Supplementary Material

Changes over time in the 100-year return value of climate model variables

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Overview

This supplementary material provides supporting information for the article referenced above.

Section SM1 provides illustrations of global annual maximum and mean data for four climate variables (`rsds`, `sfcWind`, `sfcWindmax`, `tas`) where available, and global minimum `tas`, from each of seven GCMs (`ACCESS-CM2`, `CAMS-CSM1-0`, `CESM2`, `EC-Earth3`, `MRI-ESM2-0`, `NorESM2-0-LL`, `UKESM1-0-LL`). For each combination of GCM and climate variable, figure panels give time series for multiple climate ensemble runs under three climate scenarios (`SSP126`, green; `SSP245`, orange; `SSP585`, grey). Note that the data presented are not smoothed. Plots in this section complement discussion around Figure 1 of the main text.

Section SM2 provides illustrations of climate zone annual maximum and mean data for the four climate variables where available, and climate zone minimum `tas`, from each of the seven GCMs. For each GCM, two figures are presented: one for annual maximum and `tas` minimum (in Section SM2.1), the other for annual mean (in Section SM2.2). Note that the data presented are not smoothed. Plots in this section complement discussion around Figure 2 of the main text.

Section SM3 provides illustrations of estimated slopes of linear regression lines fitted directly to annual mimumum data for `tas`, and also for annual means, per given climate zone, GCM, climate scenario and ensemble member. Plots in this section complement discussion around Figure 3 of the main text.

Section SM4 illustrates time-series of annual data for the centre locations of the North Atlantic and Celtic Sea region neighbourhoods considered, for the four climate variables from each of the seven GCMs. For each combination of GCM and climate variable, figure panels give time series for multiple climate ensemble runs under the three climate scenarios. Note that the data presented are not smoothed. Plots in this section complement discussion in Section 2.2 of the main text.

Section SM5 provides estimated posterior cumulative distribution functions for GEVR model parameters for global annual maxima and global annual minima for `tas` (panels (a)), and NHGR model parameter for global means (panels (b)) from the `UKESM1-0-LL` GCM, with separate figures for each of the climate variables. These plots support the discussion of Figures 5-7 of the main text.

Section SM6 provides supporting information for linear mixed effects modelling of $\Delta^Q = Q_{2125} - Q_{2025}$ and $\Delta^M = M_{2125} - M_{2025}$. Section SM6.1 shows box-whisker plots for the posterior distribution of Δ^Q estimated per climate variable, spatial zone, scenario, model and ensemble. Sections SM6.2 and SM6.3 give tables characterising changes Δ^Q in return values of the annual minimum, and Δ^M in the annual mean, to be compared with Tables 2 and 4 of the main text for the change Δ^Q in the 100-year value of the annual maximum for global and climate zone maxima.

SM1 Time-series of global annual maxima, `tas` minima and means

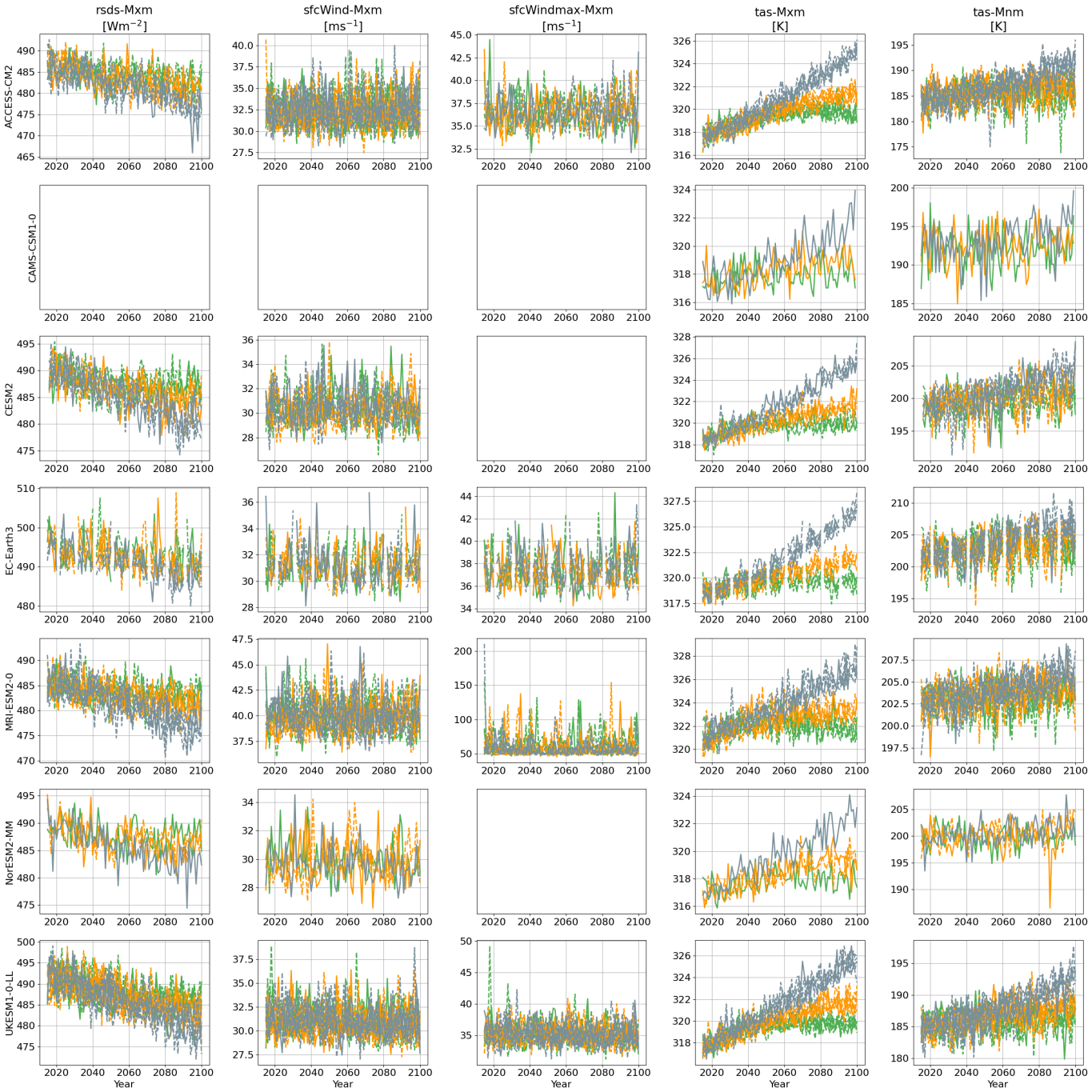


Figure SM1: Time series of global annual maximum data for four climate variables (`rsds`, `sfcWind`, `sfcWindmax`, `tas`) where available, and global minimum `tas`, from each of seven GCMs (`ACCESS-CM2`, `CAMS-CSM1-0`, `CESM2`, `EC-Earth3`, `MRI-ESM2-0`, `NorESM2-0-LL`, `UKESM1-0-LL`). Rows indicate GCM, columns indicate climate variable and type of extreme. For each combination of GCM and climate variable, panels give time series for multiple climate ensemble runs (distinguished by line style) under three climate scenarios (`SSP126`, green; `SSP245`, orange; `SSP585`, grey). Empty panels indicate that data for the specific combination of GCM and climate variable was not available for analysis. Note a suspect value in ensemble `r1i1p1f1` for annual minimum `tas` for `NorESM2-0-LL` under scenario `SSP245`, discussed in Section 2.1 of the main text.

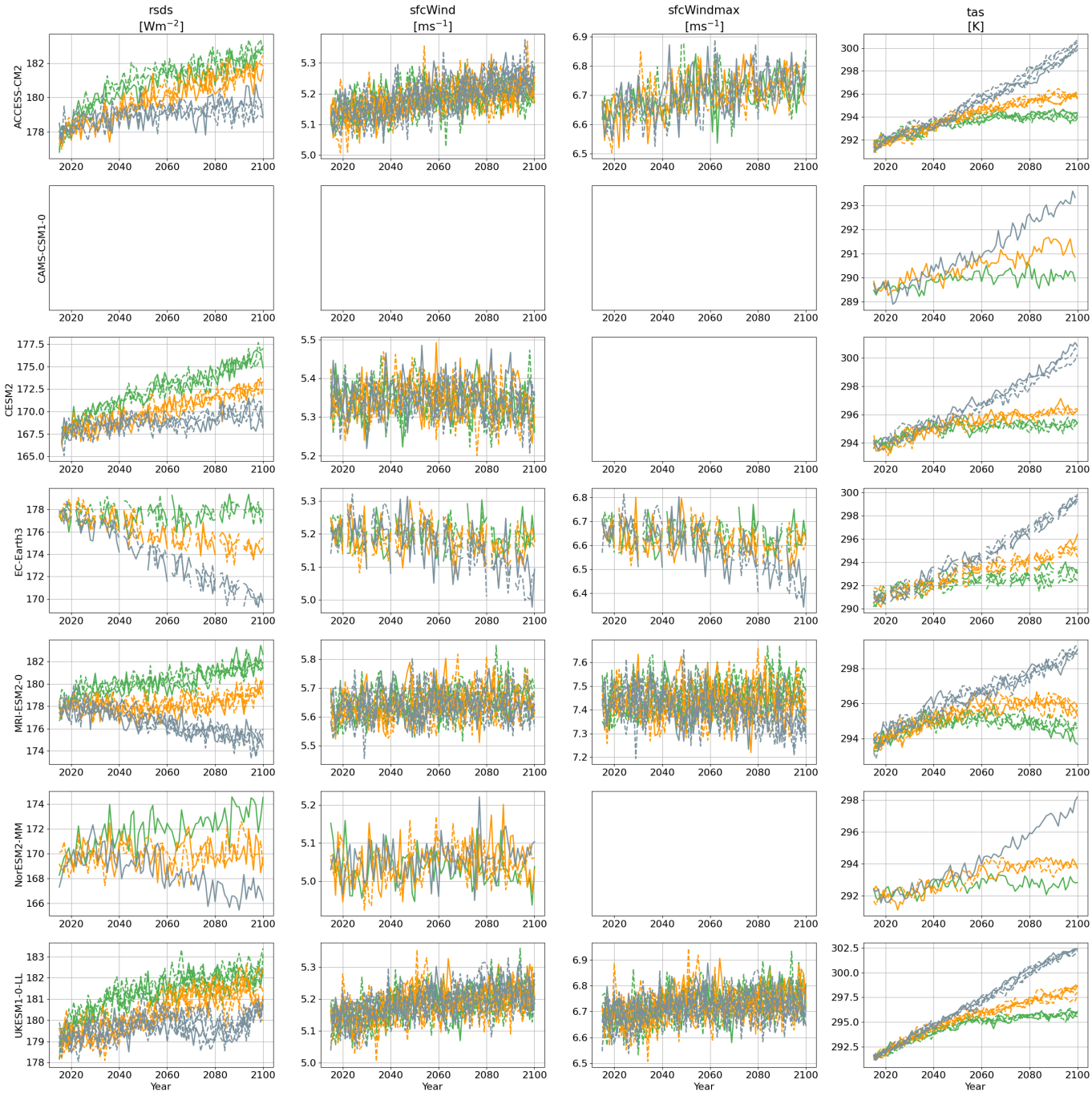


Figure SM2: Time series of global annual mean data for four climate variables (`rsds`, `sfcWind`, `sfcWindmax`, `tas`) where available, from each of seven GCMs (`ACCESS-CM2`, `CAMS-CSM1-0`, `CESM2`, `EC-Earth3`, `MRI-ESM2-0`, `NorESM2-0-LL`, `UKESM1-0-LL`). Rows indicate GCM, columns indicate climate variable. For each combination of GCM and climate variable, panels give time series for multiple climate ensemble runs (distinguished by line style) under three climate scenarios (`SSP126`, green; `SSP245`, orange; `SSP585`, grey). Empty panels indicate that data for the specific combination of GCM and climate variable was not available for analysis.

SM2 Time-series of annual maxima, tas minima and means for climate zones

SM2.1 Maxima/Minima

Figure SM3: Time-series plots of annual maximum `rsds, sfcWind, sfcWindmax, tas` (rows 1-4) and annual minimum `tas` (row 5), for each of 5 climate zones (columns), for `ACCESS-CM2`. Colour indicates climate scenario (`SSP126`, green; `SSP245`, orange; `SSP585`, grey) with different line style for each ensemble member. No smoothing of time-series is performed.

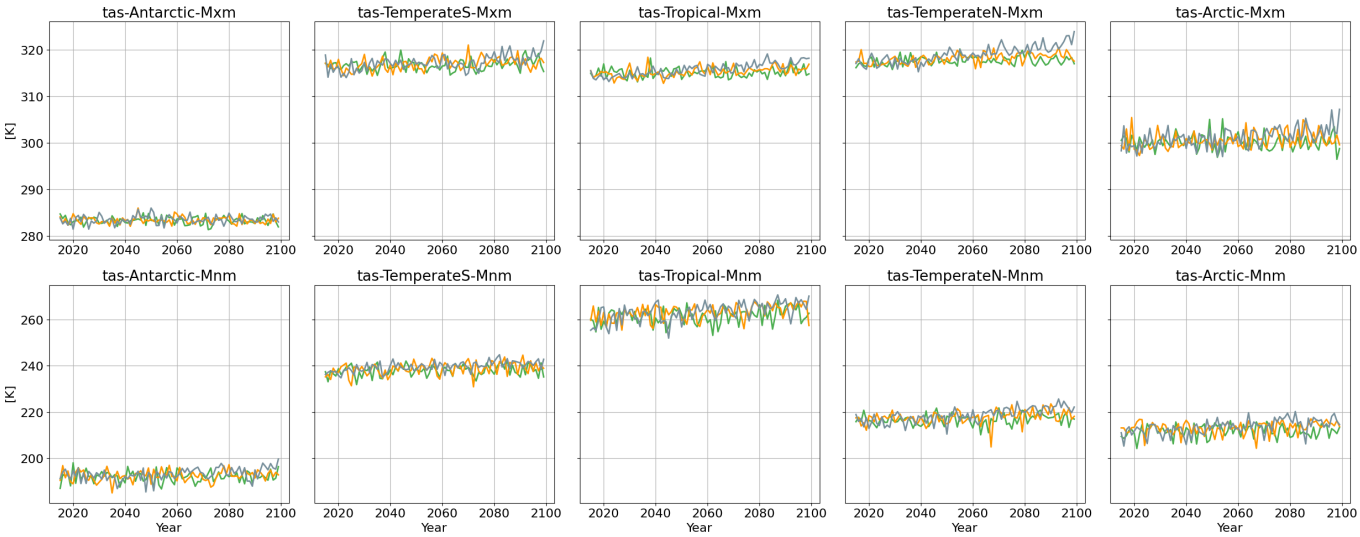


Figure SM4: Time-series plots of annual maximum `tas` (rows 1-4) and annual minimum `tas` (row 5), for each of 5 climate zones (columns), for `CAMS-CSM1-0`. Colour indicates climate scenario (`SSP126`, green; `SSP245`, orange; `SSP585`, grey) with different line style for each ensemble member. No smoothing of time-series is performed.

