Climate change: the evidence, science and current projections

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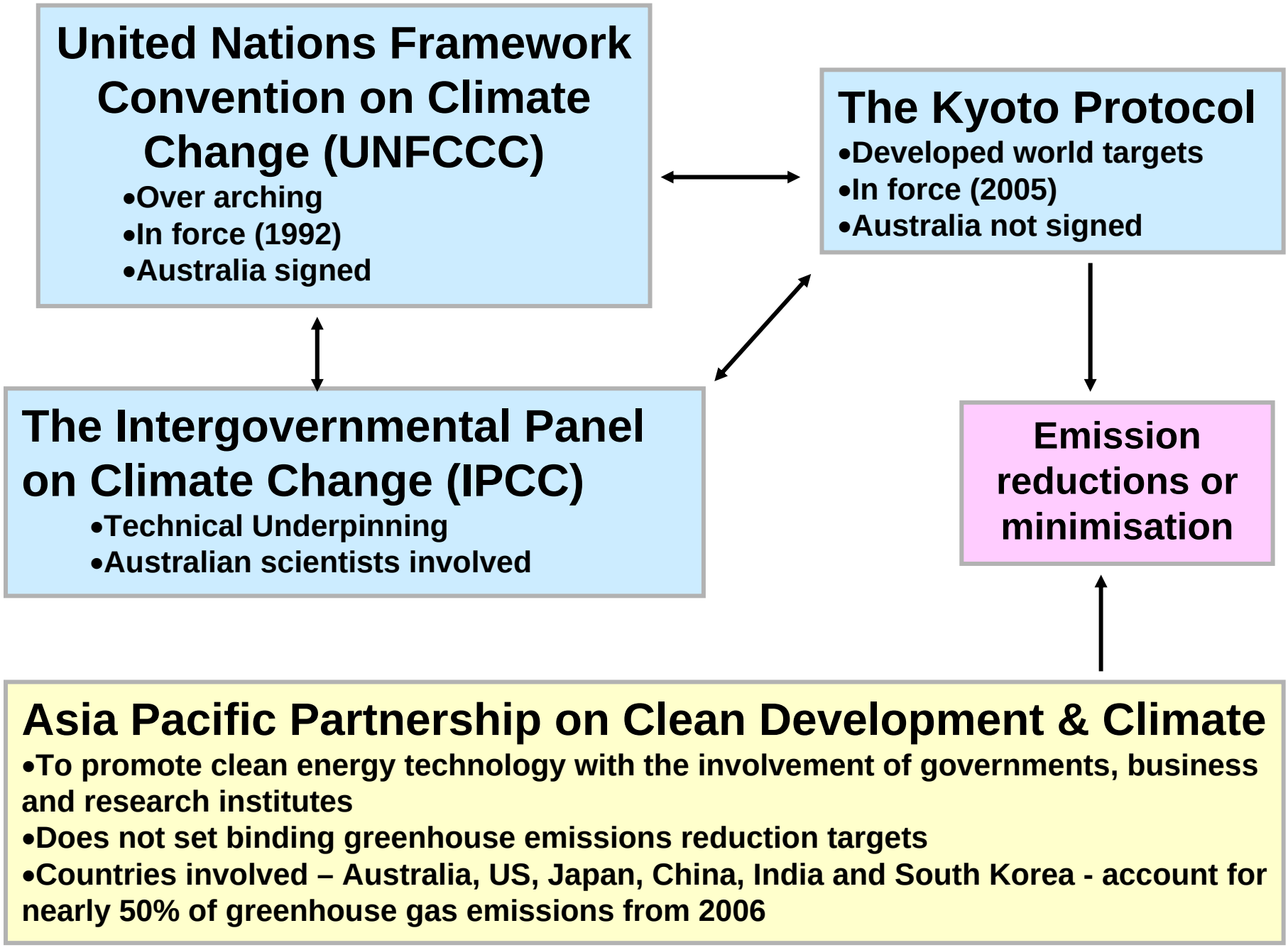
Climate change: the evidence, science and current projections

- Recent climate science assessment
- Future change in Australia
- Managing risk, complexity and uncertainty
- Conclusions


United Nations Framework Convention on Climate Change (UNFCCC)
•Over arching
•In force (1992)
•Australia signed
The Kyoto Protocol
•Developed world targets
•In force (2005)
•Australia not signed
The Intergovernmental Panel on Climate Change (IPCC)
•Technical Underpinning
•Australian scientists involved
Emission reductions or minimisation
Asia Pacific Partnership on Clean Development & Climate
•To promote clean energy technology with the involvement of governments, business and research institutes
•Does not set binding greenhouse emissions reduction targets
•Countries involved – Australia, US, Japan, China, India and South Korea - account for nearly 50% of greenhouse gas emissions from 2006

Intergovernmental Panel on Climate Change

Fourth Assessment Report

Working Group I:
The Physical Science Basis

February 2, 2007

www.abc.net.au/news/opinion/items/200702/s1838077

Working Group II:
Impacts, Adaptation & Vulnerability

April 6, 2007

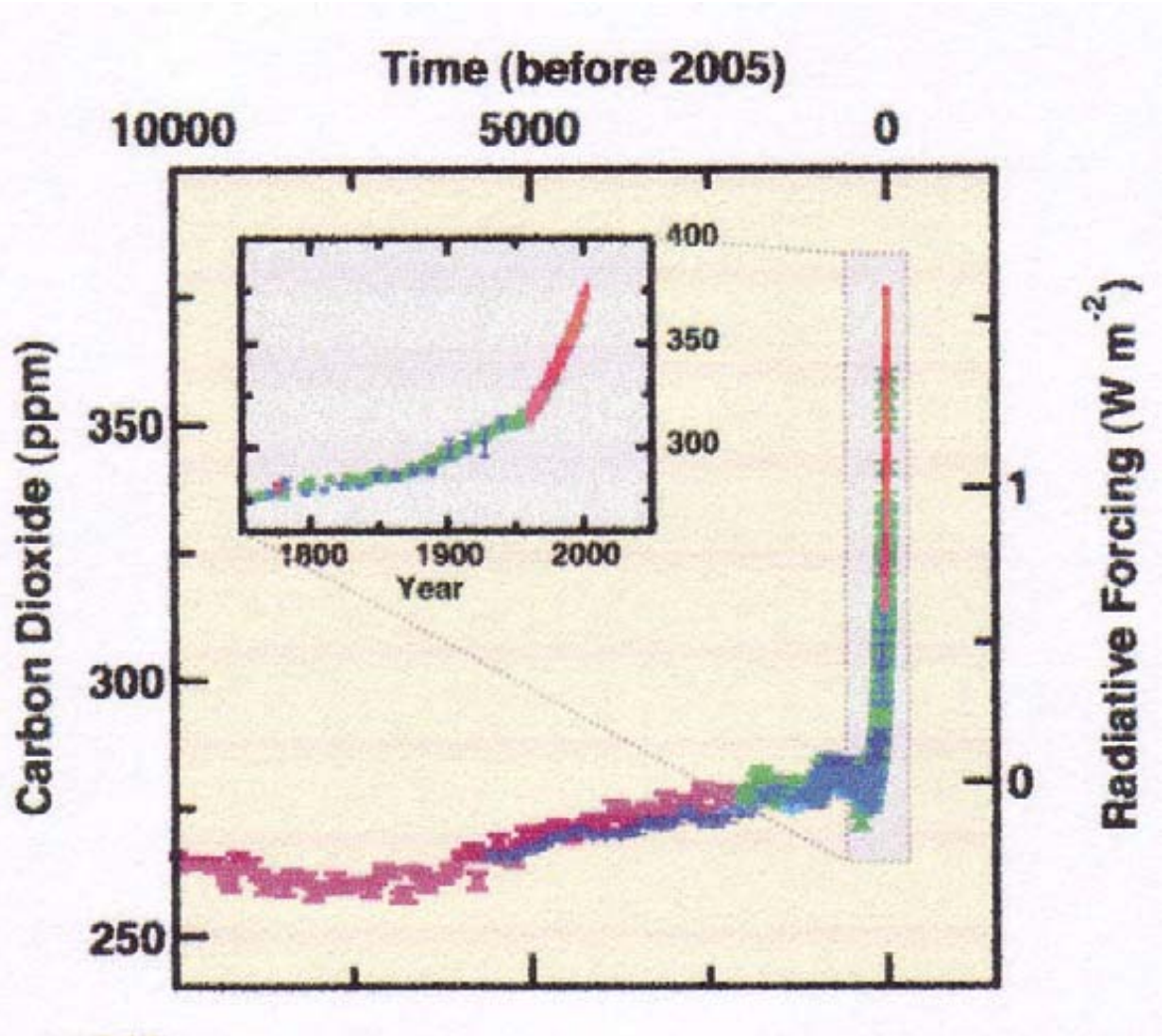
Working Group III:
Mitigation of Climate Change

