DEPARTMENT OF PLANNING, INDUSTRY & ENVIRONMENT

Climate change impacts in the NSW and ACT Alpine region

Impacts on fire weather

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ACT	Australian Capital Territory
CMIP	Coupled Model Intercomparison Project
DJF	December January February
DPIE	Department of Planning, Industry and Environment
ECL	East Coast Low
FFDI	Forest Fire Danger Index
FDR	Fire Danger Rating
GCM	Global Climate Model
JJA	June July August
KBDI	Keetch-Byram Drought Index
MAM	March April May
MCAS-S	Multi-Criteria Analysis Shell for Spatial Decision Support
mm	millimetre
MM	Murray-Murrumbidgee state planning region
NARCliM	NSW/ACT Regional Climate Modelling project
NSW	New South Wales
RCM	Regional Climate Model
SET	South East and Tablelands state planning region
SON	September October November
SRES	Special Report on Emissions Scenarios
UNSW	The University of New South Wales
WRF	Weather Research and Forecasting
WDM5	WRF Double Moment 5-class

Summary of findings

Impacts on fire weather in the NSW and ACT Alpine region

1. Clear seasonal variation in the Forest Fire Danger Index (FFDI) is observed in the central and western Murray-Murrumbidgee (MM) state planning region, likely due to the large season variations in temperature.
2. In the near future (2020 to 2039), a less than 5% decrease in FFDI is projected for the southern MM region and South East and Tableland (SET) region. A 5–10% decrease is projected for remaining parts of the study area, apart from the Alpine region.
3. These decreases are likely due to predicted increases of 10% in precipitation. While temperature is projected to increase by 0.5–1˚C, wind speed is projected to decrease by 2–4%.
4. In the Alpine region in the near future, a small increase (5%) is projected in the annual FFDI, mostly due to the predicted decrease in precipitation. Strong seasonal variation in the FFDI is seen in this region however, with an up to 30% increase in FFDI projected for winter and spring.
5. Other than the Alpine and southern SET regions, a decrease of up to 15% in FFDI is projected for most regions in the far future (2060 to 2079).
6. In the far future a greater than 30% increase in FFDI is projected for the Alpine region in winter and spring, with an annual increase of 5–10% predicted across all seasons.
7. In the near future, a small increase in the number of extreme fire days (0.5–1.5 days a year) is projected for the central and western MM region.
8. In the far future, an increase of 2–3, 1–2 and 0.5 extreme fire weather days is projected for the western MM, central MM and northern SET regions, respectively.
9. The Alpine and southern SET regions show little change in the number of extreme fire days in either the near or far future projections.

1. Introduction

1.1 Background

The New South Wales (NSW) and Australian Capital Territory (ACT) Alpine region is located in the south-eastern corner of mainland Australia and is the highest mountain range in Australia. Though it comprises only about 0.16% of Australia in size, it is an important region for ecosystems, biodiversity, energy generation and winter tourism. It forms the southern end of the Great Dividing Range, covering a total area of 1.64 million hectares that extend over 500 kilometres. The highest peak, Mount Kosciuszko, rises to an altitude of 2228 metres.

This report is part of a larger project delivered by the NSW Department of Planning, Industry and Environment on the various impacts from climate change on the NSW and ACT Alpine region, hereafter referred to as the Alpine region. The full study region covers the Murray-Murrumbidgee region (MM), South East and Tablelands (SET) and the ACT, bordering the Victorian border in the south (Figure 1).

The Alpine region is vulnerable to climate change. Observations have shown substantial changes in precipitation and temperature for this area (Di Luca et al. 2018), which have already impacted biodiversity and ecosystems (Hughes 2011). In 2014, the NSW/ACT Regional Climate Modelling (NARCliM) project was delivered. Climate snapshots for each of the 11 NSW planning regions and the ACT were developed to demonstrate observed and projected climate change; however, the snapshots only show changes for some variables and focus on each planning region.

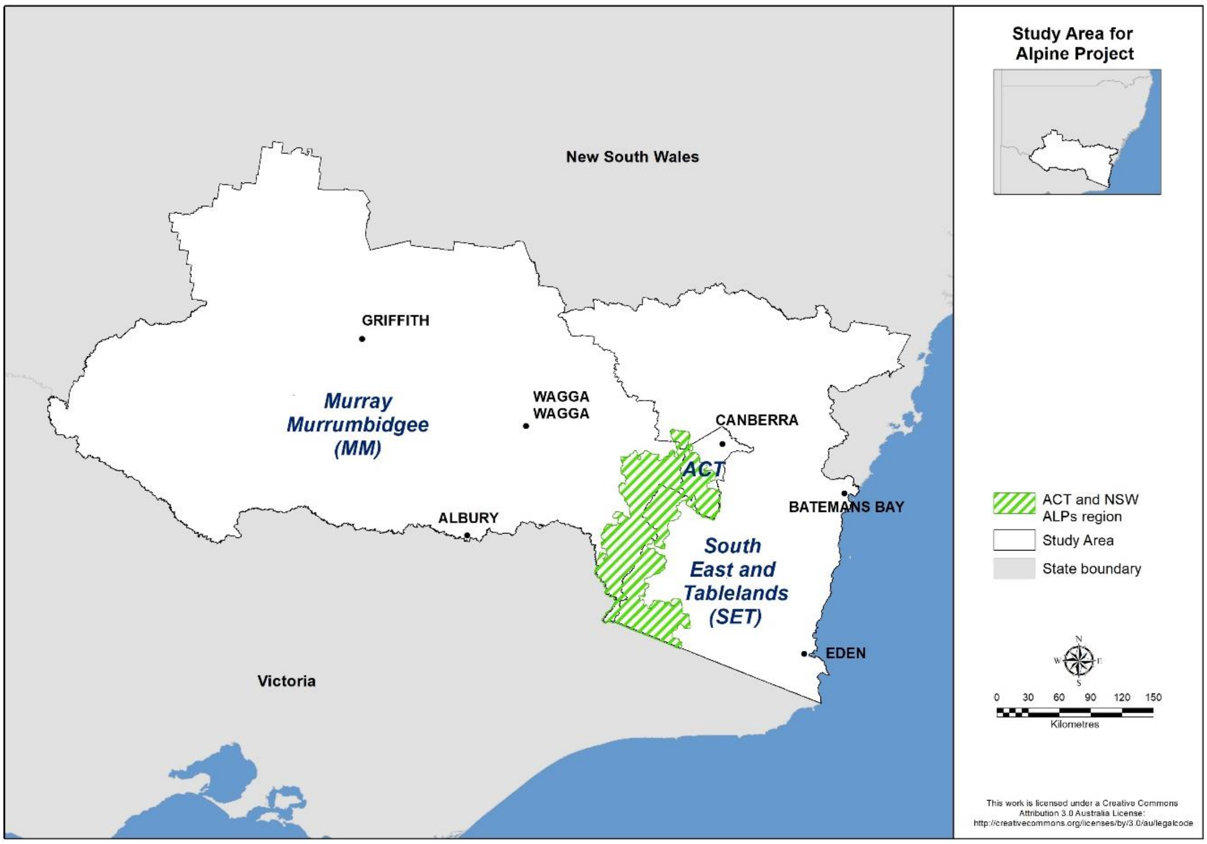

Figure 1 **The study area for the Alpine project, including the NSW and ACT Alpine region, Murray-Murrumbidgee region and South East and Tablelands**

