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Potentially dangerous consequences for biodiversity of solar geoengineering implementation and termination

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Supplementary Table 1. Estimates of median climate velocities (km yr⁻¹) for the global land and ocean surface, as well as biodiversity hotspots.

	1960– 2014	RCP4.5	G4 Implementation	G4 Continuation	G4 Termination
Global					
Land precipitation	0.2	0.4	−0.5	0.5	1.2
Land temperature	2.5	3.7	−2.7	3.4	10.4
Ocean temperature	2.0	4.8	−4.3	4.1	12.8
Biodiversity Hotspots					
Corals temperature	19.5	24.2	−37.3	24.2	74.8
Fish temperature	8.3	13.0	−11.6	12.0	38.6
Marine mammals temperature	2.8	4.5	−4.8	3.9	10.6
Mangroves temperature	17.5	21.8	−28.7	21.6	67.7
Amphibians temperature	1.9	5.4	0.0	4.8	11.3
Birds temperature	1.4	3.3	−0.1	2.9	7.6
Terrestrial mammals temperature	1.9	4.4	−0.1	3.9	9.8
Reptiles temperature	1.9	2.7	−1.8	2.6	6.8
Amphibians precipitation	0.9	−0.4	−3.6	−0.2	0.6
Birds precipitation	0.6	−0.1	−2.7	−0.1	0.4
Terrestrial mammals precipitation	0.7	−0.3	−2.9	−0.2	0.3
Reptiles precipitation	0.7	0.3	−1.5	0.4	0.9

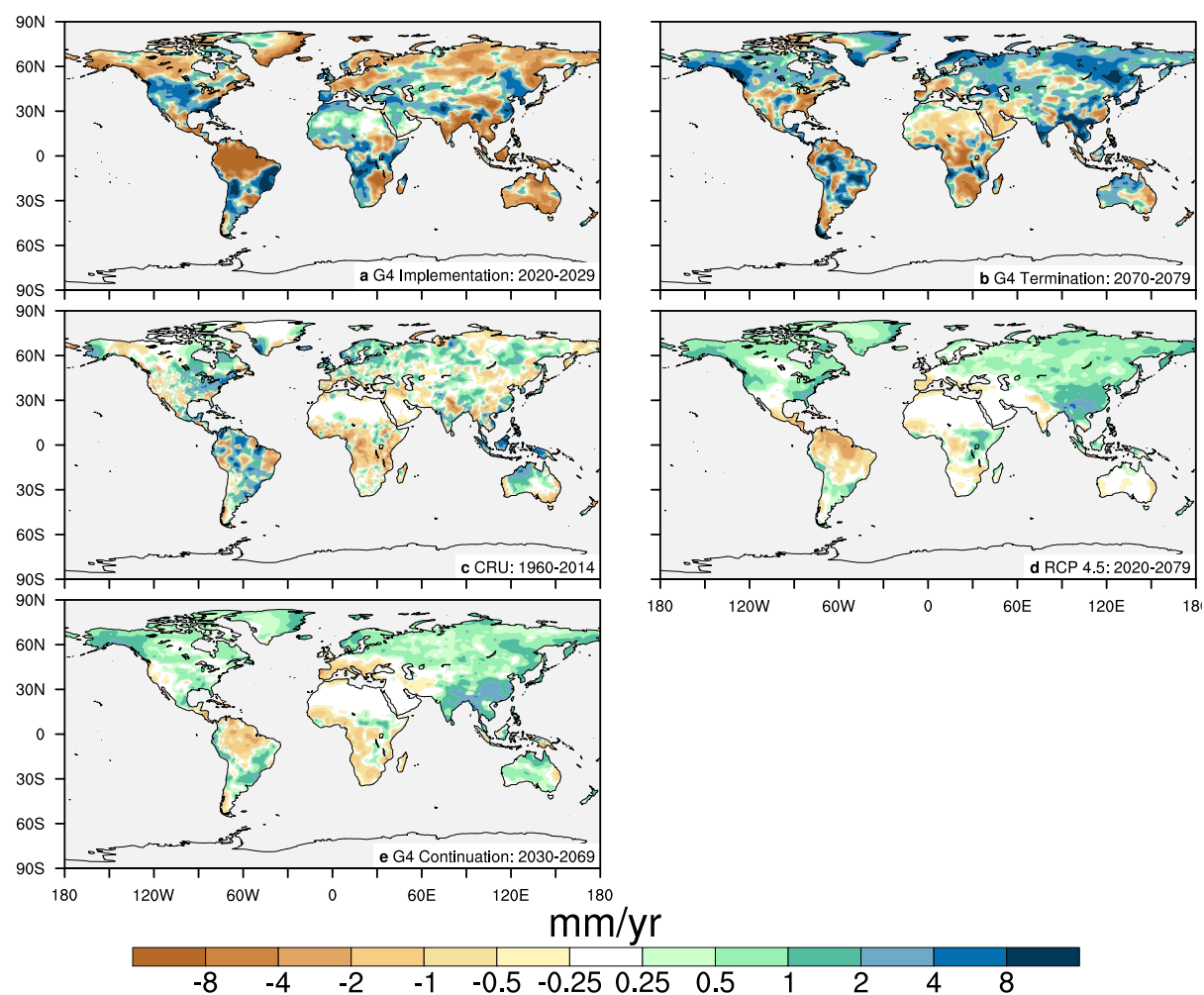
Extended Data Table 2. Percentage of biome area exposed to increased climate fragmentation: Defined as temperature and precipitation velocity vectors for sudden geoengineering termination diverging in direction by $> 90^\circ$ from each other and being more than double RCP4.5 in magnitude.

