The climate science behind… **Climate code red**

Global warming: recent observations and predictions

David Spratt

June 2008

This powerpoint contains illustrative material with accompanying notes that describes some (but by no means all) recent global warming research, observations and predictions on which the case for an urgent or emergency transition to a post-carbon economy, as advocated in the book *Climate Code Red*, is based.

A full set of sources and references available in:

Climate Code Red: The case for emergency action
by David Spratt and Philip Sutton
Scribe 2008
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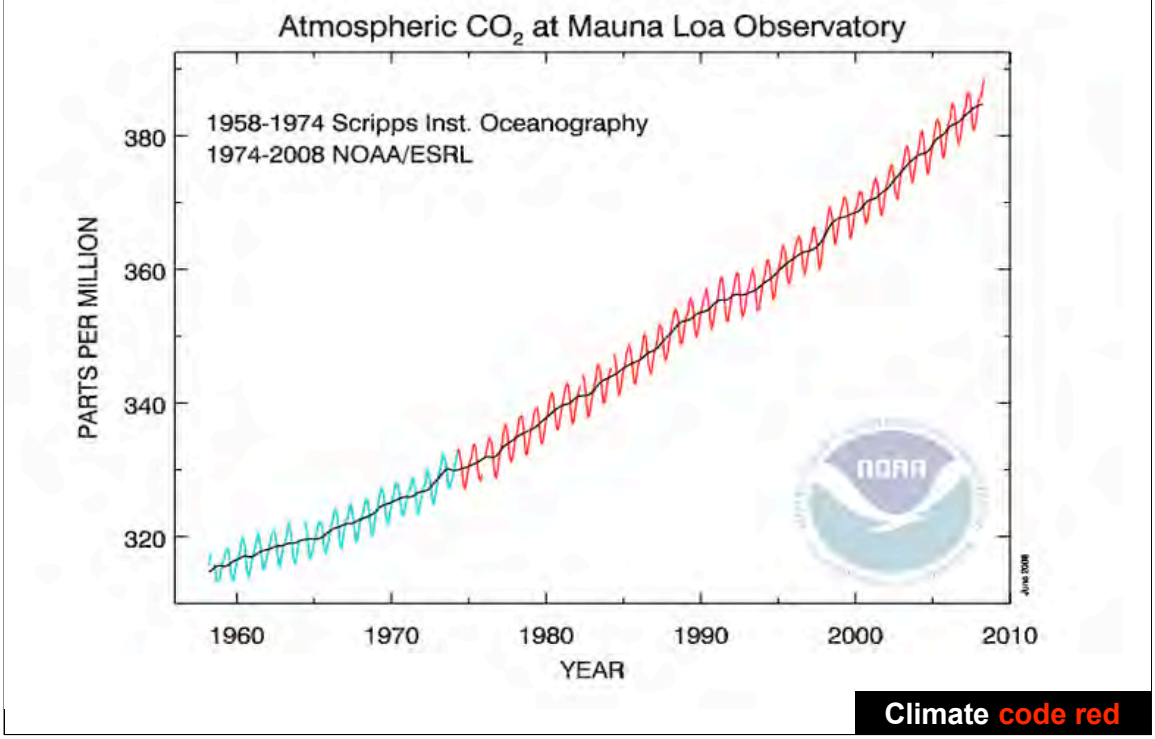
Atmospheric carbon dioxide levels 1958-2007



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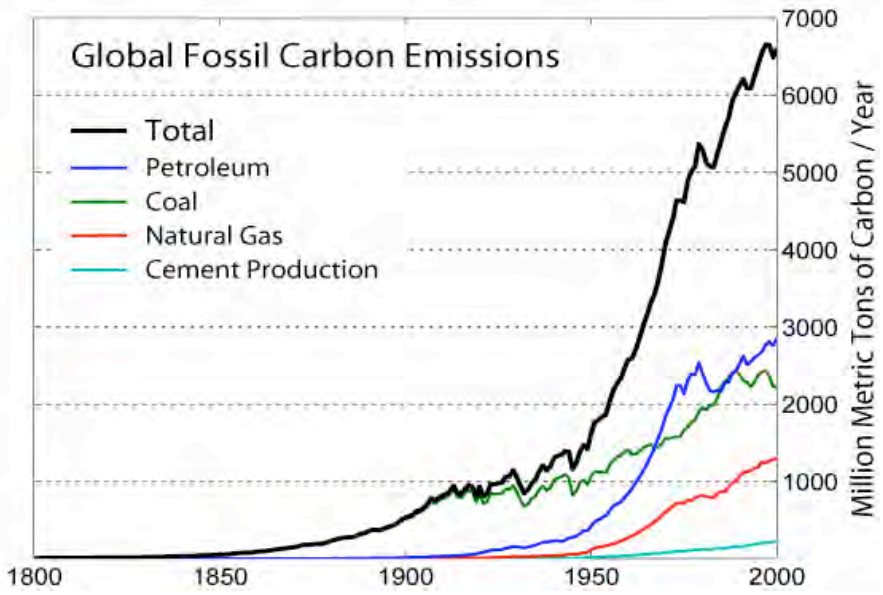
The carbon dioxide (CO2) level in the atmosphere is the highest concentration in the last 800,000 years and probably in the last twenty million years, at 387 parts per million (ppm).

It is rising at an increasing rate; in four of the last six years, the increase has been greater than 2 ppm, compared to average for 1970-2000 of 1.5 ppm.

Greenhouse gas levels increased by 30 ppm in the last 17 years. Over the last million years (prior to industrialisation), 30 ppm had never taken less than 1000 years!

Human activity is pushing the climate system at a rate unprecedented in human history.

Global fossil carbon emissions



Carbon Dioxide Information Analysis Center

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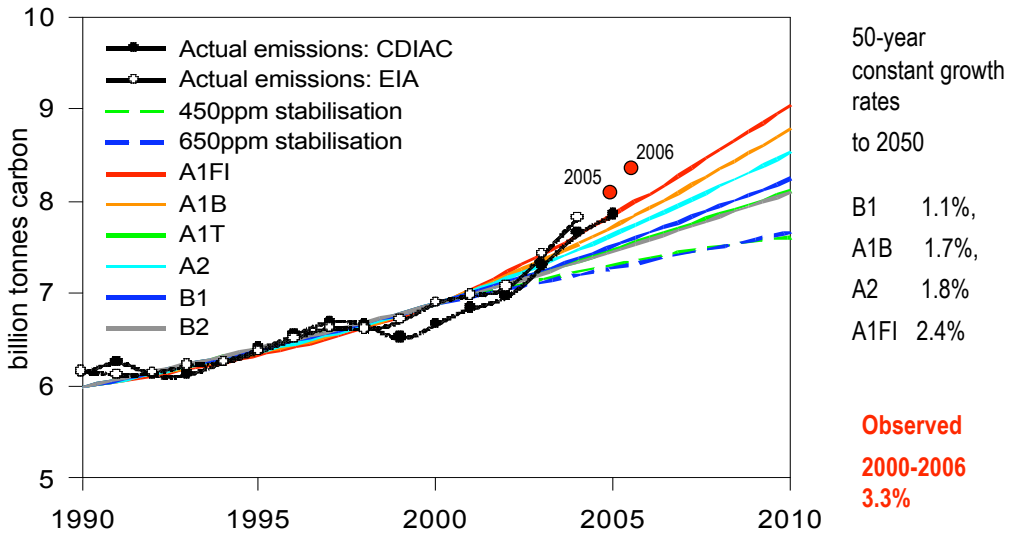
Global carbon dioxide (CO2) emissions from the burning of fossil fuels were a record 8.38 gigatons of carbon (GtC) in 2006, 20 percent above the level in 2000. Emissions grew 3.1 percent a year between 2000 and 2006, more than twice the rate of growth during the 1990s.

“Business as usual” will see global energy use more than double by 2050, from ten to twenty-two billion tonnes oil equivalent, with 70 per cent of the increase coming from fossil fuels, according to the European Union’s 2007 *World Energy Technology Outlook*.