1.2 Objectives

While bushfires are a natural phenomenon in Australia, they can cause dramatic damage and loss. The risk of bushfire in any given region depends on four ‘switches’ that must all be present for a bushfire to occur (Bradstock 2010):

1. There needs to be enough vegetation (fuel).
2. The fuel must be dry enough to burn.
3. The weather must be favourable for fire to spread.
4. There must be an ignition source.

Fuel load in Australia is projected to increase substantially by the late 21st century (Clarke 2015a). More days with extremely dry fuel in eucalypt forests are expected when a warmer and drier climate is projected (Matthews et al. 2011). Clarke (2015b) reviewed the state of knowledge about how climate change will impact bushfire risk in New South Wales. This study considers the full range of national and international research on the four ‘switches’.

Bushfires can be calculated from meteorological variables obtained directly from global and regional climate models. Fire weather has been heavily studied in Australia, with many studies investigating changes in the Forest Fire Danger Index (FFDI) (e.g. Beer & Williams 1995; Williams et al. 2001; Cary 2002; Lucas et al. 2007; Bradstock et al. 2009; Clarke et al. 2011; Fox-Hughes et al. 2014). Clarke et al. (2013) examined historical trends in FFDI. They found that the observational record of FFDI in Australia is marked by clear inter-annual variability with a large degree of spatial coherence, suggesting common drivers in its evolution.

The natural ignition source is lightning. The impact of climate change on lightning has been assessed directly by modelling the drivers of lightning (Price & Rind 1994; Goldammer & Price 1998) and indirectly by linking lightning with other weather patterns (Krawchuk et al. 2009; Penman et al. 2013).

In this study, we focus on bushfire weather. In Australia, fire weather risk is quantified using the Forest Fire Danger Index (FFDI) (Luke & McArthur 1978):

$$FFDI = 2 \times \exp\left(0.987 \times \ln(DF) + 0.0338T + 0.0234V - 0.0345RH - 0.45\right)$$

where DF = drought factor, T = air temperature (°C), V = 3pm wind speed in km/h and RH = 3pm relative humidity (%). The drought factor is calculated using the Griffiths (1999) formulation and uses the Keetch-Byram Drought Index (KBDI; Keetch & Byram 1968) to estimate the soil moisture deficit. The Mount Soil Dryness Index (Mount 1972) is a possible alternative to KBDI, but it is not well-suited to inland areas of Australia (Finkele et al. 2006).

The Fire Danger Rating (FDR) system is often used by fire agencies to reflect the behaviour of a fire and the difficulty of controlling a particular fire (Table 1).

The FFDI estimates (derived from the weather observation) are available for 17 meteorological stations across New South Wales and the Australian Capital Territory (Table 2). While these stations are spread fairly evenly across the state, there are few stations in the study area. The annual mean daily FFDI estimated for the 1990 to 2009 baseline period ranges from 3.3 in Coffs Harbour to 21.2 in Tibooburra. The highest mean FFDI occurs in summer and spring and the lowest is usually in winter.

Table 1 **Categories of the Fire Danger Rating system and the expected fire behaviour for standardised fuel**

(i.e. dry sclerophyll forest with an available fuel load of 12 tonnes/hectare on flat ground) (Vercoe 2003)

Fire Danger Rating	FFDI range	Difficulty of suppression
Low	0 to 5	Fire easily suppressed with hand tools.
Moderate	5 to 12	Fire usually suppressed with hand tools and easily suppressed with bulldozers. Generally, the upper limit for prescribed burning.
High	12 to 25	Fire generally controlled with bulldozers working along the flanks to pinch the head out under favourable conditions. Back burning may fail due to spotting.
Very high	25 to 50	Initial attack generally fails but may succeed in some circumstances. Back burning will fail due to spotting. Burning out should be avoided.
Extreme	50^{+}	Fire suppression virtually impossible on any part of the fire line due to the potential for extreme and sudden changes in fire behaviour. Any suppression actions such as burning out will only increase fire behaviour and the area burnt.

Table 2 **Annual and seasonal mean daily Forest Fire Danger Indices for the 1990 to 2009 baseline period for 17 meteorological stations within NSW and the ACT**

Station	Annual	Summer	Autumn	Winter	Spring
Bourke	16.3	24.4	13.9	8.0	19.4
Broken Hill	12.1	17.7	10.3	6.0	14.8
Canberra	6.9	11.4	7.2	2.6	6.4
Casino	6.4	5.0	4.1	6.8	10.0
Cobar	14.0	21.5	11.9	6.3	16.3
Coffs Harbour	3.3	2.8	2.0	4.0	4.3
Dubbo	10.3	16.1	10.1	4.1	10.9
Hay	9.4	15.6	8.9	3.4	10.2
Lismore	4.9	4.1	3.1	5.3	7.1
Moree	12.1	13.8	11.9	7.5	15.3
Nowra	5.2	5.6	4.3	4.4	6.6
Richmond	7.1	8.3	5.2	5.4	9.8
Sydney Airport	5.5	6.1	4.1	4.5	7.4
Tibooburra	21.2	31.1	18.2	10.3	25.1
Wagga	10.0	19.4	10.0	2.2	8.6
Wilcannia	18.5	28.3	16.4	8.6	21.2
Williamtown	5.4	6.7	3.4	4.1	7.4

Extreme fire weather conditions are estimated to occur at least once a year at all stations with the exceptions of Lismore and Coffs Harbour. Extreme fire weather days are more likely to occur in the summer and spring months (Table 3). Tibooburra and Wilcannia record considerably more days with the FFDI above 50 each year compared to other stations (20 days per year and 12 days per year, respectively).

