Climate Change and Health

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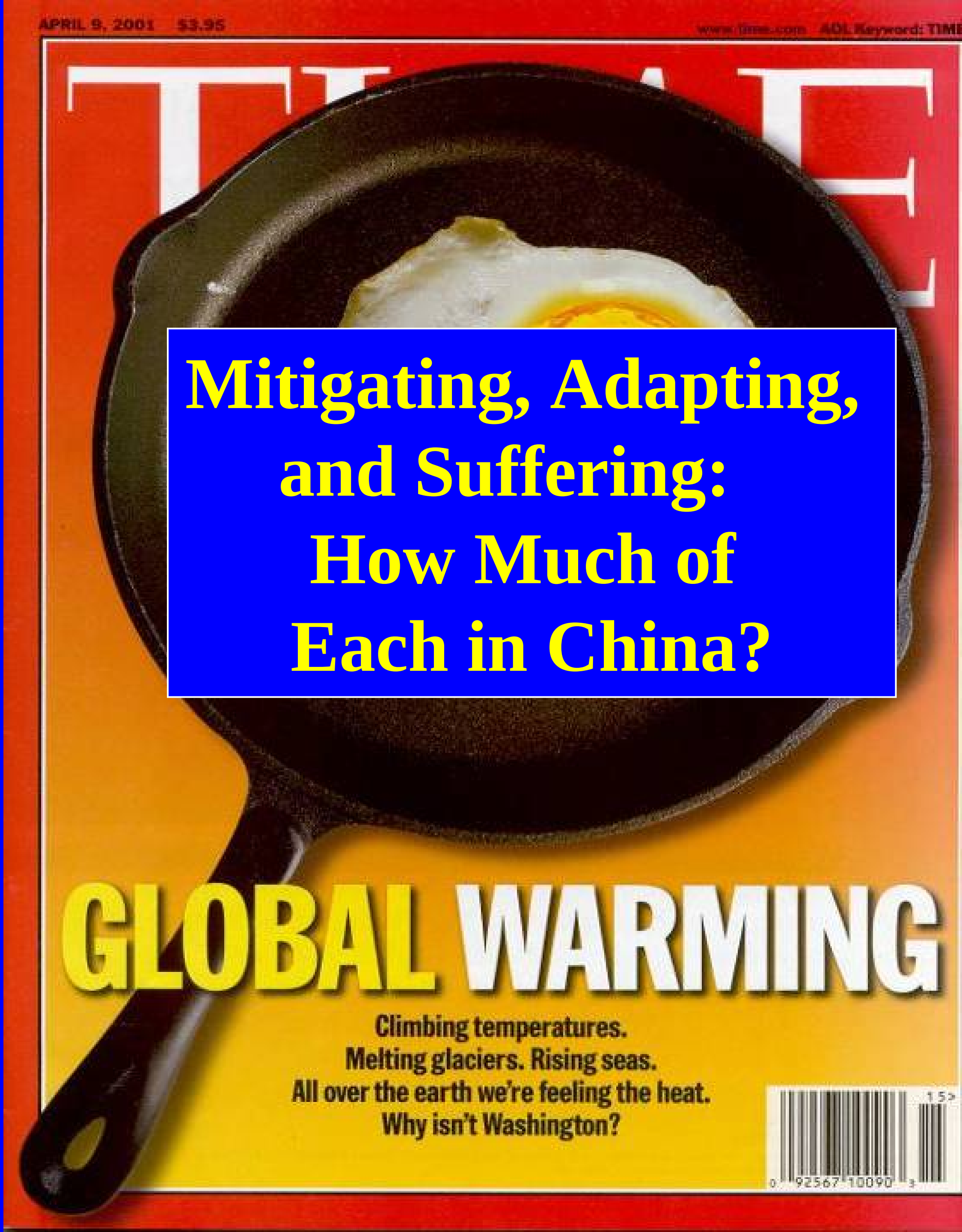
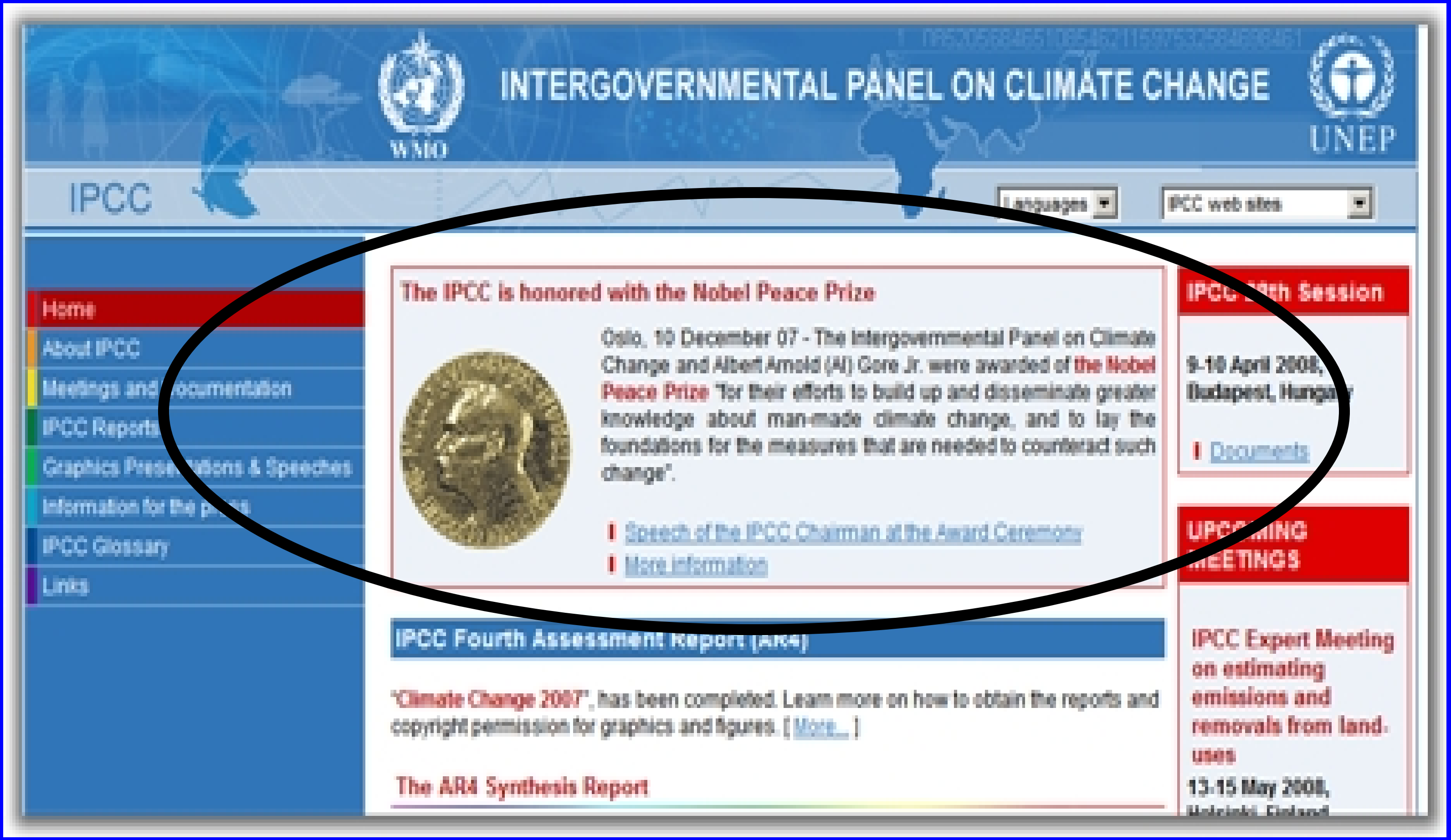
Nobel Laureate, 2007
(at the 0.03% level)

Shanghai Bio-Forum
May 30, 2008



Mitigating, Adapting, and Suffering: How Much of Each in China?



2000 Scientists Involved Worldwide

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 downtown Shanghai to
  - schistosomiasis in rural Sichuan.

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.

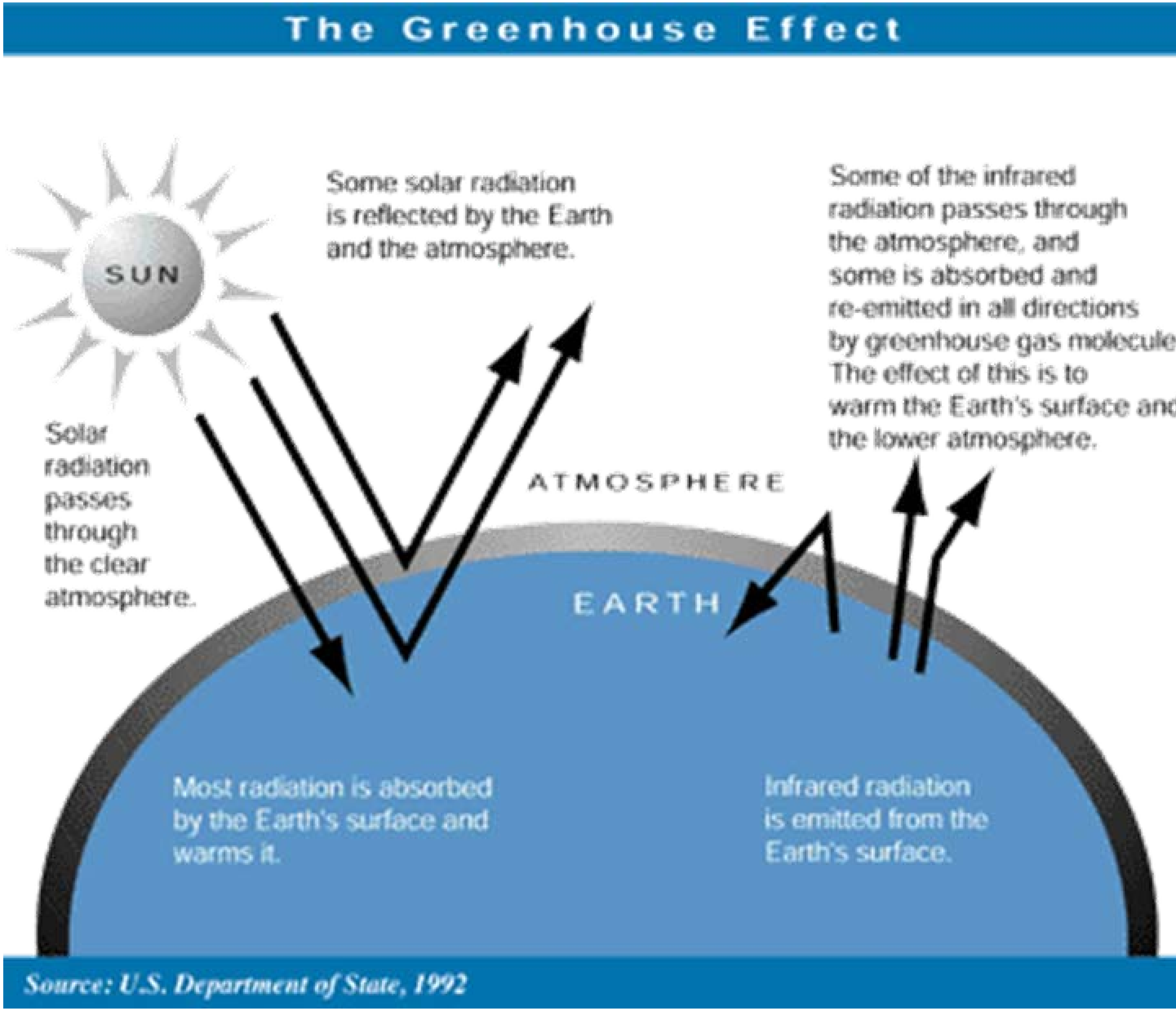
Society has three basic options for responding to human-caused climate change

- **Mitigate** 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
- **Adapt** 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.
- **Suffer,** 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.

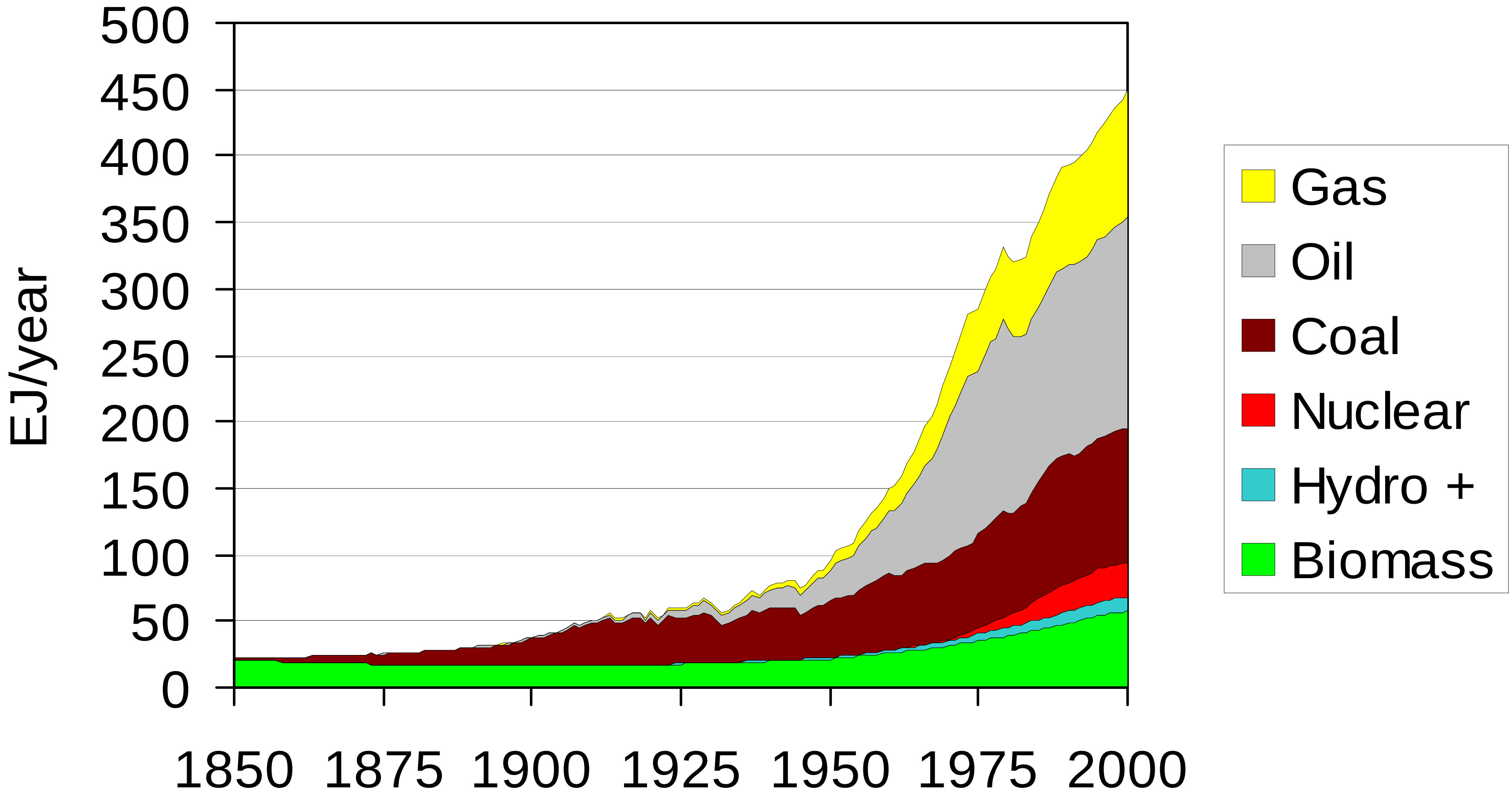
Framework from Holdren, 2006

Four short briefings

- **Basics of Climate Change**
- What **Health Effects** are estimated?
- How do the distribution of health impacts in world illustrate the difficulty of global negotiations?
- What can the health field offer for determining **Co-benefits**, i.e. jointly achieving health benefits and climate mitigation.

