

A Global Database of Soil Respiration Data, Version 4.0

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Documentation Revision Date: 2020-04-22

Dataset Version: 4.1

Summary

This dataset provides an update to the Soil Respiration Database (SRDB), a near-universal compendium of published soil respiration data. Soil respiration, the flux of autotrophically- and heterotrophically-generated CO₂ from the soil to the atmosphere, remains the least well-constrained component of the terrestrial carbon cycle. The database encompasses all published studies that report at least one of the following data measured in the field (not laboratory): annual soil respiration, mean seasonal soil respiration, a seasonal or annual partitioning of soil respiration into its source fluxes, soil respiration temperature response (Q₁₀), or soil respiration at 10 degrees C. The SRDB's orientation is thus to seasonal and annual fluxes, not shorter-term or chamber-specific measurements, and the database is dominated by temperate, well-drained forest measurement locations. Version 4 is the compilation of 1458 published studies with measurements taken between 1961 and 2016.

The dataset includes 2 files in comma-separated (.csv) format: a compilation of soil respiration data from published studies and a bibliography of the published studies.

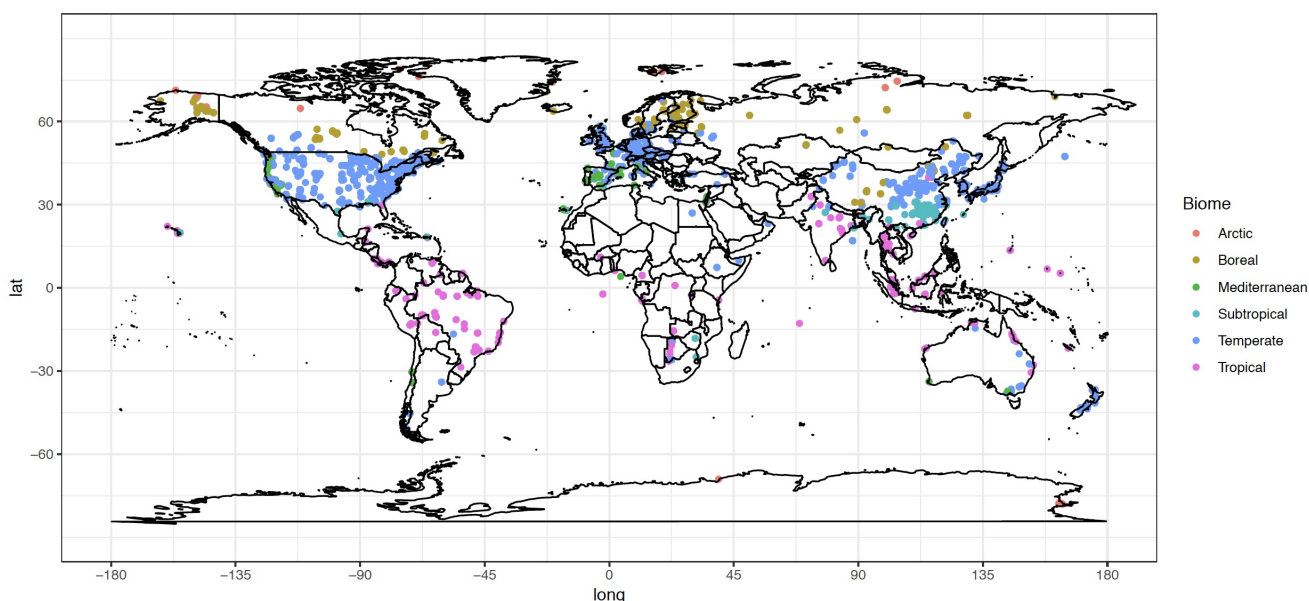


Figure 1: Locations of SRDB V4 observations, colored by biome. Map produced by the companion SRDBv4.R script.

