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Climate change projections for five tourism Australian regions

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Talk Outline

- The peer review process
- Observed changes & causes
- Climate projections
- Impacts
- Adaptation & mitigation

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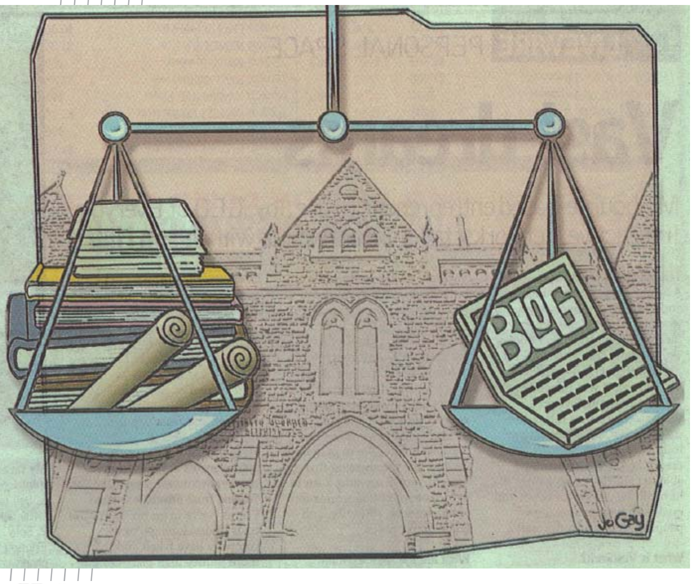
The peer-review process



- Information about climate change can be found from a variety of sources, including scientific journals, technical reports, books, media articles and blogs
- The messages are not always consistent, so it's hard to know who and what to believe
- An article that has not been peer-reviewed, such as an opinion piece in a newspaper, has no particular scientific credibility
- Peer-review ensures that published findings are objective and conform to accepted scientific standards
- Without the peer-review system, publication of research findings would be arbitrary, and possibly influenced by personal, social or political agendas

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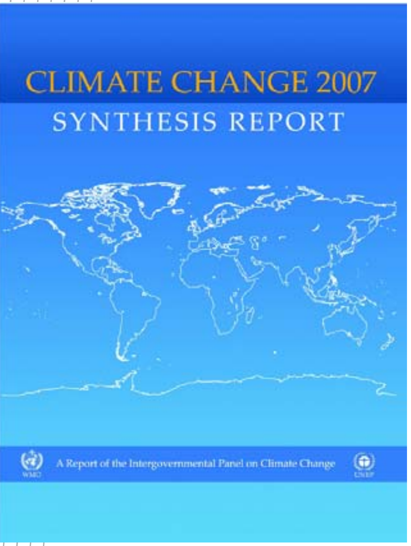
The peer-review process

- For scientific journals, the process is very rigorous and starts with the submission of a manuscript
- The editorial staff refer the manuscript to at least two impartial reviewers who are qualified to judge the quality of the research
- The reviewers' comments are passed back to the authors via the editor, indicating what changes need to be made before publication
- The final decision about whether the manuscript should be published lies with the editor

The peer review process



Not all scientific books are peer-reviewed. Even though the help of many scientists may be acknowledged, the expertise and impartiality of these scientists cannot be guaranteed

Some scientific conference proceedings include peer-reviewed papers, but the rejection rate is usually low

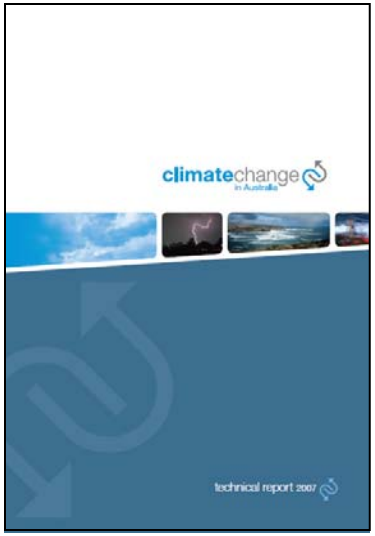
Major reports are normally peer-reviewed

- For example, the Intergovernmental Panel on Climate Change (IPCC) assesses the peer-reviewed literature on climate change
- More than 450 lead authors and more than 800 contributing authors were involved
- Comments were sought from over 2,500 scientific expert reviewers hundreds of government reviewers
- The relevant authors addressed every comment to the satisfaction of independent Review Editors
- Each Summary for Policymakers was approved line-by-line by officials from 113 governments

