Meteorological drought projections for Australia from downscaled high-resolution CMIP6 climate simulations

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Supplementary Material

This supplementary material contains Fig. S1 to Fig. S17.

1 Goodness of fit

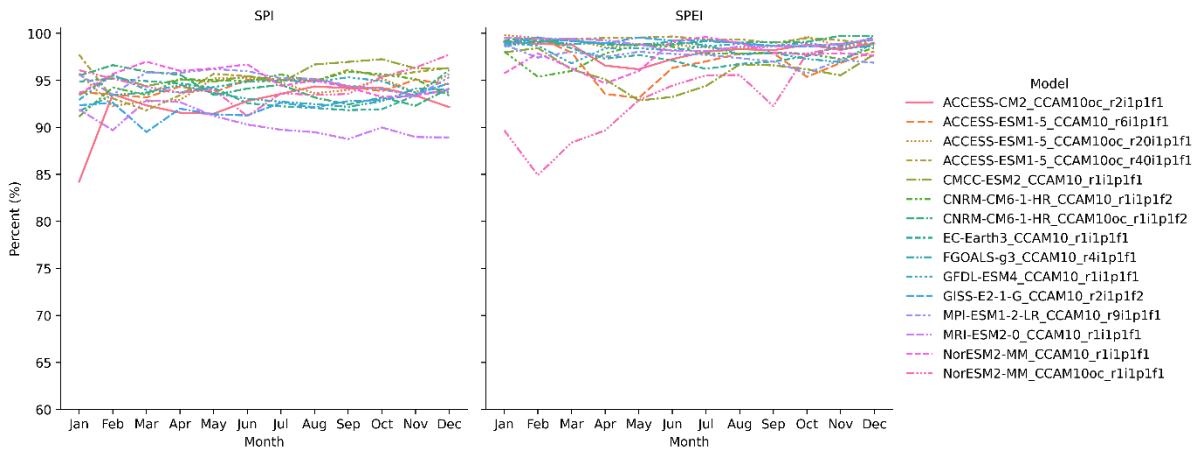



Figure S1. _Percentage of cells which pass the Shapiro-Wilk test at the 95% confidence level for normality following application of the Gamma distribution for SPI and the Log-logistic distribution for SPEI. Each month is fitted separately using data in the calibration period (1981-2010)._

2   Changes to SPI and SPEI

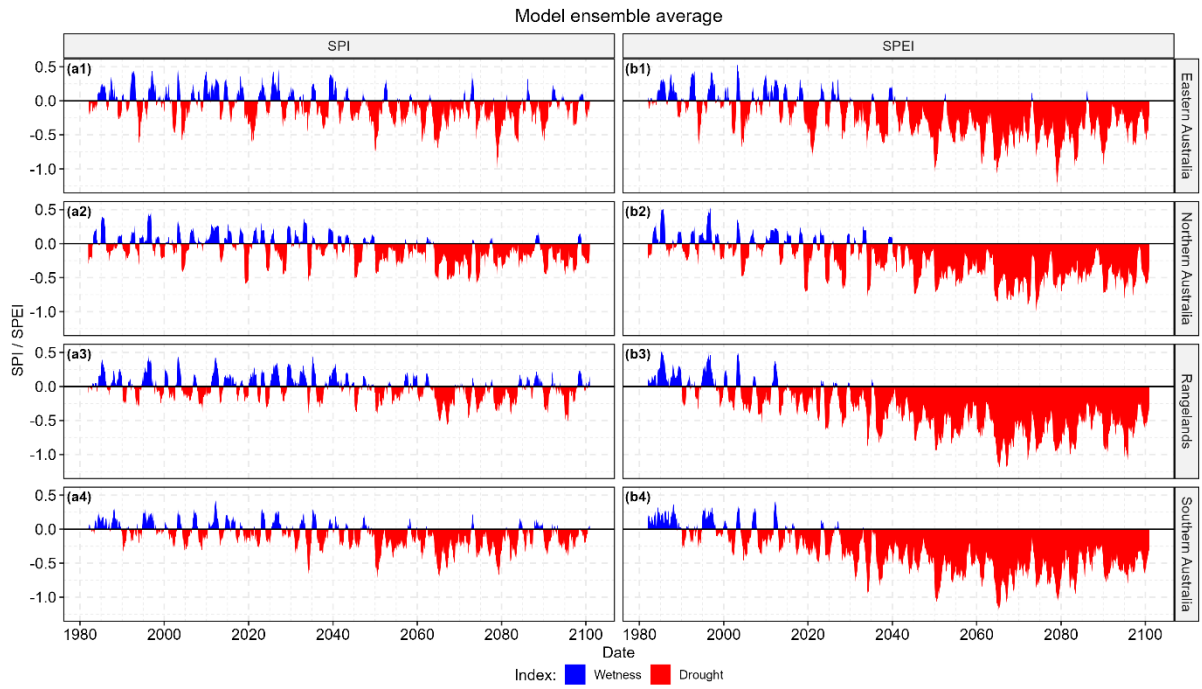



Figure S2. Timeseries of the multi-model ensemble average SPI and SPEI results for the four NRM regions considered under SSP126.

