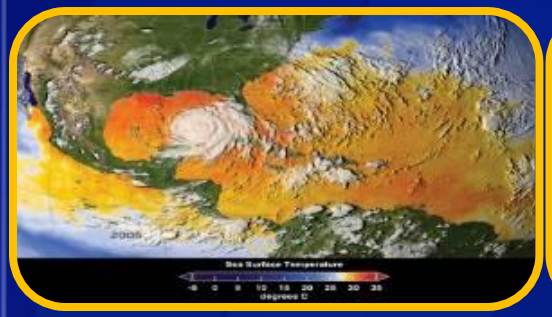
Climate Change: Emerging Public Health Threats



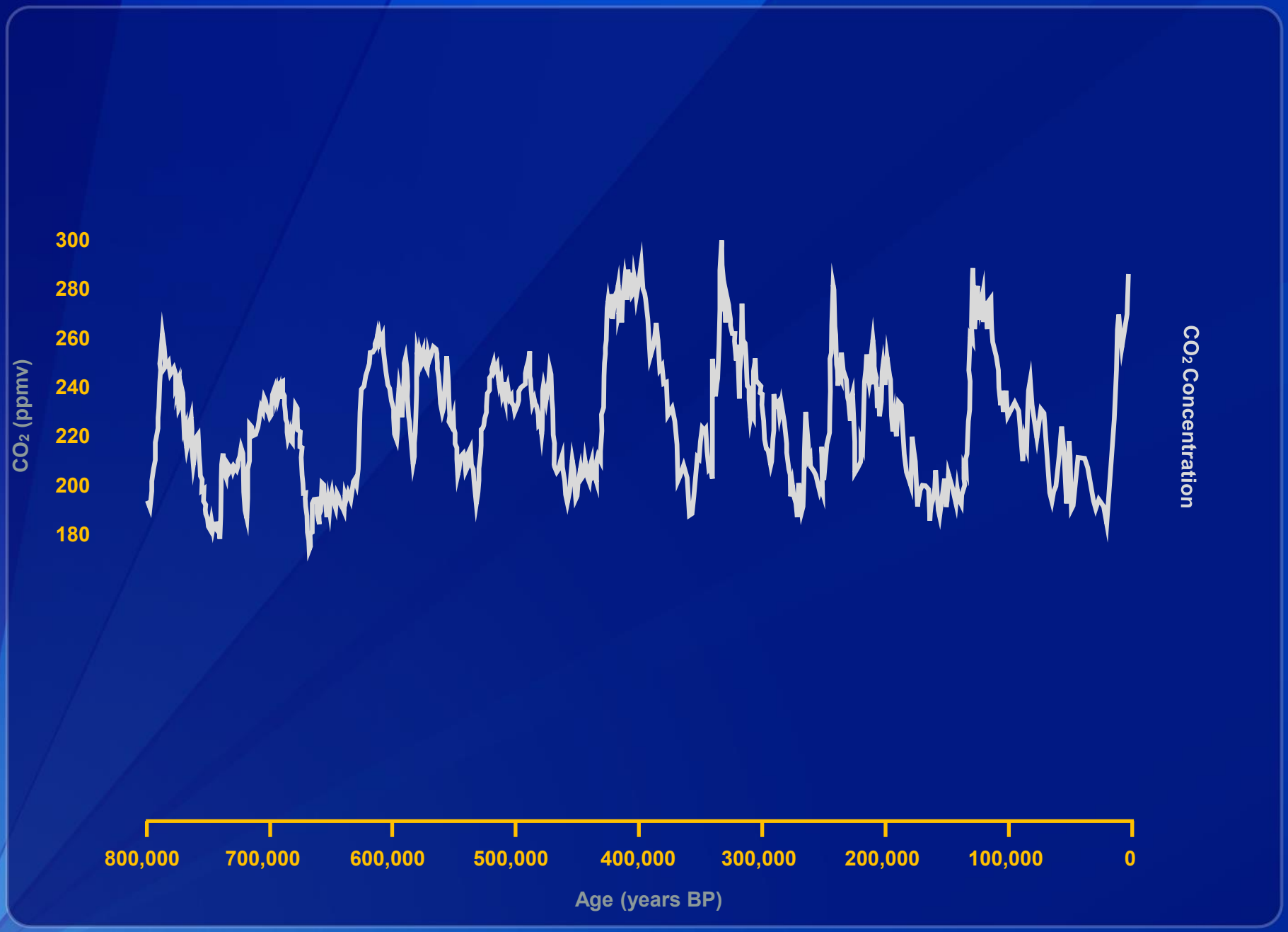

George Luber, PhD
Chief, Climate and Health Program
Centers for Disease Control and Prevention

Council of State and Territorial Epidemiologists webinar
August 4, 2015

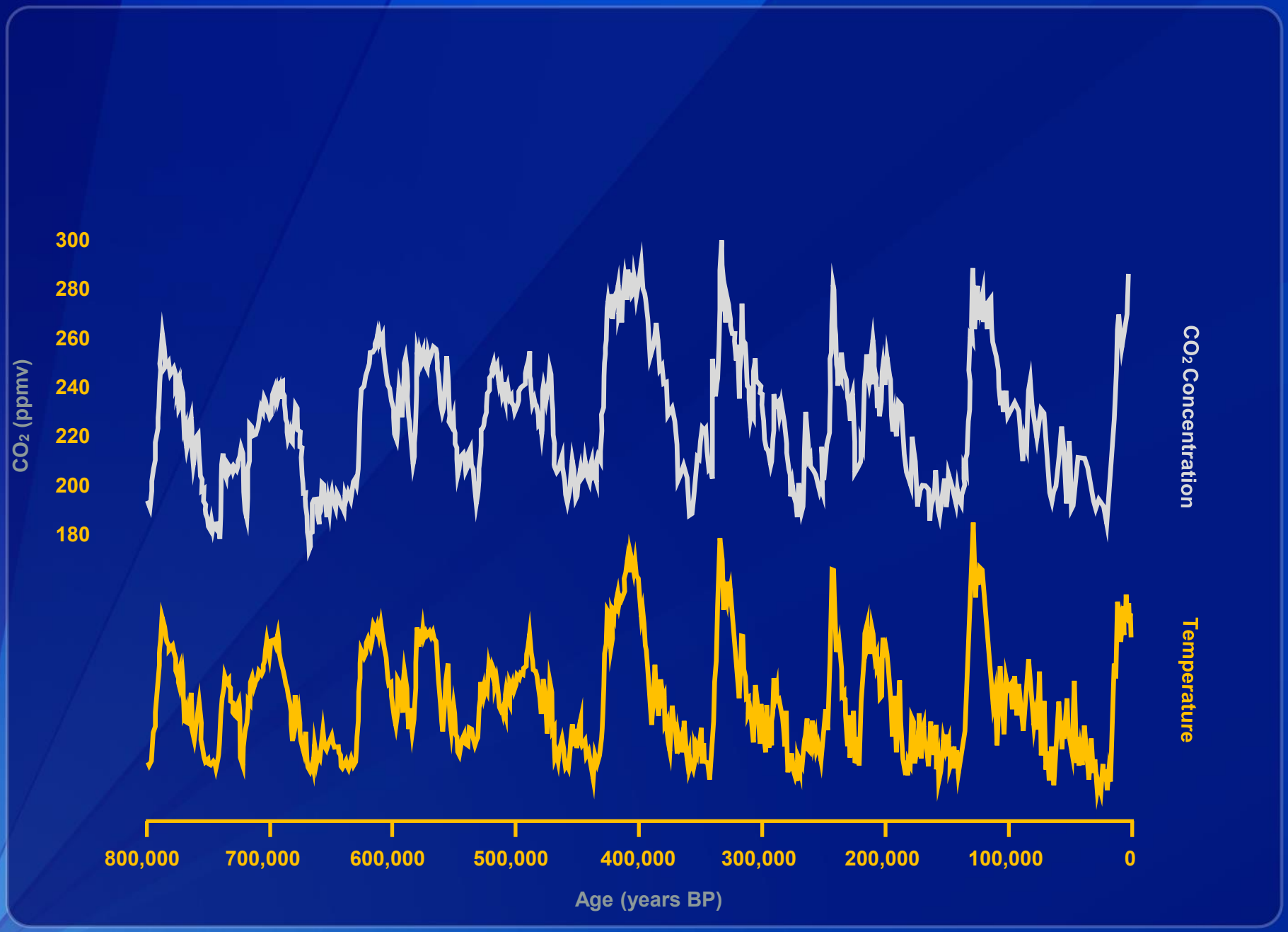
National Center for Environmental Health
Division of Environmental Hazards and Health Effects

Objectives

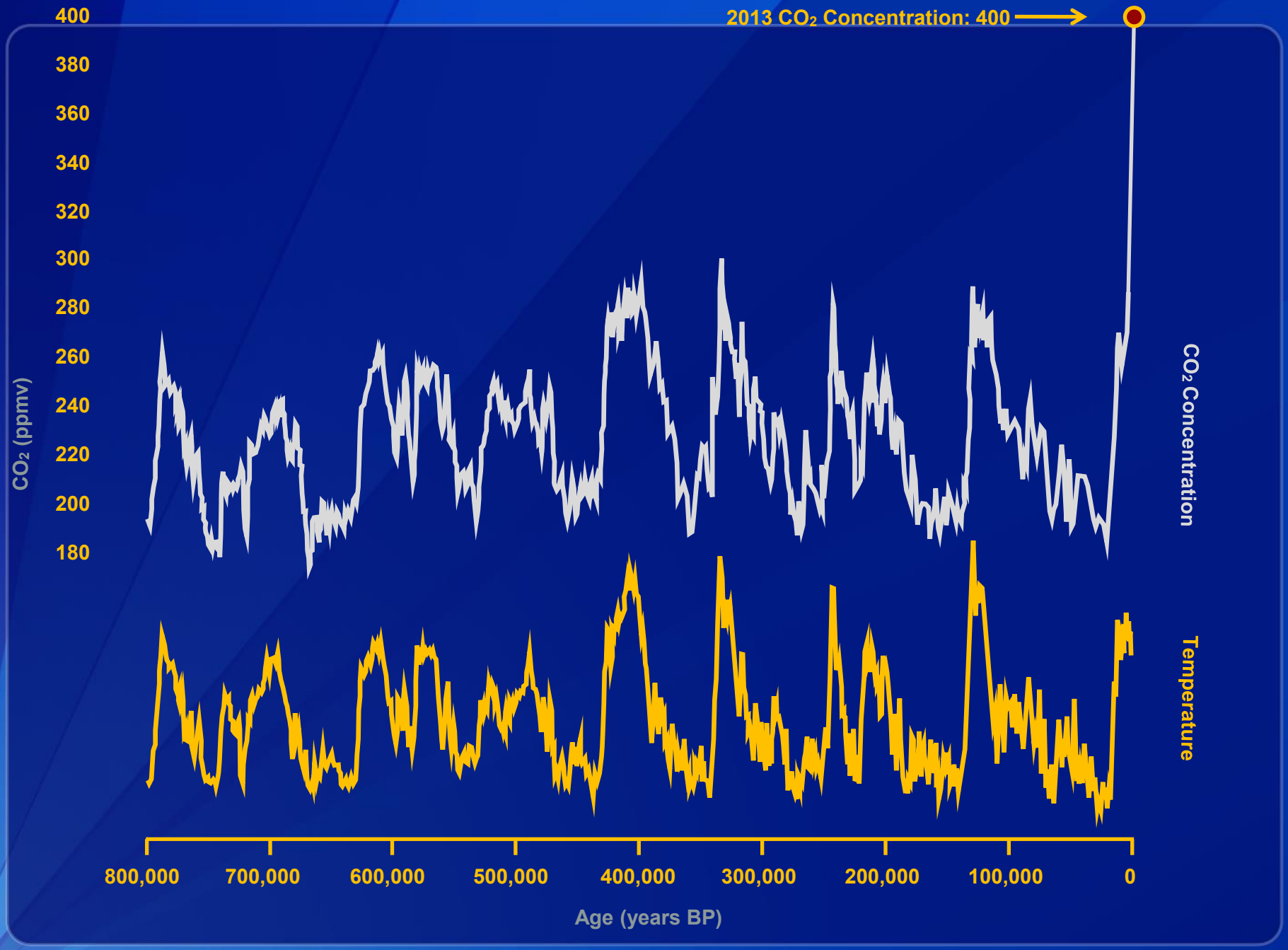
- Review evidence for climate change and its impact on human health
- Describe CDC efforts to prepare for health effects of climate change



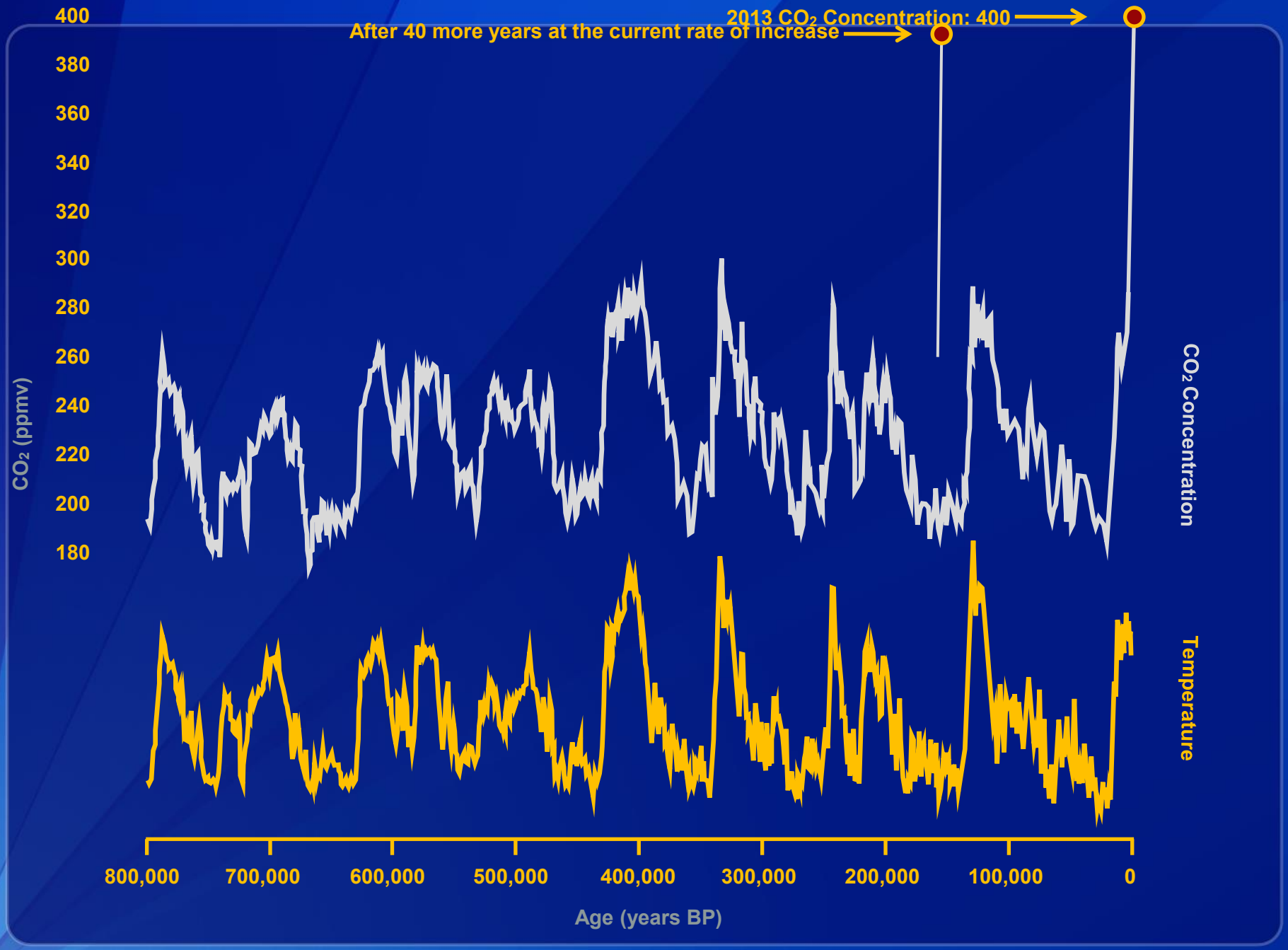
Source: National Climatic Data Center, NOAA



