Package ‘rintcal’

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Type Package

Title Radiocarbon Calibration Curves

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Description The IntCal20 radiocarbon calibration curves (Reimer et al. 2020 <doi:10.1017/RDC.2020.68>) are provided as a data package, together with previous IntCal curves (IntCal13, IntCal09, IntCal04, IntCal98), other curves (e.g., NOTCal04 [van der Plicht et al. 2004], Arnold & Libby 1951) and postbomb curves. Also provided are functions to copy the curves into memory, and to read, query and plot the data underlying the IntCal20 curves.

License GPL (>= 2)

RoxygenNote 7.3.2

Suggests knitr, rmarkdown, utf8

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`ccurve` *Copy a calibration curve*

Description

Copy one of the calibration curves into memory.

Usage

```
ccurve(
  cc = 1,
  postbomb = FALSE,
  cc.dir = NULL,
  resample = 0,
  glue = FALSE,
  as.F = FALSE
)
```

Arguments

`cc`	Calibration curve for 14C dates: `cc=1` for IntCal20 (northern hemisphere terrestrial), `cc=2` for Marine20 (marine), `cc=3` for SHCal20 (southern hemisphere terrestrial). Alternatively, one can also write, e.g., "IntCal20", "Marine13". One can also make a custom-built calibration curve, e.g. using `mix.ccurves()`, and load this using `cc=4`. In this case, it is recommended to place the custom calibration curve in its own directory, using `cc.dir` (see below).
`postbomb`	Use `postbomb=TRUE` to get a postbomb calibration curve (default `postbomb=FALSE`). For monthly data, type e.g. `ccurve("sh1-2_monthly")`
`cc.dir`	Directory of the calibration curves. Defaults to where the package's files are stored (system.file), but can be set to, e.g., `cc.dir="ccurves"`.
`resample`	The IntCal curves come at a range of 'bin sizes'; every year from 0 to 5 kcal BP, then every 5 yr until 15 kcal BP, then every 10 yr until 25 kcal BP, and every 20 year thereafter. The curves can be resampled to constant bin sizes, e.g. `resample=5`. Defaults to FALSE.
`glue`	If a postbomb curve is requested, it can be 'glued' to the pre-bomb curve. This feature is currently disabled - please use `glue.ccurves` instead

`as.F`	If loading a curve that contains 2 additional columns containing the D14C values, then these can be used instead of the curve's C14 ages and errors. Defaults to `as.F=FALSE`.

Details

Copy the radiocarbon calibration curve defined by cc into memory.

Value

The calibration curve (invisible).

References

Hammer and Levin 2017, "Monthly mean atmospheric D14CO2 at Jungfraujoch and Schauinsland from 1986 to 2016", heiDATA: Heidelberg Research Data Repository V2 doi:10.11588/data/10100

Heaton et al. 2020 Marine20-the marine radiocarbon age calibration curve (0-55,000 cal BP). Radiocarbon 62, 779-820, doi:10.1017/RDC.2020.68

Hogg et al. 2013 SHCal13 Southern Hemisphere Calibration, 0-50,000 Years cal BP. Radiocarbon 55, 1889-1903, doi:10.2458/azu_js_rc.55.16783

Hogg et al. 2020 SHCal20 Southern Hemisphere calibration, 0-55,000 years cal BP. Radiocarbon 62, 759-778, doi:10.1017/RDC.2020.59

Hua et al. 2013 Atmospheric radiocarbon for the period 1950-2010. Radiocarbon 55(4), doi:10.2458/azu_js_rc.v55i2.16177

Hua et al. 2022 Atmospheric radiocarbon for the period 1950-2019. Radiocarbon 64(4), 723-745, doi:10.1017/RDC.2021.95

Levin and Kromer 2004 The tropospheric 14CO2 level in mid latitudes of the Northern Hemisphere. Radiocarbon 46, 1261-1272

