

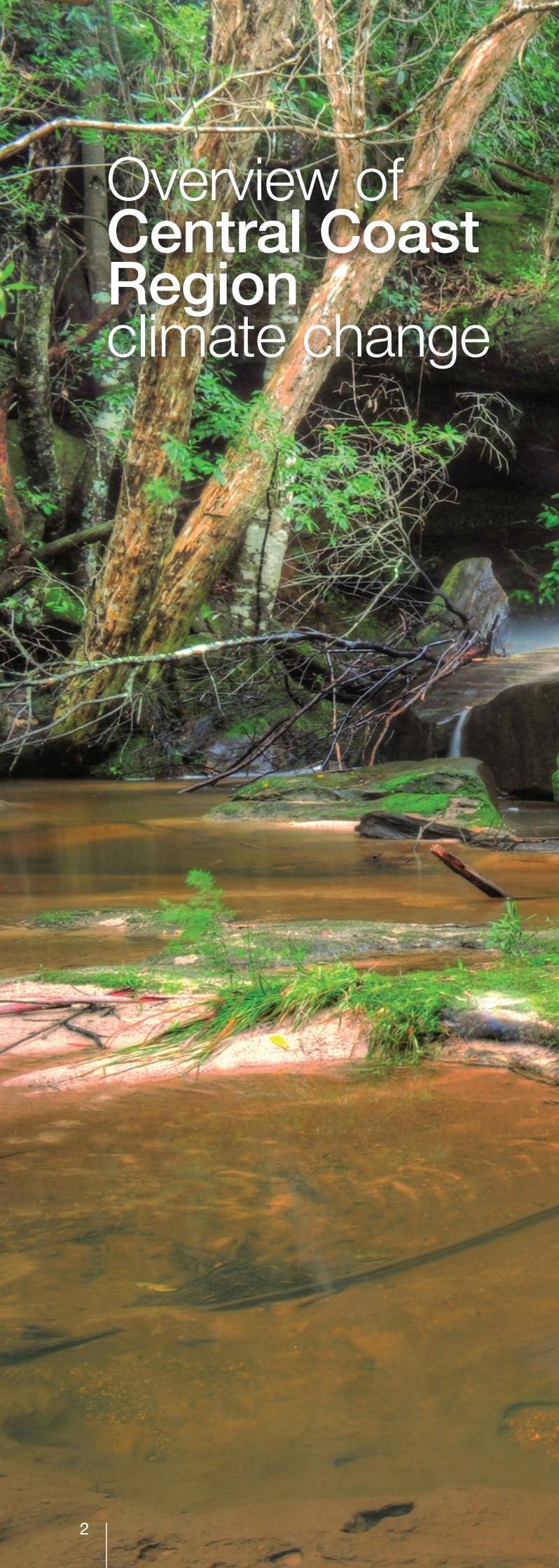


Office of  
Environment  
& Heritage

AdaptNSW

# Central Coast Climate change snapshot





# Overview of Central Coast Region climate change

Based on long-term (1910–2011) observations, temperatures in the Central Coast Region have been increasing since about 1960, with higher temperatures experienced in recent decades.

The region is projected to continue to warm during the near future (2020–2039) and far future (2060–2079), compared to recent years (1990–2009). The warming is projected to be on average about 0.7°C in the near future, increasing to about 1.9°C in the far future. The number of hot days is projected to increase, and there are projected to be fewer cold nights.

The warming trend projected for the region is large compared to natural variability in temperature, and is of a similar order to the rate of warming projected for other regions of NSW.

Front Cover: North Avoca. The weathered crater-like rock pools have a teal blue, grey colour in the rock while the surrounding surface rock is orange red. Very surreal. Focus to foreground. Copyright: Leah-Anne Thompson. Page 2: Mystic serene flowing tropical rainforest waterfall, Somersby Falls, Gosford, New South Wales, Australia. Copyright: worldswildlifewonders. Page 4: The Hawkesbury River, Windsor, New South Wales, Australia. Copyright: Phillip Minnis. Page 7: Sunrise at Hargraves Beach, Noraville, NSW, Australia with sunrays, sunburst and silhouetted rock formations. Copyright: Leah-Anne Thompson. Page 9: Whispering reeds (*Phragmites Australis*), softly swaying and moving gracefully in the blue, golden wetlands area of Tuggerah Lakes near Long Jetty at sunset. Copyright: Leah-Anne Thompson.

# Projected changes



## Projected temperature changes



Maximum temperatures are projected to **increase** in the near future by 0.3 – 1.0°C

Maximum temperatures are projected to **increase** in the far future by 1.4 – 2.5°C



Minimum temperatures are projected to **increase** in the near future by 0.4 – 0.8°C

Minimum temperatures are projected to **increase** in the far future by 1.4 – 2.5°C



The number of hot days will **increase**

The number of cold nights will **decrease**

## Projected rainfall changes



Rainfall is projected to **decrease** in spring and winter

Rainfall is projected to **increase** in summer and autumn

## Projected Forest Fire Danger Index (FFDI) changes



Average fire weather is projected to **increase** in summer and spring

Severe fire weather is projected to **increase** in summer and spring



# Regional snapshots

## NSW and ACT Regional Climate Modelling project (NARClIM)

The climate change projections in this snapshot are from the NSW and ACT Regional Climate Modelling (NARClIM) project. NARClIM is a multi-agency research partnership between the NSW and ACT governments and the Climate Change Research Centre at the University of NSW. NSW Government funding comes from the Office of Environment and Heritage (OEH), Sydney Catchment Authority, Sydney Water, Hunter Water, NSW Office of Water, Transport for NSW, and the Department of Primary Industries.

The NARClIM project has produced a suite of twelve regional climate projections for south-east Australia spanning the range of likely future changes in climate. NARClIM is explicitly designed to sample a large range of possible future climates.

Over 100 climate variables, including temperature, rainfall and wind are available at fine resolution (10km and hourly intervals). The data can be used in impacts and adaptation research, and by local decision makers. The data is also available to the public and will help to better understand possible changes in NSW climate.

## Modelling overview

The NARClIM modelling was mainly undertaken and supervised at the Climate Change Research Centre. NARClIM takes global climate model outputs and downscales these to provide finer, higher resolution climate projections for a range of meteorological variables. The NARClIM project design and the process for choosing climate models has been peer-reviewed and published in the international scientific literature (Evans et. al. 2014, Evans et. al. 2013, Evans et. al. 2012).

Go to [climatechange.environment.nsw.gov.au](http://climatechange.environment.nsw.gov.au) for more information on the modelling project and methods.

Interpreting climate projections can be challenging due to the complexities of our climate systems. 'Model agreement', that is the number of models that agree on the direction of change (for example increasing or decreasing rainfall) is used to determine the confidence in the projected changes. The more models that agree, the greater the confidence in the direction of change.

In this report care should be taken when interpreting changes in rainfall that are presented as the average of all of the climate change projections, especially when the model outputs show changes of both wetting and drying. To understand the spread of potential changes in rainfall the bar charts should be considered along with the maps provided in this document. Help on how to interpret the maps and graphs in this report is provided in Appendix 1.

