

Appendix A:

Table A1a. Summary of results for mean annual temperature (bio01) from Legacy.Climate 1.0 using the modern analogue technique (MAT). Mean bias, root mean square error (RMSE) and normalised root mean square error (RMSE) is calculated for interpolated annual temperature for each records and averaged over each subset, comparing the outputs from the Beyer et al. (2020a) 30-min model debiased using Climate Research Unit Global Climate Dataset (CRU), Beyer et al. (2020a) 30-min model debiased using WorldClim2 (WC) data, Beyer et al. (2020a) 5-min model debiased using WorldClim2 data, HadCM3 30-min model debiased using WorldClim2 data and HadCM3 5-min model debiased and downscaled using WorldClim2 data. These are compared against the chronologically equivalent proxy data reconstructed by Herzshuch *et al.* (2021) via the modern analogue (MAT) techniques.

Mean annual temperature - Modern analogue technique (MAT)																
		RMSE					NRMSE					Bias				
		Beyer 30- min (CRU)	Beyer 30- min (WC)	Beyer 5-min (WC)	HadC M3 30- min (WC)	HadC M3 5- min (WC)	Beyer 30- min (CRU)	Beyer 30- min (WC)	Beyer 5-min (WC)	HadC M3 30- min (WC)	HadC M3 5- min (WC)	Beyer 30- min (CRU)	Beyer 30-min (WC)	Beyer 5-min (WC)	HadC M3 30- min (WC)	HadC M3 5- min (WC)
All records (n = 2395)		2.86	2.73	2.73	2.77	2.78	2.86	2.17	2.66	3.65	2.05	-0.09	0.50	0.36	0.24	0.12
Asia (n = 455)		3.95	3.74	3.74	3.85	3.85	3.35	1.68	2.43	1.65	3.82	-0.11	0.48	0.63	0.16	0.31

East America (n = 613)	N	2.61	2.39	2.39	2.44	2.44	1.71	1.90	2.99	2.22	1.70	-0.28	0.31	0.21	0.22	0.11
West America (n = 328)	N	3.00	2.82	2.73	2.92	2.82	2.82	2.28	2.21	2.83	1.71	-0.03	0.62	0.35	0.43	0.17
Europe (n = 989)		2.47	2.44	2.48	2.43	2.49	3.37	2.51	2.72	5.72	1.58	0.01	0.58	0.33	0.22	0.01
Present (n = 1060)		1.90	1.73	1.60	1.73	1.60	0.64	0.65	0.67	0.65	0.67	0.44	1.05	0.80	1.05	0.80
MIS 1 (n = 2363)		2.70	2.57	2.58	2.59	2.61	2.15	2.10	2.46	3.64	1.85	0.11	0.71	0.57	0.40	0.28
MIS 2 (n = 473)		5.22	4.94	4.93	5.13	5.11	3.83	3.08	53.25	5.15	7.17	-3.28	-2.76	-2.70	-2.21	-2.16
High altitude (n = 362)		3.35	3.10	2.97	3.13	3.00	7.28	3.43	3.29	10.17	2.74	-0.62	0.02	-0.18	-0.12	-0.32
Low altitude (n = 2058)		2.78	2.67	2.69	2.70	2.74	2.13	1.96	2.54	2.56	1.95	-0.01	0.58	0.45	0.30	0.19
High roughness (n = 412)		2.94	2.74	2.71	2.78	2.76	6.42	1.61	1.88	2.18	2.55	-0.37	0.29	-0.05	0.07	-0.26

Low roughness (n=2008)	2.85	2.73	2.74	2.76	2.78	2.16	2.29	2.84	3.97	1.96	-0.04	0.54	0.44	0.27	0.19
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Table A1b. Summary of results for mean annual temperature (bio01) from Legacy.Climate 1.0 using weighted average partial least squares (WA-PLS) technique. Mean bias, root mean square error (RMSE) and normalised root mean square error (RMSE) is calculated for interpolated annual temperature, comparing the outputs from the Beyer et al. (2020a) 30-min model debiased using Climate Research Unit Global Climate Dataset (CRU), Beyer et al. (2020a) 30-min model debiased using WorldClim2 (WC) data, Beyer et al. (2020a) 5-min model debiased using WorldClim2 data, HadCM3 30-min model debiased using WorldClim2 data and HadCM3 5-min model debiased using WorldClim2 data. These are compared against the chronologically equivalent proxy data reconstructed by Herzshuch *et al.* (2021) via the weighted average partial least squares (WA-PLS) technique.

