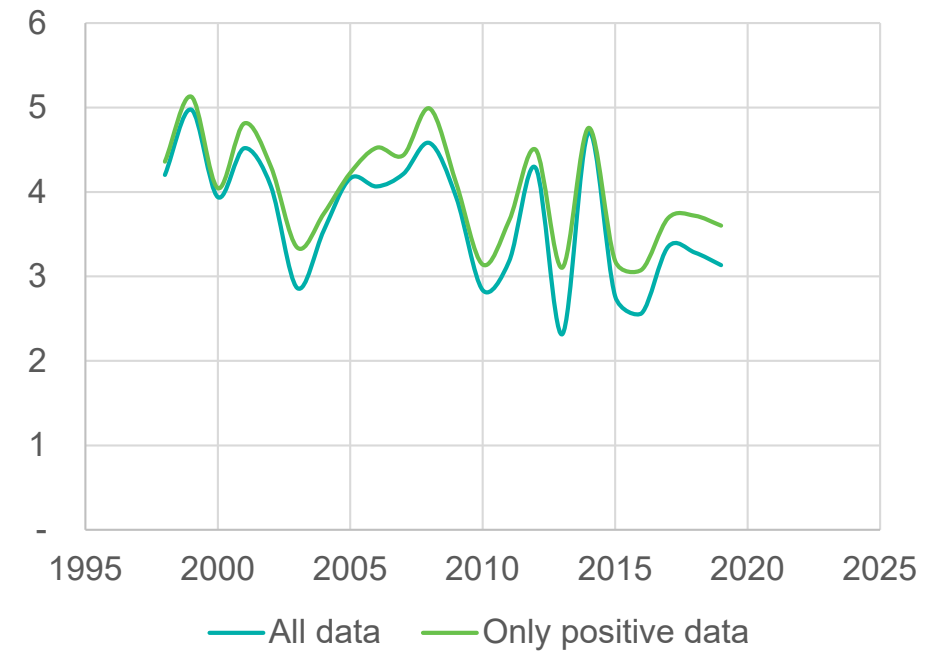
10-year Avg   3.7   4.0

CC 10-year Avg = 5.2

Buffalo, NY

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Buffalo, NY - Weather Station Locations

Urban station

Rural station

Rural station

Rural station
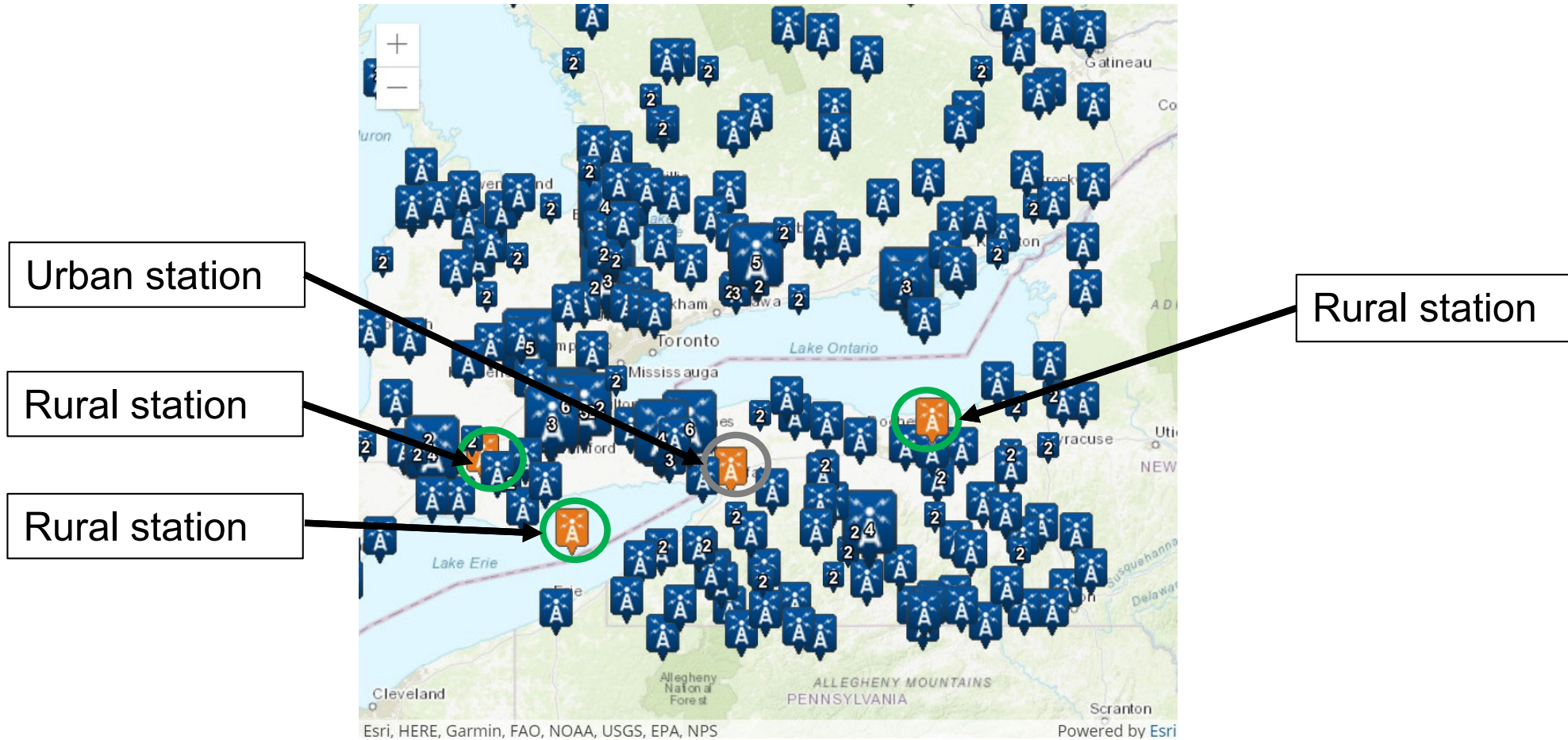
Buffalo, NY – UHI – Climate Central Methods