Citation

Bond-Lamberty, B.P., and A.M. Thomson. 2018. A Global Database of Soil Respiration Data, Version 4.0. ORNL DAAC, Oak Ridge, Tennessee, USA. <https://doi.org/10.3334/ORNLDAAC/1578>

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1. Dataset Overview

This dataset provides an update to the Soil Respiration Database (SRDB), a near-universal compendium of published soil respiration

data. Soil respiration, the flux of autotrophically- and heterotrophically-generated CO₂ from the soil to the atmosphere, remains the least well-constrained component of the terrestrial carbon cycle. The database encompasses all published studies that report at least one of the following data measured in the field (not laboratory): annual soil respiration, mean seasonal soil respiration, a seasonal or annual partitioning of soil respiration into its source fluxes, soil respiration temperature response (Q₁₀), or soil respiration at 10 degrees C. The SRDB's orientation is thus to seasonal and annual fluxes, not shorter-term or chamber-specific measurements, and the database is dominated by temperate, well-drained forest measurement locations. Version 4 is the compilation of 1458 published studies with measurements taken between 1961 and 2016.

Related Publication

Bond-Lamberty, B., and A.M. Thomson. 2010. A global database of soil respiration measurements. *Biogeosciences*. 7:1321-1344. <https://doi.org/10.5194/bgd-7-1321-2010>

User Note

The compilers of the SRDB database (Bond-Lamberty and Thomson, 2010) make it available to the scientific community both as a traditional static archive (through the ORNL DAAC) and as a dynamic community database that can be updated by users into the future. The dynamic database is hosted on GitHub at <https://github.com/bpbond/srdb>. Citations to the dynamic database should always include a version number and download date.

The information provided in the related publication will not be identical to the information provided here owing to revisions made while compiling new versions of the dataset.

2. Data Characteristics

Spatial Coverage: Global

Spatial Resolution: Point-based measurements with global extent (see Fig. 1). Coordinates are provided for each sample location.

Temporal Coverage: Compilation of published measurements taken between 1961/01/01 and 2016/06/30. The study date of each record is provided in the dataset.

Temporal Resolution: Annual and seasonal measurements for each study are provided.

Site Boundaries: (All latitude and longitude given in decimal degrees)

Site (Region)	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude	Geodetic Datum
Global (point)	-162.2	175.77	78.9	-78.20	Unknown

Data File Information

srdb-data-V4.csv is a comma-separated file of all the soil respiration and contextual data. Bibliographic information for the studies that appear in **srdb-data-V4.csv** can be found in **srdb-studies-V4.csv**. The “Study_number” field is common to both files.

Missing values are represented as -9999 for numeric data or NA for text data.

Table 1. Column names and descriptions for **srdb-data-V4.csv**.

Column Number	Column Name	Column Description and Units
Metadata		
1	Record_number	Record number
2	Entry_date	Entry date (yyyy-mm-dd)
3	Study_number	Study number; index into the studies database
4	Author	Name of first author
5	Duplicate_record	Is record a known duplicate? (Study number)
6	Quality_flag	Quality control flags: Q0 default/none Q01 estimated from figure Q02 data from another study Q03 data estimated--other Q04 potentially useful future data Q10 potential problem with data Q11 suspected problem with data Q12 known problem with data Q13 duplicate? Q14 inconsistency Further details can generally be found in the notes field (column 105)
7	Contributor	Data contributor
Site and Measurement Data		
8	Country	Country
9	Region	State/province/region
10	Site_name	Name of study site
11	Study_midyear	Year study was performed (middle year if multiple years)
12	Years_of_data	Years of data; always ≥1
13	Latitude	Latitude, decimal; positive=north, negative=south

