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Supplement of

Insights into the Australian mid-Holocene climate using downscaled climate models

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Supplement

Table S1. Vegetation mapping between the USGS classification used in WRF to the BIOME classification used in Allen et al. (2020).

USGS Category		Allen et al. (2020) BIOME	
Code	Description	Code	Description
Urb	Urban and Built-up Land		
DryCp	Dryland Cropland and Pasture		
IrrCp	Irrigated Cropland and Pasture		
MxCp	Mixed Dryland/Irrigated Cropland and Pasture		
CpGr	Cropland/Grassland Mosaic		
CpWd	Cropland/Woodland Mosaic		
Gr	Grassland	St	Steppe
		TrG	Tropical Grassland
Sh	Shrubland	TeSh	Temperate Shrubland
		TePk	Temperate Parkland
MxShGr	Mixed Shrubland/Grassland	Se-des	Semi-desert
Sav	Savannah	WTeWo	Warm Temperate Woodland
		Sav	Savannah
		TrRF	Tropical Raingreen Forest
BLDF	Deciduous Broadleaf Forest	BSBF	Boreal Summergreen Broad-leaved Forest
		TeSF	Temperate Summergreen Forest
NLDF	Deciduous Needleleaf Forest	BSNF	Boreal Summergreen Needle-leaved Forest
BLEvF	Evergreen Broadleaf Forest	TeBEF	Temperate Broad-leaved Evergreen Forest
		TrEF	Tropical Evergreen Forest
NLEvF	Evergreen Needleleaf Forest	BENF	Boreal Evergreen Needle-leaved Forest
		TeNEF	Temperate Needle-leaved Evergreen Forest
MxF	Mixed Forest	TeMxF	Temperate Mixed Forest
		BPk	Boreal Parkland
Wat	Water Bodies	OL	Ocean or Lake
HWet	Herbaceous Wetland		
WdWet	Wooden Wetland		
Bar	Barren or Sparsely Vegetated	Des	Desert
HTun	Herbaceous Tundra		
WdTun	Wooded Tundra	BWo	Boreal Woodland
MxTun	Mixed Tundra	ShT	Shrub Tundra
BGTun	Bare Ground Tundra	Tun	Tundra
SnIc	Snow or Ice	ICE	Ice Sheet
Lake	Lakes	OL	Ocean or Lake
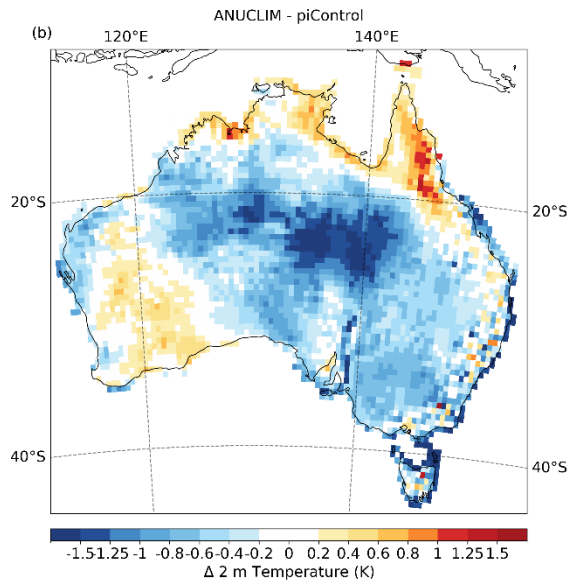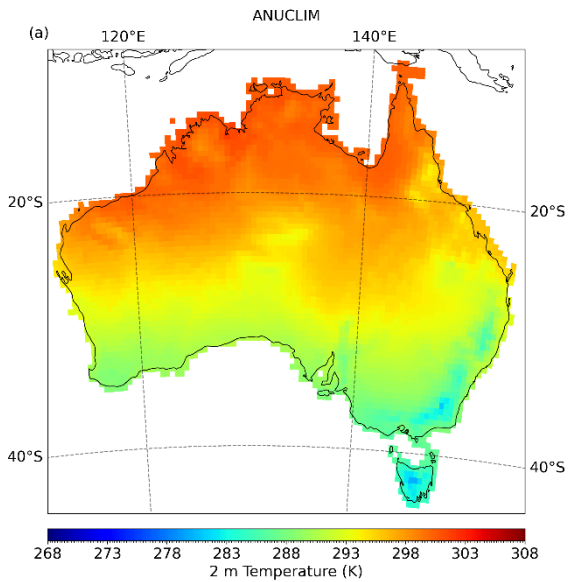
Figure S1. Annual temperature values from the ANUCLIM data set (Xu and Hutchinson, 2011) for 1970–1999 (a) and the difference between ANUCLIM and the WRF pre-industrial simulation (b).
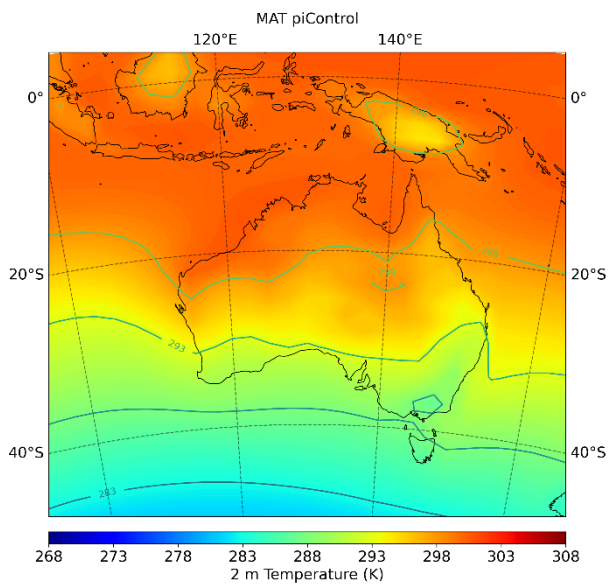
Figure S2. The 2 m temperature values for the CESM pre-industrial simulation.