Summary documents for each of the state planning regions of NSW are available and provide climate change information specific to each region.

The snapshots provide descriptions of climate change projections for two future 20-year time periods: 2020–2039 and 2060–2079.

1. The climate projections for 2020–2039 are described in the snapshots as **NEAR FUTURE, or as 2030**, the latter representing the average for the 20-year period.
2. The climate projections for 2060–2079 are described in the snapshots as **FAR FUTURE, or as 2070**, the latter representing the average of the 20-year period.

Further information about the regions will be released in 2015.

# Introduction

This snapshot presents climate change projections for the Central Coast region of NSW. It outlines some key characteristics of the region, including its current climate, before detailing the projected changes to the region's climate in the near and far future.

## Location and topography

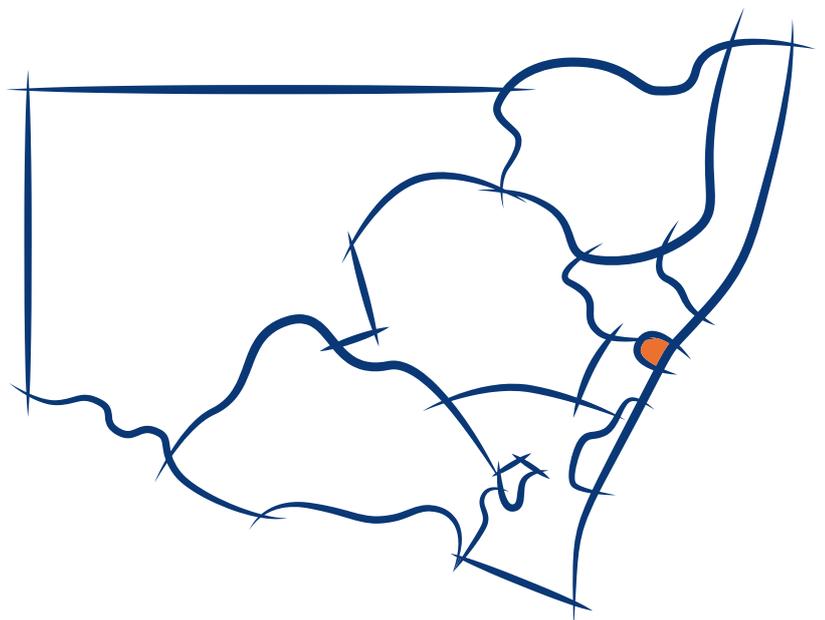
Well known for its beaches, lakes and the Hawkesbury River, the Central Coast Region extends from Broken Bay in the south to Forrester's Beach in the north. The Central Coast region lies on Hawkesbury sandstone, with the Hornsby plateau the dominant geological feature.

## Population and settlements

The Central Coast region has a population of approximately 322,600 people. There are two major town centres, Gosford and Wyong. The main industries in the region include retail, hospitality and construction. Tourism is also a major industry in this region.

## Natural ecosystems

The region covers the catchments of the Wyong River and Mangrove Creek and is characterised by a large coastal plain fringed by a steep escarpment that rises abruptly to the sandstone plateaux of the hinterland. The terrain of the region has a large influence on its ecosystems. The orographic influence of Watagan Range creates an area of high rainfall, providing sufficient moisture to support the major areas of wet sclerophyll forest and rainforest. The region's sandstone plateaux are largely covered in dry sclerophyll forest. The coastal plain supports large areas of freshwater and saline wetland ecosystems, including large coastal lakes such as Tuggerah Lake. The region marks a transition zone for many plant and animal species between the sub-tropical influences of the north to the cooler, temperate conditions of the south. Reserves in the region include the coastal sandstone plateaux of Brisbane Waters and Dharug national parks, and the moist forests of Jilliby State Conservation Area.



# Climate of the region

The Central Coast region has a fairly uniform climate. It is wettest along the coast and drier inland. It is warm in summer across the region. Winters are mild but temperatures are cooler away from the coast.

## Temperature

In summer average temperatures are around 20–22°C throughout most of the region. In winter, average temperatures range from 12–14°C along the coast and are slightly cooler inland.

Maximum temperatures during summer range from 24–26°C along the coast and 26–28°C inland. In winter, average minimum temperatures range from 8–10°C around the coastal lakes to 4–6°C inland away from the coast.

Long-term trends in the temperature record indicate that the temperature in the Central Coast Region has been increasing since around 1960. The largest increase in temperature has come in recent decades.

## Temperature extremes

Temperature extremes, both hot and cold, occur infrequently but can have considerable impacts on health, infrastructure and our environment. Changes to temperature extremes often result in greater impacts than changes to average temperatures.

## Hot days

The Central Coast Region experiences fewer than 10 hot days per year (maximum temperatures above 35°C).

## Cold nights

The Central Coast experiences very few cold nights per year (temperatures less than 2°C).

## Rainfall

Rainfall is fairly uniform across the region but there can be great variability from year to year.

There is more rain during summer and autumn, and in areas closer to the coast. Annual rainfall ranges from 1200–1600 mm near the coast to between 800–1200 mm further inland.

The region has experienced considerable rainfall variability with intermittent periods of wetter and drier conditions. During much of the first half of the 20<sup>th</sup> century the region experienced drier than average conditions. The first decade of the 21<sup>st</sup> century was characterised by below average rainfall during the Millennium Drought. This dry period ended with two of the wettest years on record for Australia (2010–2011), with 2010 the third wettest year on record for NSW.

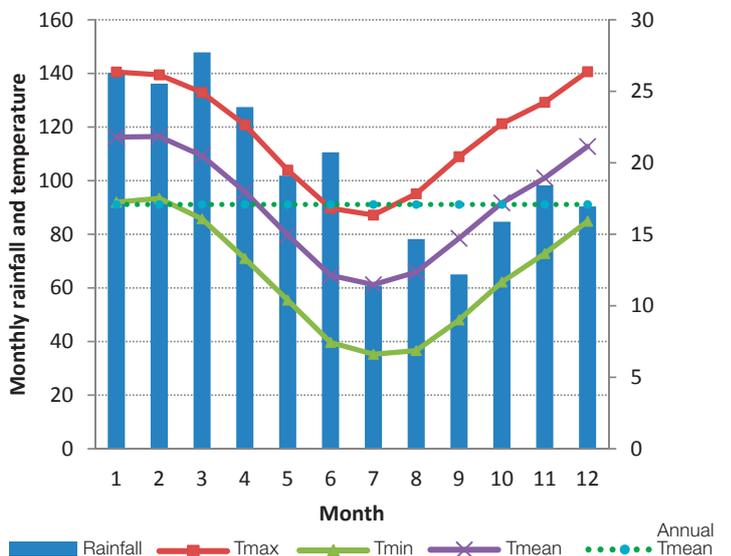


Figure 1: Seasonal rainfall and temperature variations (AWAP<sup>1</sup> data for 1960–1991)

1. Australian Water Availability Project, see [www.csiro.au/awap/](http://www.csiro.au/awap/).



## Fire weather

The risk of bushfire in any given region depends on four ‘switches’. There needs to be enough vegetation (fuel), the fuel needs to be dry enough to burn, the weather needs to be favourable for fire to spread, and there needs to be an ignition source (Bradstock 2010). All four of these switches must be on for a fire to occur. The Forest Fire Danger Index (FFDI) is used in NSW to quantify fire weather. The FFDI combines observations of temperature, humidity and wind speed with an estimate of the fuel state.

