UN Briefing Session
New York, 2 Nov 2009

Copenhagen 2009:
The Fierce Urgency of Now

Professor H. J. Schellnhuber CBE
Potsdam Institute for Climate Impact Research

PIK

nature Vol 461|24 September 2009

FEATURE

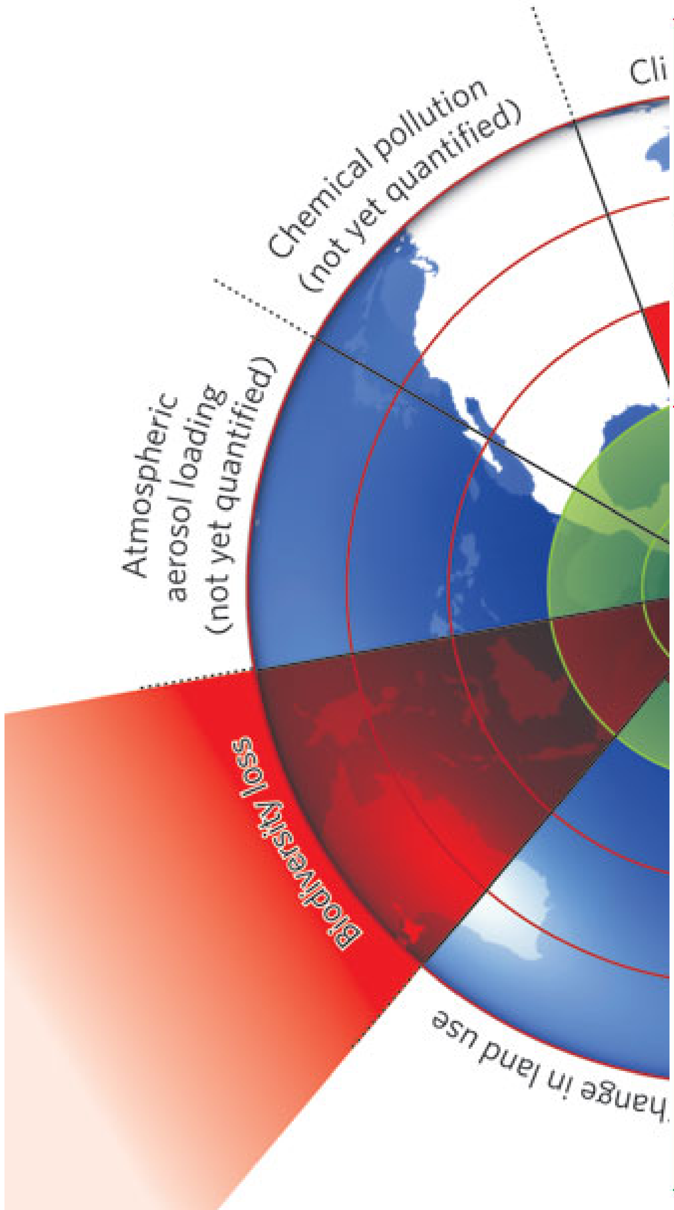
A safe operating space for humanity

Identifying and quantifying planetary boundaries that must not be transgressed could help prevent human activities from causing unacceptable environmental change, argue **Johan Rockström** and colleagues.


nature Vol 461|24 September 2009
FEATURE
A safe operating space for humanity
Identifying and quantifying planetary boundaries that must not be transgressed could help prevent human activities from causing unacceptable environmental change, argue Johan Rockström and colleagues.

Authors

Johan Rockström, Will Steffen, Kevin Noone, Åsa Persson, F. Stuart Chapin, III, Eric F. Lambin, Timothy M. Lenton, Marten Scheffer, Carl Folke, Hans Joachim Schellnhuber, Björn Nykvist, Cynthia A. de Wit, Terry Hughes, Sander van der Leeuw, Henning Rodhe, Sverker Sörlin, Peter K. Snyder, Robert Costanza, Uno Svedin, Malin Falkenmark, Louise Karlberg, Robert W. Corell, Victoria J. Fabry, James Hansen, Brian Walker, Diana Liverman, Katherine Richardson, Paul Crutzen, Jonathan A. Foley

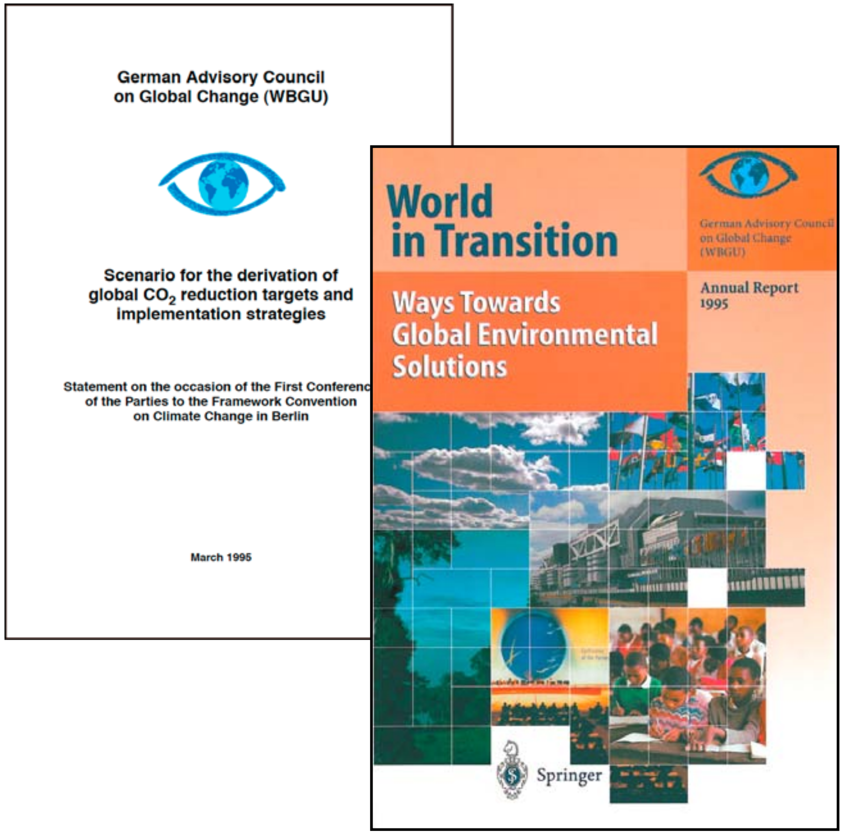


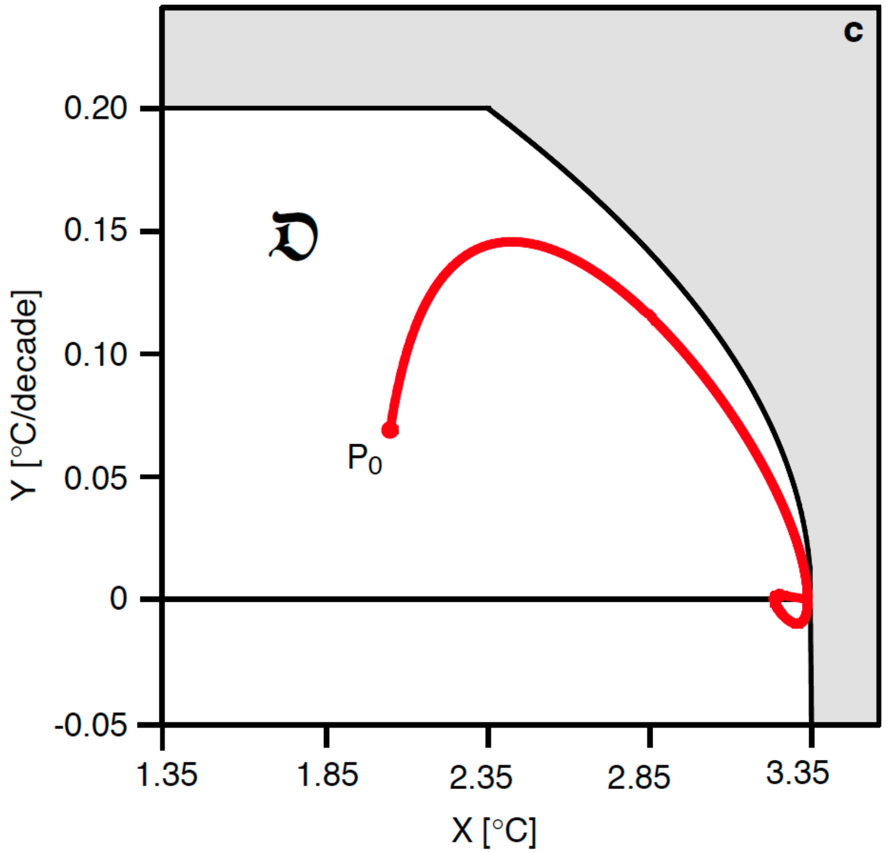
PLANETARY BOUNDARIES

Earth-system process	Parameters	Proposed boundary	Current status	Pre-industrial value
Climate change	(i) Atmospheric carbon dioxide concentration (parts per million by volume)	350	387	280
	(ii) Change in radiative forcing (watts per metre squared)	1	1.5	0
Rate of biodiversity loss	Extinction rate (number of species per million species per year)	10	>100	0.1–1
Nitrogen cycle (part of a boundary with the phosphorus cycle)	Amount of N_2 removed from the atmosphere for human use (millions of tonnes per year)	35	121	0
Phosphorus cycle (part of a boundary with the nitrogen cycle)	Quantity of P flowing into the oceans (millions of tonnes per year)	11	8.5–9.5	~1
Stratospheric ozone depletion	Concentration of ozone (Dobson unit)	276	283	290
Ocean acidification	Global mean saturation state of aragonite in surface sea water	2.75	2.90	3.44
Global freshwater use	Consumption of freshwater by humans (km^3 per year)	4,000	2,600	415
Change in land use	Percentage of global land cover converted to cropland	15	11.7	Low
Atmospheric aerosol loading	Overall particulate concentration in the atmosphere, on a regional basis		To be determined	
Chemical pollution	For example, amount emitted to, or concentration of persistent organic pollutants, plastics, endocrine disrupters, heavy metals and nuclear waste in, the global environment, or the effects on ecosystem and functioning of Earth system thereof		To be determined	

Boundaries for processes in red have been crossed. Data sources: ref. 10 and supplementary information

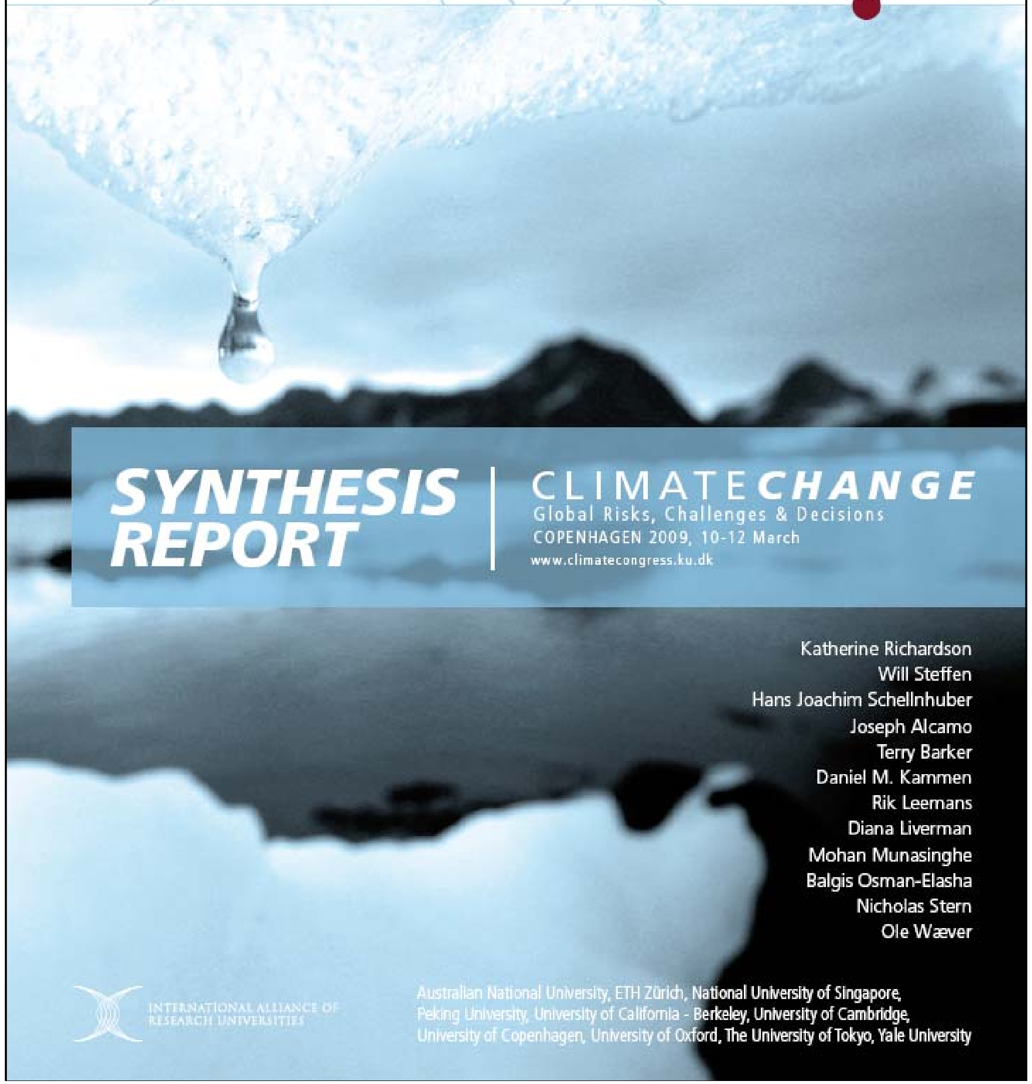
1995: The WBGU Tolerable Windows Approach