Emissions: rising more quickly than IPCC scenarios



Global Carbon Project

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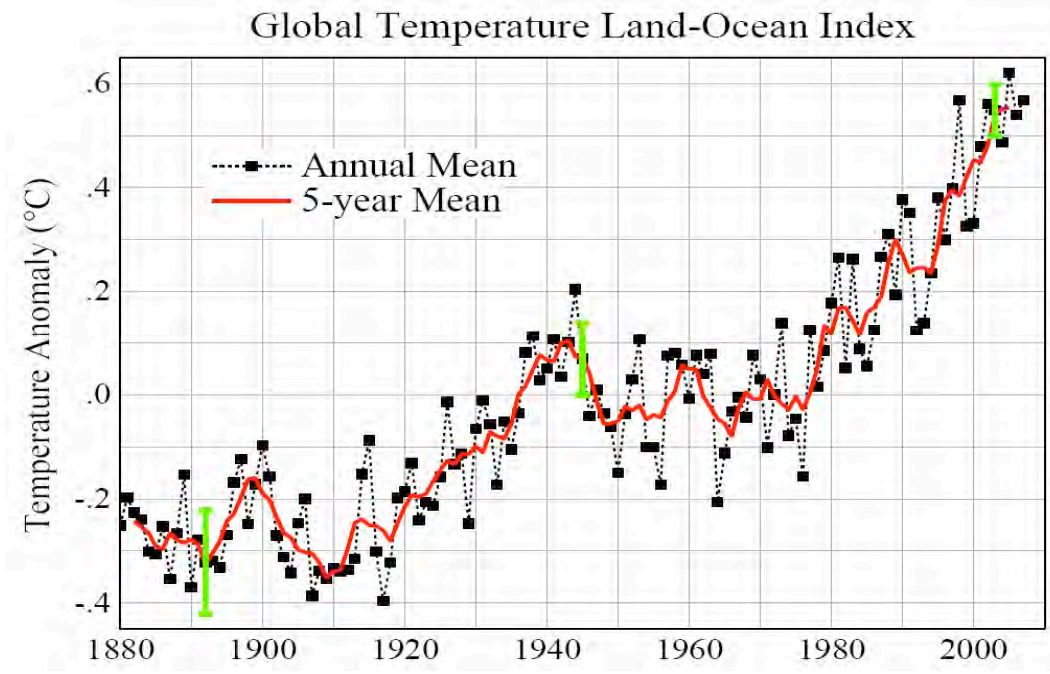
Total carbon dioxide emissions increased 70 per cent between 1970 and 2004, and are rising at an increasing rate. Their annual increase jumped from an average 1.1 per cent for 1990–1999 to more than three per cent for 2000–2004. The growth rate since 2000 is greater than for “business as usual”, the most pessimistic of the scenarios of the Intergovernmental Panel on Climate Change (IPCC).

Australia increased CO2 emissions 38% between 1994 and 2004, to be the sixth highest per capita emitter (on a base that excludes land use, land use change and forestry).

Rising temperature: 0.8C greater than pre-industrial level



NASA GISS

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During the past 11,500 years, the period of human civilisation, temperatures had varied within a narrow 1-degree band.

Now temperatures have risen 0.8 °C since the Industrial Revolution, and the Earth now is within 1°C of its highest temperature in the past million years.

125,000 years ago temperatures were similar to today and sea levels were 5-6 metres higher than today.

Oxygen isotopes in the deep-ocean fossil plankton reveal Earth was last 2°C to 3°C warmer around 3 million years ago, with carbon dioxide levels of perhaps 350 to 450 ppm. It was a dramatically different planet then, with no ice sheets in the northern hemisphere and the sea level was about 25 metres higher, give or take 10 metres.

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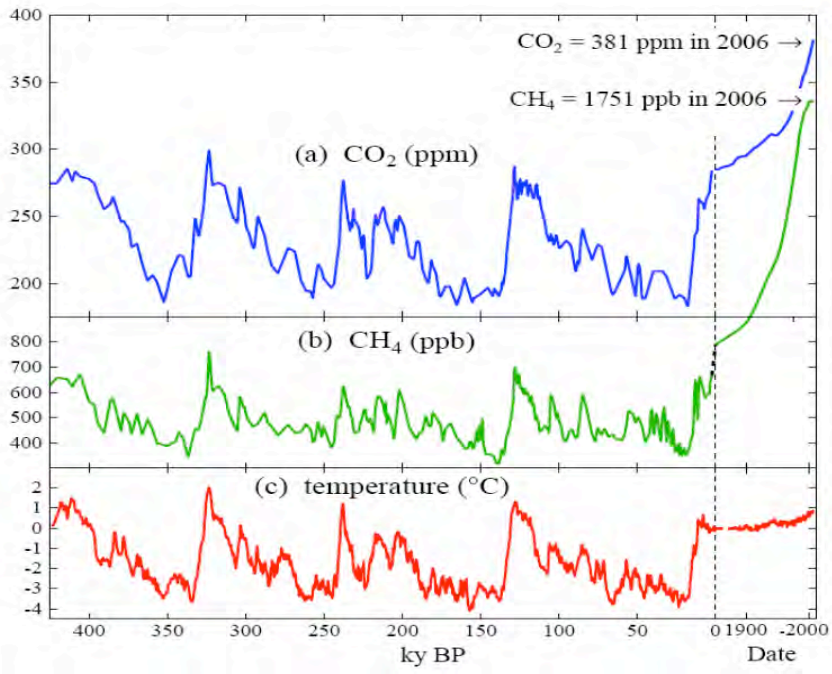
Temperature: big increases coming for present GHG levels



James Hansen / NASA

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James Hansen, Director of the NASA Goddard Institute for Space Studies predicts that current atmospheric level of greenhouse gases is sufficient, when slow feedbacks are taken into account, to produce further warming "in the pipeline" of 2°C : he says "no additional forcing is required to raise global temperatures to at least the level of the Pliocene, 2–3 million years ago..." when sea levels were 25 metres higher than today, and the world was free of ice sheets and glaciers, except for Antarctica. Hansen says that “if we go another ten years, by 2015, at the current rate of growth of CO2 emissions, which is about 2 per cent per year, the emissions in 2015 will be 35 per cent larger than they were in 2000,” and this would take emissions scenarios necessary to avoid dangerous climate change beyond reach.

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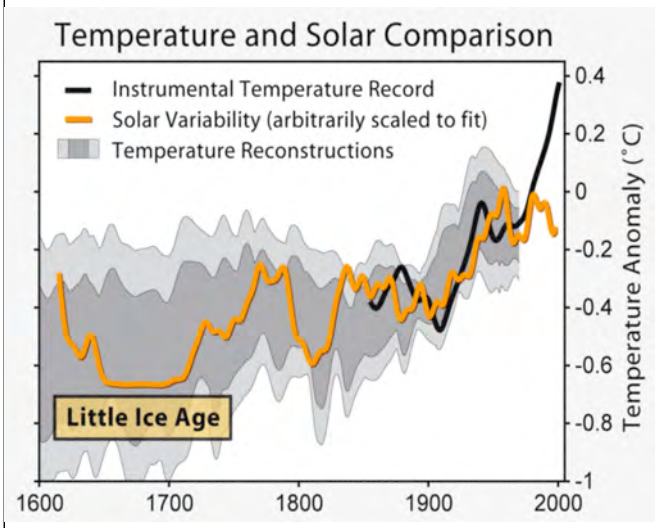
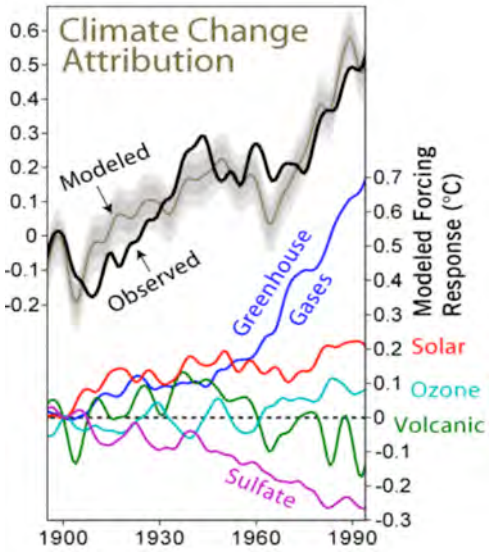
Solar variability is NOT the driver of increasing temperatures





