Climate Change and Health

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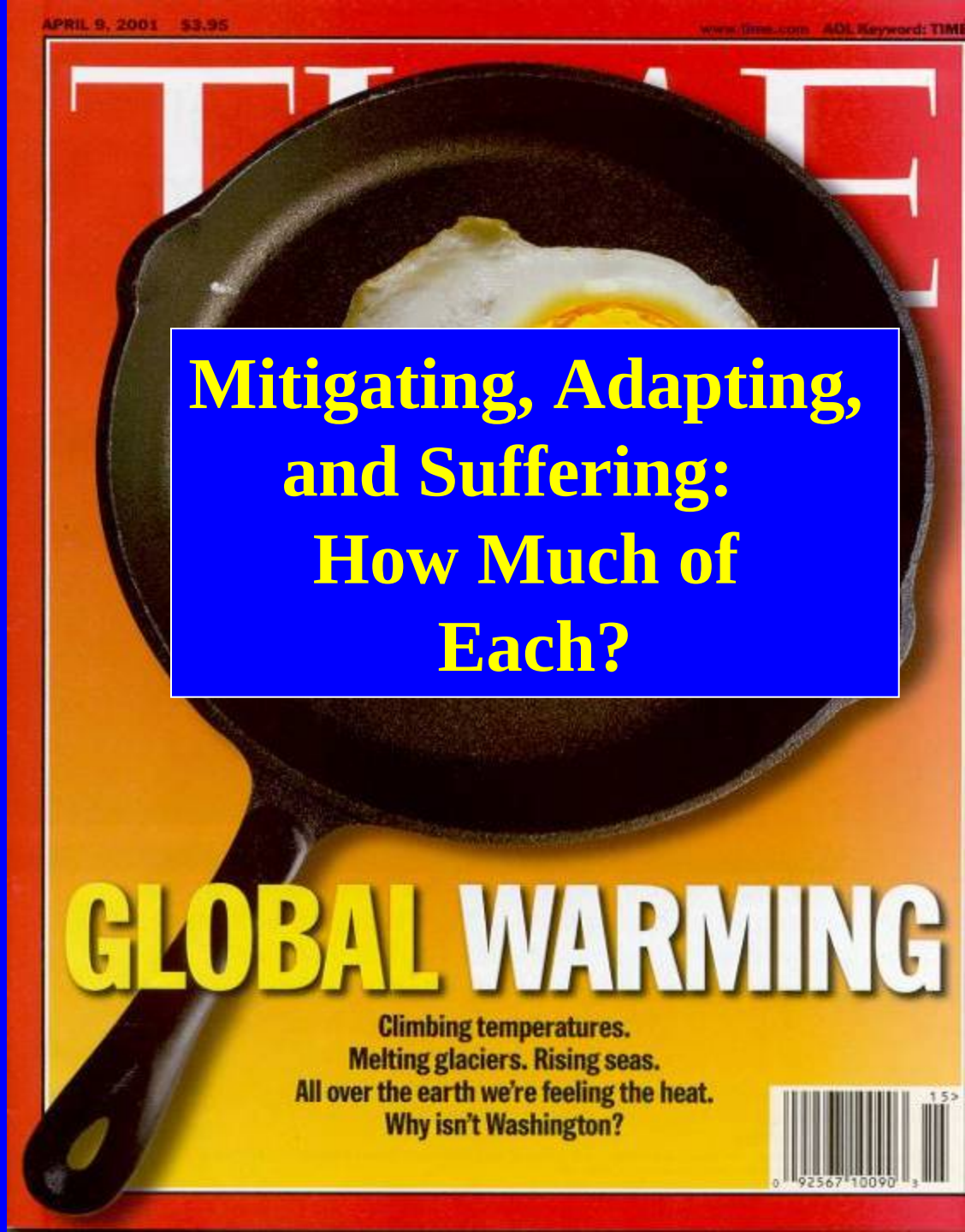
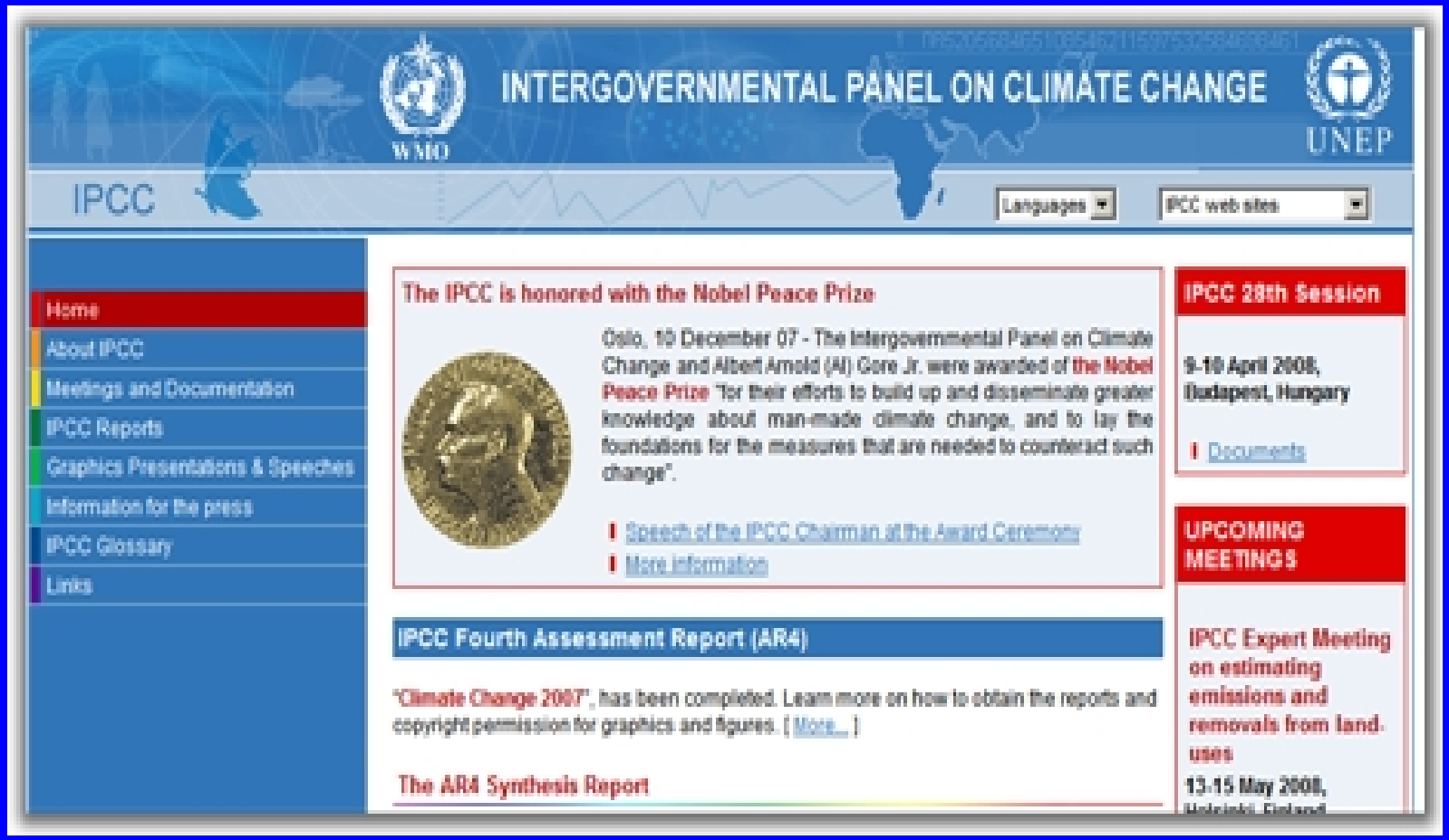


Mitigating, Adapting, and Suffering: How Much of Each?



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 San Diego
  - dengue fever in San Juan.

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

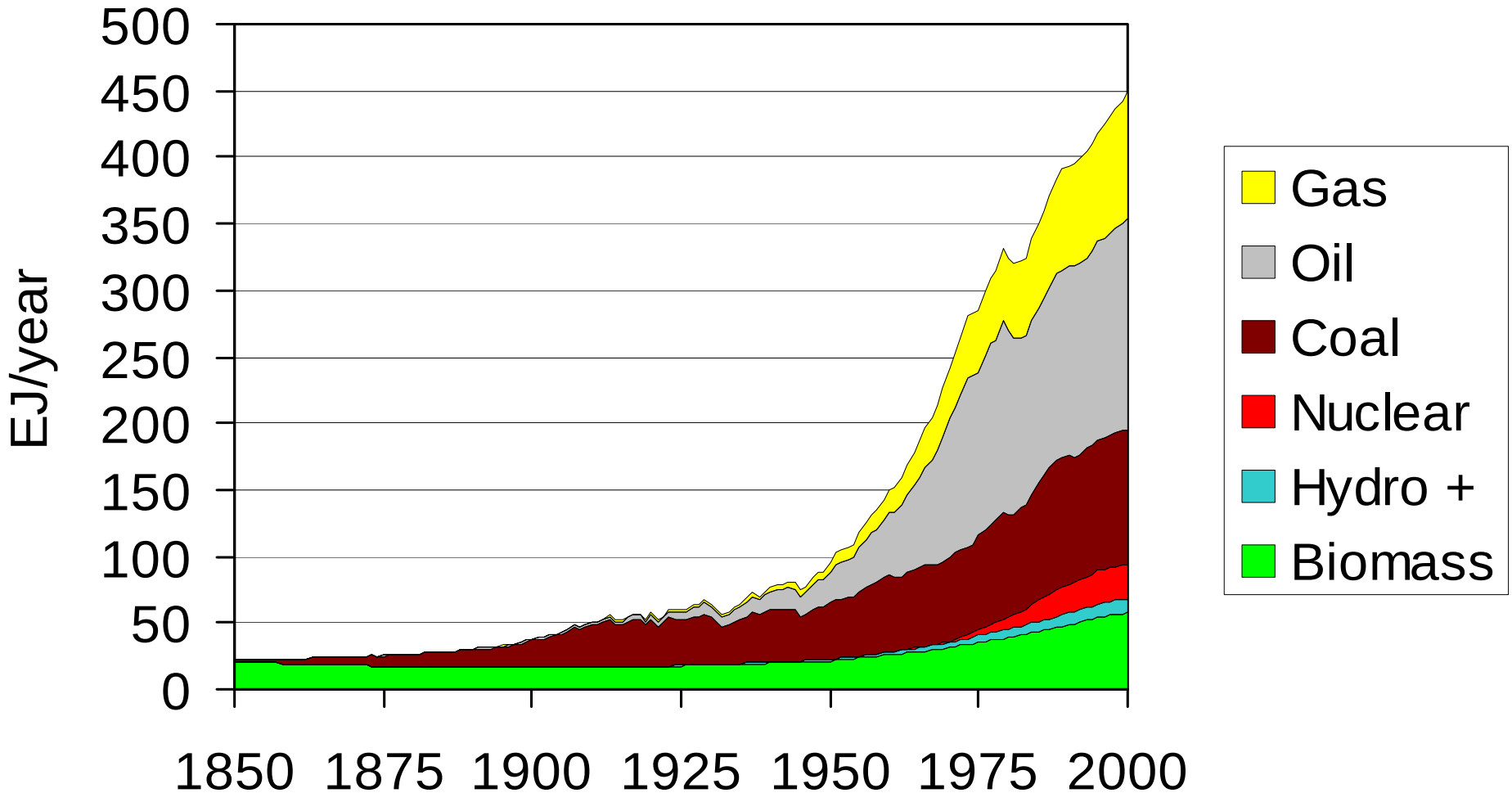
- **Mitigate** by working to reduce greenhouse gas (GHG) emissions from energy and land use or to capture them from the atmosphere in order to slow or, perhaps, reverse warming
- **Adapt** by reducing the negative effects of climate change through protecting coastlines, moving populations away from impacted 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

- Not just CO2: **Methane** and Climate Change
- What **Health Effects** are estimated?
- How do the **Distribution** of health impacts in world illustrate the difficulty of global negotiations?
- Can health **Co-benefits** help achieve both health and climate goals and reduce this global gap?

