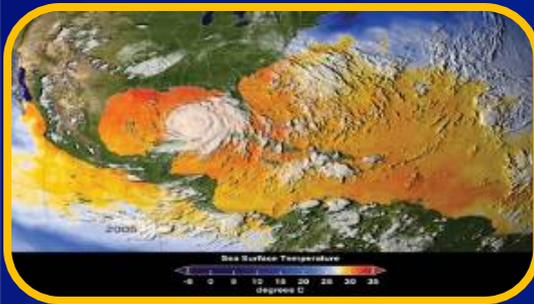


The Health Consequences of a Changing Climate

Findings from the 3rd US National Climate Assessment.



George Luber, PhD
Associate Director for Climate Change

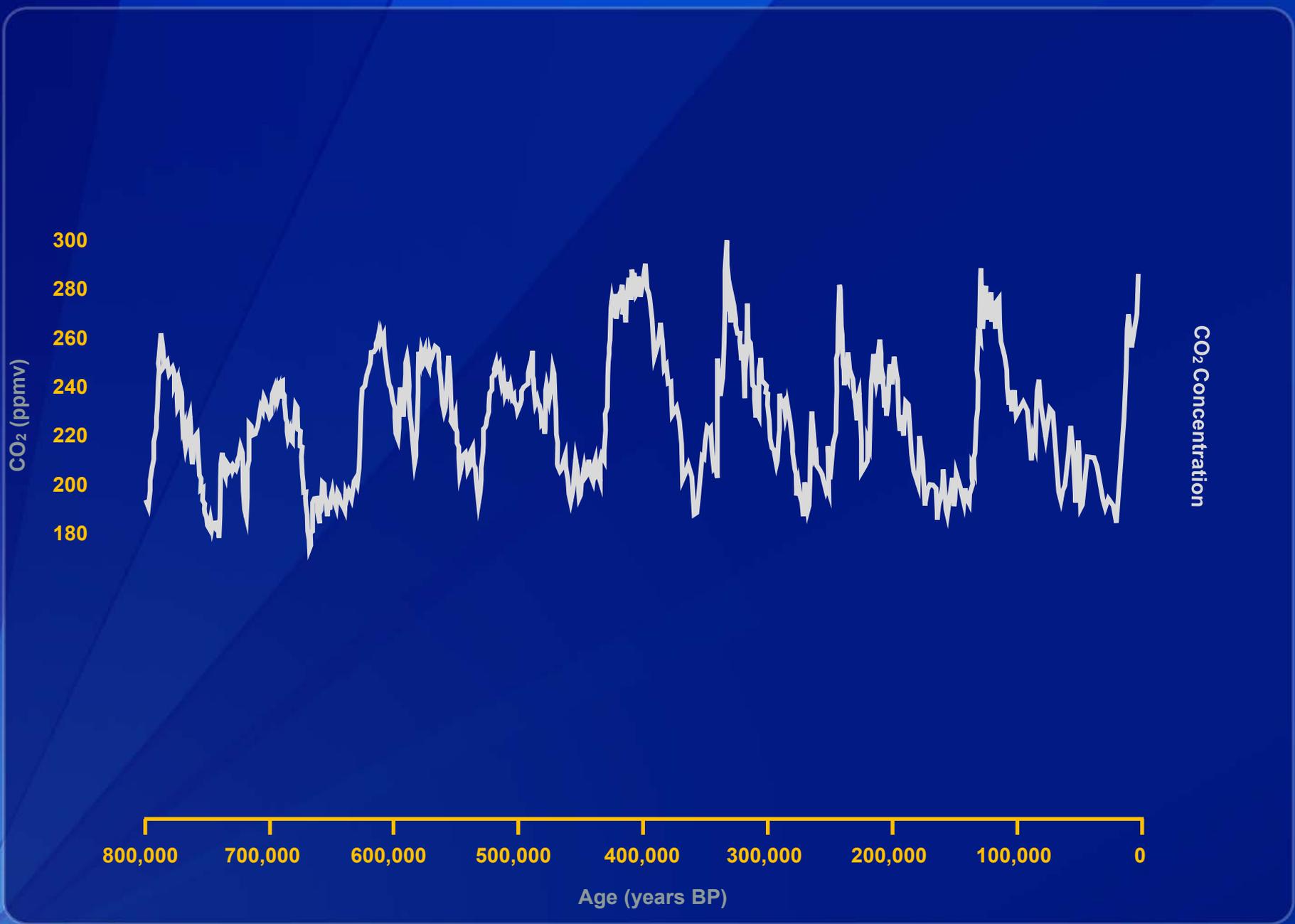
Climate and Health Program
National Center for Environmental Health
Centers for Disease Control and Prevention



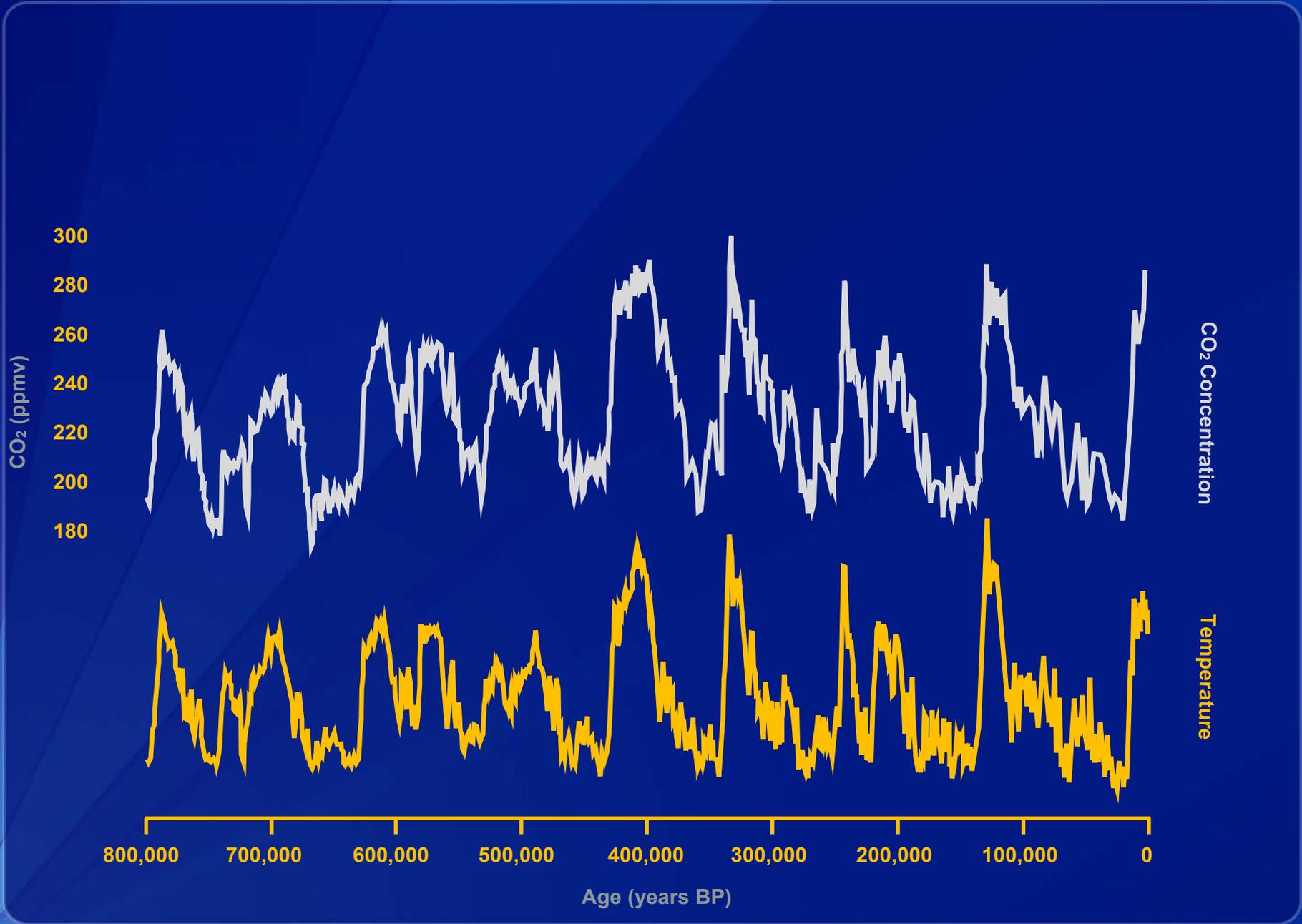
SCIENCEPHOTOLIBRARY



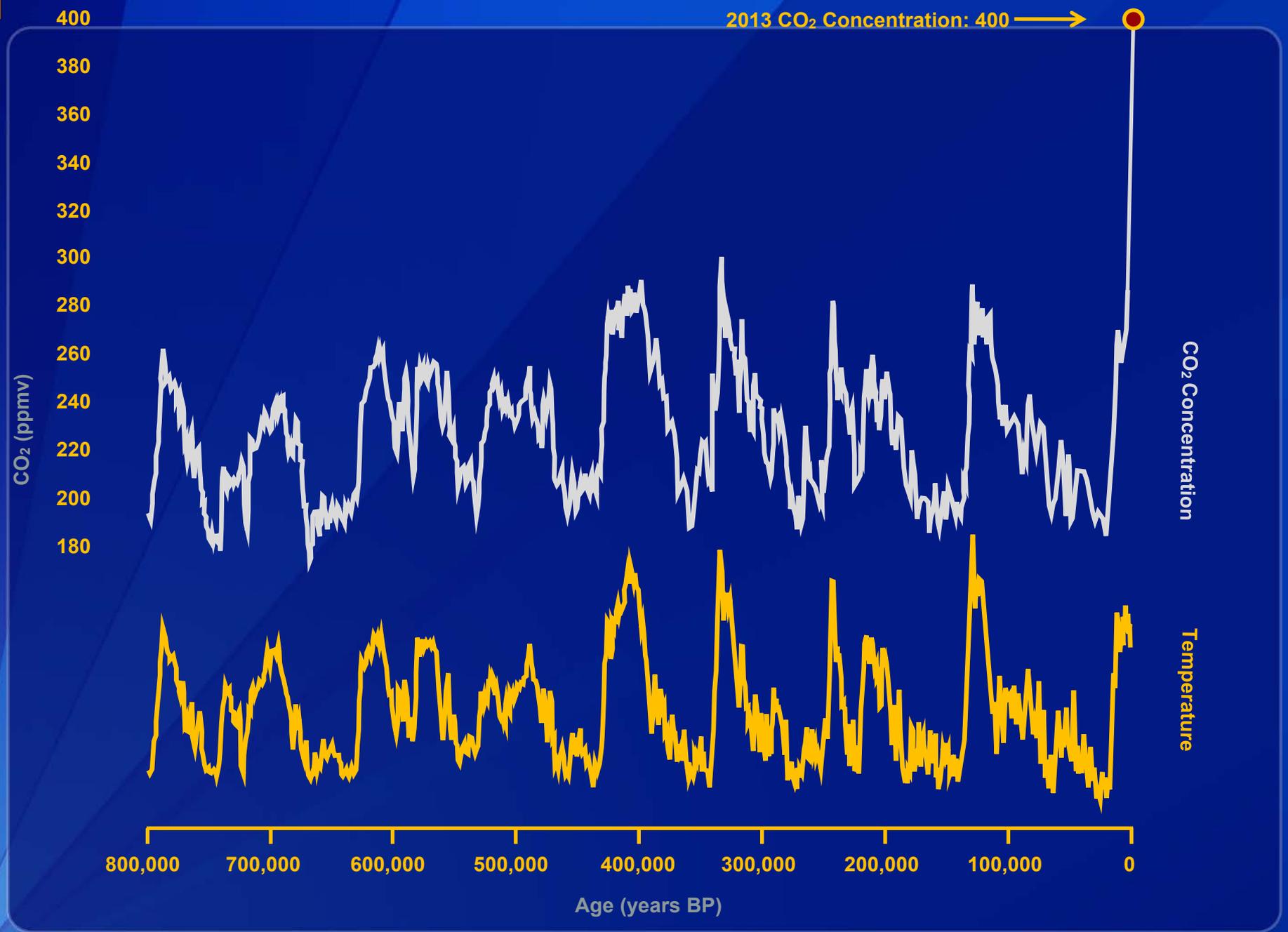
Source: NASA



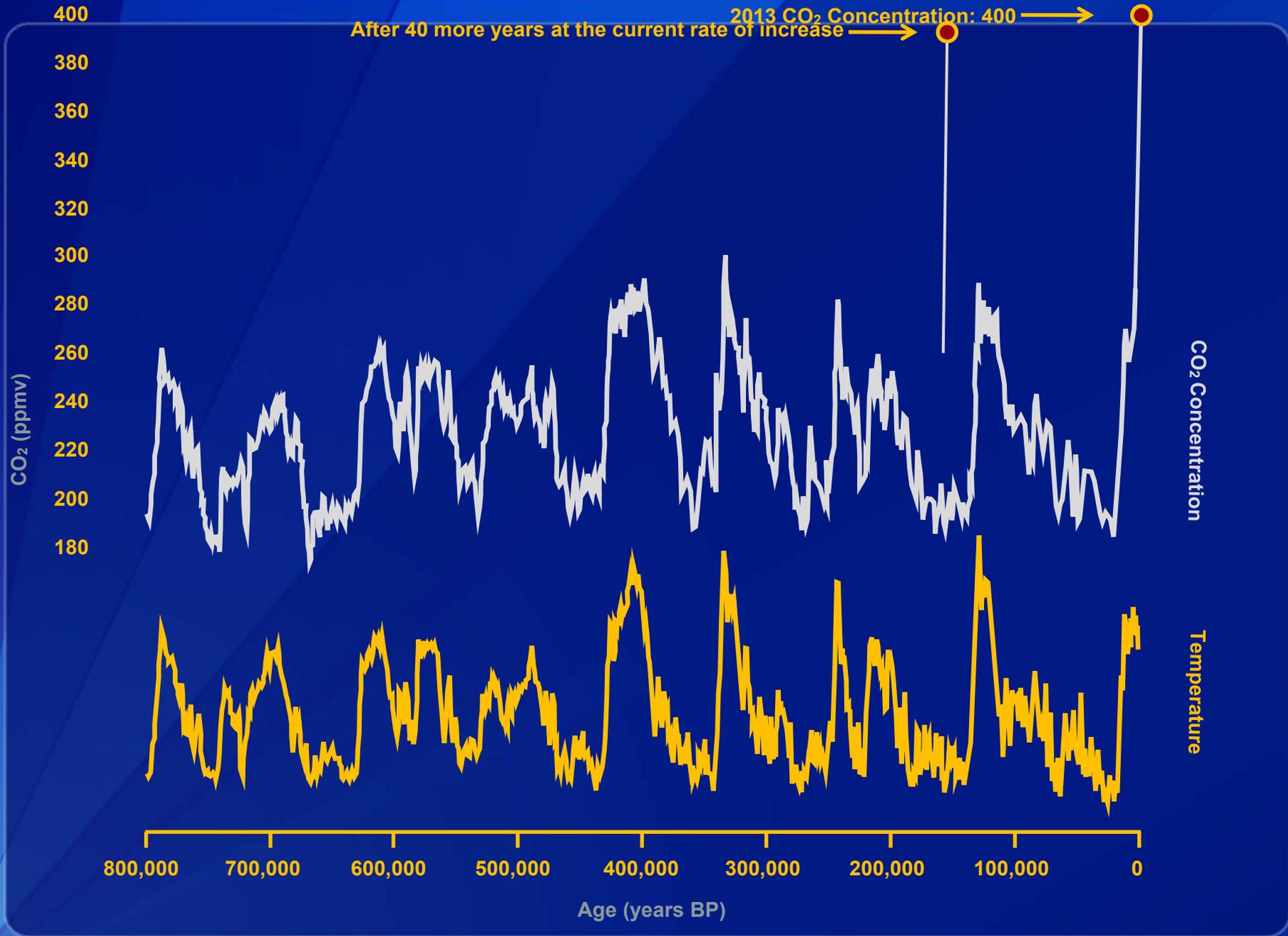
Source: National Climatic Data Center, NOAA



