City of Hobart

Policy

Title:	**Climate Change Adaptation**
Category:	**Environment, Development and Planning Control**
Date Last Adopted:	7 March 2016

1. Objectives

That the City of Hobart:

1. Takes all reasonable and practical measures to increase climate change resilience and reduce greenhouse gas emissions across the City's assets, functions, services and programs.

2. Increases the resilience of Hobart's communities, enabling better preparedness, response and recovery from inevitable climate change impacts and increased frequency and intensity of natural hazards, through targeted programs, services and appropriate management of the City's assets and other relevant resources

3. Achieves a better understanding of future climate impacts across the City, municipal area, community and the region and share this information as appropriate

4. Seeks opportunities to collaborate on climate change action (adaptation and mitigation) with key stakeholders and the Tasmanian and Australian governments

5. Prioritises actions with co-benefits of mitigation and adaptation

6. Is flexible and timely in its response to climate impacts, risks and hazards

7. Takes advantage of new economic opportunities and avoid loss and unsustainable investment through climate planning

8. Minimises the exposure of the City to potential liability for decisions made, or not made, now or in the future through better information and policies, guidelines and state-wide codes

2. Background

This Policy reviews and updates the previous climate change Policy. It reflects maturation of the City's climate change actions and programs

3. Policy

That the City of Hobart:

1. Recognises that climate change is a complex issue that affects all aspects of the City's function, processes and roles and to this end will ensure climate impacts and hazards are considered through its decision making and strategic planning processes.

2. As Tasmania's Capital City, will provide effective and strong leadership to its communities, the region and inter-regionally on climate change to increase sustainability and resilience.

3. Will continue to develop and implement actions and strategies that assist communities to reduce carbon footprints, adapt to climate change impacts and increase their awareness and understanding of climate change.

4. Ensures that it complements, collaborates and establishes strong partnerships with key stakeholders and other tiers of government that strengthen the City's responses to climate change.

5. Ensures that the City plans for and manages Hobart's adaptation to the impacts of climate change, particularly where these impacts represent a threat to people and property.

6. Recognises the legitimacy and validity of the Intergovernmental Panel on Climate Change's (IPCC) review and assessment of scientific, technical and social climate change information. The City will review relevant actions, technical climate change guidelines and policies within six months of the publication of new IPCC reports using the two highest global greenhouse gas emissions trajectories Representative Concentration Pathways.

7. Ensures that the most up to date and recent climate change science and information is used in the City's strategic planning, administrative, technical climate change guidelines, operational and decision making processes, and where this information differs from the official sources shall use this information.

8. Will develop clear and certain criteria for decision making relating to climate change and natural hazards, ensuring that all relevant law is identified and the relevant information and facts are known and understood to increase public confidence that decisions are made on the basis of the best available scientific evidence.

9. Makes available information to the community on climate change risks and hazards to enable residents, businesses and community groups to manage the impacts on private property, business and community assets and services.

