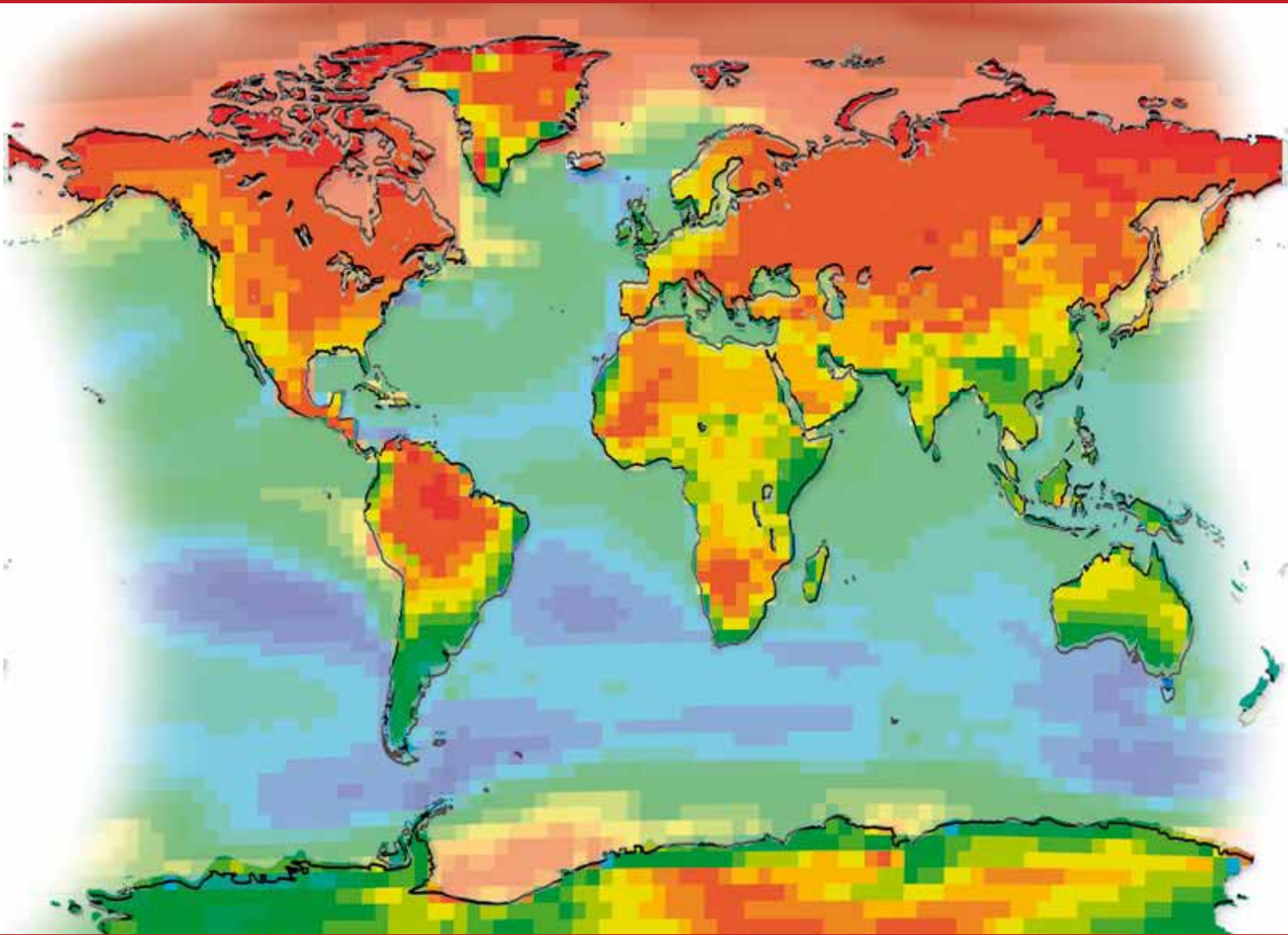


# 4 degrees hotter



**A Climate Action Centre primer**

[www.climateactioncentre.org](http://www.climateactioncentre.org)

February 2011

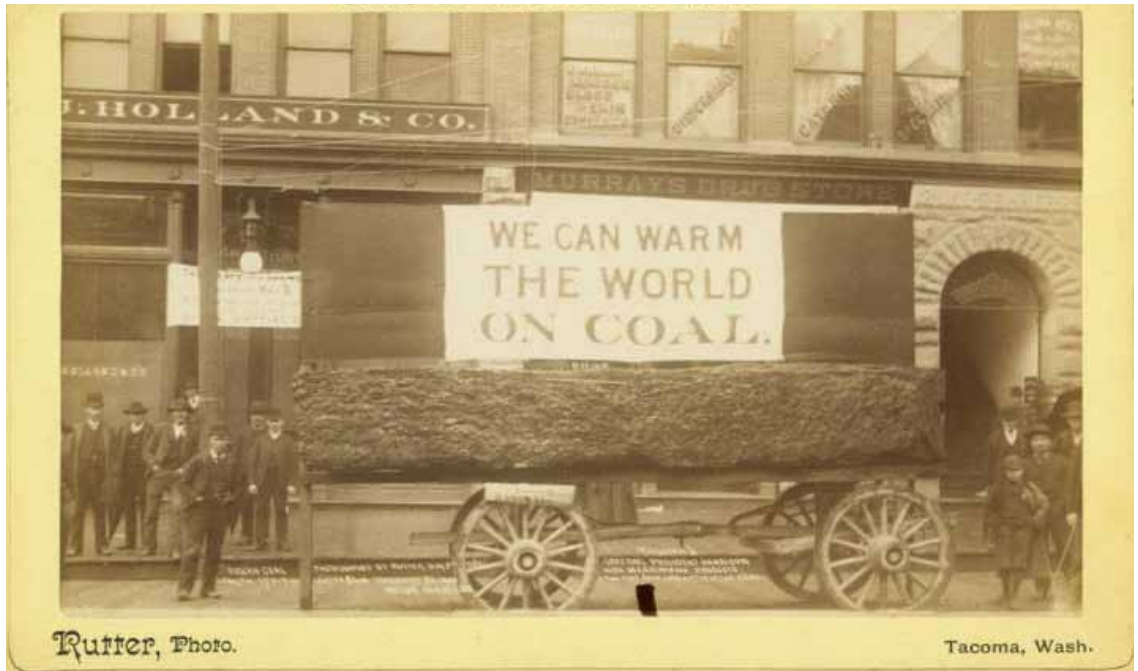


Photo courtesy Washington State Historical Society

Global political failure to reach agreement on greenhouse gas reduction measures in accord with the scientific imperatives will result in 4 degrees Celsius of global warming by 2100, if only the present levels of commitments by nations are realised.