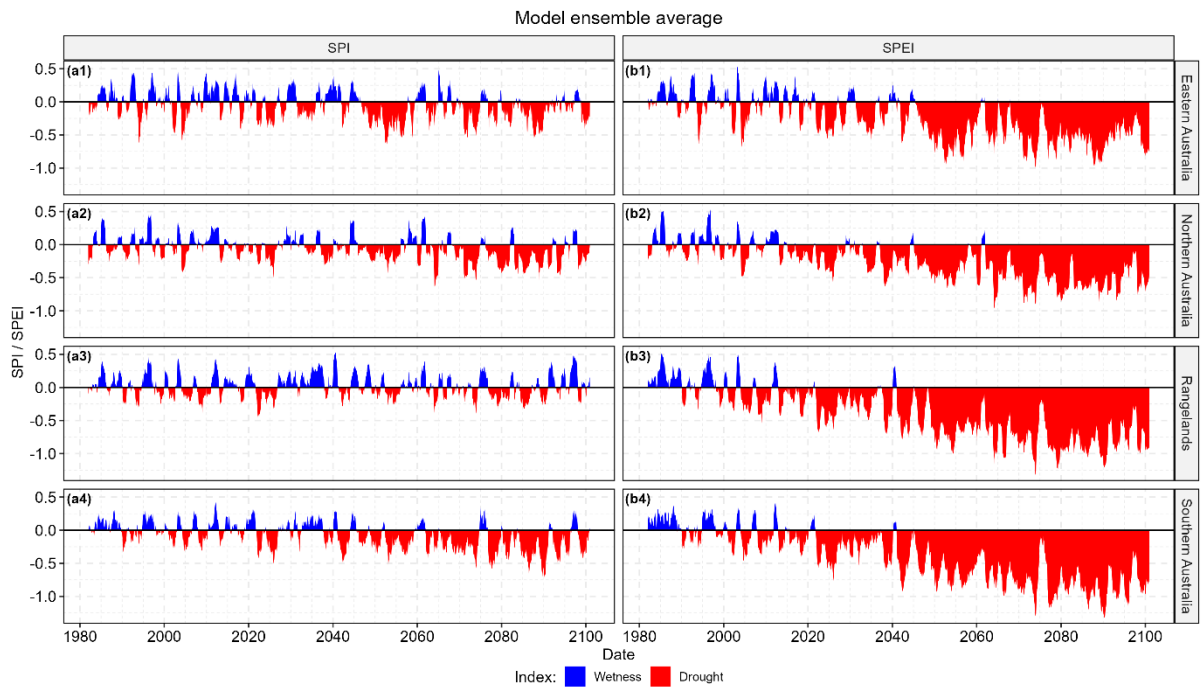
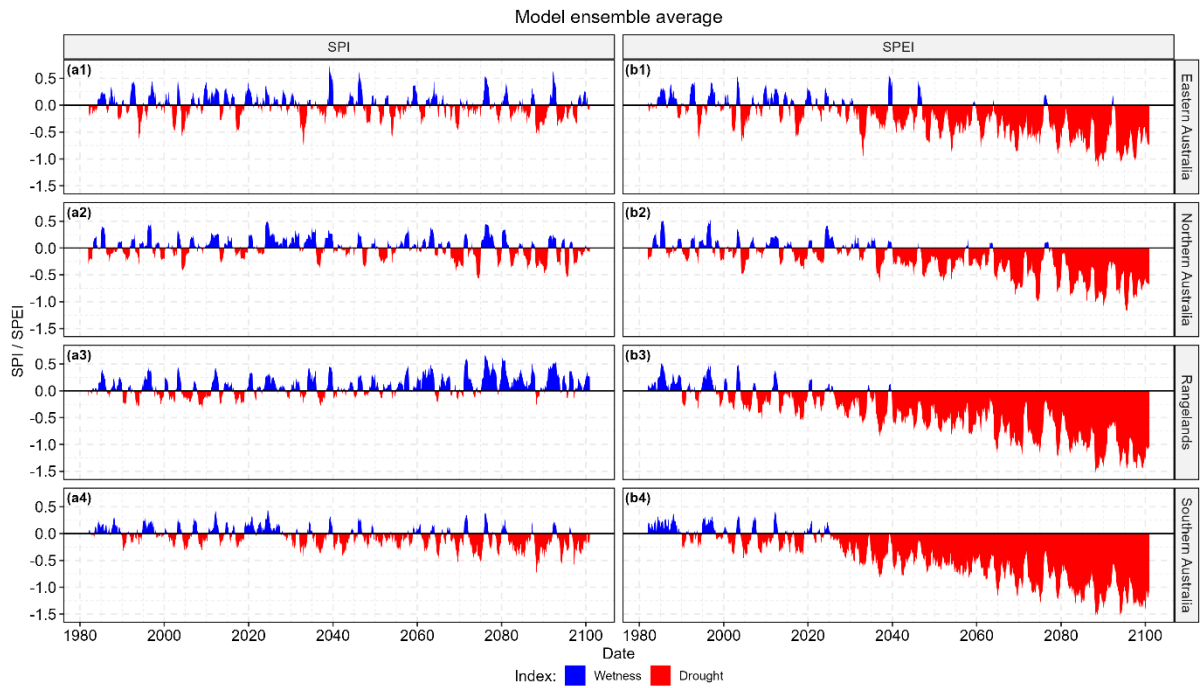



Figure S3. Timeseries of the multi-model ensemble average SPI and SPEI results for the four NRM regions considered under SSP245.

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28 ***Figure S4****. Timeseries of the multi-model ensemble average SPI and SPEI results for the four NRM regions*
29 *considered under SSP370*

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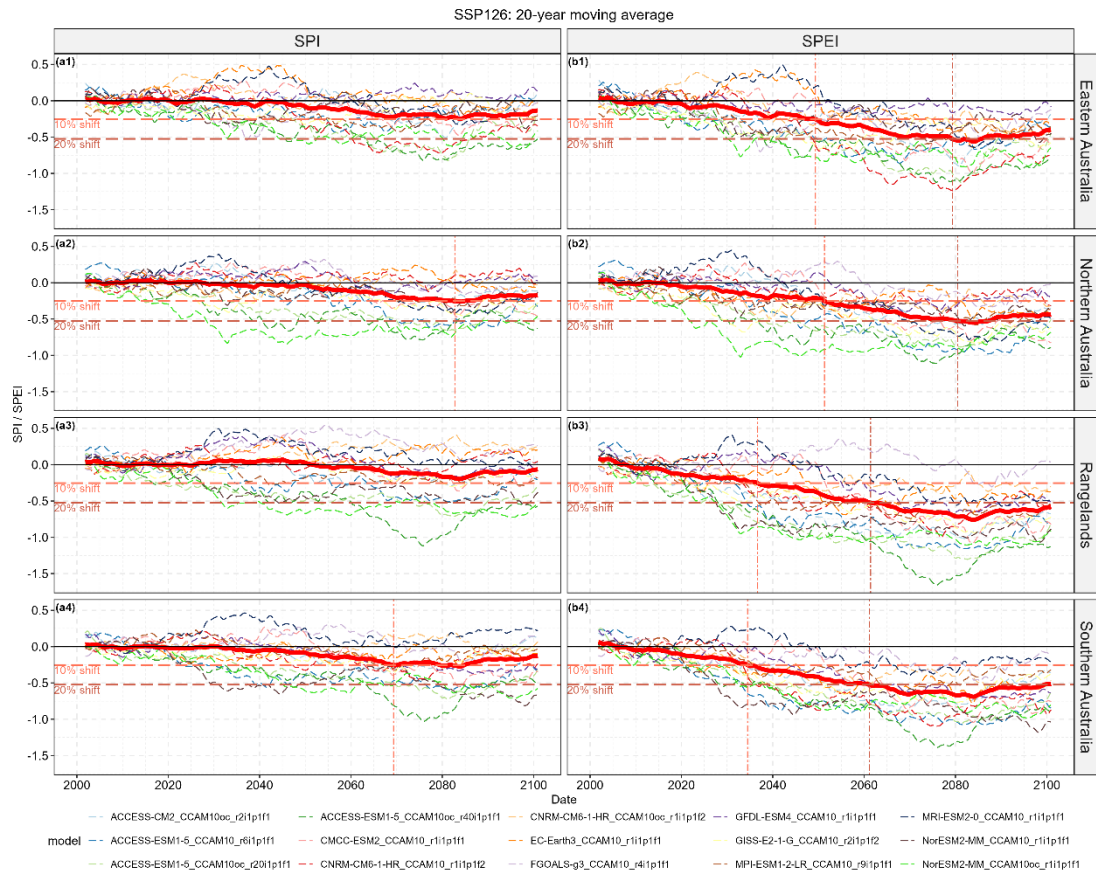
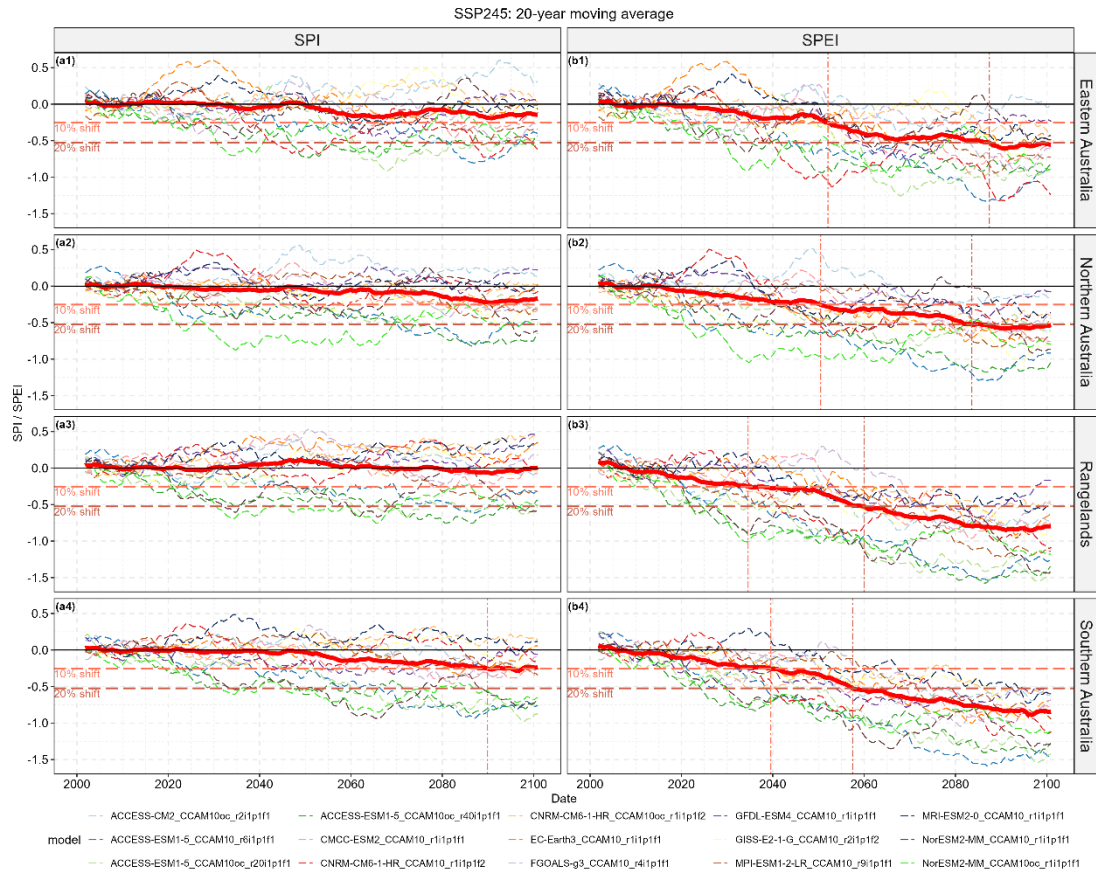

