



Office of  
Environment  
& Heritage

AdaptNSW

# North Coast Climate change snapshot



# Overview of North Coast Region climate change

Based on long-term (1910–2011) observations, temperatures have been increasing in the North Coast Region since about 1970, with higher temperatures experienced in recent decades.

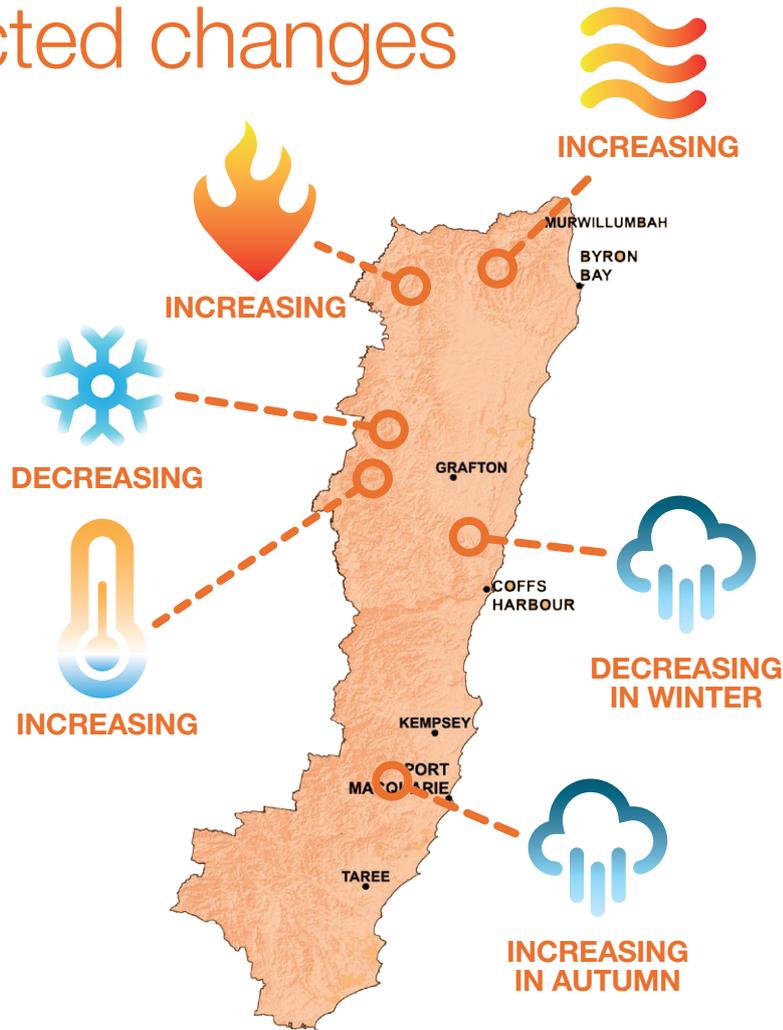
The North Coast Region is projected to continue to warm in the near future (2020–2039) and far future (2060–2079), compared to recent years (1990–2009). The warming is projected to be on average about 0.7°C in the near future, increasing to about 2°C in the far future. The number of high temperature days is projected to increase, while a reduction is anticipated in instances of potential frost risk.

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

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

Front Cover: Beautiful Australian Beach in Byron Bay, New South Wales, Australia - the most easterly point on the Australian mainland. Copyright: Jessica Kirsh. Page 2: Coastline of Coffs Harbour in New South Wales, Australia taken from the top of Muttonbird Island Nature Reserve looking towards the hills. Copyright: Steve Heap. Page 4: Sunrise over Fingal Head, Tweed Coast, Australia. Copyright: DAE Photo. Page 9: View over the caldera, Mount Warning. Copyright: Janelle Lugge.

# Projected changes



## Projected temperature changes

Maximum temperatures are projected to **increase** in the near future by 0.4 – 1.0°C

Maximum temperatures are projected to **increase** in the far future by 1.5 – 2.4°C

Minimum temperatures are projected to **increase** in the near future by 0.5 – 1.0°C

Minimum temperatures are projected to **increase** in the far future by 1.6 – 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 winter

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

## Projected Forest Fire Danger Index (FFDI) changes

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

Severe fire weather days are 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 North 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

The North Coast region extends from Port Stephens to the Queensland border, and west to the Great Dividing Range and hinterland. Dominated by large coastal embayments and dune fields, the region is also characterised by the steep sandstone slopes of the Great Dividing Range, which is part of the New England Fold Belt. Significant natural features of the region include major rivers such as the Clarence, the Tweed volcano complex and Mt Warning caldera, as well as the Gondwana Rainforests of Australia World Heritage Area.