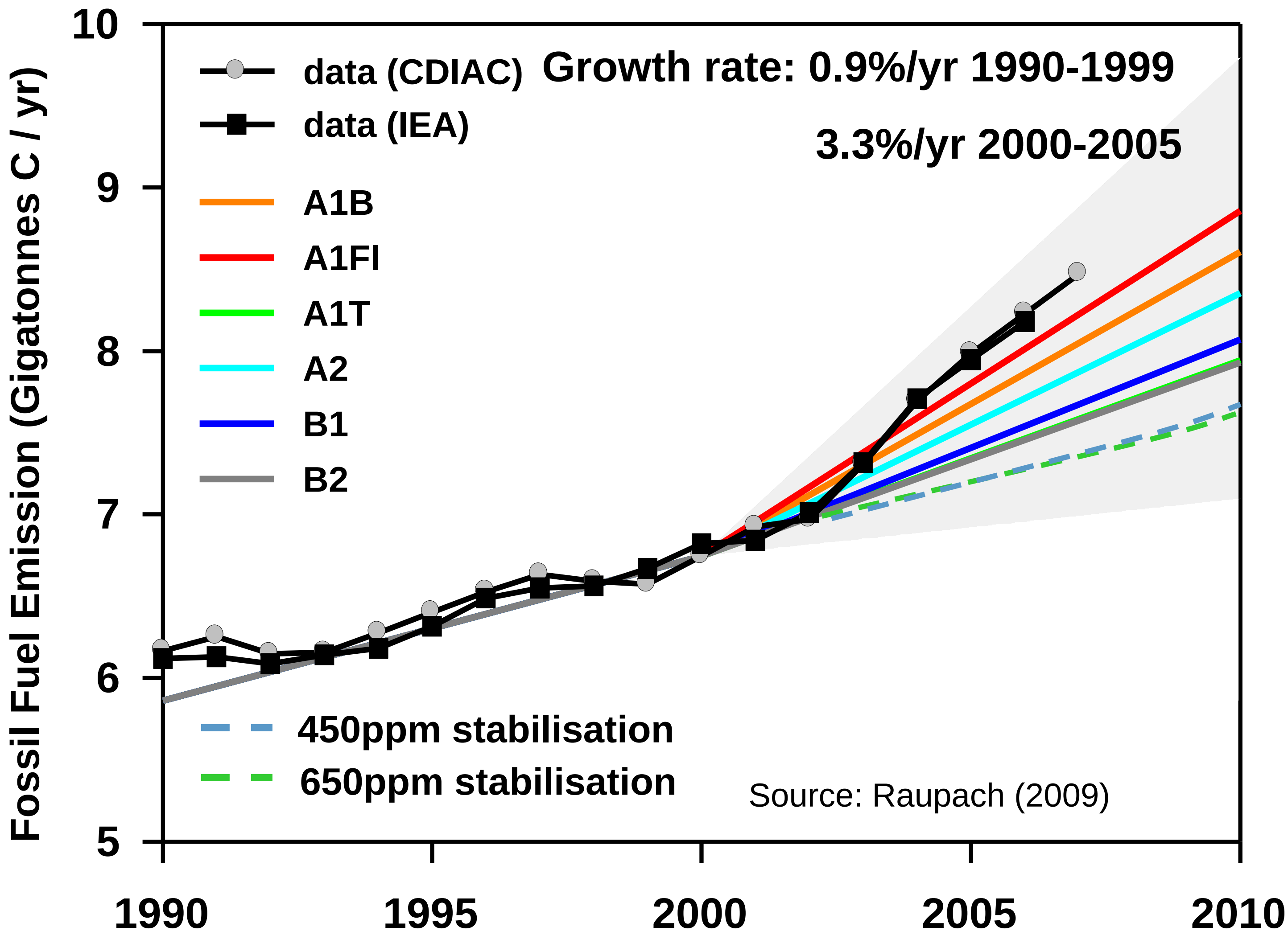
Climate change in Australia

- Climate change in Australia (CSIRO and BoM 2007) was reviewed by a number of non-CSIRO climate scientists. It describes observed climate changes causes, along with projections for 6 emission scenarios by 2030, 2050 and 2070 for a range of climate variables. See:

  http://www.climatechangeinaustralia.gov.au



Observed changes: greenhouse gases



CO_2 increase is due to human activities

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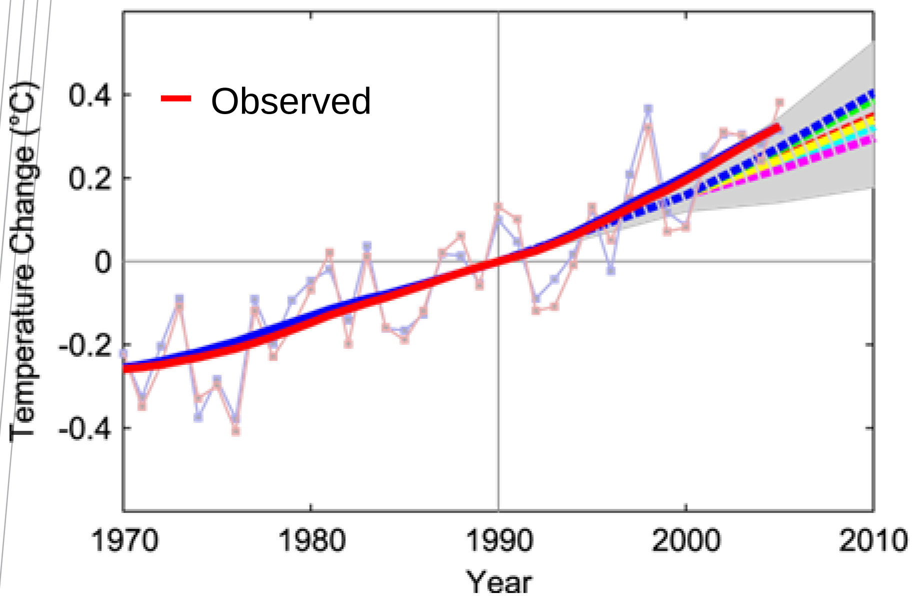
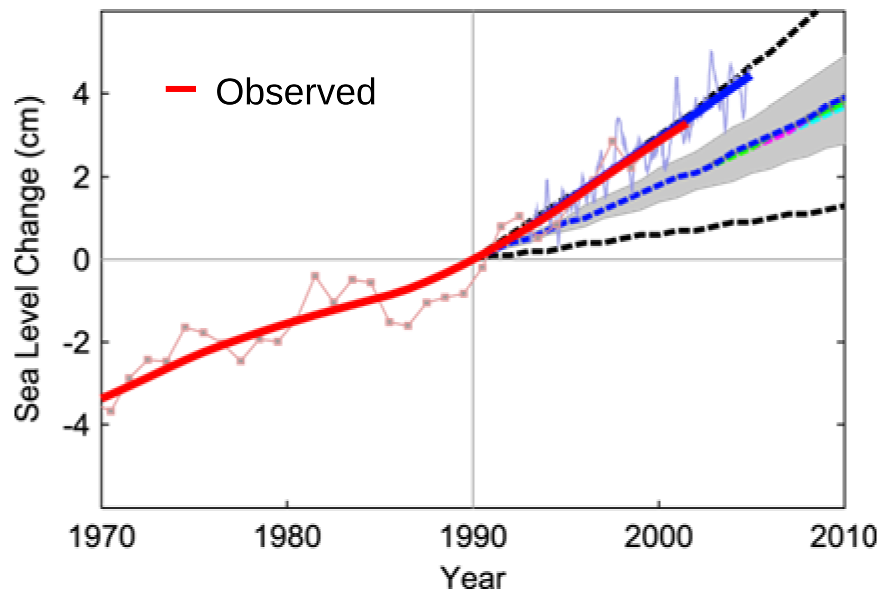
Observed changes: global average temperature and sea level

- Global average temperature and sea level are tracking the upper end of the IPCC projections
- The rate of warming since 1975 is almost 0.2^{o}C per decade
- The rate of sea level rise was 1.8 mm per year from 1961-2003, and 3.4 mm year from 1993-2007



