

SUPPLEMENTARY INFORMATION

Supplementary Tables:

Table S1| The GCMs and Ensemble Members used in the analysis.

sresa1b		sresa2		sresb1	
GCM	Ensemble Member	GCM	Ensemble Member	GCM	Ensemble Member
bccr_bcm2_0	1	bccr_bcm2_0	1	bccr_bcm2_0	1
cccma_cgcm3_1	1	cccma_cgcm3_1	1	cccma_cgcm3_1	1
cnrm_cm3	1	cnrm_cm3	1	cnrm_cm3	1
csiro_mk3_0	1	csiro_mk3_0	1	csiro_mk3_0	1
gfdl_cm2_0	1	gfdl_cm2_0	1	gfdl_cm2_0	1
gfdl_cm2_1	1	gfdl_cm2_1	1	gfdl_cm2_1	1
giss_model_e_r	2	giss_model_e_r	1	giss_model_e_r	1
inmcm3_0	1	inmcm3_0	1	inmcm3_0	1
ipsl_cm4	1	ipsl_cm4	1	ipsl_cm4	1
miroc3_2_medres	1	miroc3_2_medres	1	miroc3_2_medres	1
miub_echo_g	1	miub_echo_g	1	miub_echo_g	1
mpi_echam5	1	mpi_echam5	1	mpi_echam5	1
mri_cgcm2_3_2a	1	mri_cgcm2_3_2a	1	mri_cgcm2_3_2a	1
ncar_ccsm3_0	1	ncar_ccsm3_0	1	ncar_ccsm3_0	1
ncar_pcm1	1	ncar_pcm1	1	ncar_pcm1	2
ukmo_hadcm3	1	ukmo_hadcm3	1	ukmo_hadcm3	1

Table S2| Comparison of mean percentage of grid cells in six migration rate classes with Malcolm et al.⁶. BIOME3 and MAPSS are the two Global Vegetation Models used in their study.

Migration rate class (m year ⁻¹)				Malcolm et al. ⁶	
	mean	lower	upper	BIOME3	MAPSS
0 - 315	37.6	90.0	15.0	71.1	61.0
316 - 999	33.6	9.0	18.0	11.6	17.7
1,000 - 3,152	23.5	0.4	30.2	10.6	13.9
3,153 - 9,999	5.0	0.1	36.1	5.9	6.6
10,000 - 31,522	0.3	0.0	0.6	0.9	0.6
31,523 - 99,999	0.0	0.0	0.0	0.0	0.0

Supplementary Figures:

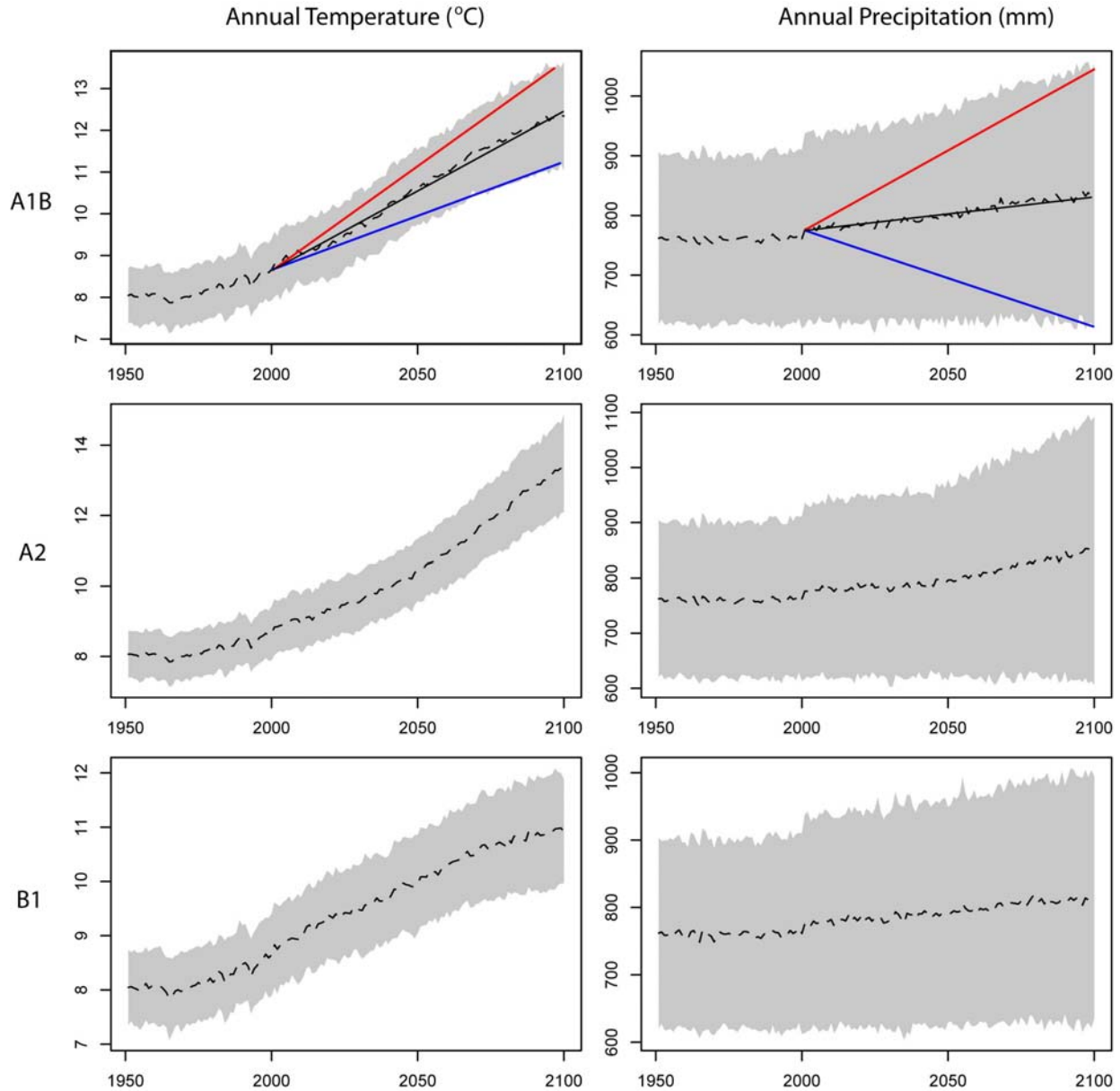


Figure S1 | Uncertainty in the temporal gradient from 16 global climate models. Trends plotted here are the average of the global land surface. The dashed black lines are mean temperature ($^{\circ}\text{C}$) and precipitation (mm) projections for the A1B, A2, and B1 emission scenarios averaged across 16 GCMs. The gray shade is one standard deviation of the 16 models. The black line is a linear regression fitted to the dashed black line from 2000-2100. Red and blue lines approximate upper and lower temporal gradients of temperature and precipitation change from these average, upper, and lower time series. They are defined as line segments connecting the height of the black line in 2000 to the height of the upper and lower time series in 2100.

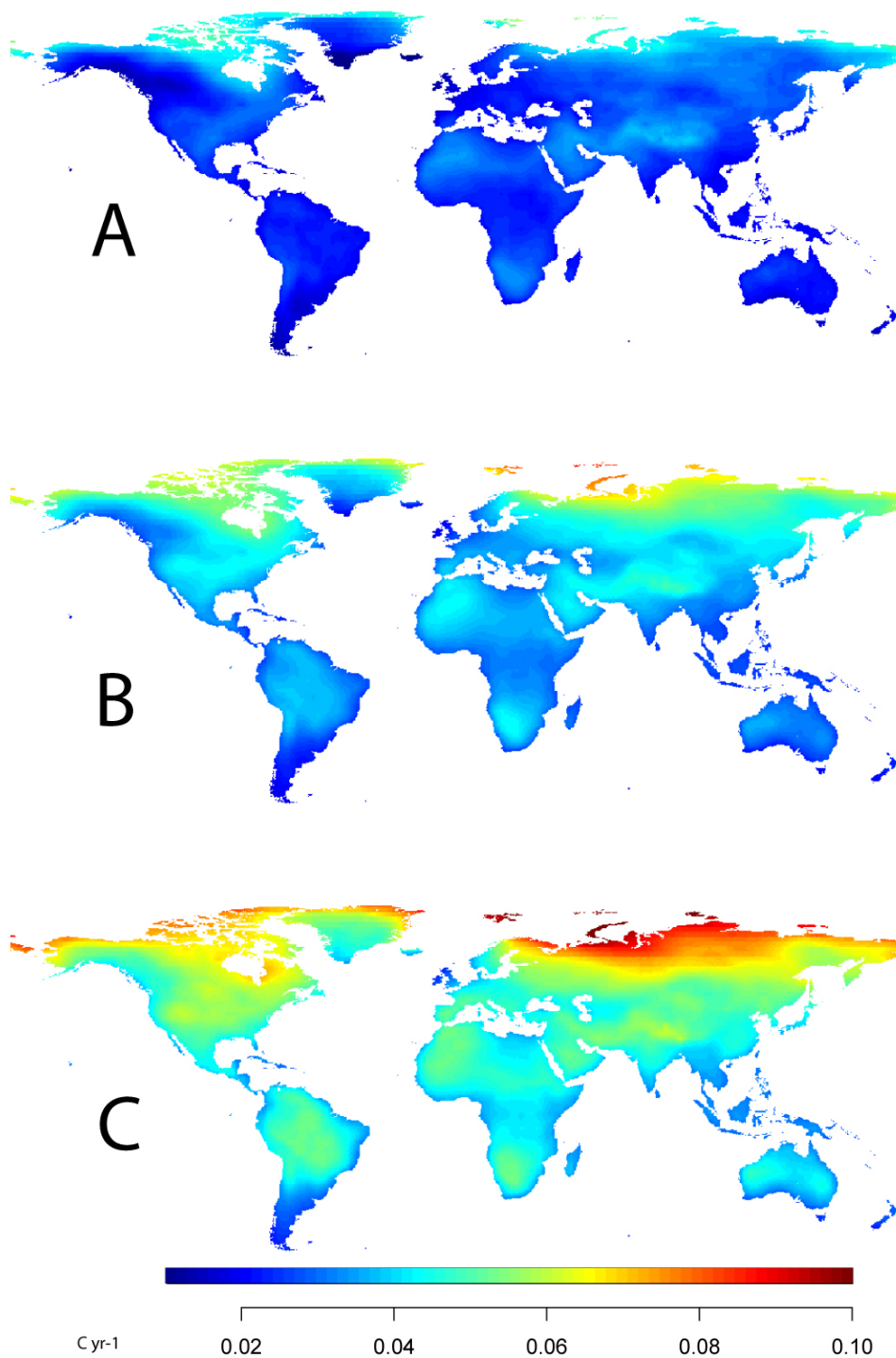


Figure S2| Mapped uncertainty in the temperature temporal gradient ($^{\circ}\text{C yr}^{-1}$). a, lower estimate b, mean estimate and c, upper estimate. Lower and upper are defined as gradients that contribute to slower and faster speeds respectively.

