APPENDICES

Appendices

Appendix A – Calibration of NHMM to SWWA Station Network

The non-homogeneous hidden Markov model (NHMM) was calibrated to a network of 29 Australian Bureau of Meteorology daily rainfall gauges across SWWA (Table A-1). These stations were selected on the basis of their relatively high data quality and their relevance to the water and agriculture sectors. NHMM selection involved determining the optimum combination of the number of weather states and the set of atmospheric predictor variables (derived from NCEP/NCAR Reanalysis). Calibration was undertaken for two seasons, the May-October 'winter' half-year and the November-April 'summer' half-year. The selected combinations are summarised in Table A-2. The weather states are best visualised by mean precipitation occurrence patterns and composite plots of their associated synoptic patterns (Figures A-1 and A-2).

Table A-1 South-west Western Australia stations selected for non-homogeneous Markov model calibration.

1	8039	Dalwallinu P.O.	31.35	116.66
2	8138	Wongan Hills Research Station	31.94	116.72
3	9007	Chidlow P.O.	32.34	116.26
4	9018	Gingin P.O.	31.96	115.90
5	9021	Perth Airport MO	32.36	115.97
6	9023	Jarrahdale	32.20	116.06
7	9031	Mundaring Weir	31.56	116.16
8	9039	Serpentine	31.73	116.00
9	9044	Wungong Dam	33.96	116.06
10	9045	Yanchep Park	34.37	115.67
11	9105	Wanneroo	33.54	115.79
12	9510	Bridgetown P.O.	33.57	116.14
13	9518	Cape Leeuwin	32.71	115.13
14	9519	Cape Naturaliste	32.50	115.02
15	9534	Donnybrook P.O.	34.45	115.82
16	9538	Dwellingup Forestry	33.36	116.06
17	9572	Mandurah Composite	33.13	115.77
18	9592	Pemberton Forestry	30.81	116.04
19	9628	Collie	31.66	116.16
20	9642	Wokalup Research Station	31.64	115.88
21	10007	Bencubbin	31.50	117.86
22	10035	Cunderdin P.O.	32.33	117.25
23	10073	Kellerberrin Composite	33.34	117.72
24	10093	Merredin Research Station	33.69	118.22
25	10536	Corrigin P.O.	33.10	117.87
26	10542	Darkan P.O.	32.68	116.74
27	10579	Katanning P.O.	31.35	117.56
28	10592	Lake Grace P.O.	31.94	118.46
29	10648	Wandering P.O.	32.34	116.67

Table A-2 Numbers of weather states and sets of atmospheric predictors of selected for non-homogeneous Markov models (NHMMs) for SWWA. The summer half-year is November through to April; the winter half-year is May though to October.

SEASON	FITTED NHMM*
Summer	4 weather states
	MSLP
	North - South MSLP gradient
	DTD @ 700 hPa
	DTD @ 850 hPa
Winter	6 weather states
	MSLP
	North - South MSLP gradient
	DTD @ 700 hPa

* MSLP = mean sea level pressure; DTD = dew point temperature depression (air temperature minus dew point temperature).

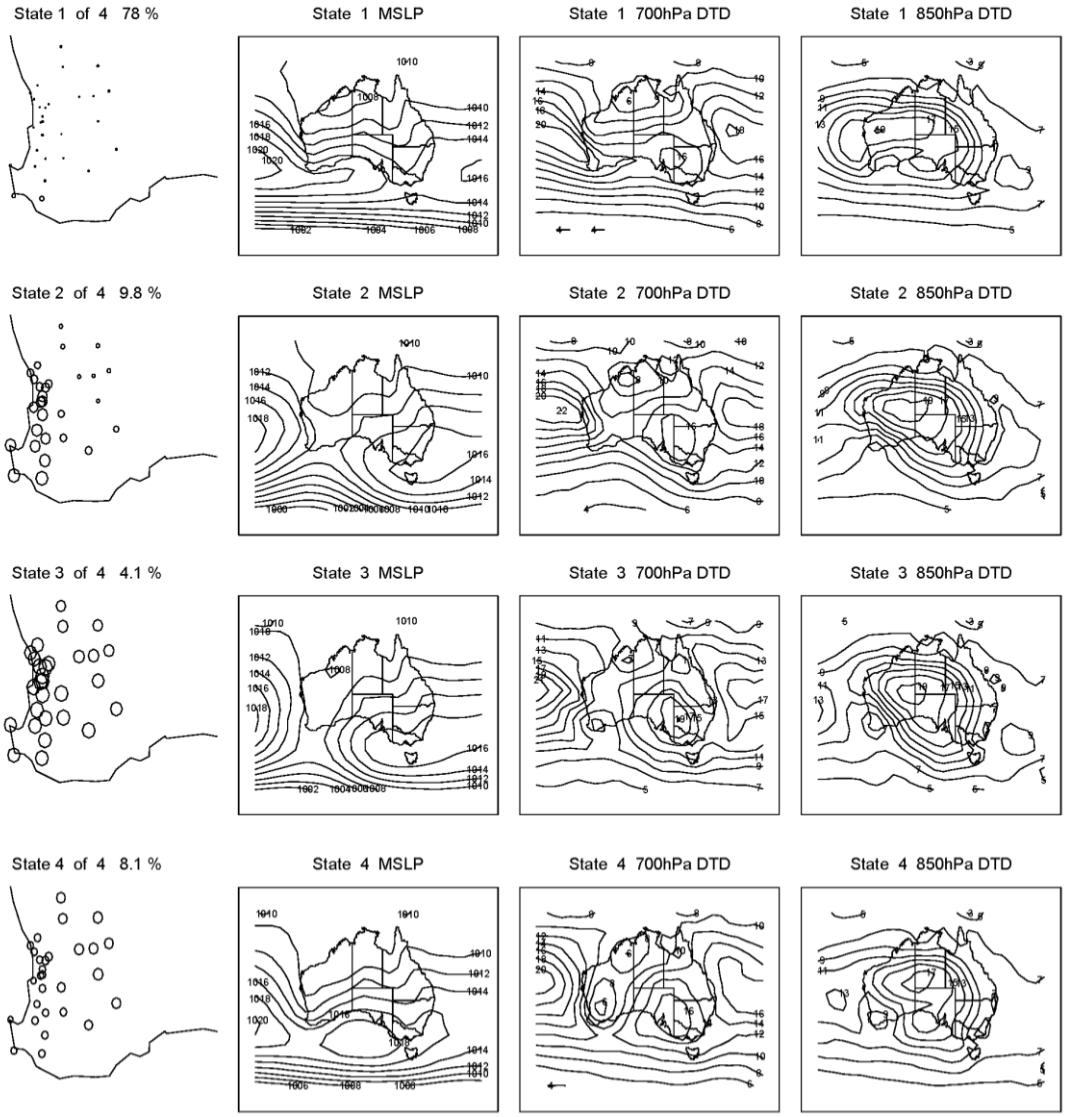

Figure A-1 Summer weather states as mean precipitation probability maps and corresponding composite atmospheric predictor fields for SWWA.

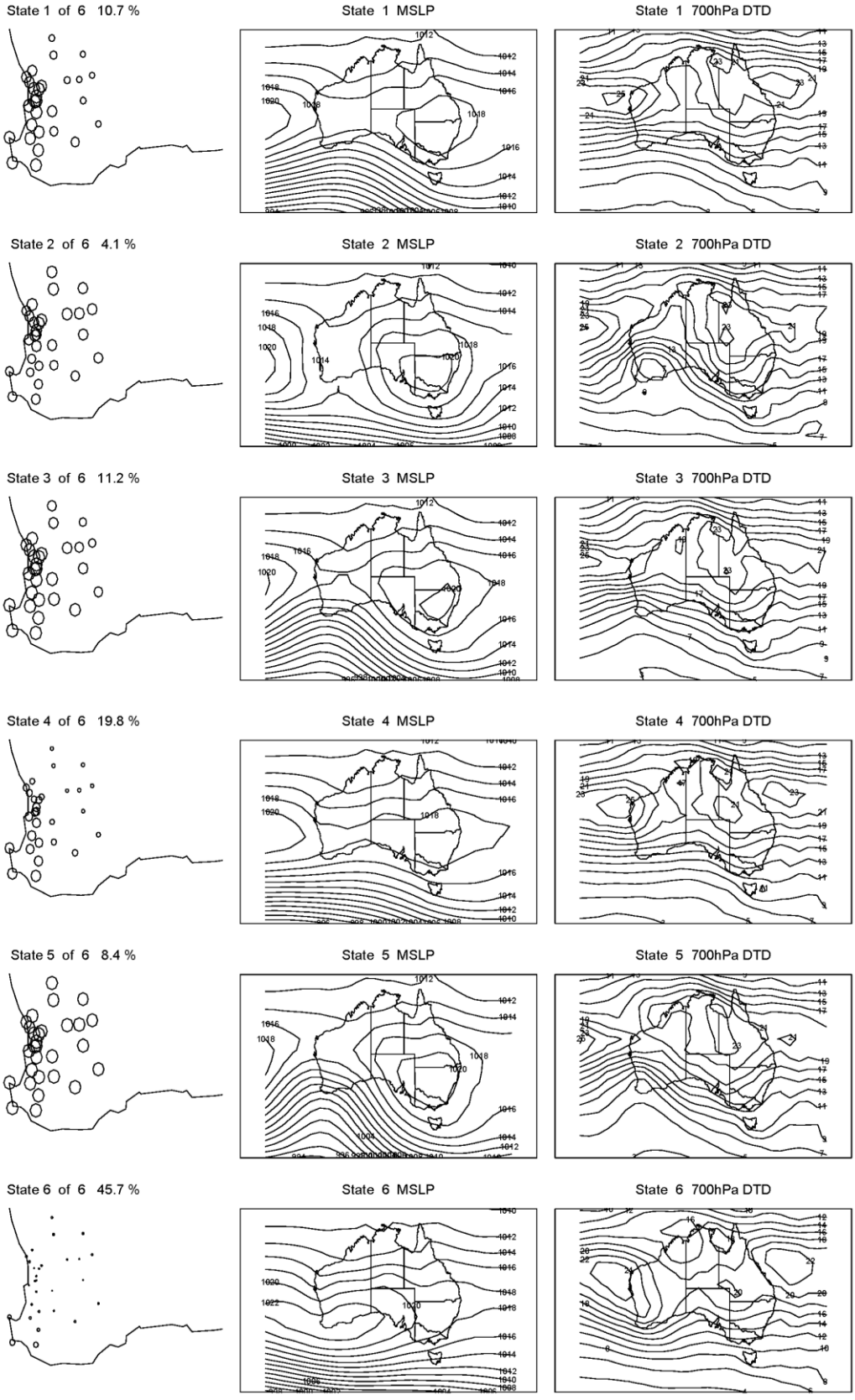

Figure A-2 Winter weather states as mean precipitation probability maps and corresponding composite atmospheric predictor fields for SWWA.

Appendix B – Downscaled SWWA Rainfall and Temperature Projections

Table B-1 Projected change in annual mean rainfall for 29 stations across SWWA, as a proportion of present-day values (1962-1999). Values are given for mid-century (2047-2064) and end-of-century (2082-2099) periods under three SRES (B1, A1B & A2) GHG emissions scenarios. The range of results in each cell reflects the range of downscaled projections produced by five global climate models, illustrating one source of uncertainty in the results.

Dalwallinu	1	0.80–0.88	0.67–0.91	0.73–0.88	0.72–0.90	0.54–0.82	0.58–0.78
Wongan Hills R. S.	1	0.79–0.88	0.65–0.91	0.72–0.87	0.70–0.91	0.52–0.81	0.56–0.78
Chidlow	1	0.76–0.90	0.64–0.93	0.69–0.89	0.70–0.95	0.51–0.83	0.53–0.80
Gingin	1	0.77–0.90	0.65–0.92	0.70–0.88	0.70–0.94	0.51–0.82	0.54–0.80
Perth Airport	1	0.77–0.90	0.64–0.93	0.69–0.88	0.70–0.94	0.51–0.82	0.53–0.79
Jarrahdale	1	0.78–0.90	0.66–0.93	0.70–0.89	0.71–0.95	0.52–0.83	0.54–0.80
Mundaring Weir	1	0.77–0.90	0.64–0.93	0.69–0.88	0.70–0.94	0.51–0.82	0.53–0.80
Serpentine	1	0.78–0.90	0.66–0.93	0.70–0.89	0.71–0.95	0.52–0.84	0.55–0.81
Wungong Dam	1	0.78–0.90	0.66–0.93	0.70–0.89	0.71–0.95	0.52–0.83	0.54–0.80
Yanchep Park	1	0.79–0.91	0.68–0.93	0.72–0.89	0.73–0.95	0.55–0.85	0.57–0.83
Wanneroo	1	0.79–0.90	0.67–0.94	0.72–0.89	0.73–0.95	0.54–0.84	0.57–0.81
Bridgetown	1	0.80–0.91	0.68–0.93	0.72–0.90	0.73–0.95	0.55–0.84	0.58–0.81
Cape Leeuwin	1	0.84–0.93	0.75–0.95	0.77–0.92	0.79–0.97	0.64–0.88	0.65–0.87
Cape Naturaliste	1	0.81–0.92	0.71–0.95	0.74–0.92	0.76–0.97	0.59–0.87	0.60–0.85
Donnybrook	1	0.79–0.91	0.68–0.94	0.72–0.90	0.74–0.96	0.55–0.85	0.57–0.82
Dwellingup Forestry	1	0.78–0.90	0.66–0.93	0.70–0.89	0.72–0.95	0.53–0.83	0.55–0.80
Mandurah Composite	1	0.78–0.90	0.67–0.93	0.70–0.89	0.71–0.95	0.52–0.84	0.55–0.81
Pemberton Forestry	1	0.82–0.92	0.72–0.95	0.74–0.91	0.77–0.96	0.60–0.87	0.61–0.84
Collie	1	0.78–0.91	0.67–0.94	0.71–0.89	0.72–0.95	0.54–0.84	0.56–0.81
Wokalup R. S.	1	0.79–0.91	0.68–0.94	0.71–0.90	0.73–0.95	0.54–0.84	0.56–0.82
Bencubbin	1	0.81–0.87	0.68–0.90	0.74–0.87	0.71–0.90	0.55–0.82	0.59–0.78
Cunderdin	1	0.79–0.88	0.65–0.90	0.71–0.87	0.70–0.91	0.51–0.80	0.55–0.77
Kellerberrin Composite	1	0.79–0.87	0.65–0.90	0.72–0.87	0.69–0.90	0.52–0.80	0.56–0.77
Merredin R.S.	1	0.81–0.88	0.68–0.90	0.74–0.87	0.71–0.91	0.55–0.82	0.58–0.78
Corrigin	1	0.79–0.87	0.66–0.90	0.71–0.87	0.70–0.90	0.51–0.80	0.56–0.77
Darkan	1	0.77–0.89	0.66–0.92	0.71–0.88	0.71–0.93	0.52–0.82	0.55–0.78
Katanning	1	0.79–0.88	0.67–0.91	0.72–0.88	0.72–0.92	0.54–0.82	0.57–0.78
Lake Grace	1	0.80–0.87	0.67–0.90	0.74–0.87	0.71–0.89	0.55–0.81	0.58–0.77
Wandering	1	0.77–0.89	0.64–0.91	0.70–0.88	0.69–0.92	0.50–0.81	0.53–0.78

Table B-2 Present-day and projected annual mean rainfall (in millimetres) for 29 stations across SWWA. Values are given for mid-century (2047-2064) and end-of-century (2082-2099) periods under three SRES emissions scenarios (B1, A1B & A2). The range of results in each cell reflects the range of downscaled projections produced by the five global climate models, illustrating one source of uncertainty in the results.