DAYTIME UHI IN BUFFALO, NY
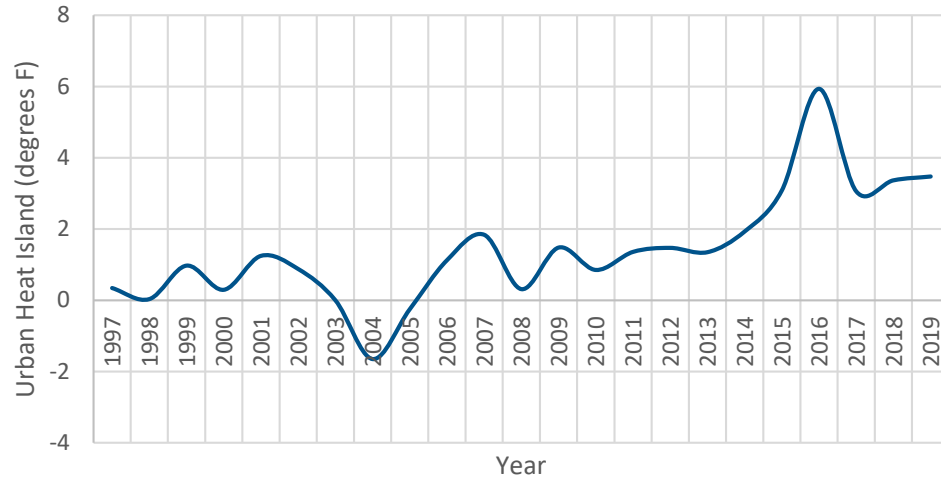
Annual UHI

ICF	0.8
CC	2.9

10-Year Average

NIGHTTIME UHI IN BUFFALO, NY

Annual UHI
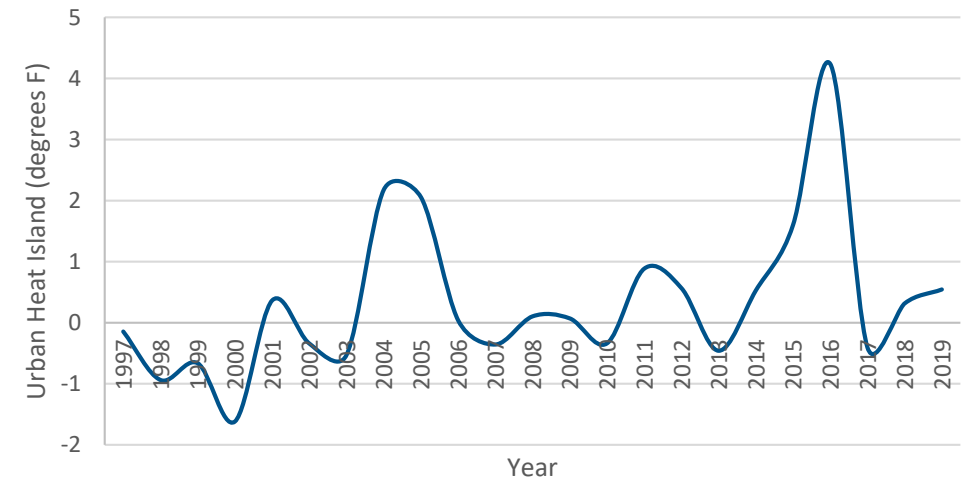
ICF	0.5
CC	6.4

10-Year Average

Buffalo, NY – UHI – Deeper Dive

DAYTIME UHI IN BUFFALO, NY
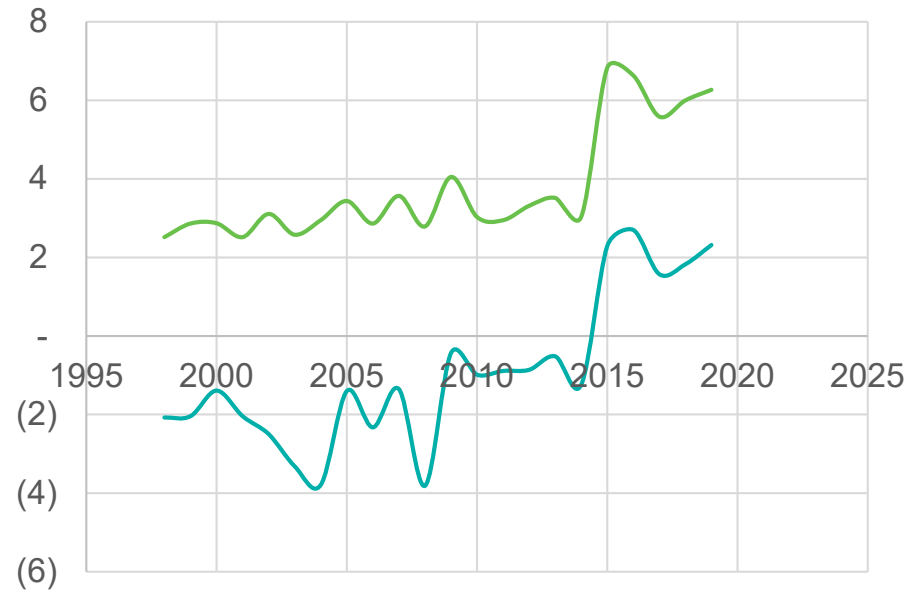