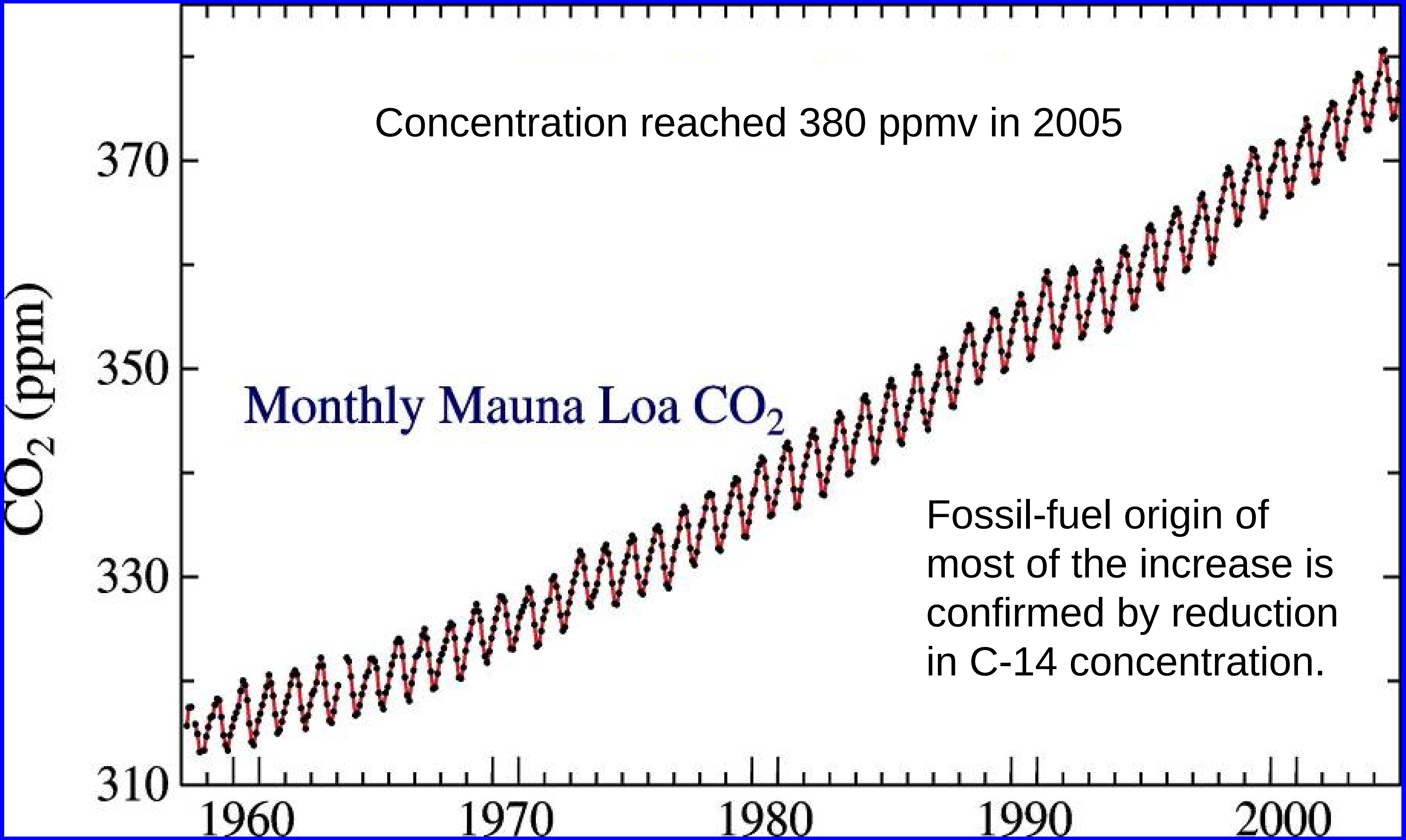

The Greenhouse Effect
SUN
Some solar radiation is reflected by the Earth and the atmosphere.
Some of the infrared radiation passes through the atmosphere, and some is absorbed and re-emitted in all directions by greenhouse gas molecules. The effect of this is to warm the Earth's surface and the lower 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)

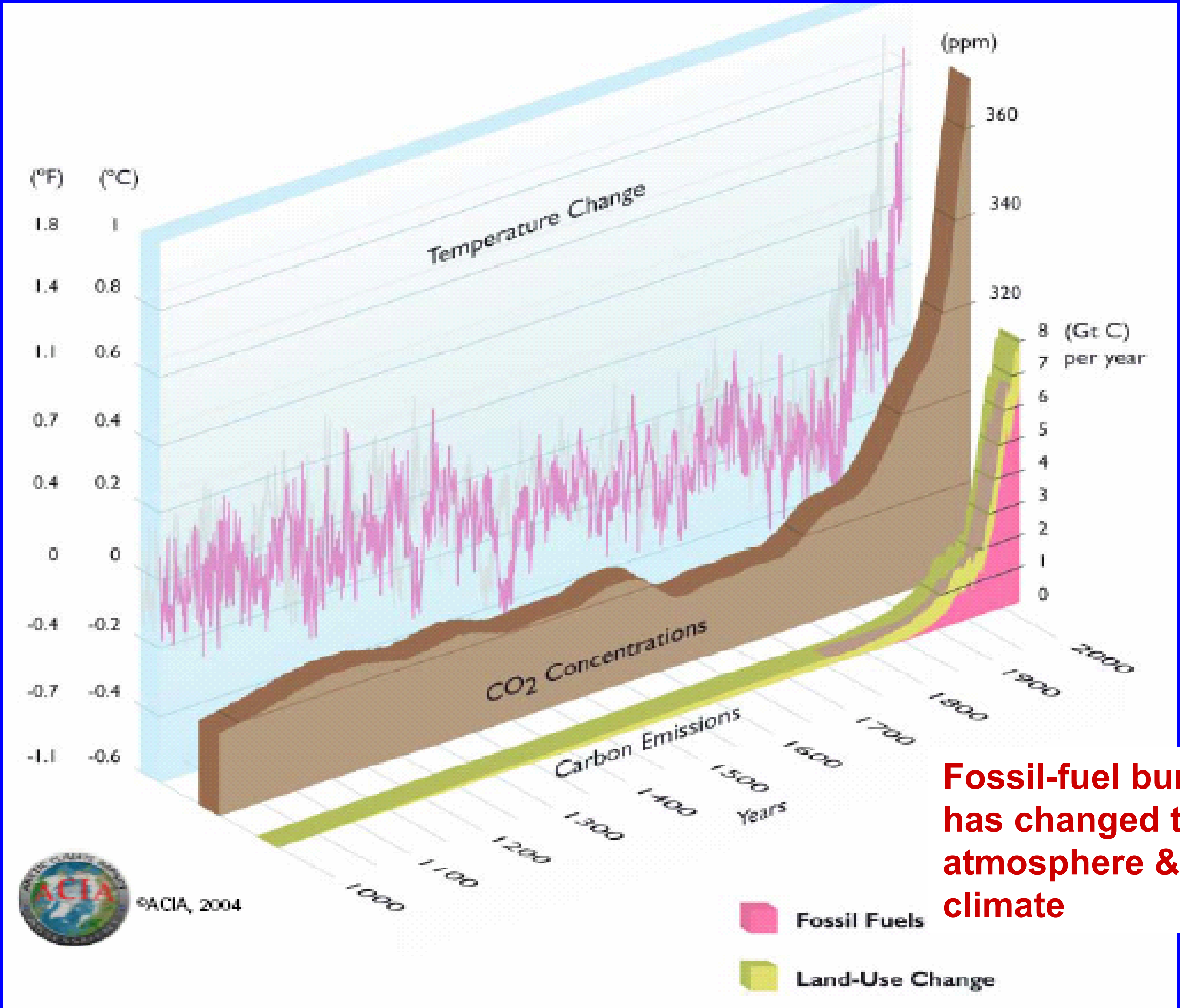
Direct measurements of CO_2 show continued rise



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

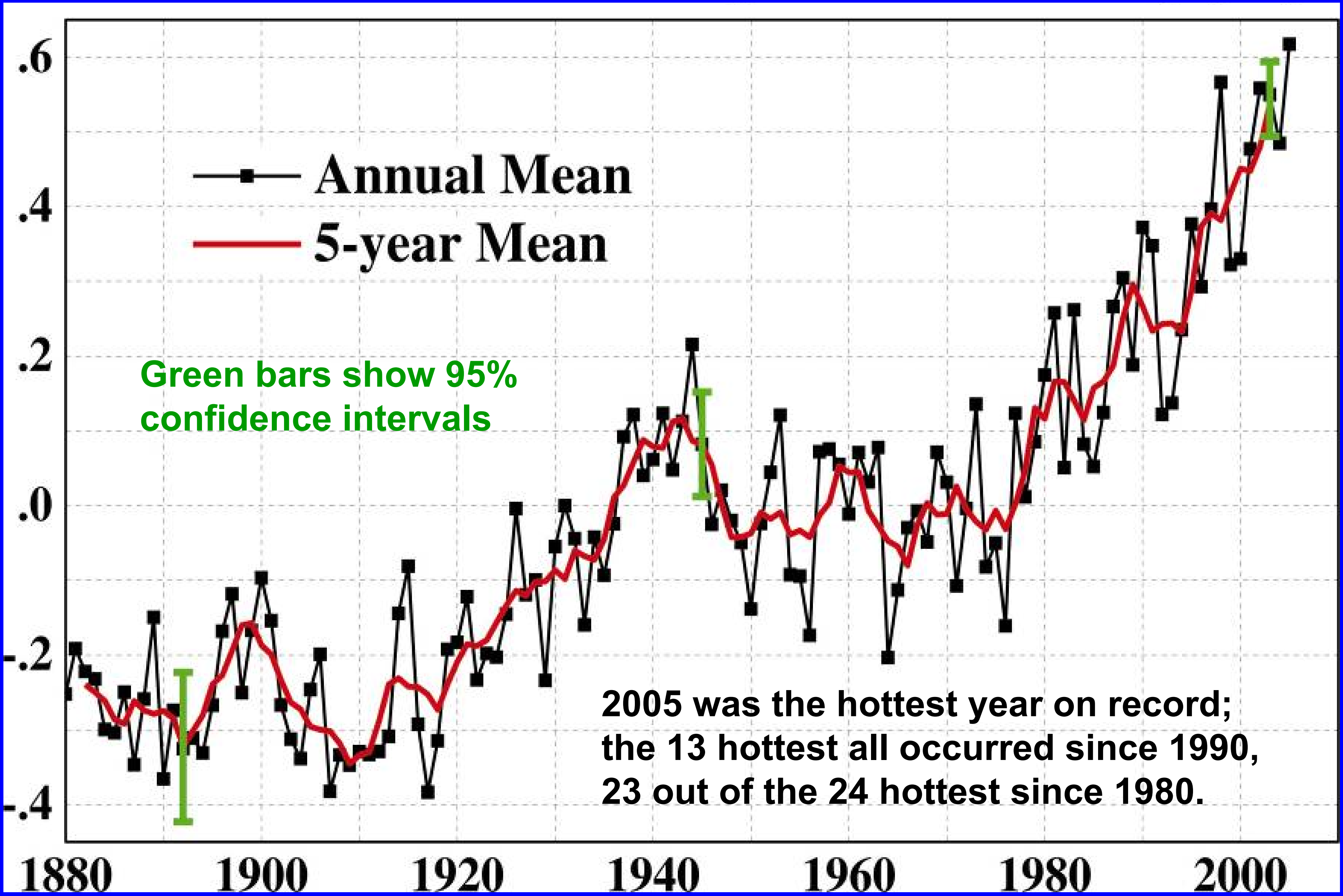


Fossil-fuel burning has changed the atmosphere & the climate

Sources of Greenhouse Gases

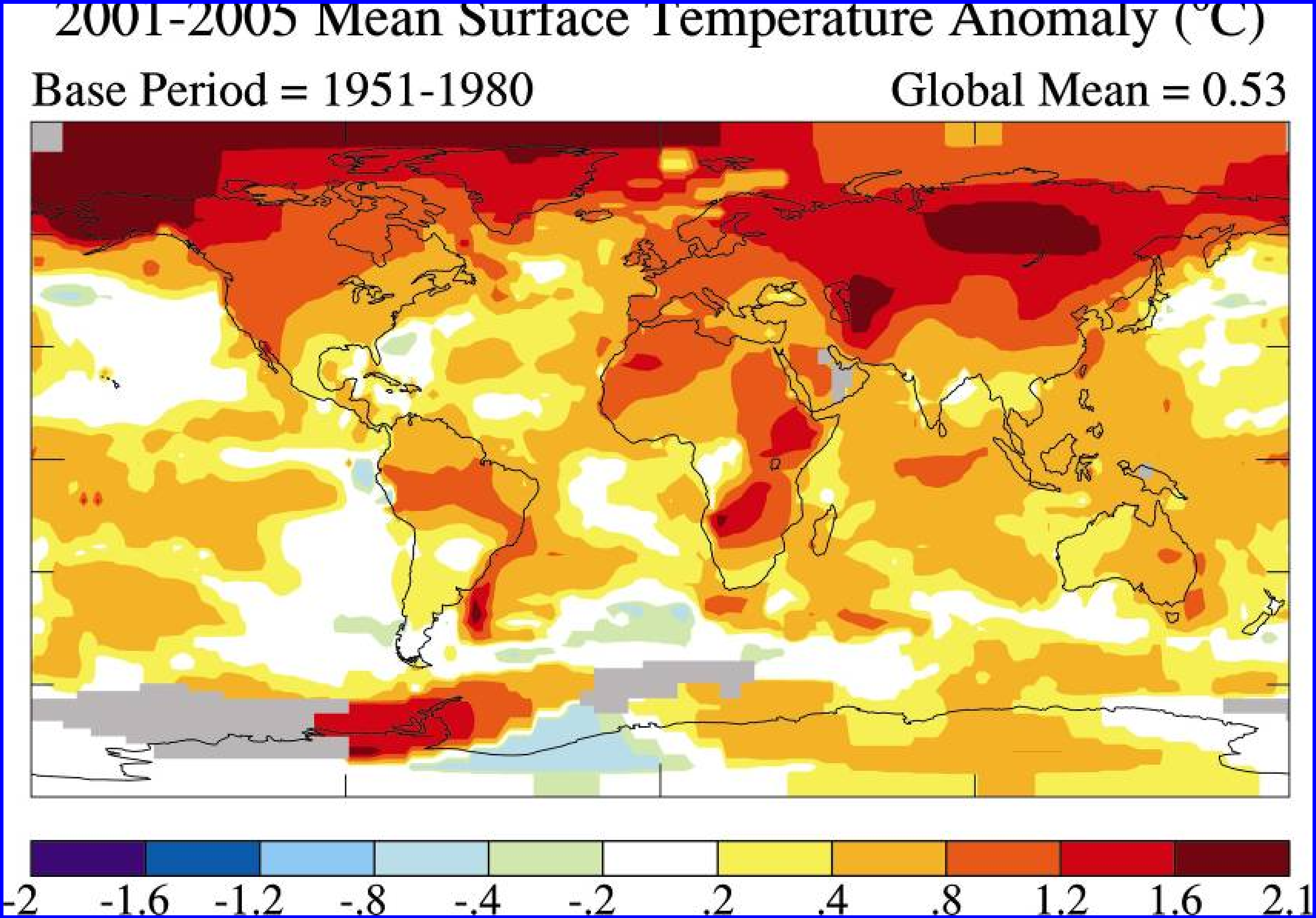
- Human activities may have upset the balance of atmospheric carbon dioxide through:
  - (1) the combustion of fossil fuels which releases carbon oxides;
  - (2) the burning of forests which produces CO2 and removes a vital consumer of CO2; and
  - (3) release of methane from agricultural and other activities

