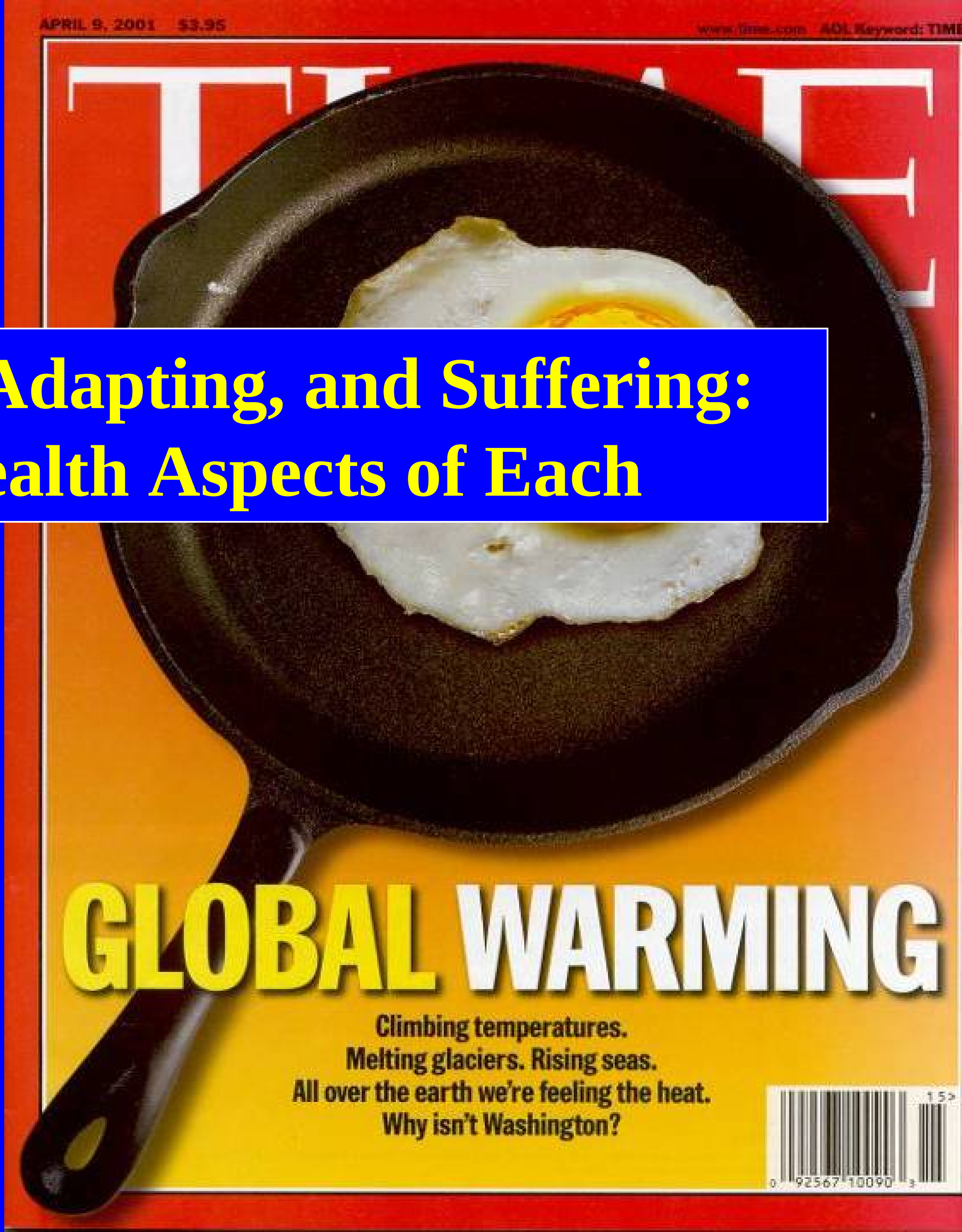
Climate Change and Health

Mitigating, Adapting, and Suffering: The Health Aspects of Each



Kirk R. Smith
Professor of
Global Environmental Health
School of Public Health

Nobel Laureate, 2007
(at the 0.03% level)

Climate Change and Health

- Climate change adds to the age-old challenges of public health due to
  - poverty
  - inequity
  - ignorance
  - complacency
  - counterproductive personal behavior
  - conflict
  - Infection, and
  - environmental stress
- It threatens to enhance existing risks at every level of development, from
  - heat stress in Barcelona to
  - malaria in Botswana.

CC and Health (cont.)

- In terms of absolute burden of disease, however, it most threatens the poorest and most vulnerable in all societies, closely in inverse proportion to income, wealth, and power.
- 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.

Society has three basic options for responding to human-caused climate change

- **<u>Mitigate</u>** by working to reduce greenhouse gas (GHG) emissions from energy and land use or to capture them from the atmosphere in order to slow or, perhaps, reverse warming
- **<u>Adapt</u>** by reducing the negative effects of climate change through protecting coastlines, moving populations away from impacted areas, increasing efforts to control climate-related vectorborne diseases, insulating cities from heat stress, and so on.
- **<u>Suffer</u>,** i.e., given that efforts in the first two arenas above are moving slowly, there is very likely to be suffering, perhaps considerable in poorer parts of the world, because of the climate change committed already
- We will be doing all three, but can reduce the third if we put more effort into the first two.

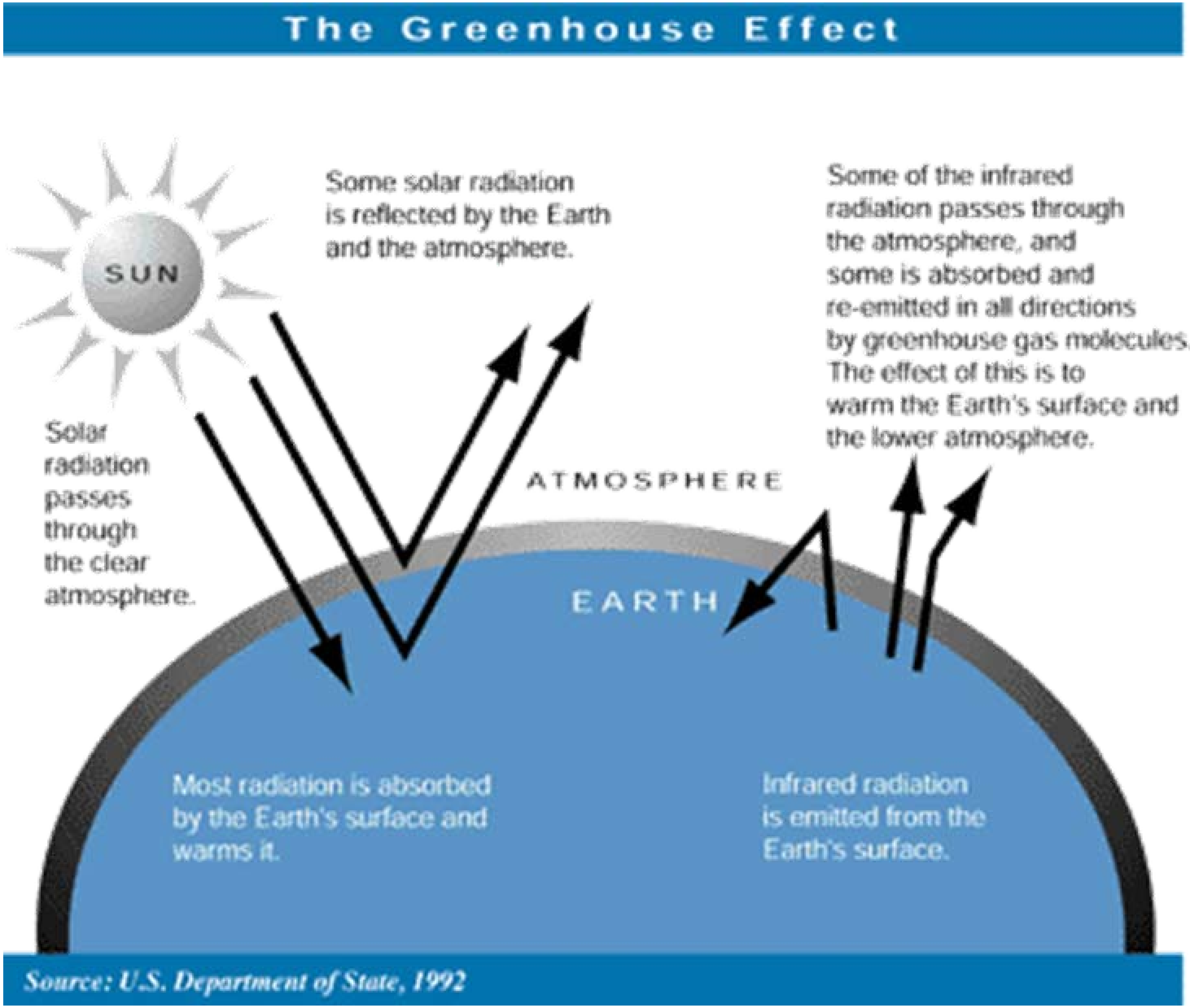
Framework from Holdren, 2006

What can the public health community do?

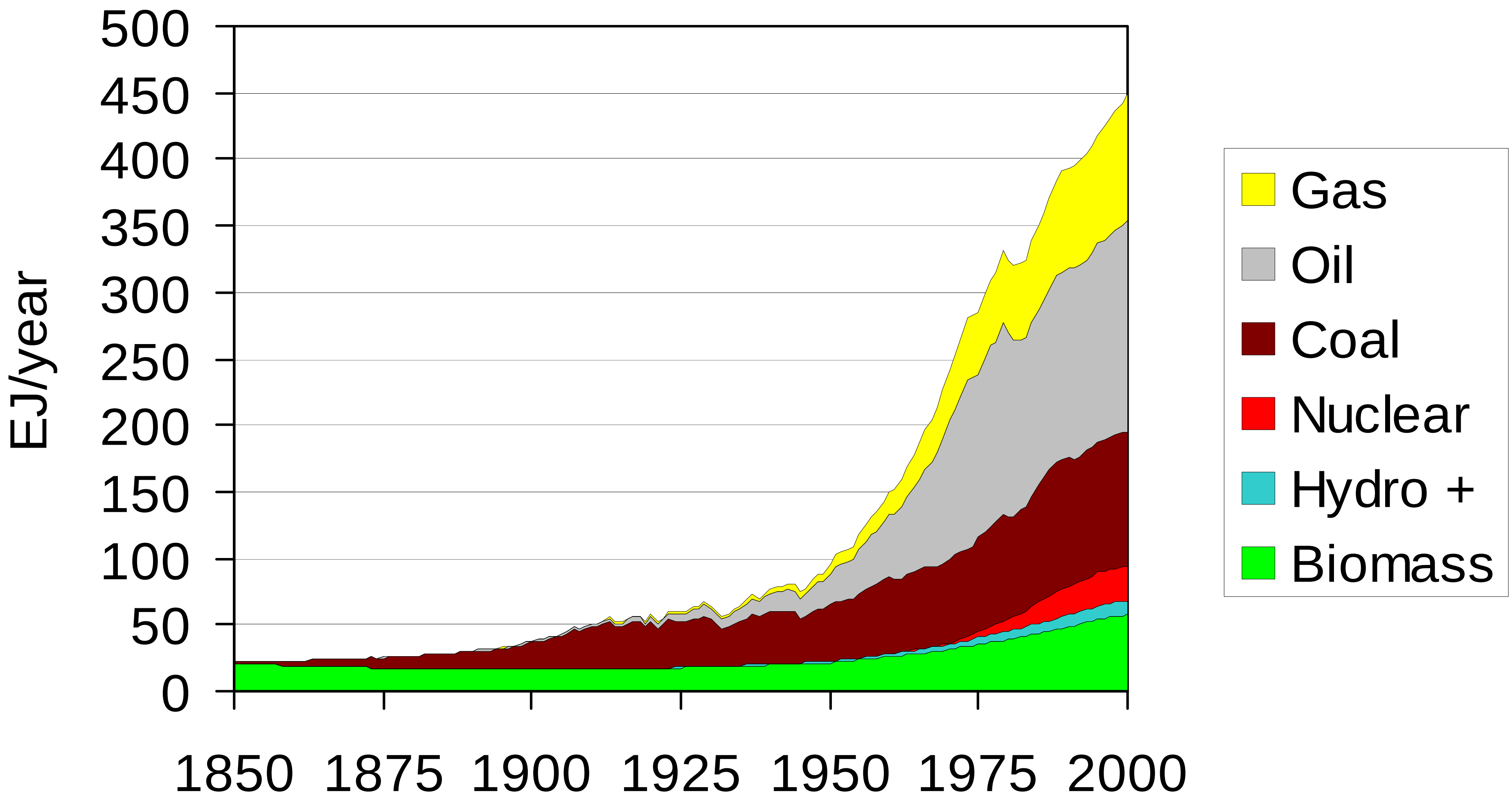
- **<u>Suffering</u>;** Apply and adapt well-developed methods in public health research to identify and quantify the size, distribution, type, and probability of health impacts to come from climate change to better gauge the value and urgency of mitigation and to direct adaptation efforts.
- **<u>Adaptation</u>;** Prepare the health community to handle the impacts that are expected and, in its traditional role in prevention, to urge people and institutions to take mitigation steps
- **<u>Mitigation</u>**; Guide mitigation measures so they avoid negative side-effects and, even better, actually help achieve other health goals. This in the realm of "co-benefits," in which activities are designed to maximize the joint product of GHG mitigation and health protection.

Four short briefings

- **Basics of Climate Change**
- What **Health Effects** are estimated?
- Keeping in mind the principle of "polluter pays," what is the global distribution of responsibility for ill-health due to climate change -- the **Natural Debt** index
- What can the health field offer for determining **Co-benefits**, i.e. jointly achieving health benefits and climate mitigation.

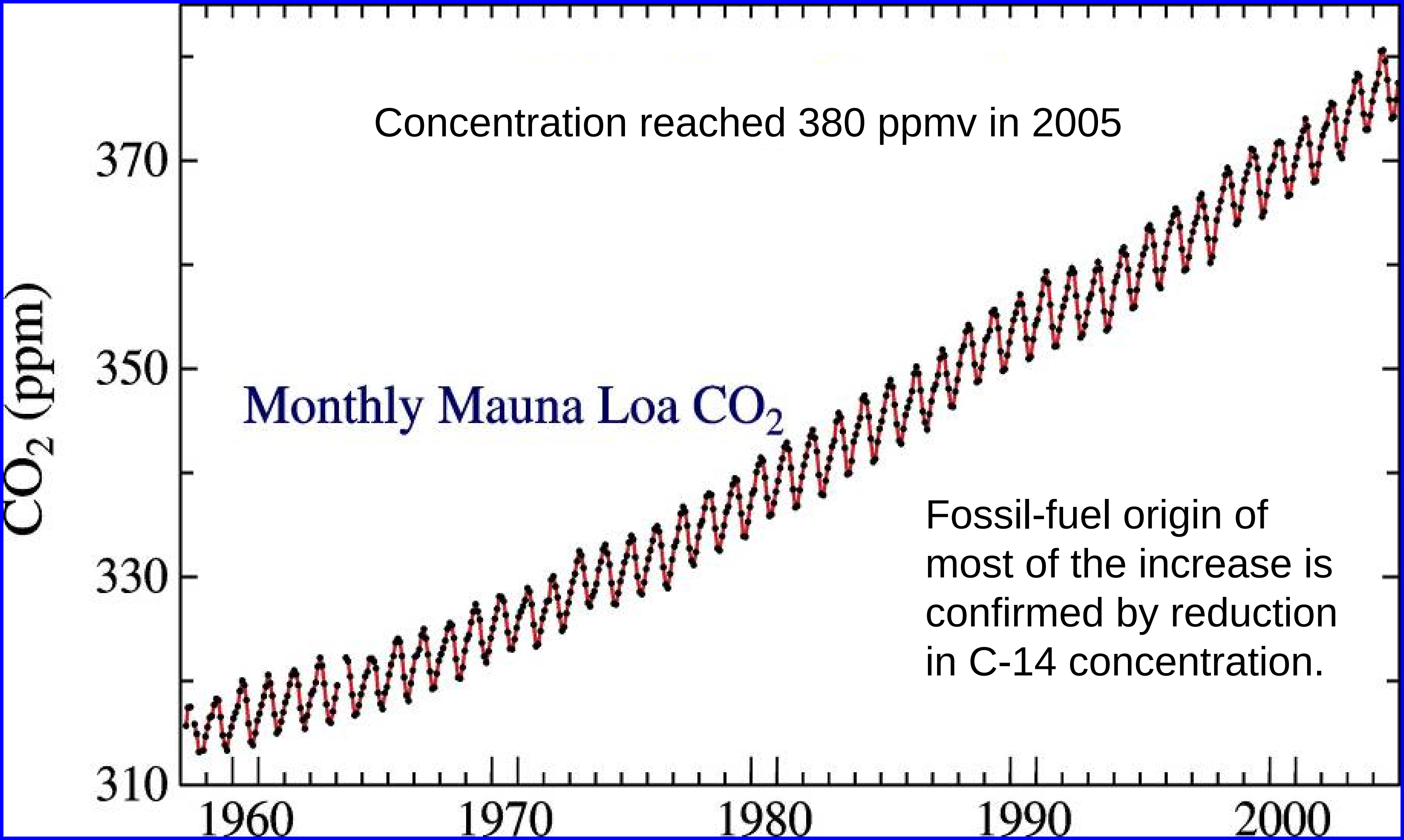

The Greenhouse Effect
SUN
Some solar radiation
is reflected by the Earth
and the atmosphere.
Some of the infrared
radiation passes through
the atmosphere, and
some is absorbed and
re-emitted in all directions
by greenhouse gas molecules.
The effect of this is to
warm the Earth's surface and
the lower atmosphere.
Solar
radiation
passes
through
the clear
atmosphere.
ATMOSPHERE
EARTH
Most radiation is absorbed
by the Earth's surface and
warms it.
Infrared radiation
is emitted from the
Earth's surface.
Source: U.S. Department of State, 1992

The rise of global dependence on fossil fuels



We live in a fossil-fuel dominated world (~80% of supply in 2000)

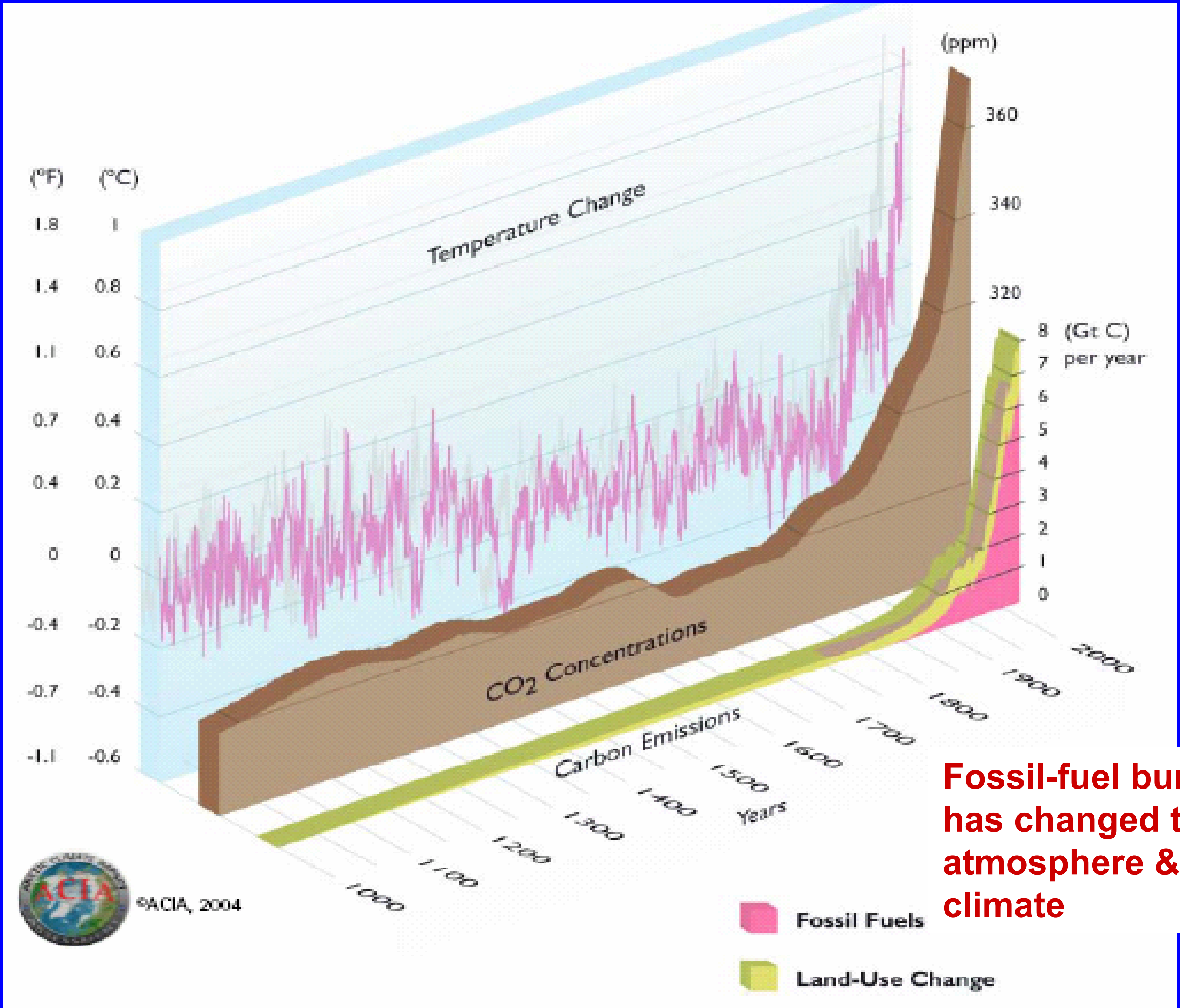
Direct measurements of CO_2 show continued rise



Atmospheric CO_2 measured at Mauna Loa, Hawaii.

