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Global spatiotemporal distribution of soil respiration modeled using a global database

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Table S1. Statistics of the parameterizations conducted using various datasets and models. When the new model was parameterized with a dataset with LAI and GPP, we used $F=(F_0+\gamma \mathrm{LAI})$, "new T-P-LAI model," or $F=(F_0+\gamma \mathrm{GPP})$, "new T-P-GPP model," respectively; where, γ is a parameter. The new T-P model was also parameterized using the datasets with LAI and GPP to compare the performance of each model structure. RMSE is the root mean square error, and N is the number of data points. AIC and BIC are the Akaike's information criteria and the Bayesian information criteria, respectively. We also parameterized the original Raich model (Raich et al., 2002) using the global dataset ("Raich model with new parameters").

Dataset	*N*	Model	Slope	Y-intercept	*P*	R^2	R^2adj	RMSE	AIC	BIC
T, *P*	1638	New T-P model	0.98	19.8	<0.001	0.32	0.32	376.8	14374	14401
		Raich model	0.79	361.1	<0.001	0.31	0.31	453.0	14672	14689
		Raich model with new parameters	0.99	7.6	<0.001	0.32	0.32	377.2	14372	14389
T, *P*, *LAI*	452	New T-P model	0.98	9.7	<0.001	0.34	0.34	320.4	3901	3921
		Raich model	0.74	440.0	<0.001	0.27	0.27	457.6	4058	4070
		Raich model with new parameters	0.98	18.0	<0.001	0.33	0.32	323.8	3901	3914
		New T-P-LAI model	0.97	26.7	<0.001	0.36	0.36	315.2	3895	3920
T, *P*, *GPP*	133	New T-P model	0.96	39.0	<0.001	0.46	0.46	251.9	1123	1137
		Raich model	0.95	313.7	<0.001	0.43	0.42	389.3	1177	1185
		Raich model with new parameters	0.95	40.9	<0.001	0.45	0.44	255.7	1121	1129
		New T-P-GPP model	0.95	34.9	<0.001	0.47	0.47	249.3	1123	1141

Table S2. List of the Earth system models in CMIP5 considered in this study.

	Earth system model
1	BCC-CSM1-1
2	BNU-ESM
3	CCSM4
4	CESM1-BGC
5	CESM1-CAM5
6	CESM1-FASTCHEM
7	CanESM2
8	GFDL-ESM2G
9	GFDL-ESM2 M
10	GISS-E2-H
11	GISS-E2-R
12	HadGEM2-CC
13	HadGEM2-ES
14	IPSL-CM5A-LR
15	IPSL-CM5B-LR
16	MIROC-ESM-CHEM
17	MIROC-ESM
18	MPI-ESM-MR
19	NorESM1-ME
20	NorESM1-M

Table S3. Estimated annual R_S, R_H, and R_A.

Year	R_S (Pg C yr^{-1})	R_H (Pg C yr^{-1})	R_A (Pg C yr^{-1})
1965	87.7	49.4	38.3
1966	90.4	50.6	39.8
1967	89.8	50.4	39.4
1968	90.8	50.7	40.1
1969	89.9	50.4	39.6
1970	88.3	49.5	38.8
1971	89.2	50.1	39.2
1972	89.0	49.9	39.1
1973	90.9	50.6	40.3
1974	90.4	50.5	39.9
1975	90.8	50.7	40.1
1976	90.1	50.5	39.6
1977	91.2	50.9	40.3
1978	91.2	50.8	40.4
1979	91.5	51.1	40.4
1980	89.2	50.0	39.1
1981	91.7	51.2	40.5
1982	91.4	51.1	40.3
1983	90.7	50.7	40.0
1984	89.0	49.9	39.1
1985	89.5	50.1	39.4
1986	90.2	50.5	39.7
1987	90.2	50.5	39.7
1988	90.8	50.9	40.0
1989	90.7	50.7	40.0
1990	91.8	51.1	40.7
1991	90.4	50.6	39.8
1992	90.9	50.8	40.0
1993	91.1	50.9	40.2
1994	90.2	50.5	39.7
1995	91.6	51.2	40.5
1996	90.7	50.7	40.0
1997	93.6	52.0	41.6
1998	93.5	51.9	41.6
1999	92.1	51.3	40.8
2000	92.4	51.4	41.0
2001	93.2	51.7	41.4
2002	91.9	51.2	40.7
2003	94.2	52.3	41.9
2004	93.5	51.9	41.6
2005	93.1	51.8	41.3
2006	93.6	52.0	41.6
2007	92.8	51.7	41.1
2008	92.4	51.4	41.0
2009	92.7	51.6	41.2
2010	95.1	52.6	42.5
2011	93.9	52.1	41.8
2012	93.2	51.8	41.4