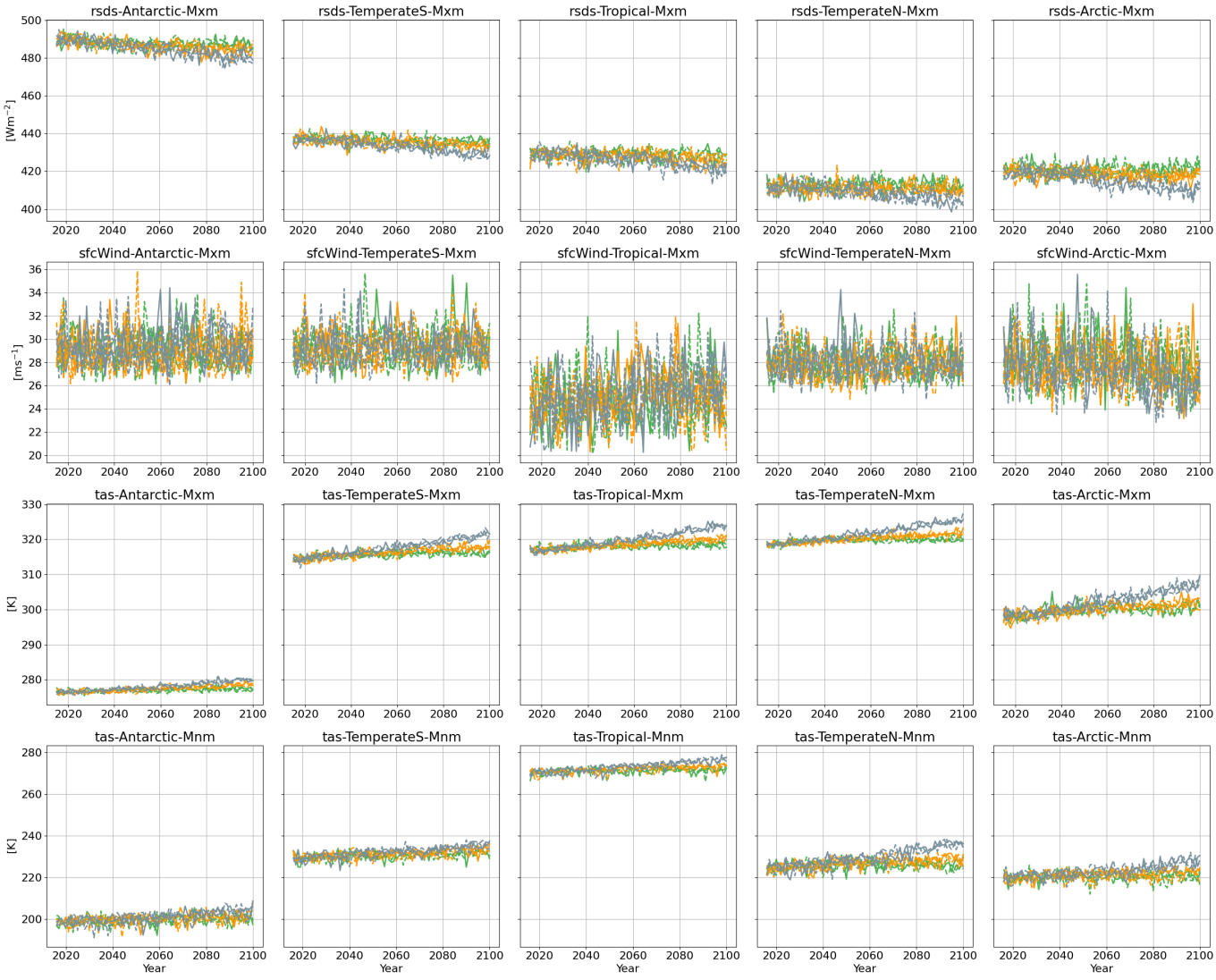


Figure SM5: Time-series plots of annual maximum `rsds, sfcWind, tas` (rows 1-4) and annual minimum `tas` (row 5), for each of 5 climate zones (columns), for `CESM2`. Colour indicates climate scenario (`SSP126`, green; `SSP245`, orange; `SSP585`, grey) with different line style for each ensemble member. No smoothing of time-series is performed.

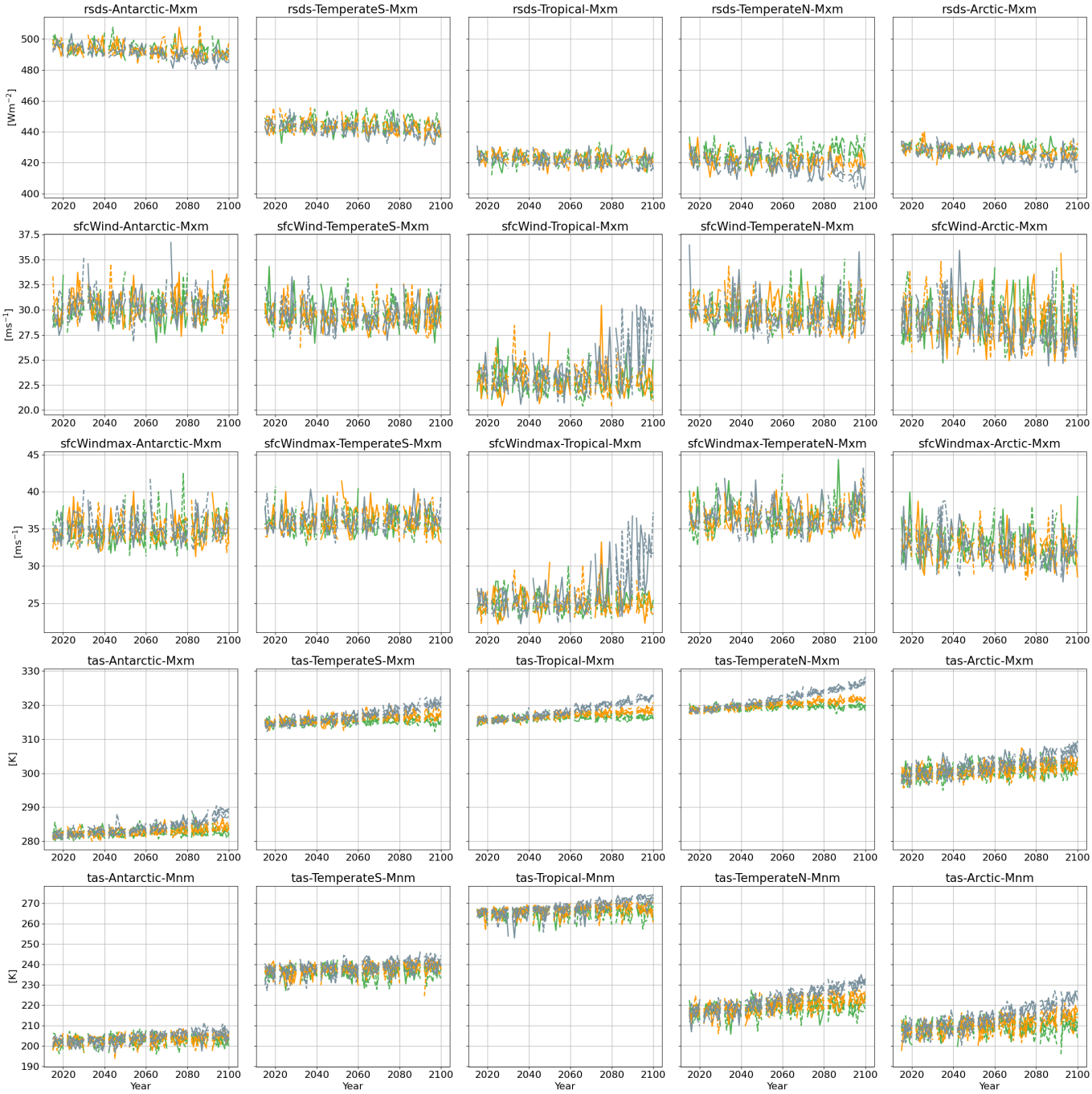


Figure SM6: Time-series plots of annual maximum `sfcWind, sfcWindmax, tas` (rows 1-4) and annual minimum `tas` (row 5), for each of 5 climate zones (columns), for `EC-Earth3`. Colour indicates climate scenario (`SSP126`, green; `SSP245`, orange; `SSP585`, grey) with different line style for each ensemble member. No smoothing of time-series is performed.

Figure SM7: Time-series plots of annual maximum `rsds, sfcWind, sfcWindmax, tas` (rows 1-4) and annual minimum `tas` (row 5), for each of 5 climate zones (columns), for `MRI-ESM2-0`. Colour indicates climate scenario (`SSP126`, green; `SSP245`, orange; `SSP585`, grey) with different line style for each ensemble member. No smoothing of time-series is performed. Note suspect values for `sfcWindmax` in the Temperate North.

Figure SM8: Time-series plots of annual maximum `rsds, sfcWind, tas` (rows 1-4) and annual minimum `tas` (row 5), for each of 5 climate zones (columns), for `NorESM2-0-LL`. Colour indicates climate scenario (`SSP126`, green; `SSP245`, orange; `SSP585`, grey) with different line style for each ensemble member. No smoothing of time-series is performed. Note suspect low value of `tas` minimum in the Antarctic under scenario `SSP245`.

Figure SM9: Time-series plots of annual maximum `rsds, sfcWind, sfcWindmax, tas` (rows 1-4) and annual minimum `tas` (row 5), for each of 5 climate zones (columns), for `UKESM1-0-LL`. Colour indicates climate scenario (`SSP126`, green; `SSP245`, orange; `SSP585`, grey) with different line style for each ensemble member. No smoothing of time-series is performed.

SM2.2 Means

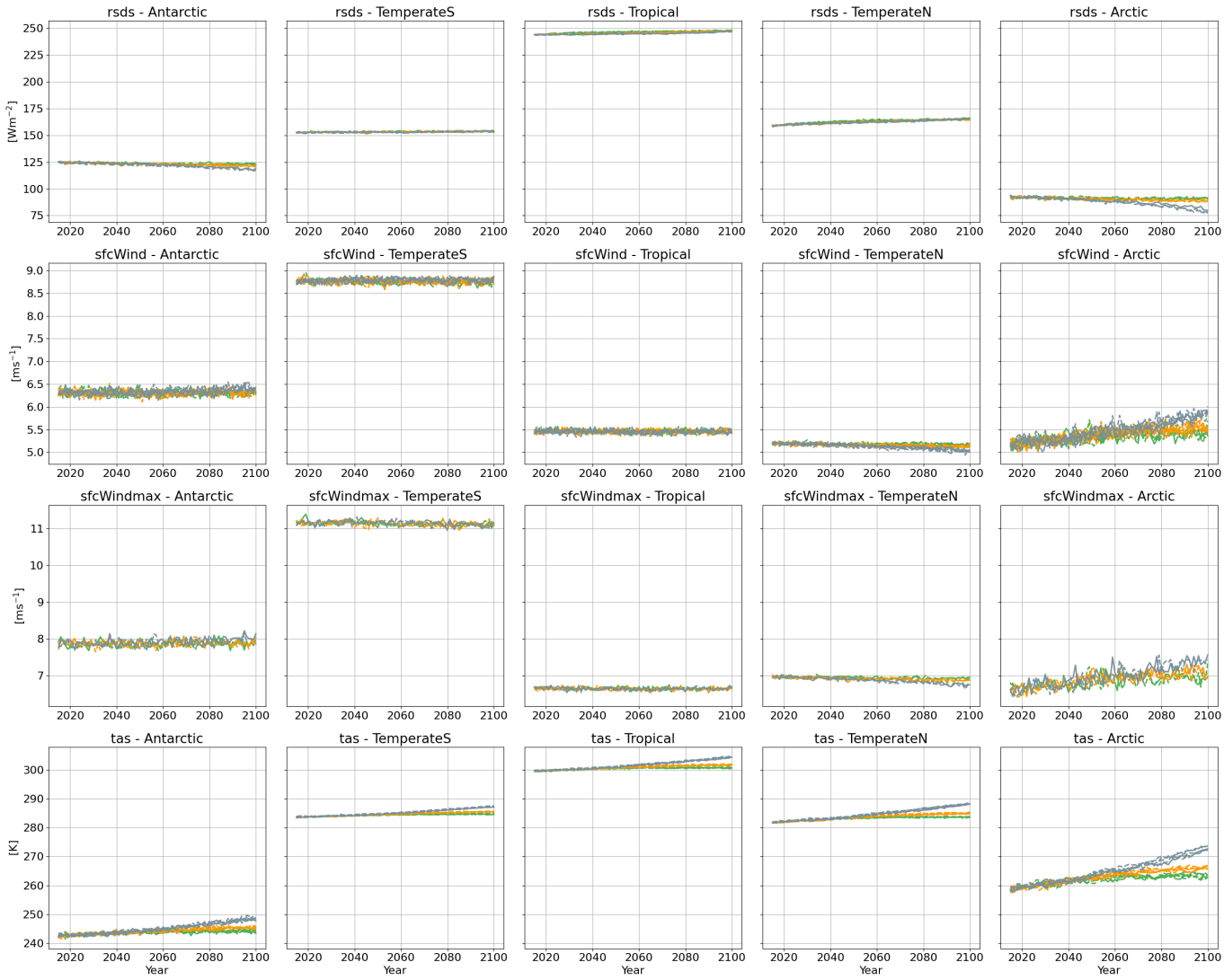


Figure SM10: Time-series plots of annual mean `rsds, sfcWind, sfcWindmax, tas` (rows), for each of 5 climate zones (columns), for `ACCESS-CM2`. Colour indicates climate scenario (`SSP126`, green; `SSP245`, orange; `SSP585`, grey) with different line style for each ensemble member. No smoothing of time-series is performed. Note unusually low value for `tas` minimum in the Antarctic.