Charts by Robert A. Rohde from published data

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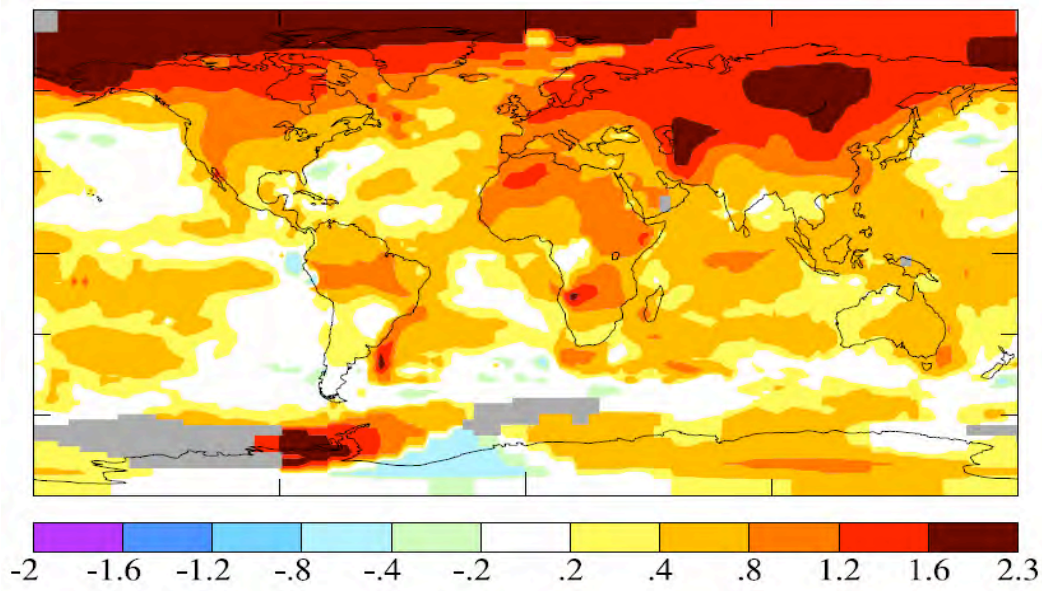
Climate skeptics like to argue that global warming is primarily a consequence of variations in solar activity.

This is contrary to both observations and the physics and chemistry knowledge that underline climate science and climate models, as the charts illustrate.

Warming is greatest in the polar north



James Hansen / NASA

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Global warming is greatest at the poles and in the northern hemisphere.

Air over the West Antarctic Peninsula has warmed nearly 6°C since 1950, compared to a global average since 1950 of about 0.6°C.

In the Arctic, the average temperature increase so far of more than 2°C is more than double global average. Arctic warming has been greatest in winter, at four times the global average.

Conservative scenarios predict an increase of more than 12°C in Arctic winter by 2050.

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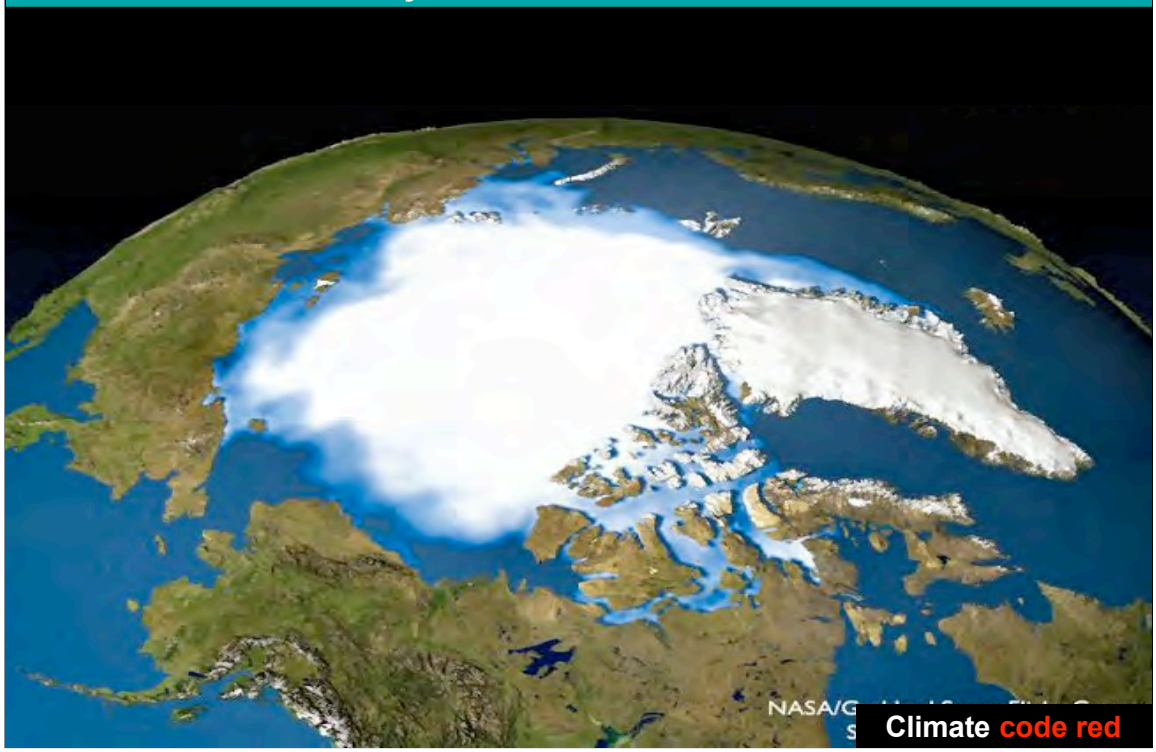
Arctic summer: The way it used to be in summer



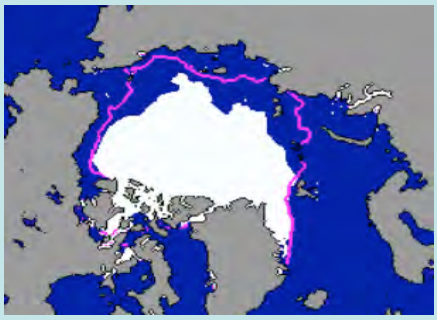
In summer, the Arctic Basin used to be covered by approx. 8 million square kilometres of sea-ice (ice floating on the ocean), an area similar to that of the Australian continent.

In addition, a large ice sheet approx. 2000 kilometres long, 1000 kilometres wide and up to 2 kilometres high sits on Greenland (at right of image).

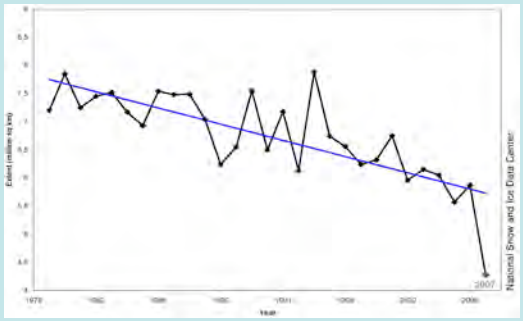
But now, significant climate “tipping points” have already been crossed for ice-sheet disintegration, and significant sea-level rises and species loss.

The complete loss of the Arctic sea-ice in summer is now inevitable.

Arctic summer sea-ice loss



Minimum ice extent 2005



Minimum ice extent 2007

NSIDC

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The Arctic sea-ice is disappearing fast, reducing in volume and thickness, so by the beginning of 2008, about 80% of the sea-ice by volume had disappeared.

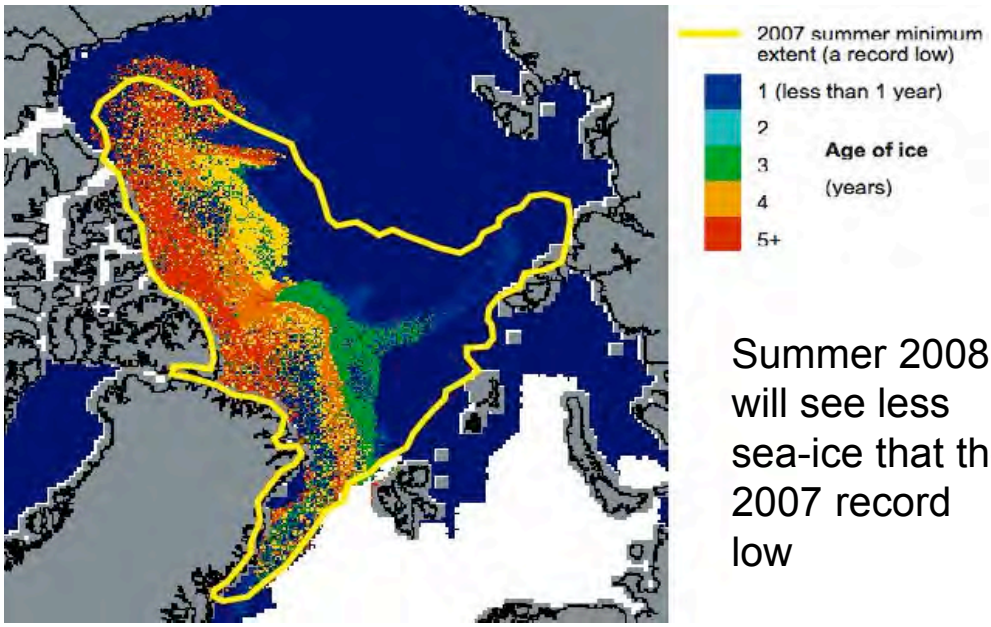
On 16 September 2007, the Arctic sea-ice minimum fell to a record low of 4.13 million sq. km., a precipitous decline in the ice extent of 22 per cent in two years.

