T H E A U S T R A L I A N C O L L A B O R A T I O N

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Beyond the IPCC Reports: Emerging Findings

The Australian Collaboration fact sheet "The Intergovernmental Panel on Climate Change: Fourth Assessment reports" summarises the findings of the three IPCC Fourth Assessment reports published in 2007. This fact sheet draws attention to recent observations and new research that suggest that climate change is happening faster than projected in the IPCC reports, with significant implications for the global health of ecosystems, water resources and human societies.

There are several key reasons why the IPCC reports tend to be conservative. First, there is a tendency for scientists to focus on the most likely result in the middle of the range of uncertainty when risk management requires that we consider the risk of changes near the top of the range. Second, there is some hesitancy to cite results that are not quantified and thus not in numerical models. Third, the early cut-off date for publications considered in IPCC reports, in order that they can be fully reviewed by peer reviewers, may mean that some reports are not reviewed. In the case of the 2007 IPCC reports, this means that only papers published up to about mid-2006 were considered. However, important new papers continue to appear.

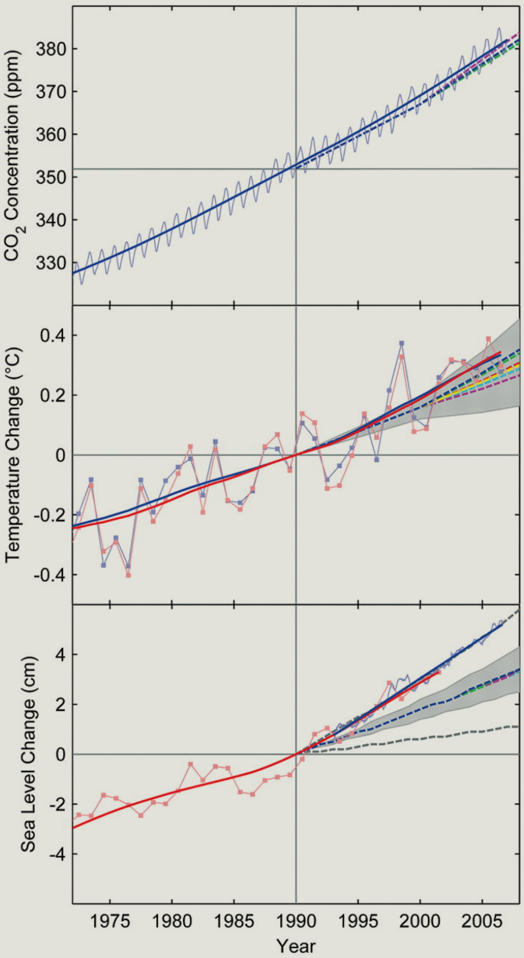
Climate change and sea-level rise are happening faster than projected

Several recent studies report that many aspects of climate change are happening faster than expected. For example, Australian scientists in 2006 reported that sea level had been rising at an accelerating rate, and a large group of international scientists in 2007 found that carbon dioxide concentrations in the atmosphere, global warming and sea level were all increasing near the maximum of the range of projected increases from 1990 levels suggested by the Intergovernmental Panel on Climate Change in its 2001 report. This is shown in Figure 1. This suggests that greenhouse gas emissions and climate sensitivity (the eventual global warming that would result from a doubling of carbon dioxide, CO_2, in the atmosphere) are both near the top end of their recognised uncertainty ranges. Research presented at an international congress in Copenhagen in March 2009 showed that sea level rise is changing at levels greater than IPCC projections, and ocean warming is occurring at a rate 50% higher than previously reported.

Carbon dioxide emissions are in fact increasing more rapidly than was expected even in the highest of the IPCC emissions scenarios, the fossil-fuel intense scenario denoted A1FI. As another paper published in 2007 reports, this is due to rapid economic growth rates in many countries, especially major developing countries such as China and India. Carbon dioxide emissions from fossil-fuel burning and industrial processes have been accelerating globally, with their growth rate increasing from 1 per cent per annum for 1990-1999 to more than 3 per cent per annum for 2000-2004. One important influence has been energy efficiency. In the earlier period there was an effective reduction in the amount of energy used and carbon emitted to produce each unit of economic production (GDP). This momentum has not been maintained and in some instances has reversed. Emissions are also increasing due to continuing increases in population and per-capita GDP. The growth rate in emissions is greatest in developing countries such as China, although emissions are still increasing in most developed countries which have been the source of most of the emissions since the industrial revolution. These developments pose serious issues regarding the fairness or equity of international efforts to reduce global emissions.

