Australia’s Wine Future
A CLIMATE ATLAS

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Australia’s Wine Future — A Climate Atlas

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Heat

Figure 1: Observed mean Growing Season Temperature (Oct–Apr) across all growing years from 1997–2017.

Figure 2: Observed change in mean Growing Season Temperature 1997–2017 minus 1961–1990.

Figure 3: Projected mean Growing Season Temperature (Oct–Apr) for 20-year time periods from 2021 to 2100.

Figure 4: Projected Growing Season Temperature (October to April) (Oct–Apr) for 20-year time periods from 2021 to 2100. Growing Season Temperature is expected to increase steadily into the future. Each grid cell is the mean of the 6 ensemble members.

Figure 5: Probability distribution of GST for 20-year time periods from 2001 to 2100. Variability can occur spatially within the region, across years, or between ensemble members. Grey shapes represent the probability distribution of GST for contrasting regions during 1997–2017. A shift to the right (left) indicates warmer (cooler) conditions.

Figure 6: Probability distribution of growing year maximum GDD for 20-year time periods from 2001 to 2100. Variability can occur spatially within the region, across years, or between ensemble members. Grey shapes represent the probability distribution of growing year maximum GDD for contrasting regions during 1997–2017. A shift to the right (left) indicates warmer (cooler) conditions.

Figure 7: Cumulative Growing Degree Days (GDD) across the growing year (July–June). Dashed lines show GDD values (1000, 1500, 2000, 2500) for some example phenological thresholds. Each growing year is represented by a coloured line. In future time periods, heat accumulates faster, thresholds are reached earlier and maximum GDD reached is higher.

Figure 8: Distribution of date when Growing Degree Days reaches threshold.
Figure 1: Observed mean Growing Season Rainfall (Oct–Apr) across all growing years from 1997–2017.

Figure 2: Change in Growing Season Rainfall (Oct–Apr) between the current (1997–2017) and historical (1961–1990) periods. Negative values indicate a trend towards drier conditions. Positive values indicate a trend towards wetter conditions.

Figure 3: Projected mean Growing Season Rainfall for 20-year time periods from 2021 to 2100. Each grid cell is the mean of the 6 ensemble members.

Figure 4: Time series of Growing Season Rainfall (mm). Blue points represent the annual values for each grid cell, for each of the 6 ensemble members. Horizontal grey bars represent the mean Growing Season Rainfall value during 1997–2017 in selected regions across Australia. These provide a comparison between current conditions (1997–2017) and future conditions in the region and help identify future analogue regions. Coloured bars represent the projected mean global temperature increase into the future (following the RCP 8.5 scenario). These can be used to make decisions based on projected temperature change rather than time.

Figure 5: As with Figure 4, but for Non-Growing Season Rainfall (May–September). Horizontal grey bars represent the mean Non-Growing Season Rainfall value during 1997–2017 in selected regions across Australia.

Figure 6: Violin plots of monthly rainfall (mm) for 20-year time periods from 2001 to 2100. Each violin represents monthly totals for each grid cell, for each of the 6 ensemble members, and for each year within the time period. In each panel the median violin indicates the expected probability distribution of rainfall across the growing year. The current period (2001–2020) is shaded underneath the future time periods to highlight any differences expected into the future. Dots represent the mean monthly rainfall for each violin. If the violin shifts lower (higher) this indicates a change towards drier (wetter) conditions.

Figure 7: Distribution of seasonal rainfall. The shape of the curve is driven by the level of variability experienced within each 20-year period. Variability can occur spatially within the region, across years, or between ensemble members. Grey shapes represent the probability distribution of seasonal rainfall for contrasting regions during 1997–2017. Differences in the shape of curves between the current and future periods indicate a change in the typical conditions. A shift to the left (right) indicates an increase in drier (wetter) conditions.

Figure 8: Number of rainy days during harvest. Harvest refers to the date when Growing Degree Days (GDD) reach example phenological thresholds (1000, 1500, 2000, 2500) which were chosen to reflect development time of different grape styles and varieties. Rainy days during harvest were defined as days with >10mm of rain from 7 days before to 7 days after the date each GDD threshold was reached. Variability can occur spatially within the region, across years, or between ensemble members. A shift in the curve to the left (right) indicates fewer (more) rainy days during harvest. A missing time period indicates that the specific phenological threshold was not reached within the growing year (July–June).
Australia's Wine Future — A Climate Atlas

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Aridity

Figure 1: Observed mean annual Aridity Index across all growing years from 1997–2017. Aridity Index is a value that characterises the ratio between the mean annual rainfall and mean annual evaporation. Low (high) values indicate drier (wetter) conditions.

Figure 2: Observed change in mean annual Aridity Index

Figure 3: Projected mean annual Aridity Index for 20-year time periods from 2021 to 2100. Each grid cell is the mean of the 6 ensemble members. Decreasing (increasing) values indicate a trend towards drier (wetter) conditions.

Figure 4: Time series of annual Aridity Index. Points are the annual means for each grid cell in the region, for each of the 6 ensemble members. Aridity Index values > 2 all indicate very wet conditions. There is no meaningful difference past this value, so higher values were not presented. Horizontal grey bars represent the mean annual Aridity Index from selected regions across Australia — these provide an example of conditions the region may transition towards in the future. Coloured bars represent the projected global temperature increase expected in the future (following the RCP 8.5 scenario) which can be used to make decisions based on projected temperature change rather than time (for example, if the rate of warming rapidly increases, where temperature changes are experienced earlier, useful information can still be extracted from these figures by using the coloured boxes instead of the time-axis).