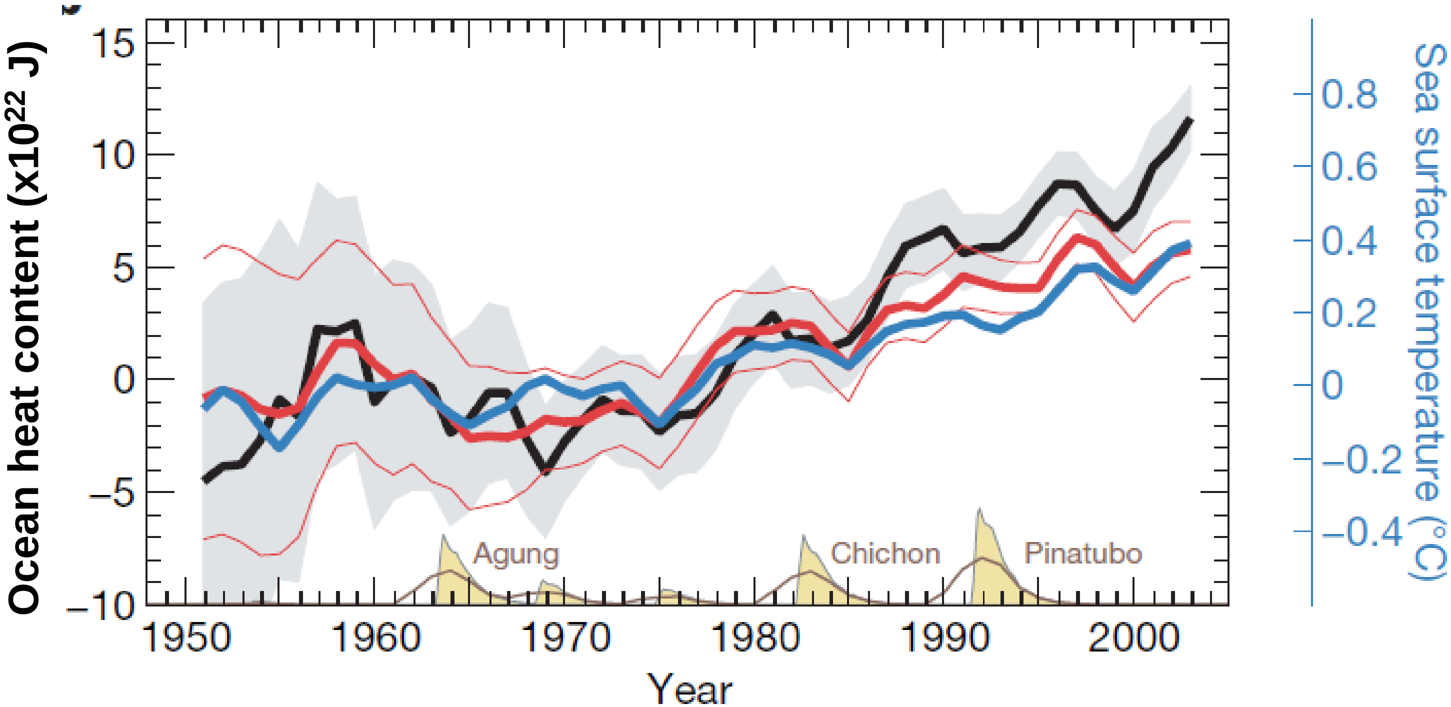


Rahmstorf et al 2007

Observed change: global warming

- Variations in global-average temperature over the past century can be measured in the near-surface air, the lowest 10 km of the atmosphere (the troposphere) and in the ocean
- All measurements indicate a long-term warming

Observed changes: ocean heat content



Increasing ocean heat content for upper 100m (red) and 700m (black) of the ocean for 1950–2003, and sea surface temperatures (blue). Source: Domingues et al (2008).

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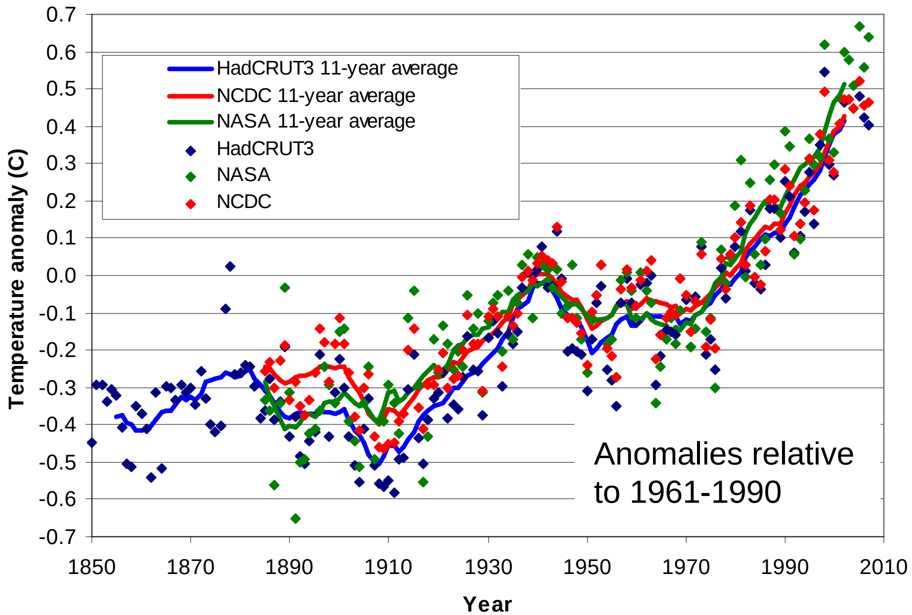
Observed changes: surface air temperatures

- **The Earth has warmed 0.74ºC since 1900**
- **13 of the past 14 years are the warmest since 1880, based on 3 datasets***

* NOAA & NASA datasets have 2005 as the warmest year, while the Hadley Centre dataset has 1998 slightly warmer than 2005



In the first half of the 20th century, increasing greenhouse gases, increasing solar radiation and a relative lack of volcanic activity all contributed to a rise in globally averaged temperature. During the 1950s and 1960s, global temperatures levelled off. This is most likely due to an increase in reflective particles in the atmosphere, known as aerosols, from increased industrialisation and the eruption of Mt. Agung in 1963. Since the 1970s, increases in greenhouse gases have dominated over all other factors, and there has been a period of sustained warming. Most of the warming since the mid-20th century is very likely (more than 90% confidence) due to anthropogenic increases in greenhouse gases (IPCC, 2007).

