Package ‘rintcal’

October 6, 2023

Type Package

Title Radiocarbon Calibration Curves

Version 0.6.4

Author Maarten Blaauw [aut, cre] (<https://orcid.org/0000-0002-5680-1515>)

Maintainer Maarten Blaauw <maarten.blaauw@qub.ac.uk>

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) and postbomb curves. Also provided are functions to copy the curves into memory, to plot the curves and their underlying data, to calibrate radiocarbon dates and to transform between different radiocarbon 'domains'.

License GPL (>= 2)

RoxygenNote 7.2.3

Suggests knitr, rmarkdown, utf8

VignetteBuilder knitr

Encoding UTF-8

NeedsCompilation no

Imports data.table, jsonlite

Language en-GB

Depends R (>= 3.5.0)

LazyData true

Repository CRAN

Date/Publication 2023-10-06 13:00:03 UTC

R topics documented:

`age.F14C` *Calculate F14C values from C14 ages*

Description

Calculate F14C values from radiocarbon ages

Usage

```
age.F14C(mn, sdev = c(), decimals = 5, lambda = 8033)
```

Arguments

`mn`	Reported mean of the 14C age.
`sdev`	Reported error of the 14C age. If left empty, will translate mn to F14C.
`decimals`	Amount of decimals required for the F14C value. Defaults to 5.
`lambda`	The mean-life of radiocarbon (based on Libby half-life of 5568 years)

Details

Post-bomb dates are often reported as F14C or fraction modern carbon. Since Bacon expects radiocarbon ages, this function can be used to calculate F14C values from radiocarbon ages. The reverse function of F14C.age.

Value

F14C values from C14 ages.

Examples

```
age.F14C(-2000, 20)
```

`age.pMC` *Calculate pMC values from C14 ages*

Description

Calculate pMC values from radiocarbon ages

Usage

```
age.pMC(mn, sdev = c(), ratio = 100, decimals = 5, lambda = 8033)
```

Arguments

`mn`	Reported mean of the 14C age.
`sdev`	Reported error of the 14C age.
`ratio`	Most modern-date values are reported against `100`. If it is against `1` instead, a warning is provided; use `age.F14C`.
`decimals`	Amount of decimals required for the pMC value. Defaults to 5.
`lambda`	The mean-life of radiocarbon (based on Libby half-life of 5568 years)

Details

Post-bomb dates are often reported as pMC or percent modern carbon. Since Bacon expects radiocarbon ages, this function can be used to calculate pMC values from radiocarbon ages. The reverse function of pMC.age.

Value

pMC values from C14 ages.

Examples

```
age.pMC(-2000, 20)
age.pMC(-2000, 20, 1)
```

calBP.14C *Find the 14C age and error belonging to a cal BP age.*

Description

Given a calendar age, the calibration curve (default cc=1) is interpolated and the corresponding 14C age and error are returned.

Usage

```
calBP.14C(yr, cc = 1, postbomb = FALSE, rule = 1, cc.dir = NULL)
```

Arguments

yr	The cal BP year.
cc	calibration curve for C14 (see `caldist()`).
postbomb	Whether or not to use a postbomb curve (see `caldist()`).
rule	How should R's approx function deal with extrapolation. If `rule=1`, the default, then NAs are returned for such points and if it is 2, the value at the closest data extreme is used.
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="curves"`.

Details

Interpolation is used, and values outside the calibration curve are given as NA. For negative cal BP ages, a postbomb curve will have to be provided.

Value

The calibration-curve 14C year belonging to the entered cal BP age

Author(s)

Maarten Blaauw

Examples

```
calBP.14C(100)
```

caldist *Calculate calibrated distribution*

Description

Calculate the calibrated distribution of a radiocarbon date.

Usage

```
caldist(
  age,
  error,
  cc = 1,
  postbomb = FALSE,
  thiscurve = c(),
  yrsteps = FALSE,
  cc.resample = FALSE,
  dist.res = 200,
  threshold = c(),
  normal = TRUE,
  t.a = 3,
  t.b = 4,
  normalise = TRUE,
  BCAD = FALSE,
  rule = 1,
  cc.dir = NULL
)
```

Arguments

`age`	Uncalibrated radiocarbon age
`error`	Lab error of the radiocarbon age
`cc`	Calibration curve to use. Defaults to IntCal20 (`cc=1`).
`postbomb`	Whether or not to use a postbomb curve. Required for negative radiocarbon ages.
`thiscurve`	As an alternative to providing cc and/or postbomb, the data of a specific curve can be provided (3 columns: cal BP, C14 age, error). Defaults to FALSE.
`yrsteps`	Steps to use for interpolation. Defaults to the cal BP steps in the calibration curve
`cc.resample`	The IntCal20 curves have different densities (every year between 0 and 5 kcal BP, then every 5 yr up to 15 kcal BP, then every 10 yr up to 25 kcal BP, and then every 20 yr up to 55 kcal BP). If calibrated ages span these density ranges, their drawn heights can differ, as can their total areas (which should ideally all sum to the same size). To account for this, resample to a constant time-span, using, e.g., `cc.resample=5` for 5-yr timespanes.

dist.res	As an alternative to yrsteps, provide the amount of 'bins' in the distribution
threshold	Report only values above a threshold. Defaults to `threshold=1e-3` for prebomb dates and `threshold=1e-7` for postbomb dates.
normal	Use the normal distribution to calibrate dates (default TRUE). The alternative is to use the t model (Christen and Perez 2016).
t.a	Value a of the t distribution (defaults to 3).
t.b	Value a of the t distribution (defaults to 4).
normalise	Sum the entire calibrated distribution to 1. Defaults to `normalise=TRUE`.
BCAD	Which calendar scale to use. Defaults to cal BP, `BCAD=FALSE`.
rule	Which extrapolation rule to use. Defaults to `rule=1` which returns NAs.
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="curves"`.

Value

The probability distribution(s) as two columns: cal BP ages and their associated probabilities

Examples

```
calib <- caldist(130,10)
plot(calib, type="l")
postbomb <- caldist(-3030, 20, postbomb=1, BCAD=TRUE)
```

---

calibrate *Plot individual calibrated dates.*

Description

Calibrate individual 14C dates, plot them and report calibrated ranges.

Usage

```
calibrate(
  age = 2450,
  error = 50,
  cc = 1,
  postbomb = FALSE,
  reservoir = 0,
  prob = 0.95,
  BCAD = FALSE,
  ka = FALSE,
  cal.lab = c(),
  C14.lab = c(),
  cal.lim = c(),
  C14.lim = c(),
```

```
    cc.col = rgb(0, 0.5, 0, 0.7),
    cc.fill = rgb(0, 0.5, 0, 0.7),
    date.col = "red",
    dist.col = rgb(0, 0, 0, 0.2),
    dist.fill = rgb(0, 0, 0, 0.2),
    hpd.fill = rgb(0, 0, 0, 0.3),
    dist.height = 0.3,
    dist.float = c(0.01, 0.01),
    cal.rev = FALSE,
    yr.steps = FALSE,
    threshold = c(),
    edge = TRUE,
    normal = TRUE,
    t.a = 3,
    t.b = 4,
    rounded = 1,
    extend.range = 0.05,
    legend.cex = 0.8,
    legend1.loc = "topleft",
    legend2.loc = "topright",
    mgp = c(2, 1, 0),
    mar = c(3, 3, 1, 1),
    xaxs = "i",
    yaxs = "i",
    bty = "l",
    cc.dir = NULL,
    ...
)
```

Arguments

age	Mean of the uncalibrated C-14 age.
error	Error of the uncalibrated C-14 age.
cc	Calibration curve for C-14 dates (1, 2, 3, or 4, or, e.g., "IntCal20", "Marine20", "SHCal20", "nh1", "sh3", or "mixed").
postbomb	Whether or not this is a postbomb age. Defaults to FALSE.
reservoir	Reservoir age, or reservoir age and age offset.
prob	Probability confidence intervals (between 0 and 1).
BCAD	Use BC/AD or cal BP scale (default cal BP).
ka	Use thousands of years instead of years in the plots and hpd ranges. Defaults to FALSE.
cal.lab	Label of the calendar/horizontal axis. Defaults to the calendar scale, but alternative names can be provided.
C14.lab	Label of the C-14/vertical axis. Defaults to the 14C scale, but alternative names can be provided.
cal.lim	Minimum and maximum of calendar axis (default calculated automatically).