The rise of global dependence on fossil fuels



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

Atmospheric Greenhouse gas concentrations

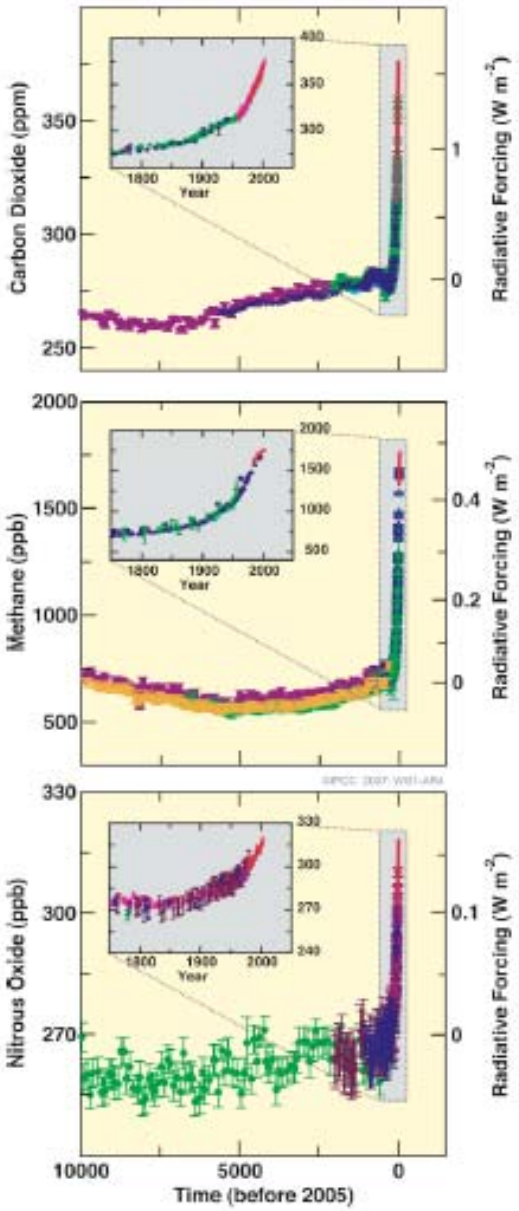


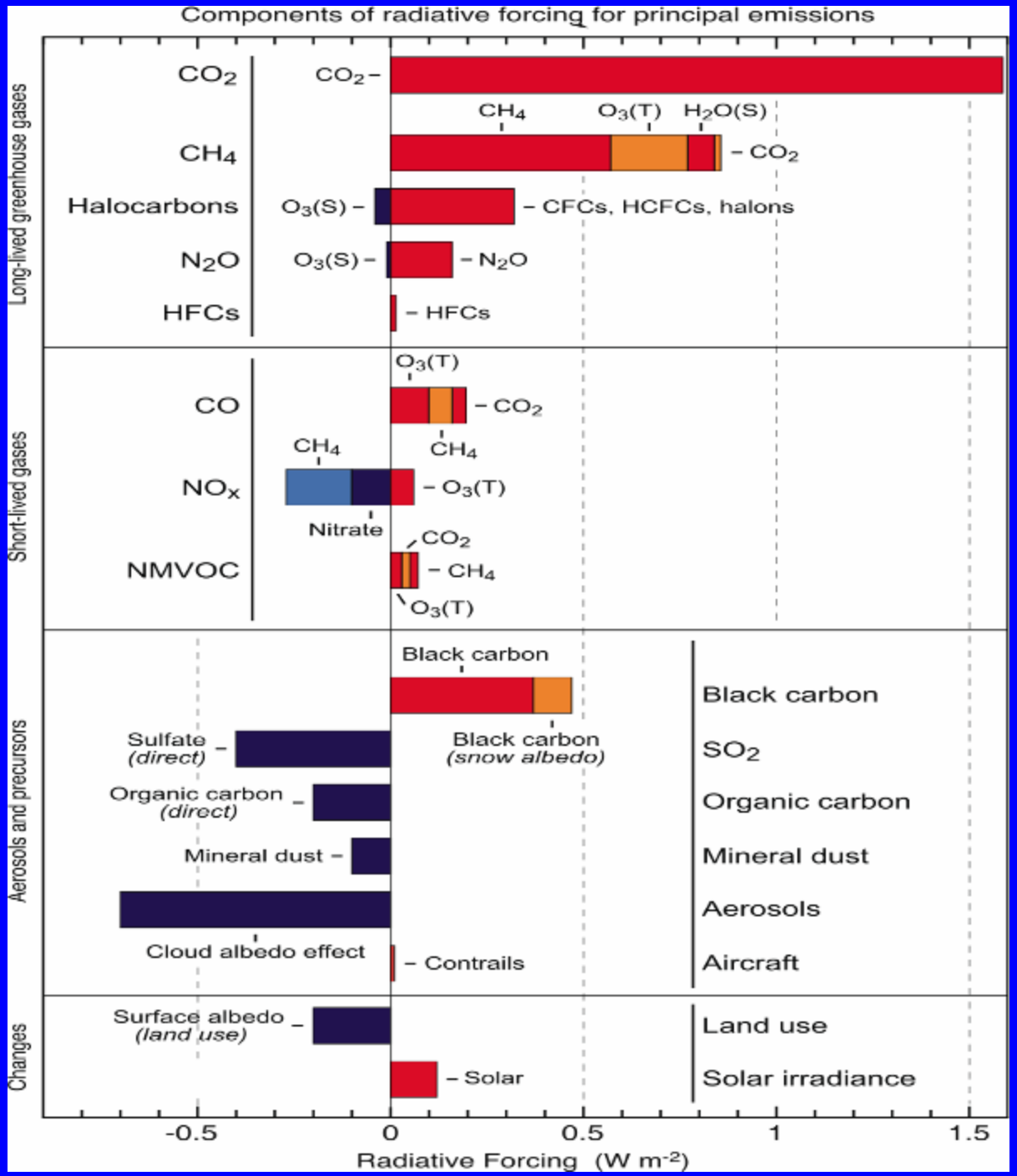
Figure SPM.1
IPCC 2007

Anthropogenic Sources

CO_2
Fossil fuels
Land use change
Cement manufacturing

Methane
Landfills
Rice
Livestock
Waste management
Fossil recovery

N_2O
Fertilizer
Planted N-fixers
Combustion

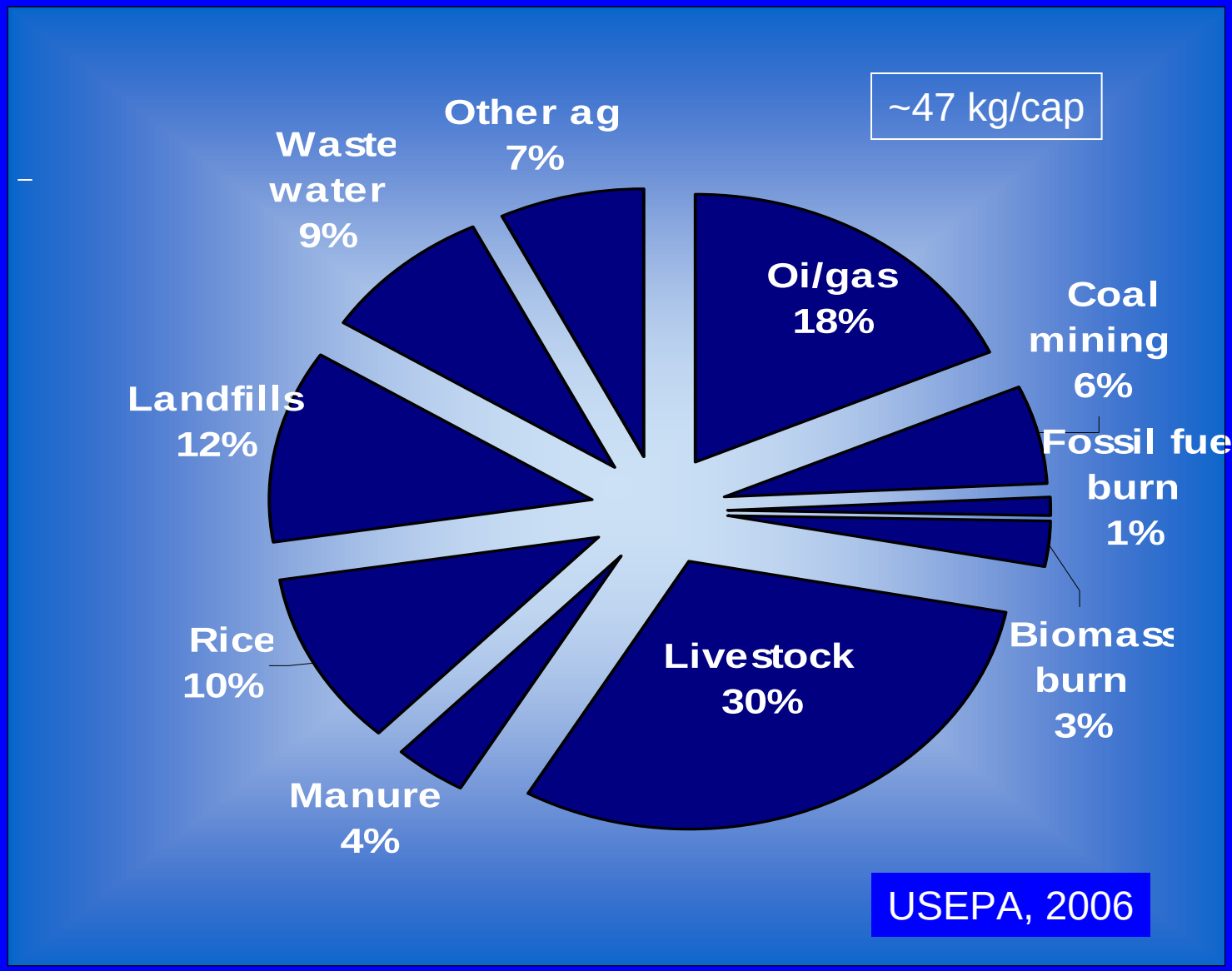


Warming in 2005 from emissions since 1750

Shorter-lived pollutants as important

IPCC, 2007

Global Anthropogenic Methane Emissions ~2005
Total ~ 305 million tons



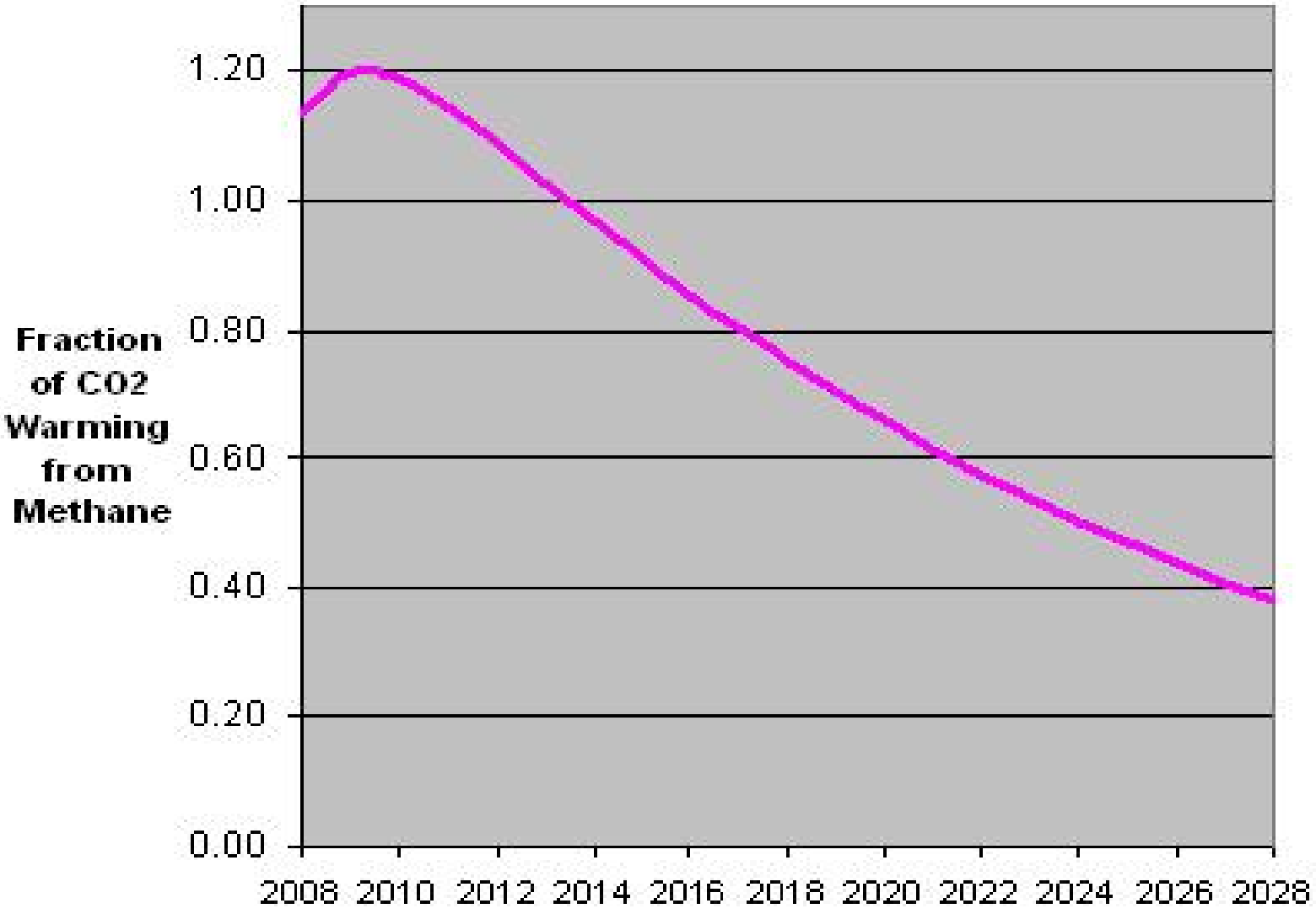
Expected to grow at ~1.5% per year

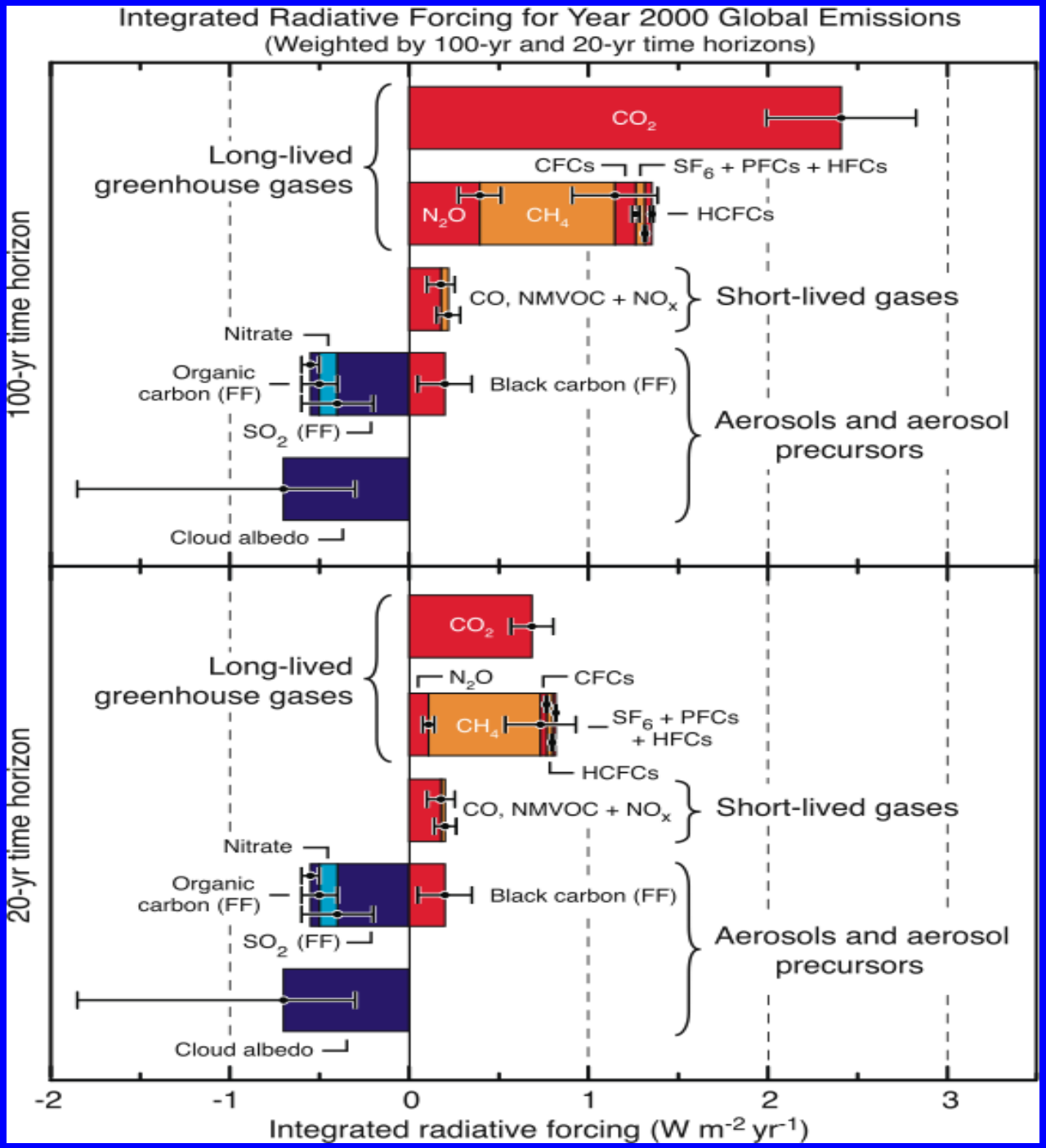
Math of GHG Decay (AR4)

- CO_2 goes into four compartments:
  - 19% of total with a lifetime* of 1.2 years
  - 34% at 18.5 y
  - 26% at 173 y
  - 21% with a lifetime of “many thousand years”
- Methane has a 12 y lifetime,
  - but contributes to ozone, a GHG
  - and eventually oxidizes to CO_2