Long-term observations of FFDI come from daily measurements of temperature, rainfall, humidity and wind speed at only a small number of weather stations in Australia, with 17 stations located in NSW and the ACT (Lucas 2010).

There are no long term FFDI estimates available for the Central Coast. The two closest stations with long term data are Sydney Airport and Williamtown. The average annual FFDI estimated for the period 1990–2009 is 5.5 in Sydney and 5.4 in Williamtown. The highest average FFDI occurs in spring and summer.

Fire weather is classified as ‘severe’ when the FFDI is above 50. FFDI values below 12 indicate low to moderate fire weather, 12-25 high, 25-49 very high, 50-74 severe, 75-99 extreme and above 100 catastrophic.

Severe fire weather days happen on average 1.4 days per year at Sydney and Williamtown, and are more likely to occur in summer and spring.

Average FFDI					
Station	Annual	Summer	Autumn	Winter	Spring
Sydney Airport	5.5	6.1	4.1	4.5	7.4
Williamtown	5.4	6.7	3.4	4.1	7.4
Number of severe fire weather days (FFDI>50)					
Sydney Airport	1.4	0.6	0.1	0.1	0.7
Williamtown	1.4	0.7	0	0	0.7

Table 1: Baseline FFDI values for meteorological stations within the Central Coast Region.



# Temperature

Climate change projections are presented for the near future (2030) and far future (2070), compared to the baseline climate (1990–2009). The projections are based on simulations from a suite of twelve climate models run to provide detailed future climate information for NSW and the ACT.

Temperature is the most reliable indicator of climate change. Across the Central Coast all of the models agree that average, maximum and minimum temperatures are increasing.

## Summary temperature

Maximum temperatures are projected to increase in the near future by 0.7°C

Maximum temperatures are projected to increase in the far future by 1.9°C

Minimum temperatures are projected to increase by near future by 0.7°C

Minimum temperatures are projected to increase by far future by 2.1°C

There are projected to be more hot days and fewer cold nights

## Projected regional climate changes

The Central Coast is expected to experience an **increase in all temperature variables** (average, maximum and minimum) for the near future and the far future (Figure 2).

Maximum temperatures are projected to increase by 0.7°C in the near future and by 1.9°C in the far future (Figure 2b). The largest changes occur in summer when maximum temperatures are projected to increase by 2.1°C in the far future (Figure 2b). Increased maximum temperatures are known to impact human health through heat stress and increasing the numbers of heatwave events.

Minimum temperatures are projected to increase by 0.7°C in the near future and by 2.1°C in the far future (Figure 2c). Increased overnight temperatures (minimum temperatures) can have a considerable effect on human health.

These increases are projected to occur across the Central Coast (Figures 3–6).

The long-term temperature trend indicates that temperatures on the Central Coast have been increasing since approximately 1960, with the largest increase in temperatures in the most recent decades.

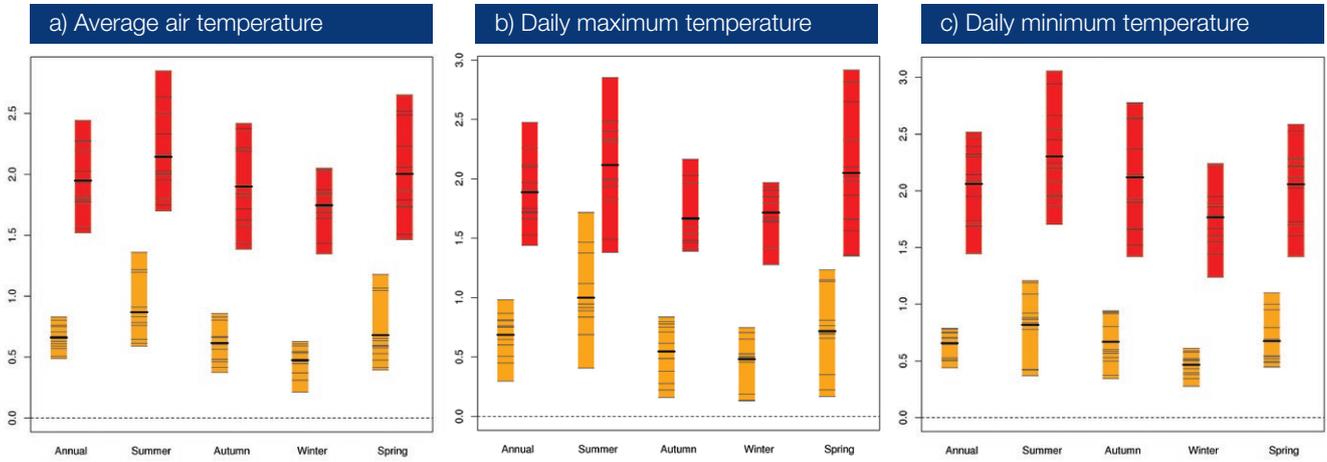


Figure 2: Projected air temperature changes for the Central Coast Region, annually and by season (2030 yellow; 2070 red): a) average, b) daily maximum, and c) daily minimum. (Appendix 1 provides help with how to read and interpret these graphs).

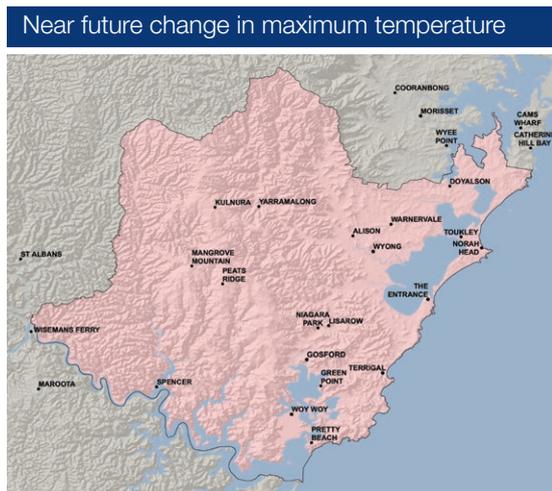


Figure 3: Near future (2020–2039) change in annual average maximum temperature, compared to the baseline period (1990–2009).

