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Supplement of

Evaluation of CORDEX ERA5-forced NARCliM2.0 regional climate models over Australia using the Weather Research and Forecasting (WRF) model version 4.1.2

Giovanni Di Virgilio et al.

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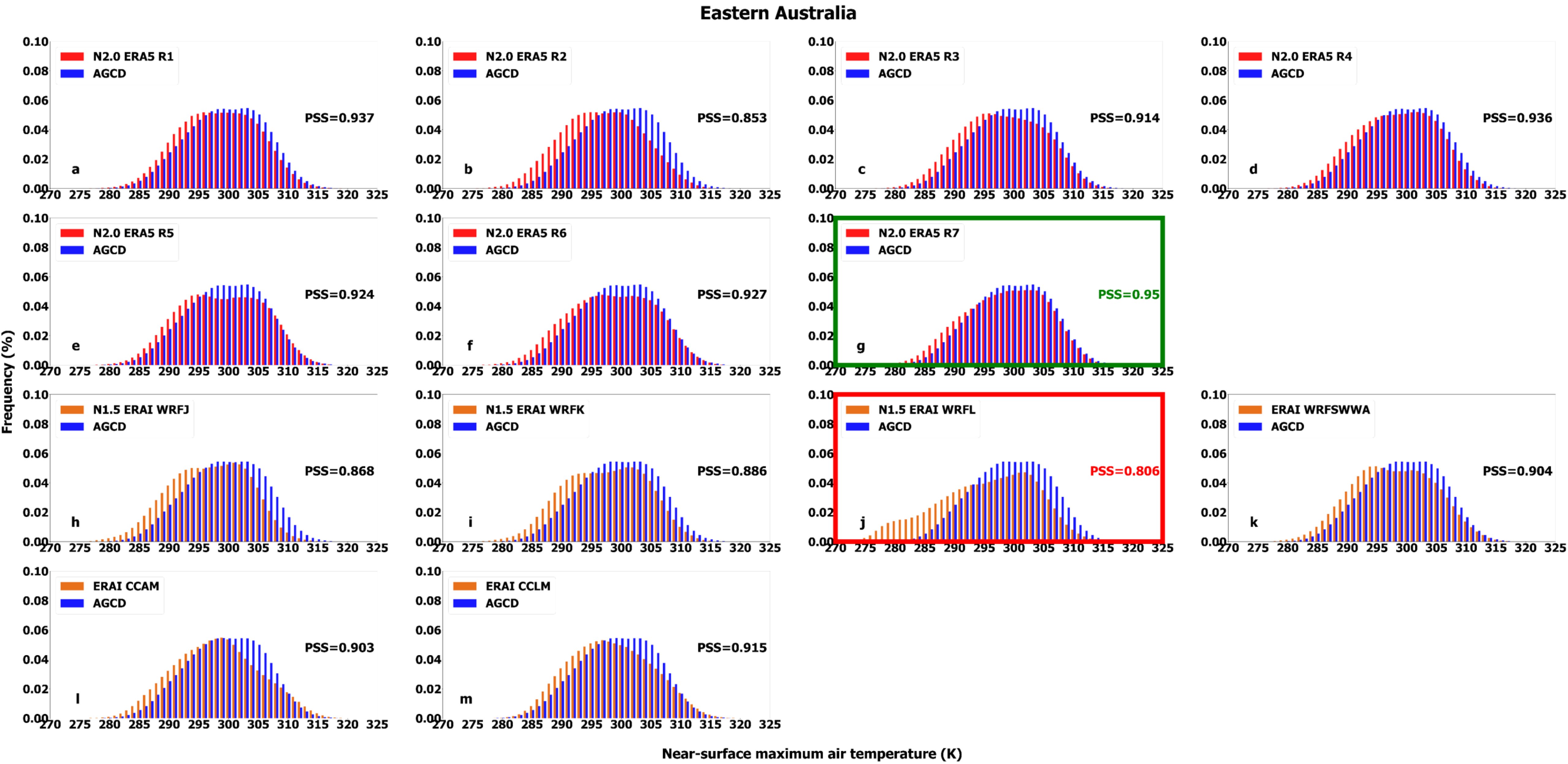

Fig. S1 Probability density functions of daily maximum near-surface air temperature (K) with bin width of 1 K in the Eastern Australia Natural Resource Management (NRM) region.

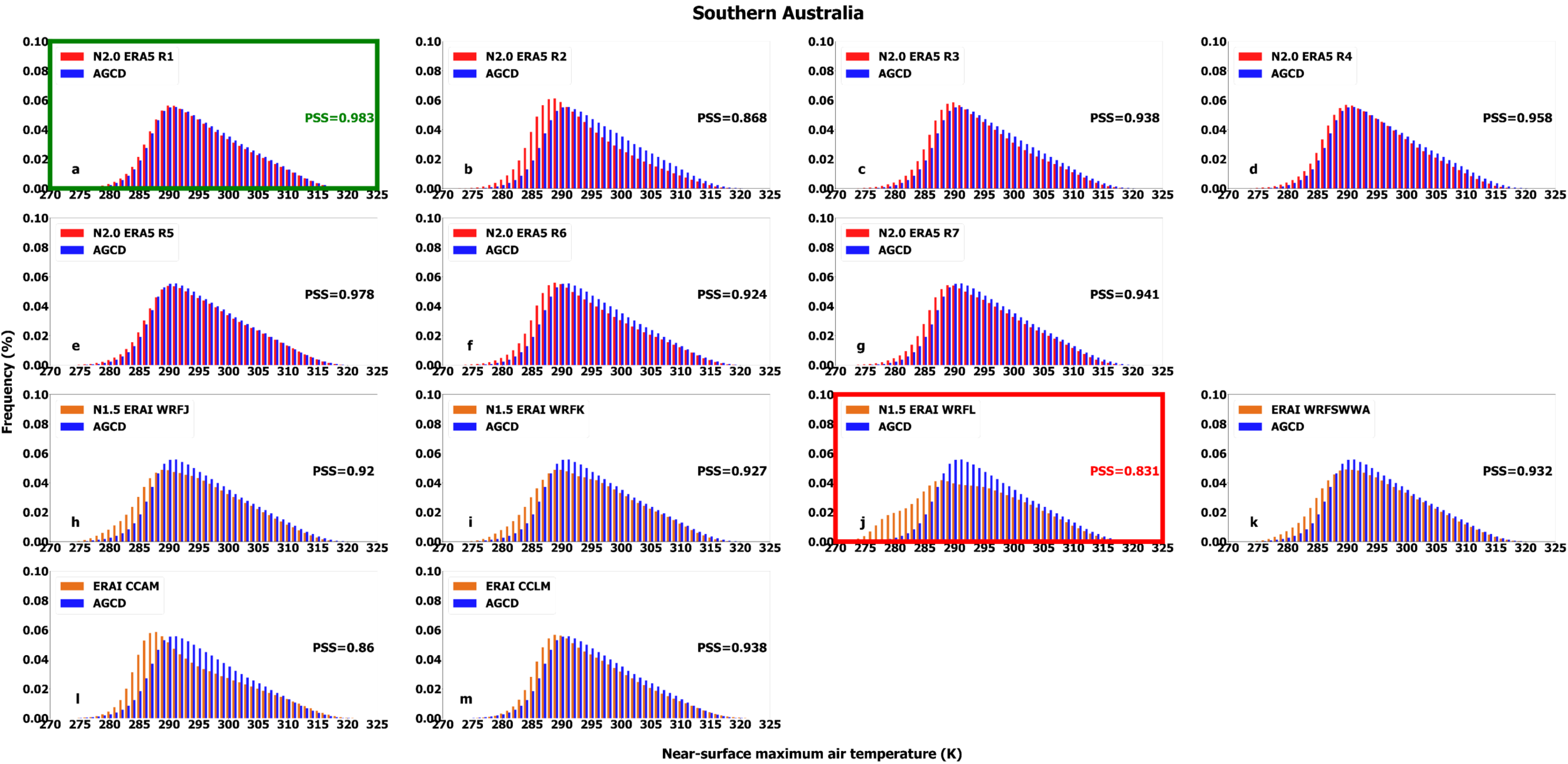

Fig. S2 Probability density functions of daily maximum near-surface air temperature (K) with bin width of 1 K in the Southern Australia Natural Resource Management (NRM) region.

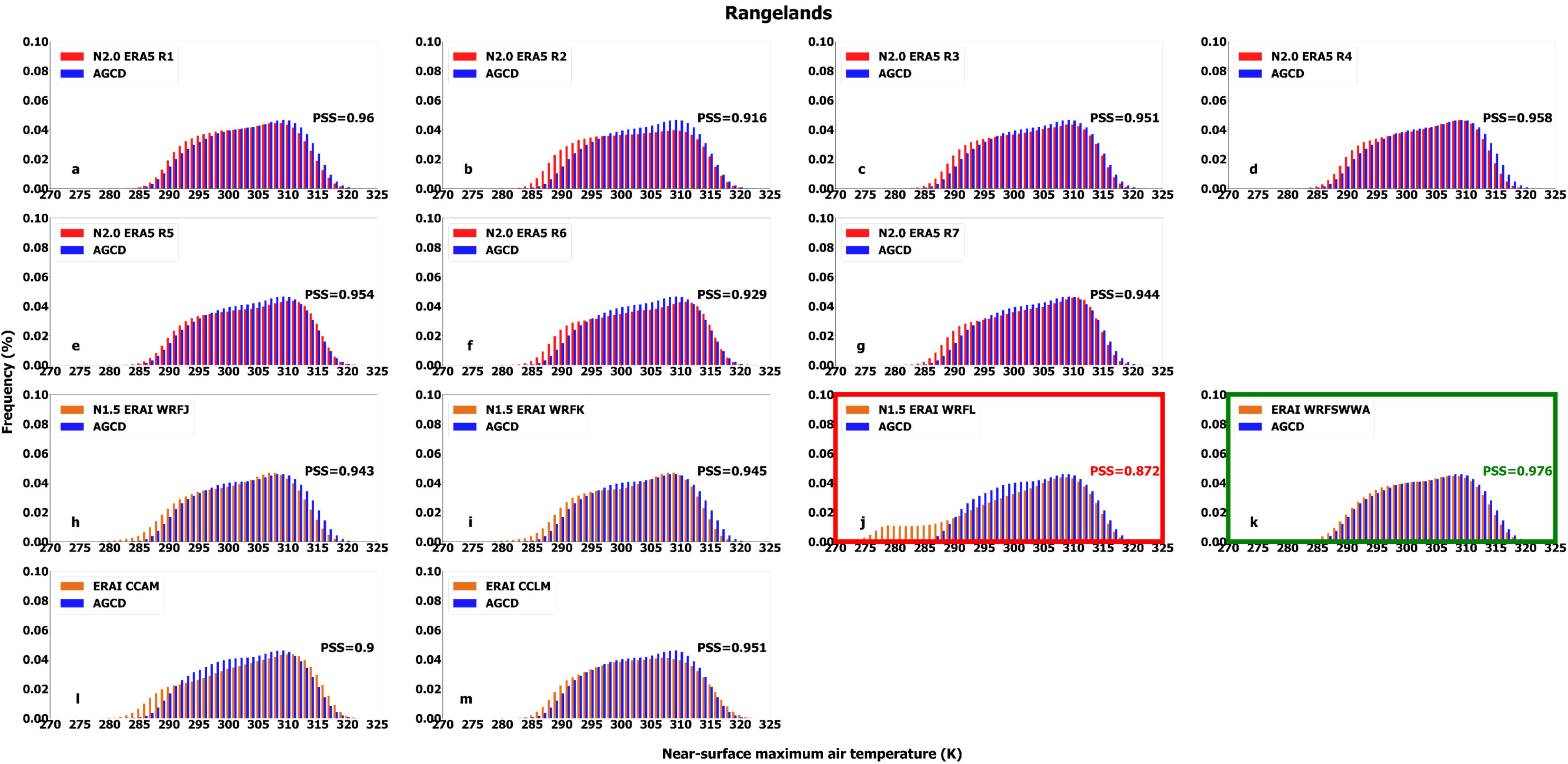

Fig. S3 Probability density functions of daily maximum near-surface air temperature (K) with bin width of 1 K in the Rangelands Natural Resource Management (NRM) region.

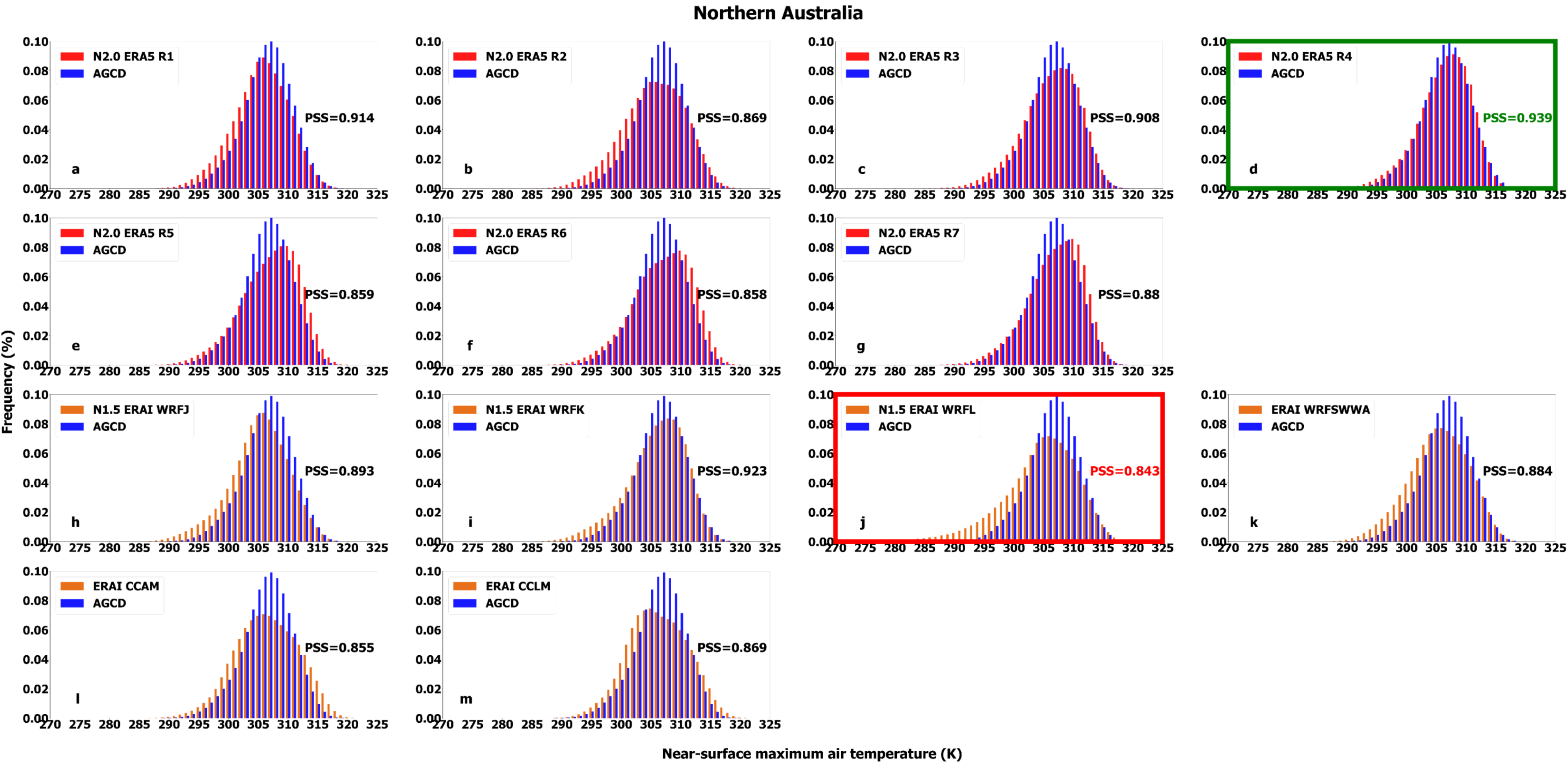

Fig. S4 Probability density functions of daily maximum near-surface air temperature (K) with bin width of 1 K in the Northern Australia Natural Resource Management (NRM) region.

