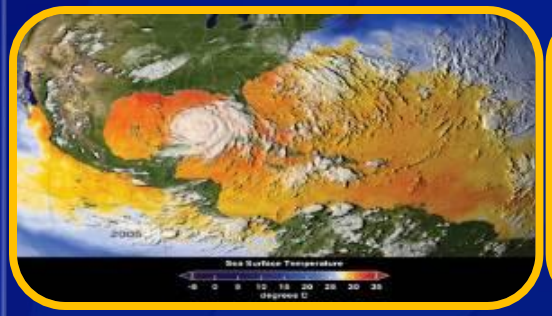
Under the Weather?

The Health Consequences of a Changing Climate



George Luber, PhD

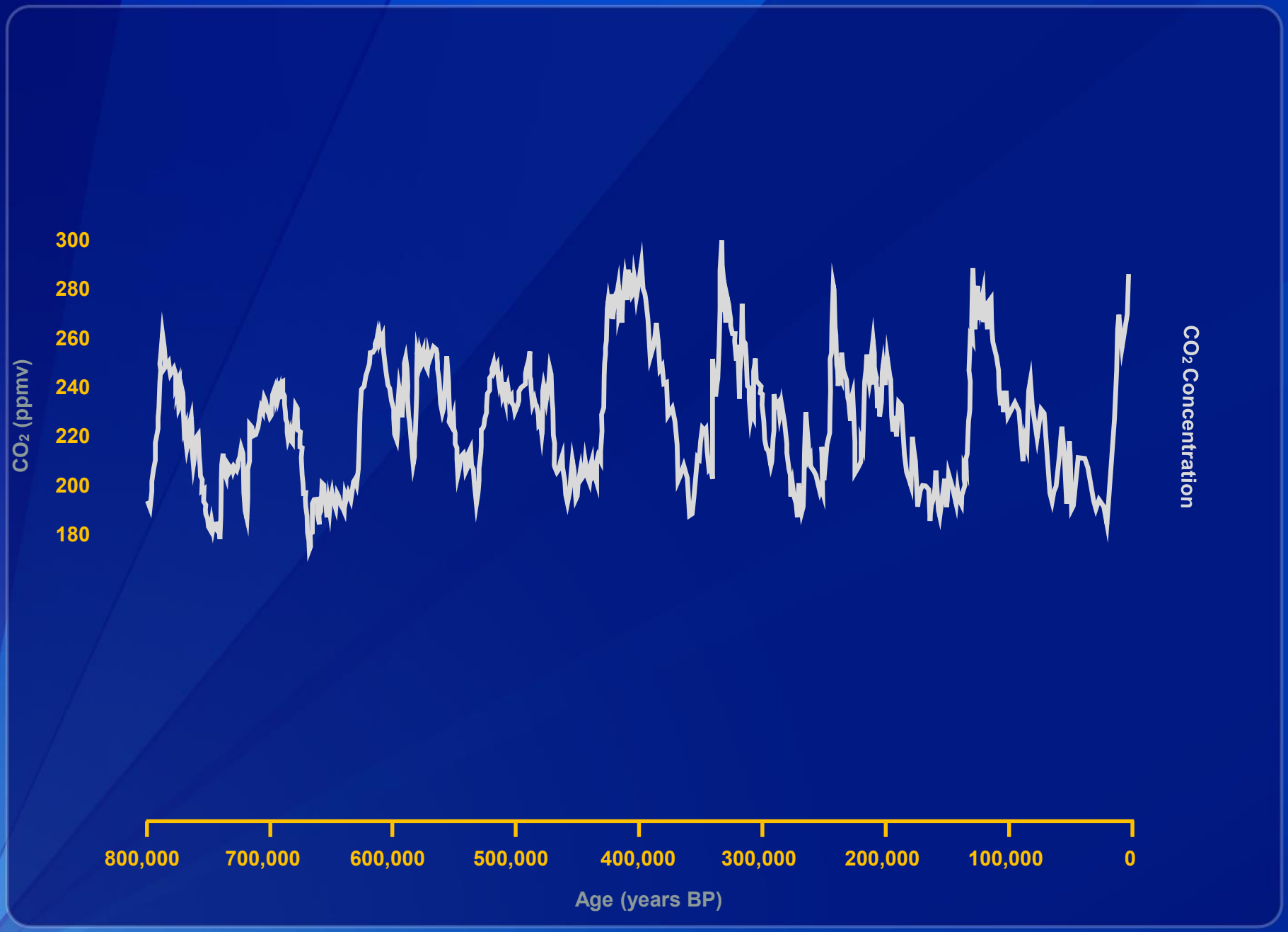
Chief,
Climate and Health Program

National Center for Environmental Health
Centers for Disease Control and Prevention

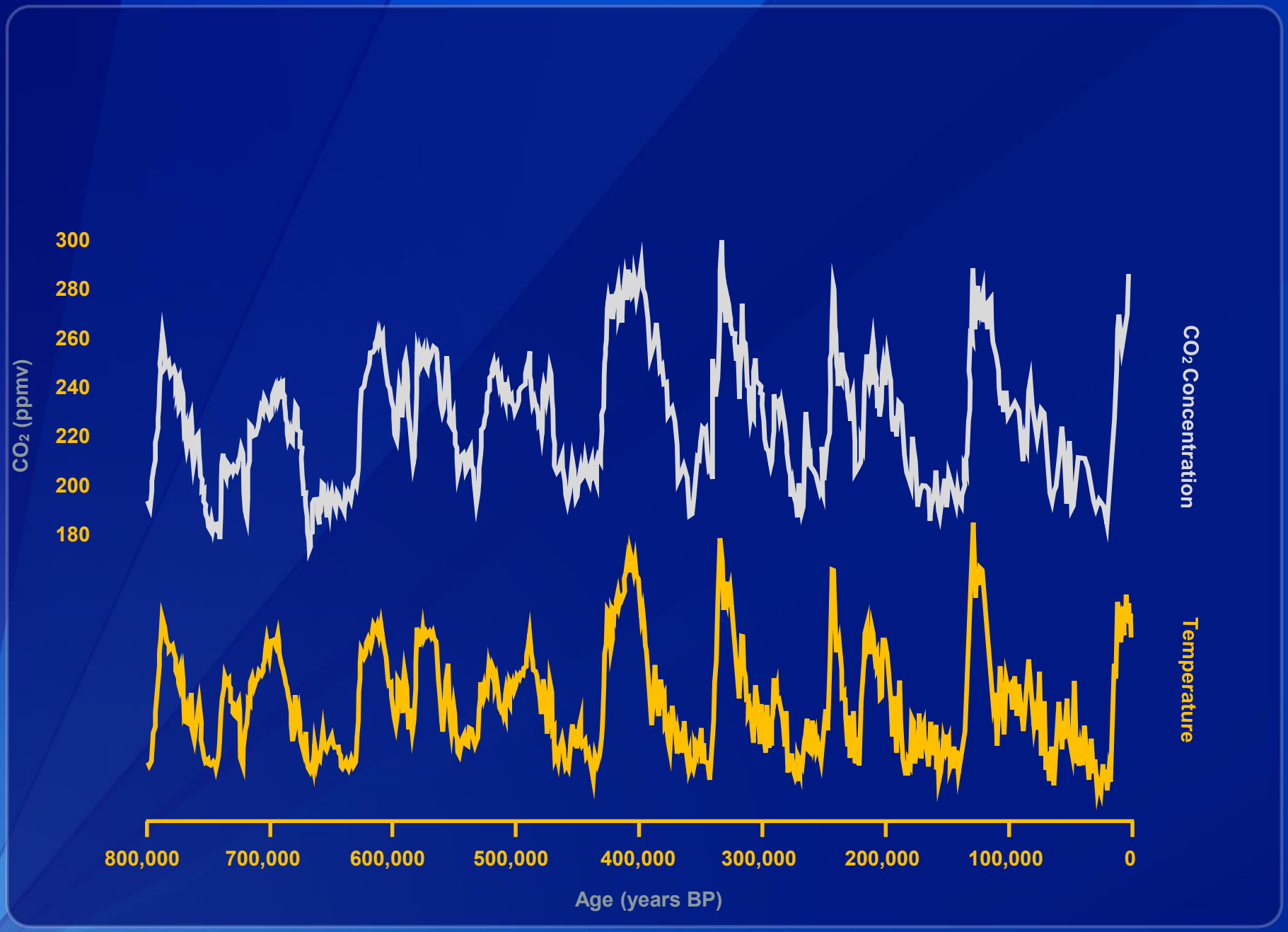
Objectives

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

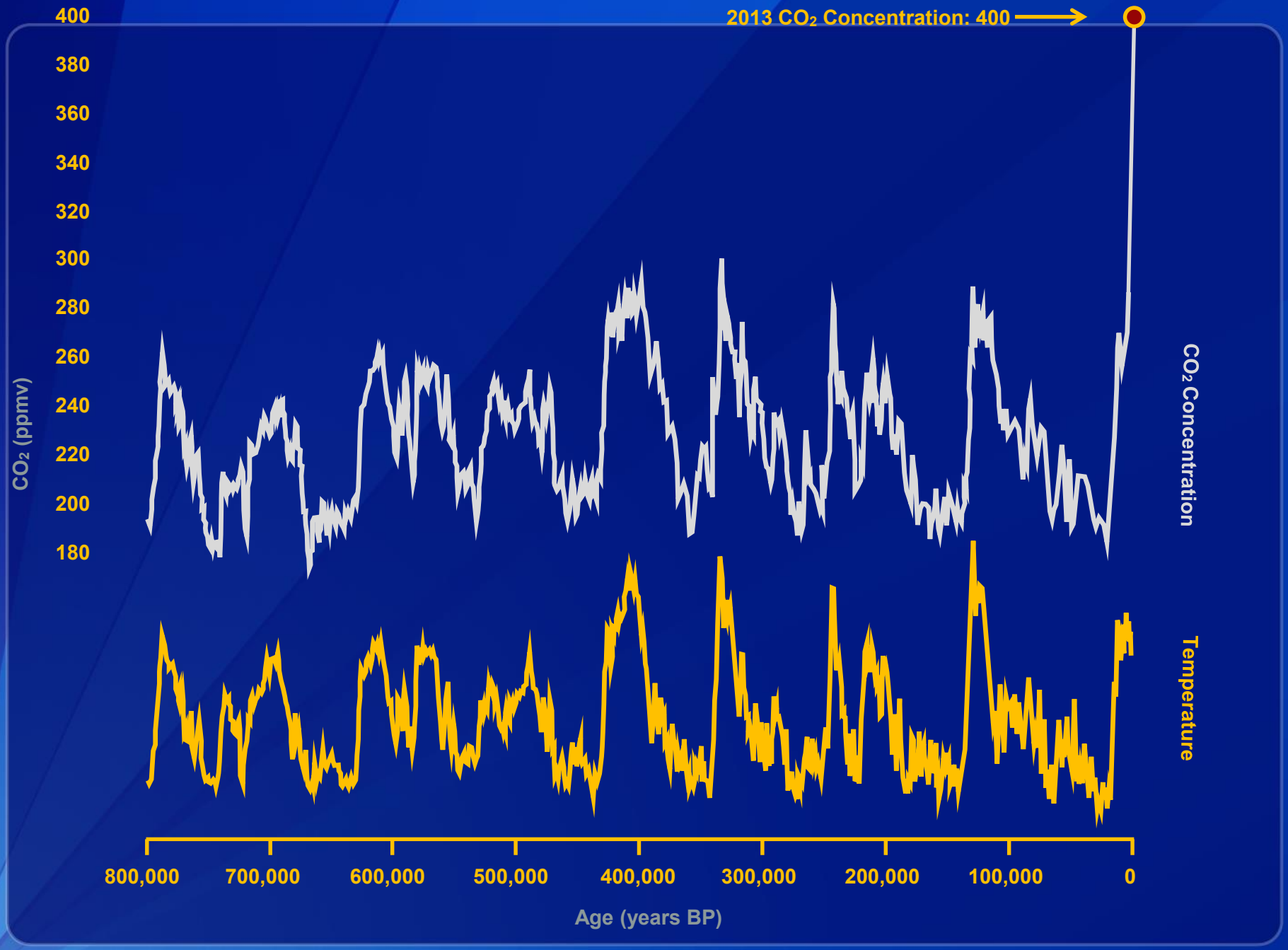




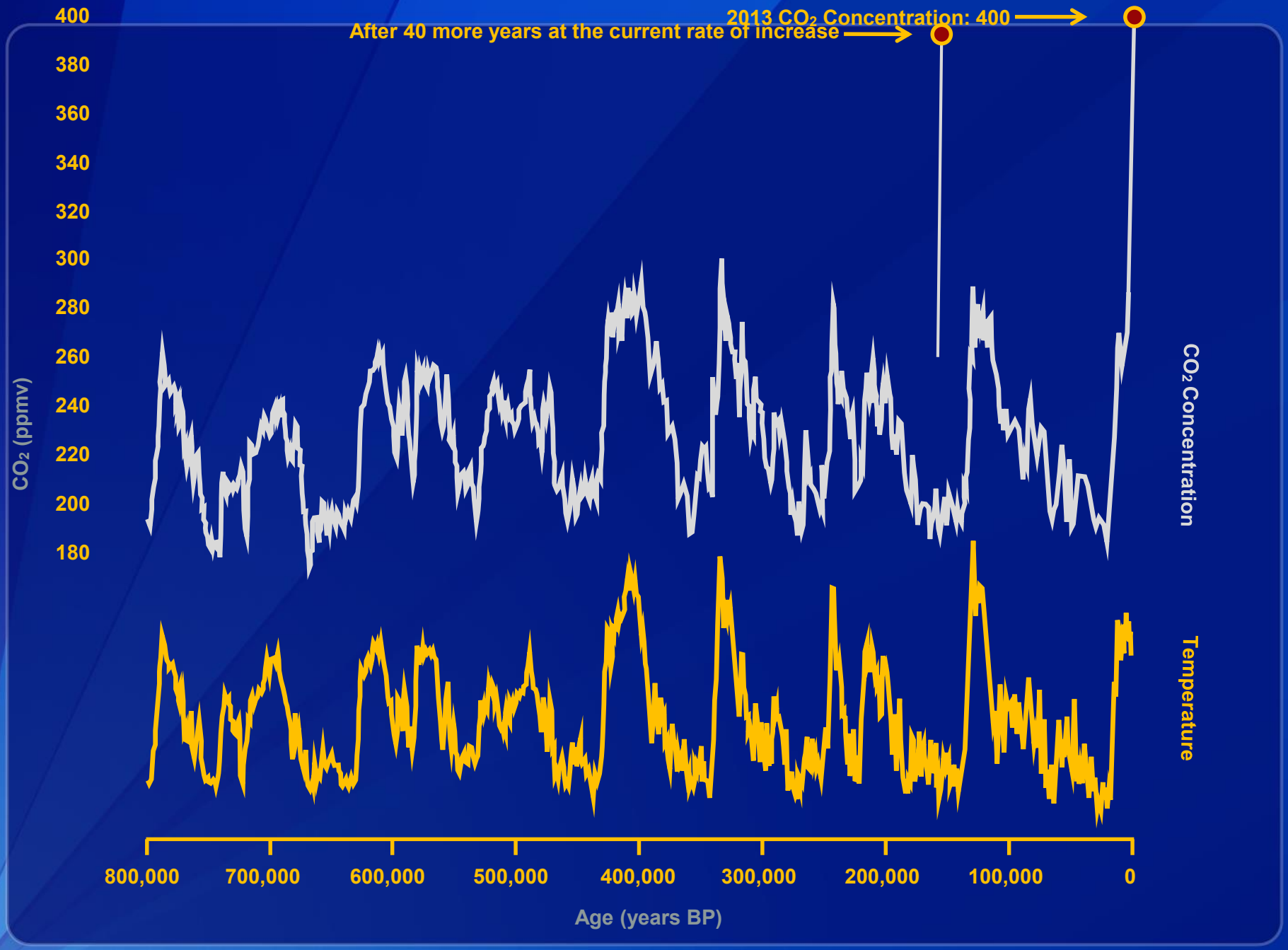
Source: National Climatic Data Center, NOAA



Source: National Climatic Data Center, NOAA



Source: National Climatic Data Center, NOAA



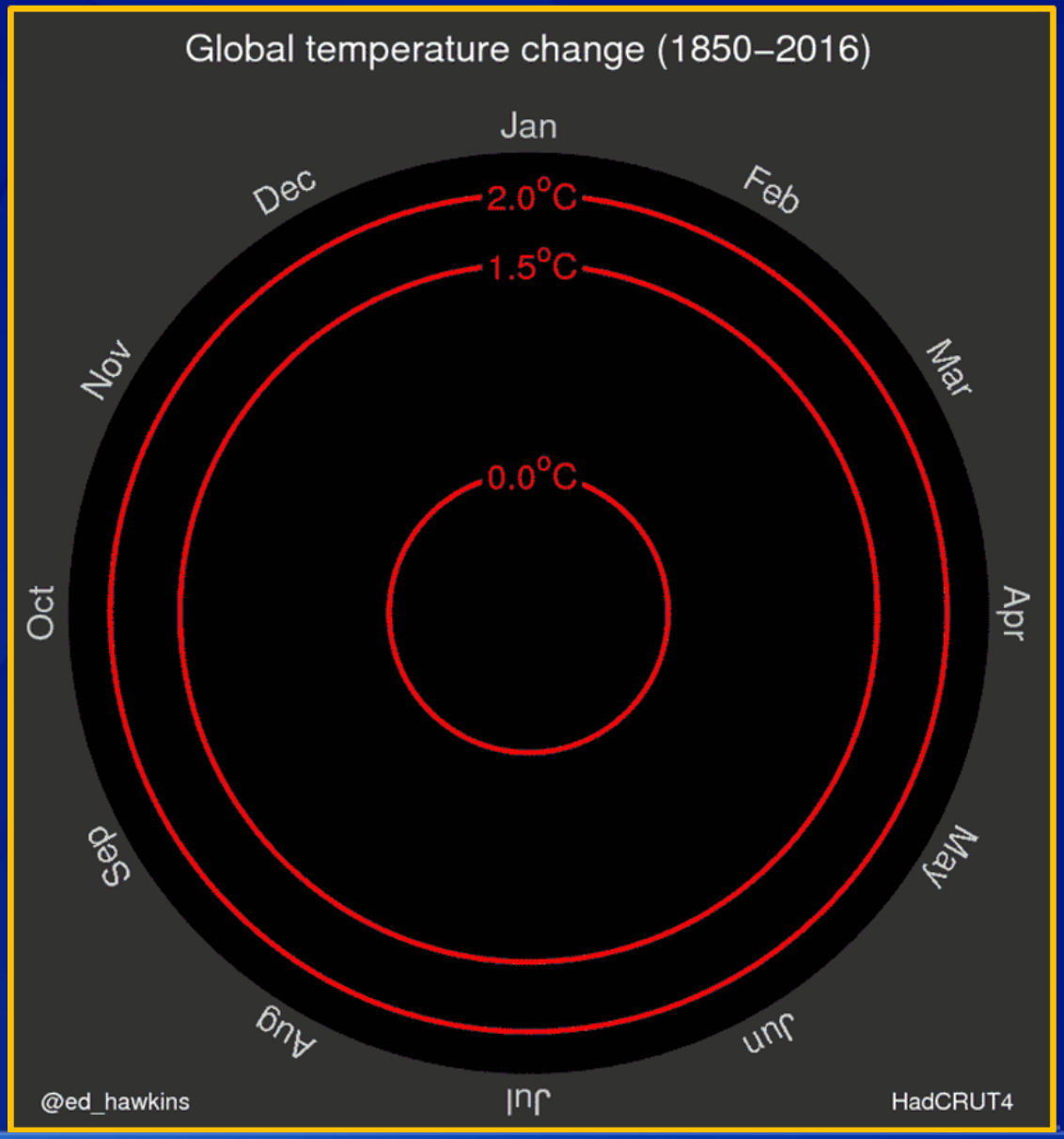
Source: National Climatic Data Center, NOAA

