Package 'rice'

September 24, 2024

Type Package

Title Radiocarbon Equations

Version 0.2.0

Date 2024-09-03

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Description Provides functions for the calibration of radiocarbon dates, as well as options to calculate different radiocarbon realms (C14 age, F14C, pMC, D14C) and estimating the effects of contamination or local reservoir offsets (Reimer and Reimer 2001 <doi:10.1017/S0033822200038339>). The methods follow long-established recommendations such as Stuiver and Polach (1977) <doi:10.1017/S0033822200003672> and Reimer et al. (2004) <doi:10.1017/S0033822200033154>. This package accompanies the data package 'rintcal'.

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Encoding UTF-8

RoxygenNote 7.3.2

Imports rintcal (>= 1.0.0), rlang, ggplot2, rnaturalearth, rnaturalearthdata

Suggests knitr, rmarkdown, utf8, remotes

Depends R (>= 3.5.0)

VignetteBuilder knitr

NeedsCompilation no

LazyData true

Repository CRAN

Date/Publication 2024-09-24 10:10:03 UTC

Contents

`rice-package` *rice: Radiocarbon Equations*

Description

Provides functions for the calibration of radiocarbon dates, as well as options to calculate different radiocarbon realms (C14 age, F14C, pMC, D14C) and estimating the effects of contamination or local reservoir offsets (Reimer and Reimer 2001 doi:10.1017/S0033822200038339). The methods follow long-established recommendations such as Stuiver and Polach (1977) doi:10.1017/S0033822200003672 and Reimer et al. (2004) doi:10.1017/S0033822200033154. This package accompanies the data package 'rintcal'.

Author(s)

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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 = 0.001,
  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 timespans.
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-6.
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,
  bombalert = TRUE,
  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 = 5e-04,
  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.
bombalert	Warn if a date is close to the lower limit of the IntCal curve. Defaults to `postbomb=TRUE`.
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))
```

`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)
```

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,
  realm = "C14",
  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.
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).
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 = rintcal::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=rintcal::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 timespans.
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 <- rintcal::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 <- rintcal::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)
```

`find.shells` *Find nearby shell-derived dR values*

Description

Find the shells closest to a chosen coordinate, and plot the dR values and feeding ecology. Uses the marine database downloaded (30 Aug 2024) from calib.org/marine. See Reimer PJ, Reimer RW, 2001. A marine reservoir correction database and on-line interface. Radiocarbon 43:461-3.

Usage

```
find.shells(
  longitude,
  latitude,
  nearest = 50,
  colour = "dR",
  rainbow = FALSE,
  size = 2,
  scale = c(),
  mincol = "yellow",
  maxcol = "red",
  symbol = "feeding",
  symbol.legend = TRUE,
  ocean.col = "aliceblue",
  land.col = rgb(0, 0.5, 0, 0.6)
)
```

Arguments

`longitude`	Longitude of the point. Can only deal with one point at a time.
`latitude`	Latitude of the point. Can only deal with one point at a time.
`nearest`	The number of shell values to be returned. Defaults to 50.
`colour`	The variable to be plotted as colour. Expects a continuous variable. Defaults to 'dR'.
`rainbow`	Whether or not to use a rainbow scale to plot the variable.
`size`	Size of the symbols. Defaults to 2.
`scale`	Resolution of the map. Can be "small", "medium" or "large". If the latter, a high-resolution dataset will have to be downloaded using the R package 'rnaturalearthhires'. Since this package is not on CRAN, you will have to download it yourself. Defaults to 'medium' if 'rnaturalearthhires' is not installed, and to 'high' if it is installed.
`mincol`	Colour for minimum values.
`maxcol`	Colour for maximum values.
`symbol`	The variable to be plotted as symbol. Expects a categoric variable. Defaults to 'feeding'.

symbol.legend	Whether or not to plot the legend for the symbols.
ocean.col	Colour for the oceans. Defaults to ocean.col="aliceblue".
land.col	Colour for the land. Defaults to semi-transparent darkgreen: land.col=rgb(0, 0.5, 0, 0.6).

Value

A dataset with the n nearest dR values, and a plot of their coordinates.

Examples

