

# Climate Change and Human Health

Curtis W. Noonan, Ph.D.  
Department of Biomedical Sciences  
College of Health Professions  
and Biomedical Sciences  
University of Montana

September 25, 2008

**CLIMATE CHANGE 2007**  
**SYNTHESIS REPORT**

**8**

**Human health**

**Coordinating Lead Authors:**  
Ulisses Confalonieri (Brazil), Bettina Menne (WHO Regional Office for Europe/Germany)

**Lead Authors:**  
Rais Akhtar (India), Krietie L. Ebi (USA), Maria Hauengue (Mozambique), R. Sari Kovate (UK), Boris Revich (Russia),  
Alistair Woodward (New Zealand)

**Contributing Authors:**  
Taraegn Abeku (Ethiopia), Mozaharul Alam (Bangladesh), Paul Beggs (Australia), Bernard Clot (Switzerland), Chris Furgal (Canada),  
Simon Halee (New Zealand), Guy Hutton (UK), Sirajul Islam (Bangladesh), Tord Kjellestrom (New Zealand/Sweden), Nancy Lewis (USA),  
Anil Markandya (UK), Glenn McGregor (New Zealand), Kirk R. Smith (USA), Christina Tirado (Spain), Madeline Thomson (UK),  
Tanja Wolf (WHO Regional Office for Europe/Germany)

**Review Editors:**  
Susanna Curto (Argentina), Anthony McMichael (Australia)

 A Report of the Intergovernmental Panel on Climate Change

**Climate Change Futures**  
Health, Ecological and Economic Dimensions



A Project of:  
The Center for Health and the Global Environment  
Harvard Medical School

Sponsored by:  
Swiss Re  
United Nations Development Programme



Epstein and Mills (Eds.) 2005.



[www.epa.gov/ord](http://www.epa.gov/ord)

# science in ACTION

BUILDING A SCIENTIFIC FOUNDATION FOR SOUND ENVIRONMENTAL DECISIONS



**GLOBAL CHANGE**  
RESEARCH PROGRAM

## REPORT ASSESSES EFFECTS OF GLOBAL CHANGE ON HUMAN HEALTH, WELFARE, AND SETTLEMENTS

FINDINGS OF THE U.S. CLIMATE CHANGE SCIENCE PROGRAM SYNTHESIS AND  
ASSESSMENT PRODUCT 4.6

July 2008

# Why be concerned about Health when discussing Climate Change?

- Humanitarian concerns
- Contribute to the policy debate
- Contribute data for quantifying the economic impact of climate change
- ADAPTATION to Public Health Threats
  - Measures aimed at Disease Prevention
  - Adaptation of public health infrastructure to response to health events.

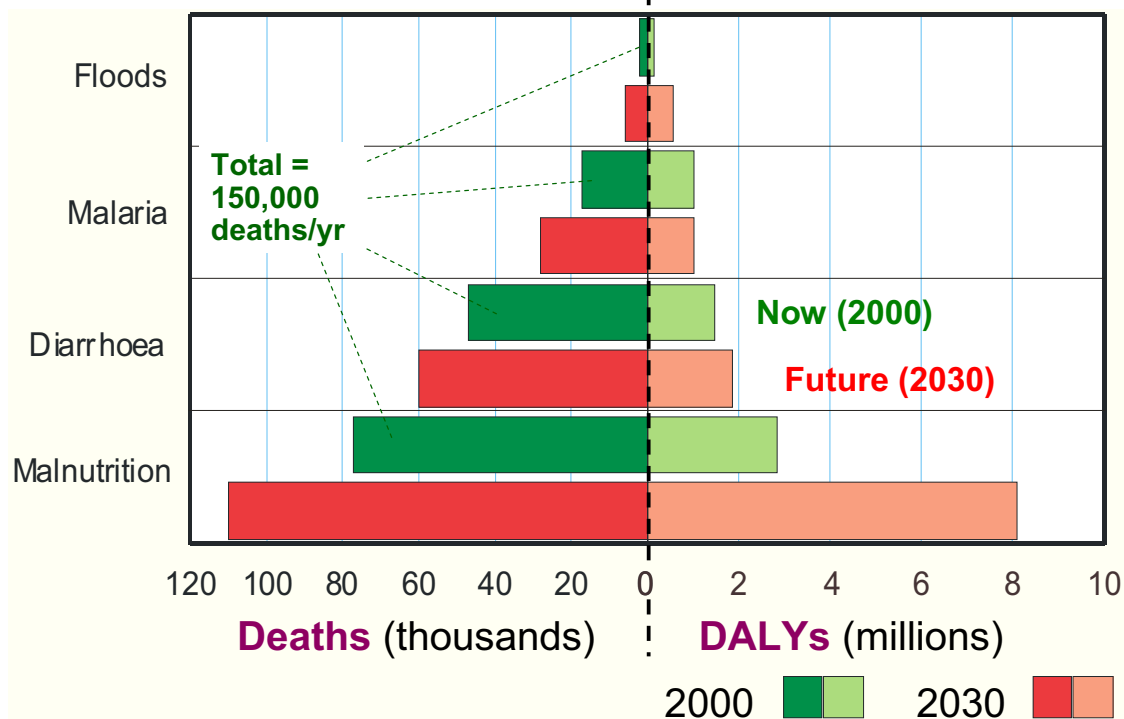
## Climate Change and Health

- How do we characterize the overall health impact?
- What are the pathways?
  - Direct Exposure: Extreme weather events
  - Indirect Exposure
    - Effects on food security and malnutrition
    - Impacts on disease transmission
    - Health-related airborne exposures
  - Social and Economic Disruption
- Complex interaction of effects
- What can be done?

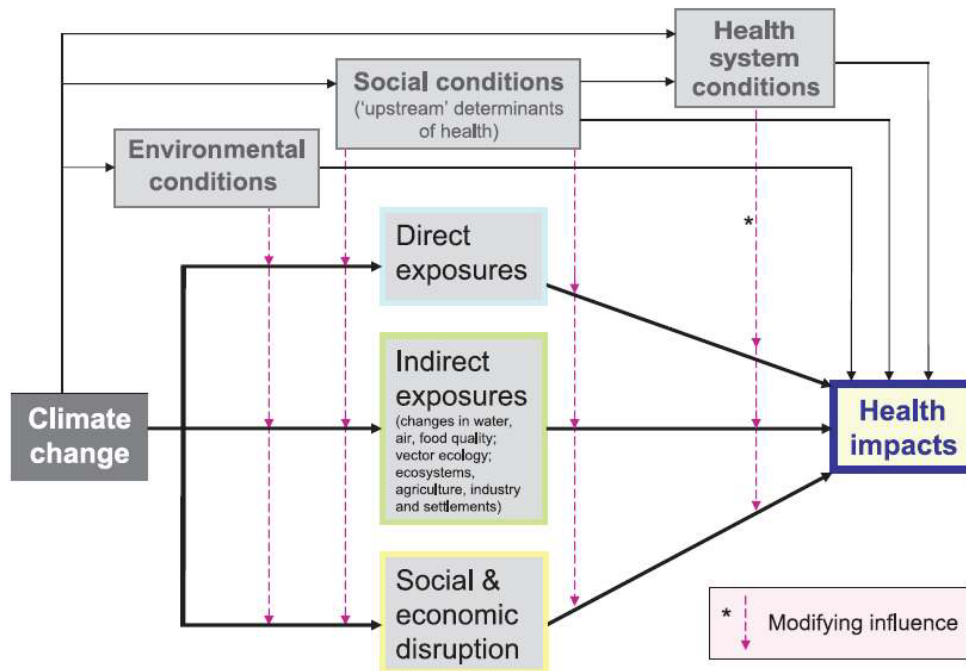
# How do we estimate the impact of Climate Change on Human Health?

