The Greenhouse effect

Solar radiation passes through the clear atmosphere.
Incoming solar radiation: 343 Watt per m²

Solar energy is absorbed by the earth’s surface and warms it...
168 Watt per m²

Some solar radiation is reflected by the atmosphere and earth’s surface
Outgoing solar radiation: 103 Watt per m²

Some of the infrared radiation is absorbed and re-emitted by the greenhouse gas molecules. The direct effect is the warming of the earth’s surface and the troposphere.

Surface gains more heat and infrared radiation is emitted again

Some of the infrared radiation passes through the atmosphere and is lost in space
Net outgoing infrared radiation: 240 Watt per m²

Net incoming solar radiation: 240 Watt per m²

Sources: Okanagan university college in Canada, Department of geography, University of Oxford, school of geography; United States Environmental Protection Agency (EPA), Washington; Climate change 1995, The science of climate change, contribution of working group 1 to the second assessment report of the intergovernmental panel on climate change, UNEP and WMO, Cambridge university press, 1996.
Direct Observations of Recent Climate Change

- Global mean temperature
- Global average sea level
- Northern hemisphere snow cover
Global mean temperatures are rising.

<table>
<thead>
<tr>
<th>Period</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Years</td>
<td>°/decade</td>
</tr>
<tr>
<td>1961-90</td>
<td>0.074 ± 0.018</td>
</tr>
<tr>
<td>1981-90</td>
<td>0.128 ± 0.026</td>
</tr>
</tbody>
</table>

Pasterze Glacier, Austria

1875

2004
Glacier Bay National Park, 1941. The glacier is 2,000 feet thick. USGS photo, available www.coasttocoastam.com/shows/2005/01/29.html
A Smaller Ice Cap

The ice covering the Arctic Ocean shrank to its smallest size in a century this summer, continuing a trend of decades.

EXTENT OF SUMMER SEA ICE
In millions of square miles

Sources: William Chapman and John Walsh (left); National Snow and Ice Data Center (above)
Impacts of Climate Change: IPCC Projections to 2100

- Higher temperatures: 1.1 – 6.4 °C (2.0 – 11.5 °F) mean global surface temperature rise
- Rising sea-levels: 0.18 - 0.59 m (7.1 – 23.2 inches)
- More severe precipitation extremes (storms and droughts)
Very likely that heat waves, and heavy precipitation events will become more frequent.

Likely that tropical cyclones will become more intense, with larger peak wind speeds and more heavy precipitation.
Extreme Weather Events

Droughts

Blizzards

Floods

Tornados

Hurricanes
A July day in Atlanta that now reaches a heat index of 105°F would reach a heat index of 115°F in the Hadley model, and 130°F in the Canadian model.
Warming in the US is projected to vary by region.
Extremes impact people more than mean.

Peterson et al., 2007b
Some occurrences will be well beyond historical experience

European heat wave of 2003, from Schär et al., 2004
**European heat wave, 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><strong>TOTAL</strong></td>
<td><strong>29,817-30,617</strong></td>
</tr>
</tbody>
</table>

**TIME LINE (FRANCE)**


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).

- Urban heat islands
Urban Heat Island can add 7° – 12° F

Thermal Satellite Image of Phoenix, AZ Night Surface Temperature
Neighborhood Microclimates within the UHI

Mean Summer Temp (F) 106°F 99°F

Heat Wave Temp (F) 118°F 104°F

Harlan et al 2006
Maximum Daily Ozone Concentrations vs. Maximum Daily Temperature

Atlanta

New York
Health Effects of Air Pollution

- Damages lung tissue
- Exacerbates respiratory disease
- Reduces lung function
- Aggravates cardiovascular disease
Global Warming May Be Spurring Allergy, Asthma

Dr. Ziska's Ragweed Loves Carbon Dioxide; Toxic Pollen in Cities?

By GAUTAM NAIK
May 3, 2007; Page A1

There's growing scientific evidence that global climate change is linked to the dramatic rise in allergies and asthma in the Western world.

