BASQUE CENTRE
FOR CLIMATE CHANGE
Klima Aldaketa Ikergai

Climate Change and Public Health

Dr. Joseph V. Spadaro
Research Professor, BC^3
Joseph.Spadaro@bc3research.org

Addressing climate change challenges from a multi-disciplinary perspective

Summer School 8th- 10th of July 2013
Palacio Miramar - San Sebastian
Bizkaia (Spain)

EUSKO JAURLARITZA GOBIERNO VASCO

HEZKUNTZA, UNIBERTSITATE ETA IKERKETA SAILA
INGURUMEN, LURRALDE PLANGINTZA, NEKAZARITZA ETA ARRANTZA SAILA

DEPARTAMENTO DE EDUCACIÓN, UNIVERSIDADES E INVESTIGACIÓN
DEPARTAMENTO DE MEDIO AMBIENTE, PLANIFICACIÓN TERRITORIAL, AGRICULTURA Y PESCA

Universidad del País Vasco
Euskal Herriko Unibertsitatea

ikerbasque
Basque Foundation for Science

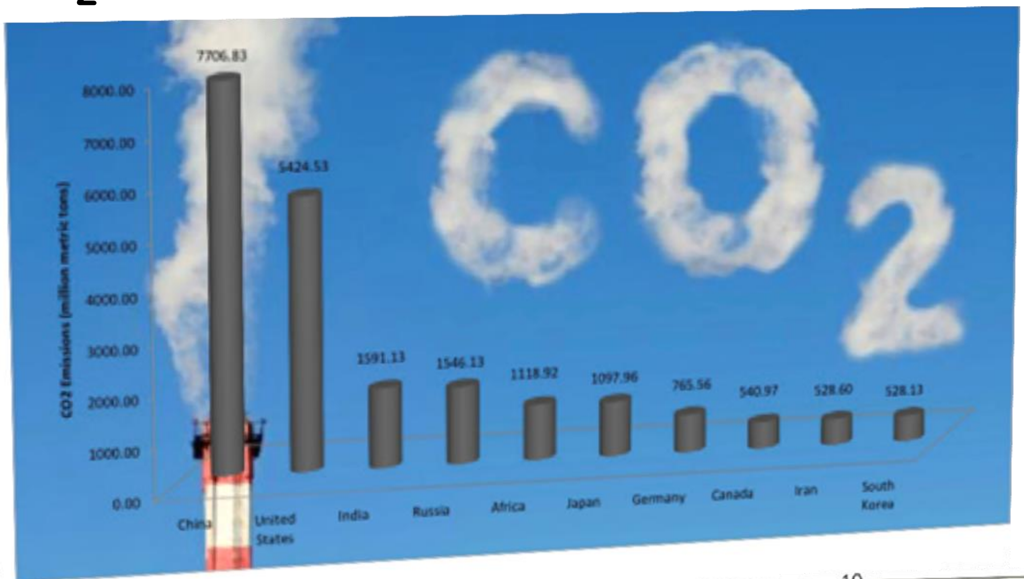
ihobe

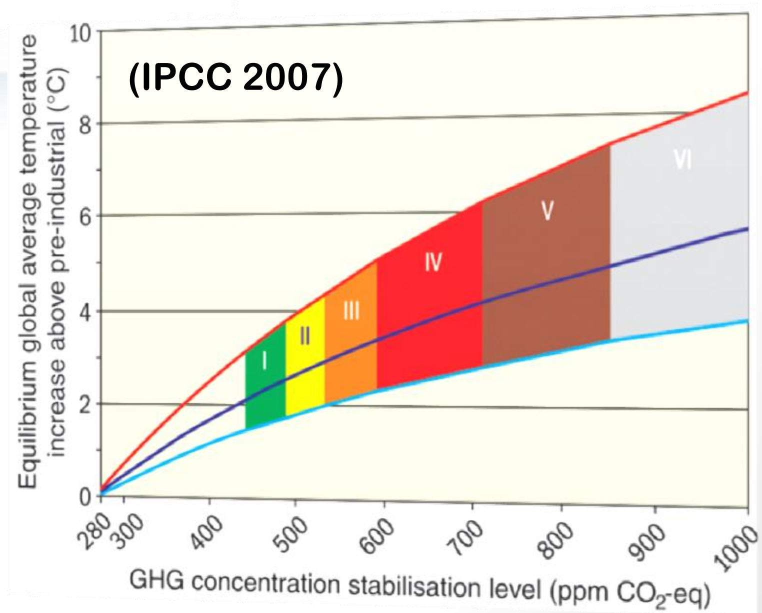
Objective and Outline of Presentation

The aim of this talk is to present a synthesis of the current and projected health burdens of climate change and costing of adaptation measures to climate change with emphasis on health protection.

- CO_2 emissions and climate change
- Observations and 21st century projections
- Adapting to a changing climate

1. CO_2 Emissions and Climate Change

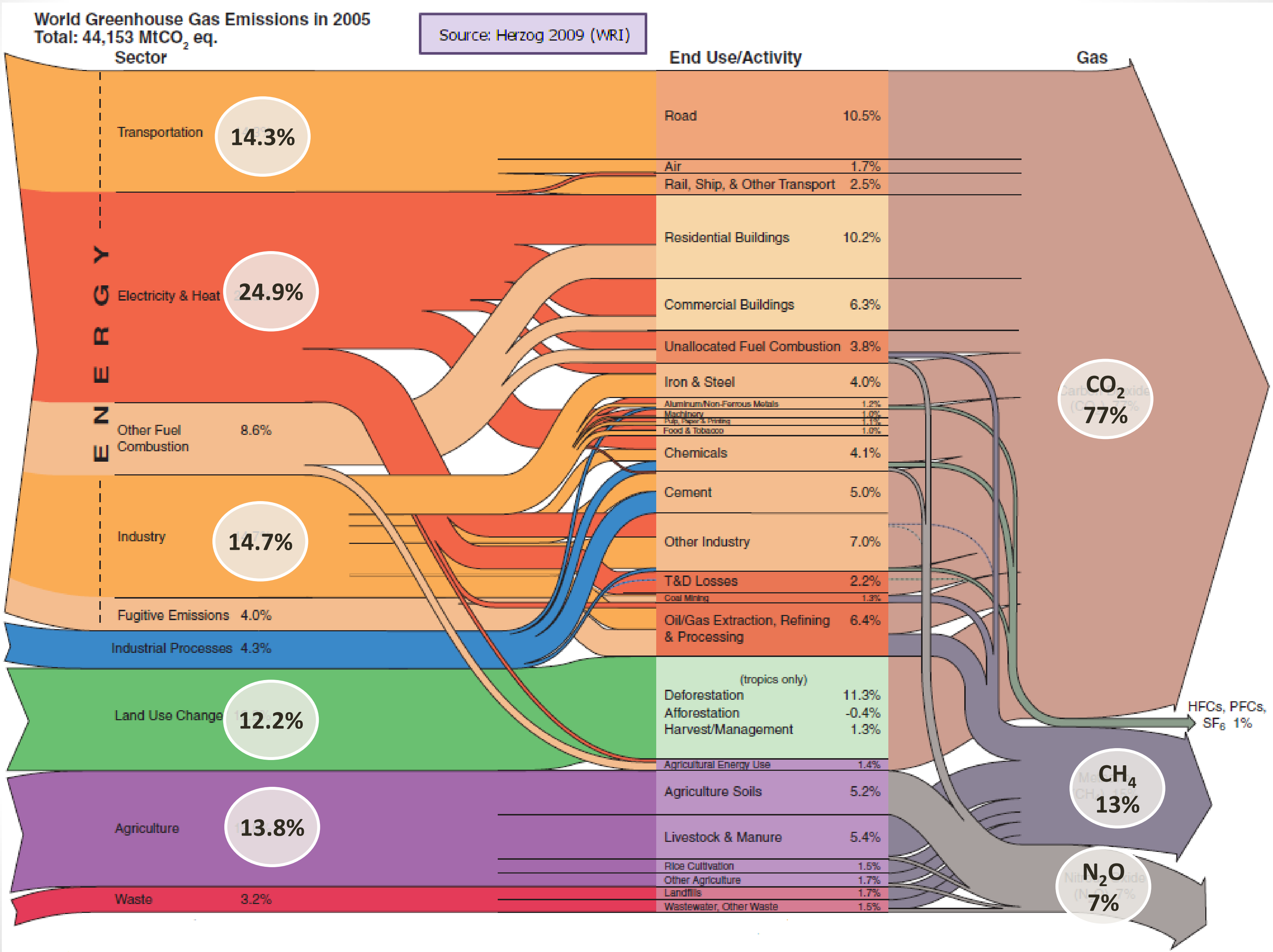




3

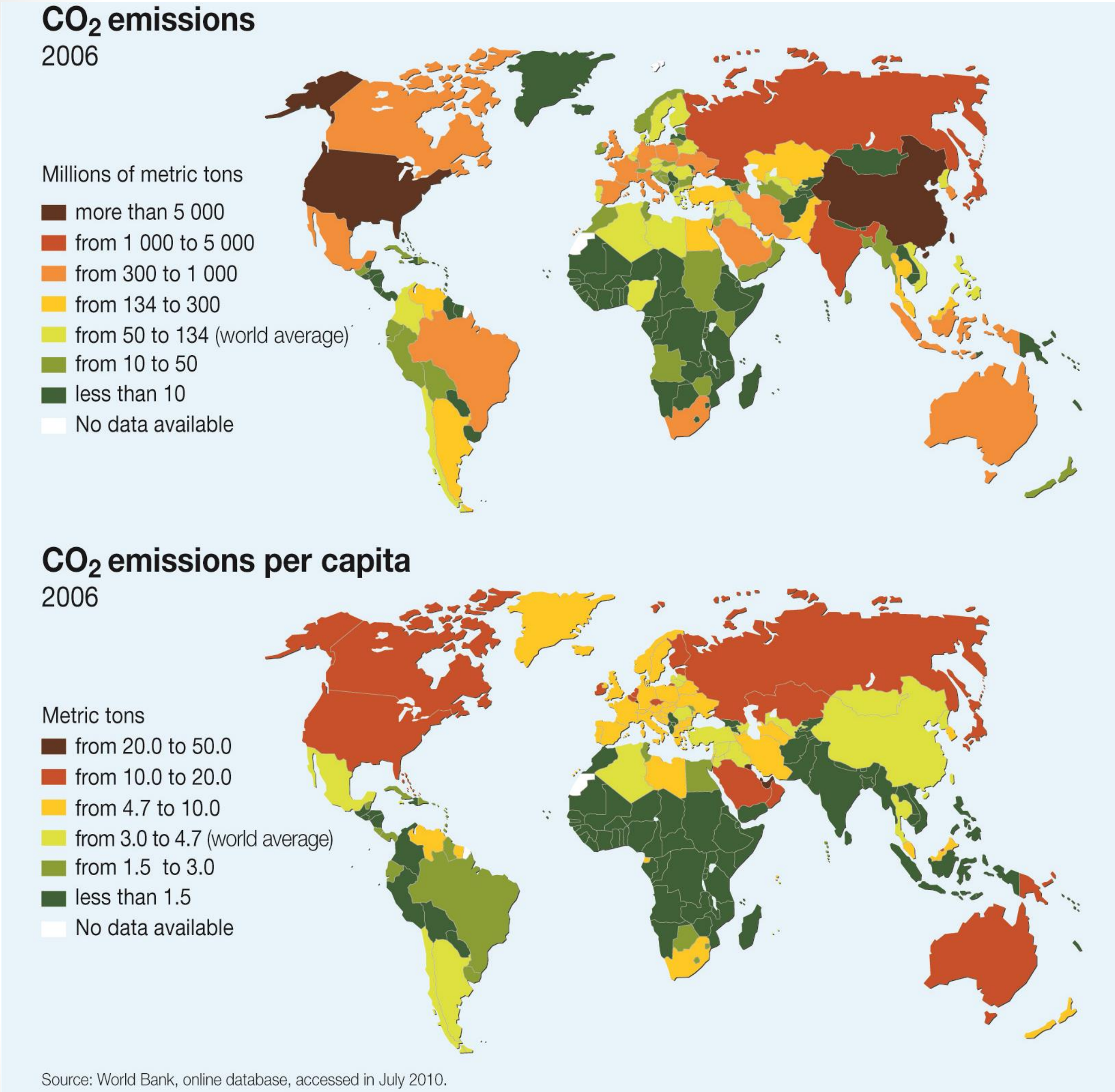
bc³

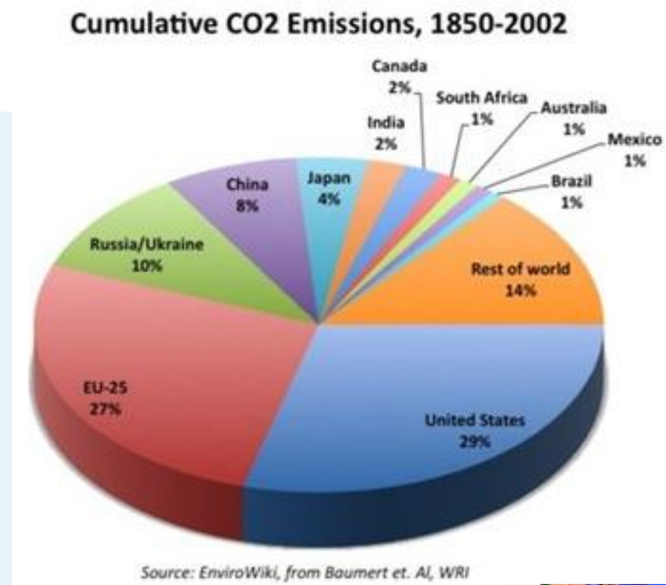
Global GHG Emissions in 2005 – 44 $GTCO_{2,eq}$



bc³

CO_2 Emissions



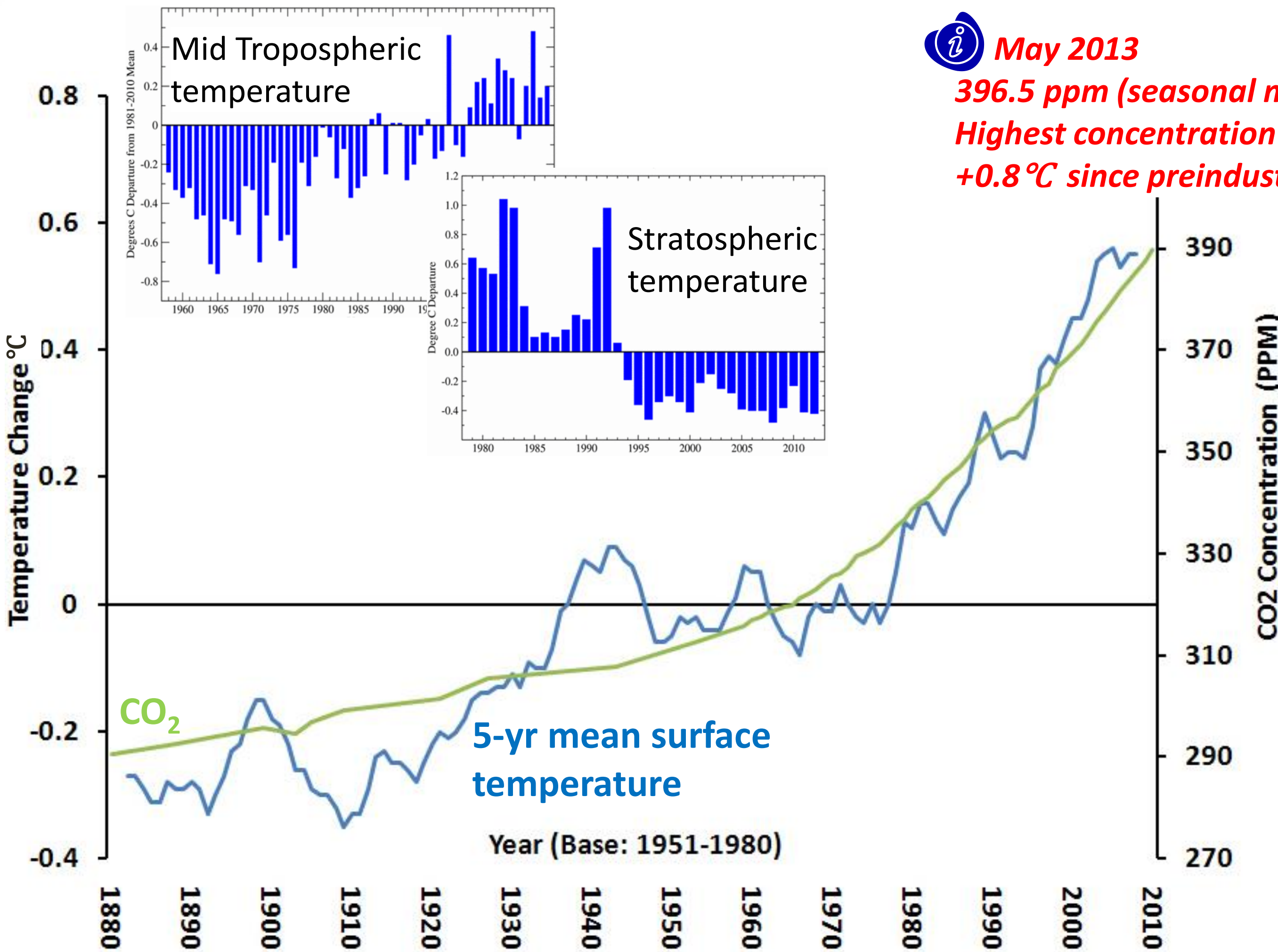


Country	CO_2 emissions	Population	Emission / Person
World	33,508,901	6,852,472,823	4.9
China	8,240,958	1,339,724,852	6.2
United States	5,492,170	312,793,000	17.6
India	2,069,738	1,210,193,422	1.7
Russia	1,688,688	142,946,800	11.8
Japan	1,138,432	128,056,026	8.9
Germany	762,543	81,799,600	9.3
Iran	574,667	75,330,000	7.6
South Korea	563,126	48,875,000	11.5
Canada	518,475	34,685,000	14.9
Saudi Arabia	493,726	27,136,977	18.2
United Kingdom	493,158	62,262,000	7.9
Indonesia	476,557	237,424,363	2.0
Mexico	466,131	112,322,757	4.1
South Africa	451,839	50,586,757	8.9
Brazil	419 537	190,732,694	2.2
Italy	407 924	60,681,514	6.7
Australia	365 513	22,794,166	16.0
France	362 556	65,821,885	5.5
Poland	309 985	38,186,860	8.1

