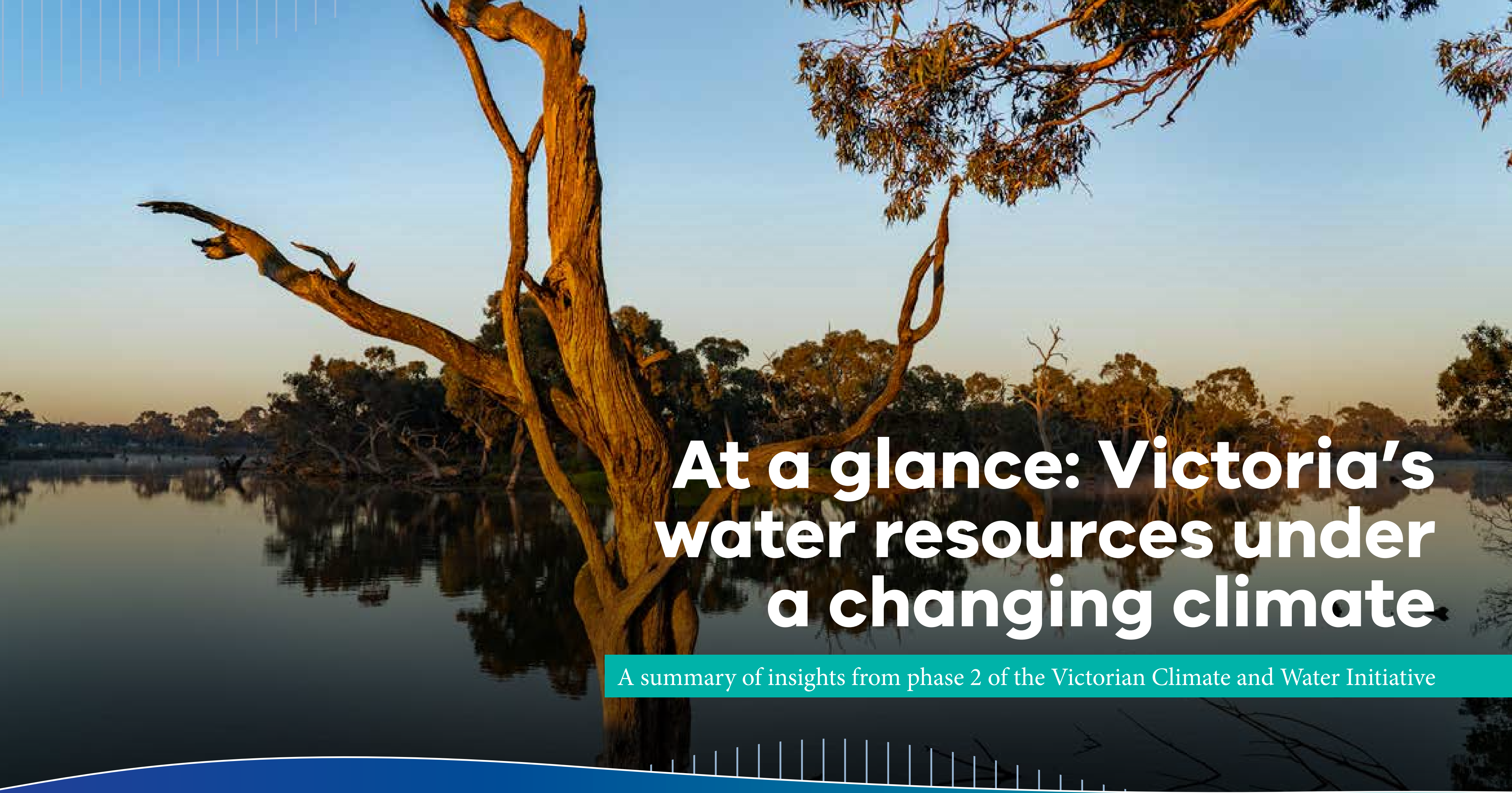

At a glance: Victoria's water resources under a changing climate

A summary of insights from phase 2 of the Victorian Climate and Water Initiative

Australian Government
Bureau of Meteorology

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VICTORIA State Government
Energy, Environment and Climate Action