14	Longitude	Longitude, decimal; positive=east, negative=west
15	Elevation	Elevation, m
16	Manipulation	Manipulation performed (CO2, fertilization, etc.)
17	Manipulation_level	Degree of manipulation performed
18	Age_ecosystem	Time since ecosystem established, years. This is used when, e.g., the time of conversion of forest to agriculture is known
19	Age_disturbance	Time since disturbance, years
20	Species	Dominant species
21	Biome	Biome (boreal, temperate, etc). Subjective
22	Ecosystem_type	Ecosystem type (grassland, forest, etc). Subjective
23	Ecosystem_state	Ecosystem state (managed, unmanaged, natural). Subjective. Unmanaged means human management or disturbance in the past, but not currently.
24	Leaf_habit	Dominant leaf habit (deciduous, evergreen)
25	Stage	Developmental stage (aggrading, mature). Subjective
26	Soil_type	Soil description (classification and texture)
27	Soil_drainage	Soil drainage (dry, wet). Subjective. Dry means well-drained uplands; wet peatlands, swamps, etc.
28	Soil_BD	Soil bulk density, g cm-3
29	Soil_CN	Soil C:N ratio
30	Soil_sand	Soil percent sand
31	Soil_silt	Soil percent silt
32	Soil_clay	Soil percent clay
33	MAT	Reported mean annual temperature, C
34	MAP	Reported mean annual precipitation, mm
35	PET	Reported potential evapotranspiration, mm
36	Study_temp	Annual temperature in year of study, C
37	Study_precip	Annual precipitation in year study of study, mm
38	Meas_method	CO2 measurement method
39	Meas_interval	Mean interval between soil respiration measurements, days
40	Annual_coverage	Annual coverage of soil respiration measurements, fraction (1.0= full year)
41	Partition_method	Method used to partition soil respiration source fluxes, following Bond-Lamberty et al. (2004)
Annual and Seasonal Rs Fluxes		
42	Rs_annual	Annual C flux from soil respiration, g C m-2. This can either be reported directly by the study, calculated from reported mean fluxes, or estimated from a figure (in which case a quality control note is made, field 6)
43	Rs_annual_err	Error (typically plot-to-plot) for soil respiration annual, g C m-2
44	Rs_interann_err	Interannual error reported for soil respiration annual, g C m-2. This is occasionally reported by authors, or defined as the standard deviation between year 'i' and year 'i+1' (N=2)
45	Rs_max	Maximum soil respiration flux, $\mu\text{mol m}^{-2} \text{ s}^{-1}$
46	Rs_maxday	Maximum soil respiration flux day of year
47	Rs_min	Minimum soil respiration flux, $\mu\text{mol m}^{-2} \text{ s}^{-1}$
48	Rs_minday	Minimum soil respiration flux day of year
49	Rlitter_annual	Annual soil respiration flux from litter, g C m-2 fraction
50	Ra_annual	Annual autotrophic soil respiration flux, g C m-2
51	Rh_annual	Annual heterotrophic soil respiration flux, g C m-2
52	RC_annual	Root contribution to soil respiration annual fraction
53	Rs_spring	Mean spring soil respiration flux, $\mu\text{mol m}^{-2} \text{ s}^{-1}$. Seasons are defined by authors
54	Rs_summer	Mean summer soil respiration flux, $\mu\text{mol m}^{-2} \text{ s}^{-1}$
55	Rs_autumn	Mean autumn soil respiration flux, $\mu\text{mol m}^{-2} \text{ s}^{-1}$
56	Rs_winter	Mean winter soil respiration flux, $\mu\text{mol m}^{-2} \text{ s}^{-1}$
57	Rs_growing	Mean growing soil respiration flux, $\mu\text{mol m}^{-2} \text{ s}^{-1}$
58	Rs_wet	Mean wet season soil respiration flux, $\mu\text{mol m}^{-2} \text{ s}^{-1}$
59	Rs_dry	Mean dry season soil respiration flux, $\mu\text{mol m}^{-2} \text{ s}^{-1}$