Biome	Percent biome area
Temperate grassland, savanna and shrubland	37.9
Temperate broadleaf and mixed forest	36.5
Temperate conifer forests	35.4
Mediterranean forest, woodland and scrub	34.3
Deserts and xeric shrublands	33.5
Mangroves	29.8
Tropical and subtropical grasslands, savannas and shrublands	28.4
Flooded grassland and savanna	27.9
Boreal Forests/Taiga	26.5
Tropical and subtropical coniferous forest	24.4
Tropical and subtropical moist broadleaf forest	22.4
Montane grasslands and shrublands	20.4
Tropical and subtropical dry broadleaf forest	16.1
Tundra	15.7

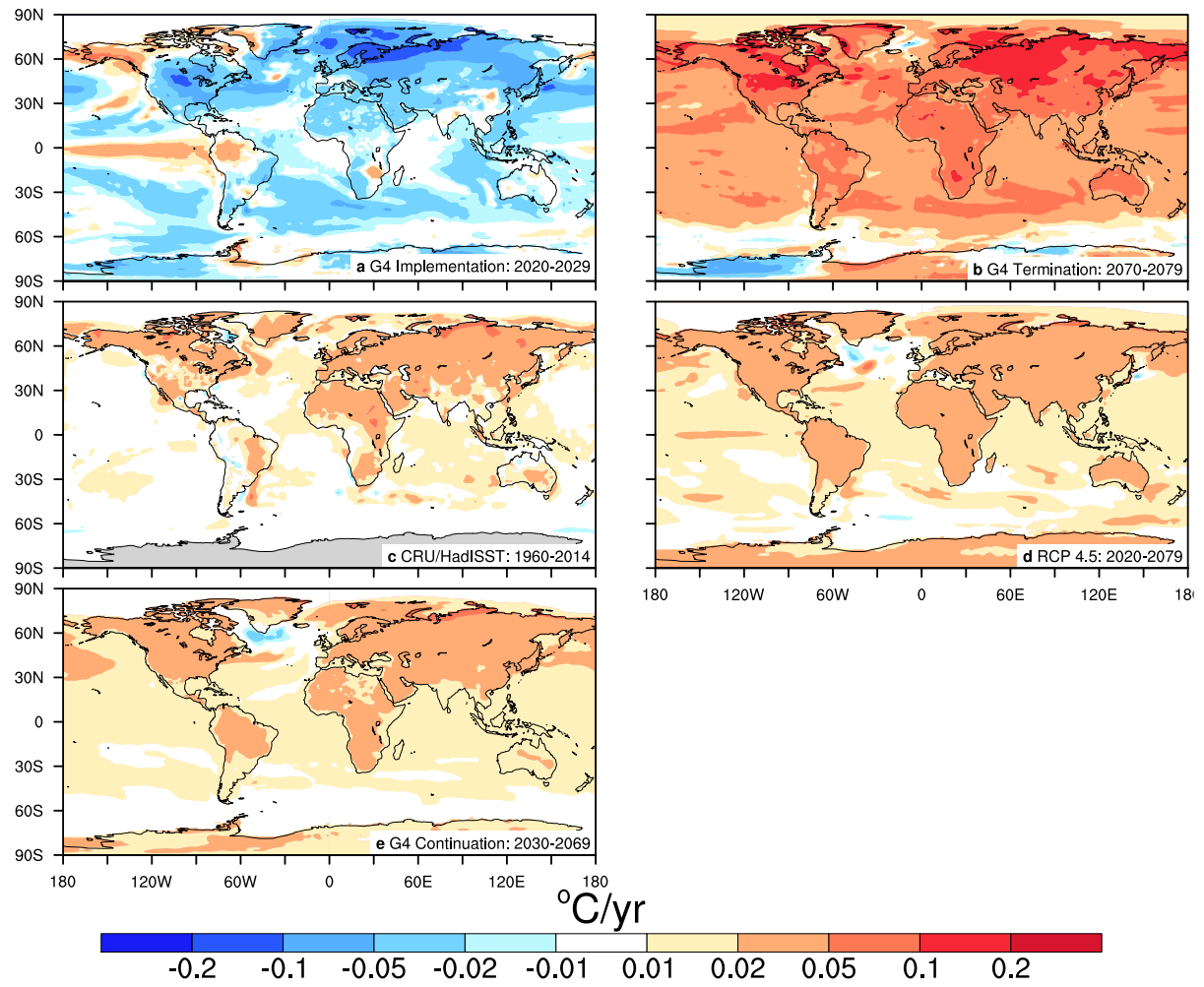
SupplementaryTable 3. Climate models participating in GeoMIP that have run the Historical, RCP4.5, and G4 experiments.