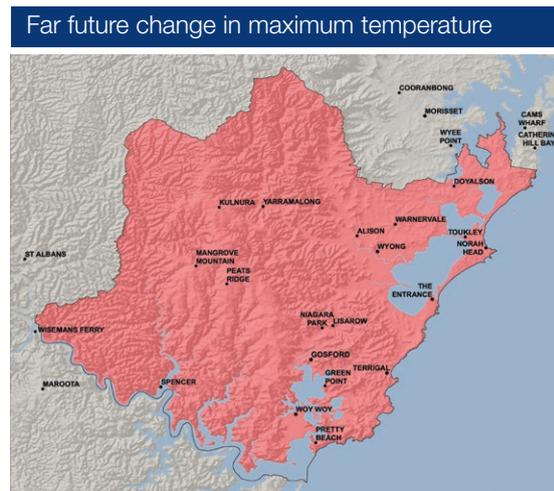


Figure 4: Far future (2060–2079) change in annual average maximum temperature, compared to the baseline period (1990–2009).

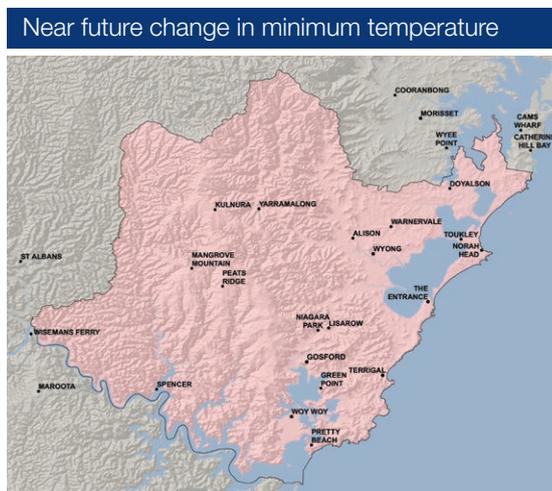


Figure 5: Near future (2020–2039) change in annual average minimum temperature, compared to the baseline period (1990–2009).

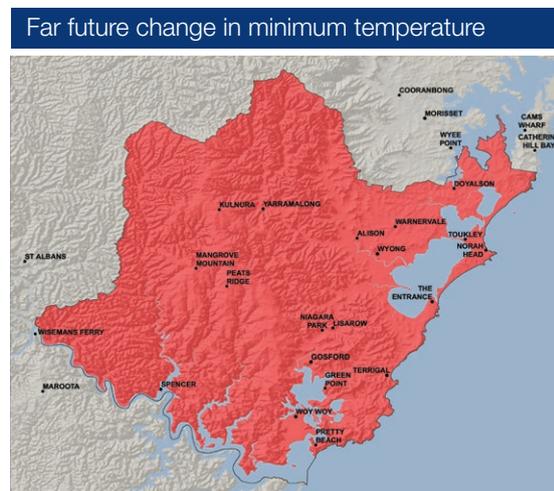
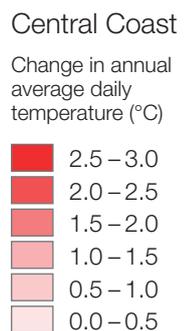


Figure 6: Far future (2060–2079) change in annual average minimum temperature, compared to the baseline period (1990–2009).



# Hot days

## DAYS PER YEAR ABOVE 35°C

The Central Coast Region sees fewer than 10 hot days each year (temperatures above 35°C). International and Australian experiences show that prolonged hot days increase the incidence of illness and death – particularly among vulnerable population groups such as people who are older, have a pre-existing medical condition or who have a disability. Seasonal changes are likely to have considerable impacts on bushfire danger, infrastructure development and native species diversity.

### Projected regional climate changes

**The Central Coast is expected to experience more hot days in the near future and the far future.**

The region, on average, is projected to experience an additional three hot days per year in the near future (0–4 days across the 12 models) and seven more hot days in the far future (2–11 days across the 12 models) (Figure 7).

These increases are projected to occur mainly in spring and summer (Figure 7). The increases are uniform across the region (Figures 8 and 9).

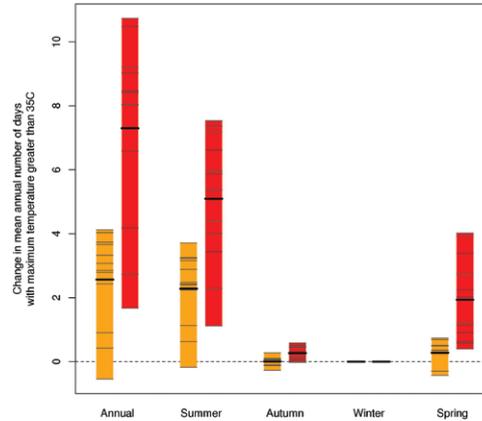


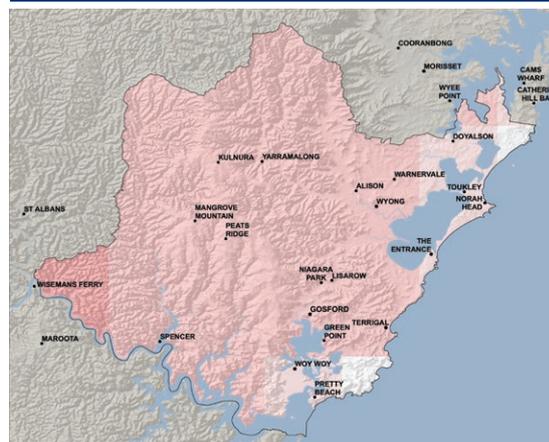
Figure 7: Projected changes in the number of hot days (with daily maximum temperature of above 35°C) for the Central Coast Region, annually and by season (2030 yellow; 2070 red). (Appendix 1 provides help with how to read and interpret these graphs).

### Near future change in days per year above 35°C



Figure 8: Near future (2020–2039) projected changes in the number of days per year with maximum temperatures above 35°C.

### Far future change in days per year above 35°C



### Central Coast

Change in annual average number of days with temperatures greater than 35°C

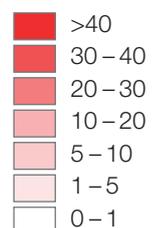


Figure 9: Far future (2060–2079) projected changes in the number of days per year with maximum temperatures above 35°C.

# Cold nights

## DAYS PER YEAR BELOW 2°C

Most of the emphasis on changes in temperatures from climate change has been on hot days and maximum temperatures, but changes in cold nights are equally important in the maintenance of our natural ecosystems and agricultural/horticultural industries; for example, some common temperate fruit species require sufficiently cold winters to produce flower buds.

### Projected regional climate changes

**The Central Coast currently does not have very many cold nights and there are projected to be fewer cold nights in future (Figure 10).**

**The projected decreases occur inland (Figures 11 and 12). The maps show little change along the coast where overnight temperatures seldom fall below 2°C.**

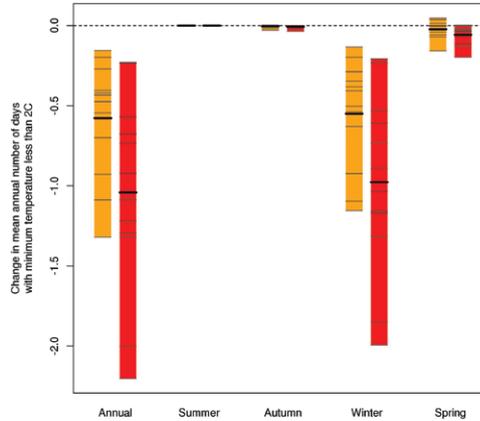


Figure 10: Projected changes in the number of low temperature nights for the Central Coast, annually and by season (2030 yellow; 2070 red). (Appendix 1 provides help with how to read and interpret these graphs).

