

Package ‘ISRaD’

December 20, 2019

Title Tools and Data for the International Soil Radiocarbon Database

Version 1.1.2

Description This is the central location for data and tools for the development, maintenance, analysis, and deployment of the International Soil Radiocarbon Database (ISRaD). ISRaD was developed as a collaboration between the U.S. Geological Survey Powell Center and the Max Planck Institute for Biogeochemistry. This R package provides tools for accessing and manipulating ISRaD data, compiling local data using the ISRaD data structure, and simple query and reporting functions for ISRaD. For more detailed information visit the ISRaD website at: <<https://soilradiocarbon.org/>>.

Depends R (>= 3.5.0)

Imports openxlsx, devtools, raster, rgdal, dplyr, tidyr, RCurl, ggplot2, maps, assertthat, rcrossref, pangear, tidyverse, stringr

License GPL-2

Encoding UTF-8

LazyData true

RoxygenNote 6.1.1

Suggests knitr,
rmarkdown

R topics documented:

checkTemplateFiles	2
compile	3
future14C	3
Gaudinski_2001	4
graven	4
ISRaD.extra	5
ISRaD.extra.Cstocks	5
ISRaD.extra.delta_delta	6
ISRaD.extra.fill_14c	7
ISRaD.extra.fill_coords	8
ISRaD.extra.fill_dates	9
ISRaD.extra.fill_fm	9
ISRaD.extra.geospatial	10
ISRaD.extra.geospatial.keys	11
ISRaD.flatten	12
ISRaD.getdata	13

ISRaD.rep.count.all	13
ISRaD.rep.count.frc	14
ISRaD.rep.entry.stats	14
ISRaD.rep.site.map	15
ISRaD.report	15
ISRaD.save.xlsx	16
QAQC	16
Index	18

checkTemplateFiles	<i>Check ISRaD Template/Info files</i>
--------------------	--

Description

Check that the template information file and the template file match appropriately.

Usage

```
checkTemplateFiles(outfile = "", verbose = T)
```

Arguments

- outfile file to dump the output report. Defaults to an empty string that will print to standard output.
- verbose if TRUE (default) will print output to specified outfile

Details

Used in compile() function, but primarily a development tool

Value

returns NULL

Examples

```
checkTemplateFiles()
```

compile	<i>Compile ISRaD data product</i>
---------	-----------------------------------

Description

Construct data products to the International Soil Radiocarbon Database.

Usage

```
compile(dataset_directory, write_report = FALSE, write_out = FALSE,
        return_type = c("none", "list")[2], checkdoi = F, verbose = T)
```

Arguments

dataset_directory	string defining directory where completed and QC passed soilcarbon datasets are stored
write_report	boolean flag to write a log file of the compilation. File will be in the specified dataset_directory at "database/ISRaD_log.txt". If there is a file already there of this name it will be overwritten.
write_out	boolean flag to write the compiled database file as .xlsx in dataset_directory
return_type	a string that defines return object. Default is "list". Acceptable values are "none" or "list" depending on the format you want to have the database returned in.
checkdoi	set to F if you do not want the QAQC check to validate doi numbers
verbose	set to TRUE to print results of function to console

Examples

```
# Load example dataset Gaudinski_2001
database <- ISRaD::Gaudinski_2001
# Save as .xlsx file
ISRaD.save.xlsx(database = database,
  template_file = system.file("extdata", "ISRaD_Master_Template.xlsx", package = "ISRaD"),
  outfile = paste0(tempdir(), "/Gaudinski_2001.xlsx"))
# Compile .xlsx file/s in dataset_directory into ISRaD database object
ISRaD.compiled <- compile(tempdir(), write_report = TRUE, write_out = TRUE,
  return_type = 'list', checkdoi = FALSE, verbose = TRUE)
```

future14C	<i>Future atmospheric 14C dataset for delta delta calculation</i>
-----------	---

