THE AUSTRALIAN NATIONAL UNIVERSITY

Global Environmental Changes and Human Health:

Extending the Research Agenda for Epidemiologists

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Outline

Epidemiology, 1850-2050: Evolution of causal thinking/models: changes in focal length

Global Environmental Change: Overload Syndrome

Climate Change

- **Basic science**
- **Health Impacts:**
  - Epidemiological research tasks
  - Examples

Mitigation and Adaptation

Conclusion

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Rudolf Virchow, 1848

His rejoinder to criticism of his official report on the causes of the typhus epidemic in Upper Silesia, winter 1847-1848:

"Medicine is a social science, and politics is nothing but medicine on a grand scale"

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Geoffrey Rose 1985 – and the "Epidemiology Wars" of the 1990s

Rose G. *Sick individuals and sick populations.*
Int J Epidemiol, 1985

"Case-centred epidemiology identifies individual susceptibility, but it may fail to identify the underlying causes of incidence."

……..

Ensuing debate: Scope, horizons, methodological capacity, and social role of epidemiology?

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Best of Times, Worst of Times?

"Application of the physical and biological sciences has made today arguably the best of times: we live longer and healthier lives, food production has doubled in the past 35 years, and energy subsidies have substituted for human labour, washing away hierarchies of servitude.

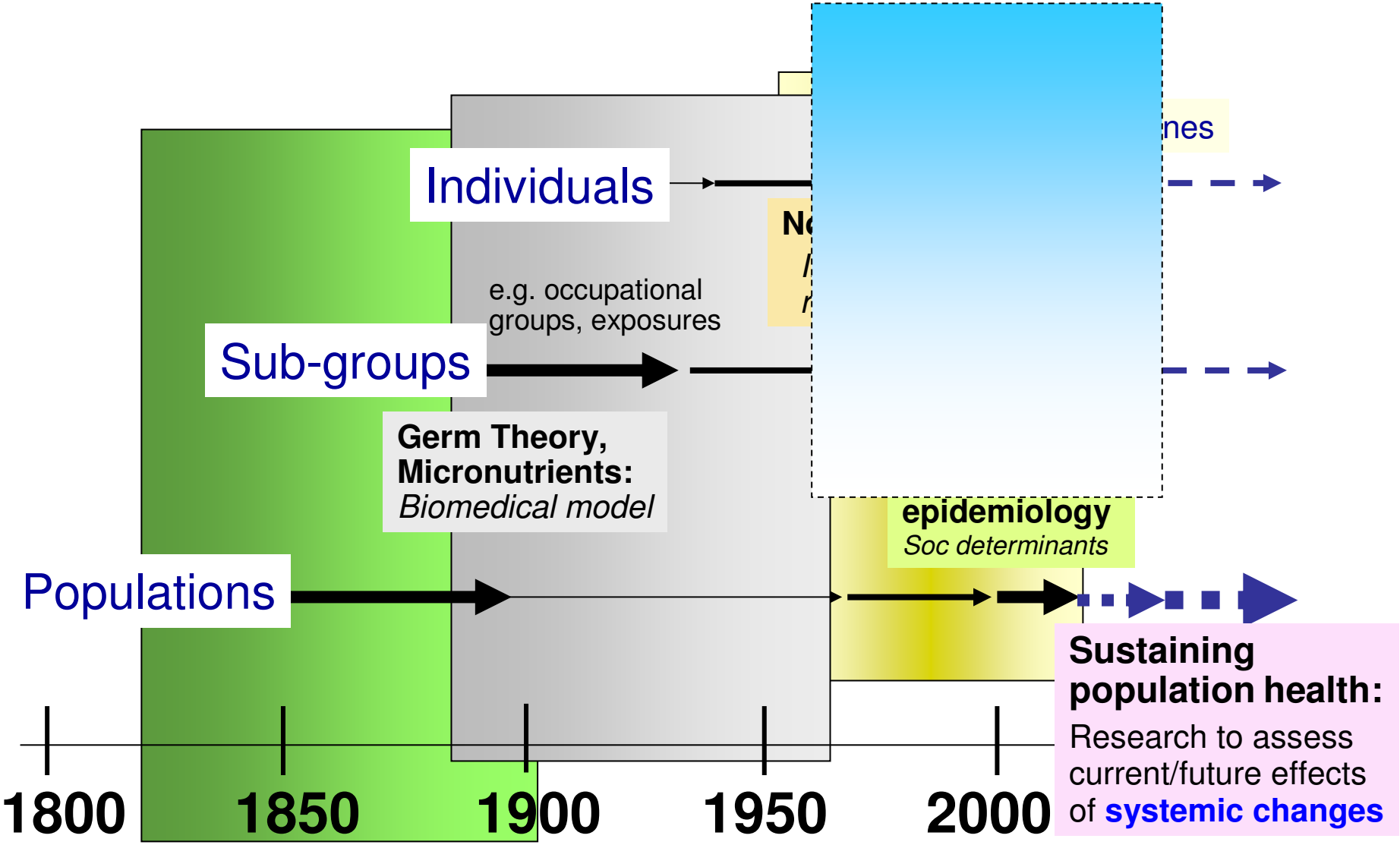
"But the unintended consequences of these well-intentioned actions – climate change, biodiversity loss, inadequate water supplies, and much else – could well make tomorrow the worst of times."

Robert May, Nov 2006, *New Scientist*

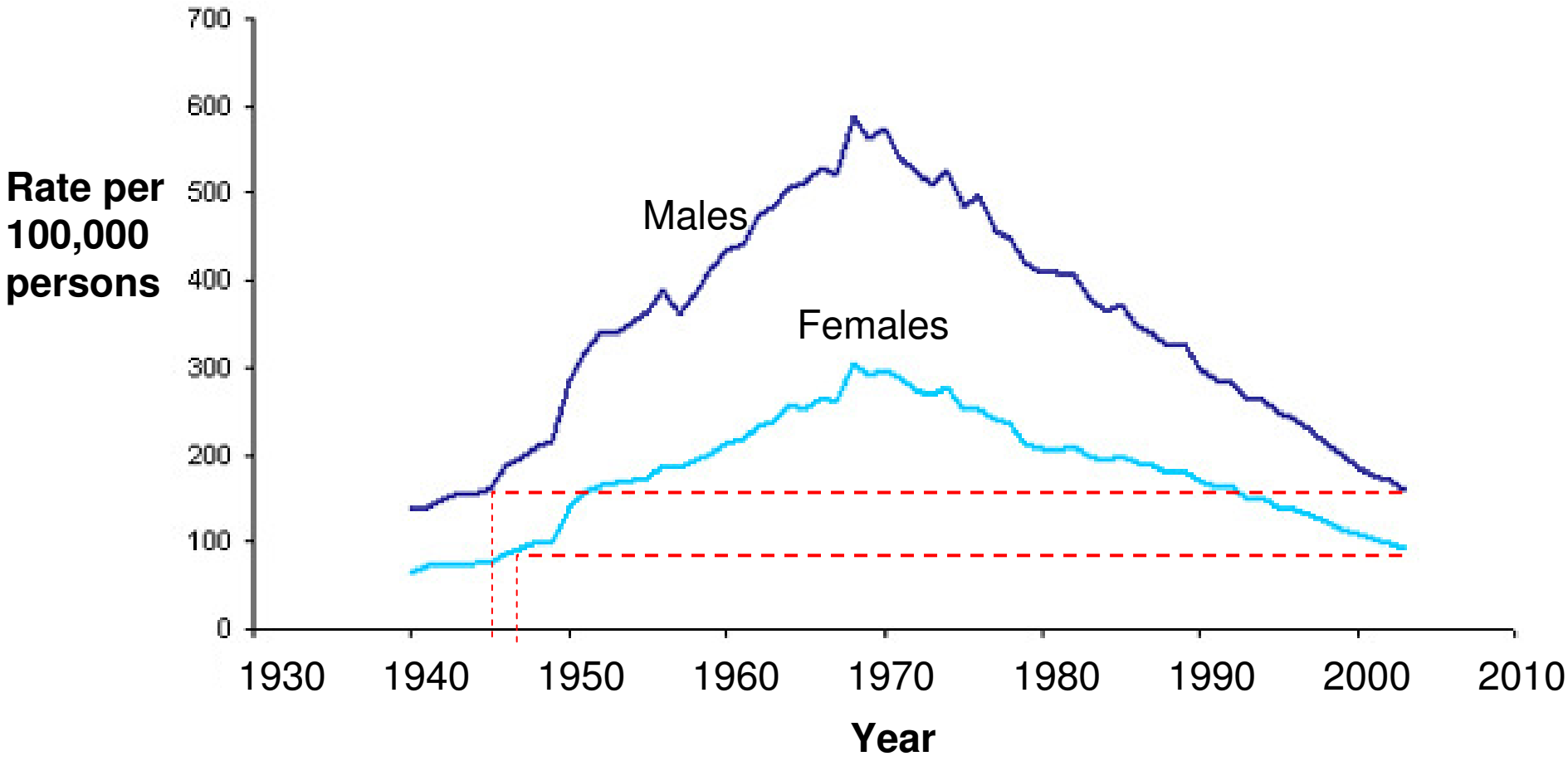
(ex-President, Royal Society; and ex-Chief Scientific Adviser, UK Government)

Epidemiology: c.1850-to-present

Changes in levels/units of analysis

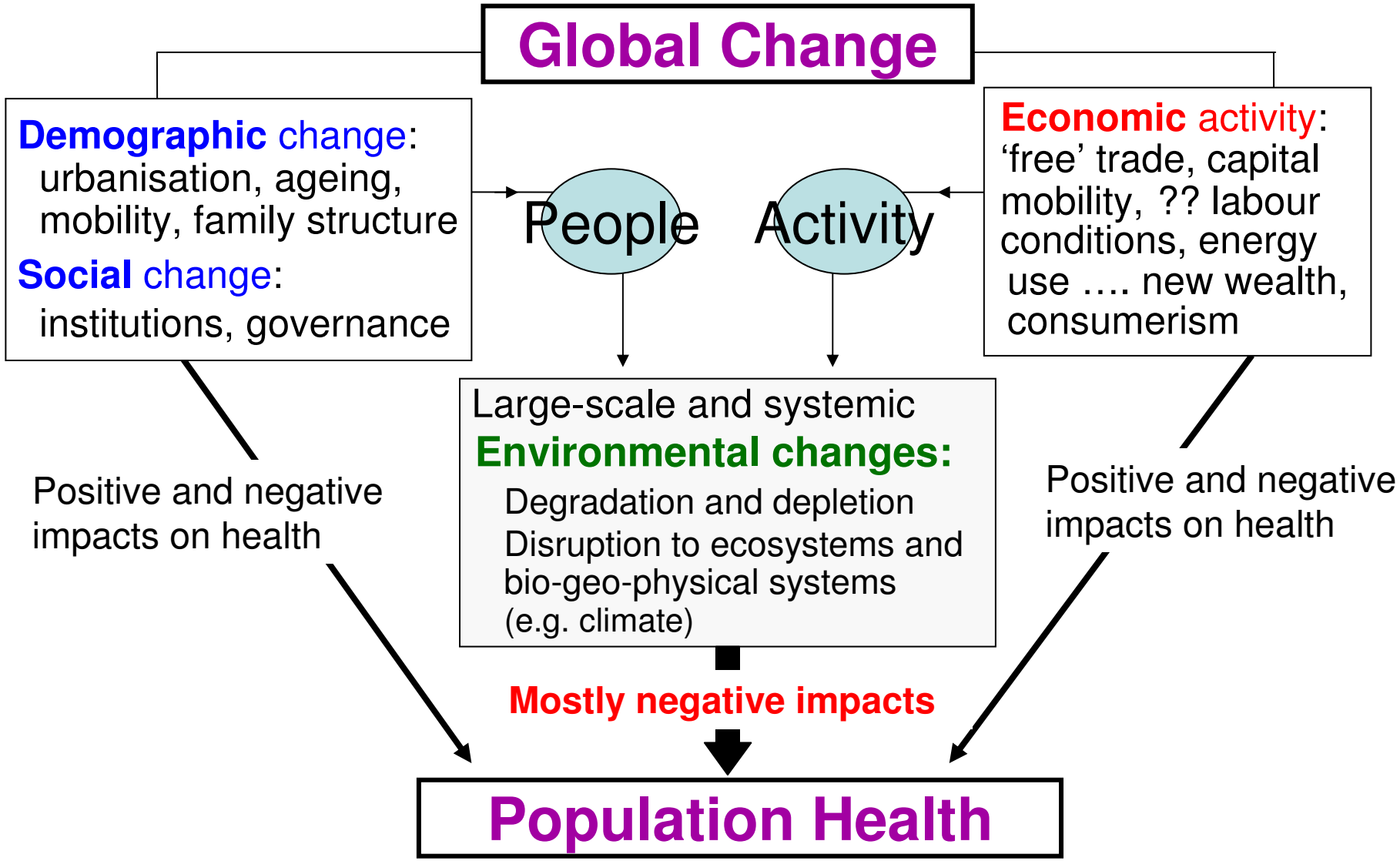


Australia: Rise and fall of coronary heart disease mortality: now as low as immediately after WWII