If 2007 rates of sea-iceloss are reproduced in 2008, sea-ice minimum will drop to new low of 2.2 million sq. kms, compared to 4.13million sq. kms in 2007

The main cause of the sea-ice loss is warming oceans and higher atmospheric temperatures.

The loss of the Arctic summer sea-ice will cause a large local warming in the Arctic region of around 5ºC and a smaller but very significant global warming of around 0.3ºC.

Winter sea-ice February 2008



Summer 2008 will see less sea-ice that the 2007 record low

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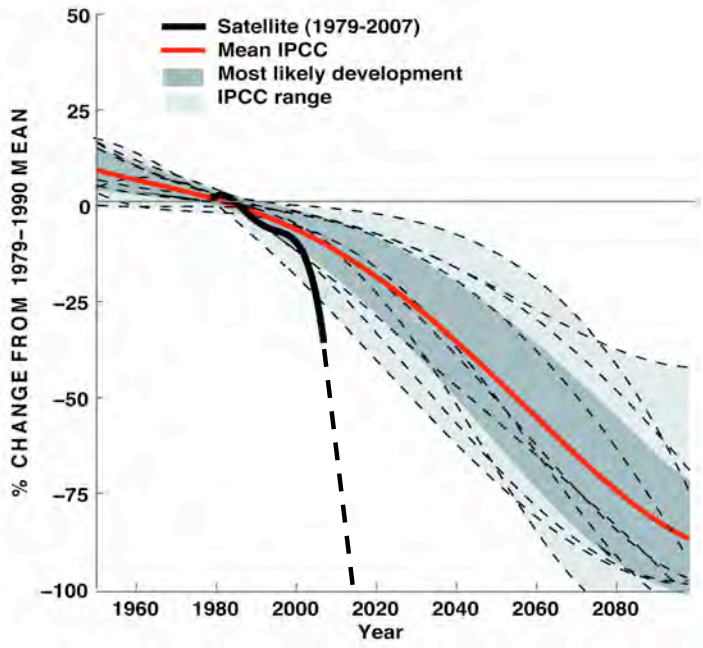
In the winter of 2007-08, most of the basin was covered by first-year ice. But only 13% of the first-year ice in 2007 survived the melt season. So summer 2008 will see less sea-ice that the 2007 record low.

"Because of the usual pattern of winds and currents we can expect [to] start the spring melt with only one-year ice in Eastern Artic Ocean. This has never happened before in the period that humans have been up there. … a summer like last year will break this up even much more than in 2007".
— Professor Olav Orheim, University of Bergen 1989-2005, Senior Adviser to the Norwegian Ministry of Environment, Executive Secretary International Polar Year Secretariat, Research Council of Norway, 10 March 2008

Arctic summer sea-ice loss predictions



Asgeir Sorteberg

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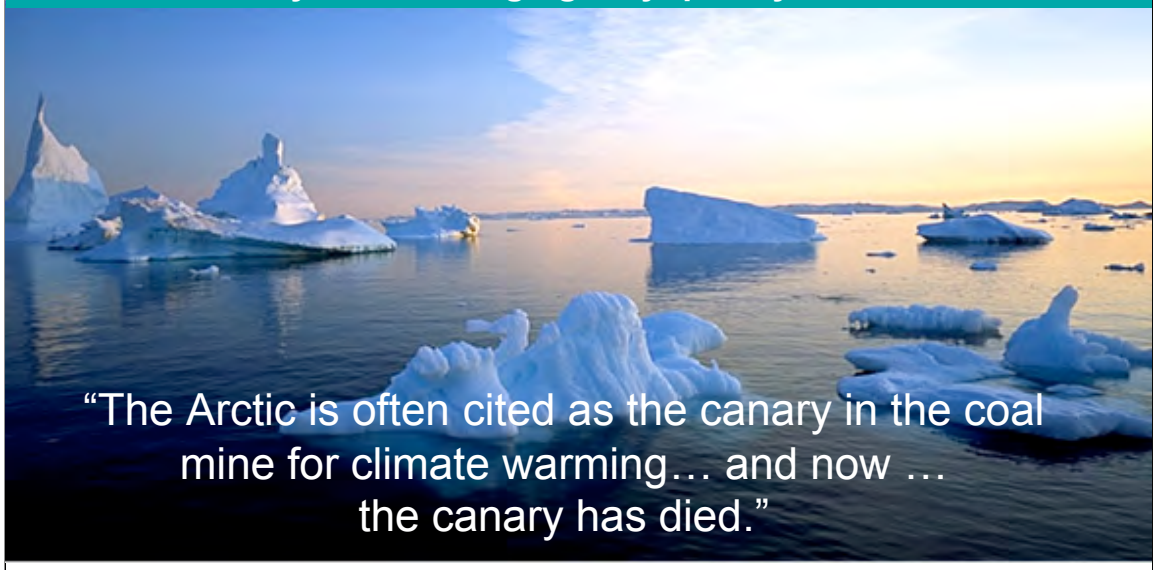
The Intergovernmental Panel on Climate Change estimated that the Arctic sea-ice would not be lost until 2100 or after (red line). But actual loss (black line) has been so great that the predictions (dotted line) are for total sea-ice loss within next five years.

“Our projection of 2013 [for total summer sea-ice loss] is already too conservative.” - Dr Wieslaw Maslowski, US Naval Postgraduate School

“Worst-case scenarios about sea-ice loss are coming true: the Arctic Ocean could be ice-free in summertime as soon as 2010’ - Louis Fortier, scientific director of Canadian research network ArcticNet

“The Arctic Ocean could be nearly ice-free at the end of summer by 2012” — Dr Jay Zwally, NASA

The Arctic eco-sytem is changing very quickly



Dr Jay Zwally, Glaciologist, NASA, December 2007

The Arctic is key to global climate system, and Arctic changes have potential to seriously destabilise global climate system.

Dr Neil Hamilton, Director WWF Arctic programme, says:

- Arctic climate models are breaking down and no longer work: "we are moving to a new Arctic climate system".
- Polar bears are totally dependent on sea-ice.
- Reindeer stocks are dropping dramatically.
- Carbon sinks in the Arctic are changing very, very quickly.
- It is not clear what any Arctic ecosystem will look like in 50 years.

The danger is that a summer-ice-free state in the Arctic will kick the climate system into run-on warming and create an aberrant new climate state many, many degrees hotter.

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Disintegration of Greenland ice-sheet

Air temperatures on Greenland ice sheet have increased by 4ºC since 1991 but Greenland's critical-melt threshold is estimated to be a regional warming of 2.7ºC.

"We are close to being committed to a collapse of the Greenland ice sheet". — Tim Lenton, Uni. East Anglia

How fast will Greenland ice sheet melt and raise sea levels by 7 metres? In past climate history 14,000 years ago, sea-levels rose as fast as 5 metres per century.

Can Greenland ice sheet be maintained if there is no summer sea-ice? The answer from most scientists is: No!

So can we avoid 'dangerous climate change' if there is no Arctic summer sea ice? The answer is also No!

Then the imperative is to cool the planet to no more than 0.5ºC above pre-industrial to restore summer sea-ice.

Antarctica

The Antarctic is now contributing to sea-level rise as much as Greenland.

A massive melting occurred in the Antarctic 3 million years ago when the average global temperature increased by only 2-3ºC above the present temperature.

Today a warming sea is melting the ice-cap edges, and beech trees and grass are taking root on the ice fringes, (*Washington Post* on 22 October, 2007).

Another warning sign was the rapid collapse in March 2002 of the 200-metre-thick Larsen B ice shelf, which had been stable for at least twelve thousand years, and which was the main outlet for glaciers draining from West Antarctica.