Source: NOAA Climate Monitoring and Diagnostic Laboratory

1000 years of global C emissions, CO_2 concentrations, and temperature

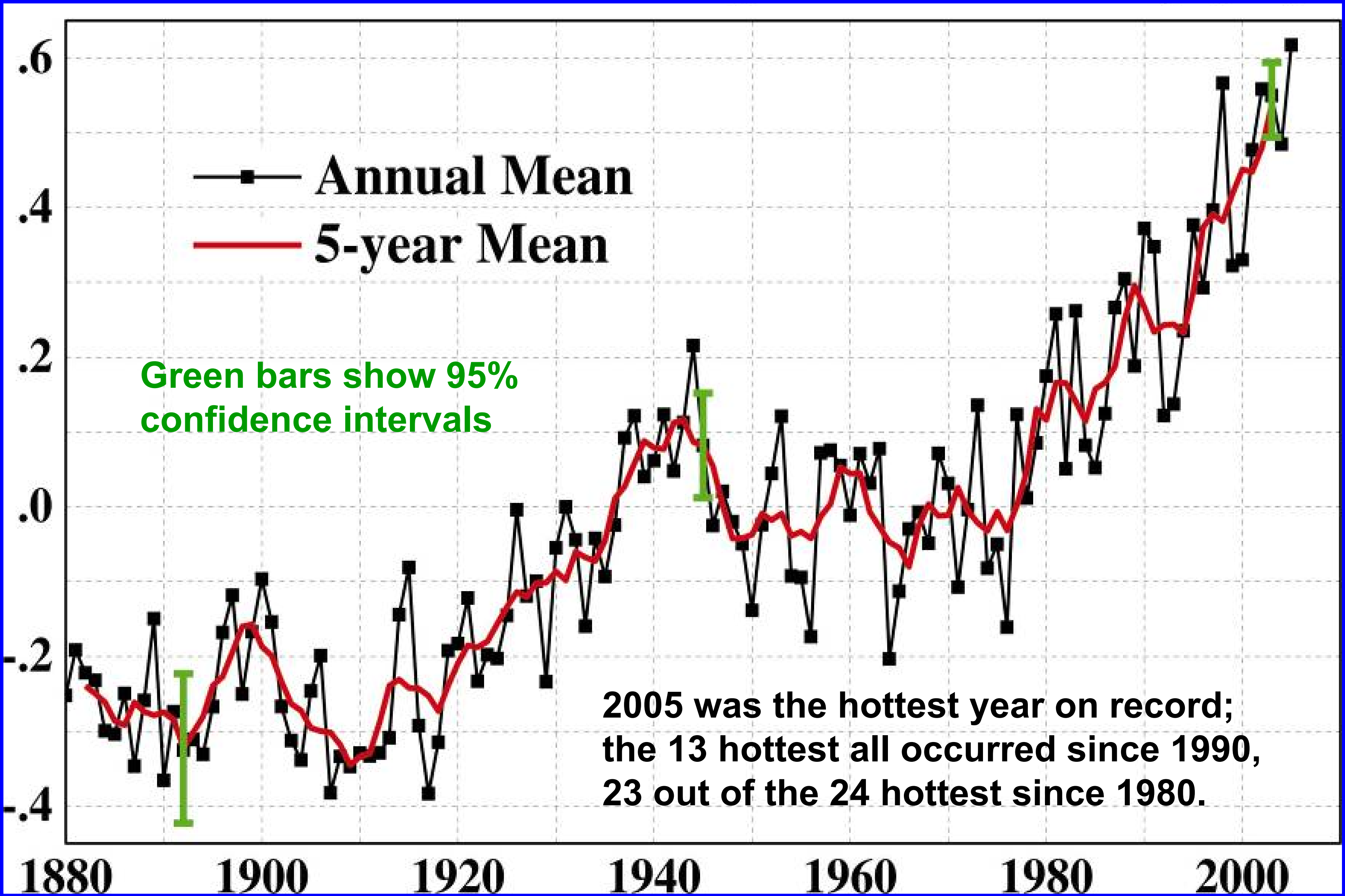


Fossil-fuel burning has changed the atmosphere & the climate

Sources of Greenhouse Gases

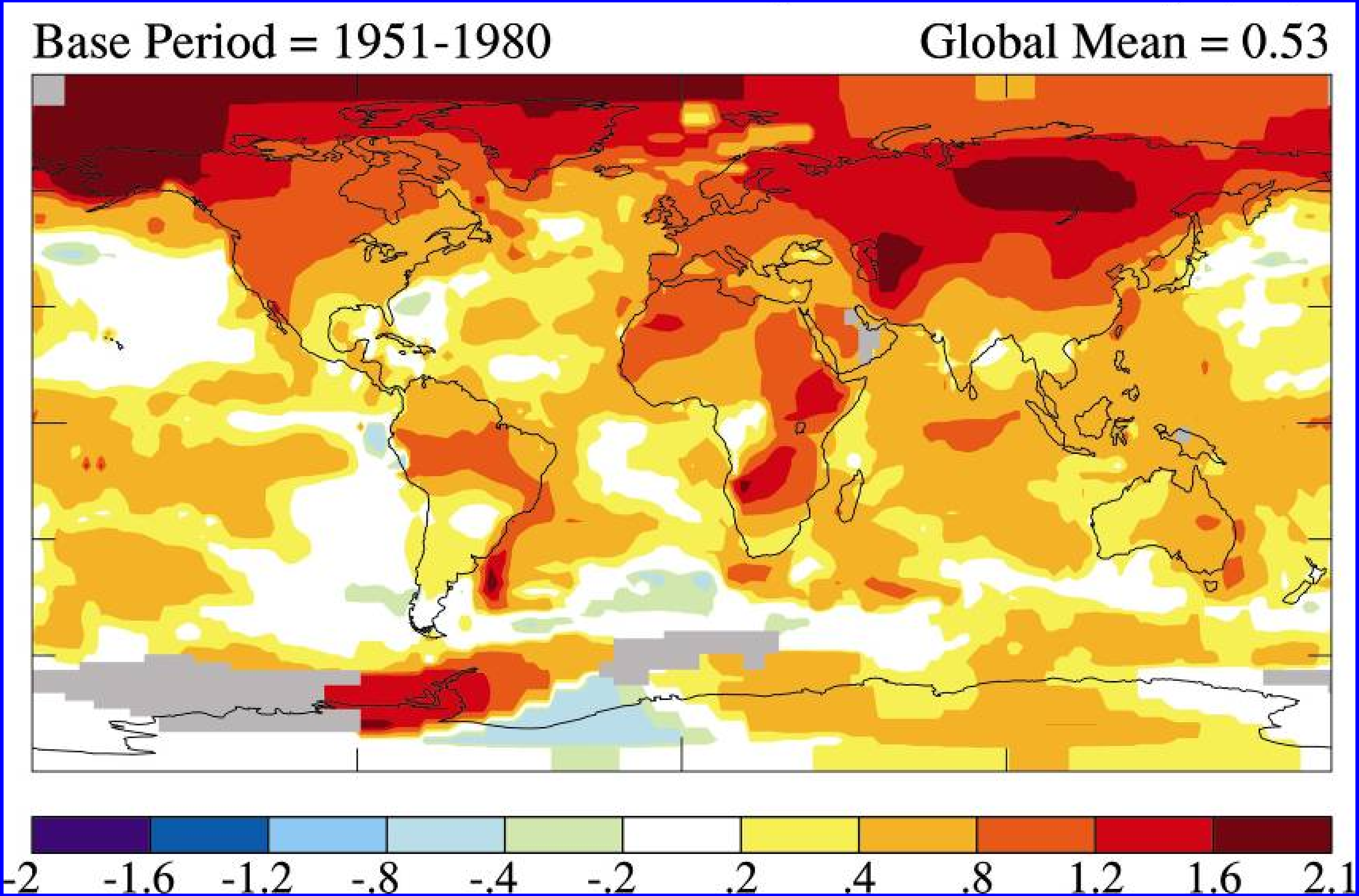
- Human activities may have upset the balance of atmospheric carbon dioxide through:
  - (1) the combustion of fossil fuels which releases carbon oxides;
  - (2) the burning of forests which produces CO_2 and removes a vital consumer of CO_2; and
  - (3) release of methane from agricultural and other activities

Global surface temperature since 1880



J. Hansen et al., *PNAS 103*: 14288-293 (26 Sept 2006)

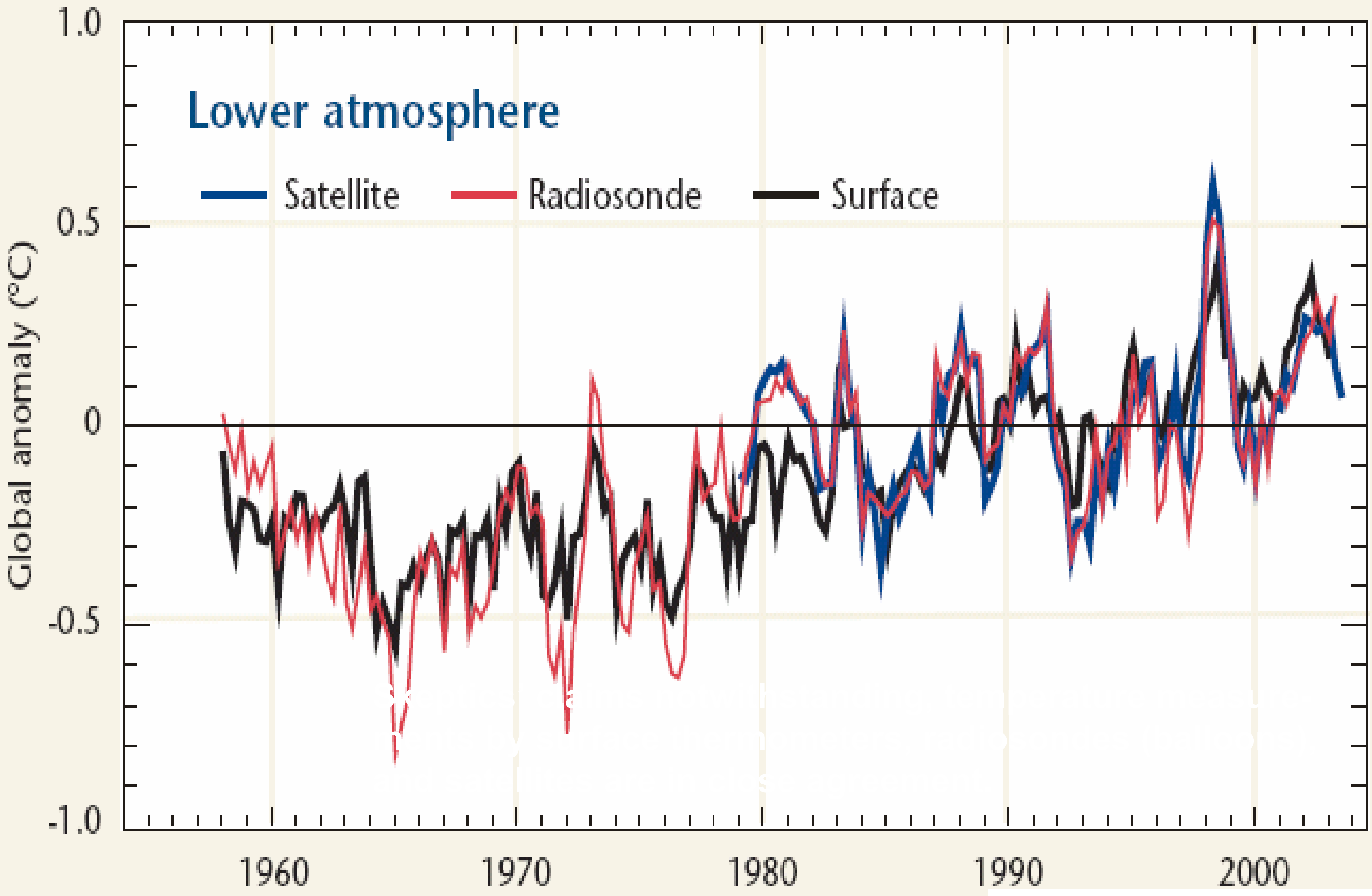
Average T in 2001-2005 versus 1951-80 base, °C



"Global warming" is a misnomer. T increases are nonuniform: higher mid-continent, highest in far North. Global average temperature is just an index of the state of the global climate.

J. Hansen et al., *PNAS 103*: 14288-293 (2006)

Temperature measurements by different methods agree

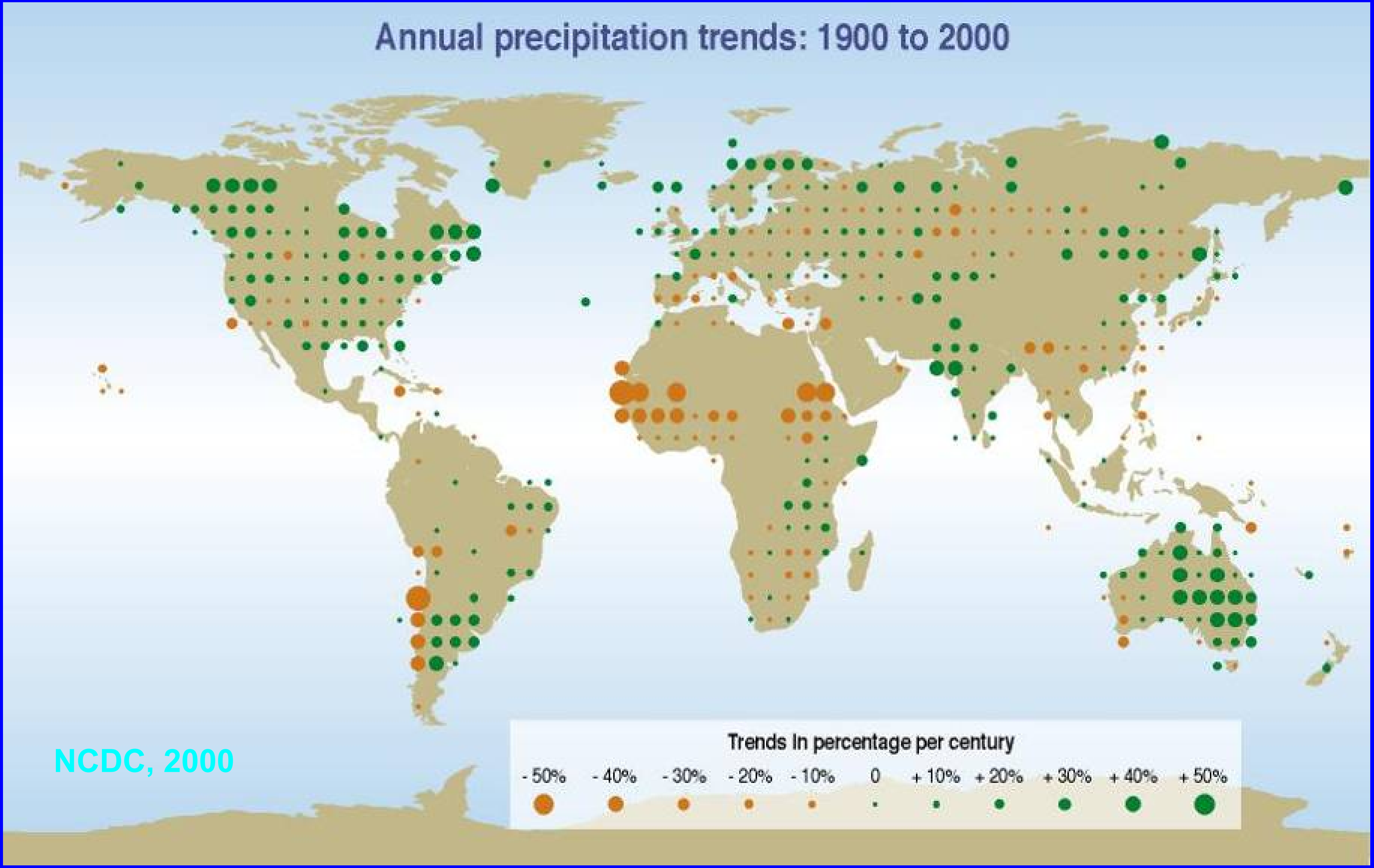


Hadley Centre, 2003

Observations over recent decades also show

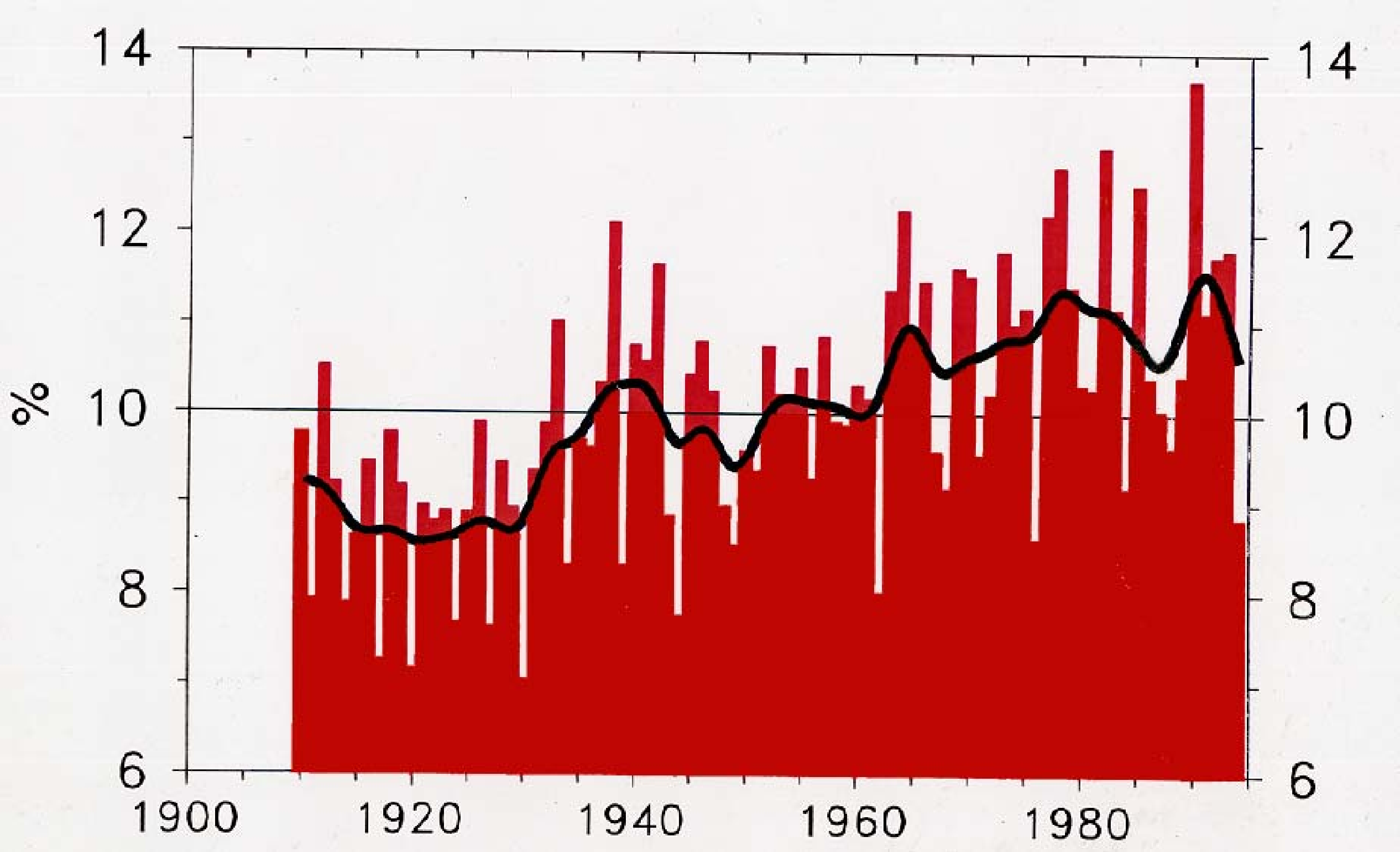
- Evaporation & rainfall are increasing;
- More extreme rainfall events
- Glaciers are retreating;
- Sea ice is shrinking;
- Sea level is rising;
- Effects are following predictions

Evaporation & precipitation are increasing



Effect is not uniform; most places getting wetter, some getting drier.

Percent of the Continental U.S. with Much Above Normal Proportion of Total Annual Precipitation From 1-day Extreme Events (more than 2 inches)

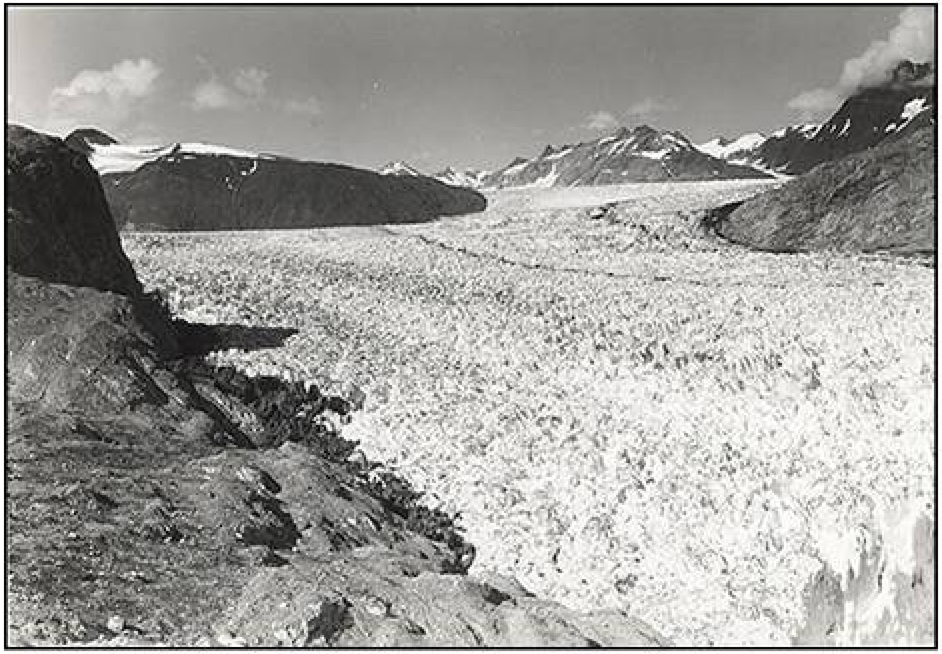


Source: Karl, et.al. 1996.

Glaciers are retreating

Muir Glacier, Alaska, 1941-2004

August 1941



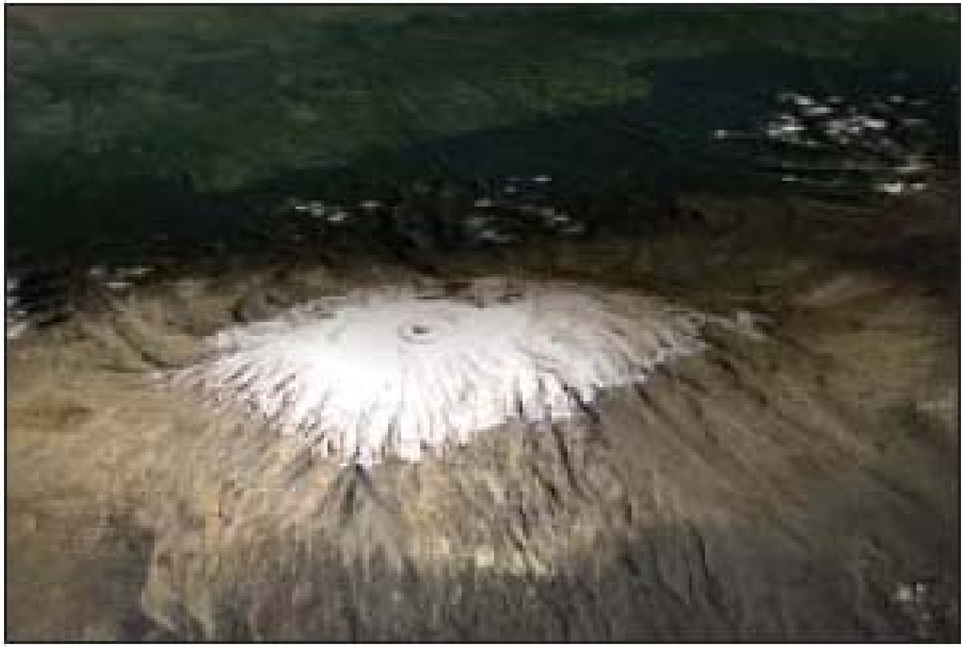
August 2004

NSIDC/WDC for Glaciology, Boulder, compiler. 2002, updated 2006. *Online glacier photograph database.* Boulder, CO: National Snow and Ice Data Center.

Some are nearly gone

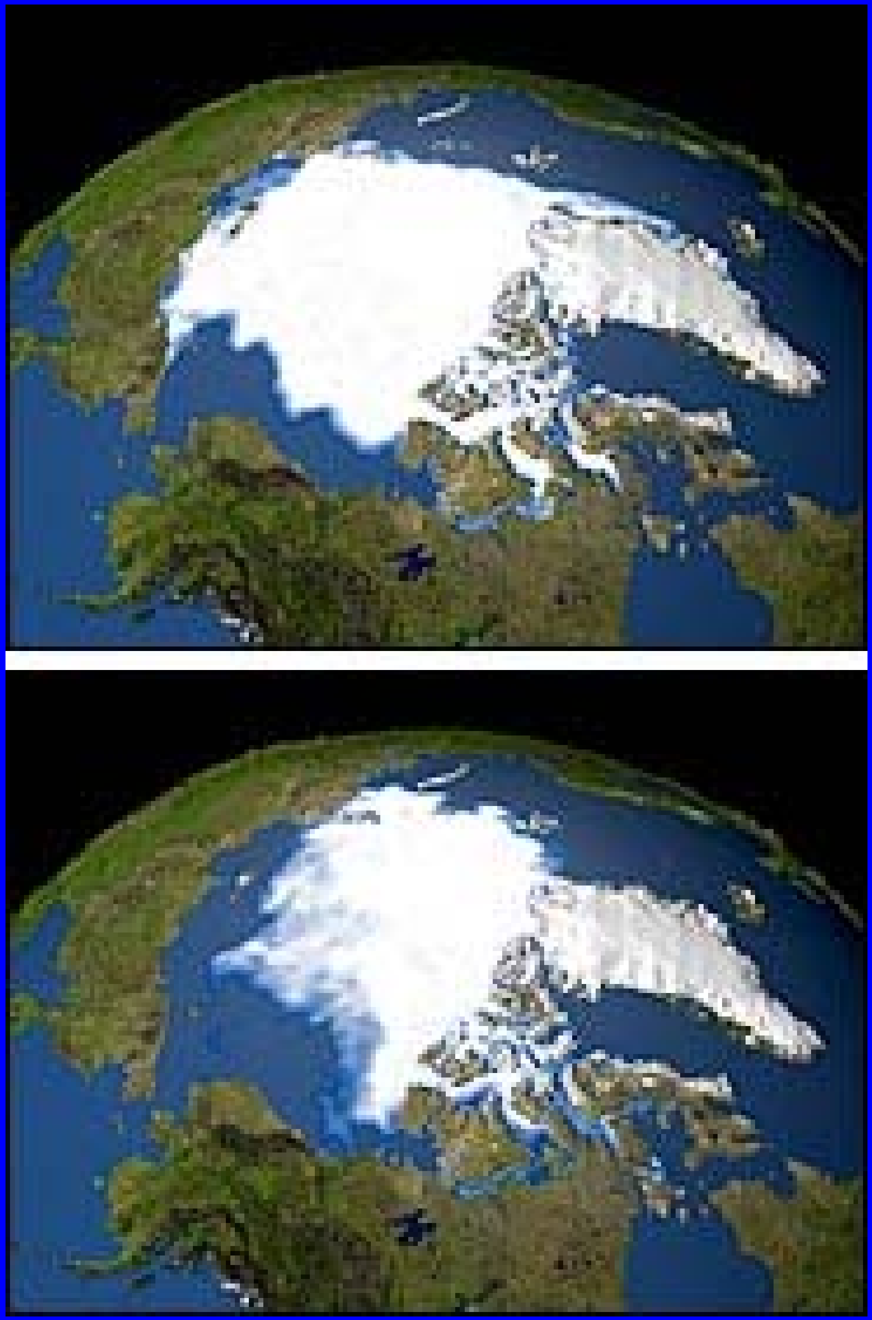
Kilimanjaro, Africa's highest mountain, is almost exactly on the equator and largely immune from climatic changes that are not global, It's ice cover shrunk by 80% between 1912 and 2000.

