GREENPEACE Briefing

# Racing Over the Edge

## Recent Science on Climate Change

***"No time to lose – the longer we wait, the greater the damage"***
*Leo Meyer, presentation on main findings IPCC AR4, October 2008*

### Introduction

The world has entered an era of dangerous and destructive climate change, and this change is increasing exponentially through lack of action to tackle the problem. Whether or not we can step back from the brink and change course will depend heavily on the level of cuts in greenhouse gas emissions the world is prepared to make over the next few years.

A multitude of new scientific findings show that climate change is racing ahead of the worst case forecasts of the International Panel on Climate Change (IPCC)[1] in its Fourth Assessment Report (AR4).

The dramatic melting of the Arctic summer sea-ice in 2007 and 2008 is probably the most visible example and has forced a significant re-evaluation of how close we may be to runaway climate change. It is now clear that it is melting substantially faster than the IPCC predicted only two years[2] ago and there are concerns that the Arctic could be ice-free in summer within the next ten years. The climate system is dangerously close to this major tipping point and many other climate change impacts are also outstripping the IPCC projections.

Changes in the real world make it clear that even the current level of global warming is too much. The Earth's capacity to deal with the effect of a continuously growing concentration of greenhouse gases in the atmosphere has already been exceeded.

Previous estimates of the required rate of emissions reductions are simply not adequate. With a greater urgency than ever before, the world must take immediate and effective action to achieve a peak in global greenhouse gas emissions by 2015 at the latest, followed by a steep and rapid decline to zero emissions as soon as possible thereafter.

### 1. The overwhelming scientific consensus

The international scientific consensus on climate change is clear. The AR4 stated that 'warming of the climate system is unequivocal', and that there is a more-than-90% probability that most of the warming since 1950 has been caused by the rapid increase in greenhouse gas

1 The Intergovernmental Panel on Climate Change (IPCC) was established to provide decision-makers with an objective source of information about climate change. The IPCC does not conduct any research but assesses - on a comprehensive, objective, open and transparent basis - the latest scientific, technical and socio-economic literature produced worldwide relevant to the understanding of the risk and future impacts of human-induced climate change, and the options to prevent these risks and impacts. The IPCC is made up of government representatives and hundreds of scientists. A rigorous process ensures its reports and assessments are agreed upon unanimously by all of the participating countries and all of the participating leading scientists.

2 Gillet N.P. et.al. 2008: Attribution of polar warming to human influence. Nature Geoscience. 1, 750-754.

concentrations due to human activities.

The range of effects expected as a result of past, current and future emissions of greenhouse gases are shown in the IPCC AR4.[3] With no reduction in emissions, global mean temperature will rise above pre-industrial levels by 1.7°C to 7°C, depending on the rate at which we continue to emit greenhouse gases. Present emissions are at the top of the projected ranges and, with no action, warming towards the upper end of the range is likely. We are already seeing serious negative impacts for ecosystems and human populations - such as the melting of the Arctic summer sea-ice - even at the current global temperature rise of only about 0.8°C above pre-industrial levels. These could cause positive feedbacks that drive the climate system to even greater extremes. The AR4 projects:

- Over the coming decades, water supplies stored in glaciers and snow cover are projected to decline, causing water shortages for more than one billion people in regions supplied by melt water from major mountain ranges;

- About 20-30% of plant and animal species assessed so far are likely to be at increased risk of extinction if increases in global average temperature exceed 1.5-2.5°C;

- At lower latitudes, especially in seasonally dry and tropical regions, even small local temperature increases of 1-2°C are expected to increase the risk of hunger due to diminished crop productivity and increased frequency of droughts and floods;

- Annually by the 2080s many millions of people are projected to be affected by flooding of their homes or businesses due to sea-level rise. Densely-populated and low-lying areas with little capacity to adapt (and already facing other challenges such as tropical storms or local coastal subsidence) will be especially at risk;

- The health of millions of people will be harmed by increases in malnutrition and by death and injury caused by climate change related heat waves, floods, storms, fires, droughts and the increased frequency of many diseases (including insect-borne ones).