First justification / operationalization of the 2° C guardrail

UNIVERSITY OF COPENHAGEN



SYNTHESIS REPORT

CLIMATE CHANGE
Global Risks, Challenges & Decisions

COPENHAGEN 2009, 10-12 March

www.climatecongress.ku.dk

Katherine Richardson
Will Steffen
Hans Joachim Schellnhuber
Joseph Alcamo
Terry Barker
Daniel M. Kammen
Rik Leemans
Diana Liverman
Mohan Munasinghe
Balgis Osman-Elasha
Nicholas Stern
Ole Wæver

INTERNATIONAL ALLIANCE OF RESEARCH UNIVERSITIES

Australian National University, ETH Zürich, National University of Singapore, Peking University, University of California - Berkeley, University of Cambridge, University of Copenhagen, University of Oxford, The University of Tokyo, Yale University

Key Message 2 - Social and Environmental Disruption

„Temperature rises above 2°C […] are likely to cause major societal and environmental disruptions through the rest of the century and beyond.“

Global mean annual temperature change relative to 1980-1999 (°C)

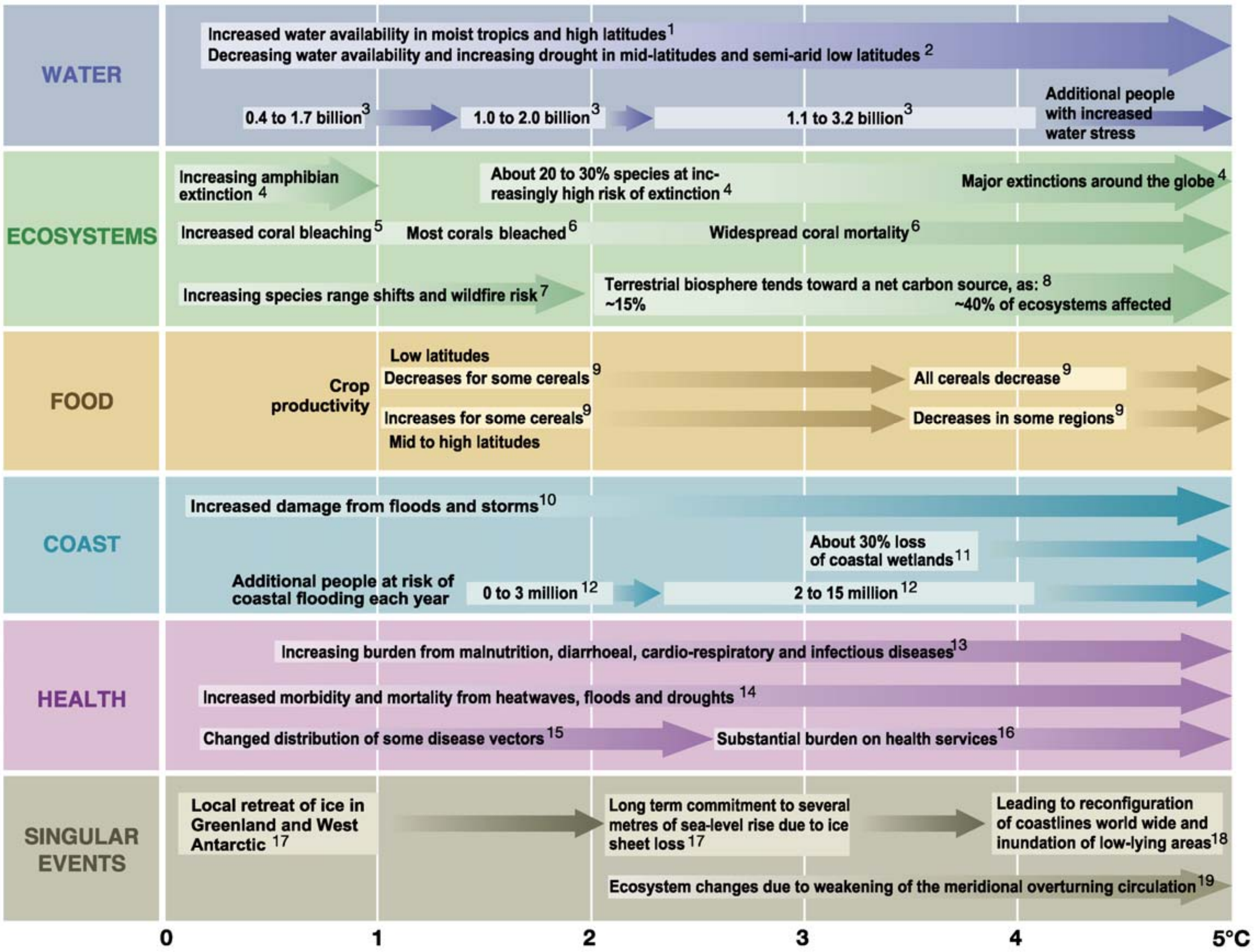
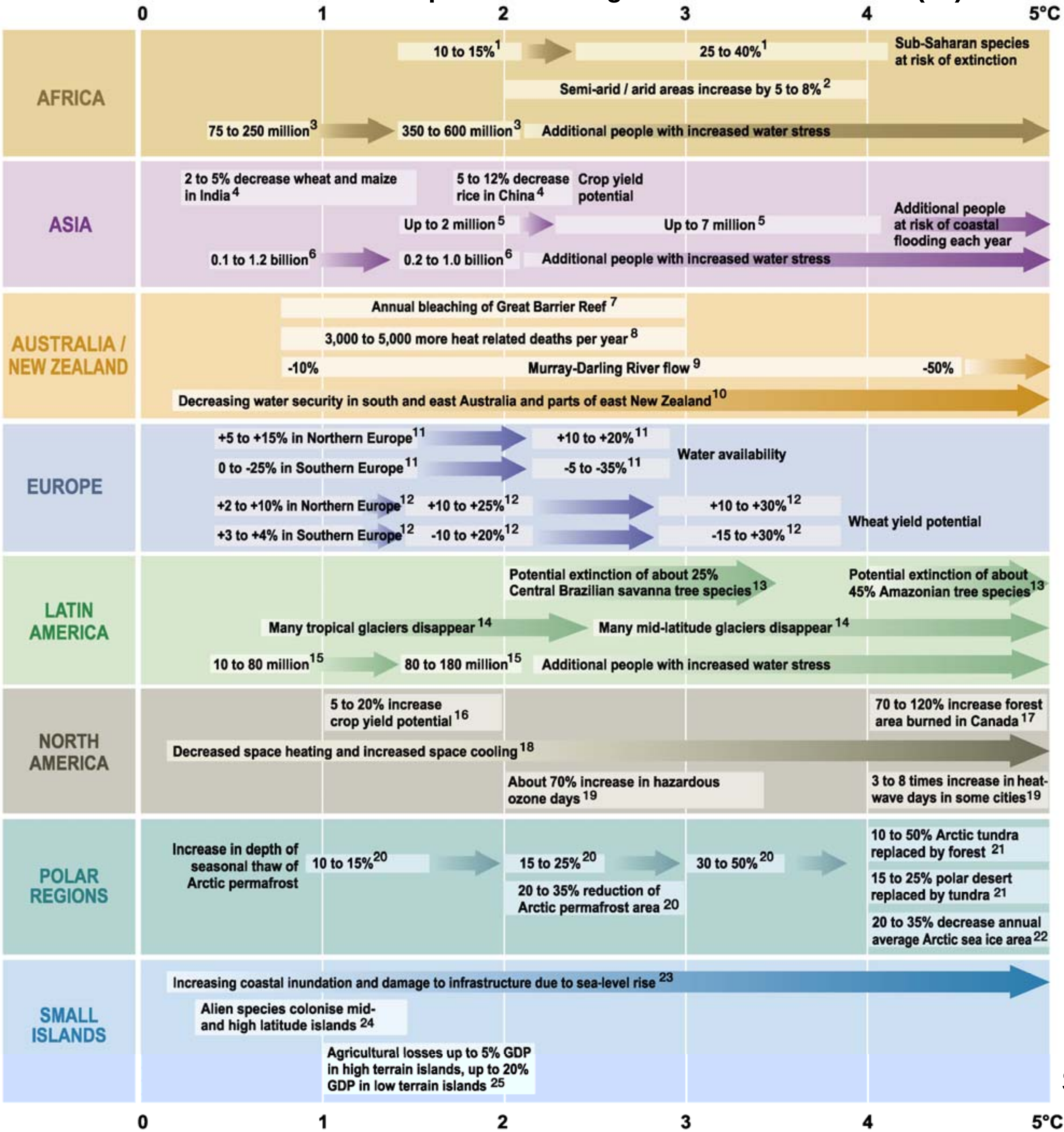


Table TS.3. *Examples of global impacts projected for changes in climate (and sea level and atmospheric CO_2 where relevant) associated with different amounts of increase in global average surface temperature in the 21st century [T20.8]. This is a selection of some estimates currently available. All entries are from published studies in the chapters of the Assessment. (Continues below Table TS.4.)*

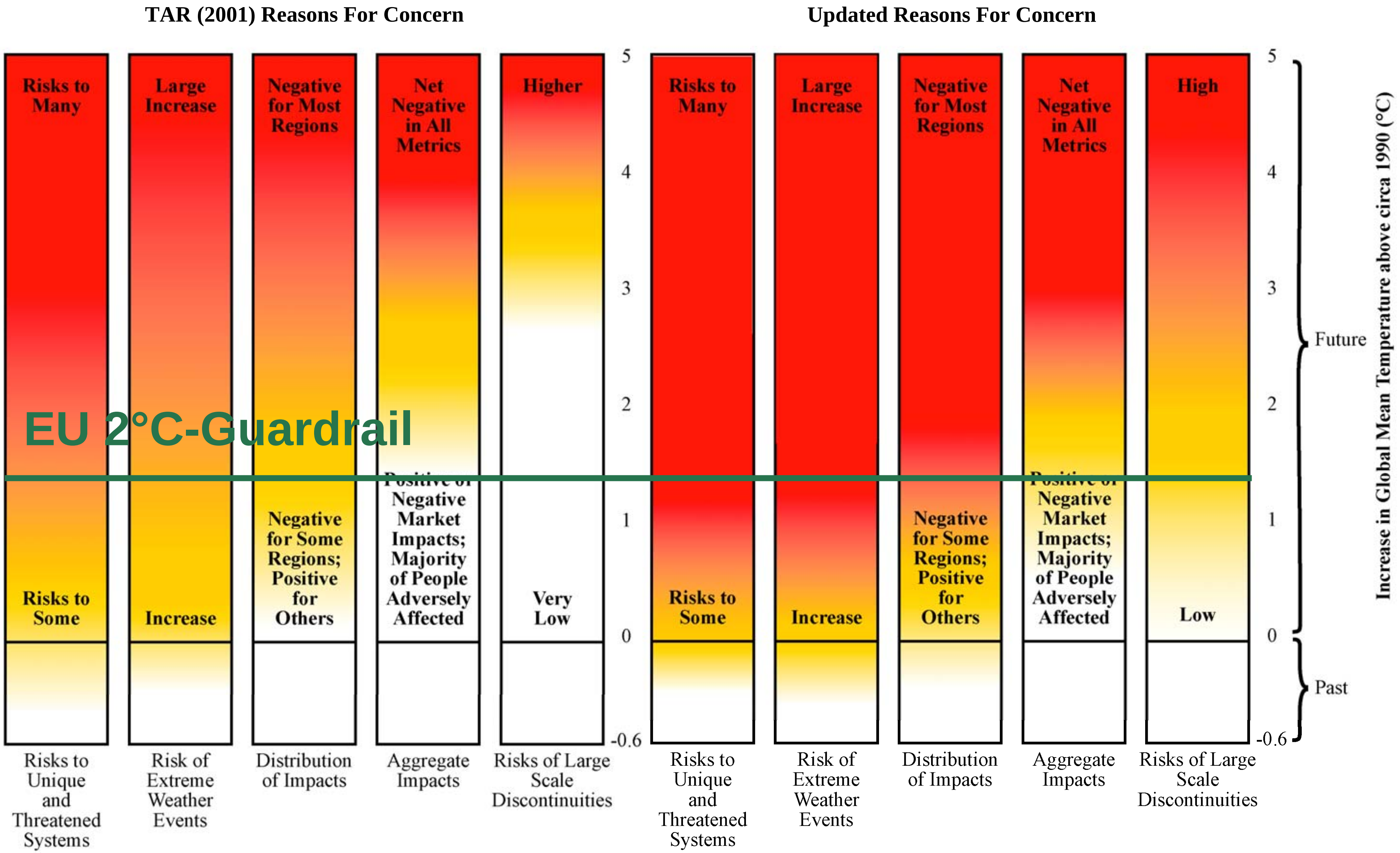
Source: IPCC

Global mean annual temperature change relative to 1980-1999 (°C)



Source: IPCC

Updated Reasons for Concern



Source: Synthesis Report (Smith et al. 2009 PNAS)