Dalwallinu	390–410	330–360	270–360	290–340	290–350	220–320	230–310
Wongan Hills	410–420	330–360	270–370	300–350	290–370	220–330	230–320
R. S. Chidlow	850–890	670–770	560–790	610–750	610–800	450–700	460–680
Gingin	680–710	540–610	450–620	490–600	490–640	360–560	370–540
Perth Airport	770–800	610–690	510–720	550–680	560–730	400–630	420–610
Jarrahdale	1130–1180	910–1020	770–1050	820–1010	830–1070	610–940	630–910
Mundaring Weir	970–1010	770–870	640–900	700–850	700–910	510–800	530–770
Serpentine	890–930	720–810	610–830	650–790	660–850	480–750	500–720
Wungong Dam	1090–1140	870–980	740–1020	790–970	800–1040	590–910	610–880
Yanchep Park	740–770	600–680	520–700	550–670	560–710	420–630	430–620
Wanneroo	780–820	640–710	540–730	590–700	580–740	440–660	450–640
Bridgetown	790–820	640–710	550–730	590–710	590–750	450–660	470–640
Cape Leeuwin	990–1020	840–920	760–950	780–920	800–960	650–880	660–860
Cape Naturaliste	820–850	680–760	600–780	630–750	640–790	490–710	510–690
Donnybrook	940–980	770–860	660–890	700–850	710–900	530–800	550–780
Dwellingup Forestry	1250–1310	1010–1130	860–1170	910–1120	920–1190	680–1040	710–1010
Mandurah Composite	870–910	710–780	600–820	640–780	640–830	470–730	490–700
Pemberton Forestry	1160–1190	970–1060	850–1100	890–1050	910–1110	710–1000	720–970
Collie	870–910	700–790	600–810	640–780	650–830	480–730	500–710
Wokalup R. S.	960–990	780–870	670–900	700–860	720–910	530–810	550–780
Bencubbin	340–360	280–310	240–310	250–300	250–310	190–280	200–260
Cunderdin	390–410	320–350	260–360	280–340	280–360	210–310	220–300
Kellerberrin	330–350	270–300	220–300	240–290	240–300	180–260	190–250
Composite Merredin R.S.	340–360	290–310	240–320	260–300	250–310	190–280	200–270
Corrigin	380–400	310–340	260–350	270–330	270–340	200–300	210–290
Darkan	510–540	410–460	350–470	380–450	380–480	280–420	290–400
Katanning	470–490	390–420	330–440	350–420	350–430	260–390	270–370
Lake Grace	360–380	300–330	250–340	270–320	270–320	200–290	210–280
Wandering	570–600	460–510	380–520	410–500	410–530	300–460	310–440

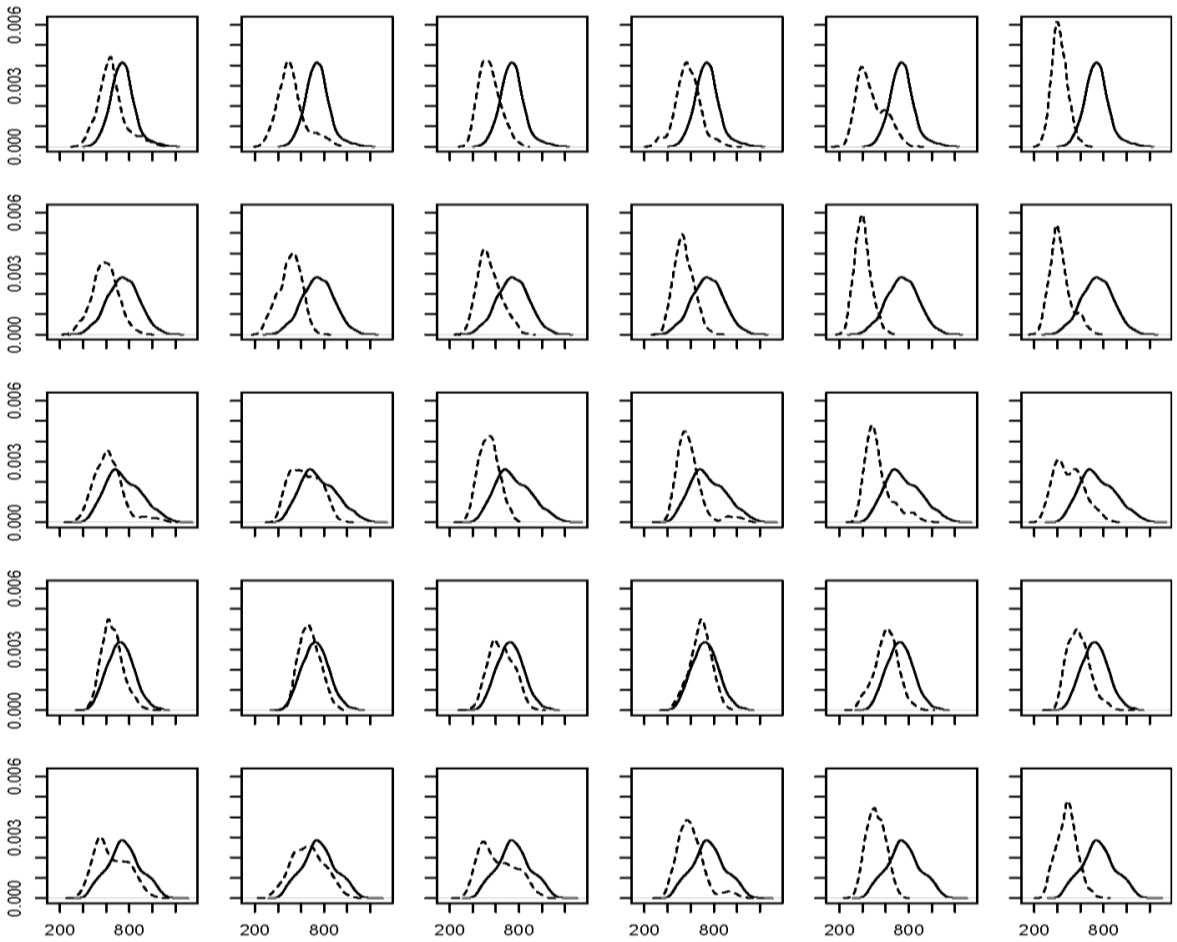

Figure B-1 The probability of realising a given level of annual rainfall under the present day and future climate. The probability distribution under the current climate run (solid lines) is compared to the projected climate (dashed lines). Downscaled results are averaged across the 29 SWWA stations. Note all projections shift to the left, implying reduced rainfall in future. Rows from top to bottom represent the five global climate models (GFDL2.0, GFDL2.1, MIROC-medres, CSIRO Mk3.5 and MPI-ECHAM5) for six SRES-scenario and period combinations (columns left to right: B1 mid-century, A1B mid-century, A2 mid-century, B1 end-century, A1B end-century and A2 end-century). The uncertainty in these results is highlighted by the differences in results across the five global climate models.

Table B-3 South-west Western Australia summer weather state means and changes. The first four data columns list the mean frequency of respective weather states. The next four columns are the changes in weather state frequencies relative to the present climate (downscaled values [203CM] for the present day [1961-2000] relative to NCEP/NCAR Reanalysis [NNR] data; and global climate model projections for mid-century and end-of-century periods relative to downscaled present-day values).

PERIOD	DATA/GCM	STATE 1	STATE 2	STATE 3	STATE 4				
Full	NNR	0.74	0.11	0.06	0.09				
1st half	NNR	0.74	0.11	0.06	0.09				
2nd half	NNR	0.74	0.11	0.06	0.09				
20C3M	GFDL2.0	0.75	0.11	0.05	0.09	0.01	0.00	-0.01	0.00
20C3M	GFDL2.1	0.75	0.10	0.06	0.09	0.01	-0.01	0.00	0.00
20C3M	MIROC	0.74	0.11	0.06	0.10	-0.01	0.00	0.00	0.01
20C3M	MK35	0.75	0.11	0.05	0.09	0.01	0.00	0.00	0.00
20C3M	ECHAM5	0.74	0.11	0.06	0.09	0.00	-0.01	0.00	0.00
B1_mid	GFDL2.0	0.79	0.10	0.04	0.07	0.04	-0.01	-0.01	-0.02
B1_mid	GFDL2.1	0.77	0.10	0.05	0.08	0.02	0.00	-0.01	-0.01
B1_mid	MIROC	0.75	0.11	0.05	0.09	0.02	0.00	-0.01	-0.01
B1_mid	MK35	0.81	0.09	0.04	0.07	0.05	-0.02	-0.01	-0.02
B1_mid	ECHAM5	0.76	0.11	0.05	0.09	0.01	0.00	0.00	-0.01
A1B_mid	GFDL2.0	0.79	0.10	0.04	0.07	0.03	-0.01	-0.01	-0.02
A1B_mid	GFDL2.1	0.81	0.09	0.04	0.07	0.06	-0.01	-0.02	-0.03
A1B_mid	MIROC	0.77	0.10	0.05	0.08	0.04	-0.01	-0.01	-0.02
A1B_mid	MK35	0.79	0.10	0.04	0.07	0.04	-0.01	-0.01	-0.02
A1B_mid	ECHAM5	0.75	0.11	0.06	0.09	0.00	0.00	0.00	-0.01
A2_mid	GFDL2.0	0.79	0.10	0.04	0.07	0.04	-0.01	-0.01	-0.02
A2_mid	GFDL2.1	0.78	0.10	0.04	0.08	0.03	0.00	-0.01	-0.02
A2_mid	MIROC	0.78	0.10	0.04	0.08	0.04	-0.01	-0.01	-0.01
A2_mid	MK35	0.79	0.10	0.04	0.07	0.04	-0.01	-0.01	-0.02
A2_mid	ECHAM5	0.76	0.10	0.05	0.08	0.02	0.00	0.00	-0.01
B1_end	GFDL2.0	0.77	0.11	0.05	0.08	0.01	0.00	0.00	-0.01
B1_end	GFDL2.1	0.80	0.09	0.04	0.06	0.05	-0.01	-0.01	-0.03
B1_end	MIROC	0.79	0.09	0.04	0.08	0.05	-0.02	-0.01	-0.02
B1_end	MK35	0.79	0.10	0.04	0.07	0.04	-0.01	-0.01	-0.02
B1_end	ECHAM5	0.79	0.10	0.04	0.07	0.04	-0.01	-0.01	-0.02
A1B_end	GFDL2.0	0.80	0.09	0.04	0.07	0.05	-0.01	-0.01	-0.02
A1B_end	GFDL2.1	0.83	0.09	0.03	0.05	0.08	-0.02	-0.02	-0.04
A1B_end	MIROC	0.78	0.10	0.04	0.08	0.05	-0.01	-0.01	-0.02
A1B_end	MK35	0.81	0.09	0.04	0.06	0.06	-0.02	-0.02	-0.02
A1B_end	ECHAM5	0.79	0.10	0.04	0.07	0.05	-0.01	-0.01	-0.02
A2_end	GFDL2.0	0.82	0.09	0.03	0.06	0.06	-0.02	-0.02	-0.03
A2_end	GFDL2.1	0.79	0.09	0.04	0.07	0.04	-0.01	-0.01	-0.02
A2_end	MIROC	0.80	0.09	0.04	0.08	0.06	-0.02	-0.02	-0.02
A2_end	MK35	0.83	0.08	0.03	0.06	0.08	-0.03	-0.02	-0.03
A2_end	ECHAM5	0.79	0.09	0.04	0.07	0.05	-0.01	-0.01	-0.02

Table B-4 South-west Western Australia summer atmospheric predictor means and changes. The first four data columns are the mean values of the respective atmospheric predictors. The next four columns are the changes in predictor values; downscaled values for the present day [1961-2000] relative to NCEP/NCAR Reanalysis [NNR] data; and projections for mid-century and end-of-century periods relative to downscaled present-day values.

PERIOD		MSLP	N-S MSLP	DTD 700	DTD 850				
Full	NNR	1016.00	-3.38	15.53	15.30				
1st half	NNR	1015.90	-3.34	14.90	15.39	-0.10	0.04	-0.63	0.09
2nd half	NNR	1016.02	-3.38	16.70	15.23	0.02	0.00	1.17	-0.07
20C3M	GFDL2.0	1016.66	-4.02	16.97	16.58	0.66	-0.64	1.44	1.28
20C3M	GFDL2.1	1016.06	-4.63	16.89	14.24	0.06	-1.25	1.36	-1.06
20C3M	MIROC	1015.97	-4.13	17.20	12.70	-0.03	-0.75	1.67	-2.60
20C3M	MK35	1016.89	-2.66	15.51	10.45	0.89	0.72	-0.02	-4.85
20C3M	ECHAM5	1016.19	-4.13	16.31	14.42	0.19	-0.75	0.78	-0.88
B1_mid	GFDL2.0	1016.74	-4.03	18.01	17.85	0.08	-0.01	1.04	1.27
B1_mid	GFDL2.1	1016.26	-4.63	17.74	14.80	0.20	0.00	0.85	0.56
B1_mid	MIROC	1016.56	-4.12	17.60	13.09	0.59	0.01	0.40	0.39
B1_mid	MK35	1017.21	-2.36	15.73	12.42	0.32	0.30	0.23	1.97
B1_mid	ECHAM5	1016.33	-4.03	16.69	14.89	0.13	0.11	0.38	0.47
A1B_mid	GFDL2.0	1016.68	-4.04	18.08	17.57	0.03	-0.02	1.11	0.99
A1B_mid	GFDL2.1	1016.54	-4.63	18.66	15.84	0.48	0.00	1.77	1.61
A1B_mid	MIROC	1016.57	-4.13	17.94	13.55	0.60	0.01	0.74	0.85
A1B_mid	MK35	1016.89	-2.28	15.85	12.53	-0.01	0.38	0.34	2.08
A1B_mid	ECHAM5	1016.31	-3.99	16.66	14.74	0.12	0.14	0.35	0.32
A2_mid	GFDL2.0	1016.86	-4.11	18.28	17.42	0.20	-0.09	1.32	0.84
A2_mid	GFDL2.1	1016.31	-4.65	18.26	14.87	0.25	-0.01	1.37	0.63
A2_mid	MIROC	1016.71	-4.24	17.96	13.11	0.74	-0.11	0.76	0.41
A2_mid	MK35	1017.01	-2.29	15.74	12.06	0.11	0.37	0.23	1.61
A2_mid	ECHAM5	1016.33	-3.95	16.83	15.27	0.13	0.19	0.52	0.85
B1_end	GFDL2.0	1016.47	-4.07	17.90	16.94	-0.18	-0.04	0.93	0.36
B1_end	GFDL2.1	1016.33	-4.68	18.57	15.64	0.27	-0.05	1.68	1.41
B1_end	MIROC	1016.85	-4.26	18.03	13.54	0.88	-0.13	0.84	0.84
B1_end	MK35	1017.08	-2.22	16.02	12.64	0.18	0.44	0.52	2.18
B1_end	ECHAM5	1016.23	-4.01	17.40	16.25	0.04	0.12	1.09	1.83
A1B_end	GFDL2.0	1016.82	-4.03	18.80	18.36	0.16	-0.01	1.83	1.78
A1B_end	GFDL2.1	1016.66	-4.66	19.21	16.73	0.60	-0.03	2.32	2.50
A1B_end	MIROC	1017.08	-4.22	18.26	13.85	1.11	-0.08	1.07	1.15
A1B_end	MK35	1016.99	-2.14	16.08	13.16	0.09	0.52	0.57	2.71
A1B_end	ECHAM5	1016.28	-3.97	17.65	16.40	0.08	0.16	1.34	1.98
A2_end	GFDL2.0	1016.88	-4.06	18.83	18.39	0.23	-0.04	1.87	1.81
A2_end	GFDL2.1	1016.28	-4.58	18.91	15.62	0.23	0.05	2.02	1.38
A2_end	MIROC	1017.49	-4.07	18.40	14.43	1.52	0.06	1.21	1.72
A2_end	MK35	1017.09	-2.22	16.29	13.79	0.20	0.44	0.78	3.33
A2_end	ECHAM5	1016.25	-4.04	17.83	16.51	0.06	0.10	1.52	2.09

Table B-5 South-west Western Australia winter weather state means and changes. First six data columns are mean frequency of respective weather state. Next six columns are the changes in weather state frequencies relative to the present climate (downscaled values [203CM] for the present day [1961-2000] relative to NCEP/NCAR Reanalysis [NNR] data; and global climate model projections for mid-century and end-of-century periods relative to downscaled present-day values).

