Package 'rice'

March 19, 2026

Type Package

Title Radiocarbon Equations

Version 2.0.1

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Description

Provides functions for the calibration of radiocarbon dates, as well as options to calculate different radiocarbon-related timescales (cal BP, cal BC/AD, C14 age, F14C, pMC, D14C) and estimating the effects of contamination or local reservoir offsets (Reimer and Reimer 2001 <doi:10.1017/S0033822200038339>). Supporting publication: Blaauw, M., Reimer, P.J., in press. An open-source toolkit for radiocarbon dating and calibration. Radiocarbon. 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 uses the calibration curves from the data package 'rintcal'.

License GPL (>= 2)

Encoding UTF-8

RoxygenNote 7.3.3

Depends R (>= 3.5.0), rintcal (>= 1.4.0)

Imports rlang, ggplot2, maps (>= 3.4.2.1)

Suggests knitr, rmarkdown, utf8, remotes, sf, flextable, rnaturalearthdata, rnaturalearth (>= 1.0.1), leaflet, htmltools, CopernicusMarine, testthat (>= 3.0.0)

Language en-GB

VignetteBuilder knitr

NeedsCompilation no

LazyData true

Config/testthat/edition 3

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Repository CRAN

Date/Publication 2026-03-19 08:20:07 UTC

Contents

`rice-package` *rice: Radiocarbon Equations*

Description

Provides functions for the calibration of radiocarbon dates, as well as options to calculate different radiocarbon-related timescales (cal BP, cal BC/AD, C14 age, F14C, pMC, D14C) and estimating the effects of contamination or local reservoir offsets (Reimer and Reimer 2001 doi:10.1017/S0033822200038339). Supporting publication: Blaauw, M., Reimer, P.J., in press. An open-source toolkit for radiocarbon dating and calibration. Radiocarbon. 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 uses the calibration curves from the data package 'rintcal'.

Author(s)

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`adjust.background` *Adjust a radiocarbon age for background measurements*

Description

Calculate the radiocarbon age by adjusting it for a measured background. It is planned to update this function to more properly reflect calculations in the 14CHRONO lab.

Usage

```
adjust.background(y, er, bg, bg.er, timescale = "C14")
```

Arguments

`y`	The age of the sample (in C14 by default, but can also be in F or pMC).
`er`	The error of the date.
`bg`	The background measurement. Should be in the same timescale as that of the sample.
`bg.er`	The error of the background measurement. Should be in the same timescale as that of the sample.
`timescale`	Type of radiocarbon age. Can be in 'C14' (default), 'F14C' or 'pMC'.

Details

Radiocarbon ages are measured using a series of standards and backgrounds, and the raw values are then corrected for these background values. Backgrounds are >0 (in F14C) owing to contamination in even the cleanest lab.

Value

The background-adjusted age.

Author(s)

Maarten Blaauw

Examples

```
adjust.background(9000, 50, 45000, 200)
```

`adjust.fractionation` *Adjust a radiocarbon age for fractionation*

Description

Calculate the radiocarbon age by adjusting a sample's d13C to the reference d13C of -25 permil. It is planned to update this function to more properly reflect calculations in the 14CHRONO lab.

Usage

```
adjust.fractionation(y, d13C, reference_d13C = -25, timescale = "C14")
```

Arguments

`y`	The age of the sample (in C14 by default, but can also be in F or pMC).
`d13C`	The measured d13C value.
`reference_d13C`	The reference/standard d13C value (OX2, oxalic acid 2, NIST SRM 4990C made from 1977 French beet molasses), set at -25 permil by default.
`timescale`	Type of radiocarbon age. Can be in 'C14' (default), 'F14C' or 'pMC'.

Details

Radiocarbon ages are corrected for fractionation (which can take place in the field, or during lab pretreatment and measurement), by calculating the radiocarbon age as if the d13C fractionation were at the d13C of the standard (-25 permil). Errors are not taken into account.

Value

The fractionation-adjusted age.

Author(s)

Maarten Blaauw

Examples

```
adjust.fractionation(5000, -17)
```

age.F14C *Deprecated. Use C14toF14C instead*

Description

Deprecated. Use C14toF14C instead

Usage

```
age.F14C()
```

Value

A deprecation message

age.pMC *Deprecated. Use C14topMC instead.*

Description

Deprecated. Use C14topMC instead.

Usage

```
age.pMC()
```

Value

A deprecation message

age.range *Calculate age ranges*

Description

Calculate the quantile age ranges of a calibrated distribution

Usage

```
age.range(calib, prob = 0.95, roundby = 0, BCAD = FALSE)
```

Arguments

calib	The calibrated distribution, as returned from caldist()
prob	Probability range which should be calculated. Default prob=0.95.
roundby	Rounding. Defaults to 0 decimals.
BCAD	Which calendar scale to use. Defaults to cal BP, BCAD=FALSE.

Value

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

Examples

```
age.range(caldist(130,20, bombalert=FALSE))
```

---

as.bin *Combine multiple radiocarbon dates within bins*

Description

Combine all calibrated dates by calculating their product for a range of calendar ages, as if all dates belonged to the same (unknown) calendar age bin.