— All data — Only positive data

10-year Avg   (1.64)   3.25

CC 10-year Avg =   2.9

NIGHTTIME UHI IN BUFFALO, NY
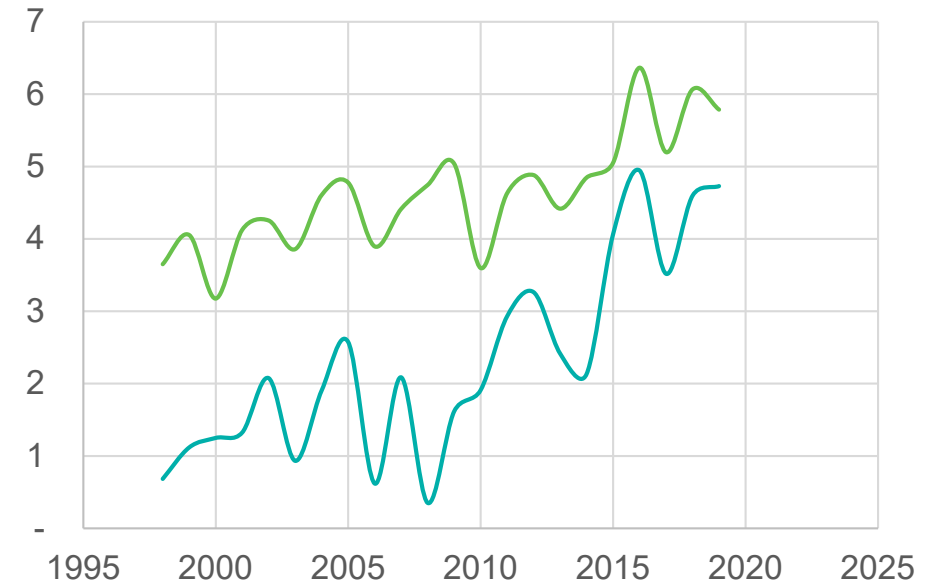
— All data — Only positive data

10-year Avg   2.0   4.5

CC 10-year Avg =   6.4

Minneapolis, MN

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Minneapolis, MN - Weather Station Locations