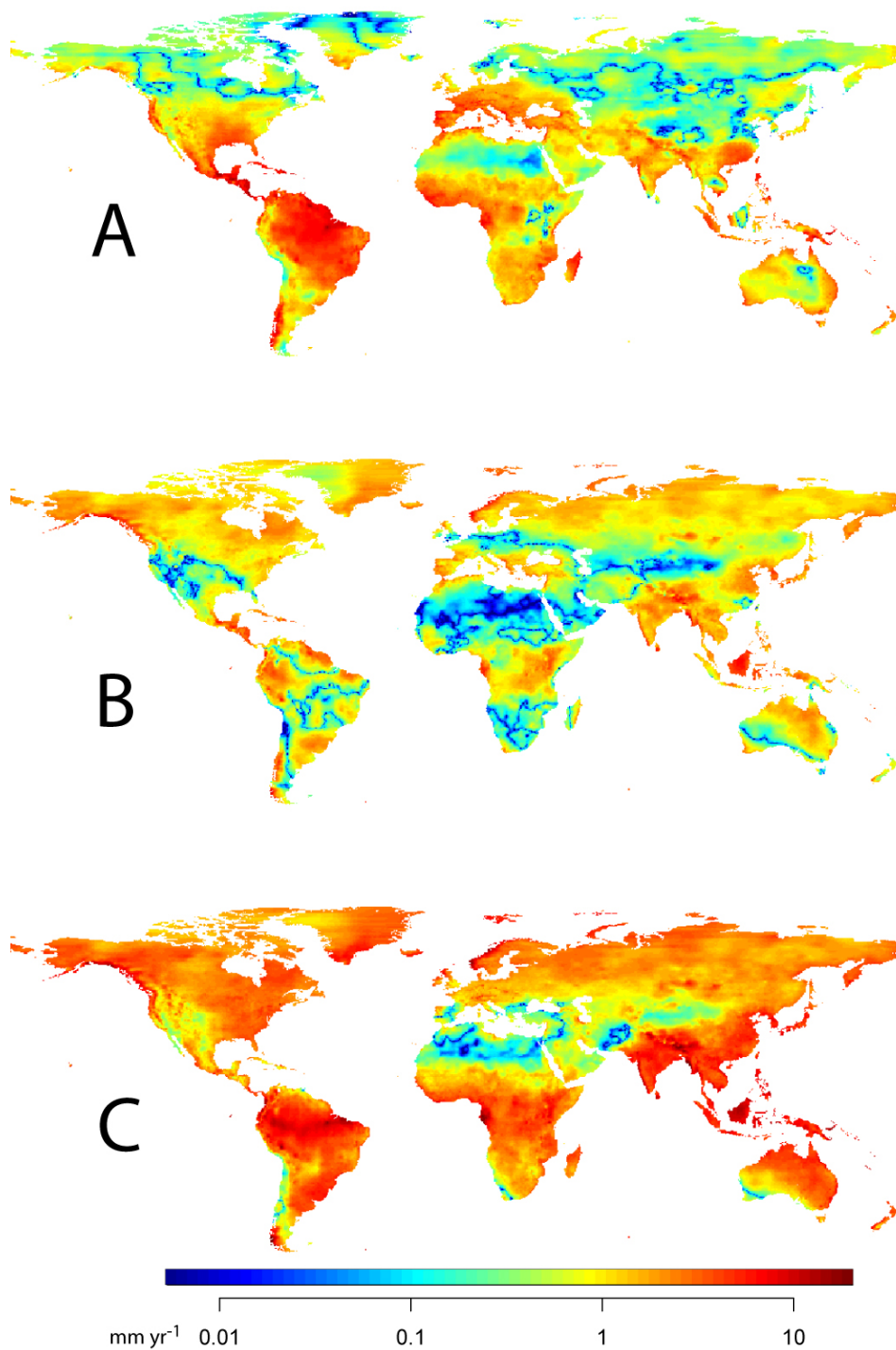


Figure S3 | Mapped uncertainty in the precipitation temporal gradient (mm yr^{-1}). a, lower estimate b, mean estimate and c, upper estimate. Lower and upper are defined as gradients that contribute to slower and faster speeds respectively.

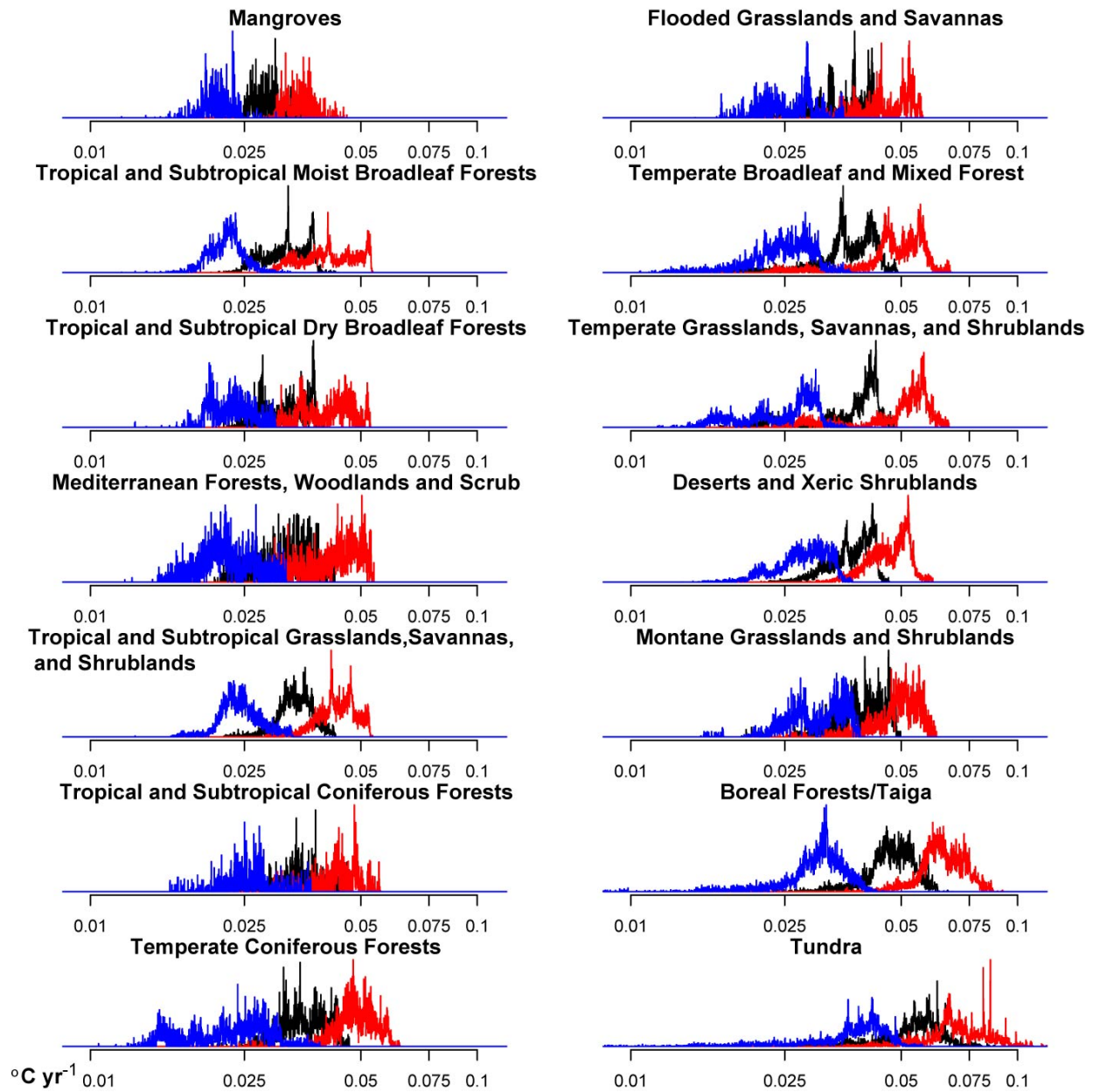


Figure S4 | Uncertainty in the temporal gradient of temperature change by biome ($^{\circ}\text{C yr}^{-1}$). Black, blue and red lines indicate mean, lower, and upper estimates. Lower and upper estimates contribute to slower and faster speeds, respectively.

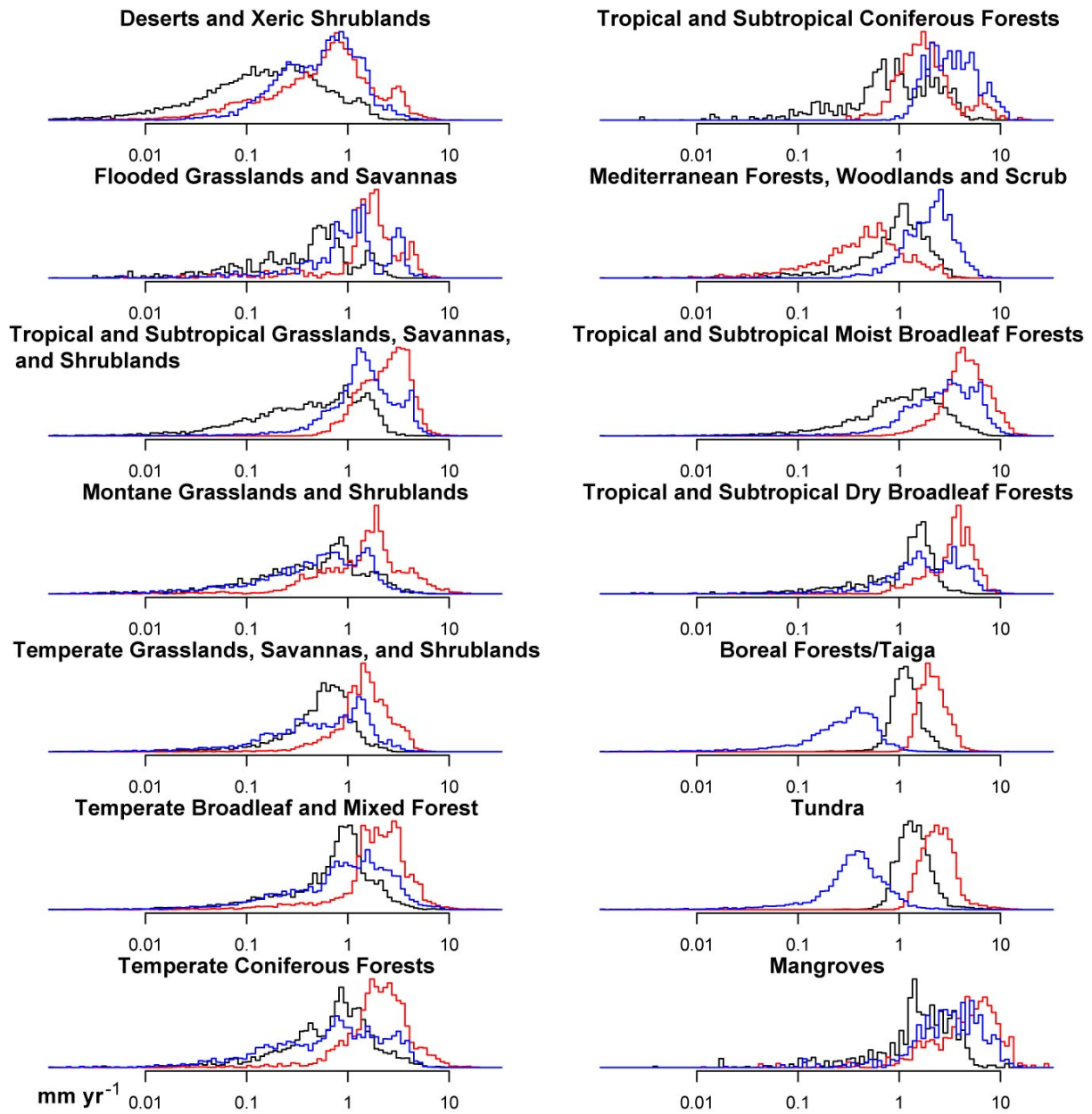


Figure S5| Uncertainty in the temporal gradient of precipitation change by biome (mm yr^{-1}). Black, blue and red lines indicate mean, lower, and upper estimates. Lower and upper estimates contribute to slower and faster speeds, respectively.