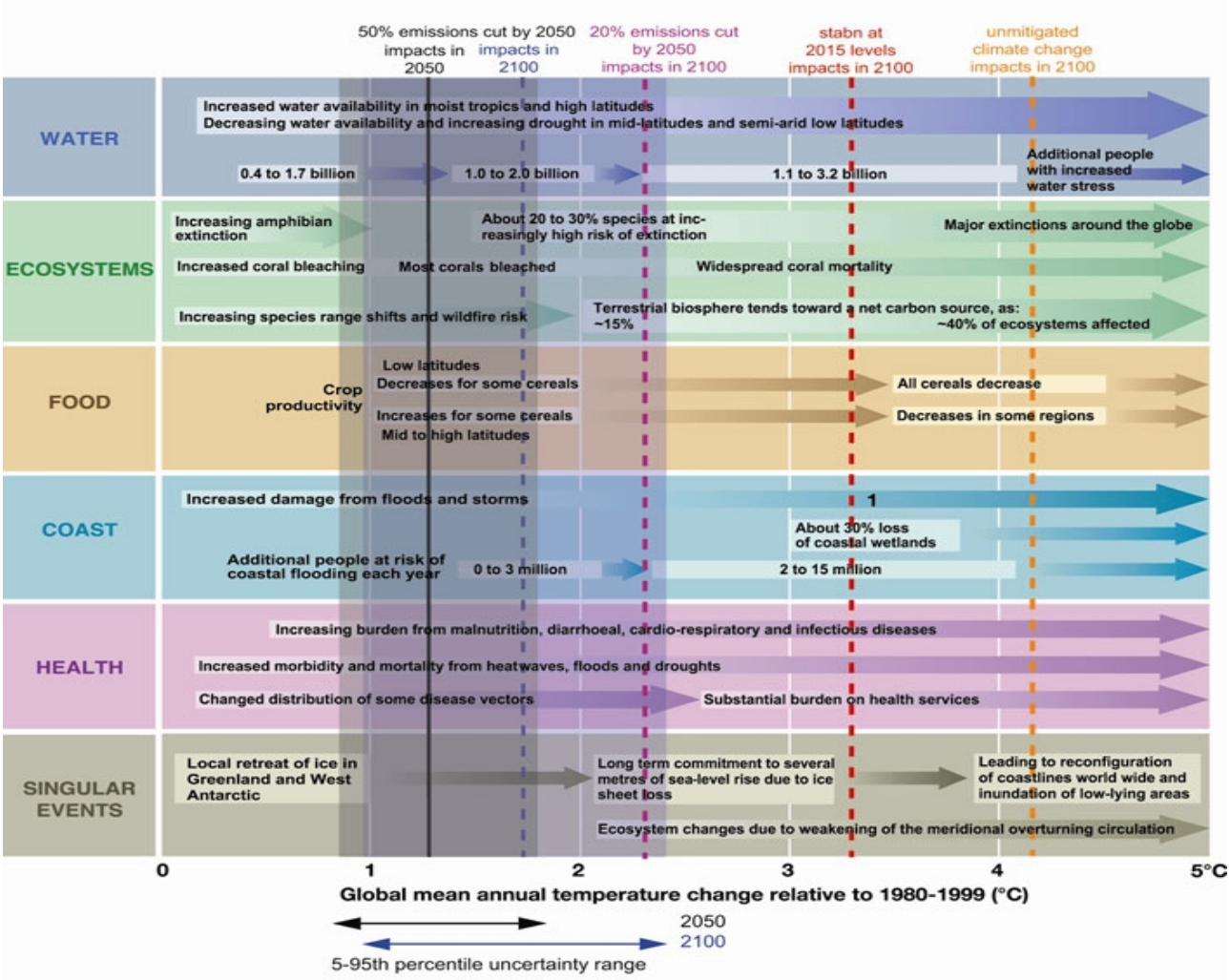
**Alarmingly, more recent studies consistently show that climate change is accelerating at a rate far than beyond the projections in AR4. Several of these studies report strong positive feedbacks that are expected to affect the climate at a fundamental level. Impacts are also being observed much earlier - sometimes by decades -than forecast by the IPCC, due to the climate system reacting more strongly than expected and greenhouse gas emissions being higher than projected.**

**In an effort to collect and synthesise existing and emerging new scientific knowledge on climate change and its impacts, the University of Copenhagen in collaboration with nine other universities organised the 'International Scientific Congress on Climate Change' from 10 to 12 March 2009 in Copenhagen. The scientific contributions to the Congress will be synthesised and published in a special report aimed at guiding the political decision-making process in the run up to the UNFCCC Conference of the Parties in Copenhagen.**

**The Examiner (14 March, 2009): Climate change experts warn that worst-case scenario is happening:**
*…The International Scientific Congress on Climate Change, a gathering of climate change experts, completed its three-day event Thursday and with it issued dire warnings for the world... The first message on climatic trends was perhaps the most stark and alarming. The warning said: 'Recent observations confirm that, given high rates of observed emissions, the worst-case IPCC scenario trajectories (or even worse) are being realised. For many key parameters, the climate system is already moving beyond the patterns of natural variability within which our society and economy have developed and thrived.'*