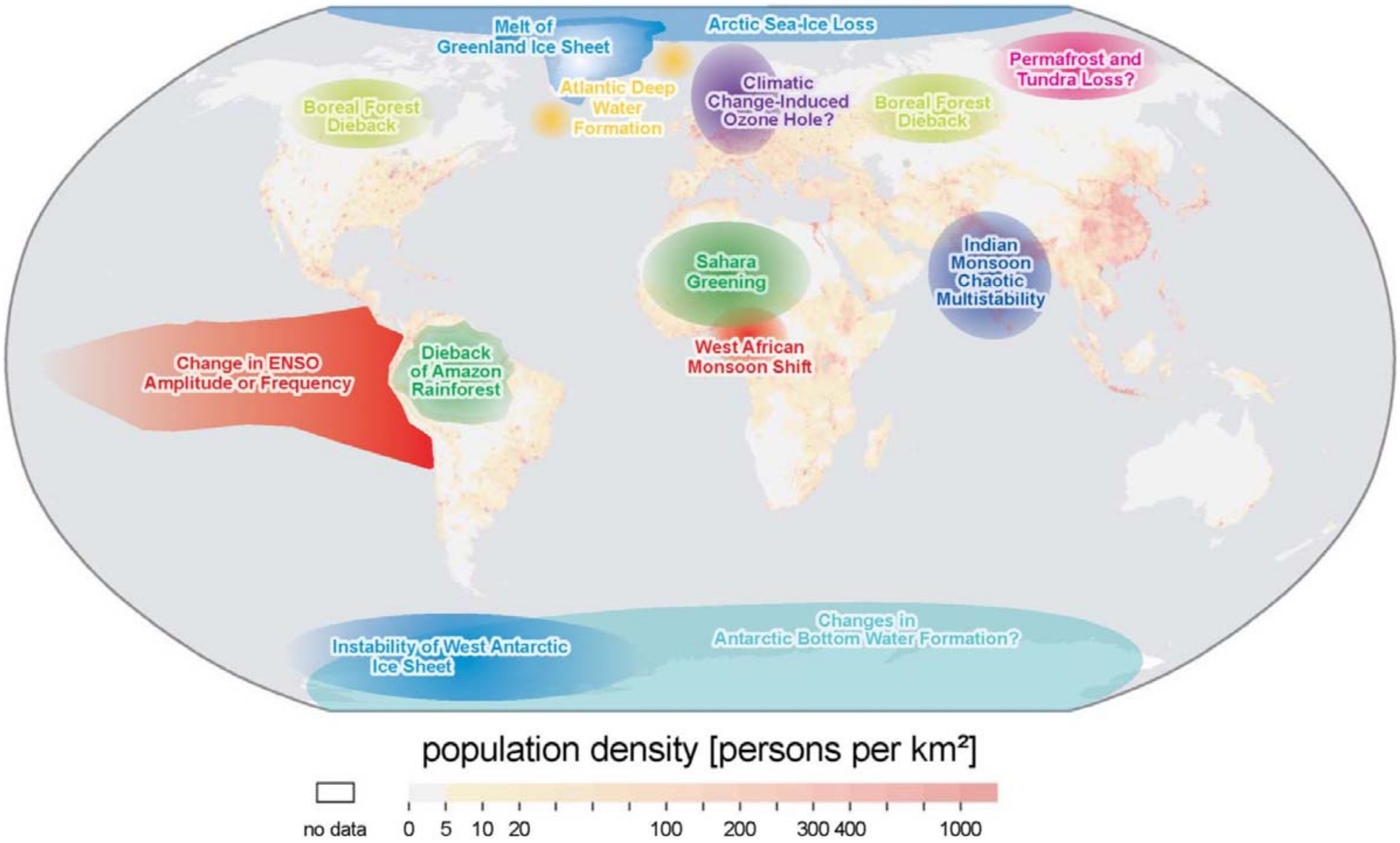
Tipping elements in the Earth's climate system

Timothy M. Lenton*†, Hermann Held‡, Elmar Kriegler‡§, Jim W. Hall¶, Wolfgang Lucht‡, Stefan Rahmstorf‡, and Hans Joachim Schellnhuber†‡‖**

*School of Environmental Sciences, University of East Anglia, and Tyndall Centre for Climate Change Research, Norwich NR4 7TJ, United Kingdom; ‡Potsdam Institute for Climate Impact Research, P.O. Box 60 12 03, 14412 Potsdam, Germany; §Department of Engineering and Public Policy, Carnegie Mellon University, Pittsburgh, PA 15213-3890; ¶School of Civil Engineering and Geosciences, Newcastle University, and Tyndall Centre for Climate Change Research, Newcastle NE1 7RU, United Kingdom; and ‖Environmental Change Institute, Oxford University, and Tyndall Centre for Climate Change Research, Oxford OX1 3QY, United Kingdom

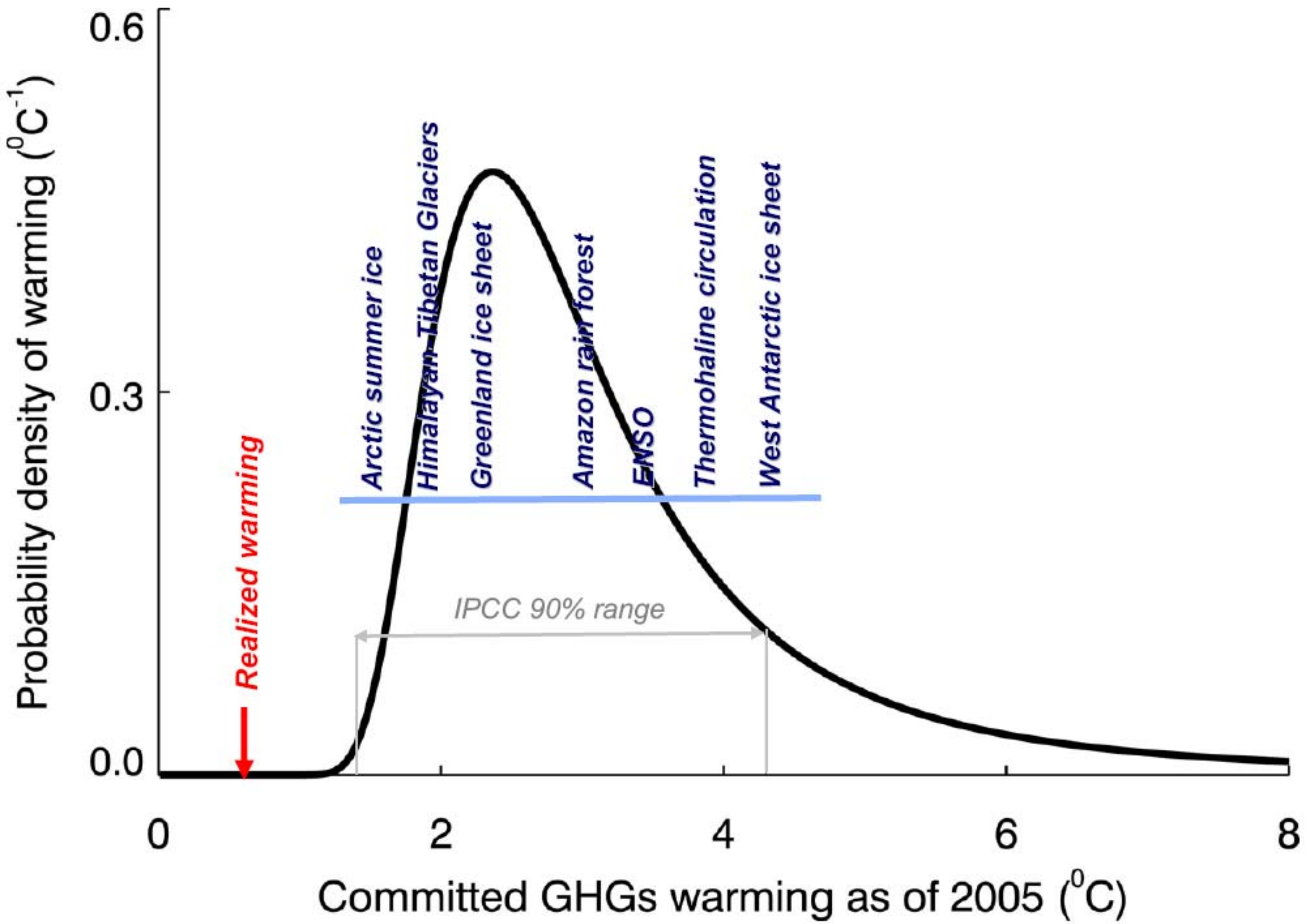
**This contribution is part of the special series of Inaugural Articles by members of the National Academy of Sciences elected on May 3, 2005.

Edited by William C. Clark, Harvard University, Cambridge, MA, and approved November 21, 2007 (received for review June 8, 2007)

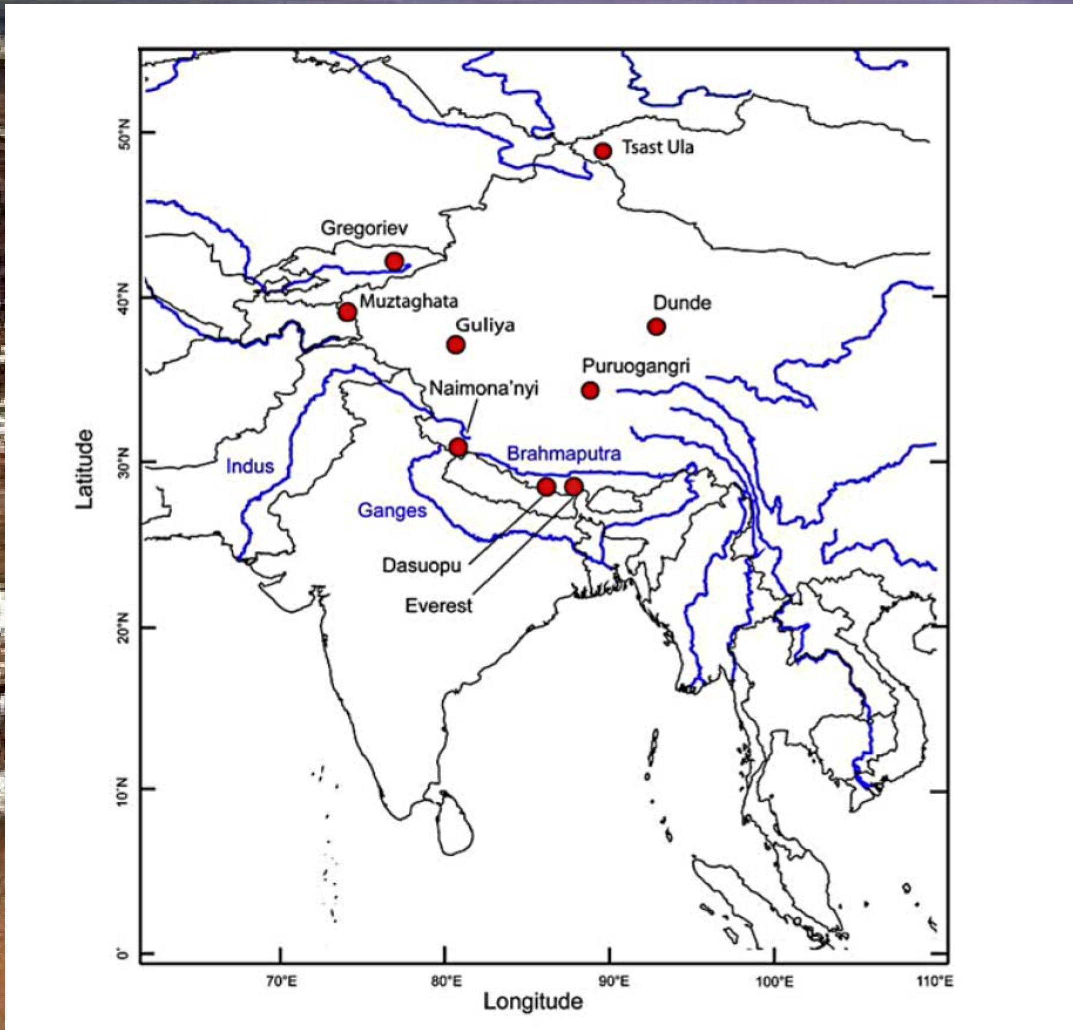


1786–1793 | PNAS | February 12, 2008 | vol. 105 | no. 6

Dangerous Warming Commitment



(Ramanathan & Feng 2008 PNAS)



„Mass loss on Himalayan glacier endangers water resources“ (Kehrwald et al. 2008 Geophys Res Lett)

Extensive dynamic thinning on the margins of the Greenland and Antarctic ice sheets

Hamish D. Pritchard[1], Robert J. Arthern[1], David G. Vaughan[1] & Laura A. Edwards[2]

