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A Global Database of Soil Respiration Data, Version 5.0

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Documentation Revision Date: 2021-02-28

Dataset Version: 5

Summary

The Soil Respiration Database (SRDB) is a near-universal compendium of published soil respiration (Rs) data. The database encompasses 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 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 5 (V5) is the compilation of 2,266 published studies with measurements taken between 1961-2017. V5 features more soil respiration data published in Russian and Chinese scientific literature for better global spatio-temporal coverage and improved global climate-space representation. The database is also restructured to have better interoperability with other datasets related to carbon-cycle science.

Soil respiration, the flux of autotrophically- and heterotrophically-generated CO_2 from the soil to the atmosphere, remains the least well-constrained component of the terrestrial carbon cycle. Previous ancillary information fields were revised for consistency and simplicity and several new fields (e.g., measurement time, collar insertion depth, and collar area) were added. V5 provides opportunities for the biogeochemistry community to better understand the spatial and temporal variability of Rs, its components, and the overall carbon cycle.

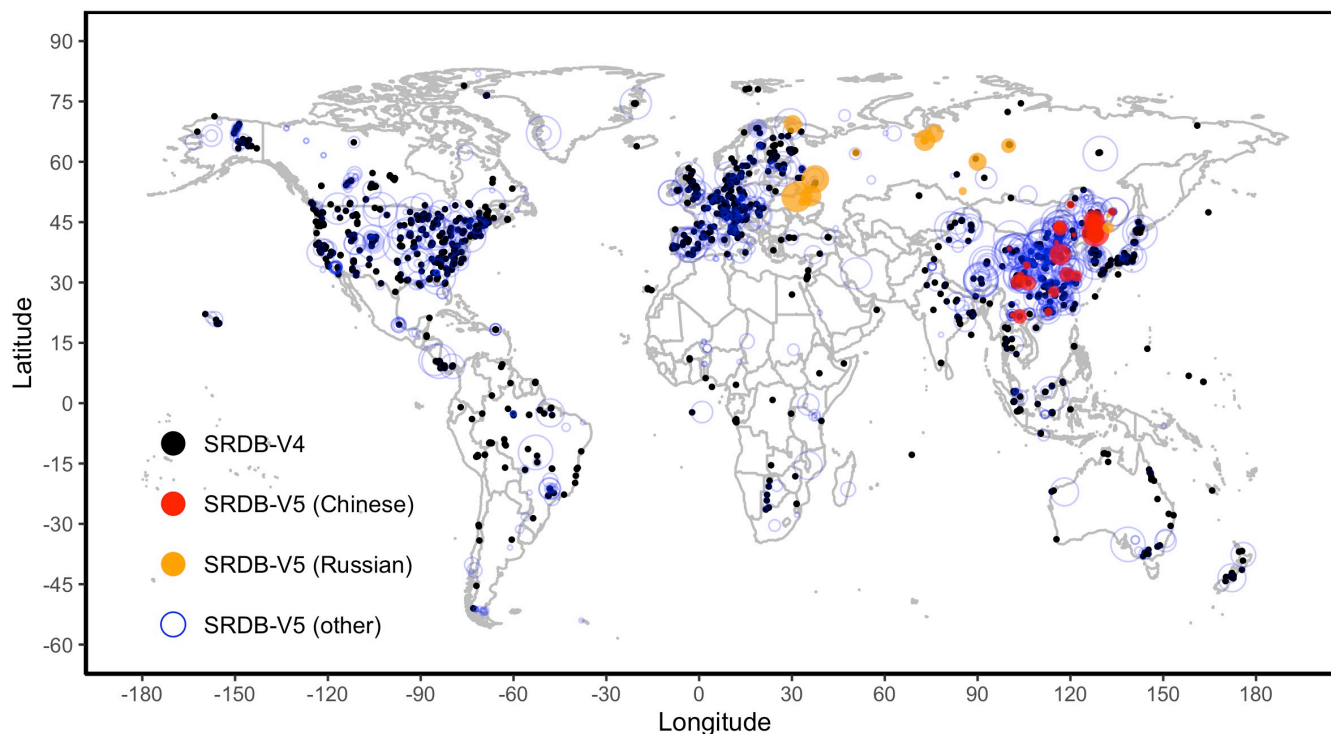There are 3 data files in comma-separated value (*.csv) format and 5 companion files included in this dataset.