Observed changes: other aspects

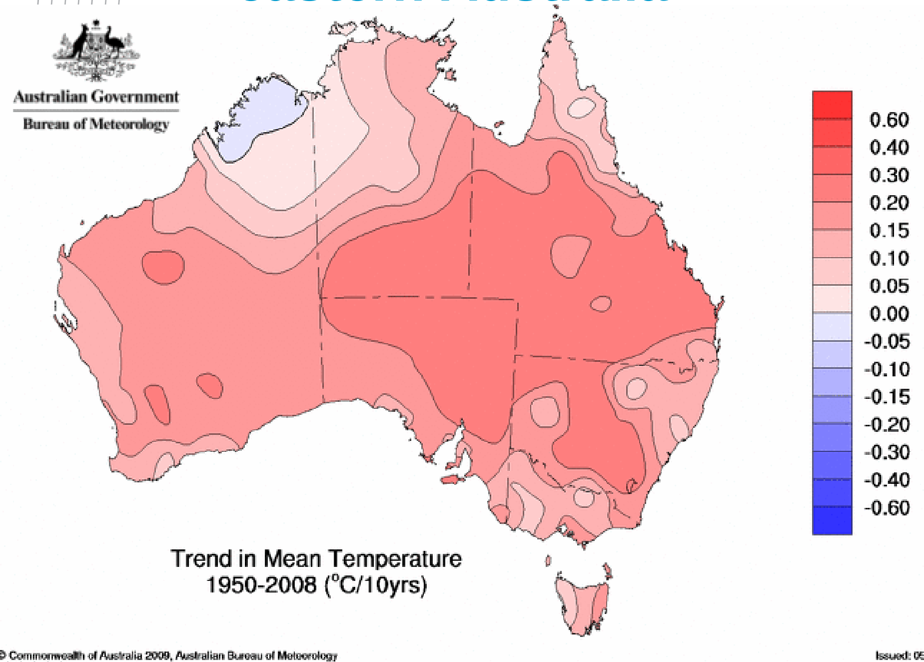
- Troposphere has warmed while the lower stratosphere has cooled
- Reduction in diurnal temperature range
- Increase in water vapour since at least 1980, consistent with theory that warmer air can hold more moisture
- More intense cyclones in North Atlantic since 1970, but no clear trend in cyclone numbers
- More-intense rainfall
- Oceans have become more acidic due to higher carbon dioxide
- Glaciers and Arctic sea-ice extent have decreased, but little change in Antarctic sea-ice
- Shifts in plant and animal locations and behaviour

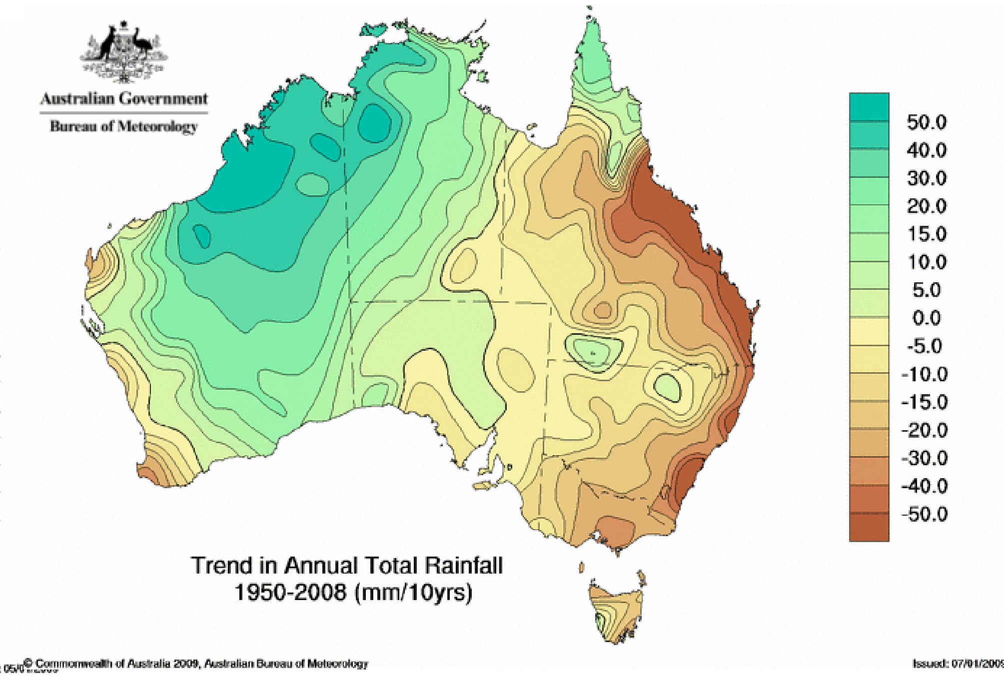
IPCC 2007

Observed changes: Australian climate

Since 1950, there has been a 0.9ºC warming, with more heat waves, fewer frosts

More rain in north-western Australia, less rain in southern and eastern Australia





Most of the warming is very likely due to increases in greenhouse gases

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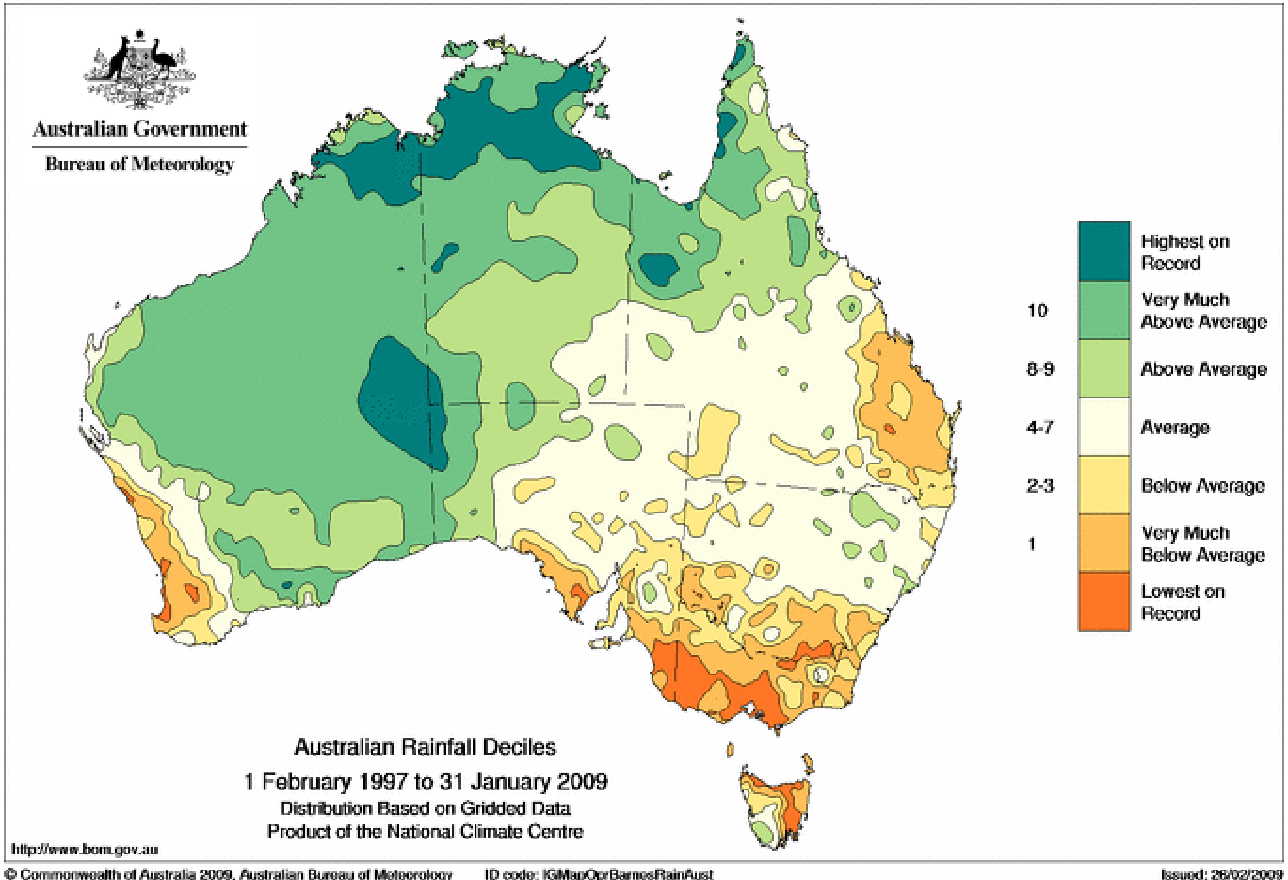
Observed changes: rainfall over past 12 years