There is now talk of, and planning for, adaptation to a 4-degree warmer world.

But is that realistic, or delusional? The consequences of 4 degrees are almost unimaginable, and appear to be poorly understood outside the scientific community.

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Produced by Climate Action Centre, Melbourne, Australia  
[www.climateactioncentre.org](http://www.climateactioncentre.org)  
 February 2011

# 4 degrees hotter

•The failure of our generation on climate change mitigation would lead to consequences that would haunt humanity to the end of time.•

Professor Ross Garnaut, “Garnaut Climate Change Review”, Cambridge, 2008, chapter 24

•The science of climate change has never been clearer... Without further action, scientists now estimate we may be heading for temperature rises of at least three to four degrees above pre-industrial levels... We have a window of only 10 to 15 years to avoid crossing catastrophic tipping points... •

Letter to European leaders by the British and Dutch prime ministers, Tony Blair and Jan Peter Balkenende, October 2006.

•We are unleashing hell on Australia.•

Professor David Karoly, University of Melbourne , “New Scientist”, 30 September 2009

## 4 degrees by 2100: intelligence agency

On 16 December 2010, “The Age” reported:

Australia’s top intelligence agency believes south-east Asia will be the region worst affected by climate change by 2030, with decreased water flows from the Himalayan glaciers triggering a “cascade of economic, social and political consequences”. The dire outlook was provided by Office of National Assessments deputy director Heather Smith in a confidential discussion on the national security implications of climate change with US embassy officials in Canberra...

The ONA, according to the cable, predicts global temperatures to rise 2 degrees Celsius (C) by 2050 and 4C by 2100. Ms Smith is reported as saying the effect of climate change in east Asia would become serious by 2030.

<http://www.theage.com.au/national/climate-change-warning-over-southeast-asia-20101215-18y6b.html>

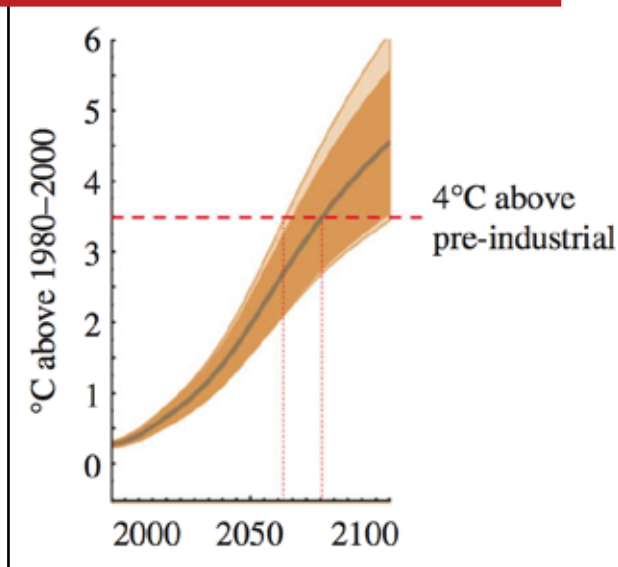
## IPCC report

The Intergovernmental Panel on Climate Change 2007 Fourth Assessment Report (IPCC AR4) gave a warming range to 2100 of 1.6–6.9C, but the upper-end possibilities were not examined in as much detail as scenarios around 2C:

The centre of the range of AR4-projected global warming was approximately 4C. The higher end of the projected warming was associated with the higher emissions scenarios and models, which included stronger carbon-cycle feedbacks. The highest emissions scenario considered in the AR4 (scenario A1FI) was not examined with complex general circulation models (GCMs) in the AR4, and similarly the uncertainties in climate-carbon-cycle feedbacks were not included in the main set of GCMs.

Betts, Collins et al, “When could global warming reach 4C”, Phil. Trans. R. Soc. A 369:67-84

## Temperature projections for “high emissions” scenario



Projections of global warming for the A1FI emissions scenario\*, using an ensemble of simulations. Dark shading shows the mean  $\pm 1$  standard deviation and the light shading shows the change in the uncertainty range when uncertainties in climate-carbon-cycle feedbacks are included. The horizontal red dashed line marks warming of 4°C relative to pre-industrial (3.5°C above 1980-2000 baseline). Source: Betts, Collins et al, “When could global warming reach 4°C”, Phil. Trans. R. Soc. A 369:67-84

\* A1FI is a high-growth, fossil-fuel intensive (“high emissions”) scenario developed by the IPCC. Global emissions are tracking just below A1FI.

## Spotlight on 4 degrees

While IPCC AR4 had again put the 4C projection on the table, it became a more sensitive issue in 2008 when an influential and controversial paper by Kevin Anderson and Alice Bows of the UK Tyndall Centre for Climate Change Research concluded that:

...it is increasingly unlikely any global agreement will deliver the radical reversal in emission trends required for stabilization at 450 parts per million carbon dioxide equivalent (ppm CO<sub>2</sub>e). Similarly, the current framing of climate change cannot be reconciled with the rates of mitigation necessary to stabilize at 550 ppm CO<sub>2</sub>e and even an optimistic interpretation suggests stabilization much below 650 ppm CO<sub>2</sub>e is improbable.

In other words, adaptation would be much better guided by stabilization at 650 ppm, which is around a 4C warming. Professor Bob Watson, the chief scientific adviser to the UK Department for the Environment, Food and Rural Affairs, warned that the UK should take active steps to prepare for dangerous climate change. Whilst a much lower outcome was necessary, Watson argued that “we should be prepared to adapt to 4C” warmer.

Watson’s plea to prepare for the worst was backed up by the government’s former chief scientific adviser, Sir David King. He said that even with a comprehensive global deal to keep carbon dioxide levels in the atmosphere at below 450 ppm there is a 50% probability that temperatures would exceed 2C and a 20% probability they would exceed 3.5C:

So even if we get the best possible global agreement to reduce greenhouse gasses on any rational basis you should be preparing for a 20% risk so I think Bob Watson is quite right to put up the figure of 4C.

But Professor Neil Adger, a Tyndall Centre climate change adaptation expert thought:

...that is a dangerous mindset to be in. Thinking through the implications of 4C of warming shows that the impacts are so significant that the only real adaptation strategy is to avoid that at all cost because of the pain and suffering that is going to cost... There is no science on how we are going to adapt to 4C warming. It is actually pretty alarming.