Models ^{Reference}	Institution
CanESM2 ¹	Canadian Centre for Climate Modeling and Analysis, Environment Canada
CSIRO-Mk3L-1-2 ²	Commonwealth Scientific and Industrial Research Organisation, Australia
GISS-E2-R ³	NASA Goddard Institute for Space Studies, USA
HadGEM2-ES ^{4,5}	Met Office Hadley Centre, UK

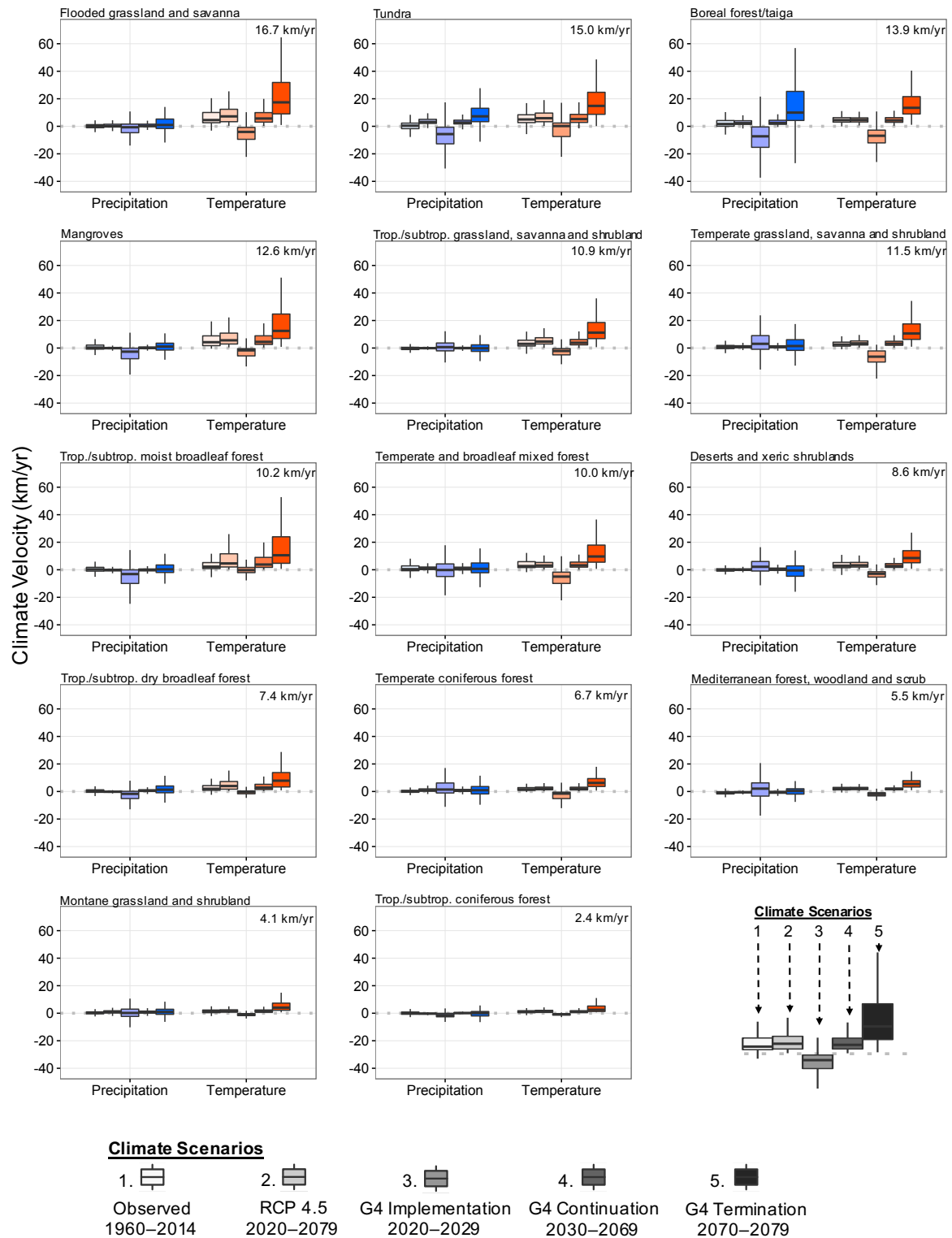
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2. Phipps, S. J., Rotstayn, L. D., Gordon, H. B., Roberts, J. L., Hirst, A. C. & Budd W. F. The CSIRO Mk3L climate system model version 1.0 - Part 1: Description and evaluation. *Geosci. Model Dev.* **4**, 483-509, doi:10.5194/gmd-4-483-2011 (2011).
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4. Collins, W. J., *et al.* Development and evaluation of an Earth-System model-HadGEM2. *Geosci. Model Dev.* **4**, 1051-1075, doi:10.5194/gmd-4-1051-2011 (2011).
5. HadGEM2 Development Team, The HadGEM2 family of Met Office Unified Model climate configurations. *Geosci. Model Dev.* **4**, 723-757, doi:10.5194/gmd-4-723-2011 (2011).



