A Chicago Regional Climate Plan
Climate Impacts & Hazards

Adaptation Webinar 2

May 29, 2020

Welcome

Kevin Burns, Mayor, City of Geneva

Chairman, Metropolitan Mayors Caucus Environment Committee and Energy Sub Committee

Speakers

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Engagement Manager
NOAA Climate Program Office &
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NEMAC-Fernleaf & U.S. Climate Resilience Toolkit
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Practical Guidance for

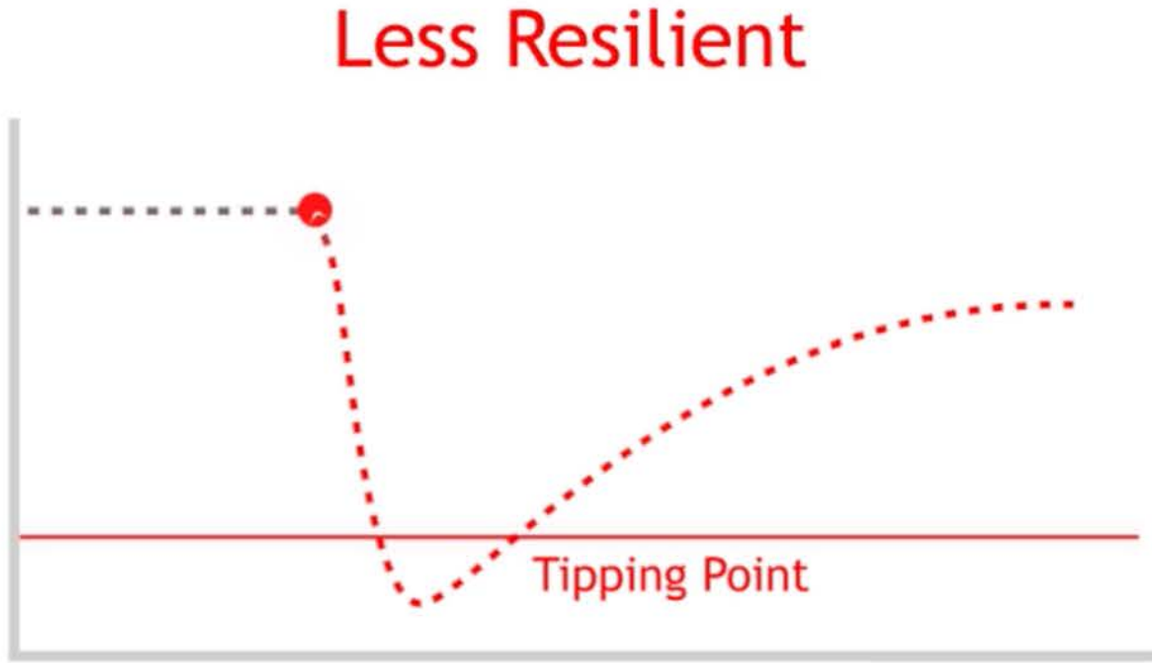
Chicago Region Climate Planning

Climate Impacts and Hazards

May 29, 2020

What is Resilience?

The ability of the natural, human, built or economic system to recover from and withstand impacts from *hazards*



$17 Billion impact of Hurricane Florence (North Carolina)

$5.7 billion

on businesses (commercial properties)

$5.6 billion

on homes (residential properties)

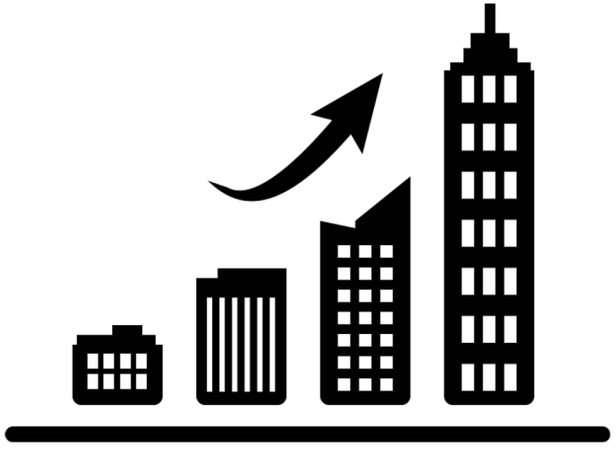
$2.4 billion

on agriculture

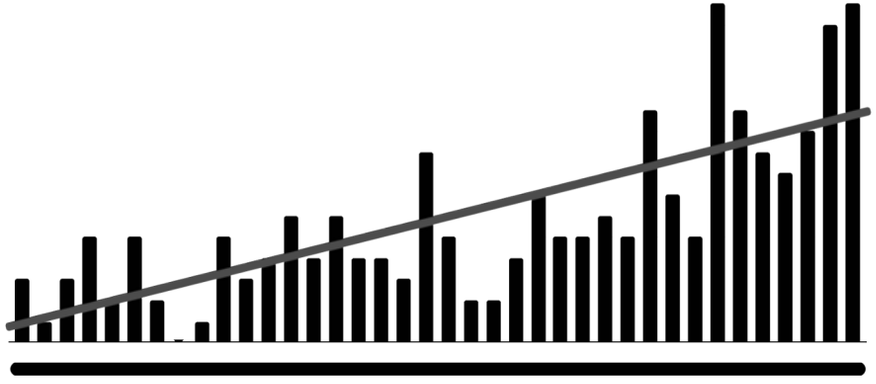
$3.3 billion

on other properties

Most costs of recovery are borne locally



GROWTH



BILLION DOLLAR DISASTERS

RISKIER INVESTMENTS

$17 Billion impact to NC

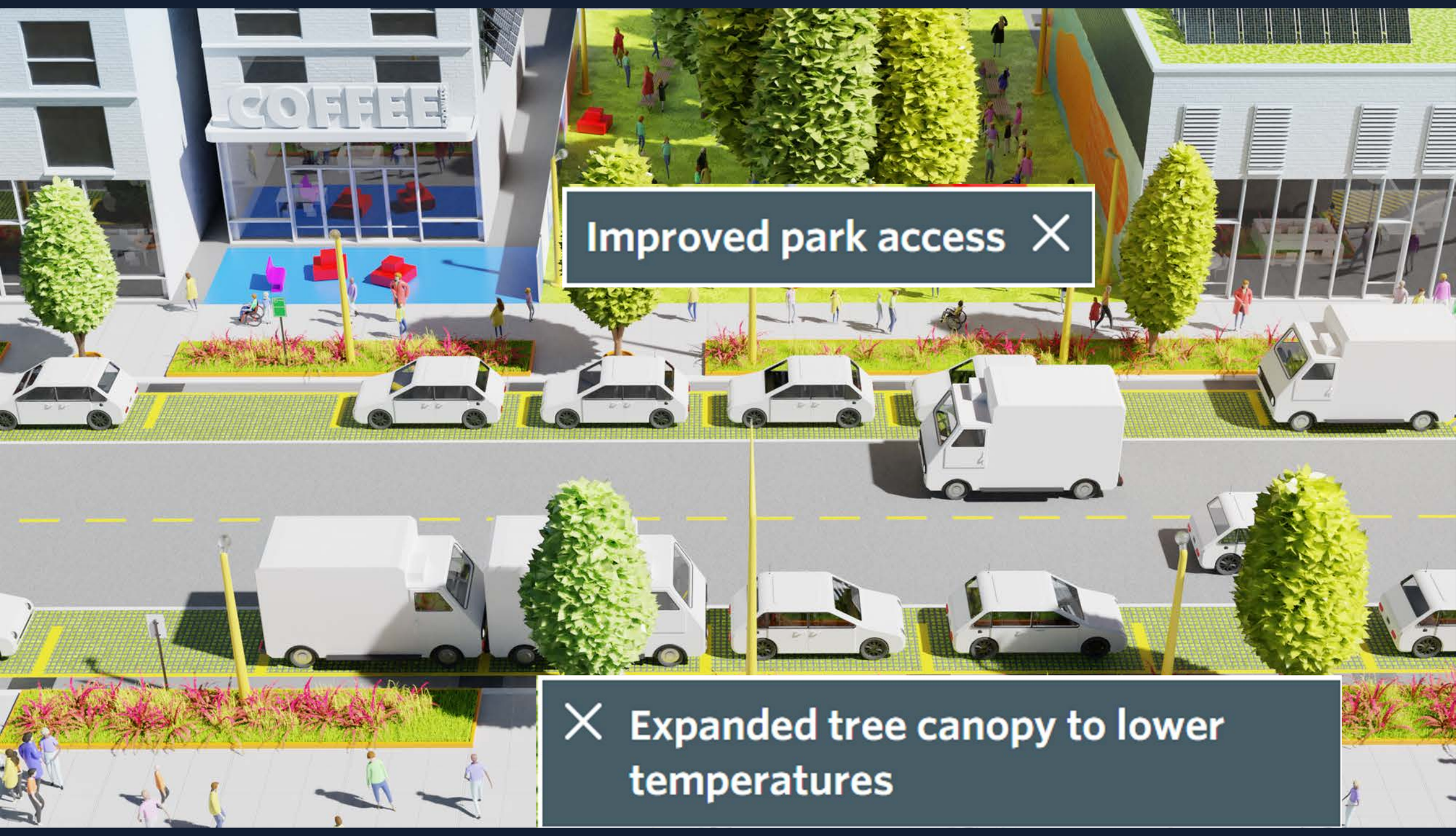
SHORTFALL (INSURERS)

$3.3 Covered by Federal and State

$4.8 Covered by Private Insurance

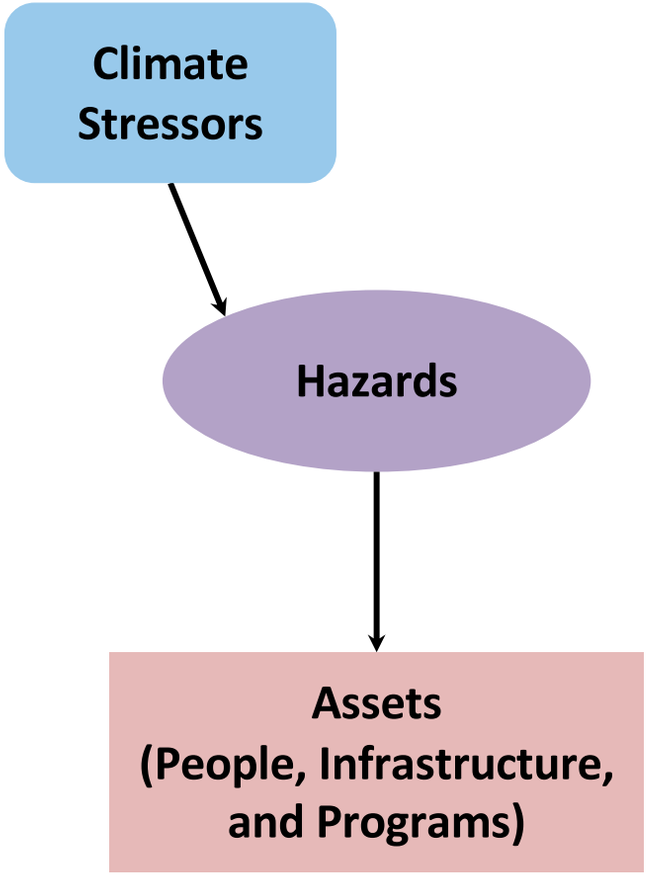
$8.8 CURRENTLY NOT COVERED

Raleigh News and Observer, 11/1/2018


COFFEE
Improved park access
Expanded tree canopy to lower temperatures

Use the Steps to Resilience to Assess the Impacts of Climate Change on Chicago

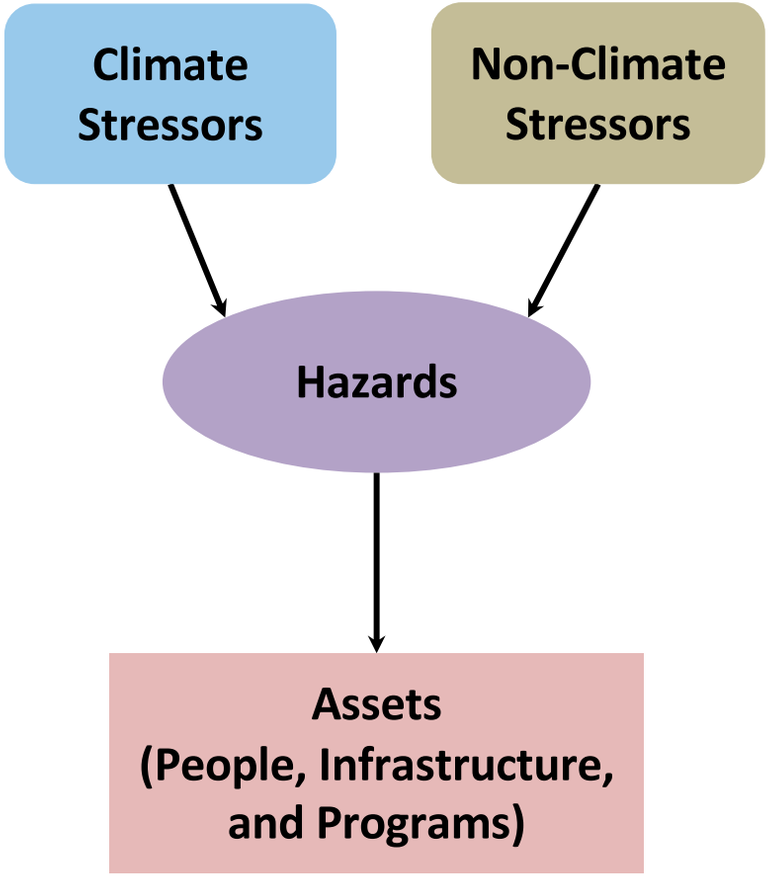
… from data to decisions to inform adaptation strategies



- Temperature Variability and Change
- Extreme Precipitation
- Drought

- Flooding
- Water shortage due to drought
- Extreme Heat

- People
- Programs
- Property
- Infrastructure



- Temperature Variability and Change
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- Development
- Impervious surfaces
- Population growth
- Energy and water demand

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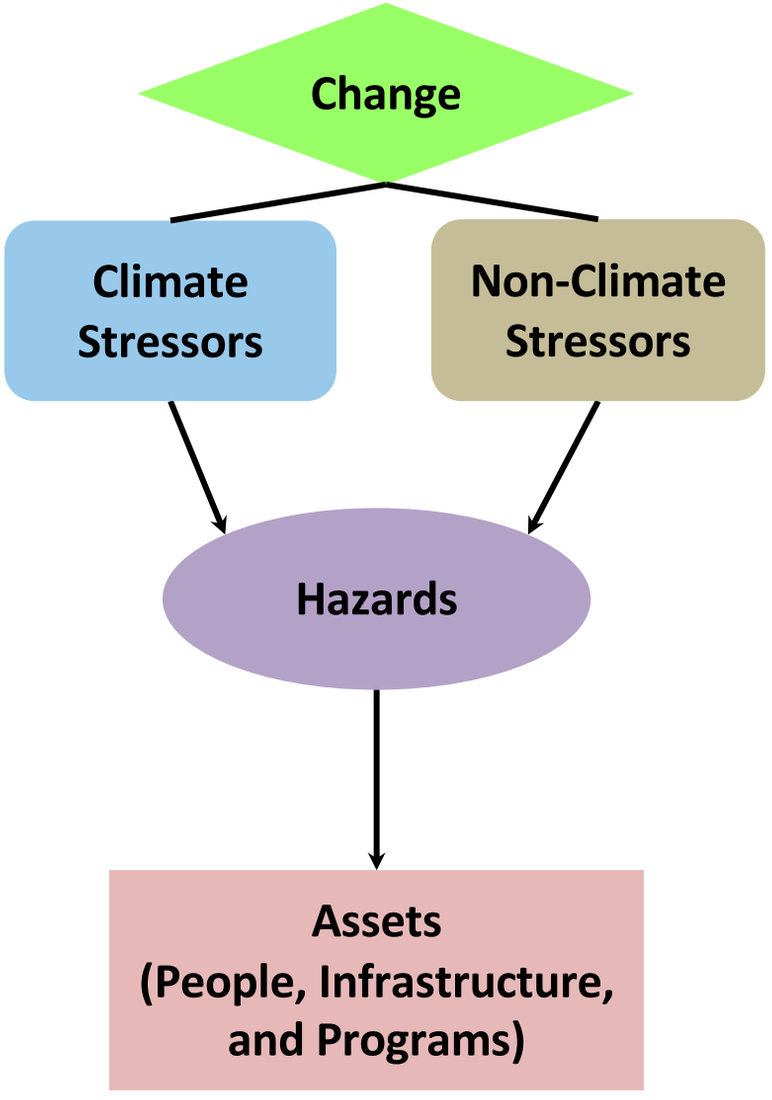

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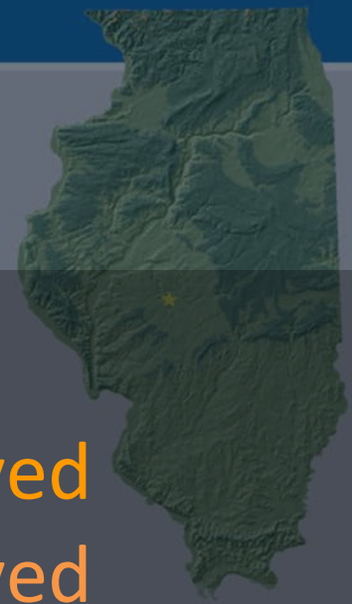
Climate trajectories

NOAA National Centers for Environmental Information | State Summaries 149-IL

ILLINOIS

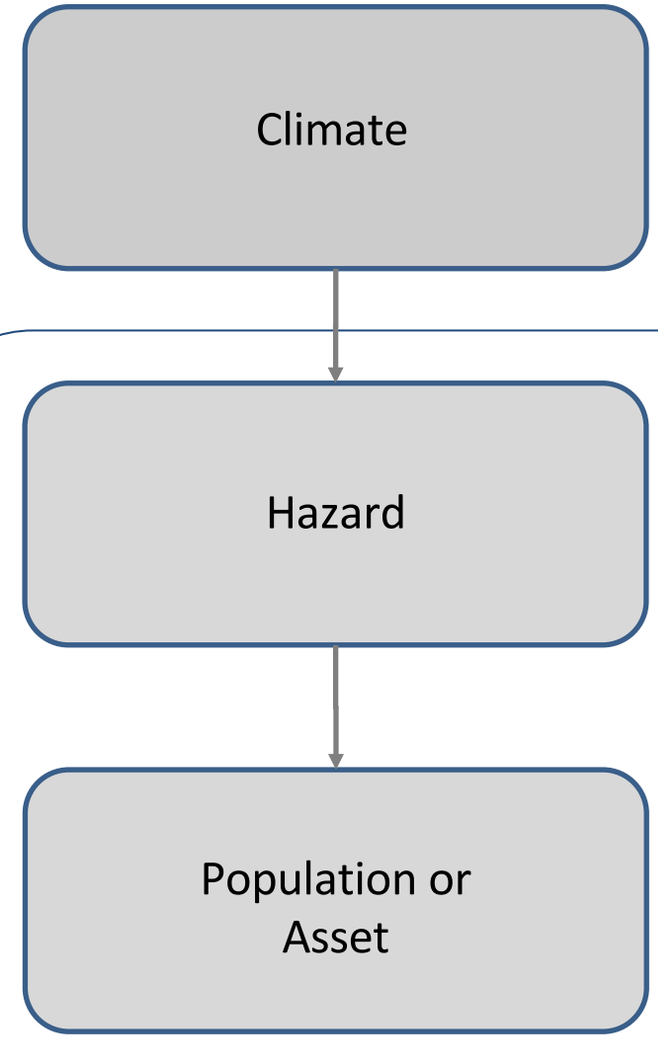


- Increased average temperature — observed
- Increased spring temperature — observed
- More spring & summer precipitation — observed
- Winter/spring precip. increase — projected
- Flooding & drought — observed & anticipated

Climate and impact assessments

Climate

describes the frequency and severity of **hazards**



Impacts

involve both a **hazard** and an **asset**

Climate and impact assessments

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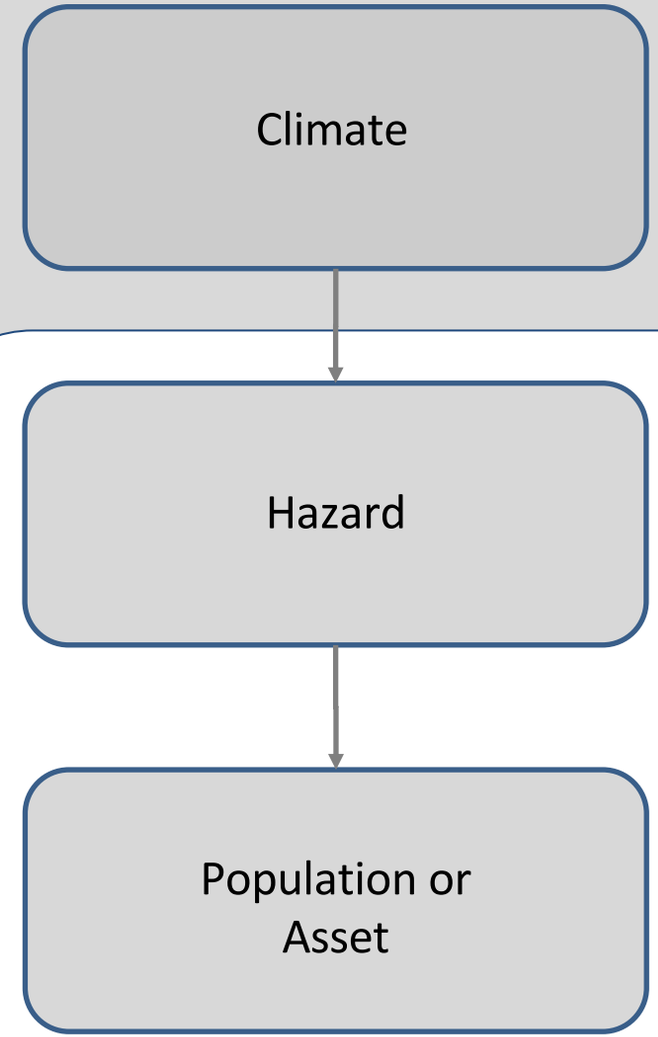

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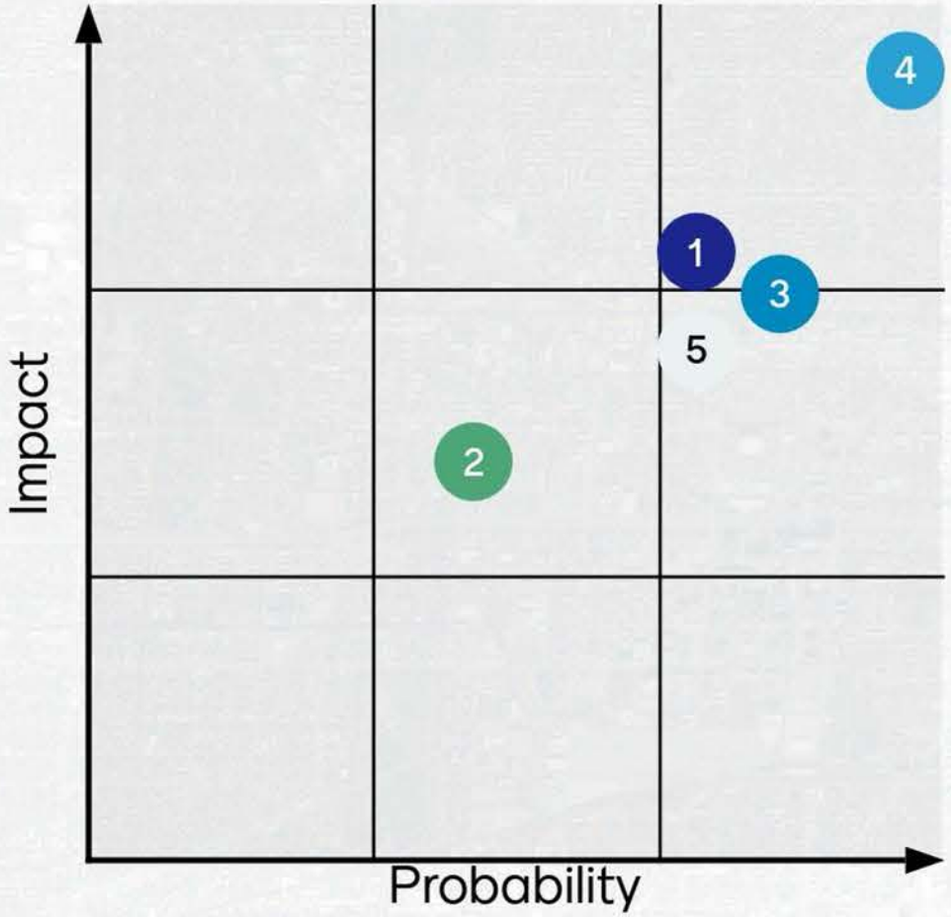
Primary Hazards



1 Extreme Heat

2 Drought

3 Severe Thunderstorms

4 Flooding

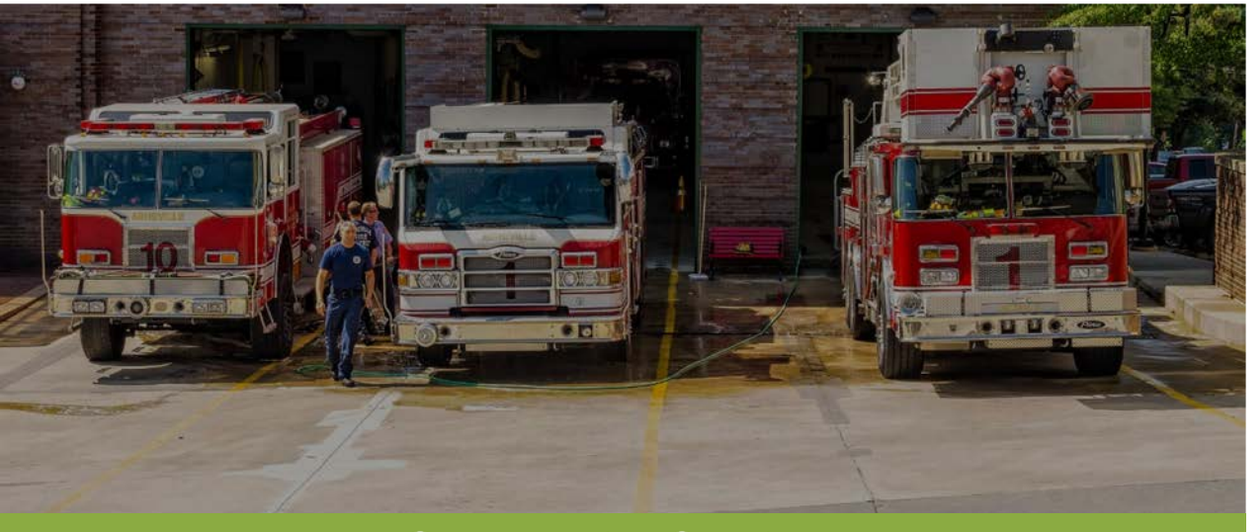
5 Severe Winter Weather

Assets

Things we Value

Residents & Residential Property

Commercial Property



Community Services

Roads & mobility

Go to **www.menti.com** and use the code **85 49 73**

What impacts (hazards and assets) concern you?