- Very much above average in the north and west (except southwest)
- Very much below average in most of the south and south-east Qld
- Many water agencies are using 1997-2008 as a new baseline
- Impact on water resources is compounded by the warming trend



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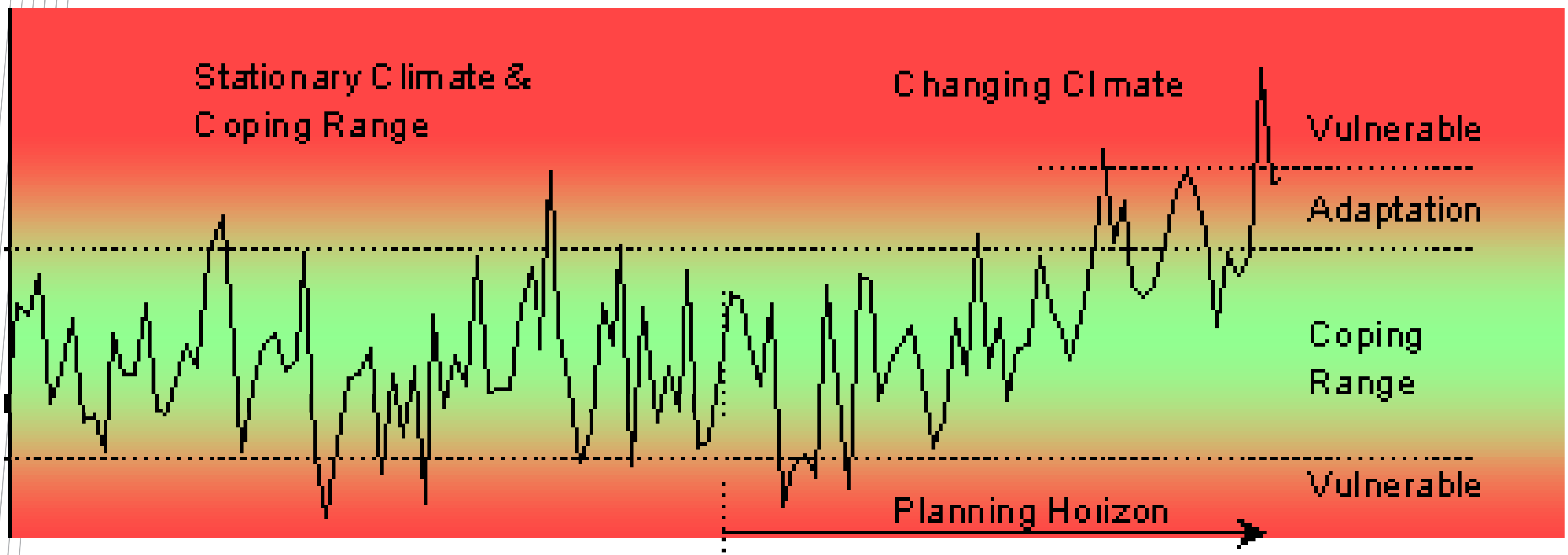
Projections: Australia

- Regional projections based on 23 climate models
- Average changes relative to 30 years centred on 1990
- Average changes will be superimposed on natural variability