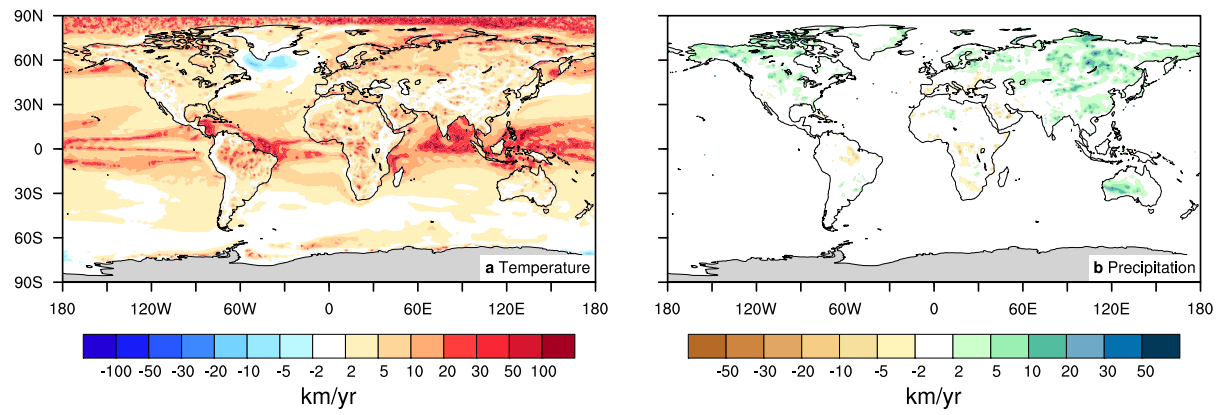
Supplementary Figure 1. Temporal trends in total annual precipitation (mm yr^{-1}). a, G4 Implementation. b, G4 Termination. c, Observed precipitation data from Climate Research Unit data set TS3.23. d, RCP4.5. e, G4 Continuation.