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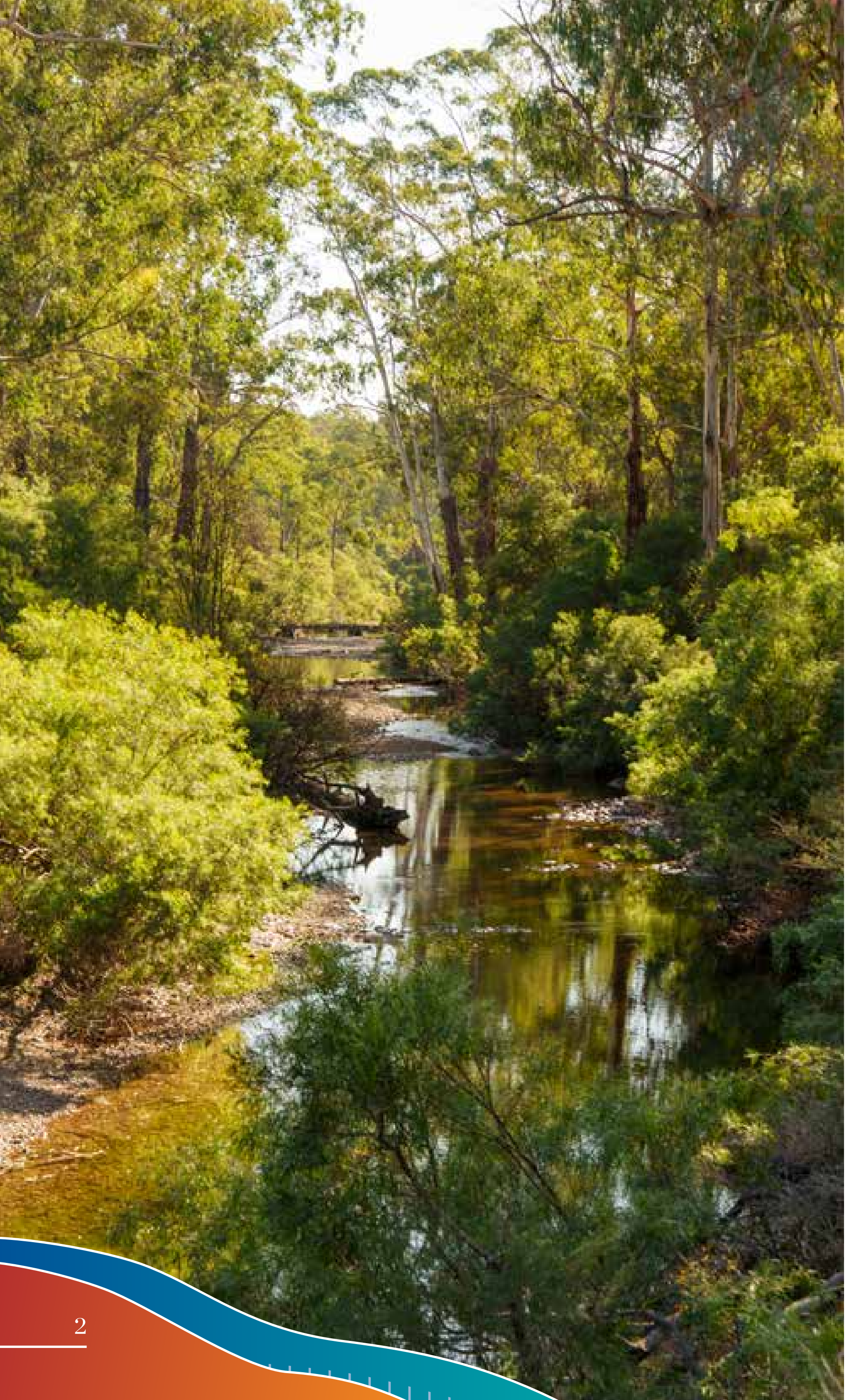


Introduction

Water is critical to our economy, environment and communities. A healthy environment with a safe, affordable, and reliable water supply is essential for the wellbeing and livelihood of Victorians.

Climate change significantly impacts Victoria's water supply and demand. Our warming and drying climate has resulted in less water in rivers, streams, dams, and less groundwater. It has also increased the risk of droughts, floods, fires and heatwaves. As the climate continues to change, likely becoming hotter and drier over the long term with more frequent extreme weather events, water managers will face growing challenges including increasing water demand and decreasing supply.