60	RC_seasonal	Root contribution to seasonal soil respiration, fraction
61	RC_season	Season of root contribution
Response of Rs to Temperature and Moisture		
62	Model_type	Type of temperature-response model used
63	Temp_effect	Temperature effect on soil respiration (none, positive, negative)
64	Model_output_units	Temperature-response model output units
65	Model_temp_min	Lower bound of soil temperature range over which model fitted
66	Model_temp_max	Upper bound of soil temperature range over which model fitted
67	Model_N	Model N
68	Model_R2	Model r-squared
69	T_depth	Depth at which soil temperature recorded, cm. A value of -200 (i.e., 2 m above ground) is used for air temperature
70	Model_paramA	Model parameter A
71	Model_paramB	Model parameter B
72	Model_paramC	Model parameter C
73	Model_paramD	Model parameter D
74	Model_paramE	Model parameter E
75	WC_effect	Soil water effect on Rs
76	R10	Soil respiration at 10 C, $\mu\text{mol m}^{-2} \text{ s}^{-1}$
77	Q10_0_10	Q10 temperature response, for 0–10, 5–15, 10–20, 0–20 °C, as well as custom ranges. Q10 values are either reported by authors, calculated from reported Rs-temperature regressions, or occasionally estimated from figures (in which case a quality control note is made, field 6)
78	Q10_5_15	Q10 temperature response, 5-15 C
79	Q10_10_20	Q10 temperature response, 10-20 C
80	Q10_0_20	Q10 temperature response, 0-20 C
81	Q10_other1	Q10 temperature response, other temp range
82	Q10_other1_min	Lower bound of temperature range of Q10_other1, C
83	Q10_other1_max	Upper bound of temperature range of Q10_other1, C
84	Q10_other2	Q10 temperature response, other temp range
85	Q10_other2_min	Lower bound of temperature range of Q10_other2, C
86	Q10_other2_max	Upper bound of temperature range of Q10_other2, C
Ancillary Pools and Fluxes		
87	GPP	Annual gross primary production at site, g C m ⁻²
88	ER	Annual ecosystem respiration at site, g C m ⁻²
89	NEP	Annual net ecosystem production at site, g C m ⁻²
90	NPP	Annual net primary production at site, g C m ⁻²
100	ANPP	Annual aboveground NPP at site, g C m ⁻²
101	BNPP	Annual belowground NPP at site, g C m ⁻²
102	NPP_FR	Annual fine root NPP at site, g C m ⁻²
103	TBCA	Total belowground carbon allocation at site, g C m ⁻²
104	Litter_flux	Annual aboveground litter flux, g C m ⁻² . This is reported very inconsistently (leaf only, leaf and fine woody material, all material, etc). Generally this should not include large woody material
105	Rootlitter_flux	Annual belowground litter flux, g C m ⁻²
106	TotDet_flux	Annual total litter flux, g C m ⁻² . This should be the sum of Litter flux and Rootlitter flux
107	Ndep	Annual nitrogen deposition, g N m ⁻²
108	LAI	Leaf area index at site, m ² m ⁻² . Hemispheric (one-sided) if possible
109	BA	Basal area at site, m ² ha ⁻¹
110	C_veg_total	Total carbon in vegetation, g C m ⁻² . This should be the sum of C_AG and C_BG. For this and all "C." fields, biomass is converted to carbon using a ratio of 0.5 unless study-specific values are available
111	C_AG	Total carbon in aboveground vegetation, g C m ⁻²
112	C_BG	Total carbon in belowground vegetation, g C m ⁻²
113	C_CR	Total carbon in coarse roots, g C m ⁻²

114	C_FR	Total carbon in fine roots, g C m ⁻²
115	C_litter	Total carbon in standing litter, g C m ⁻²
116	C_soilmineral	Total carbon in soil organic matter, g C m ⁻²
117	C_soildepth	Depth to which soil C recorded, cm
118	Notes	Notes

Table 2. Column names and descriptions for **srdb-studies-V4.csv**.