4. Legislation, Terminology and References

Local Government Act (Tas) 1993

Local Government Order (Content of Plans and Strategies) 2014

Tasmanian Energy Strategy 2015

Southern Tasmanian Regional Climate Change Strategy 2013 - 2017

Hobart City Council Corporate Climate Change Adaptation Plan 2013 - 2016

Hobart City Council Energy Savings Action Plan 2014 - 2017

City of Hobart Climate Change and Resilience Strategy 2015-2020

City of Hobart Strategic Plan

Increasing the Energy Efficiency of Councils Assets 5.12.01

Climate Change Disclosure Plan 2015

Hobart climate change information for decision making 2015

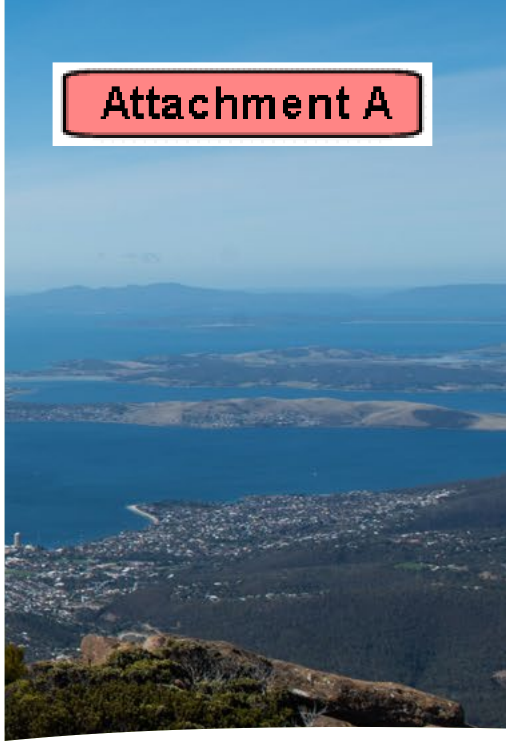
City of Hobart Strategic Risk Register

5. Attachments

Attachment A – Information for Decision Making

Attachment B – An evaluation of the Climate futures for Tasmanian projections for guiding climate change adaptation in Hobart

Responsible Officer:	Director City Planning
Policy first adopted by the Council:	25/05/2009
History	
Amended by Council	14/8/2014
Amended by Council	11/4/2016
Next Review Date:	March 2017



Attachment A

HOBART CLIMATE CHANGE

INFORMATION FOR DECISION MAKING

hobartcity.com.au

City of HOBART

The ‘Hobart Climate Change information for decision making’ (the Information) is based on the Climate Futures Tasmania ‘Local Climate Profile Hobart City Municipality’ developed by the Antarctic Climate Ecosystems Cooperative Research Centre’s Climate Futures Tasmania (CFT) project and available from the Tasmanian Governments Department of Premier and Cabinet’s website. The local climate profiles provides detailed climate models specific to Tasmania at 10 km2 intervals across the state. The Information expands these local profiles and has been developed to support decision making across the City of Hobart’s strategic, operational, service, adaptation and emergency management planning functions.

The information is to be reviewed and updated when more up-to-date and good-quality-information becomes available or at quinquennial intervals. It should be considered in conjunction with the City’s policies and strategies and alongside technical and industry standards.

CURRENT CLIMATE AND RECENT TRENDS

Hobart has a temperate, maritime climate with relatively mild winters. Long-term average temperatures have risen in the decades since the 1950s, at a rate of up to 0.1 °C per decade

Despite covering a small geographic area Hobart experiences a marked rainfall gradient in average annual rainfall from about 1100 mm on the slopes of Mt Wellington to 615 mm in the city. There has been a decline in average annual rainfall since the mid 1970s, and this decline has been strongest in autumn

EXTREME EVENTS

The changes in climate that are most likely to impact upon the City's infrastructure, roads, and the local community and environment are a magnification in intensity of extreme events. Potential impacts on Hobart, by 2100 are as follows:

The temperature of very hot days to increase by up to 3°C. Warm spells (days in a row where temperatures are in the top 5%) currently last around 5 days and may increase by up to 3 – 6 days

Extended heat waves and more extreme temperatures are likely to enhance the occurrence and intensity of bushfires

Rainfall will trend towards heavier events interspersed by longer dry periods. High daily runoff events are likely to increase, including those that may lead to erosion or flooding. Rainfall volume in a 200-year average recurrence interval (ARI) event will increase by up to 30-40%

Inundation along Derwent estuary frontage will increase. The current 100-year storm tide event is around 0.9 to 1.4 m above average sea level, and accounting for sea level rise (0.82 m), the current 100-year coastal inundation event may become a 50-year event by 2030, and a 2 to 6-year event by 2090

PROJECTED CHANGE IN CONDITIONS BY 2100 (A2[1] EMISSIONS SCENARIO)

Table 1: Projected changes for Hobart City by 2100 relative to the baseline period (1961-1990)

