

# MURRAY BASIN



## PROJECTIONS FOR AUSTRALIA'S NRM REGIONS



Australian Government  
Department of the Environment  
Bureau of Meteorology



## CLIMATE CHANGE IN THE MURRAY BASIN

THE INTERNATIONAL SCIENTIFIC COMMUNITY ACCEPTS THAT INCREASES IN GREENHOUSE GASES DUE TO HUMAN ACTIVITIES HAVE BEEN THE DOMINANT CAUSE OF OBSERVED WARMING SINCE THE MID-20TH CENTURY. CONTINUED EMISSIONS OF GREENHOUSE GASES WILL CAUSE FURTHER WARMING AND CHANGES IN ALL COMPONENTS OF THE CLIMATE SYSTEM.

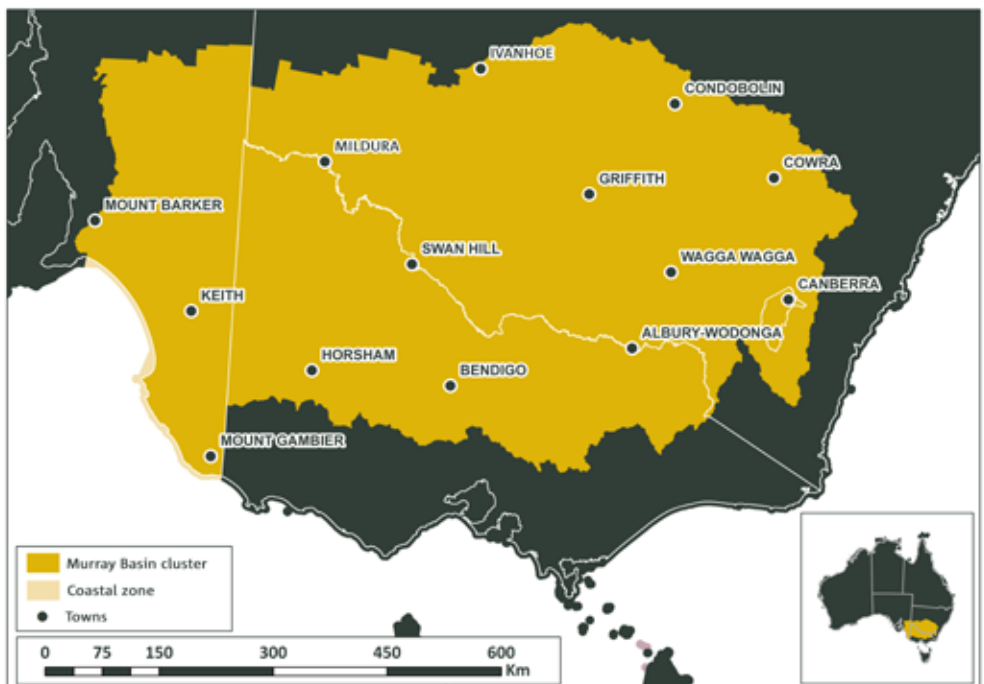
Australia's changing climate represents a significant challenge to individuals, communities, governments, businesses and the environment. Australia has already experienced increases in average temperatures over the past 60 years, with more frequent hot weather, fewer cold days, shifting rainfall patterns, and rising sea levels.

To assist the planning and management of Natural Resource Management (NRM) regions, CSIRO and the Australian Bureau of Meteorology have prepared climate change projections for eight regions of Australia, termed NRM clusters.

This brochure is for the Murray Basin cluster (Figure 1), comprising NRM regions across New South Wales, Victoria and South Australia. The cluster extends from the flatlands of inland New South Wales to the Great Dividing Range along the southern and eastern boundaries and includes Australia's highest mountain; Mt Kosciusko, at 2228m.

The cluster is relatively dry and temperate, with a warm and dry grassland climate in the north-west ranging to temperate with hot summers further east.

