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Australia's Tinderbox Drought (2017 – 2019)

The Tinderbox Drought was an exceptionally extreme event and provides important lessons about how we understand and prepare for future multi-year droughts in Australia.

The Tinderbox Drought cannot be attributed to a single factor. It involved a sequence of events which combined to sustain and intensify the drought.

Climate change played a role in causing and intensifying the drought and is likely to cause future droughts to be hotter and more intense.

During 2017 – 2019, southeast Australia experienced three consecutive years of intense drought that threatened water supplies, damaged agricultural and ecological systems, and helped enable Australia's Black Summer fire disaster. The drought has been named the Tinderbox Drought to highlight the connection between drought and fire that typified this event.

The ARC Centre of Excellence for Climate Extremes has led a multidisciplinary analysis of the Tinderbox Drought to learn more about its causes and impacts. There are key lessons for individuals, water users, fire managers, industries, communities, environmental specialists and policymakers.

Impacts of the Tinderbox Drought

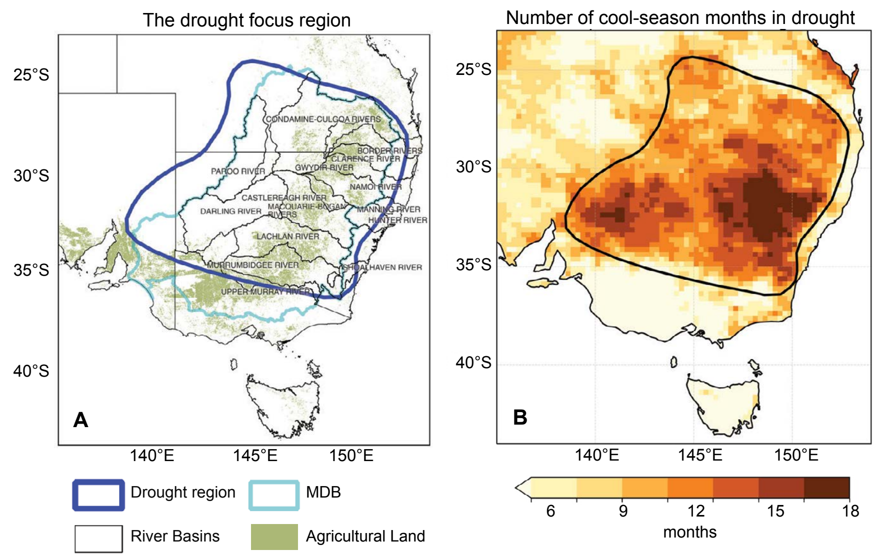

Figure 1: a) Region affected by the Tinderbox drought, b) the proportion of time in drought during April to September 2017-19. Thick black line denotes the drought area. Source: Anjana Devanand et al.

The southeast of Australia (Figure 1), encompassing the Murray-Darling Basin, is an essential area for Australia's food security and an important economic system for food exports. It is home to 2.3 million people and accounts for around 40% of Australia's agricultural produce. This region bore most of the impacts of the Tinderbox Drought which were severe across hydrological, agricultural and ecological systems (Figure 2).

The Tinderbox Drought was the driest 3-year period on record in the region outlined in Figure 1. Over the course of the 3-year drought, the cool months of the year received only around half their usual amount of rainfall. The intervening warm months of the year also experienced unusually dry conditions, receiving only a half to three quarters the amount of expected rainfall.

The impacts of the Tinderbox Drought were severe, taking rural townships to the brink of running dry and threatening Sydney's water supply. The drought led to substantial agricultural losses. Production of winter rain-fed crops of wheat and barley dropped by between 43% and 73% in 2018 and 2019 and summer irrigated rice production decreased by more than 90% in 2018/19 and 2019/20.

The drought impacted streamflow, soil moisture, and groundwater which all gradually decreased as the drought continued. River flow across most catchments effectively ceased by 2018 and 2019. Groundwater aquifers were particularly slow to recover and many had not returned to pre-drought levels more than 12 months after the Tinderbox Drought broke. Natural vegetation showed large reductions in several indicators that measure the health and functioning of these systems.