Objectives

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

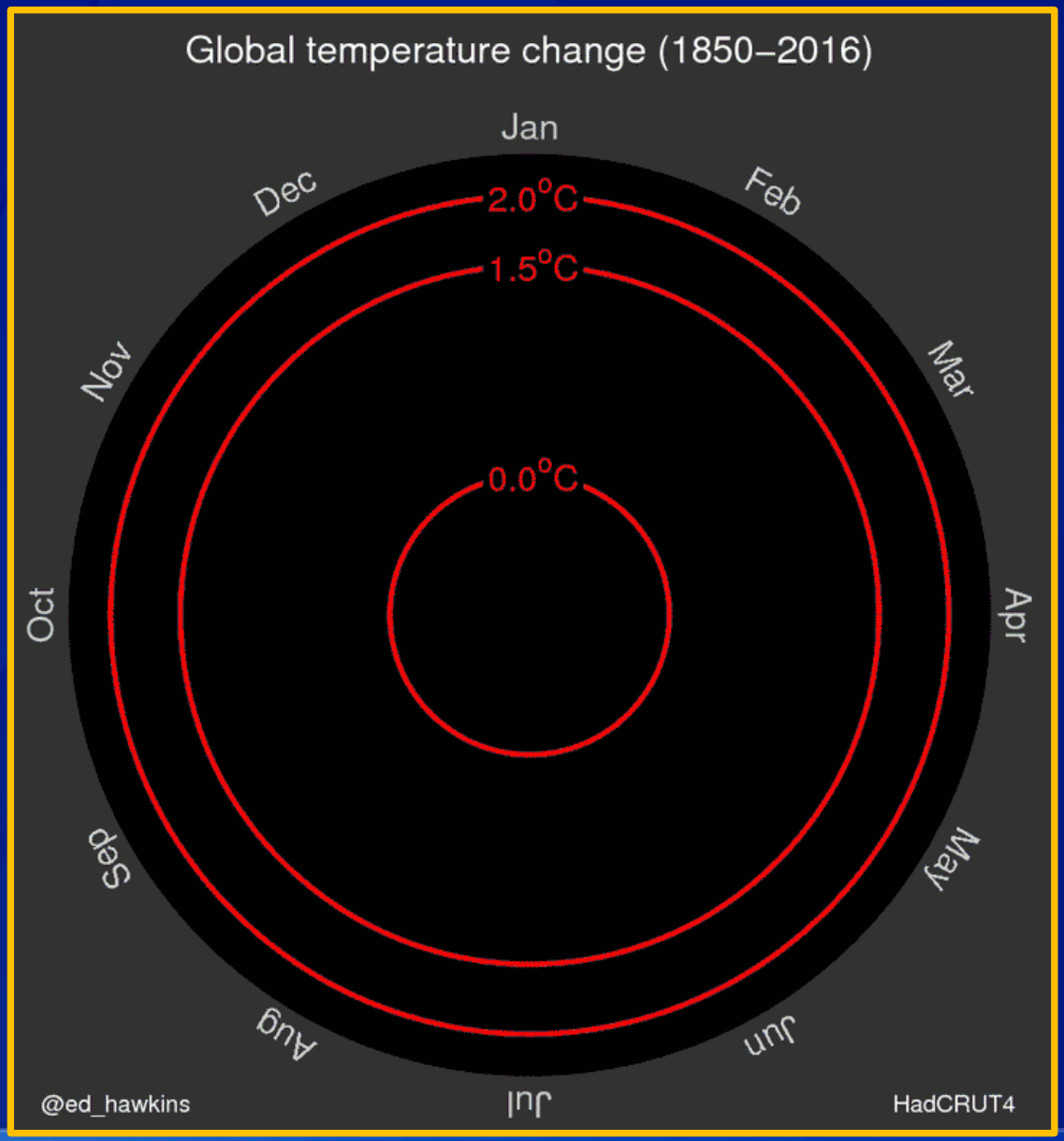


Global Average Temperatures have been increasing



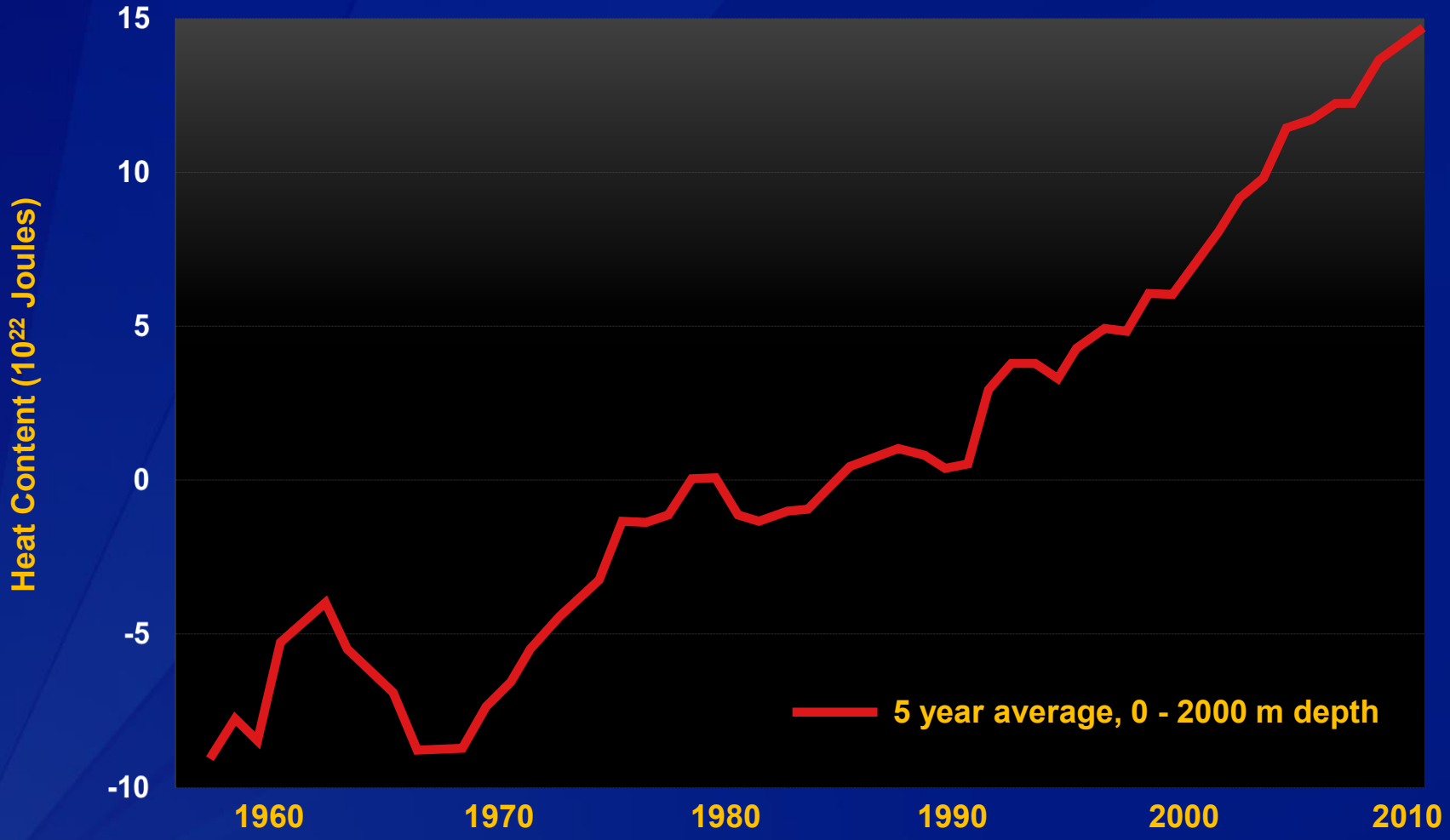
Source: http://www.climate-lab-book.ac.uk/2016/spiralling-global-temperatures/

Global Average Temperatures have been increasing



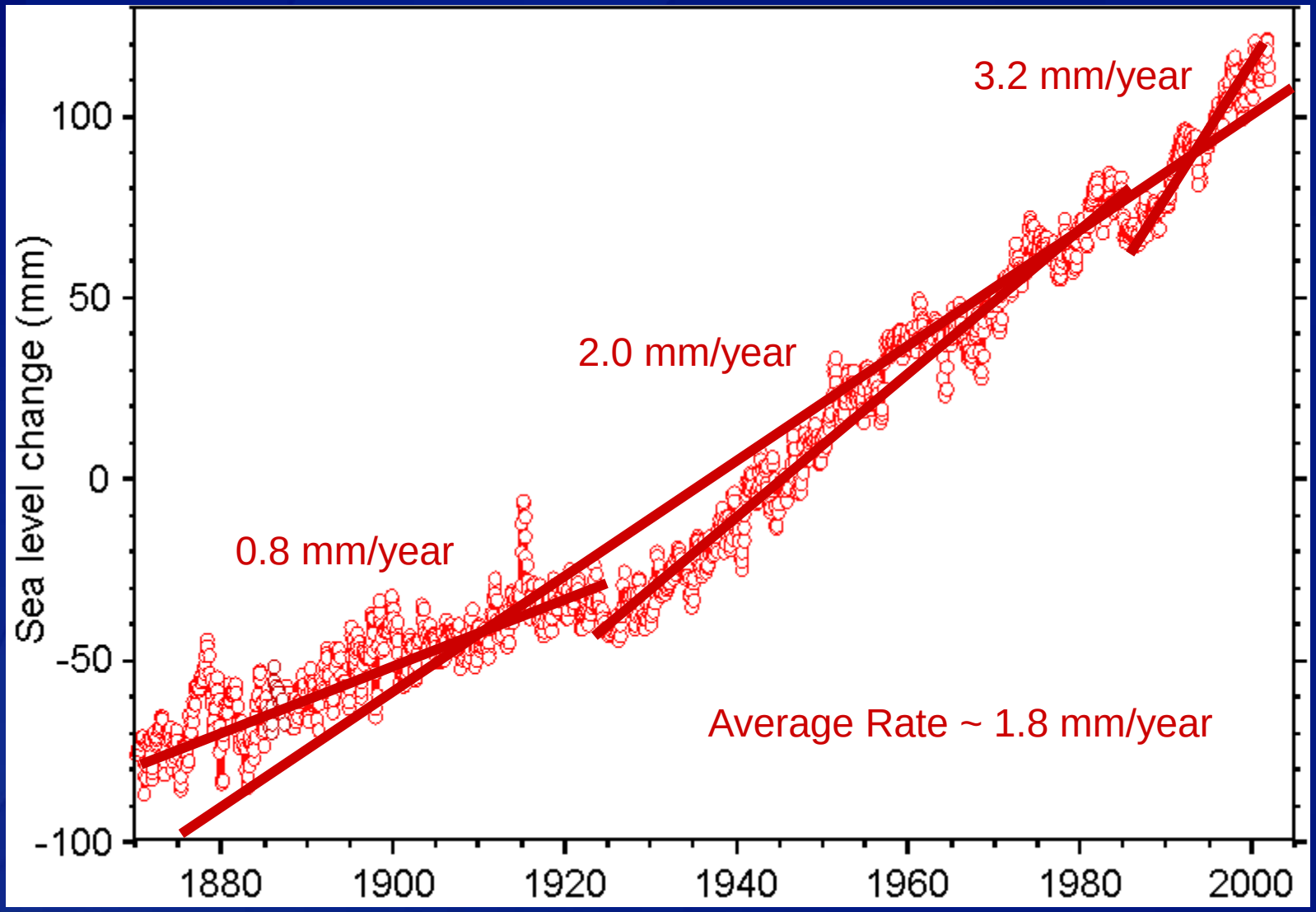
Source: http://www.climate-lab-book.ac.uk/2016/spiralling-global-temperatures/

Global Ocean Heat Content
1955 – 2010



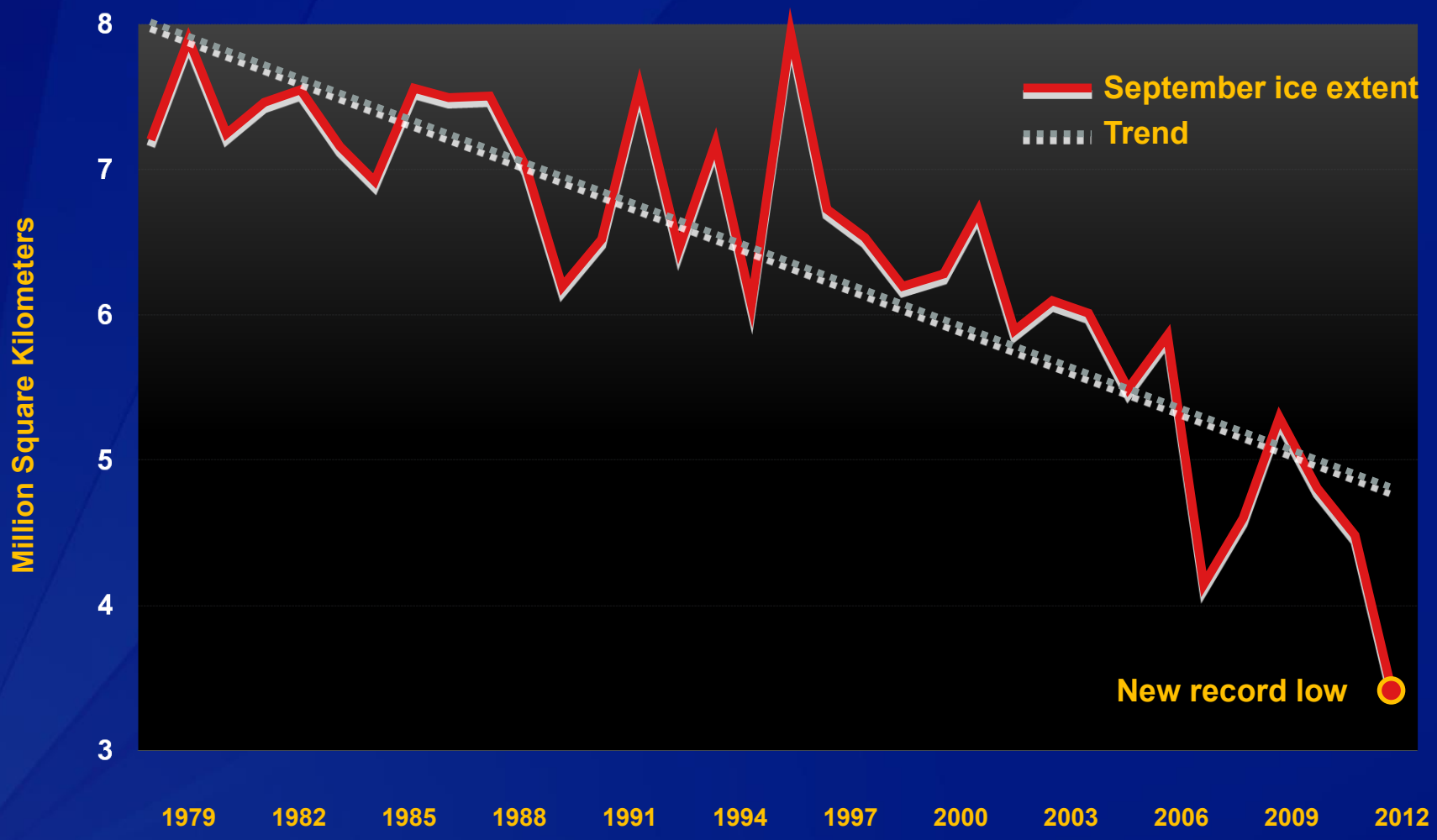
Source: NOAA/NESDIS/NODC Ocean Climate Laboratory, updated from Levitus, S., et al., "World ocean heat content and thermosteric sea level change (0-2000), 1955-2010," *Geophys. Res. Lett.* 39, doi:10.1029/2012GL051106, 2012.