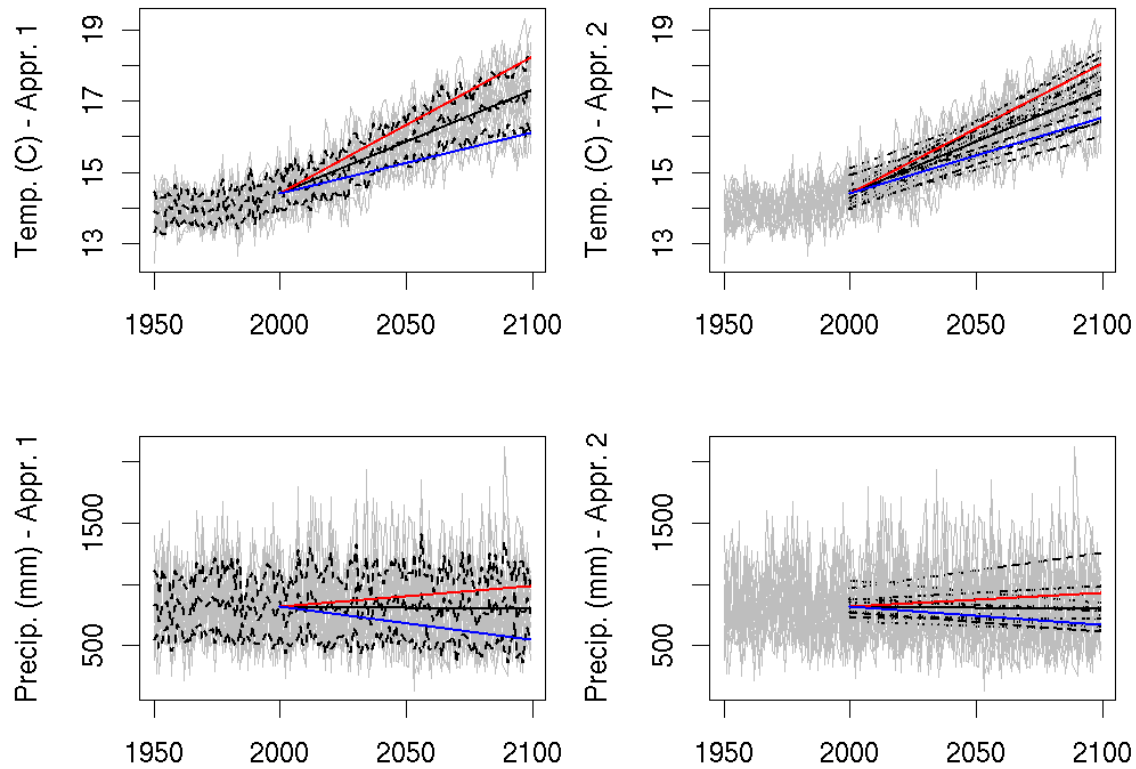


Figure S6| Comparison of temporal gradients using two approaches for a single pixel in California.

Grey lines are the 16 Global Climate Model simulations for the SRES A1B emission scenario. The variables are mean annual temperature ($^{\circ}\text{C}$) and total annual precipitation (mm). In the approach used here (Appr. 1), we first estimate mean, upper, and lower time series and then derive temporal gradients from these time series. In the alternative approach (Appr. 2), we compute temporal gradients from each time series and then estimate the mean, upper, and lower gradients from these 16 gradients.

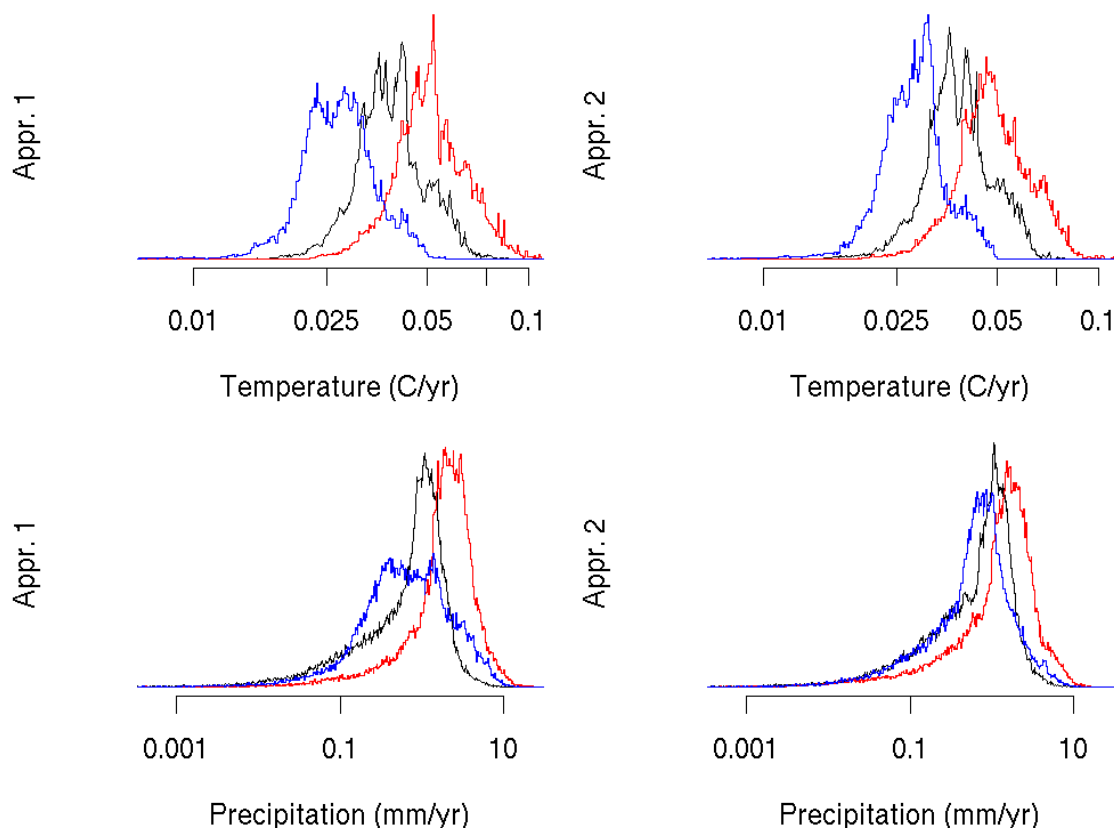


Figure S7| Comparison of temporal gradients using two approaches across the global land surface.

Apr. 1 is the approach used here. Apr. 2 is the alternative approach. Black, blue and red lines indicate mean, lower, and upper estimates. The variables are temperature change ($^{\circ}\text{C yr}^{-1}$) and precipitation change (mm yr^{-1}).

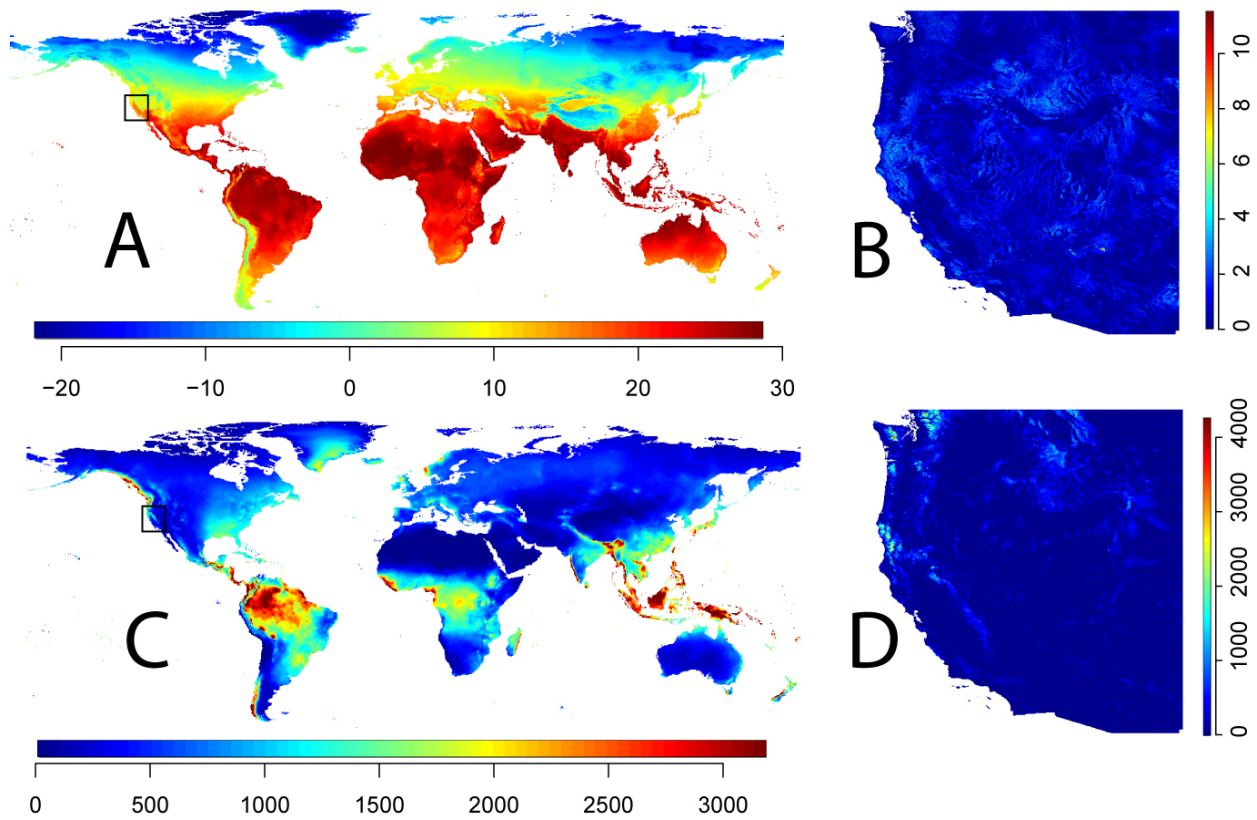


Figure S8| Maps of uncertainty in temperature and precipitation surfaces. a, Worldclim mean annual temperature ($^{\circ}\text{C}$). **c**, Worldclim total annual precipitation (mm). Rectangles indicate the areas shown in **b**, and **d**, Absolute magnitude of Worldclim minus PRISM for temperature **b**, and precipitation **d**.