Usage

```
as.bin(
  y,
  er,
  width = 100,
  move.by = c(),
  move.res = 100,
  cc = 1,
  postbomb = FALSE,
  deltaR = 0,
  deltaSTD = 0,
  is.F = FALSE,
  as.F = FALSE,
  thiscurve = NULL,
  yrsteps = 1,
  threshold = 0.001,
  normal = TRUE,
  t.a = 3,
  t.b = 4,
  BCAD = FALSE,
  cc.dir = NULL,
  age.lim = c(),
```

```
  age.lab = c(),
  d.lim = c(),
  calib.col = rgb(0, 0, 0, 0.2),
  bin.col = rgb(0, 0, 1, 0.5),
  bin.height = 0.3,
  talk = TRUE,
  prob = 0.95,
  roundby = 0,
  bty = "n"
)
```

Arguments

y	The set of radiocarbon dates to be tested
er	The lab errors of the radiocarbon dates
width	The bin width to apply. Narrower bins will result in fewer dates fitting those bins, but in more detailed bin width histograms.
move.by	Step size by which the window moves. Left empty by default, and then the moves are set by the parameter move.res.
move.res	The amount of steps taken to make the histogram. Defaults to `move.res=100` - a compromise between detail obtained and calculation speed.
cc	Calibration curve to use. Defaults to IntCal20 (`cc=1`).
postbomb	Whether or not to use a postbomb curve. Required for negative radiocarbon ages.
deltaR	Age offset (e.g. for marine samples).
deltaSTD	Uncertainty of the age offset (1 standard deviation).
is.F	Set this to TRUE if the provided age and error are in the F14C timescale.
as.F	Whether or not to calculate ages in the F14C timescale. Defaults to `as.F=FALSE`, which uses the C14 timescale.
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).
yrsteps	Steps to use for interpolation. Defaults to the cal BP steps in the calibration curve
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 b of the t distribution (defaults to 4).
BCAD	Which calendar scale to use. Defaults to cal BP, `BCAD=FALSE`.
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"`.
age.lim	Limits of the age axis. Calculated automatically by default.
age.lab	Label of the age axis. Defaults to cal BP or BC/AD.

d.lim	Limits of the depth/vertical axis. Calculated automatically by default.
calib.col	The colour of the individual calibrated ages. Defaults to semi-transparent grey.
bin.col	The colour of the combined
bin.height	The height of the combined distribution
talk	Whether or not to report the calculations made. Defaults to talk=TRUE.
prob	Probability range for highest posterior density (hpd) values. Defaults to prob=0.95.
roundby	Rounding of reported years. Defaults to 0 decimals
bty	Draw a box around a box of a certain shape. Defaults to bty="n".

Details

This calculates the amount of calibrated dates that fall within a specific bin, and calculates these bins as moving windows over the range of calendar ages to which the radiocarbon ages calibrate.

Value

The number of dates that fall within the moving bins, for each bin.

Author(s)

Maarten Blaauw

Examples

```
data(shroud)
shroudbin <- as.bin(shroud$y, shroud$er, 50, 10)
# bins of 50 yr, moving by 10 yr, slow
```

---

as.one *Combine multiple radiocarbon dates assuming they belong to the same single year*

Description

Combine all calibrated dates by calculating their product for a range of calendar ages, as if all dates belonged to the same (unknown) single calendar age. This assumes that they all belong to the same single year in time. Use with great care, as often dates could stem from material that could have accumulated over a (much) longer time-span, and if so, then the result will be wrong. See Baillie (1991)'s 'suck-in' effect, Journal of Theoretical Archaeology 2, 12-16.

Usage

```
as.one(
  y,
  er,
  cc = 1,
  postbomb = FALSE,
  deltaR = 0,
  deltaSTD = 0,
  is.F = FALSE,
  as.F = FALSE,
  thiscurve = NULL,
  yrsteps = 1,
  threshold = 0.001,
  normal = TRUE,
  t.a = 3,
  t.b = 4,
  BCAD = FALSE,
  cc.dir = NULL,
  age.lim = c(),
  age.lab = c(),
  d.lim = c(),
  calib.col = rgb(0, 0, 0, 0.2),
  one.col = rgb(0, 0, 1, 0.5),
  one.height = 0.3,
  prob = 0.95,
  talk = TRUE,
  roundby = 0,
  bty = "n"
)
```

Arguments

y	The set of radiocarbon dates to be tested
er	The lab errors of the radiocarbon dates
cc	Calibration curve to use. Defaults to IntCal20 (cc=1).
postbomb	Whether or not to use a postbomb curve. Required for negative radiocarbon ages.
deltaR	Age offset (e.g. for marine samples).
deltaSTD	Uncertainty of the age offset (1 standard deviation).
is.F	Set this to TRUE if the provided age and error are in the F14C timescale.
as.F	Whether or not to calculate ages in the F14C timescale. Defaults to as.F=FALSE, which uses the C14 timescale.
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).
yrsteps	Steps to use for interpolation. Defaults to the cal BP steps in the calibration curve

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 b of the t distribution (defaults to 4).
BCAD	Which calendar scale to use. Defaults to cal BP, BCAD=FALSE.
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".
age.lim	Limits of the age axis. Calculated automatically by default.
age.lab	Label of the age axis. Defaults to cal BP or cal BC/AD.
d.lim	Limits of the depth/vertical axis. Calculated automatically by default.
calib.col	The colour of the individual calibrated ages. Defaults to semi-transparent grey.
one.col	The colour of the combined
one.height	The height of the combined distribution
prob	Probability range for highest posterior density (hpd) values. Defaults to prob=0.95.
talk	Whether or not to provide an analysis of the results
roundby	Rounding of reported years. Defaults to 0 decimals
bty	Draw a box around a box of a certain shape. Defaults to bty="n".

Details

This calculates the product of all calibrated probabilities, over the range of calendar ages to which the radiocarbon ages calibrate.

Value

The product of all calibrated probabilities over the range of cal BP years.

Author(s)

Maarten Blaauw

Examples

```
data(shroud)
as.one(shroud$y,shroud$er, BCAD=TRUE) # but note the scatter!
Zu <- grep("ETH", shroud$ID) # Zurich lab only
as.one(shroud$y[Zu],shroud$er[Zu], BCAD=TRUE)
```

b2ktoBCAD *calculate cal BC/AD ages from b2k ages*

Description

calculate cal BC/AD ages from b2k ages

Usage

```
b2ktoBCAD(x, zero = FALSE)
```

Arguments

x	The b2k age(s) to be translated into cal BC/AD ages.
zero	Whether or not zero BC/AD should be included. Defaults to zero=FALSE.