Figure 1. Locations of SRDB V5 observations. SRDB-V4 are all observations in V4 database (n=1584). SRDB-V5 (Chinese) are new sites from Chinese literature (n=41). SRDB-V5 (Russian) are new sites from Russian literature (n=16). SRDB-V5 (other) are new sites from literature published in other languages (primarily English) (n=840). The size of circles represents the sample size at each site, where larger circles signify more data. Source: Jian et al. (2020)

Citation

Jian, J., R. Vargas, K.J. Anderson-Teixeira, E. Stell, V. Herrmann, M. Horn, N. Kholod, J. Manzon, R. Marchesi, D. Paredes, and B.P. Bond-Lamberty. 2021. A Global Database of Soil Respiration Data, Version 5.0. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1827

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1. Dataset Overview

The Soil Respiration Database (SRDB) is a near-universal compendium of published soil respiration (Rs) data. The database encompasses 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 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 5 (V5) is the compilation of 2,266 published studies with measurements taken between 1961–2017. V5 features more soil respiration data published in Russian and Chinese scientific literature for better global spatio-temporal coverage and improved global climate-space representation. The database is also restructured to have better interoperability with other datasets related to carbon-cycle science.

Soil respiration, the flux of autotrophically- and heterotrophically-generated CO_2 from the soil to the atmosphere, remains the least well-constrained component of the terrestrial carbon cycle. Previous ancillary information fields were revised for consistency and simplicity and several new fields (e.g., measurement time, collar insertion depth, and collar area) were added. V5 provides opportunities for the biogeochemistry community to better understand the spatial and temporal variability of Rs, its components, and the overall carbon cycle.

Related Publications

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

Jian, J., Vargas, R., Anderson-Teixeira, K., Stell, E., Herrmann, V., Horn, M., Kholod, N., Manzon, J., Marchesi, R., Paredes, D., and Bond-Lamberty, B.: A restructured and updated global soil respiration database (SRDB-V5). Earth System Science Data 13:255–267. https://doi.org/10.5194/essd-2020-136

User Notes

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

The compilers of the SRDB database (Bond-Lamberty and Thomson, 2010) make it available to the scientific community both as a traditional, static archive and as a dynamic community database hosted on GitHub at https://github.com/bpbond/srdb that accepts contributions from users. Citations for the dynamic database should always include a version number and download date.

2. Data Characteristics

Spatial Coverage: Global

Spatial Resolution: Points

Temporal Coverage: 1961-01-01 to 2017-12-31

Temporal Resolution: Annual and seasonal

Site Boundaries: Latitudes and longitudes are provided in decimal degrees.

Site	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude
Global	-163.71	175.897	81.8	-78.02

Data File Information

There are 3 data files in comma-separated value (*.csv) format and 5 companion files are included in this dataset.

Table 1. File names and descriptions.

File Name	Description
Data Files	
srdb-data-V5.csv	soil respiration and contextual data
srdb-studies-V5.csv	bibliographic information for the studies that appear in and or all studies reviewed for inclusion into the SRDB for which only a subset has met the criteria for inclusion in srdb-data-V5.csv (the *Study_number* field is common to both files)
srdb-equations-V5.csv	responses of soil respiration to temperature and moisture for selected studies described in srdb-data-V5.csv (the *Record_number* field is common to both files)
Companion Files	
SRDBv5.R	R script used to check SRDB data for consistency, columns types, out of bounds, etc.
srdb-data_fields_V5.txt	List of fields in srdb-data-V5.csv
srdb-studies_fields_V5.txt	List of fields in srdb-studies-V5.csv
srdb-equations_fields_V5.txt	List fields in srdb-equations-V5.csv
calculations_worksheets_V5.zip	Calculations necessary for a study to estimate annual flux and notes recorded in an Excel spreadsheet in a compressed file format

Data File Details

Missing values are represented as -9999 for numeric data or NA for text data. Many fields have empty values.

