Extreme weather: improved data products on bushfires, thunderstorms, tropical cyclones and east coast lows

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Andrew Dowdy[1], Harvey Ye[1], Kevin Tory[1], David Jones[1], Alex Evans[1], Sally Lavender[2], Marcus Thatcher[2], Tony Rafter[2], Stacey Osbrough[2], Kevin Walsh[3], Leone Cavicchia[3], Jason Evans[4], Jennifer Catto[5]

Bureau of Meteorology[1], Oceans and Atmosphere - CSIRO[2], University of Melbourne[3], University of New South Wales[4], Monash University[5]

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ABSTRACT

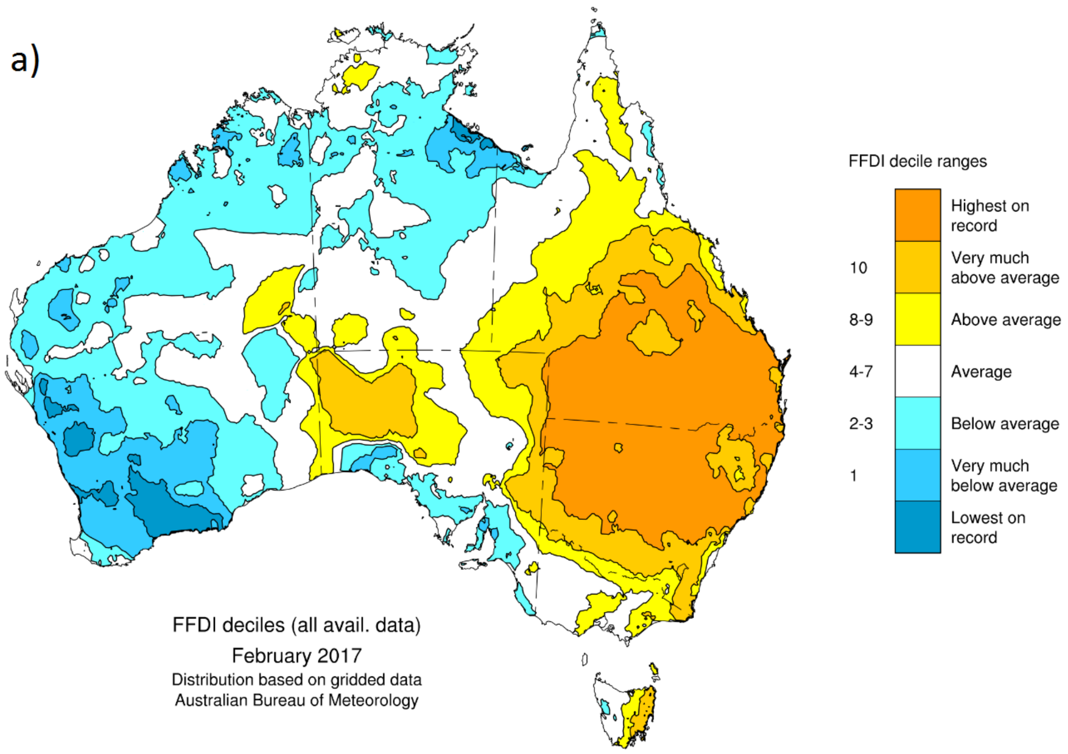
Extreme weather events can cause a wide range of impacts on different regions throughout Australia, including costs associated with damage to natural and built environments. Effective disaster risk reduction, emergency response, infrastructure design/operation, planning and policy making all require data and information about how extreme events will change in the future.

New data products and information are currently being developed on bushfires, tropical cyclones, east coast lows and thunderstorms (including associated hazards such as extreme rainfall, winds, hail and lightning) by a project on extreme weather events in the National Environmental Science Programme (NESP: http://nespclimate.com.au/extreme-weather-projections/). This project addresses knowledge gaps on the past and future frequency and intensity of these phenomena, including the physical processes that influence the long-term variations in their characteristics, to produce practical tools and guidance products for use by planners and decision makers throughout Australia.