PERIOD	DATA/GCM	STATE 1	STATE 2	STATE 3	STATE 4	STATE 5	STATE 6						
Full	NNR	0.10	0.04	0.12	0.20	0.09	0.44						
1st half	NNR	0.11	0.04	0.12	0.21	0.09	0.43	0.01	0.00	0.00	0.01	0.00	-0.01
2nd half	NNR	0.09	0.04	0.11	0.19	0.08	0.48	0.01	0.00	-0.01	-0.01	-0.01	0.04
20C3M	GFDL2.0	0.10	0.04	0.12	0.19	0.09	0.45	0.00	0.00	0.00	-0.01	0.00	0.01
20C3M	GFDL2.1	0.10	0.04	0.12	0.19	0.09	0.46	0.00	0.00	0.00	-0.01	0.00	0.02
20C3M	MIROC	0.10	0.04	0.12	0.19	0.09	0.46	0.00	0.00	0.00	-0.01	0.00	0.02
20C3M	MK35	0.10	0.05	0.11	0.20	0.09	0.46	0.00	0.01	-0.01	0.00	0.00	0.02
20C3M	ECHAM5	0.10	0.04	0.12	0.19	0.09	0.46	0.00	0.00	0.00	-0.01	0.00	0.02
B1_mid	GFDL2.0	0.09	0.03	0.11	0.19	0.07	0.51	0.01	-0.01	-0.01	-0.01	-0.01	0.05
B1_mid	GFDL2.1	0.08	0.03	0.09	0.18	0.06	0.55	0.01	-0.01	-0.03	-0.01	-0.03	0.09
B1_mid	MIROC	0.08	0.03	0.09	0.17	0.07	0.54	0.02	-0.01	-0.02	-0.02	-0.02	0.08
B1_mid	MK35	0.09	0.04	0.10	0.19	0.08	0.49	0.01	0.00	-0.01	0.00	-0.01	0.03
B1_mid	ECHAM5	0.09	0.04	0.10	0.18	0.07	0.52	0.01	-0.01	-0.02	0.00	-0.02	0.06
A1B_mid	GFDL2.0	0.07	0.03	0.08	0.18	0.05	0.59	0.03	-0.02	-0.04	-0.02	-0.04	0.14
A1B_mid	GFDL2.1	0.07	0.03	0.08	0.18	0.05	0.59	0.02	-0.02	-0.04	-0.02	-0.04	0.13
A1B_mid	MIROC	0.08	0.03	0.09	0.18	0.08	0.55	0.02	-0.01	-0.03	-0.02	-0.02	0.09
A1B_mid	MK35	0.10	0.04	0.11	0.21	0.08	0.46	0.00	0.00	0.00	0.01	0.00	0.00
A1B_mid	ECHAM5	0.08	0.03	0.10	0.18	0.07	0.53	0.01	-0.01	-0.02	-0.01	-0.02	0.07
A2_mid	GFDL2.0	0.08	0.03	0.09	0.19	0.06	0.56	0.02	-0.02	-0.03	-0.01	-0.03	0.11
A2_mid	GFDL2.1	0.08	0.03	0.08	0.18	0.05	0.58	0.02	-0.01	-0.03	-0.02	-0.04	0.12
A2_mid	MIROC	0.07	0.03	0.08	0.17	0.06	0.59	0.03	-0.01	-0.04	-0.02	-0.03	0.13
A2_mid	MK35	0.09	0.04	0.10	0.19	0.08	0.50	0.01	-0.01	-0.01	-0.01	-0.01	0.04
A2_mid	ECHAM5	0.08	0.03	0.09	0.18	0.07	0.54	0.01	-0.01	-0.02	-0.01	-0.02	0.08
B1_end	GFDL2.0	0.08	0.03	0.09	0.19	0.06	0.55	0.02	-0.02	-0.03	-0.01	-0.03	0.10
B1_end	GFDL2.1	0.08	0.03	0.09	0.18	0.06	0.57	0.02	-0.01	-0.03	-0.02	-0.03	0.11
B1_end	MIROC	0.08	0.03	0.09	0.18	0.07	0.56	0.02	-0.01	-0.03	-0.01	-0.03	0.10
B1_end	MK35	0.10	0.04	0.11	0.21	0.08	0.46	0.00	0.00	0.00	0.01	0.00	0.00
B1_end	ECHAM5	0.08	0.03	0.09	0.18	0.07	0.54	0.01	-0.01	-0.03	-0.01	-0.02	0.08
A1B_end	GFDL2.0	0.07	0.02	0.07	0.17	0.05	0.62	0.03	-0.02	-0.05	-0.03	-0.04	0.17
A1B_end	GFDL2.1	0.06	0.02	0.06	0.16	0.04	0.66	0.04	-0.02	-0.06	-0.04	-0.05	0.21
A1B_end	MIROC	0.07	0.03	0.08	0.16	0.06	0.60	0.03	-0.01	-0.04	-0.03	-0.03	0.14
A1B_end	MK35	0.09	0.04	0.10	0.21	0.07	0.49	0.00	0.00	-0.02	0.01	-0.02	0.03
A1B_end	ECHAM5	0.07	0.03	0.07	0.17	0.05	0.61	0.03	-0.02	-0.04	-0.02	-0.04	0.15
A2_end	GFDL2.0	0.06	0.02	0.06	0.16	0.04	0.66	0.04	-0.03	-0.06	-0.04	-0.05	0.21
A2_end	GFDL2.1	0.06	0.02	0.06	0.15	0.04	0.67	0.04	-0.02	-0.06	-0.04	-0.05	0.21
A2_end	MIROC	0.07	0.03	0.07	0.17	0.05	0.61	0.03	-0.01	-0.04	-0.03	-0.04	0.15
A2_end	MK35	0.09	0.04	0.10	0.20	0.07	0.51	0.01	-0.01	-0.02	0.01	-0.02	0.05
A2_end	ECHAM5	0.07	0.02	0.07	0.17	0.05	0.62	0.03	-0.02	-0.05	-0.02	-0.04	0.16

Table B-6 South-west Western Australia winter atmospheric predictor means and changes. The first three data columns are the mean values of the respective atmospheric predictors. The next three columns are the changes in predictor values; downscaled values for the present day [1961-2000] relative to NCEP/NCAR Reanalysis [NNR] data; and projections for mid-century and end-of-century periods relative to downscaled present-day values).

PERIOD	DATA/GCM	MSLP	N-S MSLP	DTD 700			
Full	NNR	1017.58	-1.46	15.25			
1st half	NNR	1017.47	-1.47	14.63	-0.11	-0.01	-0.62
2nd half	NNR	1017.93	-1.59	16.70	0.35	-0.13	1.45
20C3M	GFDL2.0	1015.69	-1.23	13.82	-1.89	0.23	-1.43
20C3M	GFDL2.1	1017.92	-2.28	15.38	0.34	-0.82	0.13
20C3M	MIROC	1016.58	-1.40	17.09	-1.00	0.06	1.84
20C3M	MK35	1021.09	-1.82	17.49	3.51	-0.36	2.24
20C3M	ECHAM5	1017.56	-1.45	15.50	-0.02	0.01	0.25
B1_mid	GFDL2.0	1015.97	-1.45	15.32	0.28	-0.22	1.49
B1_mid	GFDL2.1	1019.12	-2.77	17.18	1.20	-0.50	1.80
B1_mid	MIROC	1018.12	-1.86	18.67	1.54	-0.46	1.58
B1_mid	MK35	1021.72	-1.82	18.40	0.63	-0.01	0.90
B1_mid	ECHAM5	1018.42	-1.66	17.45	0.86	-0.21	1.96
A1B_mid	GFDL2.0	1017.41	-1.95	16.64	1.72	-0.72	2.82
A1B_mid	GFDL2.1	1019.67	-2.87	18.46	1.75	-0.59	3.08
A1B_mid	MIROC	1018.20	-1.75	18.65	1.63	-0.36	1.56
A1B_mid	MK35	1021.14	-1.75	18.18	0.05	0.07	0.68
A1B_mid	ECHAM5	1018.50	-1.75	17.14	0.94	-0.30	1.64
A2_mid	GFDL2.0	1016.83	-1.86	16.05	1.14	-0.63	2.23
A2_mid	GFDL2.1	1019.45	-2.86	17.99	1.53	-0.58	2.61
A2_mid	MIROC	1019.08	-2.23	19.07	2.50	-0.84	1.98
A2_mid	MK35	1021.50	-1.86	18.74	0.42	-0.04	1.25
A2_mid	ECHAM5	1018.82	-1.88	17.47	1.27	-0.43	1.97
B1_end	GFDL2.0	1016.57	-1.72	16.12	0.88	-0.48	2.30
B1_end	GFDL2.1	1019.45	-2.83	17.73	1.53	-0.55	2.34
B1_end	MIROC	1018.50	-1.84	18.99	1.92	-0.44	1.90
B1_end	MK35	1021.08	-1.64	18.49	-0.01	0.18	1.00
B1_end	ECHAM5	1018.61	-1.80	18.02	1.05	-0.35	2.52
A1B_end	GFDL2.0	1017.59	-2.11	17.51	1.90	-0.88	3.69
A1B_end	GFDL2.1	1020.68	-3.28	19.61	2.76	-1.00	4.23
A1B_end	MIROC	1019.28	-2.04	20.01	2.70	-0.64	2.92
A1B_end	MK35	1021.81	-1.92	18.74	0.73	-0.10	1.24
A1B_end	ECHAM5	1019.72	-2.30	19.02	2.16	-0.85	3.52
A2_end	GFDL2.0	1018.18	-2.45	18.10	2.48	-1.22	4.28
A2_end	GFDL2.1	1020.66	-3.31	20.03	2.74	-1.03	4.65
A2_end	MIROC	1019.64	-2.10	19.92	3.07	-0.71	2.83
A2_end	MK35	1021.79	-1.99	19.34	0.70	-0.17	1.85
A2_end	ECHAM5	1019.77	-2.33	19.51	2.21	-0.88	4.01

Table B-7 Downscaled projected mean annual maximum and minimum temperatures in °C for mid-century (2047-2064) and end-of-century (2082-2099) periods relative to the present day (1962-1999) for selected sites across SWWA under the SRES A2 emissions scenario.

	MINIMUM TEMPERATURE			MAXIMUM TEMPERATURE		
STATION	PRESENT DAY	MID-CENTURY A2 (HIGH)	END OF CENTURY A2 (HIGH)	PRESENT DAY	MID-CENTURY A2 (HIGH)	END OF CENTURY A2 (HIGH)
Dalwallinu	12.2	14.0–14.8	15.7–16.8	26.0	27.5–28.8	28.6–30.8
Wongan Hills R. S.	11.9	13.6–14.4	15.3–16.4	25.0	26.5–27.7	27.5–29.7
Chidlow	11.1	12.8–13.4	14.4–15.4	23.4	24.8–26.0	26.0–28.0
Gingin	12.4	14.1–14.8	15.7–16.7	24.3	25.8–26.8	26.9–28.7
Perth Airport	12.6	14.1–14.7	15.5–16.5	24.5	26.0–26.8	27.3–28.6
Jarrahdale	10.9	12.4–13.0	13.7–14.8	22.8	24.4–25.1	25.7–26.9
Mundaring Weir	11.9	13.4–14.0	14.8–15.8	24.2	25.7–26.4	26.9–28.2
Serpentine	12.2	13.7–14.2	15.0–16.0	23.9	25.4–26.1	26.7–27.9
Wungong Dam	11.6	13.1–13.7	14.5–15.6	23.3	24.9–25.6	26.1–27.4
Yanchep Park	13.6	15.1–15.7	16.5–17.5	24.0	25.6–26.2	26.8–28.0
Wanneroo	13.1	14.8–15.5	16.5–17.4	23.9	25.4–26.4	26.5–28.3
Bridgetown	8.8	10.3–10.8	11.5–12.5	22.2	23.8–24.5	25.0–26.3
Cape Leeuwin	14.1	15.3–15.8	16.5–17.1	20.1	21.3–21.7	22.5–22.9
Cape Naturaliste	13.0	14.2–14.7	15.4–16.1	21.2	22.5–22.8	23.6–24.3
Donnybrook	10.1	11.7–12.1	12.9–13.9	23.2	24.8–25.5	26.0–27.4
Dwellingup Forestry	10.0	11.4–12.0	12.7–13.8	21.9	23.5–24.2	24.8–26.0
Mandurah Composite	13.1	14.6–15.1	15.9–16.9	23.6	25.1–25.8	26.4–27.6
Pemberton Forestry	10.3	11.6–12.1	12.8–13.6	20.5	22.0–22.4	23.3–23.9
Collie	9.9	11.4–11.9	12.7–13.7	22.4	24.0–24.7	25.2–26.6
Wokalup R. S.	11.7	13.2–13.7	14.5–15.5	23.2	24.7–25.4	26.0–27.2
Bencubbin	11.8	13.7–14.5	15.5–16.7	25.6	27.0–28.5	27.9–30.5
Cunderdin	11.4	13.2–13.9	14.9–16.0	25.3	26.7–28.1	27.6–30.1
Kellerberrin Composite	11.1	12.9–13.6	14.5–15.7	25.0	26.4–27.8	27.4–29.8
Merredin R.S.	11.4	13.2–14.0	14.8–16.1	25.0	26.4–27.9	27.3–29.8
Corrigin	10.1	11.7–12.4	13.2–14.4	23.6	24.9–26.2	25.8–28.2
Darkan	9.1	10.7–11.2	12.1–13.1	21.9	23.3–24.2	24.5–26.1
Katanning	9.5	11.1–11.6	12.5–13.5	22.2	23.5–24.5	24.7–26.4
Lake Grace	10.4	12.0–12.7	13.5–14.6	23.1	24.4–25.7	25.4–27.5
Wandering	9.1	10.8–11.4	12.3–13.4	23.3	24.8–25.8	26.0–27.8

Appendix C – Calibration of NHMM to NWWA Station Network

The new version of the NHMM stochastic downscaling model (Kirshner 2005) developed under IOCI3 was calibrated to two regions in NWWA: a nine-station network in the Kimberley and a ten-station network in the Pilbara (Table C-1, Figure C-1). Of the stations available in the region, those selected had relatively high-quality historical weather records. The NHMM was calibrated for two seasons: a May-October 'winter' half-year and a November-April 'summer' half-year. Calibration involved determining an optimum combination of the number of weather states and set of predictor variables (derived from NCEP/NCAR reanalysis). These predictors represent the key atmospheric processes influencing the rainfall variability for the stations and seasons of interest, such as the position and strength of pressure systems and the degree of saturation of the lower atmosphere. The selected combinations are listed in Table C-2 and the weather states are illustrated in Figures C-2 to C-5.

Table C-1. North-west Western Australia stations selected for NHMM calibration.

		Kimberley		
1	1021	Kalumburu Mission	14.30	126.64
2	2012	Halls Creek Airport	18.23	127.66
3	2016	Lissadell	16.67	128.55
4	2019	Margaret River Station	18.62	126.86
5	3003	Broome Airport	17.95	122.23
6	3017	Mount House Station	17.05	125.70
7	3024	Udialla	17.95	123.74
8	3027	Fossil Downs	18.14	125.78
9	3030	Bidyadanga	18.68	121.78
		Pilbara		
1	4020	Marble Bar Comp	21.18	119.75
2	4032	Port Hedland Airport	20.37	118.63
3	5001	Coolawanyah	21.80	117.81
4	5007	Learmonth Airport	22.24	114.10
5	5008	Mardie	21.19	115.98
6	5052	Karratha Station	20.88	116.68
7	6011	Carnarvon Airport	24.89	113.67
8	6050	Wandagee	23.76	114.55
9	6072	Nyang Station	23.03	115.04
10	7059	Mount Vernon	24.23	118.24

Although the NHMM had been previously applied to SWWA, this was its first use for tropical and subtropical regions. The atmospheric processes influencing rainfall variability may differ between these regions. Thus it was important to assess the validity of the weather states and atmospheric predictor variables that were selected to calibrate the model. Figures C-5 and C-6 illustrate the results of this assessment for sample stations from the two regions for the wet season (i.e, the summer half-year). On the one hand, the figures show that the NHMM simulations *do* reproduce much of the observed interannual variability and long-term trends. On the other hand, they illustrate how extreme wet years can be underestimated.

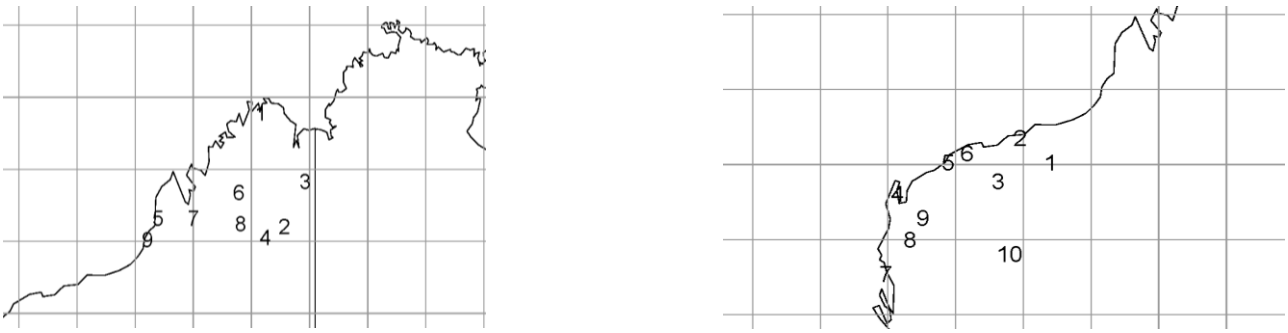

Figure C-1. Location of Kimberley and Pilbara stations used to calibrate a new version of the NHMM downscaling model (grid is the NCEP/NCAR Reanalysis predictor data grid).

