Climate Change and Health

Dynamical and Forecast Modeling

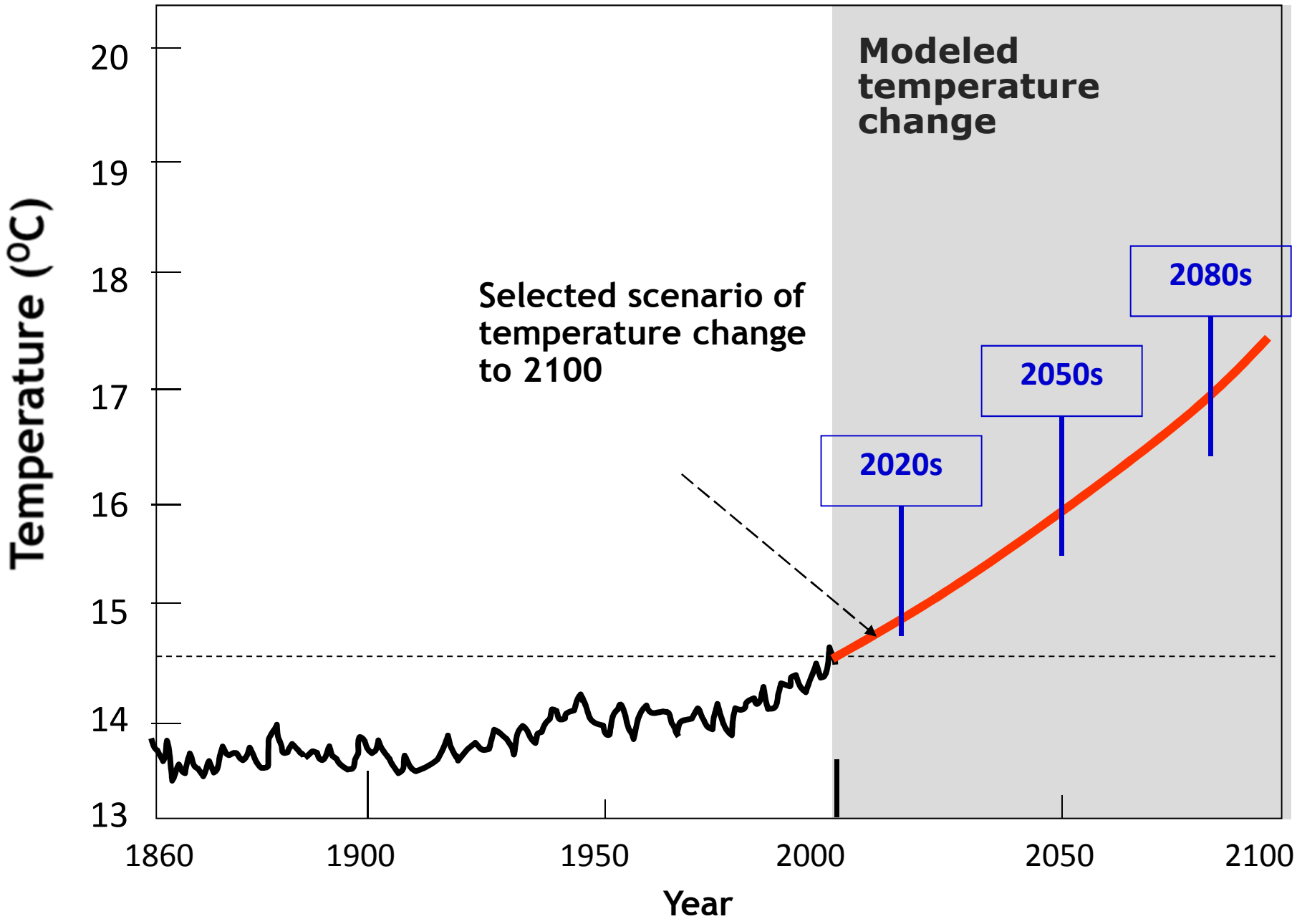
Uses and Limitations

Mark L. Wilson, Sc.D.
Professor of Epidemiology and of
Ecology and Evolutionary Biology
The University of Michigan
Ann Arbor, Michigan, USA

Training on Climate Change Related Health Impacts
Republic of Mauritius
14-18 May, 2012

Overview

- Define and discuss the scenarios used for projecting climate change
- Review approaches taken for modeling the potential health impacts of climate change


Modeled temperature change
Selected scenario of temperature change to 2100
2020s
2050s
2080s
Temperature (°C)
20
19
18
17
16
15
14
13
1860
1900
1950
2000
2050
2100
Year

WHO 2009

Estimating Future Health Impacts of Climate Change

- Expert judgment
- Simple extrapolation
- Mathematical/statistical modeling
  - Bivariate
  - Multivariate
  - Fully integrated

Mathematical/Statistical Models

- Simplified representation of a more complex, dynamic relationship
  - Reduce complexities and background noise to a simpler mathematical representation
- Necessarily “wrong” (incomplete, simplified), but useful for:
  - Insights into processes
  - Indicative estimates of future impacts
  - Enhancing communication to peers, public, and policy-makers

Models

- Models are useful
  - Consistent framework for structuring scientific knowledge
  - Explore interactions and feedbacks
  - Particularly if the relationship is strong, or involves a clear threshold above which a outcome event is very likely
- Models do not predict
  - Limited knowledge of all factors driving an outcome
  - Policy-makers must understand that models estimate changes in probability
  - Models are difficult to validate