Mean annual temperature - Weighted average partial least squares (WA-PLS)

		RMSE			NRMSE						Bias					
		Beyer 30-min (CRU)	Beyer 30-min (WC)	Beyer 5-min (WC)	HadC M3 30- min (WC)	HadC M3 5- min (WC)	Beyer 30-min (CRU)	Beyer 30-min (WC)	Beyer 5-min (WC)	HadC M3 30- min (WC)	HadC M3 5- min (WC)	Beyer 30-min (CRU)	Beyer 30-min (WC)	Beyer 5-min (WC)	HadC M3 30- min (WC)	HadC M3 5- min (WC)
All records (n = 2395)		2.77	2.64	2.71	2.64	2.72	3.20	1.75	2.66	3.22	1.90	-0.11	0.48	0.35	0.22	0.10
Asia (n = 455)		3.82	3.63	3.68	3.70	3.73	4.01	1.48	2.09	1.58	3.23	-0.05	0.54	0.70	0.23	0.38
East America (n = 613)	N	2.59	2.38	2.41	2.37	2.40	1.61	1.76	2.65	2.12	1.57	-0.44	0.16	0.06	0.06	-0.04

West America (n = 328)	N	2.93	2.76	2.77	2.81	2.81	2.67	2.34	2.22	3.20	2.03	-0.12	0.53	0.26	0.33	0.08
Europe (n = 989)		2.35	2.30	2.44	2.27	2.43	3.98	1.66	3.06	4.65	1.44	0.07	0.64	0.40	0.29	0.07
Present 1060)	(n =	2.24	2.18	2.14	2.17	2.14	0.96	0.98	1.34	0.97	1.34	0.47	1.08	0.82	1.07	0.82
MIS 1 2363)	(n =	2.64	2.51	2.59	2.51	2.61	2.37	1.73	2.53	3.24	1.83	0.09	0.69	0.55	0.38	0.26
MIS 2 473)	(n =	4.60	4.34	4.39	4.22	4.22	4.33	2.74	36.52	8.22	5.56	-3.06	-2.53	-2.48	-1.98	-1.94
High (n = 346)	altitude	3.11	2.90	2.93	2.91	2.93	9.10	3.33	4.12	9.52	2.95	-0.60	0.04	-0.16	-0.10	-0.30
Low altitude = 2023)	(n	2.72	2.59	2.68	2.59	2.69	2.21	1.48	2.42	2.16	1.73	-0.02	0.56	0.43	0.28	0.17
High roughness (n = 398)		2.76	2.55	2.66	2.59	2.70	8.02	1.48	1.75	1.89	2.38	-0.36	0.30	-0.04	0.08	-0.25
Low roughness (n=1971)		2.78	2.65	2.72	2.65	2.73	2.24	1.81	2.86	3.50	1.81	-0.06	0.52	0.42	0.25	0.17

West America (n = 328)	222.22	210.40	225.75	205.67	221.81	0.31	0.27	0.27	0.26	0.27	18.01	57.35	81.34	68.14	92.02
Europe (n = 989)	294.05	238.59	246.28	234.36	241.79	0.33	0.30	0.30	0.31	0.31	6.53	-36.48	-12.05	-48.33	-29.63
Present (n = 1060)	175.39	137.21	137.47	137.47	137.47	0.24	0.19	0.18	0.19	0.18	-14.81	-3.60	17.00	-4.02	17.00
MIS 1 (n = 2363)	230.94	205.23	211.05	203.15	208.71	0.31	0.29	0.29	0.29	0.29	-1.72	2.83	17.52	7.77	19.64
MIS 2 (n = 473)	299.17	279.95	283.03	240.27	247.04	0.46	0.60	0.65	0.79	0.65	142.10	138.68	142.04	-24.60	73.24
High altitude (n = 346)	297.38	219.76	225.67	212.06	219.56	0.36	0.33	0.34	0.35	0.36	90.02	24.08	36.36	21.34	33.76
Low altitude (n = 2023)	226.47	210.34	216.28	205.31	211.31	0.32	0.28	0.33	0.29	0.30	-12.55	4.46	19.94	6.58	18.92
High roughness (n = 398)	309.53	226.49	245.27	221.11	239.13	0.36	0.31	0.31	0.31	0.31	60.16	1.88	36.07	-1.90	29.94
Low roughness (n = 1971)	222.14	208.73	212.08	203.31	207.14	0.31	0.32	0.33	0.30	0.29	-9.22	8.43	19.56	10.89	19.30