For example, consider Kalumburu Mission. Here the NHMM under-estimates wet season rainfall for the summers of 1959/60, 1960/61, 1961/62, 1963/64, 1978/79, 1990/91, 1996/97, and 2001/2002 (Figure C-6). For Carnarvon Airport, rainfall is under-estimated for the several summers including 1962/63, 1966/67, 1969/70 and 1974/75 (Figure C-7). These results are not unexpected given the NHMM is not designed to model extreme daily rainfall.

Table C-2. Number of weather states and predictors of selected NHMMs for North-west Western Australia. Summer is November through April; winter is May through October.

SEASON	KIMBERLEY NHMM*	PILBARA NHMM*
Summer	4 States	4 States
	North - South MSLP gradient	East - West MSLP gradient
	Northerly wind speed @ 850 hPa	Easterley wind speed @ 850 hPa
	DTD @ 850 hPa	DTD @ 700 hPa
Winter	4 States	4 States
	MSLP	East - West MSLP gradient
	East - West MSLP gradient	Easterley wind speed @ 700 hPa
	DTD @ 700 hPa	DTD @ 700 hPa

* MSLP = mean sea level pressure; DTD = dew point temperature depression (air temperature minus dew point temperature).

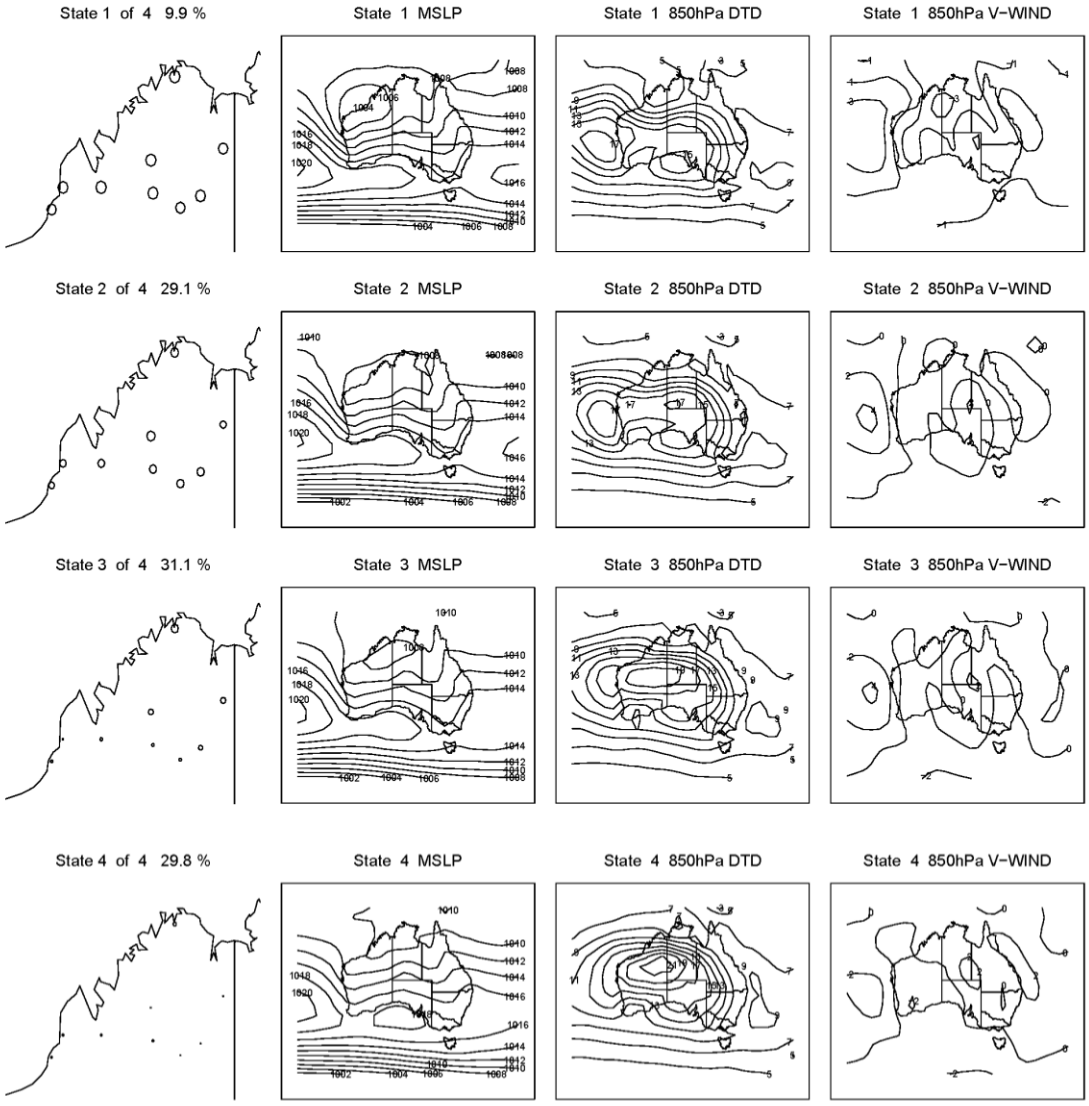

Figure C-2 Kimberley summer weather states as mean precipitation probability maps and corresponding composite atmospheric predictor plots.

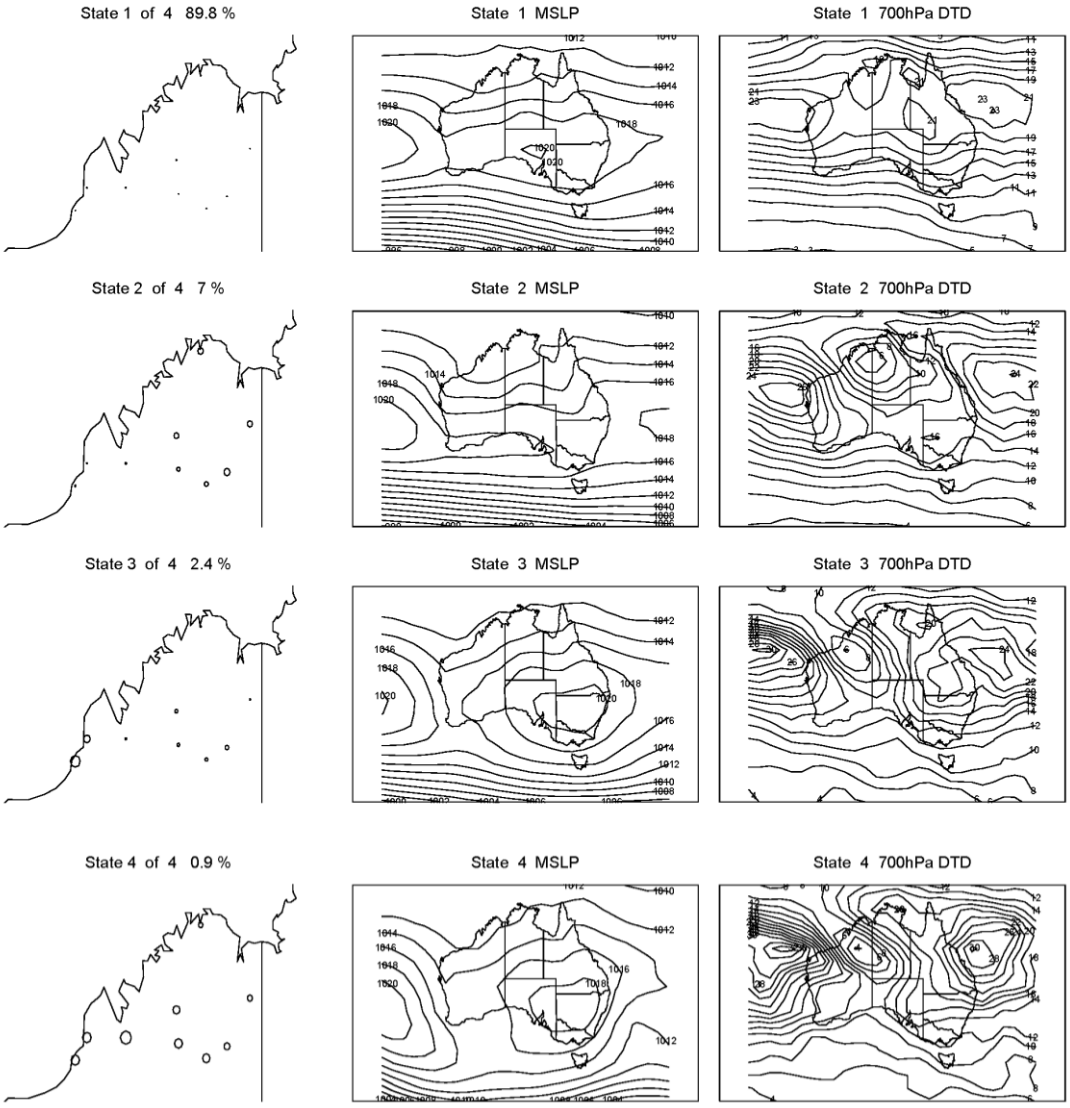

Figure C-3 Kimberley winter weather states as mean precipitation probability maps and corresponding composite atmospheric predictor plots.

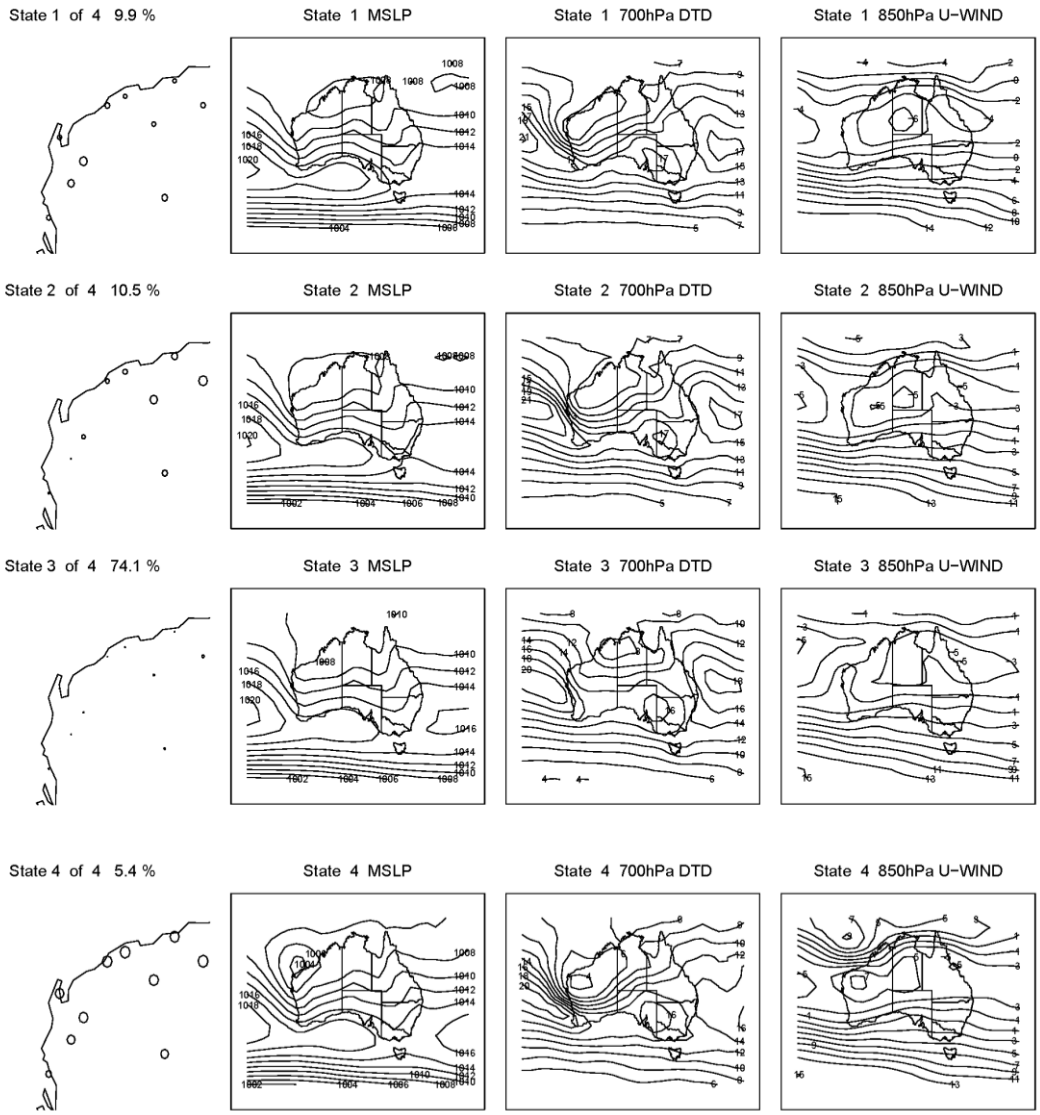

Figure C-4 Pilbara summer weather states as mean precipitation probability maps and corresponding composite atmospheric predictor plots.

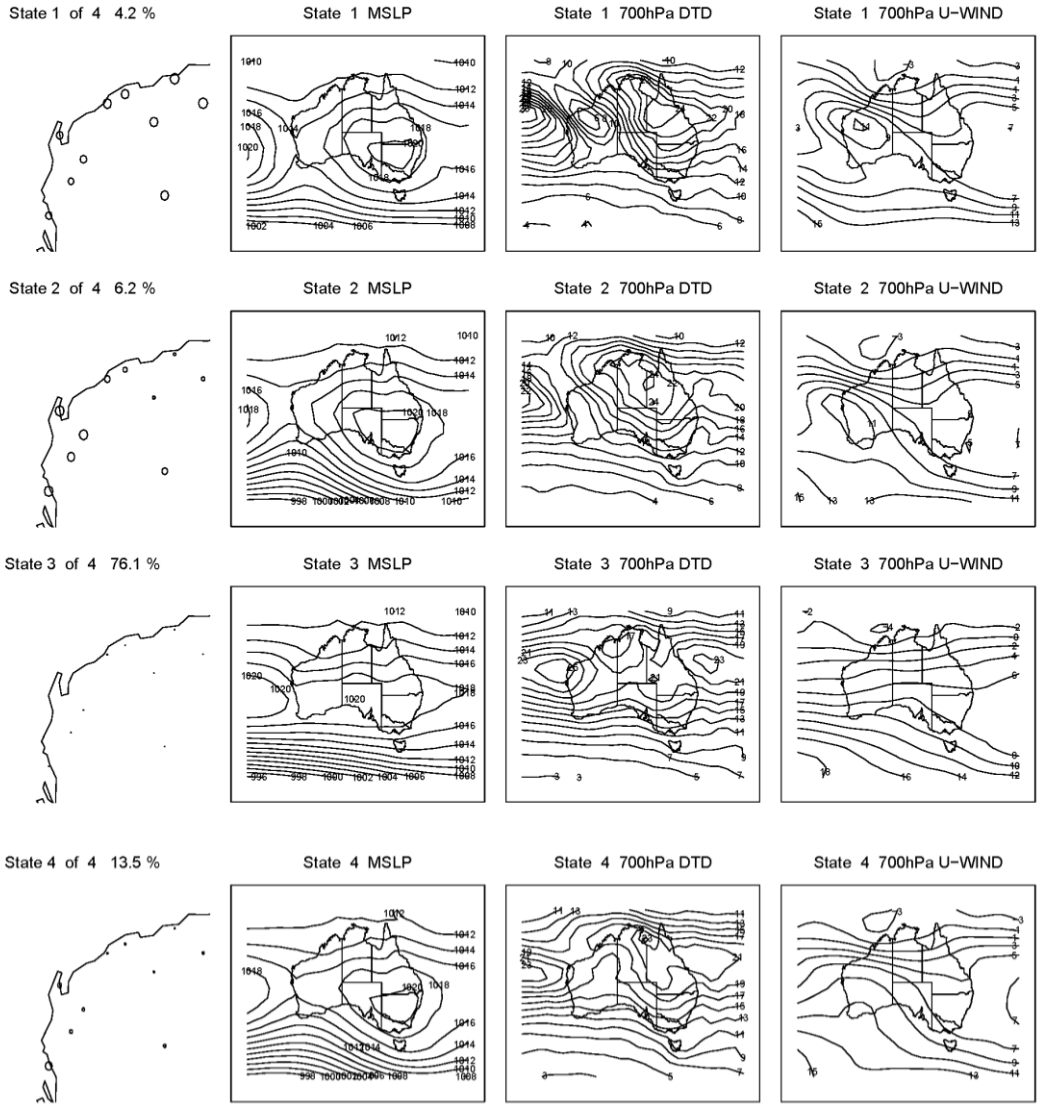

Figure C-5 Pilbara winter weather states as mean precipitation probability maps and corresponding composite atmospheric predictor plots.