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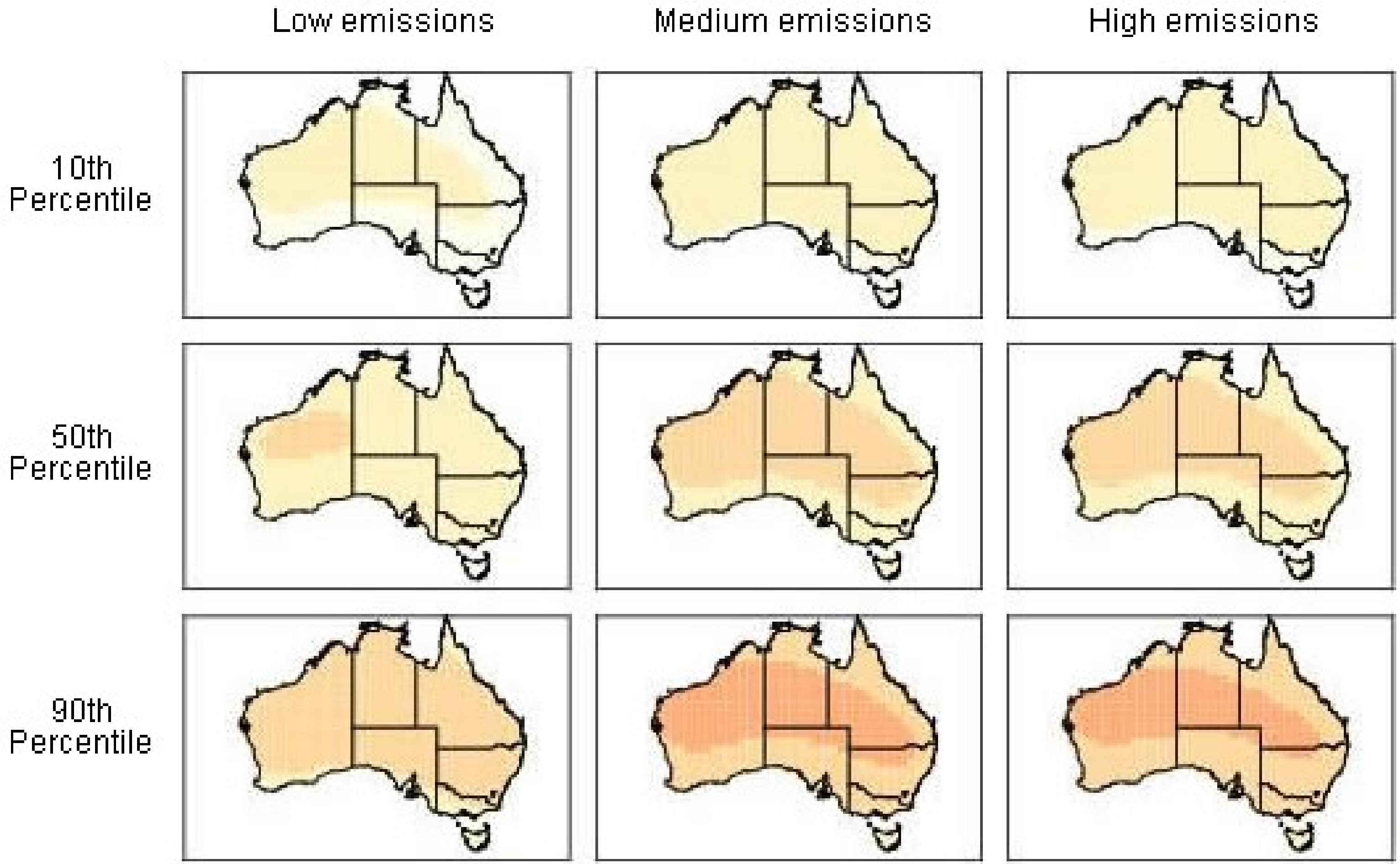
Projections: ranges of change

Ranges of uncertainty have been quantified, based on differences between emission scenarios and differences between climate model results (lowest 10% to highest 10%)



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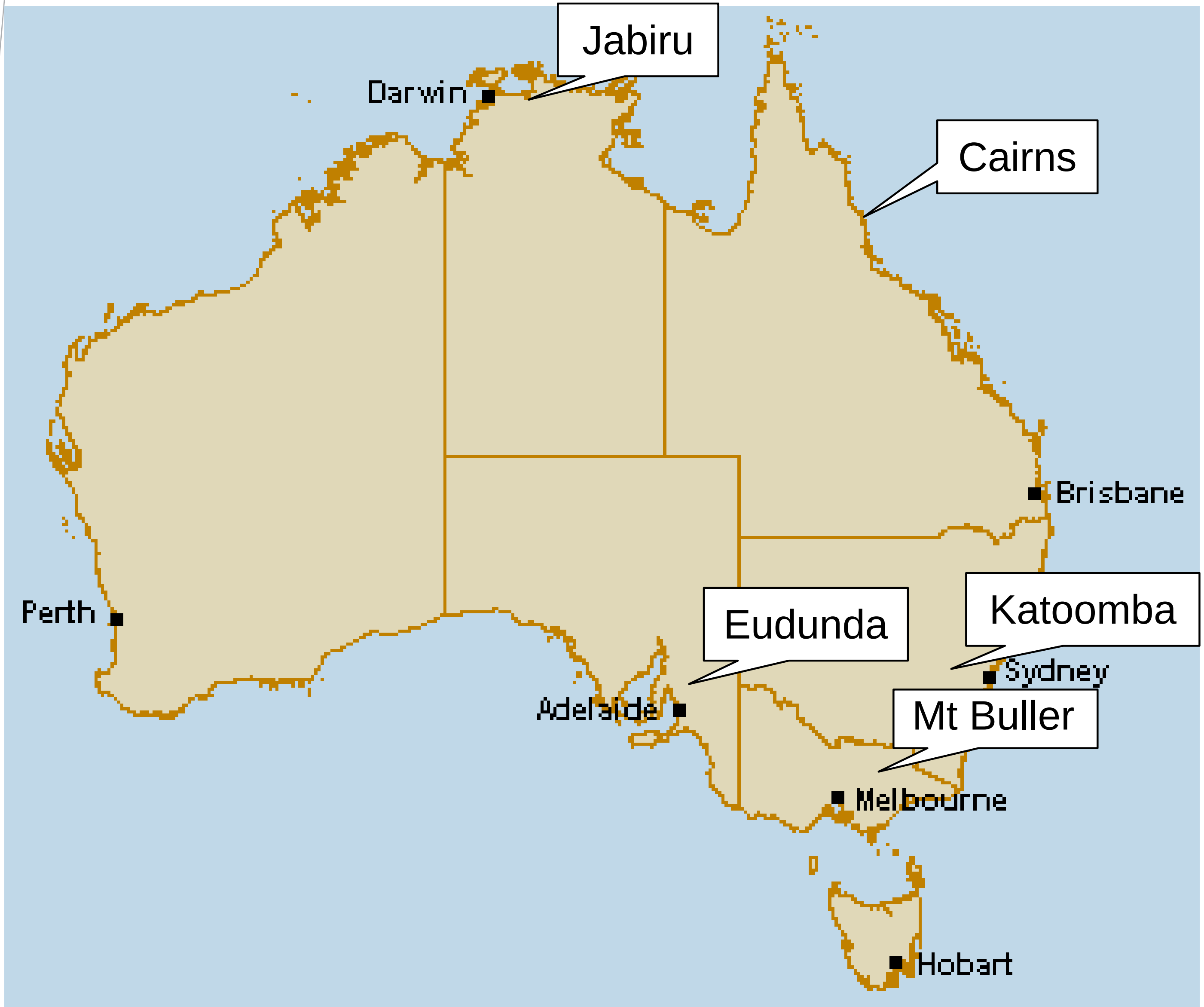
Five Australian tourism regions



Kakadu in 2020, 2050, 2070

Hotter, little change in total rainfall and rain-days, with an increase in heavy rain intensity and severe cyclone intensity

