

Changes in south-east Australian fire-weather risk

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Since 1950, rainfall has decreased in south-east Australia, droughts have become more severe and the number of extremely hot days has risen. Hotter and drier years have greater fire risk. Climate change projections indicate that the south-east is likely to become hotter and drier in future, so fire risk is likely to increase.

CSIRO, the Bureau of Meteorology and the Bushfire CRC have assessed potential changes in fire-weather risk associated with future climate change, due to the enhanced greenhouse effect (Hennessy et al., 2005). Fire weather is only one of the important factors determining fire risk and fire behaviour – fuels, terrain and suppression are also critical, but these have not been assessed. This is just a first step toward better informing fire management agencies and researchers about climate change risks. Ongoing engagement between scientists and fire management agencies is needed to maximise the value of this assessment.

The weather variables required for this analysis were daily maximum temperature, precipitation, 3 pm relative humidity and wind-speed. For the 30-year period 1974-2003, data for all four weather variables were available at 17 sites (shown below), namely:

- NSW: Coffs Harbour, Cobar, Williamtown, Richmond, Sydney, Nowra, Wagga, Bourke, Cabramurra
- Victoria: Mildura, Melbourne, Laverton, Sale, Bendigo
- ACT: Canberra
- Tasmania: Hobart, Launceston



The maximum daily Forest Fire Danger Index (FFDI) and Grassland Fire Danger Index (GFDI) were calculated at each site for “present” conditions (1974-2003). The FFDI and GFDI are used operationally to monitor fire risk, schedule prescribed burning and declare Total Fire Ban days. Climate change scenarios for 2020 and 2050 were generated from two CSIRO climate models, henceforth called CCAM (Mark2) and CCAM (Mark3). These scenarios included changes in average climate and daily weather variability, and were applied to observed daily weather data. The models provided patterns of change per degree of global warming, which were scaled by the rates of global warming from the Intergovernmental Panel on Climate Change (IPCC, 2001). The uncertainty in global warming is expressed as a low-high range, namely 0.37-0.85°C by 2020 and 0.88-2.24°C by 2050.

The climate change scenarios were applied to observed daily weather data at 17 sites. The FFDI and GFDI results were calculated in three ways.

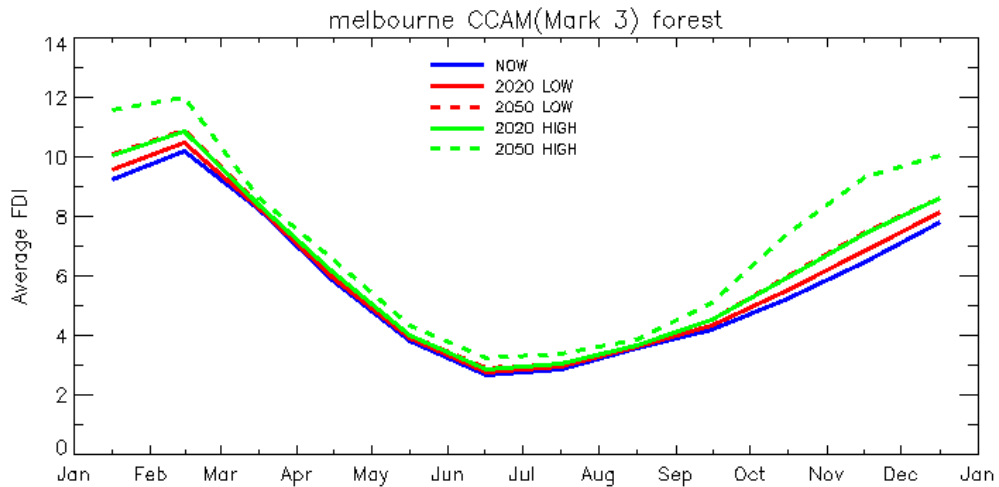
- Annual-average cumulative FFDI and GFDI, denoted Σ FFDI and Σ GFDI
- Monthly-average FFDI and GFDI
- Daily-average FFDI and GFDI

The “present” average Σ FFDI in inland areas is around 3000-5000, while southern and coastal areas have values around 1700-2600. For CCAM (Mark2), the values rise by around 2-10% by 2020 and 5-25% by 2050. For CCAM (Mark3), the values rise by around 3-10% by 2020 and 8-30% by 2050.

Annual-average Σ FFDI at 17 sites for present (1974-2003) conditions, and percentage changes for 2020 and 2050, for low and high rates of global warming.