The Victorian Water and Climate Initiative (VicWaCI) is a partnership between the Victorian Department of Energy, Environment and Climate Action (DEECA), the Bureau of Meteorology and CSIRO. The initiative and associated research have improved our understanding of current and future changes in climate and water resources across Victoria. VicWaCI research supports evidence-based planning of the region's water resources, enhancing adaptive management across the water sector and water-dependent industries. For example, application of this research informs strategies and plans such as sustainable water strategies, urban water strategies, the Water Sector Adaptation Action Plan, the Latrobe Valley Regional Rehabilitation Strategy, the Environmental Water Management Plans, and the Victorian Waterway Management Strategy.

Phase 2 of VicWaCI (2021–24) builds on the initiative's first phase (2017–20) and other research investments by the Victorian Government. The initiative was managed by the Hydrology, Climate and Energy team in the Department's Water and Catchment Group, who worked closely with researchers and government and water sector stakeholders to design and run the initiative.

This report presents key findings from the VicWaCI phase 2 summary, Victoria's Water Resources Under a Changing Climate.

Victoria's changing climate

Victoria's climate varies from year to year and decade to decade. It is influenced by large-scale climate drivers (such as the El Niño Southern Oscillation and the Indian Ocean Dipole), weather systems (such as fronts, cyclones and thunderstorms), season and location.

Over recent decades, Victoria's temperatures have increased, rainfall has declined during the April to October cool season (Figure 1), snow has decreased, and evapotranspiration has been variable. The frequency of combined drought and heatwave events has risen significantly, increasing fire risk in affected areas.

Victoria's rainfall is variable but has decreased in the cool season, with a more rapid decline in recent decades.

On average, Victoria has experienced unusually dry conditions since the start of the 21st century, which may signal a shift in the state's rainfall patterns. Fewer light to moderate rainfall events contributed to declines in average annual rainfall. This recent reduction can partly be attributed to natural variability. The influence of increasing greenhouse gas emissions has further enhanced drying. At the same time, the frequency of high-intensity rainfall events has increased since 1997.

The weather systems that contribute to Victorian rainfall changed significantly after the Millennium Drought (1997–2009). VicWaCI research has provided further insight into the influence of different rain-bearing weather systems on Victoria's runoff, such as identifying that increased rainfall during February comes from thunderstorms and the combination of fronts and thunderstorms. Increased rainfall intensity has also been observed across most weather systems. Improved understanding of factors that influence Victorian rainfall, including large-scale climate drivers, the Antarctic stratospheric vortex and weather systems, helps explain the changes in observed rainfall and better predict future rainfall.