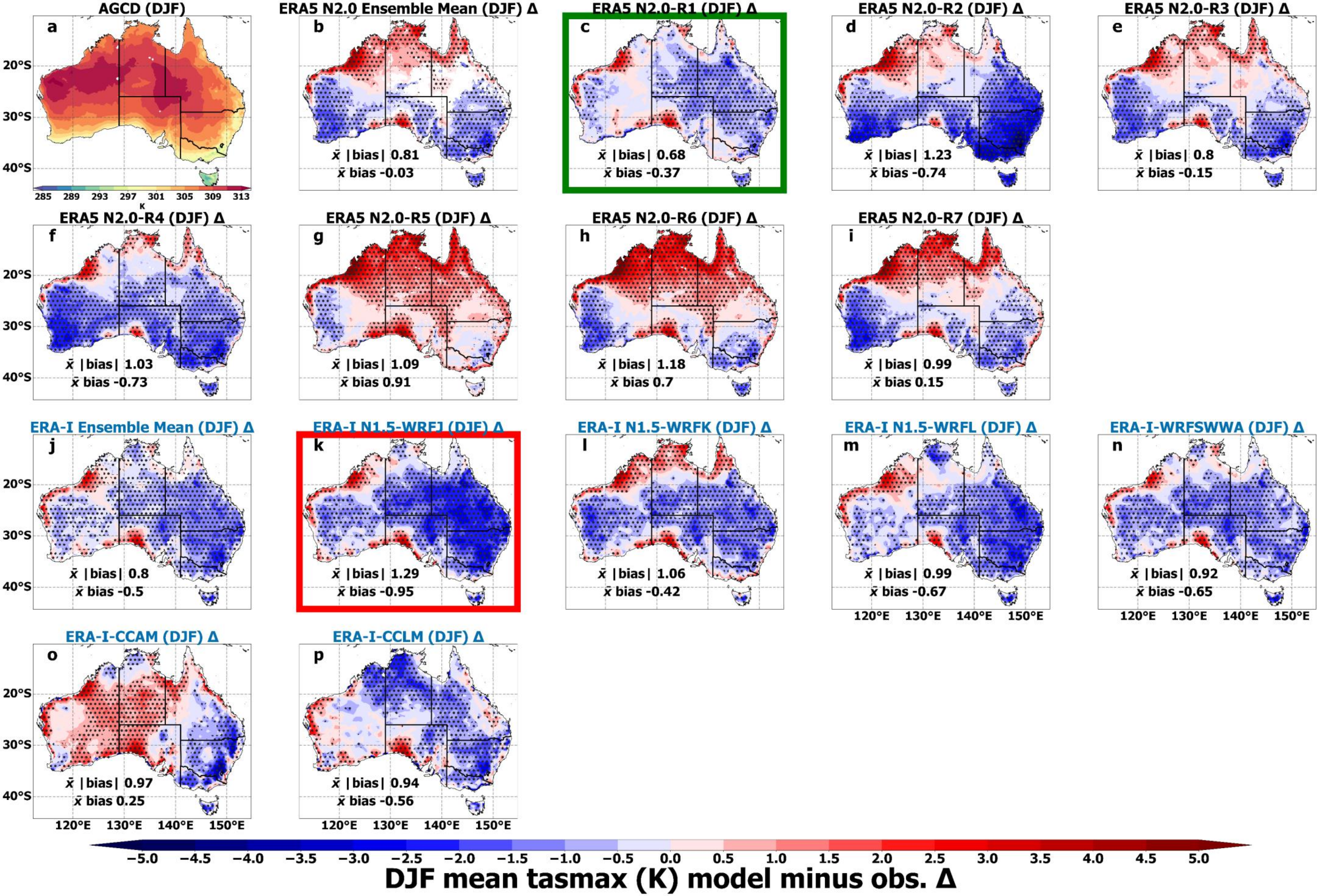

Fig. S5 Summer (DJF) maximum temperature bias with respect to Australian Gridded Climate Data (AGCD) observations for 1981-2010. Stippled areas indicate locations where an RCM shows statistically significant bias (*P* < 0.05). **b** Significance stippling for the ensemble mean bias follows Tebaldi et al. (2011) and is applied separately to each of the two RCM ensembles. Statistically insignificant areas are shown in colour, denoting that less than half of the models are significantly biased. In significant agreeing areas (stippled), at least half of RCMs are significantly biased, and at least 66% of significant RCMs in each ensemble agree on the direction of the bias. Significant disagreeing areas are shown in white, which are where at least half of the models are significantly biased and less than 66% of significant models in each ensemble agree on the bias direction - see main text for additional detail on the stippling regime. Panel boundaries in green (red) indicate the RCMs with lowest (highest) area-averaged mean absolute biases.

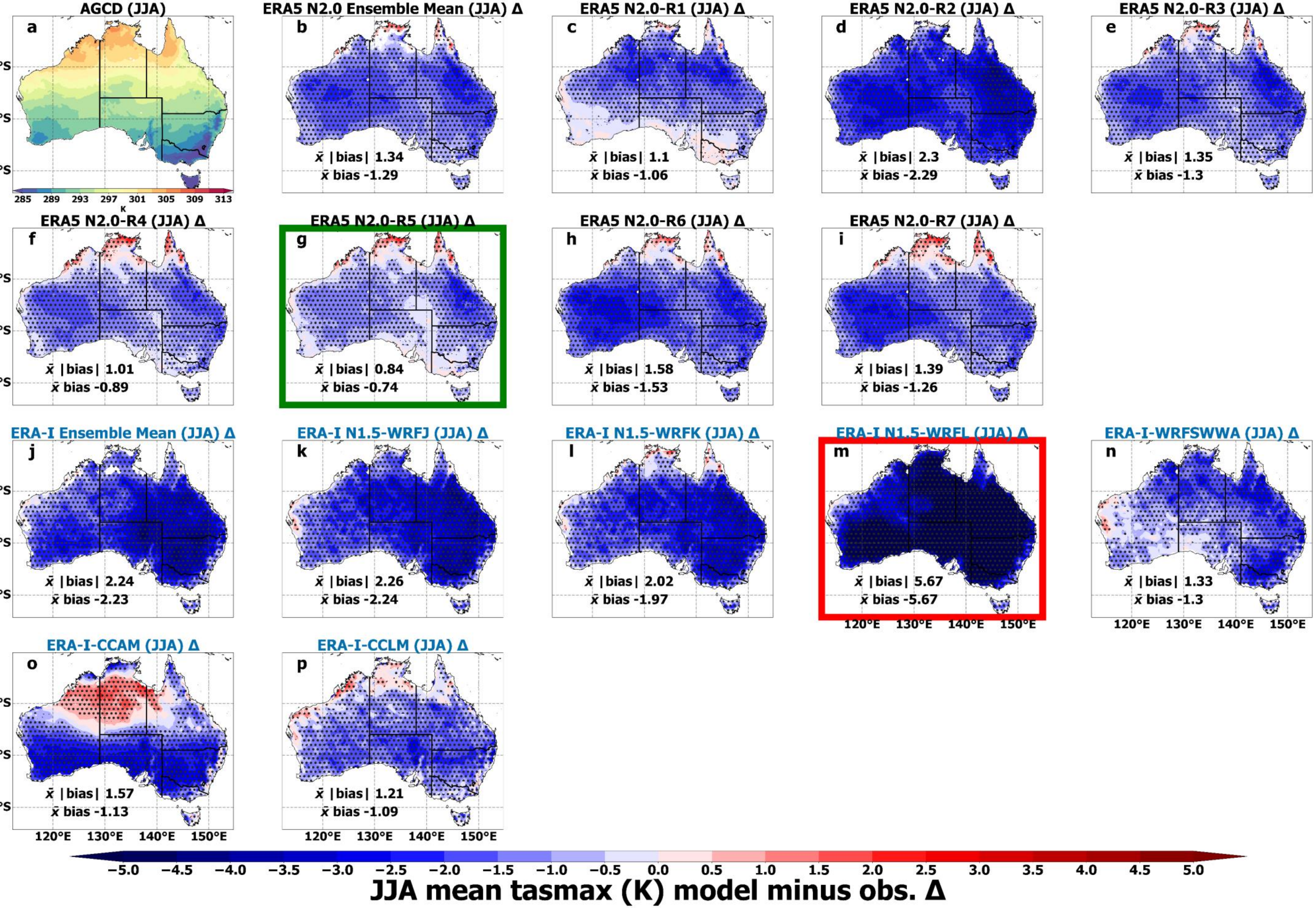

Fig. S6 Winter (JJA) maximum temperature bias with respect to gridded observations. Stippling and panel boundary colouring as per Figure S5.

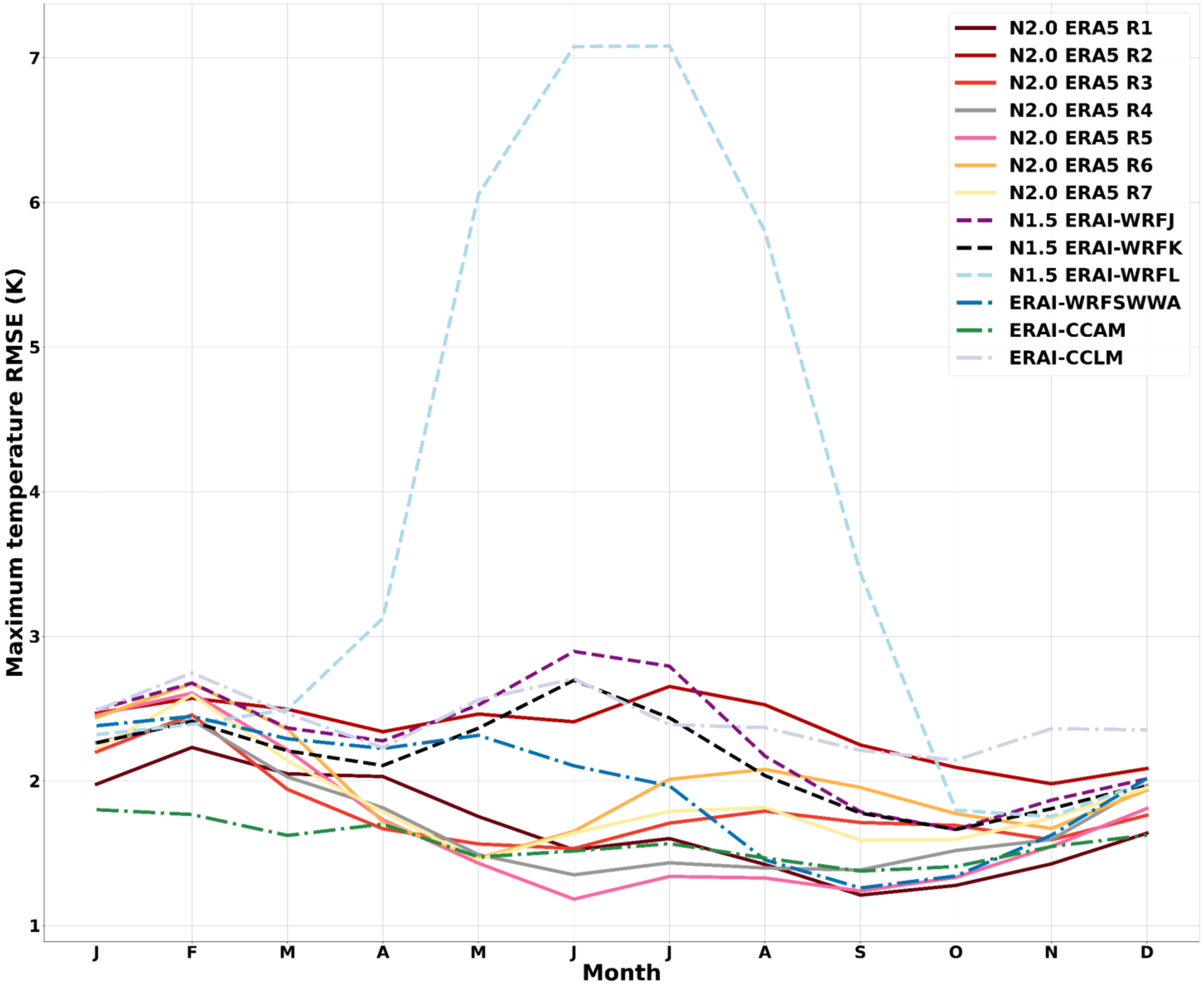

Fig. S7 RMSE annual cycle for historical maximum near surface temperature (K) as simulated over Australia by the ERA5-forced and ERA-Interim-forced RCMs.

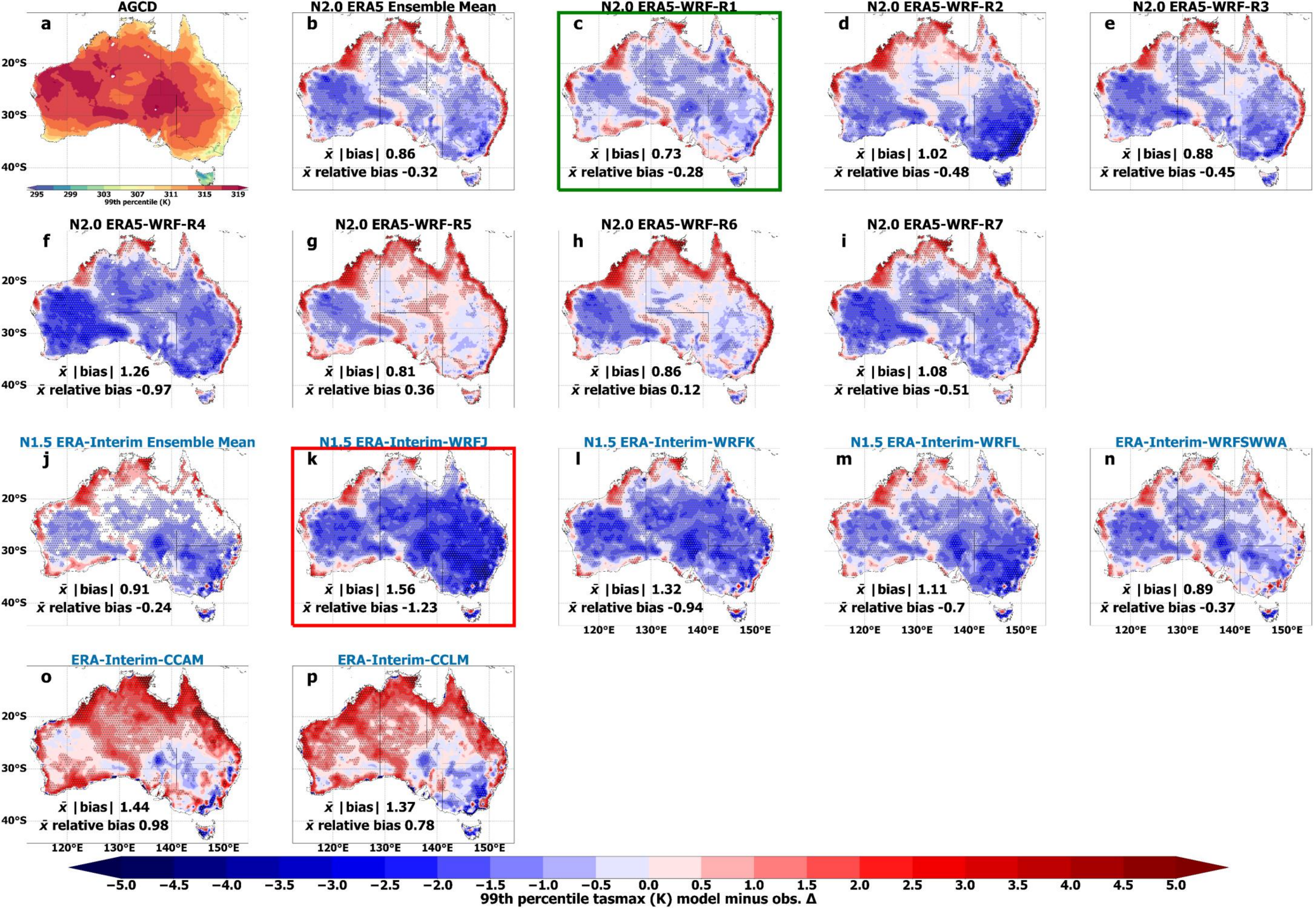

Fig. S8 Biases in 99th percentile maximum temperatures simulated by the ERA5 and ERA-Interim forced RCMs relative to AGCD gridded observations with stippling and panel boundary colouring as per Fig. S5.

Table S1. Diagnostics for seven (R1-R7) ERA5-forced regional climate models (RCMs) and six ERA-Interim-forced RCMs and their respective ensemble means for 1981-2010 with Australian Gridded Climate Data as reference data. Mean absolute biases are shown for annual and seasonal mean maximum and minimum temperature and precipitation, for annual extreme maximum and minimum temperature and precipitation, as well as Perkins Skill Scores (PSS) for the daily distributions of these variables for the CORDEX-Australasia domain over Australia (20 km resolution). Bold values indicate which of the ERA5-RCMs R1-R7 has the best diagnostic score from this RCM set.