*Lifetime refers to the time to reach 1/e (37%) of the original amount

Warming Contribution of Total ~2008 Emissions of Methane Compared to Total CO2 Emissions





100-y horizon

Time perspective makes a difference

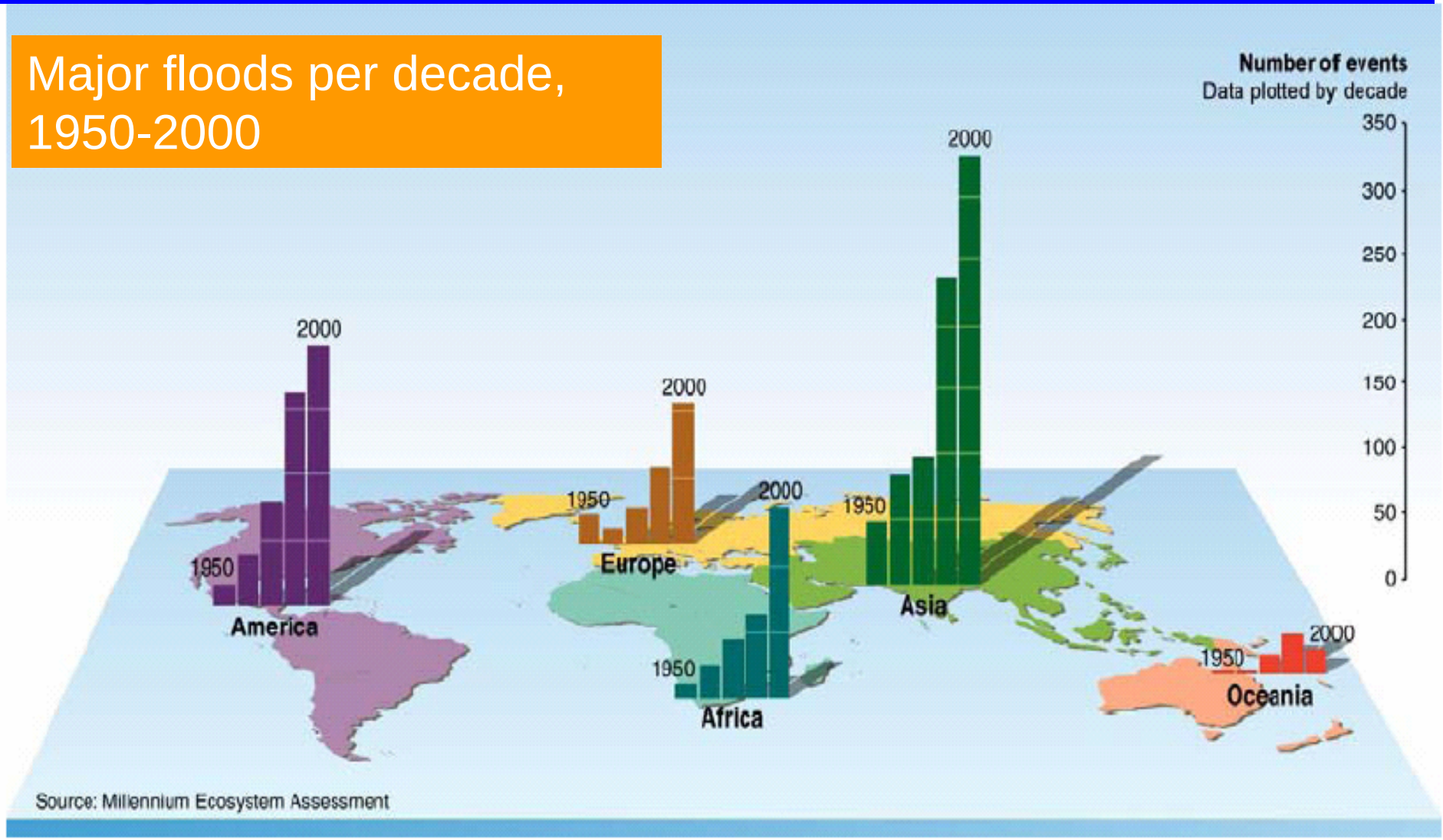
20-y horizon

IPCC, 2007

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

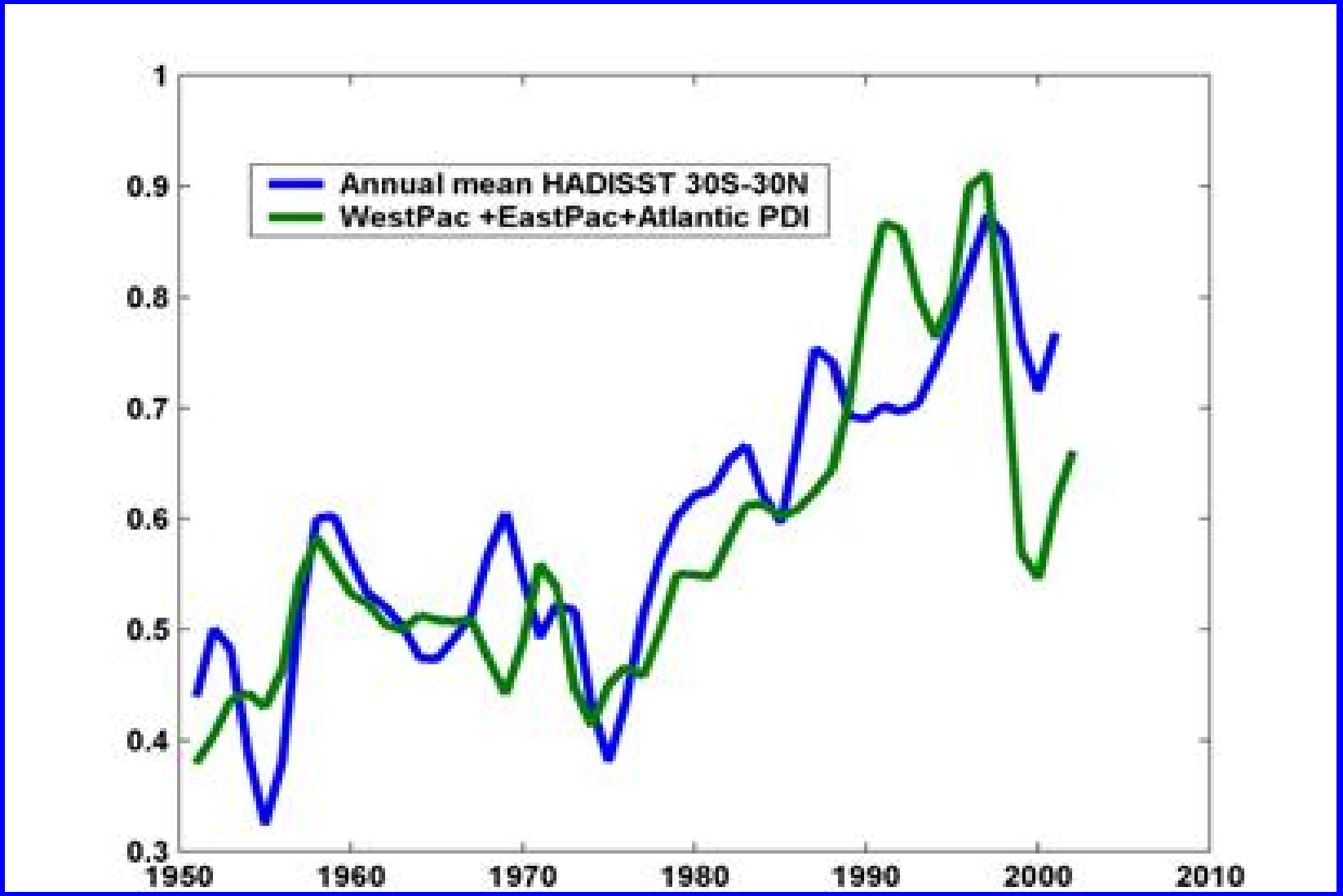
- Floods increasing
- Wildfires increasing
- Hurricanes (tropical cyclones) increasing in number and intensity
- Coral reefs dying
- Monsoon shifts

Major floods per decade, 1950-2000



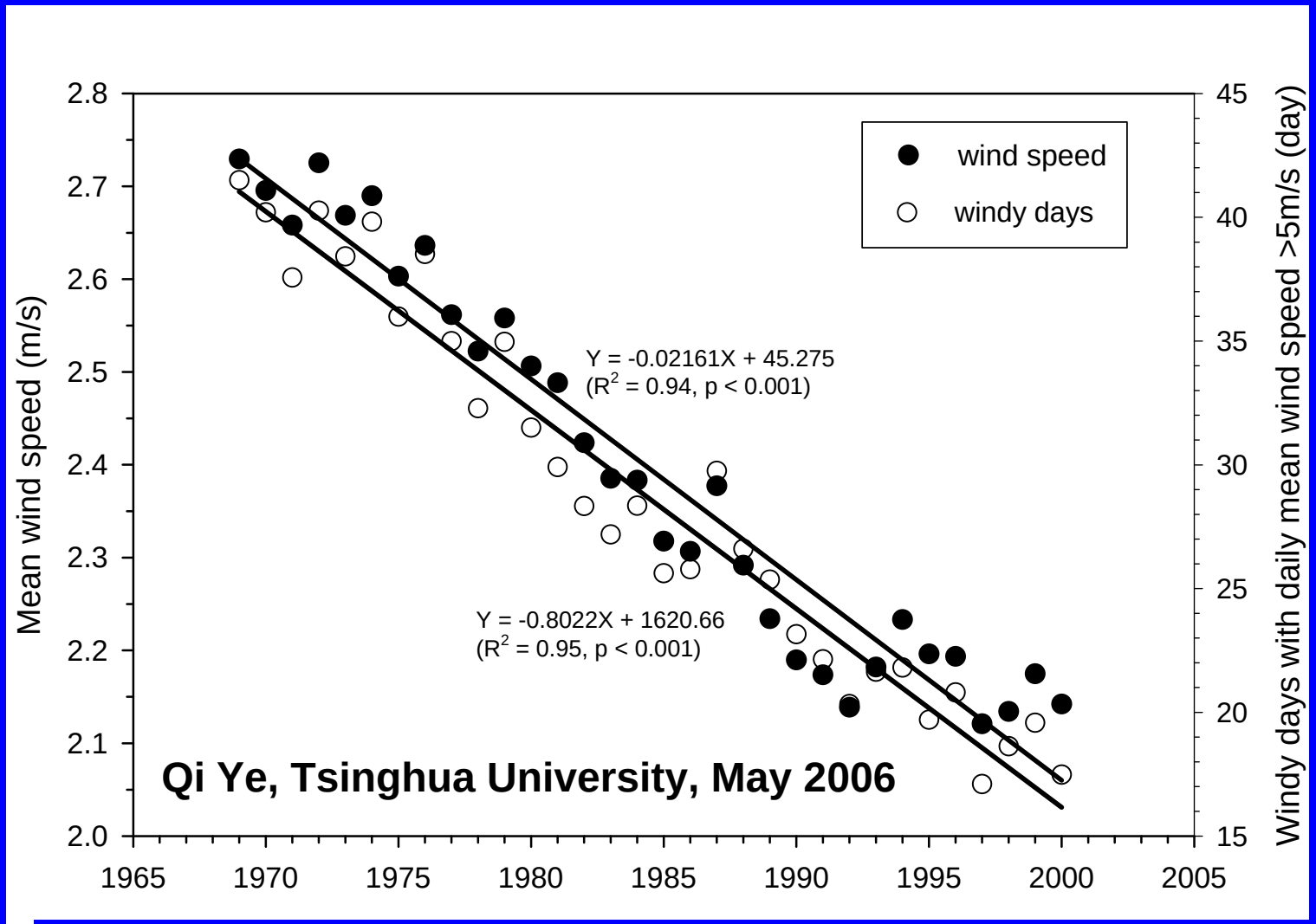
There's a consistent 50-year upward trend in every region except Oceania, where the 1990s were a bit below the 1980s.

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.

Categories of Health Impacts

1) **Direct impacts** through changing weather patterns (e.g., storms, floods, temperature extremes)
2) **Indirect impacts** through changes in water supply and quality, air pollution, and in ecosystems leading to shifts in disease vectors.
3) **Systemic impacts** through shifts in food supplies, refugee patterns, coastal and agricultural livelihoods, and the health impacts of society's responses to climate change, such as geo-engineering, carbon taxes, biofuel production, etc.
4) **Low-probability high-consequence impacts** such as extremely rapid climate change or sea level rise due to threshold phenomena in Earth's systems, e.g., runaway methane emissions from the tundra or rapid loss of parts of the Antarctic ice sheet.

Health Impacts: Just One Example

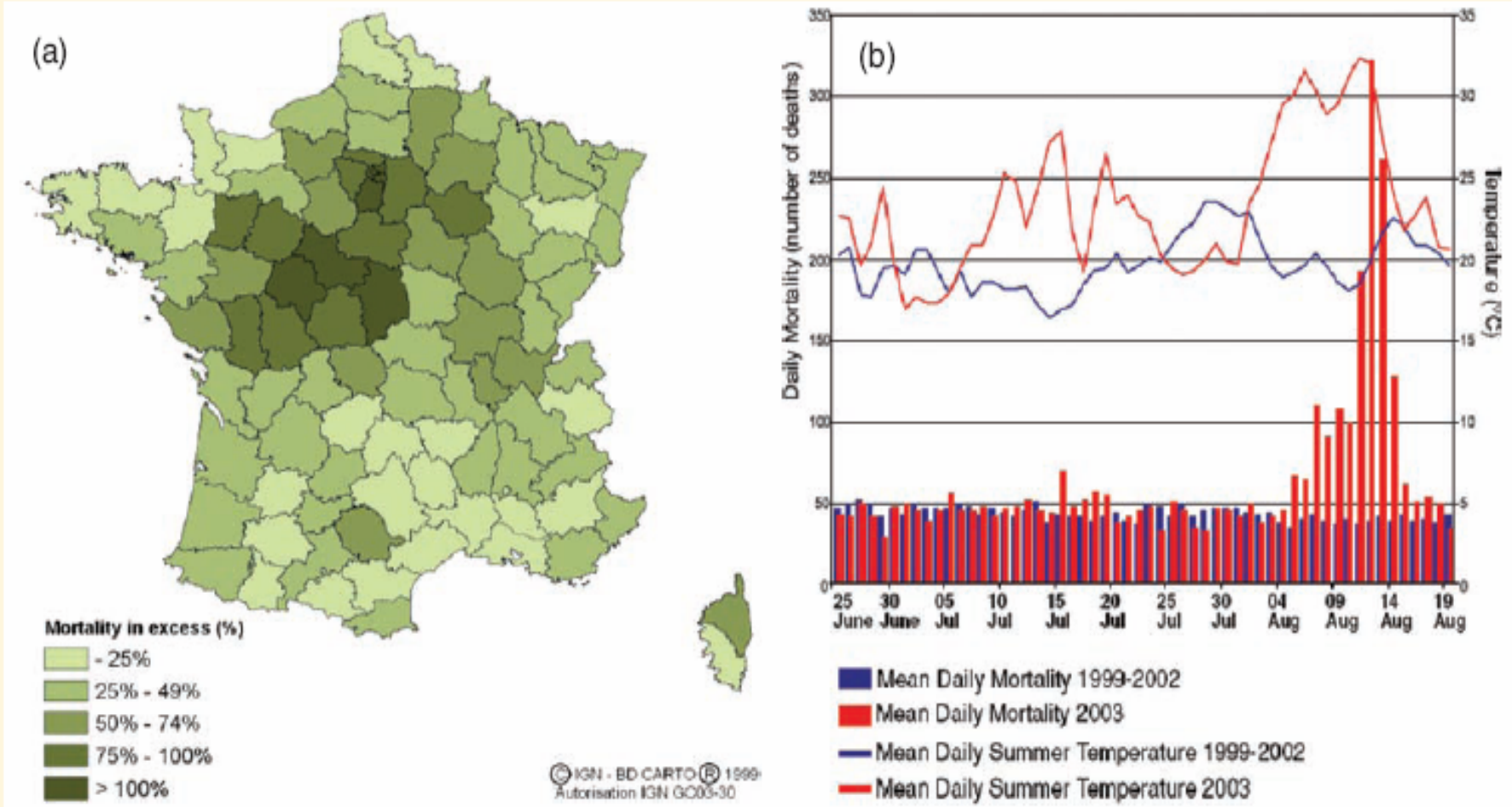
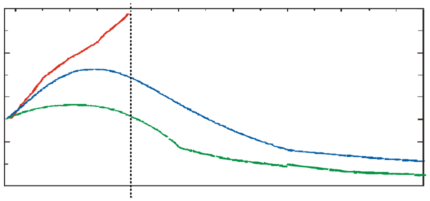