Source: National Climatic Data Center, NOAA

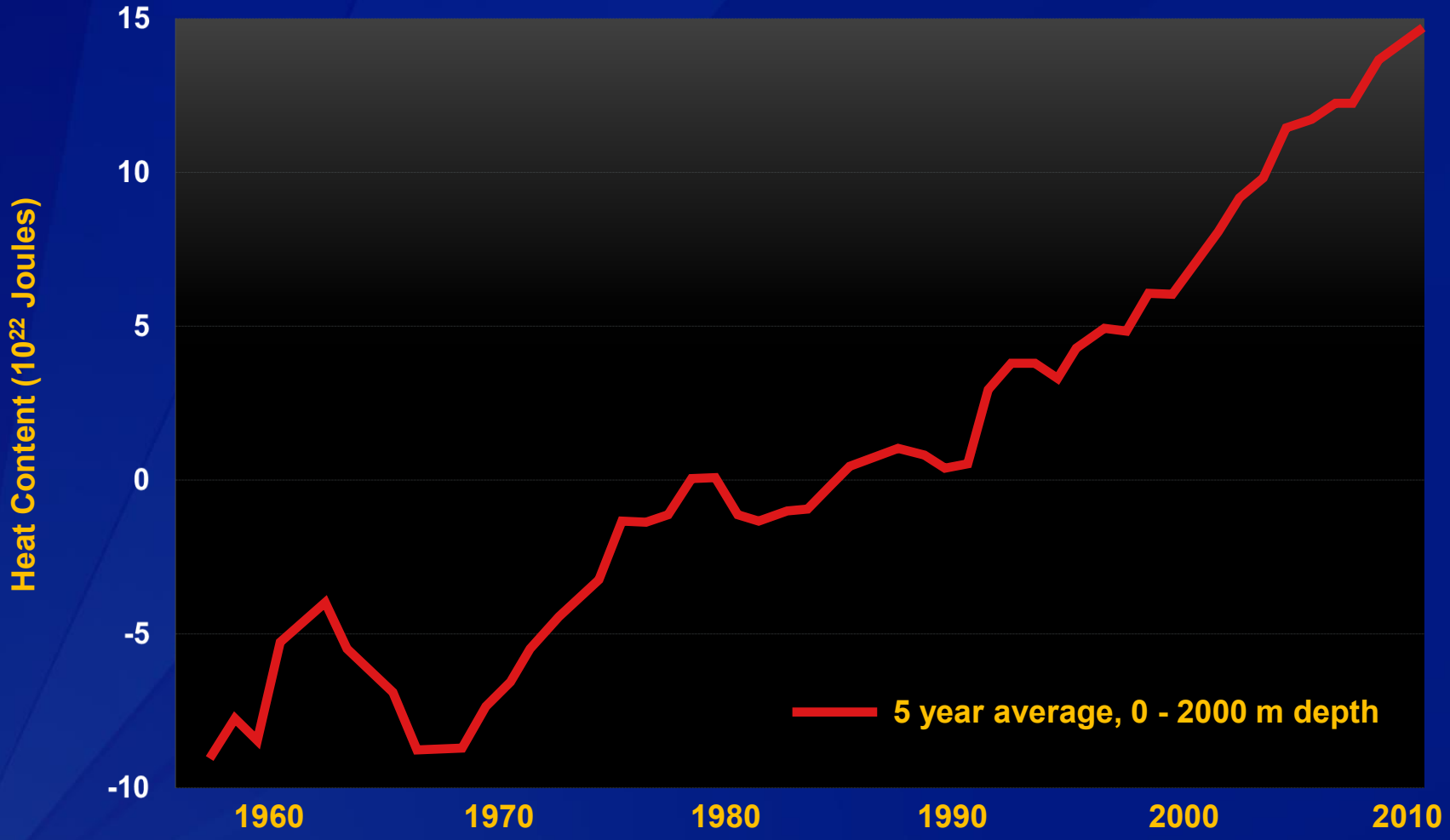


Source: National Climatic Data Center, NOAA



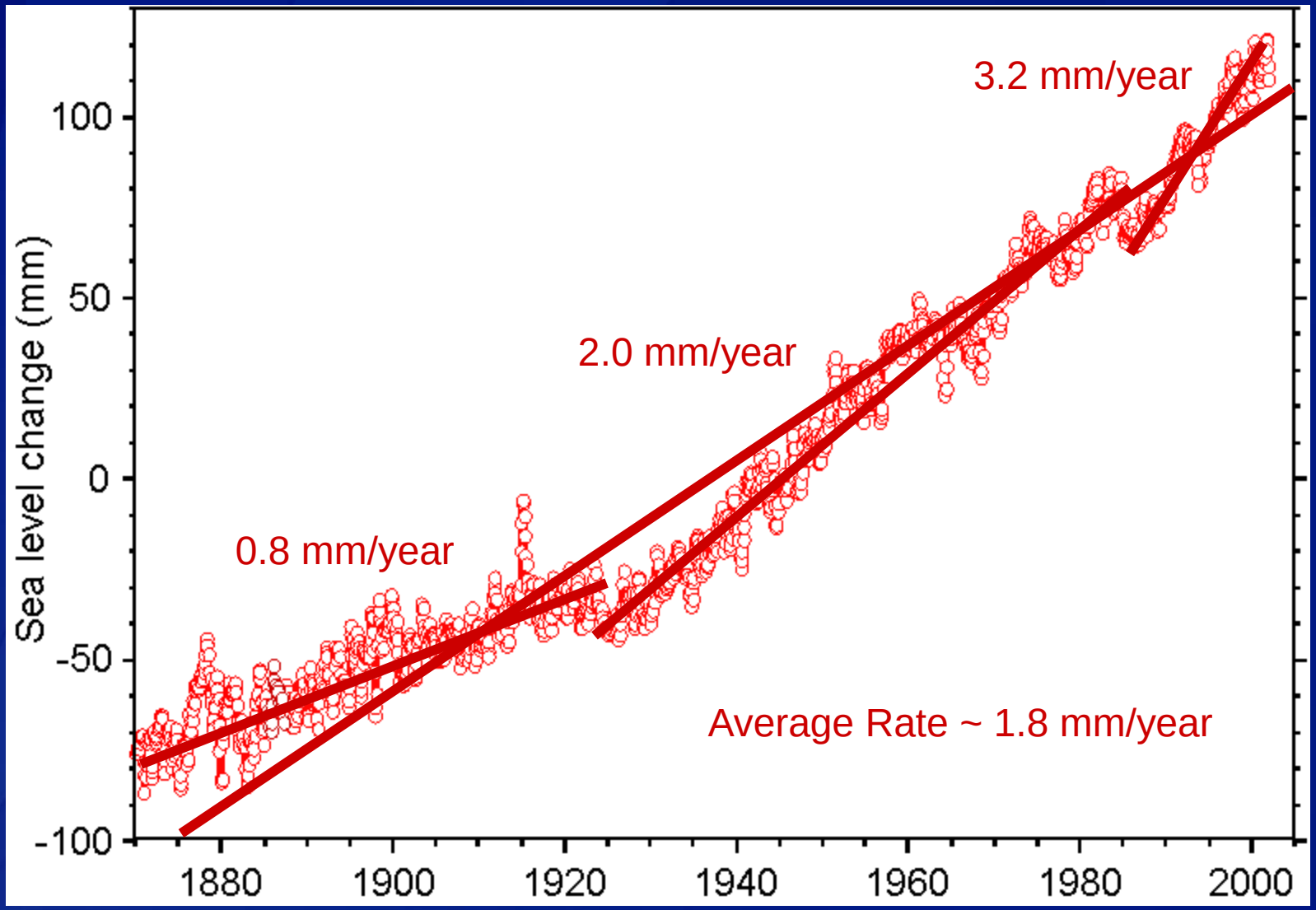
Source: National Climatic Data Center, NOAA

Global Ocean Heat Content
1955 – 2010



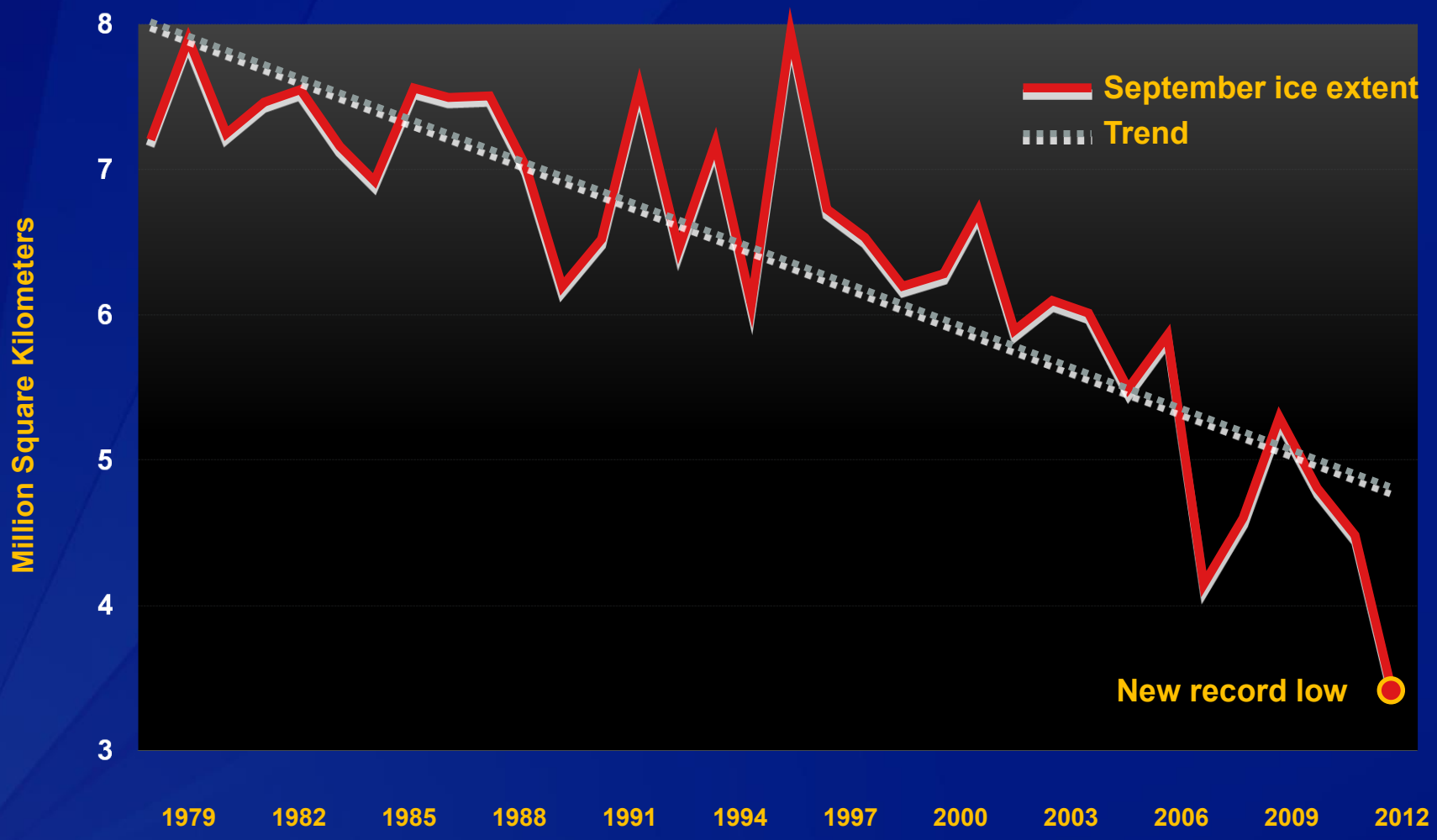
Source: NOAA/NESDIS/NODC Ocean Climate Laboratory, updated from Levitus, S., et al., "World ocean heat content and thermosteric sea level change (0-2000), 1955-2010," *Geophys. Res. Lett.* 39, doi:10.1029/2012GL051106, 2012.

Accelerating Sea Level Rise

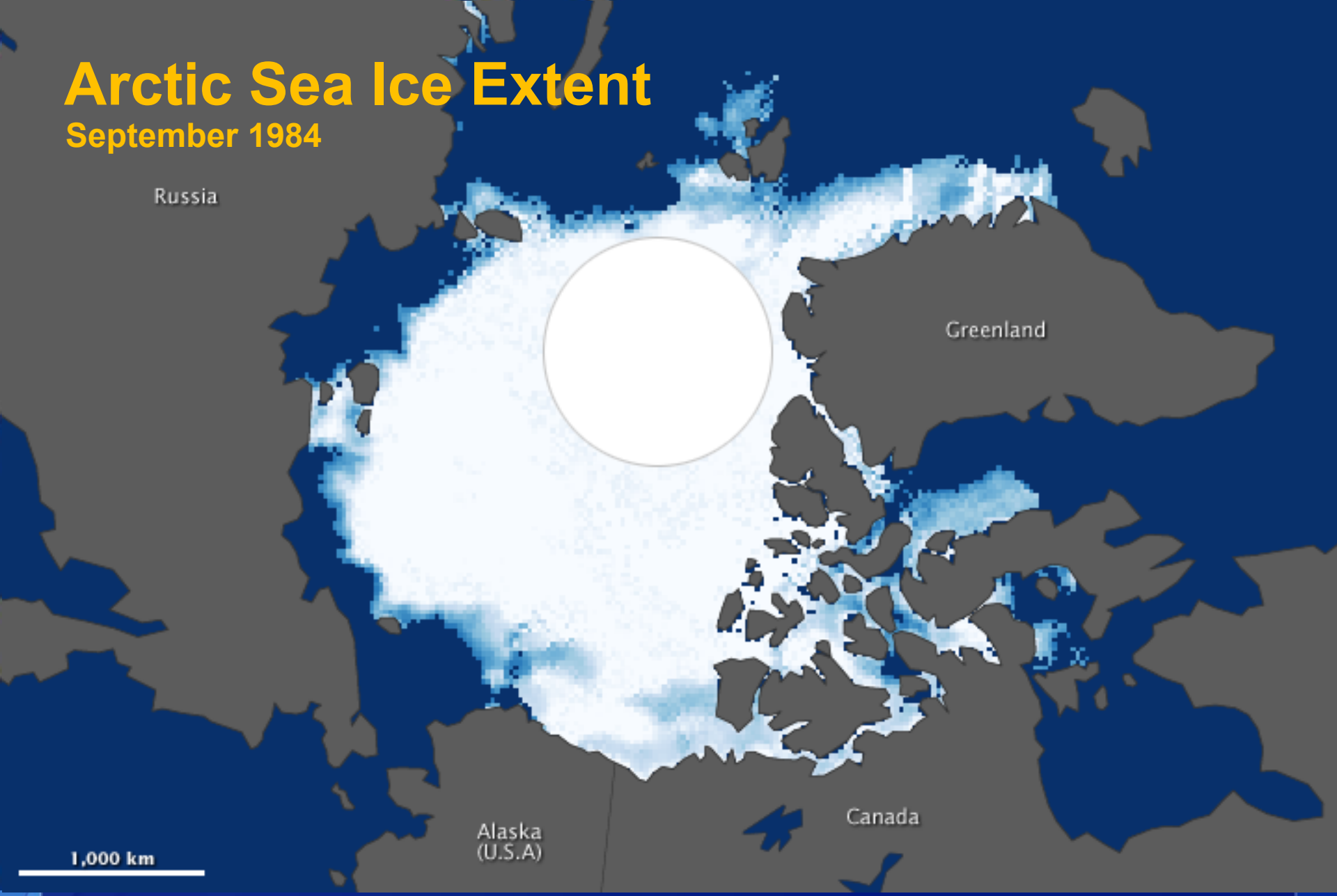


Source: Church and White 2006, GRL 33:L01602
Courtesy R.S. Nerem

September Arctic Sea Ice Extent
1979 – 2012



Source: National Snow and Ice Data Center, October 2012


Arctic Sea Ice Extent
September 1984
Russia
Greenland
Canada
Alaska
(U.S.A)
1,000 km
Sea Ice Concentration
0%
100%
Source: NASA Earth Observatory

3rd National Climate Assessment
Key Findings
Increasing Strength of the Evidence

- Average US temperature has increased by about 1.5°F since 1895.
- Extreme weather events, including heat waves, floods, and droughts, have become more frequent and intense.
- Sea level has risen by about 8 inches since 1880, projected to rise another 1 to 4 feet by 2100.
- Frost-free season has been increasing since 1980s.
- Heavy downpours have increased in most US regions.
- Number of Category 4 and 5 hurricanes in North Atlantic has increased since early 1980s.

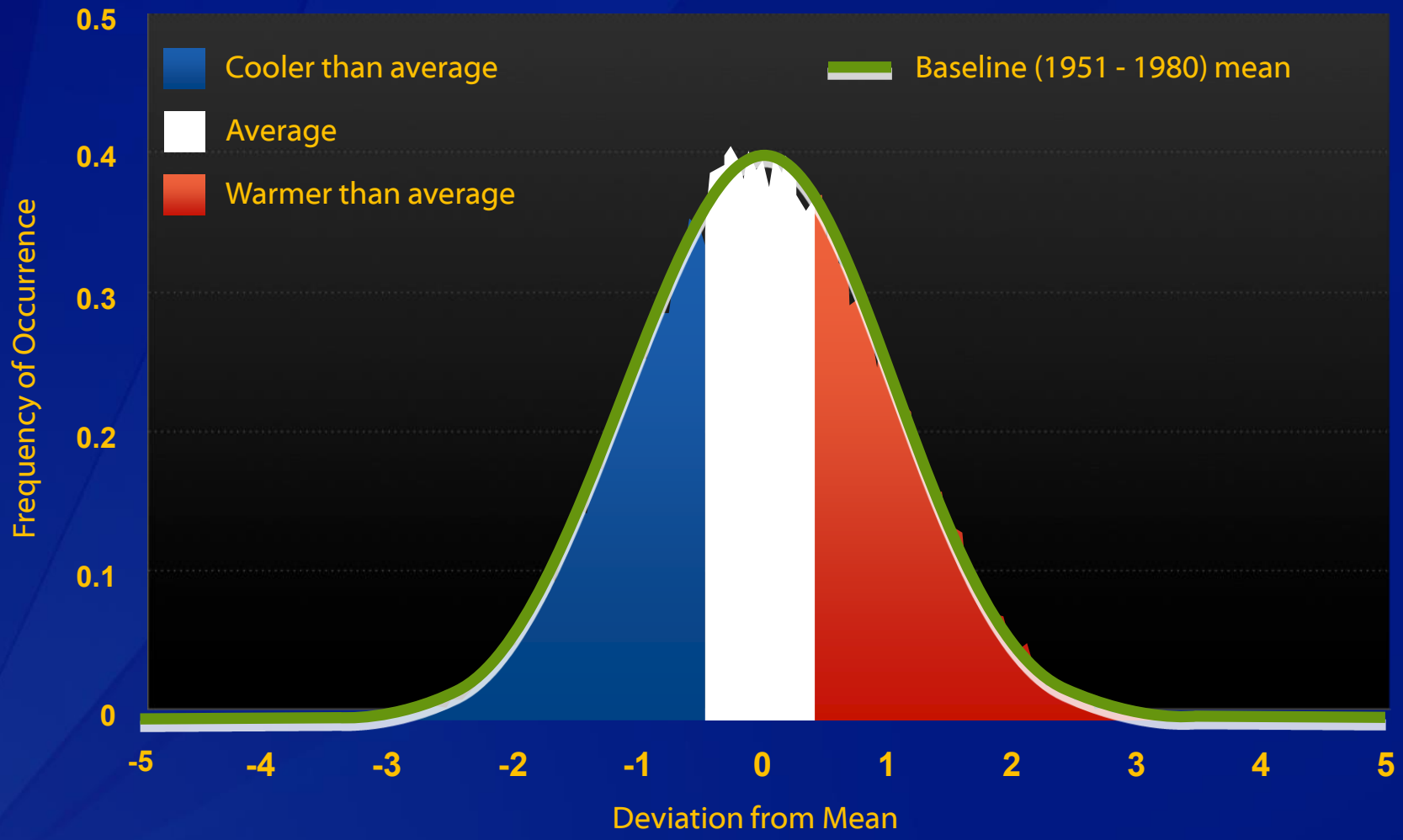
Source: National Climate Assessment Development Advisory Committee, *Draft Third National Climate Assessment Report*, http://ncadac.globalchange.gov

Climate Change Science: Key Findings

- Climate change is altering both the average (mean) global temperature *and* the global frequency of extremely hot temperatures (variance).

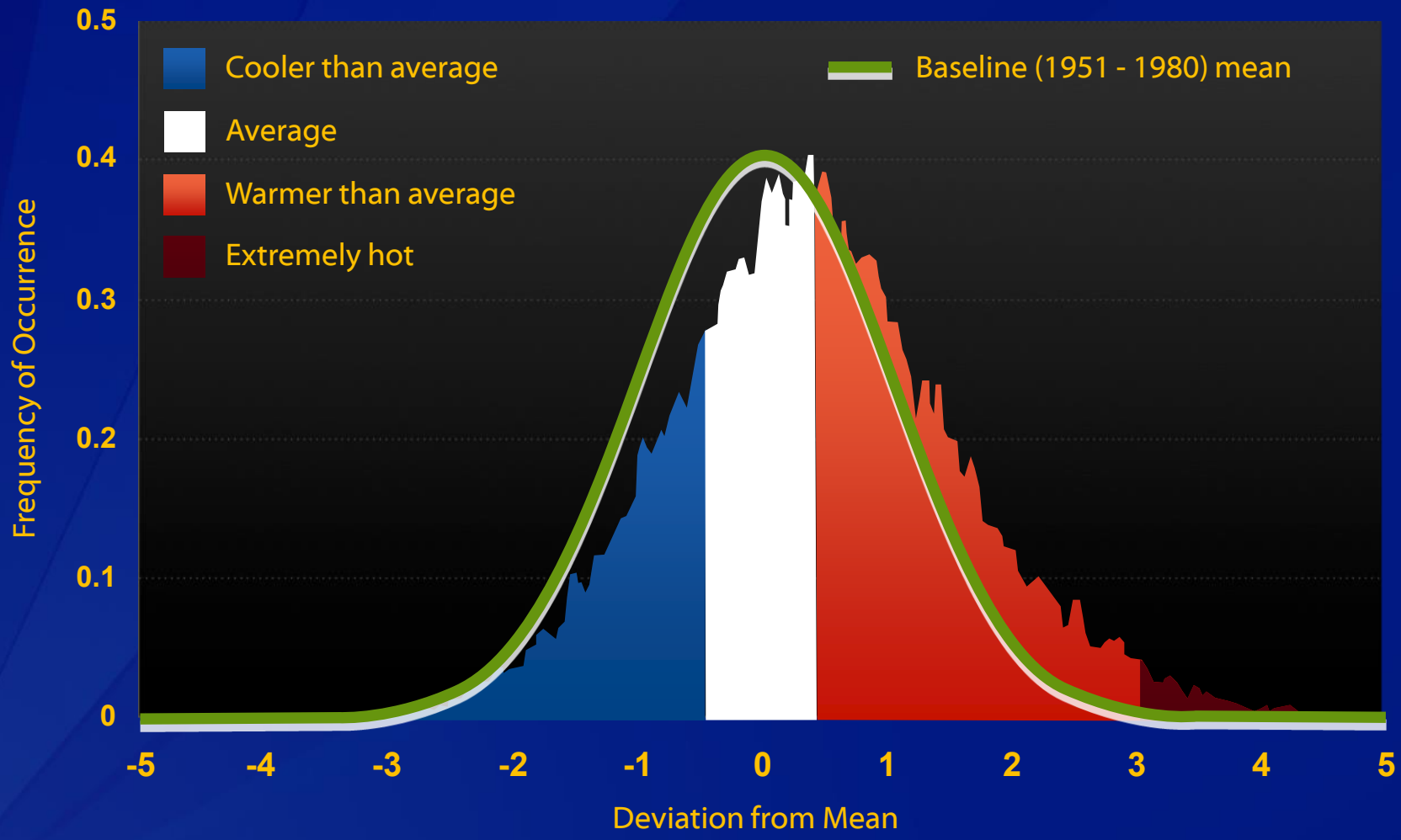
- The impacts of climate change will vary significantly by region; some places are warming faster than others.