Source: http://www.aihw.gov.au/cdarf/data_pages/mortality/index.cfm

Global Change and Human Health



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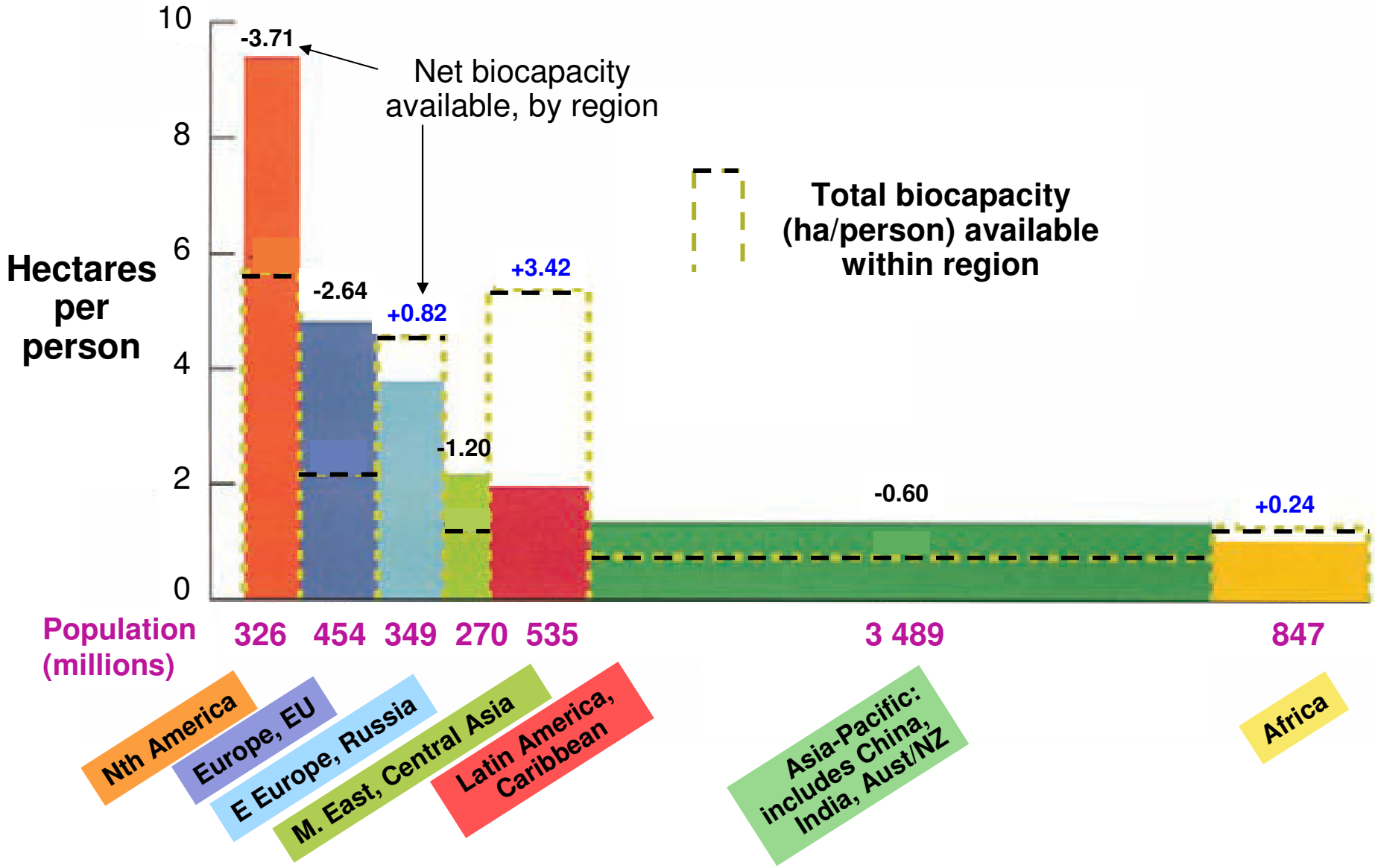
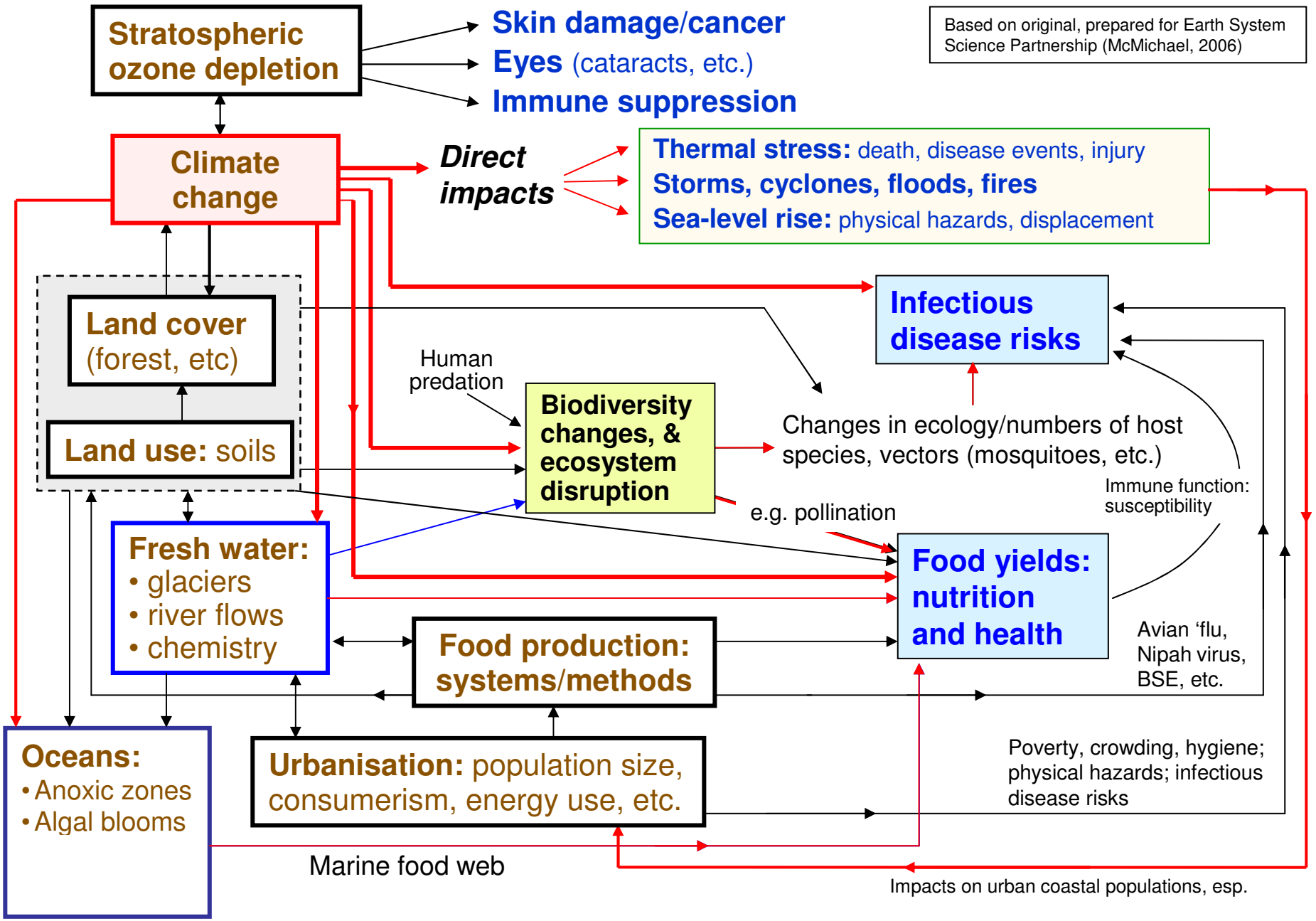
Indices of Global Growth: Last 200 Years

	1800	Now	Increase Factor (approx)
Population (billions)	**0.9**	**6.7**	**X 7**
World Economy: Gross Global Product (trillions $US, 1990 Purchasing Power Parity)	**0.5**	**40**	**X 80**
Primary Energy Use (EJoules/yr)	**12**	**480**	**X 40**
CO_2 emissions (Gtonnes carbon/yr) **– from energy generation**	**0.3**	**8**	**X 25**

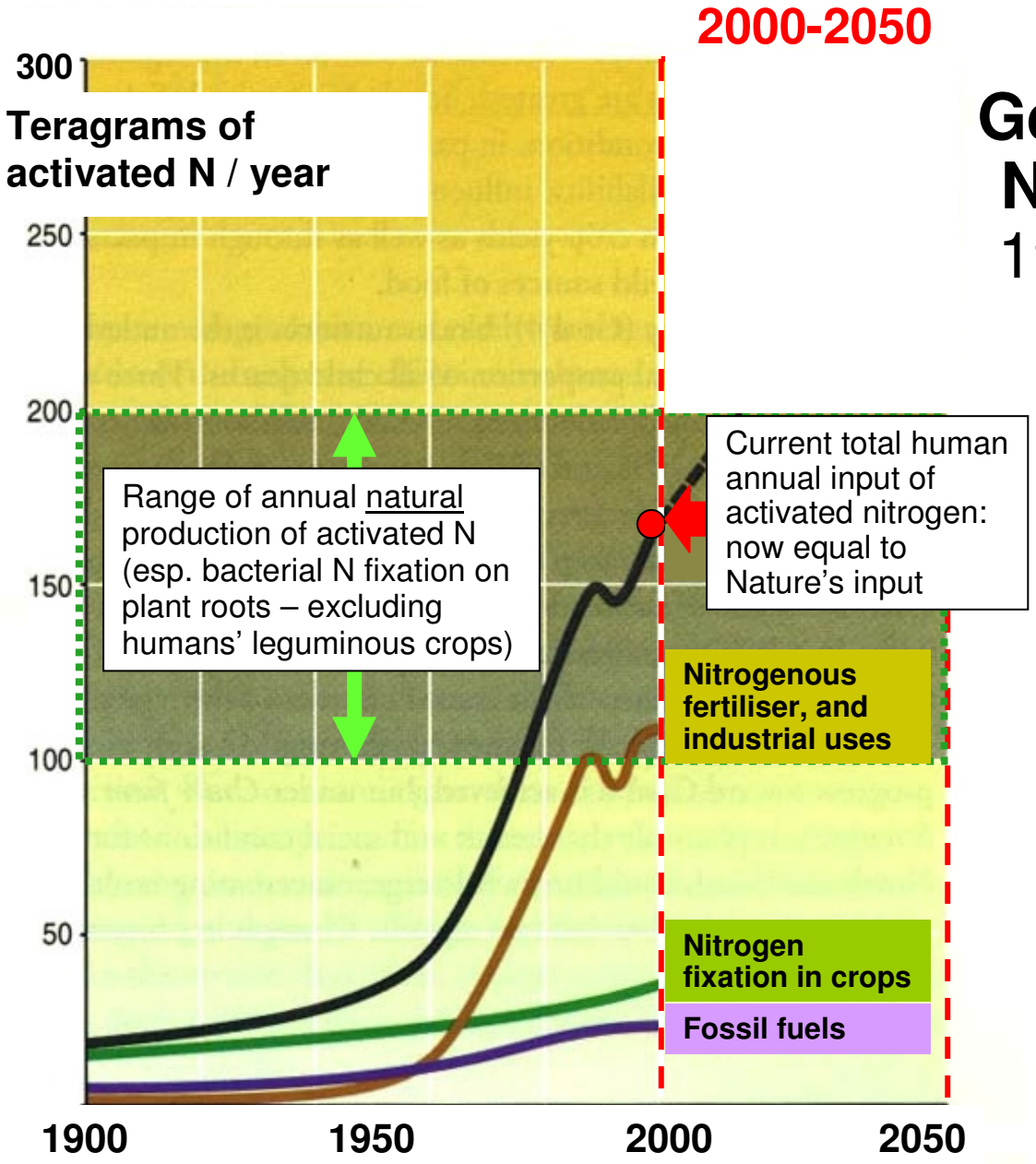
Ecological Footprint versus Biocapacity, by Region, in 2003 *[WWF Living Planet Report, 2006]*



Global Environmental Changes: health risks



Rising Human Generation of Activated Nitrogen Compounds: 1900-2000, and to 2050



Source: Millennium Ecosystem Assessment, 2005

Risks to Human Health

Reduced crop yield: nutrition
(nitrification/acidity of soils, water)

Eutrophication of waterways:
Algal blooms:
- anoxia → decreased fish yield
- cholera risk (vibrio proliferation in algae)

Also:

Air pollutants: NO_x → O_3, particulates

Met-haemoglobinaemia (babies)

Nitrates and stomach cancer (??)

