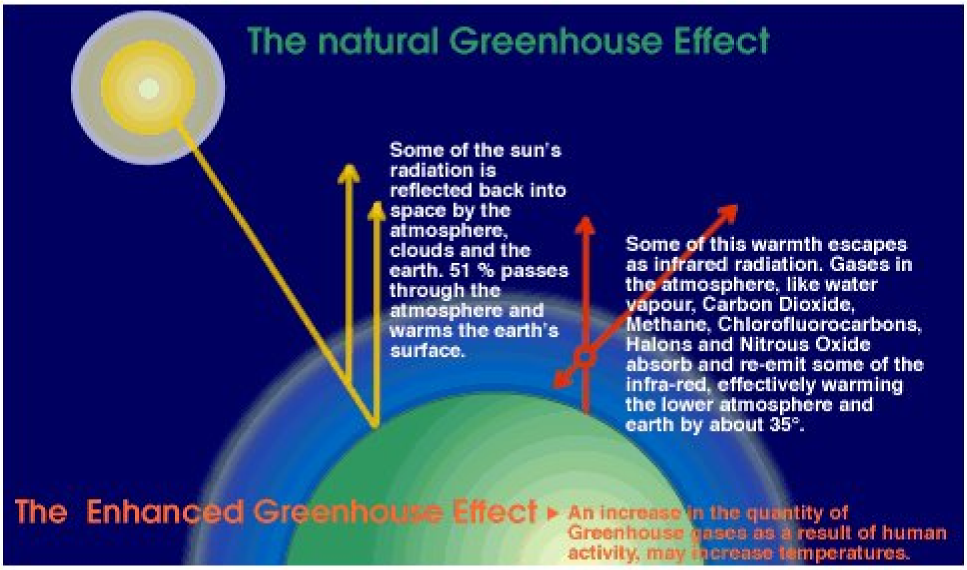
The Intergovernmental Panel on Climate Change: A Synthesis of the Fourth Assessment Report

Harvey Stern*

Bureau of Meteorology, Melbourne, Vic., Australia



1. Introduction

The World Meteorological Organisation (WMO) and the United Nations Environment Programme (UNEP) established the Intergovernmental Panel on Climate Change (IPCC). The IPCC's primary goal was to assess scientific, technical and socio-economic information relevant for the understanding of climate change, its potential impact and options for adaptation and mitigation. The purpose of the current paper is to provide a synthesis of the IPCC's Fourth Assessment Report, which was released early in 2007. Much of the material presented is drawn directly from the summaries for policy makers prepared by the IPCC's three Working Groups, namely:

I. The Physical Science Basis
   (released February 2007);
II. Impacts, Adaptation and Vulnerability
   (released April 2007); and,
III. Mitigation
   (released May 2007).

*Corresponding author address: Box 1636, Melbourne, Vic., 3001, Australia; email: h.stern@bom.gov.au *Dr Harvey Stern is a meteorologist with the Australian Bureau of Meteorology, holds a Ph. D. from the University of Melbourne (Earth Sciences), and currently heads the Climate Services Centre of the Bureau's Victorian Regional Office. Dr Stern's research into climate change includes evaluating costs associated with climate change and managing associated risks (Stern, 1992, 2005, 2006) – Fig A.1, and analysis of climate trends (Stern, 1980, 2000; Stern et al, 2004, 2005) – Fig A.2. His work has received praise in the Victorian State Parliament (Hansard, Legislative Council, pp 1940-1941, 16 Nov., 2005).*

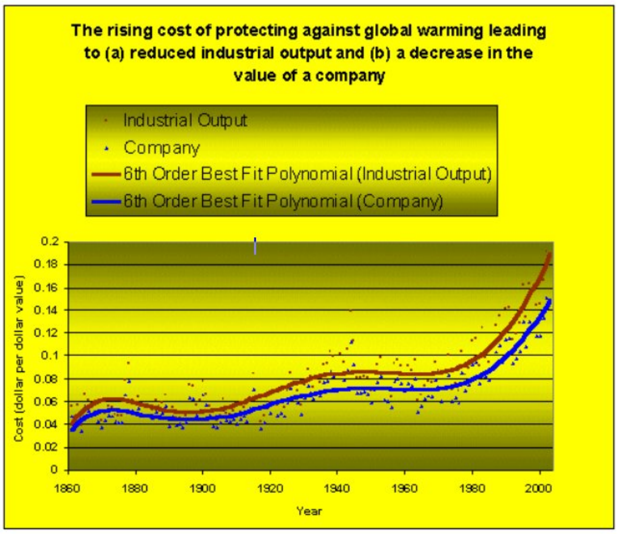


Fig A.1 The Rising Cost of Protection

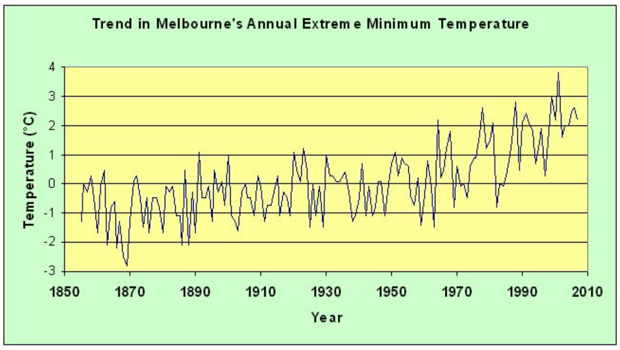


Fig A.2 Trend in Melbourne's annual extreme minimum temperature (strong upward trend)

2. The Physical Science Basis

2.1 Drivers of Climate Change

Changes in the atmospheric abundance of greenhouse gases and aerosols, in solar radiation and in land surface properties alter the energy balance of the climate system. These changes are expressed in terms of radiative forcing, which is a measure of the influence that a factor has in altering the balance of incoming and outgoing energy in the Earth-atmosphere system (Fig 1).

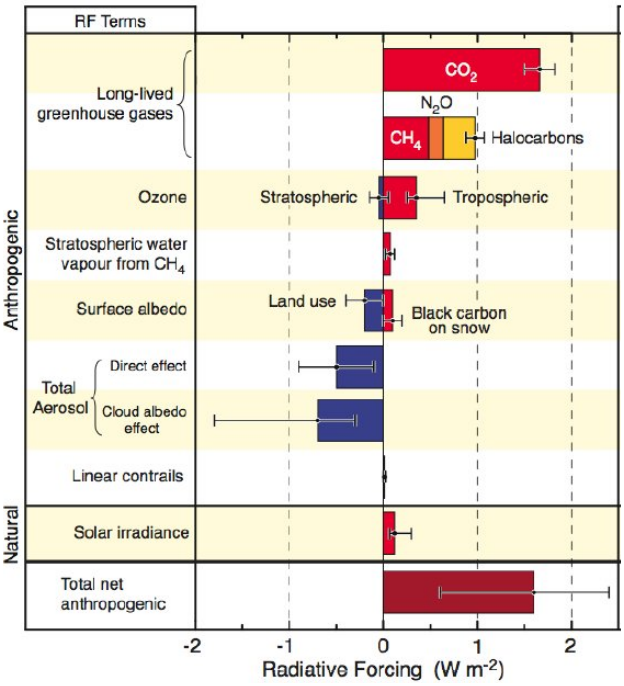


Fig 1 Radiative forcing (RF) estimates and ranges for greenhouse gases and other important agents and mechanisms (volcanic aerosols contribute an additional natural forcing but are not included because of their episodic nature)

Global atmospheric concentrations of carbon dioxide (the most important anthropogenic greenhouse gas), methane and nitrous oxide have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values determined from ice cores spanning many thousands of years (Fig 2). The global increases in carbon dioxide concentration are due primarily to fossil fuel use and land-use change, while those of methane and nitrous oxide are primarily due to agriculture.

