The scientific basis for climate change

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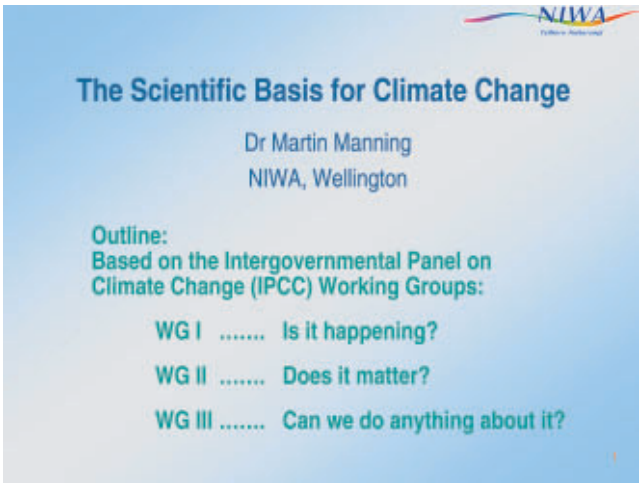
Abstract

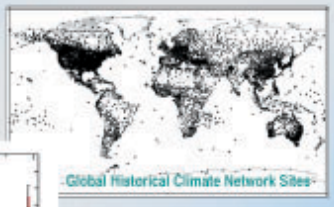
Scientists have considered the effect of increasing amounts of carbon dioxide in the atmosphere on global climate for over 100 years, but it is only in the last decade that this issue has become a factor in public policy. To a large extent, recent policy considerations have been a response to a series of comprehensive assessments carried out by the Intergovernmental Panel on Climate Change (IPCC). In this paper I will present a brief summary of some results from the IPCC's Third Assessment Report (TAR) completed in 2001.

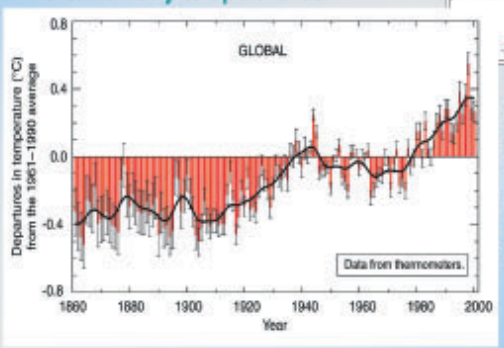
The focus of the three different IPCC Working Groups can be characterised by three conceptual questions: Is it happening? Does it matter? and Can we do anything about it? Most of the public debate has centred on the first question, however, virtually all climate scientists accept that there have been widespread and unusual changes in global climate during the last century. The TAR produced new analyses showing that an increasing greenhouse effect remains the most plausible explanation for these changes. The second question is the most complex as it involves not only a degree of value judgement but also some of the most difficult technical questions dealing with methods of adapting to change, their costs and effectiveness. The authors of the TAR concluded that projected climate change would lead to both beneficial and adverse effects, but that the larger the amount and rate of change the more that adverse effects would predominate. The third question is of particular interest to the Petroleum industry as it addresses the relationship between future fossil fuel use and climate change. Analysis of scenarios for socio-economic development and their associated greenhouse gas emissions shows global warming could range from 1.4°C to 5.8°C with about half of that range being due to future choices affecting emissions and half to uncertainty in the science projection for any given emissions pathway.



Global average surface temperature has increased over the 20th Century by about 0.6°C

Land surface temperatures have increased more than sea surface temperatures, and night temperatures more than day temperatures.



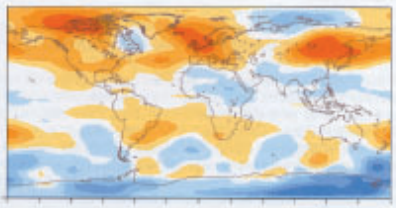


Surface temperature data have to be corrected for urban heat island effects and changes in the number and distribution of measurement stations.

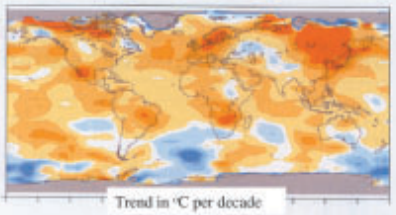
Source: IPCC Third Assessment Report, 2001

Temperature trends over the last 20 years

Trends in satellite data for air about 4 km above the surface (1979 - 98)



Trends in surface data (1979 - 98)



Source: US National Academy of Sciences, 2000 from Christy et al (2000) & Jones et al (1999).