These satellite images show the reduction just between 1993 and 2000.



Mt. Kilimanjaro, 1993 © NASA

Mt. Kilimanjaro, 2000 © NASA



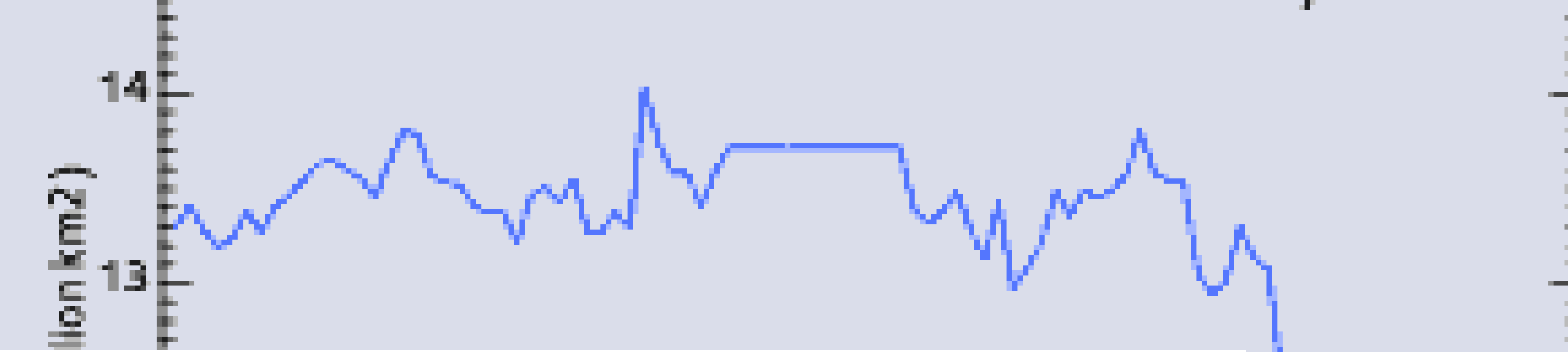
NASA photograph

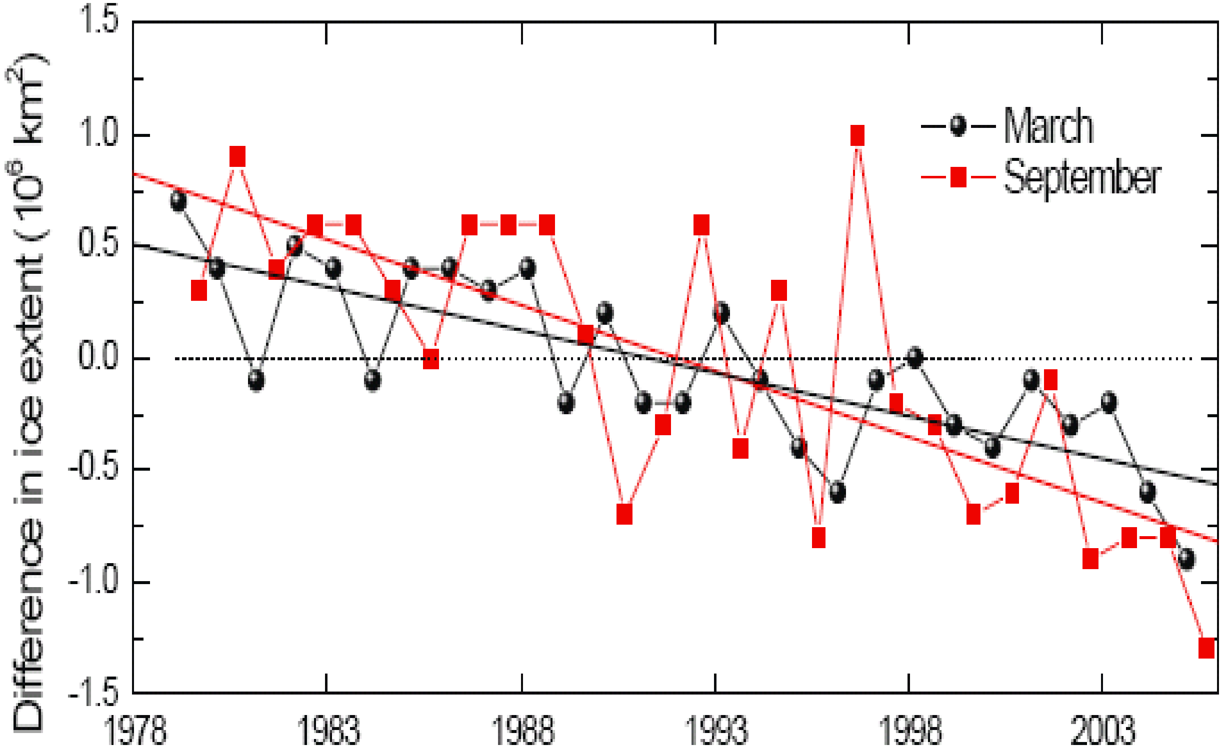
Sea ice is shrinking

Extent of Arctic summer ice in 1979 (top satellite image) and in 2003 (lower satellite image).

The North Polar ice cap is sea ice -- it's floating and so does not change sea level when it melts.   But the reduced reflectivity when the ice is replaced by water amplifies the warming effect of greenhouse gases.

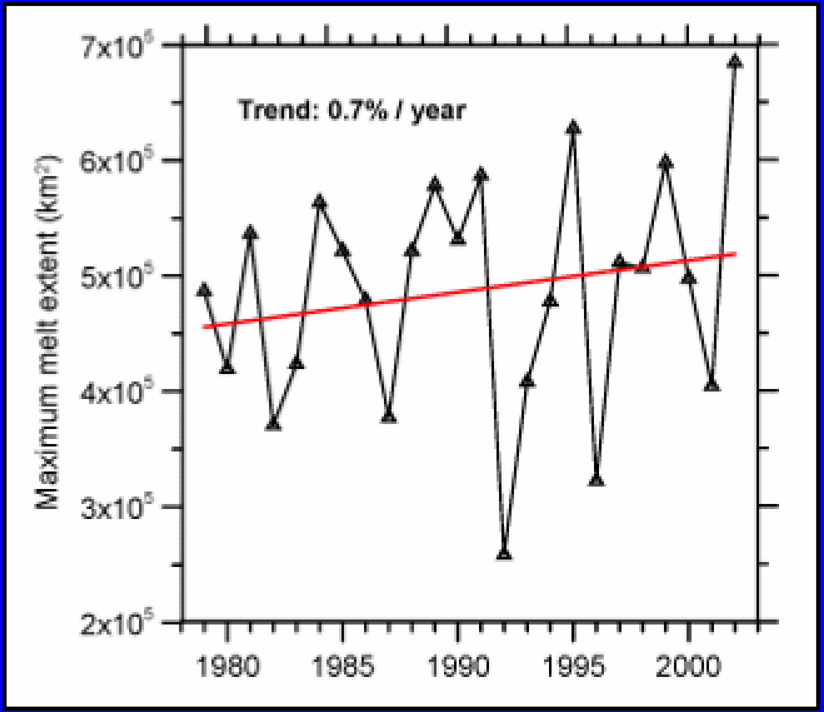
Greenland (at the right) is covered with a thick sheet of land ice. If this melts, sea level rises.

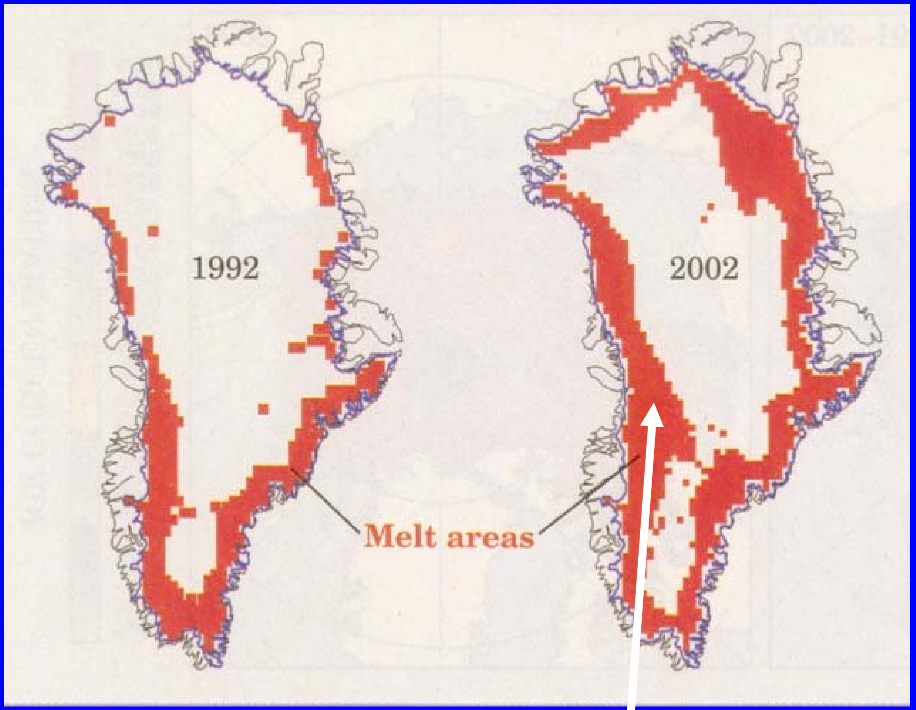




Time series of the difference in ice extent in March (maximum) and September (minimum) from
alues for 1979–2005. Based on a least-squares linear regression, the rates of decrease in March and

Greenland is melting





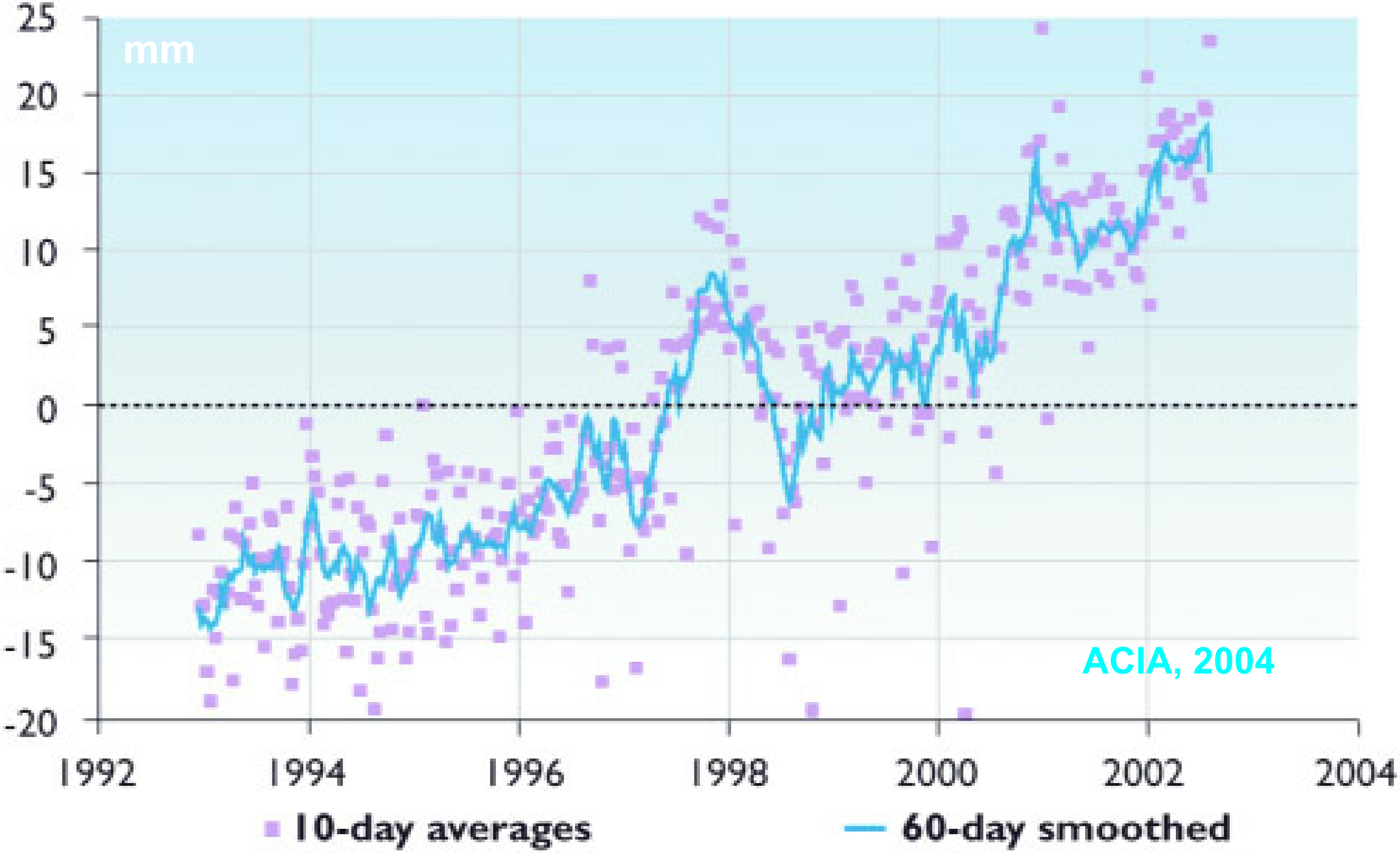
- 2002 all-time record melt area
- Melting up to elevation of 2000 m
- 16% increase from 1979 to 2002

70 meters thinning in 10 years

Satellite-era record melt of 2002 was exceeded in 2005.

Source: Waleed Abdalati, Goddard Space Flight Center

Sea-level is rising



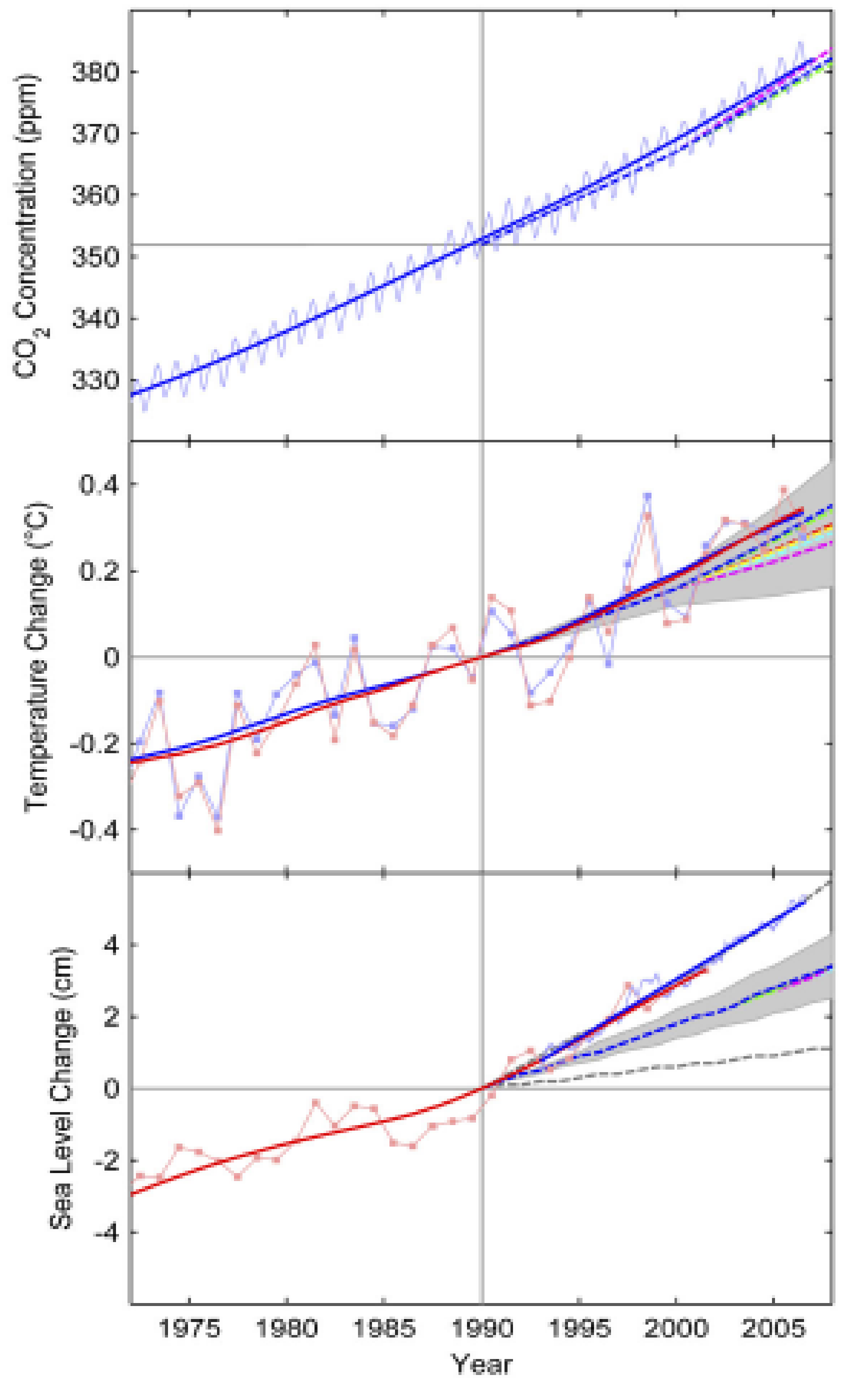
1993-2003 ≈ 35 mm = 3.5 mm/yr; compare 1910-1990 = 1.5±0.5 mm/yr.

Key variables have been tracking or exceeding IPCC projections

IPCC projections published in the 2001 assessment were based on data to 1990.

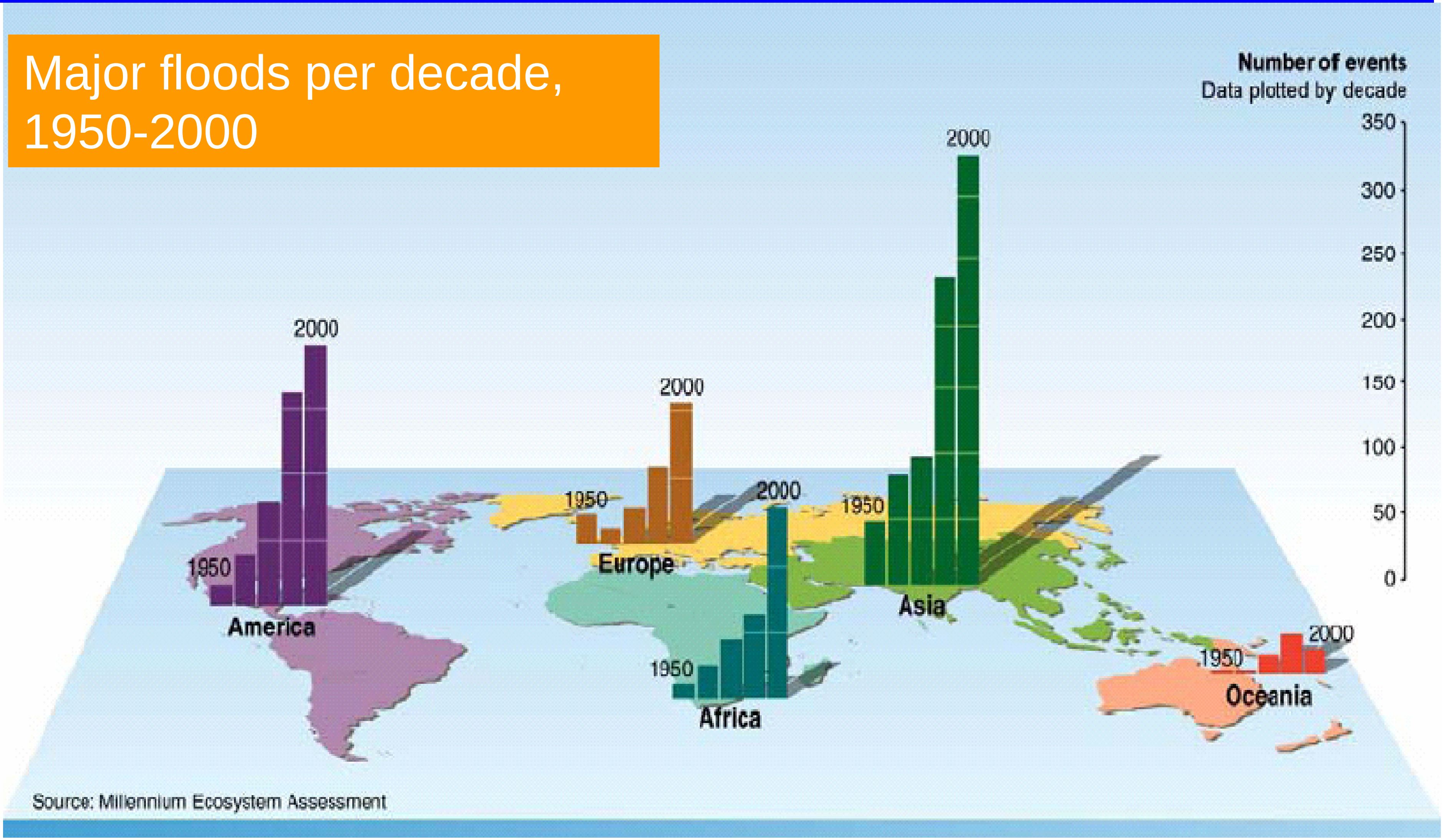
Observations since 1990 have tracked the projections for CO2, have been near the high side of projected ranges for temperature, and have been at the extreme high side of the projections for sea-level rise.

