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General climate impacts

Tasmania's climate

Tasmania's climate

Tasmania has a temperate maritime climate – no point in the island state is more than 115 km from the ocean and temperature over Tasmania is moderated by the surrounding seas. The average difference between the daily maximum and the nightly minimum temperatures at the coast is 7 °C and is around 14 °C inland. The seasonal temperature range is also small compared to areas further from the ocean, with mean maximum temperatures of 18 °C to 23 °C in summer and 9 °C to 14 °C in winter.

Tasmania experienced a stable mean temperature for the first half of the 20th century, followed by a rising mean temperature since the 1950s. This rise, however, has been less than for Australia or globally. Mean annual temperature for Tasmania has risen by 0.10 °C per decade over this period compared to the national average of 0.16 °C per decade. As is the case with other regions of the globe, daily minimum temperatures in Tasmania have risen more than daily maximum temperatures.

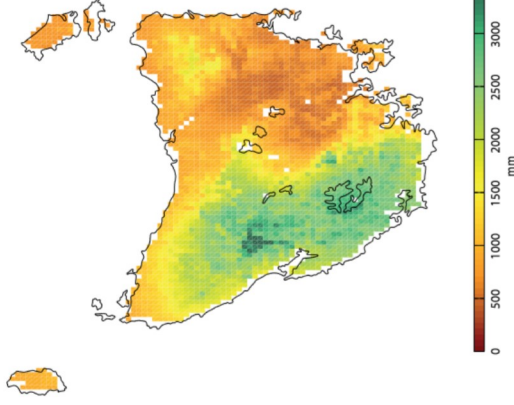
Rainfall over Tasmania results from a combination of prevailing westerly winds, mountainous topography, and seasonal pressure variations determining the position and strength of storm tracks, blocking highs and cut off lows. These processes lead to the west coast being wettest, with a total annual rainfall of more than 3000 mm; the midlands being driest, in a rain shadow with less than 600 mm; and the mountainous areas of the north-east, with a moderate rainfall of more than 1000 mm.

The annual cycle of pressure, storm tracks, blocking highs and cutoff lows also leads to different seasonal cycles of rainfall across Tasmania. The west coast has a distinct seasonal cycle with the highest rainfalls in winter and early spring. There is a smaller but still distinct annual cycle in rainfall in the north, with the peak of the rainfall cycle occurring through autumn to winter. There is no distinct annual cycle in the east, with approximately 50 mm to 70 mm falling each month of the year.

Despite the similarity of seasonal cycle in the west and north, there are marked differences in characteristics of the rainfall between these two regions. The west receives prolonged heavy rainfall events associated with a westerly airstream, whereas the north receives shorter duration rainfall events in mid to late autumn from moist north-easterly airstreams, commonly associated with cutoff lows. These cutoff lows can occasionally produce extreme rainfall events in the east and south-east of Tasmania, and the midlands.

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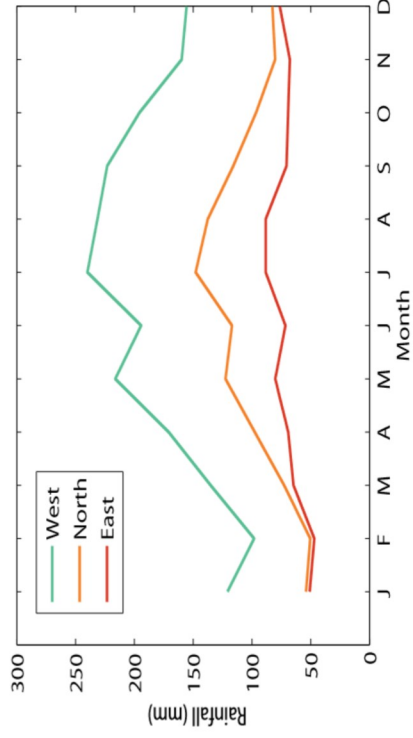
Mean Annual Rainfall



Climate Figures

The map above is of the annual average rainfall over Tasmania (1961-1990). The graph below is the annual cycle of rainfall for the west, north and east of Tasmania. Note the high rainfall in the west and lower rainfall in the east, and the large seasonal cycle of rainfall in the west, and almost constant rainfall in the east.