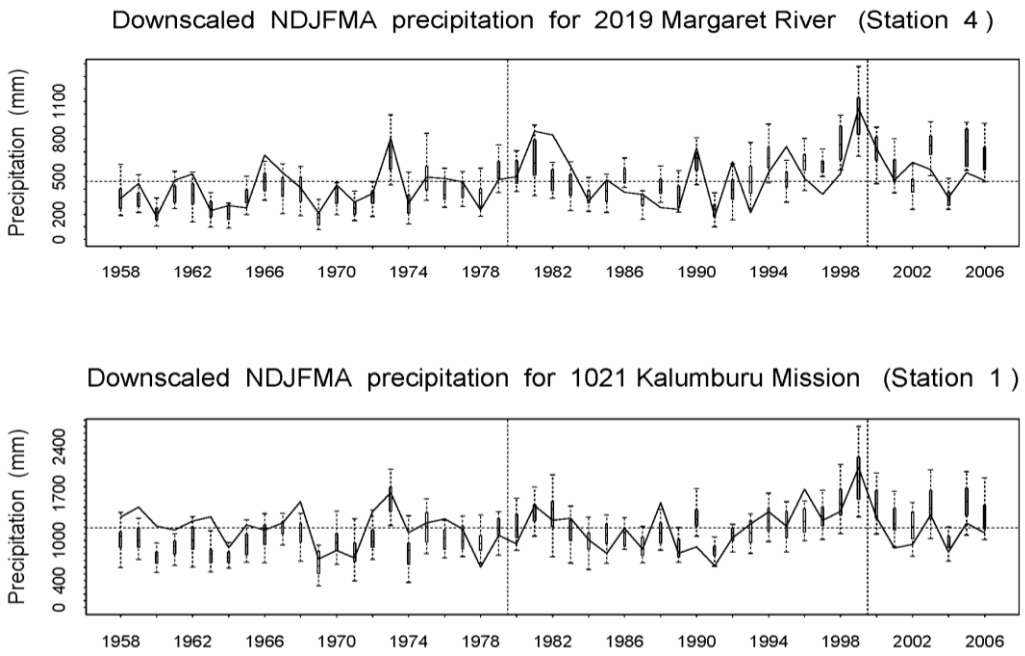

Figure C-6 NHMM simulations reproduce much of the observed interannual rainfall variability and the long-term trends, but also illustrate how extreme wet years can be underestimated. Illustrated here are November-April precipitation amounts for driest (upper plot: Margaret River) and wettest (lower plot: Kalumburu Mission) Kimberley rain gauges. Observed data is shown by solid lines, downscaled simulations by box-plots. Box–plots depict the range of 100 simulation trials (the edges of the box represent the 25th percentile and the 75th percentile of the simulations). The long-term observed mean is indicated by the horizontal dashed line. Vertical dashed lines separate the calibration period (1980/1 to 1999/2000) from the validation periods (1958/9 to 1979/80 and 2000/1 to 2006/7).

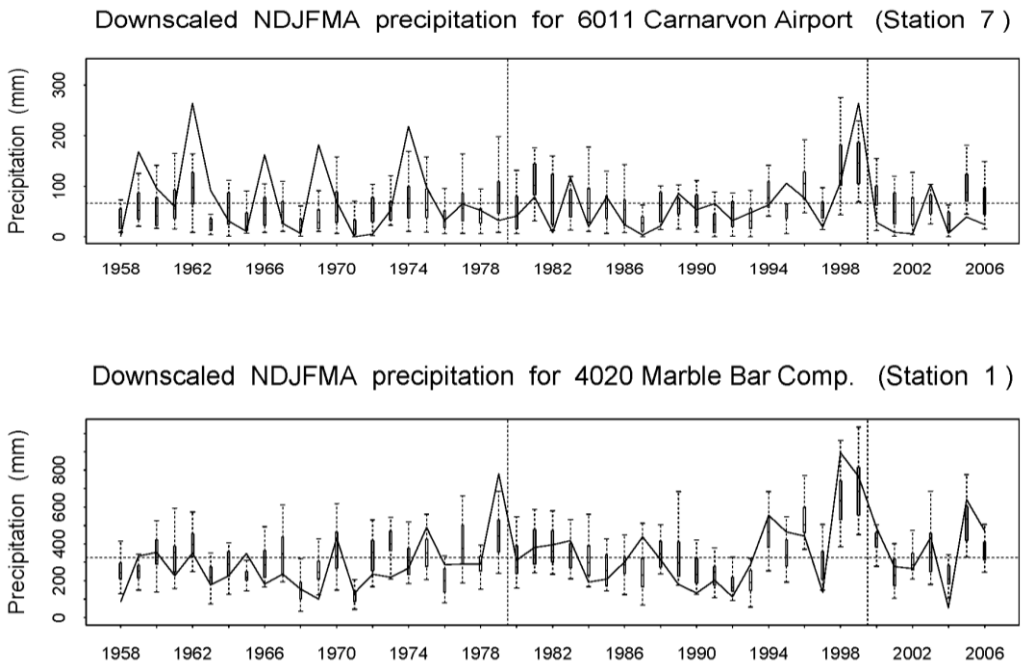

Figure C-7 As in Figure C-6 for sample Pilbara NHMM rain gauges. The Carnarvon Airport station data demonstrates how the model under-simulates several wet seasons (see 1962/63, 1966/67, 1969/70 and 1974/75), indicating that extremes-based methods, rather than the NHMM, are better suited to the task of modelling daily rainfall extremes.

Appendix D – Downscaled Rainfall and Temperature Results for NWWA

Table D-1 Projected proportional change in annual mean rainfall for nine sites in the Kimberley, as a proportion of present-day values (1962-1999). Values are given for mid-century (2047-2064) and end-of-century (2082-2099) periods under three SRES GHG scenarios (B1, A1B and A2). The range of results in each cell reflects the range of downscaled projections produced by the five GCMs, illustrating one source of uncertainty in the results.

STATION	PRESENT DAY	MID-CENTURY B1 (LOW)	MID-CENTURY A1B (MID-RANGE)	MID-CENTURY A2 (HIGH)	END OF CENTURY B1 (LOW)	END OF CENTURY A1B (MID-RANGE)	END OF CENTURY A2 (HIGH)
Kalumburu Mission	1	0.80–0.99	0.83–0.99	0.81–1.03	0.79–0.99	0.79–0.97	0.78–0.99
Halls Creek Airport	1	0.74–0.99	0.75–0.98	0.73–1.05	0.71–0.96	0.71–0.92	0.66–0.96
Lissadell	1	0.79–0.99	0.82–1.00	0.80–1.05	0.77–1.00	0.77–0.96	0.75–1.00
Margaret River Station	1	0.71–0.99	0.74–0.99	0.71–1.06	0.69–0.98	0.69–0.93	0.64–0.97
Broome Airport	1	0.72–0.98	0.73–0.97	0.69–1.06	0.68–0.95	0.68–0.93	0.61–0.96
Mount House Station	1	0.76–0.99	0.78–0.98	0.76–1.04	0.73–0.98	0.73–0.96	0.70–0.99
Udialla	1	0.72–1.00	0.74–0.97	0.71–1.05	0.70–0.97	0.70–0.93	0.65–0.96
Fossil Downs	1	0.72–0.99	0.73–0.98	0.71–1.05	0.69–0.97	0.68–0.95	0.63–0.95
Bidyadanga	1	0.70–0.97	0.74–0.98	0.70–1.04	0.68–0.96	0.68–0.93	0.62–0.94

Table D-2 Present-day and projected annual mean rainfall (in mm) for nine Kimberley stations. Values are given for mid-century (2047-2064) and end-of-century (2082-2099) periods under three SRES GHG scenarios (B1, A1B & A2). The range of results in each cell reflects the range of downscaled projections produced by the five GCMs, illustrating one source of uncertainty in the results.

STATION	PRESENT DAY	MID-CENTURY B1 (LOW)	MID-CENTURY A1B (MID-RANGE)	MID-CENTURY A2 (HIGH)	END OF CENTURY B1 (LOW)	END OF CENTURY A1B (MID-RANGE)	END OF CENTURY A2 (HIGH)
Kalumburu Mission	1260–1280	1030–1250	1070–1260	1030–1320	1010–1260	1010–1240	990–1260
Halls Creek Airport	630–640	470–620	480–610	470–660	450–610	450–590	420–600
Lissadell	670–680	530–660	550–670	540–710	520–660	520–650	510–670
Margaret River Station	530–550	390–530	400–520	380–560	380–530	370–500	340–520
Broome Airport	640–660	480–630	480–630	460–680	450–630	450–600	410–620
Mount House Station	860–890	660–860	690–880	660–920	640–870	640–850	620–860
Udialla	660–680	490–660	500–640	480–690	470–650	470–620	440–630
Fossil Downs	630–650	470–630	470–620	460–660	440–620	440–600	410–600
Bidyadanga	610–630	440–600	460–600	440–640	420–600	420–570	390–580

Table D-3 Projected change in annual mean rainfall for 10 sites in the Pilbara, as a proportion of present-day values (1962-1999), as per the description in Table D-1 above

STATION	PRESENT DAY	MID-CENTURY B1 (LOW)	MID-CENTURY A1B (MID-RANGE)	MID-CENTURY A2 (HIGH)	END OF CENTURY B1 (LOW)	END OF CENTURY A1B (MID-RANGE)	END OF CENTURY A2 (HIGH)
Marble Bar Comp	1	0.82–1.01	0.76–0.98	0.86–1.03	0.79–0.98	0.77–0.90	0.73–0.90
Port Hedland Airport	1	0.82–1.00	0.72–0.98	0.84–1.05	0.75–0.99	0.72–0.88	0.67–0.89
Coolawanyah	1	0.81–0.99	0.73–0.98	0.84–1.04	0.76–0.99	0.74–0.88	0.69–0.88
Learmonth Airport	1	0.87–1.00	0.78–1.00	0.88–1.06	0.81–1.00	0.78–0.94	0.73–0.93
Mardie	1	0.84–1.00	0.72–0.99	0.84–1.07	0.76–0.98	0.72–0.90	0.68–0.90
Karratha Station	1	0.83–0.99	0.71–0.99	0.84–1.07	0.74–0.97	0.73–0.89	0.67–0.88
Carnarvon Airport	1	0.91–1.01	0.86–1.00	0.92–1.05	0.87–1.01	0.86–0.97	0.82–0.99
Wandagee	1	0.88–0.99	0.78–0.99	0.87–1.07	0.80–1.03	0.79–0.92	0.74–0.96
Nyang Station	1	0.86–0.98	0.76–1.00	0.85–1.05	0.77–1.02	0.75–0.92	0.72–0.94
Mount Vernon	1	0.85–0.99	0.79–0.98	0.84–1.02	0.80–1.01	0.78–0.92	0.75–0.95

Table D-4 Present-day and projected annual mean rainfall (in mm) for 10 sites in the Pilbara, as per the description in Table D-2 above.

STATION	PRESENT DAY	MID-CENTURY B1 (LOW)	MID-CENTURY A1B (MID-RANGE)	MID-CENTURY A2 (HIGH)	END OF CENTURY B1 (LOW)	END OF CENTURY A1B (MID-RANGE)	END OF CENTURY A2 (HIGH)
Marble Bar Comp	430–490	350–470	330–460	370–500	340–460	330–420	310–420
Port Hedland Airport	300–360	250–340	220–340	260–380	230–340	220–300	210–310
Coolawanyah	420–480	340–460	300–450	350–500	310–460	310–410	290–410
Learmonth Airport	240–280	210–280	190–270	220–290	200–270	190–240	180–250
Mardie	310–360	260–350	220–340	260–390	230–340	220–300	210–310
Karratha Station	260–300	210–290	180–290	210–320	190–280	190–250	170–250
Carnarvon Airport	220–230	200–230	190–230	200–240	190–230	190–220	180–230
Wandagee	270–310	240–300	210–290	240–330	220–310	210–270	200–290
Nyang Station	310–360	270–350	240–340	270–380	240–360	240–310	230–330
Mount Vernon	300–320	250–310	230–310	250–330	240–320	230–290	220–300

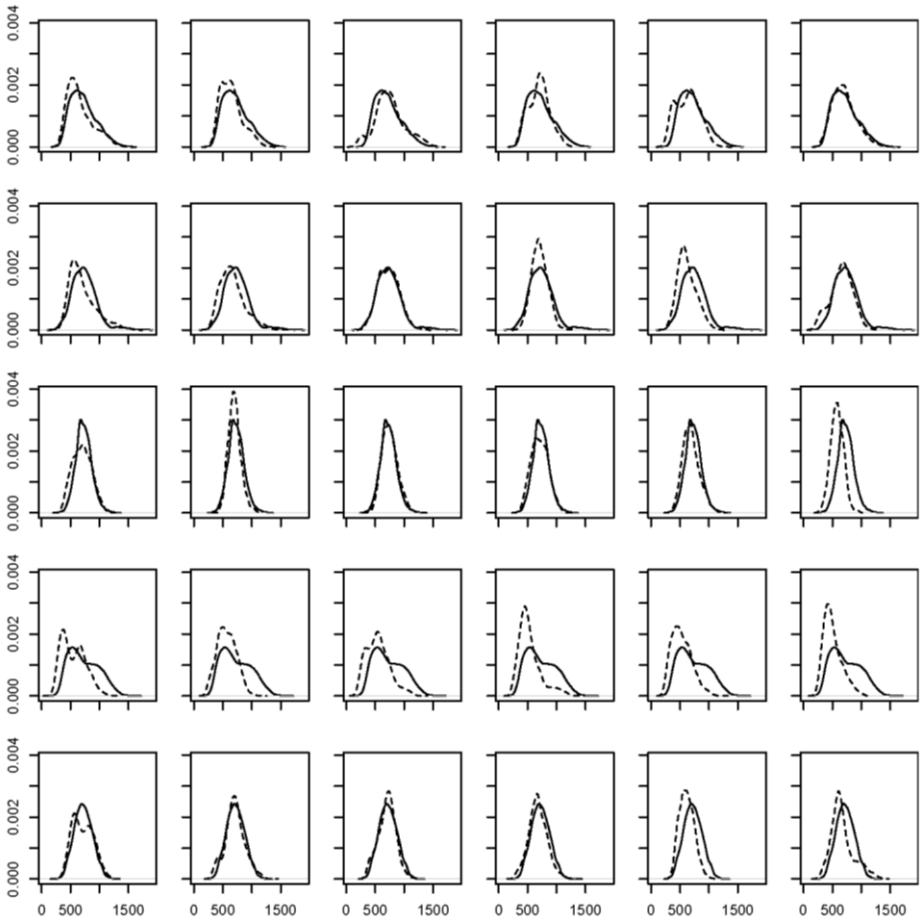

Figure D.1 The probability distribution of downscaled annual rainfall under current climate run (solid lines) compared to the projected climate (dashed lines). Results are averaged across nine Kimberly stations. A shift to the left indicates reduced rainfall in a future scenario. Rows from top to bottom represent the five GCMs (GFDL2.0, GFDL2.1, MIROC-medres, CSIRO Mk3.5 and MPI-ECHAM5) for six SRES scenario and period combinations (columns left to right: B1 mid-century, A1B mid-century, A2 mid-century, B1 end-century, A1B end-century and A2 end-century). The A1B or A2 emissions scenarios for the end of the century produce the most significant change, and suggest this region will be drier than the current period; most GCMs also produce a more peaked distribution (i.e., suggesting decreased interannual rainfall variance.)