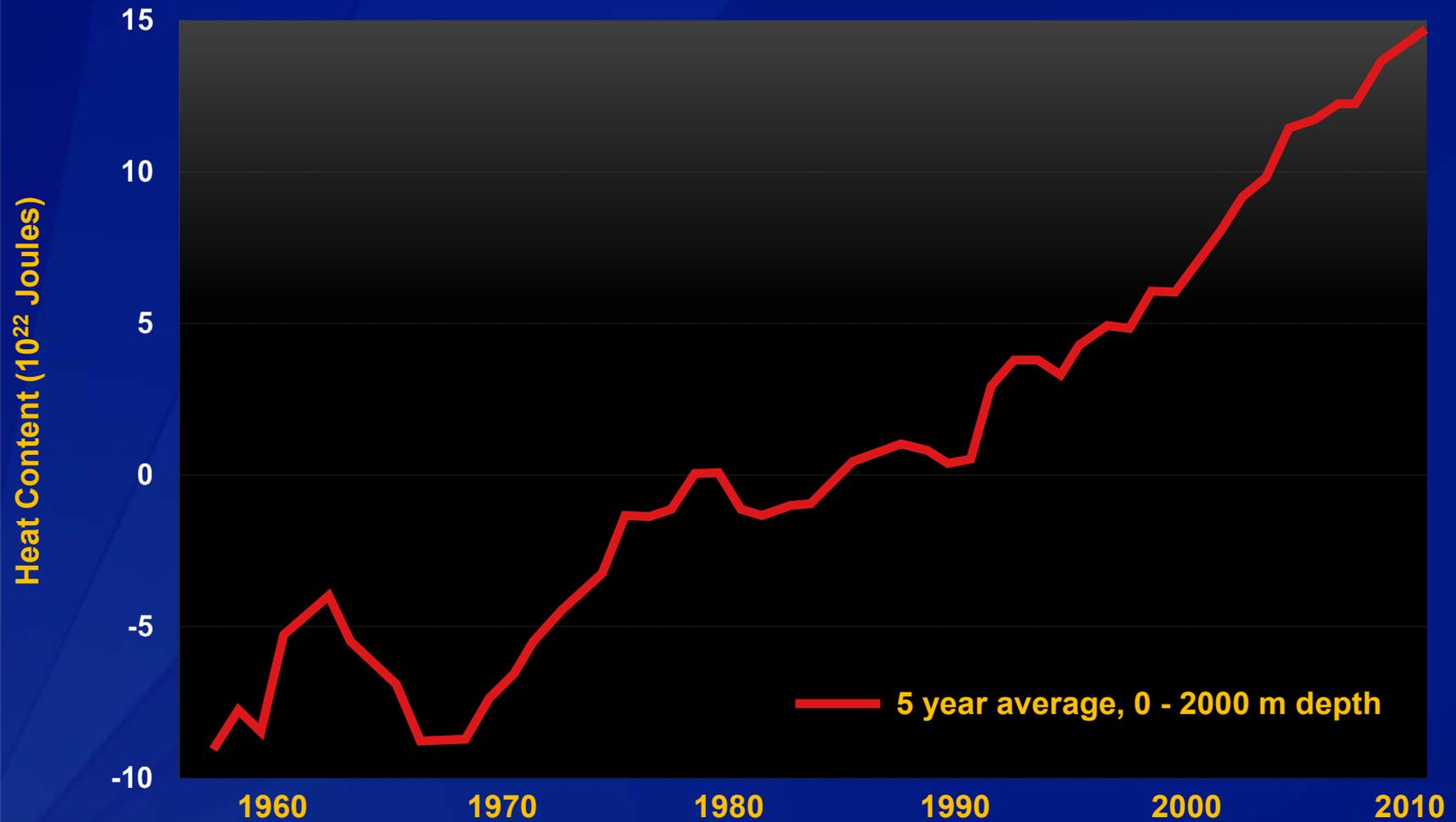
Source: National Climatic Data Center, NOAA



Source: National Climatic Data Center, NOAA



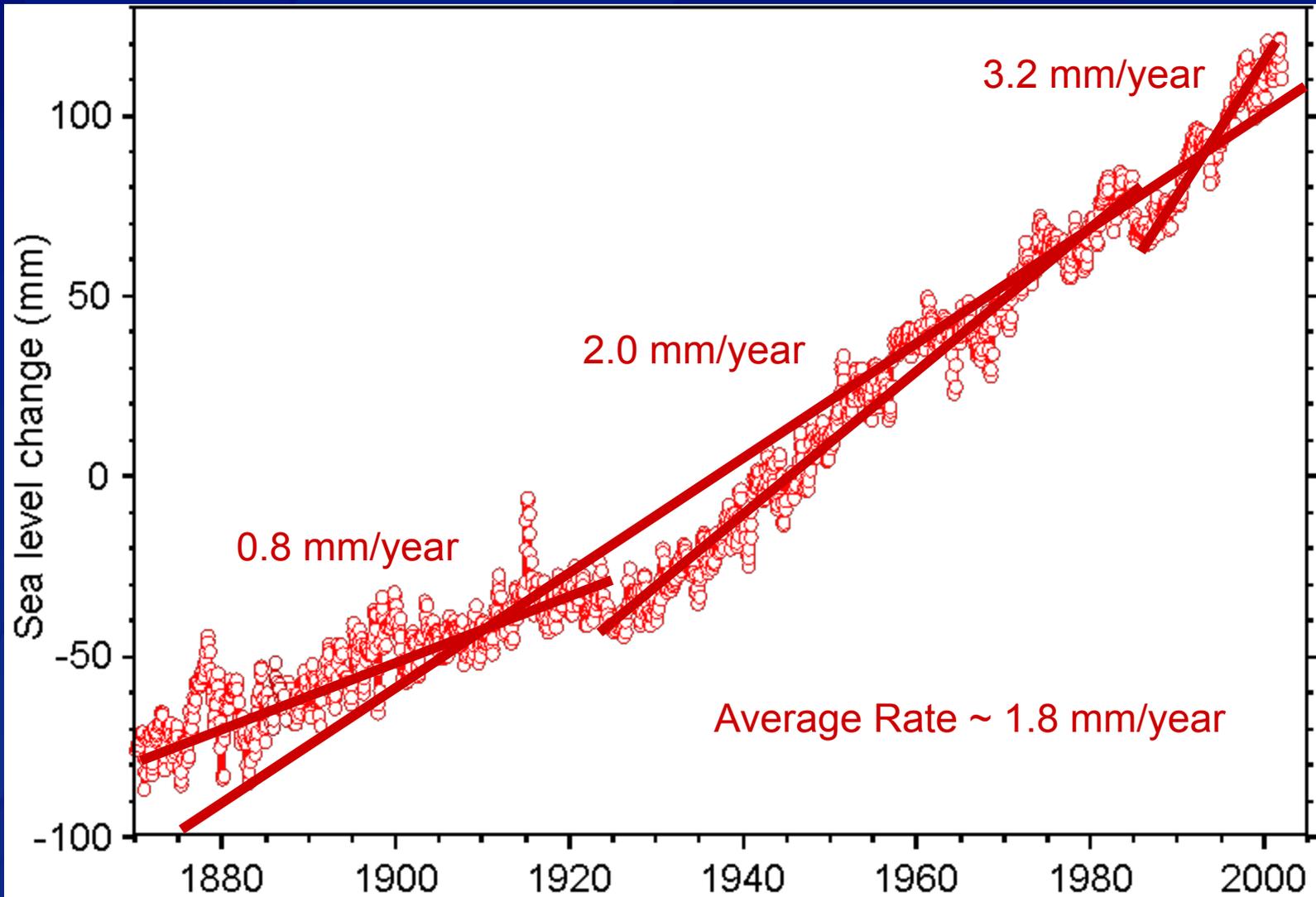
Global Ocean Heat Content 1955 – 2010



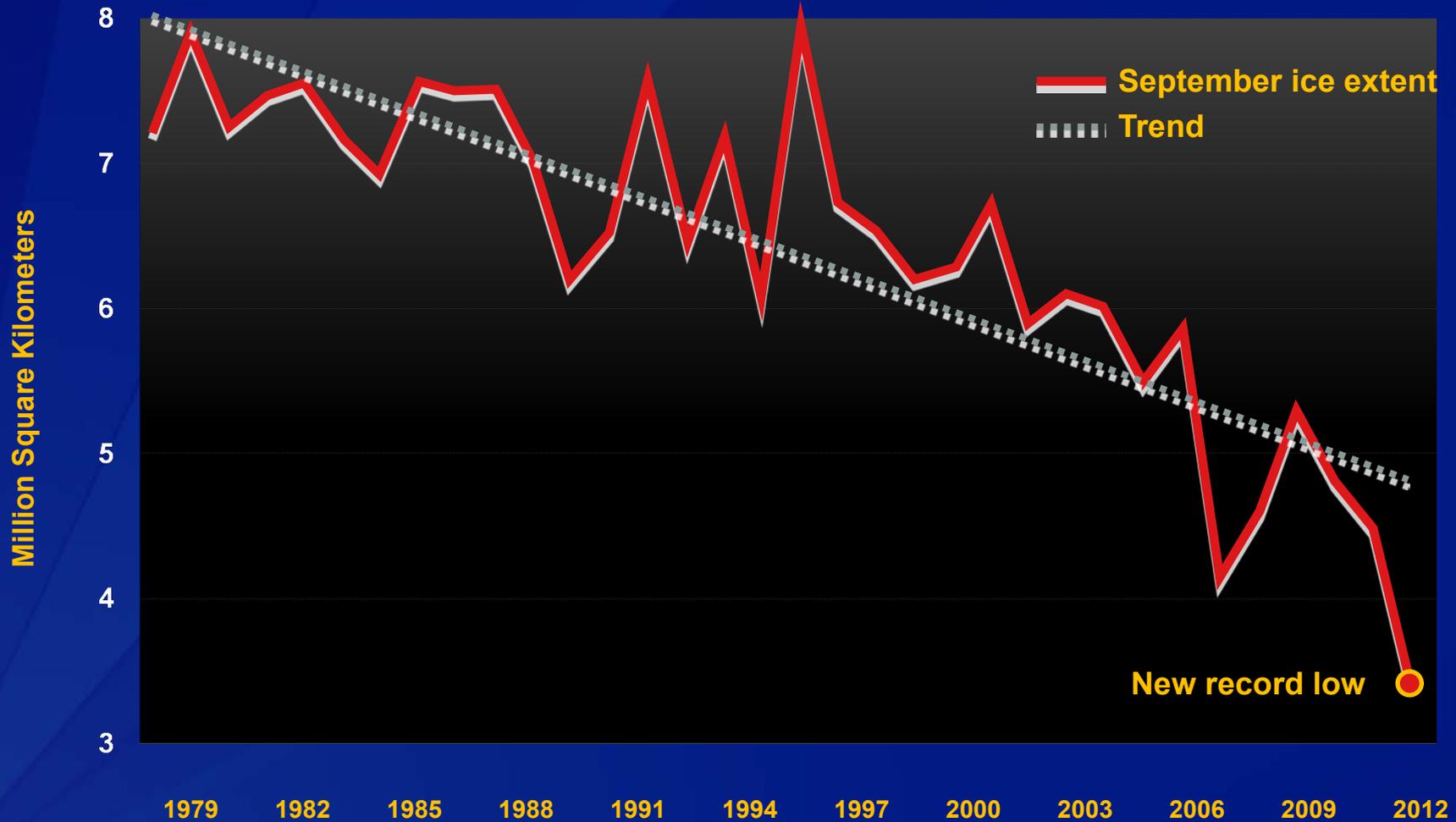
Source: NOAA/NESDIS/NODC Ocean Climate Laboratory, updated from Levitus, S., et al., "World ocean heat content and thermosteric sea level change (0-2000), 1955-2010," *Geophys. Res. Lett.* 39, doi:10.1029/2012GL051106, 2012.

© 2012 American Geophysical Union. Reproduced/modified by permission of American Geophysical Union.

Accelerating Sea Level Rise



September Arctic Sea Ice Extent 1979 – 2012



Arctic Sea Ice Extent

September 1984

Russia

Greenland

Alaska
(U.S.A)