Figure 8.2. *(a) The distribution of excess mortality in France from 1 to 15 August 2003, by region, compared with the previous three years (INVS, 2003); (b) the increase in daily mortality in Paris during the heatwave in early August (Vandentorren and Empereur-Bissonnet, 2005).*

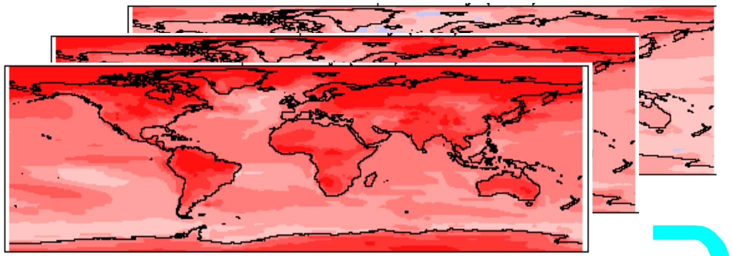
IPCC WGII, 2007

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

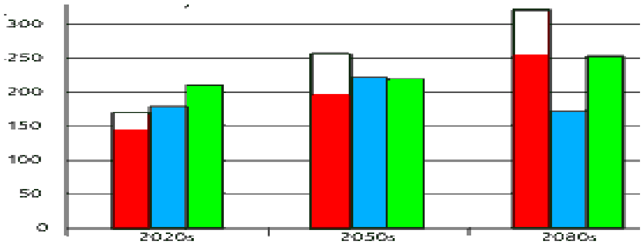
GHG emissions scenarios



GCM model:
Generates series maps of future climate



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

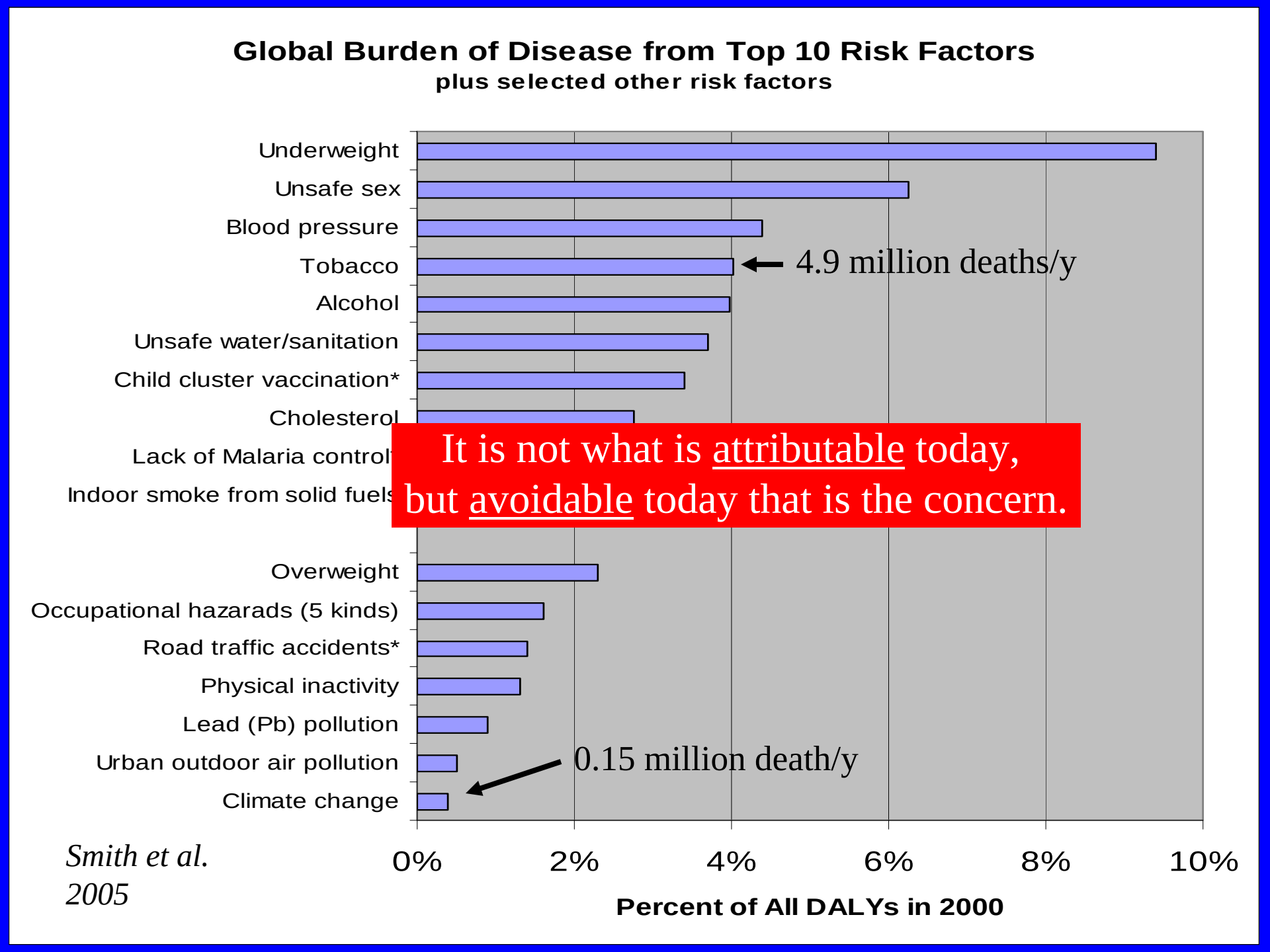


Conversion to GBD 'currency' to summation of the of different health

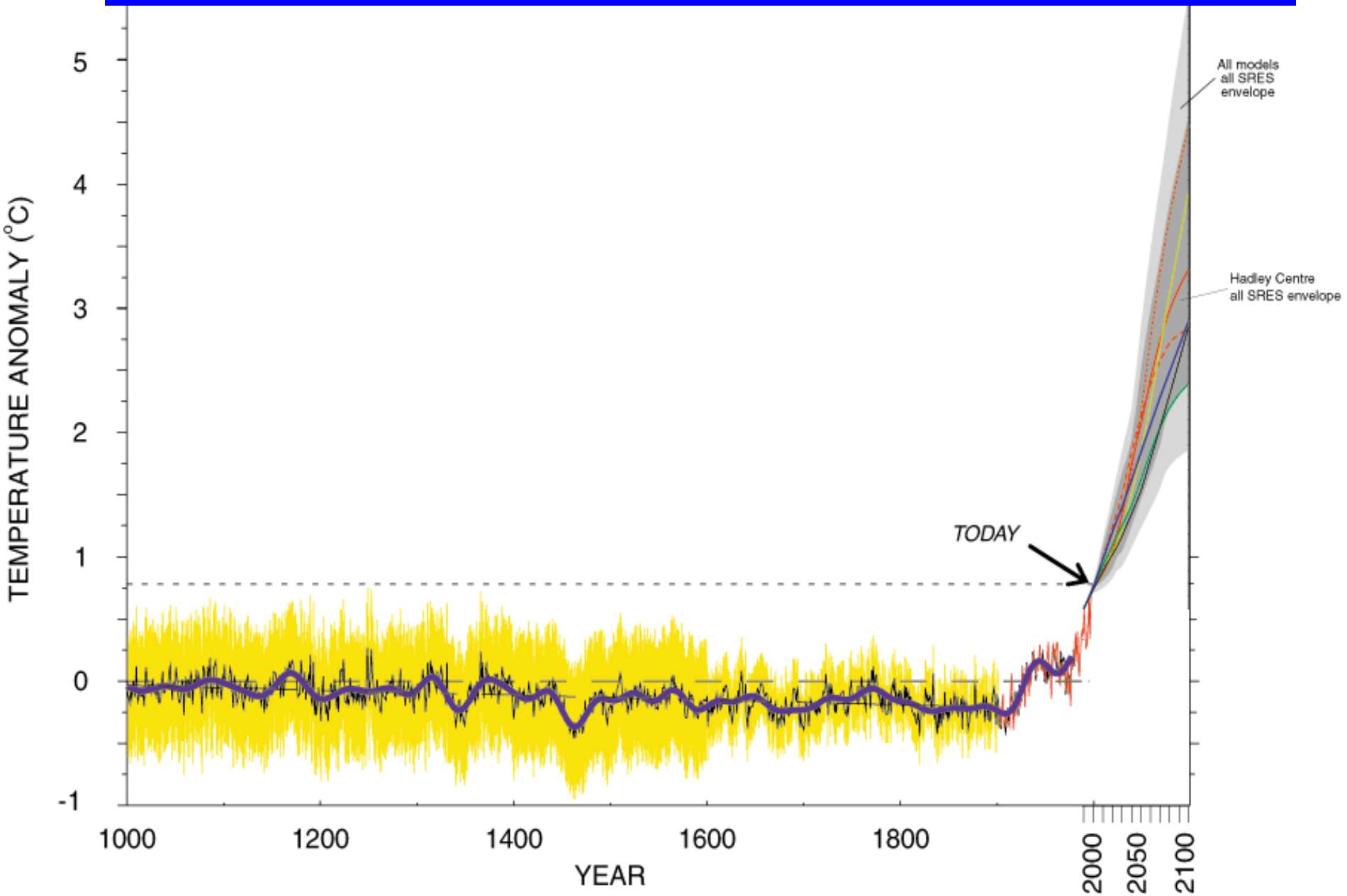
Level	Age group (years) 0-4	5-14	15-29	30-44	45-59	60-69	70+
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
3	1.7	1.7	1.7	1.7	1.7	1.7	1.7
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
3	1.7	1.7	1.7	1.7	1.7	1.7	1.7
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	1.2	1.2	1.2	1.2	1.2	1.2	1.2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

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

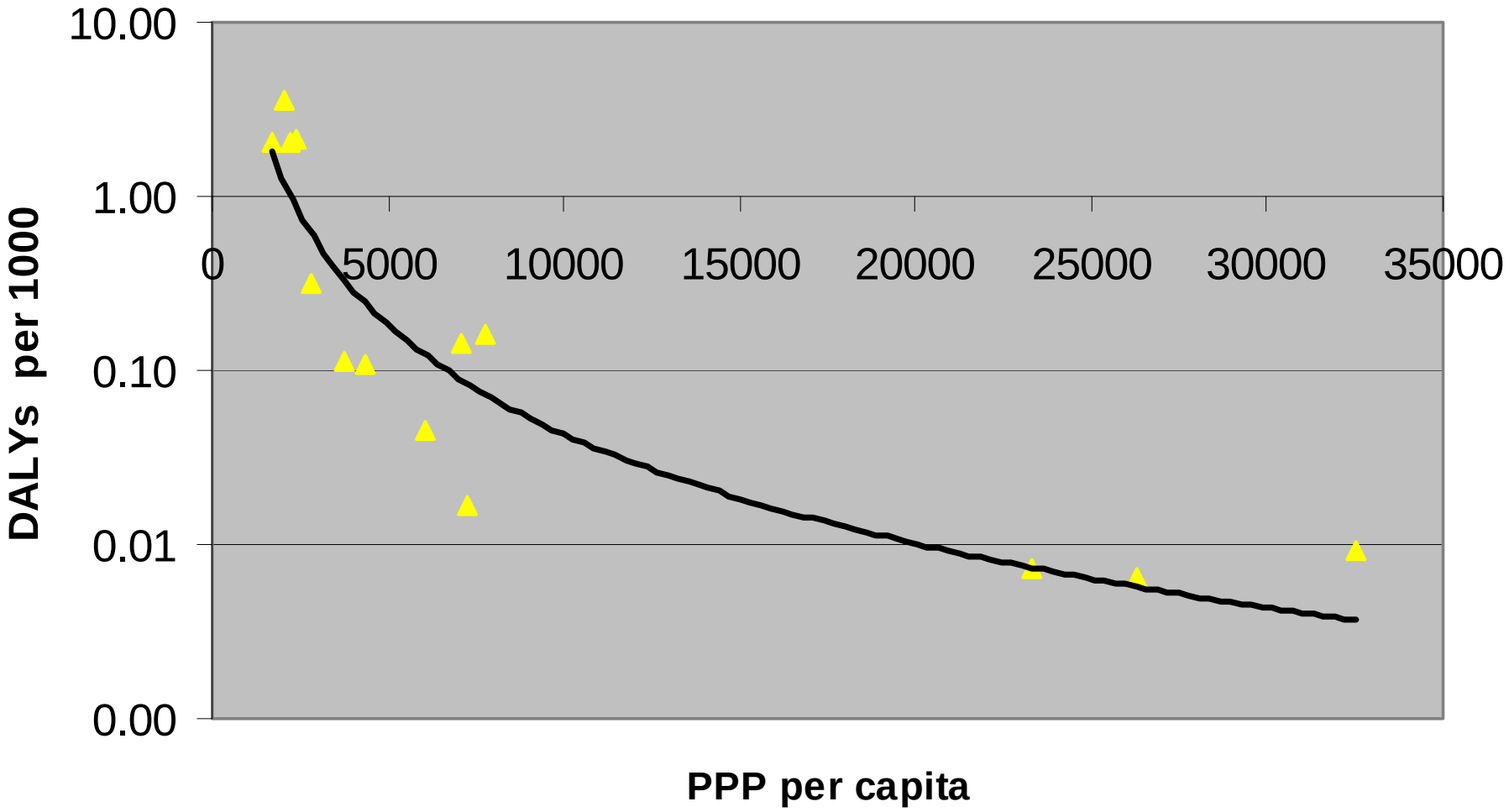
- Diarrhea – 2.4% of global burden
- Malaria – 2%; 6% in some regions
- 17% of protein-energy malnutrition
- 7% of dengue fever in some rich countries
- 150,000 deaths, 99% in poor countries
- 0.4% of all DALYs
- Most (88%) of impact in children under 5