Rahmstorf et al., *Science Express*, February 2007



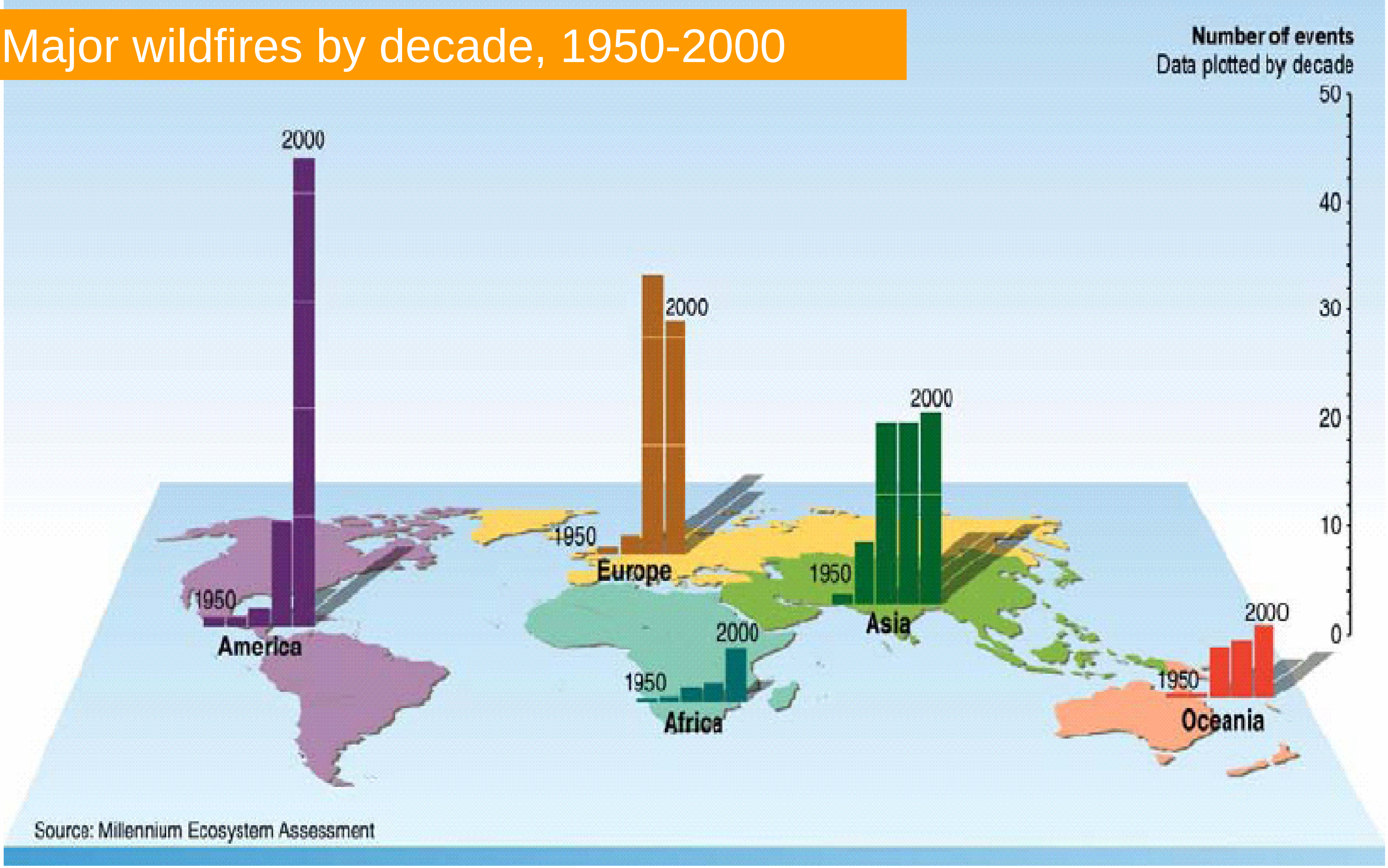
Many adverse impacts of the human-caused disruption of global climate are already evident

- Floods
- Wildfires
- Hurricanes (tropical cyclones)
- Coral reefs
- Monsoon



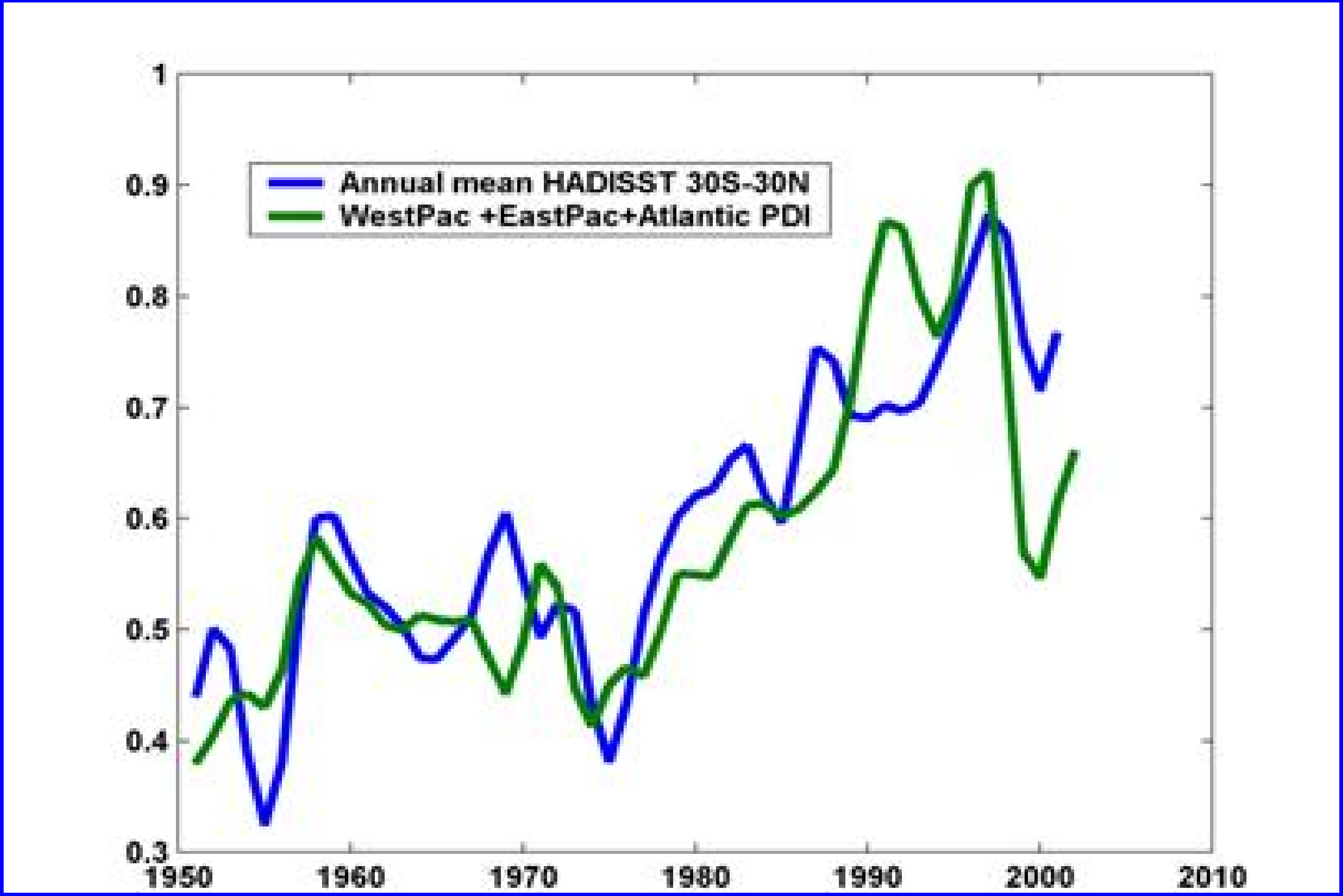
There's a consistent 50-year upward trend in every region except Oceania, where the 1990s were a bit below the 1980s.

Major wildfires by decade, 1950-2000



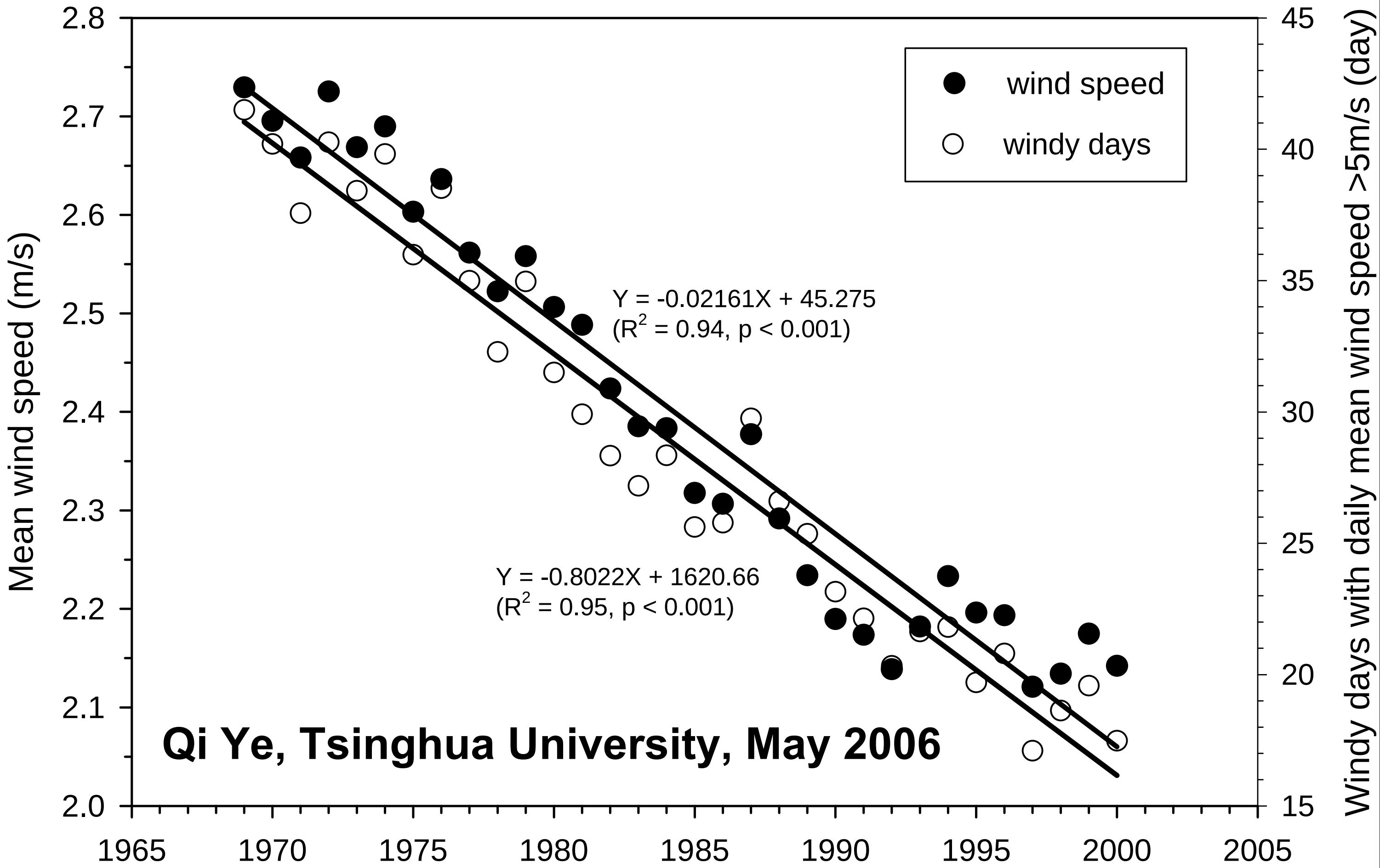
The trend has been upward everywhere.

Total power released by tropical cyclones (green) has increased along with sea surface temperatures (blue).



Kerry Emanuel, MIT, 2006

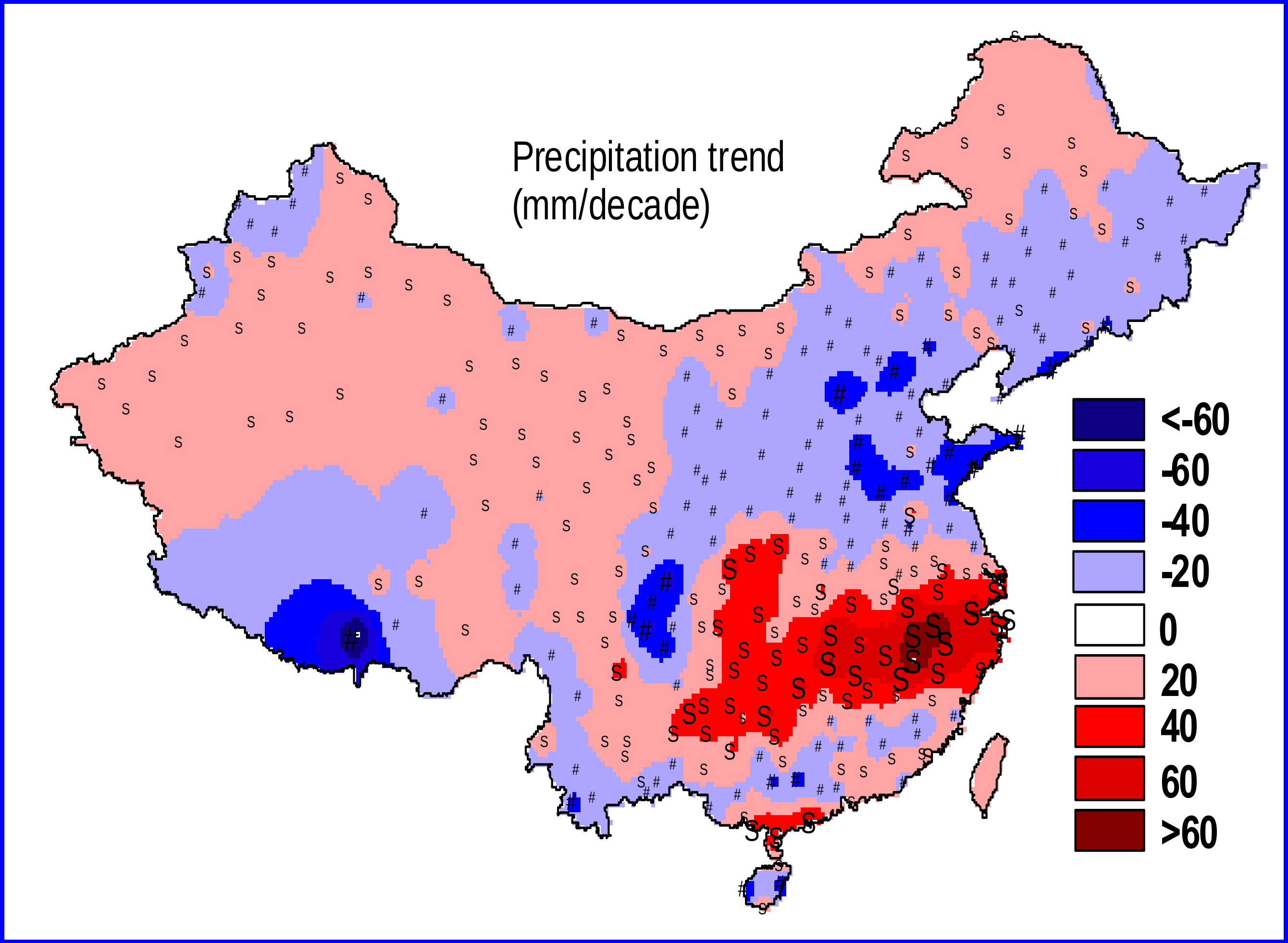
The East Asia monsoon has been weakening



The change is as predicted by Chinese climate modelers. It has produced increased flooding in the South of China and increased drought in the North.

Weakening East Asia Monsoon (continued)

Weakening monsoon means less moisture flow South to North, producing increased flooding in South, drought in North



Qi Ye, Tsinghua University, May 2006

Why Worry about Climate Change?

- Ecosystem Impacts
- Economic Impacts
- Health Impacts
  - Direct effects
  - Indirect effects
- Small-probability, but large consequence events
  - Change in Gulf Stream
  - Slippage of Antarctic ice sheet
  - Runaway methane emissions

What is climate?

Climate consists of averages and extremes of

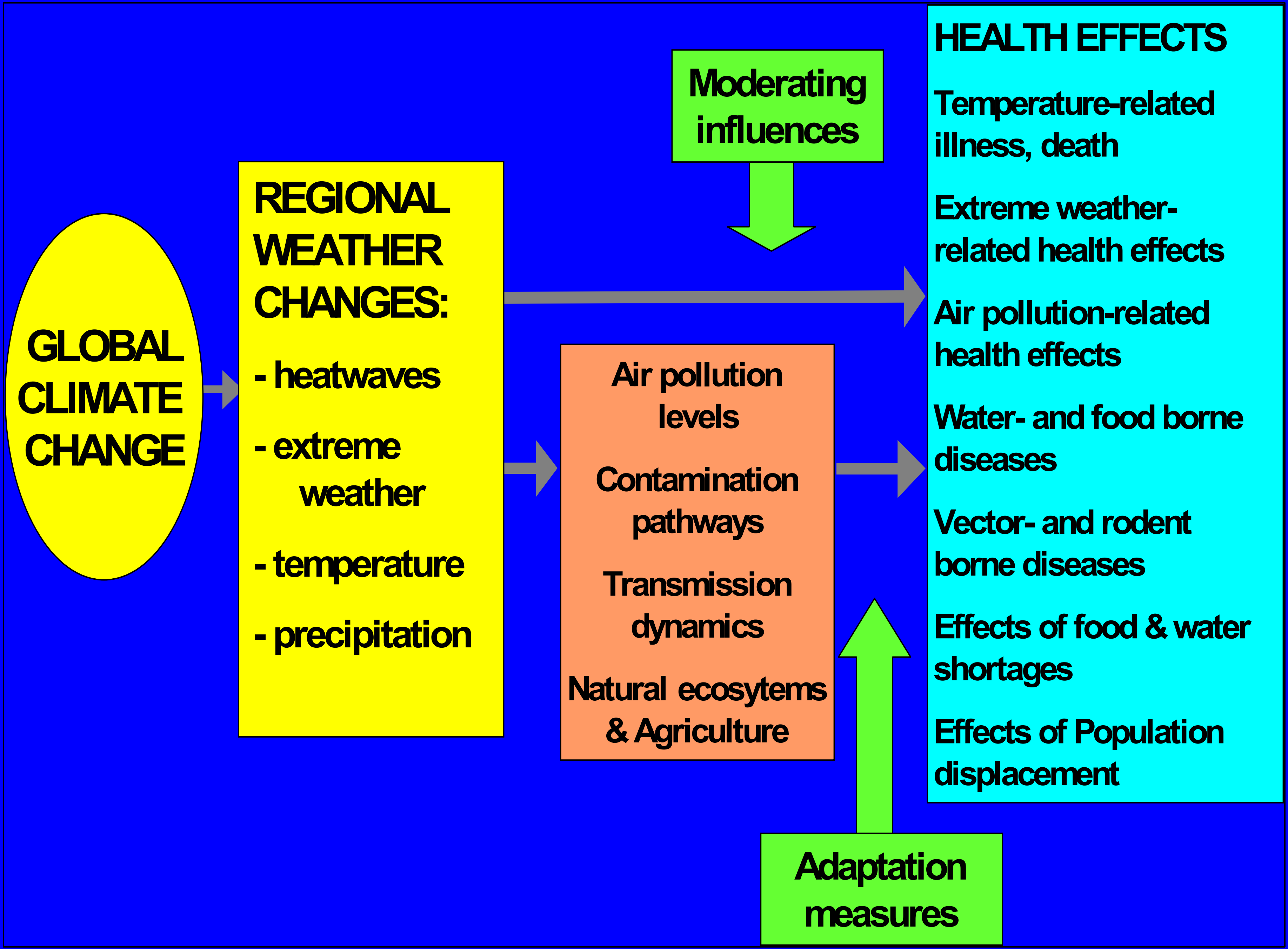
- hot & cold
- wet & dry
- snowpack & snowmelt
- winds & storm tracks
- ocean currents & upwellings

and not just how much & where, but also <u>when</u>.

Why does climate matter?

Climate governs

- Productivity of farms, forests, & fisheries
- Geography of disease
- Livability of cities in summer
- Damages from storms, floods, wildfires
- Property losses from sea-level rise
- Expenditures on engineered environments
- Distribution & abundance of species


GLOBAL CLIMATE CHANGE
REGIONAL WEATHER CHANGES:
- heatwaves
- extreme weather
- temperature
- precipitation
Moderating influences
Air pollution levels
Contamination pathways
Transmission dynamics
Natural ecosytems & Agriculture
Adaptation measures
HEALTH EFFECTS
Temperature-related illness, death
Extreme weather-related health effects
Air pollution-related health effects
Water- and food borne diseases
Vector- and rodent borne diseases
Effects of food & water shortages
Effects of Population displacement

Direct Effects

Insults / Impacts

Insults	Impacts
• Exposure to thermal extremes →	• Increase rates of heat- and cold-related illness and death (cardiovascular and respiratory)
• Increased frequency/ intensity of extreme weather events →	• Deaths, injuries, illnesses, psycho-logical disorders, damage to public health infrastructure

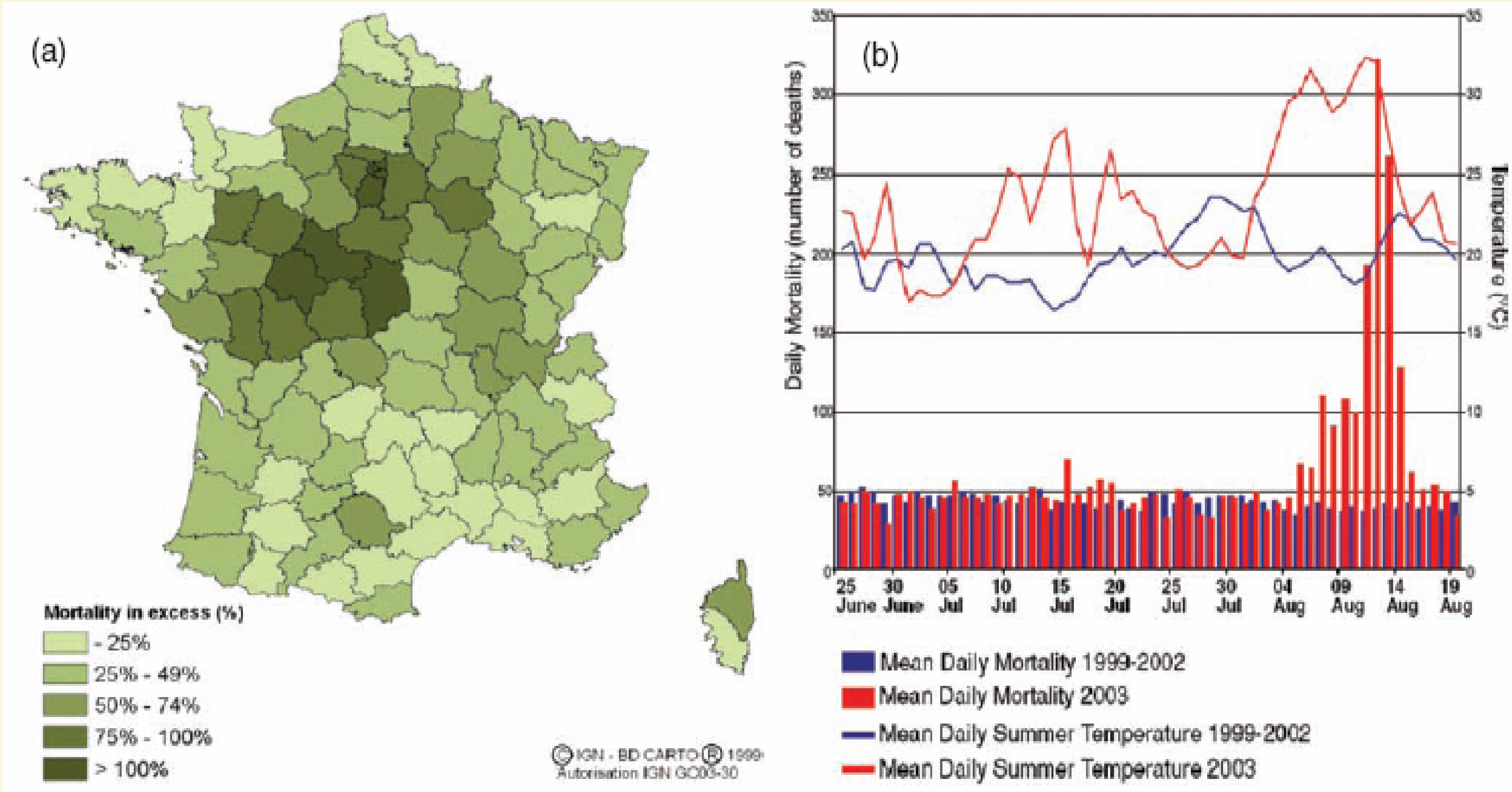
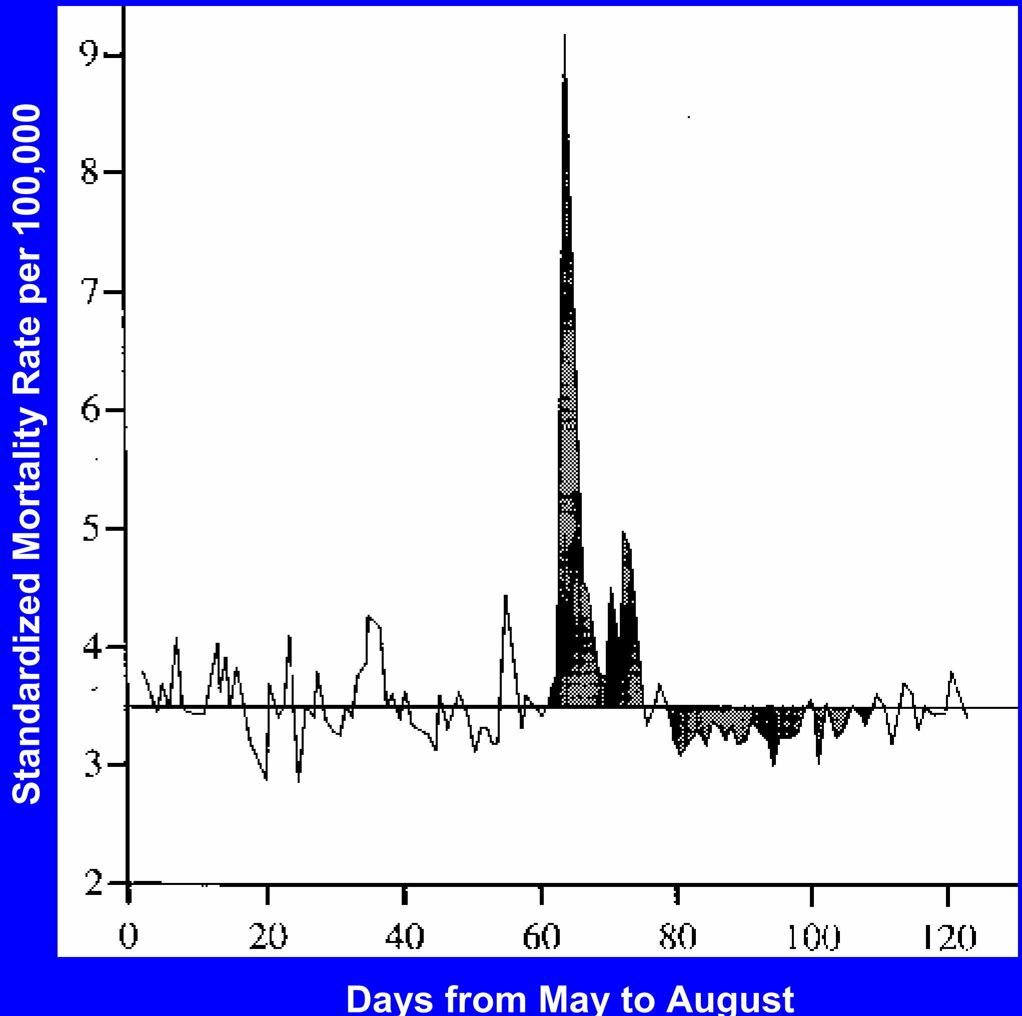


Figure 8.2. *(a) The distribution of excess mortality in France from 1 to 15 August 2003, by region, compared with the previous three years (INVS, 2003); (b) the increase in daily mortality in Paris during the heatwave in early August (Vandentorren and Empereur-Bissonnet, 2005).*

IPCC WGII, 2007

Daily summer mortality during a New York heatwave, 1966



(Kalkstein, 1993)

Indirect Effects:
Insults → Impacts

- Sea-level rise → Infectious diseases and injuries due to migration, crowding, contamination of water, etc.
- Increased air pollution including pollens/spores → Acute/chronic lung disease, allergic disorders, CVD
- Social, economic, and demographic dislocations from changes in economy, infrastructure, and resource availability → Wide range of public health consequences

Indirect Effects: Ecosystem Moderated

Insults	Impacts
Change in the range and activity of vectors →	Change in prevalence and range of vector-borne diseases - malaria is biggest
Altered local ecology of waterborne and foodborne infective agents →	Changed incidence of diarrheal and related diseases
Altered food crop productivity →	Regional malnutrition with impaired child growth

Comparative Risk Assessment (CRA) 2-year 30-institution project organized by the World Health Organization

Disease, injury, and death due to 26 major risk factors calculated by age, sex, and 14 global regions.

