Earth Systems and Climate Change Hub

National Environmental Science Programme

Our changing climate

Using climate change information to 2030

Climate change is changing the odds of climate events, but managing climate risk to 2030 means accounting for both climate change and variability.

Understanding weather, climate and variability

When we talk about 'climate', we're talking about the weather we get on average. What we experience day to day and year to year varies – hot days and cold days, dry years and wet years. It's like if you roll a dice many times: the average will come out close to 3.5, but from roll to roll you get different numbers. Sometimes you roll a 6 and sometimes you roll a 1. The variation in our climate is due to factors like the El Niño Southern Oscillation, as well as the cumulative effect of chaotic and random aspects of our weather. Under a relatively stable climate, there are certain odds of hot years and cold years, wet winters and dry winters. However, human influences are now changing the climate.

The underlying climate is changing, so the probabilities of hot years and cold years, dry seasons and wet seasons, are changing. It's as if your dice, with sides numbered from 1 to 6, is now numbered from 2 to 7 – the chances of getting a higher number are increased, the chance of a lower number are reduced, and rolling a 1 is now impossible. But not every roll is now a 7, and if you're lucky you can still get a run of lower numbers just by chance.

If the climate keeps changing, and the odds keep shifting, then no season or year will be within the bounds of the historical record. In our analogy, your '1 to 6' dice would now be '7 to 12'.

Projections and forecasts

Planning ahead for a changing climate is a challenge. The climate we experienced in the past is no longer a reliable indicator of the climate we will experience in the future. We can use climate projections as a guide to how the odds are changing, so we can make management, policy and adaptation decisions accordingly. Climate changes can become distinguishable from background climate variability on timescales longer than a decade, so generally around 2030 is the earliest future period where climate change can be realistically examined. This timeframe is relevant to many planning horizons in areas such as agricultural industries, forestry, water management, infrastructure and environmental management.

It is important to remember that climate projections out to 2030 and beyond are not predictions or forecasts. Weather forecasts tell us about the coming hours to days, based on a prediction of weather systems. Seasonal forecasts tell us about the likely climate averages of the coming weeks to months based on slower climate processes in the ocean such as the El Niño Southern Oscillation. Forecasts of climate variability and change for the coming years is the realm of multi-year to decadal predictions. Climate projections are different. They do not tell us the climate of a particular day or month or predict a specific series of events. Rather, they show how the probabilities of climate conditions (including the changing odds of extremes) may change in our changing climate.

Signals and noise

To understand climate variability and change, it is useful to think of audio engineers who want to hear specific sounds above other unwanted sounds in an audio recording. They refer to the sound they want to hear as the 'signal'; the rest the 'noise'. Good recordings have high signal-to-noise ratios.

Similarly, climate change can be thought of the 'signal', and natural variability as the 'noise'. Sometimes the signal is strong and the background variability is low, so climate change can be seen clearly. In other cases, the variability dominates what we see year to year and decade to decade. This affects how much climate change we will perceive and can plan for. The signal-to-noise ratio is higher at larger spatial scales such as the globe and longer time scales such as 100 years. At regional spatial scales, and at time scales closer to our typical planning horizons (5–20 years), the signal becomes more obscured by the noise. The signal-to-noise also varies depending on which aspect of climate we are considering.

Temperature and sea level projections can show a high signal-to-noise ratio, where we see a noticeable effect of climate change at medium to long time scales. For the regional scale and the near-term projections, natural variability is a larger factor. Even though the climate is warming, variability means that each year will not necessarily be hotter than the last and decadal trends could be high or low.