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

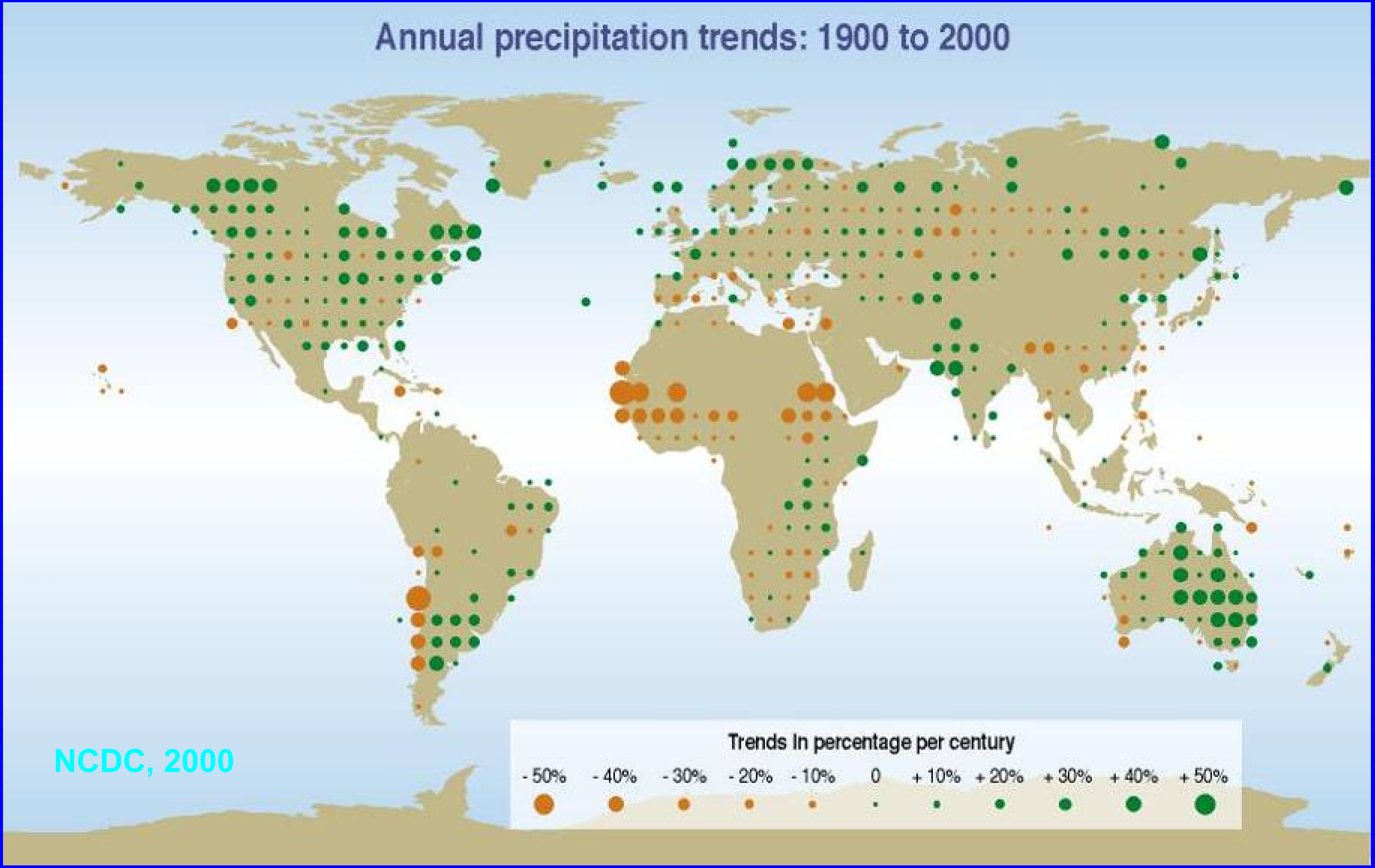


J. Hansen et al., *PNAS 103*: 14288-293 (2006)

Observations over recent decades also show

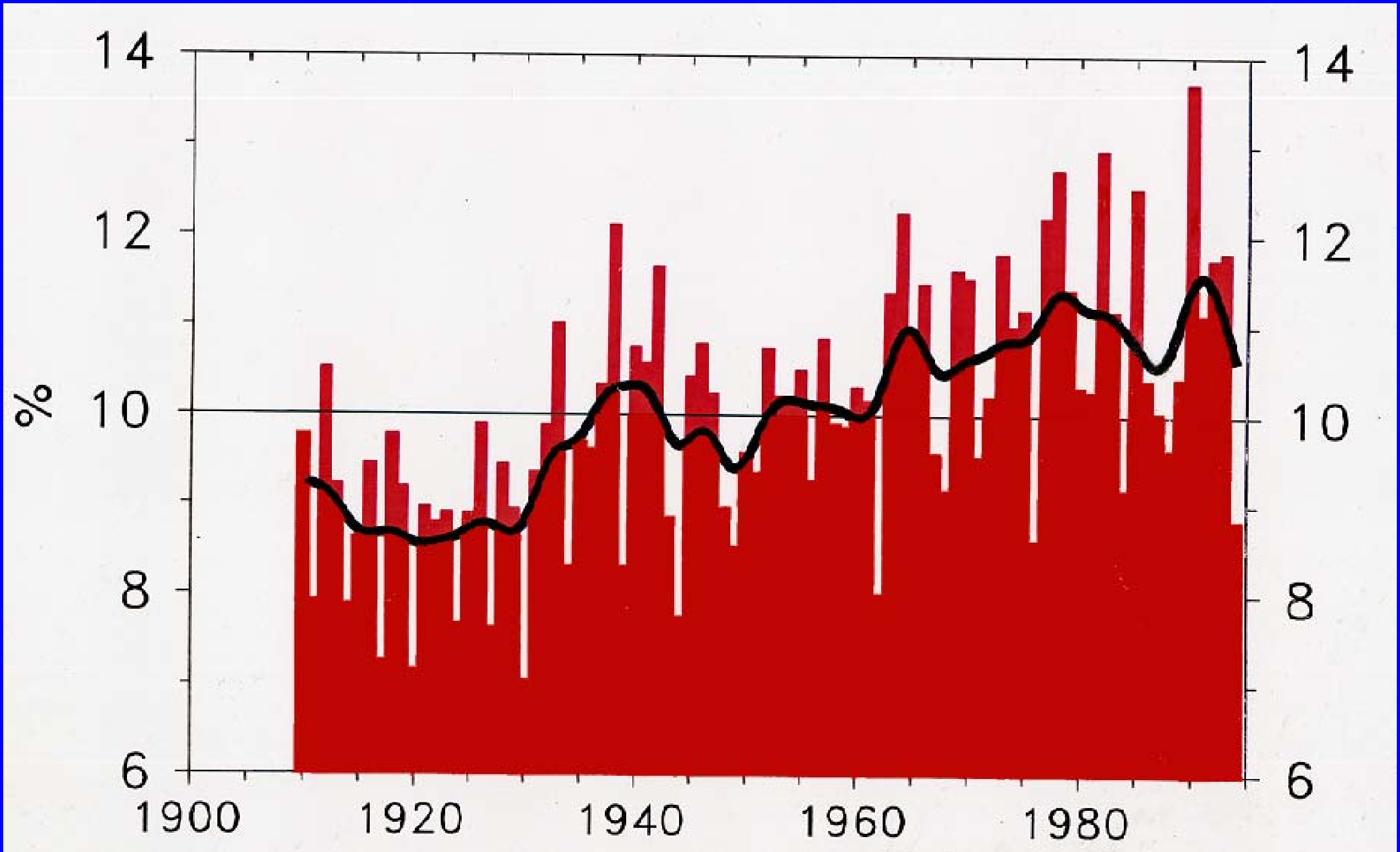
- Evaporation & rainfall are increasing;
- More extreme rainfall events
- Glaciers are retreating;
- Sea ice is shrinking;
- Sea level is rising;
- Effects are following predictions

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)

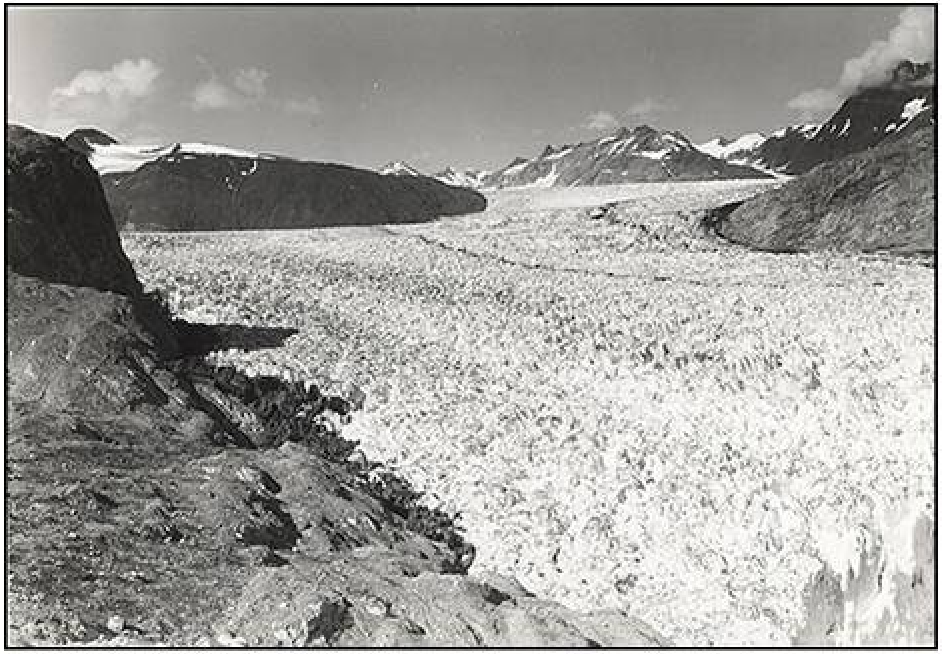


Source: Karl, et.al. 1996.

Glaciers are retreating

Muir Glacier, Alaska, 1941-2004

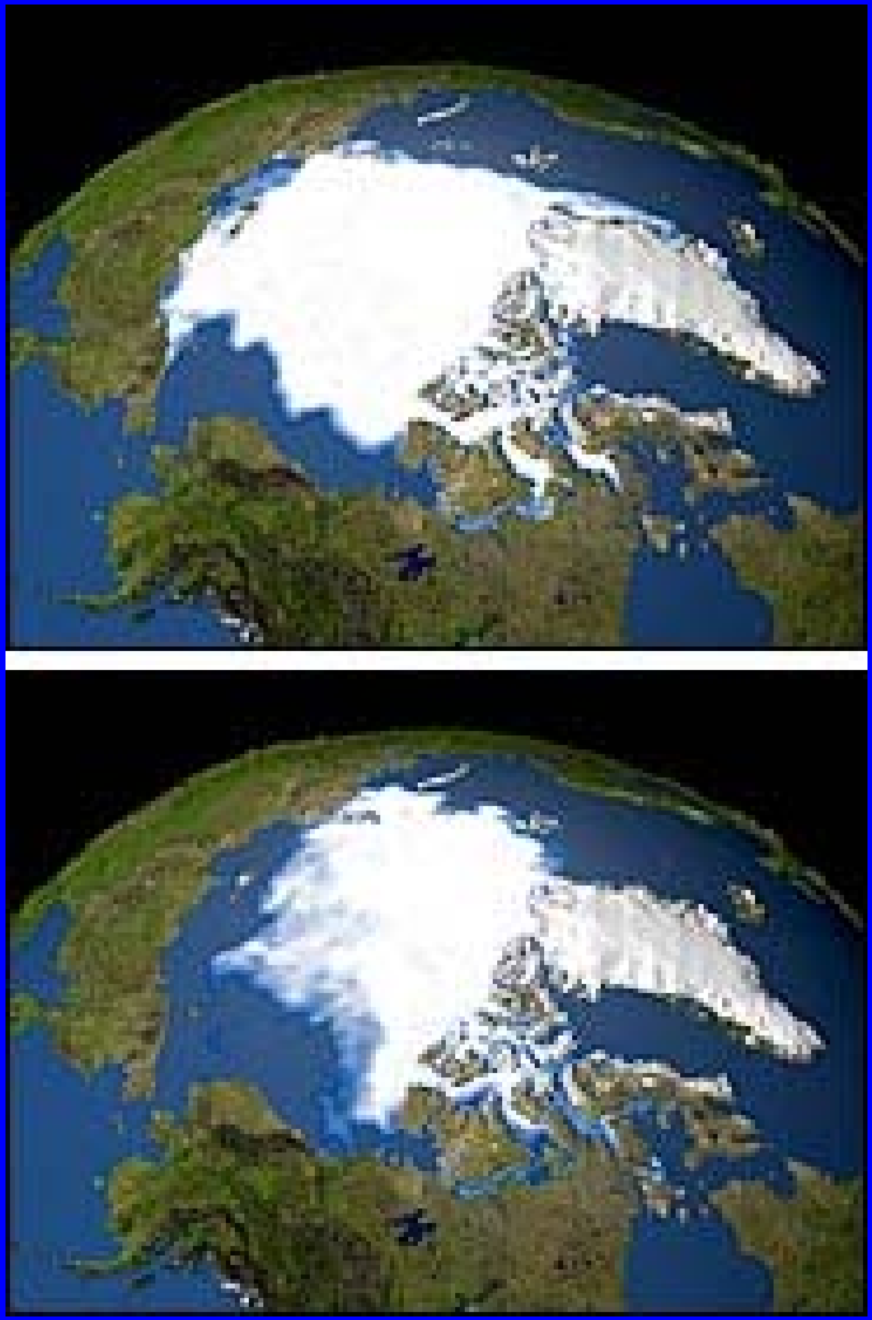
August 1941



August 2004

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

Sea ice is shrinking

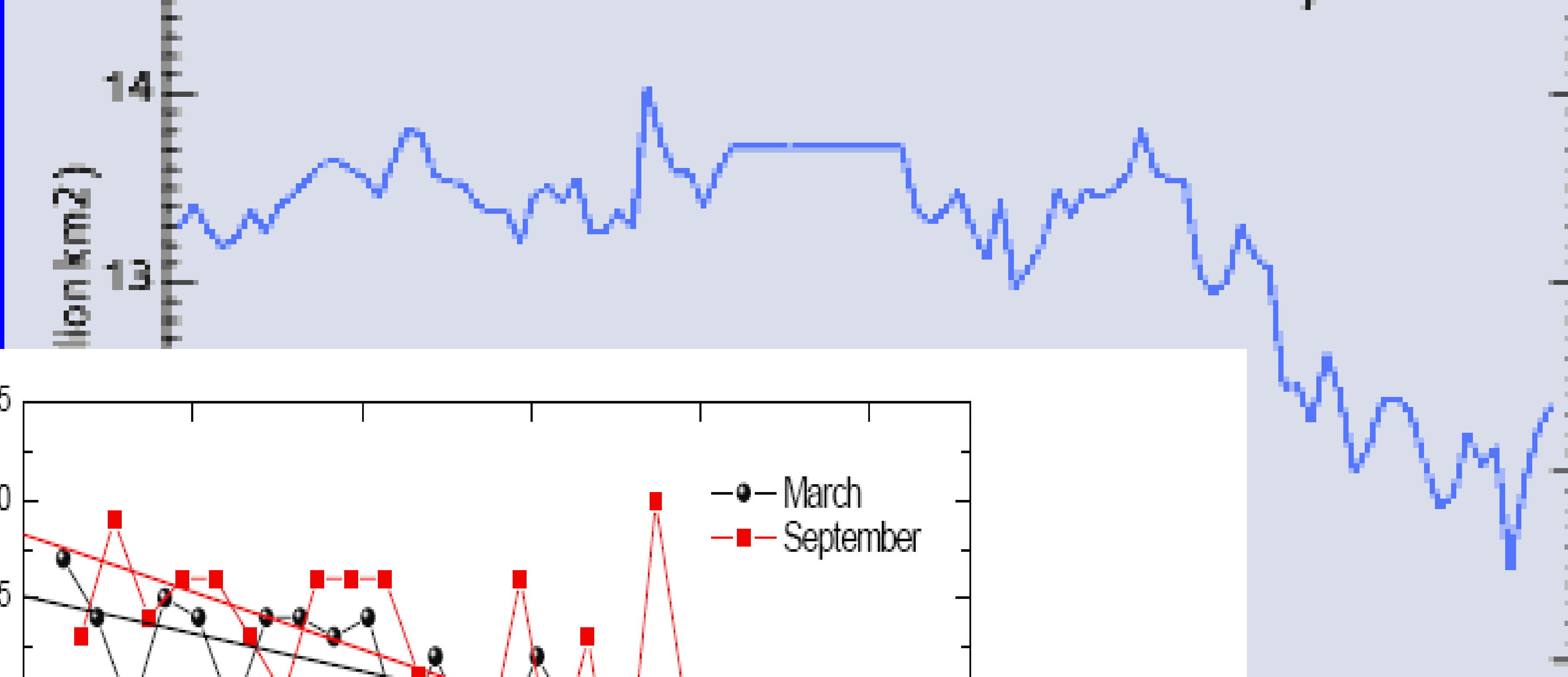


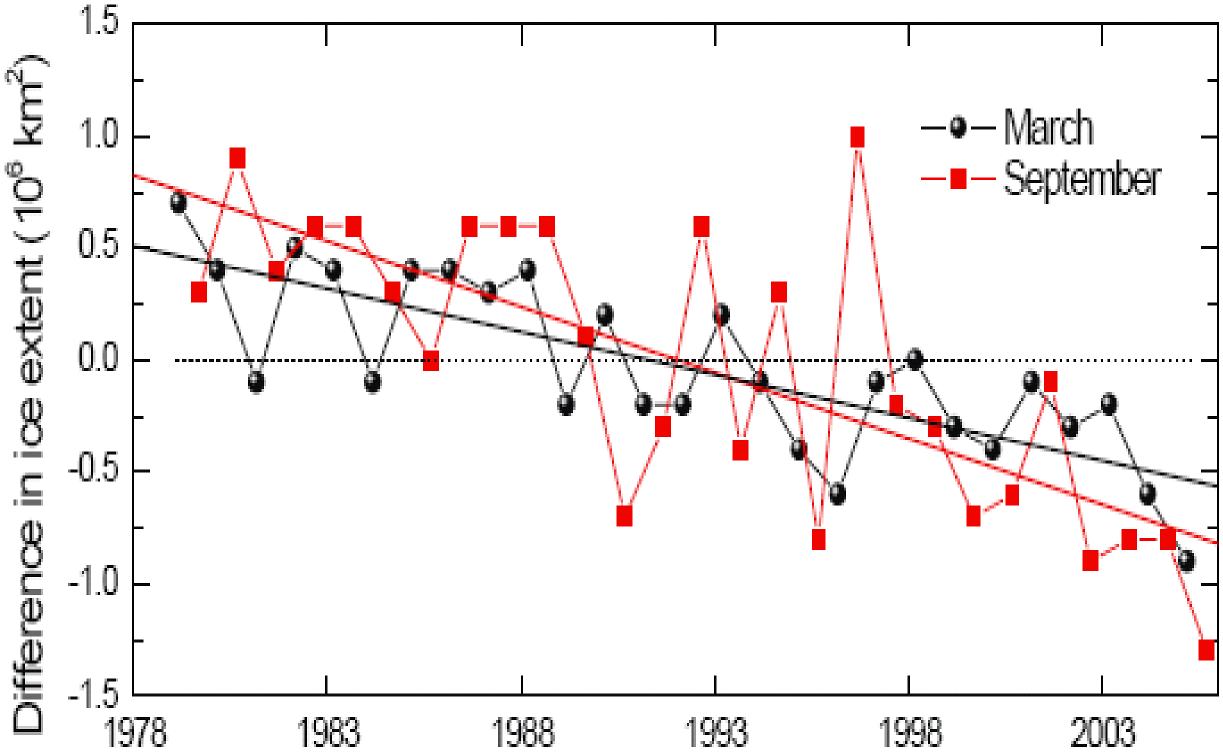
NASA photograph

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.

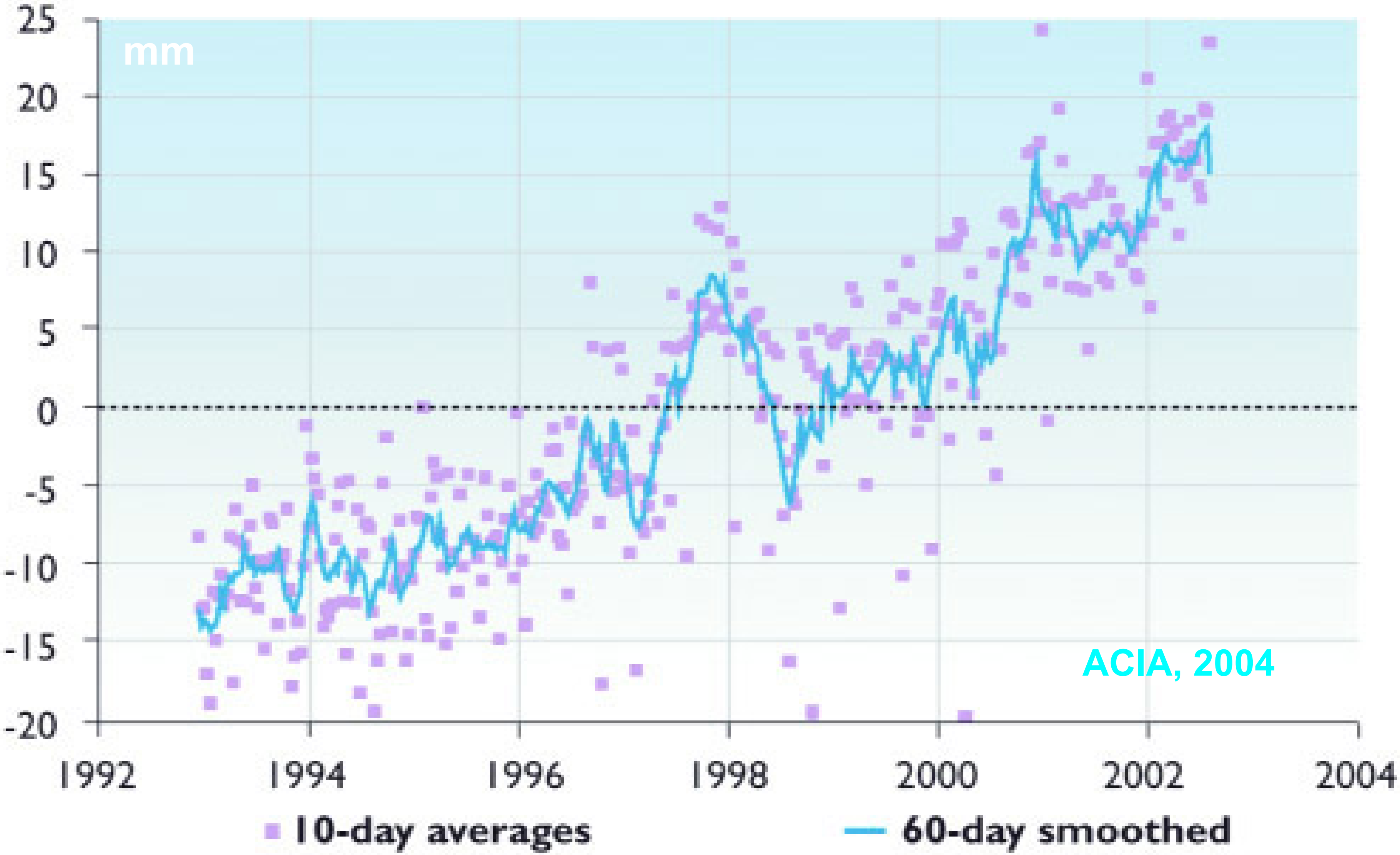
Greenland (at the right) is covered with a thick sheet of land ice. If this melts, sea level rises.