Table 3 Annual and seasonal mean extreme fire weather days for the 1990 to 2009 baseline period (FFDI >50) for stations within NSW and the ACT

Station	Annual	Summer	Autumn	Winter	Spring
Bourke	7.2	4.7	0.2	0.1	2.3
Broken Hill	2.2	0.7	0.2	0.1	1.3
Canberra	1.1	0.8	0.2	0.0	0.2
Casino	2.1	0.1	0.0	0.5	1.5
Cobar	5.3	3.4	0.2	0.0	1.8
Coffs Harbour	0.3	0.1	0.0	0.0	0.2
Dubbo	3.1	1.7	0.1	0.0	1.4
Hay	1	0.4	0.1	0.0	0.6
Lismore	0.3	0.0	0.0	0.1	0.3
Moree	3.3	1.6	0.2	0.0	1.5
Nowra	1.1	0.6	0.0	0.0	0.5
Richmond	1.8	1.0	0.1	0.0	0.7
Sydney Airport	1.4	0.6	0.1	0.1	0.7
Tibooburra	19.9	11.2	1.3	0.3	7.2
Wagga	5.2	3.7	0.2	0.0	1.3
Wilcannia	12.4	6.8	1.1	0.2	4.4
Williamtown	1.4	0.7	0.0	0.0	0.7

Observations have shown some changes in precipitation and temperature and NARCliM future climate projections indicate increases in temperature and decreases in precipitation for this region (Di Luca et al. 2018). Such changes will lead to changes in bushfire behaviour. In this study, we use NARCliM projections to assess whether bushfire weather for the Alpine region will change under future projected climate conditions.

The downscaled 10 kilometre climate projections from the NARCliM project (Evans et al. 2014) are available for a baseline period (1990 to 2009), and near future (2020 to 2039) and far future (2060 to 2079) periods. The NARCliM project produced more than 140 variables for 12 ensemble members, which were used to calculate FFDI (Clarke et al. 2016).

The objectives of this study were to (i) project the mean changes of FFDI across the alpine study area in New South Wales based on the NARCliM projections; and (ii) project changes in extreme FFDI days across the study area to assist the long-term climate change adaptation and regional planning in the Alpine region.

1.3 Outputs

Output	Details	Key users
Report	Future fire weather projection	Researchers
Data	FFDI for each of the 12 ensemble members Mean FFDI for three time periods Mean extreme FFDI days for three time periods	NSW National Parks & Wildlife Service NSW Rural Fire Service
Maps	Maps of the annual and seasonal FFDI	Councils, NSW Rural Fire Service

2. Method

2.1 Source of data

NARCliM simulations from four Coupled Model Intercomparison Project phase 3 (CMIP3) Global Climate Models (GCMs) were used to drive three Regional Climate Models (RCMs) to form a 12-member GCM/RCM ensemble (Evans et al. 2014). The four selected GCMs are MIROC3.2, ECHAM5, CCCMA3.1 and CSIRO-MK3.0. For future projections, the Special Report on Emissions Scenarios (SRES) business-as-usual A2 scenario was used (IPCC 2000). The three selected RCMs are three physics scheme combinations of the Weather Research and Forecasting (WRF) model. Each simulation consists of three 20-year runs (1990 to 2009, 2020 to 2039, and 2060 to 2079). The four GCMs were chosen based on a number of criteria: i) adequate performance when simulating historic climate; ii) most independent; iii) cover the largest range of plausible future precipitation and temperature changes for Australia. The three RCMs correspond to three different physics scheme combinations of the WRF V3.3 model (Skamarock et al. 2008), which were also chosen for adequate skill and error independence, following a comprehensive analysis of 36 different combinations of physics parameterisations over eight significant East Coast Lows (ECLs) (Evans et al. 2012; Ji et al. 2014a). For the selected three RCMs, the WRF Double Moment 5-class (WDM5) microphysics scheme and NOAH land surface scheme are used in all cases. Refer to Evans et al. (2014) for more details on each physics scheme.

We acknowledge that the results are model dependent (as all model studies are) but through the use of this carefully selected ensemble we have attempted to minimise this dependence. By using this model selection process, we have shown that it is possible to create relatively small ensembles that are able to reproduce the ensemble mean and variance from the large parent ensemble (i.e. the many GCMs) as well as minimise the overall error (Evans et al. 2013a).

Some initial evaluation of NARCliM simulations shows that they have strong skill in simulating the precipitation and temperature of Australia, with a small cold bias and overestimation of precipitation on the Great Dividing Range (Evans et al. 2013b, Ji et al. 2016). The differing responses of the different RCMs confirm the utility of considering model independence when choosing the RCMs. The RCM response to large-scale modes of variability also agrees well with observations (Fita et al. 2016). Through these evaluations we found that while there is a spread in model predictions, all models perform adequately with no single model performing the best for all variables and metrics. The use of the full ensemble provides a measure of robustness such that any result that is common through all models in the ensemble is considered to have higher confidence.

In total, there were four same GCM driven simulations (average of three members) and three same RCM used simulations (average of four members). The analyses in this study are based on the ensemble mean of these simulations.

2.2 Quality control

FFDI is calculated using NARCliM outputs, which have been subjected to comprehensive data quality assurance/quality control (Ji et al. 2014b). The method for quantifying future climate projections is widely used. Annual climate projections are similar to those shown on the AdaptNSW Climate projections for your region webpage. Seasonal and monthly future projections use the same method but for finer timescale outputs.

The data have also been evaluated as conference and journal papers (Evans et al. 2013b; Ji et al. 2016; Fita et al. 2016). Similar climate projections from NARCliM have been published as technical reports (Olson et al. 2014; Di Luca et al. 2016) and peer reviewed scientific publications (Olson et al. 2016; Di Luca et al. 2018).

2.3 Data storage and access

All output data were converted to raster format (ArcGIS ESRI grid) and supplied to the MCAS-S (Multi-Criteria Analysis Shell for Spatial Decision Support) datapacks for distribution and storage. All input data to the model and by-products are stored on hard disk drives. All data are in the NARCliM coordinate system. The extent of the datasets includes the MM region, ACT and SET with the boundary at top: –32.671254, left: 143.317445, right: 150.745676, and bottom: –37.505077.

3. Results

3.1 Forest Fire Danger Index

Mean FFDI for the 1990 to 2009 baseline period

The annual mean daily FFDI for the NARCliM baseline period (1990 to 2009) is shown in Figure 2. Generally, a moderate fire rating is simulated for the central and western MM and a low fire rating for the remaining areas. The smallest FFDI values are found in the Alpine region. The larger FFDI for the central and western MM is mostly due to the higher temperatures and lower precipitation. In contrast, the smallest FFDI values for the Alpine region are caused by the lower temperatures and wetter conditions (where annual precipitation is greater than 1800 mm).

There is a clear seasonal variation in the FFDI for the central and western MM, with the largest value in summer and the smallest value in winter (Figure 3). Relatively smaller seasonal variation is found for other regions, especially in the coastal region. In summer a high fire rating (greater than 12) is simulated for the central and western MM and a moderate fire rating (5–12) for most other areas. A low fire rating (less than 5) is simulated for almost the entire region in winter. The fire weather rating for the remaining two seasons is like that for the annual average.