Scenarios

- Coherent, internally consistent depictions of pathways to possible futures based on assumptions about economic, ecological, social, political, and technological development
- Scenarios include:
  - Qualitative storylines that describe assumptions about the initial state and the driving forces, events, and actions that lead to future conditions
  - Models that quantify the storyline
  - Outputs that explore possible future outcomes if assumptions are changed
  - Consideration of uncertainties

Goals of Scenarios

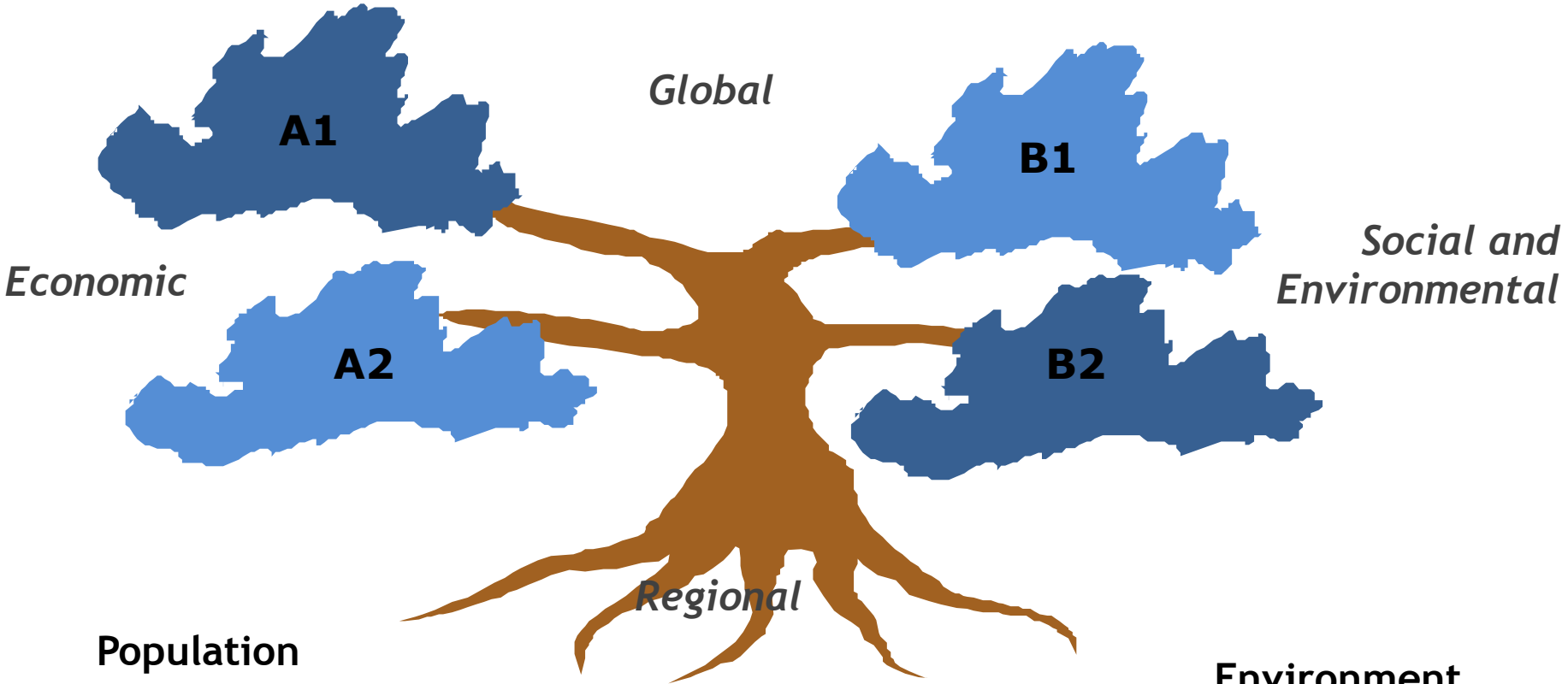
- Provide policy relevant analyses of possible consequences of mitigation policies
- Understand better the potential impacts of climate variability and change
- Facilitate the development and implementation of effective and efficient adaptation strategies, policies, and measures to reduce negative impacts

Standardized Reference Emission Scenarios (SRES)

- IPCC sponsored 40 emissions scenarios for GHGs, sulfur dioxide, and other gases — A1, A2, B1, B2
- The scenarios are published in a Special Report on Emissions Scenarios (SRES)
- Six have been used for detailed climate calculations
  - A1B, A1FI, A1T, A2, B1, B2

Nakicenovic et al. 2000

Standardized Reference Emission Scenarios (SRES)



WHO 2009

Standardized Reference Emission Scenarios (SRES)