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

Sea-level is rising

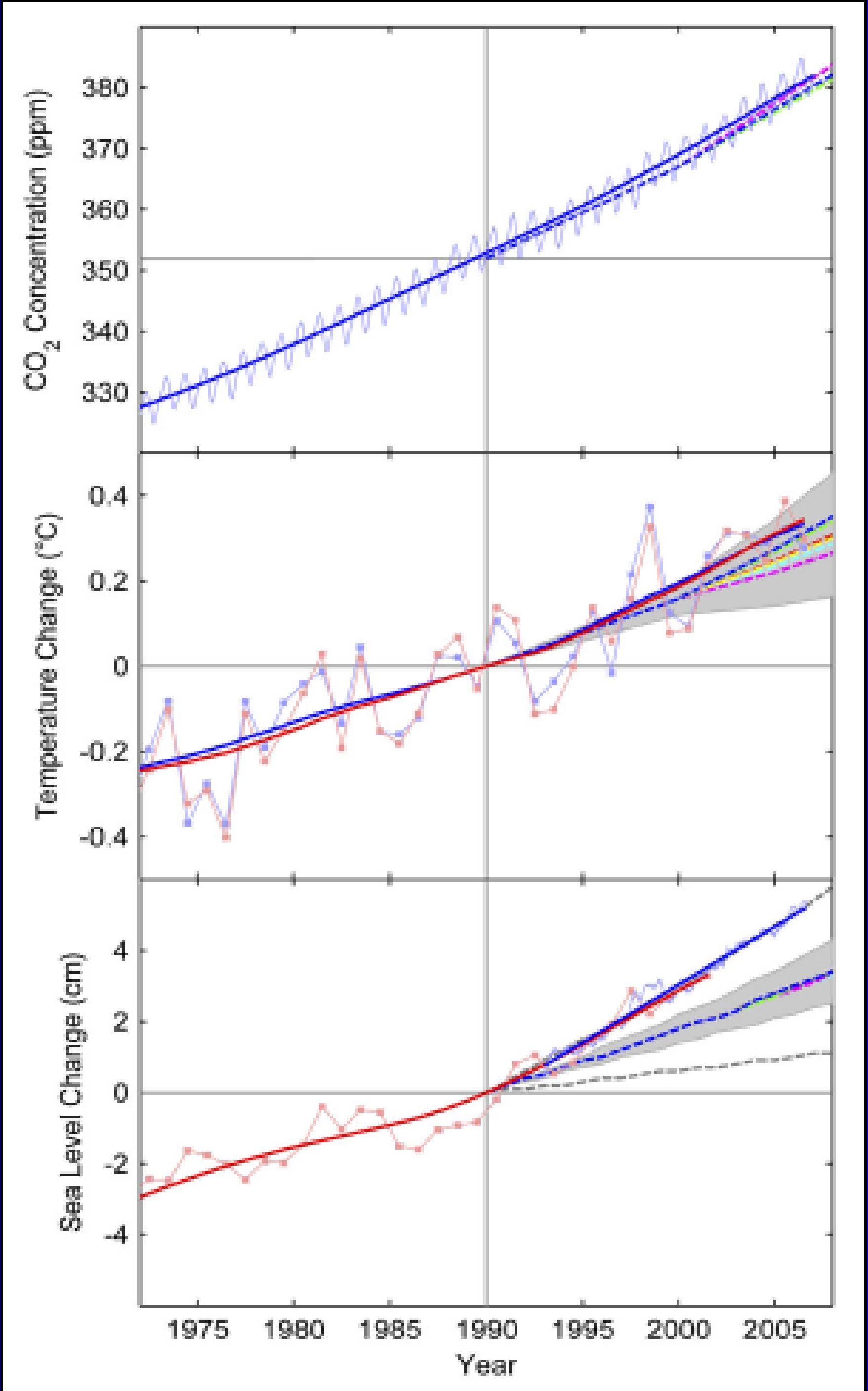


1993-2003 ≈ 35 mm = 3.5 mm/yr; compare 1910-1990 = 1.5±0.5 mm/yr.

Key variables have been tracking or exceeding IPCC projections

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

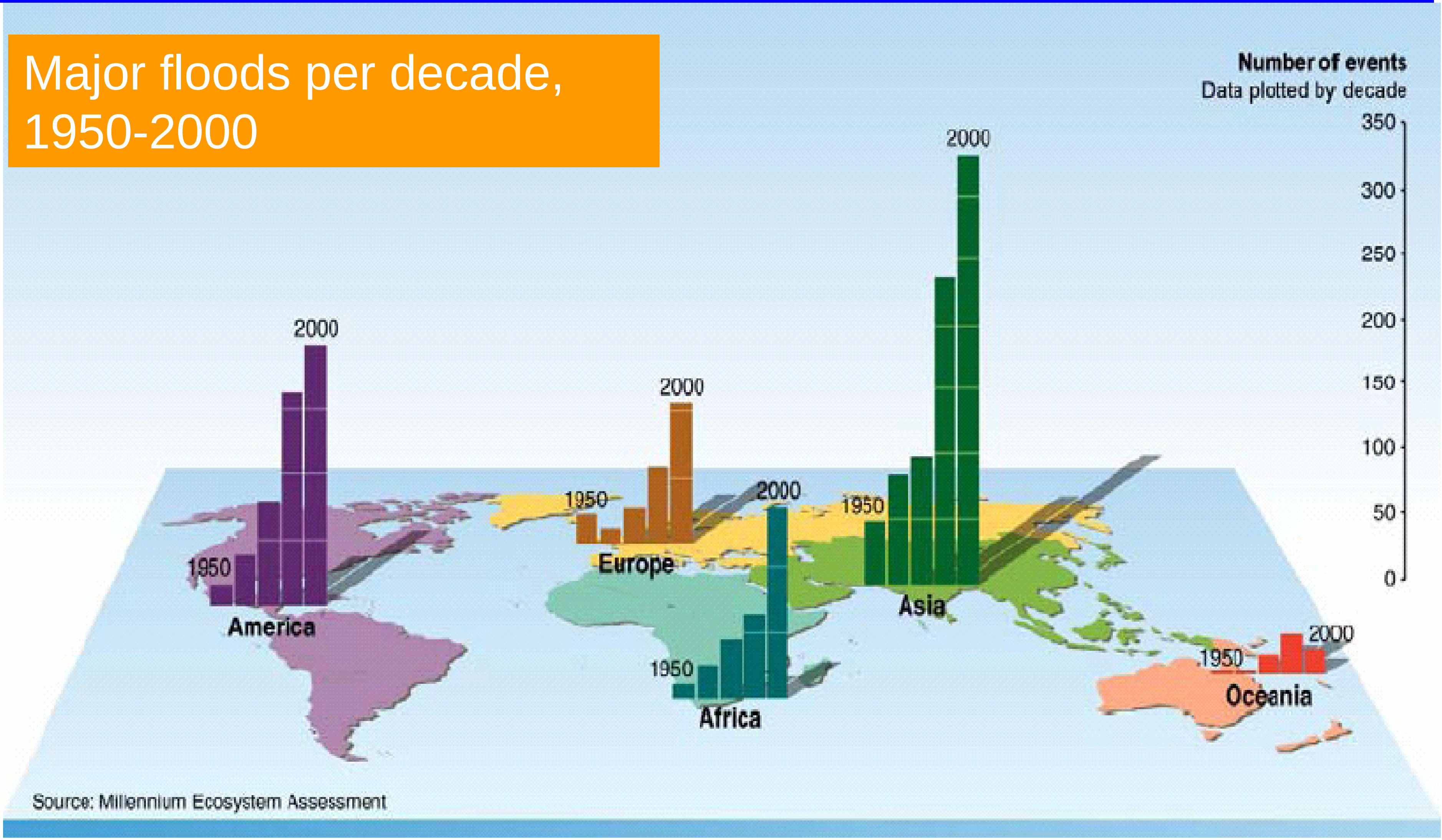
Observations since 1990 have tracked the projections for CO2, have been near the high side of projected ranges for temperature, and have been at the extreme high side of the projections for sea-level rise.



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

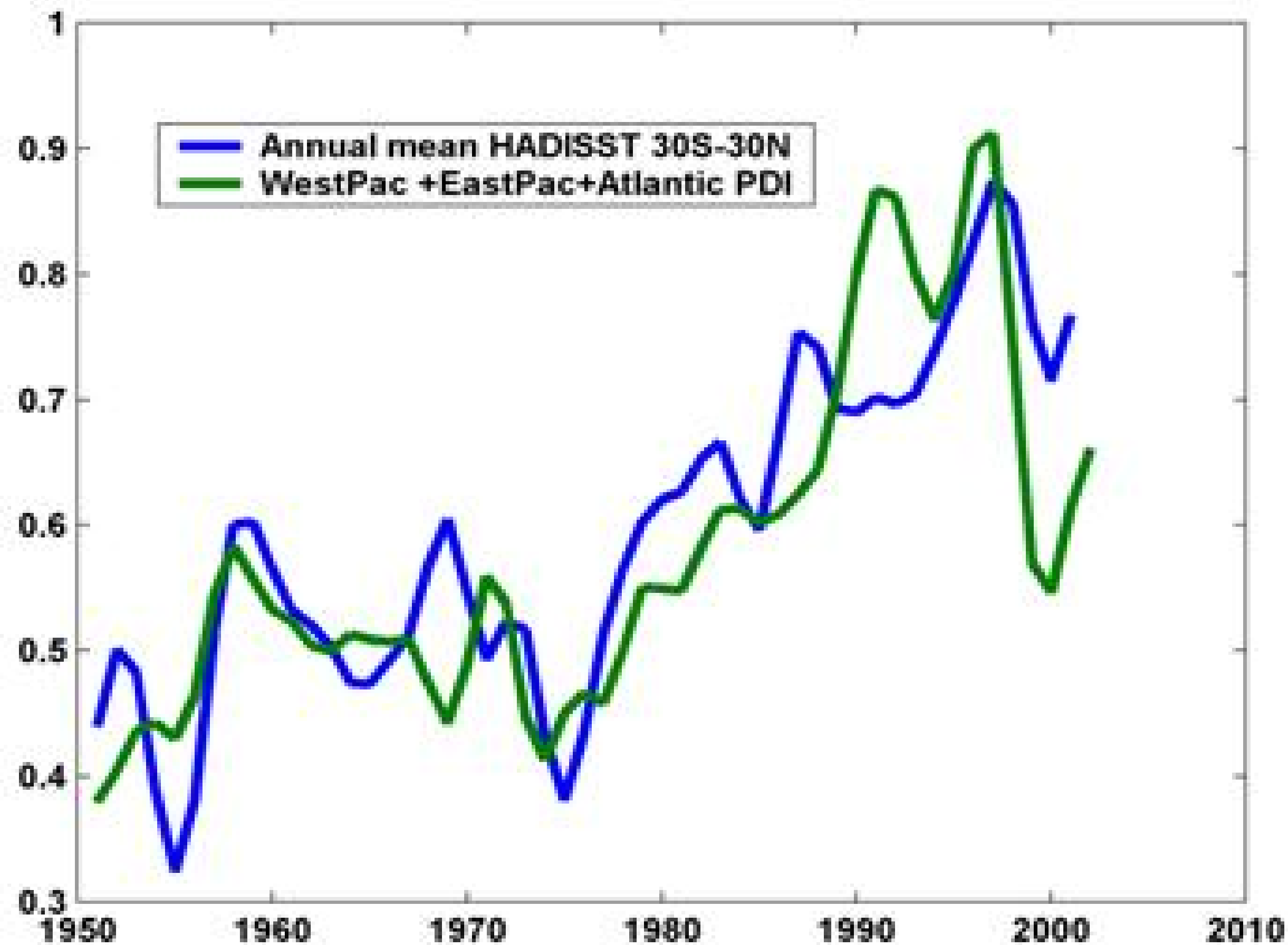
Many adverse impacts of the human-caused disruption of global climate are already evident

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



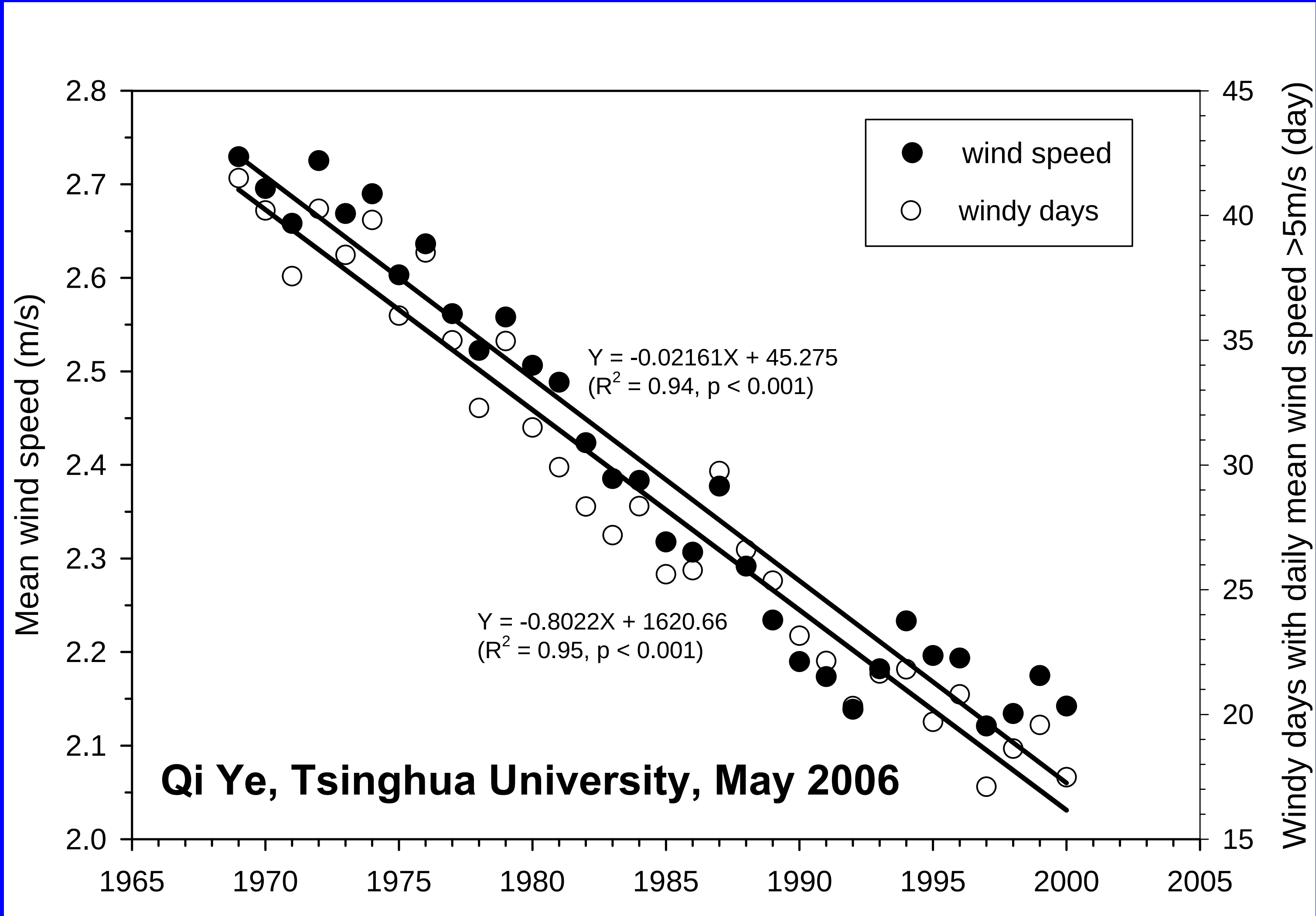
There's a consistent 50-year upward trend in every region except Oceania, where the 1990s were a bit below the 1980s.