Table 1. Column names and descriptions for srdb-data-V5.csv. Data field descriptions provide contextual information useful for filtering data, especially by fields *Quality_flag*, *CO2_method* (e.g., exclude "soda lime" measurements), *Manipulation* (e.g., filter to "None" to look at un-manipulated systems), *Ecosystem_state*, and *Ecosystem_type*.

Column Number	Column Name	Description
Metadata		
1	Record_number	Record number: Index to srdb-equations-V5.csv
2	Entry_date	Entry date (yyyy-mm-dd)
3	Study_number	Study number: Index to srdb-studies-V5.csv
4	Author	Name of first author
5	Duplicate_record	Quantifies if 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 Details can generally be found in the *Notes* field
7	Contributor	Data contributor
Site and Measurement Data		
8	Country	Country
9	Region	State/province/region
10	Site_name	Name of the study site
11	Site_ID	Identification code for study site; typically, Study_number + Site_ID + Study_midyear is unique
12	Study_midyear	Year study was performed (middle year if multiple years)
13	Years_of_data	Years of data; always ≥1
14	Latitude	Latitude in decimal degree
15	Longitude	Longitude in decimal degree
16	Elevation	Elevation in m
17	Manipulation	Manipulation performed (CO_2, fertilization, etc.)
18	Manipulation_level	Manipulation amount or description
19	Age_ecosystem	Time since ecosystem establishment in years; used when the time of conversion (e.g., forest to agriculture) is known
20	Age_disturbance	Time since disturbance in years
21	Species	Dominant species
22	Biome	Biome type assigned (e.g., boreal, temperate)
23	Ecosystem_type	Ecosystem type assigned (e.g., grassland, forest)
24	Ecosystem_state	Ecosystem state (managed, unmanaged, natural); unmanaged refers to human management or disturbance in the past but not at the time of the study
25	Leaf_habit	Dominant leaf habit (deciduous, evergreen)
26	Stage	Developmental stage assigned (aggrading, mature)
27	Soil_type	Soil description (classification and texture)
28	Soil_drainage	Soil drainage assigned (dry, wet); dry is equivalent to well-drained uplands and wet is equivalent to peatlands, swamps, etc.

Column Number	Column Name	Description
29	Soil_BD	Soil bulk density in g cm^{-3}
30	Soil_CN	Soil C:N ratio
31	Soil_sand	Soil percent sand
32	Soil_silt	Soil percent silt
33	Soil_clay	Soil percent clay
34	MAT	Reported mean annual temperature in degrees C
35	MAP	Reported mean annual precipitation in mm
36	PET	Reported potential evapotranspiration in mm
37	Study_temp	Annual temperature in year of study in degrees C
38	Study_precip	Annual precipitation in year study of study in mm
39	Meas_method	CO_2 measurement method
40	Collar_height	Total height of collar in cm
41	Collar_depth	Depth of collar insertion in cm
42	Chamber_area	Area of measurement chamber in cm^2
43	Time_of_day	Time of day measurements were made in hours (H_1 to H_2)
44	Meas_interval	Mean interval between soil respiration measurements in days
45	Annual_coverage	Fraction of annual coverage of soil respiration measurements (1.0 = full year)
46	Partition_method	Method used to partition soil respiration source fluxes (Bond-Lamberty et al., 2004)
Annual and Seasonal Rs Fluxes		
47	Rs_annual	Annual C flux from soil respiration in g C m^{-2}; this can be reported directly by the study, calculated from reported mean fluxes, or estimated from a figure (in which case, the *Quality_flag* field is employed)
48	Rs_annual_err	Error (typically plot-to-plot) for soil respiration annual in g C m^{-2}
49	Rs_interann_err	Interannual error reported for annual soil respiration in 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)
50	Rlitter_annual	Annual soil respiration flux from litter in g C m^{-2} fraction
51	Ra_annual	Annual autotrophic soil respiration flux in g C m^{-2}
52	Rh_annual	Annual heterotrophic soil respiration flux in g C m^{-2}
53	RC_annual	Root contribution to soil respiration annual fraction
54	Rs_spring	Mean spring* soil respiration flux in μmol m^{-2} s^{-1}
55	Rs_summer	Mean summer* soil respiration flux in μmol m^{-2} s^{-1}
56	Rs_autumn	Mean autumn* soil respiration flux in μmol m^{-2} s^{-1}
57	Rs_winter	Mean winter* soil respiration flux in μmol m^{-2} s^{-1}
58	Rs_growing	Mean growing season* soil respiration flux in μmol m^{-2} s^{-1}
59	Rs_wet	Mean wet season* soil respiration flux in μmol m^{-2} s^{-1}
60	Rs_dry	Mean dry season* soil respiration flux in μmol m^{-2} s^{-1}
61	RC_seasonal	Fraction of root contribution to seasonal* soil respiration