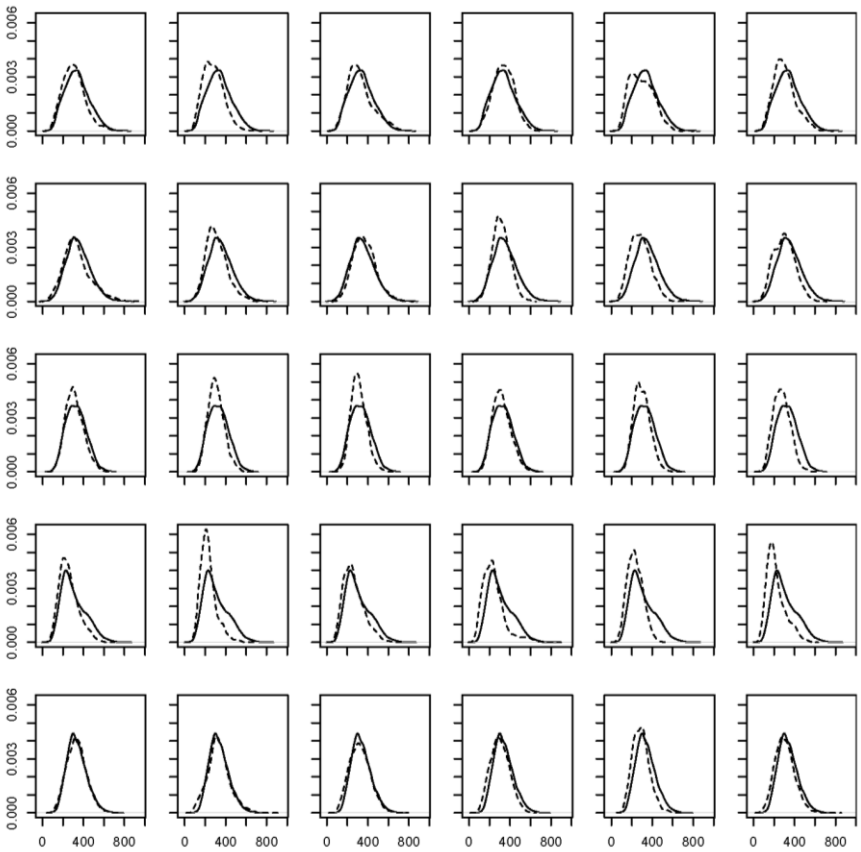

Figure D.2 As for the above, but for results averaged across the 10 Pilbara stations. In most cases an expected shift to drier conditions is projected for the end of the century, but only two global climate models project a more peaked rainfall distribution.

Table D-5 Kimberley summer weather state means and changes. First four data columns are mean frequency of respective weather state. Next four columns are the changes in weather state frequencies relative to the present climate (downscaled values [203CM] for the present day [1961-2000] relative to NCEP/NCAR Reanalysis [NNR] data; and global climate model projections for mid-century and end-of-century periods relative to downscaled present-day values).

PERIOD	DATA/GCM	STATE 1	STATE 2	STATE 3	STATE 4				
Full	NNR	0.09	0.28	0.31	0.31				
1st half	NNR	0.08	0.26	0.32	0.34	-0.01	-0.02	0.01	0.03
2nd half	NNR	0.10	0.31	0.31	0.29	0.01	0.03	0.00	-0.02
20C3M	GFDL2.0	0.10	0.30	0.30	0.29	0.01	0.02	-0.01	-0.02
20C3M	GFDL2.1	0.10	0.33	0.28	0.30	0.01	0.05	-0.03	-0.01
20C3M	MIROC	0.09	0.34	0.28	0.29	0.00	0.06	-0.03	-0.02
20C3M	MK35	0.10	0.31	0.29	0.29	0.01	0.03	-0.02	-0.02
20C3M	ECHAM5	0.10	0.32	0.28	0.30	0.01	0.04	-0.03	-0.01
B1_mid	GFDL2.0	0.09	0.29	0.32	0.30	-0.01	-0.02	0.02	0.01
B1_mid	GFDL2.1	0.10	0.32	0.29	0.30	0.00	-0.01	0.01	0.00
B1_mid	MIROC	0.09	0.33	0.29	0.29	0.00	-0.01	0.01	0.01
B1_mid	MK35	0.07	0.25	0.31	0.37	-0.03	-0.07	0.02	0.08
B1_mid	ECHAM5	0.10	0.32	0.29	0.29	0.00	0.00	0.00	0.00
A1B_mid	GFDL2.0	0.09	0.29	0.33	0.29	-0.02	-0.02	0.03	0.00
A1B_mid	GFDL2.1	0.08	0.29	0.31	0.32	-0.02	-0.03	0.03	0.02
A1B_mid	MIROC	0.08	0.36	0.30	0.26	-0.01	0.02	0.02	-0.03
A1B_mid	MK35	0.07	0.25	0.33	0.35	-0.04	-0.06	0.04	0.06
A1B_mid	ECHAM5	0.09	0.31	0.30	0.29	0.00	-0.01	0.02	-0.01
A2_mid	GFDL2.0	0.10	0.31	0.31	0.27	0.00	0.01	0.01	-0.02
A2_mid	GFDL2.1	0.10	0.31	0.29	0.30	0.00	-0.01	0.01	0.00
A2_mid	MIROC	0.10	0.37	0.30	0.24	0.00	0.02	0.02	-0.04
A2_mid	MK35	0.06	0.25	0.33	0.36	-0.04	-0.06	0.04	0.07
A2_mid	ECHAM5	0.10	0.30	0.29	0.31	0.00	-0.02	0.01	0.01
B1_end	GFDL2.0	0.09	0.33	0.32	0.26	-0.01	0.02	0.02	-0.03
B1_end	GFDL2.1	0.10	0.30	0.29	0.31	0.00	-0.02	0.02	0.01
B1_end	MIROC	0.09	0.34	0.29	0.29	-0.01	0.00	0.01	0.00
B1_end	MK35	0.06	0.24	0.31	0.39	-0.04	-0.08	0.02	0.10
B1_end	ECHAM5	0.09	0.28	0.30	0.33	-0.01	-0.04	0.02	0.03
A1B_end	GFDL2.0	0.08	0.29	0.35	0.29	-0.03	-0.02	0.04	0.00
A1B_end	GFDL2.1	0.08	0.28	0.31	0.33	-0.02	-0.04	0.03	0.03
A1B_end	MIROC	0.08	0.34	0.29	0.28	-0.01	0.00	0.02	-0.01
A1B_end	MK35	0.06	0.23	0.32	0.39	-0.04	-0.08	0.03	0.09
A1B_end	ECHAM5	0.08	0.28	0.33	0.31	-0.02	-0.04	0.04	0.02
A2_end	GFDL2.0	0.09	0.32	0.34	0.26	-0.02	0.01	0.04	-0.03
A2_end	GFDL2.1	0.08	0.30	0.32	0.30	-0.02	-0.02	0.04	0.00
A2_end	MIROC	0.06	0.30	0.31	0.33	-0.03	-0.04	0.03	0.04
A2_end	MK35	0.05	0.24	0.34	0.37	-0.05	-0.07	0.05	0.08
A2_end	ECHAM5	0.09	0.30	0.32	0.30	-0.01	-0.02	0.03	0.00

Table D-6 Kimberley summer atmospheric predictor means and changes. The first three data columns are the mean values of the respective atmospheric predictors. The next three columns are the changes in predictor values; downscaled values for the present day [1961-2000] relative to NCEP/NCAR Reanalysis [NNR] data; and projections for mid-century and end-of-century periods relative to downscaled present-day values.

PERIOD	DATA/GCM	N-S MSLP	V850	DTD850			
Full	NNR	0.22	0.20	13.47			
1st half	NNR	0.12	0.26	13.83	-0.10	0.06	0.36
2nd half	NNR	0.24	0.15	12.64	0.02	-0.05	-0.83
20C3M	GFDL2.0	0.13	-0.48	13.15	-0.09	-0.68	-0.32
20C3M	GFDL2.1	0.47	-0.21	10.25	0.25	-0.41	-3.22
20C3M	MIROC	0.31	-1.19	5.98	0.09	-1.39	-7.49
20C3M	MK35	0.25	-0.46	10.83	0.03	-0.66	-2.64
20C3M	ECHAM5	0.66	-0.58	10.07	0.44	-0.78	-3.40
B1_mid	GFDL2.0	0.12	-0.36	13.69	-0.01	0.11	0.54
B1_mid	GFDL2.1	0.40	-0.35	10.22	-0.07	-0.14	-0.03
B1_mid	MIROC	0.20	-1.18	5.92	-0.11	0.02	-0.06
B1_mid	MK35	0.23	0.12	13.27	-0.02	0.58	2.44
B1_mid	ECHAM5	0.62	-0.58	9.80	-0.04	0.00	-0.27
A1B_mid	GFDL2.0	0.03	-0.38	13.07	-0.10	0.09	-0.08
A1B_mid	GFDL2.1	0.44	-0.29	11.60	-0.03	-0.07	1.35
A1B_mid	MIROC	0.21	-1.20	5.67	-0.10	-0.01	-0.31
A1B_mid	MK35	0.23	0.04	13.10	-0.02	0.50	2.27
A1B_mid	ECHAM5	0.57	-0.65	9.88	-0.09	-0.07	-0.18
A2_mid	GFDL2.0	0.11	-0.45	12.22	-0.03	0.02	-0.93
A2_mid	GFDL2.1	0.50	-0.29	10.54	0.03	-0.07	0.29
A2_mid	MIROC	0.26	-1.38	5.41	-0.05	-0.19	-0.57
A2_mid	MK35	0.24	0.15	13.25	-0.01	0.60	2.42
A2_mid	ECHAM5	0.61	-0.55	10.18	-0.05	0.03	0.11
B1_end	GFDL2.0	0.17	-0.44	12.82	0.04	0.04	-0.34
B1_end	GFDL2.1	0.42	-0.32	10.37	-0.06	-0.11	0.12
B1_end	MIROC	0.22	-1.21	5.97	-0.09	-0.01	-0.01
B1_end	MK35	0.17	0.23	13.50	-0.08	0.69	2.67
B1_end	ECHAM5	0.63	-0.58	10.85	-0.02	0.00	0.78
A1B_end	GFDL2.0	0.03	-0.38	13.59	-0.10	0.10	0.43
A1B_end	GFDL2.1	0.35	-0.28	11.69	-0.12	-0.06	1.44
A1B_end	MIROC	0.12	-1.34	5.69	-0.19	-0.14	-0.29
A1B_end	MK35	0.25	0.18	13.90	0.00	0.63	3.07
A1B_end	ECHAM5	0.60	-0.65	11.36	-0.05	-0.07	1.29
A2_end	GFDL2.0	-0.05	-0.59	12.10	-0.18	-0.11	-1.05
A2_end	GFDL2.1	0.35	-0.30	10.60	-0.12	-0.08	0.34
A2_end	MIROC	-0.05	-1.12	6.27	-0.36	0.08	0.28
A2_end	MK35	0.28	0.30	14.36	0.03	0.75	3.53
A2_end	ECHAM5	0.67	-0.71	11.00	0.02	-0.13	0.94

Table D-7 Kimberley winter weather state means and changes. First four data columns are mean frequency of respective weather state. Next four columns are the changes in weather state frequencies relative to the present climate (downscaled values [203CM] for the present day [1961-2000] relative to NCEP/NCAR Reanalysis [NNR] data; and global climate model projections for mid-century and end-of-century periods relative to downscaled present-day values).

PERIOD	DATA/GCM	STATE 1	STATE 2	STATE 3	STATE 4				
Full	NNR	0.86	0.10	0.03	0.01				
1st half	NNR	0.86	0.10	0.03	0.01	0.00	0.00	0.00	0.00
2nd half	NNR	0.87	0.09	0.03	0.01	0.01	-0.01	0.00	0.00
20C3M	GFDL2.0	0.87	0.09	0.03	0.01	0.01	-0.01	0.00	0.00
20C3M	GFDL2.1	0.87	0.09	0.03	0.01	0.01	-0.01	0.00	0.00
20C3M	MIROC	0.87	0.09	0.03	0.01	0.01	-0.01	0.00	0.00
20C3M	MK35	0.87	0.09	0.03	0.01	0.01	-0.01	0.00	0.00
20C3M	ECHAM5	0.87	0.09	0.03	0.01	0.01	-0.01	0.00	0.00
B1_mid	GFDL2.0	0.87	0.09	0.03	0.01	0.00	0.00	0.00	0.00
B1_mid	GFDL2.1	0.87	0.09	0.03	0.01	0.00	0.00	0.00	0.00
B1_mid	MIROC	0.88	0.08	0.03	0.01	0.01	-0.01	0.00	0.00
B1_mid	MK35	0.89	0.08	0.03	0.01	0.02	-0.01	0.00	0.00
B1_mid	ECHAM5	0.88	0.08	0.03	0.01	0.01	-0.01	0.00	0.00
A1B_mid	GFDL2.0	0.88	0.08	0.03	0.01	0.01	-0.01	0.00	0.00
A1B_mid	GFDL2.1	0.89	0.08	0.03	0.01	0.02	-0.01	0.00	0.00
A1B_mid	MIROC	0.89	0.07	0.03	0.01	0.02	-0.02	0.00	0.00
A1B_mid	MK35	0.88	0.08	0.03	0.01	0.01	-0.01	0.00	0.00
A1B_mid	ECHAM5	0.88	0.08	0.03	0.01	0.01	-0.01	0.00	0.00
A2_mid	GFDL2.0	0.87	0.09	0.03	0.01	0.00	0.00	0.00	0.00
A2_mid	GFDL2.1	0.88	0.09	0.03	0.01	0.01	0.00	0.00	0.00
A2_mid	MIROC	0.89	0.07	0.03	0.01	0.01	-0.02	0.00	0.00
A2_mid	MK35	0.89	0.08	0.03	0.01	0.01	-0.01	0.00	0.00
A2_mid	ECHAM5	0.88	0.08	0.03	0.01	0.01	-0.01	0.00	0.00
B1_end	GFDL2.0	0.87	0.09	0.03	0.01	0.00	0.00	0.00	0.00
B1_end	GFDL2.1	0.88	0.08	0.03	0.01	0.01	-0.01	0.00	0.00
B1_end	MIROC	0.89	0.07	0.03	0.01	0.02	-0.02	0.00	0.00
B1_end	MK35	0.89	0.08	0.03	0.01	0.02	-0.01	0.00	0.00
B1_end	ECHAM5	0.88	0.08	0.03	0.01	0.01	-0.01	0.00	0.00
A1B_end	GFDL2.0	0.88	0.08	0.03	0.01	0.01	-0.01	0.00	0.00
A1B_end	GFDL2.1	0.89	0.07	0.03	0.01	0.02	-0.02	0.00	0.00
A1B_end	MIROC	0.90	0.06	0.03	0.01	0.03	-0.03	0.00	0.00
A1B_end	MK35	0.89	0.07	0.03	0.01	0.02	-0.01	0.00	0.00
A1B_end	ECHAM5	0.88	0.08	0.03	0.01	0.01	-0.01	0.00	0.00
A2_end	GFDL2.0	0.87	0.08	0.03	0.01	0.00	-0.01	0.00	0.00
A2_end	GFDL2.1	0.88	0.08	0.03	0.01	0.01	-0.01	0.00	0.00
A2_end	MIROC	0.90	0.06	0.03	0.01	0.03	-0.03	0.00	0.00
A2_end	MK35	0.89	0.08	0.03	0.01	0.01	-0.01	-0.01	0.00
A2_end	ECHAM5	0.88	0.08	0.03	0.01	0.01	-0.01	0.00	0.00

Table D-8 Kimberley winter atmospheric predictor means and changes. The first three data columns are the mean values of the respective atmospheric predictors. The next three columns are the changes in predictor values; downscaled values for the present day [1961-2000] relative to NCEP/NCAR Reanalysis [NNR] data; and projections for mid-century and end-of-century periods relative to downscaled present-day values.