Anderson and Bows, “Reframing the climate change challenge in light of post-2000 emission trends”, Phil. Trans. R. Soc. A 366:3863-3882

<http://www.guardian.co.uk/environment/2008/aug/06/climatechange.scienceofclimatechange>

# “4 degrees and beyond”

Just two months before the fifteenth meeting of the Coalition of the Parties (COP15) in Copenhagen, “4 degrees and beyond” was the focus of a 28-30 September 2009 International Climate Conference at Oxford. It brought together many of the leading scientists and some disturbing research, and received extensive media coverage. A number of the papers presented have just been published by the Royal Society.

The conference heard that:

- A 4C rise could turn swaths of southern Europe to desert.
- Sea levels will rise twice as fast as official estimates predict, up to 2 metres by 2100.
- Modest warming could unleash a carbon “time bomb” from Arctic soils as positive feedbacks kick in.
- A failure to cut emissions could render half of the world uninhabitable.
- Rising temperatures could kill off 85% of the Amazon rainforest by 2100.

“4 degrees” will also be the focus of a July 2011 conference at the University of Melbourne.

Conference: <http://www.eci.ox.ac.uk/4degrees/programme.php>

Selected media coverage: <http://www.eci.ox.ac.uk/4degrees/media.php>

Papers: <http://rsta.royalsocietypublishing.org/content/369/1934.toc>

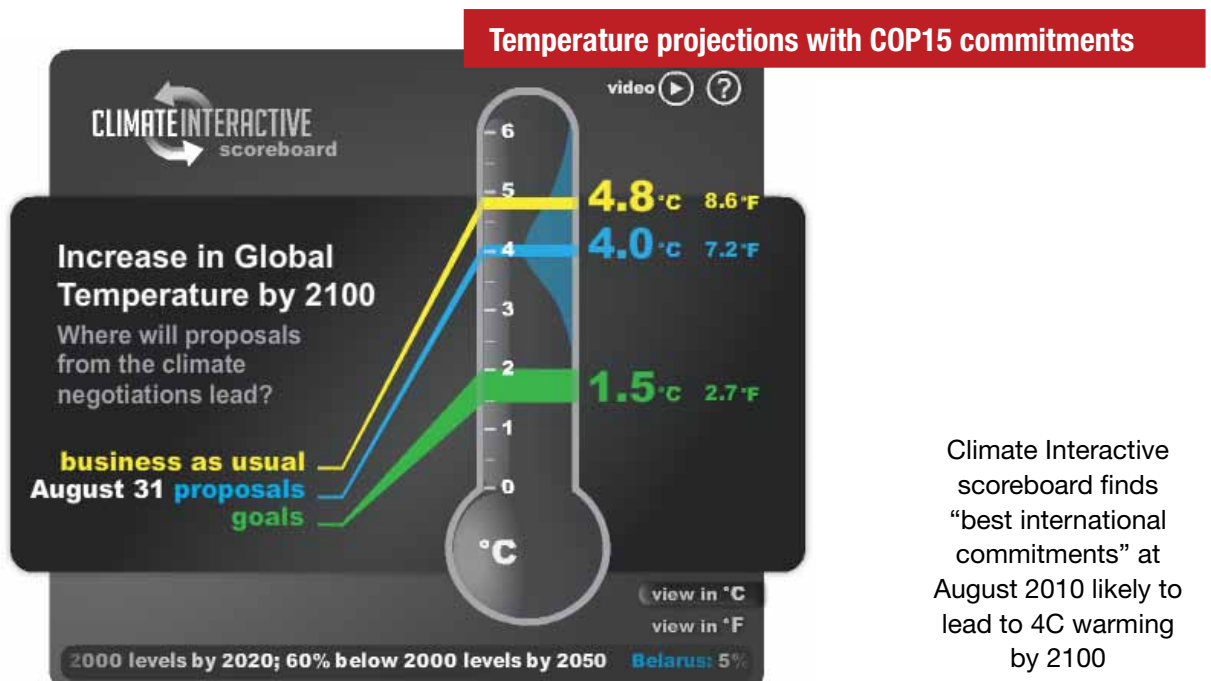
<http://www.guardian.co.uk/environment/2009/mar/13/stern-attacks-politicians-climate-change>

## Copenhagen COP-out

“...the [Copenhagen conference] draft text contains some 250 pages: a feast of alternative options, a forest of square brackets. If we don’t sort this out, it risks becoming the longest and most global suicide note in history.”

Jose Manuel Barroso, President, European Commission, December 2009

As a consequence of the “4 degrees and beyond” conference, and in the leadup to COP15, there was a substantial public discussion about the likelihood of 4C should Copenhagen fail to act decisively.



Climate Interactive scoreboard finds “best international commitments” at August 2010 likely to lead to 4C warming by 2100

A study presented at “4 degrees and beyond” by Britain’s Met Office Hadley Centre echoed a UN report which found that climate changes were outpacing worst-case scenarios forecast in IPCC 2007: global temperatures may be 4C hotter by the mid-2050s if current greenhouse gas emissions trends continue.

As COP15 commenced, a commentary in “Nature” entitled “Mind the gap” (by “4 degrees and beyond” organisers Mark New, Diana Liverman and Kevin Anderson) warned that “Policy-makers must aim to avoid a 2C temperature rise, but plan to adapt to 4C”:

At the worst end of the scale, with continued intensive fossil fuel use, temperatures could rise 4C by the 2070s, or even as early as 2060 if there are strong positive feedbacks in the carbon cycle. The situation is bleaker still once political inertia is considered. Moderate-emissions scenarios, including those arising from weak climate agreements, still result in a significant probability of exceeding 4C by the end of the century or early in the next century. As nations delay on agreeing a global climate treaty, it seems essential to explore the terra quasi-incognita of a world in which the average temperature is 4C above the pre-industrial level, and to understand the implications for nature and society. Warming of 4C or more would have consequences that might be beyond the ability of humankind to cope, particularly if those consequences are allied with other stresses. Even affluent communities would see substantial and unprecedented changes to how they live, while for the majority, fundamental transformations might be necessary for survival.