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Transformation of the Nitrogen Cycle: Recent Trends, Questions, and Potential Solutions

James N. Galloway,[1*] Alan R. Townsend,[2] Jan Willem Erisman,[3] Mateete Bekunda,[4] Zucong Cai,[5] John R. Freney,[6] Luiz A. Martinelli,[7] Sybil P. Seitzinger,[8] Mark A. Sutton[9]

Humans continue to transform the global nitrogen cycle at a record pace, reflecting an increased combustion of fossil fuels, growing demand for nitrogen in agriculture and industry, and pervasive inefficiencies in its use. Much anthropogenic nitrogen is lost to air, water, and land to cause a cascade of environmental and human health problems. Simultaneously, food production in some parts of the world is nitrogen-deficient, highlighting inequities in the distribution of nitrogen-containing fertilizers. Optimizing the need for a key human resource while minimizing its negative consequences requires an integrated interdisciplinary approach and the development of strategies to decrease nitrogen-containing waste.

Downloaded from www.sciencemag.org on May 16, 2008

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Climate Change (CC) and Health

Triple Purpose of Research

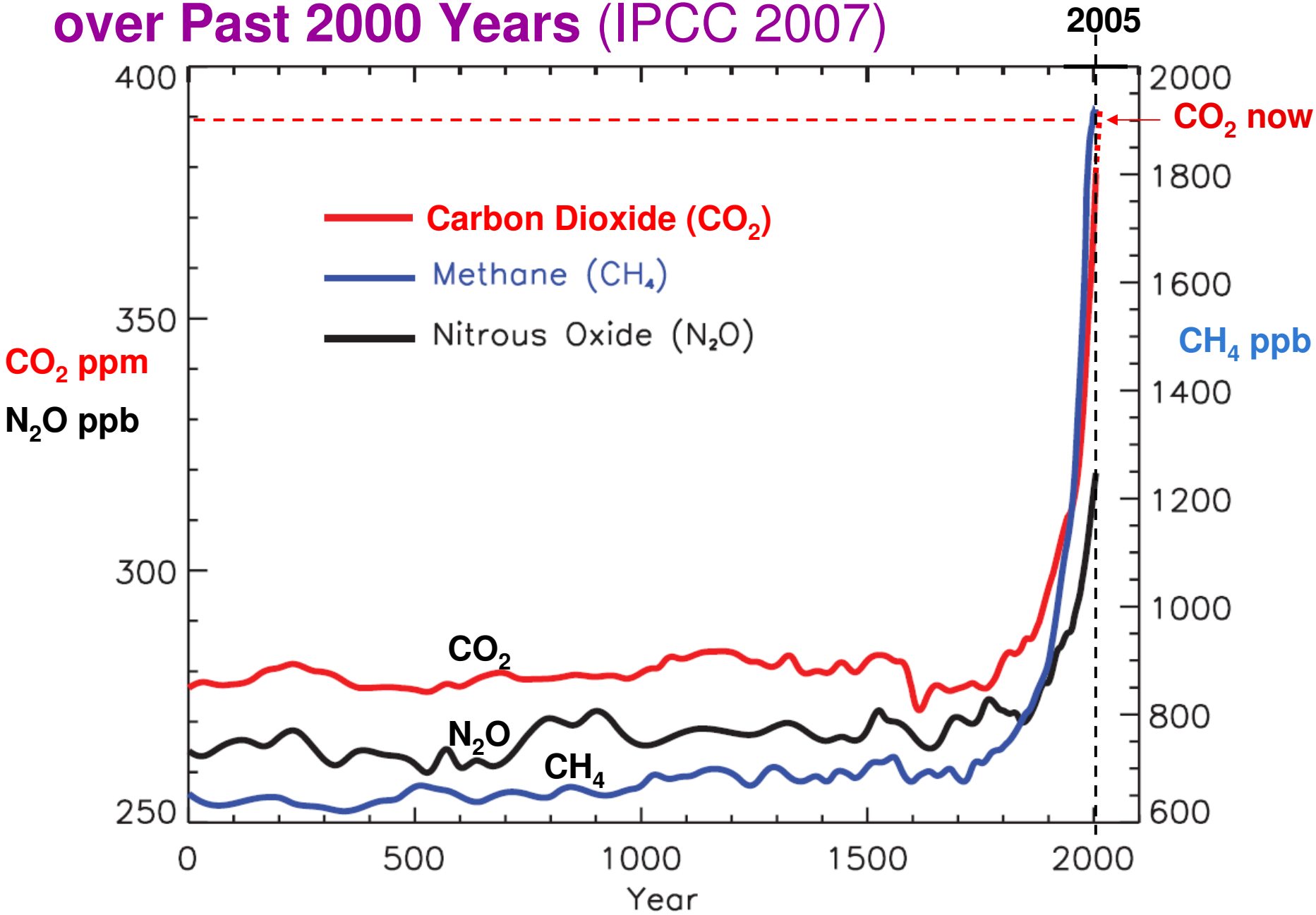
1. Recognition of health risks (present and future) will help motivate *primary* prevention: i.e., reduce GHG emissions.

2. That mitigation action, in turn, can also provide collateral health benefits (and may, thus, help to transform 'Health Promotion' within a larger, ecological, frame).

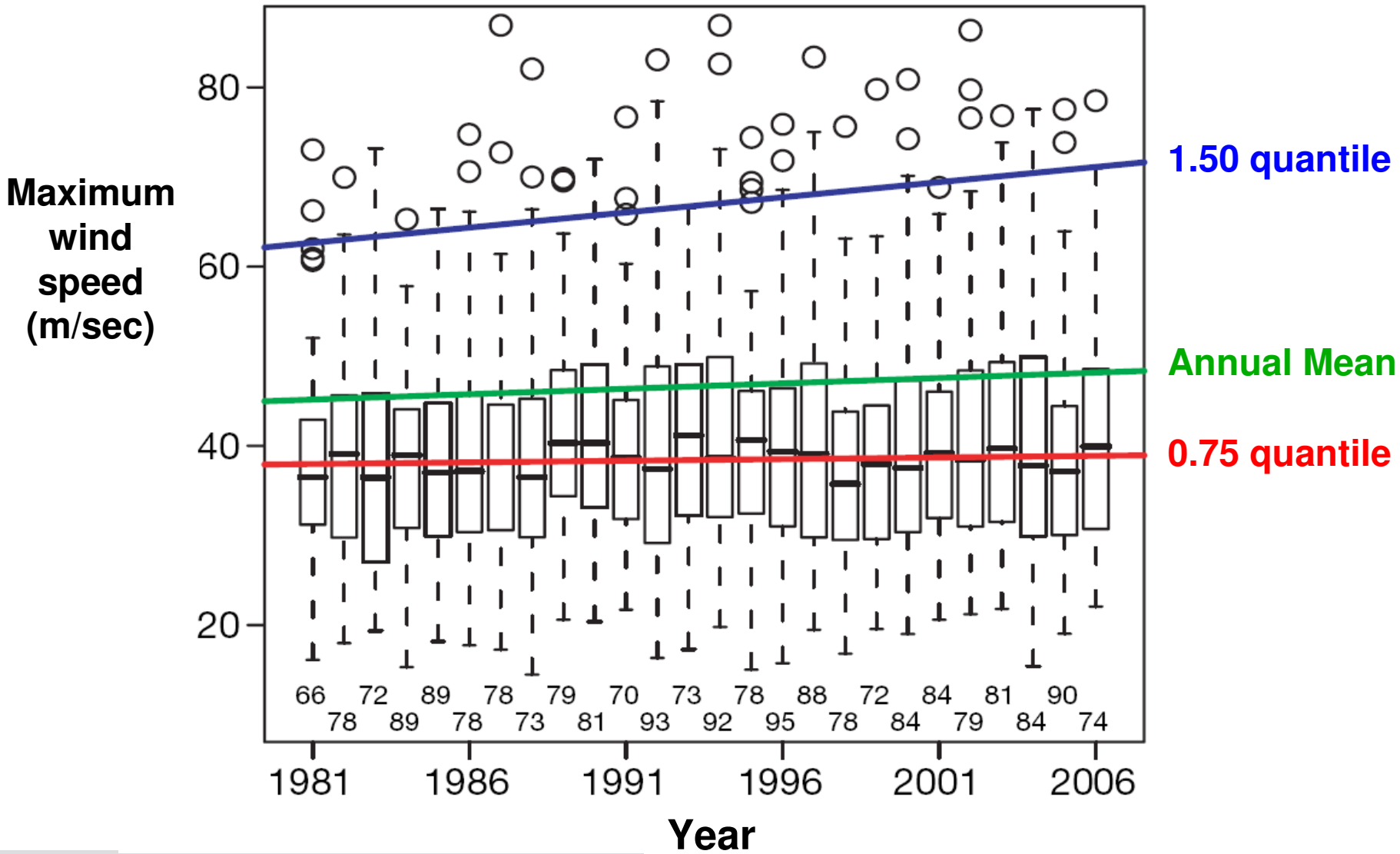
3. Health risks from CC already exist; more are unavoidable. So we must study them, to develop and evaluate adaptive (*secondary* prevention) strategies.

Note: equivalent reasoning applies to studying health risks from other systemic environmental and social changes

Concentrations of Main Greenhouse Gases over Past 2000 Years (IPCC 2007)



Atlantic tropical cyclones: time trend in intensity, 1981-2006 [Elsner et al., 2008]



Vol 455|4 September 2008|doi:10.1038/nature07234

Climate Change: the basic science is now generally agreed

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Climate Change: Health Impacts

Familiar and Unfamiliar "Exposure" Pathways

1. Exposure to direct-acting environmental hazards

- Temperature extremes (heat-waves, etc.)
- Levels of air pollutants and aeroallergens (pollens, spores)
- Extreme weather events/disasters

2. Risks due to systemic loss of 'environmental capital'

- Reduced capacity (soils/oceans) to produce food
- Reduced supplies of fresh water
- Altered natural constraints on infectious agents
- Weakened infrastructure foundations

  (e.g. **Arctic permafrost:** roads, housing, commerce, hunting)

