REGIONAL COUNCILS
CLIMATE ADAPTATION PROJECT

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Local climate profile
Clarence Municipality

Past and current climate:

- Clarence has a temperate, maritime climate with relatively mild winters and a relatively small annual temperature range compared to inland locations.
- The municipality receives an average annual rainfall of 600 mm or less with no strong seasonal cycle, for example Hobart airport receives an average annual rainfall of 495 mm per year and Sandford receives 570 mm (each site receives 35-60 mm 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.

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

- 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.

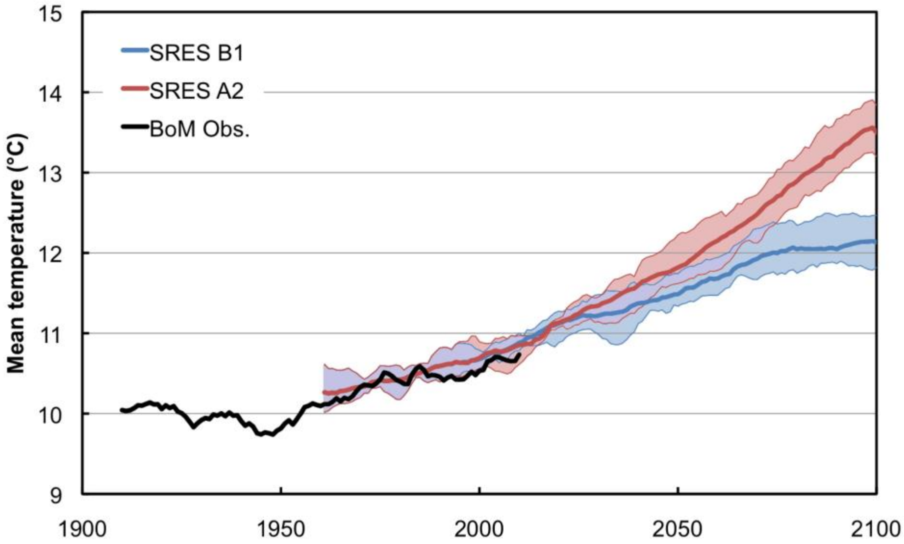

Figure 1. Tasmanian average temperature in observations (black) and model projections for the A2 scenario (red) and the B1 scenario (blue), all series are smoothed (11-year running average), shading shows the range of model projections. Changes under the higher scenario by the very end of the century 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 Clarence:
    - The number of Summer Days (>25 °C) increases from 18 days per year, to around 40 days per year.
    - The temperature of very hot days increases by a similar amount as the average temperature: 2.5 to 3.5 °C, with some seasonal variation.
    - The number of frost-risk days decline from 0 to 15 days per year, 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, are projected to last 2 to 6 days longer. Heat waves (>3 days over 28 °C) will occur every year or two.
    - The average hottest day of the year is high in the southeast compared to most places in Tasmania (up to 36 °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 Clarence will increase slightly.