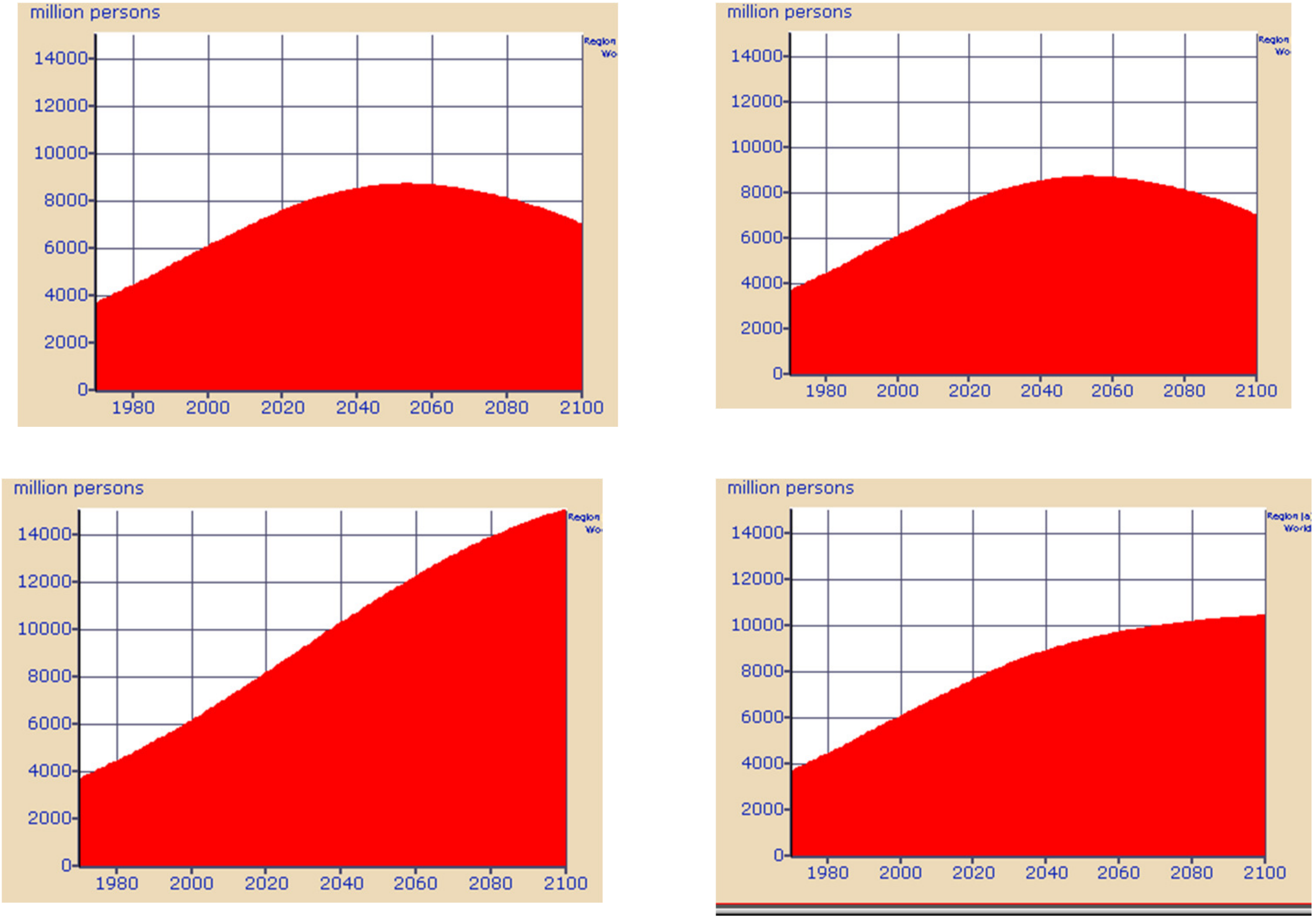
		A	B
	DRIVING THEMES	Economics	Environmentalism
1	Globalization		
2	Regionalization		

SRES: Population Growth

Complete globalization

Emphasis on material wealth

Emphasis on sustainability and equity



Strong regionalization

WHO 2009

Population Projections

- Population projections for the A2 and B2 scenarios were from the UN population projections in 1998 (high and medium projections)
- UN Population Division 2002 Revision included further consideration of the impact of the HIV/AIDS epidemic and projected a lower population in 2050 by 0.4 billion people (total 8.9 billion people; medium growth)
- If correct, there will be 400 million fewer people in 2050 engaging in activities that burn fossil fuels, etc., thus inflating the estimated cumulative CO_2 emissions
- Some demographers attach a probability of more than 90% that actual population will be lower than the trajectory adopted in the A2 scenario

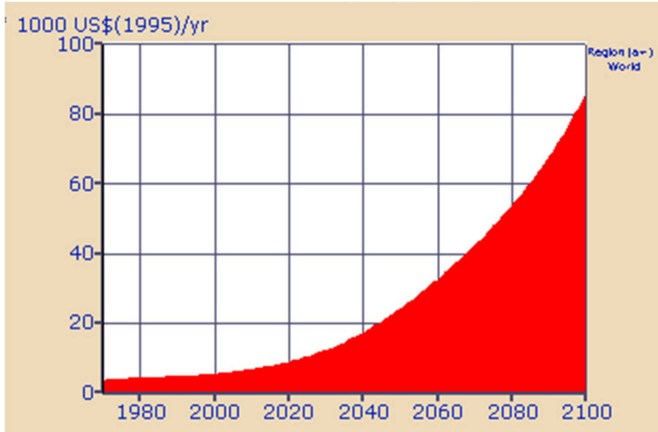
Projections of GDP Depend on:

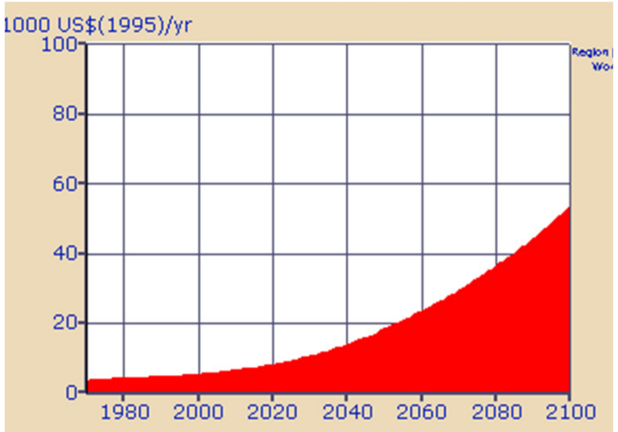
- Assumed rate of population growth
- Specific economic assumptions made about growth and the implementation of technological changes
- Characteristics of the economic model used to project GDP
- Assumptions about future exchange rates