Accelerating Sea Level Rise

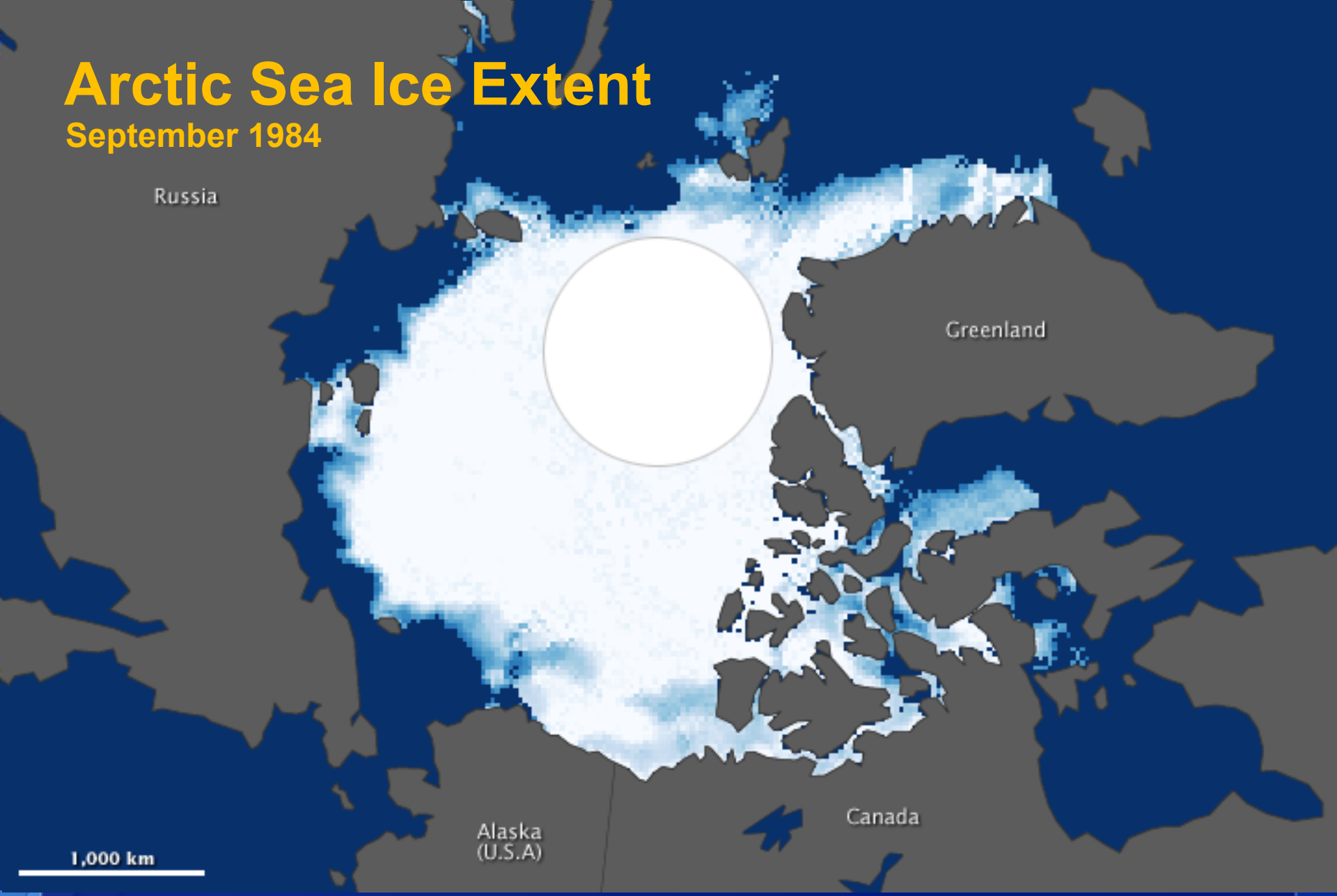


Source: Church and White 2006, GRL 33:L01602
Courtesy R.S. Nerem

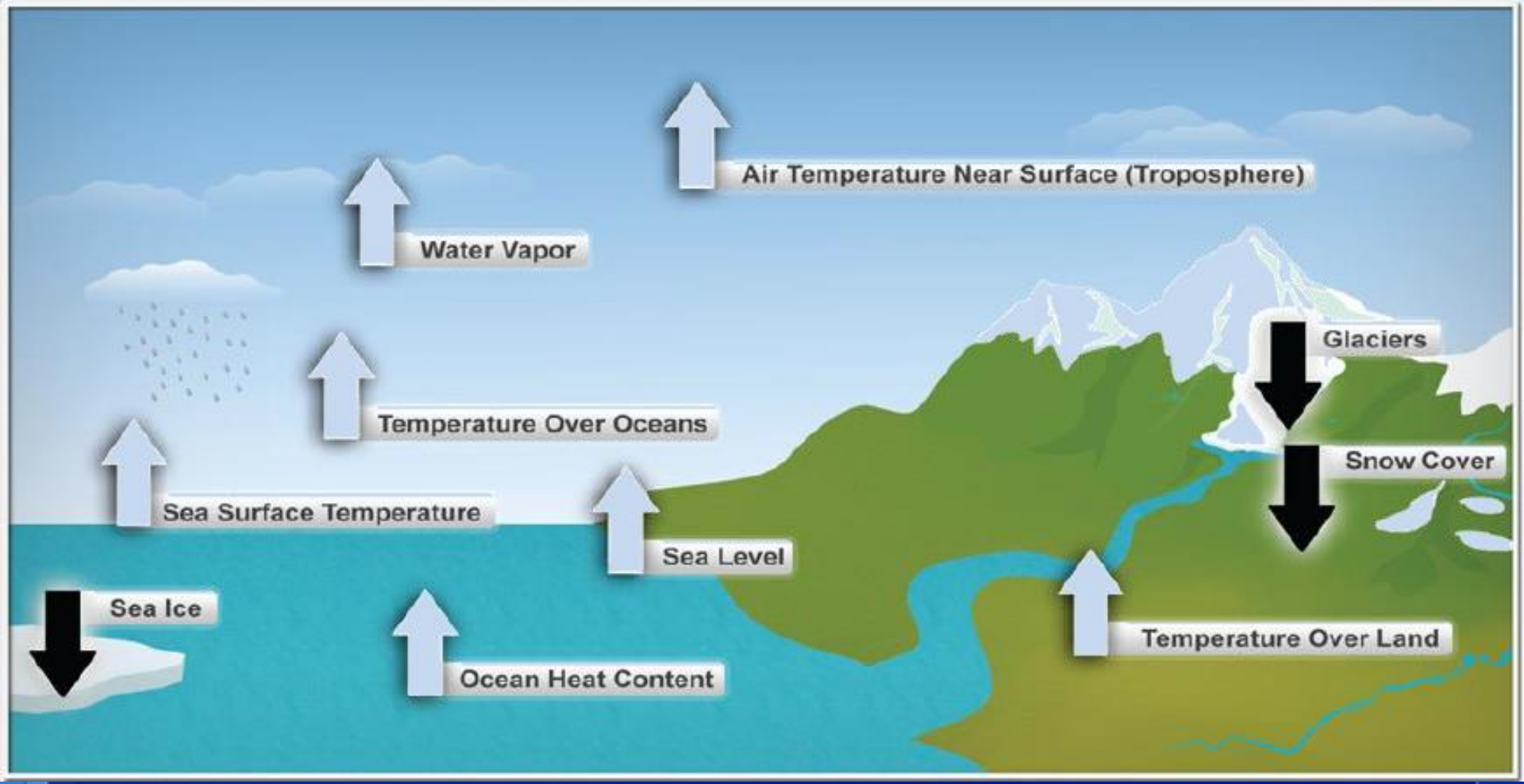
September Arctic Sea Ice Extent
1979 – 2012



Source: National Snow and Ice Data Center, October 2012


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

Ten Indicators of a Warming World



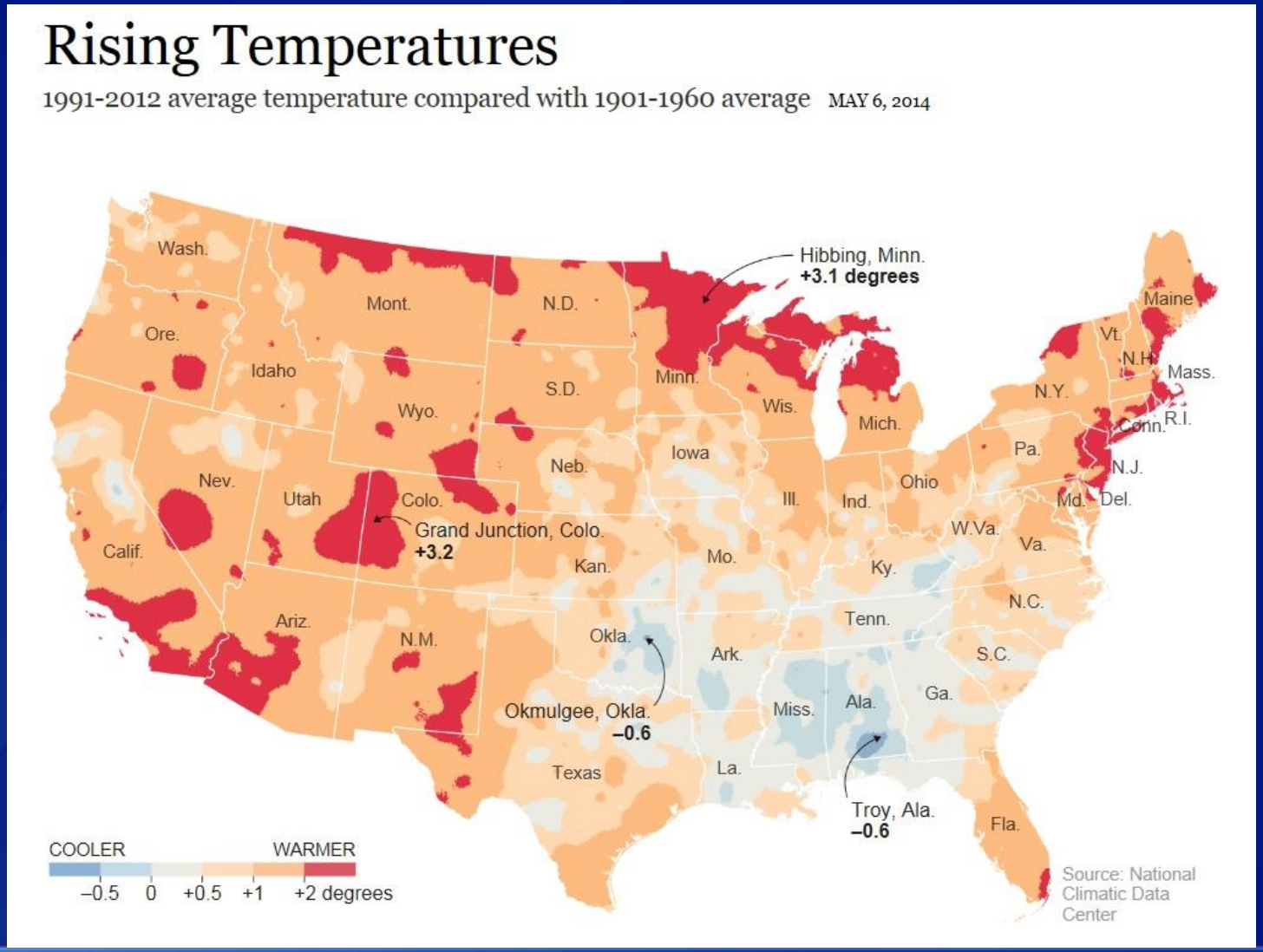
Source:

Climate Change Science: Key Findings

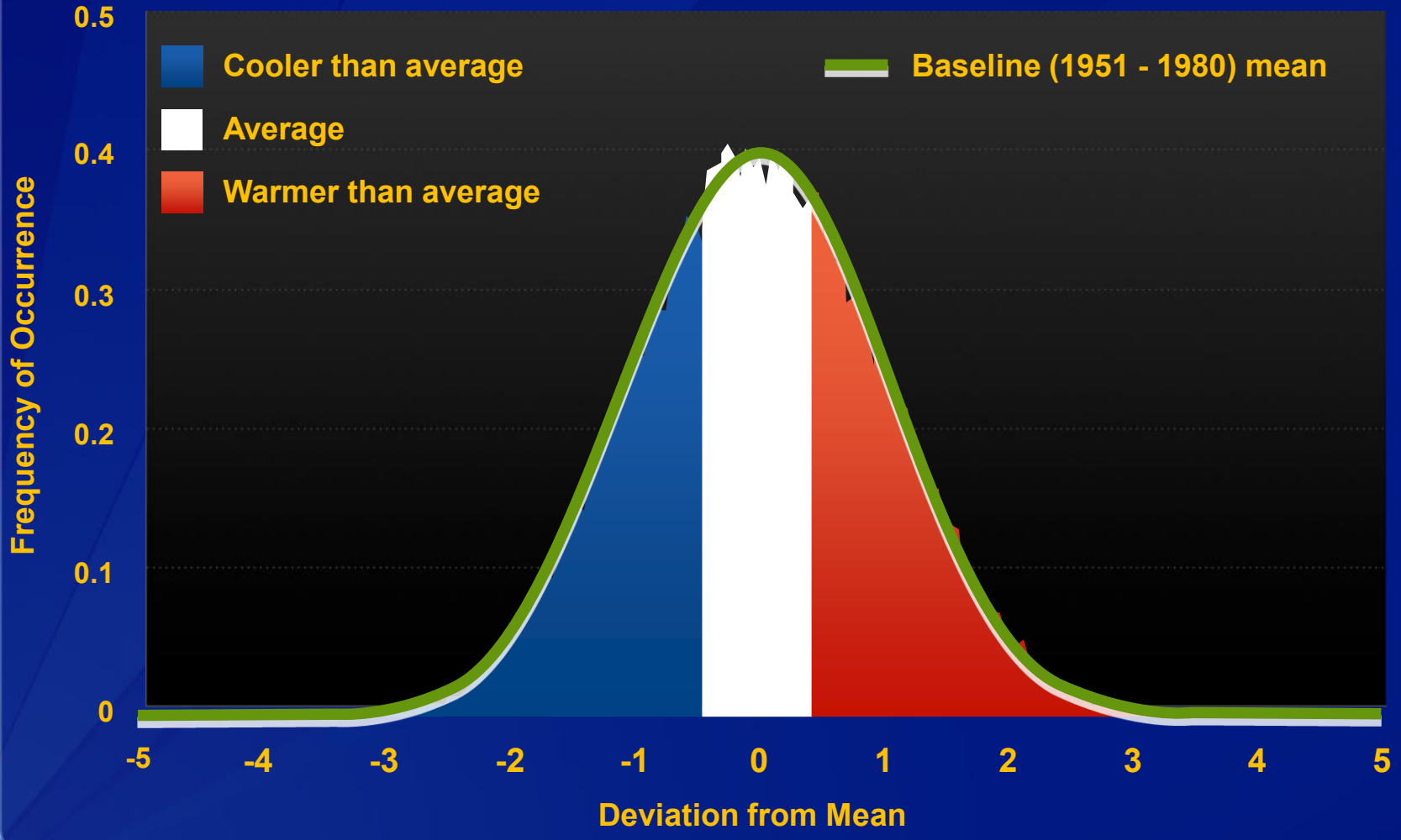
- Climate change is altering both the average (mean) global temperature *and* the global frequency of extremely hot temperatures (variance)

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

Warming has varied significantly by region (observed record)