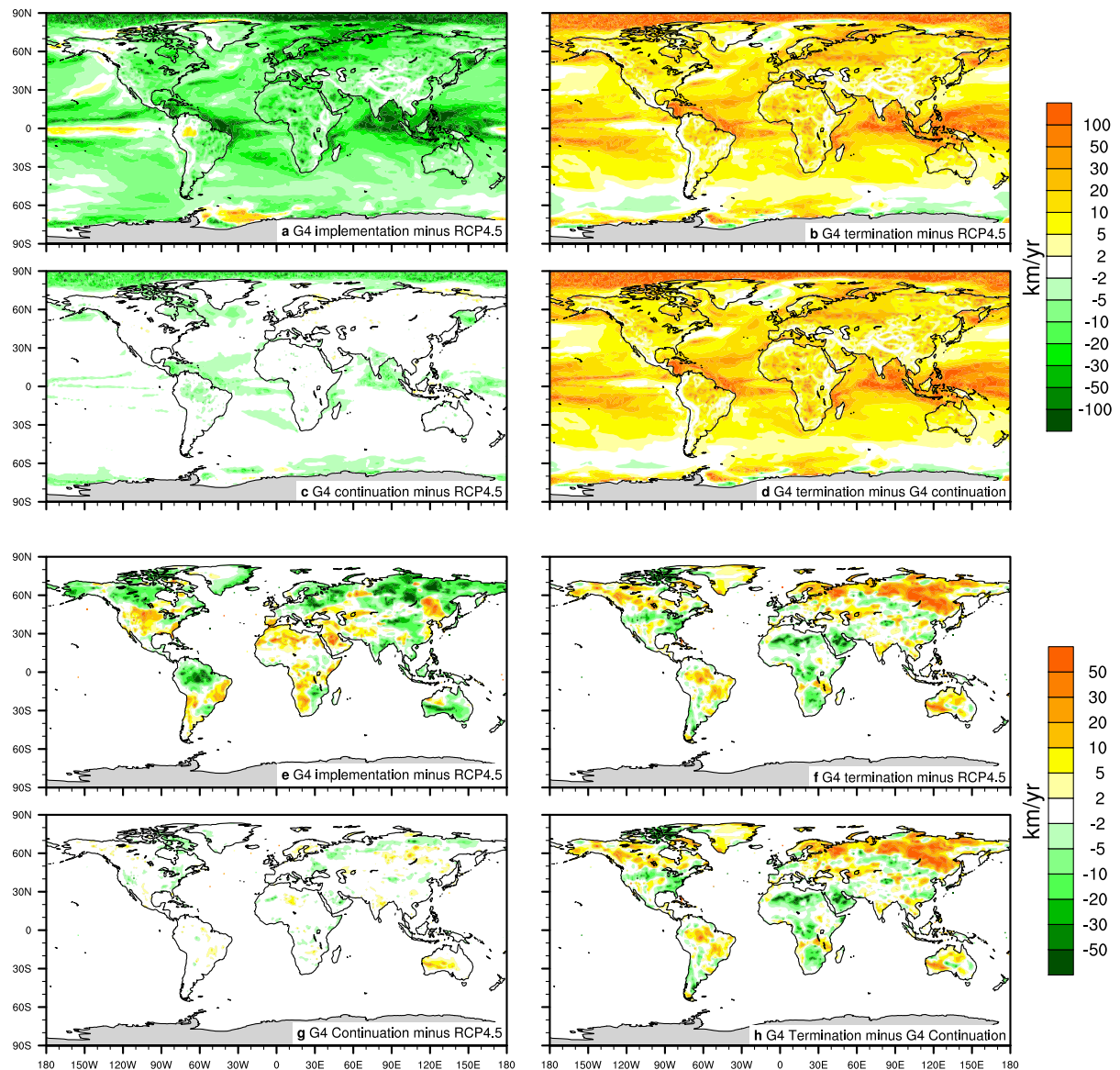
Supplementary Figure 2. Temporal trends in mean annual temperature ($^{\circ}\text{C yr}^{-1}$). **a**, G4 Implementation. **b**, G4 Termination. **c**, Observed temperature data from Climate Research Unit data set TS3.23 and Hadley Centre data set HadISST 1.1. **d**, RCP4.5. **e**, G4 Continuation.



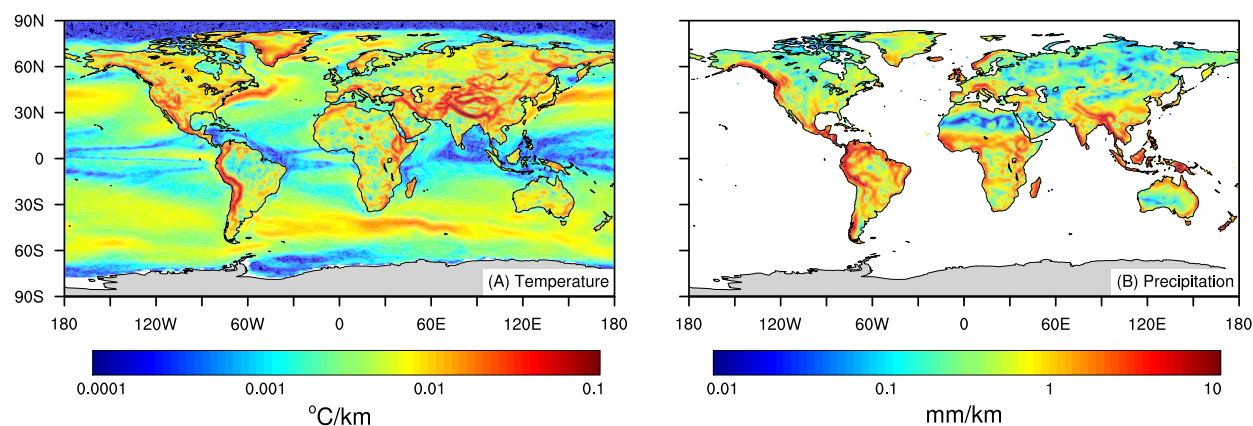
Supplementary Figure 3. Precipitation and temperature velocities (km yr^{-1}) for 14 terrestrial biomes. Blue boxes show precipitation velocities. Red boxes show temperature velocities. Box shading shows: (1) recent climates, 1960–2014, (2) RCP4.5, (3) G4 Implementation, (4) G4 Continuation and (5) G4 Termination. Biomes are ordered by their median temperature velocities for G4 Termination. The sign of the velocity indicates warming (+) or cooling (–) for temperature, and a wetter (+) or drier (–) trend for precipitation.



