Temperature and human health

Brooke Anderson

Colorado State University

October 31, 2016

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Why study temperature effects?

Human bodies and environmental temperature

Major heat waves

Temperature effects across the temperature range

Regional differences

Adaptation

Susceptibility

Other risks associated with heat

Why study weather effects?

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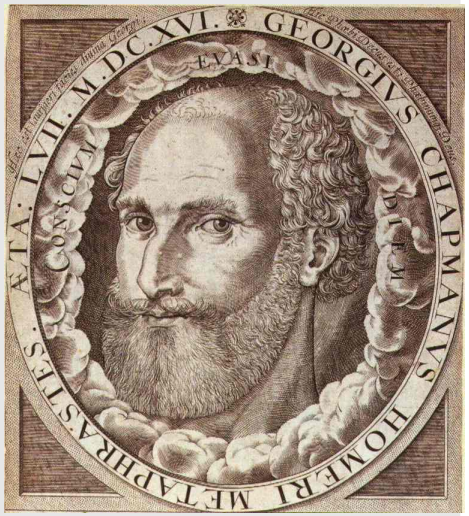
Why study weather effects?

"Extreme heat kills, and so extreme cold."
-George Chapman
1559–1634



Source: Wikipedia

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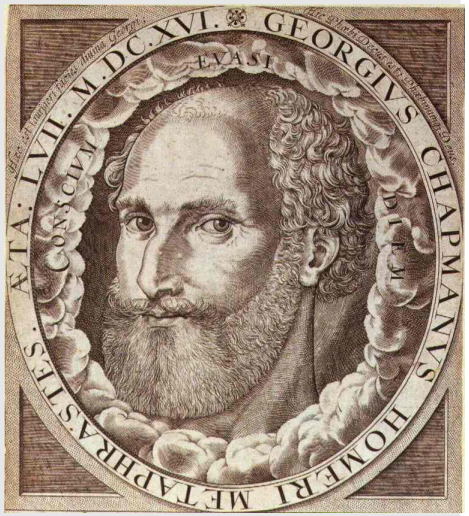

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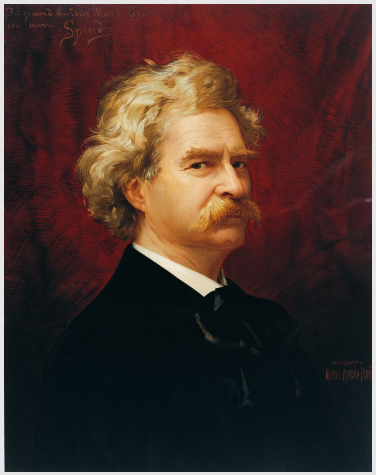

Source: berkeley.edu

"Everybody always talks about the weather, but no one ever does anything about it."

-Mark Twain
attributed

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Why study weather effects?

Investigate the range of health effect

- Heat stroke, hypothermia
- Cardiovascular deaths, respiratory deaths
- Hospitalizations

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Plan public health responses

- Identify susceptible people
- Identify high-risk situations
- Plan and assess prevention strategies

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Estimate impacts of climate change

- Quantify health impacts
- Identify highly impacted geographic locations

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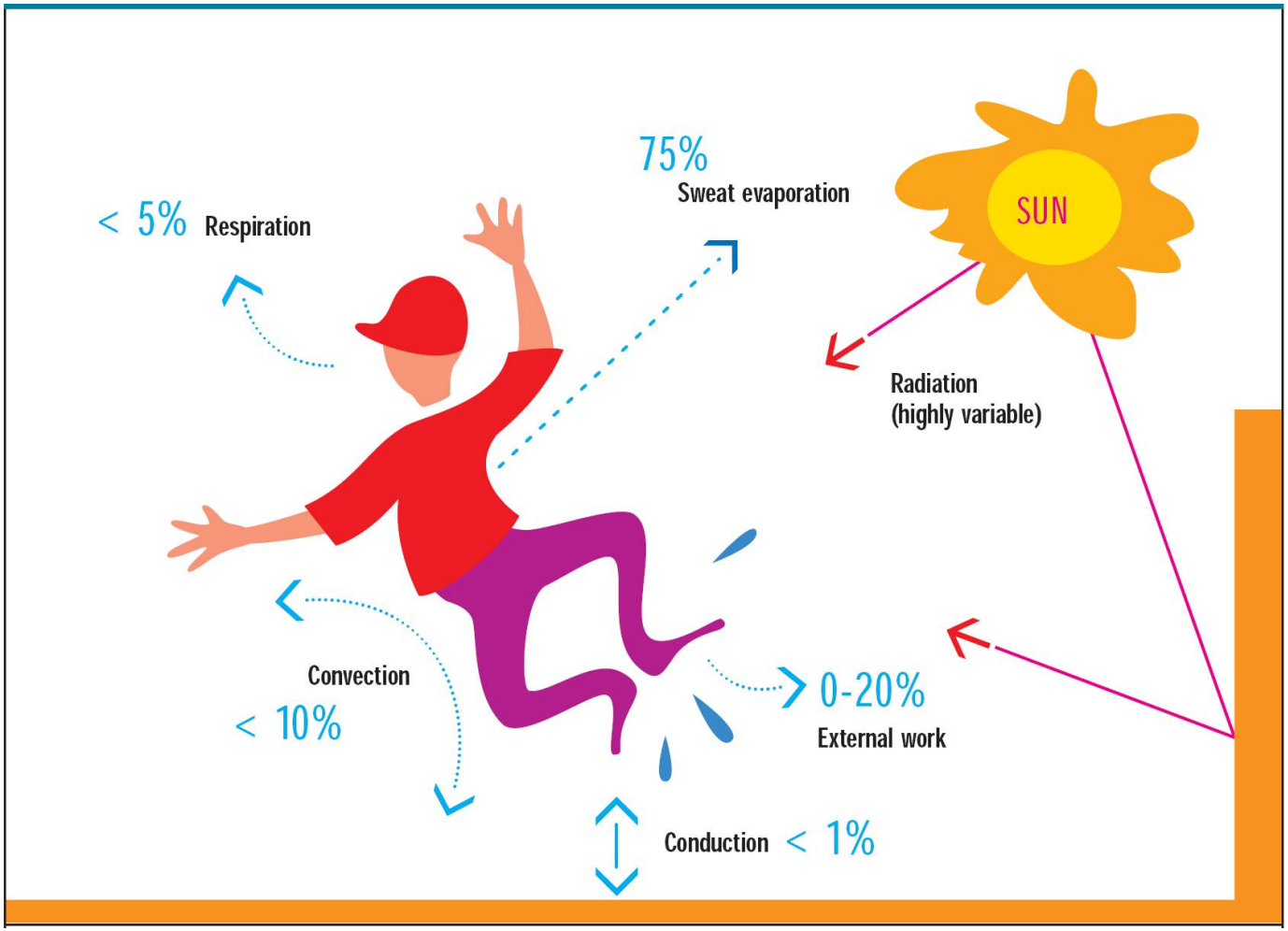
Elephant ears

Elephants sleeping at night in Africa.
Source: National Geographic, Nightstalkers series.

Body-environment temperature exchange



Avenues of temperature exchange between the body and the environment.
Source: Koppe et al., 2003, adapted from Havenith, 2003

Health outcomes

Heat effects

Cold effects

Health outcomes

Heat effects

- Heat stroke

Cold effects

- Hypothermia

Health outcomes

Heat effects

- Heat stroke
- Increased blood flow near skin

Cold effects

- Hypothermia
- Constriction of skin blood vessels

Health outcomes

Heat effects

- Heat stroke
- Increased blood flow near skin
  - Low blood pressure
  - Heat syncope

Cold effects

- Hypothermia
- Constriction of skin blood vessels

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  - Stroke
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  - Aggrevation of health problems
- Stiffness in joints and tendons
  - More falls

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- Constriction of skin blood vessels
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  - Stroke
- Increased strain on cardiovascular system
  - Aggrevation of health problems
- Stiffness in joints and tendons
  - More falls
- Infectious disease

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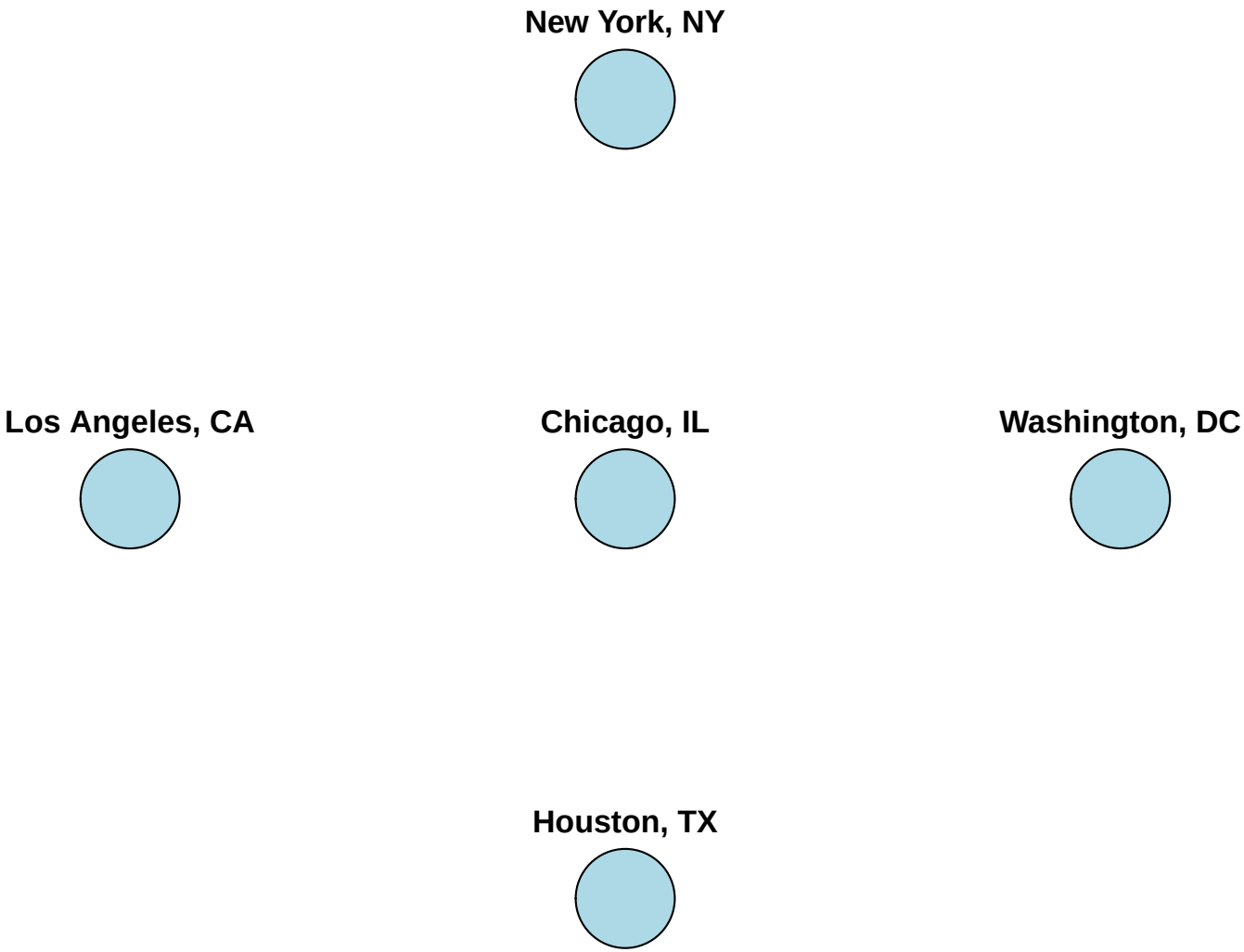
Studying environmental exposures



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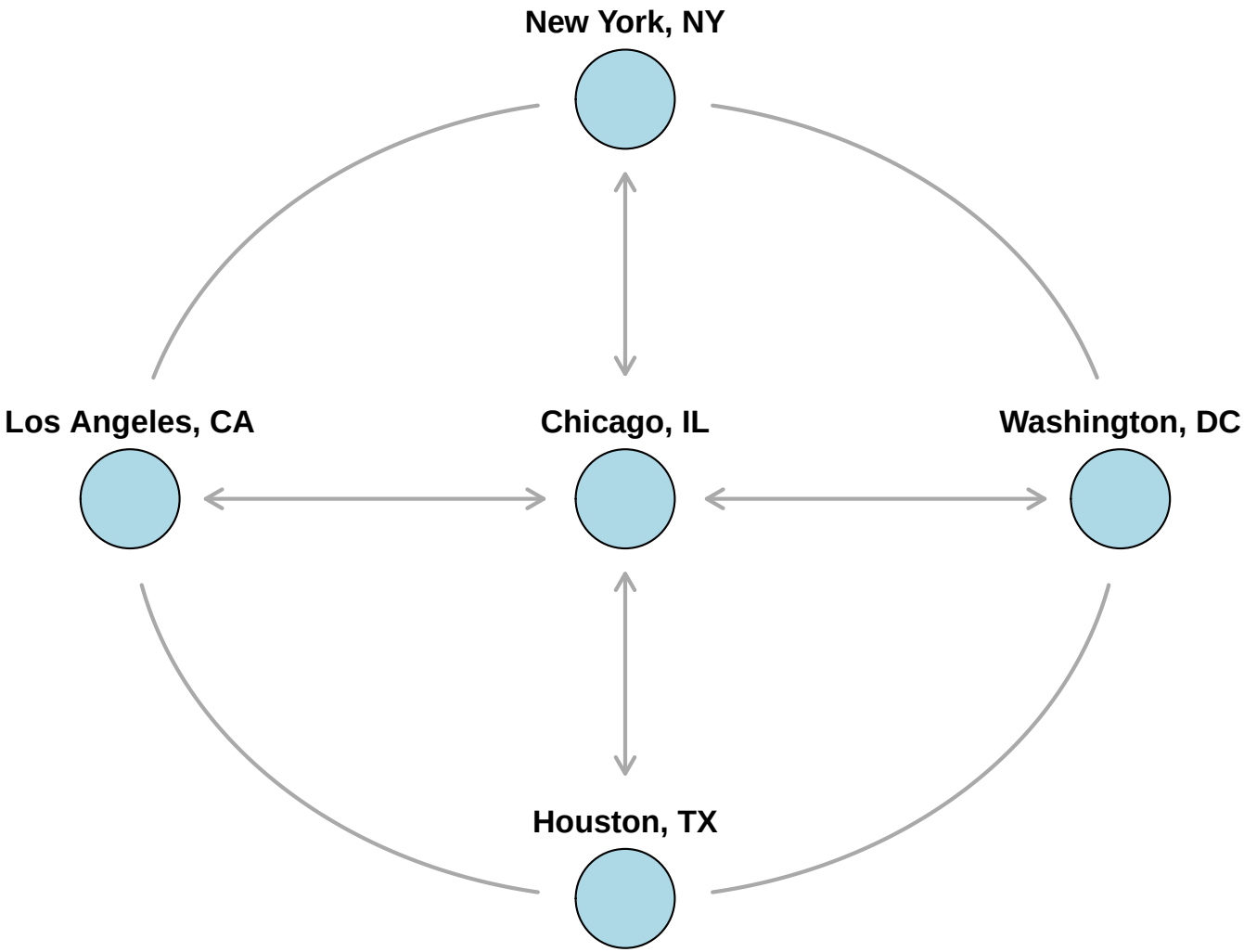
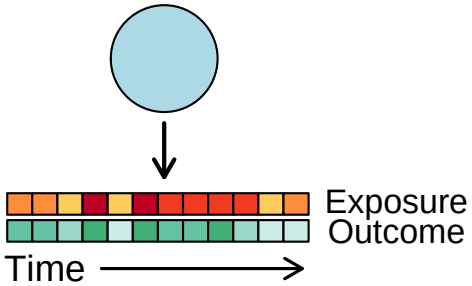