	2020			2050						2070					
	A1B			B1			A1FI			B1			A1FI		
	10	50	90	10	50	90	10	50	90	10	50	90	10	50	90
Max temp (°C)	0.5	0.7	0.9	0.8	1.2	1.6	1.3	1.9	2.6	1.1	1.6	2.2	2.2	3.1	4.2
Min temp (°C)	0.5	0.7	0.9	0.8	1.2	1.6	1.3	1.9	2.6	1.1	1.6	2.2	2.2	3.1	4.2
No. days > 35°C	13.7	25.7	33.7	31.0	61.7	78.1	66.0	87.1	125.8	60.5	77.5	112.6	109.3	143.4	181.8
Total rain (%)	-4.6	-0.3	4.3	-8.0	-0.6	7.6	-13.2	-0.9	12.4	-11.0	-0.8	10.3	-21.2	-1.5	20.0
No. of rain days	-4.6	-0.2	2.0	-8.0	-0.4	3.4	-13.1	-0.6	5.6	-10.9	-0.5	4.7	-21.1	-1.0	9.1
Heavy rainfall intensity (%)	-0.4	3.4	7.5	-0.7	6.0	13.2	-1.1	9.8	21.6	-0.9	8.2	18.0	-1.8	15.8	34.7
SST (°C)	0.3	0.5	0.7	0.6	0.9	1.2	1.0	1.4	1.9	0.8	1.2	1.6	1.6	2.3	3.1

Cairns in 2020, 2050, 2070

Hotter, little change in total rainfall and rain-days, with an increase in heavy rain intensity and severe cyclone intensity

	2020			2050						2070					
	A1B			B1			A1FI			B1			A1FI		
	10	50	90	10	50	90	10	50	90	10	50	90	10	50	90
Max temp (°C)	0.4	0.6	0.8	0.7	1.0	1.4	1.1	1.6	2.2	0.9	1.3	1.9	1.7	2.5	3.6
Min temp (°C)	0.4	0.6	0.8	0.7	1.0	1.4	1.1	1.6	2.3	0.9	1.4	1.9	1.8	2.6	3.7
No. days > 35 C	0.5	1.1	2.1	1.5	3.5	6.2	4.3	8.2	21.7	2.7	5.3	14.3	9.5	27.6	68.4
Total rain (%)	-5.3	-0.7	4.4	-9.2	-1.1	7.7	-15.0	-1.9	12.6	-12.5	-1.6	10.5	-24.2	-3.0	20.3
No. of rain-days	-2.6	0.0	1.4	-4.6	0.0	2.4	-7.5	-0.1	4.0	-6.3	0.0	3.3	-12.1	-0.1	6.4
Heavy rainfall intensity (%)	-1.4	1.8	5.1	-2.4	3.1	9.0	-3.9	5.1	14.7	-3.3	4.2	12.3	-6.3	8.2	23.7
SST (°C)	0.3	0.5	0.6	0.5	0.8	1.1	0.9	1.3	1.8	0.7	1.1	1.5	1.4	2.1	3.0

Blue Mountains in 2020, 2050, 2070

Hotter, less frost, reduced total rainfall and rain-days, with an increase in heavy rain intensity and more extreme fire weather days

	2020			2050						2070					
	A1B			B1			A1FI			B1			A1FI		
	10	50	90	10	50	90	10	50	90	10	50	90	10	50	90
Max temp (°C)	0.5	0.7	0.9	0.8	1.2	1.7	1.3	1.9	2.7	1.1	1.6	2.3	2.1	3.1	4.4
Min temp (°C)	0.4	0.6	0.9	0.8	1.1	1.6	1.2	1.8	2.5	1.0	1.5	2.1	2.0	2.9	4.1
No. days > 35 C	0.0	0.2	0.4	0.2	0.4	0.8	0.5	1.0	2.0	0.4	0.7	1.4	1.0	2.2	5.0
No. days < 2 C	-9.1	-12.7	-15.7	-12.7	-17.5	-24.2	-19.0	-26.3	-31.9	-17.2	-24.0	-30.2	-27.7	-34.1	-40.8
Total rain (%)	-5.5	-1.7	2.2	-9.6	-3.0	3.8	-15.8	-4.9	6.2	-13.1	-4.1	5.2	-25.4	-7.9	10.0
No. of rain-days	-5.9	-2.3	1.3	-10.2	-4.0	2.3	-16.7	-6.5	3.8	-14.0	-5.4	3.2	-27.0	-10.5	6.1
Heavy rainfall intensity (%)	-3.6	0.1	3.4	-6.2	0.3	5.9	-10.1	0.4	9.7	-8.5	0.3	8.1	-16.4	0.7	15.6

Victorian Alps in 2020, 2050, 2070

Hotter, less frost and snow, reduced total rainfall and rain-days, with an increase in heavy rain intensity

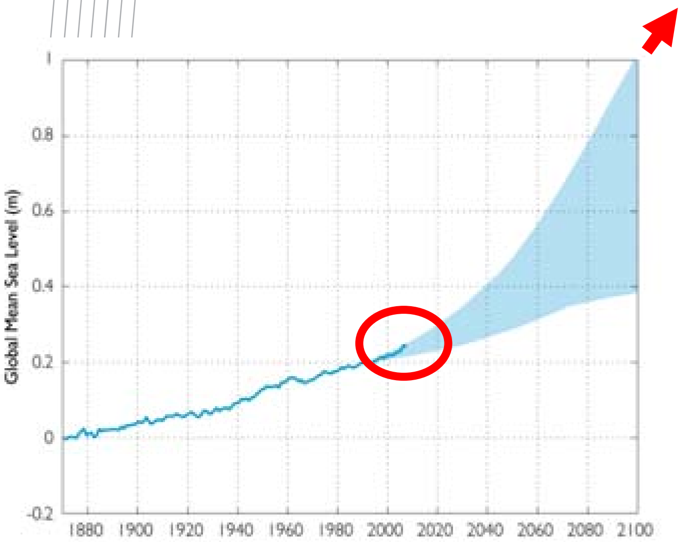
	2020			2050						2070					
	A1B			B1			A1FI			B1			A1FI		
	10	50	90	10	50	90	10	50	90	10	50	90	10	50	90
Max temp (°C)	0.4	0.6	0.9	0.8	1.1	1.6	1.3	1.8	2.6	1.1	1.5	2.1	2.0	3.0	4.1
Min temp (°C)	0.4	0.6	0.8	0.7	1.0	1.4	1.1	1.6	2.2	0.9	1.3	1.8	1.8	2.6	3.6
No. days < 2 C	-12.9	-17.3	-21.3	-18.7	-26.9	-36.7	-27.6	-40.3	-51.6	-23.7	-35.7	-45.6	-42.0	-58.0	-84.6
Total rain (%)	-5.4	-2.3	0.6	-9.4	-4.1	1.1	-15.4	-6.6	1.7	-12.9	-5.5	1.5	-24.9	-10.7	2.8
No. of rain-days	-7.7	-3.5	-1.5	-13.5	-6.2	-2.7	-22.0	-10.1	-4.4	-18.4	-8.4	-3.6	-35.5	-16.3	-7.0
Heavy rainfall intensity (%)	-3.1	1.3	6.1	-5.4	2.3	10.7	-8.8	3.8	17.5	-7.3	3.2	14.6	-14.2	6.1	28.2