Disappearing Ice

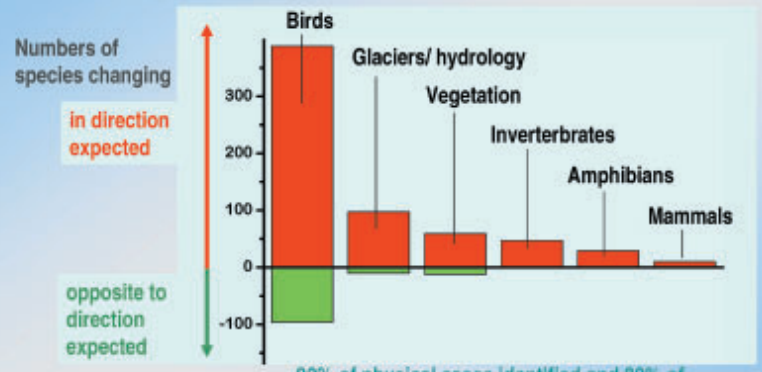
Many explorers died trying to find a passage between the Pacific and the Atlantic across the top of Canada.

This century it has been achieved many times - in the summer of 2000 by an aluminium hulled catamaran which did not touch ice.

The extent of ice cover on Mt Kilimanjaro decreased by 81% between 1912 and 2000. In 1889 the crater rim was nearly encircled by ice, today only a small fraction remains.

Glaciers and ice sheets throughout the Tibetan plateau are also decreasing.

Patterns of change in many biophysical systems suggest a warming influence

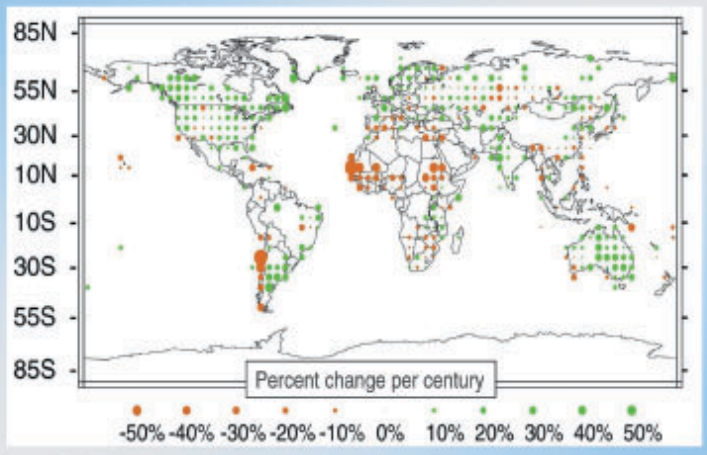


90% of physical cases identified and 80% of biological cases identified are changing in a direction consistent with well-established temperature relationships.