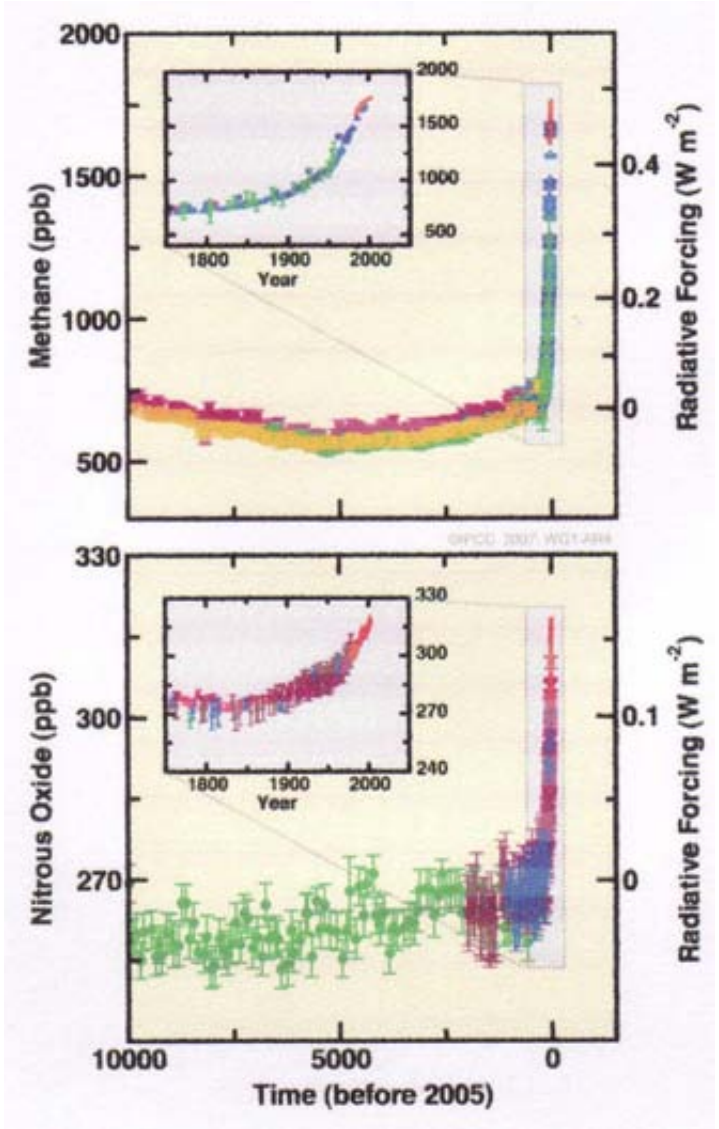
May 4, 2007

IPCC 4th Assessment Report
Summary of contents

Chapters	Title	Pages	Citations	Authors	Australian authors
Summary		14		49	Nathan Bindoff, Neville Nicholls, Penny Whetton
Glossary		27	17		
1	Historical overview of climate change science	52	265	35	
2	Changes in atmospheric constituents and in radiative forcing	158	684	52	David Etheridge, Paul Fraser
3	Observations: Surface and atmospheric climate change	115	704	78	Lisa Alexander, Neville Nicholls, Ian Simmonds, Matthew Wheeler
4	Observations: Changes in snow, ice and frozen ground	72	255	55	Ian Allison, Anthony Worby
5	Observations: Oceanic climate-change and sea level	81	287	67	Nathan Bindoff, John Church, Kurt Lambeck, Steve Rintoul, A P Wong
6	Paleoclimate	101	609	49	
7	Coupling between changes in the climate system and biogeochemistry	137	868	76	Josep Canadell, Ann Henderson –Sellers, Andrew Pitman, Michael Raupach, Peter Rayner, Leon Rotstayn, Will Steffen
8	Climate models and their evaluation	118	685	87	Robert Colman, Andrew Pitman, W Cai, Harry Hendon, Scott Power, A G Slater, Bryant McAvaney
9	Understanding and attributing climate change	122	536	53	Neville Nicholls, Scott Power, Leon Rotstayn, David Karoly
10	Climate change projections	150	545	93	Ian Watterson, J Arblaster, Mark Collier, Martin Dix
11	Regional climate projections	136	611	57	Penny Whetton, Amanda Lynch, Kathleen McInnes, Ramasamy Suppiah
Total		1283	6066	751	42 (6%)