U.S. Climate Resilience Toolkit

Go to menti.com

Enter code 85 49 73

Press **ENTER** to pause scroll

0

Flooding

Understand how climate variability and change might impact the region


N888TV

Climate Stressors

- *Four distinct seasons*
- *Variable weather patterns*
- *Precipitation greatest in spring and summer*

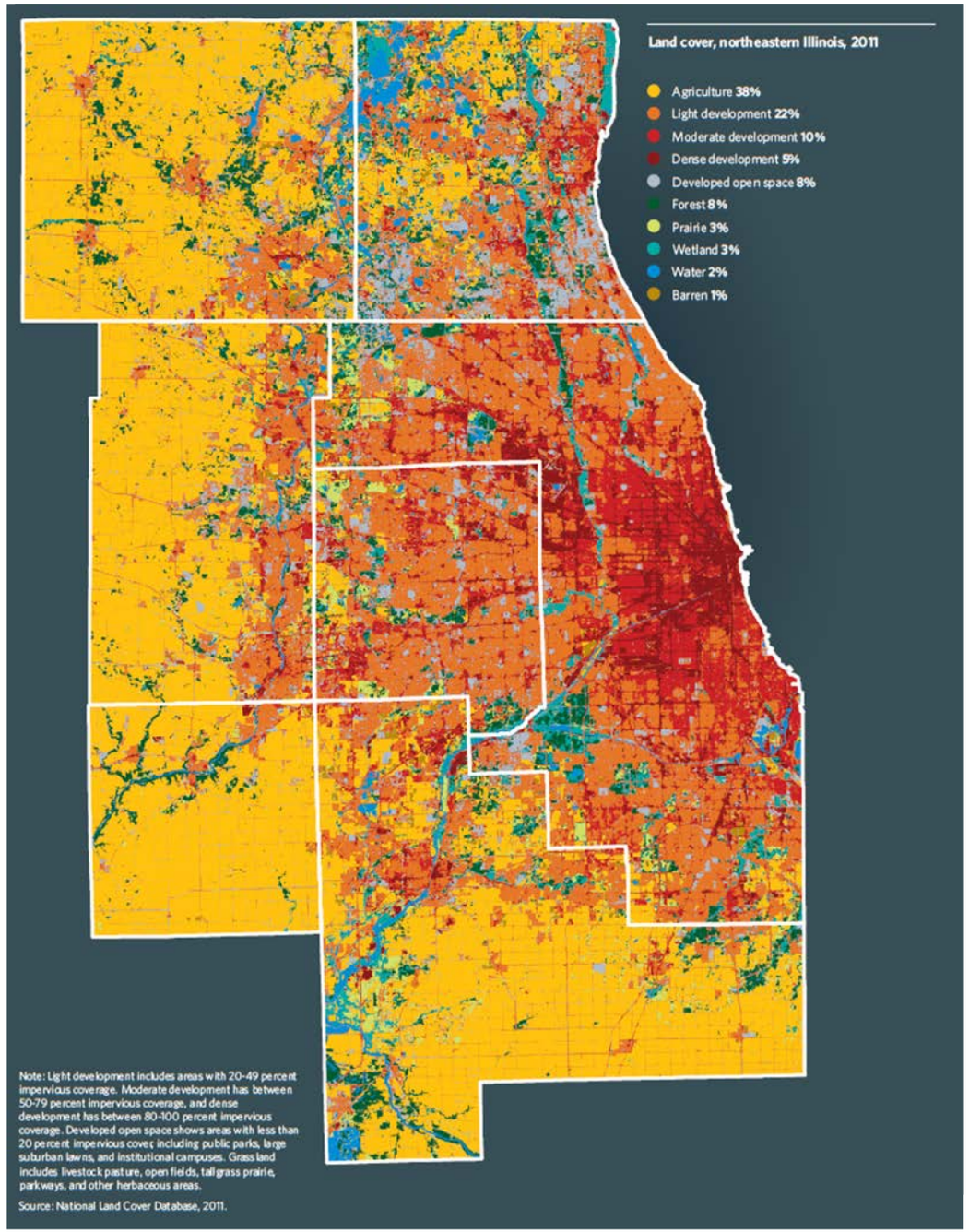
Non-Climate Stressors

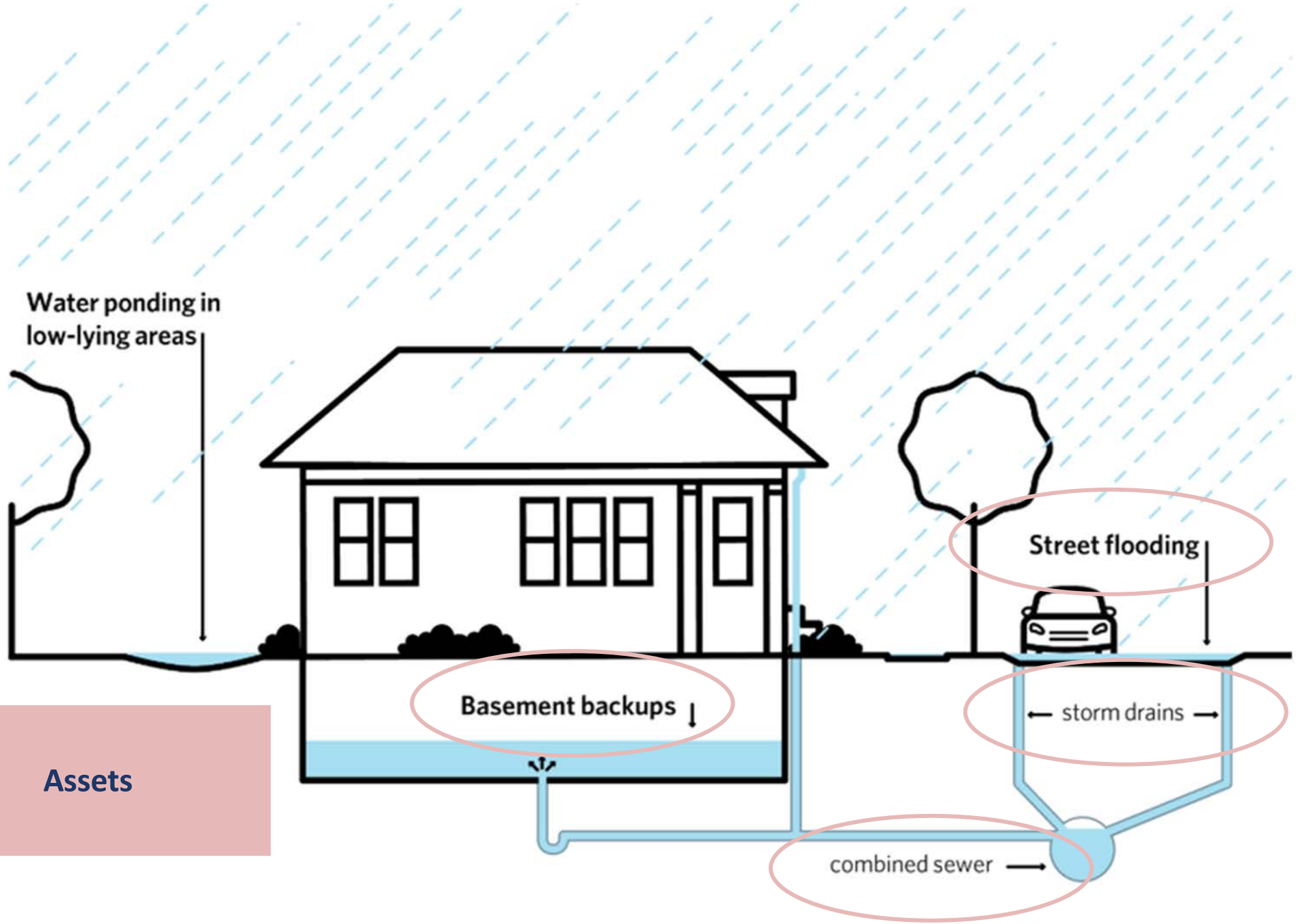
Topography

- *Limited elevation change*
- *Clay soils*

Land use

- *Heavily developed*



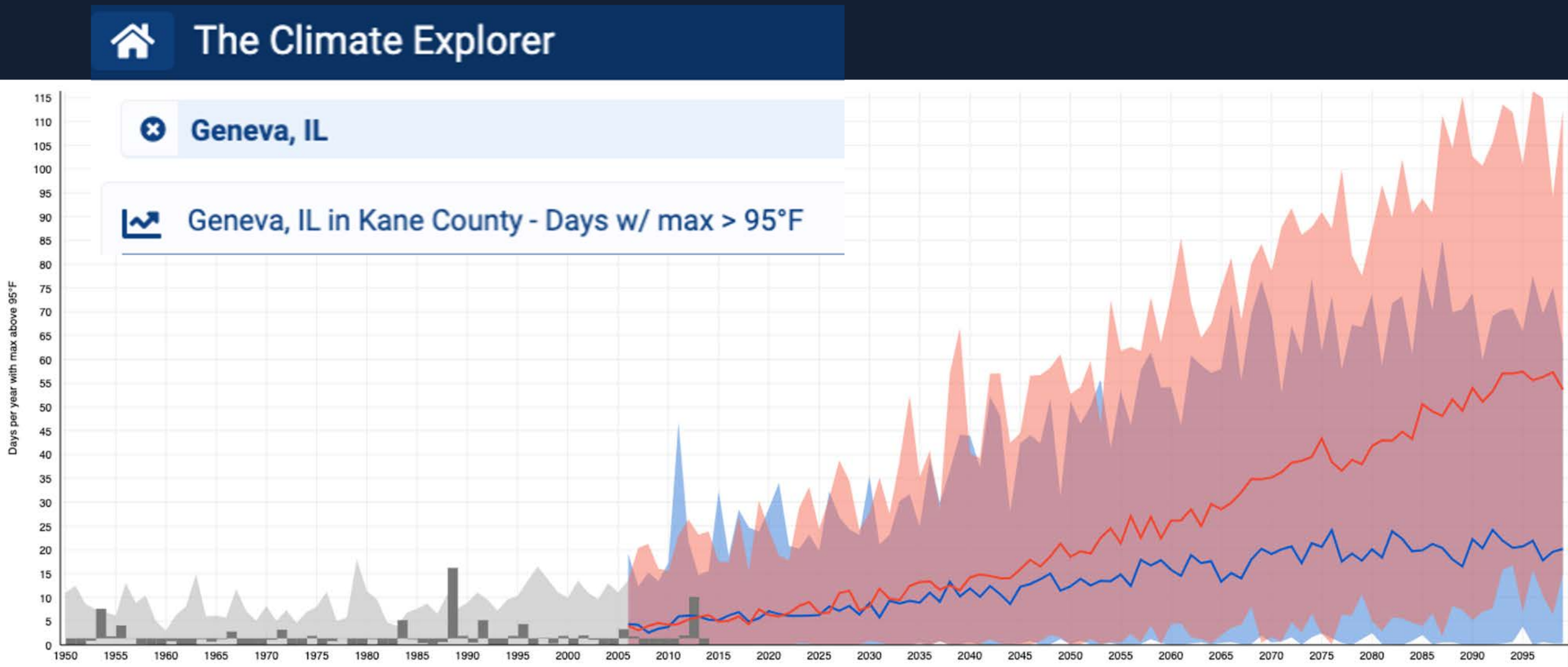

Water ponding in low-lying areas
Street flooding
Basement backups
storm drains
combined sewer

Assets

Extreme Heat

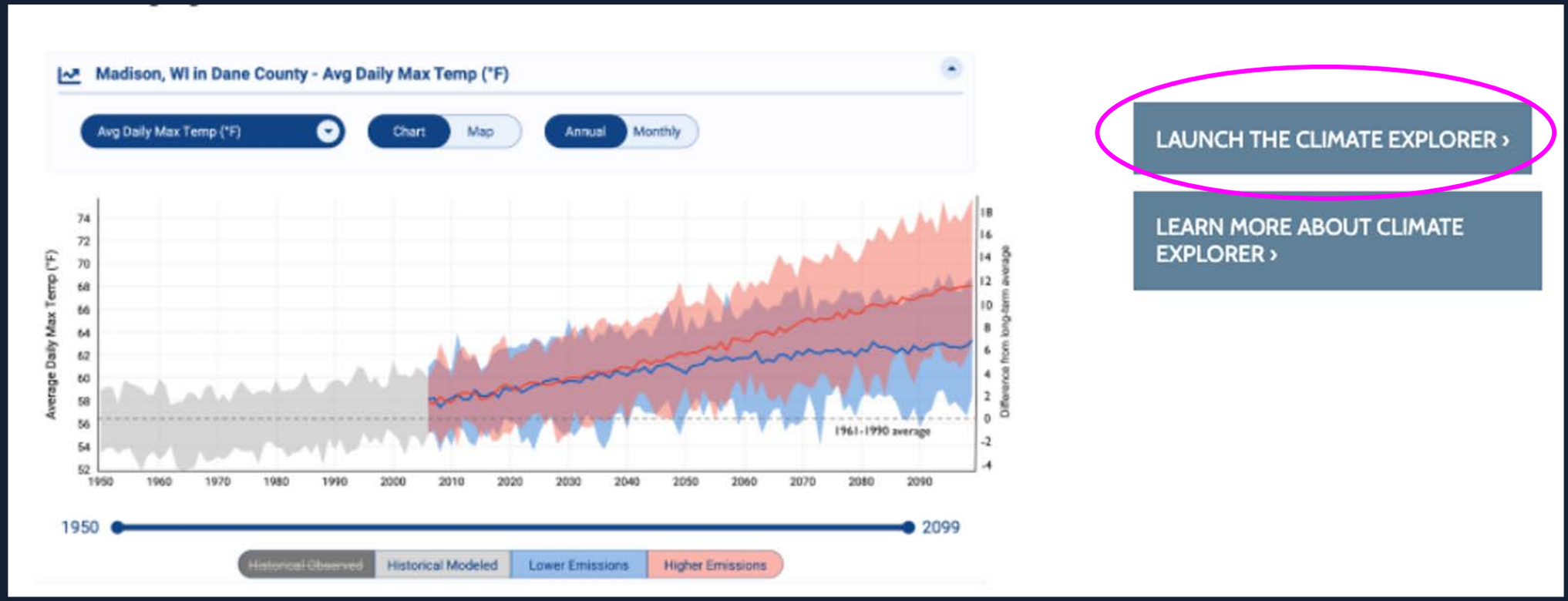
Understand how climate variability and change might threaten the region

Days/year temperature > 95°F (Geneva)



Follow the exercise in your handout

Launch Climate Explorer using the link at the bottom of *toolkit.climate.gov*



The Climate Explorer

Explore graphs and maps of historical and projected climate variables for any county in the contiguous United States.

New!
Climate projection charts are now available for boroughs in Alaska.

Enter the name of the town, county, or zip code you're interested in investigating further

Geneva

- **Geneva** IL, USA
- **Geneva** NY, USA
- **Geneva** AL, USA
- **Geneva** OH, USA
- **Geneva** FL, USA

powered by Google

The Climate Explorer

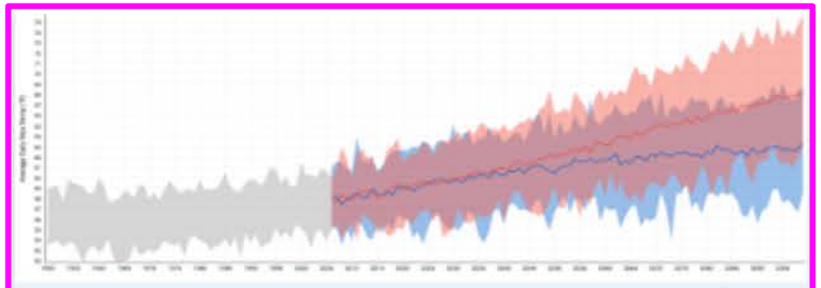
About this site

Geneva, IL

Select one of the following for Geneva, IL in Kane County

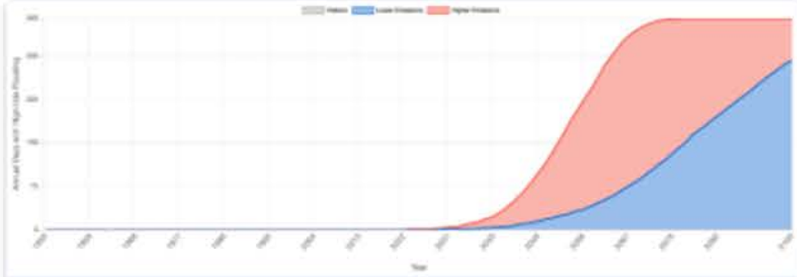
Climate Maps

Compare past and projected future conditions in your county.



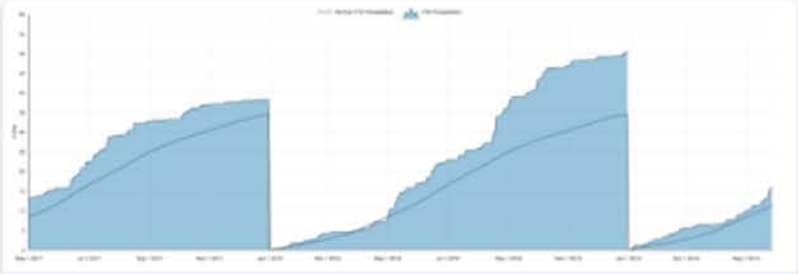
Climate Charts

Check past and projected values for climate variables.



High-Tide Flooding

View the number of high-tide floods in the past and projected for the future.



Historical Weather Data

Compare daily weather at local observing stations to long-term climate.

Historical Thresholds

Check how often temperature or precipitation has exceeded user-defined values.

Choose “Climate Charts” to query downscaled climate data for your region of interest

The Climate Explorer

About this site

Geneva, IL

Stations

Geneva, IL in Kane County - Avg Daily Max Temp (°F)

Avg Daily Max Temp (°F) | Chart | Map | Annual | Monthly | Downloads | About the graph

Temperature

- Avg Daily Max Temp (°F)
- Avg Daily Min Temp (°F)
- Days w/ max > 90°F
- Days w/ max > 95°F
- Days w/ max > 100°F
- Days w/ max > 105°F
- Days w/ max < 32°F
- Days w/ min < 32°F

Choose “Days w/ max > 95 °F”

Average Daily Max Temp (°F)

58 57 56 55

1950 1955 1960 1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070 2075 2080 2085 2090 2095

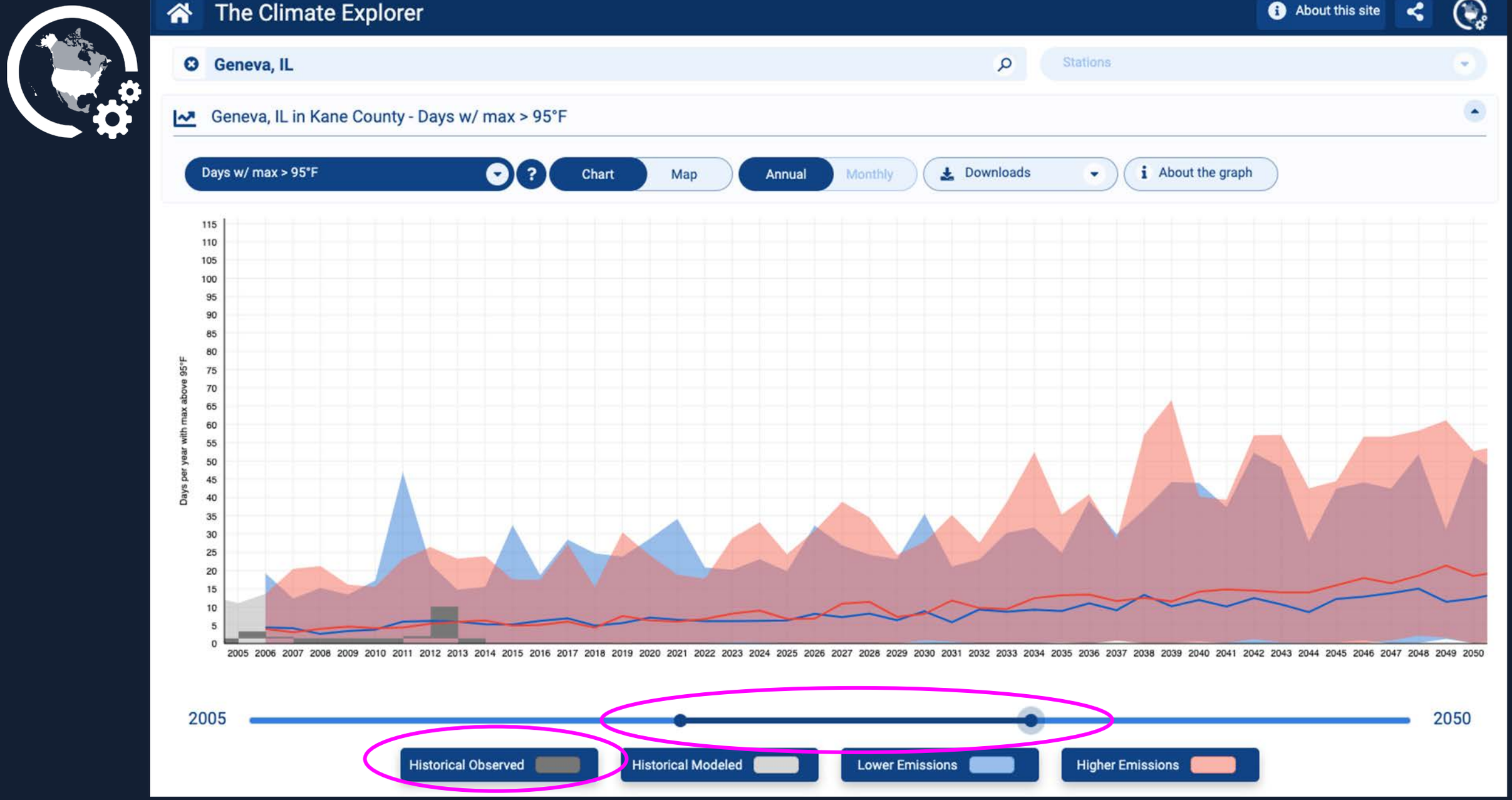
1950 2099

Historical Observed | Historical Modeled | Lower Emissions | Higher Emissions

Region Based

Station Based

Cards Home | Climate Charts | Climate Maps | Historical Weather Data | Historical Thresholds | High-Tide Flooding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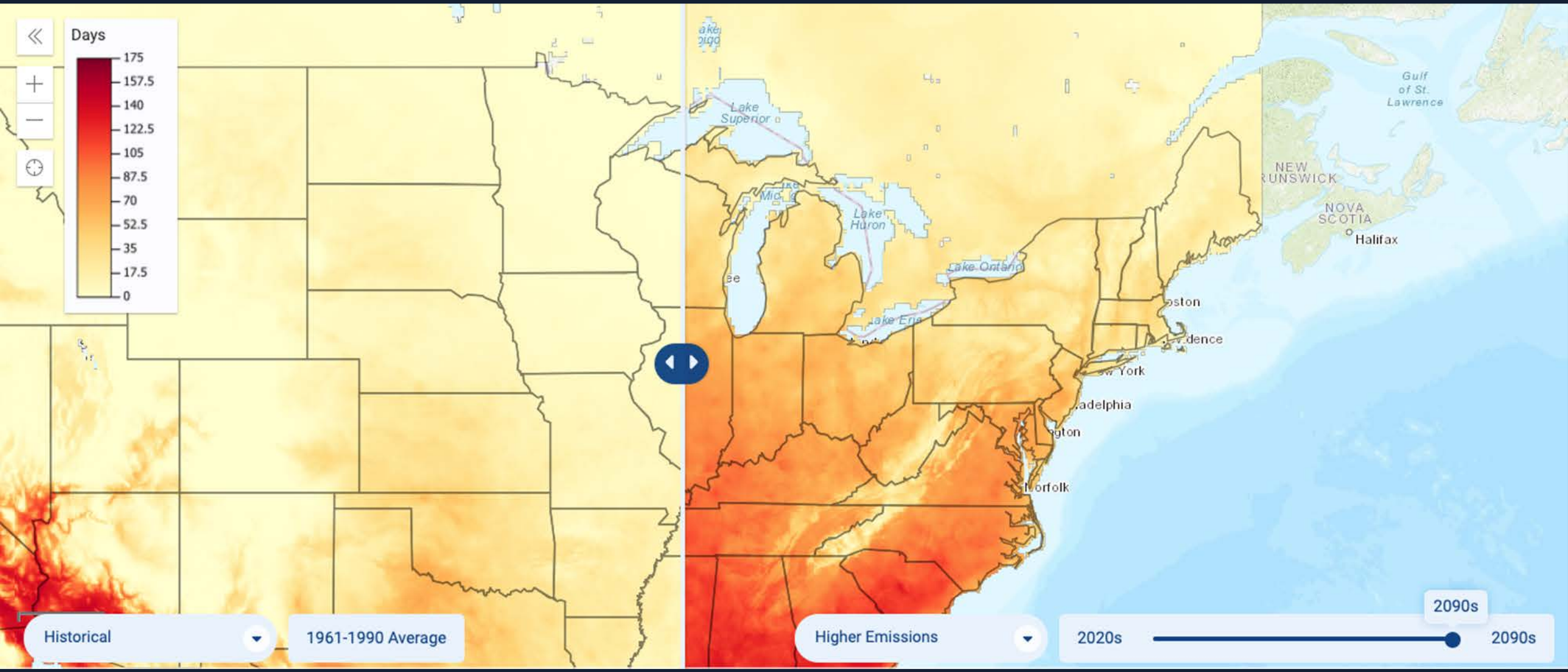
Days per year with max above 95°F
115 110 105 100 95 90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035 2036 2037 2038 2039 2040 2041 2042 2043 2044 2045 2046 2047 2048 2049 2050
2005
2050
Historical Observed
Historical Modeled
Lower Emissions
Higher Emissions

Go to menti.com

Enter code 85 49 73

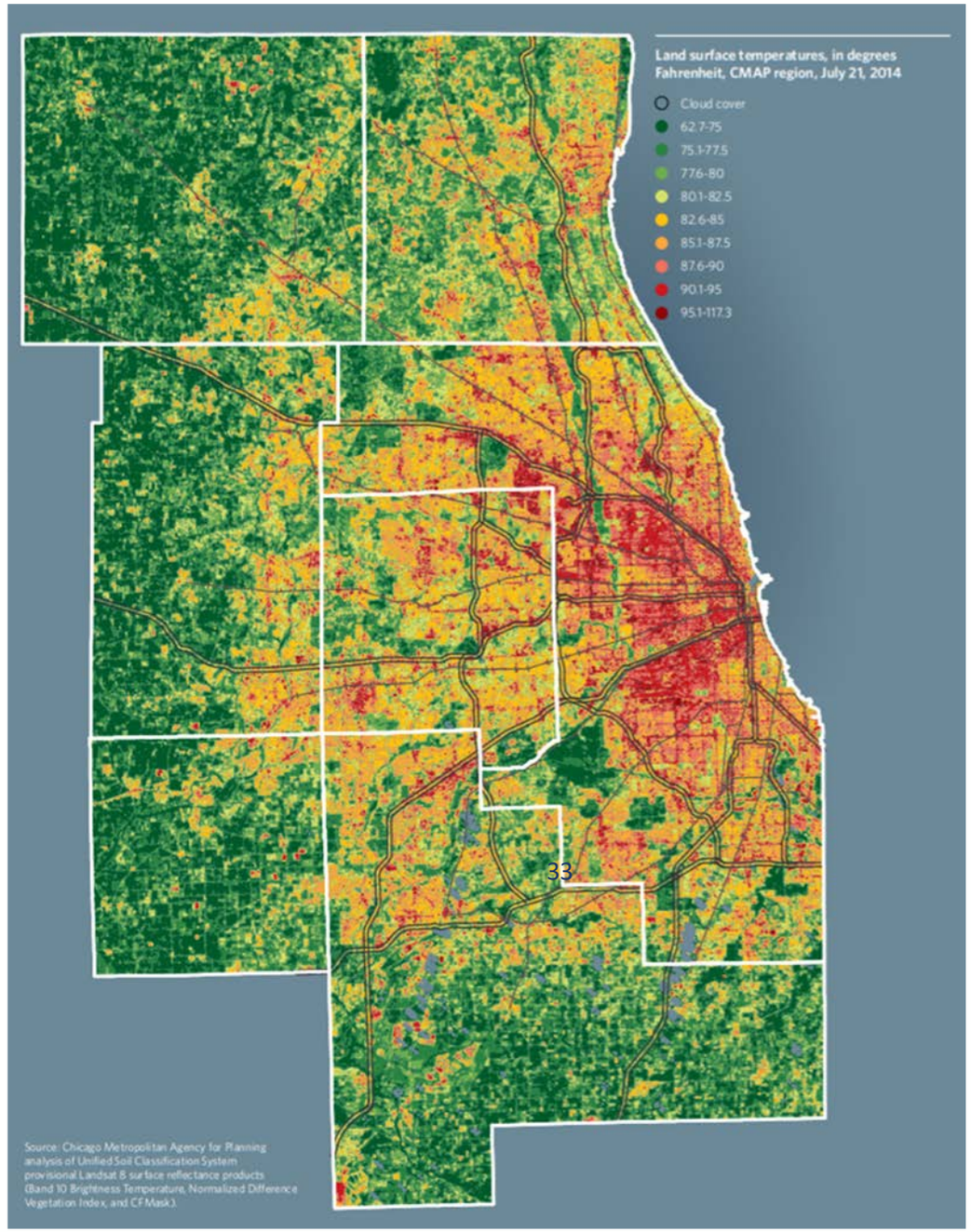
About how many days more of 95-degree temperature by 2050?