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Reimer et al. 2009 IntCal09 and Marine09 radiocarbon age calibration curves, 0-50,000 years cal BP. Radiocarbon 51, 1111-1150, doi:10.1017/S0033822200034202

Reimer et al. 2013 IntCal13 and Marine13 radiocarbon age calibration curves 0-50,000 years cal BP. Radiocarbon 55, 1869-1887, doi:10.2458/azu_js_rc.55.16947

Reimer et al. 2020 The IntCal20 Northern Hemisphere radiocarbon age calibration curve (0-55 cal kBP). Radiocarbon 62, 725-757, doi:10.1017/RDC.2020.41

Stuiver et al. 1998 INTCAL98 radiocarbon age calibration, 24,000-0 cal BP. Radiocarbon 40, 1041-1083, doi:10.1017/S0033822200019123

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Examples

```
intcal20 <- ccurve(1)
marine20 <- ccurve(2)
shcal20 <- ccurve(3)
marine98 <- ccurve("Marine98")
pb.sh3 <- ccurve("sh3")
```

---

copyCalibrationCurve *Copy a calibration curve*

Description

Copy one of the calibration curves into memory. Renamed to ccurve, and copyCalibrationCurve will become obsolete

Usage

```
copyCalibrationCurve(cc = 1, postbomb = FALSE)
```

Arguments

`cc`	Calibration curve for 14C dates: `cc=1` for IntCal20 (northern hemisphere terrestrial), `cc=2` for Marine20 (marine), `cc=3` for SHCal20 (southern hemisphere terrestrial). Alternatively, one can also write, e.g., "IntCal20", "Marine13".
`postbomb`	Use `postbomb=TRUE` to get a postbomb calibration curve (default `postbomb=FALSE`).

Details

Copy the radiocarbon calibration curve defined by cc into memory.

Value

The calibration curve (invisible).

---

glue.ccurves *Glue calibration curves*

Description

Produce a custom curve by merging two calibration curves, e.g. a prebomb and a postbomb one for dates which straddle both curves.

Usage

```
glue.ccurves(
  prebomb = "IntCal20",
  postbomb = "NH1",
  thisprebombcurve = c(),
  thispostbombcurve = c(),
  cc.dir = c()
)
```

Arguments

`prebomb` The prebomb curve. Defaults to "IntCal20"

`postbomb` The postbomb curve. Defaults to "NH1" (Hua et al. 2013)

`thisprebombcurve` As an alternative to using existing curves, a tailor-made curve can be provided for the prebomb curve (as three columns: cal BP, C14 age, error)

`thispostbombcurve` As an alternative to using existing curves, a tailor-made curve can be provided for the postbomb curve (as three columns: cal BP, C14 age, error)

`cc.dir` Directory of the calibration curves. Defaults to where the package's files are stored (system.file), but can be set to, e.g., `cc.dir="ccurves"`.

Value

The custom-made curve (invisibly)

Examples

```
my.cc <- glue.ccurves()
```

---

intcal *IntCal20 json file*

Description

The IntCal20 calibration curves and their underpinning data. This is based on a json file produced by Prof. Christopher Bronk Ramsey, University of Oxford.

Usage

```
intcal
```

Format

‘intcal‘ A list with six main entries:

json_application IntChron project name

records a list with 139 entries for each IntCal dataset

project_series_list a list with 5 entries: IntCal20, Marine20, SHCal20, a list of the underlying datasets, and a GICC vs IntCal20 comparison

parameters an empty list

bibliography a list with 141 bibliography entries

options a list of 17 options (not used)