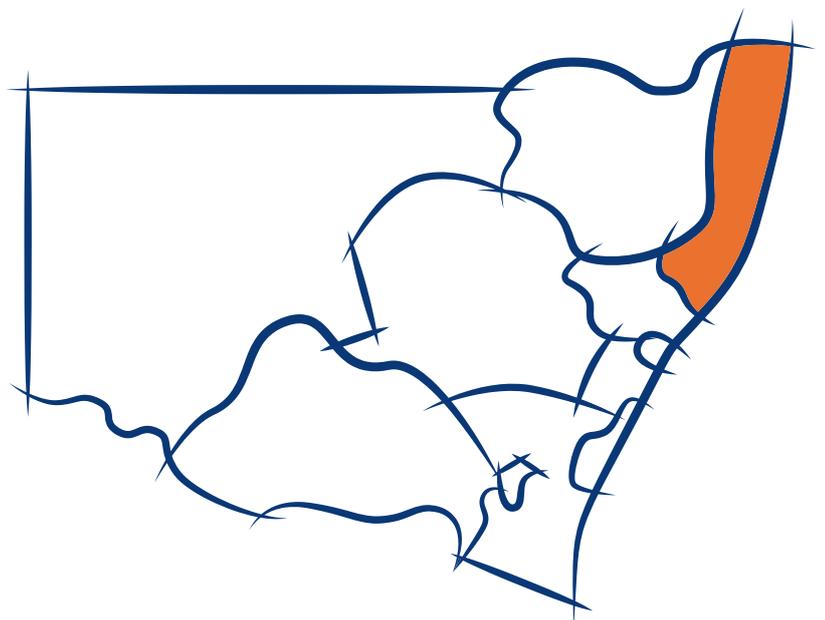
## Population and settlements

The population of the North Coast Region is approximately 584,100, with the largest cities in the region including Port Macquarie, Tweed Heads, Grafton and Coffs Harbour. Hospitality, retail and educational services help provide employment to the work force of approximately 214,800 people in the North Coast Region. As one of the fastest growing populations in NSW, the North Coast Region is also reliant on primary industries and tourism for employment and business opportunities.

## Natural ecosystems

The North and Mid North Coast area is one of the most biologically diverse regions in NSW. Whilst many of the natural ecosystems of the area are relatively well conserved, with close to one-fifth of the region protected within national parks or nature reserves, these are mainly on the coast and escarpment. Clearing for agriculture and urban development has been extensive on many parts of the coast and the river floodplains have had a long history of timber harvesting.

The importance of the region is evident with its two World Heritage areas: the Lord Howe Island Group, and parts of the Gondwana Rainforests of Australia. It also has a number of large river systems including the Clarence River, the largest coastal river in NSW. A significant number of the state's rare and threatened flora, fauna and endangered ecological communities occur within the region and remain vulnerable to a number of threatening processes including those associated with climate change.



# Climate of the region

The topography of the region and coastal setting results in climate conditions that vary across the region. It is very wet along coast, especially in the north, but drier inland. Summers are warm across the region, with cool winters in the foothills and along the Great Dividing Range.

## Temperature

In summer, average temperatures range from 16–18°C along the mountains to 24–26°C north of Grafton. In winter, temperatures range from 4–6°C along the mountains to 14–16°C along the far north coast.

Average maximum temperatures during summer range from 30–32°C near Casino to 20–22°C in the mountains. In winter, the minimum temperature ranges from 0–2°C along parts of the Great Dividing Range to 10–12°C on the far north coast.

Seasonal variations are shown by the monthly average, minimum and maximum temperatures averaged over the region (Figure 1). The average monthly temperatures range from around 11°C in July to just over 22.5°C in January.

The long-term temperature records indicate that the temperature in the North Coast region has been increasing since the 1960s, with the most sustained period of increase occurring in the last few 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

On average, the North Coast experiences fewer than 10 hot days per year (maximum temperature is greater than 35°C).

## Cold nights

The number of cold nights per year (minimum temperature less than 2°C) increases moving away from the coast. Along the coast there are on average fewer than 10 cold nights per year while in the mountains there are on average over 50 cold nights per year.

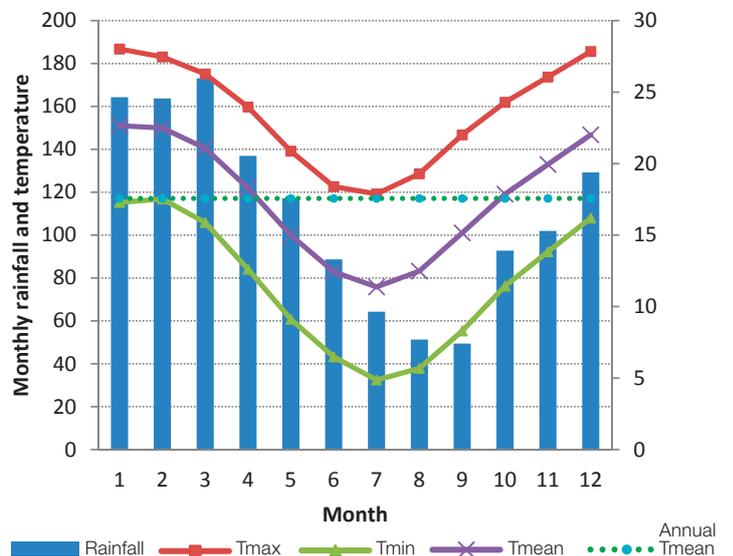


Figure 1: Seasonal rainfall and temperature variations (AWAP<sup>1</sup> data for 1960–1991).

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



## Rainfall

Rainfall varies significantly over the region, with average annual rainfall ranging from over 1600 mm on parts of the far north coast to 800–1200 mm along parts of the Great Dividing Range.

Along the southern and central parts of the coast, annual rainfall is typically 1200–1600 mm. Rainfall generally decreases as you move away from the coast.

Rainfall is very seasonal with much more rain falling in summer than winter. During summer, the North Coast experiences 400–600 mm of rainfall, with some areas receiving over 600 mm. During winter, much of the region sees 100–200 mm, and on average 200–300 mm along the coast.

The North Coast region experiences its greatest spatial variation in rainfall during August, where it varies from more than 600 mm along parts of the far north coast to between 200–300 mm in some parts of the west.