<http://uk.reuters.com/article/idUKTRE58R01C20090928>

<http://www.nature.com/climate/2009/0912/full/climate.2009.126.html>

## Consequences

COP15’s failure set the world on a path to a 3.5-4C rise by 2100. “New Scientist” reported:

Western leaders began to leave Copenhagen in the early hours of Saturday morning, claiming to have secured a global agreement to keep global warming below 2C. But the deal provoked immediate anger for failing to include concrete measures to reach that target, and scientists at the talks said it would set the world on a path to 3.5C of warming by 2100 (based on analysis led by Michiel Schaeffer of Climate Analytics). With no new commitments on the table, and loopholes still wide open, Schaeffer and colleagues find that the world is on track to warm by 3.5C by 2100, and concentrations of carbon dioxide are set to rise to around 700 parts per million – far above the 450 ppm scientists say constitute the limit for keeping global warming below 2C.

<http://www.newscientist.com/article/dn18309-copenhagen-chaos-sets-world-on-track-for-35-c.html>

On 21 April 2010, “The Times” reported a study by Potsdam Institute researchers published in “Nature” which found that pledges made at COP15 would result in warming of more than 3C.

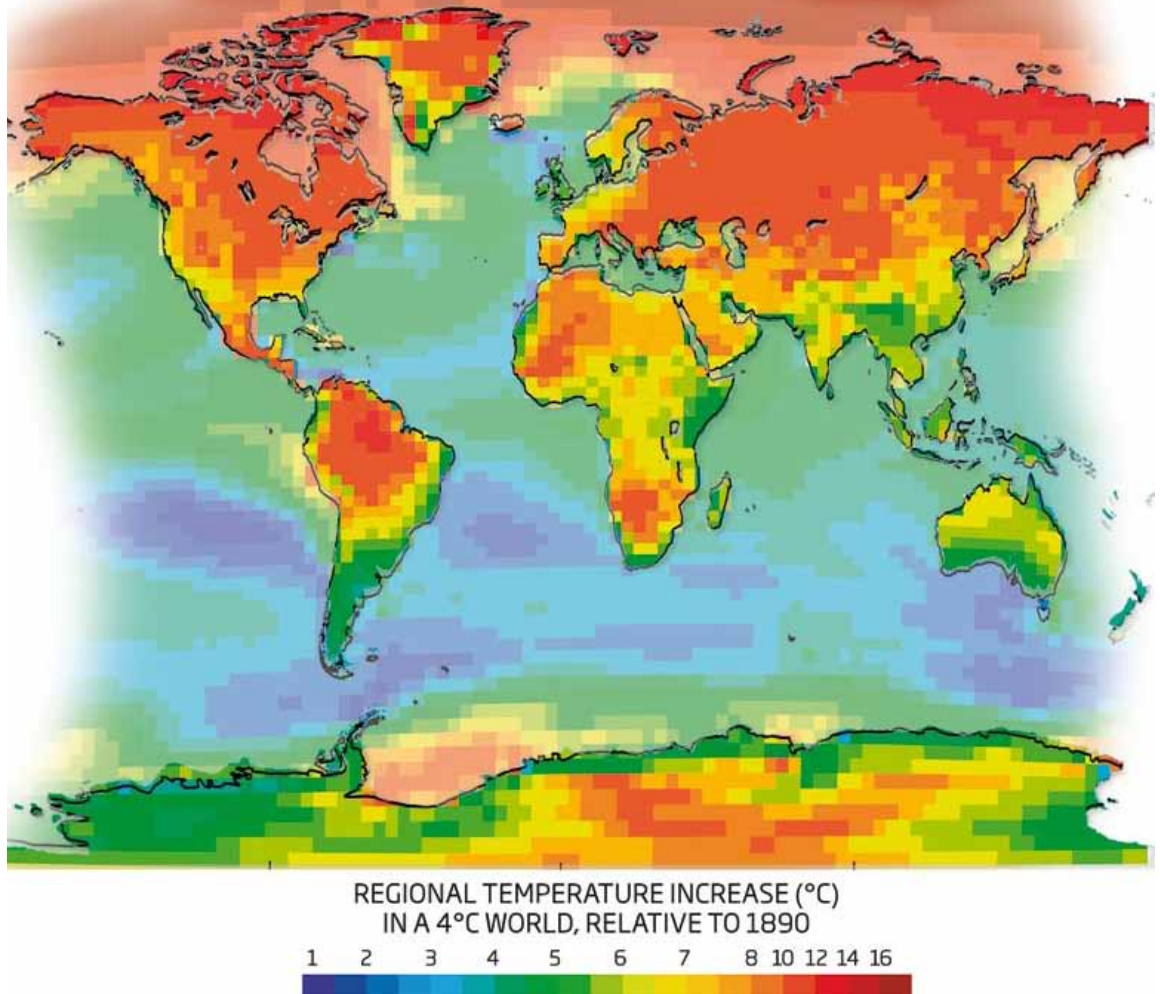
A number of Institutes have maintained updated scoreboards on what the current commitments of government would imply for temperature at 2100.

- Climate Interactive calculates warming to 2100 after COP16 to be heading to 4.0C.
- Climate Action Tracker calculates warming to 2100 after COP16 to be heading to 3.2C.

A unique study at MIT published in May 2010 using the MIT Integrated Global Systems Model, a detailed computer simulation of global economic activity and climate processes, indicates a median probability of surface warming of 5.2C by 2100, with a 90% probability range of 3.5–7.4C.