Source

<https://intchron.org/archive/IntCal/IntCal20/index.json>

`intcal.data` *plot the IntCal20 data*

Description

plot the C14 ages underpinning the IntCal20/Marine20/SHCal20 calibration curves

Usage

```
intcal.data(
  cal1,
  cal2,
  cc1 = "IntCal20",
  cc2 = NA,
  calcurve.data = "IntCal20",
  select.sets = c(),
  realm = "C14",
  BCAD = FALSE,
  cal.lab = NA,
  cal.rev = FALSE,
  c14.lab = NA,
  c14.lim = NA,
  c14.rev = FALSE,
  ka = FALSE,
  cc1.col = rgb(0, 0, 1, 0.5),
  cc1.fill = rgb(0, 0, 1, 0.2),
  cc2.col = rgb(0, 0.5, 0, 0.5),
  cc2.fill = rgb(0, 0.5, 0, 0.2),
  data.cols = c(),
  data.pch = c(1, 2, 5, 6, 15:19),
```

```
  pch.cex = 0.5,
  legend.loc = "topleft",
  legend.ncol = 2,
  legend.cex = 0.7,
  cc.legend = "bottomright",
  bty = "l",
  ...
)
```

Arguments

`cal1`	First calendar year for the plot
`cal2`	Last calendar year for the plot
`cc1`	Name of the calibration curve. Can be "IntCal20", "Marine20", "SHCal20", or for the previous curves "IntCal13", "Marine13" or "SHCal13".
`cc2`	Optional second calibration curve to plot. Can be "IntCal20", "Marine20", "SHCal20", or for the previous curves "IntCal13", "Marine13" or "SHCal13". Defaults to nothing, NA.
`calcurve.data`	Which dataset to use. Defaults to `calcurve.data="IntCal20"`, but can also be `calcurve.data="SHCal20"`. Note that Marine20 is based on IntCal20 and a marine carbon cycle model.
`select.sets`	Which datasets to plot. Defaults to all datasets within the selected period.
`realm`	Which 'realm' of radiocarbon to use. Defaults to `realm="C14"` but can also be set to `realm="F14C"`, `realm="pMC"` or `realm="D14C"`. Can be shorted to, respectively, "C", "F", "P" or "D" (or their lower-case equivalents).
`BCAD`	The calendar scale of graphs and age output-files is in cal BP (calendar or calibrated years before the present, where the present is AD 1950) by default, but can be changed to BC/AD using `BCAD=TRUE`.
`cal.lab`	The labels for the calendar axis (default `age.lab="cal BP"` or `"BC/AD"` if `BCAD=TRUE`), or to `age.lab="kcal BP"` etc. if ka=TRUE.
`cal.rev`	Reverse the calendar axis.
`c14.lab`	Label for the C-14 axis. Defaults to 14C BP (or 14C kBP if ka=TRUE).
`c14.lim`	Axis limits for the C-14 axis. Calculated automatically by default.
`c14.rev`	Reverse the C-14 axis.
`ka`	Use kcal BP (and C14 kBP).
`cc1.col`	Colour of the calibration curve (outline).
`cc1.fill`	Colour of the calibration curve (fill).
`cc2.col`	Colour of the calibration curve (outline), if activated (default cc2=NA).
`cc2.fill`	Colour of the calibration curve (fill), if activated (default cc2=NA).
`data.cols`	colours of the data points. Defaults to R's colours 1 to 8 (black, red, green, darkblue, lightblue, purple, orange, and grey)
`data.pch`	Symbols of the data points. Defaults to R's symbols 1, 2, 5, 6, and 15 to 19 (open circle, open upward triangle, open diamond, open downward triangle, closed square, closed circle, closed upward triangle, closed diamond)

`pch.cex`	Size of the data symbols. Defaults to 0.5.
`legend.loc`	Location of the data legend. Defaults to topleft. Set to NA for no plotting.
`legend.ncol`	Number of columns of the data legend.
`legend.cex`	Size of the legend. Defaults to 0.7.
`cc.legend`	Location of the legend for the calibration curve(s).
`bty`	Box type around the plot. Defaults to "l"-shaped.
`...`	Any additional optional plotting parameters.

