CENTRAL SLOPES

CLIMATE CHANGE IN AUSTRALIA

PROJECTIONS FOR AUSTRALIA´S NRM REGIONS

CSIRO

Australian Government

Department of the Environment

Bureau of Meteorology

CLIMATE CHANGE IN THE CENTRAL SLOPES

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 Central Slopes cluster (Figure 1), comprising NRM regions to the west of the Great Dividing Range from the Darling Downs in Queensland (Qld) to the central west of New South Wales (NSW). The cluster features a number of important headwater catchments for the Murray Darling Basin, and is extensively developed for dryland and irrigated agriculture, grazing and forestry.

The cluster area has a range of climates, from sub-tropical in the north, through to temperate in the south, with a typically drier winter and wetter summer.

FIGURE 1: MAP OF THE CENTRAL SLOPES CLUSTER

CLIMATE CHANGE PROJECTIONS

Projections for the Central Slopes 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 Central Slopes 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 CENTRAL SLOPES, READ THE CLUSTER REPORT AVAILABLE ON THE CLIMATE CHANGE IN AUSTRALIA WEBSITE: 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.

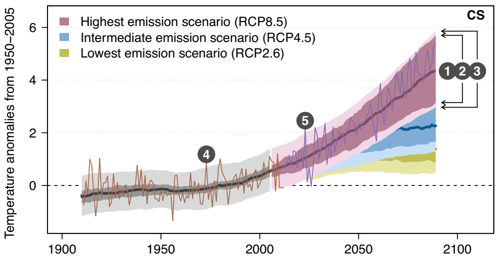
For the near future (2030), the annually averaged warming across all emission scenarios is projected to be around 0.6 to 1.5 °C above the climate of 1986–2005.

By late in the century (2090), for a high emission scenario (RCP8.5) the projected range of warming is 3.0 to 5.4 °C (Table 1 and Figure 2). Under an intermediate scenario (RCP4.5) the projected warming is 1.4 to 2.7 °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	0.9 (0.6 to 1.2)	1.0 (0.6 to 1.3)	1.1 (0.7 to 1.5)
2090	1.1 (0.6 to 1.8)	2.1 (1.4 to 2.7)	4.2 (3.0 to 5.4)

FIGURE 2: SIMULATED HISTORICAL AND PROJECTED TEMPERATURE (°C) TIME-SERIES FOR THE CENTRAL SLOPES 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 Central Slopes experienced notable prolonged periods of extensive drying in the early 20th century, but annual rainfall shows no long-term trend between 1910 and 2013. The seasonal rainfall characteristics are determined by complex interactions of rain-bearing systems from the east, south-west and sub-tropical north. Year to year variability is strongly influenced by the El Niño Southern Oscillation.

RAINFALL PROJECTIONS

In the near future (2030) natural variability is projected to predominate over trends due to greenhouse gas emissions. Late in the century, climate model results indicate decreasing winter rainfall with *high confidence*. There is a good understanding of the physical mechanisms driving this change (southward shift of winter storm systems together with rising mean pressure over the region). Decreases are also projected in spring, with *medium confidence*.

The direction of change in summer and autumn cannot be confidently projected due to the complexity of rain producing systems in this region, the large spread of model results, and some inconsistent results from finer scale modelling. Impact assessment in this region should consider the risk of both a drier and wetter summer and autumn.

Average winter rainfall is projected to decrease with *high confidence*. There is only *medium confidence* in spring decrease. Changes in summer and autumn are possible but unclear. For the near future natural variability is projected to dominate any projected changes.

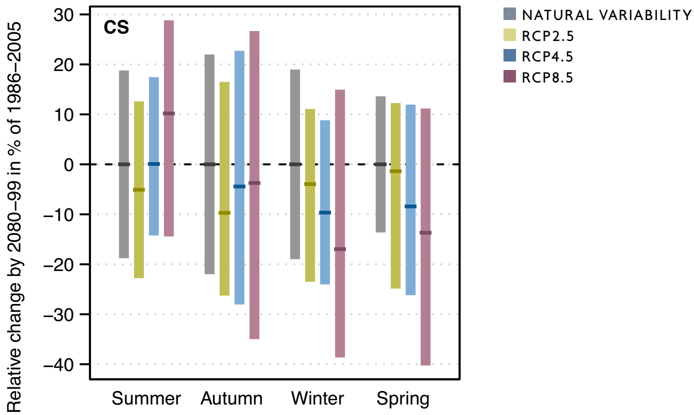
CONSULT THE CENTRAL SLOPES CLUSTER REPORT FOR MORE DETAILED DESCRIPTIONS OF THE RESULTS USING DIFFERENT MODELLING METHODS (E.G. DOWNSCALING).