The understanding of anthropogenic warming and cooling influences on climate leads to very high confidence (Fig 3) that the globally averaged net effect of human activities since 1750 has been one of warming.

2.2 Observations of Climate Change

Warming of the climate system is unequivocal (Figs 4, 5, 6, 7, and 8), as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level (Fig 9). At continental, regional and ocean basin scales, numerous long-term changes in climate have been observed. These include changes in Arctic temperatures (Fig 10) and ice, widespread changes in precipitation amounts (Figs 11, 12, 13, and 14), ocean salinity, wind patterns and aspects of extreme weather including droughts, heavy precipitation (Fig 15), heat waves and the intensity of tropical cyclones. Paleoclimate information supports the interpretation that the overall warmth of the last half-century is unusual in at least the previous 1300 years.

However, some aspects of climate have not been observed to change (Figs 16 and 17). For example, Antarctic sea ice extent shows no statistically significant average trends, consistent with the lack of warming reflected in atmospheric temperatures averaged across the region.

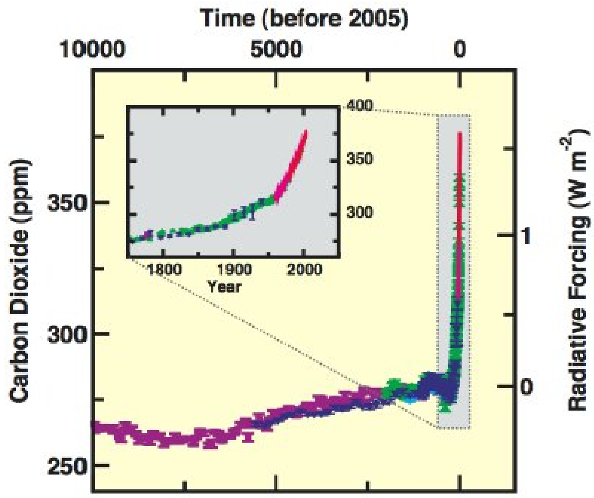


Fig 2 Changes in concentrations of carbon dioxide over the last 10000 years (large panel) and since 1750 (inset panel)

Endbox 2. Communication of Uncertainty in the Working Group II Fourth Assessment

A set of terms to describe uncertainties in current knowledge is common to all parts of the IPCC Fourth Assessment.

Description of confidence

Authors have assigned a confidence level to the major statements in the Technical Summary on the basis of their assessment of current knowledge, as follows:

Terminology	Degree of confidence in being correct
Very high confidence	At least 9 out of 10 chance of being correct
High confidence	About 8 out of 10 chance
Medium confidence	About 5 out of 10 chance
Low confidence	About 2 out of 10 chance
Very low confidence	Less than a 1 out of 10 chance

Description of likelihood

Likelihood refers to a probabilistic assessment of some well defined outcome having occurred or occurring in the future, and may be based on quantitative analysis or an elicitation of expert views. In the Technical Summary, when authors evaluate the likelihood of certain outcomes, the associated meanings are:

Terminology	Likelihood of the occurrence/ outcome
Virtually certain	>99% probability of occurrence
Very likely	90 to 99% probability
Likely	66 to 90% probability
About as likely as not	33 to 66% probability
Unlikely	10 to 33% probability
Very unlikely	1 to 10% probability
Exceptionally unlikely	<1% probability

Fig 3 Communicating uncertainty

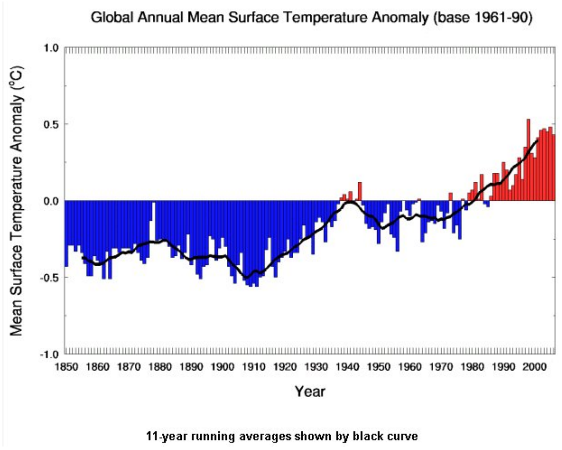


Fig 4 Trend in the global mean temperature (overall warming trend interspersed with some short cooler periods)

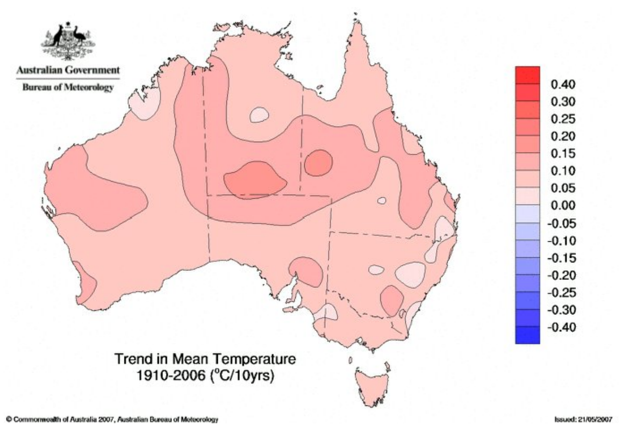


Fig 5 Trend in the Australian mean temperature over the past 100 years (overall warming in all areas)

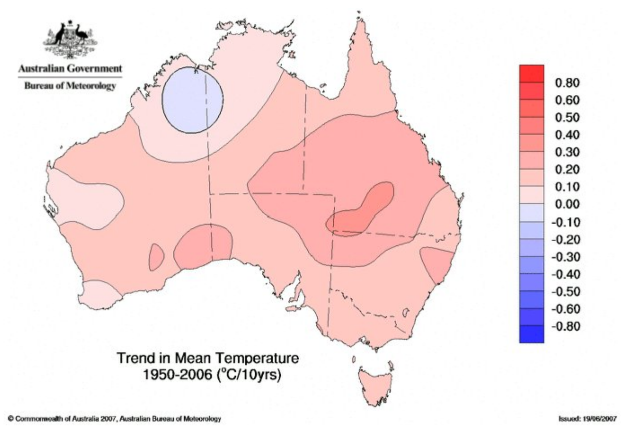


Fig 6 Trend in the Australian mean temperature over the past 50 years (warming in all areas except for the northwest)