```
N_UK <- map.shells(53, -11, 60, 2, scale="medium")
mean(N_UK$dR)
```

---

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)
```

`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 = rintcal::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 the `rintcal` package).
`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
```

`map.shells` *Plot regional shell-derived dR values*

Description

Find the shells that fit within a rectangular region (bounded by N, E, S and W), and plot the dR values and feeding ecology. Uses the marine database downloaded (30 Aug 2024) from calib.org/marine. See Reimer PJ, Reimer RW, 2001. A marine reservoir correction database and on-line interface. Radiocarbon 43:461-3. Expects the coordinates for the map to be provided (starting south, then clockwise as with R axes).

Usage

```
map.shells(
  S = 48,
  W = -15,
  N = 62,
  E = 5,
  colour = "dR",
  rainbow = FALSE,
  size = 2,
  scale = c(),
  mincol = "yellow",
  maxcol = "red",
  symbol = "feeding",
  symbol.legend = TRUE,
  ocean.col = "aliceblue",
  land.col = rgb(0, 0.5, 0, 0.6)
)
```

Arguments

`S`	The southern limit of the rectangular region.
`W`	The western limit of the rectangular region.
`N`	The northern limit of the rectangular region.
`E`	The eastern limit of the rectangular region.
`colour`	The variable to be plotted as colour. Expects a continuous variable. Defaults to 'dR'.
`rainbow`	Whether or not to use a rainbow scale to plot the variable.
`size`	Size of the symbols. Defaults to 2.

scale	Resolution of the map. Can be "small", "medium" or "large". If the latter, a high-resolution dataset will have to be downloaded using the R package 'rnaturalearthhires'. Since this package is not on CRAN, you will have to download it yourself. Defaults to 'medium' if 'rnaturalearthhires' is not installed, and to 'high' if it is installed.
mincol	Colour for minimum values.
maxcol	Colour for maximum values.
symbol	The variable to be plotted as symbol. Expects a categoric variable. Defaults to 'feeding'.
symbol.legend	Whether or not to plot the legend for the symbols.
ocean.col	Colour for the oceans. Defaults to `ocean.col="aliceblue"`.
land.col	Colour for the land. Defaults to semi-transparent darkgreen: `land.col=rgb(0, 0.5, 0, 0.6)`.

Value

A plot and the relevant dR values.

Examples

```
N_UK <- map.shells(53, -11, 60, 2, scale="medium")
mean(N_UK$dR)
```

`older` *Find the probability of a calibrated date being older than a certain age*

Description

Find the probability of a calibrated date being older than an age x.

Find the probability that a sample is older than a certain calendar age x, by calculating the proportion of the calibrated distribution 'after' x (i.e., 1 - the summed calibrated distribution up to year x).

Usage

```
older(
  x,
  y,
  er,
  cc = 1,
  postbomb = FALSE,
  normal = TRUE,
  t.a = 3,
  t.b = 4,
  BCAD = FALSE,
  threshold = 0
)
```

Arguments

x	The year of interest, in cal BP by default.
y	The radiocarbon date's mean.
er	The radiocarbon date's lab error.
cc	calibration curve for the radiocarbon date(s) (see the rintcal package).
postbomb	Whether or not to use a postbomb curve (see caldist()).
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).
BCAD	Which calendar scale to use. Defaults to cal BP, BCAD=FALSE.
threshold	Report only values above a threshold. Defaults to threshold=0.

Details

The function can only deal with one date at a time.

Value

The probability of a date being older than a certain calendar age.

Author(s)

Maarten Blaauw

Examples

```
older(2800, 2450, 20)
older(2400, 2450, 20)
calibrate(160, 20, BCAD=TRUE)
older(1750, 160, 20, BCAD=TRUE)
```

---

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)
```

---

shells *shells Data*

Description

A dataset containing the deltaR values and accompanying data from the marine database

Usage

```
shells
```

Format

A data frame with 1968 rows and 15 variables.