31
32 ***Figure S5****. Timeseries results for SPI and SPEI calculated as a 20-year moving average for each climate model*
33 *considered with the model average shown in red for each of the regions under the SSP126 scenario. Dotted lines*
34 *show the time taken for the ensemble average value to shift by 10% and 20% (according to the Z-score).*

35
36 ***Figure S6***. *Timeseries results for SPI and SPEI calculated as a 20-year moving average for each climate model*
37 *considered with the model average shown in red for each of the regions under the SSP245 scenario. Dotted lines*
38 *show the time taken for the ensemble average value to shift by 10% and 20% (according to the Z-score).*
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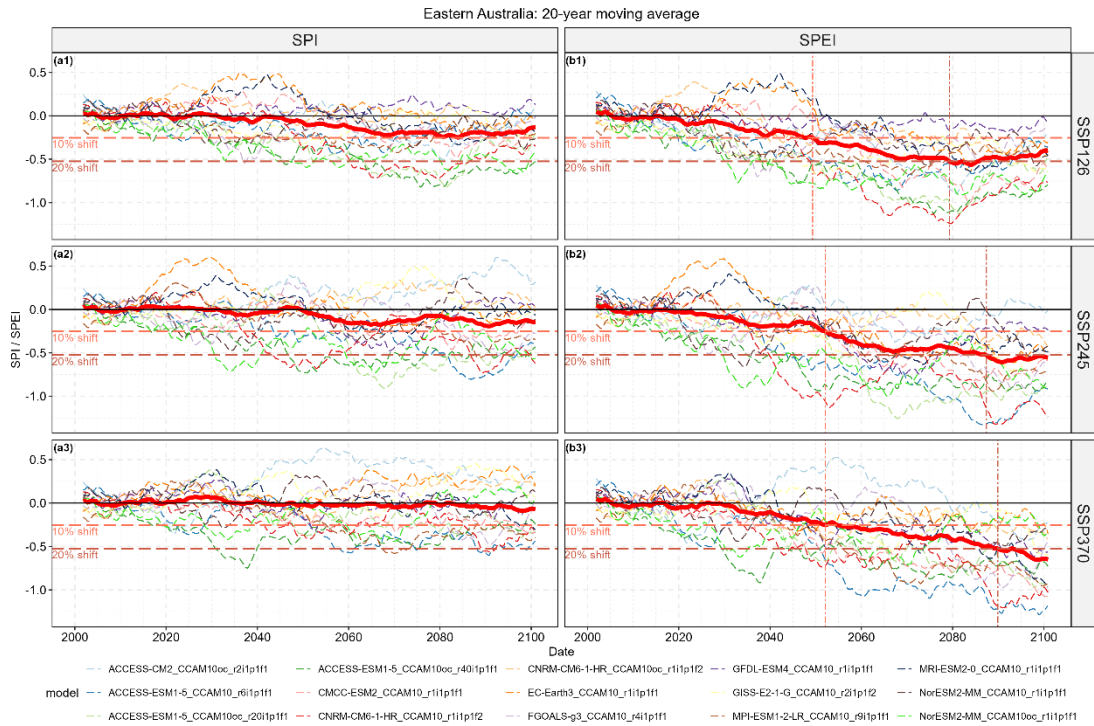
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43 ***Figure S7****. Timeseries results for SPI and SPEI calculated as a 20-year moving average for each climate model*
44 *considered with the ensemble average shown in red for each of the emissions scenarios for Eastern Australia.*
45 *Dotted lines show the time taken for the ensemble average value to shift by 10% and 20% (according to the Z-*
46 *score).*