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



Kerry Emanuel, MIT, 2006

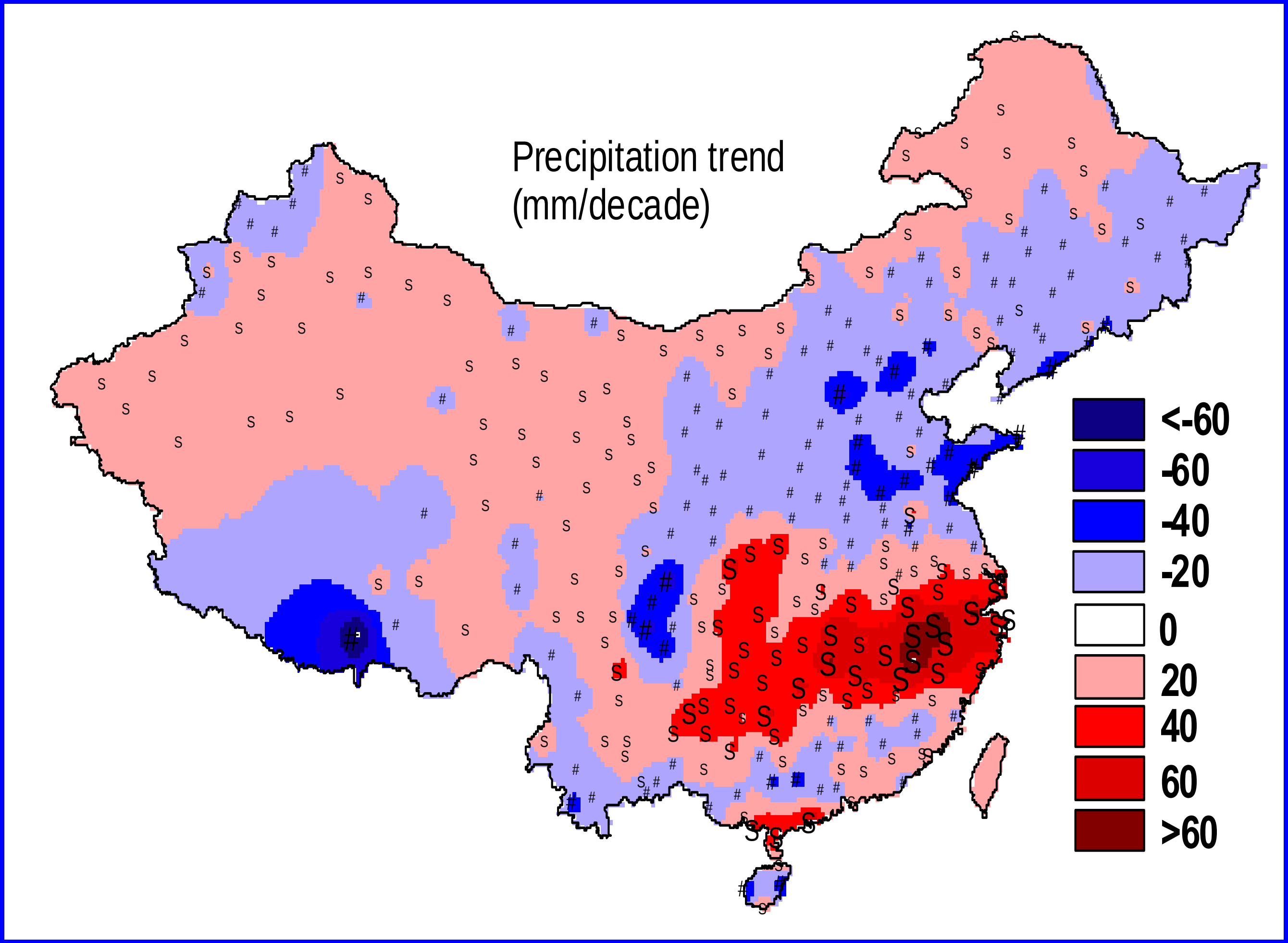
The East Asia monsoon has been weakening



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

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

Health Impacts: Just One Example

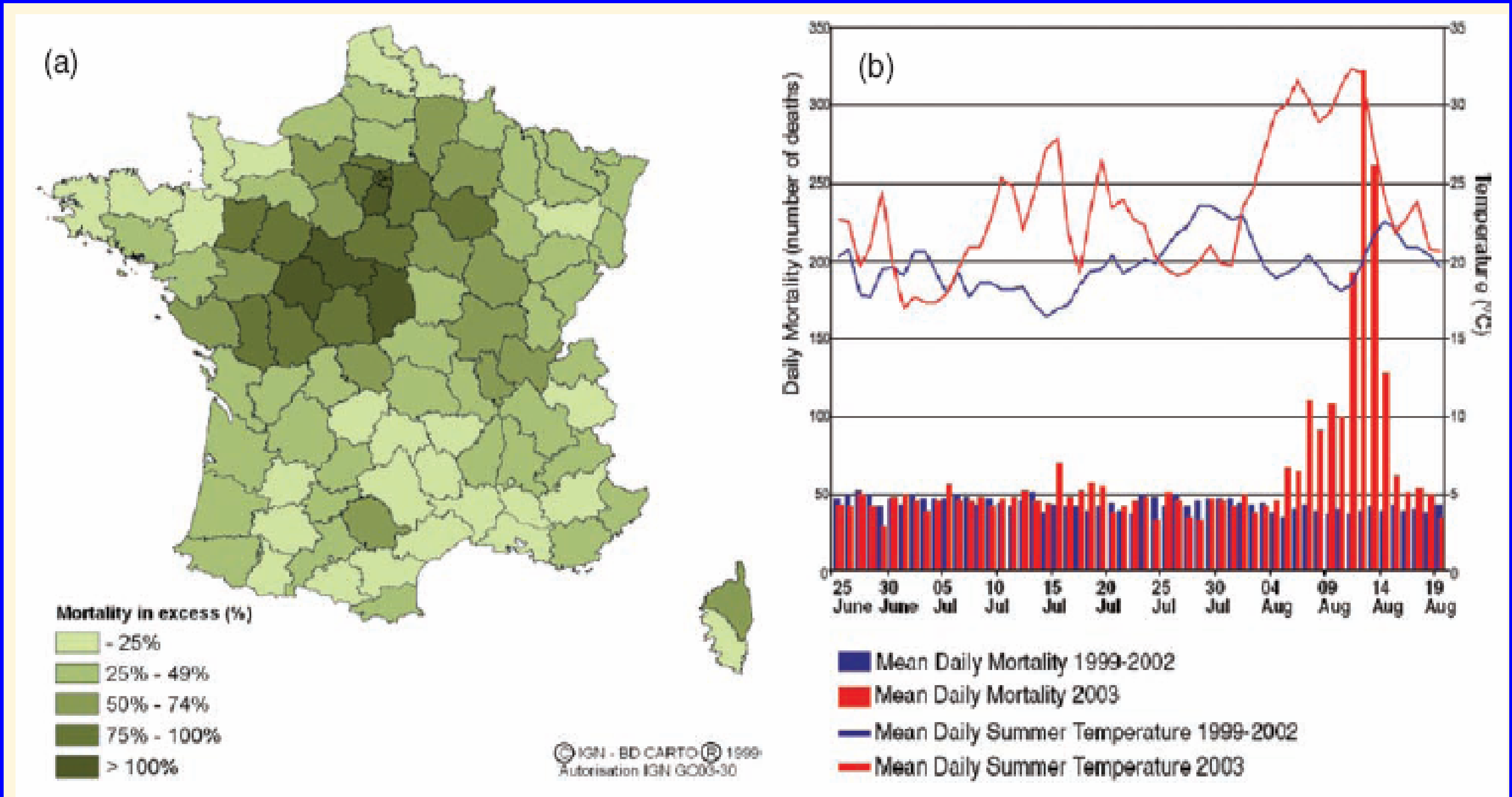
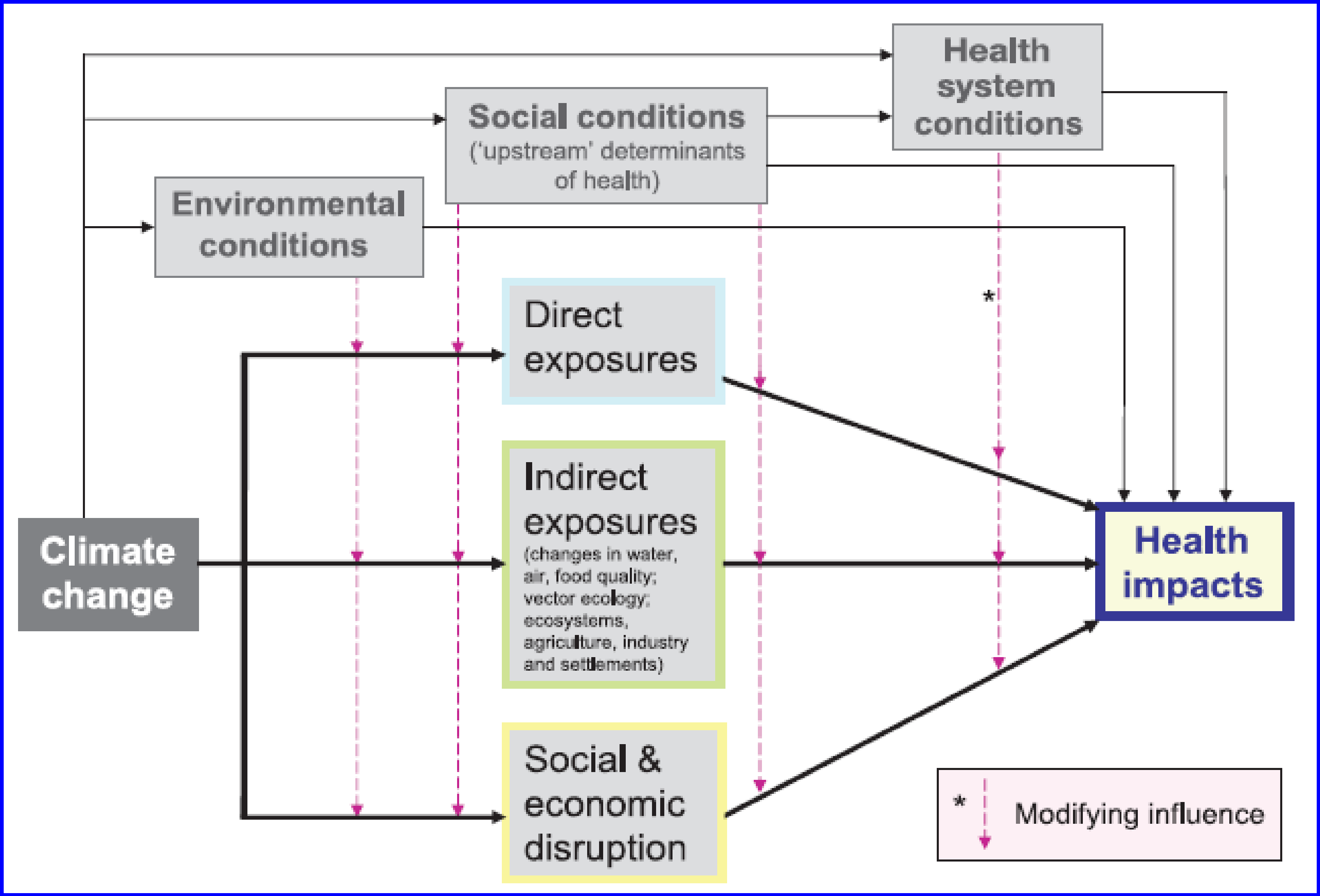


Figure 8.2. *(a) The distribution of excess mortality in France from 1 to 15 August 2003, by region, compared with the previous three years (INVS, 2003); (b) the increase in daily mortality in Paris during the heatwave in early August (Vandentorren and Empereur-Bissonnet, 2005).*

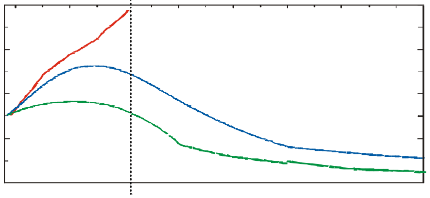
IPCC WGII, 2007



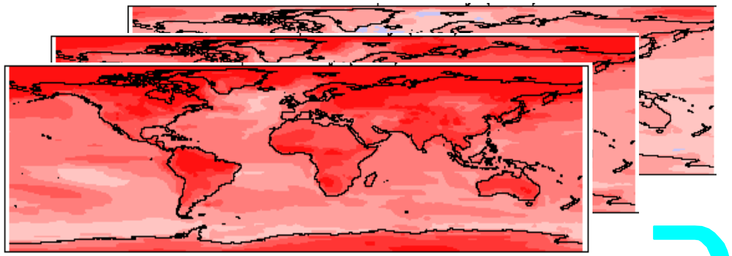
IPCC WGII, 2007

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

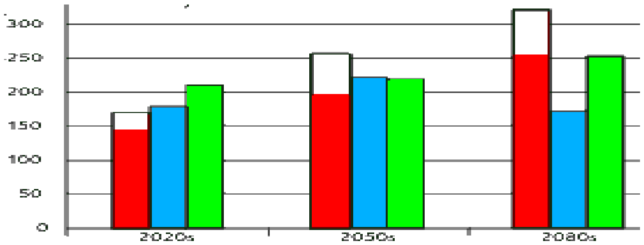
GHG emissions scenarios



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

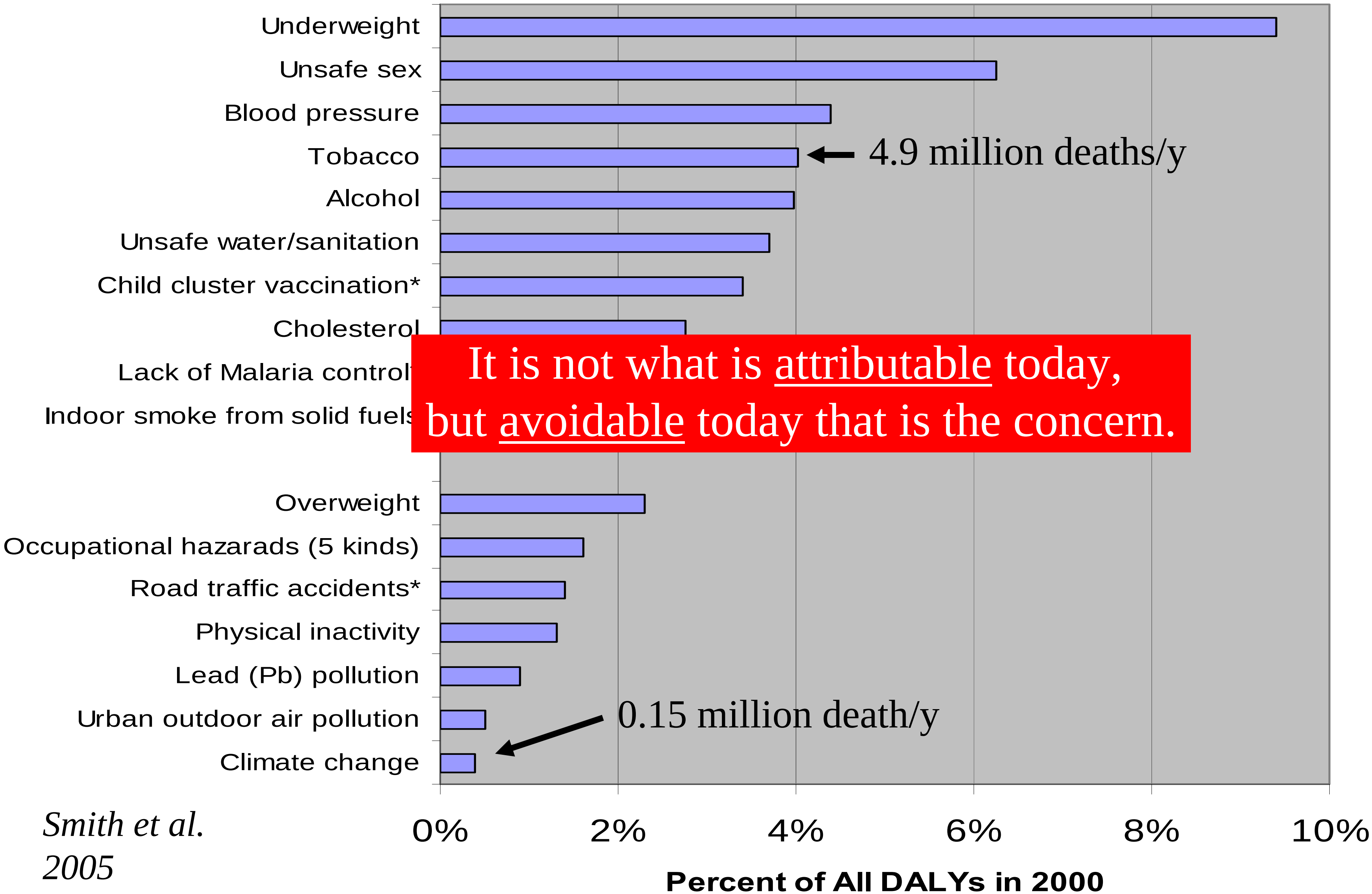
LONDON SCHOOL OF HYGIENE & TROPICAL MEDICINE

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
- 0.4% of all DALYs
- Most (88%) of impact in children under 5
- Not large today, but growing rapidly.