- Quantifiable estimates (e.g., DALYs) include a great deal of uncertainty
- Systems approach includes
  - complex relationship between direct/indirect “exposures” to Climate Change; and
  - Climate Change-related impacts that can have a modifying influence on health effects

**Estimated deaths and DALYs attributable to climate change**  
Selected health outcomes in developing countries



# Pathways by which climate change could affect health



IPCC 2007

## Summary of Direction, Magnitude, and Certainty of Projected Health Impacts

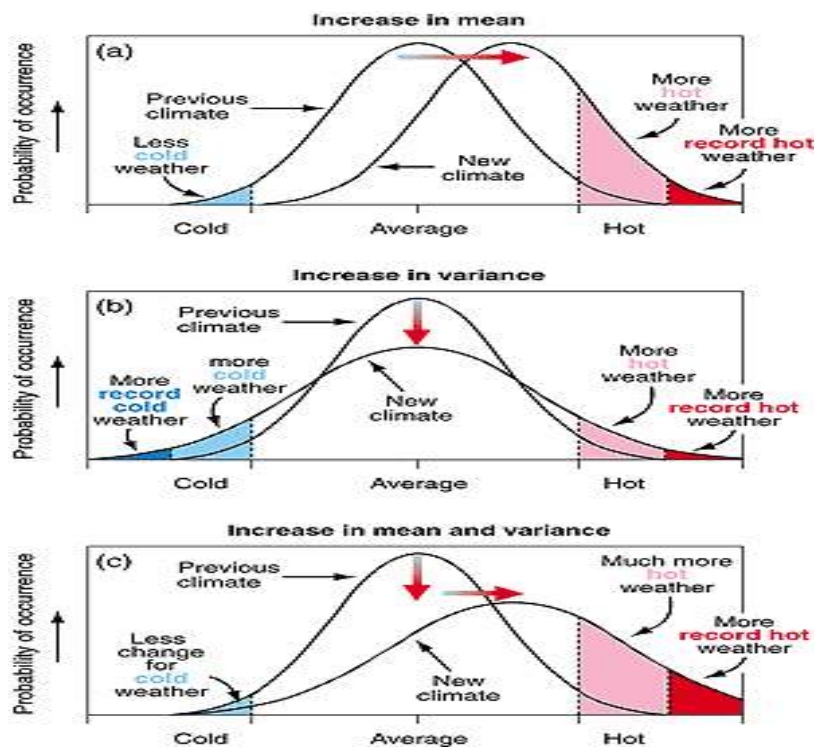
	Negative Impact	Positive Impact
<u>Very High Confidence</u>		
<b><i>Effects on geographic range &amp; incidence of malaria</i></b>	←	→
<u>High Confidence</u>		
<b><i>Undernutrition &amp; consequent disorders</i></b>	←	
<b><i>Extreme events (heatwaves, storms, floods, droughts)</i></b>	←	
<b><i>Illness/death due to (amplified) poor air quality</i></b>	←	
<b><i>Change in range of disease vectors</i></b>	←	→
<b><i>Cold-related deaths</i></b>		→
<u>Medium Confidence</u>		
<b><i>Diarrhoeal diseases</i></b>	←	

IPCC 2007

# Direct effects of climate change on health

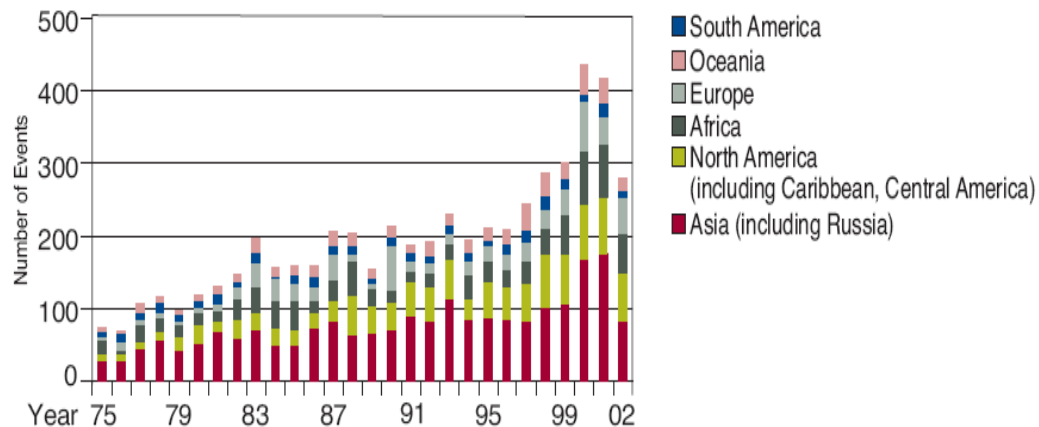
- Extreme weather events
- Storms and floods

## Increases in temperature mean and variance



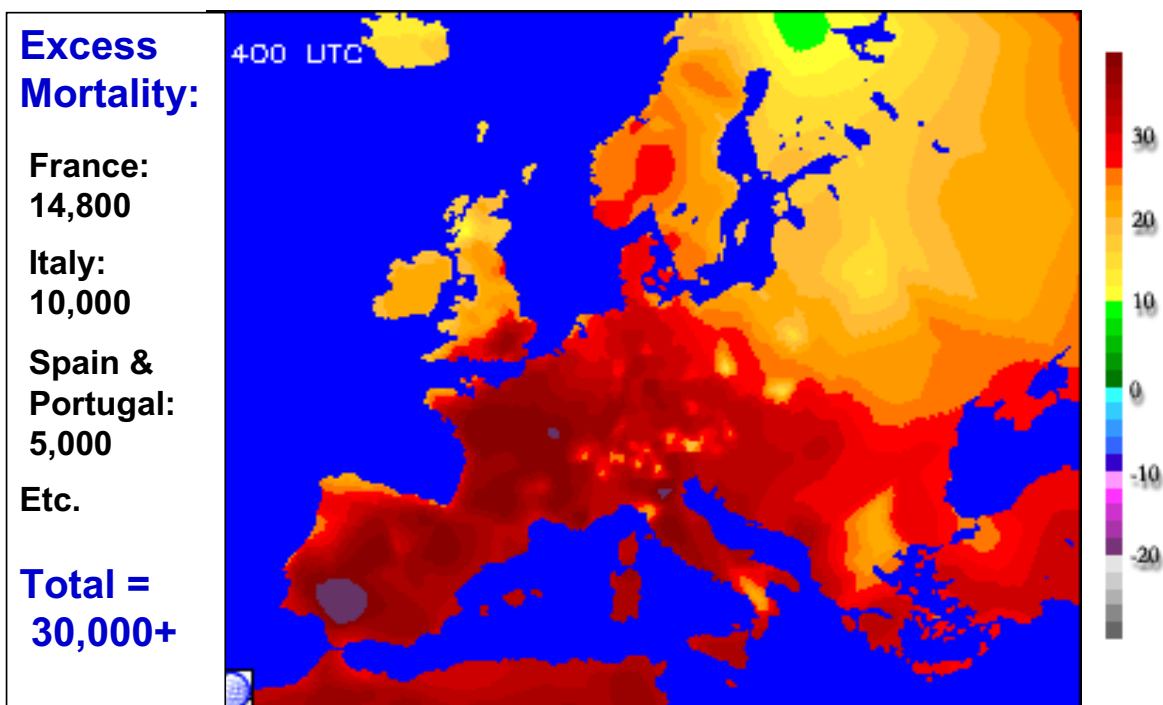
# Increased frequency of extreme weather events: Emergency Events Database, 1975-2002