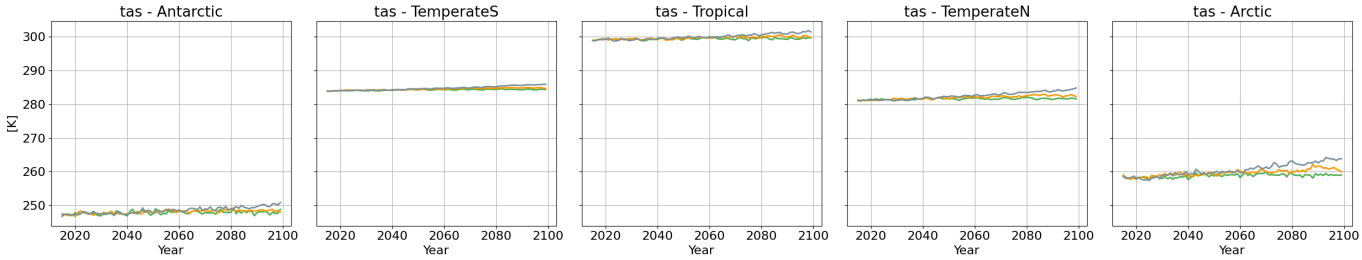


Figure SM11: Time-series plots of annual mean `tas` (rows), for each of 5 climate zones (columns), for `CAMS-CSM1-0`. Colour indicates climate scenario (`SSP126`, green; `SSP245`, orange; `SSP585`, grey) with different line style for each ensemble member. No smoothing of time-series is performed. Note unusually low value for `tas` minimum in the Antarctic.

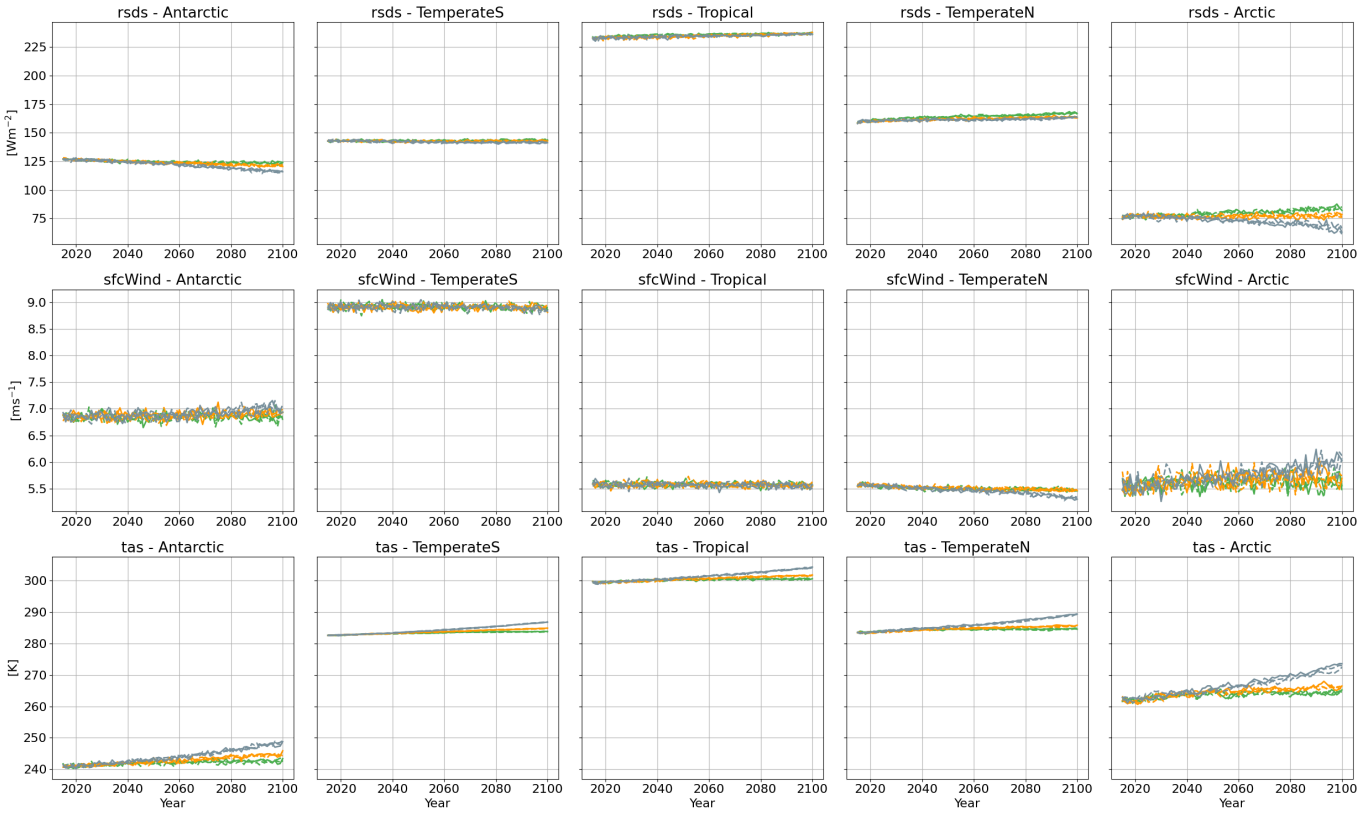


Figure SM12: Time-series plots of annual mean `rsds, sfcWind, tas` (rows), for each of 5 climate zones (columns), for `CESM2`. Colour indicates climate scenario (`SSP126`, green; `SSP245`, orange; `SSP585`, grey) with different line style for each ensemble member. No smoothing of time-series is performed. Note unusually low value for `tas` minimum in the Antarctic.

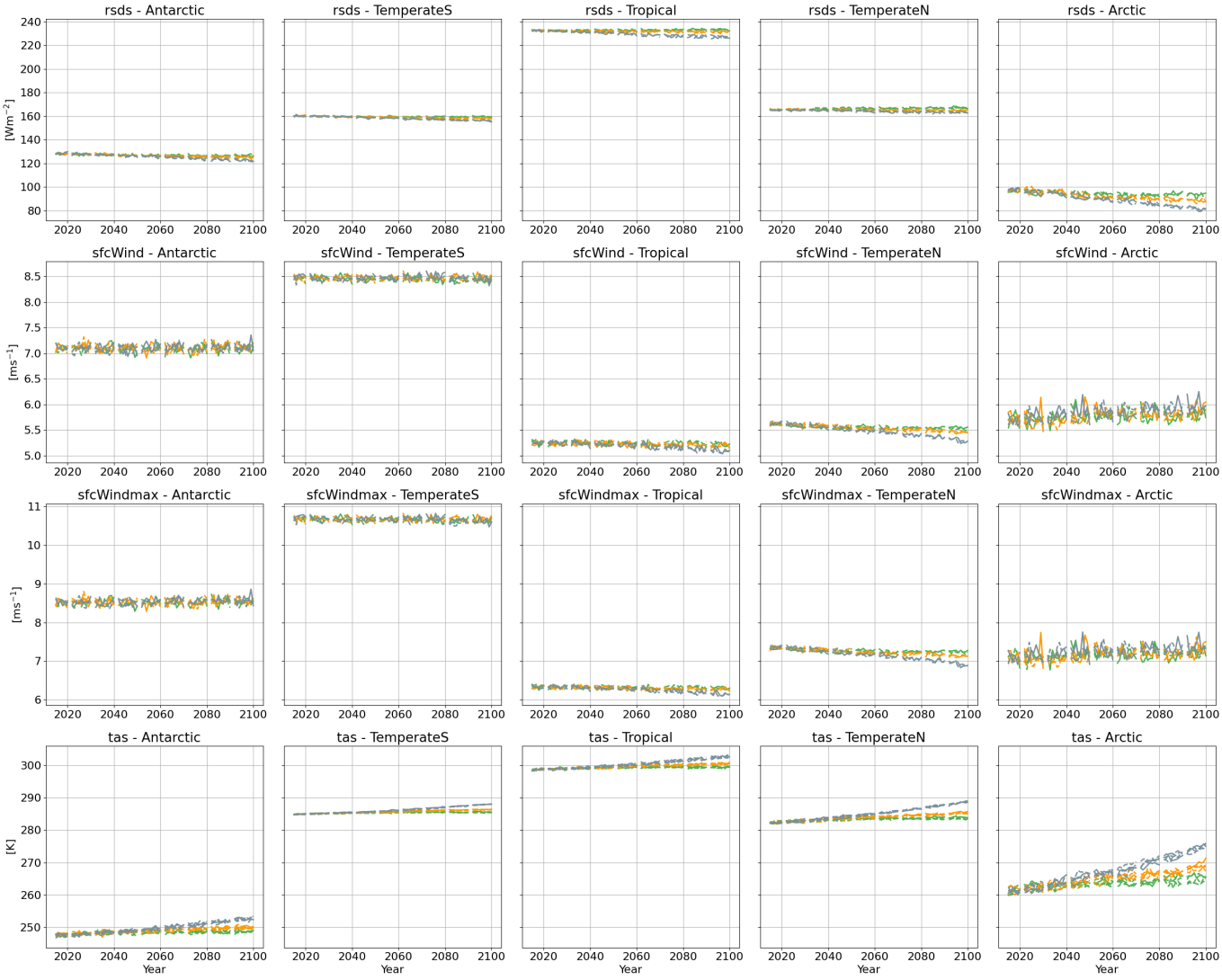


Figure SM13: Time-series plots of annual mean `sfcWind, sfcWindmax, tas` (rows), for each of 5 climate zones (columns), for `EC-Earth3`. Colour indicates climate scenario (`SSP126`, green; `SSP245`, orange; `SSP585`, grey) with different line style for each ensemble member. No smoothing of time-series is performed. Note unusually low value for `tas` minimum in the Antarctic.

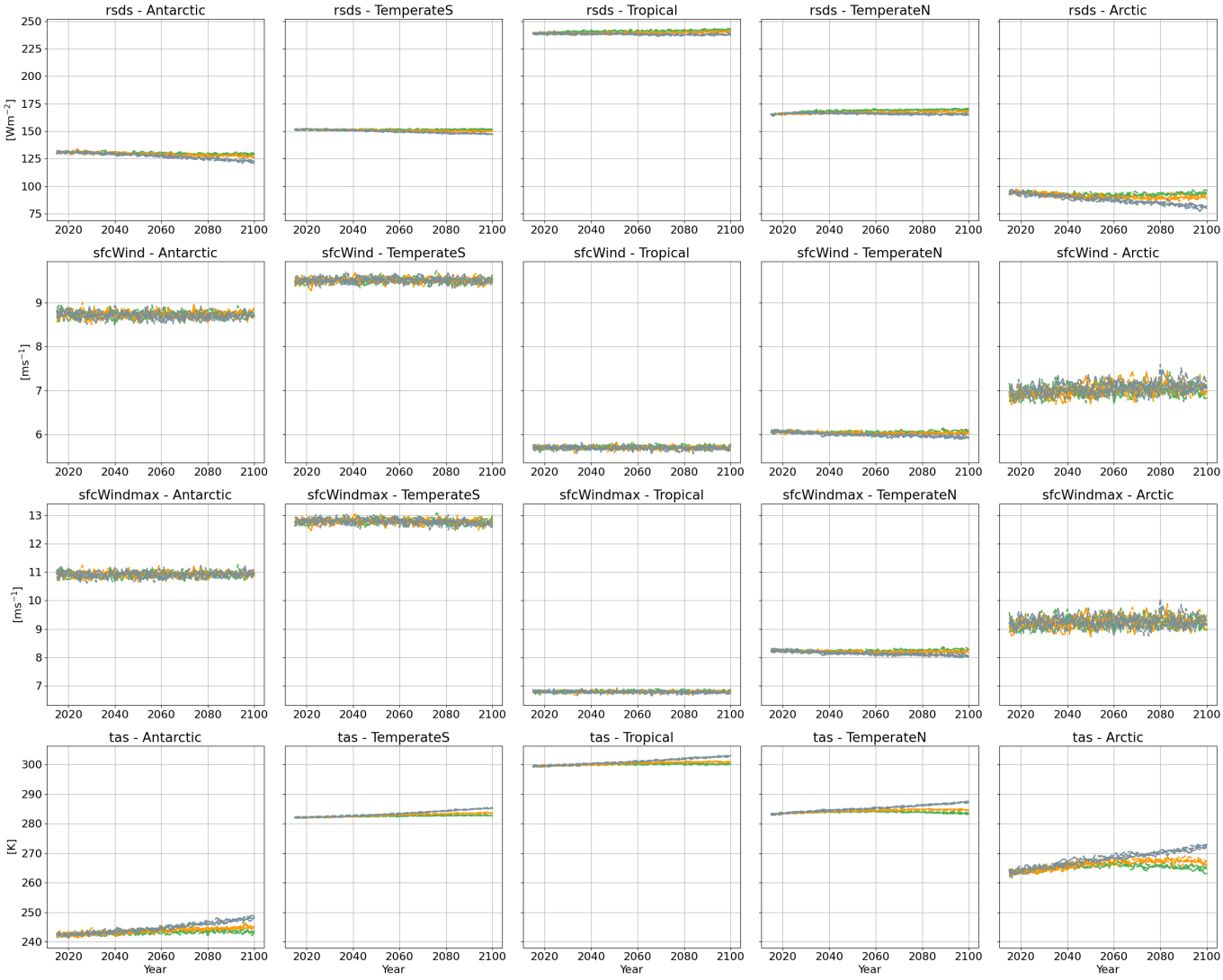


Figure SM14: Time-series plots of annual mean `rsds, sfcWind, sfcWindmax, tas` (rows), for each of 5 climate zones (columns), for `MRI-ESM2-0`. Colour indicates climate scenario (`SSP126`, green; `SSP245`, orange; `SSP585`, grey) with different line style for each ensemble member. No smoothing of time-series is performed. Note unusually low value for `tas` minimum in the Antarctic.