			CORDEX Australasia (20 km)				
			Climate Means: Mean |bias|			**Climate Extremes: Mean |bias|**	**PSS**
Variable	**Generation**	**RCM**	**Annual**	**DJF**	**JJA**	**Annual**	
tasmax (K)	ERA5-RCMs	Ensemble	0.85	0.81	1.34	0.86	N/A
		R1	0.83	**0.68**	1.10	**0.73**	0.957
		R2	1.61	1.23	2.30	1.02	0.917
		R3	0.90	0.80	1.35	0.88	0.950
		R4	0.92	1.03	1.01	1.26	**0.958**
		R5	**0.54**	1.09	**0.84**	0.81	0.942
		R6	0.85	1.18	1.58	0.86	0.922
		R7	0.85	0.99	1.39	1.08	0.938
	ERAI-RCMs	Ensemble	1.33	0.80	2.24	0.91	N/A
		WRFJ	1.58	1.29	2.26	1.56	0.940
		WRFK	1.37	1.06	2.02	1.32	0.945
		WRFL	2.67	0.99	5.67	1.11	0.880
		WRFSWWA	1.07	0.92	1.33	0.89	0.952
		CCAM	0.98	0.97	1.57	1.44	0.904
		CCLM	0.92	0.94	1.21	1.37	0.946
tasmin (K)	ERA5-RCMs	Ensemble	0.73	0.89	0.96	1.48	N/A
		R1	0.95	1.12	0.85	1.30	0.943
		R2	**0.77**	1.03	**0.70**	**1.02**	0.935
		R3	**0.77**	1.02	0.96	1.47	0.938
		R4	0.81	**0.73**	1.23	1.90	**0.944**
		R5	0.93	1.22	1.07	1.55	0.937
		R6	0.89	1.23	1.24	1.69	0.933
		R7	0.89	0.99	1.41	1.97	0.930
	ERAI-RCMs	Ensemble	0.73	0.69	0.76	1.01	N/A
		WRFJ	0.63	0.69	0.76	0.96	0.976
		WRFK	0.70	0.72	0.78	0.96	0.975
		WRFL	1.47	0.78	2.80	2.86	0.915
		WRFSWWA	1.75	1.78	1.68	2.15	0.912
		CCAM	1.07	0.59	1.82	1.50	0.945
		CCLM	2.25	1.75	2.75	3.33	0.900
pr (mm)	ERA5-RCMs	Ensemble	7.28	18.42	4.31	8.64	N/A
		R1	13.48	27.82	5.17	20.02	0.773
		R2	11.33	22.79	5.06	14.83	**0.817**
		R3	8.31	19.72	**5.02**	9.80	0.805
		R4	**7.46**	**16.33**	5.67	**9.21**	0.801
		R5	12.59	33.93	5.21	11.40	0.814
		R6	16.29	49.29	6.16	10.25	0.787
		R7	15.92	46.43	6.23	9.91	0.787
	ERAI-RCMs	Ensemble	7.48	12.73	5.96	7.60	N/A
		WRFJ	20.65	31.54	12.38	8.75	0.798
		WRFK	12.86	23.31	9.83	11.06	0.770
		WRFL	7.81	15.96	7.63	9.45	0.678
		WRFSWWA	9.81	16.82	7.75	20.94	0.806
		CCAM	10.39	22.85	9.17	15.77	0.837
		CCLM	11.66	24.05	5.61	17.69	0.798

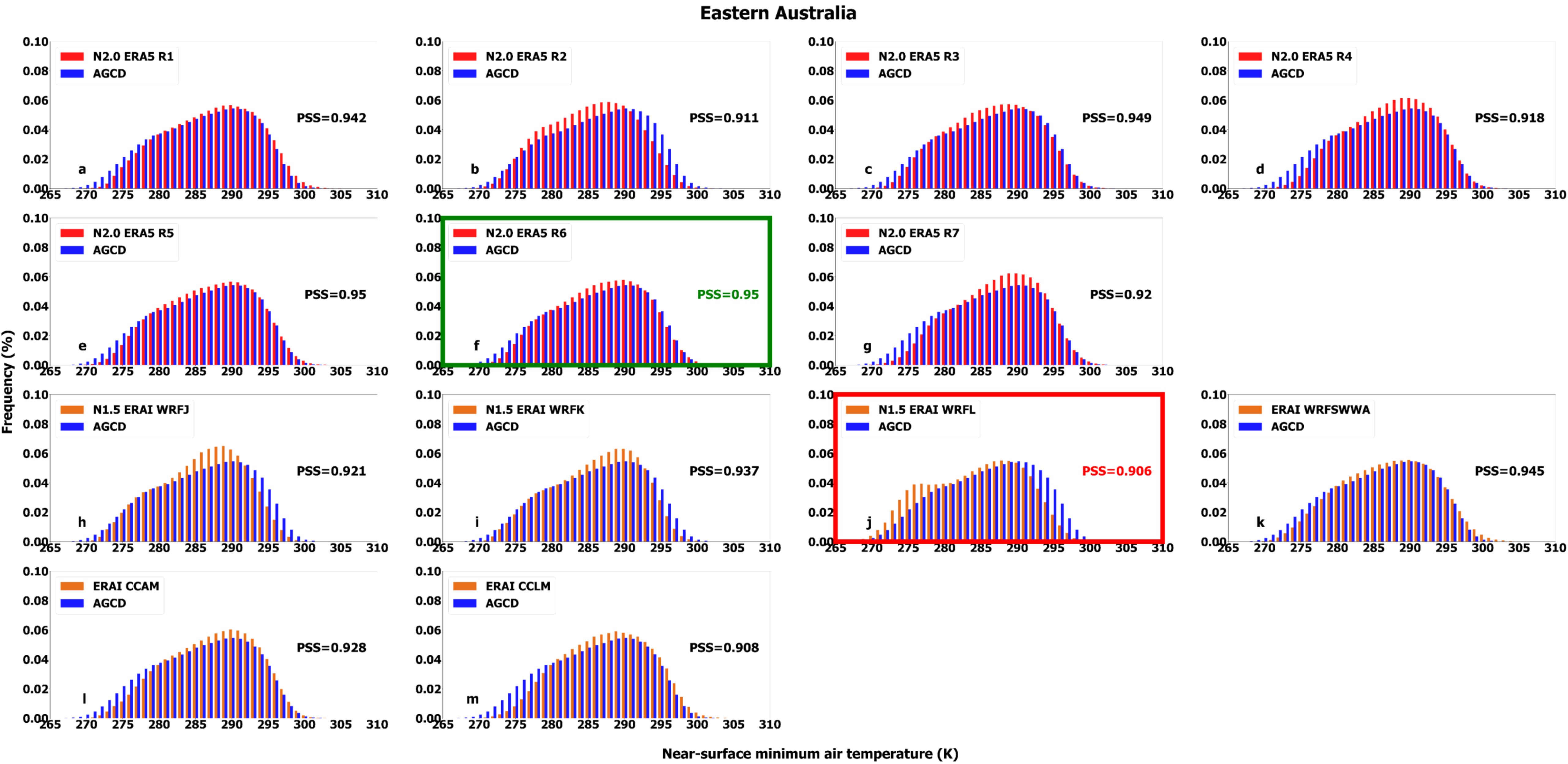

Fig. S9 Probability density functions of daily minimum near-surface air temperature (K) with bin width of 1 K in the Eastern Australia Natural Resource Management (NRM) region.

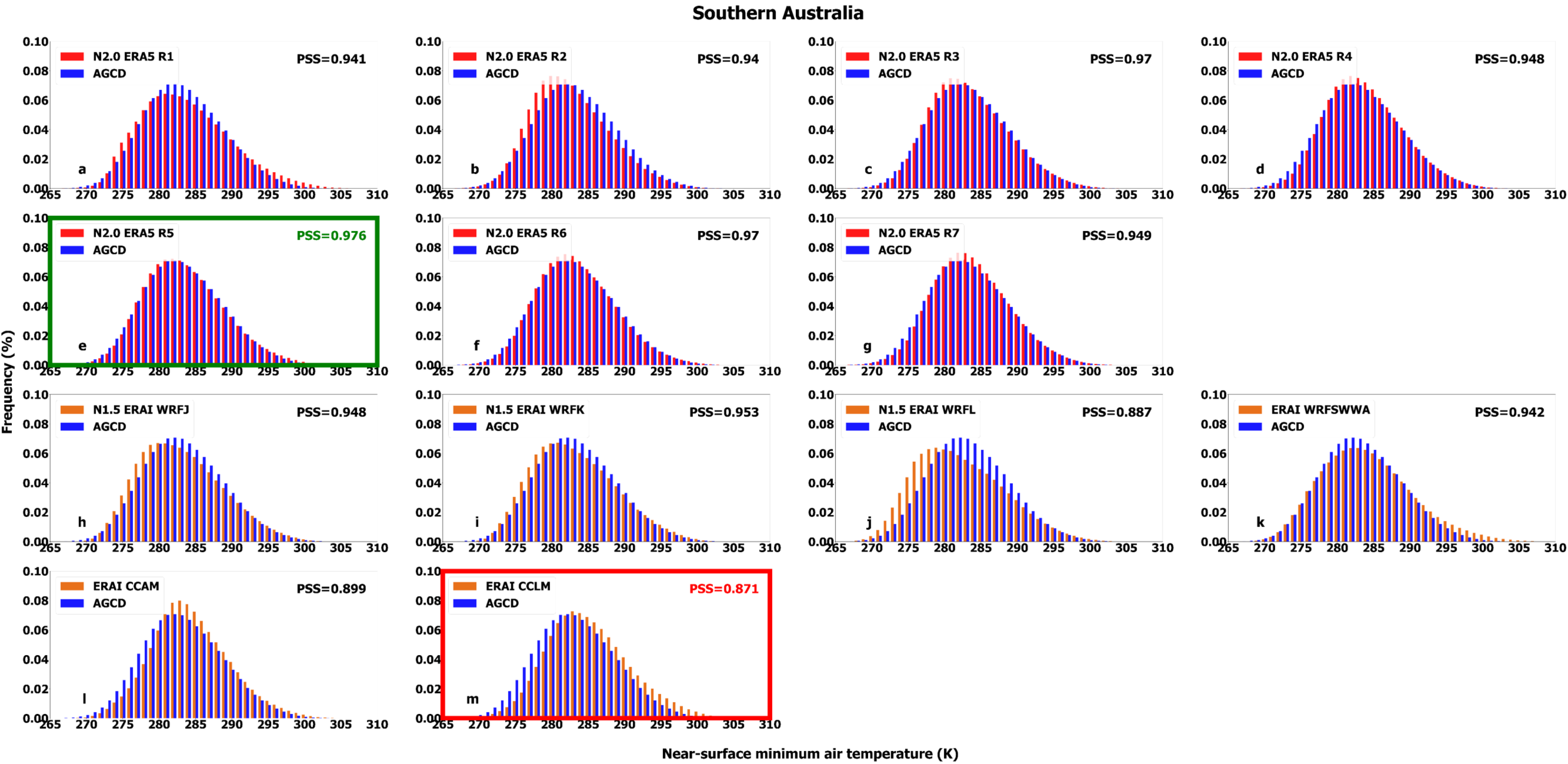

Fig. S10 Probability density functions of daily minimum near-surface air temperature (K) with bin width of 1 K in the Southern Australia Natural Resource Management (NRM) region.

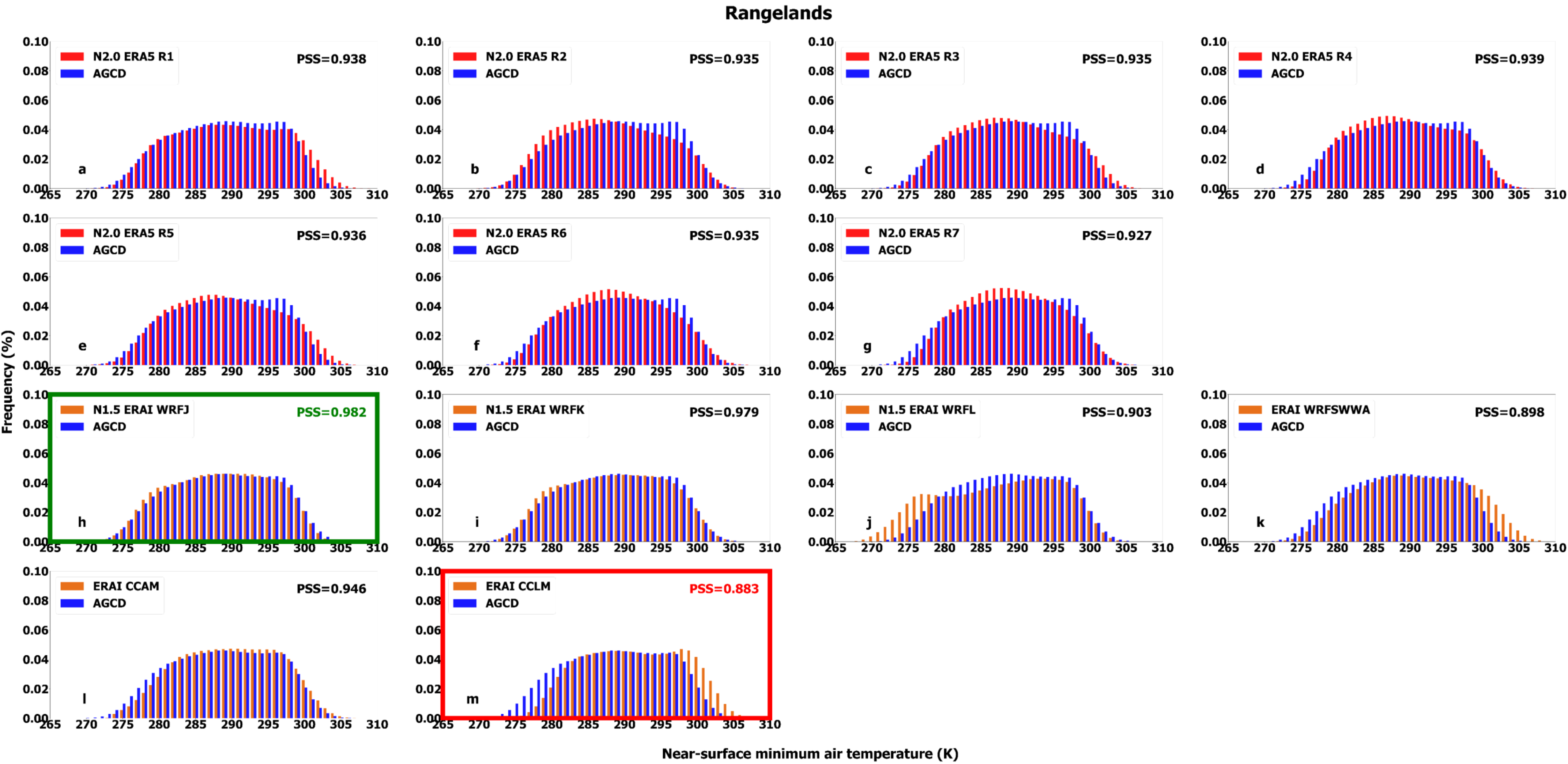

Fig. S11 Probability density functions of daily minimum near-surface air temperature (K) with bin width of 1 K in the Rangelands Natural Resource Management (NRM) region.