FIGURE 1: MAP OF THE MURRAY BASIN CLUSTER



# CLIMATE CHANGE PROJECTIONS

Projections for the Murray Basin are based on the outputs of a set of 40 global climate models (GCMs) developed by Australian and international scientists. Climate models are based on established laws of physics and are rigorously tested for their ability to reproduce past climate. These projections draw on the full breadth of available data and peer-reviewed literature to provide a robust assessment of the potential future climate.

Projections for the Murray Basin are based on four Representative Concentration Pathways (RCPs) underpinned by emission scenarios. More information on climate models and RCPs can be found inside this brochure.

► **FOR MORE COMPREHENSIVE INFORMATION ABOUT THE MURRAY BASIN, READ THE CLUSTER REPORT AVAILABLE ON THE CLIMATE CHANGE IN AUSTRALIA WEBSITE: [WWW.CLIMATECHANGEINAUSTRALIA.GOV.AU](http://WWW.CLIMATECHANGEINAUSTRALIA.GOV.AU)**

## PAST TEMPERATURE TRENDS

Temperatures have increased over the past century, with the rate of warming higher since 1960. Mean temperature increased between 1910 and 2013 by around 0.8 °C. Daily minimum temperatures have warmed more than daily maximum temperatures.

## TEMPERATURE PROJECTIONS



Average temperatures will continue to increase in all seasons (*very high confidence*).

There is *very high confidence* in continued substantial increases in projected mean, maximum and minimum temperatures in line with our understanding of the effect of further increases in greenhouse gas concentrations.

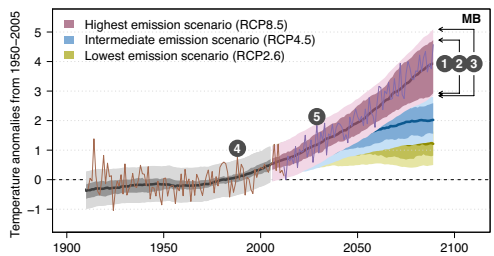
For the near future (2030), the annually averaged warming across all emission scenarios is projected to be around 0.6 to 1.3 °C above the climate of 1986–2005.

By late in the century (2090), for a high emission scenario (RCP8.5) the projected range of warming is 2.7 to 4.5 °C (Table 1 and Figure 2). Under an intermediate scenario (RCP4.5) the projected warming is 1.3 to 2.4 °C.

**TABLE 1: PROJECTED TEMPERATURE CHANGE (°C), COMPARED TO 1986–2005, FOR 20-YEAR PERIODS (CENTRED ON 2030 AND 2090) AND THREE RCPs. THE MEDIAN PROJECTION ACROSS THE MODELS IS SHOWN, WITH THE 10TH TO 90TH PERCENTILE RANGE OF MODEL RESULTS IN BRACKETS.**

	RCP2.6 Low emissions	RCP4.5 Intermediate emissions	RCP8.5 High emissions
2030	0.8 (0.6 to 1)	0.8 (0.6 to 1.1)	0.9 (0.7 to 1.3)
2090	1.0 (0.6 to 1.5)	1.8 (1.3 to 2.4)	3.8 (2.7 to 4.5)

**FIGURE 2: SIMULATED HISTORICAL AND PROJECTED TEMPERATURE (°C) TIME-SERIES FOR THE MURRAY BASIN CLUSTER, SHOWN AS DIFFERENCES FROM THE 1950–2005 AVERAGE. (SEE EXPLANATION BELOW).**



### EXPLANATION OF THE TEMPERATURE TIME-SERIES:

1. The projected multi-model median temperature. Half the models have projections above, and half below, this line.
2. 10th to 90th percentile of projected 20-year average climate. 80 per cent of model results lie in this range.
3. 10th to 90th percentile of individual years (taking into account year to year variability). 80 per cent of years lie in this range.
4. The observed time-series for 1910–2013 is overlaid on the simulated climate for the corresponding period (grey line and shading as per 1–3).
5. One climate model is shown to illustrate how the warming future may unfold. Note that models simulate realistic variability in annual temperature.

## PAST RAINFALL TRENDS

The Murray Basin experienced notable prolonged periods of extensive drying in the early 20th century, but annual rainfall shows no long-term trend between 1910 and 2013.