PERIOD	DATA/GCM	MSLP	E-W MSLP	DTD700			
Full	NNR	1013.20	-0.24	17.36			
1st half	NNR	1013.07	-0.28	16.67	-0.13	-0.04	-0.69
2nd half	NNR	1013.31	-0.11	18.86	0.11	0.13	1.50
20C3M	GFDL2.0	1012.15	-0.43	17.09	-1.05	-0.19	-0.27
20C3M	GFDL2.1	1011.85	-0.37	15.66	-1.35	-0.13	-1.70
20C3M	MIROC	1012.96	0.39	13.65	-0.24	0.63	-3.71
20C3M	MK35	1015.63	0.45	16.11	2.43	0.69	-1.25
20C3M	ECHAM5	1012.76	0.04	18.70	-0.44	0.28	1.34
B1_mid	GFDL2.0	1012.13	-0.40	17.51	-0.02	0.03	0.42
B1_mid	GFDL2.1	1011.89	-0.26	15.06	0.04	0.11	-0.60
B1_mid	MIROC	1013.45	0.45	13.09	0.49	0.05	-0.56
B1_mid	MK35	1016.42	0.32	17.44	0.79	-0.13	1.33
B1_mid	ECHAM5	1013.10	0.10	19.38	0.33	0.06	0.68
A1B_mid	GFDL2.0	1012.44	-0.35	17.09	0.30	0.08	0.00
A1B_mid	GFDL2.1	1012.44	-0.32	17.31	0.59	0.04	1.65
A1B_mid	MIROC	1013.78	0.45	13.79	0.82	0.05	0.15
A1B_mid	MK35	1016.05	0.35	16.08	0.42	-0.10	-0.03
A1B_mid	ECHAM5	1013.02	0.16	18.80	0.26	0.12	0.10
A2_mid	GFDL2.0	1012.11	-0.41	17.31	-0.04	0.02	0.23
A2_mid	GFDL2.1	1012.06	-0.32	16.22	0.21	0.05	0.56
A2_mid	MIROC	1013.57	0.49	12.69	0.61	0.09	-0.96
A2_mid	MK35	1016.18	0.32	16.56	0.55	-0.13	0.45
A2_mid	ECHAM5	1013.15	0.14	18.94	0.38	0.10	0.24
B1_end	GFDL2.0	1012.07	-0.37	16.62	-0.07	0.06	-0.47
B1_end	GFDL2.1	1012.11	-0.34	16.45	0.25	0.03	0.78
B1_end	MIROC	1013.89	0.40	13.78	0.93	0.00	0.13
B1_end	MK35	1016.29	0.31	17.41	0.65	-0.14	1.31
B1_end	ECHAM5	1013.11	0.08	19.06	0.35	0.04	0.35
A1B_end	GFDL2.0	1012.29	-0.29	17.21	0.15	0.14	0.12
A1B_end	GFDL2.1	1012.44	-0.28	18.07	0.59	0.09	2.41
A1B_end	MIROC	1014.23	0.45	14.02	1.27	0.06	0.37
A1B_end	MK35	1016.43	0.32	16.57	0.80	-0.13	0.47
A1B_end	ECHAM5	1013.06	0.13	18.47	0.30	0.09	-0.24
A2_end	GFDL2.0	1012.23	-0.30	15.76	0.08	0.13	-1.33
A2_end	GFDL2.1	1012.31	-0.30	16.71	0.46	0.06	1.05
A2_end	MIROC	1014.31	0.47	13.51	1.35	0.08	-0.14
A2_end	MK35	1016.25	0.27	17.37	0.62	-0.18	1.26
A2_end	ECHAM5	1013.11	0.12	19.12	0.35	0.08	0.42

Table D-9 Pilbara summer weather state means and changes. First four data columns are mean frequency of respective weather state. Next four columns are the changes in weather state frequencies relative to the present climate (downscaled values [203CM] for the present day [1961-2000] relative to NCEP/NCAR Reanalysis [NNR] data; and global climate model projections for mid-century and end-of-century periods relative to downscaled present-day values).

PERIOD	DATA/GCM	STATE 1	STATE 2	STATE 3	STATE 4				
Full	NNR	0.11	0.11	0.73	0.05				
1st half	NNR	0.10	0.10	0.74	0.05	-0.01	-0.01	0.01	0.00
2nd half	NNR	0.11	0.12	0.72	0.05	0.00	0.01	-0.01	0.00
20C3M	GFDL2.0	0.12	0.11	0.70	0.07	0.01	0.00	-0.03	0.02
20C3M	GFDL2.1	0.12	0.12	0.69	0.07	0.02	0.01	-0.04	0.02
20C3M	MIROC	0.11	0.13	0.69	0.06	0.01	0.02	-0.04	0.01
20C3M	MK35	0.11	0.12	0.71	0.05	0.01	0.01	-0.02	0.00
20C3M	ECHAM5	0.12	0.11	0.70	0.07	0.01	0.01	-0.04	0.02
B1_mid	GFDL2.0	0.11	0.10	0.73	0.06	-0.01	-0.01	0.03	-0.01
B1_mid	GFDL2.1	0.12	0.10	0.71	0.07	0.00	-0.01	0.02	-0.01
B1_mid	MIROC	0.11	0.13	0.70	0.06	0.00	0.00	0.01	-0.01
B1_mid	MK35	0.10	0.09	0.77	0.04	-0.01	-0.02	0.05	-0.01
B1_mid	ECHAM5	0.11	0.11	0.71	0.07	-0.01	0.00	0.01	0.00
A1B_mid	GFDL2.0	0.12	0.10	0.73	0.05	0.00	-0.01	0.03	-0.02
A1B_mid	GFDL2.1	0.11	0.09	0.74	0.06	-0.01	-0.02	0.05	-0.02
A1B_mid	MIROC	0.10	0.13	0.72	0.05	-0.01	0.00	0.02	-0.01
A1B_mid	MK35	0.09	0.10	0.78	0.03	-0.02	-0.02	0.07	-0.02
A1B_mid	ECHAM5	0.11	0.11	0.71	0.06	0.00	0.00	0.01	0.00
A2_mid	GFDL2.0	0.13	0.11	0.70	0.06	0.01	0.00	0.00	-0.01
A2_mid	GFDL2.1	0.13	0.11	0.69	0.08	0.00	-0.01	0.00	0.00
A2_mid	MIROC	0.10	0.13	0.71	0.06	-0.01	0.00	0.01	-0.01
A2_mid	MK35	0.09	0.10	0.77	0.04	-0.02	-0.02	0.05	-0.01
A2_mid	ECHAM5	0.10	0.11	0.73	0.06	-0.02	-0.01	0.03	-0.01
B1_end	GFDL2.0	0.14	0.12	0.68	0.07	0.02	0.01	-0.02	0.00
B1_end	GFDL2.1	0.11	0.10	0.73	0.06	-0.02	-0.01	0.04	-0.01
B1_end	MIROC	0.11	0.13	0.70	0.06	0.00	0.00	0.01	0.00
B1_end	MK35	0.08	0.09	0.79	0.03	-0.03	-0.03	0.08	-0.02
B1_end	ECHAM5	0.11	0.10	0.74	0.05	-0.01	-0.01	0.04	-0.01
A1B_end	GFDL2.0	0.11	0.10	0.74	0.05	-0.01	-0.01	0.04	-0.02
A1B_end	GFDL2.1	0.10	0.09	0.76	0.05	-0.03	-0.02	0.07	-0.02
A1B_end	MIROC	0.10	0.12	0.73	0.05	-0.02	-0.01	0.04	-0.01
A1B_end	MK35	0.08	0.09	0.79	0.03	-0.03	-0.03	0.08	-0.02
A1B_end	ECHAM5	0.09	0.09	0.76	0.05	-0.02	-0.02	0.06	-0.02
A2_end	GFDL2.0	0.14	0.11	0.70	0.05	0.03	0.00	0.00	-0.02
A2_end	GFDL2.1	0.13	0.10	0.72	0.05	0.01	-0.02	0.03	-0.02
A2_end	MIROC	0.09	0.11	0.75	0.05	-0.02	-0.02	0.06	-0.02
A2_end	MK35	0.08	0.09	0.80	0.03	-0.03	-0.03	0.09	-0.03
A2_end	ECHAM5	0.10	0.10	0.74	0.06	-0.01	-0.01	0.04	-0.01

Table D-10 Pilbara summer atmospheric predictor means and changes. The first three data columns are the mean values of the respective atmospheric predictors. The next three columns are the changes in predictor values; downscaled values for the present day [1961-2000] relative to NCEP/NCAR Reanalysis [NNR] data; and projections for mid-century and end-of-century periods relative to downscaled present-day values.

PERIOD	DATA/GCM	E-W MSLP	U850	DTD700			
Full	NNR	-0.70	-1.46	13.19			
1st half	NNR	-0.78	-1.78	13.01	-0.08	-0.32	-0.18
2nd half	NNR	-0.62	-1.07	13.66	0.08	0.39	0.47
20C3M	GFDL2.0	-0.57	-1.68	15.28	0.13	-0.22	2.09
20C3M	GFDL2.1	-0.24	0.03	13.58	0.46	1.49	0.39
20C3M	MIROC	0.34	-0.56	10.48	1.04	0.90	-2.71
20C3M	MK35	-0.18	-0.24	13.22	0.52	1.22	0.03
20C3M	ECHAM5	-0.07	-0.36	12.03	0.63	1.10	-1.16
B1_mid	GFDL2.0	-0.63	-1.96	15.72	-0.06	-0.28	0.44
B1_mid	GFDL2.1	-0.30	-0.26	13.59	-0.06	-0.29	0.01
B1_mid	MIROC	0.31	-0.90	10.12	-0.04	-0.34	-0.36
B1_mid	MK35	-0.39	-1.17	13.21	-0.21	-0.93	0.00
B1_mid	ECHAM5	-0.07	-0.43	12.12	0.00	-0.07	0.09
A1B_mid	GFDL2.0	-0.69	-1.98	15.59	-0.12	-0.31	0.31
A1B_mid	GFDL2.1	-0.44	-0.44	14.23	-0.19	-0.47	0.65
A1B_mid	MIROC	0.33	-0.48	10.98	-0.02	0.08	0.50
A1B_mid	MK35	-0.47	-0.82	13.90	-0.29	-0.58	0.68
A1B_mid	ECHAM5	-0.08	-0.65	11.99	-0.01	-0.29	-0.04
A2_mid	GFDL2.0	-0.61	-1.44	15.08	-0.04	0.24	-0.20
A2_mid	GFDL2.1	-0.32	0.21	13.75	-0.08	0.18	0.17
A2_mid	MIROC	0.33	-0.40	10.79	-0.01	0.16	0.31
A2_mid	MK35	-0.33	-0.96	13.65	-0.15	-0.71	0.43
A2_mid	ECHAM5	-0.12	-0.65	12.38	-0.05	-0.29	0.35
B1_end	GFDL2.0	-0.56	-1.59	14.38	0.00	0.09	-0.91
B1_end	GFDL2.1	-0.35	-0.29	14.12	-0.10	-0.32	0.54
B1_end	MIROC	0.31	-0.50	10.56	-0.03	0.06	0.08
B1_end	MK35	-0.45	-1.19	13.86	-0.27	-0.95	0.65
B1_end	ECHAM5	-0.22	-0.81	12.26	-0.15	-0.45	0.23
A1B_end	GFDL2.0	-0.68	-2.16	15.15	-0.12	-0.48	-0.14
A1B_end	GFDL2.1	-0.50	-0.61	14.38	-0.26	-0.64	0.80
A1B_end	MIROC	0.28	-0.65	11.33	-0.06	-0.09	0.85
A1B_end	MK35	-0.49	-1.15	14.12	-0.31	-0.91	0.90
A1B_end	ECHAM5	-0.25	-1.01	12.81	-0.18	-0.65	0.78
A2_end	GFDL2.0	-0.64	-2.13	14.25	-0.07	-0.46	-1.04
A2_end	GFDL2.1	-0.46	-0.31	13.25	-0.21	-0.34	-0.33
A2_end	MIROC	0.29	-1.46	11.26	-0.05	-0.90	0.78
A2_end	MK35	-0.49	-1.22	13.93	-0.31	-0.98	0.71
A2_end	ECHAM5	-0.17	-0.70	12.43	-0.10	-0.34	0.40

Table D-11 Pilbara winter weather state means and changes. First four data columns are mean frequency of respective weather state. Next four columns are the changes in weather state frequencies relative to the present climate (downscaled values [203CM] for the present day [1961-2000] relative to NCEP/NCAR Reanalysis [NNR] data; and global climate model projections for mid-century and end-of-century periods relative to downscaled present-day values)

PERIOD	DATA/GCM	STATE 1	STATE 2	STATE 3	STATE 4				
Full	NNR	0.04	0.07	0.67	0.22				
1st half	NNR	0.04	0.07	0.67	0.22				
2nd half	NNR	0.05	0.08	0.65	0.22				
20C3M	GFDL2.0	0.04	0.07	0.66	0.22	0.00	0.00	-0.01	0.00
20C3M	GFDL2.1	0.04	0.07	0.66	0.22	0.00	0.00	-0.01	0.00
20C3M	MIROC	0.05	0.07	0.66	0.22	0.01	0.00	-0.01	0.00
20C3M	MK35	0.05	0.07	0.66	0.22	0.01	0.00	-0.01	0.00
20C3M	ECHAM5	0.05	0.07	0.66	0.22	0.01	0.00	-0.01	0.00
B1_mid	GFDL2.0	0.05	0.07	0.66	0.22	0.00	0.00	0.00	0.00
B1_mid	GFDL2.1	0.05	0.08	0.65	0.22	0.00	0.00	-0.01	0.00
B1_mid	MIROC	0.05	0.08	0.66	0.22	0.00	0.00	-0.01	0.00
B1_mid	MK35	0.04	0.07	0.67	0.22	0.00	-0.01	0.01	0.00
B1_mid	ECHAM5	0.05	0.07	0.66	0.22	0.00	0.00	0.00	0.00
A1B_mid	GFDL2.0	0.05	0.08	0.65	0.22	0.00	0.00	-0.01	0.00
A1B_mid	GFDL2.1	0.05	0.08	0.66	0.22	0.00	0.00	-0.01	0.00
A1B_mid	MIROC	0.04	0.08	0.66	0.22	0.00	0.00	-0.01	0.00
A1B_mid	MK35	0.04	0.07	0.68	0.22	0.00	-0.01	0.01	0.00
A1B_mid	ECHAM5	0.05	0.08	0.65	0.22	0.00	0.00	-0.01	0.00
A2_mid	GFDL2.0	0.05	0.07	0.66	0.22	0.00	0.00	0.00	0.00
A2_mid	GFDL2.1	0.05	0.08	0.65	0.22	0.00	0.00	-0.01	0.00
A2_mid	MIROC	0.05	0.08	0.65	0.23	0.00	0.00	-0.01	0.00
A2_mid	MK35	0.04	0.07	0.67	0.22	0.00	0.00	0.01	0.00
A2_mid	ECHAM5	0.05	0.08	0.65	0.22	0.00	0.00	-0.01	0.00
B1_end	GFDL2.0	0.05	0.08	0.66	0.22	0.00	0.00	-0.01	0.00
B1_end	GFDL2.1	0.05	0.08	0.66	0.22	0.00	0.00	-0.01	0.00
B1_end	MIROC	0.04	0.07	0.66	0.22	0.00	0.00	0.00	0.00
B1_end	MK35	0.04	0.07	0.67	0.22	0.00	-0.01	0.01	0.00
B1_end	ECHAM5	0.05	0.08	0.66	0.22	0.00	0.00	0.00	0.00
A1B_end	GFDL2.0	0.05	0.08	0.65	0.22	0.00	0.00	-0.01	0.00
A1B_end	GFDL2.1	0.05	0.08	0.65	0.22	0.00	0.00	-0.01	0.00
A1B_end	MIROC	0.05	0.08	0.65	0.22	0.00	0.00	-0.01	0.00
A1B_end	MK35	0.04	0.06	0.68	0.22	0.00	-0.01	0.02	-0.01
A1B_end	ECHAM5	0.05	0.07	0.66	0.22	0.00	0.00	0.00	0.00
A2_end	GFDL2.0	0.05	0.08	0.65	0.22	0.00	0.00	-0.01	0.00
A2_end	GFDL2.1	0.05	0.08	0.65	0.22	0.00	0.00	-0.01	0.00
A2_end	MIROC	0.05	0.08	0.65	0.22	0.00	0.00	-0.01	0.00
A2_end	MK35	0.04	0.06	0.68	0.21	0.00	-0.01	0.02	-0.01
A2_end	ECHAM5	0.05	0.08	0.66	0.22	0.00	0.00	0.00	0.00

Table D-12 Pilbara winter atmospheric predictor means and changes. The first three data columns are the mean values of the respective atmospheric predictors. The next three columns are the changes in predictor values; downscaled values for the present day (1961-2000] relative to NCEP/NCAR Reanalysis (NNR) data; and projections for mid-century and end-of-century periods relative to downscaled present-day values.