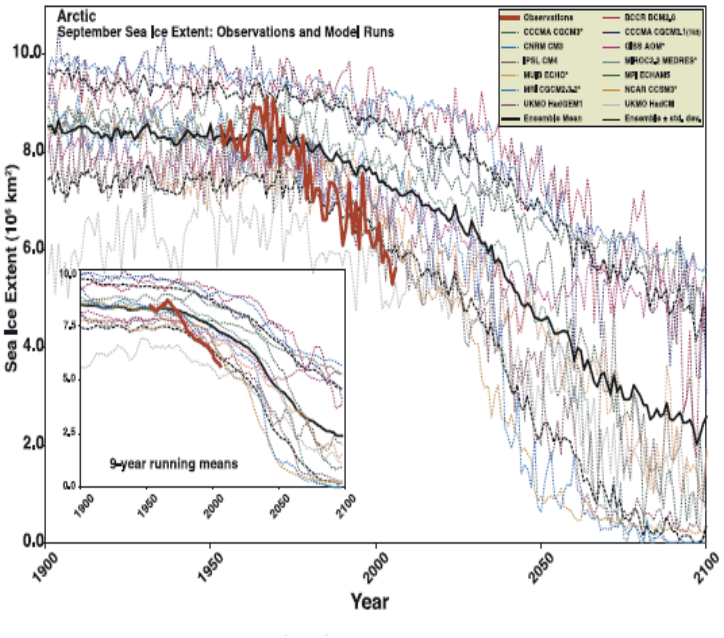
3 IPCC 2007: Climate Change 2007: Synthesis Report. Fourth Assessment Report of the Intergovernmental Panel on Climate Change.

Figure 1: expected impacts of emission reduction scenarios. Source: IPCC, AR4. Temperature levels are shown with respect to 1980-1999. Add about 0.6°C to convert to temperatures above pre-industrial times.



**BBC News (10 March, 2009): Sea rise 'to exceed projections'**
*…The global sea level looks set to rise far higher than forecast because of changes in the polar ice-sheets, a team of researchers has suggested. Scientists at a climate change summit in Copenhagen said earlier UN estimates were too low and that sea levels could rise by a metre or more by 2100. The projections did not include the potential impact of polar melting and ice breaking off, they added. The implications for millions of people would be 'severe', they warned. 10% of the world's population - about 600 million people - live in low-lying areas.*

Figure 2: Arctic Sea Ice Extent. Source: Strouve



## 2. Observations show some impacts are occurring earlier and at lower increases in global temperature than expected

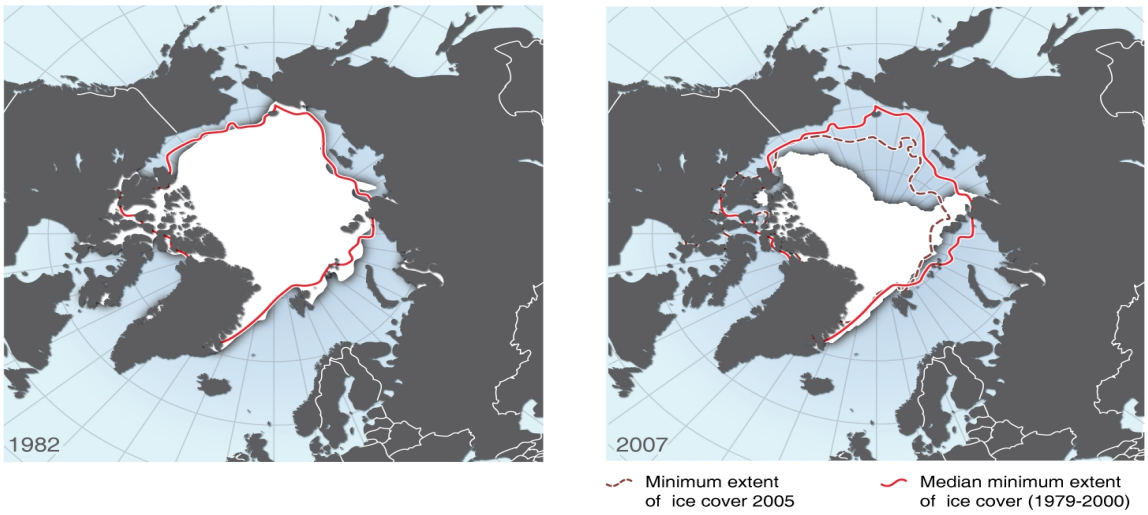
### The Arctic

With only a 0.8$^{O}$C rise in global mean temperature, there is an immediate danger of passing one of the climate systems' tipping points - the disappearance of most of the Arctic summer sea-ice. This loss is likely to lead to rapid and abrupt regional climate changes with irreversible impacts.

The Arctic Ocean is losing summer sea-ice at a rate that is 30 or more years ahead of the AR4 projections, according to researchers from Harvard University and the National Snow and Ice Data Center (NSIDC).[4] The Arctic could be ice-free in summer in less than ten years, a state not seen on the planet for more than a million years. Arctic sea-ice coverage during the 2007 and 2008 melt seasons dropped to the lowest levels since satellite measurements began, as reported by the NSIDC.[5] The '08 September low was 34% below the long-term average from '79 to 2000.