Demonstration: regional climate change

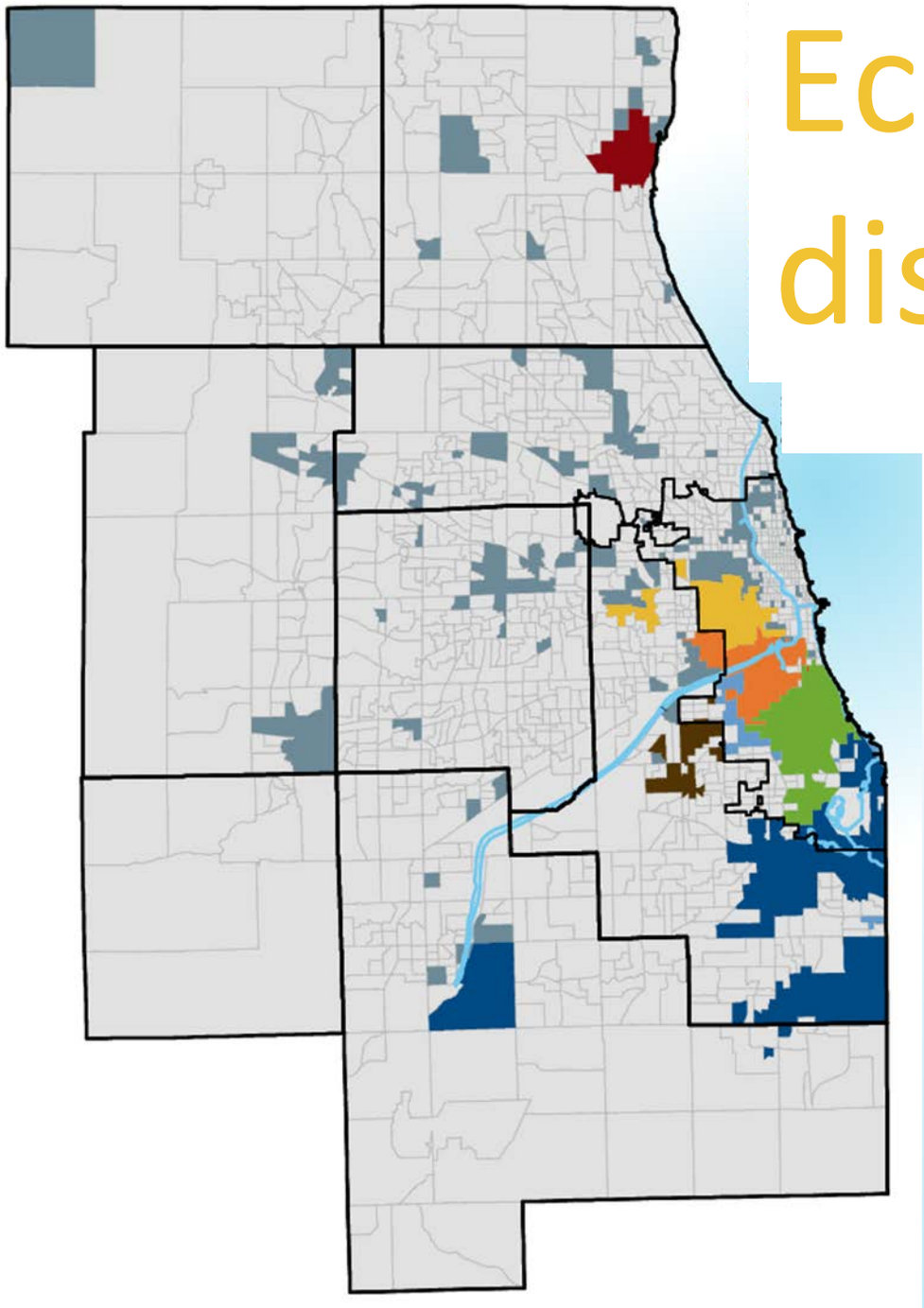


Extreme heat

- *Heat island is closely linked to development intensity and design*
  - *-Impervious surfaces*
  - *-Dark surfaces*
- *Occurs in summer and winter*

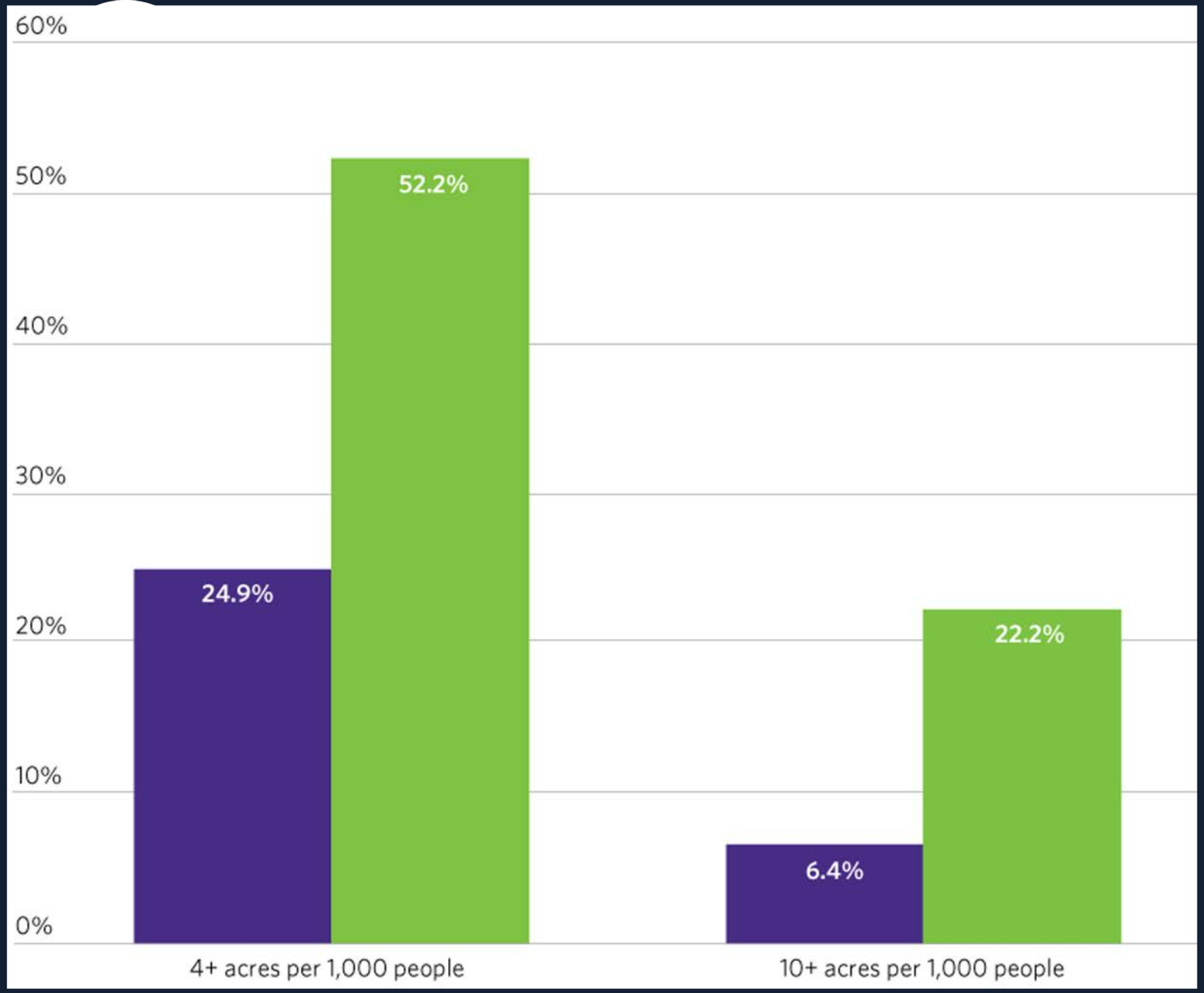


Economically disconnected areas



- Waukegan area (Cluster 1)
- SW suburbs (Cluster 2)
- S. Chicago (Cluster 3)
- SW Chicago (Cluster 4)
- W. Chicago (Cluster 5)
- S. suburbs and Joliet (Cluster 6)
- NW Chicago and remaining collar counties (Cluster 7)
- Tracts

Population, Equity, Heat Islands: Access to Parks within Region



Key

Population in EDAs and Disinvested Areas

Population in rest of the region

Source

CMAP analysis of data from the CMAP Land Use Inventory and the United States Census Bureau's 2010 Census.

Explore Hazards

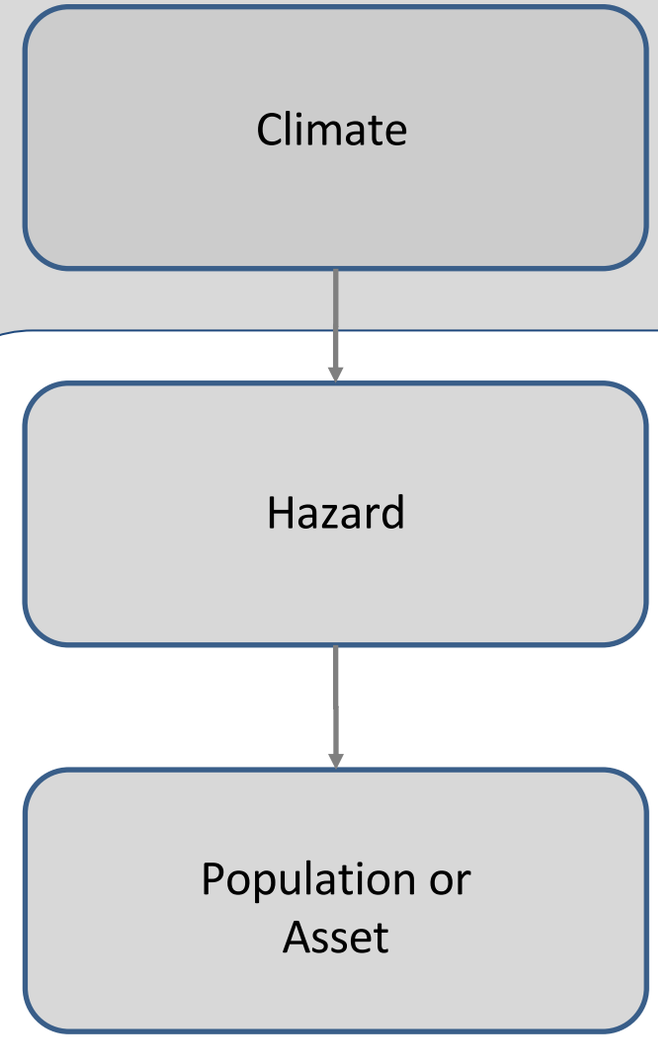
- *Gather a team of people who want to protect local assets.*
- *Check past weather events and future climate trends.*
- *List the things you value that could be damaged.*
- *Determine which of your assets are exposed to harm.*

Do weather and climate represent a hazard to things you value?

Climate and impact assessments

Climate

describes the frequency and severity of **hazards**



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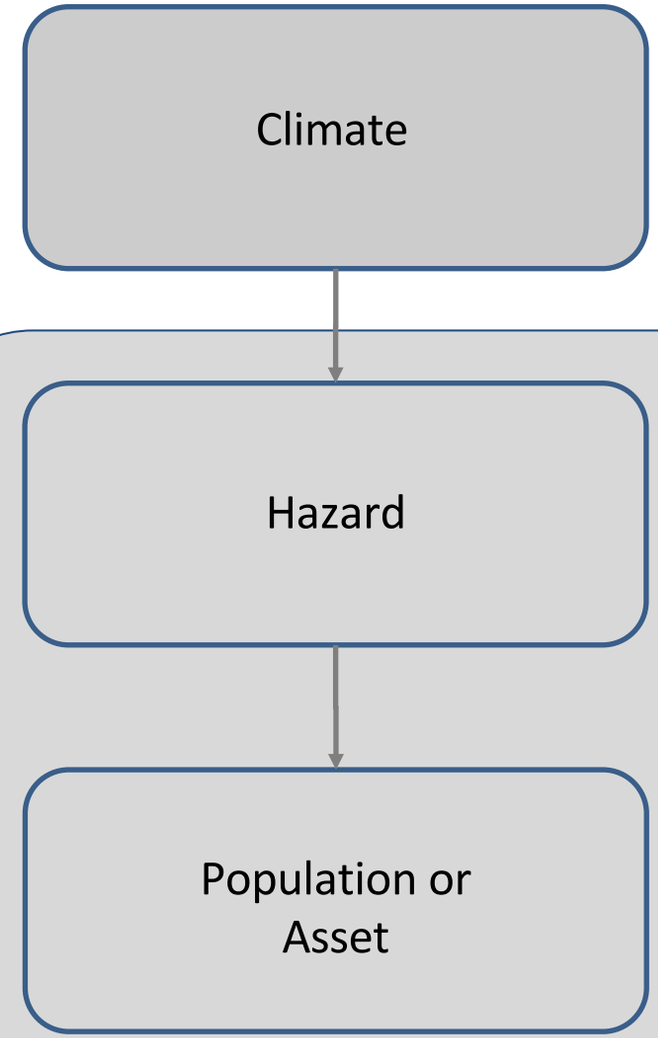


Impacts

involve both a **hazard** and an **asset**

Climate Impacts on the Chicago Metropolitan Region

Downscaling

Dr. Rao Kotamarthi

Chief Scientist, Environmental Sciences Division
Argonne National Lab

Argonne NATIONAL LABORATORY

ENVIRONMENTAL
SCIENCE
DIVISION

Downscaling

RAO KOTAMARTHI

Chief Scientist
Environmental Science Division

High Resolution Output For Adaptation Planning

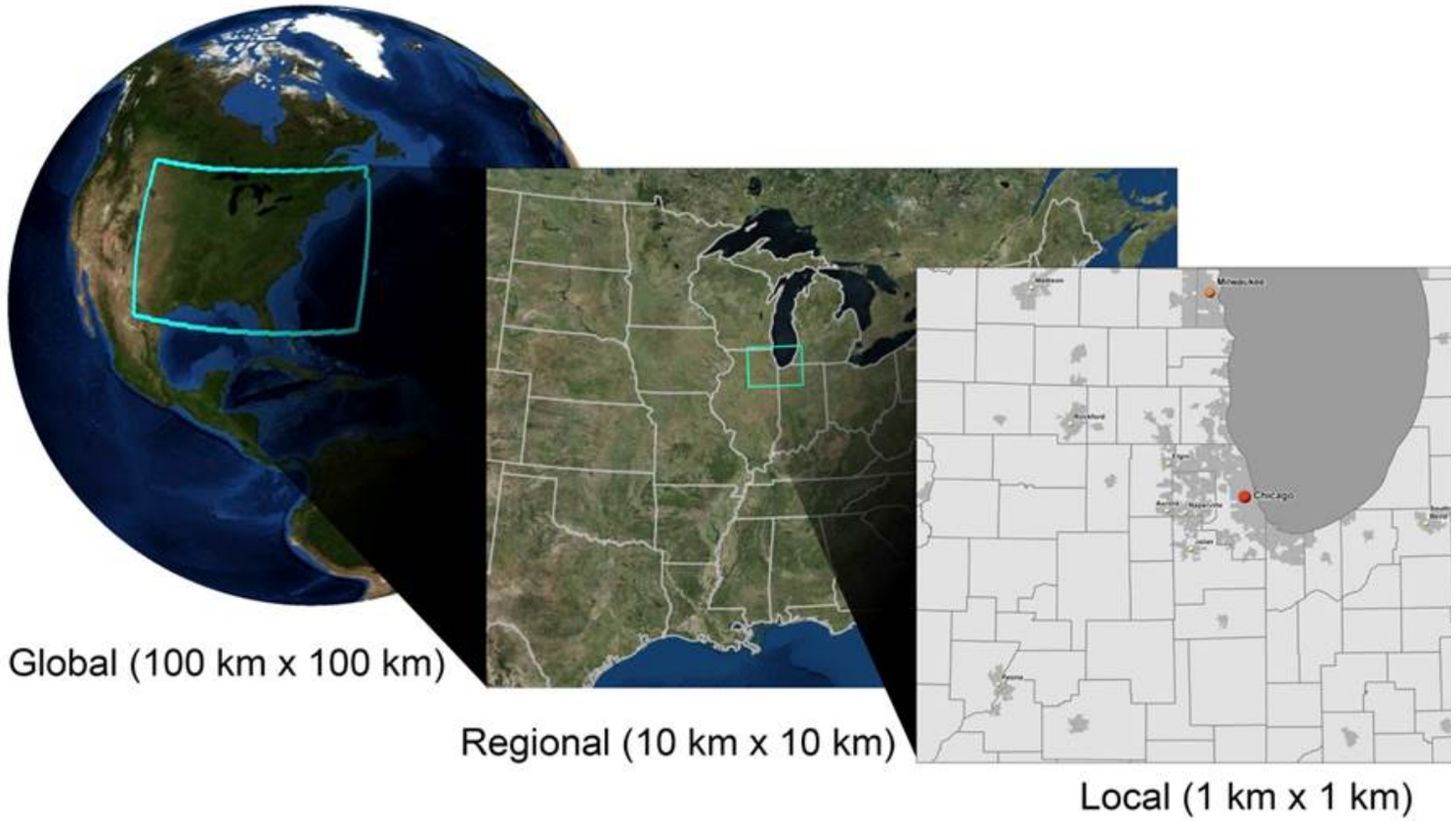
Information is needed at the point of action

Infrastructure Scale

Installation Scale

Urban Scale

Operations Scale



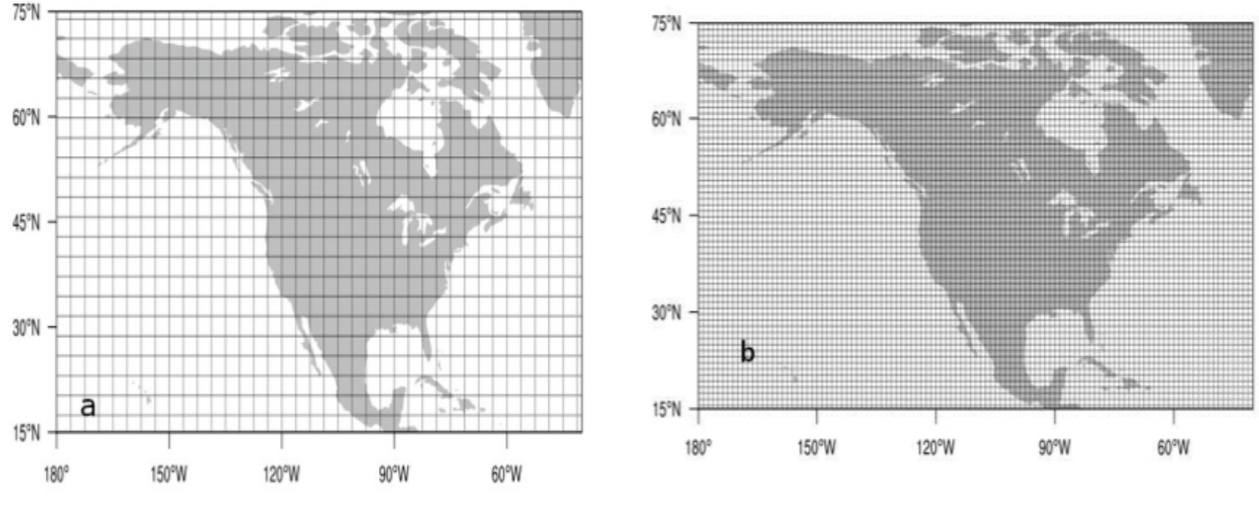
Spatial Scales For Climate Modeling

What is downscaling?

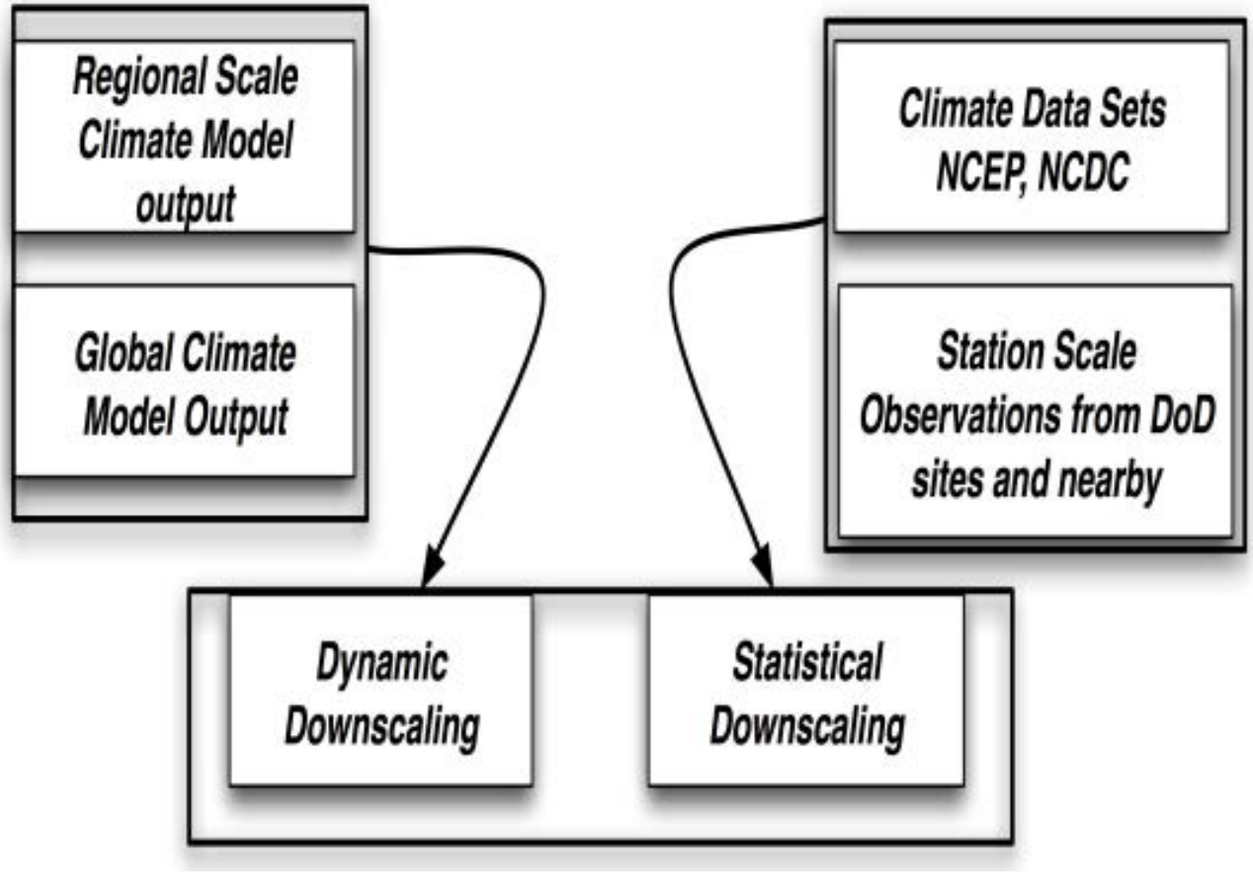
Downscaling is a process of rescaling coarse resolution (space and time) to a desired spatial and time scales for use in climate assessments and adaptation needs.

Downscaling approaches are selected based on their ability to reduce differences between model and observations (bias) and add new information to the dataset that is not available from a GCM output

The new information is gained by performing either a (1) using a higher resolution modeling of physical processes, or (2) correcting model bias using historical observations and carrying that forward.



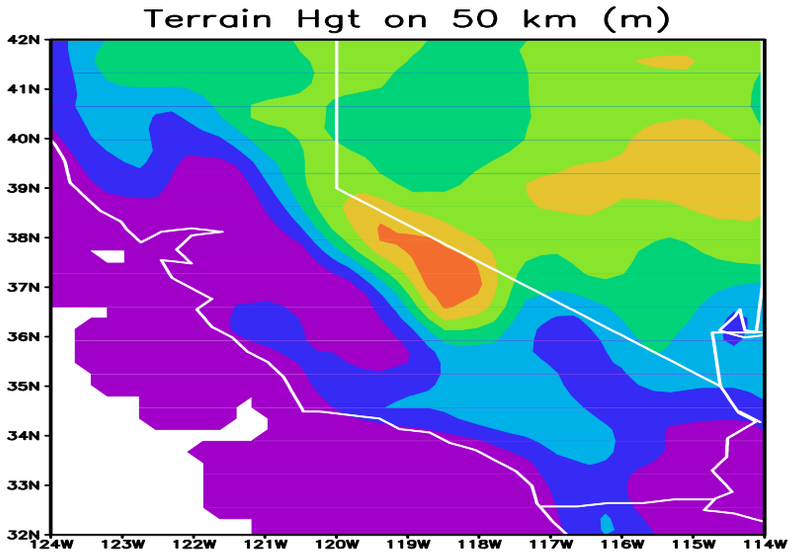
Two approaches to downscaling

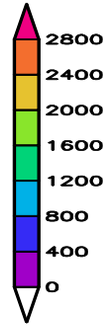


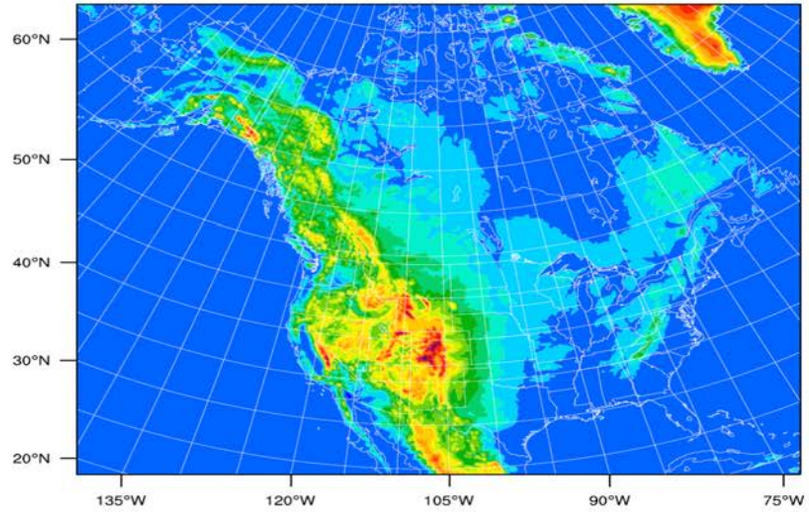
More info from higher-resolution modeling

More info from historical observations

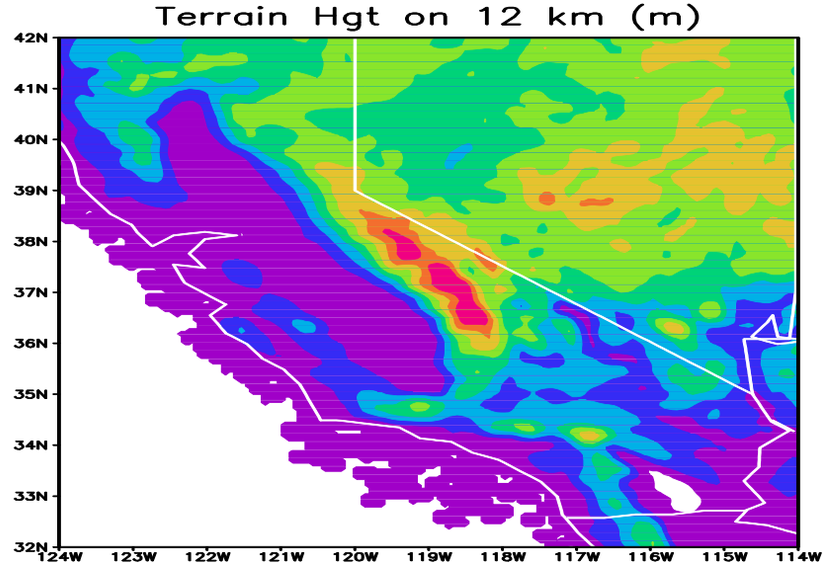
Dynamic Downscaling







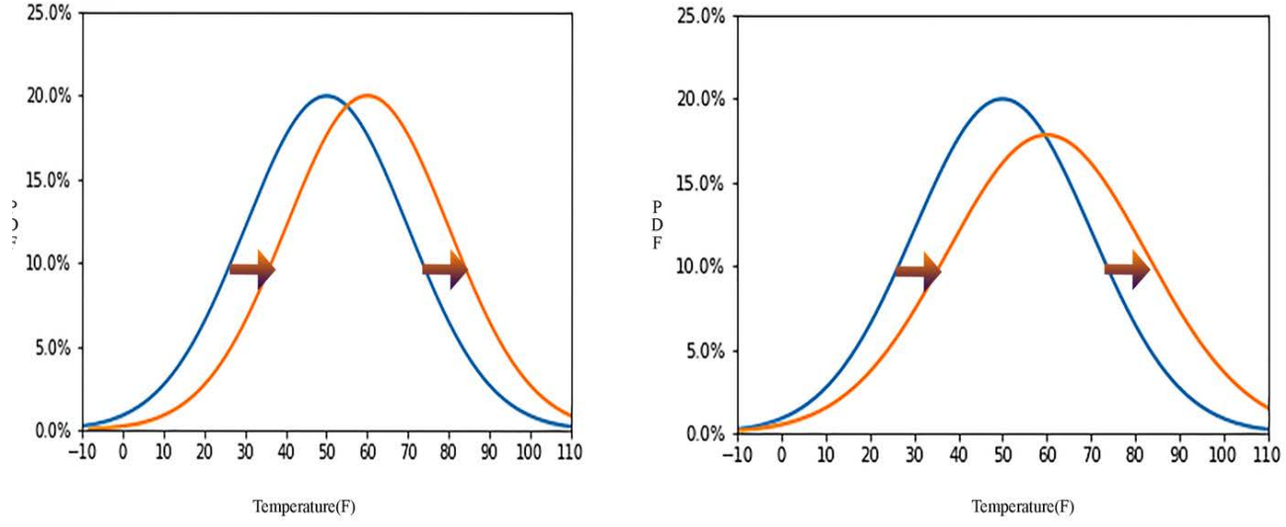
Model Covers North America/CONUS



Needs High Performance Computing Resources

Empirical-Statistical Downscaling Models

- Encompass a broad range of techniques
- Develop statistical relationships between historical GCM and OBS
- Use these relationships to downscale future GCM projections
- Generate projections at spatial scale of observations, including both grids and individual weather stations



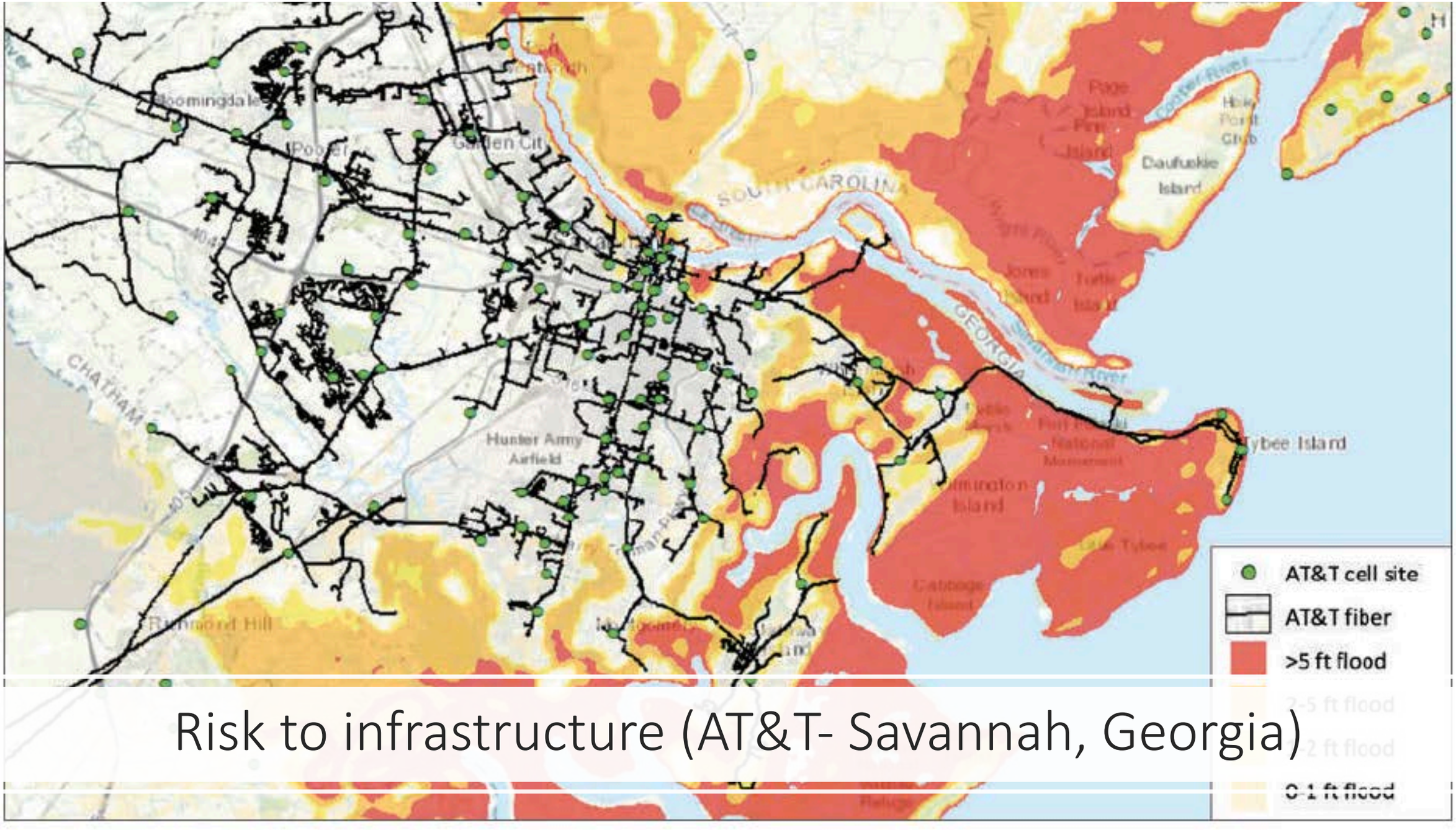
A conceptual diagram illustrating the delta approaches to statistical downscaling where (a) a single mean change factor, and (b) a change factor plus a scaling factor derived from a GCM simulation is applied to the observed historical distribution(blue) to create future projections (range) at the spatial and temporal scale of the observations.

