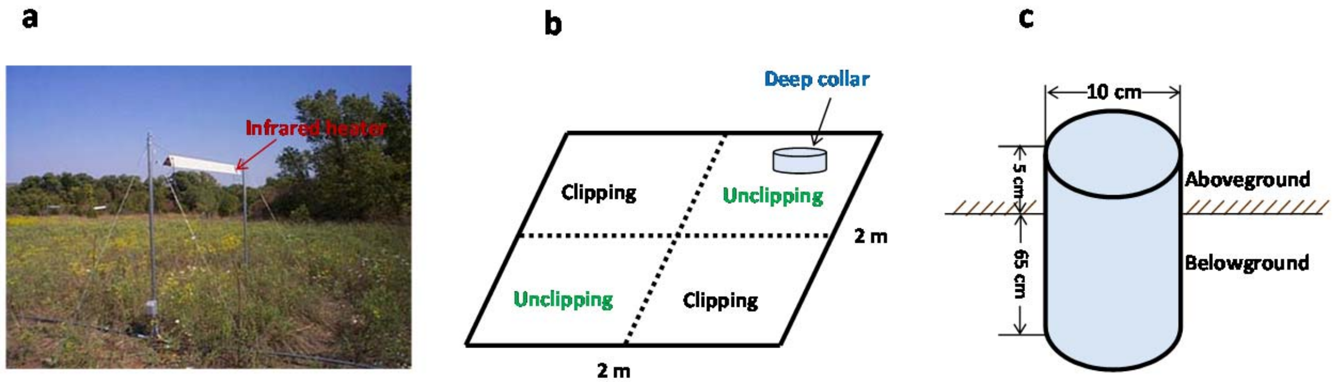

Figure S1. A simple illustration of the Oklahoma long-term warming experiment. (**a**) An overview of the experimental site located in Oklahoma, USA. The warming study was initiated in November, 1999. (**b**) Schematic map of an experiment plot. (**c**) Diagram of the deep collar. Deep collars were installed in October, 2001. The design allowed us to exclude the impacts of new carbon inputs from roots, mycorrhizal fungi and plant litter on SOM decomposition. Soil samples were taken in October, 2010.

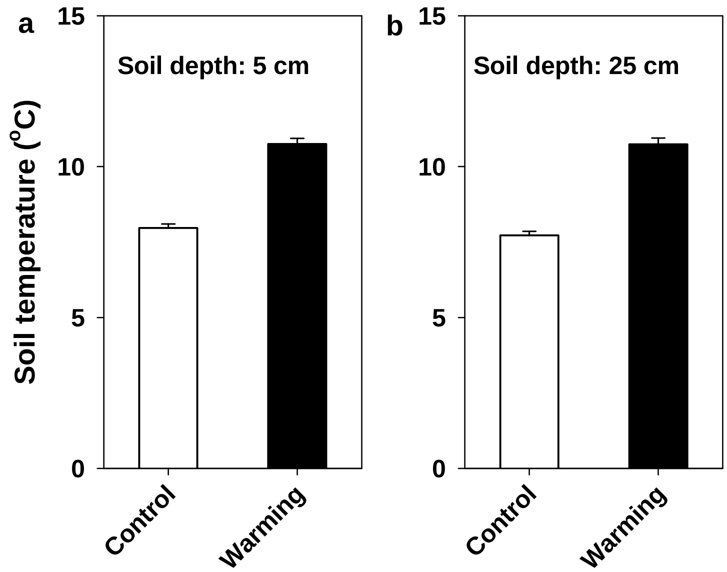

Figure S2. Soil temperature measured at 5 cm (a) and 25 cm (b) soil depths adjacent to the deep collars under control and warming plots (Oklahoma field experiment). Soil temperature was measured from 9:00 am to 1:00 pm of each day in the winter 2015 using a LI-COR 8100 gas flux system coupled with a thermo-probe sensor. Data shown are means of treatment plots (n = 6) ± s.e.m. The heating effects were comparable at 5 cm and 25 cm soil depths over the measuring time period.