Studying environmental exposures

New York, NY

Los Angeles, CA



Chicago, IL

Washington, DC

Houston, TX

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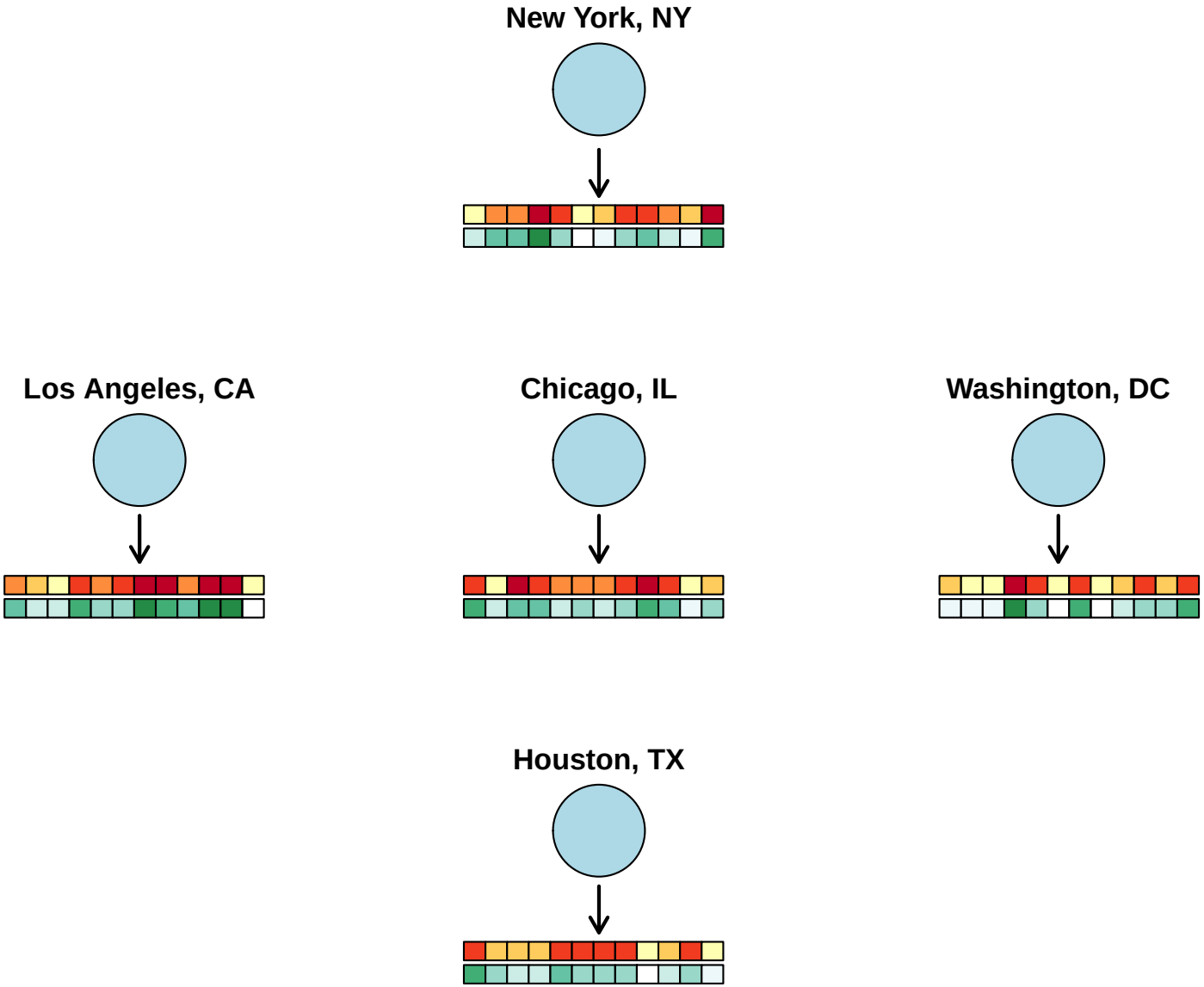
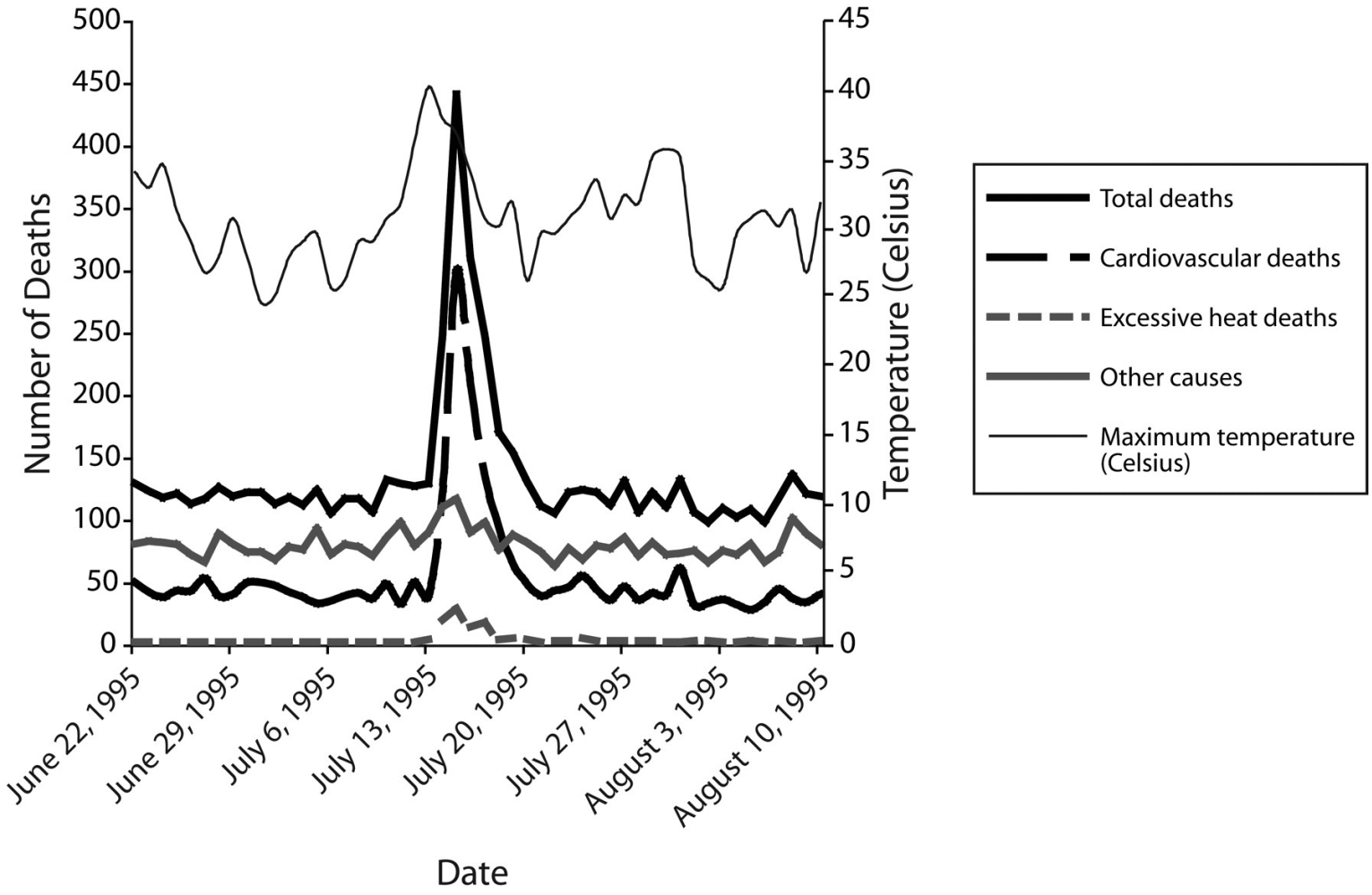


Mortality during the 1995 Chicago heat wave



Daily mortality and temperature during the 1995 heat wave in Chicago, IL.

Source: Kaiser et al., 2007

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Chicago, 1995

Mortality during the 1995 heatwave in Chicago, IL.

Left: Refrigerated trucks were needed to store bodies (Source: Life Magazine). Right: Many heatwave victims were buried in a mass grave (Source: New York Times).

Chicago, 1995

Mortalities associated with 1995 heatwave in Chicago:

> 700

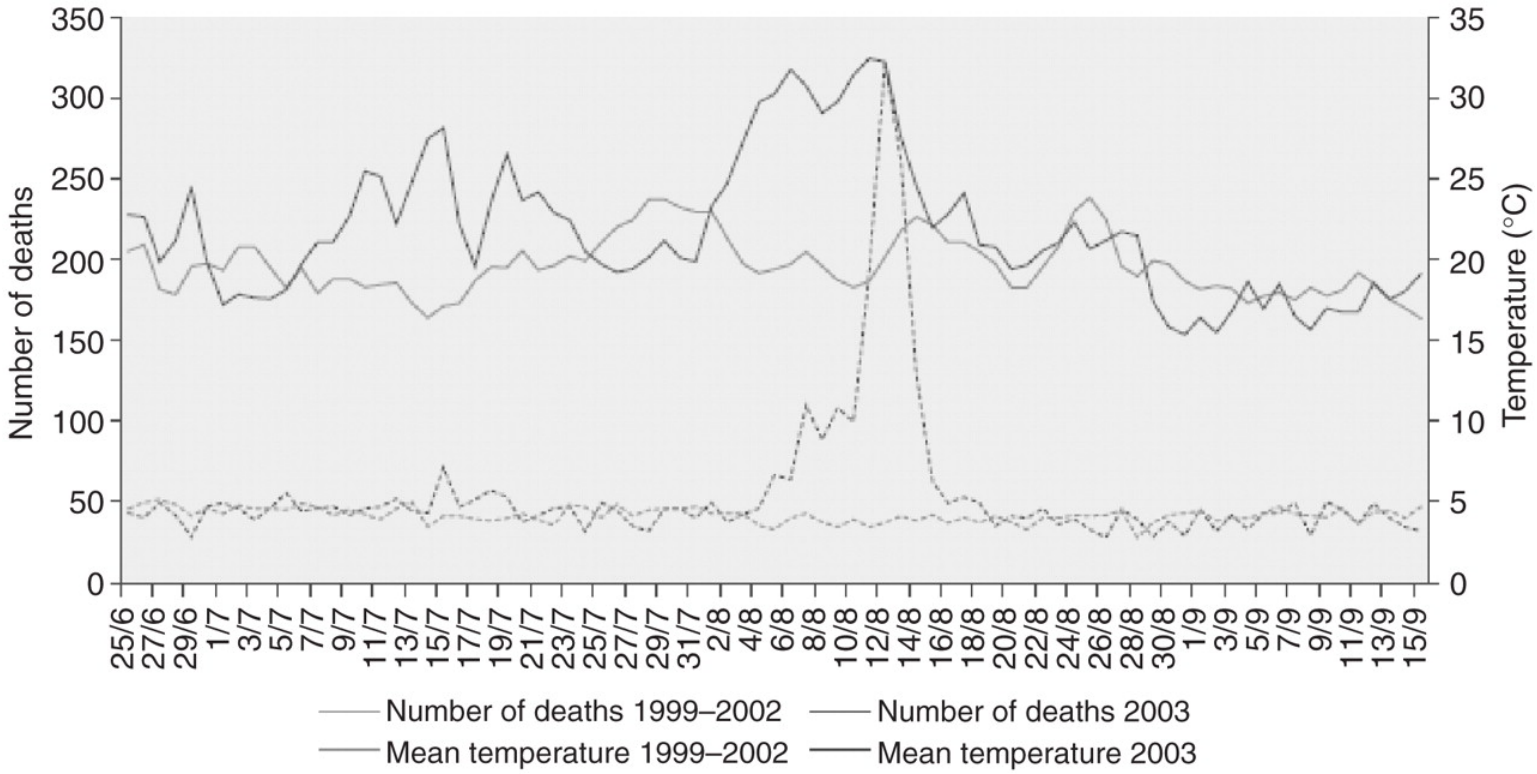
Source: Whitman et al., 1997, Am J Public Health (87) 9, 1515-1518

Traffic fatalities in Cook County, Illinois, 1995:

437

Source: http://www-fars.nhtsa.dot.gov

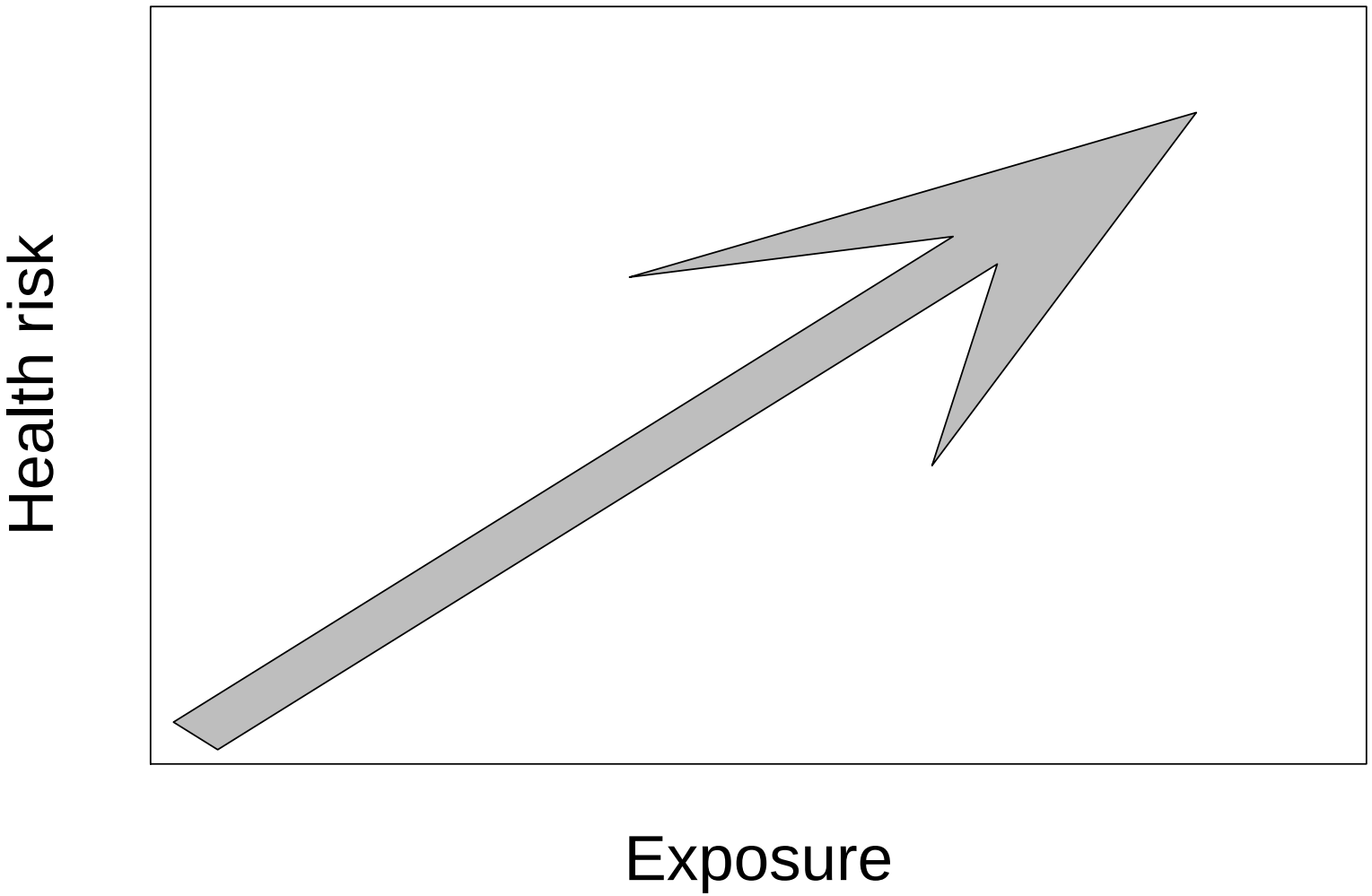
Mortality during the 2003 French heat wave



Daily mortality and temperature in Paris, France, during the 2003 heat wave.

Source: Kovats and Ebi, 2006

Studying environmental exposures



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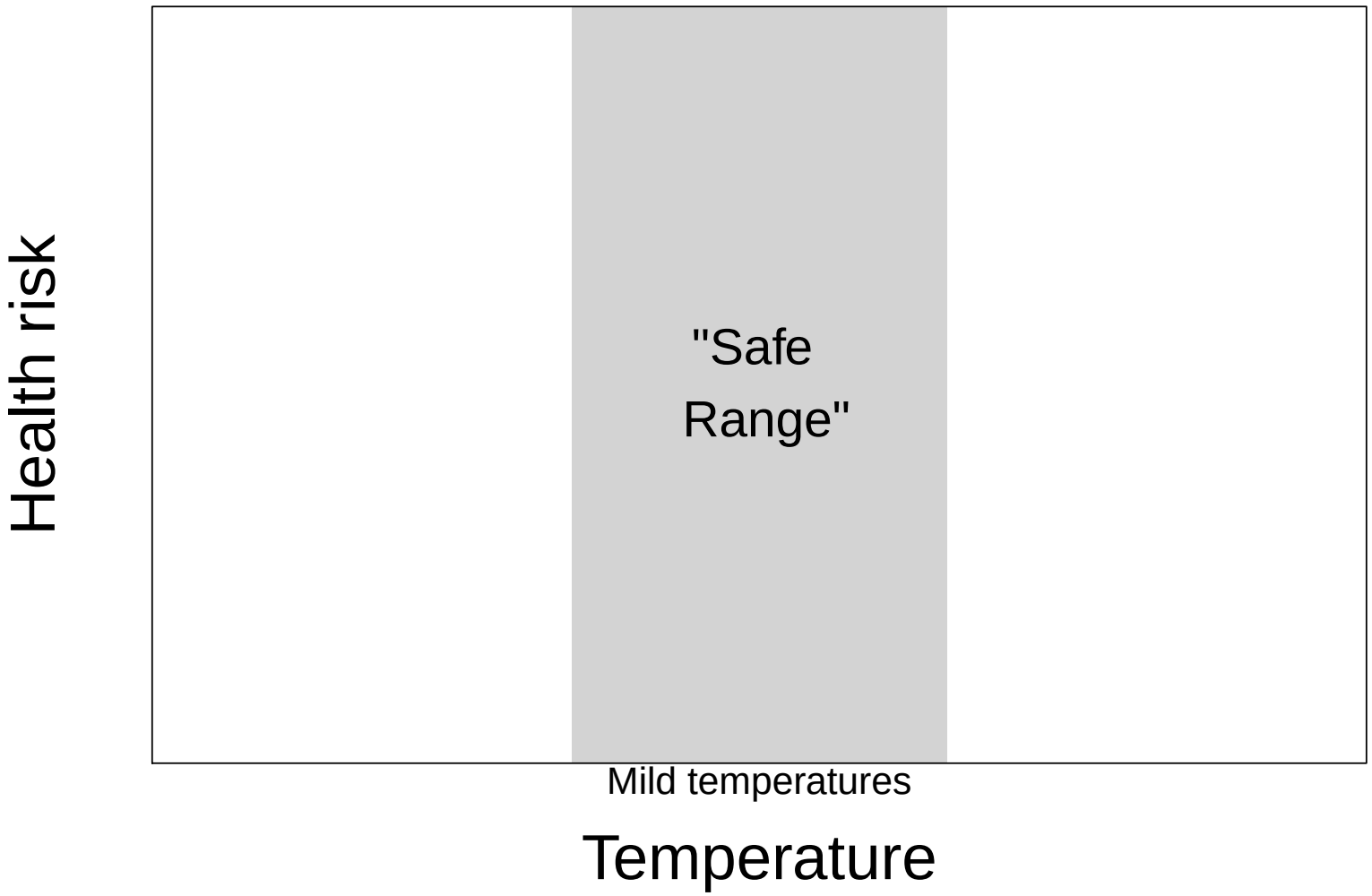

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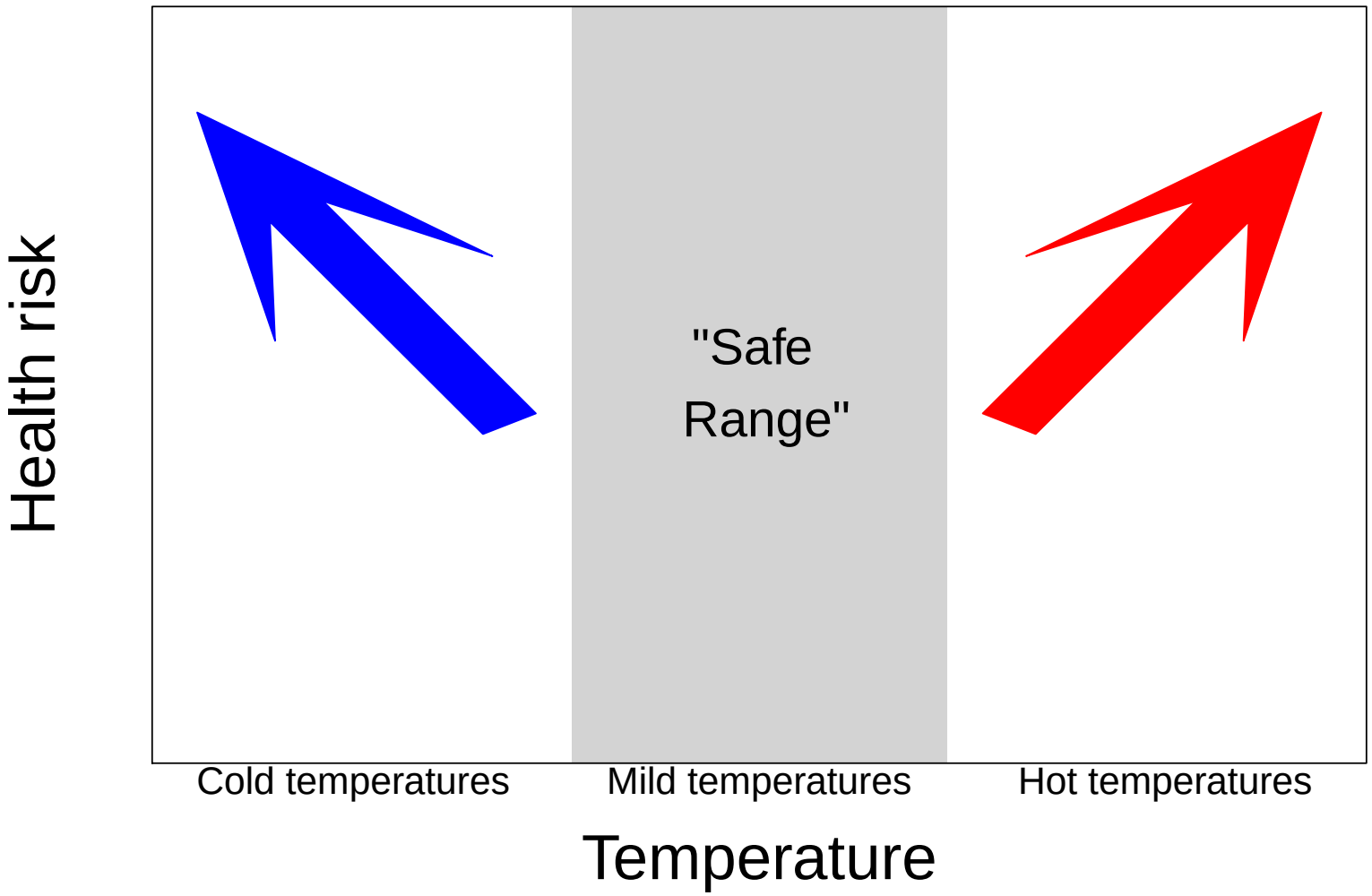

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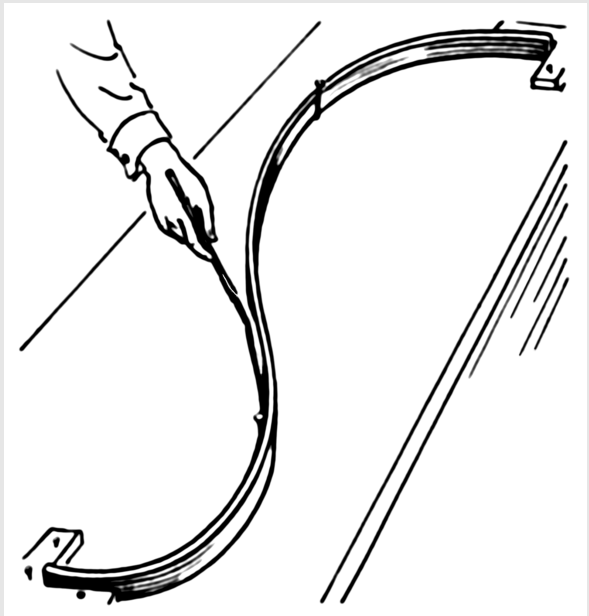
Modeling non-linear temperature effects

Spline

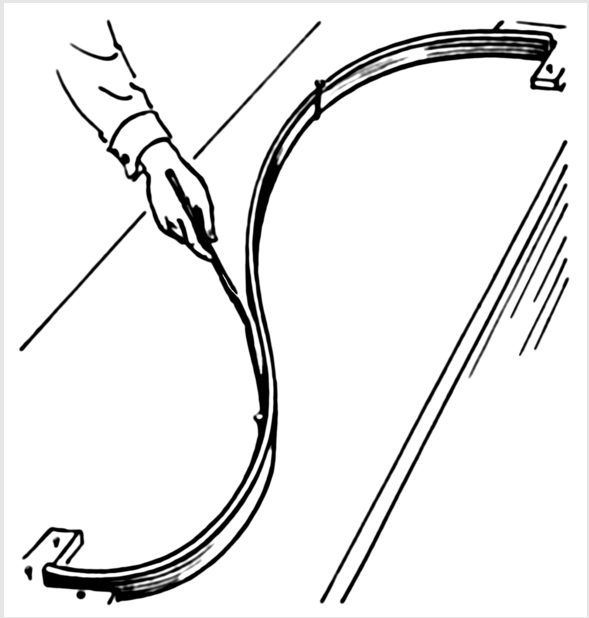


Source: Wikipedia

Modeling non-linear temperature effects

Spline

A type of function that fits a curve through a set of points as smoothly as possible.