Canada

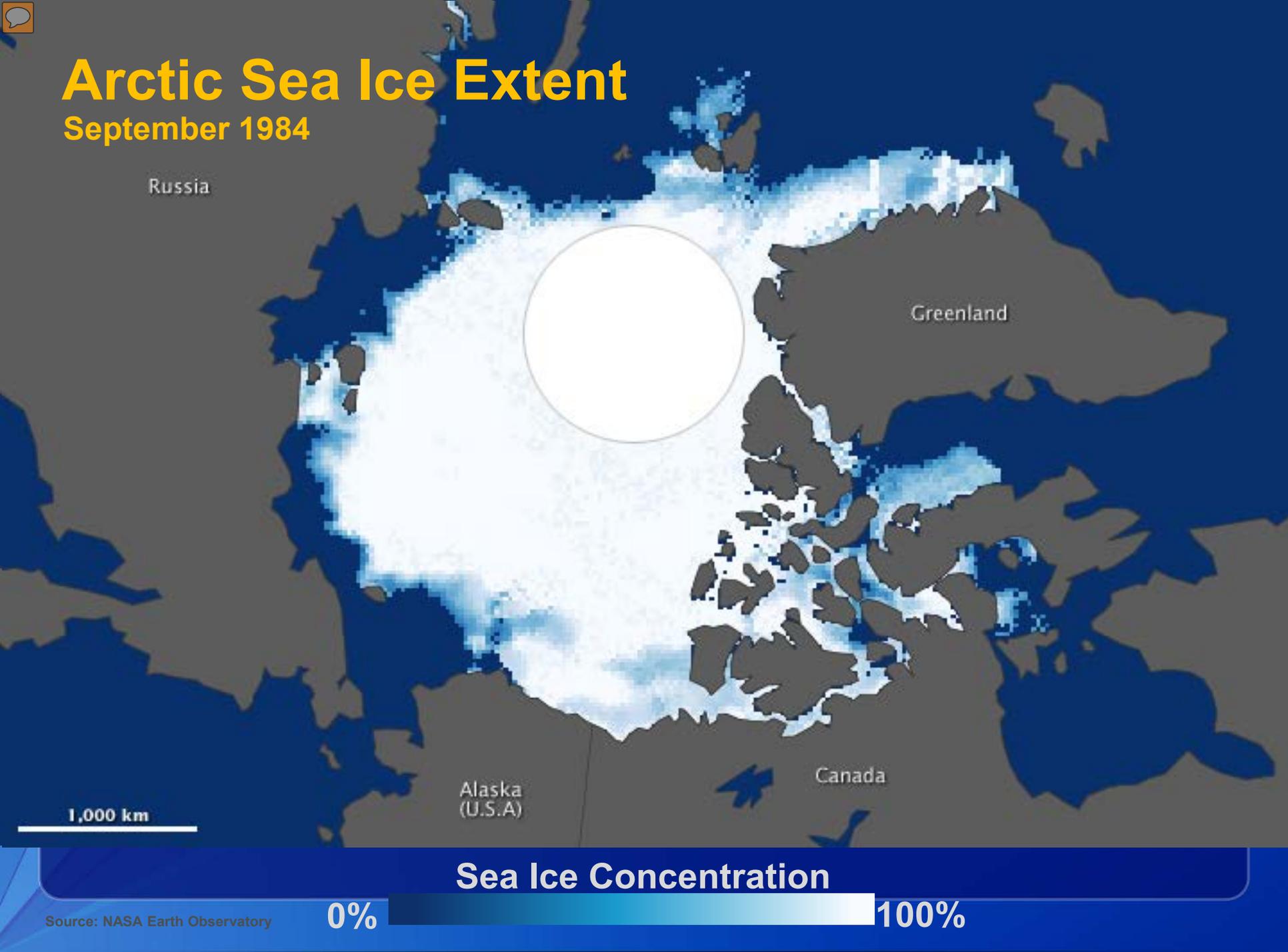
1,000 km

Sea Ice Concentration

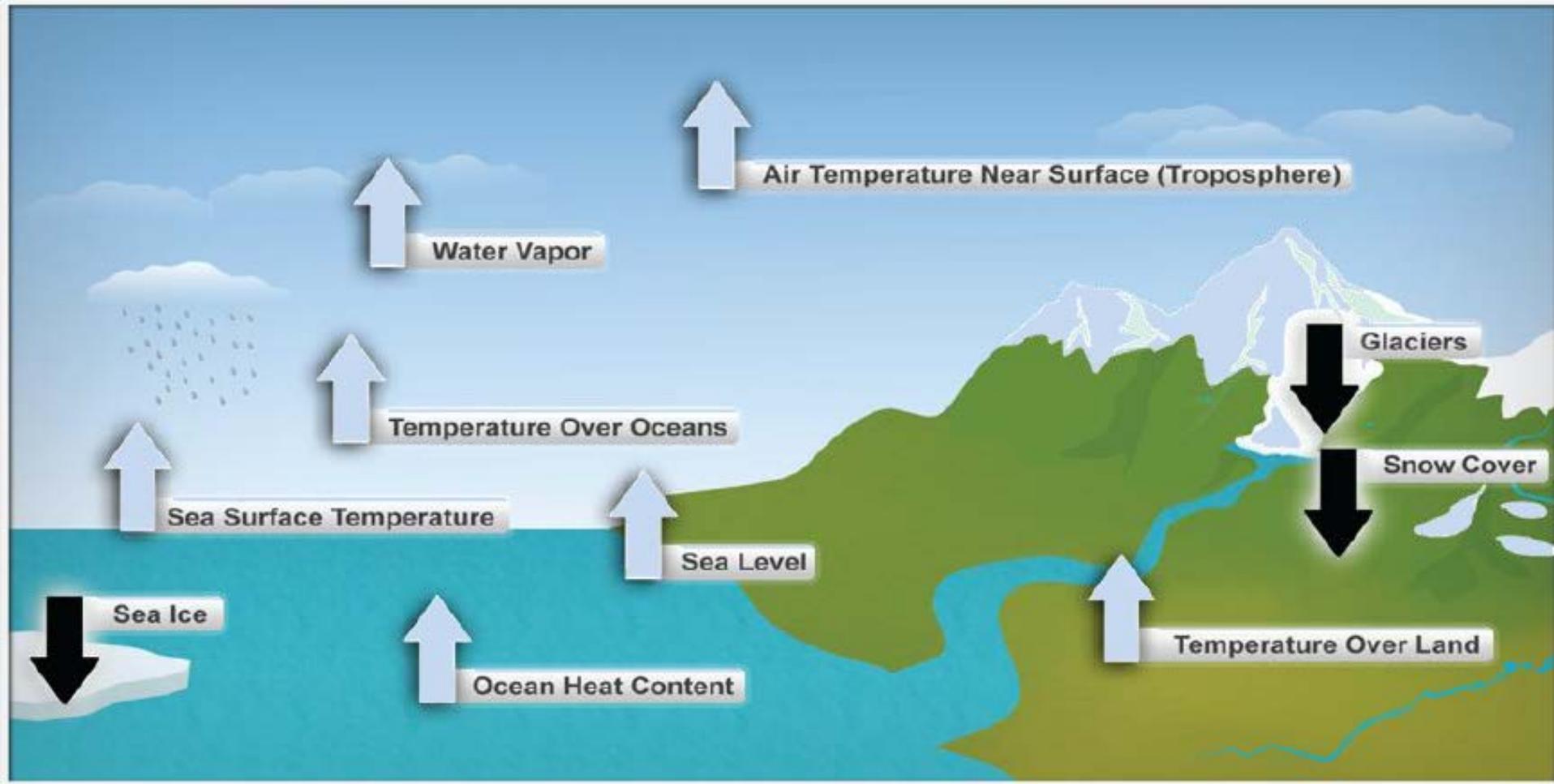
0%

100%

Source: NASA Earth Observatory



Ten Indicators of a Warming World



Objectives

- ❑ Summarize findings from 3rd US National Climate Assessment
- ❑ Review evidence for climate change and its impact on human health
- ❑ Describe CDC efforts to prepare for health effects of climate change



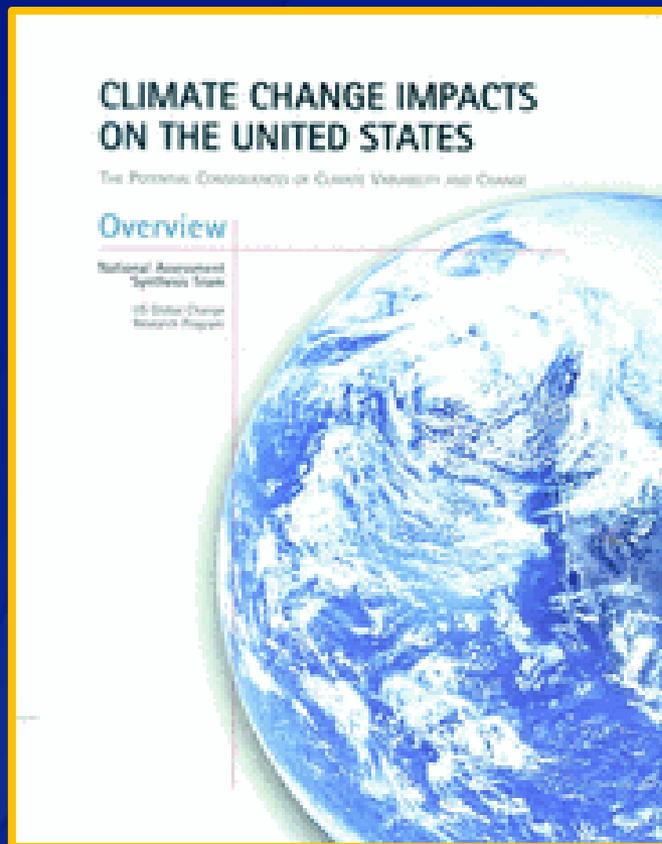
What is the National Climate Assessment?

- ❑ **Established through Global Research Act of 1990**
- ❑ **Led by White House Office of Science and Technology Policy**
 - Authors from academia; local, state, and federal government; private and nonprofit sectors
- ❑ **Analyzes impact of global climate change on various sectors of society, including public health**
- ❑ **Evaluates current trends in human-associated and natural global climate change**
- ❑ **Projects major climate trends in US for next 25-100 years**

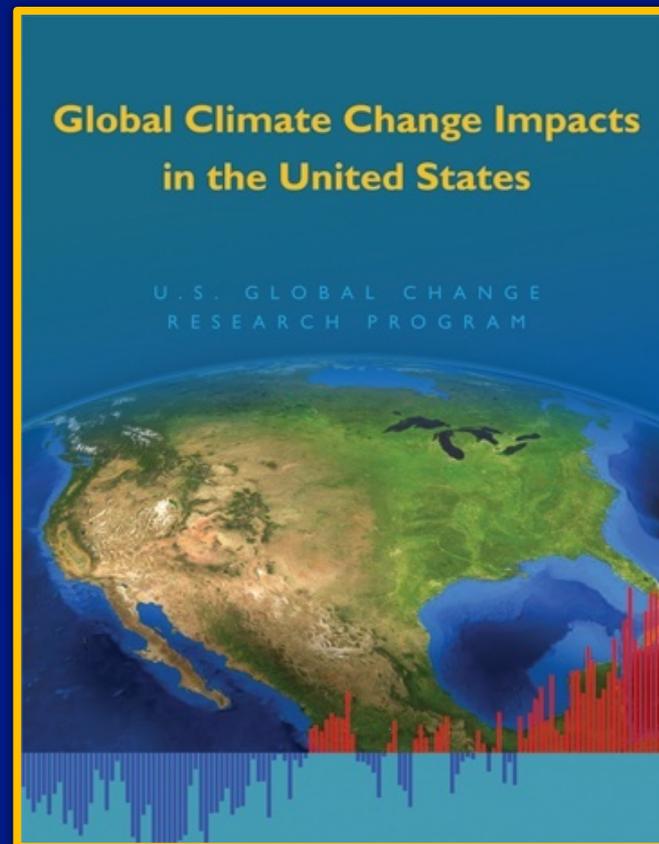
Source: National Climate Assessment Development Advisory Committee, *Draft Third National Climate Assessment Report*, <http://ncadac.globalchange.gov>

Previous National Climate Assessments

2000



2009



3rd National Climate Assessment

- ❑ 3 year effort
- ❑ 240 authors
- ❑ 30 chapters
- ❑ Summarizes impacts for many sectors including public health, energy, water, transportation, and agriculture
- ❑ Will be published in spring 2014



United States
Global Change
Research Program

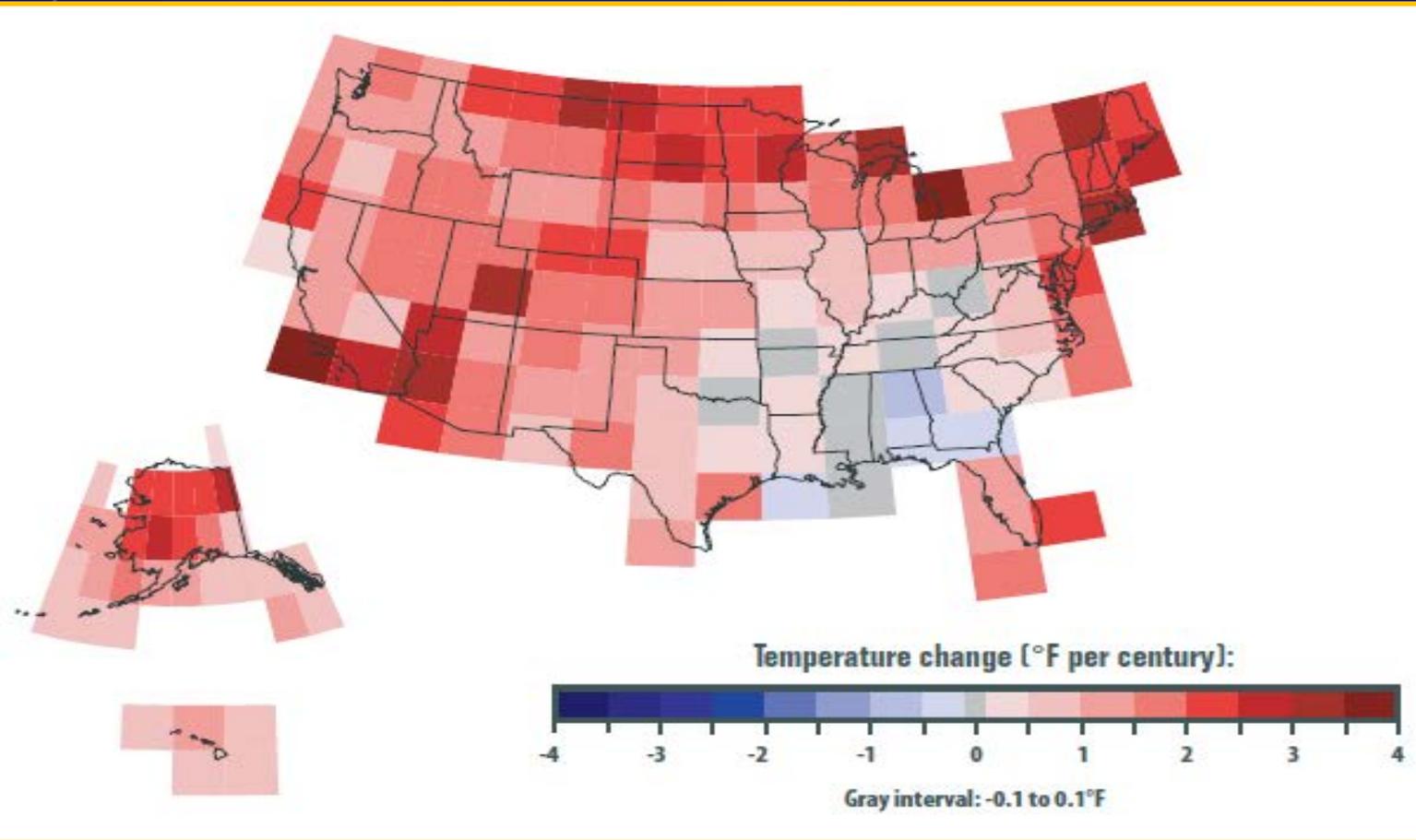
3rd National Climate Assessment

Key Findings

Increasing Strength of the Evidence

- ❑ **Average US temperature has increased by about 1.5°F since 1895 ; more than 80% of this increase has occurred since 1980.**
- ❑ **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.**

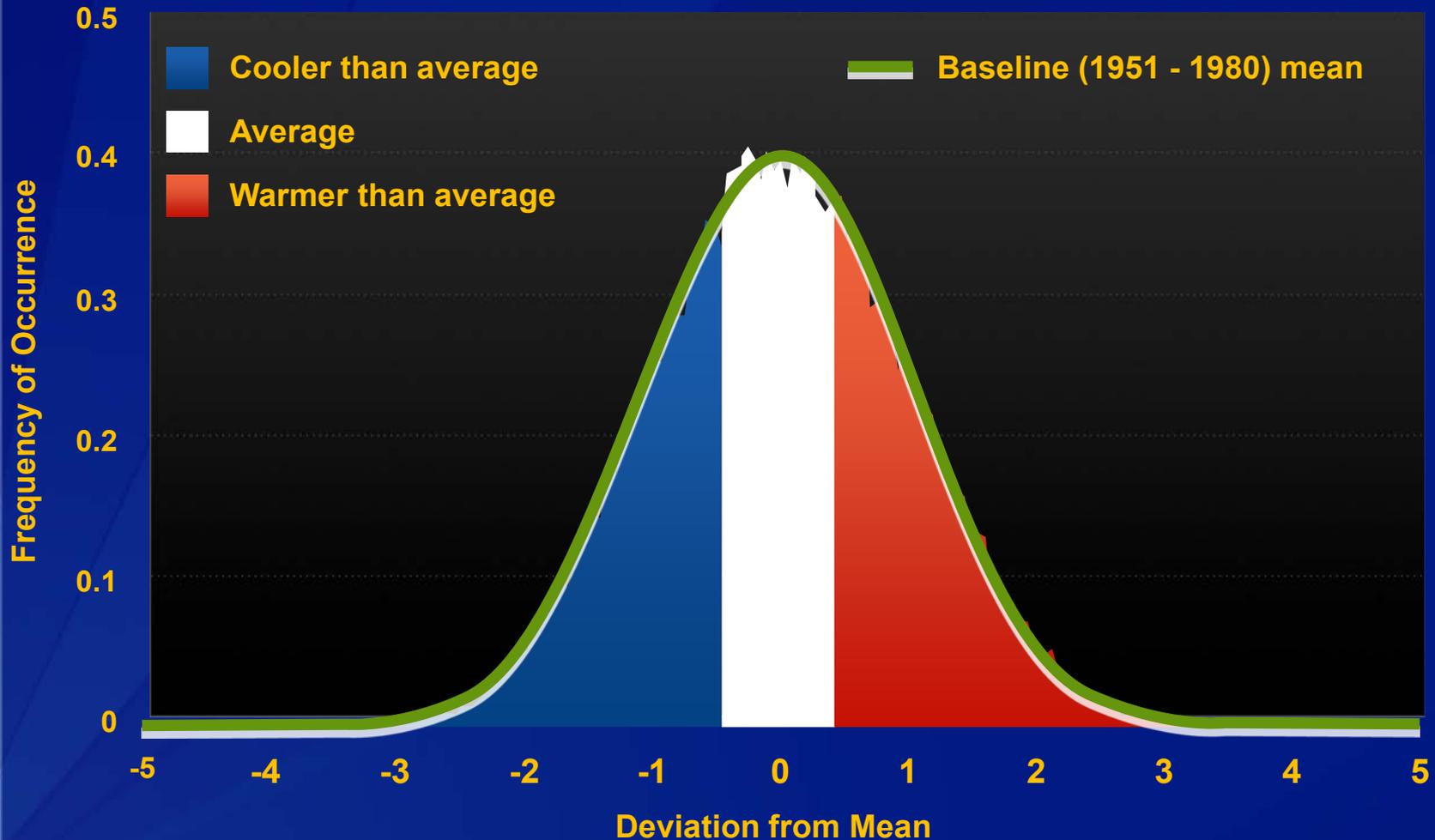
Warming has varied significantly by region (observed record)