Global Burden of Disease from Top 10 Risk Factors
plus selected other risk factors
Underweight
Unsafe sex
Blood pressure
Tobacco
Alcohol
Unsafe water/sanitation
Child cluster vaccination*
Cholesterol
Lack of Malaria control
Indoor smoke from solid fuels
Overweight
Occupational hazarads (5 kinds)
Road traffic accidents*
Physical inactivity
Lead (Pb) pollution
Urban outdoor air pollution
Climate change
4.9 million deaths/y
0.15 million death/y
It is not what is attributable today,
but avoidable today that is the concern.
0%
2%
4%
6%
8%
10%
Percent of All DALYs in 2000
Smith et al.
2005

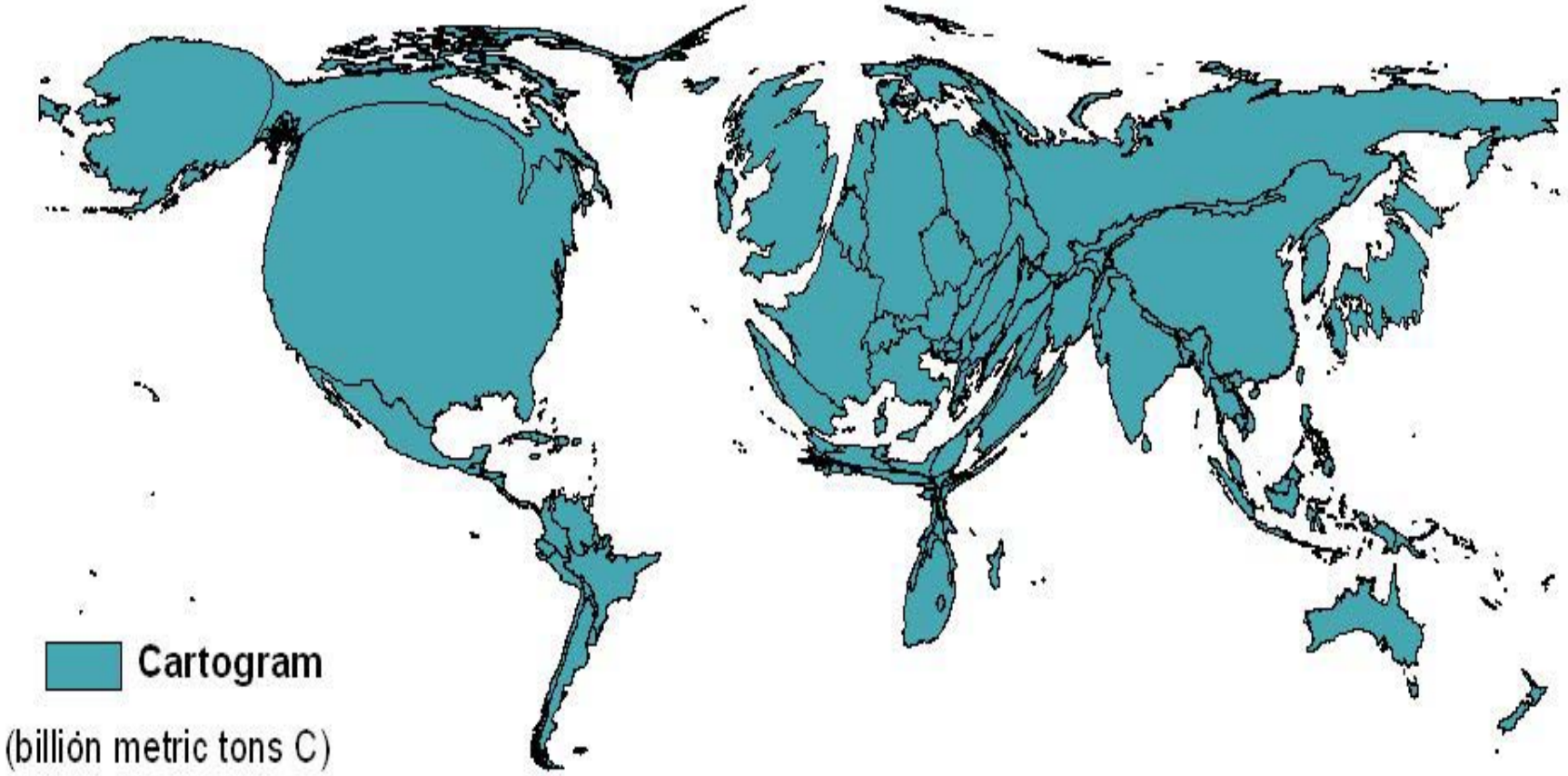
1000 years of Earth temperature history…and 100 years of projection



Global Risk Transition
(Experiencing Risks)

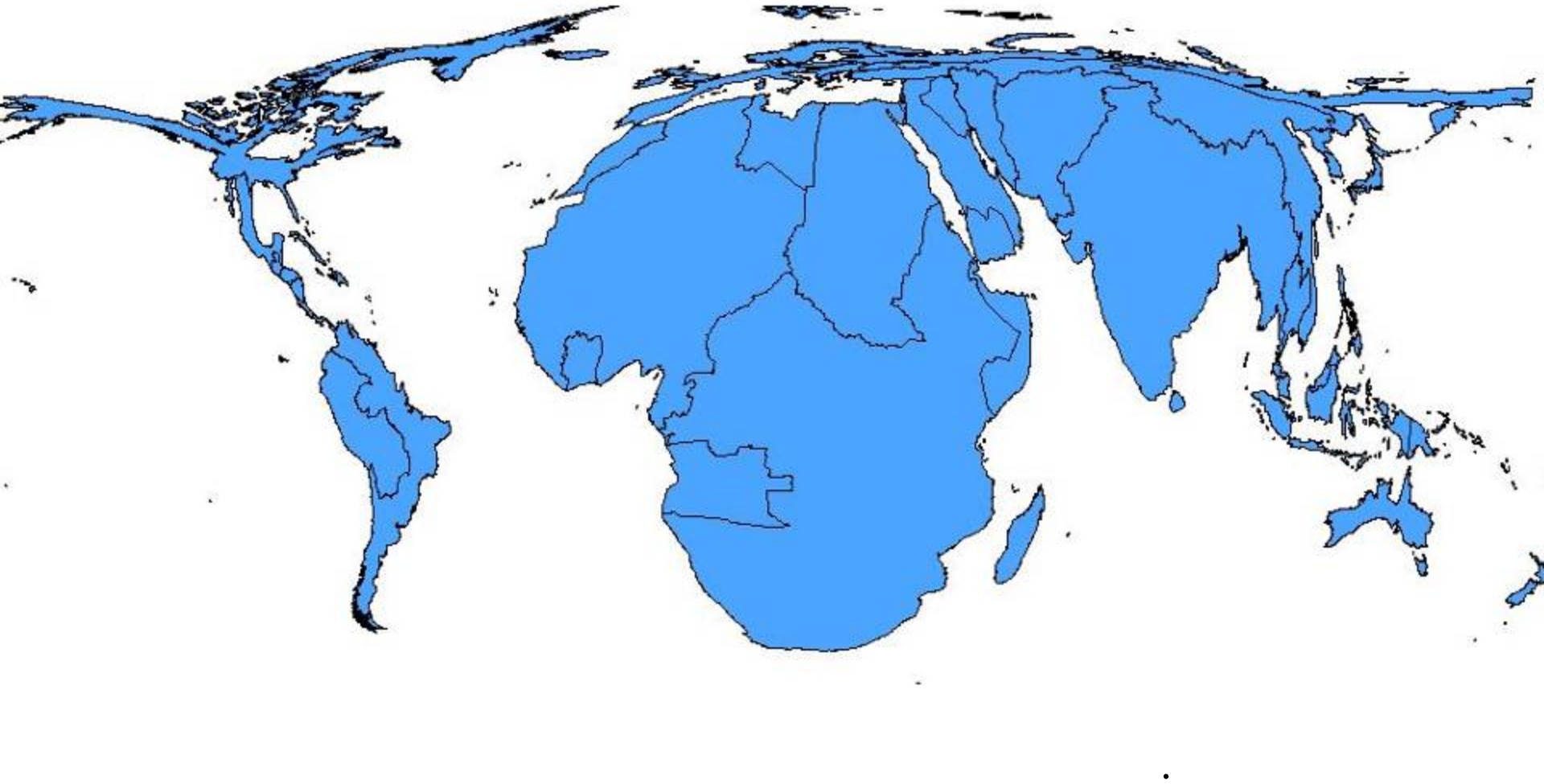


Cumulative CO_2 emissions from fossil fuels (as depleted by natural processes)



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.

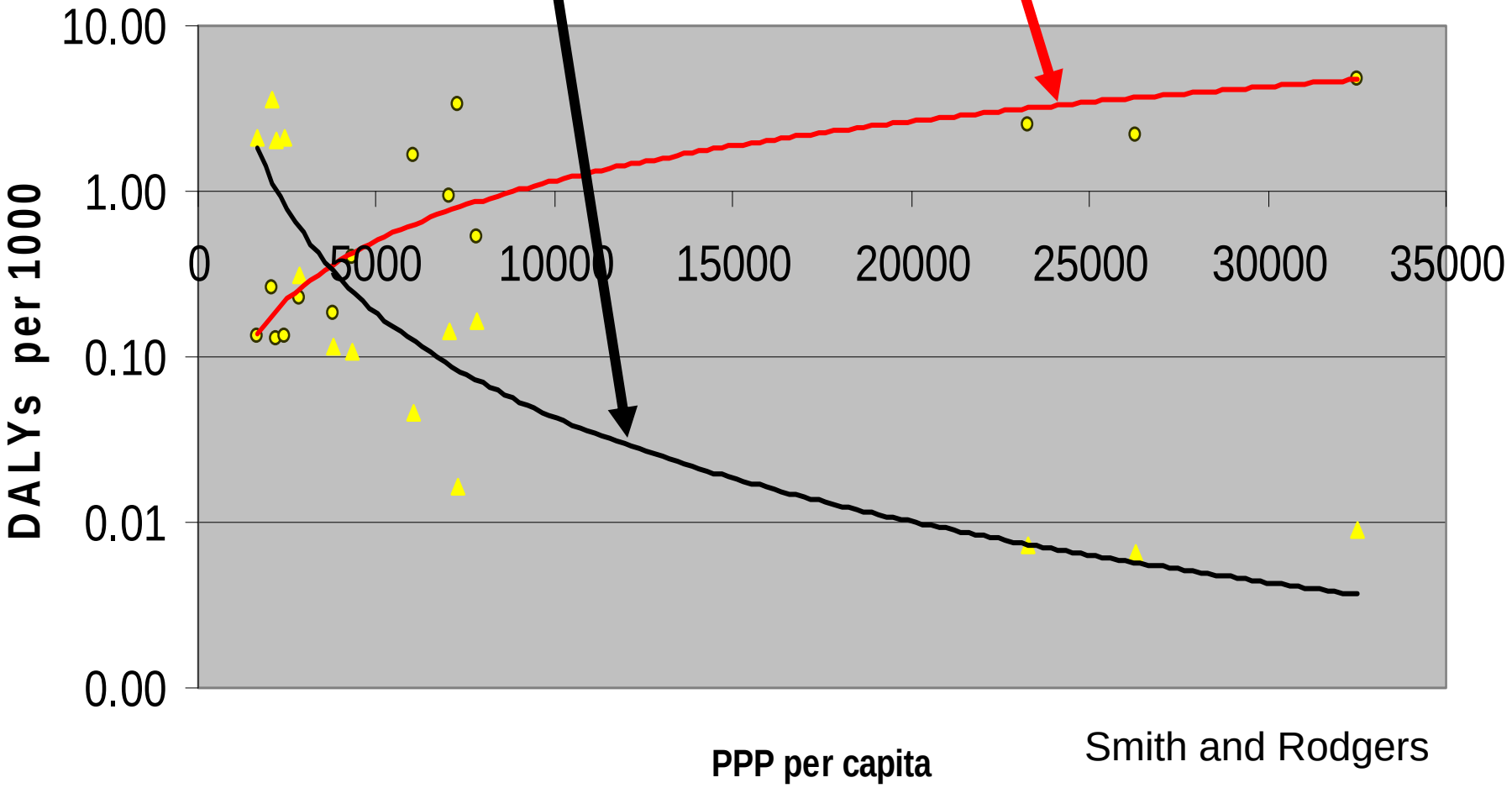
Cartogram of Climate-related Mortality (per million pop) yr. 2000



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.

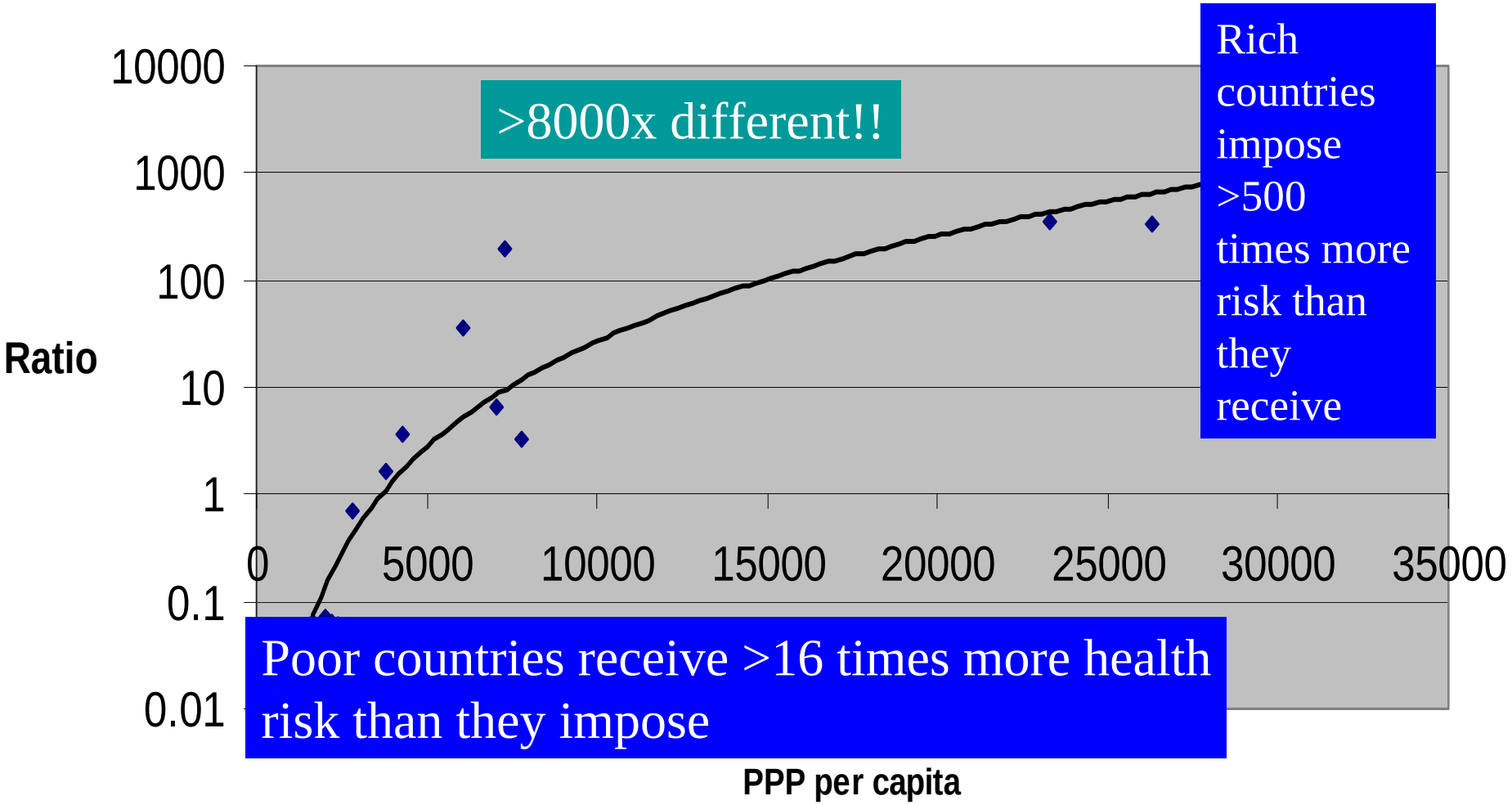
Distribution of Health Impacts from Climate Change