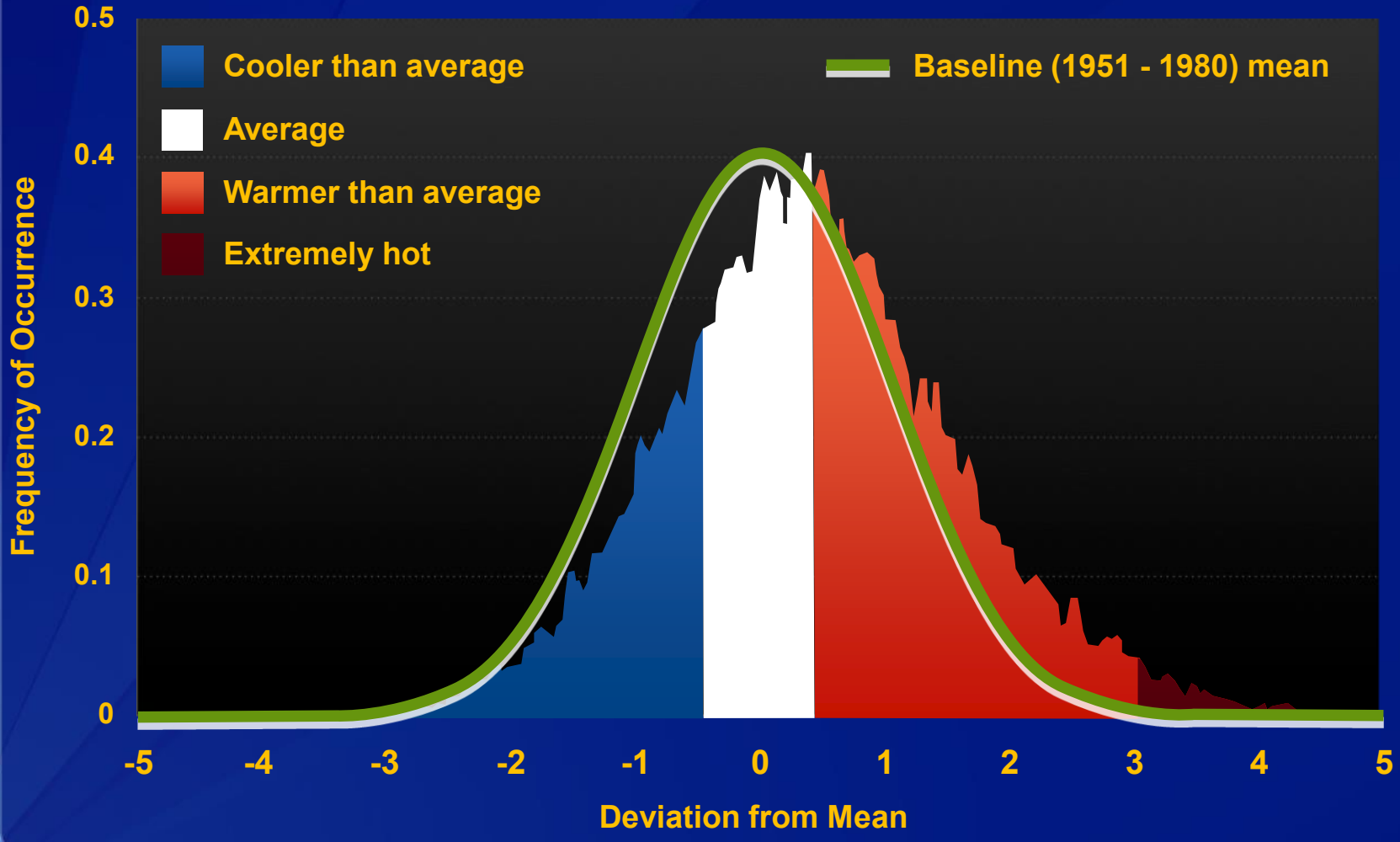


Summer Temperatures Have Shifted 1951 – 1980



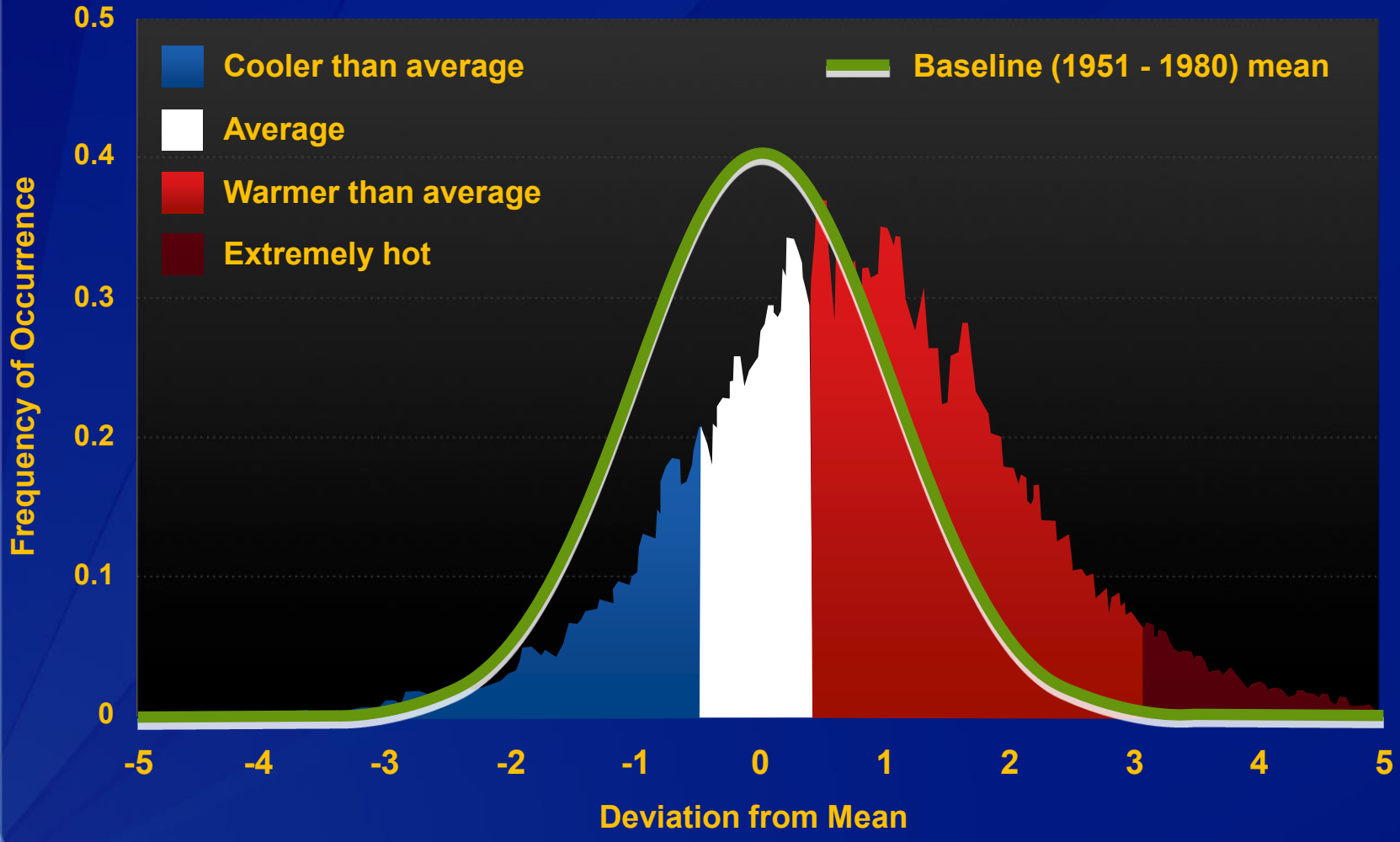
Source: NASA/GISS; Hansen, et al., "Perceptions of Climate Change," *Proc. Natl. Acad. Sci. USA* 10.1073, August 2012

Summer Temperatures Have Shifted 1981 – 1991



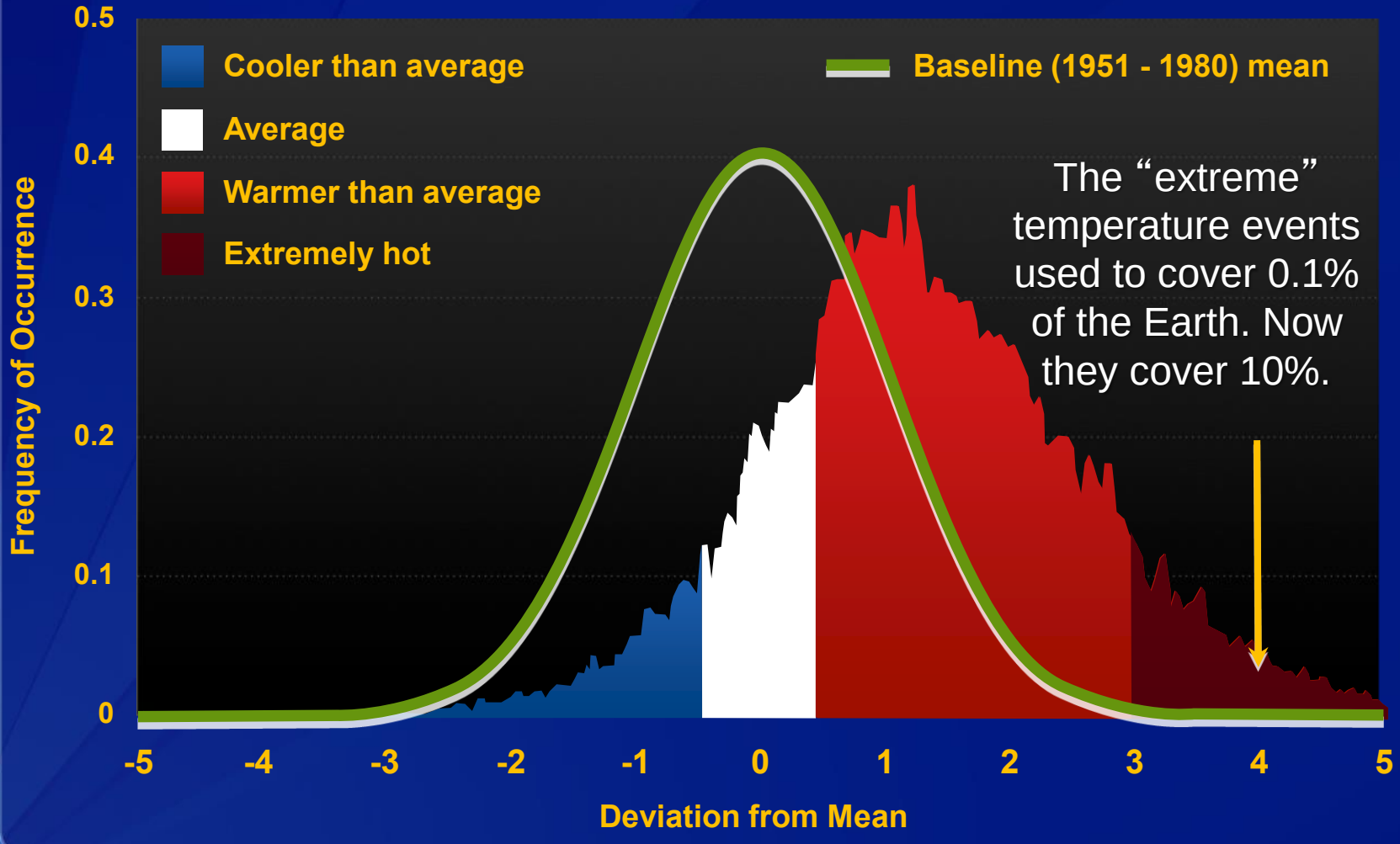
Source: NASA/GISS; Hansen, et al., "Perceptions of Climate Change," *Proc. Natl. Acad. Sci. USA* 10.1073, August 2012

Summer Temperatures Have Shifted 1991 – 2001



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

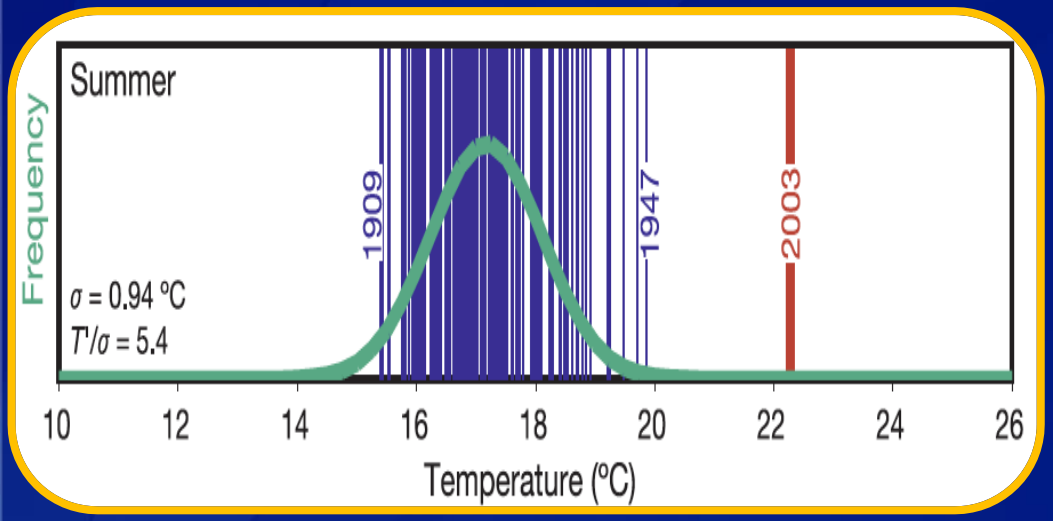
Summer Temperatures Have Shifted 2001 – 2011



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

Some Extreme Events will be well beyond historical experience

European Heat Wave of 2003



Confirmed Mortality

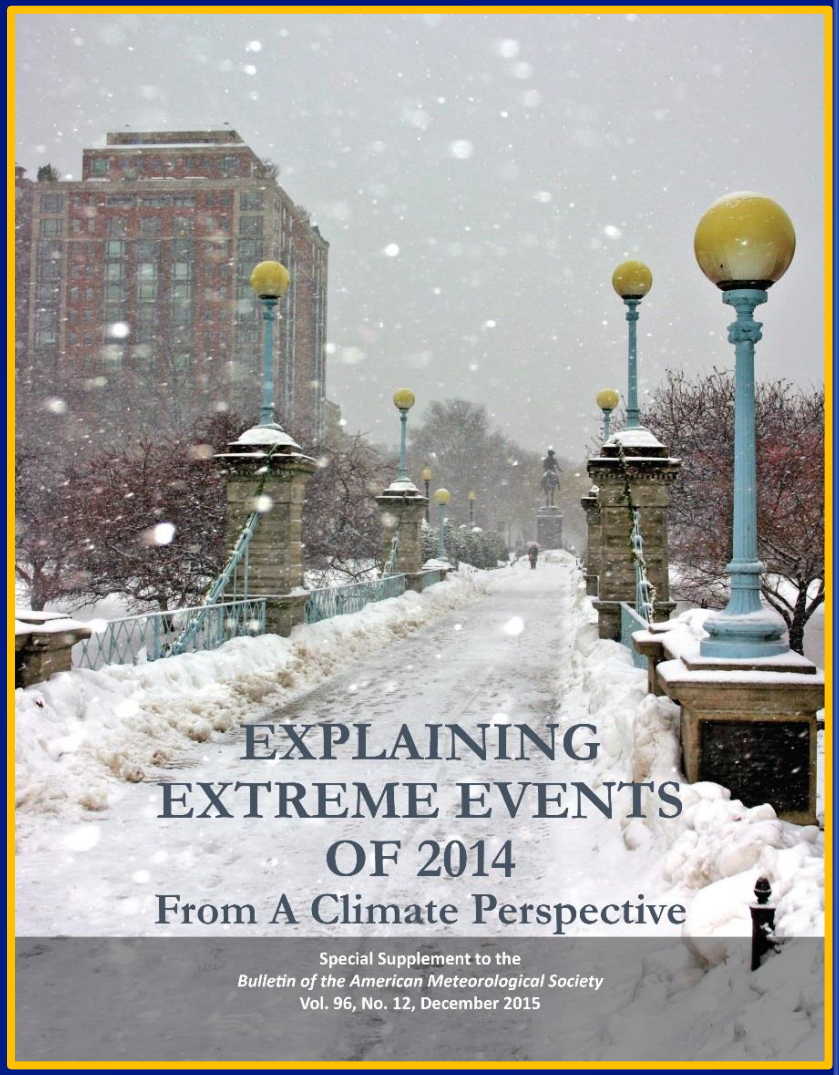
UK	2,091
Italy	3,134
France	14,802
Portugal	1,854
Spain	4,151
Switzerland	975
Netherlands	1,400-2,200
Germany	1,410
TOTAL	29,817-30,617

Haines et al. *Public Health* 2006;120:585-96.

Vandentorren et al. *Am J Public Health 2004; 94(9):1518-20.*

Climate Change: Event Attribution

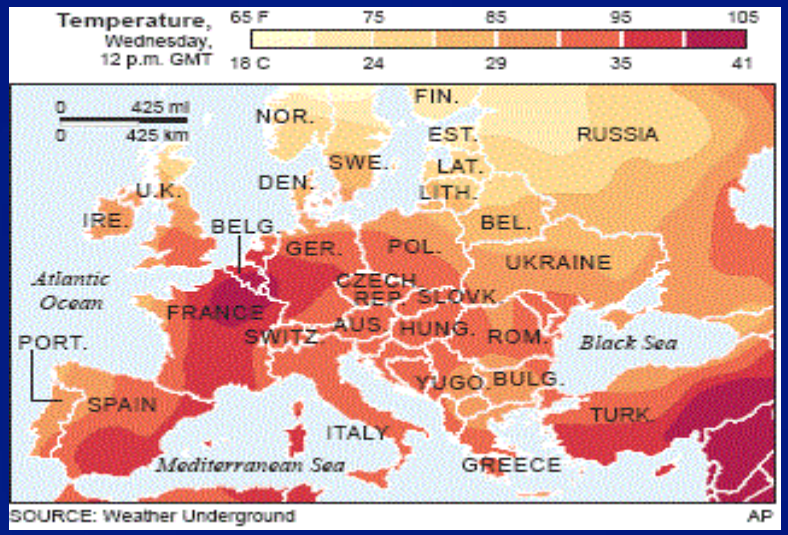
- Attribution science has made major steps forward over the past four years.
- Uses model experiments to calculate how climate change has altered the probability of an event occurring
- Some events are more amenable to attribution
  - Heatwaves, precipitation events and cold weather events



Case Studies: European Heat Wave 2003

Fraction of Attributable Risk (FAR) 0.70 (±0.07)

Anthropogenic climate change altered the return period from a 1 in 92 year event to 1 in 30 year event



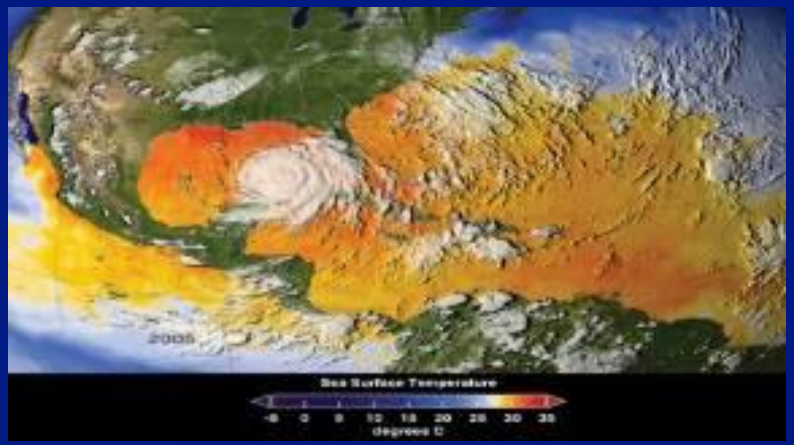
Extreme Canadian Flood on the Southeastern Canadian Prairies 2014

- Anthropogenic forcings as well as human land use amplified the rainfall effects

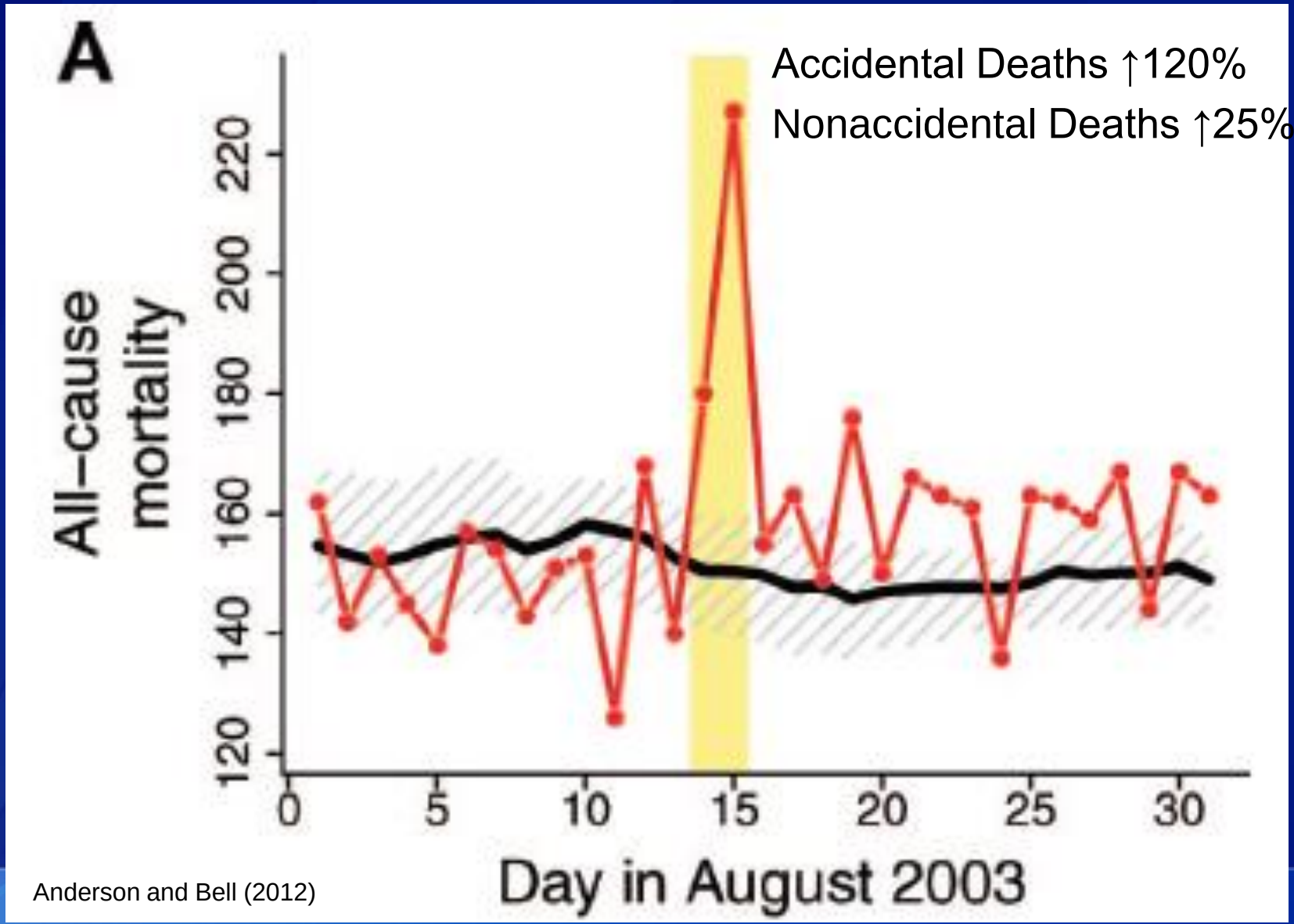
Key Health Threats from Climate Change

“Disaster within a disaster”

Extreme events increase the probability of “complex emergencies” where multiple system failures can occur which can exceed response capacity.