Source: CDIAC 2010

Since 1959, 350 GTC (1280 $GTCO_2$) have been emitted, of which 55% have ended up in land and oceans

Temperature Trends and CO_2 Concentration



May 2013
396.5 ppm (seasonal mean); ~ 2 ppm/yr
Highest concentration in the last 15M years
+0.8℃ since preindustrial levels (mid 19th)

Preindustrial: 260 to 280 ppm CO_2

Looking ahead: +2.3 to 4.5℃ (IPCC 2007, SRES)
+1.6 to 4.7℃ (RCP, WB 2012)
above preindustrial temperatures
(best guesses)

Source: NASA-GISS, CDIAC, NOAA ESRL

bc³

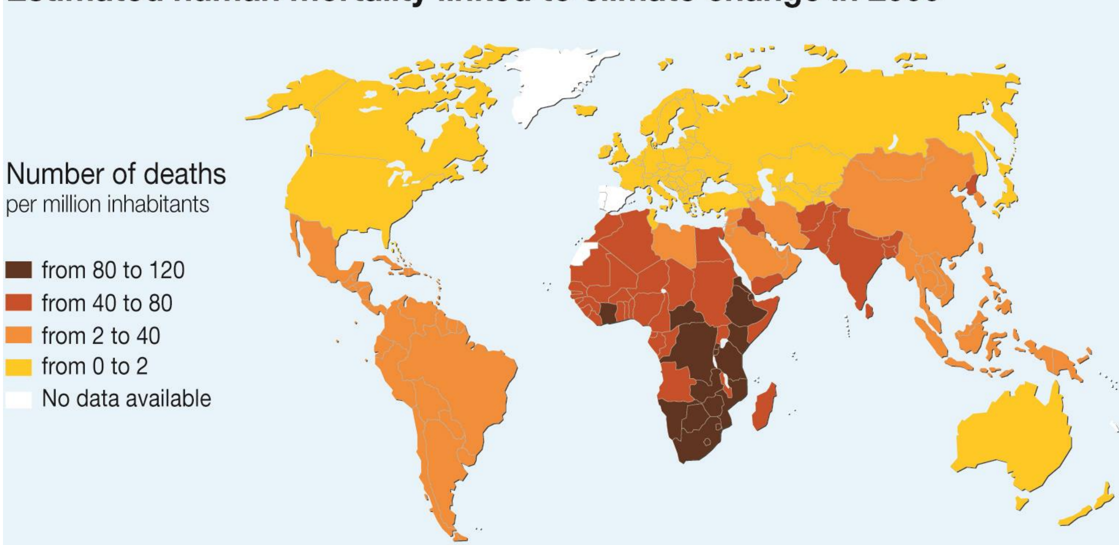
Health Burdens of Climate Change
Deaths by cause in the year 2000

	Number of deaths and disease burden (DALYs) in thousands							All causes	
WHO region	Diarrhea		Malaria		Malnutrition		Temperature	Total per 10^6 people	
	Deaths	DALYs	Deaths	DALYs	Deaths	DALYs	Deaths†	Deaths	DALYs
Africa	13	414	23	860	17	616	2	90	3,067
Americas	1	17	< 1	3	–	–	1	5	117
Eastern Mediterranean	8	291	3	112	9	313	1	42	1,586
Europe	< 1	9	–	–	–	–	< 1	< 1	18
Southeast Asia	23	640	–	–	52	1,918	8	56	1,704
Western Pacific	2	89	1	43	–	–	< 1	2	104
Total	**47**	**1,459**	**27**	**1,018**	**77**	**2,846**	**12**	**28**	**925**

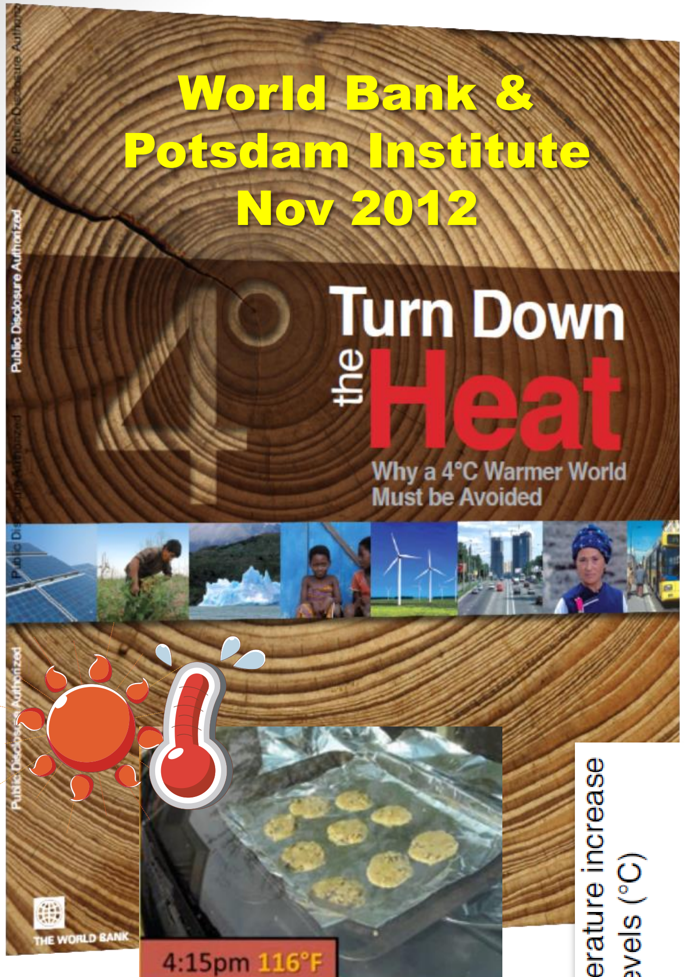
Source: Adapted from McMichael et al., 2004

- Deaths account for 2-3% of current burden, and are expected to double or triple by 2030 (UNFCCC 2007).
- Disability adjusted life years (DALY) measures disease burden due to ill-health, disability and premature death
- † Cardio-Vascular Disease temperature-related advanced (premature or displaced) deaths (acute mortality). Estimates do not include the mortality burden associated with indirect effects of extreme temperatures. Heat-related displaced deaths for the 2003 heatwave in France contributed only a modest share of the total heatwave mortality burden.

Estimated human mortality linked to climate change in 2000



Source: ECLAC, *Climate Change and development in Latin America and the Caribbean. Overview 2009*, on the basis of WHO, *Climate Change and Human Health. Risks and Responses. Summary*, 2003.



Hot enough to bake cookies in car!
(2013 US heatwave)

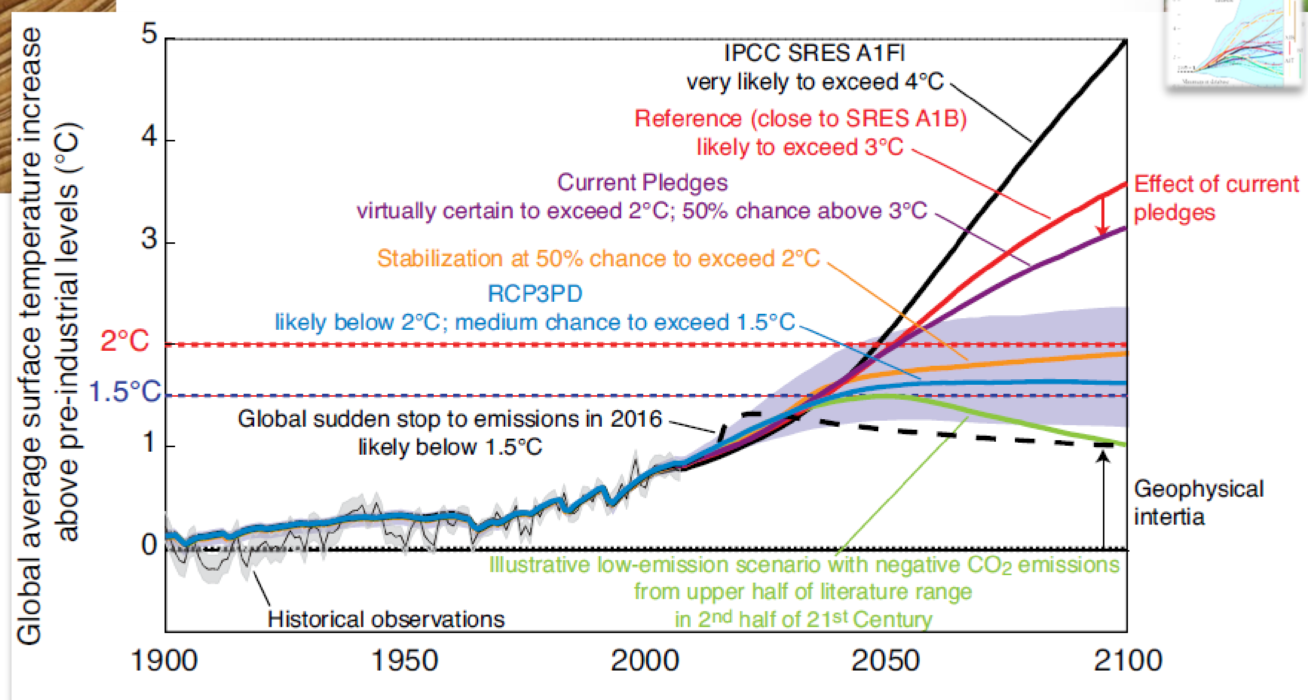
"Without further commitments and actions to reduce (GHG Emissions), the world is likely to warm by more than 3°C above the preindustrial climate."

"Even with the current mitigation commitments and pledges fully implemented, there is roughly a 20 percent likelihood of exceeding 4°C by 2100."

"If they are not met, a warming of 4°C could occur as early as the 2060s. Such a warming level and associated sea-level rise of 0.5 to 1 meter, or more, by 2100 would not be the end point: a further warming to levels over 6°C, with several meters of sea-level rise, would likely occur over the following centuries."

25% prob. to exceed 2°C by 2050 if emissions capped at 1000 $GTCO_2$ between 2000-2050

(Meinshausen et al., Nature, 458, April 2009)



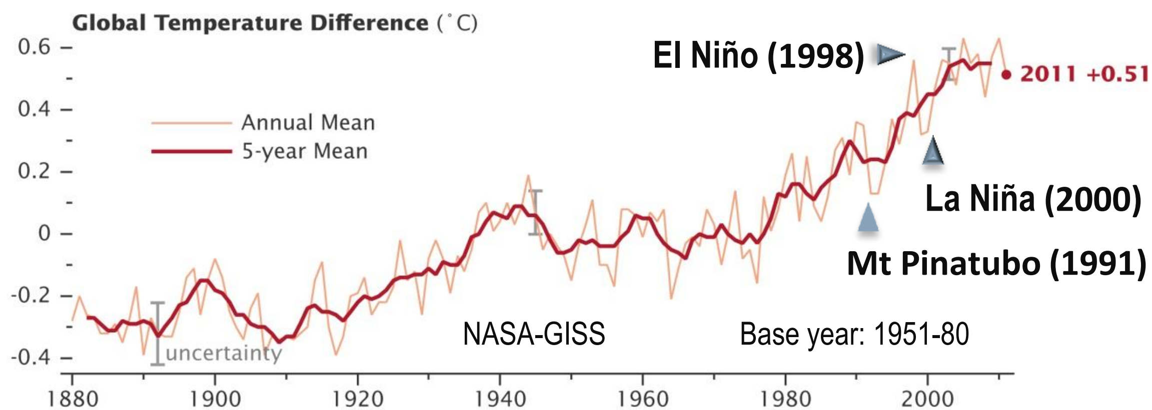
2. Observations and 21ST Century Projections

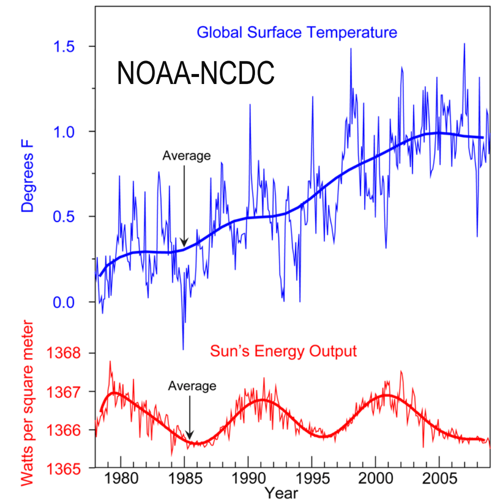
bc3

The Earth's Climate System is Changing!

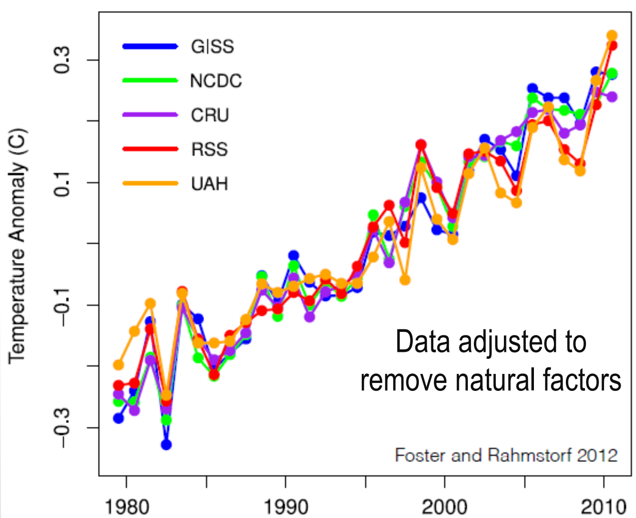
The planet is warming up. While there are a number of **short-term** influences on the climate system, such as solar variability, changing atmospheric aerosols due to volcanic activity and natural variability (e.g., ENSO), it is increasingly clear that **long-term** warming can be attributed to increasing GHGE from human activities.

ΔT ≈ 0.8°C since mid 1800's





Human-induced forcing



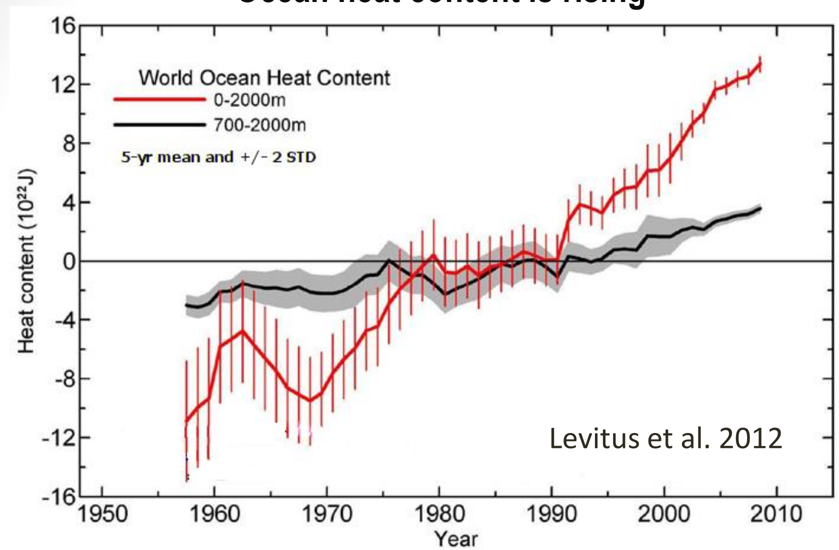
Projections: Without further commitments to reduce CO_2 emissions and assuming current pledges are implemented, it is virtually certain global mean temperature will exceed 2°C, the limit to avoid undesirable consequences of climate change. In fact, there is a 50% of exceeding 3°C , and 20% likelihood of temperature reaching as high as 4°C by 2100.

A global mean temperature change of 4°C is similar in magnitude to the difference between today's temperatures and those existing during the time of the last ice age (4.5°C to 7°C lower than today).