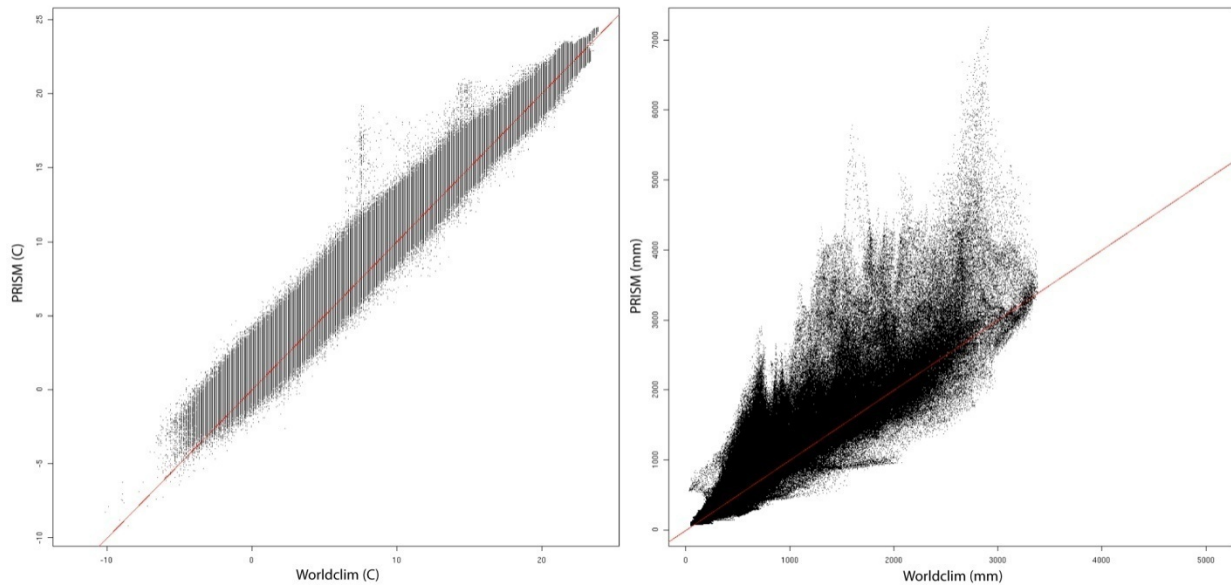


Figure S9| Uncertainty in temperature and precipitation surfaces. The left graph is mean annual temperature ($^{\circ}\text{C}$). The right graph is total annual precipitation (mm). The x-axis is Worldclim and the y-axis is PRISM for the area indicated in Fig. S13.

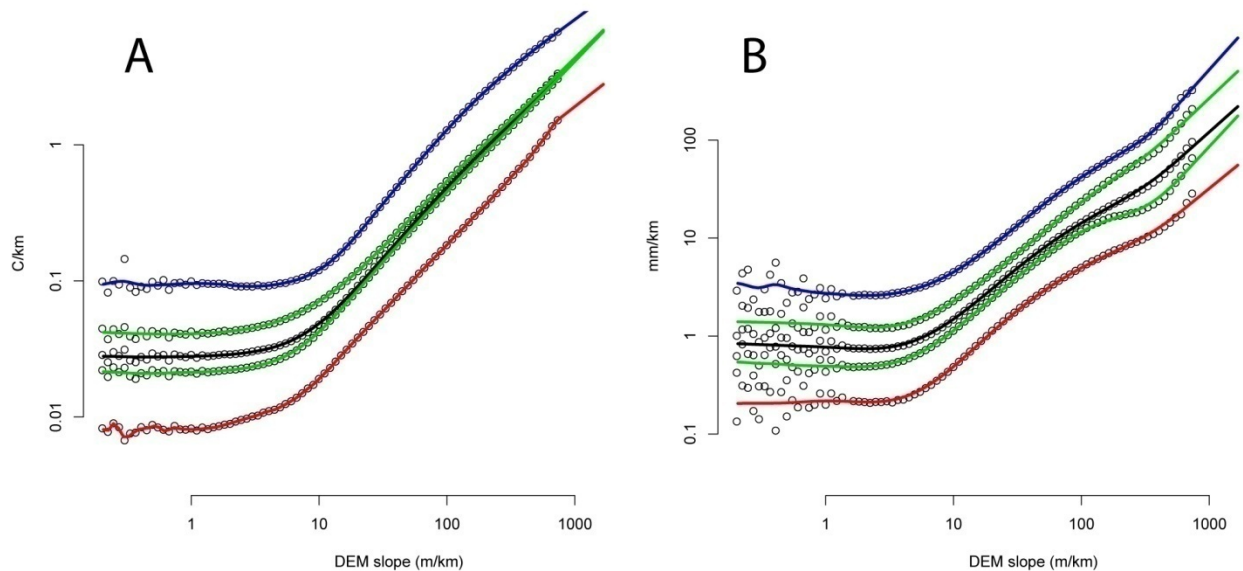


Figure S10| Uncertainty in the spatial gradient. Black line is the empirical mean spatial gradient of Worldclim temperature ($^{\circ}\text{C}$) **a**, and precipitation (mm) **b** grouped by elevation (DEM) slope for the area indicated in Fig. S13. Green lines are the respective standard deviations. Assuming PRISM represents the true temperature and precipitation, the blue and red lines are the upper and lower empirical standard deviations of the Worldclim data from the PRISM data grouped by elevation slope.

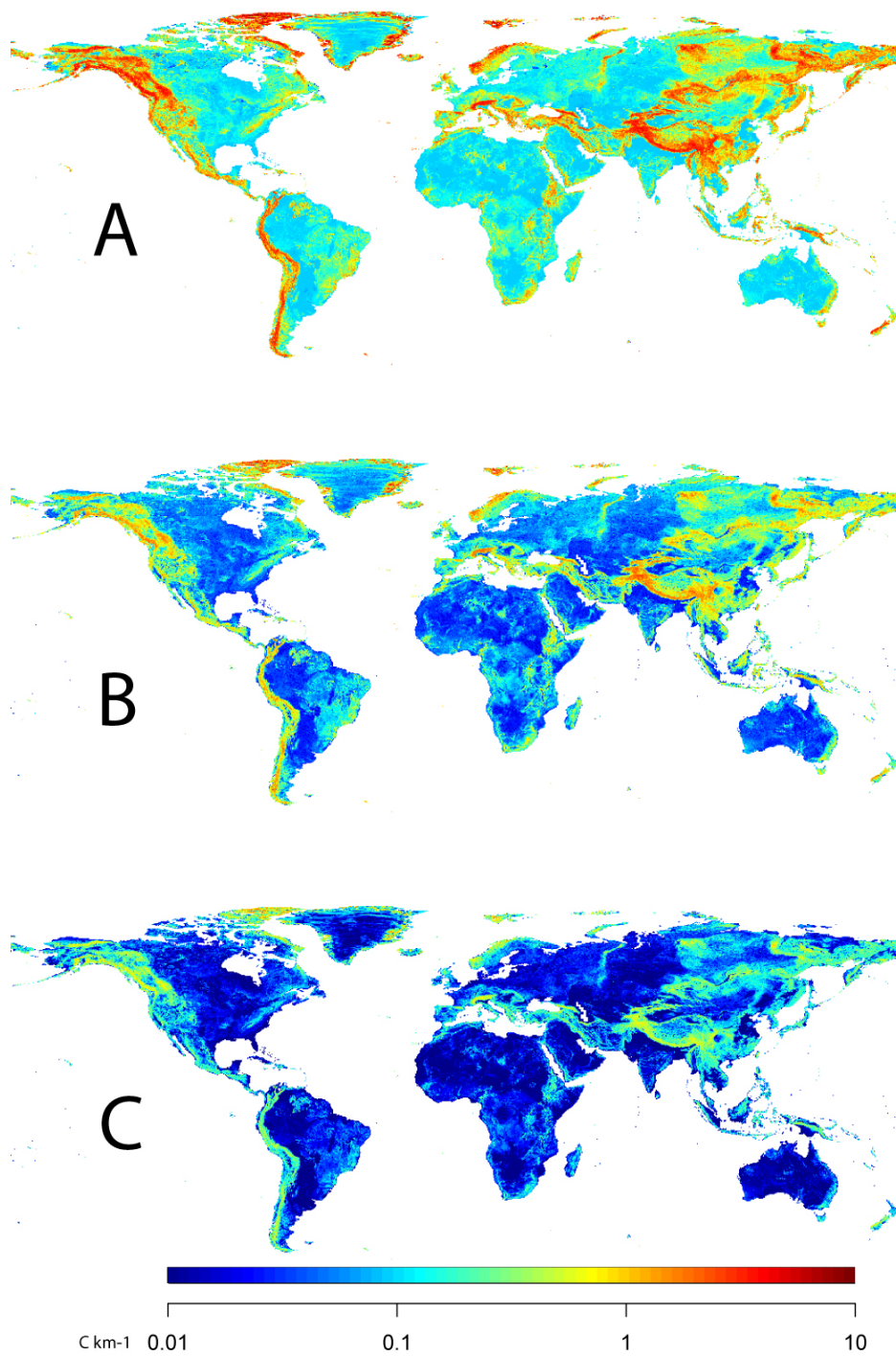


Figure S11 | Mapped uncertainty in the temperature spatial gradient ($^{\circ}\text{C km}^{-1}$). a, lower estimate b, mean estimate and c, upper estimate. Lower and upper are defined as gradients that contribute to slower and faster speeds respectively.

