Unmodelled futures and the Victorian Climate Projections 2024

The *Victorian Climate Projections* (VCP24) presents a plausible range of future Victorian climates based on scenarios of global greenhouse gas emissions and modelling of how the climate may respond to those scenarios. However, climate projections can never cover all possible future possibilities. This fact sheet outlines some possible climate outcomes and changes not modelled by VCP24, including 'tipping points' and some relevant extreme climate hazards.

Key messages:

- VCP24 describes a range of possible future changes in Victoria's climate but the projections do not represent all possible future climate changes for the State.
- Global tipping points are abrupt and irreversible changes to the global climate, triggered by global warming. They are not included in the VCP24 modelling but if they are triggered would have important impacts on Victoria.
- Limitations of climate models mean than not all climate hazards are confidently modelled in VCP24. These include for example storms, megadroughts and compound events, where multiple hazards occur together.
- Decision-makers should use a risk management approach that considers high-impact, low likelihood risks to account for tipping points and unmodelled hazards.

VCP24 does not describe all possible future climate changes for Victoria

VCP24 provides a useful tool to explore changes in Victoria's climate under low and high scenarios for future global emission of greenhouse gases. However, there are possible future climate changes that are not represented in the projections.

In VCP24, future climate change is presented for two plausible greenhouse gas emissions scenarios bracketing a useful range of global emissions:

- a low emissions scenario where global emissions are reduced rapidly and global warming is limited to 2 °C (the Paris Agreement goal)
- a high emissions scenario where emissions roughly double present levels by 2100, resulting in large changes in climate

VCP24 presents the likely range of change in Victoria's climate under these emissions scenarios, but also includes some representations of changes outside the *likely* range, for example models showing a very hot, low-likelihood, high warming.

However, it is important to acknowledge the possibility that there may be future changes which are not well represented in the VCP24 projections, with three main ways we could experience them:

- Through scenarios of anthropogenic emissions which are different to the two selected (such as an "overshoot" scenario where technology is used to rapidly drawdown greenhouse gases); or through major natural events such as large volcanic eruptions producing temporary climate effects.
- Large-scale climate responses that are outside the range of the typical changes we model – through abrupt changes such as 'regime shifts' in the climate system, and the reaching of 'tipping points' (see below); or global changes that are not yet well understood and represented in global climate models.

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- Extreme events that remain hard to model and are not fully represented even in the latest cutting edge and high-resolution models. These include some types of severe and hail storms, but also could possibly include megadroughts (that we know have occurred in the last few hundred years) and other, or compound events.

Further detail is provided below on two areas of strong interest to decision makers; Tipping points and climate hazards not modelled in VCP24.

Global climate tipping points are not accounted for in VCP24

Global tipping points are relatively abrupt and effectively irreversible changes to global climate triggered by global warming. They are not included in the climate modelling considered by VCP24 but may have important impacts on Victoria.

It is being increasingly acknowledged that major components of the Earth system are at risk of abruptly 'tipping' into a changed state in a rapid and self-perpetuating way that is irreversible on a long timescale. We know that tipping points have been triggered in the Earth's past, and they can happen again. Examples include the rapid transition of Greenland and Antarctic ice sheets to a low ice state, the thawing of permafrost, and the shutdown of major ocean circulations that transfer heat and nutrients across the globe. There are also local-scale climate and ecological tipping points and regime changes that can occur, such as a change from woodland to grassland through frequent fires. Further global warming increases the risk of triggering tipping points, with different thresholds for different tipping elements.

VCP24 projections acknowledge that abrupt climate changes and global climate tipping points changes can occur. However, the global and regional climate modelling used in VCP24 does not account for tipping points and no quantitative detail about when and how they could occur or what the effect would be is provided. This is because while we know that abrupt change can occur, there remain considerable unknowns about how and when they might take place and the full dynamic effect they have.

The effects of triggering tipping points would be significant, but specific to how and when they are triggered. Therefore, rather than give explicit predictions that are likely to be incorrect, we note abrupt changes as a possibility that cannot be ignored, especially for the higher warming scenario. This additional risk should be accounted for in addition to the risks implied by the projections (see below).

Different global climate tipping points would have different effects on Victoria.

- A collapse of the Greenland or Antarctic ice sheets would lead to greater and more rapid sea level rise than in the reported range of *likely* change.
- Rapid permafrost thaw or Amazon dieback would produce enhanced global and regional warming, with some effect on Victoria.