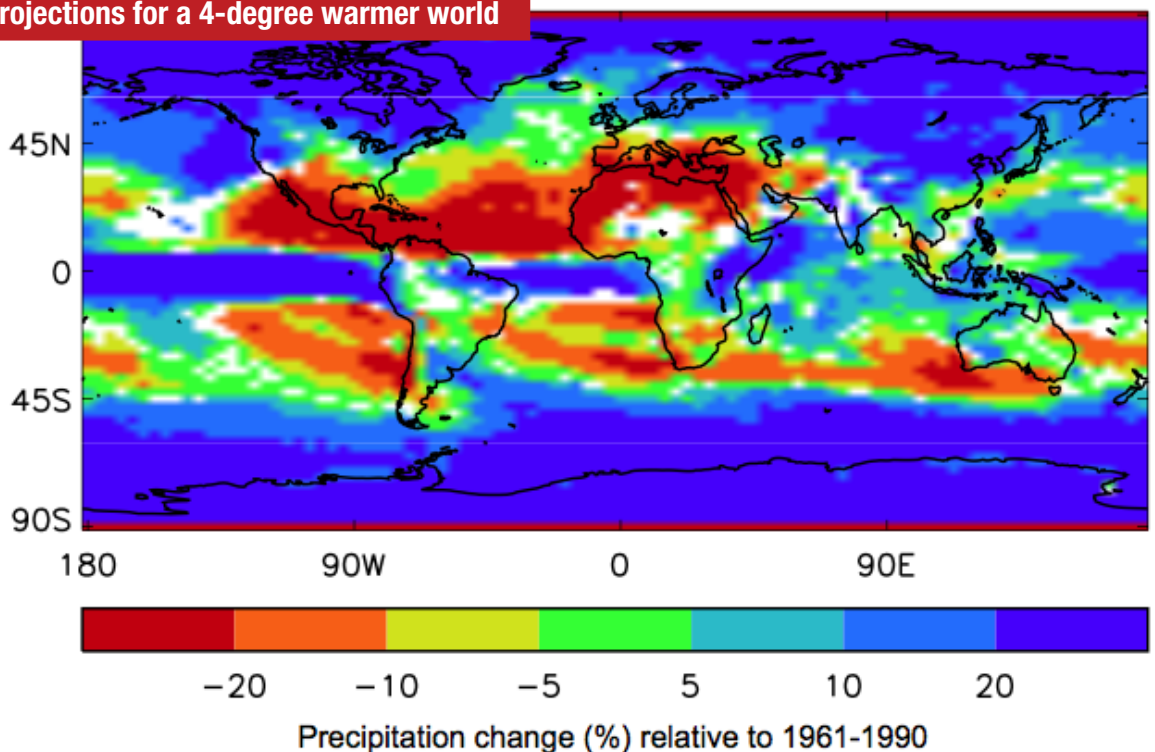
## Temperature projections for a 4-degree warmer world

The average global temperature is likely to be 4C higher than in pre-industrial times by 2055 if greenhouse gas emissions are not slowed – that means a 16C rise in the Arctic (Source: Met Office Hadley Centre)



## Precipitation projections for a 4-degree warmer world

Precipitation changes by 2090s relative to 1961-1990 for A1B scenario, mean of “high-end” IPCC simulations (3 models) with mean global warming of 4.3 (Source: Met Office Hadley Centre)



Analysis in a UNEP report released in November 2010 found that even if governments implement all they have pledged to do, that would "...imply a temperature increase of between 2.5-5C [from pre-industrial times] before the end of the century".

<http://www.timesonline.co.uk/tol/news/environment/article7104776.ece#cid>

<http://climateinteractive.org/scoreboard>

<http://www.climateactiontracker.org>

<http://globalchange.mit.edu/news/news-item.php?id=76>

[http://globalchange.mit.edu/files/document/MITJPSPGC\\_Rpt169.pdf](http://globalchange.mit.edu/files/document/MITJPSPGC_Rpt169.pdf)

<http://www.bbc.co.uk/news/science-environment-11813578>

[http://www.iop.org/news/page\\_44805.html](http://www.iop.org/news/page_44805.html)

## How soon?

Global greenhouse gas emissions are tracking a little below the worst scenario of the IPCC, the high-growth, fossil-fuels-intensive scenario known as A1FI. A paper from the "4 degrees and beyond" conference finds:

...our best estimate is that the A1FI emissions scenario would lead to a warming of 4C relative to pre-industrial during the 2070s. If carbon-cycle feedbacks are stronger, which appears less likely but still credible, then 4C warming could be reached by the early 2060s in projections that are consistent with the IPCC's 'likely range'.

Betts, Collins et al, "When could global warming reach 4C",  
Phil. Trans. R. Soc. A 369:67-84

And:

The continued rise in greenhouse gas emissions in the past decade and the delays in a comprehensive global emissions reduction agreement have made achieving this target extremely difficult, arguably impossible, raising the likelihood of global temperature rises of 3C or 4C within this century.

New, Liverman et al, "Four degrees and beyond: the potential for a global temperature increase of four degrees and its implications", Phil. Trans. R. Soc. A 369:6-19

## Adapting to 4 degrees?

Much work is now being undertaken on what a 4-degree world would look and feel like, and some adaptation planning includes explicit 4-degree scenarios. As just one example, the flood planning policy framework in Queensland includes:

Recommendation 2—The following temperatures and timeframes should be used for the purposes of applying the climate change factor in Recommendation 1: 2C by 2050; 3C by 2070; 4C by 2100.

In fact, any A1FI scenario to 2070 is effectively a look at a 4C-warmer world. A glimpse of 4-degree impacts on temperature and precipitation for selected Australia locations can be seen in the 2007 CSIRO report, "Climate Change in Australia", by referring to the A1FI scenarios for 2070.

<http://www.climatechange.qld.gov.au/whatsbeingdone/queensland/inlandfloodingstudy.html>

"Climate Change in Australia", CSIRO, 2007, ISBN 9781921232947 (PDF), Appendix B  
[eprints3.cipd.esrc.unimelb.edu.au/258/12/TR\\_Web\\_AppendixB.pdf](http://eprints3.cipd.esrc.unimelb.edu.au/258/12/TR_Web_AppendixB.pdf)

As noted earlier, Professor Bob Watson, the chief scientific adviser to the UK Department for the Environment, Food and Rural Affairs, argued that "we should be prepared to adapt to 4C". And that is what governments are now actively contemplating.

But the question often overlooked is this: is it realistic to talk about adapting to 4C? What are the impacts?



# Life in a 4C world:

## (1) Less than a billion people will survive

A 4C global average rise means on average about 5.5–6C warmer over land, especially away from the coast. Where people could actually live with land suitable for growing food (with the much greater evaporation rates implicit at +6C), and above existing deltas and flood plains as sea-levels rise, would be limited. On 30 November 2007, Reuters reported:

Children born today in countries such as Spain and Italy will witness a 7 degrees Celsius rise in summer temperatures by the end of their lives, the European Union's environment watchdog warned on Tuesday.

Much of the tropics would be too hot, much of the temperate regions desertified. The "4 degrees and beyond" conference heard that 4C could render half of the world uninhabitable. Populations would be driven towards the poles, and practically-speaking that means the north pole. How many would survive? On 29 September 2009, at the conclusion of the "4 degrees and beyond" conference, "The Scotsman" reported:

Professor Kevin Anderson, director of the Tyndall Centre for Climate Change, believes only around 10 per cent of the planet's population – around half a billion people – will survive if global temperatures rise by 4C...

Current Met Office projections reveal that the lack of action in the intervening 17 years – in which emissions of climate changing gases such as carbon dioxide have soared – has set the world on a path towards potential 4C rises as early as 2060, and 6C rises by the end of the century.