The region has experienced considerable rainfall variability in the past with periods of both wetter and drier conditions. During much of the first half of the 20<sup>th</sup> century the region experienced drier conditions. The first decade of the 21<sup>st</sup> century saw a long period of 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 being the third wettest year on record for NSW.

## 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).

FFDI estimates are available for three stations in the region: Lismore, Casino and Coffs Harbour. The average annual FFDI estimated for 1990–2009 is lowest in Coffs Harbour (3.3) and highest in Casino (6.4). The highest average FFDI occurs in spring and the lowest in autumn.

Fire weather is classified as ‘severe’ when the FFDI is above 50, and most of the property loss from major fires in Australia has occurred when the FFDI reached this level (Blanchi et al. 2010). 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 conditions are estimated to occur on average two days per year at Casino, but are rare at Lismore and Coffs Harbour. Spring is the peak season for extreme fire weather conditions in Casino.

Average FFDI					
Station	Annual	Summer	Autumn	Winter	Spring
Lismore	4.9	4.1	3.1	5.3	7.1
Casino	6.4	5	4.1	6.8	10
Coffs Harbour	3.3	2.8	2	4	4.3
Number of severe fire weather days (FFDI>50)					
Lismore	0.3	0	0	0.05	0.25
Casino	2.05	0.1	0	0.5	1.45
Coffs Harbour	0.25	0.1	0	0	0.15

Table 1: Baseline FFDI values for meteorological stations within the North 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 North Coast region 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 2.0°C

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

## Projected regional climate changes

The North 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 by 2070 (Figure 2b). Summer will see the greatest changes in maximum temperatures, increasing 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 number of heatwave events.

Minimum temperatures are projected to increase by 0.7°C in the near future and by 2°C by 2070 (Figure 2c). Increased overnight temperatures (minimum temperatures) can have a considerable effect on human health.

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

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

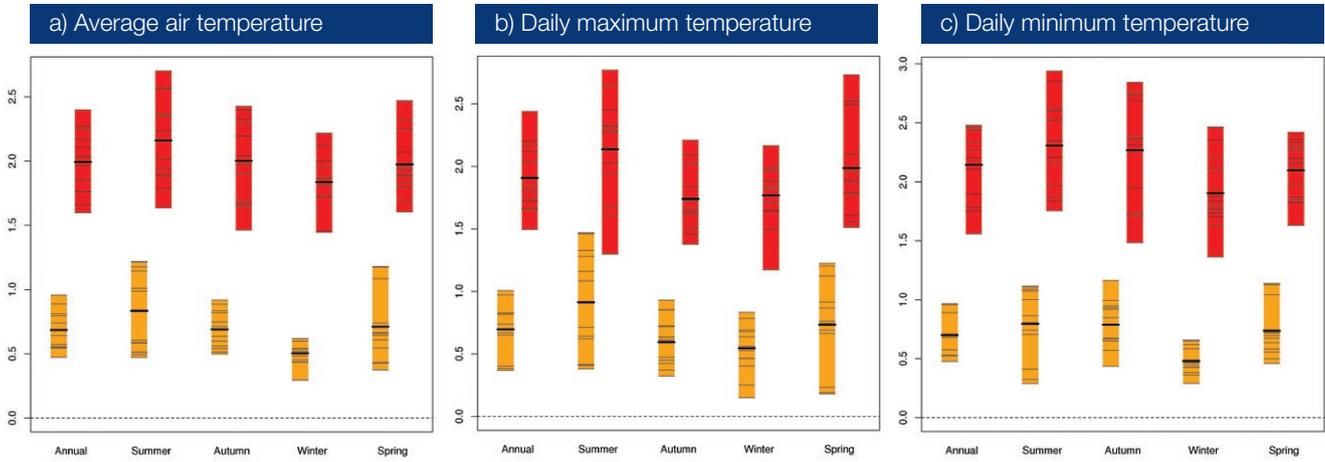


Figure 2: Projected air temperature changes for the North Coast Region, annually and by season (2030 yellow; 2070 red): a) average, b) daily maximum, and c) daily minimum. (Appendix 1 provides help with how to read and interpret these graphs).

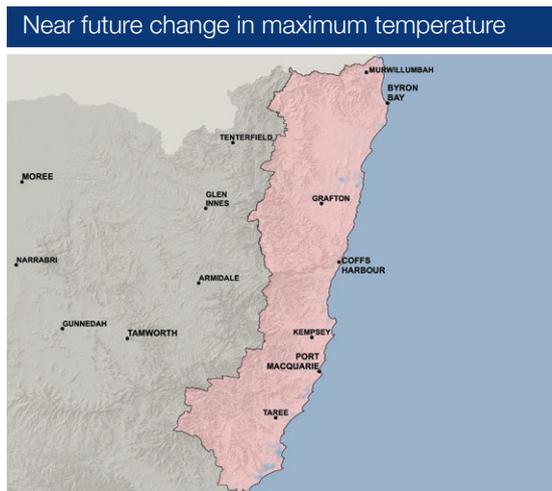


Figure 3: Near future (2020–2039) change in annual average maximum temperature, compared to the baseline period (1990–2009).

