# Climate hazards and extreme weather projections for Australia

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**Introduction**

Natural disasters in Australia are commonly associated with weather and ocean hazards. These hazards, and costs associated with their impacts, are likely to change in a warmer world. Consequently, there is an evolving need to better understand and communicate the influence of climate change on extreme weather and ocean hazards. This would have large benefits, through being able to manage a more tightly constrained uncertainty range, for sectors such as energy, finance, biodiversity and emergency management.

This paper describes various approaches that can be used to examine the influence of climate change on extreme weather and ocean conditions, including ensemble approaches and new downscaling projections for Australia. A synthesis of available knowledge is then provided on a range of climate hazards for Australian conditions. While noting that regional variations can occur, these knowledge products are intended for general use around communicating the influence of climate change on a range of extreme weather and ocean hazards in Australia.

**Ensemble approaches and development of new downscaling projections**

Ensemble approaches can help understand uncertainties, including multi-model ensembles or multi-method approaches (e.g., ensembles of ensembles). Given the substantial uncertainties around projected future changes in some extreme phenomena, approaches that synthesise all available lines of evidence can be useful, including based on combining modelling, observations and physical process understanding. However, even with that type of synthesis approach it can still sometimes be difficult to know how much of the plausible uncertainty space has been sampled, in which case there is a need to effectively communicate this uncertainty as accurately as possible (as is done in the following section ‘General summaries on future changes in hazards’).

There is a relatively small number of downscaling methods with projections of future climate available for Australia, as compared to other regions of the world such as Europe and North America where larger ensembles exist based on multiple regional modelling methods. To help address this need for the Australian region, recent work has tested dynamical downscaling from global climate models (GCMs) using a similar framework to that used recently for the BARRA reanalysis produced by the Bureau. This projections modelling framework was named similar to BARRA, but with a P standing for projections rather than a R for reanalysis: **B**ureau of Meteorology **A**tmospheric High-**R**esolution **P**rojections for **A**ustralia (BARPA).

The idea behind BARPA was to produce dynamically downscaled projections of future climate that were as seamless as possible with the BARRA reanalysis, including to help improve our understanding of extreme weather projections as needed for climate risk applications (e.g., national vulnerability assessments and disaster risk reduction). The CCSM4 model (from the CMIP5 ensemble of GCMs) was selected for the initial runs for developing this downscaling method. Historical time slices were selected to allow an examination of the ability of the downscaling to improve the representation of features such as convection in the tropics (including thunderstorms over the Tiwi Islands) as well as low pressure systems in the extratropical regions of Australia. It is intended that there will be further development of BARPA, including eventually based on multiple GCMs and different future emissions scenarios, leading to a useful set of projections that could help contribute to the broader efforts around multi-method ensembles (such as forming part of the CORDEX set of downscaling and the next generation of projections for Australia).

Improvements in multi-method approached (ensemble of ensembles based on multiple regional models) for Australia could help better-constrain uncertainties around some extremes for which the influence of climate change is largely unknown at the moment (e.g., for the risk of extreme wind events associated with severe thunderstorms). Further details on the influence of climate change on weather and ocean hazards, including uncertainties, are provided in the next section.

**General summaries on future changes in hazards**

This section presents a synthesis of available knowledge around the influence of climate change on different types of natural hazards that impact Australia. Table 1 presents a concise overview of this. General talking points are provided after the table for each individual hazards type. These talking points are intended for general guidance, for practical applications around communicating climate risks, while also noting some regional variations.