C14.lim	Minimum and maximum of C-14 axis (default calculated automatically).
cc.col	Colour of the lines of the calibration curve. Defaults to semi-transparent dark green; `cc.col=rgb(0,.5,0,0.7)`.
cc.fill	Colour of the inner part of the calibration curve. Defaults to semi-transparent dark green; `cc.col=rgb(0,.5,0,0.7)`.
date.col	Colour of the "dot-bar" plot of the C14 date. Defaults to `date.col="red"`.
dist.col	Colour of the outer lines of the distributions. Defaults to semi-transparent grey, `dist.col=rgb(0,0,0,0.2)`.
dist.fill	Colour of the inner part of the distributions. Defaults to semi-transparent grey, `dist.col=rgb(0,0,0,0.2)`.
hpd.fill	Colour of the highest posterior density. Defaults to semi-transparent grey, `dist.col=rgb(0,0,0,0.3)`.
dist.height	Maximum height of the C14 and calibrated distributions (as proportion of the invisible secondary axes). Defaults to 0.3.
dist.float	The probability distributions float a bit above the axes by default. Can be set to distinct heights of the axes, e.g.: `dist.float=c(0.05, 0.1)`, or to `dist.float=0`.
cal.rev	Whether or not to reverse the direction of the calendar axis.
yr.steps	Temporal resolution at which C-14 ages are calibrated (in calendar years). By default follows the spacing in the calibration curve.
threshold	Below which value should probabilities be excluded from calculations.
edge	How to treat dates are at or beyond the edge of the calibration curve. If dates are truncated, a warning is given. If they lie beyond the calibration curve, an error is given.
normal	Use the normal distribution to calibrate dates (default TRUE). The alternative is to use the t model (Christen and Perez 2016).
t.a	Value a of the t distribution (defaults to 3).
t.b	Value a of the t distribution (defaults to 4).
rounded	Rounding of the percentages of the reported hpd ranges. Defaults to 1 decimal.
extend.range	Range by which the axes are extended beyond the data limits. Defaults to 5%.
legend.cex	Size of the font of the legends. Defaults to 0.8.
legend1.loc	Where the first legend (with the calibration curve name and the uncalibrated date) is plotted. Defaults to topleft.
legend2.loc	Where the second legend (with the hpd ranges) is plotted. Defaults to topright.
mgp	Axis text margins (where should titles, labels and tick marks be plotted).
mar	Plot margins (amount of white space along edges of axes 1-4).
xaxs	Whether or not to extend the limits of the horizontal axis. Defaults to `xaxs="i"` which does not extend the limits.
yaxs	Whether or not to extend the limits of the vertical axis. Defaults to `yaxs="i"` which does not extend the limits.
bty	Draw a box around the graph ("n" for none, and "l", "7", "c", "u", "]" or "o" for correspondingly shaped boxes).
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="curves"`.
...	Other plotting parameters.

Details

Type `calibrate()` to see how a date of 2450 +- 50 14C BP gets calibrated (the calibration curve happens to show a plateau around this 14C age). To calibrate a different date, provide its reported mean and error (1 standard deviation error as reported by the radiocarbon laboratory) as follows: `calibrate(mean, error)`, e.g., for a date of 130 +- 10 14C BP, type calibrate`(age=130, error=10)` or, shorter, `calibrate(130,10)`.

In case the date has a reservoir effect or age offset, e.g. of 100 14C years, provide this as follows: `calibrate(130, 10, reservoir=100)`. If you want to include an uncertainty for this offset, provide this as follows, e.g., for an uncertainty of 50yr, `calibrate(130,10,reservoir=c(100, 50))`. The uncertainty for the age offset will then be added to the error (by taking the square root of the sum of the squared error and the squared offset uncertainty). If the carbon of your sample has mixed marine/terrestrial sources, instead apply the marine offset using mix.curves and calibrate the date using that custom-built curve (cc="mixed").

If you prefer to work with, e.g., 68 % as opposed to the default 95 % confidence intervals, type: `calibrate(130, 10, prob=0.68)` or `calibrate(130, 10,, 0.68)` (the commas between the brackets indicate the position of the option; the standard deviation is the fourth option of the `calibrate` function). The calibrated distribution can be calculated for every single calendar year (`yrsteps=1`) within a wide range of the 14C date. Probabilities below a threshold (default `threshold=0.0005`) will be neglected.

By default the northern hemisphere terrestrial calibration curve is used (`cc=1 or cc1="IntCal20"`). To use alternative curves, use `cc=2` (`cc2="Marine20"`), `cc=3` (`cc3="SHCal20C"`), `cc=4` (`cc4="mixed.14C"`), or specify a postbomb curve (e.g., `cc="nh1"`).

Calibrate works in cal BP (calendar years before AD 1950) by default, but can work with cal BC/AD through the option `BCAD=TRUE`.

By default the Gaussian distribution is used to calibrate dates. For use of the t distribution (Christen and Perez 2016) instead, set `normal=FALSE` provide values for t.a and t.b (defaults to `t.a=3` and `t.b=4`).

Calibrated distributions are usually reduced to their 68% or 95% calibrated ranges, taking into account the asymmetric and multi-peaked shape of these distributions. Calibrated ranges at 68% will obviously result in narrower confidence intervals, and a perceived higher precision, than 95% ranges. However, given the often asymmetric and multi-modal nature of calibrated distributions, the probability that the 'true' calendar date lies outside the 1 standard deviation hpd ranges is considerable (c. 32%). Therefore the use of 95% calibrated ranges is preferable, and default.

Negative radiocarbon ages are calibrated with postbomb curves, but the user needs to tell which curve to use. For example, to use the first of the three northern hemisphere curves, provide the option `cc="nh1"`, `cc="nh2"`, `cc="nh3"`, while for southern hemisphere samples, use `cc="sh1-2"` or `cc="sh3"`.

A graph of the calibration is produced, and it can be adapted in several ways. The limits of the horizontal (calendar scale) and vertical (14C scale) axes are calculated automatically but can be changed by providing alternative values for the options `cal.lim`, `C14.lim`. The titles of both axis can be changed by providing alternative titles to `cal.lab` and/or `C14.lab`. The heights of the distributions of the 14C and calibrated ages can be set to alternative values using `dist.height` (default `0.3` which plots the distribution up to 30% of the height of the entire graph). Parameters for white space around the graph can be changed (default `mar=c(3.5, 2, 2, 1)` for spacing below, to the left, above and to the right respectively), as can the spacing for the axis labels (`mgp=c(2,1,0)`).

By default, the axes are connected at the lower left, `bty="l"`. Check the R documentation of `par()` for more options.