Details

Turn b2k ages (popular in the ice core community) into cal BC/AD (or cal BCE/CE). Negative ages indicate BC, positive ages AD. Since the Gregorian and Julian calendars do not include 0 BCAD (i.e., 31 December of 1 BC is followed by 1 January of AD 1), zero can be omitted. The years then go from -1 (i.e., 1 BC) to 1 AD. Other calendars, such as the astronomical one, do include zero. The often-used BCE/CE ages are equivalent to BC/AD.

Value

The cal BC/AD age(s). BC ages are negative, AD ages are positive.

Examples

```
b2ktoBCAD(0)
b2ktoBCAD(1990:2010, zero=TRUE)
b2ktoBCAD(1990:2010, zero=FALSE)
```

b2ktoC14 *Find the 14C age and error belonging to a b2k age.*

Description

Given a b2k age (years before AD 2000, popular in the ice core community), the calibration curve (default cc=1) is interpolated and the corresponding 14C age and error are returned.

Usage

```
b2ktoC14(
  x,
  cc = 1,
  postbomb = FALSE,
  rule = 1,
  cc.dir = NULL,
  thiscurve = NULL,
  roundby = Inf
)
```

Arguments

`x`	The b2k 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"`.
`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).
`roundby`	Amount of decimals required for the output. Defaults to `roundby=Inf`, no rounding.

Details

Interpolation is used, and values outside the calibration curve are given as NA. For ages younger than 50 b2k, a postbomb curve will have to be provided.

Value

The calibration-curve 14C year belonging to the entered b2k age

Author(s)

Maarten Blaauw

Examples

```
b2ktoC14(100)
```

b2ktocalBP *calculate cal BP ages from b2k ages*

Description

calculate cal BP ages from b2k ages

Usage

```
b2ktocalBP(x)
```

Arguments

x	The b2k age(s) to be translated into cal BP age(s).

Details

Turn b2k ages (often used in the ice core community, AD 2000) into cal BP ages.

Value

The cal BP age(s).

Examples

```
b2ktocalBP(0)
```

b2ktoDelta14C *Find the Delta14C and error belonging to a b2k age.*

Description

Given a b2k age (years before AD 2000, popular in the ice core community), the calibration curve (default cc=1) is interpolated and the corresponding Delta14C value and error are returned.

Usage

```
b2ktoDelta14C(
  x,
  cc = 1,
  postbomb = FALSE,
  rule = 1,
  cc.dir = NULL,
  thiscurve = NULL,
  roundby = Inf
)
```

Arguments

x	The b2k year.
cc	calibration curve (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".
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).
roundby	Amount of decimals required for the output. Defaults to roundby=Inf, no rounding.

Details

Interpolation is used, and values outside the calibration curve are given as NA. For b2k < 50, a postbomb curve will have to be provided.

Value

The calibration-curve 14C year belonging to the entered b2k age

Author(s)

Maarten Blaauw

Examples

```
b2ktoDelta14C(100)
```

---

b2ktoF14C *Find the F14C and error belonging to a b2k age.*

Description

Given a b2k age (years before AD 2000, popular in the ice core community), the calibration curve (default cc=1) is interpolated and the corresponding F14C and error are returned.

Usage

```
b2ktoF14C(
  x,
  cc = 1,
  postbomb = FALSE,
  rule = 1,
  cc.dir = NULL,
  thiscurve = NULL,
  roundby = Inf
)
```

Arguments

x	The b2k 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".
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).
roundby	Amount of decimals required for the output. Defaults to roundby=Inf, no rounding.

Details

Interpolation is used, and values outside the calibration curve are given as NA. For ages younger than 50 b2k, a postbomb curve will have to be provided.

Value

The calibration-curve F14C belonging to the entered b2k age

Author(s)

Maarten Blaauw

Examples

```
b2ktoF14C(100)
```

b2ktopMC *Find the pMC and error belonging to a b2k age.*

Description

Given a b2k age (years before AD 2000, popular in the ice core community), the calibration curve (default cc=1) is interpolated and the corresponding pMC and error are returned.

Usage

```
b2ktopMC(
  x,
  cc = 1,
  postbomb = FALSE,
  rule = 1,
  cc.dir = NULL,
  thiscurve = NULL,
  roundby = Inf
)
```

Arguments

x	The b2k 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".
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).
roundby	Amount of decimals required for the output. Defaults to roundby=Inf, no rounding.

Details

Interpolation is used, and values outside the calibration curve are given as NA. For ages younger than 50 b2k, a postbomb curve will have to be provided.

Value

The calibration-curve F14C belonging to the entered b2k age

Author(s)

Maarten Blaauw

Examples

```
b2ktopMC(100)
```

BCADtob2k *calculate b2k from cal BC/AD ages*

Description

calculate b2k from cal BC/AD ages

Usage

```
BCADtob2k(x, zero = FALSE)
```

Arguments

x	The BCAD age(s) to be translated into b2k age(s). BC ages are negative, AD ages are positive.
zero	Whether or not zero BC/AD should be included. Defaults to zero=FALSE.

Details

Turn cal BC/AD (or BCE/CE) ages into b2k ages. b2k ages are used frequently in the ice core community. Negative ages indicate BC, positive ages AD. Since the Gregorian and Julian calendars do not include 0 BC/AD (i.e., 31 December of 1 BC is followed by 1 January of AD 1), zero can be omitted. The years then go from -1 (i.e., 1 BC) to 1 AD. Other calendars, such as the astronomical one, do include zero. The often-used BCE/CE ages are equivalent to BC/AD.