Sea-level rise

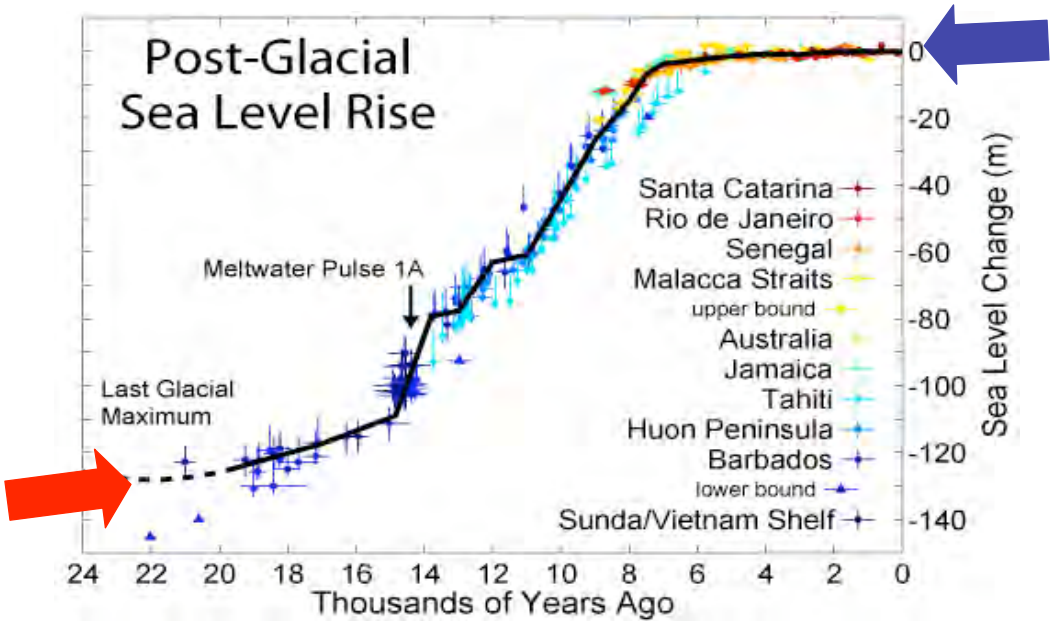

Chart by Robert A. Rohde from published data

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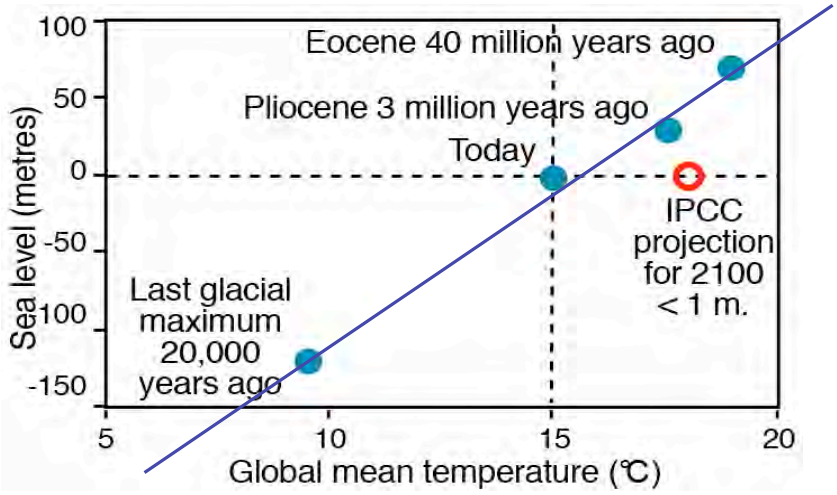
For the past 100,000 years, humans and their predecessors have survived and adapted as the Earth's temperature has fluctuated by up to 7ºC.

The current global average temperature is within 1ºC of the maximum temperature known to have occurred during the past million years, but conditions 6ºC colder were experienced during the depths of the recurring ice ages.

At a cold point 20,000 years ago, so much ice was stacked on the land that sea levels were 120 metres lower than they are now.

Sea levels have been almost constant over the last few thousand years of human civilisation and, more significantly, over recent centuries, when most climate-sensitive infrastructure has been built.

Sea-levels in paleoclimate record



The last time temperatures were 2-3C higher (three million years ago) sea levels were 25 metres higher

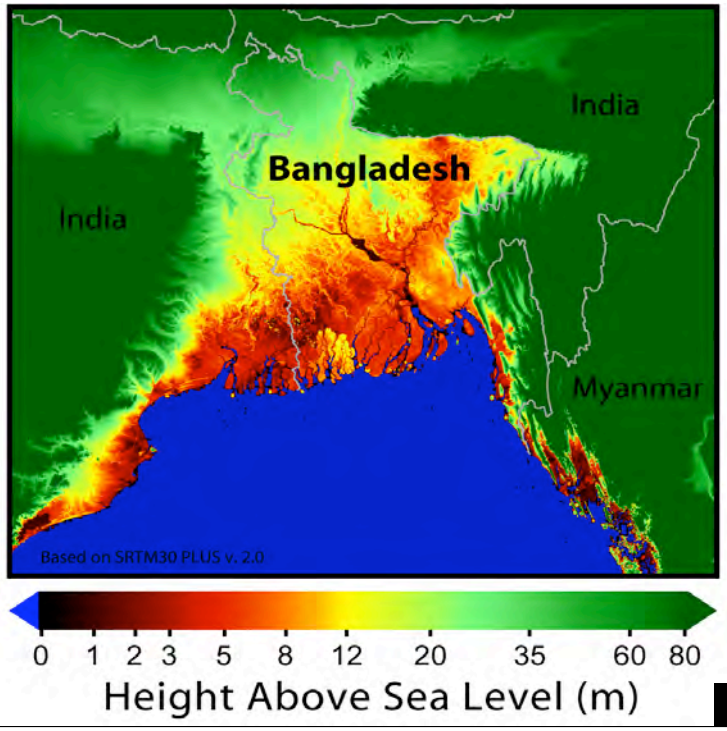
From David Archer

Many climate scientists received the 2007 IPPC report's suggestion of a sea-level rise of 18–59 centimetres by 2100 with dismay because it seriously underestimated the problem.

Stefan Rahmstorf, an ocean physicist, said that the data now available "raises concerns that the climate system, in particular sea level, may be responding more quickly than climate models indicate".

"Scientists monitoring [Arctic] events this summer say the acceleration could be catastrophic in terms of sea-level rise and make predictions this February [2007] by the [IPCC] far too low" — Paul Brown, *Guardian*, 7 September 2007.

Sea-level risk: Bangladesh



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“Let us say that ice sheet melting adds 1 centimetre to sea level for the decade 2005 to 2015, and that this doubles each decade until the West Antarctic ice sheet is largely depleted. This would yield a rise in sea level of more than 5 meters by 2095. Of course, I cannot prove that my choice of a 10-year doubling time is accurate but I’d bet $1000 to a doughnut that it provides a far better estimate of the ice sheet’s contribution to sea-level rise than a linear response. In my opinion, if the world warms by 2°C to 3°C, such massive sea-level rise is inevitable, and a substantial fraction of the rise would occur within a century. ‘Business as usual’ global warming would almost surely send the planet beyond a tipping point, guaranteeing a disastrous degree of sea-level rise.”

