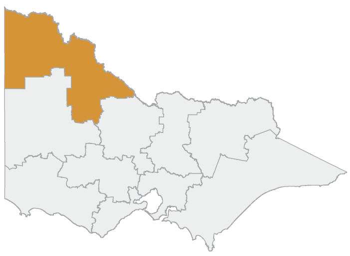
Mallee Climate Projections 2019



Maximum and minimum daily temperatures will continue to increase over this century (very high confidence).

By the 2030s, increases in daily maximum temperature of 0.8 to 1.6°C (since the 1990s) are expected.

Rainfall will continue to be very variable over time, but over the long term it is expected to continue to decline in winter and spring (medium to high confidence), and autumn (low to medium confidence), but with some chance of little change.

Extreme rainfall events are expected to become more intense on average through the century (high confidence) but remain very variable in space and time.

By the 2050s, the climate of Mildura could be more like the current climate of Menindee, NSW, and Swan Hill more like Balranald, NSW.

Introduction

Multiple lines of evidence indicate the global climate has changed predominantly due to human activity, and changes are projected to continue. Here we present projections of future climate change to help understand the scope and scale of changes to the climate we can expect locally in the Mallee region.

This report presents a snapshot of the *Victorian Climate Projections 2019* (VCP19) results for the Mallee region, and complements previous climate projections such as the *Victorian Climate Initiative*. Here we focus on the results from the new 5 km resolution downscaled climate simulations. Additional notes are provided drawing on earlier global climate model (GCM) and downscaled results when it adds important information.

Results are shown for two plausible scenarios of future greenhouse gas emissions: medium emissions (RCP4.5) and high emissions (RCP8.5). A more comprehensive set of results are provided in Tables 3–5 on the final pages. For more detail, please refer to the VCP19 Technical Report (TR).

Temperature

Victoria's temperature increased by just over 1°C between 1910 and 2018 (TR, Ch.5). This warming is expected to continue and, as a result, temperatures in the Mallee region will also increase. However, as Figure 1 shows, the amount of increase in the second half of the current century depends on the world's greenhouse gas emissions over the coming decades. Importantly, the upper range of temperature results from the VCP19 high-resolution modelling shows that a hotter future than that projected by the earlier GCM results is possible.

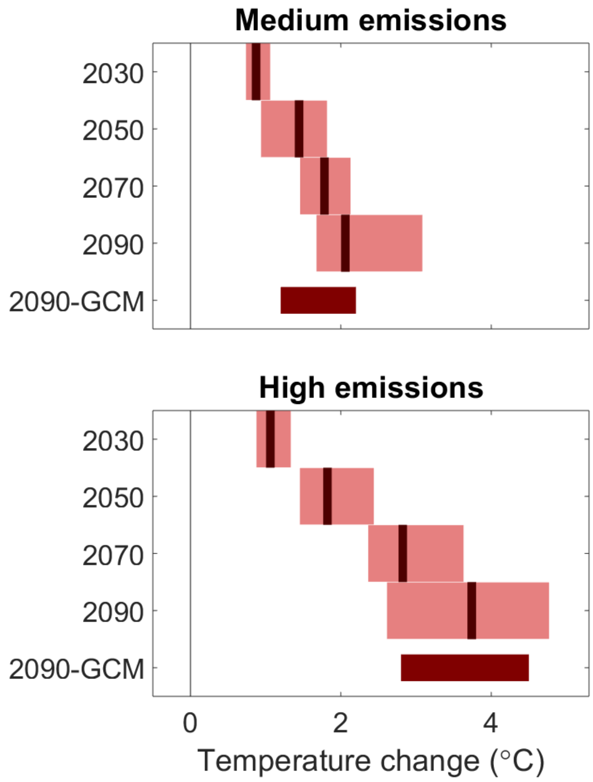


Figure 1. Projected changes (compared to 1986-2005) in annual mean temperature for medium emissions (top) and high emissions (bottom). Light red bars: results from the full range of new downscaled modelling. Dark vertical line: median. Dark red bar: 2090s results from the most recent generation of global climate models for comparison.

Under the high emissions scenario, maximum temperatures in the Mallee region are expected to show a median increase of 1.3°C by the 2030s (2020–2039), compared to 1986–2005. By mid-century, the increase is likely to be greater, with a median of 2.2°C. Under medium emissions, the mid-century maximum temperatures increase by a median of 1.7°C.