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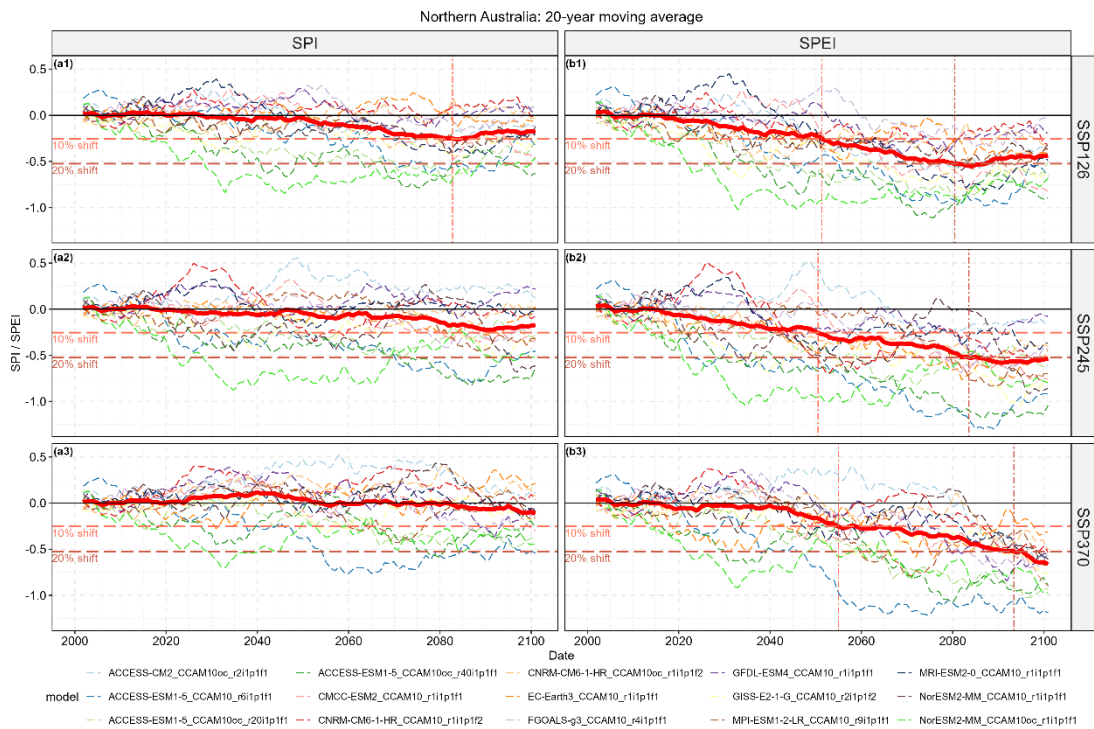
48
49 ***Figure S8****. Timeseries results for SPI and SPEI calculated as a 20-year moving average for each climate model*
50 *considered with the ensemble average shown in red for each of the emissions scenarios for Northern Australia.*
51 *Dotted lines show the time taken for the ensemble average value to shift by 10% and 20% (according to the Z-*
52 *score).*

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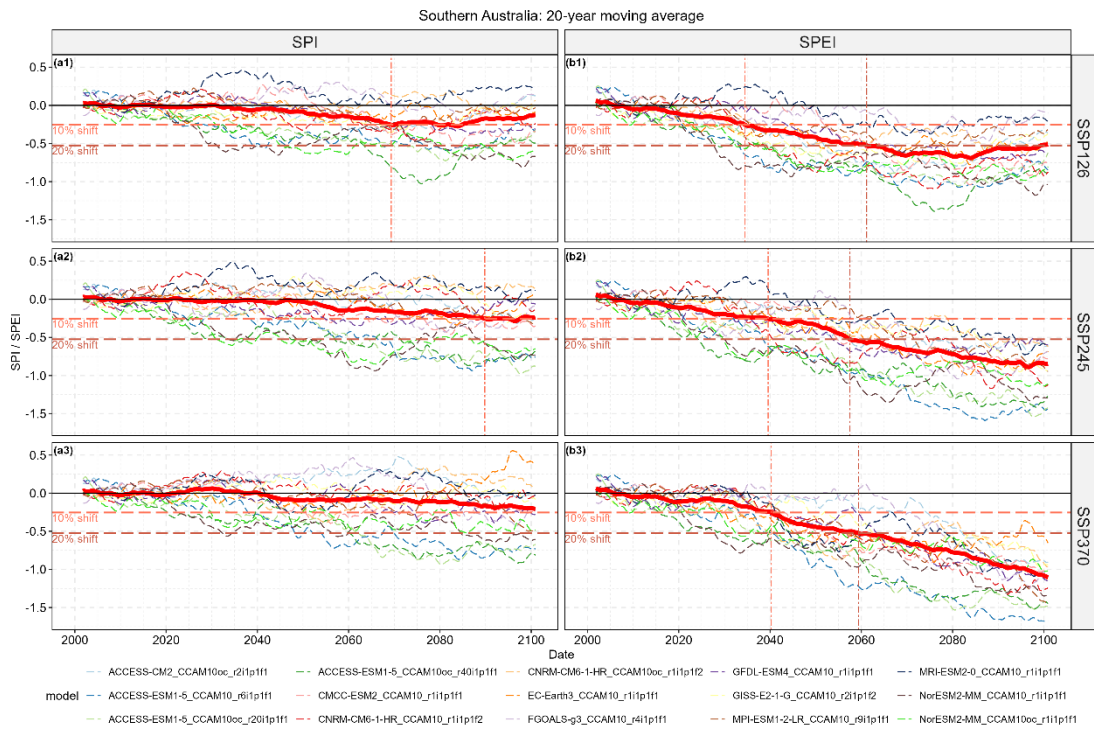
54
55 ***Figure S9**. Timeseries results for SPI and SPEI calculated as a 20-year moving average for each climate model*
56 *considered with the ensemble average shown in red for each of the emissions scenarios for Southern Australia.*
57 *Dotted lines show the time taken for the ensemble average value to shift by 10% and 20% (according to the Z-*
58 *score).*