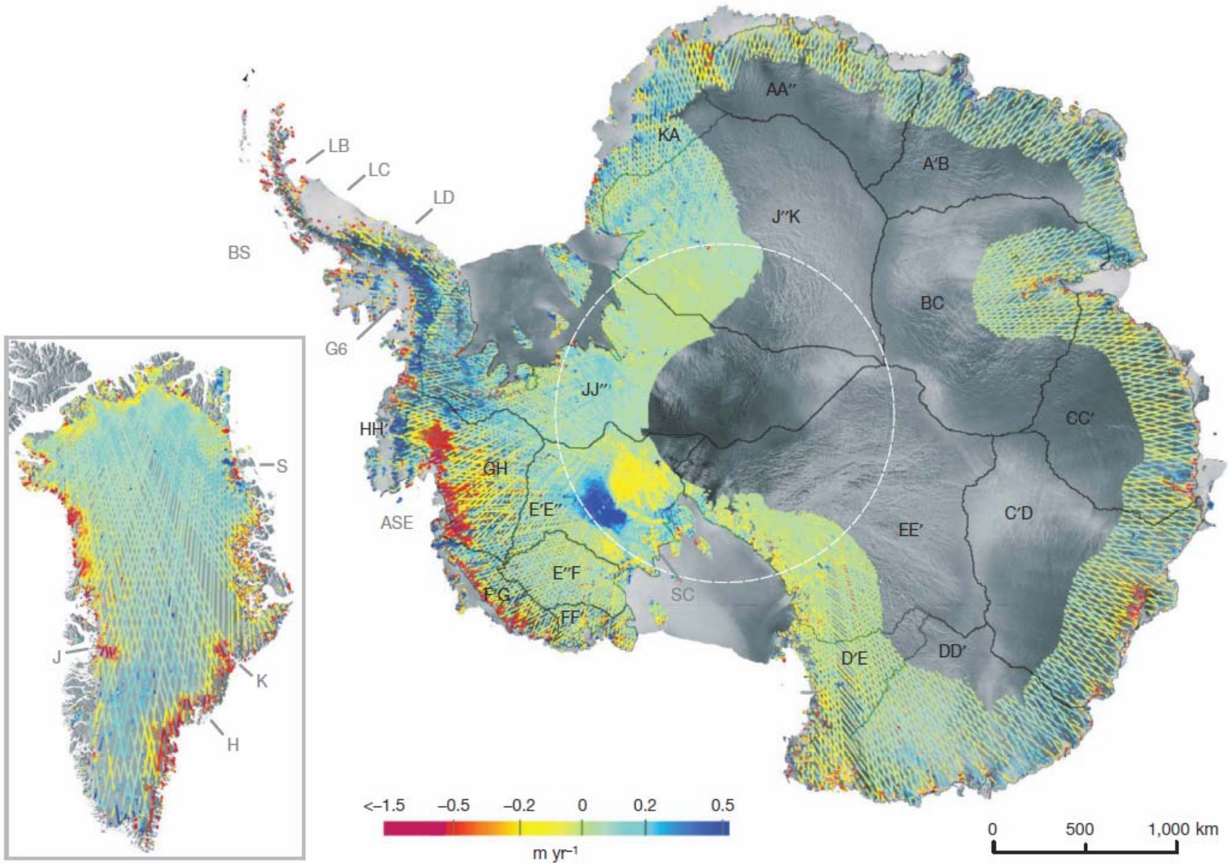


Figure 2 | Rate of change of surface elevation for Antarctica and Greenland. Change measurements are median filtered (10-km radius), spatially averaged (5-km radius) and gridded to 3 km, from intervals (Δt) of at least 365 d, over the period 2003–2007 (mean Δt is 728 d for Antarctica and 746 d for Greenland). East Antarctic data cropped to 2,500-m altitude. White dashed line (at 81.5° S) shows southern limit of radar altimetry measurements. Labels are for sites and drainage sectors (see text).

Nature, 24 Sep 2009

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B
BIOLOGICAL SCIENCES

ISSN 0962-8436
volume 363
number 1498
pages 1725–1932

In this issue

Climate change and the fate of the Amazon

Papers of a Theme Issue compiled and edited by Yadvinder Malhi, Richard Betts and Timmons Roberts

Royal Society **Publishing**
Informing the science of the future

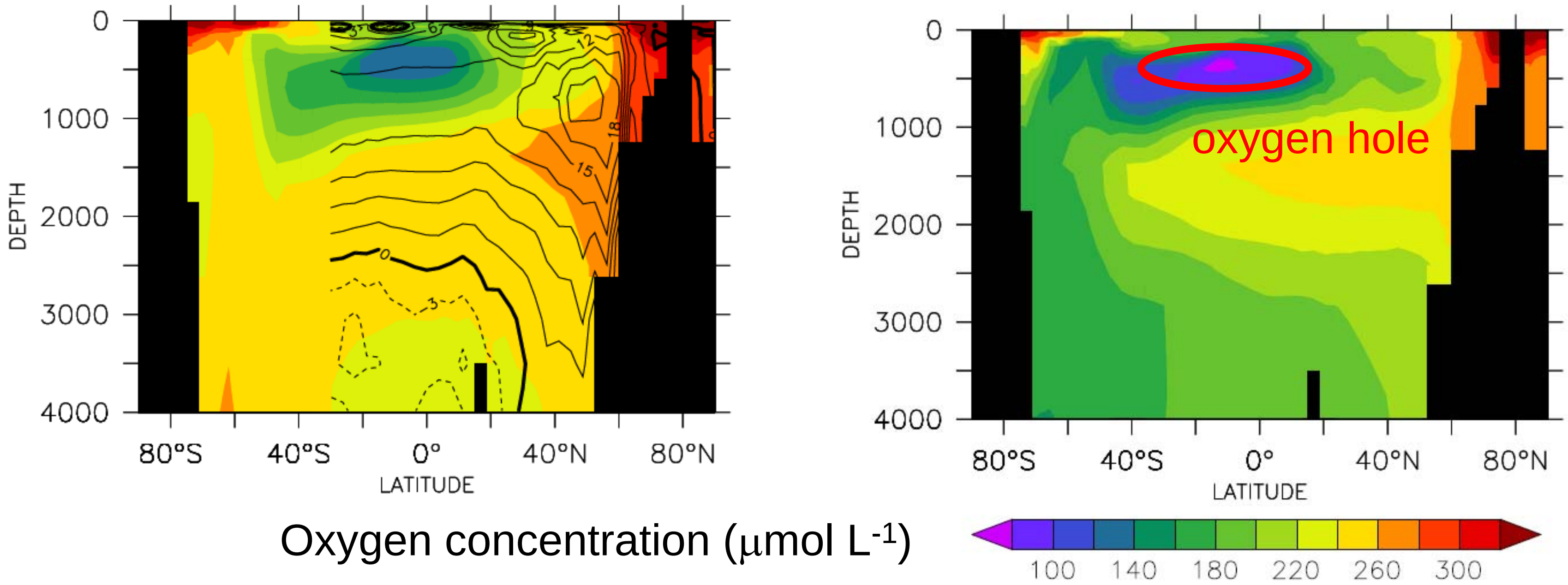
defra

27 May 2008

Ocean Acidification Triggers Marine Oxygen Holes

present day

year 3000
global warming
+ reduced ballast



Oxygen concentration (μmol L^{-1})

Key Message 2 Synthesis Report (Hofmann&Schellnhuber 2009 PNAS)

PNAS Special Feature on Tipping Elements, December 2009

Editor Hans Joachim Schellnhuber

1. Washington R *et al.* Dust as a tipping element: The Bodélé Depression
2. Malhi Y *et al.* Exploring the likelihood and mechanism of a climate-change induced dieback of the Amazon rainforest
3. Levermann A *et al.* Basic mechanism for abrupt monsoon transitions
4. Latif M *et al.* El Niño/Southern Oscillation response to global warming
5. Notz D The big melt: Is the loss of ice sheets and Arctic sea ice unstoppable?
6. Riebesell U *et al.* Sensitivity of marine carbon fluxes to ocean change
7. Archer D *et al.* Ocean methane hydrates as a slow tipping point in the global carbon cycle
8. Hofmann M *et al.* On the stability of the Atlantic Meridional Overturning Circulation
9. Molina M *et al.* Reducing abrupt climate change risk using Montreal Protocal and other regulatory actions to complement cuts in CO2 emissions

G8 and Emerging Economies Agree on
2° C Long-term Target

DECLARATION OF THE LEADERS
THE MAJOR ECONOMIES FORUM ON
ENERGY AND CLIMATE

We, the leaders of Australia, Brazil, Canada, China, the European Union, France, Germany, India, Indonesia, Italy, Japan, the Republic of Korea, Mexico, Russia, South Africa, the United Kingdom, and the United States met as the Major Economies Forum on Energy and Climate in L'Aquila, Italy, on July 9, 2009, and declare as follows:

1. Consistent with the Convention's objective and science:

Our countries will undertake transparent nationally appropriate mitigation actions, subject to applicable measurement, reporting, and verification, and prepare low-carbon growth plans. Developed countries among us will take the lead by promptly undertaking robust aggregate and individual reductions in the midterm consistent with our respective ambitious long-term objectives and will work together before Copenhagen to achieve a strong result in this regard. Developing countries among us will promptly undertake actions whose projected effects on emissions represent a meaningful deviation from business as usual in the midterm, in the context of sustainable development, supported by financing, technology, and capacity-building. The peaking of global and national emissions should take place as soon as possible, recognizing that the timeframe for peaking will be longer in developing countries, bearing in mind that social and economic development and poverty eradication are the first and overriding priorities in developing countries and that low-carbon development is indispensible to sustainable development. We recognize the scientific view that the increase in global average temperature above pre-industrial levels ought not to exceed 2 degrees C. In this regard and in the context of the ultimate objective of the Convention and the Bali Action Plan, we will work between now and Copenhagen, with each other and under the Convention, to identify a global goal for substantially reducing global emissions by 2050. Progress toward the global goal would be regularly reviewed, noting the importance of frequent, comprehensive, and accurate inventories.

We will take steps nationally and internationally, including under the Convention, to reduce emissions from deforestation and forest degradation and to enhance removals of greenhouse gas emissions by forests, including providing enhanced support to developing countries for such purposes.

2. Adaptation to the adverse effects of climate change is essential. Such effects are already taking place. Further, while increased mitigation efforts will reduce climate impacts, even the most aggressive mitigation

RESPONSIBLE LEADERSHIP FOR A SUSTAINABLE FUTURE

Climate change and environment

Fighting climate change

63. This is a crucial year for taking rapid and effective global action to combat climate change. We welcome the decision taken within the UN Framework Convention on Climate Change (UNFCCC) in Poznan to enter full negotiating mode, in order to shape a global and comprehensive post-2012 agreement by the end of 2009 in Copenhagen, as mandated by the Bali Conference in 2007. We must seize this decisive opportunity to achieve a truly ambitious global consensus.

64. We reconfirm our strong commitment to the UNFCCC negotiations and to the successful conclusion of a global, wide-ranging and ambitious post-2012 agreement in Copenhagen, involving all countries, consistent with the principle of common but differentiated responsibilities and respective capabilities. In this context we also welcome the constructive contribution of the Major Economies Forum on Energy and Climate to support a successful outcome in Copenhagen. We call upon all Parties to the UNFCCC and to its Kyoto Protocol to ensure that the negotiations under both the Convention and the Protocol result in a coherent and environmentally effective global agreement.

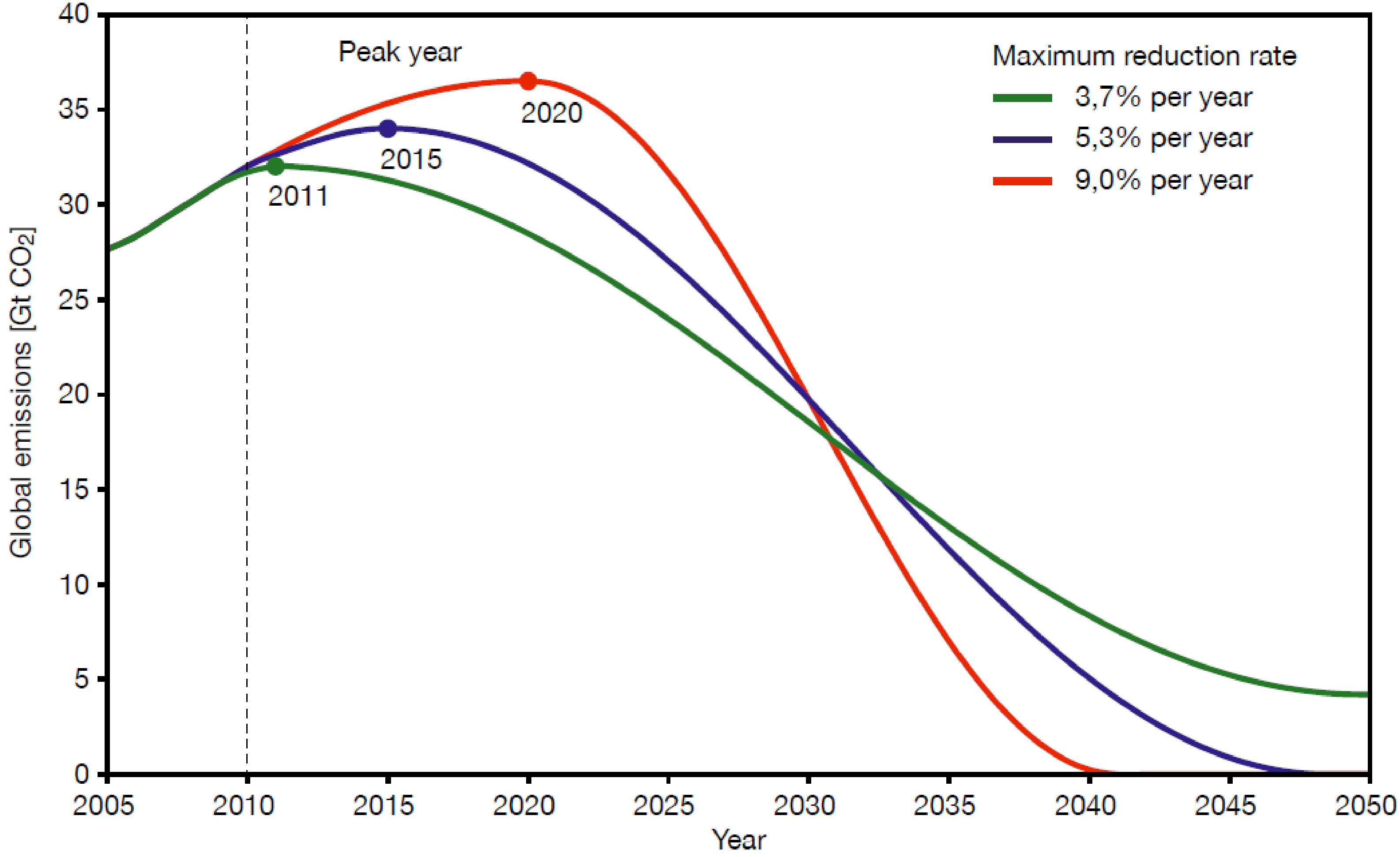
65. We reaffirm the importance of the work of the Intergovernmental Panel on Climate Change (IPCC) and notably of its Fourth Assessment Report, which constitutes the most comprehensive assessment of the science. We recognise the broad scientific view that the increase in global average temperature above pre-industrial levels ought not to exceed 2°C. Because this global challenge can only be met by a global response, we reiterate our willingness to share with all countries the goal of achieving at least a 50% reduction of global emissions by 2050, recognising that this implies that global emissions need to peak as soon as possible and decline thereafter. As part of this, we also support a goal of developed countries reducing emissions of greenhouse gases in aggregate by 80% or more by 2050 compared to 1990 or more recent years. Consistent with this ambitious long-term objective, we will undertake robust aggregate and individual mid-term reductions, taking into account that baselines may vary and that efforts need to be comparable. Similarly, major emerging economies need to undertake quantifiable actions to collectively reduce emissions significantly below business-as-usual by a specified year.