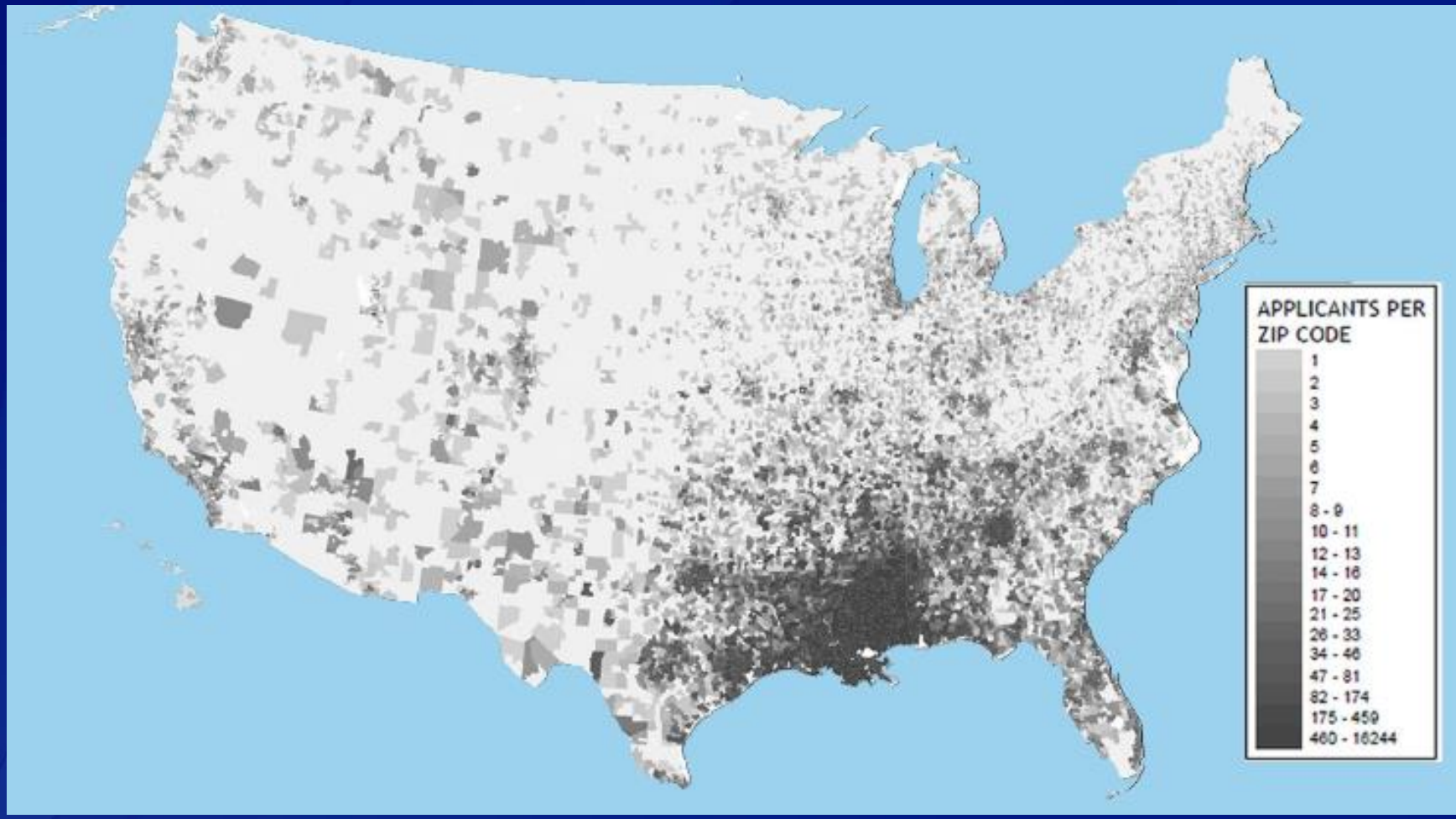


NY Power Outage and All-Cause Mortailty



Anderson and Bell (2012)

Katrina Diaspora



Key Health Threats from Climate Change

"Morbidity and Mortality by a thousand cuts"

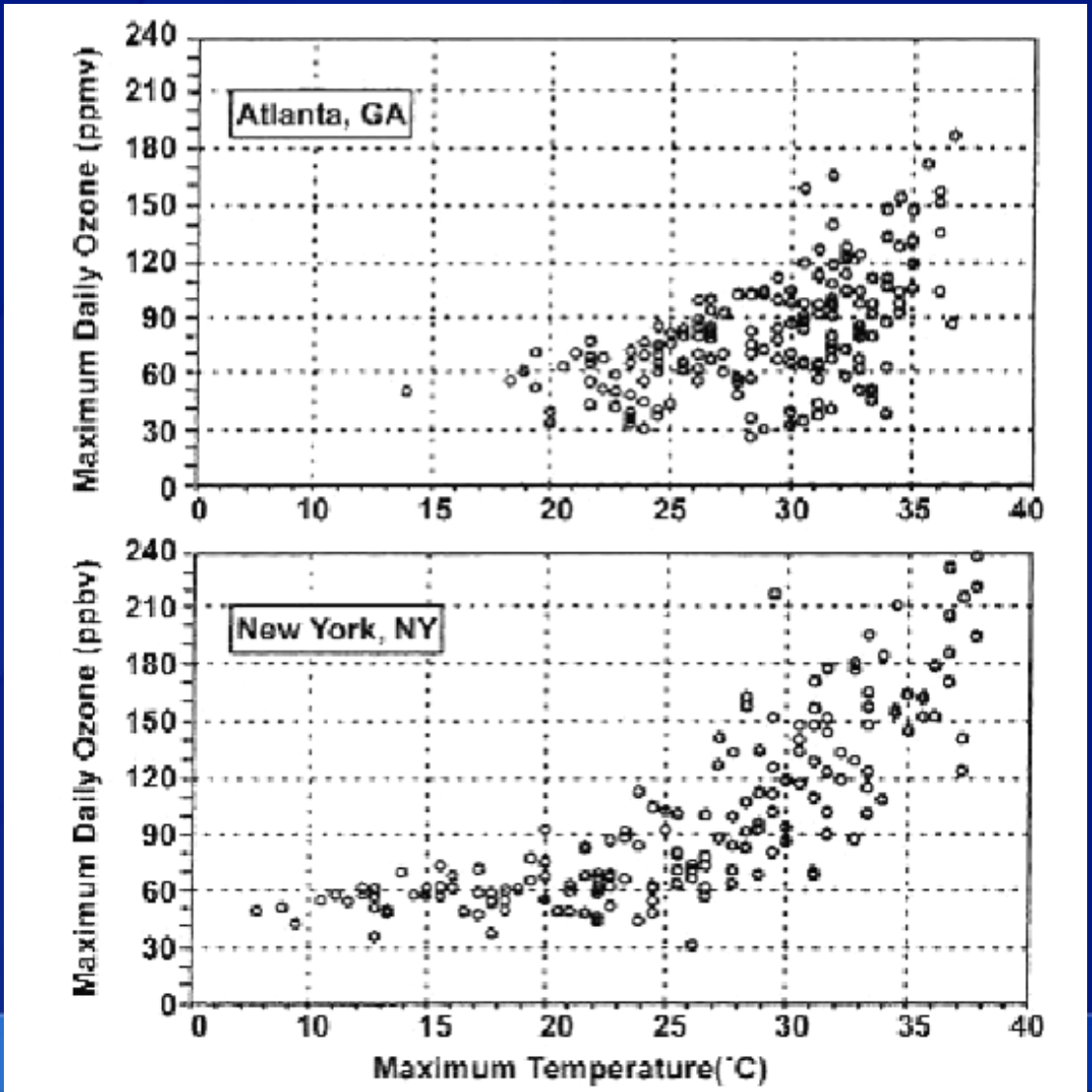
Impacts add to the *cumulative* stresses currently faced by vulnerable populations and in locations most vulnerable to extreme events & ongoing, persistent climate-related threats

Heat Impacts on Air Pollution

Maximum Daily Ozone Concentrations vs. Maximum Daily Temperature

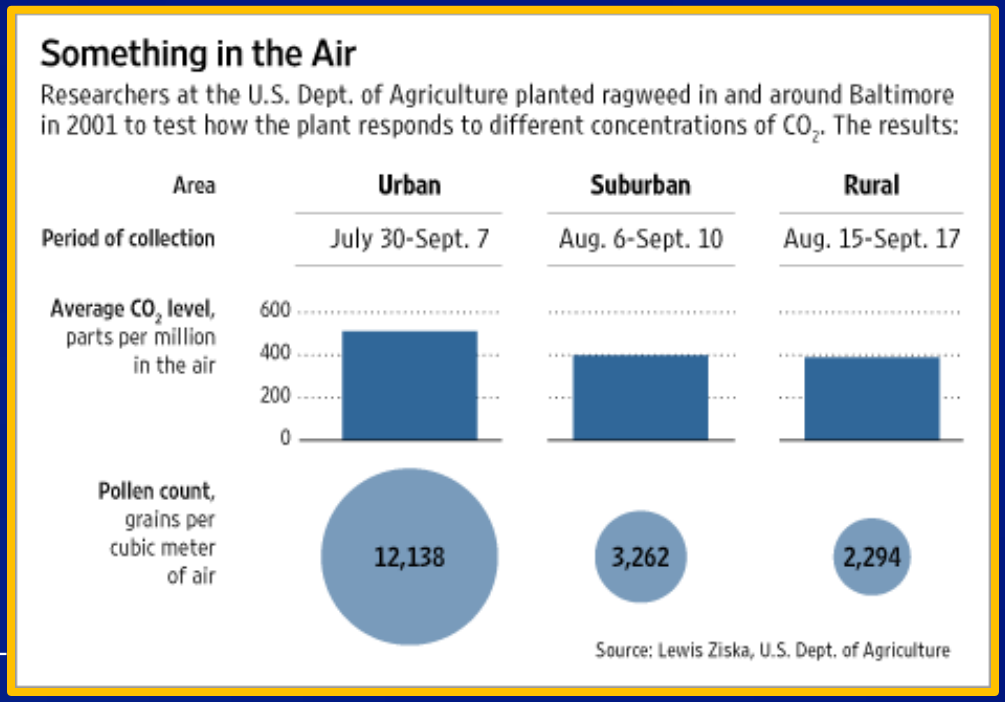
Atlanta

New York



Climate Change Impacts Air Quality: Pollen

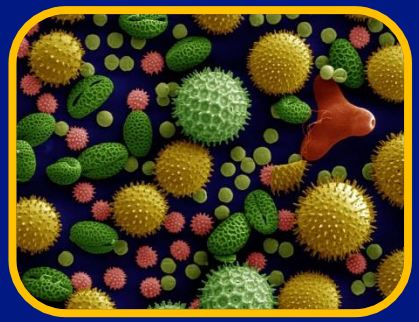
- **Ragweed**
  - ↑ CO_2 and temperature
  - ↑ Pollen counts, longer growing season



Source: Ziska et al., *J Allerg Clin Immunol* 2003;111:290-
Graphic: *Wall Street Journal*, 3 May 2007.

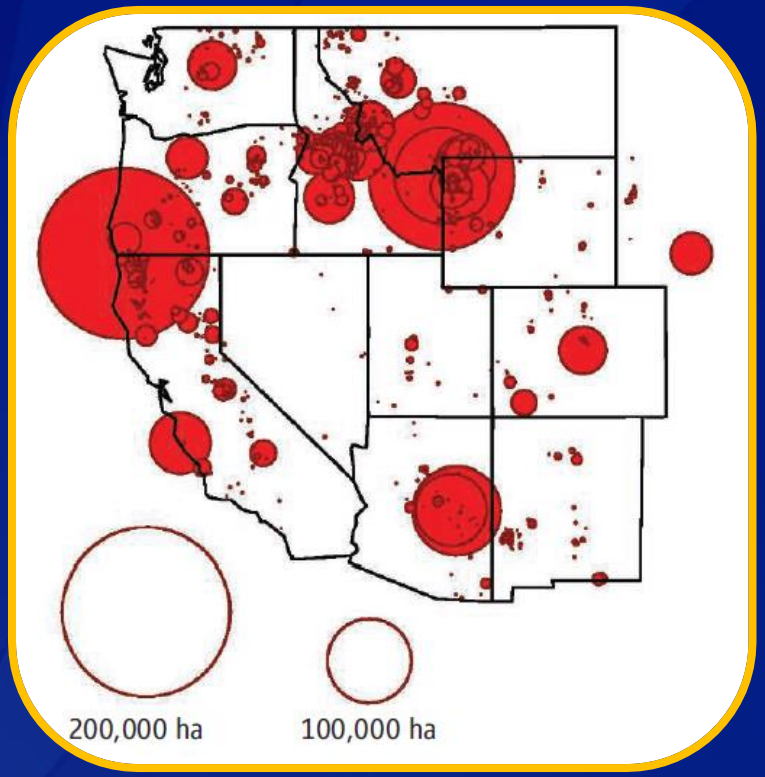
Pollen and Health

- Outdoor allergenic pollen and mold are the primary cause for allergic rhinitis or hay fever (Grammer, Greenberger, 2009).
- Annual treatment costs for allergic rhinitis are $11.2B (Blaiss, 2010) ; annual economic costs $5.4B (Kessler et al., 2001).
- As pollen count increases, allergy-related illnesses also increase (Heguy et al. 2008, Darrow et al., 2011).



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

Mortality and morbidity from wildfire smoke

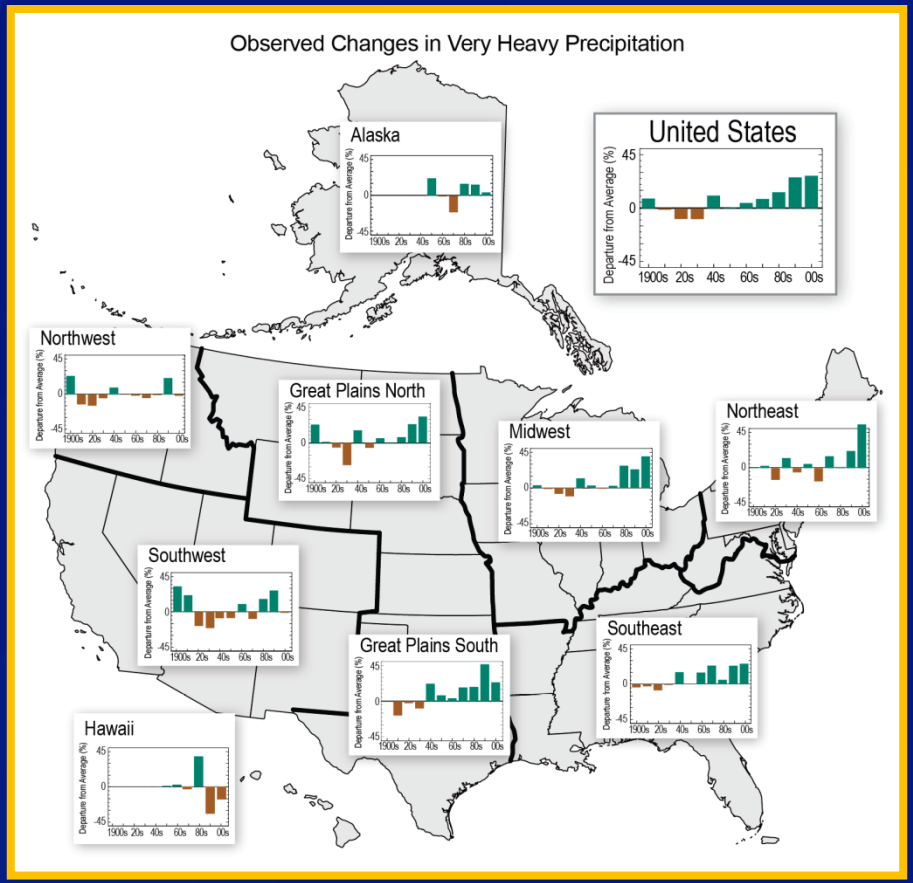
- An increase of 10µg/m^3 in PM_{10} from wildfires results in approximately 1% increase in non-accidental mortality.[1,2,3]

- During Australian bushfires:
  - Overall mortality rose 5%
  - Hospital admissions for respiratory illnesses increased from 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. 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

Heavy Precipitation and Water-borne Disease:

Milwaukee 1993

Cryptosporidiosis epidemic

405,000 cases, 54 deaths

Preceded by heaviest rainfall in 50 years (Curriero et al., 2001)

$31.7 million in medical costs

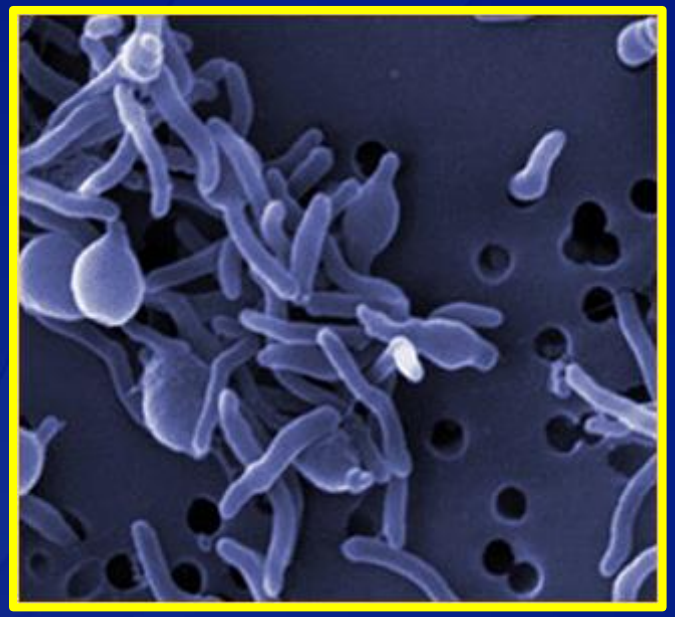
$64.6 million in lost productivity

(Corso et al., 2003).

Key Health Threats from Climate Change

Novel threats emerge

Large scale ecological perturbations facilitate disease emergence and redistribution.