Another reason for the more rapid warming is that the cooling effect of pollution particles in the atmospheric (which reflect sunlight back into space), sometimes referred to as 'global dimming', was larger in the 1950s and 1960s than assumed. It is now decreasing as sources of particulate pollution are brought under control especially in North America and Europe.

Figure 1. Changes in key global climate-related variables since 1973 compared with the scenarios developed by the IPCC in its 2001 report (dashed lines with grey shading for ranges of uncertainty) that start in 1990. Top: Monthly CO2 concentration and its smoothed trend line at Mauna Loa observatory (blue). Middle: Annual land and ocean combined surface temperatures from two different data sets (red and blue lines). Bottom: Annual data and smoothed trends of sea level from tide gauge stations (red) and satellite altimeter measurements (blue).



Acknowledgement: S. Rahmstorf and others in *Science*, vol.316, p.709 (4 May 2007).

The rapid rate of climate change is being increased by a number of positive feedback or amplifying effects that have been observed to be happening in recent decades. Several of these are not yet fully accounted for in the climate models. These effects include:

- Arctic permafrost (frozen ground) and snow cover are decreasing, leading to more absorption of incoming sunlight as reflective surfaces are replaced by water or vegetation.
- Artic sea ice is retreating more rapidly than predicted, leading to more absorption of sunlight and greater regional warming. Since 1953 about half a million square kilometres of sea ice has been lost each decade.
- Observations are showing that the living biosphere is already changing from being an absorber of atmospheric CO2 to being an emitter due to warming, drought stress of plants and increasing forest and peat fires. This was not predicted to occur until the middle of this century.
- Changes in air and sea circulations in middle and high latitudes are accelerating changes in higher latitudes. Mid-latitude westerlies in both hemispheres have moved pole-wards and surface ocean gyres (ocean-wide currents) have accelerated. This has affected the East Australian Current, with more heat being transported pole-wards, possibly adding to destabilisation of the West Antarctic Ice Sheet through melting the underside of ice shelves.
- Rapid changes are taking place in Greenland and Antarctica, including increased surface melting in summer and undercutting and disintegration of floating ice shelves and tidewater (i.e., floating) glaciers that retard ice outflow. These processes are not included so far in glaciological models.
- Mountain glaciers are also retreating rapidly, adding to sea-level rise and causing problems for communities that rely on summer melt-water for water supply. Increasingly they will experience winter floods and summer water shortages.
- The increasing carbon dioxide concentrations in the air are also causing acidification of the oceans as dissolved carbon dioxide forms weak carbonic acid. This effect is already measurable. Greater acidity is likely to have a particularly detrimental effect on ocean creatures that form shells, including coral. This will impact on coral reefs and the ocean food chain leading to complex effects on ocean ecosystems and fisheries.

Some of these mechanisms are mentioned in the 2007 IPCC report but, because they were not in the computer models, no firm numbers were included in the IPCC projections.

New estimates of sea-level rise and their importance

The 2007 IPCC report projects sea-level rise by 2100 in the range 18 to 59 cm. But the report explicitly does not include uncertainties in climate-carbon feedbacks nor the full effects of changes in ice dynamics. It adds that increased ice flow from Antarctica and Greenland could add another 10 to 20 cm by 2100. This numerical estimate has in fact an upper limit that is lower than in the previous IPCC report in 2001.

A new estimate in 2007, based on a constant relationship between observed 20th century rates of sea-level rise and global warming relative to pre-industrial times, shows that the sea-level rise by 2100 should be in the range of 50 to 140 cm., depending on the rate of global warming. However, if the rate of sea-level rise were to increase faster than global warming due to positive feedback processes, as is argued by James Hansen and colleagues, sea level rise by 2100 could be several meters.