As with other recent science, the observations are on the most extreme side of expectations (see Figure 2), indicating a likely deterioration of the climate system that is moving beyond even the worst-case predictions. Figure 3 shows the loss in Arctic summer sea-ice over the last 30 years, and in particular a huge loss of sea-ice between 2005 and 2007. A study by the University College of London indicates that the Arctic sea-ice is now even melting during winter and that the ice sheet is not only receding but also thinning at a dramatic rate.[6]

Figure 3: Arctic sea-ice trends. Source: UNEP/GRID




### The Antarctic

Similarly, the observed loss of Antarctic sea-ice exceeds AR4 projections. Floating tide-water glaciers in the Antarctic Peninsula are losing ice faster and are making a greater contribution to global sea level rise than reported in the AR4.[7] Ice-loss in West Antarctica as a whole was about 75% faster in 2006 than in 1996.[8] New studies project that, by the end of the century, sea level rise due to changes in ice dynamics of both Greenland and Antarctica may be up to 1.4 metres. This is significantly more than the 0.59 metre upper estimate of AR4.[9]

4 Stroeve J. et.al. 2007: Arctic sea-ice decline: faster than forecast. Geophysical research Letters. 34, L09501 and Eisenman I. et al. 2008: On the reliability of simulated Arctic sea-ice in global climate models. Geophysical Research Letters 35(4).

5 NSIDC. 2008: Arctic sea-ice down to second lowest extend. Likely record-low volume. Press release. 2 October 2008.

6 Giles K.A. et.al. 2008: Antarctic sea-ice elevation from satellite radar altimetry. Geophysical Research Letters. Vol. 35, L03503.

7 Pritchard H.D. And Vaughan D.G. 2007: Widespread acceleration of tidewater glaciers on the Antarctic Peninsula. Journal of Geophysical Research. 112, FO3S29.

8 Rignot E. et.al. 2008: Recent Antarctic ice mass loss from radar interferometry and regional climate modelling. In: Nature Geoscience 1 (106-110). January 2008.

9 Grinsted A. et.al. 2009: Reconstructing sea level from paleo and projected temperatures 200 to 2100 AD.

**Global impacts**
Observed global mean warming is also at the high end of AR4's projected range[10] and intensification of extremes such as heat waves and droughts is occurring significantly earlier[11]. Stronger negative impacts on human livelihoods and on ecosystems are being observed already.[12] Glaciers are losing mass and are melting faster than foreseen, with negative impacts on water supply availability soon to follow.[13] Global warming is also linked to the faster and stronger occurrence of widespread coral bleaching[14] and impacts on water supply are being observed from unusual droughts in Australia and in other regions.

New evidence shows that, since 1981, the trend in global warming has led to world-wide reduced yields of wheat, maize and barley of about 40 million tonnes per annum, equalling a cost of USD 5 billion (€3.2 billion). South Asia and southern Africa will likely suffer significant yield reductions of several crops that are important for feeding their populations.[15] A weakening of the $CO_2$ absorption capability of Earth's largest $CO_2$ sink, the Southern Ocean, is now more apparent, due to the observed increase in southern ocean winds[16].

In an effort to provide some insight into dangerous climate change the IPCC identified, in its Third Assessment Report, five 'reasons for concern' and used a figure (known as 'burning embers') to illustrate the increasing danger to the planet from rising temperatures. In 2009, the authors of these 'reasons for concern' published a revised diagram (see Figure 4). Based on literature that was assessed in the AR4 as well as additional research published since AR4, the results show that smaller increases in temperature rise are now estimated to lead to significant impacts.

**Not only are we heading to a possible complete loss of the Arctic summer sea-ice, the scale, magnitude and timing of observed impacts in many other places is clearly stronger and faster than previously assessed by the IPCC. More importantly, the indicators of impending calamity are being observed at lower temperatures than ever thought possible until now. All this is ominous for vulnerable regions such as sub-Saharan Africa and the small island states, where substantial impacts on food production, water supply, ecosystems, and weather are to be expected at levels of warming over 1.5°C above pre-industrial levels.[17]**

Climate Dynamics. January 2009.

10 Rahmstorf S. et.al. 2007: Recent Climate Observations compared to Projections. Science 316(6825):709.

11 Thomas R.K. et.al. 2008: Weather and Climate Extremes in a Changing Climate. US Climate Change Science Program.

12 Rosenzweig C. et.al. 2008: Attributing Physical and Biological Impacts to Anthropogenic Climate Change. Nature 453(7193): 353-357.

13 Barnett T.P. et.al. 2005: Potential impacts of a warming climate on water availability in snow-dominated regions. Nature 438(7066), 303-309.

