Earth Systems and Climate Change Hub
National Environmental Science Programme

climate change **science brief**

What role does climate change play in extreme events?

Extreme climate events such as heatwaves, floods and droughts have huge impacts on Australia's communities and natural and economic resources.

Understanding what causes these extreme events is important for managers of a range of systems, including ecosystems, urban planning and water resources, to allow them to better plan for and respond to current and future extreme events.

Earth Systems and Climate Change Hub researchers have been working on advancing the scientific field of 'attribution' of these extreme climate events to determine the factors, including human-induced greenhouse gas emission, behind many events recently experienced in Australia.

Extreme climate events are often the result of complex interactions between various climate drivers. They can be triggered by a range of naturally-occurring climate variations, such as El Niño–Southern Oscillation in the Pacific Ocean or the Indian Ocean Dipole. In addition, the duration or intensity of an event can also be affected by human-induced climate change.

Our global climate has always experienced natural variability, including slow temperature fluctuations over decades or even centuries. While the nature of this variability is the subject of much research, we know that the increase in global temperatures over the last 60 years is due to the increase in atmospheric greenhouse gas concentrations.

If our climate continues to warm, can we expect extreme events to become increasingly frequent and severe?

Understanding the causes of extreme climate events

The field of event attribution science can reveal the relative contribution from human-induced changes in the climate to a particular extreme climate event. It does this by identifying the climate drivers leading up to an observed extreme event and quantifying their respective contributions. Attribution studies can be successfully applied to events that are generally broad-scale in both space (e.g. all of NSW) and time (from a few weeks to a few months, with some success even at daily or multi-day scales).

What do we know?

Previous attribution studies have shown that abnormally high temperatures and associated extreme weather is indeed related to human-induced climate change. For example, human-induced climate change was found to have substantially increased the likelihood of the record-breaking hot Australian summer of 2013 by more than five times. Climate change has also been found to have at least doubled the likelihood of the northern Europe heatwave in 2018.

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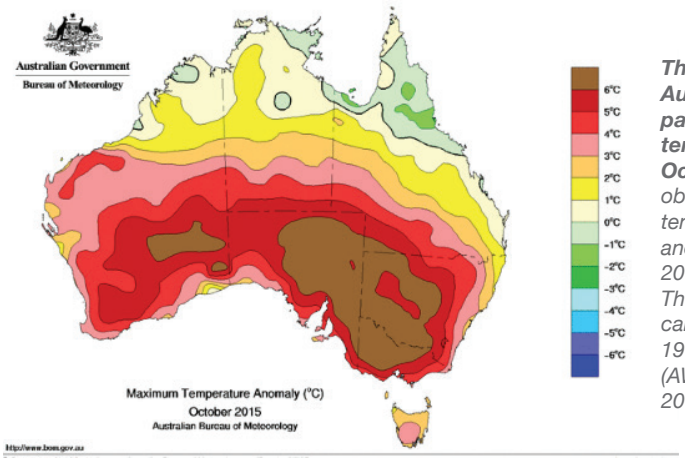
New methods to understand the drivers of extreme events

The Hub is supporting the development of event attribution methods to diagnose the underlying causes of an extreme event. This also allows us to better understand how human-induced climate change contributes to a particular event.

The attribution system can be used operationally by weather and climate services, meaning we can get access to information about what has caused an extreme event much more quickly, potentially before an extreme event even occurs.

This is called a 'forecast attribution method' and is being developed by the Hub. Under this method, two sets of forecasts for an extreme event are generated: one set of forecasts with the current level of carbon dioxide (CO_2) concentration and observed atmosphere, land and ocean conditions, and a second set of forecasts with 1960's level of CO_2 concentration and cooler atmosphere, land and ocean conditions (to reflect 1960's observed conditions). These two forecasts are then compared to show the contribution of human-induced climate change since 1960 to the event.

To date this method has been applied to sub-seasonal forecasts of extreme heat across Australia in the spring of 2014 and 2015, the record wet Murray Darling Basin spring of 2016, an extensive frost period in south-west Western Australia in 2016, and a period of extreme fire weather across eastern Australia in February 2017.



The southern region of Australia experienced particularly extreme temperatures during October 2015. *Map of observed daily maximum temperature (Tmax) anomalies in October 2015 across Australia. The Tmax anomaly is calculated relative to the 1961-1990 climatology. (AWAP; Jones et al., 2009)*

Human-caused climate change and recent extreme events in Australia

Hub research over the past three years has shown that long-term changes in ocean temperatures caused by increasing greenhouse gases make a significant contribution to extreme temperatures in Australia.

During the record heat of October 2015 across most of Australia, half of the excess heat was caused by the increase of CO_2 emissions, while the other half was caused by contributions from ENSO, the Indian Ocean Dipole and weather conditions at the time. In Tasmania there was a small but significant signature of climate change in the record dry experienced in October 2015.

Climate change also influenced the extreme fire weather experienced across central eastern Australia in February 2017 by promoting high temperatures. On the other hand, the record-high September rainfall over south eastern Australia in 2016 was found to be largely driven by the record strong negative Indian Ocean Dipole and a weak La Niña, with no direct impact of human-induced climate change on the event. Research into this event is continuing. The Hub also contributed to research showing that the increased length and intensity of periods of elevated sea surface temperature, known as marine heatwaves, has a clear human fingerprint.

Our research, supported by the findings of other national and international research, demonstrates that climate extreme events are projected to increase with rising greenhouse gas emissions. Understanding how climate change contributes to past and near future extreme events will provide valuable information for governments and industries to consider when planning and preparing for these events.

More frequent and/or intense dry conditions will particularly impact our agriculture sector, especially as the main growing season for many crops important for Australia's economy is likely to become drier over the coming century.

This research was led by ESCC Hub Project 2.2: *Enhancing Australia's capacity to manage climate variability and climate extremes in a changing climate*.

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