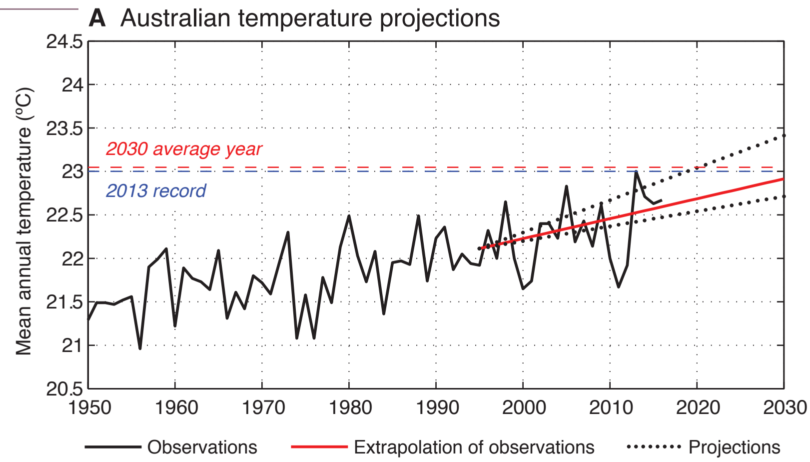
Projections of rainfall typically show a lower signal-to-noise ratio than temperature, since variability is often high compared to projected change. Also, the signal is for a rainfall increase in some places, decrease in others, and is unclear in some other places (compared to say temperature where warming is occurring virtually everywhere). This means that while we should plan for important changes to our rainfall patterns, we should also expect large ongoing variability.

How climate variability and human-induced climate change could combine over the coming years to 2030: Australian mean annual temperature

Australian mean annual temperature[1] shows a clear signal of increase since the 1950s amid the variability 'noise' (standard deviation of de-trended series is 0.3 °C). The record temperature in 2013 was 23.0 °C. Climate projections[2] for Australian temperature show:

- Change for 1986–2005 to 2020–2039 under all emissions scenarios: 0.6 to 1.3 °C
- In 2030, an average year is slightly warmer than the 2013 record.

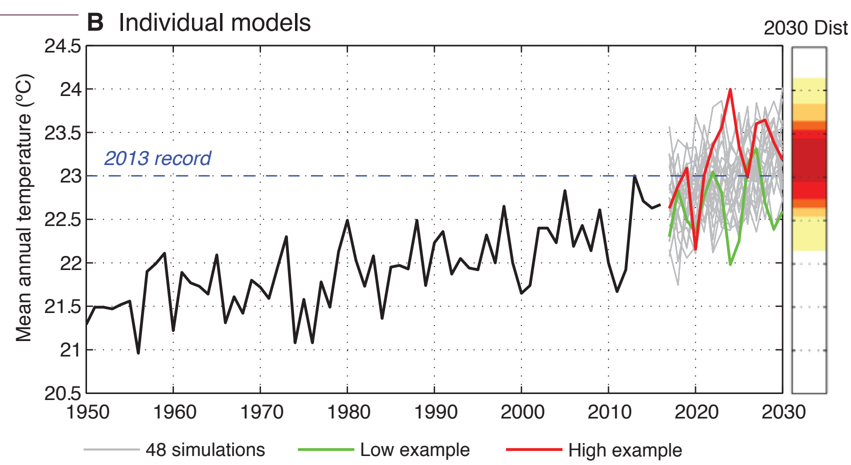
If the observed trend from 1995–2016 continues to 2030, we will be in the mid-range of the projections.



Forty-eight global climate model simulations of Australian temperature show a window of variability and change to 2030 (grey lines), and a distribution of possible temperatures at 2030 warmer than the historical record (shown by colours to the right).

Simulations include climate change and show their own version of climate variability (their own run of climate dice rolls):

- A simulation with lower change and a run of cool rolls of the climate dice sees a negligible temperature trend and only one year breaking the 2013 record (green)
- Greater change and a run of hot rolls sees the record broken eight times (red).

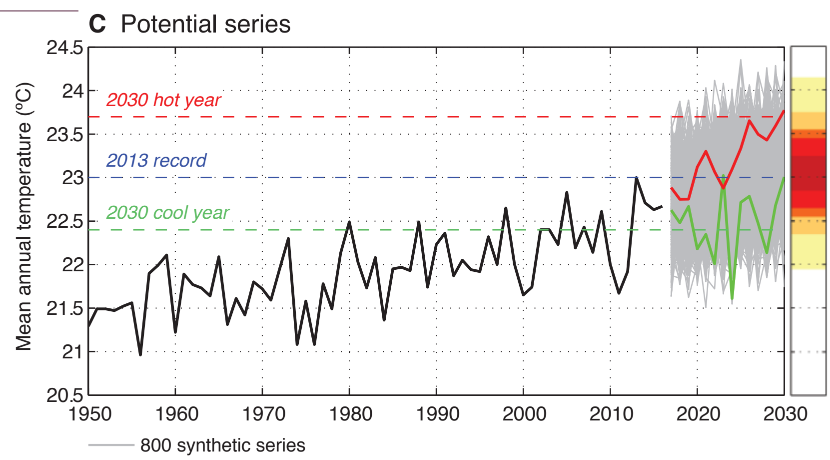


If we use a statistical technique[3] to generate 800 possible series of Australian temperature that include the projected trend and have the same variability character as observations, we can see a larger sample of possibilities (the grey shading).