Table A2b. Summary of results for mean total annual precipitation (bio12) from Legacy.Climate 1.0 using weighted average partial least squares (WA-PLS) technique. Mean bias, root mean square error (RMSE) and normalised root mean square error (RMSE) is calculated for interpolated annual precipitation, comparing the outputs from the Beyer et al. (2020a) 30-min model debiased using Climate Research Unit Global Climate Dataset (CRU), Beyer et al. (2020a) 30-min model debiased using WorldClim2 (WC) data, Beyer et al. (2020a) 5-min model debiased using WorldClim2 data, HadCM3 30-min model debiased using WorldClim2 data and HadCM3 5-min model debiased using WorldClim2 data. These are compared against the chronologically equivalent proxy data reconstructed by Herzshuch *et al.* (2021) via the weighted average partial least squares (WA-PLS) technique.

Mean total annual precipitation - Weighted average partial least squares (WA-PLS)

	RMSE					NRMSE					Bias				
	Beyer 30-min (CRU)	Beyer 30-min (WC)	Beyer 5-min (WC)	HadC M3 30- min (WC)	HadC M3 5- min (WC)	Beyer 30- min (CRU)	Beyer 30- min (WC)	Beyer 5-min (WC)	HadC M3 30- min (WC)	HadC M3 5- min (WC)	Beyer 30-min (CRU)	Beyer 30- min (WC)	Beyer 5-min (WC)	HadC M3 30- min (WC)	HadC M3 5- min (WC)
All records (n = 2395)	228.91	211.12	217.76	206.27	210.54	0.32	0.32	0.33	0.30	0.31	-8.04	-2.99	11.98	-1.76	10.55
Asia (n = 455)	187.28	192.43	201.02	180.10	189.80	0.37	0.49	0.53	0.41	0.43	5.66	24.98	26.66	23.47	26.27
East N America (n = 613)	177.35	173.37	172.03	164.04	164.24	0.27	0.25	0.24	0.22	0.22	-39.19	14.47	19.23	33.73	36.60

West N America (n = 328)	217.52	217.75	234.28	205.28	222.60	0.32	0.29	0.30	0.27	0.27	18.95	58.28	82.27	69.07	92.95
Europe (n = 989)	283.79	240.90	284.33	239.28	244.78	0.33	0.31	0.31	0.32	0.32	-3.99	-47.00	-22.57	-58.85	-40.15
Present (n = 1060)	194.19	172.78	178.90	172.27	178.90	0.27	0.25	0.25	0.25	0.25	-22.28	-11.07	9.53	-11.49	9.53
MIS 1 (n = 2363)	222.29	204.37	210.98	201.43	207.38	0.31	0.30	0.30	0.29	0.30	-13.05	-8.49	6.19	-3.56	8.31
MIS 2 (n = 473)	295.46	273.61	272.93	224.25	228.86	0.45	0.57	0.61	0.87	0.67	154.24	150.82	154.18	84.65	85.63
High altitude (n = 346)	287.16	229.44	237.83	217.33	227.33	0.35	0.34	0.35	0.35	0.36	80.14	14.20	26.48	11.46	23.89
Low altitude (n = 2023)	219.33	208.27	214.56	202.00	207.97	0.31	0.32	0.33	0.30	0.30	-23.43	-6.24	9.05	-4.30	8.04
High roughness (n = 398)	289.89	234.98	253.52	228.46	246.67	0.35	0.32	0.32	0.32	0.32	43.22	-15.06	19.13	-18.84	13.00
Low roughness (n = 1971)	216.99	206.59	210.78	199.34	203.55	0.31	0.32	0.33	0.30	0.31	-18.71	-1.06	10.07	1.40	9.81

Table A3a. Summary of results for mean July temperature (bio10) from Legacy.Climate 1.0 using the modern analogue technique (MAT). Mean bias, root mean square error (RMSE) and normalised root mean square error (RMSE) is calculated for interpolated July temperature, comparing the outputs from the Beyer et al. (2020a) 30-min model debiased using Climate Research Unit Global Climate Dataset (CRU), Beyer et al. (2020a) 30-min model debiased using WorldClim2 (WC) data, Beyer et al. (2020a) 5-min model debiased using WorldClim2 data, HadCM3 30-min model debiased using WorldClim2 data and HadCM3 5-min model debiased using WorldClim2 data. These are compared against the chronologically equivalent proxy data reconstructed by Herzshuch *et al.* (2021) via the modern analogue (MAT) techniques.