lon Longitude of the datapoint

lat Latitude of the datapoint

no Map or ID number of the datapoint

taxonN Taxon number of the datapoint

dR calculated deltaR of the datapoint

dSTD uncertainty of the deltaR of the datapoint

collected Collection year for the datapoint

res Reservoir effect of the datapoint

res.error Uncertainty of the reservoir effect of the datapoint

C14 Radiocarbon age of the datapoint

er Error of the radiocarbon age of the datapoint

lab Lab code of the datapoint

ref Reference for the datapoint

taxon Taxon of the datapoint

feeding Feeding ecology of the datapoint (if known)

Source

Data downloaded from calib.org/marine

Examples

```
data(shells)
head(shells)
```

`shells.mean` *Plot and summarize the dR values*

Description

After selecting a relevant range of shell values, plot them and calculate the weighted mean and variance.

Usage

```
shells.mean(
  dat,
  feeding = c(),
  draw = TRUE,
  distance = FALSE,
  pch = 20,
  col.mn = 1,
  lty.mn = 2,
  col.sd = rgb(0, 0, 0, 0.1)
)
```

Arguments

`dat`	The data, as returned from the function 'plot.shells'.
`feeding`	Whether or not to select a specific feeding behaviour. Defaults to empty (no selection of feeding behaviour).
`draw`	Whether or not to draw the values.

distance	Plot the dR values according to their distance (if you've used find.shells; assumes that 'dat' has a final column with the distances).
pch	Symbol to be plotted. Defaults to a closed circle (pch=20).
col.mn	Colour for the weighted mean. Defaults to black, col.mn=1.
lty.mn	Line type for the weighted mean. Defaults to dashed, lty.mn=2.
col.sd	Colour of the rectangle of the error. Defaults to transparent grey, col.sd=rgb(0,0,0,.1).

Value

A plot of the dR values, as well as the weighted mean (vertical line) and (weighted) error (rectangle).

Examples

```
N_UK <- map.shells(53, -11, 60, 2, scale="medium")
shells.mean(N_UK)
nearby <- find.shells(0,56,20) # somewhere in Scotland
shells.mean(nearby, distance=TRUE) # distance matters
```

---

weighted_means *Calculate the weighted mean of C14 ages*

Description

Calculating the weighted mean of multiple C14 ages, using their means and lab errors.

Usage

```
weighted_means(y, er, round = 1, talk = TRUE)
```

Arguments

y	The C14 ages.
er	The lab errors of the C14 ages.
round	Rounding to be applied (defaults to 1 decimal).
talk	Report details of the found values.

Value

The weighted mean and error (the latter is the maximum of the weighted error and the square root of the variance).

Examples

```
N_UK <- map.shells(53, -11, 60, 2, scale="medium")
weighted_means(N_UK$dR, N_UK$dSTD)
```

younger *Find the probability of a calibrated date being of a certain age or younger than it*

Description

Find the probability that a sample is of a certain calendar age x or younger than it, by calculating the proportion of the calibrated distribution up to and including x (i.e., summing the calibrated distribution up to year x).

Usage

```
younger(
  x,
  y,
  er,
  cc = 1,
  postbomb = FALSE,
  normal = TRUE,
  t.a = 3,
  t.b = 4,
  BCAD = FALSE,
  threshold = 0
)
```

Arguments

x	The year of interest, in cal BP by default.
y	The radiocarbon date's mean.
er	The radiocarbon date's lab error.
cc	calibration curve for the radiocarbon date(s) (see the `rintcal` package).
postbomb	Whether or not to use a postbomb curve (see `caldist()`).
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).
BCAD	Which calendar scale to use. Defaults to cal BP, `BCAD=FALSE`.
threshold	Report only values above a threshold. Defaults to `threshold=0`.

Details

The function can only deal with one date at a time.

Value

The probability of a date being of a certain calendar age or younger than it.

Author(s)

Maarten Blaauw

Examples

```
younger(2800, 2450, 20)
younger(2400, 2450, 20)
calibrate(160, 20, BCAD=TRUE)
younger(1750, 160, 20, BCAD=TRUE)
```

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