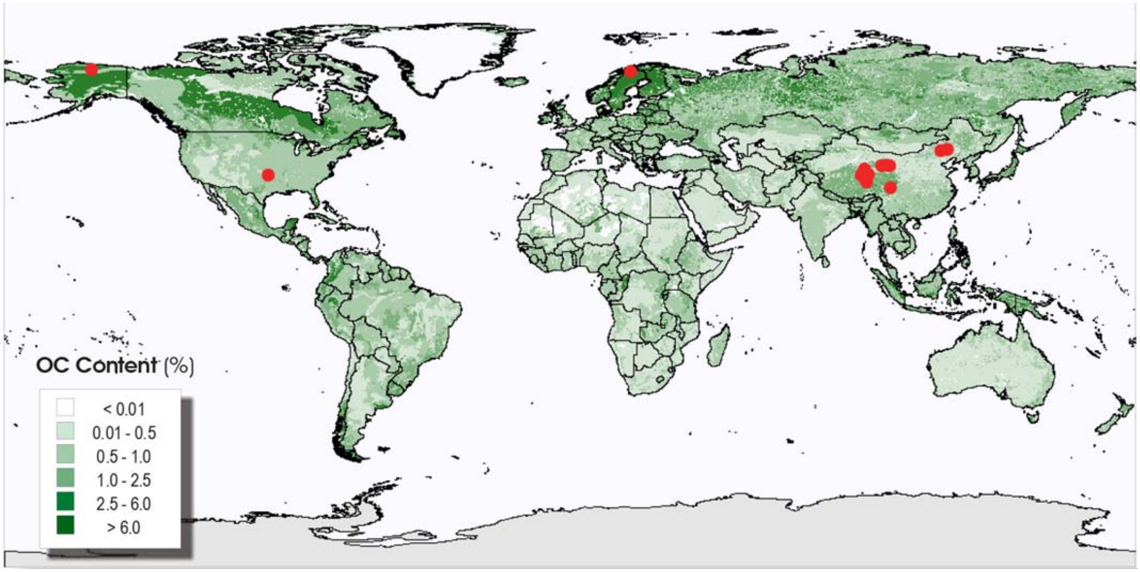

Figure S3. Global distribution of the field sites included in the meta-analysis study. We only included field studies that examined the warming effects on decomposition of SOM in both topsoil and subsoil layers. Those studies were primarily located at sites in high latitudes or sites with high elevations in the northern hemisphere, where ecosystems have been projected to be more responsive to climatic warming compared to those of low latitudes and altitudes. The background global organic carbon (OC) content of combined topsoil and subsoil layers (0-100 cm) is from ref.52 (Hiederer & Köchy, 2011).

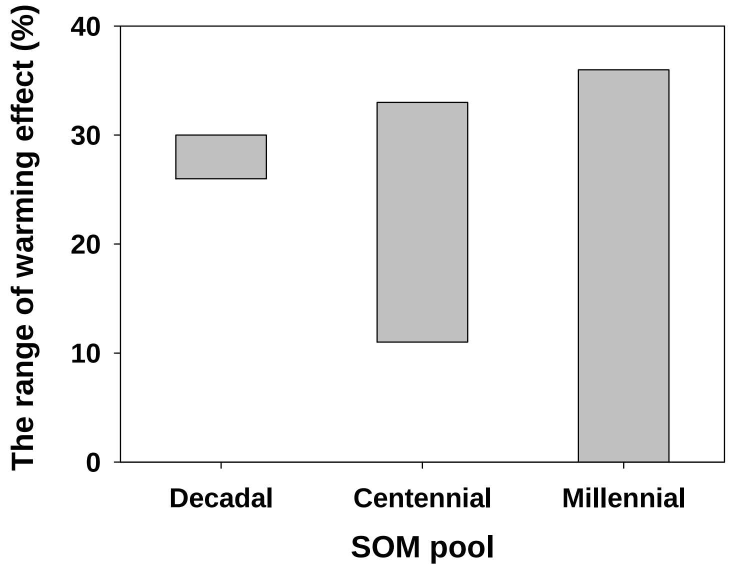

Figure S4. Predicted range of net warming effects on the decomposition of decadal, centennial and millennial SOM pools (Oklahoma field experiment). Modelling and calculations are shown in methods and Supplementary Table 2.