Global Burden of Disease from Top 10 Risk Factors

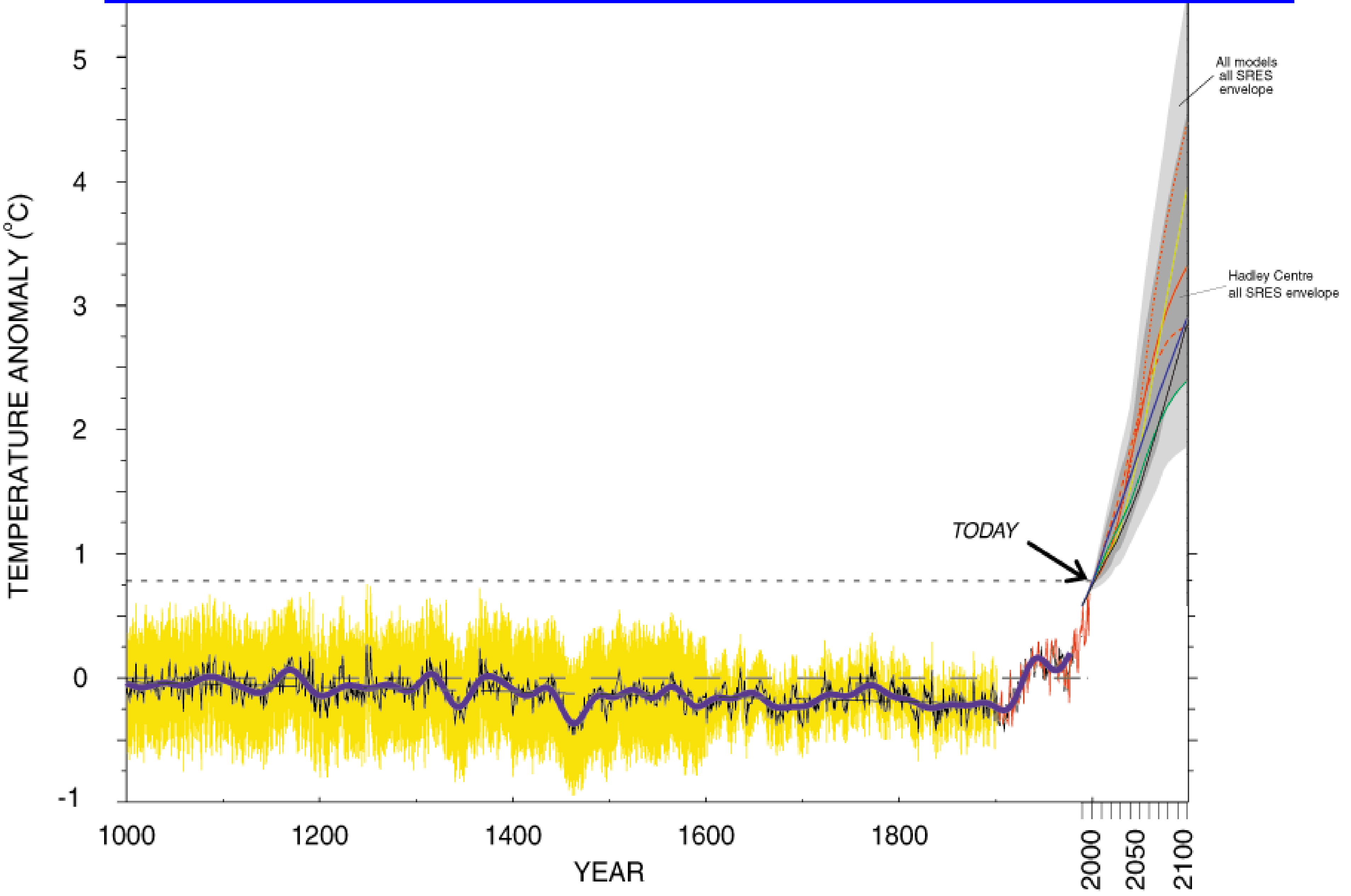
plus selected other risk factors

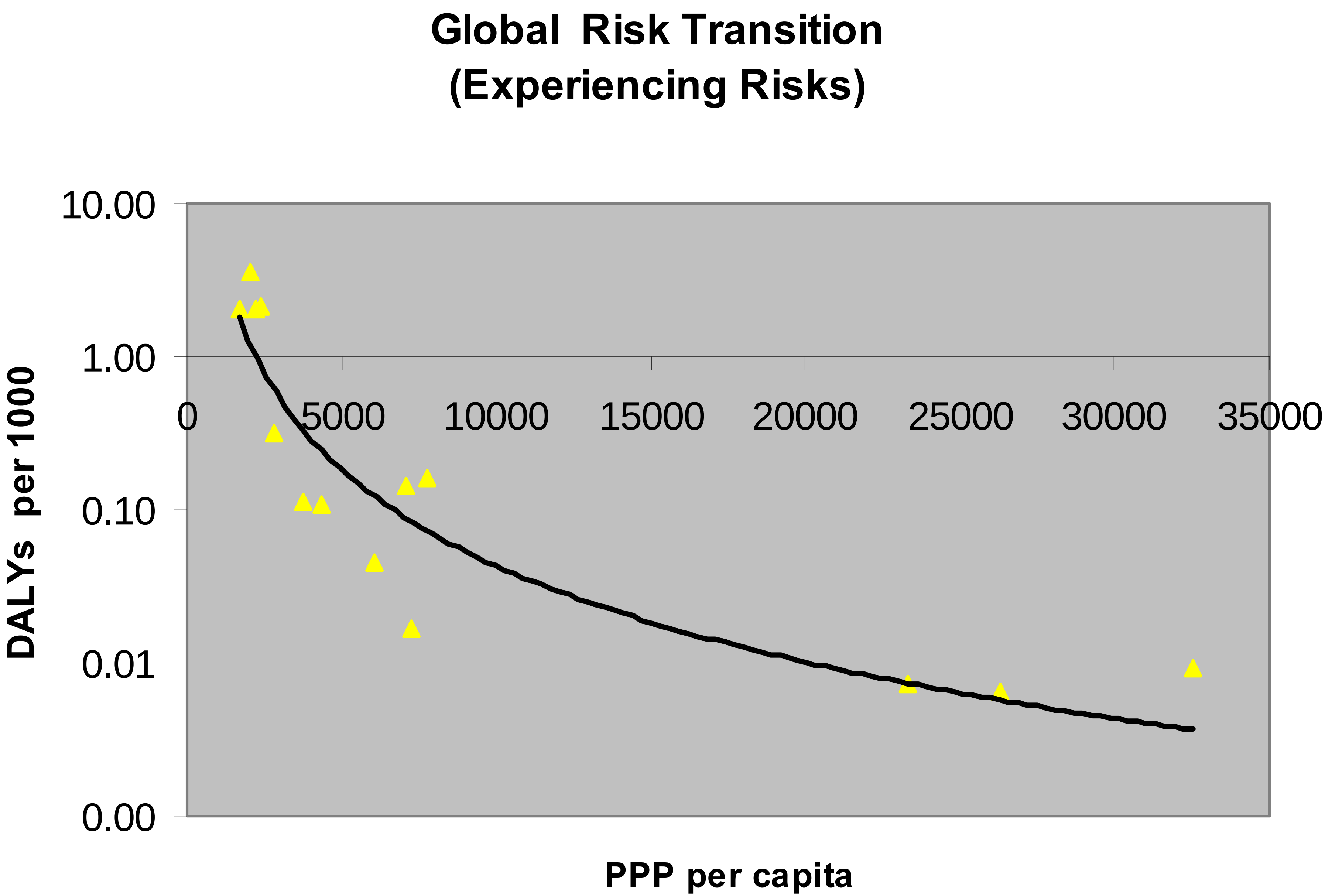


It is not what is attributable today,
but avoidable today that is the concern.

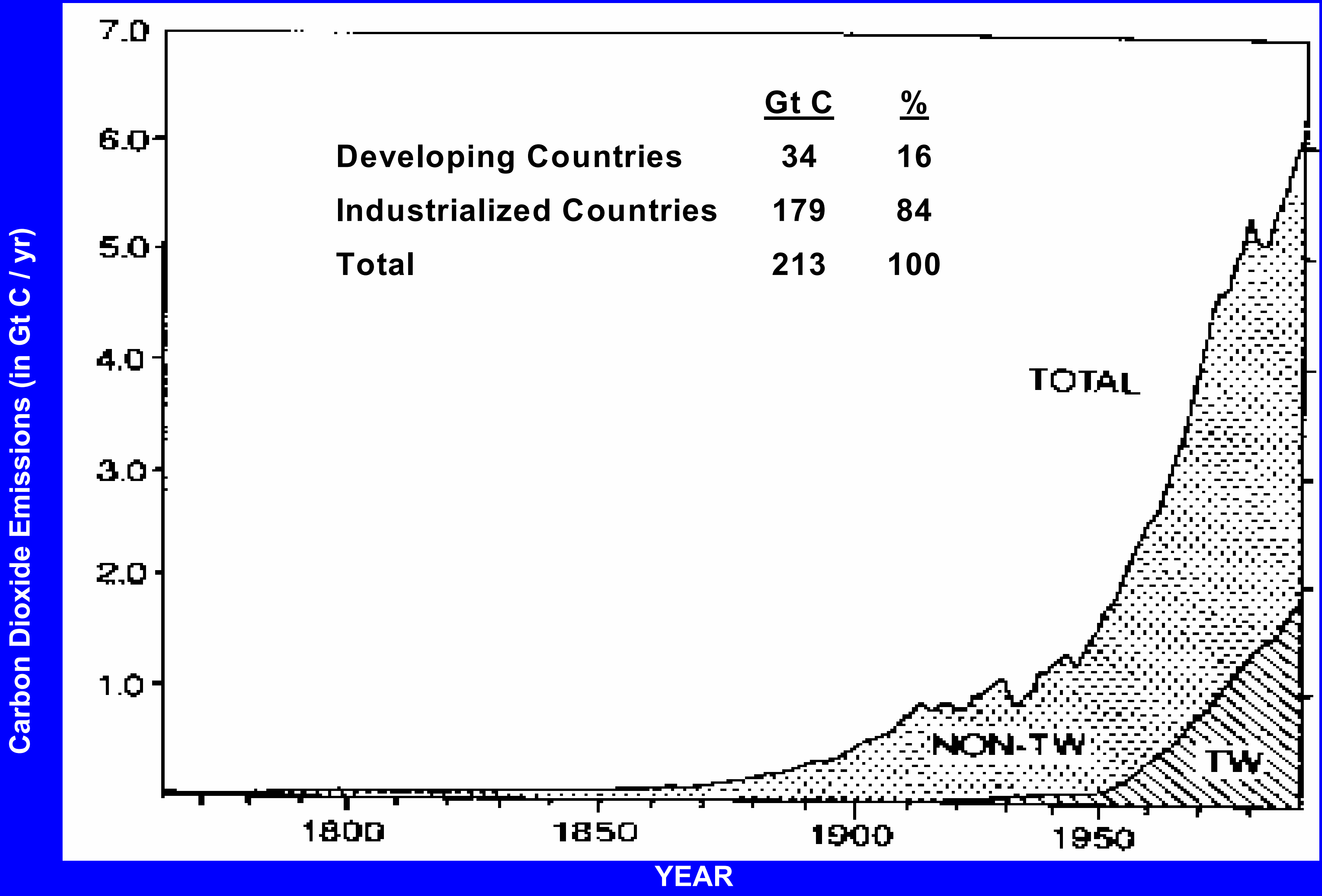
Smith et al. 2005

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

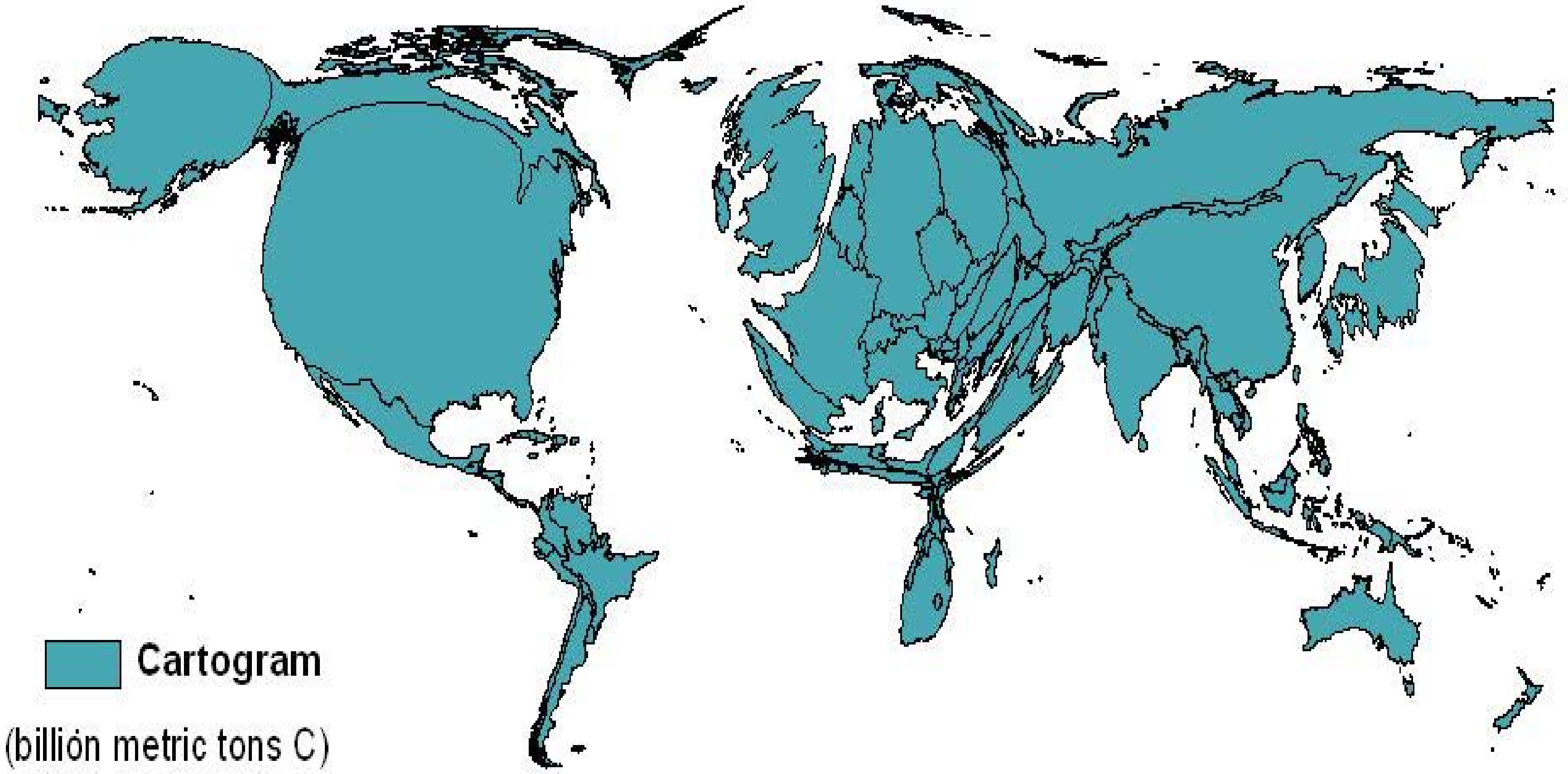



Global Risk Transition
(Experiencing Risks)
10.00
1.00
0.10
0.01
0.00
0
5000
10000
15000
20000
25000
30000
35000
DALYs per 1000
PPP per capita

Carbon Emissions from Fossil Fuel Burning

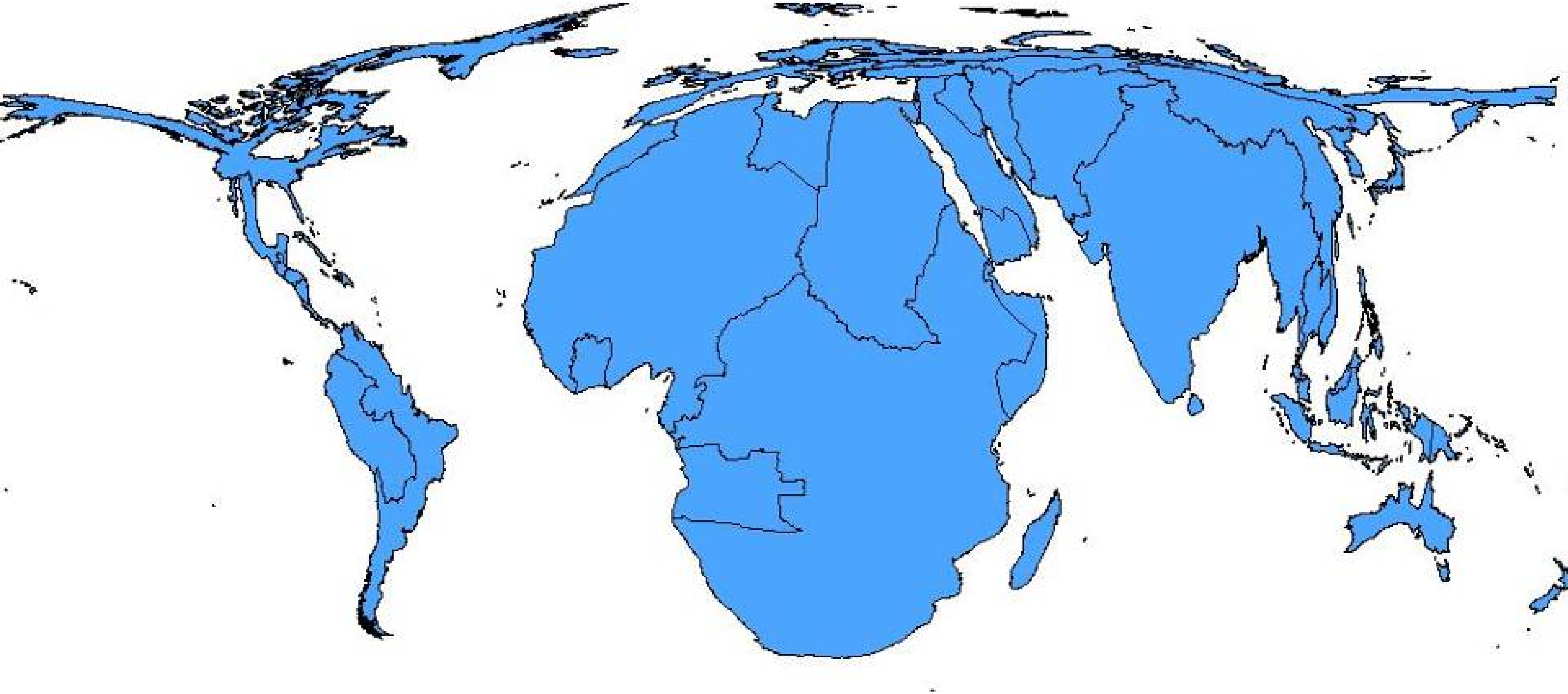


Cumulative CO_2 emissions from fossil fuels (as depleted by natural processes)



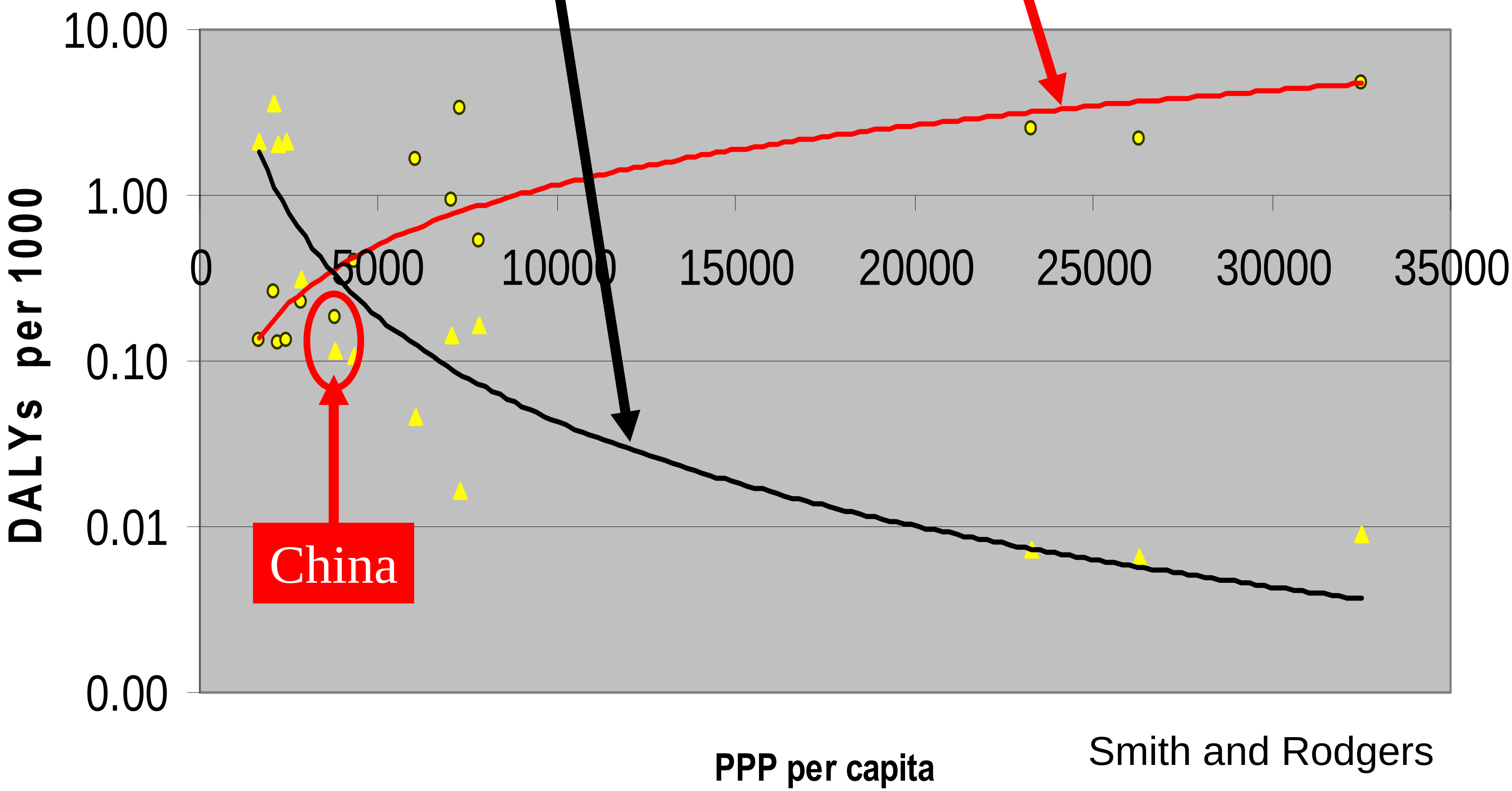
Patz JA, Gibbs HK, Foley JA, Rogers JV, Smith KR, 2007, **Climate change and global health: Quantifying a growing ethical crisis**, EcoHealth 4(4): 397–405, 2007.