Extreme Weather Events by Region

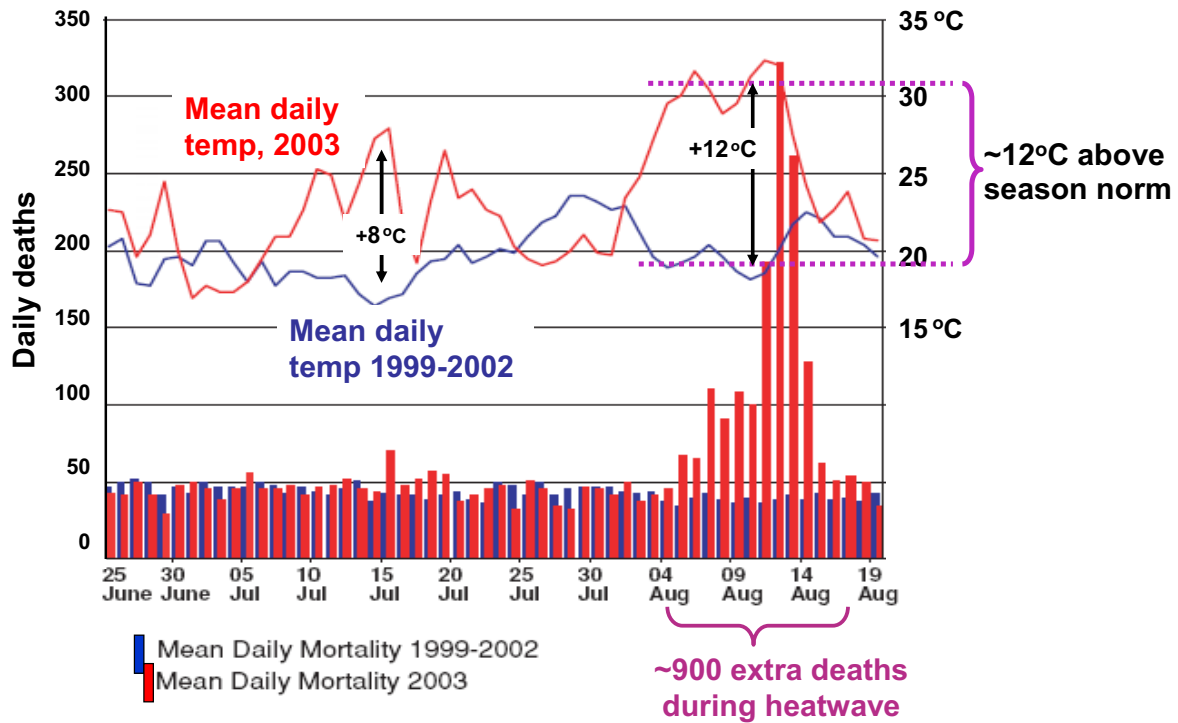


Climate Change Futures. Epstein and Mills (Eds.) 2005.

## European Heatwave: August 3-14, 2003

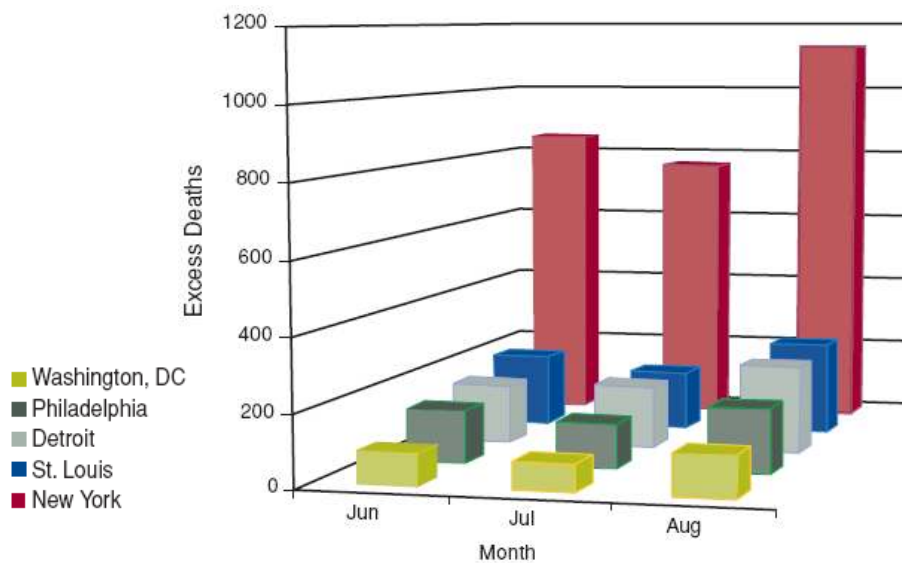


## Paris, Heatwave (Aug 2003): Daily Mean Temps and Deaths



Based on: Vandentorren S, et al. AJP 2004;94:1518-20.

## Projected Excess Death in 5 U.S. Cities Under Europe 2003 Conditions



Climate Change Futures. Epstein and Mills (Eds.) 2005.



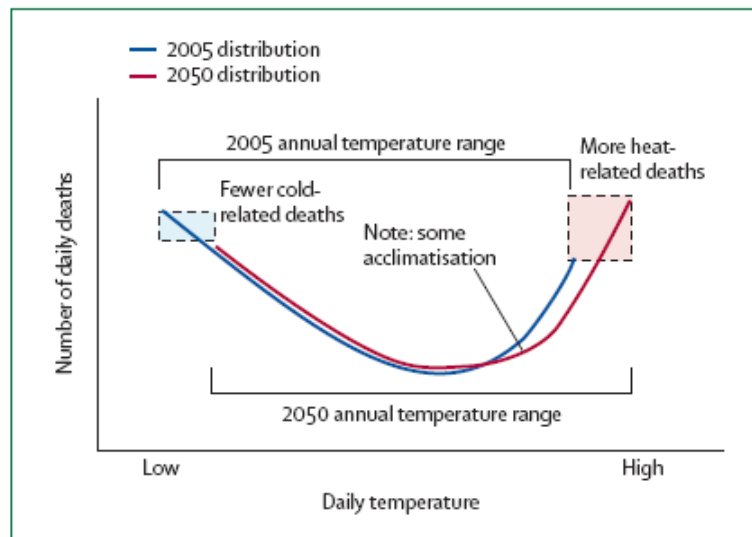


Figure 2: Schematic representation of how an increase in average annual temperature would affect annual total of temperature-related deaths, by shifting distribution of daily temperatures to the right

McMichael et al. Lancet 2006;367:859-69

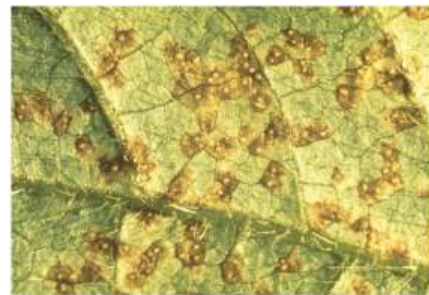
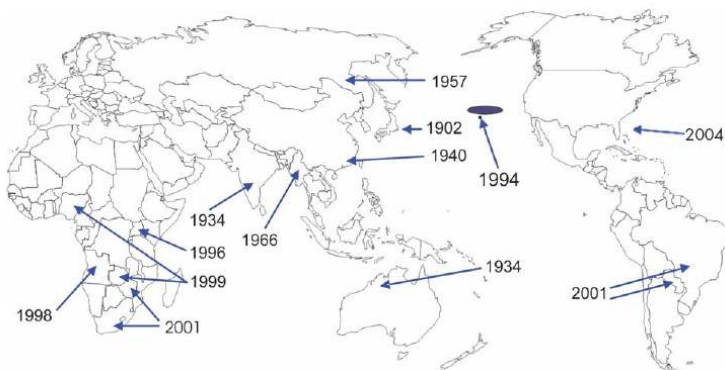
## Indirect effects of climate change on health

- Effects on food security and malnutrition
- Impacts on disease transmission
  - Water-related diseases
  - Vector-borne diseases
  - Food-borne diseases
- Health-related airborne exposures
  - Pollution
  - Aeroallergens

# Nutrition and Food Security

- Regional water scarcity
- Salinization of agricultural lands
- Destruction of crops
  - Flood events
  - Plant diseases/pests (e.g., soybean rust)
- Disruption of food logistics/trade through disasters
- Threat to ocean food sources (e.g., harmful algal blooms)

## Soybean rust spread



Soybean rust is believed to have the U.S. via dust transported by Hurricane Ivan in 2004.

Soybean yield reductions in the Americas resulted in price rise from \$5/bu in 2003 to \$11-\$14/bu in 2004.