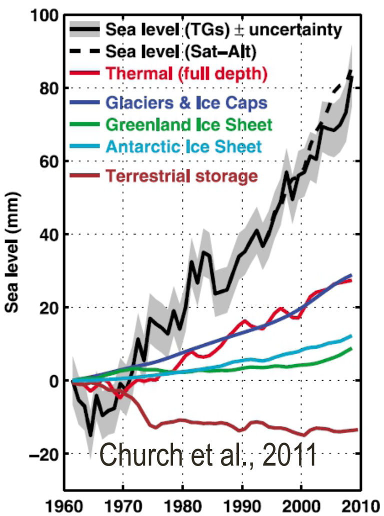
bc³

Other Indicators of Change

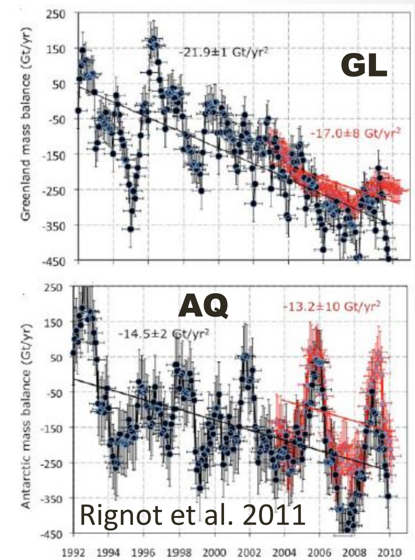
Ocean heat content is rising

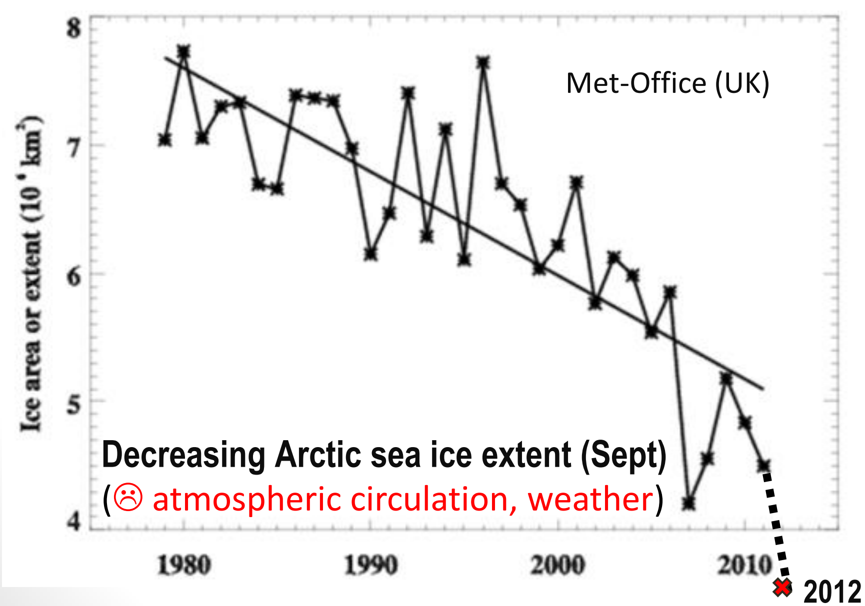


Rising global sea level



Continued ice sheet loss





Decreasing Arctic sea ice extent (Sept)
(☹ atmospheric circulation, weather)

- 93% of the additional heat absorbed by the earth system due to increasing GHGs has been stored in the oceans (☹ increase in sea-level, MeHg in fish).
- In the future expect further changes in ocean salinity (☹ disruption of thermohaline circulation), acidity (☹ coral reefs, other marine biota), heat content (☹ impact to biodiversity, rise in sea, O_2 concentration, stratification).
- Further ice-melt (land-ice, arctic ice & ice-sheets) will increase sea-level: 1.7 cm/decade in 20th century and 3.2 cm/decade in the 1990s. (☹ coastal populations at risk, damage to property and landscape, inundation)

bc³

The 2003 European Heatwave

Box 2: Lessons from the 2003 heat event in France

A severe heat event in August 2003 resulted in an estimated 14 800 excess deaths in 13 French cities. Metéo France issued warnings to the media, but authorities' awareness of the heat-wave's health impacts was delayed. The common heat-related causes of this large number of deaths, mostly in the elderly, were not detected promptly because data from emergency and medical services and from death certificates were not commonly used for rapid detection. An inquiry by the General Directorate of Health (DGS) concluded that the 2003 heat event was unforeseen and only detected belatedly, and highlighted deficiencies in the French public health system, including too few experts, lack of preparation for a heat event, poor definition of responsibility across public organizations and weak information exchange mechanisms.

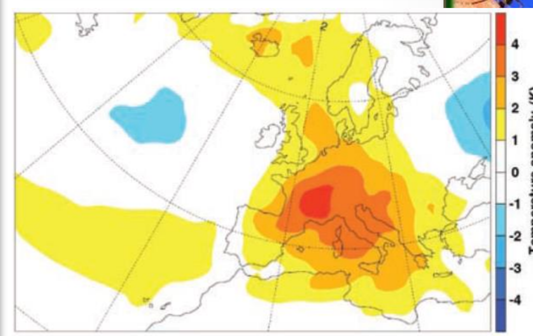
It was further noted that health authorities and crematoria and cemeteries were overwhelmed by the influx of patients and bodies; few nursing homes were equipped with air-conditioning; and a large number of elderly people were living alone without a support system and without guidelines for appropriate responses to a heat event *(9–10)*.

Since 2003, the French government has formulated short and medium-term actions to reduce health impacts from heat events, including the development of a national heat health warni[…] sponsoring research on the risk factors associated with heat-event-related […] health and environmental surveillance programme, and developing nati[…] heat events *(9)*.

Source: Health and climate change: The "now and how", A policy action guide, 2005

Western Europe: 35,000 deaths

Country	Excess mortality
Baden-Württemberg, Germany	1410
Belgium	Not significant
England and Wales	2091
France	14802
Italy	9704
Portugal	1854
Spain	3166
Switzerland	960
The Netherlands	650



Crop losses: 13 B€
Sénat, 2004

Join us for a glass of iced tea!

ADAPTATION RESPONSES

- ✓ Research on health risks
- ✓ Surveillance & Action
- ✓ Preparedness & Resources
- ✓ Communication, Coordination & Social support

Climate-Related Health Costs: US Price Tag from Six Events, 2002-09 ($\$_{2008}$)

Source: Knowlton K et al., 2011. Health Affairs 30(11)

Heat wave (2006):
655 premature deaths
1,620 hospitalizations
16,000 ER visits

Over a two-week heat wave, 655 deaths, 1,620 hospitalizations, and more than 16,000 excess emergency room visits, resulted in nearly \$5.4 billion dollars in costs. Major heat waves such as this are expected to occur more frequently in the future.

Wildfires (2003):
69 deaths
778 hospitalizations
47,600 doctor visits

These fires burned more than 736,000 acres and resulted in 69 deaths, 778 hospitalizations, and more than 47,600 outpatient visits. Together, this resulted in health-related costs exceeding \$578 million. Conditions conducive to wildfires, including drought and extreme heat, are expected to worsen in many parts of the country due to climate change.

During the Red River and associated floods, two deaths, 263 emergency room visits, and an estimated 3,000 outpatient visits resulted in nearly \$20.4 million in health-related costs. Seasonal river flooding will increasingly affect many areas of the country, resulting in more injuries and deaths. Increased heavy downpours are projected from climate change as temperatures rise, raising levels of both evaporation and precipitation in many areas.

Flooding (2009):
2 premature deaths
263 ER visits
3,000 doctor visits

Across the U.S. in 2002, nearly 288 million Americans were exposed to ozone smog levels above the health-based standard, which was then 80 ppb. This exposure hastened death for 795 people, and caused 4,150 hospitalizations and more than 365,000 outpatient visits, at a cost of \$6.5 billion. Smog levels are anticipated to rise in the coming years, in the absence of strategies to reduce precursor emissions, because as climate change increases temperatures, ozone-forming chemical reactions also increase.

Ozone (2002):
795 premature deaths
4,150 hospitalizations
365,000 doctor visits

Four major hurricanes caused 144 premature deaths, nearly 2,200 hospitalizations, 2,600 emergency room visits, and \$1.4 billion in health-related costs. Climate change is projected to increase the intensity of hurricanes, as sea surface temperature rise in the North Atlantic and provide more energy to drive storm systems. Some climate models project a doubling in the most intense hurricanes (Category 4 and 5) by late in this century.[5]

Hurricanes (2004):
144 premature deaths
2,200 hospitalizations
2,600 ER visits

...ak of West Nile Virus in Louisiana in 2002 ... an estimated 24 premature deaths, 204 ...tions, and nearly 5,800 outpatient visits. ...ated costs totaled \$207 million. Mosquito-borne ...re expected to emerge and spread into more ...limates as temperatures increase and create ...table environments for mosquitoes.

VBD(2002):
24 premature deaths
204 hospitalizations
5,800 doctor visits

Table 1. Health costs in climate change-related case study areas, with costs per health effect, 2002 through 2009.

Climate Change-Related Case Study	Premature Death	Illness	Total Health Cost by Case Study
Ozone smog pollution	\$6.3 Billion	\$254 Million	\$6.5 Billion
Heat wave	\$5.2 Billion	\$179 Million	\$5.3 Billion
Hurricane	\$1.1 Billion	\$255 Million	\$1.4 Billion
Wildfire	\$545 Million	\$34 Million	\$578 Million
Mosquito-borne infectious disease	\$190 Million	\$18 Million	\$207 Million
River flooding	\$16 Million	\$5 Million	\$20 Million
Total costs (in U.S. dollars, 2008)	\$13.3 Billion	\$744 Million	\$14.1 Billion

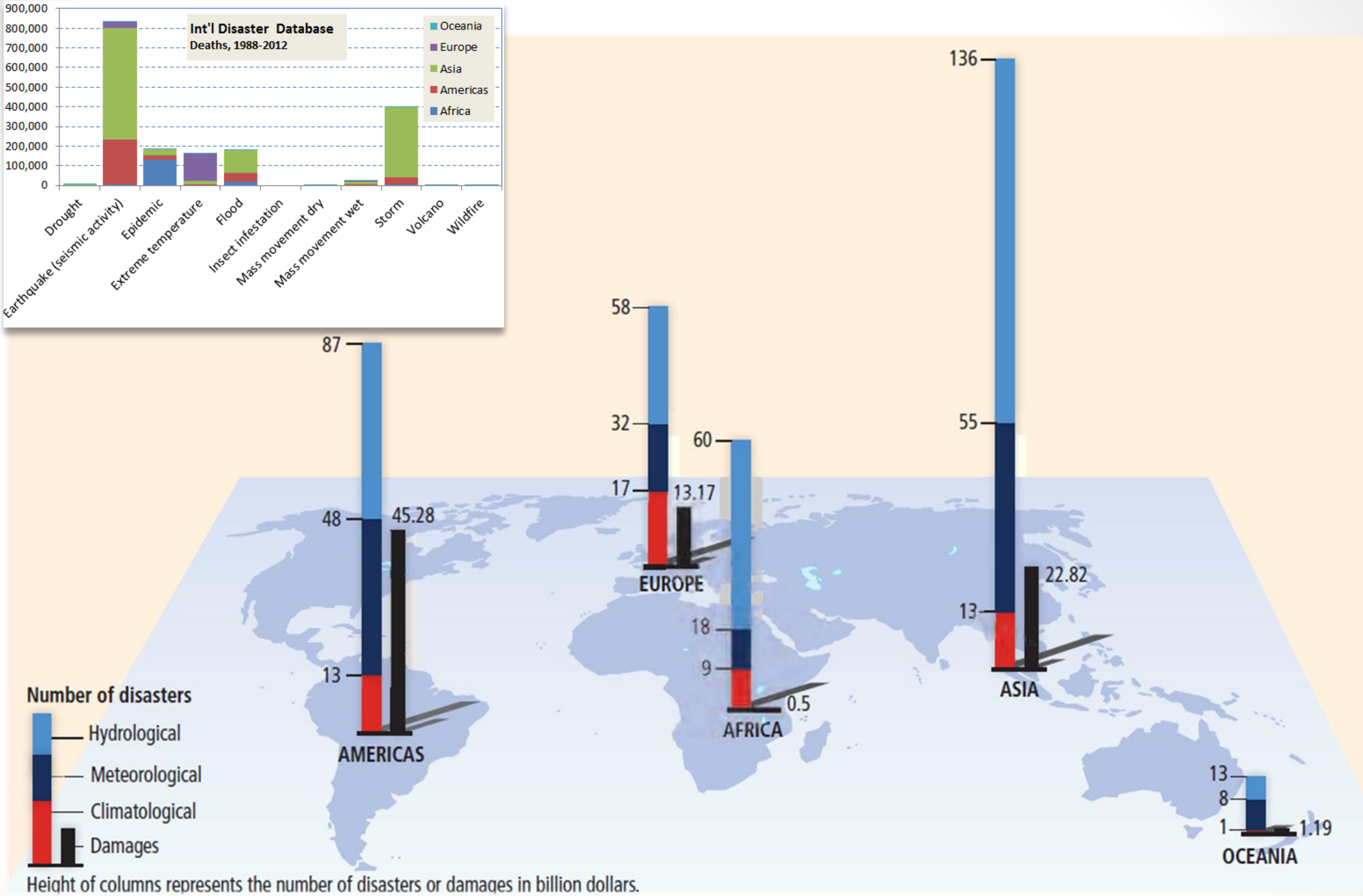
Damage cost	B\$/yr
Obesity	147-190
Alcohol	185
Drug use	181
Traffic accidents	180
Smoking	158
Air Pollution	
Electricity (coal)	62
Transport	56
Natural disasters	35
Deaths	3

Estimates from various sources

Katrina (2005) (NOAA 2011)
1,800 deaths (≈14B\$)
Total damage ≈108B\$

bc³

Health Damage Costs ($_{2009}$) of Natural Disasters by Region, 2000-08








Hydrological: Floods & Landslides
Meteorological: Storms, etc.
Climatological: Extreme temperature, droughts & wildfires
% GDP: 1% rapidly developing, 0.3% low-income & 0.1% high income

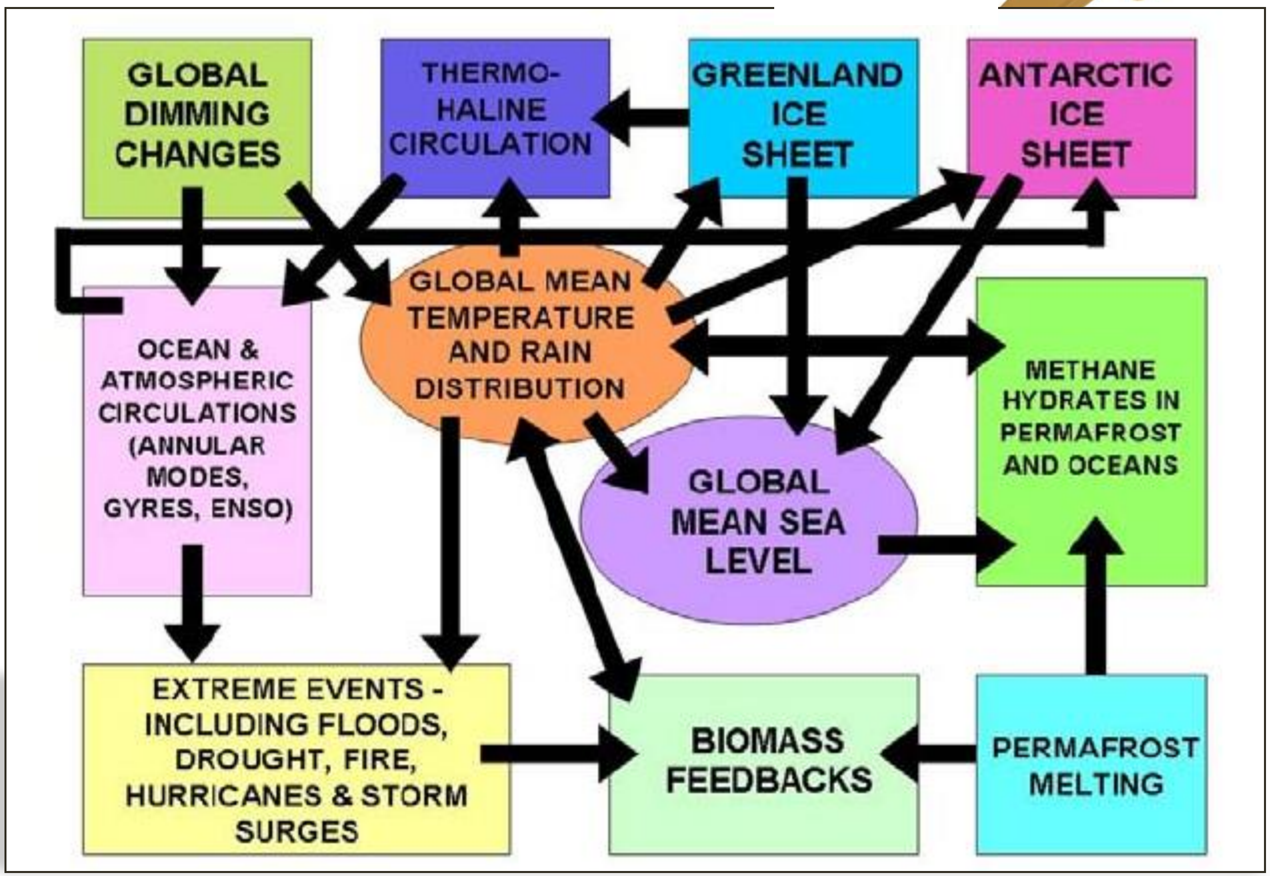
Source: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation, Special Report of the Intergovernmental Panel on Climate Change, March 2012