Summer Temperatures 1951–1980



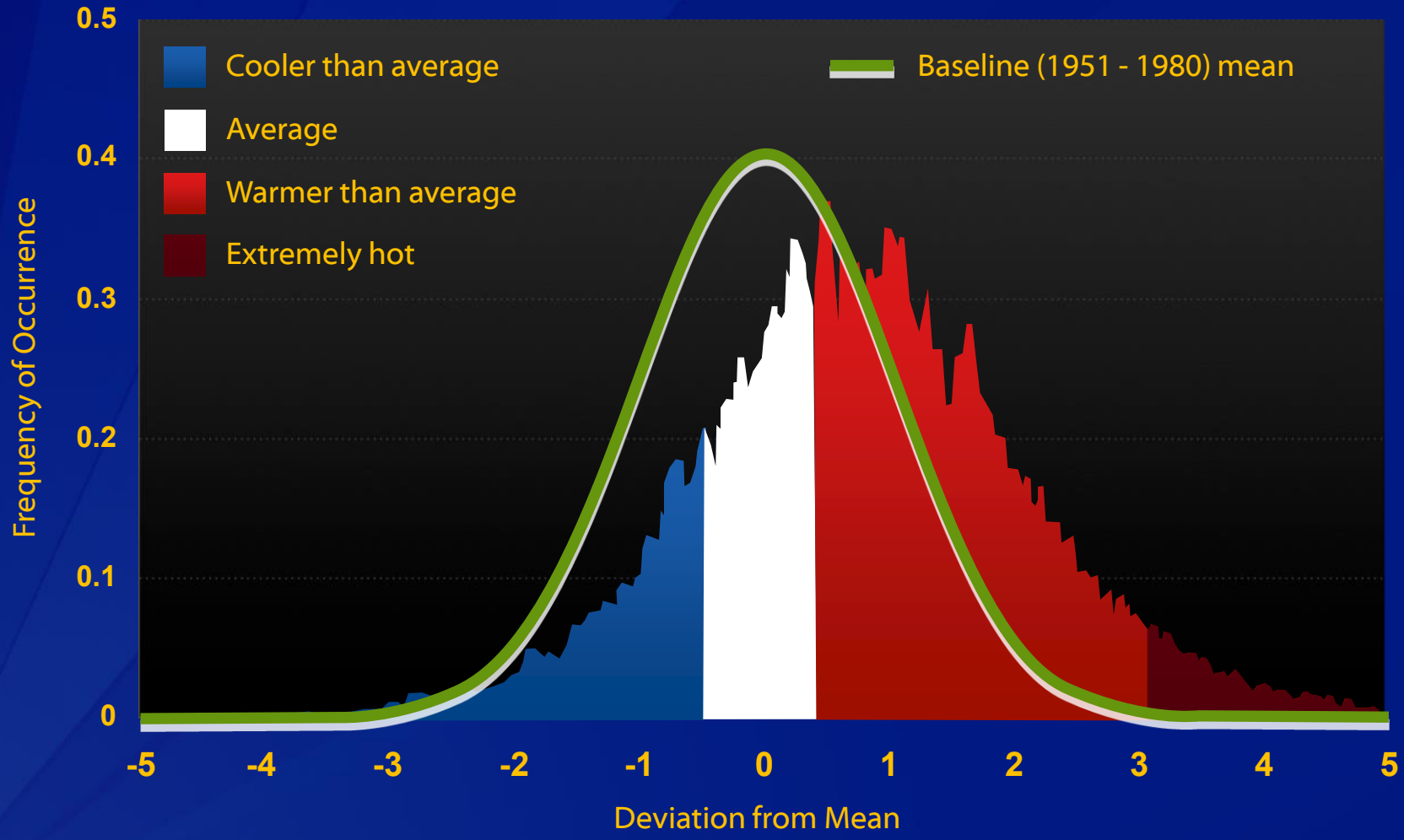
Source: NASA/GISS; Hansen, et al., "Perceptions of Climate Change," Proc. Natl. Acad. Sci. USA 10.1073, August 2012

Summer Temperatures 1981–1991



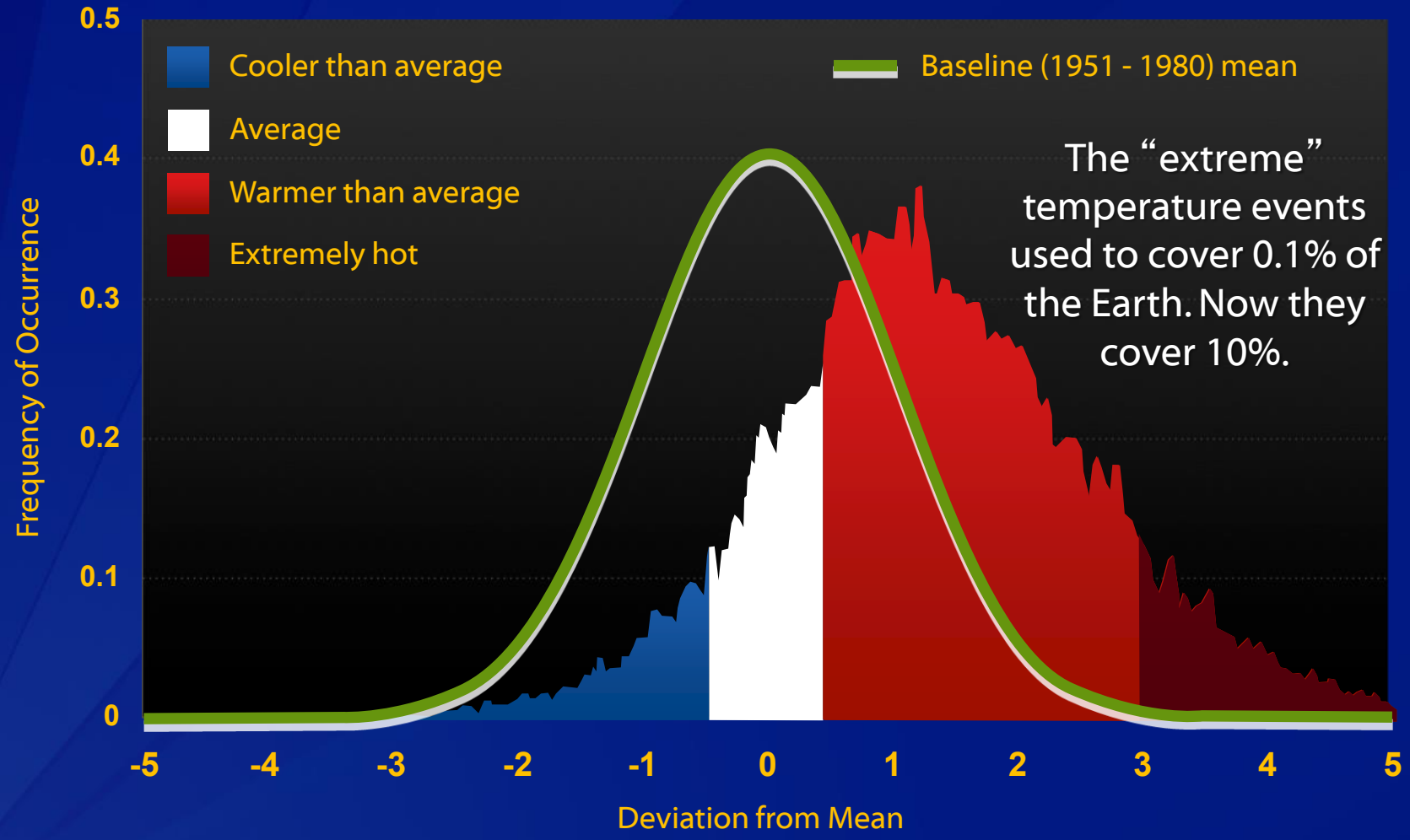
Source: NASA/GISS; Hansen, et al., "Perceptions of Climate Change," Proc. Natl. Acad. Sci. USA 10.1073, August 2012

Summer Temperatures 1991–2001



Source: NASA/GISS; Hansen, et al., "Perceptions of Climate Change," Proc. Natl. Acad. Sci. USA 10.1073, August 2012

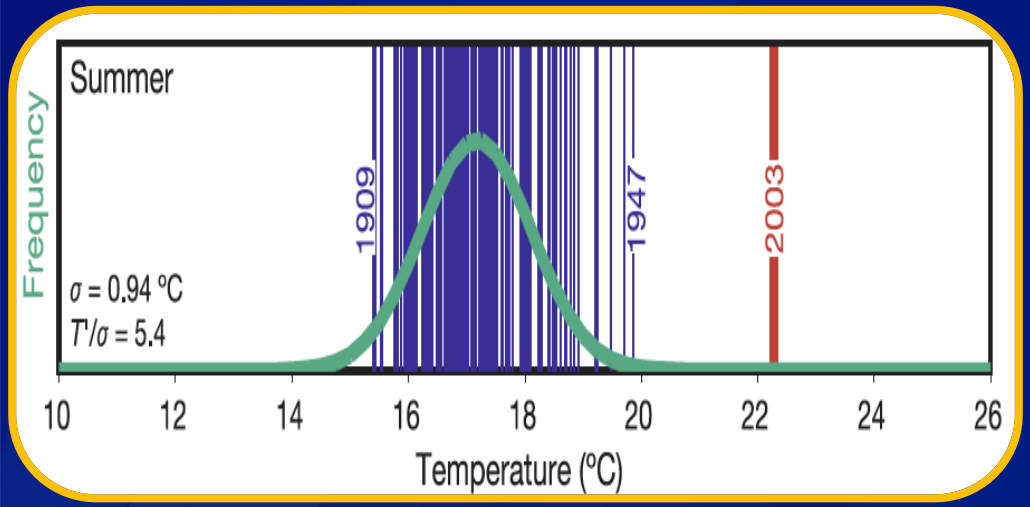
Summer Temperatures 2001–2011



Source: NASA/GISS; Hansen, et al., "Perceptions of Climate Change," Proc. Natl. Acad. Sci. USA 10.1073, August 2012

Heat Waves Impact Human Health

European Heat Wave of 2003

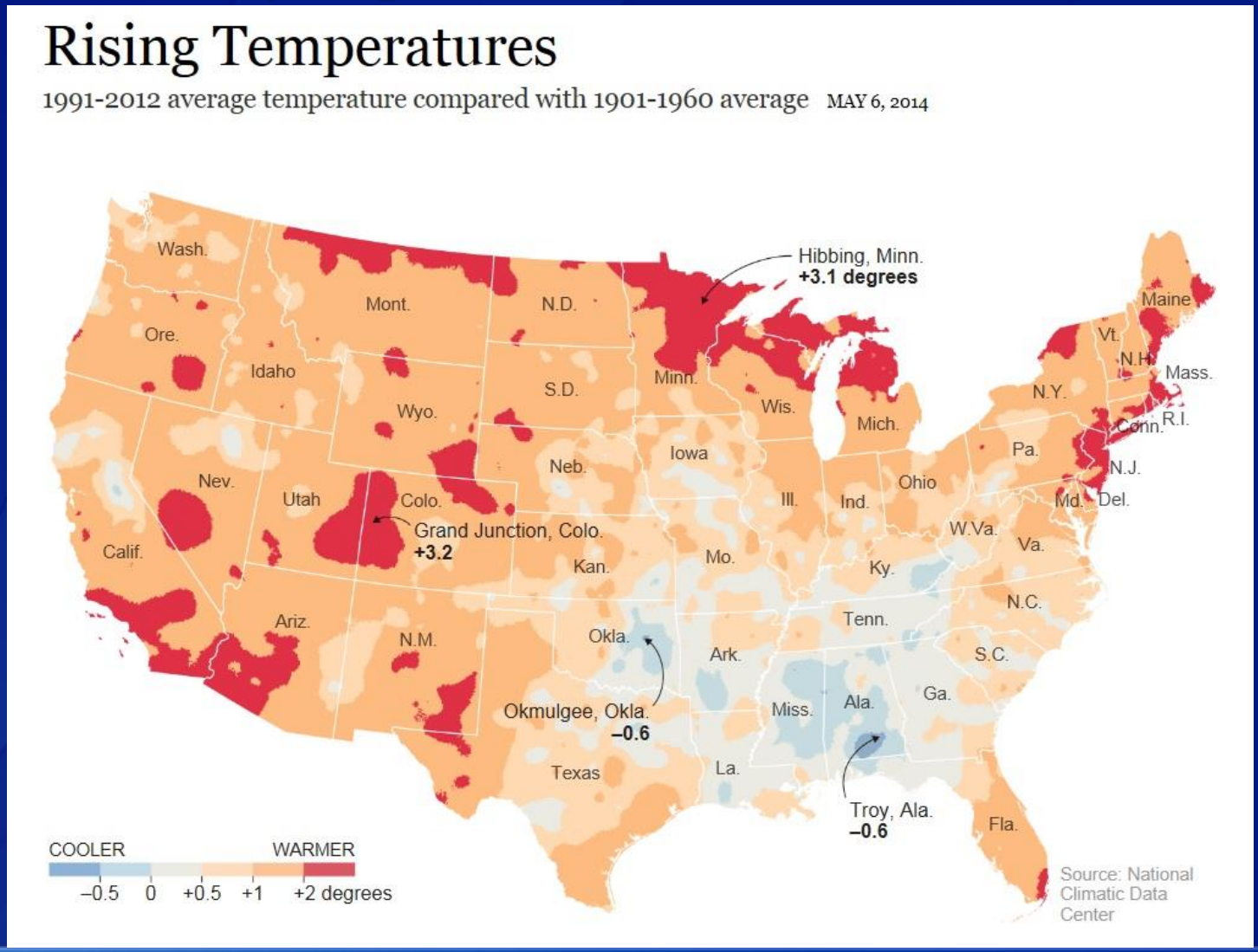


Confirmed Mortality

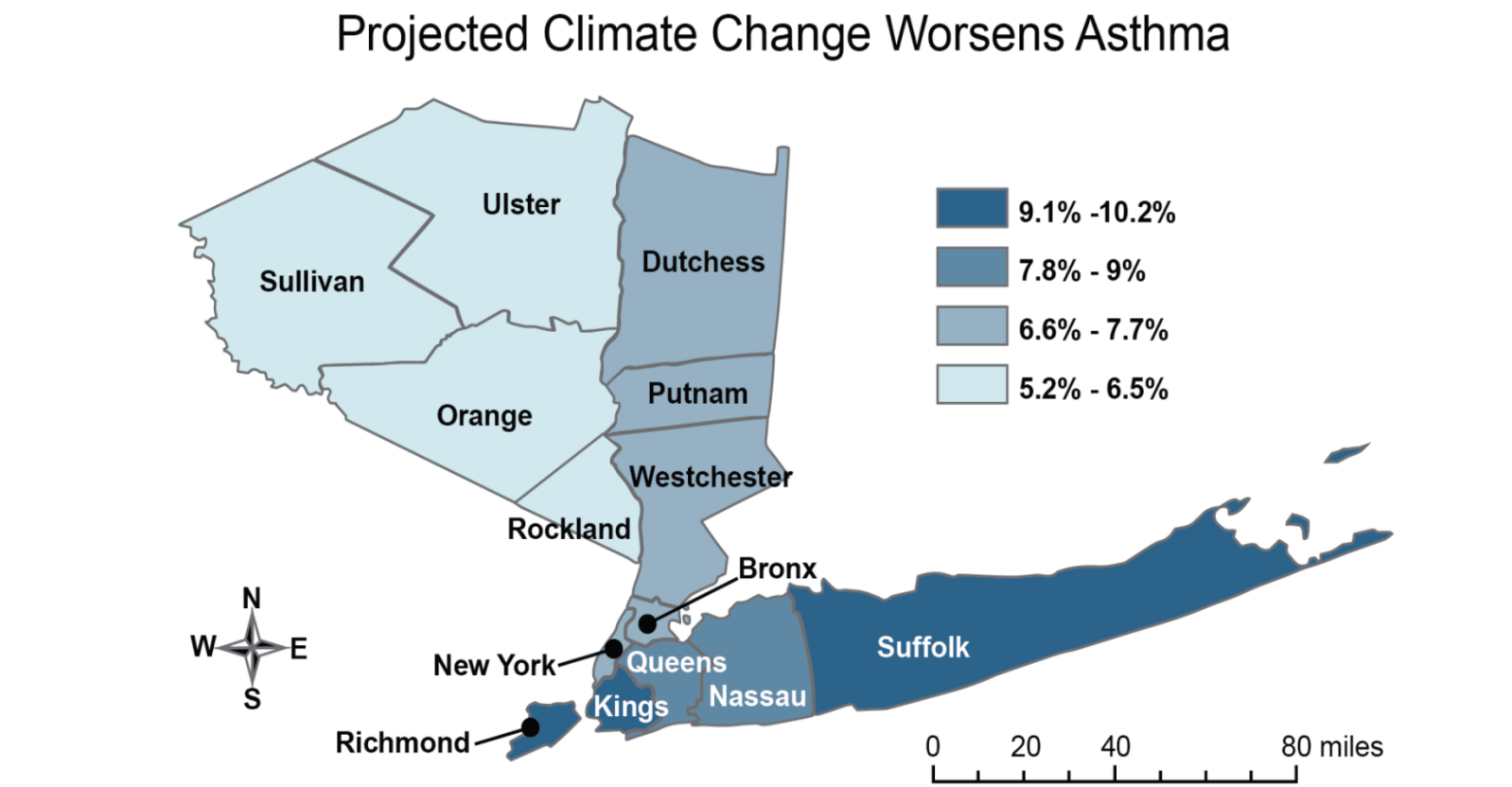
UK	2,091
Italy	3,134
France	14,802
Portugal	1,854
Spain	4,151
Switzerland	975
Netherlands	1,400-2,200
Germany	1,410
TOTAL	29,817-30,617

Vandentorren et al. *Am J Public Health* 2004; 94(9):1518-20.
Haines et al. *Public Health* 2006;120:585-96.