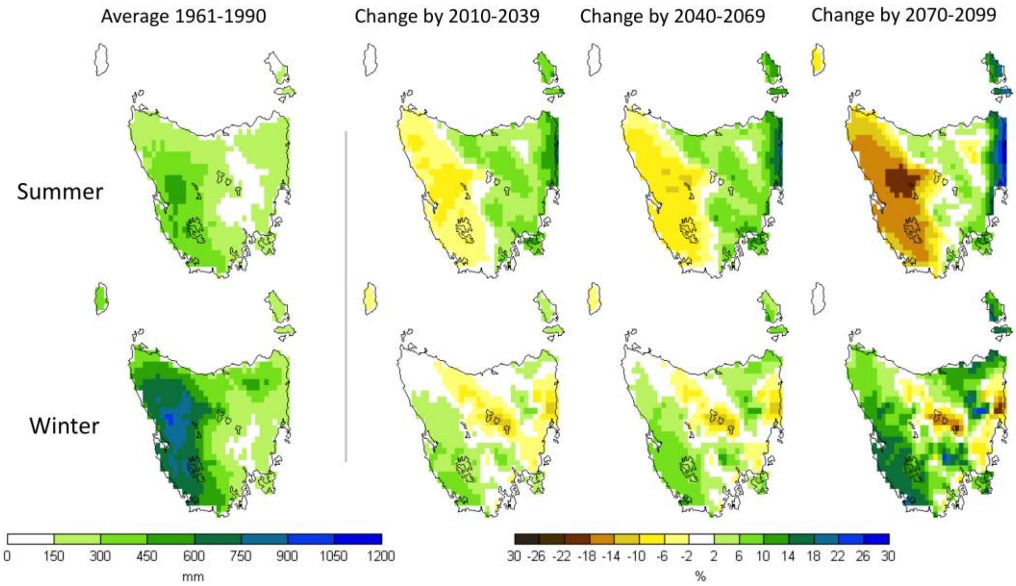

Figure 2. Average rainfall in summer and winter – the left hand side plots show the average rainfall in the baseline period (1961-1990), the plots to the right show the proportional change (%) from that amount in various periods in the 21st century in the average of six climate model projections under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

- Average annual rainfall is projected to increase (5-10%) by the end of the century under the high emissions scenario.
- Rainfall is projected to increase in all seasons, with the strongest increases in autumn (up to 20%).
- 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 may stay similar what was experienced in the twentieth century or even decrease slightly.
- 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. On the eastern shore of the Derwent River under the A2 scenario by the end of the century there is projected to be:
  - Up to 7 days less rainfall per year, and 16% more rainfall per rain day.
  - 1-3 more very wet days, including 0-2 more days of >10 mm rainfall each year.
  - An increase in the maximum instantaneous rainfall rate of over 30% in some locations in some seasons, up to 25 % more rainfall on the wettest day of the year, and a similar increase for the wettest 5-day run of wet days.
  - Rainfall brought by rare extreme events will increase: a 200-year average recurrence interval (ARI) event is currently around 100 mm, and this is projected to increase 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 to increase in all seasons.
  - Proportional (%) increases in runoff are larger than the change to rainfall, some changes in runoff exceed 30% in some seasons.
  - High daily runoff amounts are projected to increase, including those that may lead to erosion or flooding, low daily runoff amounts are projected to stay much the same.
  - Average flows in the Derwent River are projected to increase slightly: the central estimate is 10% by the end of the century (flood flows see the section below).

3. Agricultural impacts

- Frost risk days are projected to become much less frequent with a warming climate. At the end of winter in the Coal Valley region frost risk days occur every 10 days, but will occur only very 40 days by the end of century. Damaging spring frosts may still occur rarely.
- Chilling affects the growth and flowering of berries, fruits and nuts. Accumulated chill hours decrease given the warming under the two future climate scenarios. Under the A2 scenario, accumulated chill hours in the area around Campania are projected to reduce from around 2500 hours annually, to around 1700 hours by the end of the century.
- Growing degree days (GDDs) are a measure of the heat available for the growth and flowering of crops. GDDs are projected to increase significantly. Under the A2 scenario, total GDDs steadily increase from 1100 in the baseline climate, to 1400 in the middle of the century and 1900 at the end of the century. This will affect growing conditions and also reduce the length of time to maturity. Currently in the Coal Valley, 50 GDDs accumulate by October 1 and by the end of the century under the high emissions scenario 50 GDDs will accumulate by August 13.
- Conditions to grow wine grapes are projected to change markedly, which will affect choices such as grape variety and harvest date. Vineyards in the Coal Valley currently experience around 1100 annual Biologically Effective GDDs, making them suitable for growing Pinot grapes. Under the A2 scenario, this is projected to change to around 1300 BEGDD in the coming decades, and up to

1800 BEGDD in the last decades of the century, making the temperature conditions similar to current conditions in the Coonawarra or even Rutherglen regions. If the vineyard continues growing Pinot grapes, the harvest date will move forward from June to February and the grape quality will be affected. Otherwise, the wine grower may plant other varieties of grapes, such as Shiraz and Cabernet Sauvignon. As well as temperature, other climate changes are likely to impact upon the wine industry, including heavy rain events leading to soil erosion and potential for fungal diseases.

4. 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 is projected to 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.

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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