The colours of the 14C date, the calibration curve, the distributions, and the highest posterior density (hpd) ranges, can be changed by providing an alternative colour in `date.col`, `cc.col`, `dist.col`, and/or `hpd.col`, respectively. The default colours are transparent grey for the dates probability distributions (`dist.col=rgb(0,0,0, 0.3)` and `sd.col=rgb(0,0,0, 0.5)`; change the last value of rgb for different greyscale values), red for the uncalibrated mean and error bars (`date.col="red"`), and transparent green for the calibration curve (`cc.col=rgb(0, 0.5, 0, 0.7)`). R's rgb() function expects values between `0` and `1` for red, green and blue, respectively, followed by a value for the semi-transparency (also between 0 and 1). Some graphic devices such as postscript are unable to use transparency; in that case provide different colours or leave the fourth value empty.

Value

A graph of the raw and calibrated C-14 date, the calibrated ranges and, invisibly, the calibrated distribution and hpd ranges.

Examples

```
calibrate()
calibrate(130, 10)
cal <- calibrate(2550, 20, reservoir=100)
cal; plot(cal[[1]])
calibrate(130, 10, prob=0.68)
calibrate(age=130, error=10, BCAD=TRUE)
calibrate(4450, 40, reservoir=c(100, 50))
```

`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)
```

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

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

Reimer et al. 2004 IntCal04 terrestrial radiocarbon age calibration, 0-26 cal kyr BP. Radiocarbon 46, 1029-1058, doi:10.1017/S0033822200032999

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

Examples

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

---

contaminate — *Simulate the impact of contamination on a radiocarbon age*

Description

Given a certain radiocarbon age, calculate the observed impact of contamination with a ratio of material with a different 14C content (for example, 1

Usage

```
contaminate(y, sdev = c(), fraction, F14C, F14C.er = 0, decimals = 5)
```

Arguments

`y`	the true radiocarbon age
`sdev`	the error of the true radiocarbon age
`fraction`	Relative amount of contamination. Must be between 0 and 1
`F14C`	the F14C of the contamination. Set at 1 for carbon of modern radiocarbon age, at 0 for 14C-free carbon, or anywhere inbetween.
`F14C.er`	error of the contamination. Defaults to 0.
`decimals`	Rounding of the output. Since details matter here, the default is to provide 5 decimals.

Value

The observed radiocarbon age and error

Author(s)

Maarten Blaauw

Examples

```
contaminate(5000, 20, .01, 1) # 1% contamination with modern carbon
# Impacts of different amounts of contamination with modern carbon:
real.14C <- seq(0, 50e3, length=200)
contam <- seq(0, .1, length=101) # 0 to 10% contamination
contam.col <- rainbow(length(contam))
plot(0, type="n", xlim=c(0, 55e3),
  xlab="real", ylim=range(real.14C), ylab="observed")
```

```
for(i in 1:length(contam))
  lines(real.14C, contaminate(real.14C, c(), contam[i], 1, decimals=5), col=contam.col[i])
contam.legend <- seq(0, .1, length=6)
contam.col <- rainbow(length(contam.legend))
text(52e3, contaminate(50e3, c(), contam.legend, 1), labels=contam.legend, col=contam.col, cex=.7)
```

`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).

`D14C.F14C` *Transform D14C into F14C*

Description

Transform D14C into F14C

Usage

```
D14C.F14C(D14C, t)
```

Arguments

D14C	The Delta14C value to translate
t	the cal BP age

Details

As explained by Heaton et al. 2020 (Radiocarbon), 14C measurements are commonly expressed in three domains: Delta14C, F14C and the radiocarbon age. This function translates Delta14C, the historical level of Delta14C in the year t cal BP, to F14C values. Note that per convention, this function uses the Cambridge half-life, not the Libby half-life.

Value

The corresponding F14C value

Examples

```
D14C.F14C(-10, 238)
```

---

draw.ccurve *Draw a calibration curve.*

Description

Draw one or two of the calibration curves, or add a calibration curve to an existing plot.

Usage

```
draw.ccurve(
  cal1 = c(),
  cal2 = c(),
  cc1 = "IntCal20",
  cc2 = NA,
  cc1.postbomb = FALSE,
  cc2.postbomb = FALSE,
  BCAD = FALSE,
  cal.lab = NA,
  cal.rev = FALSE,
  c14.lab = NA,
  c14.lim = NA,
  c14.rev = FALSE,
  ka = FALSE,
  add.yaxis = 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),
```

```
  add = FALSE,
  bty = "l",
  cc.dir = NULL,
  legend = "topleft",
  ...
)
```

Arguments

cal1	First calendar year for the plot. Defaults to 0 cal BP.
cal2	Last calendar year for the plot. Defaults to 55,000 cal BP.
cc1	Name of the calibration curve. Can be "IntCal20", "Marine20", "SHCal20", or for the previous curves "IntCal13", "Marine13" or "SHCal13". Can also be "nh1", "nh2", "nh3", "sh1-2", "sh3", "nh1_monthly", "nh1_monthly", "nh2_monthly", "nh3_monthly", "sh1-2_monthly", "sh3_monthly", "Kure", "LevinKromer" or "Santos" for postbomb curves.
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.
cc1.postbomb	Use `postbomb=TRUE` to get a postbomb calibration curve for cc1 (default `cc1.postbomb=FALSE`).
cc2.postbomb	Use `postbomb=TRUE` to get a postbomb calibration curve for cc2 (default `cc2.postbomb=FALSE`).
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).
add.yaxis	Whether or not to plot the second calibration. Defaults to `add.yaxis=FALSE`.
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).
add	Whether or not to add the curve(s) to an existing plot. Defaults to FALSE, which draws a new plot
bty	Draw a box around a box of a certain shape. Defaults to `bty="l"`.
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="curves"`.
legend	Location of the legend (only activated if more than one curve is plotted). Plotted in the topleft corner by default. Use `legend=c()` to leave empty
...	Any additional optional plotting parameters.

Value

A plot of the calibration curve

Examples

```
draw.ccurve()
draw.ccurve(1000, 3000, cc2="Marine20")
draw.ccurve(1800, 2020, BCAD=TRUE, cc2="nh1", cc2.postbomb=TRUE)
draw.ccurve(1800, 2010, BCAD=TRUE, cc2="nh1", add.yaxis=TRUE)
```

---

draw.contamination *Draw contamination impacts*

Description

Show how contamination with different fractions of modern carbon affect observed C-14 ages.

Usage

```
draw.contamination(
  from = 0,
  to = 50000,
  ka = TRUE,
  age.res = 500,
  xlim = c(),
  ylim = c(),
  colours = rainbow(age.res),
  max.contam = 0.1,
  contam.F14C = 1,
  contam.legend = max.contam * c(1/100, (1:5)/50, (1:4)/5, 1),
  legend.pos = 0.07,
  legend.cex = 0.6,
  grid = TRUE,
  xaxs = "i",
  yaxs = "i"
)
```

Arguments

`from`	Minimum 14C age for the plot. Defaults to 0
`to`	Maximum 14C age for the plot. Defaults to 50e3.
`ka`	Use C14 kBP. Defaults to TRUE.
`age.res`	Resolution of age scale. Defaults to 500, which results in smooth curves. Higher numbers will take longer to draw.
`xlim`	Limits of the horizontal axis.
`ylim`	Limits of the vertical axis.

`colours`	Colours of the percentages. Defaults to rainbow colours.
`max.contam`	Maximum contamination level as a fraction of the sample. Defaults to 0.1 (10%).
`contam.F14C`	14C activity of the sample. Defaults to 'modern' 14C, F14C=1.
`contam.legend`	Percentages for which numbers will be plotted.
`legend.pos`	horizontal position beyond which the percentage values will be plotted
`legend.cex`	font size of the legend
`grid`	Whether to plot a grid. Defaults to TRUE
`xaxs`	Whether or not to extend the limits of the horizontal axis. Defaults to `xaxs="i"` which does not extend.
`yaxs`	Whether or not to extend the limits of the vertical axis. Defaults to `yaxs="i"` which does not extend.

Value

A plot of real and observed (contamination-impacted) C14 ages.

Examples