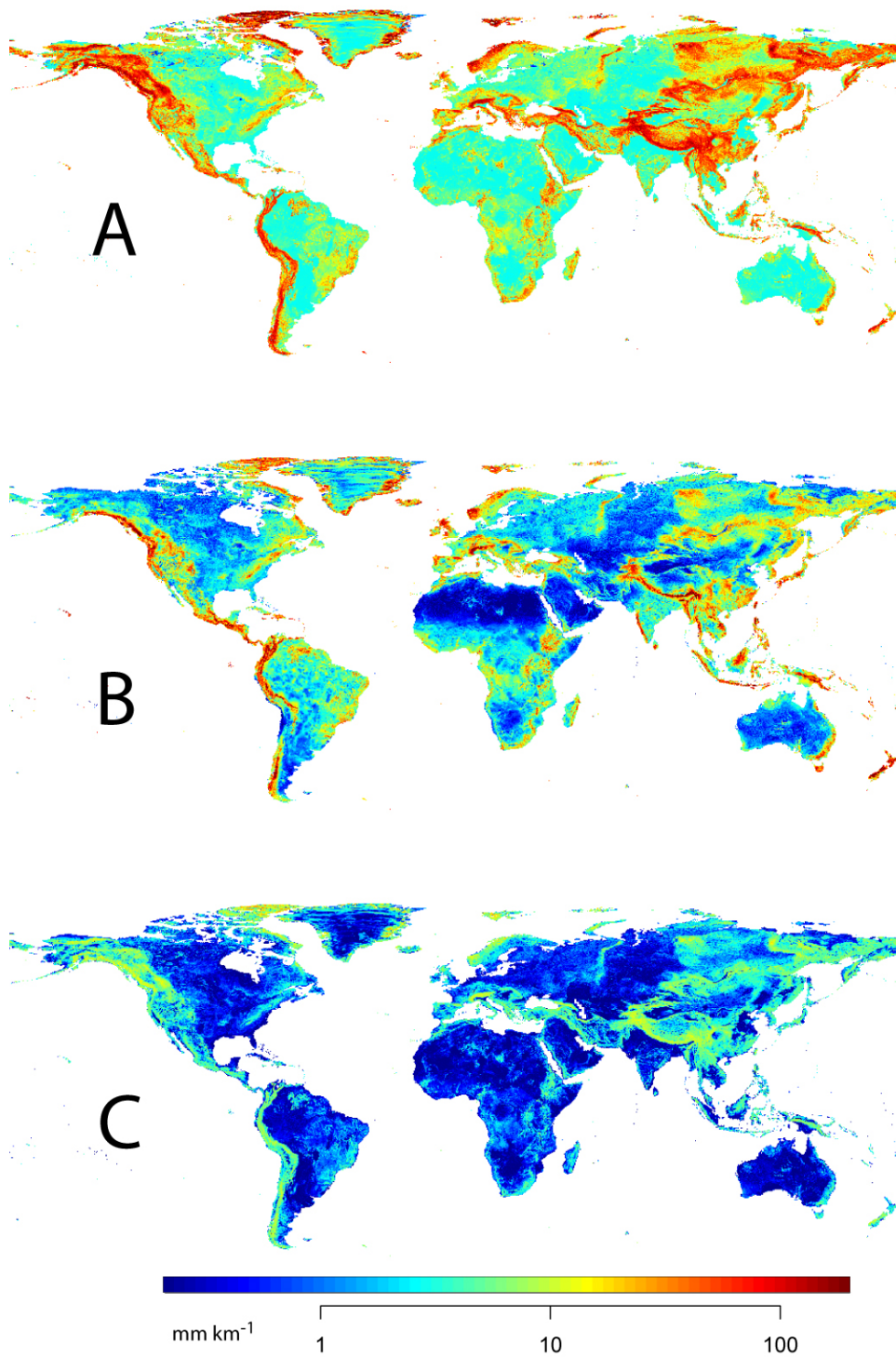


Figure S12 | Mapped uncertainty in the precipitation spatial gradient (mm km^{-1}). a, lower estimate b, mean estimate and c, upper estimate where lower and upper contribute to slower and faster speeds respectively.

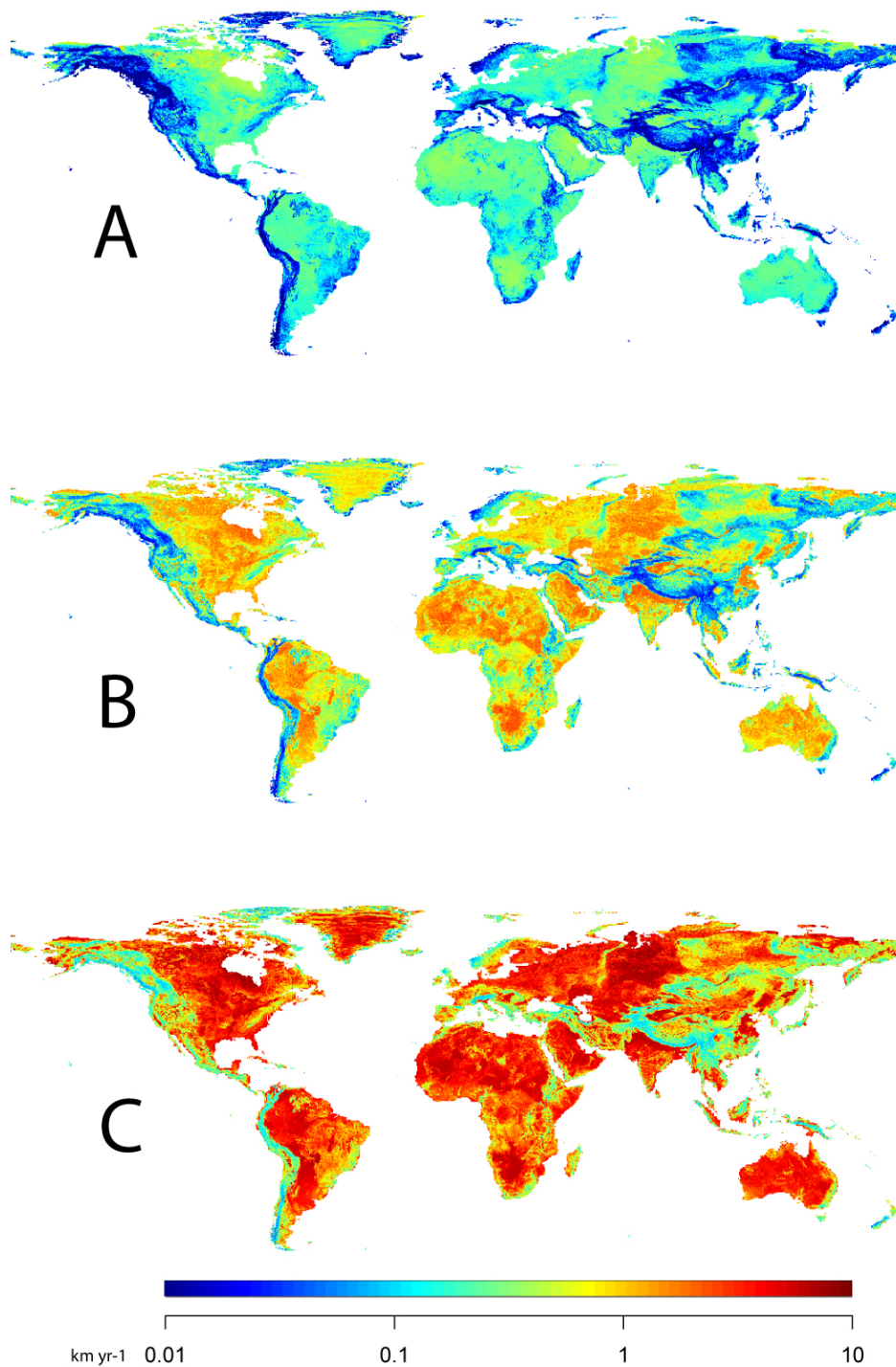


Figure S13 | Mapped uncertainty in the speed of temperature change (km yr^{-1}). a, lower estimate b, mean estimate and c, upper estimate. Lower and upper are defined as gradients that contribute to slower and faster speeds respectively.

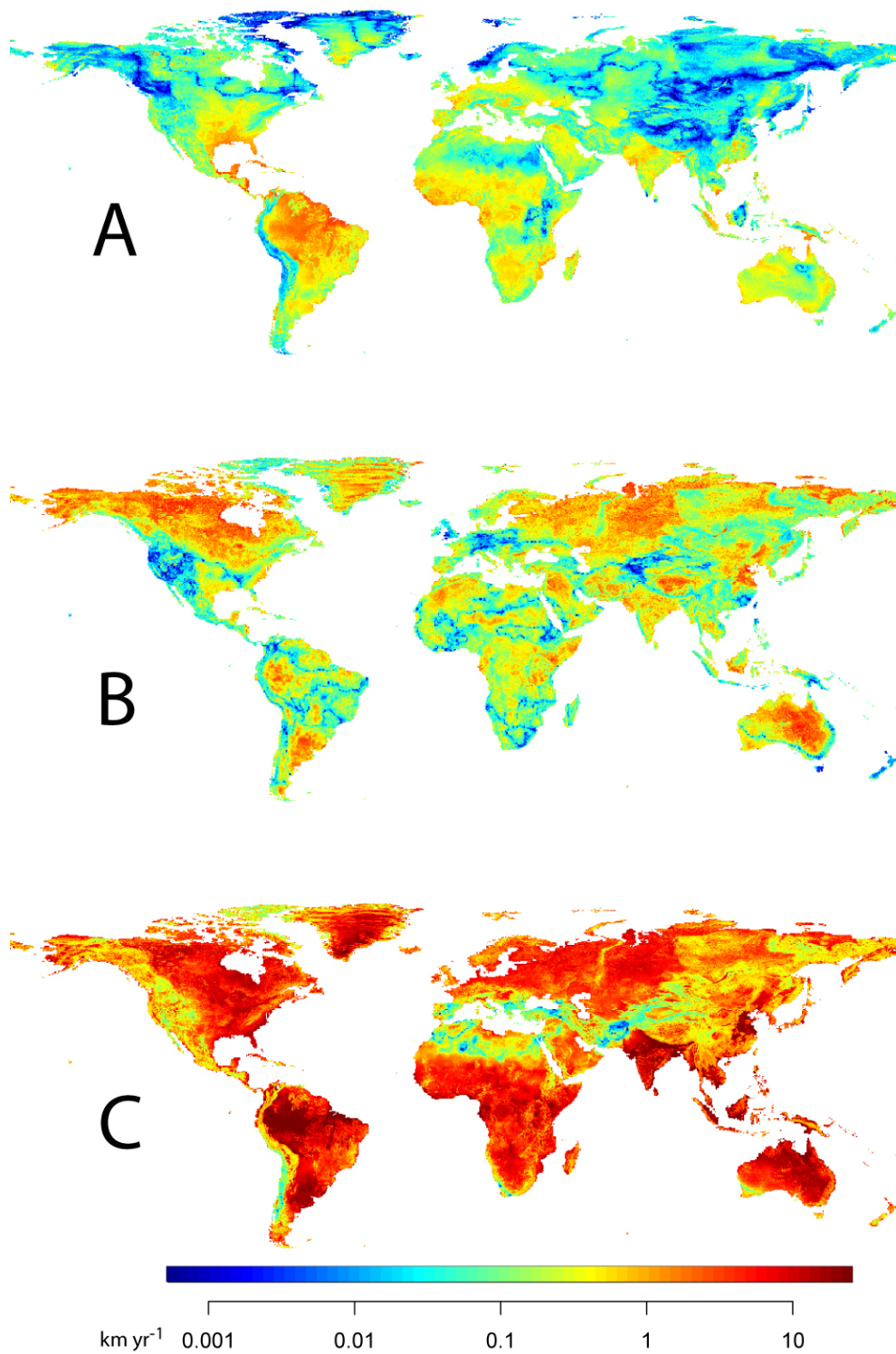


Figure S14 | Mapped uncertainty in the speed of precipitation change (km yr^{-1}). a, lower estimate b, mean estimate and c, upper estimate. Lower and upper are defined as gradients that contribute to slower and faster speeds respectively.

