Local climate profile
Kingborough Municipality

Past and current climate:

- Kingborough has a temperate, maritime climate with relatively mild winters and a relatively small annual temperature range compared to inland locations (e.g. Bull Bay experiences an average daily maximum temperature of 21 °C in January and 12.5 °C in July).
- The municipality receives a range of average annual rainfall amounts, from 640 mm at Taroona to 950 mm at Cape Bruny lighthouse, but all locations have the same weak seasonal cycle in rainfall (e.g. Blackmans Bay receives an average of between 35 and 60mm of rainfall each month of the year). Rainfall can come from the regular westerly frontal rain systems that cross Tasmania, or from episodic systems from the north and east.
- Year-to-year rainfall variability in this municipality shows some correlation with the El Niño Southern Oscillation in winter (where El Niño winters are generally drier than average, La Niña winters are generally wetter than average), and some correlation with atmospheric blocking in summer and spring .
- 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). Daily minimum temperatures have risen slightly more than daily maximum temperatures.
- 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 in the recent two years has been close to 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 projected 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 projected change over the entire century is 1.3 to 2.0 °C. A time series of projected mean Tasmanian temperature is shown in Figure 1.

- The projected change in average temperatures is similar to the rest of Tasmania, but less than the global average and significantly less than northern Australia and many regions around the world, especially the large northern hemisphere continents and the Arctic.

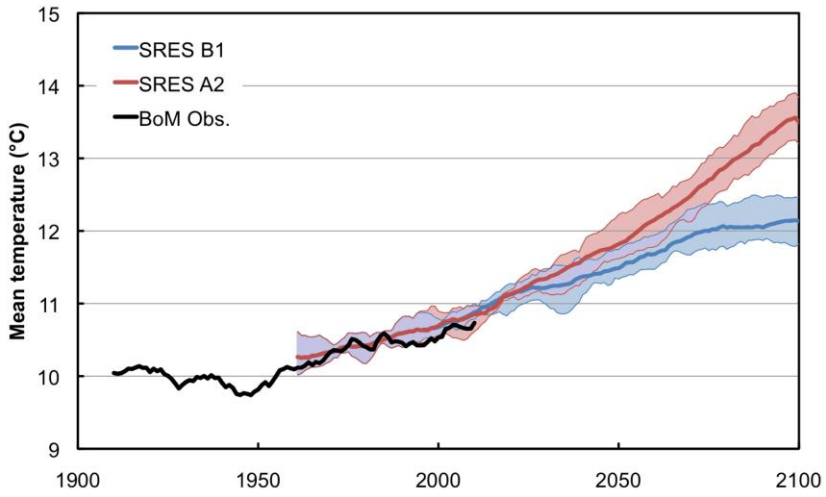

Figure 1. Tasmanian average temperature in observations (black) and model projections for the A2 scenario (red) and the B1 scenario (blue), all series are smoothed (11-year running average), shading shows the range of model projections. Changes under the higher scenario by the very end of the century 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 Blackmans Bay:
    - The number of Summer Days (>25 °C) increases from 15-20 to 40 or more.
    - The temperature of very hot days increases by a similar amount as the average temperature: 2.5 to 3.5 °C, with the biggest increase in winter and spring temperatures.
    - Frost risk days are currently infrequent, generally less than 15 days per year, and are projected to become rare events.
    - Warm spells (days in a row where temperatures are in the top 5% of baseline levels) currently last around 4 days, will last 2 to 6 days longer. Heat waves (>3 days over 28 °C) are projected to occur every year or two.
    - The average hottest day of the year is currently around 32 °C, this is projected to increase by up to 3 °C.

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 indicated by these model projections is that average annual rainfall in Kingborough will stay within historical ranges, but with changes in the different seasons.