66. We recognize that the accelerated phase-out of HCFCs mandated under the Montreal Protocol is leading to a rapid increase in the use of HFCs, many of which are very potent GHGs. Therefore we will work with our partners to ensure that HFC emissions reductions are achieved under the appropriate framework. We are also committed to taking rapid action to address other significant climate forcing agents, such as black carbon. These efforts, however, must not draw away attention from

constitutes the most comprehensive assessment of the science. We recognise the [broad] scientific view that the increase in global average temperature above pre-industrial levels ought not to exceed 2°C. Because this global challenge can only be

Meinshausen et al. 2009a
Allen et al. 2009

The world's CO_2 budget



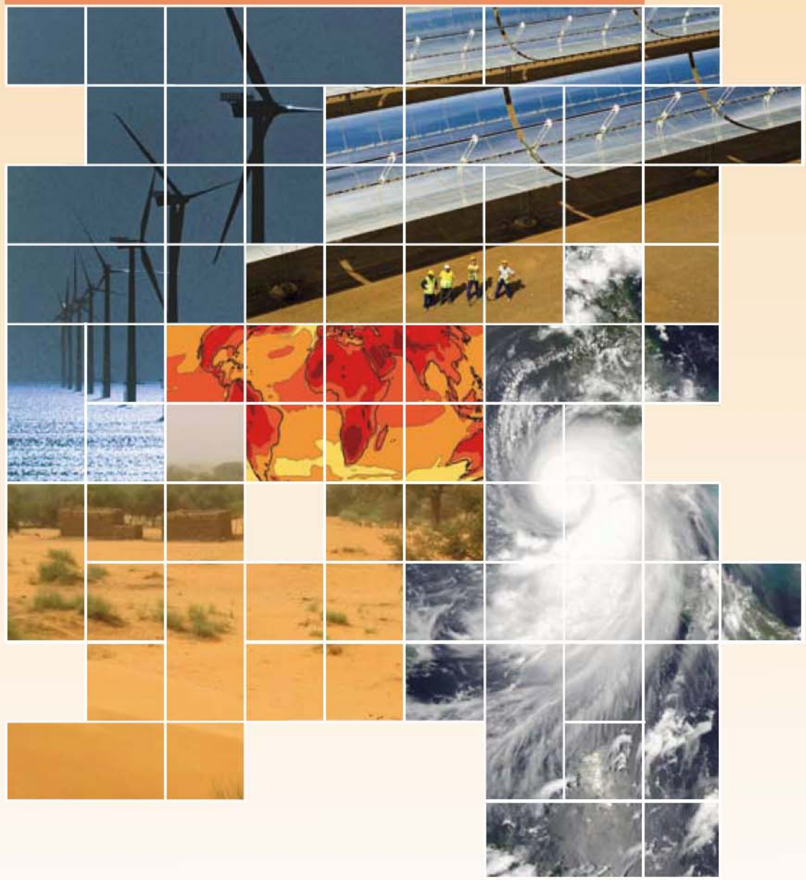
Exemplary emission pathways in order to remain within a budget of 750 Gt between 2010 and 2050. At this level, there is a 67% probability of staying below a warming of 2 ° C.

WBGU

German Advisory Council on Global Change (WBGU)

Solving the climate dilemma: The budget approach

Special Report



"World Formula" for Climate Policy

$$C_{glob}(p) = \int_{T_1}^{T_2} E_{glob}(t)\,dt$$

Total global CO_2 budget in period $[T_1, T_2]$ that keeps global warming below 2°C with probability p

Integral over global profile of CO_2 emissions

$$C_{nat} = \int_{T_1}^{T_2} E_{nat}(t)\,dt = C_{glob}(p)\,\frac{M_{nat}(T_M)}{M_{glob}(T_M)}$$

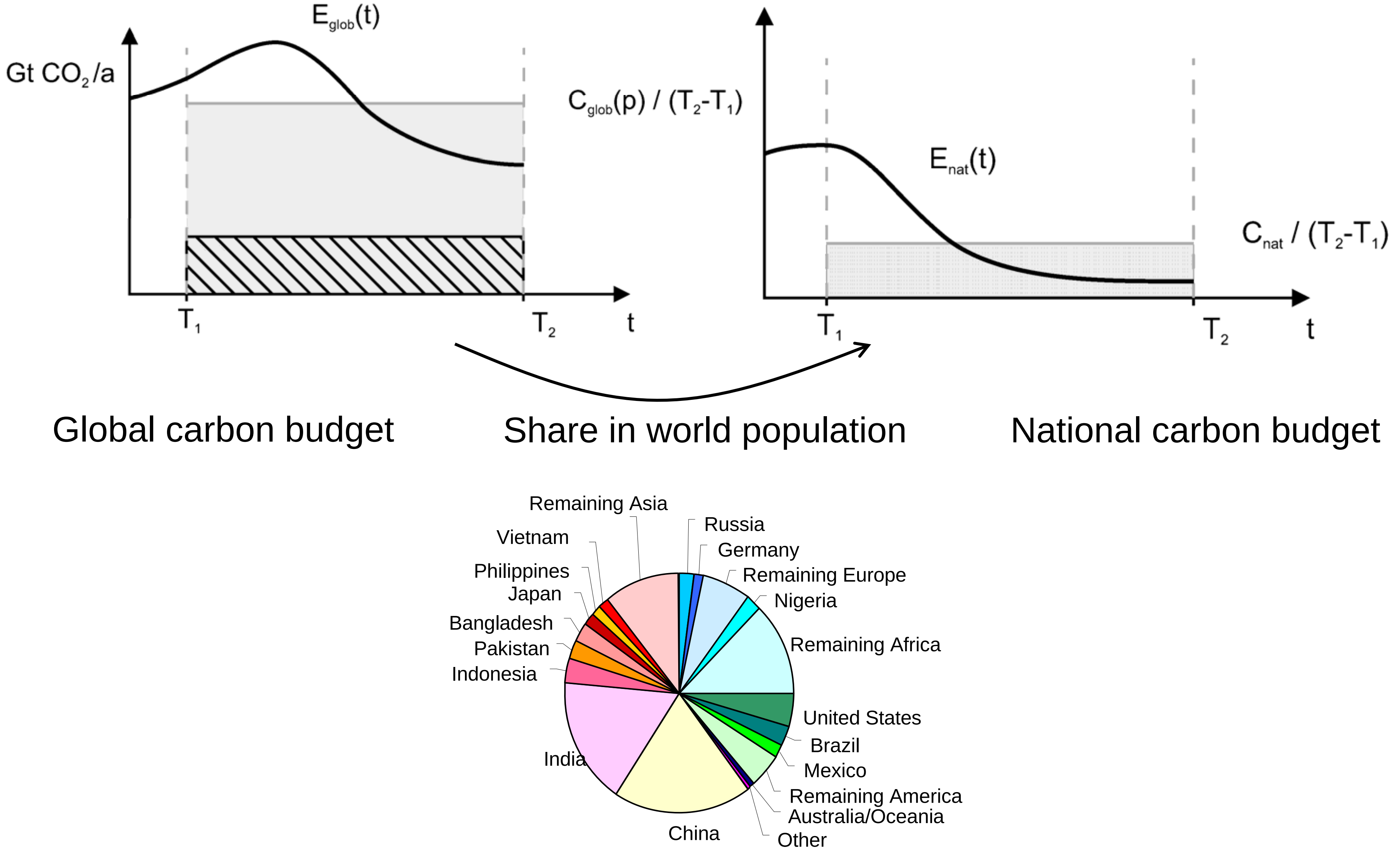
National CO_2 budget in $[T_1, T_2]$

Integral over national emission profile

Fraction of global CO_2 budget as defined by ratio of national population M_{nat} to world population M_{glob} at time T_M