### Near future change in number of cold nights (below 2°C) per year

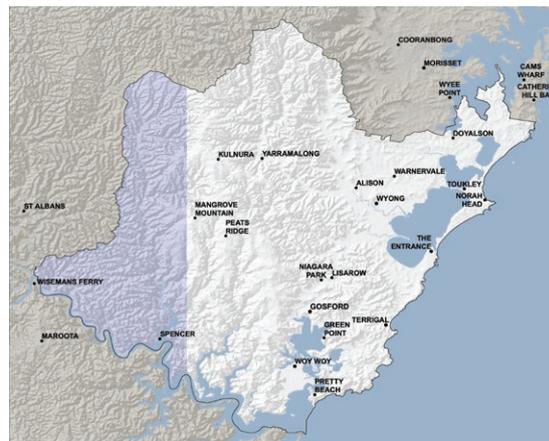
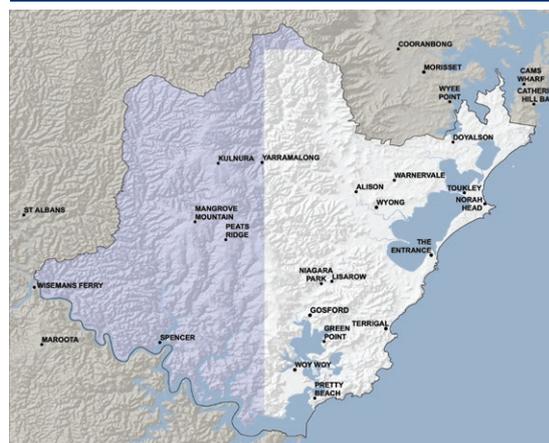


Figure 11: Near future (2020–2039) change in the number of days per year with minimum temperatures below 2°C, compared to the baseline period (1990–2009).

### Far future change in number of cold nights (below 2°C) per year



### Central Coast

Change in annual average number of days with temperatures less than 2°C

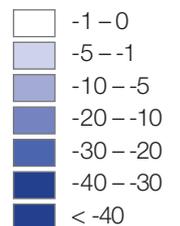


Figure 12: Far future (2060–2079) change in the number of days per year with minimum temperatures below 2°C, compared to the baseline period (1990–2009).

# Rainfall

Changes in rainfall patterns have the potential for widespread impacts. Seasonal shifts in rainfall can impact native species' reproductive cycles as well as impacting agricultural productivity; for example crops that are reliant on winter rains for peak growth.

Rainfall changes are also associated with changes in the extremes, such as floods and droughts, as well as secondary impacts such as water quality and soil erosion that occur as a result of changes to rainfall intensity.

Modelling rainfall is challenging due to the complexities of the weather systems that generate rain. 'Model agreement', that is the number of models that agree on the direction of change (increasing or decreasing rainfall) is used to determine the confidence in the projected change. The more models that agree, the greater the confidence in the direction of change.

Care should be taken when interpreting changes in rainfall from averaging climate change projections when the model outputs project changes of both wetting and drying. To understand the spread of potential changes in rainfall the bar charts should be considered along with the maps provided in this document.

## Rainfall is projected to increase in autumn

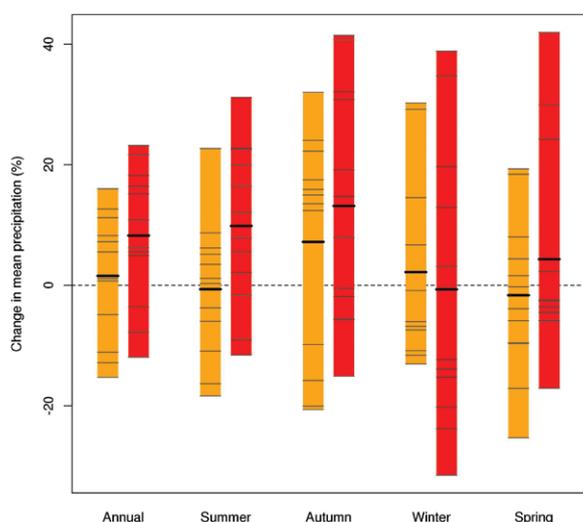


Figure 13: Projected changes in average rainfall for the Central Coast Region, annually and by season (2030 yellow; 2070 red). (Appendix 1 provides help with how to read and interpret these graphs).

## Projected regional climate changes

For the Central Coast Region the majority of models agree that **autumn rainfall will increase in the near future (7 out of 12) and far future (8 out of 12)**. The projected increase is greatest inland in the near future, but is more uniform in the far future (Figures 13, 14b and 15b).

Summer rainfall is projected by the majority of the models to increase in the near future (7 out of 12 models) and the far future (9 out of 12 models) (Figure 13).

Spring rainfall is projected to decrease by the majority of models in the near future (7 out of 12 models) and to increase in the far future (8 out of 12 models).

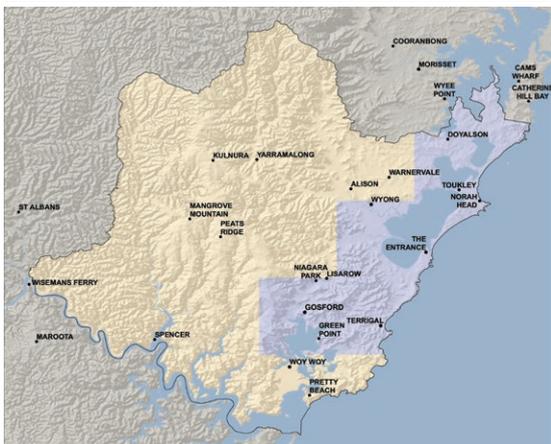
Winter rainfall is projected to decrease by the majority of the models (7 out of 12 models) in both the near and far future.

Seasonal rainfall projections for both the near and far futures span both drying and wetting scenarios. The range in the near future is: summer (-18% to +23%), autumn (-21% to +32%), winter (-13% to +30%), and spring (-25% to -19%); in the far future the range is: summer (-12% to +31%), autumn (-15% to +41%), winter (-32% to +39%), and spring (-17% to -42%) (Figure 13).