Warming has varied significantly by region (observed record)



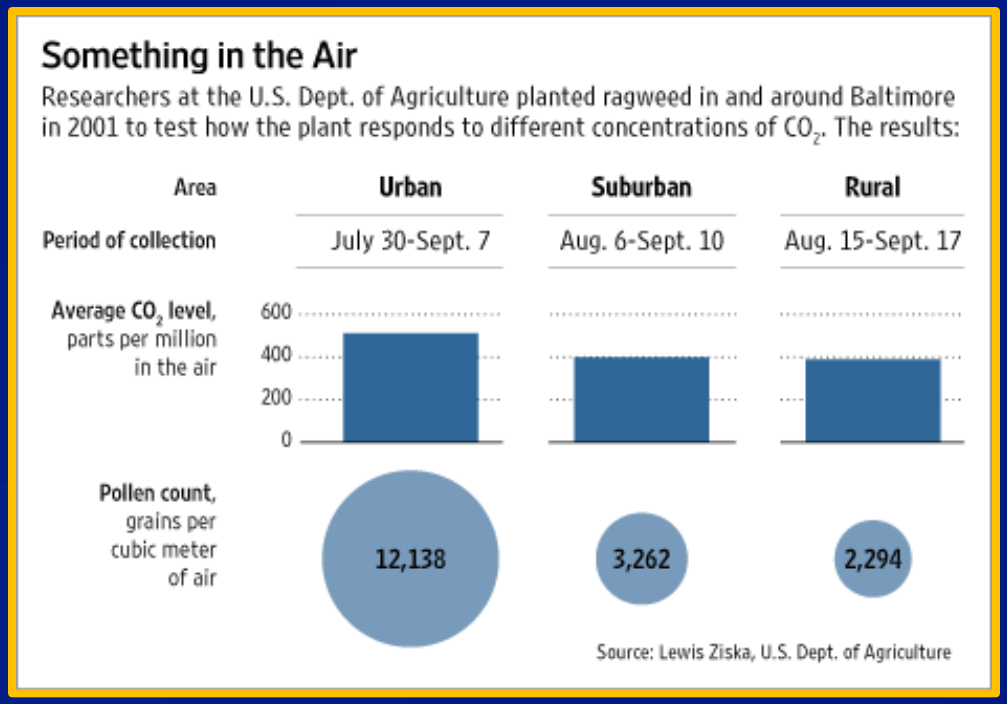
Impact of Increased Ozone:
Projected Increase in ED Visits for Asthma in 2020



Source: Sheffield PE, Knowlton K, Carr JL, Kinney PL. 2011. Modeling of Regional Climate Change Effects on Ground-Level Ozone and Childhood Asthma. American Journal of Preventive Medicine 41(3):251-257

Climate Change Impacts Air Quality: Pollen

- **Ragweed**
  - ↑ CO_2 and temperature
  - ↑ Pollen counts, longer growing season

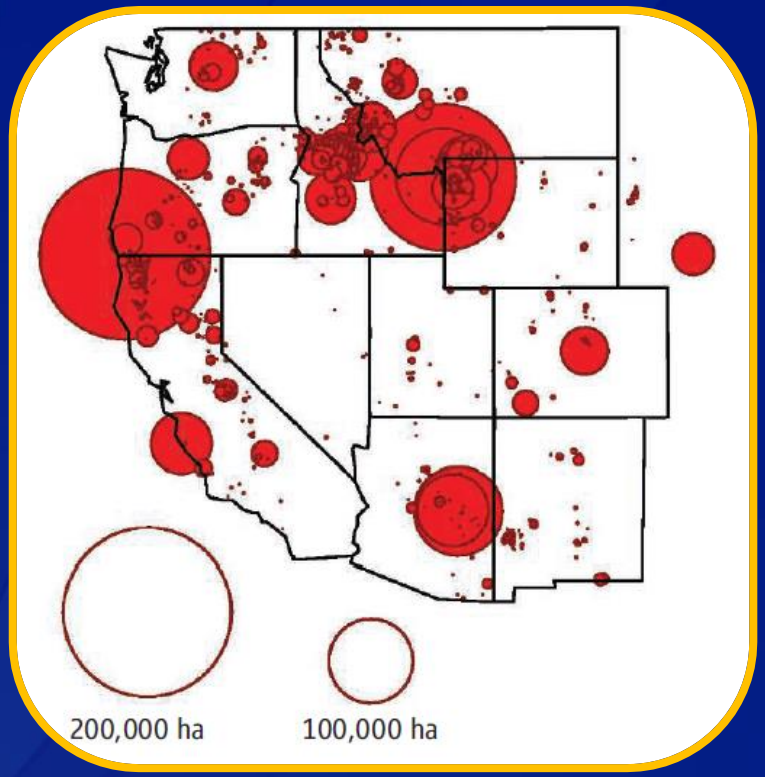


Source: Ziska et al., *J Allerg Clin Immunol* 2003;111:290-95

Graphic: *"Ambrosia psilostachya kz1" by Krzysztof Ziarnek Kenraiz via Wikimedia Commons*

Climate Change Impacts Air Quality: Wildfire Smoke

Wildfire Activity Since 1970



- **Since 1970**
  - Western US wildfire season increased by 78 days
  - Average duration of fires increased five fold

Westerling et al. Warming and earlier spring increase western U.S. forest wildfire activity *Science*. 2006 Aug 18;313(5789):940-3

Climate Change Impacts Air Quality: Wildfire Smoke (cont.)

- **Increase of 10µg/m^3 in PM_{10} from wildfires results in about 1% increase in non-accidental mortality[1,2,3]**
- **During Australian bushfires**
  - Overall mortality rose 5%
  - Hospital admissions for respiratory illnesses increased 3-5%[4]

[1]Morgan G et al. Effects of bushfire smoke on daily mortality and hospital admissions in Sydney, Australia. *Epidemiology*. 2010 Jan;21(1):47-55.

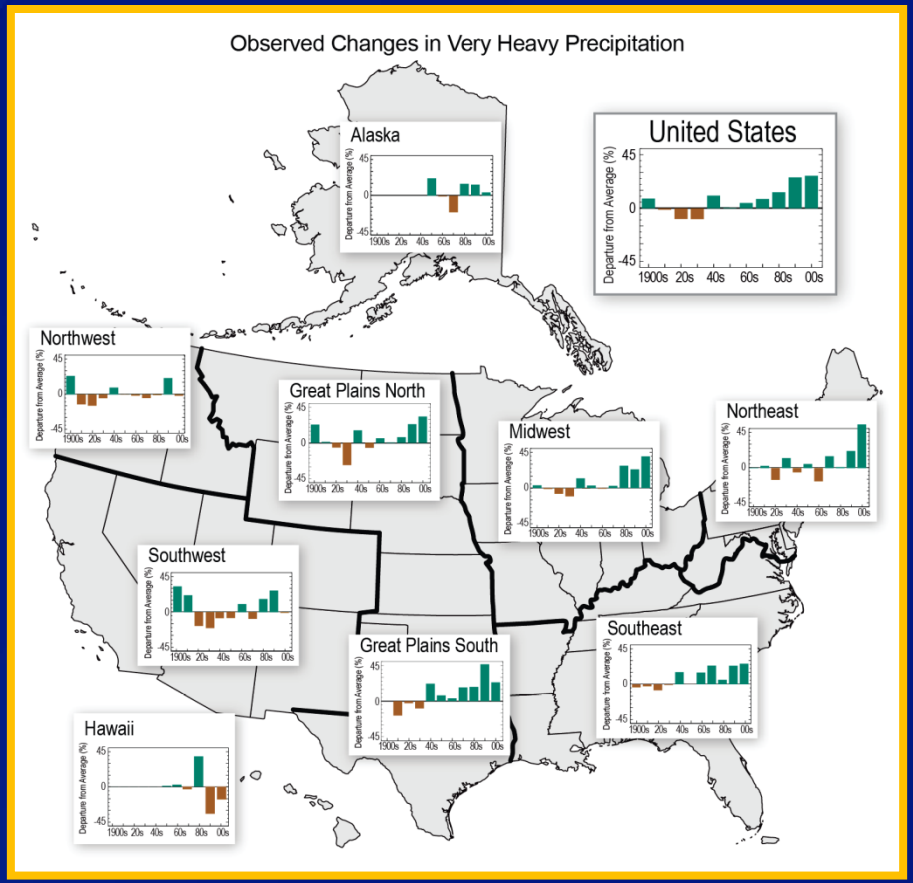
[2]Sastry N. Forest fires, air pollution, and mortality in southeast Asia. *Demography*. 2002 Feb;39(1):1-23.

[3]Hanninen OO. Population exposure to fine particles and estimated excess mortality in Finland from an East European wildfire episode. *J Expo Sci Environ Epidemiol*. 2009 May;19(4):414-22

[4]Johnston F et al. Extreme air pollution events from bushfires and dust storms and their association with mortality in Sydney, Australia 1994-2007. *Environ Res*. 2011 Aug;111(6):811-6.

Extreme Precipitation Events Impact Human Health: Waterborne Disease

- 67% of waterborne disease outbreaks preceded by precipitation above 80th percentile (across 50 year climate record)
- Heavy precipitation events projected to occur more frequently



Observed Increases in Very Heavy Precipitation (heaviest 1% of all events) 1901 to 2011

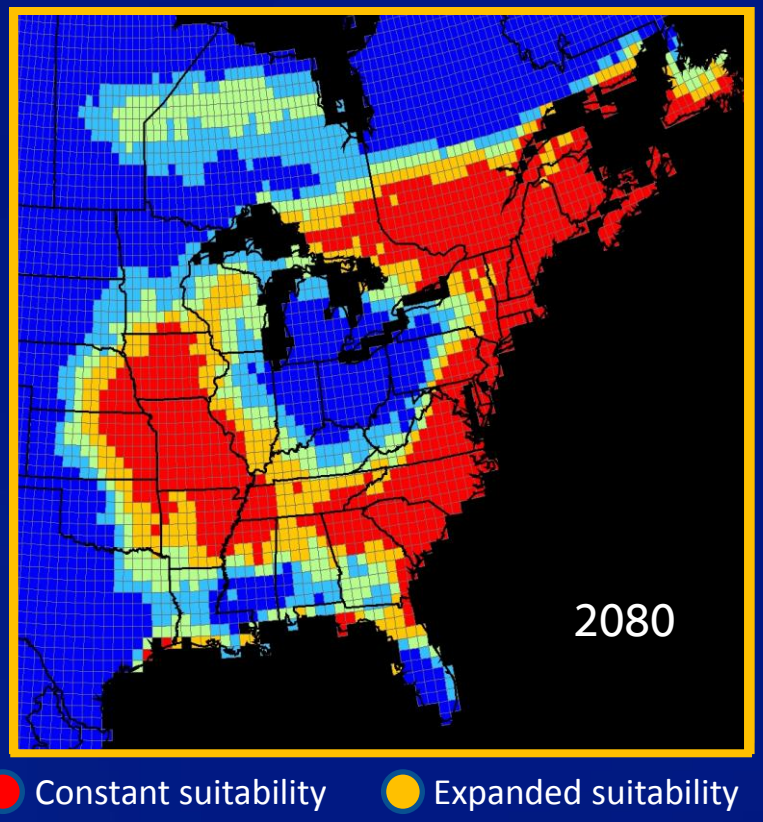
Curriero, Patz, et al, 2001.

Source: Walsh et al. 2013: *Draft NCA Report*, Chapter 2

Precipitation, Humidity, and Temperature Changes Impact Human Health. Example: Lyme Disease

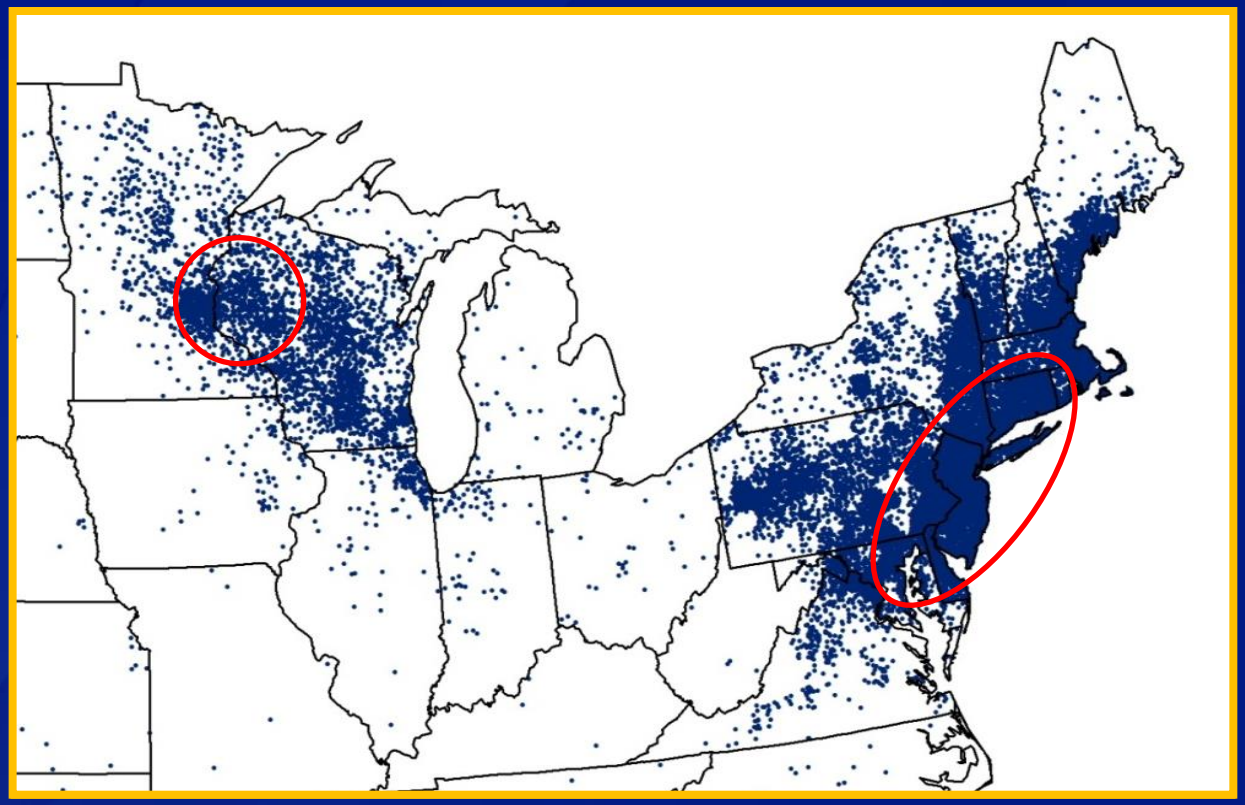
- **Spread of Lyme disease factors**
  - Climate
  - Ecological
  - Social

Range of suitable conditions for *Ixodes scapularis*, the Lyme disease tick



Source: Brownstein JS, Holford TR, Fish D. A climate-based model predicts the spatial distribution of the Lyme Disease vector *Ixodes scapularis* in the United States. *Environ Health Persp* 2003;111(9):1152-57.

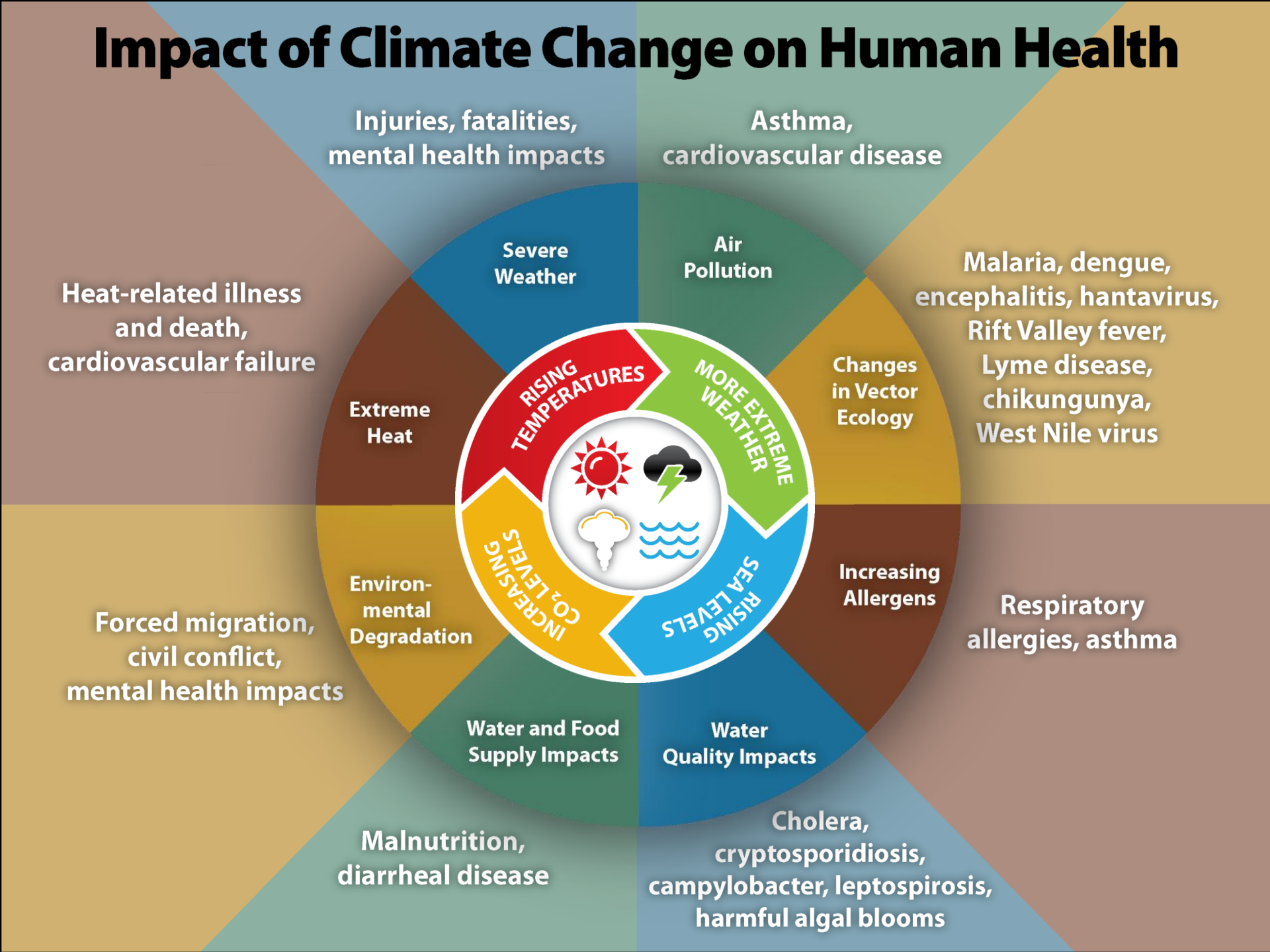
Lyme Disease Case Distribution Change in the United States



1996

http://www.cdc.gov/lyme/stats/maps/interactiveMaps.html

Impact of Climate Change on Human Health



Climate Change and Health - Pollen

Paul J. Schramm, MS, MPH
Arie Manangan, Shubhayu Saha, Christopher Uejio,
Claudia Brown, Jeremy Hess, George Luber

Centers for Disease Control and Prevention
Climate and Health Program

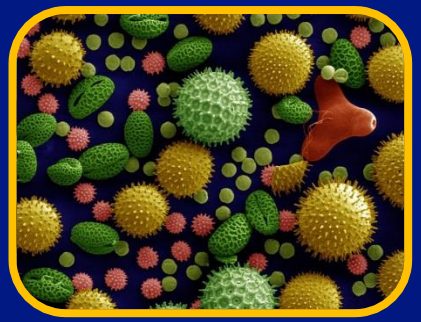
National Center for Environmental Health
Division of Environmental Hazards and Health Effects

Pollen and Health

- **Outdoor pollen and mold are the primary cause for allergic rhinitis (hay fever)**

- **Seasonal allergic rhinitis affects 15%-20% of adults in the US**
  - Annual treatment costs $11.2 billion
  - Additional economic costs $5.4 billion

- **As pollen count increases, allergy-related illnesses also increase**



Sources: (Grammer and Greenberger, 2009; Blaiss, 2010; Kessler et al. 2001; Heguy et al. 2008; Darrow et al.2011

Climate Affects Pollen

Recent climate shifts:

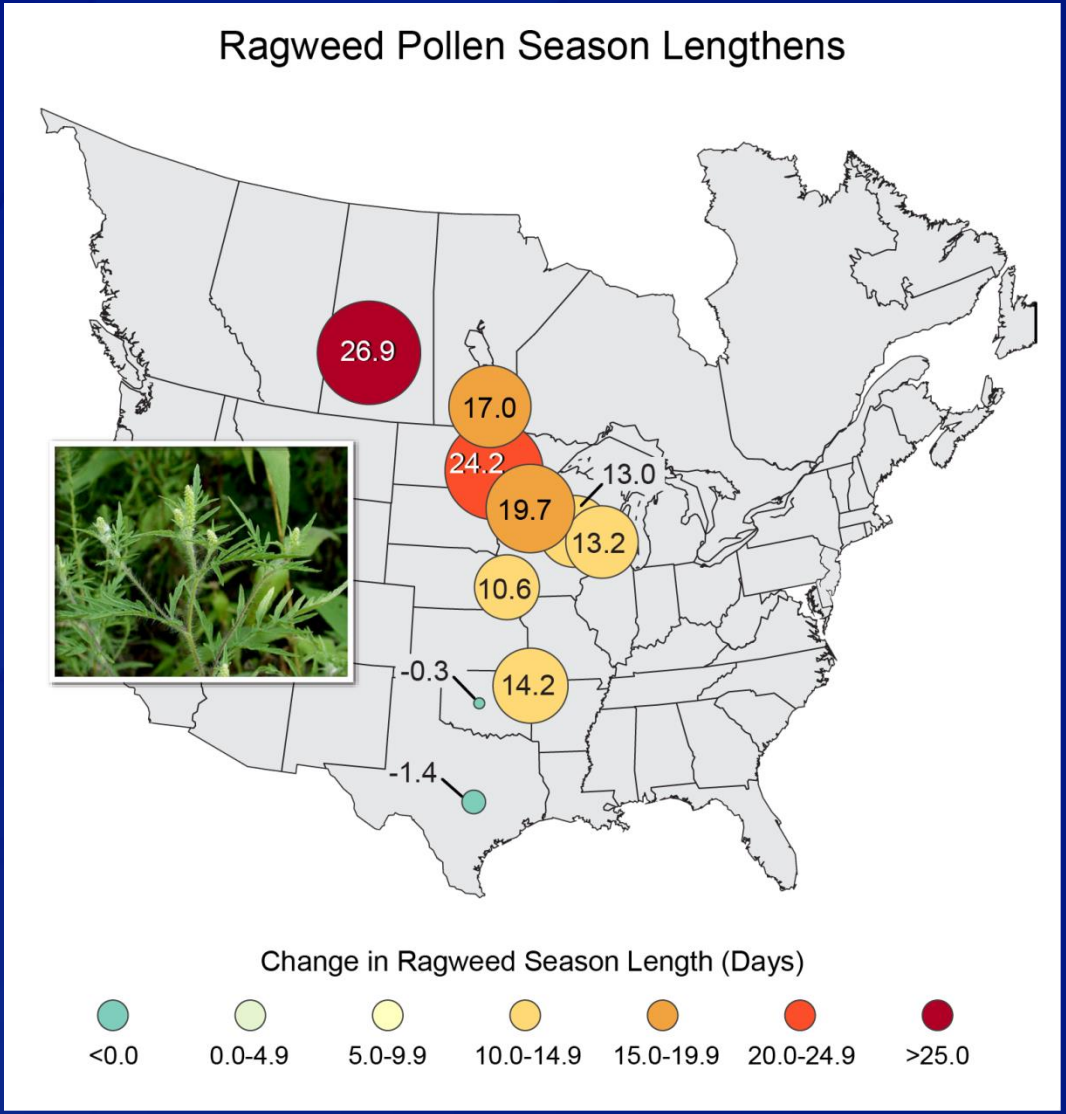
- Increased atmospheric CO_2
- More frost-free days
- Warmer seasonal air temperatures
- Shifts in precipitation