DYNAMIC

- Many variables
- Computationally expensive
- Require additional bias correction
- Can be used even if observations lacking
- Don’t need to assume stationarity at scale of resolved processes

STATISTICAL

- Often limited to T,P
- More computationally affordable
- Incorporate bias correction into model
- Limited by available observations
- Assume GCM-OBS relationship holds in the future

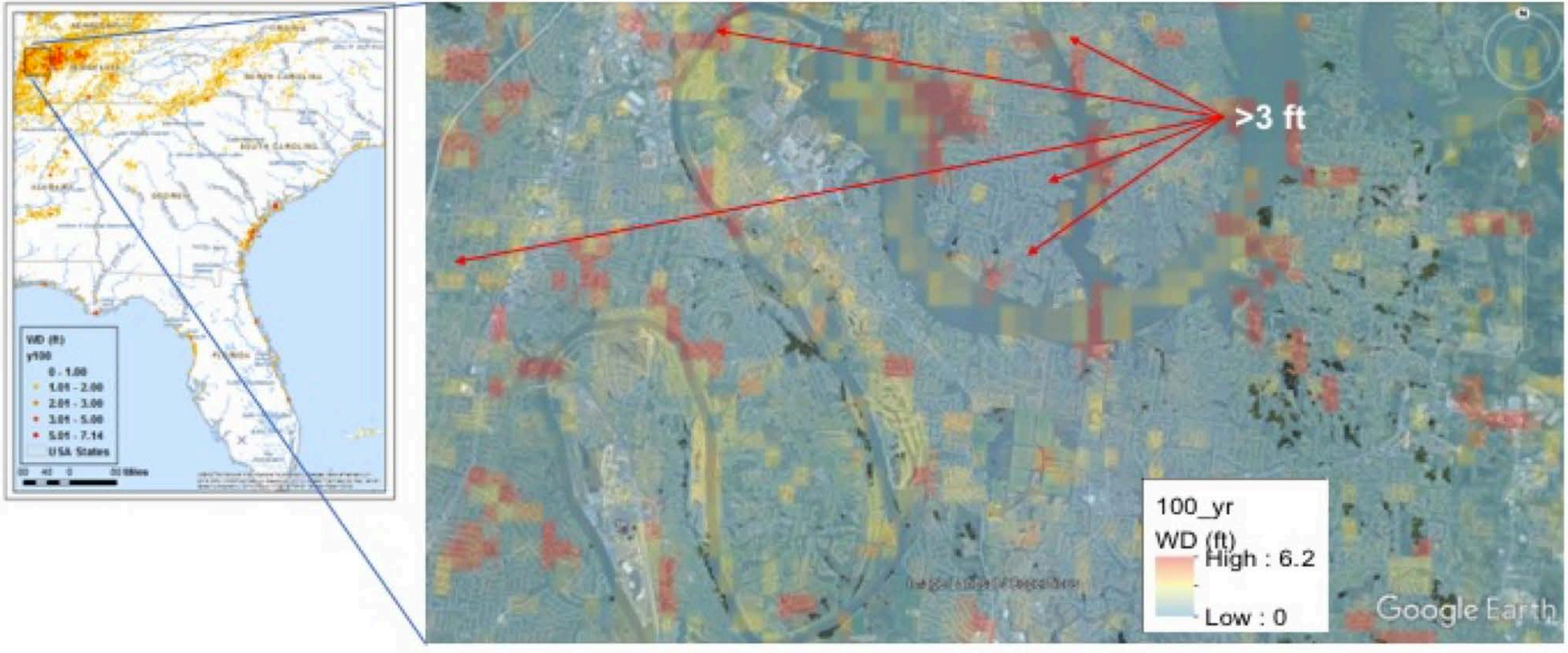


Risk to infrastructure (AT&T- Savannah, Georgia)

Visualization of flooding data overlaid on AT&T fiber and cell sites.

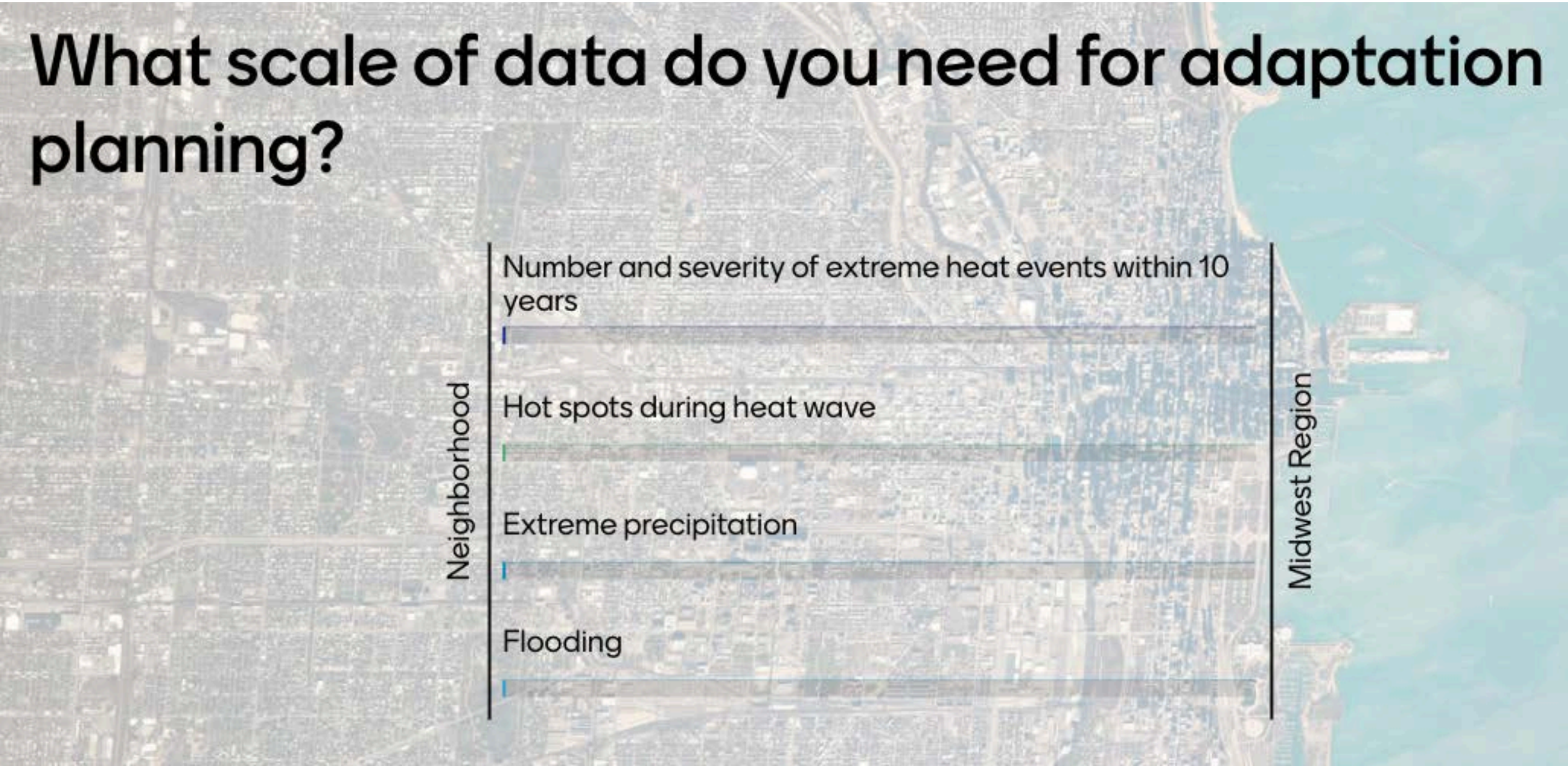
Risk Projections at Neighborhood scale

Predicted inland 100-yr water depth



Thanks

Go to menti.com Enter code 85 49 73



Climate Impacts

Climate Change in the Chicago Region

Donald J. Wuebbles, PhD.

The Harry E. Preble Professor of Atmospheric Sciences

& Presidential Fellow,

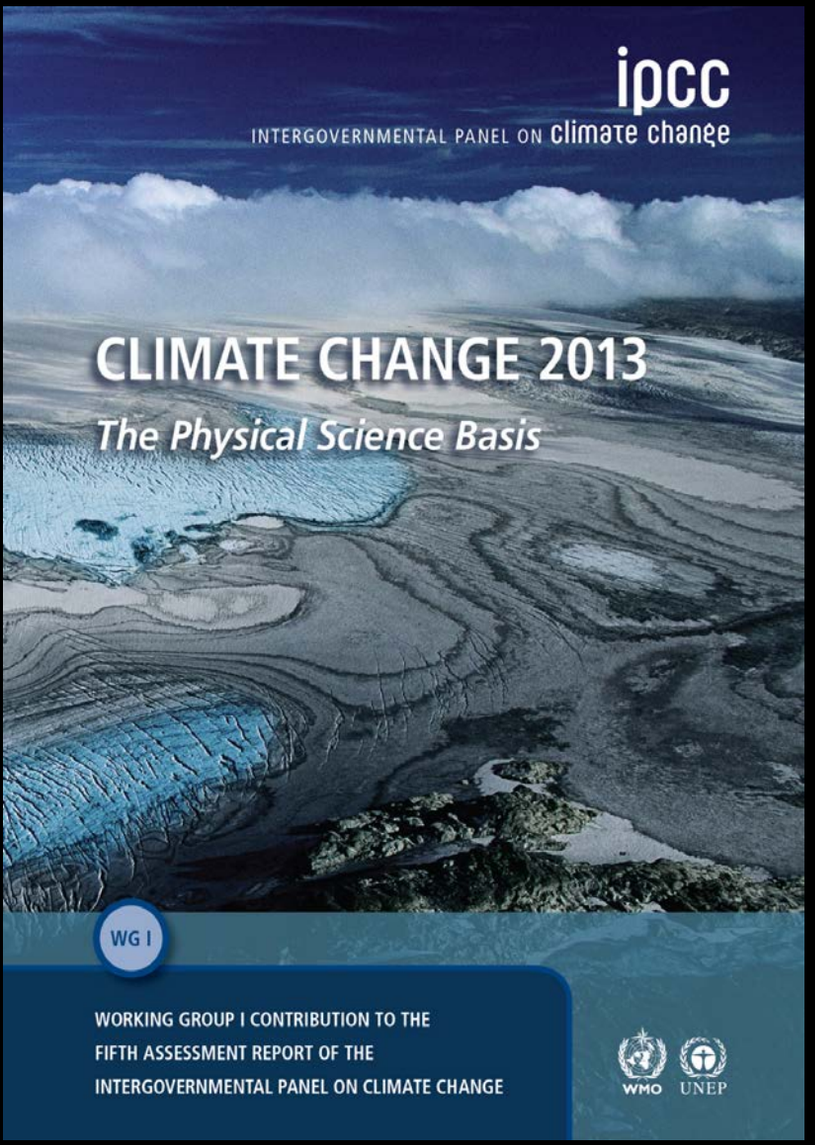
University of Illinois

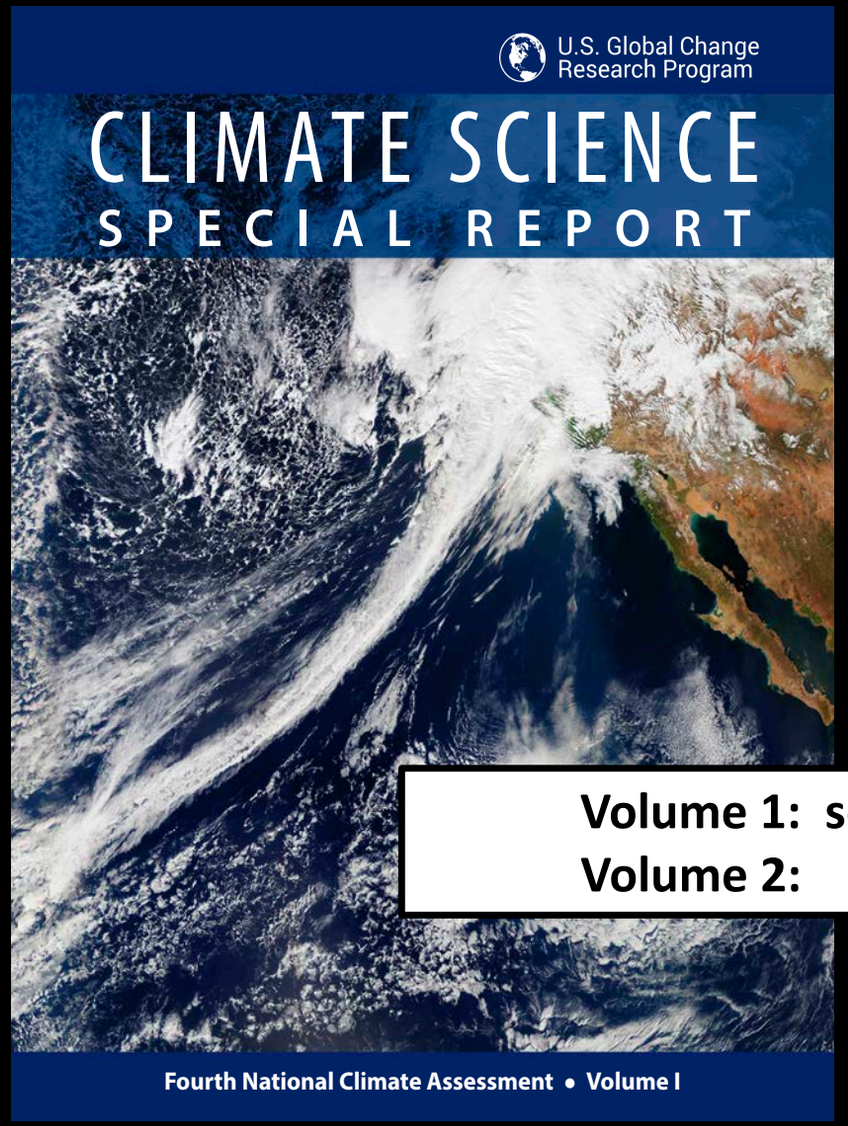
Climate Change in the Chicago Region

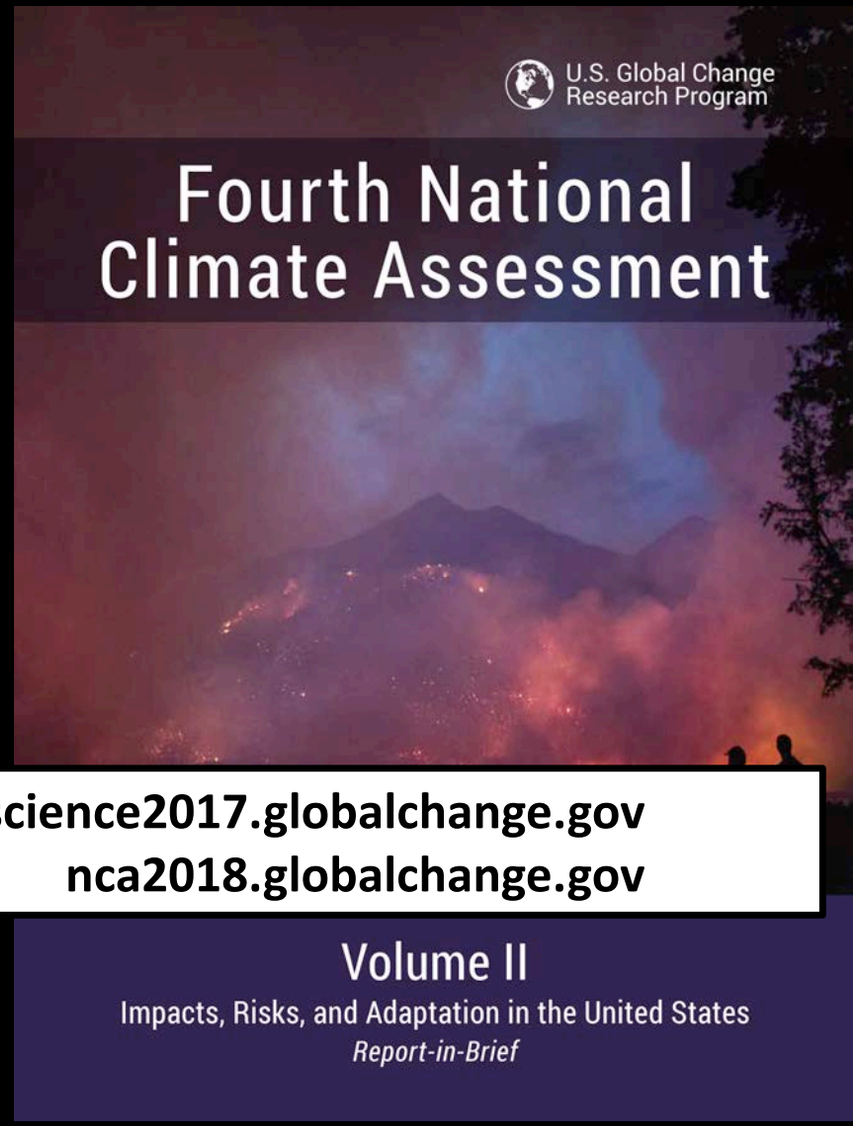
Don Wuebbles
University of Illinois
Urbana, IL

MMC May 29, 2020

Every 4-6 Years Scientists Assess the Science of the Changing Climate and its Societal Impacts







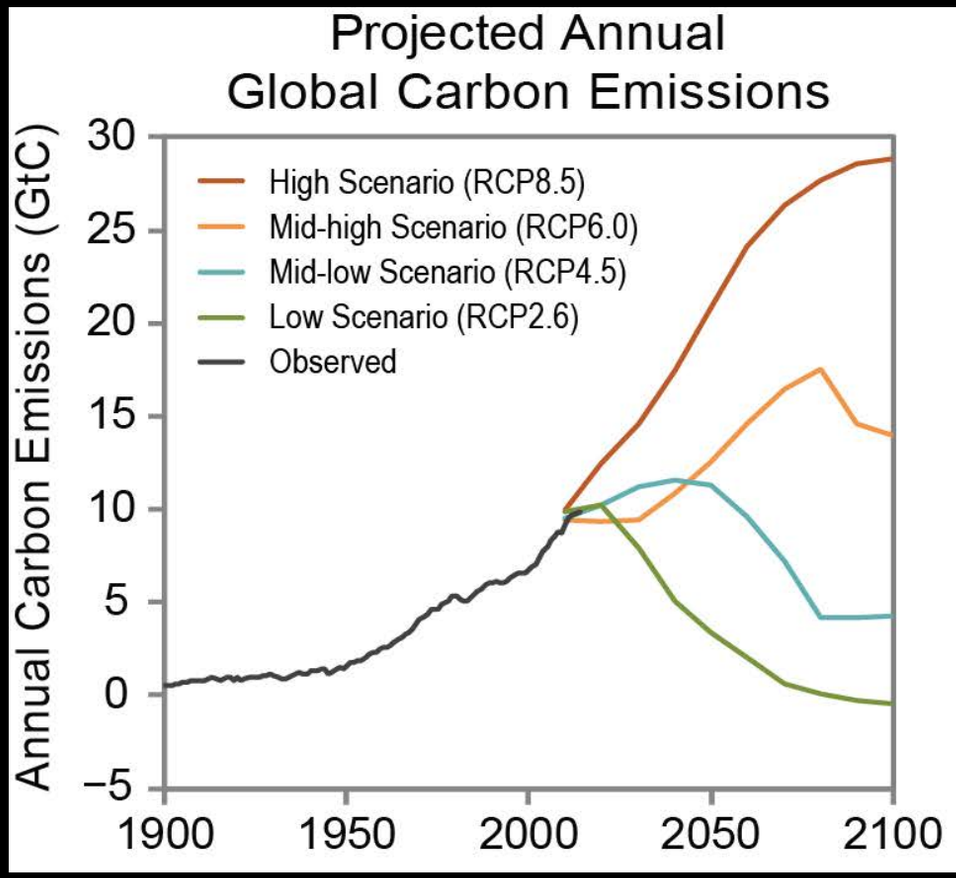
Volume 1: science2017.globalchange.gov
Volume 2: nca2018.globalchange.gov

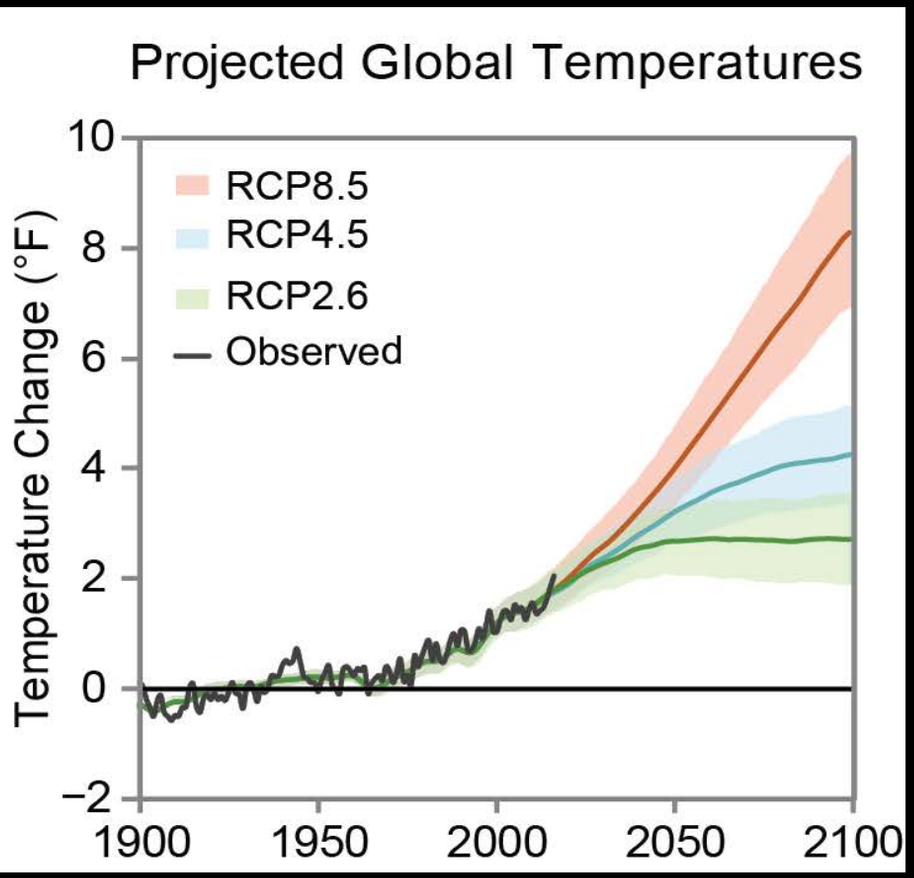
The Science: The Bottom Line

- Our climate is changing,
  - It is happening now;
  - It is happening extremely rapidly;
- Severe weather is becoming more intense;
- Sea levels are rising and oceans affected;
- It is largely happening because of human activities and associated pollution;
- The climate will continue to change over the coming decades.

The Forecast: Climate will Continue to Change

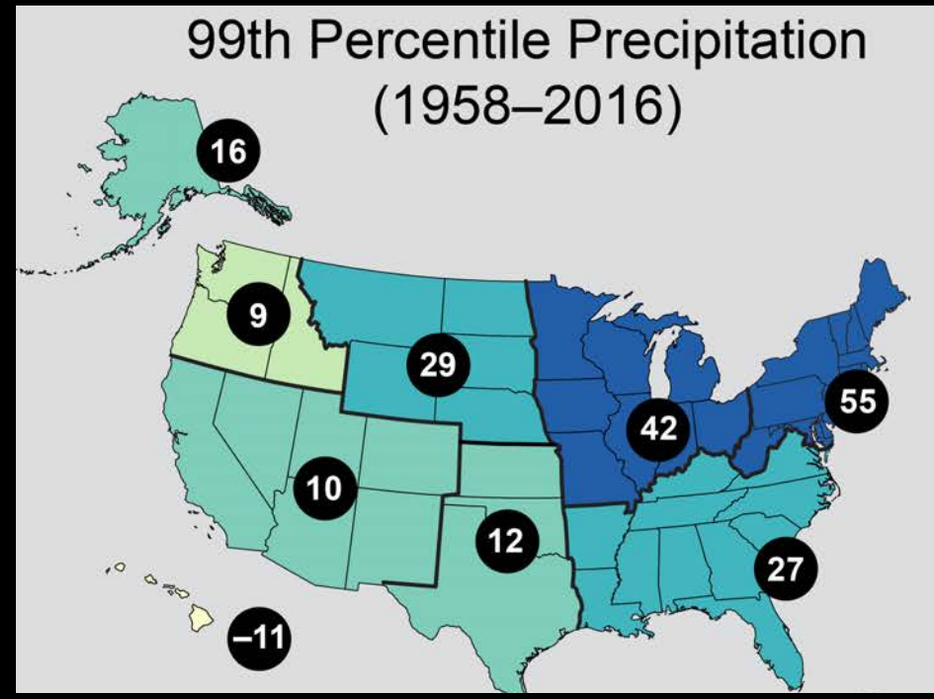
Climate change beyond the next few decades depends primarily on the **heat-trapping gases emitted** and the remaining uncertainty in the **sensitivity of Earth's climate** to those emissions.