The Economic Costs of Climate Change

Source	Estimates
Tol et al. 2004	Global annual burden of 300 to 350B$ (1% of world GDP)
World Bank 2006	Without adaptive measures, economic costs 0.5% to 2% of world GDP for a 2.5 deg C temperature increase
De Bruin et al., 2009	Strong regional disparities, with India and Africa especially impacted. Health effects dominate damage costs in Africa (75% of total) (4-5% GDP loss), whereas damages in India arise from agricultural losses, health effects and from extreme weather events (4-5% GDP loss).
Ciscar et al., 2009	2020 – health burden range 13 to 30 B€$_{2005}$ 2100 – health burden range 50 to 180 B€$_{2005}$ (w/o adaptation) 2100 – health burden range 8 to 80 B€$_{2005}$ (incl. adaptation)
IPCC 2007	Economic value of loss of life – 6 to 88 B\$$_{1990}$
Climate Vulnerability Monitor, 2nd Ed. 2012	2010 – 400,000 deaths are attributed to climate change, mostly affecting children in developing countries (malnutrition accounts for more than half of this cost); estimated health cost is 23 B$ (2010 PPP); total cost (incl. labor productivity losses due to hotter temperatures) reaches 700 B$, or 0.9% of world GDP. 2030 – 700,000 deaths (106 B$, 2010 PPP), total = 4400 B$ (2.1% GDP)

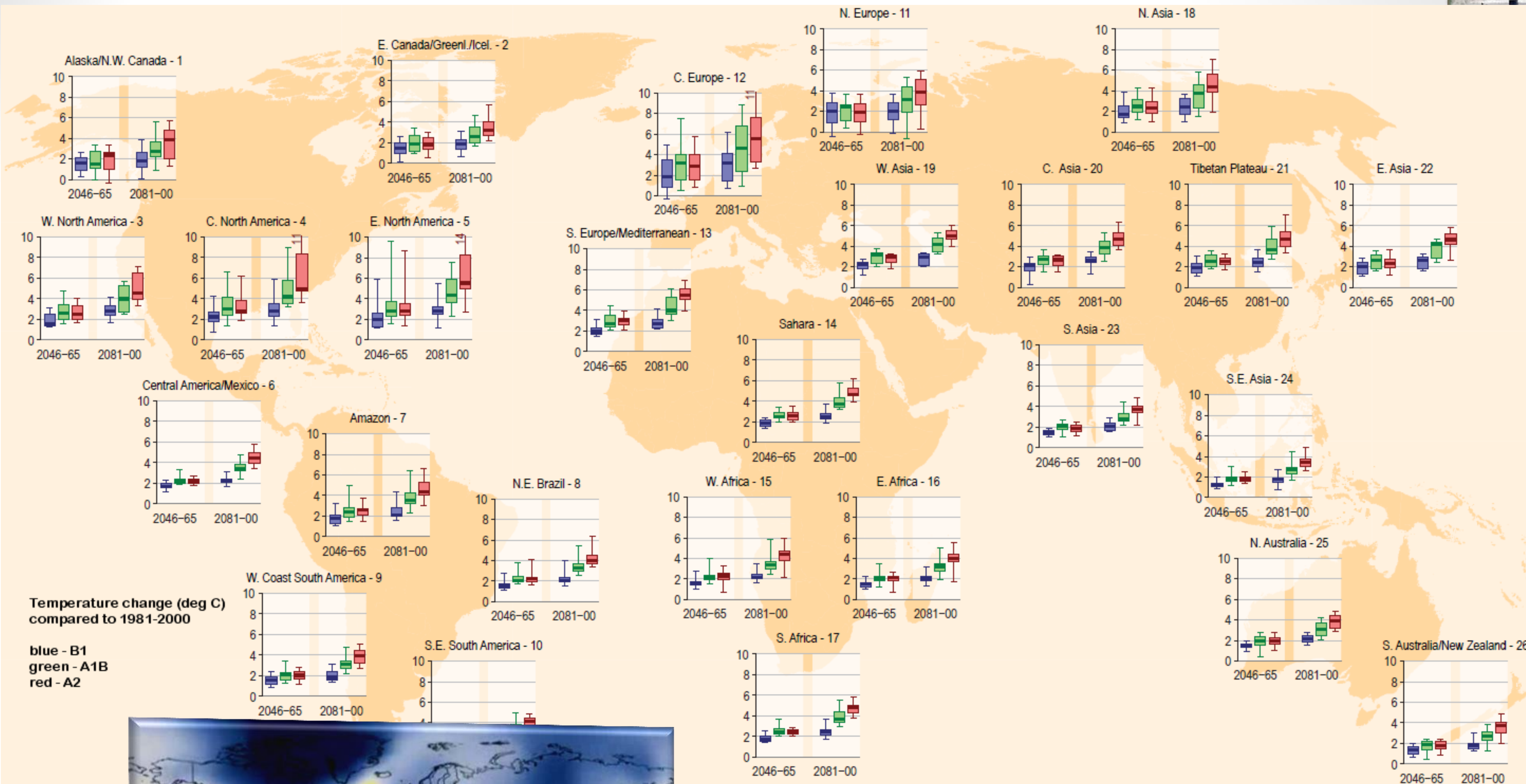
bc^3

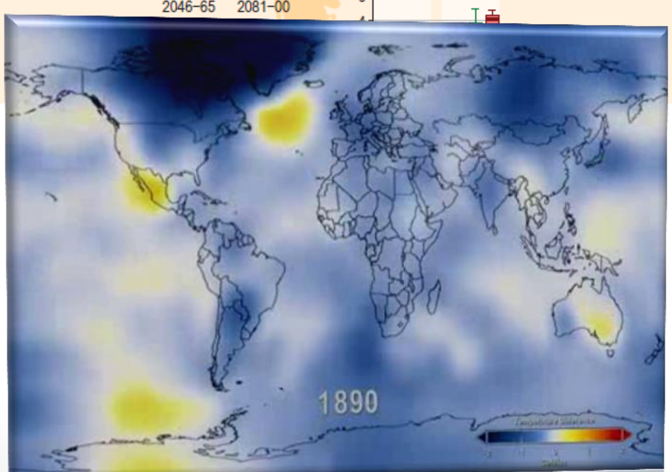
FORECASTING FUTURE PATHWAYS

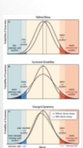


bc3

Projected Changes of Annual Max of Daily Max Temperatures







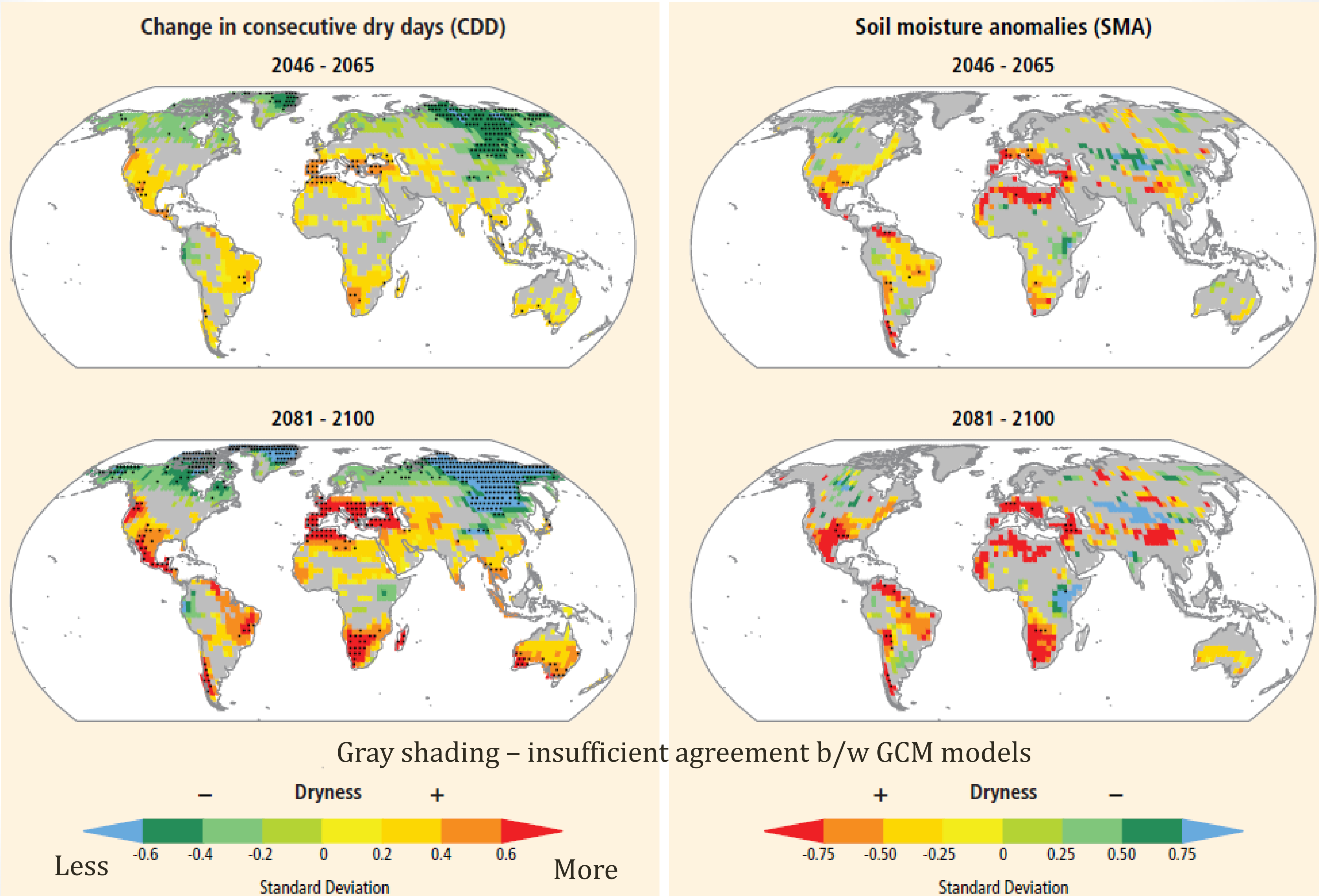
Source: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation, Special Report of the Intergovernmental Panel on Climate Change, March 2012

Source: Surface temperature anomaly relative to 1951-80
http://www.nasa.gov/topics/earth/features/2012-temps.html

bc^3

Projected Changes in Global Precipitation (A2 scenario)

... but more frequent and more severe heavy rain days



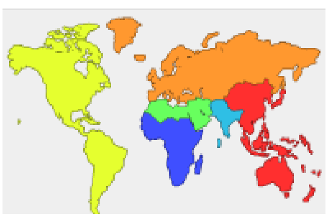
Gray shading – insufficient agreement b/w GCM models

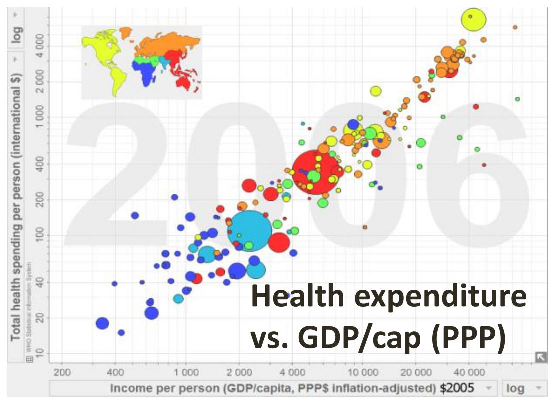
Source: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation, Special Report of the Intergovernmental Panel on Climate Change, March 2012

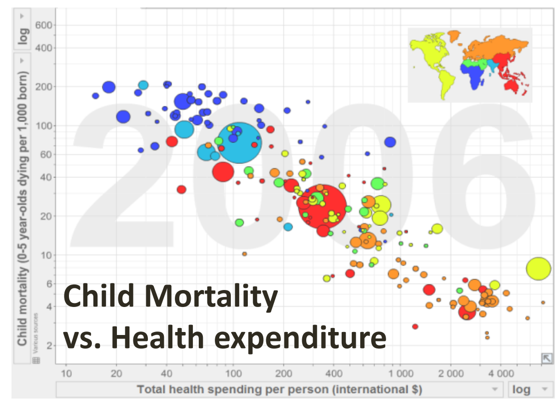
bc³

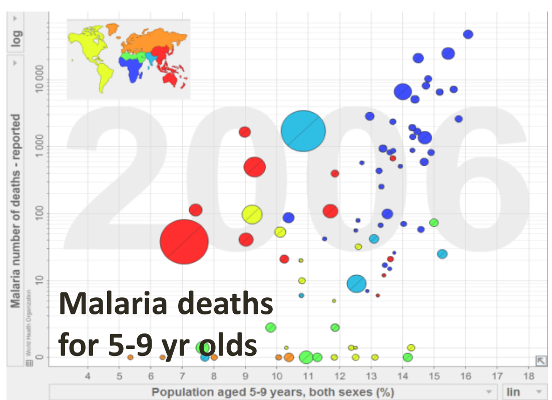
Public health focuses on protecting and improving the health of communities

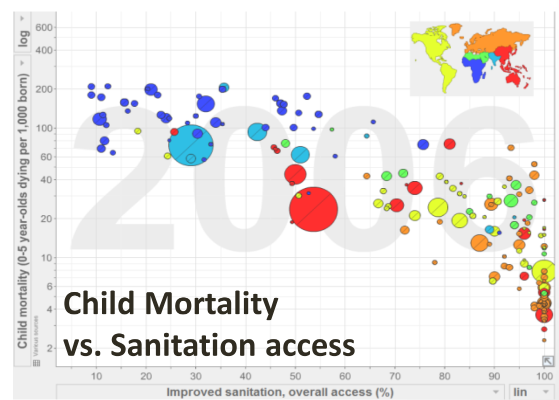
- Good health is fundamental to sustainable development, just as much as concerns about economic prosperity and environmental protection.
- Health in its most basic definition is more than just the absence of illness or infirmity; rather, it is a state of complete physical, mental and social well-being.
- The severity of the potential consequences of climate change will depend to a large extent on the health status of the population affected. Globally, population health has undergone positive change over the second half of the 20th century; however, important regional differences exist within and between individual countries, especially between rich and low income nations. Children have higher disease risk factors than adults, and they bare a heavier burden of disease.











bc3

There are various pathways through which climate change may affect directly or indirectly human health

Global Climate Change
Long-term change in weather conditions over and above natural variations

Regional changes attributable to extreme weather events, including changes in frequency and severity of cold- and heat-waves, storms, floods, droughts, etc.

Burdens
– Environmental conditions
– Socio-economic disruption
– Human health
– Health care services
– etc.

Moderating influence
Mitigation measures

Moderating influence
Adaptation measures

Health outcomes

– Direct and Indirect effects due to changes in air- and water-quality, food-, water- and vector-borne diseases, malnutrition, mental health (1 in 5 will suffer PTS), allergic responses

– Loss of life, illness and injury

– Vulnerable populations include the young and the elderly, particularly in low-income countries

– Uncertainty linked to knowledge gaps, limited number of studies in developing countries, population behavior, health status, and socio-economic development

Severity of climate sensitive diseases due to changes in temperature, precipitation, floods, droughts, storms and fires depends on mitigating and adaptive measures (moderating influences), population health status, access to medical care and clinical treatment (prevention and disease control), preparedness of the healthcare system (monitoring, surveillance and response), community resilience (public awareness, access to housing, clean water and sanitation infrastructure, etc.) and institutional and political support.

Additional Deaths (in 1000s) for a 1℃ Increase in Global Temperature

	Malaria	Schisto[a]	Dengue	C-Heat[b]	C-Cold[c]	Resp.[d]	Total	
OECD-A	0 (0)	0 (0)	0 (0)	11.4 (5.9)	−64.4 (4.4)	3.0 (9.7)	−50.0	**N. America**
OECD-E	0 (0)	0 (0)	0 (0)	11.7 (4.0)	−99.8 (2.6)	−2.8 (5.7)	−90.9	**Europe**
OECD-P	0 (0)	0 (0)	0 (0)	3.5 (2.8)	−13.1 (2.2)	1.0 (4.8)	−8.6	**Pacific**
CEE&fSU	0 (0)	0 (0)	0 (0)	10.7 (4.4)	−87.5 (5.2)	4.5 (11.)	−72.3	**C/E Europe Soviet Union**
ME	0.2 (0.1)	−0.1 (0.0)	0 (0)	2.5 (0.4)	−8.9 (1.3)	9.9 (2.6)	3.6	**Middle East**
LA	1.1 (0.8)	−0.1 (0.0)	0 (0)	8.1 (1.8)	−20.0 (3.5)	11.1 (7.0)	0.2	**Latin America**
S&SEA	8.2 (5.9)	−0.1 (0.0)	6.7 (1.2)	17.5 (2.9)	−63.8 (16.9)	141.2 (34.1)	109.7	**S & S/E Asia**
CPA	0 (0)	−0.1 (0.0)	0.4 (0.1)	24.3 (4.6)	−103.4 (21.7)	62.8 (44.4)	−16.0	**Centrally planned Asia**
AFR	56.5 (40.9)	−0.5 (0.1)	0.3 (0.1)	4.7 (0.5)	−18.2 (6.0)	24.8 (6.0)	68.3	**Africa**

[a]Schistosomiasis.
[b]Heat-related, cardiovascular mortality.
[c]Cold-related, cardiovascular mortality.
[d]Heat-related, respiratory mortality.
Source: Own calculations, after Martens (1997), Martin and Lefebvre (1995), and Morita et al. (1994).