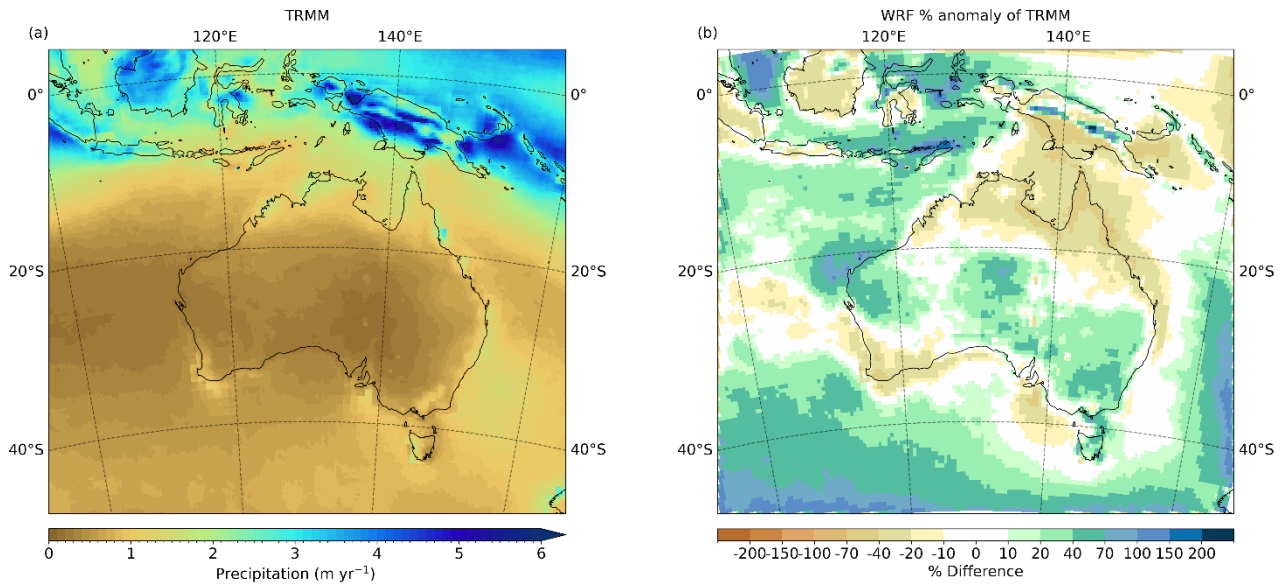
Figure S3. Annual precipitation values from the Tropical Rainfall Measuring Misson (TRMM) for 1998–2019 (a) and the difference between the WRF pre-industrial simulation and TRMM given as a percentage of TRMM precipitation (b).
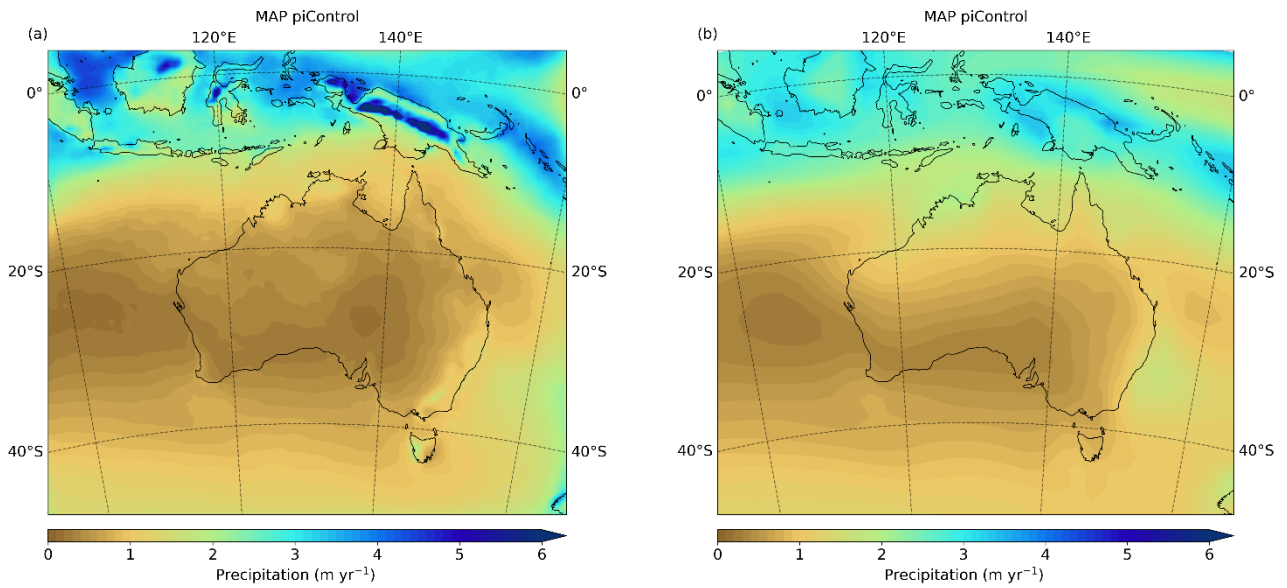
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Figure S4. Annual precipitation from the WRF pre-industrial simulation (a) and the CESM pre-industrial simulation (b).
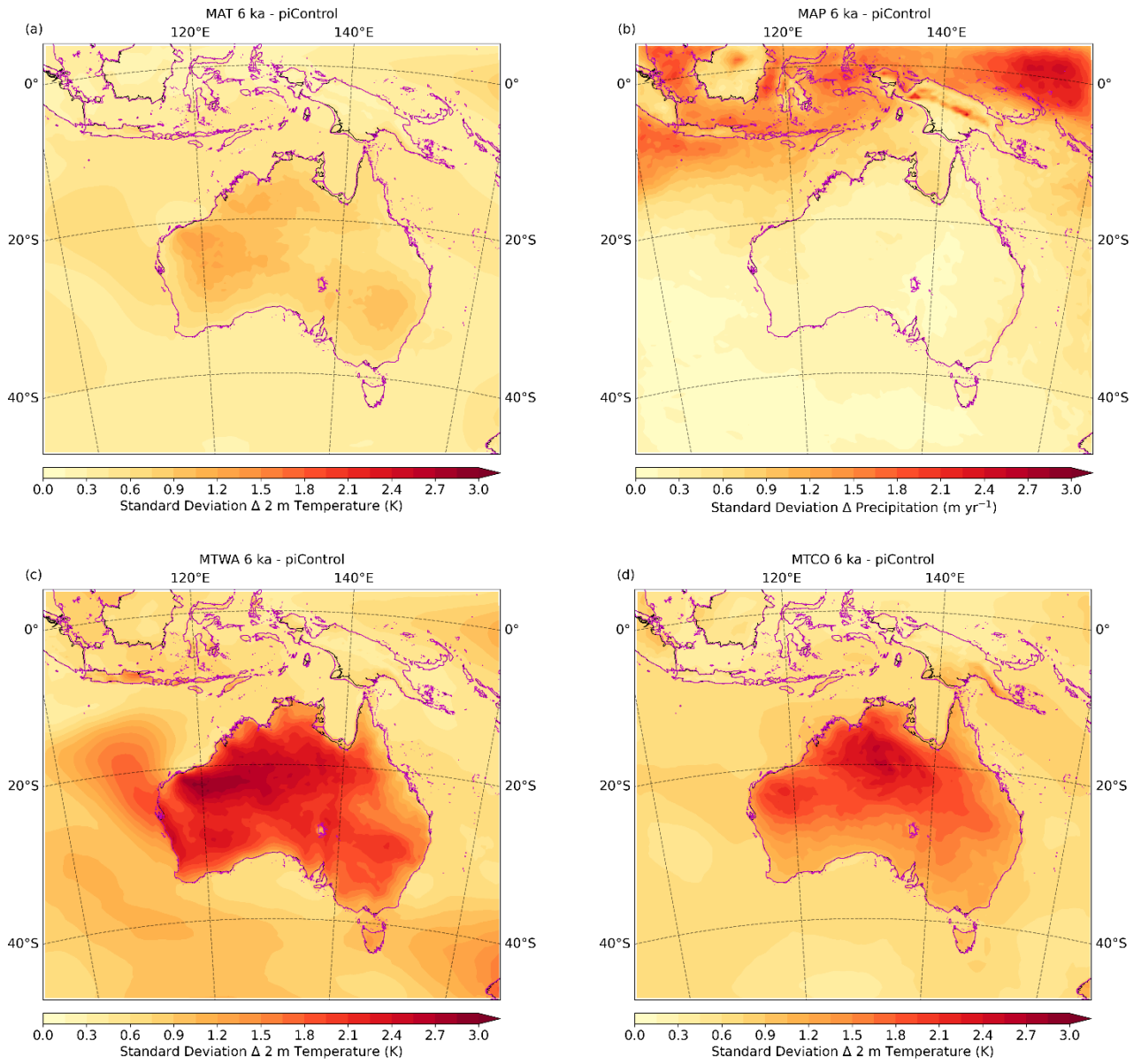
Figure S5. The inter-year spread (given as the standard deviation) from the WRF simulations in annual temperature (a), annual precipitation (b), MTWA (c), and MTCO (d). The purple line is the coastline in the mid-Holocene.
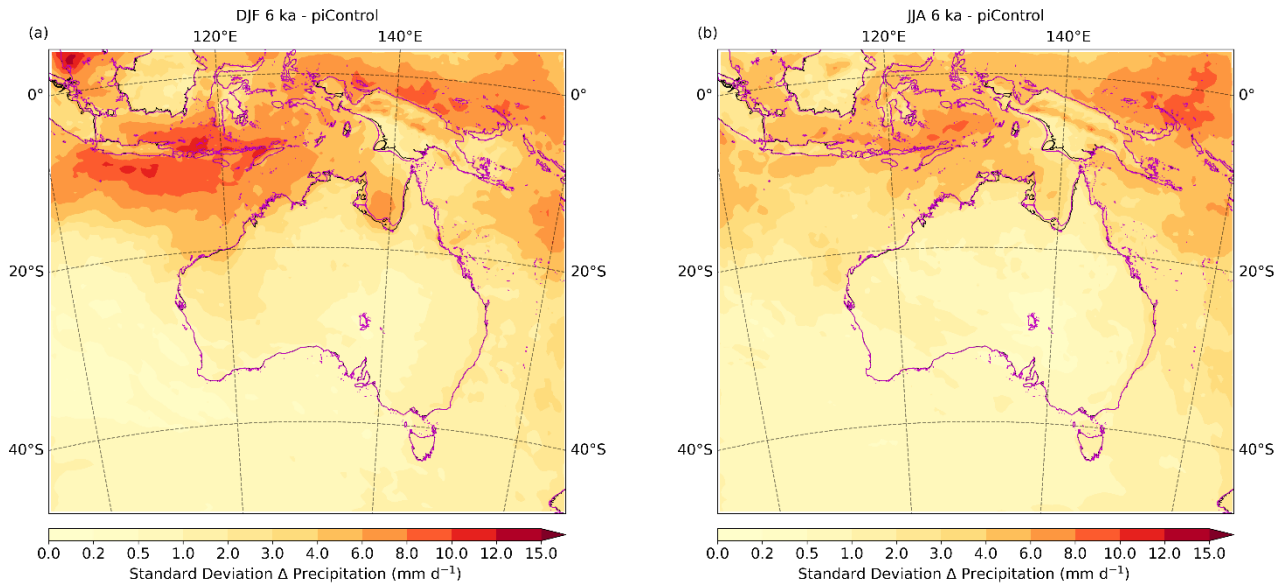
Figure S6. The standard deviation from the WRF simulations of precipitation for December, January, and February (a), and June, July, and August (b). The purple line is the coastline in the mid-Holocene. Note the different units from compared to Fig. S5b.