Details

These datasets were downloaded from Intcal.org. All data have both uncertainties in C14 age and on the calendar scale. For trees this is the sample thickness (e.g., 10 years or 1 year). The name of each dataset starts with a lower-case letter which indicates their nature (t = tree-rings, l = lake sediment, c = coral, m = marine sediment, s = speleothem), followed by either the radiocarbon laboratory's placename or the lastname of the main author. Most of the tree-ring datasets are dated at calendar year precision; tSeattle (references 1-2), tBelfast (3-5), tWaikato (4-7), tGroningen (8-10), tHeidelberg (11-14), tPretoria (16), tIrvine (17-20), tGalimberti (21), tMannheim (22-25), tAix (26-27), tAarhus (22, 28-30), tManningKromer (31-32), tVienna (33-34), tTokyo (35-39), tArizona (40), tMiyake (41), tPearson (22, 41-45), and tZurich (22-23, 25, 41, 43, 46-49). Horizontal error bars for these series indicate the numbers of rings in the samples (e.g., 10 tree-rings; 1-yr samples do not have error bars). Additionally, there are some floating tree-ring datasets with imprecisely known calendar ages; tAdolphy (50) and tTurney (51-52). For these and the following datasets, horizontal error bars indicate their 1 sd calendar age uncertainties. Beside trees, other datasets include lake sediment (lSuigestu, 53-54), corals (cBard 55-56, cFairbanks 57, cCutler 58 and cDurand 61, marine sediment (mCariaco 59-60, 62-63, mBard 64-65) and speleothems (sSouthon 66-67, sHoffman 68, sBeck 69). The southern hemisphere calibration curve SHCal20 is mostly modelled on IntCal20, but it contains datasets from the southern hemisphere; tPretoria (70), tWaikato (72-75), tBelfast (76-67), tSydney (78-80), tLivermore (81), tArizona, tIrvineWaikato and tZurich (82-83).

Value

A plot of the IntCal curve and the underlying data, as well as (invisibly) the data themselves

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Examples

```
intcal.data(100, 200)
intcal.data(40e3, 55e3, ka=TRUE)
# plot Suigetsu and Cariaco data only
dat <- intcal.data(20e3, 25e3)
unique(dat$set) # ordered against their appearance in the plot's legend
dat <- intcal.data(20e3, 25e3, select.sets=c(109, 120), data.cols=c(1,2))
```

intcal.data.frames — *Extract from the intcal file*

Description

Extract items from the intcal json file.

Usage

```
intcal.data.frames(obj, ...)
```

Arguments

`obj`	Name of the object
`...`	Additional options can be provided, see examples

Examples

```
intcal <- intcal.read.data()
# all datasets from the Southern Hemisphere:
sh.data <- intcal.data.frames(intcal, intcal_set_type='SH')
head(sh.data)
Irish.oaks <- intcal.data.frames(intcal, intcal_set=3)
head(Irish.oaks[[2]]$data)
```

intcal.read.data — *Read data underlying the IntCal curves.*

Description

Download the json file that contains the IntCal20 radiocarbon calibration curves and the contributing data series.

Usage

```
intcal.read.data(from.intchron.org = FALSE, from.jsonfile = FALSE)
```

Arguments

`from.intchron.org`	Download the IntCal20 json file the inchron.org server. Defaults to FALSE, and then the data will be loaded from within the rintcal package
`from.jsonfile`	The name and location of the json file (if used). Defaults to FALSE, and then the data will be loaded from within the rintcal package

Details

The intcal curves consist of the IntCal20, SHCal20 and Marine20 calibration curves. The details of these curves can be loaded, as well as the underlying data such as tree-ring records.

Examples

```
intcal <- intcal.read.data()
```

`intcal.write.data` *Write intcal data to a file.*

Description

Write the intcal.json file that comes with the rintcal packages to somewhere local. This can be useful if you want to avoid repeatedly downloading the json file from intchron.org.