Increases in minimum temperatures are expected to be smaller, with a median of 0.8°C by the 2030s and 1.6°C by the 2050s (2040–2059) under high emissions.

Rainfall

Rainfall in Victoria has declined in most seasons over recent decades, with the greatest decreases in the cooler seasons (TR, Ch.5). The Mallee region's rainfall is naturally highly variable and this natural variability will dominate the rainfall over the next decade or so.

Over time, annual rainfall totals are likely to decline, particularly under high emissions (see Figure 2), with the greatest drying in spring. By late-century under high emissions, the climate change trend becomes obvious compared to natural variability (not shown) with a median of 21% decrease in annual totals, larger (35%) in spring.

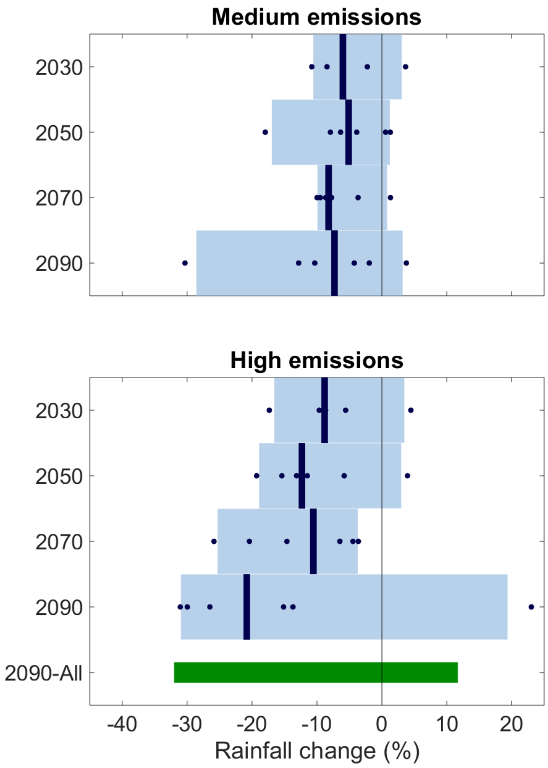


Figure 2. Projected changes (compared to 1986-2005) in annual mean rainfall for medium emissions (top) and high emissions (bottom). Bars show the 10th to 90th percentile range.
Blue bars: results from the new downscaled modelling. Dark vertical line: median. Dark blue dots: individual models. Green bar: results from all available modelling (high resolution and GCM) for comparison at 2090.

Extremes

As warming continues, we expect more heat extremes in the decades to come. Projections show that in the 2050s under high emissions, the 1-in-20-year hottest summer day is likely to increase by a median value of 2.3°C compared to 1986–2005 (see Figure 3). Under medium emissions, the median increase for the 2050s is 1.7°C.

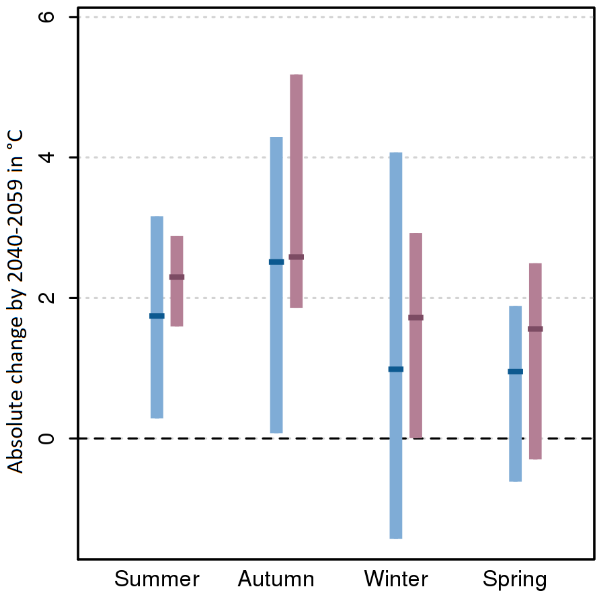


Figure 3. Projected changes in the 1-in-20-year hottest day for 2040–2059 compared to 1986–2005. Blue bars (left): medium emissions. Purple bars (right): high emissions. Dark horizontal lines: median.