Mean July temperature - Modern analogue technique (MAT)																
		RMSE					NRMSE					Bias				
		Beyer	Beyer	Beyer	HadC	HadC	Beyer	Beyer	Beyer	HadC	HadC	Beyer	Beyer	Beyer	HadC	HadC
		30-min	30-	5-min	M3	M3 5-	30-	30-	5-min	M3	M3 5-	30-	30-	5-min	M3	M3 5-
		(CRU)	min	(WC)	30-	min	min	min	(WC)	30-	min	min	min	(WC)	30-	min
			(WC)		min	(WC)	(CRU)	(WC)		min	(WC)	(CRU)	(WC)		min	(WC)
All records (n = 2395)		3.01	2.72	2.74	2.74	2.75	0.27	0.20	0.20	0.23	0.23	-0.76	-0.27	-0.41	-0.29	-0.40
Asia (n = 455)		3.95	3.72	3.76	3.70	3.68	0.42	0.28	0.28	0.35	0.32	-0.16	0.09	0.24	-0.19	-0.03
East America (n = 613)		N 2.82	2.41	2.38	2.33	2.31	0.23	0.17	0.17	0.18	0.18	-0.98	-0.47	-0.55	-0.44	-0.52

West America (n = 328)	N	3.03	2.60	2.56	2.75	2.69	0.27	0.19	0.19	0.33	0.30	-0.78	-0.22	-0.49	-0.34	-0.57
Europe (n = 989)		2.68	2.48	2.55	2.56	2.62	0.21	0.17	0.19	0.19	0.20	-0.88	-0.32	-0.59	-0.22	-0.45
Present (n = 1060)		2.21	1.78	1.77	1.79	1.77	0.19	0.13	0.14	0.13	0.14	-0.95	-0.50	-0.78	-0.52	-0.78
MIS 1 (n = 2363)		2.84	2.55	2.57	2.55	2.56	0.23	0.18	0.18	0.20	0.20	-0.53	-0.04	-0.18	-0.06	-0.17
MIS 2 (n = 473)		5.42	5.22	5.17	5.39	5.35	1.25	0.74	0.76	2.72	0.79	-3.53	-3.19	-3.14	-3.26	-3.21
High altitude (n = 346)		3.60	3.18	3.10	3.15	3.04	0.35	0.26	0.25	0.31	0.26	-1.23	-0.69	-0.89	-0.67	-0.86
Low altitude (n = 2023)		2.91	2.64	2.68	2.68	2.71	0.25	0.19	0.19	0.22	0.22	-0.67	-0.19	-0.32	-0.22	-0.33
High roughness (n = 398)		3.21	2.86	2.86	2.85	2.85	0.40	0.23	0.24	0.24	0.24	-1.09	-0.48	-0.85	-0.42	-0.77
Low roughness (n =1971)		2.97	2.70	2.72	2.72	2.74	0.24	0.19	0.19	0.23	0.23	-0.69	-0.22	-0.32	-0.26	-0.33

Table A3b. Summary of results for mean July temperature (bio10) from Legacy.Climate 1.0 using weighted average partial least squares (WA-PLS) technique. Mean bias, root mean square error (RMSE) and normalised root mean square error (RMSE) is calculated for interpolated July temperature, comparing the outputs from the Beyer et al. (2020a) 30-min model debiased using Climate Research Unit Global Climate Dataset (CRU), Beyer et al. (2020a) 30-min model debiased using WorldClim2 (WC) data, Beyer et al. (2020a) 5-min model debiased using WorldClim2 data, HadCM3 30-min model debiased using WorldClim2 data and HadCM3 5-min model debiased using WorldClim2 data. These are compared against the chronologically equivalent proxy data reconstructed by Herzshuch *et al.* (2021) via the weighted average partial least squares (WA-PLS) technique.