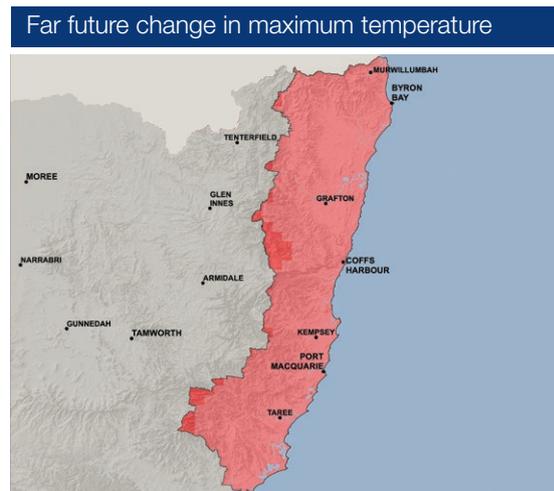


Figure 4: Far future (2060–2079) change in annual average maximum temperature, compared to the baseline period (1990–2009).

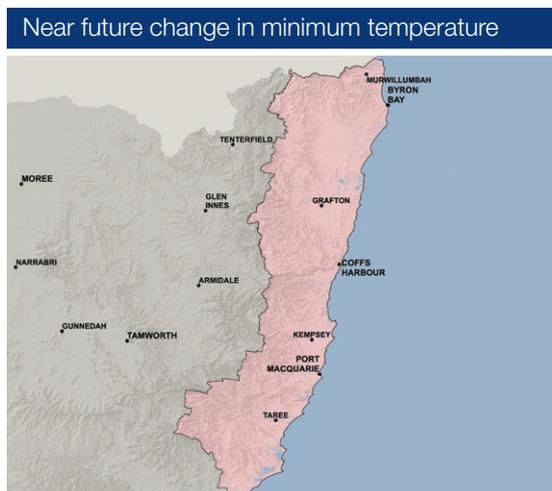


Figure 5: Near future (2020–2039) change in annual average minimum temperature, compared to the baseline period (1990–2009).

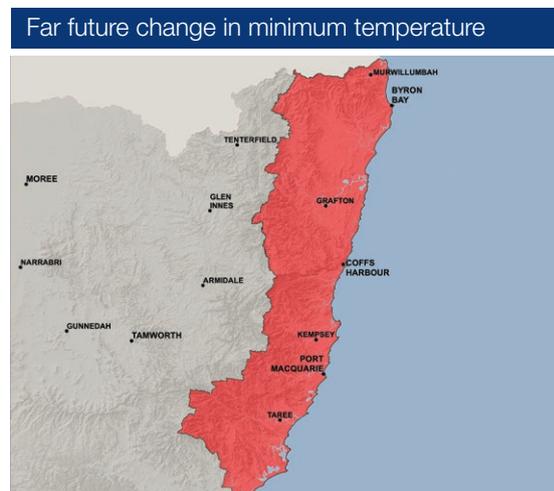
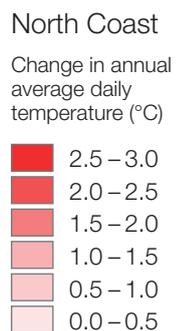


Figure 6: Far future (2060–2079) change in annual average minimum temperature, compared to the baseline period (1990–2009).



# Hot days

## DAYS PER YEAR ABOVE 35°C

Currently the North Coast region experiences an average of 10 days above 35°C each year. 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 North Coast is expected to experience more hot days in the near future and the far future (Figure 7).**

**Inland around Casino and the Richmond Valley have a relatively greater increase with an additional 5–10 hot days in the near future (Figure 8) and up to 20 more hot days per year by 2070 (Figure 9).**

**The region, on average, is projected to experience an additional three hot days in the near future (0–5 days per year across the 12 models) and nine more hot days in the far future (3–12 days per year across the 12 models) (Figure 7).**

**The increases are dominated by increases in summer, however more substantial increases are also projected for spring by 2070 (Figure 7).**

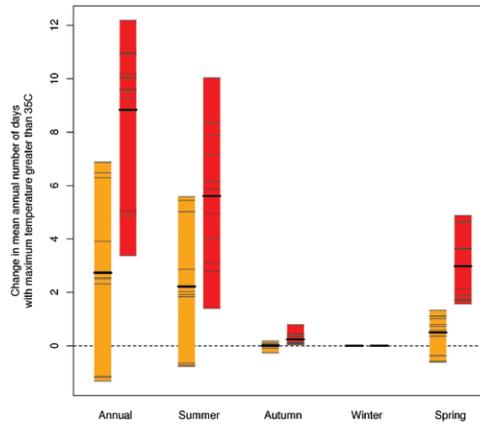


Figure 7: Projected changes in the number of hot days (with daily maximum temperature of above 35°C) for the North Coast Region, annually and by season (2030 yellow; 2070 red). (Appendix 1 provides help with how to read and interpret these graphs).

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

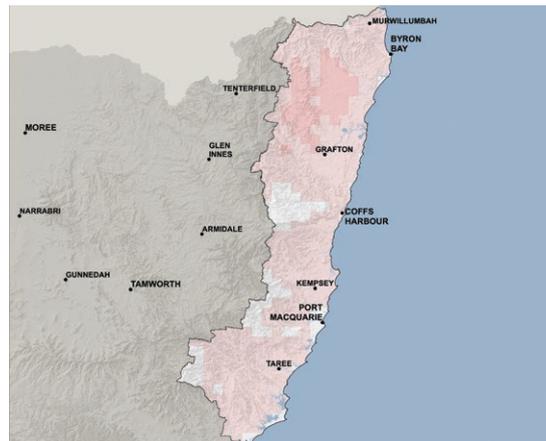


Figure 8: Near future (2020–2039) projected changes in the number of days per year with maximum temperatures above 35°C.