Table S4. Previous estimates of global R_S.

R_S (Pg C yr^{-1})	Uncertainty/Range	Year	Reference
98	±12 (C.I.)	2008	Bond-Lamberty and Thomson, 2010b
80.4	79.3–81.8 (interannual)	1980–1994	Raich et al., 2002
78	64–95 (C.I.)	1980–2009	Hashimoto, 2012
76.5	-	-	Raich and Potter, 1995
75	-	-	Schlesinger, 1977
68	±4 (S.D., variation due to different biome area data)	-	Raich and Schlesinger, 1992

Table S5. Comparison of reported NPP and R_H trends and the R_H trends estimated in this study (Pg C yr^{-2}).

NPP			R_H		
Reference	Year	Trend	Reference	Year	Trend
Nemani et al., 2003[*1]	1982–1999	0.19	This study	1980–1999	0.05
Ichii et al., 2001[*1]	1983–1991	0.10 0.24			
Ichii et al., 2001[*2]	1980–1989	0.06			
Ito and Sasai, 2006[*2]	1982–2001	0.08–0.21			
Sitch et al., 2015, (CO_2 and climate effect)[*2]	1990–2009	0.22	Sitch et al., 2015, (CO_2 and climate effect)[*2]	1990–2009	0.16
Sitch et al., 2015, (climate effect only)[*2]	1990–2009	0.15	Sitch et al., 2015, (climate effect only)[*2]	1990–2009	0.04
Ito and Inatomi, 2012[*2]	2000–2009	0.06	This study	2000–2012	0.04
Ahlström et al., 2012[*2]	2000–2009	0.33			
Zhao and Running, 2011[*1]	2000–2009	−0.055			

[*1] Satellite based estimate.

[*2] Model based estimate.

Table S6. Temperature sensitivities estimated in previous studies. R_E indicates ecosystem respiration.

Q_{10}	Respiration	Temperature	Reference
1.5	R_S	Air	Bond-Lamberty and Thomson, 2010b
1.4	R_E	Air	Mahecha et al., 2010
1.43–2.03[*1]	R_H	Air	Zhou et al., 2009
1.37	R_H	Soil	Ise and Moorcroft, 2006
1.5–2.6	R_H	Soil	Todd-Brown et al., 2013
1.2–2[*2]	R_H	Air	Kaminski et al., 2002
2.1	R_H	Air	Jones and Cox, 2001

[*1] The mean values for multiple biomes.

[*2] Range of the optimized value taken from the figure.

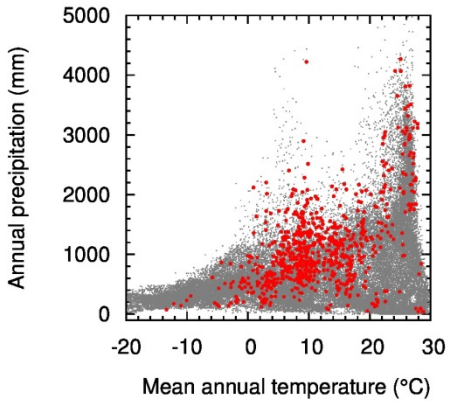

Figure S1. Distribution of the data in the climate space. Grey circles represent the climate conditions on land based on CRU 3.21, and red circles indicate the climate conditions for the R_S data.