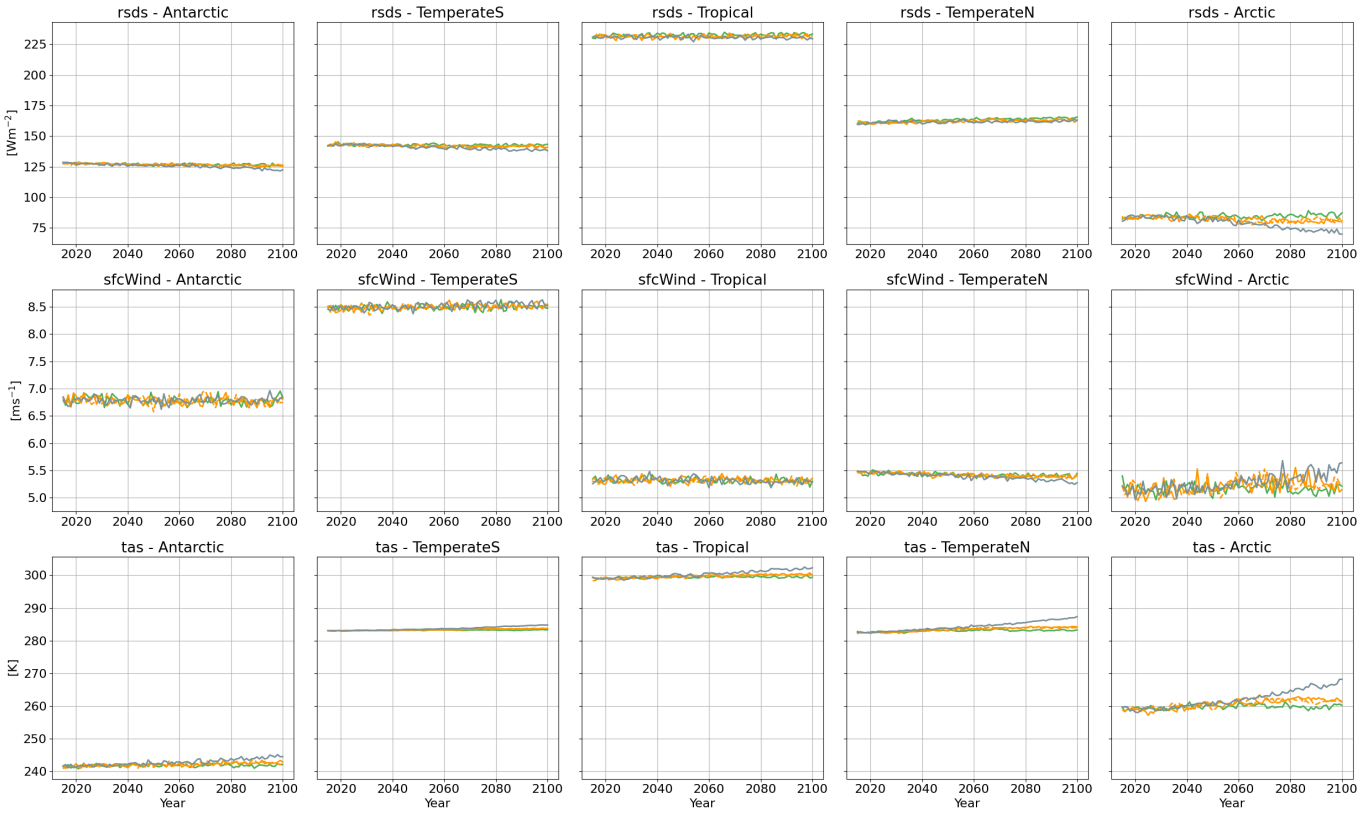


Figure SM15: Time-series plots of annual mean `rsds, sfcWind, tas` (rows), for each of 5 climate zones (columns), for `NorESM2-0-LL`. Colour indicates climate scenario (`SSP126`, green; `SSP245`, orange; `SSP585`, grey) with different line style for each ensemble member. No smoothing of time-series is performed. Note unusually low value for `tas` minimum in the Antarctic.

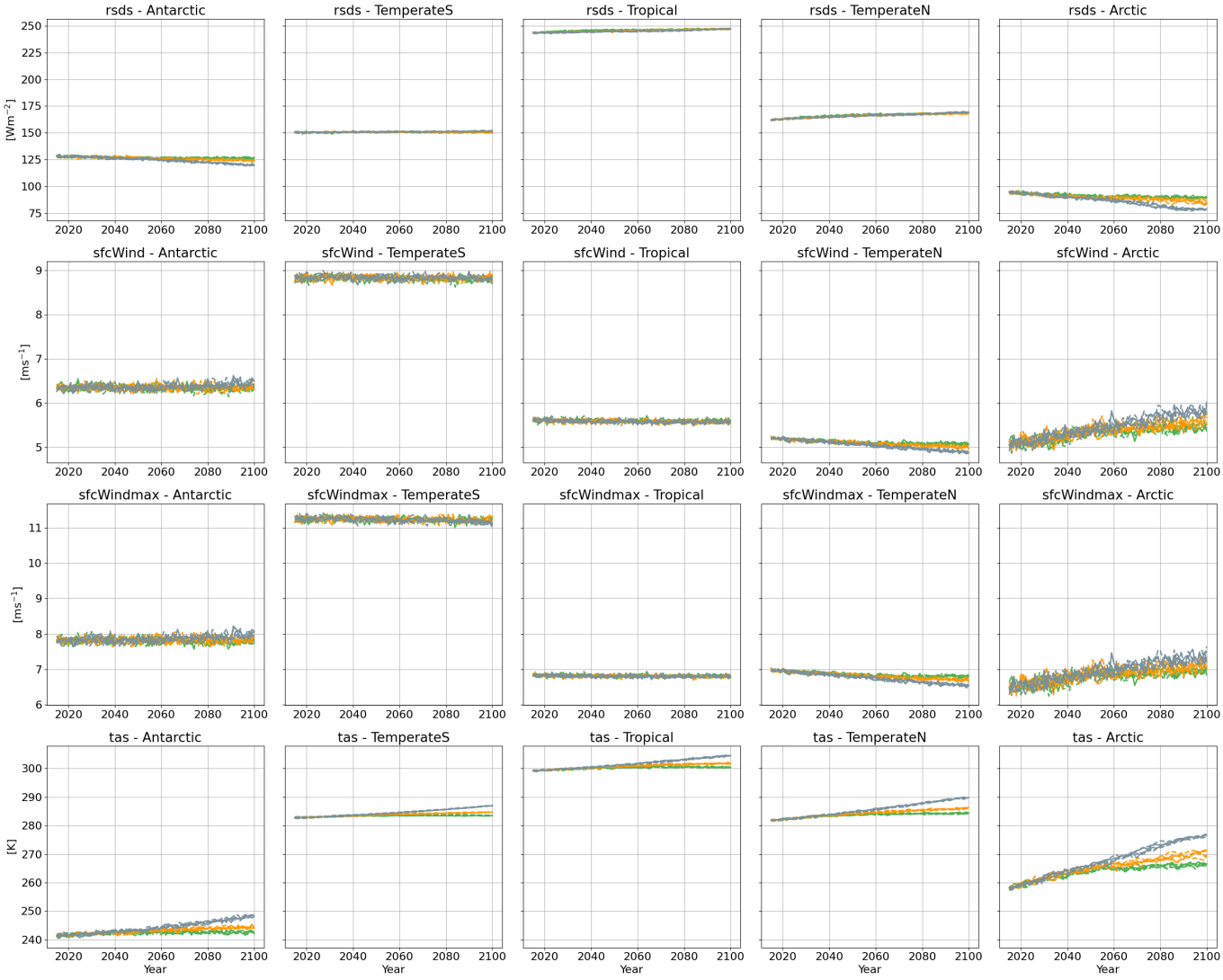


Figure SM16: Time-series plots of annual mean `rsds, sfcWind, sfcWindmax, tas` (rows), for each of 5 climate zones (columns), for `UKESM1-0-LL`. Colour indicates climate scenario (`SSP126`, green; `SSP245`, orange; `SSP585`, grey) with different line style for each ensemble member. No smoothing of time-series is performed. Note unusually low value for `tas` minimum in the Antarctic.

SM3 Slopes of linear regression lines through annualised data

SM3.1 Minima

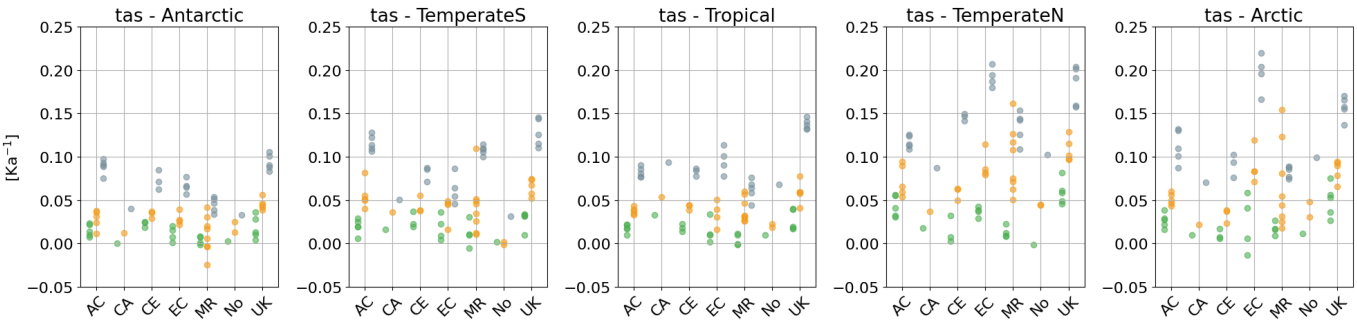


Figure SM17: Estimated slopes of linear regression lines fitted directly to the annual mimumum data for `tas` per given climate zone, GCM, climate scenario and ensemble member. Columns indicate climate zone. Discs indicate slopes for ensemble members, and disc colour indicates climate scenario (`SSP126`, green; `SSP245`, orange; `SSP585`, grey).

SM3.2 Means

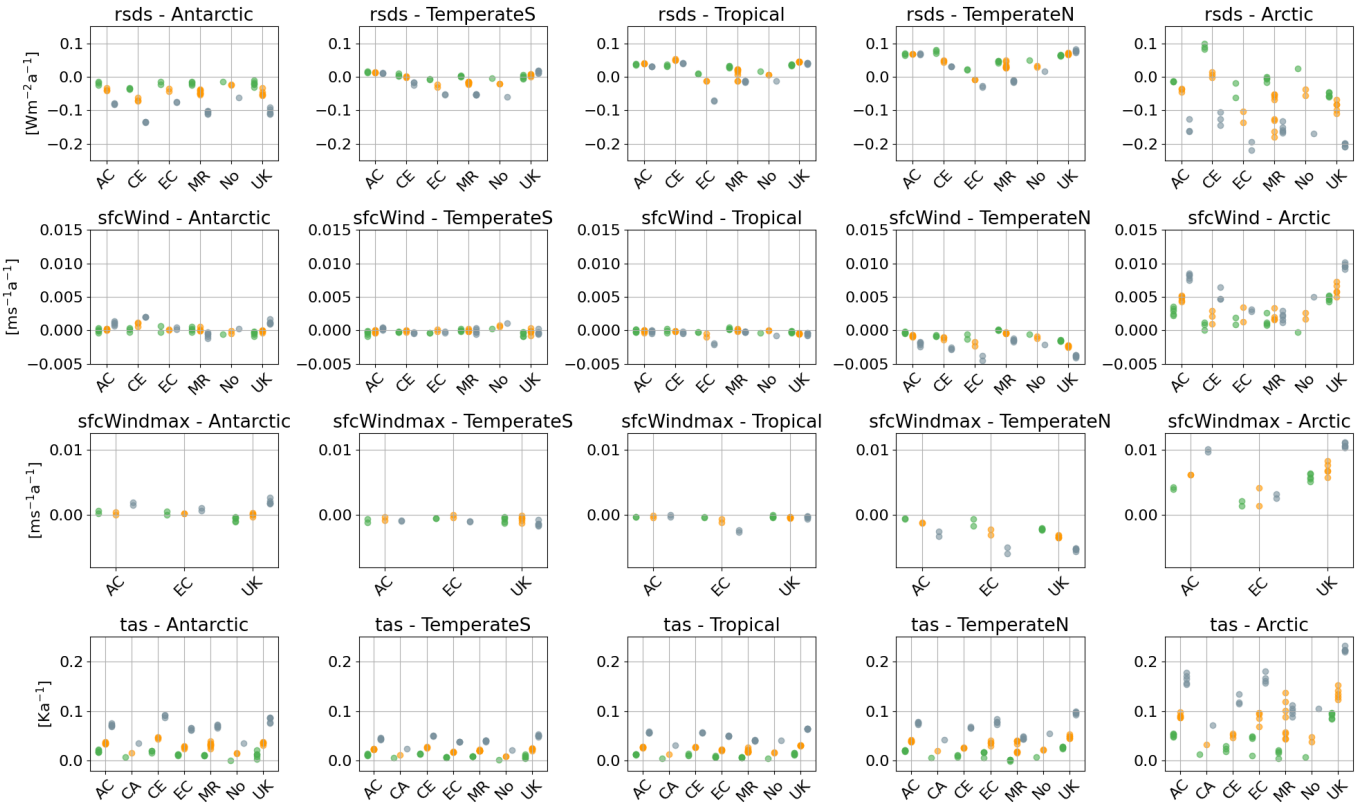


Figure SM18: Slopes of linear regression lines fitted directly to the annual mean data for each climate variable, given climate zone, GCM, climate scenario and ensemble member. Rows indicate different climate variables. Columns indicate climate zone. Discs indicate slopes for ensemble members, and disc colour indicates climate scenario (`SSP126`, green; `SSP245`, orange; `SSP585`, grey).