## RAINFALL PROJECTIONS

In the near future (2030) natural variability is projected to predominate over trends due to greenhouse gas emissions. Late in the century (2090) cool season (April to October) rainfall is projected to decline under both an intermediate (RCP4.5) and high (RCP8.5) emission scenario.

In the warm season (November to March), little change, increases and decreases of rainfall are projected by different models.

The magnitude of projected changes for late in the century (2090) span approximately -40 to +5 per cent in winter and -15 to +25 per cent in summer for a high emissions case (RCP8.5).



By late in the century (2090), less rainfall is projected during the cool season, with *high confidence*. There is *medium confidence* that rainfall will remain unchanged in the warm season. For the near future natural variability is projected to dominate any projected changes.

► CONSULT THE MURRAY BASIN CLUSTER REPORT FOR MORE DETAILED DESCRIPTIONS OF THE RESULTS USING DIFFERENT MODELLING METHODS (E.G. DOWNSCALING).

TABLE 2: PROJECTED RAINFALL DIFFERENCES (PER CENT), COMPARED TO 1986–2005, FOR 20-YEAR PERIODS (CENTRED ON 2030 AND 2090) AND THREE RCPs. THE 10TH TO 90TH PERCENTILE RANGE OF MODEL RESULTS IS SHOWN. FOR 2030, RESULTS FOR ALL RCPs ARE SIMILAR SO ONLY RCP4.5 VALUES ARE SHOWN.

	RCP4.5 2030	RCP2.6 2090	RCP4.5 2090	RCP8.5 2090
ANNUAL	-9 to +5	-19 to +3	-16 to +4	-27 to +9
SUMMER	-15 to +13	-27 to +6	-17 to +10	-13 to +27
AUTUMN	-24 to +12	-25 to +16	-23 to +18	-29 to +26
WINTER	-15 to +8	-13 to +6	-21 to +7	-38 to +4
SPRING	-16 to +12	-31 to +10	-28 to +5	-48 to +6

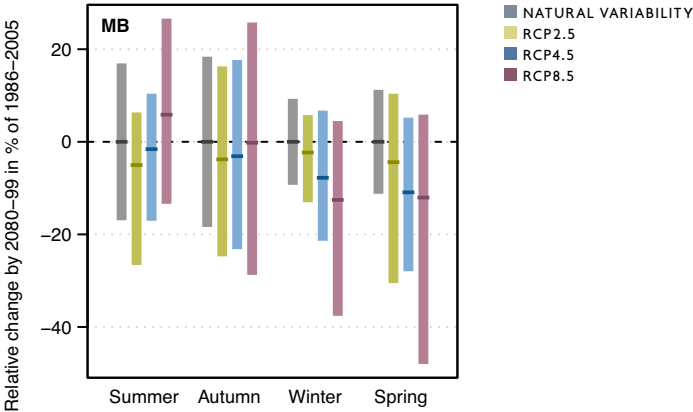
RESULTS ARE TABULATED HERE FOR STANDARD SEASONS.

MEDIAN RESULTS ARE NOT SHOWN HERE BECAUSE MODELS DO NOT ALWAYS AGREE ON THE DIRECTION OF CHANGE.

## SNOW

Snowfall has experienced significant inter-annual variability. Trends of snowfall decline over the past 60 years relate to the regional warming trend rather than the rainfall decline. Snowfall is projected to further decline (*very high confidence*) over time with the magnitude dependent on the emissions scenarios and the altitude.

FIGURE 3: PROJECTED RAINFALL DIFFERENCES (PER CENT) FOR THREE RCPs FOR THE MURRAY BASIN FOR 20 YEARS CENTRED ON 2090 COMPARED TO 1986–2005. BARS INDICATE THE 10TH TO 90TH PERCENTILE RANGE OF MODEL RESULTS. THE HORIZONTAL LINE INDICATES THE MEDIAN.