Cool and warm season rainfall and trends

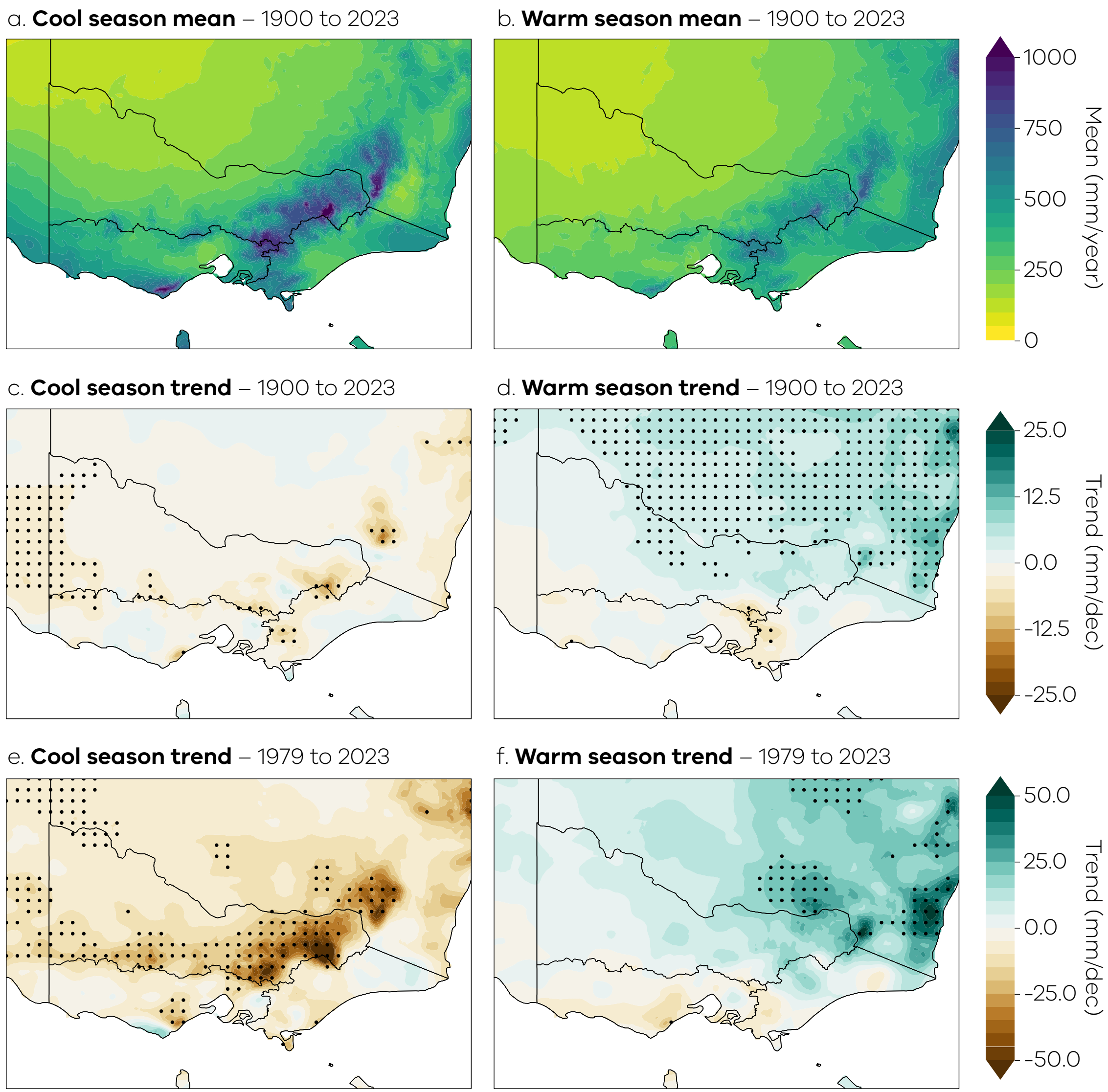


FIGURE 1 Mean rainfall (a and b for 1900–2023, mm/year) and trends (c and d for 1900–2023, and e and f for 1979–2023, mm/decade) during cool and warm seasons. Stippling indicates areas where the trends are statistically significant (at the 90% confidence interval). Data sourced from the Australian Gridded Climate Data, Bureau of Meteorology.

Victoria's changing hydrology

Average runoff in Victoria has declined since the 1960s, largely due to rainfall declines. A significant reduction in rainfall and runoff occurred during the Millennium Drought (Figure 2). In many Victorian catchments, the decrease in runoff was more significant than expected from the reduced rainfall. Despite recent wet years, this drought-like, low runoff state persists in about one-third of the assessed catchments, particularly in central and western Victoria.

Analysis of streamflow and groundwater during the Millennium Drought provides insights into catchment responses to a hotter and drier climate. In some catchments, the drought led to persistent changes in streamflow characteristics, such as intermittent flow and increased no-flow days. Average and high flow conditions were also affected, but to a lesser extent. These changes mainly occurred in catchments at lower altitudes, in dry, sub-humid to semi-arid climates, and in flatter terrain with less forest cover.

Groundwater levels declined during the Millennium Drought in some regions of Victoria. In the Wimmera region, catchment water balances have changed from a net rainfall surplus before the Millennium Drought to a small net rainfall deficit during and after the drought.

> After the end of the Millennium Drought, streamflow has remained significantly lower than average in many central and western catchments.

The length of the Millennium Drought is likely the primary climatic driver of the observed changes in Victoria's catchment response during and after the drought. Catchment processes related to surface-groundwater interactions and increased evaporative demand may also have contributed.

Change in mean rainfall and streamflow during (1997–2009) and after (2010–2023) the Millennium Drought