Rural station

Rural station

Rural station

Urban station
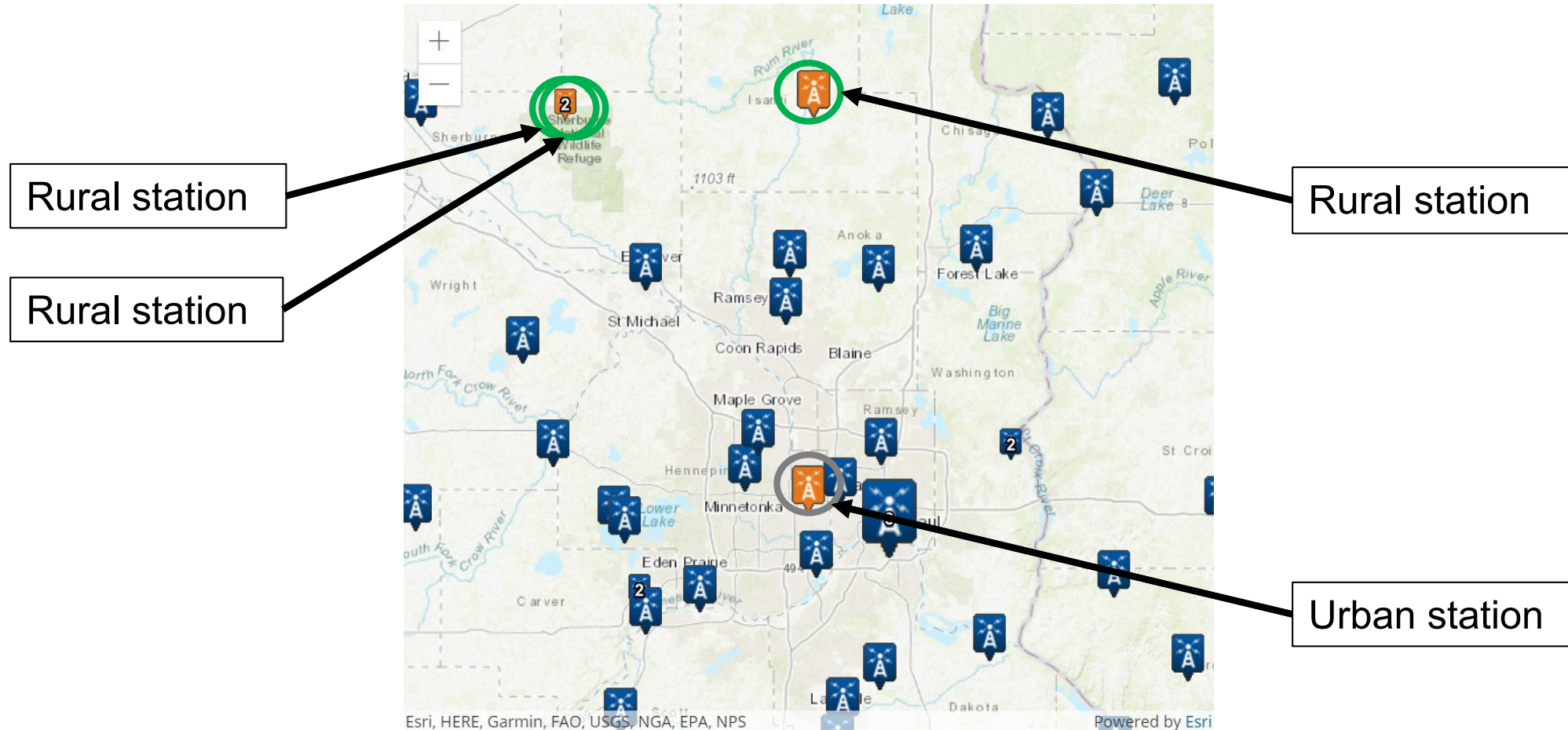
Minneapolis, MN – UHI – Climate Central Methods