## Indirect effects of climate change on health

- Effects on food security and malnutrition
- Impacts on disease transmission
  - Water-related diseases
  - Vector-borne diseases
  - Food-borne diseases
- Health-related airborne exposures
  - Pollution
  - Aeroallergens

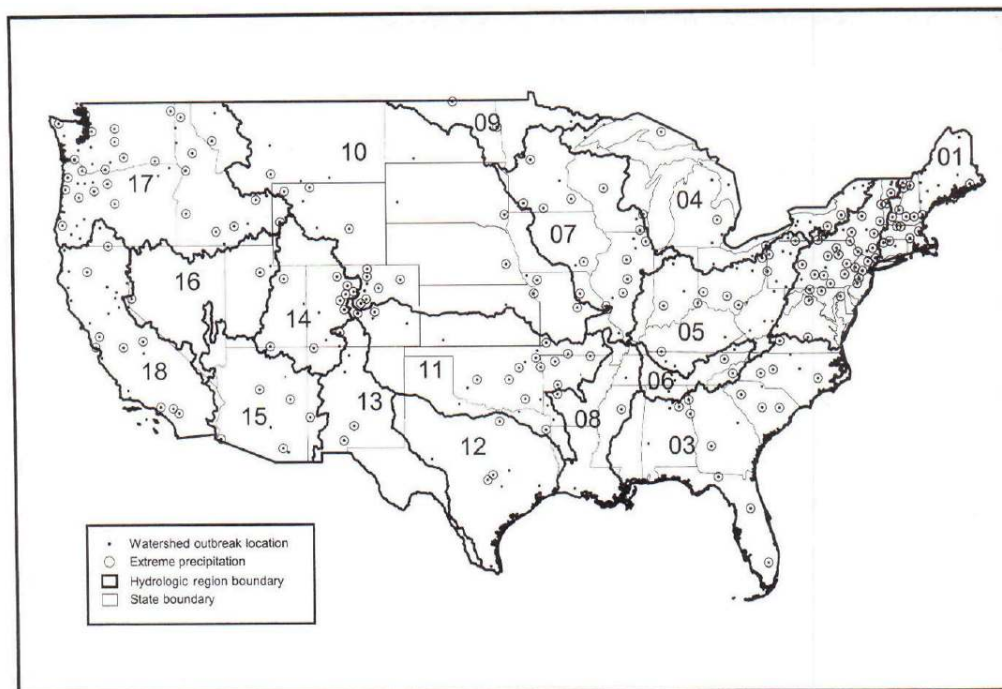
## Disease Transmission: water-related diseases

- Climate change has effects on rainfall, water availability, and water quality
- Floods/storms can result in blocked drains, resulting in increased disease transmission
- Storm surges can result in failures of water treatment systems
- Reductions in rainfall results in low river flows, reducing effluent dilution and resulting in increased pathogen loading

# Disease Transmission: water-related diseases

- Low income countries with less infrastructural adaptability are more prone to the water-related disease effects resulting from extreme weather events;
- But associations between precipitation and water-borne outbreaks are observed in the United States as well...

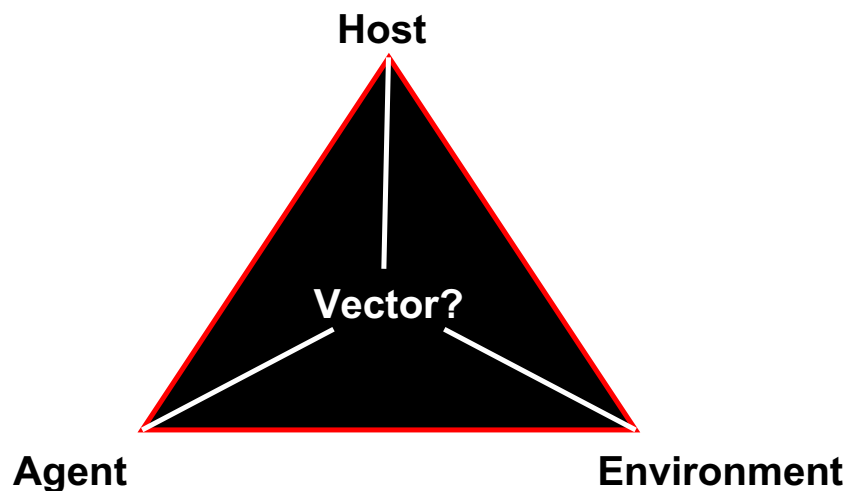
Waterborne outbreaks associated with extreme precipitation events (>90%ile) with 2-month lag, US, 1948-94



# Indirect effects of climate change on health

- Effects on food security and malnutrition
- Impacts on disease transmission
  - Water-related diseases
  - Vector-borne diseases
  - Food-borne diseases
- Health-related airborne exposures
  - Pollution
  - Aeroallergens