Fully published in late 2004

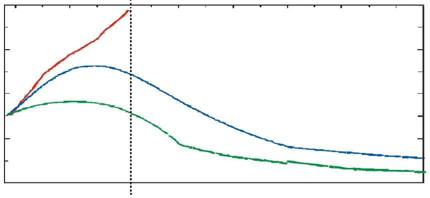
(Being updated 2007-2009)

Metric Used for Health Assessments

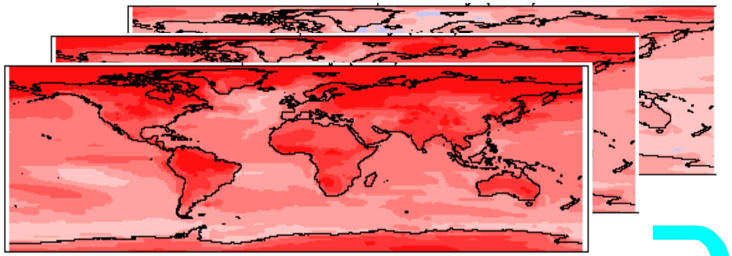
- Lost life years only type of unit ever proposed that systematically includes premature mortality and morbidity
- And puts everyone on Earth on an equal basis, i.e., we all share the right and capability of the same length of healthy life
- The Disability Adjusted Life Year, DALY, one such metric, is the only one with systematic, worldwide databases that allow consistent comparisons across age, sex, disease, risk factor, and region the world.

OVERVIEW OF THE PROCESS OF COMPARATIVE RISK ASSESSMENT (CRA) FOR CLIMATE CHANGE

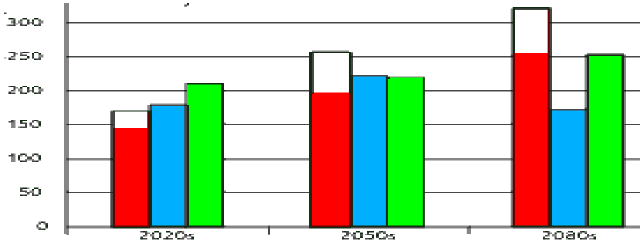
GHG emissions scenarios



GCM model:
Generates series maps of future climate



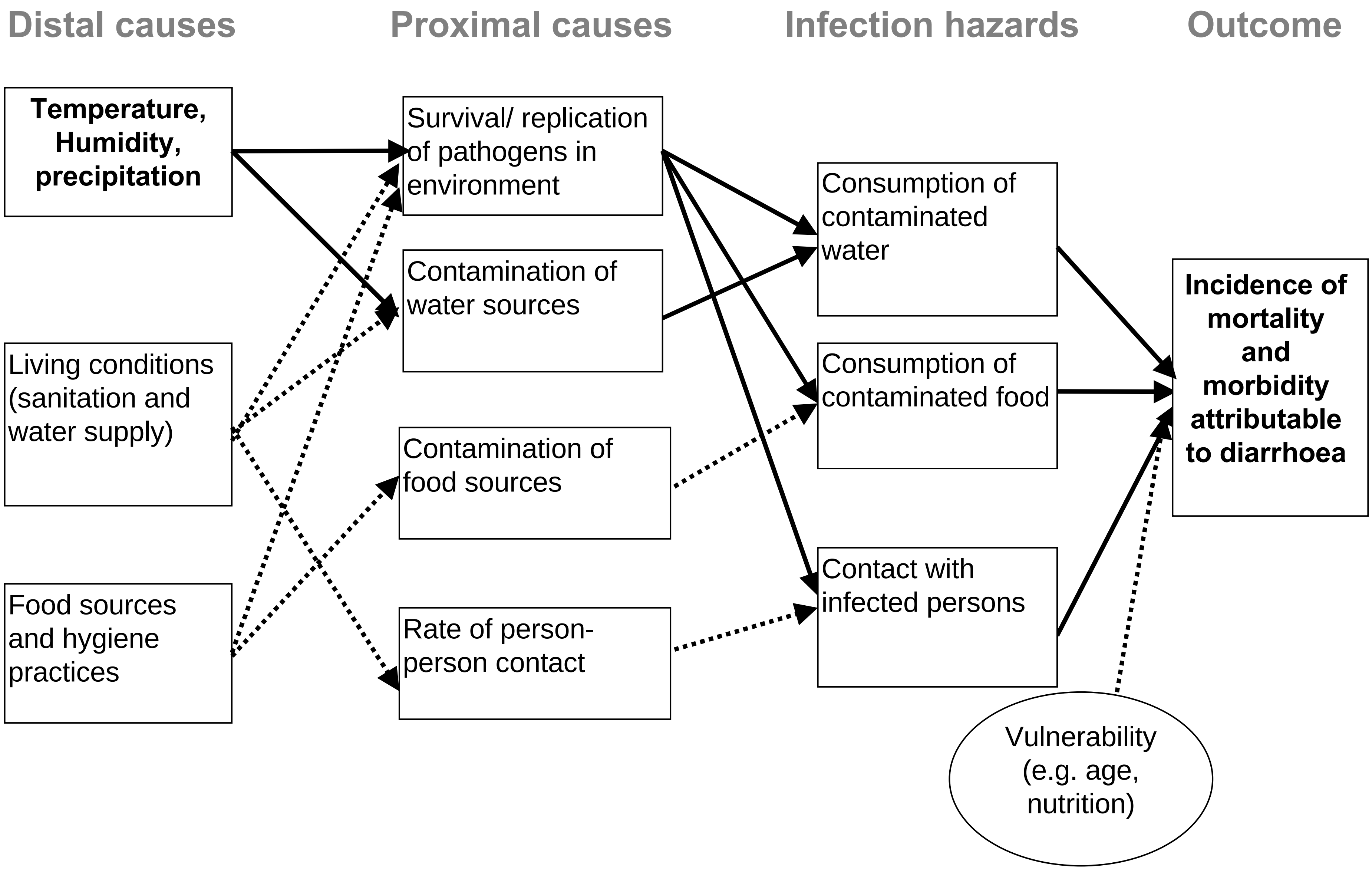
Health impact model
Generates estimates of the impact of each scenario on specific outcome



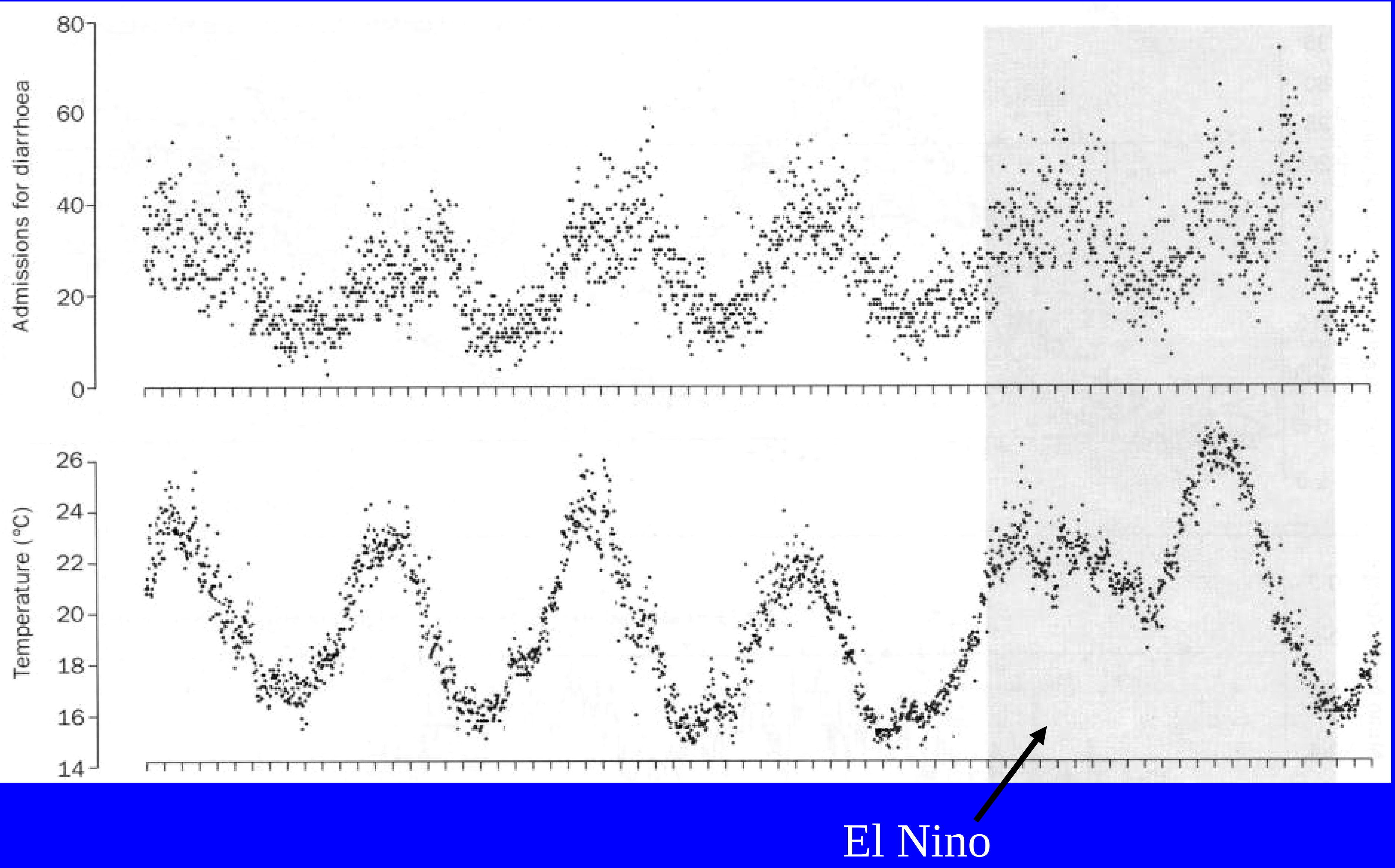
Conversion to GBD 'currency' to summation of the of different health

Level	Age group (years) 0-4	5-14	15-29	30-44	45-59	60-69	70+
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
3	1.7	1.7	1.7	1.7	1.7	1.7	1.7
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
3	1.7	1.7	1.7	1.7	1.7	1.7	1.7
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
3	1.7	1.7	1.7	1.7	1.7	1.7	1.7
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
3	1.7	1.7	1.7	1.7	1.7	1.7	1.7
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
3	1.7	1.7	1.7	1.7	1.7	1.7	1.7

LONDON SCHOOL OF HYGIENE & TROPICAL MEDICINE


Distal causes
Proximal causes
Infection hazards
Outcome
Temperature, Humidity, precipitation
Living conditions (sanitation and water supply)
Food sources and hygiene practices
Survival/ replication of pathogens in environment
Contamination of water sources
Contamination of food sources
Rate of person-person contact
Consumption of contaminated water
Consumption of contaminated food
Contact with infected persons
Vulnerability (e.g. age, nutrition)
Incidence of mortality and morbidity attributable to diarrhoea

Hospitalizations for diarrhoea (upper line), corresponds closely with temperature (lower line) at a clinic in Lima, Peru.

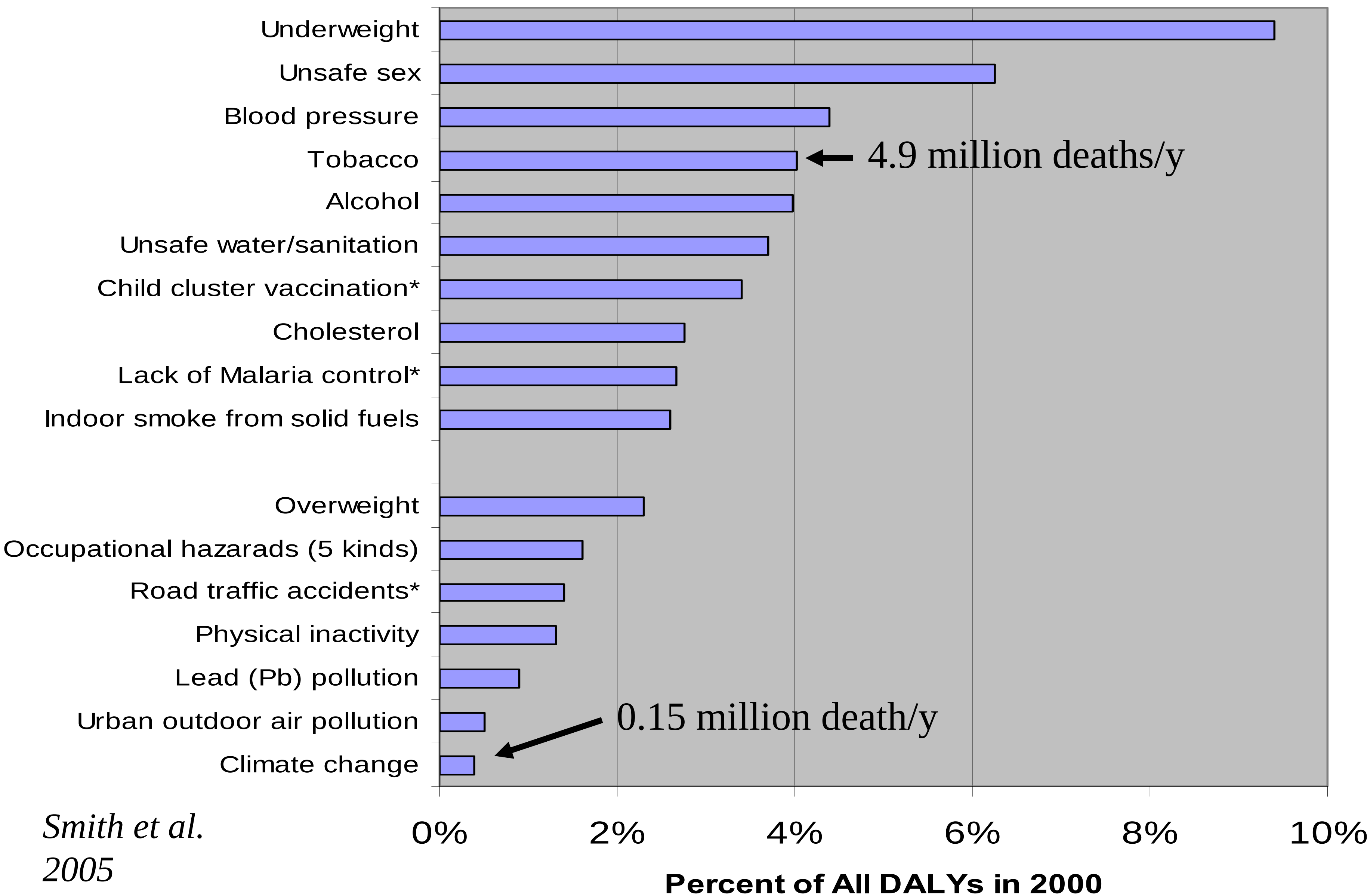


WHO Comparative Risk Assessment – 2004 Climate Change Health Impacts as of 2000

- Diarrhea – 2.4% of global burden
- Malaria – 2%; 6% in some regions
- 17% of protein-energy malnutrition
- 7% of dengue fever in some rich countries
- 150,000 deaths, 99% in poor countries (46% in South Asia)
- 0.4% of all DALYs
- Most (88%) of impact in children under 5
- Not large today, but growing rapidly.
- It is not what is attributable today, but avoidable today that is the concern.

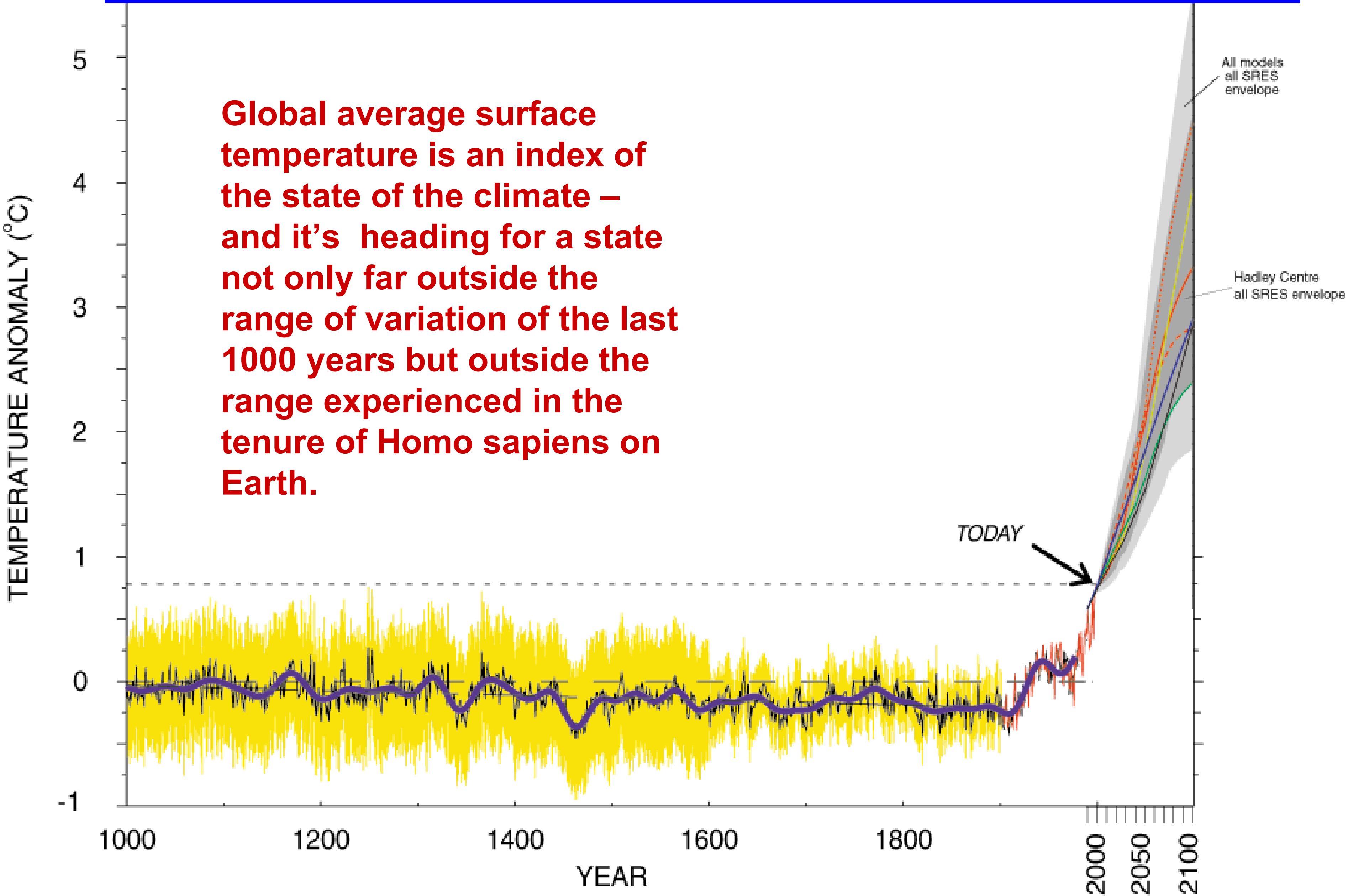
Global Burden of Disease from Top 10 Risk Factors

plus selected other risk factors



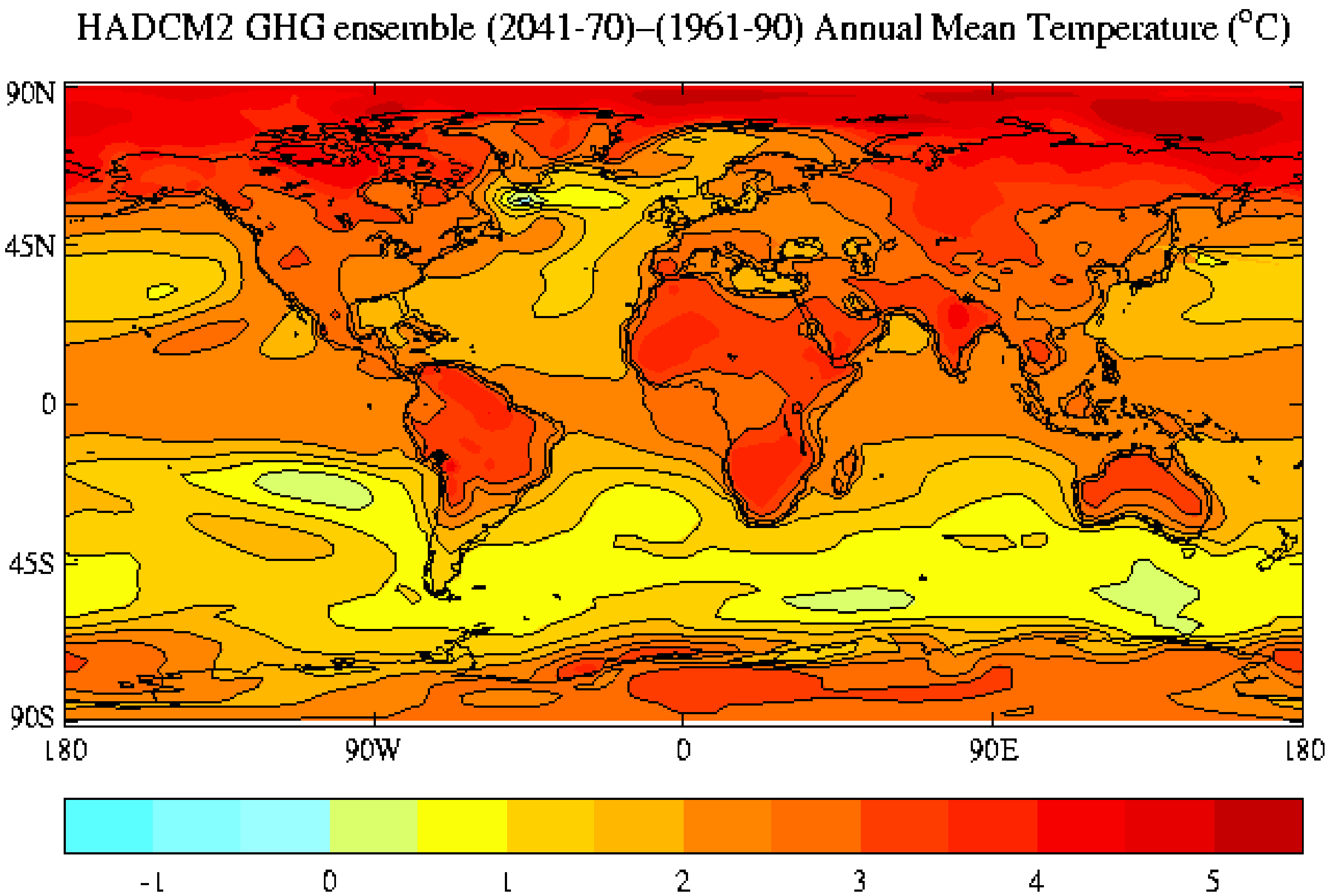
Smith et al. 2005

1000 years of Earth temperature history…and 100 years of projection



Global average surface temperature is an index of the state of the climate – and it's heading for a state not only far outside the range of variation of the last 1000 years but outside the range experienced in the tenure of Homo sapiens on Earth.