C-Heat < C-Cold

"(The regression equation) parameter estimates are significant at the 95% level, but the fit is not impressive: R^2 varies between 22% and 51%."

*Source: Tol, R. 2002. Estimates of the Damage Costs of Climate Change, Environmental and Resource Economics, **21**.*

Climate Change and Heat-Related Mortality in Six Cities

Summer heat-related mortality rates (per 100,000)							
City	Present	Future (SRES-A2; 2070-99)					
		Total			Climate attributable		
		No Accl†	Accl (2°C)	Accl (4°C)	No Accl†	Accl (2°C)	Accl (4°C)
Boston	3.1	354	192	102	351	188	98
Budapest	5.4	99	70	48	93	64	42
Dallas	1.4	34	15	6	32	14	5
Lisbon	4.6	561	257	115	557	253	111
London	1.8	13	6.8	4	11	5	2
Sydney	1.6	7	4	3	5	3	1

† Accl = acclimatization

*Source: Gosling et al., 2009. International Journal of Biometeorology, **53**:31-51.*

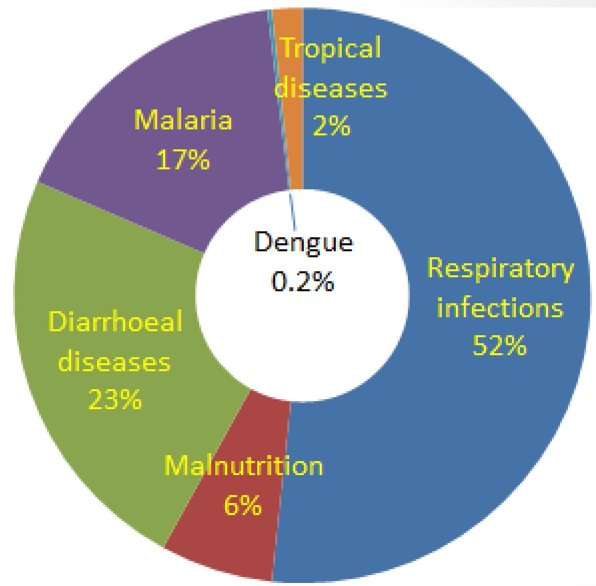
*"(Our) results demonstrate that **higher mortality is attributed to increases in the mean and variability of temperature** with climate change rather than with the change in mean temperature alone."*

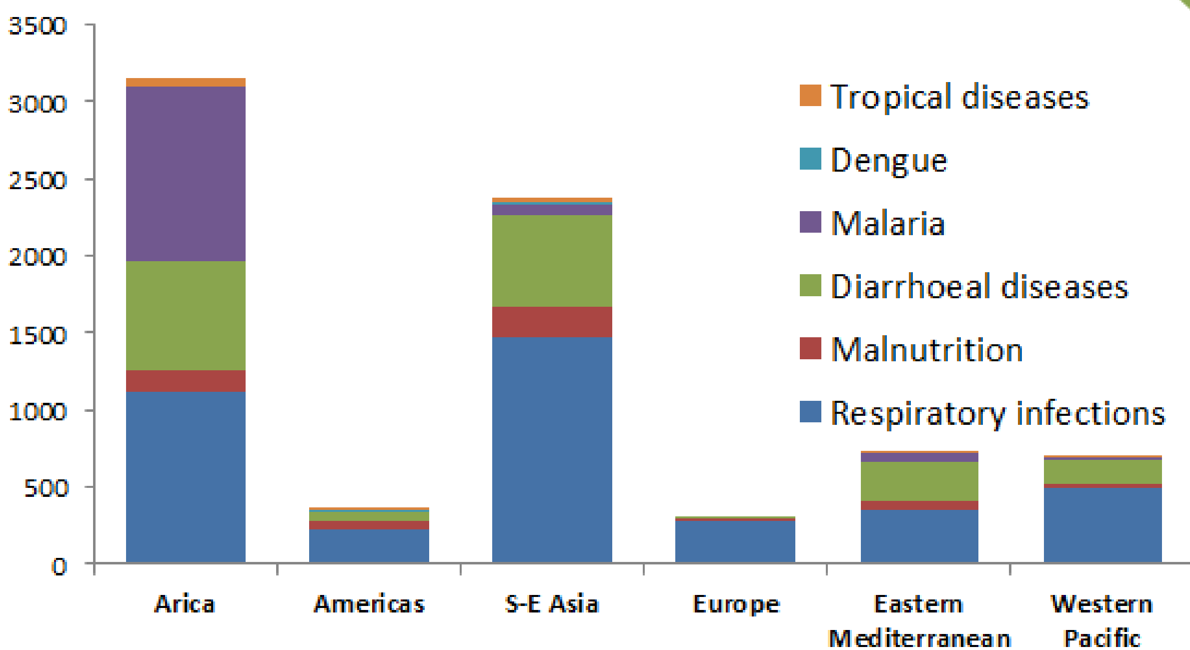
*"Allowing for **acclimatization** to an extra 2℃ in mean temperatures **reduced future heat-related mortality by approximately half** that of no acclimatization in each city."*

*"(Our results) demonstrated that extreme temperatures were generally more common in the simulated present climate than in the observed climate. Such discrepancies between observed and modelled extremes are common." "**Generally, (estimates are) underestimated [overestimated] maximum daily temperatures in northern [southern] Europe**…."* Therefore, Lisbon ↘ and London ↗.

bc3

Cause-specific Annual Deaths in thousands (WHO 2004)



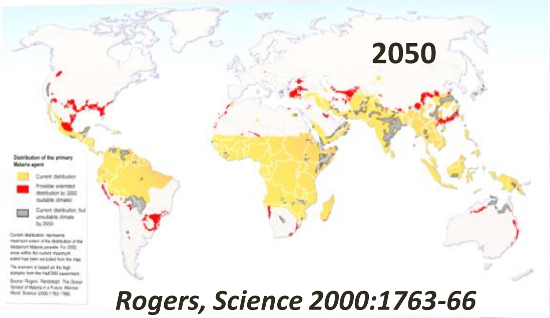


bc³

The Future of Malaria

Beguin et al., 2011. The opposing effects of climate change and socio-economic development on the global distribution of malaria. Global Environmental Change, 21.

The current global geographic distribution of malaria results from a complex interaction between climatic and non-climatic factors. Over the past century, socio-economic development and public health measures have contributed to a marked contraction in the distribution of malaria. Previous assessments of the potential impact of global changes on malaria have not quantified the effects of non-climate factors. In this paper, we describe an empirical model of the past, present and future-potential geographic distribution of malaria which incorporates both the effects of climate change and of socio-economic development. A logistic regression model using temperature, precipitation and gross domestic product per capita (GDPpc) identifies the recent global geographic distribution of malaria with high accuracy (sensitivity 85% and specificity 95%). Empirically, climate factors have a substantial effect on malaria transmission in countries where GDPpc is currently less than US$20,000. Using projections of future climate, GDPpc and population consistent with the IPCC A1B scenario, we estimate the potential future population living in areas where malaria can be transmitted in 2030 and 2050. In 2050, the projected population at risk is approximately 5.2 billion when considering climatic effects only, 1.95 billion when considering the combined effects of GDP and climate, and 1.74 billion when considering GDP effects only. Under the A1B scenario, we project that climate change has much weaker effects on malaria than GDPpc increase. This outcome is, however, dependent on optimistic estimates of continued socioeconomic development. Even then, climate change has important effects on the projected distribution of malaria, leading to an increase of over 200 million in the projected population at risk.



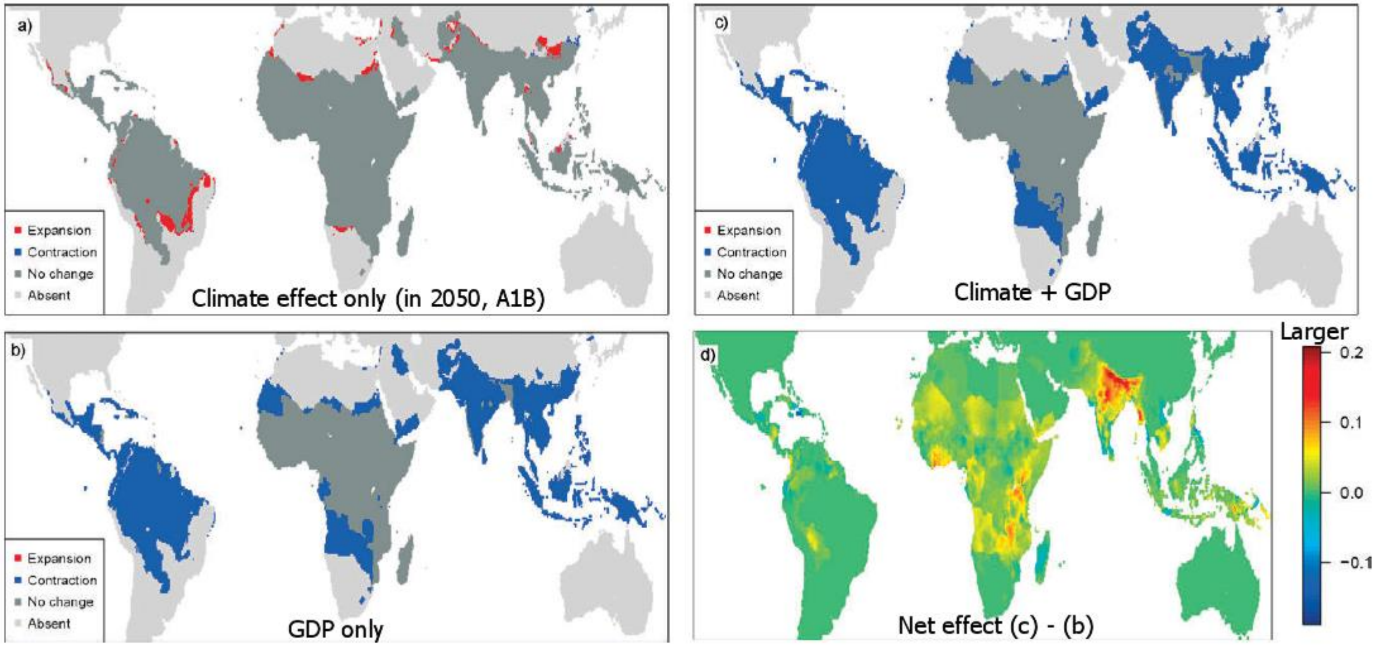
Rogers, Science 2000:1763-66

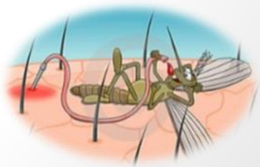
Minimum Temp ↑ (risk)

Precipitation ↑

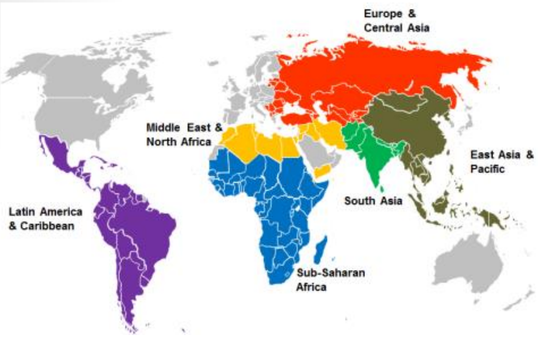
GDP/cap ↓

Population at risk (A1B, 2050)
5.2 billion (climatic effects)
1.74 billion (GDP effect only)
1.95 billion (climate + GDP)
0.2 billion (net effect)





Additional Cases and Burdens of Diarrhea and Malaria for 2010-50 (Wet scenario, WB 2010)



	Diarrheal disease			Malaria		
	2010	*2030*	*2050*	*2010*	*2030*	*2050*
Incidence (thousand)						
East Asia and Pacific	47.9	3.7	0.8	127	48	52
Europe and Central Asia	2.2	1.3	0.0	0	0	0
Latin America and Caribbean	1.7	0.6	0.4	134	67	64
Middle East and North Africa	6.0	2.2	0.8	0	0	0
South Asia	36.4	19.5	2.9	1	174	116
Sub-Saharan Africa	28.2	19.8	24.0	11,990	6,301	7,905
High-income countries	0.0	0.0	0.0	0	0	0
Total	122.7	47.2	28.8	12,251	6,591	8,136
DALYs (thousand)						
East Asia and Pacific	203	32	15	12	4	4
Europe and Central Asia	46	19	0	0	0	0
Latin America and Caribbean	16	5	4	7	3	2
Middle East and North Africa	90	52	18	0	0	0
South Asia	732	312	88	0	38	20
Sub-Saharan Africa	1030	714	863	1,751	949	1,007
High-income countries	0	0	0	0	0	0
Total	2,117	1,133	987	1,771	993	1,033

Current burden: 4.5 billion cases Diarrhea, 200-400 million Malaria

3. Adapting to a Changing Climate

Photo credit: World Bank, 2010

A Prudent Approach to Health Protection from Climate Change

"*All scientific work is incomplete - whether it be observational or experimental. All scientific work is liable to be upset or modified by advancing knowledge. This does not confer upon us a freedom to ignore the knowledge that we already have, or to postpone the action that appears to demand at a given time*."

Hill, A.B. The environment and disease: association or causation? Proceedings of the Royal Society of Medicine 58:295-300 (1965).

"… there will always be some element of unpredictability in climate variations and infectious disease outbreaks. Therefore, a prudent strategy is to set a high priority on reducing people's overall vulnerability to infectious disease through strong public health measures such as vector control efforts, water treatment systems and vaccination programmes."

NRC: "Under the weather", 2001

Source: From Diarmid Campbell-Lendrum, "Climate change, Extreme Events and Infectious Disease Emergence", WHO 2012.

bc³

Costing Adaptation to Climate Change

Adaptation refers to preventive measures intended to reduce environmental and infrastructural impacts, economic losses and community vulnerability to climate change – *manage the unavoidable*!

Interventions aim to:

- Protect natural resources (ecosystems, forests, fisheries, and water supply)
- Maintain agricultural productivity (food security)
- Preserve landscape and physical property – Climate-proofing (preservation of coastal zones and Infrastructure maintenance)
- Limit socio-economic disruptions and population displacement
- Lessen risks and disease burdens from exposure to climate extremes.

Access to technology and funds, availability and access to medical services and public awareness and education are crucial to enhance community resilience to long-term trend changes in meteo conditions.

Strategic planning, mitigation and/or adaptation responses, can significantly reduce, but not completely eliminate, the adverse effects of climate change.

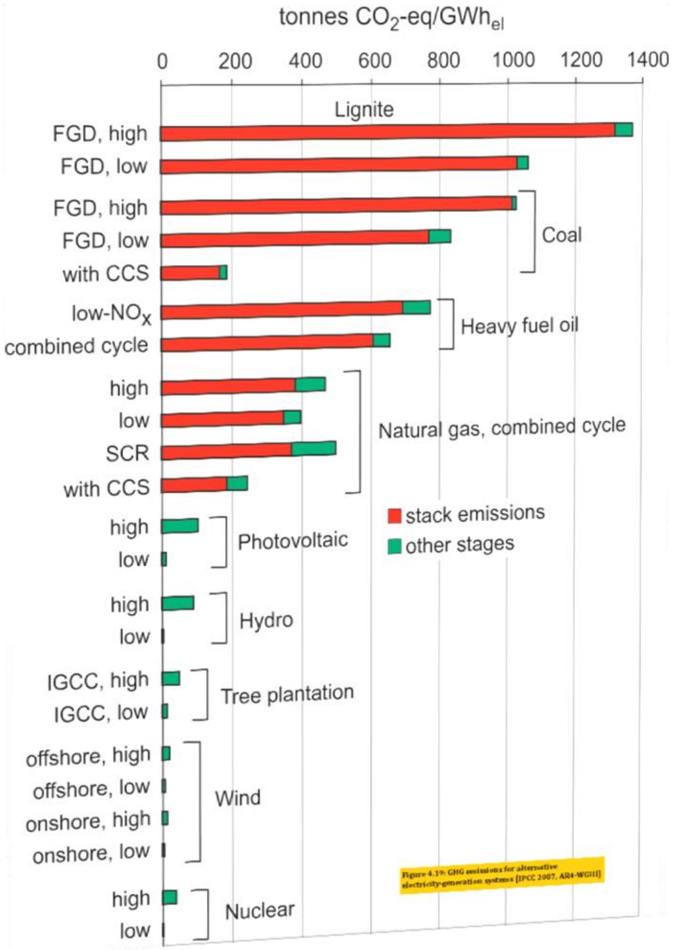
While adaptation is more cost effective than mitigation in limiting residual climate costs in the short-term, mitigation investments will result in lower marginal and aggregate residual costs over the long-term future.