Value

The b2k age(s).

Examples

```
BCADtob2k(2025)
BCADtob2k(-1, zero=TRUE)
BCADtob2k(-1, zero=FALSE)
```

BCADtoC14 *Find the 14C age and error belonging to a cal BC/AD age.*

Description

Given a calendar age, the calibration curve (default cc=1) is interpolated and the corresponding 14C age and error are returned. BC ages are negative. In this implementation, the year 0 BC/AD does exist.

Usage

```
BCADtoC14(
  x,
  cc = 1,
  postbomb = FALSE,
  zero = FALSE,
  rule = 1,
  cc.dir = NULL,
  thiscurve = NULL,
  roundby = Inf
)
```

Arguments

x	The cal BC/AD year.
cc	calibration curve for C14 (see `caldist()`).
postbomb	Whether or not to use a postbomb curve (see `caldist()`).
zero	Whether or not zero BC/AD should be included. Defaults to `zero=FALSE`.
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"`.
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).
roundby	Amount of decimals required for the output. Defaults to `roundby=Inf`, no rounding.

Details

Interpolation is used, and values outside the calibration curve are given as NA. For ages younger than AD 1950, a postbomb curve will have to be provided.

Value

The calibration-curve 14C year belonging to the entered BC/AD age

Author(s)

Maarten Blaauw

Examples

```
BCADtoC14(100)
```

`BCADtocalBP` *calculate cal BP ages from cal BC/AD ages*

Description

calculate cal BP ages from cal BC/AD ages

Usage

```
BCADtocalBP(x, zero = FALSE)
```

Arguments

`x`	The cal BCAD age(s) to be translated into cal BP age(s). BC ages are negative, AD ages are positive.
`zero`	Whether or not zero BC/AD should be included. Defaults to `zero=FALSE`.

Details

Turn cal BC/AD (or BCE/CE) ages into cal BP ages. Negative ages indicate BC, positive ages AD. Since the Gregorian and Julian calendars do not include 0 BC/AD (i.e., 31 December of 1 BC is followed by 1 January of AD 1), zero can be omitted. The years then go from -1 (i.e., 1 BC) to 1 AD. Other calendars, such as the astronomical one, do include zero. The often-used BCE/CE ages are equivalent to BC/AD.

Value

The cal BP age(s).

Examples

```
BCADtocalBP(2025)
BCADtocalBP(-1, zero=TRUE)
BCADtocalBP(-1, zero=FALSE)
```

BCADtoDelta14C *Find the Delta14C and error belonging to a cal BC/AD age.*

Description

Given a calendar age, the calibration curve (default cc=1) is interpolated and the corresponding Delta14C value and error are returned.

Usage

```
BCADtoDelta14C(
  x,
  zero = FALSE,
  cc = 1,
  postbomb = FALSE,
  rule = 1,
  cc.dir = NULL,
  thiscurve = NULL,
  roundby = Inf
)
```

Arguments

x	The cal BC/AD year.
zero	Whether or not zero BC/AD should be included. Defaults to zero=FALSE.
cc	calibration curve (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".
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).
roundby	Amount of decimals required for the output. Defaults to roundby=Inf, no rounding.

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 BC/AD age.

Author(s)

Maarten Blaauw

Examples

```
BCADtoDelta14C(1900)
```

BCADtoF14C *Find the F14C and error belonging to a cal BC/AD age.*

Description

Given a calendar age, the calibration curve (default cc=1) is interpolated and the corresponding F14C and error are returned. BC ages are negative.

Usage

```
BCADtoF14C(
  x,
  cc = 1,
  postbomb = FALSE,
  zero = FALSE,
  rule = 1,
  cc.dir = NULL,
  thiscurve = NULL,
  roundby = Inf
)
```

Arguments

x	The cal BC/AD year.
cc	calibration curve for C14 (see `caldist()`).
postbomb	Whether or not to use a postbomb curve (see `caldist()`).
zero	Whether or not zero BC/AD should be included. Defaults to `zero=FALSE`.
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"`.
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).
roundby	Amount of decimals required for the output. Defaults to `roundby=Inf`, no rounding.

Details

Interpolation is used, and values outside the calibration curve are given as NA. For ages younger than AD 1950, a postbomb curve will have to be provided.

Value

The calibration-curve F14C belonging to the entered BC/AD age

Author(s)

Maarten Blaauw

Examples

```
BCADtoF14C(100)
```

`BCADtopMC` *Find the pMC and error belonging to a cal BC/AD age.*

Description

Given a calendar age, the calibration curve (default cc=1) is interpolated and the corresponding pMC and error are returned. BC ages are negative.

Usage

```
BCADtopMC(
  x,
  cc = 1,
  postbomb = FALSE,
  zero = FALSE,
  rule = 1,
  cc.dir = NULL,
  thiscurve = NULL,
  roundby = Inf
)
```

Arguments

`x`	The cal BC/AD year.
`cc`	calibration curve for C14 (see `caldist()`).
`postbomb`	Whether or not to use a postbomb curve (see `caldist()`).
`zero`	Whether or not zero BC/AD should be included. Defaults to `zero=FALSE`.
`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".
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).
roundby	Amount of decimals required for the output. Defaults to roundby=Inf, no rounding.

Details

Interpolation is used, and values outside the calibration curve are given as NA. For ages younger than AD 1950, a postbomb curve will have to be provided.

Value

The calibration-curve F14C belonging to the entered cal BC/AD age

Author(s)

Maarten Blaauw

Examples

```
BCADtopMC(100)
```

C14tob2k *Find the b2k age(s) crossing a C14 age.*

Description

Find the b2k ages (years before AD 2000, popular in the ice core community) where the calibration curve crosses a given C14 age. This function is for illustration only and not to be used for, e.g., calibration, because intercept calibration is an outdated method.