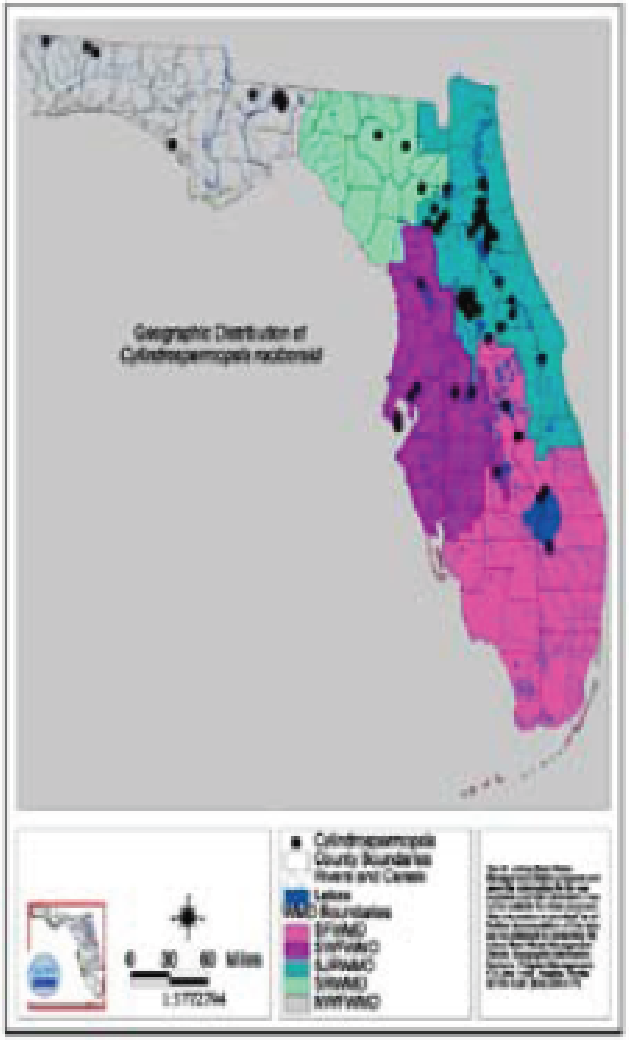


Harmful Algal Blooms (Red-tides)

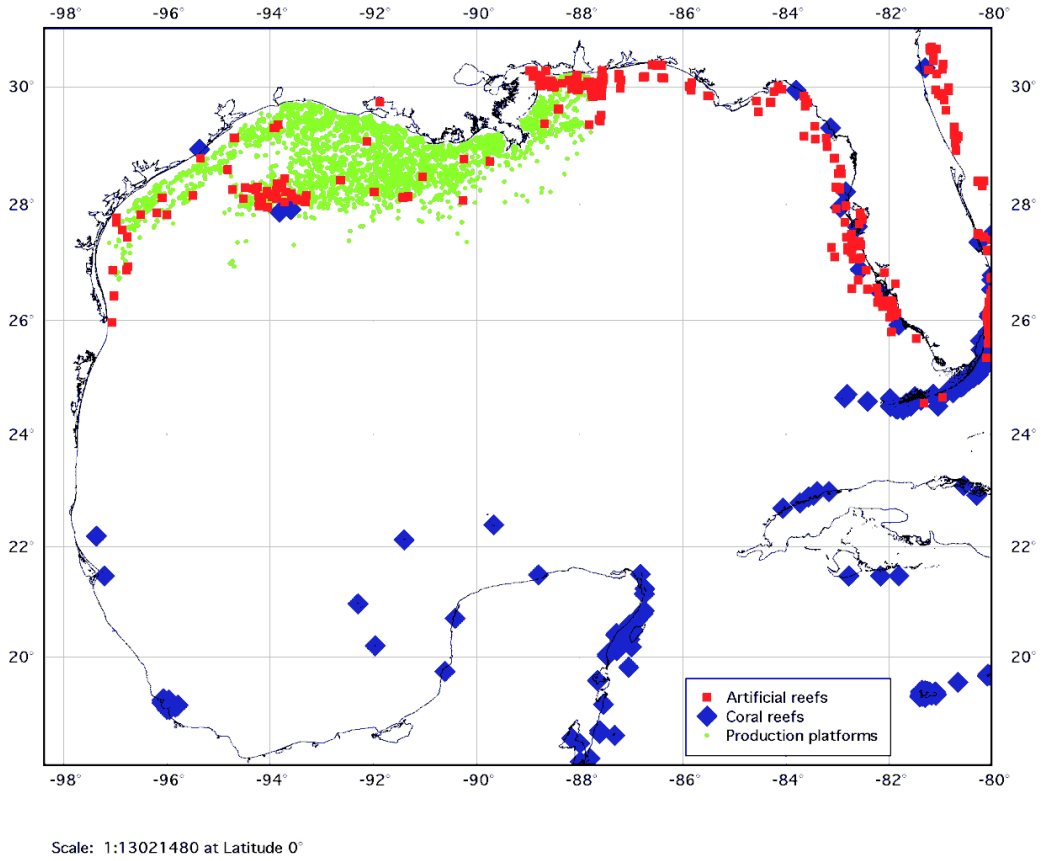
Enhanced by:

- Increased water temps
- Nutrient runoff
- Upwelling events

Figure 2. Distribution of the CyanoHAB, *Cylindrospermopsis raciborskii,* in Florida (Williams 2001, Fristachi et al. 2007). *C. raciborskii,* which produces potent hepatotoxins (Table 2), was originally found only in tropical areas but has recently spread to cooler regions.

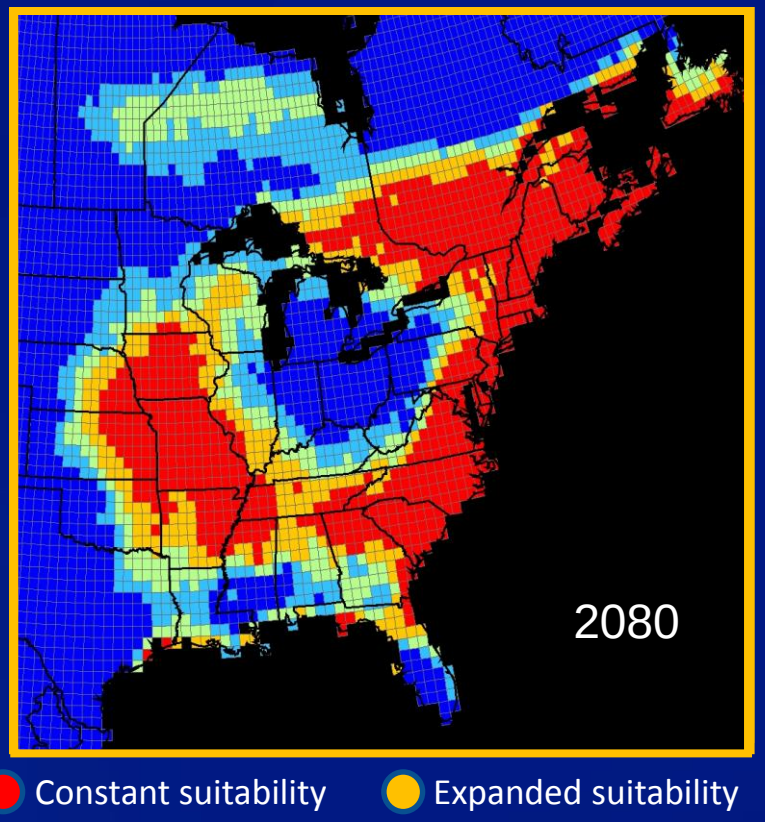


Ciguatera Fish Poisoning on Texas Coast Oil Rigs



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

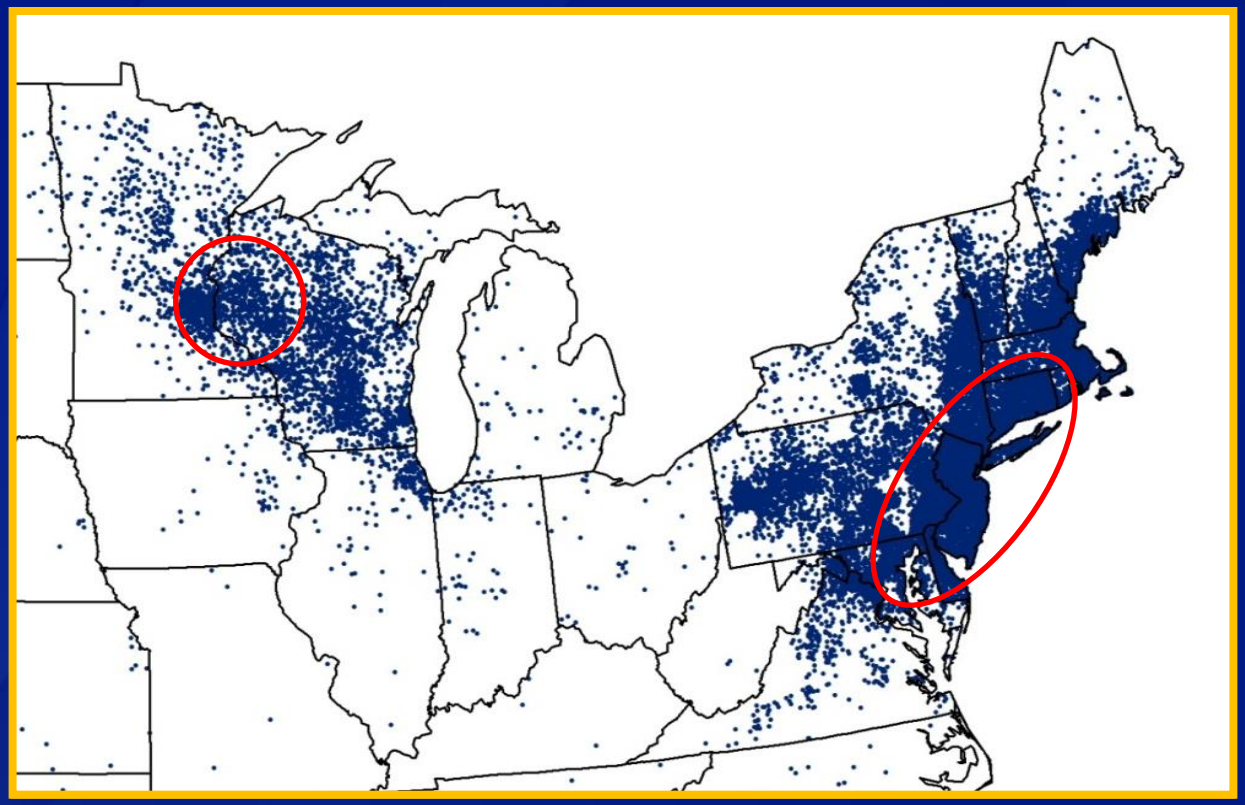
- **Spread of Lyme disease factors**
  - Climate
  - Ecological
  - Social



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

2016

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

CLIMATE

Food Security Under Climate Change

Food insecurity is likely to increase under climate change, unless early warning systems and development programs are used more effectively.

Molly E. Brown and Christopher C. Funk

Crop and pasture response to climate change

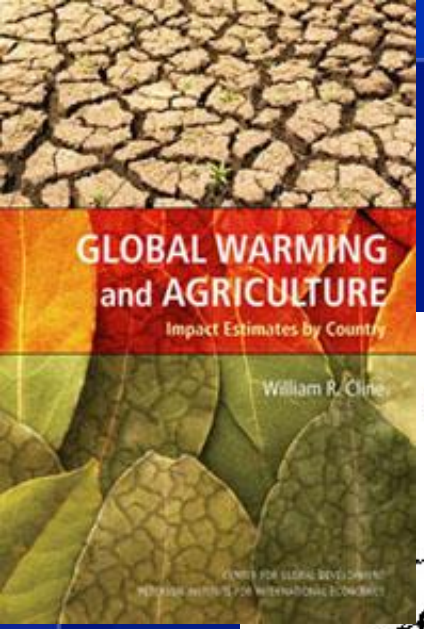
Francesco N. Tubiello*†‡, Jean-François Soussana§, and S. Mark Howden¶

*Goddard Institute for Space Studies, Columbia University, 2880 Broadway, New York, NY 10025; †International Institute for Applied Systems Analysis, Schlossplatz 1, A-2361 Laxenburg, Austria; §Unité de Recherche 874 Agronomy, Institut National de la Recherche Agronomique, 234 Avenue du Brézet, F-63100 Clermont-Ferrand, France; and ¶Commonwealth Scientific and Industrial Research Organization Sustainable Ecosystems, GPO Box 284, Canberra 2601, Australia

Global food security under climate change

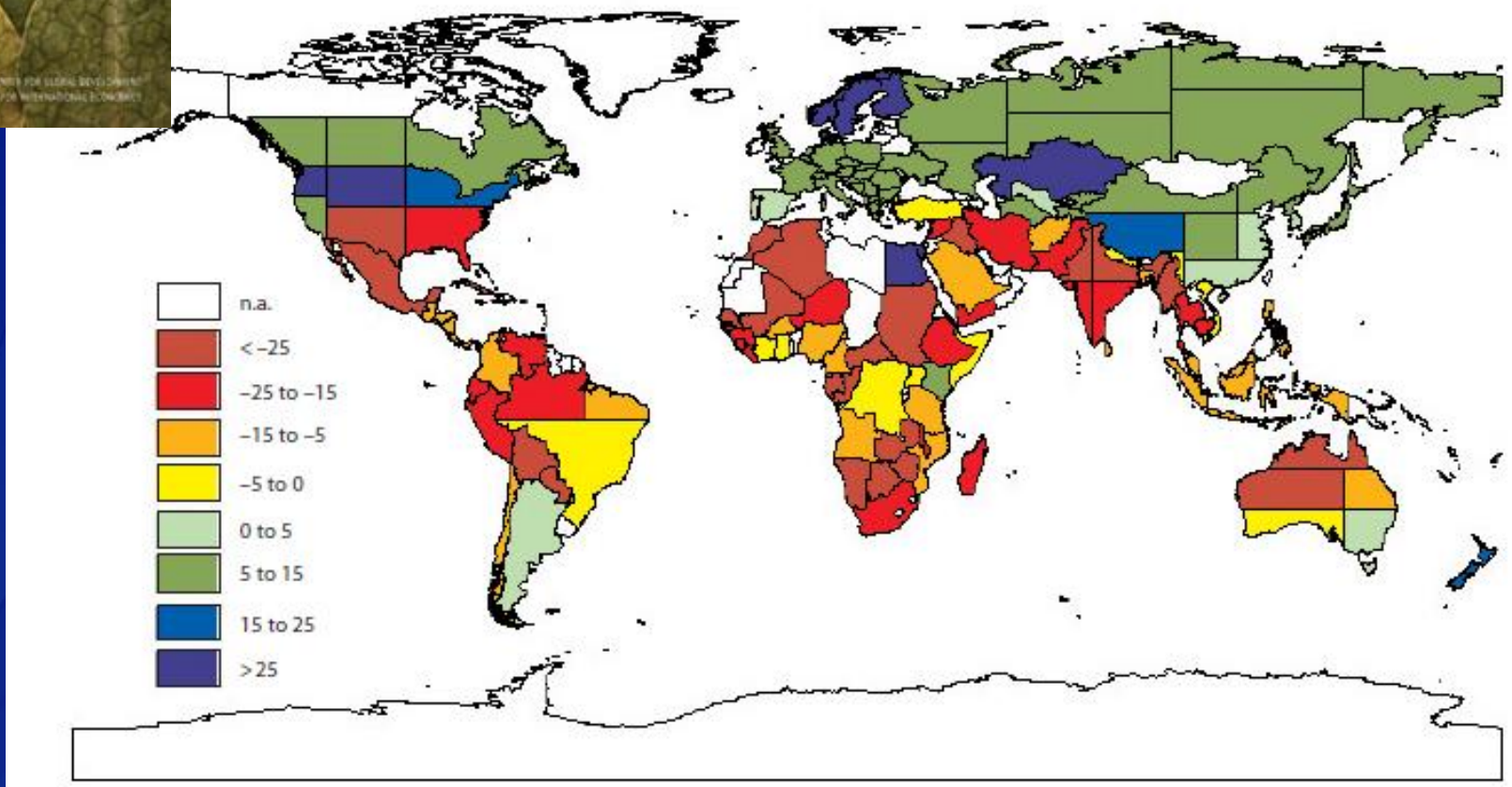
Josef Schmidhuber*† and Francesco N. Tubiello‡§

*Global Perspective Studies Unit, Food and Agriculture Organization, 00100 Rome, Italy; ‡Center for Climate Systems Research, Columbia University, New York, NY 10025; and §Land Use Change Program, International Institute for Applied Systems Analysis, A-2361 Laxenburg, Austria



Carbon Fertilization and Agricultural Productivity

Impact on agricultural productivity with carbon fertilization (percent)



Global Change Biology (2008) 14, 565–575, doi: 10.1111/j.1365-2486.2007.01511.x

Effects of elevated CO_2 on the protein concentration of food crops: a meta-analysis

DANIEL R. TAUB*†, BRIAN MILLER* and HOLLY ALLEN†

*Biology Department, Southwestern University, 1001 East University Avenue, Georgetown, TX 78626, USA, †Environmental Studies Program, Southwestern University, 1001 East University Avenue, Georgetown, TX 78626, USA

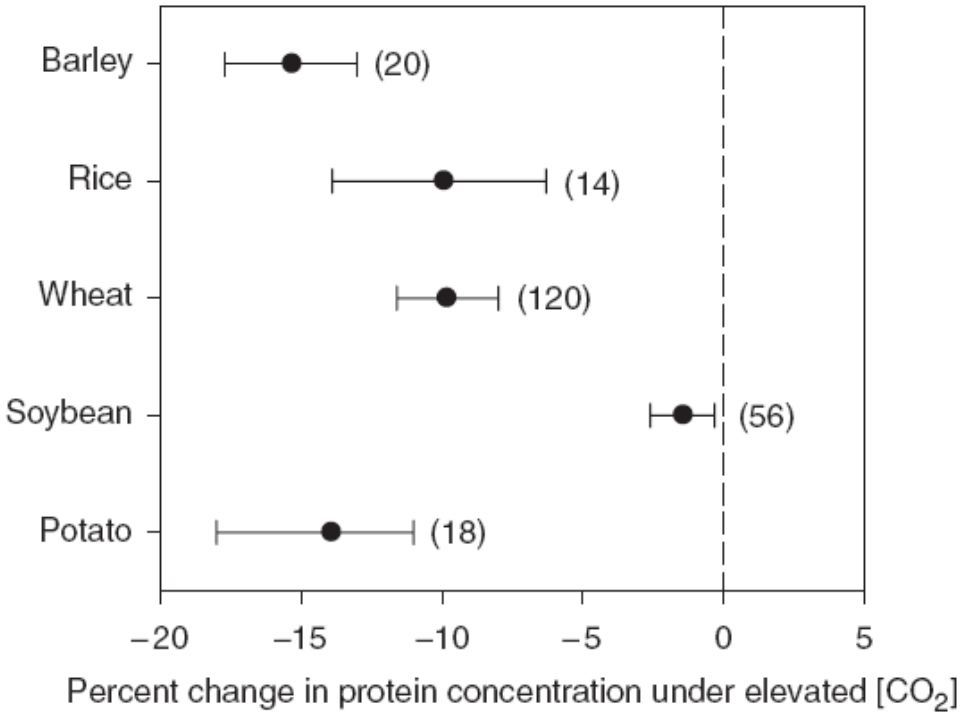
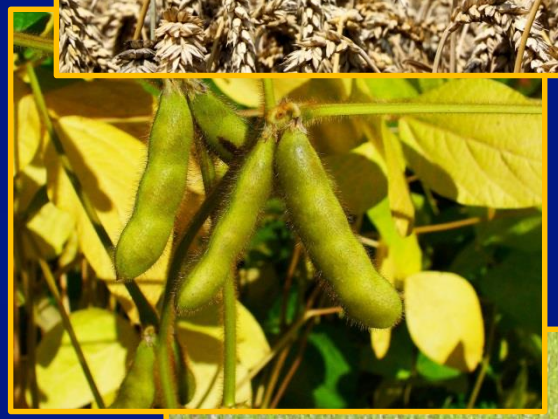


Fig. 1 Response of crop protein concentrations to growth at elevated CO_2 for five major crops. Means and 95% confidence limits are depicted. Numbers of experimental observations for each species are in parentheses.