Site	Present	CCAM (Mark2)				CCAM (Mark3)			
		2020 low %	2020 high %	2050 low %	2050 high %	2020 low %	2020 high %	2050 low %	2050 high %
Canberra	2913	4	8	10	26	4	10	11	29
Bourke	5869	4	9	9	25	3	7	7	19
Cabramurra	501	5	10	10	26	7	14	15	40
Cobar	5818	4	10	10	26	3	8	8	22
Coffs Harbour	2002	2	5	5	12	3	6	6	15
Nowra	2507	1	4	4	13	2	6	6	18
Richmond	3049	4	8	8	20	4	8	8	21
Sydney	2158	2	4	5	12	3	7	7	19
Wagga	4047	4	8	9	23	4	9	9	25
Williamstown	2641	2	5	5	13	3	7	7	18
Bendigo	2854	3	8	8	22	3	8	8	23
Laverton	2456	3	8	8	21	4	9	9	24
Melbourne	2121	3	8	8	21	3	8	8	22
Mildura	5898	3	7	7	17	3	8	8	21
Sale	2207	3	8	8	21	4	8	8	23
Hobart	1723	0	0	0	1	0	1	1	2
Launceston	1677	1	3	3	8	3	6	6	17

The monthly-average FFDI results show that most sites currently have the highest fire danger in spring and summer (blue curves in plot below). A spring peak is distinctive for coastal NSW sites, whereas the summer peak is typical of southern and inland sites. In 2020 and 2050, the curves move upward, indicating higher fire danger, particularly in spring, summer and autumn. Periods suitable for prescribed (control) burning are likely to move toward winter.



Monthly-average FFDI at Melbourne for “now” (1974-2003), 2020 and 2050, based on the CCAM (Mark3) climate change scenarios.

The daily-average frequency distributions of FFDI have five intensity categories: low (less than 5), moderate (5-12), high (13-25), very high (25-49) and extreme (at least 50). At all sites, except Hobart, Launceston and Cabramurra, there is an increase in the frequency of very high and extreme days by 2020 and 2050. These are the categories of most interest to fire management agencies. By 2020, the combined frequencies of very high and extreme FFDI generally increase 4-20% for CCAM (Mark2) and 6-25% for CCAM (Mark3). By 2050, the increases are generally 15-55% for CCAM (Mark2) and 20-70% for CCAM (Mark3).

Average number of days when the FFDI rating is “very high” or “extreme” under present conditions (1974-2003) for the years 2020 and 2050.

Site	Present	CCAM (Mark2)				CCAM (Mark3)			
		2020 low	2020 high	2050 low	2050 high	2020 low	2020 high	2050 low	2050 high
Canberra	23.1	25.6	27.5	27.9	36.0	26.0	28.6	28.9	38.3
Bourke	69.5	75.2	83.3	84.0	106.5	73.9	80.3	80.6	96.2
Cabramurra	0.3	0.3	0.4	0.4	0.7	0.4	0.4	0.5	1.0
Cobar	81.8	87.9	96.2	96.6	118.3	86.6	92.8	93.0	108.6
Coffs Harbour	4.4	4.7	5.1	5.1	6.3	4.7	5.6	5.6	7.6
Nowra	13.4	13.9	14.7	14.8	17.5	14.2	15.6	15.6	19.9
Richmond	11.5	12.9	14.0	14.1	17.5	13.1	14.3	14.4	19.1
Sydney	8.7	9.2	9.8	9.8	11.8	9.5	11.1	11.3	15.2
Wagga	49.6	52.7	57.3	57.6	71.5	52.8	57.4	57.7	71.9
Williamstown	16.4	17.2	18.2	18.4	20.9	17.3	19.4	19.4	23.6
Bendigo	17.8	19.5	21.3	21.4	27.3	19.7	21.9	22.0	29.8
Laverton	15.5	16.4	17.3	17.3	21.2	16.6	17.8	17.8	22.3
Melbourne	9.0	9.8	10.7	10.8	13.9	9.8	11.1	11.2	14.7
Mildura	79.5	83.9	89.5	89.9	104.8	84.6	90.7	90.9	107.3
Sale	8.7	9.3	10.0	10.1	12.1	9.6	10.7	10.8	14.0
Hobart	3.4	3.4	3.4	3.4	3.4	3.4	3.5	3.5	3.5
Launceston	1.5	1.5	1.5	1.6	2.0	1.6	1.9	1.9	3.1

Changes in the frequencies of extreme FFDI days are generally largest inland, e.g. at Bourke, Cobar, Mildura and Wagga. By 2020, the increases are generally 10-30% for CCAM (Mark2) and 15-40% for CCAM (Mark3). By 2050, the increases are generally 20-80% for CCAM (Mark2) and 40-120% for CCAM (Mark3). At many sites, there is a doubling (or greater) of the number of extreme days by 2050 for the high scenario. Tasmania is relatively unaffected. In Hobart, the rise in temperature is offset by a rise in humidity.