SM4 Examples of time-series for annual maxima from the North Atlantic and Celtic Sea region

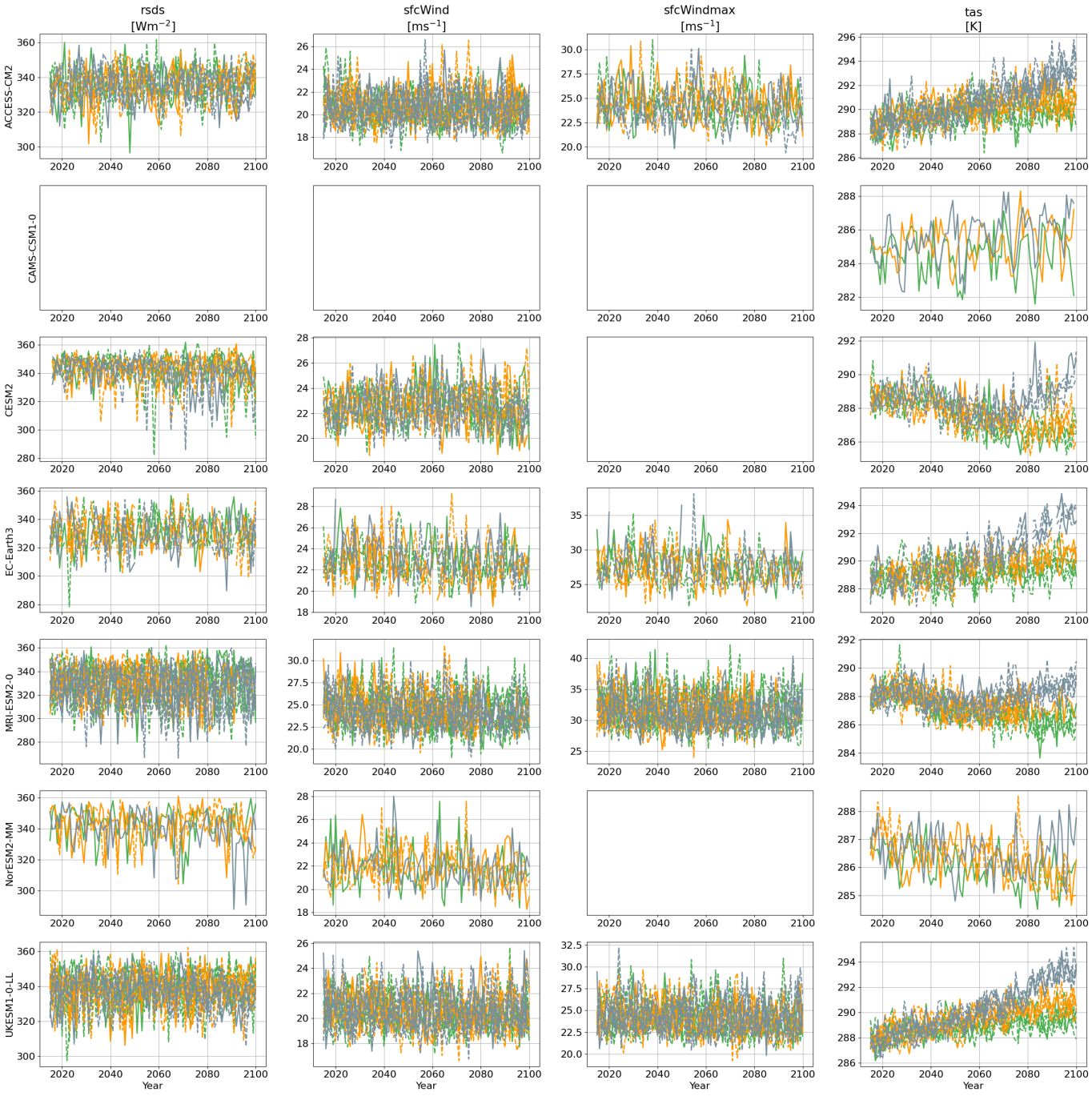


Figure SM19: Time-series of annual maximum data for the centre location of the North Atlantic neighbourhood, for the four climate variables from each of the seven GCMs. For each combination of GCM and climate variable, panels give time series for multiple climate ensemble runs (distinguished by line style) under the three climate scenarios (`SSP126`, green; `SSP245`, orange; `SSP585`, grey). Note that the data presented are not smoothed.

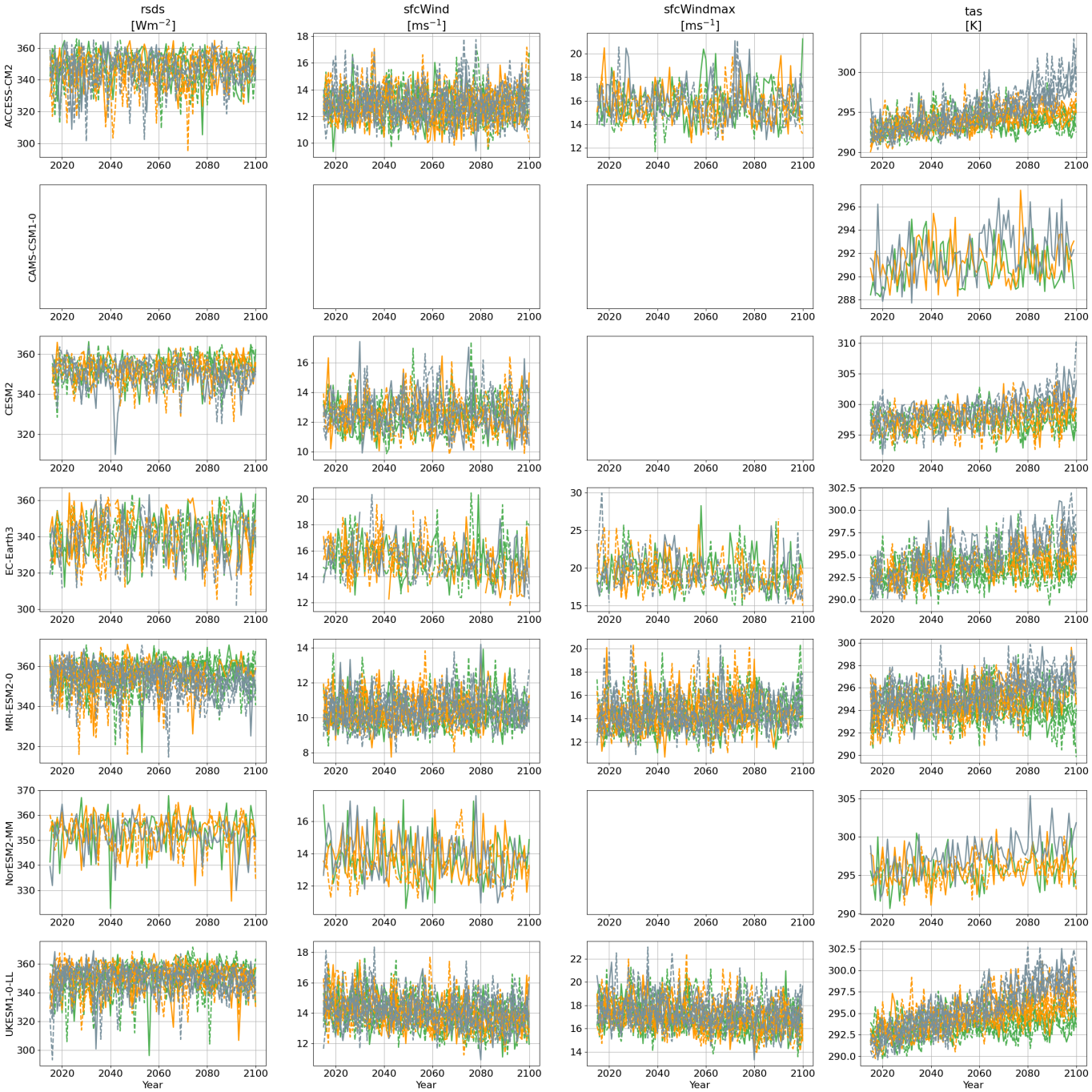
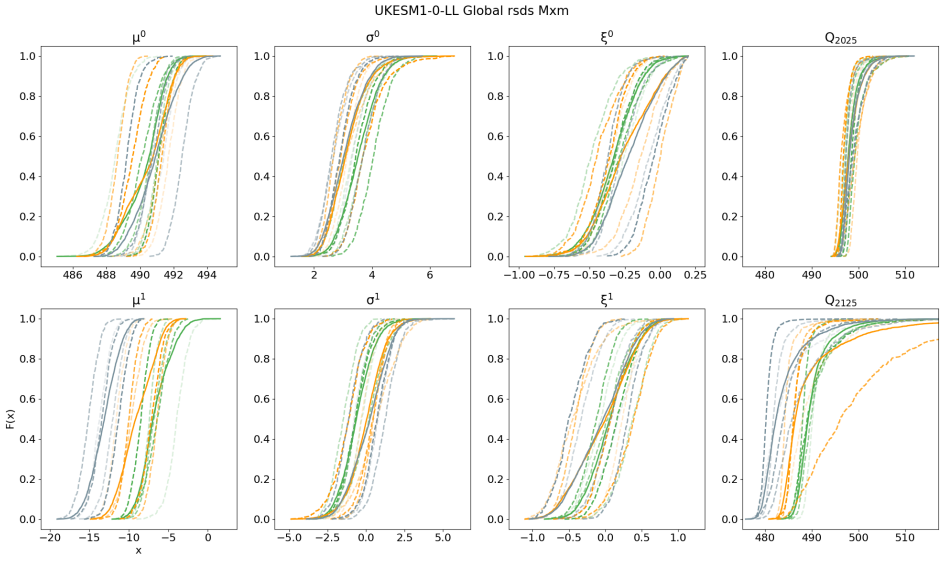
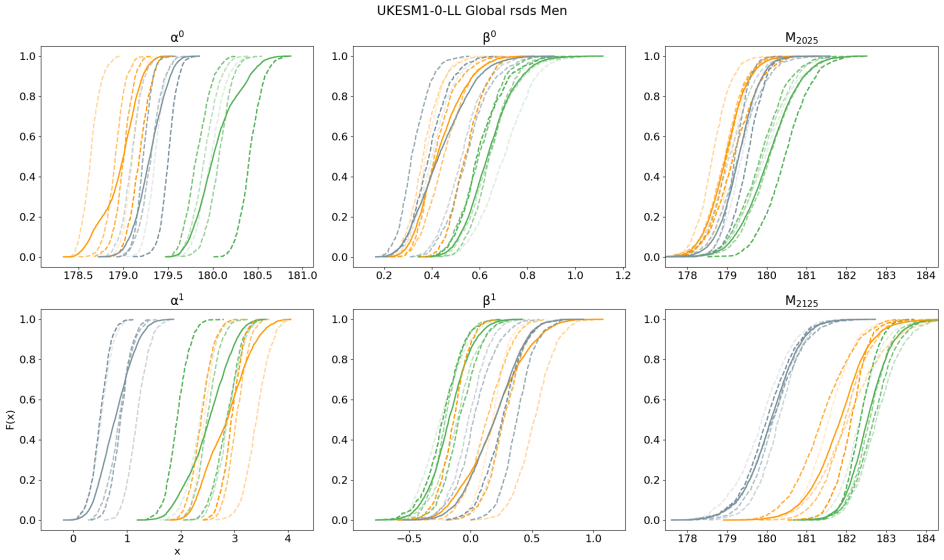


Figure SM20: Time-series of annual maximum data for the centre location of the Celtic Sea neighbourhood, for the four climate variables from each of the seven GCMs. For each combination of GCM and climate variable, panels give time series for multiple climate ensemble runs (distinguished by line style) under the three climate scenarios (`SSP126`, green; `SSP245`, orange; `SSP585`, grey). Note that the data presented are not smoothed.

SM5 Diagnostic plots for GEVR model fitting to global annual data, and NHGR modelling fitting to global means, for UKESM1-0-LL

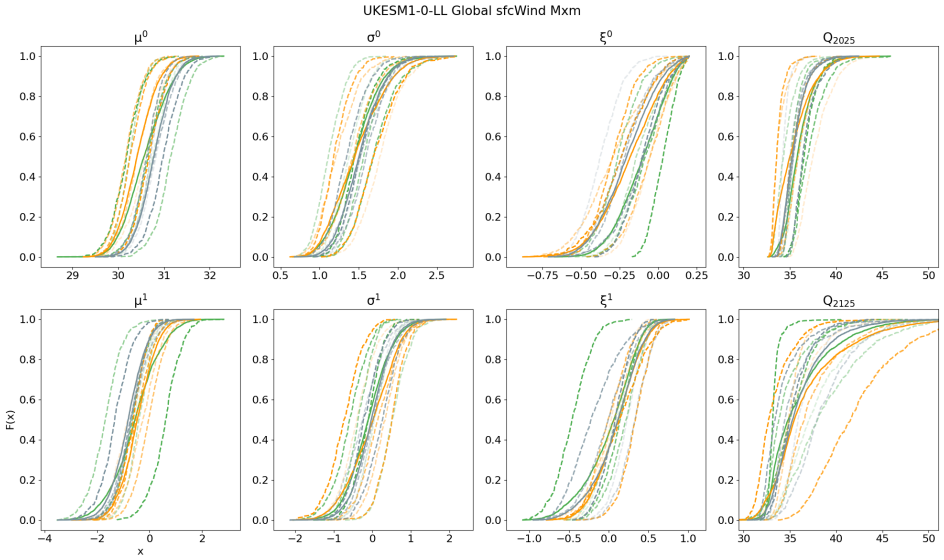


(a) Estimated posterior cumulative distribution functions for GEVR model parameters and 100-year return values (Q_{2025}, Q_{2125}, for years 2025 and 2125), for global annual maxima from the specified GCM and climate variable. Colours indicate climate scenario (`SSP126`, green; `SSP245`, orange; `SSP585`, grey). Dashed line styles indicate inferences for different ensemble members; a solid line corresponds to the ensemble mean cumulative distribution function. Model parameters are the GEV location μ^0, scale σ^0 and shape ξ^0 in 2015, and the changes μ^1, σ^1 and ξ^1 in those parameters over the period (2015,2100). Return value for year t is denoted by Q_t.