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- Advantages:
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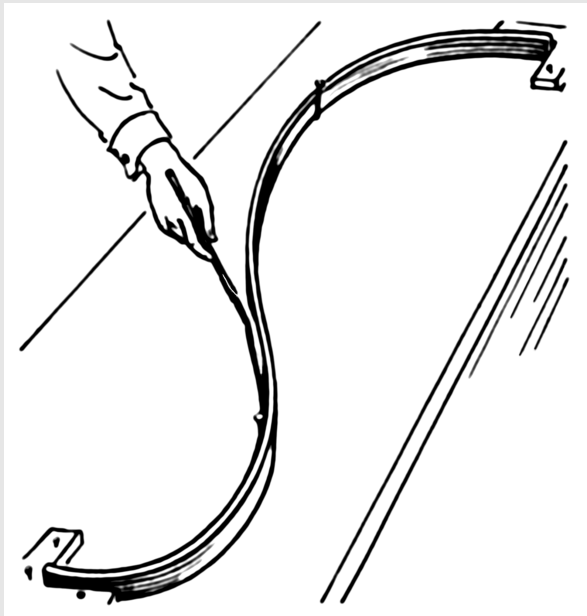
  - Requires no assumptions about shape of function



Source: Wikipedia

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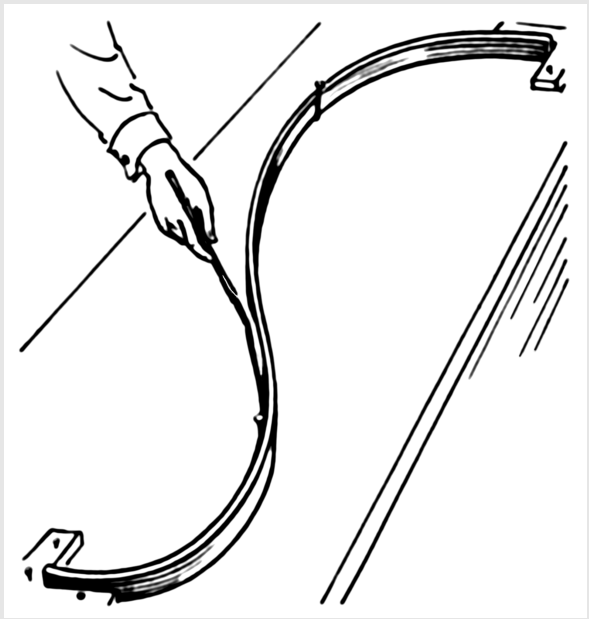
A type of function that fits a curve through a set of points as smoothly as possible.

- Advantages:
  - Smooth function
  - Requires no assumptions about shape of function
- Disadvantage:
  - No parameters to summarize relationships



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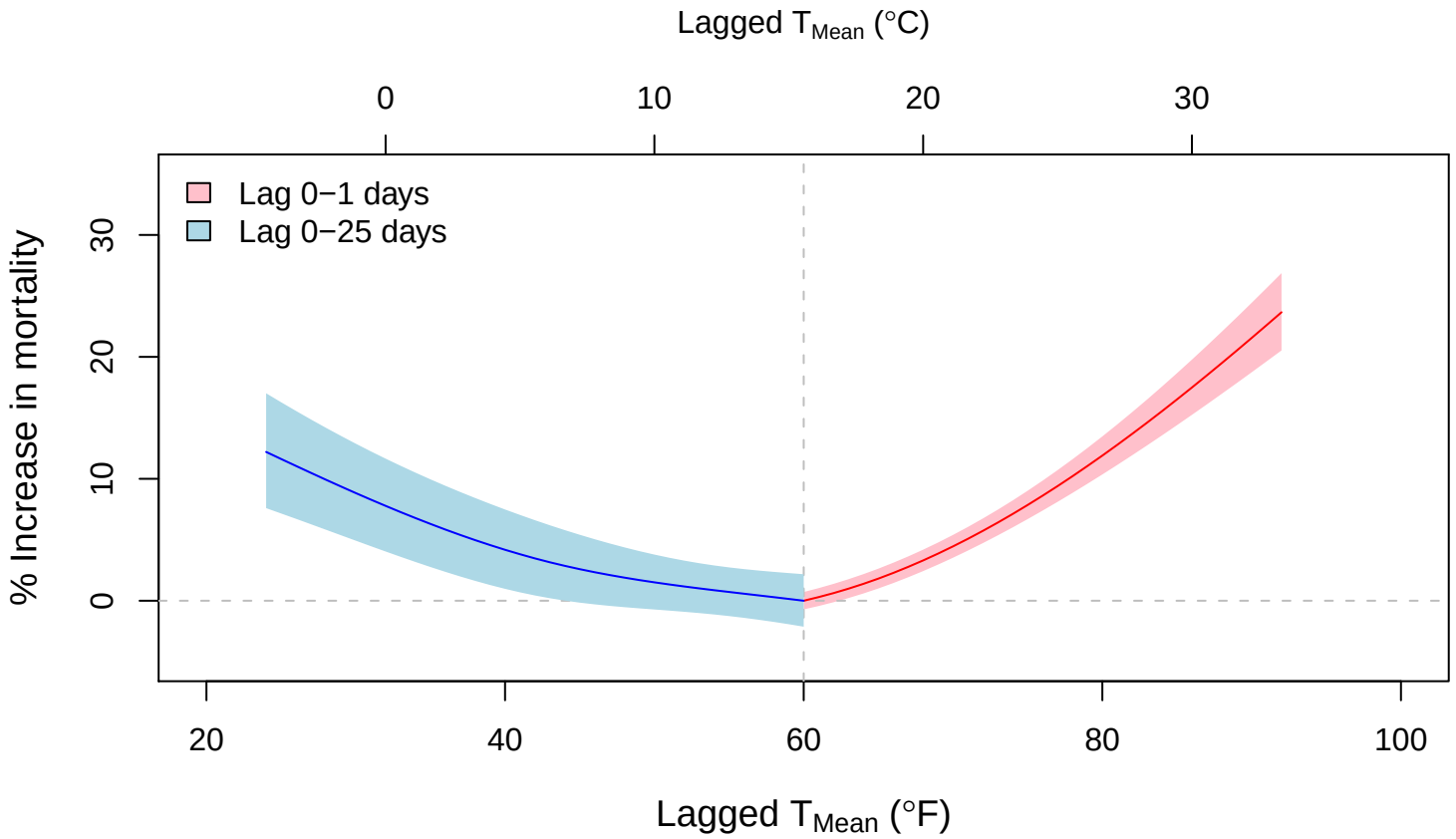
Temperature-mortality curve



Temperature-mortality curve for New York, NY (1987–2000).

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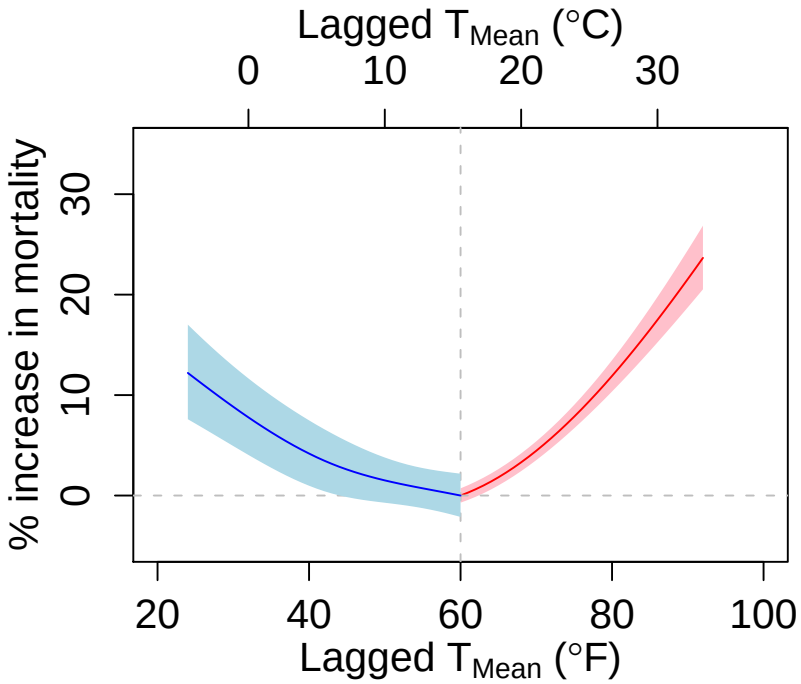
Measuring temperature effects

Absolute cold effect: % increase in mortality risk at 40°F compared to 60°F.



Example of measuring absolute cold effects, New York, NY.

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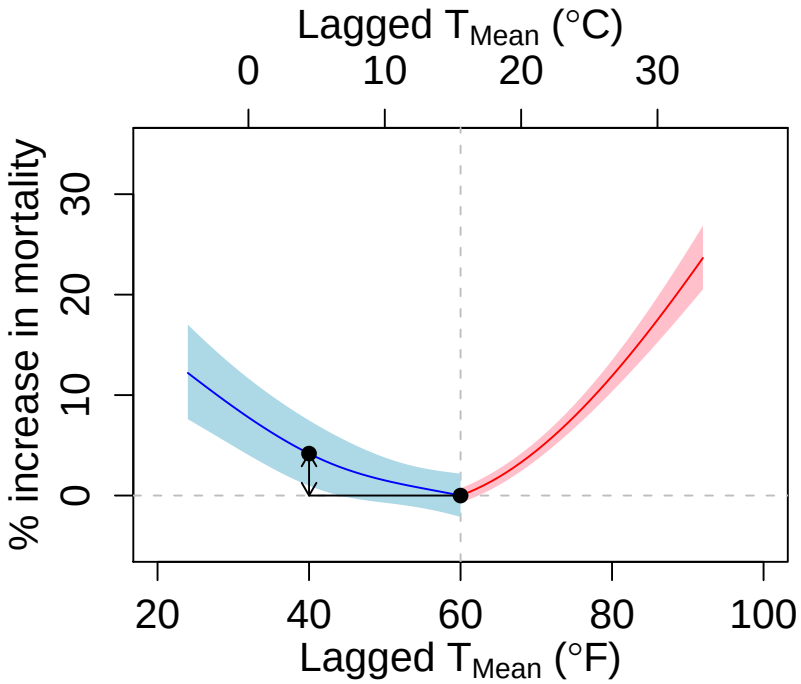

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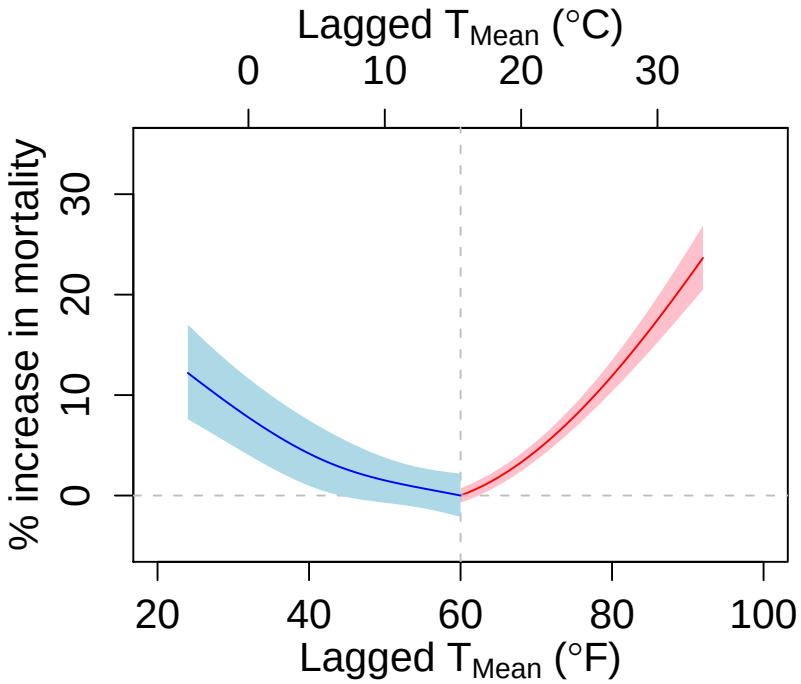
Relative cold effect: % increase in mortality risk at 1st percentile T_{mean} compared to the 10th percentile T_{mean}.



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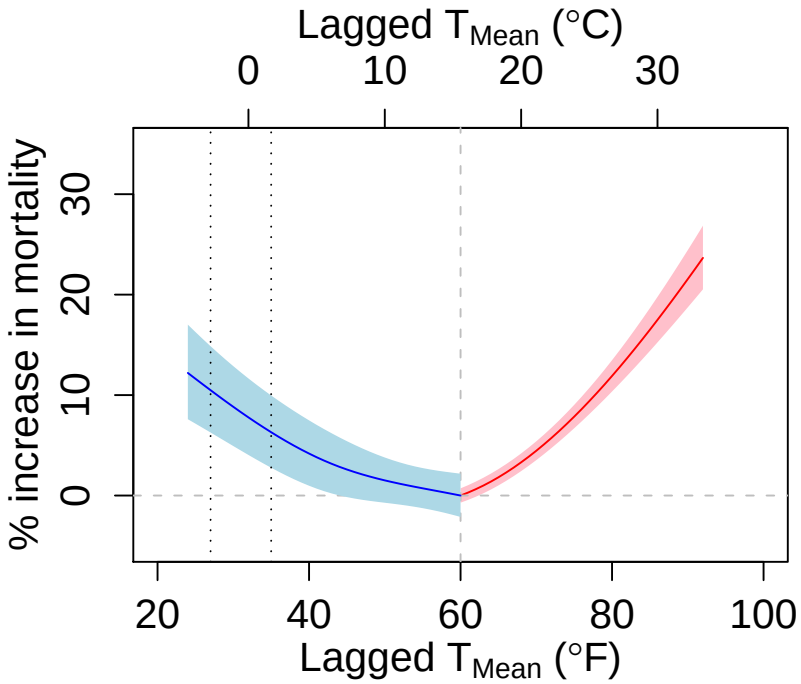

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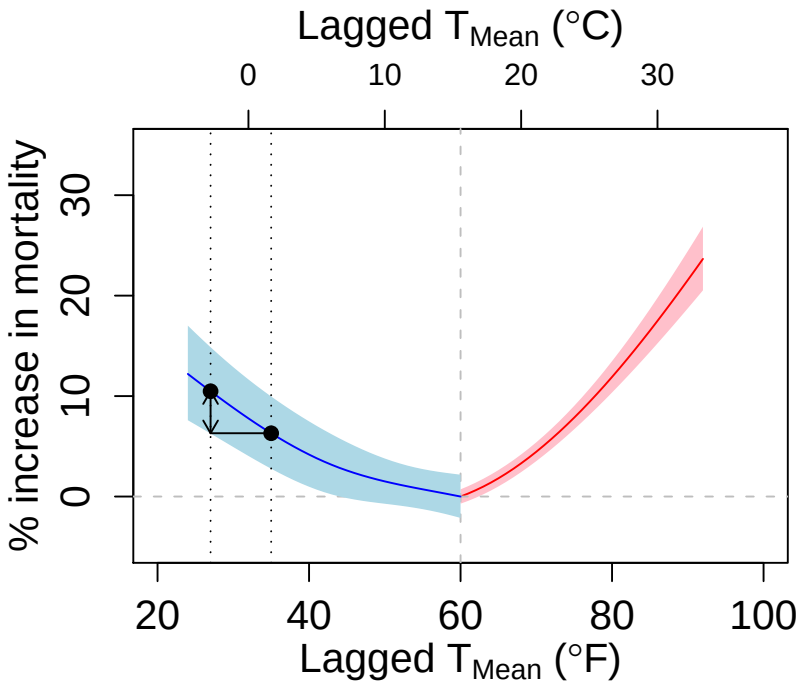

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Temperature effect measurements

Absolute cold effect % increase in mortality risk at 40°F compared to 60°F.