PERIOD	DATA/GCM	E-W MSLP	U700	DTD700			
Full	NNR	-0.45	3.70	20.72			
1st half	NNR	-0.50	3.87	19.41	-0.05	0.17	-1.31
2nd half	NNR	-0.34	3.31	22.60	0.11	-0.39	1.88
20C3M	GFDL2.0	-0.83	4.74	24.44	-0.38	1.04	3.72
20C3M	GFDL2.1	-0.71	4.25	22.20	-0.26	0.55	1.48
20C3M	MIROC	0.23	3.43	18.74	0.68	-0.27	-1.98
20C3M	MK35	0.28	4.99	20.74	0.73	1.29	0.02
20C3M	ECHAM5	-0.49	2.88	22.01	-0.04	-0.82	1.29
B1_mid	GFDL2.0	-0.83	4.68	25.35	0.00	-0.05	0.91
B1_mid	GFDL2.1	-0.63	3.64	22.47	0.08	-0.61	0.27
B1_mid	MIROC	0.29	3.51	18.69	0.06	0.08	-0.05
B1_mid	MK35	0.15	4.56	20.73	-0.14	-0.42	0.00
B1_mid	ECHAM5	-0.50	2.70	23.43	-0.01	-0.18	1.42
A1B_mid	GFDL2.0	-0.79	4.20	25.22	0.04	-0.53	0.78
A1B_mid	GFDL2.1	-0.71	3.42	24.76	0.00	-0.82	2.57
A1B_mid	MIROC	0.29	3.48	18.84	0.05	0.05	0.10
A1B_mid	MK35	0.14	4.67	19.79	-0.14	-0.32	-0.95
A1B_mid	ECHAM5	-0.43	2.87	23.01	0.06	-0.01	1.00
A2_mid	GFDL2.0	-0.83	4.52	25.36	0.00	-0.21	0.92
A2_mid	GFDL2.1	-0.69	3.60	23.74	0.02	-0.64	1.54
A2_mid	MIROC	0.36	2.99	17.71	0.13	-0.44	-1.04
A2_mid	MK35	0.12	4.94	20.86	-0.16	-0.05	0.12
A2_mid	ECHAM5	-0.45	2.75	23.14	0.04	-0.13	1.13
B1_end	GFDL2.0	-0.79	4.39	25.01	0.04	-0.35	0.57
B1_end	GFDL2.1	-0.72	3.93	23.95	-0.01	-0.31	1.75
B1_end	MIROC	0.24	3.40	18.89	0.01	-0.04	0.14
B1_end	MK35	0.13	4.77	20.69	-0.15	-0.21	-0.04
B1_end	ECHAM5	-0.49	2.94	23.85	0.00	0.06	1.84
A1B_end	GFDL2.0	-0.73	4.05	25.62	0.09	-0.68	1.18
A1B_end	GFDL2.1	-0.67	3.21	24.82	0.04	-1.03	2.62
A1B_end	MIROC	0.30	3.28	19.23	0.07	-0.15	0.49
A1B_end	MK35	0.13	4.21	19.31	-0.15	-0.78	-1.43
A1B_end	ECHAM5	-0.48	2.32	23.20	0.01	-0.56	1.19
A2_end	GFDL2.0	-0.74	4.40	24.26	0.09	-0.33	-0.18
A2_end	GFDL2.1	-0.69	3.58	24.57	0.02	-0.67	2.38
A2_end	MIROC	0.32	3.16	19.09	0.08	-0.27	0.35
A2_end	MK35	0.06	4.32	20.11	-0.22	-0.67	-0.63
A2_end	ECHAM5	-0.49	2.33	23.55	0.00	-0.55	1.54

Table D-13 Downscaled projected mean annual maximum and minimum temperatures in oC for nine Kimberley stations for mid-century (2047-2064) and end-of-century (2082-2099) periods for the SRES A2 GHG emissions scenario, relative to present day (1962-1999).

STATION	MINIMUM TEMPERATURE			MAXIMUM TEMPERATURE		
	PRESENT DAY	MID-CENTURY A2 (HIGH)	END OF CENTURY A2 (HIGH)	PRESENT DAY	MID-CENTURY A2 (HIGH)	END OF CENTURY A2 (HIGH)
Kalumburu Mission	21.0	23.0–23.6	25.0–25.7	34.4	36.0–37.2	37.5–38.8
Halls Creek Airport	20.3	22.4–23.2	24.7–25.7	33.6	35.5–36.5	37.5–38.6
Lissadell	21.5	23.6–24.4	25.8–26.8	35.3	37.1–38.2	38.9–40.1
Margaret River Station	20.5	22.6–23.4	24.9–25.8	34.6	36.6–37.5	38.5–39.7
Broome Airport	21.2	22.8–23.2	24.5–25.2	32.3	33.6–33.9	35.2–35.8
Mount House Station	19.7	21.7–22.3	23.9–24.6	34.2	35.9–37.0	37.6–38.9
Udialla	21.3	23.3–24.1	25.7–26.3	34.7	36.5–37.6	38.4–39.7
Fossil Downs	20.8	22.9–23.6	25.3–26.0	35.6	37.4–38.4	39.3–40.4
Bidyadanga	20.7	22.8–23.4	25.0–25.7	33.3	35.1–35.9	37.1–37.7

Table D-14. Downscaled projected mean annual maximum and minimum temperatures in oC for selected Pilbara stations for mid-century (2047-2064) and end-of-century (2082-2099) periods for an SRES A2 GHG emissions scenario relative to present day (1962-1999).

STATION	MINIMUM TEMPERATURE			MAXIMUM TEMPERATURE		
	PRESENT DAY	MID-CENTURY A2 (HIGH)	END OF CENTURY A2 (HIGH)	PRESENT DAY	MID-CENTURY A2 (HIGH)	END OF CENTURY A2 (HIGH)
Marble Bar Comp	20.4	22.5–23.4	25.3–25.9	35.2	37.3–38.4	39.3–40.8
Port Hedland Airport	19.7	21.7–22.5	24.3–24.8	33.3	35.2–36.2	37.3–38.4
Coolawanyah	19.2	21.4–22.2	24.0–24.7	33.1	35.3–36.3	37.2–38.7
Learmonth Airport	17.7	19.0–19.5	20.4–21.3	31.6	32.9–33.3	34.2–35.0
Mardie	19.0	20.6–21.0	22.3–23.0	34.2	35.8–36.0	37.2–37.9
Karratha Station	20.5	22.5–23.0	24.6–25.1	33.1	35.0–35.5	36.9–37.5
Carnarvon Airport	17.3	18.7–19.3	20.3–21.0	27.5	29.0–29.4	30.4–31.0
Wandagee	17.6	19.5–19.9	21.6–22.1	31.5	33.2–34.3	35.2–36.4
Nyang Station	18.1	20.1–20.6	22.4–22.9	33.4	35.3–36.4	37.4–38.6
Mount Vernon	17.3	19.4–20.2	22.1–22.7	32.1	34.1–35.3	36.0–37.6

Appendix E – Evaluation of Hot Spell Model for SWWA

Figure E-1 shows that the spatial pattern of thresholds estimated by the hot spell model using CCAM outputs (Figure E-1b) resembles that when using AWAP data (Figure E-1a). For example, southern parts of south Western Australia show relatively low threshold estimates (less than 30 °C), while the threshold estimate for the northern part are higher (above 35 °C). CCAM tends to underestimate the threshold by about 2-4 °C over the west and south coastal regions, and overestimates it by about 4 °C in north-east inland parts of south Western Australia (Figure E-1c).

The intensity of hot spells estimated from the CCAM data is largely consistent with that estimated from the AWAP-station data, with only minor overestimation of 2 °C over north-east inland SWWA (Figure E-1d-f).

Compared to the frequency of hot spells calculated from the AWAP and station data, the frequency of hot spells calculated from the CCAM data is slightly higher (1-2 events) over a large part of SWWA, and lower (by one event) in coastal regions (Figure E-1g-h).

For duration, there is a high level of consistency between the event lengths calculated from the CCAM and from the AWAP-station data, with only a 0 or 1 day difference over all of SWWA (Figure E-1j-l).

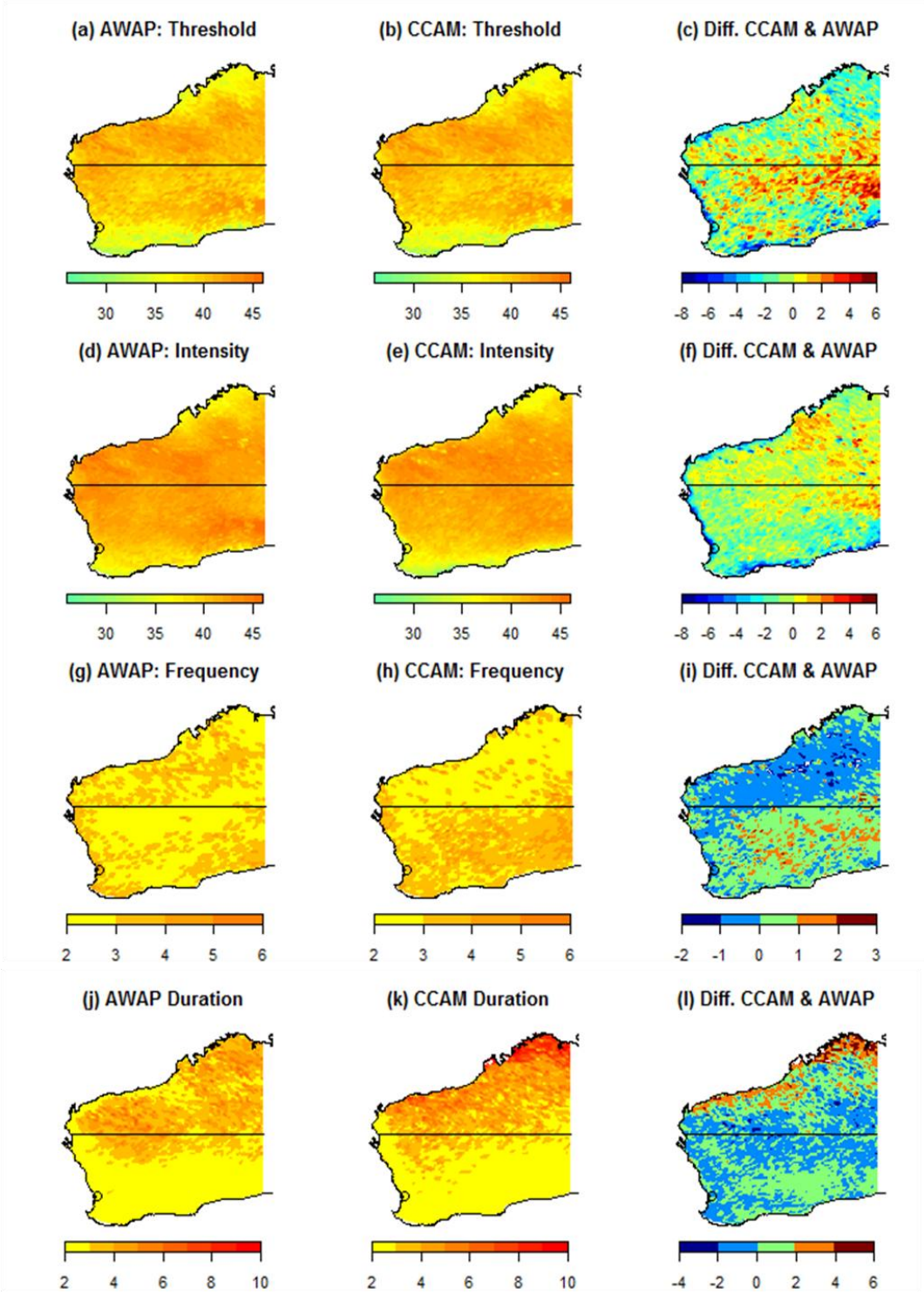

Figure E-1. Upper panel: spatial distribution of hot spell threshold estimates from the AWAP data (a); the CCAM data (b); and their difference (CCAM minus AWAP; c) during the 1981-2000 period; (d)-(f), same as (a)-(c), but for hot spell intensity; (g)-(i), same as (a)-(c), but for hot spell frequency. (d)-(f), same as (a)-(c), but for hot spell intensity; (j)-(l), same as (a)-(c), but for hot spell duration. Intensity is given in degrees Celsius, frequency in numbers of events, and duration in days. The black horizontal line at 25°S indicates the boundary between 'south Western Australia' (south of 25° S) and 'north Western Australia' (north of 25° S).

Appendix F – Evaluation of Hot Spell Model for NWWA

IOCI3 scientists evaluated the hot spell model's ability to reproduce the historical hot spell characteristics (intensity, frequency and duration) of north Western Australia by comparing model outputs with characteristics derived from summer (December through January) temperature observations at Port Hedland and Meekatharra airports for the period 1958-2011 (Figures F-1 and F-2). The estimated intensities (black curves) from the generalised Pareto distribution fit the data quite well (Figures F-1a and F-2a). The Poisson distributions (black curves) fit the observed frequencies well with two thirds of the Port Hedland and half of the Meekatharra observations for frequency falling on or within the area of the fitting (Figures F-1b and F-2b). Similarly, the geometric distribution fits (black curves) for these two stations are exceptionally good, with all observed durations falling within the area of the fitting (Figures F-1c and 2c).

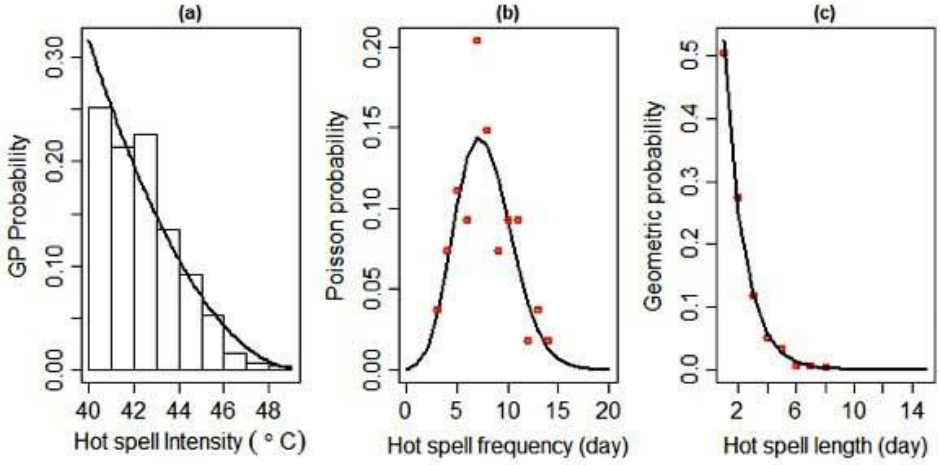

Figure F-1 Performance of distribution types chosen to model hot spell characteristics at Port Hedland Airport for summer (December through February) and the period 1958-2011. Hot spell model outputs are compared to station data obtained for the same period. (a) Histogram and estimated generalised Pareto distribution (black curve) for the intensity having a maximum excess within each of the hot spells; (b) empirical estimates (red circles) and estimated Poisson distribution (black curve) for the frequency of hot spells per summer; (c) empirical estimates (red circles) and estimated geometric distribution (black curve) for the duration of hot spell per summer.

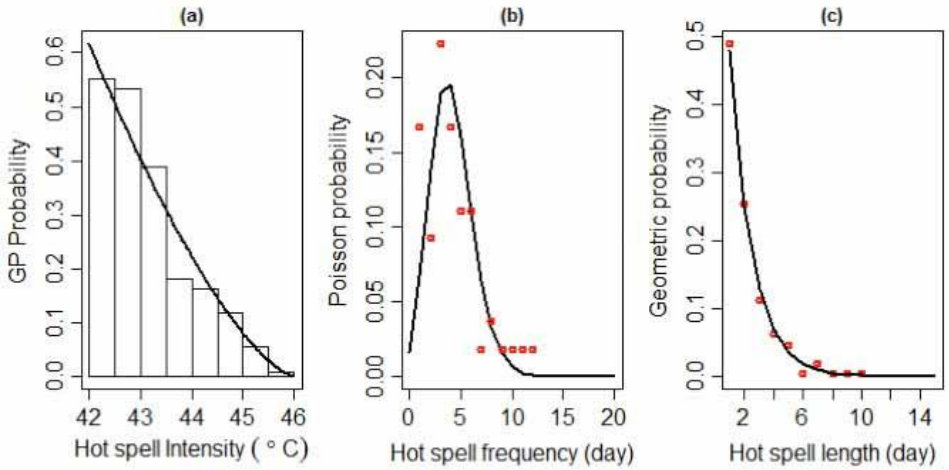

Figure F-2. As above, but for Meekatharra Airport.

Appendix G – Evaluation of CCAM Model Use in Hot Spell Simulations

Before producing projections for the characteristics of future north Western Australia hot spells, IOCI3 scientists compared ('observed') AWAP data and (modelled) CCAM outputs to test the hot spell model's ability to estimate north Western Australia hot spell characteristics for the present-day (1981-2010) climate.

Figure E-1 illustrates how the hot spell model results using AWAP data and CCAM output compare. The simulations produced using CCAM data overestimated thresholds by 2 to 5 °C in inland areas of north-western Australia, and underestimated hot spell thresholds by 3 to 6 °C along the south-western part of the Pilbara coast (Figure E-1c).

For hot spell intensity there is an overestimation of 0 to 2 °C and an underestimation of 2 to 5 °C (Figure E-1f).

For hot spell frequency, the CCAM simulations were consistent with the AWAP data in most of north-western Australia, with disparities of one or two events per summer. Along the Kimberly coastal region, this disparity was somewhat higher, from one to three events per summer (Figures E-1g-i).

As for duration, the CCAM simulations overestimated the length of hot spells along the Kimberly and Pilbara coastal regions by four to six days, and two to four days, respectively (Figures E-1j-l).