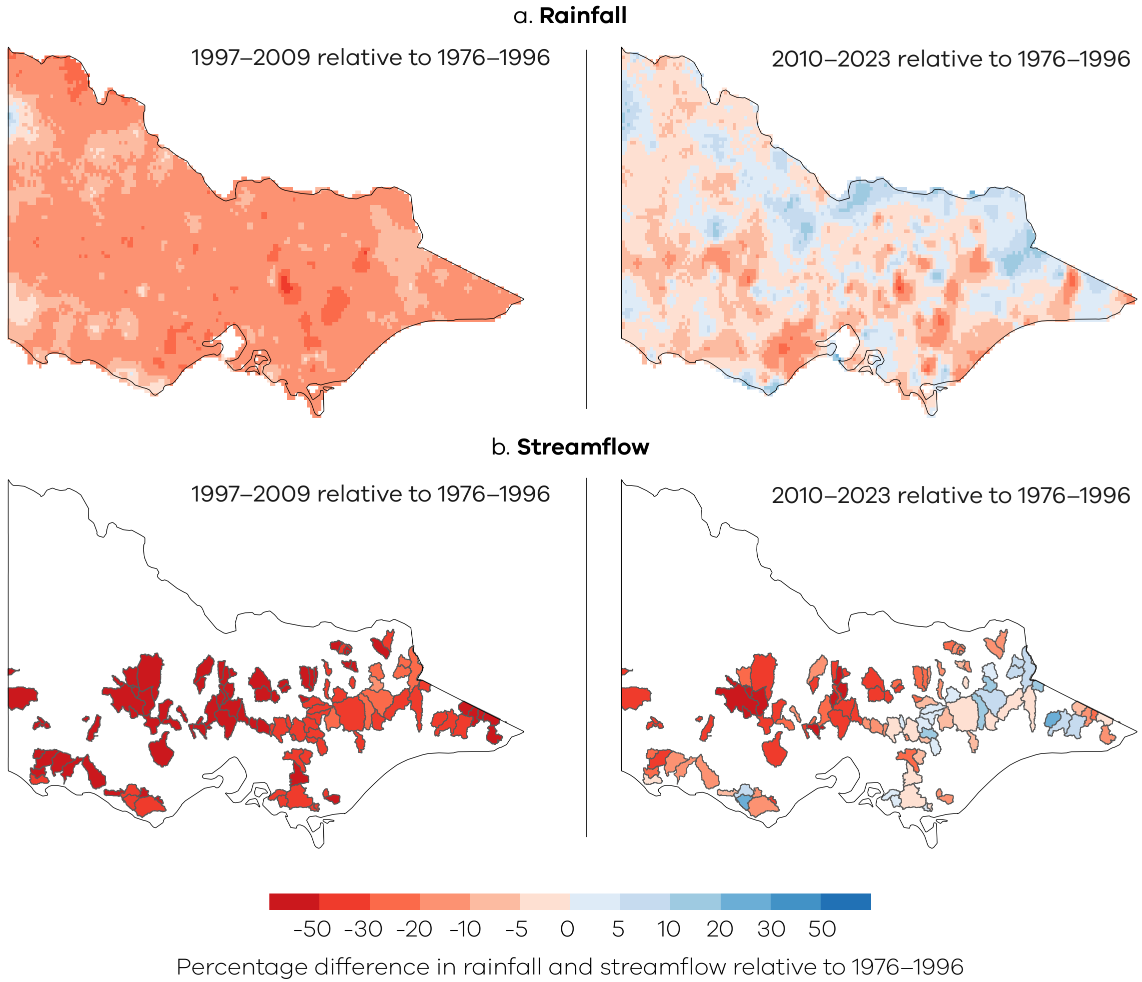


FIGURE 2 Percentage change in observed mean rainfall (a) and mean streamflow (b) in 1997–2009 during the Millennium Drought (left column) and in 2010–2023 after the drought (right column) relative to 1976–96 (pre-drought). Blue colours represent increased rainfall and streamflow, while red colours represent a reduction.

Victoria's future climate and hydrology

Victoria's climate is expected to continue warming through the 21st century, and cool season rainfall is projected to continue declining significantly, especially under a high emissions scenario (Figure 3). Changes to warm season (November to March) rainfall are less certain.

Since the end of last century, some catchments in Victoria have experienced significant declines in streamflow and changes in streamflow patterns. It is possible that these catchments may not return to the conditions experienced in the 20th century.

Victoria's average temperature will continue to increase over future decades and average cool season rainfall will continue to decline.

Projections indicate that, under a high emissions scenario, there is a high likelihood of significant declines in average cool season rainfall towards the end of the 21st century. Under a warmer climate, droughts in southeast Australia will likely become longer, more frequent, and more intense than those observed in the 20th century.