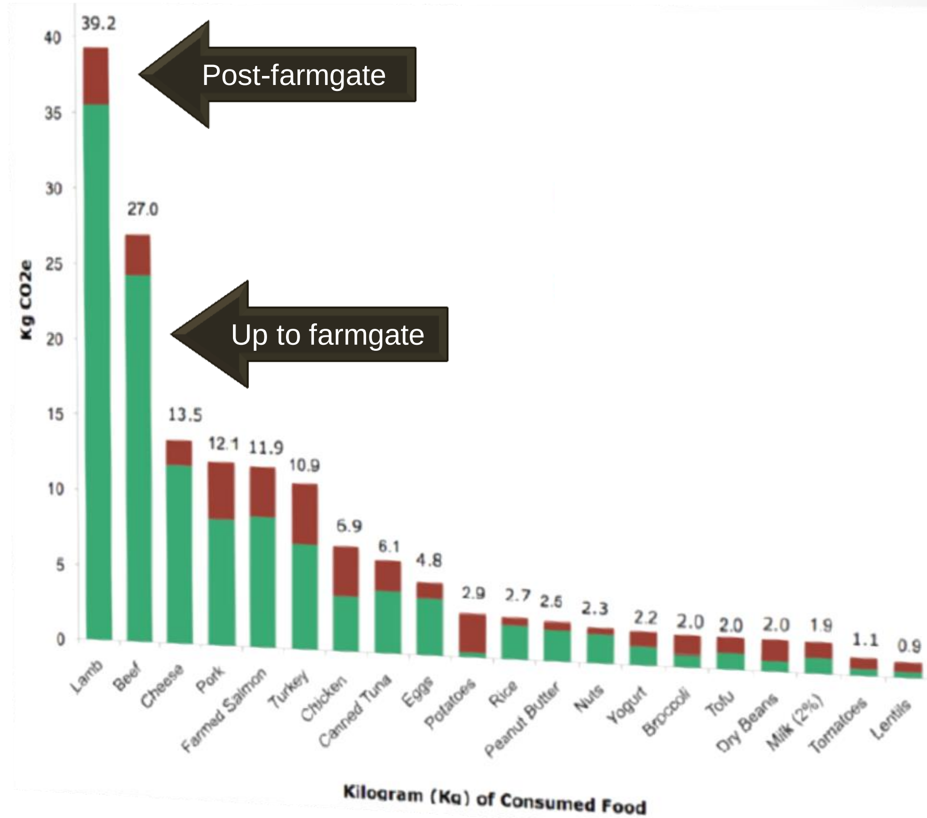



Costing Adaptation to Climate Change (cont.)

Mitigation options aim to limit or control climate variability using technological and behavioral options to reduce GHG emissions – *avoid the unmanageable*!



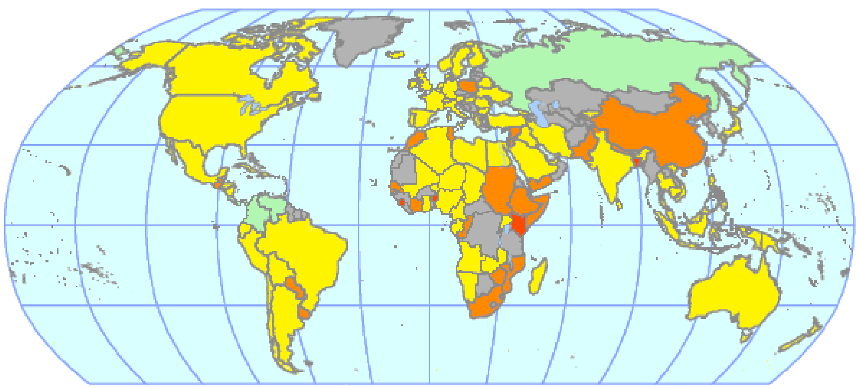
Source: IPCC 2007 (AR4, WG III)



Source: Meat Eater's Guide, 2011

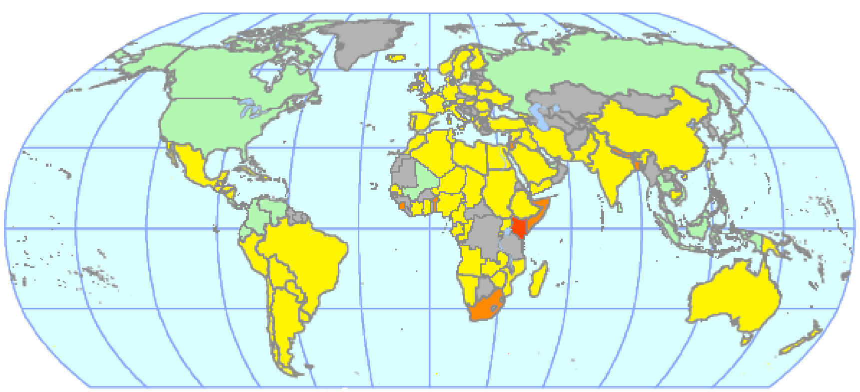
bc3

Global Vulnerability and the Role of Adaptive Capacity & Mitigation
SRES-A2 ($\Delta T = 5.5°C$), 2050



Panel A: portrays vulnerability with a static representation of current adaptive capacity

Panel B: shows vulnerability with relatively rapid development of enhanced adaptive capacity worldwide



Panel C: displays the geographical implications of mitigation designed to cap effective atmospheric concentrations of greenhouse gases at 550 ppm along a least-cost WRE intervention scenario

Panel D: offers a portrait of the combined complementary effects of mitigation to a 550 ppm concentration limit and the rapid development of enhanced adaptive capacity

extreme vulnerability | significant vulnerability | moderate vulnerability | little or no vulnerability | not in sample

$$Vulnerability = \left[\frac{Mean\ temperature\ change}{Adaptive\ capacity}\right]_{country}$$

Source: Yohe, et al., 2006. Global Distributions of Vulnerability to Climate Change.

bc³

Adapting to a Changing Climate: Finding Solutions

Prerequisits of adaptation
- Linkage between health and climate
- Capacity building
  Strengthening of exisiting and overcome obstacles;
  Share lessons accross sectors and countries;
  Revise standards;
  International solidarity;
  Local solidarity;
- Communication

Health sector adaptation possibilities
- Implement effective responses to early warning
- Strengthen health system preparedness
- Risk management
- Strengthen disease surveillance and health prtoection measures
- Vector and host control
- Awareness raising and education
- Treatment and vaccination

Health driven adaptation-mitigation necessities
- Land – use change
- Urban planning
- Housing improvement
- Structural and non-structural measures
- Transport, energy and agriculture policies

Increasing "adaptability"
- Reducing inequalities
- Investment in health protection and prevention
- Achieving/maintaining highest levels of health care coverage
- Access to information and technology

Source: Health and climate change: The "now and how", A policy action guide, WHO 2005






bc3

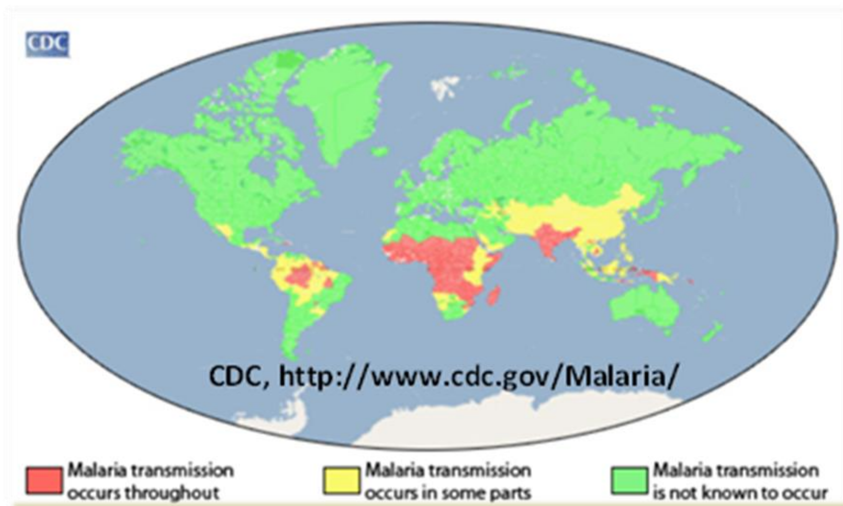
Malaria mosquito dosed with disease-fighting bacteria

(Bian et al., Science, May 2013.)

"Malaria spreads in human populations because female *Anopheles* mosquitoes carrying malaria-inducing *Plasmodium* parasites bite people and pass it into their bloodstream."

"Globally, WHO estimates that **in 2010, 219 million clinical cases of malaria occurred, and 660,000 people died of malaria, most of them children in Africa**. Because malaria causes so much illness and death, the disease is a great drain on many national economies. Since many countries with malaria are already among the poorer nations, the disease maintains a vicious cycle of disease and poverty. There is currently **no malaria vaccine** approved for human use."

"**New study shows it may be possible to use a bacterium (Wolbachia) that stops the parasite developing in the mosquito and create a stable population where female mosquitoes pass this parasite immunity onto their daughters** (a mosquito with the right bacterial infection could bite people without delivering the parasite that causes malaria). Bacterium kills malaria parasite in mosquito gut and salivary glands."



bc³

"Africa's GDP would be up to $100 billion greater this year if malaria had been eliminated years ago"†

† Economics of Malaria. Harvard University Center for International Development and the London School of Hygiene and Tropical Medicine (HUCID and LSHTM), October 2000 (http://www.malaria.org/jdsachseconomic.html)

According to a report by Harvard, London School and WHO, sub-Saharan Africa's GDP would be up to 32% greater in 2000 had malaria been eradicated 35 years earlier. This represents up to **$100 billion added to sub-Saharan Africa's GDP of $300 billion**. The extra $100 billion represents nearly five times the development aid given to Africa in 2000.

The report recommends **spending $1 billion annually worldwide to prevent and treat malaria** (many times the current budget), with most of this expenditure allocated to Africa. The authors of the report argue that spending this amount is **economically justifiable as the short-term benefits of malaria control can reasonably be estimated between $3 and $12 billion per year.**

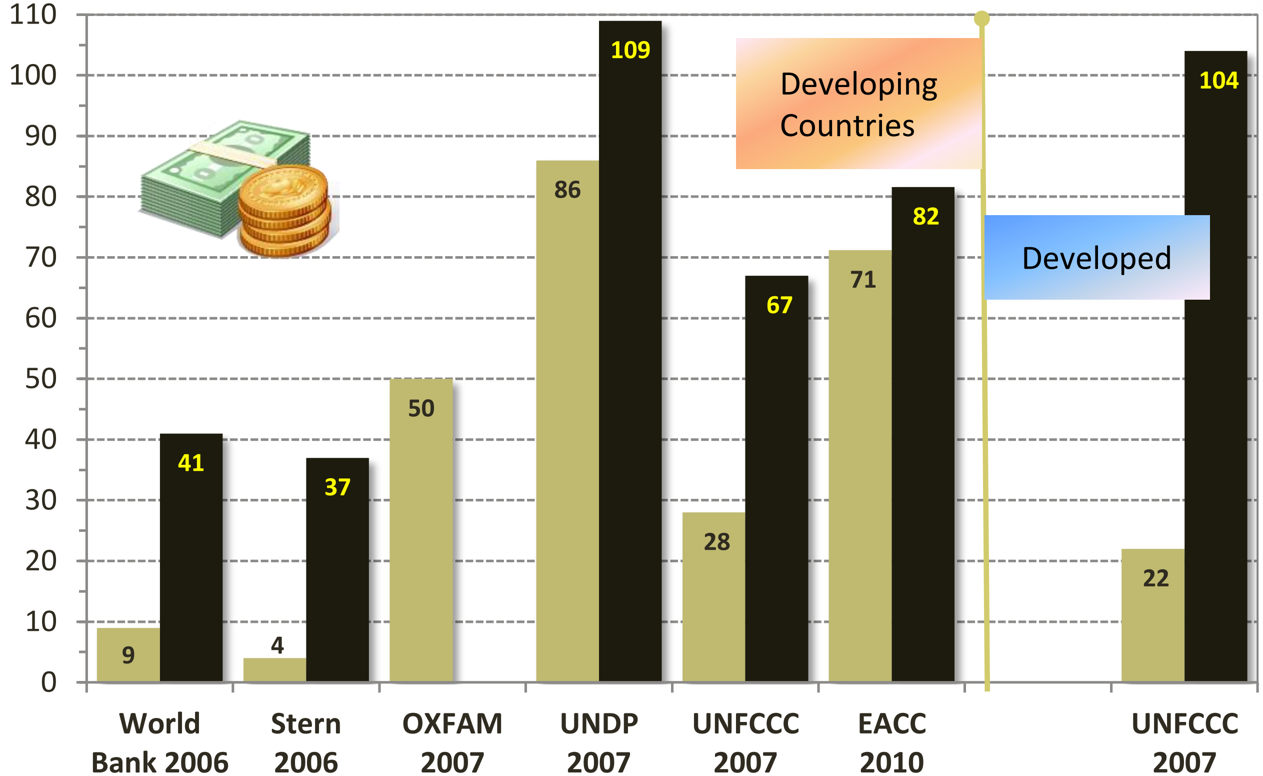
- Researchers found that the wider availability and use of insecticide treated bednets would result in 50% fewer cases of malaria in children. Yet presently, only 2% of African children are protected at night with a treated bednet.
- For every $1 to $8 spent on effectively treating malaria cases would result in a gain of 1 DALY, which makes the malaria treatment as cost-effective a public health investment as measles vaccinations.



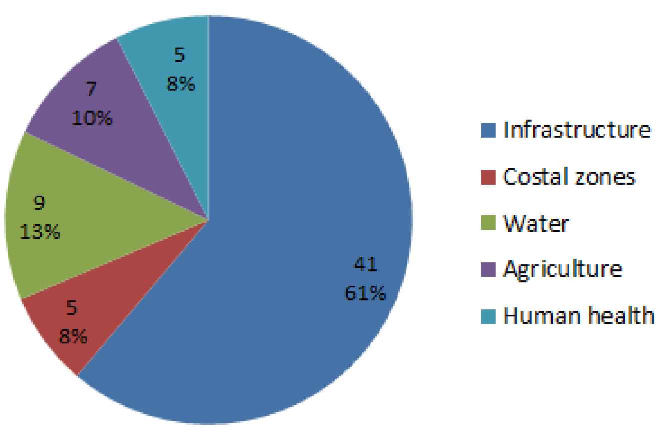



bc^3

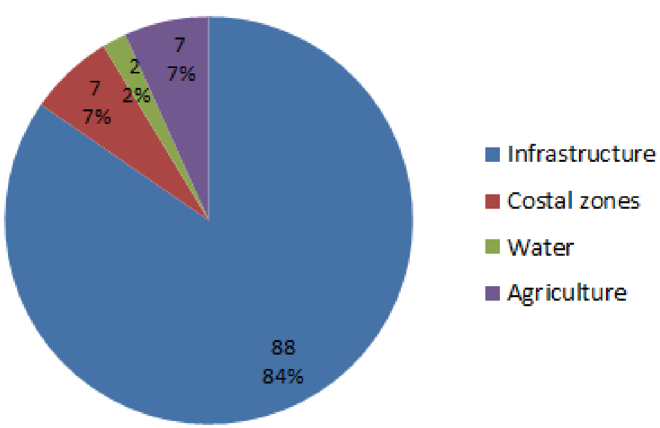
Estimates of adaptation costs range in the billions $/yr



UNFCCC 2007 (67 B$, Developing)



UNFCCC 2007 (104 B$, Developed)



bc3

Adapting to a warmer world in which global ambient temperature will increase by 2℃ above pre-industrial levels by 2050 will cost 70-100 B$/yr over the period 2010-50 in developing countries (World Bank 2010)

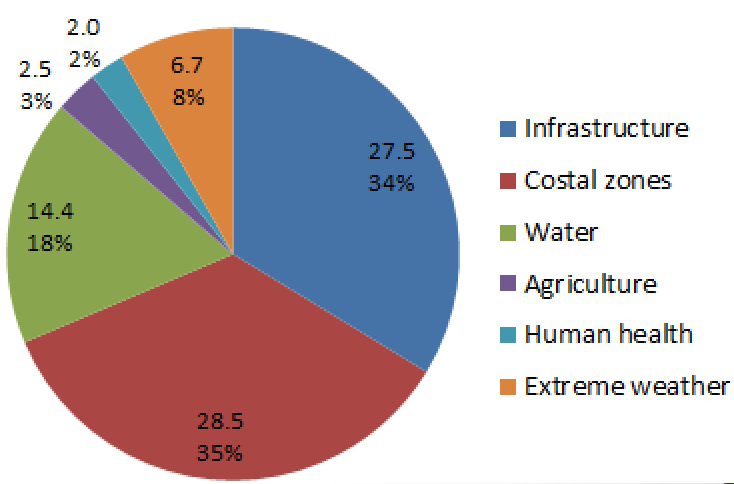
Cost is comparable to current financial aid given to developing nations

Sector	Wettest climate (Partial accounting)	Driest climate (Partial accounting)	Comparison to [UNFCCC 2007]
Infrastructure	27.5 (34% of total)	13.0 (18% of total)	2 to 41
Coastal zones	28.5 (35%)	27.6 (39%)	5
Water supply & flood management	14.4 (18%)	19.7 (28%)	9
Agriculture, forestry & fisheries	2.5	3.0	7
Human health	**Prevention and treatment of Diarrhea & Malaria** **2.0** **(2.5% of total)**	**1.5** **(2% of total)**	**Diarrhea, Malaria and Malnutrition (<2% cost)** **5†** **(7% to 18% of total)**
Extreme weather	6.7	6.4	
All sectors	**81.5**	**71.2**	**28 to 67**