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Column Number	Column Name	Description
62	RC_season	Season* of root contribution
Ancillary Pools and Fluxes		
63	GPP	Annual gross primary production at the site in g C m^{-2}
64	ER	Annual ecosystem respiration at the site in g C m^{-2}
65	NEP	Annual net ecosystem production at the site in g C m^{-2}
66	NPP	Annual net primary production at the site in g C m^{-2}
67	ANPP	Annual aboveground NPP at the site in g C m^{-2}
68	BNPP	Annual belowground NPP at the site in g C m^{-2}
69	NPP_FR	Annual fine root NPP at the site in g C m^{-2}
70	TBCA	Total belowground carbon allocation at the site in g C m^{-2}
71	Litter_flux	Annual aboveground litter flux in g C m^{-2}; (leaf only, leaf and fine woody material, all material, etc); generally, should not include large woody material; inconsistently reported
72	Rootlitter_flux	Annual belowground litter flux in g C m^{-2}
73	TotDet_flux	Annual total litter flux in g C m^{-2}; (~ *Litter_flux + Rootlitter_flux*)
74	Ndep	Annual nitrogen deposition in g N m^{-2}
75	LAI	Leaf area index at the site in m^2 m^{-2}; hemispheric (one-sided) when possible
76	BA	Basal area at site in m2 ha^{-1}
77	C_veg_total	Total carbon** in vegetation in g C m^{-2} (*C_AG + C_BG*)
78	C_AG	Total carbon** in aboveground vegetation in g C m^{-2}
79	C_BG	Total carbon** in belowground vegetation in g C m^{-2}
80	C_CR	Total carbon in** coarse roots in g C m^{-2}
81	C_FR	Total carbon** in fine roots in g C m^{-2}
82	C_litter	Total carbon** in standing litter in g C m^{-2}
83	C_soilmineral	Total carbon** in soil organic matter in g C m^{-2}
84	C_soildepth	Depth of soil for which carbon was measured in cm
85	Notes	Notes

* The temporal extent of a season was defined by the investigators.
** *C_* fields related to biomass are converted to carbon using a ratio of 0.5 unless study-specific values were available.

Table 2. Column names and descriptions for srdb-studies-V5.csv. The content includes bibliographic information for <u>all</u> studies reviewed for inclusion into the SRDB. Only a subset has met the criteria (as outlined in Section 5).