Usage

```
C14tob2k(
  y,
  cc = 1,
  postbomb = FALSE,
  rule = 1,
  cc.dir = NULL,
  thiscurve = NULL,
  roundby = Inf
)
```

Arguments

y	The C14 age.
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".
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).
roundby	Amount of decimals required for the output. Defaults to roundby=Inf, no rounding.

Details

. Whereas each calendar age will only have one single IntCal radiocarbon age (mu), the same cannot be said for the other way round. Recurring C14 ages do happen, especially during periods of plateaux and wiggles. Therefore, there can be multiple cal BP ages for a single C14 age. In the early days, radiocarbon calibration used an 'intercept method' to find possible calendar ages belonging to a radiocarbon age, but this is problematic since small deviations in the C14 age can easily cause more or fewer crossing cal BP ages (try for example C14tocalBP(130) vs C14tocalBP(129)), and moreover, this approach does not deal well with the errors in either a date of the calibration curve. Therefore, the probabilistic approach to radiocarbon calibration (which starts with a cal BP age and then looks up the corresponding C14 age) has taken over as the standard.

Value

The b2k age(s) belonging to the entered C14 age

Author(s)

Maarten Blaauw

Examples

```
C14tob2k(130, 20)
```

C14toBCAD *Find the cal BCAD age(s) crossing a C14 age.*

Description

Find the BCAD ages where the calibration curve crosses a given C14 age. This function is for illustration only and not to be used for, e.g., calibration, because intercept calibration is an outdated method.

Usage

```
C14toBCAD(
  y,
  cc = 1,
  postbomb = FALSE,
  rule = 1,
  zero = FALSE,
  cc.dir = NULL,
  thiscurve = NULL,
  roundby = Inf
)
```

Arguments

y	The C14 age.
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.
zero	Whether or not zero BC/AD should be included. Defaults to zero=FALSE.
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".
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).
roundby	Amount of decimals required for the output. Defaults to roundby=Inf, no rounding.

Details

. Whereas each cal BC/AD age will only have one single IntCal radiocarbon age (mu), the same cannot be said for the other way round. Recurring C14 ages do happen, especially during periods of plateaux and wiggles. Therefore, there can be multiple cal BC/AD ages for a single C14 age. In the early days, radiocarbon calibration used an 'intercept method' to find possible calendar ages belonging to a radiocarbon age, but this is problematic since small deviations in the C14 age

can easily cause more or fewer crossing cal BC/AD ages (try for example C14toBCAD(130) vs C14toBCAD(129)), and moreover, this approach does not deal well with the errors in either a date of the calibration curve. Therefore, the probabilistic approach to radiocarbon calibration (which starts with a cal BC/AD age and then looks up the corresponding C14 age) has taken over as the standard.

Value

The cal BCAD age(s) belonging to the entered C14 age

Author(s)

Maarten Blaauw

Examples

```
y <- 130
calibrate(y, 10, BCAD=TRUE)
abline(h=y)
abline(v=C14toBCAD(y))
```

C14tocalBP *Find the calBP age(s) crossing a C14 age.*

Description

Find the cal BP ages where the calibration curve crosses a given C14 age. This function is for illustration only and not to be used for, e.g., calibration, because intercept calibration is an outdated method.

Usage

```
C14tocalBP(
  y,
  cc = 1,
  postbomb = FALSE,
  rule = 2,
  cc.dir = NULL,
  thiscurve = NULL,
  roundby = Inf
)
```

Arguments

y	The C14 age. No errors are assumed. Can only deal with one C14 age at a time.
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".
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).
roundby	Amount of decimals required for the output. Defaults to roundby=Inf, no rounding.

Details

. Whereas each cal BP age will only have one single IntCal radiocarbon age (mu), the same cannot be said for the other way round. Recurring C14 ages do happen, especially during periods of plateaux and wiggles. Therefore, there can be multiple cal BP ages for a single C14 age. In the early days, radiocarbon calibration used an 'intercept method' to find possible calendar ages belonging to a radiocarbon age, but this is problematic since small deviations in the C14 age can easily cause more or fewer crossing cal BP ages (try for example C14tocalBP(130) vs C14tocalBP(129)), and moreover, this approach does not deal well with the errors in either a date of the calibration curve. Therefore, the probabilistic approach to radiocarbon calibration (which starts with a cal BP age and then looks up the corresponding C14 age) has taken over as the standard.

Value

The cal BP age(s) belonging to the entered C14 age

Author(s)

Maarten Blaauw

Examples

```
y <- 130
calibrate(y,10)
abline(h=y)
abline(v=C14tocalBP(y))
```

C14toDelta14C *Transform C14 age(s) into Delta14C*

Description

Transform C14 age(s) into Delta14C

Usage

```
C14toDelta14C(y, er = NULL, t, roundby = Inf, lambda = 5730/log(2))
```

Arguments

y	The C14 age to translate
er	Reported error of the C14 age. Returns just the mean if left empty.
t	the cal BP age
roundby	Amount of decimals required for the output. Defaults to roundby=Inf, no rounding.
lambda	Radiocarbon's mean-life, based on the Cambridge half-life

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 C14 ages 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 Delta14C value

Examples

```
C14toDelta14C(0.985, 20, 222)
```

C14toF14C *Calculate F14C values from C14 ages*

Description

Calculate F14C values from radiocarbon ages

Usage

```
C14toF14C(y, er = NULL, roundby = Inf, lambda = 8033, botherrors = FALSE)
```

Arguments

y	Reported mean of the 14C age.
er	Reported error of the 14C age. If left empty, will translate y to F14C.
roundby	Amount of decimals required for the output. Defaults to roundby=Inf, no rounding.
lambda	The mean-life of radiocarbon (based on Libby half-life of 5568 years).
botherrors	Since going from C14 to F14C involves a logarithmic transformation (F=exp(-y/lambda)), errors that are symmetric on the C14 scale will become asymmetric on the F14C scale. By default, only the largest error is reported, but if botherrors=TRUE, both errors are reported.