Barossa Valley in 2020, 2050, 2070

Hotter, less frost, reduced total rainfall and rain-days, with a decrease in heavy rain intensity and more extreme fire weather days

	2020			2050						2070					
	A1B			B1			A1FI			B1			A1FI		
	10	50	90	10	50	90	10	50	90	10	50	90	10	50	90
Max temp (°C)	0.4	0.6	0.9	0.8	1.1	1.6	1.2	1.8	2.6	1.0	1.5	2.2	2.0	2.9	4.2
Min temp (°C)	0.4	0.6	0.8	0.7	1.0	1.4	1.1	1.6	2.3	0.9	1.3	1.9	1.7	2.6	3.7
No. days > 35 C	1.8	2.9	4.3	3.3	4.9	8.6	5.3	9.4	15.5	4.4	7.5	12.2	10.1	16.7	26.8
No. days < 2 C	-2.8	-4.3	-5.3	-4.5	-6.2	-7.9	-6.8	-8.2	-9.7	-5.4	-7.7	-9.3	-8.3	-9.7	-10.2
Total rain (%)	-6.8	-3.0	1.2	-11.9	-5.2	2.1	-19.5	-8.6	3.4	-16.3	-7.1	2.9	-31.5	-13.8	5.5
No. of rain-days	-8.7	-4.8	-1.7	-15.1	-8.5	-3.0	-24.7	-13.8	-4.9	-20.6	-11.5	-4.1	-39.9	-22.3	-7.9
Heavy rainfall intensity (%)	-7.1	-1.3	5.8	-12.4	-2.3	10.1	-20.3	-3.7	16.5	-16.9	-3.1	13.8	-32.7	-5.9	26.6

Sea level rise projections



Hunter et al (submitted), based on IPCC (2007)

18-79 cm by 2095, relative to 1990, but *larger values cannot be excluded*. No estimates prior to 2095 (IPCC 2007)

8 to 14cm by 2020, 19 to 37cm by 2050 and 32 to 56cm by 2070 (Horton et al. 2008)

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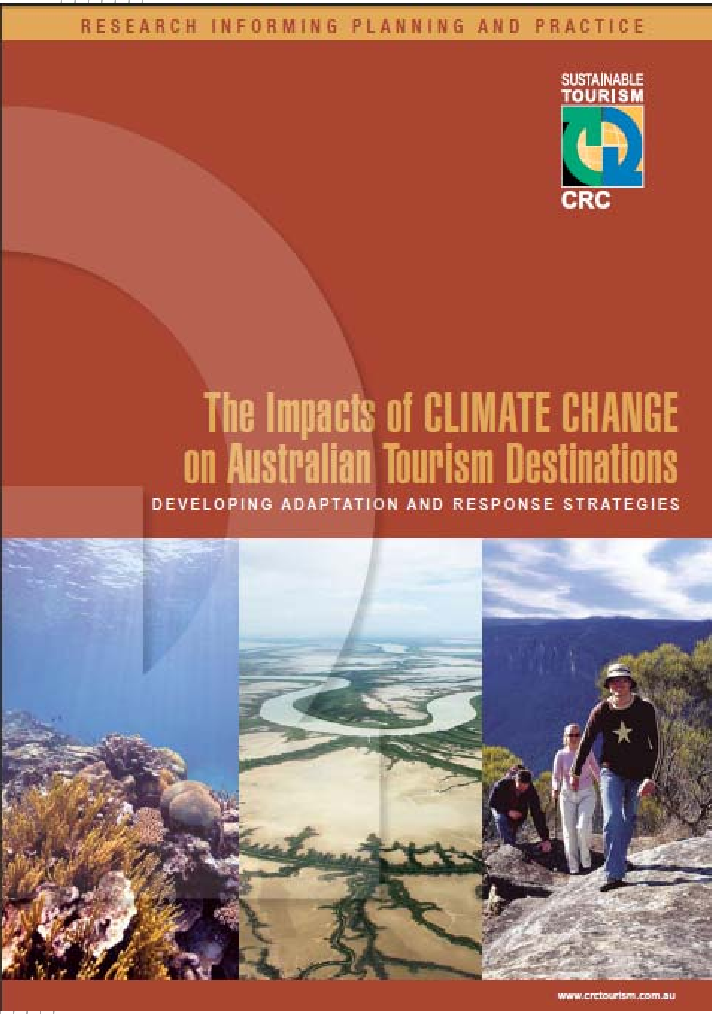
Sea level rise projections

ACE CRC (2008): statistical models give sea level rise estimates of up to 140 cm by 2100, relative to 1990. Estimates available for 2010-2100. Uncertainty about dynamic ice response

Pfeffer et al. (2008): Sea level may rise 0.8-2.0 m by 2100, allowing for dynamic ice sheet loss

John Church (as quoted in The Age, 12 Mar 2009): sea level could rise by more than a metre by 2100, relative to 1990, … due to changes in the polar ice sheets that were not included in earlier calculations

Impacts



Climate projections were used in stakeholders workshops

Very few impact studies

Heat stress, loss of wetlands, vector-borne and water-borne illness, damage from extreme weather, higher insurance costs, greater power demand for cooling, more power outages, coastal inundation, changes in species distribution and behaviour, bleaching of GBR, ocean acidification, less skiing, park closures due to fire risk, reduced grape quality, greater water use

Some scepticism and concern about uncertainty in projections

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Mitigation and adaptation

Mitigation

Policies (e.g. ETS)
Technologies (e.g. clean coal)

Behaviours (e.g. energy efficiency)
Adaptive management (e.g. offsets)

Adaptation

Policies (e.g. drought)
Technologies (e.g. infrastructure)

Behaviours (e.g. water use)
Adaptive capacity and management (e.g. rural planning)

Regional to local scale
Incremental and transformative

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