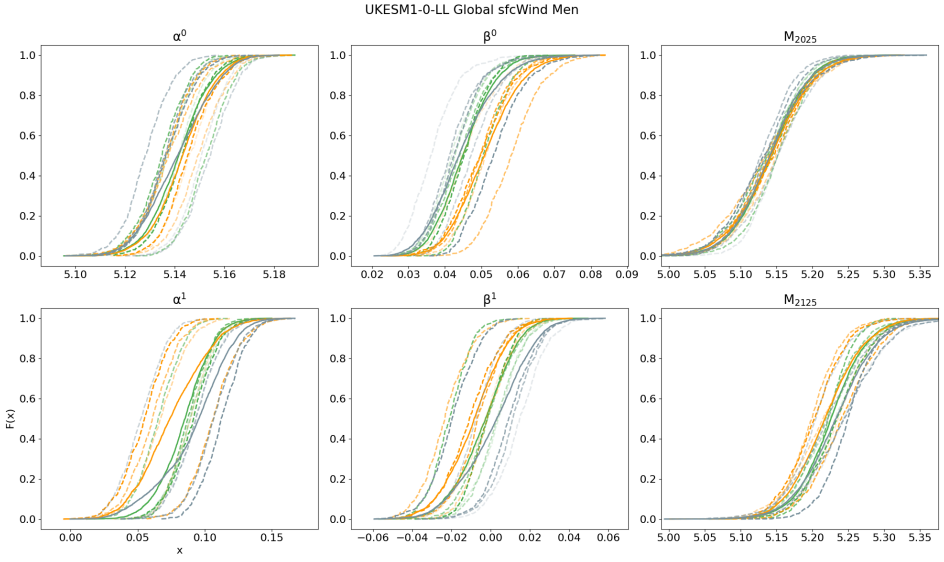


(b) Estimated posterior cumulative distribution functions for NHGR model parameters and predicted values (M_{2025}, M_{2125}, for years 2025 and 2125), for the global annual mean from the specified GCM and climate variable. Colours indicate climate scenario: SSP126 (green), SSP245 (orange), SSP585 (grey). Dashed line styles indicate inferences for different ensemble members; solid line corresponds to the ensemble mean. Model parameters are the NHGR mean α^0, scale β^0 in 2015, and the changes α^1, β^1 in those parameters over the period (2015,2100). Predicted value for year t is denoted by M_t.

Figure SM21: `UKESM1-0-LL`, `rsds`

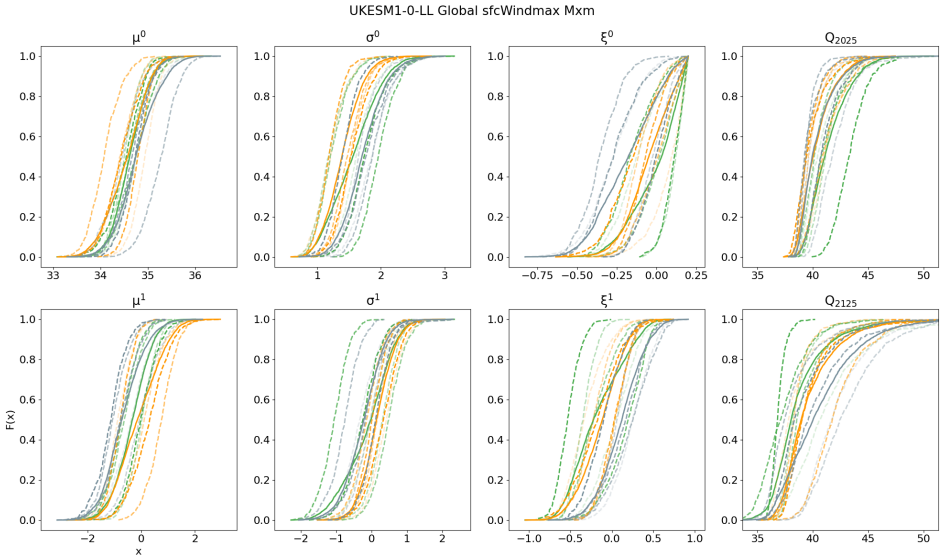


(a) Estimated posterior cumulative distribution functions for GEVR model parameters and 100-year return values (Q_{2025}, Q_{2125}, for years 2025 and 2125), for global annual maxima from the specified GCM and climate variable. Colours indicate climate scenario (`SSP126`, green; `SSP245`, orange; `SSP585`, grey). Dashed line styles indicate inferences for different ensemble members; a solid line corresponds to the ensemble mean cumulative distribution function. Model parameters are the GEV location μ^0, scale σ^0 and shape ξ^0 in 2015, and the changes μ^1, σ^1 and ξ^1 in those parameters over the period (2015,2100). Return value for year t is denoted by Q_t.

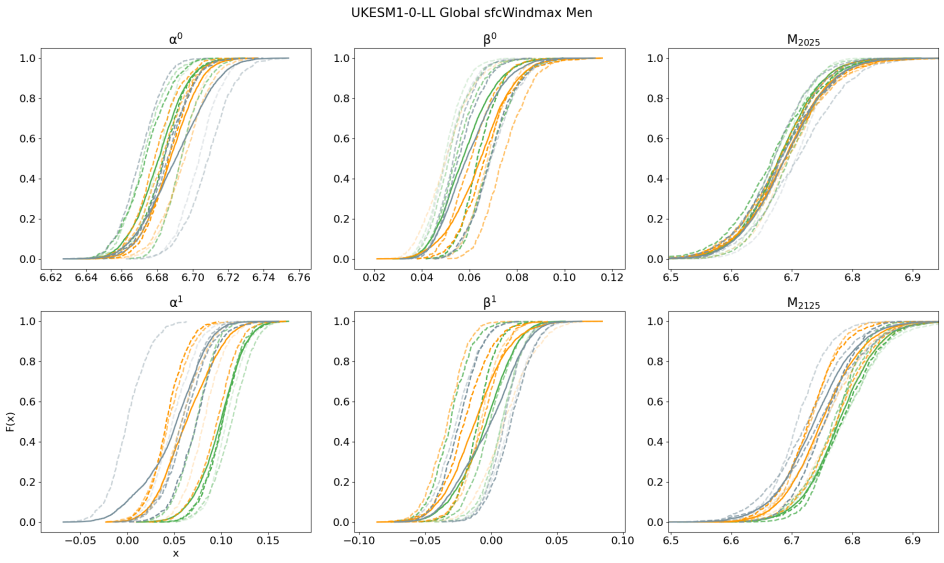


(b) Estimated posterior cumulative distribution functions for NHGR model parameters and predicted values (M_{2025}, M_{2125}, for years 2025 and 2125), for the global annual mean from the specified GCM and climate variable. Colours indicate climate scenario: SSP126 (green), SSP245 (orange), SSP585 (grey). Dashed line styles indicate inferences for different ensemble members; solid line corresponds to the ensemble mean. Model parameters are the NHGR mean α^0, scale β^0 in 2015, and the changes α^1, β^1 in those parameters over the period (2015,2100). Predicted value for year t is denoted by M_t.

Figure SM22: `UKESM1-0-LL`, `sfcWind`

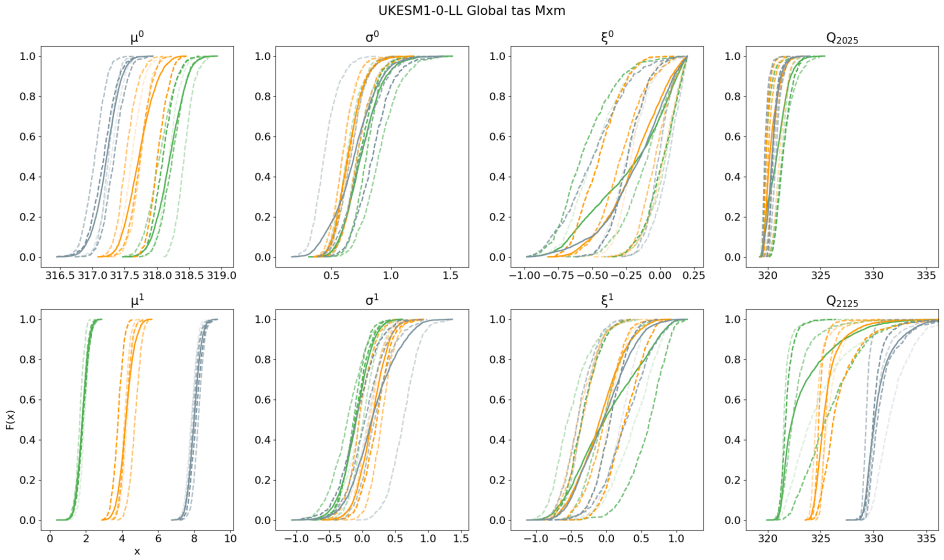


(a) Estimated posterior cumulative distribution functions for GEVR model parameters and 100-year return values (Q_{2025}, Q_{2125}, for years 2025 and 2125), for global annual maxima from the specified GCM and climate variable. Colours indicate climate scenario (`SSP126`, green; `SSP245`, orange; `SSP585`, grey). Dashed line styles indicate inferences for different ensemble members; a solid line corresponds to the ensemble mean cumulative distribution function. Model parameters are the GEV location μ^0, scale σ^0 and shape ξ^0 in 2015, and the changes μ^1, σ^1 and ξ^1 in those parameters over the period (2015,2100). Return value for year t is denoted by Q_t.

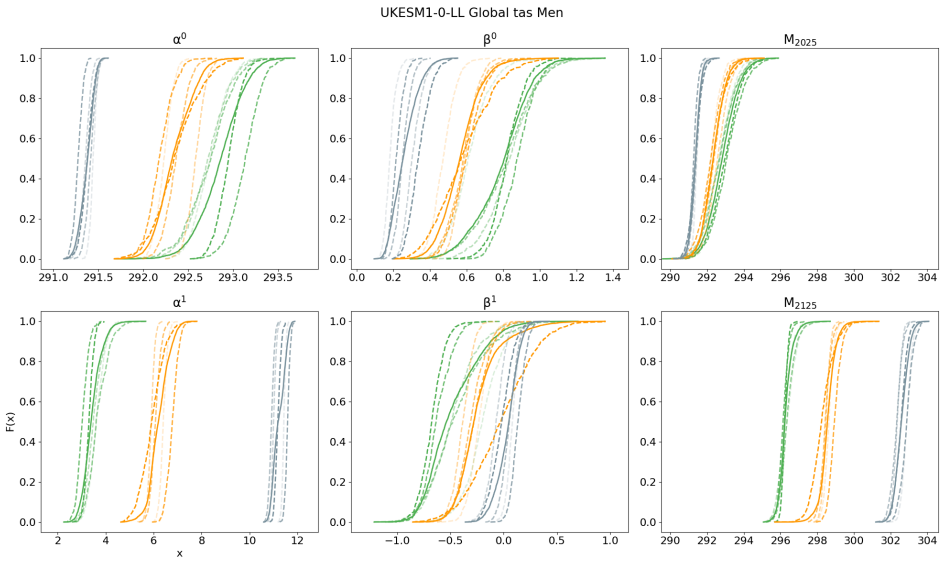


(b) Estimated posterior cumulative distribution functions for NHGR model parameters and predicted values (M_{2025}, M_{2125}, for years 2025 and 2125), for the global annual mean from the specified GCM and climate variable. Colours indicate climate scenario: SSP126 (green), SSP245 (orange), SSP585 (grey). Dashed line styles indicate inferences for different ensemble members; solid line corresponds to the ensemble mean. Model parameters are the NHGR mean α^0, scale β^0 in 2015, and the changes α^1, β^1 in those parameters over the period (2015,2100). Predicted value for year t is denoted by M_t.

Figure SM23: `UKESM1-0-LL`, `sfcWindmax`

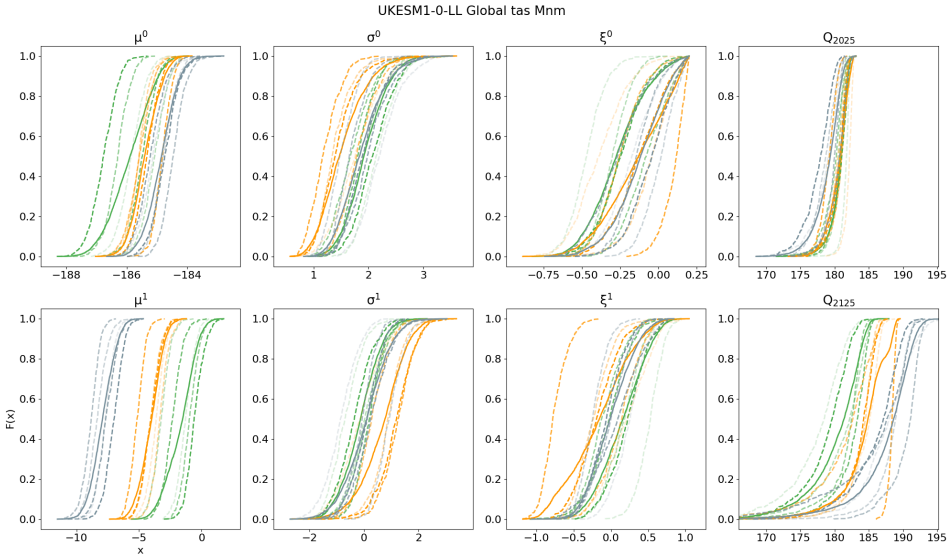


(a) Estimated posterior cumulative distribution functions for GEVR model parameters and 100-year return values (Q_{2025}, Q_{2125}, for years 2025 and 2125), for global annual maxima from the specified GCM and climate variable. Colours indicate climate scenario (`SSP126`, green; `SSP245`, orange; `SSP585`, grey). Dashed line styles indicate inferences for different ensemble members; a solid line corresponds to the ensemble mean cumulative distribution function. Model parameters are the GEV location μ^0, scale σ^0 and shape ξ^0 in 2015, and the changes μ^1, σ^1 and ξ^1 in those parameters over the period (2015,2100). Return value for year t is denoted by Q_t.