Column Number	Column Name	Description
1	Study_number	Study number: Index to srdb-data-V5.csv
2	Authors	Study authors
3	Title	Study title
4	Source	Study source, usually the journal name
5	Volume	Volume number

Column Number	Column Name	Description
6	Issue	Issue number
7	Bp	Beginning page
8	Ep	Ending page
9	Pubyear	Publication year
10	Notes	Notes
11	Citations	Citations
12	DE	Data entry: Entered into srdb-data-V5.csv (Y/N)
13	DLD	Downloaded: Study acquired (Y/N)
14	DOI	Digital object identifier
15	nonEnglish	Study in a non-English language (Y/N)
16	Rank	Rank (1=highly relevant to 4=not relevant); this score is not an assessment of the study's scientific merit or validity but a judgment, based on reading the abstract and title, of how relevant this study is to the data (i.e., the likelihood of having appropriate data)
17	SearchDate	Date search performed (yyyy-mm-dd)
18	SearchTerm	Web of Science search term used

Table 3. Column names and descriptions for srdb-equations-V5.csv. The content represents the response of Rs to temperature and moisture.

Column Number	Column Name	Description
0	Record_number	Record number: Index to srdb-data-V5.csv
1	Model_type	Temperature-response model used
2	Temp_effect	Temperature effect on Rs (none, positive, negative)
3	Model_output_units	Temperature-response model output units
4	Model_temp_min	Minimum soil temperature over which model fitted in degrees C
5	Model_temp_max	Maximum soil temperature over which model fitted in degrees C
6	Model_N	Model N
7	Model_R2	Model R-squared
8	T_depth	Depth at which soil temperature recorded in cm; a value of -200 (i.e., 2 m above ground) is used for air temperature
9	Model_paramA	Model parameter A
10	Model_paramB	Model parameter B
11	Model_paramC	Model parameter C
12	Model_paramD	Model parameter D
13	Model_paramE	Model parameter E
14	WC_effect	Soil water effect on Rs
15	R10	Rs at 10 degrees C in $\mu mol\ m^{-2}\ s^{-1}$
16	Q10_0_10	Q10 temperature response*** (0-10 degrees C)
17	Q10_5_15	Q10 temperature response*** (5-15 degrees C)
18	Q10_10_20	Q10 temperature response*** (10-20 degrees C)
19	Q10_0_20	Q10 temperature response*** (0-20 degrees C)

Column Number	Column Name	Description
20	Q10_other1	Q10 temperature response*** (other temp range)
21	Q10_other1_temp_min	Minimum soil temperature over which *Q10_other1* fitted in degrees C
22	Q10_other1_temp_max	Maximum soil temperature over which *Q10_other1* fitted in degrees C
23	Q10_other2	Q10 temperature response*** (other temp range)
24	Q10_other2_temp_min	Minimum soil temperature over which *Q10_other2* fitted in degrees C
25	Q10_other2_temp_max	Maximum soil temperature over which *Q10_other2* fitted in degrees C

*** Values for *Q10* fields are either reported by authors, calculated from reported Rs temperature regressions, or occasionally estimated from figures (in which case, the *Quality_flag* field is employed).

3. Application and Derivation

This is a database compiled from published studies about soil surface CO_2 flux (i.e., soil respiration) measured in the field and is intended to serve as a resource for scientific analysis.

The V5 database was restructured to have has better interoperability with other datasets related to carbon cycle science. V5 has all fields from the previous version, but the fields have been revised for consistency and simplicity and several new fields have been added to include ancillary information (e.g., Rs measurement times, collar insertion depth, collar area). In addition, the *Site_ID* field (a unique identifier for a study site) was added allowing linkage to an hourly timescale global soil respiration database (HGRsD; Jian and Steele, 2018) and the open community database of continuous soil respiration and other chamber flux data (COSORE; Bond-Lamberty et al., 2020), enabling researchers to explore data integration and comparative studies.

The primary soil respiration units used were g C m^{-2} yr^{-1} for annual fluxes and µmol m^{-2} s^{-1} for mean seasonal fluxes. When necessary, the units were converted from those provided in the study. A variety of ancillary data were also included when provided in the literature, including site-related and experimental data, information on ecosystem structure and function, and methods. A ratio of 12:44 was assumed for C to CO_2 molecular weights and biomass was assumed to be 50% C unless specified otherwise in the study.