Relative cold effect % increase in mortality risk at 1st percentile T_{mean} compared to the 10th percentile T_{mean}.

Absolute heat effect % increase in mortality risk at 80°F compared to 60°F.

Relative heat effect % increase in mortality risk at 99th percentile T_{mean} compared to the 90th percentile T_{mean}.

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Variations in climate across US

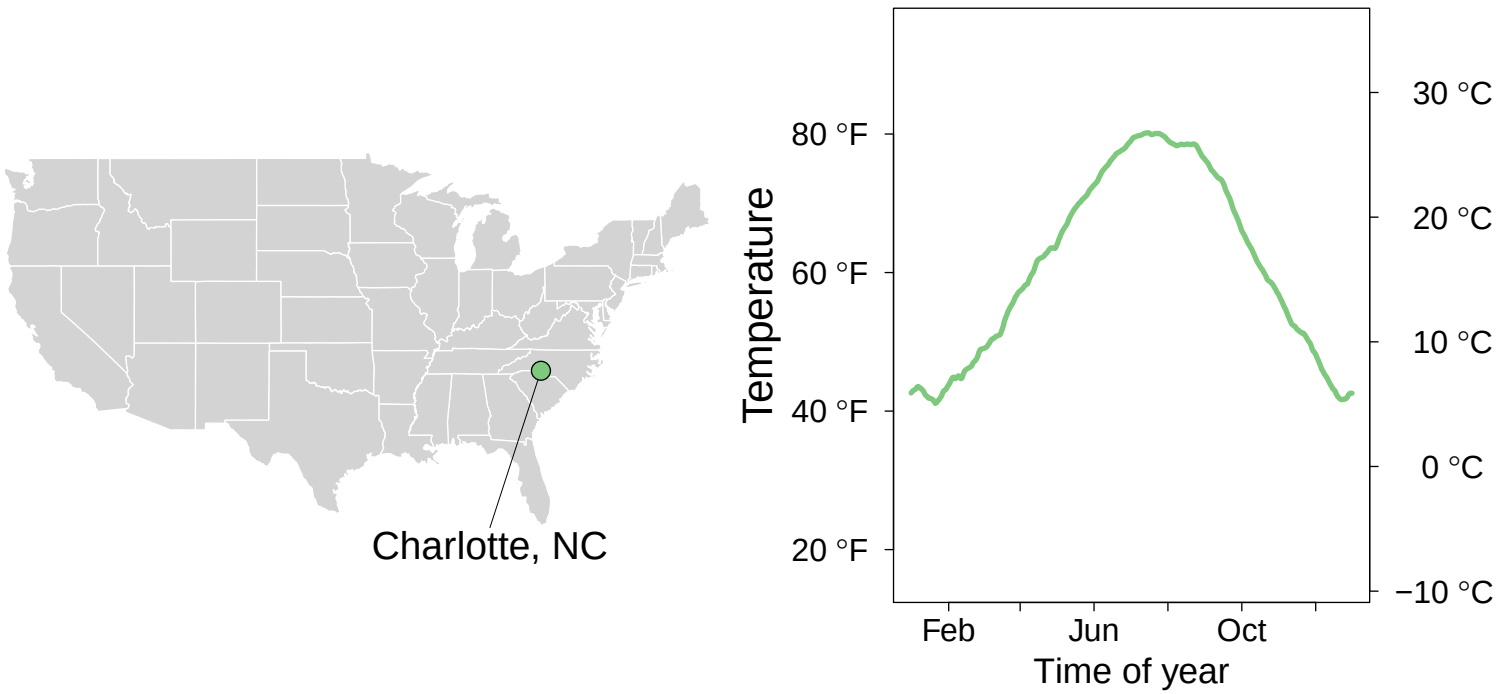

Figure: Typical daily mean temperature values, 1987–2005.

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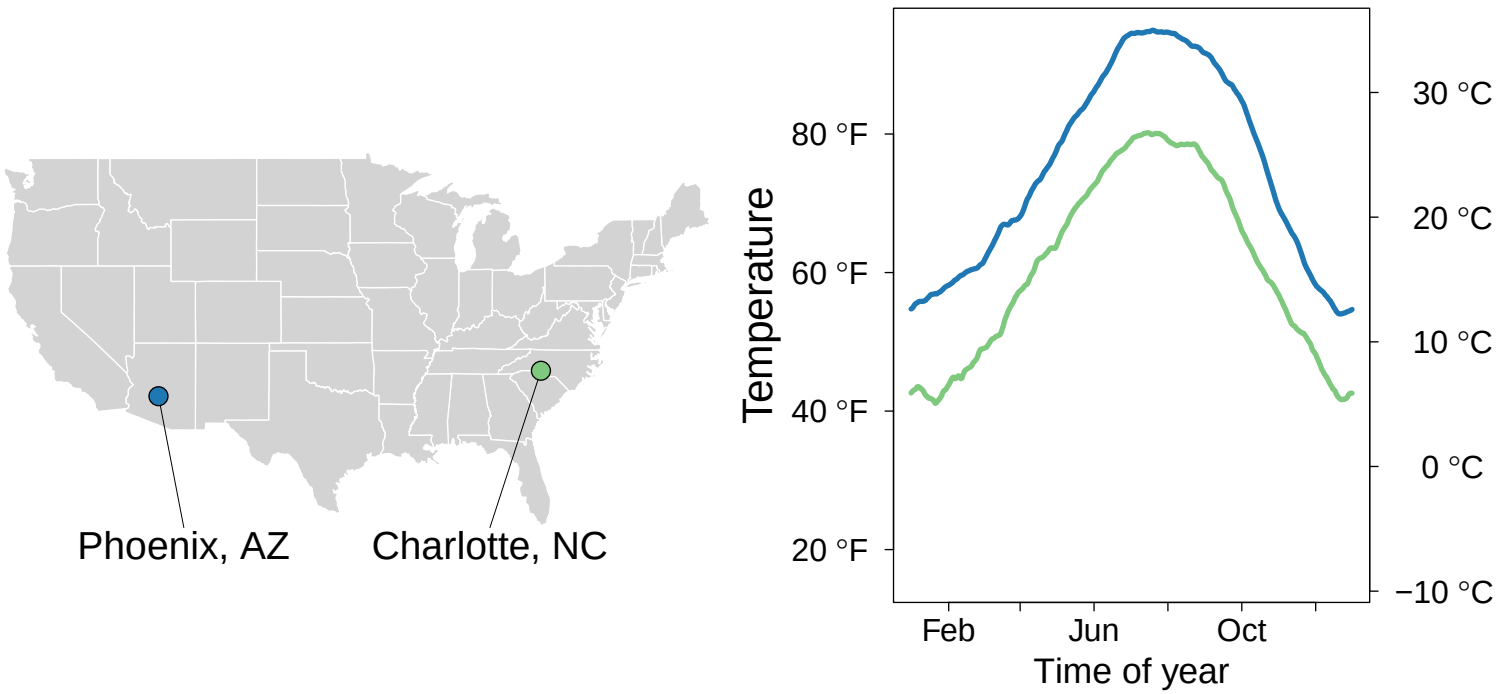

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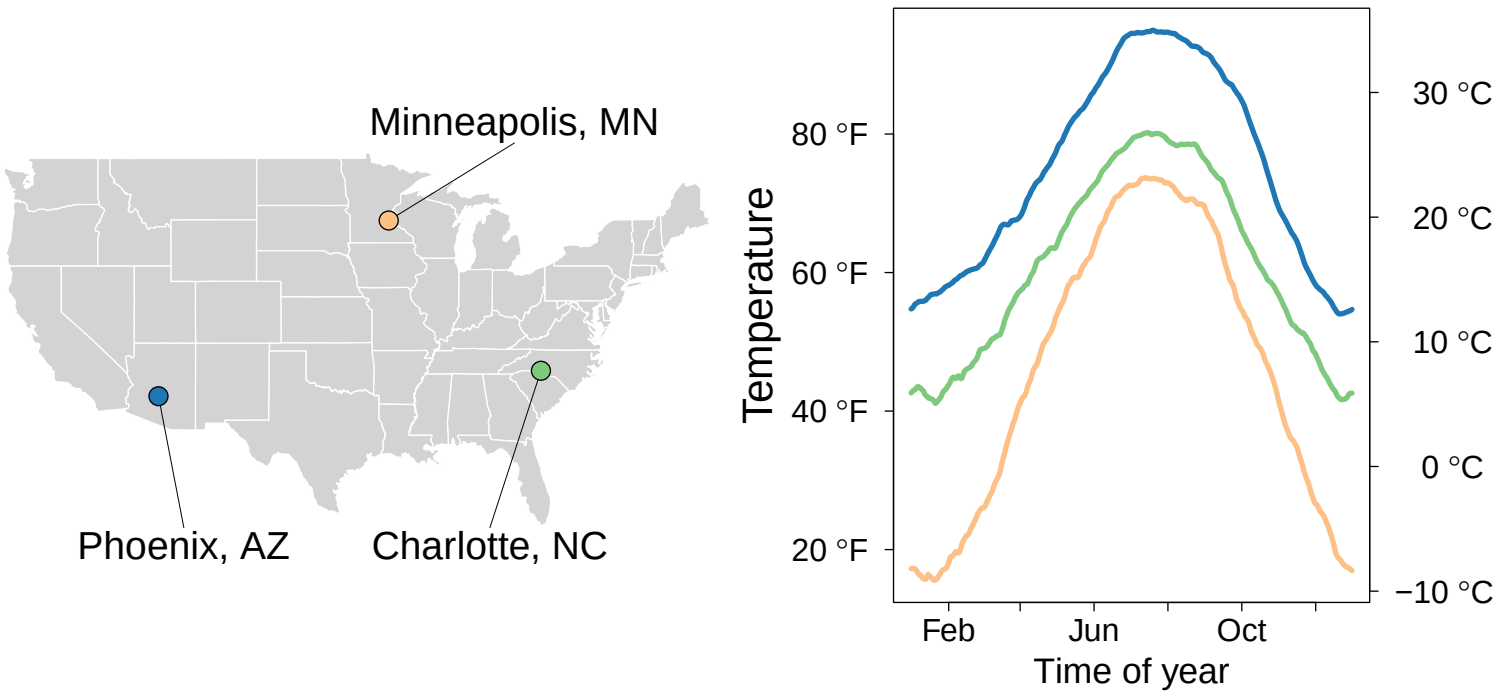

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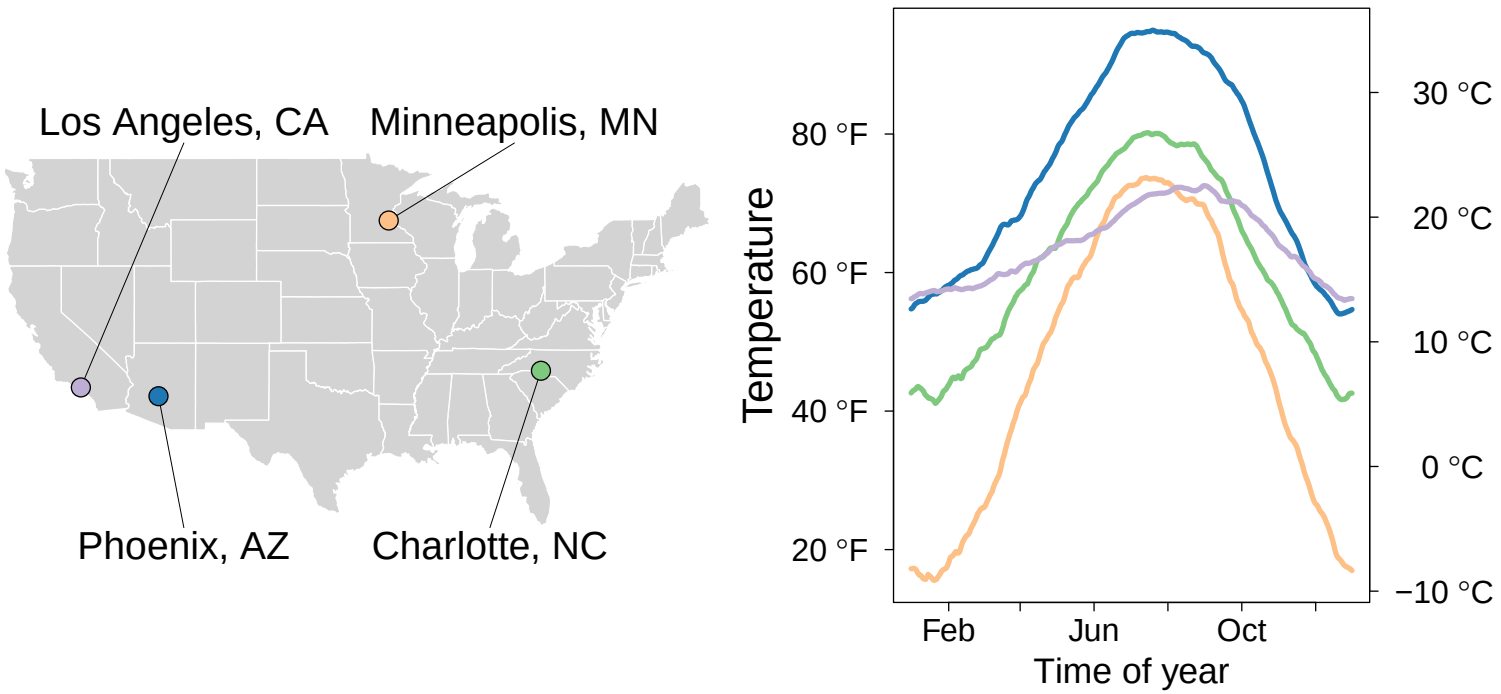