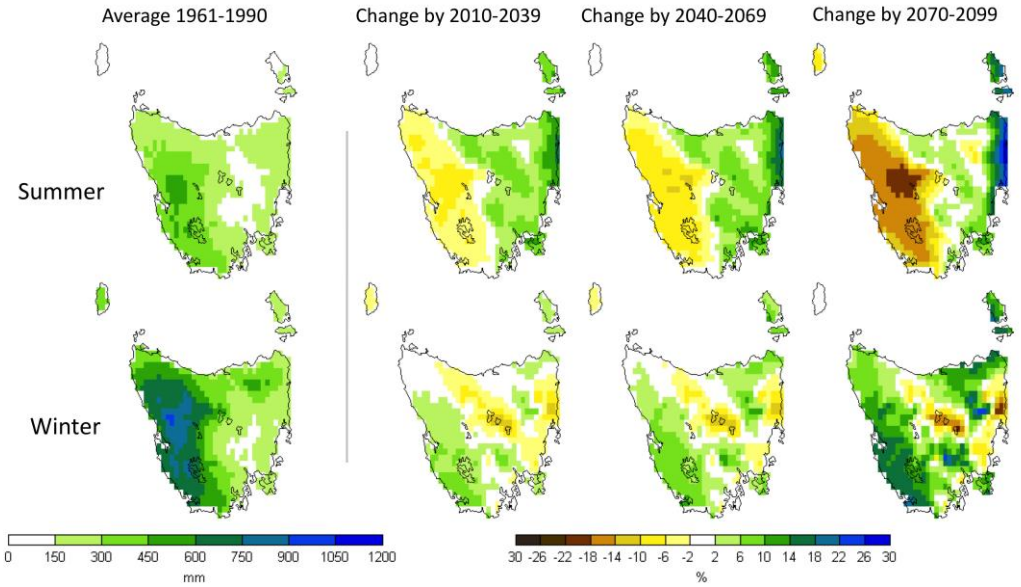

Figure 2. Average rainfall in summer and winter – the left hand side plots show the average rainfall in the baseline period (1961-1990), the plots to the right show the proportional change (%) from that amount in various periods in the 21st century in the average of six climate model projections under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

- The model simulaitons show that mean annual rainfall is projected to stay within ±15% of historical average rainfall.
- Average rainfall is projected to increase slightly in autumn, winter and summer, but decrease slightly in spring (all 0 to 15% change).
- 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 in Kingborough will stay similar to what is currently experienced.
- The projected increase in rainfall is driven by changes to the average circulation over Tasmania, combined with increasing ocean temperatures off the east coast (brought by a continued strengthening of the East Australia Current) and changes to the incidence of episodic weather systems from the east and north.
- A major influence of greenhouse warming on rainfall is the tendency for heavier rainfalls interspersed by longer dry periods, and for greater extremes. Under the A2 scenario by the end of the century there is projected to be:

  - Up to 7 less days with >1 mm of rainfall per year and longer runs of dry days, but with an increase in the average rainfall per rain day.
  - More very wet days, including 1 to 2 more days of over 10 mm rainfall each year.
  - Increases in the maximum instantaneous rainfall rates of >30% in some places in some seasons, an increase of 20 % more rainfall on the wettest day of the year, and 15% more rainfall on the wettest 5-day run of wet days.
  - An increase in the rainfall brought by rare extreme events: a 200-year average recurrence interval (ARI) event is currently around 100 mm and this increases by up to 30-40%. More common ARI events (ARI-10, ARI-50) increase by a similar proportion.

- Pan evaporation is projected 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:
  - Average runoff is projected stay the same or increase in all seasons.
  - Proportional (%) increases in runoff are larger than the change to rainfall, some projected changes in runoff exceed 30% in some seasons.
  - Runoff during high daily runoff events are projected to stay approximately within historical ranges, but extreme events that may lead to erosion or flooding may increase, runoff amounts during low daily runoff events are projected to increase.
  - Average flows in the North West Bay Rivulet are projected to stay approximately within historical ranges. Average flows in the Derwent River are projected to increase slightly: the central estimate is 10% by the end of the century (for flood flows see the section below).

3. Extreme sea level events

High water events causing coastal inundation comes from a combination of sea level, tide, storm surge and wind waves. Sea level has been rising at a rate of 3.3 ±0.4 mm/year in the recent period, and are expected to continue rising with further climate warming. The upper range of model projections indicates a rise of up to 0.82 m global average sea level by 2100 under a high emissions scenario. The sea level rise varies in different locations, and for Tasmania the sea level rise for this scenario is close to the global average.

In the east and southeast coasts of Tasmania, the very high tide height and the coastal surge contribute a roughly equal amount to high sea level events – the current 100-year storm tide event is around 0.9 to 1.4 m above average sea level. High storm heights in the southeast are generally brought by westerly cold frontal systems with a low-pressure system to the south of Tasmania. Changes to storm surges by the end of the century will not be as large as sea level rise. Accounting for all effects, the current 100-year event in Hobart will be 1.87 m in 2090 under the high emissions scenario. This means that the current 100-year event would be approximately a 50-year event by 2030, and a 2 to 6-year event by 2090 under this scenario. Changes in the Kingborough municipality are likely to be similar (e.g. Kingston Beach and Blackmans Bay).

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.

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