	2010 -2039			2040 - 2069			2070 - 2099		
Climate Variable	Value	Change	% Change	Value	Change	% Change	Value	Change	% Change
Temperature									
Average Daily Mean (annual)	12.0°C	0.8 °C	+7.0%	12.8°C	1.5°C	+13.5%	13.8°C	2.5°C	+2.5%
Average daily maximum temperature (annual)	16.5°C	0.7°C	+4.7%	17.2°C	1.5°C	+9%	18.2°C	2.4°C	+16%
Summer days (>25°C)/year	22.5 days	4.3 days	+24%	28.6 days	10.4 days	+57%	39.4 days	21	+116%
Warm spell duration (# days)	5 days	+ 1 days	+25%	6 days	+1°C days	+25%	8 days	+3 days	+75%
Hottest daily temperature of the year	34.3°C	0.7°C	+2%	35.2°C	1.6°C	+5%	36.2°C	2.6°C	+7.6%
Mean Minimum -Asphalt Critical Viscosity	152014	40881	+37%	202151	91018	+82%	299599	188466	+170%
Cold nights (minimum temperature < lowest 10%)	-	-	-4%	-	-	-7%	-	-9%	-
Warm nights (minimum temperature > highest 10%)	-	-	+5%	-	-	+11%	-	-	+20%
Frost risk days/year (<2°C)	15.3 days	-14.1 days	-48%	7.7 days	-21.8 days	-74%	2.7 days	-26.7 days	-91%
Freeze days/year (0°C)	2.6 days	-3.5 days	-52%	1.09 days	-5.0 days	-82%	0.3 days	-6 days	-96%
Extreme Warm Days (number of days > 30°C)	4.2 days	1 day	31%	5.8 days	2.6 days	+80%	8 days	4.8 days	+150%
Extreme Heat Days (number of days > 40°C)	0.01 day	0	0%	0.02 day	0.02 day	+300%	0.08 day	0.07 day	+1300%
Rainfall									
Rainfall (total annual average)	725.4 mm	12.0 mm	+1.7%	740.9 mm	27.6 mm	+4%	732.9 mm	19.5 mm	+2.7%
Seasonal Rainfall - Summer	179.3 mm	12.2 mm	+7%	183.8 mm	16.7 mm	+10%	179.0 mm	11.8 mm	+7%
Seasonal Rainfall - Winter	187.7 mm	-2.8 mm	-1.5%	190.2 mm	-0.3 mm	-0.1%	188.2 mm	-2.3 mm	-1%
Seasonal Rainfall - Autumn	172.2 mm	10.4 mm	+6%	176.5 mm	14.7 mm	+9%	180.3 mm	18.6 mm	+11.5%

[1] The IPCC developed a series of global greenhouse gas emission scenarios that outline alternative images of the future. The scenarios are based on consideration of demographic development, socio-economic development and technological change. The scenarios outline alternative images of the future. The A2 emissions scenario was selected as it is consistent with (slightly less than) the current concentration of greenhouse gases emitted into the atmosphere.

	2010 -2039			2040 - 2069			2070 - 2099		
Climate Variable	Value	Change	% Change	Value	Change	% Change	Value	Change	% Change
Seasonal Rainfall - Spring	186.2 mm	-7.8 mm	-4%	190.4 mm	-3.6 mm	-2%	185.4 mm	-8.6 mm	-4%
Rainfall (wettest day of the year)	48 mm (48 to 49)	-	+9%	51 mm (50 to 62)	-	+16%	52 mm (45 to 64)	-	+18%
Rainfall extreme (24hr) - 10% AEP	72 mm	6 mm	+9%	78 mm	12 mm	+18%	79 mm	13.6 mm	+21%
Rainfall extreme (24hr) - 1% AEP	119 mm	26.9 mm	+29%	127 mm	35.1 mm	+38%	119 mm	26.8 mm	+29%
Rainfall extreme (24 hr) 0.5% AEP	131 mm	31 mm	+31%	140 mm	40 mm	+40%	130 mm	30 mm	+30%
Rainfall extreme (48hr) - 10% AEP	102 mm	13.2 mm	+15%	97 mm	10.7 mm	+12%	78 mm	-11.3 mm	-13%
Rainfall extreme (48hr) - 1% AEP	150 mm	25.9 mm	+21%	123 mm	-0.6 mm	-0.5%	75 mm	-48.6 mm	-39%
Rainfall extreme (48 hr) – 0.5% AEP	163 mm	29 mm	+22%	128 mm	-6 mm	-4%	80 mm	-54 mm	-41%
Runoff	459.1 mm	13.0 mm	+3%	474.7 mm	28.6 mm	+6%	474.5 mm	28.4mm	+6%
River Derwent annual flow	3200 mm	-	-2%	3070 mm	-	-6%	3102 mm	-	-5% (-16% to +14%)
Evaporation	919.4 mm	20.1 mm	+2.2%	942.2 mm	42.9 mm	+4.8%	984.1 mm	84.8 mm	+9.5%
Relative Humidity	737.8 RH	3.3 RH	+0.5%	741.7 RH	7.1 RH	+1%	745.5 RH	11.0 RH	+1.5%
Fire									
Fire Danger (FFDI)	Fire season longer, earlier start Places with high fire danger currently projected to get worse more rapidly								
Wind speed									
Wind speed (ms^{-1})	Little change projected by 2085 (<5%) Change in seasonality, with higher speeds in July-October, and lower speeds in November - May								