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

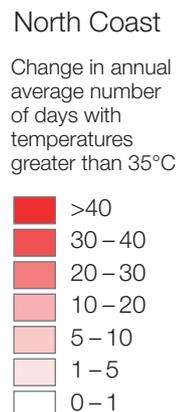
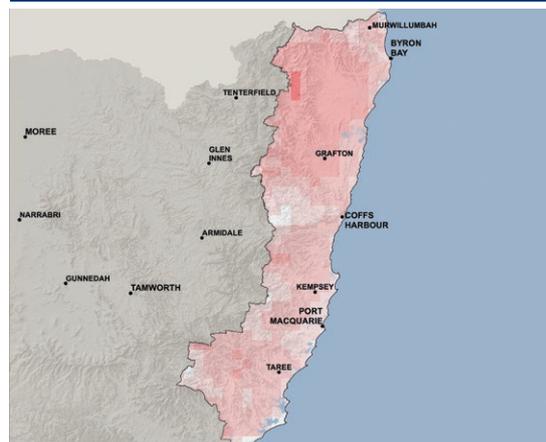


Figure 9: Far future (2060–2079) projected changes in the number of days per year with maximum temperatures above 35°C.

# 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 North Coast is expected to experience fewer cold nights in the near future and the far future (Figure 10).**

**The greatest decreases are projected to occur along the mountains where there may be 10–20 fewer cold nights in the near future and over 30 fewer cold nights by 2070. There will be little change along the coast (Figures 11 and 12).**

**All models agree that the region as a whole will see a decrease in cold nights with an average of approximately four fewer cold nights per year in the near future (ranging from 2–5 nights across the individual models). The decrease in cold nights is projected to be greater in the far future, with an average of eight fewer cold nights per year, ranging from 7–10 nights across the individual models (Figure 10).**

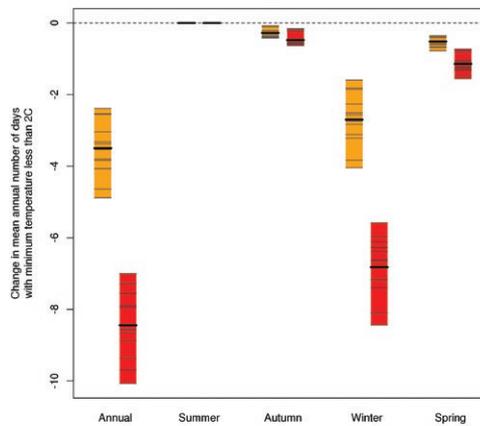


Figure 10: Projected changes in the number of low temperature nights for the North Coast, annually and by season (2030 yellow; 2070 red). (Appendix 1 provides help with how to read and interpret these graphs).

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

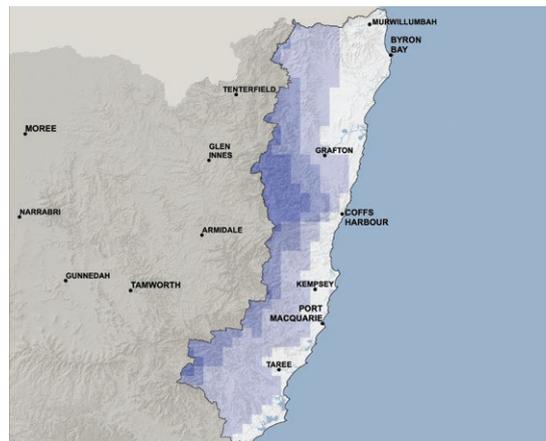
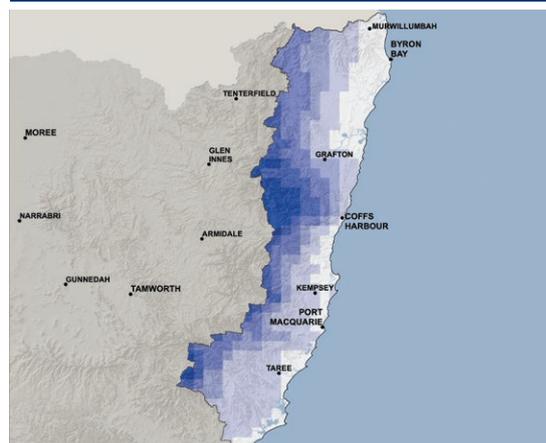


Figure 11: Near future (2020–2039) change in the number of days per year with minimum temperatures below 2°C, compared to the baseline period (1990–2009).

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



### North Coast

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

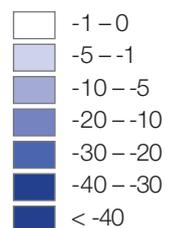


Figure 12: Far future (2060–2079) change in the number of days per year with minimum temperatures below 2°C, compared to the baseline period (1990–2009).