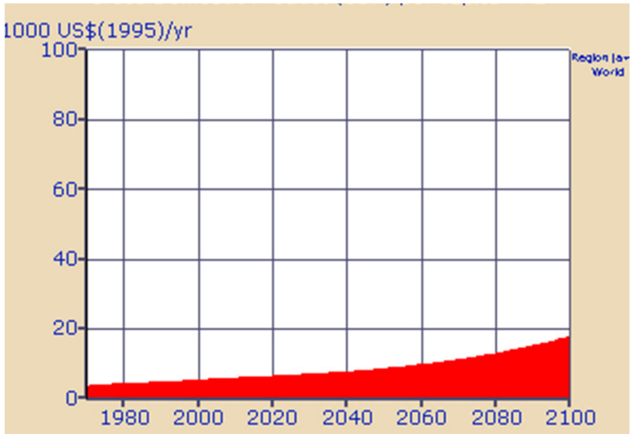
SRES: Economic Growth

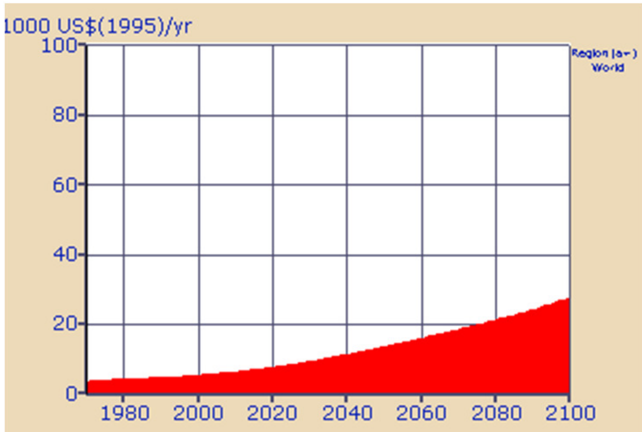
Complete globalization

Emphasis on material wealth









Emphasis on sustainability and equity

Strong regionalization

WHO 2009

Per Capita Income Ratio (High to Low Countries) in SRES

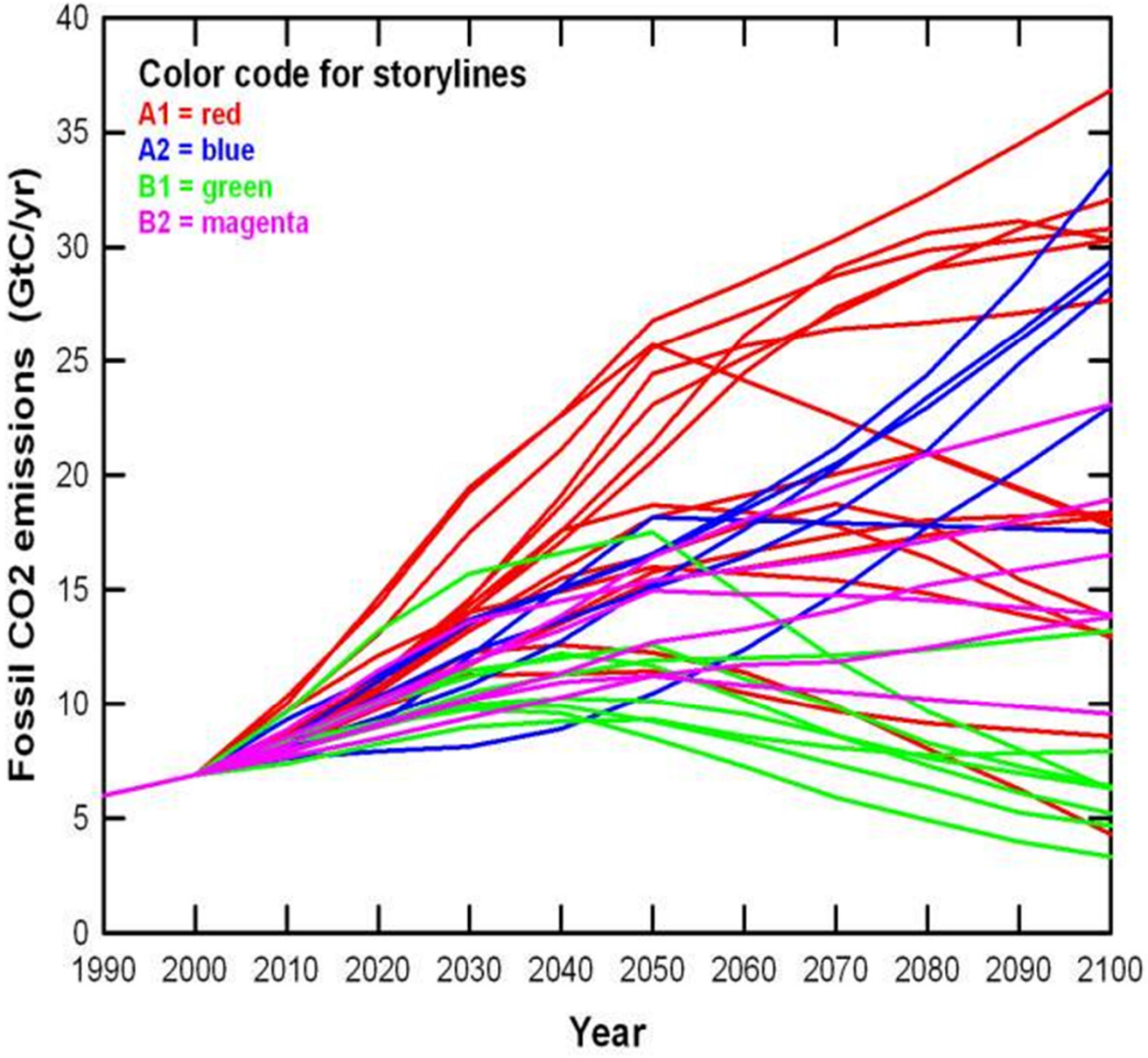
- GDP grows in all countries, from 10- to 26-fold
- There is a narrowing of income differences comparing high income to low income countries

