Climate change – the latest findings of the IPCC

Stuart Parkinson outlines the stark conclusions that emerge from the latest report of the Intergovernmental Panel on Climate Change.

During the course of 2007, the Intergovernmental Panel on Climate Change (IPCC) – the scientific body that compiles the research on climate change for the United Nations – is publishing its Fourth Assessment Report (AR4). At the time of writing the summaries (and some of the detailed content) of the report have been published, with the rest due to appear by the end of the year. This article summarises the main findings demonstrating the ever-growing evidence base, the huge scale of the problem and the urgent need for more action.

The IPCC have published 'Assessment Reports', summarising climate change related research across the disciplines, every five to six years since 1990. AR4 has been compiled by three working groups, whose remits are as follows:

- Working Group I (WGI): The physical science basis[1] – which examines the evidence that climate change is happening, the extent to which humans are to blame, and the way in which our current and future activities may cause further change.
- Working Group II (WGII): Impacts, adaptation and vulnerability[2] – which examines the scale of the climate impacts on human society and ecosystems across the globe, the potential to adapt to climate change, and the vulnerability of different communities and ecosystems.
- Working Group III (WGIII): Mitigation of climate change[3] – which examines the policies, technologies and other measures to curb the greenhouse gas (GHG) emissions that are causing climate change, as well as the associated costs and time scales.

Over 3,500 researchers were involved in compiling AR4[4].

The findings from WGI – see Box 1 – show that the evidence that the climate is changing and that humans are the main cause has strengthened significantly since the last assessment report in 2001. Global warming is now "unequivocal", while climate scientists are now more than 90% certain that most of the warming observed over the last 50 years is due to humans. Warming over the 21st century is projected to be between 1.1ºC and 6.4ºC, with the upper end of the range associated with continuing high fossil fuel use and a large global population. The role of positive feedbacks – which could significantly amplify the warming – is more clearly recognised, but their quantification is still at an early stage.

The work of WGII – see Box 2 – deals with the impacts of climate change. The key conclusion of this analysis is that the greatest impacts will be felt by the poorest communities and the most vulnerable ecosystems. It highlights the extensive evidence that the first effects of human-induced climate change are already being felt across the globe. It then documents the wide range of future impacts likely over the coming century if action is not taken to curb GHG emissions, pointing to the huge numbers of people that will be affected, especially if the global temperature rises by much more than around 2ºC (above the pre-industrial level). It also stresses that adaptation to climate change is becoming more important as time lags in the climate system mean that the full effects of past and current emissions have yet to materialise. Again, the evidence base has increased considerably since the 2001 report.

The analysis of WGIII – see Box 3 – outlines the scale of the effort needed to curb GHG emissions. It documents how sharply emissions have risen in recent decades (and the inequality of these rises across different countries) and how much they are projected to continue rising without climate related action. It discusses the costs of mitigating these emissions – highlighting "substantial economic potential" for action – but presents clear evidence that the window of opportunity for action that will limit the rise to below 2ºC (above the pre-industrial level) is closing very fast.

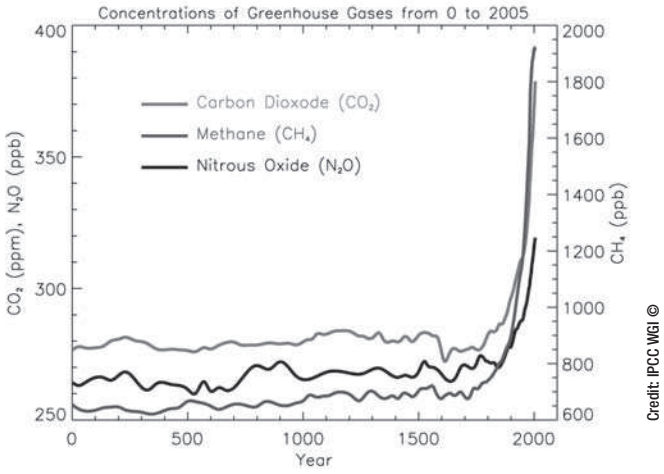

Figure 1 – Atmospheric concentrations of carbon dioxide, methane and nitrous oxide over the last 2,005 years (IPCC WGI)