Details

Post-bomb dates are often reported as F14C or fraction modern carbon. Since software such as 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

```
C14toF14C(-2000, 20)
```

`C14topMC` *Calculate pMC values from C14 ages*

Description

Calculate pMC values from radiocarbon ages

Usage

```
C14topMC(y, er = NULL, roundby = Inf, lambda = 8033)
```

Arguments

`y`	Reported mean of the C14 age.
`er`	Reported error of the C14 age.
`roundby`	Amount of decimals required for the output. Defaults to `roundby=Inf`, no rounding.
`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 pMCtoC14.

Value

pMC values from C14 ages.

Examples

```
C14topMC(-2000, 20)
C14topMC(-2000, 20, 1)
```

calBPtob2k *calculate b2k ages from cal BP ages*

Description

calculate b2k ages from cal BP ages

Usage

```
calBPtob2k(x)
```

Arguments

x	The calBP age(s) to be translated into b2k ages.

Details

Turn cal BP ages into b2k ages (years before AD 2000), which are often used in the ice core community.

Value

The b2k ages.

Examples

```
calBPtob2k(-50)
```

calBPtoBCAD *calculate cal BC/AD ages from cal BP ages*

Description

calculate cal BC/AD ages from cal BP ages

Usage

```
calBPtoBCAD(x, zero = FALSE)
```

Arguments

x	The calBP age(s) to be translated into cal BC/AD ages.
zero	Whether or not zero BC/AD should be included. Defaults to zero=FALSE.

Details

Turn cal BP ages into cal BC/AD (equivalent to cal BCE/CE). Negative ages indicate cal BC, positive ages cal AD. Since the Gregorian and Julian calendars do not include 0 BCAD (i.e., 31 December of 1 BC is followed by 1 January of AD 1), zero can be omitted. The years then go from -1 (i.e., 1 BC) to 1 AD. Other calendars, such as the astronomical one, do include zero.

Value

The cal BC/AD age(s). BC ages are negative, AD ages are positive.

Examples

```
calBPtoBCAD(2024)
calBPtoBCAD(1945:1955, zero=FALSE)
calBPtoBCAD(1945:1955, zero=TRUE)
```

---

calBPtoC14 *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

```
calBPtoC14(
  x,
  cc = 1,
  postbomb = FALSE,
  rule = 1,
  cc.dir = NULL,
  thiscurve = NULL,
  roundby = Inf
)
```

Arguments

x	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"`.

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).
roundby	Amount of decimals required for the output. Defaults to roundby=Inf, no rounding.

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

```
calBPtoC14(100)
```

---

calBPtoDelta14C *Find the Delta14C and error belonging to a cal BP age.*

Description

Given a calendar age, the calibration curve (default cc=1) is interpolated and the corresponding Delta14C value and error are returned.

Usage

```
calBPtoDelta14C(
  x,
  cc = 1,
  postbomb = FALSE,
  rule = 1,
  cc.dir = NULL,
  thiscurve = NULL,
  roundby = Inf
)
```

Arguments

x	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".
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).
roundby	Amount of decimals required for the output. Defaults to roundby=Inf, no rounding.

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 Delta14C belonging to the entered cal BP age

Author(s)

Maarten Blaauw

Examples

```
calBPtoDelta14C(100)
```

---

calBPtoF14C *Find the F14C and error belonging to a cal BP age.*

Description

Given a calendar age, the calibration curve (default cc=1) is interpolated and the corresponding F14C value and error are returned.

Usage

```
calBPtoF14C(
  x,
  cc = 1,
  postbomb = FALSE,
  rule = 1,
  cc.dir = NULL,
  thiscurve = NULL,
  roundby = Inf
)
```

Arguments

x	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".
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).
roundby	Amount of decimals required for the output. Defaults to roundby=Inf, no rounding.

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

```
calBPtoF14C(100)
```

`calBPtopMC` *Find the pMC and error belonging to a cal BP age.*

Description

Given a calendar age, the calibration curve (default cc=1) is interpolated and the corresponding F14C value and error are returned.

Usage

```
calBPtopMC(
  x,
  cc = 1,
  postbomb = FALSE,
  rule = 1,
  cc.dir = NULL,
  thiscurve = NULL,
  roundby = Inf
)
```

Arguments

`x`	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"`.
`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).
`roundby`	Amount of decimals required for the output. Defaults to `roundby=Inf`, no rounding.

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

```
calBPtopMC(100)
```

`caldist` *Calculate calibrated distribution*

Description

Calculate the calibrated distribution of a radiocarbon date.

Usage

```
caldist(
  y,
  er,
  cc = 1,
  postbomb = FALSE,
  bombalert = TRUE,
  glue = 0,
  deltaR = 0,
  deltaSTD = 0,
  is.F = FALSE,
  is.pMC = FALSE,
  as.F = TRUE,
  thiscurve = NULL,
  yrsteps = FALSE,
  cc.resample = FALSE,
  pb.steps = 0.05,
  cc0.res = 5000,
  threshold = 0.001,
  normal = TRUE,
  t.a = 3,
  t.b = 4,
  normalise = TRUE,
  BCAD = FALSE,
  rule = 1,
  cc.dir = NULL,
  col.names = NULL
)
```