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3   Changes to drought extent
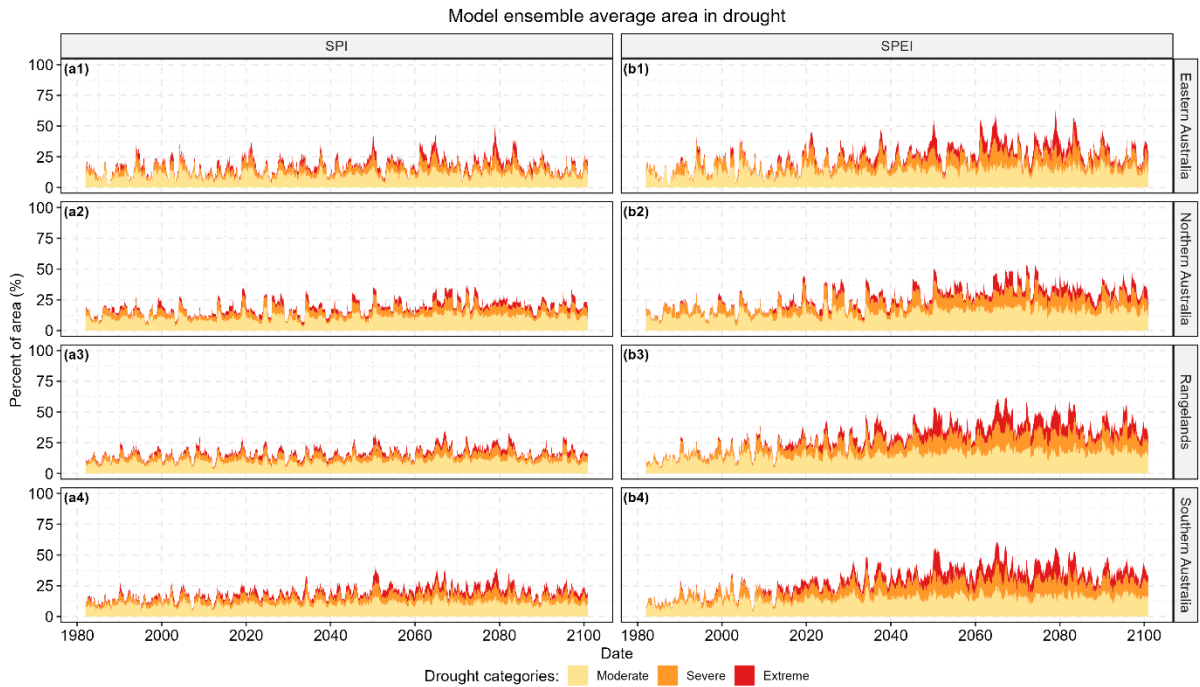
Figure S10. Timeseries of the multi-model ensemble area in drought for SPI and SPEI results for the four NRM regions considered under SSP126.
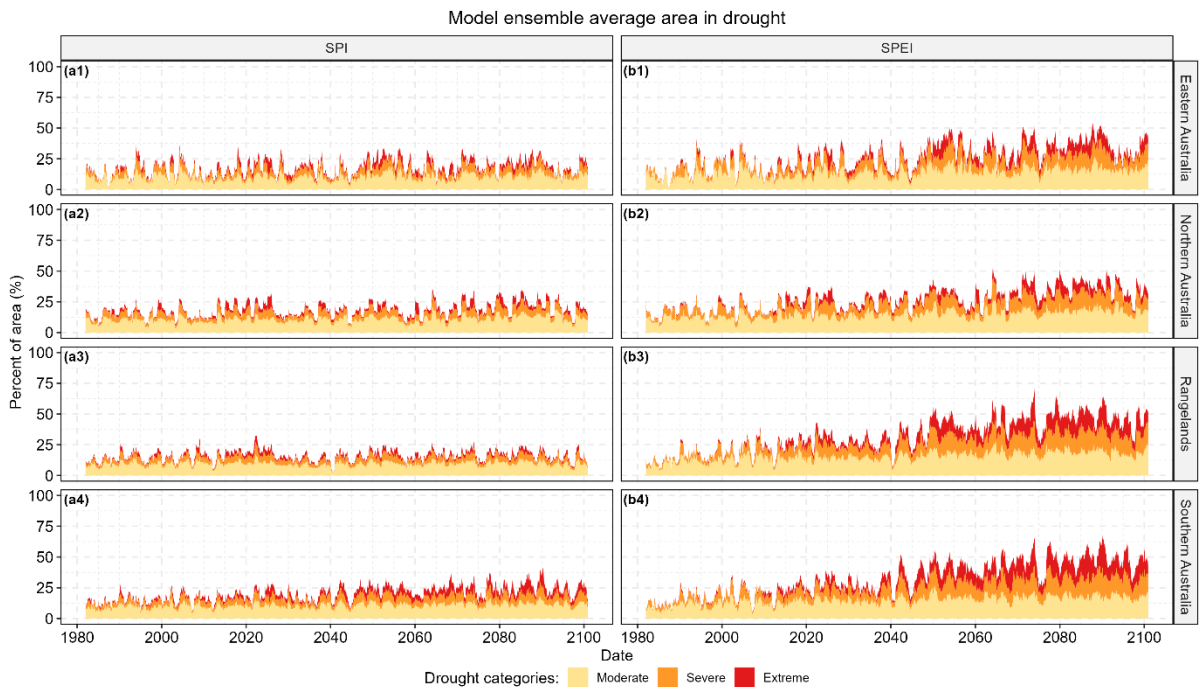
Figure S11. Timeseries of the multi-model ensemble area in drought for SPI and SPEI results for the four NRM regions considered under SSP245.

71 Table S1. Projected absolute percent change to the percent of time spent in different drought and
72 wetness categories by the 2050s and 2090s compared to the reference period (1995-2014) using the
73 ensemble average under SSP245. Red colours denote larger increases, while green colours denote
74 decreases.

Index	Category	Eastern Australia		Northern Australia		Rangelands		Southern Australia	
		2050s	2090s	2050s	2090s	2050s	2090s	2050s	2090s
SPI	Extreme drought	1.86	1.65	0.74	1.77	0.55	0.46	2.97	4.05
	Severe drought	1.35	1.53	0.72	2.22	0.48	0.65	2.17	2.75
	Moderate drought	1.26	1.53	0.76	3.1	0.08	0.55	1.71	2.55
	Near normal	-0.38	-1.27	-0.53	-4	-1.9	-2	-6.17	-7
	Moderate wetness	-2.5	-2.13	-1.22	-2.4	-0.45	-1.01	-1.35	-2.27
	Severe wetness	-1.28	-1.08	-0.67	-0.94	0.06	-0.1	-0.3	-0.81
	Extreme wetness	-0.32	-0.23	0.2	0.25	1.19	1.45	0.97	0.73
SPEI	Extreme drought	4.06	6.28	2.49	5.28	6.66	11.64	7.73	13.39
	Severe drought	3.73	6.04	3.45	6.69	6.1	9.36	6.04	9.16
	Moderate drought	3.91	5.01	3.06	6.12	3.6	5.86	4.36	5.85
	Near normal	-3.54	-7.6	-2.52	-9.12	-8.95	-17.09	-11.03	-18.14
	Moderate wetness	-4.59	-5.34	-3.58	-5.64	-4.74	-6.63	-4.6	-6.49
	Severe wetness	-3.12	-3.66	-2.59	-3.03	-2.85	-3.42	-2.72	-3.76
	Extreme wetness	-0.6	-0.97	-0.34	-0.42	-0.05	-0.25	-0.04	-0.52

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76 Table S2. Projected absolute percent change to the percent of time spent in different drought and
77 wetness categories by the 2050s and 2090s compared to the reference period (1995-2014) using the
78 ensemble average under SSP126. Red colours denote larger increases, while green colours denote
79 decreases.

Index	Category	Eastern Australia		Northern Australia		Rangelands		Southern Australia	
		2050s	2090s	2050s	2090s	2050s	2090s	2050s	2090s
SPI	Extreme drought	1.15	1.18	1.05	1.84	0.73	1.05	2.27	2.08
	Severe drought	1.46	0.8	1.37	1.97	0.85	1	1.97	1.6
	Moderate drought	1.19	0.86	1.81	2.3	0.75	0.97	1.96	1.55
	Near normal	0.17	2.42	-1.67	-2.51	-2.1	-1.53	-4.6	-3.39
	Moderate wetness	-2.18	-2.65	-1.78	-2.45	-0.93	-1.45	-1.82	-1.86
	Severe wetness	-1.35	-1.75	-0.8	-1.15	-0.22	-0.5	-0.63	-0.82
	Extreme wetness	-0.44	-0.86	0.02	0	0.92	0.47	0.85	0.84
SPEI	Extreme drought	3.59	3.64	3.05	4.5	6.12	6.88	6.83	6.38
	Severe drought	3.43	3.38	4.12	5.17	5.75	7.07	5.84	5.65
	Moderate drought	3.1	3.6	4.21	4.71	3.99	5.22	4.23	4.91
	Near normal	-2.68	-1.14	-5.21	-6.85	-9.47	-11.13	-10.42	-9.57
	Moderate wetness	-3.97	-5.09	-3.66	-4.6	-4.22	-4.9	-4.28	-4.81
	Severe wetness	-3.05	-3.63	-2.32	-2.78	-2.42	-2.95	-2.61	-2.86
	Extreme wetness	-0.56	-0.9	-0.25	-0.28	0.05	-0.39	0.18	0.15

