Under the Weather?
The Health Consequences of a Changing Climate

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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
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Source: National Climatic Data Center, NOAA
After 40 more years at the current rate of increase.

Source: National Climatic Data Center, NOAA
Objectives

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• 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

Heat Content (10^2 Joules)

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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

Sea Ice Concentration

Source: NASA Earth Observatory
Ten Indicators of a Warming World
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)

Rising Temperatures
1991-2012 average temperature compared with 1901-1960 average

MAY 6, 2014

Source: National Climatic Data Center
Summer Temperatures Have Shifted 1951 – 1980

Summer Temperatures Have Shifted

Summer Temperatures Have Shifted
1991 – 2001

Summer Temperatures Have Shifted 2001 – 2011

The “extreme” temperature events used to cover 0.1% of the Earth. Now they cover 10%.

Some Extreme Events will be well beyond historical experience

European Heat Wave of 2003

Confirmed Mortality

<table>
<thead>
<tr>
<th>Country</th>
<th>Mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td>UK</td>
<td>2,091</td>
</tr>
<tr>
<td>Italy</td>
<td>3,134</td>
</tr>
<tr>
<td>France</td>
<td>14,802</td>
</tr>
<tr>
<td>Portugal</td>
<td>1,854</td>
</tr>
<tr>
<td>Spain</td>
<td>4,151</td>
</tr>
<tr>
<td>Switzerland</td>
<td>975</td>
</tr>
<tr>
<td>Netherlands</td>
<td>1,400-2,200</td>
</tr>
<tr>
<td>Germany</td>
<td>1,410</td>
</tr>
<tr>
<td>TOTAL</td>
<td>29,817-30,617</td>
</tr>
</tbody>
</table>

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

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 Mortality

Accidental Deaths ↑120%
Nonaccidental Deaths ↑25%

Anderson and Bell (2012)
Katrina Diaspora
“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**
  - ↑ 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:

<table>
<thead>
<tr>
<th>Area</th>
<th>Period of collection</th>
<th>Average CO₂ level, parts per million in the air</th>
<th>Pollen count, grains per cubic meter of air</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban</td>
<td>July 30-Sept. 7</td>
<td>600</td>
<td>12,138</td>
</tr>
<tr>
<td>Suburban</td>
<td>Aug. 6-Sept. 10</td>
<td>400</td>
<td>3,262</td>
</tr>
<tr>
<td>Rural</td>
<td>Aug. 15-Sept. 17</td>
<td>200</td>
<td>2,294</td>
</tr>
</tbody>
</table>

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).
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/m³ 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%.\(^{4}\)

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67% of waterborne disease outbreaks preceded by precipitation above 80th percentile (across 50 year climate record)

Heavy precipitation events projected to occur more frequently

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

Lyme Disease Case Distribution Change in the United States

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 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§

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Carbon Fertilization and Agricultural Productivity
Effects of elevated CO₂ on the protein concentration of food crops: a meta-analysis

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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.
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 countries dependent on C3 grains for protein.

Mental Health Problems From Katrina Persist

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

ATLANTA, Nov. 9 —Hurricane Katrina and the gutted houses and empty streets along more than a year after the storm have left the faces of people who were once known for their resilience sundered in a panel...
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."

Climate change takes a mental toll

By Emily Anthes
Globe Correspondent / February 9, 2009

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, Alaska

Gravesite erosion

Ancient graves pulled to sea

ANCIENT graveyards are being dragged out to sea by the rate of erosion that scientists now confirm is occurring in some parts of the Arctic. Human remains... dragged to sea.

By SEBASTIAN LANDER
in Alaska
Published: 03 May 2008
Add a comment (5)

MULTIMEDIA

Grave danger in the Arctic

RELATED STORIES

Alaska's not on
Impact of Climate Change on Human Health

- Injuries, fatalities, mental health impacts
- Asthma, cardiovascular disease
- Heat-related illness and death, cardiovascular failure
- Malaria, dengue, encephalitis, hantavirus, Rift Valley fever, Lyme disease, chikungunya, West Nile virus
- Forced migration, civil conflict, mental health impacts
- Respiratory allergies, asthma
- Malnutrition, diarrheal disease
- Cholera, cryptosporidiosis, campylobacter, leptospirosis, harmful algal blooms

Key Points:
- Rising CO2 Levels: Climate Change
- Severe Weather
- Air Pollution
- Changes in Vector Ecology
- Increasing Allergens
- Rising Sea Levels
- Water and Food Supply Impacts
- Water Quality Impacts
- Extreme Heat
- Environmental Degradation

These factors contribute to a range of health impacts, from immediate threats like heat-related illness to chronic issues like respiratory allergies.
Adaptation: Shifting the Coping Range

Stationary Climate & Coping Range

Changing Climate

Vulnerable

Adaptation

Coping Range

Vulnerable

Planning Horizon
How to Shift a Coping Range?

- Return to the risk equation
  - Reduce hazard probability
  - Reduce hazard exposure
  - Reduce vulnerability

- It is an iterative process

- Requires modeling, learning, and adaptive management

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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 Luber1

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

01 Forecasting Climate Impacts and Assessing Vulnerabilities
02 Projecting the Disease Burden
03 Assessing Public Health Interventions
04 Developing and Implementing a Climate and Health Adaptation Plan
05 Evaluating Impact and Improving Quality of Activities

BRACE
Building Resilience Against Climate Effects
NEW YORK CITY:
Creating Resilient Communities

ARIZONA: 
Readying for Extremes

THE THREAT TO HEALTH:
- Average winter temperature in 2010 was 12°F below normal
- The rate of death due to heat-related causes more than doubled from 1999 to 2005
- Arizona residents are very healthy overall, but severe heat-related illnesses can happen to anyone

ADAPTATION IN ACTION:
- Solar panels and energy-efficient buildings have been installed across the state
- Hot days are now declared a public health emergency

MICHIGAN:
Responding to Local Needs

THE THREAT TO HEALTH:
- More than 2,000 people in Michigan suffered from heat-related illnesses in 2010
- The rate of hospitalizations due to heat-related illnesses has increased by 50% since 1999

ADAPTATION IN ACTION:
- Programs to assist low-income families with energy-efficient upgrades have been implemented
- Public education campaigns on heat safety have been launched

To learn more about the Arizona effort, visit the Arizona Climate Action Plan website: [www.azclimateplan.org](http://www.azclimateplan.org)

To learn more about the Michigan Climate and Health Adaptation Program, visit [www.michigan.gov/climatehealth](http://www.michigan.gov/climatehealth)
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

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
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The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.