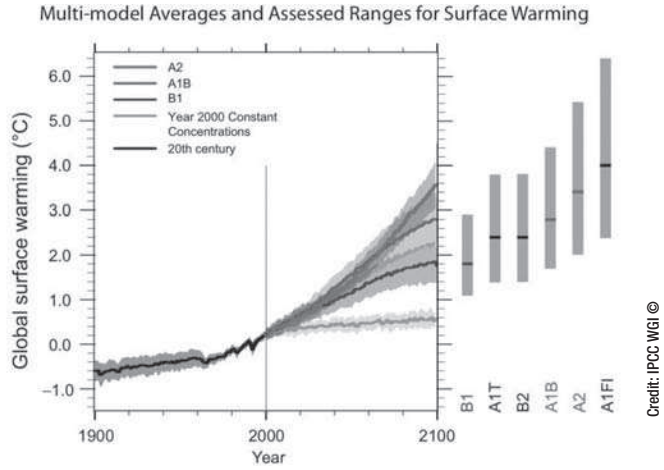

Figure 2 – Observed global temperature change (1900 – 2000) and projected global temperature change (2001 – 2100) derived from a range of IPCC scenarios and climate models. Temperature change is relative to 1990. In 2100, the full range derived from the six scenarios is 1.1 – 6.4ºC (IPCC WGI)

One important thing to bear in mind, when considering the IPCC report, is the extent of the scrutiny by both the scientific community and government representatives. The summaries in particular have to be approved line by line by all government representatives of the more than 100 member countries of the IPCC. This includes sceptical governments like the USA and Saudi Arabia. Hence, evidence that is especially uncertain or controversial is not included in the summaries. Some scientists have consequently argued that the present report is too conservative, especially in terms of potential damage from positive feedbacks (e.g. ice sheet melting)[5].

Even if the summaries of the IPCC report have been 'watered down', they still make stark reading. Evidence of the scale of the problem has continued to accumulate, and only the most blinkered can be left standing in denial. The potential consequences of not curbing GHG emissions will be very severe, especially for the most vulnerable – so we must act much faster to reduce emissions if we are to keep the impacts at a manageable level.

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References and notes

1. IPCC WGI (2007). Climate Change 2007: The physical science basis. (Summary for policy-makers.) Working Group I of the Intergovernmental Panel on Climate Change. http://www.ipcc.ch/WG1_SPM_17Apr07.pdf

2. IPCC WGII (2007). Climate Change 2007: Impacts, adaptation and vulnerability. (Summary for policy-makers.) Working Group II of the Intergovernmental Panel on Climate Change. http://www.ipcc.ch/SPM13apr07.pdf

3. IPCC WGIII (2007). Climate Change 2007: Mitigation of climate change. (Summary for policy-makers.) Working Group III of the Intergovernmental Panel on Climate Change. http://www.ipcc.ch/SPM040507.pdf

4. IPCC (2007). Fact sheet. http://www.ipcc.ch/press/factsheet.htm

5. Pearce, F (2007). Climate change: What the IPCC didn't tell us. New Scientist, 9 February. http://environment.newscientist.com/channel/earth/climate-change/mg19325903.800

Box 1 - 'The physical science basis': WGI main findings

Climate forcing factors

- Atmospheric concentrations of the main greenhouse gases (carbon dioxide, methane, nitrous oxide) continue to increase – see Figure 1. The 2005 level of carbon dioxide is 379 parts per million (ppm), 35% higher than its pre-industrial level. This is higher than at any time for at least the last 650,000 years. Its rate of increase is rising.
- Human emissions of carbon dioxide, mainly due to fossil fuel combustion and deforestation, are accelerating.
- The main warming effect is due to carbon dioxide, and this has increased 20% in ten years.
- The net warming effect due to human activities is currently more than ten times that due to changes in solar activity.