# 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 decrease in winter and to increase in autumn and spring

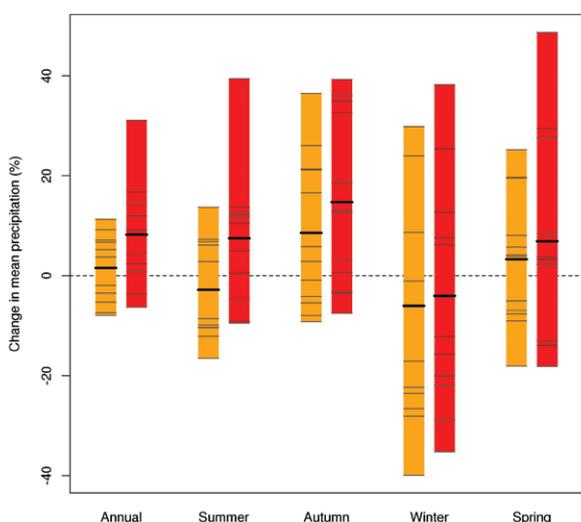


Figure 13: Projected changes in average rainfall for the North Coast Region, annually and by season (2030 yellow; 2070 red). (Appendix 1 provides help with how to read and interpret these graphs).

## Projected regional climate changes

For the North Coast region the majority of models (7 out of 12) agree that **autumn and spring rainfall will increase in the near future and far future (9 out of 12) (Figures 13, 14 and 15).**

For the North Coast Region the majority of models (8 out of 12) agree that **winter rainfall will decrease in the near future and far future (7 out of 12) (Figures 13, 14 and 15).**

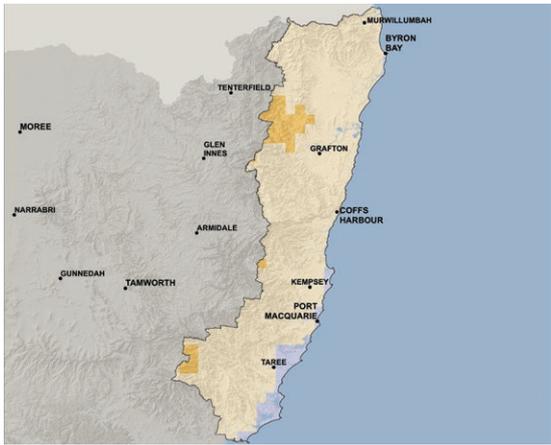
A decrease in summer rainfall is projected by 7 out of 12 models in the near future, while 9 out of 12 models project that summer rainfall will increase in the far future (Figure 13).

Seasonal rainfall projections for the near future and far future span both drying and wetting scenarios. The range of projected changes for the near future are: summer -17% to +14%, autumn -9% to +37%, winter -40% to +30% and spring -18% to +25%. In the far future the range of projected changes are: summer -10% to +39%, autumn -8% to +39%, winter -35% to +38% and spring -18% to +49% (Figure 13).

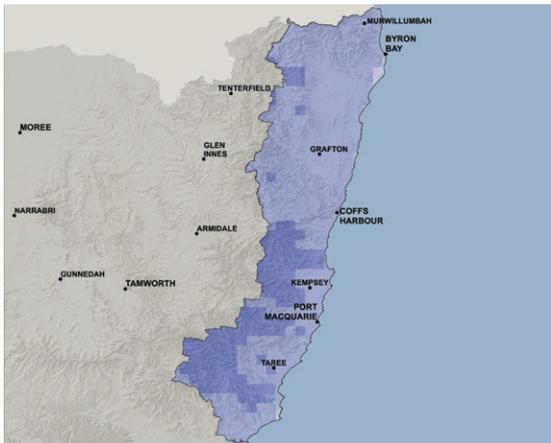
Projections of changes in annual rainfall also span both wetting and drying scenarios. The range of projected changes are -8% to +11% for the near future and -6% to +31% for the far future.

Projections for the region's annual average rainfall range from a decrease (drying) of 8% to an increase (wetting) of 11% by 2030 and still span both drying and wetting scenarios (-6% to +31%) by 2070.