— James Hansen, NASA

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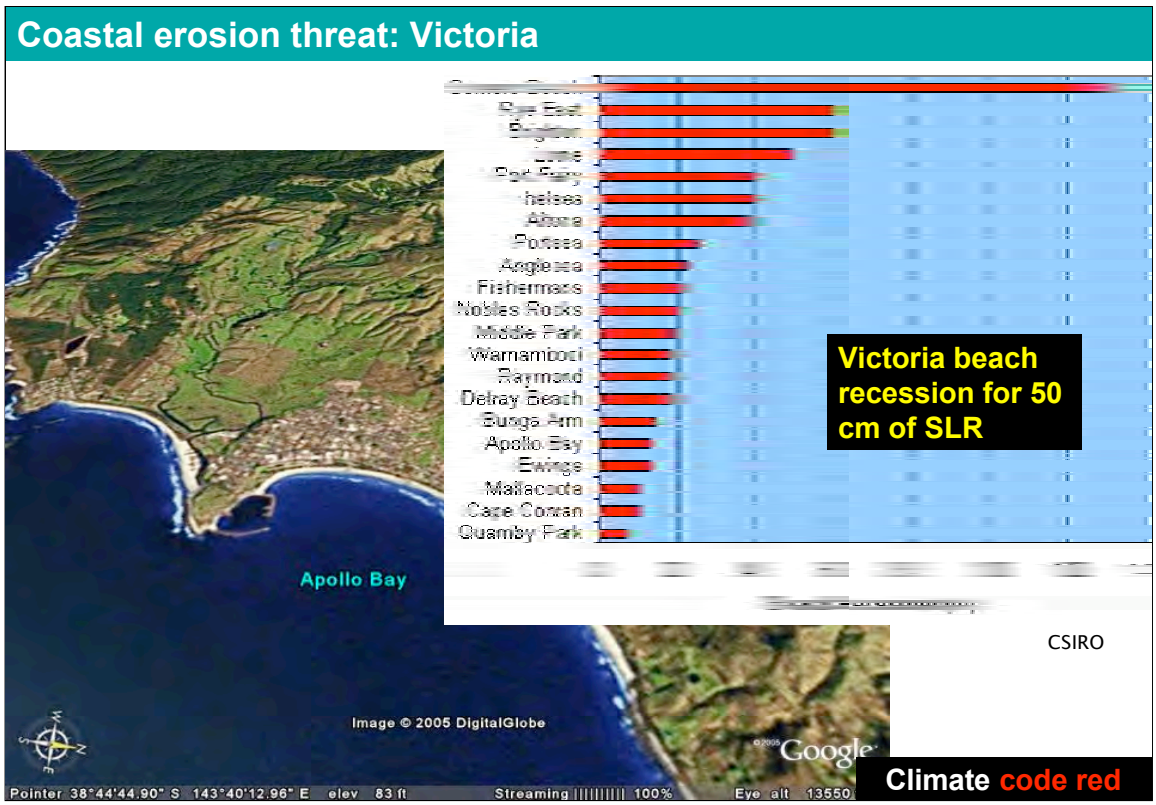

While large sea-level-rise figures may seem abstract, a rise of 1 metre will have a devastating impact on densely populated river deltas in the developing world, as homes and agricultural land are lost and damaged by storm surges.

In industrialised regions, small rises will have severe impacts on coastal infrastructure: loss of beaches, ports, and shipping facilities; flooding of transport links; inundation of underground facilities, including sewers, water, electricity transmission, and communications infrastructure; as well as the loss of industrial and domestic building.

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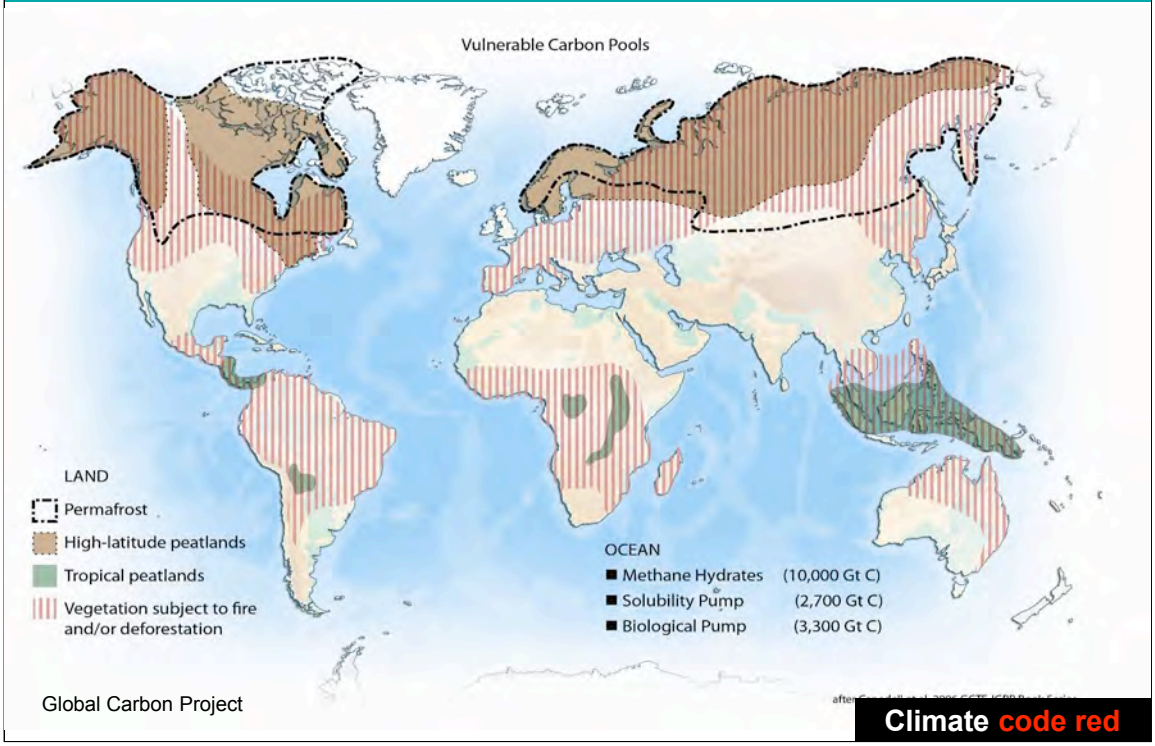
Melting permafrost

The National Centre for Atmospheric Research in Boulder predicts that half of the permafrost in the Arctic north will thaw to a depth of 3 metres by 2050. Glaciologist Ted Scambos says, “That’s a serious runaway … a catastrophe lies buried under the permafrost.”

Dr Sergei Zimov says: “Permafrost areas hold 500 billion tonnes of carbon, which can fast turn into greenhouse gases … If you don’t stop emissions of greenhouse gases into the atmosphere … the Kyoto Protocol will seem like childish prattle.”

Vulnerable carbon pools in the 21st century



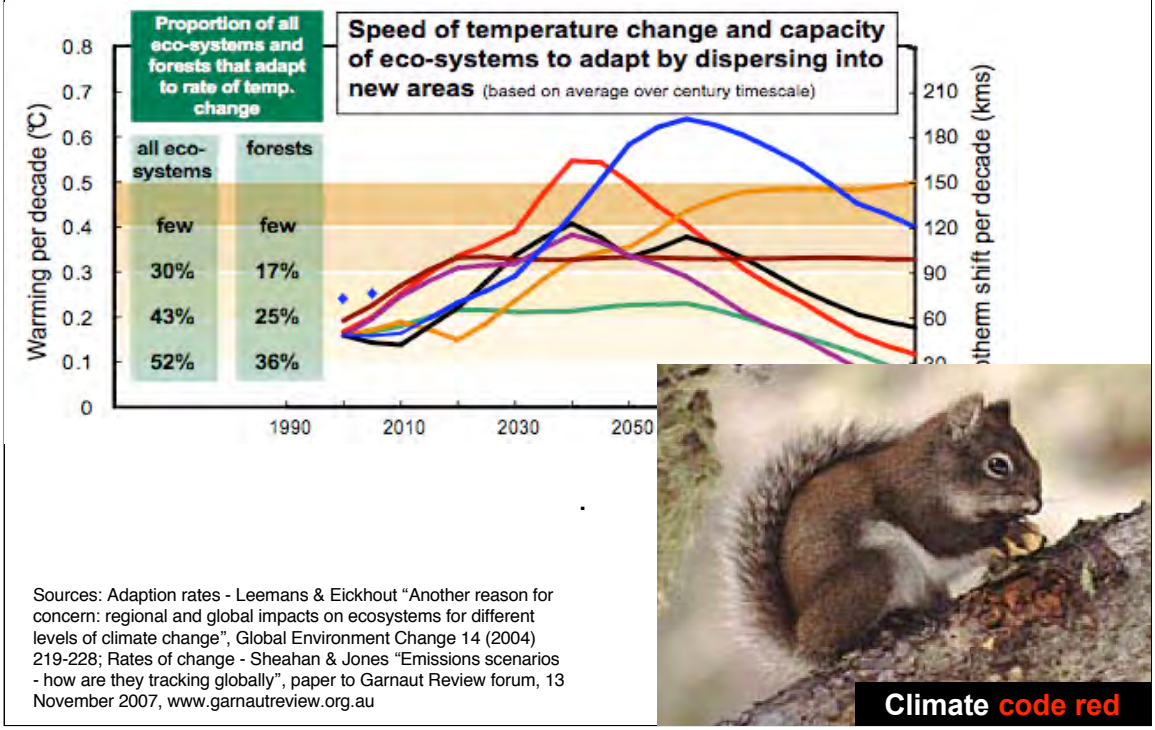
Under a business-as-usual scenario, the terrestrial biosphere will act as an overall carbon sink only until about 2050, when it will fail and revert to being a carbon source.