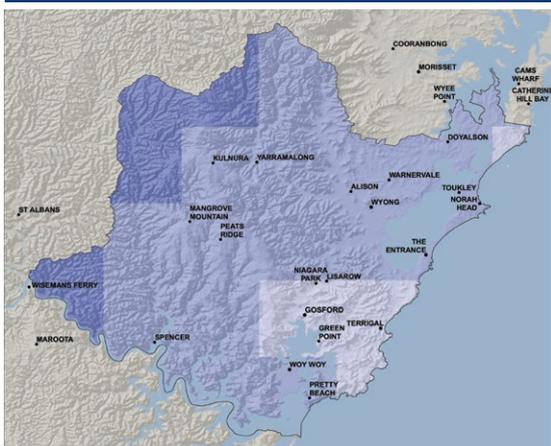
Projections for the region's annual average rainfall range from a decrease (drying) of 15% to an increase (wetting) of 16% by 2030 and still span both drying and wetting scenarios (-12% to +23%) by 2070.

The Central Coast currently experiences considerable rainfall variability from year-to-year and this variability is also reflected in the projections.

Summer 2020–2039



Autumn 2020–2039



Winter 2020–2039

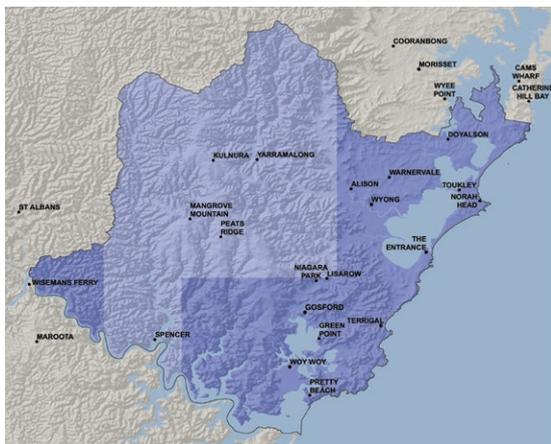


Spring 2020–2039

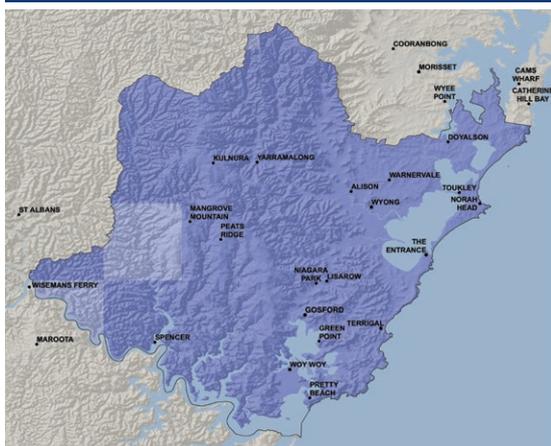


Figure 14: Near future (2020–2039) projected changes in average rainfall by season.

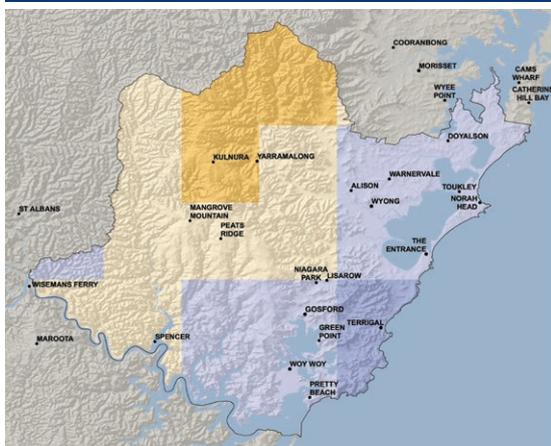
Summer 2060–2079



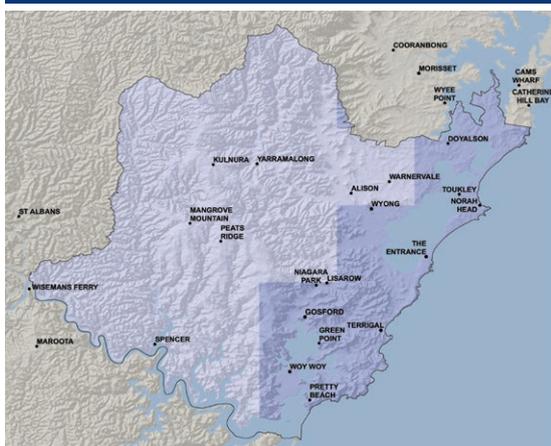
Autumn 2060–2079



Winter 2060–2079



Spring 2060–2079



Central Coast  
Change in average rainfall (%)

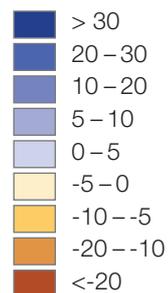


Figure 15: Far future (2060–2079) projected changes in average rainfall by season.

# Fire weather

The Bureau of Meteorology issues Fire Weather Warnings when the FFDI is forecast to be over 50. High FFDI values are also considered by the Rural Fire Service when declaring a Total Fire Ban.

Average FFDI values are often used to track the status of fire risk. These values can be used when planning for prescribed burns and help fire agencies to better understand the seasonal fire risk. The FFDI is also considered an indication of the consequences of a fire if one was to start – the higher the FFDI value the more dangerous the fire could be.

FFDI values below 12 indicate low to moderate fire weather, 12-25 high, 25-49 very high, 50-74 severe, 75-99 extreme and above 100 catastrophic.

**Severe and average fire weather is projected to increase**

**Severe fire weather in the near future is projected to decrease in autumn**

## Projected regional climate changes

**The Central Coast is expected to experience an increase in severe and average fire weather in the near future and the far future (Figures 16 and 17).**

**Increases in severe fire weather are projected in summer and spring (Figures 17 and 19). Although these changes are small in magnitude (approx 1 more day every year) they are projected in prescribed burning periods (spring) and the peak fire risk season (summer) (Figure 19).**

**Average fire weather is projected to increase in all seasons by 2030 except for autumn (Figure 18). The increases are in prescribed burning periods (spring) and the peak fire risk season (summer), reducing the ability for preventative works.**

**Autumn is projected to have a decreased fire risk. As fire weather measurements take into account rainfall, it is likely that the decrease in autumn FFDI is due to projected increases in autumn rainfall (compare Figures 14 and 15 with Figures 18 and 19).**

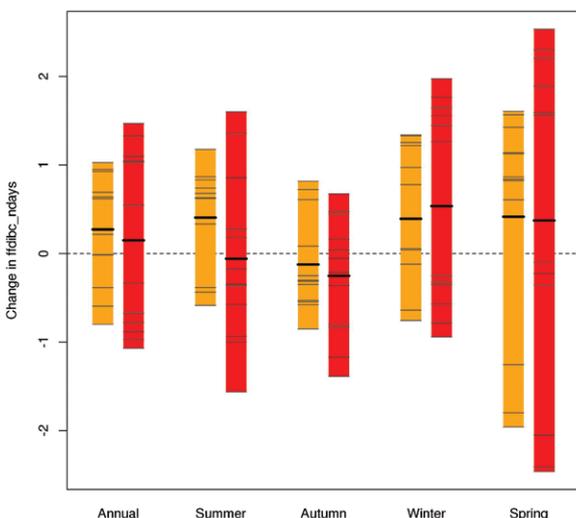


Figure 16: Projected changes in the average daily forest fire danger index (FFDI) for the Central Coast Region, annually and by season (2030 yellow; 2070 red). (Appendix 1 provides help with how to read and interpret these graphs).