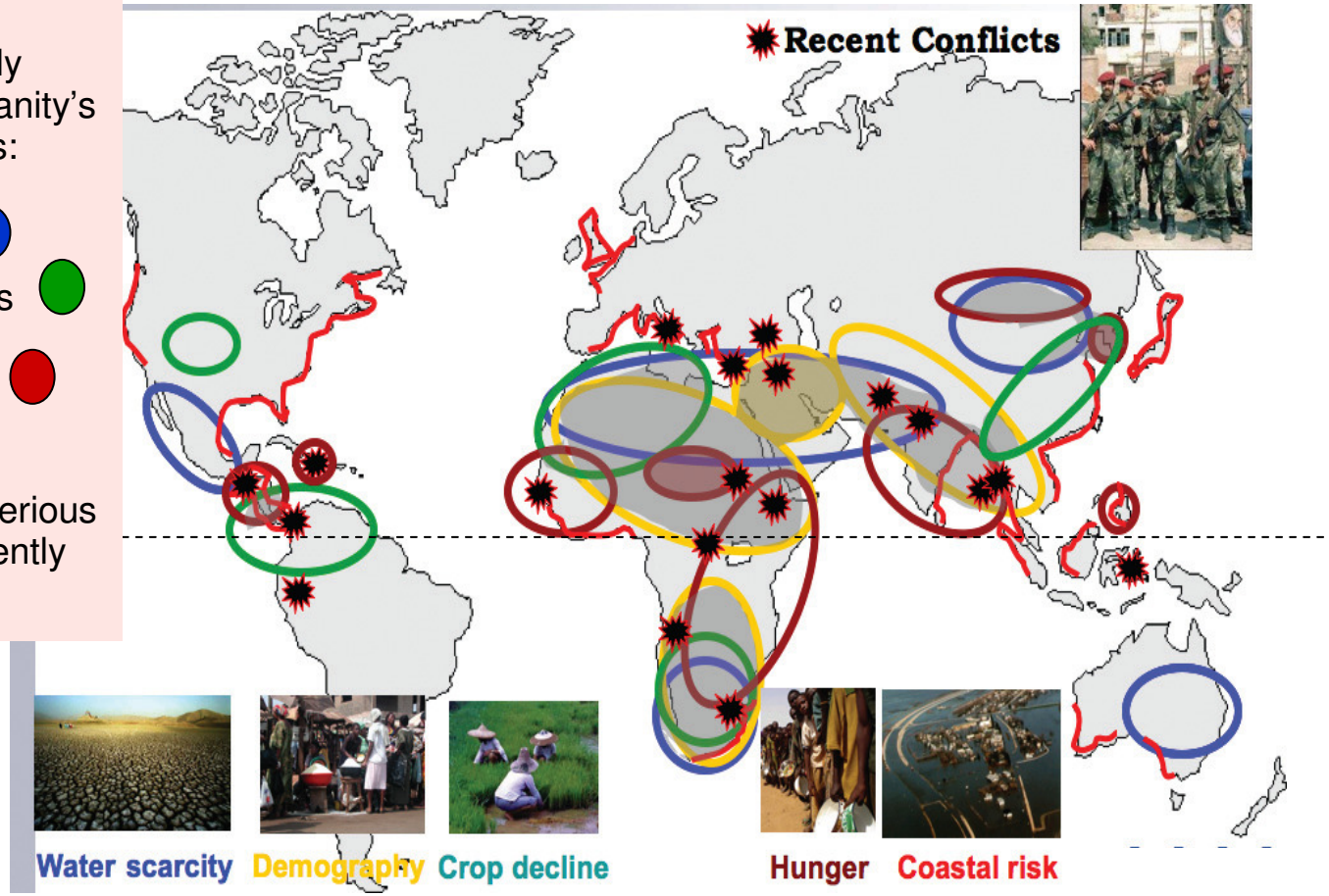
Climate Change: A Multiplier for Instability

From UK Ministry of Defence
[cited in: May RM, *2007 Lowy Institute Lecture*]

Assessment of regions particularly afflicted by problems due to humanity's increasing environmental impacts:

- **population** pressure
- insufficient **water** supplies
- **climate change** affecting crops
- **sea level** rise
- … or, more generally, **hunger**

"Stars" indicate regions where serious armed conflicts exist or have recently occurred.



Climate Change & Health: **6 'Core' Research Tasks**

Data-based studies

1. Learn from recent past & present: baseline climate-health relations

2. Detect impacts

3. Estimate current CC-related burden

Scenario-based projections

4. Prediction of future health risks (modelling)

Past | Present | Future

Health Protection

5. Assess adaptive strategies

Environmental Protection: Mitigation of CC

6. Assess health impacts of mitigation ('co-benefits')

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IPCC 4th Assessment Report (2007): **Main Health Impacts of Climate Change**

Emerging evidence [from some locations] **of health impacts:**

Altered distribution of some infectious disease vectors

Altered seasonal distribution of some pollen species

Increased incidence of heat-wave deaths

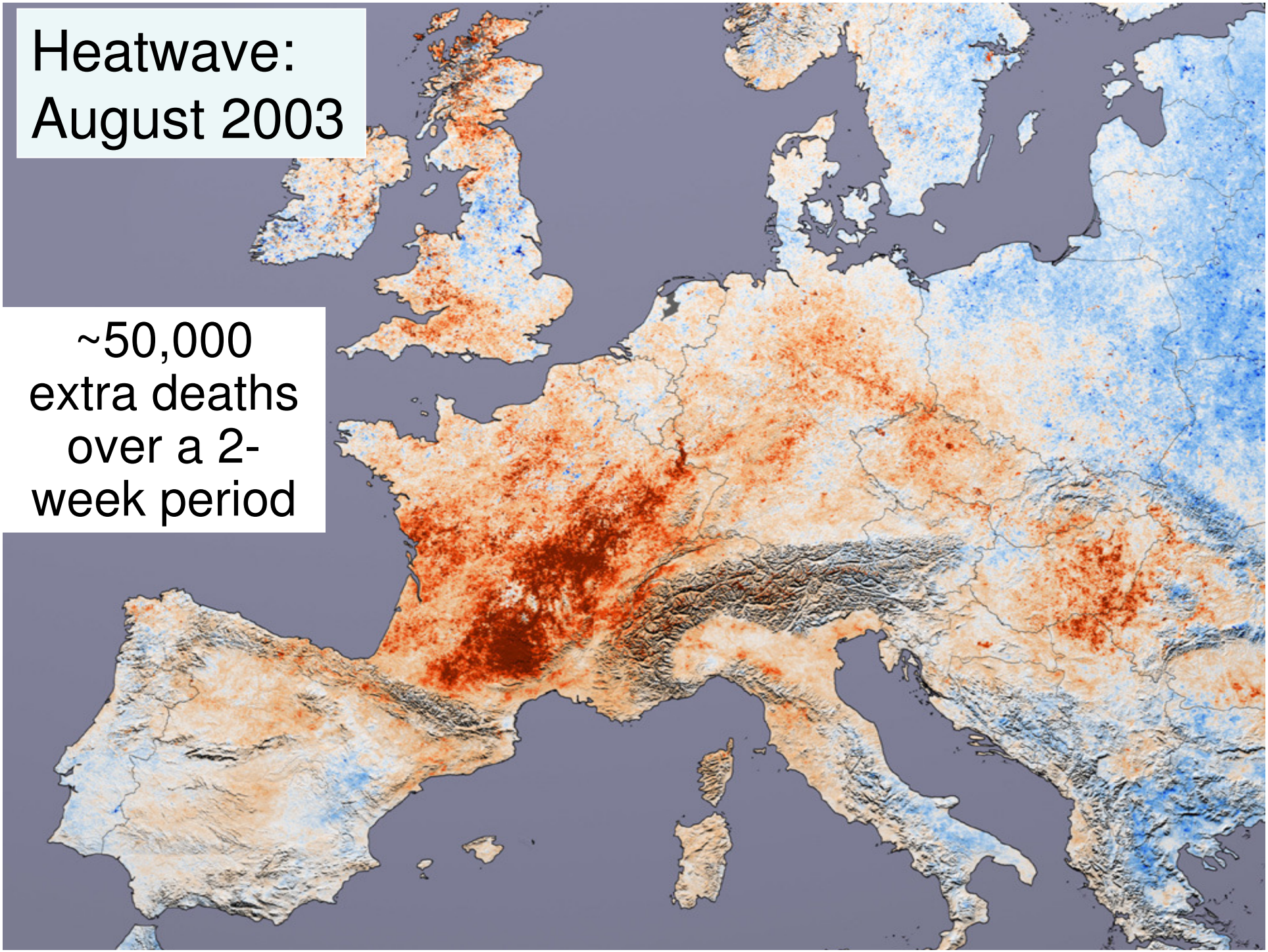
Projected trends/risks:

Increases in:

- under-nutrition and related disorders
- injury, disease and deaths due to extremes: heat-waves, floods, droughts, windstorms, and fires
- cardiovascular disease due to increased ground-level ozone (which forms more rapidly in warmer and sunnier conditions)
- number of people at risk of dengue fever
- burden of diarrheal diseases

Mixed effects on malaria (some increases, some decreases)

Note: Some health benefits will also occur


Heatwave:
August 2003
~50,000
extra deaths
over a 2-
week period

What Portion of Health Impacts of Extreme Weather Events is Attributable to Climate Change?

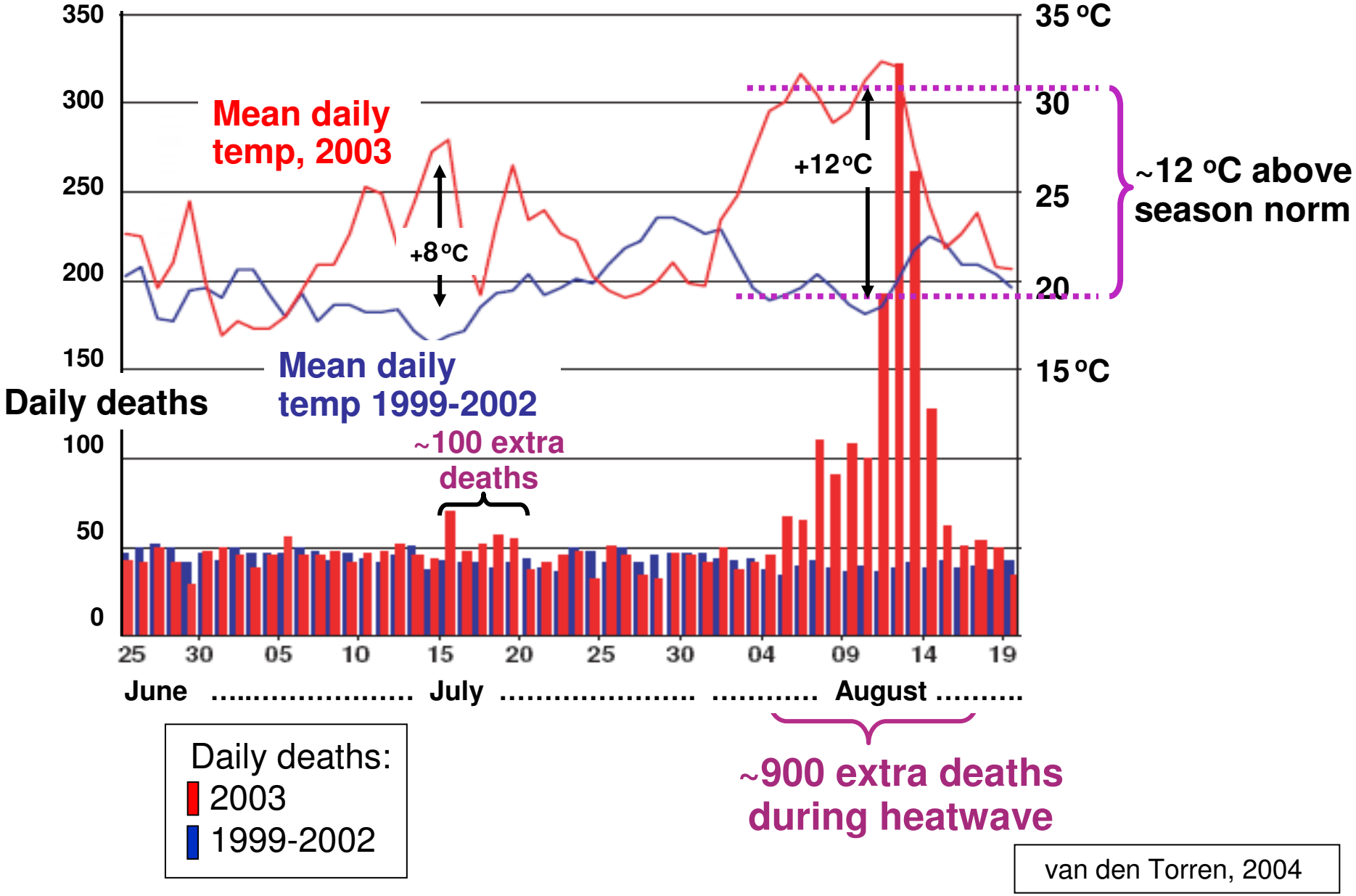
".. urgent need to develop improved methods and tools of climate [health] impact assessment (such as the use of probabilities and Bayesian analysis)."