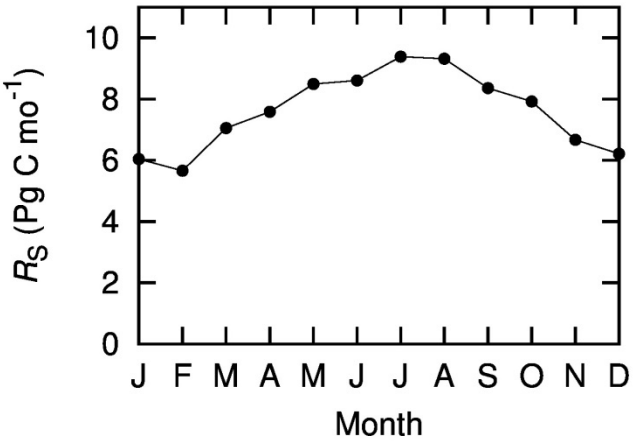

Figure S2. Seasonality of global R_S.

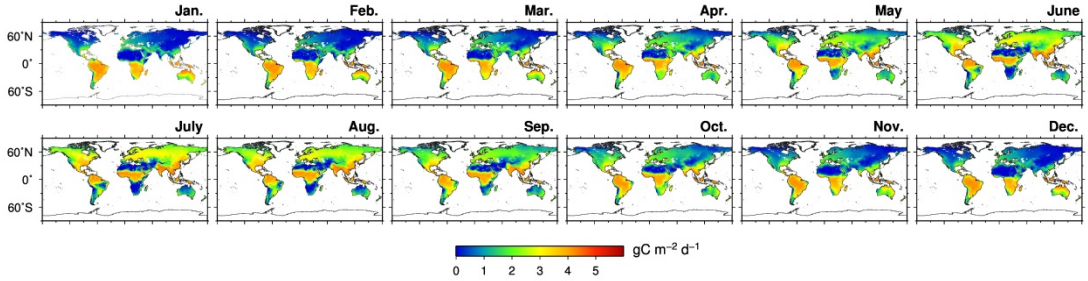

Figure S3. Distribution of monthly R_S.

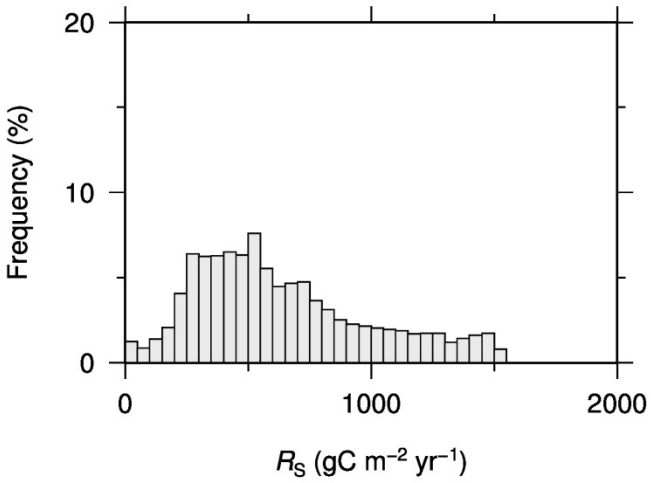

Figure S4. Histogram of modeled R_S (values for each grid cell).