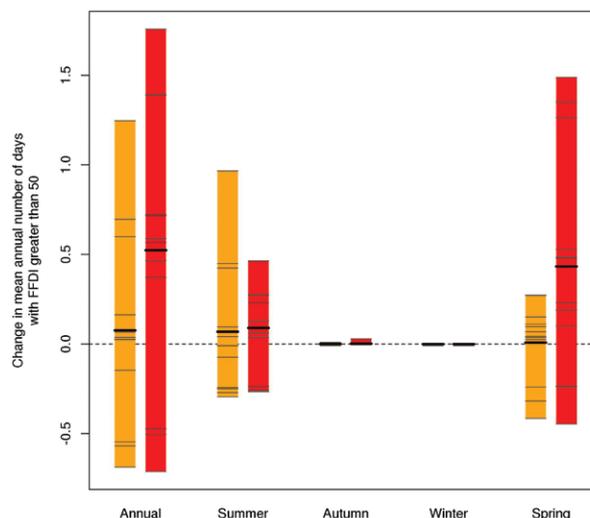
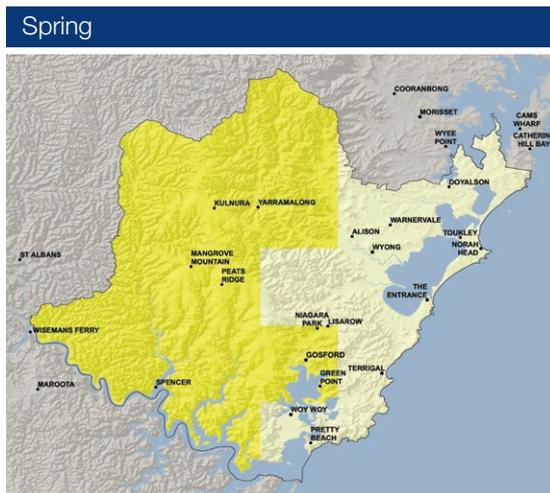
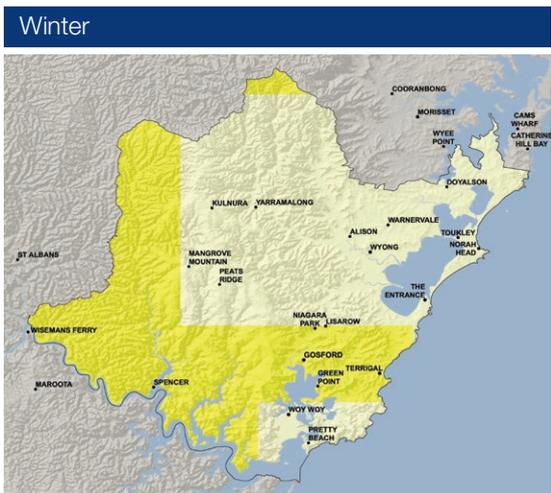
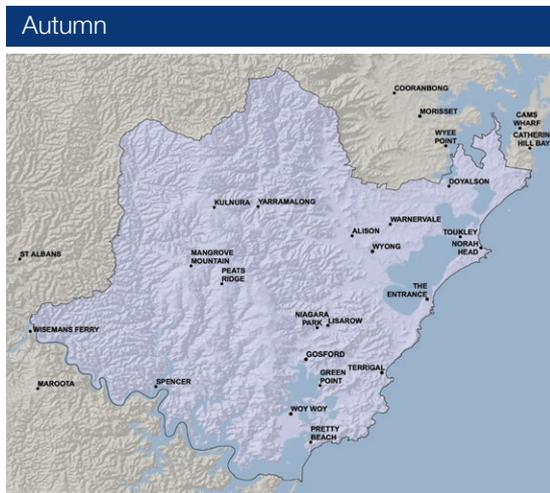
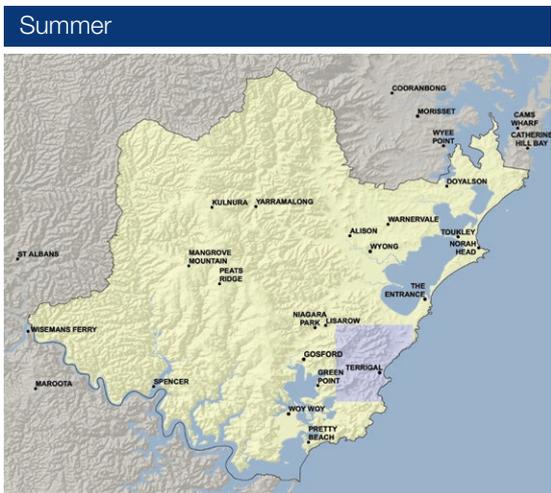


Figure 17: Projected changes in average annual number of days with a forest fire danger index (FFDI) greater than 50 for the Central Coast Region, annually and by season (2030 yellow; 2070 red).



Central Coast

Change in average FFDI

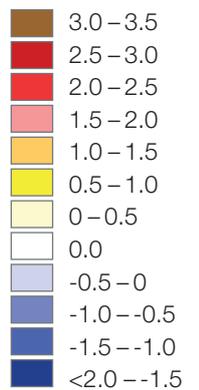
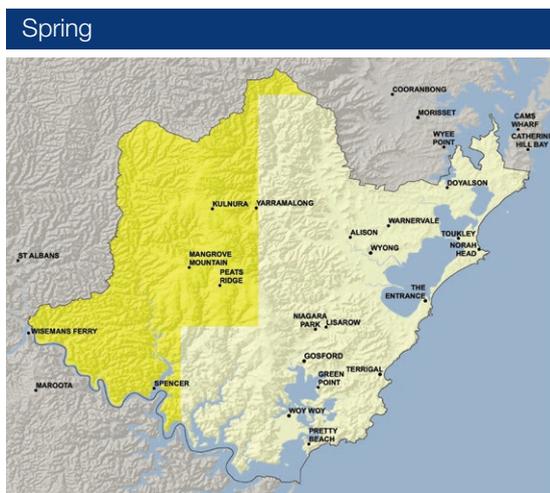
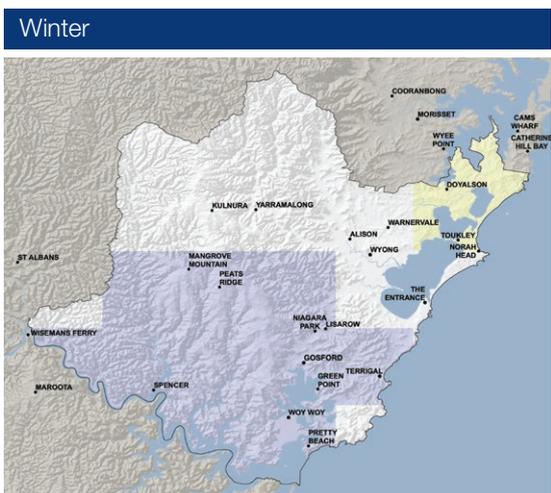
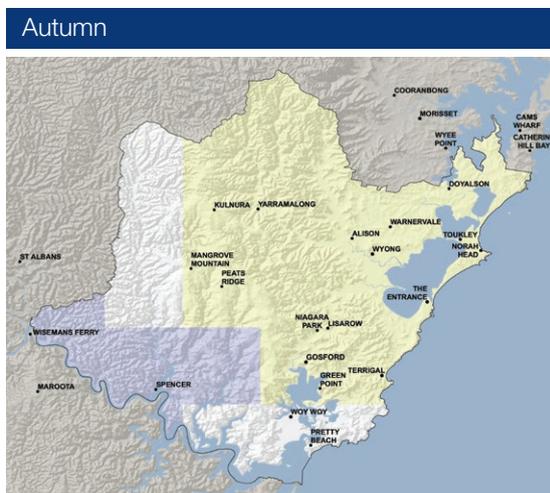
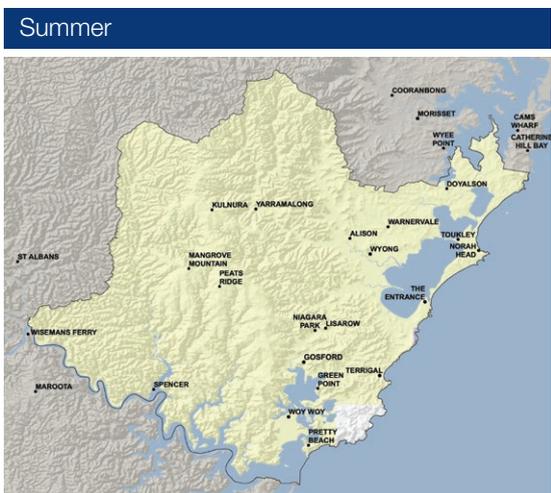