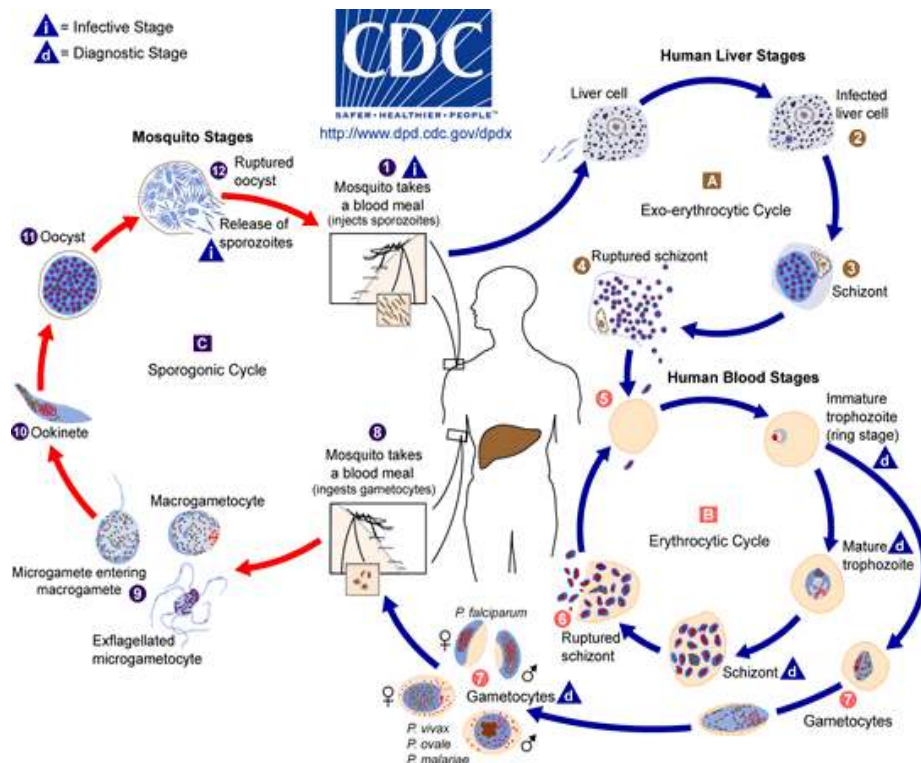
## Traditional Epidemiology Triad



# Disease transmission: vector-borne diseases

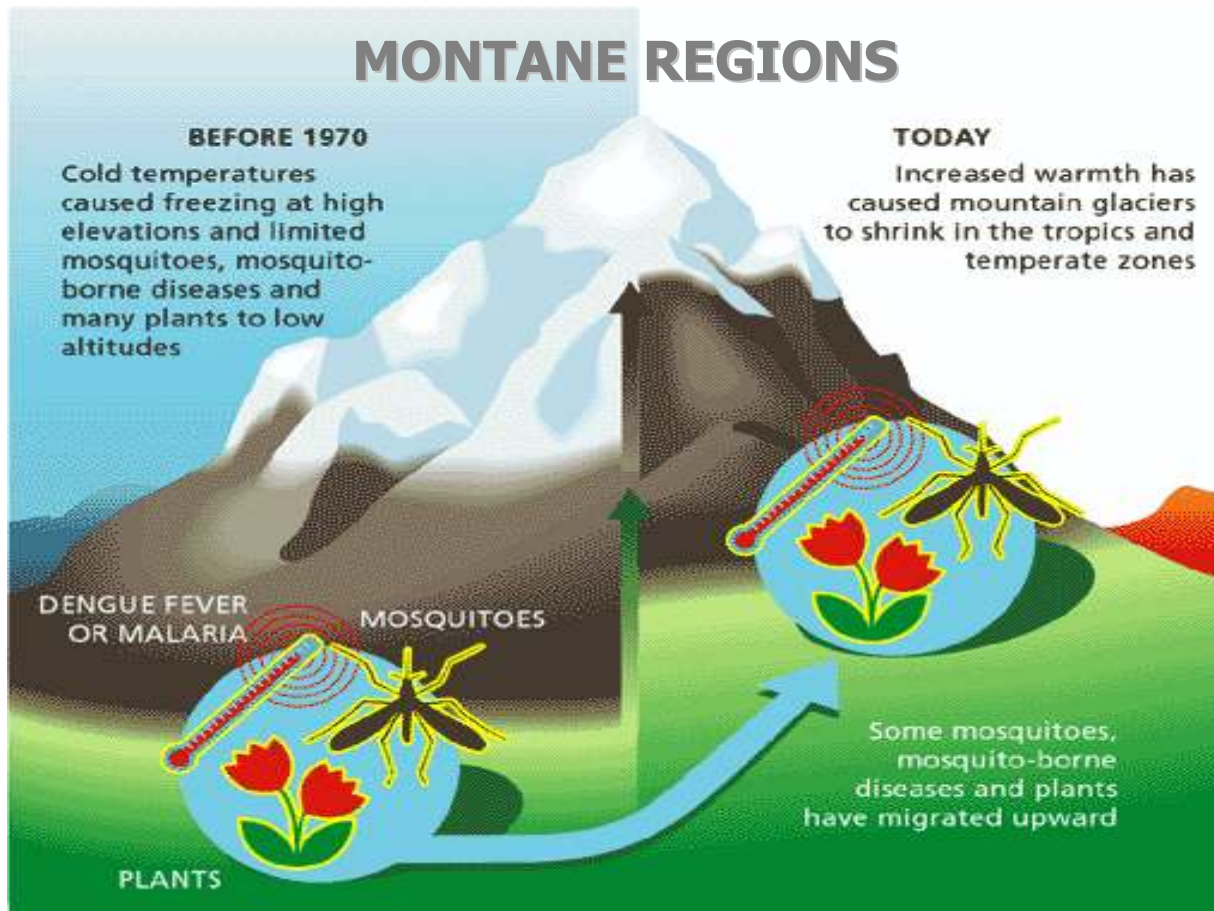
- Climate changes affect habitat of disease vectors (e.g., mosquitoes, ticks, fleas...)
- Examples
  - Malaria
  - Dengue in Australia
  - Tick borne encephalitis in Sweden
  - Schistosomiasis in China
  - Lyme disease in United States and Canada