As noted in the accompanying 'Projected climate' report, there is a larger seasonal variation in temperature for the central and western MM; however, the seasonal variations of rainfall and wind speed are relatively small. This implies that larger seasonal variation in the FFDI is mostly determined by the larger seasonal variation in temperature for those areas.

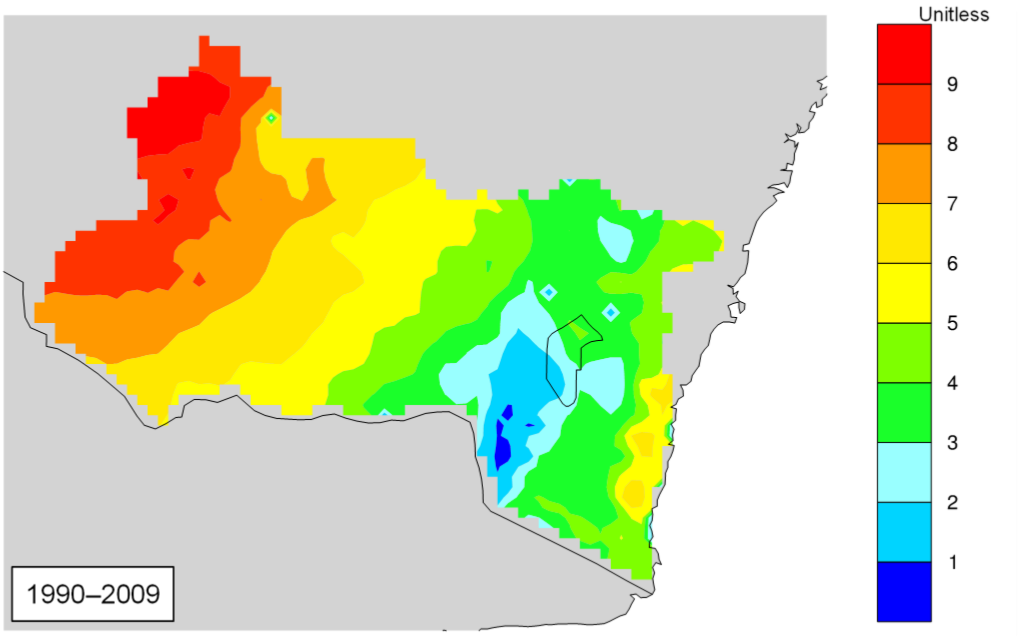

Figure 2 Annual mean daily FFDI for the 1990 to 2009 baseline period

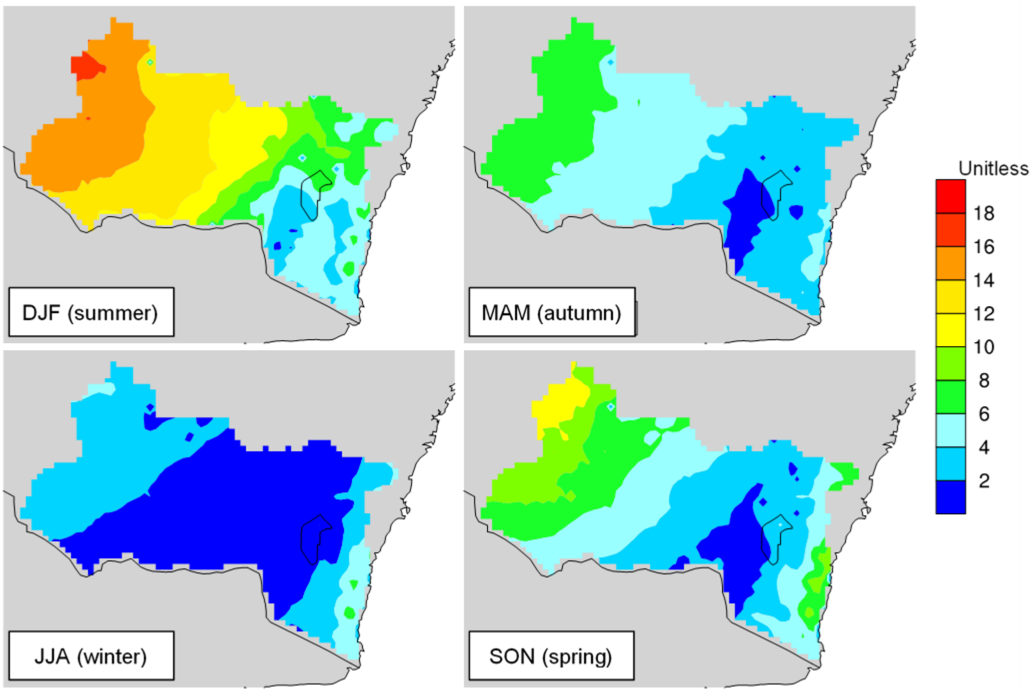

Figure 3 Seasonal mean daily FFDI for the 1990 to 2009 baseline period

Changes in mean FFDI for 2020 to 2039

Relative changes in the annual mean daily FFDI for the near future (2020 to 2039) are shown in Figure 4. A less than 5% increase in FFDI is projected for the Alpine region, but a decrease in the FFDI is projected for most of the study area. Larger decreases (above 10%) are projected for the northern SET and north-east MM. A less than 5% decrease is projected for the southern MM and south-western SET region. A 5–10% decrease is projected for the remaining regions.

An increase in daily FFDI for the Alpine region is mostly due to a decrease in precipitation. For the Alpine region, up to a 10% decrease in precipitation is projected for the near future, and temperature is projected to increase by 0.5–1°C. Wind speed on the other hand is projected to decrease by 2–4%. Similarly, a decrease in daily FFDI for other regions is also determined by increases in precipitation as there is little difference in projected change in temperature between the alpine and other regions.