Arguments

y	Uncalibrated radiocarbon age
er	Lab error of the radiocarbon age
cc	Calibration curve to use. Defaults to IntCal20 (cc=1), can be Marine20 (cc=2), SHCal20 (cc=3), or if postbomb=TRUE, NH1 (cc=1), NH2 (cc=2), NH3 (cc=3), SH1-2 (cc=4) or SH3 (cc=5).
postbomb	Whether or not to use a postbomb curve. Required for negative radiocarbon ages.
bombalert	Stop if a date is overly close to the younger limit of the IntCal curve. Defaults to bombalert=TRUE. This error can be avoided by either providing a postbomb curve (e.g., postbomb=1) or typing bombalert=FALSE (in this case, part of the date will be truncated).
glue	Glue postbomb and prebomb curves together. Defaults to 0 (none), can be 1 (IntCal20 + NH1), 2 (IntCal20 + NH2), 3 (IntCal20 + NH3), 4 (SHCal20 + SH1-2) or 5 (SHCal20 + SH3). Note that this will override the value of cc.
deltaR	Age offset (e.g. for marine samples). This assumes that the radiocarbon age is provided as 14C BP (not F14C or pMC).
deltaSTD	Uncertainty of the age offset (1 standard deviation).
is.F	Set this to TRUE if the provided age and error are in the F14C timescale.
is.pMC	Set this to TRUE if the provided age and error are in the pMC timescale.
as.F	Whether or not to calculate ages in the F14C timescale. Defaults to as.F=TRUE, so not using the C14 timescale (will be more accurate especially for dates with larger errors, e.g., older ones).
thiscurve	As an alternative to providing cc and/or postbomb/glue, the data of a specific curve can be provided (3 columns: cal BP, C14 age, error).
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.
pb.steps	Yearly steps for postbomb curves. Defaults to 20 steps per year, pb.steps=0.05.
cc0.res	Length of 'curve' when cc=0 (no calibration curve). Defaults to 5000, in order to provide enough points for detailed distributions.
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 b 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".
col.names	Names for the output columns. Defaults to calBP/BCAD and probs, respectively (depending on the value of BCAD).

Value

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

Examples

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

---

calib.t

Comparison dates calibrated using both the t distribution (Christen and Perez 2009) and the normal distribution.

Description

Visualise how a date calibrates using the t distribution and the normal distribution.

Usage

```
calib.t(
  y = 2450,
  er = 50,
  t.a = 3,
  t.b = 4,
  cc = 1,
  postbomb = FALSE,
  deltaR = 0,
  deltaSTD = 0,
  as.F = FALSE,
  is.F = FALSE,
  BCAD = FALSE,
  cal.rev = TRUE,
  cc.dir = c(),
  normal.col = "red",
  normal.lwd = 1.5,
  t.col = rgb(0, 0, 0, 0.25),
  t.border = rgb(0, 0, 0, 0, 0.25),
  xlim = c(),
  ylim = c()
)
```

Arguments

y	The reported mean of the date.
er	The reported error of the date.
t.a	Value for the t parameter a.
t.b	Value for the t parameter b.
cc	calibration curve for the radiocarbon date(s) (see the rintcal package).
postbomb	Which postbomb curve to use for negative 14C dates.
deltaR	Age offset (e.g. for marine samples).
deltaSTD	Uncertainty of the age offset (1 standard deviation).
as.F	Whether or not to calculate ages in the F14C timescale. Defaults to as.F=FALSE, which uses the C14 timescale.
is.F	Use this if the provided date is in the F14C timescale.
BCAD	Which calendar scale to use. Defaults to cal BP, BCAD=FALSE.
cal.rev	Reverse the calendar age axis. Defaults to TRUE
cc.dir	Directory where the calibration curves for C14 dates cc are allocated. By default cc.dir=c(). Use cc.dir="." to choose current working directory. Use cc.dir="Curves/" to choose sub-folder Curves/.
normal.col	Colour of the normal curve
normal.lwd	Line width of the normal curve
t.col	Colour of the t histogram
t.border	Colour of the border of the t histogram
xlim	x axis limits
ylim	y axis limits

Details

Radiocarbon and other dates are usually modelled using the normal distribution (red curve). The t approach (grey distribution) however allows for wider tails and thus tends to better accommodate outlying dates. This distribution requires two parameters, called 'a' and 'b'.

Author(s)

Maarten Blaauw

Examples

```
calib.t()
```

`calibratable` *Make a table of calibrated dates*

Description

Calibrate a number of radiocarbon dates and make a table containing the calibrated ranges (both highest posterior densities and quantiles).

Usage

```
calibratable(
  y,
  er,
  lab = c(),
  cc = 1,
  BCAD = FALSE,
  postbomb = FALSE,
  bombalert = TRUE,
  glue = 0,
  cc.dir = c(),
  thiscurve = c(),
  is.F = FALSE,
  is.pMC = FALSE,
  deltaR = 0,
  deltaSTD = 0,
  prob = 0.95,
  prob.round = 1,
  age.round = 0,
  docx = c()
)
```

Arguments

`y`	The radiocarbon dates
`er`	The laboratory errors of the radiocarbon dates
`lab`	The labels of the radiocarbon dates (if any)
`cc`	The calibration curve to smooth. 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). Explanations of the numbers are provided in the table footer. If there is more than one cc provided, they will be printed in an extra table column.

BCAD	Which calendar scale to use. Defaults to cal BP, BCAD=FALSE. For the BCAD scale, BC ages are negative.
postbomb	Use 'postbomb=TRUE' to get a postbomb calibration curve (default 'postbomb=FALSE'). For monthly data, type e.g. 'ccurve("sh1-2_monthly")'
bombalert	Warn if a date is close to the lower limit of the IntCal curve. Defaults to postbomb=TRUE.
glue	Glue postbomb and prebomb curves together. Defaults to 0 (none), can be 1 (IntCal20 + NH1), 2 (IntCal20 + NH2), 3 (IntCal20 + NH3), 4 (SHCal20 + SH1-2) or 5 (SHCal20 + SH3). Note that this will override the value of cc.
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"'.
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 c().
is.F	Set this to TRUE if the provided age and error are in the F14C timescale.
is.pMC	Set this to TRUE if the provided age and error are in the pMC timescale.
deltaR	Age offset (e.g. for marine samples). If provided, the deltaR and deltaSTD values will be provided as an extra table column.
deltaSTD	Uncertainty of the age offset (1 standard deviation). If provided, the deltaR and deltaSTD values will be provided as an extra table column.
prob	Probability range which should be calculated. Default prob=0.95.
prob.round	Rounding for reported probabilities. Defaults to 1 decimal.
age.round	Rounding for ages. Defaults to 0 decimals.
docx	By default, the table is written to your web browser. If you wish to write it to a MS-Word document instead, provide the file (with .docx extension) and its location here, e.g., docx="C14_table.docx".

