How do the Victorian Climate Projections 2024 compare with previous climate projections for Victoria?

The *Victorian Climate Science Report 2024*[1] summarises the best available scientific evidence on climate change for our state. This includes the *Victorian Climate Projections 2024* (VCP24)[2]. These add to the *Victorian Climate Projections 2019* (VCP19)[3]. This fact sheet helps decision-makers understand how the projections compare.

Key messages:

- VCP24 is an update to VCP19 which supplements, rather than replaces, the previous climate projections for Victoria.
- VCP24 draws on the most recent (CMIP6) generation of Global Climate Models, whereas VCP19 drew on the previous (CMIP5) generation. VCP24 also draws on a wider range of regional climate models (regional downscaling) than VCP19.
- VCP24 adds projections for two new emissions scenarios (low and high) to the projections available from VCP19 for two different scenarios (medium and very high – the latter was referred to as "high" at the time).
- VCP24 includes fewer climate variables than VCP19 but it includes heatwave and drought variables that were not in VCP19.
- VCP24 supports the findings of VCP19 that Victoria will get hotter and drier.

VCP24 builds on and does not supersede VCP19

VCP24 provides an update to VCP19 based on new climate modelling. However, that does not mean that the new projections contradict or replace previous climate projections for Victoria – rather, they represent an evolution of VCP19.

Our understanding of the past and future climate continually improves, and climate models increase in sophistication over time. Every new set of future simulations adds to our understanding of how the climate may evolve.

VCP24 has taken an approach to producing climate change projections consistent with that used for VCP19. In both sets of projections, researchers analysed data from a range of different climate models and assigned confidence statements to results based on multiple lines of scientific evidence, including from observational data and current scientific understanding of climate processes.

VCP24 draws on the latest generation of climate modelling

VCP24 draws on the most recent generation of Global Climate Models (GCMs) from the international Coupled Model Intercomparison Project phase 6 (CMIP6)[4], whereas VCP19 drew on the previous generation of global models (CMIP5)[5]. In addition, VCP24 draws on a wider range of regional models than VCP19. This will aid integration of VCP24 with emerging national projections.

CMIP is a project of the World Climate Research Programme (WCRP) that provides data from global

[1] Victorian Climate Science Report 2024

[2] Victorian Climate Projections 2024 Technical Report

[3] Victorian Climate Projections 2019 Technical Report

[4] CMIP Phase 6 (CMIP6) - Coupled Model Intercomparison Project (wcrp-cmip.org)

[5] CMIP Phase 5 (CMIP5) - Coupled Model Intercomparison Project (wcrp-cmip.org)

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climate models to help scientists to understand past, present and future climate changes. CMIP6 provides more global simulations at a higher resolution than CMIP5 and the models are based on more up-to-date climate science, resulting in incremental improvements in the simulation of Australia's climate. Both VCP19 and VCP24 add regional detail to the GCMs through a process called 'dynamical downscaling', whereby a regional climate model is used to simulate the global climate model output at a finer spatial resolution, better accounting for local geography, land use and other complex atmospheric dynamics.

As well as reporting results from a wide range of GCMs, VCP19 included results from regional downscaling of 6 GCMs. CSIRO downscaled these GCMs to a resolution of ~5 km over Victoria for VCP19. VCP24 incorporates regional downscaling of more GCMs from a wider range of global and regional models, totalling 32 regionally downscaled simulations for each emissions scenario. This includes ~4 km resolution regional downscaling over southeast Australia from the NSW Government's NARCliM2.0 project[6]. It also includes national-scale ~10-20 km downscaling from the Queensland Government and the Australian Climate Service, a partnership between the Bureau of Meteorology, CSIRO, the Australian Bureau of Statistics and Geoscience Australia[7]. This multi-model approach is in alignment with the goals of the *Climate Projections Roadmap for Australia* published by the Australian Government.[8] It allows greater comparability with emerging national and state projections which draw on some of the same modelling.

VCP24 adds projections for new emissions scenarios not included in VCP19

VCP19 included projections for medium and very high scenarios for future global greenhouse gas emissions. VCP24 adds projections for two new emissions scenarios, with low and high emissions. This broad range of scenarios supports decision makers with different needs.

