Earth Systems and Climate Change Hub

National Environmental Science Programme

Bushfires and climate change in Australia

Fires burning on Mount Solitary in the Blue Mountains, NSW, in 2018

> Human-caused climate change has resulted in more dangerous weather conditions for bushfires in recent decades for many regions of Australia.

> Observations show a trend towards more dangerous conditions during summer and an earlier start to the fire season, particularly in parts of southern and eastern Australia.

> These trends are very likely to increase into the future, with climate models showing more dangerous weather conditions for bushfires throughout Australia due to increasing greenhouse gas emissions.

Bushfires are an intrinsic part of Australia's environment but have the potential to cause severe impacts including loss of life, damage to property and large economic costs.

The costs associated with extreme weather hazards and disasters, including those caused by bushfires, are likely to change in the future due to increasing greenhouse gas emissions. Understanding extreme weather hazards and how they may change as the climate continues to warm is valuable for increasing Australia's preparedness and resilience.

Researchers in the Earth Systems and Climate Change Hub are developing improved resources on bushfire conditions and how they may change in the future to help us plan for and deal with climate change with greater confidence.

Bushfire conditions in the current climate

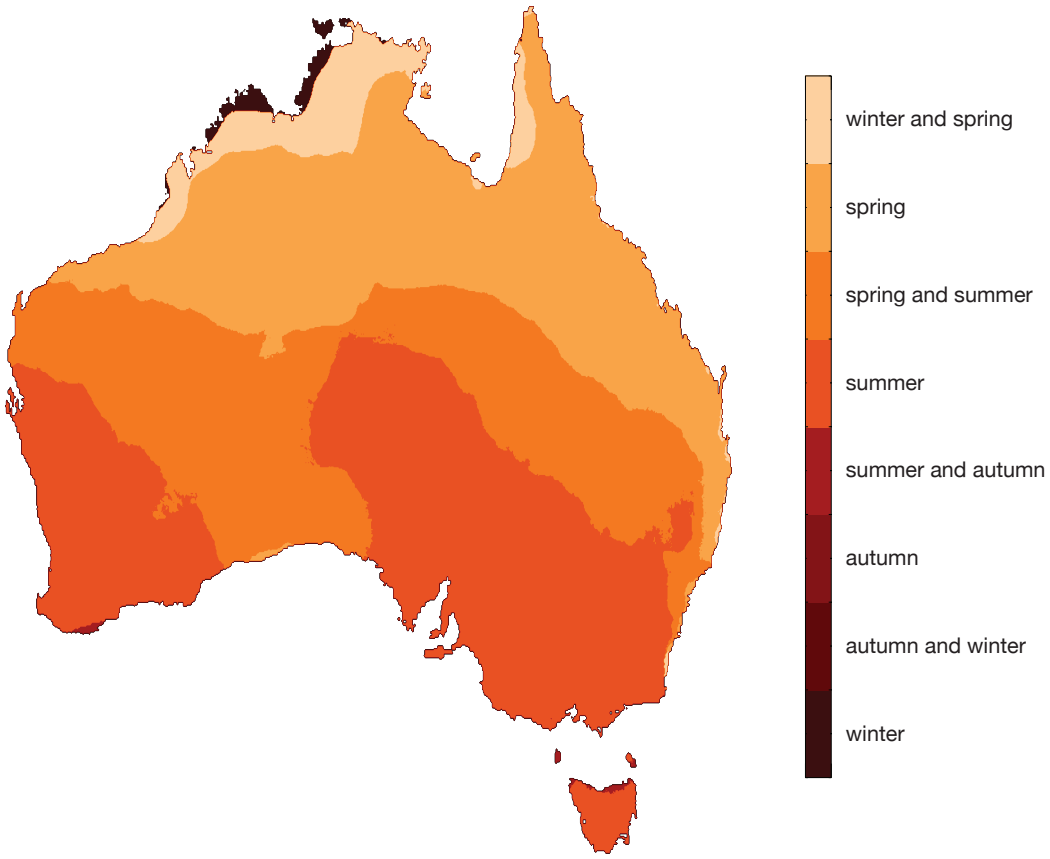
Bushfires in Australia are caused by the combined influences of climate, weather, vegetation and ignition sources.