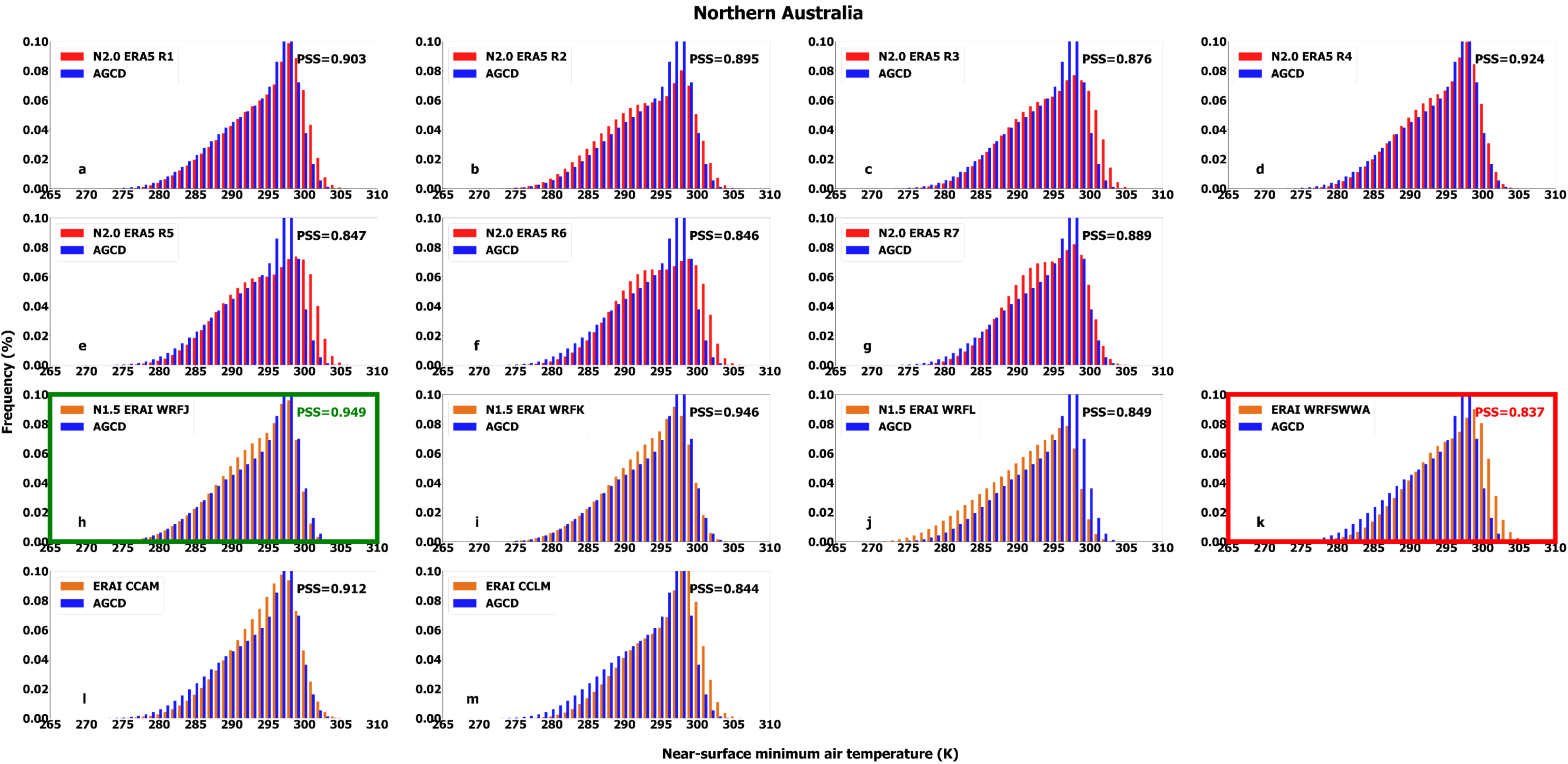

Fig. S12 Probability density functions of daily minimum near-surface air temperature (K) with bin width of 1 K in the Northern Australia Natural Resource Management (NRM) region.

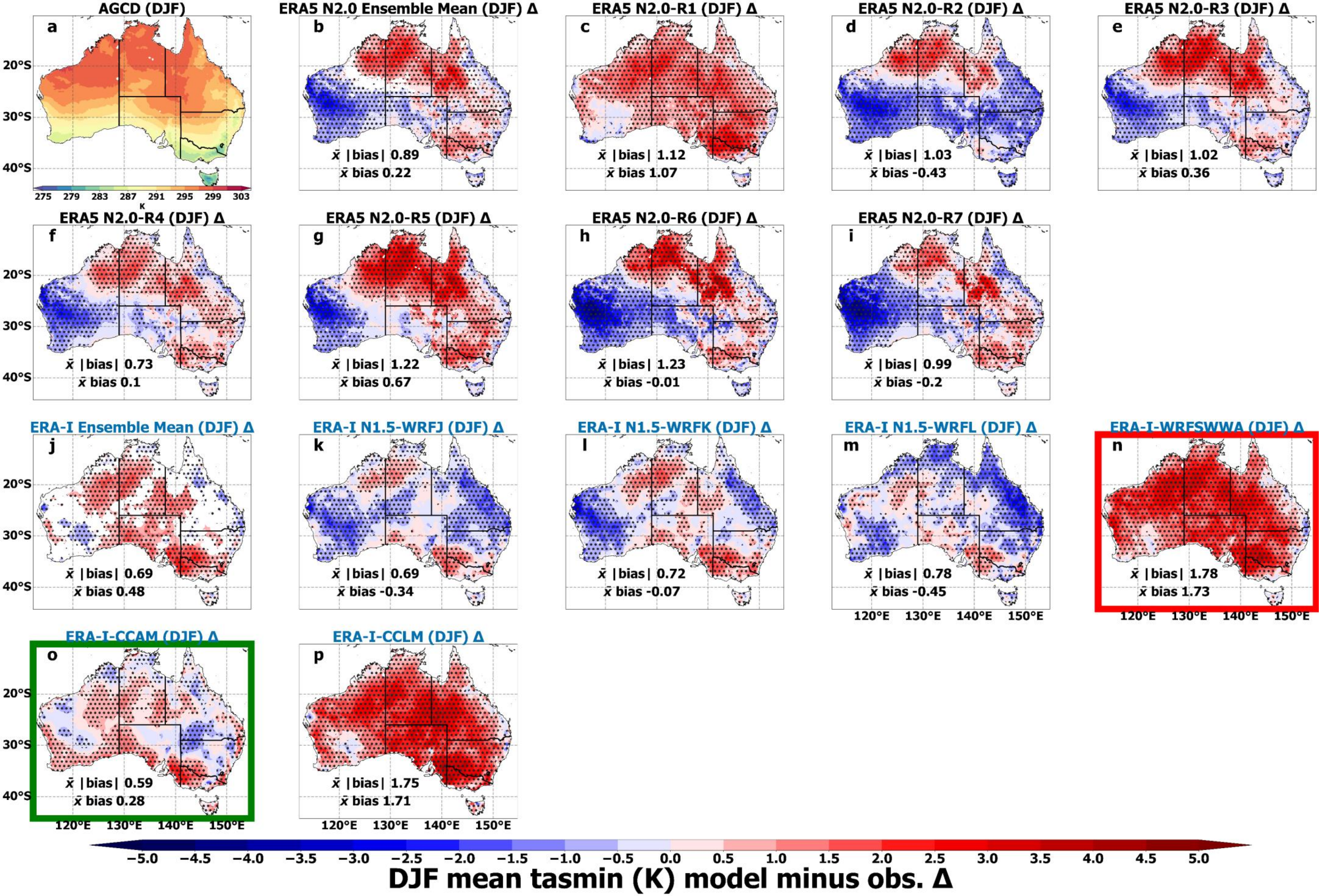

Fig. S13 Summer (DJF) minimum temperature bias with respect to gridded observations with stippling and panel boundaries as per Fig. S5.

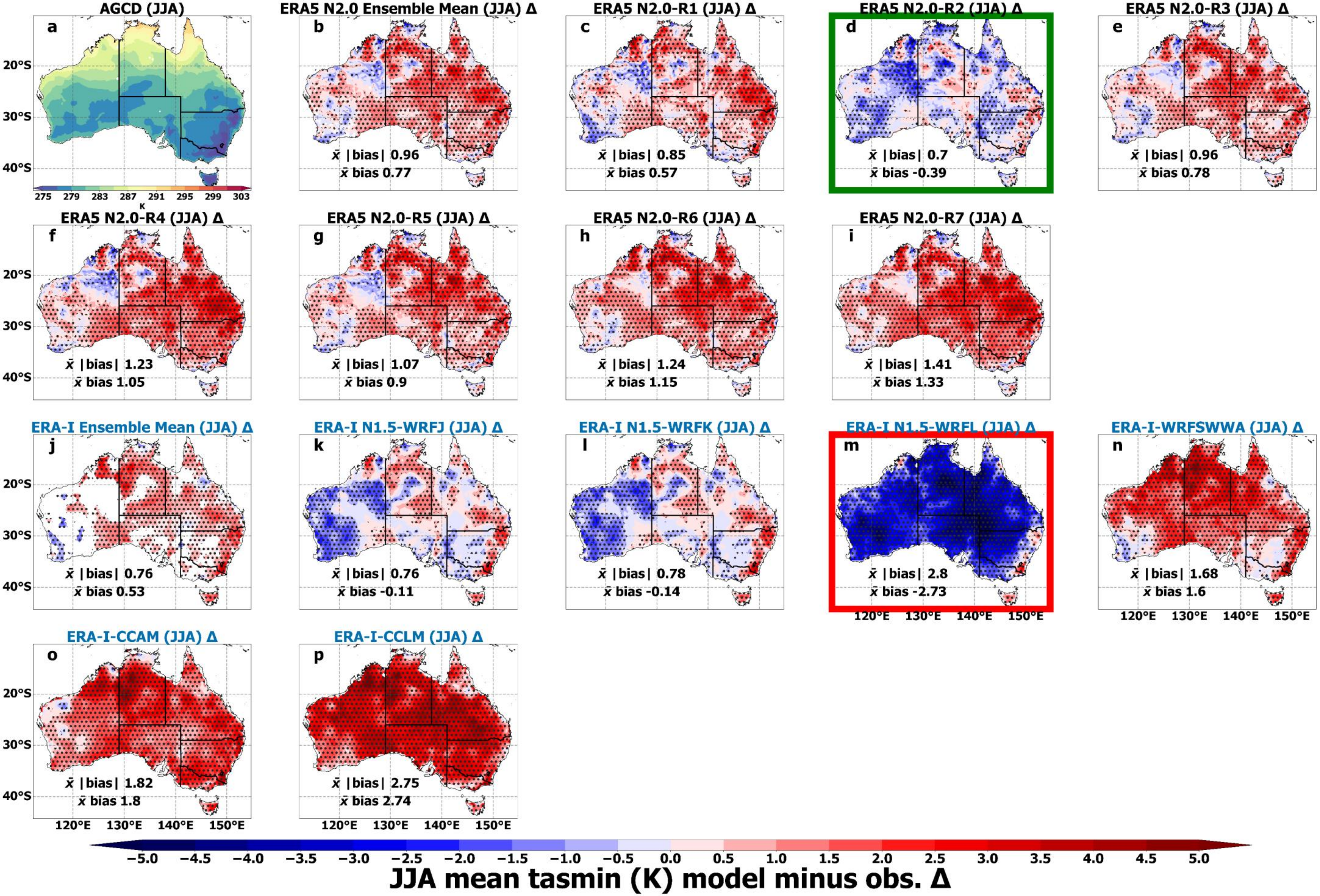

Fig. S14 Winter (JJA) minimum temperature bias with respect to gridded observations with stippling and panel boundary colouring as per Fig. S5.

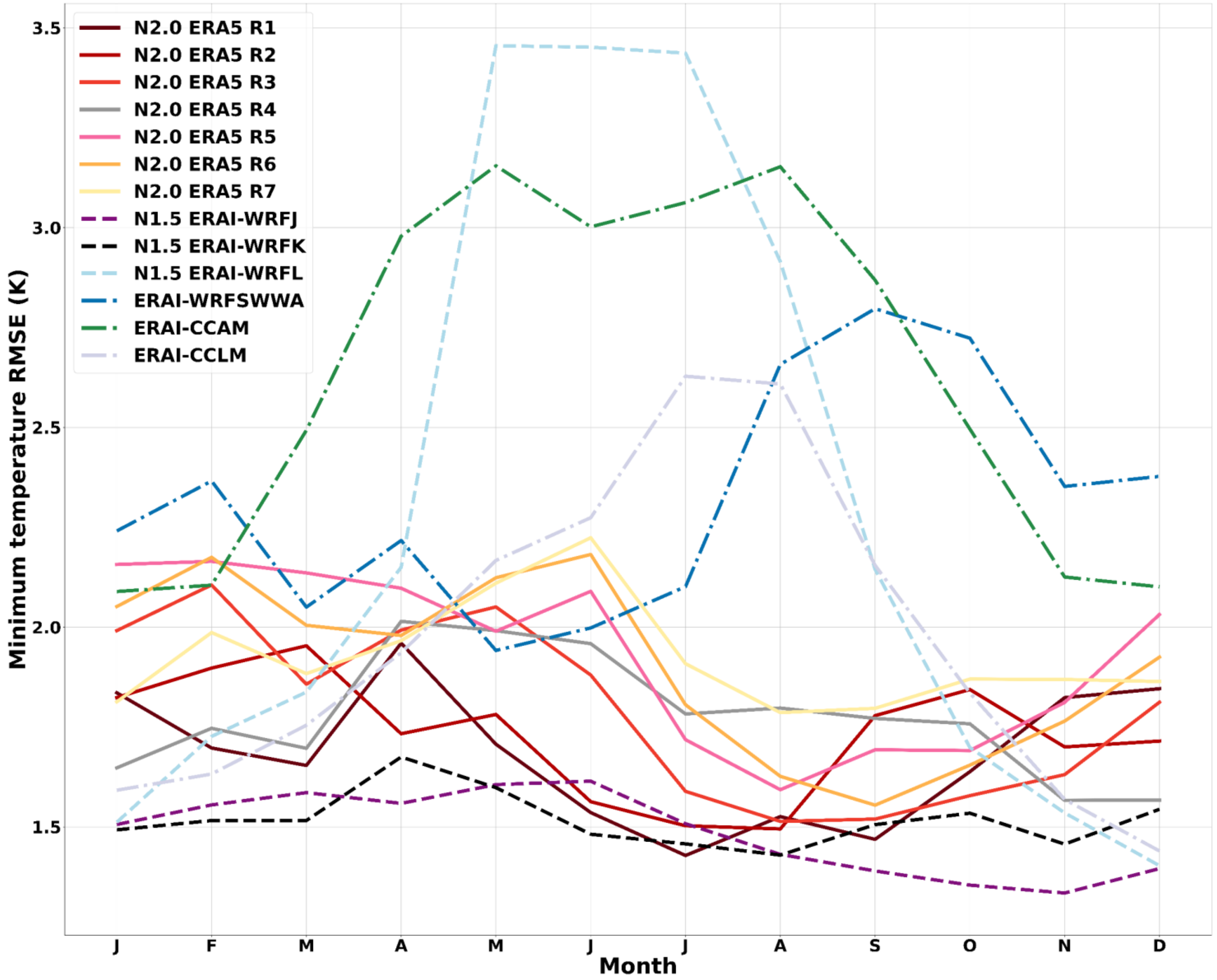

Fig. S15 RMSE annual cycle for historical minimum near surface temperature (K) as simulated over Australia by the ERA5-forced and ERA-Interim-forced RCMs.

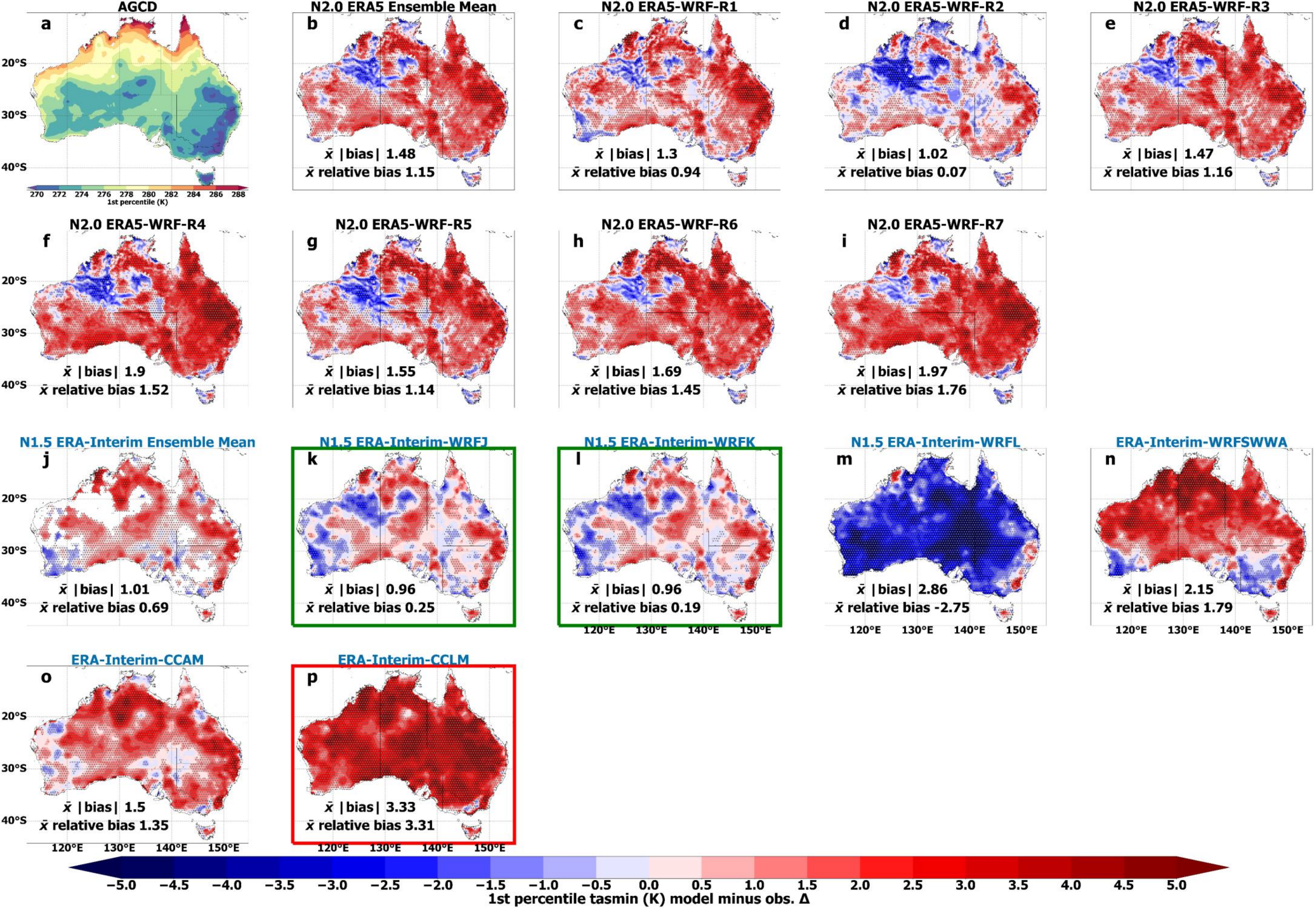

Fig. S16 Biases in 1st percentile minimum temperatures simulated by the ERA5 and ERA-Interim forced RCMs relative to AGCD gridded observations with stippling and panel boundary colouring as per Fig. S5.

