Risks and consequences, timescales and uncertainties

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Key points

- Scientists have learned a lot about climate change
- But science keeps seeing ‘surprises’ as well – and more risks can become serious
- We need to remember the ‘precautionary principle’ that was agreed in 1992
- This should lead to a collective approach for risk management.
Recognising the importance of CO$_2$ – but then a first ‘surprise’

Svante Arrhenius (Nobel prize winner) in 1906:

… “any doubling of the percentage of carbon dioxide in the air would raise the temperature of the Earth’s surface by 4°C.”

That was amazingly correct for someone who did not have computers to do the climate modelling work.

But Arrhenius and his colleagues thought that this would take a thousand years to happen because the CO$_2$ coming from fossil fuels would mainly just be dissolved into the oceans.
Oops: it’s going to warm up much sooner

Then in the 1950s …

Roger Revelle in California discovers that CO$_2$ is not very soluble in the ocean.

Athol Rafter in DSIR, NZ, finds that carbon in the atmosphere was getting much “older” – due to fossil fuel burning meaning an increase in CO$_2$.

Otago Daily Times cite Rafter in a conference at Dunedin during the International Geophysical Year in 1957
So do we know how much warming?

In the early 1960s two estimates of the warming for a doubling of atmospheric CO$_2$ were 2$^\circ$C and 4$^\circ$C – so it was concluded that it would be somewhere in the range 1.5$^\circ$C to 4.5$^\circ$C.

Forty years later (2007) some who are trying to combine information from many sources say the best estimate would be 3$^\circ$C and it’s likely to be within 2$^\circ$C to 4.5$^\circ$C.

But others still point out that it depends on what happens to the forests and ice sheets as a result of the warming and then how far into the future do you want to know the answer.

Should we just watch this space ….

... or recognise that the warming will be significant.
Local changes are more important than the global average

The warming that is expected in New Zealand is smaller than the global average – but …

This warming is larger relative to our summer to winter variations than is the case for most countries in the Northern Hemisphere.

Studies of the metabolic effects of warmer temperatures on a range of biological systems show that those in the tropics are more sensitive than those in the mid latitudes of the Northern Hemisphere because they have evolved in a less variable climate.¹

¹Dillon et al, Nature, 2010
Another Oops: There are actually quite a lot of other greenhouse gases

In the 1970s quite a number other greenhouse gases were discovered.

And then there is a cooling effect due to sulphate aerosols coming from combustion and vehicles.

So there is much more uncertainty for quantifying all the processes.

... but the warming can still be significant.
And some of them are destroying the ozone layer

In the 1920s, Thomas Midgely invents CFCs for refrigeration and shows these are perfectly safe if you accidentally breathed them into your lungs.

Then in 1974 Sherry Rowland and Mario Molina discover CFCs are starting to destroy the ozone layer and so will increase skin cancers.

This deserves the Nobel prize in chemistry, but …

Then in 1985 comes the surprise … over much of Antarctica most of the ozone layer is getting wiped out in spring time by CFCs.

So pollutants emitted in the Northern Hemisphere can have more impact on the other side of the world.
We save the ozone layer but shift the load on our environment

So we replace the CFCs with some other greenhouse gases that will be removed in the lower atmosphere and that increases our reliance on some other chemistry that we don’t fully understand yet.

Every day most of the removal of our forcing effect on the climate system is coming from complex atmospheric chemistry in the troposphere.

We have discovered that this chemical removal of gases seems to be more widespread than expected, but large forest fires in Indonesia were also seen to cause significant reductions in it right down into the Antarctic.
Sea level rise estimates have changed

Early estimates included contributions from loss of ice sheets.

Little direct evidence for that happening, so IPCC estimates were predominantly just for thermal expansion of the ocean.

But in 2007, IPCC had to say that we could not give an upper bound as there was growing evidence for changes in the major ice sheets.
Major ice sheets melting faster than expected

Loss of this ice modifies the Earth’s gravitational field so is expected to lead to more sea level rise on the other side of the world – e.g. in New Zealand.