Annual Rainfall Cycles



Tasmania's climate

- Tasmanian temperatures have risen since the 1950s, but at a slower rate than mainland Australia.
- There has been a reduction in total annual rainfall in Tasmania and a change in year-to-year rainfall variability since 1975. This reduction has been greatest in autumn, and is similar to other regions of southern Australia.
- There have been shifts in the large-scale climate drivers over the Australasian region in the last fifty years. Some studies show that the subtropical ridge of high pressure north of Tasmania has moved southward and intensified in recent decades. There has been an increase in the frequency of El Niño events and a strengthening of the Southern Annular Mode. Atmospheric blocking in summer has also increased.
- Changes in Tasmania's rainfall appear to be linked to these climate drivers, although the contribution from each driver and the combination of drivers is still not fully understood.



General climate outlooks

Large-scale drivers of Tasmania's climate variability

Tasmania's climate is influenced by a number of large-scale climate drivers.

The climate drivers most relevant to Tasmania are:

- the Southern Annular Mode (SAM)
- El Niño Southern Oscillation (ENSO)
- Indian Ocean Dipole (IOD)
- cutoff lows and blocking highs.

The diagram (at right) is a schematic representation of the main climate drivers of rainfall variability in the Australian region.

Of these drivers, the El Niño Southern Oscillation (ENSO) has the strongest influence on rainfall in the north and east of Tasmania during autumn and winter, while the Indian Ocean Dipole (IOD) has a greater influence on rainfall than the other drivers in spring for the north and midlands.

The influence of the Southern Annular Mode (SAM) on rainfall is greater than the other climate drivers in the west of Tasmania throughout winter, spring and summer. The influence of atmospheric blocking on rainfall is greater than the other climate drivers in the east in spring, summer and autumn, and in the west throughout autumn and winter.

The influence from these climate drivers contribute to the different modes of year-to-year rainfall variability in the different districts of Tasmania.

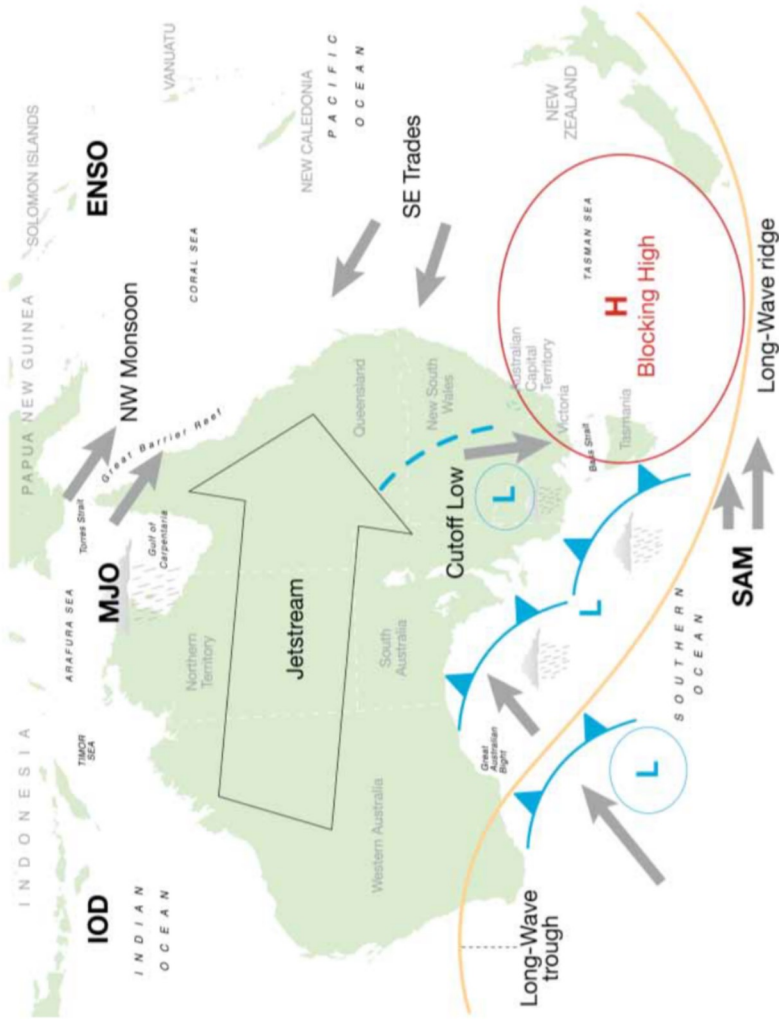
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Modelling Tasmania's future climate