Anderson, who advises the government on climate change, said the consequences were "terrifying". "For humanity it's a matter of life or death," he said. "We will not make all human beings extinct as a few people with the right sort of resources may put themselves in the right parts of the world and survive. But I think it's extremely unlikely that we wouldn't have mass death at 4C. If you have got a population of nine billion by 2050 and you hit 4C, 5C or 6C, you might have half a billion people surviving."

Earlier, in March 2009, at the Copenhagen science conference, Professor Hans Joachim Schellnhuber, director of the Potsdam Institute, and one of Europe's most eminent climate scientists, told his audience that at 4C, population "... carrying capacity estimates (are) below 1 billion people."

Three years earlier, in 2006, James Lovelock — scientist extraordinaire, inventor of the microwave oven and propounder of the Gaia thesis — told an audience that the Earth has a fever that could boost temperatures by up to 8C (more on this later), making large parts of the surface uninhabitable and threatening billions of peoples' lives. He said a traumatised Earth might only be able to support less than a tenth of its six billion people: "We are not all doomed. An awful lot of people will die, but I don't see the species dying out... A hot Earth couldn't support much over 500 million."

<http://climatecongress.ku.dk/speakers/schellnhuber-plenaryspeaker-12march2009.pdf>

<http://news.scotsman.com/latestnews/Warming-will-39wipe-out-billions39.5867379.jp>

<http://www.alertnet.org/thenews/newsdesk/L28841108.htm>

<http://in.reuters.com/article/idINIndia-53238020101130>

# Life in a 4C world:

## (2) “Mind the gap”

In “Mind the gap” by Mark New, Diana Liverman and Kevin Anderson, many of the scientific findings presented at the “4 degrees and beyond” conference were summarised:

A world where the average temperature was 4C higher than in pre-industrial times would be very different from the one we now inhabit, and even from one with 2C of warming. Studies suggest that 2–4C of warming would trigger the permanent break-up of the Greenland ice sheet, causing sea level to rise by up to seven metres in the long term. With warming of 3C, the Arctic Ocean would most likely be ice-free in summer. At 4C, most reef-building corals would be unable to adapt to changes in ocean temperature and acidification, in which case tropical coral reefs would die out or become far less diverse. While thresholds or tipping points in other systems are less well known, the risk of major shifts in ecosystems such as tropical forests increases as global temperature rises from 2 to 4C.

A 4C, the world would probably be warmer than any time in the last 800,000 years and certainly the last 18,000 years, the period in which modern humans evolved. Moreover, the rate of climate change would be as fast as or faster than any previously experienced. Because land areas warm faster than the ocean and higher latitudes more than lower latitudes, temperature increases would exceed 4C in many regions. Approximately 13 per cent of land including the Amazon, the Sahara-Sahel-Arabia region, India and northern Australia could experience average temperatures for which there are no spatial analogues in today’s climate; in other words, the temperature in these regions would be higher than the average at any place on Earth today. Correspondingly, present-day climates in the tropics and subtropics would shift short distances to higher elevations or in some cases several thousands of kilometres polewards...

Some recent estimates of sea level rise exceed previous projections by the IPCC, suggesting increases of more than one metre in a 4C world by 2100 if recent contributions from melting land ice continue. Deltas and other low-lying coastal regions would be particularly vulnerable. Over 136 port cities with present-day populations greater than 1 million would be at risk, requiring protection or translocation of over 500 million people...

Substantial changes in the structure and function of ecosystems, including disturbance by fires and insects, are very likely for temperatures above 2C. Recent assessments of faunal change based on relatively low-emissions scenarios suggest that increased temperatures, including regional changes of up to 4C, could result in local loss of at least ten per cent of endemic vertebrates in the Americas and the replacement of 90 per cent of species in the tundra, Central America and the Andes. Although ecosystems and species can be resilient, a 4C world would require unprecedented interventions regardless of whether the choice is to maintain the current portfolio of conservation areas or to plan new conservation areas suitable for a changed climate.

<http://www.nature.com/climate/2009/0912/full/climate.2009.126.html>

# Life in a 4C world:

## (3) Oceans as deserts

In 2006 and subsequently, NASA satellites have shown that phytoplankton – which absorb vast quantities of carbon dioxide – are finding it harder to live in the more stratified layers of the warmer ocean, which restrict the mixing of vital nutrients. Since 2000, when the sea surface temperatures began to rise more noticeably, the photosynthetic productivity of phytoplankton have decreased in some ocean regions by 30 per cent.

James Lovelock points out that as the ocean surface temperature warms to over 12C: “a stable layer of warm water forms on the surface that stays unmixed with the cooler, nutrient-rich waters below. This purely physical property of ocean water denies nutrients to the life in the warm layer, and soon the upper sunlit ocean water becomes a desert”, recognized by the clear azure blue, dead water of 80 per cent of today’s ocean surface. In such nutrient-deprived water, ocean life cannot prosper and soon “the surface layer is empty of all but a limited and starving population of algae”.

Algae, which comprise most of the ocean’s plant life, are the world’s greatest CO<sub>2</sub> sink, pumping down carbon dioxide, as well as contributing to cloud cover by releasing dimethyl sulphide (DMS) into the atmosphere, a gas “connected with the formation of clouds and with climate”, so that warmer seas and less algae will likely reduce cloud formation and further enhance positive feedback. Severe disruption of the algae/DMS relation would signal spiralling and irreversible climate change.

Algae prosper in waters below 10C so, as the climate warms, the algae population reduces. In computer modelling of climate warming and regulation carried out by James Lovelock and Lee Kump and published in “Nature”, it was found that:

... as the carbon dioxide abundance approached 500 ppm (or a rise of about 3C), regulation began to fail and there was a sudden upward jump in temperature. The cause was the failure of the ocean ecosystem. As the world grew warmer, the algae were denied nutrients by the expanding warm surface of the oceans, until eventually they became extinct. As the area of ocean covered by algae grew smaller, their cooling effect diminished and the temperature surged upwards.

The end result was a temperature rise of 8C above pre-industrial levels, which would result in the planet being habitable only from the latitude of Melbourne south to the south pole, and northern Europe, Asia and Canada to the north pole. Everything in between would be desert and uninhabitable, billions of people would not be able to survive.

This devastating research, peer-reviewed and published in the world’s most eminent science journal, has not been refuted or seriously challenged; it has simply been ignored by all but a few.