## Malaria

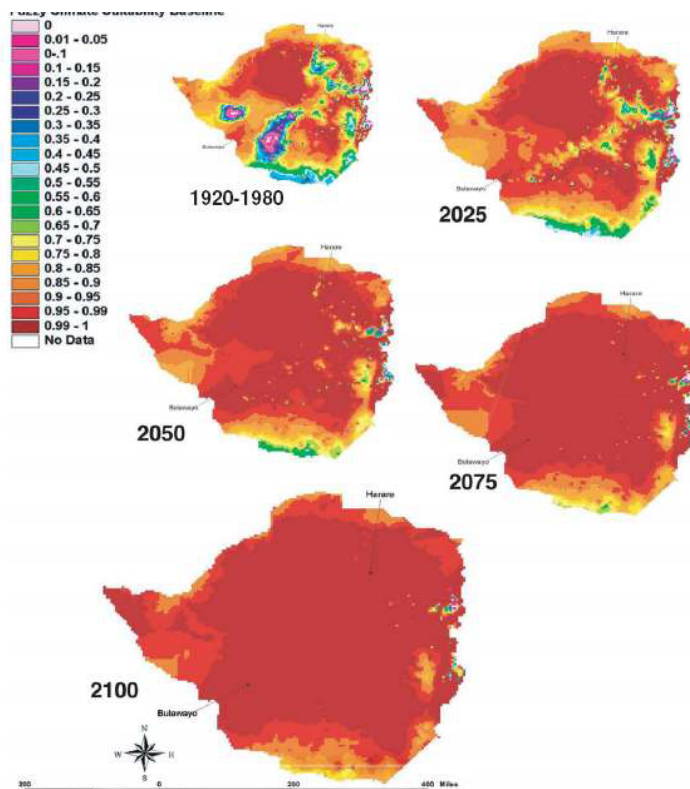




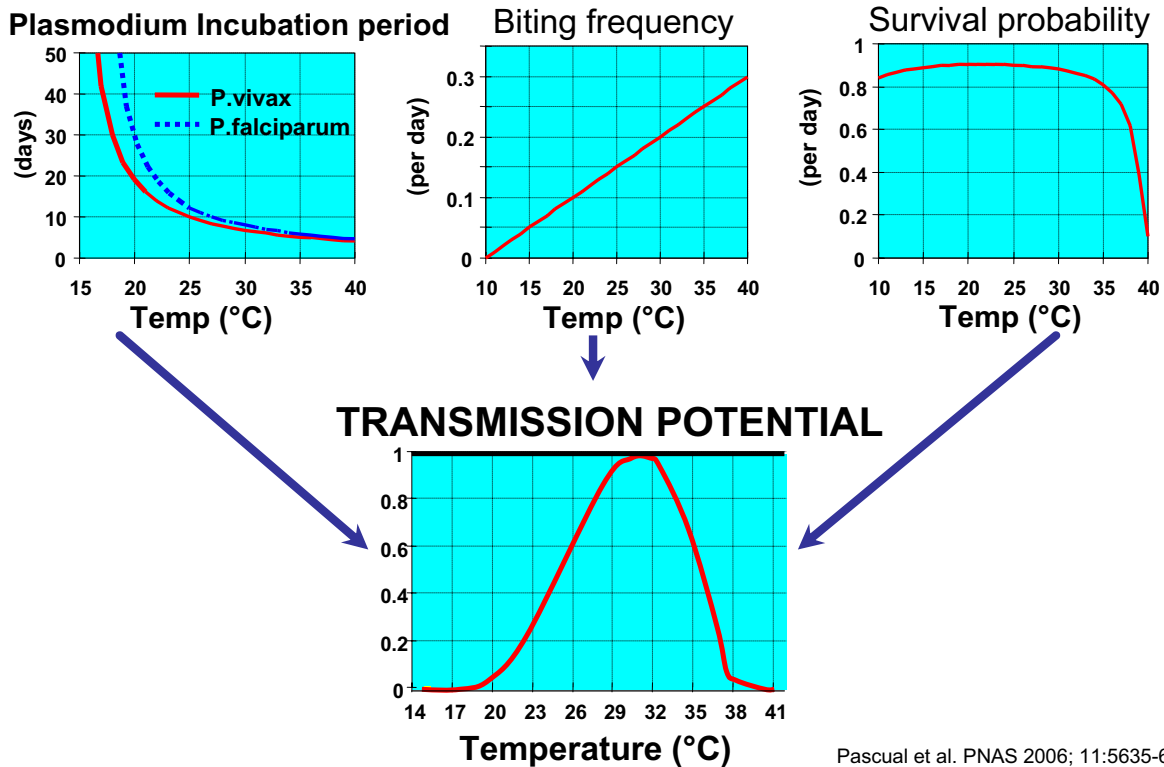
# MONTANE REGIONS



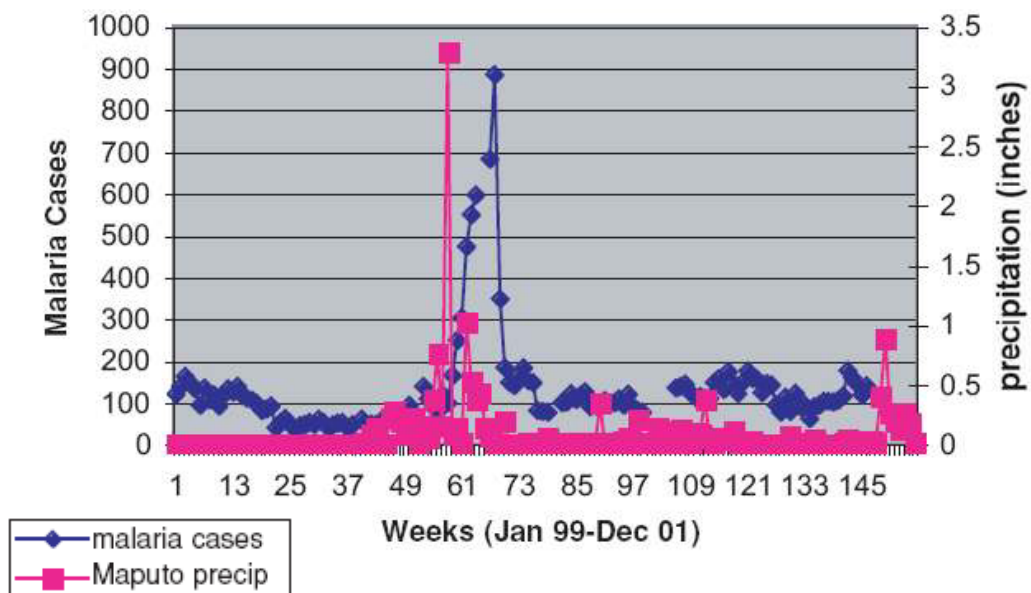
Climate Suitability for Stable Malaria Transmission: Zimbabwe



# Malaria Transmissibility: Temperature and Biology

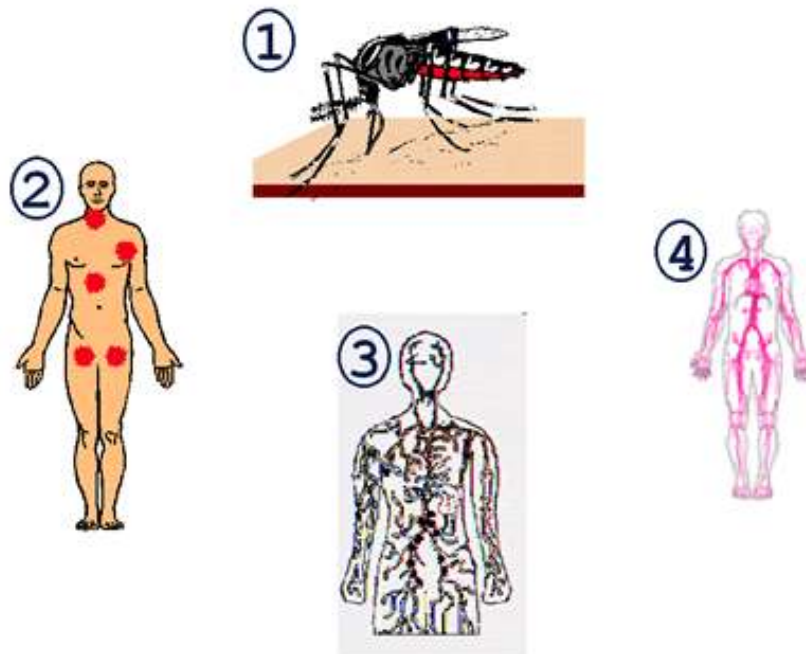


## Impact of Precipitation on Malaria Transmission: Mozambique





# Dengue Fever



## Projected increase in range of dengue vector: *A. aegyptii*

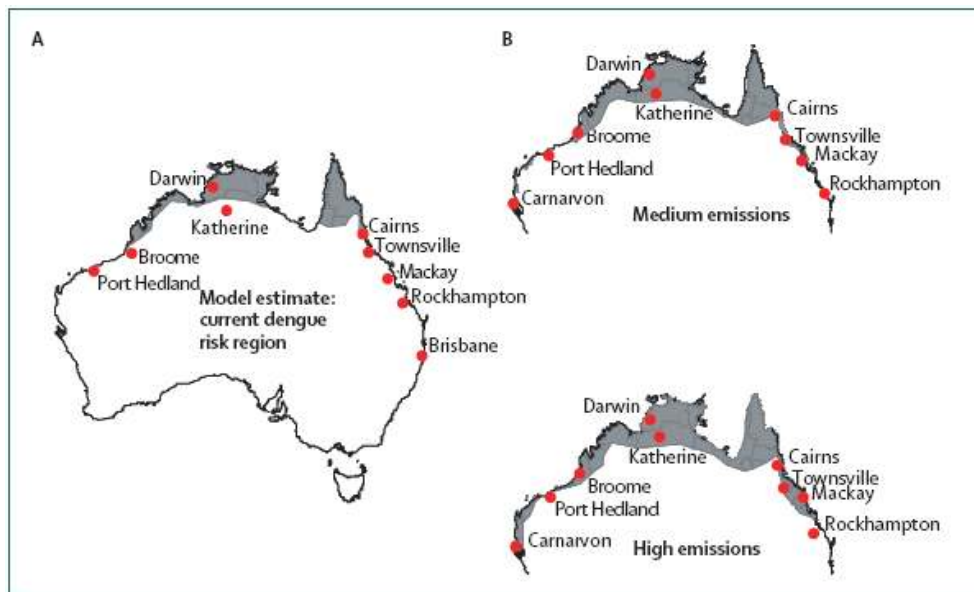
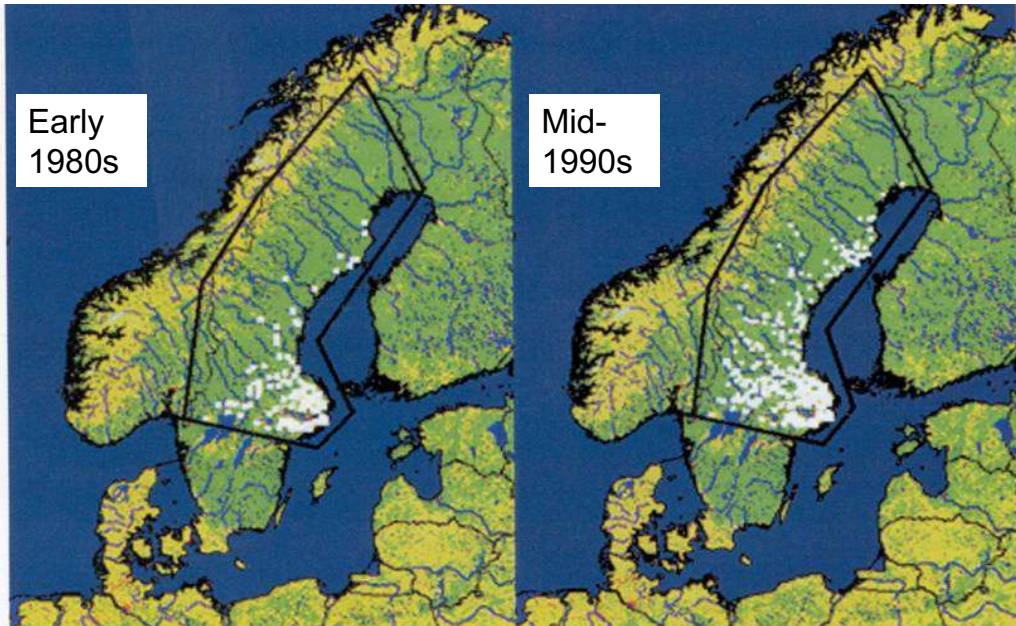


Figure 4: Modelled estimates of the current (A) and future (2050) (B) geographic regions (shaded areas) suitable for maintenance of the dengue vector *Ae aegyptii* in Australia

Model based on baseline (1961–90) estimates of water vapour pressure estimates for current climate and for future climate, in settings of medium and high global emissions of greenhouse gases.<sup>35</sup>