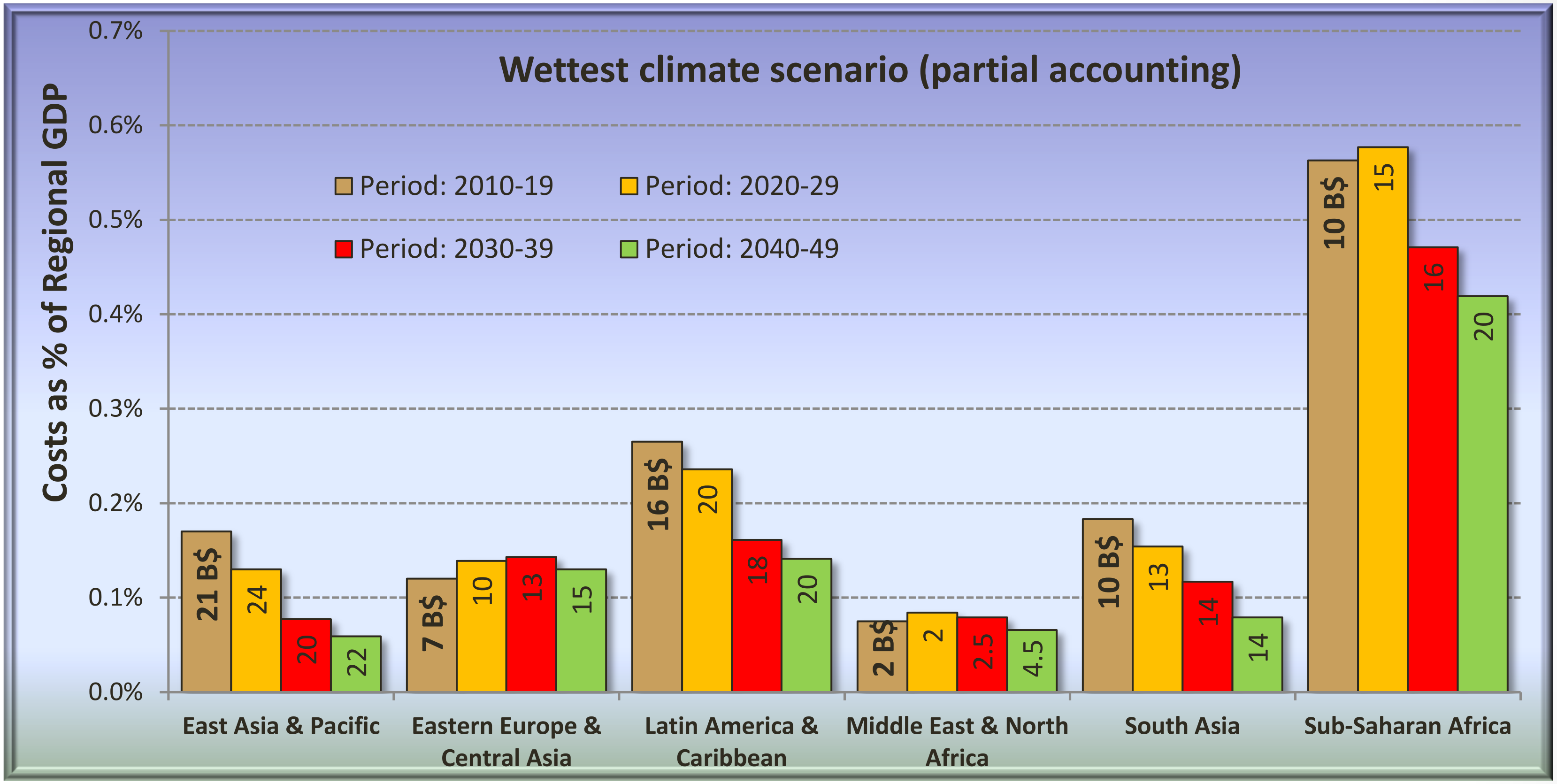
WB 2010: AVERAGE ANNUAL ADAPTATION COST TO PREVENT AND TREAT MALARIA AND DIARRHEA, BY YEAR, 2010–50 (BILLION 2005 DOLLARS)

	2010	2020	2030	2040	2050
Wettest Climate					
Diarrheal Disease	4.6	2.4	1.8	1.2	1.1
Malaria	0.2	0.1	0.1	0.1	0.1
Total	4.8	2.5	1.9	1.3	1.2
Driest Climate					
Diarrheal Disease	3.2	2.0	1.7	1.1	0.9
Malaria	0.1	0.1	0.1	0.1	0.1
Total	3.3	2.1	1.8	1.2	1.0

WB 2010 (81.5 B$, Developing)



Adaptation costs increase with time, and there is a strong disparity across countries (World Bank 2010)



bc³

Limitations of Adaptation Costs to Climate Change

- **Uncertainties of current climate costs (adaptation, mitigation and residual damages) are large** due to knowledge gaps in forecasting long-term weather-related effects on natural and social systems and in projecting long-term trends of major socio-economic parameters.

- **Lack of longitudinal health data** (empirical and disaggregated), especially from low-income counties that will be disproportionally affected by climate change, also contributes to uncertainty. Developing nations have much higher local incidence rates of malaria, diarrhea and malnutrition than populations living in richer countries, and are, therefore, more vulnerable to the adverse consequences of climate change.

- Current modeling is limited to **assessing only a few of what are believed to be the most important climate-sensitive health burdens**: diarrhea, malaria, malnutrition, direct effects of thermal stress (displaced mortality) and the effects of air pollution on morbidity and mortality of cardio-pulmonary diseases. But, how important will be non-climatic factors, such as preventive and reactive actions undertaken by the population and the role and effectiveness of clinical care?

- Very **few studies have undertaken a comprehensive (bottom-up) and dynamic (cross-sectoral) macro-economic analysis** (IAM). Consequently, the health-related adaptation costs of climate change cited by UNFCCC (2007) and the World Bank (2010) are low ball figures. At best, current literature results of climate costs (and impacts) should be interpreted as preliminary, order of magnitude risks of climate sensitive impacts and costs.

bc^3

BASQUE CENTRE
FOR CLIMATE CHANGE
Klima Aldaketa Ikergai

Eskerrik asko zure arretagatik

Gracias por su atención

Climate Change and Public Health

Dr. Joseph V. Spadaro
Research Professor, BC^3
Joseph.Spadaro@bc3research.org

Addressing climate change challenges from a multi-disciplinary perspective

Summer School 8^{th}- 10^{th} of July 2013
Palacio Miramar - San Sebastian
Bizkaia (Spain)

EUSKO JAURLARITZA GOBIERNO VASCO

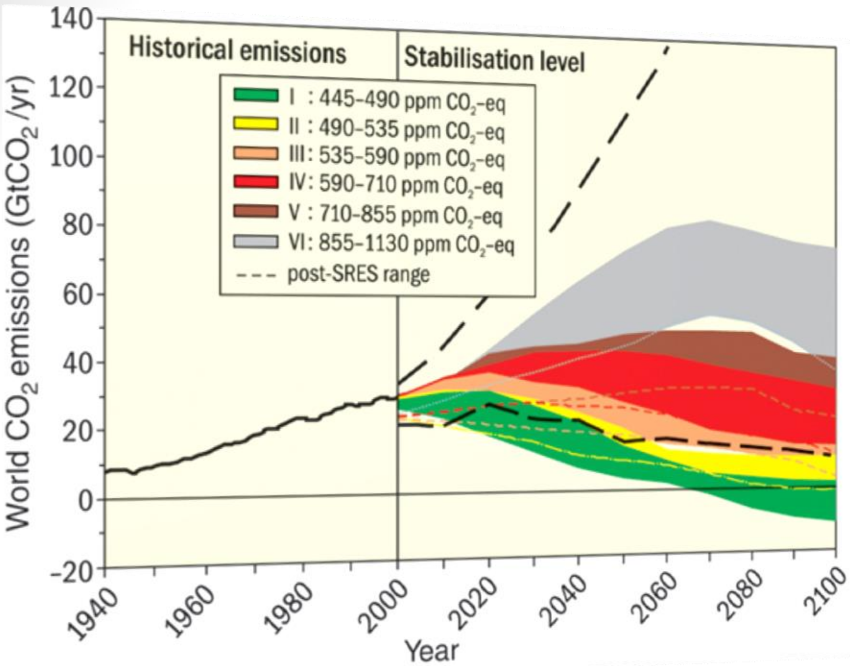
Universidad del País Vasco Euskal Herriko Unibertsitatea

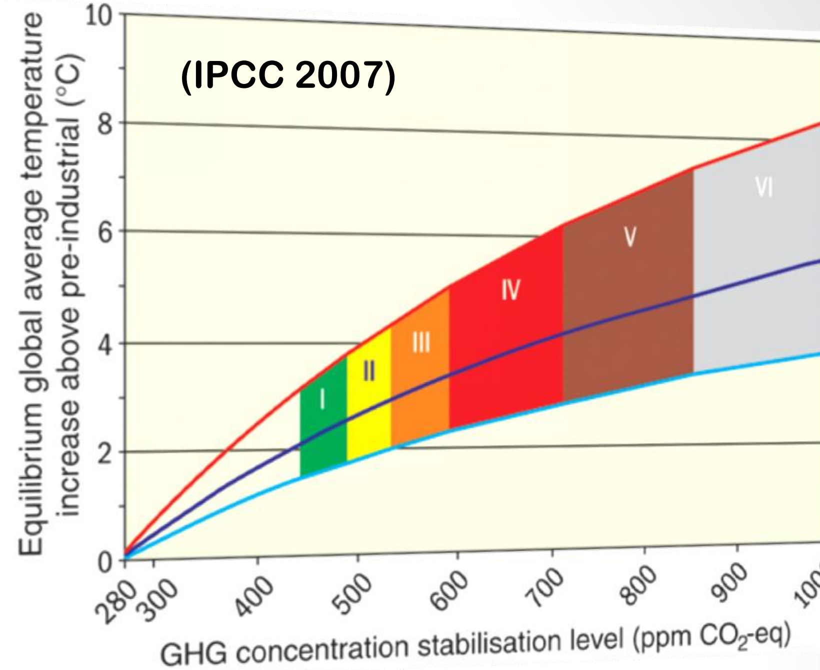
ikerbasque Basque Foundation for Science

ihobe

Additional Slides

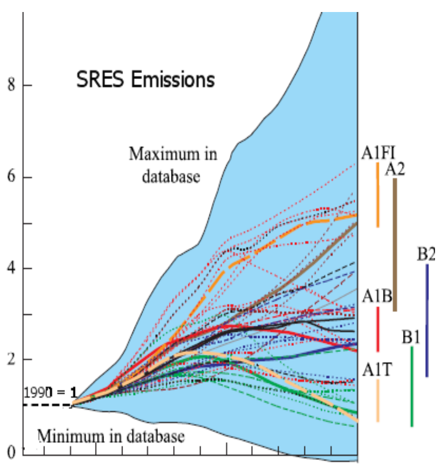
Emissions Pathways





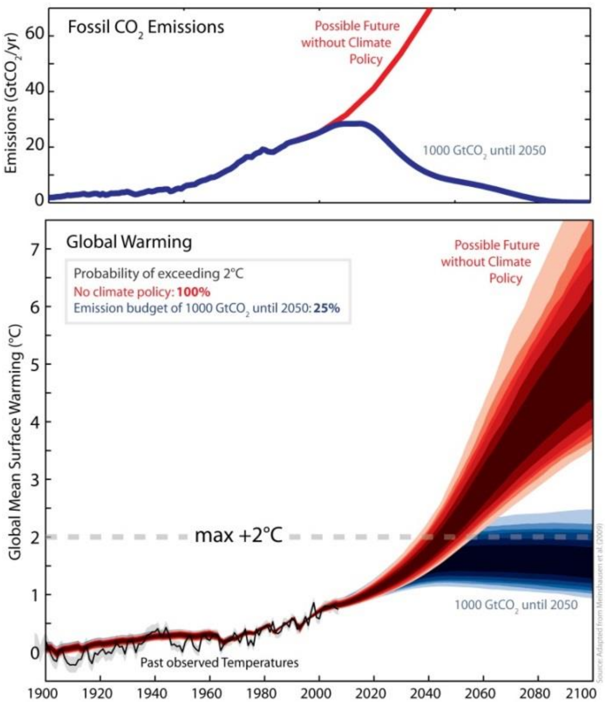
Futures without climate policy SRES (IPCC 2000)

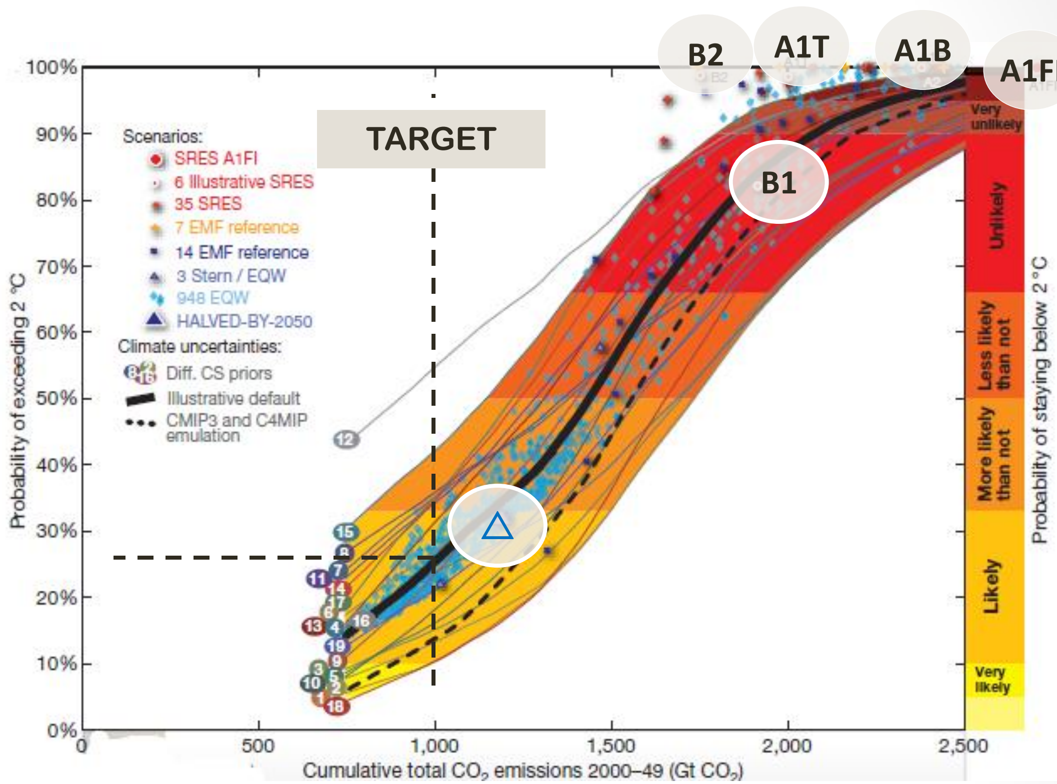
Almost certain to exceeding 2℃ above preindustrial levels by 2050, 100% by 2100



Case	Temperature Change (°C at 2090-2099 relative to 1980-1999)[a] Best estimate	*Likely* range	Sea Level Rise (m at 2090-2099 relative to 1980-1999) Model-based range excluding future rapid dynamical changes in ice flow
Constant Year 2000 concentrations[b]	0.6	0.3 – 0.9	NA
B1 scenario	1.8	1.1 – 2.9	0.18 – 0.38
A1T scenario	2.4	1.4 – 3.8	0.20 – 0.45
B2 scenario	2.4	1.4 – 3.8	0.20 – 0.43
A1B scenario	2.8	1.7 – 4.4	0.21 – 0.48
A2 scenario	3.4	2.0 – 5.4	0.23 – 0.51
A1FI scenario	4.0	2.4 – 6.4	0.26 – 0.59