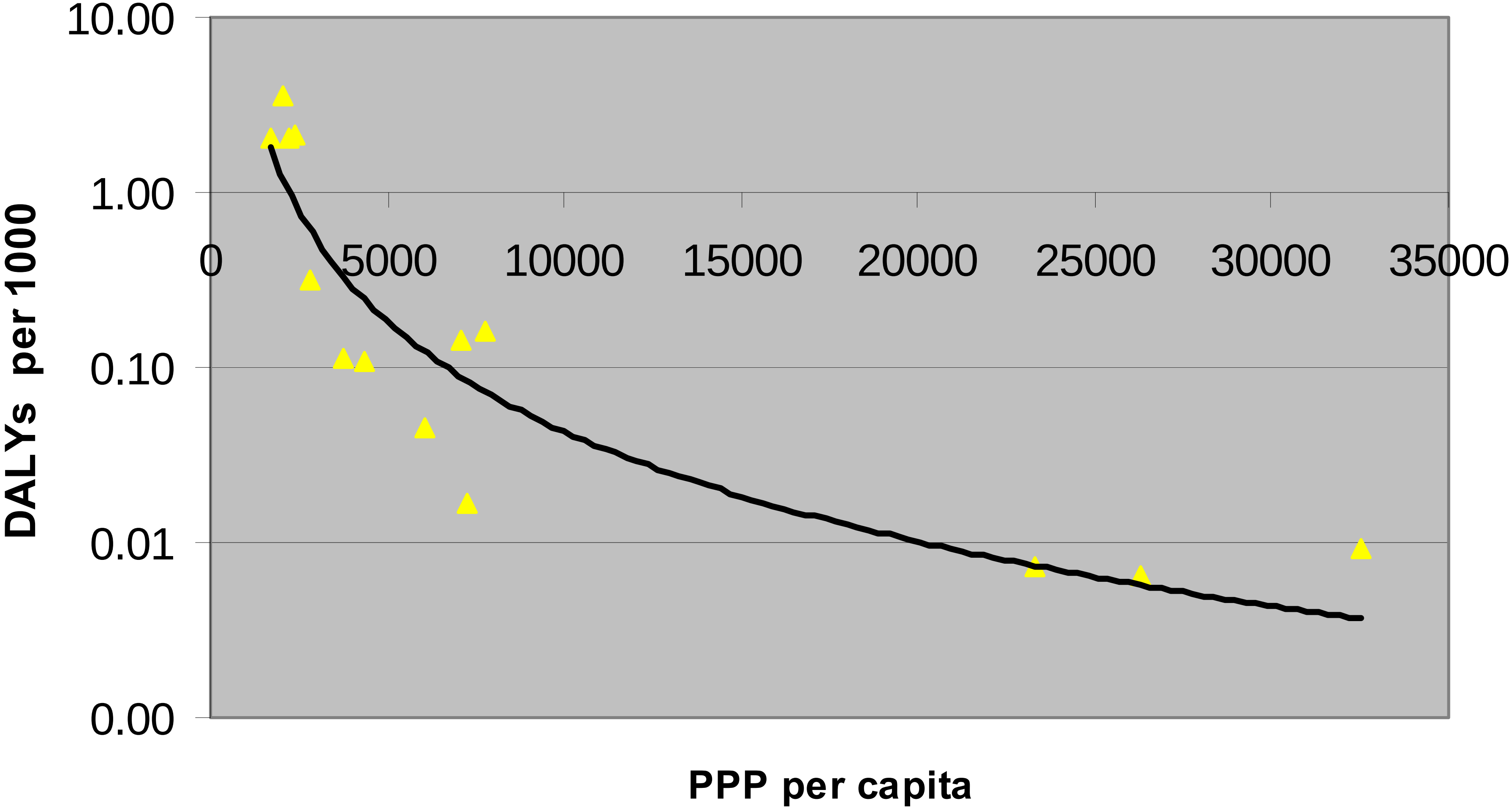
Where we're headed without any serious mitigation.



Hadley Centre for Climate Prediction and Research

Computer simulation of mid-21st-century warming under BAU: consequences come sooner because warming is non-uniform.

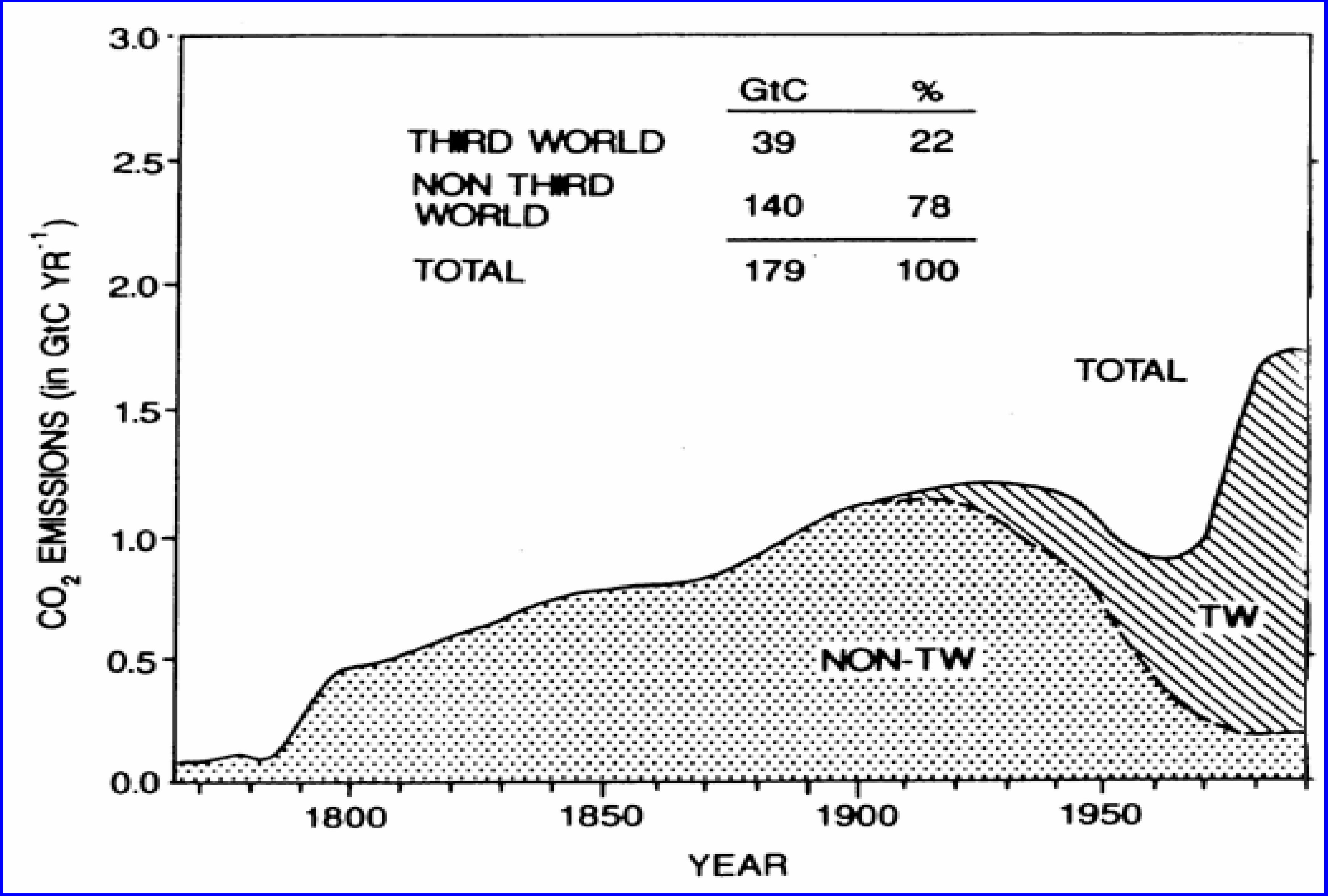
Global Risk Transition (Experiencing Risks)



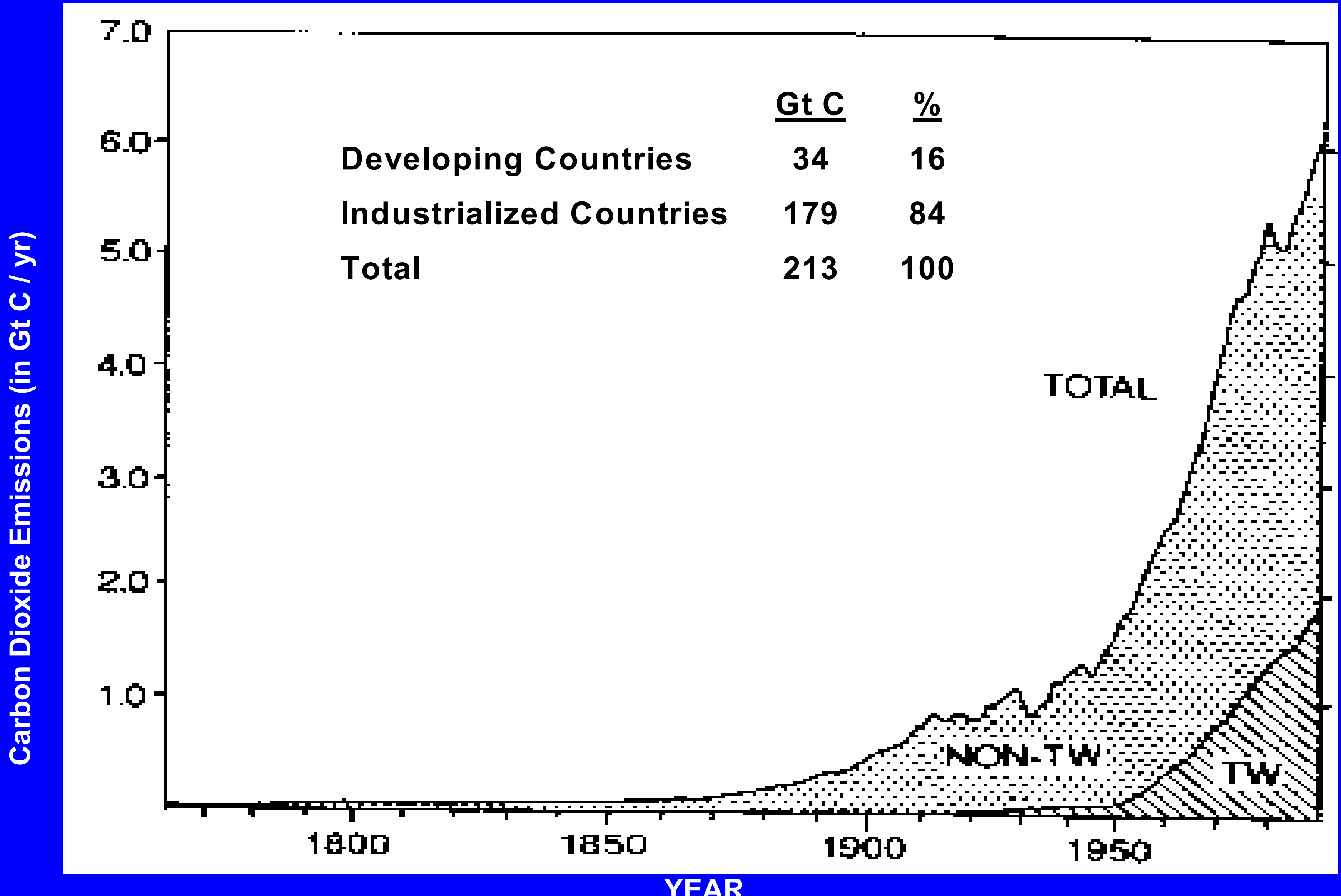
Who causes climate change?

- Need to know in order to implement “common but differentiated responsibility” of UNFCCC
- Should “polluter pays” principle be applied?
- Should it be current emissions only that determine responsibility or cumulative emissions?
- What about emissions before anyone knew about climate change?

Carbon Emissions from Land-Use Changes



Carbon Emissions from Fossil Fuel Burning



Introduction to Natural Debt

- Warming of GHGs this year is not directly due to this year’s emissions but to the amount in the atmosphere.
- Is thus due to the GHG accumulation of all past emissions that are still left today in the atmosphere
- Current emissions are a problem only if they add GHGs faster than they are removed by natural processes, i.e. exceed assimilative capacity
- We have been adding GHGs faster, thus borrowing assimilative capacity from the future, building up a “natural debt”

Natural Debt (cont.)

- Natural debt is analogous to “national debt”, which we build up by borrowing financial resources from the future.
- A bit of debt is probably ok, but too much of either type can be serious
- For greenhouse pollutants, our Natural Debt is measured as the cumulative amount of emissions per capita from past activities minus the amount removed by natural processes (mainly capture by the ocean)

Smith, 1991

Natural Assimilation

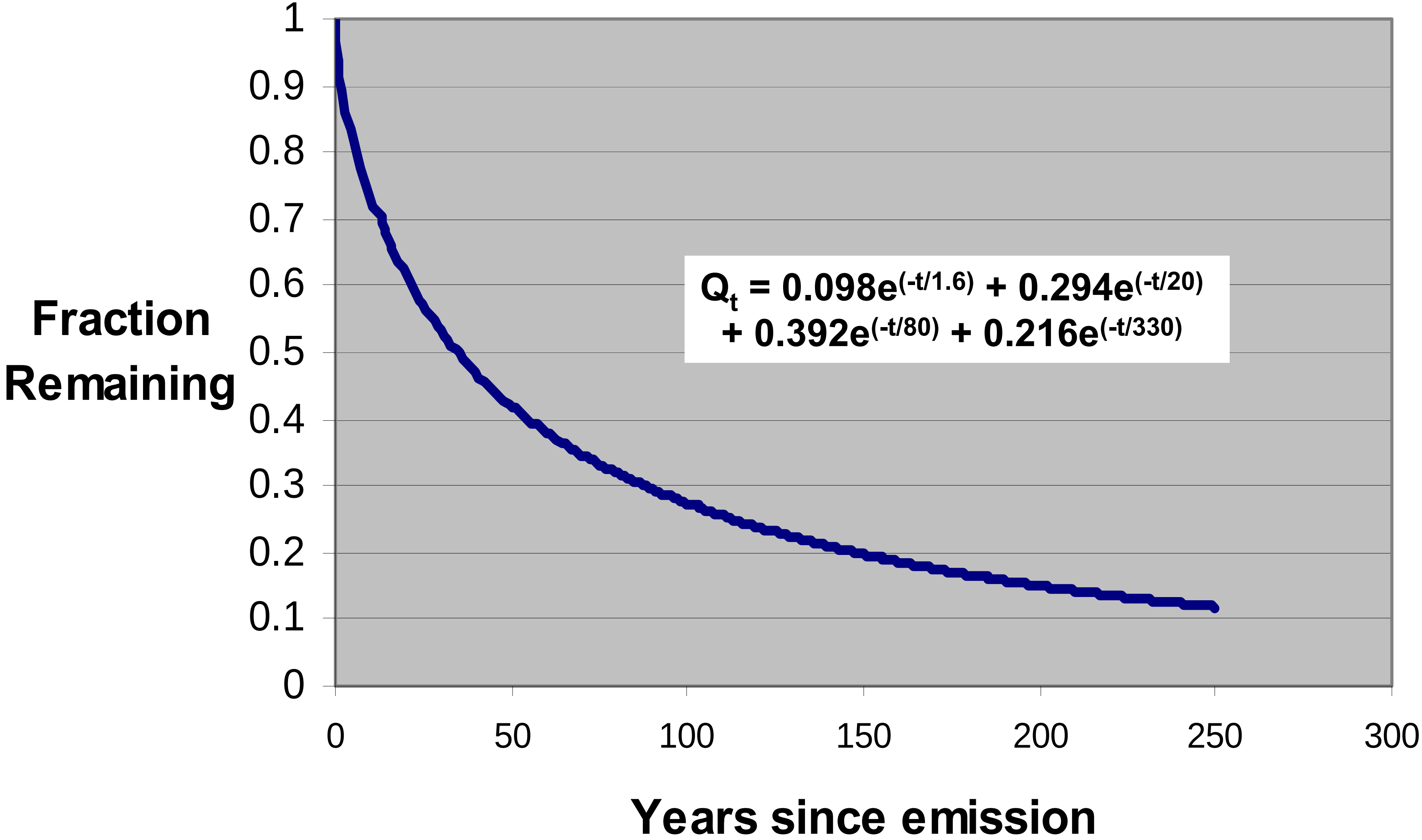
- Earth's assimilative capacity for CO_2 emissions is complex, but most analyses use the so-called "Bern Model" (Joos et al. 1996)
- Fraction remaining at time t = $0.098e^{(-t/1.6)} + 0.294e^{(-t/20)} + 0.392e^{(-t/80)} + 0.216e^{(-t/330)}$
- Roughly half is assimilated within 35 years of release, with the remaining 50% taking another 80 years to be half gone, and the remaining 25% another 160 years to be half gone
- Leaving 12.5% 240 years after the original year of emissions.

Sources and Fates of Human Carbon Emissions

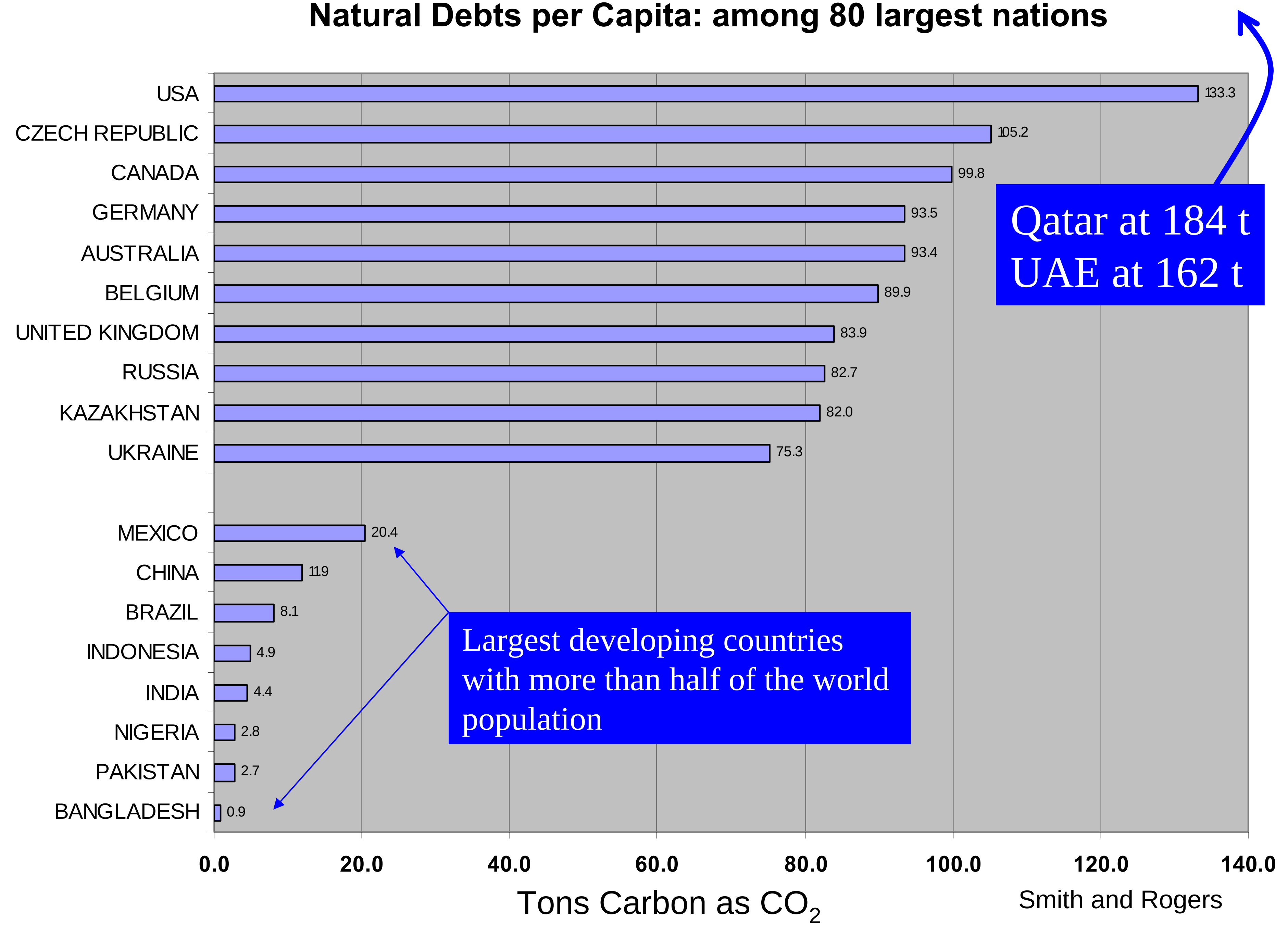
- Fossil fuels ~ 5.5
- Tropical deforestation ~ 1.6
- Total ~ 7.1 +/- 1.1

- Uptake by oceans ~ 2.0
- Uptake by terrestrial ecosystems ~ 1.8
- Storage in atmosphere ~ 3.3

Carbon Dioxide Depletion

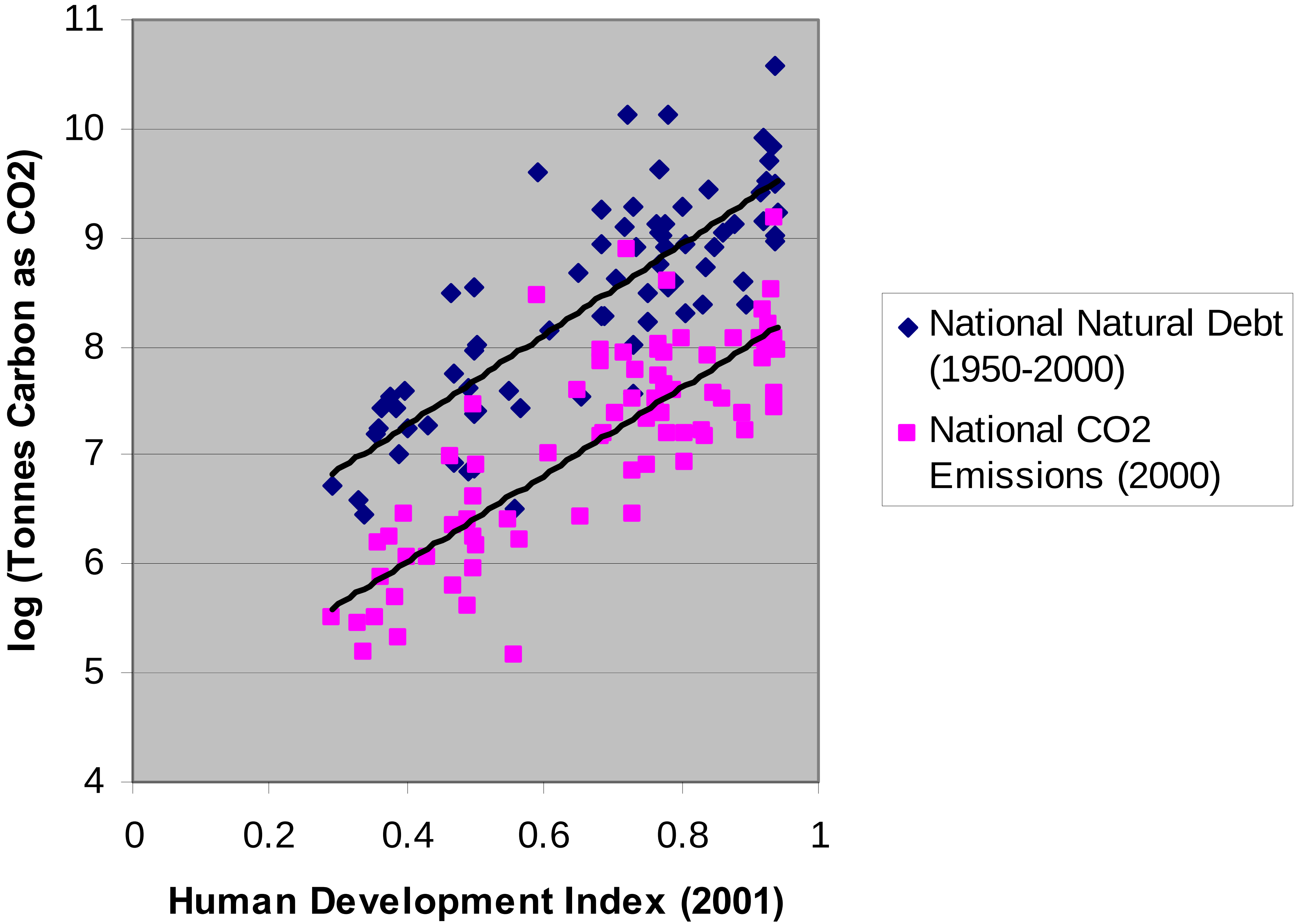


Natural Debts per Capita: among 80 largest nations



Distribution

- Global ND: ~150 Gt (half of all emitted since pre-industrial times)
- Global Mean: 24 t/capita
- Without the USA, 17 t.
- Relative responsibilities of countries varies dramatically by whether current emissions or natural debt is used


log (Tonnes Carbon as CO2)
11
10
9
8
7
6
5
4
0
0.2
0.4
0.6
0.8
1
Human Development Index (2001)
National Natural Debt (1950-2000)
National CO2 Emissions (2000)

Prefer Natural Debt

	Million Population	Strength of Preference
BANGLADESH	138.4	150%
SUDAN	38.1	145%
VIET NAM	81.8	139%
BURMA (MYANMAR)	45.6	129%
THAILAND	63.3	111%
ETHIOPIA	69.6	108%
MALAYSIA	23.1	96%
NEPAL	26.5	90%
IRAN	64	89%
INDONESIA	223.1	76%
ALGERIA	31.7	69%
SOUTH KOREA	48.2	68%
CAMEROON	16.5	66%
TAIWAN	22.6	64%
CHINA	1291.5	63%
PAKISTAN	156.1	59%
KENYA	33	54%
GHANA	21.1	54%
MADAGASCAR	17.2	54%
EGYPT	74.7	49%
UGANDA	26.3	48%
INDIA	1057.5	47%
TURKEY	68.1	46%
SYRIA	17.6	43%
SAUDI ARABIA	25.2	40%
MOROCCO	31.7	32%
YEMEN	19.3	30%
(total population-million)	~3700	