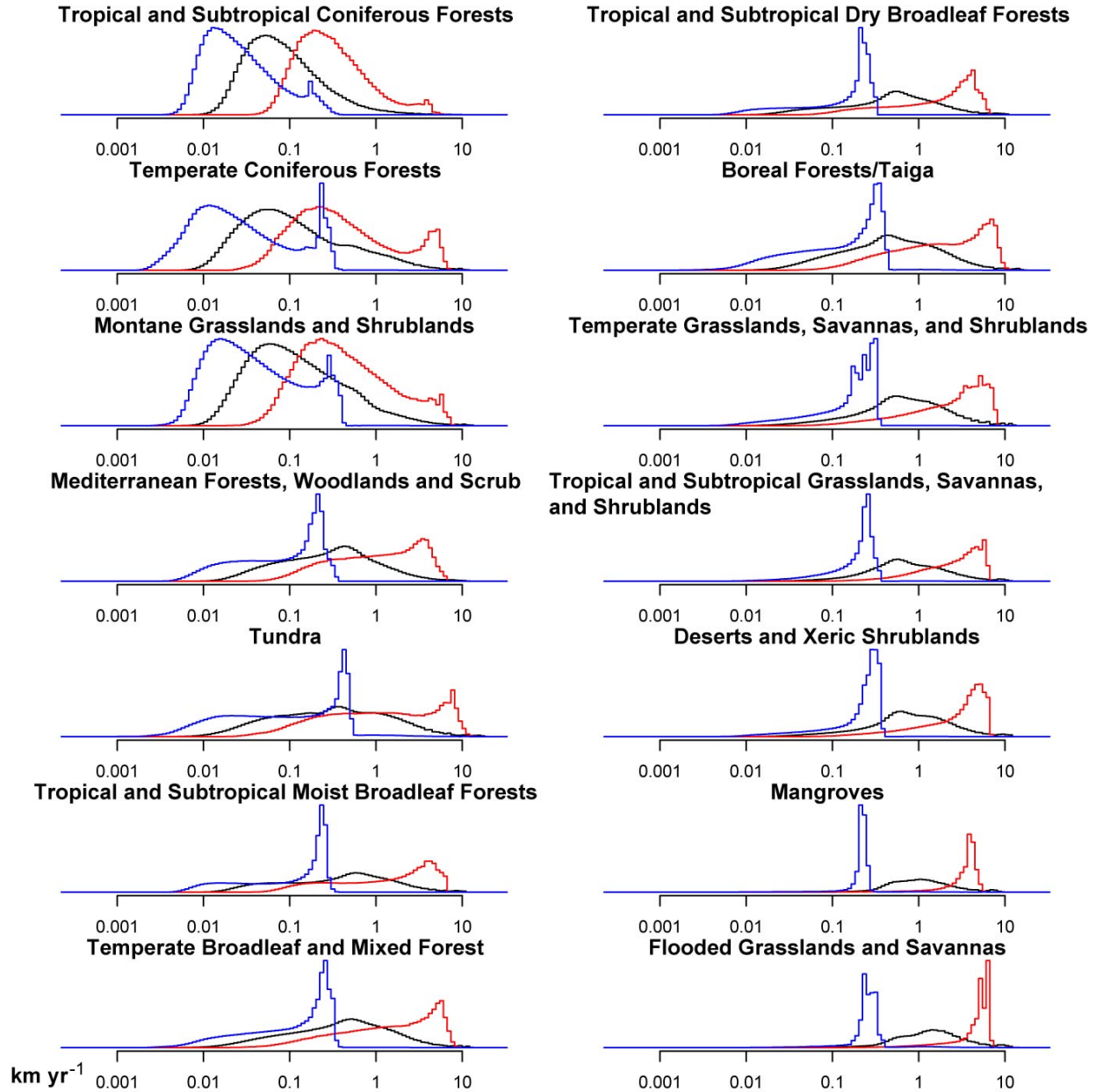


Figure S15| Uncertainty in the speed of temperature change by biome (km yr⁻¹). Black, blue and red lines indicate mean, lower, and upper estimates. Lower and upper are defined as gradients that contribute to slower and faster speeds respectively.

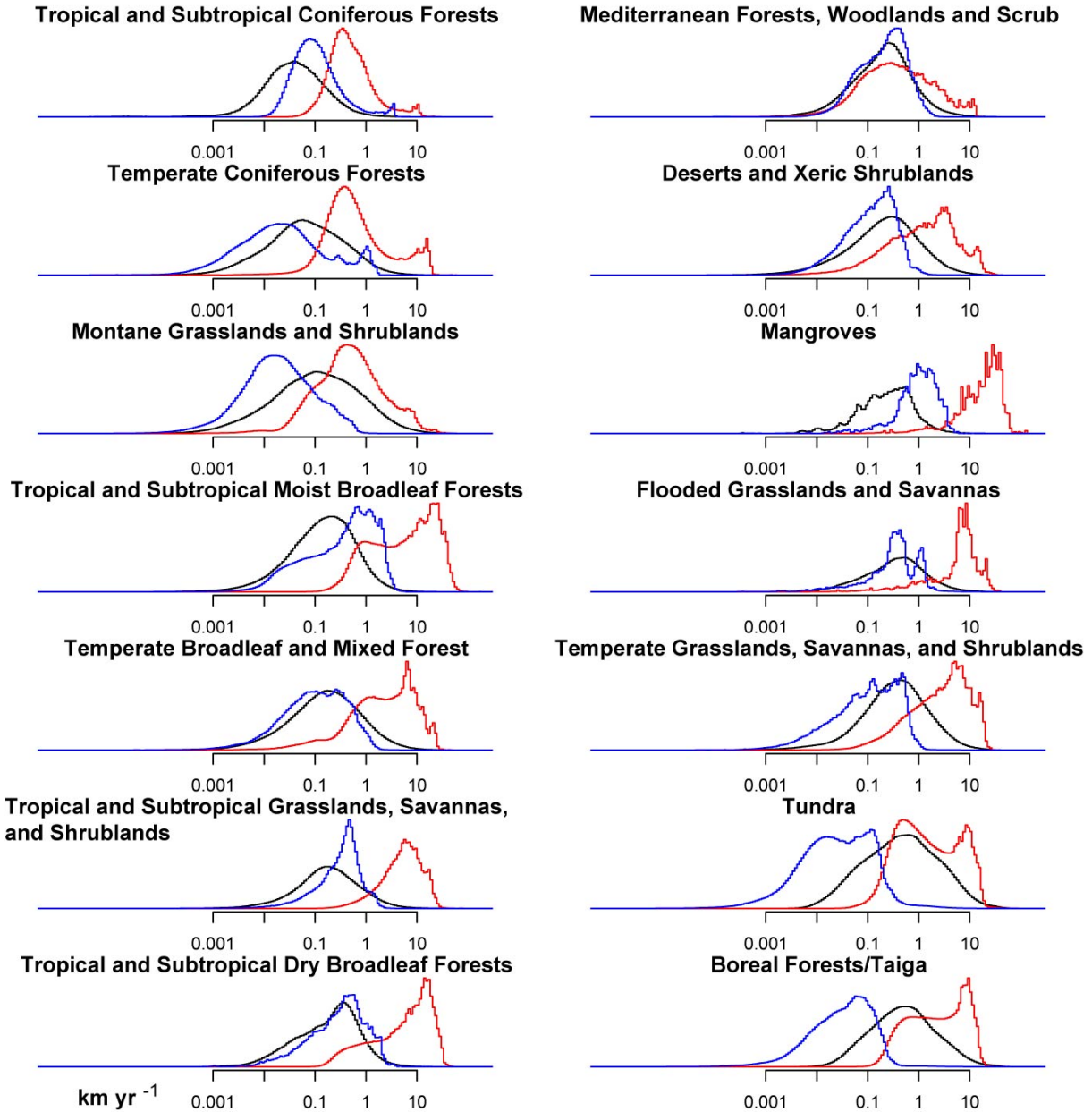


Figure S16| Uncertainty in the speed of precipitation change by biome (km yr^{-1}). Black, blue and red lines indicate mean, lower, and upper estimates. Lower and upper are defined as gradients that contribute to slower and faster speeds respectively.

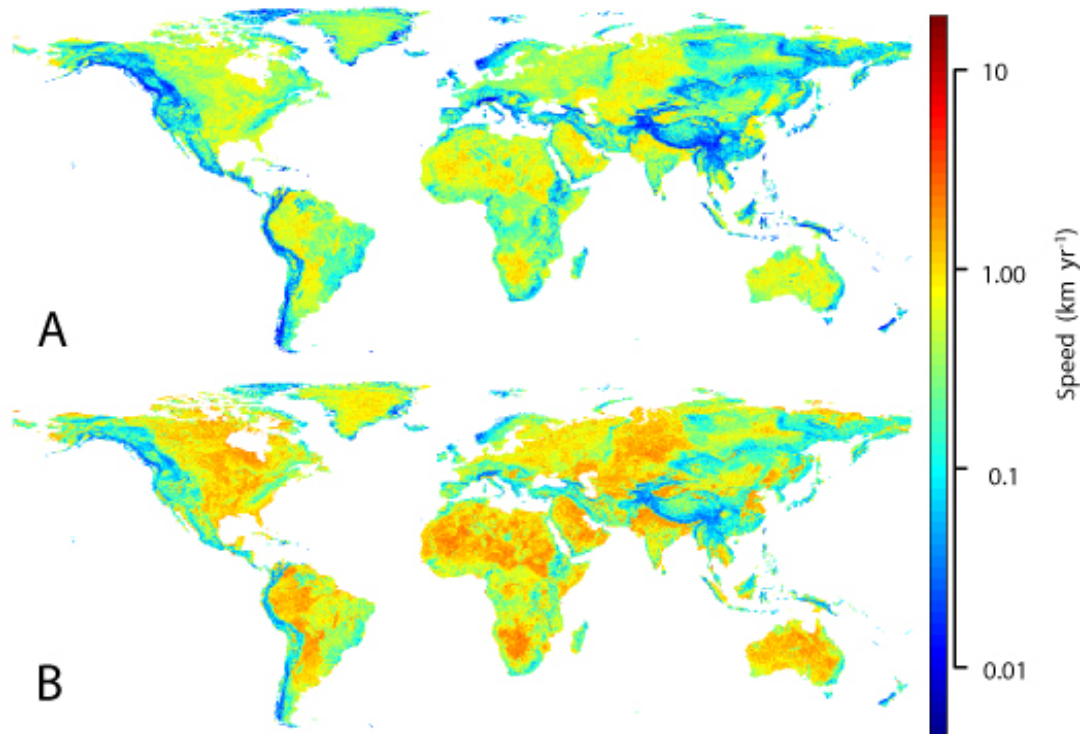


Figure S17 | The speed of temperature change globally. Global maps of climate velocity (km yr^{-1}) calculated using the 2050 – 2100 **a**, SRES B1 and **b**, SRES A2 emissions scenario temporal gradient.