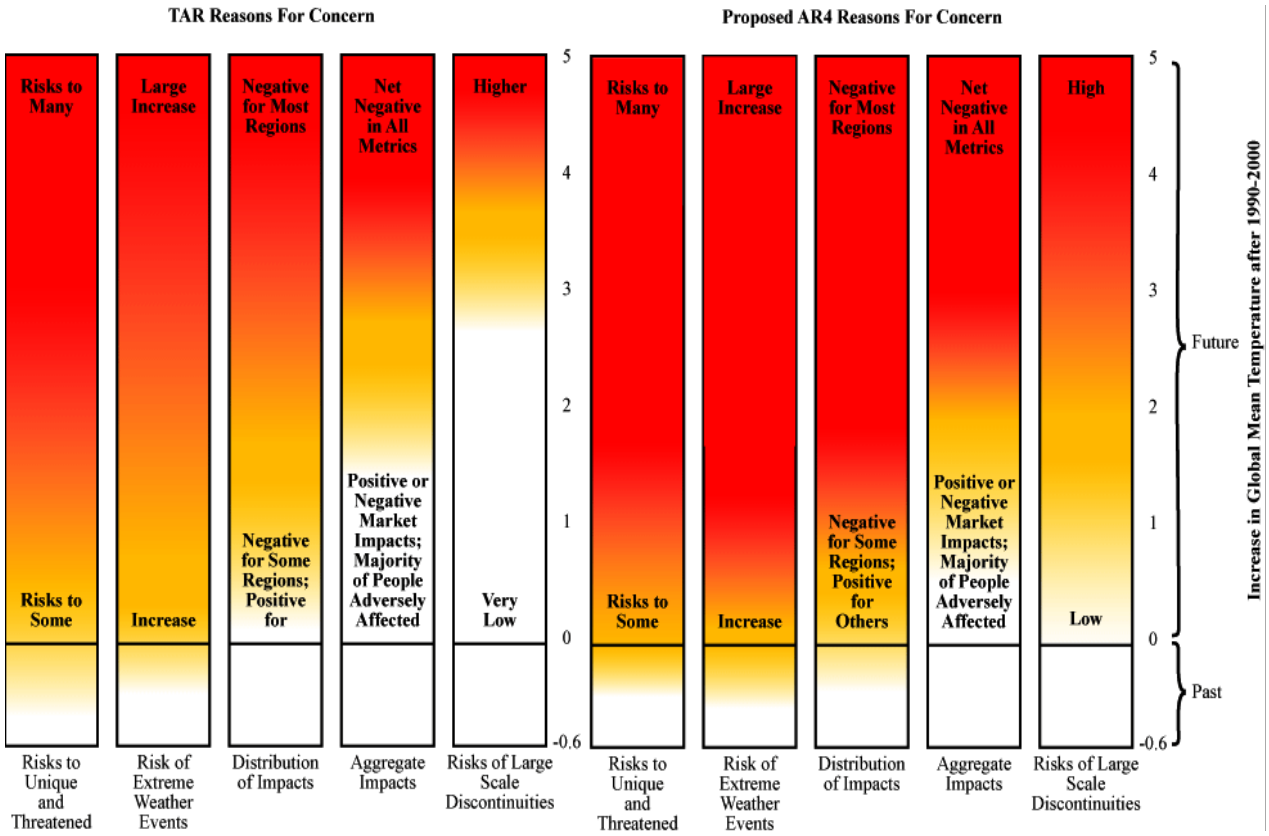
14 Cao, L. and K. Caldeira. 2008: Atmospheric $CO_2$ stabilization and ocean acidification. Geophysical Research Letters. doi:10.1029/2008GL035072.

15 Lobell D.B. And Field C.B. 2007: Global scale climate-crop yield relationships and the impacts of recent warming. Environmental Research Letters. 2, 014002. and Lobell D.B. et.al. 2008: Prioritizing climate change adaptation needs for food security in 2030. Science. 319(5863), 607-610 and Tebaldi C. et.al. 2008: Towards probabilistic projections of climate change impacts on global crop yields. Geophysical Research Letters 36(8). and Battisti D.S. et.al. 2009: Historical Warnings of Future Food Insecurity with Unprecedented Seasonal Heat. In: Science 323. January 2009.