FIRE WEATHER

A number of fire weather products are being developed, based on new gridded datasets designed for use by end users, to provide improved capability to understand and prepare for the impacts of climate change on extreme fire weather conditions throughout Australia. In relation to the current climatology and the changes that have already occurred, a daily dataset of the Forest Fire Danger Index (FFDI: McArthur 1967) from 1950 to present has been produced. This dataset was produced based on a gridded analysis of temperature, rainfall and vapour pressure observations from the Australian Water Availability Project, AWAP (Jones et al. 2009), as well as NCEP/NCAR reanalysis (Kalnay et al. 1996) used for wind speed (with bias correction applied to provide a better match to the wind speeds used operationally by BoM for producing fire weather forecast products).

This FFDI dataset was recently provided to the Climate Information Services section within BoM for use with their existing analysis tools, allowing them to produce climatological guidance products such as shown in Figure 1a (highlighting how extreme the February conditions were during 2017 as compared to other years back to 1950). This AWAP-based dataset is also being used for assessing new climate model projections of extreme fire weather conditions, as well as for assessing the potential for long-range model predictions of FFDI (based on hindcasts from ACCESS-S, BoM's seasonal forecasting model: Figure 1b).



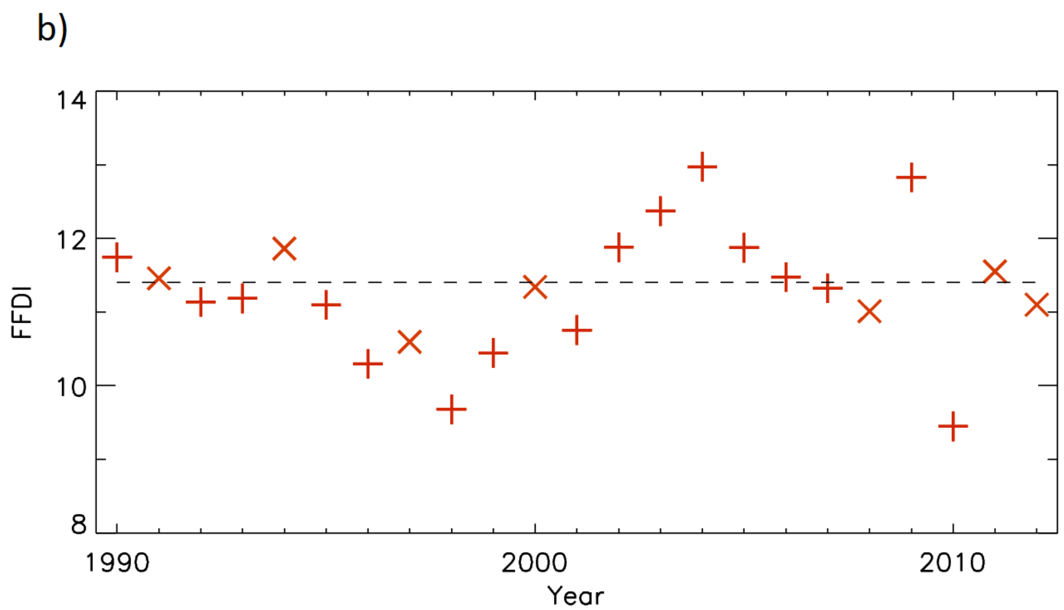


Figure 1: Climatological guidance and new capability development based on gridded fire weather data products. **a)** Mean FFDI values for February during 2017 as compared with other years from 1950-2017 based on AWAP data. **b)** Long-range prediction of FFDI values based on ACCESS-S model run from November 1st input conditions, with correct ('+') and incorrect ('x') predictions (assessed against the AWAP-based FFDI dataset) of mean FFDI in the southern half of Australia during summer (December-February).