Observed and projected Victorian annual temperature, average cool season and average warm season rainfall

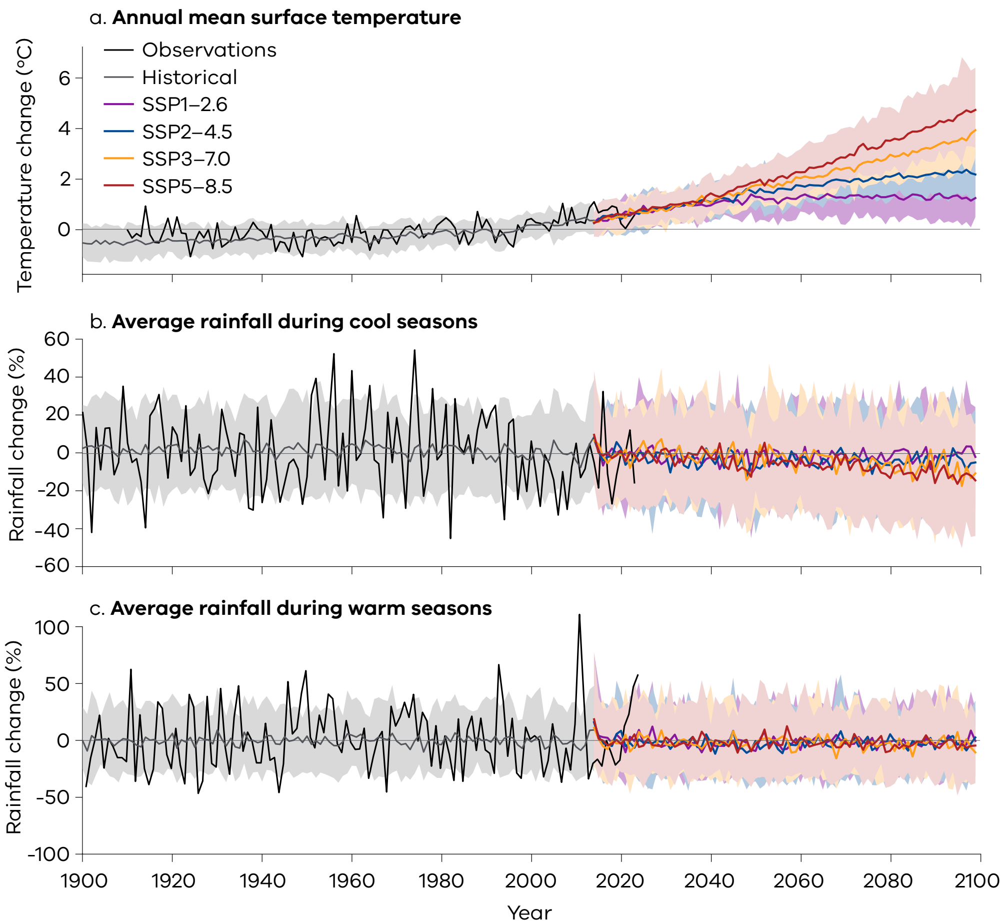


FIGURE 3 Observed and projected change in Victoria's (a) annual mean surface temperature, and averaged rainfall during (b) cool and (c) warm seasons from 1900 to 2100. CMIP6 historical model average and range to 2015 are shown in grey. Future change is projected from CMIP6 models and shown for SSP1-2.6 (low emissions scenario), SSP2-4.5 (moderate emissions scenario), SSP3-7.0 (high emissions scenario) and SSP5-8.5 (very high emissions scenario) as °C change for temperature and % change for rainfall, all relative to the baseline period (1986–2005). Observations are shown in black, historical simulations from models in grey and future scenarios in colours. Thick lines show the multi-model mean while shading shows the 10th to 90th percentile spread across models. The multi-model mean smooths out the year-to-year variability and represents the average change at that time. Source: AGCD observations and CMIP6 models.

Extreme rainfall events, such as those occurring once a year or less on average, are projected to become more intense due to increased moisture in the atmosphere. The increased intensity is expected to be greater for short-duration (less than a day) rainfall events than for long-duration (multi-day) rainfall events.

The projected decline in cool season rainfall combined with higher potential evapotranspiration will likely result in reduced catchment runoff and water resources. By 2060, average annual runoff is projected to decline across Victoria. The projected change varies from little change to more than a 40% reduction under a very extreme dry scenario. Hydrological drought (a sustained period of low water availability) is projected to become more frequent and severe (Figure 4). Multi-year wet and dry periods observed in the past will continue to occur against this background trend.

Future annual runoff in Victoria is projected to decline.

Year to year variability in rainfall and runoff is projected to increase, which could worsen hydrological drought and reduce the reliability of water resource systems. However, the projected significant reduction in average rainfall and runoff affects water system reliability more than the increased rainfall variability.