The amount of climate change that will be experienced globally, and in Victoria, will depend on the future trajectory of global greenhouse gas emissions. Because this trajectory is unknowable, climate projections results are often given for a range of plausible but different scenarios for future global emissions.

The global-scale climate projections presented in the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC)[9] used **Representative Concentrations Pathways** (RCPs) as a basis for emissions scenarios. RCPs are underpinned by scenarios for future changes in the energy imbalance of the climate system, or 'radiative forcing', due to emissions of greenhouse gases and aerosols into the atmosphere and changes in land use. VCP19 used two emissions scenarios selected from the larger range of RCPs available.

In 2021, the IPCC released projections based on updated emissions scenarios, called **Shared Socioeconomic Pathways** (SSPs), as part of its Sixth Assessment Report[10]. SSPs are underpinned by narratives about the future socio-economic development of the planet, which are then linked to scenarios of radiative forcing. The two SSPs chosen for analysis in VCP24 are consistent with current international standards on priorities for regional downscaling.

Details of the RCP and SSP scenarios are described in Table 1 and shown in Figure 1.

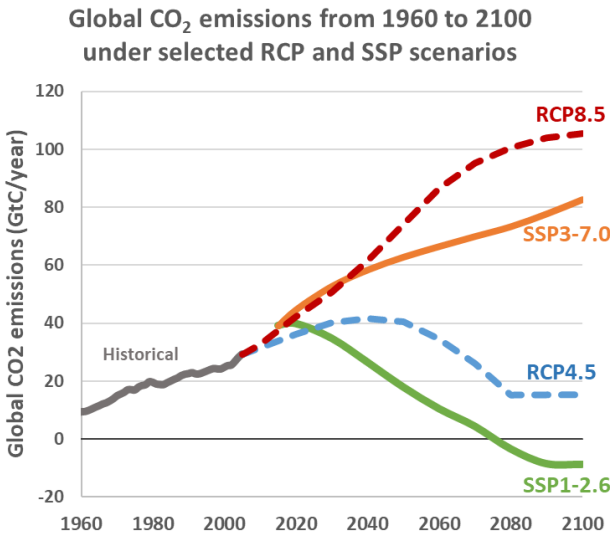

Figure 1. Emissions scenarios used in VCP19 and VCP24.

The SSP3-7.0 high emissions scenario used by VCP24 has emissions significantly lower than those of RCP8.5 by 2100, but still appropriately high to support challenging yet plausible climate scenarios for risk analysis and adaptation planning. The RCP8.5

[6] N2-Factsheet-General.pdf (nsw.gov.au)

[7] Australian Climate Service (acs.gov.au)

[8] DCCEEW - Climate Projections Roadmap for Australia

[9] AR5 Climate Change 2013: The Physical Science Basis — IPCC

[10] AR6 Climate Change 2021: The Physical Science Basis — IPCC

projections from VCP19 provides what are now considered low likelihood, worst case projections.

The SSP1-2.6 low emissions scenario used by VCP24 assumes more immediate reductions in global emissions than the RCP4.5 medium emissions scenario used by VCP19 and represents the future climate if global emissions are reduced in alignment with the Paris Agreement, reaching global net zero emissions by around 2075.

In addition to VCP24, in the *Victorian Climate Science Report 2024* includes information from peer-reviewed literature on future changes in climate-related hazards. For sea level projections, this includes five SSPs. Projections for some of these SSPs for other climate variables may become available over time as work on regional downscaling continues.

VCP24 and VCP19 include different climate variables

VCP24 prioritises analysis of changes in average and extreme temperature and rainfall across a wider range of modelling then VCP19, and as a result, not all of the climate variables included in VCP19 are included in VCP24. However, VCP24 includes heatwave and drought variables that were not included in VCP19.