Source: IPCC WG II Third Assessment Report

6

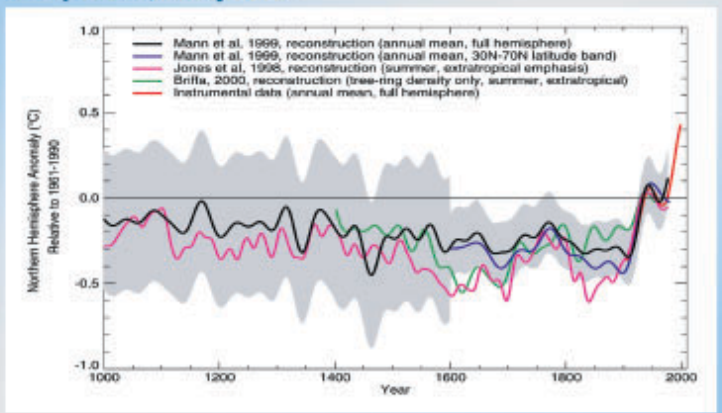
Trends in rainfall over 1900 - 1999



Source: IPCC Third Assessment Report

7

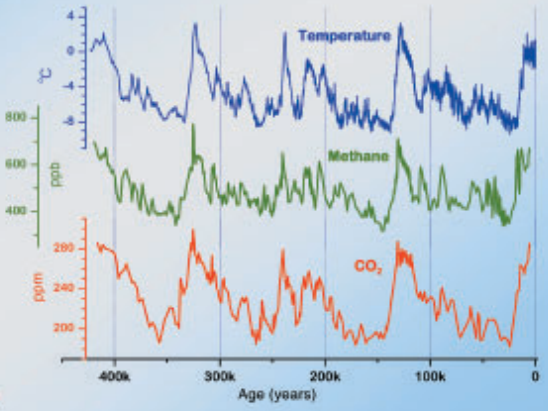
20th century northern hemisphere warming is likely to have been the largest of any century in the past 1,000 years



8

Ice core data show changes in greenhouse gases associated with climate change

Air from the past is trapped in bubbles in the ice and can be analysed for different gases.



Source: Petit et al, Nature, 1999.
Berger &Loutre, QSR, 1991

9

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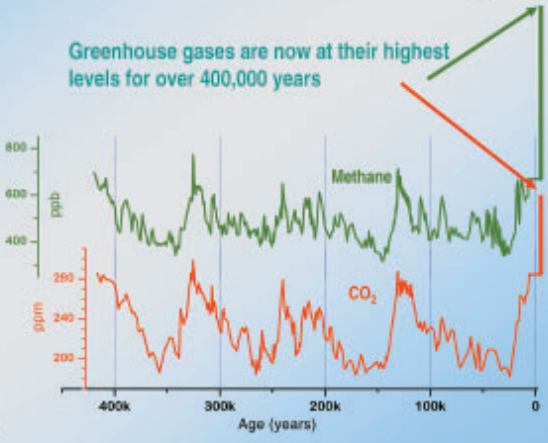


Source: Petit et al, Nature, 1999.
Berger &Loutre, QSR, 1991

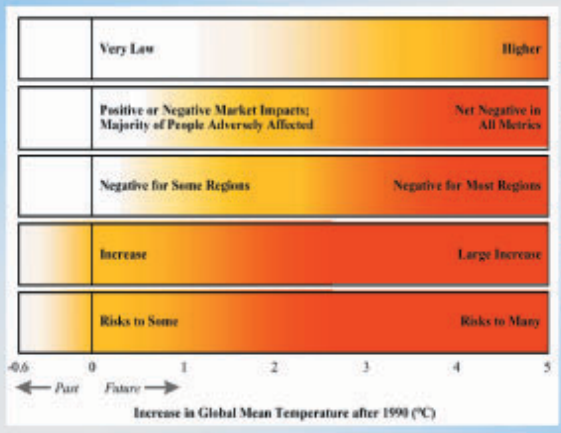
10

Does it matter?

- Some reasons for concern
- Examples

11

Reasons for concern –
different thresholds depending on your viewpoint



Risks from future large scale discontinuities

Aggregate impacts

Distribution of impacts

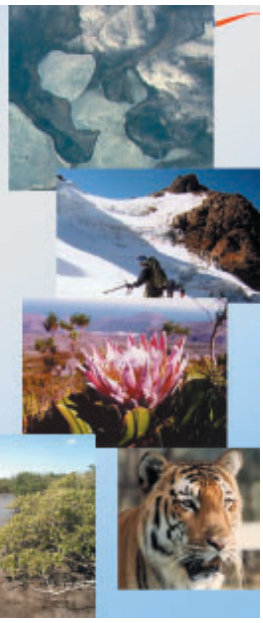
Risks from extreme climate events

Risks to unique and threatened systems

Examples of threatened Systems

- Endorheic lakes: Caspian and Aral seas
- Tropical glaciers and associated water flows
- Geographically constrained ecosystems - e.g. Cape Floral Kingdom, S Africa
- Coral Reefs (1% of ocean area, 30% of marine species)
- Mangrove ecosystems - e.g. Sundarbans, Bangaladesh & India, last habitat of Royal Bengal Tiger

The geographical extent of biodiversity loss, and number of systems affected, increases with the rate and magnitude of climate change.

