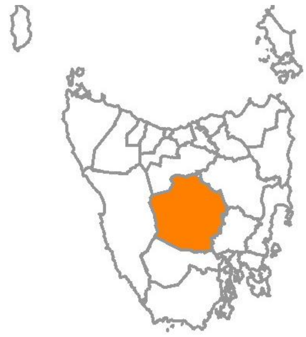
Local climate profile
Central Highlands Municipality



Past and current climate:

- The Central Highlands contains the highest-altitude and most inland of Tasmania's landmass. As such, it has cooler temperatures and a larger daily temperature range than at the coast. The region experiences cold nighttime temperatures and frosts over winter.
- The municipality has a large east-west gradient of rainfall. The western half of the municipality receives over 1600 mm average annual rainfall with a strong seasonal cycle (driest in February, wettest in August), brought mainly from frontal rain systems coming from the west. The eastern part of the municipality receives less than 600 mm average annual rainfall with no significant seasonal cycle (35 to 55 mm rainfall each month), from a variety of weather systems.
- The influence of large-scale rainfall drivers on year-to-year rainfall variability also differs across the municipality. The El Niño Southern Oscillation has an influence on the eastern part of the municipality, especially in summer. Rainfall in the west is correlated with drivers that influence the westerly systems that bring rain: with the Southern Annular Mode in most seasons and with the incidence of atmospheric blocking in autumn.
- Long-term average temperatures have risen in the decades since the 1950s, at a rate similar to the rest of Tasmania (up to 0.1 °C per decade).
- There has been a decline in average rainfall and a lack of very wet years in the municipality since the mid 1970s, and this decline has been strongest in autumn. This decline was exacerbated by the 'big dry' drought of 1995-2009. Rainfall since the end of the drought has been average or slightly above average.

Future scenarios - from the Climate Futures for Tasmania project

Fine-scale model projections of Tasmanian climate were made for two hypothetical but plausible scenarios of human emissions for the 21st Century (taken from the special report on emissions scenarios (SRES) from the Intergovernmental Panel on Climate Change (IPCC)). The scenarios are of ongoing high emissions, A2, and one where emissions plateau and fall, B1. 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 later half of the 21st Century.

1. Temperature

- Under the higher emissions scenario (A2), the municipality is likely to experience a rise in average temperatures of 2.6 to 3.3 °C over the entire 21st Century. The rise in daily minimum temperature is expected to be slightly greater than daily maximum temperature, and fairly similar in the different seasons. Under the lower emissions scenario (B1), the change over the entire century is likely to be 1.3 to 2.0 °C.
- The projected change in average temperatures is similar to the rest of Tasmania, but significantly less than northern Australia and many regions around the world. It is also less than the global average.

Produced by Michael Grose, Antarctic Climate and Ecosystems Cooperative Research Centre,
using material from the technical reports of the Climate Futures for Tasmania project

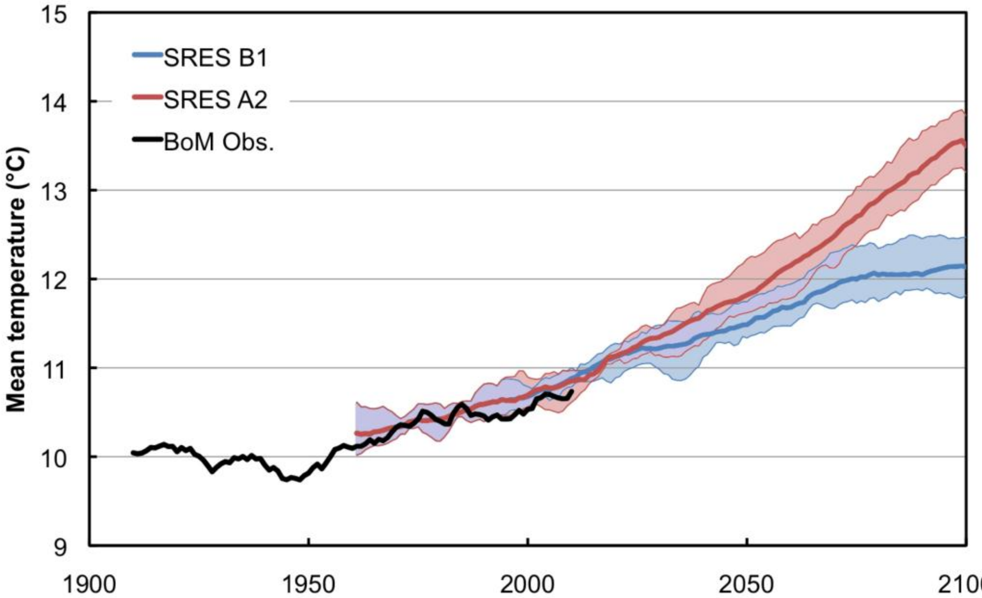


Figure 1. Tasmanian average temperature in observations (black) and model projections for the A2 scenario (red) and the B1 scenario (blue), all series are smoothed (11-year running average), shading shows the range of model projections. Changes under the higher scenario by the very end of the century are discussed in the examples below