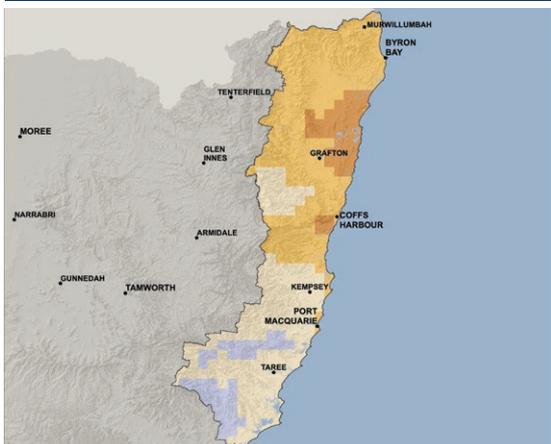
Summer 2020–2039



Autumn 2020–2039



Winter 2020–2039



Spring 2020–2039

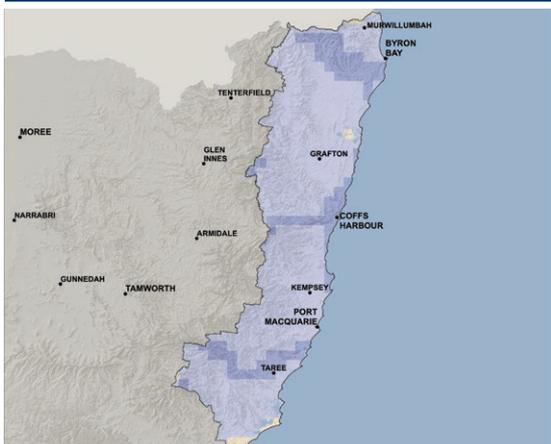
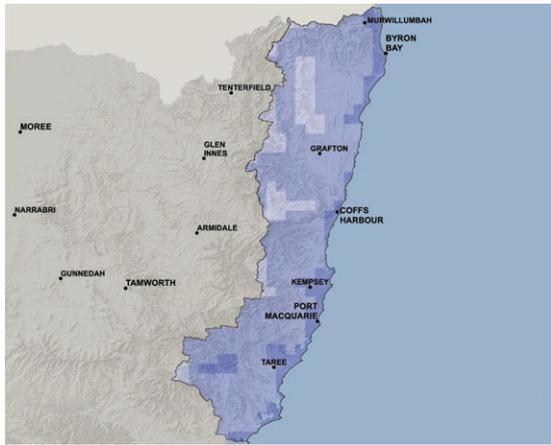
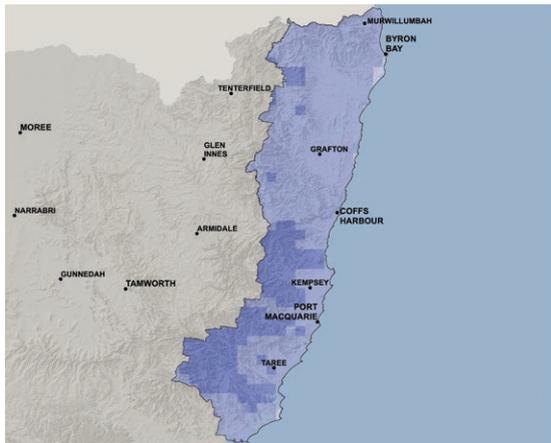


Figure 14: Near future (2020–2039) projected changes in average rainfall by season.

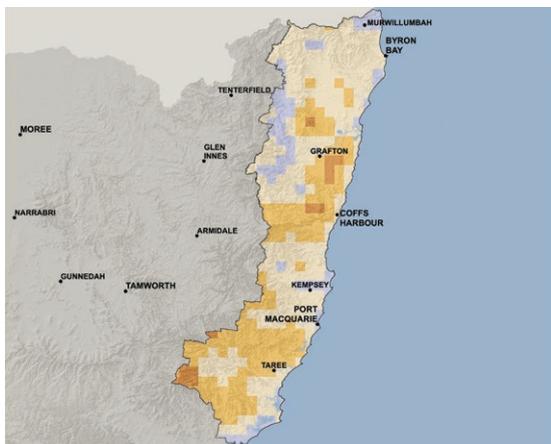
Summer 2060–2079



Autumn 2060–2079



Winter 2060–2079



Spring 2060–2079

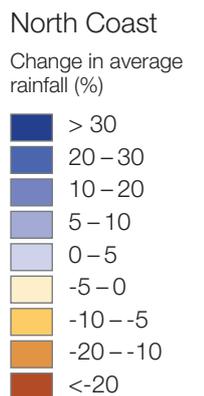
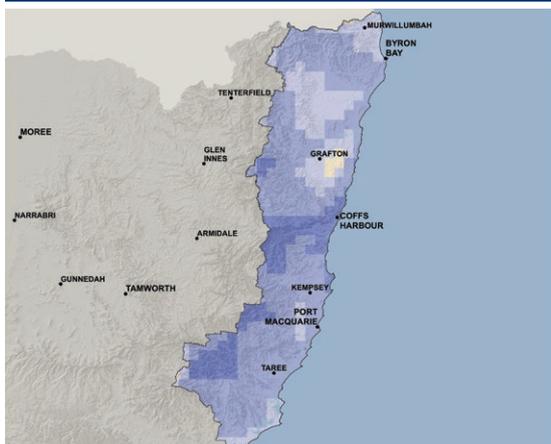


Figure 15: Far future (2060–2079) projected changes in average rainfall by season.

# 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 FFDI is projected to increase

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

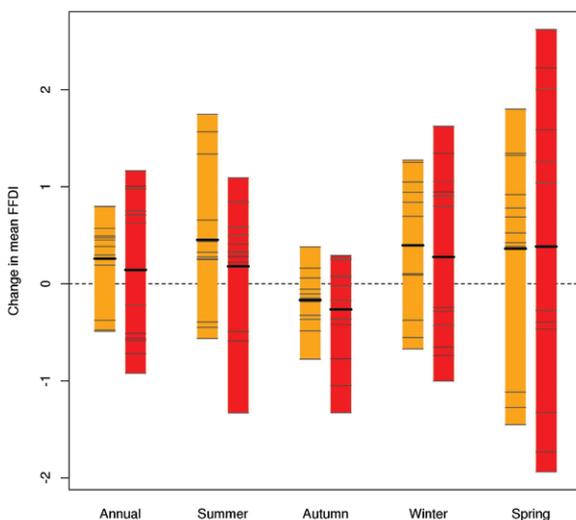


Figure 16: Projected changes in the average daily forest fire danger index (FFDI) for the North Coast Region, annually and by season (2030 yellow; 2070 red). (Appendix 1 provides help with how to read and interpret these graphs).

## Projected regional climate changes

The North Coast is expected to experience an increase in severe and average FFDI values in the near future and the far future (Figures 16 and 17).

The increases are projected in summer and spring (Figures 18 and 19). Although these changes in severe fire weather are relatively small in magnitude (up to one additional day every two years) they are projected to occur in prescribed burning periods (spring) and the peak fire risk season (summer) (Figure 17).

Autumn is projected to have slight decreases in fire weather. 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 across the region (compare Figure 13 with Figures 16 and 17).