Another way to look at extreme temperatures is to look at temperature exceedances per year. For example, on average between 1981 and 2010, Mildura experienced 7.8 days per year when the temperature exceeded 40°C (see Table 1). By the 2050s under high emissions, this is expected to increase to between 15 and 23 days. The increase is slightly less under medium emissions, reaching 11 to 17 days on average. Importantly for many people, minimum (usually overnight) temperatures are also expected to increase. For example, Mildura's daily minimum temperature exceeded 22°C on average 12.4 days per year between 1981 and 2010. Under high emissions, by the 2050s, these hot nights are expected to occur 23 to 37 days per year on average.

Table 1. Historic and projected days (median, 10th and 90th percentile) per year with maximum temperature greater than 40°C for two locations in 2040–2059. Projected values for medium emissions (RCP4.5) are in blue (top); high emissions (RCP8.5) are in red (bottom).

Town	Days/year above 40°C	
	1981–2010	2040–2059
Mildura	7.8	RCP4.5 14.5 (11.5 to 16.2) RCP8.5 15.8 (15.4 to 22.2)
Swan Hill	5.2	RCP4.5 10.4 (7.5 to 12.8) RCP8.5 12.8 (10.3 to 16.6)

A warmer climate is expected to bring more heavy rainfall events, but variability in high rainfall events is naturally large so there is a large range of possibilities in any 20-year period. VCP19 shows a range of median changes in annual extreme daily rainfall for a 20-year return period between -13 to +13% by the 2050s for the Mallee region, depending on the season and emissions scenario (see Figure 4).

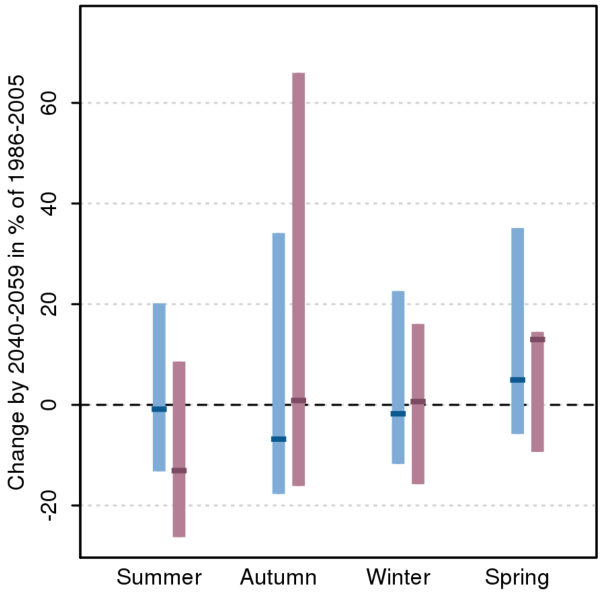


Figure 4. Projected percentage change in the 1-in-20-year maximum daily rainfall for 2040–2059 compared to 1986–2005. Blue bars (left): medium emissions. Purple bars (right): high emissions. Dark horizontal lines: median.

Frost

In a warming climate, frosts are expected to become less frequent over time. However, it is possible for there to be an increased risk of frost in some regions and seasons when cold clear nights persist longer than is suggested by the projected change in minimum temperature (TR, Ch.5). Over time the effect of increasing minimum temperatures is expected to gradually overpower the other effects and lead to a decrease in frost risk in almost all regions and seasons.

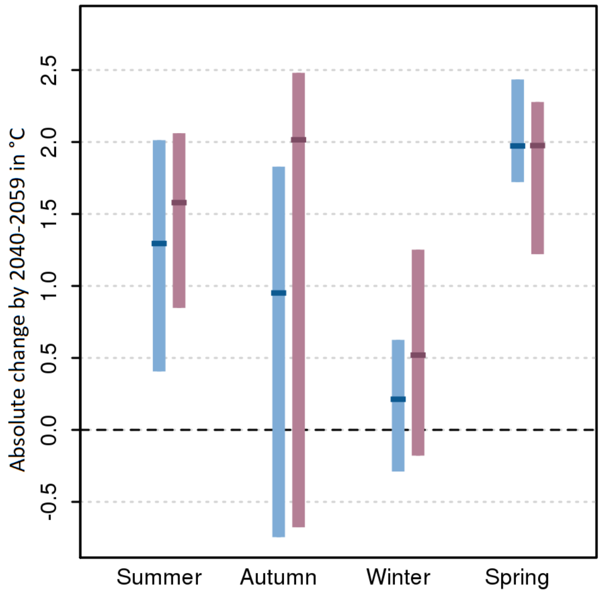


Figure 5. Projected changes in the 1-in-20-year coldest daily minimum temperature for 2040–2059 compared to 1986–2005. Blue bars (left): medium emissions. Purple bars (right): high emissions. Dark horizontal lines: median.