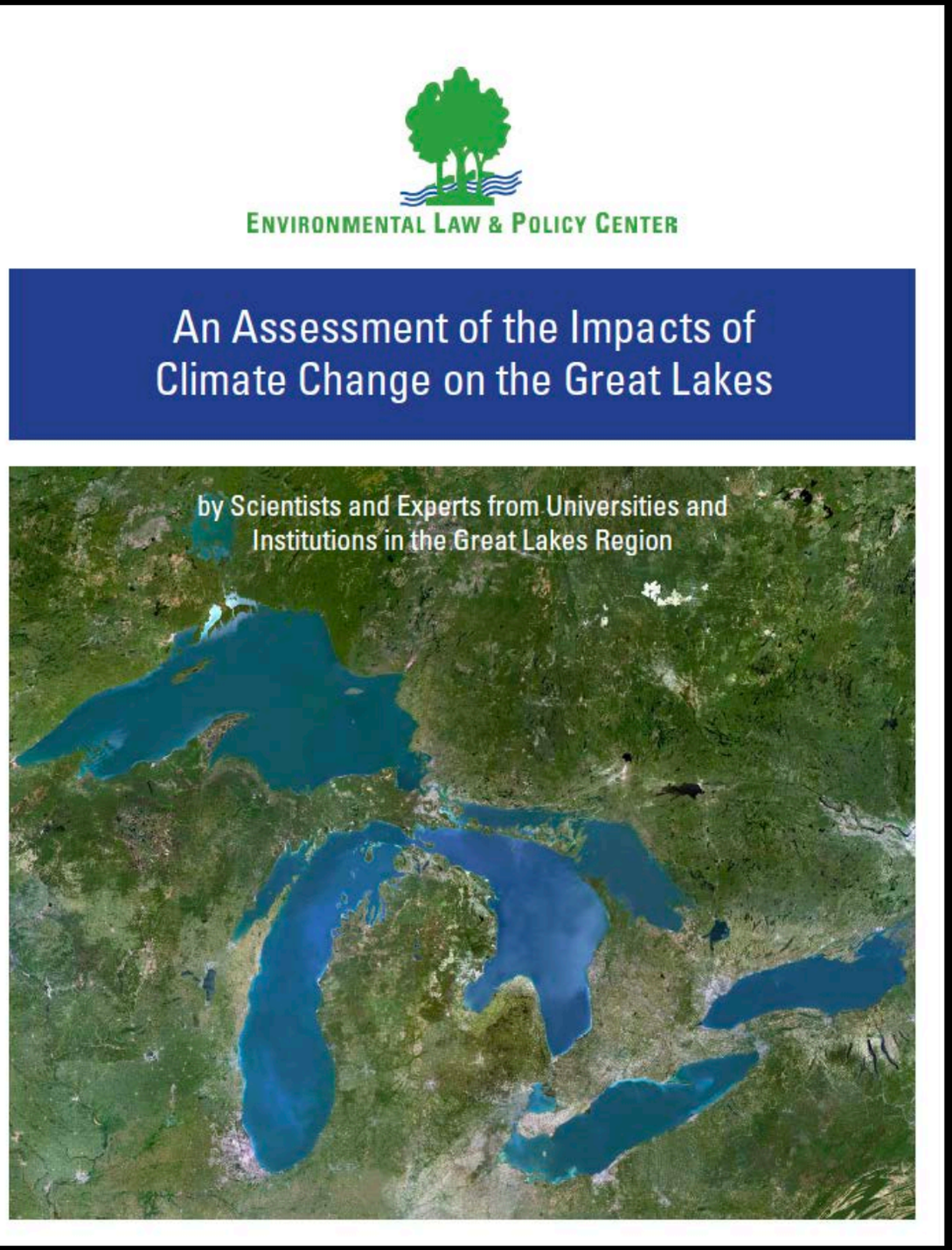


Certain Types of Extreme Events Show Important Trends Globally and in United States

- Heat waves are generally increasing in number and intensity;
- Cold waves are decreasing.
- More precipitation coming as larger events.
- Increasing risk of floods (NE, MW).
- Increasing intensity of droughts (SW, SE).
- Incidence of large wildfires has increased (esp. West, Alaska)
- Increasing intensity of hurricanes expected.
- Tornado activity more variable – increase in outbreaks.



These trends are expected to continue.



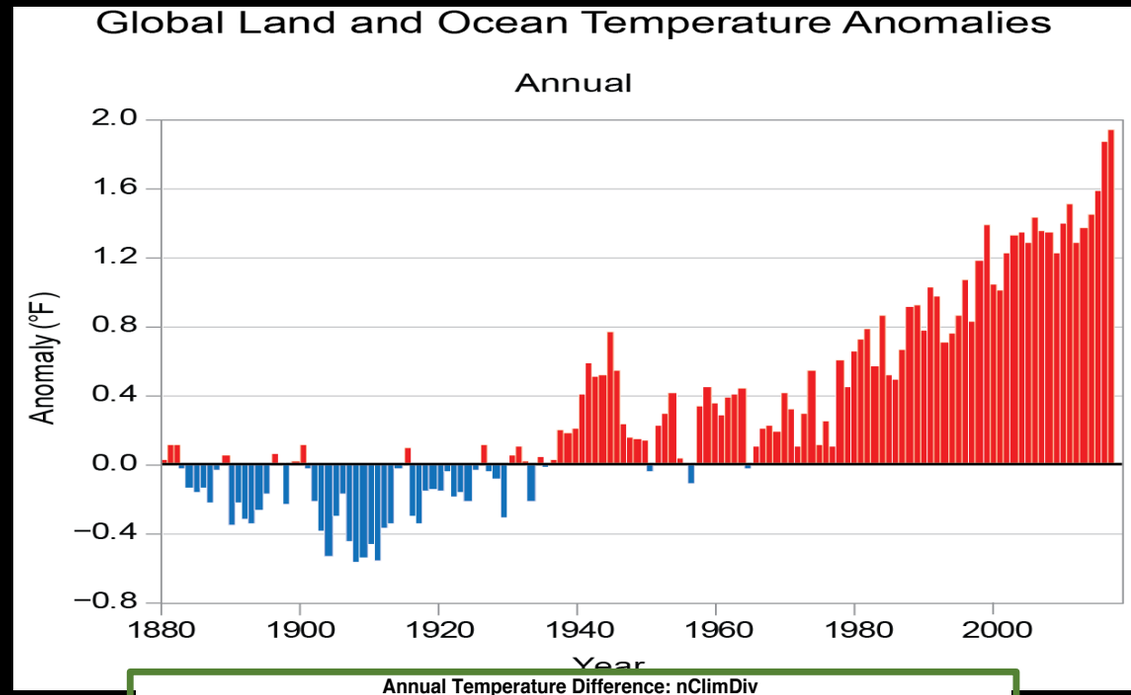
More Recent Assessment

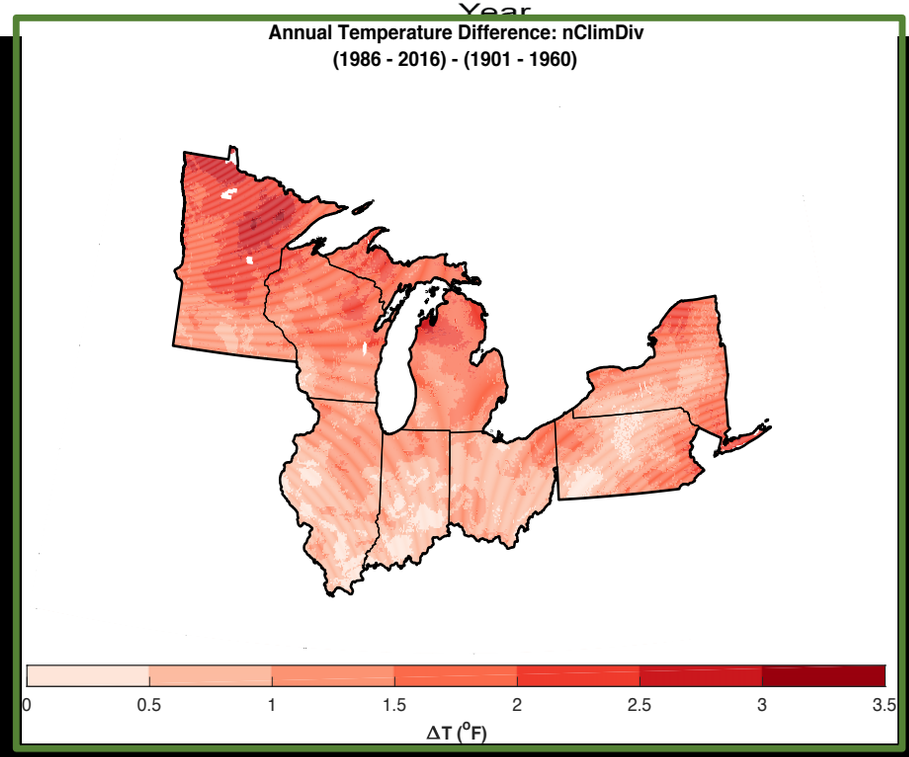
Assessment of the Great Lakes Region published in March 2019

Ongoing Assessment of Illinois being done for TNC to be published later this year.

Temperature in Great Lakes Region

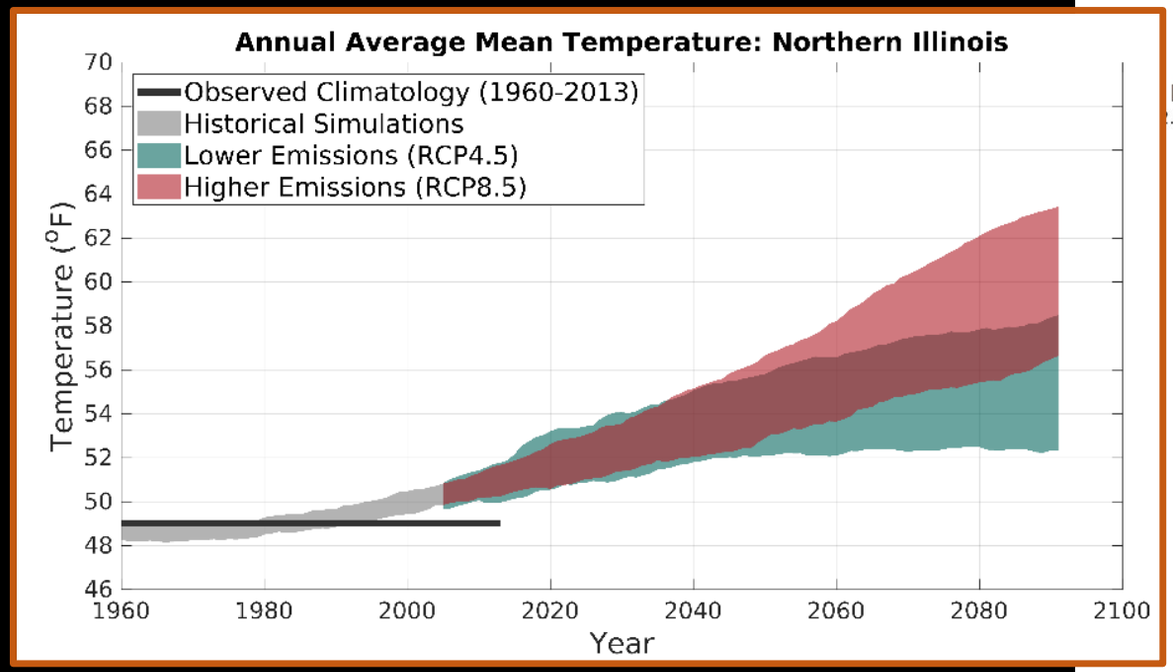
- Climate change is already affecting both the climate of the Great Lakes region and the physical behavior of the Great Lakes themselves.
- Since 1901, temperature has increased 1.8°F since 1901.
- Temperature in U.S. part of the Great Lakes region has changed by 1.4°F for 1985-2016 relative to 1901-1960.