1990	16.1	A1	B2
2020		9.4	7.7
2050		6.6	4.0
2100		4.2	3.0

Economic Growth in SRES

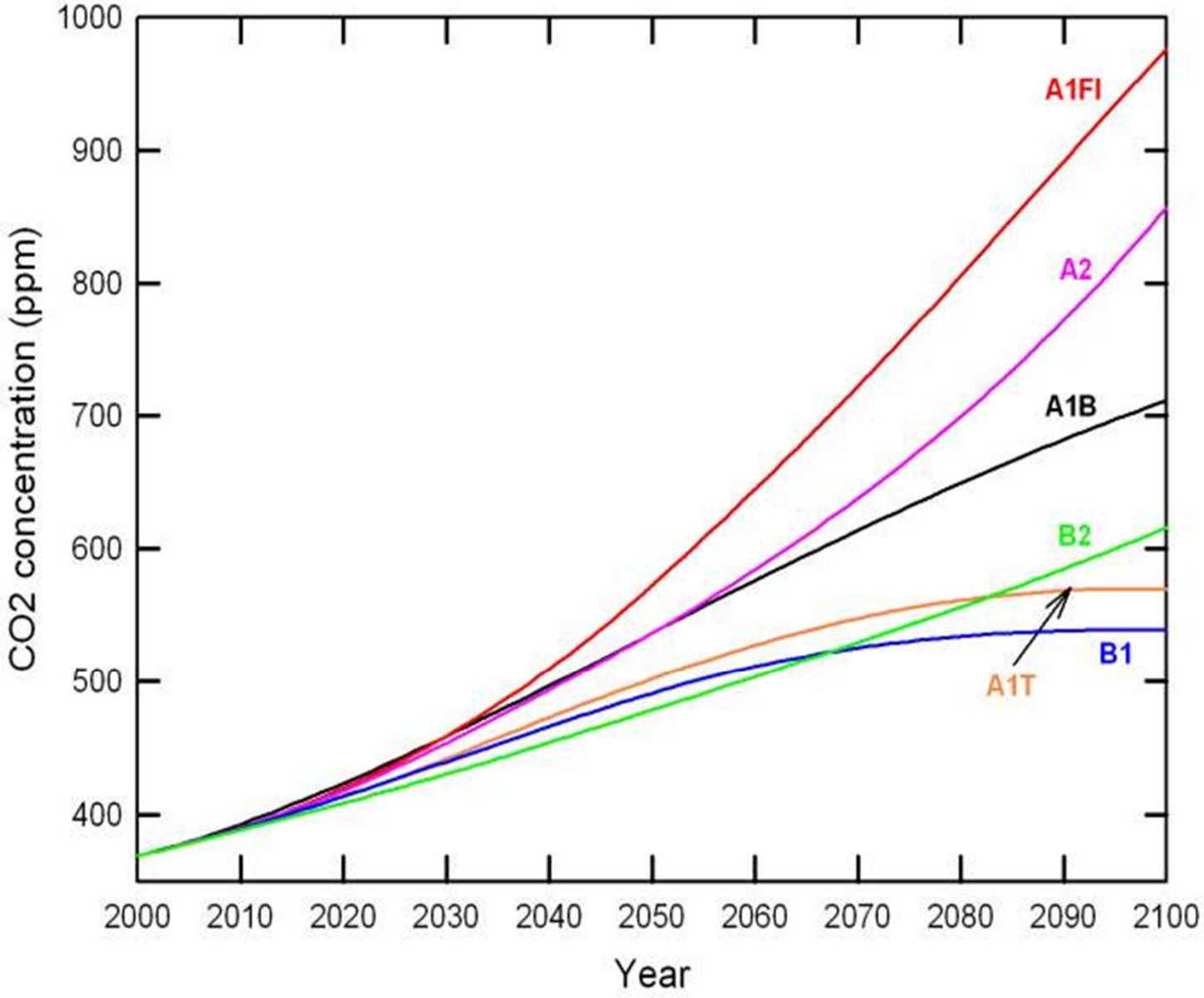
- 1990 income per capita income
  - $900 in low income countries
  - $19,100 in OECD countries
- Projections for low income counties
  - A2 = $3,900 in 2050 to $11,000 in 2100
  - B2 = $8,100 in 2050 to $18,000 in 2100
- Projections for OECD countries
  - A2 = $34,600 in 2050 to $58,500 in 2100
  - B2 = $39,200 in 2050 to $61,000 in 2100