So the Southern Hemisphere seems to come out worse again.
Oops: sea level rise estimates are higher

Summary of recent peer reviewed scientific papers on estimates of SLR by 2100. Solid dots are projections for this century, open dots are from analogies with the last time the Earth warmed up.
How does NZ deal with new issues

New Zealand has a large amount of coastline, and many of our towns and cities are on low lying land.

We also have several of our main transport corridors on low lying land, and we tend to increase this area of potential vulnerability.

Scientists talk of ‘mal-adaptation’.

Others should wonder if we have really planned for our future.
The expected trend towards more extreme storm events will combine with sea level rise to mean that some coastal impacts will come sooner and penetrate further inland.

Ohope, February 2011, Martin Manning
So do we know everything that will happen now?
Oops: did we tell you that climate change means extreme cold events in some places?

"An important result of our simulations is that a decrease of the wintertime sea ice cover in the Barents and Kara seas does not always result in a priori expected warming over the adjacent continental areas. A robust cooling may also be associated with the sea ice reduction within a certain range, which can be important in perspective of global climate change.


Their paper was submitted in November 2009, this type of event happened in early 2010, and the paper was published afterwards.
Oops: looks like extreme rainfall is coming sooner than we thought

“Here we show that human-induced increases in greenhouse gases have contributed to the observed intensification of heavy precipitation events found over approximately two-thirds of data-covered parts of Northern Hemisphere land areas.

“Changes in extreme precipitation projected by models, and thus the impacts of future changes in extreme precipitation, may be underestimated because models seem to underestimate the observed increase in heavy precipitation with warming.

Hmmm – Perhaps floods and fires have got linked together now?

Drought and widespread fires in Russia at the same time as record breaking flooding down the Indus valley in Pakistan and near-record flooding across much of China is raising the question of correlations between extreme events.

Extremes like this have been expected to become more frequent, for some time - but some climate scientists are now concerned about the likely connections between them.
Can scientists attribute these events to anthropogenic climate change

At a meeting of climate scientists covering extreme events in August 2010, Kevin Trenberth gave a detailed explanation of potential connections between:

- Arctic ice sheet loss,
- warming of the Indian Ocean,
- blocking of weather patterns over much of Asia,
- record droughts in Russia,
- record floods in Pakistan, and
- extreme flooding across much of China.

Do we need to wait for that to be resolved before we adapt to more widespread extreme events?
More in January 2011

Then in late-December 2010 and January 2011
Sri Lanka:– heaviest rains for about 100 years, 300,000 displaced.

Philippines:– by Jan 25 four weeks of sustained rain over a third of the country’s provinces, 1.9 million people affected.

Brazil:– by Jan 14 over 600 dead and this their deadliest natural disaster on record.
Australia in January 2011

And then there were the Queensland floods at the same time.

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Queensland floods can be attributed to the strong La Nina conditions that started in mid-2010.

Some have argued that the Brazil flooding was due to very warm conditions in the Atlantic ocean.

Trenberth’s explanation for the wide pattern of extreme events in the Northern Hemisphere does not seem to apply to the Southern Hemisphere.
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The last few years have seen even broader patterns of extreme events than have been shown here, and include persistent droughts.

Is this a new aspect of climate change?
And impacts in one country can propagate

In 2010 a research paper suggested that effective globalization of water resources through a growing dependence on international trade for agriculture leaves fewer options for coping with exceptional droughts and crop failure – and so global trade can reduce our resilience to climate impacts.

See: D’Odorico et al, GRL, July 2010

….and this was then seen after the serious Russian drought later that year, when Vladimir Putin banned exports of grain.

There was a rapid and large increase in global prices for grain that were linked with food riots in Mozambique.

The Observer, 5 Sep 2010
We better think about the major risks a bit more
Scientists did say that ‘surprises’ can happen

“Future unexpected, large and rapid climate system changes (as have occurred in the past) are, by their nature, difficult to predict. This implies that future climate changes may also involve "surprises". In particular, these arise from the nonlinear nature of the climate system. When rapidly forced, nonlinear systems are especially subject to unexpected behaviour.