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



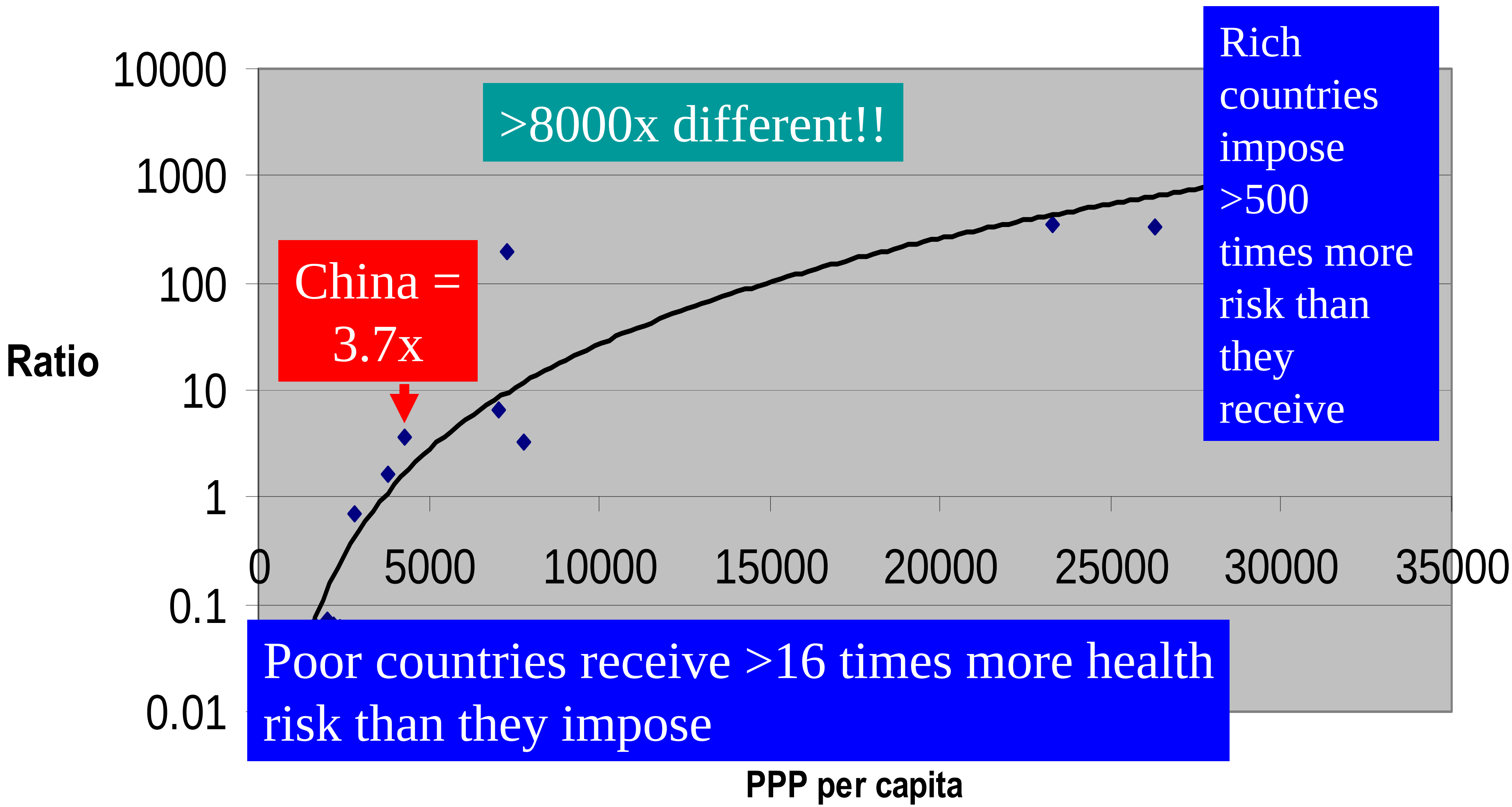
Patz JA, Gibbs HK, Foley JA, Rogers JV, Smith KR, 2007, **Climate change and global health: Quantifying a growing ethical crisis**, EcoHealth 4(4): 397–405, 2007.

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



Smith and Rodgers

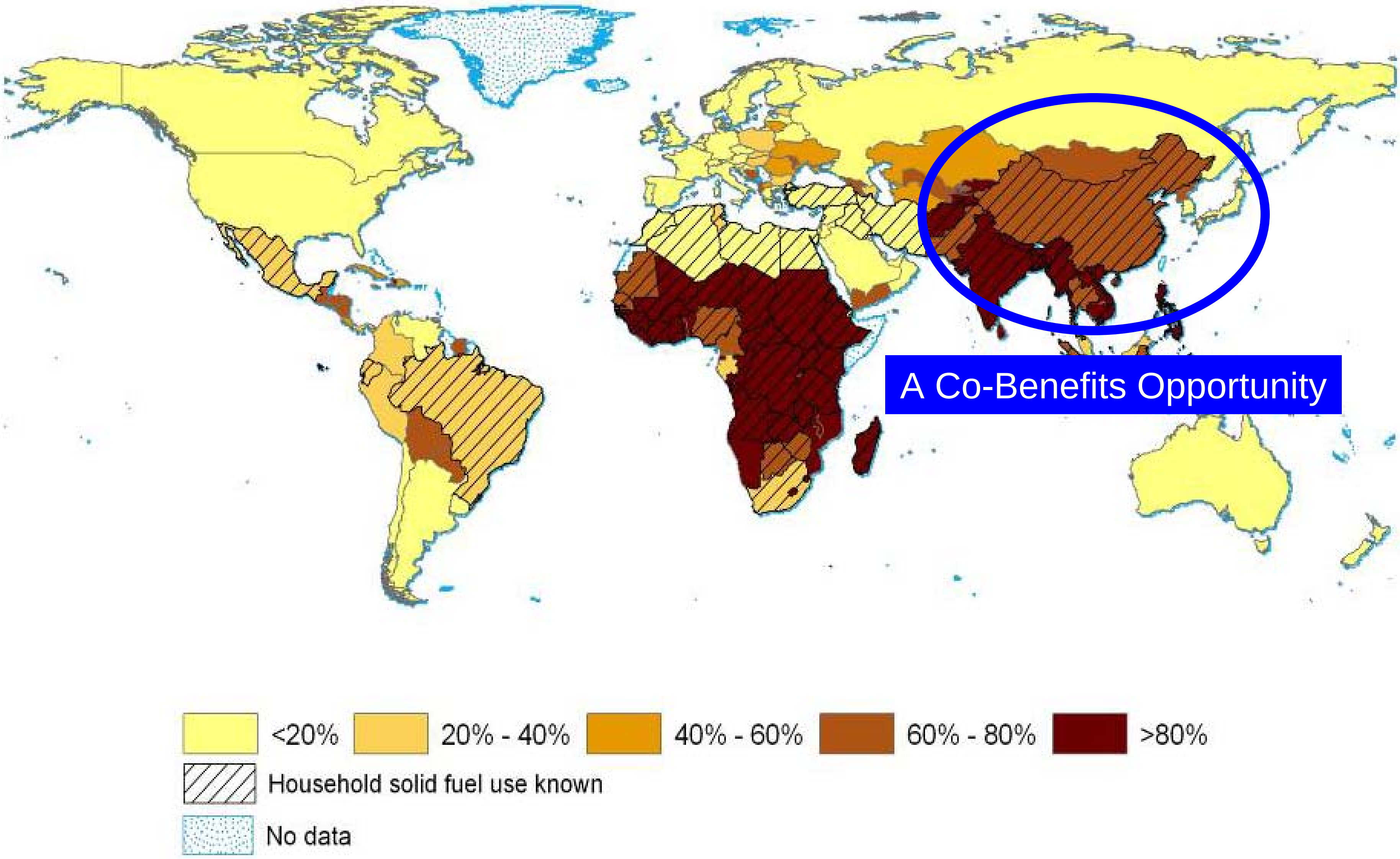
Distribution of Health Impacts from Climate Change (Ratio: Imposing/Experiencing)



Being Smart about Mitigation

- **Co-benefits**: Guide mitigation measures so they help achieve other societal goals, including health protection.
- **No-regrets:** providing a short-term more certain return (health) on a long-term more uncertain investment (climate protection)
- **Political bridge** over the international divide between developed and developing countries

National Household Solid Fuel Use, 2000



Chinese household rural energy:

Energy flows in a well-operating traditional wood-fired Chinese cookstove

A Toxic Waste Factory!!

Typical biomass cookstoves convert 6-20% of the fuel carbon to toxic substances

Into Pot	In PIC	Waste Heat
2.8 MJ	1.2 MJ	11.3 MJ
18%	8%	74%

PIC = products of incomplete combustion = CO, HC, C, etc.

Source: Smith, et al., 2000

Toxic Pollutants in Biomass Fuel Smoke from Simple (poor) Combustion

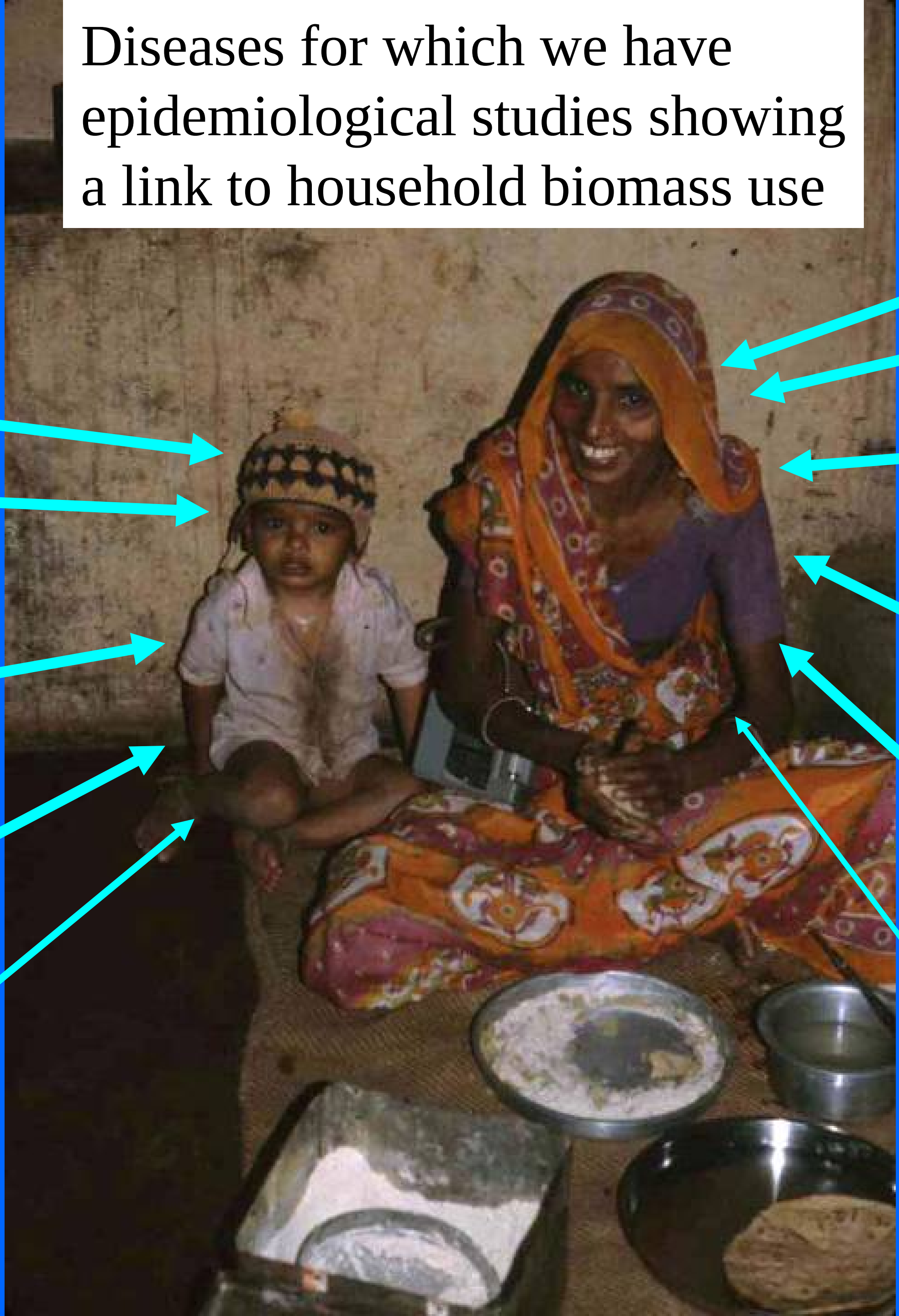
- Small particles, CO, NO_2
- Hydrocarbons
  - 25+ saturated hydrocarbons such as *n-hexane*

Plus methane,
a powerful GHG!

- Oxygenated organics
  - 20+ aldehydes including *formaldehyde* & *acrolein*
  - 25+ alcohols and acids such as *methanol*
  - 33+ phenols such as *catechol* & *cresol*
  - Many quinones such as *hydroquinone*
  - Semi-quinone-type and other radicals
- Chlorinated organics such as *methylene chloride* and *dioxin*

Naeher, et al. 2007

Diseases for which we have epidemiological studies showing a link to household biomass use



ALRI/
Pneumonia
(meningitis)

Asthma

Low birth weight

Early infant death

Cognitive Impairment?

Chronic obstructive lung disease

Interstitial lung disease

Cancer
(lung, NP, cervical, aero-digestive)

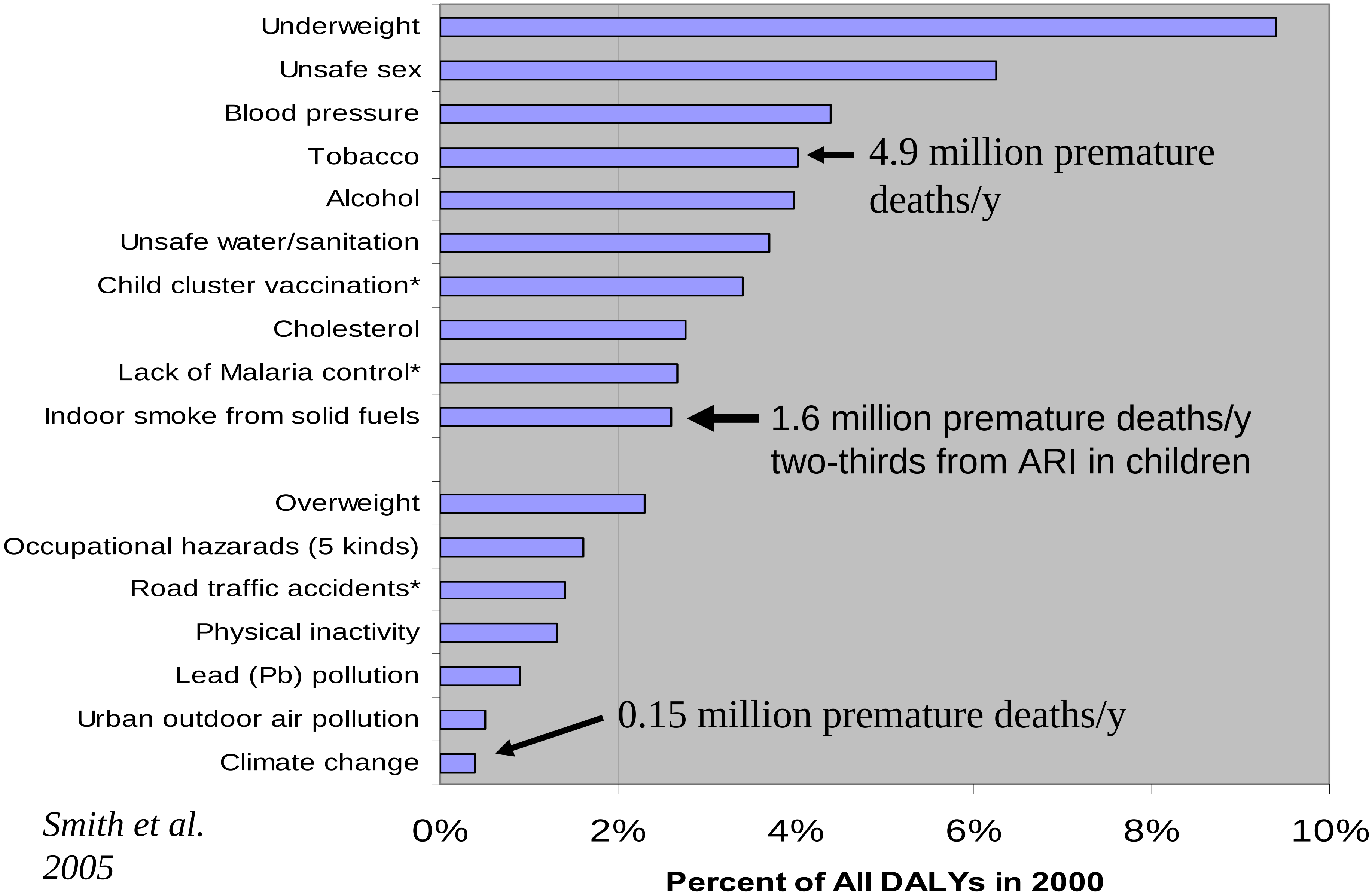
Blindness
(cataracts, trachoma)

Tuberculosis

Heart disease?