Figure 18: Far future (2060–2079) projected changes in average daily FFDI, compared to the baseline period (1990–2009).



Central Coast

Change in average number of days with FFDI greater than 50

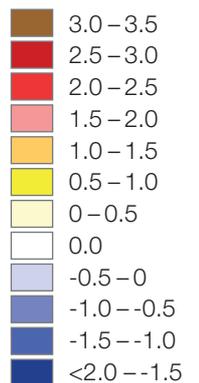


Figure 19: Far future (2060–2079) projected changes in average annual number of days with a FFDI greater than 50, compared to the baseline period (1990–2009).

## Appendix 1 Guide to reading the maps and graphs

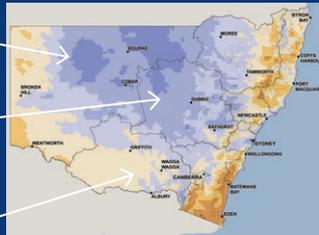
This document contains maps and bar graphs of the climate change projections. The maps present the results of the twelve models as an average of all twelve models. The bar graphs show projections averaged across the entire state and do not represent any particular location within the state. The bar graphs also show results from each individual model. See below for more information on what is displayed in the maps and bar graphs.

### How to read the maps

The maps display a **10km** grid.

NSW has been divided into State Planning Regions and each region has a Local Snapshot report.

The colour of each grid is the average of all **12** models outputs for that grid.



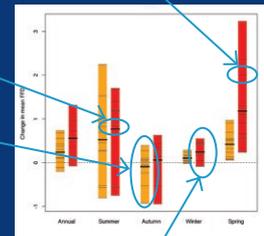
### How to read the bar graphs

The thin grey lines are the **individual models**. There are 12 thin lines for each bar.

The thick line is the **average of all 12 models** for the region.

The length of the bar shows the **spread of the 12 model values** for the region

Each bar is the **average for one model** for the region. They do not represent a single location in the region.



Note: The yellow bars represent near future scenarios (2020–2039), while the red bars represent far future scenarios (2060–2079).

## References

Blanchi, R, Lucas, C, Leonard, F and Finkele, K (2010), 'Meteorological conditions and wildfire-related house loss in Australia', *International Journal of Wildland Fire*, vol. 19, pp. 914–926.

Bradstock, R (2010), 'A biogeographic model of fire regimes in Australia: current and future implications', *Global Ecology and Biogeography*, vol. 19, pp. 145–158.

Department of Planning & Environment (2014), *NSW Statewide Profile 2014*, NSW Department of Planning & Environment, Sydney, available at [www.planning.nsw.gov.au/Portals/0/PlanningYourRegion/2014\\_NSW\\_StatewideProfile.pdf](http://www.planning.nsw.gov.au/Portals/0/PlanningYourRegion/2014_NSW_StatewideProfile.pdf).

Evans, J. P., Ji, F., Lee, C., Smith, P., Argüeso, D., and Fita, L. (2014) A regional climate modelling projection ensemble experiment – NARCLIM, *Geoscientific Model Development*, 7(2), 621-629, doi: 10.5194/gmd-7-621-2014.

Evans, J.P., F. Ji, G. Abramowitz and M. Ekström (2013) Optimally choosing small ensemble members to produce robust climate simulations. *Environmental Research Letters* 8, 044050, DOI: 10.1088/1748-9326/8/4/044050.

Evans, J. P., M. Ekström, and F. Ji (2012) Evaluating the performance of a WRF physics ensemble over South-East Australia. *Climate Dynamics*, 39(6), 1241-1258, DOI: 10.1007/s00382-011-1244-5.

**Disclaimer:** OEH has prepared this report in good faith, exercising all due care and attention, but no representation or warranty, express or implied, is made as to the relevance, accuracy, completeness or fitness for purpose of this information in respect of any particular user's circumstances. With respect to the content of this report, it should also be noted that some projections currently involve a considerable degree of uncertainty.

This material may be reproduced for educational or non-commercial purposes, in whole or in part, provided the meaning is unchanged and the source is acknowledged. © Copyright State of NSW and the NSW Office of Environment and Heritage.

**Published by:**  
Office of Environment and Heritage  
59–61 Goulburn Street  
PO Box A290  
Sydney South 1232  
Report pollution and environmental incidents  
Environment Line: 131 555 (NSW only) or  
[info@environment.nsw.gov.au](mailto:info@environment.nsw.gov.au)  
See also [www.environment.nsw.gov.au](http://www.environment.nsw.gov.au)

Phone: (02) 9995 5000 (switchboard)  
Phone: 131 555 (environment information and publications requests)  
Phone: 1300 361 967 (national parks, climate change and energy efficiency information and publications requests)  
Fax: (02) 9995 5999  
TTY users: phone 133 677 then ask for 131 555  
Speak and Listen users: phone 1300 555 727 then ask for 131 555  
Email: [info@environment.nsw.gov.au](mailto:info@environment.nsw.gov.au)  
Website: [www.environment.nsw.gov.au](http://www.environment.nsw.gov.au)

OEH 2014/0835 – 978 1 74359 835 1  
ISSN 1837–5650

November 2014

Printed on environmentally sustainable paper