These factors can vary throughout Australia due to its large size and distinct regional climates (e.g. tropical climate in the north and temperate climate in the south). Regional climate differences within Australia are evident in the distinct timing of the fire season for different locations around Australia during the year.

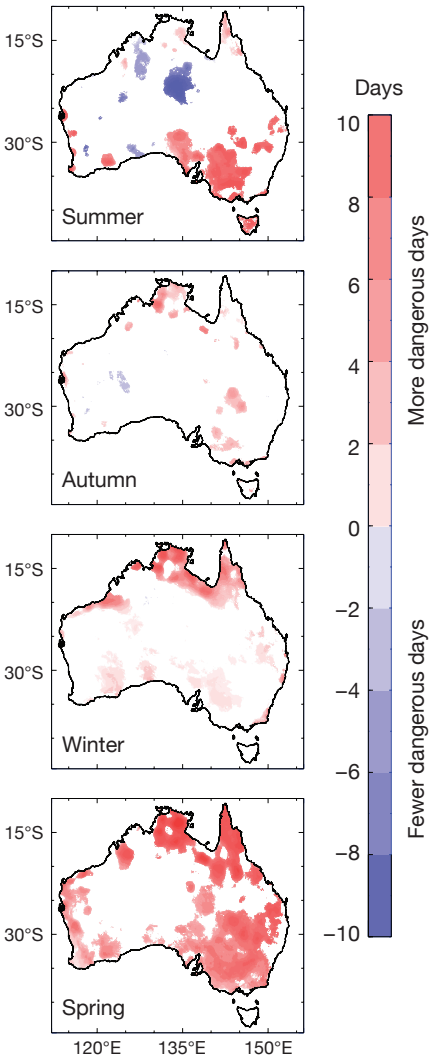
The most dangerous weather conditions for bushfires typically occur during spring in many parts of northern Australia and during summer in southern Australia.

There is also considerable year to year variability of bushfire risk in Australia, with El Niño events generally associated with more dangerous bushfire conditions than La Niña events, depending on the season and region.

The Forest Fire Danger Index (FFDI) is used in Australia as a general indicator of conditions associated with dangerous bushfires. The Index is based on a combination of temperature, humidity, wind and drought information, and provides a useful way to indicate fire weather risk.



LEFT: **Season with the most dangerous weather conditions for bushfires, mapped for different regions of Australia.** For each location the seasons shown correspond to the highest average value of the Forest Fire Danger Index (FFDI, based on daily data from 1950 to 2016).

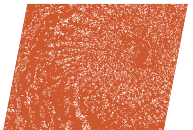


LEFT: **Long-term increases in the number of days with severe fire weather.** The difference in severe fire weather days from the time period 1983–1999 to the time period 2000–2016 is shown, based on the number of days that the Forest Fire Danger Index (FFDI) is high (> 90th percentile) at a given location. Changes are only shown if statistically significant for an individual season.

Australia has already experienced a variety of changes related to temperatures and heatwaves. Average temperatures across Australia have increased by about 1°C since 1900 due to human-caused greenhouse gas emissions. Multi-day heatwave events have also increased in frequency and duration across many regions, and single-day extreme heat records in Australia have outnumbered extreme cool records by about 3-to-1 for daytime maximum temperatures and 5-to-1 for night-time minimum temperatures since 2001. Increasing temperatures can influence fire danger in various ways, including through their effect on humidity and the moisture content of vegetation.

Northern Australia sees significant fire activity during the dry season. Increases in monsoonal rainfall prior to the dry season have helped to increase fuel growth in recent decades. This is a key factor influencing fire danger in the region.