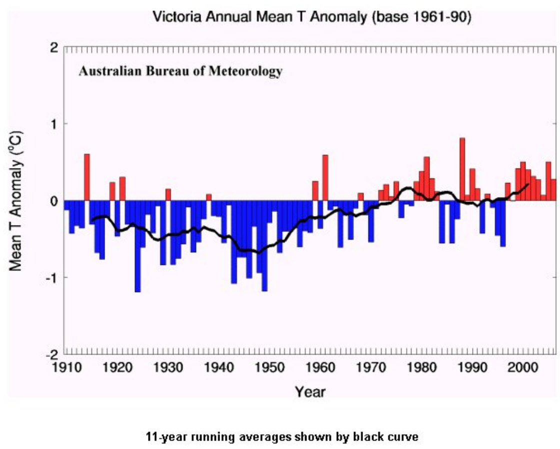


Fig 7 Trend in Victoria's mean temperature (recent warming trend preceded by a cooling period)

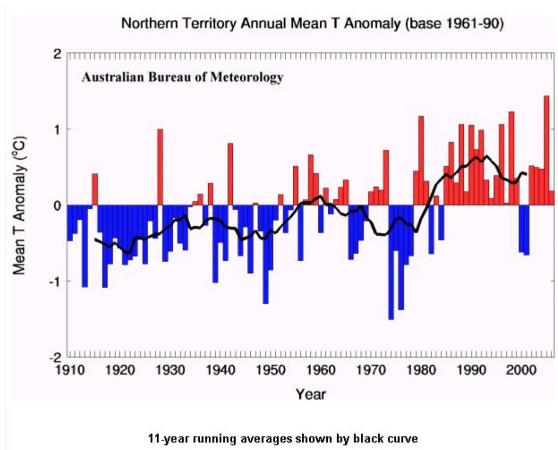


Fig 8 Trend in Northern Territory's mean temperature (overall warming trend interspersed with some short cooler periods)

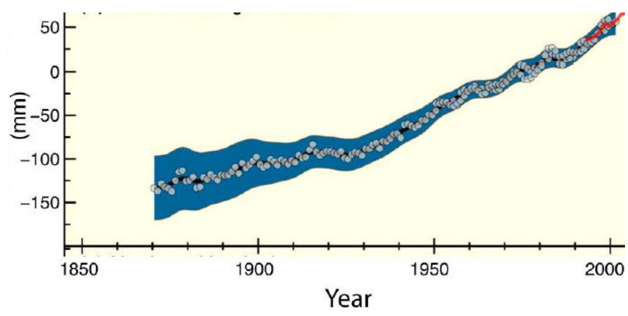


Fig 9 Observed changes in global average sea level (relative to 1961-1990 average)

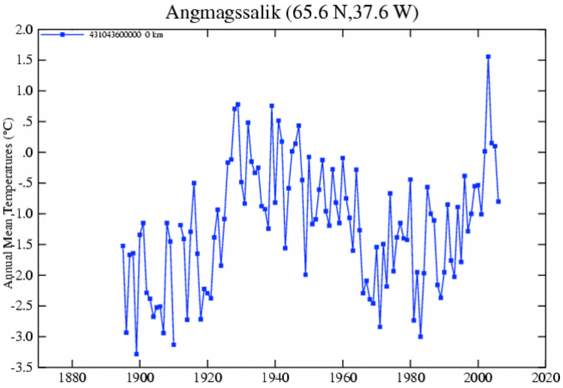


Fig 10 Trend in Greenland's mean temperature (overall warming trend broken by an extended cooler period)

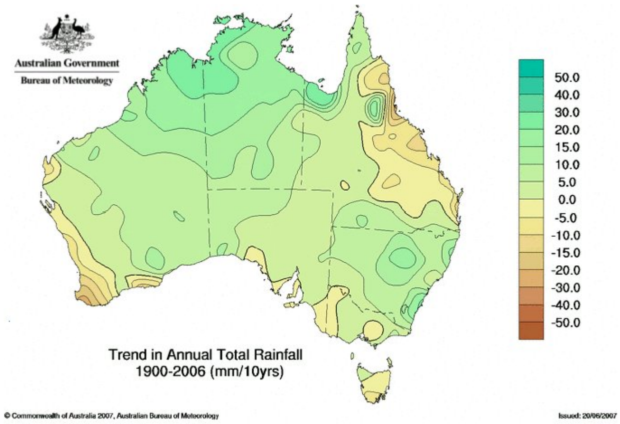


Fig 11 Trend in the Australian annual rainfall over the past 100 years (overall increase, especially in the northwest, but declines in south-western and also in a few eastern areas)

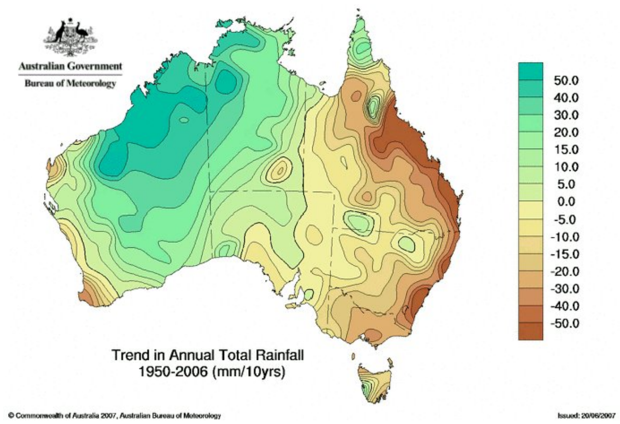
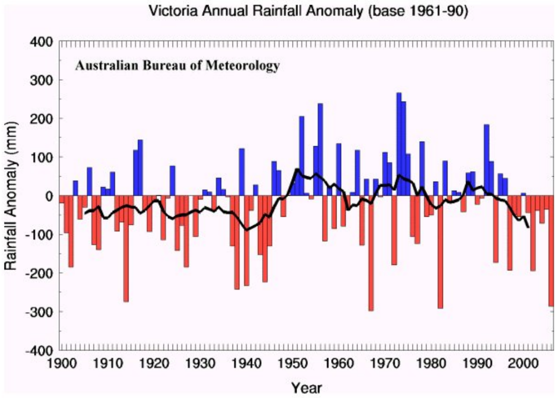
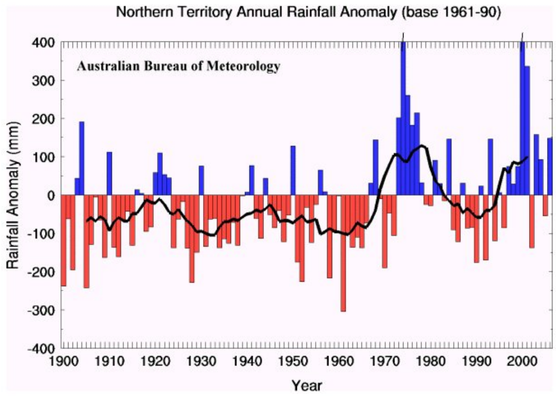