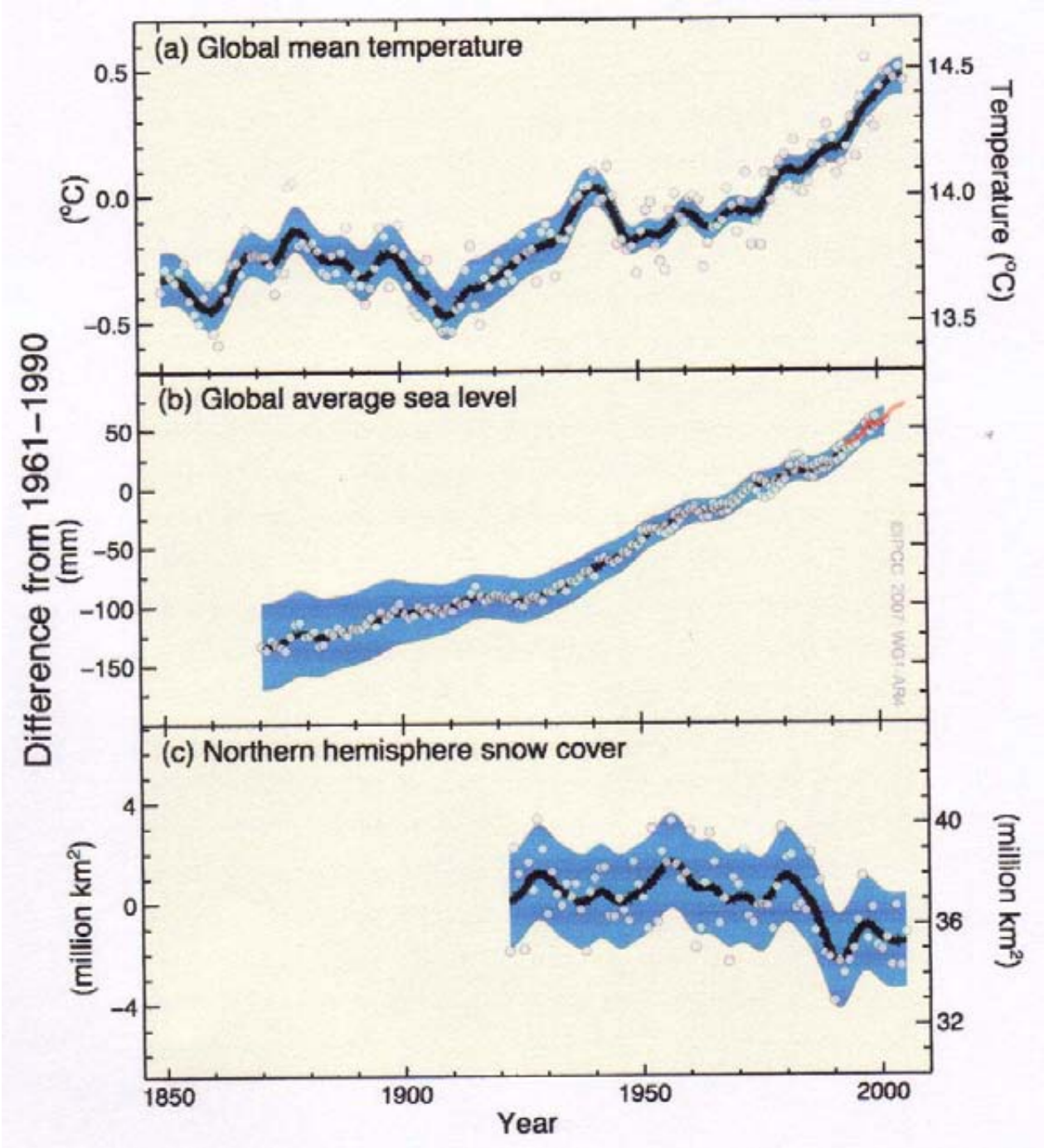
Changes in greenhouse gases





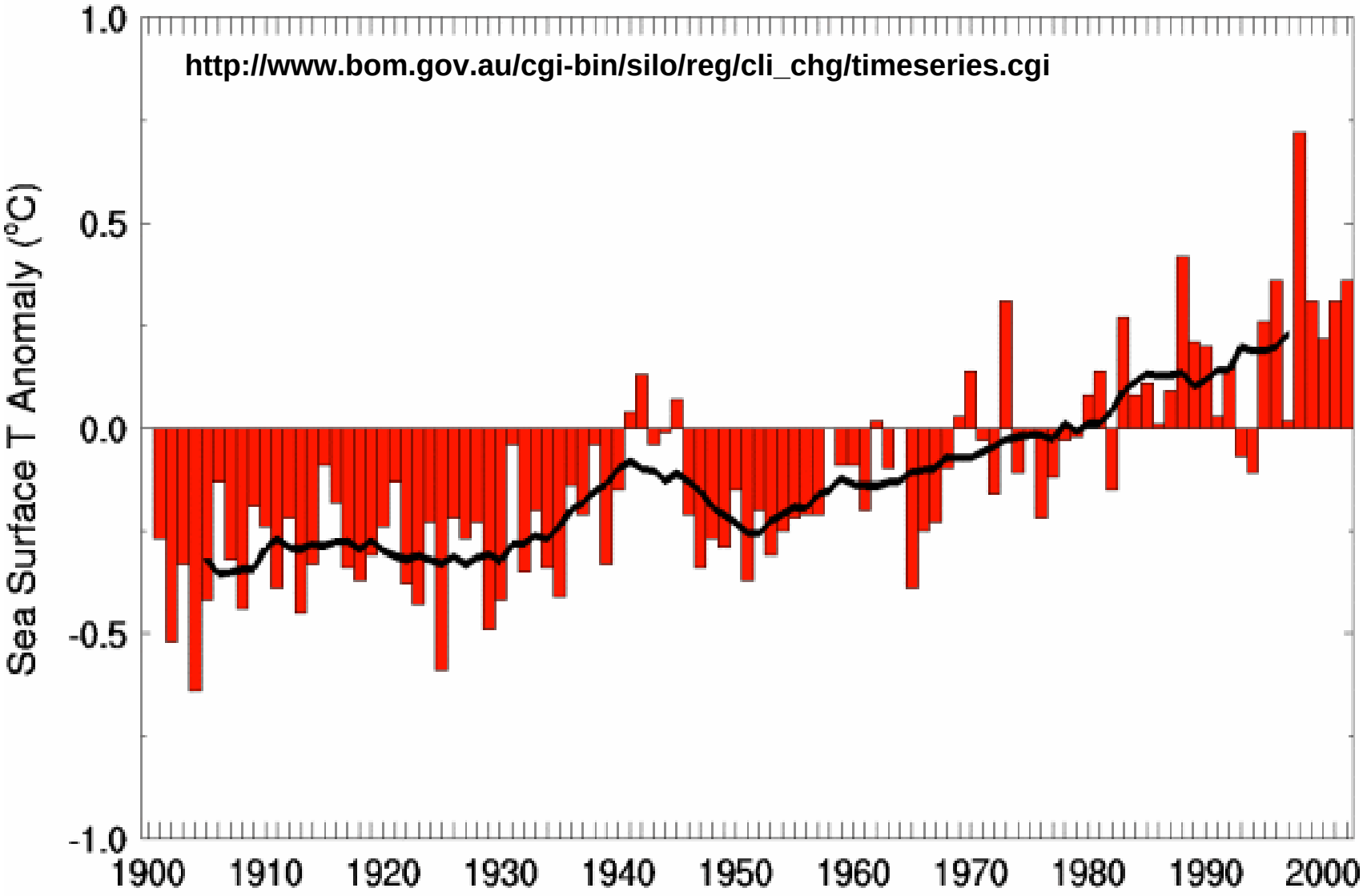
Source, IPCC 4AR, SPM, 2007

Changes of global temperature and northern hemisphere snow cover

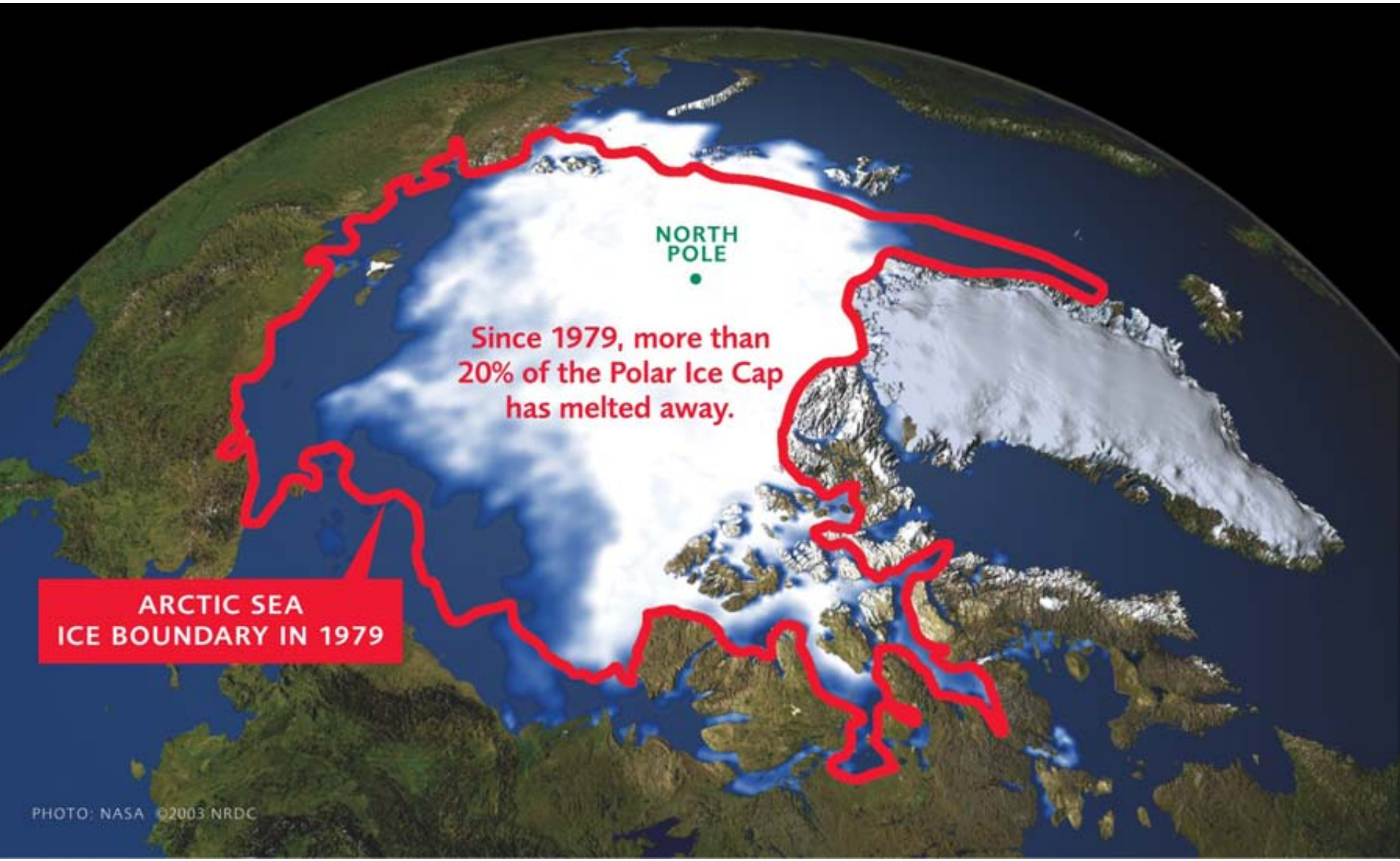


Source: IPPC 4AR, SPM

North Australian tropics annual sea surface temperature anomaly (from1961-1990)