Observed changes

- Warming of the climate system is "unequivocal". The global temperature increase since around 1870 is 0.76ºC. Again, the annual rate is increasing.
- Sea level rise during the 20th century was 17cm.
- The Arctic is warming at twice the rate of the globe. Since 1978, the summer extent of the Arctic sea ice has shrunk by 7.4% per decade.
- Observations show more intense and longer droughts (especially in tropics and sub-tropics) and more frequent storms over most land masses.
- An increase in the intensity of hurricanes has been observed in the North Atlantic.
- Temperature across the northern hemisphere is likely higher than for at least 1,300 years.
- Most of the warming observed over the last 50 years is "very likely" (more than 90% certain) to be due to human emissions of greenhouse gases. Extensive research using a range of climate models concludes that the observed changes in climate can only be fully explained by including the effect of human activities.

Future projections

- Projected global temperature rise over the 21st century is likely to be 1.1 – 6.4ºC – see Figure 2. (This range is broadly similar to that in the 2001 IPCC report, although the upper estimates are somewhat higher due to greater inclusion of positive feedbacks.)
- Projected sea level rise over the 21st century is 18 – 59 cm. (This is lower than in the 2001 IPCC report, but does not include some important positive feedback effects, such as falling ocean uptake of carbon dioxide or increasing melt rates of ice sheets.)
- The incidence of extreme weather events (droughts and storms) is likely or very likely to increase in the future (depending on the type of weather event). Hurricanes and typhoons are likely to become more intense.
- Sea ice will shrink in the Arctic and Antarctic. Some projections show that sea ice will completely disappear in the Arctic in late summer late this century.
- New estimates of the contribution of positive feedbacks – in particular climate-carbon cycle coupling – mean that GHG emission cuts will need to be greater than previously estimated.
- There is a lot of uncertainty in the magnitude and speed of positive feedbacks.

Box 2 - 'Impacts, adaptation and vulnerability': WGII main findings

Observed impacts

- Observations show that many natural systems are already being affected by climate change, e.g. earlier leaf-unfolding and bird-laying, poleward shift in ranges of plants and animals, and changes in polar ecosystems.
- Emerging climate-related effects include changes in heat-related mortality in Europe, loss of coastal wetlands, increasing damage from coastal flooding, and reduced growing season in the African Sahel.
- Of more than 29,000 high quality environmental data sets that show significant changes, 89% are consistent with the change expected due to a warming world.

Future impacts

- By mid-century, major changes are projected in river run-off and water availability. Water supplies from glaciers and snow cover will decline. Some areas, which are already water-stressed, will get drier. In Africa, by 2020, water stress is likely to affect between 75 and 250 million people. In Asia, more than a billion people could be adversely affected by the 2050s.
- Carbon uptake by forests and other land ecosystems is likely to begin falling by mid-century and may even reverse (i.e. they become a net carbon source).
- 20 – 30% of plant and animal species are likely to be at increased risk of extinction if global temperature rises by 1.5 – 2.5ºC above the 1990 level.
- Biodiversity-rich ecosystems, e.g. corals, mangrove swamps and tropical forests are vulnerable to the effects of climate change.

continued on page 14...

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- At lower latitudes (e.g. tropics) crop productivity is expected to decrease even for small temperature changes. Larger temperature changes are expected to have a net negative effect on crop productivity across the globe.
- Many millions more people are projected to be flooded every year due to sea-level rise by the 2080s. Numbers will be largest in the mega-deltas of Asia and Africa.
- Poor communities are especially vulnerable, particularly if they are already in high-risk areas.
- The health of millions of people is likely to be affected by climate change through, for example, increases in malnutrition, increased casualties due to extreme weather, and increases in many diseases.
- It is anticipated that nearly all European regions will be negatively affected by some future aspects of climate change.
- By mid-century, temperature and rainfall changes in eastern Amazonia will lead to a shrinking of the tropical forest area with a risk of "significant" biodiversity losses.
- Partial deglaciation of Greenland and West Antarctic ice sheets could result if a 1 – 4ºC temperature rise (relative to 1990) is maintained for centuries to millennia, leading to a sea level rise of 4 – 6 m or more.