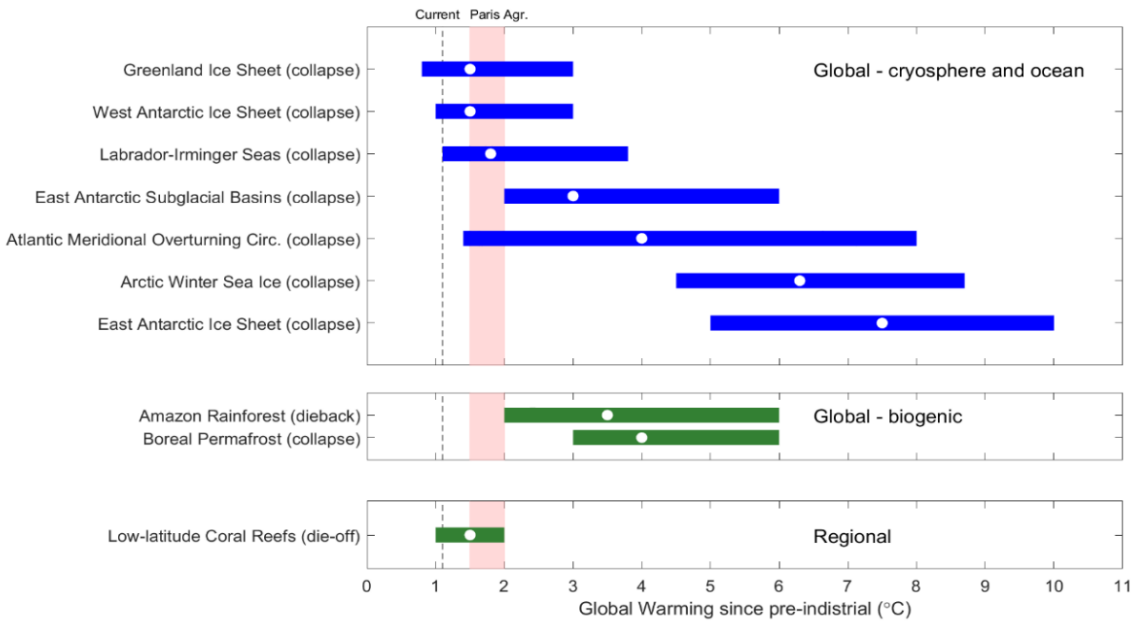

Figure 1 Nine global climate tipping points and one relevant regional tipping point listed in recent global review. Coloured horizontal bars show the review's assessed ranges of global warming where the tipping may be triggered. Assessed ranges may differ from other studies. Sourced from Armstrong McKay et al. (2022)[1].

- A shutdown or reversal of the Atlantic Meridional Overturning Circulation (AMOC)[1] would result in dramatic changes in the northern hemisphere climate but also possible changes to the average and extreme temperature and rainfall of Victoria, as well as climate extremes.
- Indirect effects of major climate disruption in other places around the world would potentially flow on to Victoria in the form of disruptions to trade, supply chains, migration, conflict and other factors.

A recent CSIRO report provides a more detailed summary of tipping points and their possible effect on Australia[2].

Unmodelled climate hazards

Not all climate hazards are confidently modelled in VCP24 due to limitations in representing the full set of relevant processes at all scales in computer models. These include storms and associated extreme winds and precipitation. Other risks not well accounted for in VCP24 may include very rare events such as megadroughts, or compound events where multiple hazards can occur together.

Modelling storms is still limited due to many challenges in representing the full range of meteorological processes at all relevant spatial scales. To understand the effect of climate change on the extreme wind and precipitation (including rain and hail) from severe storms at an individual location, we need to understand change at a variety of scales, from large scale weather systems around the entire southern hemisphere through to the effect of local topography and more.

Given the challenges in modelling, we currently cannot confidently say if extreme winds will become more likely in the future in a warmer climate for Victoria or for any region within the State. So how should decision-makers account for these risks if extreme winds and storms pose a risk? Even though we can't be confident in the assessment of changes to storms or give quantitative projections, there is credible evidence that extreme storms of various types could very plausibly become more damaging with climate change. Given the damage and impact they cause even without this plausible super-charge from climate change, it makes sense to increase the resilience of systems that are particularly vulnerable to this hazard, as proposed on thunderstorms and the electricity grid[3].

Very rare extreme events, such as megadroughts, are also not necessarily well represented in climate model simulations, even if we know they have occurred in the past and could occur again. For this risk, it useful to consider evidence from the paleoclimate record, and as with tipping points, to consider this an additional risk overlain onto the risks explicitly implied in the projections.

The full effect of compound and consecutive extremes, including cascading impacts, is not directly explored in VCP24 projections. Compound extremes include 'hot and dry' events such as a hot drought setting up conditions ideal for fire; as well as 'wet and windy' events such as a coastal storm creating coastal and riverine flooding plus wind damage. These can create 'cascading impacts' across ecosystems and society.

Decision-makers can account for tipping points and unmodelled hazards

Decision-makers can account for tipping points and unmodelled hazards by taking a risk management approach. It is important that this does not ignore high-impact, low-likelihood risks.

A risk management lens is needed and the additional risk of unmodelled hazards should be accounted for in addition to the risks implied by the projections.

Changes and events that are sometimes called High Impact, Low Likelihood risks (HILLs) can't be ignored, but similarly we shouldn't only plan for the worst. We must consider the full range of possibilities, the implications, and what can be done to mitigate the risks. The clearest case to mitigate the worst case or 'tail' risks is where the impacts are potentially very large, and the timeframe is very long. For example, it is reasonable to build large new critical infrastructure such as new hospitals, airports or power plants that might have a >100-year lifespan with a very high sea level 'allowance' that accounts for the risk of ice sheet collapse and rapid sea level rise.

More detail on using the VCP24 Climate Projections in planning for changing climate can be found in the *Using the Victorian Climate Projections 2024* Fact Sheet[4].

[1] AMOC refers to the system of ocean currents within the Atlantic Ocean.

[2] Understanding the risks to Australia from global climate tipping points

[3] We can't say yet if grid-breaking thunderstorms are getting worse – but we shouldn't wait to find out

[4] Link TBA

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.

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