16 Le Quere C. et.al. 2007: Saturation of the Southern Ocean $CO_2$ Sink Due to Recent Climate Change. Science: 1136188.

17 Hare B. 2008: Science of Climate Change. Breaking the Climate Deadlock. Briefing Paper

Figure 4: Burning embers. Source: PNAS

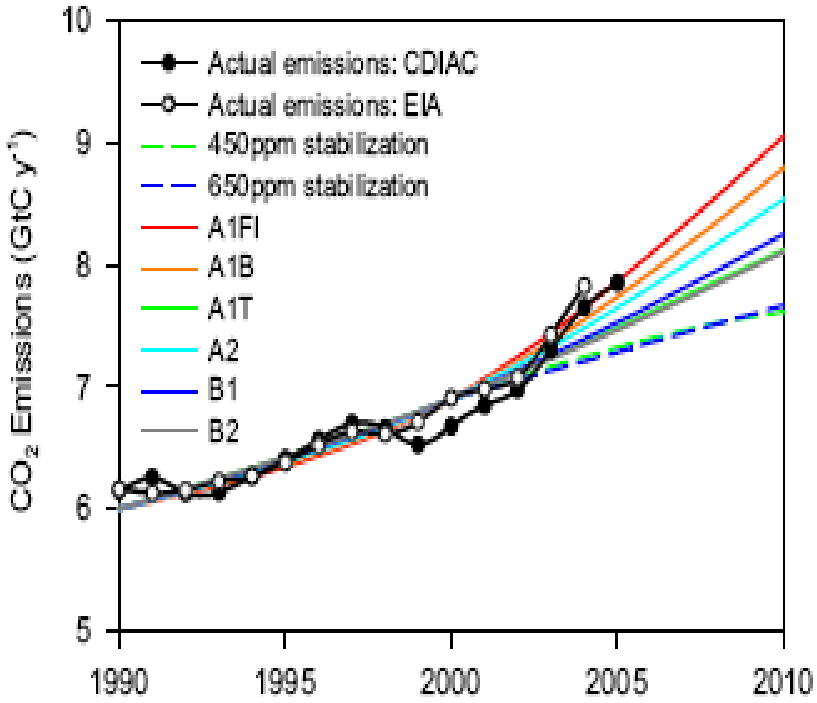


## 3. Greenhouse gas emissions are growing fast and atmospheric concentrations are already beyond projections

The actual growth rate of greenhouse gas emissions since 2000 is at the top or beyond any of the projected scenarios used by the IPCC in either the Third Assessment Report or AR4, as shown in Figure 5.[18] In 2007, the atmospheric $CO_2$ concentration reached 383 parts per million (ppm). The annual rate of increase of 2.2 ppm was up from the average of 2.0 ppm over the prior seven years, according to the Global Carbon Project's report, Carbon Budget 2007.[19] Since 2000, anthropogenic $CO_2$ emissions have been growing four times faster than over the previous decade.

At the current rate of emissions, we may be heading towards a temperature rise of 4°C or even 6°C by 2100, above the 1980-1999 average temperature.[20] A 6°C temperature rise would have catastrophic consequences: a global extinction of species, widespread loss of major ecosystems, disruption of water and food supplies, dramatic sea level rise and wide-ranging adverse consequences for human society.[21]

Figure 5: Global C02 emissions as compared to IPCC scenarios. Source: Raupach (PNAS)




18 Raupach M.R. et.al. 2007: Global and regional drivers of accelerating $CO_2$ emissions. Proceedings of the National Academy of Sciences. 104(24), 10288-10293.

19 Le Quere C et.al. 2008: Carbon Budget 2007. An annual update of the global carbon budget and trends. Global Carbon Project.

20 IPCC 2007: Climate Change 2007: Synthesis Report. Fourth Assessment Report of the Intergovernmental Panel on Climate Change.

21 IPCC 2007: Climate Change 2007: Synthesis Report. Fourth Assessment Report of the Intergovernmental Panel on Climate Change.

**The Guardian (11 March, 2009): Amazon could shrink by 85% due to climate change, scientists say**

*…Global warming will wreck attempts to save the Amazon rainforest, according to a devastating new study which predicts that one-third of its trees will be killed by even modest temperature rises.. Up to 85% of the forest could be lost if spiralling greenhouse gas emissions are not brought under control, the experts said. But even under the most optimistic climate change scenarios, the destruction of large parts of the forest is 'irreversible'... It found that a 2°C rise above pre-industrial levels, widely considered the best-case global warming scenario and the target for ambitious international plans to curb emissions, would still see 20-40% of the Amazon die off within 100 years... Chris Jones, who led the research, told the conference: 'A temperature rise of anything over 1°C commits you to some future loss of Amazon forest.'*

## 4. Tipping points in the climate system

Scientists have identified a number of tipping points[22] - levels of warming capable of triggering changes in large-scale components of the climate system – that could cause the impacts of dangerous climate change to come in abrupt 'jumps' even if greenhouse gas emissions are only increasing gradually. If we do not reduce emissions fast enough, some of these jumps will be irreversible or very difficult to reverse at best. Further, they are likely to multiply due to positive feedbacks triggered by warming temperatures.[23]

Recent scientific findings have identified a number of climate system elements that can contribute to reaching dangerous climate change:

- Oceanic carbon sinks turning into carbon sources: Presently, about half of the $CO_2$ emitted from human activities is re-absorbed by forests, soils and oceans. However, global warming is likely to reduce the oceans' capacities to take up $CO_2$, as warm water holds less $CO_2$ than cold water[24];

