Climate Change: Observed & Projected Impacts

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Consumer Liaison Committee

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Entering our 4th 5-year cycle of review and synthesis of scientific literature

• 1300 Authors; 1100 Expert Reviewers
• Policy relevant (not policy prescriptive)
The Greenhouse effect

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

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

...and is converted into heat causing the emission of longwave (infrared) radiation back to the atmosphere

Net outgoing infrared radiation: 240 Watt per m²

Not incoming solar radiation: 240 Watt per m²
CO₂ Creates a Heat-Trapping Blanket

A Tale of Three Planets

Mars
Thin atmosphere
(Almost all CO₂ in ground)
Average temperature: -50°C

Earth
0.03% of CO₂ in the atmosphere
Average temperature: +15°C

[minus 15°C (or 5°F) without CO₂]

Venus
Thick atmosphere containing 96% of CO₂
Average temperature: +420°C

[only 50°C without CO₂]
Greenhouse Gases

- Observed climate-change phenomena are consistent with the predictions of climate science for human-caused GHG-induced warming.

- No alternative “culprit” identified so far – no potential cause of climate change other than greenhouse gases – yields this “fingerprint” match.

- A credible alternate theory would need to explain both what the alternative cause of the observed changes is and how it could be that GHGs are NOT having the effects that all current scientific understanding says they should have.
Natural (solar + volcanic) forcing alone does not account for warming in the past 50 years. 1°F average warming thus far.

• human influences alone (greenhouse gases and sulfate aerosols) brings the models and observations into pretty good agreement.

Fingerprint:
Temperatures higher than in past 1000 years, and increasing at fastest rate over this period

>> “Warming Commitment” is greater:
Most of warming still locked in the oceans

Major cause is human activity IPCC (2001)
Average temperature throughout human agricultural history

IPCC (2001) forecast:
+ 1.4-5.8°C (3-8°F)

2x CO² (only)

21st century: rapid rise

End of last ice age
Younger Dryas
Holocene Optimum
Mesopotamia flourishes
Vikings in Greenland
Black Death
Little Ice Age in Europe (15th-18th centuries)
Medieval Warm

Temp. change (°C)

10,000 20,000 1,000 300 100 1940 Now +100

Agriculture emerges

10,000
2,000
1,000
300
100
Now
+100

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Fingerprints: Temperature and Precipitation Departures from Normal

**Temperature**

Red circles reflect warming; Blue circles reflect cooling

**Precipitation**

Red circles reflect increasing precipitation; Blue circles reflect decreasing precipitation

Note: Cooling in southeast U.S. may be due to sulfate aerosol influence

Source: Karl et al. (1996)
Fingerprint: Percent of the Continental U.S. with Above-normal Proportion of Torrential Rainfall
Fingerprint: Torrential Rain
Great Lakes Region

Projections:
- Doubling of heavy precipitation events
- Seasonal shifts in precipitation –
  * More rain in winter and spring (planting season)
  * Less rain during the summer and fall growing seasons
Fingerprint: Loss of Ice & Snow Cover

1979

Implications:

- Loss of land ice contributes to sea-level rise
- “Darkens” Earth’s surface
- “Sweetens” northern oceans

1979-2003: 44% reduction in thickness

2003

90 deg N
August 7, 2004
Harvard University expedition to North Pole
Fingerprint: Sea-Ice Extent Has Dropped by 1 M miles² Since 1970
Fingerprint: Worldwide Glacier Retreat

Americas
Europe
Asia
Africa
Australasia

Grinell Glacier, “Glacier” National Park, USA
Fingerprint: Sea Level Rise

Increase: 10-20 cm (4-8 inches) in 20\textsuperscript{th} Century
Fingerprint: Rise in Number and Change in Mix of Natural Disasters

Source: Center for Research in the Epidemiology of Disasters (CRED)
Climate change leads to a range of important impacts

**Climate Changes**
- Temperature
- Precipitation
- Sea Level Rise

**Health Impacts**
- Weather-related mortality/heat stress
- Infectious diseases
- Air quality-induced respiratory effects

**Agriculture Impacts**
- Crop yields and commodity prices
- Irrigation demands
- Pests and weed

**Forest Impacts**
- Change in forest composition
- Shift geographic range of forests
- Forest health and productivity

**Water Resource Impacts**
- Changes in water supply and timing
- Water quality
- Increased competition for water

**Coastal Area Impacts**
- Erosion of beaches
- Inundation of coastal wetlands
- Costs to defend coastal communities

**Ecosystem Impacts**
- Shifts in ecological zones
- Loss of habitat and species
- Coral reefs threatened
Changes in Averages Create Even Greater Changes in Extremes

Source: IPCC, Third Assessment Report
Example: the 2003 European Heat Wave
(hottest summer since 1500 AD)

- Multiple correlated, impacts:
  - 22,000-35,000 human fatalities
  - $13.6B in crop losses
  - $1.7B in wildfires in Portugal alone + respiratory illness
  - Nuclear power plant curtailment (insufficient cooling water)
  - Unhealthy air masses (smog, particulate)

Green: Fitted Gaussian distribution; Red: 2003
Source: Schar 2004 (Nature)
Shifting *Location* of Extremes

By the end of this century, temperatures expected to rise 9-18 degrees F in summer; 7-13 degrees F in winter.