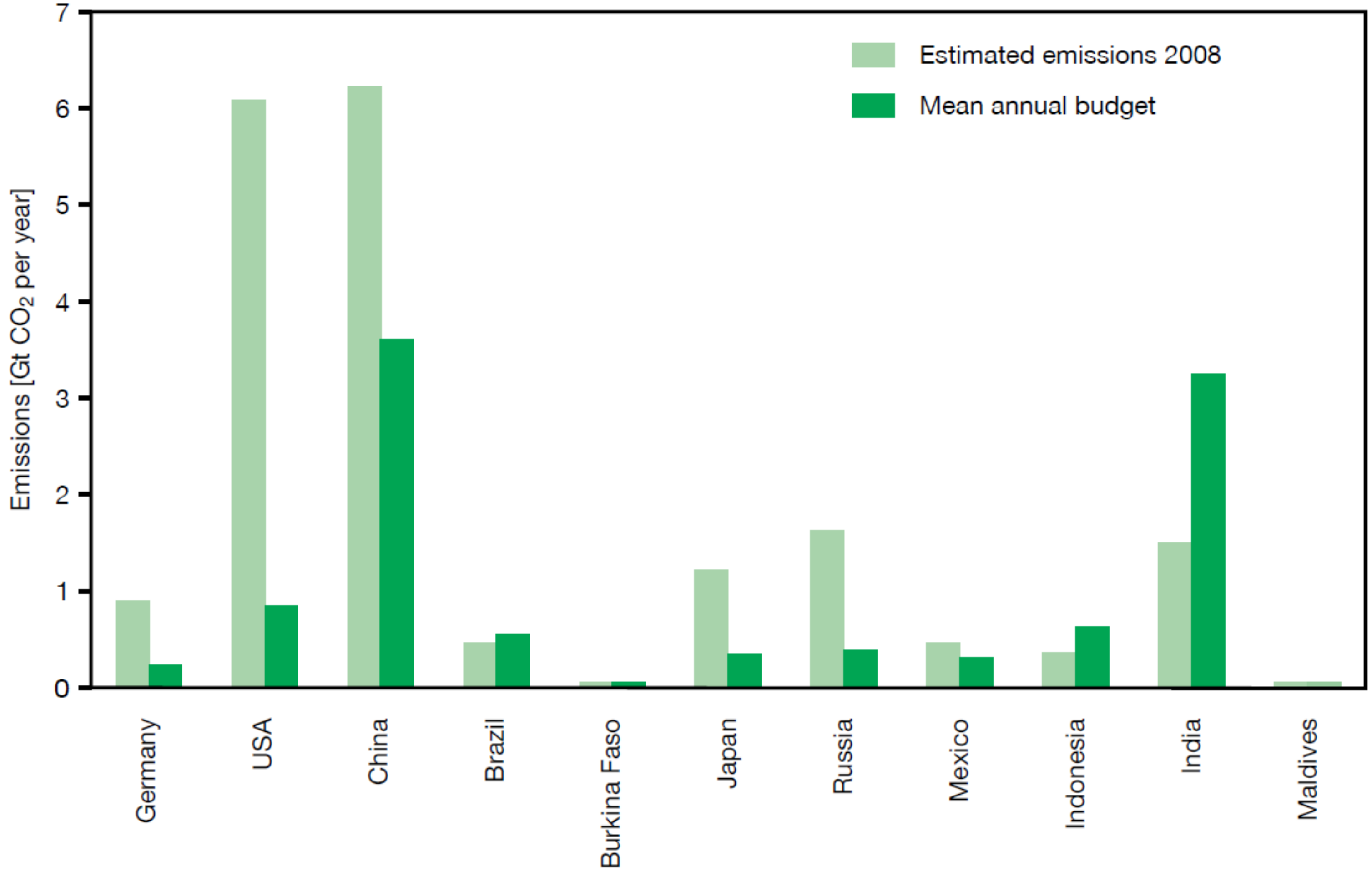
“World Formula“ for Climate Policy

Illustration



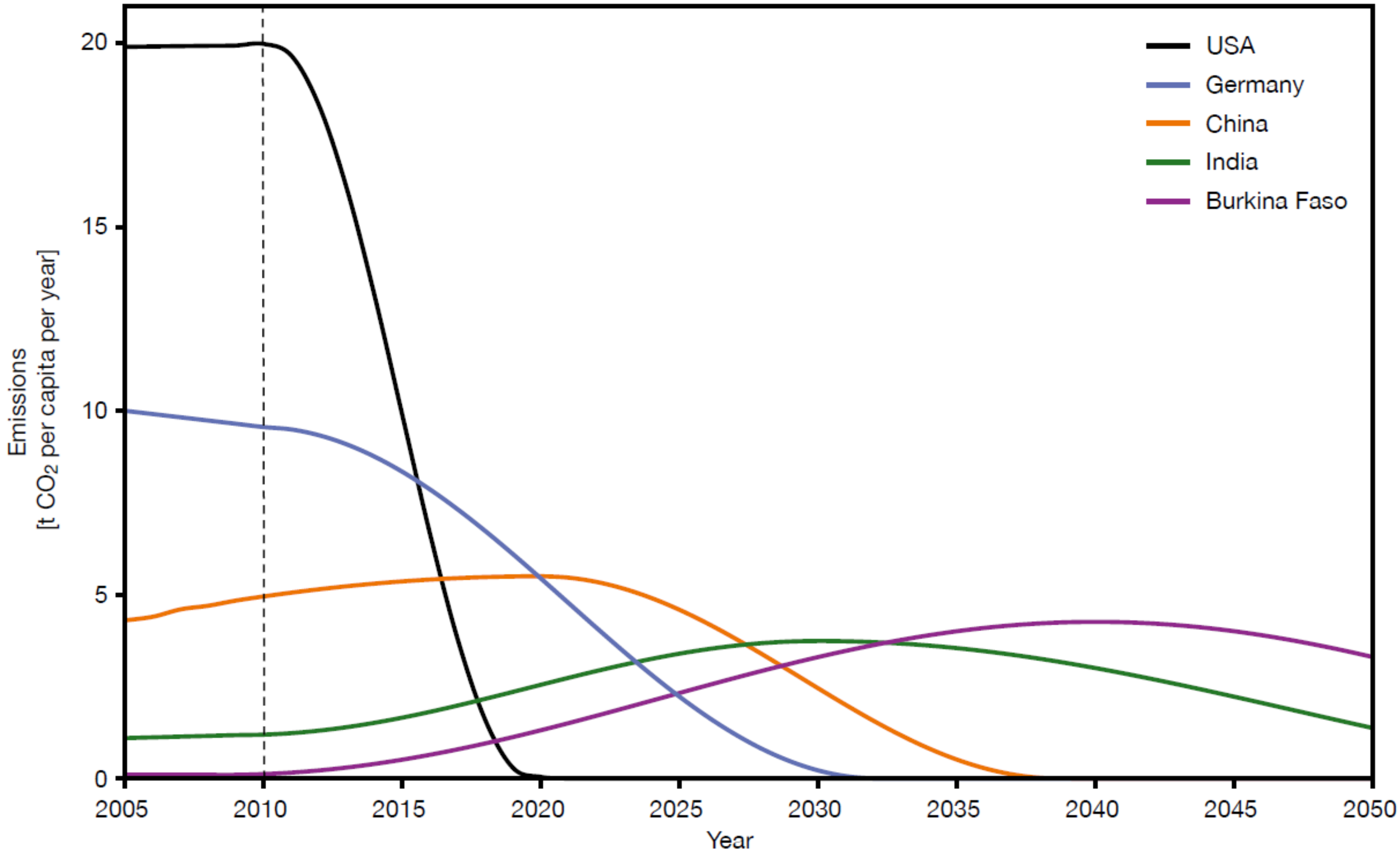
Scenario 2: Future responsibility approach

T_1 = 2010, T_2 = 2050, T_M = 2010, p = 2/3



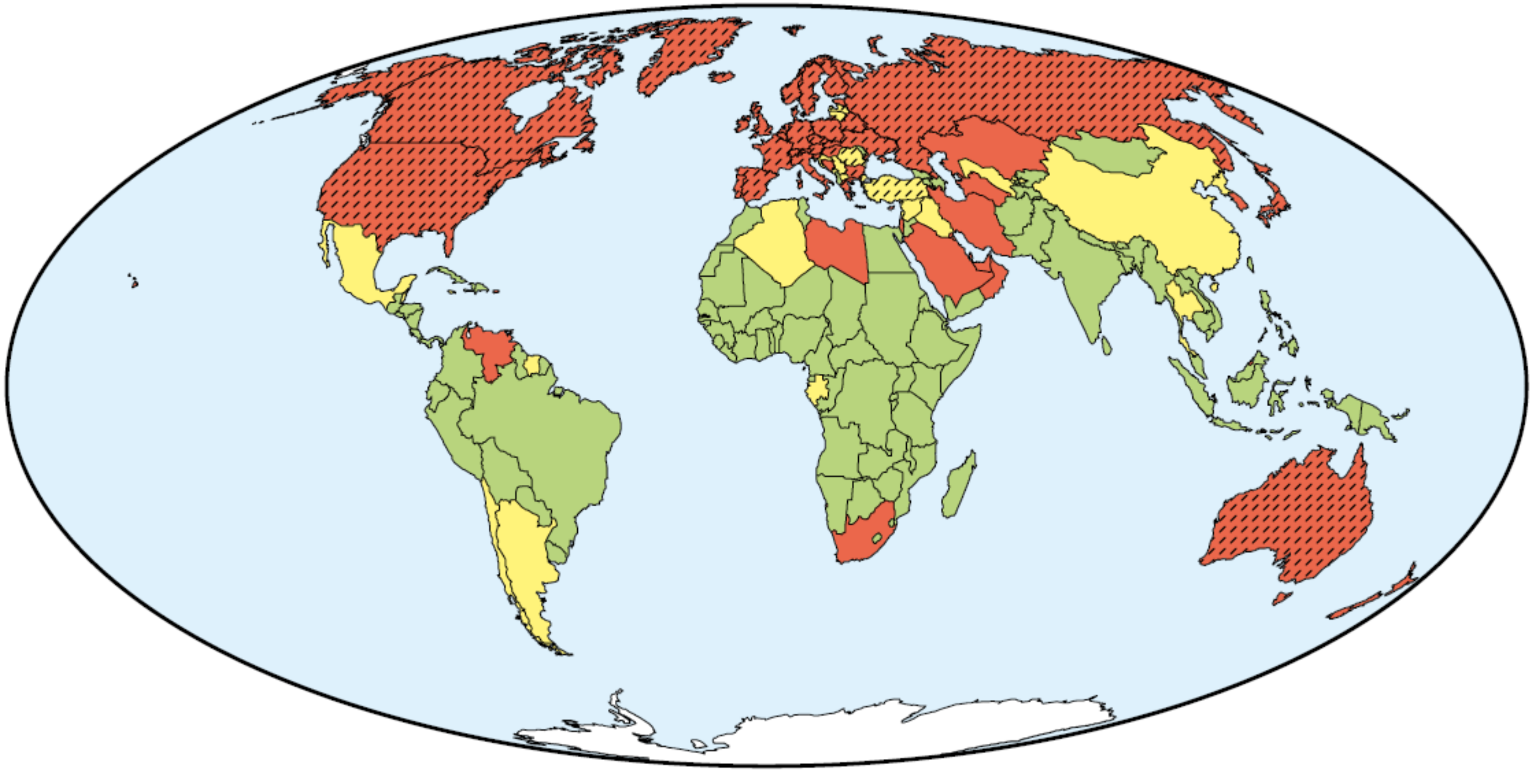
CO_2 emissions in 2008 (light green) and permissible average annual budgets (dark green) according to the WBGU approach for selected countries.

Examples of theoretical emission trajectories



Examples of equal per-capita emissions of selected countries for 2010 - 2050, **without emissions trading**. Trajectories start from current emission levels.

CO_2 emissions by country



Countries with per-capita CO_2 emissions above 5,4 t

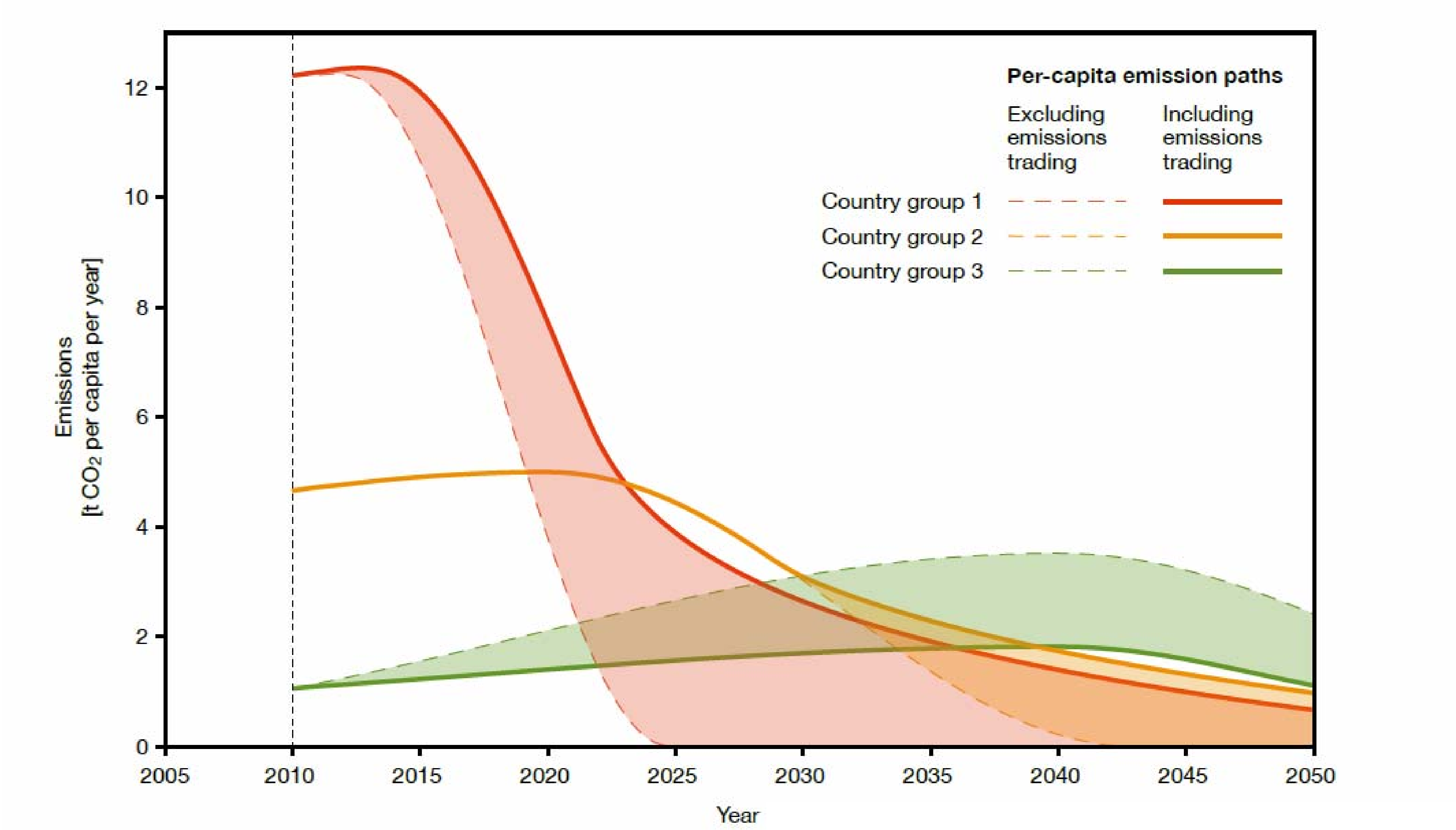
Countries with per-capita CO_2 emissions of 2,7–5,4 t