Modelling Tasmania's future climate

- To generate useful information about likely changes to the general climate, we simulated Tasmania's future climate with six global climate models.
- Climate models are designed to simulate the main components of the earth's climate system (the atmosphere, ocean, sea-ice and land surface) under different scenarios of rising greenhouse gas emissions and aerosols.
- Climate Futures for Tasmania considered two emissions scenarios for the coming century – the A2 (high emissions) and B1 (low emissions) scenarios from the Intergovernmental Panel on Climate Change's *Special Report on Emissions Scenarios*.
- The output from global climate models is at a resolution of 200 km to 300 km. This is too coarse to be useful for understanding changes in rainfall and temperature over Tasmania. To overcome this problem, output from global climate model is put through another climate model that creates the detailed information necessary to simulate local climate conditions. This process is called downscaling. In this study, the downscaling was carried out in two stages: firstly from the original grid resolution down to a 0.5-degree latitude/longitude grid (approximately 50 km), and then down to a 0.1-degree grid (approximately 10 km).

Remote Climate Drivers that Influence Australian Rainfall Variability



Climate Drivers Schematic

A schematic representation of the main climate drivers of rainfall variability in the Australian region. The climate drivers most relevant to Tasmania are the Southern Annular Mode (SAM), El Niño Southern Oscillation (ENSO), Indian Ocean Dipole (IOD), cutoff lows and blocking highs.

Source: Risbey JS, Peck MI, McIntosh PC, Wheeler MC and Hendon HH, 2009, *On the remote drivers of rainfall variability in Australia*, Monthly Weather Review 137: 3233-3253.



General climate impacts

Tasmania's future temperature

Temperature

Under the high emissions scenario (A2), the central estimate of the simulations suggests Tasmania will experience a change in mean temperature of 2.9 °C over the 21st century (model range 2.6 °C to 3.3 °C). The temperature increase for Tasmania under this emissions scenario is less than the projected global warming of 3.4 °C. The projections suggest temperature increases are smaller in the early part of the century, but the rate of change increases towards the end of the century.

Under the lower emissions scenario (B1), the central estimate of the simulations shows a rise in mean temperature of 1.6 °C over the 21st century (model range 1.3 °C to 2.0 °C). Again, under this emissions scenario, the projected temperature change for Tasmania is less than the projected global change of 1.8 °C. Compared to the high emissions scenario simulations, the rate of temperature rise under the lower emissions scenario in the later part of the century increases at a slower rate.

The high and low emissions scenarios show almost uniform patterns of change over the 21st century. Daily minimum temperature is projected to increase more than daily maximum temperature, in line

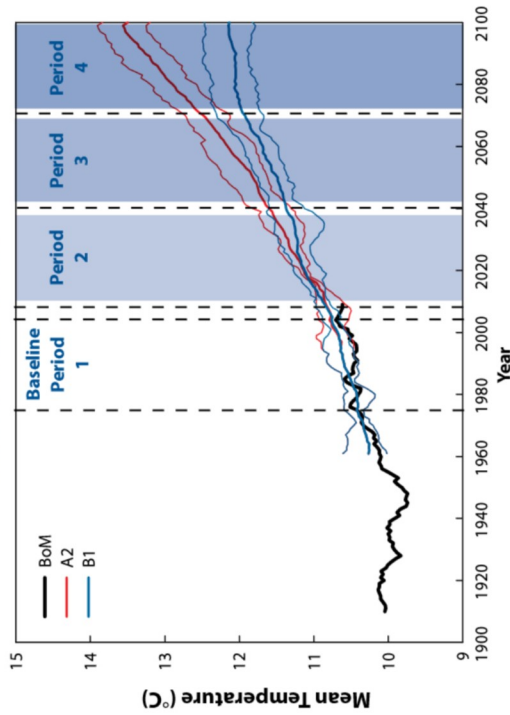
with the observed changes from the recent past and climate projections from other regions of Australia and the globe.