This slow feedback will increase temperatures by another 1.5 degrees by 2100, on top on predicted incraeses of 2–6ºC .

From 1959 to 2006, there was an implied decline of 10 per cent in the efficiency of natural sinks.

The world could be tracking towards irreversible climate change as warming takes place much quicker than previously thought, says Professor Barry Brook: "Two degrees has the potential to lead to three or four degrees because of carbon-cycle feedbacks."

Species loss

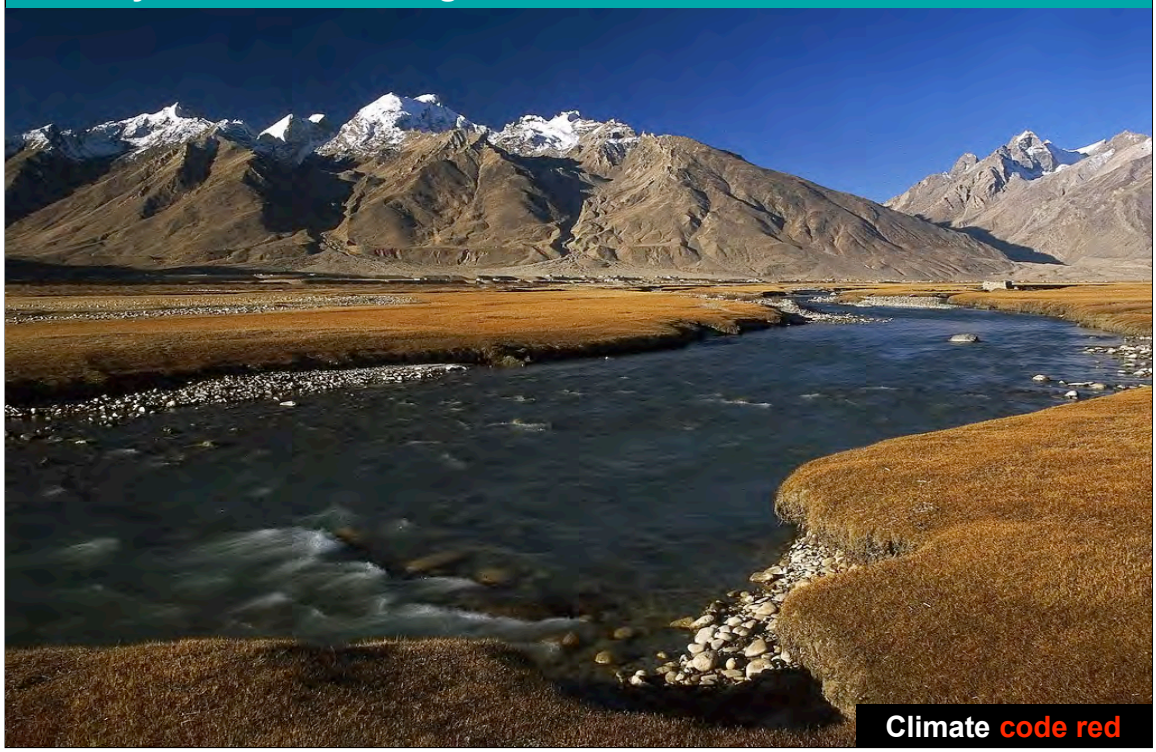


Sources: Adaption rates - Leemans & Eickhout "Another reason for concern: regional and global impacts on ecosystems for different levels of climate change", Global Environment Change 14 (2004) 219-228; Rates of change - Sheahan & Jones "Emissions scenarios - how are they tracking globally", paper to Garnaut Review forum, 13 November 2007, www.garnautreview.org.au

As temperatures rise, species must adapt and shift towards the poles. It is estimated that 70 per cent of all ecosystems and 80 pr cent of forests are unlikely to adapt at temperature rises of 3ºC per century. A 3ºC rise this century is in the middle of the range of IPCC predictions.

Dr Ken Caldeira of Stanford says: "Our carbon dioxide emissions are heating the planet and acidifying the oceans. Our physical environment is changing at a rate that is faster than at any time in the past hundreds of millions of years, except for those rare cataclysmic events that have killed off most life on Earth."

Himalayan ice-sheet and glacier loss

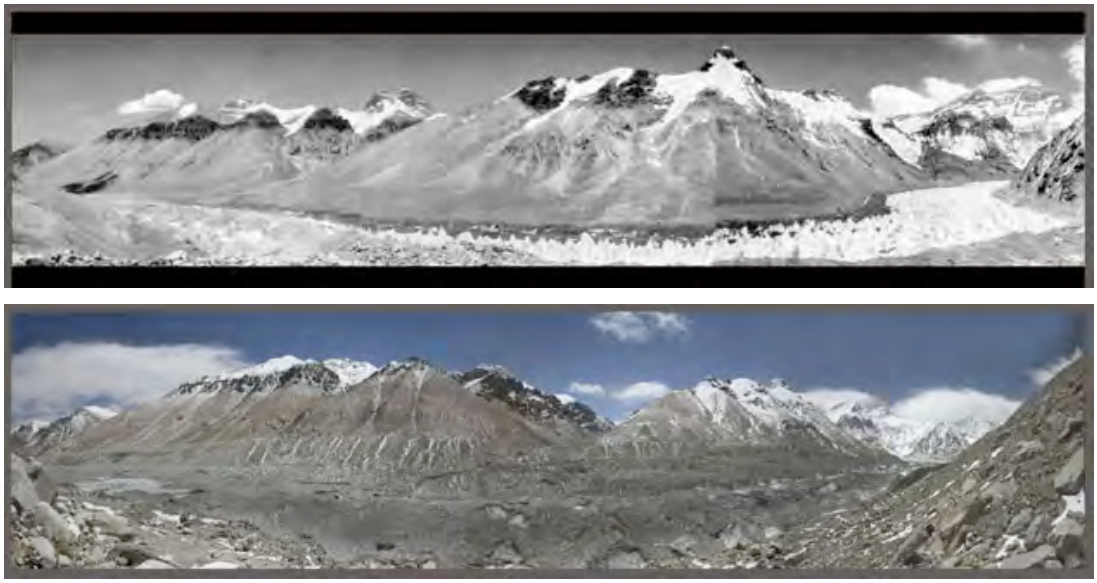


One-sixth of the Earth's population relies on glaciers and seasonal snow packs for their water supply. Taken together with those on the neighbouring Tibetan plateau, theHimalayan–Hindu Kush glaciers represent the largest body of ice on the planet outside the polar regions.

This ice sheet and its glaciers feed seven of the Asia's great river systems: the Indus, Ganges, Brahmaputra, Salween, Mekong, Yangtze and Huang He (Yellow). The basins of these rivers are home to 1.3 billion people from Pakistan to Indochina, including parts of India and China.

The conditions already exist for the complete loss of the HKH ice sheet. Many scientist are now of the view that the complete loss of the Himalayan glaciers is now inevitable, given the warming trend and the current political inertia.

Himalayan ice-sheet and glacier loss



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The 2007 IPCC report found that: “Glaciers in the Himalaya are receding faster than in any other part of the world and, if the present rate continues, the likelihood of them disappearing by the year 2035 and perhaps sooner is very high if the Earth keeps warming at the current rate.”

A significant portion of the low flow contribution of Himalayan rivers during the dry season is from snow and glacier melt in the Himalayan region. The dry season is when water is needed most to irrigate the rice and wheat crops on which hundreds of millions of people depend for their staple calories

Barnett et al. found that the Himalayas supply “as much as 70 per cent of the summer flow in the Ganges and 50–60 per cent of the flow in other major rivers. In China, 23 per cent of the population lives in the western regions, where glacial melt provides the principal dry season water source.”

Himalayan ice-sheet and glacier loss

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INDUS: The Indus Valley forms the backbone of agriculture and food production in Pakistan; 60 per cent of Pakistan's people depend on grain irrigated by the Indus river. The Indus delta is one of the driest in the Indian subcontinent, and the river is especially critical as rainfall is meagre in the lower Indus valley. If global temperatures rise by three degrees, water flows in upper Indus increase 14-9 [per cent due to increased melt rates, and then drop by 90 per cent by 2100.

GANGES: The Ganges is the largest source of surface water irrigation in India, and is a leading source of water for the 407 million people living in the Gangetic Basin. The Gangotri Glacier alone supplies 70 per cent of the flow of the Ganges in the dry season. The loss of glacier meltwater would reduce July-September flows by two thirds, causing water shortages for 500 million people and 37 percent of India’s irrigated land.