Countries with per-capita CO_2 emissions below 2,7 t

Annex I countries

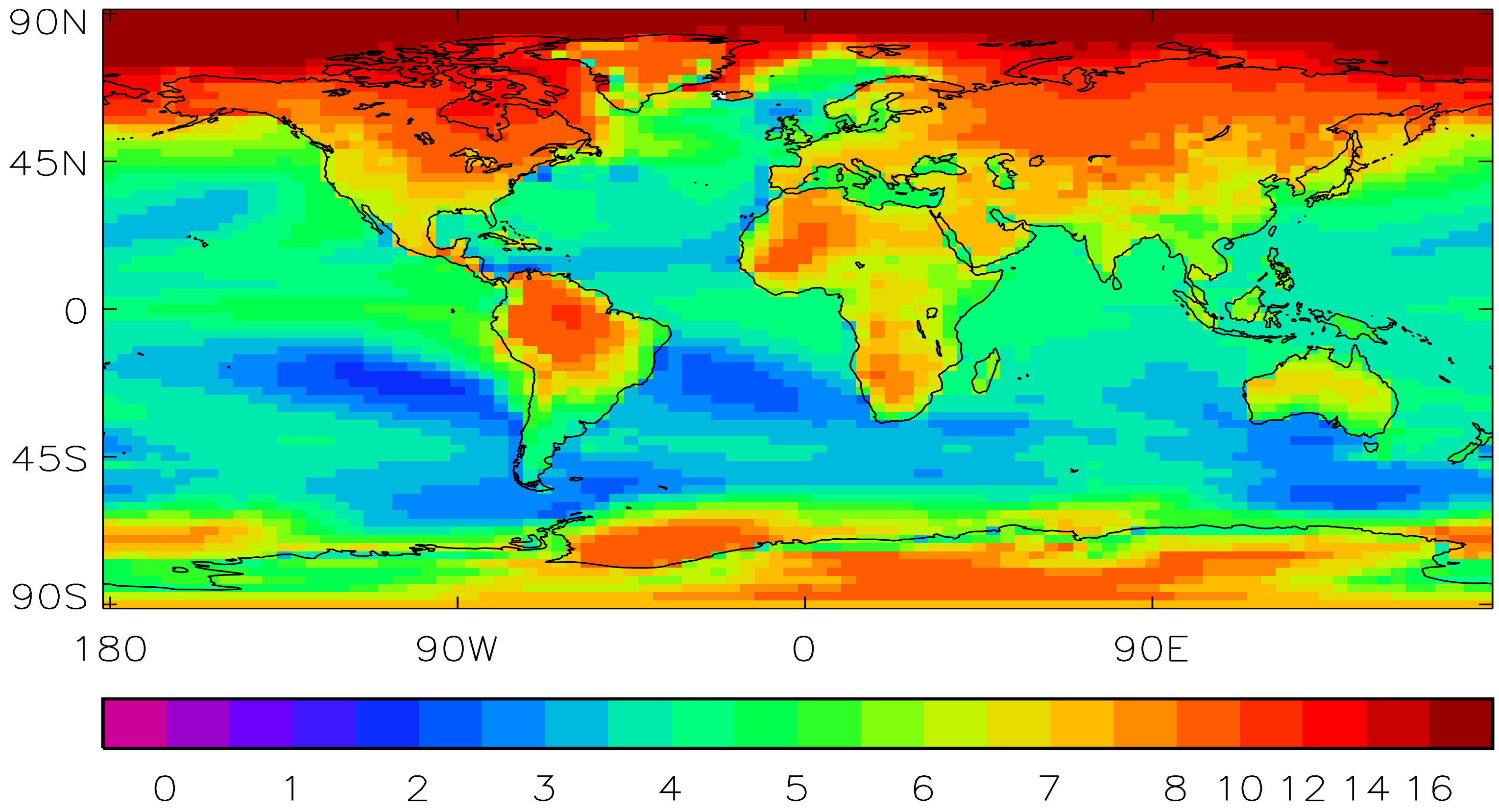
Per-capita CO_2 emissions in 2005, differentiated by emission levels and country.

Examples of Per-Capita Emissions Paths of CO_2 for Three Groups of Countries - *without Emissions Trading*



Source: WBGU Special Report 2009

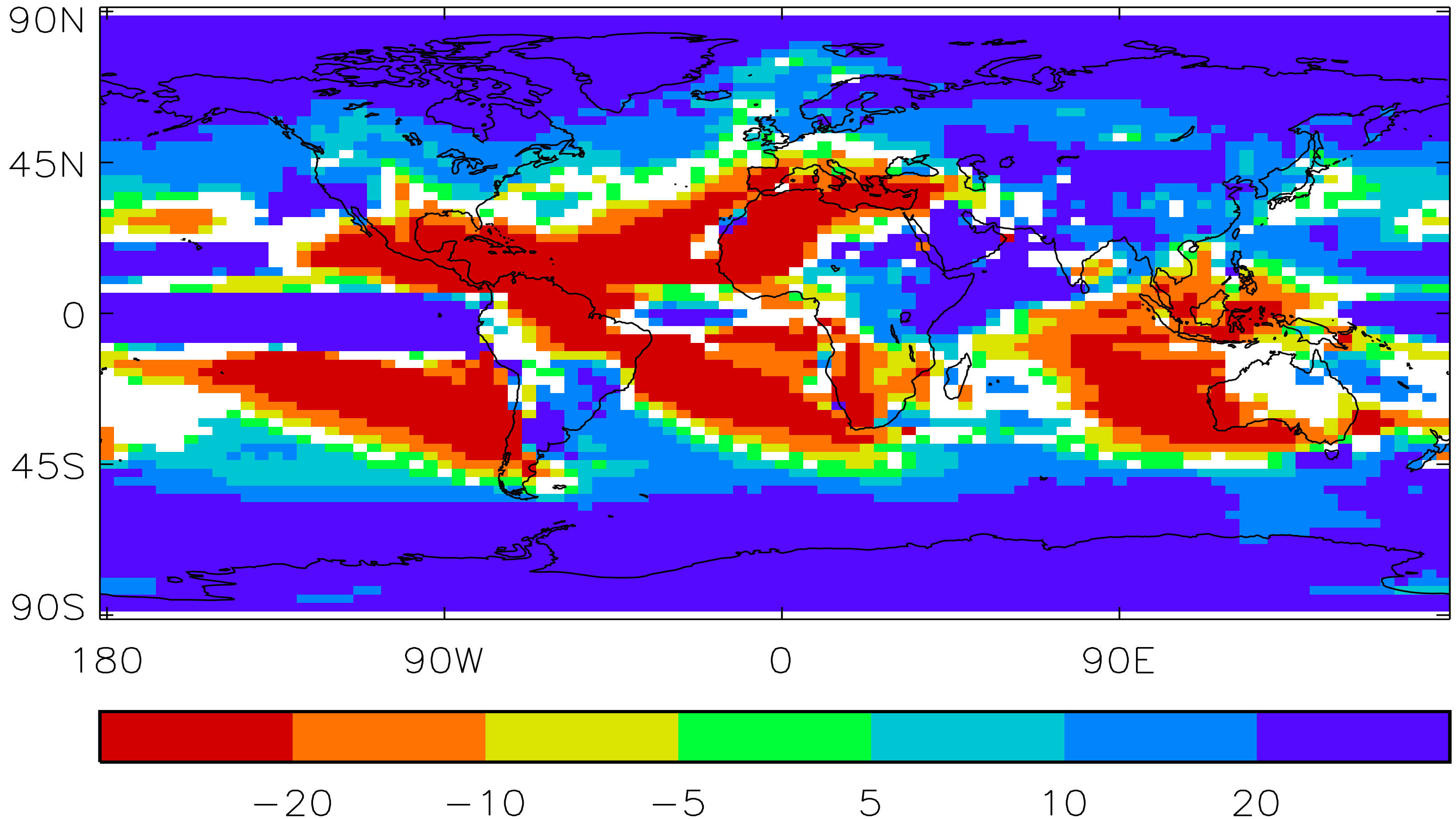
Pattern of warming by 2090s, A1FI Mean of “high-end” MOHC simulations (14 simulations, mean global warming 5.4°C)



Temperature change (°C) relative to 1961-1990

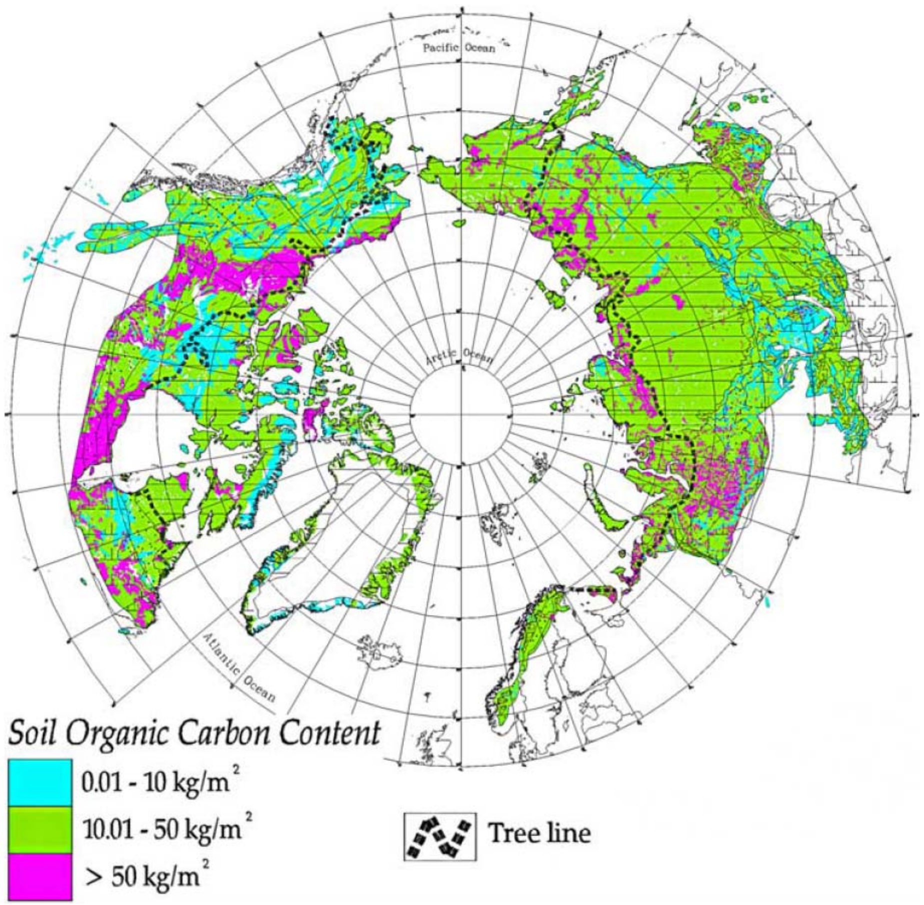
Source: Met Office Hadley Centre

Precipitation changes by 2090s, A1FI Mean of "high-end" MOHC simulations (14 simulations, mean global warming 5.4°C)



Source: Met Office Hadley Centre

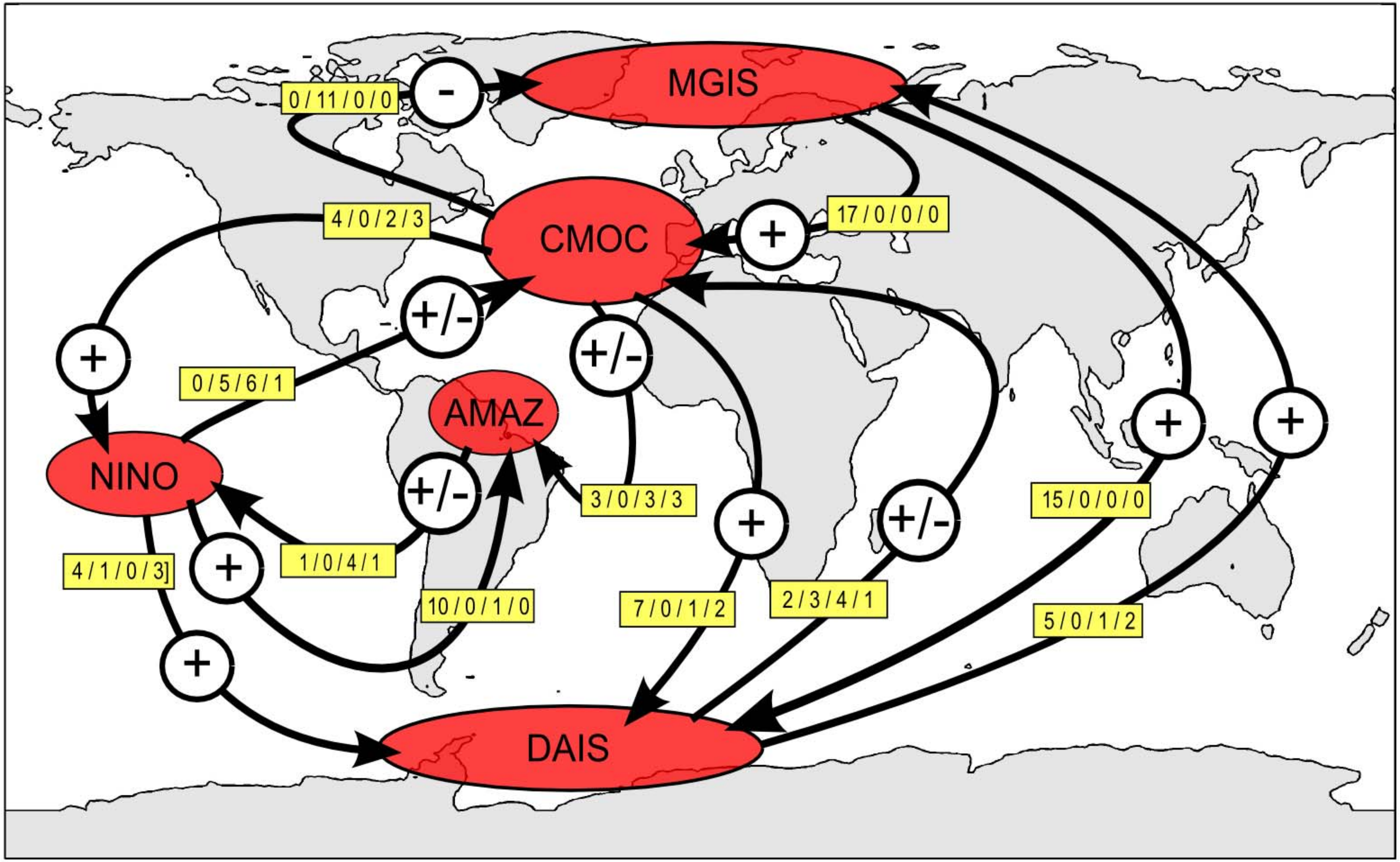
Carbon Stored in Permafrost Soils
Estimates Corrected Upwards



The new estimate of frozen carbon stored in permafrost soils of the circumpolar region is over 1.5 trillion tons, about twice as much carbon as contained in the atmosphere.