The projected temperature changes for both emissions scenarios are less than the Australian and the global average changes for the same period, and are much less than some individual regions of the globe. The Southern Ocean is projected to have the slowest rate of warming of any region on the globe. These smaller projected changes for Tasmania are largely due to the Southern Ocean storing the excess heat and thus moderating the future Tasmanian climate.

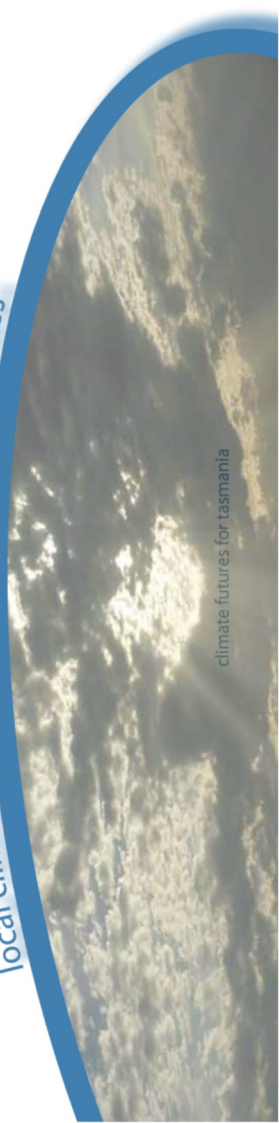
Tasmania's future temperature

- Over the 21st century, Tasmanian temperature is projected to rise by about 2.9 °C under the high emissions scenario, and about 1.6 °C under the low emissions scenario. In both emissions scenarios, this is less than the projected global average temperature rise, due to the moderating influence of the Southern Ocean.
- Increasing temperatures are also likely to lead to increases in evaporation, decreased average cloud cover, increases in relative humidity and increased winds in spring.

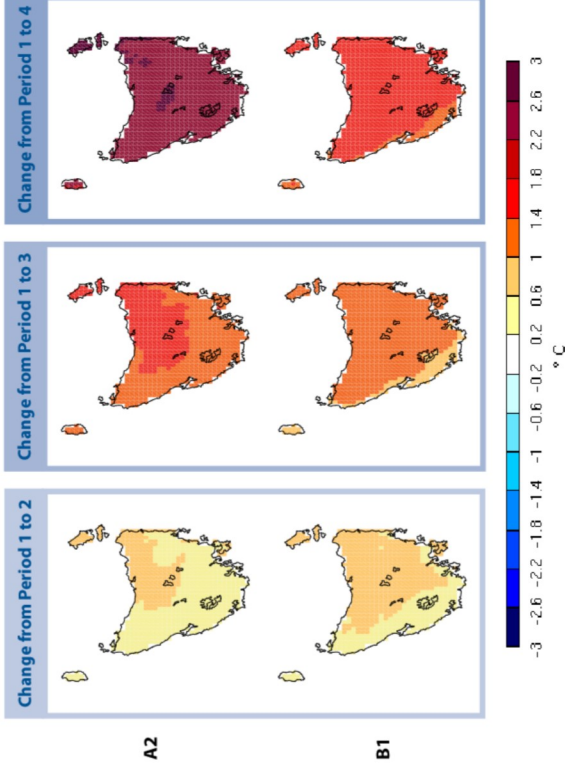
Mean Temperature



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Temperature Figures

The time series (opposite page) from 1900 to 2100 shows the Tasmanian mean temperature from observed records to the present (bold black line), the simulated temperature for the high emissions scenario (bold red line) with the range (faint red line) and the low emissions scenario (bold blue line) with the range (faint blue line). The above maps show the change in mean temperature over Tasmania from the baseline period (1 = 1978-2007) to the central estimate of the simulations for three future periods (2 = 2010-2039, 3 = 2040-2069, 4 = 2070-2099). Note the agreement between observations and simulations in the time series, and the large future changes compared with the observed period.