SRES Fossil CO_2 Emissions



WHO 2009

SRES CO_2 Concentration Projections

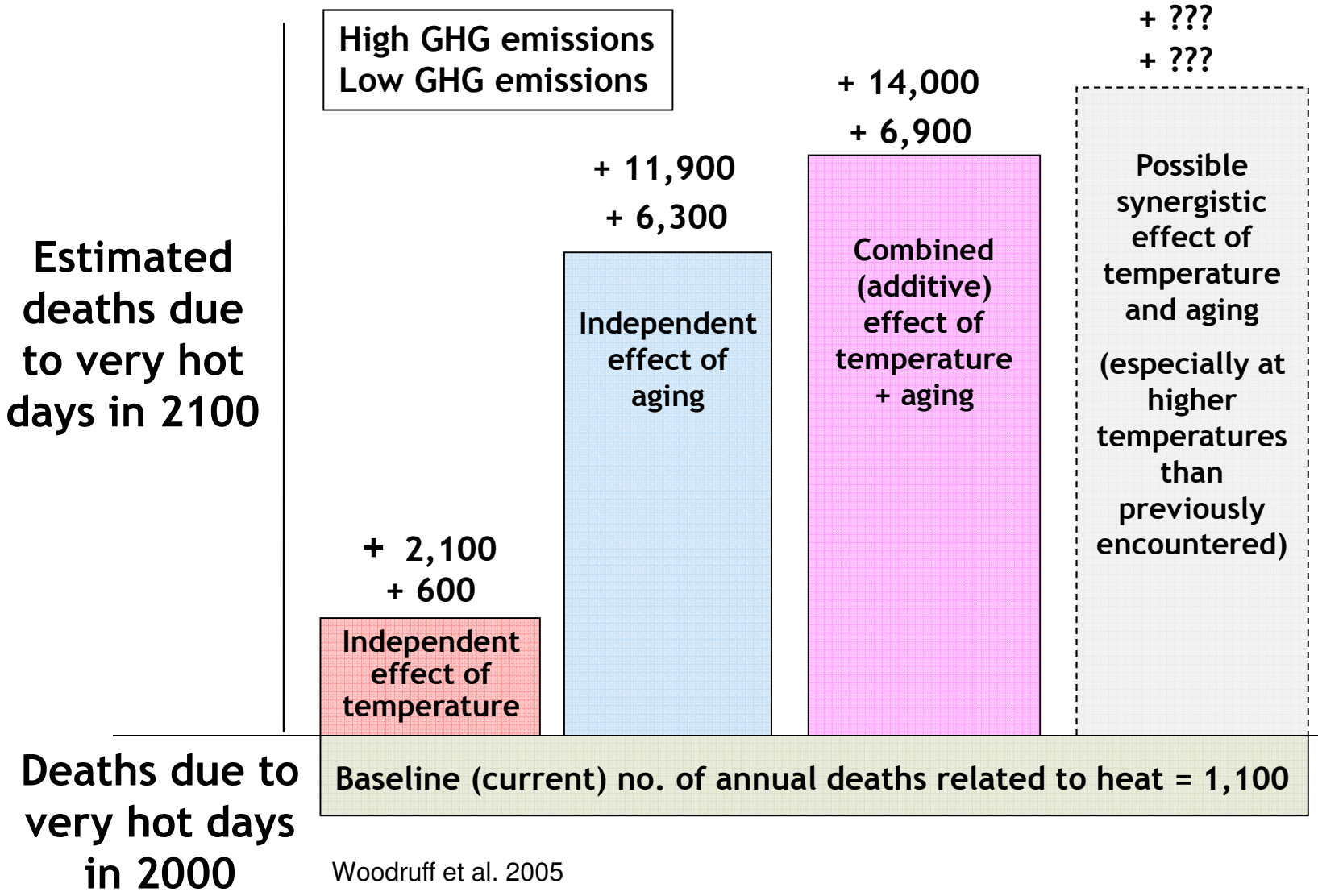


WHO 2009

Sources of Uncertainty

- Full range of “not improbable” futures captured?
- Model uncertainty
  - Were appropriate models chosen?
  - Are assumptions and associations likely to remain constant over time?
  - Rate, speed, and regional extent of climate change
- Policy uncertainty
  - Changes in economic development, technology, etc.
  - How populations in different regions will respond
  - Effectiveness of mitigation and adaptation strategies and policies

Projected Heat-Related Deaths in Adults > 65, Due to Higher Mean Annual Temperatures, Australia 2100