James Lovelock, “The Revenge of Gaia”, London, Allen Lane (2006)

Lovelock and Kump, “Failure of climate regulation in a geophysiological model”, Nature 369:732–34.

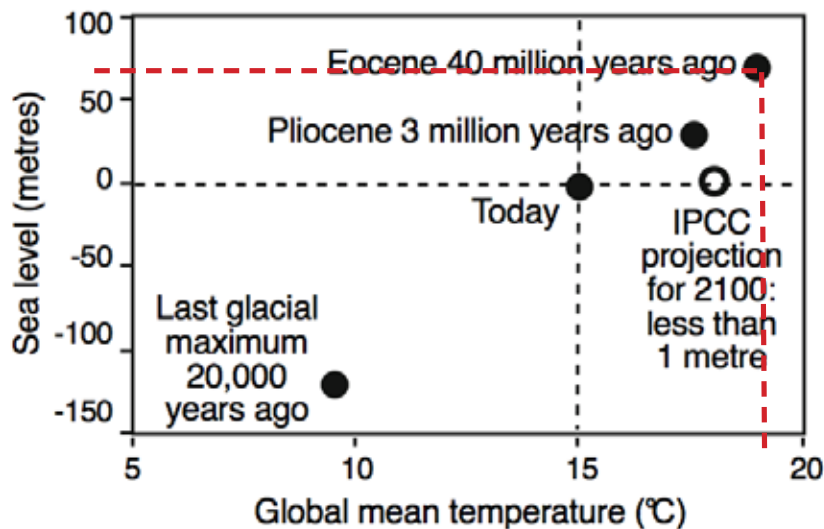
## Life in a 4C world:

### (4) Mark Lynas

Scientists draw on a number of disciplines and methods to answer the question as to future impacts of rising temperatures, including paleo-climatology (study of past climate history), complex mathematical models of the world’s climate system tested and refined against past climate data, observation of current events and specific research testing hypotheses. Mark Lynas surveyed much of this peer-reviewed research for his book “Six Degrees: Our place on a hotter planet”, devoting a chapter to each one degree of temperature increase. Much more paleoclimate data, observations and modelling are available for 1–3 degrees than the 4–6C range. However, at 4C Lynas found, amongst many impacts in the literature, that:

- Hundreds of billions of tonnes of carbon locked up in Arctic permafrost – particularly in Siberia – enter the melt zone, releasing globally warming methane and carbon dioxide in immense quantities.

## Temperature and sea level



Mean global temperature and sea level (relative to today's) at different times in Earth's history, compared with the IPCC projection for the year 2100. A 4C temperature increase suggests a 65–70 metre sea-level rise (red dashed lines). Adapted from David Archer

- The West Antarctic ice sheet may lift loose from its bedrock and collapse as warming ocean waters nibble away at its base, much of which is anchored below current sea levels.
- In Europe, new deserts will be spreading in Italy, Spain, Greece and Turkey: the Sahara will have effectively leapt the Straits of Gibraltar. In Switzerland, summer temperatures may hit 48C, more reminiscent of Baghdad than Basel. The Alps will be so denuded of snow and ice that they resemble the rocky moonscapes of today's High Atlas – glaciers will only persist on the highest peaks such as Mont Blanc. The sort of climate experienced today in Marrakech will be experienced in southern England, with summer temperatures in the home counties reaching a searing 45C. Europe's population may be forced into a “great trek” north.

## The adaptation trap

Because so much research on climate impacts, by its very nature, focuses on particular events and localities, sometimes the big picture fades to the background. So to be clear what 4C warmer means, let's draw a few threads together, including research not specifically covered above.

- The world would be warmer than during any part of the period in which modern humans evolved, and the rate of climate change would be faster than any previously experienced by humans.
- 3C may be the “tipping point” where global warming could be driven by positive feedbacks, leaving us powerless to intervene as planetary temperatures soared. America's most eminent climate scientist, James Hansen, says warming has brought us to the “precipice of a great tipping point”. If we go over the edge, it will be a transition to “a different planet”, an environment far outside the range that has been experienced by humanity. There will be “no return within the lifetime of any generation that can be imagined, and the trip will exterminate a large fraction of species on the planet”.
- Half of the world would be uninhabitable. Likely population capacity: under one billion people. Whilst the loss will be exponential, on average it means more than a million human global warming deaths every week, every year for the next 90 years. The security implications need no discussion.

- The world's sixth mass extinction would be in full swing. Isotherms (temperature bands) would be shifting towards the poles at a pace beyond the capacity of most ecosystems to keep up. At 0.2C/decade, isotherms are moving towards the poles at about 50-60km per decade. If the rate should exceed 0.4C per decade, most ecosystems will be quickly destroyed, opportunistic species will dominate, and the breakdown of biological material will lead to even greater emissions of CO<sub>2</sub>.
- Sea levels: paleoclimatology tells us that the last time temperatures were 4C above pre-industrial, there were no large ice-sheets on the planet and sea levels were 65–70 metres higher than today. Whilst ice sheets take considerable time to lose mass, and the rise to 2100 may be only 1–2 metres (or possibly a couple more according to James Hansen), the world would be on the way to 65–70 metres. It is sobering to note the findings of Professor Eelco Rohling, University of Southampton that: “Even if we would curb all CO<sub>2</sub> emissions today, and stabilise at the modern level (387 parts per million by volume), then our natural relationship suggests that sea level would continue to rise to about 25 metres above the present.” The Insurance Council says 425,000 Australian addresses less than 4 metres above sea level and within 3km of shoreline are “vulnerable”.
- Arctic feedbacks: Carbon stored in Arctic permafrost is double the amount of carbon in the atmosphere. Work by Celia Bitz, Philippe Ciais and others suggests that the tipping point for the large-scale loss of permafrost carbon is around 8–10C regional temperature increase. As temperatures rise, it is projected (consistent with paleoclimatology data) that Arctic amplification (the multiple by which the Arctic warms compared to the global average) would be at least X3, so around a 3C increase in global temperature is probably more than enough to detonate the permafrost timebomb. (Research presented at “4 degrees and beyond” estimated that an average global increase of 4C translates to a rise of up to 15C at the North Pole. Summers in parts of the Arctic would be as balmy as California's Napa valley.) This feedback in the carbon cycle would drive temperatures significantly higher. Ciais told the March 2009 Copenhagen science conference that: “A global average increase in air temperatures of 2C and a few unusually hot years could see permafrost soil temperatures reach the 8C threshold for releasing billions of tonnes of carbon dioxide and methane”.
- Forest carbon feedback: “New Scientist”, reports on “4 degrees and beyond”:
 