The main message is essentially the same as the climate models:

- We may see small trends in Australian temperature (a 'slowdown')
- We may see a strong trend (an 'acceleration'), with many hot years.

Both are consistent with the climate projections. We also see that it is very likely (but not guaranteed) that Australia will match or exceed the previous 2013 record temperature at least once before 2030, and possible that it will be broken in most years of the 2020s.



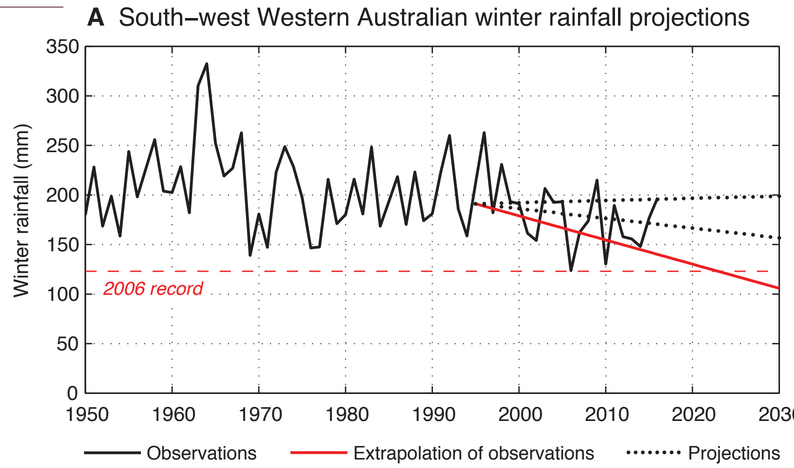
1. Dataset used is the Australian Climate Observations Reference Network-Surface Air Temperature (ACORN-SAT): www.bom.gov.au/climate/change/acorn-sat/
2. Projections and averaging region shown at: www.climatechangeinaustralia.gov.au.
3. Series were generated using a 3-factor auto-regressive statistical model using the trends from the climate projections and the temporal character of recent observations. Please contact us for more details of the methods used

How climate variability and human-induced climate change could combine over the coming years to 2030: South-west Western Australian winter rainfall

This example considers regional rainfall rather than the Australian average rainfall, as rainfall and projected rainfall change is very different in different regions. Drying of south-west Western Australia in winter since the 1970s[4] is one of the clearest climate change signals in rainfall (the dry record was 2006), but this is amid significant noise (standard deviation of de-trended series is 31 mm/month). Climate projections show:

- Change from 1986–2005 to 2020–2039 under any emissions scenario: +4 to −18%
- Ongoing lack of wet years, no return to the climate of the 1960s.

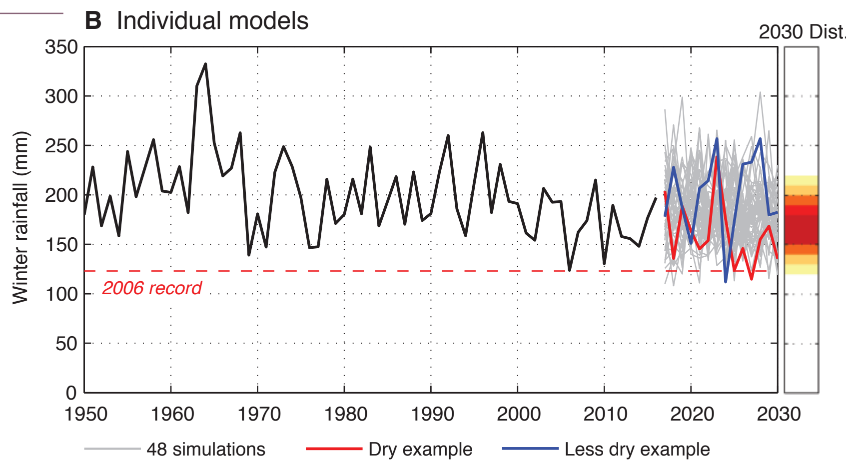
If the strong observed trend from 1995–2016 continues to 2030, we will in fact be below the projected range, with the mean below the 2006 record (however, it is probable that this trend will not continue linearly).