## REPRESENTATIVE CONCENTRATION PATHWAYS

- Future changes in greenhouse gases, aerosols (suspended particles in the atmosphere) and land use depend on human behaviour.
- The scientific community defined a set of four scenarios, called Representative Concentration Pathways (RCPs) for the *Fifth Assessment Report* of the Intergovernmental Panel on Climate Change.
- The RCPs reflect plausible trajectories of future greenhouse gas and aerosol concentrations to the year 2100 and represent a range of economic, technological, demographic, policy, and institutional futures.
- Climate projections are available from model simulations using four RCPs: RCP8.5 (high emissions), RCP6.0 and RCP4.5 (intermediate scenarios resulting from moderate emissions reduction, with differing timing of peak emissions) and RCP2.6 (low emissions; ambitious and sustained global emissions reduction). RCPs are named in accordance with the level of influence these gases have on the Earth’s energy balance.
- Not every combination of RCP and climate variable is available for all GCMs in the projections presented here.
- Projections for RCP6.0 are not presented in this brochure, but are available on the website.

## EXTREME TEMPERATURE

Extreme temperatures are projected to increase at a similar rate to mean temperature, with a substantial increase in the temperature reached on hot days, the frequency of hot days, and the duration of warm spells (*very high confidence*).

Frost risk days (minimum temperatures under 2 °C) are projected to decrease across the cluster (*high confidence*), and could halve by late in the century.



More hot days and warm spells are projected with *very high confidence*. Fewer frosts are projected with *high confidence*.

► **CALCULATE THE FREQUENCY OF DAYS EXCEEDING SELECTED TEMPERATURE THRESHOLDS ON THE WEBSITE THRESHOLD CALCULATOR.**

TABLE 3: AVERAGE ANNUAL NUMBER OF DAYS ABOVE 35 AND 40 °C FOR CANBERRA (ACT) FOR THE 30-YEAR PERIOD CENTRED ON 1995 (1981–2010) AND FOR FUTURE 30-YEAR PERIODS (CENTRED ON 2030 AND 2090).

THRESHOLD	CANBERRA (ACT)			
	1995	2030 RCP4.5	2090 RCP4.5	2090 RCP8.5
OVER 35 °C	7.1	12 (9.4 to 14)	17 (13 to 23)	29 (22 to 39)
OVER 40 °C	0.3	0.6 (0.4 to 0.8)	1.4 (0.8 to 2.8)	4.8 (2.3 to 7.5)
BELOW 2 °C	91	81 (87 to 76)	68 (75 to 61)	43 (52 to 35)

## EXTREME RAINFALL & DROUGHT

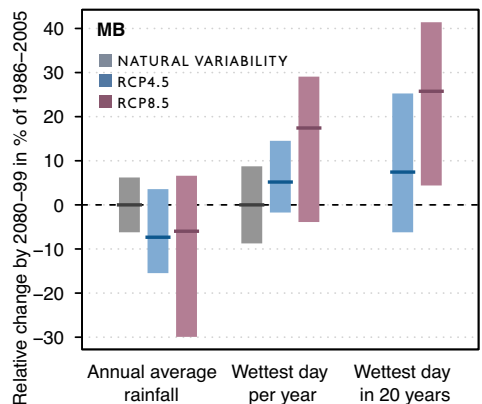
Understanding of the physical processes that cause extreme rainfall, coupled with modelled projections (Figure 4), indicate with *high confidence* a future increase in the intensity of extreme rainfall events, although the magnitude of the changes cannot be confidently projected.

Time spent in drought is projected, with *medium confidence*, to increase over the course of the century.



Even though mean annual rainfall is projected to decline, heavy rainfall intensity is projected to increase, with *high confidence*.

FIGURE 4: MODELLED DIFFERENCES (PER CENT) IN ANNUAL AVERAGE RAINFALL, RAINFALL ON THE WETTEST DAY PER YEAR, AND RAINFALL ON THE WETTEST DAY IN 20 YEARS FOR 2080–2099 COMPARED TO 1986–2005. (BARS AS PER FIGURE 3).



## MARINE AND COASTAL PROJECTIONS

For 1966 to 2009, the average rate of relative sea-level rise for Australia, from observations along the coast, was 1.4 mm/year.