Can result in changes in:

- Pollen seasonality (season length, season start date or end date, peak pollen date)
- Quantity of pollen produced
- Allergenicity of pollen
- Pollen species distribution

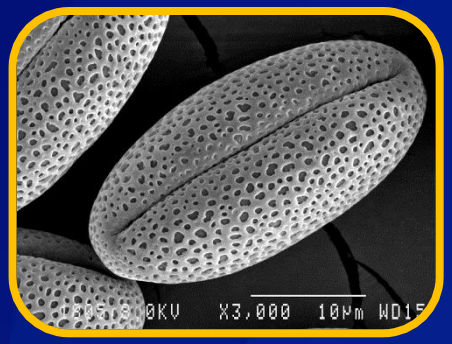
Luber et al, National Climate Assessment, Health Chapter, 2014

Shifts in Pollen Production



Luber et al, National Climate Assessment, Health Chapter, 2014; Ziska et al., 2012

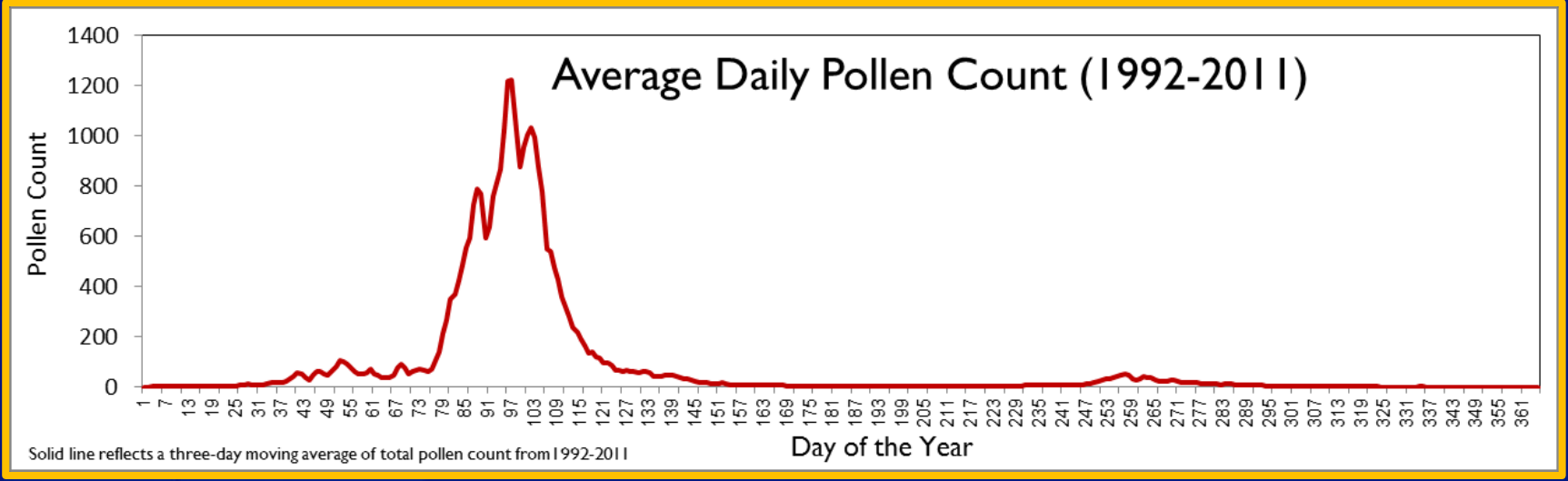
CDC Atlanta Pollen Study



- Investigate long-term pollen production trends
- Identify timing for pollen seasons (onset, peak, end, length)
- Determine relationship between pollen and seasonal climate

Manangan et al., in preparation

Descriptive Results – Average Pollen Count



Pollen Type	Spring Season	Fall Season
Oak	39.2%	0.2%
Pine	29.7%	2.2%
Juniper	3.4%	1.5%
Elm	1.8%	4.8%
Grasses	1.7%	5.9%
Ragweed	0.1%	55.9%

Percentage of Total Pollen for the Spring and Fall Pollen Seasons

Results – Pollen Count Trends

Pollen Count Trends per Taxa

Pollen Group	Trend	R^2	p-value	Change per Year
Alder (Spring)	Increase	.25	0.015	14 PPCM
Birch	Increase	.31	.01	50 PPCM
Elm (Spring)	Increase	.61	.00005	43 PPCM
Elm (Fall)	Increase	.28	.016	18 PPCM
Hickory	Increase	.35	.006	26 PPCM
Juniper (Spring)	Increase	.25	.03	37 PPCM
Maple	Decrease	.24	.03	26 PPCM
Mulberry	Increase	.43	.001	53 PPCM
Oak	Increase	.34	.005	445 PPCM
Sheep Sorel (Spring)	Increase	.24	.03	6 PPCM
Sycamore	Increase	.57	.0001	66 PPCM

Results – Pollen Season Timing

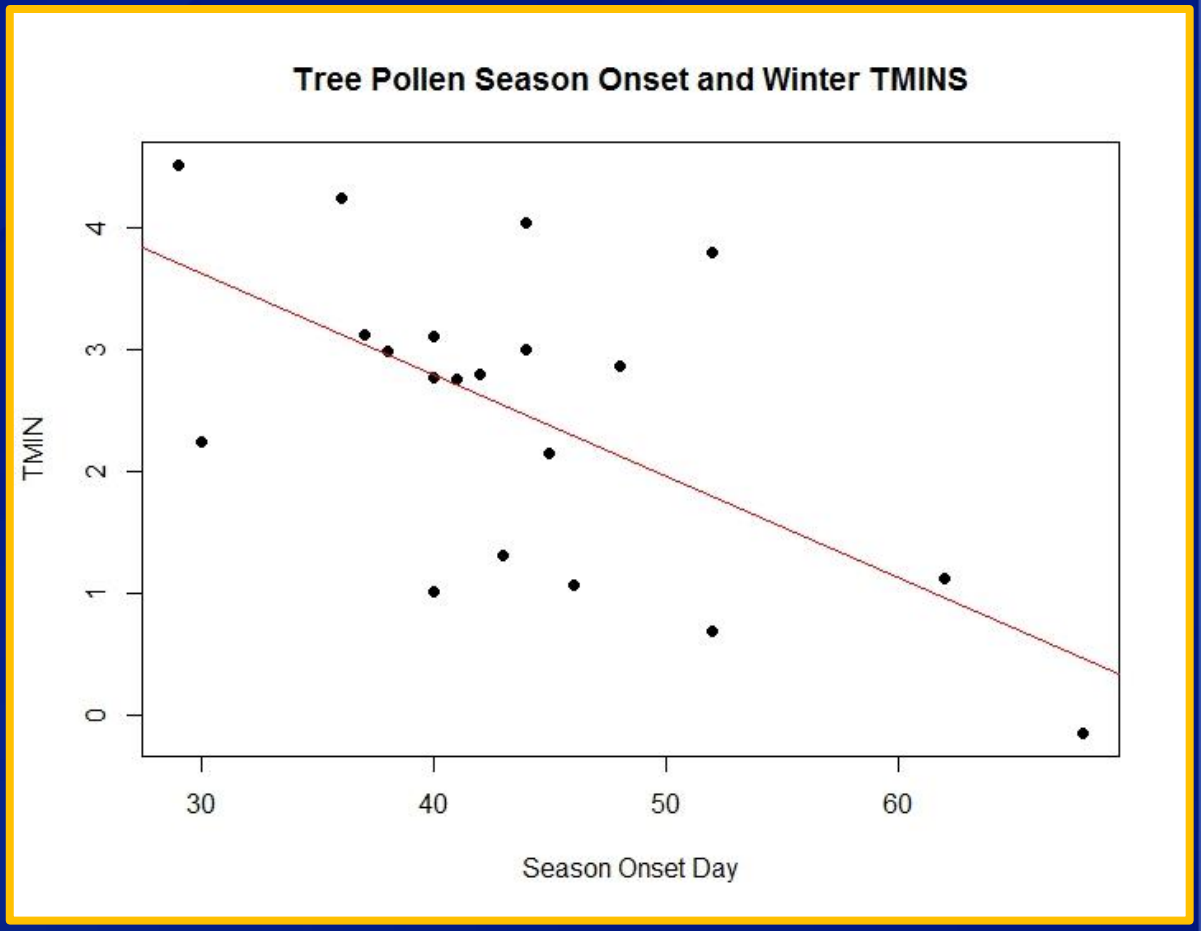
Increase in pollen season length for 4 species

Pollen Group	Trend	p-value	R^2
Ash	4.3 days	0.015	0.287
Beech	4.1 days	<0.001	0.67
Sycamore	1.3 days	.048	0.1997
Willow	6.3 days	<0.001	0.51

Results – Pollen Season and Winter Temperatures

- **Warmer Winter Temps Advance Spring Tree Pollen Season**

- Lower average daily winter (Dec-Feb) temperature minimums delay season onset
- $R^2 = 0.38$,
- p-value<0.004



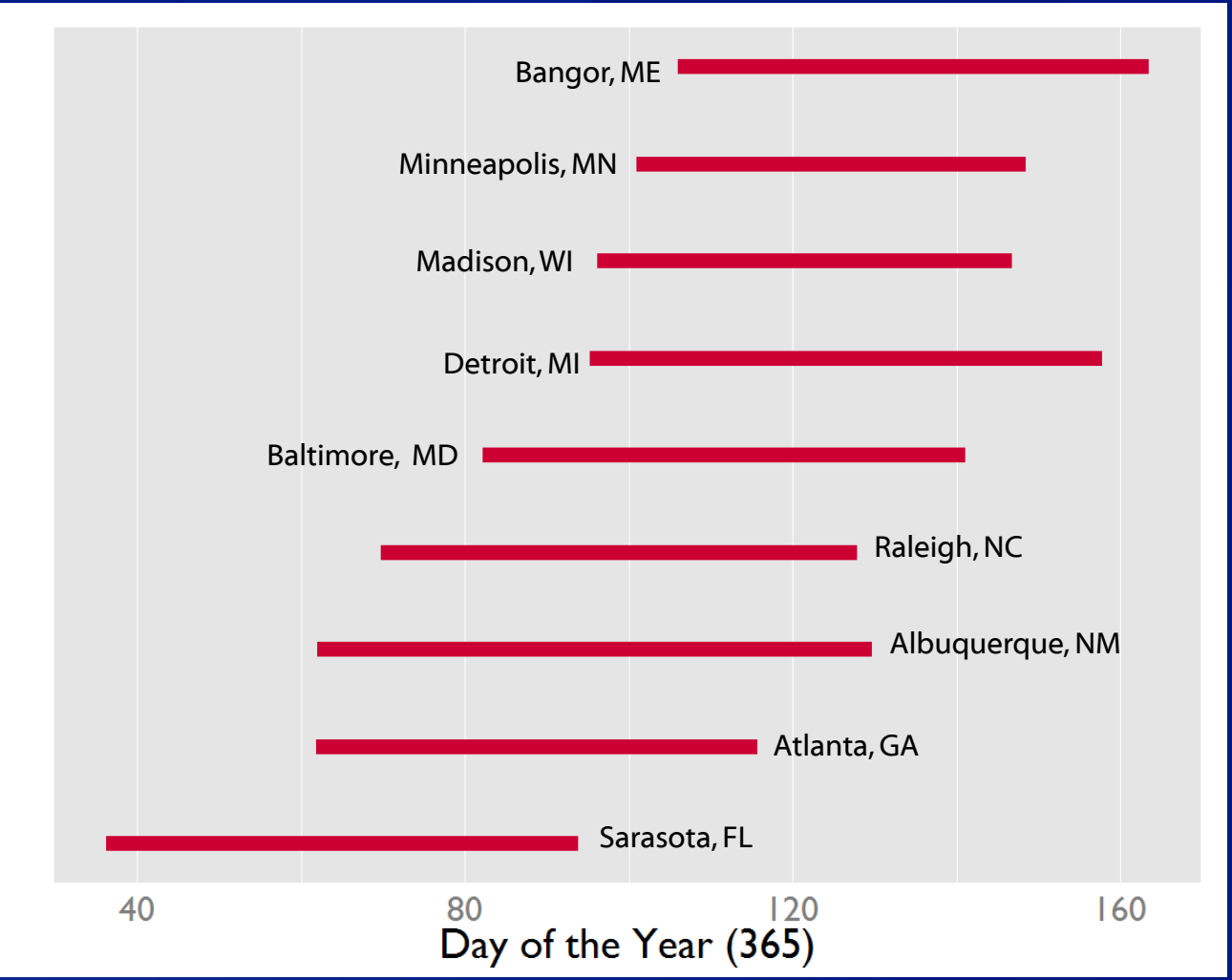
Multiple Site CDC Pollen Study

Pollen data from 9 monitoring stations:

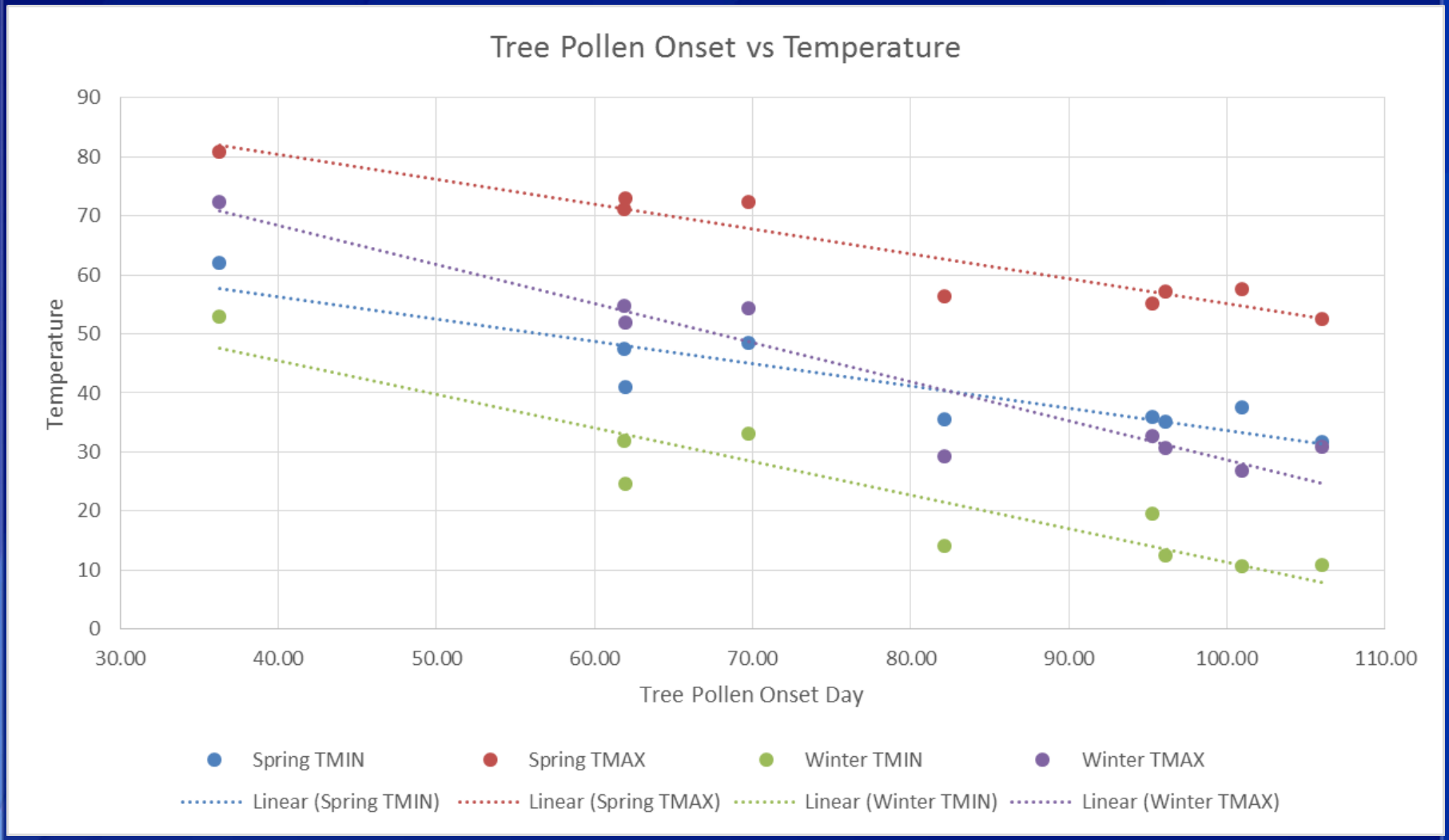
- Albuquerque, NM
- Atlanta, GA
- Baltimore, MD
- Bangor, ME
- Detroit, MI
- Madison, WI
- Minneapolis, MN
- Raleigh, NC
- Sarasota, FL

Manangan et al., in preparation

Spring Pollen Season Timing

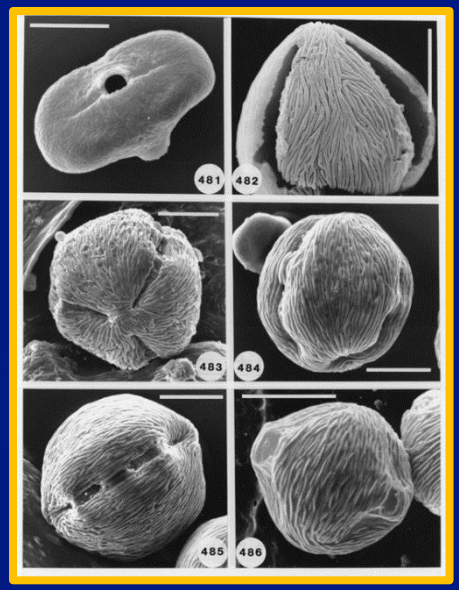


Spring Tree Pollen Season Onset and Temperature

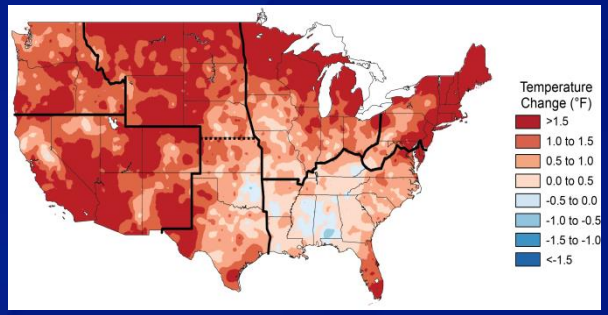


Future Directions

- Continue to collect more pollen datasets from around the country
- Effect of year-to-year climate variability on pollen counts and pollen season timing
- Effect of precipitation on pollen
- Assess the effectiveness of using proxy data to estimate pollen counts