What caused the Tinderbox Drought?

The Tinderbox drought cannot be attributed to a single factor. It involved a sequence of interwoven events that compounded drying of the atmosphere and land.

The first two years of the Tinderbox Drought cannot be explained by the remote climate drivers (e.g. El Niño, Indian Ocean Dipole) that are typically associated with droughts in southeast Australia. Instead, our analysis reveals that atmospheric circulation patterns diverted rainfall, normally destined to fall over southeast Australia, towards northern parts of the country. As the drought continued, the drying landscape further reduced rainfall that would normally have come from local sources. The drought peaked in 2019, intensified by a strong positive Indian Ocean Dipole. El Niño did not contribute significantly to the Tinderbox drought during any year.

The impacts of the Tinderbox Drought were amplified by a very dry atmosphere. The drought was marked by record high vapour pressure deficit, a measure of the 'thirstiness' of the atmosphere. This helped extract moisture from the soils and vegetation, drying them out more than they would normally dry. The intensification of drying was a major factor in the unprecedented Black Summer fires at the end of the Tinderbox Drought.

The Tinderbox Drought was also hotter than it otherwise should have been. The intensely dry land surface amplified heatwaves by up to 2.5°C during 2019. The drought, in combination with the long-term effects of human-caused climate warming, led to 2019 being Australia's hottest and driest year on record.

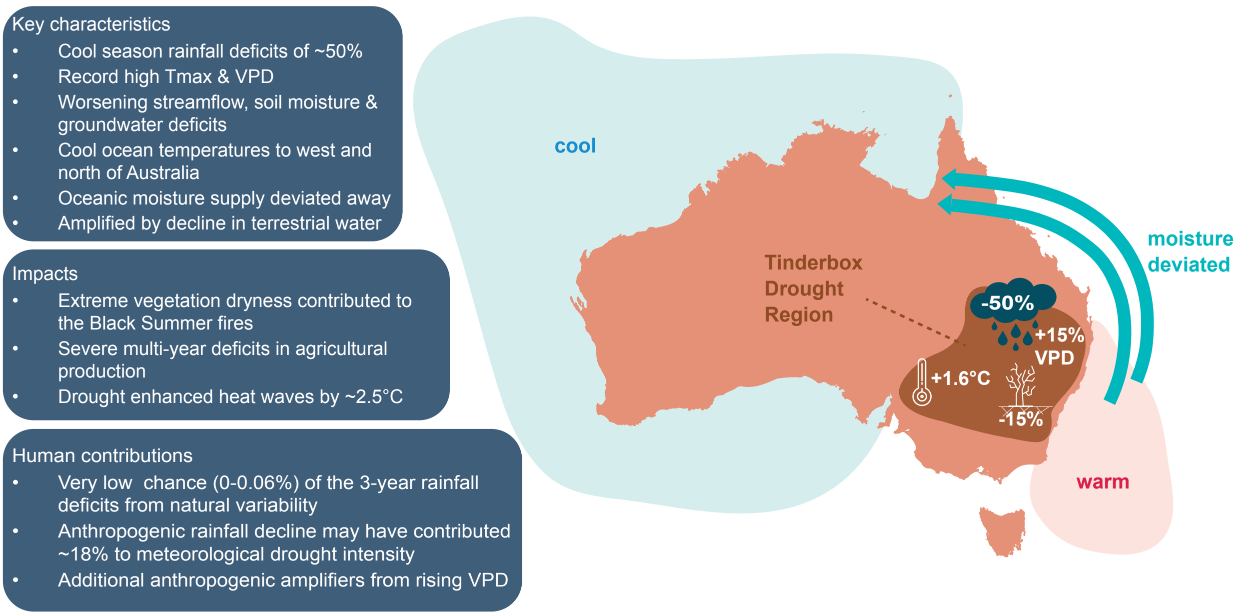

Figure 2: Key characteristics of the Tinderbox Drought. Source: Anjana Devanand et al.

