TABLE S1. Temperature response functions used in 69 Earth System Models.

Types	Temperature response functions	Land carbon	Land surface models	Modelling centre	Models	References
1	$f(T) = 1.5^{\frac{T-25}{10}}$	CLM5	CLM5	CESM	CESM2	Emmons et al. (2020)
				NCC	NorESM2-LM	Seland et al. (2019)
					NorESM2-MM	Bentsen et al. (2019)
				NCAR	CESM2	Danabasoglu (2019a)
					CESM2-FV2	Danabasoglu (2020a)
					CESM2-WACCM	Danabasoglu (2019b)
					CESM2-WACCM-FV2	Danabasoglu (2020b)
		CLM4.5	CLM4.5	CMCC	CMCC-CM2-SR5	Oleson et al. (2013)
					CMCC-ESM2	Lovato, Peano, and Butenschön (2021)
		CLM4	CLM4	FIO-QNLM	FIO-ESM-2-0	Song et al. (2019)
				SNU	SAM0-UNICON	Park and Shin (2019)
				AS-RCEC	TaiESM1	Tseng, Lee, and Liang (2020)
				NCC	NorCPM1	Bethke et al. (2019)
		ELM	ELM	E3SM-1.1	E3SM-1-1-ECA	Burrows et al. (2020)
		JULES	CABLE2.5+JULES	CSIRO	ACCESS-CM2	Dix et al. (2019)
	$f(T) = 2^{\frac{T-30}{10}}$	ORCHIDEE	ORCHIDEE	IPSL	IPSL-CM5A2-INCA	Boucher, Denvil, et al. (2020)

		ISBA-CTRIP	ISBA-CTRIP	CNRM	CNRM-ESM2-1	Séférian et al. (2019)
		ORCHIDEE branch 2.0	ORCHIDEE branch 2.0	IPSL	IPSL-CM6A-LR	Boucher, Servonnat, et al. (2020)
	$f(T) = 2^{\frac{T-25}{10}}$	JULES-ES-1.0	JULES-ES-1.0	UK	UKESM1-0-LL	Good et al. (2019)
	$f(T) = 2^{\frac{T-10}{10}}$	CoLM1.0	CoLM1.0	CAMS	CAMS-CSM1-0	Rong (2019)
				CAS	CAS-ESM2-0	Chai (2020)
		INM-LND1	INM-LND1	INM	INM-CM5-0	EM Volodin et al. (2017)
					INM-CM4-8	Evgeny Volodin et al. (2019)
	$f(T) = 1.71^{\frac{T-35}{10}}$	CASA-CNP	CABLE2.4+CASA-CNP	CSIRO	ACCESS-ESM1.5	Ziehn et al. (2019)
2	$f(T) = \begin{cases} 2.1^{\frac{T-35}{10}}, & T \leq 35 \\ 1.0, & T > 35 \end{cases}$	CANDY	CANDY	ULHG	CANDY	Franko, Oelschlägel, and Schenk (1995)
	$f(T) = \frac{47.9}{1 + exp\left(\frac{106}{T + 18.3}\right)}$	JULES-HadGEM3-GL7.1	JULES-HadGEM3-GL7.1	MOHC	UK-ESM1.0-LL	Sellar et al. (2019)
		RothC	JULES-HadGEM3-GL7.1	MOHC	UK-ESM1-0-LL	Armstrong, Lee, Hedges, Honjo, and Wakeham (2001)
			ROTHC	Rothamsted	RothC	Coleman and Jenkinson (1996)