DAYTIME UHI IN MINNEAPOLIS, MN

Annual UHI
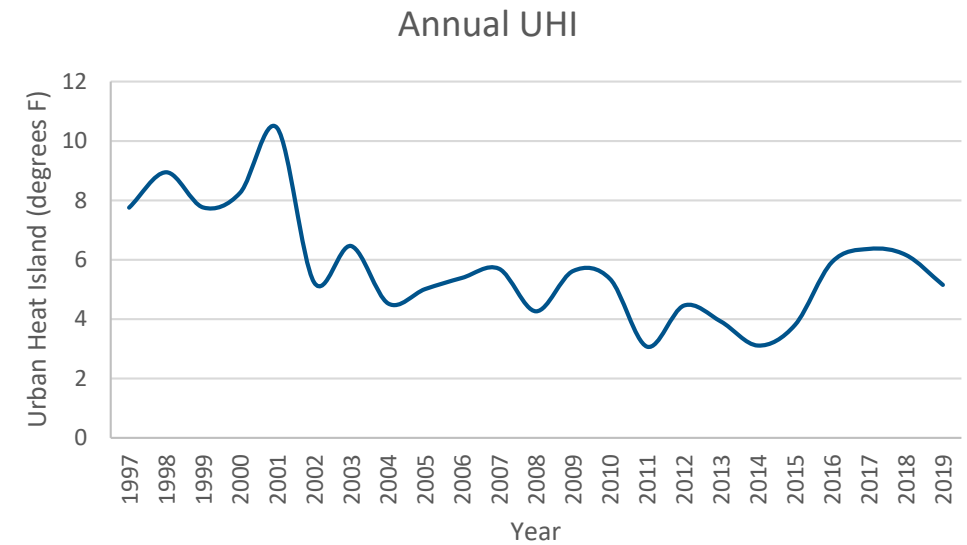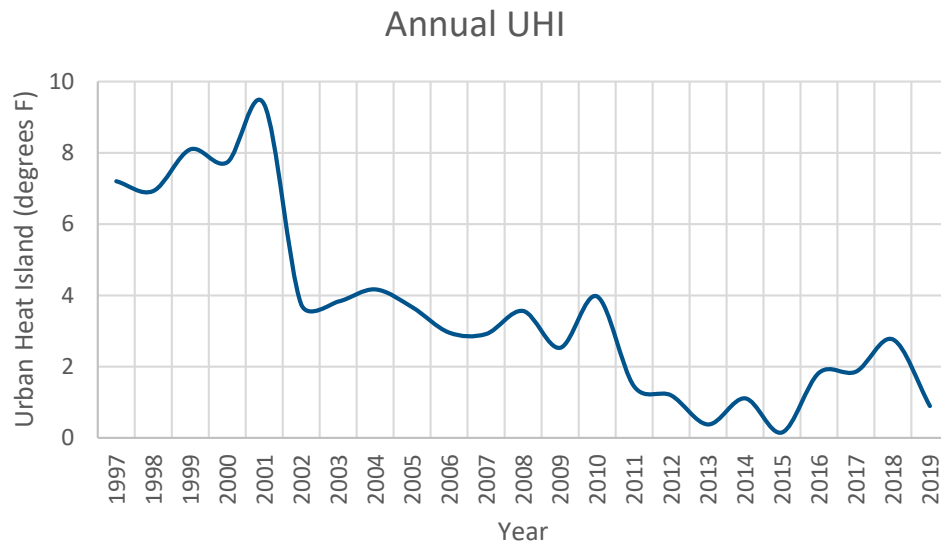
ICF	2.7
CC	4.3

10-Year Average

NIGHTTIME UHI IN MINNEAPOLIS, MN

Annual UHI

ICF	4.7
CC	6.1

10-Year Average
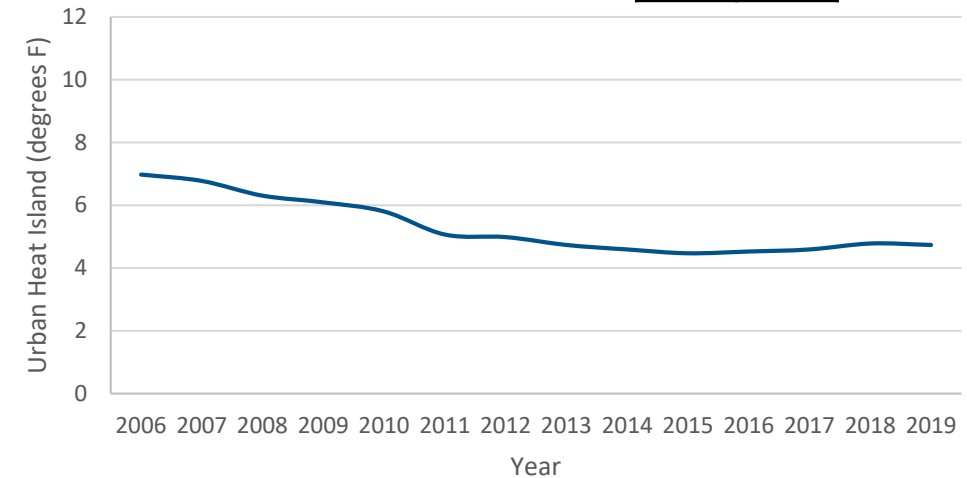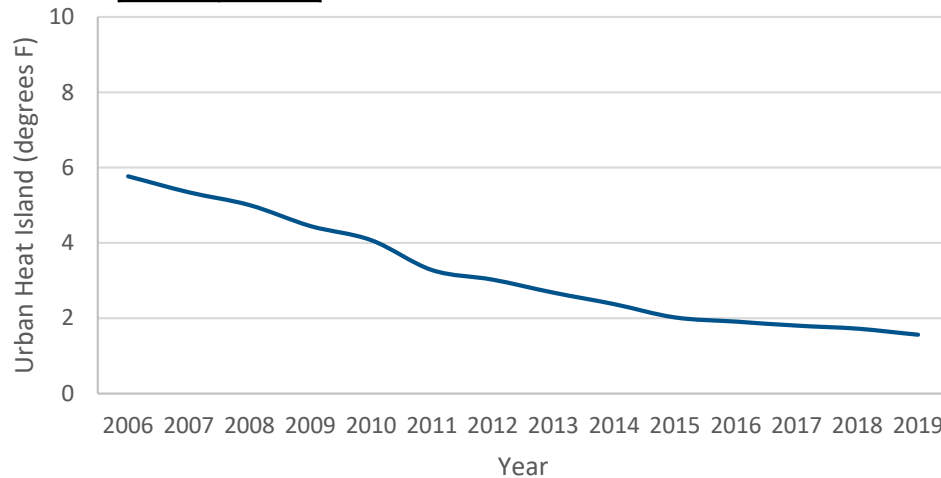
Minneapolis, MN – UHI – Deeper Dive