Increased CO_2 Threatens Nutrition

- **Increased CO2 concentrations:**
  - Decreased concentrations of zinc and iron in C3 grasses (rice, wheat, soybeans)
  - Decreased iron concentration in maize, a C4 crop.
  - Decrease protein content in C3 grasses; less of an effect on legumes.
- **Health Implications**
  - Potential to exacerbate problem in zinc and iron deficiencies
  - Threatens public health due to potential protein deficiencies, especially in in coutries dependent on C3 grains for protein.



Source: Myers S, Zanobetti A, et al., 2014. “Increasing C02 threatens Human Nutrition”. Nature. , 2014/05/07 (advance online publication).

Mental Health: Post-Disaster

ELSEVIER

Clinical Psychiatry News

www.clinicalpsychiatrynews.com

VOL. 33, NO. 10 — *The Leading Independent Newspaper for the Psychiatrist—Since 1973* — OCTOBER 2005

INSIDE

Katrina Survivors' Psychiatric Needs Unpredictable

'Cascade of disasters' magnifies trauma.

Mental Health Problems From Katrina Persist

By Dorie Turner
Associated Press
Thursday, November 9, 2006; Page A12

ATLANTA, Nov… gutted houses a… empty streets alon…

The most devasta… housands of peo… and destroyed en… e faces of people… more than a year … d in a panel … discussion Wedne…

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'A Very Long Recovery'

A psychologist talks about the emotional fallout from disasters like Hurricane Katrina and what can be done to help the victims cope.

Carlos Barria / Reuters

Mental health workers say many hurricane survivors may need psychological help in the weeks to come

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Is New Orleans Having a Mental Health Breakdown?

By RUSSELL MCCULLEY/NEW ORLEANS — Tuesday, Aug. 01, 2006

Over the past several months, psychiatrist James Barbee has witnessed a disturbing trend among his patients in New Orleans — a noticeable slide from post-Katrina anxiety to more serious, and harder to treat, cases of major depression. At the same time, the city□s system for dealing with mental health care is suffering a major breakdown of its own. "People are just wearing down," says Barbee. "There was an initial spirit about bouncing back and recovering, but it's diminished over time, as weeks have become months."

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Mental health: Anticipatory

washingtonpost.com

Climate Change Scenarios Scare, and Motivate, Kids

By Darragh Johnson
Washington Post Staff Writer
Monday, April 16, 2007; Page A01

The boy has drawn, in his third-grade class, a global warming timeline that is his equivalent of the mushroom cloud.

"That's the Earth now," the 9-year-old says, pointing to a dark shape at the bottom. "And then," he says, tracing the progressively lighter stripes across the page, "it's just starting to fade away."

BBC NEWS

Last Updated: Tuesday November 14 2006 11:15 GMT
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Climate change is kids' top fear

How we're damaging the environment is more of a worry to you than getting a girl or boyfriend, says a survey.

The results showed three quarters of 11 to 14-year-olds worry about climate change, compared to 41% who are worried about going out with someone.

oks like you lot aren't just all talk - 63% turn off s when you leave a room, 82% of you recycle, and we should recycle more.

ey quizzed 1,554 kids on their views on the

The Boston Globe

HOME / LIFESTYLE / GREEN LIVING

Climate change takes a mental toll

The Boston Globe

By Emily Anthes
Globe Correspondent / February 9, 2009

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Last year, an anxious, depressed 17-year-old boy was admitted to the psychiatric unit at the Royal Children's Hospital in Melbourne. He was refusing to drink water. Worried about drought related to climate change, the young man was convinced that if he drank, millions of people would die. The

Solastalgia

"This past summer, I got deeply depressed about our planet—as if I didn't have enough problems of my own."

Loss of Cultural Resources Impacts Mental Health

Moving a traditional village site: Shishmaref,

Gravesite erosion

Ancient graves pulled to sea

Human remains ... dragged to sea

By SEBASTIAN LANDER
in Alaska

Published: 03 May 2008

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ANCIENT graveyards are being dragged out to

MULTIMEDIA

Grave danger in the Arctic

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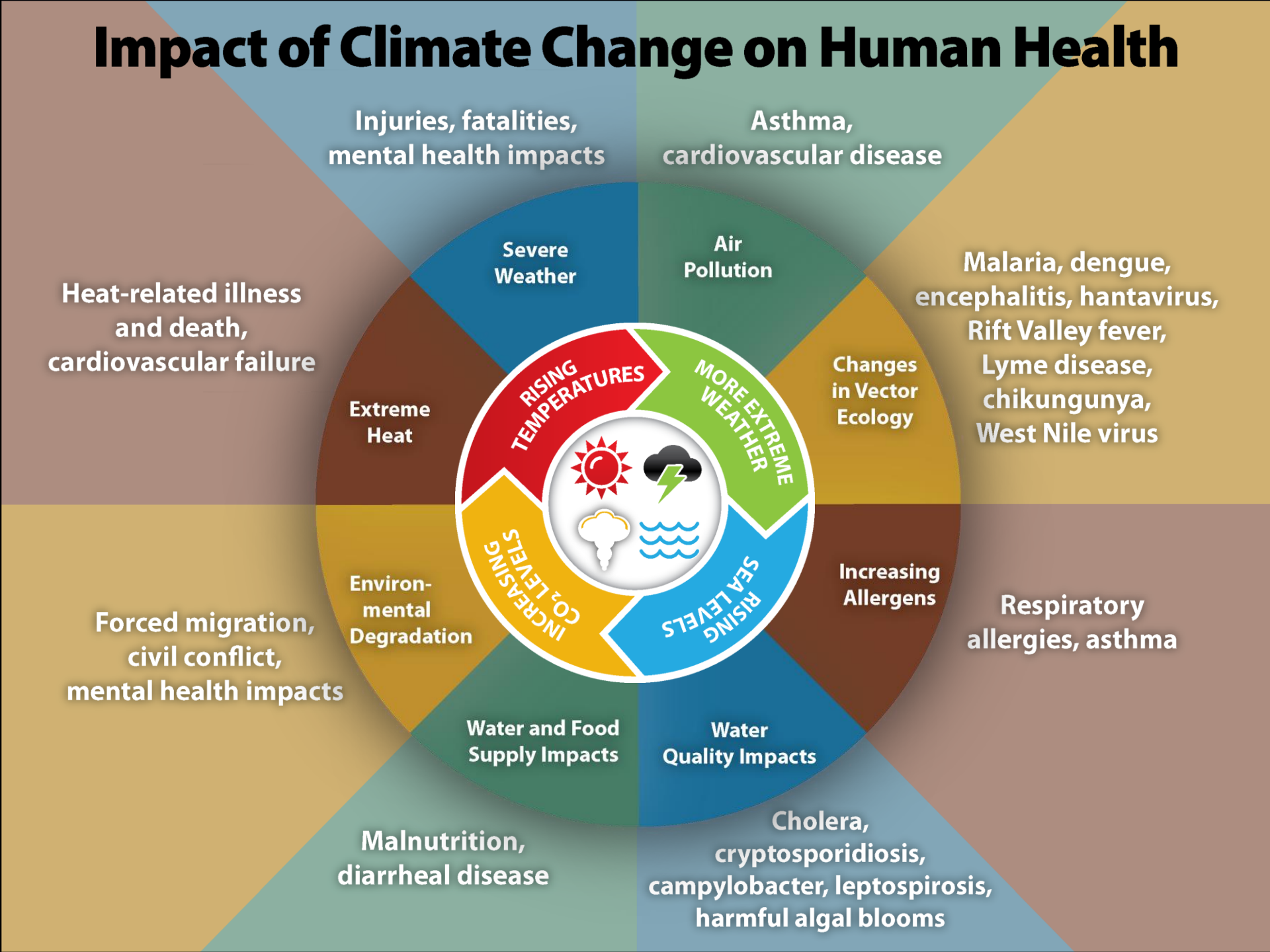
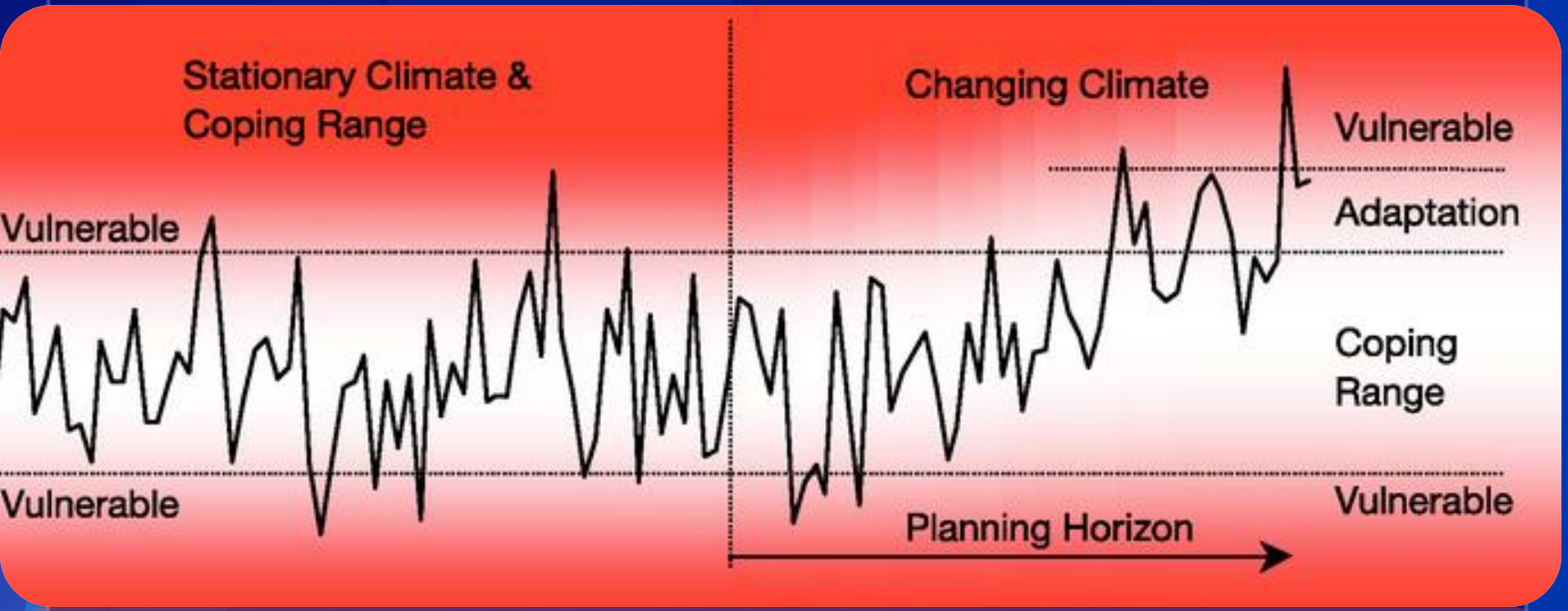
Impact of Climate Change on Human Health



Adaptation: Shifting the Coping Range



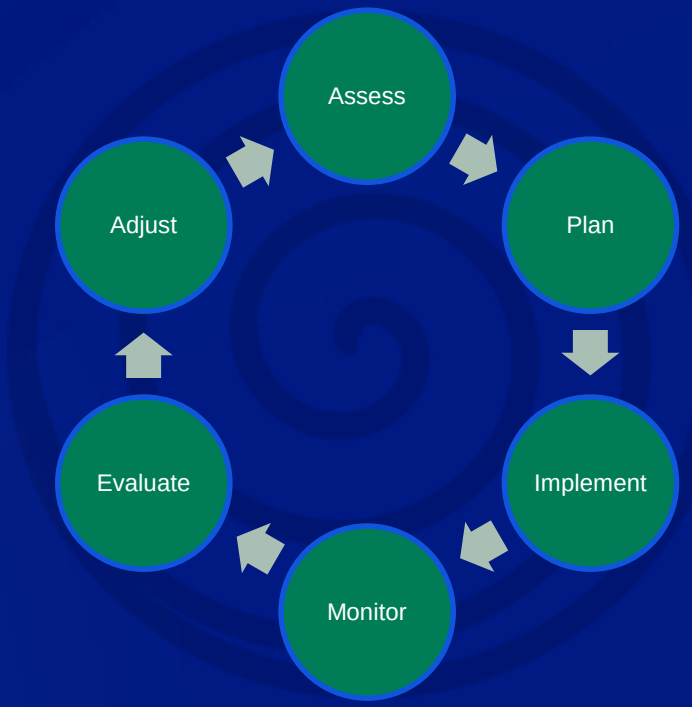
How to Shift a Coping Range?

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



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

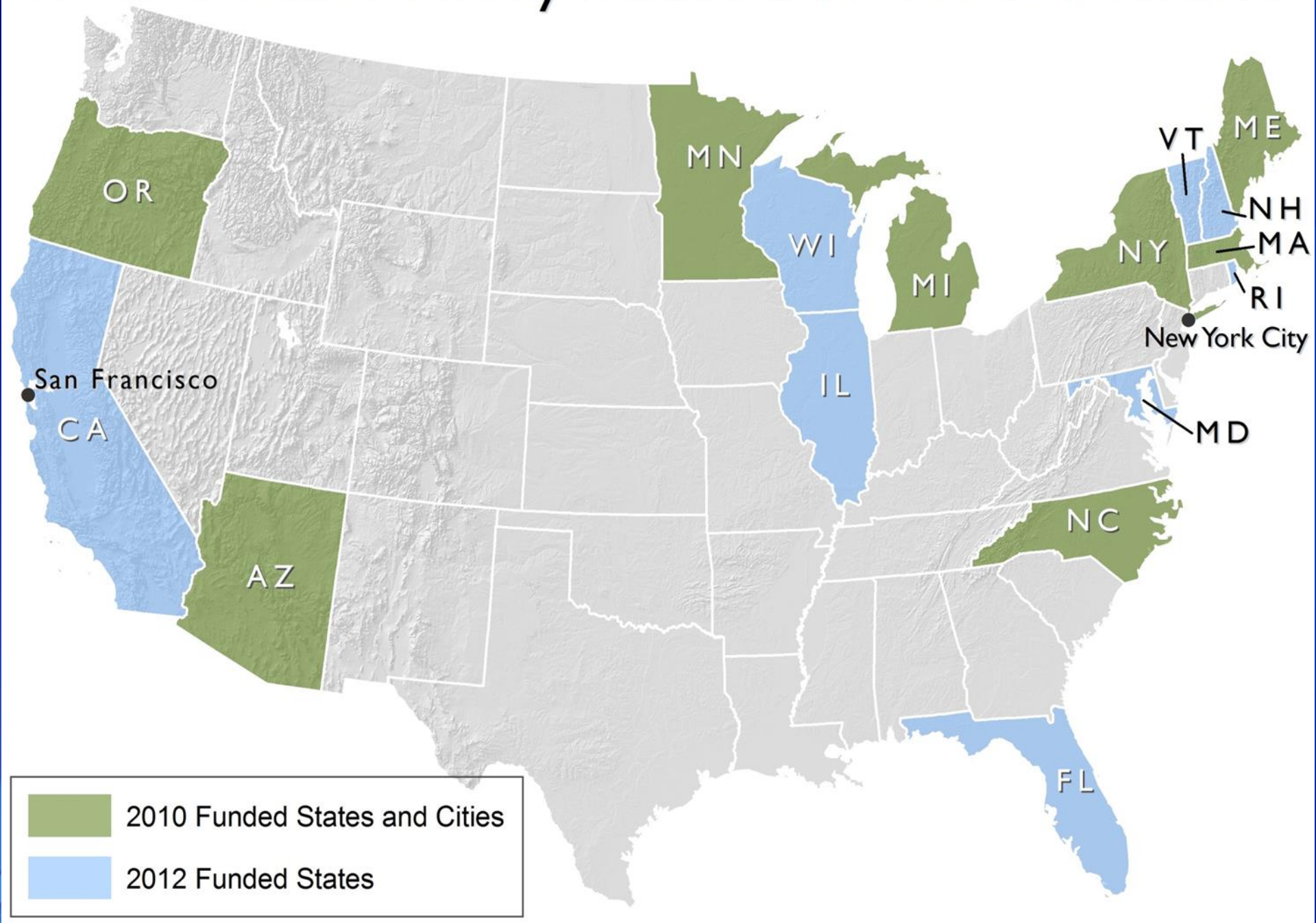
- **CDC's Climate and Health Program – nation's only investment in climate change preparedness for public health sector**