Population of countries with no preference: ~1700 million

Population of countries not included: 360 million

Current Emissions

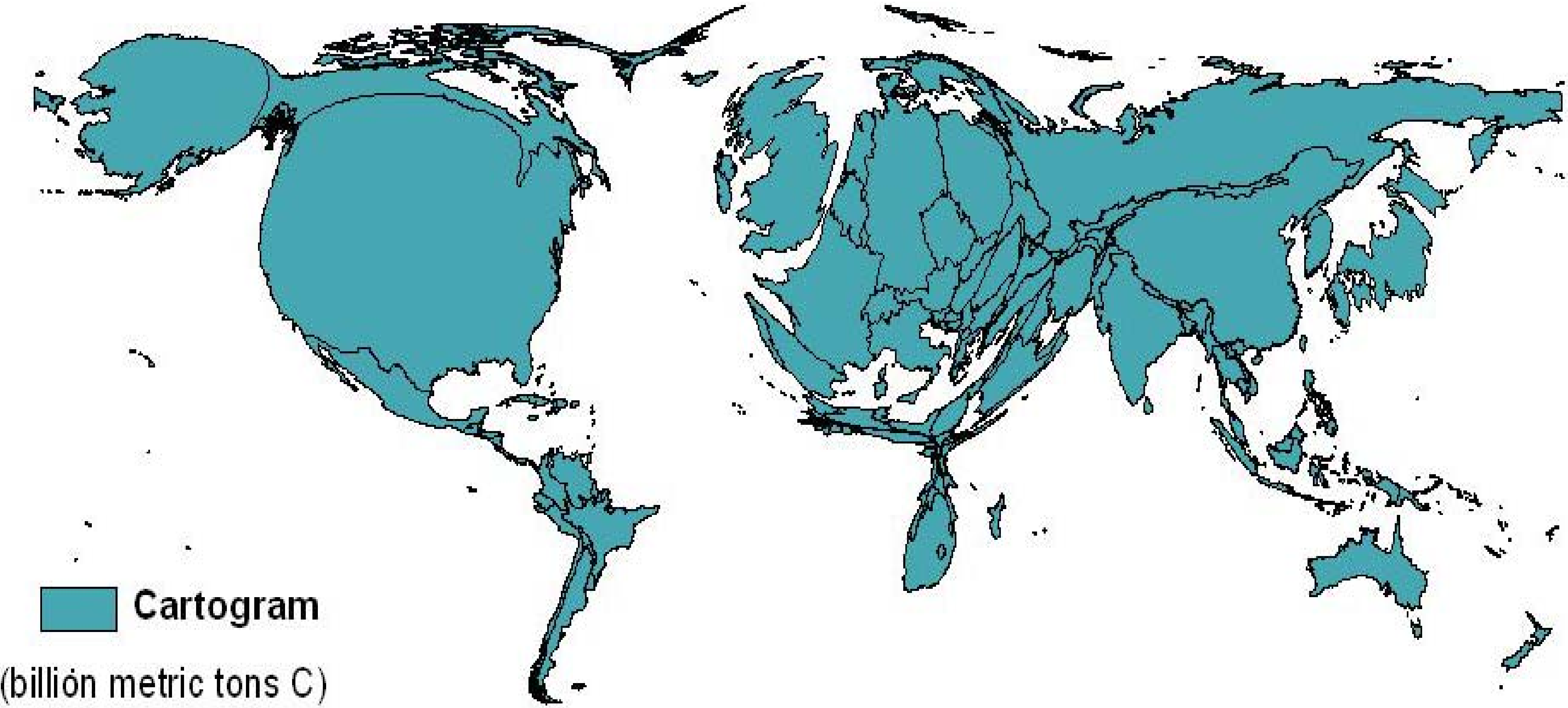
	Million Population	Strength of Preference
UZBEKISTAN	26.0	58%
NORTH KOREA	22.5	58%
AFGHANISTAN	27.1	53%
CONGO	57.1	51%
BELARUS	10.0	49%
UKRAINE	47.7	49%
ROMANIA	22.4	46%
MALAWI	12.4	46%
MOZAMBIQUE	19.4	46%
GERMANY	82.4	38%
CZECH REPUBLIC	10.3	37%
HUNGARY	10.1	36%
UNITED KINGDOM	60.1	36%
BELGIUM	10.3	35%
POLAND	38.6	35%
FRANCE	60.2	31%
(total population - million)	~520	

Pop with ND preference: 3.7 billion
with CE preference: 0.5 billion

Preferences less than 30%:

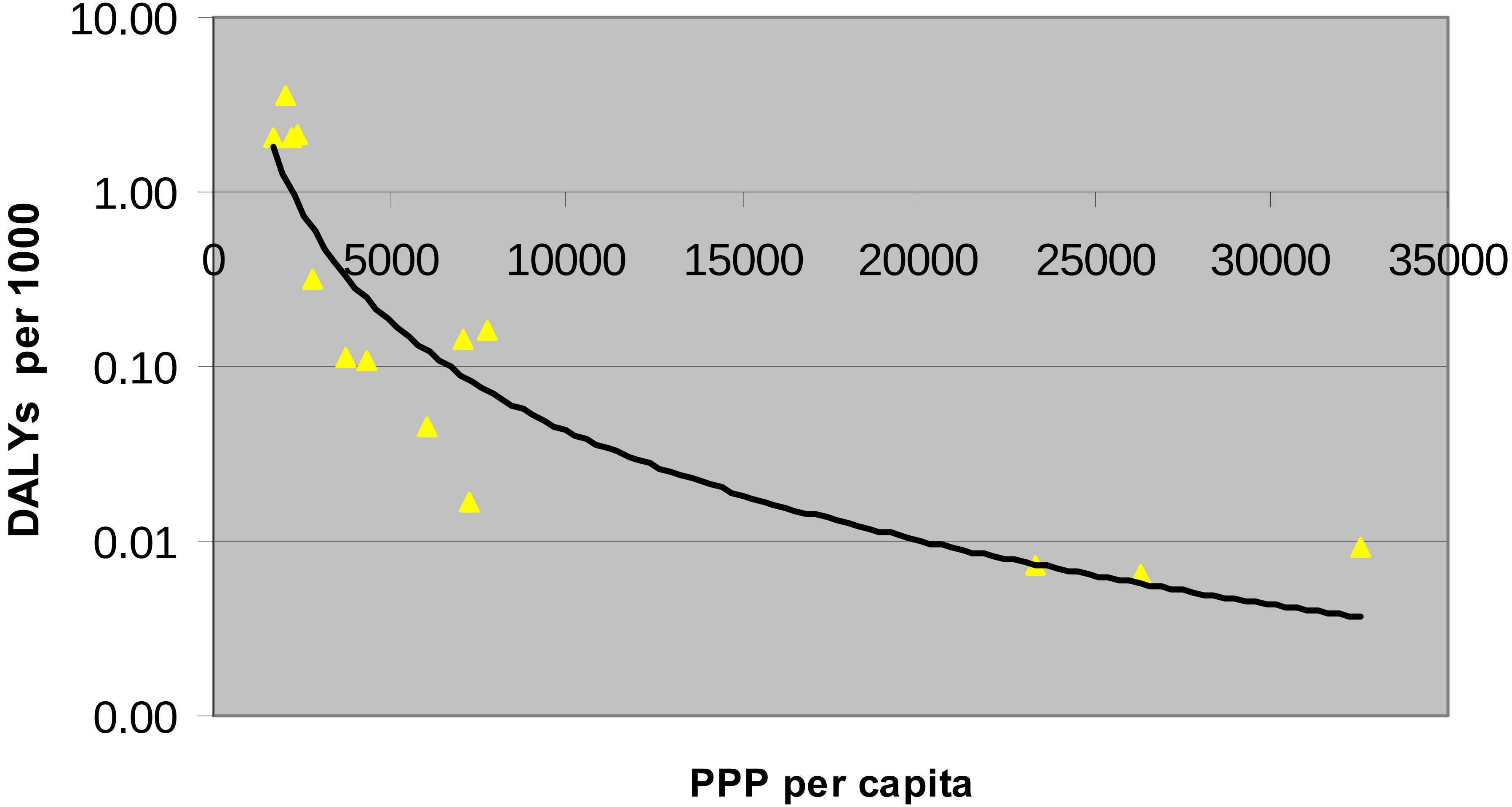
ND: USA (13%)
Current: Brazil (6%)

Distribution of Natural Debt by Country: Carbon in Cumulative CO_2 emissions

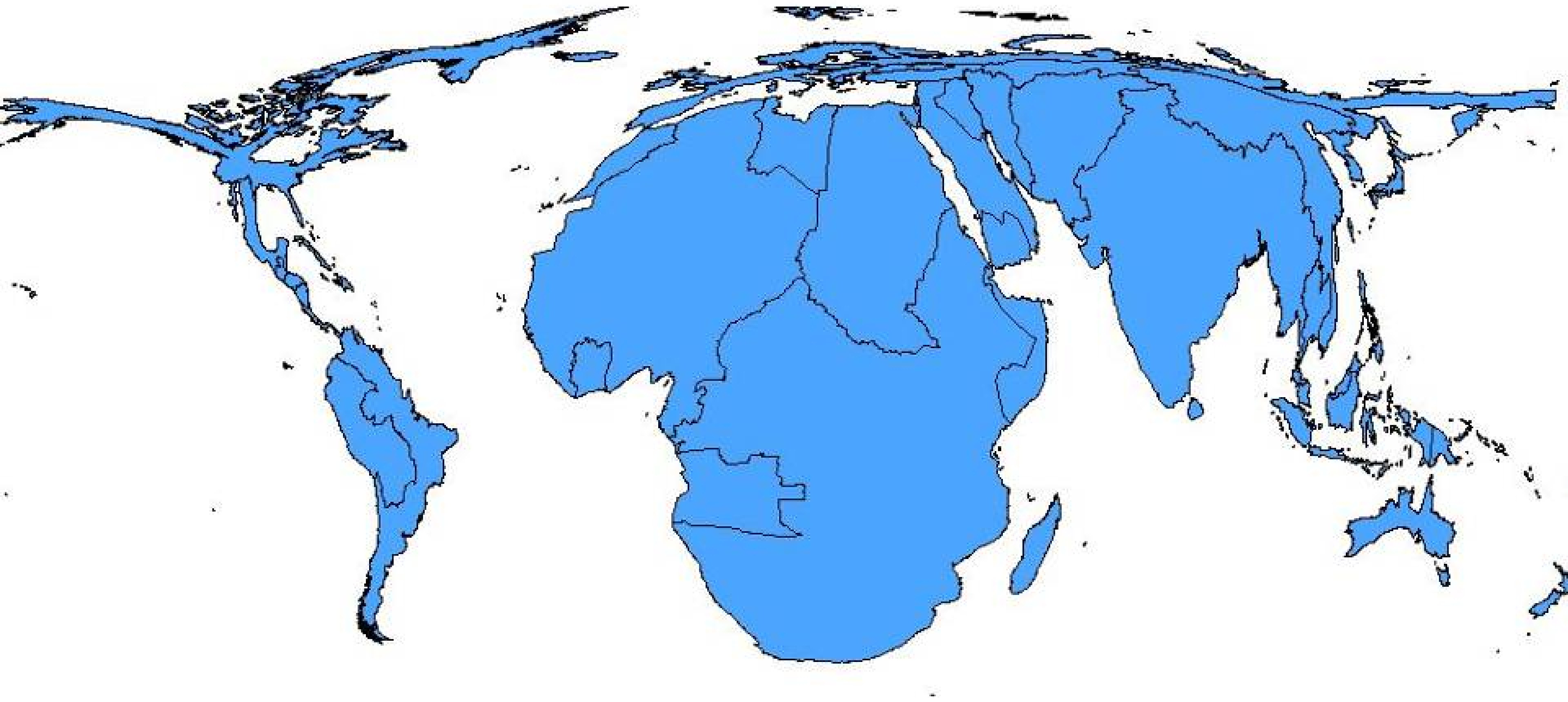


Patz et al.

Global Risk Transition (Experiencing Risks)



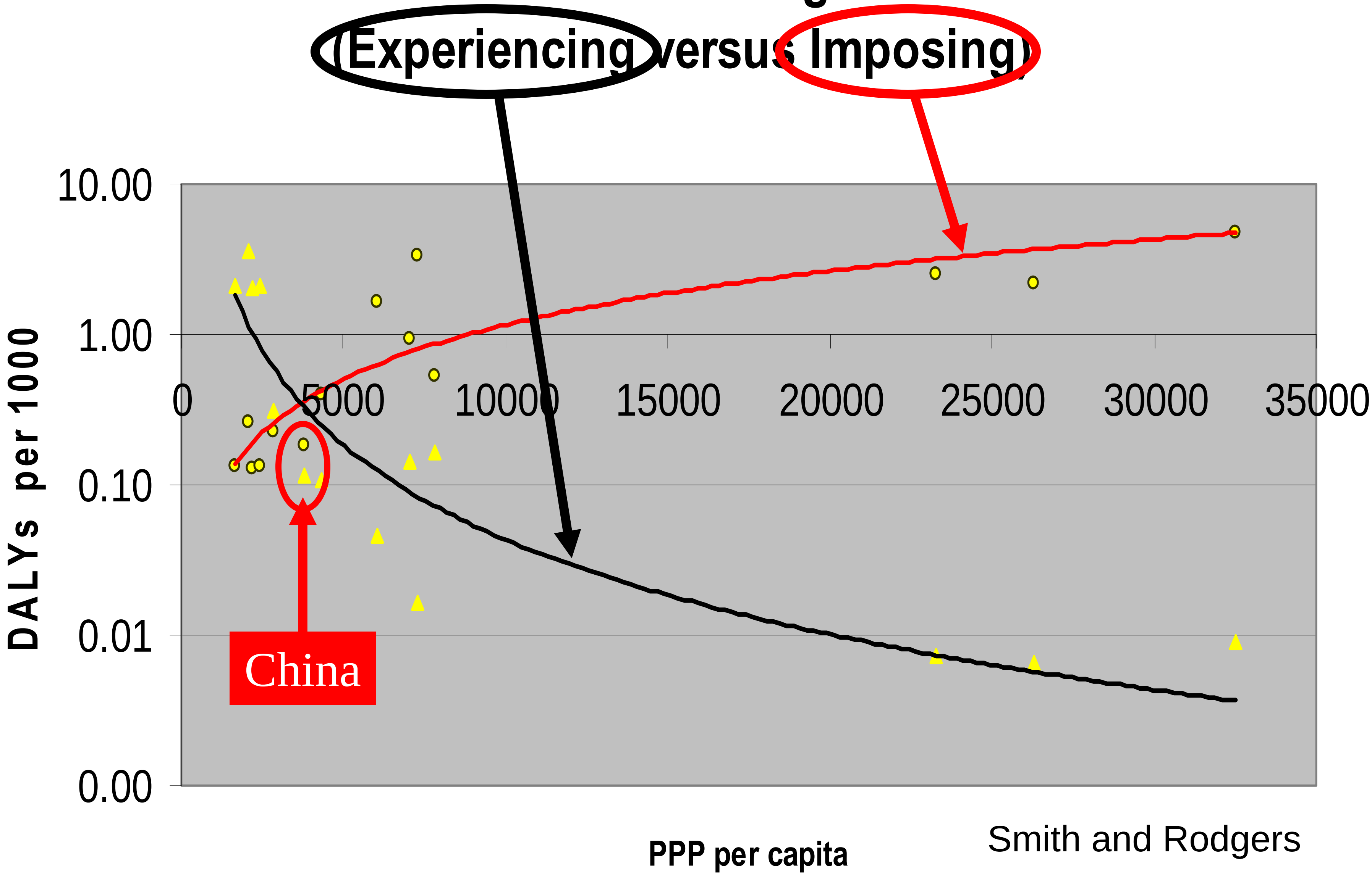
Cartogram of Climate-related Mortality (per million pop) yr. 2000



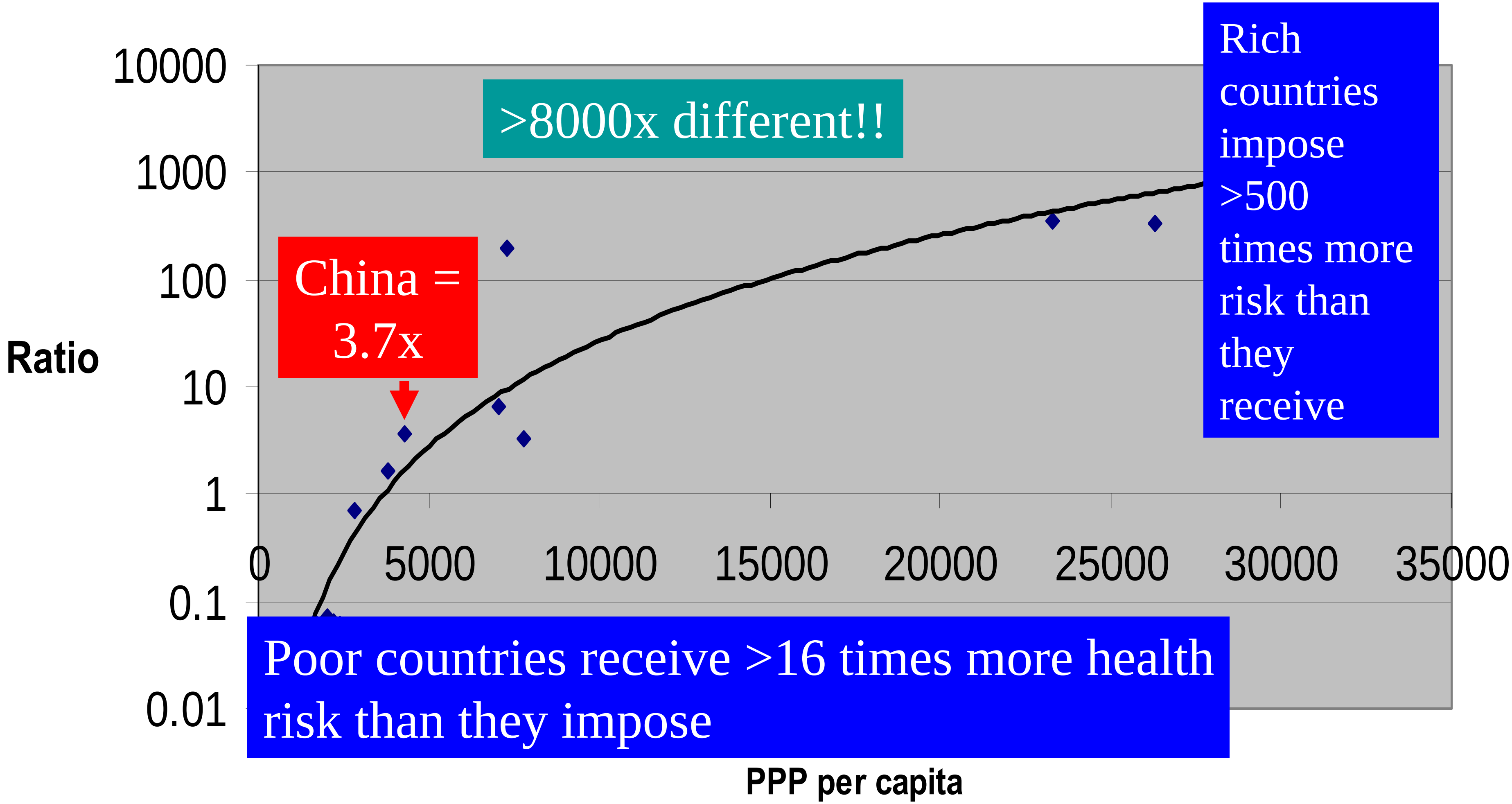
Patz et al.

This map shows estimated mortality (per million people) attributable to climate change by the year 2000. Map is a density-equalizing cartogram in which the sizes of the 14 WHO regions are proportional to the increased mortaility.

Distribution of Health Impacts from Climate Change (Experiencing versus Imposing)



Distribution of Health Impacts from Climate Change (Ratio: Imposing/Experiencing)



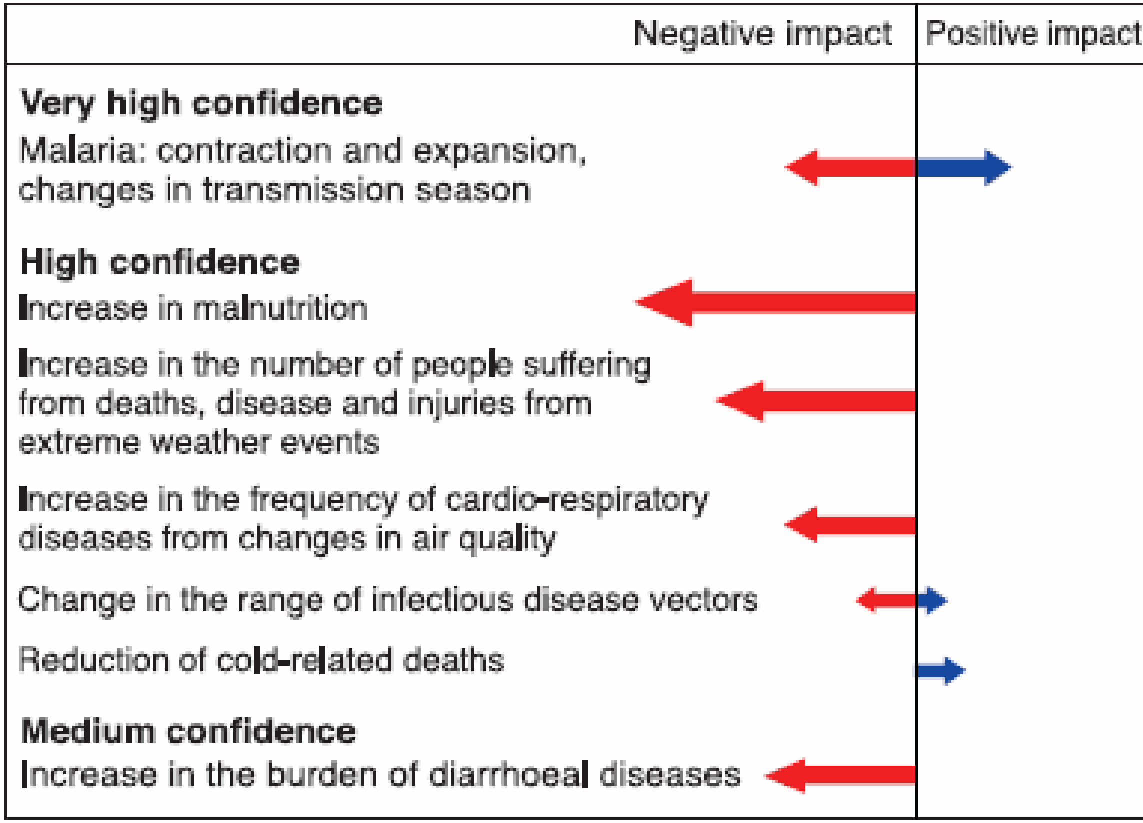


Figure 8.3. *Direction and magnitude of change of selected health impacts of climate change (confidence levels are assigned based on the IPCC guidelines on uncertainty, see http://www.ipcc.ch/activity/uncertaintyguidancenote.pdf).*

IPCC WGII, 2007

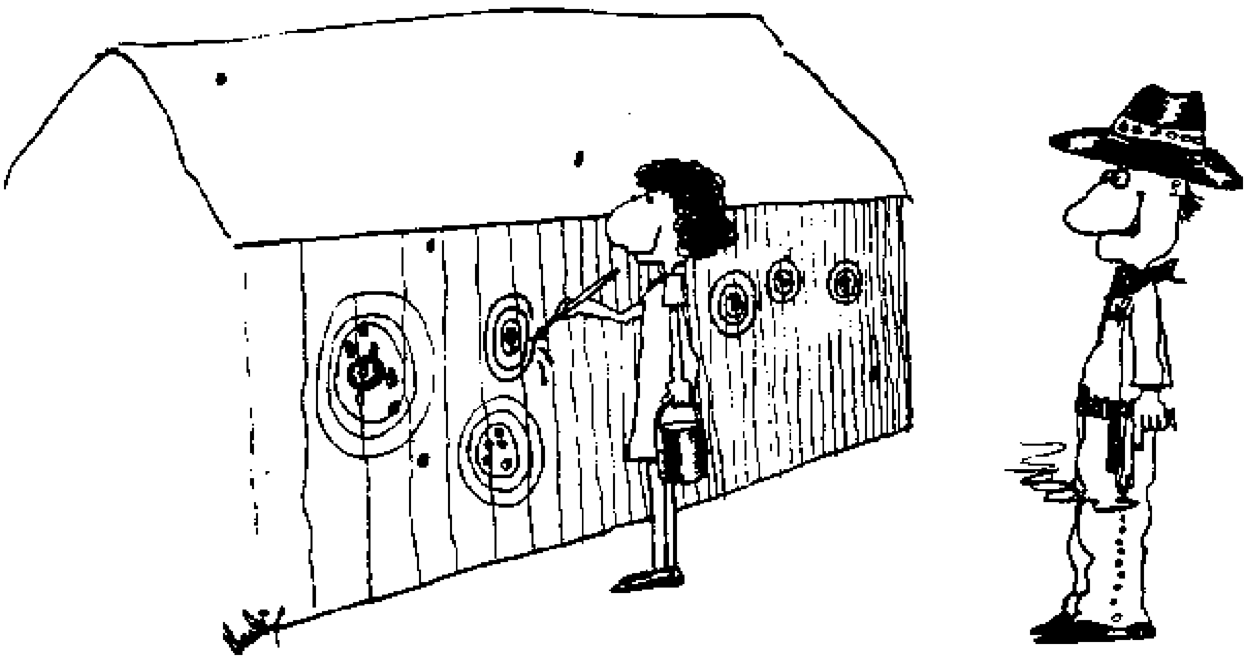
To Bring Co-benefits Into Policy

- Need consistent, repeatable, credible, quantified assessments
- Health field has much to offer
- Indeed, compared to major parts of the energy and emissions worlds, public health science is far ahead, e.g., we have
  - Standard methods and expectations about peer review
  - Clear rules about study design and the level of evidence provided
  - Ways of dealing with confounding and other bias
  - Understanding and ways of handing misclassification
  - Relative risks and confidence intervals
  - Etc.