TROPICAL CYCLONES

Tropical cyclone (TC) formation and intensity observations are being examined in detail and a subsequent extensive analysis of climate models and higher resolution downscaled simulations are being used to provide more detailed and regionally specific projections of TCs under future climate conditions. This will include projections of changes in TC maximum potential intensity.

Changes in TC activity are also being analysed in relation to tropical expansion. Possible implications of tropical expansion on TCs include TCs travelling further south of their typical current-climate range. A number of other knowledge gaps are being examined in relation to observed TC track directionality and intraseasonal variability, including in relation to the influence of the Madden-Julian oscillation (MJO), so as to provide improved intraseasonal guidance and enhanced preparedness to TC impacts on the Australian region (Lavender and Dowdy 2016).

EAST COAST LOWS

Although fewer east coast lows (ECLs) are expected in the future in general, particularly during the cooler months of the year, there are significant gaps in relation to projected changes in the intensity of extreme weather conditions associated with these storms. To help address these gaps, the role of model resolution in relation to representing extreme weather associated with ECLs is being investigated to help assess different methods of downscaling for producing projections of future ECL characteristics. Additionally, the energetics of ECLs and associated extreme weather conditions are being investigated, including the relative contributions of baroclinic and barotropic forcings for their development.

Improved understanding of the drivers of ECL development and associated extreme weather conditions, as well as of the ability of modelling methods to represent these conditions, will lead to increased understanding and greater confidence in projected changes in extreme weather associated with ECLs. This research will underpin a review and synthesis of the current understanding of the influence of climate change on ECLs and associated hazards, with the outputs of this review process designed to meet the needs of end users.

THUNDERSTORMS

The characteristics of thunderstorms and associated extremes (such as extreme rainfall, winds, hail and lightning) are expected to change in a warmer world. Modelling methods to examine the influence of climate change on thunderstorms and associated extremes are being developed as part of this research, with the goal of producing the first-ever projections of these extremes for different regions throughout Australia for direct use in informing planning and adaptation.

The projections will examine the variation between different models and methods in representing the range of different extreme weather conditions associated with thunderstorms, including based on global climate model output as well as finer-scale dynamical downscaling (with horizontal grid spacing of about 2 km in some locations and 50 km more broadly throughout Australia).

MULTI-HAZARD CONCURRENT EXTREMES

The impact of thunderstorms in combination with other phenomena such as cyclones and fronts is also being investigated. Although these phenomena have been examined in numerous studies, they have not all been systematically examined in combination with each other, including in relation to extreme precipitation and extreme winds. Consequently, the combined influence of these phenomena represents a substantial gap in the current understanding of the causes of extreme weather events.

The highest risk of extreme rain and wind events is found to be associated with a triple storm type characterized by concurrent thunderstorm, cyclone and front occurrences, with this type of storm being of particular importance in coastal regions for eastern Australia (Dowdy and Catto, 2017). The results provide new insight on the relationships between thunderstorms, cyclones and fronts and clearly demonstrate the importance of concurrent phenomena in causing extreme weather. Additionally, an improved ability to decompose different causes of extreme weather could also have benefits for climate modelling applications, such as for distinguishing different drivers of variability and constraining uncertainty estimates in projected changes to extreme events

SUMMARY

Understanding extreme events is an important research priority, particularly given that many of the early impacts of global warming are expected to be experienced through hazards associated with extreme events. It is intended that an improved understanding of extreme weather events, including based on observations for the current climate and model output for the projected future climate, will help lead to improved resilience to their impacts as well as inform the prioritisation of disaster risk reduction and adaptation efforts. This project intends to provide enhanced quality, utility, discoverability and accessibility of information, communication products and decision support tools to improve resilience to extreme weather events, covering bushfires, tropical cyclones, east coast lows as well as thunderstorms and associated impacts on regions throughout Australia. This paper represents an overview of the project including describing some initial results as well as intended outputs prior to the finalisation of the project in June 2019.

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