Projected change in future mean annual runoff and hydrological drought

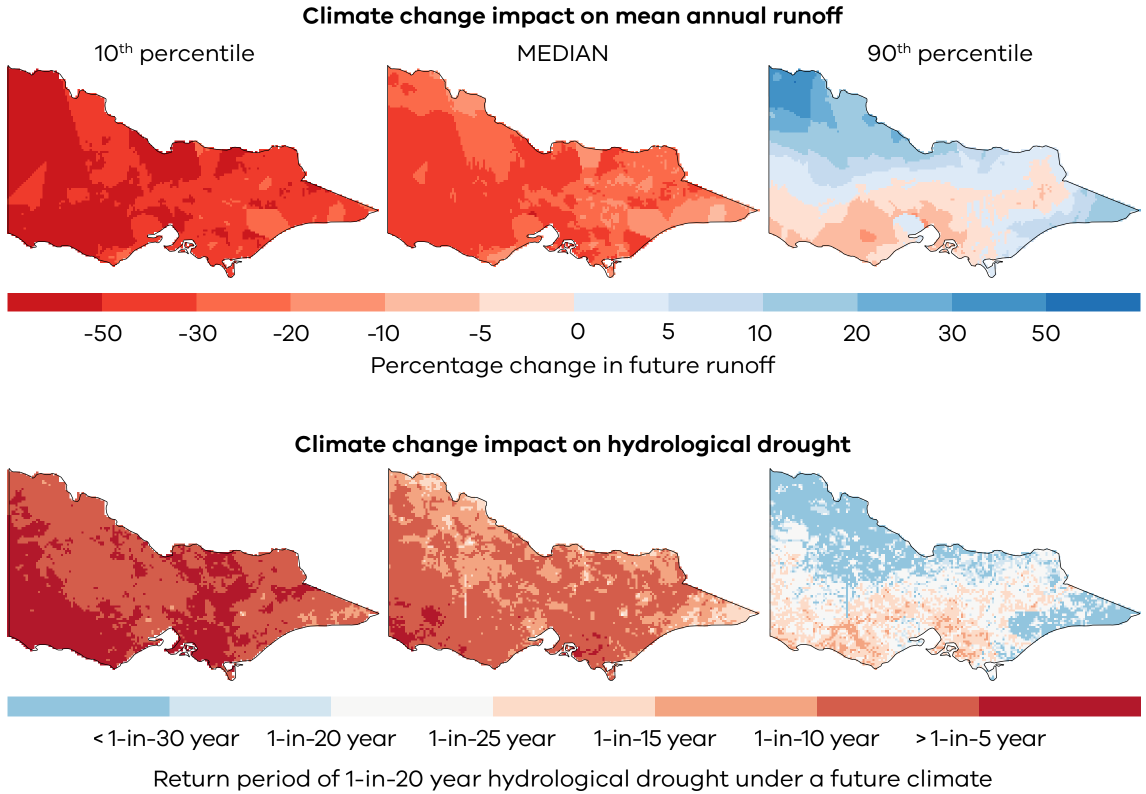
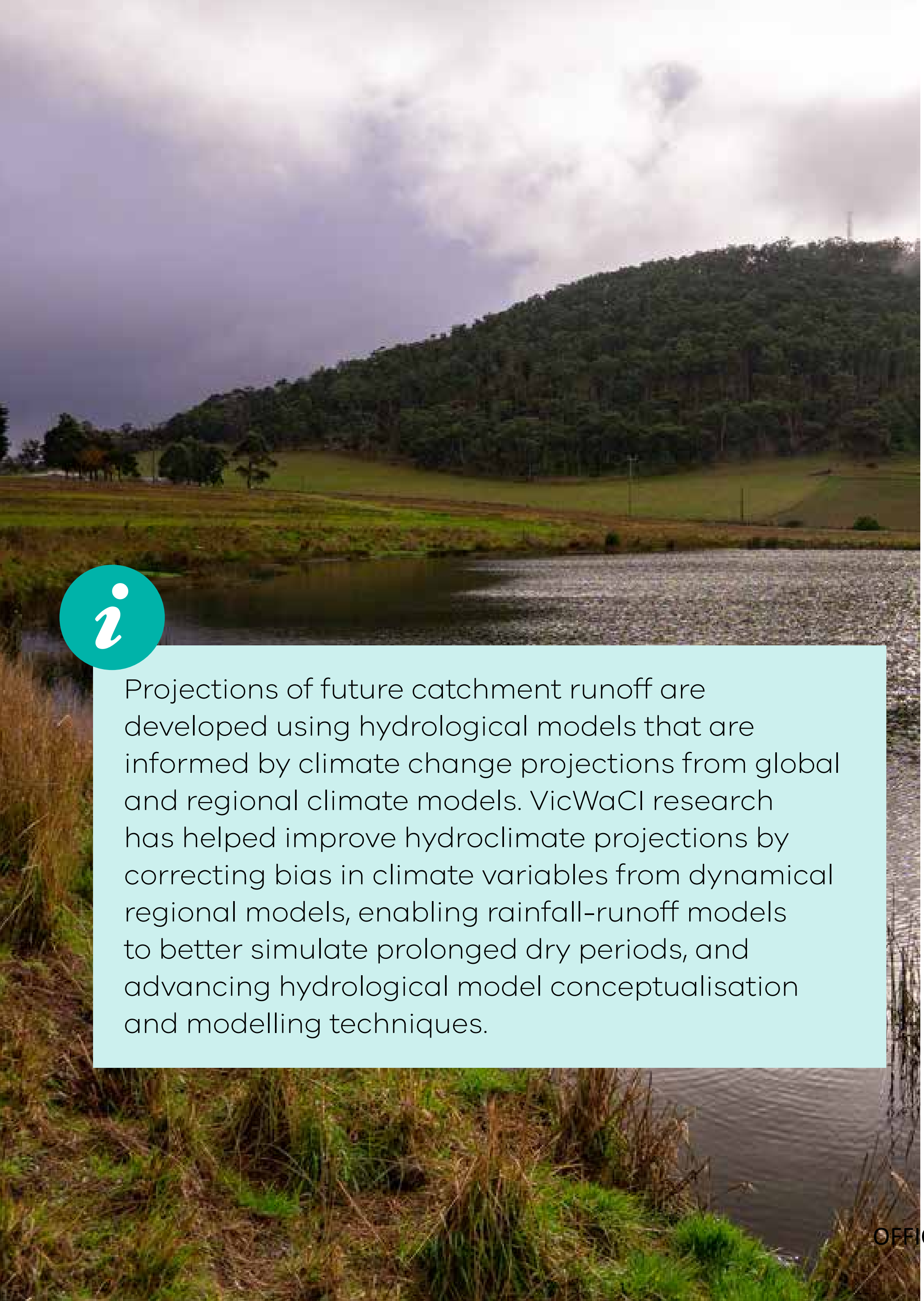