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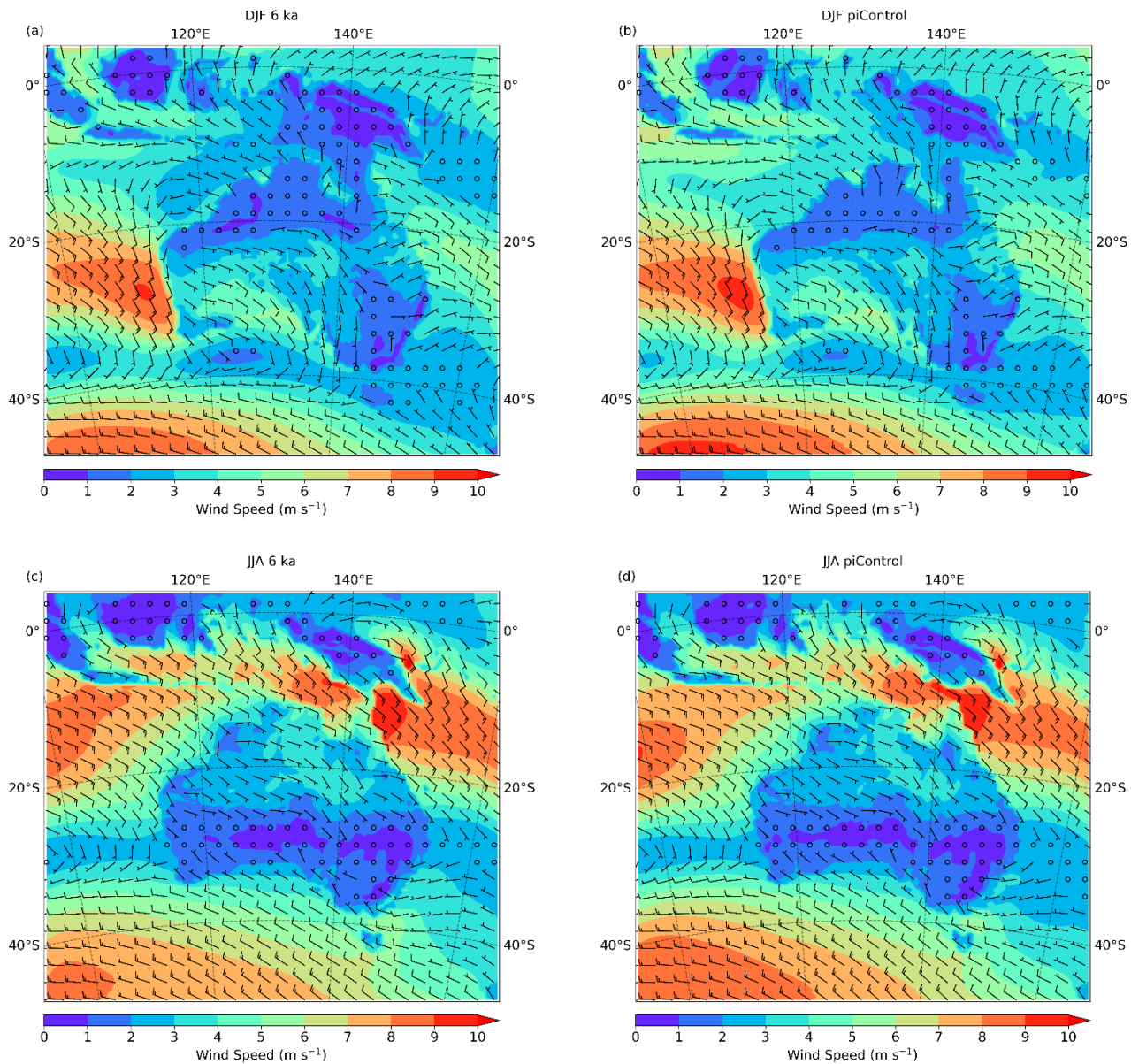
Figure S7: Seasonal 10 m wind barbs from the WRF simulations for December, January, and February mid-Holocene (a), December, January, and February pre-industrial (b), June, July, and August mid-Holocene (c), and June, July, and August pre-industrial (d).
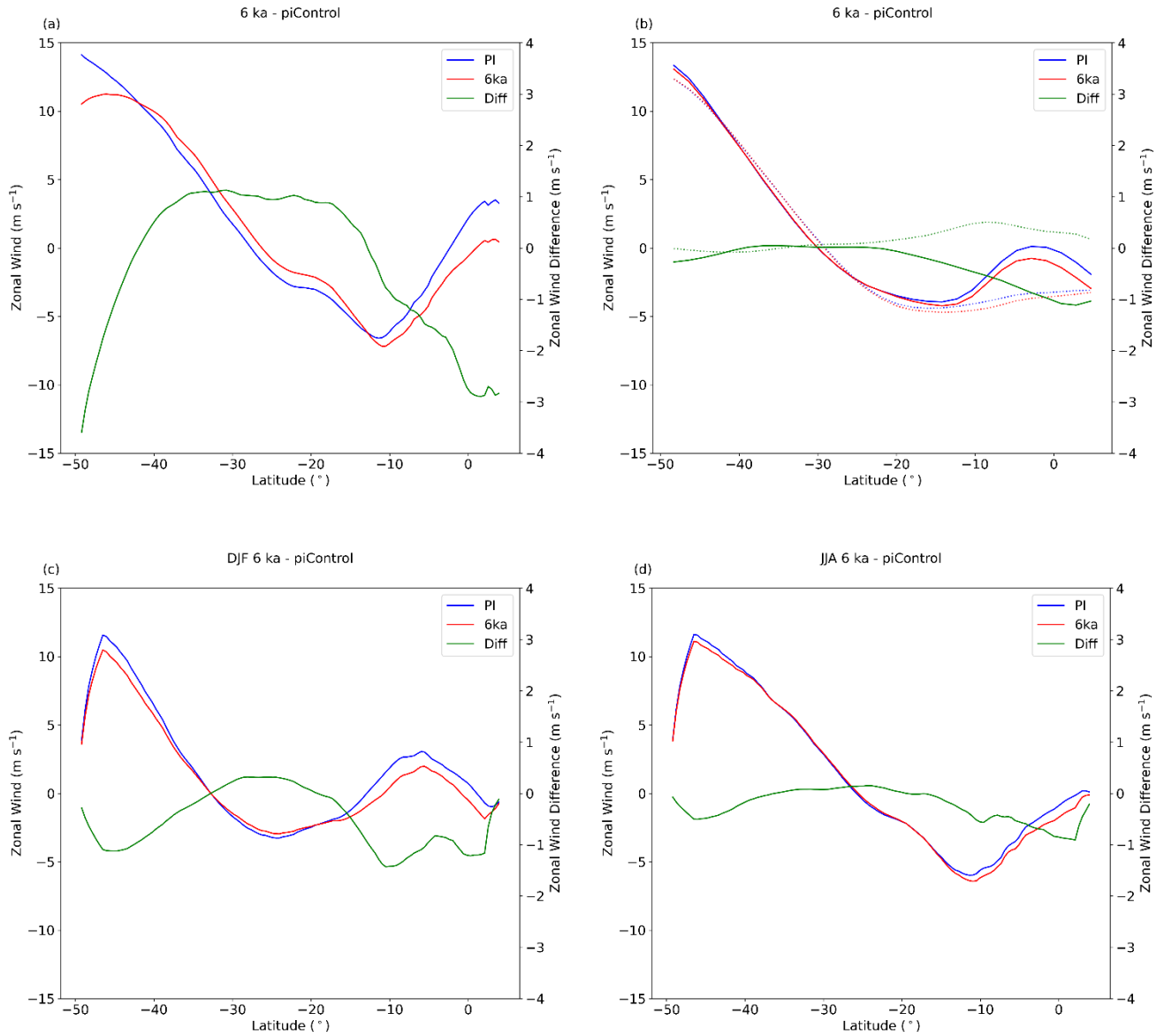
Figure S8. 850 hPa zonal wind for the pre-industrial and mid-Holocene. The annual mean from the WRF simulations (a). The annual mean from the CESM simulations, the solid lines are the Australian domain (100°E–170°E) and the dotted lines are the global values (b). The December, January, and February mean from the WRF simulations (c). The June, July, and August mean from the WRF simulations (d).