(Experiencing versus Imposing)



Smith and Rodgers

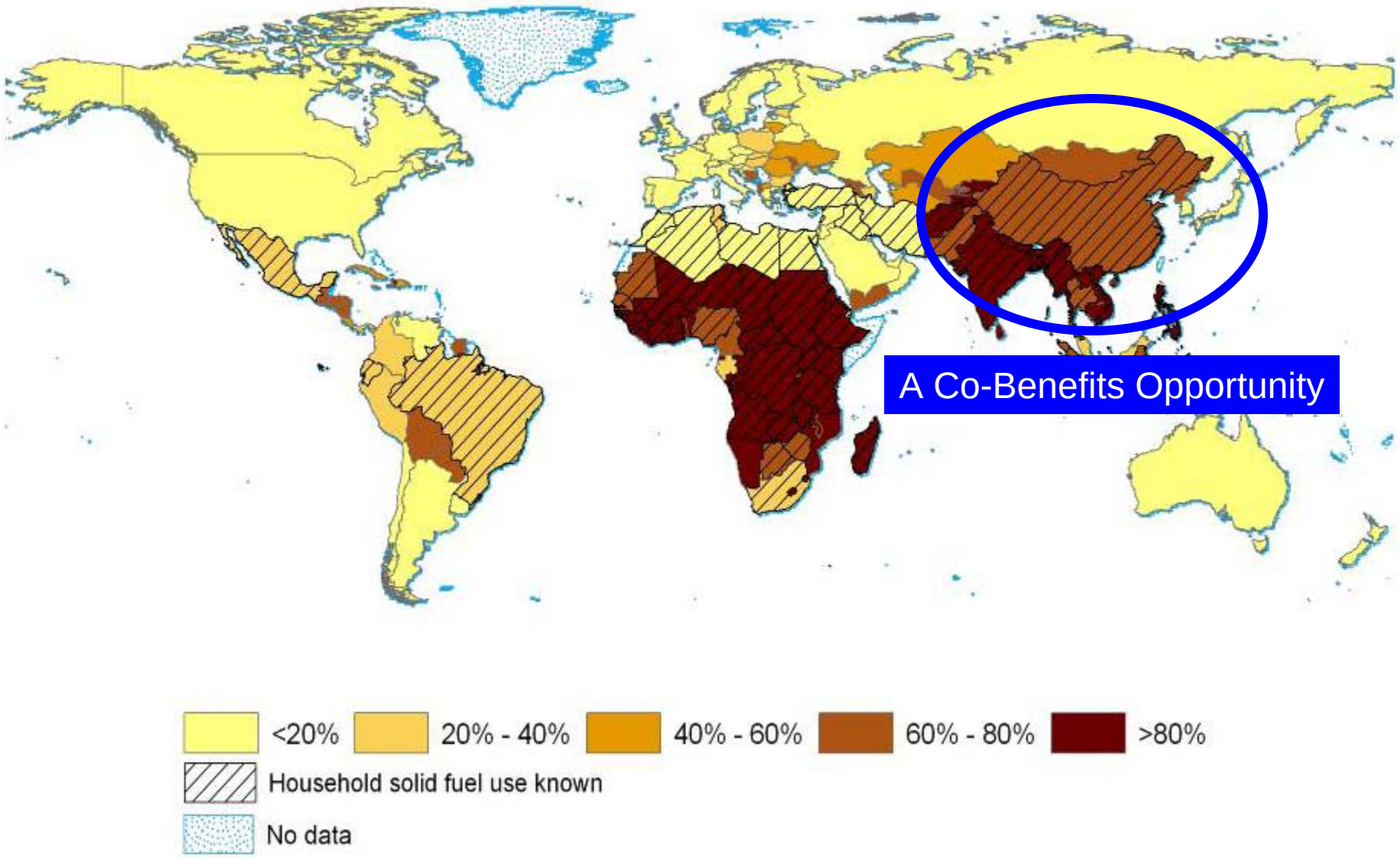
Distribution of Health Impacts from Climate Change (Ratio: Imposing/Experiencing)



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

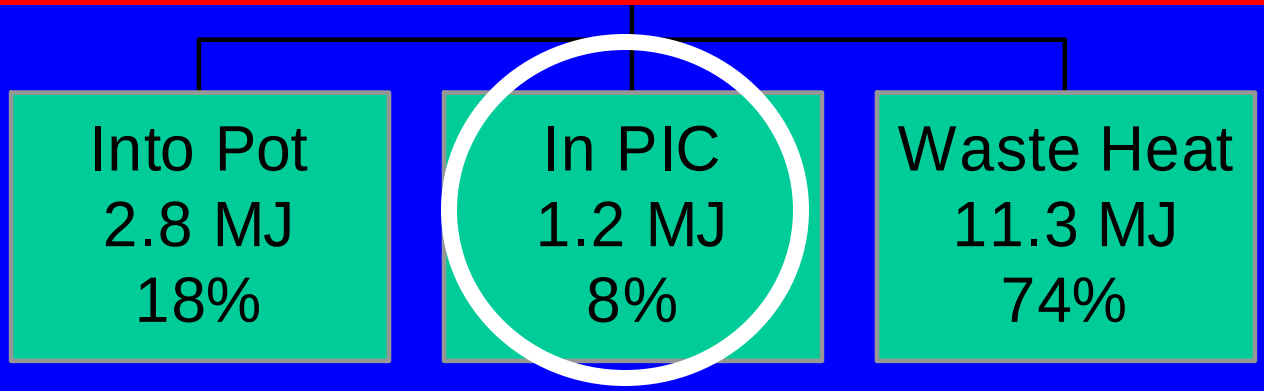


Chinese household rural energy:

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

A Toxic Waste Factory!!

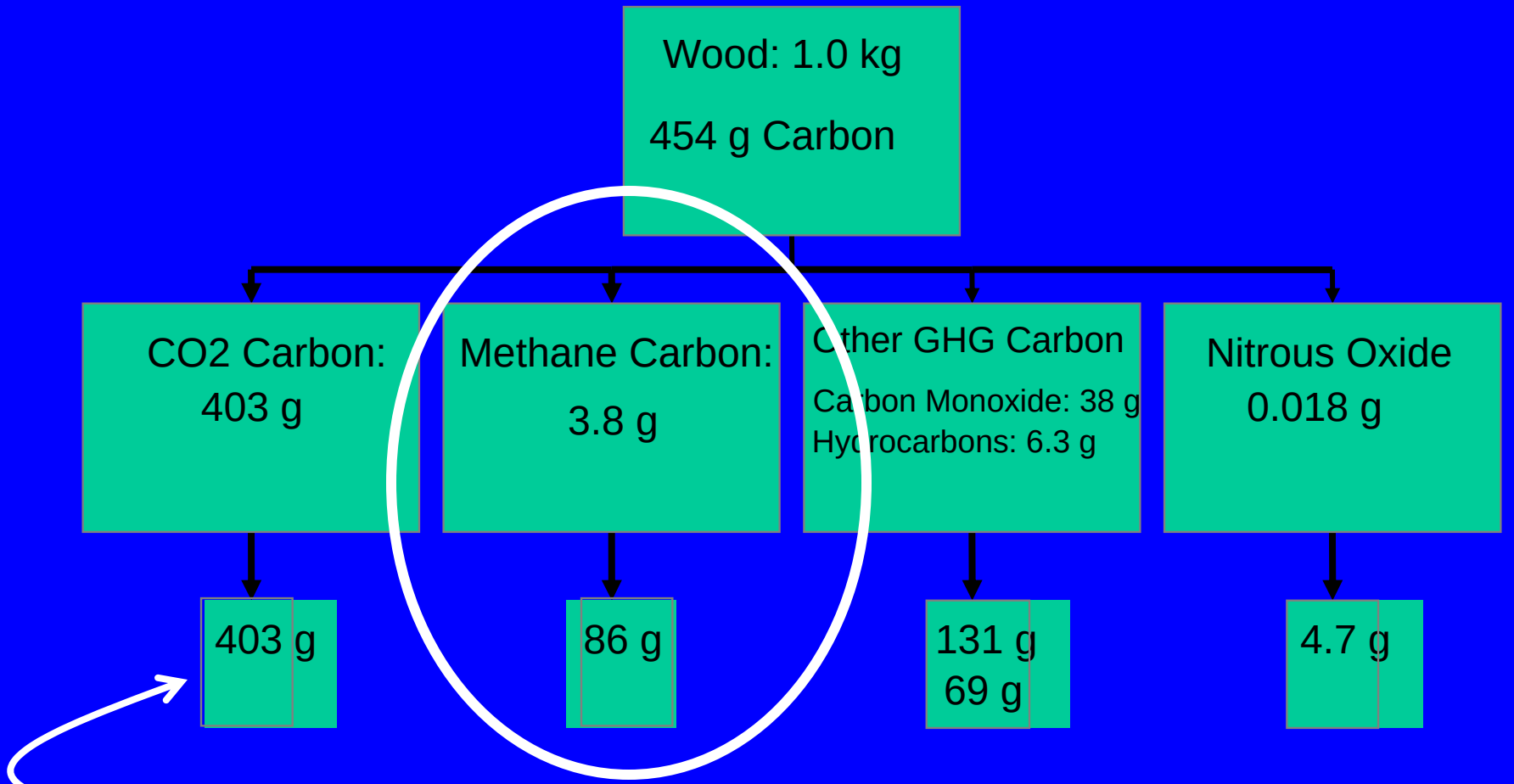
Typical biomass cookstoves convert 6-20% of the fuel carbon to toxic substances