Sea level rise Planning Allowances [2]	2050 - 0.2 metres	2100 - 0.8 metres

[2] The Sea Level Rise Planning Allowances are endorsed by the Tasmanian Government and were developed separately from the CFT profiles. Information on the methodology used to develop the allowances is detailed in 'Derivation of Tasmanian Sea Level Rise Planning Allowances, technical Paper August 2012'

NOTES:

- All values are based on the Climate Futures for Tasmania projections, using previously published results in the Climate Futures for Tasmania reports and the ClimateAsyst tool (http://www.pittsh.com.au/climateasyst/). The projections were completed in 2009 using climate models from the CMIP3 archive. See accompanying report "An evaluation of the Climate Futures for Tasmania projections for guiding climate change adaptation in Hobart" for details. The Climate Futures for Tasmania reports can be found at http://www.dpac.tas.gov.au/divisions/climatechange/climate_change_in_tasmania/impacts_of_climate_change. The exception being the sea level rise values which are endorsed by the Tasmanian government and available at http://www.dpac.tas.gov.au/divisions/climatechange/climate_change_in_tasmania/impacts_of_climate_change/coastal_impacts.
- Values given are the multi-model mean of the six Global Climate Models downscaled in the Climate Futures for Tasmania project. Averaging the six models smooths out the variability and shows the forced climate response independent of the model variability. For most variables, the range between climate models is not large relative to the percent change projected. For example, the range in the number of Summer days/year is 22 to 23 days by the 2025 period; 28 to 30 by 2055, and 38 to 42 days per year by the end of the century period (2085). This represents a maximum range of 10%. The range in rainfall projections for Hobart is less than 5% for the near and mid-century periods (2010 to 2039 and2040 to 2069), and 5-7.5% for the end of century period (2070 to 2099) (see Report on CFT context for more detail about uncertainty).
- The AEP is a measure of the rarity of a rainfall event. It is expressed as the probability that a given rainfall total accumulated over a given duration will be exceeded in any one year. So, on average, there is a 10% chance that more than 72mm rain will fall in Hobart over a 24 hour period in 2010-2039. By the end of the century the amount of rainfall with the same probability increases to 79mm.

- Cechet, R. P., L. A. Sanabria, C. B. Divi, C. Thomas, T. Yang, W. C. Arthur, M. Dunford, K. Nadimpalli, L. Power, C. J. White, J. C. Bennett, S. P. Corney, G. K. Holz, M. R. Grose, S. M. Gaynor, and N. L. Bindoff. 2012. Climate Futures for Tasmania: Severe wind hazard and risk technical report. Geosciences Australia.
- Corney, S. P., J. J. Katzfey, J. L. McGregor, M. R. Grose, J. C. Bennett, C. J. White, G. K. Holz, S. M. Gaynor, and N. L. Bindoff. 2010. Climate Futures for Tasmania: climate modelling technical report. Antarctic Climate & Ecosystems Cooperative Research Centre, Hobart, Tasmania.
- Grose, M. R., I. Barnes-Keoghan, S. P. Corney, C. J. White, G. K. Holz, J. B. Bennett, S. M. Gaynor, and N. L. Bindoff. 2010. Climate Futures for Tasmania: general climate impacts technical report. Antarctic Climate & Ecosystems Cooperative Research Centre, Hobart, Tasmania.
- Holz, G. K., M. R. Grose, J. C. Bennett, S. P. Corney, C. J. White, D. Phelan, K. Potter, D. Kriticos, R. Rawnsley, D. Parsons, S. Lisson, S. M. Gaynor, and N. L. Bindoff. 2010. Climate Futures for Tasmania: impacts on agriculture technical report. Antarctic Climate and Ecosystems Cooperative Research Centre, Hobart, Tasmania.