The magnitude of the grassland fire danger index is always higher than the FFDI since the GFDI is more strongly influenced by wind-speed and we have assumed a worst-case scenario of 100% curing. By 2020, the number of very high or extreme GFDI days increases by around 0-15% for CCAM (Mark2) and 5-20% for CCAM (Mark3). By 2050, the increases are generally 5-30% for CCAM (Mark2) and 15-40% for CCAM (Mark3). By 2020, the number of extreme GFDI days increases by around 5-20% for CCAM (Mark2) and 10-30% for CCAM (Mark3). By 2050, the increases are generally 10-30% for CCAM (Mark2) and 30-80% for CCAM (Mark3).

Average number of days when the GFDI rating is “very high” or “extreme” under present conditions (1974-2003) and for the years 2020 and 2050.

Site	Present	CCAM (Mark2)				CCAM (Mark3)			
		2020 low	2020 high	2050 low	2050 high	2020 low	2020 high	2050 low	2050 high
Canberra	96.8	100.3	103.7	104.0	113.1	103.5	110.3	110.6	129.0
Bourke	90.6	97.5	102.9	103.3	117.9	97.7	102.7	103.0	117.0
Cabramurra	11.6	11.6	11.8	11.8	12.6	12.5	13.8	13.9	18.6
Cobar	112.8	124.1	129.0	129.4	146.6	124.0	129.5	130.1	148.1
Coffs Harbour	86.4	99.9	101.8	101.8	109.1	101.5	105.2	105.6	117.7
Nowra	71.7	80.3	81.7	81.8	86.3	83.5	88.5	88.9	104.0
Richmond	40.4	44.1	44.8	44.8	47.1	45.3	47.4	47.5	55.1
Sydney	116.2	117.6	120.0	120.1	126.8	122.1	129.3	129.7	153.5
Wagga	104.6	110.7	114.4	114.4	123.5	112.5	118.7	119.0	134.2
Williamstown	123.1	132.2	134.9	135.1	144.1	135.0	141.8	142.5	162.9
Bendigo	61.1	63.6	65.8	65.9	72.4	65.0	69.5	69.7	81.7
Laverton	110.1	109.4	111.7	111.9	118.6	111.8	117.4	117.9	131.7
Melbourne	38.7	41.2	41.2	42.2	45.7	42.3	45.0	45.2	54.5
Mildura	146.7	149.1	153.6	153.9	165.6	150.6	157.6	157.0	174.6
Sale	95.4	102.5	104.0	104.1	109.3	104.9	110.2	110.3	124.2
Hobart	67.5	67.5	67.2	67.2	66.1	68.1	68.8	69.0	71.5
Launceston	73.3	73.4	72.3	72.3	69.4	78.5	85.0	85.5	102.8

A number of uncertainties remain:

- Quality of observed daily wind and humidity data at most sites in Australia
- The effect of scenarios based on other climate models
- Assessment of changes in the range (and sensitivity) of seasonal indicators used by fire management agencies for fire preparedness planning.
- Changes in rainfall thresholds required to control fires
- Changes in ignition (natural and anthropogenic)
- Changes in fuel load, allowing for carbon dioxide fertilization on vegetation
- Potential impacts on biodiversity, water yield and quality from fire affected catchments, forestry, greenhouse gas emissions, emergency management and insurance.

Priorities for further research include:

- Testing and rehabilitation of observed humidity and wind data
- Creation of climate change scenarios from other models
- Fine scale fire modelling that captures vegetation and terrain features and fire management
- Hydrological and ecological modelling to assess impacts on water and biodiversity
- Using satellite remote sensing to monitor the extent and nature of fire, recovery of vegetation after fire, and greenhouse gas emissions from fire.

References

- Hennessy, K. J., Lucas, C., Nicholls, N., Bathols, J. M., Suppiah, R., and Ricketts, J. R. (2005). Climate change impacts on fire-weather in south-east Australia. Consultancy report by CSIRO Marine and Atmospheric Research, Bureau of Meteorology and Bushfire CRC. 88 p. http://www.cmar.csiro.au/e-print/open/hennessykj_2005b.pdf
- IPCC (2001). *Summary for Policymakers*, in Houghton, J.T., Ding, Y., Griggs, D.J., Noguer, M., Van Der Linden, P.J. and Xiaosu, D (eds) *Climate Change 2001: The Scientific Basis, Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, Cambridge, 944 pp. www.ipcc.ch