```
draw.contamination()
draw.contamination(40e3, 50e3, ka=FALSE)
```

`draw.D14C` *Draw d14C and the calibration curve.*

Description

Draw a proxy of the atmospheric 14C concentration (d14C) as well as the calibration curve.

Usage

```
draw.D14C(
  cal1 = c(),
  cal2 = c(),
  cc = ccurve(),
  BCAD = FALSE,
  mar = c(4, 4, 1, 4),
  mgp = c(2.5, 1, 0),
  xaxs = "r",
  yaxs = "r",
  bty = "u",
  ka = FALSE,
  cal.lab = c(),
  cal.rev = FALSE,
  C14.lab = c(),
```

```
  C14.lim = c(),
  cc.col = rgb(0, 0.5, 0, 0.5),
  cc.border = rgb(0, 0.5, 0, 0.5),
  D14C.lab = c(),
  D14C.lim = c(),
  D14C.col = rgb(0, 0, 1, 0.5),
  D14C.border = rgb(0, 0, 1, 0.5)
)
```

Arguments

`cal1`	First calendar year for the plot. Defaults to youngest calendar age of the calibration curve
`cal2`	Last calendar year for the plot. Defaults to oldest calendar age of the calibration curve
`cc`	The calibration curve to use. Defaults to IntCal20
`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`.
`mar`	Plot margins (amount of white space along edges of axes 1-4).
`mgp`	Axis text margins (where should titles, labels and tick marks be plotted).
`xaxs`	Whether or not to extend the limits of the horizontal axis. Defaults to `xaxs="r"` which extends it by R's default.
`yaxs`	Whether or not to extend the limits of the vertical axis. Defaults to `yaxs="r"` which extends it by R's default.
`bty`	Draw a box around the graph ("n" for none, and "l", "7", "c", "u", "]" or "o" for correspondingly shaped boxes).
`ka`	Use kcal BP (and C14 kBP). Defaults to FALSE.
`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 (defaults to FALSE).
`C14.lab`	Label for the C-14 axis. Defaults to 14C BP (or 14C kBP if ka=TRUE).
`C14.lim`	Limits for the C-14 axis. Calculated automatically by default.
`cc.col`	Colour of the calibration curve (fill).
`cc.border`	Colour of the calibration curve (border).
`D14C.lab`	Label for the D14C axis.
`D14C.lim`	Axis limits for the D14C axis. Calculated automatically by default.
`D14C.col`	Colour of the D14C curve (fill).
`D14C.border`	Colour of the D14C curve (border).

Value

A plot of d14C and the calibration curve

Examples

```
draw.D14C()
draw.D14C(30e3, 55e3, ka=TRUE)
draw.D14C(cc=ccurve("NH1_monthly"), BCAD=TRUE)
```

---

draw.dates *add calibrated distributions to a plot.*

Description

Add individual or multiple calibrated dates to a plot.

Usage

```
draw.dates(
  age,
  error,
  depth,
  cc = 1,
  postbomb = FALSE,
  reservoir = c(),
  normal = TRUE,
  t.a = 3,
  t.b = 4,
  prob = 0.95,
  threshold = 0.001,
  BCAD = FALSE,
  draw.hpd = TRUE,
  hpd.lwd = 2,
  hpd.col = rgb(0, 0, 1, 0.7),
  cal.hpd.col = rgb(0, 0.5, 0.5, 0.35),
  mirror = TRUE,
  up = FALSE,
  draw.base = TRUE,
  col = rgb(0, 0, 1, 0.3),
  border = rgb(0, 0, 1, 0.5),
  cal.col = rgb(0, 0.5, 0.5, 0.35),
  cal.border = rgb(0, 0.5, 0.5, 0.35),
  add = FALSE,
  ka = FALSE,
  rotate.axes = FALSE,
  ex = 1,
  normalise = TRUE,
  cc.resample = 5,
  age.lab = c(),
  age.lim = c(),
  age.rev = FALSE,
```

```
  d.lab = c(),
  d.lim = c(),
  d.rev = TRUE,
  labels = c(),
  label.x = 1,
  label.y = c(),
  label.cex = 0.8,
  label.col = border,
  label.offset = c(0, 0),
  label.adj = c(1, 0),
  label.rot = 0,
  cc.dir = NULL,
  dist.res = 100,
  ...
)
```

Arguments

age	Mean of the uncalibrated C-14 age (or multiple ages).
error	Error of the uncalibrated C-14 age (or ages).
depth	Depth(s) of the date(s). Can also be their relative positions if no depths are available.
cc	Calibration curve for C-14 dates (1, 2, 3, or 4, or, e.g., "IntCal20", "Marine20", "SHCal20", "nh1", "sh3", or "mixed"). If there are multiple dates but all use the same calibration curve, one value can be provided.
postbomb	Whether or not this is a postbomb age. Defaults to FALSE.
reservoir	Reservoir age, or reservoir age and age offset.
normal	Use the normal distribution to calibrate dates (default TRUE). The alternative is to use the t model (Christen and Perez 2009).
t.a	Value a of the t distribution (defaults to 3).
t.b	Value a of the t distribution (defaults to 4).
prob	Probability confidence intervals (between 0 and 1).
threshold	Report only values above a threshold. Defaults to `threshold=0.001`.
BCAD	Use BC/AD or cal BP scale (default cal BP).
draw.hpd	Whether or not to draw the hpd ranges as a line
hpd.lwd	Width of the line of the hpd ranges
hpd.col	Colour of the hpd rectangle for all dates or radiocarbon dates
cal.hpd.col	Colour of the hpd rectangle for cal BP dates
mirror	Plot distributions mirrored, a bit like a swan. Confuses some people but looks nice to the author so is the default.
up	If mirror is set to FALSE, the distribution can be plotted up or down, depending on the direction of the axis.
draw.base	By default, the base of the calibrated distributions is plotted. This can be avoided by supplying `draw.base=FALSE` as an option.

`col`	Colour of the inside of the distribution
`border`	Colour of the border of the distribution
`cal.col`	Colour of the inside of distribution of non-radiocarbon dates that didn't need calibration
`cal.border`	Colour of the border of the distribution of non-radiocarbon dates that didn't need calibration
`add`	Whether or not to add the dates to an existing plot. If set to FALSE (default), a plot will be set up.
`ka`	Whether or not to plot ages as thousands of years. Defaults to `ka=FALSE`.
`rotate.axes`	By default, the calendar age axis is plotted on the horizontal axis, and depth/position on the vertical one. Use `rotate.axes=TRUE` to rotate the axes.
`ex`	Exaggeration of the height of the distribution, defaults to `ex=1`.
`normalise`	If TRUE, the age distributions are normalised by plotting each distribution with the same total area. Precise dates will therefore peak higher than less precise dates (default). If `normalise=FALSE`, the peak of each date will be drawn at the same height.
`cc.resample`	The IntCal20 curves have different densities (every year between 0 and 5 kcal BP, then every 5 yr up to 15 kcal BP, then every 10 yr up to 25 kcal BP, and then every 20 yr up to 55 kcal BP). If calibrated ages span these density ranges, their drawn heights can differ, as can their total areas (which should ideally all sum to the same size). To account for this, resample to a constant time-span, using, e.g., `cc.resample=5` for 5-yr timespanes.
`age.lab`	Title of the calendar axis (if present)
`age.lim`	Limits of the calendar axis (if present)
`age.rev`	Reverse the age axis. Defaults to TRUE
`d.lab`	Title of the vertical axis (if present)
`d.lim`	Limits of the vertical axis (if present)
`d.rev`	Reverse the y-axis. Defaults to TRUE
`labels`	Add labels to the dates. Empty by default.
`label.x`	Horizontal position of the date labels. By default draws them before the youngest age (1), but can also draw them after the oldest age (2), or above its mean (3).
`label.y`	Vertical positions of the depths/labels. Defaults to 0 (or 1 if label.x is 3 or 4).
`label.cex`	Size of labels.
`label.col`	Colour of the labels. Defaults to the colour given to the borders of the dates.
`label.offset`	Offsets of the positions of the depths/labels, giving the x and y offsets. Defaults to c(0,0).
`label.adj`	Justification of the labels. Follows R's adj option: A value of "0" produces left-justified text, "0.5" (the default) centered text and "1" right-justified text.
`label.rot`	Rotation of the label. 0 by default (horizontal).
`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="curves"`.
`dist.res`	Resolution of the distribution polygons. Defaults to `dist.res=100`.
`...`	Additional plotting options

Value

A plot of the (calibrated) dates

Examples