Table S2. MTWA (°C) difference between the mid-Holocene and pre-industrial from the pollen proxy dataset, WRF, and CESM simulations re-gridded to 2°. The proxy standard error (SE) is the pooled standard error (Herbert and Harrison, 2016).

| Latitude (°)	Longitude (°)	Proxy ± SE	WRF	CESM
-43	145	-0.22 ± 2.33	0.56	0.64
-43	147	-0.88 ± 2.65	0.42	0.50
-43	149	4.49 ± 2.83	0.50	0.46
-41	145	2.53 ± 2.44	0.40	0.41
-41	147	9.90 ± 3.72	0.16	0.21
-39	141	0.88 ± 2.54	0.23	0.45
-39	143	-0.14 ± 2.56	0.22	0.38
-39	145	1.09 ± 2.62	0.13	0.19
-39	147	3.29 ± 3.30	-0.03	-0.04
-37	141	-0.95 ± 2.31	0.04	0.02
-37	143	0.45 ± 2.77	-0.14	-0.38
-37	145	-4.46 ± 2.52	-0.14	-0.72
-37	147	-2.27 ± 3.00	-0.42	-0.57
-37	149	1.00 ± 3.04	-0.35	-0.34
-37	151	-2.32 ± 2.24	0.03	-0.15
-35	115	-1.40 ± 5.32	0.14	0.18
-35	117	-1.36 ± 3.73	0.09	0.15
-35	119	-1.15 ± 2.53	0.07	0.13
-35	139	-3.16 ± 2.41	-0.10	-0.09
-35	143	-0.16 ± 2.21	-0.37	-0.84
-35	149	1.15 ± 3.02	-0.66	-0.61
-35	151	-1.93 ± 2.31	-0.10	-0.34
-33	115	0.56 ± 3.08	0.00	-0.01
-33	141	-7.94 ± 2.41	-0.54	-0.84
-33	151	-3.26 ± 2.67	-0.54	-0.52
-31	115	-2.64 ± 2.78	-0.15	-0.28
-31	127	-1.97 ± 2.84	-0.55	-0.19
-31	139	-2.13 ± 2.93	-0.77	-0.79
-31	143	-1.10 ± 2.24	-0.94	-0.79
-31	151	-4.88 ± 2.92	-0.75	-0.55