Fig 12 Trend in the Australian annual rainfall over the past 50 years (sharp increases in the northwest, but sharp decreases in south-western and most eastern areas)



11-year running averages shown by black curve

Fig 13 Trend in Victoria's mean rainfall (recent decline to levels early in the 20th century)



11-year running averages shown by black curve

Fig 14 Trend in Northern Territory's mean rainfall (recent increase in contrast to Victoria's trend)

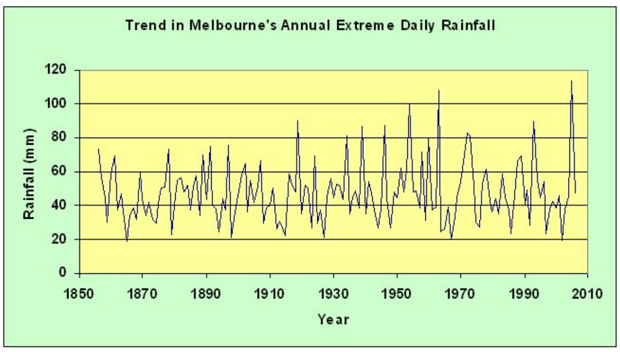


Fig 15 Trend in the variability of Melbourne's annual extreme daily rainfall (increasing)

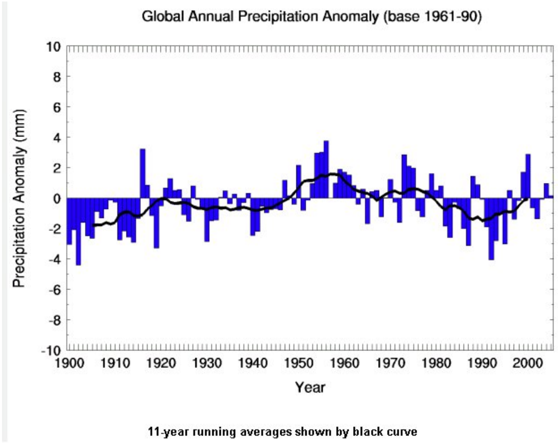


Fig 16 Trend in the global mean rainfall (little change)

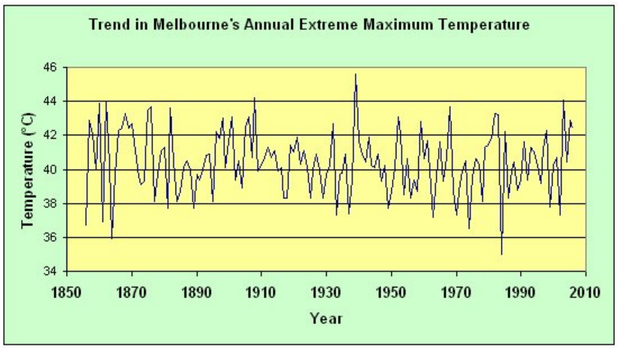


Fig 17 Trend in the Melbourne Annual Extreme Maximum temperature (little change)

3. Impacts, Adaptation and Vulnerability

3.1 Many Systems Affected

Observational evidence shows that many natural systems are being affected by regional climate changes, particularly temperature increases, and a global assessment of data shows that it is likely that anthropogenic warming has had a discernible influence on many physical and biological systems, although many effects on natural and human environments are difficult to discern due to adaptation and non-climatic drivers.

Confidence has increased that some weather events will become more frequent, more widespread and/or more intense (Fig 18), and more is known about their potential effects.

However, not all impacts are negative - beneficial impacts in northern Polar Regions would include reduced heating costs and more navigable sea routes (Fig 19).

Over most land areas, warmer and fewer cold days and nights, warmer and more frequent hot days and nights	Virtually certain[b]
Warm spells/heat waves. Frequency increases over most land areas	Very likely
Heavy precipitation events. Frequency increases over most areas	Very likely
Area affected by drought increases	Likely

Fig 18 Likelihood of future trends

Intense tropical cyclone activity increases	Likely
Increased incidence of extreme high sea level (excludes tsunamis)[c]	Likely[d]

Fig 18 (cont.) Likelihood of future trends

BREAKING THE ICE

Arctic Development and Maritime Transportation

Prospects of the Transarctic Route – Impact and Opportunities

Akureyri, March 27 – 28, 2007 at Hotel KEA

Organized by the Icelandic Government

Contribution to the Arctic Council's Arctic Marine Shipping Assessment

Fig 19 More navigable Arctic sea routes

3.2 Impacts on Australia

More specific information is now available across a wide range of systems, sectors and regions concerning the nature of future impacts, for example, in Australia:

- As a result of reduced precipitation (Fig 20) and increased evaporation, water security problems are projected to intensify by 2030 in southern and eastern parts of the country;
- Significant loss of biodiversity is projected to occur by 2020 in some ecologically-rich sites including the Great Barrier Reef, the Queensland wet tropics, the Kakadu wetlands, southwest Australia, subantarctic islands and alpine areas;
- Ongoing coastal development, and population growth in areas such as Cairns and southeast Queensland, are projected to exacerbate risks from sea-level rise and increases in the severity and frequency of storms and coastal flooding by 2050;
- Production from agriculture and forestry by 2030 is projected to decline over much of southern and eastern Australia due to increased drought and fire; and,
- Although the region has substantial adaptive capacity due to well-developed economies and scientific and technical capabilities, there are considerable constraints to implementation and major challenges from changes in extreme events, and natural systems have limited adaptive capacity.

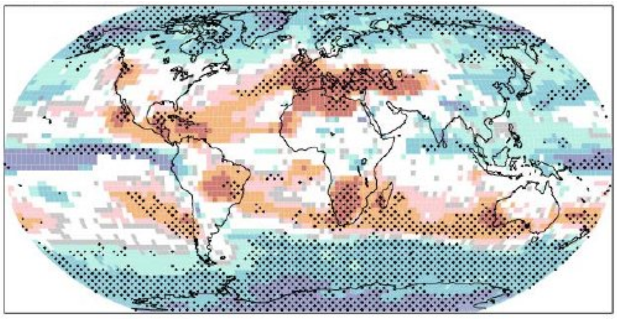


Fig 20 Projected patterns of precipitation changes during the southern winter – brown tones represent anticipated declines; blue tones represent anticipated increases (note the declines anticipated over much of southern and eastern Australia)

Also of interest to Australia, is the impact of sea-level rise upon many of the nations of the southwest Pacific. Small islands have characteristics which make them especially vulnerable, and sea-level rise is expected to exacerbate inundation, storm surge, erosion and other coastal hazards, thus threatening vital infrastructure, settlements and facilities that support the livelihood of island communities (Fig 21).