Keeping this in mind, it is useful to look at projected changes in very cold days. By the 2050s under high emissions, the 1-in-20-year coldest winter daily minimum temperature is projected to warm by a median of 0.5°C. Under medium emissions, the median increase in the coldest daily minimum temperature is approximately 0.2°C (see Figure 5).

As with hot days, it is useful to look at minimum temperature thresholds (Table 2). Historically from 1981 to 2010, Mildura experienced on average 3.8 days per year below 0°C whereas Swan Hill experienced 5.0 days. By the 2050s under high emissions, this may decline to between 1 and 2.4 days per year for Mildura and 1.8 to 3.3 days per year for Swan Hill. Under medium emissions, the expected reductions are less.

Table 2. Historic and projected days (median, 10th and 90th percentile) per year with minimum temperature less than 0°C for two locations in 2040–2059. Projected values for medium emissions (RCP4.5) are in blue (top); high emissions (RCP8.5) are in red (bottom).

Town	Days/year below 0°C	
	1981–2010	2040–2059
Mildura	3.8	RCP4.5 2.4 (1.4 to 3.1) RCP8.5 1.8 (1.0 to 2.4)
Swan Hill	5.0	RCP4.5 2.5 (2.0 to 3.6) RCP8.5 2.2 (1.8 to 3.3)

Fire danger

Fire weather has become more dangerous in southern Australia since the mid-1900s. In addition, fire seasons have become longer and commenced earlier over this time. This is likely to continue, with the severity of ongoing changes dependent on the emissions pathway that the world follows.

For example, there is high confidence that the number of fire days where the Forest Fire Danger Index is greater than the 95th percentile for 1986–2005 is predicted to increase at Mildura by a median value of 9.1 days per year by the 2050s under high emissions (or a 50% increase).


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Table 3. Summary of changes (compared to 1986-2005) for selected climate variables (median, 10th and 90th percentile) from new 5 km downscaled results for greenhouse gas emissions scenarios RCP 4.5 (blue, 1st row) and RCP 8.5 (red, 2nd row). Bold black values (3rd row) for rainfall represent the projected range of change in rainfall using a distribution based on all climate modelling available, past and present.