- The projected change in average temperature is accompanied by a change in the frequency, intensity and duration of hot and cold extremes of temperature. For the A2 scenario by the end of the century at Miena:
    - The number of Summer Days (>25 °C) increases from around 4 to more than 8 days per year.
    - The temperature of very hot days increases more than the average temperature (by more than
      3 °C in some seasons).
    - Frost-risk days reduce considerably from over 100 days per year to less than 75.
    - Warm spells (days in a row where temperatures are in the top 5% of baseline levels) that currently last about a week, are projected to last up to five days longer.
    - Heat waves (>3 days >28 °C) will still be very rare events, but “cold waves” (>3 days <5 °C) will become much less common and almost rare.
- The higher altitude of the region, and the reduction in cloud and rainfall mean that the day-night temperature difference is expected to increase in all months, unlike at the coasts.

2. Rainfall, runoff and rivers

- The climate response to rainfall and runoff is similar in nature between the two scenarios, but stronger by the end of the century under the A2 scenario. The general long-term influence of climate warming by the end of the century is for generally reduced annual rainfall in the Central Highlands municipality, especially the highest regions around Great Lake.

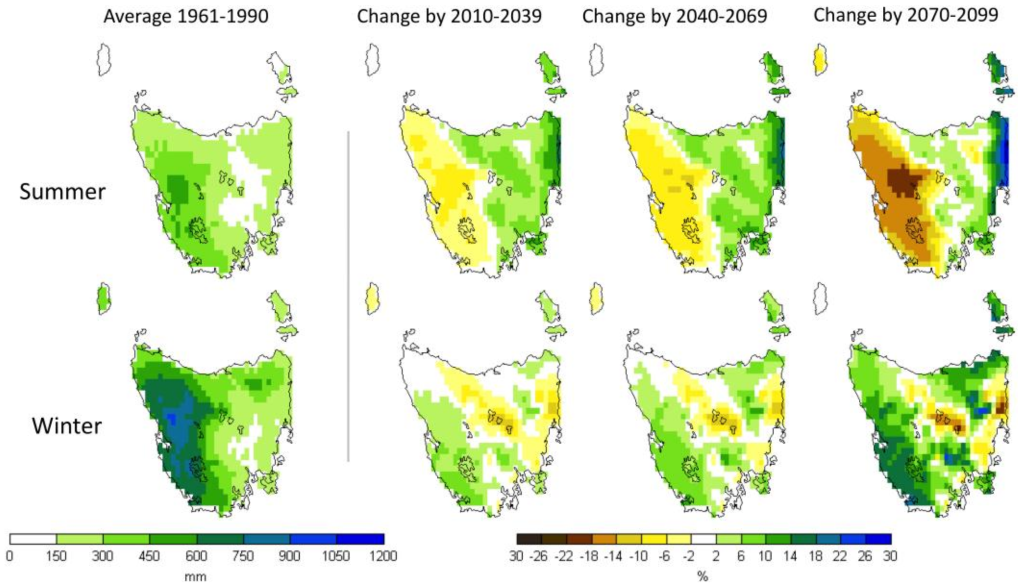


Figure 2. Average rainfall in summer and winter – the left hand side plots show the average rainfall in the baseline period (1961-1990), the plots to the right show the proportional change (%) from that amount in various periods in the 21st century in the average of six climate model projections under the A2 (higher) emissions scenario

- Rainfall is projected to decrease in the central highlands in all seasons, generally by up to 5 to 10%.
- The projected decrease in rainfall in summer and autumn is linked to decreases across the western half of Tasmania, whereas the decrease in winter and spring is not. There appears to be a link to the topography in all seasons, where the highest regions show the greatest rainfall decline .
- The long-term effect of greenhouse warming is on top of the usual cycles of rainfall, including droughts, termed ‘natural variability’. The model projections indicate that the recent dry conditions of the ‘big dry’ drought is not a new ongoing climate average state. These projections indicate that in the long term, drought frequency and severity be greater on average due to the decreased average rainfall.

- A major influence of greenhouse warming on rainfall is the tendency for heavier rainfalls interspersed by longer dry periods, and for greater extremes. However, this effect is not as strong in this area as it is in some other places. Under the A2 scenario by the end of the century at Miena.
    - The average number of rain days decreases by more than 13 days per year.
    - The average number of consecutive dry days increases from around 12 days to more than 13 days.
    - Rainfall on the wettest day of the year increases by an average of 8 mm (15% increase).
    - Rainfall brought by rare extreme events increases slightly: a 200-year average recurrence interval (ARI) event increases by around 5 mm (5 % increase). More common ARI events (ARI-10, ARI-50) increase by a similar proportion.
- Pan evaporation is likely to increase, by up to 19% under the A2 scenario by the end of the century, driven by the increases in temperature but also changes to relative humidity, wind speeds, cloudiness and radiation.
- Changes to rainfall and evaporation lead to changes in water runoff and river flows. This in turn has impacts on the inflows into dams and water storages. Under the A2 scenario by the end of the century the projections indicate:
    - Average runoff decreases in the highest altitude areas in all seasons, by more than 20% in some seasons.
    - Proportional (%) increases in runoff are larger than the equivalent change to rainfall, with decreases of more than 20% possible.
    - Along with average runoff, runoff amounts during high events and low events are also likely to decrease.
    - Average flows in the Nive River at Gowan Brae decrease in all seasons, especially in autumn. Average flows in the Derwent Estuary decrease slightly (central estimate is -5%).
    - Inflows into Lake Crescent/Sorell at the eastern border of the Central Highlands municipality steadily decreases over the century, and its reliability for meeting demand falls below 100% after 2030, and may decrease to an average of less than 80% by the end of the century.
    - Inflows to Great Lake decrease.