- More precipitation in winter and spring
- Less precipitation in summer and fall
- More precipitation falling in extreme events (50-150% higher than today)
“Catastrophe insurers can't simply extrapolate past experience.”

- Warren Buffett (1992)

Note: diagram shows only large events (small events double these totals) and excludes health/life losses. Including small scale events would double these numbers; health-related losses unknown
Small-scale, Gradual, Diffuse, and Indirect Events Often Overlooked

• **Small-scale**
  – Storms, Subsidence, Lightning, Hail, Ice Storms, Wildfire, Equipment Breakdown, Blackouts, Vehicle damages/injuries, Mudslides

• **Gradual/Diffuse**
  – Sea-level rise, Drought, Infectious diseases

• **Indirect**
  – Eroded water quality
  – Eroded air quality
  – Health (human, crops, etc.)
  – Amplification of poverty (slows market growth; elevates political risk)
Temperature-Related Insurance Loss Experience

Subsidence claims increase with drought: UK 1975-1999

Source: Association of British Insurers
Temperature-Related Insurance Loss Experience

Lightning-related claims *accelerate* with temperature

5-6% increase in air-ground lightning for each 1-degree increase in air temperature

Each symbol represents a lightning storm event

Source: Hartford Steam Boiler Inspection and Insurance Co.
Temperature-Related Insurance Loss Experience

Air-conditioning breakdown claims increase with cooling degree days: 1994-1999

Source: Hartford Steam Boiler Inspection and Insurance Co, 2001
Future Sea-level Rise

Nationally: 25% of homes within 150 yards of current high-tide mark at risk over next 60 years

Source: Heinz Center (for FEMA)

Source: USEPA
Property Loss from Coastal Erosion

60-year coastal erosion outlook for South Bethany, Delaware -- 3 rows of homes to be lost

Source: Heinz Foundation (for FEMA)
Wildfire

Fingerprint:
Average area of North American boreal forest burned has doubled since 1970

Development in wildland/urban interface compounds the problem

California wildfires increase up to 4x under climate change

Includes Full available suppression

Source: Ton et al. (1995)
Human Health

• Heat catastrophes (mortality and morbidity)
• Respiratory Illness
  – Pollen - e.g. 60% more ragweed pollen at 2x CO₂
  – Mold - product of increased CO₂, temps, and moisture
  – Particulate - fossil fuel combustion; wildfire
  – Temperature-dependent air pollution
• Infectious disease
  – Resurgent and redistributing: dengue fever, Encephalitus, Malaria, Rift Valley Fever, West Nile Virus, Hantavirus, Cholera, Lyme Disease
  – Newly Emerging: Nipah Virus - highly contagious; lethal in > 40% of cases

WHO estimates 150,000 human mortalities each year due to current climate change
Correlation of Disease Outbreaks with the 1997-1998 El Nino

El Nino expected to become more frequent under climate change

Source: Harvard Medical School, Center for Health and the Global Environment (Science)
Health: Other Systems

- Other Systems
  - Insect super-infestations
  - Crop damages and diseases
  - Coral bleaching - implications for coastal protection; tourism; fresh water salinization

Pine Beetle Infestation:
- Great Lakes
- Residential property and intermixed beetle-kill

Temperature-driven pine beetle "super infestations"
Spread of West Nile Virus in North America: 1999-2002

Drought-Mosquito-Bird Vector chain

Human Impacts:
2001: 66 cases; 9 deaths
2002: 4161 cases; 284 deaths


233 Other species

Sources: U.S. Army Environmental Programs Directorate, from Centers for Disease Control, Health Canada, USGS, and ProMED-mail as of 14 May 2003)
Sectoral Impacts: Energy

- Vulnerabilities
  - Storm - power transmission
  - Lightning - outages
  - Drought - hydro
  - Temperature - peak demand
  - Subsidence & permafrost melt - pipelines, generators
  - Sea level rise - refineries

Current insured losses from outages unknown: most are below PCS threshold for being “worth” counting.

US total ~$80B/year.

Munich Re
Why Worry?

• The future that will *not* mirror the past
• Losses becoming less predictable
• Increased loss frequency
• A shift in location of loss
• More co-incidence and correlation of loss
• Trends not necessarily gradual or linear
• New types of losses (“surprise”)
• Financial and physical CAT models based on past outcomes will have decreasing accuracy
"Everybody talks about the weather, but nobody does anything about it." -- Charles Dudley Warner (Hartford Courant (1897)

More Information

http://eetd.lbl.gov/insurance

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