Tuvalu at Risk of Rising Sea Levels

The World Today - Thursday, 3 August , 2006 12:46:00

Reporter: Peter Lewis

ELEANOR HALL: Tuvalu is one of the smallest and flattest countries on earth. And because of global warming and rising sea levels, it may soon produce the world's first 'environmental' refugees.

About a quarter of the population has already left for New Zealand and many more are likely to follow.

A new documentary, looking at the plight of the islanders has just had its Pacific premiere in Auckland.

Fig 21 Extract from an ABC report on the risks faced by Tuvalu from rising sea levels

3.3 Potential for Very Large Impacts

Magnitudes of impact can be estimated systematically for a range of possible increases in global average temperature (Fig 22). Some large-scale climate events have the potential to cause very large impacts, especially after the 21st century (for example, substantial sea level rises from widespread deglaciation of ice sheets). Climate changes are very likely to impose net annual costs, which will increase over time.

3.4 Adaptation and Vulnerability

Some adaptation is occurring now, but on a limited basis, and more adaptation will be necessary to address impacts from warming which is already unavoidable due to past emissions, and to reduce vulnerability from future changes. Vulnerability to climate change can be exacerbated by the presence of other stresses, such as poverty and unequal access to resources.

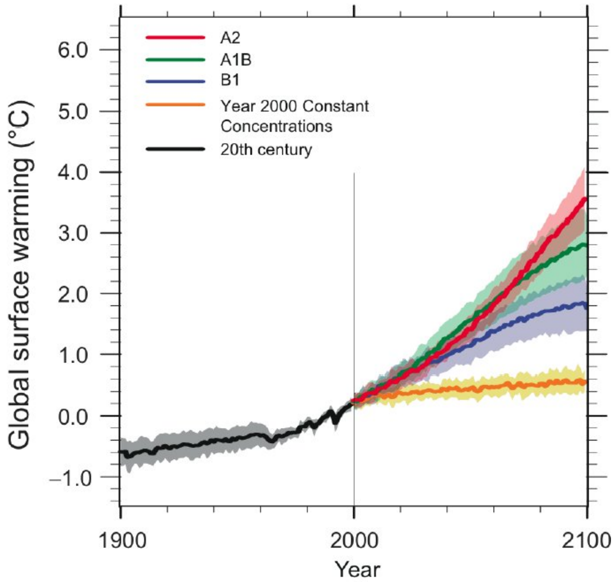


Fig 22 Expected global warming for various emission scenarios

4. Mitigation

4.1 Economic Potential

Global greenhouse gas emissions have grown since pre-industrial times and differences in terms of per capita emissions among countries remain significant. The (more wealthy) Annex 1 countries, holding a 20% share in world population, account for 46% of global greenhouse gas emissions (Figs 23, 24).

With current climate change mitigation policies and related sustainable development practices, global greenhouse gas emissions will continue to grow over the next few decades. However, there is substantial economic potential for the mitigation of global greenhouse gas emissions over the coming decades (for example, reduced emissions of pollutants), which could offset the potential growth of global emissions or reduce emissions below current levels (Fig 25).

Furthermore, there is growing evidence that decisions about macroeconomic policy, agricultural policy, multilateral bank lending, insurance practices, electricity market reform, energy security and forest conservation, for example, which are often treated as being apart from climate policy, can significantly reduce emissions (Fig 26).

4.2 Commercial Availability

Mitigation technologies and practices are currently commercially available in a range of sectors.

For example, in the *Energy Supply* sector, there is the potential for improved supply and distribution efficiency, fuel switching from coal to gas (Fig 27), nuclear power (Fig 28), renewable heat and power (hydropower, solar, wind, geothermal and bioenergy), and early applications of carbon capture and storage.

In the *Transport* sector, there is the potential for more fuel efficient vehicles, hybrid vehicles, cleaner diesel vehicles, biofuels, shifts from road transport to rail and public transport (Fig 29), non-motorised transport (cycling – refer to Fig 30, walking), as well as land-use and transport planning.

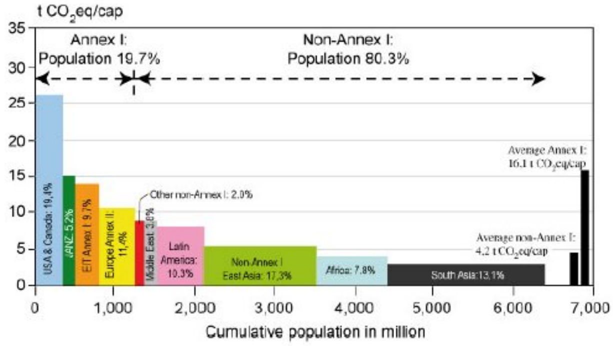


Fig 23 Year 2004 regional per capita greenhouse gas emissions

Rich urged to cut emissions

Liz Minchin
August 7, 2007

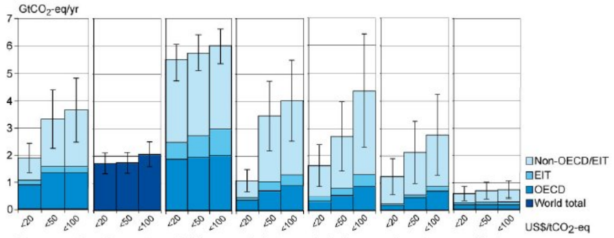
RICH countries including Australia must do more to cut their own greenhouse gas emissions to break the international "logjam" over climate change, the head of the world's leading climate change body has warned.

Speaking to *The Age* before his arrival in Australia today, the Intergovernmental Panel on Climate Change's chairman, Dr Rajendra Pachauri, said major developing countries such as China and India were watching wealthy countries for signs of serious action on cutting greenhouse gas emissions.

"In this whole business of (international climate) negotiations, each party is waiting to see who's going to blink first, and unfortunately the developed countries, if I may say it, have created an atmosphere of lack of confidence," Dr Pachauri said.

"If you talk to policymakers in the developing countries, they will say, 'Look, we know these guys (in developed nations) are not going to do anything on their own and when push comes to shove they're going to ask us to take action.'

Fig 24 Restoring the balance – article in The Age (7 Aug 2007) reporting how rich countries are being urged to cut greenhouse gas emissions



Energy supply	Transport	Buildings	Industry	Agriculture	Forestry	Waste
(potential at <US$100/tCO$_2$-eq: 2.4 - 4.7 Gt CO$_2$-eq/yr)	*(potential at <US$100 /tCO$_2$-eq: 1.6 - 2.5*	*(potential at <US$100 /tCO$_2$-eq: 5.3 -6.7*	*(potential at <US$100/ tCO$_2$-eq: 2.5 - 5.5*	*(potential at <US$100/t CO$_2$-eq: 2.3 -6.4*	*(potential at <US$100 /tCO$_2$-eq: 1.3 - 4.2*	*(potential at <US$100 /tCO$_2$-eq: 0.4 - 1 Gt*

Fig 25 Estimated sectoral economic potential for global mitigation for different regions as a function of carbon price

Why sustainability really does matter

Anna Degotardi
The Age,
August 13, 2007

...THE doyen of investors, Terry Campbell of Goldman Sachs JBWere, believes that sustainability can add 25 per cent to a company's value ...