General climate impacts

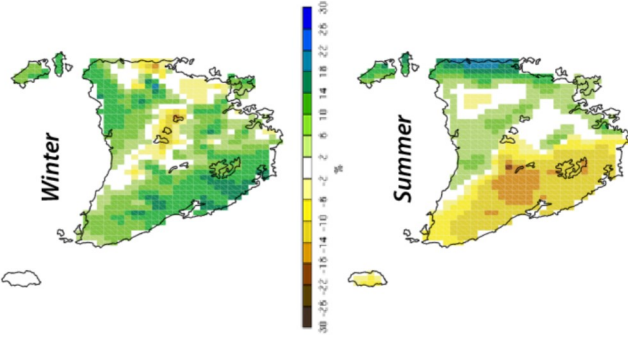
Tasmania's future rainfall

Tasmania's future rainfall

- Rainfall patterns across Tasmania, and from season-to-season, show significant changes under the high and low emissions scenarios.
- The changes in seasonal rainfall are much greater than changes in annual total rainfall.
- The projections show a steadily emerging pattern of increased rainfall over the coastal regions, and reduced rainfall over central Tasmania and in the north-west of Tasmania.
- Projected rainfall changes are in line with our knowledge of Tasmania's climate drivers.

are associated with the subtropical ridge of high pressure moving southward and intensifying, especially in summer, and an increasing prevalence of the high phase of the Southern Annular Mode. This increase is likely to drive the changes to west coast rainfall.

The increase in sea surface temperature off the east coast of Tasmania is caused by a southward extension of the East Australia Current over the 21st century. The sea surface temperature rise, along with changes to the dominant pressure patterns, is projected to lead to an increase in atmospheric blocking in summer and autumn, as well as an increase in convective rainfall events, consistent with the increase in rainfall on the east coast during these seasons.



Rainfall Figures

The above maps show the pattern of rainfall change for winter and summer between Period 1 (1978-2007) and Period 2 (2070-2099). Note the general increase over the state in the winter, except for the central plateau, and in the summer, large increases in rainfall in the east of up to 20%, and large decreases in the west of up to 18%.

Rainfall

There is no significant change to projected total annual rainfall over Tasmania under the two emissions scenarios. Total annual rainfall over the state is expected to remain within the historical range of 1390 ± 200 mm. However, there are significant changes in the regional pattern of rainfall across the state.

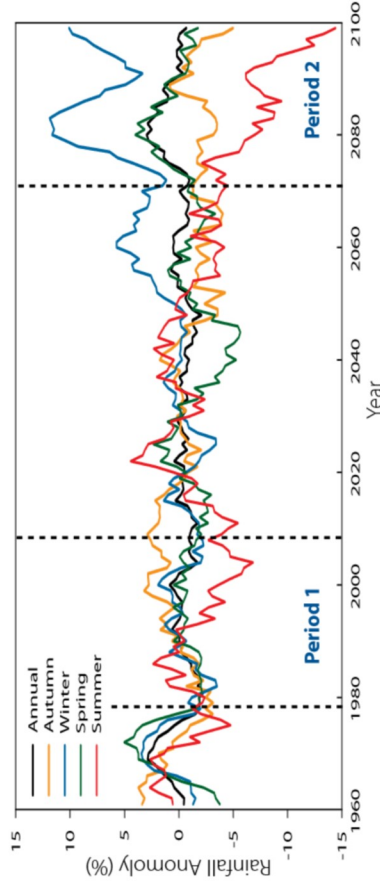
Annually, there is a steadily emerging pattern of increased rainfall over the coastal regions, and reduced rainfall over central Tasmania and in the north-west of Tasmania.