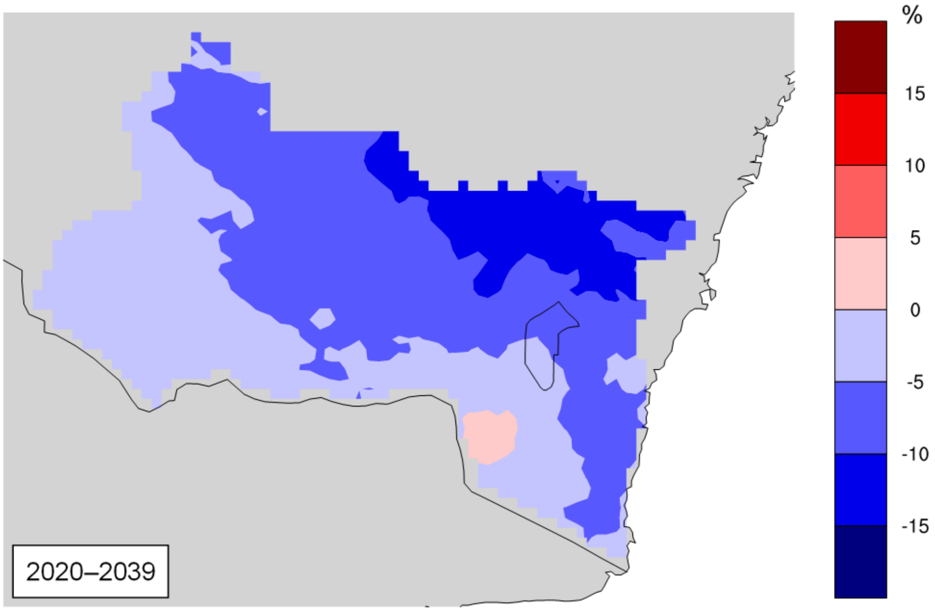

Figure 4 **Changes in annual mean daily FFDI (%) for 2020 to 2039 relative to 1990 to 2009**

An up to 30% increase in the FFDI is projected for the Alpine region in winter and spring (Figure 5). This is mainly due to a 10–20% decrease in rainfall for the region during the same period. Large increases in temperature in spring projected for the Alpine region may also contribute to the larger increase in FFDI for the same season. The FFDI in other regions is projected to decrease, particularly for the northern study area where an up to 20% decrease is projected for summer due to more precipitation for the region in future.

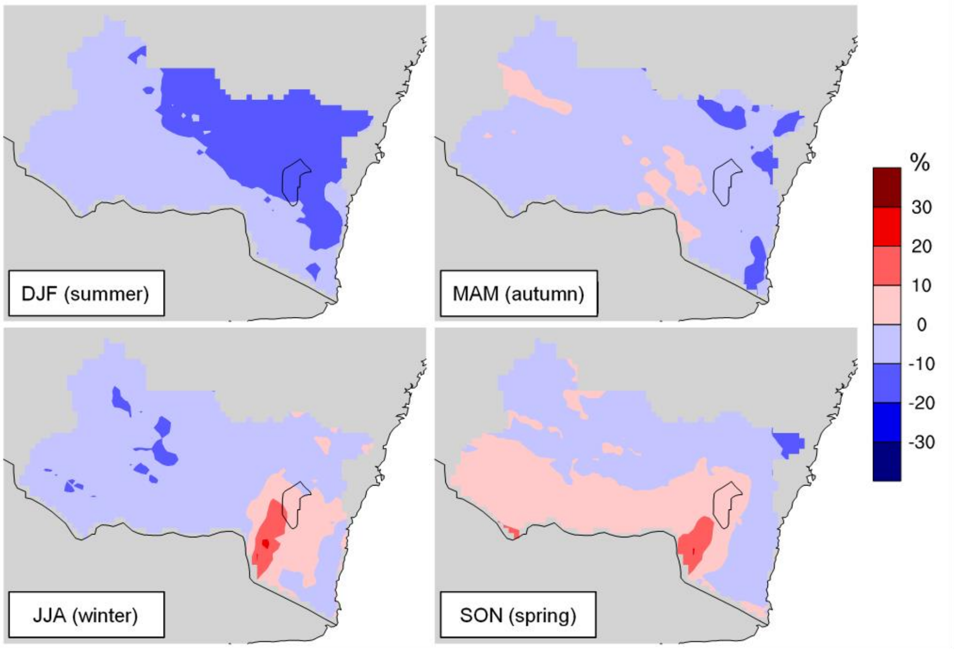

Figure 5 **Changes in seasonal mean daily FFDI (%) for 2020 to 2039 relative to 1990 to 2009**

Changes in mean FFDI for 2060 to 2079

A 5–10% increase in the FFDI is projected for the Alpine region in the far future (Figure 6), which is larger than the projected increase for the near future. The larger increase in FFDI is determined by an up to 10% decrease in precipitation, a large increase in the number of dry days and a large increase in maximum temperature.

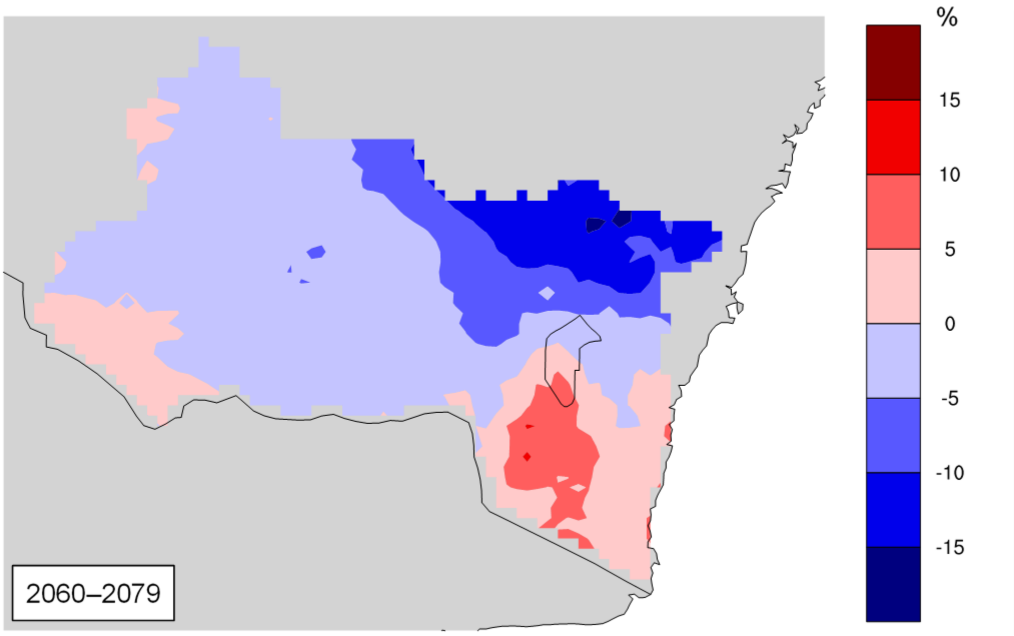

Figure 6 **Changes in annual mean daily FFDI (%) for 2060 to 2079 relative to 1990 to 2009**

Additionally, a greater than 30% increase in the FFDI is projected for the Alpine region in winter and spring (Figure 7). This is mostly caused by the larger decrease in precipitation during these seasons. Increases in temperature for the Alpine region may contribute to increases in FFDI.