(Tarnocai et al. 2009 Global Biogeochemical Cycles)

Interdependency Between Tipping Points

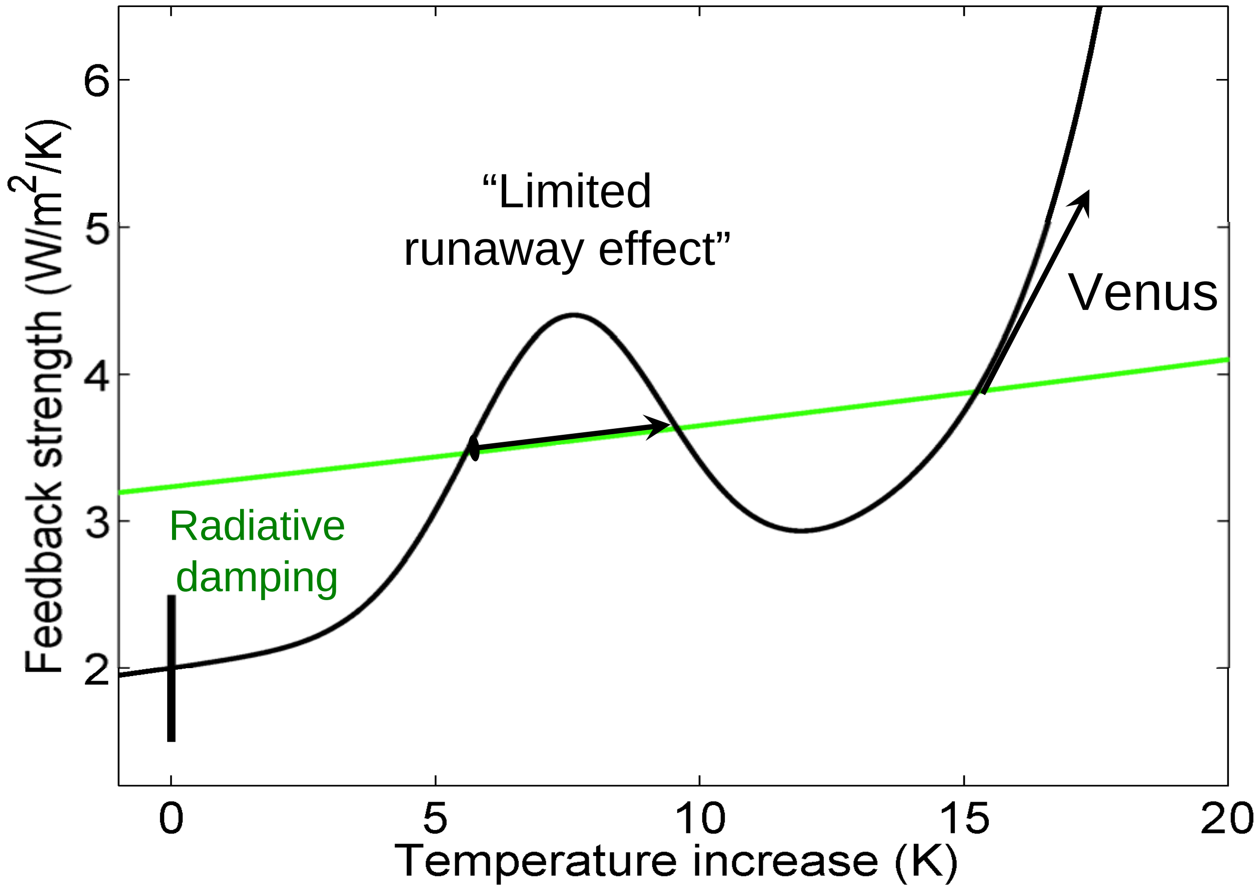


(Kriegler et al. 2009 PNAS)

“Runaway Greenhouse Effect”

Conceptual approach

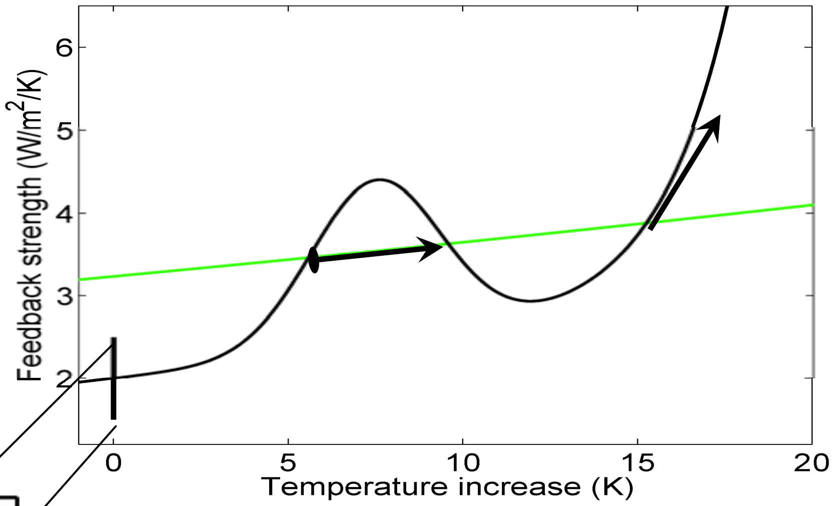
Energy gain per additional degree of warming [W/m²/K]
vs.
Energy export through thermal radiation



(Levermann & Schneider v. Deimling, pers. comm., 2009)

“Runaway Greenhouse Effect”

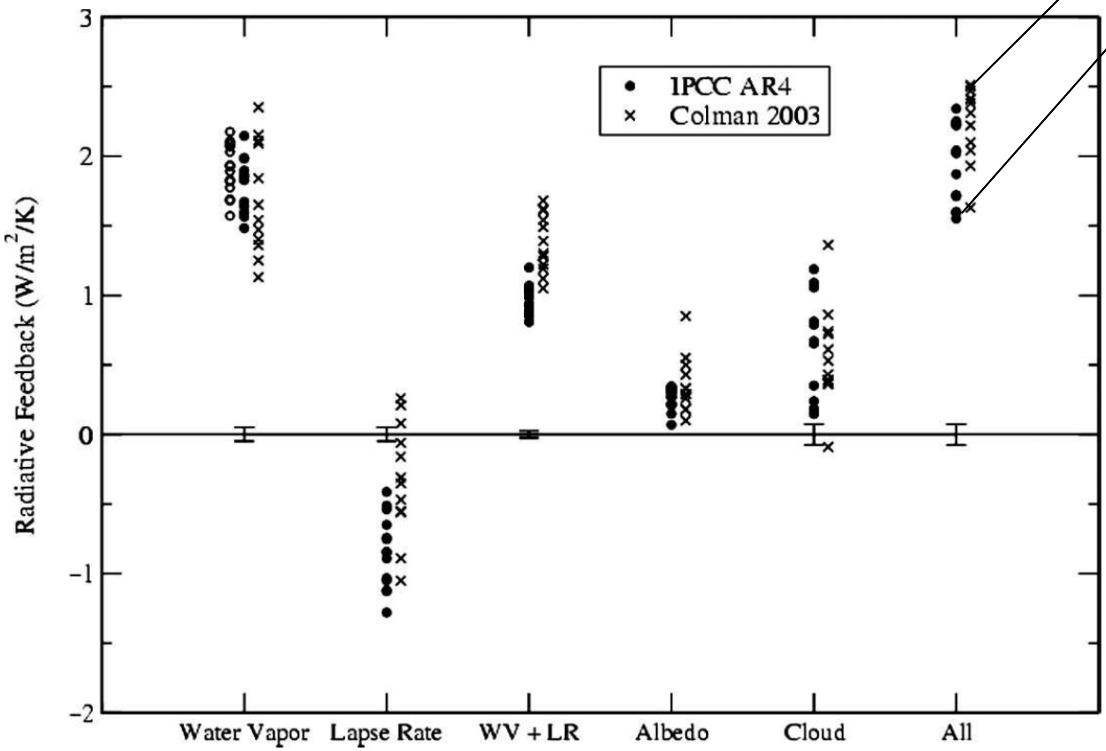
Where do we stand at present ?



Present estimate of

physical feedbacks

1.5 – 2.5 W/m²/K



Distance to Runaway Limit

0.7 – 1.7 W/m²/K

(Soden & Held, J. Clim, 2006)

Potsdam Symposium Series

ST. JAMES'S PALACE
NOBEL LAUREATE
SYMPOSIUM

"Global Sustainability – A Nobel Cause"

ST. JAMES'S PALACE
NOBEL LAUREATE SYMPOSIUM

The St James Palace Memorandum

"Action for a Low Carbon and Equitable Future"

London, UK, 26 – 28 May 2009

MILESTONES of the Great Transformation

An effective and just global agreement on climate change

A low carbon infrastructure

Forest protection, conservation and restoration

„[…] we should confine the temperature rise to 2°C to avoid unmanageable climate risks. This can only be achieved

- with a **peak of global emissions** of all greenhouse gases **by 2015**
- at least a 50% emission reduction by 2050 on a 1990 baseline. […] developed countries have to aim for a 25-40% reduction by 2020.

[…] a **total carbon budget** […] should be accepted as the base for measuring the effectiveness of short-term (2020) and long-term (2050) targets"

ST. JAMES'S PALACE
NOBEL LAUREATE
SYMPOSIUM

Memorandum Signatories

#	Name	Prize	Country
1	Professor Peter Agre	Chemistry 2003	United States
2	Professor Kenneth Arrow	Economics 1972	United States
3	Professor Françoise Barré-Sinoussi	Medicine 2008	France
4	Dr Paul Berg	Chemistry 1980	United States
5	Dr Mario Capecchi	Medicine 2007	United States
6	Professor John Coetzee	Literature 2003	South Africa
7	Professor Paul Crutzen	Chemistry 1995	Germany
8	Professor Johann Deisenhofer	Chemistry 1988	Germany
9	Dr Mohamed ElBaradei	Peace 2005	Austria
10	Professor Claude Cohen-Tannoudji	Physics 1997	France
11	Professor Peter Doherty	Medicine 1996	Australia
12	Professor Richard Ernst	Chemistry 1991	Switzerland
13	Professor Dr Gerhard Ertl	Chemistry 2007	Germany
14	Mr Mikhail Gorbachev	Peace 1990	Russia (Former USSR)
15	Ms Nadine Gordimer	Literature 1991	South Africa
16	Dr Paul Greengard	Medicine 2000	United States
17	Professor David Gross	Physics 2004	United States
18	Professor Robert Grubbs	Chemistry 2005	United States
19	Dr Roger Guillemin	Medicine 1977	United States
20	Dr Lee Hartwell	Medicine 2001	United States
21	Professor Alan Heeger	Chemistry 2000	United States
22	Professor Dudley Herschbach	Chemistry 1986	United States
23	Professor Antony Hewish	Physics 1974	United Kingdom
24	Professor Roald Hoffmann	Chemistry 1981	United States
25	Professor Gerardus 't Hooft	Physics 1999	Netherlands
26	Professor Aaron Klug	Chemistry 1982	United Kingdom
27	Professor Walter Kohn	Chemistry 1998	United States
28	Professor Masatashi Koshiba	Physics 2002	Japan
29	Professor Sir Harold Kroto	Chemistry 1996	United Kingdom
30	His Holiness the Dalai Lama	Peace 1989	Tibet
31	Professor Yuan Tseh Lee	Chemistry 1986	United States
32	Ms Doris Lessing	Literature 2007	United Kingdom
33	Professor Wangari Maathai	Peace 2004	Kenya
34	Dr Toshihide Maskawa	Physics 2008	Japan
35	Professor Eric Maskin	Economic Sciences 2007	United States
36	Professor Dr Hartmut Michel	Chemistry 1988	Germany
37	Professor James Mirrlees	Economic Sciences 1996	United Kingdom
38	Professor Mario Molina	Chemistry 1995	United States
39	Professor Roger Myerson	Economics 2007	United States
40	Professor Doctor Erwin Neher	Medicine 1991	Germany
41	Dr Ryoji Noyori	Chemistry 2001	Japan
42	Sir Paul Nurse	Medicine 2001	United Kingdom
43	Professor Douglas Osheroff	Physics 1996	United States
44	Dr. Rajendra Pachauri on behalf of IPCC	Peace 2007	India
45	Professor Edmund Phelps	Economic Sciences 1996	United States
46	Professor John Polanyi	Chemistry 1986	Canada
47	Professor David Politzer	Physics 2004	United States
48	Professor Burton Richter	Chemistry 1976	United States
49	Professor F. Sherwood Rowland	Chemistry 1995	United States
50	Professor Carlo Rubbia	Physics 1984	Italy
51	Dr Hideki Shirakawa	Chemistry 2007	Japan
52	Dr Jens Christian Skou	Chemistry 1997	Denmark
53	Professor Wole Soyinka	Literature 1986	Nigeria
54	Professor Jack Steinberger	Physics 1988	United States
55	Sir John Sulston	Medicine 2002	United Kingdom
56	Professor Susumu Tonegawa	Medicine 1987	Japan
57	Professor Klaus von Klitzing	Physics 1985	Germany
58	Professor Sir John Walker	Chemistry 1997	United Kingdom
59	Dr Torsten Wiesel	Medicine 1981	United States