Description

Data from: Sierra, C. "Forecasting atmospheric radiocarbon decline to pre-bomb values", Radiocarbon, Vol 60, Nr 4, 2018, p 1055–1066 DOI:10.1017/RDC.2018.33

Usage

future14C

Format

dataframe

Gaudinski_2001

Gaudinski Harvard Forest example dataset

Description

Data from Gaudinski, J., 2001, Belowground carbon cycling in three temperate forests of the eastern United States, University of California Irvine, Ph.D. thesis

Usage

Gaudinski_2001

Format

list

graven

Graven dataset for delta delta calculation

Description

Data from Graven et al 2017 <https://www.geosci-model-dev.net/10/4405/2017/gmd-10-4405-2017.pdf>

Usage

graven

Format

dataframe

ISRaD.extra	<i>ISRaD.extra</i>
-------------	--------------------

Description

Fills in transformed and geospatial data where possible, generating an enhanced version of ISRaD.

Usage

```
ISRaD.extra(database, geodata_directory)
```

Arguments

database	soilcarbon dataset object
geodata_directory	directory where geospatial data are found

Details

Fills fraction modern, delta 14C, delta-delta values, profile coordinates, BD, orgC, and SOC stocks from entered data; fills soil and climatic data from external geospatial data products

Value

returns new ISRaD_extra object with derived, transformed, and filled columns

Examples

```
# Load example dataset Gaudinski_2001
database <- ISRaD::Gaudinski_2001
# Fill ISRaD.extra data
database.x <- ISRaD.extra(database,
  geodata_directory = system.file("extdata", "geodata_directory", package = "ISRaD"))
```

ISRaD.extra.Cstocks	<i>ISRaD.extra.Cstocks</i>
---------------------	----------------------------

Description

Calculates soil organic carbon stock

Usage

```
ISRaD.extra.Cstocks(database)
```

Arguments

database	ISRaD dataset object.
----------	-----------------------

Details

Function first fills `lyr_bd_samp`, `lyr_c_org`, `lyr_c_org`, `lyr_coarse_tot`. Notes: 1) SOC stocks can only be calculated if organic carbon concentration and bulk density data are available, 2) SOC stocks are calculated for the fine earth fraction (<2mm).

Value

returns ISRaD_data object with filled columns "lyr_coarse_tot_filled", "lyr_bd_samp_filled", "lyr_c_inorg_filled", "lyr_c_org_filled", "lyr_soc_filled"

Author(s)

J. Beem-Miller

Examples

```
# Load example dataset Gaudinski_2001
database <- ISRaD::Gaudinski_2001
database.x <- ISRaD.extra.Cstocks(database)
```

ISRaD.extra.delta_delta

ISRaD.extra.delta_delta

Description

Calculates the difference between sample delta 14C and the atmosphere for the year of collection (delta-delta)

Usage

```
ISRaD.extra.delta_delta(database, future = TRUE)
```

Arguments

database	ISRaD dataset object
future	Project atmospheric radiocarbon into the future? T/F

Details

Creates new column for delta-delta value. Observation year and profile coordinates must be filled (use `ISRaD.extra.fill_dates`, and `ISRaD.extra.fill_coords` fxs). The relevant atmospheric d14C data (northern or southern hemisphere, or tropics) are determined by profile coordinates. Projection for 2016 to 2021 uses the four quarter average projected atmospheric radiocarbon concentration for Central Europe as estimated in Sierra (2019). Central Europe projection used for northern hemisphere (performs better against observation than northern hemisphere projection), while southern hemisphere and tropic atmospheric radiocarbon projection lagged by 2.5 per mille, as this is the mean lag observed from 2000 to 2015 in the Graven (2017) dataset.