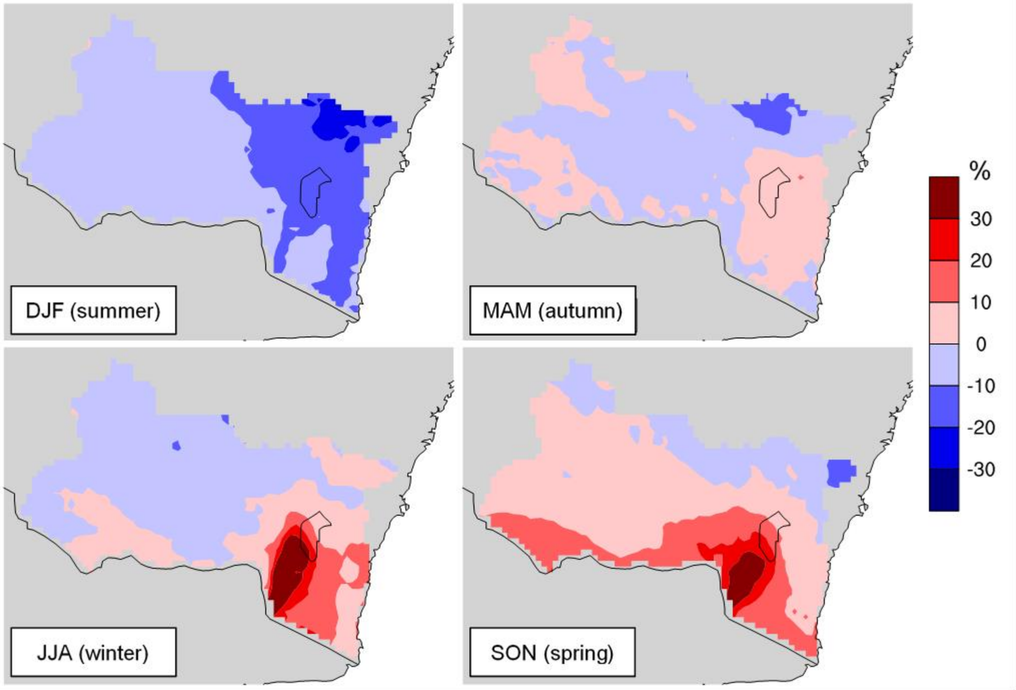

Figure 7 **Changes in seasonal mean daily FFDI (%) for 2060 to 2079 relative to 1990 to 2009**

3.2 Extreme fire weather days

Extreme fire weather days for the 1990 to 2009 baseline period

Extreme fire weather is defined by an FFDI greater than 50. For the 1990 to 2009 baseline period, there are almost no extreme fire weather days for the ACT and SET regions, 1–2 extreme fire weather days per year for the eastern MM, and 2–5 extreme fire weather days for central and western MM (Figure 8). Extreme fire weather in the central and western MM is due to high temperatures and low rainfall in these regions. In contrast, there is no extreme fire weather in other regions due to lower temperatures and higher rainfall.

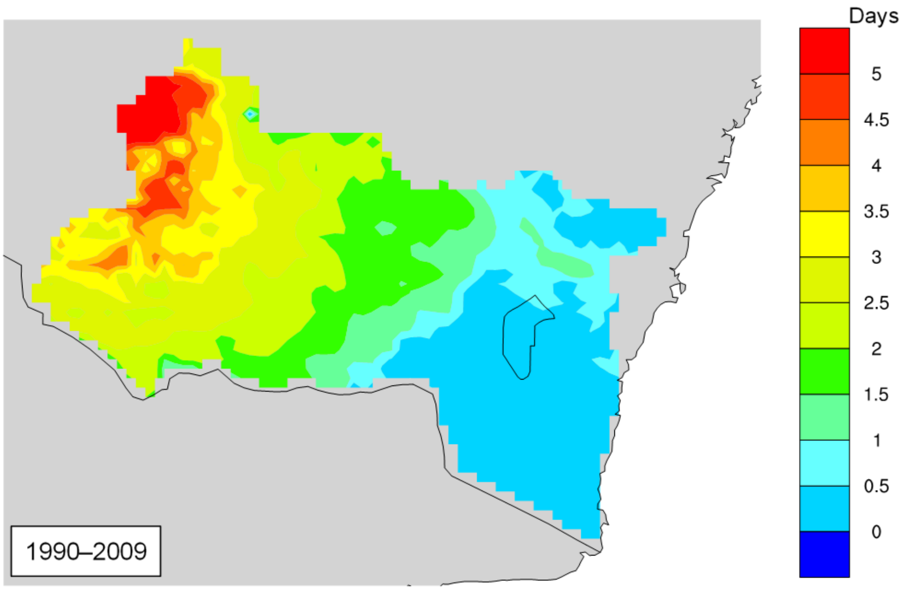

Figure 8 **Annual mean extreme FFDI days (days with FFDI >50) for the 1990 to 2009 baseline period**

Extreme fire weather days are mostly in summer for the MM, with few extreme fire weather days in spring, particularly for the western MM (Figure 9). There is no extreme fire weather in autumn and winter.

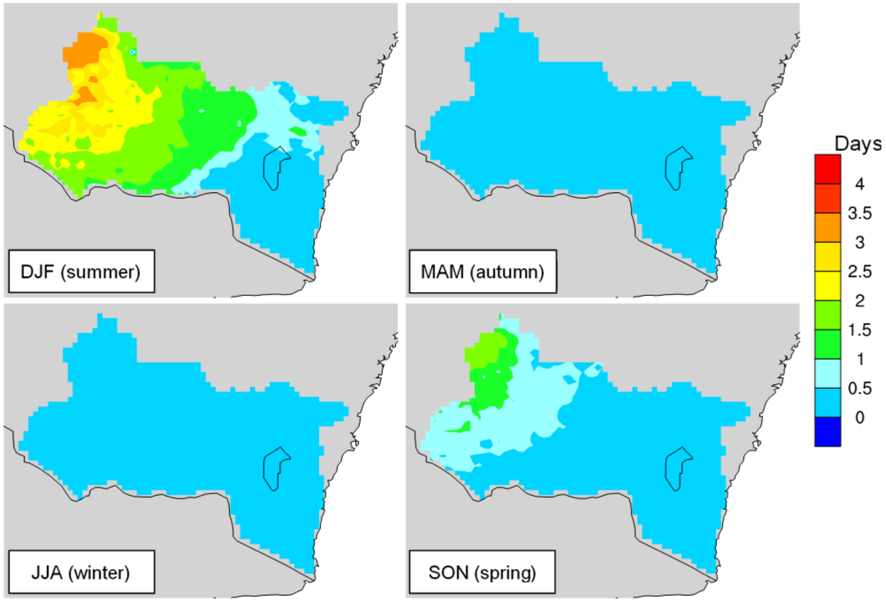

Figure 9 **Seasonal mean extreme FFDI days (days with FFDI >50) for the 1990 to 2009 baseline period**

Changes in the number of extreme fire weather days for 2020 to 2039

Changes in the number of extreme fire weather days for the near future projection period of 2020 to 2039 are relatively small (Figure 10). Little change is projected for SET, ACT and eastern MM. A small increase (0.5–1.5 days a year) is projected for the central and western MM. Increases in extreme fire weather days are mostly in spring and summer for the central and western MM, with minor changes for other regions and other seasons (Figure 11).