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-27	153	-1.91 ± 2.53	-0.34	-0.50
-25	153	-5.22 ± 3.29	-0.29	-0.34
-17	127	-8.28 ± 3.87	0.23	0.18
-17	145	-2.83 ± 3.13	0.12	-0.06
-17	147	-2.58 ± 3.83	0.24	0.09
-15	127	-9.16 ± 2.43	0.28	0.40
-15	137	-6.10 ± 4.26	0.99	0.23
-15	145	0.15 ± 2.23	0.29	0.15
-13	137	-2.40 ± 3.35	0.49	0.30
-13	141	-8.73 ± 2.74	0.40	0.30
-13	143	-1.30 ± 3.53	0.60	0.22
-11	143	-0.92 ± 2.97	0.55	0.34

Table S3 MTCO (°C) difference between the mid-Holocene and pre-industrial from the pollen proxy dataset, WRF, and CESM simulations re-gridded to 2°. The proxy standard error (SE) is the pooled standard error (Herbert and Harrison, 2016).

Latitude (°)	Longitude (°)	Proxy ± SE	WRF	CESM
-43	145	-0.55 ± 2.82	-0.16	-0.16
-43	147	-1.42 ± 3.07	-0.30	-0.09
-43	149	3.34 ± 2.94	-0.04	-0.04
-41	145	-0.10 ± 2.87	-0.31	-0.19
-41	147	8.01 ± 4.90	-0.40	-0.16
-39	141	-0.49 ± 2.92	-0.10	-0.09
-39	143	-1.19 ± 3.23	-0.13	-0.11
-39	145	-0.2 ± 2.82	-0.23	-0.14
-39	147	4.96 ± 4.19	-0.52	-0.17
-37	141	-0.53 ± 2.85	-0.03	-0.01
-37	143	2.19 ± 3.29	-0.05	-0.06
-37	145	-3.12 ± 3.08	-0.05	-0.07
-37	147	-0.03 ± 3.63	-0.33	0.02
-37	149	2.41 ± 4.12	-0.18	0.02
-37	151	-0.62 ± 2.67	-0.07	-0.01
-35	115	-2.69 ± 6.98	-0.16	-0.11
-35	117	-2.46 ± 4.94	-0.06	-0.06

-35	119	-2.36 ± 2.72	-0.13	-0.06
-35	139	-0.49 ± 3.42	0.08	0.02
-35	143	0.02 ± 2.67	0.17	0.00
-35	149	4.56 ± 4.89	-0.20	-0.09
-35	151	-1.60 ± 2.71	-0.11	-0.07
-33	115	1.24 ± 3.84	-0.16	0.02
-33	141	-2.25 ± 2.82	0.20	0.17
-33	151	-2.35 ± 3.35	-0.08	-0.14
-31	115	0.92 ± 3.73	-0.03	0.02
-31	127	-0.93 ± 2.83	0.17	0.17
-31	139	-0.05 ± 2.89	0.23	0.30
-31	143	0.13 ± 3.02	0.12	0.25
-31	151	-2.35 ± 3.67	-0.09	-0.05
-27	153	-0.13 ± 2.92	-0.16	-0.04
-25	153	-3.15 ± 3.44	-0.16	-0.01
-17	127	-7.97 ± 4.23	0.62	0.61
-17	145	-3.52 ± 4.01	-0.20	0.28
-17	147	-4.33 ± 5.14	-0.27	-0.02
-15	127	-9.92 ± 3.25	0.35	0.36
-15	137	-7.15 ± 5.84	-1.18	-0.06
-15	145	0.25 ± 2.87	-0.24	-0.03
-13	137	-3.17 ± 4.03	-0.59	-0.16
-13	141	-15.71 ± 3.49	-0.46	-0.09
-13	143	-1.10 ± 5.19	-0.08	0.00
-11	143	-1.77 ± 4.71	-0.11	0.00

45 **Table S4. Annual precipitation (mm yr^{-1}) difference between the mid-Holocene and pre-industrial from the pollen proxy dataset, WRF, and CESM simulations re-gridded to 2°. The proxy standard error (SE) is the pooled standard error (Herbert and Harrison, 2016).**

Latitude (°)	Longitude (°)	Proxy ± SE	WRF	CESM
-43	145	33.90 ± 316.12	66.22	65.92
-43	147	488.81 ± 400.77	67.38	60.04
-43	149	340.52 ± 337.83	80.61	72.61

-41	145	-192.24 ± 362.11	41.45	30.93
-41	147	-134.70 ± 351.44	15.06	32.04
-39	141	-1.39 ± 345.53	10.60	30.90
-39	143	127.76 ± 320.80	29.09	31.17
-39	145	-34.94 ± 332.51	61.13	21.35
-39	147	648.35 ± 589.47	21.36	15.02
-37	141	344.40 ± 314.35	-18.07	15.47
-37	143	435.95 ± 350.25	-29.52	1.80
-37	145	733.33 ± 310.24	-27.23	-16.58
-37	147	347.46 ± 387.13	-42.87	-36.82
-37	149	236.91 ± 338.02	-30.80	-43.34
-37	151	-118.95 ± 294.92	10.83	-31.38
-35	115	94.10 ± 405.65	-63.02	-25.75
-35	117	360.51 ± 361.18	-48.75	-19.54
-35	119	145.40 ± 315.22	-27.85	-10.35
-35	139	337.95 ± 409.06	-38.62	-6.33
-35	143	-6.69 ± 294.87	-60.56	-37.41
-35	149	218.66 ± 346.99	16.16	-85.87
-35	151	92.32 ± 304.07	24.34	-87.94
-33	115	149.26 ± 354.93	-40.78	-12.89
-33	141	350.91 ± 300.04	-27.81	-48.09
-33	151	329.92 ± 315.23	24.86	-109.28
-31	115	974.56 ± 323.65	-37.76	-10.04
-31	127	366.88 ± 330.12	-13.09	7.58
-31	139	227.16 ± 334.44	-27.88	-47.97
-31	143	9.63 ± 295.29	-19.10	-88.31
-31	151	529.72 ± 328.49	-52.97	-114.56
-27	153	-100.25 ± 412.28	-9.60	-141.84
-25	153	-35.77 ± 320.70	-36.36	-135.03
-17	127	105.82 ± 300.74	-128.38	-71.26
-17	145	896.86 ± 476.20	-193.95	-121.25
-17	147	-2065.91 ± 630.63	-137.36	-72.54