Woodruff et al. 2005

WHO 2009

Malaria in Zimbabwe

Cases by month

Source: South African Malaria Research Programme

Ebi et al. 2005

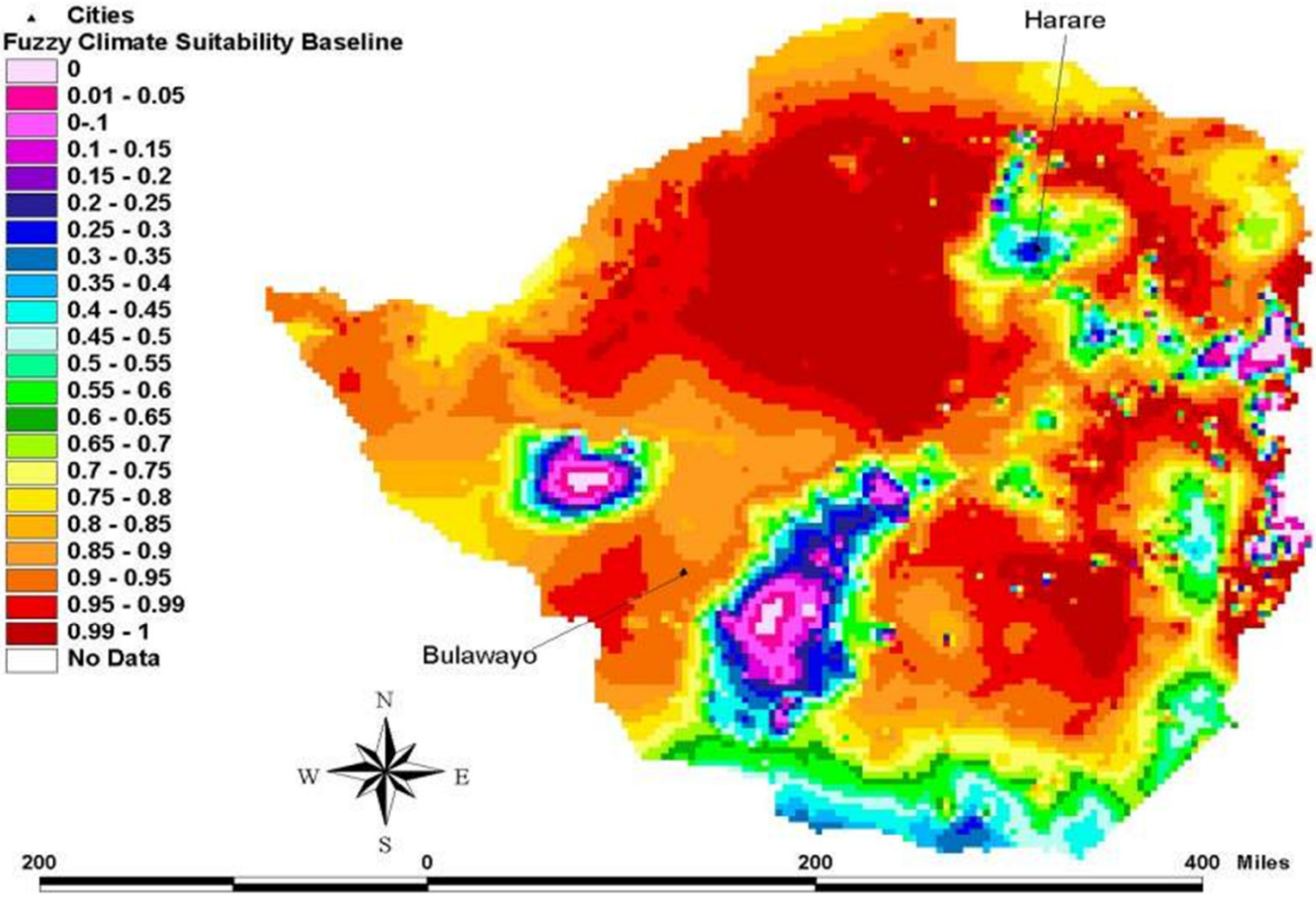
- Patterns of stable transmission follow pattern of precipitation and elevation (which in turn influences temperature)
- > 9,500 deaths and 6.4 million cases between 1989 and 1996
- Recent high-altitude outbreaks

Climate and Stable Malaria Transmission

- Climate suitability is a primary determinant of whether the conditions in a particular location are suitable for stable malaria transmission
- A change in temperature may lengthen or shorten the season in which mosquitoes or parasites can survive
- Changes in precipitation or temperature may result in conditions during the season of transmission that are conducive to increased or decreased parasite and vector populations