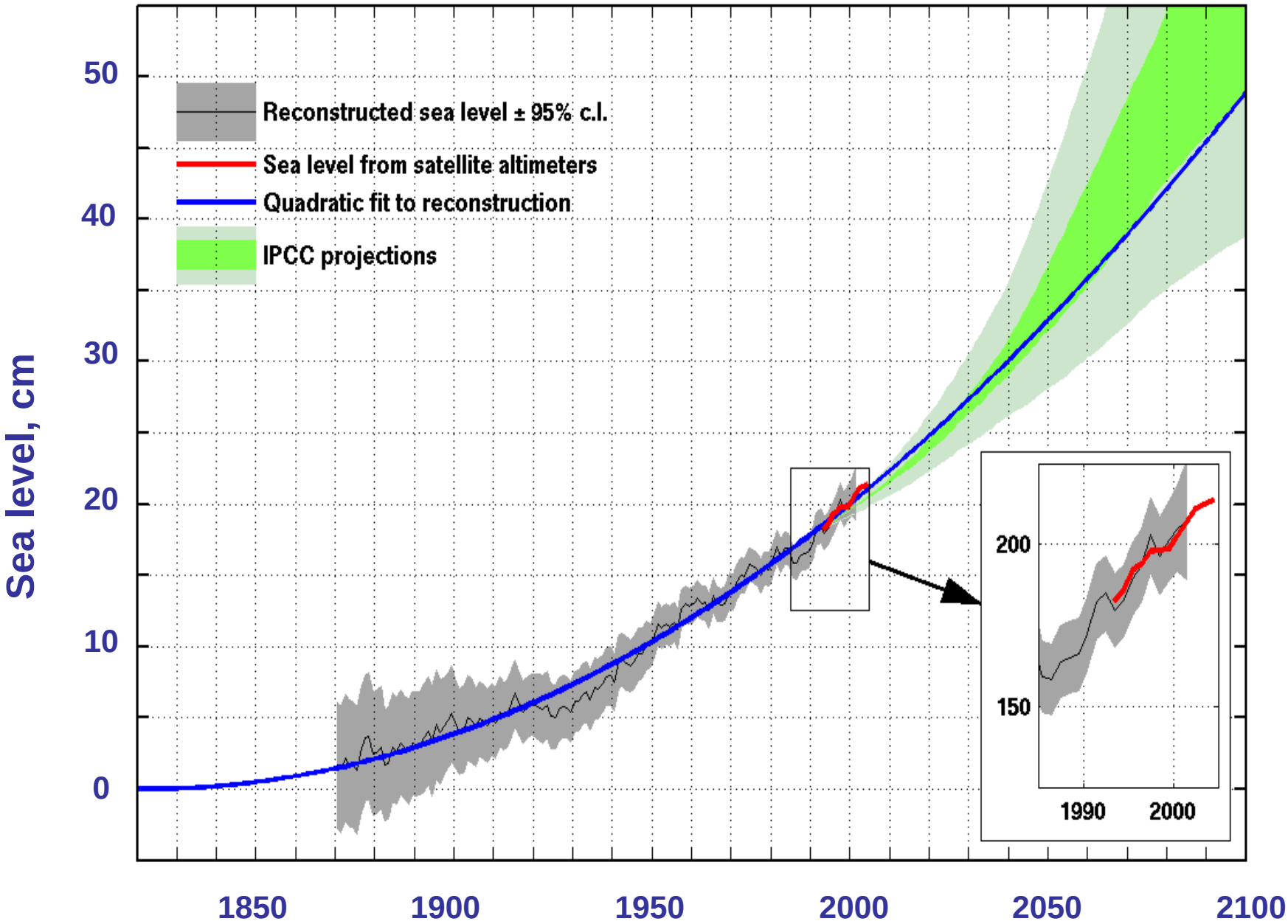
The Earth is de-glaciating



Key Findings: Observed change

Over past century:

- **Global temperatures risen by 0.74 ±0.18 °C**
- **11 of last 12 years rank amongst the 12 warmest years**
- **Snow cover decreased in most regions, especially in spring and summer**
- **Summer period extended 12.3 days**



After J Church, personal communication

Key Findings: Observed change

- **Arctic sea-ice extent decline of 2.7 ±0.6 per cent per decade**

- **Sea levels have risen at a rate of:**
  - **1961-2003 1.9 ± 0.5 mm yr-1**
  - **1900-2000 1.7 ± 0.5 mm yr^{-1}**

- **Ocean acidification**
  - **0.1 pH unit so far**

Key Messages

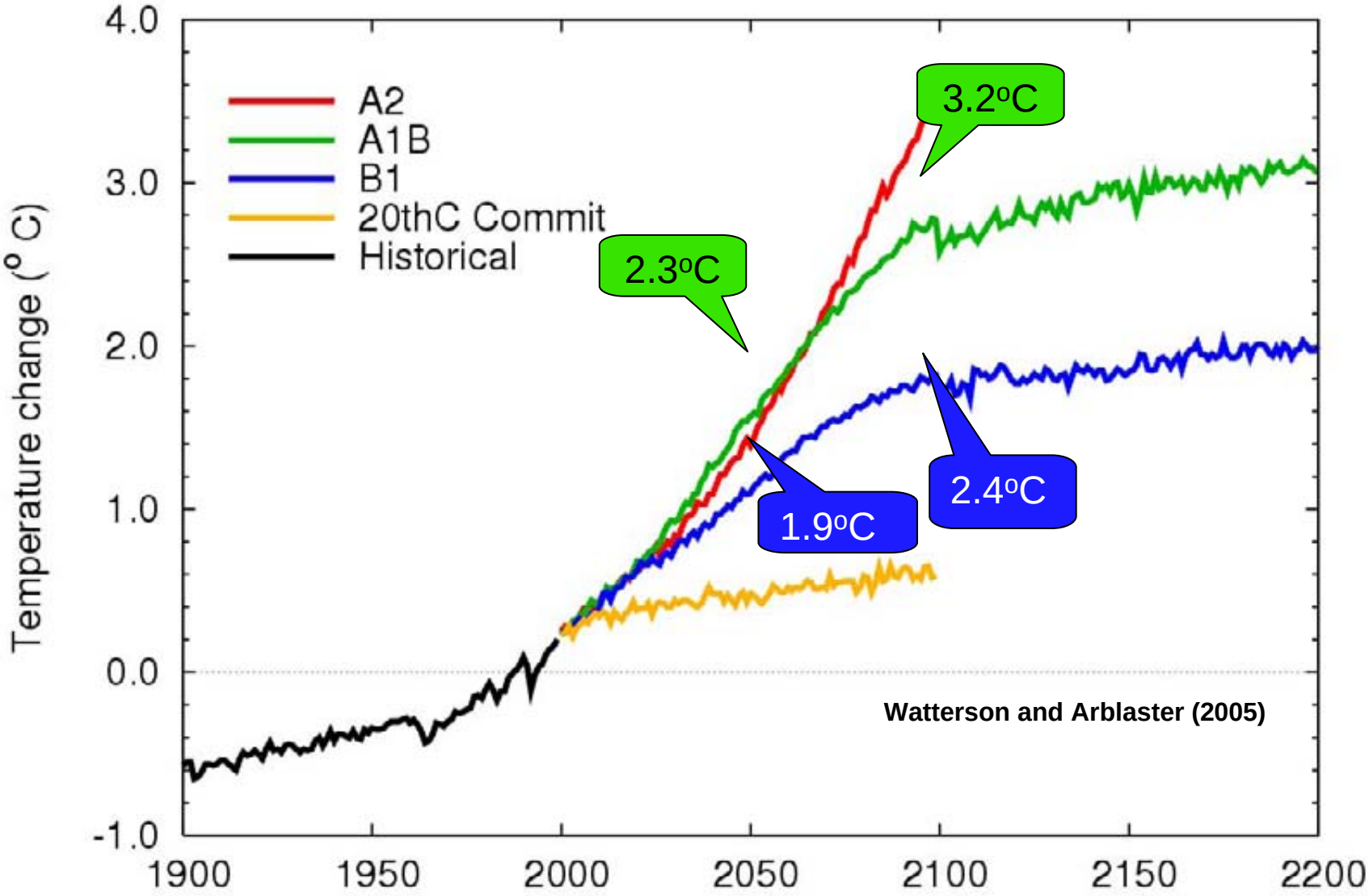
Gases

- **Current carbon dioxide and methane concentrations far exceed those of last 650,000 years**
- **Increases primarily due to fossil fuel use, agriculture and land-use changes**

Warming

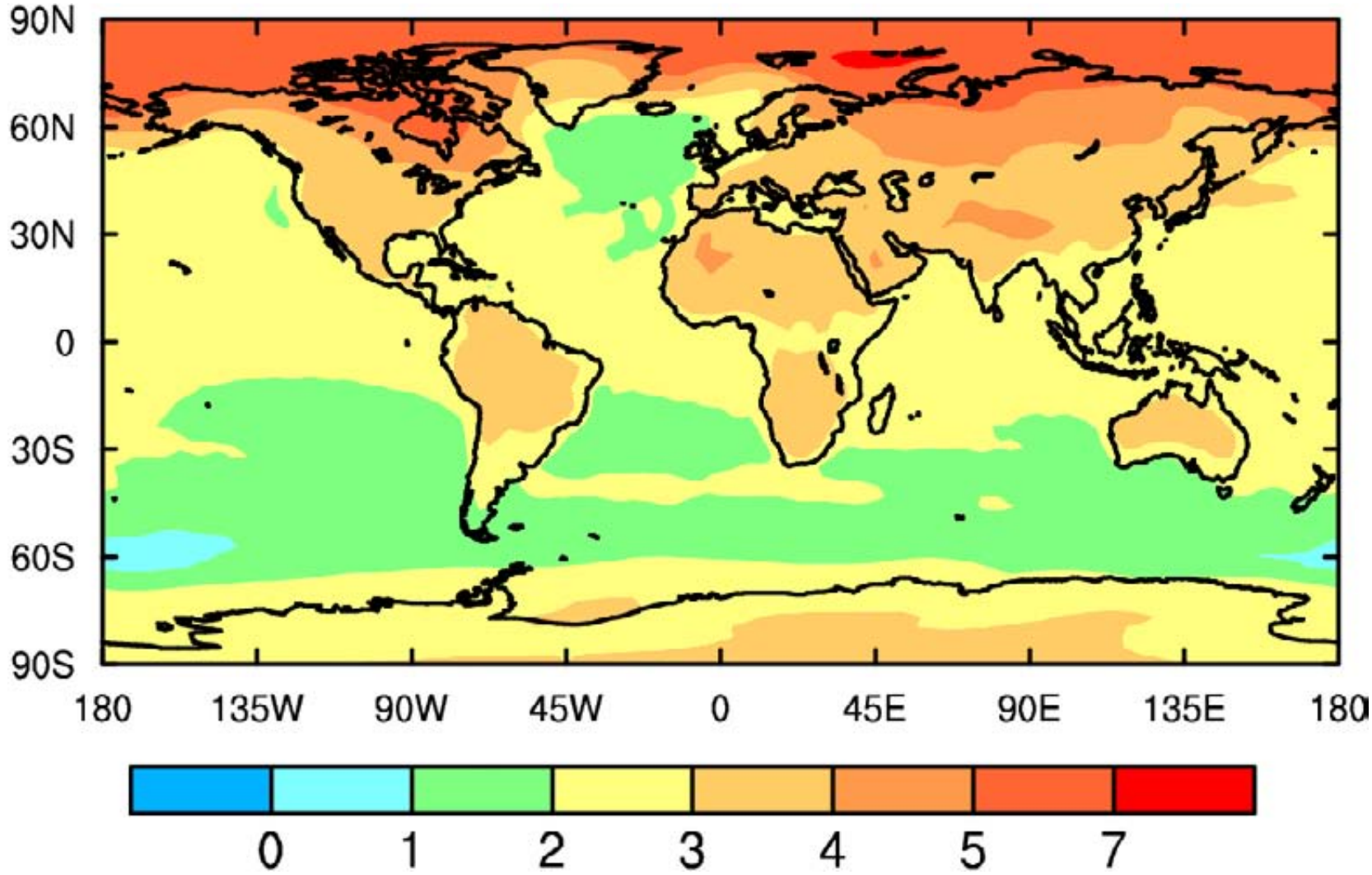
- **Unequivocal, evident in air and ocean temperatures, melting of snow and ice and rising sea-levels**
- **Warming an effect of human activities - at least 5 times greater than that due to solar output change**