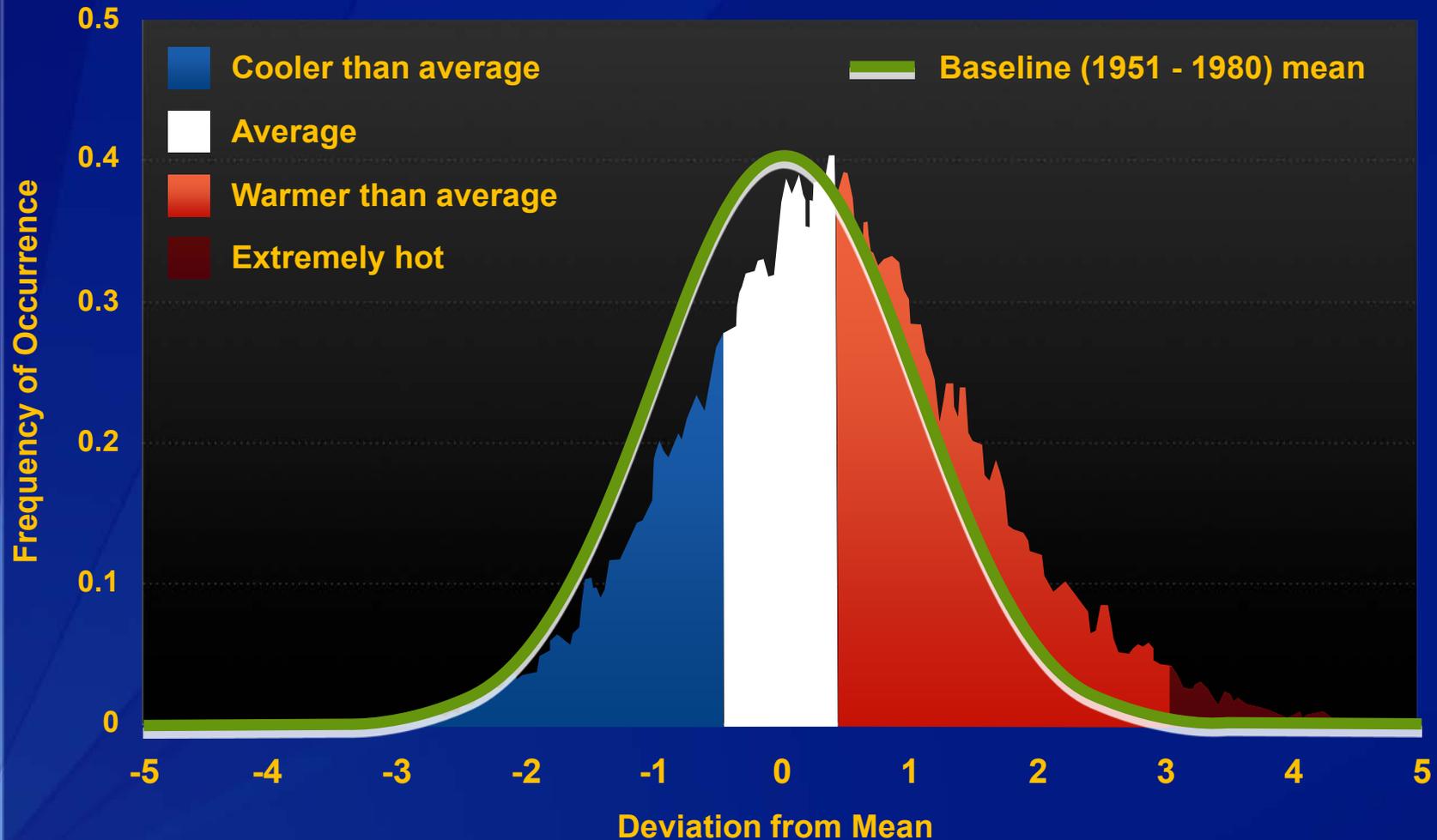
**Temp.
Change
1901-
2008**

IPCC 4AR 2007

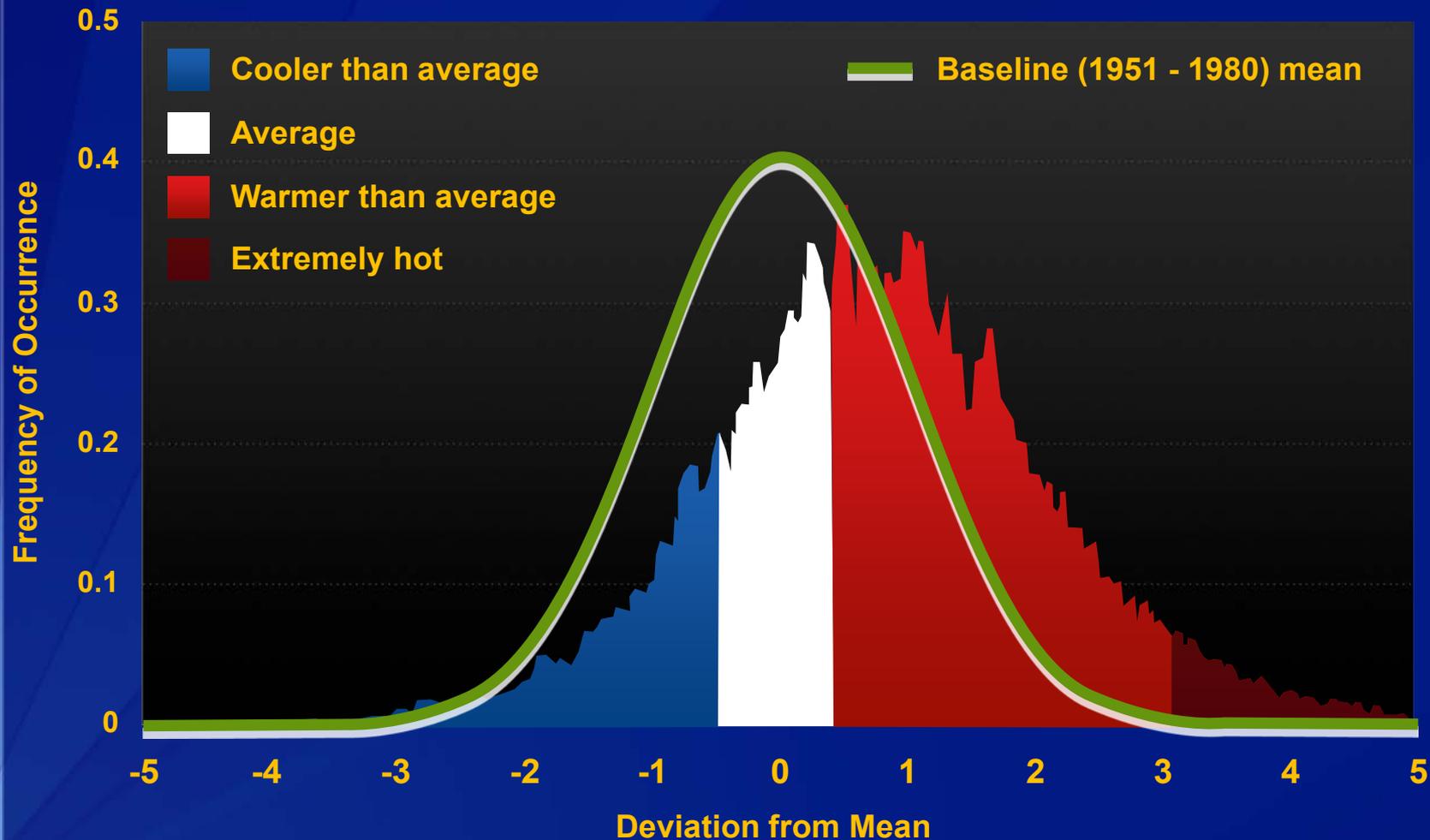
Summer Temperatures Have Shifted 1951 – 1980



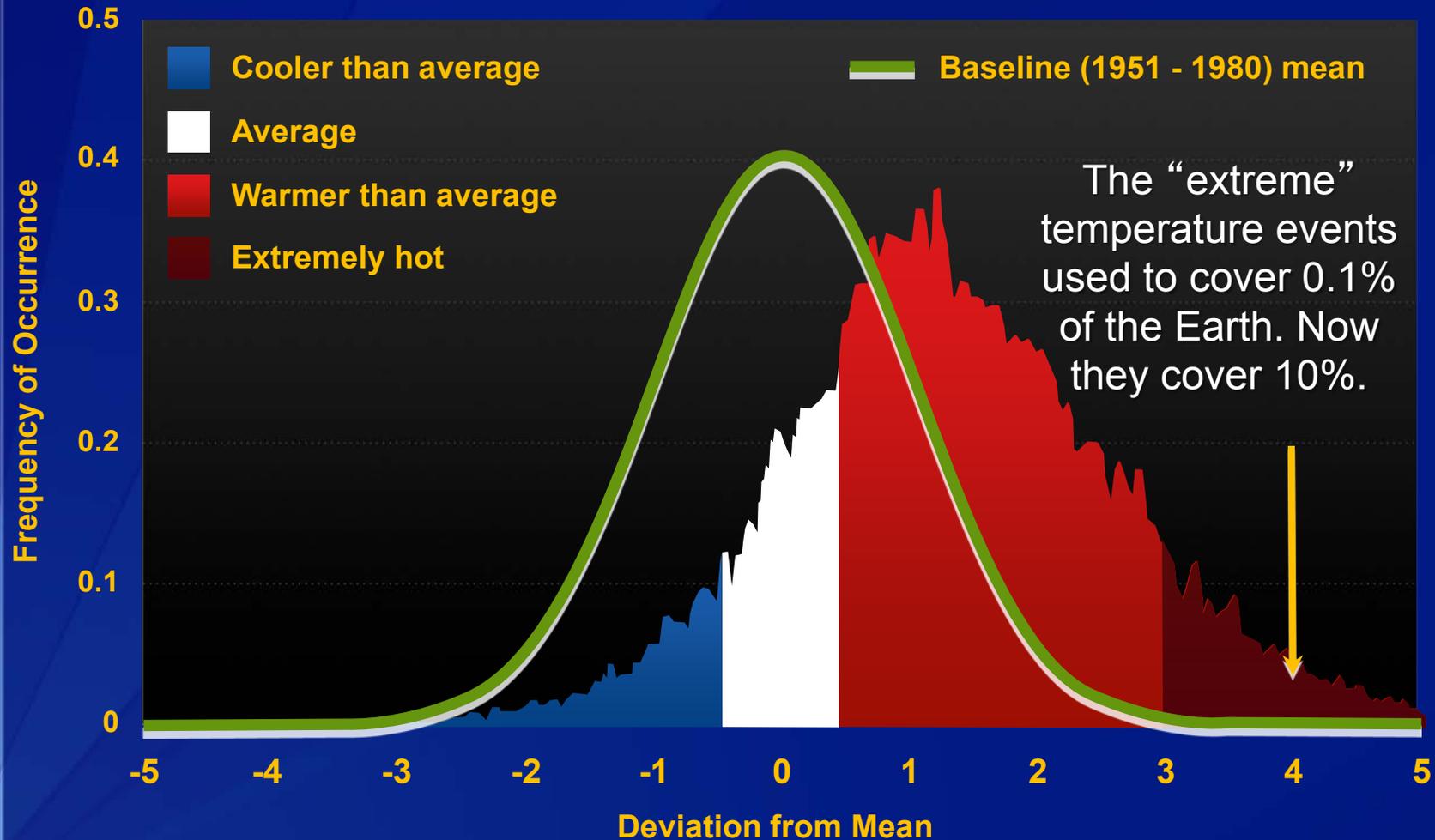
Summer Temperatures Have Shifted 1981 – 1991



Summer Temperatures Have Shifted 1991 – 2001

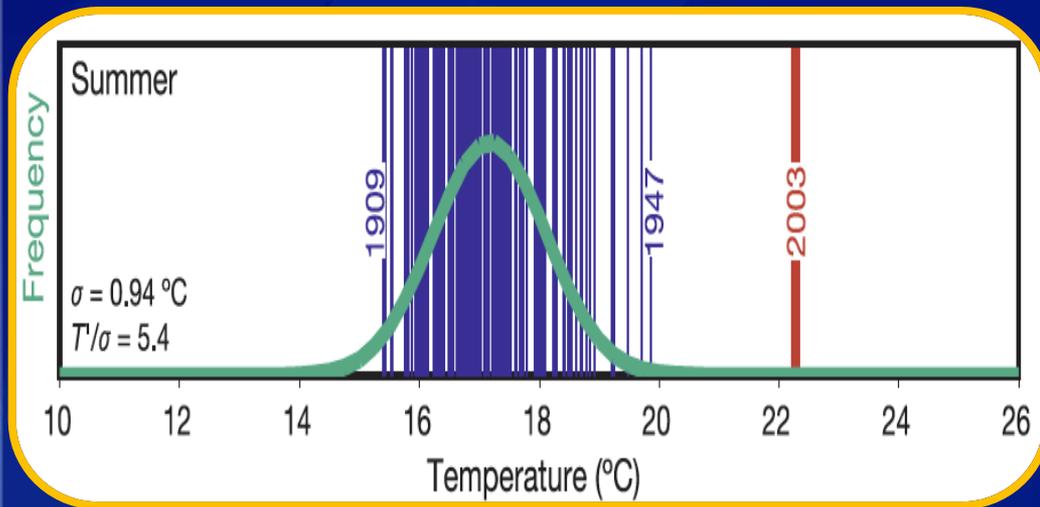


Summer Temperatures Have Shifted 2001 – 2011



Some Extreme Events will be well beyond historical experience

European Heat Wave of 2003



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

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

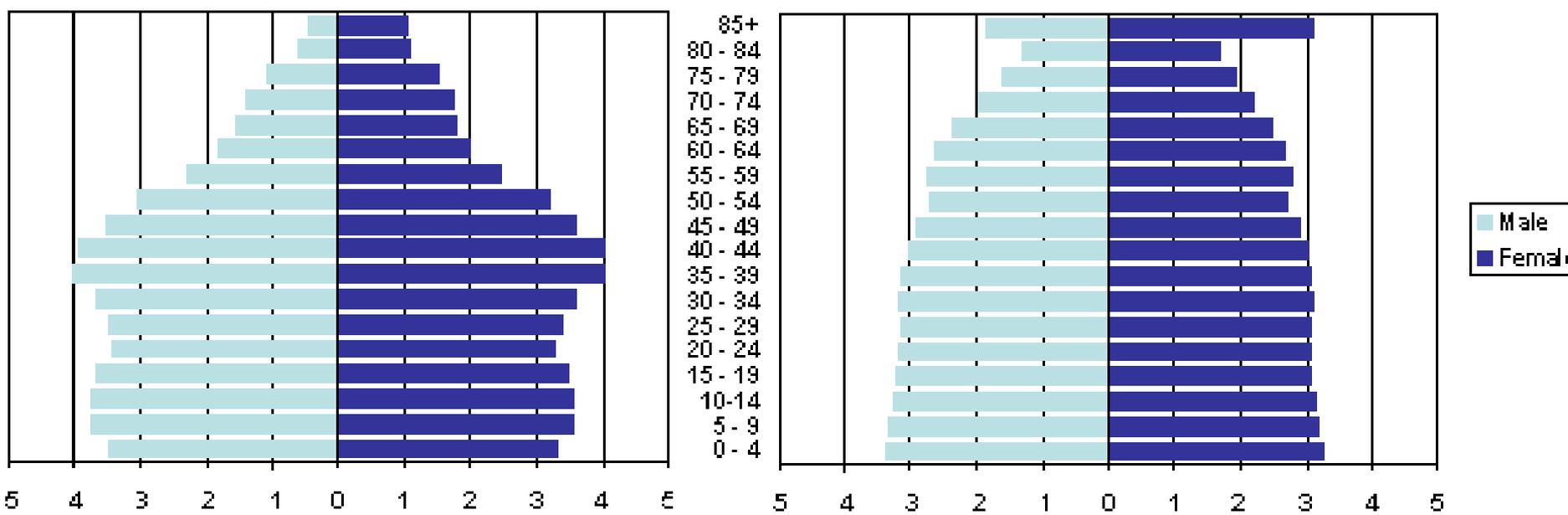
Confirmed Mortality

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

Climate Change and Urban “Built” Environments

- Cities and climate are coevolving in a manner that will place more populations at risk:
- Increase in vulnerable populations:
 - Today, more than half of the world’s population lives in cities, up from 30% in 1950.
 - By 2100 there will be 100 million more people > 65 years old (relative to 2000) (Ebi et al. 2006).
- Intensification of exposures: Urban heat islands and stagnant air masses