DAYTIME UHI IN MINNEAPOLIS, MN
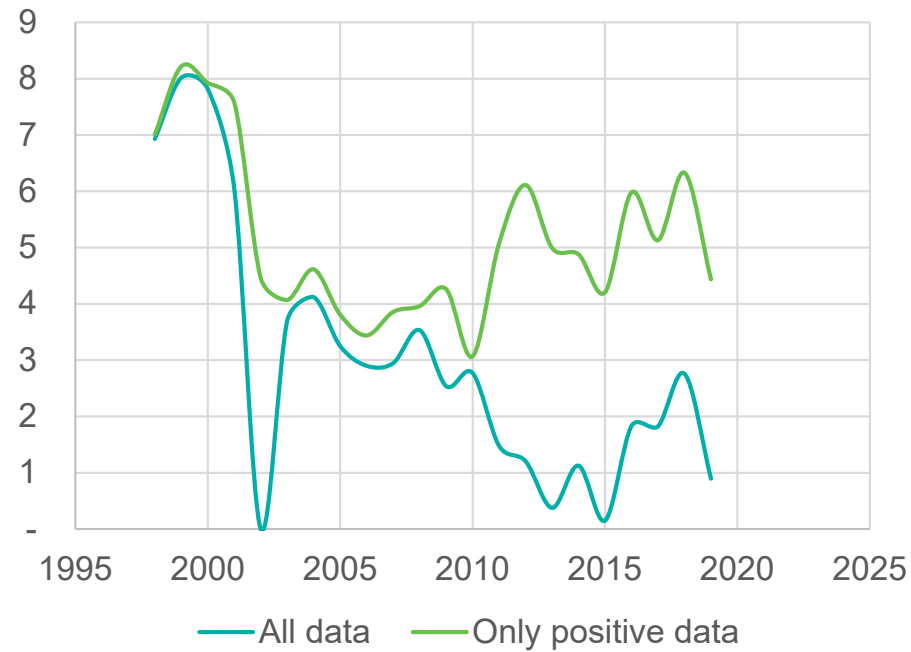
10-year Avg	2.5	4.3