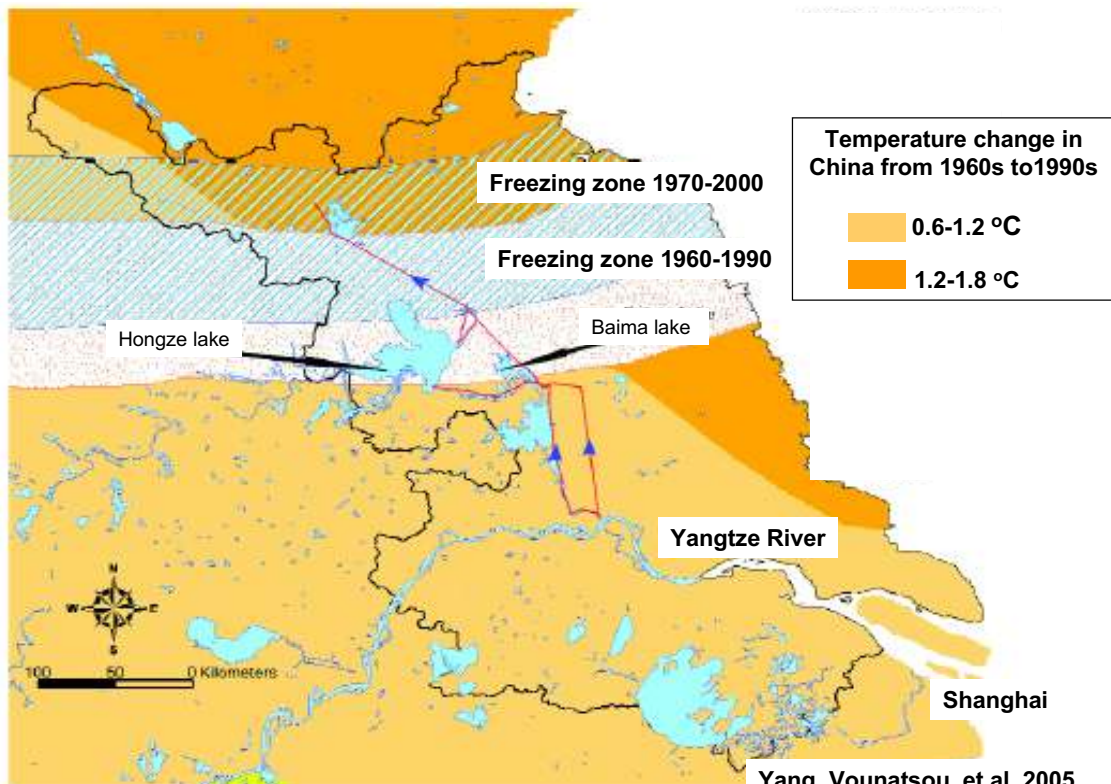
Tick-borne (viral) Encephalitis, Sweden: 1990s v 1980s  
Changing Distribution of the Tick Vector



White dots indicate locations where ticks were reported. Black line indicates study region.

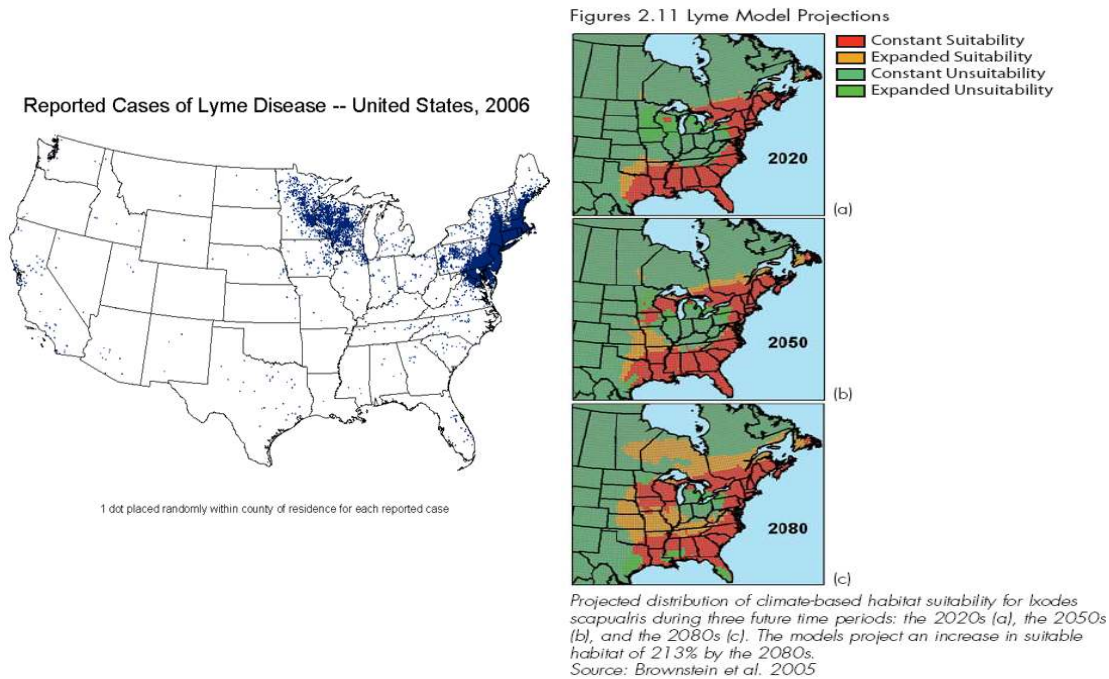
Lindgren et al., 2000, 2001

Schistosomiasis: Potential transmission of *S japonicum*  
in Jiangsu province due to raised average January temperature.



Yang, Vounatsou, et al. 2005

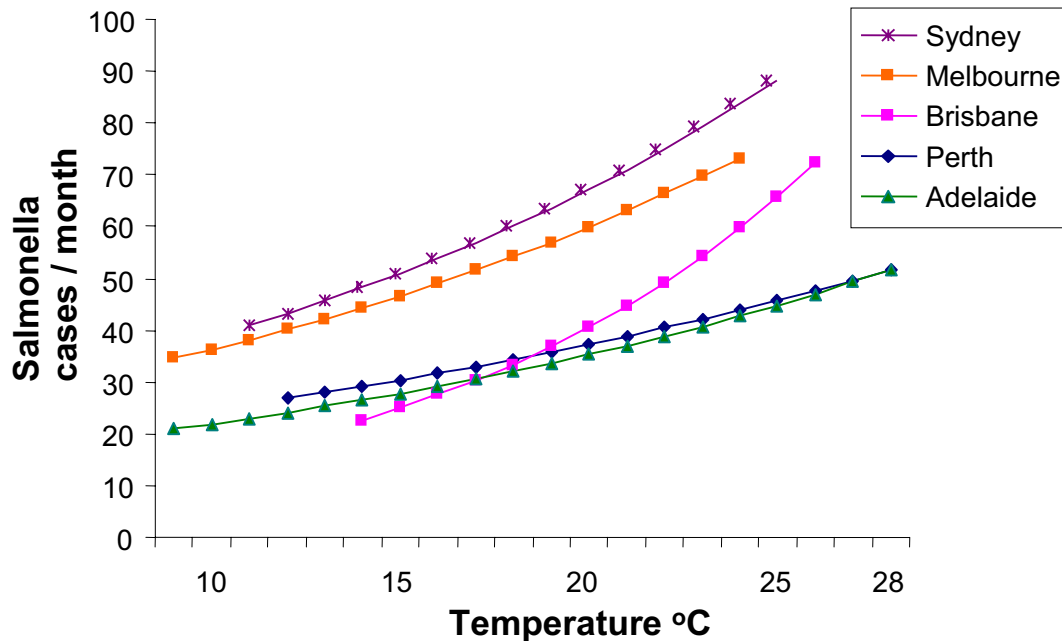
# Projected change in potential for Lyme disease transmission



## Indirect effects of climate change on health

- Effects on food security and malnutrition
- Impacts on disease transmission
  - Water-related diseases
  - Vector-borne diseases
  - Food-borne diseases
- Health-related airborne exposures
  - Pollution
  - Aeroallergens

Monthly cases of *Salmonella* food-poisoning in relation to monthly temperature  
Australian cities, 1991-2001 (modelled best-fit graphs)