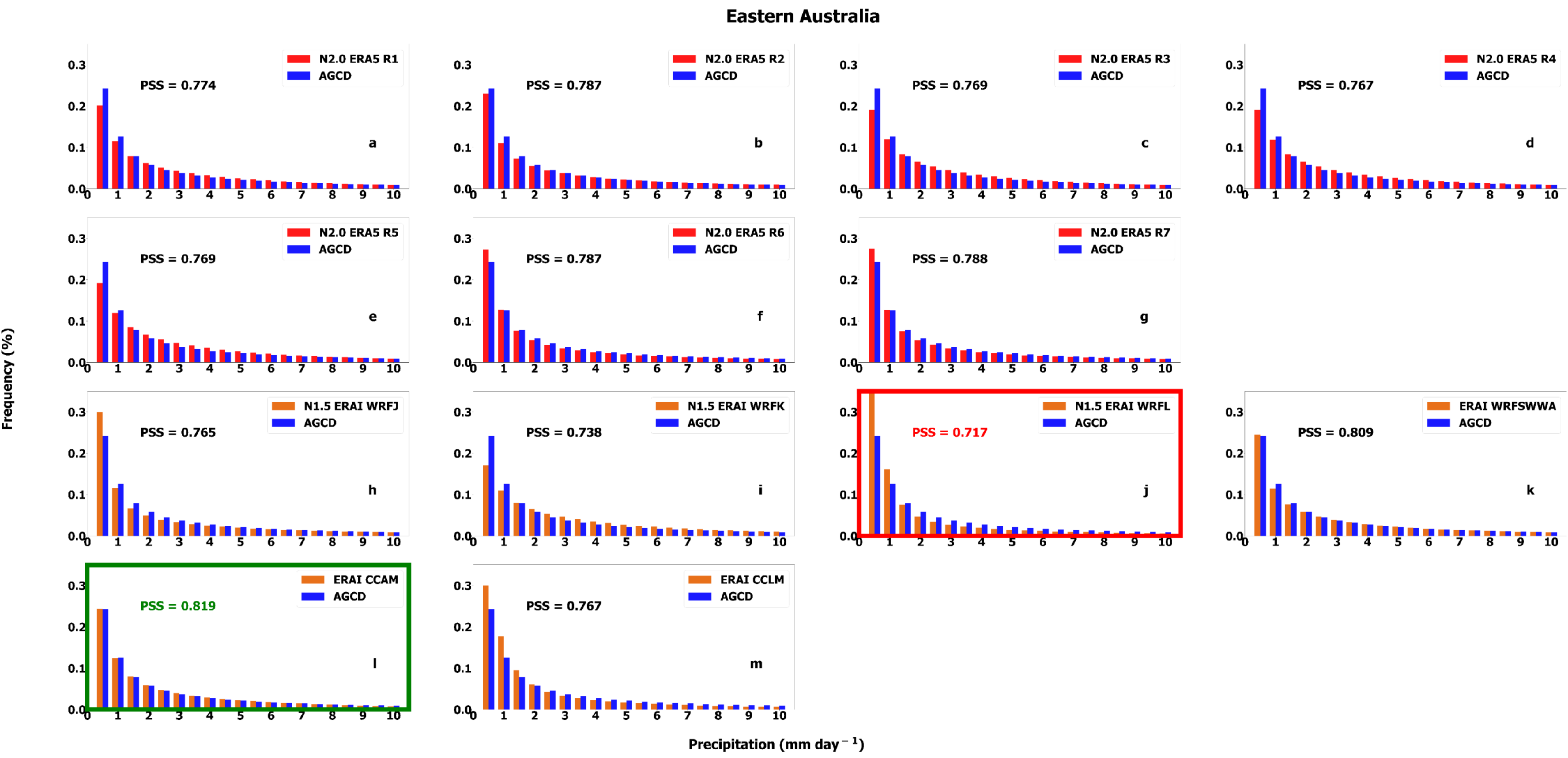

Fig. S17 Probability density functions of daily precipitation (mm day^{-1}) with bin width of 0.5 mm in the Eastern Australia Natural Resource Management (NRM) region.

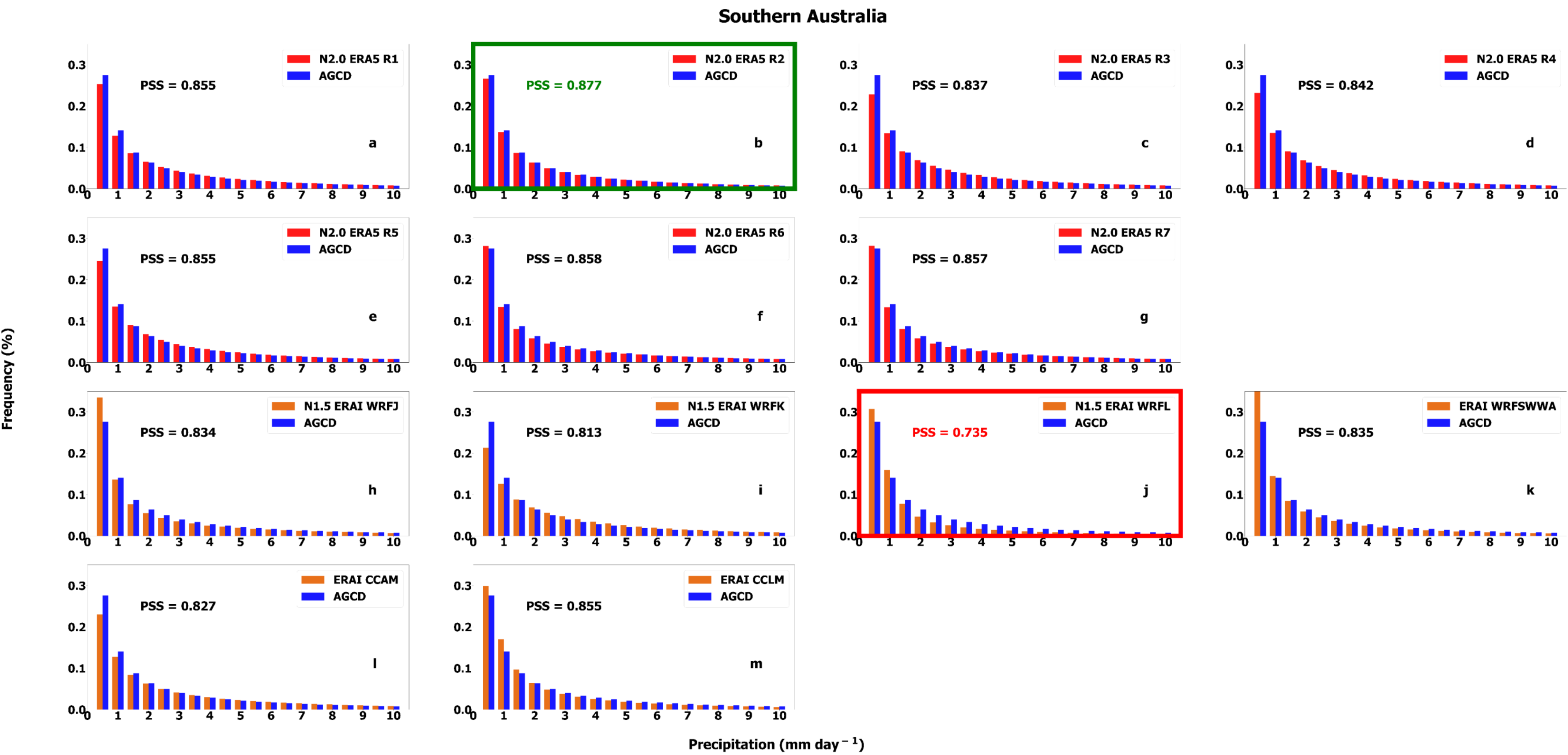

Fig. S18 Probability density functions of daily precipitation (mm day^{-1}) with bin width of 0.5 mm in the Southern Australia Natural Resource Management (NRM) region.

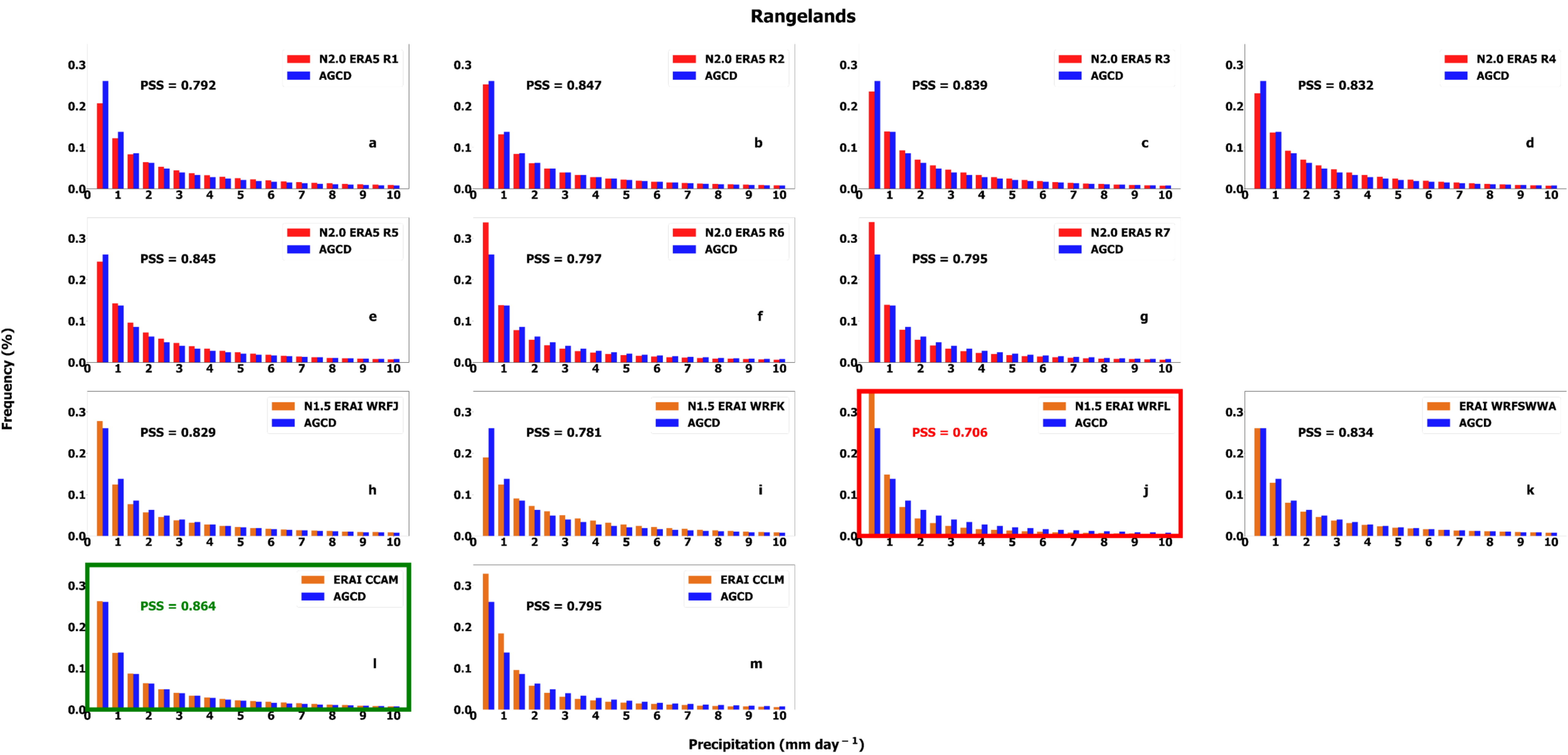

Fig. S19 Probability density functions of daily precipitation (mm day^{-1}) with bin width of 0.5 mm in the Rangelands Natural Resource Management (NRM) region.

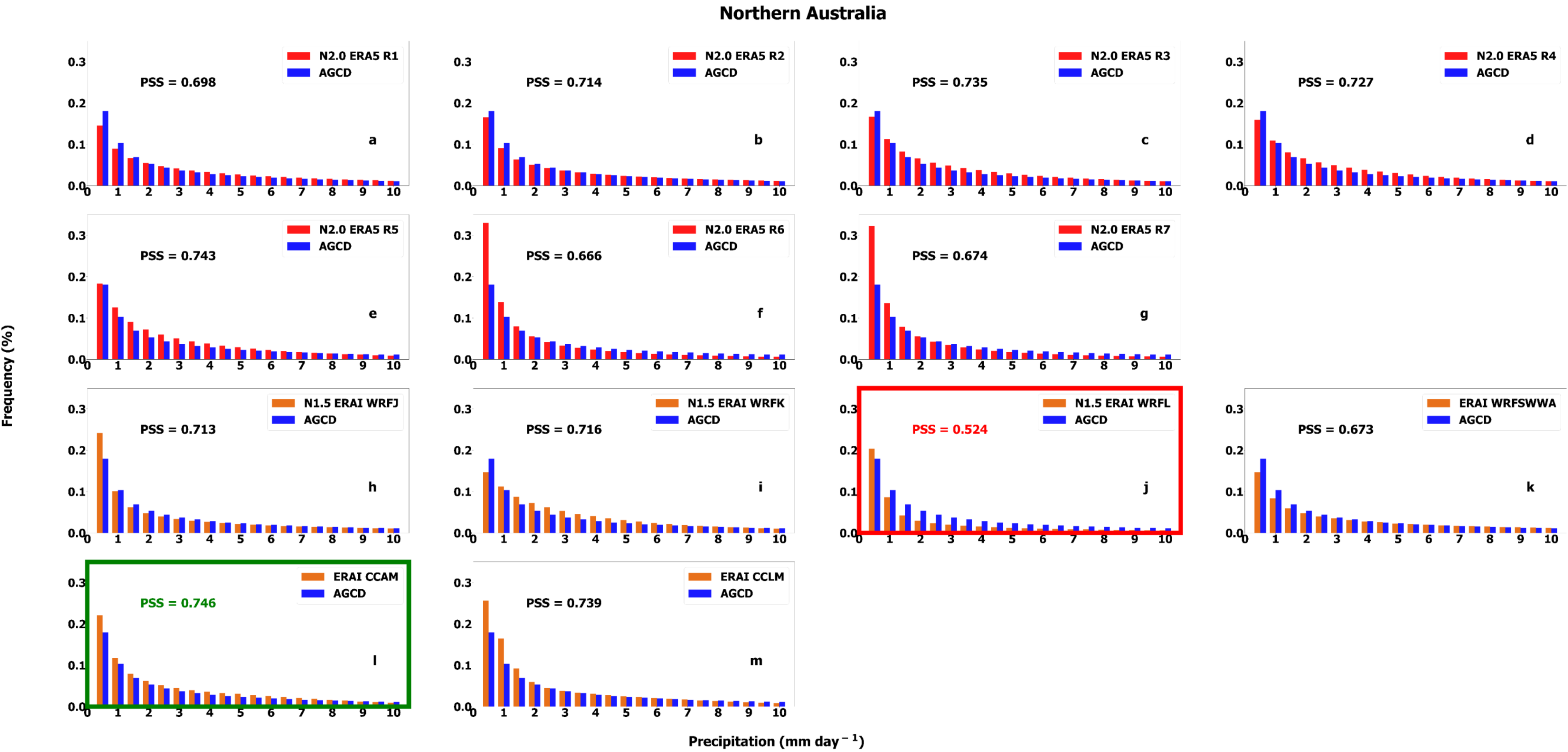

Fig. S20 Probability density functions of daily precipitation (mm day^{-1}) with bin width of 0.5 mm in the Northern Australia Natural Resource Management (NRM) region.