Column Number	Column Name	Column Description
1	study_number	Study number; used as a lookup from srdb-data.
2	authors	Study authors.
3	title	Study title.
4	abstract	Abstract.
5	bp	Beginning page.
6	citations	Citations.
7	copy	SRDB Team Member.
8	de	Data entry: entered into srdb-data (Y/N)?
9	dld	Downloaded: study acquired (Y/N)?
10	doi	Digital object identifier.
11	ep	Ending page.
12	issue	Issue number.
13	nonenglish	Is study in a non-English language (Y/N)?
14	notes	Notes.
15	pubyear	Publication year.
16	rank	Rank (1=highly relevant, 4=not relevant). Note this score is not an assessment of the study's scientific merit or validity; it's simply a judgment, based on reading the abstract and title, of how relevant this study is to the database (i.e., is it likely to have appropriate data?)
17	requested	Study requested.
18	searchdate	Date search performed (yyyy-mm-dd).
19	searchterm	Web of Science search term used.
20	sn	The ISSN, which is the international standardized code for publication.
21	source	Study source (usually journal name).
22	tf	Additional publication identifiers to accompany those in column ut.
23	ut	Additional publication identifiers.
24	volume	Volume number.

Companion File Information

- The R script **SRDBv4.R** containing functions for error-checking, mapping of study locations, summary statistics, and summary graphics are included. Note that this script requires the installation of the following R packages: ggplot2, ggExtra, maps, and mapdata. The script must be run from the same directory that contains the data files: **srdb-data-V4.csv** and **srdb-studies-V4.csv**, as well as the companion file **srdb-data_fields-V4.txt**. Error-checking functions include helper functions to check the valid range and data type of each field. Summary statistics include the breakdown of data by the following fields: Biome, Ecosystem, Rs_annual, R_10, and Q_10. Scripts to create maps are provided for the world map (Fig. 1 above) and regional maps. Summary graphics include Rs summary distributions by Biome and Ecosystem, as well as a plot of Rs_annual vs Rh_annual.
- The file **srdb-data_fields-V4.txt** contains a list of the fields in **srdb-data-V4.csv**.
- When it was necessary to calculate or estimate annual flux for one of the studies, these calculations and notes were recorded in an Excel spreadsheet. These spreadsheets are provided as a companion file and have been compiled and compressed into **calculations_worksheets_v4.zip**.

3. Application and Derivation

This is a database compiled from published studies about soil surface CO₂ flux (soil respiration) measured in the field and intended to serve as a resource for scientific analysis.

The primary soil respiration units used were gC/m²/yr for annual fluxes and umol/m²/s for mean seasonal fluxes. When necessary, the units were converted from those provided in the study. A variety of ancillary data were also entered when provided, including site-related and experimental data, information on ecosystem structure and function, methods used, etc. A ratio of 12:44 was assumed for C to CO₂ molecular weights and biomass was assumed to be 50% C unless specified otherwise in the study.

4. Quality Assessment

Data were crosschecked against a number of other soil respiration data collections and meta-analyses (Hibbard et al., 2005; Chen and Tian, 2005; Burton et al., 2008; Sotta et al., 2004). Quality flags were assigned based on information provided in a given study and best

5. Data Acquisition, Materials, and Methods

For the compilation of Version 1.0, investigators collected all available studies in the peer-reviewed scientific literature reporting soil respiration measured in the field; lab incubation studies were not included. Web of Science was used to search for publications through the year 2008, and the search terms included "soil respiration," "soil CO₂ evolution," etc. Each study's title and abstract were used to decide whether to acquire it. Approximately 40% of the almost 4700 studies were acquired and examined.

In Version 2.0, publications from 2009, 2010, and from the first half of 2011 were included and Rs data from 164 studies were added. The Google Earth (*.kmz) file of site locations was updated. Values for the "Age_disturbance" field were corrected and completed. The "Partition_method" field was fixed for many records. Finally, three fields "Chamber_method," "CH₄_flux," "N₂O_flux" were deleted because the fields were inconsistent or almost never used.