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

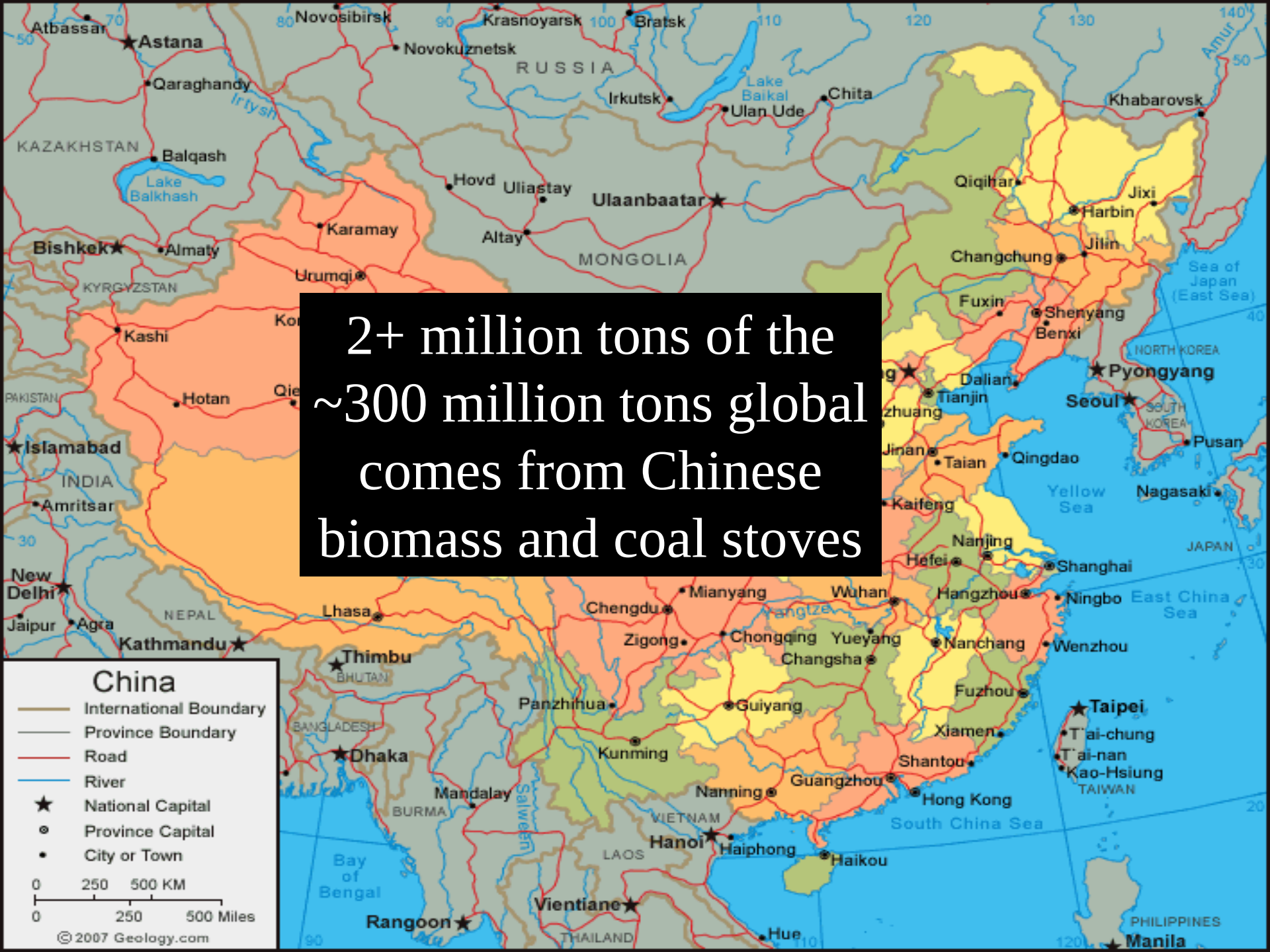
Source: Smith, et al., 2000

Greenhouse warming commitment per meal for typical wood-fired cookstove in China



Global warming commitments of each of the gases as CO_2 equivalents

Source: Smith, et al., 2000


2+ million tons of the ~300 million tons global comes from Chinese biomass and coal stoves
China
International Boundary
Province Boundary
Road
River
National Capital
Province Capital
City or Town
0 250 500 KM
0 250 500 Miles
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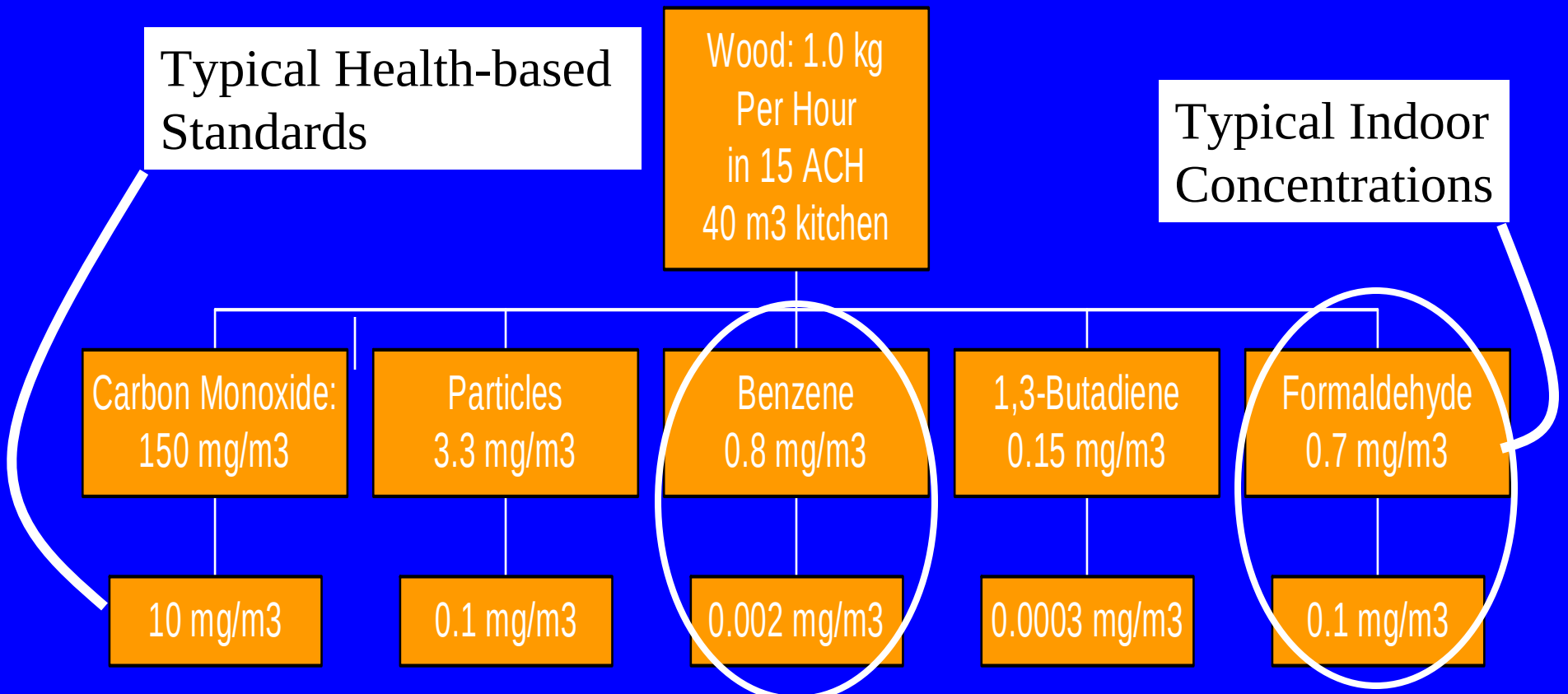
RUSSIA
KAZAKHSTAN
MONGOLIA
KYRGYZSTAN
PAKISTAN
INDIA
NEPAL
BHUTAN
BANGLADESH
BURMA
VIETNAM
LAOS
THAILAND
NORTH KOREA
SOUTH KOREA
JAPAN
TAIWAN
PHILIPPINES
Yellow Sea
East China Sea
South China Sea
Sea of Japan (East Sea)
Bay of Bengal
Lake Baikal
Lake Balkhash
Irtysh
Amur
Yangtze
Salween
Atbassar
Astana
Qaraghandy
Balqash
Novosibirsk
Novokuznetsk
Krasnoyarsk
Bratsk
Irkutsk
Ulan Ude
Chita
Khabarovsk
Hovd
Uliastay
Ulaanbaatar
Altay
Karamay
Urumqi
Bishkek
Almaty
Kashi
Hotan
Islamabad
Amritsar
New Delhi
Jaipur
Agra
Kathmandu
Lhasa
Thimbu
Dhaka
Mandalay
Rangoon
Vientiane
Hanoi
Haiphong
Hue
Qiqihar
Harbin
Jixi
Changchung
Jilin
Fuxin
Shenyang
Benxi
Dalian
Tianjin
Pyongyang
Seoul
Pusan
Jinan
Taian
Qingdao
Kaifeng
Nagasaki
Nanjing
Hefei
Shanghai
Mianyang
Chengdu
Wuhan
Hangzhou
Ningbo
Zigong
Chongqing
Yueyang
Changsha
Nanchang
Wenzhou
Fuzhou
Panzhihua
Guiyang
Xiamen
Taipei
T'ai-chung
T'ai-nan
Kao-Hsiung
Kunming
Shantou
Nanning
Guangzhou
Hong Kong
Haikou
Manila

Health-Damaging Air Pollutants From Typical Woodfired Cookstove.



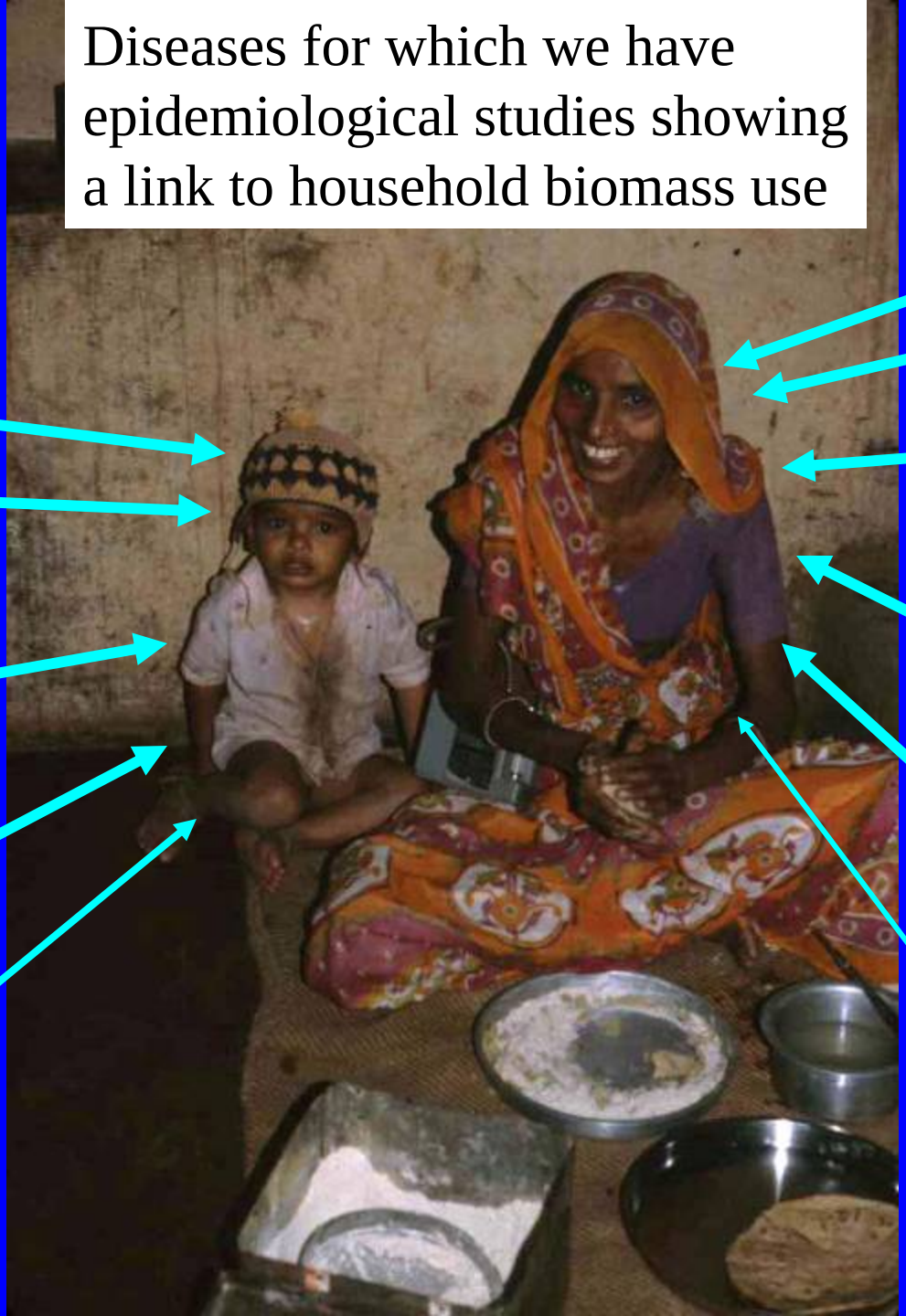
IARC Group 1 Carcinogens

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

- Small particles, CO, NO_2 + Methane
- Hydrocarbons
  - 25+ saturated hydrocarbons such as *n-hexane*
  - 40+ unsaturated hydrocarbons such as *1,3 butadiene*
  - 28+ mono-aromatics such as *benzene & styrene*
  - 20+ polycyclic aromatics such as *benzo(α)pyrene*
- 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

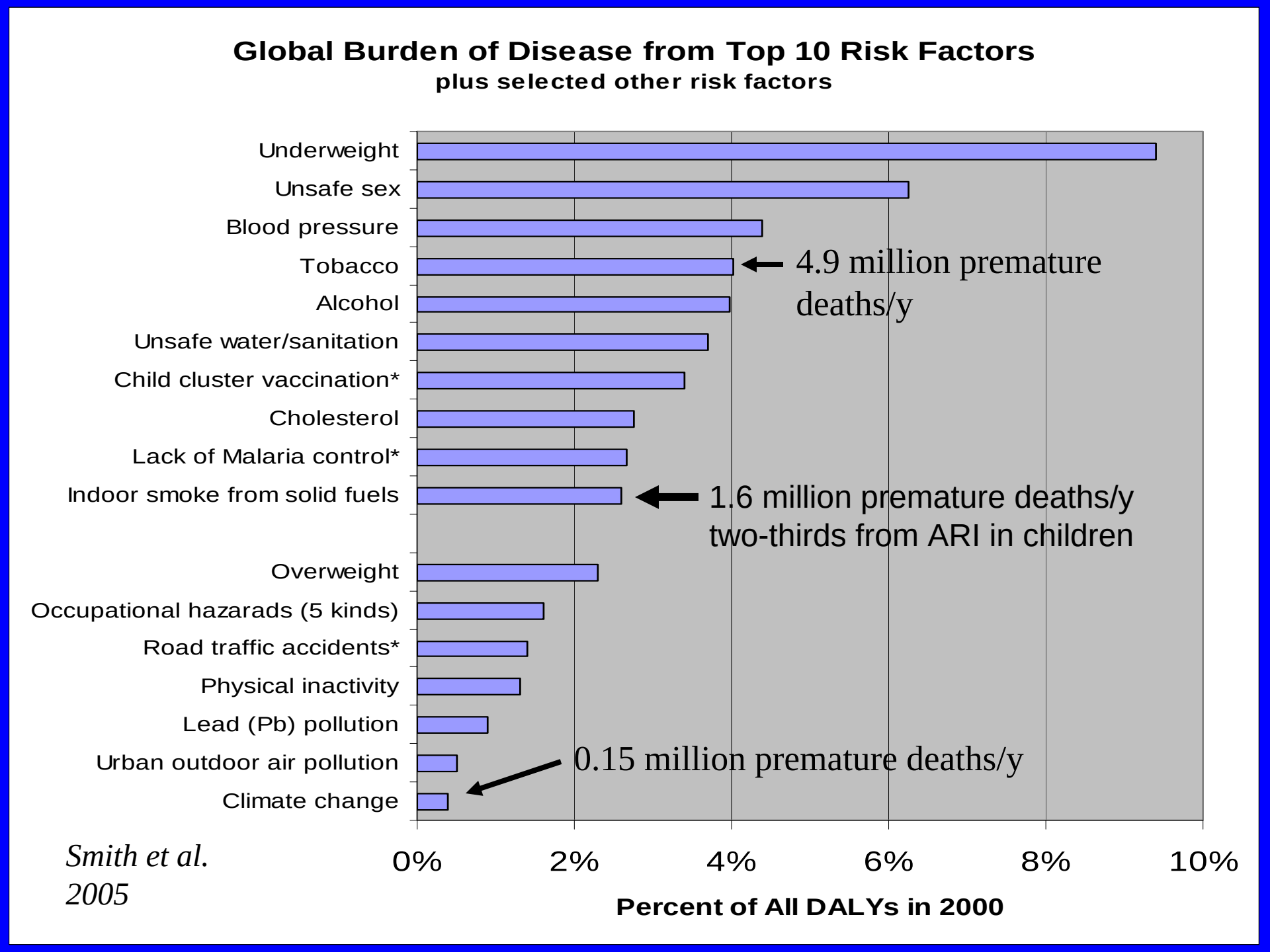
Interstitial lung disease

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

Blindness (cataracts, trachoma)

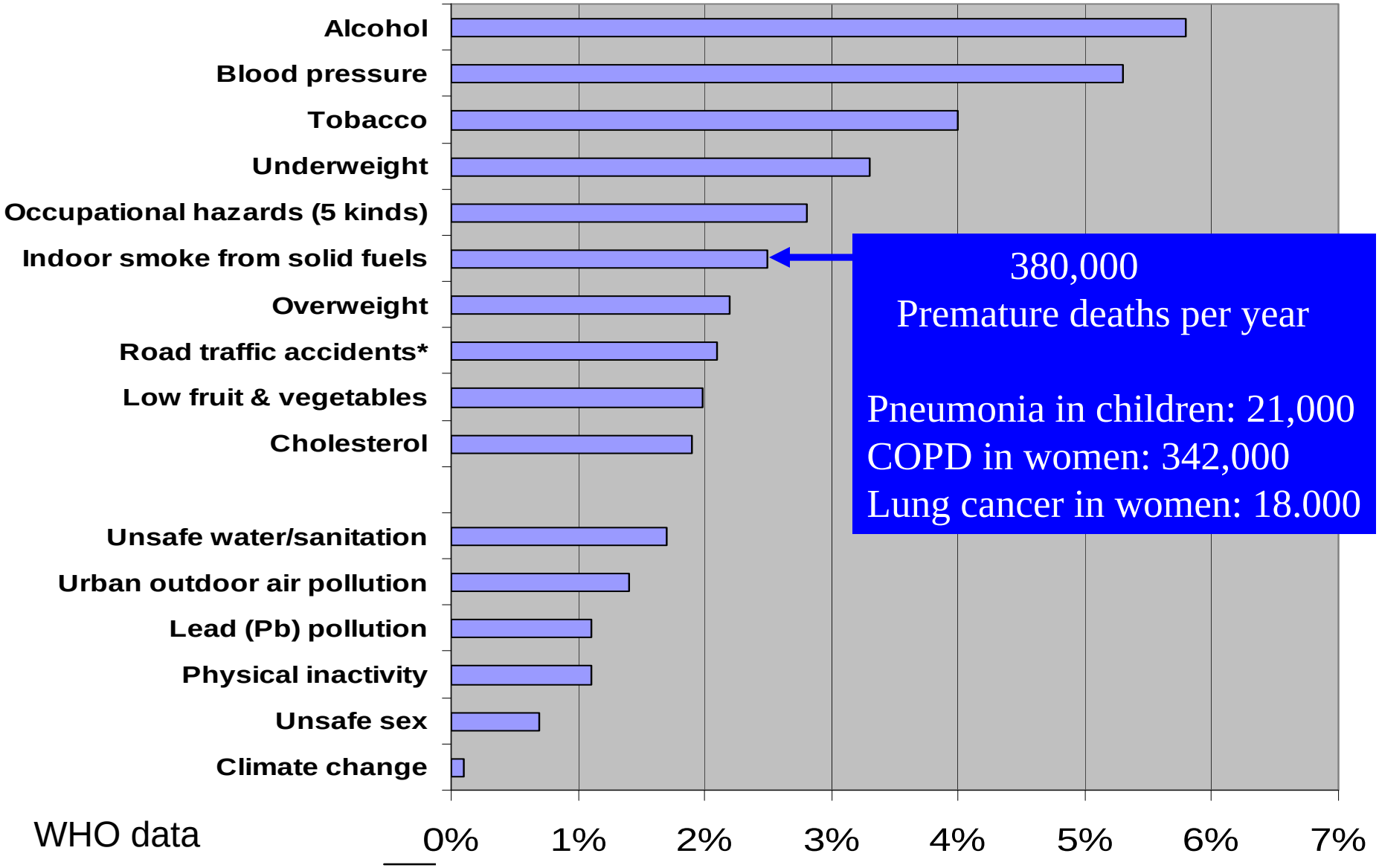
Tuberculosis

Heart disease?