CC 10-year Avg =   4.3

NIGHTTIME UHI IN MINNEAPOLIS, MN

10-year Avg	4.6	5.9

CC 10-year Avg =   6.1

Results
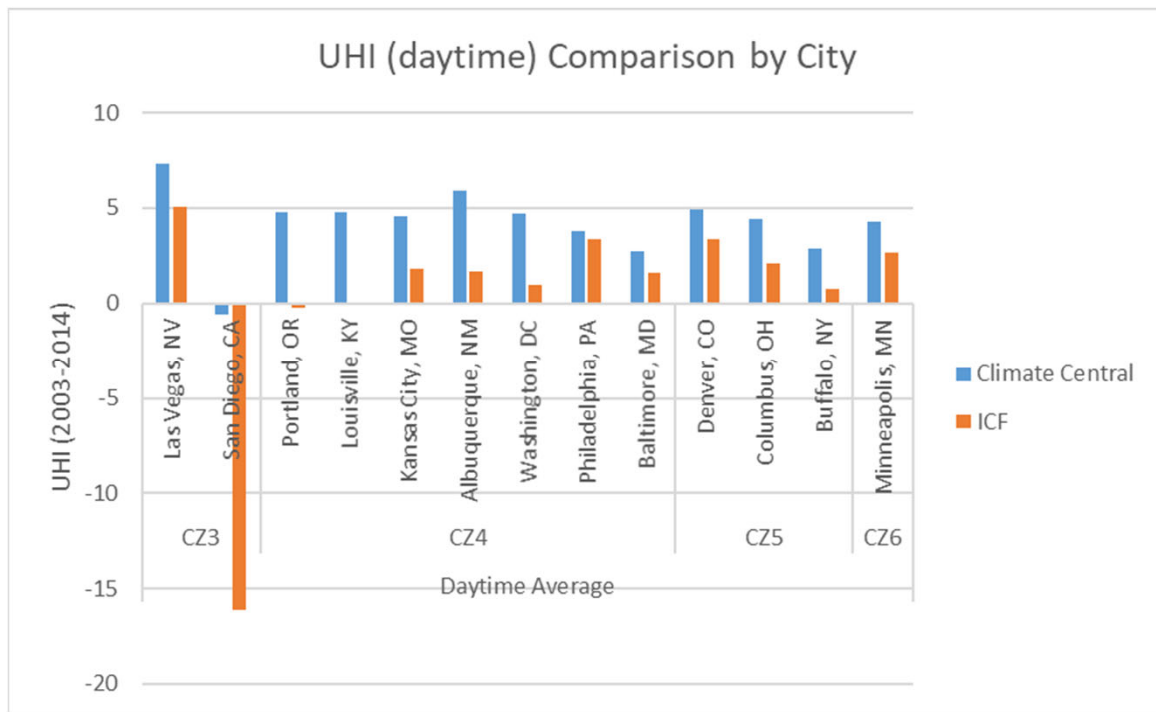
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UHI Comparative Analysis Results

DAYTIME UHI

NIGHTTIME UHI
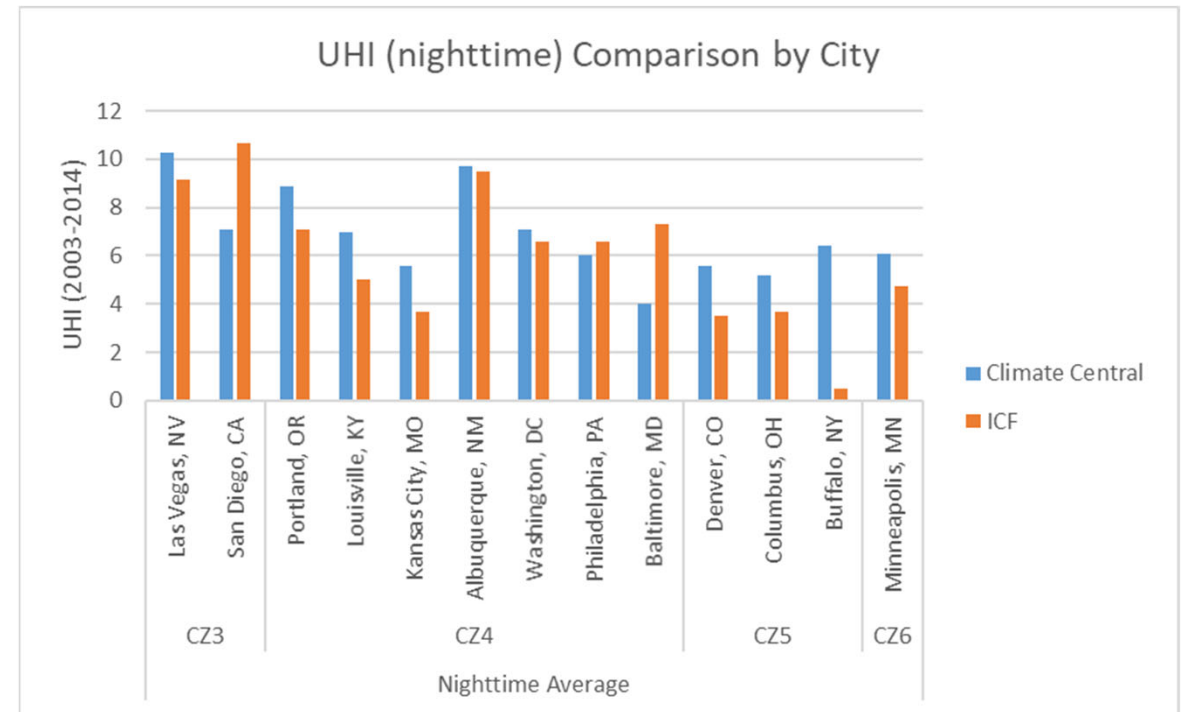
UHI Comparative Analysis Results