Climate Change and Health - Heat

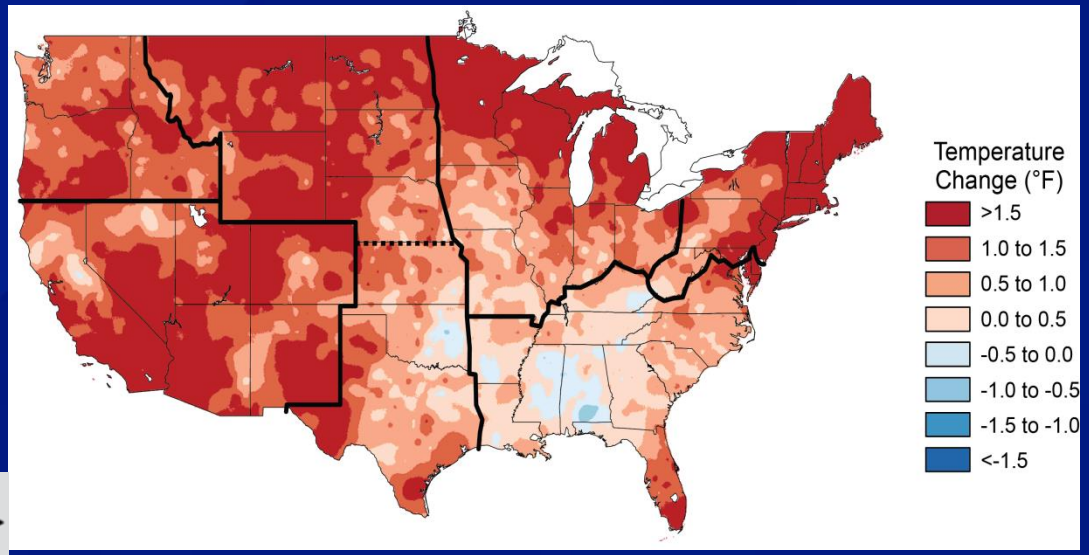


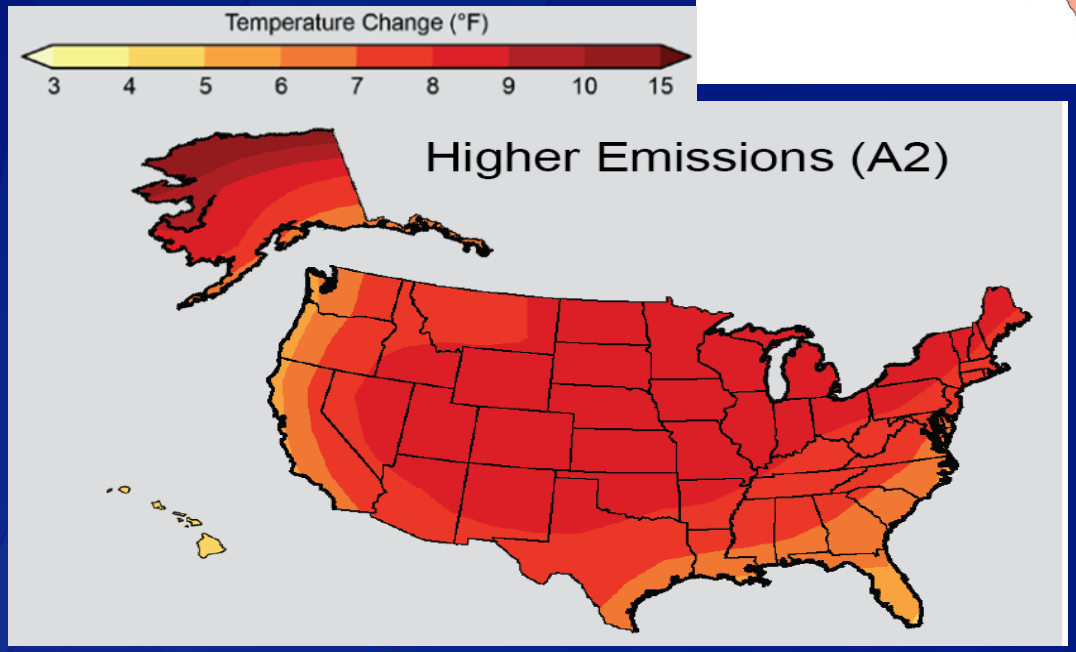
Shubhayu Saha, PhD.
Ambarish Vaidyanathan, John Brock, George Luber

Centers for Disease Control and Prevention
Climate and Health Program

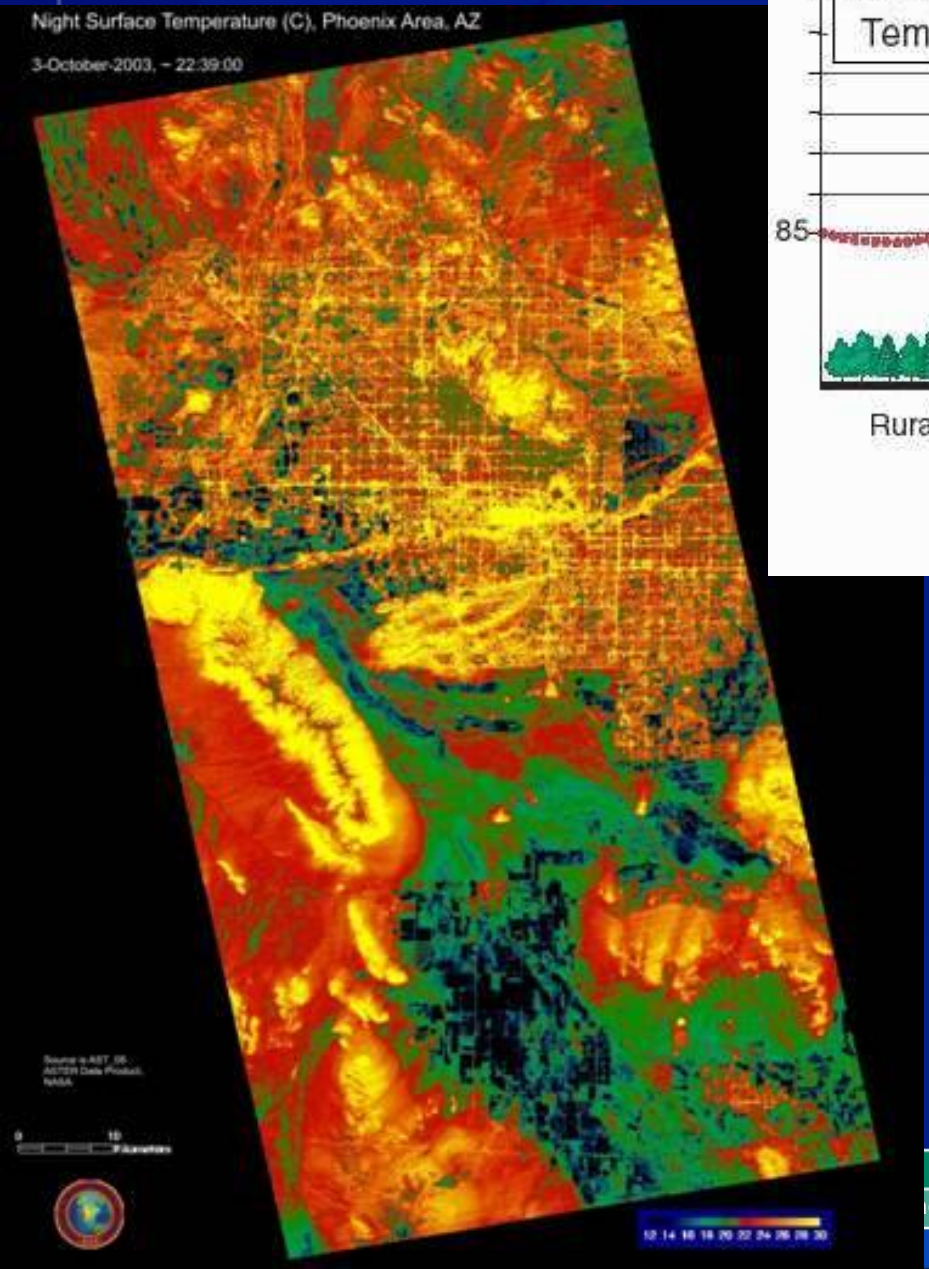
US National Climate Assessment, 2014

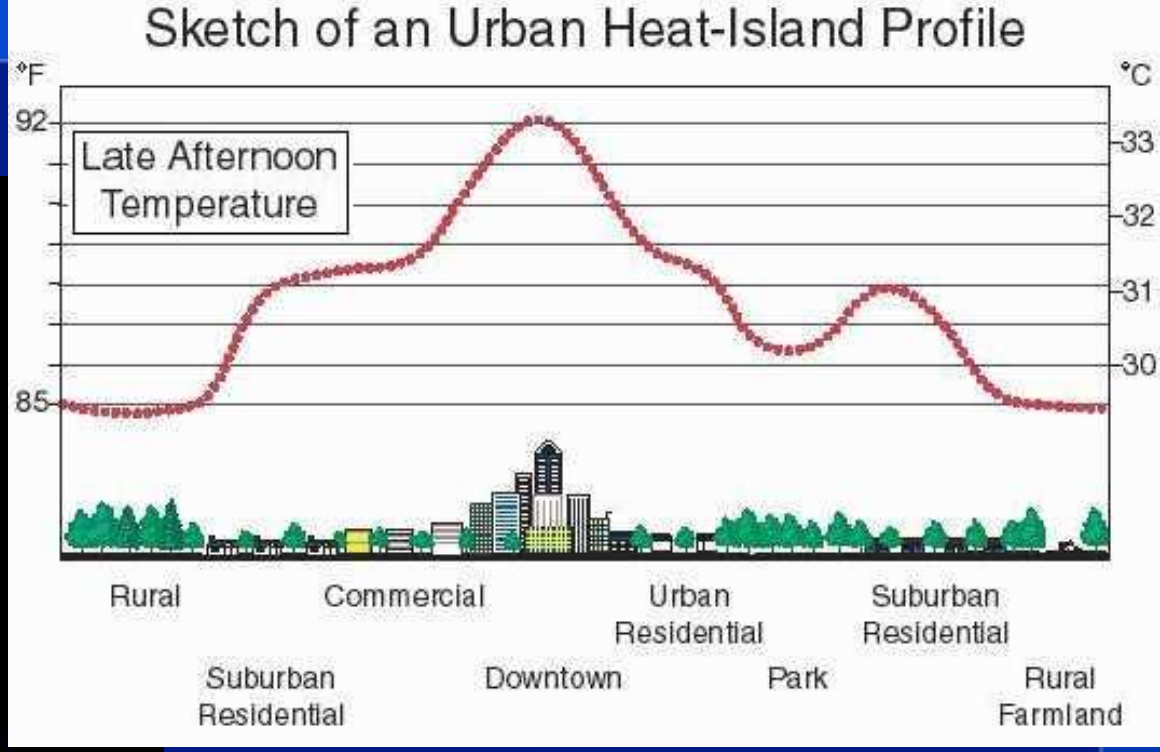
Observed change in temperature (1990-2012) compared to (1901-1960)





Projected change in average surface temperature (2070-2099) compared to (1970-1999); A2 scenario assumes continued increase in global emissions

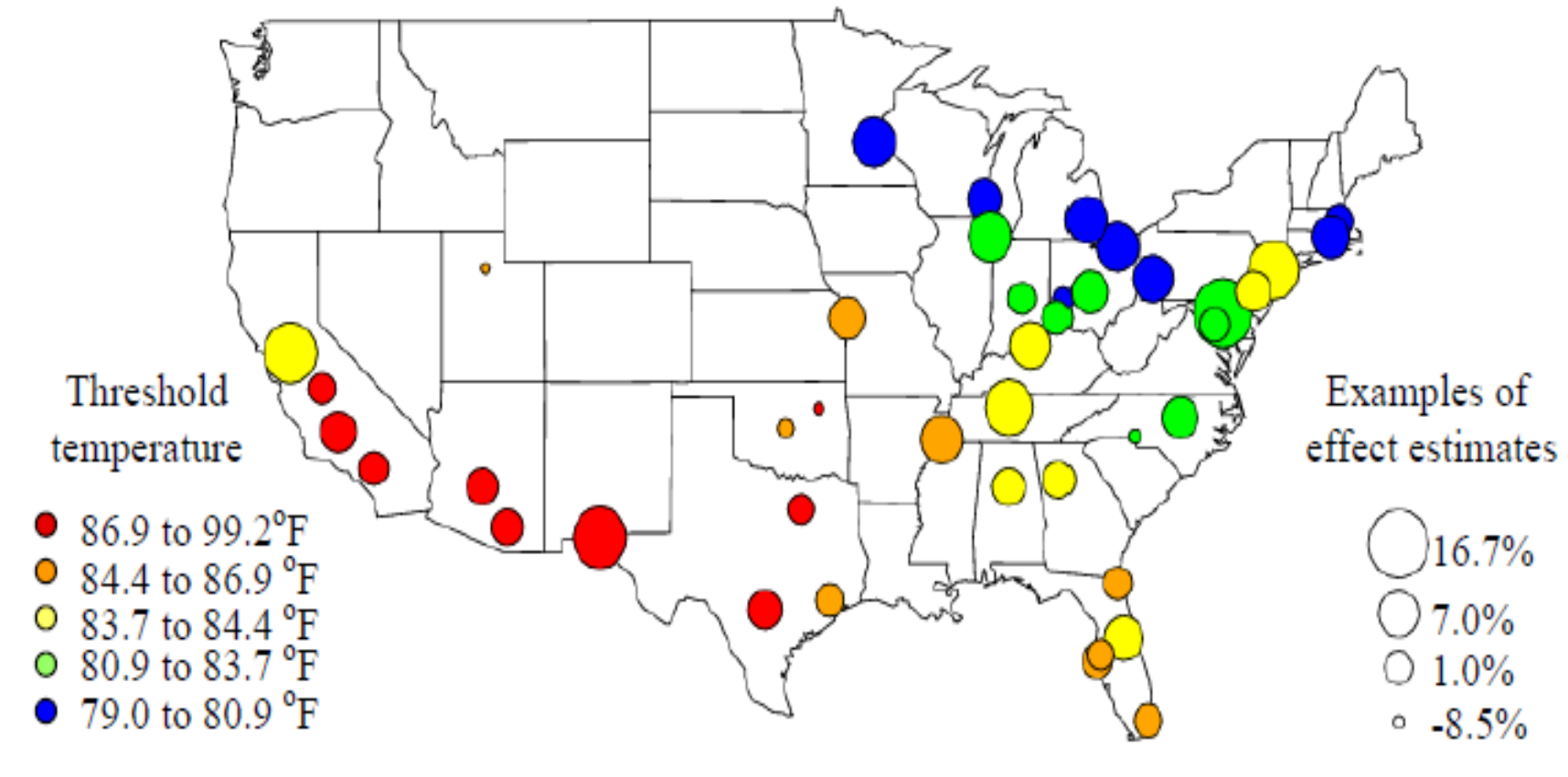




Urban Heat Island can add 7° – 12° F

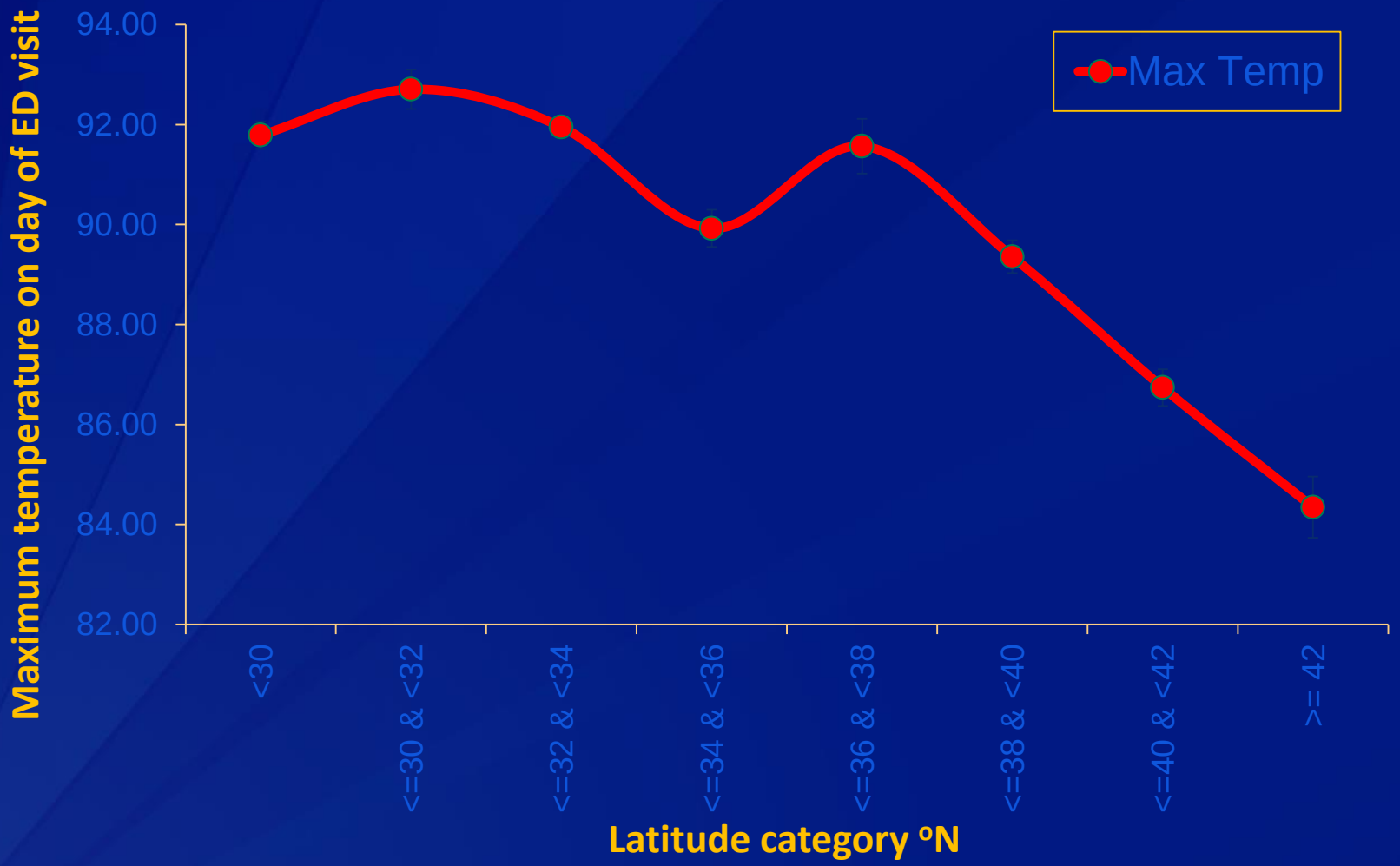
ASTER Thermal Satellite Image of Phoenix, AZ Night Surface Temperature