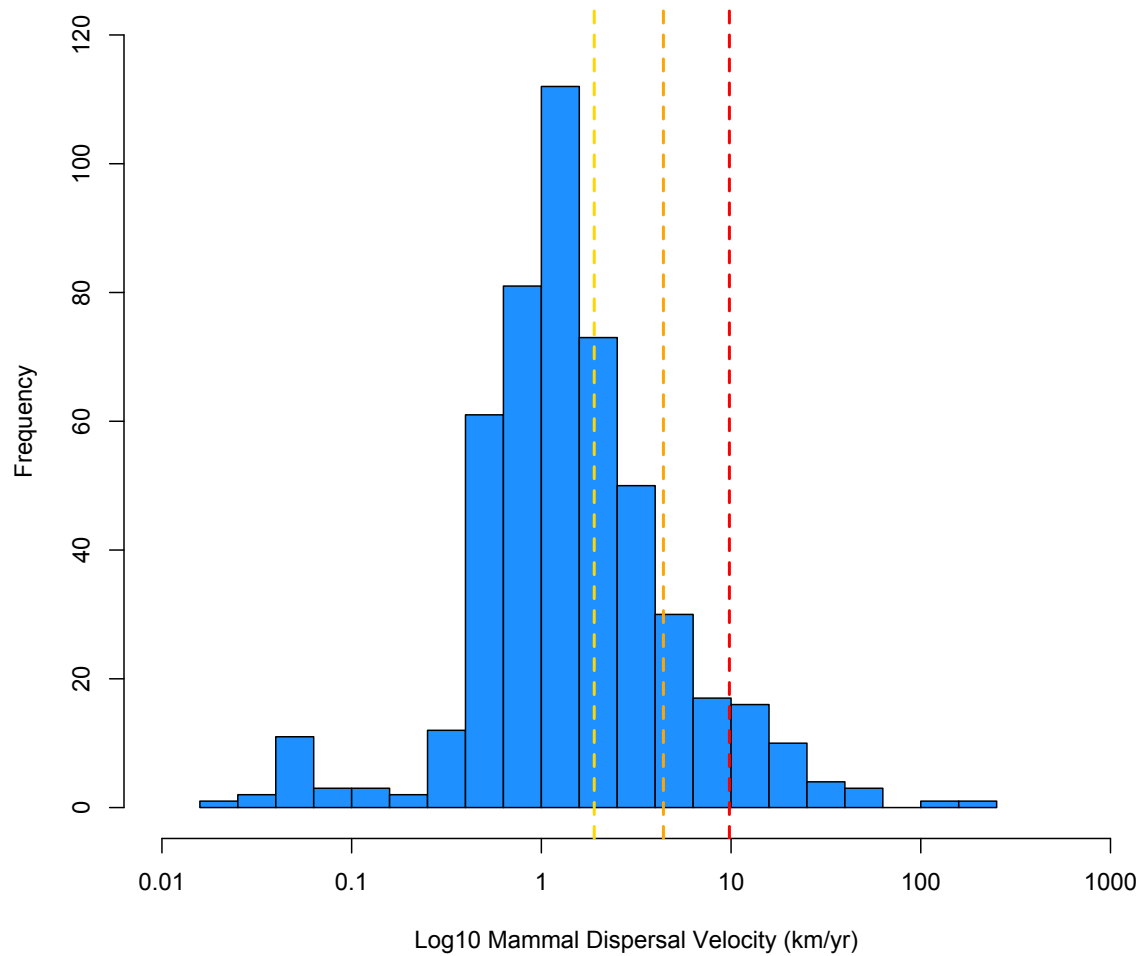
Supplementary Figure 4. Climate velocities for G4 continuation, the 40 years of geoengineering (2030–2069) after the 10-year implementation period. a, temperature velocities. b, precipitation velocities. The sign of the velocity value indicates local warming (+) or cooling (–) for temperature, and wetting (+) or drying (–) for precipitation.