What was the role of climate change?

Multiple lines of evidence point towards the Tinderbox Drought being an extreme natural event that human-caused climate change made even worse.

There is evidence that climate change is leading to long-term reductions in cool season rainfall in the drought-affected regions. The intensity of the 3-year rainfall deficits during this drought exceeded what could have been expected from natural climate variability alone. Quantification of the human-caused contribution to rainfall deficits during the Tinderbox Drought have considerable uncertainty. However, our best estimate is that climate change worsened the meteorological drought by around 18% compared with what otherwise could have been expected.

Climate change is expected to result in long-term reductions in cool season rainfall this century in the drought-affected region, further increasing the likelihood and severity of meteorological droughts. An important contributor to the intensification and impacts of the Tinderbox Drought was also the increase in vapour pressure deficit, which is a further consequence of our warming atmosphere due to human-caused climate change.

Lessons for future multi-year droughts in Australia

Early warning is an important aspect for drought preparedness in Australia. Even though the Tinderbox Drought did not show strong links to the remote climate drivers that influence drought risk in Australia, our analysis found that it was possible to skilfully predict the Tinderbox Drought using machine learning.

Combining traditional seasonal forecasting (which did forecast important characteristics of the drought) with new machine learning approaches may provide hope for improving early warning for future drought risk.

A feature of some parts of the Tinderbox Drought was a rapid onset and/or intensification of drought ("flash droughts"). Flash droughts may be an increasingly important feature of droughts in a warming world and would present challenges for preparedness and resilience to drought.

Australia will be subject to very significant future warming and associated climate change. Human-caused climate change means that future multi-year droughts in Australia will be hotter, and the atmosphere drier, than an equivalent drought would have been in the past. This strongly points to the risk of droughts, heatwaves and fire growing in the future. This, while worrying, highlights the urgent need to deeply cut human emissions of greenhouse gases, and to invest in adaptation strategies to build better community resilience to droughts.

Written by

Dr Anjana Devanand
is a former researcher in the ARC Centre of Excellence for Climate Extremes with expertise in hydrology and land-atmosphere interactions. She now works in CSIRO.

Professor Nerilie Abram
is a Chief Investigator with the ARC Centre of Excellence for Climate Extremes. She uses paleoclimate records to study how Earth's climate has behaved in the past to provide a long-term perspective on recent climate change.

Professor Jason Evans
is a Chief Investigator in the ARC Centre of Excellence for Climate Extremes with expertise in regional climate modelling and climate change. He works to understand how climate change is impacting human and natural systems.

Dr Anna Ukkola
is a Chief Investigator at the ARC Centre of Excellence for Climate Extremes and co-leads the centre's Drought research program. Her research focuses on understanding drought, and how to better predict droughts in the near-term.

Associate Professor Ailie Gallant
is a Chief Investigator of the ARC Centre of Excellence for Climate Extremes in the drought research program. Her research focuses on understanding how weather, and its associated rainfall, change during drought.

Professor Andy Pitman
is the Director of the ARC Centre of Excellence for Climate Extremes. His expertise focuses on land surface processes, including water, carbon and energy fluxes, extremes and the robustness of climate models at various scales.

Produced by

Engagement and Impact Team - Knowledge brokers: Angela Kaplish, Alice Wilson
Communications: Laure Poncet **Graphic design:** Georgina Harmer

References

1. Devanand, A., Falster, G.M., Gillett, Z.E., Hobeichi, S., Holgate, C.M., Jin, C., Mu, M., Parker, T., Rifai, S.W., Rome, K.S., Stojanovic, M., Vogel, E., Abram, N.J., Abramowitz, G., Coats, S., Evans, J.P., Gallant, A.J.E., Pitman, A.J., Power, S.B., Rauniyar, S.P., Taschetto, A.S., Ukkola, A.M., 2024. Australia's Tinderbox Drought: An extreme natural event likely worsened by human-caused climate change. Science Advances 10, eadj3460. https://doi.org/10.1126/sciadv.adj3460

Contact
clex@unsw.edu.au

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