The changes in seasonal rainfall are much greater than for annual total rainfall. The west coast of Tasmania shows a significant increase in rainfall in winter and a significant decrease in summer rainfall after 2050. The central plateau district shows a steady decrease in rainfall in every season throughout the 21st century. A narrow strip along the northern east coast shows a steady increase in autumn and summer rainfall.

The projected rainfall trends are consistent with projected changes to the large-scale climate drivers, including changes to the dominant pressure patterns over the region and to the sea surface temperature in the surrounding seas. There is a projected increase in pressure in the mid-latitudes on either side of Tasmania, and a decrease in mean pressure at high latitudes. These pressure changes

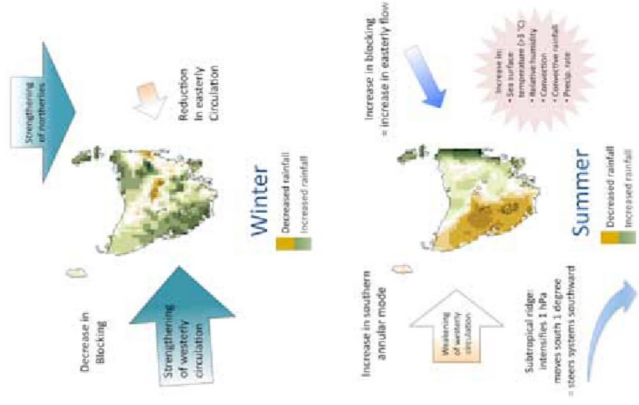
Seasonal Rainfall Projections

A2 Emissions Scenario



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Influence of Climate Drivers on Seasonal Rainfall





General climate impacts

About the project

Other climate variables

The projected changes to the general climate in the Climate Futures for Tasmania simulations also impact on a range of other environmental variables. The projections suggest spatially complex changes to the average wind speed. Average cloud cover is projected to decrease slightly and radiation is projected to remain relatively constant. Relative humidity is projected to increase on average, but with a spatially varied pattern over Tasmania. The increasing temperature over the 21st century is the dominant driver of a significant increase in pan evaporation of up to 19%; this is likely to impact water availability. Below are comments based on the projections for the high emissions scenario (A2) only. Projections of the low emissions scenario (B1) show a similar but smaller response.

Mean wind speed

Under the high emissions scenario average 10-metre wind speed over the land surface of Tasmania shows a slight decline (<5%) by the end of the century. A change in seasonality of mean wind speed is apparent, with higher speeds in July to October and lower wind speeds in November through to May. Wind speeds and the projected change to wind speeds are greater over the oceans surrounding Tasmania than over the land surface.

Cloud

A slight decrease in cloud cover is projected under the high emissions scenario, meaning there will be more reduced-cloud days or cloud-free days over Tasmania in the future. This decrease is not uniform across the state, and differs from season to season, with the greatest reduction in cloud cover over the west coast in summer. The areas of greatest reduction in cloud cover are also the areas of greatest rainfall decline.

Radiation

Average annual radiation over Tasmania shows a slight increase through the projections under the high emissions scenario. However, the changes are quite small, generally less than 5%.

Relative humidity

Relative humidity is projected to increase around the coasts and decrease over inland, high-altitude regions of Tasmania with a different pattern in each season. Under the high emissions scenario a 0.5% to 1.5% increase is projected over much of Tasmania except for the central highland region where there is a slight decrease.

Evaporation

An increase in temperature over the 21st century is the dominant driver for a significant increase in pan evaporation of up to 19%; this is likely to impact on aspects of water availability. There is a greater increase in the north and west and less in the east and south, and the increase is greater in summer than in winter.

Climate change

There is overwhelming scientific evidence that the earth is warming and that increased concentrations of greenhouse gases caused by human activity are contributing to our changing climate.

Change is a feature of the 21st century global climate. The need to understand the consequences and impacts of climate change on Tasmania and to enable planning for adaptation and mitigation of climate change at a regional level has been recognised by both the state and federal governments.

Increased temperatures are just one aspect of climate change. Global warming also causes changes to rainfall, wind, evaporation, cloudiness and other climate variables. These changes will not only become apparent in changes to average climate conditions but also in the frequency and intensity of extreme events such as heatwaves, flooding rains or severe frosts.