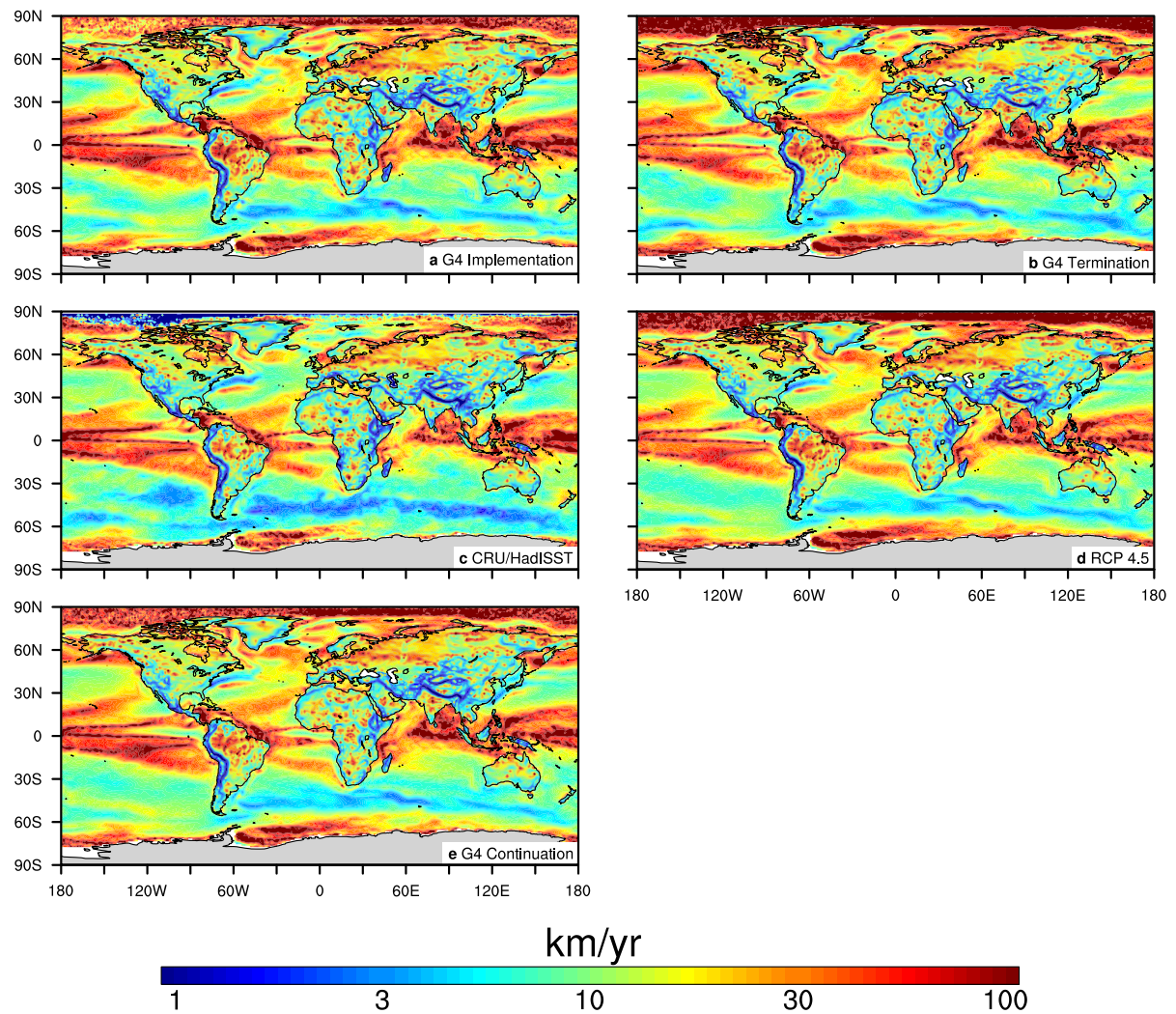
Supplementary Figure 5. Differences in the speed of climate velocity (km yr⁻¹) between G4 geoengineering and RCP4.5. Orange, positive values indicate faster climate velocities for G4 geoengineering whereas negative, green values indicate faster climate velocities for RCP4.5 without geoengineering. **a**, Difference between G4 implementation and RCP4.5 temperature velocities. **b**, Differences between G4 termination and RCP 4.5 temperature velocities. **c**, Difference between G4 Continuation and RCP4.5 temperature velocities. **d**, Difference between G4 Termination and G4 continuation temperature velocities. **e**, Difference between G4 implementation and RCP4.5 precipitation velocities. **f**, Difference between G4 termination and RCP4.5 precipitation velocities. **g**, Difference between G4 Continuation and RCP4.5 precipitation velocities. **h**, Difference between G4 Termination and G4 continuation precipitation velocities.