Studies have found that a higher level of carbon dioxide turbocharges the growth of plants whose pollen triggers allergies. In 2001 Lewis Ziska planted ragweed -- the main cause of hay fever in the fall -- at urban, suburban and rural sites near Baltimore. The plots had the same seeds and soil and were watered in the same way. Yet the downtown plants soon exploded in size, flowering earlier and producing five times the pollen of rural plants. The city pollen was a lot more toxic, too. The likely cause? The city plants experienced warmer temperatures and 20% more carbon dioxide, the effect of more cars and pollution.
Ragweed

- Genus *Ambrosia*
- ↑ CO$_2$ and temperature → ↑ pollen counts, longer growing season

Poison Ivy

- *Toxicodendron radicans*
- $\uparrow$ CO$_2$ leads to
  - $\uparrow$ photosynthesis
  - $\uparrow$ water use efficiency
  - $\uparrow$ growth
  - $\uparrow$ biomass
  - More allergenic urushiol
- Greater CO$_2$ stimulation than most other woody species

Prediction:
Because of Climate Change, Vector distributions will increase in latitude and altitude.
Associated Press

Updated: 4:57 p.m. ET March 30, 2007

The deadly hemorrhagic form of dengue fever is increasing drastically in Mexico, and experts predict a surge throughout Latin America fueled by climate change, migration and faltering mosquito eradication efforts.

Overall dengue cases have increased by more than 600 percent in Mexico since 2001, and worried officials are sending special teams to tourist resorts to spray pesticides and remove garbage and standing water where mosquitoes breed ahead of the peak Easter Week vacation season.

“A multidisciplinary panel of the World Health Organization, made up of the world’s leading climate scientists, predicted in March that global warming and climate change would cause an upsurge in dengue. In Mexico, officials say longer rainy seasons already are leading to more cases.

“It used to be seasonal, in the hottest, wettest months, and now in some regions we are seeing it practically all year,” said Joel Navarrete, an epidemiologist with the Mexican Social Security Institute.
Reported Cases of Dengue 1980-1999

Climate is one determinant of vector-borne disease incidence
International commerce and travel

Human behavior and prevention strategies

Land use and deforestation

Climate change and variability

Water storage and irrigation

Vector-borne diseases

Human population growth

Poverty

<table>
<thead>
<tr>
<th>Climate Change:</th>
<th>Potential Health Effects of Climate Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature rise</td>
<td>Heat stress, cardiovascular failure</td>
</tr>
<tr>
<td>Sea level rise</td>
<td>Injuries, fatalities</td>
</tr>
<tr>
<td>Hydrologic extremes</td>
<td>Asthma, cardiovascular disease</td>
</tr>
</tbody>
</table>

**HEAT**
- Heat stress, cardiovascular failure

**SEVERE WEATHER**
- Injuries, fatalities

**AIR POLLUTION**
- Asthma, cardiovascular disease

**ALLERGIES**
- Respiratory allergies, poison ivy

**VECTOR-BORNE DISEASES**
- Malaria, dengue, encephalitis, hantavirus, Rift Valley fever

**WATER-BORNE DISEASES**
- Cholera, cryptosporidiosis, campylobacter, leptospirosis

**WATER AND FOOD SUPPLY**
- Malnutrition, diarrhea, harmful algal blooms

**MENTAL HEALTH**
- Anxiety, despair, depression, post-traumatic stress

**ENVIRONMENTAL REFUGEES**
- Forced migration, civil conflict

Adapted from J. Patz
Other Considerations

- There will be significant regional variation in the effects of climate change
- There will be significant variation in the demographic groups affected by climate change
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
“Because we anticipate that as climate changes, there will be health consequences... We believe there are unpredictable health consequences that will occur and our job is to anticipate what they might be, to make sure that we have systems in place that can detect them, and, most importantly, that we take steps now to be able to help mitigate whatever those harms are. 

We're just at the very beginning of this, but we've already convened on climate change and health consequences and we are at the table.”