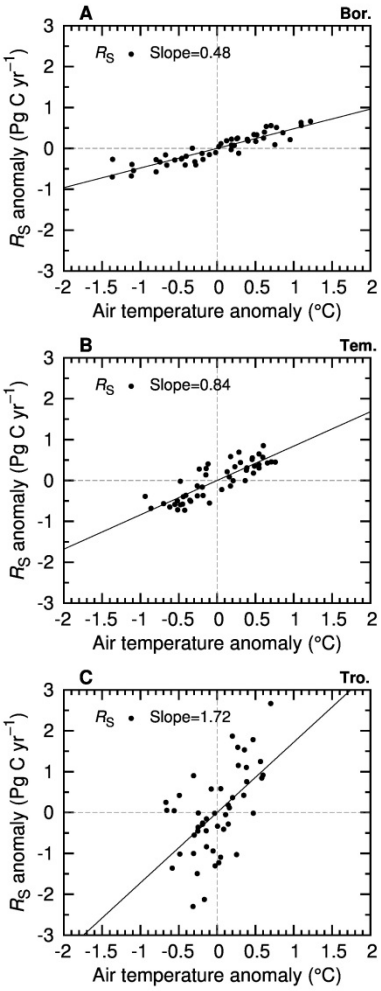

Figure S5. Relationships between the air temperature anomaly and R_S in boreal (A), temperate (B), and tropical regions (C). The anomaly is the deviation from the 1965–2012 mean.

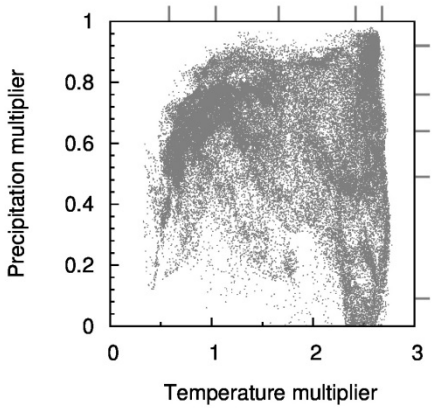

Figure S6. Relationship between the mean temperature multiplier and mean precipitation multiplier, at the level of the grid cell. The tick marks on the top and right axes indicate the 2.5, 25, 50, 75, and 97.5 % quantiles.

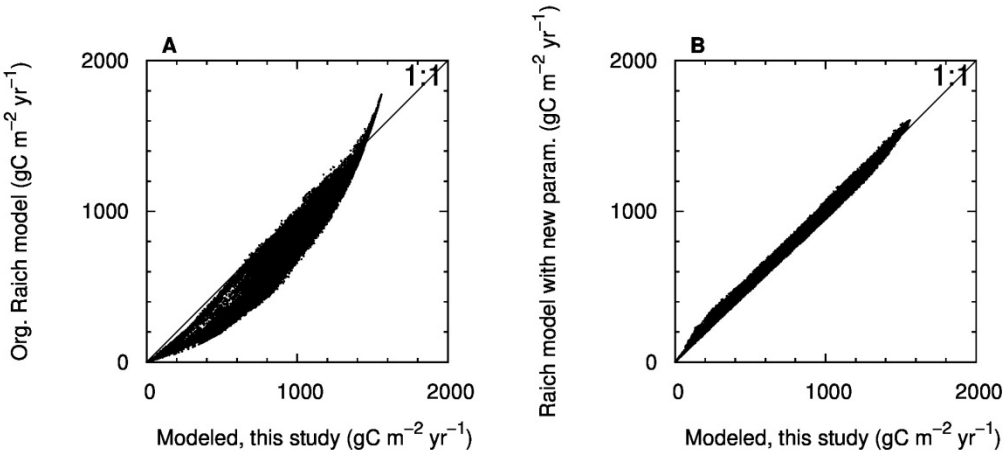

Figure S7. Relationship between the grid-scale R_S estimated by our model and (A) the values of R_S estimated using the original Raich model, as well as (B) the values of R_S estimated using the original Raich model with newly determined parameters. Hence, the Raich model was run with the original parameters (A) and with new parameters that were determined using the global dataset (B) (see Table S1).

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