Global warming relative to 1980-1999
17-model average, 4 emission futures



Annual warming for 2080-2099

17-model average, A1b emission futures



Watterson and Arblaster (2005)

Key Findings: Future warming

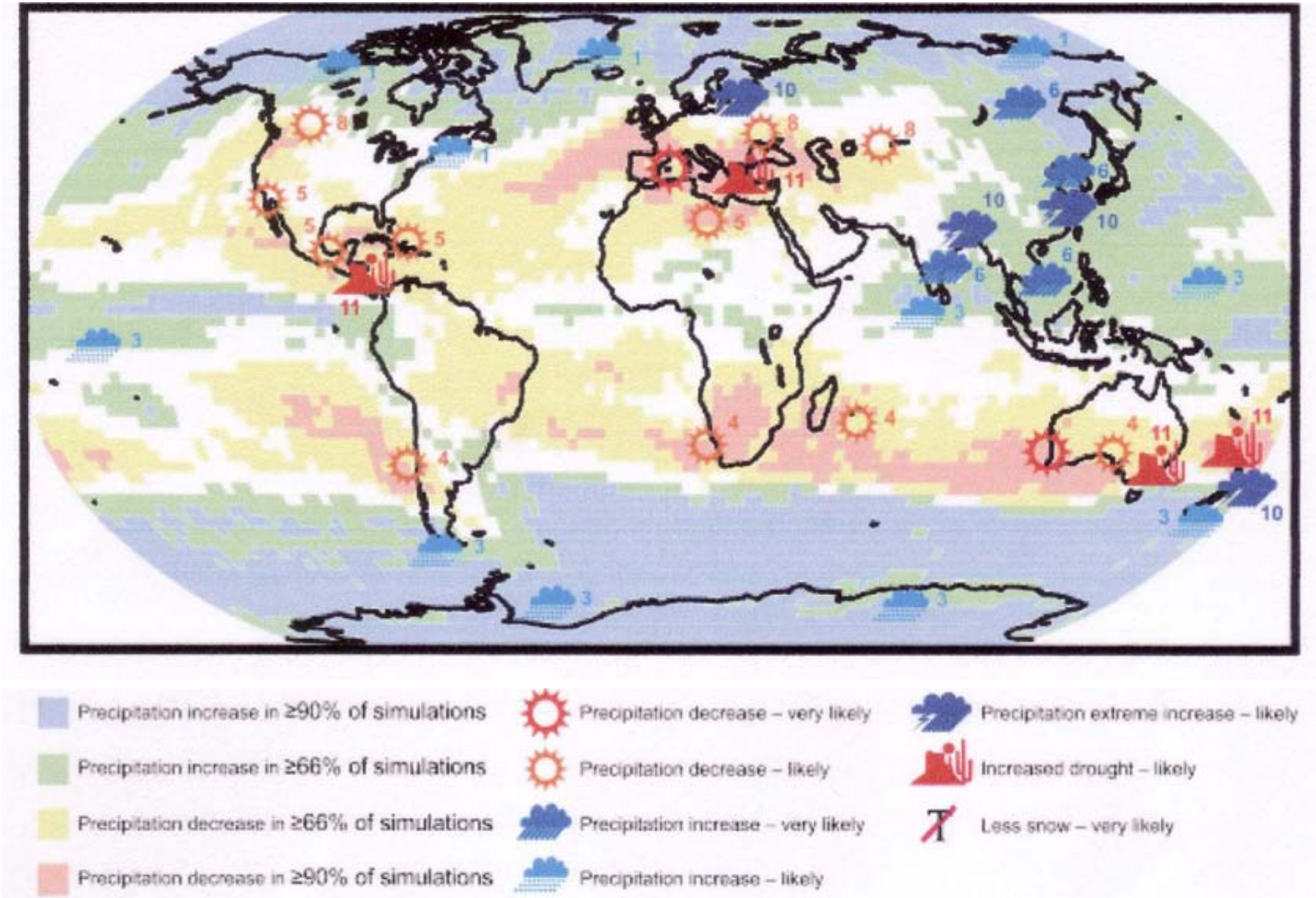
Based on up to 23 global climate models

- **Mean temperatures**
  - 2025 0.6-0.7 ^{o}C Higher over land/high latitude
  - 2055 1.3-1.7 ^{o}C
  - 2095 1.7-4.0 ^{o}C
  - Transient at time of doubling CO_2 2-4.5 ^{o}C
- **Extreme temperatures**
  - More frequent, intense, longer lived heat waves
  - Minimum temperatures warm faster than maximum
  - Decrease in frost days Mid to high latitudes
  - Increased growing season Mid to high latitudes

Key Findings: Precipitation

- **Mean precipitation**
  - Increase tropics (monsoon)/high latitudes
  - Decrease subtropics/mid latitudes
- **Extreme precipitation**
  - Intensity of events to increase
  - Longer periods between events (sub-tropics/mid latitudes)
- **Tropical cyclones (hurricanes, typhoons)**
  - Increased peak wind and precipitation
  - Possible overall less frequent
  - Geographic shifts
- **Mid latitude storms**
  - Fewer- pole ward shift (several degrees)
  - Lower central pressure- increased wind speed/ waves

June-July-August



Key Findings

- **El Nino**
  - To continue- still confused trends if any
- **Monsoons**
  - Increase precipitation but projections confused by aerosols
- **Snow and ice**
  - Snow cover and sea ice extent decrease
  - Glaciers and ice caps lose mass
  - Loss of Arctic sea ice as early as mid 21st century
  - Increase of thaw depth
- **Carbon cycle**
  - Unanimous agreement: loss of CO_2 absorption efficiency
  - Greater atmospheric accumulation of CO_2
  - Still significant model difference/uncertainties

Key Findings: The oceans

- **Sea level**
  - By end of century a further rise of 0.19-0.58 m
  - Regionally different
  - Limited knowledge of ice flows and sea level contribution
- **Ocean acidification**
  - 0.1 pH unit so far
  - 0.14-0.35 pH units in the 21st century
  - Southern Ocean exhibits under-saturation
- **Atlantic ocean overturning**
  - Decrease by less than 0-25% no collapse by 2100