- The material in this report is based on computer modelling projections for climate change scenarios and, as such, there are inherent uncertainties involved. While every effort has been made to ensure the material in this report is accurate, Antarctic Climate & Ecosystems Cooperative Research Centre (ACE) provides no warranty, guarantee or representation that material is accurate, complete, up to date, non-infringing or fit for a particular purpose. The use of the material is entirely at the risk of a user. The user must independently verify the suitability of the material for its own use. To the maximum extent permitted by law, ACE, its participating organisations and their officers, employees, contractors and agents exclude liability for any loss, damage, costs or expenses whether direct, indirect, consequential including loss of profits, opportunity and third party claims that may be caused through the use of, reliance upon, or interpretation of the material in this report.

Attachment B

An evaluation of the Climate Futures for Tasmania projections for guiding climate change adaptation in Hobart.

The Climate Futures for Tasmania project

The Hobart City Council Technical Climate Change Adaptation Guidelines are based on projections of future climate produced as part of the Climate Futures for Tasmania (CFT) project. Six Global Climate Models (GCMs) were dynamically downscaled to a resolution of ~10km using a regional climate model, the Conformal Cubic Atmospheric Model (CCAM), developed by the Commonwealth Scientific and Industrial Research Organisation (CSIRO). Data are available for the years 1960 – 2099, enabling researchers, planners and managers to explore the likely implications of climate change on priority species, communities and hazards.

The Climate Futures for Tasmania projections were completed in 2012 using the most up-to-date climate models available at the time. The global climate models came from the archive of Phase three of the Coupled Model Intercomparison Project (CMIP3), which coordinated the work of modelling groups from around the world to provide the science basis for the Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC 2007). Since then, a new archive of climate models has been developed by the World Climate Research Programme's Working Group on Coupled Modelling. The CMIP5 model archive underpins the science of the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC, 2013). The Hobart City Council has requested an overview of how the CFT outputs compare to climate models from the more recent archive. The CFT outputs remain the highest resolution data available for Tasmania (~10km compared to ~50km resolution available for CMIP5 models downscaled as part of the AdaptNRM project (http://adaptnrm.csiro.au/)).

This report first outlines some key differences between the old and new archives (CMIP3 and CMIP5), and relates these to the CFT projections. It then considers the downscaling technique used in CFT, and identifies areas where the downscaling has been found to add value to the coarse global climate model projections. A comparison of the changes projected to occur over Tasmania by global climate models from the CMIP3 and CMIP5 archives is provided first (older vs newer global climate models), followed by a comparison of the changes projected by the Climate Futures for Tasmania project and CMIP5 archives (downscaled CFT vs recent global climate models). Finally, sources of uncertainty in projections of future climate are described, and levels of confidence that can be ascribed to the key variables are discussed.

A report for Hobart City Council, produced by R. Harris and T. Remenyi, Antarctic Climate and Ecosystems Cooperative Research Centre, November 2015

DEFINITION OF TERMS AND ABBREVIATIONS USED IN THIS REPORT

CCAM

The Conformal Cubic Atmospheric Model (CCAM) is the regional climate model used to generate the Climate Futures for Tasmania projections. It was developed by the Commonwealth Scientific and Industrial Research Organisation (CSIRO).

Climate Futures for Tasmania project

The Climate Futures for Tasmania project, managed by the Antarctic Climate and Ecosystems Cooperative Research Centre, provided the first fine-scale climate information for Tasmania by downscaling six global climate models with two emission scenarios (high emissions scenario - A2 and lower emissions scenario - B1) to generate climate information from 1961 to 2100.

Climate projections

A climate projection is a model-derived description of possible future climates under a given set of plausible scenarios of climate forcings (any influence on the climate that originates from outside the climate system itself). Climate projections differ from climate predictions because they depend on the emission/concentration/radiative forcing scenario used. Such scenarios are based on assumptions about future socio–economic and technological developments that are subject to substantial uncertainty. A projection is therefore a probabilistic statement of what could happen if certain assumed conditions prevail in the future.