```
plot(0, xlim=c(500,0), ylim=c(0, 2))
draw.dates(130, 20, depth=1)
x <- sort(runif(10, 1000, 10000)) # draw 10 random calendar ages
cc <- ccurve() # get the calibration curve
y <- approx(cc[,1], cc[,2], x)$y # find the IntCal 14C ages
er <- .01 * y
draw.dates(y, er, 1:length(x))
draw.dates(y, er, y, d.lab="Radiocarbon age (BP)")
draw.ccurve(add=TRUE, cc1.col=rgb(0,.5,0,.5))
```

F14C.age   *Calculate C14 ages from F14C values.*

Description

Calculate C14 ages from F14C values of radiocarbon dates.

Usage

```
F14C.age(mn, sdev = c(), decimals = 5, lambda = 8033)
```

Arguments

mn	Reported mean of the F14C
sdev	Reported error of the F14C. Returns just the mean if left empty.
decimals	Amount of decimals required for the radiocarbon age. Quite sensitive, defaults to 5.
lambda	The mean-life of radiocarbon (based on Libby half-life of 5568 years)

Details

Post-bomb dates are often reported as F14C or fraction modern carbon. Since Bacon expects radiocarbon ages, this function can be used to calculate radiocarbon ages from F14C values. The reverse function is age.F14C.

Value

Radiocarbon ages from F14C values. If F14C values are above 100%, the resulting radiocarbon ages will be negative.

Examples

```
F14C.age(1.10, 0.5) # a postbomb date, so with a negative 14C age
F14C.age(.80, 0.5) # prebomb dates can also be calculated
```

F14C.D14C	*Transform F14C into D14C*

Description

Transform F14C into D14C

Usage

```
F14C.D14C(F14C, t)
```

Arguments

F14C	The F14C value to translate
t	the cal BP age

Details

As explained by Heaton et al. 2020 (Radiocarbon), 14C measurements are commonly expressed in three domains: Delta14C, F14C and the radiocarbon age. This function translates F14C values into Delta14C, the historical level of Delta14C in the year t cal BP. Note that per convention, this function uses the Cambridge half-life, not the Libby half-life.

Value

The corresponding D14C value

Examples

```
F14C.D14C(0.985, 222)
cc <- ccurve()
# plot IntCal20 as D14C:
cc.Fmin <- age.F14C(cc[,2]+cc[,3])
cc.Fmax <- age.F14C(cc[,2]-cc[,3])
cc.D14Cmin <- F14C.D14C(cc.Fmin, cc[,1])
cc.D14Cmax <- F14C.D14C(cc.Fmax, cc[,1])
plot(cc[,1]/1e3, cc.D14Cmax, type="l", xlab="kcal BP", ylab=expression(paste(Delta, ""^{14}, "C")))
lines(cc[,1]/1e3, cc.D14Cmin)
```

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", cc.dir = c())
```

Arguments

`prebomb`	The prebomb curve. Defaults to "IntCal20"
`postbomb`	The postbomb curve. Defaults to "NH1" (Hua et al. 2013)
`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()
```

hpd *Calculate highest posterior density*

Description

Calculate highest posterior density ranges of calibrated distribution

Usage

```
hpd(calib, prob = 0.95, return.raw = FALSE, rounded = 1)
```

Arguments

`calib`	The calibrated distribution, as returned from caldist()
`prob`	Probability range which should be calculated. Default `prob=0.95`.
`return.raw`	The raw data to calculate hpds can be returned, e.g. to draw polygons of the calibrated distributions. Defaults to `return.raw=FALSE`.
`rounded`	Rounding for reported probabilities. Defaults to 1 decimal.

Value

The highest posterior density ranges, as three columns: from age, to age, and the corresponding percentage(s) of the range(s)

Examples