FIGURE 4 Projected change in future mean annual runoff (top) and hydrological drought (bottom) for 2046–75 (relative to 1976–2005) under a high emissions scenario. There is a large range of runoff projections, which is represented here as dry (10th percentile), median, and wet (90th percentile) projections. Red shades indicate locations projected to experience the most severe runoff reductions and where the historical 1-in-20 year hydrological drought is projected to occur more frequently in the future. Blue shades show runoff increases and reduced occurrence of drought.



Projections of future catchment runoff are developed using hydrological models that are informed by climate change projections from global and regional climate models. VicWaCI research has helped improve hydroclimate projections by correcting bias in climate variables from dynamical regional models, enabling rainfall-runoff models to better simulate prolonged dry periods, and advancing hydrological model conceptualisation and modelling techniques.

Research implications and applications for water resource management

Victoria's changing climate and hydrology have implications for managing the state's water resources. For example, a warmer and drier climate will likely reduce water availability for the state's streams, lakes, and storages. The decrease in light to moderate rainfall and the increase in heavy and extreme rainfall will influence catchment wetness, streamflow generation and flood risk. Victoria's variable climate conditions will also likely be exacerbated in the future, so water resource assessments should consider the risk of more extreme dry and wet periods.

Victoria's investment in climate and hydrological research, such as through VicWaCI, provides evidence-based guidance to inform water planning, policy, and investment decisions. This includes assessments of groundwater availability, recommendations for environmental flow, and advice on how to apply climate change scenarios to long-term water availability, supply, and demand assessments, enhancing adaptive management across the water sector and water-dependent industries.

Understanding the past changes and projected impacts of climate change on water availability enables the assessment and sustainable management of Victoria's water resources.

More details about the VicWaCI phase 2 research findings can be found in the report [Victoria's water resources under a changing climate](#).

Acknowledgements

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We acknowledge and respect Victorian Traditional Owners as the original custodians of Victoria's land and waters, their unique ability to care for Country and deep spiritual connection to it.

We honour Elders past and present whose knowledge and wisdom has ensured the continuation of culture and traditional practices.

DEECA is committed to genuinely partnering with Victorian Traditional Owners and Victoria's Aboriginal community to progress their aspirations.

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