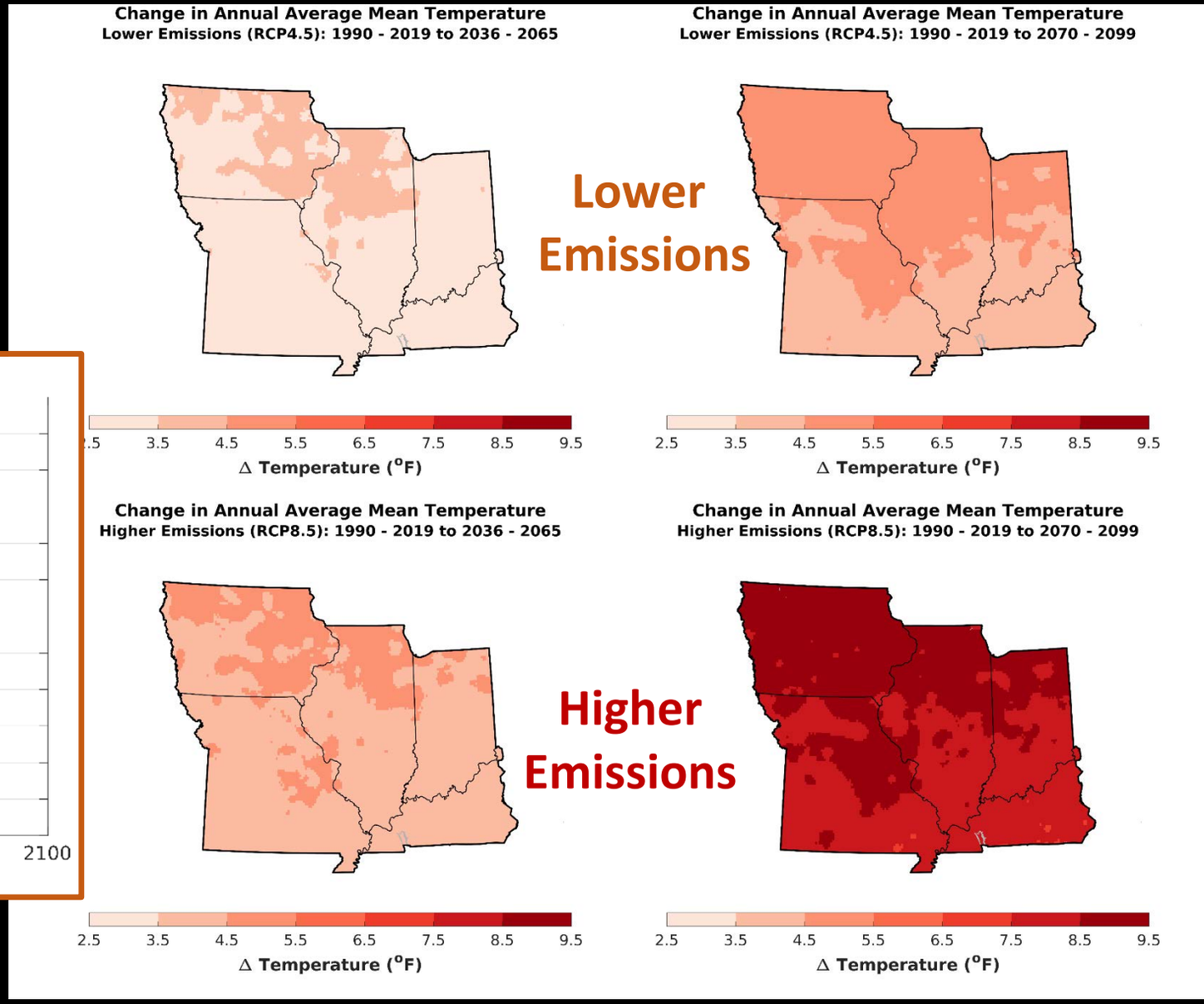
Projected Annual Average Temperature

Northern Illinois



Mid-21st Century

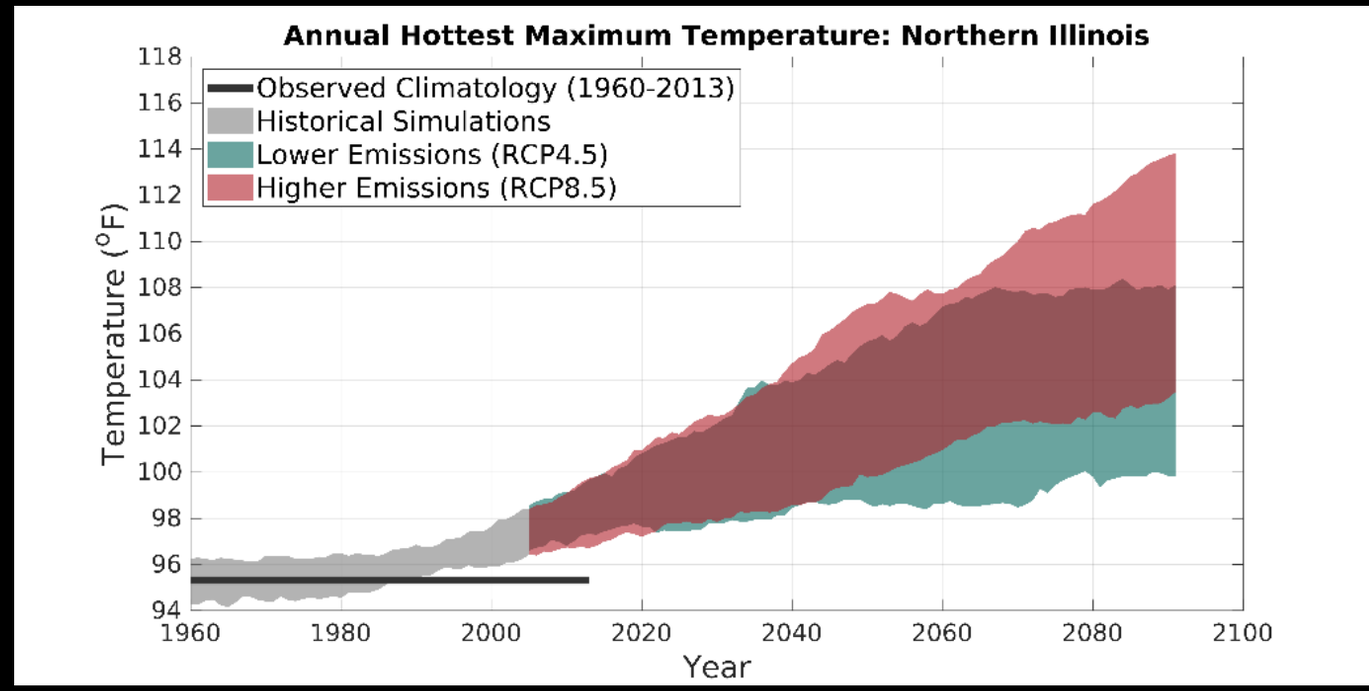
Late 21st Century

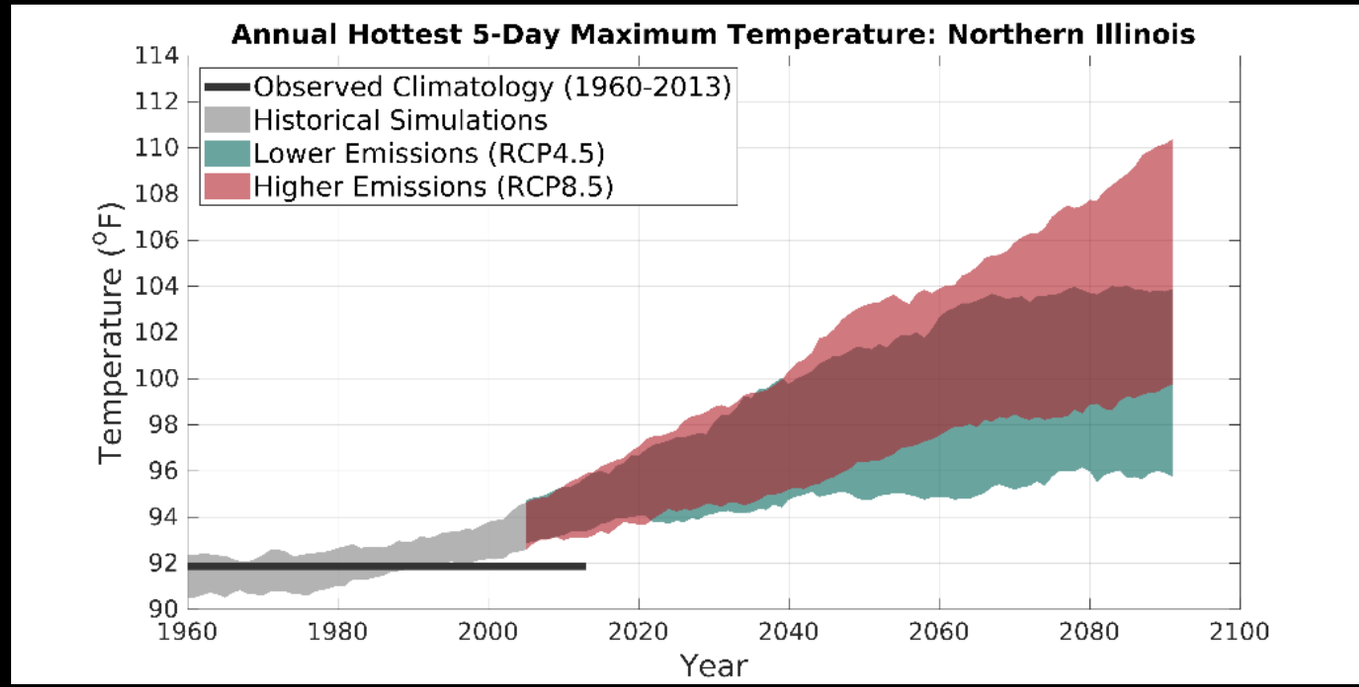


Annual Hottest Maximum Temperature

Northern Illinois

Annual Hottest 5-Day Maximum Temperature

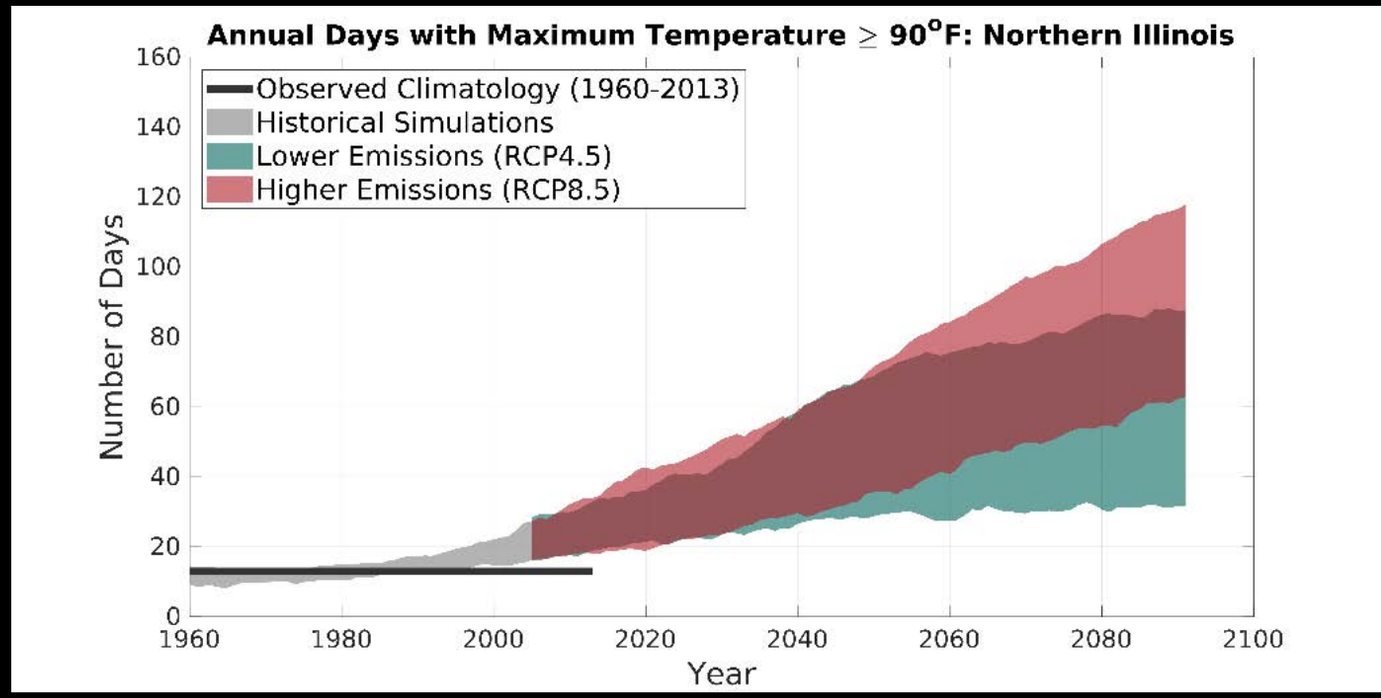


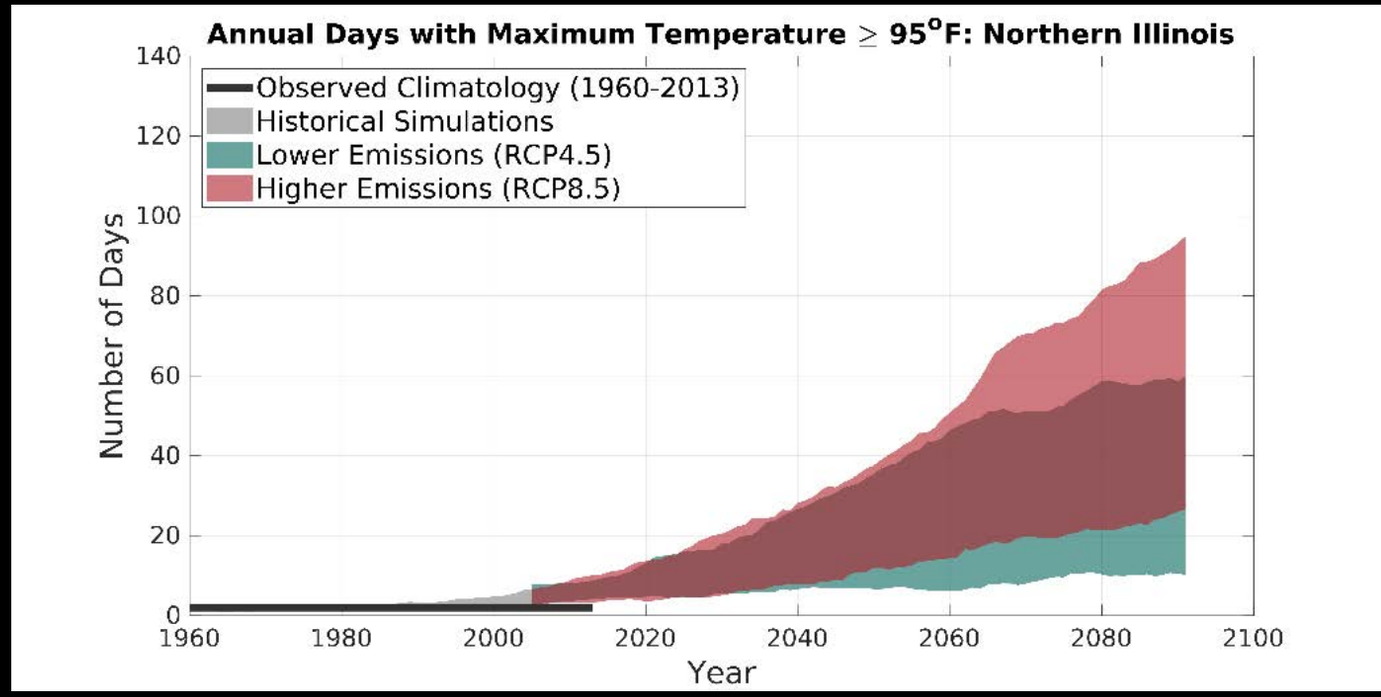


Annual Number of Days with Maximum Temperature ≥ 90°F

Northern Illinois

Annual Number of Days with Minimum Temperature ≥ 95°F

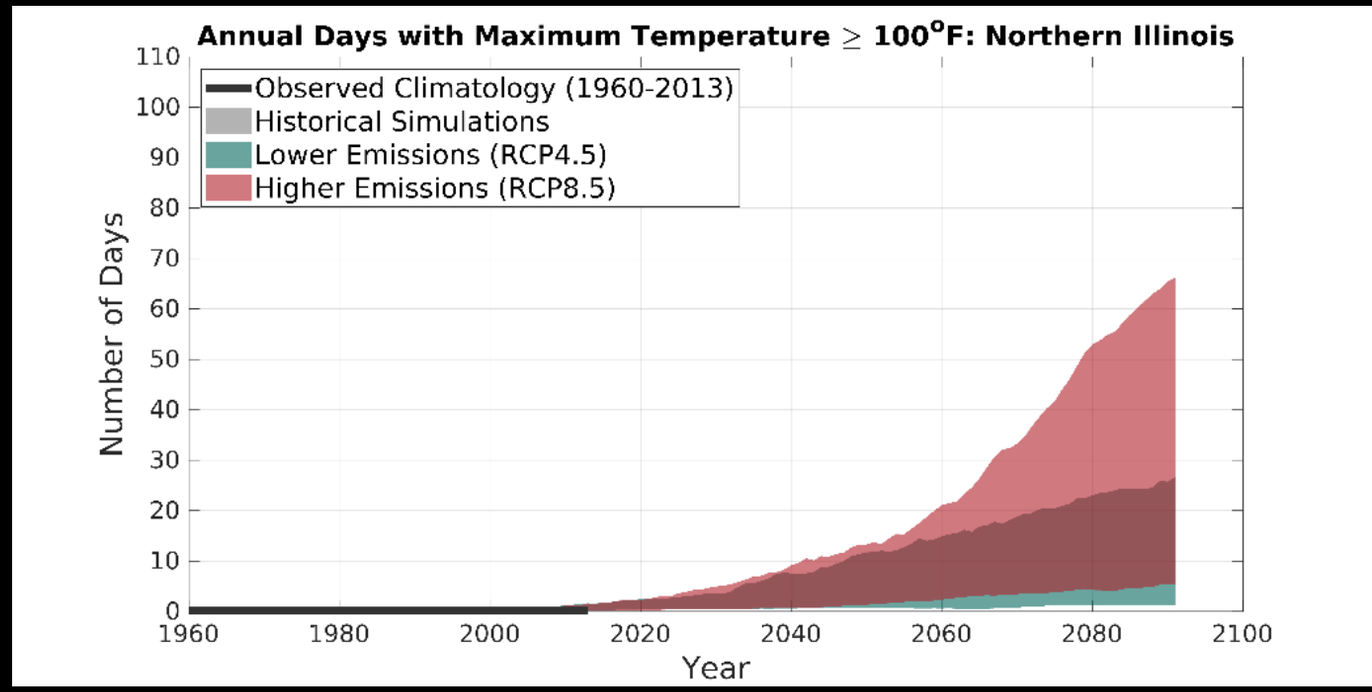


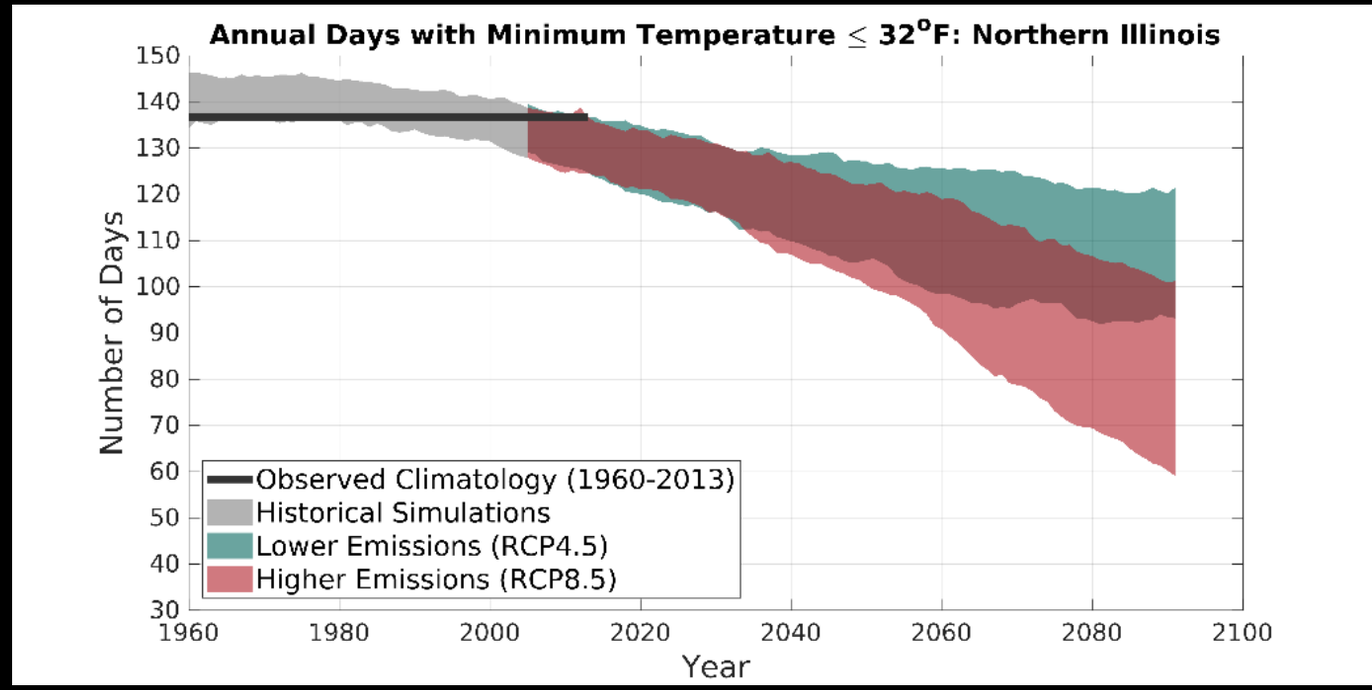


Annual Number of Days with Maximum Temperature ≥ 100°F

Northern Illinois

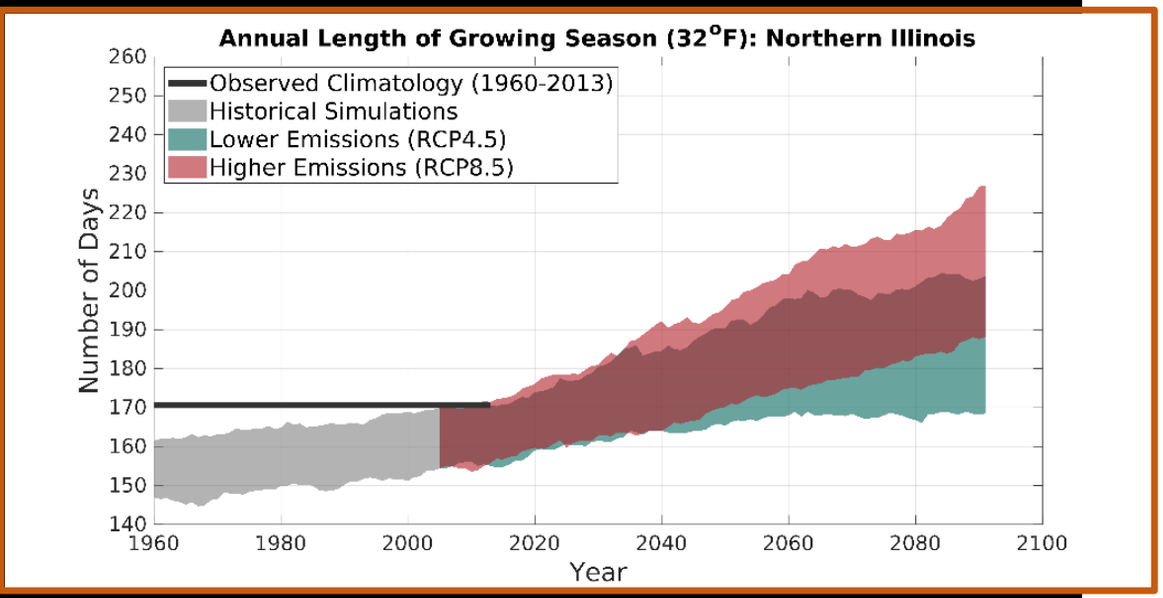
Annual Number of Days with Minimum Temperature ≤ 32°F



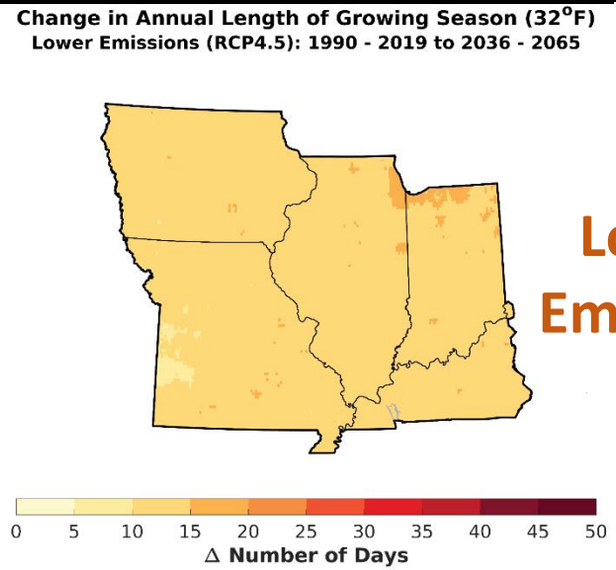


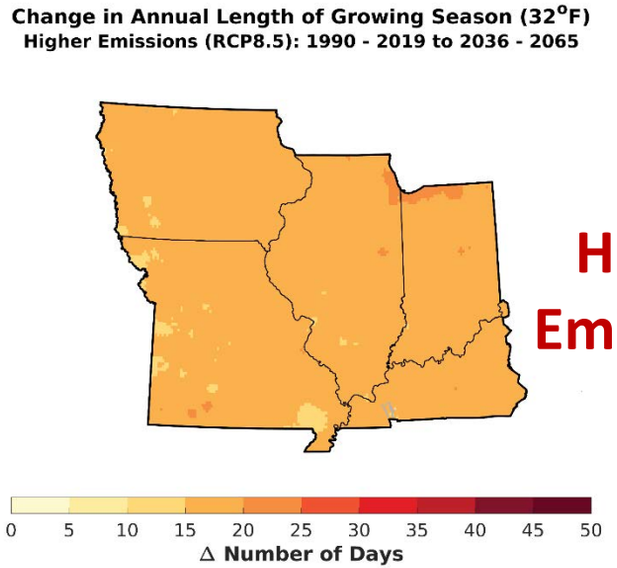
Length of Growing Season

Northern Illinois

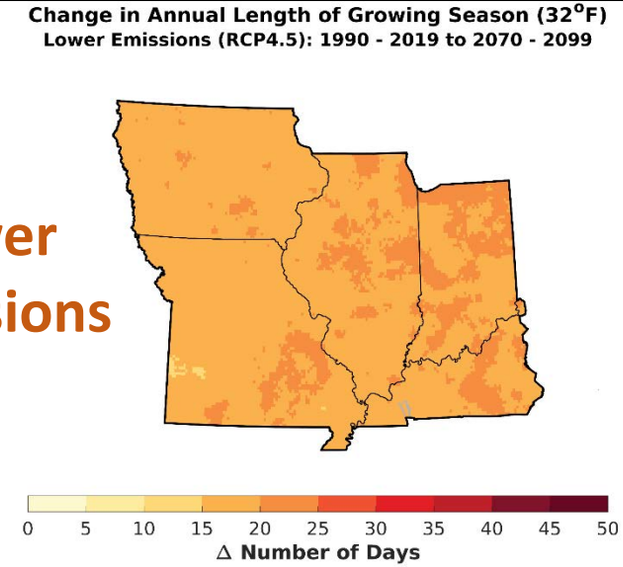


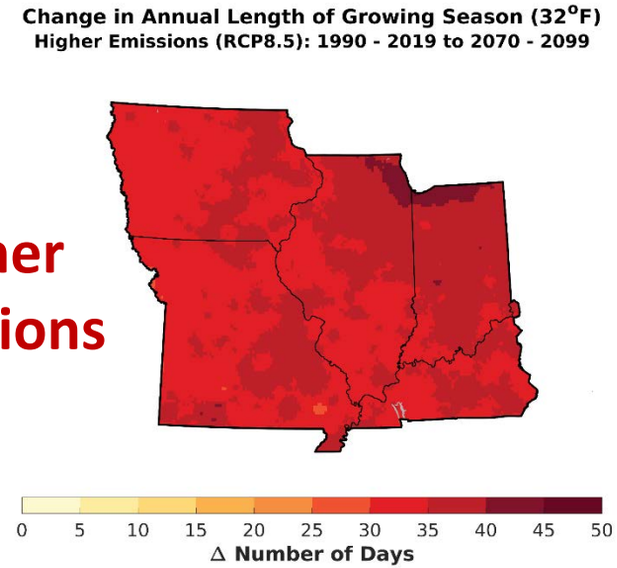
Mid-21st Century





Late 21st Century



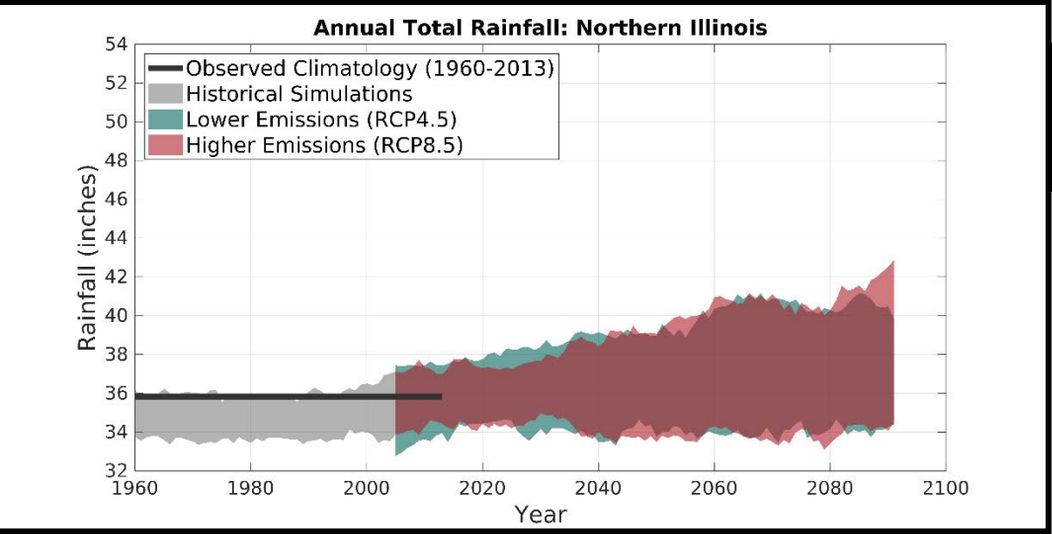


Lower Emissions

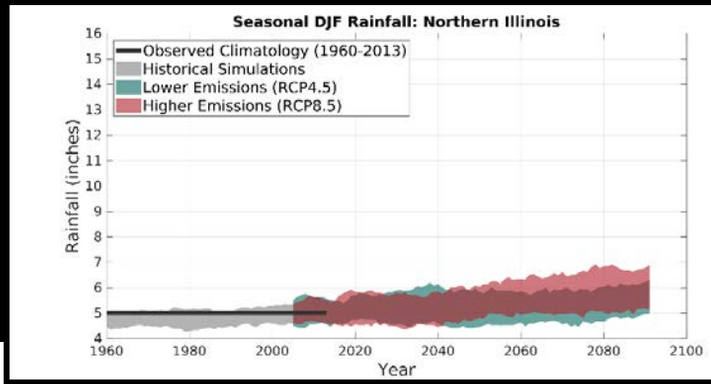
Higher Emissions

Seasonal Rainfall Northern Illinois

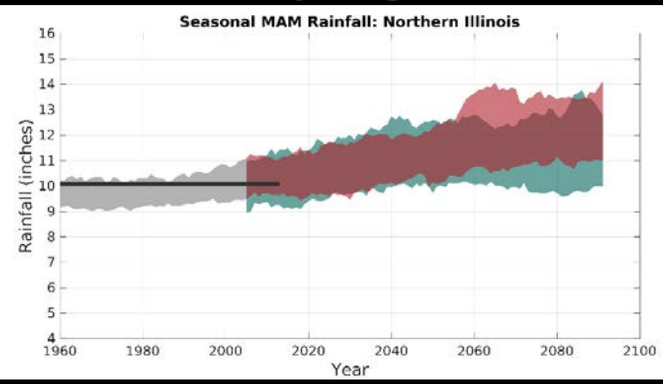
Annual



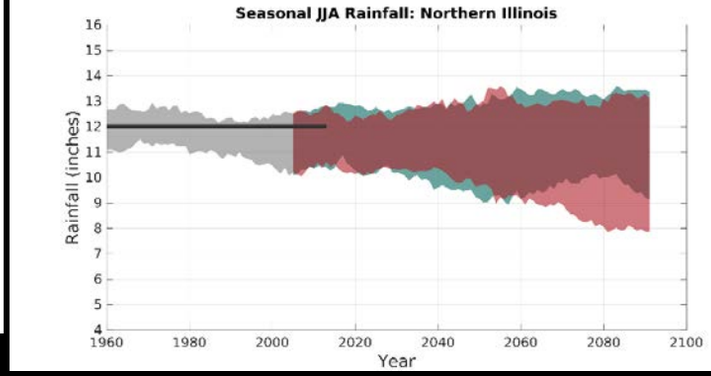
Winter



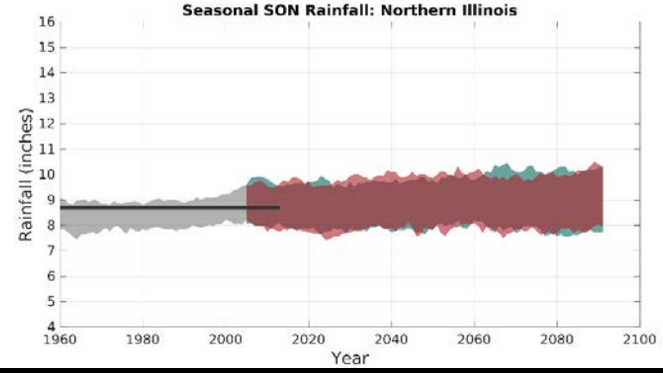
Spring



Summer

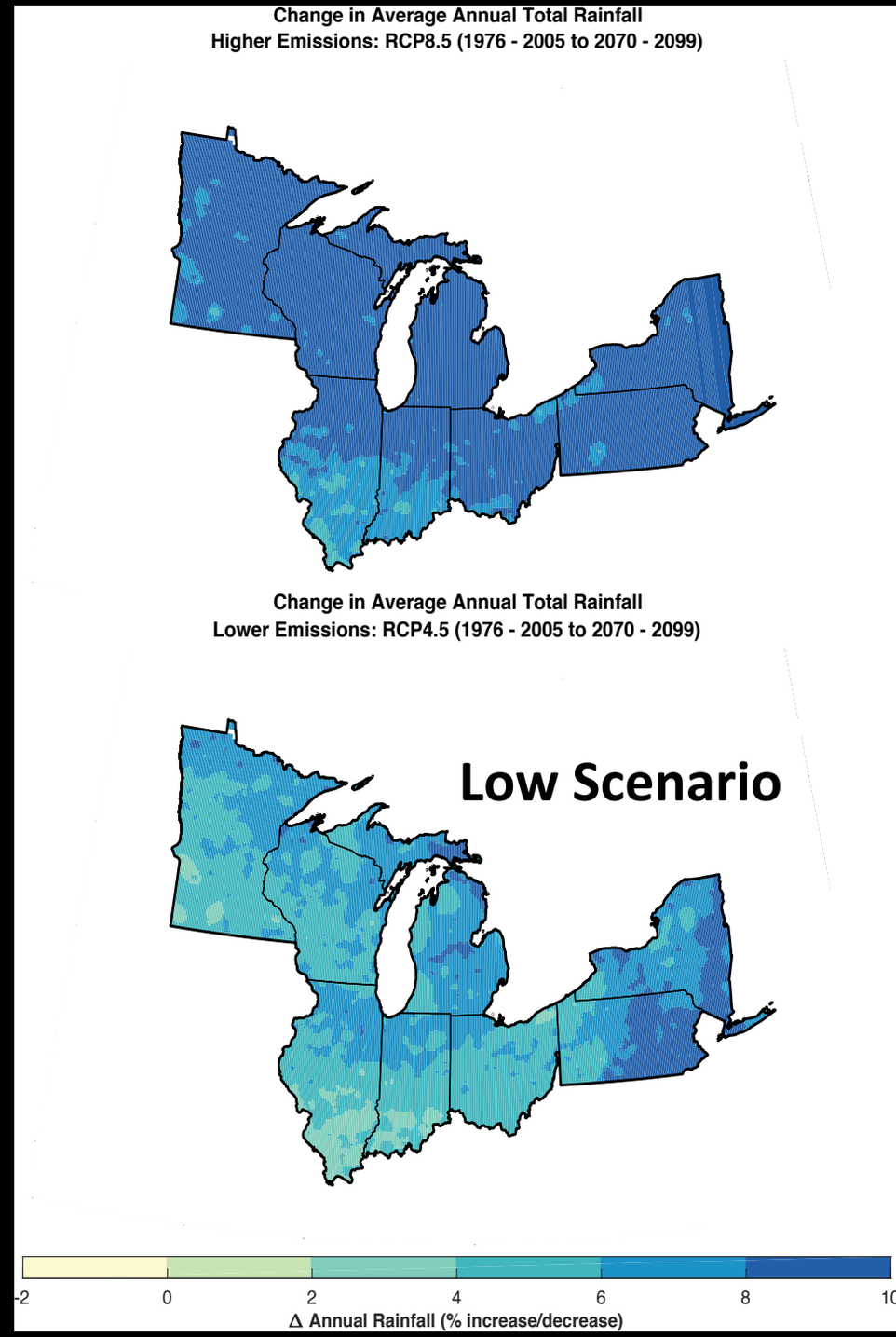


Fall



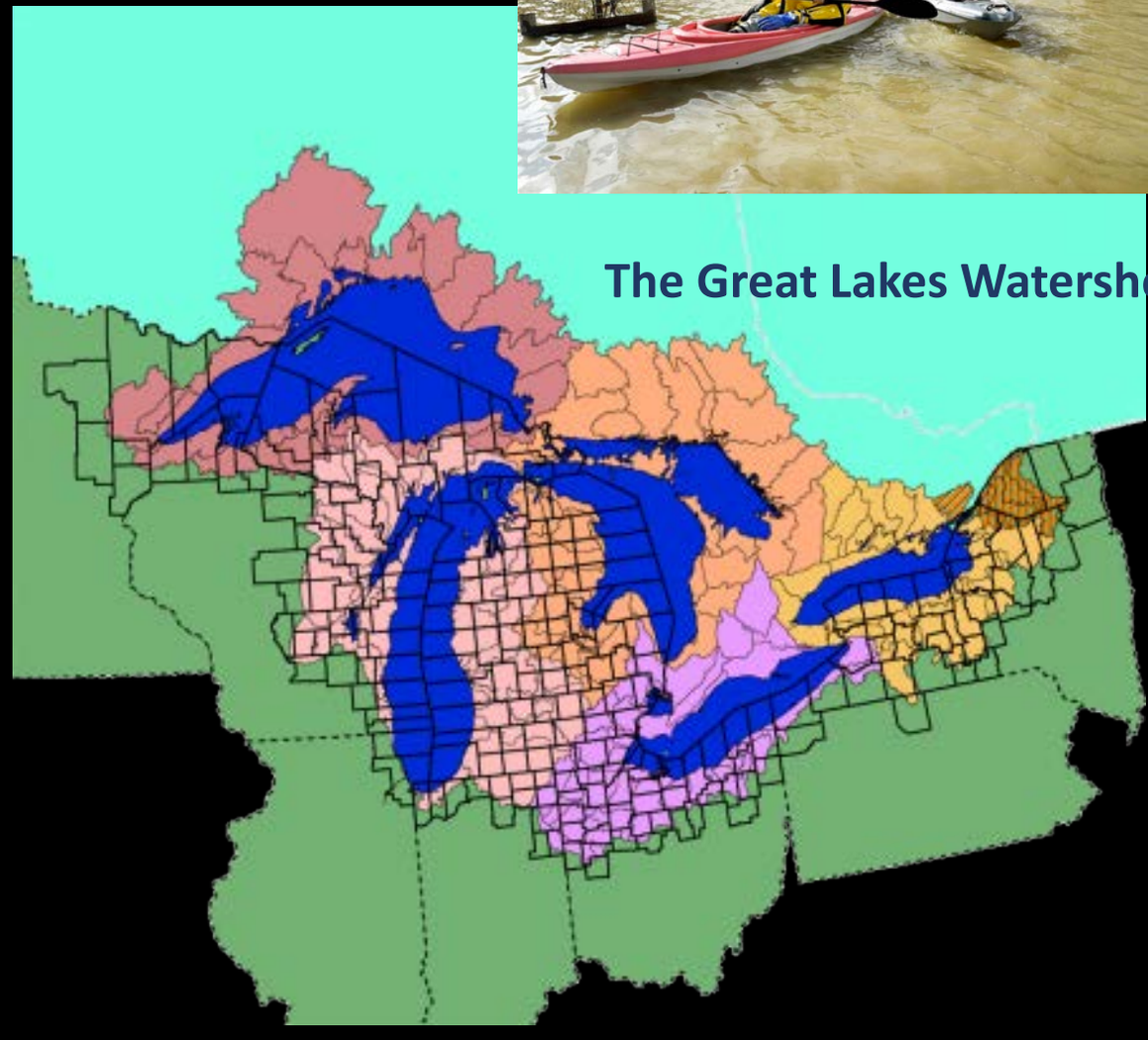
Precipitation: The Great Lakes Region

- Precipitation has increased by 10% in the Great Lakes region.
- Projected increased precipitation for end of this century is as much as another 10%.
- Increasing trends for precipitation coming as larger events will continue.
  - As much as 19% more precipitation for 5-year return events (1 in 5 years) by 2070-2099.



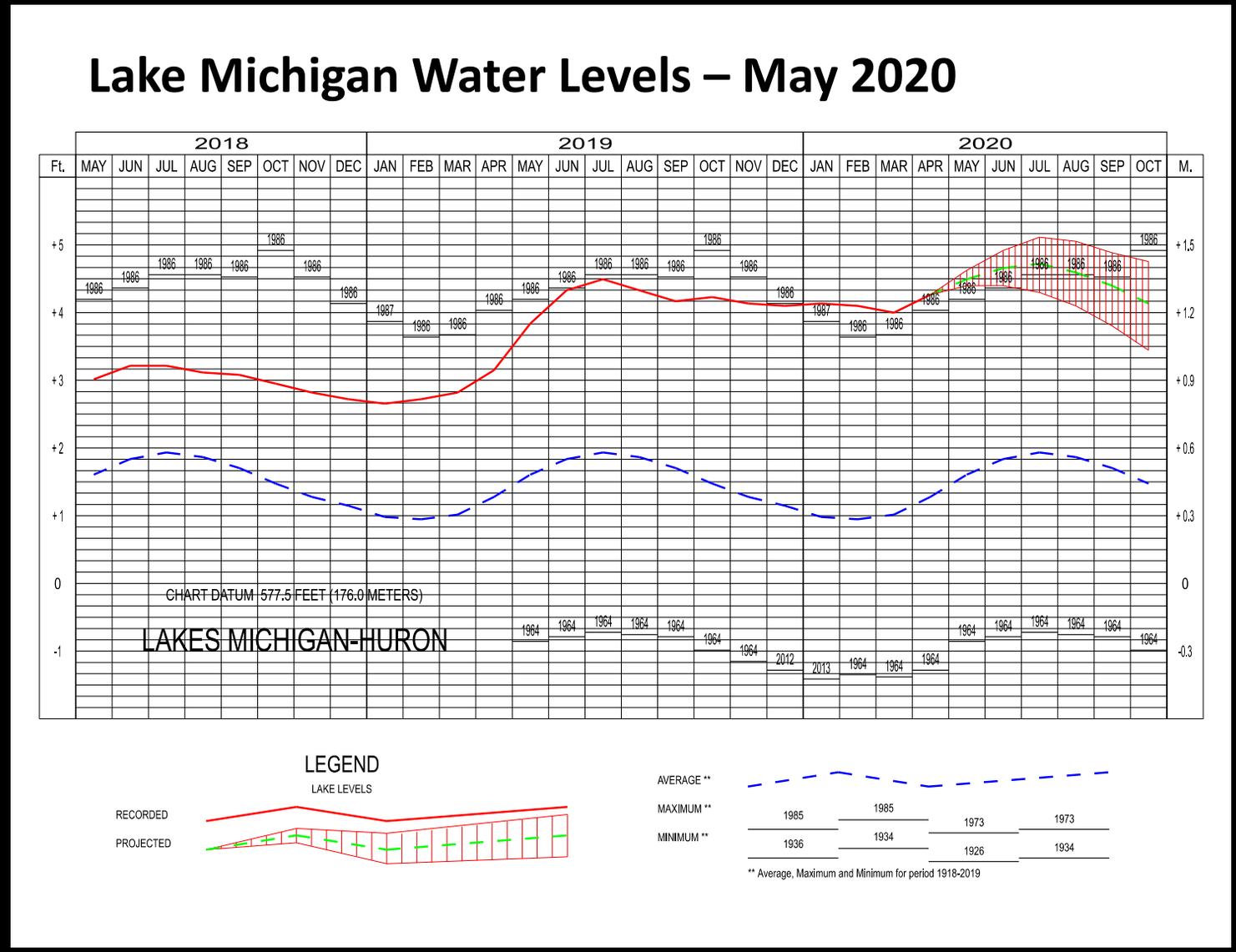
Changes in Great Lakes: Watershed Hydrology

- Increases in precipitation will likely increase flooding across the region.
- Higher summer and fall air temperatures will increase evaporation during growing season.
- Coupled with summer precipitation that is increasingly variable and likely lower, summer river flows will likely be lower by the end of the century.