Kovats et al. **Climate change and human health: Estimating avoidable deaths and disease**. *Risk Analysis*, 2005; *25*: 1409–18.

"In a Bayesian setting, different expert assessments on temperature trends and volatility can be formalized as probability distributions, with initial weights (priors) attached to them. By Bayesian learning, these weights can be adjusted in the light of data. The fraction of heat-wave risk attributable to anthropogenic climate change can then be computed from the posterior distribution …. very different priors consistently lead to the result that anthropogenic climate change has contributed >90% to the probability of the [2003] summer heatwave."

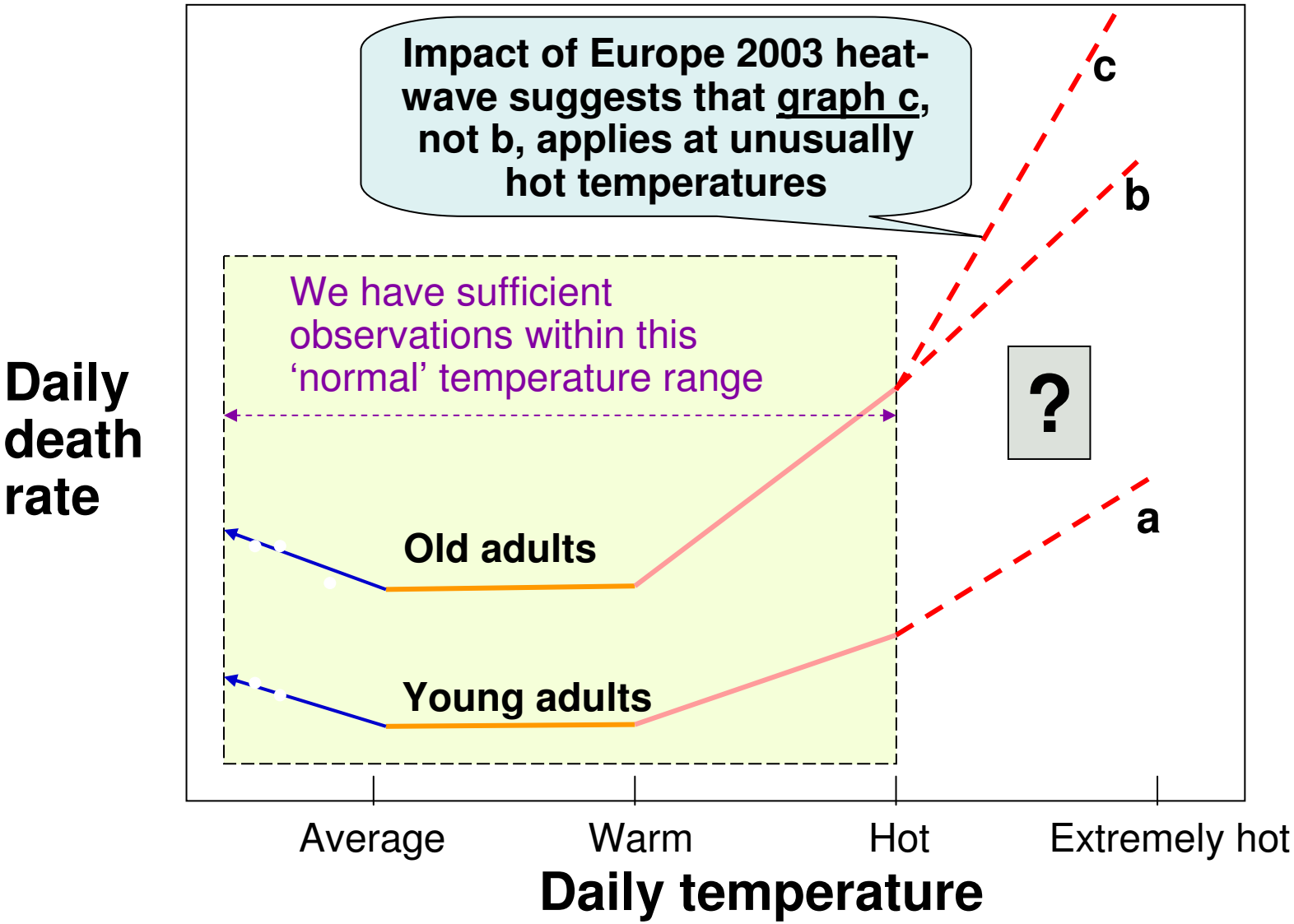
Jaeger et al. **A Method for Computing the Fraction of Attributable Risk Related to Climate Damages.** *Risk Anal* 2008 doi: 10.1111/j.1539-6924.2008.01070.x

Paris, Heatwave (Aug 2003): Daily Mean Temps and Deaths



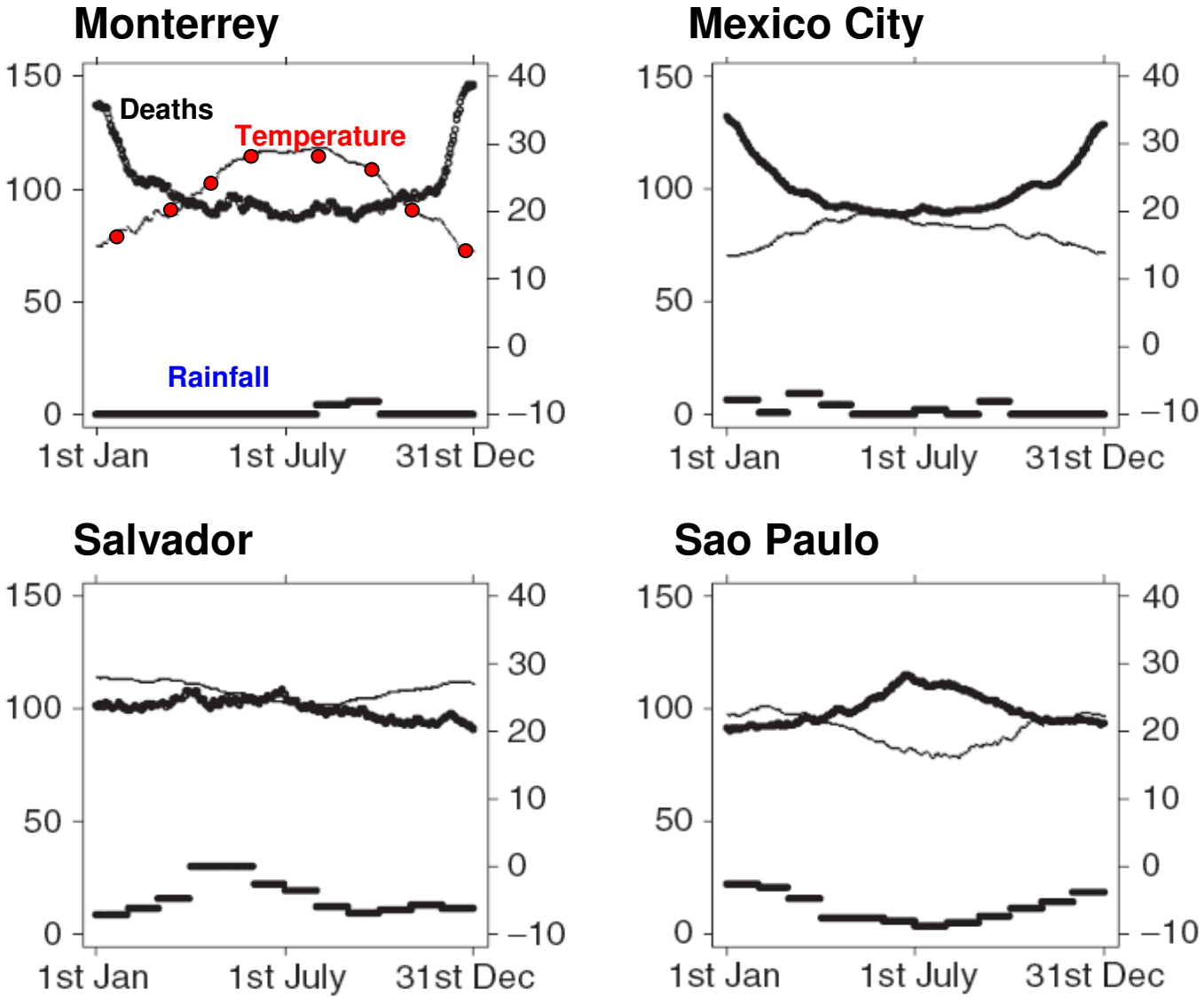
van den Torren, 2004

Daily temperature and deaths: What happens at even higher temperatures?



Average Annual Relationship between Daily Deaths, Temperature and Monthly Rainfall

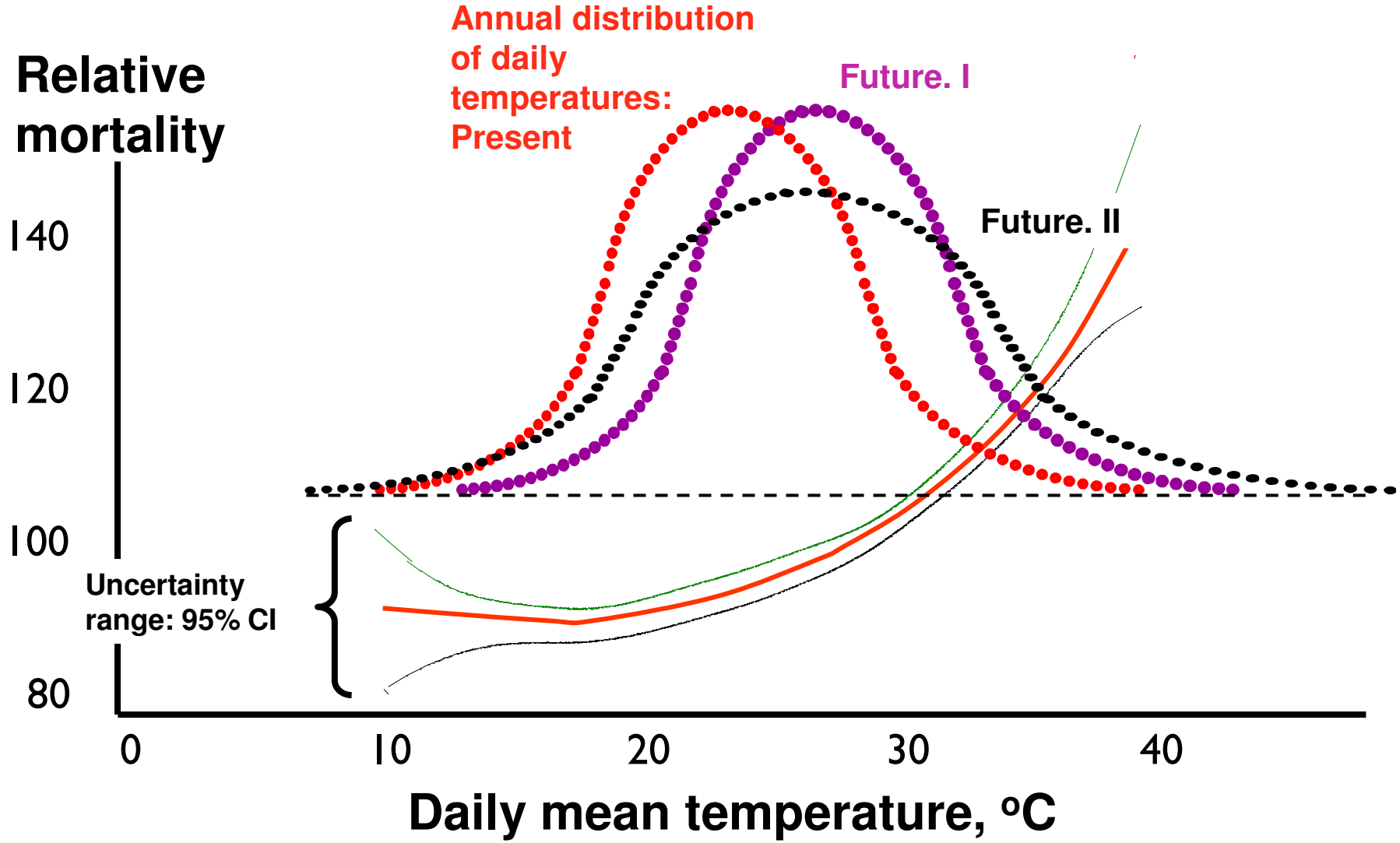
Mortality (% of annual average)



McMichael et al. ISOTHURM Study, *Int J Epidemiol*, 2008

Temperature-related daily mortality, Delhi, 1991-94

Model fitted with generalised additive model, cubic-spline smoothing



ANU Reported warming-*associated* shifts in infectious disease patterns: a signal?