Value

returns ISRaD_data object with new delta delta columns in relevant tables

Author(s)

J. Beem-Miller and C. Hicks-Pries

References

Graven et al. 2017 <<https://www.geosci-model-dev.net/10/4405/2017/gmd-10-4405-2017.pdf>>; Sierra, C. "Forecasting atmospheric radiocarbon decline to pre-bomb values", Radiocarbon, Vol 60, Nr 4, 2018, p 1055–1066 DOI:10.1017/RDC.2018.33

Examples

```
# Load example dataset Gaudinski_2001
database <- ISRaD::Gaudinski_2001
# Fill profile coordinates
database.x <- ISRaD.extra.fill_coords(database)
# Fill dates
database.x <- ISRaD.extra.fill_dates(database.x)
# Fill delta 14C from fraction modern
database.x <- ISRaD.extra.fill_14c(database.x)
# Fill delta delta
database.x <- ISRaD.extra.delta_delta(database.x)
```

ISRaD.extra.fill_14c *ISRaD.extra.fill_14c*

Description

: Fills delta 14C from fraction modern if delta 14C not reported.

Usage

```
ISRaD.extra.fill_14c(database)
```

Arguments

database ISRaD dataset object.

Details

: Warning: xxx_obs_date_y columns must be filled for this to work!

Value

returns ISRaD_data object with filled delta 14C columns

Author(s)

: J. Beem-Miller & A. Hoyt

References

: Stuiver and Polach, 1977

Examples

```
# Load example dataset Gaudinski_2001
database <- ISRaD::Gaudinski_2001
# Fill dates
database.x <- ISRaD.extra.fill_dates(database)
# Fill delta 14C from fraction modern
database.x <- ISRaD.extra.fill_14c(database.x)
# Column flx_14c in the "flux" table is now filled
```

ISRaD.extra.fill_coords

ISRaD.extra.fill_coords

Description

Fills profile coordinates from site coordinates if profile coordinates not reported.

Usage

```
ISRaD.extra.fill_coords(database)
```

Arguments

database ISRaD dataset object.

Value

returns ISRaD_data object with filled profile coordinates

Author(s)

J. Beem-Miller

Examples

```
# Load example dataset Gaudinski_2001
database <- ISRaD::Gaudinski_2001
# Fill profile coordinates
database.x <- ISRaD.extra.fill_coords(database)
```

```
ISRaD.extra.fill_dates
      ISRaD.extra.fill_dates
```

Description

Fills frc_obs_date_y and inc_obs_date_y columns from lyr_obs_date_y if not reported.

Usage

```
ISRaD.extra.fill_dates(database)
```

Arguments

database ISRaD dataset object.

Details

This function must be run prior to the ISRaD.extra.fill_14c, ISRaD.extra.fill_fm, and ISRaD.extra.delta_delta for the layer and fraction tables.

Value

returns ISRaD_data object with filled obs_date_y columns

Examples

```
# Load example dataset Gaudinski_2001
database <- ISRaD::Gaudinski_2001
# Fill dates
database.x <- ISRaD.extra.fill_dates(database)
# Fraction table now has lyr_obs_date_y values in frc_obs_date_y field
```

```
ISRaD.extra.fill_fm    ISRaD.extra.fill_fm
```

Description

Fills fraction modern from delta 14C if fraction modern not reported.

Usage

```
ISRaD.extra.fill_fm(database)
```

Arguments

database ISRaD dataset object.

Details

: Warning: xxx_obs_date_y columns must be filled for this to work!

Value

returns ISRaD_data object with filled fraction modern columns

Author(s)

: J. Beem-Miller & A. Hoyt

References

: Stuiver and Polach, 1977

Examples

```
# Load example dataset Gaudinski_2001
database <- ISRaD::Gaudinski_2001
# Fill dates
database.x <- ISRaD.extra.fill_dates(database)
# Fill fraction modern from delta 14C
database.x <- ISRaD.extra.fill_fm(database.x)
```

ISRaD.extra.geospatial

ISRaD.extra.geospatial

Description

Extracts data from a user-supplied raster file and adds data as a new variable at the profile level