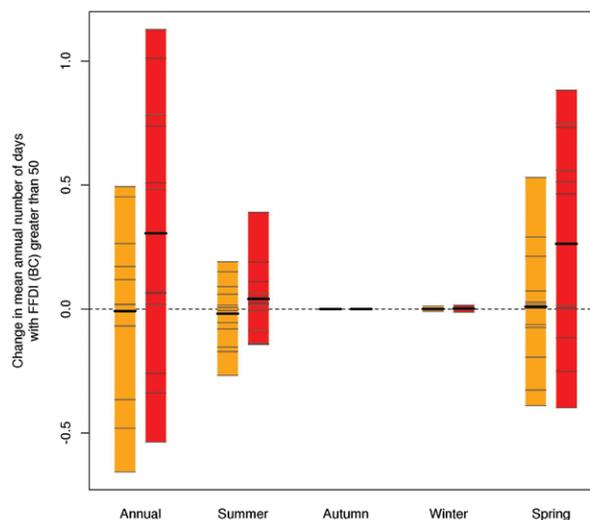


Figure 17: Projected changes in average annual number of days with a forest fire danger index (FFDI) greater than 50 for the North Coast Region, annually and by season (2030 yellow; 2070 red). (Appendix 1 provides help with how to read and interpret these graphs).

Summer



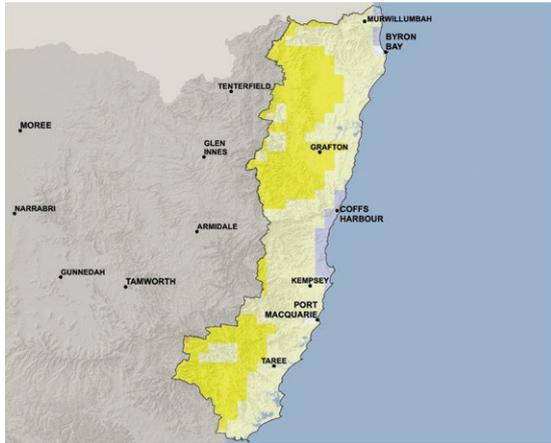
Autumn



Winter



Spring



North Coast

Change in average FFDI

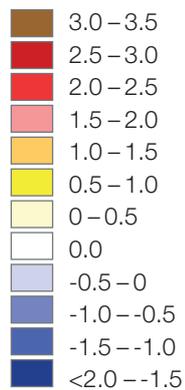


Figure 18: Far future (2060–2079) projected changes in average daily FFDI, compared to the baseline period (1990–2009).

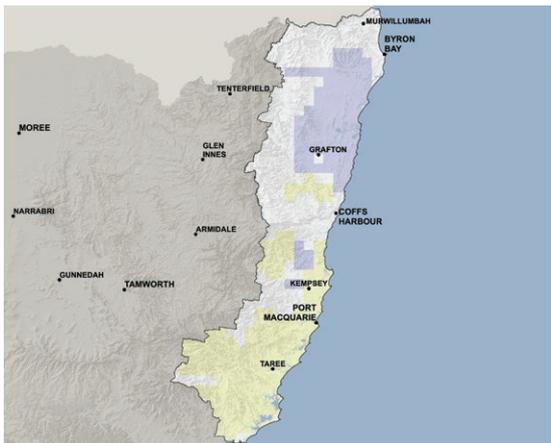
Summer



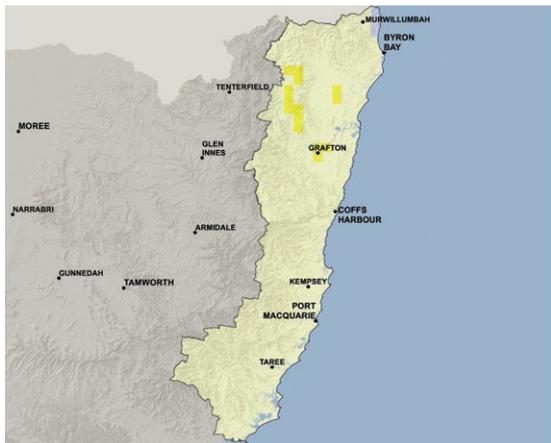
Autumn



Winter



Spring



North Coast

Change in average number of days with FFDI greater than 50

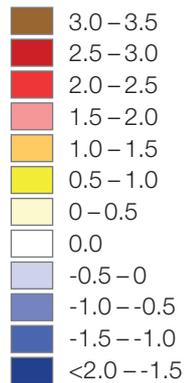


Figure 19: Far future (2060–2079) projected changes in average annual number of days with a FFDI greater than 50, compared to the baseline period (1990–2009).

## Appendix 1 Guide to reading the maps and graphs

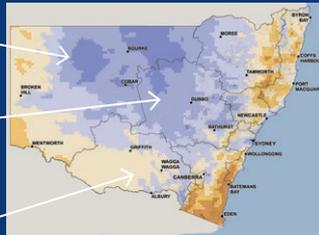
This document contains maps and bar graphs of the climate change projections. The maps present the results of the twelve models as an average of all twelve models. The bar graphs show projections averaged across the entire state and do not represent any particular location within the state. The bar graphs 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.



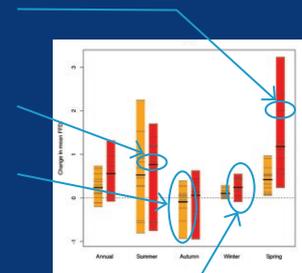
### How to read the bar graphs

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 line is the **average 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).

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