Forty-eight global climate model simulations of south-west Western Australian winter rainfall show a window of variability and change to 2030 (grey lines) and a distribution of possible rainfall at 2030 drier than the historical record (shown by colours to the right).

Simulations include climate change and show their own version of climate variability (their own run of climate dice rolls):

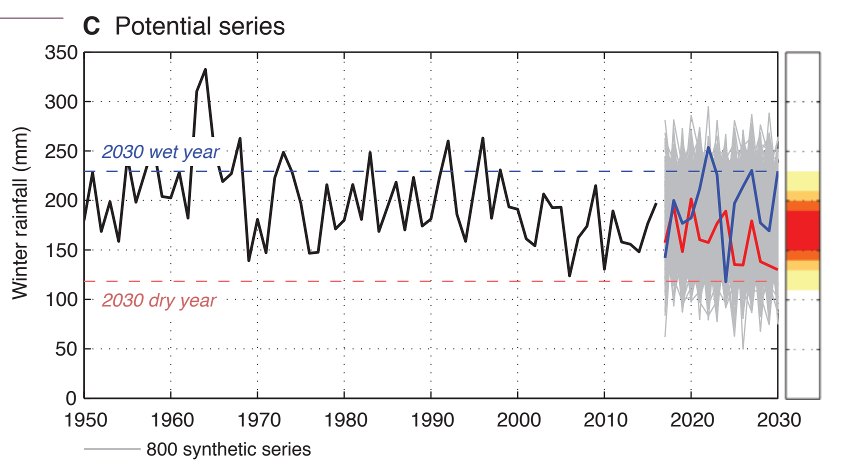
- A simulation with smaller change and a run of wetter rolls of the climate dice sees a negligible rainfall trend and only one year breaking the 2006 record (blue)
- Greater change and a run of dry rolls (e.g. a major drought) sees a very dry decade in the 2020s with a few years near or breaking the 2006 record (red).



If we generate 800 possible series we can see a larger sample of possibilities. The main message is the same as the climate models but with some even more extreme possibilities:

- A dry run sees a dry decade in the 2020s, with some extremely dry years
- A less dry series sees a decade similar to the 1990s (but no very wet years).

Breaking the 2006 record becomes more likely but still far from guaranteed (8% chance compared to 0.5% chance in the past). So even in this case, the signal can be quite obscured by variability to 2030. Mean rainfall changes in most other locations and seasons will show a lower signal-to-noise than this strong example.



4. Dataset used is the Australian Water Availability Project (AWAP) gridded climate dataset: **www.bom.gov.au/jsp/awap/**