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	-11 to +7	-18 to +8	-16 to +6	-23 to +18
SUMMER	-9 to +16	-23 to +13	-14 to +17	-14 to +29
AUTUMN	-22 to +19	-26 to +17	-28 to +23	-35 to +27
WINTER	-20 to +11	-24 to +11	-24 to +9	-39 to +15
SPRING	-18 to +12	-25 to +12	-26 to +12	-40 to +11

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

FIGURE 3: PROJECTED RAINFALL DIFFERENCES (PER CENT) FOR THREE RCPs FOR THE CENTRAL SLOPES FOR 20 YEARS CENTRED ON 2090 (2080–2099 PERIOD) 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 expected to decrease across the cluster (*high confidence*).

Some parts of the cluster could experience around twice the average number of days above 35 °C under an intermediate emission scenario by late in the century (Table 3).

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 DUBBO (NSW) AND ST. GEORGE (QLD) FOR THE 30-YEAR PERIOD CENTRED ON 1995 (1981–2010) AND FOR FUTURE 30-YEAR PERIODS (CENTRED ON 2030 AND 2090).

THRESHOLD	DUBBO (NSW)				ST GEORGE (Qld)			
	1995	2030 RCP4.5	2090 RCP4.5	2090 RCP8.5	1995	2030 RCP4.5	2090 RCP4.5	2090 RCP8.5
OVER 35 °C	22	31 (26 to 37)	44 (36 to 54)	65 (49 to 85)	40	54 (48 to 62)	70 (59 to 87)	101 (79 to 127)
OVER 40 °C	2.5	3.9 (3.2 to 5.6)	7.8 (5.1 to 12)	17 (9.9 to 26)	5.1	8.2 (6.3 to 11)	15 (11 to 23)	31 (20 to 49)
BELOW 2 °C	39	30 (34 to 27)	21 (26 to 13)	6.0 (10 to 2.4)	17	12 (15 to 11)	8.3 (11 to 5.5)	1.5 (3.5 to 0.5)

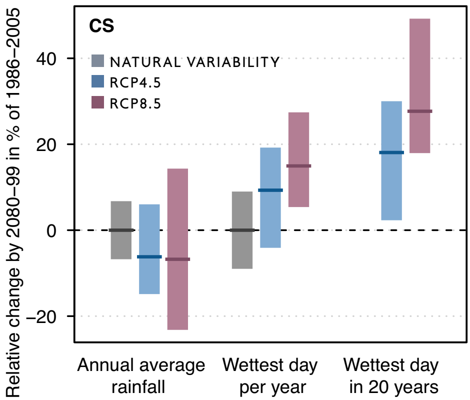
EXTREME RAINFALL & DROUGHT

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 increases cannot be confidently projected.

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

Increased intensity of extreme daily rainfall events is projected, 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).



OTHER VARIABLES

HUMIDITY: A decline in relative humidity is projected for winter and spring (*high confidence*) and summer and autumn (*medium confidence*), although changes in the near term are projected to be small.

SOLAR RADIATION: Related to the projected decline in winter rainfall, winter solar radiation is projected to increase with *medium confidence*.

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 *low confidence* in the magnitude of the change as this is strongly dependent on the rainfall projection.

A harsher fire-weather climate in the future.

WWW.CLIMATECHANGEINAUSTRALIA.GOV.AU

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 CENTRAL SLOPES

- Average temperatures will continue to increase in all seasons.
- More hot days and warm spells, and fewer frosts.
- Average winter and spring rainfall is projected to decrease. Changes in summer and autumn are possible but unclear.
- Increased intensity of extreme daily rainfall events.
- 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.

B&M | 14-139