--Dr. Julie Gerberding, Director, CDC

TOWARD A PUBLIC HEALTH FRAMEWORK FOR ADDRESSING CLIMATE CHANGE

Guiding principles, both practical and ethical:

- Public Health Prevention Framework
- Co-Benefits and synergies
- Precautionary principle
- Environmental Justice
- Complexity/Ecosystems thinking
A PUBLIC HEALTH FRAMEWORK FOR ADDRESSING CLIMATE CHANGE

Guiding principles:

Public Health Prevention Framework:

- Primary prevention: aims to prevent the onset of injury or illness
  - Corresponds with *mitigation*—efforts to slow, stabilize, or reverse climate change by reducing greenhouse gas emissions.

- Secondary and Tertiary Prevention: aims to diagnose disease early in order to control its advance and reduce the resulting morbidity
  - Corresponds with *adaptation*—efforts to anticipate and prepare for the effects of climate change, and thereby to reduce the associated health burden.
Public Health role in Primary prevention (mitigation)

Mitigation efforts will largely occur in sectors other than health, however public health can:

- Reduce GHG emissions in our own operations (health care settings)
- Assess health implications of various mitigation strategies
- Educate the public and policymakers on health benefits of mitigation approaches.
Public Health Adaptations

Correspond closely to conventional public health practices.

These can include:

- Track and monitor disease (surveillance)
- Enhance emergency response capacity
- “Weatherize” communities
A PUBLIC HEALTH FRAMEWORK FOR ADDRESSING CLIMATE CHANGE

Guiding principles:

The Precautionary Principle:

“When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically”
Co-benefits and synergies

- Efforts to mitigate or adapt to the effects of climate change frequently yield other health benefits, both direct and indirect.
Physical activity

Air pollution

Infrastructure costs

Social capital

Carbon dioxide emissions

Injuries

Osteoporosis

And by the way...

Social capital
<table>
<thead>
<tr>
<th>Health &amp; Climate Change Adaptation Synergies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat wave plans using “buddy systems”</td>
</tr>
<tr>
<td>↑ social capital,</td>
</tr>
<tr>
<td>↑ community resiliency</td>
</tr>
<tr>
<td>↓ vehicular travel</td>
</tr>
<tr>
<td>↓ car crashes, ↓ air pollution</td>
</tr>
<tr>
<td>↑ fuel efficiency</td>
</tr>
<tr>
<td>↓ air pollution</td>
</tr>
<tr>
<td>Locally grown food</td>
</tr>
<tr>
<td>↓ pesticide loading, ↓ fuel</td>
</tr>
<tr>
<td>Energy-efficient buildings</td>
</tr>
<tr>
<td>↓ operating costs</td>
</tr>
<tr>
<td>Alternative energy sources</td>
</tr>
<tr>
<td>Business opportunities</td>
</tr>
</tbody>
</table>
Environmental Justice

Climate change will disproportionately threaten certain populations, especially poor people and members of ethnic and racial minority groups.
The United States emits one quarter of the world's gases that cause global warming.
Persons killed by disasters: 1975 - 2004

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.
A PUBLIC HEALTH FRAMEWORK FOR ADDRESSING CLIMATE CHANGE

Guiding principles:

*Complexity and Ecosystems thinking*
CDC’s Priority actions for Climate Change

- A set of “priority actions” that guide the public health approach

- Emerged from recommendations to the CDC Climate Change Workgroup during the January 2007 meeting

- Forms the cornerstone for CDC’s policy on Climate Change
  http://www.cdc.gov/nceh/climatechange/
CDC’s Priority health actions for climate change

#1 Serve as a credible source of information on the health consequences of climate change
CDC’s Priority health actions for climate change

#2 Track data on environmental conditions, disease risks, and disease occurrence related to climate change.