Variable	Season	1986–2005 average Mildura[1]	Emissions scenario	Projected changes		
				2020–2039	2040–2059	2080–2099
Maximum temperature (°C)	Annual	23.9°C	RCP4.5	1.1 (0.8 to 1.4)	1.7 (1.0 to 2.0)	2.4 (2.0 to 3.8)
			RCP8.5	1.3 (0.9 to 1.6)	2.2 (1.6 to 2.8)	4.3 (2.6 to 5.5)
	Summer	31.5°C	RCP4.5	1.0 (0.5 to 1.7)	1.5 (1.2 to 2.2)	2.1 (1.8 to 3.5)
			RCP8.5	1.0 (0.6 to 1.8)	2.1 (1.6 to 2.9)	3.9 (2.3 to 5.4)
	Autumn	23.9°C	RCP4.5	1.1 (0.2 to 1.4)	1.7 (0.7 to 2.2)	2.1 (1.8 to 3.6)
			RCP8.5	1.2 (0.9 to 1.7)	2.0 (1.6 to 2.6)	4.3 (2.6 to 5.3)
	Winter	16.2°C	RCP4.5	0.9 (0.7 to 1.1)	1.3 (0.5 to 1.7)	1.9 (1.7 to 3.6)
			RCP8.5	1.1 (0.7 to 1.3)	1.9 (1.5 to 2.0)	4.1 (2.5 to 5.0)
	Spring	24.1°C	RCP4.5	1.4 (1.0 to 1.8)	2.4 (1.3 to 2.7)	2.9 (2.6 to 4.5)
			RCP8.5	1.8 (1.1 to 2.2)	2.9 (1.6 to 3.7)	5.1 (2.8 to 6.6)
Minimum temperature (°C)	Annual	10.3°C	RCP4.5	0.7 (0.7 to 0.7)	1.2 (0.9 to 1.6)	1.9 (1.4 to 2.5)
			RCP8.5	0.8 (0.7 to 1.1)	1.6 (1.4 to 2.1)	3.3 (2.8 to 4.1)
	Summer	15.9°C	RCP4.5	0.9 (0.5 to 1.4)	1.6 (1.1 to 2.3)	2.2 (1.3 to 2.6)
			RCP8.5	0.9 (0.5 to 1.4)	2.1 (1.3 to 2.6)	3.7 (3.0 to 4.9)
	Autumn	10.2°C	RCP4.5	0.6 (0.5 to 0.8)	1.2 (0.7 to 1.6)	1.8 (1.3 to 2.8)
			RCP8.5	0.8 (0.5 to 1.0)	1.6 (1.0 to 2.3)	3.3 (3.0 to 4.3)
	Winter	5.1°C	RCP4.5	0.5 (0.2 to 0.6)	0.8 (0.5 to 1.1)	1.4 (1.0 to 2.1)
			RCP8.5	0.6 (0.3 to 1.0)	1.1 (0.9 to 1.4)	2.7 (2.2 to 3.2)
	Spring	9.9°C	RCP4.5	0.9 (0.7 to 1.0)	1.4 (1.0 to 1.9)	2.0 (1.7 to 2.4)
			RCP8.5	1.2 (0.8 to 1.4)	1.8 (1.5 to 2.4)	3.7 (2.7 to 4.4)
Rainfall (%)	Annual	278.5 mm	RCP4.5	-6 (-11 to 3)	-5 (-17 to 1)	-7 (-28 to 3)
			RCP8.5	-9 (-16 to 3)	-12 (-19 to 3)	-21 (-31 to 19)
						(-32 to +12)
	Summer	70.1 mm	RCP4.5	-3 (-11 to 3)	-4 (-10 to 9)	-5 (-34 to 30)
			RCP8.5	-15 (-23 to 12)	-7 (-20 to 3)	-8 (-13 to 38)
						(-34 to +37)
	Autumn	46.7 mm	RCP4.5	-5 (-15 to 18)	-7 (-27 to 33)	-3 (-22 to 22)
			RCP8.5	1 (-22 to 6)	-7 (-13 to 4)	-17 (-28 to 17)
						(-38 to +7)
	Winter	80.5 mm	RCP4.5	-9 (-22 to 2)	-9 (-17 to 14)	-10 (-32 to 0)
			RCP8.5	-7 (-22 to 9)	-14 (-23 to 1)	-27 (-37 to 12)
						(-47 to +8)
	Spring	81.2 mm	RCP4.5	-6 (-15 to 23)	-4 (-39 to 3)	-11 (-42 to -3)
			RCP8.5	-11 (-15 to -4)	-20 (-24 to 15)	-35 (-47 to 12)
						(-22 to +29)

Notes:
1. Bureau of Meteorology monthly station data from Mildura Airport (1986–2005).

Table 4. Summary of changes (compared to 1986-2005) for selected climate variables (median, 10th and 90th percentile) from new 5 km downscaled results for greenhouse gas emissions scenarios RCP 4.5 (blue, 1st row) and RCP 8.5 (red, 2nd row).