Mortality risk from heat waves



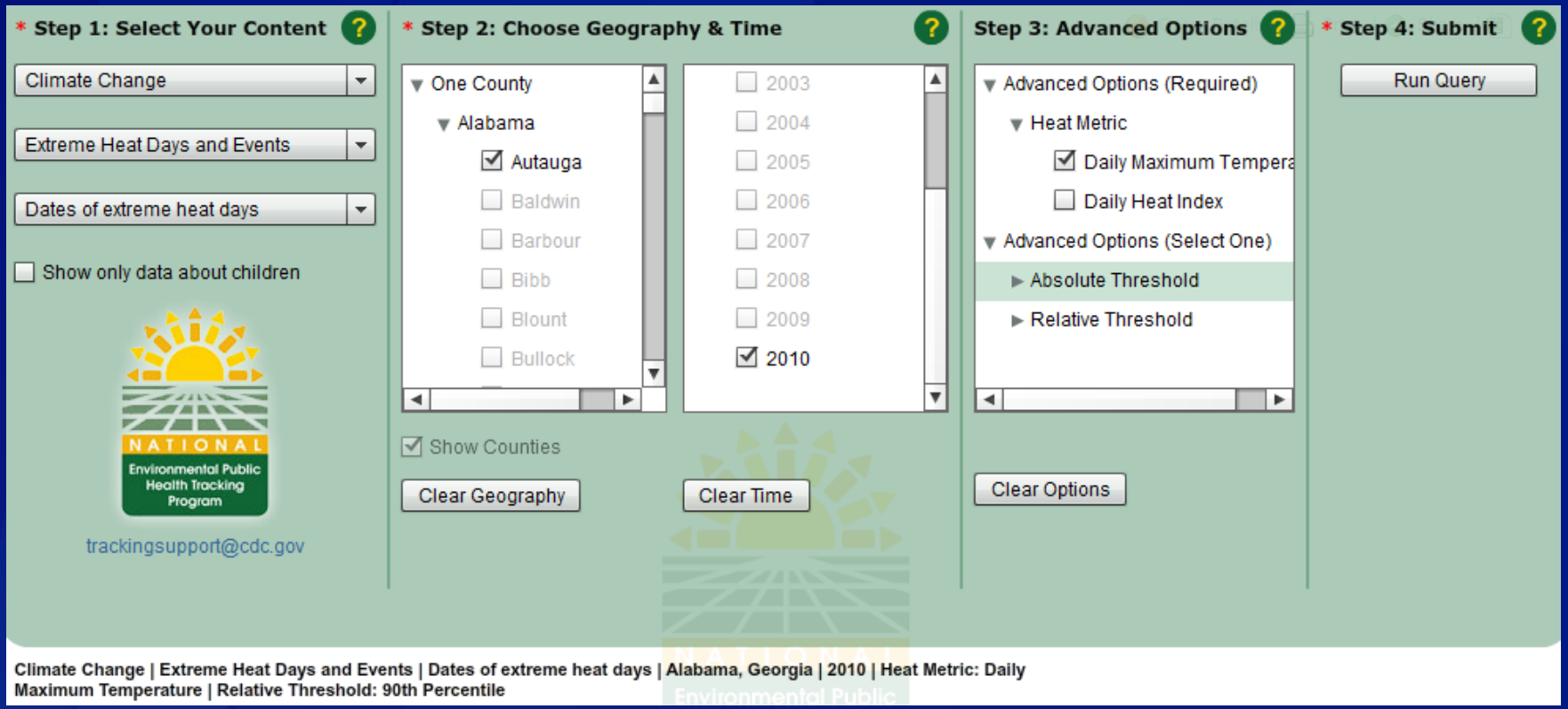
Andersen and Bell, 2011, Environmental Health Perspectives

Temperature profile on ED visit days for Hyperthermia



Saha et al., 2015; Environmental Health

The National Environmental Public Health Tracking Network

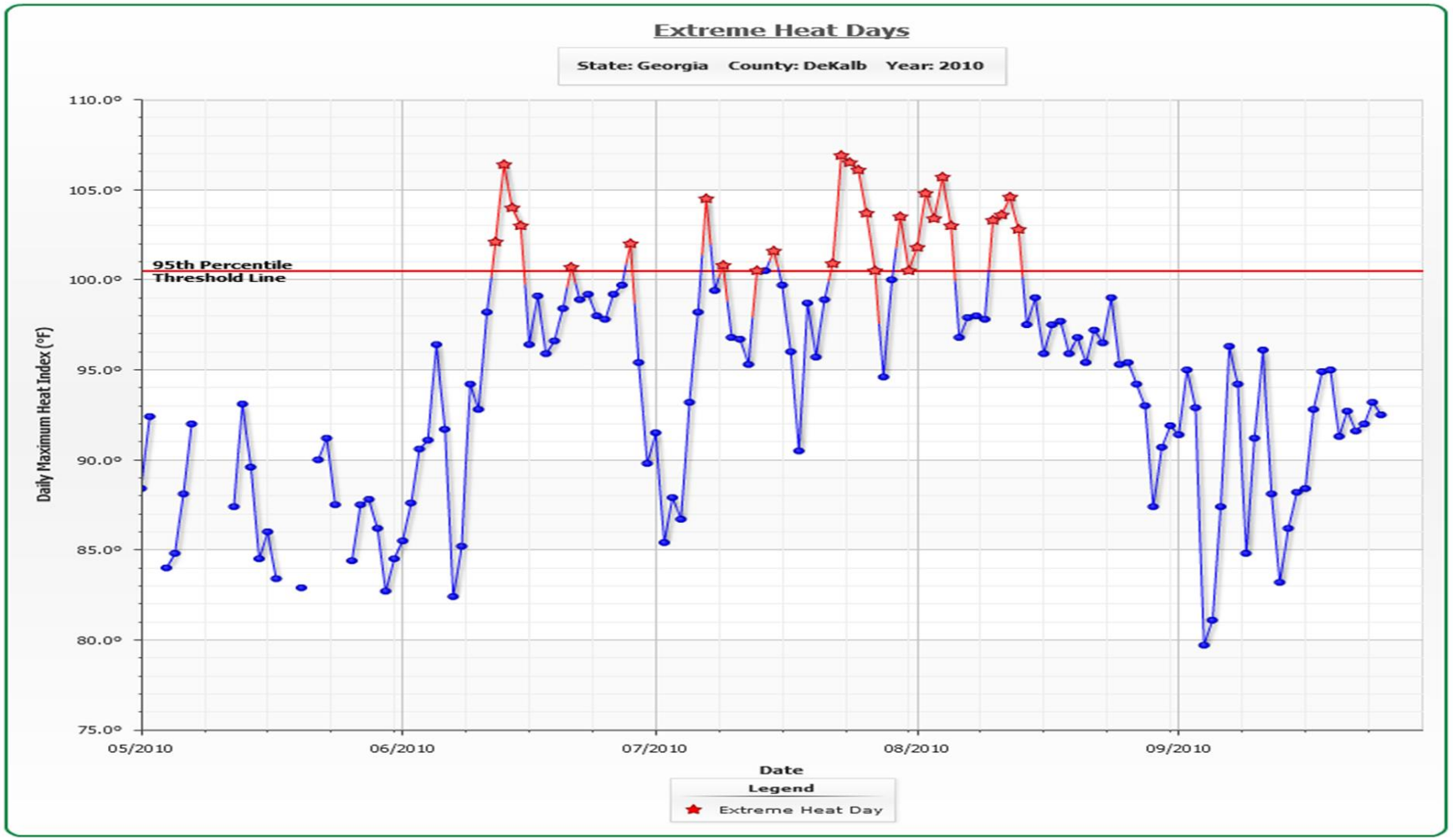


The network provides data on:

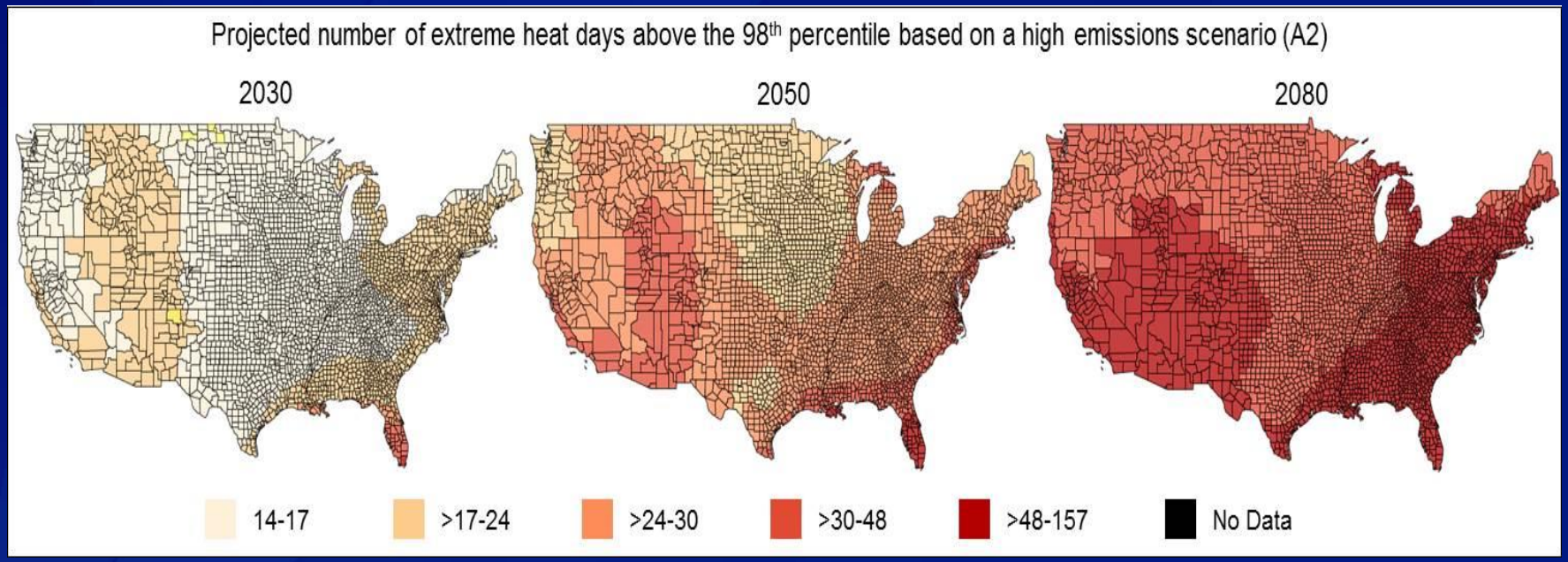
- Extreme heat days and events
- Heat vulnerability
- Health effects associated with extreme heat

http://ephtracking.cdc.gov

Historic temperature data (EPHTN)

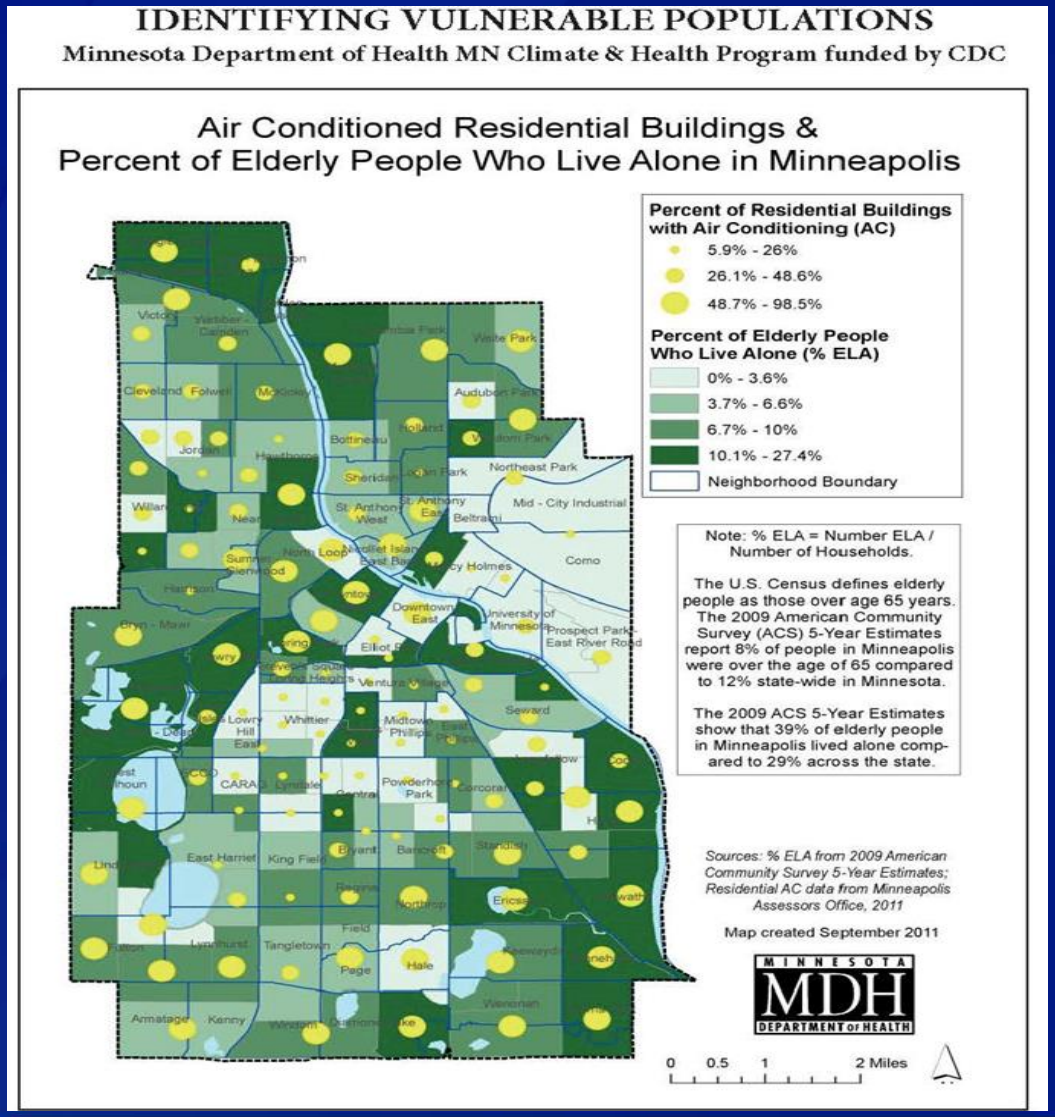


Future modeled temperature data (EPHTN)

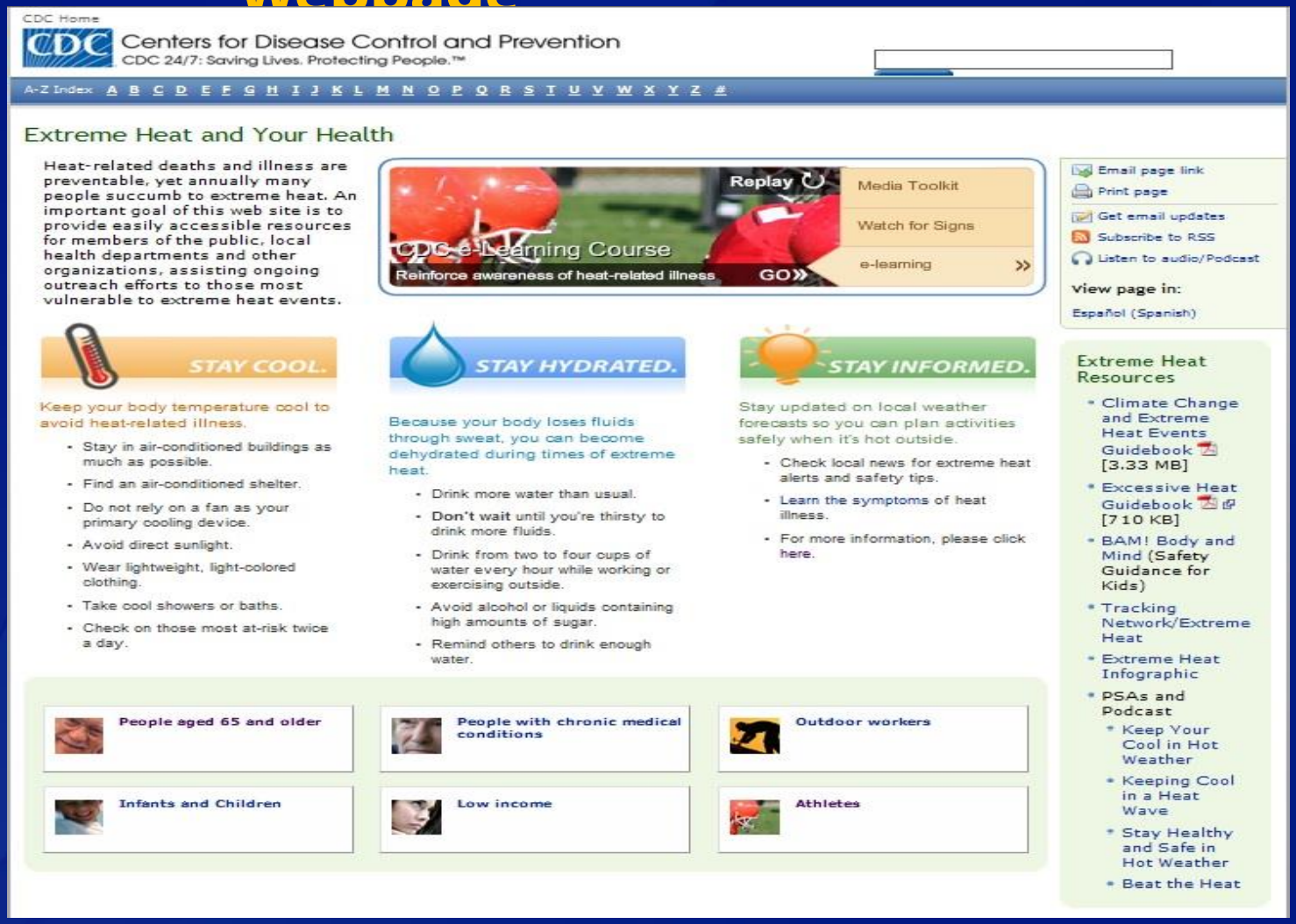


Source: NOAA, National Climate Assessment 2014

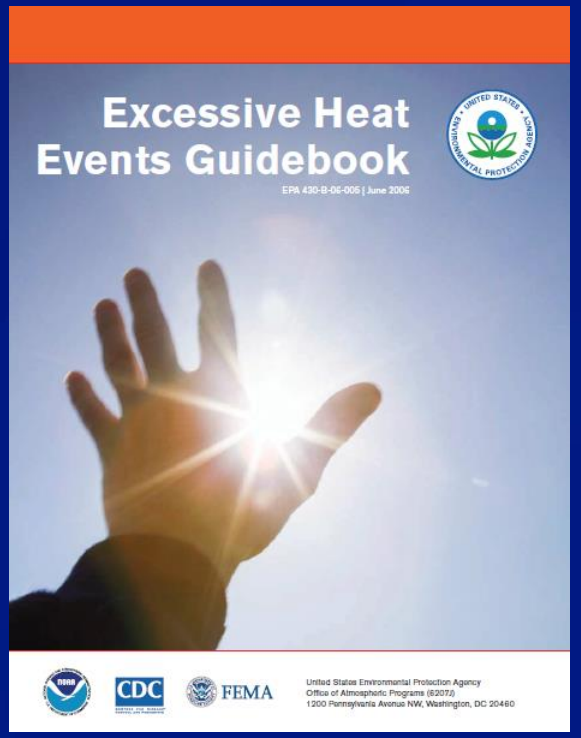
Vulnerable neighborhoods during a heat wave



CDC's Extreme Heat Webpage



Guidance for preventing heat-related illness



- Defining and responding to extreme heat events
- Climate change and extreme heat events
- Variables that affect extreme heat events
- Development and implementation of extreme heat event programs (case studies)