New evidence that positive feedbacks have commenced comes from satellite observations of rapid decreases in Arctic sea ice extent. Data from the US National Snow and Ice Data Center on 10 September 2007 indicates that the sea ice extent is at a record low of 424 million square kilometres. This is more than a million square kilometres below the previous minimum in 2005. Thus, the Arctic Ocean has lost a mirror roughly the size of NSW and Victoria combined, meaning that much more solar energy is being absorbed by the ocean. This will lead to further decreases in sea ice and undermining of floating (tidewater) glaciers in Greenland, causing a further acceleration of sea level rise.

Hansen argues that in the 20th century only, thermal expansion of the water and melting alpine glaciers made much contribution to sea-level rise, but several accelerating processes are now, or soon will be, in operation. These include: loss of fringing ice shelves that presently hold back outlet glaciers; lubrication of outlet glaciers by surface meltwater penetration down crevasses, and lifting of grounded ice by sea-level rise in the case of tidewater glaciers and much of the West Antarctic Ice Sheet which sits on rock below sea level. This would reduce resistance to outflow as less of the ice would be scraping on the bottom. In addition, Hansen points out that meltwater zones on the surface will rapidly move into new areas as warming occurs due to the flat dome-like profile of the main ice sheets, and that increased outflow will lead to a slumping of the ice sheets, lowering their elevation and so leading to more surface melting and more precipitation falling as rain rather than snow. Hansen suggests that instead of the ice sheet contribution to sea-level rise increasing in proportion to the global warming, it might increase more rapidly. This is consistent with paleo-climatic evidence for multi-metre higher sea level with global temperatures only a few degrees above pre-industrial. The real uncertainty is not whether such large sea level rises are likely to occur given global warmings of several degrees, but how rapidly sea level will respond to the warming.

The impacts of such sea-level rises will be amplified by complex coastal effects brought on by wave and storm activity. A simple rule (the Brunn Rule) used by coastal engineers is that on a very long straight sandy shoreline, erosion will cause the shoreline to retreat 50-100 metres for every one metre of average sea level rise. On more complicated coasts, erosion will mobilise sand that drifts along the shore, causing rapid erosion in the lee of headlands and rock walls and increased deposition on the windward side. This will change beach alignment, river mouths and coastal wetlands.

The implications of higher sea level rise estimates are serious due to high vulnerability in many coastal regions. Whatever the exact numbers, a metre of more of sea level rise would displace many millions of people globally, with huge expenses for resettlement and the protection or replacement of infrastructure, and the possibility of many international refugees.

In Australia, large areas of our coastal cities and towns would be flooded by sea-level rise of metres and huge investments in ports, roads, railways, airports, factories, power stations, homes and sea-side developments would be lost. Coastal areas in Australia are the fastest growth areas, with increasing populations and huge investments. Insurance against flooding from the sea would become impossible and many families and businesses would ‘go under’. Even slow but steady sea-level rise would undermine confidence in coastal development, with loss of property values.

Emission reduction targets

Conclusions from the 2007 IPCC report strongly suggest that global average warming of around 2°C is close to that which might be considered 'dangerous' under the terms of the United Nations Framework Convention on Climate Change, although the definition of what is dangerous is a subjective judgement. There are also uncertainties about impacts for global warming and about global warming for a given concentration of greenhouse gases in the atmosphere. Thus setting targets for greenhouse emissions reductions is necessarily subjective and strongly dependent on the degree of risk that is considered acceptable.

Even at only 450 ppm carbon dioxide equivalent, global warming is in the range of about 1.4 to 3.1°C, with about a 50 per cent chance of exceeding 2°C. This indicates the degree of risk associated with such a target greenhouse gas concentration. The IPCC also states that "to reach the lower stabilization levels some scenarios deploy removal of CO_2 from the atmosphere (negative emissions) using technologies such as biomass energy production utilizing carbon capture and storage."

Such results suggest that very ambitious emissions reduction targets may be needed to avoid a serious risk of dangerous climate change. As later reductions will need to be faster if initial reductions are slower, this is a strong argument for urgent emission reductions as soon as possible.