4. Quality Assessment

Data were cross-checked against a number of other soil respiration data collections and metaanalyses including Hibbard et al. (2005), Chen and Tian (2005), Burton et al. (2008), and Sotta et al. (2004). Quality flags were assigned based on information provided in a given study and the investigator's judgment.

5. Data Acquisition, Materials, and Methods

SRDB Inclusion Criteria

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 were 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, so estimates were made from a figure. This is documented using the *Quality_flag* field.

Flux Calculation Log

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). The name of the Excel files begin with the *Study_number* indexed in srdb-studies-V5.csv and srdb-data-V5.csv (e.g., "0020 WitkampEcology 1966.xlsx", "4634 Webster JGR 2008.xlsx"). The spreadsheets are provided as the companion file calculations_worksheets_v5.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 5.0

Contact for Data Center Access Information:

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

7. References

Bondâ Â Â⁻Â Â   Lamberty, Ben, Danielle S. Christianson, Avni Malhotra, Stephanie C. Pennington, Debjani Sihi, Amir AghaKouchak, Hassan Anjileli et al. "COSORE: A community database for continuous soil respiration and other soilâ Â Â⁻Â Â   atmosphere greenhouse gas flux data." *Global change biology* 26, no. 12 (2020): 7268-7283. https://doi.org/10.1111/gcb.15353

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Sotta, E.D., P. Meir, Y. Malhi, A.D. Nobre, M. Hodnett, and J. Grace. 2004. Soil CO_2 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

Version	Release Date	Number of Records	Date Range
5.0	2021-02-28	10,366	1961–2017
4.1	2018-12-17	6,633	1961–2016
4.0	2018-11-21	6,631	1961–2016
3.0	2014-07-24	5,173	1961–2012
2.0	2012-03-01	4,387	1961–2009
1.0	2010-04-30	3,379	1961–2007

SRDB Version History Details

Version 1

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 CO_2 evolution," and others. Each study's title and abstract were used to decide whether to acquire it. Approximately 40% of the almost 4,700 studies were acquired and examined.

Version 2

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*, and *N2O_flux*, were deleted because the fields were inconsistent or almost never used.

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 an R script for error-checking and mapping was created. The compressed Keyhole Markup Language (*.kmz) file was removed and the *CO2_method* field was renamed to *Meas_method*. Additionally, two new fields, *Meas_interval* and *Annual_coverage*, were added.

Version 4.0

Publications through 2017 were reviewed, and data from 1,750 studies were added constituting 6,631 records total. Many corrections were made to older data. The data are dominated by temperate, well-drained forests. The materials were collected from the GitHub repository.

Version 4.1

The file srdb-studies-V4.csv was updated with a new file available from the GitHub repository.

<u>Version 5.0</u>

V5 includes data from 2,266 unique published studies through 2017. Observations increased by more than 3,000 to 10,366. This version features more Rs data published in the Russian and Chinese scientific literature for improved global spatio-temporal coverage and improved global climate-space representation. V5 is described in detail in Jian et al. (2020).

Changes implemented in srdb-data-V5.csv data file included:

- The set of columns related to the response of Rs to temperature and moisture were removed from srdb-data-V5.csv and are provided in the new data file srdb-equations-V5.csv**.** The *Record_number* field is common to both files.
- Additional fields include *Site_ID*, *Collar_height*, *Collar_depth*, *Chamber_area*, and *Time_of_day*.
- Removed fields include *Rs_max*, *Rs_maxday*, *Rs_min*, and *Rs_minday*.

Changes implemented in srdb-studies-V5.csv data file included:

- Removed the fields *abstract*, *tf*, *ut*, *sn*, and *copy*.

The srdb-equations-V5.csv data file is new for V5 but includes previously provided data columns related to the response of Rs to temperature and moisture extracted from srdb-data-V5.csv. The *Record_number* field is common to both files.

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