Adaptation and vulnerability

- A wide variety of adaptation options exist, including technological, behavioural and policy, but all have economic, social and environmental implications. Some limited adaptation to observed climate change is already happening.
- Vulnerability of different societies to climate-related problems is significantly greater under future scenarios that feature high levels of poverty and/or population growth.
- Responses to climate change must include a combination of mitigation and adaptation activities. Failure to do so will increase the detrimental effects.
- For increases in global temperature greater than about 2 – 3ºC above 1990 levels, it is very likely that all regions will experience an increase in negative effects.

Box 3 - 'Mitigation of climate change': WGIII main findings

Greenhouse gas (GHG) emission trends

- Global GHG emissions grew 70% between 1970 and 2004, with the biggest increases in the energy supply sector and transport. Two of the major drivers of this rise have been global economic growth and global population growth.
- Average GHG emissions per head in industrialised countries are 16.1 tonnes of carbon dioxide equivalent (tCO_2eq)*, nearly four times the average in developing countries.
- Global GHG emissions up until 2030 – in the absence of further controls – are projected to increase by between 45% and 110%.

Mitigation across the economy until 2030

- There exists "substantial economic potential" for the control and/or reduction of global GHG emissions over the coming decades. For example, for less than US$100 per tCO_2eq, an emission reduction of 23 – 63% below the baseline in 2030 is projected.
- Controlling emissions in order to stabilise atmospheric concentrations of GHGs at levels between 445 and 710 parts per million of carbon dioxide equivalent ($ppmCO_2eq$) is estimated to cost between 3% of global GDP and less than 0% in 2030, depending on the stringency of the controls. These estimates do not take account of the benefits to the climate or other aspects of society resulting from emissions controls.
- Co-benefits – in terms of improvements in, for example, local air quality, energy security, agricultural productivity and biodiversity – could be large from action to mitigate GHG emissions.
- The largest and cheapest potential for reducing GHG emissions exists in the buildings sector. About 30% of the projected emissions of this sector in 2030 can be avoided with net economic benefit.
- Major opportunities to curb emissions exist in the energy sector. Energy efficiency is a particularly attractive option and has many co-benefits. Renewable energy could double its share of electricity production for carbon prices up to US$50 per tCO_2eq.
- In the transport sector there are many options for curbing emissions, but their effect may be counteracted by growth in the sector and consumer resistance.
- Improving agricultural practices and curbing deforestation can make significant low-cost contributions to reducing emissions.

Mitigation after 2030

- In order to stabilise atmospheric GHG concentrations, global emissions need to peak and then decline. For stabilisation at lower concentrations, mitigation efforts over the next two to three decades are especially important. For example, to stabilise in the range 445 – 490 $ppmCO_2eq$ – amounting to a global temperature increase in the region of 2.0 – 2.4ºC above the pre-industrial level – emissions need to peak in the period 2000 – 2015 and then reduce by 50 – 85% by 2050.
- Controlling emissions in order to stabilise atmospheric concentrations of GHGs at levels in the range 445 – 710 $ppmCO_2eq$ is estimated to cost between 5% of global GDP and -1% (i.e. a net gain) in 2050, depending on the stringency of the controls. Again, this neglects climate-related benefits or co-benefits of emission reduction.
- Early, stringent mitigation is economically justified if there are 'vulnerability thresholds' after which the damage costs of climate change rapidly increase.

Policies

- A variety of national policies are needed to help tackle climate change. Policies that provide a real or implicit price of carbon can lead to significant investment in low-GHG technologies and processes. Modelling studies show that carbon prices rising to US$30 – 155 per tCO_2eq by 2050 to be consistent with stabilisation at 550$ppmCO_2eq$.
- Government support is essential for effective technology development, innovation and deployment. Yet, government funding for energy research is now at about half its 1980 level.
- The Climate Change Convention and Kyoto Protocol have established a global response to the problem, but action is still limited. There are many further options for international co-operation to reduce emissions, and these will help reduce costs.

Note:

* Carbon dioxide equivalent (CO2eq) is a standard measure that allows the combination of the effects of different greenhouse gases into a single metric.