Population Pyramids of the U.S. 2000 and 2050 (Interim Projections from 2000 Census)



2000

% of Total Population

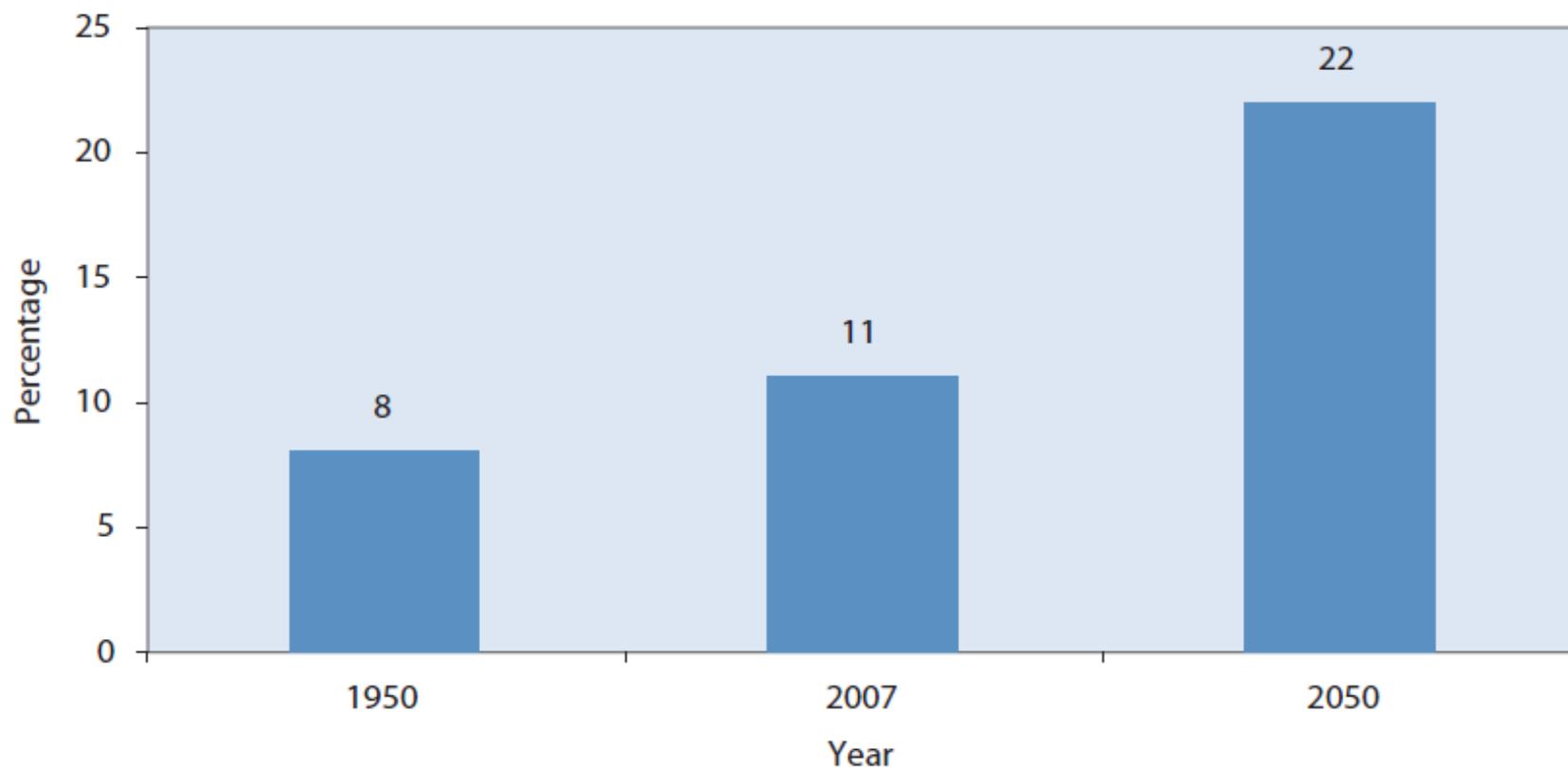
2050

Data source: Census Population Projections
<http://www.census.gov/ipc/www/usinterimproj/>

Trend: Global Population over Age 60

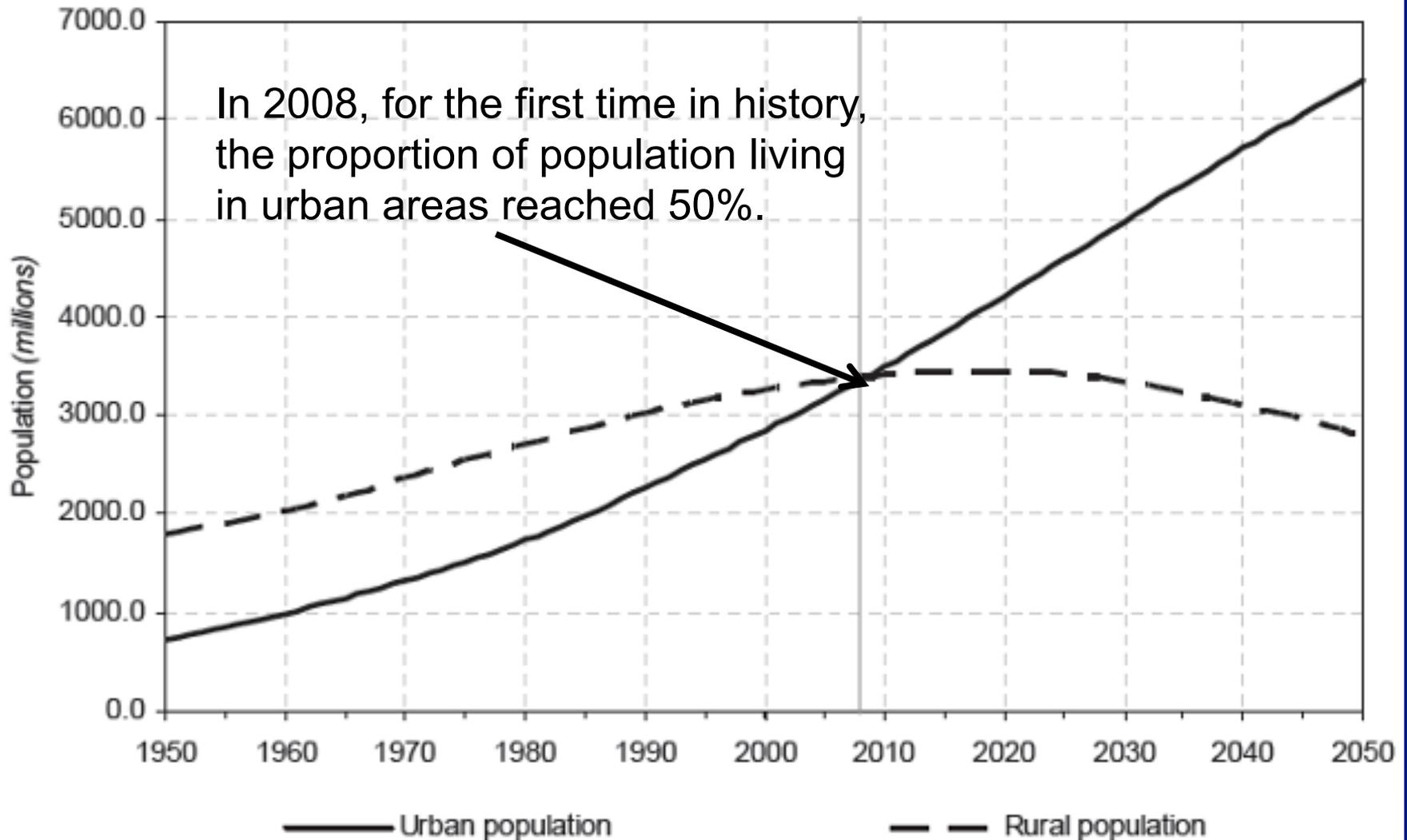
Figure 1

Proportion of population 60 years or over: world, 1950-2050



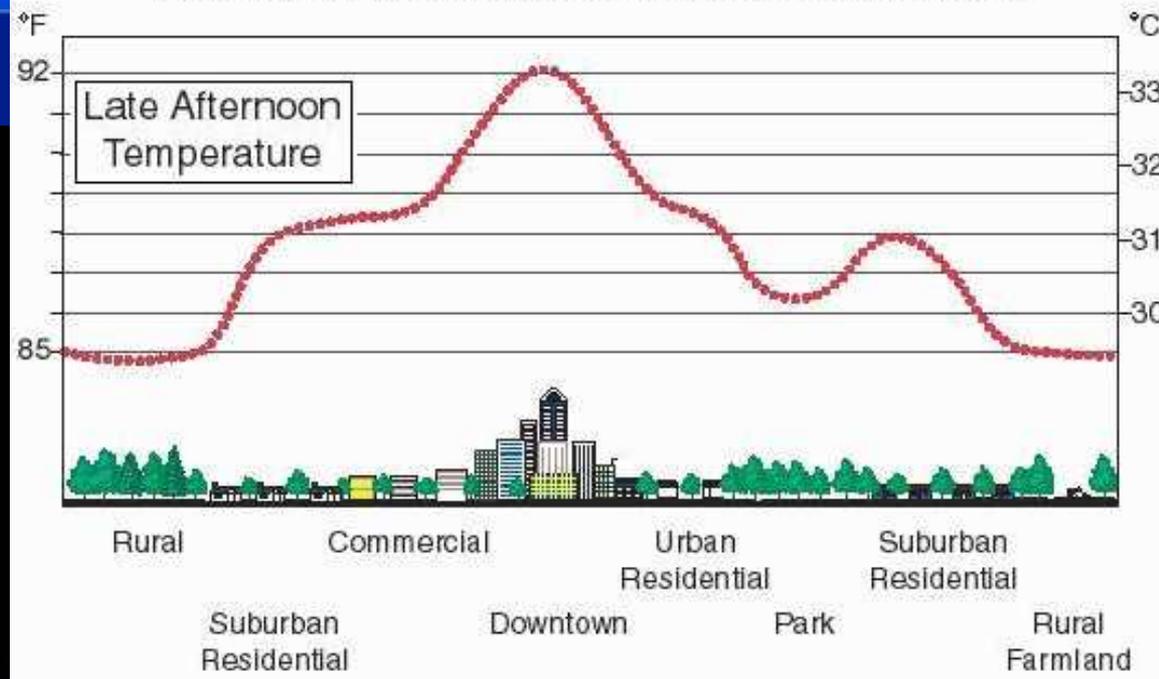
Source: United Nations *World Population Ageing, 2007*