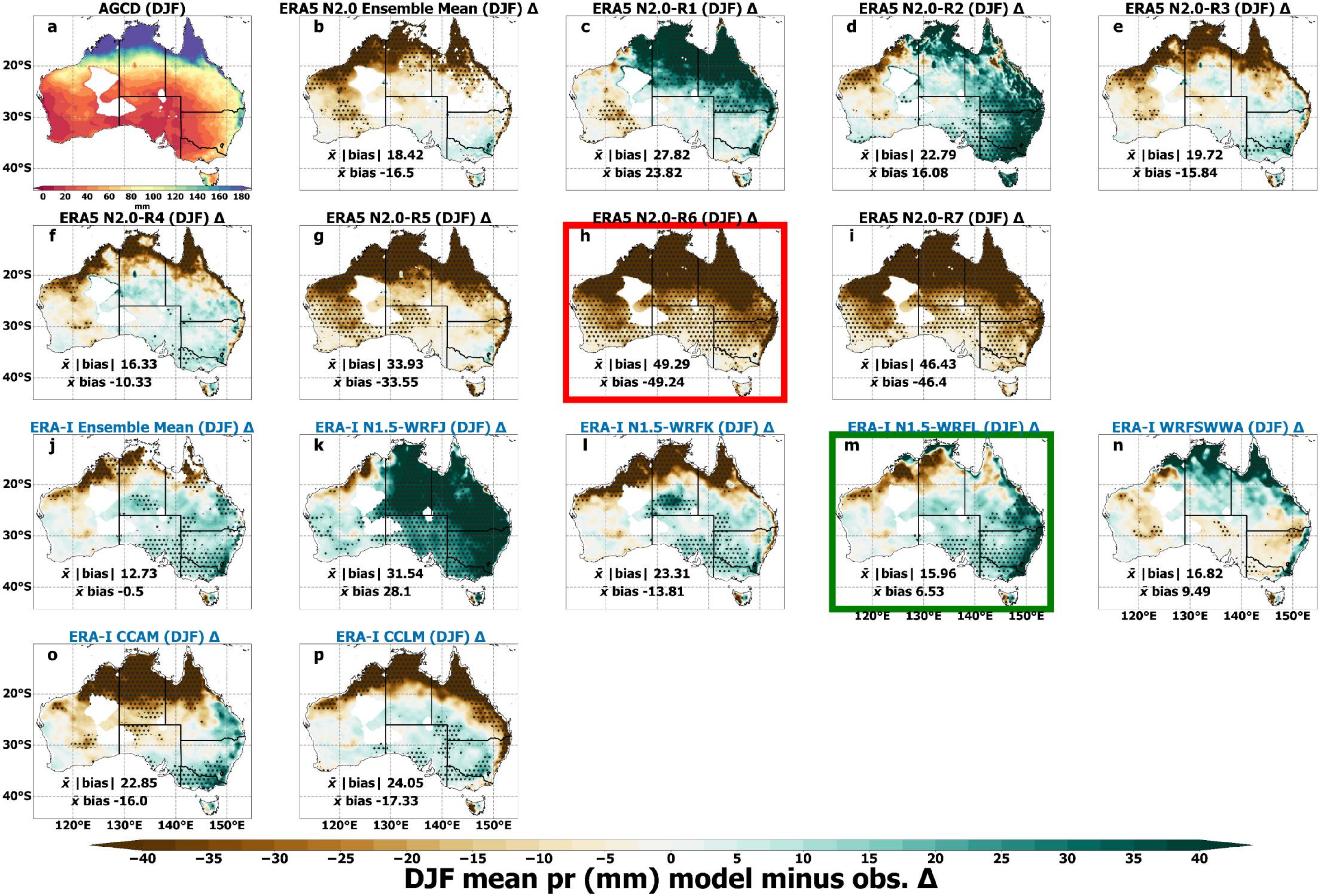

Fig. S21 Summer (DJF) precipitation bias with respect to gridded observations with stippling and panel boundary colouring as per Fig. S5.

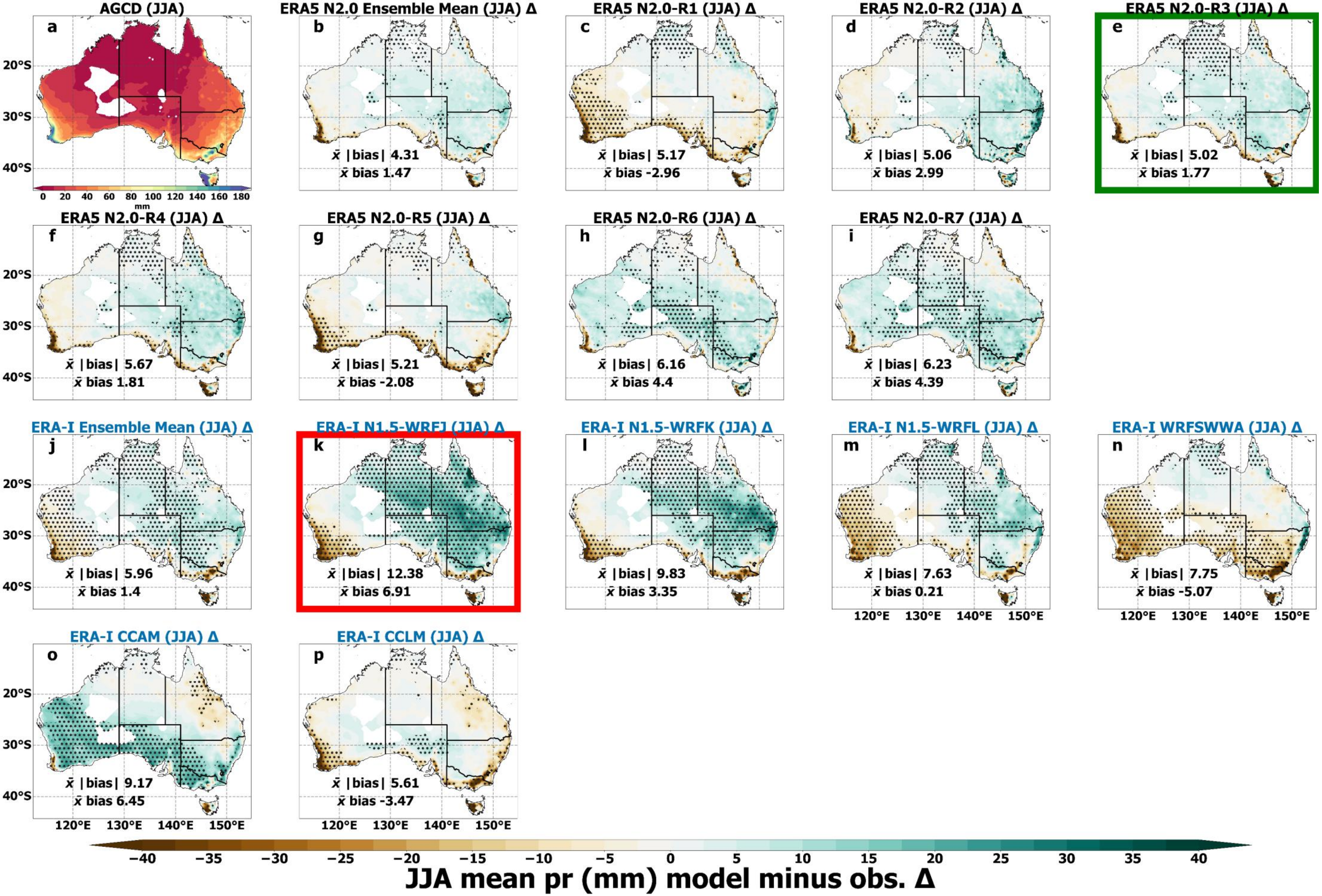

Fig. S22 Winter (JJA) precipitation bias with respect to gridded observations with stippling and panel boundary colouring as per Fig. S5.

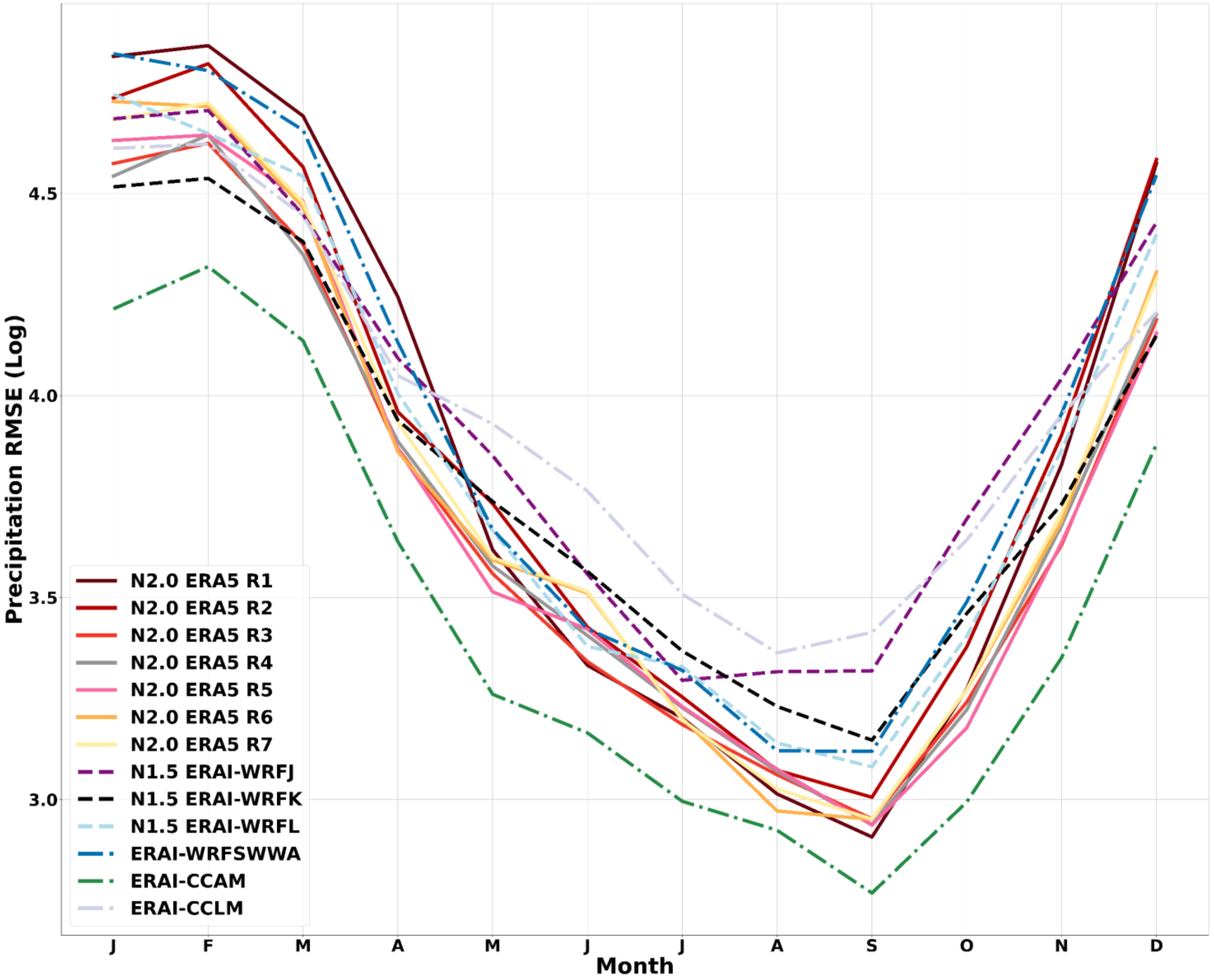

Fig. S23 RMSE (log-transformed) annual cycle for historical precipitation as simulated over Australia by the ERA5-forced and ERA-Interim-forced RCMs.

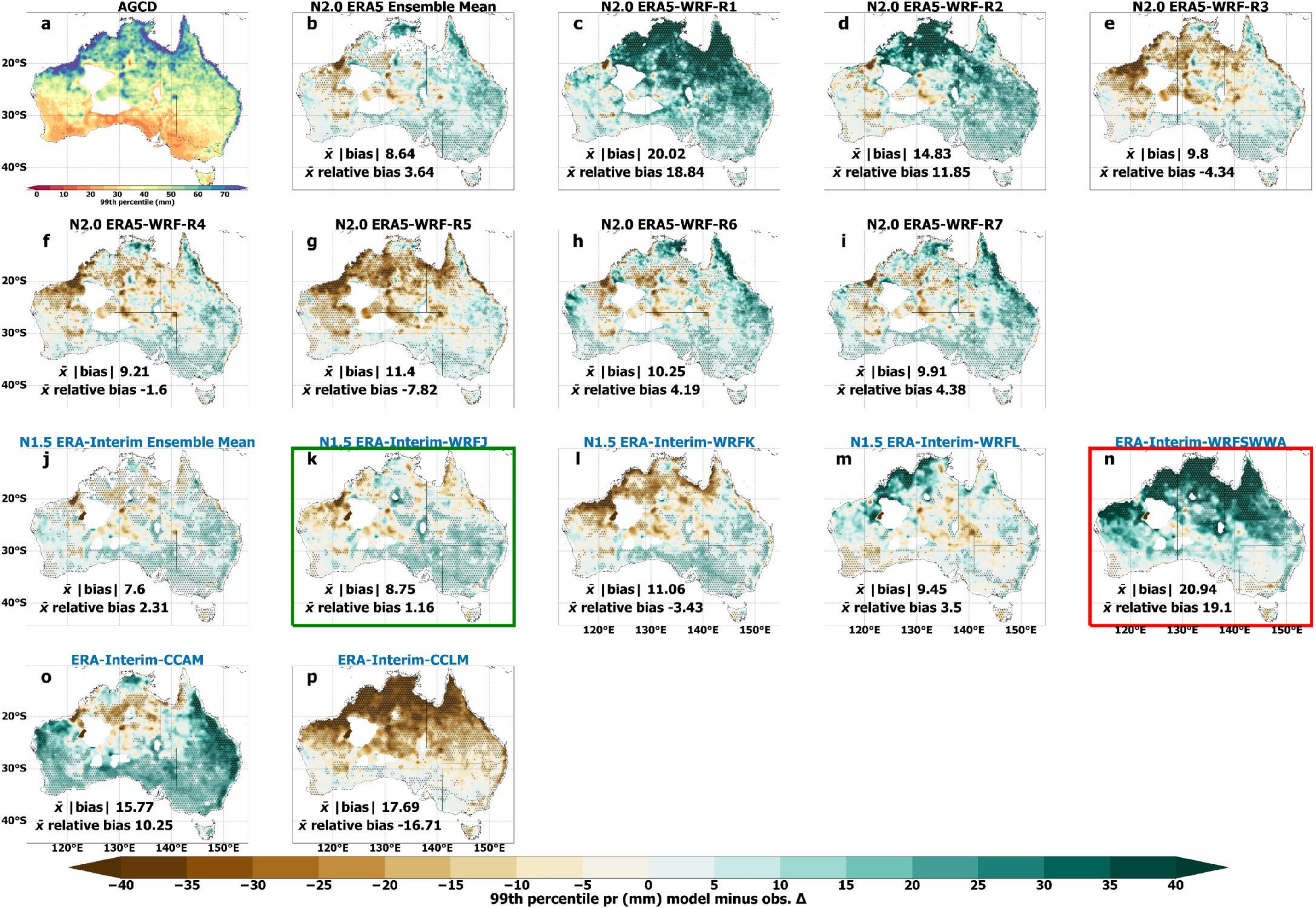

Fig. S24 Biases in 99th percentile precipitation simulated by the ERA5 and ERA-Interim forced RCMs relative to AGCD gridded observations with stippling and panel boundary colouring as per Fig. S5.