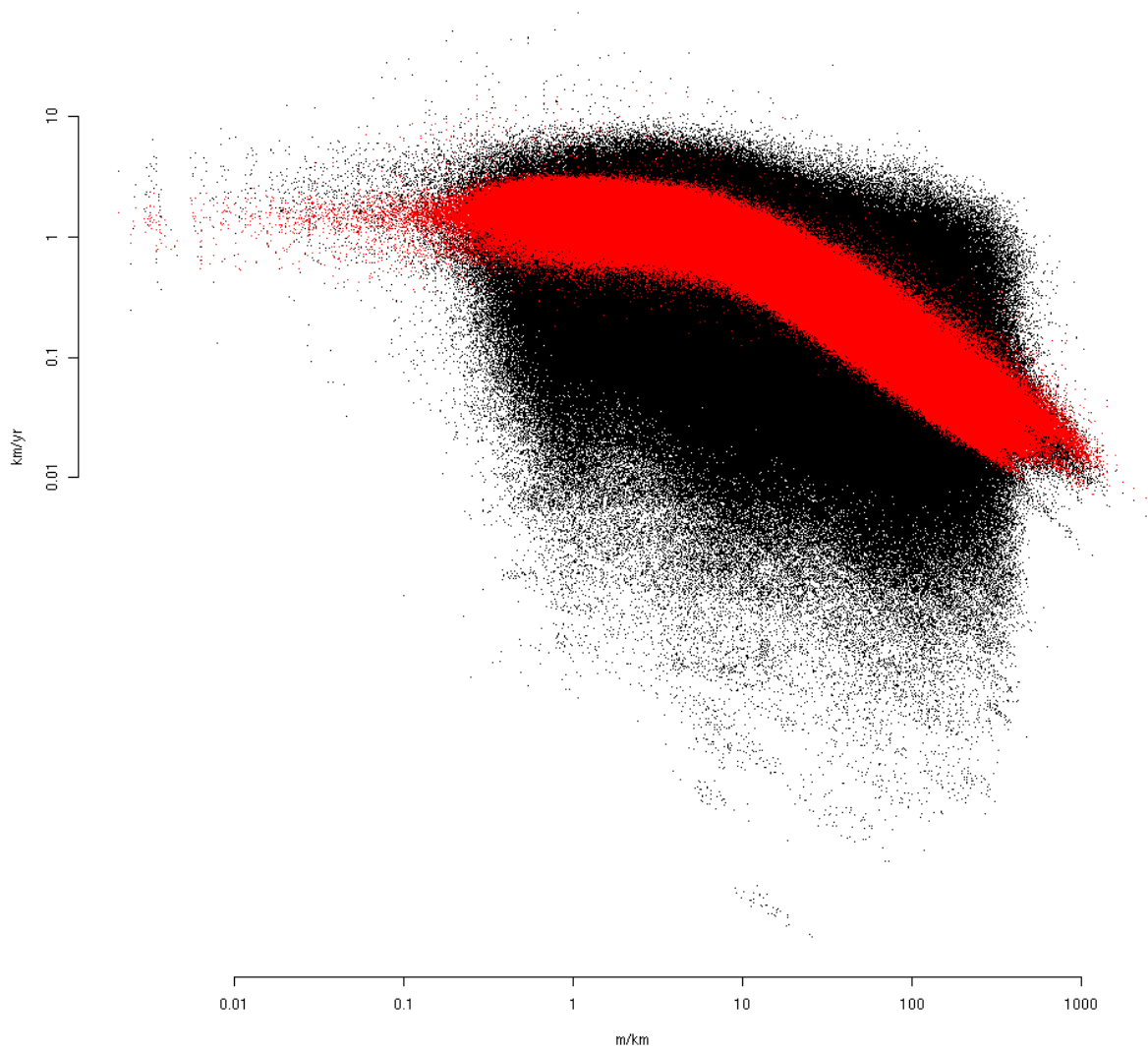


Figure S18| The speed (km yr^{-1}) of temperature and precipitation change vs. elevation slope (m km^{-1}). Red points are speeds of temperature change for each pixel (correlation coefficient = -0.92). Black points are speeds of precipitation change (correlation coefficient = -0.46).

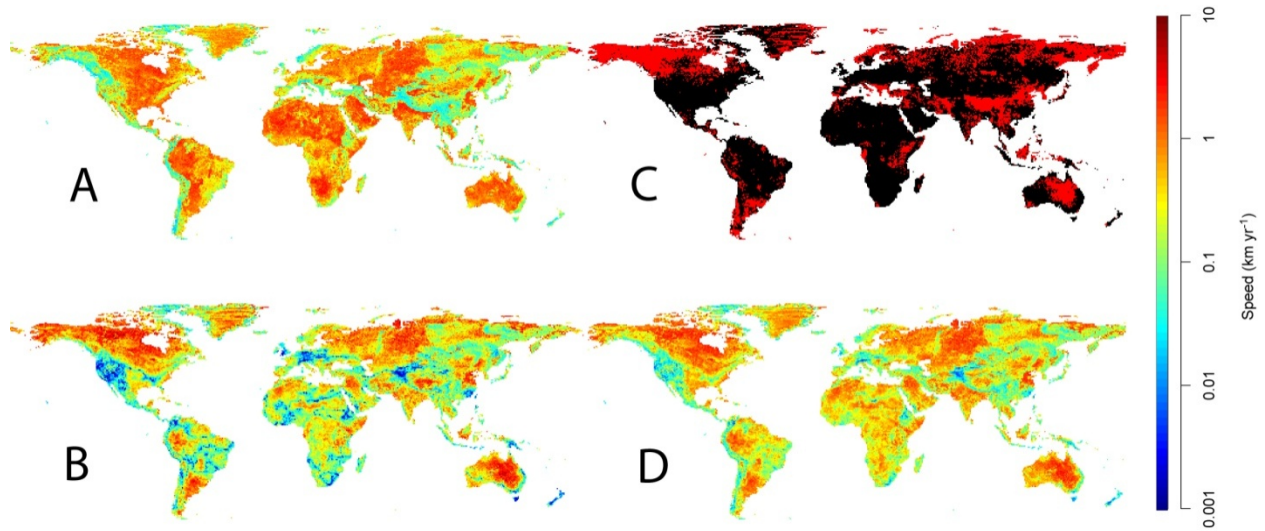


Figure S19| The speed of precipitation change (km yr^{-1}) globally. a, Speed of temperature change. b, Speed of precipitation change. c, Red areas indicate where the speed from precipitation change is greater than the speed from temperature change. d, The average of the speed of temperature change and the speed of precipitation change.

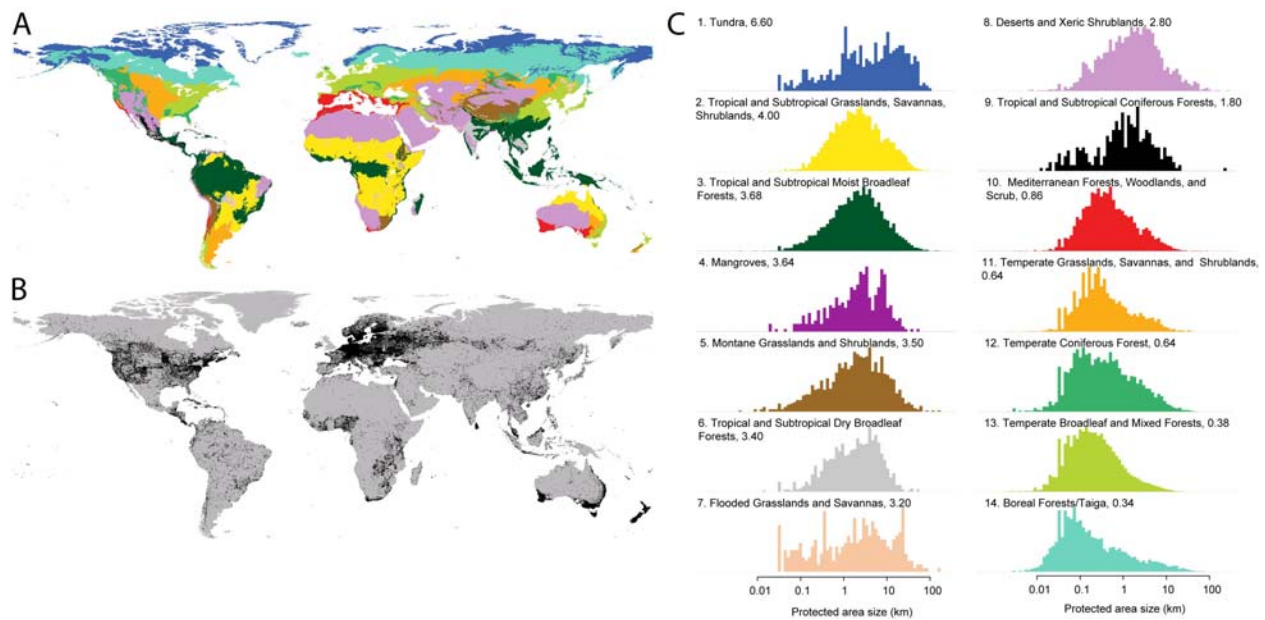


Figure S20| Reserve size (km) by biome. a, A map of biomes from the World Wildlife Fund Terrestrial Ecoregions². b, A map of the centroids of 126,068 protected areas from the World Database on Protected Areas. c, Histograms of protected area size (diameters in km) grouped by biome. Histograms are normalized for comparison, and geometric means follow the biome labels.