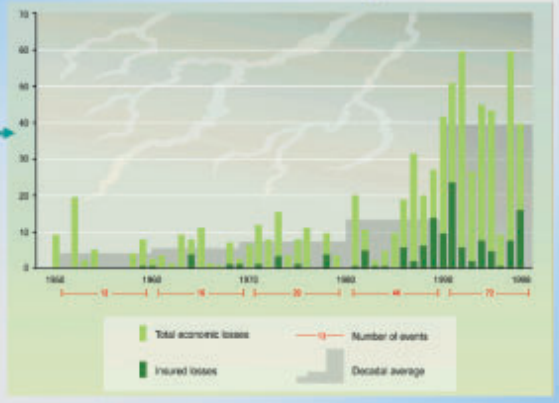


Extreme events - Global costs are rising

Annual losses due to extreme weather events in billions of US$ (inflation adjusted) →

are 10 times higher in the 1990s than 1950s

Losses from small, non-catastrophic weather-related events show similar trends.



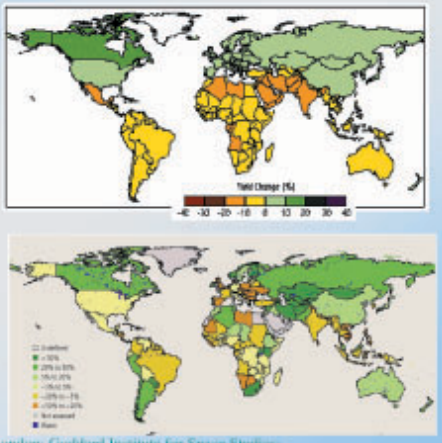
Part of the upward trend is linked to socio-economic factors (population growth, increased wealth, urbanization in vulnerable areas), and part to regional climatic factors (changes in precipitation, flooding events).

Distribution of impacts - Crop yield change patterns

Two analyses shown here of percentage changes in crop yield contain agreements and disagreements, typical of our present state of knowledge.

Generally mid and high latitude countries see gains for small amounts of warming, while tropical countries see losses.

Climate change raises issues of global food security and water security.



Source: Jackson Institute, University College London; Goddard Institute for Space Studies; International Institute for Applied Systems Analysis; Max Planck Institute, Hamburg

Global Aggregate: Benefit + Cost

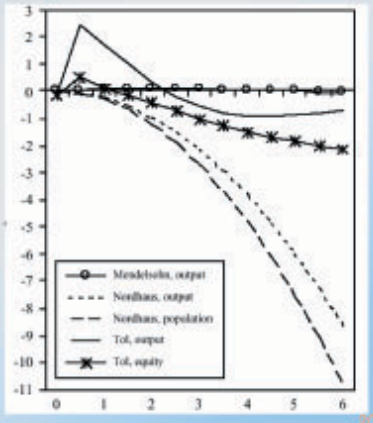
Monetary impacts (% global GDP) as a function of global average warming

Aggregate benefit cost results are sensitive to

- assumptions about adaptation
- valuation of impacts
- output vs population weighting

Studies tend to ignore extreme weather events and any compounding effect of multiple stresses.

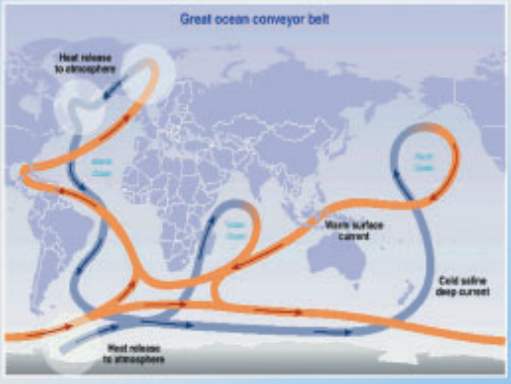
Also they can not include all non-market impacts.



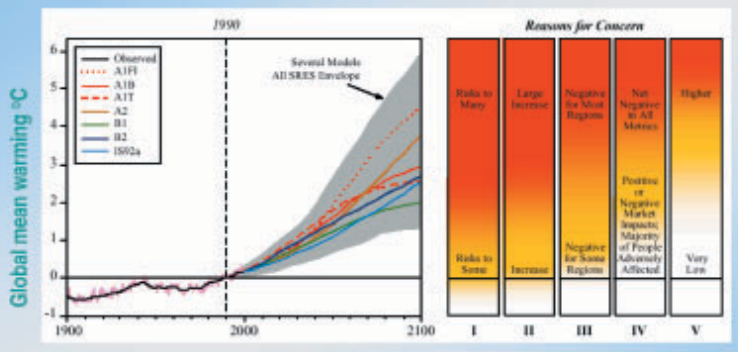
Risks of large scale discontinuities

Paleoclimatic records show that ocean circulation and the Gulf Stream have changed abruptly in the past.