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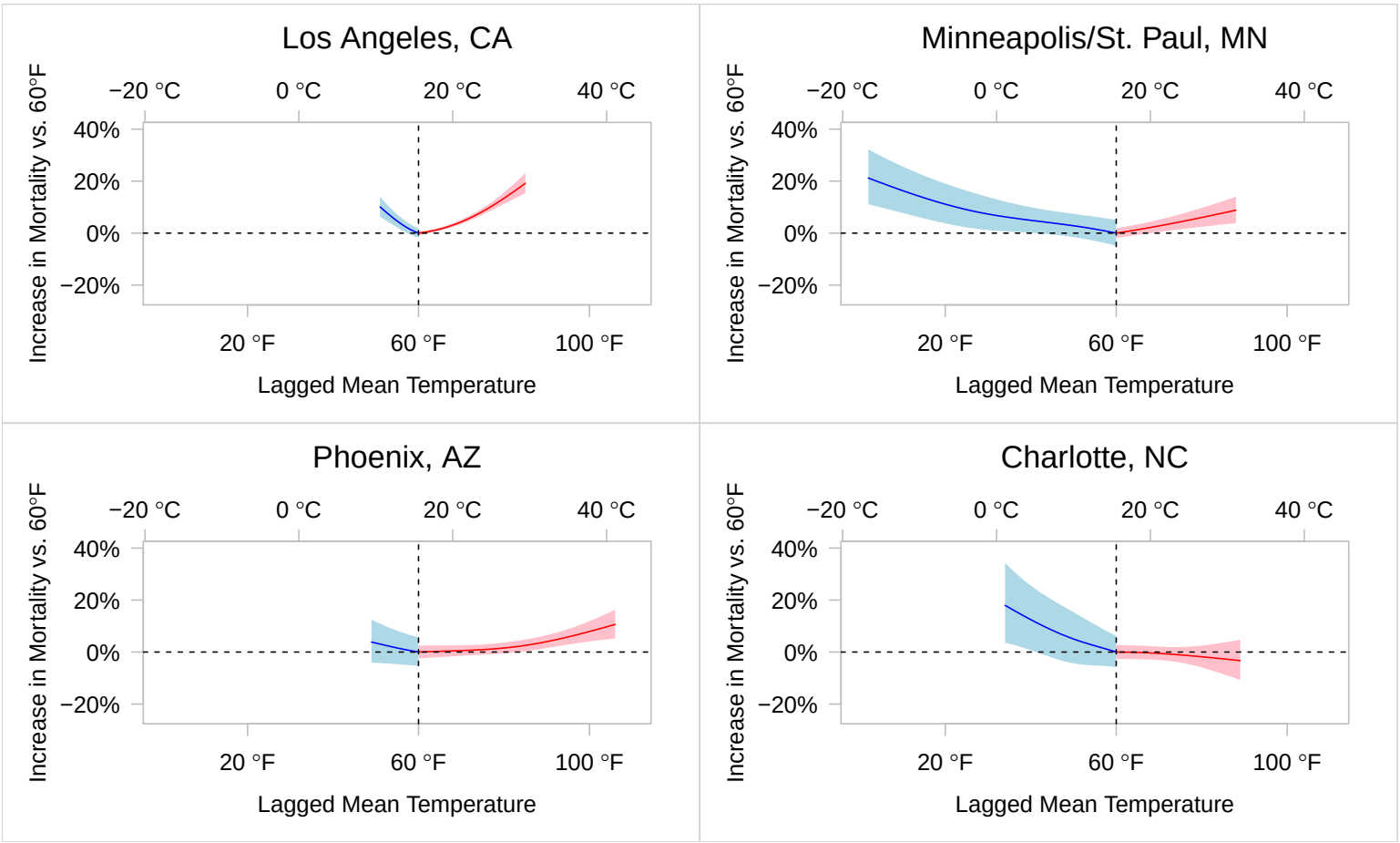
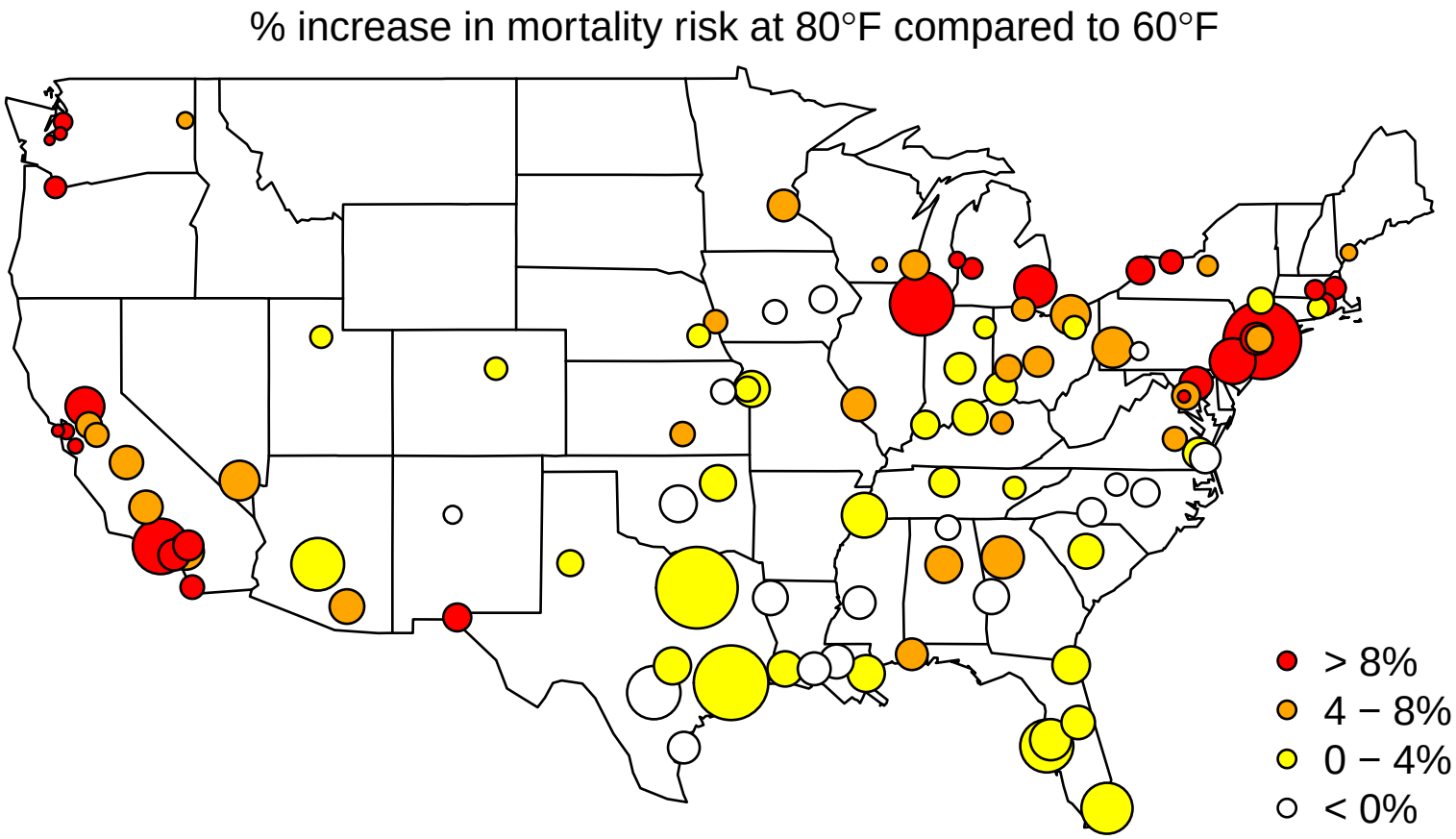
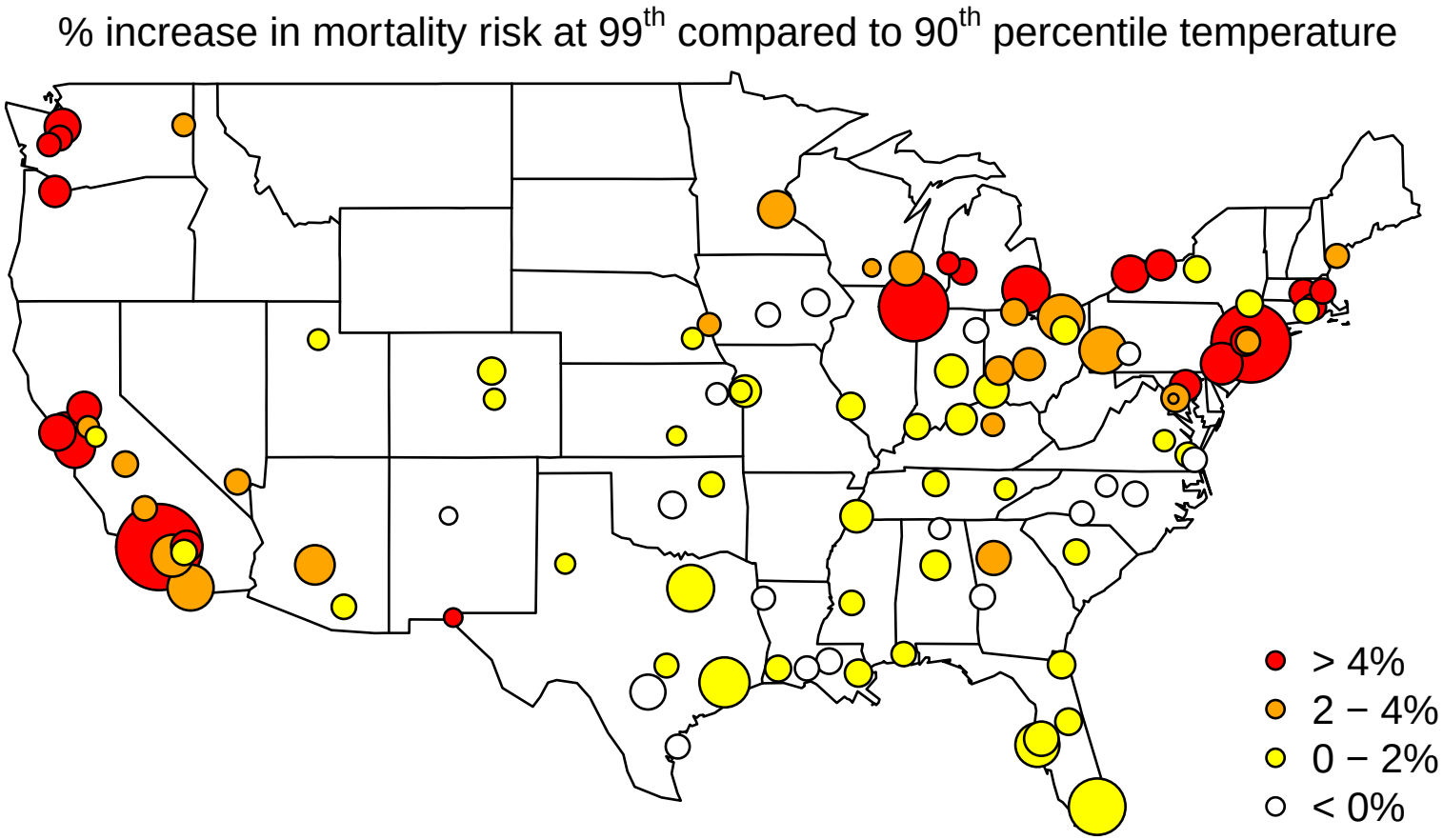


Heat effects in US (absolute metric)



Circle size corresponds to certainty of estimate
(larger circles indicate estimates of higher certainty).