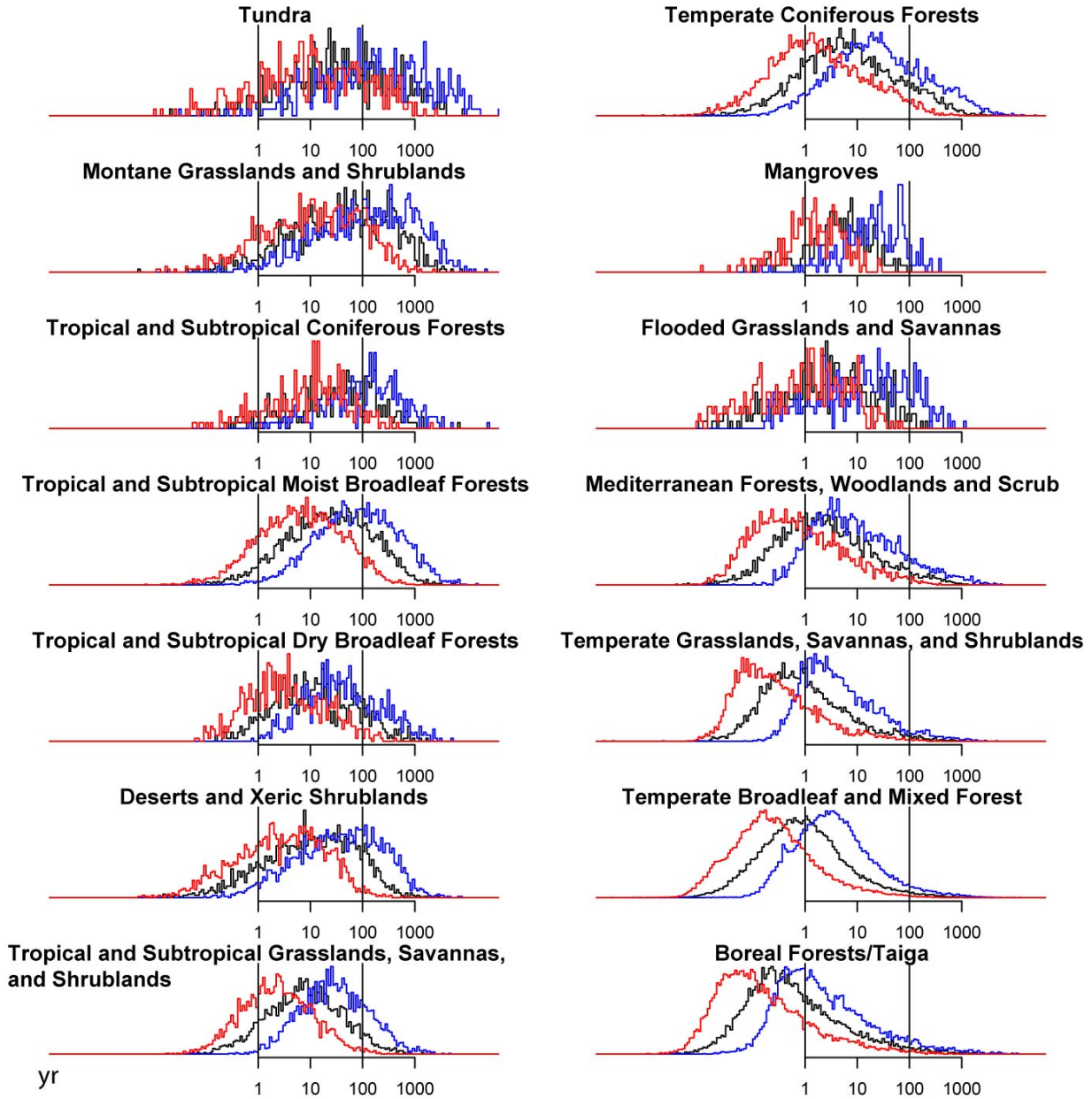


Figure S21 | Uncertainty in residence time in protected areas from temperature change by biome (yr). Black, blue and red lines indicate mean, lower, and upper estimates. Lower and upper estimates are driven by slower and faster speeds, respectively.

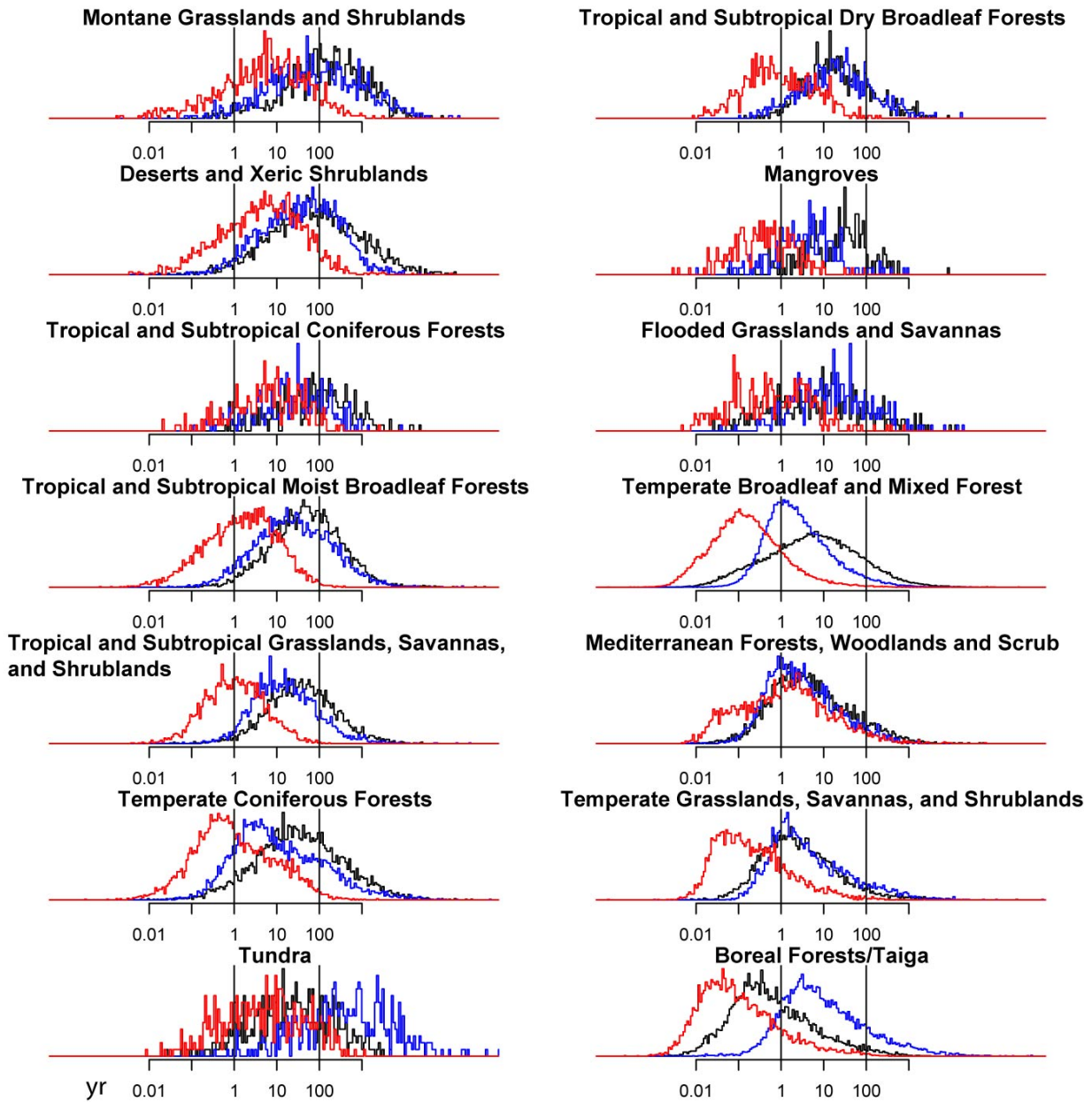


Figure S22 | Uncertainty in residence time in protected areas from precipitation change by biome (yr).

Black, blue and red lines indicate mean, lower, and upper estimates. Lower and upper estimates are driven by slower and faster speeds, respectively.

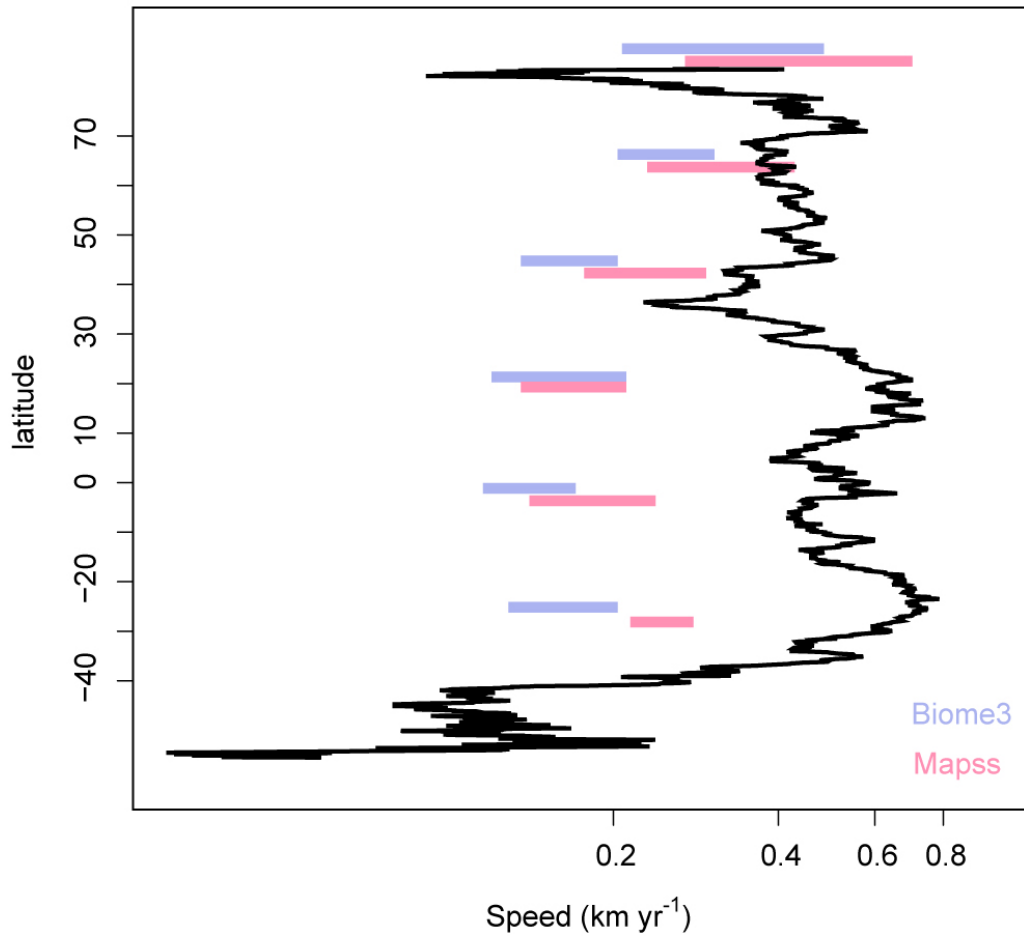


Figure S23 | The speed of temperature change (km yr⁻¹) by latitude. Pink and blue dashes are speeds calculated by Malcolm et al.⁶ from the Biome3 and MAPPs models respectively.