Figure I.1. Urban and rural populations of the world, 1950-2050

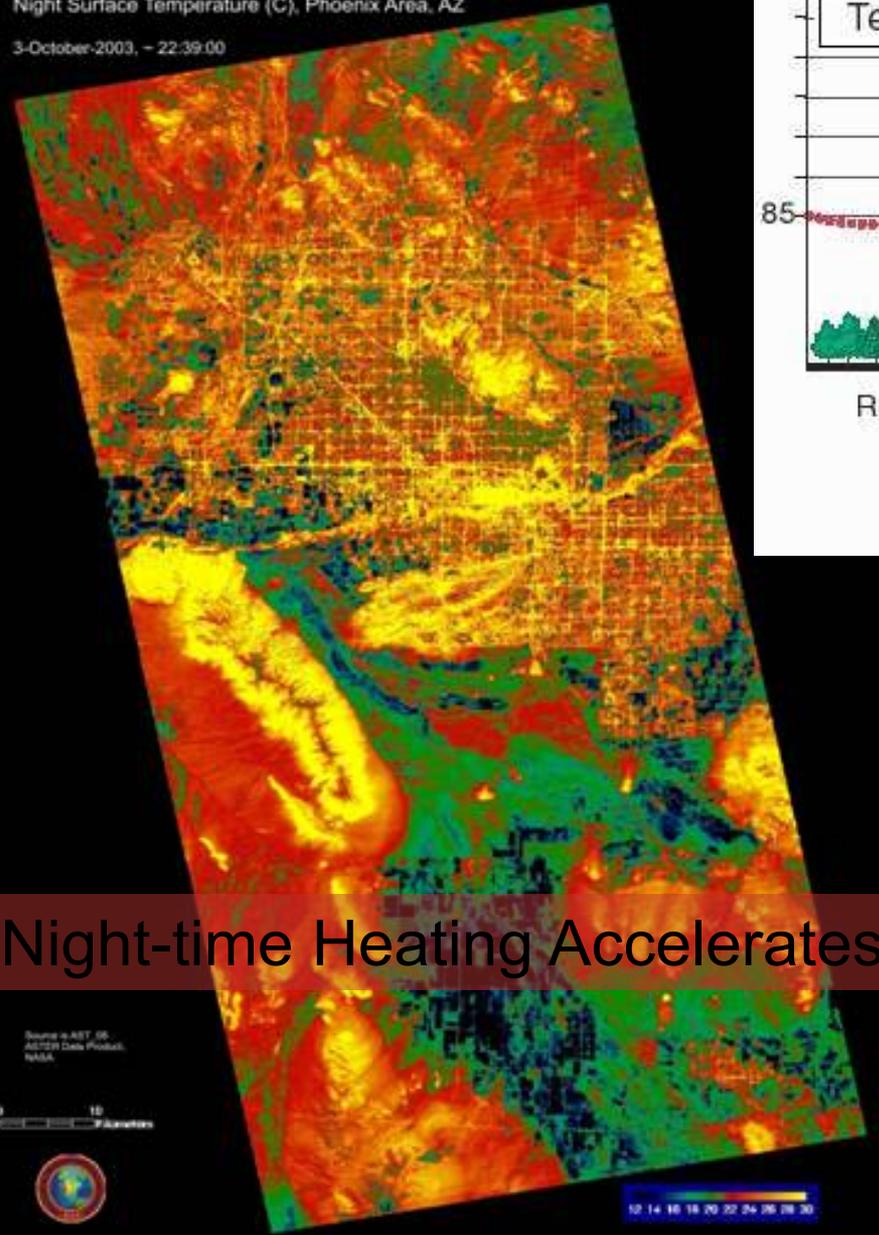


Source: United Nations World Urbanization Prospects, 2008

Sketch of an Urban Heat-Island Profile



Night Surface Temperature (C), Phoenix Area, AZ
3-October-2003, - 22:39:00



Urban Heat Island
can add 7° – 12° F

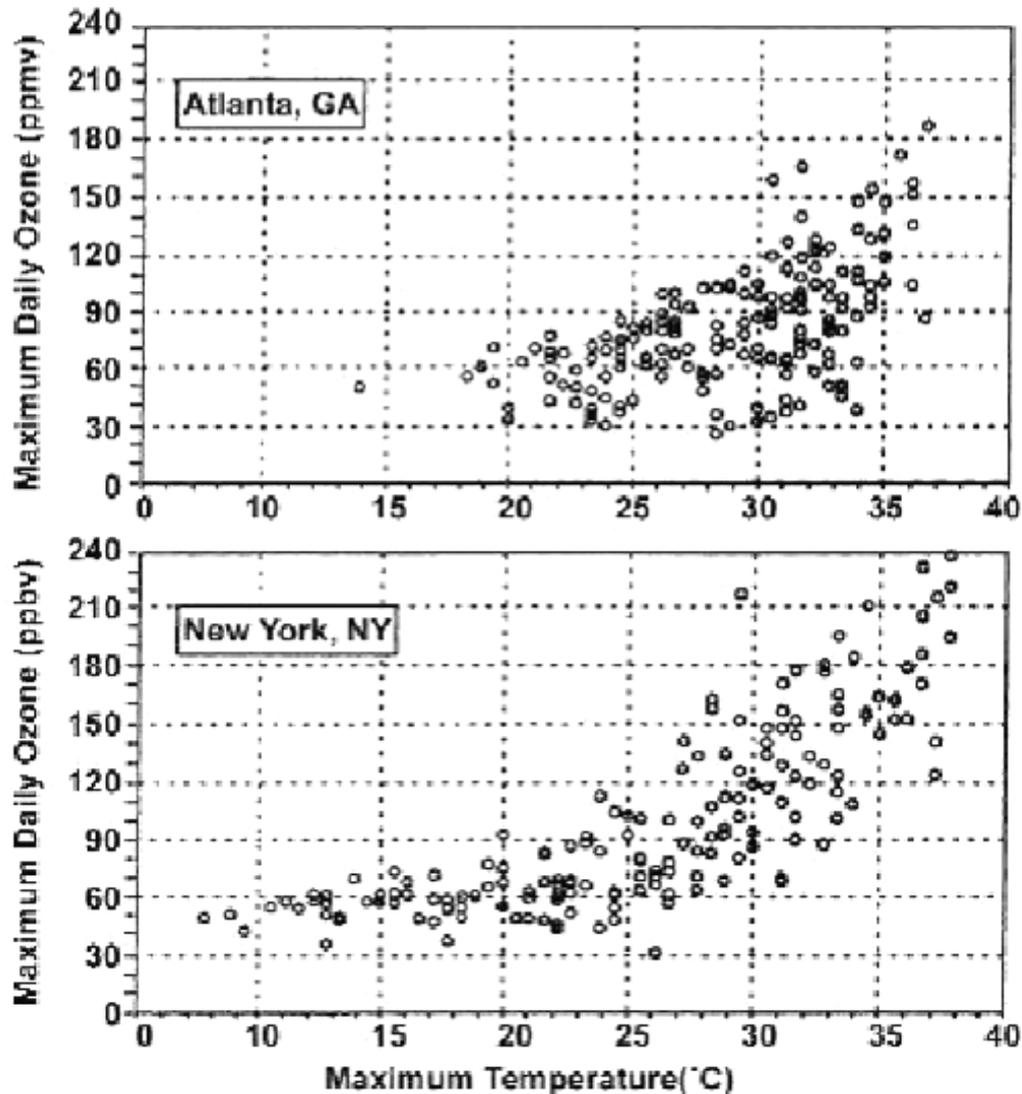
Night-time Heating Accelerates

Thermal Satellite Image of
Phoenix, AZ Night Surface
Temperature



Heat Island Impacts on Air Pollution

Maximum Daily Ozone Concentrations vs. Maximum Daily Temperature



Atlanta

New York

Climate Change Impacts Air Quality: Pollen

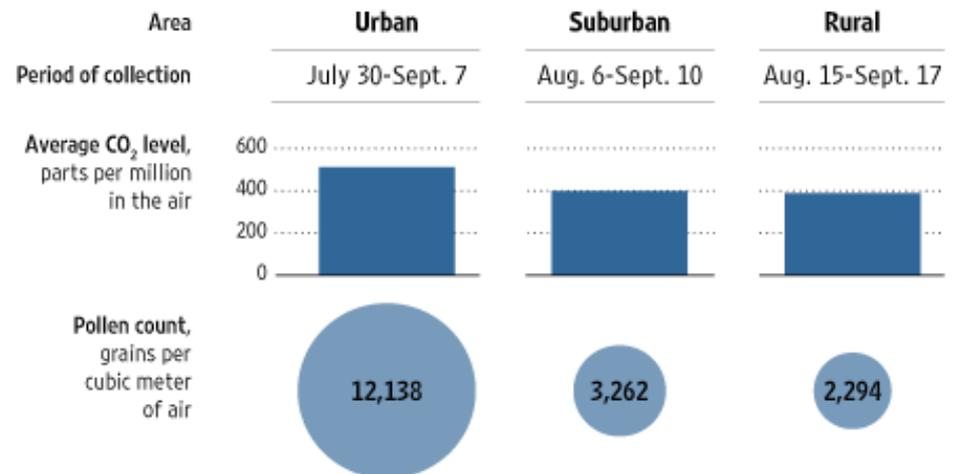


□ Ragweed

- ↑ CO₂ and temperature
- ↑ Pollen counts, longer growing season

Something in the Air

Researchers at the U.S. Dept. of Agriculture planted ragweed in and around Baltimore in 2001 to test how the plant responds to different concentrations of CO₂. The results:



Source: Lewis Ziska, U.S. Dept. of Agriculture

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

Climate Change Impacts on Allergens: Poison Ivy

- *Toxicodendron radicans*
- \uparrow CO₂ leads to
 - \uparrow photosynthesis
 - \uparrow water use efficiency
 - \uparrow growth
 - \uparrow biomass
 - More allergenic urushiol
- Greater CO₂ stimulation than most other woody species



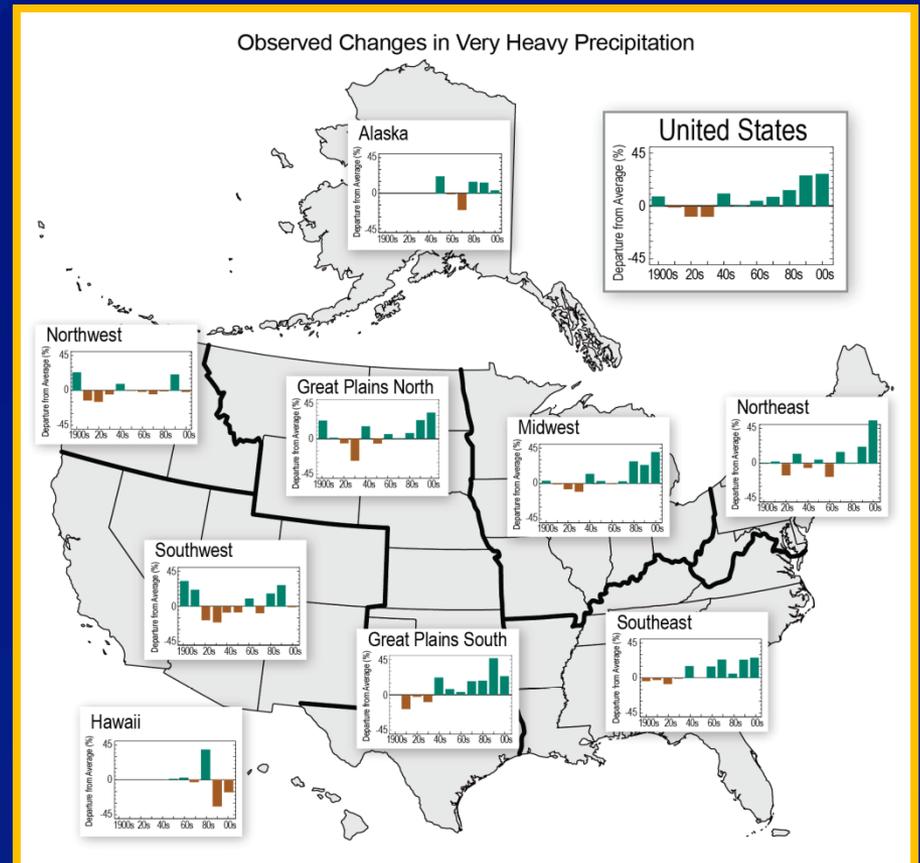
Source: Mohan et al. *PNAS* 2006;103:9086-89.

Climate Change: Impacts on the Hydrologic Cycle

With each additional 1° (C) of temperature, the atmosphere's capacity to hold water vapor increases by 7%. There is already 4% more water vapor over the oceans than there was only 30 years ago.

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).

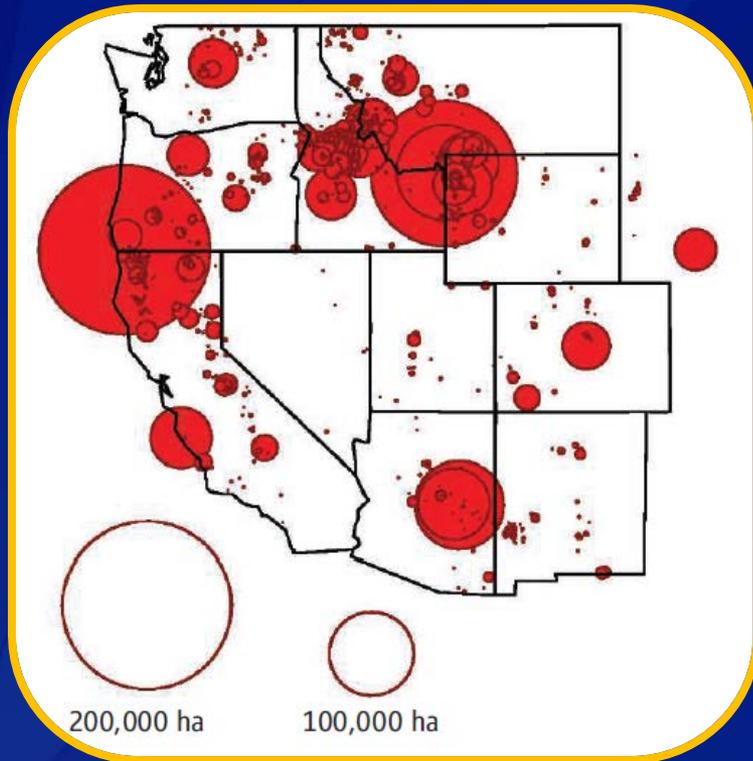
Investigation Continues Into Outbreak

Lake Michigan



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

Mortality and morbidity from wildfire smoke

- An increase of $10\mu\text{g}/\text{m}^3$ 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. 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.

Dust Storms and Health

- ❑ Greater likelihood of injuries from motor vehicle accidents.
- ❑ Increased risk of asthma related hospitalizations.
- ❑ Increased Indoor and Outdoor Air Pollution ($PM_{2.5}$ and PM_{10})



Kanatani, et al., 2010. Desert dust exposure is associated with increased risk of asthma hospitalization in children. *Am J Respir Crit Care Med*.

Kuo, H. , 2009. Indoor and outdoor $PM_{2.5}$ and PM_{10} concentrations in the air during a dust storm. *Building and Environment*.

Chen, et al., 2010. Ambient Influenza and Avian Influenza Virus during Dust Storm Days and Background Days. *Environ Health Perspect*.

Dust Storms and Health - Coccidioidomycosis (Valley Fever)

- ❑ *Coccidioides immitis* primarily dispersed by wind and dust storms.
- ❑ *C. immitis* thrives during wet periods following droughts
- ❑ Infections occur during dry season



Source:

Pappagianis and Einstein, 1978. Epidemiology of coccidioidomycosis. Current Topics in Mycology.

Zender and Talamantes, 2006. Climate controls on valley fever incidence in Kern County, California. Int J Biometeorol.

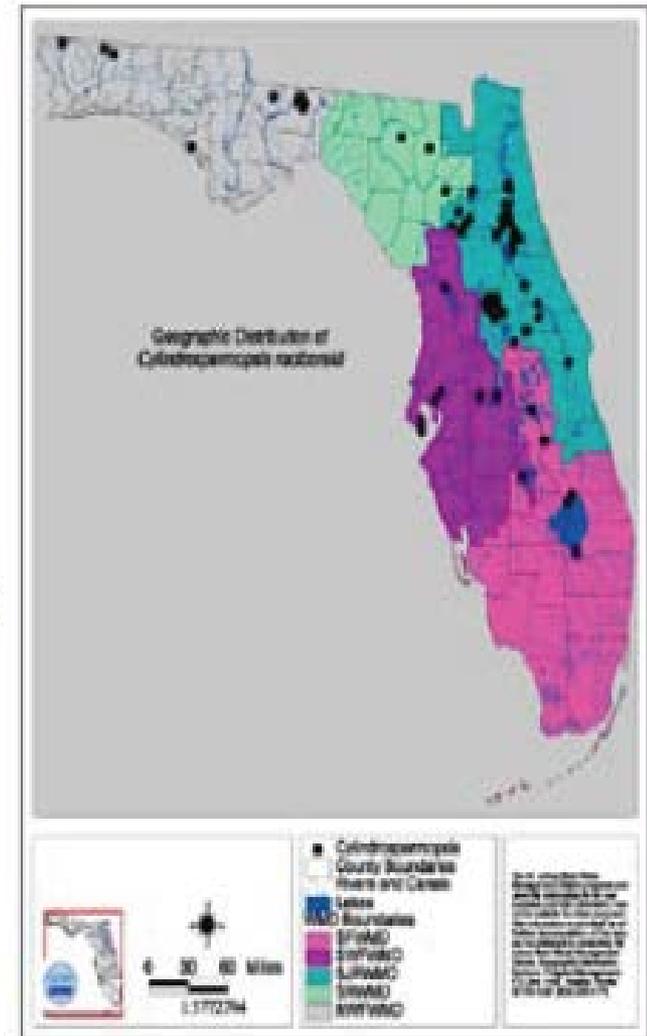
Harmful Algal Blooms (Red-tides)

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.



got ciguatera?

Have you ever become sick from eating fish caught offshore in Texas? If you answered YES, contact us at

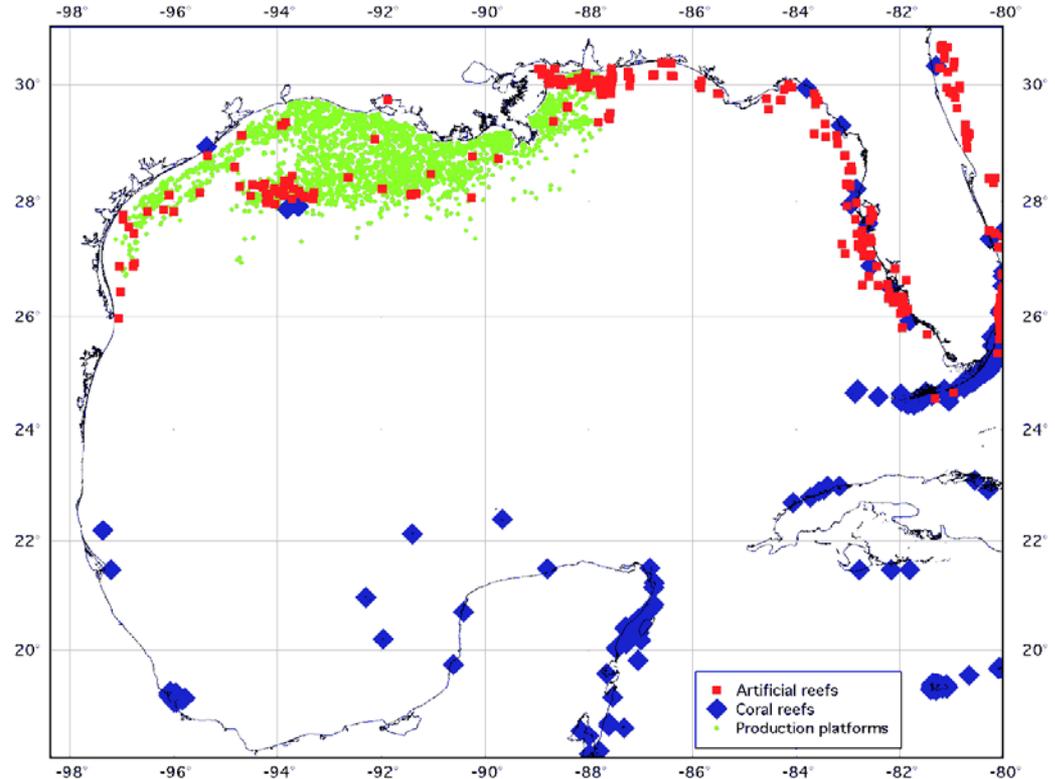
1-888-474-5929

We'd like to talk with you about your symptoms.
E-mail us for more information at ciguatera@cdc.gov
or visit www.cdc.gov/nceh/ciguatera.



This study is conducted by the
Austin, Marine Science Institute
Centers for Disease Control and Prevention

Ciguatera Fish Poisoning on Texas Coast Oil Rigs



Scale: 1:13021480 at Latitude 0°

HEALTH PROFESSIONALS AND SCIENTISTS WARN OF SPREADING INFECTIOUS DISEASES.