CMIP3 archive

The Coupled Model Intercomparison Project archive. The CMIP3 archive includes a standard set of model simulations that have been assessed as providing plausible projections of future climate change. Models admitted to the CMIP3 archive informed the IPCC's Fourth Assessment Report in 2007.

CMIP5 archive

The most recent Coupled Model Intercomparison Project archive. Models admitted to the CMIP5 archive informed the IPCC's Fifth Assessment Report in 2013.

Emissions scenarios (SRES and RCPs)

The IPCC addressed the uncertainty about future rates of greenhouse gas and aerosol emissions using SRES emissions scenarios in the first to fourth Assessment Reports, and Representative Concentration Pathways (RCPs) in the Fifth Assessment Report (AR5).

Host models

The Global Climate Models used in this study were ECHAM5/MPI-OM, GFDL-CM2.0, GFDL-CM2.1, MIROC3.2(medres), UKMO-HadCM3 and CSIRO-Mk3.5. They represent a range of plausible futures under climate change.

IPCC

The Intergovernmental Panel on Climate Change is the leading international body for the assessment of climate change. The IPCC releases Assessment Reports which give an up-to-date overview of the current state of scientific knowledge about climate change.

Baseline and Future time periods

The Hobart City Council Technical Climate Change Adaptation Guidelines have been updated to provide the change projected to occur between the baseline period (1961-1990) and three future time periods (2010-2039; 2040-2069, and 2070-2099, referred to as 2025, 2055 and 2086, respectively). Means of 30-year periods are used to incorporate the yearly and decadal variability that is natural in the climate system, for example, during droughts or cool seasons.

Multi-model mean

Results are presented in this report as the average of six climate models. This approach is commonly used in climatology to provide a 'central estimate' of the projections. Since all climate models admitted to the archives are considered to represent plausible representations of possible futures, a range of climate models are used to incorporate the uncertainty due to the range in climate models.

Differences between the CMIP3 and CMIP5 archives

There are two main differences between the two archives that should be considered when comparing CMIP3 and CMIP5, and using their output in practical applications. These are the different emissions scenarios and models used, which are considered below.

New emission scenarios

In the AR4, the IPCC addressed the uncertainty around future greenhouse gas emissions using socioeconomic scenarios which result in alternative levels of greenhouse gas emissions in the future (SRES). There were four scenario families in the SRES set, A1, A2, B1, and B2, each consisting of different demographic, societal, economic, and technical change storylines.

In the CMIP5 archive used in the AR5, SRES scenarios are replaced by Representative Concentration Pathways (RCPs). Rather than starting with socioeconomic scenarios, the RCPs represent alternative greenhouse gas concentration trajectories. The four RCPs (2.6, 4.5, 6, and 8.5 W/m2) refer to the radiative forcing projected for the year 2100. The radiative forcing is the imbalance in longwave and solar radiation caused by changes in greenhouse gases and aerosols relative to preindustrial conditions (converted to 'CO2 equivalence').

The SRES scenarios follow different trajectories through the 21st Century than the new representative concentration pathways (RCPs) (Figure 1). There will therefore be slight differences between previous work and new work solely from the scenarios used as input. For example, warming (and other changes) under the RCP8.5 is likely to be greater than that for A2 because it represents greater emissions. RCP8.5 projects a similar acceleration in temperature to SRES A2, although median temperatures are consistently higher in the RCP8.5 (Harris et al. 2014).

The Climate Futures for Tasmania projections are based on the SRES emissions scenarios, because they were based on models from the CMIP3 archive of the AR4. The scenarios are of ongoing high emissions, A2, and one where emissions are lower and plateau, B1. The Hobart City Council has decided to base adaptation decisions on the A2 high emissions scenario, because global emissions are currently tracking above this scenario (Peters et al. 2013). The climate response under the two scenarios is similar through the first half of the century, but the changes under the higher emissions scenario become much stronger than the lower scenario in the latter half of the 21st Century (see Figure 1).