Heat effects in US (relative metric)



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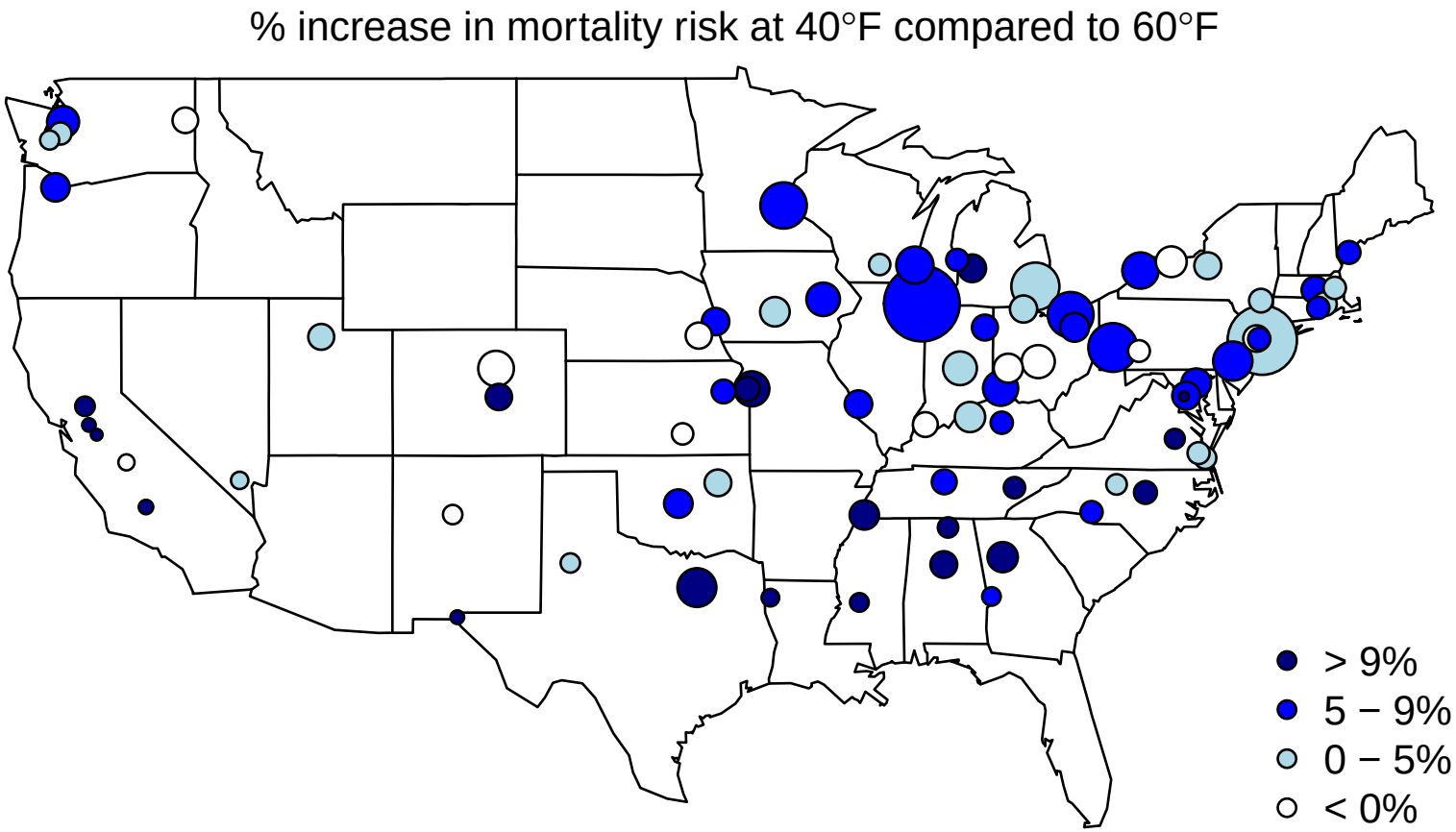
Cold effects in US (absolute metric)



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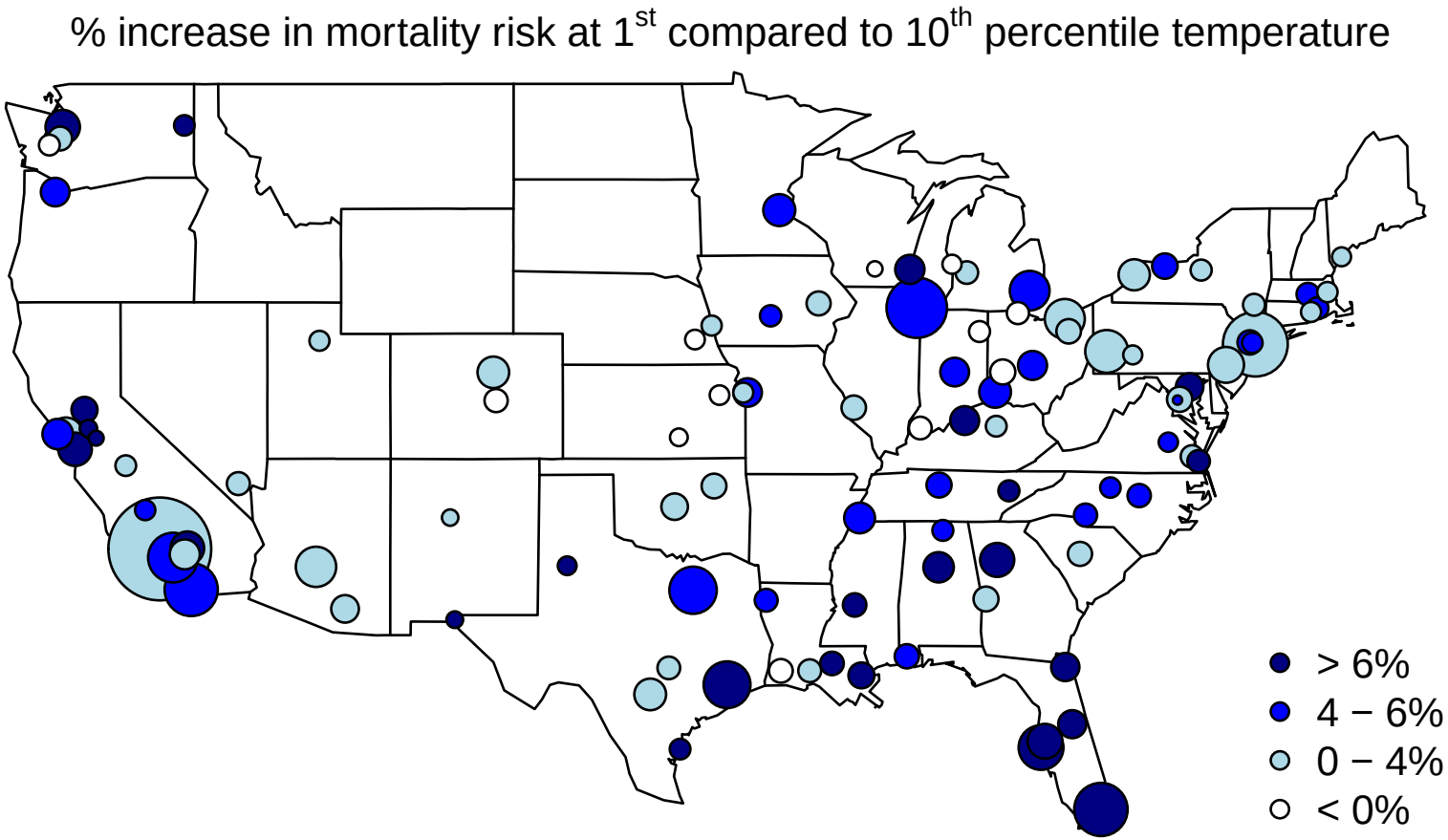
Cold effects in US (relative metric)



Circle size corresponds to certainty of estimate
(larger circles indicate estimates of higher certainty).

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- Short-term: days to weeks

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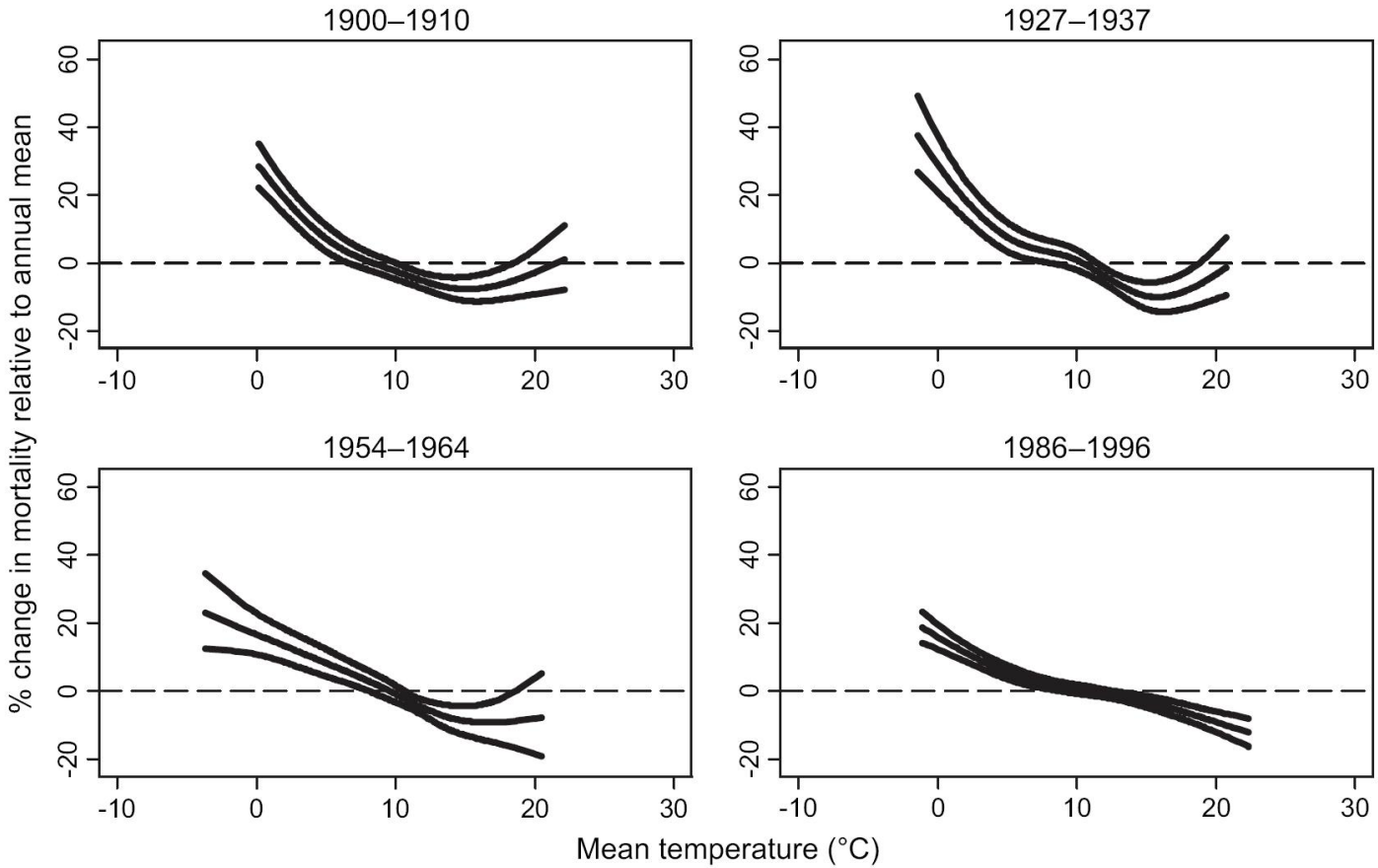
Changes in temperature effects over time



Temperature-mortality curves for London, England, at four different time periods.
Source: Carson et al., 2006

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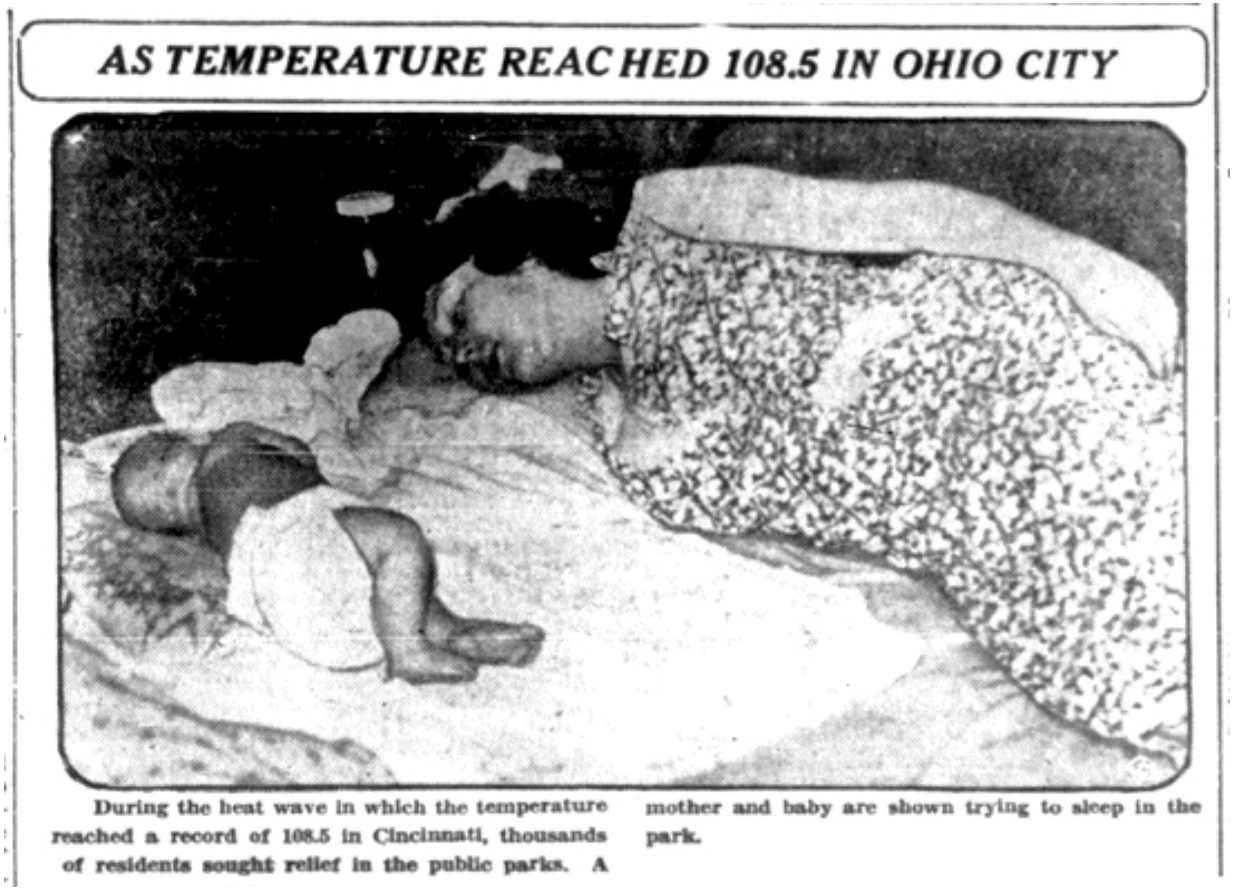
- Short-term: days to weeks
- Improved thermoregulation
  - Start sweating at lower temperature
  - Less cardiovascular stress

Long-term adaptation

- Long-term: years to decades
- Changes in:
  - housing
  - medical care
  - health of population
  - behaviors to cope with temperature extremes

Coping with heat waves, 1930s



AS TEMPERATURE REACHED 108.5 IN OHIO CITY

During the heat wave in which the temperature reached a record of 108.5 in Cincinnati, thousands of residents sought relief in the public parks. A mother and baby are shown trying to sleep in the park.