Most coupled ocean - atmosphere models show a significant decrease in this ocean circulation over the 21st century –
but any major collapse is believed to be unlikely before 2100.



Comparing reasons for concern



I Risks to Unique and Threatened Systems
II Risks from Extreme Climate Events
III Distribution of Impacts
IV Aggregate Impacts
V Risks from Future Large-Scale Discontinuities

22

Can we do anything about it ?

- Can we predict the future?
- Scenarios for greenhouse gas emissions
- A range of future climates
- Where does the Kyoto Protocol fit in

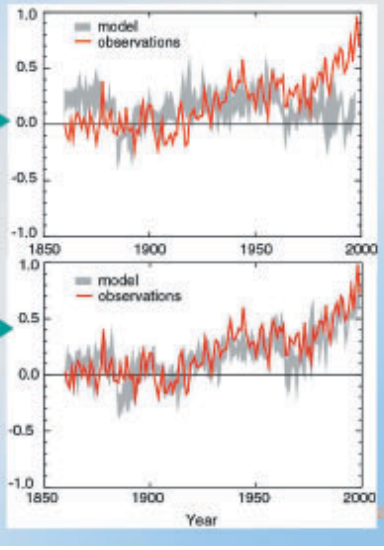
23

Climate models show warming is consistent with greenhouse effect

Climate model results (grey band) for global average temperature taking into account solar and volcanic effects, and observations (red).

Climate model results (grey band) when greenhouse gases and aerosols are included.

Source: Stott et al, Science 2000

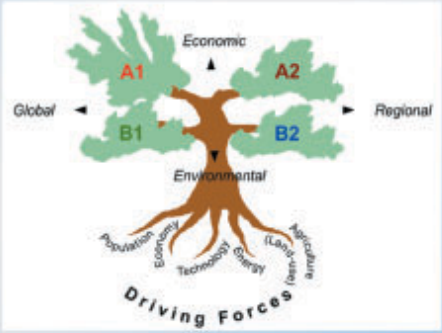


24

IPCC Emission Scenarios for the 21st Century

Socio economic backgrounds for emission scenarios take into account economy versus environment choices and globalisation versus regionalisation choices.

This leads to four families of scenarios. Six different groups constructed 40 different scenarios for these families.