Usage

```
ISRaD.extra.geospatial(database, geodata_directory,
  crs = "+proj=longlat +datum=WGS84 +no_defs +ellps=WGS84 +towgs84=0,0,0",
  fillWorldClim = TRUE)
```

Arguments

database	ISRaD dataset object
geodata_directory	directory where geospatial data are found
crs	coordinate reference system used for geospatial datasets
fillWorldClim	option to fill climate data from the Worldclim dataset (downloads data from web)

Details

Generic function that uses geographic coordinates of profiles to extract data from one or more raster files. Raster data will be added as new variables at the profile level.

The new variable name will be a concatenation of "pro_", and the file name (excluding the file extension). The ISRaD recommended file name convention for geospatial files uses a 6 component string, separated by "_". Missing components can be replaced with "x" ("x"s will be dropped before creating variable names). The 6 components are as follows:

- 1) Short description of the data type, e.g. "bd" for bulk density
- 2) Top layer depth or exact depth (numeric, cm)
- 3) Bottom layer depth (numeric, cm)
- 4) Year of data observation (numeric)
- 5) Data units (e.g. mmyr for mean annual precipitation)
- 6) Any relevant notes

Coordinate reference system can be specified with the "crs" argument; default is WGS84. Note that all files in geodata_directory must use the same crs.

Option "fillWorldClim" fills climate data from worldclim V1.4 at 2.5 resolution (<http://www.worldclim.org/bioclim>).

Variable descriptions are as follows:

- bio1 = Annual Mean Temperature,
- bio2 = Mean Diurnal Range (Mean of monthly (max temp - min temp)),
- bio3 = Isothermality (BIO2/BIO7) (* 100),
- bio4 = Temperature Seasonality (standard deviation *100),
- bio5 = Max Temperature of Warmest Month,
- bio6 = Min Temperature of Coldest Month,
- bio7 = Temperature Annual Range (BIO5-BIO6),
- bio8 = Mean Temperature of Wettest Quarter,
- bio9 = Mean Temperature of Driest Quarter,
- bio10 = Mean Temperature of Warmest Quarter,
- bio11 = Mean Temperature of Coldest Quarter,
- bio12 = Annual Precipitation,
- bio13 = Precipitation of Wettest Month,
- bio14 = Precipitation of Driest Month,
- bio15 = Precipitation Seasonality (Coefficient of Variation),
- bio16 = Precipitation of Wettest Quarter,
- bio17 = Precipitation of Driest Quarter,
- bio18 = Precipitation of Warmest Quarter,
- bio19 = Precipitation of Coldest Quarter

Value

returns updated ISRaD_extra object with new columns at the profile level

ISRaD.extra.geospatial.keys

ISRaD.extra.geospatial.keys

Description

Recode numeric values from categorical geospatial data products

Usage

```
ISRaD.extra.geospatial.keys(database, geodata_keys)
```

Arguments

database	ISRaD dataset object
geodata_keys	directory where geospatial data are found

Details

Generic function that reads .csv files paired with categorical raster data and recodes extracted data in the ISRaD_extra object. For the function to work, the .csv filenames must be identical to the corresponding raster filenames, except for the file extension. Additionally, the first column of the .csv file must contain the numeric identifier and the second column the corresponding character value.

Value

returns updated ISRaD_extra object with recoded columns

ISRaD.flatten	<i>ISRaD.flatten</i>
---------------	----------------------

Description

: Joins tables in ISRaD based on linking variables and returns "flat" dataframes

Usage

```
ISRaD.flatten(database, table)
```

Arguments

database	ISRaD dataset object: e.g. ISRaD_data, or ISRaD_extra
table	ISRaD table of interest ("flux", "layer", "interstitial", "fraction", "incubation"). Must be entered with "".

Details

: ISRaD.extra.flatten generates flat files (2 dimensional matrices) for user specified ISRaD tables by joining higher level tables (metadata, site, profile, layer) to lower level tables (layer, fraction, incubation, flux, interstitial).