- Malaria [mosquitoes] ascent in E African highlands
- Tick-borne encephalitis in Sweden: → northwards
- Schistosomiasis [water-snails] in China → northwards ?
- *Vibrio parahaemolyticus* in Alaskan oysters: warmer coastal waters
- Cholera in Bangladesh: recent strengthening of correlation with El Nino events

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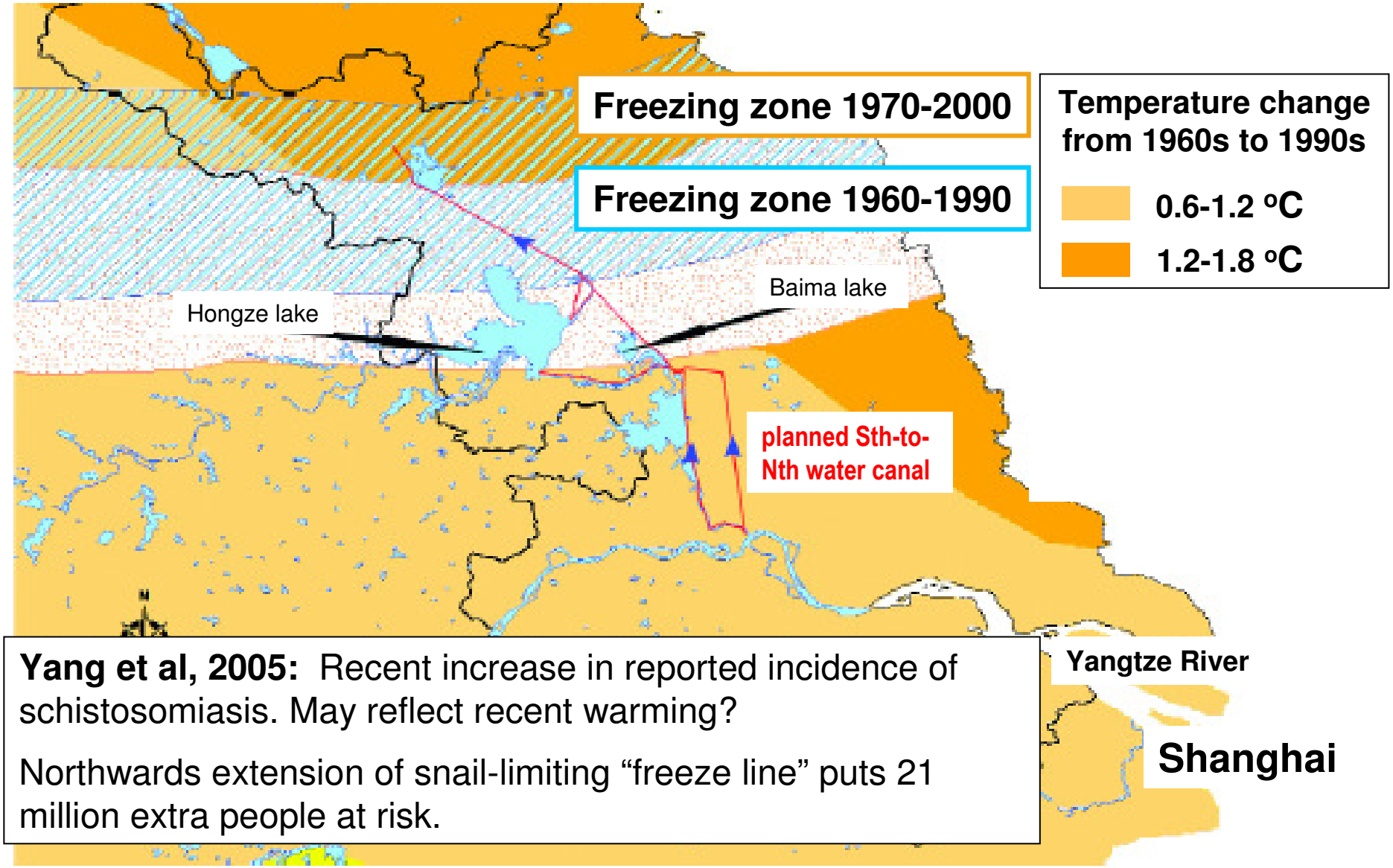
- Blue tongue virus and its midge vector in Europe 1998-2004: moving north

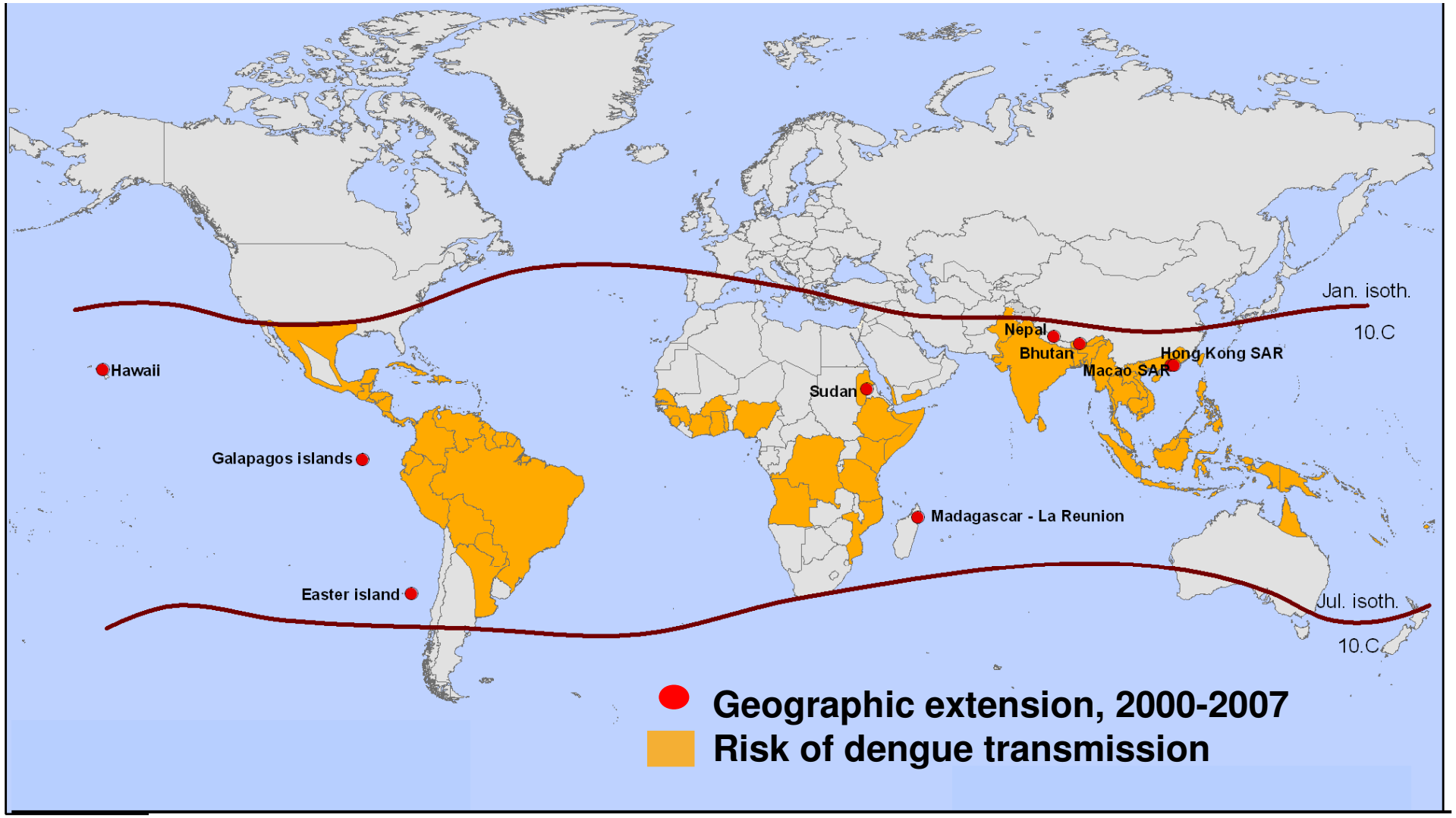
Schistosomiasis, China: Northwards extension of potential transmission associated with rise in average January temperature since 1960. Snail survival is limited by winter 'freezing zone'.



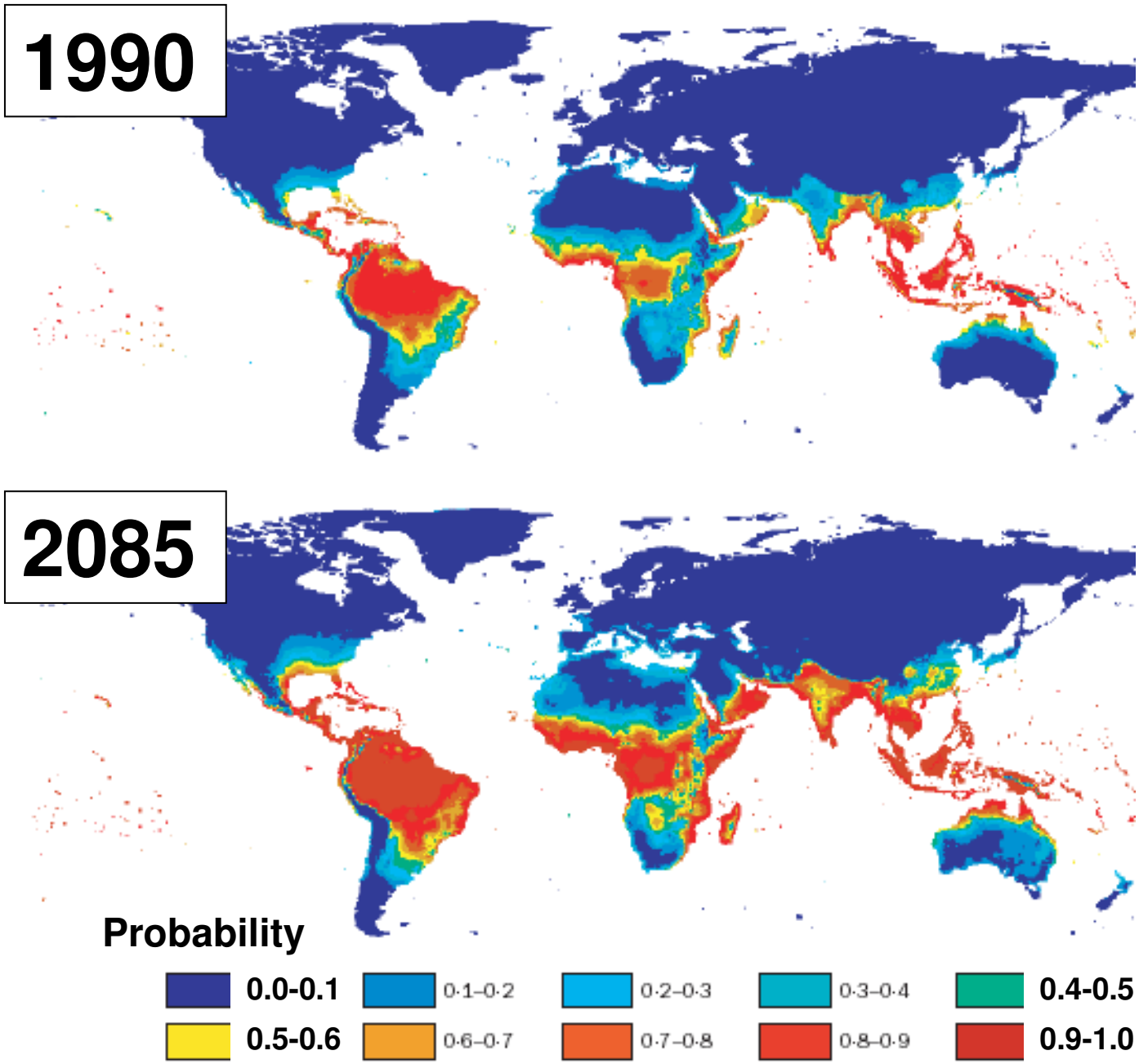
Yang et al, 2005: Recent increase in reported incidence of schistosomiasis. May reflect recent warming?