While the model simulations underpinning both VCP19 and VCP24 encompass a wide variety of climate variables, VCP19 provided detailed projections for more of these variables, such as pressure, winds, humidity and evaporation. VCP24 includes results from many more climate model simulations than VCP19 but focuses on projections of average and extreme temperature and rainfall, which are generally most of interest to general audiences and decision makers. Although the overall number of climate variables included in VCP24 is less than in VCP19, VCP24 includes some key impact-relevant variables related to heatwaves and drought variables that VCP19 does not.

Different measures of extreme heat and extreme rainfall were used in each set of projections: VCP19 provided projections of change in 1-in-20 year hot days and heavy rainfall days whereas VCP24 looked at 99th percentile (approximately 3-4 times per year) and 99.9th percentile (approximately 3-4 times per decade) hot days and heavy rainfall days.

VCP24 broadly supports the main findings of VCP19 – that Victoria will get hotter and drier

Both VCP24 and VCP19 find that Victoria will become hotter and drier in the future, with hotter heat extremes, less cool season rainfall, and more intense extreme rainfall events.

Both VCP19 and VCP24 project with confidence that:

- warming of the **average temperature** of Victoria will continue at a rate close to the rate of warming of the global average temperature;
- **heat extremes** (i.e. the temperature reached on hot days) will warm by more than the rate of average temperatures;
- **average rainfall** during the cool season (April to October) and annual rainfall are likely to decrease in Victoria in the future, but rainfall will continue to vary from year-to-year and decade-to-decade; and
- **extreme rainfall events** will become more intense, with the more extreme rainfall events intensifying the most.

Emissions scenario	Average annual temperature increase by 2090
SSP1-2.6 (VCP24)	0.6 – 1.8 °C (1.0 °C median)
RCP 4.5 (VCP19)	1.3 – 2.2 °C (1.8 °C median)
SSP 3-7.0 (VCP24)	2.2 – 3.6 °C (3.1 °C median)
RCP 8.5 (VCP19)	2.6 – 4.7 °C (3.6 °C median)

Table 1. Summary of average temperature projections under the different emissions scenarios used in VCP19 and VCP24, as change by 2090 from a 1986-2005 baseline.

VCP24 provides some new findings

While the findings of the VCP24 projections are largely consistent with the VCP19 projections, there are some differences, particularly for rainfall.

While there is agreement between the VCP24 and VCP19 on a continued decrease in cool season rainfall, there is less certainty around future changes in summer rainfall. VCP19 noted that increases and decreases in summer rainfall are possible. The new VCP24 rainfall projections do not narrow the outlook, with simulations showing a mix of increasing and decreasing summer rainfall. Notably, the new ~4 km NARCliM2.0 simulations project more pronounced decreases in average summer rainfall than were projected by any of the modelling contributing to VCP19, whereas some other new regional climate model simulations (such as those prepared as part of the Australian Climate Service) show large increases in summer rainfall.

High-resolution regional modelling can potentially represent spatial patterns in future rainfall change at levels of detail that global models cannot. However, the highest-resolution modelling contributing to VCP19 and VCP24, the ~5 km resolution modelling from CSIRO and the ~4 km resolution NARCliM2.0 modelling respectively, project quite different spatial patterns of future rainfall changes for Victoria. More in depth analysis is being done by the Australian climate science community to understand these differences.

A new feature of VCP24 that arises from the use of CMIP6 global modelling is the inclusion of several climate models simulations that project especially rapid warming in response to future increases in the amount of greenhouse gas in the atmosphere. Such 'high climate sensitivity' simulations were not as numerous in CMIP5 and did not influence VCP19 to the same degree as VCP24. Research on 'high climate sensitivity' models is ongoing. Currently, the high-warming futures arising from these models are not considered to be likely. However, they cannot be ruled out and so are presented separately in VCP24 as 'low-likelihood, high-warming' temperature projections.

Both VCP19 and VCP24 show that extreme temperatures will warm more than average temperatures. However, the difference between warming rates is less pronounced in VCP24.

What kind of projections for Victoria should we expect to see in the future?

As work on downscaled climate projections continues across Australia, more information on future climate hazards for Victoria will become available. Further into the future, new climate projections for Victoria may be based on the next generation of global climate models.