Mean July Temperature - Weighted average partial least squares (WA-PLS)

RMSE																NRMSE																Bias															
		Beyer	Beyer	Beyer	HadCM	HadCM	Beyer	Beyer	Beyer	HadC	HadCM	Beyer	Beyer	Beyer	HadC	HadC																															
		30-min	30-min	5-min	3	30-	3	5-min	30-min	30-min	5-min	M3	30-	3	5-min	30-min	30-min	5-min	M3	30-	M3	5-																									
		(CRU)	(WC)	(WC)	min	(WC)	(CRU)	(WC)	(WC)	(WC)	(WC)	min	(WC)	(CRU)	(WC)	(WC)	(WC)	(WC)	min	(WC)	min	(WC)																									
All records (n = 2395)		2.89	2.63	2.72	2.59	2.67	0.26	0.19	0.20	0.23	0.23	-0.78	-0.29	-0.43	-0.31	-0.43																															
Asia (n = 455)		3.92	3.72	3.79	3.68	3.70	0.42	0.28	0.28	0.36	0.33	0.02	0.27	0.41	-0.01	0.15																															
East N America (n = 613)		2.71	2.34	2.35	2.19	2.21	0.23	0.17	0.17	0.17	0.18	-1.09	-0.58	-0.66	-0.55	-0.63																															
West N America (n = 328)		2.87	2.50	2.57	2.62	2.66	0.23	0.19	0.20	0.33	0.31	-1.03	-0.47	-0.74	-0.59	-0.82																															
Europe (n = 989)		2.54	2.37	2.51	2.34	2.48	0.26	0.17	0.19	0.17	0.19	-0.87	-0.31	-0.58	-0.21	-0.44																															
Present (n = 1060)		2.22	1.93	2.04	1.94	2.04	0.20	0.15	0.17	0.15	0.17	-0.99	-0.53	-0.81	-0.55	-0.81																															
MIS 1 (n = 2363)		2.74	2.49	2.58	2.43	2.51	0.22	0.17	0.18	0.19	0.20	-0.56	-0.06	-0.21	-0.08	-0.20																															
MIS 2 (n = 473)		4.90	4.65	4.65	4.67	4.69	1.13	0.70	0.79	3.05	0.73	-3.35	-3.02	-2.96	-3.08	-3.03																															

High altitude (n = 346)	3.42	3.05	3.14	3.03	3.06	0.34	0.26	0.26	0.31	0.28	-1.28	-0.75	-0.95	-0.72	-0.92
Low altitude (n = 2023)	2.81	2.57	2.66	2.52	2.61	0.24	0.18	0.19	0.21	0.22	-0.69	-0.21	-0.34	-0.24	-0.35
High roughness (n = 398)	3.01	2.68	2.83	2.64	2.77	0.38	0.22	0.24	0.23	0.24	-1.08	-0.48	-0.84	-0.41	-0.76
Low roughness (n=1971)	2.87	2.63	2.71	2.59	2.65	0.23	0.19	0.20	0.23	0.22	-0.72	-0.25	-0.35	-0.29	-0.36

Table A4. Results from bootstrapping of climatic records that routinely fall into the worse performing 5% in terms of model-data coherence, representing the most divergent time series of the dataset. O = observed proportion, P = mean of bootstrapped proportion, U = upper 95% confidence interval. Statistically significant ($p < 0.05$) results are shaded grey, indicating where higher proportions are observed than expected by random chance.

	Present			MIS 1			MIS 2			Asia			East North America			West North America			Europe			High altitude			Low altitude			High roughness			Low roughness		
	O	P	U	O	P	U	O	P	U	O	P	U	O	P	U	O	P	U	O	P	U	O	P	U	O	P	U	O	P	U			
Mean annual temperature (N = 44)	0.75	0.44	0.46	0.37	0.99	0.9	0.61	0.21	0.2	0.77	0.11	0.2	0.17	0.27	0.2	0.06	0.44	0.4	0.0	0.3	0.1	0.6	0.24	0.88	0.64	0.08	0.1	0.91	0.88	0.26			
Mean annual precipitation (N = 21)	0.81	0.45	0.4	0.76	0.98	0.8	0.24	0.21	0.2	0.22	0.44	0.27	0.7	0.5	0.2	0.2	0.11	0.1	0.33	0.44	0.1	0.9	0.4	0.88	0.1	0.5	0.24	0.6	0.81	0.3			

Mean	0.1	0.4	0.4	0.6	0.	0.9	0.3	0.	0.2	0.	0.	0.	0.1	0.	0.2	0.	0.	0.	0.0	0.	0.	0.	0.	0.1	0.	0.8	0.	0.	0.	0.1	0.9	0.	0.
July	3	4	6		9	9	7	2	1	7	1	2	0	2	7	0	1	1	7	4	4	3	1	6	6	4	8	1	1	8	0	8	8
tempe rature (N = 30)					9			0		7	9	0		6		7	4	5		1	3	7	4		3		6	0	7		2	6	