Usage

```
intcal.write.data(data, fname)
```

Arguments

`data`	intcal variable as obtained from intcal.read.data()
`fname`	Name of the file to be written

Examples

```
intcal <- intcal.read.data()
myintcal <- tempfile()
intcal.write.data(intcal, myintcal)
```

`list.ccurves` *List the calibration curves*

Description

List the file names of the calibration curves available within the rintcal package.

Usage

```
list.ccurves()
```

Value

A list of the available calibration curves

mix.ccurves	*Build a custom-made, mixed calibration curve.*

Description

If two curves need to be 'mixed' to calibrate, e.g. for dates of mixed terrestrial and marine carbon sources, then this function can be used. The curve will be returned invisibly, or saved in a temporary directory together with the main calibration curves. This temporary directory then has to be specified in further commands, e.g. for rbacon: `Bacon(, cc.dir=tmpdr)` (see examples). It is advisable to make your own curves folder and have cc.dir point to that folder.

Usage

```
mix.ccurves(
  proportion = 0.5,
  cc1 = "IntCal20",
  cc2 = "Marine20",
  postbomb1 = FALSE,
  postbomb2 = FALSE,
  name = "mixed.14C",
  cc.dir = c(),
  thiscurve1 = c(),
  thiscurve2 = c(),
  save = FALSE,
  offset = cbind(0, 0),
  round = c(),
  sep = " "
)
```

Arguments

`proportion`	Proportion of the first calibration curve required. e.g., change to `proportion=0.7` if `cc1` should contribute 70% (and `cc2` 30%) to the mixed curve.
`cc1`	The first calibration curve to be mixed. Defaults to the northern hemisphere terrestrial curve IntCal20.
`cc2`	The second calibration curve to be mixed. Defaults to the marine curve IntCal20.
`postbomb1`	Option to provide a postbomb curve for the first curve (defaults to FALSE).
`postbomb2`	Option to provide a postbomb curve for the second curve (defaults to FALSE).
`name`	Name of the new calibration curve.
`cc.dir`	Name of the directory where to save the file. Since R does not allow automatic saving of files, this points to a temporary directory by default. Adapt to your own folder, e.g., `cc.dir="~/ccurves"` or in your current working directory, `cc.dir="."`.
`thiscurve1`	As an alternative to using curves that come with the package, a tailor-made curve can be provided for the first curve (as three columns: cal BP, C14 age, error).

thiscurve2	As an alternative to using curves that come with the package, a tailor-made curve can be provided for the second curve (as three columns: cal BP, C14 age, error).
save	Save the curve in the folder specified by dir. Defaults to FALSE.
offset	Any offset and error to be applied to cc2 (default 0 +- 0). Entered as two columns (possibly of just one row), e.g. `offset=cbind(100,0)`
round	The entries can be rounded to a specified amount of decimals. Defaults to no rounding.
sep	Separator between fields (tab by default, "\t")

Details

The proportional contribution of each of both calibration curves has to be set.

Value

A file containing the custom-made calibration curve, based on calibration curves cc1 and cc2.

Examples

```
tmpdir <- tempdir()
new.ccdir(tmpdir)
mix.ccurves(cc.dir=tmpdir)
# now assume the offset is constant but its uncertainty increases over time:
cc <- ccurve()
offset <- cbind(rep(100, nrow(cc)),  seq(0, 1e3, length=nrow(cc)))
# clean up:
unlink(tmpdir)
```

---

new.ccdir *Make directory and fill with calibration curves*

Description

Make an alternative 'curves' directory and fill it with the calibration curves.

Usage

```
new.ccdir(cc.dir)
```

Arguments

cc.dir	Name and location of the new directory. For example, this could be a folder called 'ccurves', living within the current working directory, `cc.dir="./ccurves"`.

Details

Copies all calibration curves within the 'rintcal' package to the new directory.

Value

A message informing the user the name of the folder into which the calibration curves have been copied.

Examples

```
new.ccdir(tempdir())
```

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