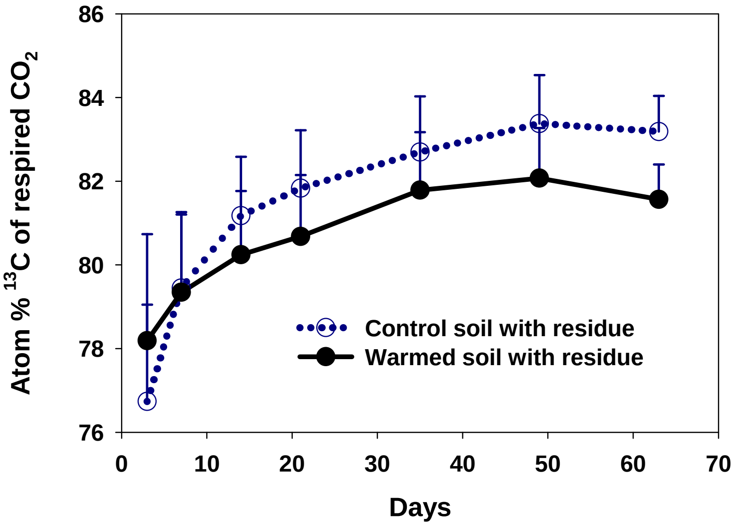

Figure S5. The atomic percentage of ^{13}C in CO_2 respired from incubated control (dotted line) and warmed (solid line) soils with the addition of U-^{13}C labelled plant residues (SIP microcosm experiment). Data were analyzed using repeated measures ANOVA with different variance-covariance structures. Statistical results were reported using models with the variance-covariance structure that had lowest AIC and BIC values. Data were means (n = 6) ± s.e.m. Warming, $P = 0.39$; time, $P < 0.01$; warming × time, $P = 0.95$.

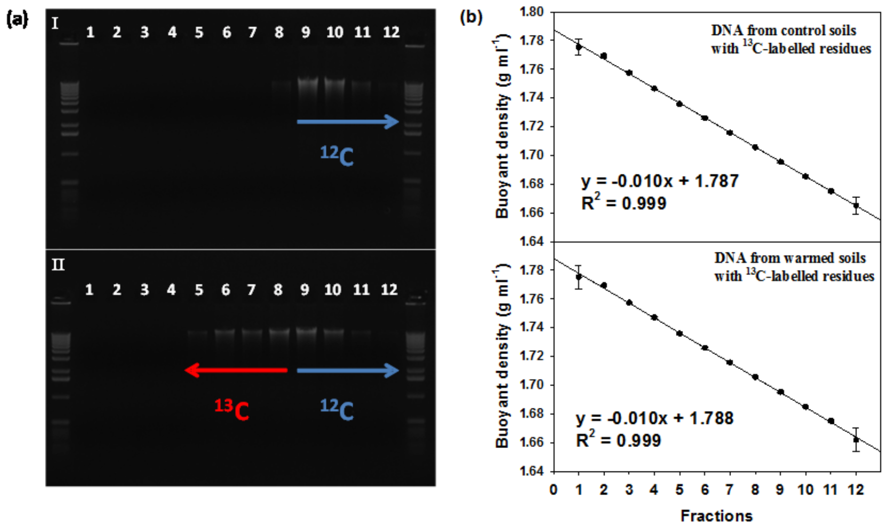

Figure S6. Results for DNA-SIP gradient fractionation. (**a**) Aliquots of gradient fractions on a 1% agarose gel for the SIP experiment. Top panel (I), Gel image of a gradient contained only ^{12}C-DNA. Soils from a control plot were incubated without the addition of ^{13}C-labelled plant residues. Bottom panel (II), Gel image of a gradient contained both ^{12}C- and ^{13}C-labelled DNA. Soils from the same control plot as the panel II were incubated with the ^{13}C-labelled plant residues. (**b**) Buoyant density for each fraction. Top panel: DNA extracted from control soils incubated with ^{13}C labelled plant residues. Bottom panel: DNA extracted from warmed soils incubated with ^{13}C labelled plant residues. Genomic DNA (including both ^{12}C- and ^{13}C-DNA) was used for SIP fractionation. Values of each fraction are means ($n = 6$) ± s.e.m.