Value

returns a dataframe with nrow=nrow(table) and ncol=sum(ncol(meta),ncol(site),ncol(profile),...,ncol(table))

Author(s)

: J. Beem-Miller

References

:

Examples

```
# Load example dataset Gaudinski_2001
database <- ISRaD::Gaudinski_2001
fractions <- ISRaD.flatten(database, "fraction")
layers <- ISRaD.flatten(database, "layer")
```

ISRaD.getdata	<i>ISRaD.getdata</i>
---------------	----------------------

Description

ISRaD.getdata

Usage

```
ISRaD.getdata(directory, dataset = "full", extra = F,
               force_download = F)
```

Arguments

directory	location of ISRaD_database_files folder. If not found, it will be created.
dataset	Specify which data you want. Options are c("full", "flux", "interstitial", "incubation", "fraction", "layer")
extra	T or F. If T, the ISRaD_extra object will be returned. If F, ISRaD_data will be returned. Default is F.
force_download	T or F. If there are already ISRaD_database files in the directory you specify, new data will not be downloaded by default. However, if you set force_downlaod to T, the newest data from github will be downloaded regardless.

Value

ISRaD data object

Examples

```
# Return full dataset ("full")
ISRaD_full <- ISRaD.getdata(tempdir(), dataset = "full", extra = FALSE)
# Return full dataset plus "extra" filled data
ISRaD_extra <- ISRaD.getdata(tempdir(), dataset = "full", extra = TRUE)
# Return only fraction data, including filled fraction data
ISRaD_fractions <- ISRaD.getdata(tempdir(), dataset = "fraction", extra = TRUE)
```

ISRaD.rep.count.all	<i>ISRaD.rep.count.all</i>
---------------------	----------------------------

Description

Generates a report of counts of observations at each level of the database

Usage

```
ISRaD.rep.count.all(database = NULL)
```

Arguments

database	ISRaD data object
----------	-------------------

Examples

```
# Load example dataset Gaudinski_2001
database <- ISRaD::Gaudinski_2001
ISRaD.rep.count.all(database)
```

ISRaD.rep.count.frc	<i>ISRaD.rep.count.frc</i>
---------------------	----------------------------

Description

Generates a report of fraction level observations, including fraction scheme and properties

Usage

```
ISRaD.rep.count.frc(database = NULL)
```

Arguments

database	ISRaD data object
----------	-------------------

Examples

```
# Load example dataset Gaudinski_2001
database <- ISRaD::Gaudinski_2001
ISRaD.rep.count.frc(database)
```

ISRaD.rep.entry.stats	<i>ISRaD.rep.entry.stats</i>
-----------------------	------------------------------

Description

Generates a report of metadata statistics for all entries

Usage

```
ISRaD.rep.entry.stats(database = NULL)
```

Arguments

database	ISRaD data object
----------	-------------------

Examples

```
# Load example dataset Gaudinski_2001
database <- ISRaD::Gaudinski_2001
ISRaD.rep.entry.stats(database)
```

ISRaD.rep.site.map	<i>ISRaD.rep.site.map</i>
--------------------	---------------------------

Description

Generate a world map showing locations of all ISRaD sites

Usage

```
ISRaD.rep.site.map(database = NULL)
```

Arguments

database	ISRaD data object
----------	-------------------

Examples

```
# Obtain current ISRaD data
database <- ISRaD.getdata(tempdir(), dataset = "full", extra = FALSE)
# Generate a map of all ISRaD sites
ISRaD.rep.site.map(database)
```

ISRaD.report	<i>ISRaD.report</i>
--------------	---------------------

Description

Generate basic summary reports of ISRaD data

Usage

```
ISRaD.report(database, report)
```

Arguments

database	ISRaD data object
report	Parameter to define which type of report you want. The default is "count.all" other options include "entry.stats", "count.frc", or "site.map".