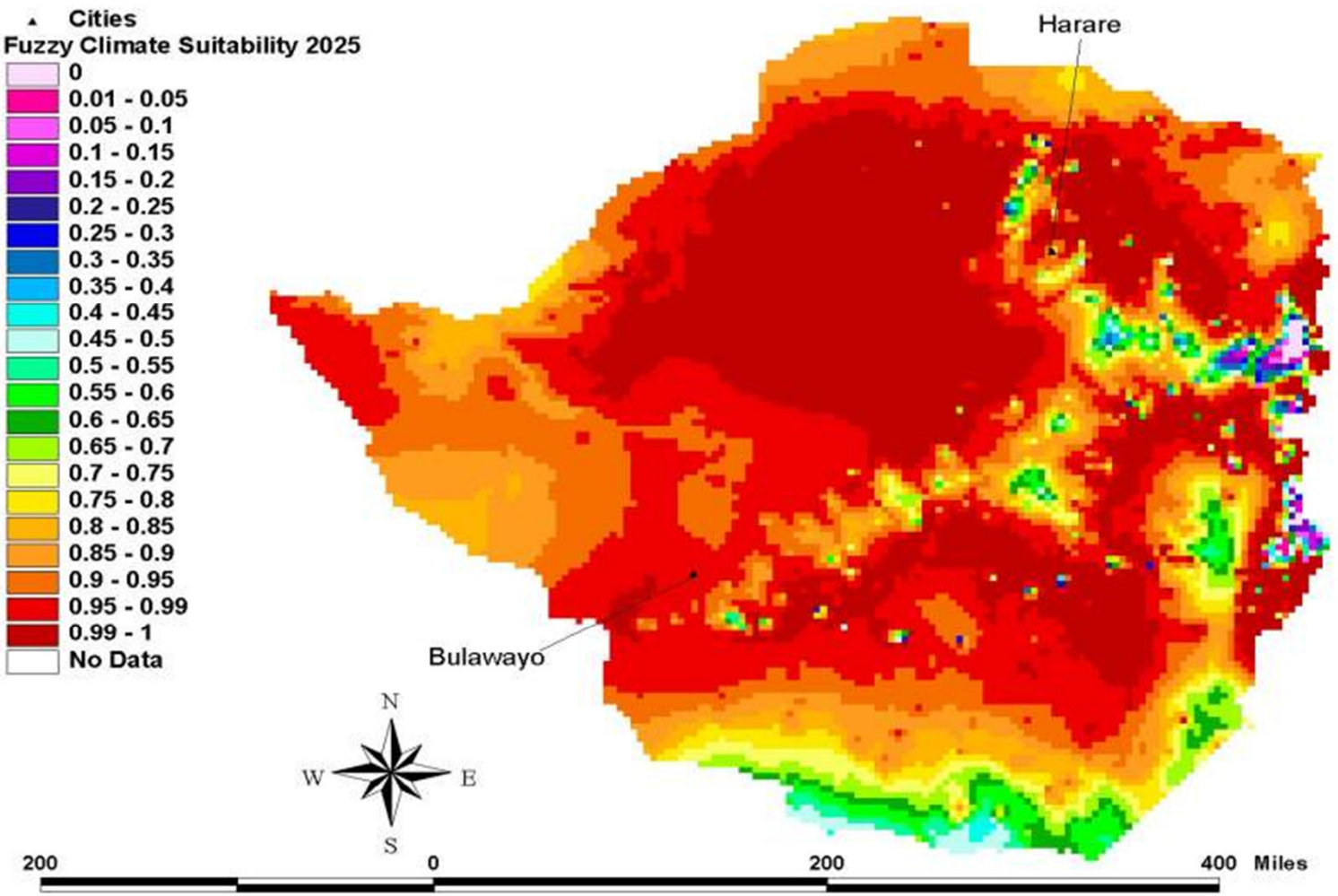
Ebi et al. 2005

Baseline



Ebi et al. 2005

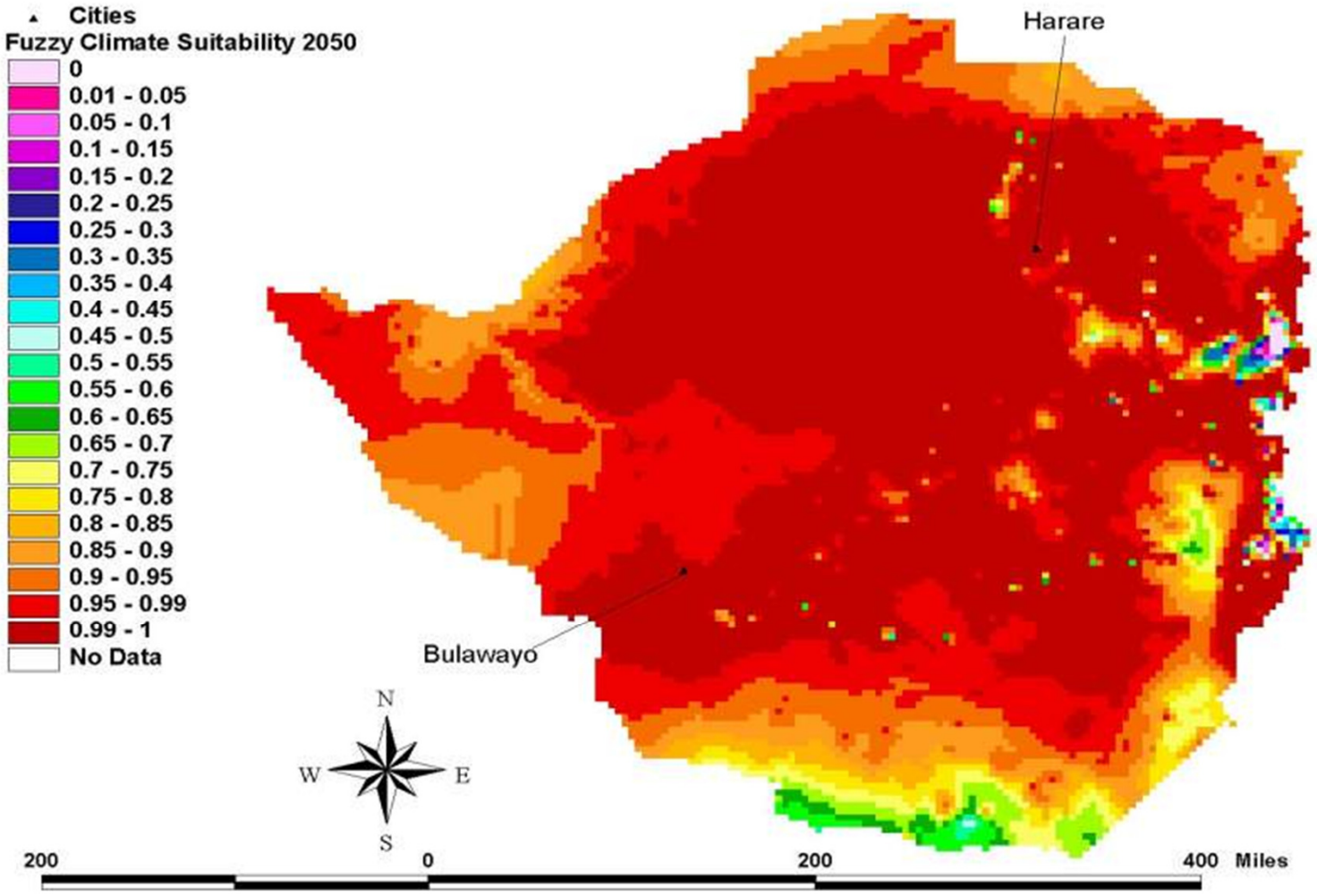
2025



Ebi et al. 2005

WHO 2009

2050



Ebi et al. 2005

Climate Change and Malaria:
SRES Climate and Socioeconomic Scenarios

- MIASMA 2.2
- HadCM3 with A1F1, A2, B1, B2
- 0.5˚ by 0.5˚ grid
  - Downscaled to national level
  - Re-aggregated by region
- Expert judgment of adaptive capacity (SES, current malaria control)

Van Lieshout et al. 2004

Discussion

Questions?

Thoughts?

Concerns?

Suggestions?

http://thefuturebuzz.com/2008/10/13/stunning-images-flickr-creative-commons/

Acknowledgements

- Based in part on lectures developed by the author for courses taught at the University of Michigan, Ann Arbor, MI, USA.

- Some material was modified from the WHO “Training course for public health professionals on protecting our health from climate change (2009).”

- Supported by the Mauritius Ministry of Environment & Sustainable Development (No: MoESD/AAP/02/11)