As time goes by, additional analysis will be done on the climate model simulations considered by VCP24. For example, the Australian Climate Service is developing new national climate hazard projections for Australia from some of the national-scale simulations considered by VCP24.

Other projections information to come will be based on additional climate modelling. In the near future, additional regional modelling for Australia may allow projections for more SSPs to be developed. A priority will be SSP2-4.5, a medium emissions scenario with emissions between those of SSP1-2.6 and SSP3-7.0.

Further into the future, it is likely that Australia will move to using even more advanced climate modelling as a basis for climate projections. The next phase of CMIP, CMIP7[11], is currently being planned and offers the opportunity for CMIP7-based downscaled climate projections for Australia to be developed sometime after 2026.

[11] CMIP Phase 7 (CMIP7) - Coupled Model Intercomparison Project (wcrp-cmip.org)

	What was in VCP19?	What's in VCP24?
Global modelling project	**CMIP5**	**CMIP6**
Regional downscaling (the process of running the results of a global climate model through a higher spatial resolution regional climate model, to better simulate local geography, land use, atmospheric dynamics etc.)	• **Downscaling to ~ 5 km** using one regional climate model to downscale 6 global models	• **Downscaling to ~ 4 km** for southeast Australia using two regional climate model variants to downscale 5 global models • **National-scale downscaling to ~10-20 km** from three regional climate modelling centres (each downscaling 6 or 7 global models)
Emissions scenarios	• **RCP4.5 -** a **medium emissions scenario** with global emissions of carbon dioxide **peaking around 2040** before declining to **1960s levels by 2100**. Net zero emissions are not achieved under this scenario. • **RCP8.5** - a **very high emission scenario** with carbon dioxide emissions continuing to increase to almost **triple present levels by 2100**. In VCP19 this is termed the 'high' emission scenario.	• **SSP1-2.6** - a **low emissions scenario** following a 'sustainability' narrative with immediate significant cuts in emissions to reach **net zero around 2075**, roughly compliant with the Paris Agreement. Equivalent to RCP2.6. • **SSP3-7.0** - **a high emissions scenario** following a 'fossil-fuelled development' narrative with carbon dioxide emissions continuing to increase to roughly double present levels by 2100. There is no equivalent RCP.
Climate variables	• average temperature and rainfall • extreme temperature (1-in-20-year hottest day and night and coldest night) • days above heat thresholds (days above 35 and 45 °C) • extreme rainfall (1-in-20 year wettest day) • other variables, such as pressure, winds, humidity and evaporation	• average temperature and rainfall • extreme temperature (99th and 99.9th percentile hottest days and nights) • days above heat thresholds (days above 99th and 99.9th percentile) • extreme rainfall (99th and 99.9th percentile daily rainfall) • drought (months below 10th percentile) • excess heat factor heatwave metrics
Results: warming of average temperature	Victoria to warm at a similar rate to global average warming	Consistent with VCP19
Results: warming of temperature extremes	Temperature extremes warm more than average temperatures	As for VCP19, but less pronounced (likely due to different measure of temperature extremes used and different regional climate modelling)
Results: change in cool season rainfall	Likely decrease, high confidence	Consistent with VCP19
Results: change in summer rainfall	Both increases and decreases are possible	As for VCP19, but with more pronounced potential increases and decreases (further analysis needed to determine confidence in the more pronounced results)
Result: changes in extreme rainfall	More intense extreme rainfall events	As for VCP19, but with some smaller increases in intensity (likely due to different measures of rainfall extremes used and different regional climate modelling)

Table 2. Summary of comparison of VCP24 and VCP19

We acknowledge Victorian Traditional Owners and their Elders past and present as the original custodians of Victoria's land and waters and commit to genuinely partnering with them and Victoria's Aboriginal community to progress their aspirations.

The State of Victoria acknowledges the contribution of CSIRO, Australia's national science agency, in producing this document. The information in this document is drawn from the Victorian Climate Projections 2024 Technical Report which should be consulted for more detail (Round V, Grose M, Macadam I, Bodman R, King M, Truong S, Heady C, Thatcher M, Clarke J M (2024) Victorian Climate Projections 2024 Technical Report. CSIRO).

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