Objectives

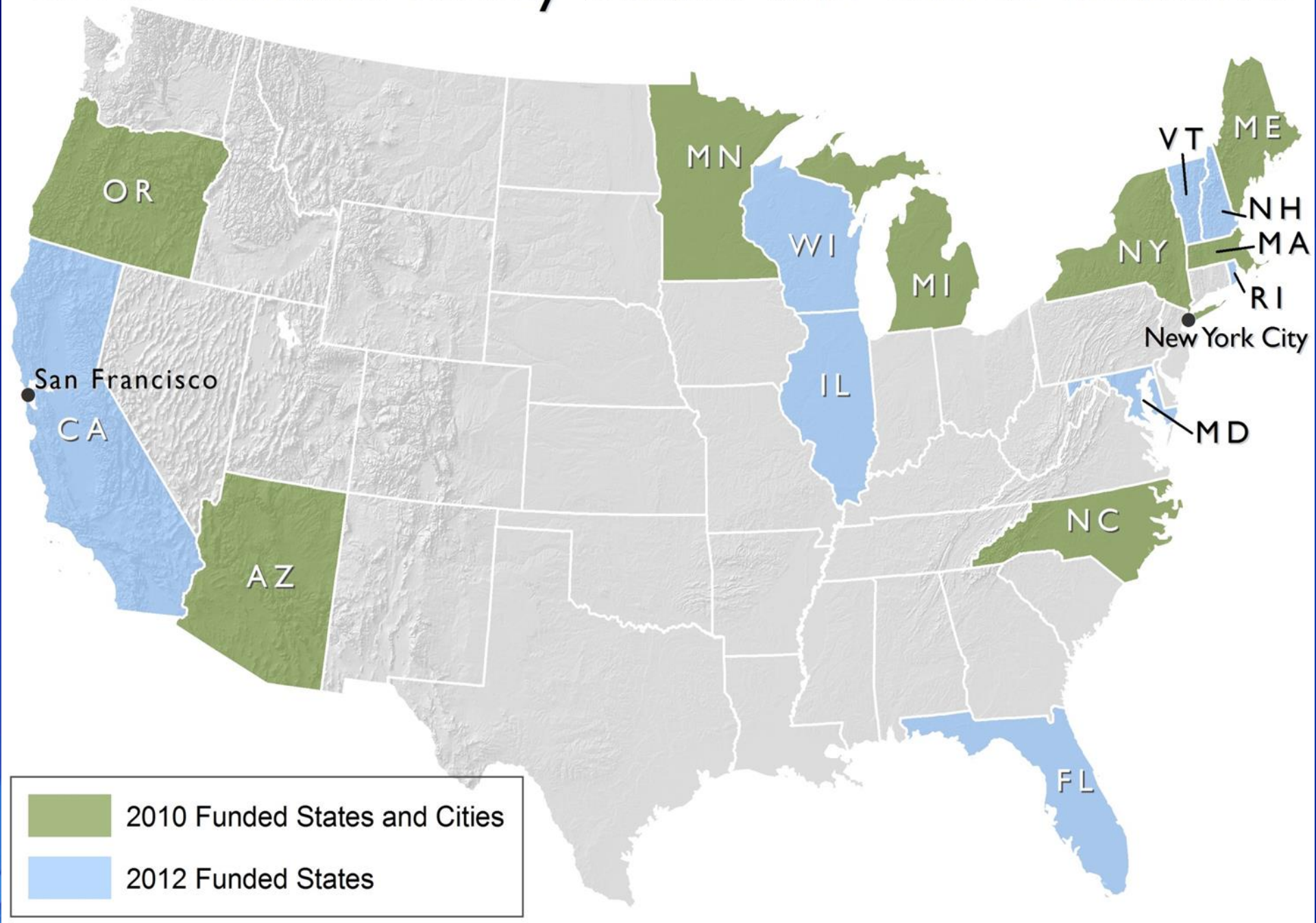
- Review evidence for climate change and its impact on human health
- Describe CDC efforts to prepare for health effects of climate change



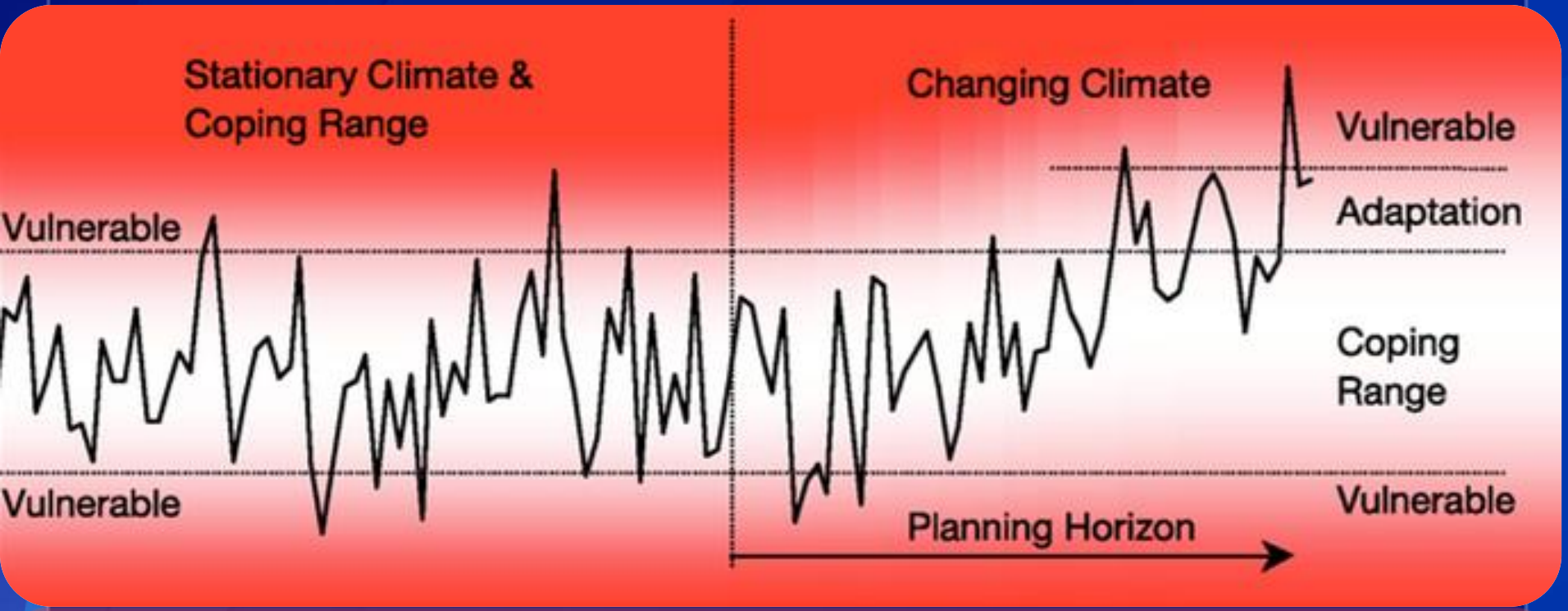
What is CDC doing to prepare for health effects of climate change?

- **CDC helps states and cities prepare for health challenges of climate change by:**
  - Providing scientific guidance
  - Developing decision support tools
  - Ensuring public health concerns are considered in climate change adaptation and mitigation strategies
  - Creating partnerships between public health and other sectors
- **CDC's Climate and Health Program –only Federal investment in climate change preparedness for public health sector**

CDC Climate Ready States and Cities Initiative



The Path Forward: Shifting the Coping Range



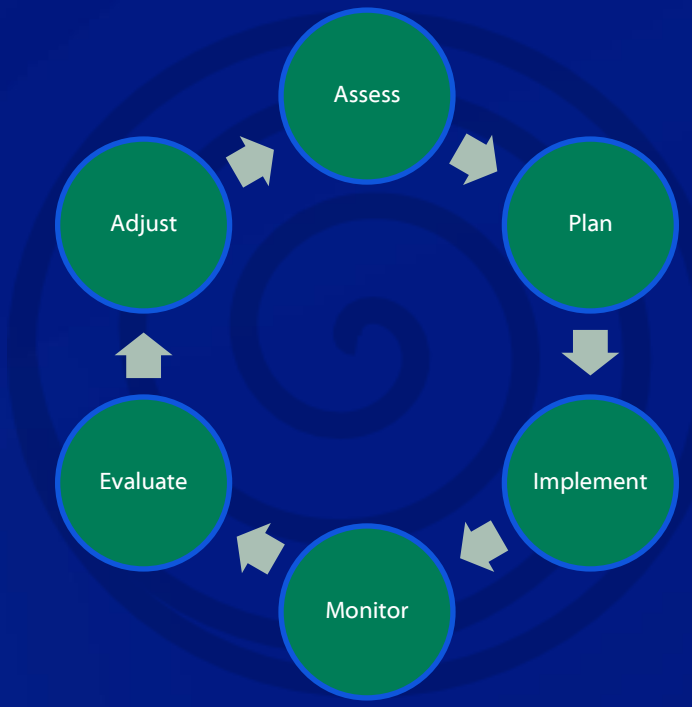
How to Shift a Coping Range?

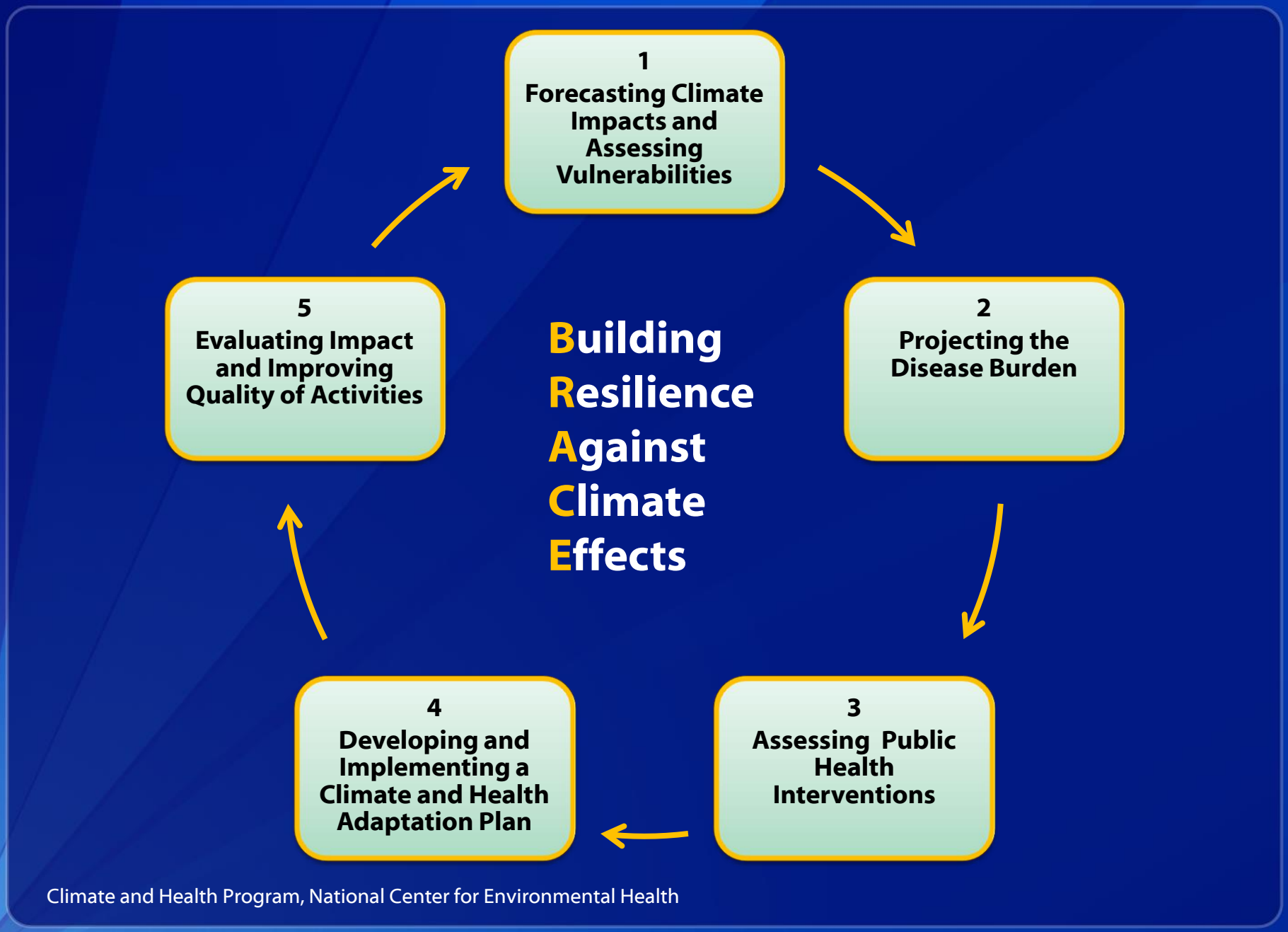
Integrating Climate Change Adaptation into Public Health Practice: Using Adaptive Management to Increase Adaptive Capacity and Build Resilience

Jeremy J. Hess,[1,2,3] Julia Z. McDowell,[1,2] and George Luber[1]

[1]Climate and Health Program, Division of Environmental Hazards and Health Effects, National Center for Environmental Health, Centers for Disease Control and Prevention, Atlanta, Georgia, USA; [2]Department of Environmental Health, Rollins School of Public Health, and [3]Department of Emergency Medicine, Emory University School of Medicine, Emory University, Atlanta, Georgia, USA

- Return to the risk equation
  - Reduce hazard probability
  - Reduce hazard exposure
  - Reduce vulnerability
- It is an iterative process
- Requires modeling, learning, and adaptive management

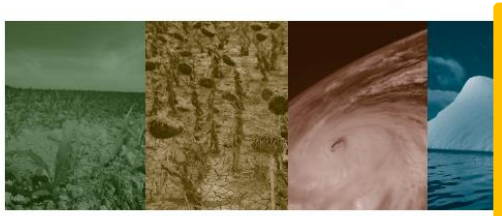



1
Forecasting Climate Impacts and Assessing Vulnerabilities
2
Projecting the Disease Burden
3
Assessing Public Health Interventions
4
Developing and Implementing a Climate and Health Adaptation Plan
5
Evaluating Impact and Improving Quality of Activities
Building Resilience Against Climate Effects
Climate and Health Program, National Center for Environmental Health

BRACE Technical Guidance

Climate Models and the Use of Climate Projections:

A Brief Overview for Health Departments



Climate and Health Technical Report Seri

Climate and Health Program, Centers for Disease Control and Prev

Paul J. Schramm[1], Christopher K. Uejio[2], Jeremy J. Hess[1,3,4], Gino D. Marinucci[1], George Luber[1]

[1]Climate and Health Program, Division of Environmental Hazards and Health Effects (DEHHE), Natio
Environmental Health (NCEH), Centers for Disease Control and Prevention (CDC) Atlanta, GA

[2]Department of Geography, Florida State University, Tallahassee, FL, USA

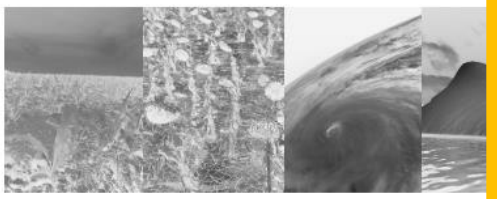
[3]Department of Emergency Medicine, School of Medicine, Emory University, Atlanta, GA, US

[4]Department of Environmental Health, Rollins School of Public Health, Emory University, Atlanta,

National Center for Environmental Health
Division of Environmental Hazards and Health Effects

Assessing Health Vulnerability to Climate Change

A Guide for Health Departments



Climate and Health Technical Report Seri

Climate and Health Program, Centers for Disease Control and Prev

Arie Ponce Manangan[1], Christopher K. Uejio[2], Shubhayu Saha[1], Paul J. Schramm[1],
Gino D. Marinucci[1], Claudia Langford Brown[1], Jeremy J. Hess[1,3,4], George Luber[1]

[1]Climate and Health Program, Division of Environmental Hazards and Health Effects (DEHHE), Natio
Environmental Health (NCEH), Centers for Disease Control and Prevention (CDC) Atlanta, GA

[2]Department of Geography, Florida State University, Tallahassee, FL, USA

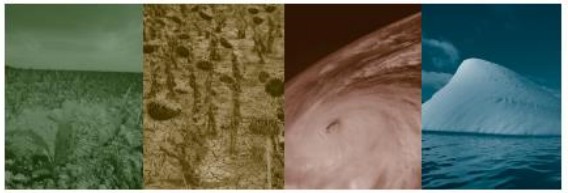
[3]Department of Emergency Medicine, School of Medicine, Emory University, Atlanta, GA, US

[4]Department of Environmental Health, Rollins School of Public Health, Emory University, Atlanta,

National Center for Environmental Health
Division of Environmental Hazards and Health Effects

Projecting Climate-Related Disease Burden:

A Guide for Health Departments



Climate and Health Technical Report Series

Climate and Health Program,
Centers for Disease Control and Prevention

Jeremy J. Hess[1,2,3*], Shubhayu Saha[1*], Paul J. Schramm[1], Kathryn C. Conlon[1,4],
Christopher K. Uejio[1,5], George Luber[1]

[1]Climate and Health Program, Division of Environmental Hazards and Health Effects (DEHHE), National Center for Environmental Health (NCEH), Centers for Disease Control and Prevention (CDC), Atlanta, GA, USA

[2]Department of Emergency Medicine, School of Medicine, Emory University, Atlanta, GA, USA

[3]Department of Environmental Health, Rollins School of Public Health, Emory University, Atlanta, GA, USA

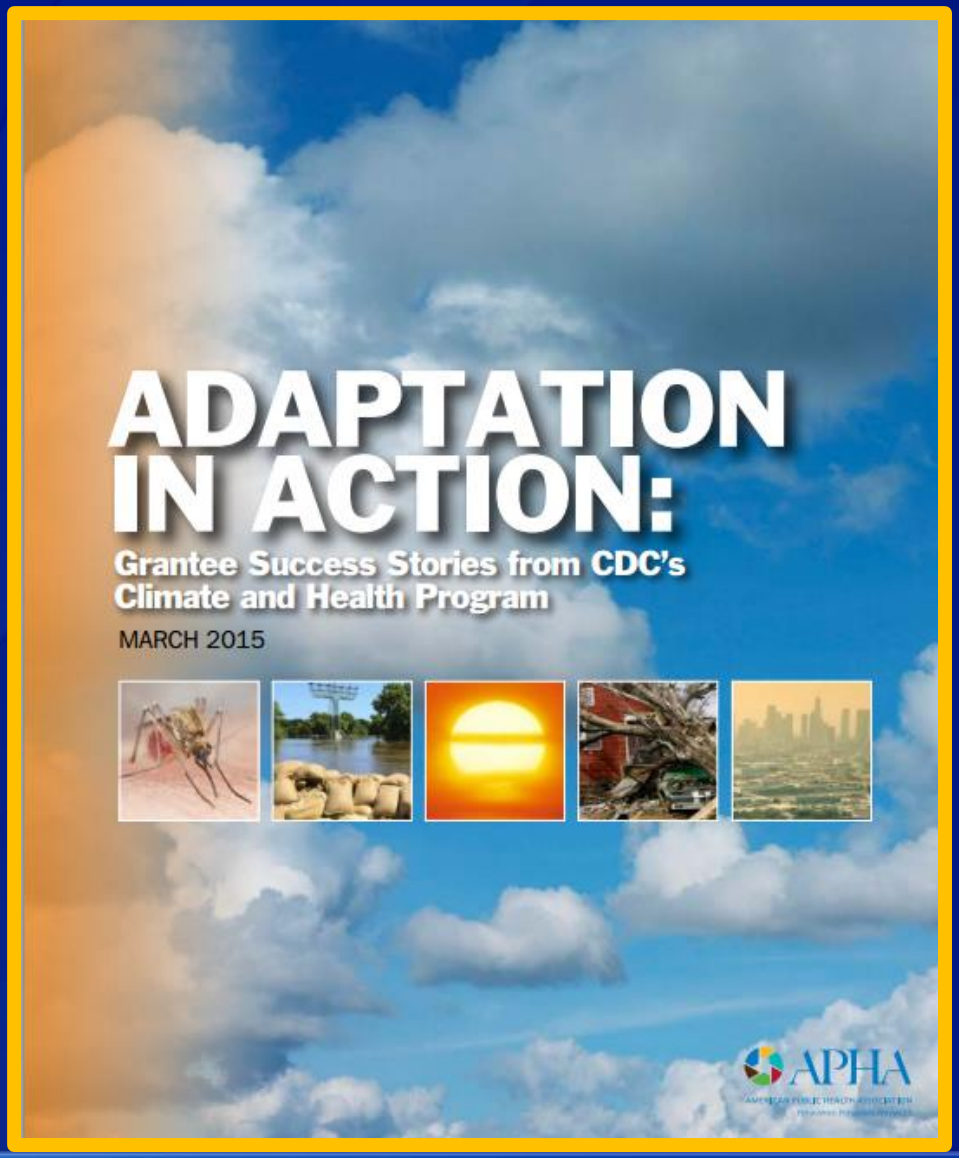
[4]National Center for Atmospheric Research, Boulder, CO, USA

[5]Department of Geography, Florida State University, Tallahassee, FL, USA

*these authors contributed equally to this work

National Center for Environmental Health
Division of Environmental Hazards and Health Effects

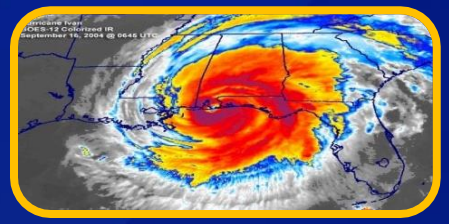
Adaptation in Action



cdc.gov/climateandhealth







George Luber, PhD
Shubhayu Saha, PhD
Paul Schramm, MS, MPH

For more information please contact Centers for Disease Control and Prevention

1600 Clifton Road NE, Atlanta, GA 30333
Telephone: 1-800-CDC-INFO (232-4636)/TTY: 1-888-232-6348
E-mail: cdcinfo@cdc.gov Web: http://www.cdc.gov

National Center for Environmental Health
Division of Environmental Hazards and Health Effects