Local climate profile

Circular Head Municipality

Past and current climate:

- The Circular Head municipality has a temperate maritime climate with a small temperature range (Smithton has an average daily maximum temperature is around 22 °C in February, and 13.1 °C in July, Luncheon Hill experiences an average daily maximum temperature of 21 °C in February and 11 °C in July).
- There is a slight gradient in average annual rainfall from less than 1000 mm per year at the north coast to around 1500 mm per year in the southern and western regions, and all locations have a distinct seasonal cycle. For example, Smithton (Grant St) receives an average of 1106 mm per year (22 mm in February, 138 mm in July), Redpa receives 1149 mm per year (42 mm in February and 217 mm in July) and Balfour receives 1963 mm (85 mm in February and 241 mm in July)
- Rainfall in the municipality comes mainly from the regular westerly frontal rain systems that cross Tasmania. However, rainfall also comes from episodic systems from the north and east, including cutoff lows, especially near the north coast.
- Year-to-year rainfall variability in the western part of the municipality is correlated with the strength of the westerly circulation over the area, and therefore related to drivers such as the Southern Annular Mode (SAM) in most seasons. Rainfall variability in the northern part of the municipality is partly correlated with the El Niño Southern Oscillation and the Indian Ocean Dipole in winter and spring (where El Niño winters are generally drier than average, La Niña winters are generally wetter than average).
- 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 Circular Head 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. The recent two years have seen generally above average rainfalls.

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.

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

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.

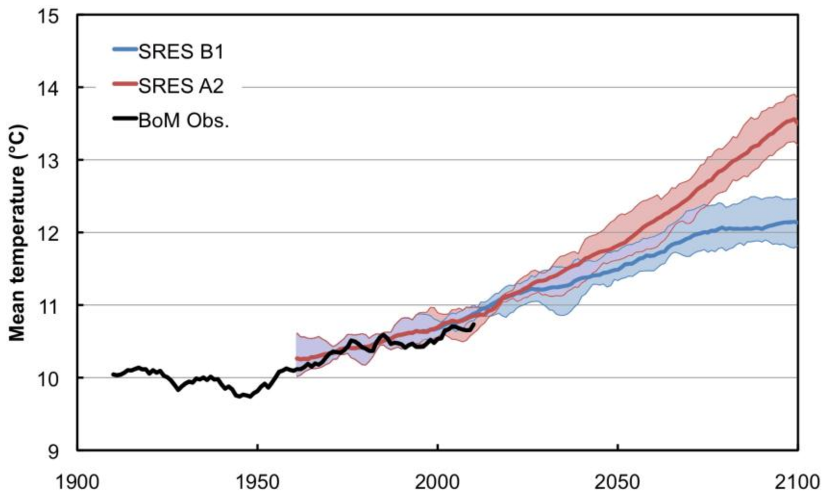

Figure 1. Tasmanian average temperature in observations (black) and model projections for the A2 scenario (red) and the B1 scenario (blue), all series are smoothed (11-year running average), shading shows the range of model projections. Changes under the higher scenario by the very end of the century 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 Smithton under the A2 (higher) scenario by the end of the century the projections indicate:
    - The number of Summer Days (>25 °C) increases from less 10 days per year, to more than 25 days per year.
    - The temperature of very hot days increases more than the change in average temperature (by 3-4 °C in some locations in some seasons).
    - A reduction in frost-risk days to a very low incidence.
    - Warm spells (days in a row where temperatures are in the top 5% of baseline levels) currently last around 6 days, are projected to last up to 12 days longer.

2. **Rainfall, runoff and rivers**

- The projected pattern of change 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 model projections indicate that the general long-term influence of climate warming by the end of the century is for a slight increase to annual average rainfall at the coast, but decreased rainfall inland.