Variable	Season	Emissions scenario	Projected changes		
			2020–2039	2040–2059	2080–2099
Relative humidity (%)	Annual	RCP4.5	-1.9 (-3.2 to -0.2)	-2.6 (-4.5 to -0.3)	-3.1 (-7.5 to -1.3)
		RCP8.5	-2.4 (-4.5 to -0.3)	-3.7 (-5.3 to -0.8)	-7.3 (-8.5 to 1.0)
	Summer	RCP4.5	-1.0 (-3.3 to -0.3)	-1.3 (-2.9 to 0.1)	-2.7 (-6.1 to 0.8)
		RCP8.5	-1.9 (-3.8 to 0.4)	-3.0 (-3.6 to -0.2)	-4.0 (-5.3 to 3.2)
	Autumn	RCP4.5	-2.0 (-3.9 to 2.4)	-1.7 (-4.8 to 1.5)	-2.6 (-5.9 to 0.2)
		RCP8.5	-1.6 (-5.2 to -0.5)	-3.2 (-4.9 to -0.5)	-7.3 (-8.1 to 2.1)
	Winter	RCP4.5	-1.4 (-2.1 to 0.0)	-1.5 (-3.2 to 1.0)	-2.0 (-6.8 to -1.0)
		RCP8.5	-1.2 (-4.1 to 0.1)	-2.2 (-4.6 to -1.4)	-6.4 (-8.6 to -0.7)
	Spring	RCP4.5	-3.5 (-5.4 to -0.4)	-4.5 (-9.2 to -1.5)	-6.0 (-11.8 to -4.1)
		RCP8.5	-4.6 (-5.5 to -0.9)	-7.1 (-8.3 to -0.5)	-11.9 (-14.0 to -0.7)
Pan evaporation (%)	Annual	RCP4.5	14.4 (9.9 to 22.1)	24.5 (10.3 to 29.3)	31.5 (27.8 to 58.0)
		RCP8.5	17.7 (8.6 to 23.4)	32.5 (16.5 to 41.6)	66.4 (23.7 to 86.9)
	Summer	RCP4.5	22.6 (9.3 to 42.4)	31.4 (20.4 to 54.2)	48.5 (39.7 to 90.7)
		RCP8.5	21.9 (13.8 to 42.6)	47.8 (29.9 to 74.1)	103.7 (38.9 to 144.3)
	Autumn	RCP4.5	12.1 (-5.0 to 16.7)	13.7 (2.6 to 25.8)	21.2 (11.3 to 40.3)
		RCP8.5	10.8 (3.9 to 21.1)	22.3 (10.7 to 26.8)	48.0 (14.6 to 56.9)
	Winter	RCP4.5	3.5 (0.8 to 5.3)	4.3 (-1.9 to 11.3)	9.8 (4.9 to 21.6)
		RCP8.5	4.1 (-0.3 to 7.7)	8.2 (3.7 to 11.5)	19.2 (5.9 to 30.8)
	Spring	RCP4.5	23.3 (14.0 to 31.9)	36.0 (18.5 to 49.8)	49.3 (39.8 to 82.0)
		RCP8.5	25.7 (14.9 to 31.2)	48.9 (19.9 to 60.6)	92.1 (36.4 to 119.4)
Solar radiation (%)	Annual	RCP4.5	1.6 (0.4 to 2.1)	1.5 (0.3 to 2.3)	2.2 (1.2 to 4.5)
		RCP8.5	1.3 (0.3 to 2.3)	2.0 (0.2 to 2.5)	3.4 (-0.6 to 4.6)
	Summer	RCP4.5	0.2 (-0.2 to 1.9)	-0.2 (-1.4 to 0.8)	0.1 (-1.5 to 2.2)
		RCP8.5	0.3 (-1.5 to 1.3)	0.3 (-0.8 to 1.3)	0.2 (-3.1 to 1.2)
	Autumn	RCP4.5	1.1 (-0.3 to 3.2)	1.2 (-1.1 to 2.6)	0.9 (0.4 to 2.5)
		RCP8.5	1.5 (-0.8 to 4.5)	1.9 (-0.9 to 3.9)	4.2 (-1.9 to 6.0)
	Winter	RCP4.5	2.6 (1.9 to 3.6)	3.6 (0.4 to 4.8)	4.8 (2.6 to 10.2)
		RCP8.5	3.5 (0.4 to 4.4)	5.2 (3.2 to 7.3)	9.4 (4.7 to 12.0)
	Spring	RCP4.5	2.4 (0.1 to 3.2)	2.3 (1.3 to 4.5)	3.6 (2.8 to 6.7)
		RCP8.5	1.6 (0.7 to 2.8)	2.4 (0.7 to 3.6)	4.9 (1.3 to 6.4)
Surface wind speed (%)	Annual	RCP4.5	-1.3 (-1.9 to 0.1)	-0.8 (-2.0 to 0.5)	-1.2 (-1.6 to 0.4)
		RCP8.5	-1.5 (-2.6 to 0.2)	-1.0 (-2.2 to -0.3)	-1.7 (-4.0 to 0.4)
	Summer	RCP4.5	-0.5 (-2.2 to 0.3)	-0.9 (-2.1 to 0.7)	-1.0 (-1.6 to 0.5)
		RCP8.5	-1.0 (-1.3 to 0.4)	-0.2 (-2.9 to 0.6)	-0.1 (-4.0 to 1.4)
	Autumn	RCP4.5	-1.1 (-2.7 to 0.4)	-1.3 (-2.3 to 0.4)	-1.5 (-4.0 to 0.0)
		RCP8.5	-1.6 (-3.7 to -0.9)	-2.0 (-2.3 to 0.5)	-2.6 (-4.4 to -1.2)
	Winter	RCP4.5	-3.5 (-4.9 to -1.1)	-2.3 (-4.2 to -0.7)	-1.9 (-3.6 to -0.3)
		RCP8.5	-3.1 (-4.7 to 0.5)	-3.3 (-5.9 to -1.5)	-4.7 (-8.0 to -0.8)
	Spring	RCP4.5	0.6 (-1.5 to 2.0)	0.5 (-1.4 to 3.3)	0.5 (-0.2 to 3.1)
		RCP8.5	0.5 (-2.7 to 1.8)	-0.3 (-1.0 to 2.2)	(-1.6 to 4.2)