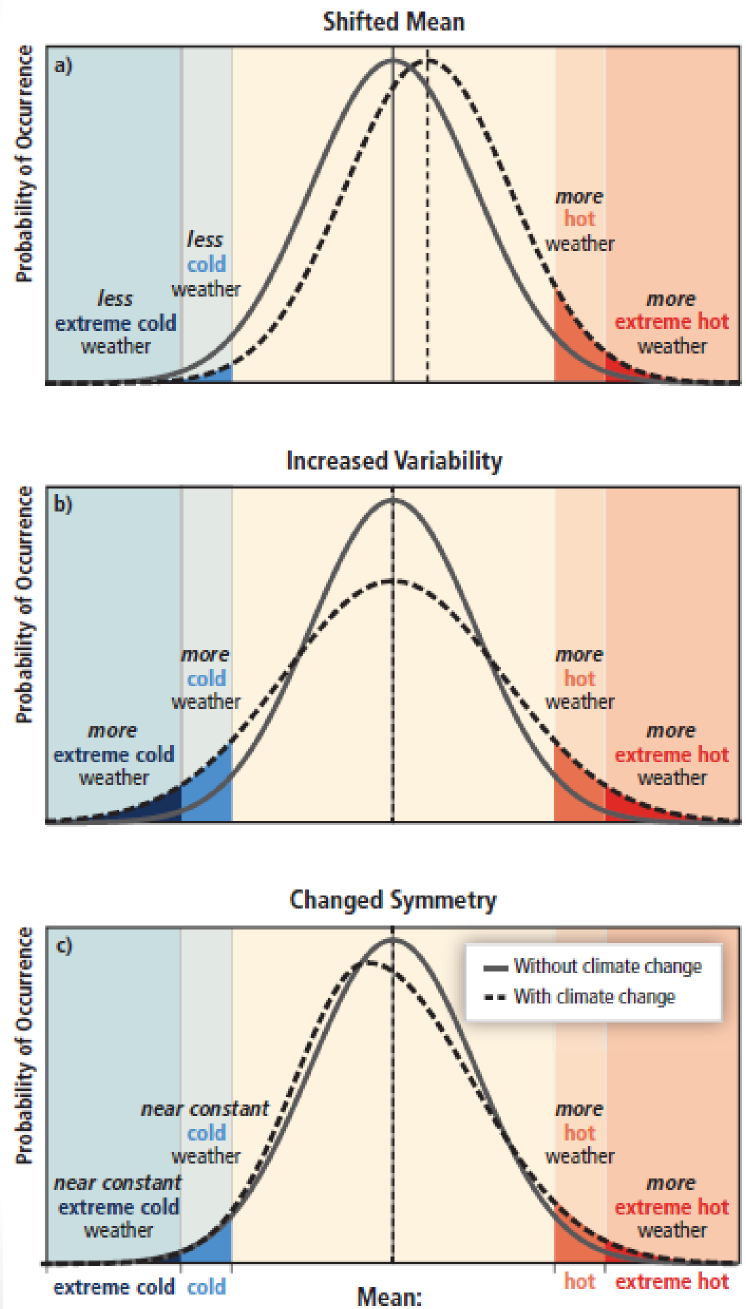
GHG Emission Targets for Limiting Global Warming to 2℃
Meinshausen et al., Nature, 458 (April 2009)





bc3

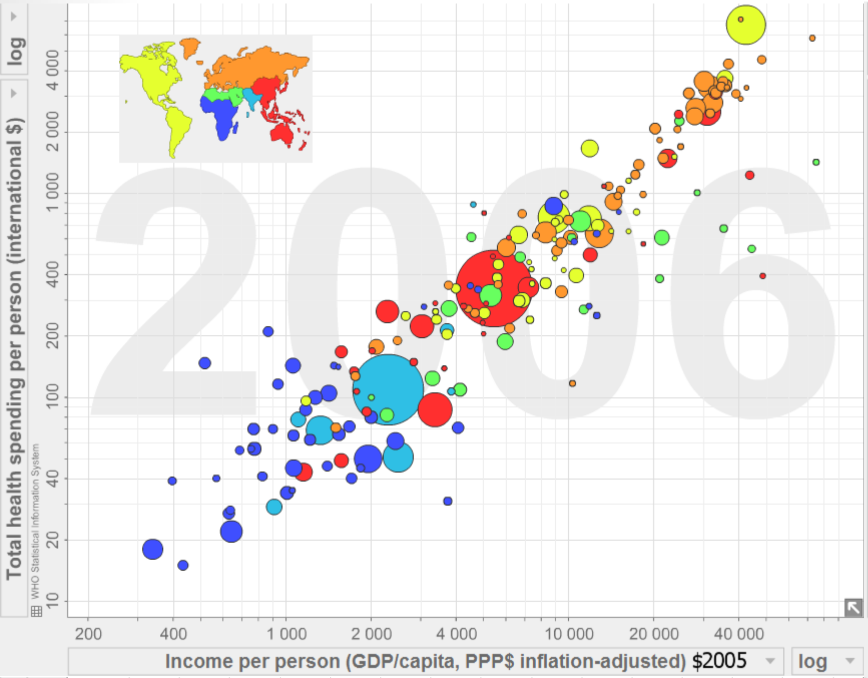
Effect of Changes in Temperature Distribution on Extreme Heat/Cold

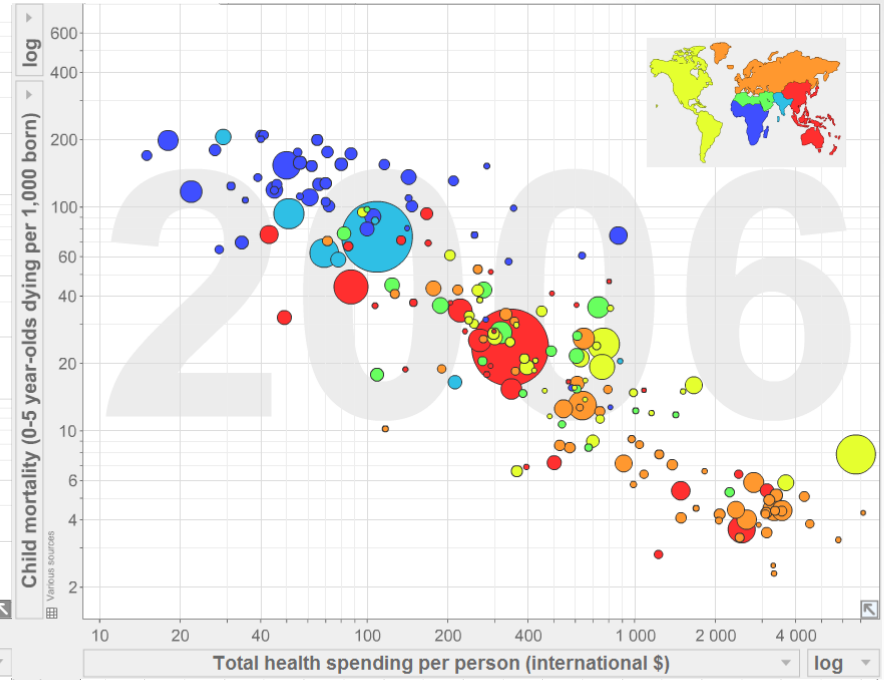


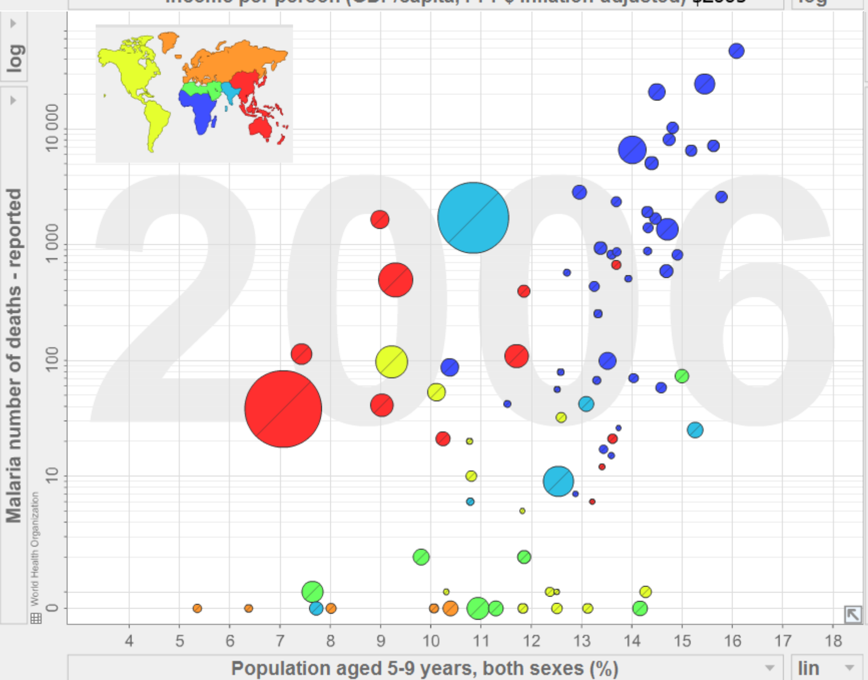
Source: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation, Special Report of the Intergovernmental Panel on Climate Change, March 2012

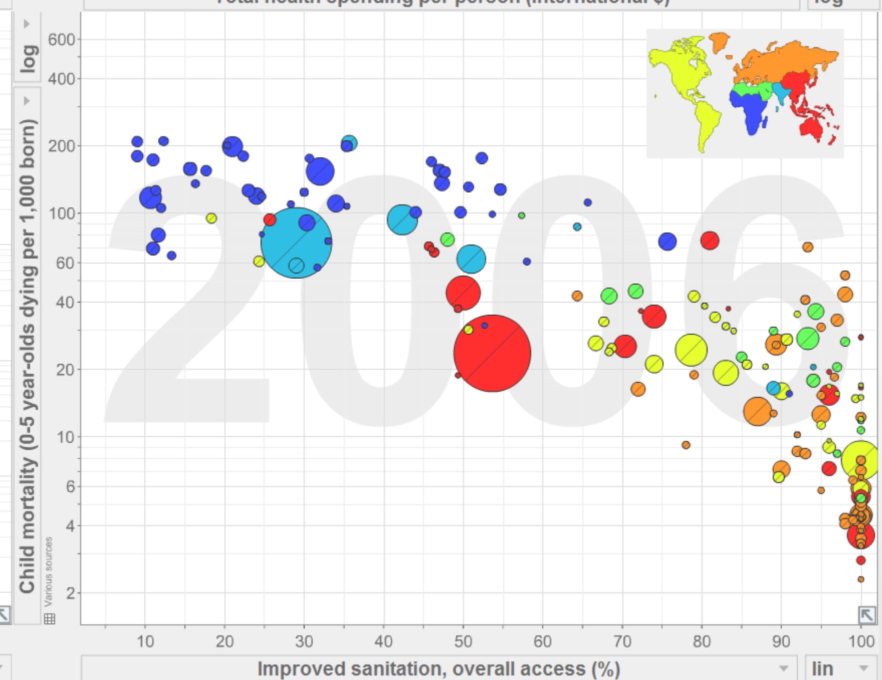
bc3

Public health focuses on protecting and improving the health of communities



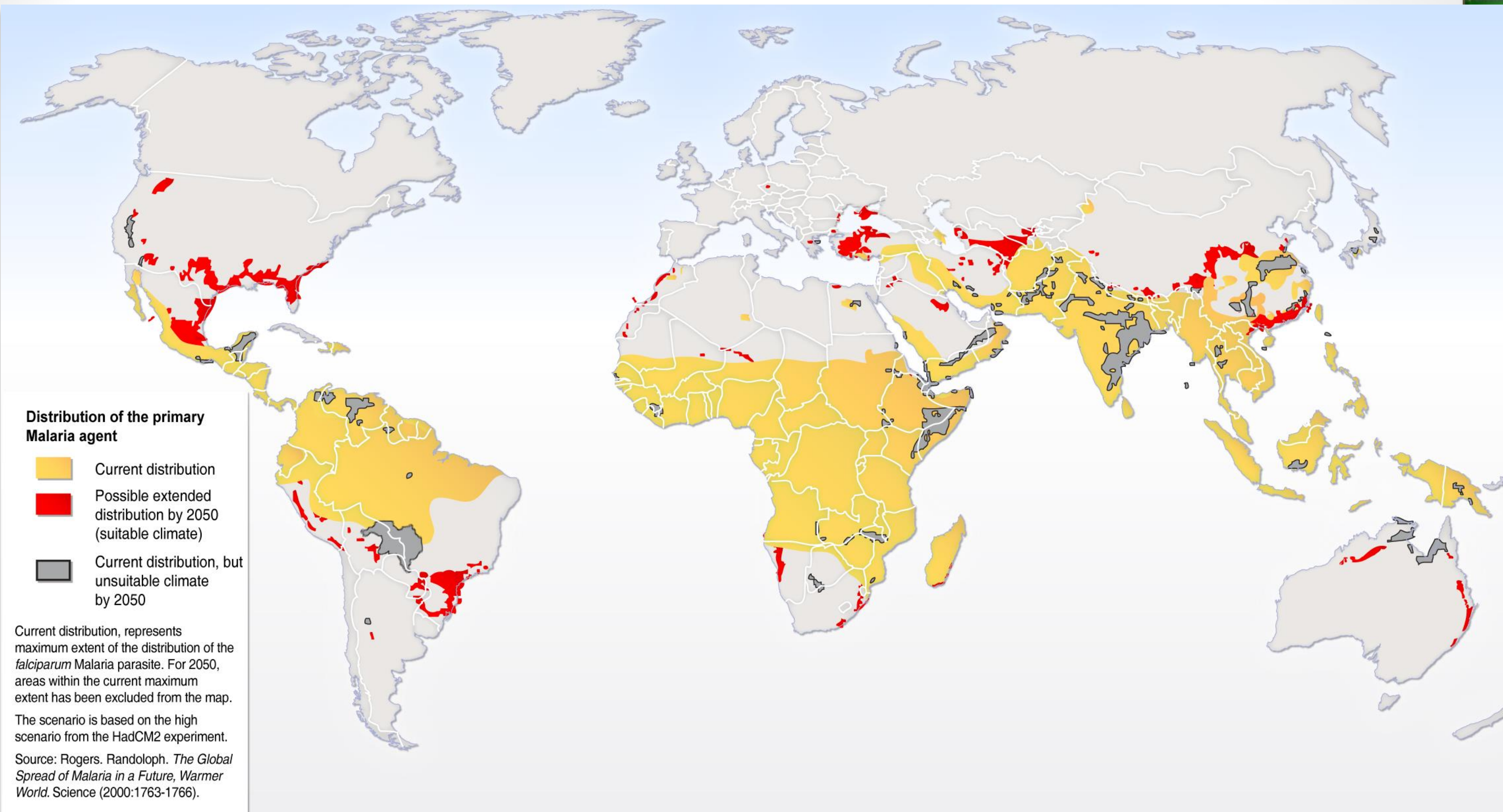






bc³

The Effect of Climate Change on Malaria



Source: Rogers, 2000. The Global Spread of Malaria in a Future Warmer World, Science, 1763-66.

bc3

Vulnerability Index

Vulnerability depends on exposure, sensitivity, and adaptive capacity (IPCC 2001, Chapter 18). The relative strength of adaptive capacity is derived from a relatively short list of fundamental determinants. Changes over time t in the annual-mean temperature ΔT_{mean} (t) at the national level for a given country reflect exposure to climate change. These changes are computed using GCM simulations for the IPCC baseline scenario SRES-A2. For the sake of comparison, the baseline A2 results are compared with results from a least-cost Wigley-Richels-Edmonds (WRE) emissions trajectory that stabilizes GHG† concentrations to 550 ppm. An index of national adaptive capacity AC(t) is based on the methodology from Brenkert & Malone that is normalized to unity for the global mean.

The combined roles of exposure and adaptive capacity are combined as a simple quotient

$$\mathbf{V(t) = \Delta T_{mean}(t) / AC(t)}$$

This index of vulnerability allows exposure to larger changes in temperature to reflect higher vulnerability that could be diminished by enhanced adaptive capacity.

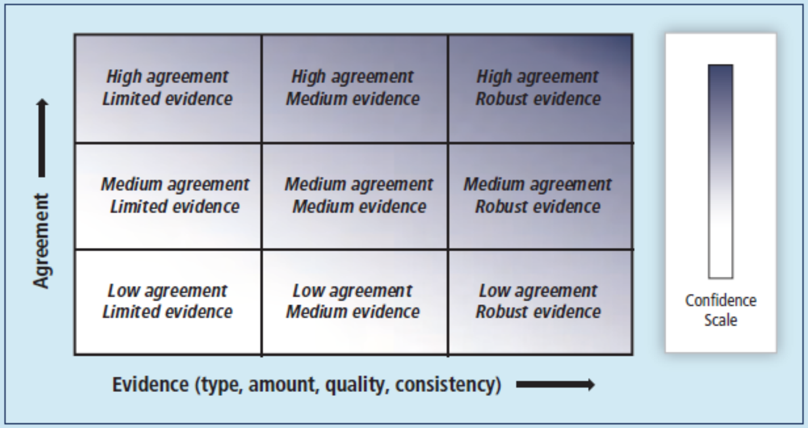
(From Yohe, et al. 2006. Global Distributions of Vulnerability to Climate Change. *The Integrated Assessment Journal*, **6**(3):35-44.)

†GCM – A General Circulation Model is the most advanced type of climate model used for projecting changes in climate due to increasing greenhouse-gas concentrations, aerosols and external forcings like changes in solar activity and volcanic eruptions. These models contain numerical representations of physical processes in the atmosphere, ocean, cryosphere and land surface on a global three-dimensional grid, with the current generation of GCMs having a typical horizontal resolution of 100 to 300 km. (WBC 2013)

bc3

How the IPCC Handles Uncertainty

The following summary terms are used to describe the available evidence: *limited*, *medium*, or *robust*; and for the degree of agreement: *low*, *medium*, or *high*. A level of confidence is expressed using five qualifiers: *very low*, *low*, *medium*, *high*, and *very high*. The accompanying figure depicts summary statements for evidence and agreement and their relationship to confidence. There is flexibility in this relationship; for a given evidence and agreement statement, different confidence levels can be assigned, but increasing levels of evidence and degrees of agreement are correlated with increasing confidence.



A depiction of evidence and agreement statements and their relationship to confidence. Confidence increases toward the top-right corner as suggested by the increasing strength of shading. Generally, evidence is most robust when there are multiple, consistent independent lines of high-quality evidence.

The following terms indicate the assessed likelihood:

Term*	Likelihood of the Outcome
Virtually certain	99–100% probability
Very likely	90–100% probability
Likely	66–100% probability
About as likely as not	33–66% probability
Unlikely	0–33% probability
Very unlikely	0–10% probability
Exceptionally unlikely	0–1% probability

* Additional terms that were used in limited circumstances in the Fourth Assessment Report (*extremely likely:* 95–100% probability, *more likely than not:* >50–100% probability, and *extremely unlikely:* 0–5% probability) may also be used when appropriate.

Source: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation, Special Report of the Intergovernmental Panel on Climate Change, March 2012

bc³