Northwards extension of snail-limiting "freeze line" puts 21 million extra people at risk.

Countries/areas at risk of dengue transmission, 2007 … and winter 10°C isotherms



World Health Organization

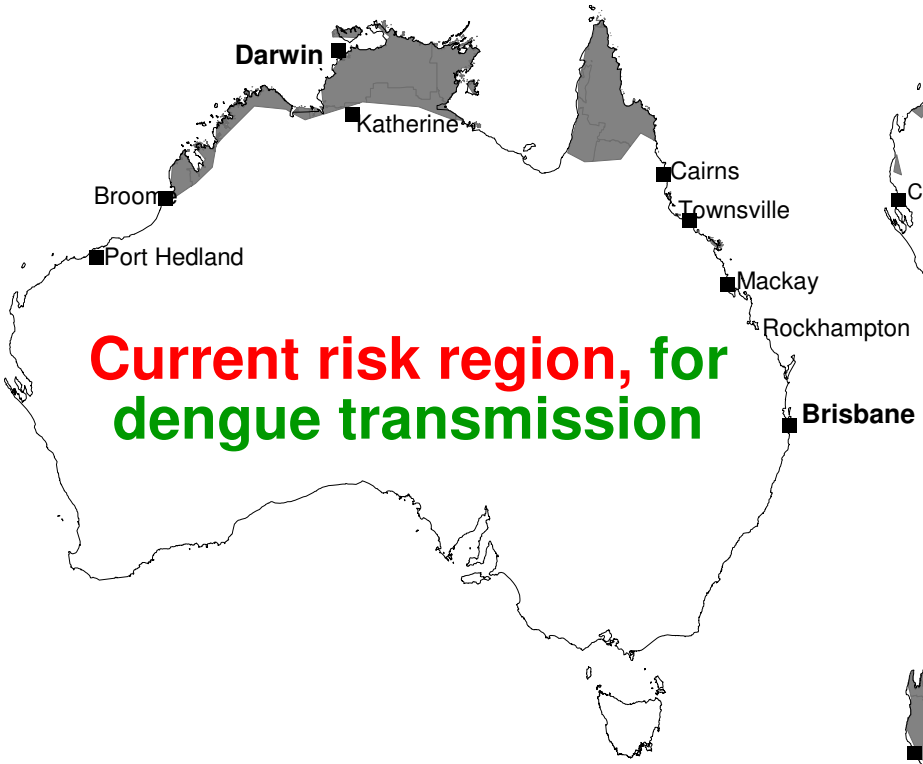


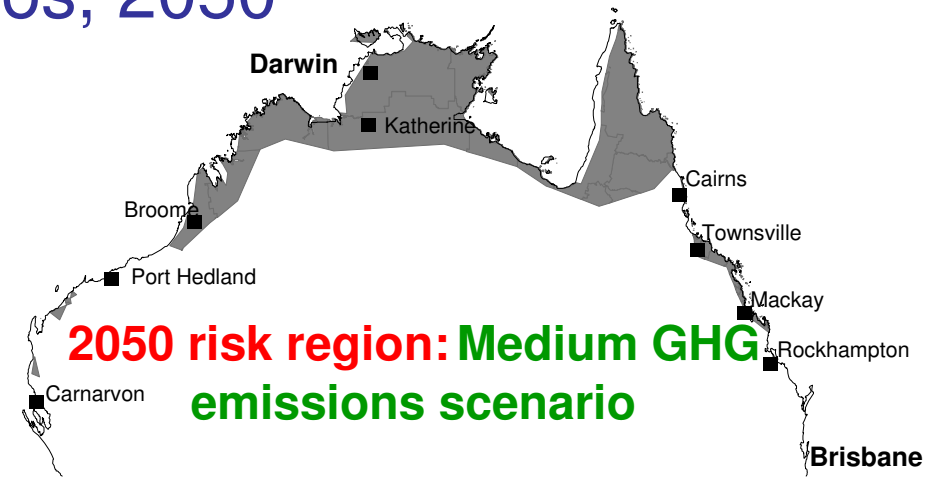
Estimated regions at risk of **Dengue Fever** under median climate change:

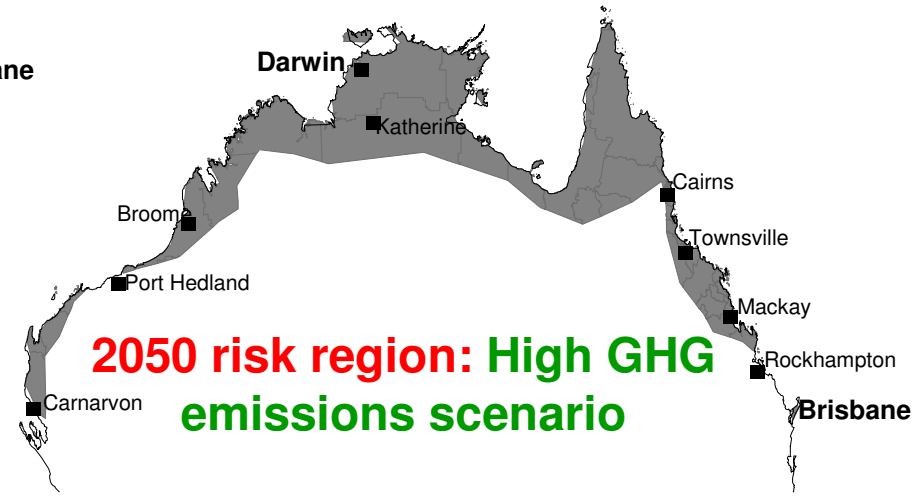
2085 vs 1990

Hales et al. *Lancet*, 2002: using basic global statistical model

DENGUE FEVER: Estimated geographic region suitable* for *Aedes aegypti,* hence transmission: Climate scenarios, 2050

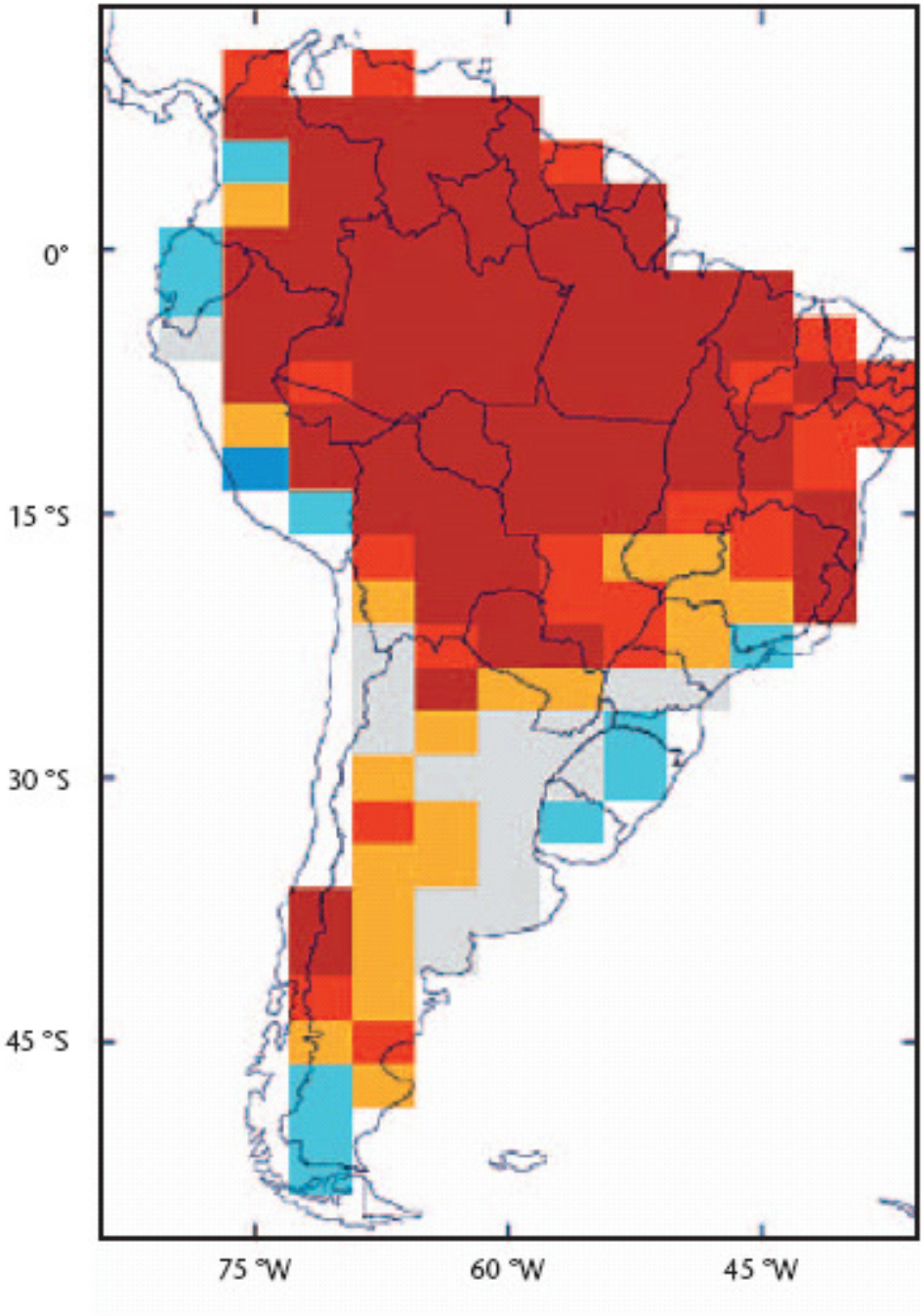






* Function of rainfall and water vapour pressure. Global statistical model (Hales), applied to Australia

Source: NCEPH/CSIRO/BoM/UnivOtago, 2003



Drought Severity: Future Prospect

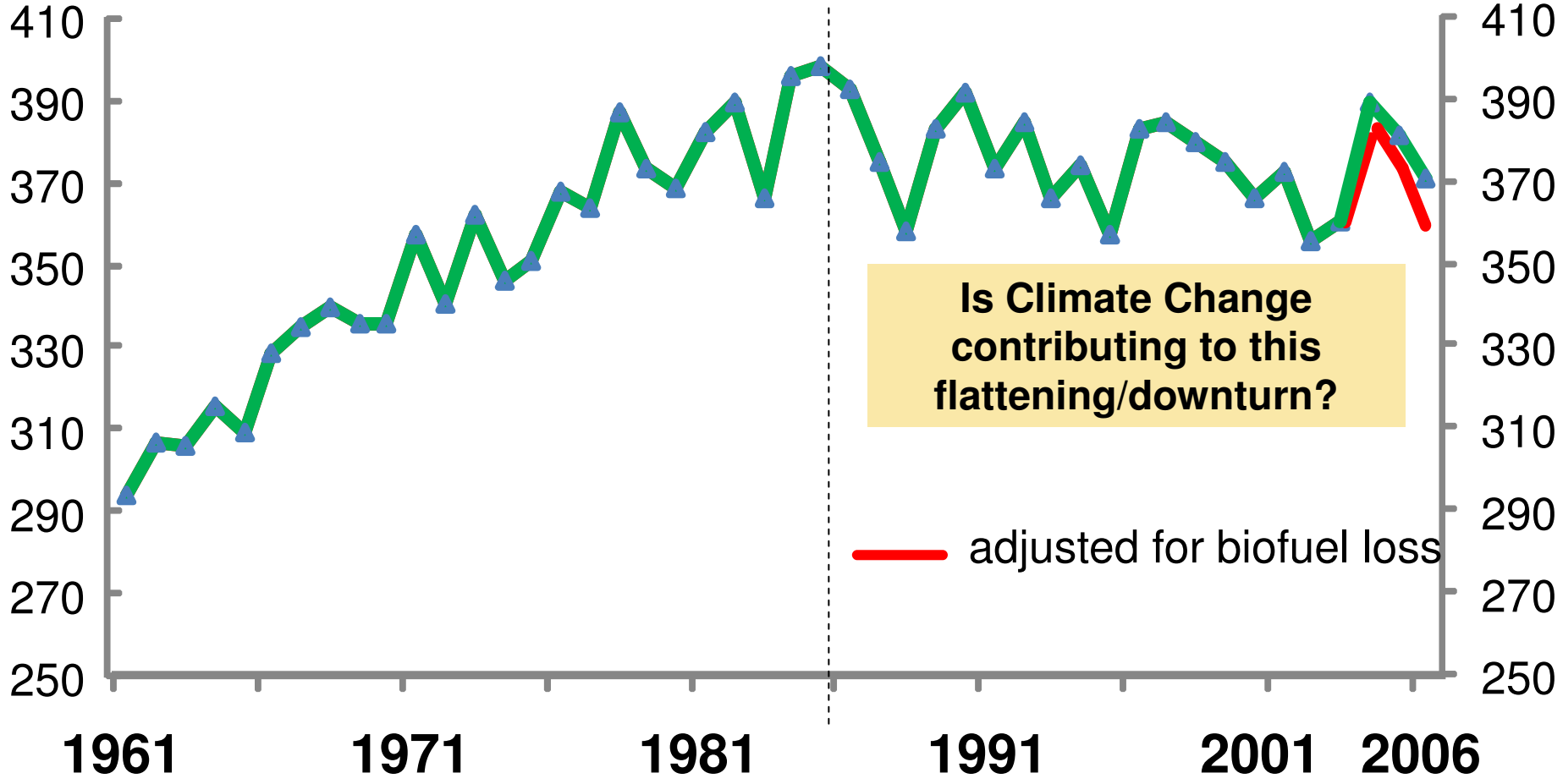
Average modelled future change in Palmer Drought Severity Index over South America by 2090s

Based on one greenhouse gas emission scenario, using UK Hadley Centre global climate model (2006).