Global Warming's greatest

Prediction:

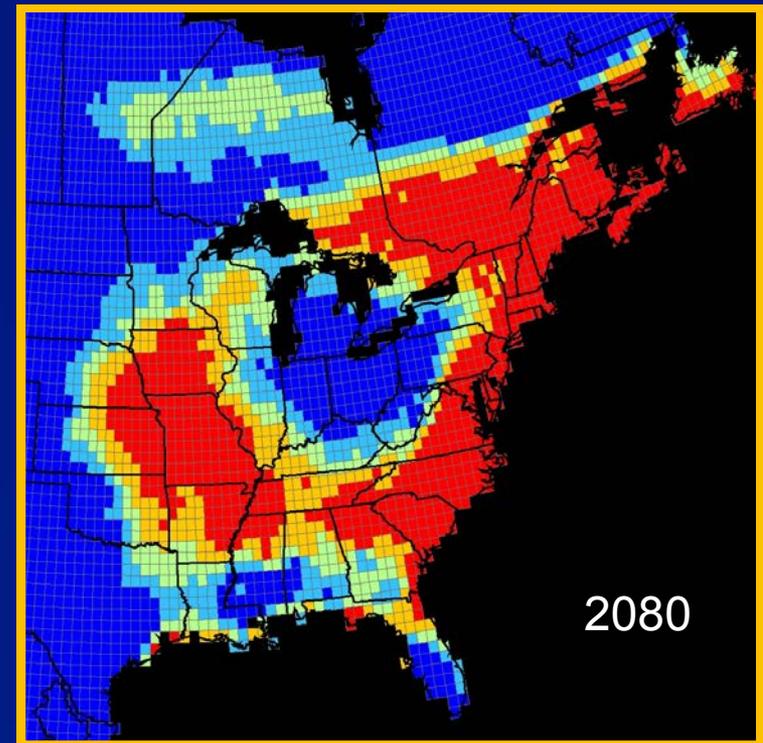
Because of Climate
Change, Vector
distributions will
increase in
latitude and altitude

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

□ Spread of Lyme disease factors

- Climate
- Ecological
- Social

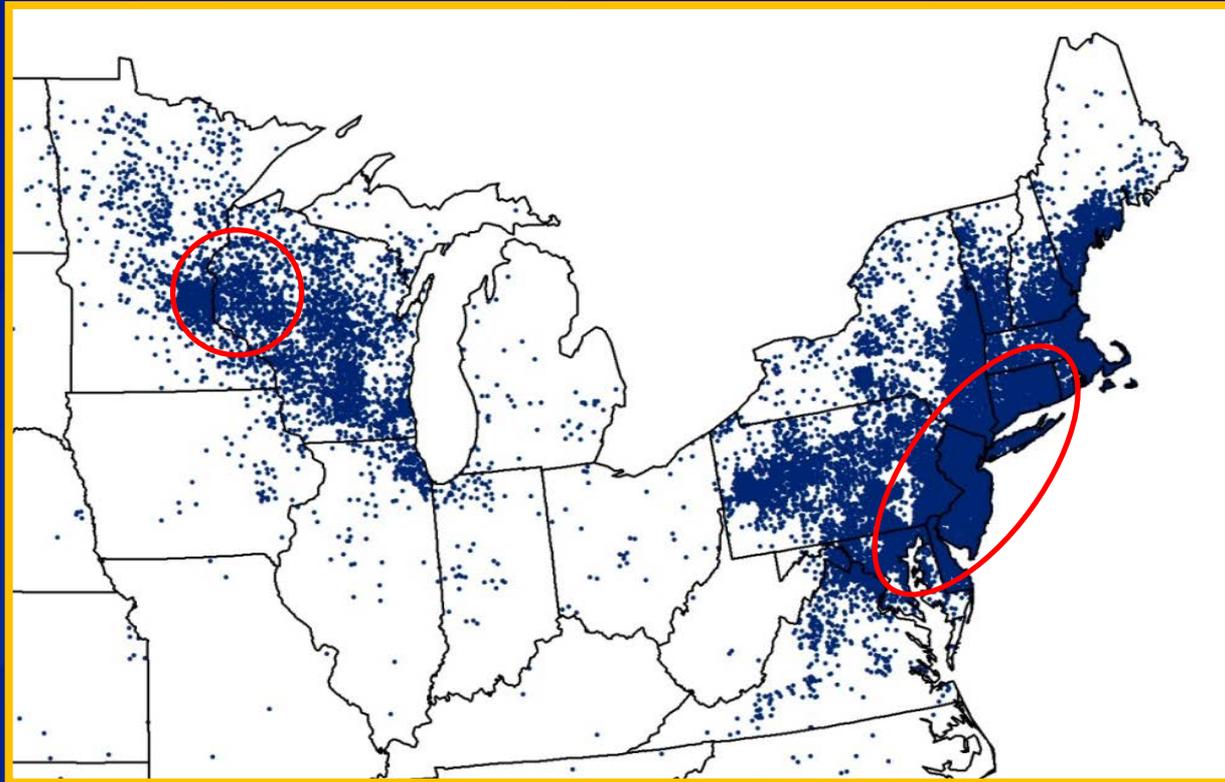
Range of suitable conditions for *Ixodes scapularis*, the Lyme disease tick



● Constant suitability ● Expanded suitability

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



2096



CLIMATE

Food Security Under Climate Change

Molly E. Brown and Christopher C. Funk

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

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 Brézat, 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

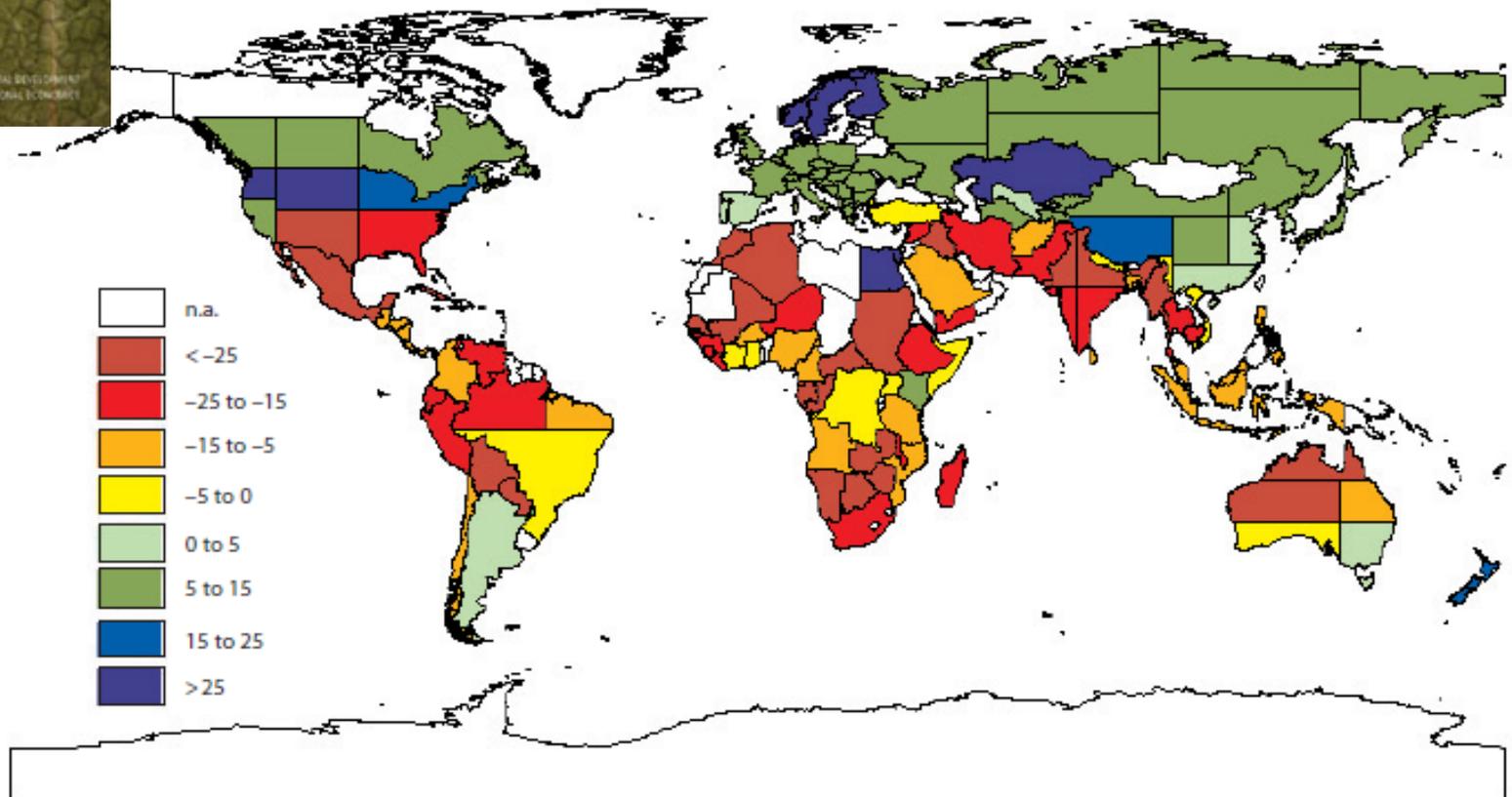
GLOBAL WARMING and AGRICULTURE

Impact Estimates by Country

William R. Cline

CENTER FOR GLOBAL DEVELOPMENT
INTERNATIONAL INSTITUTE FOR ECONOMIC RESEARCH

Impact on agricultural productivity with carbon fertilization (percent)



Cereal yield: Developed vs. Developing Countries, 2060

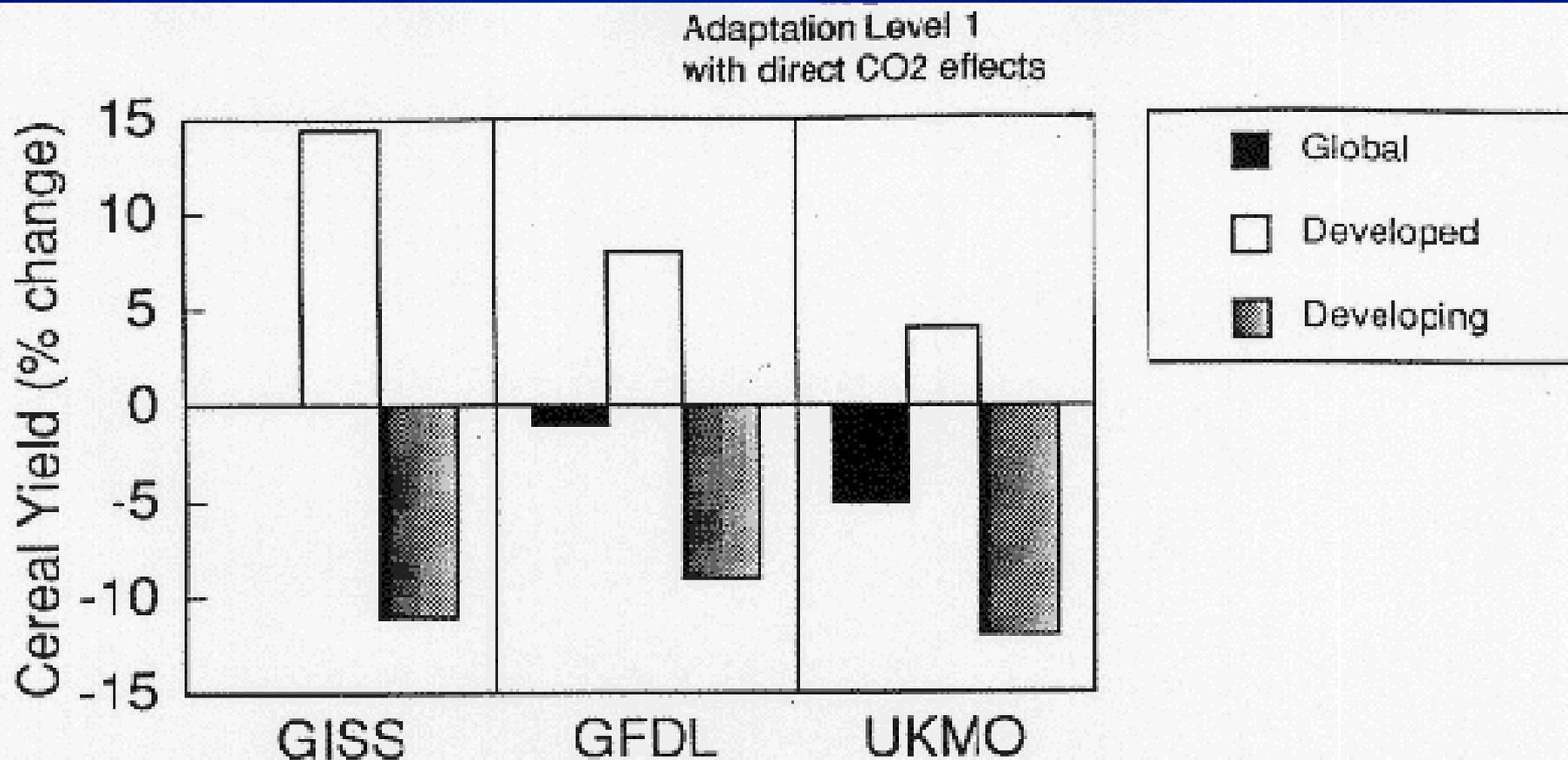


Figure 4. Predicted change in cereal production in 2060 in developed and developing countries, and at the global level. Three climate model scenarios are also compared. These values based on farmer Adaptation Level 1 response to climate change (minor adjustments), and an assumption of positive direct effects of CO₂ on yields. Source: Rosenzweig and Parry (1993).

Effects of elevated CO₂ 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

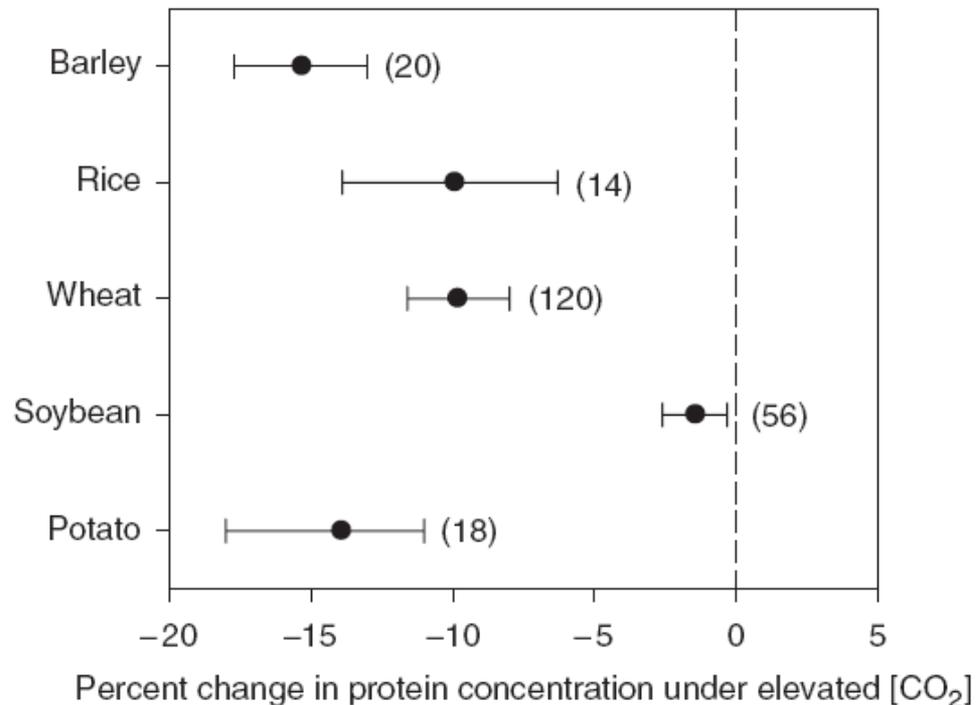
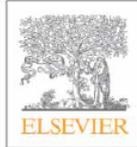


Fig. 1 Response of crop protein concentrations to growth at elevated CO₂ for five major crops. Means and 95% confidence limits are depicted. Numbers of experimental observations for each species are in parentheses.