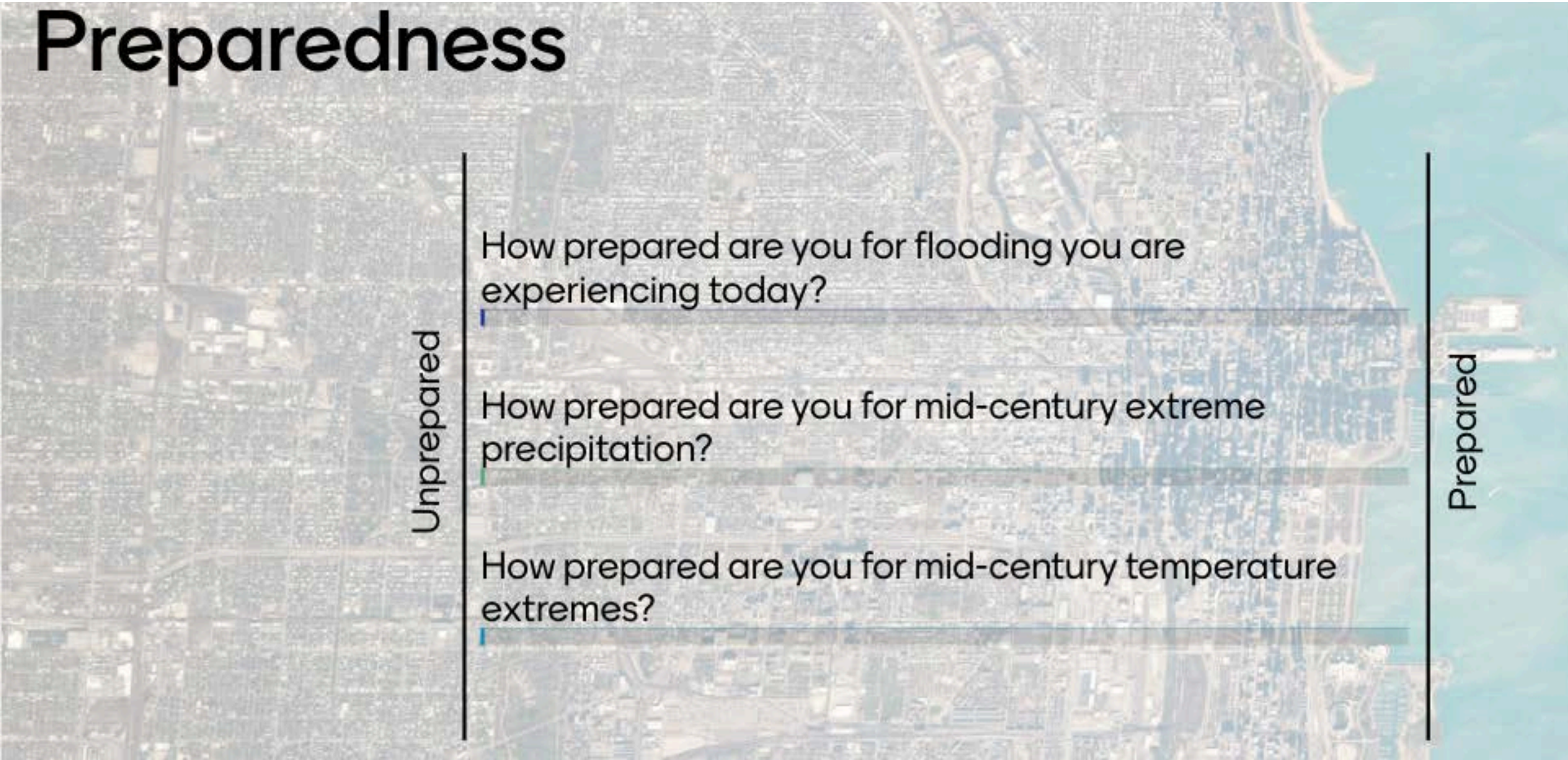
Changes in the Great Lakes: Lake Levels

- Water levels have fluctuated considerably over multi-decadal time scales and will likely continue to do so.
- But large uncertainties remain about future lake levels.



Thank You!

Go to menti.com Enter code 85 49 73



Climate Impacts

Urban Heat Impacts & Solutions

Dr. Ashish Sharma

Illinois Research Climatologist

Illinois Water Survey

Adjunct Professor, Atmospheric Sciences

University of Illinois

Urban heat impacts and solutions in the Chicago region

Ashish Sharma

Illinois Research Climatologist
Illinois State Water Survey | Prairie Research Institute

University of Illinois at Urbana-Champaign, IL, USA

29 May, 2020

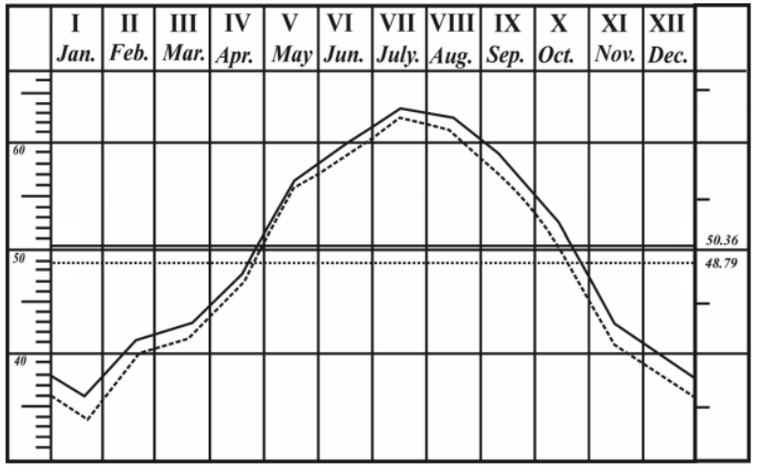
Email: sharmaa@illinois.edu
Twitter: @A_Sharma007

Luke Howard (1772-1864)

Howard (1833)

Howard was an amateur meteorologist with broad interests in meteorology;

--- was also the first to recognize the effect that urban areas have on local climate.



London mean temperature for ten years (1807-1816)

London showed 1.57°C warmer than the country.

Kristovich, Sharma *et al.* (2019) *Meteorol. Monogr.*

Topics for urban discussion

Urban systems

- **Multiscale, interdependent, social, natural and engineered complex systems**

Adaptive choices

- **What solutions do we have?**

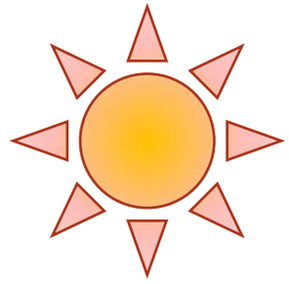
Decision support

- **Where should cities invest?**

Urban systems

Natural-Urban Environment

Day



T_{max} - Urban
- higher or same increases compared to rural

Radiation (in/out) reduces

Entrainment

High albedo of urban surfaces

- Cloud cover Increases

absorb radiation
T_{max} increases slowly

Long wave trap

GHG
H_2O

Irrigation – oasis
Impervious - dry

Irrigation/impervious
H_2O

Radiation trapping

Urban systems

Natural-Urban Environment

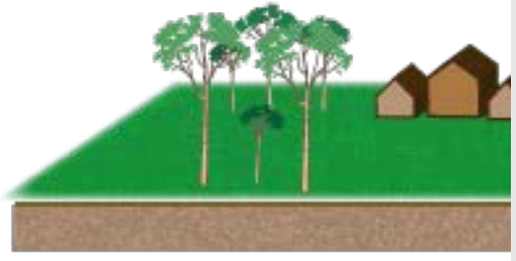
- **Significant increase of T_{min} (compared to rural)**
- **reduction of DTR is larger**
- **UHI at night in amp**

Night

T_{min} increases faster than T_{max}

- Cloud cover + GHG reduces outgoing radiation

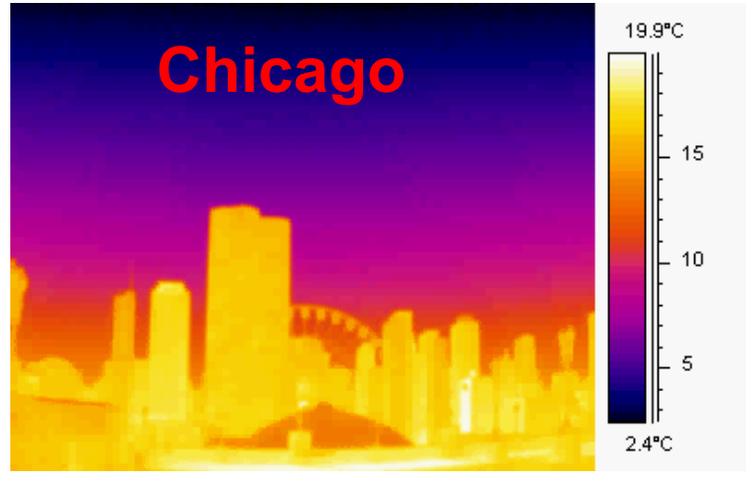
Long wa
trap



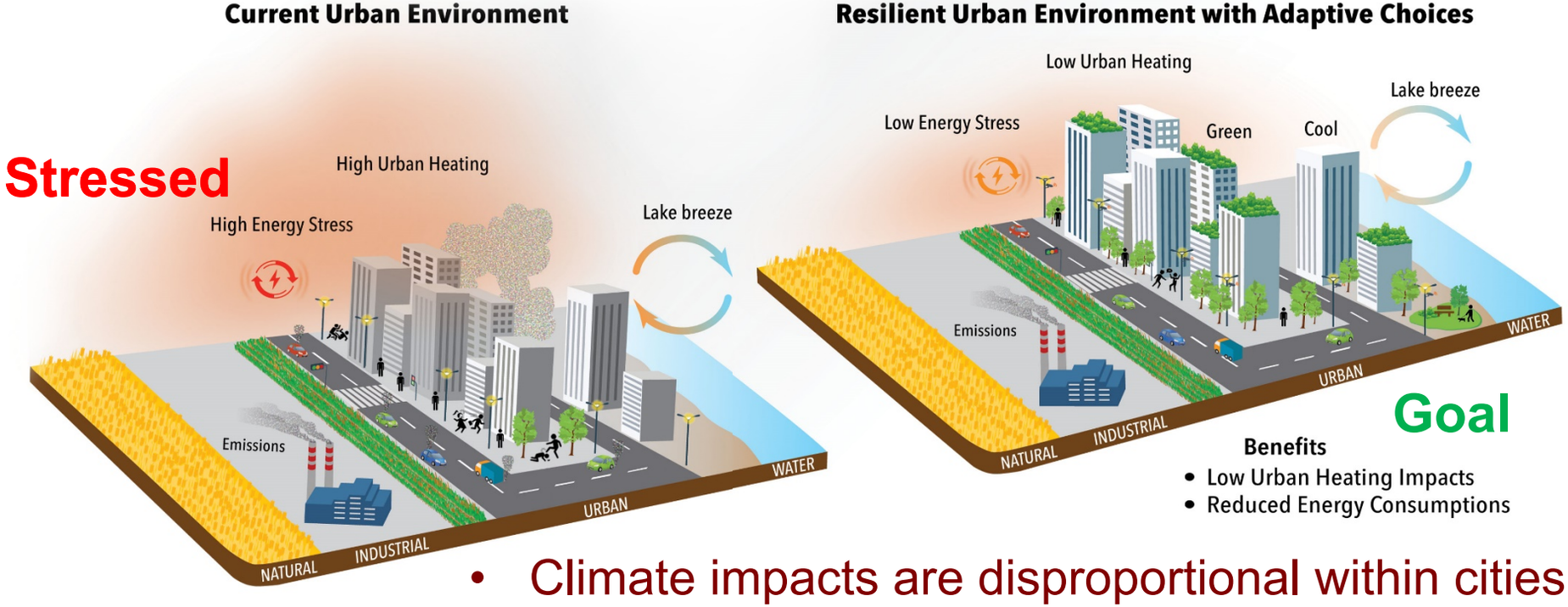
Urban systems

Urban communities

- Mid-90s heat wave
  - Record 106 °F at Chicago Midway
  - 465 deaths
- Chicago Climate Action Plan: 2008
  - Plan and implement urban heat adaptation initiatives in face of climate change



Kristovich, Sharma *et al.* (2019) *Meteorol. Monogr.*

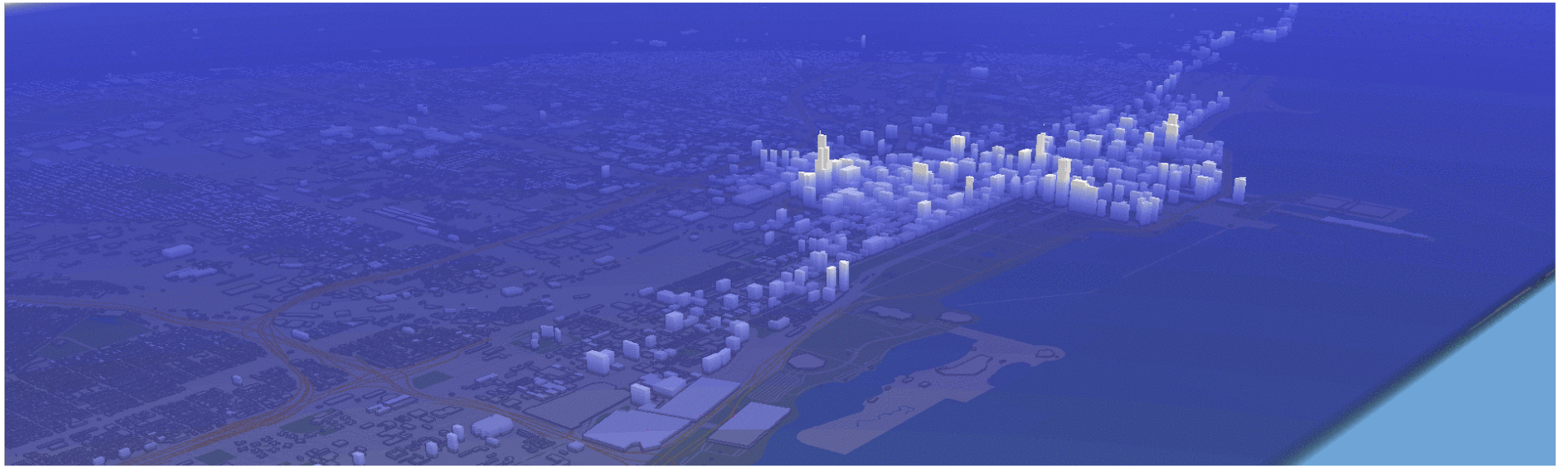


- Climate impacts are disproportional within cities.

Urban systems

Urban Environment

- **Urban systems**: Multiscale, interdependent, social, natural and engineered complex systems.

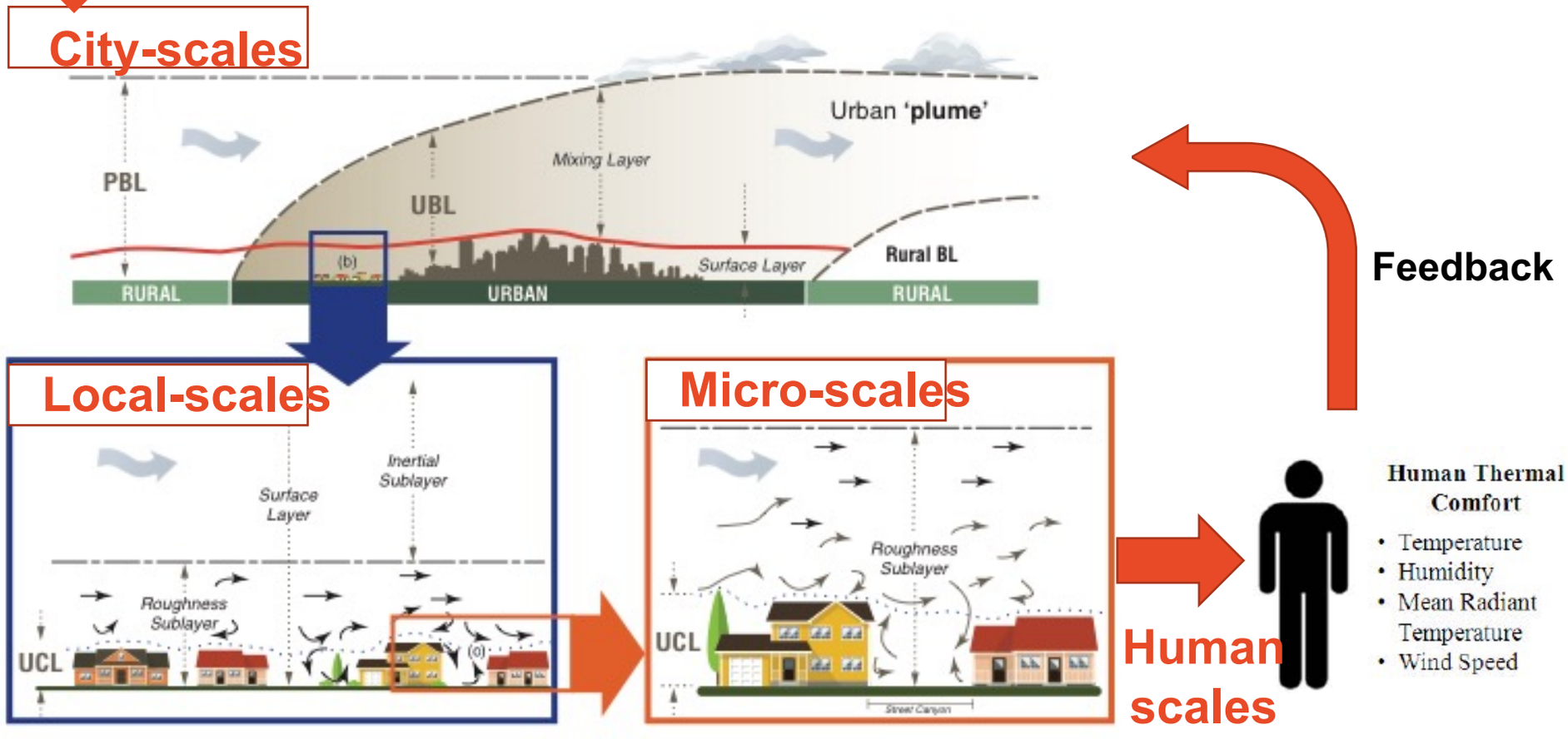


Visualization: Miranda and Sharma

- Improvements in urban boundary layer processes.
- Fundamental and translational research that uses **science to serve the society**.

Urban systems

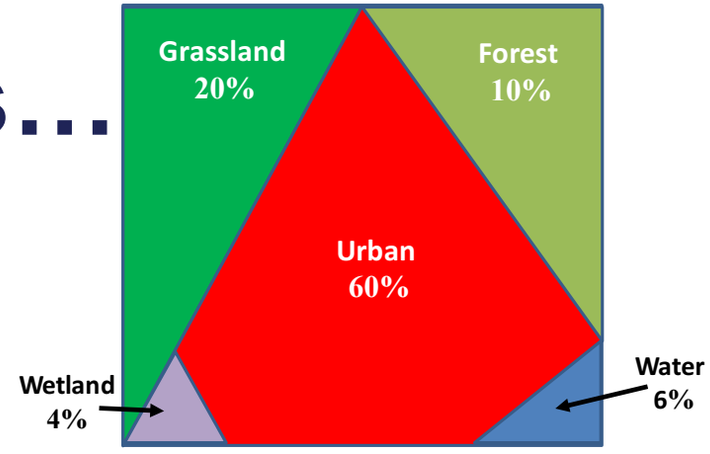
Bridging urban scales…



- Need **tools** with which large-, medium-, and small- cities will benefit.
- Complicated models to train simplistic models.

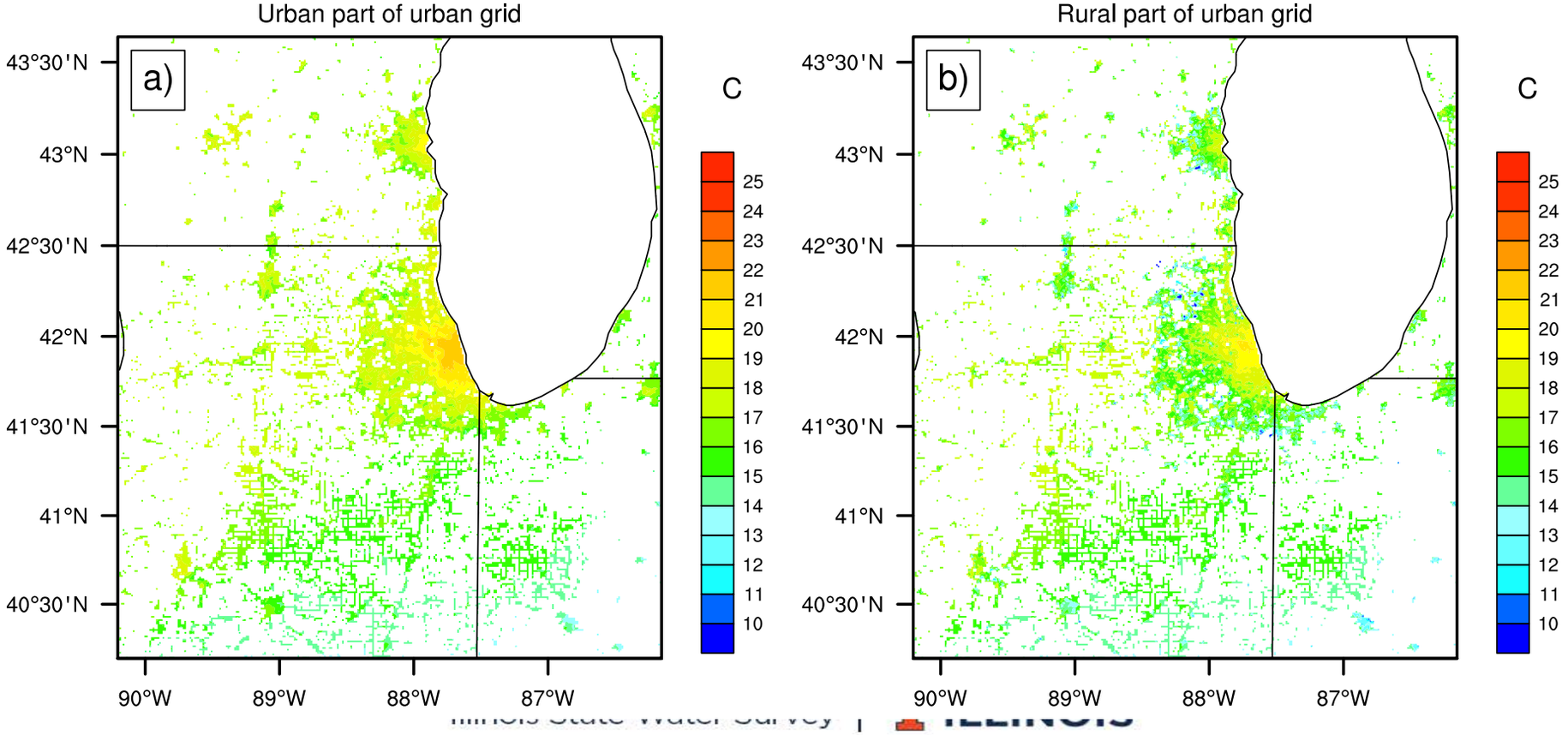
Urban systems

At regional scales…



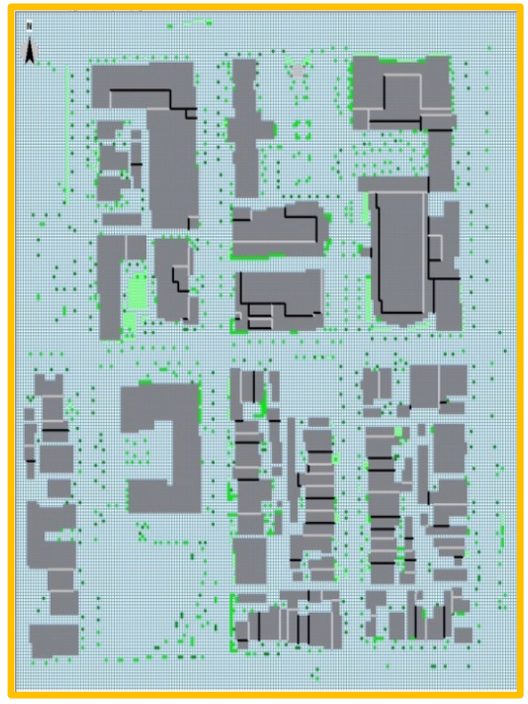
Urban part of an urban grid

Non-urban part of an urban grid

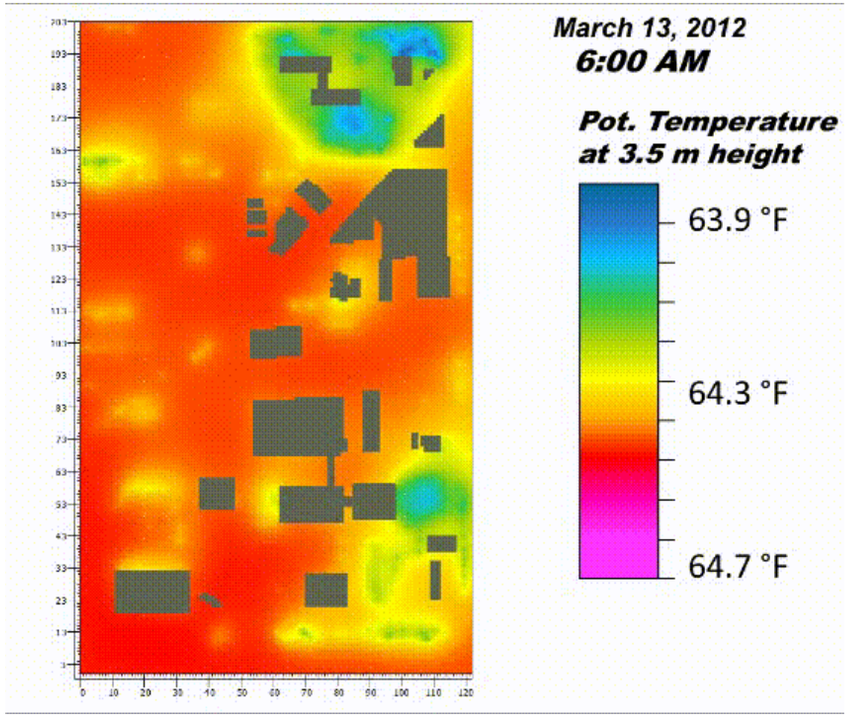


Urban systems

At local/neighborhood scales..



ENVI-met model

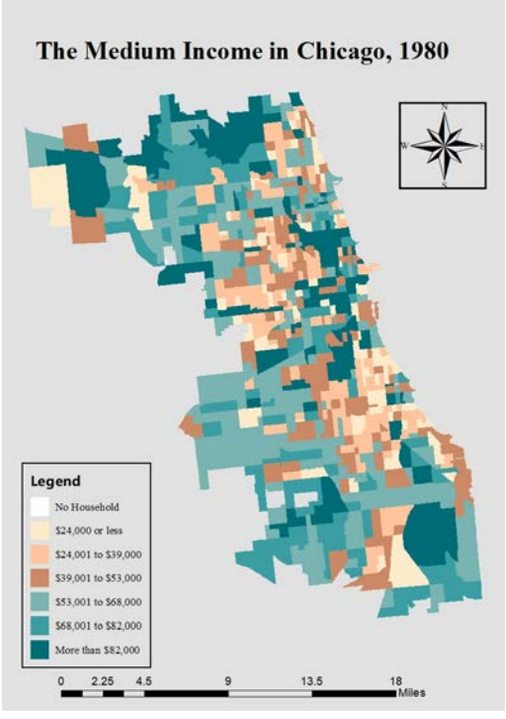


Conry, Sharma et al. (2015) *J. Appl. Meteorol. Climatol.*

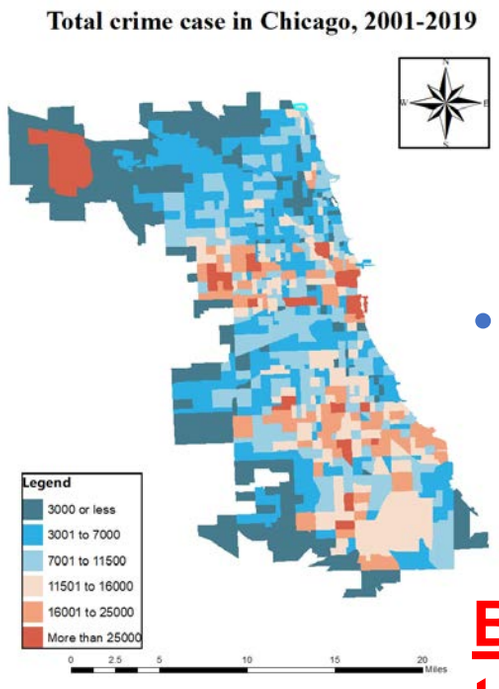
Urban systems

Divide within cities

Income analysis



Crime analysis



- Chicago 8th in income inequality among the nation's largest cities.
- '**Healthy**' level of inequality is needed to encourage growth and progress.

But how much inequality is too much?

Figure Credits: Lei Zhou and Swarnali Sanyal

Topics for urban discussion

Urban systems

- **Multiscale, interdependent, social, natural and engineered complex systems**

Adaptive choices

- **What solutions do we have?**

Decision support

- **Where should cities invest?**

Potential solutions

Cool rooftops

https://theconversation.com

Permeable pavements

Electric cars

Photovoltaic rooft

https://sustainability.uic.edu/

Green rooftops

Student Union at the UIS campus

✓ Technological-engineered-ecological mix of solutions.