	$f(T) = 0.0326 + 0.00351 \cdot T^{1.652} - \left(\frac{T}{41.748}\right)^{7.19}$	LPJ-GUESS	LPJ-GUESS	EC-Earth	EC-Earth3-CC	Smith et al. (2014)
3	$f(T) = \begin{cases} 0.01, & -5 \geq T \\ 0.04, & -5 < T \leq 0 \\ 0.04 + 0.06 \cdot T, & 0 < T \leq 5 \\ 0.07 + 0.016 \cdot (T-5), & 5 < T \leq 10 \\ 0.15 + 0.03 \cdot (T-10), & 10 < T \leq 35 \\ 0.95, & 35 < T \leq 40 \\ 0.95 - 0.135 \cdot (T-40), & 40 < T \leq 47 \\ 0, & 47 < T \end{cases}$	AVIM2	BCC-AVIM2	BCC	BCC-CSM2-MR	Ji and Yu (1999)
	$f(T) = 0.56 + 0.465 \cdot arctan\left(0.097 \cdot (T - 15.7)\right)$	CENTURY	CENTURY	CSU	CENRUTY	Parton, Schimel, Cole, and Ojima (1987)
	$f(T) = Q_{10}^{\frac{T-15}{10}}$ $Q_{10} = 1.44 + 0.56 \cdot tanh\left(0.075 \cdot (46 - T)\right)$	CLASS-CTEM	CLASS-CTEM	CCCma	CanESM5	Swart et al. (2019)
	$f(T) = T_1^{0.2} \cdot T_2$	GFDL	GFDL-ESMM2M	GFDL	GFDL-ESMM2M	Shevliakova et al. (2009)
	$f(T) = 0.68 \cdot exp\left(0.1 \cdot (T - 7.1)\right)$	PnET	PnET-CN	UNH	PnET-CN	Aber, Ollinger, and Driscoll (1997)
4	$f(T) = exp\left(3.36 \cdot \left(\frac{T-40}{T+46.05}\right)\right)$	K2000	K2000	CSIRO	K2000	Kirschbaum (2000)
	$f(T) = exp\left(\frac{E \cdot (T - T_{20})}{R \cdot (273.15 + T) \cdot (273.15 + T_{20})}\right)$ $R = 8.314\, J\, K^{-1}\, mol^{-1}$, $E = 55.5\, kJ\, mol^{-1}$, $T_{20} = 20$ ℃	SOILCO2	SOILCO2	USDA	SOILCO2	Šimůnek and Suarez (1993)
	$f(T) = exp\left(308.56 \cdot \left(\frac{1}{56.02} - \frac{1}{T + 46.02}\right)\right)$	MATSIRO VISIT-s	MATSIRO VISIT-s	JAMSTEC	MIROC-ES2L	Yamamoto et al. (2019)

		VISIT-e 1	MATSIRO visit-e 1	MIROC	MIROC6	Tatebe et al. (2019)
		LPJ	MRI-LCCM2	MRI	MRI-ESM-2.0	Yukimoto et al. (2019)
		MATSIRO visit-e 1	MATSIRO visit-e 1	MIROC	MIROC-ES2L	Hajima et al. (2020)
		MRI-LCCM2	MRI-LCCM2	MRI	MRI-LCCM2	Obata and Adachi (2019)
NONE	NONE	NONE	CIESM-LM	THU	CIESM	Huang (2019)
			ISBA-CTRIP	CNRM	CNRM-CM6-1	Voldoire (2018)
					CNRM-CM6-1-HR	Voldoire (2019)
			ELM	E3SM	E3SM-1-0	Bader, Leung, Taylor, and McCoy (2019)
			HTESSEL	EC-Earth	EC-Earth3-AerChem	Consortium (2020)
			HTESSEL + LPJ-GUESS	EC-Earth	EC-Earth3-Veg	Consortium (2019)
			CLM4.0 / CAS-LSM	CAS	FGOALS-f3-L	Yu (2019)
					FGOALS-g3	Li et al. (2020)
			LM4.0	NOAA-GFDL	GFDL-CM4	Silvers et al. (2018)
			GISS LSM	NASA-GISS	GISS-E2-1-G	Studies (2018)
					GISS-E2-1-H	Studies (2019b)
					GISS-E2-2-G	Studies (2019a)
			JULES-HadGEM3-GL7.1	MOHC	HadGEM3-GC31-LL	Gregory (2021)
					HadGEM3-GC31-MM	Jackson (2020)
			NOAH LSM 2.7.1	CCCR-IITM	IITM-ESM	Panickal et al. (2019)

	ORCHIDEE	IPSL	IPSL-CM6A-LR	Boucher et al. (2018)
	JULES-HadGEM3-GL7.1	NIMS-KMA	KACE-1-0-G	Byun et al. (2019)
	Manabe bucket scheme	University of Arizona	MCM-UA-1-0	Stouffer (2019)
	JSBACH3.1	NUIST	NESM3	Cao and Wang (2019)
	JSBACH3.2	MPI-M	MPI-ESM-1-2-HR	Mauritsen et al. (2019)
			MPI-ESM-1-2-LR	Mauritsen et al. (2019)
		AWI	AWI-CM-1-1-MR	Semmler et al. (2018)
		HAMMOZ-Consortium	MPI-ESM-1-2-HAM	Neubauer et al. (2019)
		MPI	MPI-ESM1.2-LR	Wieners et al. (2019)
	MATSIRO6.0	MIROC	MIROC6	Tatebe et al. (2019)
	HAL 1.0	MRI	MRI-ESM-2-0	Yukimoto et al. (2019)