```
hpd(caldist(130,20))
plot(tmp <- caldist(2450,50), type='l')
abline(v=hpd(tmp)[,1:2], col=4)
```

---

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(),
  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.
`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

References

[1]Stuiver, M, and Braziunas, TF. 1993. Sun, ocean, climate and atmospheric 14CO2: an evaluation of causal and spectral relationships. Holocene 3: 289-305.

[2] Stuiver, M, Reimer, PJ, Braziunas, TF. 1998. High-precision radiocarbon age calibration for terrestrial and marine samples. Radiocarbon 40:1127-1151.

[3] McCormac FG, Bayliss A, Baillie MGL, Brown DM. 2004. Radiocarbon calibration in the Anglo-Saxon period: AD 495-725. Radiocarbon 46(3):1123-5.

[4] McCormac, FG, Hogg, AG, Higham, TFG, Lynch-Stieglitz, J, Broecker, WS, Baillie, MGL, Palmer, J, Xiong, L, Pilcher, JR, Brown, D, Hoper, ST, 1998. Temporal variation in the interhemispheric C-14 offset. Geophysical Research Letters 25, 1321-1324.

[5] Pearson, G. W., Pilcher, J. R., Baillie, M. G. L., Corbett, D. M., and Qua, F. (1986). High-Precision C-14 Measurement of Irish Oaks to Show the Natural C-14 Variations from AD 1840 to 5210 BC Radiocarbon 28: 911-934.

[6] Hogg, A. G., McCormac, F. G., Higham, T. F. G., Reimer, P. J., Baillie, M. G. L., and Palmer, J. G. (2002). High-precision radiocarbon measurements of contemporaneous tree-ring dated wood from the British Isles and New Zealand: AD 1850-950. Radiocarbon 44: 633-640.

[7] Hogg, A., Palmer, J., Boswijk, G., Reimer, P., and Brown, D. (2009). Investigating the interhemispheric C-14 offset in the 1st millennium AD and assessment of laboratory bias and calibration errors. Radiocarbon 51, 1177-1186.

[8] de Jong, A. F. M., Becker, B., and Mook, W. G. (1986). High-precision calibration of the radiocarbon time scale, 3930-3230 cal BC. Radiocarbon 28: 939-941.

[9] de Jong, AFM, Becker, B, Mook, WG, 1989. Corrected calibration of the radiocarbon time scale. Radiocarbon 31:201-210.

[10] Kuitems, M, Plicht, Jvd, Jansma, E, Wood from the Netherlands around the time of the Santorini eruption dated by dendrochronology and Radiocarbon. Radiocarbon this issue.

[11] Kaiser, K. F., M. Friedrich, C. Miramont, B. Kromer, M. Sgier, M. Schaub, I. Boeren, S. Remmele, S. Talamo, F. Guibal and O. Sivan (2012). 'Challenging process to make the Lateglacial tree-ring chronologies from Europe absolute-an inventory.' Quaternary Science Reviews 36: 78-90.

[12] Kromer, B., and Spurk, M. (1998). Revision and tentative extension of the tree-ring based C-14 calibration, 9200-11,855 cal BP. Radiocarbon 40: 1117-1125.

[13] Kromer, B., Manning, S.W., Kuniholm, P.I., Newton, M.W., Spurk, M. & Levin, I. 2001. Regional 14CO2 offsets in the troposphere: magnitude, mechanisms, and consequences. Science 294: 2529-2532.

[14] Kromer, B., S. W. Manning, M. Friedrich, S. Talamo and N. Trano (2010). 14C Calibration in the 2nd and 1st Millennia BC Eastern Mediterranean Radiocarbon Comparison Project (EMRCP). Radiocarbon 52(3): 875-886.

[15] Hua, Q., Barbetti, M., Fink, D., Kaiser, K. F., Friedrich, M., Kromer, B., Levchenko, V. A., Zoppi, U., Smith, A. M., and Bertuch, F. (2009). Atmospheric 14C variations derived from tree rings during the early Younger Dryas. Quaternary Science Reviews 28, 2982-2990.

[16] Vogel, J. C., and van der Plicht, J. (1993). Calibration Curve for Short-Lived Samples, 1900-3900 BC. Radiocarbon 35: 87-91.

[17] Taylor, R.E. and Southon, J., (2013). Reviewing the Mid-First Millennium BC 14C 'warp' using 14C/bristlecone pine data. NIMB Research Section B: Beam Interactions with Materials and Atoms, 294, pp.440-443

[18] Hogg, A., Southon, J., Turney, C., Palmer, J., Ramsey, C.B., Fenwick, P., Boswijk, G., Buentgen, U., Friedrich, M., and Helle, G., 2016. Decadally resolved lateglacial radiocarbon evidence from New Zealand kauri: Radiocarbon, v. 58, p. 709

[19] Park, J., Southon, J., Fahrni, S., Creasman, P., & Mewaldt, R. (2017). Relationship between solar activity and D14C peaks in AD 775, AD 994, and 660 BC. Radiocarbon, 59(4), 1147-1156. doi:10.1017/RDC.2017.59

[20] Simon M. Fahrni, John Southon, Benjamin T. Fuller, Junghun Park, Michael Friedrich, Raimund Muscheler, Lukas Wacker, R. E. Taylor;Single-year German oak and Californian bristlecone pine 14C data at the beginning of the Hallstatt plateau from 856 BC to 626 BC; Radiocarbon

[21] Galimberti, M, Bronk Ramsey, C, and Manning, S W, 2004 Wiggle-match dating of tree-ring sequences, Radiocarbon, 46, 917-24

[22] Friedrich, R, Kromer, B, Wacker, L, Olsen, J, Remmele, S, Lindauer, S, Land, A, Pearson, C. A new annual 14C dataset for calibrating the Thera eruption. Radiocarbon this issue

[23] Sookdeo A, Kromer B, Buentgen U, Friedrich M, Friedrich R, Helle G, Pauly M, Nievergelt D, Reinig F, Treydte K, Synal HA, Wacker, L 2019a. Quality Dating: A well-defined protocol implemented at ETH for high-precision 14C dates tested on Late Glacial wood. Radiocarbon.

[24] Friedrich, R, Kromer, B, Sirocko, F, Esper, J, Lindauer, S, Nievergelt, D, Heussner, K, Westphal, T. Annual 14C tree-ring data around 400AD: mid and high-latitude records. Radiocarbon: in press

[25] Usoskin, I. G., B. Kromer, F. Ludlow, J. Beer, M. Friedrich, G. A. Kovaltsov, S. K. Solanki and L. Wacker (2013). 'The AD775 cosmic event revisited: the Sun is to blame.' Astronomy & Astrophysics 552(L3): 1-4.

[26] Capano, M, Miramont, C, Guibal, F, Kromer, B, Tuna, T, Fagault, Y, Bard, E, 2018. Wood 14C Dating with AixMICADAS: Methods and Application to Tree-Ring Sequences from the Younger Dryas Event in the Southern French Alps. Radiocarbon 60, 51-74.

[27]C apano M, Miramont C, Shindo, L, Guibal F, Marschal, C, Kromer B, Tuna T, Bard E. Onset of the Younger Dryas recorded with 14C at annual resolution in French subfossil trees. Radiocarbon, 2020.

[28] Fogtmann-Schulz, A, Kudsk, SGK, Trant, PLK, Baittinger, C, Karoff, C, Olsen, J, Knudsen, MF, 2019. Variations in Solar Activity Across the Spoerer Minimum Based on Radiocarbon in Danish Oak. Geophysical Research Letters 46, 8617-8623.

[29] Fogtmann-Schulz, A, Ostbo, SM, Nielsen, SGB, Olsen, J, Karoff, C, Knudsen, MF, 2017. Cosmic ray event in 994 C.E. recorded in radiocarbon from Danish oak. Geophysical Research Letters 44, 8621-8628.

[30] Kudsk, S., B. Philippsen, C. Baittinger, A. Fogtmann-Schulz, M. Knudsen, C. Karoff, J. Olsen, 'New single-year radiocarbon measurements based on Danish oak covering the periods AD 692-790 and 966-1057 AD', (in press), Radiocarbon.

[31] Manning, S. W. and B. Kromer (2012). 'Considerations of the Scale of Radiocarbon Offsets in the East Mediterranean, and Considering a Case for the Latest (Most Recent) Likely Date for the Santorini Eruption.' Radiocarbon 54(3-4): 449-474.

[32] Manning, S.W., Griggs, C., Lorentzen, B., Bronk Ramsey, C., Chivall, D., Jull, A.J.T., Lange, T.E. 2018. Fluctuating Radiocarbon Offsets Observed in the Southern Levant and Implications for Archaeological Chronology Debates. Proceedings of the National Academy of Sciences of the United States of America 115:6141-6146.

[33] Dellinger, F, Kutschera, W, Nicolussi, K, Schiessling, P, Steier, P, and Wild, E M, 2004 A 14C calibration with AMS from 3500 to 3000 BC, derived from a new high-elevation stone-pine tree-ring chronology, Radiocarbon, 46, 969-83

[34] Steier, P, Dellinger, F, Kutschera, W, Priller, A, Rom, W, and Wild, E M, 2004 Pushing the precision limit of 14C AMS, Radiocarbon, 46, 5-17

[35] Ozaki, H, Imamura, M, Matsuzaki, H, Mitsutani, T, 2007. Radiocarbon in 9th to 5th century BC tree-ring samples from the Ouban 1 archaeological site, Hiroshima, Japan. Radiocarbon 49, 473-479.

[36] The origin of the farming in the Yayoi Period and East Asia: Establishment of High-Precision Chronology by carbon 14 age analysis. National Museum of Japanese History Edited by Toyohiro Nishimoto, 524p, 2009. (in Japanese, final progress report of JSPS Grant-in-Aids (16GS0118))

[37] Sakamoto, M, Imamura, M, van der Plicht, J, Mitsutani, T, Sahara, M, 2003. Radiocarbon calibration for Japanese wood samples. Radiocarbon 45, 81-89.

[38] Okuno, M, Hakozaki, M, Miyake, F, Kimura, K, Masuda, K, Sakamoto, M, Hong, W, Yatsuzuka, S, Nakamura, T, 2018. Chronological significance of d14C spike and precise age determination of the B-Tm Tephra, China/ North Korea, 23rd International Radiocarbon Conference, Trondheim, Norway.

[39] Sakamoto, M, Hakozaki, M, Nakao, N, Nakatsuka, T, 2017. Fine structure and reproducibility of radiocarbon ages of middle to early modern Japanese tree rings. Radiocarbon 59, 1907-1917.

[40] Jull, AT, Panyushkina, I, Miyake, F, Masuda, K, Nakamura, T, Mitsutani, T, Lange, TE, Cruz, RJ, Baisan, C, Janovics, R, 2018. More Rapid 14 C Excursions in the Tree-Ring Record: A Record of Different Kind of Solar Activity at About 800 BC? Radiocarbon 60, 1237-1248.