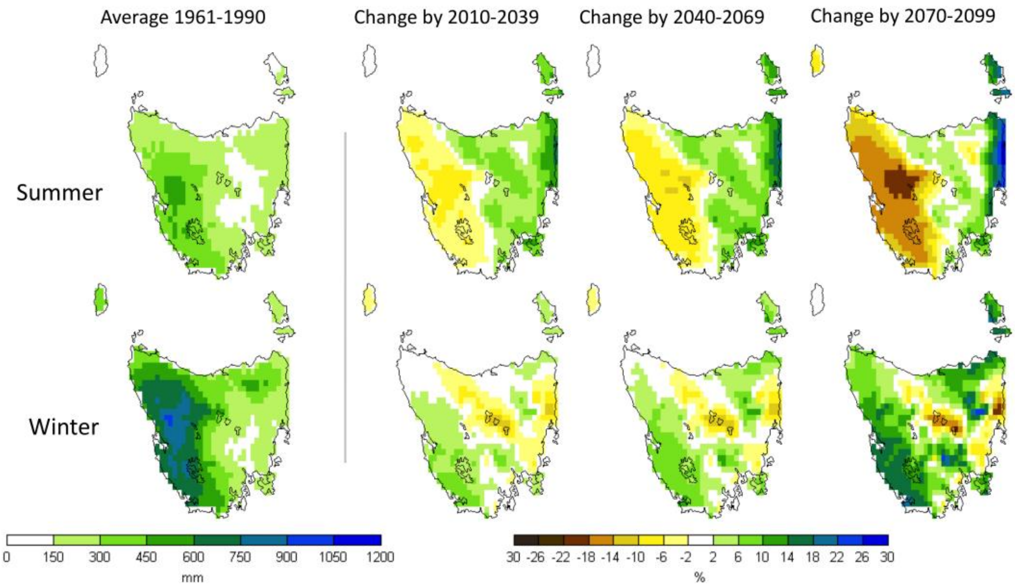

Figure 2. Average rainfall in summer and winter – the left hand side plots show the average rainfall in the baseline period (1961-1990), the plots to the right show the proportional change (%) from that amount in various periods in the 21st century in the average of six climate model projections under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

- The central estimate of the projections indicates a slight increase in annual average rainfall under the A2 scenario by the end of the century near the coast (model mean is for less than 5% change), but a decrease inland (also less than 5%).
- Rainfall in the Circular Head municipality is projected to decrease in summer and autumn (by over 5 to 15%) but increase in winter (by 10 to 15%), with little change in spring. See Fig. 2 for summer and winter.
- 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.
- The projected changes to rainfall are largely driven by changes to the average strength of the westerlies bringing frontal rainfall (an increase in winter, a decrease in summer and autumn).
- 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 varies in different areas. For the Circular Head municipality under the A2 (higher) scenario by the end of the century there is projected to be:

- Up to 15 fewer days with >1 mm rain per year on average, but significantly more rain per rain day.
- Around 2 more very wet days each year (where rainfall exceeds the baseline 95th percentile), and the possibility of 2 more days per year that exceed 20 mm.
- An increase in the maximum instantaneous rainfall rate of over 20% in some seasons, and an increase of >5 mm of rainfall on the wettest day of the year (a 10-15% increase).
- Rainfall brought by rare extreme events will increase: a 200-year average recurrence interval (ARI) event for daily rainfall at is projected to increase by more than 25 mm (>25% increase). More common ARI events (ARI-10, ARI-50) are projected to 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:
    - There is little change projected for average annual runoff amounts (generally less than 5%), but this is due to a combination of increases in winter and spring of up to 15% together with decreases in summer and autumn of up to 20%.
    - There is projected to be an increase in runoff during high events of more than 20% in some places. Runoff amounts during low events are projected to decline by more than 20% for most of the municipality.
    - Projections of increased rainfall in winter contribute to slightly higher average river flows by the end of the century under the higher emissions scenario, despite rainfall declines in summer and autumn. For example, in the Nelson Bay River (central estimate is +3%), the Welcome River (+2%), the Montague River (+5%) and the Duck River (+7%). The exception to this trend is the Arthur, Rapid and Hellyer River system (-2%). There is a projected change to the seasonality of flows.

3. Agricultural impacts

- There is a projected increase in Growing Degree Days (GDD, a measure of the heat to grow and ripen crops). This will affect where crops can be grown, reduce the time to harvest of many crops, and affect many aspects of crop management.
- Frost risk days are projected to become much less frequent with a warming climate. 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 both of the future climate scenarios.
- The reduction in summer and autumn rainfall contribute to a projected increase in the average time spent in meteorological drought measured as the proportion of time where the standardized precipitation index (SPI) is less than minus two. The proportion is projected to increase from about 1.9% to 2.9% under the higher emissions scenario by the end of the century.

- Projections indicate that the growth of grass for dairying will be slightly increased under the higher emissions scenario. Simulations of growing conditions at Woolnorth indicate that the annual cut yield of dryland ryegrass is projected to increase by up to 10% in the coming 20 years and then plateau, with the majority of the increase in spring growth. The increase is caused mainly by a reduction in temperature limitation and then the plateau is due to water limitation. Projected yields of irrigated ryegrass show a moderate increase to the middle of the century, then a decline due to an increase in days over the upper threshold for growth (28 °C). Switching to other cultivars (such as Kikuyu) may give higher yields, and increasing carbon dioxide concentrations can lead to greater water use efficiency.
- For more information on agricultural impacts see Holz et al. (2011).

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 is expected to continue rising with further climate warming. The last IPCC assessment report gave a central estimate of a rise of 0.82 m global average sea level by 2100 under a high emissions scenario. The sea level rise varies in different locations, and for the coasts of Tasmania the sea level rise for this scenario is close to the global average.

Circular Head lies on the border between two different tidal regimes, with a higher tidal range on the north coast of Tasmania, and lower tidal ranges on the west coast. The difference in the influence of tide means there is a difference in the 1 in 100 year storm tide height – 1.84 m at Stanley and 0.78 m at Granville Harbour on the west coast. Changes to storm surges by the end of the century will not be as large as sea level rise. Accounting for all effects, the 100-year event is projected to increase by the end of the century under the higher emissions scenario to around 2.42 m at Stanley and 1.37 m at Granville Harbour.

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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