Examples

```
# Obtain current ISRaD data
database <- ISRaD.getdata(tempdir(), dataset = "full", extra = FALSE)
# Report metadata statistics
ISRaD.report(database, report = "entry.stats")
# Report summary statistics for all levels of the database
ISRaD.report(database, report = "count.all")
# Generate a map of all ISRaD sites
ISRaD.report(database, report = "site.map")
```

ISRaD.save.xlsx	<i>ISRaD.save.xlsx</i>
-----------------	------------------------

Description

Saves ISRaD data object as .xlsx file in ISRaD template format

Usage

```
ISRaD.save.xlsx(database, template_file = system.file("extdata",
  "ISRaD_Master_Template.xlsx", package = "ISRaD"), outfile)
```

Arguments

- database ISRaD data object.
- template_file path and name of template file to use (defaults to ISRaD_Master_Template).
- outfile path and name to save the excel file

Author(s)

J Grey Monroe

Examples

```
# Load example dataset Gaudinski_2001
database <- ISRaD::Gaudinski_2001
ISRaD.save.xlsx(database = database,
  template_file = system.file("extdata", "ISRaD_Master_Template.xlsx", package = "ISRaD"),
  outfile = paste0(tempdir(), "/Gaudinski_2001.xlsx"))
```

QAQC	<i>QAQC</i>
------	-------------

Description

Check the imported soil carbon dataset for formatting and entry errors

Usage

```
QAQC(file, writeQCreport = F, outfile_QAQC = "", summaryStats = T,
  dataReport = F, checkdoi = T, verbose = T)
```


Arguments

file	directory to data file
writeQCreport	if TRUE, a text report of the QC output will be written to the outfile. Default is FALSE
outfile_QAQC	filename of the output file if writeQCreport==TRUE. Default is NULL, and the outfile will be written to the directory where the dataset is stored, and named by the dataset being checked.
summaryStats	prints summary statistics. Default is TRUE
dataReport	prints list structure of database. Default is FALSE
checkdoi	set to F if you do not want the QAQC check to validate doi numbers
verbose	set to TRUE to print results of function

Details

This function is also called by the online QAQC tool available at the ISRaD website <<http://soilradiocarbon.org>>.

Examples

```
# Load example dataset Gaudinski_2001
database <- ISRaD::Gaudinski_2001
# Save as .xlsx file
ISRaD.save.xlsx(database = database,
  template_file = system.file("extdata", "ISRaD_Master_Template.xlsx", package = "ISRaD"),
  outfile = paste0(tempdir(), "/Gaudinski_2001.xlsx"))
# Run QAQC
QAQC(paste0(tempdir(), "/Gaudinski_2001.xlsx"))
```

Index

*Topic **datasets**

- future14C, [3](#)
- Gaudinski_2001, [4](#)
- graven, [4](#)

- checkTemplateFiles, [2](#)
- compile, [3](#)

- future14C, [3](#)

- Gaudinski_2001, [4](#)
- graven, [4](#)

- ISRaD.extra, [5](#)
- ISRaD.extra.Cstocks, [5](#)
- ISRaD.extra.delta_delta, [6](#)
- ISRaD.extra.fill_14c, [7](#)
- ISRaD.extra.fill_coords, [8](#)
- ISRaD.extra.fill_dates, [9](#)
- ISRaD.extra.fill_fm, [9](#)
- ISRaD.extra.geospatial, [10](#)
- ISRaD.extra.geospatial.keys, [11](#)
- ISRaD.flatten, [12](#)
- ISRaD.getdata, [13](#)
- ISRaD.rep.count.all, [13](#)
- ISRaD.rep.count.frc, [14](#)
- ISRaD.rep.entry.stats, [14](#)
- ISRaD.rep.site.map, [15](#)
- ISRaD.report, [15](#)
- ISRaD.save.xlsx, [16](#)

- QAQC, [16](#)