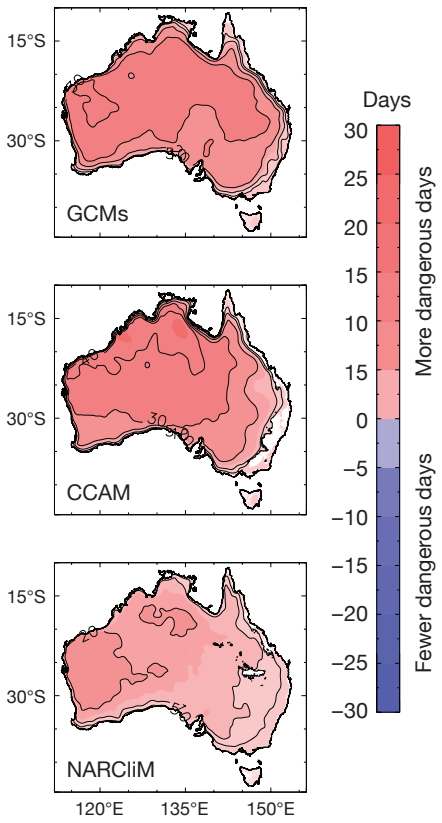
In southern and eastern Australia, there has recently been a number of devastating fire events associated with thunderstorm development due to strong convection within the fire plume (known as 'pyroconvection'). Hazards caused by extreme pyroconvection events can include more erratic winds with the potential to influence fire behaviour as well as the risk of new ignitions from lightning generated in the fire plume. This occurred during the Black Saturday fires of 2009, with a new fire igniting about 100 km ahead of the main area of the fire front. Risk factors associated with extreme pyroconvection events can be indicated by various indices (such as the C-Haines index which represents vertical atmospheric stability and moisture), with increased risk factors for the occurrence of dangerous pyroconvection events indicated in southern Australia over recent decades.



Future bushfire conditions under a changing climate

Fire danger is very likely to increase in the future for many regions of Australia, exacerbated by the increased occurrence of extreme heat events. Climate projections show that more dangerous weather conditions for bushfires are very likely to occur throughout Australia in the future due to increasing greenhouse gas emissions. Climate models also indicate a future increase in dangerous pyroconvection conditions for many regions of southern Australia (based on the C-Haines index).

Lightning activity is the primary natural ignition source for bushfires. Although there are some indications from recent research based on observations and modelling that climate change could potentially influence the risk of ignitions from dry-lightning (lightning that occurs without significant rainfall), there are relatively large uncertainties in our current understanding of dry-lightning risk and how this could be influenced by climate change. Future changes in fuel conditions are also not well-understood, but we know they are a major driver of fire danger, particularly in many regions of northern Australia.



LEFT: **Future projections of fire weather conditions show increasing fire danger days.** This is shown for three different climate modelling approaches, including global climate models (GCMs) and CCAM and NARCliM (both of which are based on methods for regional downscaling of climate models). Results are presented as the percentage change from the time period 1990–2009 to 2060–2079, in the number of dangerous days (based on FFDI exceeding a value of 25 which represents conditions classed as 'very high' in operational fire danger forecasts). The projections are for increasing greenhouse gas concentrations over this century under a high emission scenario. The results use a 15-member ensemble of GCMs, an 8-member ensemble from CCAM and a 12-member ensemble from NARCliM. Coloured regions represent locations where at least two thirds of the models agree on the direction of change.

Tools, data and further information

- Data access for historical fire weather data and climate guidance information:
  - **http://www.bom.gov.au/jsp/ncc/climate_averages/ffdi/index.jsp**
  - **https://journals.ametsoc.org/doi/full/10.1175/JAMC-D-17-0167.1**
  - **https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2017GL076654**
- Future projections of fire weather throughout Australia:
  - **https://www.nature.com/articles/s41598-019-46362-x**
  - **https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2019GL083699**
- Extreme weather research under Project 2.8 of the Earth Systems and Climate Change Hub – including links to a variety of research publications on this topic: **http://nespclimate.com.au/extreme-weather-projections/**
- Bates BC, McCaw L, Dowdy AJ. 2018. Exploratory analysis of lightning-ignited wildfires in the Warren Region, Western Australia. *Journal of Environmental Management*, doi:10.1016/j.jenvman.2018.07.097
- Dowdy AJ, Fromm MD, McCarthy N. 2017. Pyrocumulonimbus lightning and fire ignition on Black Saturday in southeast Australia. *Journal of Geophysical Research – Atmospheres*, doi:10.1002/2017JD026577

For more information, please contact: Dr Andrew Dowdy
andrew.dowdy@bom.gov.au
www.nespclimate.com.au

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