There is *very high confidence* in future sea-level rise. By 2030 the projected range of sea-level rise for the cluster coastline is 0.07 to 0.18 m above the 1986–2005 level, with only minor differences between emission scenarios. As the century progresses, projections are sensitive to concentration pathways. By 2090, the intermediate emissions case (RCP4.5) is associated with a rise of 0.28 to 0.64 m and the high case (RCP8.5) a rise of 0.39 to 0.84 m. Under certain circumstances, sea-level rises higher than these may occur (see Table 4 caption).

Late in the century warming of the Murray Basin coastal waters poses a significant threat to the marine environment through biological changes in marine species, including local abundance, community structure, and enhanced coral bleaching risk. Sea surface temperature is projected to increase in the range of 1.5 to 3.4 °C by 2090 under high emissions (RCP8.5). The sea will also become more acidic, with acidification proportional to emissions growth.



Mean sea level will continue to rise and height of extreme sea-level events will also increase (*very high confidence*).

TABLE 4: PROJECTED SEA-LEVEL CHANGE (METRES) FOR VICTOR HARBOUR (SA) AND PORTLAND (VIC), COMPARED TO 1986–2005. FOR 20-YEAR PERIODS (CENTRED ON 2030 AND 2090) AND THREE RCPs. THE MEDIAN PROJECTION ACROSS THE MODELS IS SHOWN, WITH THE RANGE OF MODEL RESULTS IN BRACKETS. THESE RANGES OF SEA-LEVEL RISE ARE CONSIDERED 'LIKELY'. HOWEVER, IF A COLLAPSE IN THE MARINE BASED SECTORS OF THE ANTARCTIC ICE SHEET WERE INITIATED, THESE PROJECTIONS COULD BE SEVERAL TENTHS OF A METRE HIGHER BY LATE IN THE CENTURY.

SEA-LEVEL CHANGE	VICTOR HARBOUR (SA)		PORTLAND (Vic)	
	2030	2090	2030	2090
RCP2.6	0.12 (0.07 to 0.16)	0.38 (0.23 to 0.55)	0.12 (0.08 to 0.17)	0.39 (0.23 to 0.55)
RCP4.5	0.12 (0.08 to 0.16)	0.45 (0.28 to 0.63)	0.12 (0.08 to 0.16)	0.46 (0.29 to 0.64)
RCP8.5	0.13 (0.08 to 0.17)	0.60 (0.39 to 0.83)	0.13 (0.08 to 0.18)	0.61 (0.39 to 0.84)

## OTHER VARIABLES

### HUMIDITY & SOLAR RADIATION:

Small changes are projected for solar radiation and relative humidity for the near future (2030). Later in the century (2090), there is *high confidence* in projected increased winter and spring radiation (related to decreases in cloudiness associated with reduced rainfall) along with a projected decrease for relative humidity.

### EVAPORATION:

Potential evapotranspiration is projected to increase in all seasons as warming progresses (*high confidence*).

## FIRE WEATHER

There is *high confidence* that climate change will result in a harsher fire-weather climate in the future. However, there is only *low confidence* in the magnitude of the change to fire weather. This depends on the rainfall projection and its seasonal variation. Enhanced summer rainfall projected in some scenarios could moderate the number of severe fire weather days.



A harsher fire-weather climate in the future.

This website provides comprehensive information about the future climate and its impacts, and how communities, in particular the NRM sector, can adapt to these projected changes.

A number of interactive tools allow exploration of a range of climate variables up to late in the 21st century.

A full report for the cluster can be found on the site, as well as specific impacts and adaptation information.

## KEY MESSAGES FOR THE MURRAY BASIN



Average temperatures will continue to increase in all seasons.



More hot days and warm spells, and fewer frosts.



Less rainfall is projected during the cool season. Rainfall may remain unchanged in the warm season.



Increased intensity of extreme daily rainfall events.



Mean sea level will continue to rise. Height of extreme sea-level events will also increase.



A harsher fire-weather climate in the future.



On annual and decadal basis, natural variability in the climate system can act to either mask or enhance any long-term human induced trend, particularly in the next 20 years and for rainfall