Red/orange areas projected to become more prone to droughts.
Blue areas: projected to become wetter, less drought- prone.

Magrin et al., 2007

Per capita global grain and soy production (kgs), 1961-2006



data source: http://faostat.fao.org

(graph prepared by CD Butler, ANU, Canberra)

Modelled range of climate change impacts on global cereal grain production: % change, 1990-to-2080

	Range (% change)		
World	**-0.6**	**to**	**-0.9**
Developed countries	+2.7	to	+9.0
Developing countries	-3.3	to	-7.2
Southeast Asia	-2.5	to	-7.8
South Asia	-18.2	to	-22.1
Sub-Saharan Africa	-3.9	to	-7.5
Latin America	+5.2	to	+12.5

From: Tubiello & Fischer, 2007

‘Mitigation’ and ‘Adaptation’

Mitigation

(avoiding the unmanageable: extreme climate change)

True primary prevention

Adaptation

(managing the unavoidable: current/pending risks)

Secondary prevention: a transitional activity

Main adaptive strategies:

- reduce exposure
- increase resilience
- enhance recovery

Health 'Co-Benefits' from Mitigation

Reduce fossil fuel combustion:

Less cardio-respiratory disease from local air pollution (esp. reduced particulates)

Improve public transport:

More walking, cycling:
….. less obesity, improve blood lipid profiles, more social contact

Reduce consumption of red (ruminant*) meat

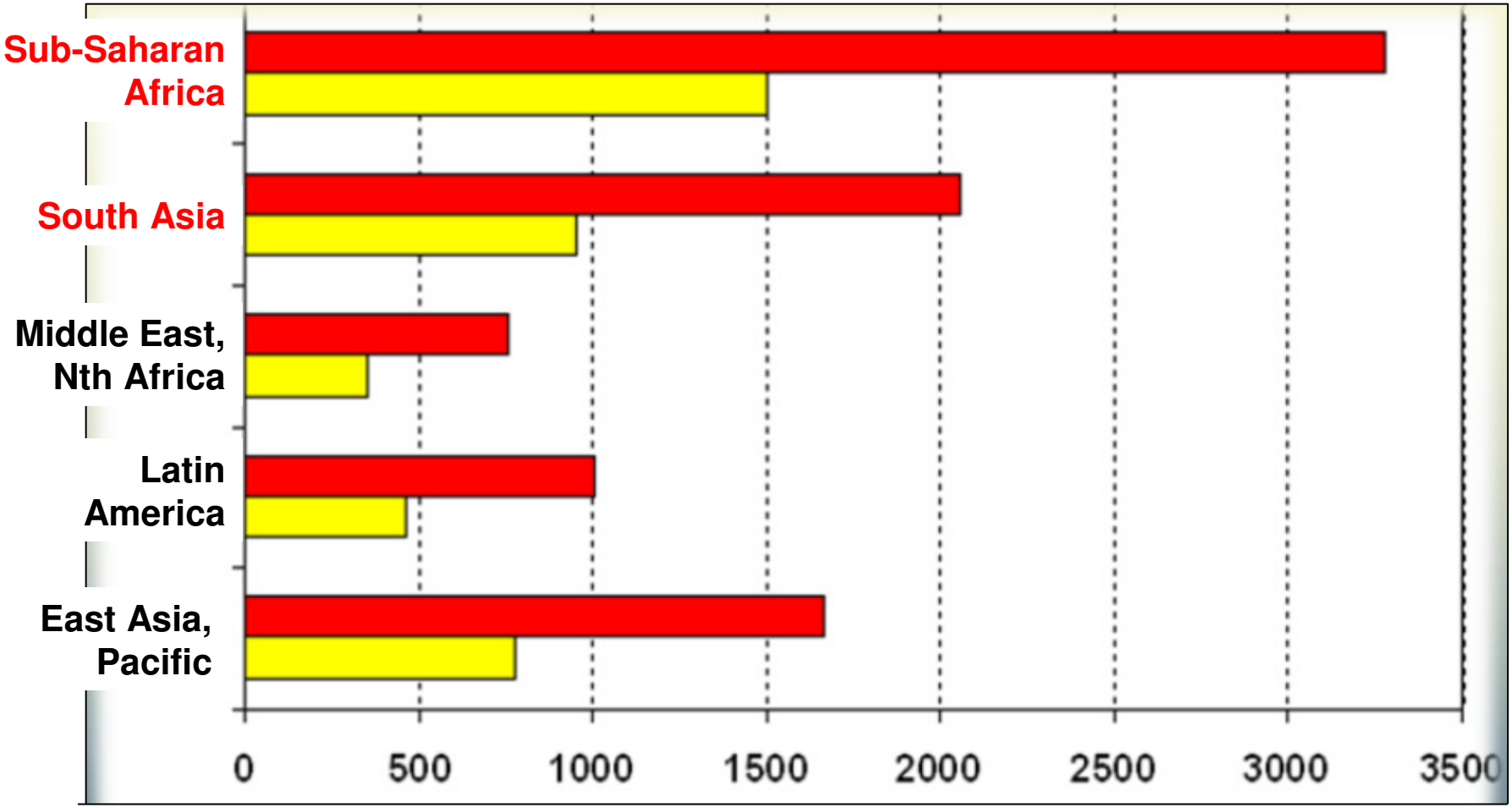
Livestock sector is a major source of GHG emissions, esp. methane

Total livestock sector emissions = ~ total transport sector emissions

Reduce risks of: colon ca, ?breast ca; also heart disease (less dietary fat)

* Digastric cloven-hooved animals: cattle, sheep, goats, buffaloes, camels

Modelled Changes in Number of Malnourished Preschool Children by 2020 (thousands) for Two Biofuel Scenarios: Expansion Drastic Expansion



Source: Int'l Food Policy Res Inst (IFPRI) *IMPACT* projections: *Impact of Climate Change on Nutrition, 2008*

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Main Types of Adaptive Strategies

DIVERSE SECTORS

Public education, awareness

Early-warning systems: heatwaves, other extreme events, likely infectious disease outbreaks

Neighbourhood support schemes, for vulnerable persons

Exposure reduction, eg:

- climate-proofed housing (ventilation, insulation)
- cooler urban design (green space, wind corridors)
- eliminate mosquito breeding sites

HEALTH SECTOR

Disaster preparedness, including health-system 'surge' capacity:

…….. facilities, staffing, knowledge

Enhanced infectious disease control programs

vaccines, vector control, case detection and treatment

Improved surveillance, for:

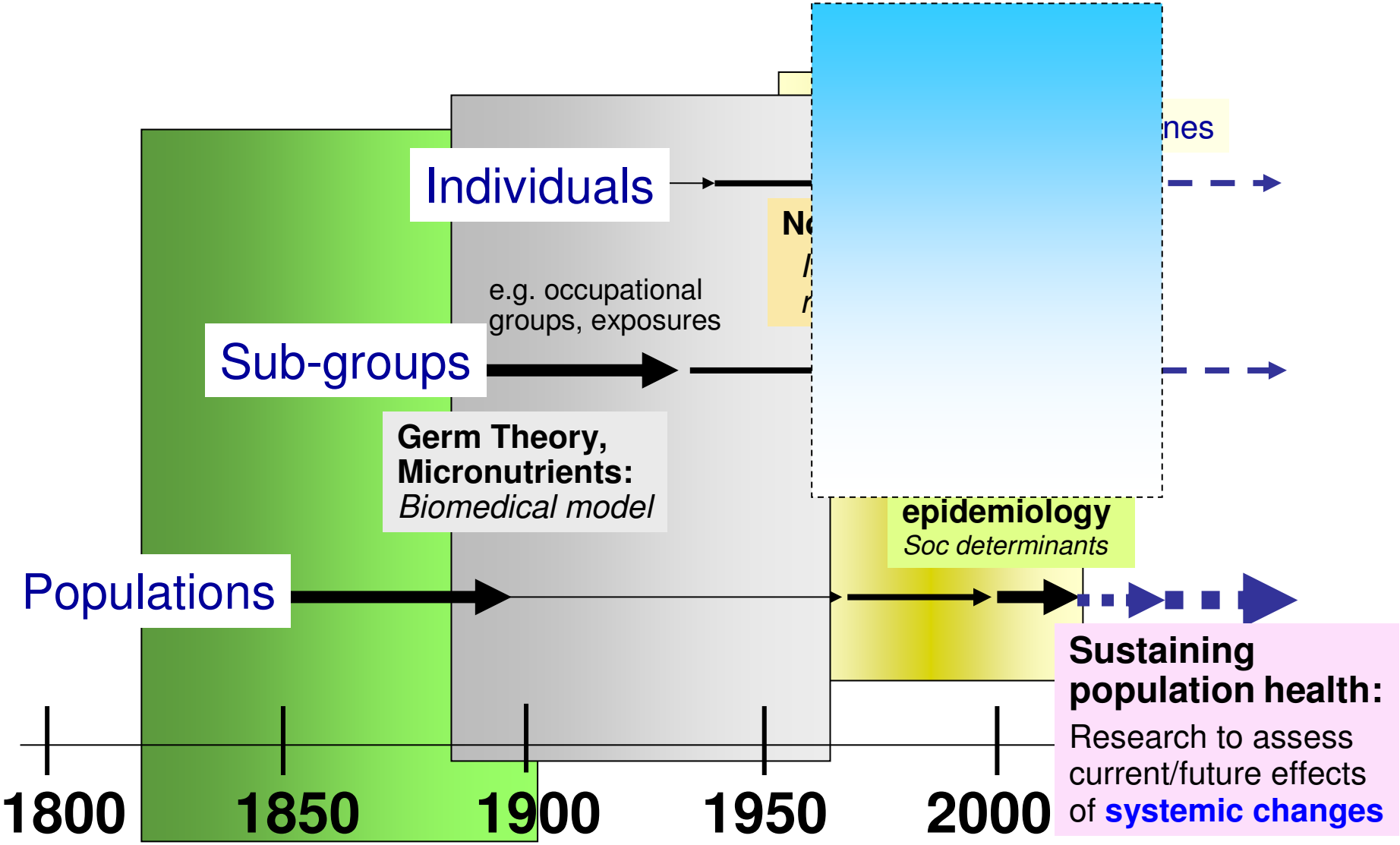
Risk indicators (e.g. mosquito numbers, aeroallergen concentration)

Health outcomes (e.g. inf dis outbreaks, rural suicide rates, seasonal asthma peaks)

Workforce capacity-building, and mid-career training

Epidemiology: c.1850-to-present

Changes in levels/units of analysis



To finish on a cheerful pro-mitigation note

(a billboard from Australia)

Think Global,
Act Local