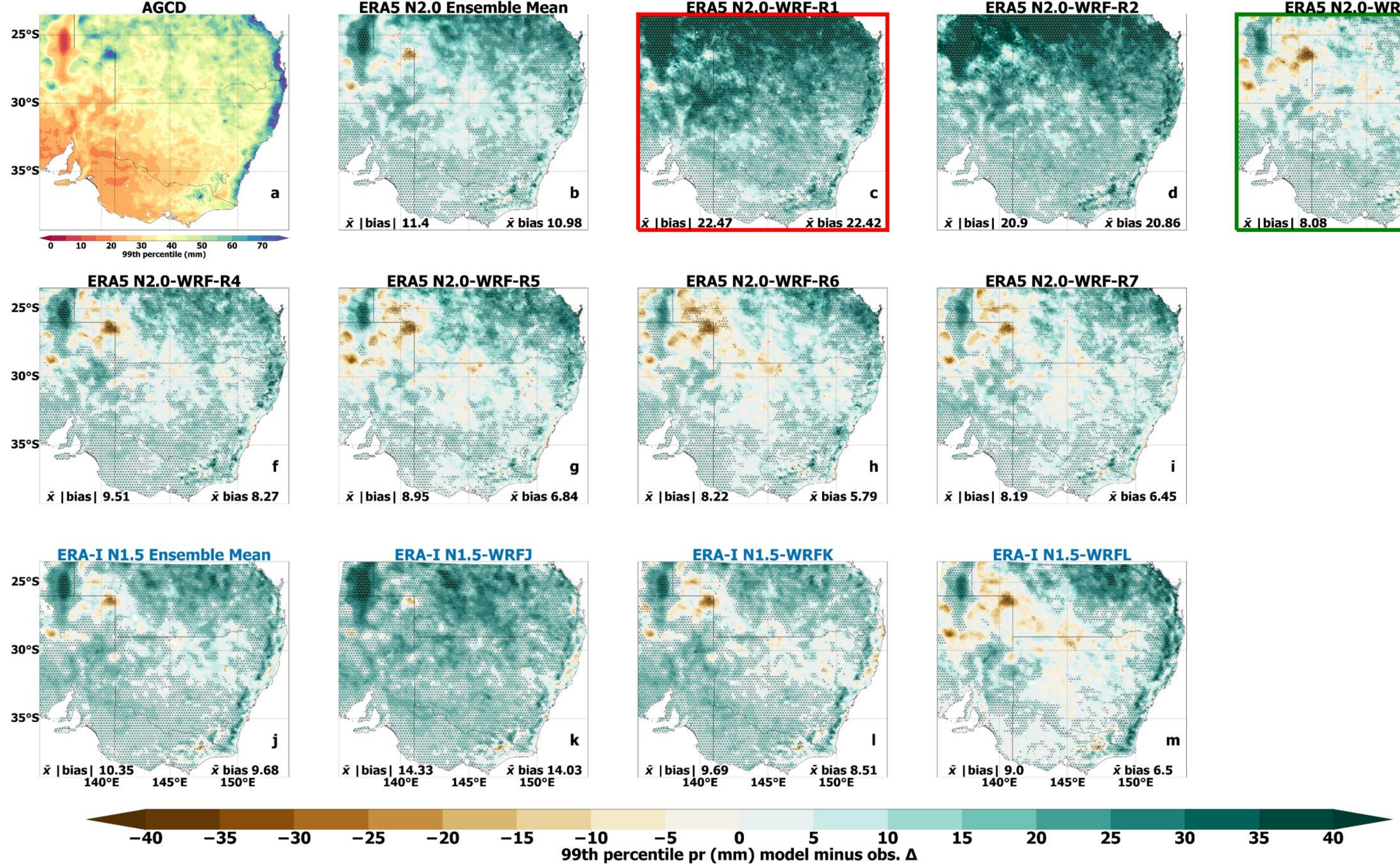

Fig. S25 Biases in 99th percentile precipitation simulated over south-eastern Australia (WRF simulation inner domain) by the ERA5 and ERA-Interim forced RCMs relative to AGCD gridded observations with stippling and panel boundary colouring as per Fig. S5.

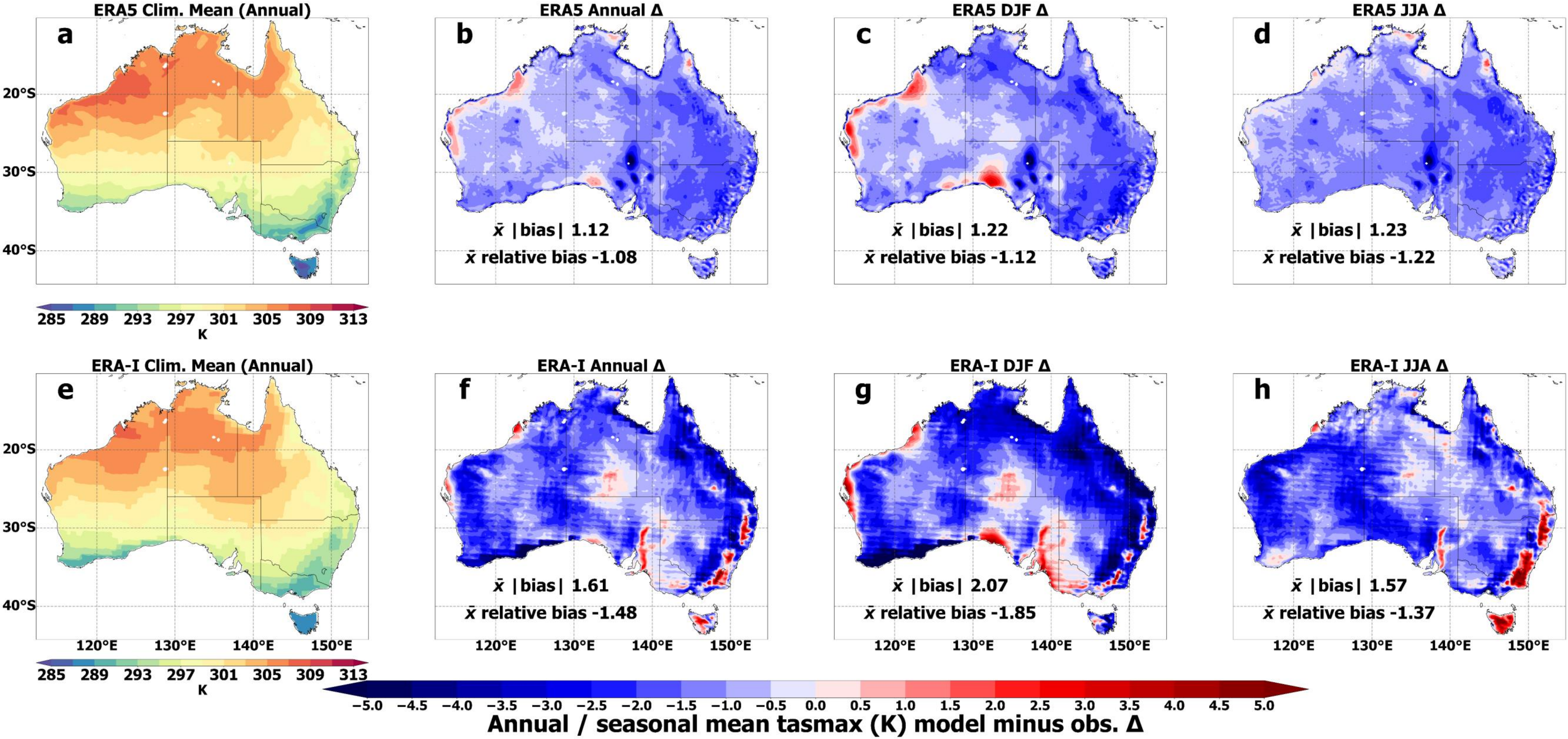

Fig. S26 Annual, summer, and winter mean near-surface atmospheric maximum temperature bias for ERA5 and ERA-Interim reanalyses data sets with respect to Australian Gridded Climate Data (AGCD) observations (1981-2010).

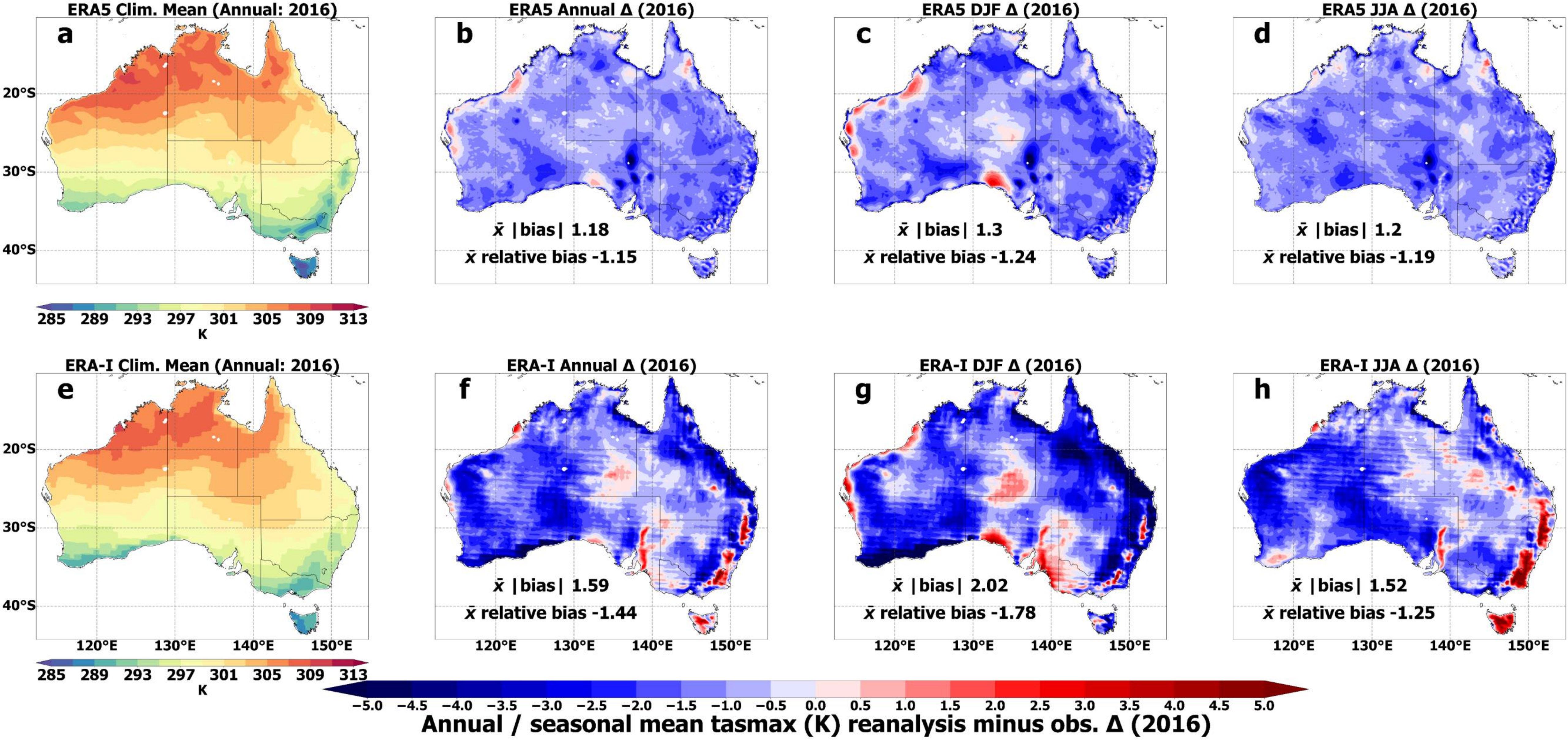

Fig. S27 As per Fig. S26 but for 2016.

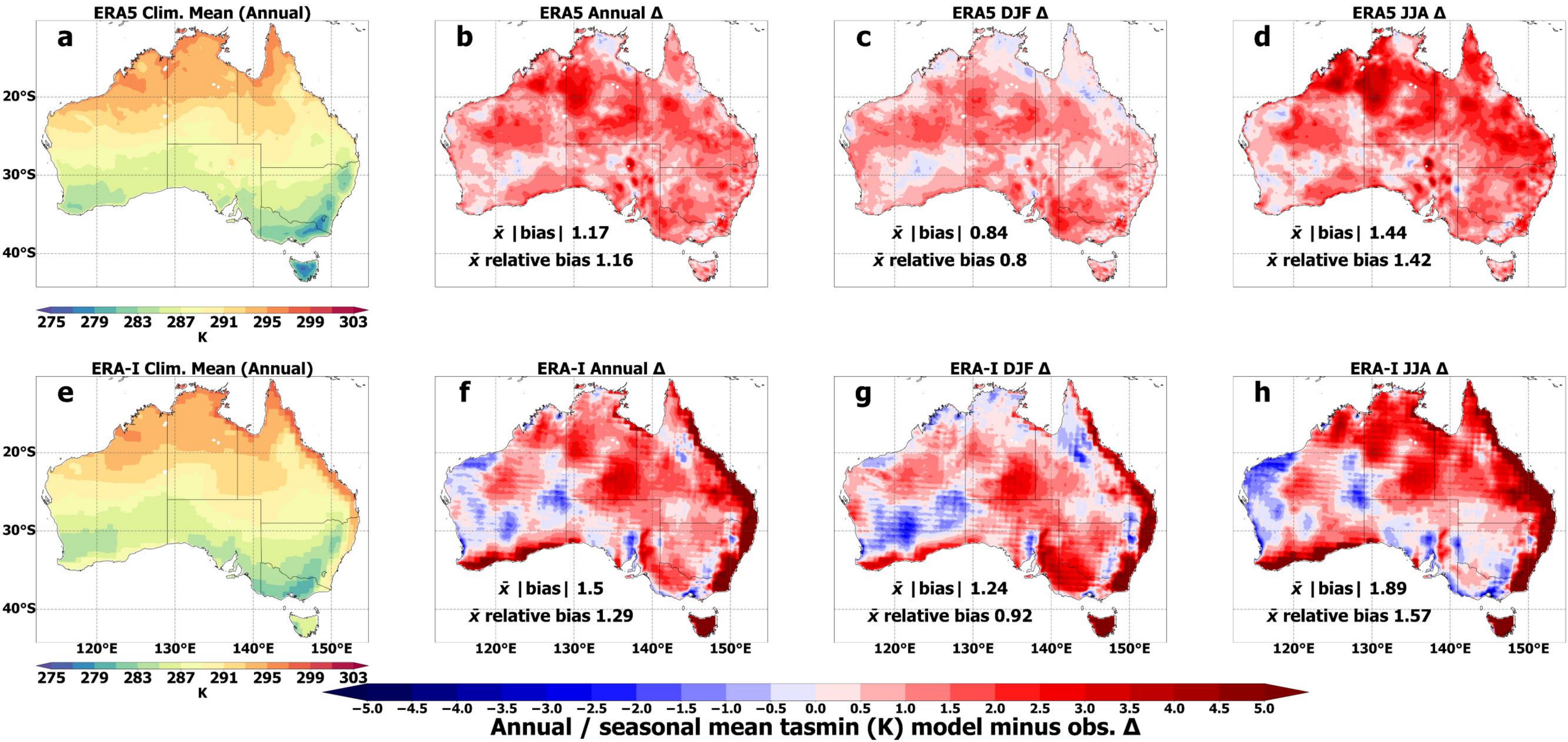

Fig. S28 Annual, summer, and winter mean near-surface atmospheric minimum temperature bias for ERA5 and ERA-Interim reanalyses data sets with respect to Australian Gridded Climate Data (AGCD) observations (1981-2010).