3. Agricultural impacts

- Chill hours are a measure of cool temperatures that influence the growth and flowering of berries, fruits and nuts. With a warming climate, annual accumulation of chill hours at Bronte Park are likely to actually increase (from around 2100 hours to over 2500 hours), since current temperatures are in fact too cold to accumulate the maximum biological chill hours. Chilling is currently close to optimal at Bothwell (around 2500 hours), so chill hours show a very slight increase to the middle of the century, then a slight decrease to the end of the century. Chill hours show a decrease at all coastal sites, so this may influence the choice of where to grow crops such as blackcurrants (requiring around 2500 chill hours).

- Grazing is an important activity around Bothwell. Simulations of grazing systems at Bothwell including both phalaris and trifolium grasses show that potential annual yields will increase, perhaps even double by the end of the century under the high emissions scenario. This mainly comes from a large increase in spring yield, but also some increase in autumn. The increase is driven mainly by a decrease in the temperature limitation but also carbon dioxide fertilization. Importantly, carbon dioxide fertilization may also lead to a reduction in feed quality and protein content in the pasture.
- Wheat is grown in the Bothwell region. Simulations of wheat cropping assuming the Tennant cultivar is grown, current levels of fertilizer is applied and no new technology is developed suggest that yields could be expected to decrease slightly from now until the end of the century (by less than 10%). This is the net result of various drivers, where increased nitrogen stress outweighs a decrease in temperature limitation and increased water use efficiency due to increased carbon dioxide concentrations. However, given unlimited resources (nitrogen, water etc) wheat yields could increase through the century. There is also a shorter time to maturity meaning there is less growth prior to flowering.
- For more information on agricultural impacts see Holz et al. (2011).

4. River floods – Derwent River

Changes to design flood hydrographs were calculated for the 1:10, 1:50, 1:100 and 1:200 annual exceedance probability events for future periods using the climate model outputs and flood hydraulic models by partners at Entura consulting. Short duration events are projected to become more intense, so catchments with critical durations of less than 72 hours are projected to experience higher flood levels and faster flow responses. However, the Derwent River has a critical duration of more than 72 hours, so is not projected to see any significant increase in peak discharge, or in flood inundation caused by larger rain events for the Derwent River.

Appendix – details of climate projections

Greenhouse gas emissions have an influence on the Earth's climate system, along with other human activities such as the emission of ozone-depleting substances, emission of aerosol (particles) and changing the land cover (e.g. deforestation). Sophisticated model simulations can be used to project the likely effect of these influences into the future given our current state of knowledge. It is impossible to predict exactly what future human emissions will be, so models are run under a set of plausible hypothetical emissions scenarios. A model simulation shows the likely effect if we follow that scenario, so it is not a single 'prediction' of the future. The simulation can't include the effect of things that are impossible to predict (such as major volcanic eruptions) .

The Climate Futures for Tasmania project produced a set of climate projections at the regional scale for Tasmania. Two emissions scenarios were considered – one of ongoing high emissions (SRES A2), and one where emissions plateau and fall (SRES B1). 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.

Climate warming causes many complex changes to the earth's climate system. These changes include alterations to ocean currents, average atmospheric circulation and ocean-atmosphere cycles such as the El Niño Southern Oscillation. Projected effects that are relevant to Tasmania include a continued extension of the East Australia Current bringing warmer waters off the east and northeast coast of Tasmania, a pole-ward shift of the subtropical ridge of high pressure and shifts in the mid-latitude westerlies (the 'Roaring 40s'), and a change in remote climate drivers such as atmospheric blocking, the El Niño Southern Oscillation and the Southern Annular Mode. The position of Tasmania adjacent to the Southern Ocean means that the effect of climate warming is not as severe as other more continental regions.

The results presented in this report were made using established methods, including:

- Extreme value distribution fitting in a generalized Pareto distribution to calculate the average recurrence intervals (ARIs).
- Hydrology runoff models developed and calibrated for the Tasmanian Sustainable Yields project to estimate the runoff, river flows and inflows to storages.
- Standard agricultural indices such as the Utah model to calculate chill hours and standard equations and a 10 °C threshold to calculate Growing Degree Days.

All information is drawn from the Climate Futures for Tasmania Technical reports please see these reports for more details, and to cite in other written work.

Reference list

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