(b) Estimated posterior cumulative distribution functions for NHGR model parameters and predicted values (M_{2025}, M_{2125}, for years 2025 and 2125), for the global annual mean from the specified GCM and climate variable. Colours indicate climate scenario: SSP126 (green), SSP245 (orange), SSP585 (grey). Dashed line styles indicate inferences for different ensemble members; solid line corresponds to the ensemble mean. Model parameters are the NHGR mean α^0, scale β^0 in 2015, and the changes α^1, β^1 in those parameters over the period (2015,2100). Predicted value for year t is denoted by M_t.

Figure SM24: `UKESM1-0-LL`, `tas`



Estimated posterior cumulative distribution functions for GEVR model parameters and 100-year return values (Q_{2025}, Q_{2125}, for years 2025 and 2125), for global annual minima from the `tas` from `UKESM1-0-LL`. Colours indicate climate scenario (`SSP126`, green; `SSP245`, orange; `SSP585`, grey). Dashed line styles indicate inferences for different ensemble members; a solid line corresponds to the ensemble mean cumulative distribution function. Note that extreme value analysis is performed on negated annual minimum `tas`. Model parameters are the GEV location μ^0, scale σ^0 and shape ξ^0 in 2015, and the changes μ^1, σ^1 and ξ^1 in those parameters over the period (2015,2100). 100-year return values for annual minimum `tas` in year t is denoted by Q_t. Results indicate that extremely low temperatures become less frequent in future with increasing climate forcing.

Figure SM25: `tas` for `UKESM1-0-LL`

SM6 Supporting information for synoptic modelling of Δ^Q and Δ^M

SM6.1 Box-whisker plots for Δ^Q per climate ensemble for global climate zones

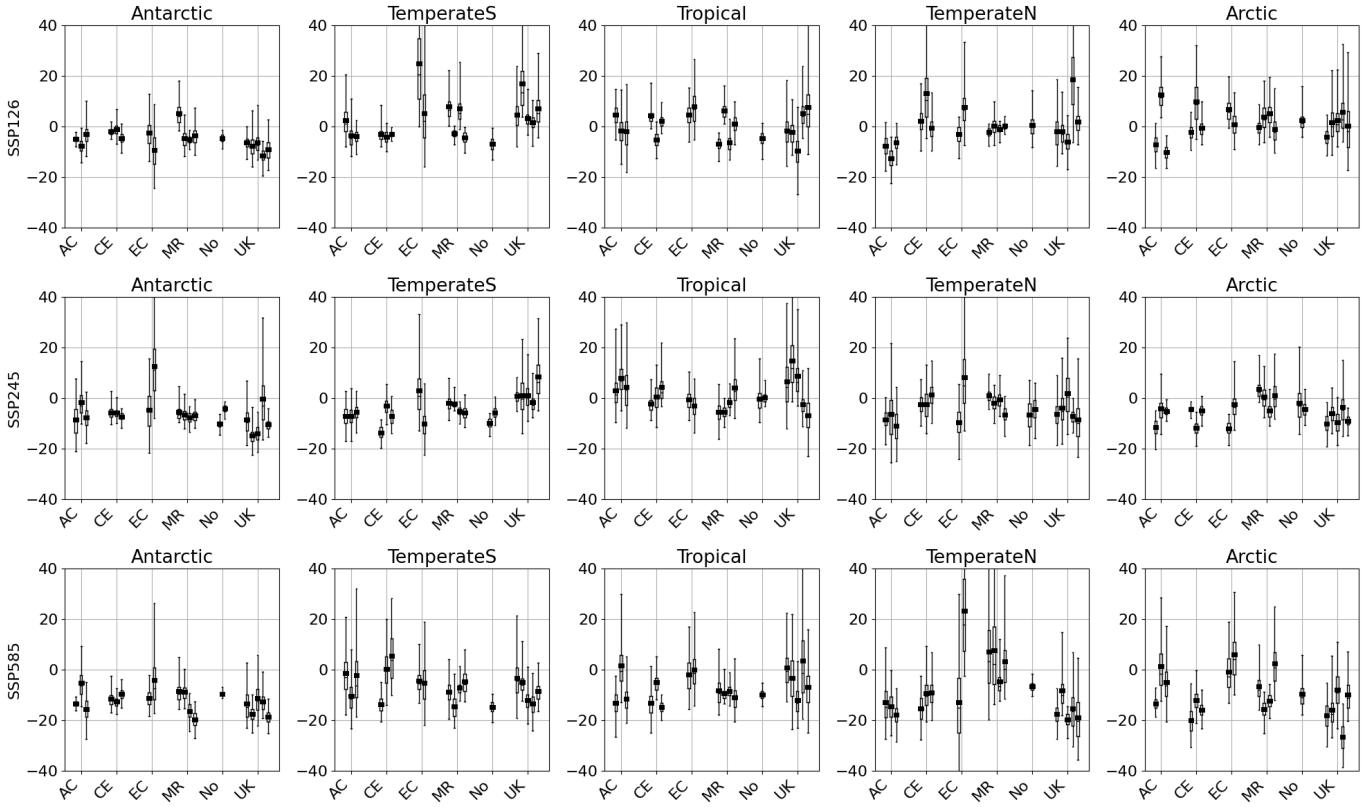


Figure SM26: Box-whisker plots for the posterior distribution of the change Δ^Q in 100-year return value Q_t of spatial annual maximum over the next 100-years per climate ensemble, for `rsds`. Rows represent climate scenarios (`SSP126`, `SSP245`, `SSP585`), and columns spatial domain (Antarctic, Temperate South, Tropical, Temperate North and Arctic). Each panel gives box-whiskers per climate ensemble grouped by GCM (`ACCESS-CM2`, `CESM2`, `EC-Earth3`, `MRI-ESM2-0`, `NorESM2-0-LL` and `UKESM1-0-LL`). The first two characters of the GCM name are used for concise labelling. For each box-whisker, the box represents the central (25%, 75%) interval for the posterior distribution, and the whisker the central (2.5%, 97.5%) interval. The posterior median is shown as a thin horizontal line (of the same width as the box), and the posterior mean as a thicker horizontal line. Vertical extents of panels have been restricted so that all central (25%, 75%) intervals is clear.

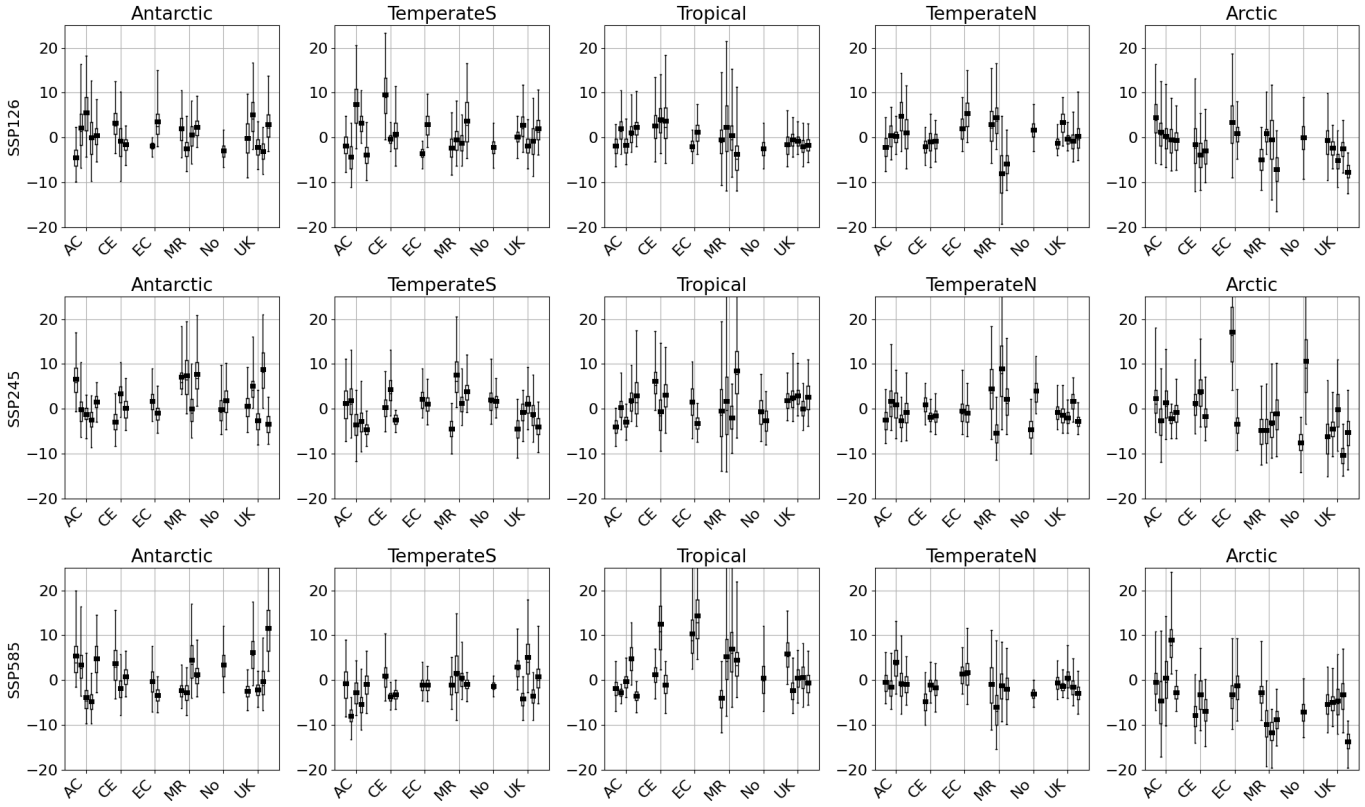


Figure SM27: Box-whisker plots for the posterior distribution of the change Δ^Q in 100-year return value Q_t of spatial annual maximum over the next 100-years per climate ensemble, for `sfcWind`. For details, see Figure SM26.

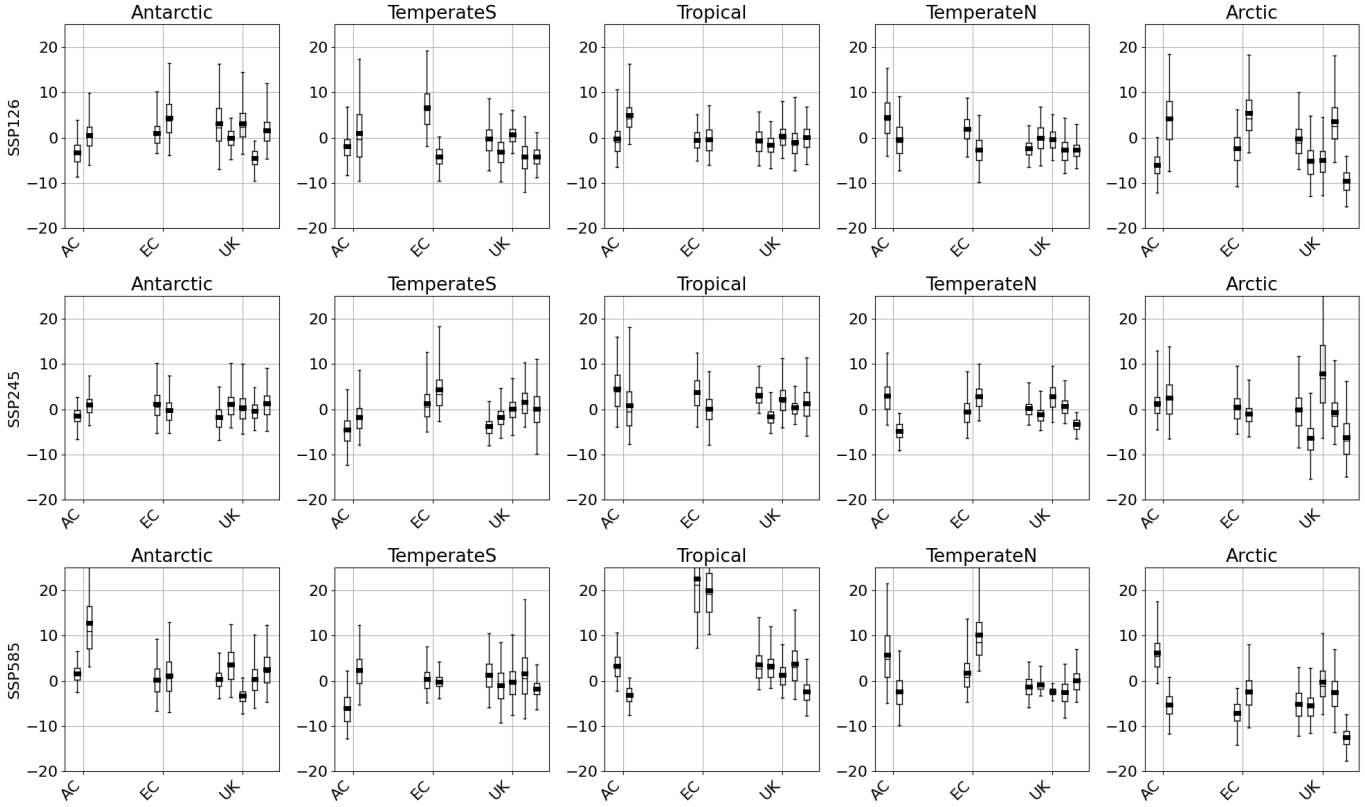


Figure SM28: Box-whisker plots for the posterior distribution of the change Δ^Q in 100-year return value Q_t of spatial annual maximum over the next 100-years per climate ensemble, for `sfcWindmax`. For details, see Figure SM26.