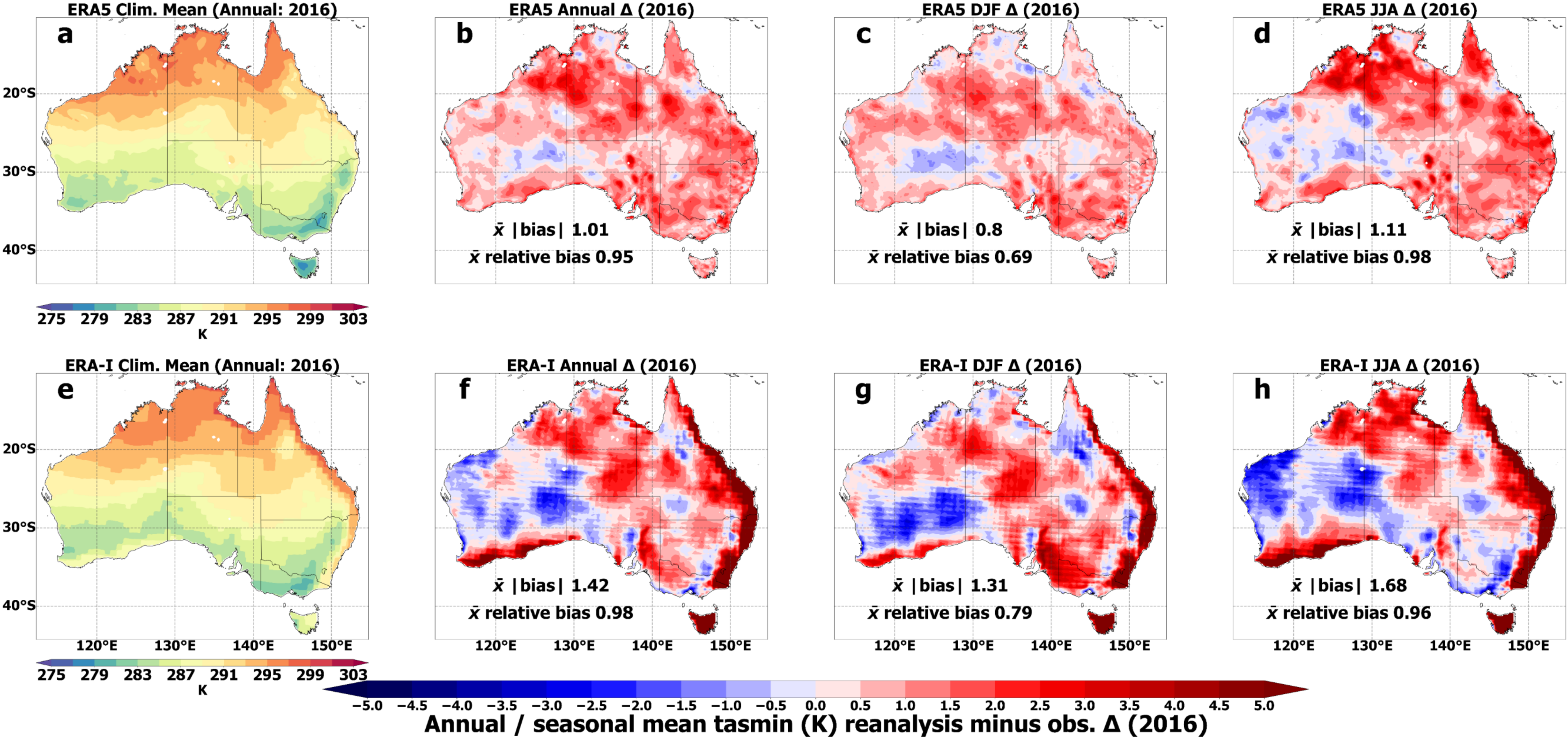

Fig. S29 As per Fig. S28 but for 2016.

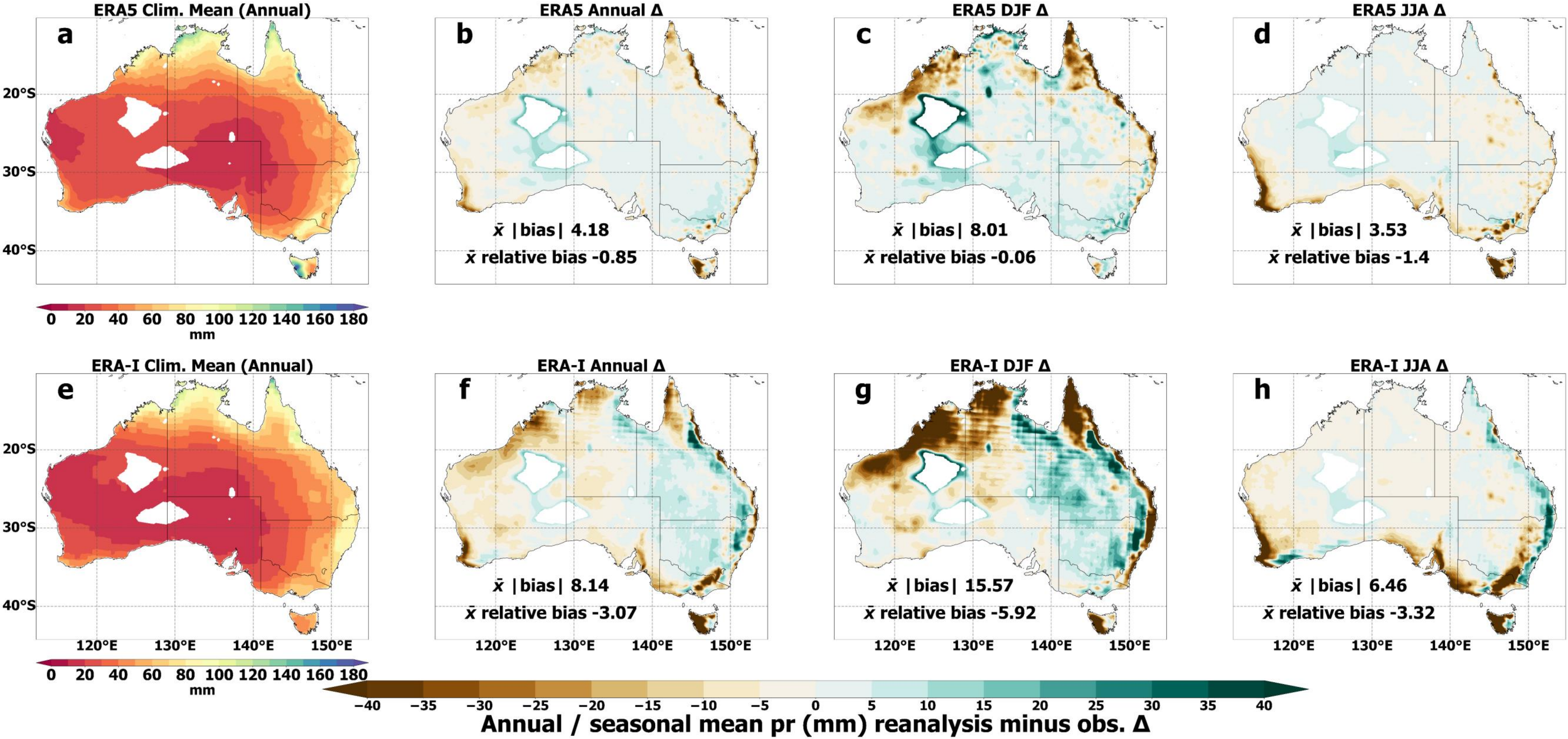

Fig. S30 Annual, summer, and winter mean precipitation bias for ERA5 and ERA-Interim reanalyses data sets with respect to Australian Gridded Climate Data (AGCD) observations (1981-2010).

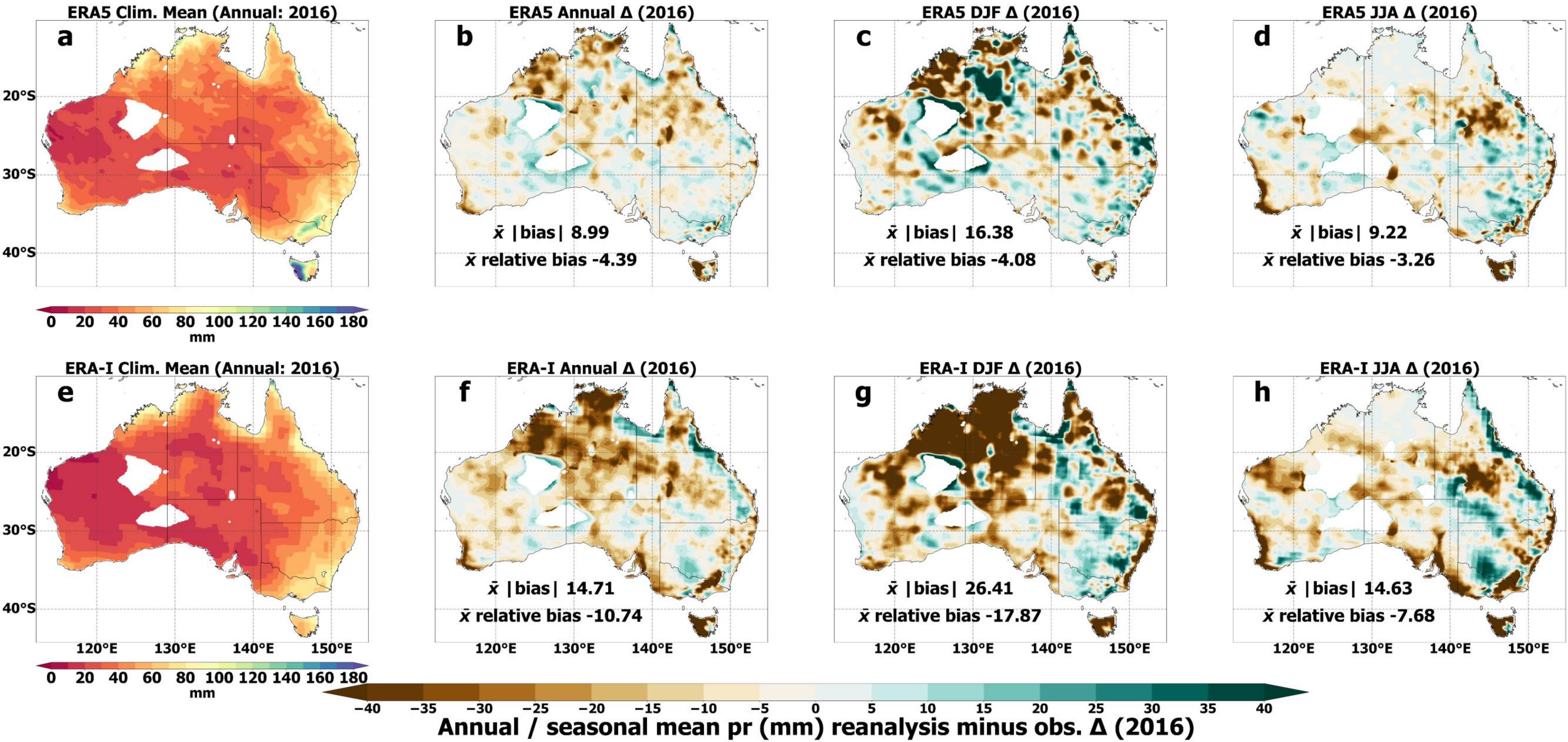

Fig. S31 As per Fig. S30 but for 2016.

Fig. S32 Namelist settings for the CORDEX-CMIP6 NARCliM2.0 ERA5-forced RCMs R1-R7: left panel shows physics settings for each RCM; right panel shows settings universal to each of R1-R7.

	Domain	CORDEX Australasia 20 km outer domain							Southeast Australia Convection-permitting 4 km inner domain						
	RCM	R1	R2	R3	R4	R5	R6	R7	R1	R2	R3	R4	R5	R6	R7
	mp_physics	6	6	8	8	8	8	8	6	6	8	8	8	8	8
	ra_sw_physics	5	4	4	4	4	4	4	5	4	4	4	4	4	4
	ra_lw_physics	5	4	4	4	4	4	4	5	4	4	4	4	4	4
	sf_sfclay_physics	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	sf_surface_physics	2	4	4	4	4	4	4	2	4	4	4	4	4	4
	bl_pbl_physics	1	5	5	5	7	7	7	1	5	5	5	7	7	7
	cu_physics	2	1	2	2	2	6	6	0	0	0	0	0	0	0
	sf_urban_physics	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	radt	10	10	10	10	10	10	10	10	10	10	10	10	10	10
	cudt	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	bldt	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	prec_acc_dt	60	60	60	60	60	60	60	60	60	60	60	60	60	60
	bucket_mm	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
	levsiz	59	59	59	59	59	59	59	59	59	59	59	59	59	59
physics	paerlev	29	29	29	29	29	29	29	29	29	29	29	29	29	29
	cam_abs_dim1	4	4	4	4	4	4	4	4	4	4	4	4	4	4
	cam_abs_dim2	45	45	45	45	45	45	45	45	45	45	45	45	45	45
	isfflx	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	urface_input_sourc	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	num_soil_layers	4	4	4	4	4	4	4	4	4	4	4	4	4	4
	sst_update	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	tmn_update	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	lagday	150	150	150	150	150	150	150	150	150	150	150	150	150	150
	sst_skin	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	usemonalb	.True.	.True.	.True.	.True.	.True.	.True.	.True.	.True.	.True.	.True.	.True.	.True.	.True.	.True.
	rdmaxalb	.True.	.True.	.True.	.True.	.True.	.True.	.True.	.True.	.True.	.True.	.True.	.True.	.True.	.True.
	slope_rad	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	topo_shading	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	shadlen	25000	25000	25000	25000	25000	25000	25000	25000	25000	25000	25000	25000	25000	25000
	dveg		2	2	4	2	2	4		2	2	4	2	2	4
	opt_crs		1	1	1	1	1	1		1	1	1	1	1	1
	opt_sfc		1	1	1	1	1	1		1	1	1	1	1	1
	opt_btr		1	1	1	1	1	1		1	1	1	1	1	1
	opt_run		3	3	1	3	3	1		3	3	1	3	3	1
	opt_frz		1	1	1	1	1	1		1	1	1	1	1	1
	opt_inf		1	1	1	1	1	1		1	1	1	1	1	1
	opt_rad		3	3	3	3	3	3		3	3	3	3	3	3
noah_mp	opt_alb		2	2	2	2	2	2		2	2	2	2	2	2
	opt_snf		1	1	1	1	1	1		1	1	1	1	1	1
	opt_tbot		2	2	2	2	2	2		2	2	2	2	2	2
	opt_stc		1	1	1	1	1	1		1	1	1	1	1	1
	opt_gla		1	1	1	1	1	1		1	1	1	1	1	1
	opt_rsf		1	1	1	1	1	1		1	1	1	1	1	1
	opt_soil		1	1	1	1	1	1		1	1	1	1	1	1
	opt_pedo		1	1	1	1	1	1		1	1	1	1	1	1
	opt_crop		0	0	0	0	0	0		0	0	0	0	0	0

time_control		
run_days	6	
run_hours	0	
run_minutes	0	
run_seconds	0	
start_year	2016	2016
start_month	5	5
start_day	1	1
start_hour	0	0
start_minute	0	0
start_second	0	0
end_year	2016	2016
end_month	5	5
end_day	7	7
end_hour	0	0
end_minute	0	0
end_second	0	0
interval_seconds	21600	
input_from_file	TRUE	TRUE
history_interval	180	180
frames_per_outfile	8	8
restart	TRUE	
restart_interval	1440	
override_restart_timers	TRUE	
write_hist_at_0h_rst	TRUE	
io_form_history	2	
io_form_restart	2	
io_form_input	2	
io_form_boundary	2	
debug_level	0	
output_diagnostics	1	
auxinput4_inname	"wrflowinp_d<domain>"	
auxinput4_interval	360	360
io_form_auxinput4	2	
auxhist3_outname	xtrm_d<domain>_<date>"	
io_form_auxhist3	2	
auxhist3_interval	1440	1440
frames_per_auxhist3	6	6
auxhist4_outname	fhrly_d<domain>_<date>"	
io_form_auxhist4	2	
auxhist4_interval	60	60
frames_per_auxhist4	144	144
! auxhist8_outname	rfdly_d<domain>_<date>"	
! auxhist8_interval	1440	1440
! io_form_auxhist8	2	
! frames_per_auxhist8	6	6
iofields_filename	"iofields.txt"	"iofields.txt"
domains		
time_step	90	
time_step_fract_num	0	
time_step_fract_den	1	
max_dom	2	
s_we	1	1
e_we	540	616
s_sn	1	1
e_sn	363	501
s_vert	1	1
e_vert	45	45
dzbot	50	
max_dz	1000	
dzstretch_s	1.2	
dzstretch_u	1.05	
p_top_requested	5000	
dx	19567.24	3913.447
dy	19567.24	3913.447
grid_id	1	2
parent_id	0	1
i_parent_start	1	205
j_parent_start	1	90
parent_grid_ratio	1	5
parent_time_step_ratio	1	5
feedback	0	
smooth_option	0	
nproc_x	-1	
nproc_y	-1	
dynamics		
rk_ord	3	
w_damping	1	
diff_opt	1	1
km_opt	4	4
diff_6th_opt	0	0
diff_6th_factor	0.12	
base_temp	290	
damp_opt	1	
zdamp	5000	5000
dampcoef	0.01	0.01
khdif	0	0
kvdif	0	0
non_hydrostatic	TRUE	TRUE
moist_adv_opt	1	1
scalar_adv_opt	1	1
gwd_opt	1	
bdy_control		
spec_bdy_width	5	
spec_zone	1	
relax_zone	4	
specified	TRUE	FALSE
nested	FALSE	TRUE
namelist_quilt		
nio_tasks_per_group	0	
nio_groups	0	