And these words were put together by Steve Schneider with some help from Martin Manning.
Society should take over from science when it comes to risk management

Scientists usually want to be sure of what they know, and understand the limits for what they don’t know, before they say it.

So do we wait till the science is sure or do we follow the …

*The United Nations Precautionary Principle agreed by all governments in 1992 which said …*

“Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing cost-effective measures to prevent environmental degradation.”
The IPCC communicates between science and the international policy process.
We now need a broader framework ...

Growing involvement of Industry & Investment

Climate stabilisation options
Risk Management

Consideration of future generations
Investment priorities

Science
IPCC
Policy

The mediator sensed that the negotiations were in trouble.
Summary

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- But science keeps seeing ‘surprises’ as well – and more risks can become serious.
- We need to remember the ‘precautionary principle’ that was agreed in 1992.
- This should lead to a collective approach for risk management.
The Y-Junction depends on views?

- Politics has to be based on winning the next election
- Our children can look after themselves
- Perhaps in 10 years time we can start to do something
- We want security for long term investments
- We will be judged by what we pass on to future generations

![Graph showing climate change projections](image)
Public perceptions seem different in developing countries and some rapid shifts in energy sources

The Honkong Shanghai Banking corporation has been finding consistently that people in developing countries are more concerned about climate change than those in developed countries.

(By the way this corporation has its head office in London!)

Despite its smaller GDP, China has been investing more than the USA in renewable energy since 2009.

China has most of the world’s solar water heating and is moving rapidly on wind power and solar photovoltaics.

However, despite the 2008 recession, renewables accounted for 60% of new installations in the EU and 50% in the USA.
Warming versus what we are used to

- **Boreal forest**
- **Moist Mid-latitude**
- **Tundra**
- **Dry Mid-latitude**
- **Dry Tropical**
- **New Zealand**

- **Temperature °C**
  - Summer to winter seasonal range in temperature
  - Amount of warming due to climate change

The diagram compares the temperature range and warming due to climate change across different regions.
Warming versus what we are used to

Impacts depend on sensitivity to change
We are still learning what the effects may be

“Global metabolic impacts of recent climate warming”,

Points out that the impacts of warming on the biosphere depend on its physiology and the metabolic rate which determines its energy needs.

Even though warming has been less in the tropics, this work shows that the impact on metabolic rate has been equivalent in magnitude to that in the north temperate-zone regions, and far greater than in the Arctic.

It concludes that because of temperature’s nonlinear effects on metabolism, tropical organisms, which constitute much of Earth’s biodiversity, are likely to be profoundly affected by climate warming.
Human Vulnerability to Climate Change

A Global climate–demography vulnerability index (CDVI). Blue regions are where population growth is below, and red areas where it is above, what is consistent with climate change.
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A Global climate–demography vulnerability index (CDVI). Blue regions are where population growth is below, and red areas where it is above, what is consistent with climate change.

“The regions of greatest vulnerability are generally distant from the high-latitude regions where the magnitude of climate change will be greatest.

“Furthermore, populations contributing the most to greenhouse gas emissions on a per capita basis are unlikely to experience the worst impacts of climate change, satisfying the conditions for a moral hazard in climate change policies.
August 2003 Heat Wave in Europe

A wide area temperature anomaly of about 3°C

Was more than 7°C warmer than usual in some places

About 30,000 premature deaths

Unprecedented drop in crop yields

This is now twice as likely as it was 50 years ago due to global warming.
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Growing evidence for a lack of planning to adapt

In New Orleans, major planning for hurricanes, after Hurricane Betsy occurred in 1965, was never completed. Hurricane Katrina in 2005 was more extreme, and also revealed structural inertia in planning.

- ‘The greatest overall disaster in U.S. history at a time of unprecedented U.S. wealth and power
- ‘Creating community resilience takes time and longer than anticipated
- ‘Surprises should be expected & anticipation was insufficient
- ‘Despite 290 years of effort, overall vulnerability to hurricanes has grown