Major key messages

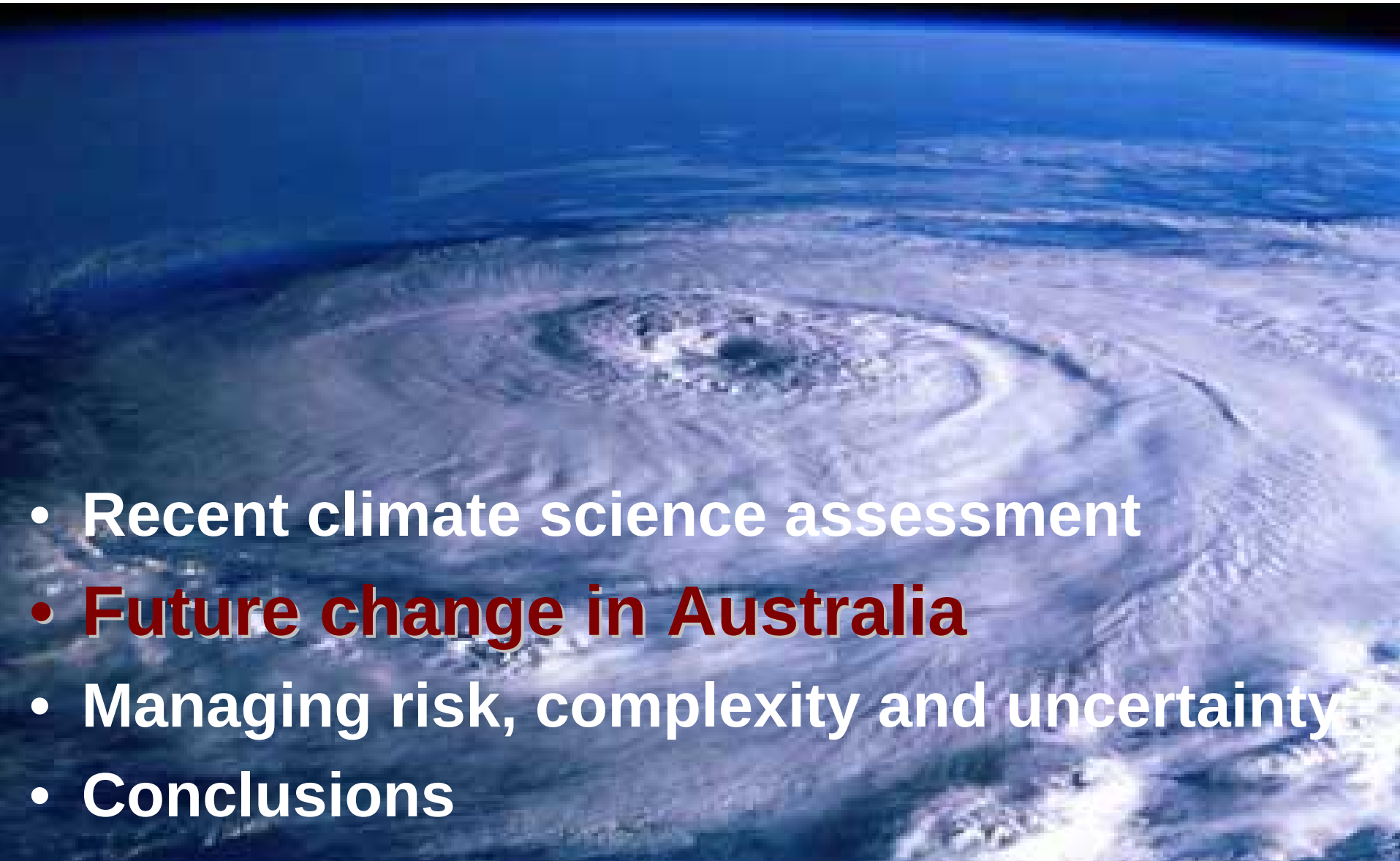
Cause of warming

- Very likely (>90%) greenhouse-gas increase caused most of warming since mid-20th century
- Extremely unlikely (<5%) warming caused by natural variability

Future warming

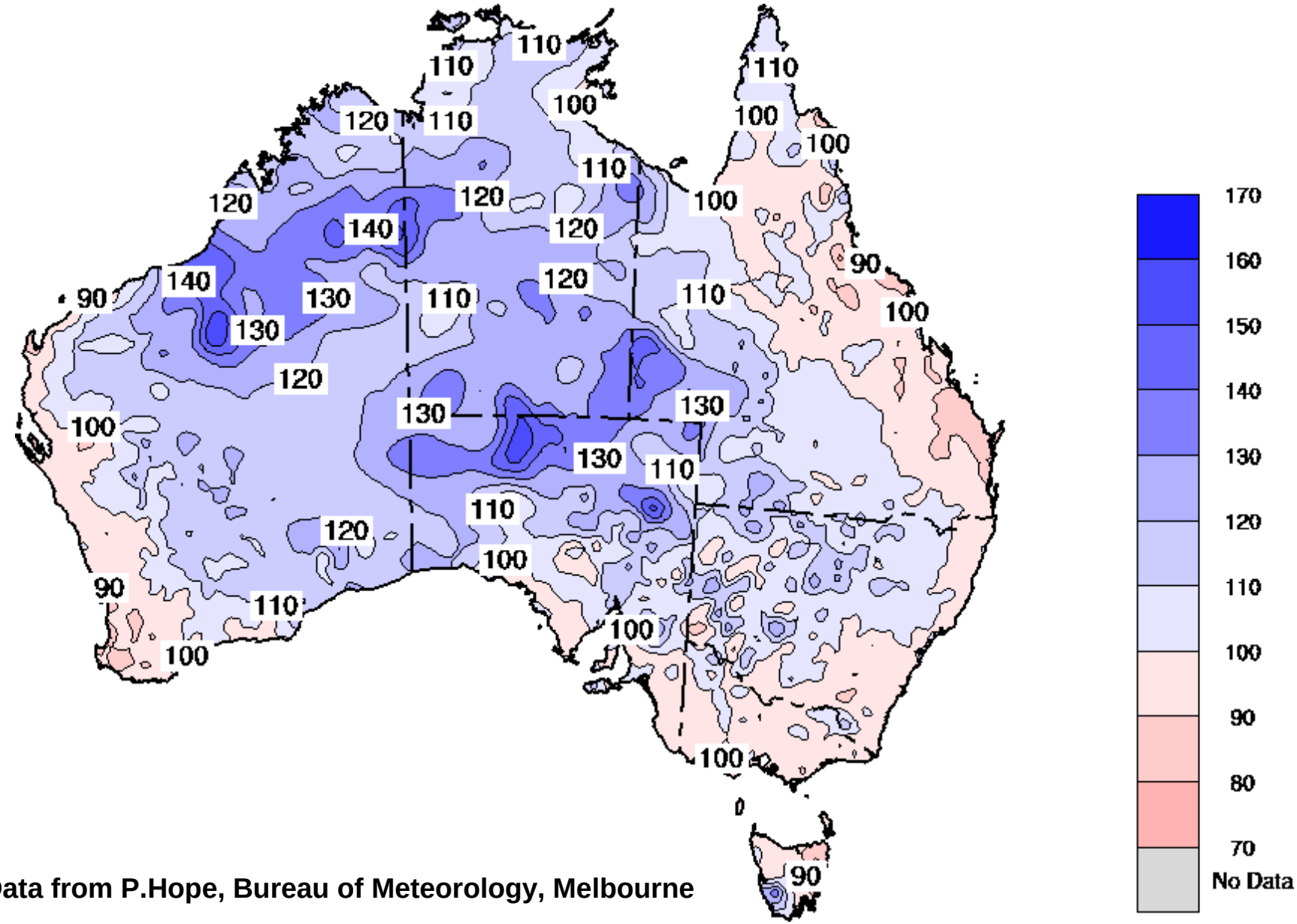
- Warming for next 2 decades to be 0.2^{o}C/decade
- BAU emissions would very likely (>90%) to cause 21st century warming larger than during 20th century