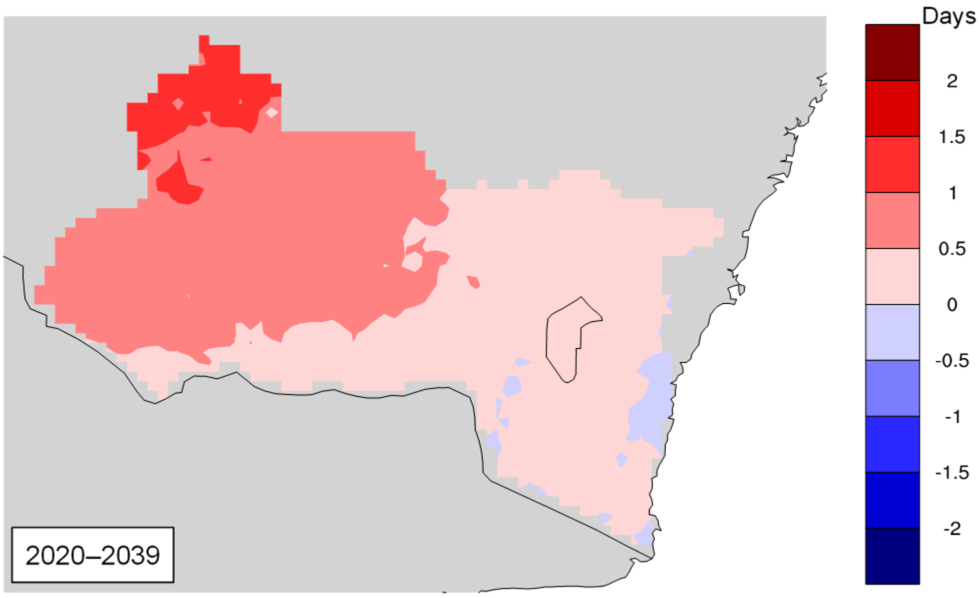

Figure 10 **Changes in annual extreme FFDI days (days with FFDI >50) for 2020 to 2039 relative to 1990 to 2009**

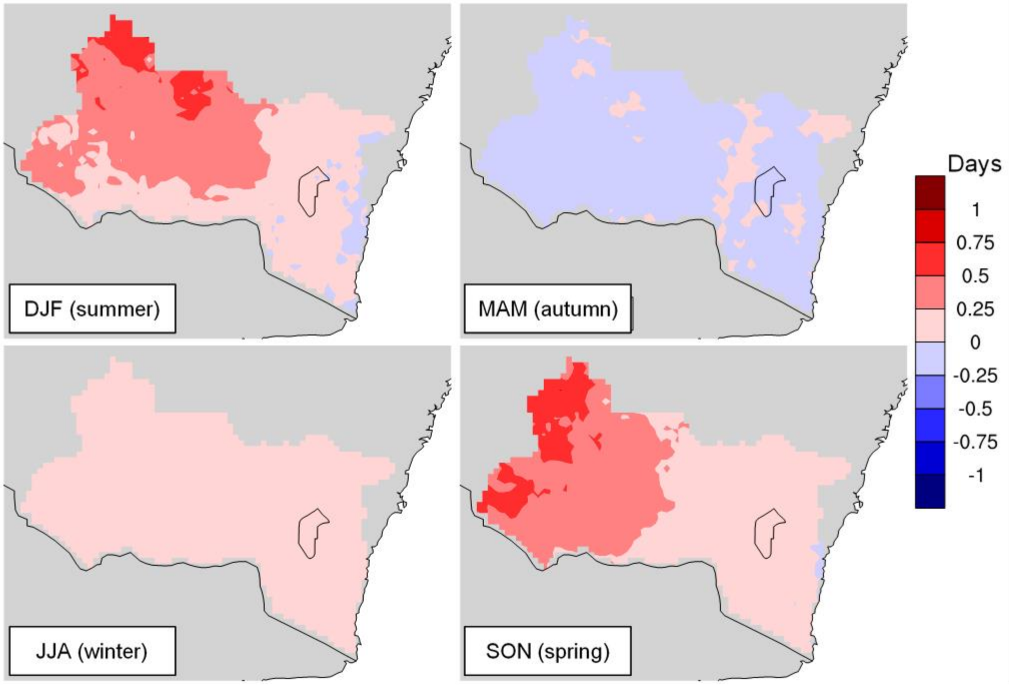

Figure 11 **Changes in seasonal extreme FFDI days (days with FFDI >50) for 2020 to 2039 relative to 1990 to 2009**

Changes in the number of extreme fire weather days for 2060 to 2079

Changes in annual extreme fire weather days for the far future (2060 to 2079) are larger than those for the near future (2020 to 2039). There is a projected increase of 2–3 days in extreme fire weather for the western MM, 1–2 days for the central MM, and a small increase for the northern SET region (more than 0.5 days a year) (Figure 12). There is little change for other regions, notably for the Alpine region. Increases in extreme fire weather days are mostly in spring and summer for the central and western MM, with little change for other regions and other seasons (Figure 13).