[41] Miyake F., Jull A.J.T., Panyushkina I.P., Wacker L., Salzer M., Baisan C., Lange T., Cruz R., Masuda K., Nakamura T. 2017. Large 14C excursion in 5480 BC indicates an abnormal sun in the mid-Holocene. PNAS Physical Sciences - Earth, Atmospheric, and Planetary Sciences 114 (3), doi:10.1073/pnas.161314411

[42] Pearson, C.L., Brewer, P.W., Brown, D., Heaton, T.J., Hodgins, G.W., Jull, A.T., Lange, T. and Salzer, M.W., (2018). Annual radiocarbon record indicates 16th century BCE date for the Thera eruption. Science advances, 4(8), p.eaar8241.

[43] Pearson, CL, Wacker, L, Bayliss, A, Brown, DM, Salzer, M, Brewer, PW, Bollhalder, S, Boswijk, G, Hodgins, GWL, Annual variation in atmospheric 14C between 1700 BC and 1480 BC: Radiocarbon: this issue

[44] Jull A.J.T., Panyushkina I.P., Lange T.E., Kukarskih V.V., Clark K.J., Myglan V.S., Salzer M., Burr G.S., Leavitt S.L. Excursions in the 14C record at AD 774-775 from tree rings from Russia and America.2014. Geophysical Research Letters 41 (8): 3004-3010. 10.1002/2014GL059874

[45] Miyake F., Masuda K., Nakamura T., Kimura K., Hakozaki M., Jull A.T., Lange T., Cruz R., Panyushkina I.P., Baisan C., Salzer M. 2017. Search for annual 14C excursions in the past. Radiocarbon 59 (2): 315-320. DOI: 10.1017/RDC.2016.54

[46] Wacker et al. in prep

[47] Sookdeo, A, Kromer, B, Adolphi, F, Beer, J, Brehm, N, Buntgen, U, Christl, M, Eglinton, TI, Friedrich, M, Guidobaldi, G, Helle, G, Nievergelt, D, Pauly, M, Reinig, F, Tegel, W, Treydte, K, Synal, H-A, Wacker, L, submitted. There Goes the Sun: 14C in trees reveals reduced solar activity during the Younger Dryas. Nature Geoscience.

[48] Buntgen, Ulf, et al, (2018),'Tree rings reveal globally coherent signature of cosmogenic radiocarbon events in 774 and 993 CE'. Nature Communications 9, 3605

[49] Bayliss et al. in prep

[50] Adolphi, F., R. Muscheler, M. Friedrich, D. Guttler, L. Wacker, S. Talamo and B. Kromer (2017). 'Radiocarbon calibration uncertainties during the last deglaciation: Insights from new floating tree-ring chronologies.' Quaternary Science Reviews 170: 98-108.

[51] Turney CS, Palmer J, Ramsey CB, Adolphi F, Muscheler R, Hughen KA, Staff RA, Jones RT, Thomas ZA, Fogwill CJ. 2016. High-precision dating and correlation of ice, marine and terrestrial sequences spanning Heinrich Event 3: Testing mechanisms of interhemispheric change using New Zealand ancient kauri (Agathis australis). Quaternary Science Reviews 137:126-34.

[52] Turney, C.S.M., Fifield, L.K., Hogg, A.G., Palmer, J.G., K., H., Baillie, M.G.L., Galbraith, R., Ogden, J., Lorrey, A., Tims, S.G., Jones, R.T., 2010. Using New Zealand kauri (Agathis australis) to test the synchronicity of abrupt climate change during the Last Glacial Interval (60,000-11,700 years ago). Quaternary Science Reviews 29, 3677-3682.

[53] Bronk Ramsey, C, Staff, RA, Bryant, CL, Brock, F, Kitagawa, H, van der Plicht, J, Schlolaut, G, Marshall, MH, Brauer, A, Lamb, HF, Payne, RL, Tarasov, PE, Haraguchi, T, Gotanda, K, Yonenobu, H, Yokoyama, Y, Tada, R, Nakagawa, T, 2012. A Complete Terrestrial Radiocarbon Record for 11.2 to 52.8 kyr BP. Science 338, 370-374.

[54] Gordon Schlolaut, Richard A Staff, Michael H Marshall, Achim Brauer, Christopher Bronk Ramsey, Henry F Lamb, Takeshi Nakagawa, 2018, An extended and revised Lake Suigetsu varve chronology from ~50 to ~10 ka BP based on detailed sediment micro-facies analyses, Quaternary Science Reviews 200, 351-366

[55] Bard, E, Hamelin, B, Fairbanks, RG, Zindler, A. 1990. Calibration of the 14C timescale over the past 30,000 years using mass spectrometric U-Th ages from Barbados corals. Nature 345: 405-410.

[56] Bard, E, Arnold, M, Hamelin, B, Tisnerat-Laborde, N, Cabioch, G, 1998. Radiocarbon calibration by means of mass spectrometric Th- 230/U-234 and C-14 ages of corals: An updated database including samples from Barbados, Mururoa and Tahiti. Radiocarbon 40, 1085-1092.

[57] Fairbanks, RG, Mortlock, RA, Chiu, TC, Cao, L, Kaplan, A, Guilderson, TP, Fairbanks, TW, Bloom, AL, Grootes, PM & Nadeau, MJ. 2005. Radiocarbon calibration curve spanning 0 to 50,000 years BP based on paired Th-230/U-234/U-238 and C-14 dates on pristine corals. Quaternary Science Reviews 24(16-17): 1781-96.

[58] Cutler, KB, Gray, SC, Burr, GS, Edwards, RL, Taylor, FW, Cabioch, G, Beck, JW, Cheng, H, and Moore, J. 2004. Radiocarbon calibration to 50 kyr BP with paired 14C and 230Th dating of corals from Vanuatu and Papua New Guinea. Radiocarbon 46: 1127-1160.

[59] Hughen, KA, Southon, JR, Lehman, SJ, Overpeck, JT, 2000. Synchronous radiocarbon and climate shifts during the last deglaciation. Science 290, 1951-1954.

[60] Hughen, KA, Southon, JR, Bertrand, CJH, Frantz, B, Zermeno, P. 2004. Cariaco Basin calibration update: revisions to calendar and 14C chronologies for core PL07-58PC. Radiocarbon 46: 1161-1187.

[61] Durand, N, Deschamps, P, Bard, E, Hamelin, B, Camoin, G, Thomas, AL, Henderson, GM, Yokoyama, Y, Matsuzaki, H. 2013. Comparison of 14C and U-Th in corals from IODP #310 cores offshore Tahiti. Radiocarbon 55 (4), 1947-1974.

[62] Hughen, K, Southon, J, Lehman, S, Bertrand, C, Turnbull, J, 2006. Marine-derived 14C calibration and activity record for the past 50,000 years updated from the Cariaco Basin. Quaternary Science Reviews 25, 3216-3227.

[63] Hughen, K, Heaton, TJ. Updated Cariaco Basin 14C Calibration Dataset from 0-60k BP, in prep

[64] Bard, E, Rostek, F, Menot-Combes, G, 2004. Radiocarbon calibration beyond 20,000 14C yr B.P. by means of planktonic foraminifera of the Iberian Margin. Quaternary Research 61, 204-214.

[65] Edouard Bard, Guillemette Menot, Frauke Rostek, Laetitia Licari, Philipp Boening,R Lawrence Edwards, Hai Cheng, Yongjin Wang, Timothy J Heaton, (2013) 'Radiocarbon calibration/comparison records based on marine sediments from the Pakistan and Iberian margins', Radiocarbon, Vol 55, Nr 4, 2013, p 1999-2019

[66] Southon J, Noronha AL, Cheng H, Edwards RL, Wang YJ. (2012). A high-resolution record of atmospheric C-14 based on Hulu Cave speleothem H82. Quaternary Science Reviews 33:32-41

[67] Cheng H, Edwards RL, Southon J, Matsumoto K, Feinberg JM, Sinha A, Zhou W, Li H, Li X, Xu Y. 2018. Atmospheric 14C/12C changes during the last glacial period from Hulu Cave. Science 362(6420):1293-7

[68] Dirk L. Hoffmann, J. Warren Beck, David A. Richards, Peter L. Smart, Joy S. Singarayer, Tricia Ketchmark, Chris J. Hawkesworth. 2010. Towards radiocarbon calibration beyond 28 ka using speleothems from the Bahamas,Earth and Planetary Science Letters,289:1-10.

[69] J. Warren Beck, David A. Richards, R. Lawrence Edwards, Bernard W. Silverman, Peter L. Smart, Douglas J. Donahue, Sofia Hererra-Osterheld, George. S. Burr, Leal Calsoyas, A. J. Timothy Jull, Dana Biddulph. 2001. Extremely Large Variations of Atmospheric 14C Concentration During the Last Glacial Period Science 292:2453

[70] Vogel et al. 1993. Pretoria calibration curve for short-lived samples, 1930-3350 BC. Radiocarbon 35: 73-85.

[71] Stuiver, Braziunas 1998. Anthropogenic and solar components of hemispheric 14C. Geophysical Research Letters 25: 329-332.

[72] Hogg et al. 2002 High-precision radiocarbon measurements of contemporaneous tree-ring dated wood from the British Isles and New Zealand: AD 1850-950. Radiocarbon 44: 633-640.

[73] McCormac et al. 1998. Temporal variation in the interhemispheric C-14 offset. Geophysical Research Letters 25: 1321-1324.

[74] Hogg et al. 2011 High-precision radiocarbon measurements of tree-ring dated wood from New Zealand: 195 BC-AD 995. Radiocarbon 53, 3: 529-542.

[75] Hogg et al. 2013 Is there any evidence for regional 14C offsets in the Southern Hemisphere? doi:10.2458/azu_js_rc.v55i2.16104

[76] Hogg et al. 2002 High-precision radiocarbon measurements of contemporaneous tree-ring dated wood from the British Isles and New Zealand: AD 1850-950. Radiocarbon 44: 633-640.

[77] McCormac et al. 1998. Temporal variation in the interhemispheric C-14 offset. Geophysical Research Letters 25: 1321-1324.

[78] Hua et al. 2009 Atmospheric 14C variations derived from tree rings during the early Younger Dryas. Quaternary Science Reviews, v. 28, 25-26: 2982-2990.

[79] Hua et al. 2004 Radiocarbon in tropical tree rings during the Little Ice Age. Nuclear Instruments and Methods in Physics Research B 223-224:489-94.

[80] Hogg et al. 2013 SHCal13 Southern Hemisphere calibration, 0-50,000 cal yr BP. Radiocarbon 55, 2

[81] Zimmerman et al. 2010 Extension of the Southern Hemisphere atmospheric radiocarbon curve, 2120-850 years BP: results from Tasmanian huon pine. Radiocarbon 52, 203: 887-94.

[82] Boentgen et al. 2018 Tree rings reveal globally coherent signature of cosmogenic radiocarbon events in 774 and 993 CE. Nature Communications, 9: 3605. doi:10.1038/s41467-018-06036-0.
[83] Sookdeo et al. 2020 Quality Dating: A well-defined protocol implemented at ETH Zurich for high-precision 14C dates tested on Late Glacial wood. Radiocarbon. doi:10.1017/RDC.2019.132

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, selectsets=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)
```