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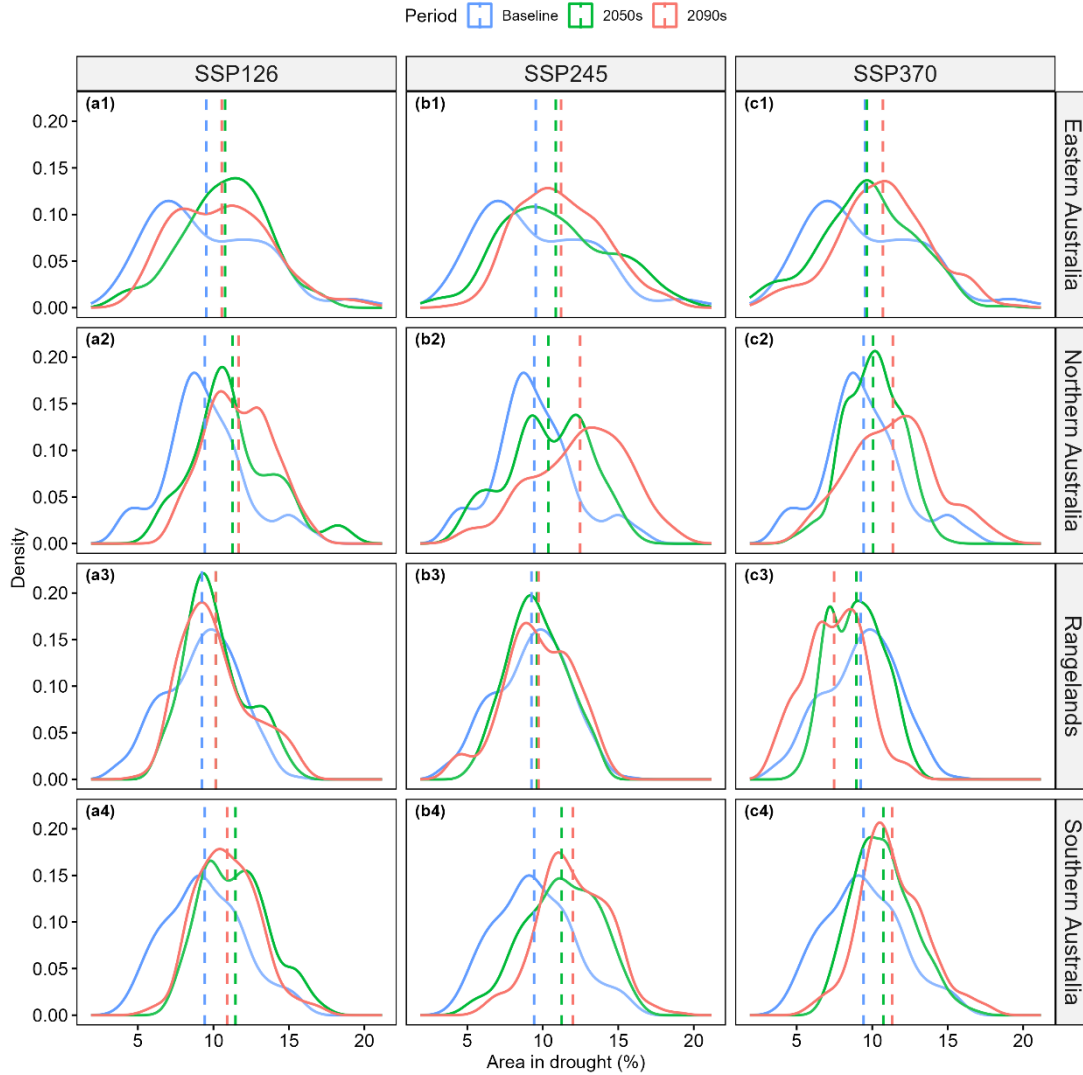
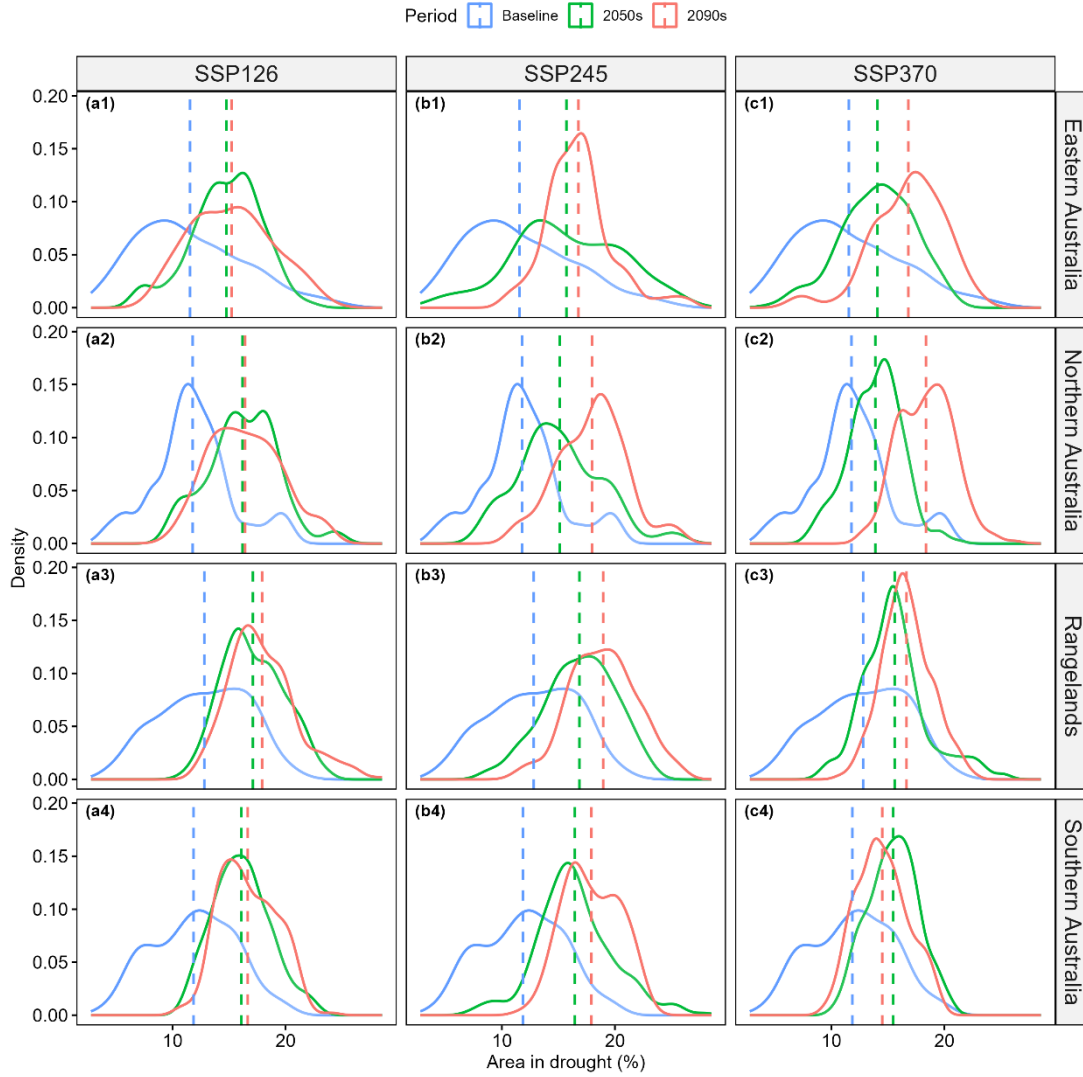