In Version 3.0, publications from 2012 and Rs data from a total of 466 new studies were added. Many corrections were made to older data and a new R script for error-checking and mapping was created. The Google Earth (*.kmz) file was removed and the field "CO₂_method" was renamed to "Meas_method." Additionally, two new fields titled "Meas_interval" and "Annual_coverage" were added.

In Version 4.0, publications through 2017 were reviewed and more than 1400 observations were added. Many corrections were made to older data.

Short term experiments (i.e., soil respiration measurements made over less than 1-2 weeks) were not entered unless the study authors extrapolated their results to seasonal or annual values; the database is generally not designed to accommodate instantaneous or short-term measurements. In general, no additional research was performed to find older publications that were not listed in the Web of Science. To qualify for inclusion, a study had to report at least one of the following data:

- Annual soil respiration
- Mean seasonal soil respiration
- Annual or seasonal partitioning of soil respiration sources
- Q₁₀ and associated temperature range
- R₁₀ (soil respiration at 10 degrees C)

If at least one of these data was reported or could be calculated with few or no assumptions (e.g., easily estimated from points in a figure), the study was entered into the database. For example, sometimes a study will show monthly soil respiration in a figure but not compute an annual flux, and so estimates were made from the figure. This was noted in a quality flag.

When it was necessary to calculate or estimate annual flux for one of the studies, these calculations and notes were recorded in an Excel spreadsheet (*.xlsx). File names start with the assigned four-digit "Study_number" that indexes the srdb-studies and srdb-data files (e.g., "0020 WitkampEcology 1966.xlsx" and "4634 Webster JGR 2008.xlsx"). These spreadsheets are provided in the file **calculations_worksheets_v4.zip**.

6. Data Access

These data are available through the Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC).

[A Global Database of Soil Respiration Data, Version 4.0](#)

Contact for Data Center Access Information:

- E-mail: uso@daac.ornl.gov
- Telephone: +1 (865) 241-3952

7. References

Bond-Lamberty, B., and A.M. Thomson. 2010. A global database of soil respiration measurements. *Biogeosciences*. 7:1321-1344. <https://doi.org/10.5194/bgd-7-1321-2010>

Burton, A.J., J.M. Melillo, and S.D. Frey. 2008. Adjustment of forest ecosystem root respiration as temperature warms. *Journal of Integrative Plant Biology*, 50:1467-1483. <https://doi.org/10.1111/j.1744-7909.2008.00750.x>

Chen, H., and H.Q. Tian. 2005. Does a general temperature-dependent Q(10) model of soil respiration exist at biome and global scale? *Journal of Integrative Plant Biology*, 47:1288-1302. <https://doi.org/10.1111/j.1744-7909.2005.00211.x>

Hibbard, K.A., B.E. Law, and J. Sulzman. 2005. An analysis of soil respiration across northern hemisphere temperate ecosystems. *Biogeochemistry*, 73:29-70. <https://doi.org/10.1007/s10533-004-2946-0>

Sotta, E.D., P. Meir, Y. Malhi, A.D. Nobre, M. Hodnett, and J. Grace. 2004. Soil CO₂ efflux in a tropical forest in the central Amazon. *Global Change Biology*, 10:601-617. <https://doi.org/10.1111/j.1529-8817.2003.00761.x>

8. Dataset Revisions

SRDB Version	ORNL DAAC Release Date	Number of Records	Study Date Range
Version 4.0	2018/11/21	6631	1961-2016
Version 3.0	2014/07/24	5173	1961-2012
Version 2.0	2012/03/01	4387	1961-2009
Version 1.0	2010/04/30	3379	1961-2007

Version 4.0 Data from 1750 studies have been entered into the database, constituting 6631 records. The data span the years 1961-2016 and are dominated by temperate, well-drained forests. The source for Version 4.0 is the GitHub site <https://github.com/bpbond/srdb> accessed on November 21, 2018.

Version 4.1 The file **srdb-studies-V4.csv** was updated with the file from the GitHub site <https://github.com/bpbond/srdb> accessed on December 17, 2018.

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