While climate change is a global phenomenon, its specific impacts at any location will be felt as a change to local weather conditions. This means we need regional studies to understand the effects of climate change to specific areas. Climate Futures for Tasmania is one such regional study, producing fine-scale climate change projections that will allow for the analysis of climate impacts at different locations within Tasmania, and of changes to seasonality and extreme events.

About Climate Futures for Tasmania

The Climate Futures for Tasmania project is the Tasmanian Government's most important source of climate change data at a local scale. It is a key part of Tasmania's climate change strategy as stated in the Tasmanian Framework for Action on Climate Change and is supported by the Commonwealth Environment Research Facilities as a significant project.

This project has used a group of global climate models to simulate the Tasmanian climate. The project is unique in Australia: it was designed from conception to understand and integrate the impacts of climate change on Tasmania's weather, water catchments, agriculture and climate extremes, including aspects of sea level, floods and wind damage. In addition, through complementary research projects supported by the project, new assessments were made of the impacts of climate change on coastal erosion, biosecurity and energy production, and the development of tools to deliver climate change information to infrastructure asset managers and local government.

As a consequence of this wide scope, Climate Futures for Tasmania is an interdisciplinary and multi-institutional collaboration of twelve core participating partners (both state and national organisations). The project was driven by the information requirements of end users and local communities.

'The Summary' is an at-a-glance snapshot of the General Climate Impacts Technical Report. Please refer to the full report for detailed methods, results and references.

The Climate Futures for Tasmania project complements climate analysis and projections done at the continental scale for the Intergovernmental Panel on Climate Change's Fourth Assessment Report, at the national scale in the Climate Change in Australia Report and data tool, as well as work done in the south-east Australia region in the South Eastern Australia Climate Initiative. The work also complements projections done specifically on water availability and irrigation in Tasmania by the Tasmania Sustainable Yields Project.

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Climate Futures for Tasmania is possible with support through funding and research of a consortium of state and national partners.



Photo Credits

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To access the modelling outputs:

www.tpac.org.au

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Technical Reports

Bennett JC, Ling FLN, Graham B, Grose MR, Corney SP, White CJ, Holz GK, Post DA, Gaynor SM & Bindoff NL 2010, *Climate Futures for Tasmania: water and catchments technical report*, Antarctic Climate and Ecosystems Cooperative Research Centre, Hobart, Tasmania.

Cechet RP, Sanabria A, Divi CB, Thomas C, Yang T, Arthur C, Dunford M, Nadimpalli K, Power L, White CJ, Bennett JC, Corney SP, Holz GK, Grose MR, Gaynor SM & Bindoff NL 2010, *Climate Futures for Tasmania: severe wind hazard and risk technical report*, Antarctic Climate and Ecosystems Cooperative Research Centre, Hobart, Tasmania.

Corney SP, Katzfey JJ, McGregor JL, Grose MR, Bennett JC, White CJ, Holz GK, Gaynor SM & Bindoff NL 2010, *Climate Futures for Tasmania: climate modelling technical report*, Antarctic Climate and Ecosystems Cooperative Research Centre, Hobart, Tasmania.

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Holz GK, Grose MR, Bennett JC, Corney SP, White CJ, Phelan D, Potter K, Kriticos D, Rawnsley R, Parsons D, Lisson S, Gaynor SM & Bindoff NL 2010, *Climate Futures for Tasmania: impacts on agriculture technical report*, Antarctic Climate and Ecosystems Cooperative Research Centre, Hobart, Tasmania.

McInnes KL, O'Grady JG, Hemer M, Macadam I, Abbs DJ, White CJ, Bennett JC, Corney SP, Holz GK, Grose MR, Gaynor SM & Bindoff NL 2010, *Climate Futures for Tasmania: extreme tide and sea level events technical report*, Antarctic Climate and Ecosystems Cooperative Research Centre, Hobart, Tasmania.

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All project reports and summaries (when released) will be available for download from:

www.climatechange.tas.gov.au