New models

There are more models in CMIP5 than were in CMIP3, and each is the latest version of models that have undergone development in recent years. However, model development and addition of new models has not led to any major revision of the conclusions drawn from work using CMIP3. The major patterns and magnitudes of projections are broadly similar between the two groups of models, once the effect of emission scenarios is accounted for.

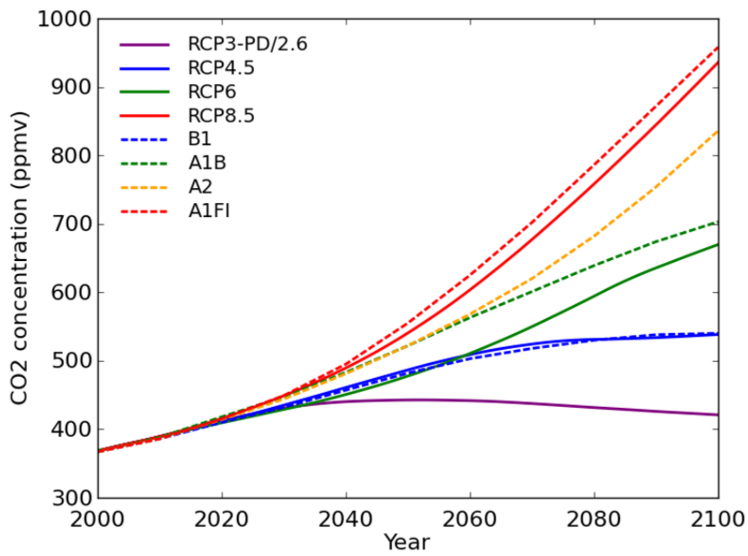


Figure 1: Historical and projected total anthropogenic radiative forcing (W/m2) for Special Report on Emissions Scenarios (SRES) and Representative Concentration Pathways (RCPs) (relative to preindustrial (~1765) between 1950 and 2100). IS92a refers to a Second Assessment Report (SAR) scenario. From Chapter 1, Fifth Assessment Report of the Intergovernmental Panel on Climate Change, 2013.

Downscaling

The CFT results were produced using a dynamical downscaling model (CCAM). Dynamically downscaled climate models represent the climate processes that operate over small distances, in contrast to statistical downscaling methods, which assume a statistical relationship between large-scale patterns of climate and local climate, or simple scaling techniques that interpolate coarse-scale model output to the local scale (Harris et al., 2014). They therefore have the potential to capture regional variation in the climate change signal. This is particularly relevant in Tasmania, which has a complex topography and coastline, and a range of regional climate influences.

However, it is worth noting that the CFT results were produced using only one downscaling technique (CCAM), and used input from six Global Climate Models (GCMs) out of the set of 23 CMIP3 models available. The six models have been assessed against the full group of 23, and have been shown to be fairly representative of the archive. They cover a range of plausible futures, and do not only include models at one extreme end of the projections for Tasmania or southeast Australia for any season (Grose et al. 2015a).

Grose et al. (2015b) compared the CFT outputs with those from a statistical downscaling method (BOM-SDM) and from GCMs at resolutions of 100-250km. They found that CFT produced greater regional detail and regional patterns of change which are consistent with topographic influences and regional drivers that are not resolved by coarse global models. These patterns include a difference in the range of projected rainfall change in the east of Tasmania compared to the west in some seasons. This ‘added value’ in the projected change is the main advantage of using the CFT projections.

Comparison of changes projected by the CMIP3 and CMIP5 archives over Tasmania

CSIRO recently released a comprehensive assessment of past and future climate change in Australia, the Climate Futures for Australia projections (http://www.climatechangeinaustralia.gov.au/en/). The assessment included an overview of projections for Australian regions based on the CMIP5 models, and a comparison of the changes in climate that are projected by the CMIP3 and CMIP5 archives (CSIRO and Bureau of Meteorology 2015). Regional comparisons of the CMIP3 and CMIP5 projections for Australia have found them to give largely consistent results for temperature, rainfall, wind speed, humidity, solar radiation and potential evapotranspiration (Irving et al. 2012, Lee et al. 2013, CSIRO and Bureau of Meteorology 2015).