- Terrestrial carbon sinks turning into carbon sources: Global warming is upsetting the fragile balance of many ecosystems: plants and trees will become less and less effective at taking up $CO_2$, and potentially lead to forests and soils turning from carbon sinks into carbon sources;[25]

- Permafrost methane: Siberia contains an area of frozen peat the size of France and Germany combined. Rising temperatures will lead to the melting of this permafrost, which will then release huge quantities of methane, a greenhouse gas 20 times more potent than $CO_2$.[26] Other permafrost methane reservoirs in jeopardy are in the high Arctic of Canada and Alaska;

- Methane hydrates turning to sources: Very large amounts of methane are stored as methane hydrate crystals in shallow ocean margins around the world. A high-enough rise in ocean temperature could trigger the release of this methane into the atmosphere. Recent scientific research in the Laptev Sea indicates that methane releases from Arctic waters may be increasing at a rapid pace;[27]

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22 Examples of elements of the climate system that are susceptible to tipping include: Arctic sea-ice; Greenland ice sheet; West Antarctic ice sheet; Atlantic thermohaline circulation; and the Amazon rainforest.

23 Pope V. 2008: Met office's bleak forecast on climate change. The Guardian. October 1 2008.

24 Park G.H. et.al. 2008: Sudden, considerable reduction in recent uptake of anthropogenic $CO_2$ by the East/Japan Sea. In: Geophysical Research Letters. December 2008.

25 Canadell et.al. 2007: Contributions to accelerating atmospheric $CO_2$ growth from economic activity, carbon intensity, and efficiency of natural sinks. PNAS.

26 Khvorostyanov D.V. et.al. 2008: Vulnerability of east Siberia's frozen carbon stores to future warming. Geophysical Research Letter. Vol. 35.

27 Bernama. 2008: Methane Discharges in the Arctic Pose Threat to Earth's Climate. Bernama. 20 August 2008.

- Ocean Acidification: $CO_2$ emissions are acidifying the ocean, leading to potentially disastrous consequences for marine life that could undermine the marine food chain, a vital protein source for humans;[28]

A recent assessment of tipping points[29] shows that some of them may be reached at warming levels of as little as 1°C to 1.5°C above pre-industrial levels or even, as may be the case with the Arctic summer sea-ice, at current temperatures. Irreversible meltdown of the Greenland ice sheet could already start at 1.5°C, leading to widespread or near total deglaciation and a sea level rise of between 2 and7 metres during the next centuries or millennia.

Even if we stopped all greenhouse gas emissions tomorrow, we will still see significant additional warming due to historic emissions. Oceans take up heat over long timescales[30] and important carbon pools have very long lifetimes[31], so significant warming is already loaded into the climate system. We are therefore already committed to an additional half degree of warming and associated impacts, regardless of the level of emission reductions the world will undertake during this timeframe.

**We must reduce emissions urgently and at the greatest rate possible due to the uncertainties and the unpredictability of the climate system and the possible tipping points that could be triggered by the temperature rise we are already committed to.**

**Time (13 March, 2009): Scientists Warn of 'Irreversible' Climate Shifts**
*…Hundreds of leading scientists warned Thursday that global warming is accelerating beyond the worst predictions and threatening to trigger 'irreversible' climate shifts on the planet... 'The worst-case scenario trajectories (or even worse) are being realised," the scientists said in a statement. 'There is a significant risk that many of the trends will accelerate, leading to an increased risk of abrupt or irreversible climate shifts.'... 'Recent observations show that societies are highly vulnerable to even modest levels of climate change with poor nations and communities particularly at risk,' the statement said.*

## 5. Temperature threshold targets and likely outcomes

In 1990, a World Meteorological Organization advisory group[32] warned that a global temperature increase beyond 1°C could lead to unpredictable and non-linear responses resulting in extensive ecosystem damage.[33] The UN Framework Convention on Climate Change (1992), while enshrining the concept of an ecological limit in its Article 2,[34] did not identify a specific temperature target. The 1996 decision of the European Union's Council of Ministers to limit temperature rise to 2°C above pre-industrial times introduced the concept of a temperature target into the mainstream climate debate, and established the 2°C target as the main threshold.[35]

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28 Le Quere C. 2007: Saturation of the Southern Ocean $CO_2$ sink due to recent climate change. Science, 316 (5832).

29 Lenton T.M. et.al. 2008: Inaugural Article: Tipping Elements in the Earth's Climate System. Proceedings of the National Academy of Sciences 105(6).

30 Stouffer R.J. 2004: Time Scales of Climate Response. Journal of Climate 17(1): 209-217.

31 Archer D. 2005: Fate of fossil fuel $CO_2$ in geological time. Journal of Geophysical Research 110(C9): 1-6.

32 In fact, the group was established by the World Meteorological Organization, the International Council of Scientific Union, and the United Nations Environment Program to discus the ecological limits of climate change.