-15	127	746.57 ± 357.96	-187.28	-39.63
-15	137	298.54 ± 298.73	-256.83	-102.90
-15	145	137.11 ± 319.76	-169.01	-58.75
-13	137	37.03 ± 334.55	-290.04	-57.62
-13	141	-789.80 ± 330.85	-316.59	-65.74
-13	143	8.88 ± 363.29	-210.47	-53.56
-11	143	-22.07 ± 334.56	-132.95	-37.33

Table S5: α difference between the mid-Holocene and pre-industrial from the pollen proxy dataset, WRF, and CESM simulations
re-gridded to 2°. The proxy standard error (SE) is the pooled standard error (Herbert and Harrison, 2016). Locations where there
are no WRF or CESM values were water in the PI simulation and have no output from the land component of the simulation.

Latitude (°)	Longitude (°)	Proxy ± SE	WRF	CESM
-43	145	0.0000 ± 0.0971		
-43	147	0.0265 ± 0.1020		
-43	149	0.0152 ± 0.1098		
-41	145	-0.1337 ± 0.0983		
-41	147	-0.1781 ± 0.1527		-0.0078
-39	141	-0.0532 ± 0.1302		
-39	143	0.0414 ± 0.1116		
-39	145	-0.0495 ± 0.1451		
-39	147	-0.0145 ± 0.1072		-0.0039
-37	141	0.2339 ± 0.1195	-0.0053	-0.0033
-37	143	0.0931 ± 0.1400	-0.0025	-0.0069
-37	145	0.2544 ± 0.1102	-0.0106	-0.0096
-37	147	0.0650 ± 0.1290	-0.0068	-0.0270
-37	149	-0.0170 ± 0.1211	-0.0161	
-37	151	-0.1508 ± 0.0984		
-35	115	0.1778 ± 0.1646		
-35	117	0.2084 ± 0.1407		-0.0086
-35	119	0.1549 ± 0.1452		-0.0061
-35	139	0.2376 ± 0.1469	-0.0093	-0.0059
-35	143	-0.0034 ± 0.0971	-0.0254	-0.0173
-35	149	-0.0315 ± 0.1181	-0.0045	-0.0187

-35	151	0.0283 ± 0.1090		
-33	115	0.1347 ± 0.1438		
-33	141	0.5122 ± 0.1006	-0.0046	-0.0224
-33	151	0.1332 ± 0.1018	-0.0171	-0.0191
-31	115	0.3877 ± 0.1244		
-31	127	0.3249 ± 0.1703	-0.0053	0.0008
-31	139	0.1824 ± 0.1683	-0.0030	-0.0212
-31	143	0.0089 ± 0.0987	-0.0067	-0.0341
-31	151	0.2113 ± 0.1127	-0.0213	-0.0222
-27	153	-0.0817 ± 0.1585		
-25	153	0.0299 ± 0.1049		
-17	127	0.2538 ± 0.1376	-0.0089	0.0005
-17	145	0.2457 ± 0.1148	-0.0246	-0.0331
-17	147	-0.2435 ± 0.1209		
-15	127	0.3490 ± 0.1140	0.0002	-0.0115
-15	137	0.3037 ± 0.1560		
-15	145	0.0228 ± 0.1060		-0.0322
-13	137	0.0786 ± 0.1244		
-13	141	0.2548 ± 0.1142		-0.1114
-13	143	0.0401 ± 0.1170	-0.0433	
-11	143	0.0486 ± 0.1153		

References

Allen, J. R. M., Forrest, M., Hickler, T., Singarayer, J. S., Valdes, P. J., and Huntley, B.: Global vegetation patterns of the past 140,000 years, J. Biogeogr., 47, 2073–2090, https://doi.org/10.1111/jbi.13930, 2020.

Herbert, A. V. and Harrison, S. P.: Evaluation of a modern-analogue methodology for reconstructing Australian palaeoclimate from pollen, Rev. Palaeobot. Palynol., 226, 65–77, https://doi.org/10.1016/j.revpalbo.2015.12.006, 2016.

Xu, T. and Hutchinson, M.: ANUCLIM version 6.1 user guide, Fenner School of Environment and Society, Australian National University, 90 pp., https://fennerschool.anu.edu.au/files/anuclim61.pdf (last access: 3 August 2021), 2011

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