The Texas Sharpshooter Problem

Shoots First, Then Draws Targets Around the Holes!

Only way to be sure that the targets are meaningful and if one has met them is to draw them first using standard criteria



Background to Central Premise

- Methods for determining benefits in terms of carbon credits, health improvements, economic development, etc. are complex and in flux, and vary according to a range of explicit and implicit assumptions made by the analyst. e.g.:
  - Basic metrics for health, economic development, etc.
  - Economic valuation approaches
  - Discount rates
- Nevertheless, there has been much progress in recent years within the context of major international collaborative assessments for some of the benefits being considered

Recent International Collaborative Assessments Provide Inputs for Co-benefits Analysis

- IPCC/UNFCCC: *Inter alia*, metrics and procedures for calculating carbon credits
- Millennium Development Goals: 8 MDGs with ~30 explicit indicators and metrics
- Commission on Macro-economics and Health: established health burden metrics and standard methods for cost-effectiveness analysis
- WHO Comparative Risk Assessment: Metrics of exposure and health burden with estimated exposure –response relationships and uncertainties

IPCC/UNFCCC/Carbon Market

- Standard methods for CO_2-equivalent GHG emissions
- Six “Kyoto” gases
- Global Warming Potentials for each
- 100-year time horizons, equivalent to 0.7% discount rate
- Default emission factors for many sectors

Millennium Development Goals (MDGs)

were officially established at the Millennium Summit in 2000 where 189 world leaders adopted an action plan to achieve them by 2015, with specific indicators under each

1. **Eradicate extreme poverty and hunger**
2. **Achieve universal primary education**
3. **Promote gender equality and empower women**
4. **Reduce child mortality**
5. **Improve maternal health**
6. **Combat HIV/AIDS, malaria, and other diseases**
7. **Ensure environmental sustainability**
8. **Develop a global partnership for development**

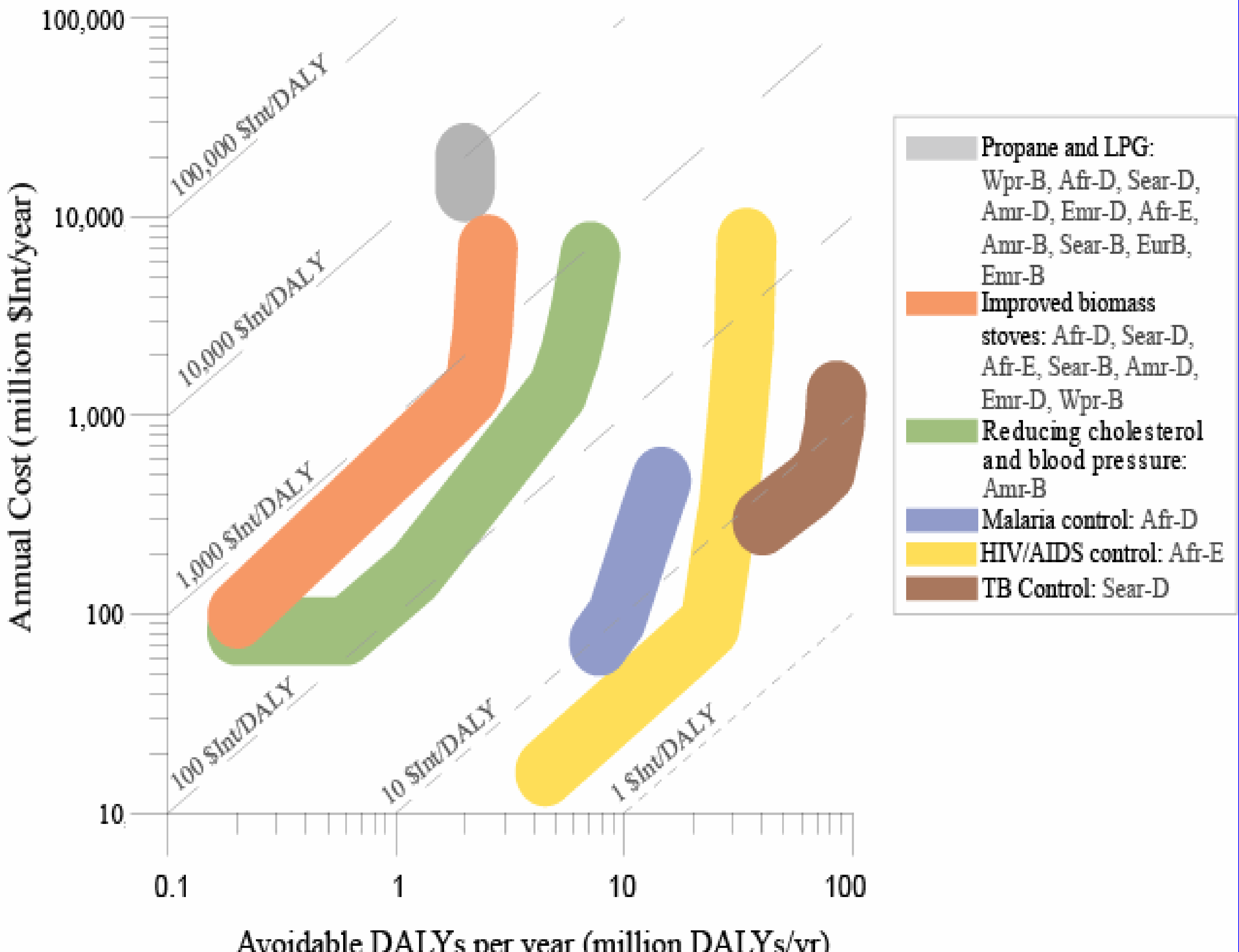
Commission on Macro-economics and Health, 2001

- Recommended methods and criteria for setting priorities among health interventions based on
  - DALYs: saved healthy life years
  - Cost: in terms of local income levels

- Adopted by World Health Organization and World Bank

Recommendations

- **“Very Cost-Effective”:** Less than the local $GDP/capita per DALY should be considered part of primary health promotion and be undertaken as quickly and widely as possible.
- **“Cost-Effective” :** Between one and three times the local $GDP/capita-DALY, interventions should be seriously considered and with appropriate attention to the needs of special populations, regions, etc; the cheaper ones should generally be undertaken first.
- **“Not Cost-Effective” :** More than three times the local $GDP/capita-DALY, interventions should be left to private markets and not be part of government or donor activities.



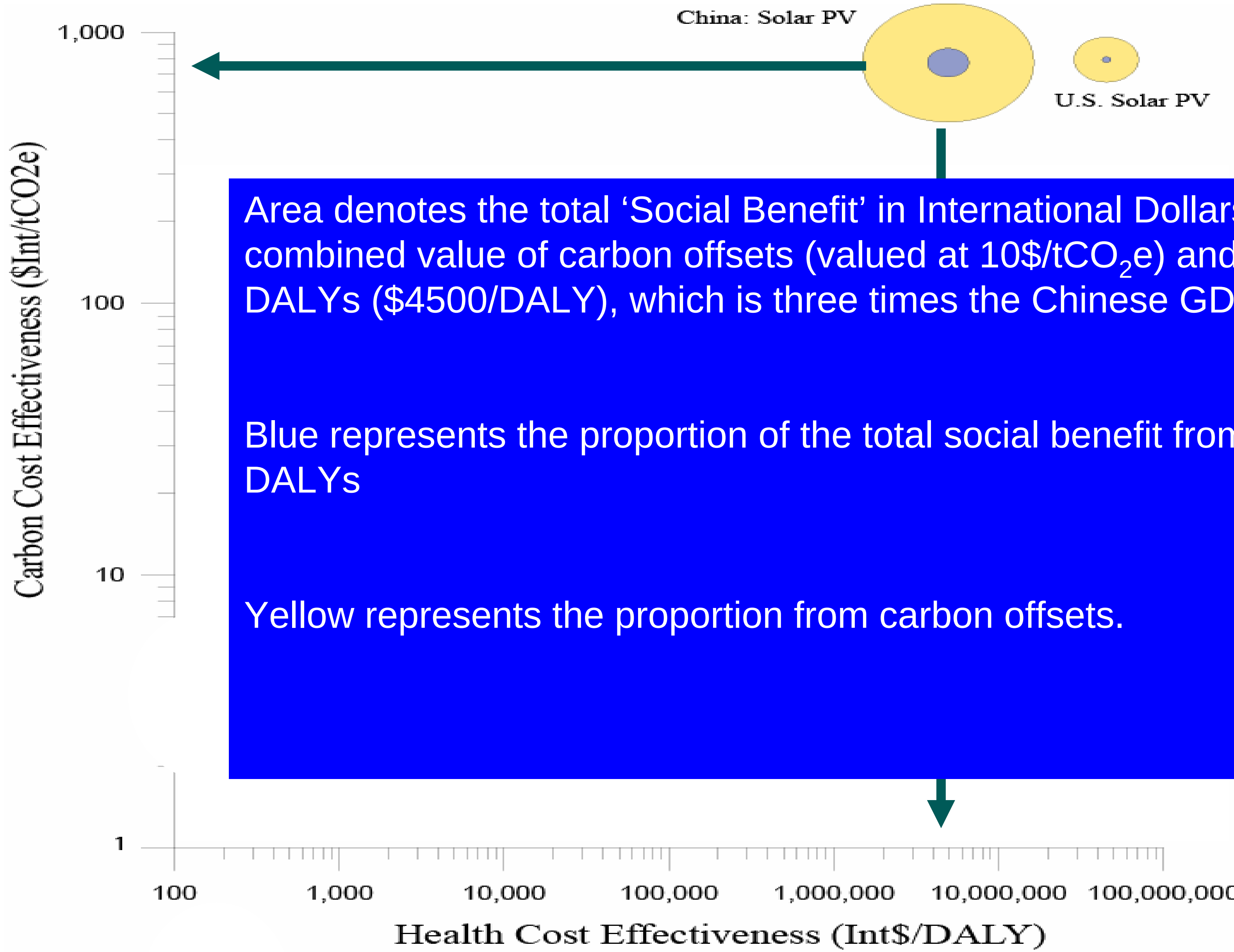
100,000
10,000
1,000
100
10
Annual Cost (million $Int/year)
0.1
1
10
100
Avoidable DALYs per year (million DALYs/yr)
100,000 $Int/DALY
10,000 $Int/DALY
1,000 $Int/DALY
100 $Int/DALY
10 $Int/DALY
1 $Int/DALY
Propane and LPG: Wpr-B, Afr-D, Sear-D, Amr-D, Emr-D, Afr-E, Amr-B, Sear-B, EurB, Emr-B
Improved biomass stoves: Afr-D, Sear-D, Afr-E, Sear-B, Amr-D, Emr-D, Wpr-B
Reducing cholesterol and blood pressure: Amr-B
Malaria control: Afr-D
HIV/AIDS control: Afr-E
TB Control: Sear-D

WHO Comparative Risk Assessment - 2004

- Large international multi-year effort
- Standard methods and metrics
- Common databases
- “Consensual Discipline”
- Heavily peer-reviewed
- Published in detail
- Regular update
  - Next update starting Sep 2007

Summary metrics for use in co-benefits scoping.

	Health	Climate Change	Money	
Metric	DALYs (Disability-Adjusted Life Years)	GWC (Global Warming Commitment)	International Dollars	
Unit	Years	Tons CO_2 equivalent	US Dollars	
Formulation	Years lost from premature death plus weighted years lost to disability	Tons CO_2 plus tons other GHGs multiplied by their global warming potentials (GWPs)	Local currency adjusted by its capability to buy standard market basket of purchases	
Discount Rates	DALYs	GWPs	Benefits	Costs
Kyoto Case	0%	100-year ~ 0.7%	1%	3%
Base Case	3%	20-year ~ 4.3%	3%	3%
Financial Case	3%	20-year ~ 4.3%	3%	6%



Area denotes the total 'Social Benefit' in International Dollars from the combined value of carbon offsets (valued at 10$/t$CO_2$e) and averted DALYs ($4500/DALY), which is three times the Chinese GDP/capita.

Blue represents the proportion of the total social benefit from averted DALYs

Yellow represents the proportion from carbon offsets.

Figure: Smith & Haigler, in press

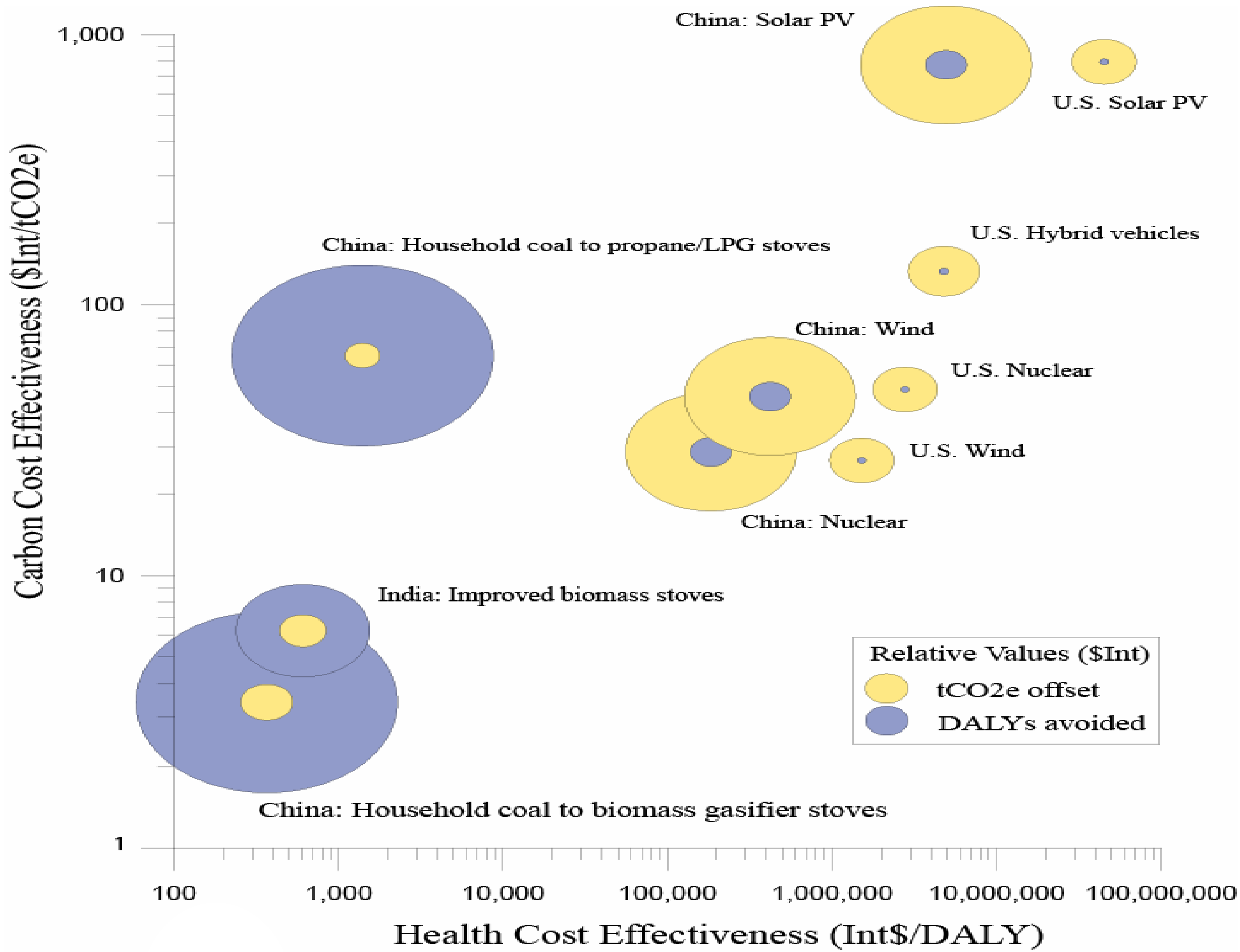
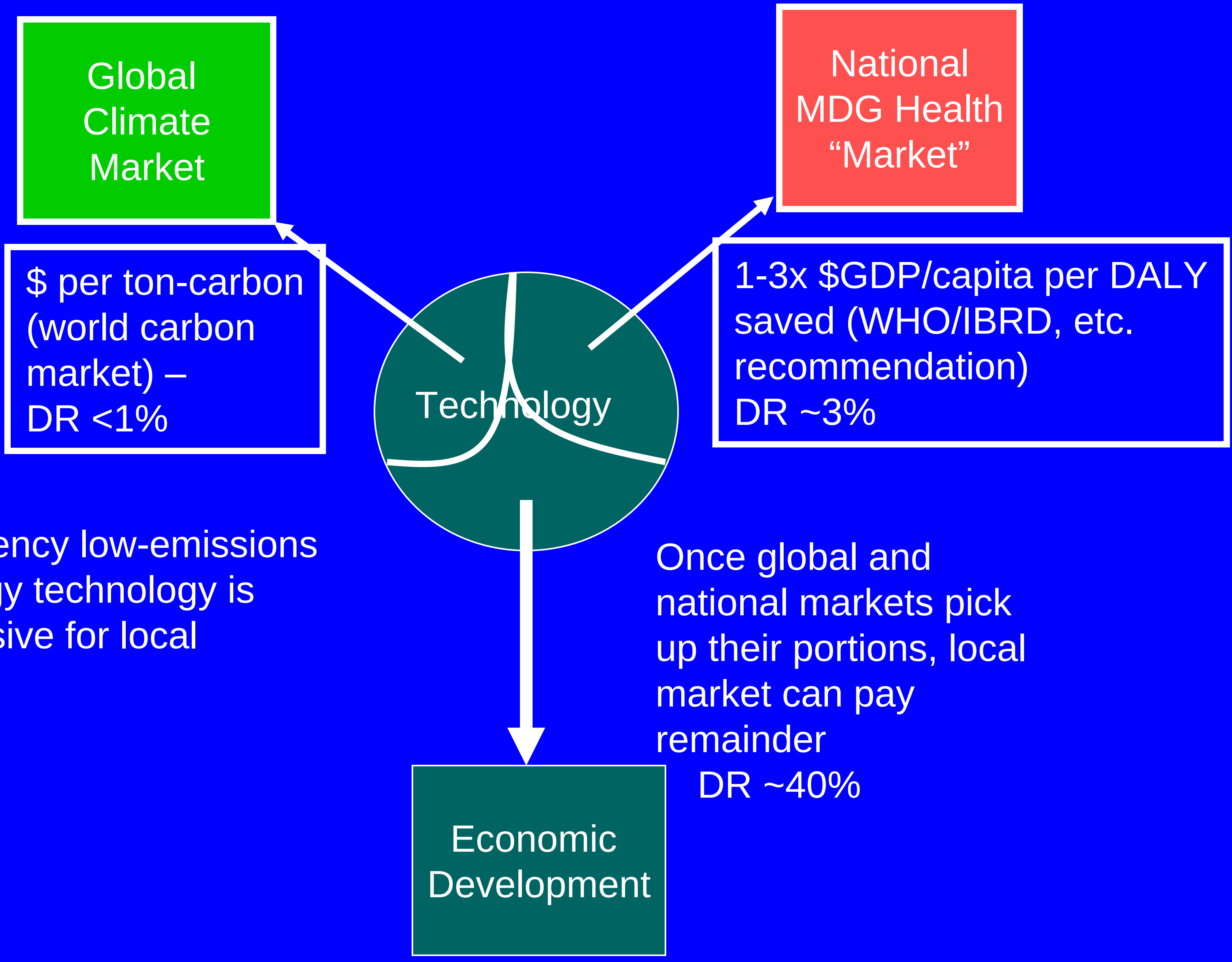


Figure: Smith & Haigler, in press

Paying for Rural Energy Development



High-efficiency low-emissions rural energy technology is too expensive for local markets

Once global and national markets pick up their portions, local market can pay remainder

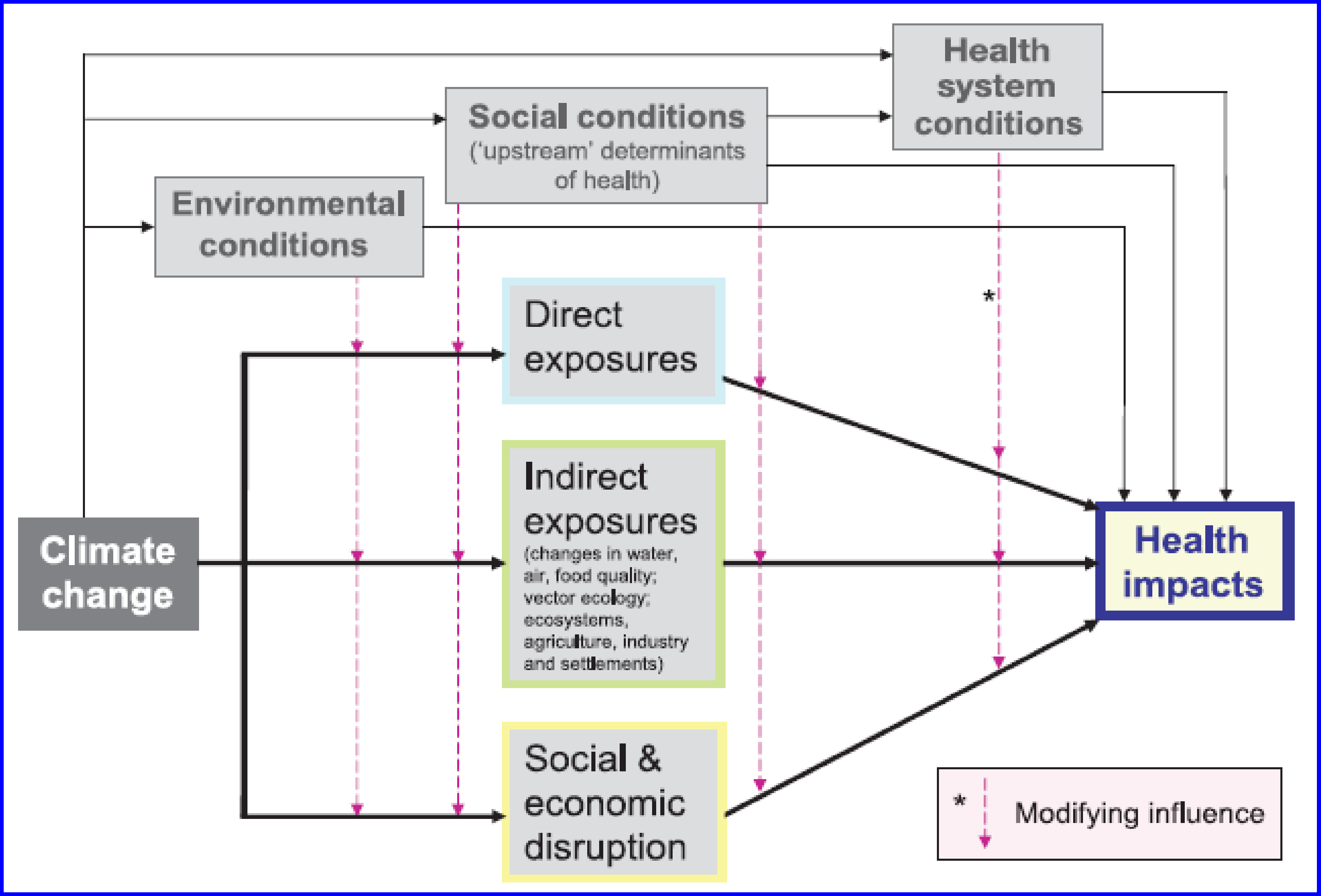
DR ~40%

Conclusion

- Perhaps the most telling simple definition of public health is that it is the
  - “Science and art of making people healthy before they are wealthy (and then keeping them that way).”
- Although altering both the rules and the stakes, the emergence of climate change on the world stage reinforces this vision of public health’s mission.
- The profession has much to offer, both directly and indirectly through its well-developed methods for making quantitative judgments about the effectiveness of interventions to promote human welfare
- It will also, however, need infusions of new methods, strategies, and resources in order to prevent climate change from slowing or reversing progress toward acceptable standards of health worldwide.

Climate and Human Welfare

- Most of humanity has spent most of history trying to protect itself from environmental stress and uncertainty.
- Half of humanity still suffers from not being able to do so.
- Climate change’s main health impact is to make this struggle more difficult, i.e., to set back the efforts of the poor half of humanity to deal with environmental stress and uncertainty
- The great stores of high-quality fossil fuels left to us by nature are the cumulative wealth of millions of years of solar energy
- Let’s make sure we use them for the highest value uses, which includes bringing the environmental vulnerability of poorest among us down to acceptable levels.
- With or without climate change



IPCC WGII, 2007

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Thank you