Global Burden of Disease from Top 10 Risk Factors
plus selected other risk factors
Underweight
Unsafe sex
Blood pressure
Tobacco
Alcohol
Unsafe water/sanitation
Child cluster vaccination*
Cholesterol
Lack of Malaria control*
Indoor smoke from solid fuels
Overweight
Occupational hazarads (5 kinds)
Road traffic accidents*
Physical inactivity
Lead (Pb) pollution
Urban outdoor air pollution
Climate change
4.9 million premature deaths/y
1.6 million premature deaths/y
two-thirds from ARI in children
0.15 million premature deaths/y
0%
2%
4%
6%
8%
10%
Percent of All DALYs in 2000
Smith et al. 2005

Chinese Burden of Disease from Top 10 Risk Factors

Plus Selected Other Risk Factors



380,000
Premature deaths per year

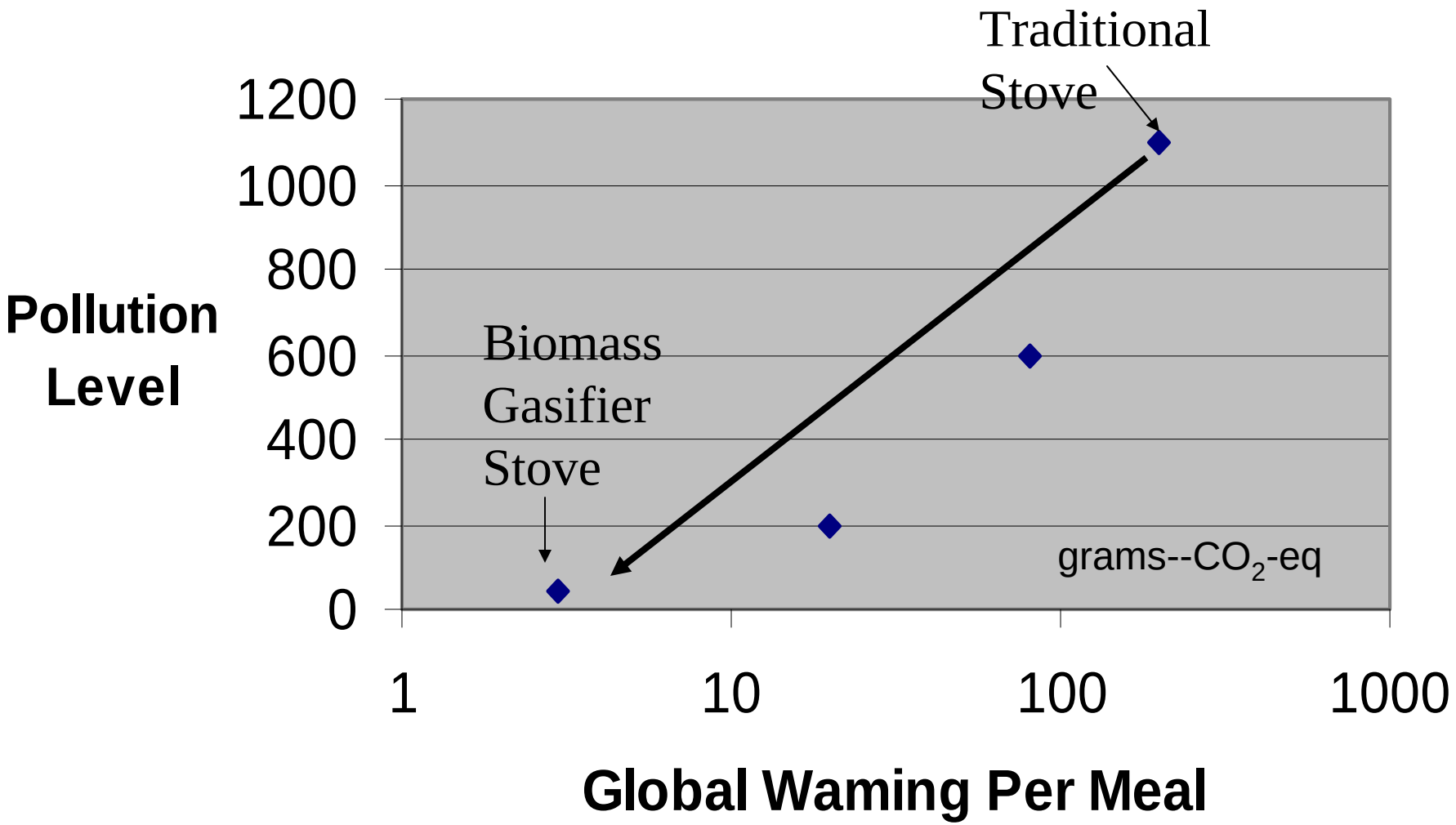
Pneumonia in children: 21,000
COPD in women: 342,000
Lung cancer in women: 18.000

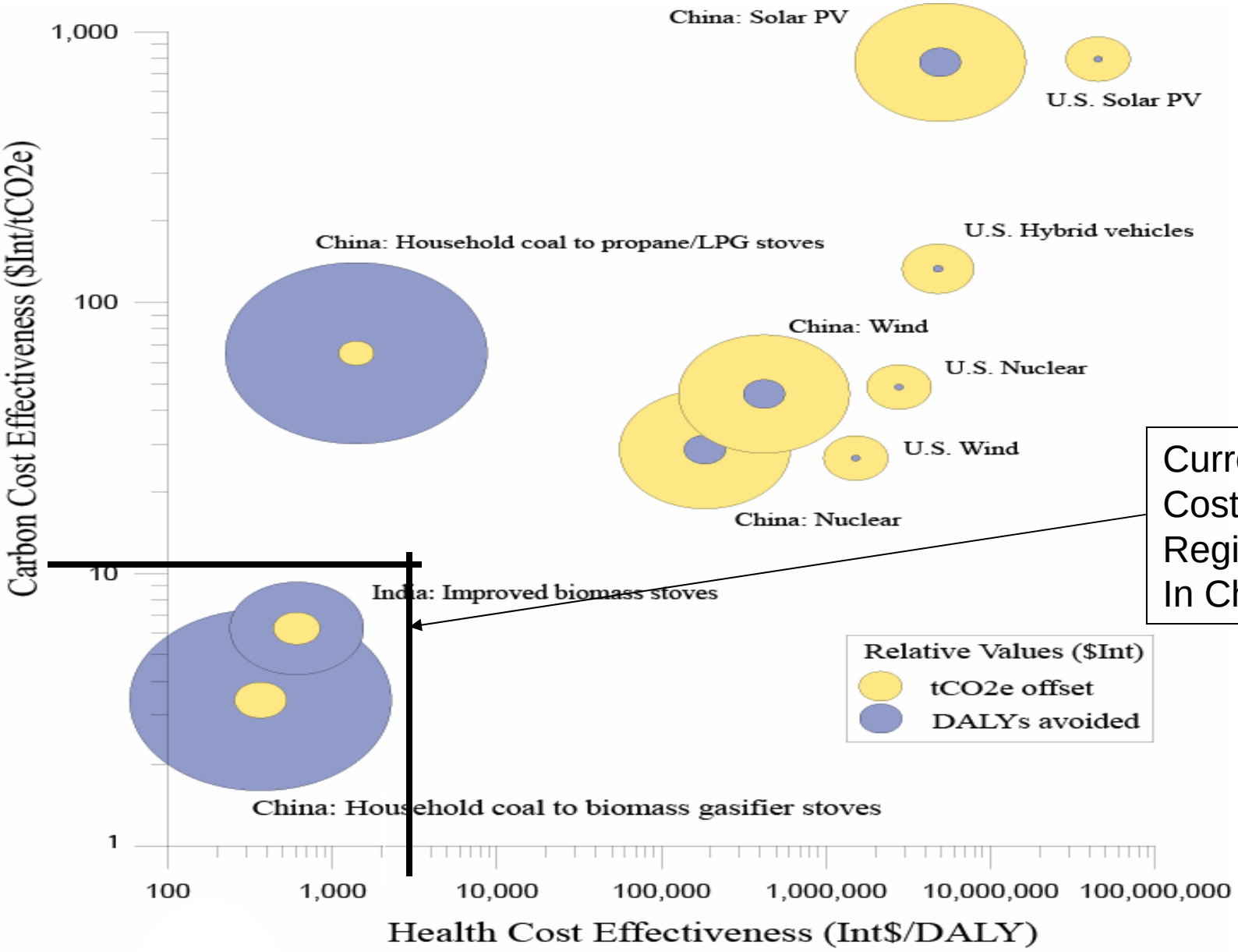
WHO data

A Biomass Gasifier Stove

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

Health and Greenhouse Gas Benefits of Biomass Stove Options





Current Cost-effective Region In China

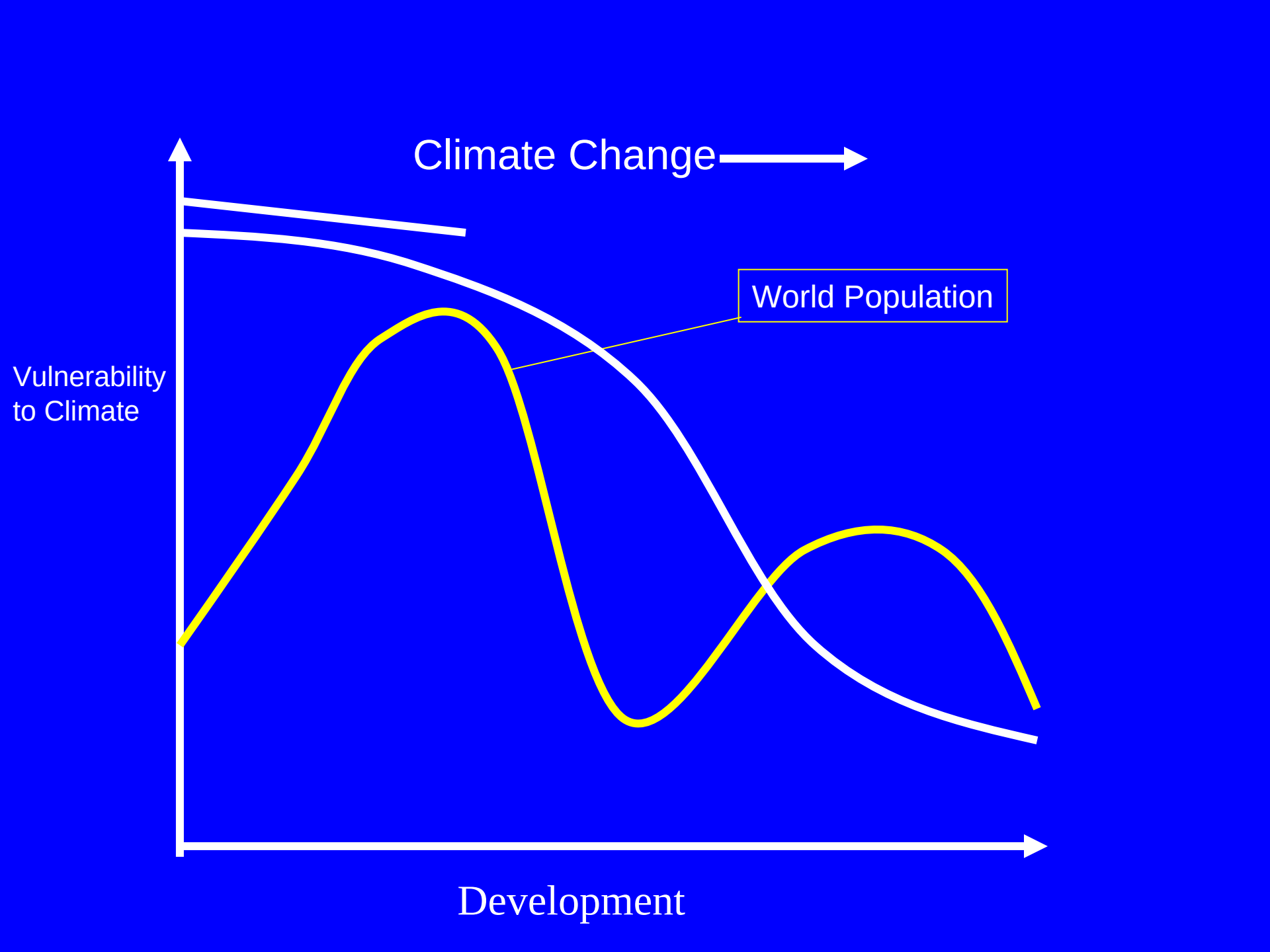
Smith & Haigler, 2008

Methane Co-Benefits

- Methane emissions are more important than current official weighting factors indicate because of its large effect over the next generation
- Methane is emitted as part of the poor combustion process of solid fuels, which also produce much health-damaging pollution
- Contributes directly to global tropospheric ozone levels
- Improving this combustion offers substantial GHG as well as health benefits in a cost-effective manner
- Ways to control are quite different from CO_2
- And may be easier in the short term

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


Climate Change
World Population
Vulnerability
to Climate
Development

Climate and Human Welfare, cont.

- 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 already experienced by the poorest among us
- There are co-benefits opportunities to do so.

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

Thank you

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