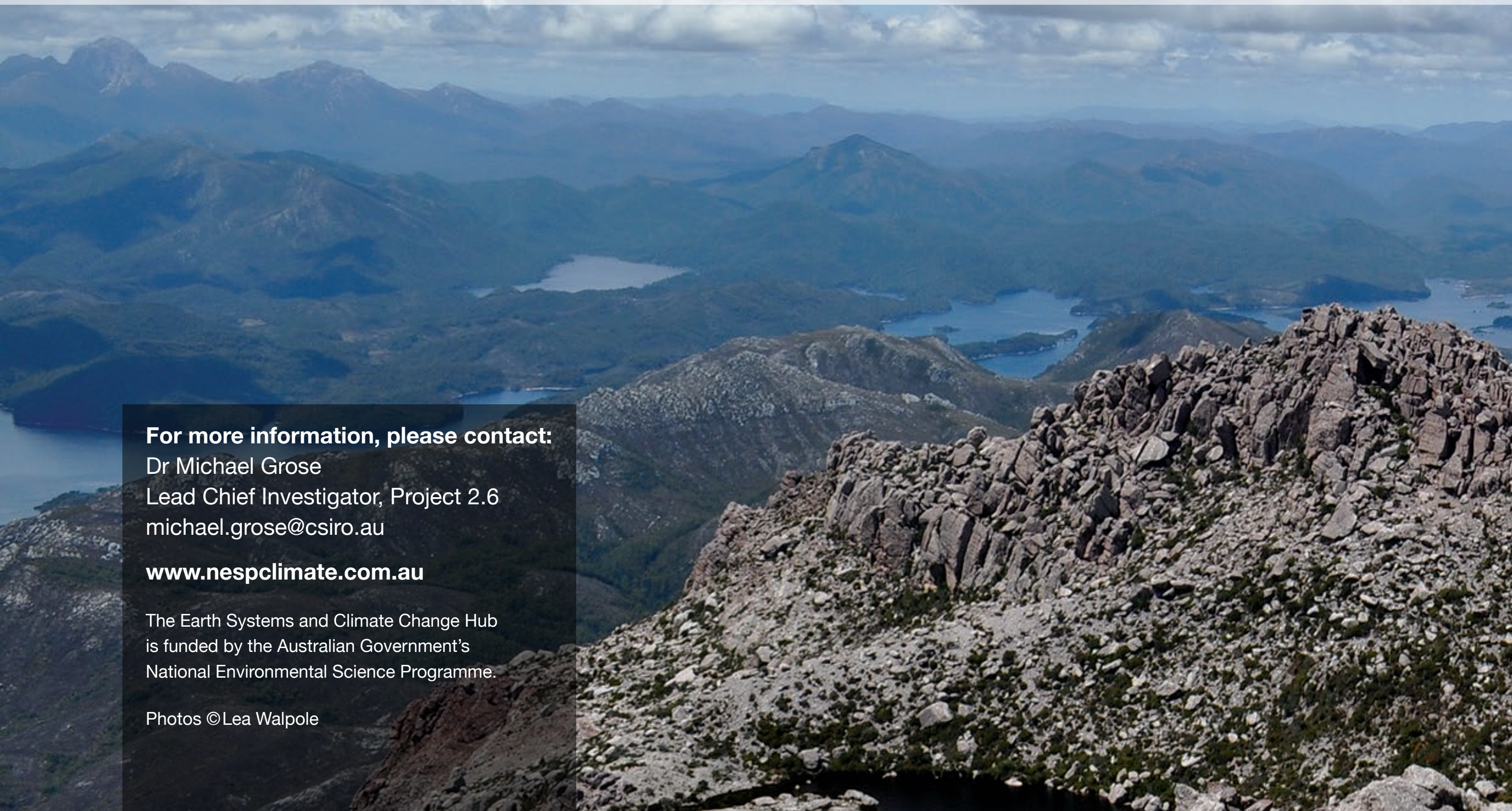
So, how useful are climate projections for 2030?

Even where there is a strong climate change signal caused by humans, the climate variability ‘noise’ is still a major factor in our climate to 2030. This means that climate projections are a useful planning tool, but we must also account for climate variability. When using climate projections to 2030, it is important to:

1. Understand climate variability – look at the full range of observations available and understand your climate risk in the past and current climate, understand the relevant processes involved (e.g. El Niño events).
2. Understand the range of projections – use the Climate Futures tool at www.climatechangeinaustralia.gov.au to explore ranges of change for the relevant climate variables
3. Put variability and change in perspective (the signal-to-noise ratio), and what this means to you. For example, you might explore if and where climate change makes an important difference to the odds of crossing an important threshold, then assess how you can manage these changing odds. If the signal-to-noise ratio is very low, then it may be best to plan for the full range of current climate variability.

In a wider sense, it is also important to:

- Understand your climate exposure – what aspects of the climate affect your area of interest? Which variables, and which aspects of the climate? What are the key climate thresholds or relationships?
- Consider other changes that are relevant (e.g. regulation, population change, new technology).
- Consider if your planning horizon extends beyond 2030. If you need to look ahead to 2050, 2070 or 2090, you will need to consider the different emissions scenarios, as their influence becomes greater than climate variability. For more information visit www.climatechangeinaustralia.gov.au.



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