Figure S12. *Probability density function plot the percent area under moderate drought using SPI values from the weighted averaged of the model ensemble for the baseline (1995-2014), 2050s (2041-2060), and 2090s (2081-2100). Results are shown for the three SSPs in the four NRM regions considered. Dotted lines show mean values and percents show the difference in the overlap between the future and baseline densities.*

88
89 **Figure S13**. *Probability density function plot the percent area under moderate drought using SPEI values from the*
90 *weighted averaged of the model ensemble for the baseline (1995-2014), 2050s (2041-2060), and 2090s (2081-*
91 *2100). Results are shown for the three SSPs in the four NRM regions considered. Dotted lines show mean values*
92 *and percents show the difference in the overlap between the future and baseline densities.*

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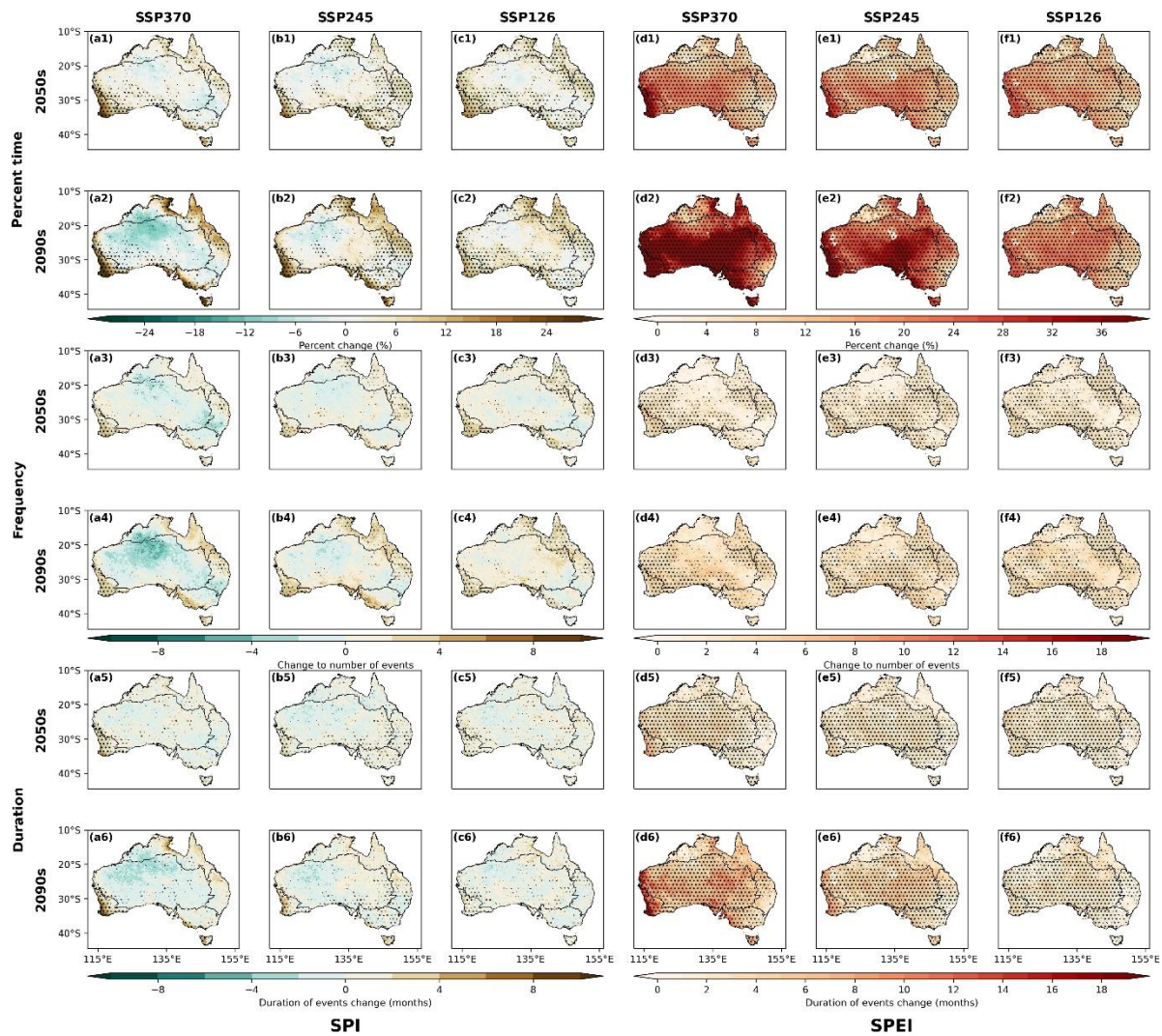
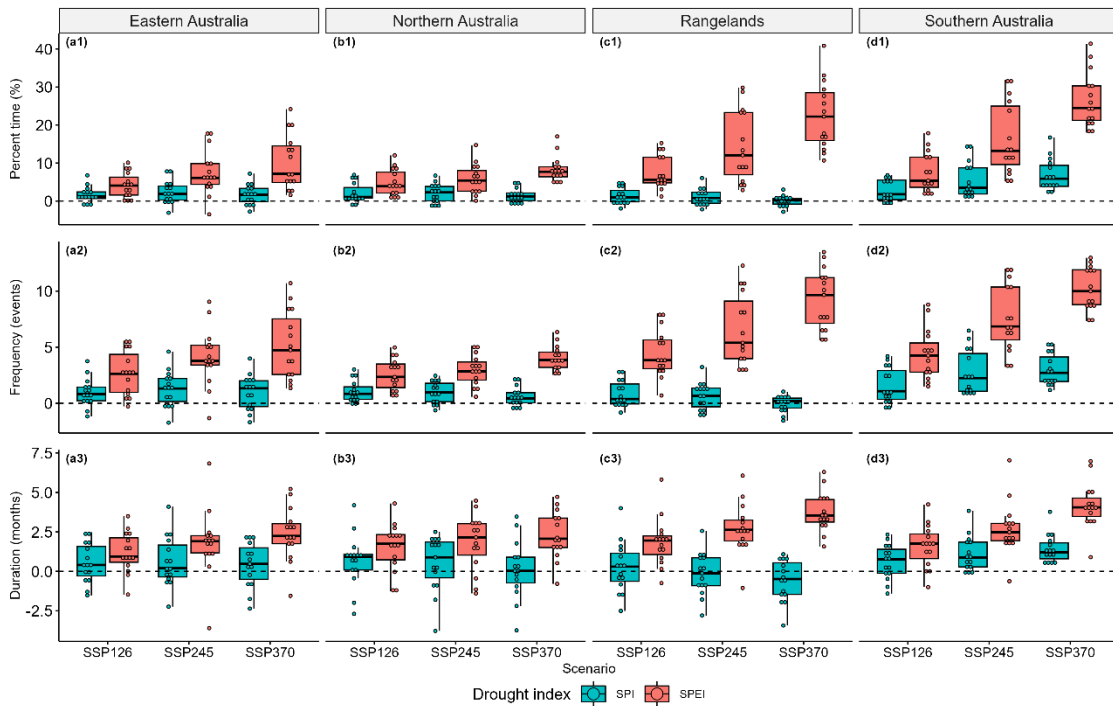
4   Changes to drought metrics