Climate-Ready States and Cities Initiative

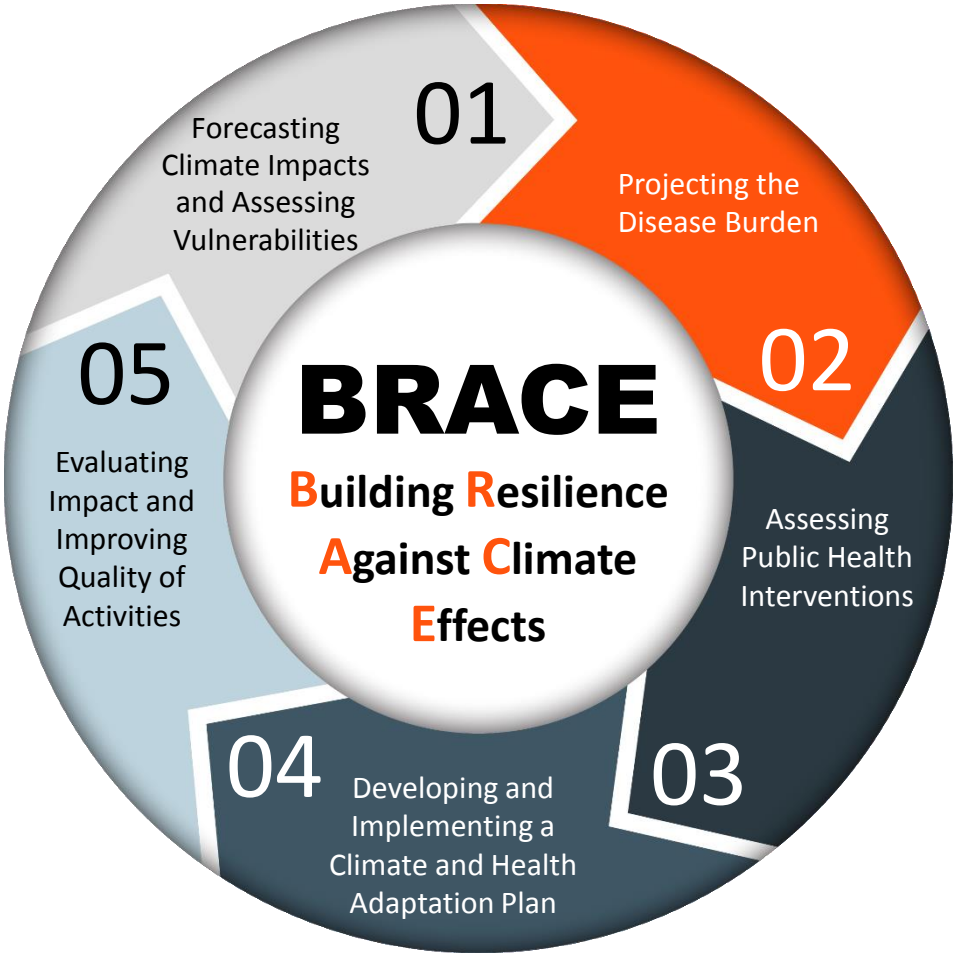
- **CDC effort to enhance capacity of state and local health agencies to deal with health challenges associated with climate change**

- **CDC accomplishes this by**
  - Funding 18 state and local health departments
  - Providing framework and tools for planning, implementing, and evaluating climate adaptation strategies
    - Tools to identify populations and places vulnerable to climate impacts
    - Materials to help communicate climate and health issues to public health partners (e.g., extreme heat toolkit)

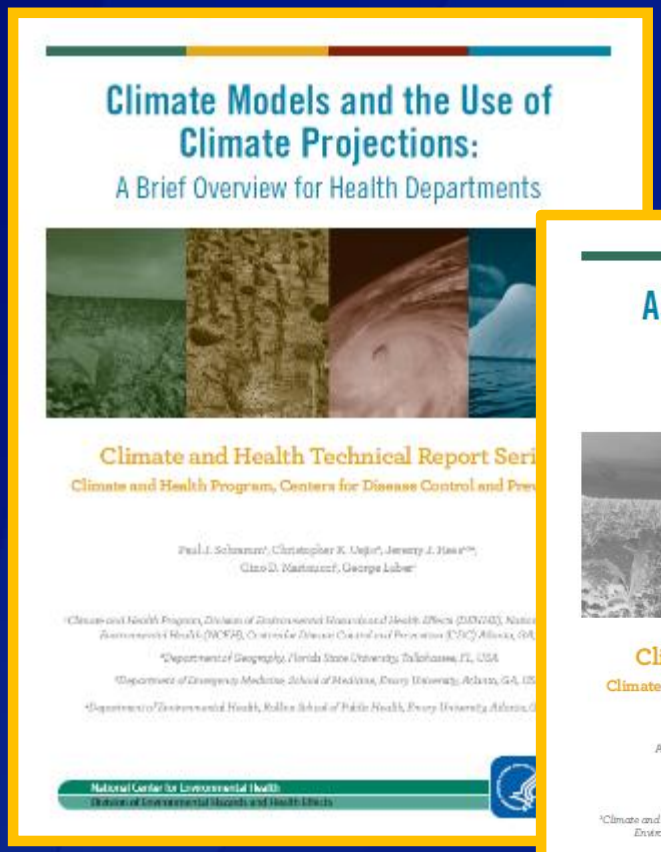
CDC Climate Ready States and Cities Initiative

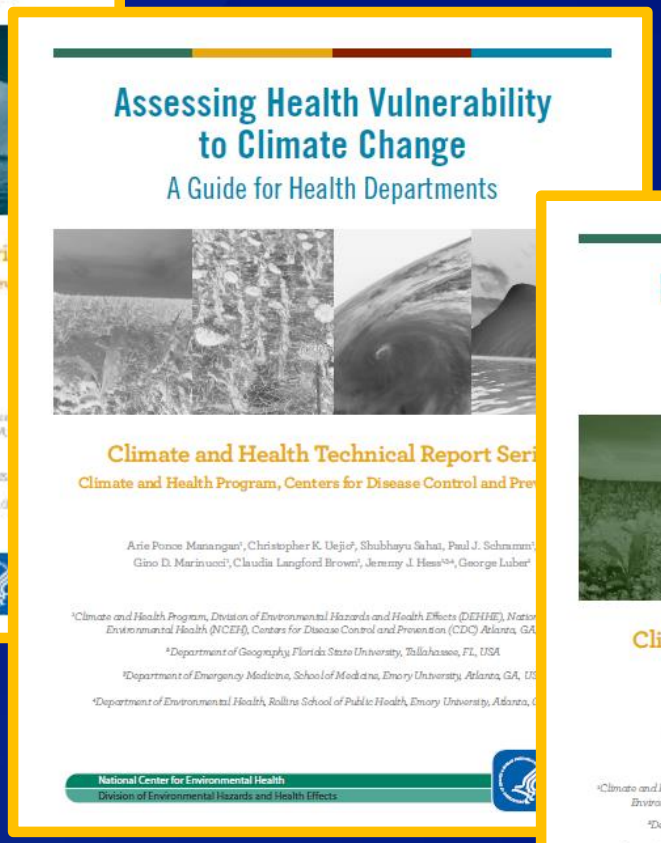


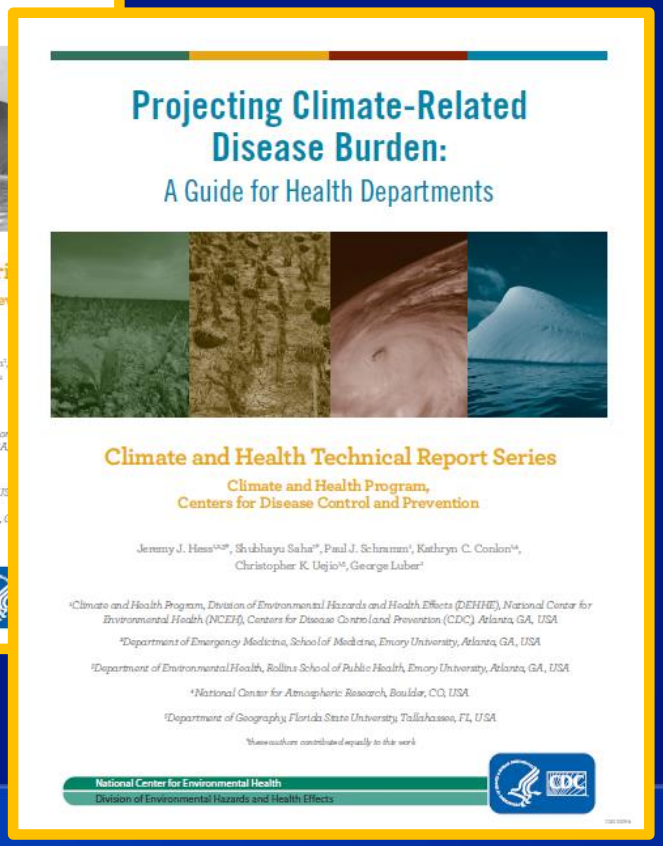
Building Resilience Against Climate Effects



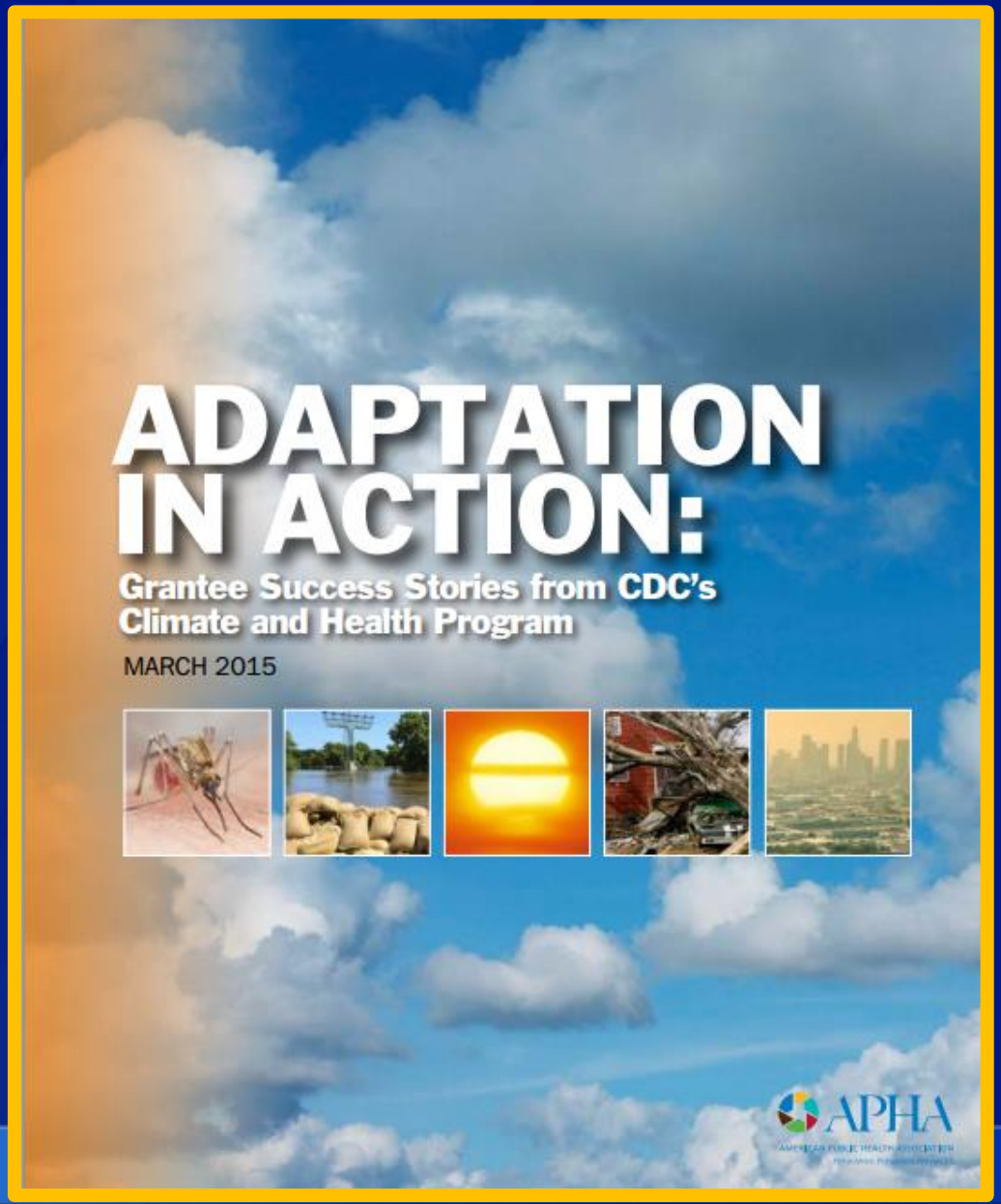
BRACE Technical Guidance







APHA Report: *Adaptation in Action*



cdc.gov/climateandhealth

NEW YORK CITY: Creating Resilient Communities

"The events of the past few years show the serious public health threats New York City's 8.2 million residents already face from extreme weather events like heat waves and coastal storms. With climate change, the severity of these risks will increase. It is imperative that citywide climate adaptation and mitigation measures include health-focused strategies."

Andriana Azarias
ACTING DIRECTOR, CLIMATE AND HEALTH PROGRAM,
NEW YORK CITY DEPARTMENT OF HEALTH AND MENTAL HYGIENE

THE THREAT TO HEALTH:

- Average summer temperatures in New York City
increasing and more heat waves are predicted for
future, which will increase the risk of heat-related
and illness among vulnerable populations.
- Hotter temperatures coupled with poor air quali
lead to increased hospital admissions for cardiov
and respiratory problems.
- Flooding from coastal storms is projected to incr
in frequency and severity and can result in more
outages and home displacements.
- Power outages, from coastal storms or increased
demand on the electrical grid during hot weather
lead to a variety of health and safety hazards incl
food and drinking water contamination and heat

ADAPTATION IN ACTION:

- The Climate and Health Program has conducted
risk assessments on rising summer temperatures
extreme heat and ground-level ozone, and coastal
flooding and power outages to help inform cityw
climate adaptation planning and improve public
resilience.

(Note to review
still und

ARIZONA: Readying for Extremes

"Arizona is a beautiful place to live, where extreme heat, drought, monsoons and dust storms are the norm. Our program helps residents learn to respect and adapt to these extremes."

Matthew Roach
ENVIRONMENTAL EPIDEMIOLOGIST, EXTREME WEATHER AND PUBLIC HEALTH PROGRAM, ARIZONA DEPARTMENT OF HEALTH SERVICES

THE THREAT TO HEALTH:

- Extreme heat is the nation's No. 1 weather-related cause of death, and Arizona is home to some of the country's hottest communities. From 1992 to 2009, 1,500 heat-related deaths occurred in Arizona. About 500 heat-related inpatient admission visits and 2,000 emergency department visits happen in Arizona every year.
- The rate of death due to heat exposure in Arizona is three to seven times higher than the overall U.S. rate.
- Arizona is experiencing an increase in the number and extent of extreme heat days. In fact, research conducted in the aftermath of an Arizona heat wave found that every 1-degree increase in temperature was associated with a 6 percent increase in mortality risk.

ADAPTATION IN ACTION:

- The Arizona Extreme Weather and Public Health Program conducted a department-wide assessment to measure the agency's overall capacity to monitor climate and health effects and to pinpoint gaps. Staff also reached out to local public health departments with the same assessment, which covered topics such as assessments, outreach and education, and policy development. The results will eventually be used to shape an extreme weather action plan.
- The Arizona p
capacity to col
residents as p
2013, health of
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To learn more about the Arizona Extrem

MICHIGAN: Responding to Local Needs

"Climate change is a global and national issue, but its impacts are felt at the local level, affecting the health and well-being of people in every community. Public health needs to engage with community partners, emergency response and citizen groups to advocate for the protection of the vulnerable and to promote tools and adaptations that make our community healthy, resilient and desirable places to live and work."

Lorraine Cameron
MANAGER, EPIDEMIOLOGY AND SURVEILLANCE SECTION, DIVISION OF ENVIRONMENTAL HEALTH, MICHIGAN DEPARTMENT OF COMMUNITY HEALTH

THE THREAT TO HEALTH:

- Extreme heat events are associated with increased health care utilization. Between April and August of 2013, Michigan health officials recorded more than 4,500 heat-related emergency room visits.
- During a 2013 heat wave in Michigan, dehydration complaints increased nearly 80 percent, sun-associated complaints (i.e. sun burn, sun poisoning or sunscreen reactions) rose by nearly 127 percent, and heat-associated complaints (i.e. heat exhaustion, heat stroke or heat reaction) went up 900 percent.
- In Detroit alone, climate models predict the city will experience 30 to 50 days per year of 90 degrees or hotter and 25 to 50 days with temperatures above 97 degrees.

ADAPTATION IN ACTION:

- Thanks to CDC support, the Michigan Climate and Health Adaptation Program is improving state and local capacity to conduct climate change-related health impact assessments (HIA). An HIA is a process that helps evaluate the potential health effects of a plan, project or policy before it is built or implemented.[4] Such assessments help public health officials more effectively protect people's health. As of 2013, the program had funded two local assessment projects: one in East Lansing and another in Grand Rapids. In East Lansing, local public health officials assessed and offered recommendations to enhance nonmotorized transportation improvements, which can help reduce the emissions that cause climate change while offering safe opportunities for physical activity and reducing pedestrian and bicyclist injuries. In Grand Rapids, local health officials assessed a major traffic corridor undergoing redevelopment. The recommendations from the assessment are helping city planners to better consider the health impacts of these activities.
- The program is involved in the Detroit Climate Action Collaborative, which works to ensure that the city's climate action plan protects and benefits all residents. Among its many activities, the collaborative is partnering with the Great Lakes Integrated Sciences and Assessments Center to develop Detroit-specific climate projections. The collaborative is also working with the University of Michigan College of Architecture and Urban Planning to assess the characteristics of climate vulnerable neighborhoods.
- The program works with academic and private sectors to translate research into practice. For example, health officials helped pilot a tool called I-HEAT, which involves the spatial mapping of heat and social vulnerabilities. Health officials also helped pilot a dynamic heat model developed by researchers at Michigan State University. The model considers heat-related social and behavioral factors, such as what prevents or motivates residents from going to cooling centers. The I-HEAT tool could be used by local health departments to better identify communities vulnerable to heat exposure.
- To tailor adaptations to community needs, the program funded two local health departments to assess residents' heat readiness. Altogether, more than 3,000 surveys were conducted, and the results are already shaping local response and outreach efforts. For example, in Ingham County, health officials learned that local food banks were an ideal venue to reach vulnerable residents with cooling center information.

To learn more about the Michigan Climate and Health Adaptation Program, visit www.michigan.gov/mdch/0,4612,7-132-54783_54784_55975---,00.html.

[4] US Centers for Disease Control and Prevention: http://www.cdc.gov/healthyplaces/hia.htm


OREGON
Climate and
HEALTH
Resilience Plan

Oregon Climate and Health Program

www.healthoregon.org/climatechange

Oregon Health Authority

Emily York, MPH | Program Coordinator
Emily.A.York@state.or.us

Climate Ready Tribes and Territories Initiative

- New 2016 funding will be awarded later this year
- Will support climate and health adaptation activities within tribal groups and territories
- Will work with partners to identify vulnerable areas and populations
- Approximately 3 tribes and 2 territories will be funded

http://planetsave.com/wp-content/uploads/2012/02/young-navajo-climate-activist.png

Re-Framing the Climate Change Dialogue

Summary

- The effects of climate change are already evident in our communities
- Climate change must be framed as a human welfare and public health issue.
- Early action, through evidence-based approaches, can help to protect the public's health

Thank You

Contact:

George Luber, PhD

Climate Change
National Center for Environmental Health
gluber@cdc.gov