Table S1. Significance test of warming effects on the taxonomic (a) and functional gene structure (b) of microbial communities using three different non-parametric multivariate analyses.

(a) Taxonomic structure of microbial communities based on 16*S* rRNA data.

Microbial communities	Adonis†		ANOSIM‡		MRPP¶	
	R^2	P	R	P	δ	P
Field experiment						
Total DNA	0.051	0.943	-0.144	0.988	969	0.980
SIP microcosm experiment						
^{12}C-DNA	0.062	0.872	-0.115	0.916	1530	0.404
^{13}C-DNA	0.072	0.698	-0.039	0.593	1934	0.411

(b) Functional gene structure of microbial communities based on GeoChip data.

Microbial communities	Adonis†		ANOSIM‡		MRPP¶	
	R^2	P	R	P	δ	P
Field experiment						
Total DNA	0.192	**0.018**	0.269	**0.012**	122	**0.001**
Bacterial	0.218	**0.012**	0.207	**0.025**	121	**0.003**
Fungal	0.239	**0.005**	0.172	**0.017**	40	**< 0.001**
SIP microcosm experiment						
^{12}C-DNA	0.214	**0.002**	0.356	**0.002**	741	**0.005**
Bacterial	0.217	**0.004**	0.361	**0.003**	652	**0.003**
Fungal	0.231	**0.002**	0.431	**0.003**	150	**0.004**
^{13}C-DNA	0.228	**0.003**	0.494	**0.002**	734	**0.003**
Bacterial	0.229	**0.001**	0.494	**0.002**	646	**0.003**
Fungal	0.269	**0.001**	0.639	**0.004**	144	**0.002**

†Adonis, permutational multivariate analysis of variance using distance matrices. Significance tests of Adonis were performed using F-tests based on sequential sums of squares from permutations of the raw data rather than residuals. ‡ANOSIM, analysis of similarities. ¶MRPP, multi response permutation procedure. Both ANOSIM and MRPP test statistically whether significant difference exists between two or more groups of sampling units. P values ≤ 0.05 are considered statistically significant.

Table S2. Effects of warming on decomposition of decadal, centennial and millennial SOM pools. We used a four-C age model (see Methods) to calculate the possible range of the ratio of $C_{consumed,\ warming}$ to $C_{consumed,\ control}$ for each pool. All calculations were performed using MATLAB.

Decadal (50 yr) carbon pool

The range of $C_{consumed,\ warming}$ / $C_{consumed,\ control}$[a] for 50 yr carbon pool: 1.26 ~ 1.30

[c]A minimum value of $C_{consumed,\ warming}$ / $C_{consumed,\ control}$

[e]Initial total carbon（g/kg）: 30				
[f]Proportions (%)				
pool age(yr)	50	500	5k	50k
initial	0.40	0.40	0.10	0.10
warming	0.09	0.09	0.41	0.41
control	0.24	0.28	0.24	0.24
[g]Contents (g/kg)				
pool age(yr)	50	500	5k	50k
initial	11.94	11.94	3.06	3.06
warming	0.67	0.71	3.06	3.06
control	2.98	3.49	3.06	3.06
[h]Consumed C (g/kg)				
pool age(yr)	50	500	5k	50k
warming	11.27	11.23	0.00	0.00
control	8.96	8.44	0.00	0.00
warming/control	**1.26**	1.33	---[b]	---[b]

[d]A maximum value of $C_{consumed,\ warming}$ / $C_{consumed,\ control}$

Initial total carbon（g/kg）: 30				
Proportions (%)				
pool age(yr)	50	500	5k	50k
initial	0.46	0.22	0.22	0.11
warming	0.04	0.25	0.28	0.43
control	0.27	0.21	0.26	0.26
Contents (g/kg)				
pool age(yr)	50	500	5k	50k
initial	13.82	6.48	6.48	3.22
warming	0.27	1.87	2.13	3.22
control	3.40	2.70	3.28	3.22
Consumed C (g/kg)				
pool age(yr)	50	500	5k	50k
warming	13.55	4.61	4.35	0.00
control	10.42	3.78	3.20	0.00
warming/control	**1.30**	1.22	1.36	---[b]