In a 4C world, climate change, deforestation and fires spreading from degraded land into pristine forest will conspire to destroy over 83 per cent of the Amazon rainforest by 2100, according to climatologist Waofgang Cramer at the Potsdam Institute for Climate Impact Research in Germany. His climate models show global warming alone converting 30% of the Amazon into degraded shrub land and mixed woodland by 2100. Even this grim estimate is based on the hopeful assumption that extra CO<sub>2</sub> in the atmosphere will “fertilise” the forest, buffering it from drought. But we can't be sure this will happen, says Cramer. “If we've overestimated the magnitude of CO<sub>2</sub> fertilisation, we risk losing the entire Amazon.
- Food and water security. A model developed at Potsdam University, which reflects the physics that drives monsoons, suggests that in a 4C-warmer world there will be a mix of extremely wet monsoon seasons and extremely dry ones, making it hard for farmers to plan what to grow. Fine aerosol particles released into the atmosphere by burning fossil fuels could put a complete stop to the monsoon rains in central southern China and northern India.
- Oceans: acidification would have rendered many calcium-shelled organisms, such as coral and many at the base of the ocean food chain, artefacts of history. Ocean

ecosystems and food chains would collapse. Professor Jean-Pierre Gattuso, of France's Centre National de la Recherche Scientifique says 10% of the Arctic Ocean will be corrosively acidic by 2018; 50% by 2050; and 100% ocean by 2100.

Rohling, Grant et al, "Antarctic temperature and global sea level closely coupled over the past five glacial cycles", *Nature Geoscience* 2:500-504

Ciais, Khvorostianov et al, "Frozen carbon: A time bomb in the future?", *IOP Conf. Ser.: Earth Environ. Sci.* 6:092009

Permafrost: <http://www.guardian.co.uk/environment/2009/mar/10/climate-change-copenhagen>

Bitz, Ridley et al, "Global Climate Models and 20th and 21st Century Arctic Climate Change", [http://www.atmos.washington.edu/~bitz/Bitz\\_et\\_al2008.pdf](http://www.atmos.washington.edu/~bitz/Bitz_et_al2008.pdf)

<http://climatecodered.blogspot.com/2011/01/rethinking-safe-climate-have-we-already.html>

Hansen, "Tipping point: Perspective of a climatologist" in "The State of the Wild 2008: A Global Portrait of Wildlife, Wildlands, and Oceans", E. Fearn and K.H. Redford (eds), Wildlife Conservation Society/Island Press.

<http://www.newscientist.com/article/dn17864-no-rainforest-no-monsoon-get-ready-for-a-warmer-world.html>

And now we are talking about how we might adapt to a 4-degree warmer world? Have we gone mad?

In part, there is ignorance, real or feigned. Former prime minister John Howard told Tony Jones on ABC's "Lateline" in 2007 that an increase of 4–6 degrees would be "less comfortable for some than it is now". But there is also a pervasive assumption that our species can adapt to whatever is thrown at us by climate change. After all, we are the masters of the planet whose industrial revolution gave us the tools to conquer distance, hold back the elements and tame nature.

In his 2010 book, "Requiem for a Species", Clive Hamilton lays bare the trap of the "adaptation myth":

The new understanding of the climate system and the likely influences of tipping points induced by human intervention also forces us to reconsider one of the other foundations of international negotiations and national climate strategies, the belief in the ability to adapt. From the outset of the global warming debate some have argued that as much emphasis should be placed on adapting to climate change as on mitigating it. As the setting and meeting of targets appears more difficult, more people began talking about the need to adapt.

Underlying the discussion is an unspoken belief that one way or another we (in rich countries) will be able to adapt in a way that broadly preserves our way of life because global warming will change things slowly, predictably and manageably. Wealthy countries can easily afford to build flood defences to shield roads and shopping centres from storm surges, and we can 'climate proof' homes against the effects of frequent heatwaves. Yet if our belief in our ability to stabilise the Earth's climate is misconceived then so is our belief in our ability to adapt easily to climate change. If instead of a smooth transition to a new, albeit less pleasant, climate warming sets off a runaway process, adaptation will be a never-ending labour.

The adaptation trap finds voice in those sceptics and delayers such as Roger Pielke Jr and Bjorn Lomborg, who insist that it is cheaper and more effective to adapt to global warming than to fight it. Pielke calls for "rejecting bad policy arguments when offered in the way of substitutes for adaptation, like the tired old view that today's disaster losses are somehow a justification for changes to energy policies".

Events such as New Orleans after cyclone Katrina should disavow the notion that adaptation (rebuilding the city) is more economical than mitigation (strengthening the

storm defences before the event). And it won't take too long to figure out that building a new energy system is cheaper than constantly rebuilding lives and buildings and infrastructure and agriculture when "1-in-a-100 year" extreme heatwaves, droughts, fires, floods and cyclones become regular events on the hotter planet calendar.

It is clear that our collective survival depends on the most radical mitigation effort we can imagine. Climate change is already dangerous, it is no longer a future-tense proposition. The hour is late. James Hansen, in a new paper, says that "...goals of limiting human-made warming to 2C and CO2 to 450 ppm are prescriptions for disaster." At just 0.8C warming so far, he says we have little or no "cushion" left to avoid dangerous climate change.

[www.abc.net.au/lateline/content/2006/s1840963.htm](http://www.abc.net.au/lateline/content/2006/s1840963.htm).

Cline Hamilton, "Requiem for a Species", Allen&Unwin, 2010

<http://climateprogress.org/2008/03/28/adaptation-trap-and-nonskeptical-deniers-roger-pielke-1/>

[http://cstpr.colorado.edu/prometheus/archives/climate\\_change/001372la\\_times\\_on\\_adaptati.html](http://cstpr.colorado.edu/prometheus/archives/climate_change/001372la_times_on_adaptati.html)

<http://www.crikey.com.au/2011/01/27/nasa-climate-chief-labors-targets-a-recipe-for-disaster/>

Restoring a safe climate means the world very quickly building a zero-emissions economy without fossil fuels, and reducing the current level of greenhouse gases. It is a vast undertaking akin to a post-war reconstruction, but we have the technologies and the economic capacity. What we presently lack is an honest conversation about where we are headed, and the political will to build the solutions that are already available to us.

Our time is better spent working out how to make the impossible happen, rather than living the delusion that reasonable adaptation is possible to a 4-degree warmer world.

David Spratt

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