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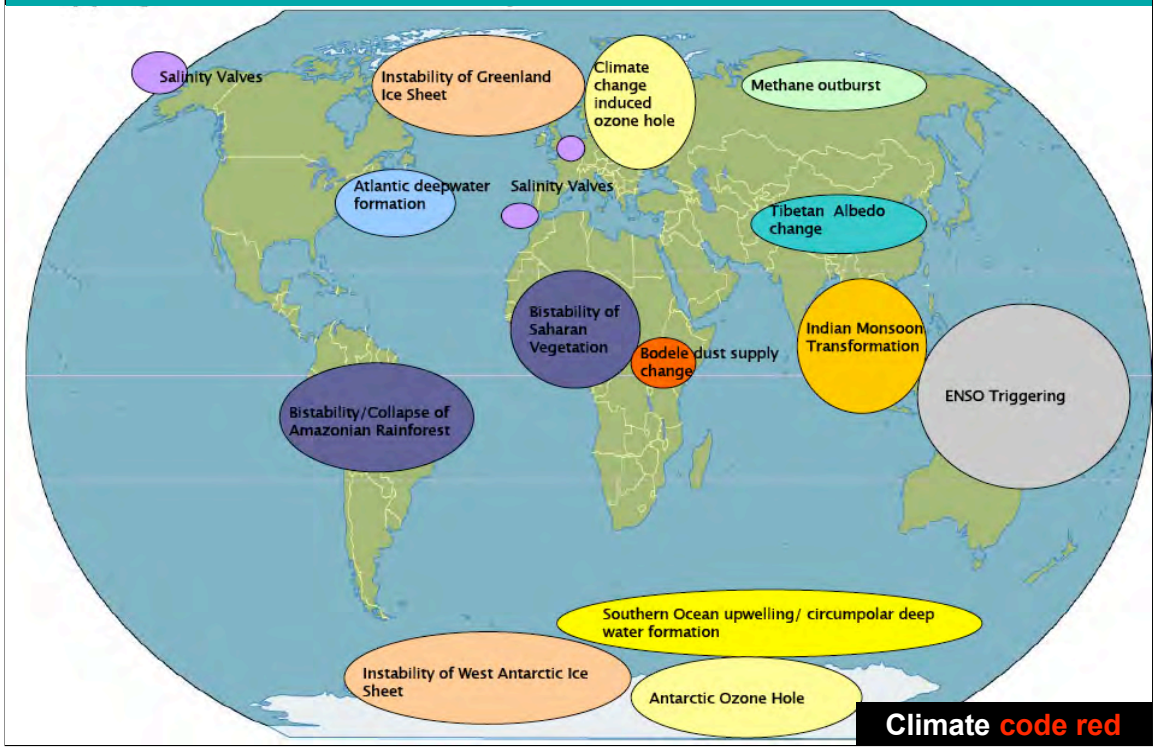
Tipping points in the climate system

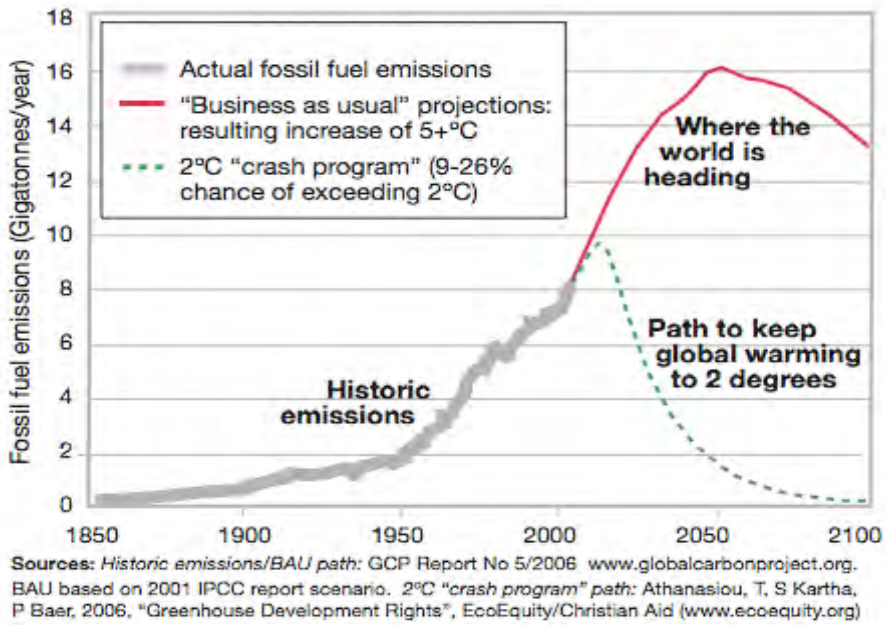


Lenton et al. surveyed 88 experts in 2007 about climate "tipping points" as follows:

- 1 year: Indian monsoon destabilises (m)
- 10 year: total Arctic sea-ice loss (h); West Africa monsoon collapse (m)
- 50 years: Boreal forest dies (m); Amazon forest dies (m)
- 100 years: El Nino strengthens (m); thermohaline circulation (inc. Gulf Steam) collapses (l)
- 300 years: West Antarctic Ice Sheet collapses (m)

L: low risk M: medium risk H: high risk

The emissions gap



Sources: *Historic emissions/BAU path:* GCP Report No 5/2006 www.globalcarbonproject.org. BAU based on 2001 IPCC report scenario. *2°C "crash program" path:* Athanasiou, T, S Kartha, P Baer, 2006, "Greenhouse Development Rights", EcoEquity/Christian Aid (www.ecoequity.org)

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Even a 2-degree target (which is far too high) requires a crash programme to reduce emissions.

In summary:

1. Our goal is a safe-climate future – we have no right to bargain away species or human lives.
2. We are facing rapid warming impacts: the danger is immediate, not just in the future.
3. For a safe climate future, we must take action now to stop emissions and to cool the earth.
4. Plan a large-scale transition to a post-carbon economy and society.
5. Recognise a climate and sustainability emergency, because we need to move at a pace far beyond business and politics as usual

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Assessment of CO2 target by James Hansen (now 387 ppm)

Phenomenon	Target CO_2 (ppm)
1. Arctic Sea Ice	300-325
2. Ice Sheets/Sea Level	300-350
3. Shifting Climatic Zones	300-350
4. Alpine Water Supplies	300-350
5. Avoid Ocean Acidification	300-350

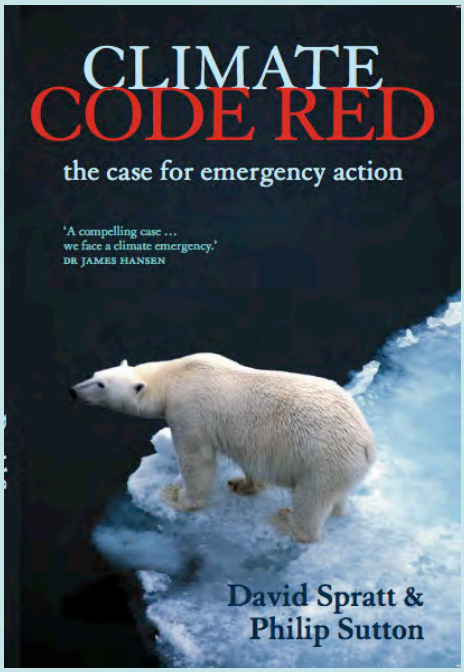
→ **Initial Target CO_2 = 350* ppm**

*assumes CH_4, O_3, Black Soot decrease

In the draft for "Science" released in April 2008, James Hansen and seven co-authors say that a carbon dioxide level of "300–325 parts per million may be needed to restore [Arctic] sea ice to its area of 25 years ago". In other words, the amount of carbon dioxide in the atmosphere would need to be significantly reduced from the current level of 387 parts per million.

Hansen says "Recent greenhouse gas emissions place the Earth perilously close to dramatic climate change that could run out of our control, with great dangers for humans and other creatures. There is already enough carbon in the Earth's atmosphere for massive ice sheets such as West Antarctica to eventually melt away, and ensure that sea levels will rise metres in coming decades. Climate zones such as the tropics and temperate regions will continue to shift, and the oceans will become more acidic, endangering much marine life. We must begin to move rapidly to the post-fossil fuel clean energy system. Moreover, we must remove some carbon that has collected in the atmosphere since the Industrial Revolution."

The climate science behind… **Climate code red**



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