Ways of reducing emissions are discussed in the Australian Collaboration's two energy fact and issue sheets ("Energy issues in Australia" and "Clean energy alternatives"). Various suggestions have also been made for "geo-engineering" measures to limit global warming. These include placing some sort of reflector between the Sun and the Earth to reduce sunlight reaching the surface, and fertilising the ocean so that they take up more carbon dioxide in algal blooms. These and similar measures could, however have serious undesirable environmental consequences and possibly lead to international conflict if measures are taken unilaterally. Furthermore the use of geo-engineering would reduce the sense of urgency and encourage "business-as-usual" attitudes to greenhouse gas emissions.

Summary and conclusions

The 2007 IPCC projections indicate a likelihood of greater global warmings by 2100 than previously projected. However, real observations show that global greenhouse gas emissions, global average warming and sea-level rise are now tracking near the top of the IPCC range of uncertainty, indicating greater risks than hitherto envisaged.

The problem now is not so much with the science (even though that needs improvement) but with policy. Policy must be about risk management, that is, how to avoid the unacceptable, not about what is most likely to happen. The real question is no longer whether climate change is happening, but how to adapt to what is now unavoidable, and how to reduce greenhouse gas emissions to avoid what we may not be able to adapt to.

A key policy question that follows is: what is a reasonable emissions reduction target? It is clear from the 2007 IPCC results that this must be at or below 450 ppm CO_2 equivalent, which will require large reductions in emissions as soon as possible. Present day emissions are increasing the concentration of CO_2 alone (which was 380 ppm in 2006) by more than 2 ppm each year. Delay will only make the task more difficult later on. This creates an opportunity for visionary investment in energy conservation and in renewable and other low-carbon technologies. More controversial and expensive options such as carbon capture and sequestration, as well as nuclear power, will take decades to have much effect in reducing emissions, even if they are economic.

Another key question is: how to encourage and enable developing countries to limit their emissions while still enabling them to have rising living standards? This will require genuine empathy for the problems of developing countries, technological assistance and also create opportunities for creative partnerships between developed and developing countries.

Useful sources

The Australian Greenhouse Office, Department of the Environment and Heritage
http://www.greenhouse.gov.au/

Pittock, B. (2005). *Climate Change: Turning up the Heat,* Melbourne: CSIRO Publishing.
http://www.publish.csiro.au/pid/4992.htm
This book presents a comprehensive analysis of climate change, covering past assessments, projections for the future and suggestions for major adaptations.

Earth Negotiation Bulletin:
http://www.iisd.ca/process/climate_atm.htm
This site contains blow-by-blow reports of the proceedings of negotiation sessions of the Framework Convention on Climate Change and the IPCC Assemblies at which the IPCC reports are debated. It provides useful insights into key issues and national positions.

Intergovernmental Panel on Climate Change:
http://www.ipcc.ch/
The AR4 Synthesis Report, Summary for Policymakers and full versions of each of the 2007 IPCC Working Group reports are available on this site.

James E. Hansen (NASA Goddard Institute for Space Studies):
http://www.columbia.edu/~jeh1/
This site contains various papers by James E. Hansen.

Pearman, G., & Dupont, A (2006) *Heating Up the Planet: Climate Change and Security*, Lowy Institute for International Policy, Paper 12, 2006.
http://www.lowyinstitute.org/Publication.asp?pid=391
Pearman and Dupont assess the security consequences of climate change for the Asia-Pacific region.

US National Snow and Ice Data Center:
http://nsidc.org/news/press/2007_seaiceminimum/20070810_index.html
This site provides regular updates on Arctic sea ice and on Greenland.

World Glacier Monitoring Service
www.geo.unizh.ch/wgms/
This site has data on the retreat of mountain glaciers around the world.

NASA Earth Observatory
www.earthobservatory.nasa.gov
This site has news and images of Greenland, the Arctic and Antarctica.

Author

This Fact and Issue Sheet was written by Dr Barrie Pittock, climate scientist and author. Last revised July 2009.