Global Burden of Disease from Top 10 Risk Factors

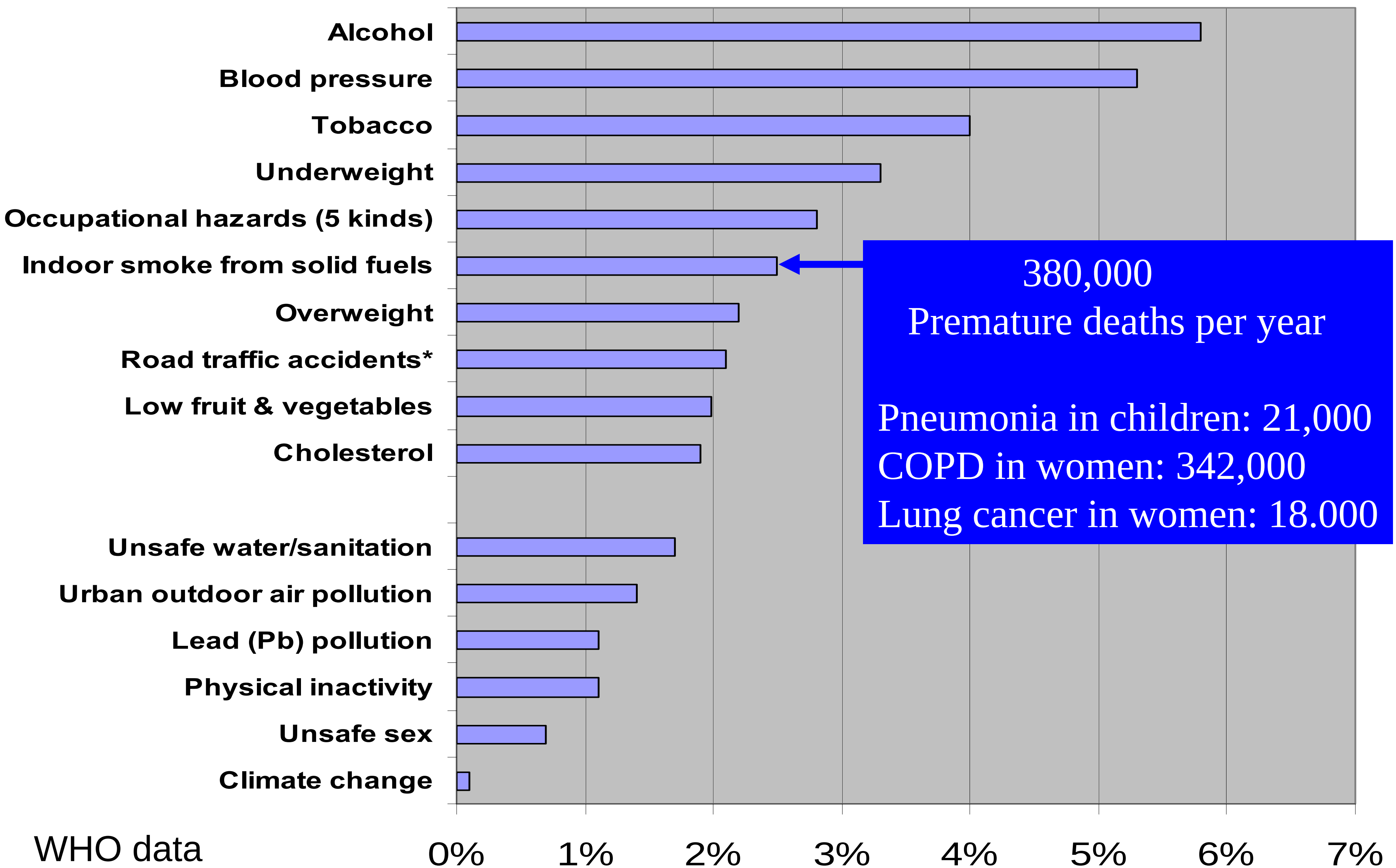
plus selected other risk factors



Smith et al. 2005

Chinese Burden of Disease from Top 10 Risk Factors

Plus Selected Other Risk Factors



WHO data

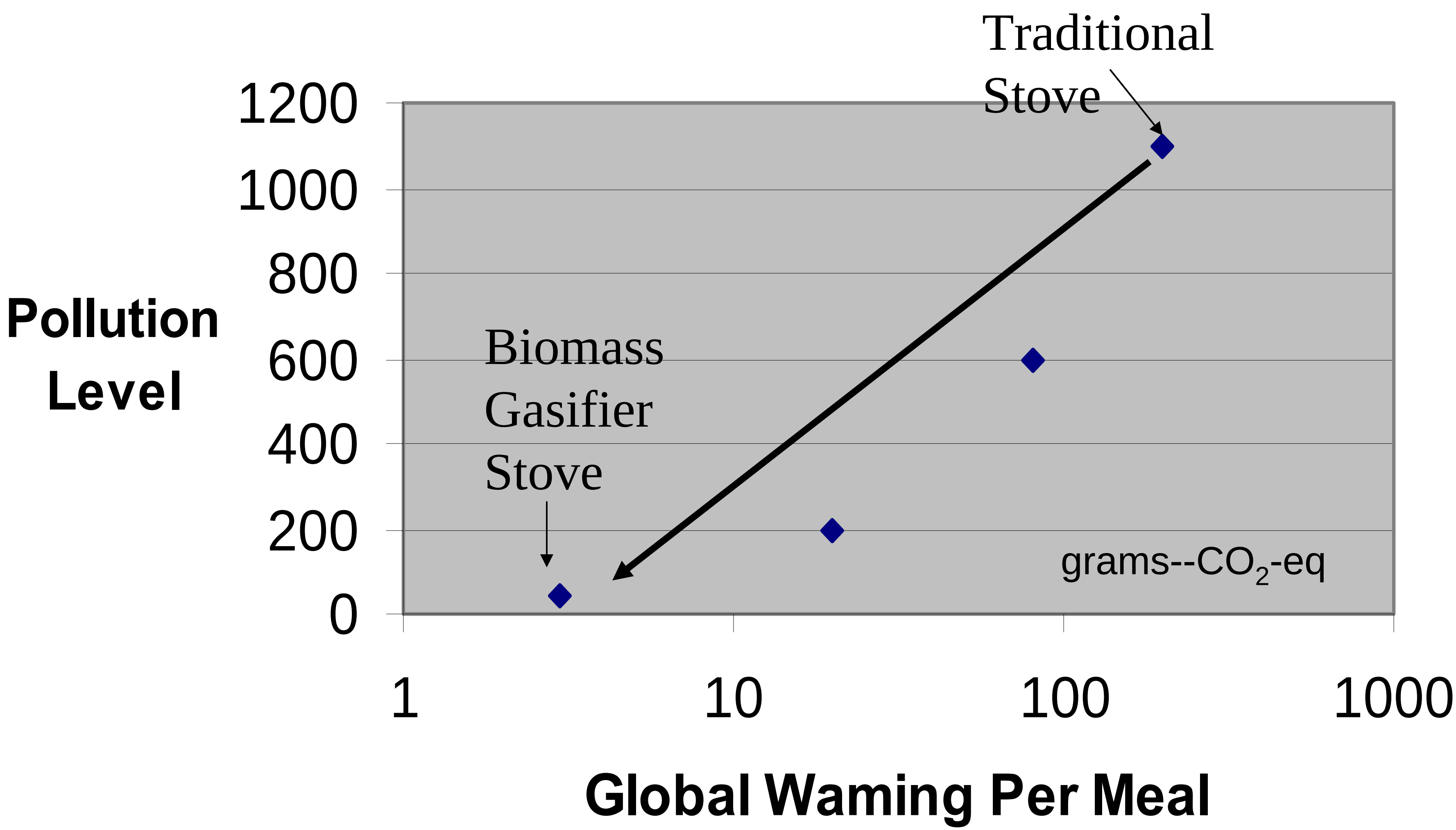
Percent of total lost life years in China - DALYs

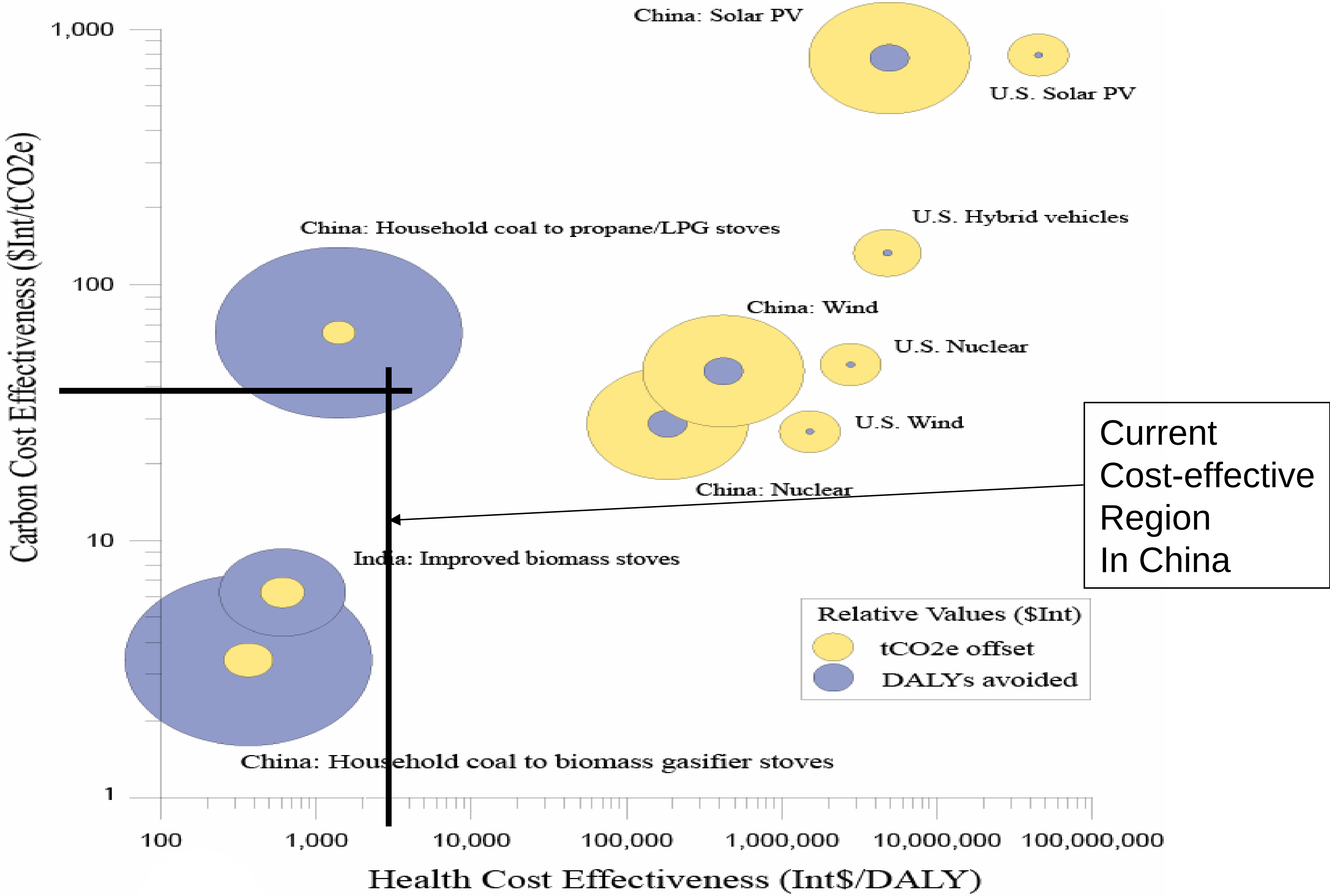
A Biomass Gasifier Stove

Tests show emissions nearly at levels of gas stoves:
Low health risk and essentially no greenhouse emissions

Winner of Chinese national contest announced March 2007 for best stove meeting emissions and reliability criteria:
cost ~350 RMB

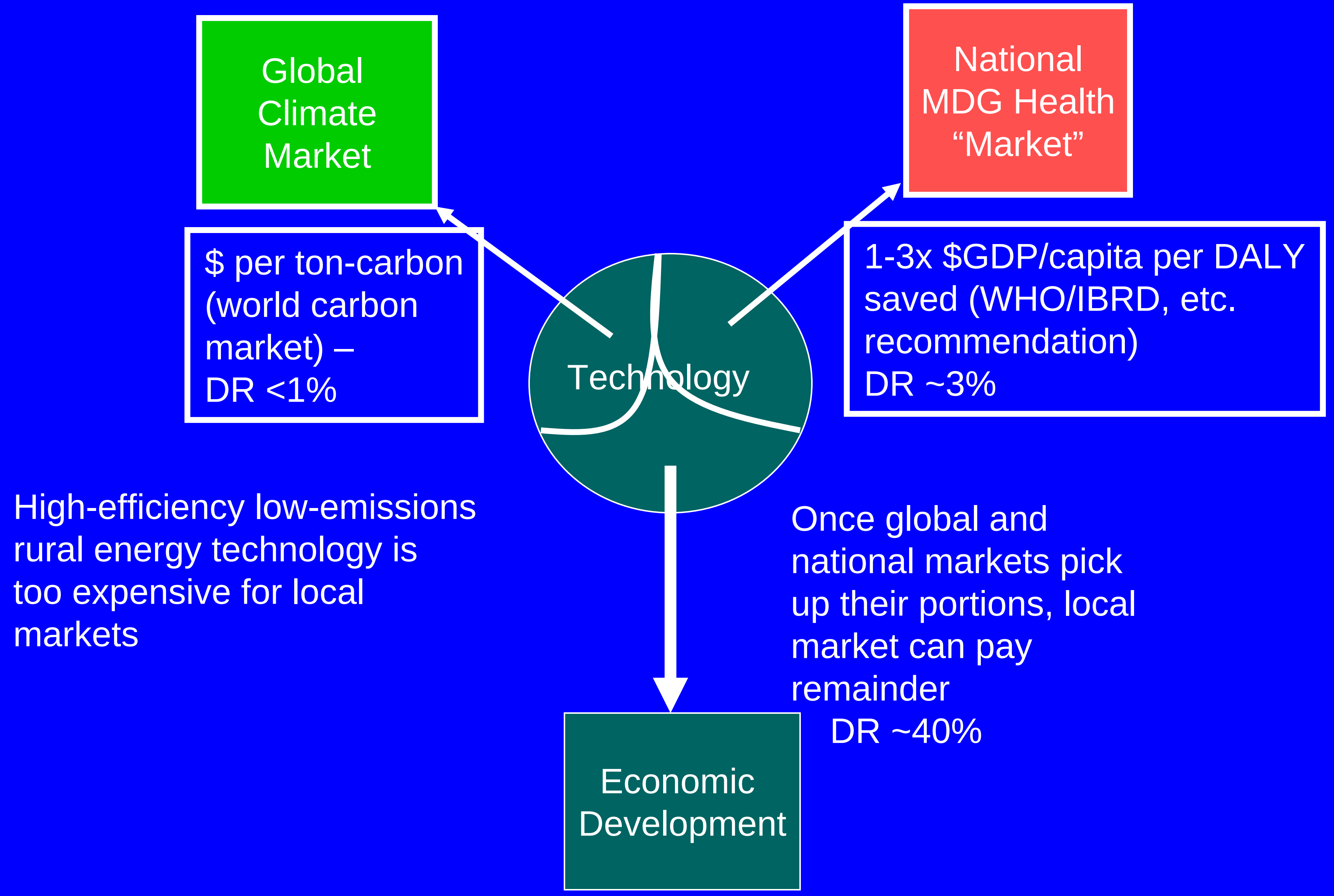
Health and Greenhouse Gas Benefits of Biomass Stove Options





Smith & Haigler, 2008

Paying for Rural Energy Development



Mechanisms for achieving these co-benefits are weak at present

- Clean Development Mechanism – Kyoto Pr
  -
    politics
  - No real credit for the “D” in CDM
  - Difficulty with verification
- Voluntary Carbon Market
  - Scale is limited and volatile
  - Accounting and verification inconsistent

You don’t get what you expect,
you get what you inspect.

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 task before humanity is move our civilization onto a sustainable path on a finite planet.
- This requires finding ways to avoid changing the climate precipitously
- But any definition of sustainability also includes bringing the reducing the vulnerability and ill-health experience by the poorest among us

Publications available at
http://ehs.sph.berkeley.edu/krsmith/

Thank you

Recent references

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