D'Souza, Hall, et al., NCEPH/ANU, 2003

## Indirect effects of climate change on health

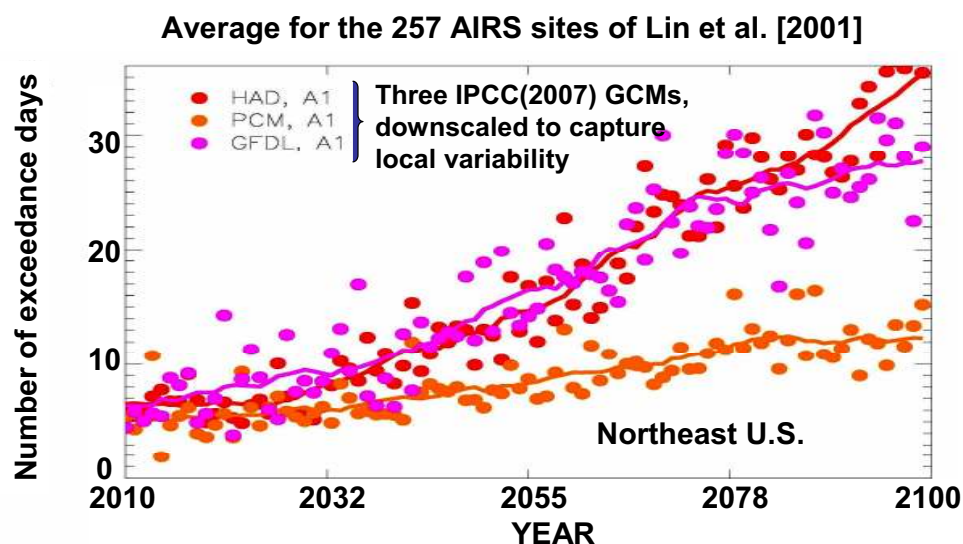
- Effects on food security and malnutrition
- Impacts on disease transmission
  - Water-related diseases
  - Vector-borne diseases
  - Food-borne diseases
- Health-related airborne exposures
  - Pollution
  - Aeroallergans



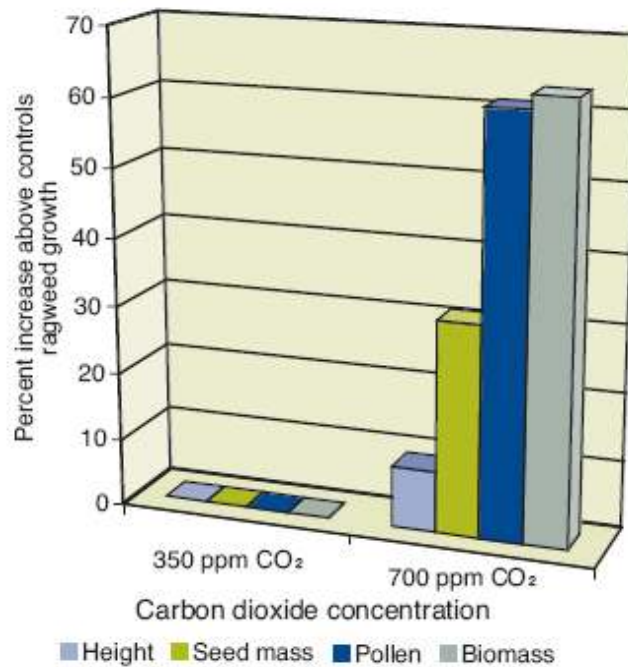
# Climate Change impacts on Health-related airborne exposures

- Ground-level Ozone
- Particulate matter (PM) (e.g., forest fires)
- Aeroallergens
- Ultraviolet Radiation (UV)

## Projection of future exceedances of ozone NAAQS in the Northeast United States



## Ragweed pollen production under elevated CO<sub>2</sub>

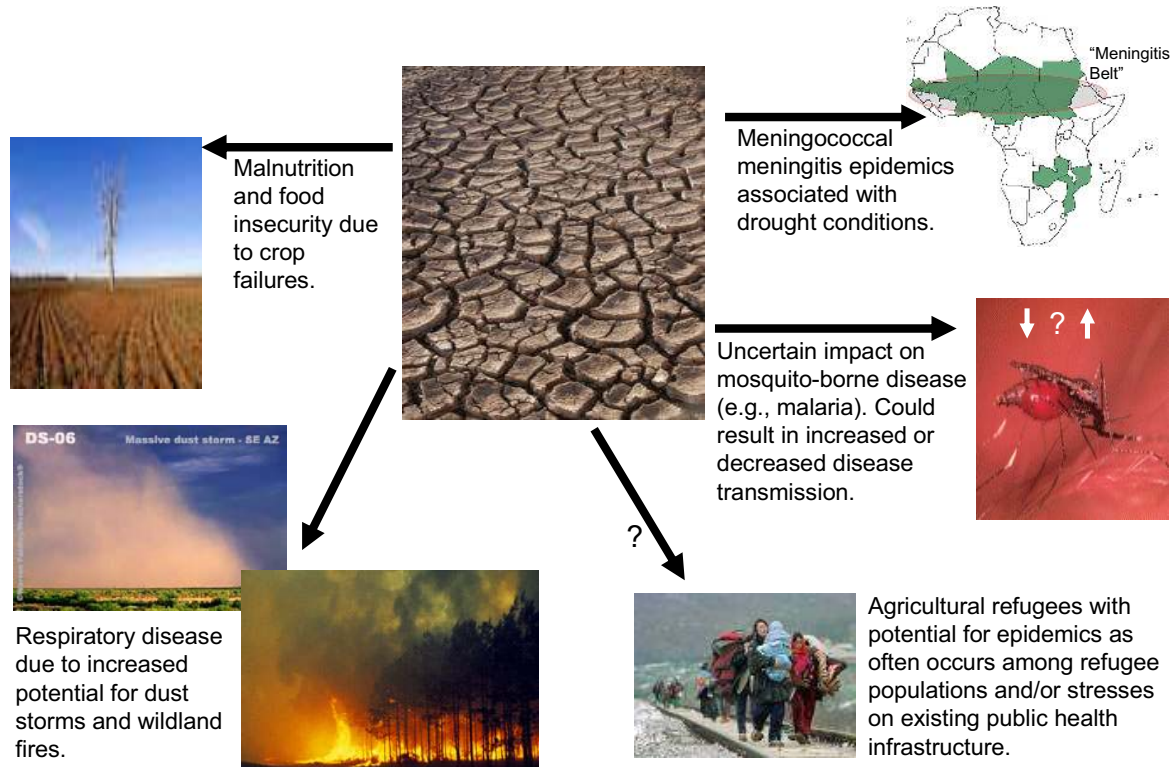


Climate Change Futures. Epstein and Mills (Eds.) 2005.

## Social and Economic Disruption

- Environmental catastrophes
  - Example: Hurricane Katrina
- Populations displaced by gradual environmental shifts
  - Desertification
  - Diminishing water supplies
  - Rising sea levels

## Example: complex impact of drought on health



## How confident are we in these health-related projections?

There are numerous potential modifiers, for example:

- Infectious diseases could become more prominent due to failing health systems or newly emergent pathogens.
- Improvements in medical technology could partially offset anticipated adverse health outcomes from climate change, but this could serve to further highlight health disparities.
- Unanticipated large-scale migrations could overwhelm global capacity to respond.

# Major Domains of Adaptation

- Strengthening natural and infrastructural defences against physical disasters
  - Institutional disaster preparedness
- Advance warning of epidemic outbreaks
- Managing water resources
  - Safety/quality and access
  - Mosquito breeding
- Reducing urban vulnerability
  - Protecting energy systems (decentralisation?)
  - Minimising heat islands
- Protecting food-producing systems and food access
- Data systems: Monitoring, surveillance, analysis, dissemination
- Health-care system: structure, staffing, connectedness
- Engage in inter-sectoral discussions and policy development

## Summary

- Human health effects associated with Climate Change can be described in quantitative (e.g., mortality, DALYs) or qualitative (directionality coupled with measures of confidence). Each approach has advantages and disadvantages.
- Human health effects associated with Climate Change could be discussed as
  - Direct health impacts;
  - Indirect health impacts; or
  - Impacts on Social/Economic disruption
- These potential effects cannot be considered in isolation. They must be considered within a complex system of inter-relating effects (e.g., drought).
- Adaptation strategies can help in preventing, or responding to, the health impacts of climate change, but inter-regional disparities will be highlighted by countries ability to implement these strategies.