- Will require *enhancement and expansion* of national disease surveillance systems and the *integration* of infectious and environmental disease information systems
CDC’s National Environmental Public Health Tracking Program
#3 Expand capacity for modeling and forecasting health effects that may be climate-related.
Risk for Hyperthermia: Thermal & Census Model

Legend
- Death from Hyperthermia (Primary Cause)
- Risk as Predicted from Neural Network
  - Low
  - Moderate
  - High

Death Locations are in Assigned Census Tracts but are Randomly Offset to Protect Privacy
CDC’s Priority health actions for climate change

#4 Enhance the science base to better understand the relationship between climate change and health outcomes.

Sponsor extramural research, Centers of Excellence in Climate Change
CDC’s Priority health actions for climate change

#5 Identify locations and population groups at greatest risk for specific health threats, such as heat waves.

Examples:
Epidemiologic investigations
Vulnerability mapping
Composite Vulnerability Map

Sensitivity to heat stress in London

sensitivity index based on percentages per district (Lower Level Output Area) on high age, preexisting illness, people living in communal establishments, population density, Index of multiple deprivation (IMD), living in flats, households on 5th floor and higher and single pensioners.
#6 Communicate the health-related aspects of climate change, including risks and ways to reduce them, to the public, decision makers, and healthcare providers.
CAUTION

THIS SIGN HAS SHARP EDGES

DO NOT TOUCH THE EDGES OF THIS SIGN

ALSO, THE BRIDGE IS OUT AHEAD
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."
Go to an air conditioned place during a heat wave.

Heat waves can kill you. A heat wave is when the temperature is over 90 degrees for 3 days or longer. During heat waves, many people die or get very sick. Your body may not be able to stay cool if you do not have air conditioning or your electricity goes off. People who are over 65 with other health problems are in the most danger. Going to a cooler place, even for 2 or 3 hours a day, gives your body a chance to cool down. This can save your life.

If you are over 65, you may be in danger even if you do not feel hot.
- Look at a thermometer to see the temperature in your home or apartment.
- Some prescription drugs make it harder to stay cool or know when you are too hot.
- Check on your older neighbors and relatives to make sure their home is cool.

Spend two to three hours in air conditioning during the hottest part of the day. Cool places include:
- public libraries
- malls
- senior centers
- air-conditioned homes of friends/relatives
- emergency cooling centers

If you need a ride,
- Ask for help. Call your local bus service or health department for information on getting to an Emergency Cooling Center.
- You may also ask a friend, relative, or church for help.
- In an emergency, always call 911.
Priority health actions for climate change

#7 Develop partnerships with other government agencies, the private sector, nongovernmental organizations, universities, and international organizations
Priority health actions for climate change

#8 Provide technical advice and support to partners in developing and implementing response plans for health threats.
Excessive Heat Events (EHE) Guidebook

- Assists in the development of city-specific heat response plans

- Provides guidance on:
  - Options for defining EHE conditions
  - How to assess local vulnerability
  - EHE notification and response actions that work
Priority health actions for climate change

#9 Promote workforce development by ensuring the training of a new generation of competent, experienced public health staff to respond to the health threats posed by climate change.
Adaptation strategies for health

- Study and predict links between climate change and health
- Track diseases and trends related to climate change
- Investigate infectious water-, food-, and vector-borne disease outbreaks
- Communicate effectively on climate change
- Heat wave and severe storm response plans; focus on the most vulnerable
- Partnerships with private sector, civic groups, NGOs, faith community, etc.
- Public health workforce prepared to respond
- Investigate infectious water-, food-, and vector-borne disease outbreaks
- Monitor Health
- Inform, Educate, Empower
- Mobilize Community Partnerships
- Develop Policies
- Enforce Laws
- Link to / Provide Care
- Assure Competent Workforce
- Evaluate
- System Management
- Research
- Diagnose & Investigate
- Policy Development
Conclusions

- Climate change is a mainstream issue
- Climate change is a public health issue
- Opportunity costs of not taking action are high
- There are effective, science-based activities and messages for public health to conduct and deliver
Thank You

Contact:
George Luber, PhD
Associate Director for Global Climate Change
National Center for Environmental Health

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Tel: 770-488-3429