Fig 26 Extract from a report that companies with proven environmental, social and governance policies outperform

Citigroup downgrades US coal stocks due to climate policy

Researchers at Citigroup released a report on 19 July predicting a dark future for the US coal industry because political momentum toward cutting carbon is building.

The report downgraded US coal stocks "across the board," saying the coal industry has failed to address concerns about climate change by delaying research and development of coal-burning technologies that reduce greenhouse gas emissions.

The coal sector's lack of interest in carbon capture and storage technologies, which aim to take carbon emitted from the burning of coal for electricity and store it underground, has perpetuated a bad image for the fuel among policymakers, according to the report.

"We expect anti-coal politics to intensify, with carbon constraints almost certain to pinch," the report says of current efforts in the federal government and states to implement mandatory carbon caps on emitters, which would hit coal-burning utilities especially hard.

Fig 27 Coal stocks downgraded (*Carbon Market North America 1 Aug 2007 – Point Carbon*)

No uranium for India: Macfarlane

AUSTRALIA will not sell uranium to India until it signs the nuclear Non-Proliferation Treaty, federal Resources Minister Ian Macfarlane has said.

The Age 23/05/2007

Fig 28 Concern about nuclear proliferation is influencing policy development on uranium exports

Mitigation technologies and practices are also currently commercially available in the *Buildings* sector (for example, efficient lighting and daylighting, improved insulation, passive and active solar design for heating and cooling), in the *Industry* sector (for example, more efficient end-use electrical equipment, material recycling and substitution), in the *Agriculture* sector (for example, improved crop and grazing land management to increase soil carbon storage, restoration of cultivated peaty soils and degraded lands, dedicated energy crops to replace fossil fuel use, improved rice cultivation techniques and livestock and manure management to reduce CH_4 emissions), in the *Forestry* sector (for example, afforestation, reforestation, reduced deforestation) and in the *Waste* sector (for example, landfill methane recovery, waste incineration with energy recovery).

New mitigation technologies (currently under development) are projected to be commercialised in all of these sectors before 2030. Health benefits from reduced air pollution, as a result of actions to reduce greenhouse gas emissions, can be substantial and may offset a portion of the mitigation costs.

Rail City: blueprint looks at city's options

Stephen Moynihan
The Age, August 9, 2007

MELBOURNE'S forefathers have always been mindful of the city's future needs. Decades ago, road planners reserved a huge tract of land from Ringwood to Frankston. It's now the EastLink freeway. And the same can be said for today's rail engineers.

The Age can reveal what one day could be Melbourne's rail network. A leaked copy of the blueprint, "Transit Opportunities Kept Open", envisages a plethora of new rail lines and the reopening of several old ones.

Fig 29 Extract from a report in The Age on a blueprint to dramatically expand Melbourne's rail network

Euro-style bike lanes plan for city

Coming this way: a Copenhagen cyclist passes a row of parked cars keeping him segregated from moving traffic.
Photo: *Casual Cas*

Clay Lucas
The Age, September 3, 2006

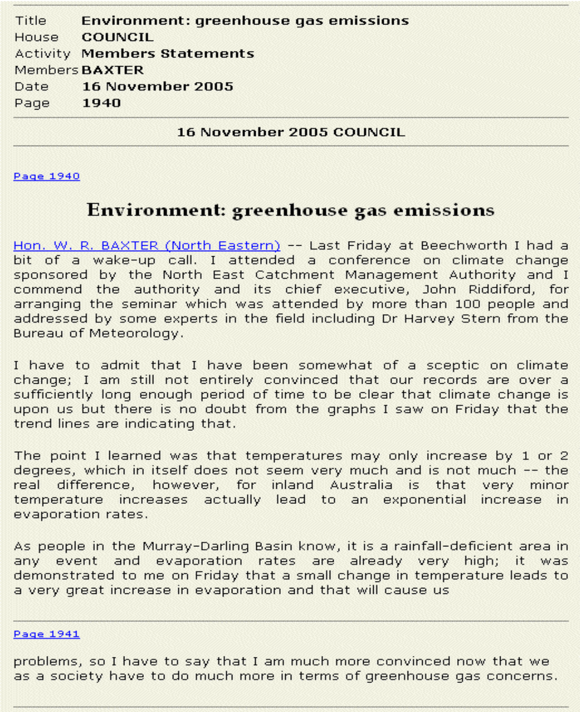
MELBOURNE is to get its first taste of European-style bike lanes that separate cyclists and car traffic by putting a parking lane between them.

Fig 30 Extract from a report in The Age on plans to make conditions safer for cyclists

4.3 Policies and Instruments

Political figures in all countries are increasingly playing a vital leadership role by incorporating the management of risk associated with climate change into policy formulation (Fig 31). And there are, indeed, a wide variety of national policies and instruments that are available to governments to create incentives for mitigation action. For example:

- Regulations and standards generally provide some certainty about emission levels, but may not induce innovations and more advanced technologies;
- Taxes and charges can set a price for carbon, but cannot guarantee a particular level of emissions, whilst tradeable permits will establish a carbon price, but fluctuations in that price make it difficult to estimate the total cost of complying with emission permits.
- Financial incentives (subsidies and tax credits – Fig 32) stimulate the development of new technologies, but economic costs are generally higher than for the foregoing instruments.
- Voluntary agreements between industry and governments are politically attractive, but the majority of such agreements have not achieved significant emissions reductions.



Title	Environment: greenhouse gas emissions
House	COUNCIL
Activity	Members Statements
Members	BAXTER
Date	16 November 2005
Page	1940

16 November 2005 COUNCIL

Page 1940

Environment: greenhouse gas emissions

Hon. W. R. BAXTER (North Eastern) -- Last Friday at Beechworth I had a bit of a wake-up call. I attended a conference on climate change sponsored by the North East Catchment Management Authority and I commend the authority and its chief executive, John Riddiford, for arranging the seminar which was attended by more than 100 people and addressed by some experts in the field including Dr Harvey Stern from the Bureau of Meteorology.

I have to admit that I have been somewhat of a sceptic on climate change; I am still not entirely convinced that our records are over a sufficiently long enough period of time to be clear that climate change is upon us but there is no doubt from the graphs I saw on Friday that the trend lines are indicating that.

The point I learned was that temperatures may only increase by 1 or 2 degrees, which in itself does not seem very much and is not much -- the real difference, however, for inland Australia is that very minor temperature increases actually lead to an exponential increase in evaporation rates.

As people in the Murray-Darling Basin know, it is a rainfall-deficient area in any event and evaporation rates are already very high; it was demonstrated to me on Friday that a small change in temperature leads to a very great increase in evaporation and that will cause us

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problems, so I have to say that I am much more convinced now that we as a society have to do much more in terms of greenhouse gas concerns.