l.calib — *Find the calibrated probability of a calendar age for a 14C date.*

Description

Find the calibrated probability of a cal BP age for a radiocarbon date. Can handle either multiple calendar ages for a single radiocarbon date, or a single calendar age for multiple radiocarbon dates.

Usage

```
l.calib(yr, y, er, cc = ccurve(1, FALSE), normal = TRUE, t.a = 3, t.b = 4)
```

Arguments

`yr`	The cal BP year.
`y`	The radiocarbon date's mean.
`er`	The radiocarbon date's lab error.
`cc`	calibration curve for the radiocarbon date(s) (see `ccurve()`).
`normal`	Use the normal distribution to calibrate dates (default TRUE). The alternative is to use the t model (Christen and Perez 2016).
`t.a`	Value a of the t distribution (defaults to 3).
`t.b`	Value b of the t distribution (defaults to 4).

Details

The function cannot deal with multiple calibration curves if multiple calendar years or radiocarbon dates are entered.

Value

The calibrated probability of a calendar age for a 14C age

Author(s)

Maarten Blaauw

Examples

```
l.calib(100, 130, 20)
l.calib(100:110, 130, 20) # multiple calendar ages of a single date
l.calib(100, c(130,150), c(15,20)) # multiple radiocarbon ages and a single calendar age
```

`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",
  name = "mixed.14C",
  cc.dir = 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.
`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="."`.
`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).
`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()
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())
```

---

pMC.age *Calculate C14 ages from pMC values.*

Description

Calculate C14 ages from pMC values of radiocarbon dates.

Usage

```
pMC.age(mn, sdev = c(), ratio = 100, decimals = 0, lambda = 8033)
```

Arguments

`mn`	Reported mean of the pMC.
`sdev`	Reported error of the pMC.
`ratio`	Most modern-date values are reported against `100`. If it is against `1` instead, use `1` here.
`decimals`	Amount of decimals required for the radiocarbon age.
`lambda`	The mean-life of radiocarbon (based on Libby half-life of 5568 years)

Details

Post-bomb dates are often reported as pMC or percent modern carbon. Since Bacon expects radiocarbon ages, this function can be used to calculate radiocarbon ages from pMC values. The reverse function is age.pMC.

Value

Radiocarbon ages from pMC values. If pMC values are above 100%, the resulting radiocarbon ages will be negative.

Examples

```
pMC.age(110, 0.5) # a postbomb date, so with a negative 14C age
pMC.age(80, 0.5) # prebomb dates can also be calculated
pMC.age(.8, 0.005, ratio=1) # throws a warning, use F14C.age instead
```

`point.estimates` *Calculate a point estimate*

Description

Calculate a point estimate of a calibrated distribution - either the weighted mean, the median or the mode (maximum). Note that point estimates often tend to be very poor representations of entire calibrated distributions, so please be careful and do not reduce entire calibrated distributions to just 1 point value.

Usage

```
point.estimates(
  calib,
  wmean = TRUE,
  median = TRUE,
  mode = TRUE,
  midpoint = TRUE,
  prob = 0.95,
  rounded = 1
)
```

Arguments

calib	The calibrated distribution, as returned from caldist()
wmean	Report the weighted mean (defaults to TRUE)
median	Report the median (defaults to TRUE)
mode	Report the mode, which is the year with the maximum probability (defaults to TRUE)
midpoint	Report the midpoint of the hpd range(s)
prob	probability range for the hpd range(s)
rounded	Rounding for reported probabilities. Defaults to 1 decimal.

Value

The chosen point estimates

Examples

```
point.estimates(caldist(130,20))
plot(tmp <- caldist(2450,50), type='l')
abline(v=point.estimates(tmp), col=1:4)
```

Index