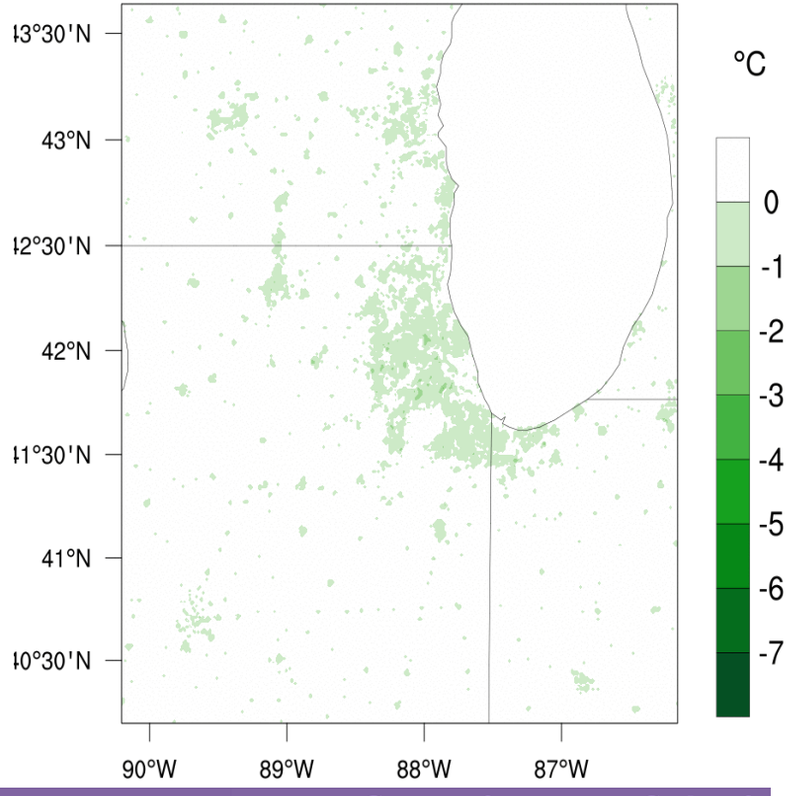
Adaptive choices

Green roofs

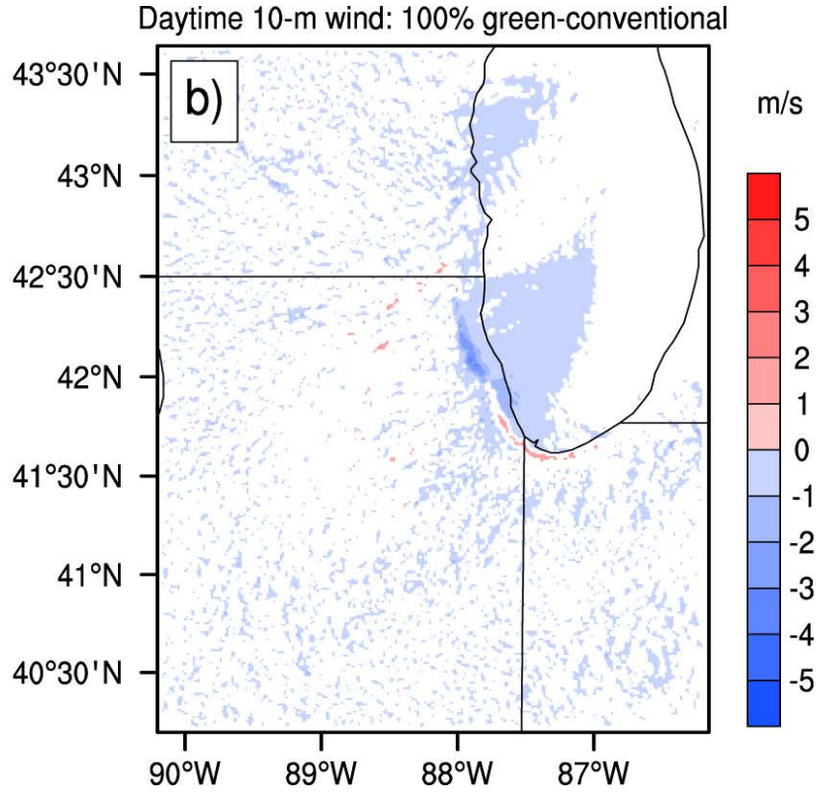
Student Union at the UIS campus

100% green - conventional

Roof surface temperature



10-m wind



	Green roofs				Cool roofs
Urban landuse category	**25%**	**50%**	**75%**	**100%**	**100%**
Low intensity residential	0.56	1.11	1.68	2.24	1.6
Medium-intensity residential	1.63	3.25	4.97	6.68	7.01
High-intensity/commercial	**2.02**	4.07	6.27	**8.34**	**10.09**
All urban areas	0.84	1.68	2.56	3.41	3.22

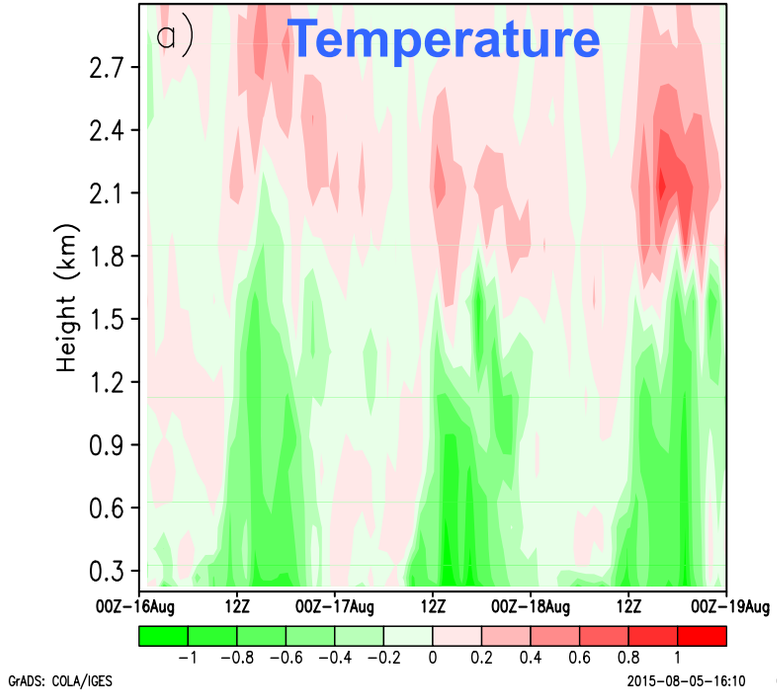
Lake breeze reduced

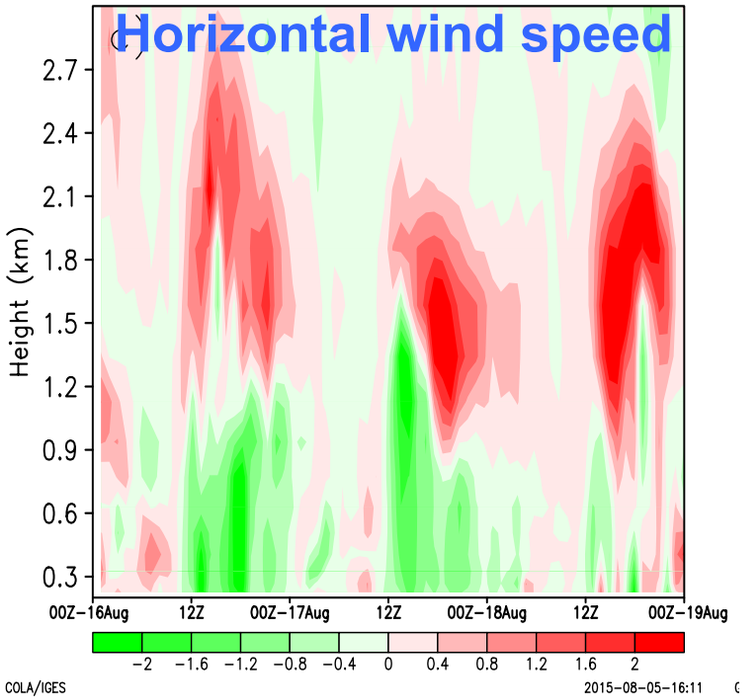
RMSE: 1.3 °C
MAE: 0.9 °C

Adaptive choices

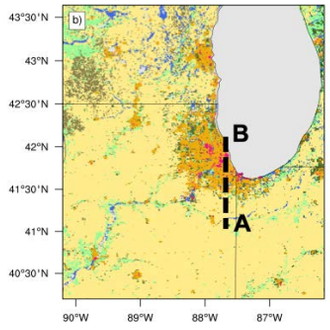
Vertical profiles

Green-Conventional



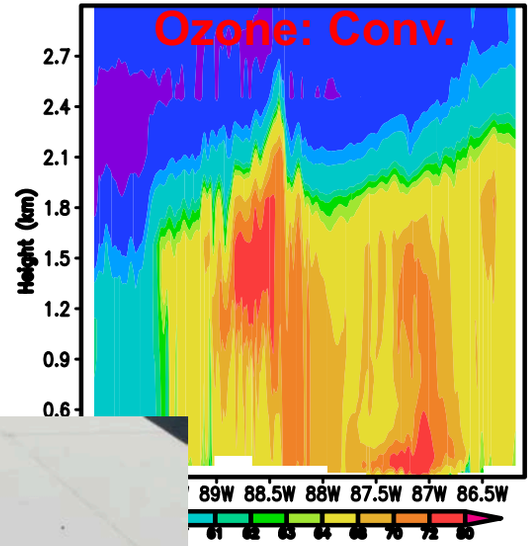


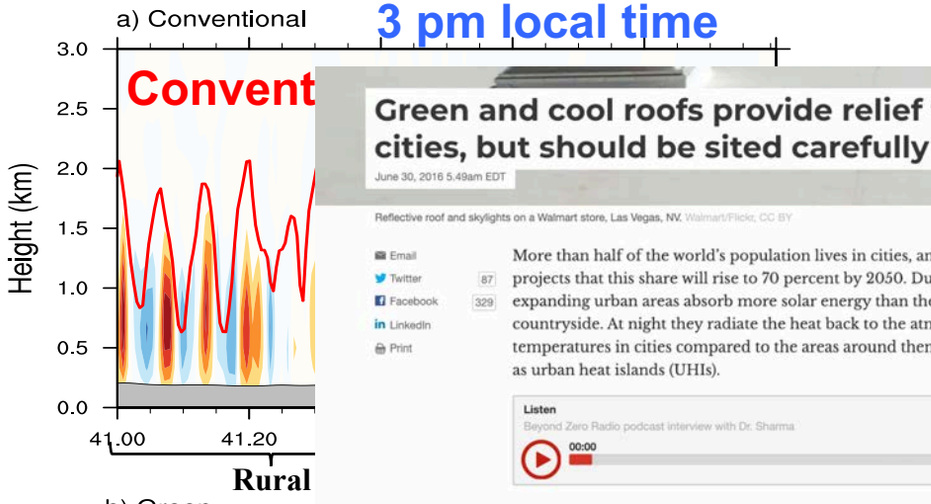
- Decrease in horizontal wind speed due to **reduced vertical mixing** of momentum, and an increase above it.



Transport OR photochemical processes

— Which are dominant?





Green and cool roofs provide relief for hot cities, but should be sited carefully

June 30, 2016 5.49am EDT

Reflective roof and skylights on a Walmart store, Las Vegas, NV. Walmart/Flickr, CC BY

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More than half of the world's population lives in cities, and the United Nations projects that this share will rise to 70 percent by 2050. During the daytime, these expanding urban areas absorb more solar energy than the surrounding countryside. At night they radiate the heat back to the atmosphere. Higher temperatures in cities compared to the areas around them create what are known as urban heat islands (UHIs).

Listen
Beyond Zero Radio podcast interview with Dr. Sharma
00:00 29:17
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Urban heat islands threaten urban sustainability and public health in cities. The heat island effect raises death rates, increases energy demand for cooling, and makes life uncomfortable even for healthy residents. It affects various communities differently: poor and elderly residents and small children are most

Author
Ashish Sharma
Research Assistant Professor, University of Notre Dame

Disclosure statement
Ashish Sharma is affiliated with the Environmental Change Initiative, ND Energy and the Department of Civil and Environmental Engineering and Earth Sciences at the University of Notre Dame. Research described in this article is supported by the National Science Foundation, the Notre Dame Environmental Change Initiative, the Notre Dame Center for Sustainable Energy, and the City of Chicago.

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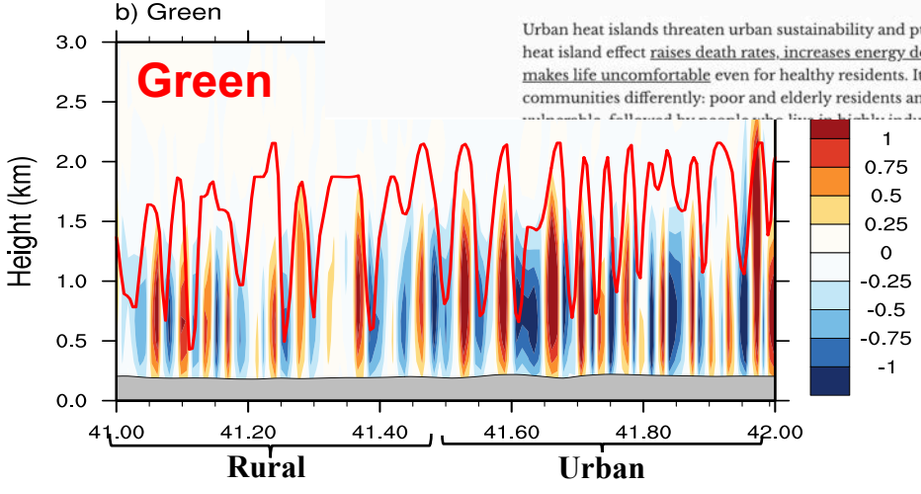
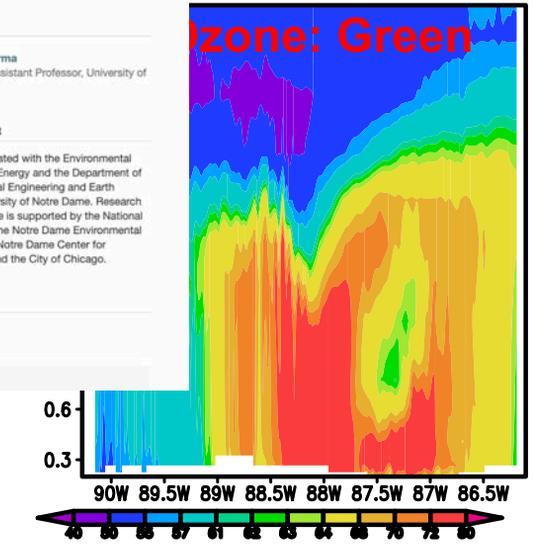




✓ One solution can't fit all.

✓ Need a mix of solutions.

Sharma et al. (2018) *Env. Res. Lett.* Illinois State Water Survey | ILLINOIS Sharma et al. (in prep.)

Topics for urban discussion

Urban systems

- **Multiscale, interdependent, social, natural and engineered complex systems**

Adaptive choices

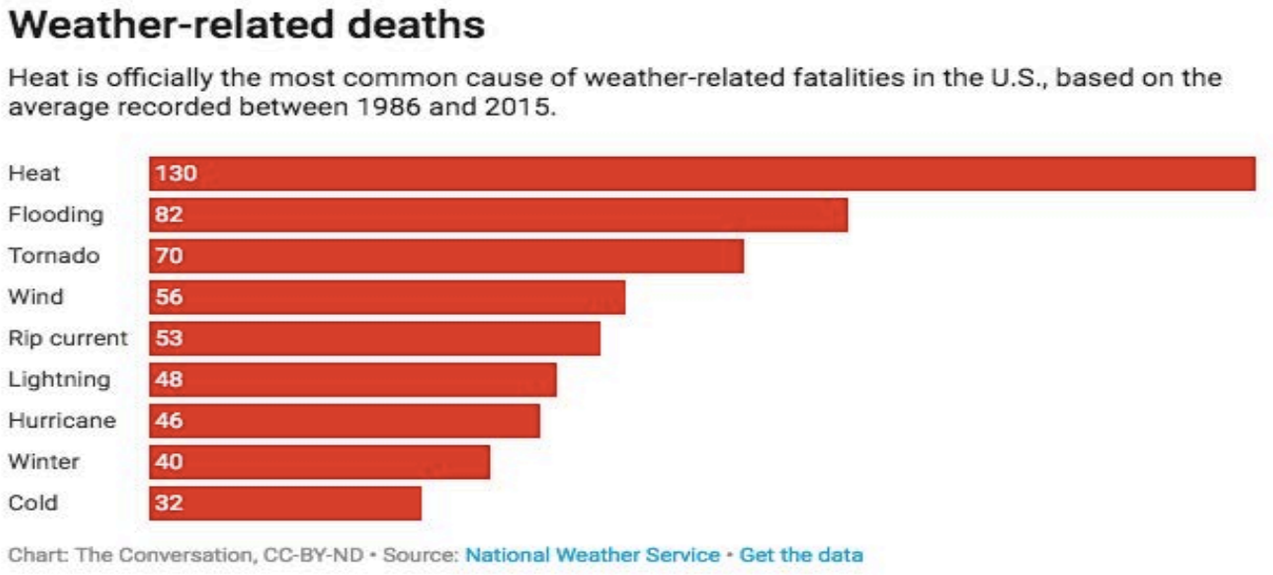
- **What solutions do we have?**

Decision support

- **Where should cities invest?**

Decision support

Urban Heat Vulnerability



https://theconversation.com/green-roofs-in-cities-like-chicago-102234

- A decision making approach for planners and managers to apply heat mitigation strategies
- Identify and prioritize urban areas to implement adaptive strategy

Sharma et al. (2018) *Env. Res. Lett.*

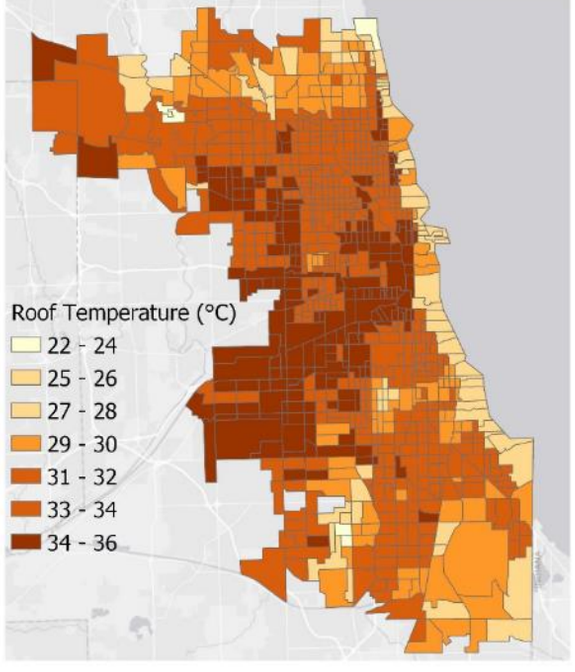
Decision support

How can we help communities?

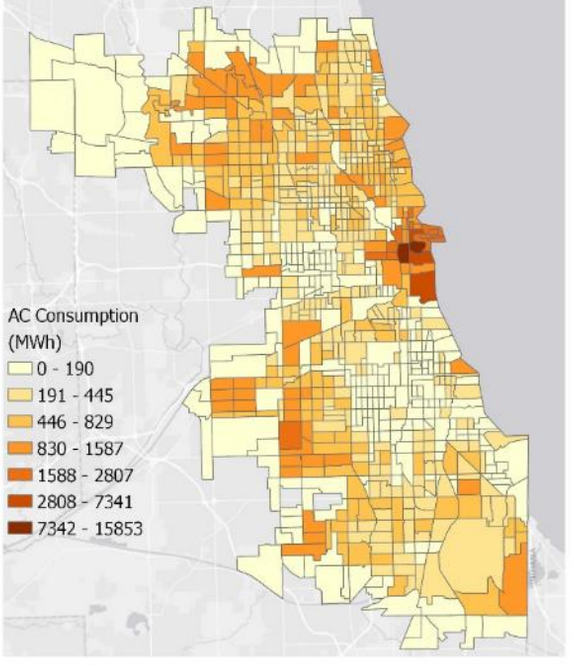
✓ Integrated urban sustainability solutions

✓Multi-disciplinary and multi-stakeholder engagements for actionable research-based and cost-effective sustainable solutions

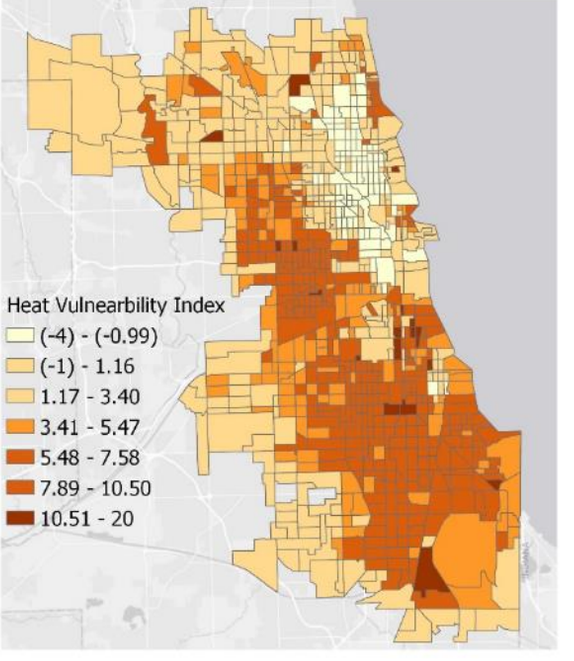
Roof Temperatures



AC Consumption



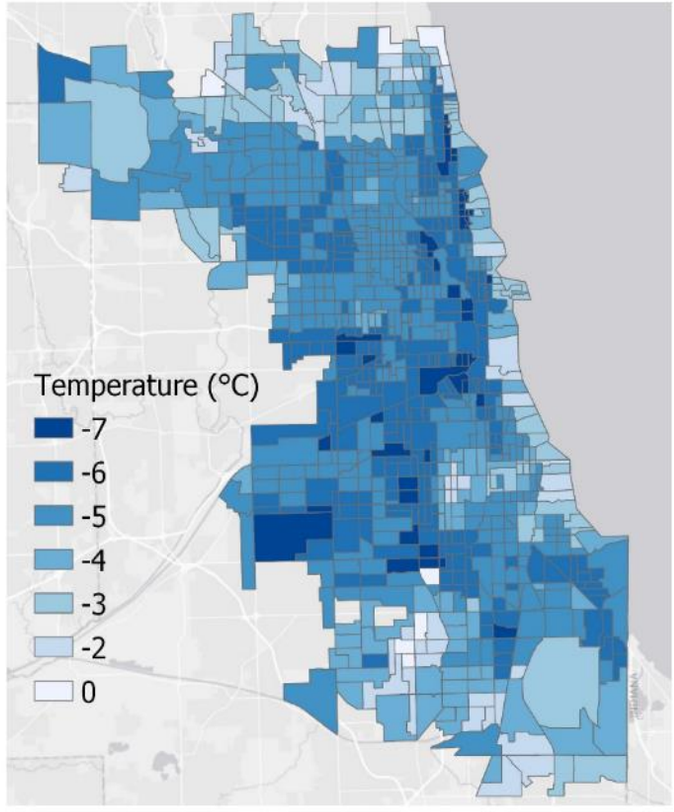
Heat Vulnerability Index

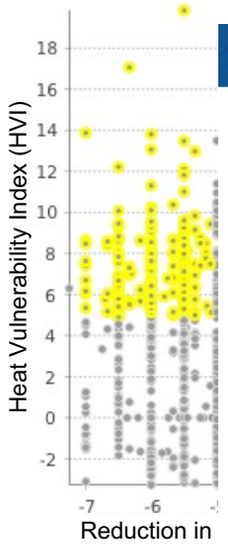


Decision support

Strategic investments!

Changes in temperature with green roofs





CNBC MARKETS BUSINESS NEWS INVESTING TECH POLITICS

Low-income neighborhoods would gain the most from green roofs in cities like Chicago

COMMENTARY

Ashish Sharma

Published 3:14 PM ET Fri, 7 Sept 2018 | Updated 4:02 PM ET Fri, 7 Sept 2018

The Conversation

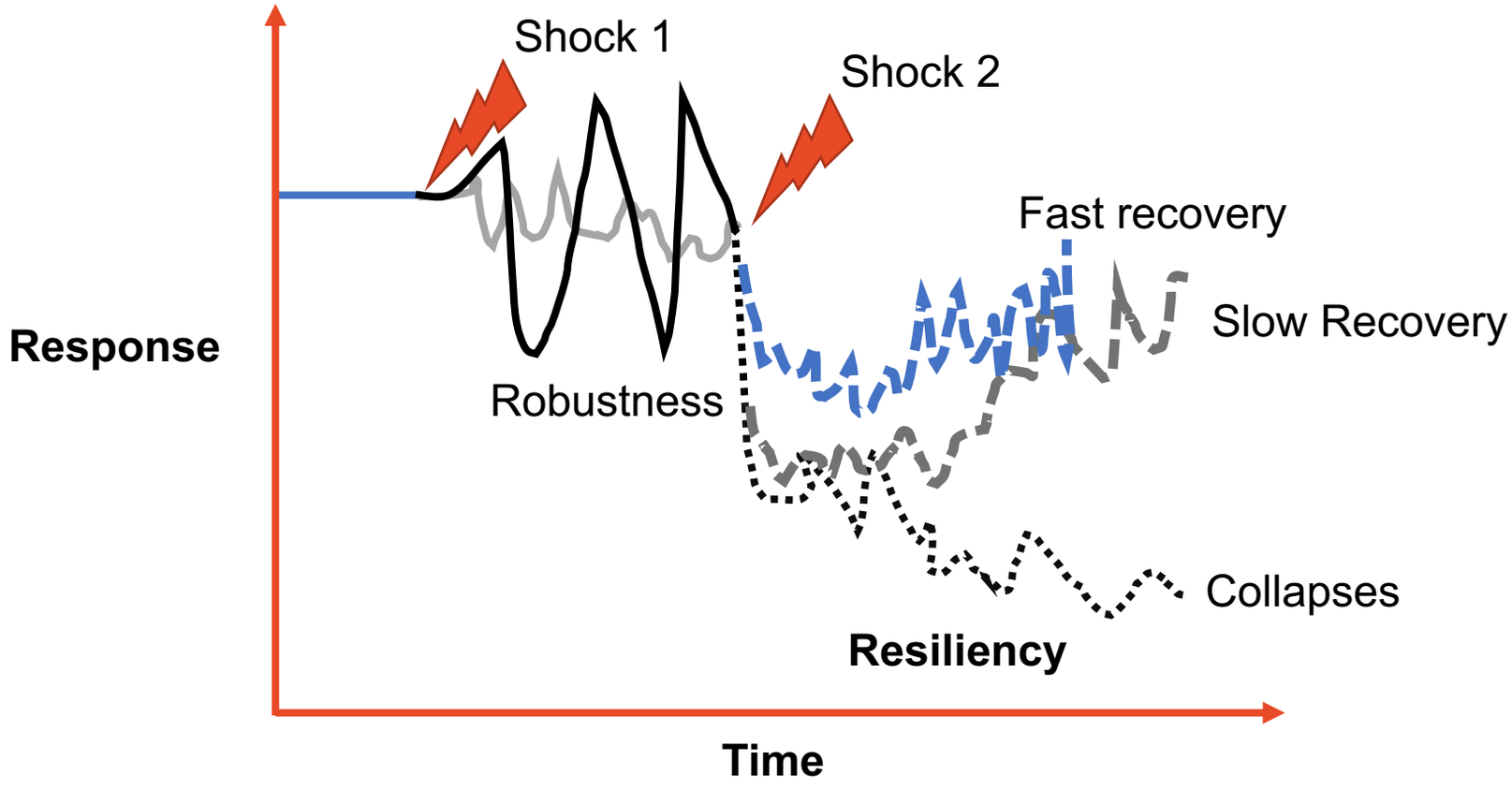
Tim Boyle | Getty Images

✓Identified neighborhoods that can gain the most from green roofs.

Sharma *et al.* (2018) *Env. Res. Lett.*

Working problem:

Sensitivity of urban systems



- **Shocks**: due to exposure (e.g., climate extremes; major policy decisions)
- **Response**: depends on adaptive capacity; resources provisioning)

Takeaways!!!

Fundamental → Applied → Translational -> Collaborative research

- Climate impacts communities, however, the impacts are disproportional within cities.
- Bridge scale gaps: regional <—> local <—> hyper-local
- Design tools for the specific science questions and research needs.
- One solution can't fit all → Need a mix of solutions.
- Multi-disciplinary and multi-stakeholder engagements for actionable research-based and cost-effective sustainable solutions.

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QUESTIONS?

Please join us for the next 2 climate adaptation webinars

3. **Climate Risk and Vulnerability** - June 5, 2020, 1:00 – 2:30 pm
4. **Adaptation Planning & Prioritization Workshop** - June 12, 2020, 1:00 – 3:00 pm

https://mayorscaucus.org/climatewebinars/

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