96   *Figure S14*. *Maps showing changes to the percent time (rows 1 to 2), frequency (rows 3 to 4), and duration (rows*
97   *5 to 6) of moderate to extreme droughts according to SPI (columns a, b, and c) and SPEI (column d, e, and f) for*
98   *the 2050s and 2080s relative to the baseline period. Hatching used where there was high inter-model agreement*
99   *on the sign of change (>70%).*

100
101 ***Figure S15***. *Changes to the percent time, frequency, and duration of extreme droughts using SPI and SPEI in the*
102 *2090s compared to the baseline period. The box and whisker plot shows the interquartile range (box), and the*
103 *median (bar), while the whiskers extend from the box to the furthest datapoint within 1.5x the interquartile range.*
104 *Dots show projections for each of the climate models.*

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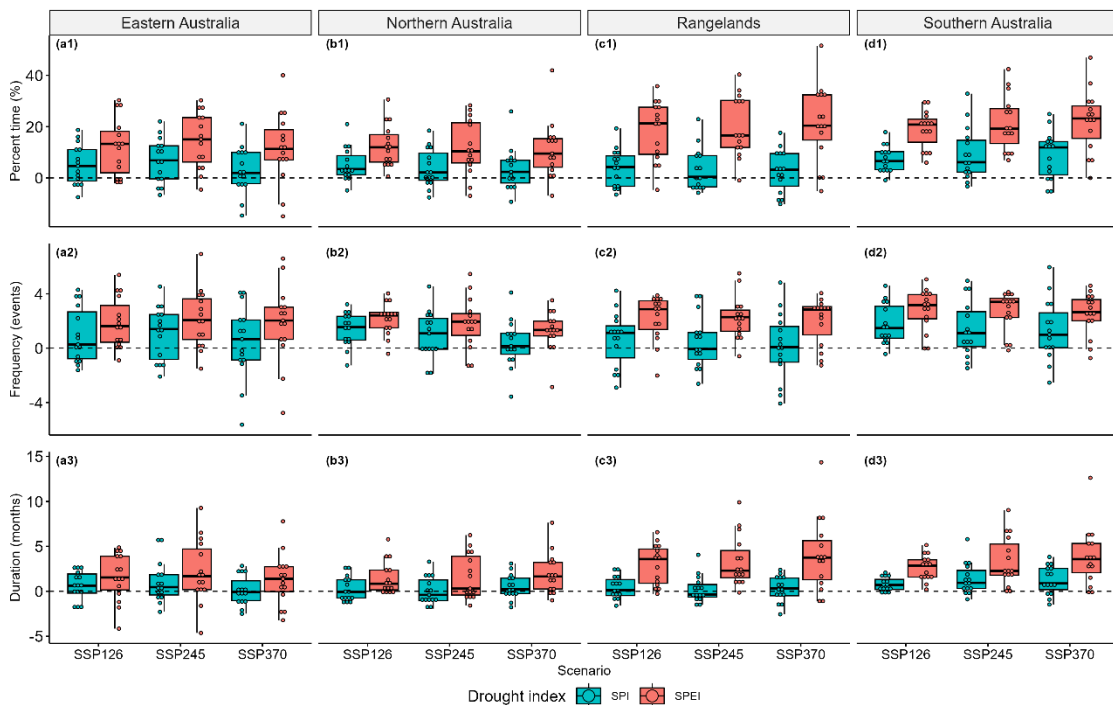
106
107 ***Figure S16***. *Changes to the percent time, frequency, and duration of moderate to extreme droughts using SPI and*
108 *SPEI in the 2050s compared to the baseline period. The box and whisker plot shows the interquartile range (box),*
109 *and the median (bar), while the whiskers extend from the box to the furthest datapoint within 1.5x the interquartile*
110 *range. Dots show projections for each of the climate models.*
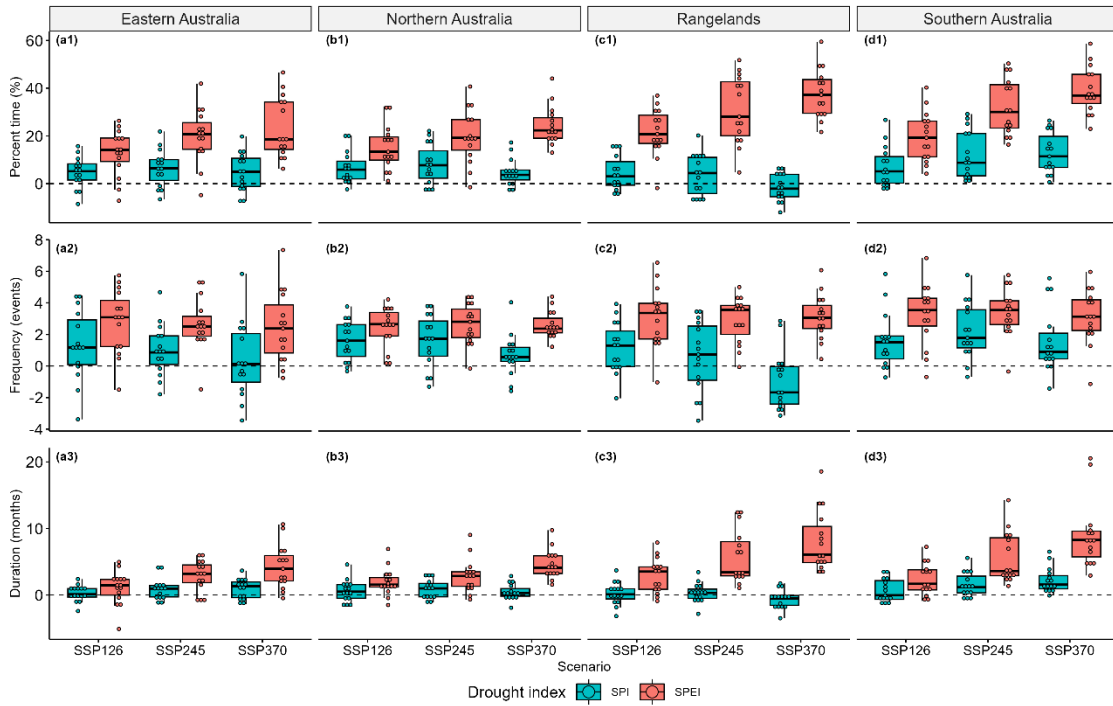
Figure S17. *Changes to the percent time, frequency, and duration of moderate to extreme droughts using SPI and SPEI in the 2090s compared to the baseline period. The box and whisker plot shows the interquartile range (box), and the median (bar), while the whiskers extend from the box to the furthest datapoint within 1.5x the interquartile range. Dots show projections for each of the climate models.*