33 Rijsberman F.J. et.al. 1990: Targets and Indicators of Climate Change. Environment Institute, Stockholm.

34 'The ultimate objective of this Convention and any related legal instruments that the Conference of the Parties may adopt is to achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.' - The United Nations Framework Convention on Climate Change, June 1992.

35 1939th meeting of the Council of Ministers of the European Union, Luxembourg, 25 June 1996.

In 2000, the IPCC Special Report on Emission Scenarios[36] identified 40 greenhouse gas emission scenarios with differing assumptions for future emissions, land-use and other driving forces. These scenarios are organised in 6 families. The most optimistic range of scenarios envisions a temperature rise of about 1.8°C (above 1980-1999 levels), while the highest emissions scenarios will lead to temperature rises of 4°C to possibly over 6.4°C. The IPCC AR4 indicates that only the lowest range of scenarios can potentially hold temperature rise to around 2°C (as compared to pre-industrial levels). This will require global $CO_2$ emissions to peak between now and 2015, and global emissions to be reduced by 50% to 85% from Year 2000 level.

Since the publication of the AR4, a number of its lead authors, including Martin Parry and Jean Palutikof[37] as well as other eminent climate change scientists, including Hans Joachim Schellnhuber[38] and James Hansen[39], have called for urgent global action to peak emissions as soon as possible and achieve deep emissions reductions in line with or exceeding the top end of the 50-85% range. As the IPCC stated as a 'key finding' in a recent presentation on the AR4: '***No time to lose – the longer we wait, the greater the damage.'***[40]

**ClimateWire (13 March 2009): Scientists see more grim effects of climate change, but economists hope to avoid some of them**
*…At the congress, it seemed that all the scientists had to share with their peers was bad news, but a number of economists saw the climate crisis rather as an historic opportunity to reorganise the world economy and develop new, clean and job-creating activities. Lord Nicholas Stern, former chief economist for the World Bank, added his own dose of gloom by saying that his now-famous report on the risks of global warming, written for the British government in 2006, had underestimated them. 'The reason is that emissions are growing faster than we thought, the absorption capacity of the planet is less than we thought, the probability of high temperatures is likely higher than we thought, and some of the effects are coming faster than we thought,' he explained.*

## 6. Conclusions and recommendations

The IPCC AR4 painted an unequivocal and dire picture of global climate change. Since that time, observations and a range of new studies have shown that climate change is happening faster than even the worst case projections of the IPCC. It is clear that previous estimates of required emission reductions need urgent revision. The world needs far more urgent and deep cuts in greenhouse gas emissions than previously thought if we are to have any chance of avoiding dangerous climate change.

Recent literature, much of it published after the AR4, shows that climate change is already having serious social, ecological and economic impacts and that we are already close to thresholds of irreversible change for some elements of the climate system, such as the Arctic summer sea-ice.

The current level of warming is already taking the Earth's climate closer to tipping points which may lead to dangerous climate change. Therefore global temperature rise needs to peak as soon as humanly possible and return to well below current levels. An increase in temperature of even 1.5°C could lead to the irreversible meltdown of the Greenland ice sheet and 2°C risks triggering catastrophic climate change. Therefore global greenhouse gas emissions need to peak by 2015 and start declining thereafter, reaching as close to zero as possible by mid-century.

36 IPCC 2000: Special Report on Emission Scenarios.
37
38 Schellnhuber H.J. 2008: Global warming: Stop worrying, start panicking? PNAS. September 2008.
39 Hansen J. et.al. 2008: Target Atmospheric $CO_2$: Where Should Humanity Aim?
40 Leo Meyer, presentation on main findings IPCC AR4, October 2008.

**In order to achieve this, Greenpeace is calling for:**

- A binding international agreement that ensures global greenhouse gas emissions will peak by 2015;

- Strong leadership by the industrialised countries, as a group, towards achieving this peak in emissions by:
  - rapidly reducing their greenhouse gas emissions by at least 40% by 2020, compared to 1990 levels. At least three-quarters of this reduction needs to be met by domestic action; and
  - on top of this 40% reduction, provide financial and technological support to developing countries in order to assist them to achieve a reduction of 15 to 30% of their greenhouse gas emissions as compared to a business-as-usual projection;

- Developing countries to achieve, with financial and technological support from industrialised countries, as a group and by 2020, a 15-30% deviation from business-as-usual growth. Developing countries would unilaterally implement those negative and zero-cost ('no regret') measures that can be achieved without external assistance.

- To achieve this, strong and rapid emissions reductions to very low levels will be required from virtually all sectors, including the energy, forests and agriculture sectors, as well as from all greenhouse gases, including f-gases and other non-$CO_2$ gases. We will need technological innovations and changes in lifestyle, consumption and trade patterns.