Climate change: the evidence, science and current projections



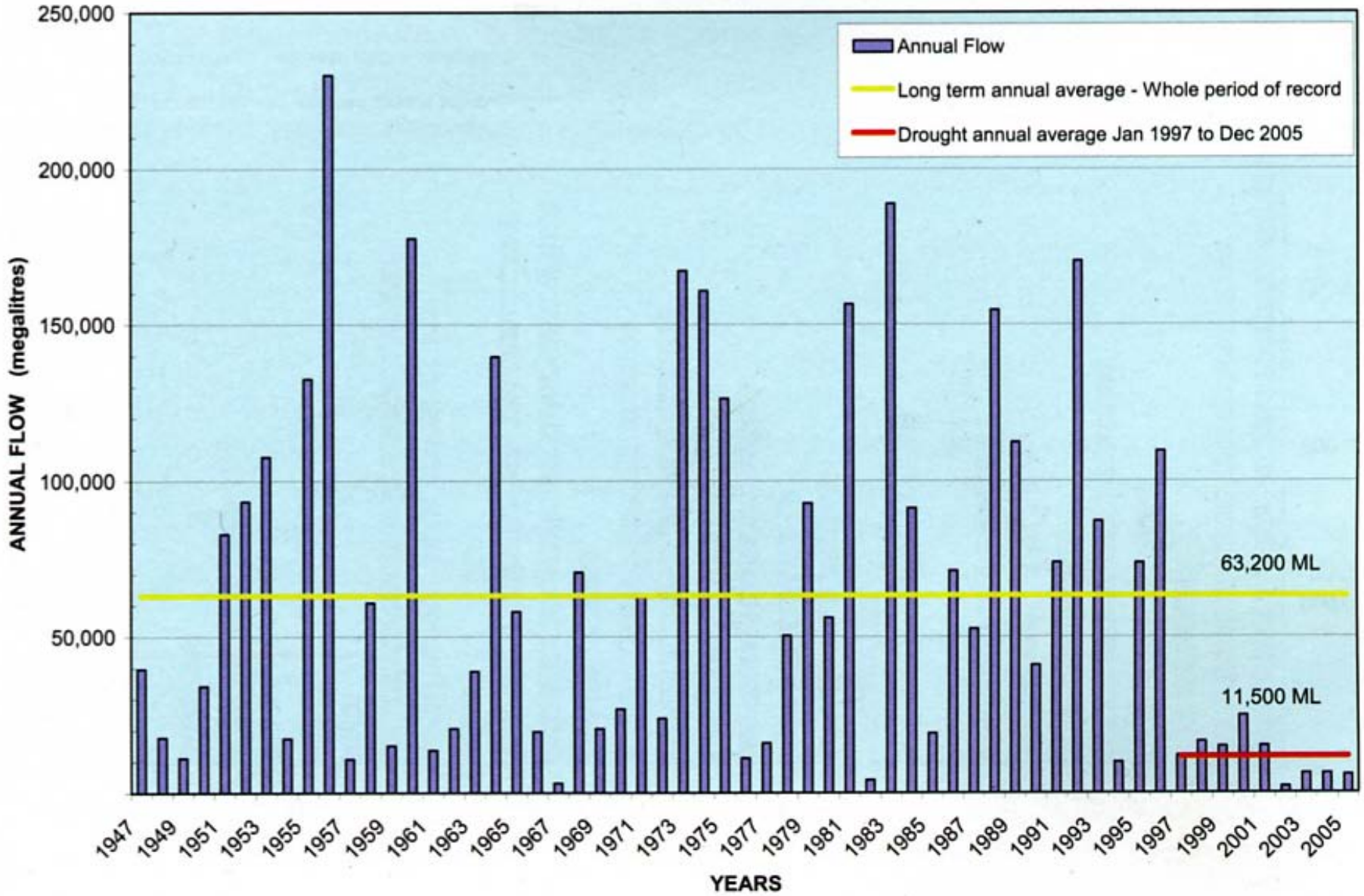
- Recent climate science assessment
- **Future change in Australia**
- Managing risk, complexity and uncertainty
- Conclusions

Annual Rainfall: ((1976-2003)/(1925-1975))x100



Data from P.Hope, Bureau of Meteorology, Melbourne

Long-term annual average flow
1947-2005, Wimmera River at Glynwylin



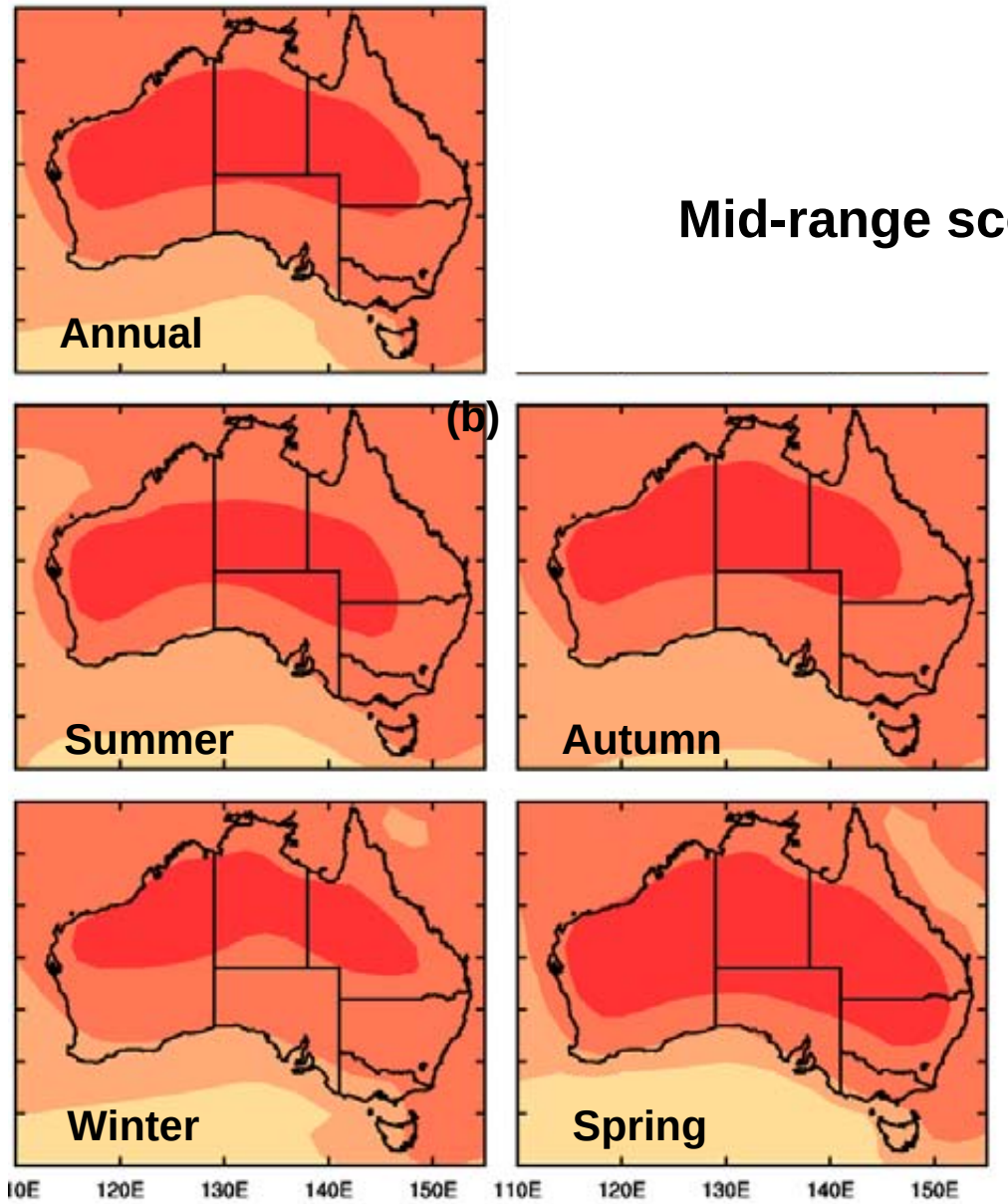
Natural system changes linked to climate change in Australia/New Zealand

- **Ecosystems**
  - Semi arid woodlands, Eucalypt savannas, rain forest/woodland, subalpine, mangroves, coral reefs
- **Genera**
  - birds, Antarctic beech, mammals, insects (including genetic changes), sea urchins, marine mammals, fish, invasive species
- **Behaviour**
  - flowering phenology, earlier migration and egg laying, seed production

Lough (2000); Evans et al. (2003): Hughes (2003); Thresher et al. (2003); Chambers et al. (2005); Umina et al. (2005); etc.

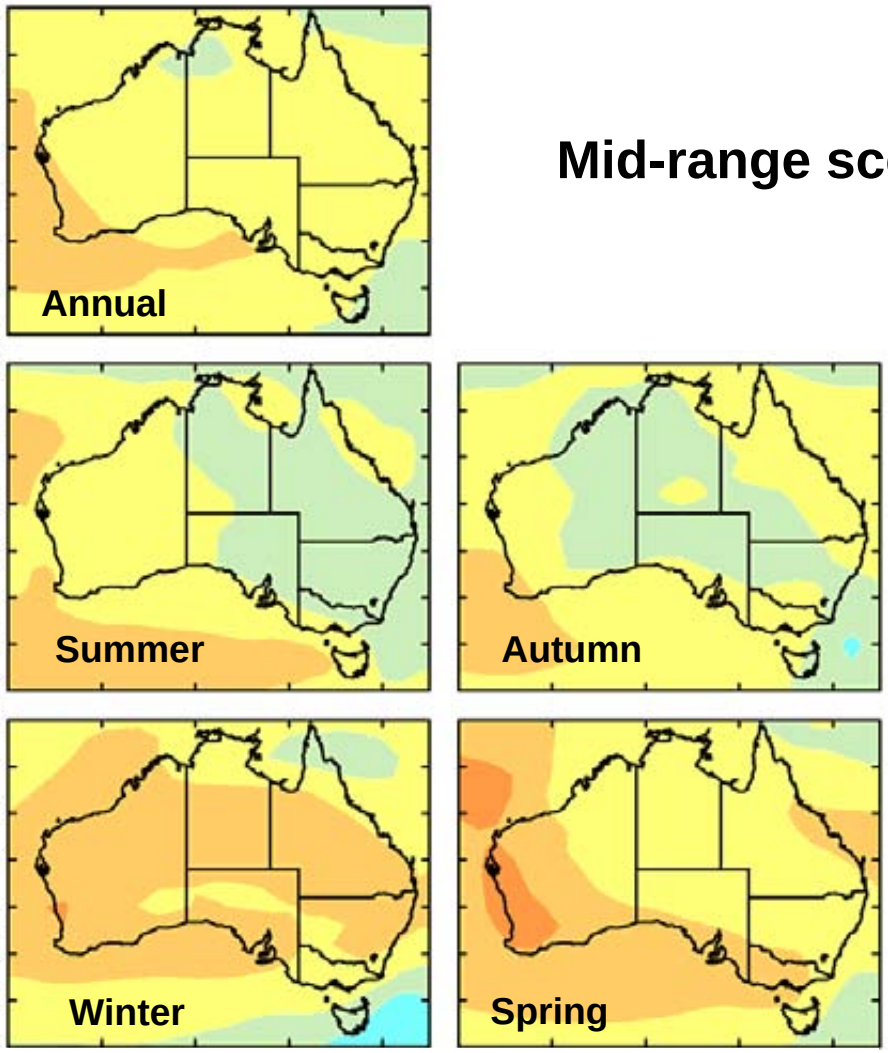
15-model average changes in temperature by 2070, relative to 1990