Table 5. Summary of changes (compared to 1986-2005) for selected climate extremes (median, 10th and 90th percentile) from new 5 km downscaled results for greenhouse gas emissions scenarios RCP 4.5 (blue, 1st row) and RCP 8.5 (red, 2nd row).

Variable	Season	Emissions scenario	Projected changes		
			2020–2039	2040–2059	2080–2099
Extreme (ARI20) daily maximum temperature (°C)	Annual	RCP4.5	1.0 (-0.1 to 2.4)	1.6 (0.2 to 3.1)	2.2 (1.3 to 5.5)
		RCP8.5	0.8 (0.2 to 2.2)	2.2 (1.8 to 3.4)	4.4 (3.7 to 5.5)
	Summer	RCP4.5	1.1 (-0.1 to 2.1)	1.7 (0.3 to 3.2)	2.5 (1.5 to 5.5)
		RCP8.5	0.7 (0.5 to 2.2)	2.3 (1.6 to 2.9)	4.5 (3.8 to 6.2)
	Autumn	RCP4.5	1.3 (-0.1 to 2.6)	2.5 (0.1 to 4.3)	2.7 (2.5 to 4.8)
		RCP8.5	1.1 (0.2 to 2.1)	2.6 (1.9 to 5.2)	4.8 (3.1 to 6.9)
	Winter	RCP4.5	1.4 (-0.8 to 3.2)	1.0 (-1.4 to 4.1)	2.3 (1.3 to 5.3)
		RCP8.5	1.8 (-1.7 to 3.0)	1.7 (0.0 to 2.9)	4.3 (1.1 to 10.3)
	Spring	RCP4.5	1.3 (0.6 to 2.5)	1.0 (-0.6 to 1.9)	2.0 (1.2 to 4.3)
		RCP8.5	0.2 (-1.0 to 2.1)	1.6 (-0.3 to 2.5)	4.4 (4.1 to 5.8)
Extreme (ARI20) daily rainfall (%)	Annual	RCP4.5	1 (-11 to 7)	3 (-14 to 26)	2 (-11 to 19)
		RCP8.5	-2 (-22 to 17)	-4 (-13 to 11)	9 (-8 to 31)
	Summer	RCP4.5	1 (-15 to 6)	-1 (-13 to 20)	-8 (-21 to 30)
		RCP8.5	-19 (-25 to 22)	-13 (-26 to 9)	3 (-8 to 21)
	Autumn	RCP4.5	-4 (-8 to 35)	-7 (-18 to 34)	7 (-7 to 50)
		RCP8.5	-4 (-21 to 65)	1 (-16 to 66)	27 (-10 to 54)
	Winter	RCP4.5	-5 (-16 to 18)	-2 (-12 to 23)	4 (-18 to 16)
		RCP8.5	16 (-27 to 39)	1 (-16 to 16)	6 (-6 to 33)
	Spring	RCP4.5	6 (-10 to 22)	5 (-6 to 35)	6 (-18 to 20)
		RCP8.5	10 (-6 to 16)	13 (-9 to 14)	-17 (-25 to 37)

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