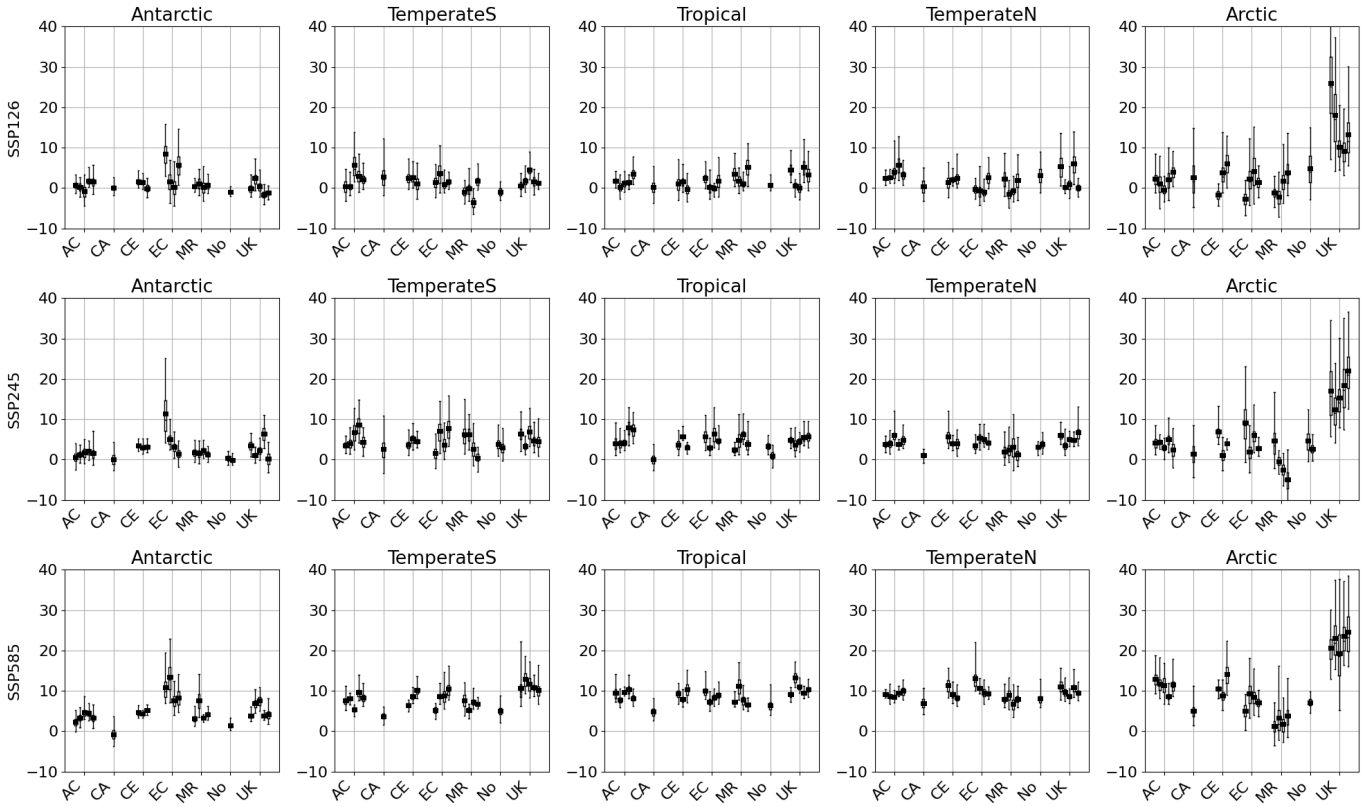


Figure SM29: Box-whisker plots for the posterior distribution of the change Δ^Q in 100-year return value Q_t of spatial annual maximum over the next 100-years per climate ensemble, for `tas`. For details, see Figure SM26.

SM6.2 Summary tables for the change Δ^Q in the annual minimum

Variable	Zone	$\mathbb{E}(\Delta^Q)$			$\mathbb{P}(\Delta^Q > 0)$		
		126	245	585	126	245	585
tas [K]	GL	-0.61	2.2	5.84	0.56	0.74	0.87
	AN	-0.28	2.25	5.88	0.58	0.74	0.87
	TS	1.65	5.24	9.18	0.67	0.85	0.89
	TR	1.33	2.44	8.86	0.66	0.74	0.93
	TN	2.94	7.02	17.42	0.74	0.87	0.98
	AR	1.64	3.16	11.38	0.65	0.75	0.92

Table SM1: Estimated expected change $\mathbb{E}(\Delta^Q)$ and probability of increase $\mathbb{P}(\Delta^Q > 0)$ of the 100-year return values over the period (2025,2125) for annual `tas` minima over 6 climate zones (GL: global; AN: Antarctic; TS: Temperate South; TR: Tropical; TN: Temperate North; AR: Arctic). Columns under "$\mathbb{E}(\Delta^Q)$" show expected changes per scenario, in the units of the variable; thus we estimate an increase of 7.02K in the 100-year minimum `tas` in the Temperate North under scenario `SSP585` over the next 100 years. Columns under "$\mathbb{P}(\Delta^Q > 0)$" show corresponding probabilities of increasing return value. Estimates are calculated assuming equal weighting for each climate model. See notes about suspect values for `sfcWindmax` under model `MRI-ESM2-0`, and suspect run `r1i1p1f1` for annual minimum `tas` for `NorESM2-0-LL` under scenario `SSP245`, discussed in Section 2.1 of the main text.

Variable	Zone	SSP effect			Model standard deviations					R^2	
		$\iota + \gamma_1$	$\gamma_2 - \gamma_1$	$\gamma_3 - \gamma_1$	τ_R	τ_{FE}	τ_ϵ	τ_δ	τ_ζ	R^2_{FE}	R^2_{ME}
tas [K]	GL	-0.69	3.0	6.45	6.51	5.95	5.49	0.32	2.26	0.16	0.29
	AN	-0.33	2.7	6.16	6.38	5.86	5.45	0.52	2.09	0.16	0.27
	TS	0.97	3.65	7.53	7.77	7.13	6.32	2.26	2.43	0.16	0.34
	TR	1.48	0.85	7.51	6.61	5.72	5.04	1.03	2.47	0.25	0.42
	TN	1.85	3.93	14.49	9.38	7.11	6.16	3.53	2.34	0.43	0.57
	AR	1.67	1.46	9.74	9.97	9.0	8.46	0.0	3.02	0.18	0.28

Table SM2: Summary of linear mixed effects modelling for the change Δ^Q in the 100-year return value of annual minima for `tas` over 6 climate zones (GL: global; AN: Antarctic; TS: Temperate South; TR: Tropical; TN: Temperate North; AR: Arctic). Columns under "SSP effect" show intercept ι and fixed effect parameter estimates γ_j for the change in 100-year return value of the given variable over the period (2025,2125) under scenario j, in the units of the variable. Columns under "Model standard deviations" provide estimates of the various standard deviations of model fitting. τ_R: the (full unconditional) standard deviation of the response R; τ_{FE}: the model error standard deviation after fitting only the fixed effects (FE, of climate scenario); τ_ϵ: the model error standard deviation after fitting the full mixed effects model. τ_δ: standard deviation of climate model random effect; τ_ζ: standard deviation due to nested random effect of climate ensemble within climate model. R^2 statistics are also provided, from fitting only the fixed effects (FE), and from fitting the full mixed effects (ME) model. Further, since sample size for model fitting is huge, estimates of uncertainties and "significance" are of little practical value, and are omitted. See notes about suspect values for `sfcWindmax` under model `MRI-ESM2-0`, and suspect run `r1i1p1f1` for annual minimum `tas` for `NorESM2-0-LL` under scenario `SSP245`, discussed in Section 2.1 of the main text.

SM6.3 Summary tables for the change Δ^M in the annual mean

Variable	Zone	$\mathbb{E}(\Delta^M)$			$\mathbb{P}(\Delta^M > 0)$		
		126	245	585	126	245	585
`rsds` [Wm^{-2}]	GL	3.5	2.1	-1.19	0.95	0.83	0.53
	AN	-1.91	-3.56	-8.56	0.08	0.03	0.0
	TS	0.21	-0.5	-1.71	0.57	0.4	0.41
	TR	2.39	2.08	0.82	0.96	0.8	0.62
	TN	4.3	3.34	2.53	1.0	0.91	0.65
	AR	-0.66	-5.08	-14.12	0.35	0.09	0.0
`sfcWind` [ms^{-1}]	GL	0.04	0.05	0.04	0.7	0.71	0.68
	AN	-0.01	0.02	0.06	0.48	0.55	0.68
	TS	-0.02	-0.0	-0.01	0.39	0.48	0.47
	TR	-0.01	-0.02	-0.04	0.45	0.38	0.3
	TN	-0.06	-0.11	-0.22	0.19	0.05	0.0
	AR	0.2	0.31	0.51	0.82	0.9	0.94
`sfcWindmax` [ms^{-1}]	GL	0.07	0.05	0.0	0.77	0.69	0.6
	AN	-0.01	0.01	0.14	0.46	0.53	0.84
	TS	-0.06	-0.04	-0.1	0.27	0.32	0.16
	TR	-0.02	-0.04	-0.06	0.36	0.26	0.28
	TN	-0.13	-0.23	-0.41	0.05	0.01	0.0
	AR	0.38	0.49	0.74	0.93	0.95	0.96
`tas` [K]	GL	1.76	3.97	7.99	0.9	1.0	1.0
	AN	1.16	2.52	6.06	0.91	0.99	1.0
	TS	0.77	1.6	3.77	0.99	1.0	1.0
	TR	0.83	1.91	4.48	0.97	1.0	1.0
	TN	1.02	2.63	6.08	0.85	1.0	1.0
	AR	3.45	6.51	13.06	0.93	1.0	1.0

Table SM3: Estimated expected change $\mathbb{E}(\Delta^M)$ and probability of increase $\mathbb{P}(\Delta^M > 0)$ of the annual mean over the period (2025,2125), for four climate variables over 6 climate zones (GL: global; AN: Antarctic; TS: Temperate South; TR: Tropical; TN: Temperate North; AR: Arctic). Columns under "$\mathbb{E}(\Delta^M)$" show expected changes per scenario, in the units of the variable. Columns under "$\mathbb{P}(\Delta^M > 0)$" show corresponding probabilities of increasing change. Estimates are calculated assuming equal weighting for each climate model. Note that the first (year 2015) observation for `rsds` in all `CESM2` runs is spurious and has been omitted. Multiple values for `sfcWindmax` from `MRI-ESM2-0` are also suspect (with some values > 100 ms^{-1}); for this reason `MRI-ESM2-0` output is ignored for variable `sfcWindmax`.

Variable	Zone	SSP effect			Model standard deviations					R^2	
		$\iota+\gamma_1$	$\gamma_2-\gamma_1$	$\gamma_3-\gamma_1$	τ_R	τ_{FE}	τ_ϵ	τ_δ	τ_ζ	R^2_{FE}	R^2_{ME}
rsds [Wm^{-2}]	GL	3.05	-1.32	-4.69	3.49	2.89	1.5	2.76	0.32	0.31	0.82
	AN	-1.42	-2.2	-6.65	3.3	1.83	1.33	1.09	1.03	0.69	0.84
	TS	-0.03	-0.6	-1.76	1.99	1.84	1.24	1.28	0.65	0.15	0.61
	TR	1.71	0.25	-1.45	2.47	2.38	1.47	2.05	0.62	0.07	0.65
	TN	3.79	-0.48	-1.57	2.76	2.67	1.52	2.24	0.41	0.06	0.7
	AR	-0.38	-4.51	-13.49	6.7	3.94	2.42	3.14	0.81	0.65	0.87
sfcWind [ms^{-1}]	GL	0.02	0.01	-0.0	0.1	0.1	0.08	0.06	0.01	0.0	0.34
	AN	-0.01	0.02	0.07	0.12	0.12	0.11	0.03	0.03	0.05	0.14
	TS	-0.02	0.02	0.02	0.09	0.09	0.09	0.02	0.01	0.01	0.08
	TR	-0.01	-0.01	-0.04	0.07	0.07	0.06	0.03	0.01	0.04	0.18
	TN	-0.06	-0.05	-0.17	0.11	0.08	0.04	0.06	0.02	0.42	0.82
	AR	0.15	0.12	0.32	0.29	0.26	0.19	0.16	0.05	0.2	0.58
sfcWindmax [ms^{-1}]	GL	0.06	-0.02	-0.07	0.13	0.13	0.1	0.1	0.01	0.05	0.43
	AN	-0.01	0.02	0.15	0.15	0.13	0.13	0.0	0.02	0.2	0.22
	TS	-0.06	0.02	-0.04	0.1	0.1	0.09	0.0	0.02	0.05	0.1
	TR	-0.03	-0.02	-0.04	0.08	0.08	0.07	0.04	0.01	0.05	0.26
	TN	-0.11	-0.1	-0.27	0.15	0.09	0.06	0.07	0.03	0.59	0.84
	AR	0.32	0.11	0.37	0.33	0.29	0.23	0.19	0.04	0.21	0.52
tas [K]	GL	1.21	2.27	6.23	3.17	1.87	0.86	1.57	0.35	0.65	0.93
	AN	0.75	1.64	4.93	2.33	1.16	0.84	0.89	0.49	0.75	0.87
	TS	0.51	1.01	3.02	1.36	0.57	0.32	0.52	0.3	0.83	0.94
	TR	0.58	1.29	3.69	1.66	0.73	0.43	0.61	0.23	0.81	0.93
	TN	0.67	1.87	5.16	2.42	1.27	0.58	1.03	0.3	0.72	0.94
	AR	2.33	3.64	9.81	5.16	3.37	1.56	2.92	0.7	0.57	0.91

Table SM4: Summary of linear mixed effects modelling for change Δ^M in the annual mean of four climate variables over 6 climate zones (GL: global; AN: Antarctic; TS: Temperate South; TR: Tropical; TN: Temperate North; AR: Arctic). Columns under "SSP effect" show fixed effect parameter estimates γ_j for the change in 100-year return value of the given variable over the period (2025,2125) under scenario j, in the units of the variable; thus we estimate a reduction in 3.6ms^{-1} in the return value for `sfcWind` under scenario `SSP585`. Columns under "Model standard deviations" provide estimates of the various standard deviations of model fitting. τ_R: the (full unconditional) standard deviation of the response R; τ_{FE}: the model error standard deviation after fitting only the fixed effects (FE, of climate scenario); τ_ϵ: the model error standard deviation after fitting the full mixed effects model. τ_δ: standard deviation of climate model random effect; τ_ζ: standard deviation due to nested random effect of climate ensemble within climate model. R^2 statistics are also provided, from fitting only the fixed effects (FE), and from fitting the full mixed effects (ME) model. Note that the first (year 2015) observation for `rsds` in all `CESM2` runs is spurious and has been omitted. Multiple values for `sfcWindmax` from `MRI-ESM2-0` are also suspect (with some values > 100 ms^{-1}); for this reason `MRI-ESM2-0` output is ignored for variable `sfcWindmax`. Further, since sample size for model fitting is huge, estimates of uncertainties and "significance" are of little practical value, and are omitted.