**Table 1:** Summaries on the influence of climate change on weather and ocean hazards.

|  |  |
| --- | --- |
| **Hazards type** | **General influence of climate change** |
| **Extreme heat events** | More frequent and intense extreme heat events |
| **Bushfires** | More dangerous bushfire conditions in some regions, particularly in southern and eastern Australia, including an earlier start to the fire season |
| **Extreme rainfall** | More intense extreme rain events are likely throughout Australia, with potentially large increases for short duration events |
| **Flooding** | Increased risk of flash flood in urban areas, and larger uncertainties for other types of flooding |
| **Sea level rise and storm surge** | Sea levels will continue to rise around Australia, increasing storm surge risk |
| **Thunderstorms** | Potentially large increases for short-duration rainfall extremes, with larger uncertainties for extreme winds, tornadoes, hail and lightning |
| **Cyclones and low-pressure systems**:  | Fewer but potentially more intense cyclones in some regions, including tropical cyclones and Australian East Coast Lows |

**Climate change background**

Based on the scientific evidence now available, it is clear that human-caused climate change has already influenced various weather and ocean hazards in Australasia.

Scientific literature has well-established human-caused greenhouse gas emissions are the primary cause of climate change observed during the 20th century and continuing into the 21st century. Indicators are long-term trends such as global warming and rising sea levels.

Increasing atmospheric greenhouse gas concentrations into the future will continue amplifying many weather and ocean hazards.

**Extreme heat events**

Average temperatures across Australasia have increased by about 1°C since 1900 due to human-caused greenhouse gas emissions.

The warming trend has led to an increase in the number of extreme heat events that have occurred.

Multi-day heat wave events have increased in frequency and duration across many regions of Australia; it is almost certain climate change will continue to worsen the impacts of extreme heat events, with longer heat waves, more frequent extreme heat days, and temperatures above historical records.

**Bushfires**

Human-caused climate change has already influenced the frequency and severity of dangerous bushfire conditions in Australasia and other regions of the world.

Significant changes have been observed in recent decades towards more dangerous bushfire weather conditions in some regions of Australasia, indicating a longer and more severe fire season particularly in southern and eastern Australia.

Bushfire weather conditions in future years are projected to increase in severity for many regions of Australasia.

In Australia, there is high confidence that bushfire weather conditions in the future will increase in severity in southern and eastern regions.

**Extreme rainfall**

There is evidence climate change has increased the intensity of extreme rainfall events in some regions.

Global warming can have a direct influence on extreme rainfall potential, as the moisture capacity of the atmosphere increases with temperature by about 7% per degree of warming.

Short-duration extreme rainfall events as produced by thunderstorms or tropical cyclones could potentially increase in intensity by about 15% per degree of warming in some cases, while noting a range of plausible values above and below this best estimate.

**Flooding**

An increase in flash flooding risk is possible due to the potential of increased intensity of short-duration rainfall events, particularly for urban environments where soil moisture has less influence on flood risk.

When combined with increasing sea level, projected increases in extreme rainfall intensity suggest flooding will likely increase in frequency and magnitude in the future for many coastal and estuarine regions throughout Australasia.

**Sea level rise and storm surge**

Global warming is causing sea levels to rise due to the combined effects of melting glaciers and thermal expansion of the oceans, with a global average rise of about 20 cm since the mid-19th century, with similar trends in Australasia.

Sea level rise has accelerated in recent decades, with a global increase of 2.6-2.9 mm/year from 1993 to mid-2014.

These projections do not fully capture the potential contribution to sea level rise from the large ice sheets (Greenland and Antarctica), whose response to global warming is uncertain and possibly underestimated, with rises exceeding 2.4 m being physically possible later this century.

Due to rising sea levels, the frequency and magnitude of coastal flooding is expected to increase significantly this century, regardless of potential changes in storm events.

**Thunderstorms (including hail, lightning and tornadoes)**

Trends in extreme wind events, including as caused by thunderstorms, are difficult to determine in Australia due to a lack of a long-term high-quality observations.

Future changes in thunderstorm hazards are relatively uncertain for lightning, hail, tornados and extreme wind gusts, with potentially large increases for short-duration rainfall extremes.

**Cyclones and low-pressure systems**

Climate change is likely to affect cyclone activity in a number of ways, with these changes being variable between different types of cyclones.

Observations show a downward trend in the number of tropical cyclones that have occurred in recent decades in Australasia.

Fewer east coast lows are likely to occur in the future near Australia, while noting that those that do occur could potentially cause more severe coastal hazards including due to rising sea levels as well as heavier rainfall.

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