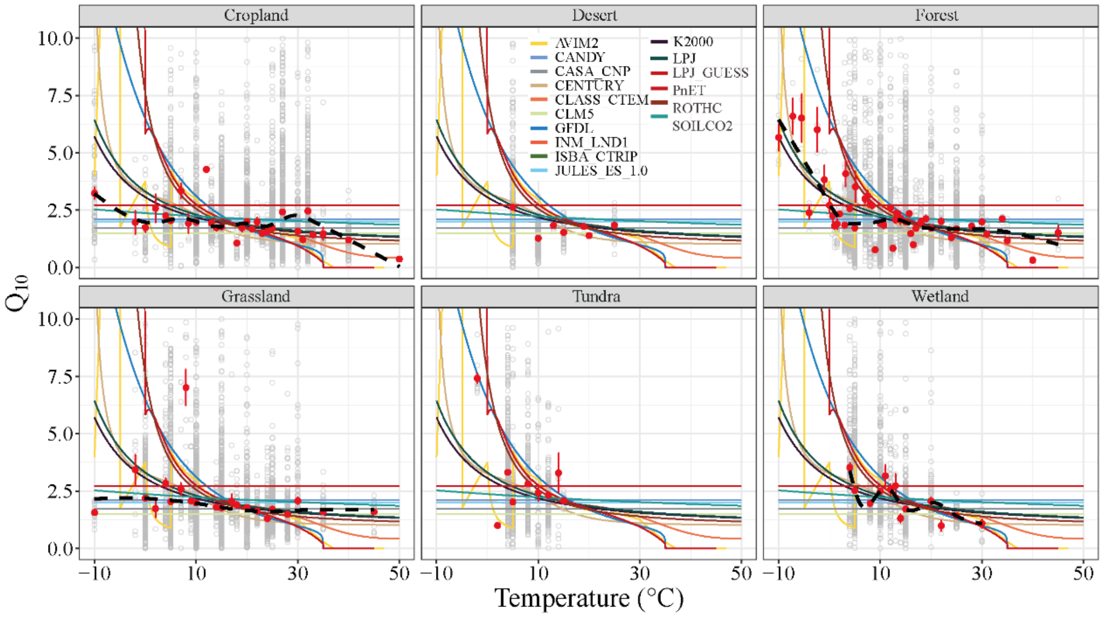

FIGURE S1. Performance assessment of soil carbon temperature response functions in Earth System Models across different ecosystem types. Solid lines in different colors represent the temperature sensitivity (Q_{10}) values predicted by the temperature response functions. Gray open points represent observed Q_{10} values at different temperatures, while the black dashed line shows the best-fit relationship between observed Q_{10} and temperature based on locally weighted polynomial regression. Red points indicate the observed mean values under the corresponding temperatures, and error bars represent one standard error of the observations. Note that the number of independent temperature observations in deserts and tundra is insufficient for curve fitting.

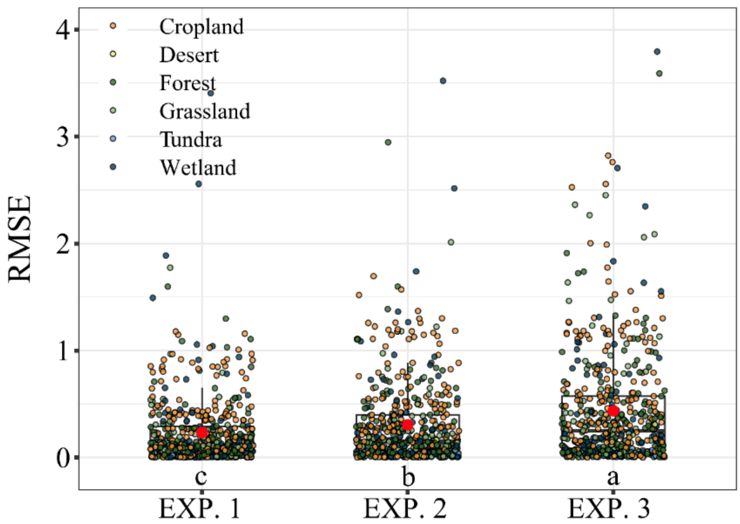

FIGURE S2. Root mean square error (RMSE) between the observed carbon mineralization rates and those predicted by the three simulation experiments. EXP. 1 represents the best-fit model and serves as the baseline for comparison, EXP. 2 aims to assess the relative importance of the intrinsic temperature response, and EXP. 3 aims to assess the relative importance of external environmental constraints. Different letters indicate significant difference (p<0.05).

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