Figure 5: Violin plots of monthly Aridity Index for 20-year time periods from 2001 to 2100. Each violin represents monthly averages for each grid cell, for each of the 6 ensemble members, and for each growing year within the time period. This shows the variability across the region. Dots represent the mean monthly Aridity Index for each violin. If the violin shifts lower (higher) this indicates a change towards drier (wetter) conditions.

Figure 6: Distribution of seasonal Aridity Index

Figure 7: Mean annual Aridity Index accumulated from start of the growing season (July) to date of harvest, presented as a probability distribution for each 20-year period. Variability can occur spatially within the region, across years, or between ensemble members. A shift to the left (right) indicates an increase in drier (wetter) conditions. Aridity Index values > 2 all indicate very wet conditions.
Australia’s Wine Future — A Climate Atlas

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Extremes — Hot

Figure 1: Observed mean Excess Heat Factor (EHF) during heatwaves (as per Nairn and Fawcett (2013)), across all growing years from 1997–2017. EHF is an index that characterises heatwaves, high values indicate more intense heatwaves. The mean EHF is the mean value from all heatwaves that occurred from 1997–2017.

Figure 2: Change in mean EHF during heatwaves between the current (1997–2017) and historical (1961–1990) periods. Positive (negative) values indicate a trend towards more (less) intense heatwaves.

Figure 3: Projected mean EHF during heatwaves for 20-year time periods from 2021 to 2100. Each grid cell is the mean of the 6 ensemble members. Increasing (decreasing) values indicate a trend towards more (less) intense heatwaves.

Figure 4: Time series of the number of days per growing year with temperatures greater than 30°C, 35°C, 40°C and 45°C. Axes indicate the number of days each threshold is exceeded per growing year. Values are averaged across all grid cells and the 6 ensemble members. Colours indicate each of the extreme threshold values. Generally increasing frequencies reflect a warming climate.

Figure 5: Time series of the number of days per growing year with High human heat stress. This is defined as days when daily maximum temperatures are >30°C and daily minimum humidity is >60%. These conditions cause severe risk of heat stress to humans (and potentially low productivity) to those working in exposed areas. Humans cannot work in high temperature, high humidity environments without appropriate adaptive behaviours and equipment. Points are for each grid cell from each of the 6 ensemble members. Coloured bars represent the projected global temperature increase expected into the future (following the RCP 8.5 scenario) which can be used to make decisions based on projected temperature change rather than time.

Figure 6: Violins plots of high temperatures (°C) per growing year for 20-year time periods from 2001 to 2100. Colours indicate extreme threshold values (90th, 95th and 99th percentile) of temperature during each growing year. The 99th percentile value reflects the 4th hottest day each growing year; the 95th percentile is the 18th hottest day each growing year; and the 90th percentile is the 36th hottest day each growing year. Generally increasing values reflect a warming climate.

Figure 7: Probability distributions of daily maximum temperatures and minimum overnight temperatures during heatwaves. Colour of each curve indicates different 20-year periods. The shape of the curve is driven by the level of variability experienced within each 20-year period. Variability can occur spatially within the region, across years, or between ensemble members. A shift to the right (left) indicates higher (lower) temperature heatwaves.

Figure 8: Probability distribution of the date when heatwaves occur. The shape of the curve is driven by the level of variability experienced within each 20-year period. Variability can occur spatially within the region, across years, or between ensemble members. A shift to the right (left) indicates heatwaves occurring earlier (later).
Figure 1: Observed monthly minimum temperature for each month for 20-year periods from 2001 to 2100. Each violin represents daily data for each grid cell, for each of the 6 ensemble members, and for each growing year within the time period. High (low) values indicate increased (decreased) frost risk.

Figure 2: Monthly average cumulative frost days for 20-year periods from 2001 to 2100. Values are averaged across all grid cells, for all years with each 20-year period, for each of the 6 ensemble members. This reflects how frost risk varies across the year within each 20-year period. The period 2001–2020 has been shaded underneath future time periods to highlight any differences expected into the future.

Figure 3: Projected monthly minimum temperature for each month for 20-year periods from 2001 to 2100. Each violin represents daily data for each grid cell, for each of the 6 ensemble members, and for each growing year within the time period. High (low) values indicate increased (decreased) frost risk.

Figure 4: Projected monthly frost risk days for 20-year periods from 2001 to 2100. Values are summarized across all grid cells, for each of the 6 ensemble members. This reflects how frost risk varies across the year within each 20-year period. The period 2001–2020 has been shaded underneath future time periods to highlight any differences expected into the future.

Figure 5: Projected cumulative frost intensity, which is the cumulative total of temperatures less than -2°C over a growing season. High values indicate exposure to cold conditions. Points are for each grid cell, averaged across the 6 ensemble members.

Figure 6: Time-series of the number of days per growing year when temperature falls below selected thresholds (-2°C, -3°C, -4°C). Areas indicate the number of days temperatures fall below each threshold per growing year. Values are averaged across all grid cells and the 6 ensemble members. Fewer instances reflect a warming climate.