Mid-range scenario



Suppiah et al. (in prep)

15-model average changes in rainfall by 2030 relative to 1990



Suppiah et al. (in prep)

Mid-range scenario

Mid refers to middle range global warming values used to scale the patterns of change

Rainfall change (%)

Key Findings: Australian Region

- **Mean temperature**
  - South of 30°S by 2100 2.6 (2.4-2.9 inter-quart range)
  - North of 30°S by 2100 3.0 (2.8-3.5)
  - Less in coastal regions more inland
- **Mean precipitation**
  - South of 30°S, JJA, 2100, -26 to -7%
  - East coast increase in summer, decrease in winter. Less robust
- **Snow cover**
  - 30-days snow cover reduced to14-54% by 2020 and 30-93% by 2050
- **Potential evaporation**
  - Almost all indications are for a moisture balance deficit- a drier Australian environment

Key Findings: Australian Region

- **Mean temperature**
  - **South of 30ºS by 2100 2.6ºC (2.4-2.9 inter-quart. range)**
  - **North of 30ºS by 2100 3.0ºC (2.8-3.5)**
- **Mean precipitation**
  - **South of 30ºS, July-August by 2100, -26 to -7%**
- **Potential evaporation**
  - **Almost all indications are for a moisture balance deficit- a drier Australian environment**

Key Findings:
Australian Region- Extremes

- Days over 35ºC
  - Melbourne 8 to 9-12 (2020) and 10-20 (2070)
  - Perth 15 to 16-22 (2020) and 18-39
- Commonly return period of extreme rainfall events halve through 21st century
- NSW/Qld rainfall 30% increase in magnitude, 1 in 40 becoming 1 in 15 year event
- Marked increase frequency of rainfall deficits, doubling in some case by 2050

Potentially vulnerable systems

Vulnerable	Drivers of change	Impacts	Economy
Eastern Australian Alps	Reduced precipitation & snow cover	Shortened winter season. Loss of plant species, increased shrubs, less herbs	Threats to built environment, biodiversity, ski industry viability/costs and tourism
Eastern Queensland	Coastal impacts of sea level rise, storm intensity	Losses to infrastructure and coastal amenity	Tourism implications. Infrastructure costs and insurance risk
Kakadu	Salt water intrusions	Displacement of freshwater wetlands with mangroves	Biodiversity and tourism implications
Murray Darling Basin	Reduced river flow	Enhanced water competition for natural flows, irrigation and town water supplies	Higher cost of water. Loss of agricultural production and biodiversity
Queensland wet tropics	Coastal impacts of sea-level rise & storm Intensity	Species extinction, loss of coral reefs, coastal flooding and infrastructure damage	Tourism implications. Infrastructure costs & insurance risk
SW Western Australia	Drying	Water shortages, fragmentation of ecosystems	Loss of agriculture production or enforced changes. Loss of biodiversity
Sub Antarctica islands	Warming & de-glaciation	Loss of key species and rapid changes to ecosystem assemblages	Loss of biodiversity

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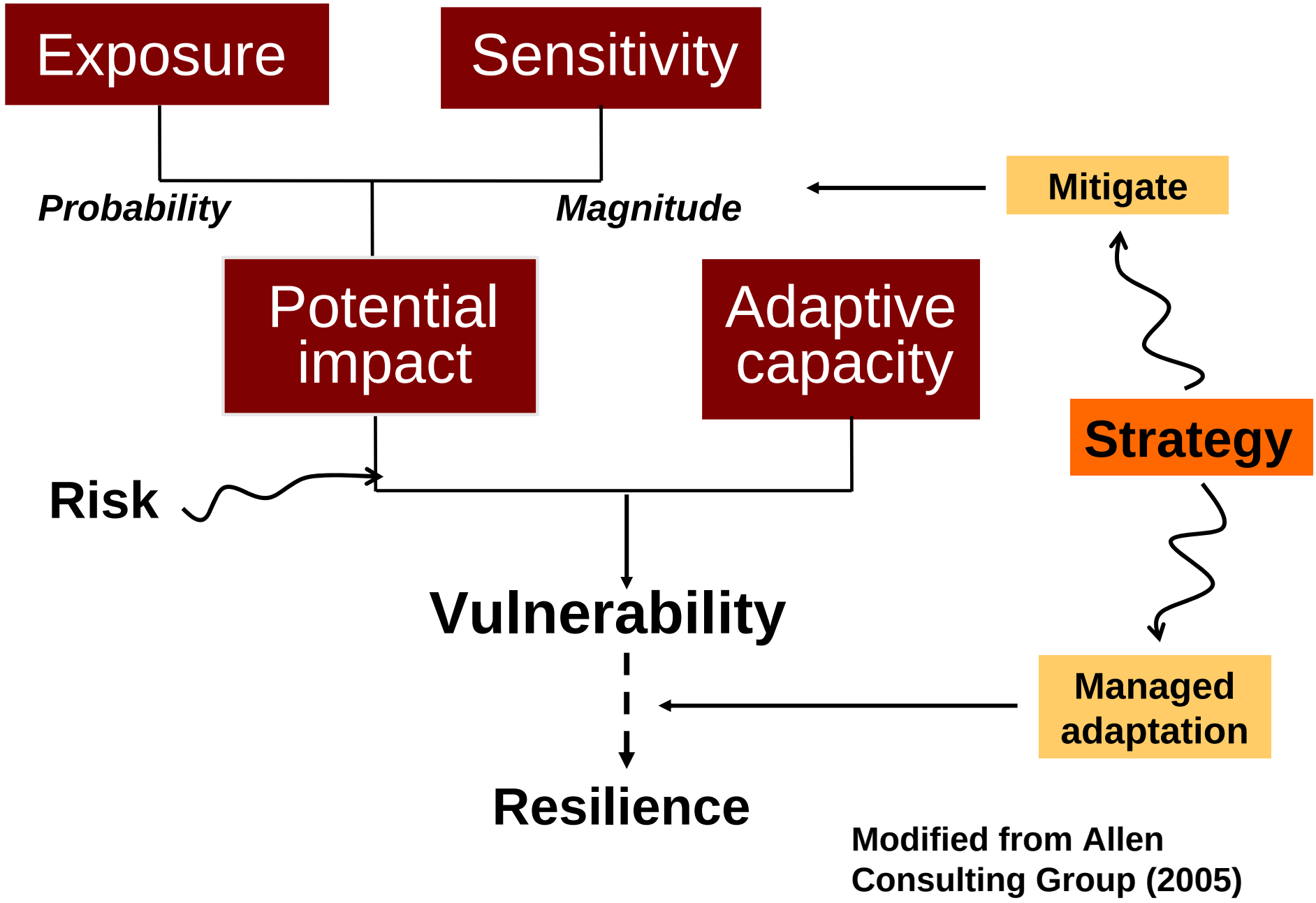

Modified from Allen Consulting Group (2005)

Managing complexity

- **Multi-sectorial/disciplinary knowledge and applications (impacts and adaptation)**
  - **Biodiversity production**
  - **Human health**
  - **Energy supply/demand (technological options)**
  - **Security**
  - **Food and fibre**
  - **Water supply**
  - **Etc.**
- **Multi-aspirational**
  - **Economic strength**
  - **Social well-being**
  - **Environmental protection**
  - **Intergenerational equity**

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UK Foreign Secretary, Margaret Beckett, The Age, Oct. 26, 2006

"This is not just an environmental problem.
It is a defence problem.
It is a problem for those who deal with economics and development, conflict prevention, agriculture, finance, housing, transport … trade and health".

Conclusions

- **Recent science strongly reinforces the views that:**
  - **Global warming is occurring**
  - **It is primarily a result of human activities**
- **Australia, particularly south of 30^{o}S is likely to:**
  - **Lose 10-30% precipitation though the 21st century**
  - **Experience a drier climate**
- **Tertiary effects of climate trends have probably been grossly understated**
- **There is a rapidly emerging urgency for both adaptive and mitigative action**
- **Challenges exist in how we manage the sheer complexity of climate change and the response options- *Coping with sustainability***