A mother and baby sleep in a park during the 1934 heat wave in Cincinatti, OH.
Source: ohiohistory.org

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Coping with heat waves, 1950s

Sleeping on a fire escape during a heat wave.
Source: Alfred Hitchcock, *Rear Window*

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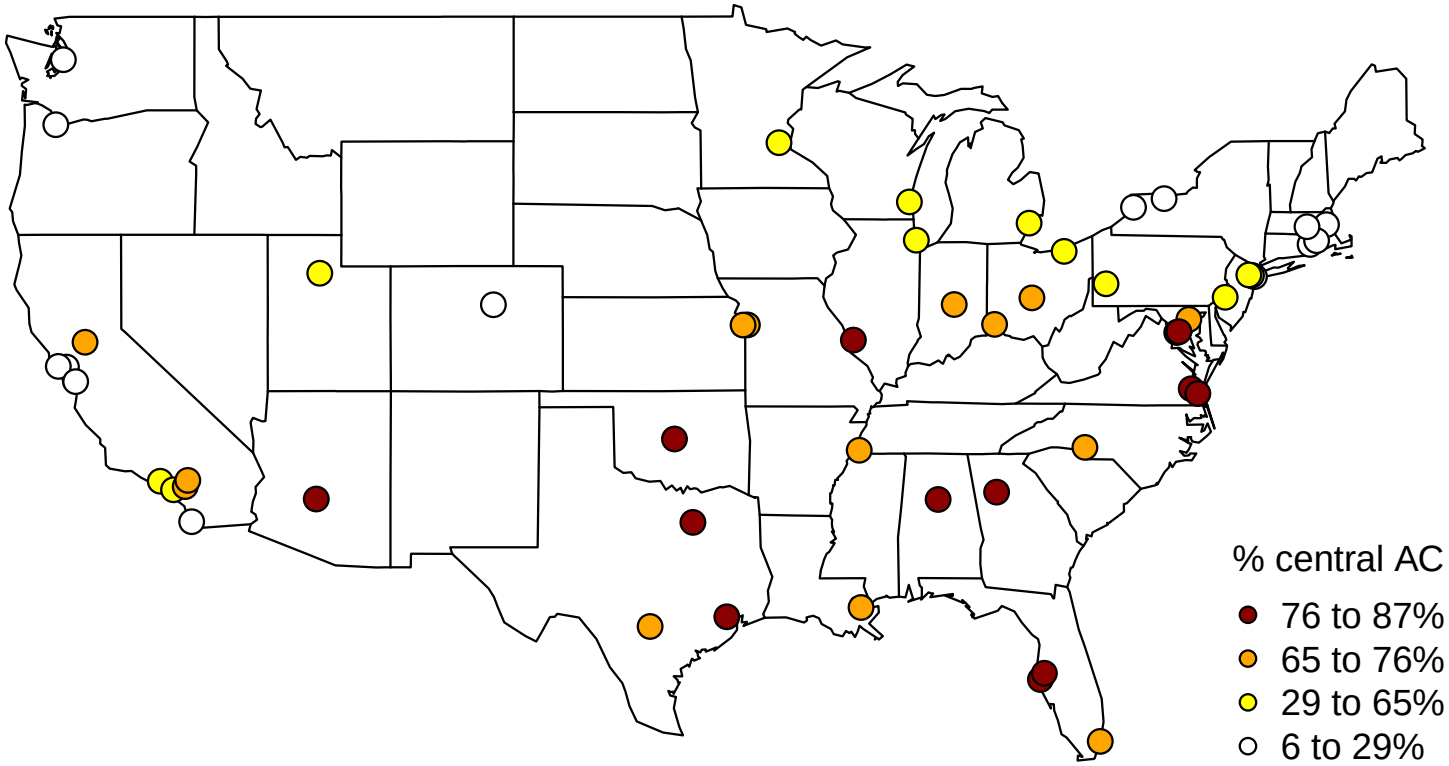
Air conditioning prevalence



Prevalence of air conditioning in US communities, 1987–2000.

Community responses

- Energy subsidies (heating and cooling)
- Suspend utility shut-downs
- Phone hotline
- Heat warning systems
- Making shelter available (homeless shelters, cooling centers)
- Create policies to limit urban heat island effects

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Infants, elderly, people with underlying health conditions, people taking certain medications

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Cognitive impairments

Mental illness, drug or alcohol abuse

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Cognitive impairments

Mental illness, drug or alcohol abuse

Economic constraints

Limited access to air conditioning, fear of crime

Susceptibility

Physical constraints

Infants, elderly, people with underlying health conditions, people taking certain medications

Cognitive impairments

Mental illness, drug or alcohol abuse

Economic constraints

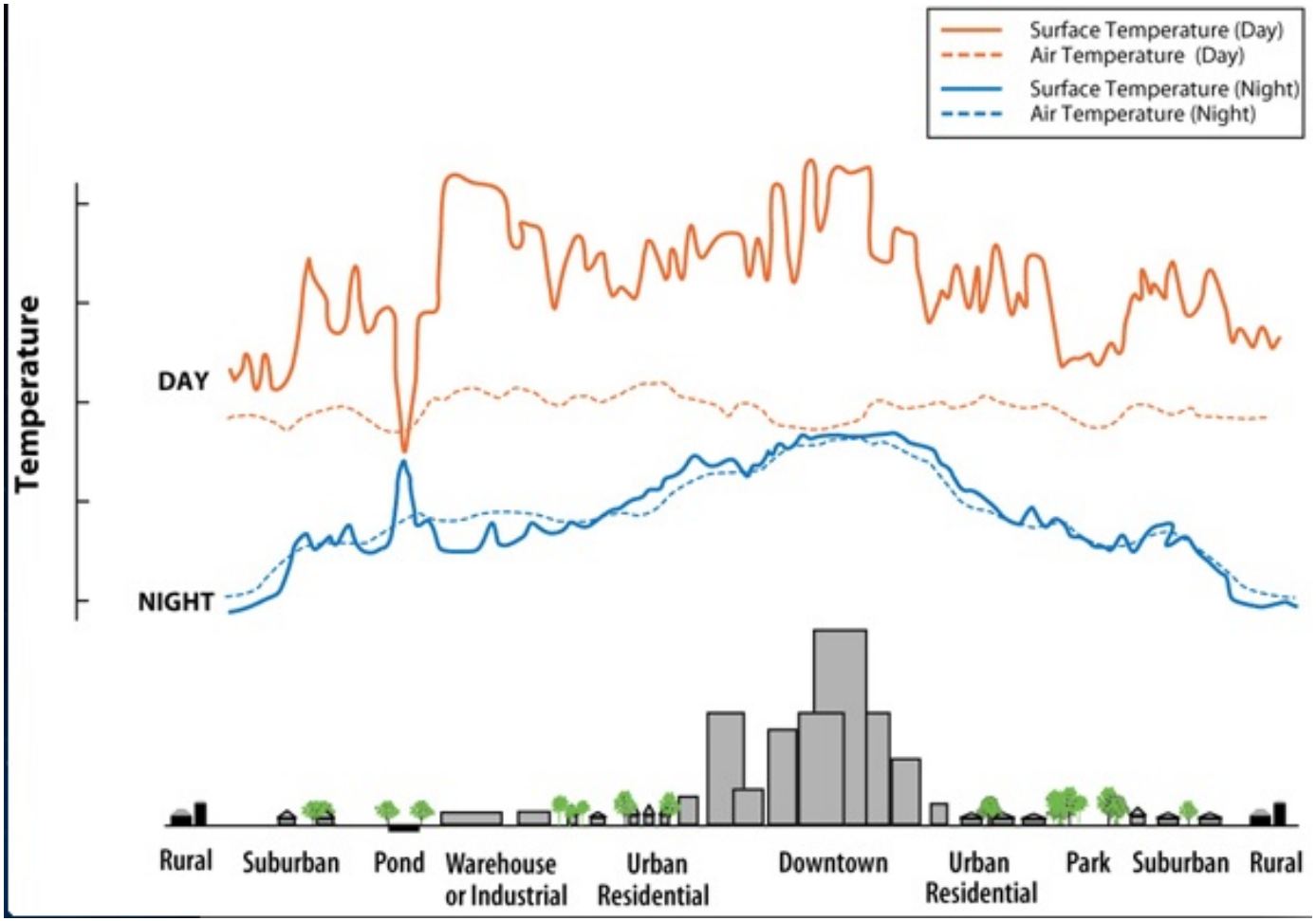
Limited access to air conditioning, fear of crime

Social isolation

Homeless, people who live alone

Based on EPA, 2006.

Urban heat island



Example of urban heat island effects.

Sourceh: epa.gov

Pollution

Air pollution in Moscow, Russia, during the 2010 heat wave.
Source: pbs.org

Pollution

Headlines from the 2010 Russian heat wave:

Russian heatwave kills 5,000 as fires rage out of control

Russia's devastating summer heatwave has cost almost 5,000 lives, according to officials who conceded yesterday that the state was struggling to gain control over the worst wildfires in decades. Friday 07 October 2011 The Telegraph

Death rate doubles in Moscow as heatwave continues 9 August 2010 Last updated at 11:51 ET BBC

Moscow death toll soars as heat wave persists

High temperatures and smog from raging forest fires take their toll central Russia, especially in Moscow, where the normal daily death rate has doubled to 700, officials say.

August 10, 2010 | By Sergei L. Loiko, Los Angeles Times

Russia Heat Wave May Kill 15,000, Shave $15 Billion of GDP

By Lucian Kim and Maria Levitov - Aug 10, 2010 11:02 AM ET Bloomberg

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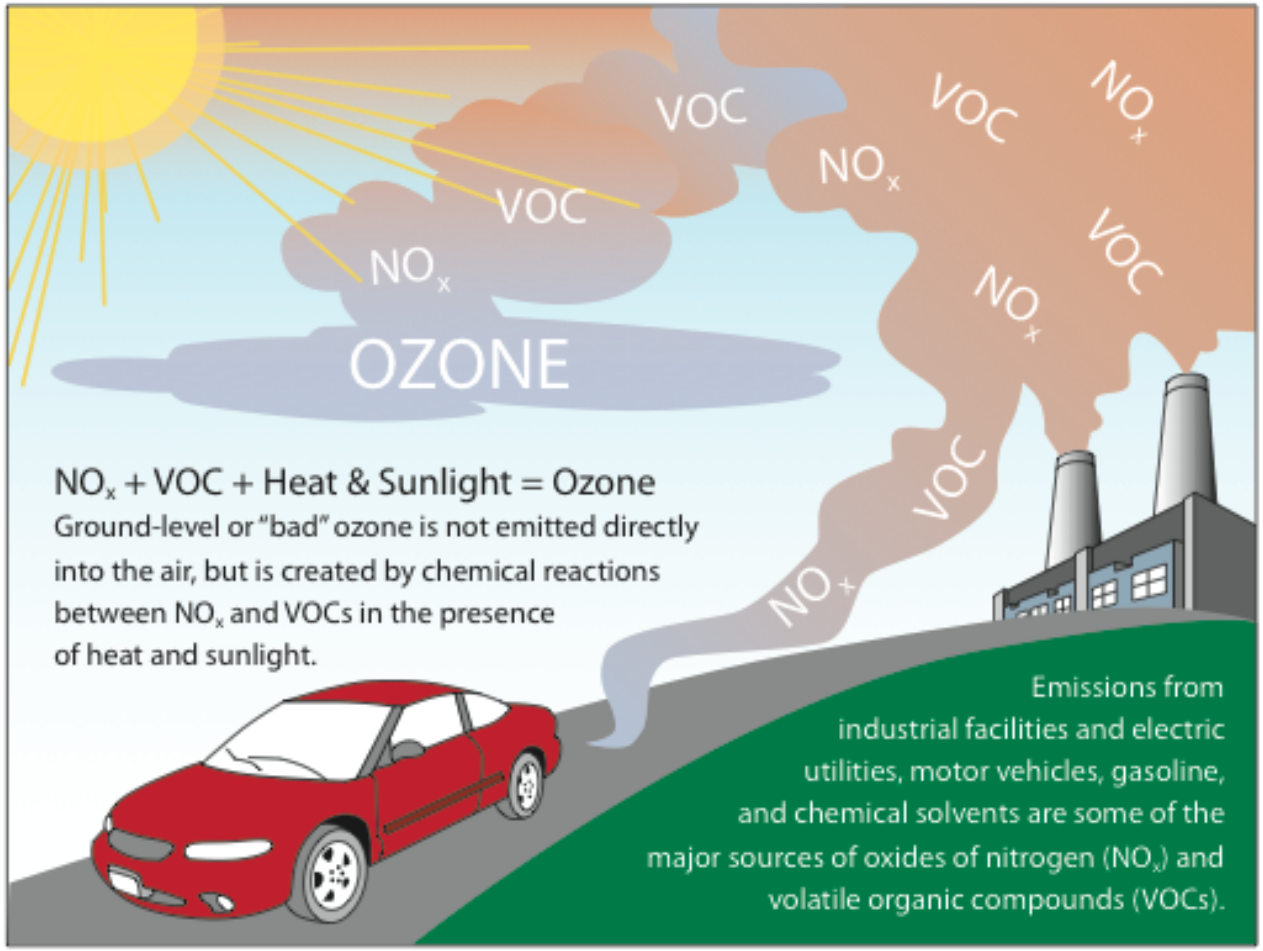
Formation of tropospheric ozone.



Source: Adapted from EPA 2010.

Source: cleanenergy.org, adapted from EPA, 2010

Power outages

The Red Cross distributes food and water on the seventh day of a heatwave-related power outage in Queens, New York in 2006.
Source: New York Times

Power outages

Full story at:
https://www.wired.com/magazine/2011/07/st_process_coned/

Summary

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- Extreme temperatures can increase human mortality from a variety of causes
- Severe heat waves can have catastrophic health consequences.
- The effects of temperature can vary dramatically across regions and over time.
- Certain groups of people are much more susceptible to temperature extremes.
- The effects of temperature can be aggrevated by associated risks, including pollution and power outages.