Fig 31 Transcript of a speech delivered to the Victorian State Parliament

THE AUSTRALIAN IT

Selina Mitchell | *August 07, 2007*

TECHNOLOGY companies need to tread lightly on the environment for the sake of the future sustainability of the planet as well as their bottom lines.

British Telecom climate change head Donna Young said every company, including technology companies, needed to start taking responsibility for reducing carbon emissions.

It was not just a matter of purchasing offsets, such as tree-planting programs, Ms Young said. BT had started a program to empower its 106,000 employees to reduce their own carbon emissions at work and at home, he said.

Ms Young described purchasing offsets instead of cutting emissions as an attempt to go scot free - something BT would not promote.

Fig 32 Criticism of the process whereby one might receive credits as a result of purchasing offsets

Policies that provide a real or implicit price for carbon (Fig 33) could create incentives for producers and consumers to significantly invest in low greenhouse gas emission products, technologies and processes.

For example, in the *Energy Supply* sector, measures shown to be environmentally effective include reduction of fossil fuel subsidies, taxes or carbon charges on fossil fuels, feed-in tariffs for renewable energy technologies, renewable energy obligations and producer subsidies.

In the *Transport* sector, such measures include mandatory fuel economy, taxes on vehicle purchase, registration, use and motor fuels, road and parking pricing, land use regulations and infrastructure planning to influence mobility use, and investment in attractive public transport and non-motorised forms of transport.

Measures shown to be environmentally effective are also applicable to the *Buildings* sector (for example, building codes and certification), the *Industry* sector (for example, subsidies and tax credits), the *Agriculture* sector (for example, financial incentives and regulations for improved land management), the *Forestry* sector (for example, financial incentives to increase forest area, to reduce deforestation, and to maintain and manage forests), and the *Waste* sector (for example, renewable energy incentives or obligations).

However, whilst there are constraints, such as resistance by vested interests that may make them difficult to implement, there are also opportunities – for example, studies indicate that there is substantial economic potential for the mitigation of global greenhouse gas emissions over the coming decades, that could offset the projected growth of global emissions or reduce emissions below current levels.

Fig 33 Fluctuations in the price of carbon

5. Concluding Remarks

A synthesis of the IPCC's Fourth Assessment Report has been provided in the foregoing paragraphs. However, this material should be regarded as merely a brief snapshot of the findings from a huge research effort involving numerous scientists, and readers are urged to visit the IPCC Website (http://www.ipcc.ch) for more information.

To conclude, Fig 34 shows the current "state of play" with regard to the existing range of climate classes across Australia. The key implication of the likely future changes in global climate, which are described in the foregoing paragraphs, is that the spatial distribution of these climate classes is also likely to change.

It must be emphasised that the understanding of anthropogenic warming and cooling influences on climate leads one down the risk management pathway (Fig 35) when deciding on what strategies to adopt to mitigate the impact of human activities on climate change. This is because the conclusions of the Working Groups are all couched in terms that define the level of certainty with which they are proposed (Fig 36). For example:

- There is at least a 9 out of 10 chance that the globally averaged net effect of recent human activities has been one of *warming*, that is, there is very high confidence in the proposition;
- There is a greater than 99% probability that, in the future, over most land areas, it will be warmer, with fewer cold days and nights and more frequent hot days and nights, that is, it is virtually certain that such a change in climate will occur;
- There is a 66% to 90% probability that, in the future, *intense* tropical cyclone activity will increase, that is, it is likely that the activity will increase; and,
- There is a 66% to 90% probability that, in the future, the incidence of extreme high sea level will increase (Fig 37), that is, it is likely that the incidence will increase.

Before closing, I leave you with the words of Dr Rajenda Pachauri, chairman of the IPCC (as quoted in The Age of 11 August 2007):

Some Australian industries may be 'discomforted' by stronger action on climate change (and) the cost to the Australian economy was likely to be higher (than that to other countries) due to (Australia's) dependence on fossil fuels.

(However), over a period of time some of these measures would actually result in more jobs being created.

Making deep emission cuts would shave (only) about 0.12 per cent a year off global economic growth to 2030.

***Table SPM.4**: Estimated global macro-economic costs in 2030[a] for least-cost trajectories towards different long-term stabilization levels.[b), c)]*

Stabilization levels (ppm CO_2-eq)	Median GDP reduction[d)] (%)	Range of GDP reduction[d), e)] (%)	Reduction of average annual GDP growth rates[d), f)] (percentage points)
590-710	0.2	-0.6 – 1.2	< 0.06
535-590	0.6	0.2 – 2.5	<0.1
445-535[g)]	not available	< 3	< 0.12

That would mean most people would keep getting richer (albeit) at a slightly slower pace, while greatly reducing the risk of catastrophic damage to the planet.

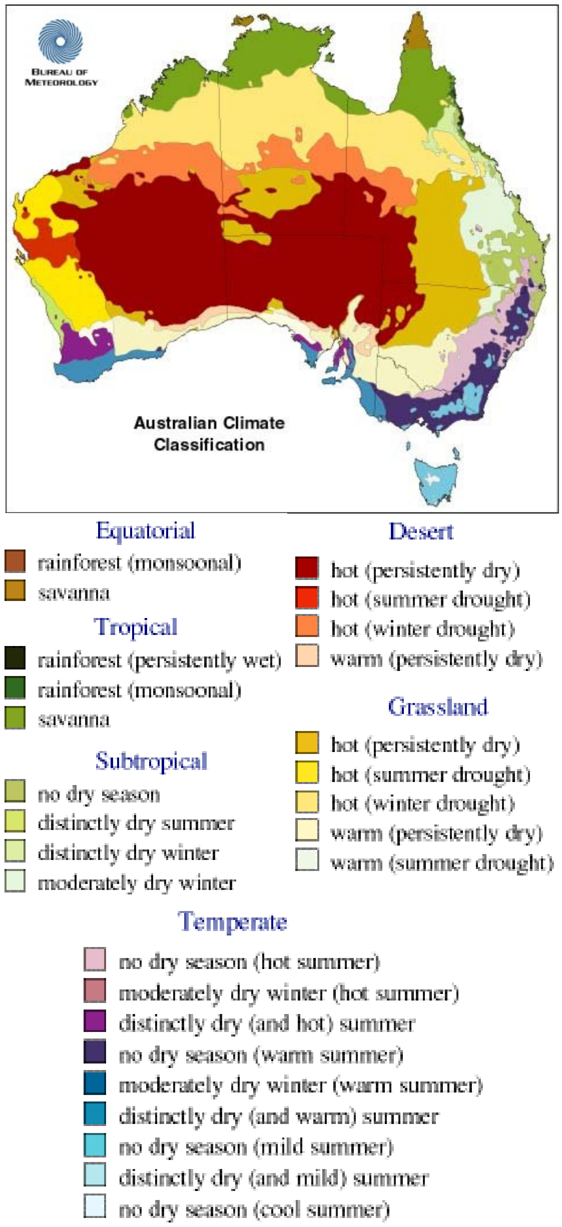

Fig 34 Climate regimes prevailing across Australia

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Deputy Prime Minister's speech on Energy Risk Management in Beijing

As you are aware, risks in the energy sector take many forms. There is the risk of insufficient supply of energy to sustain economic growth and a high standard of living. This is a risk which can affect nations. Even where national supply is adequate, it can still affect groups within the nation. As a nation with its own North Sea oil supply, we are well aware of that. Our Government in the UK has taken active measures to tackle the risk of fuel poverty - where low income households struggle to pay their fuel bills.