Mental Health: Post-Disaster



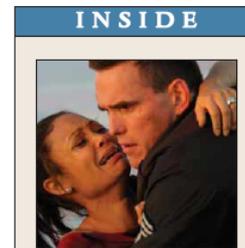
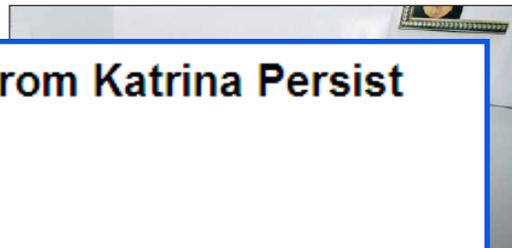
Clinical Psychiatry News

www.clinicalpsychiatrynews.com

VOL. 33, No. 10

The Leading Independent Newspaper for the Psychiatrist—Since 1973

OCTOBER 2005



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. 8 (AP) — Hurricane Katrina's gutted houses and empty streets alone

The most devastating and destroyed en more than a year discussion Wedne

Newsweek Home » Healthbeat

Newsweek Health

Subscribe Now | Make Newsweek Your Homepage | Newsletters | RSS

'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.

thousands of people faces of people id in a panel

TIME

IN PARTNERSHIP WITH CNN

HOME U.S. WORLD BLOGS BUSINESS & TECH HEALTH & SCIENCE ENTERTAINMENT

Is New Orleans Having a Mental Health Breakdown?

By RUSSELL MCCULLLEY/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."

ARTICLE TOOLS

- Print
- Email
- Sphere
- AddThis
- RSS

SPONSORED BY



Mental health: Anticipatory

BBC
NEWS

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."

The Boston Globe

HOME / LIFESTYLE / GREEN LIVING

Climate change takes a mental toll

By [Emily Anthes](#)

Globe Correspondent / February 9, 2009

Email | Print | Single Page | [Yahoo! Buzz](#) | [ShareThis](#)

The Boston Globe

Text size - +

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

Last Updated: Tuesday November 14 2006 11:15 GMT

E-mail this to a friend

Printable version

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.

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

The survey quizzed 1,554 kids on their views on the

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

[Add a comment \(5\)](#)



ANCIENT graveyards are being dragged out to

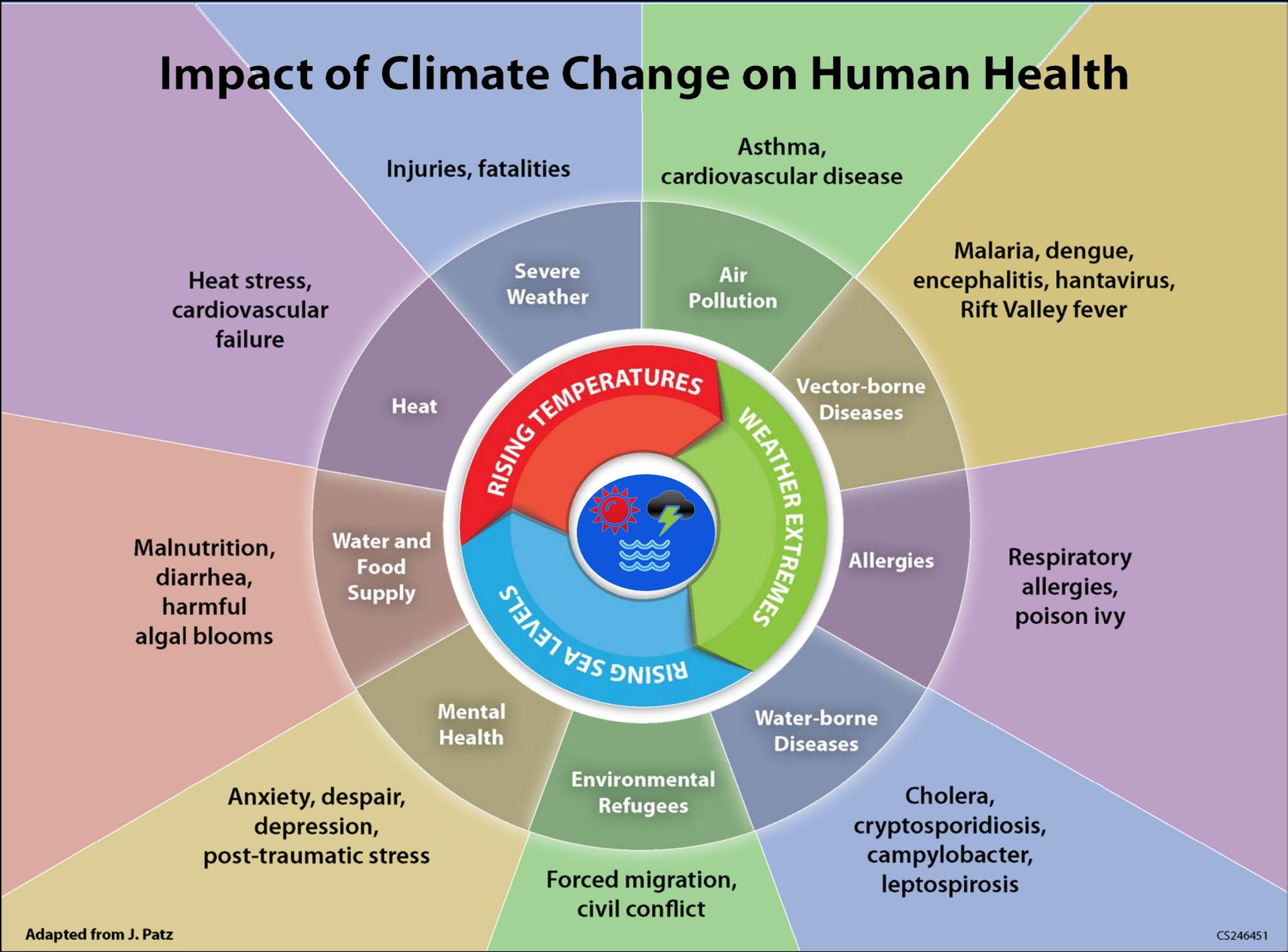
MULTIMEDIA

[Grave danger in the Arctic](#)

RELATED STORIES

Alaska's net on

Impact of Climate Change on Human Health



Now the bad news...

- Despite existing breadth of organizations and sectors with initiatives on climate change
- Despite the likelihood of anticipated health effects of climate change

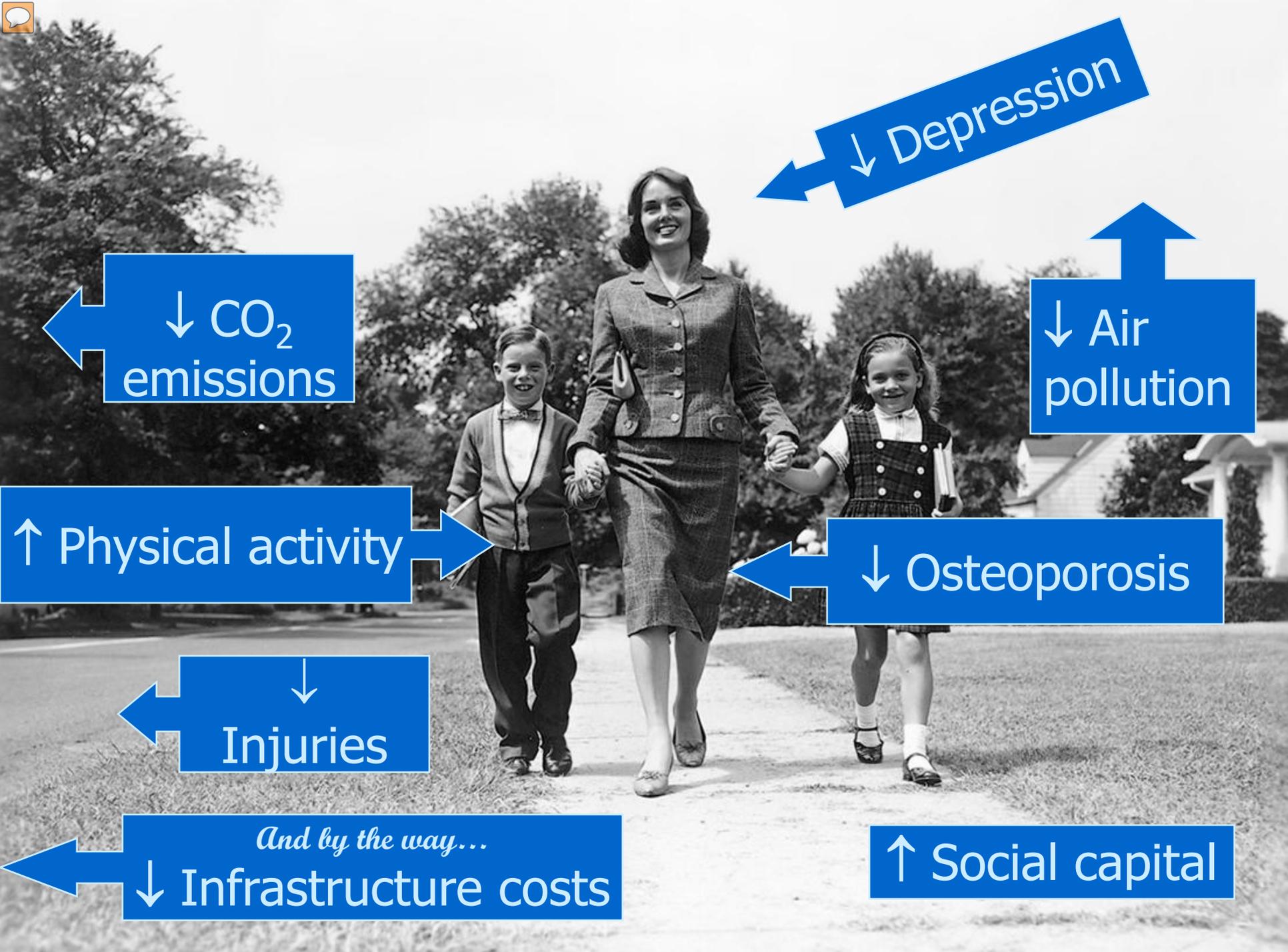
Public health effects of climate change remain largely unaddressed

The Path(s) Forward

Framing Climate Change as a Societal Issue, (and not just an Environmental one)

Path #1: Identify Co-benefits and Synergies

- Efforts to mitigate or adapt to the effects of climate change frequently yield other health benefits.



↓ Depression

↓ CO₂ emissions

↓ Air pollution

↑ Physical activity

↓ Osteoporosis

↓ Injuries

And by the way...
↓ Infrastructure costs

↑ Social capital

Climate Change Synergies

Heat wave plans using “buddy systems”	↑ social capital, ↑ community resiliency
↓ vehicular travel	↓ car crashes, ↓ air pollution
↑ fuel efficiency	↓ air pollution
Locally grown food	↓ pesticide loading, ↓ fuel
Energy-efficient buildings	↓ operating costs
Alternative energy sources	Business opportunities



Path #2: Focus on the Most Vulnerable in Our Communities

Environmental Justice, poverty and
disempowerment as critical vulnerability factors

**“The rich will find their world to be more
expensive, inconvenient, uncomfortable,
disrupted and colorless — in general, more
unpleasant and unpredictable, perhaps greatly
so. The poor will die.”**

Kirk R. Smith, 2008

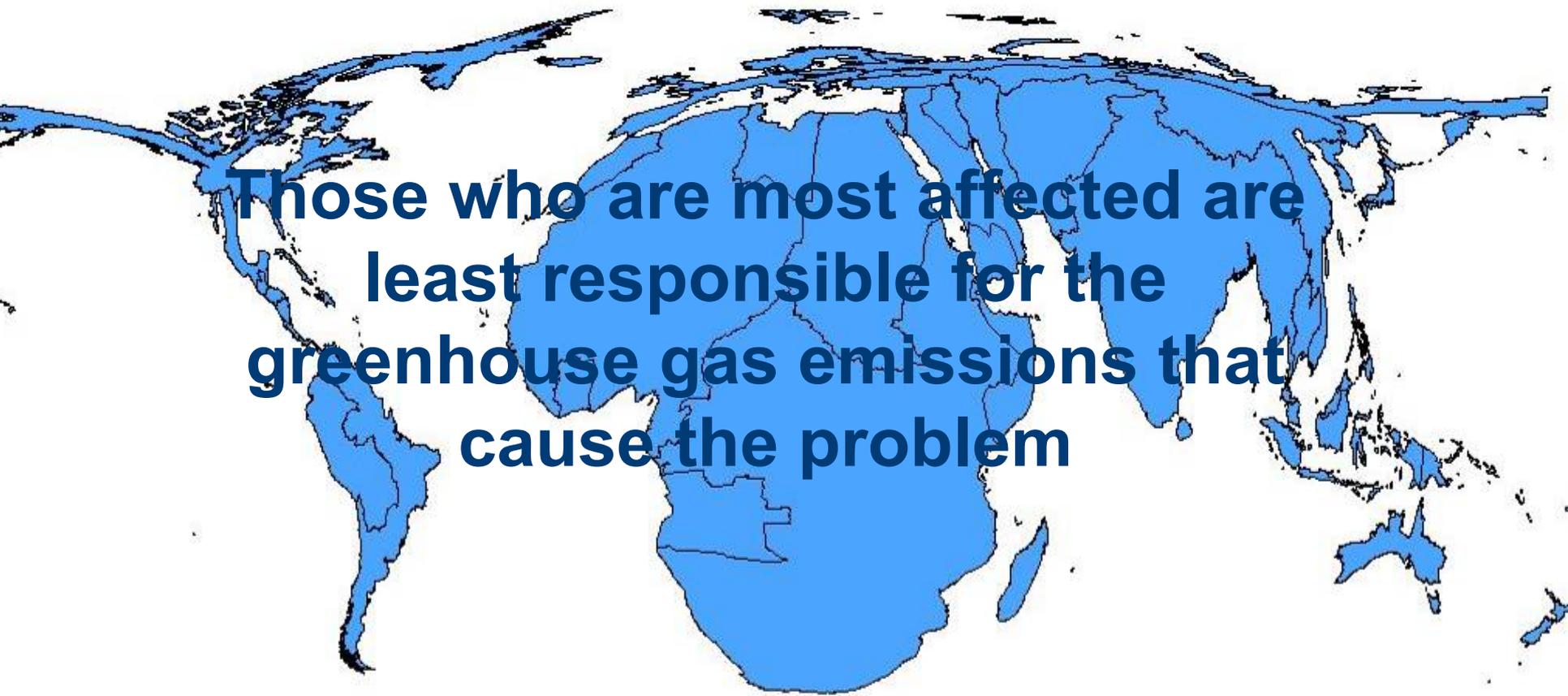
Professor, Environmental Health Sciences, UC- Berkeley

Carbon Emissions

(Density-Equalizing Cartogram)

The United States emits one quarter of the worlds gases that cause global warming.

Climate-Related Mortality

A world map with a light blue background and black outlines of continents. The text is centered over the map.

**Those who are most affected are
least responsible for the
greenhouse gas emissions that
cause the problem**



Low-income people typically lack insurance to replace possessions lost in storms. Only 25 percent of renters have renters insurance.



Path #3: Bringing the Community into the Dialogue

Effective adaptation planning must start with community input.

Qualitative approaches must augment environmental monitoring to elucidate pathways for exposure, and system vulnerabilities



Community-Based Participatory Research for Adaptation Planning

- **Building community partnerships – Citizen Science**
 - **Systematic , on-going, collection of community observations of unusual shifts in local ecosystems and health hazards**
 - **Develop culturally appropriate risk communications and inform adaptation planning for Health and other sectors**



Alaskan coastal erosion from permafrost degradation



Re-Framing the Climate Change Dialogue



Conclusions



- Climate change is now a mainstream issue
- Climate change must also be framed as a human welfare and public health issue.
- Opportunity costs of not taking action are high



Thank You



Contact:

George Luber, PhD

Associate Director for Global Climate Change

National Center for Environmental Health

gluber@cdc.gov

Tel: 770-488-3429

SAFER • HEALTHIER • PEOPLE™