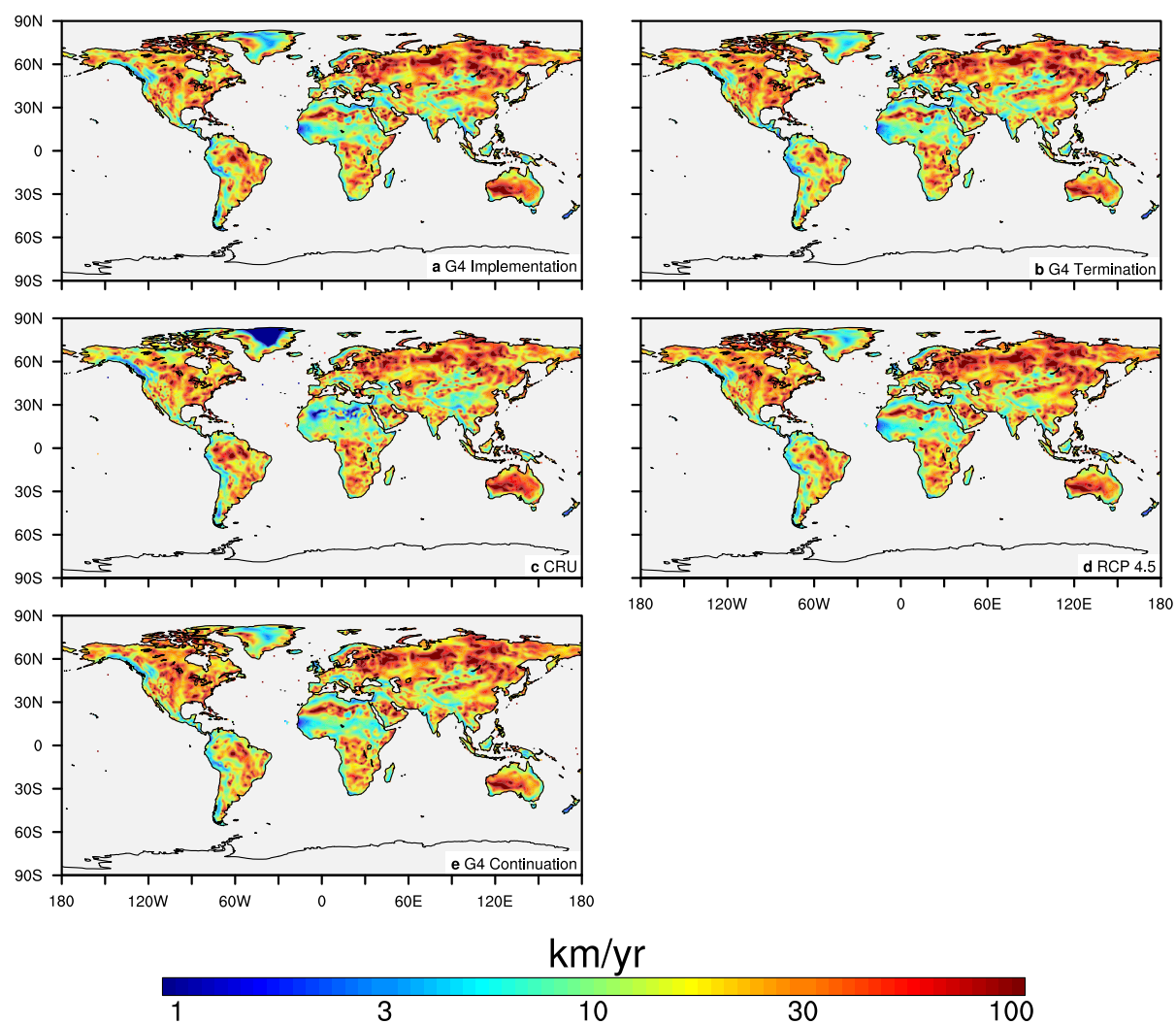
Supplementary Figure 6. Spatial gradients in climate variables. a, surface temperature ($^{\circ}\text{C km}^{-1}$). **b**, precipitation (mm km^{-1}). Spatial gradients were calculated using the long-term mean of temperature and precipitation for observed climate data from Climate Research Unit data set TS3.23 and Hadley Centre data set HadISST 1.1 over the period 1960–2014.



Supplementary Figure 7: Median dispersal velocities (km/yr) for 493 nonvolant mammal species versus temperature velocities in mammal biodiversity hotspots. Climate change 1960–2014 (1.9 km yr^{-1} , yellow), RCP4.5 (4.4 km yr^{-1} , orange) and G4 geoengineering termination (9.8 km yr^{-1} , red). Data on mammal dispersal from Schloss et al. (ref. 19).



Supplementary Figure 8. Uncertainty (standard deviation) in temperature velocity for the land and ocean. a, geoengineering implementation. **b,** geoengineering termination. **c,** historical observations for 1960–2014 (CRU TS3.23 for land and HadISST 1.1 for oceans). **d,** RCP 4.5 **e,** geoengineering continuation.



Supplementary Figure 9. Uncertainty (standard deviation) in precipitation. a, geoengineering implementation. **b,** geoengineering termination. **c,** historical observations for 1960–2014 (CRU TS3.23 for land and HadISST 1.1 for oceans). **d,** RCP 4.5 **e,** geoengineering continuation.