Comparison of changes projected by the Climate Futures for Tasmania project and CMIP5 archives

Grose et al. (2015a, 2015b) compared the Climate Futures for Tasmania projections with a range of CMIP3 models, CMIP5 models, and new downscaling (~50km) using a more recent version of the CCAM model than that used in the Climate Futures for Tasmania project. For Tasmania, the report concluded that once the difference in emissions scenarios is accounted for:

Projections of temperature from the Climate Futures for Tasmania project "are broadly consistent with the new CMIP5 results" (Grose et al. 2015a, pg 20).

The Climate Futures for Tasmania projections of annual rainfall, and summer, autumn and winter rainfall show similar trends to the new models. However, the CFT results show little trend in spring rainfall across Tasmania, while other models project a decrease in spring rainfall. This suggests that the CFT results across Tasmania "are at the wetter end of the plausible range of spring rainfall projections" (Grose et al. 2015a, pg 28). The projections for Hobart, as opposed to the mean across Tasmania, do show a slight decrease in spring rainfall.

Projections of heavy rainfall in the Climate Futures for Tasmania results "are supported by the CMIP5 results." (Grose et al. 2015a, pg 29)

Confidence in projections of future climate

The Climate Futures for Tasmania results are based on best practice. However, as with all projections of future climate, there are uncertainties inherent in the results. Uncertainty arises from three main sources:

1. uncertainty around future emissions scenarios;
2. uncertainty represented by the range in climate models, and
3. natural variability of the climate system.

The relative importance of each of these sources of uncertainty varies at different temporal and spatial scales. In the short term, the greatest sources of uncertainty are natural variability and model uncertainty, which also increase at smaller spatial scales. In the longer term, the dominant sources of uncertainty are those associated with emissions scenarios and models. The relative contribution from natural variability generally declines over time as the signal of climate change strengthens (Harris et al. 2014).

Additionally, simulations of some climate processes are more uncertain than others. For example, rainfall projections have a larger degree of uncertainty than those for temperature, because the large-scale storm tracks in the projections are uncertain (Risbey and O'Kane 2011), and it is difficult to fully resolve the many physical processes involved in precipitation or the fine-scale spatial variability. This is why it is not unusual for projections of rainfall to range from positive to negative (CSIRO and Bureau of Meteorology 2015). Similarly, projections of wind and clouds, storms, and other extreme events are highly uncertain. The intensity of observed extreme winds across land is substantially modified by the terrain and vegetation, and the meteorological systems that generate extreme winds are also not fully resolved within climate models. Nevertheless, plausible future trends at large scales can be simulated, and are useful in assessing potential responses into the future.

It is important that the degree of uncertainty be considered when using climate projections in adaptation decision-making. Table 1 summarises the confidence for each variable over Tasmania, taken from the Climate Change in Australia report (CSIRO and Bureau of Meteorology 2015). The level of confidence is based on the level of agreement between a range of climate models (CMIP3 and CMIP5 models) and downscaling techniques, and consistency with recent climate observations and physical drivers of climate, following the language specified by the IPCC in the Fifth Assessment Report.

Conclusions

There are more models in CMIP5 than were in CMIP3, and each is the latest version of models that have undergone development in recent years. However, model development and addition of new models has not led to any major revision of the conclusions drawn from work using CMIP3. Comparisons with projections from global climate models and other downscaling show that the Climate Futures for Tasmania projections remain a valuable resource for Tasmania.

Variable	Confidence
Temperature	**Very high confidence** that temperatures will increase
Temperature extremes	**Very high confidence** that there will be more frequent and hotter hot days and warmer cold extremes
Rainfall	Natural variability remains significant compared to any climate change signal out to 2100
	Medium confidence that there will be little or no change in winter rainfall
Extreme rainfall	**High confidence** that intensity will increase, but the magnitude of change cannot be reliably projected
Increased fire danger	**High confidence** that fire danger will increase
Wind speed	Natural variability remains significant compared to any climate change signal out to 2030.
	High confidence that winter wind speed will increase but the magnitude of change cannot be reliably projected
Extreme winds	**Medium confidence** that extreme wind speeds will increase

Table 1: Confidence in projections of key variables over Tasmania from the Climate Change in Australia report

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