DAYTIME AND NIGHTTIME UHI

City	Climate Zone	UHI Condition	Climate Central	ICF	Directional Difference
Las Vegas, NV	CZ3	Daytime Average	7.30	5.08	
		Nighttime Average	10.30	9.14	
San Diego, CA	CZ3	Daytime Average	(0.60)	(16.14)	
		Nighttime Average	7.10	10.64	
Portland, OR	CZ4	Daytime Average	4.80	(0.25)	
		Nighttime Average	8.90	7.10	
Louisville, KY	CZ4	Daytime Average	4.80	(0.10)	
		Nighttime Average	7.00	5.00	
Kansas City, MO	CZ4	Daytime Average	4.60	1.80	
		Nighttime Average	5.60	3.70	
Albuquerque, NM	CZ4	Daytime Average	5.90	1.70	
		Nighttime Average	9.70	9.50	
Washington, DC	CZ4	Daytime Average	4.70	1.00	
		Nighttime Average	7.10	6.60	
Philadelphia, PA	CZ4	Daytime Average	3.80	3.40	
		Nighttime Average	6.00	6.60	
Baltimore, MD	CZ4	Daytime Average	2.70	1.57	
		Nighttime Average	4.00	7.30	
Denver, CO	CZ5	Daytime Average	4.90	3.36	
		Nighttime Average	5.60	3.52	
Columbus, OH	CZ5	Daytime Average	4.40	2.09	
		Nighttime Average	5.20	3.70	
Buffalo, NY	CZ5	Daytime Average	2.90	0.79	
		Nighttime Average	6.40	0.47	
Minneapolis, MN	CZ6	Daytime Average	4.30	2.68	
		Nighttime Average	6.10	4.73	

DAYTIME AND NIGHTTIME UHI WARMING RATE (°F/DECADE)

City	Climate Zone	UHI Condition	Climate Central	ICF	Directional Difference
Las Vegas, NV	CZ3	Summer UHI Intensity Change	0.31	0.07	
	CZ3	Summer Overnight UHI Intensity Change	0.95	-0.09	
San Diego, CA	CZ3	Summer UHI Intensity Change	-0.74	0.42	
	CZ3	Summer Overnight UHI Intensity Change	-0.17	-1.38	
Portland, OR	CZ4	Summer UHI Intensity Change	0.00	-0.12	
	CZ4	Summer Overnight UHI Intensity Change	0.17	0.20	
Louisville, KY	CZ4	Summer UHI Intensity Change	0.65	-0.12	
	CZ4	Summer Overnight UHI Intensity Change	0.63	-0.06	
Kansas City, MO	CZ4	Summer UHI Intensity Change	0.07	0.02	
	CZ4	Summer Overnight UHI Intensity Change	-0.31	0.05	
Albuquerque, NM	CZ4	Summer UHI Intensity Change	0.20	-0.03	
	CZ4	Summer Overnight UHI Intensity Change	0.93	-0.06	
Washington, DC	CZ4	Summer UHI Intensity Change	0.42	0.20	
	CZ4	Summer Overnight UHI Intensity Change	0.42	0.01	
Philadelphia, PA	CZ4	Summer UHI Intensity Change	0.53	-0.18	
	CZ4	Summer Overnight UHI Intensity Change	0.65	-0.14	
Baltimore, MD	CZ4	Summer UHI Intensity Change	0.66	0.35	
	CZ4	Summer Overnight UHI Intensity Change	0.51	0.22	
Denver, CO	CZ5	Summer UHI Intensity Change	-0.62	0.05	
	CZ5	Summer Overnight UHI Intensity Change	-1.30	-0.19	
Columbus, OH	CZ5	Summer UHI Intensity Change	0.84	0.05	
	CZ5	Summer Overnight UHI Intensity Change	0.61	-0.12	
Buffalo, NY	CZ5	Summer UHI Intensity Change	0.16	0.33	
	CZ5	Summer Overnight UHI Intensity Change	0.30	0.05	
Minneapolis, MN	CZ6	Summer UHI Intensity Change	0.77	-0.37	
	CZ6	Summer Overnight UHI Intensity Change	0.81	-0.06	

UHI Source: Climate Central report
http://assets.climatecentral.org/pdfs/UrbanHeatIsland.pdf