There is a second set of risks associated with the steps taken by Governments to ensure security of supply. Ever growing demand and competition for the world's limited resources can be a worrying source of international friction. You do not have to look far back in history to see how the struggle for resources has incited conflict, ranging from border skirmishes to full-blown wars. Indeed, much of the early industrialisation of colonial nations was achieved by acquiring resources by conquest.

There are technical risks for companies working in extraction and transportation. This is a sector where a single mistake or failure can lead to death and injury for those working in the industry and for citizens, and massive damage to the environment.

There is reputational risk. A single serious failure can blight the prospects of a business, or even an entire industry, for a generation.

There are financial risks. With energy deals worth billions of dollars, financial risks include not only trading risk but also the risk of a rogue trader, or a corrupt official, causing damage and suffering.

Above and beyond all these risks, there is the risk of global warming. Climate change is now recognised as the greatest global challenge facing mankind. Climate change is directly linked to our energy consumption. We also need our energy companies to invest in the innovation and technology we need to manage and avert the risk of global warming. As a European Union negotiator at the Kyoto convention on climate change in 1997, and since then, I have been active in the global political debate on how to tackle climate change.

The United Kingdom was instrumental in launching the Kyoto Protocol on climate change which now covers more than 160 countries and over 55% of global greenhouse gas emissions. Since Kyoto, the momentum for international cooperation and action on climate change has been growing relentlessly.

Fig 35 Extract from Speech (24 April 2007) by Britain's Deputy Prime Minister Prescott

Australia's most senior weatherman and a senior player in the IPCC process, director of the Bureau of Meteorology Dr Geoff Love, observes a disconnection between the way scientists think and the way policymakers and the public think. As a result, much is lost in translation.

"Scientists are trained to be sceptical - but in a different way to lawyers, in particular, for whom one counter-fact destroys an argument," says Love.

"A non-scientist will see a piece of data that is at odds with the most likely conclusion as disproving the theory; the scientist says there's probably more going on here, let's look at the long run of data, and construct probability statements."

Scientists, recognising the communication gap, try to unpack the language, but to protect themselves from misinterpretation, they err on the conservative side.

Fig 36 Bridging the communication gap (The Age, 8 Aug 2007)

Fig 37 June 2007 Paynesville yacht club photograph (by Mr Peter Bush) illustrating the combined impact of high sea levels and floodwaters

In a 1992 paper presented to the *5th International Meeting on Statistical Climatology* (Stern, 1992), the author introduced a methodology for calculating the cost of protecting against the onset of global warming. The paper, *'The likelihood of climate change: A methodology to assess the risk and the appropriate defence'*, was presented to the meeting held in Toronto, Canada, under the auspices of the American Meteorological Society (AMS).

In this first application of what later was to become known as 'weather derivatives', the methodology used options pricing theory from the financial markets to evaluate hedging and speculative instruments that may be applied to climate fluctuations. Two illustrative examples were presented, namely, protecting against the risk of diminishing industrial output associated with global warming; and, protecting against the risk of decreasing value of a company likely to be adversely affected by global warming (e.g. a manufacturer of ski equipment).

Use of these financial instruments leads to those concerned being compensated provided they are on the correct side of the contract. Conversely, those on the wrong side of the contract would have to provide that compensation. The methodology provided a tool whereby the cost of the risk faced can be evaluated (whether it is the case of determining that risk on a global scale, or on a company specific scale). Published data from the *Carbon Dioxide Information Analysis Center* were used in the evaluation.

Since the early 1990s, the global mean temperature has risen significantly, and the methodology was 'revisited' in a 2005 paper presented to the *16th Conference on Climate Variability and Change* at the AMS Annual Meeting of that year (Stern, 2005), with a view to recalculating the cost taking into account the additional, more recent, data. The same examples were used in 2005 as were used in the 1992 study. It was shown that the cost of protection has, indeed, risen since 1992.

Fund managers rate climate change as the second most important influence (after globalisation) on asset performance over the next five years (Mercer Investment Consulting, 2006). Increasingly, the application of financial market mathematics in the context of developing strategies to address the impact of climate change is becoming the subject of research (Tang, 2005). The presentation explores the application of some of these strategies.

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Fig 38 Abstract of Stern's (2006) paper on the application of financial market mathematics to translating climate forecasts into decision making, which was presented to the 3rd International Conference on Climate Impacts Assessments.

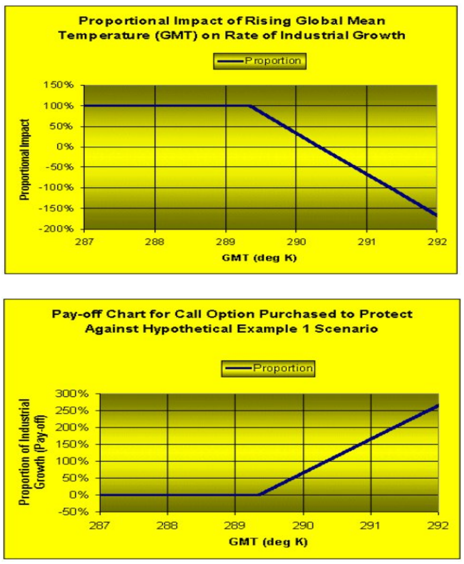

Fig 39 Application of financial market mathematics to evaluating impact of climate change on the rate of industrial growth (Example 1)

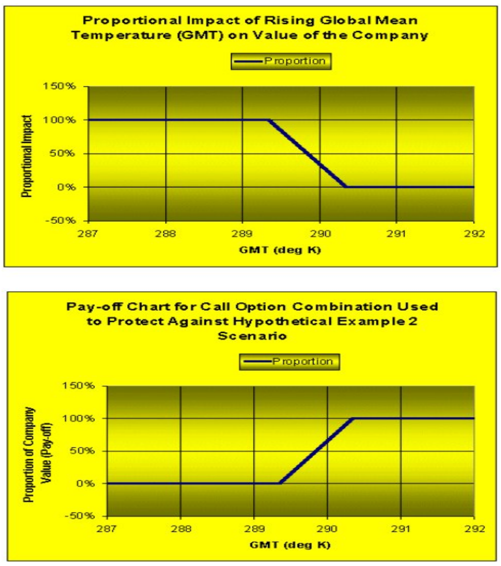

Fig 40 Application of financial market mathematics to evaluating impact of climate change on the value of a company (Example 2)