Table S2 continued

Centennial (500 yr) carbon pool

The range of $C_{consumed, warming} / C_{consumed, control}$[a] for 500 yr carbon pool: 1.11 ~ 1.33

[c]A minimum value of $C_{consumed, warming} / C_{consumed, control}$				
[e]Initial total carbon（g/kg）: 30				
[f]**Proportions (%)**				
pool age(yr)	50	500	5k	50k
initial	0.49	0.19	0.19	0.13
warming	0.00	0.47	0.00	0.53
control	0.27	0.30	0.12	0.31
[g]**Contents (g/kg)**				
pool age(yr)	50	500	5k	50k
initial	14.65	5.70	5.70	3.95
warming	0.00	3.55	0.00	3.95
control	3.38	3.76	1.51	3.95
[h]**Consumed C (g/kg)**				
pool age(yr)	50	500	5k	50k
warming	14.65	2.15	5.70	0.00
control	11.27	1.94	4.19	0.00
warming/control	1.30	**1.11**	1.36	---[b]

[d]A maximum value of $C_{consumed, warming} / C_{consumed, control}$				
Initial carbon（g/kg）: 30				
Proportions (%)				
pool age(yr)	50	500	5k	50k
initial	0.39	0.39	0.11	0.11
warming	0.09	0.12	0.36	0.43
control	0.24	0.28	0.22	0.26
Contents (g/kg)				
pool age(yr)	50	500	5k	50k
initial	11.78	11.78	3.22	3.22
warming	0.69	0.88	2.71	3.22
control	3.04	3.58	2.76	3.22
Consumed C (g/kg)				
pool age(yr)	50	500	5k	50k
warming	11.09	10.90	0.51	0.00
control	8.74	8.20	0.46	0.00
warming/control	1.27	**1.33**	1.11	---[b]

Table S2 continued

Millennial (5000 yr) carbon pool

The range of $C_{consumed, warming} / C_{consumed, control}$ [a] for 5000 yr carbon pool: stable ~ 1.36

[c]A minimum value of $C_{consumed, warming} / C_{consumed, control}$					[d]A maximum value of $C_{consumed, warming} / C_{consumed, control}$				
[e]Initial carbon（g/kg）: 29.9					Initial carbon（g/kg）: 30				
[f]**Proportions (%)**					**Proportions (%)**				
pool age(yr)	50	500	5k	50k	pool age(yr)	50	500	5k	50k
initial	0.40	0.38	0.13	0.09	initial	0.40	0.40	0.10	0.10
warming	0.11	0.00	0.52	0.37	warming	0.07	0.13	0.39	0.41
control	0.25	0.22	0.31	0.22	control	0.23	0.29	0.23	0.24
[g]**Contents (g/kg)**					**Contents (g/kg)**				
pool age(yr)	50	500	5k	50k	pool age(yr)	50	500	5k	50k
initial	11.93	11.38	3.87	2.81	initial	11.94	11.94	3.06	3.06
warming	0.81	0.01	3.87	2.81	warming	0.54	1.00	2.90	3.06
control	3.12	2.80	3.87	2.81	control	2.89	3.71	2.94	3.06
[h]**Consumed C (g/kg)**					**Consumed C (g/kg)**				
pool age(yr)	50	500	5k	50k	pool age(yr)	50	500	5k	50k
warming	11.12	11.37	0.00	0.00	warming	11.40	10.94	0.16	0.00
control	8.81	8.58	0.00	0.00	control	9.06	8.23	0.12	0.00
warming/control	1.26	1.32	**---** [b]	**---** [b]	warming/control	1.26	1.33	**1.36**	**---** [b]

[a] The ratio of C consumed (or respired) under warming to C consumed under control for each C pool.

[b] A possible situation that this carbon pool is stable under both warming and control.

[c] The left columns are results of the minimum ratio of $C_{consumed, warming}$ / $C_{consumed, control}$ for a C pool.

[d] The right columns are results of the maximum ratio of $C_{consumed, warming}$ / $C_{consumed, control}$ for a C pool.

[e] The initial total soil C before the experiment

[f] The proportion of each C pool under initial conditions, and under warming and control

[g] The C concentration of each pool under initial conditions, and under warming and control

[h] The concentration of consumed (or respired) C under warming and control for each pool after a decade of experimental duration