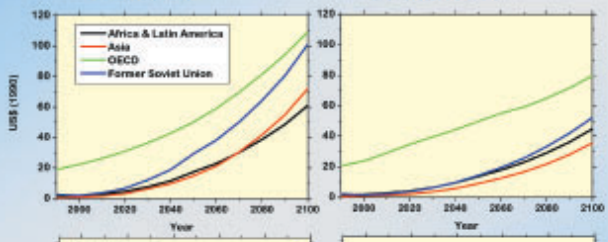


Source: IPCC Special Report on Emission Scenarios, 2000, courtesy IIASA, Vienna

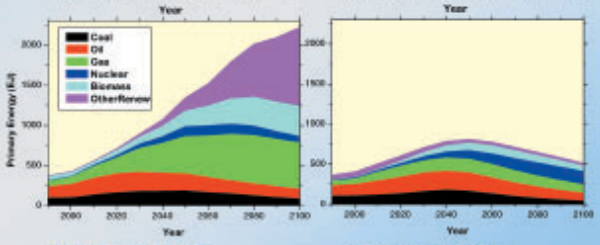
25

Scenario A1 / Scenario B1

GDP per person by region



Energy use by fuel type

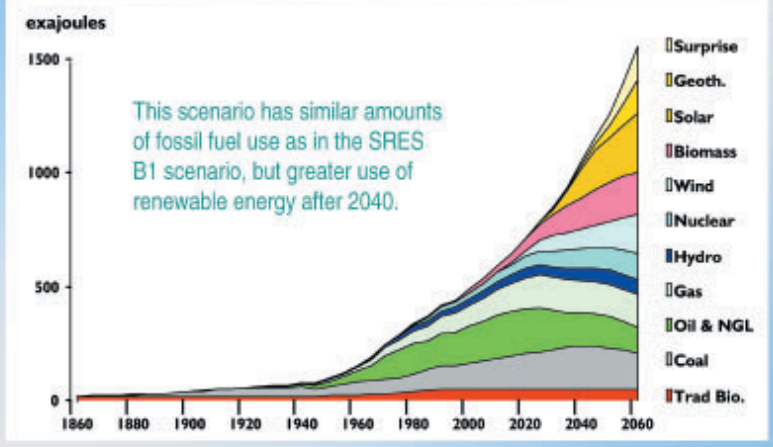


Warming by 2100: 2.1 to 3.8°C

Warming by 2100: 1.4 to 2.6°C

26

Shell "Sustained growth scenario" for Energy Supply

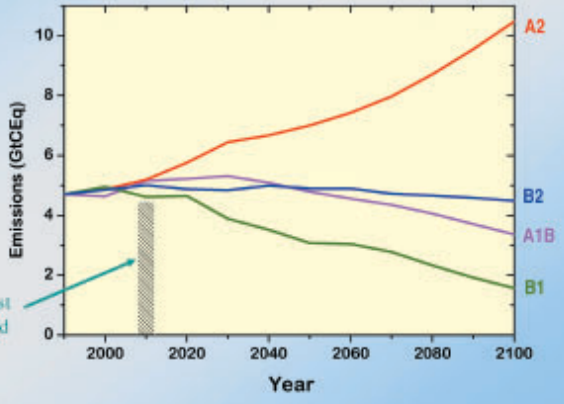


27

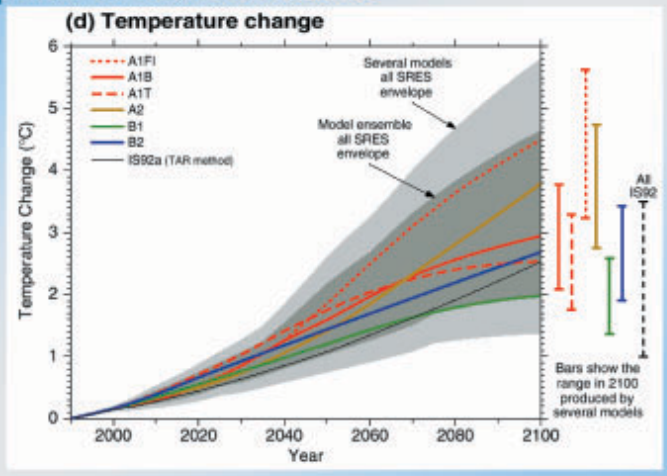
Source: Shell International Limited.

Scenarios for Annex I Party GHG Emissions

The A1 scenario family suggests that high GDP growth is not dependent on high Annex I Party emissions.

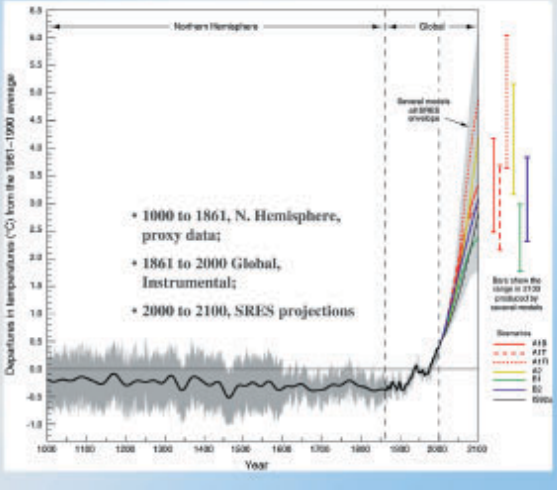


Rate and magnitude of warming depends on future emissions



Variations of the Earth's Surface Temperature: 1000 to 2100

Even, if our current climate science is only roughly correct, then 21st century climate will be unlike anything experienced during human civilisation.



Author

Dr Martin Manning is a Principal Scientist at NIWA responsible for research on greenhouse gases in the atmosphere. He is an author of over 80 papers and reports on atmospheric and climate research, and is regularly asked to address international conferences, Government ministers, or senior policymakers. Since 1997 he has been a Vice Chairman on the IPCC Bureau which supervises regular assessments of climate change science for Governments and as such had a significant role in preparation of the IPCC Third Assessment Report.