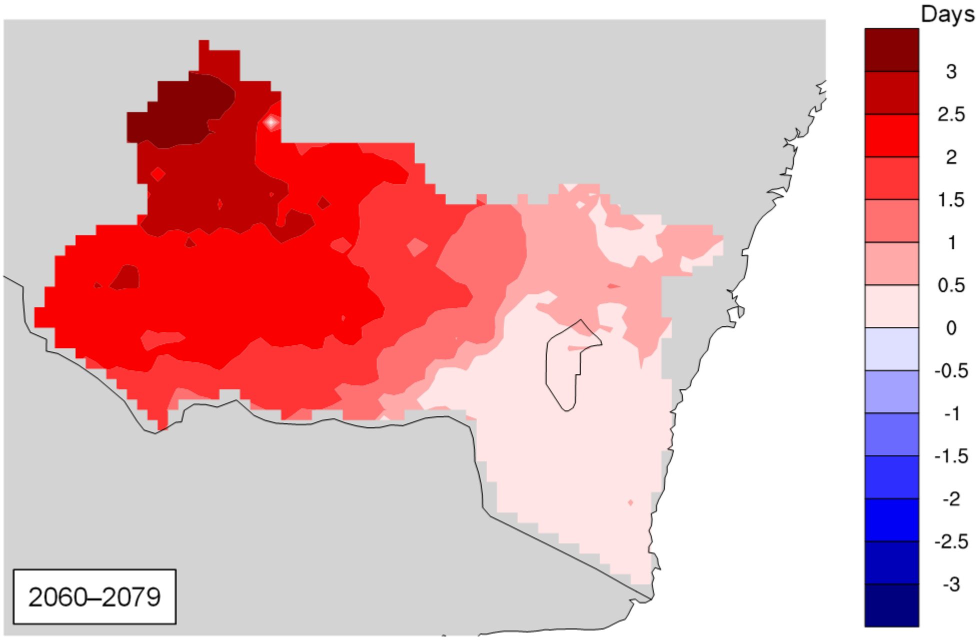

Figure 12 **Changes in annual extreme FFDI days (days with FFDI >50) for 2060 to 2079 relative to 1990 to 2009**

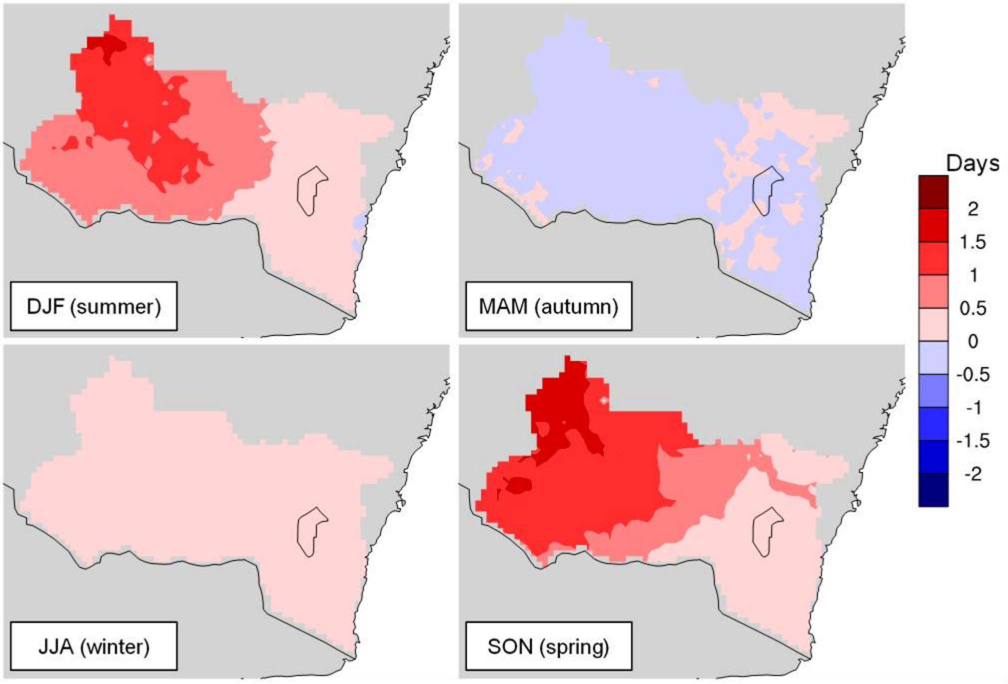

Figure 13 **Changes in seasonal extreme FFDI days (days with FFDI >50) for 2060 to 2079 relative to 1990 to 2009**

4. Discussion

4.1 Key findings

The results of this report show changes in the FFDI that are projected for the Alpine region and surrounding areas. The overall key findings indicate:

- The annual mean daily FFDI is generally small for the study area with a moderate fire weather rating for the central and western MM and a small fire weather rating for other regions.
- The central and western MM shows clear seasonal variation in FFDI, generally having its highest fire rating in summer and spring. This is likely due to the large season variations in temperature.
- For the near future, decreases in the annual mean daily FFDI are projected for all regions except the Alpine region. These decreases are mostly projected for the summer months and are likely due to predicted increases in precipitation. While temperature is projected to increase in these areas, wind speed is projected to decrease.
- In the Alpine region in the near future, up to 30% increases in seasonal mean daily FFDI are projected in winter and spring.
- For the far future, a decrease of up to 15% in the annual mean daily FFDI is projected for most regions except for the Alpine and southern SET regions, where a more than 30% increase in seasonal mean daily FFDI is projected in winter and spring.
- Large decreases in mean daily FFDI are mostly projected for the north-east MM, ACT and SET regions in the far future.
- In the near future, a small increase in the number of extreme fire days (0.5–1.5 days a year) is projected for the central and western MM region.

- In the far future, an increase of 2–3, 1–2 and 0.5 extreme fire weather days is projected for the western MM, central MM and northern SET regions, respectively.
- The Alpine and southern SET regions show little change in the number of extreme fire days in either the near or far future projections.

4.2 Limitations and further research

NARCliM data were used in the study. NARCliM has its limitations, such as using an older generation CMIP ensemble (i.e. CMIP3), being at a relatively coarse resolution, having limited ensemble members and having only short time periods for analysis.

Results presented in the report are based on the multi-model mean. The same weight was used for each of the 12 GCM/RCM ensemble members. Four GCMs were selected to represent the CMIP3 ensemble. A selected GCM represents different numbers of GCMs in the CMIP3 ensemble. We should consider giving a different weight to each GCM according to the number of GCMs in the ensemble it represents. We should also consider the simulation performance to adjust the weight factor.

Given the short duration of the project, we did not look at the statistical significance and model agreement. This should be assessed in further research.

5. Conclusion

The daily FFDI derived from the NARCliM simulations are used to analyse the change in annual and seasonal means of daily FFDI, and extreme fire weather days (daily FFDI greater than 50). The multi-model mean is taken as the best estimation.

Small decreases in the FFDI are projected for most parts of the study area in both the near and far futures, likely due to predicted increases in precipitation in these regions. The Alpine region is the exception (and the southern SET region in the far future), where large increases in FFDI are projected for winter and spring, likely due to predicted decreases in precipitation during these seasons and possibly also due in part to increased temperatures.

Extreme fire weather days are mostly seen in the central and western MM in summer and spring. There is no extreme fire weather day in other regions and other seasons. For the near future, 0.5–1.5 days per year more extreme fire days are projected for the central and western MM and with significant change elsewhere. The increases are mostly in spring and summer. For the far future, 1–3 more extreme fire weather days are projected for the central and western MM, 0.5–1 more extreme fire weather day for the north-east MM and northern SET regions, and not much change in other regions. The increases are greatest during spring and summer.

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