Details

Calibration is done taking into account calibration curves and any age offsets (deltaR, deltaSTD). The table will be displayed in an Internet browser, or alternatively saved to a .docx file. Based on ideas by Dr. Vegard Martinsen, NMBU, Norway). If you have a mix of pre- and postbomb dates, they can be calibratabled as follows: y <- c(.9, .8, 1.5); er <- rep(.01, 3) calibrate.table(y, er, is.F=T, thiscurve=glue.ccurves(,1), BCAD=T)

Author(s)

Maarten Blaauw

Examples

```
calibratable(130, 20, bombalert=FALSE)
data(shroud)
calibratable(shroud$y, shroud$er, shroud$ID)
```

`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,
  glue = 0,
  deltaR = 0,
  deltaSTD = 0,
  thiscurve = c(),
  as.F = TRUE,
  is.F = FALSE,
  is.pMC = FALSE,
  reservoir = 0,
  prob = 0.95,
  BCAD = FALSE,
  ka = FALSE,
  draw = TRUE,
  cal.lab = c(),
  C14.lab = c(),
  cal.lim = c(),
  C14.lim = c(),
  cc.col = rgb(0, 0.5, 0, 0.7),
  cc.border = cc.col,
  date.col = "red",
  dist.col = rgb(0, 0, 0, 0.3),
  dist.border = dist.col,
  hpd.col = dist.col,
  dist.height = 0.3,
  dist.float = c(0.01, 0.01),
  cal.rev = TRUE,
  yr.steps = FALSE,
  cc.resample = NA,
  threshold = 5e-04,
  edge = TRUE,
  normal = TRUE,
  t.a = 3,
  t.b = 4,
```

```
  rounded = 1,
  round.age = c(),
  round.hpd.ages = c(),
  round.hpd.probs = 1,
  every = NA,
  extend.range = 0.05,
  legend.cex = 0.8,
  legend1.loc = "topleft",
  legend2.loc = "topright",
  warning.loc = "right",
  print.truncate.warning = TRUE,
  mgp = c(2, 1, 0),
  mar = c(3, 3, 1, 1),
  xaxs = "i",
  yaxs = "i",
  bty = "l",
  cc.dir = NULL,
  cc.er = 0,
  asymmetric = TRUE,
  ...
)
```

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`.
glue	Glue postbomb and prebomb curves together. Defaults to 0 (none), can be 1 (IntCal20 + NH1), 2 (IntCal20 + NH2), 3 (IntCal20 + NH3), 4 (SHCal20 + SH1-2) or 5 (SHCal20 + SH3). Note that this will override the value of cc.
deltaR	Age offset (e.g. for marine samples). Can also be provided as option 'reservoir'.
deltaSTD	Uncertainty of the age offset (1 standard deviation). Can also be provided within option 'reservoir'.
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 c().
as.F	Whether or not to calculate ages in the F14C timescale. Defaults to `as.F=TRUE`, since it takes better care of asymmetric distributions and older dates close to the dating limit. If set as `as.F=FALSE`, the C14 timescale will be used.
is.F	Use `is.F=TRUE` if the date and error are entered as F14C.
is.pMC	Use `is.pMC=TRUE` if the date and error are entered as pMC.
reservoir	Reservoir age, or reservoir age and age offset as two values (e.g., `reservoir=c(100,10)`). This is an alternative to using deltaR and deltaSTD.

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.
draw	Whether or not to draw the date. Can be set as FALSE to speed up things
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 calibration curve. Defaults to semi-transparent dark green; `cc.col=rgb(0,.5,0,0.7)`.
cc.border	Colour of the borders of the calibration curve. Defaults to cc.col.
date.col	Colour of the "dot-bar" plot of the C14 date. Defaults to `date.col="red"`.
dist.col	Colour of the distributions. Defaults to semi-transparent grey, `dist.col=rgb(0,0,0,0.2)`.
dist.border	Colour of the borders of the distributions. Defaults to that of dist.col.
hpd.col	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 1.8.
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. Defaults to `cal.rev=TRUE`.
yr.steps	Temporal resolution at which C-14 ages are calibrated (in calendar years). By default follows the spacing 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. Defaults to no resampling (cc.resample=NA).
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 b of the t distribution (defaults to 4).
rounded	Rounding of the percentages of the reported hpd ranges. Defaults to 1 decimal.
round.age	Rounding of the uncalibrated 14C age as reported on the plot. Defaults to 0 decimals for 14C ages, 4 for F14C values.

round.hpd.ages	Rounding of the ages of the hpd ranges. Defaults to 0 decimals.
round.hpd.probs	Rounding of the percentages of the hpd ranges. Defaults to 1 decimal.
every	Deprecated. See 'rounded'.
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.
warning.loc	Location for any warnings. Defaults to right.
print.truncate.warning	Whether or not a truncation warning is printed on the plot. Defaults to print.truncate.warning=TRUE.
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".
cc.er	The error of the calibration curve. Only used for plotting the uncalibrated C14 distribution, which by default only shows the date's uncertainty (the calibration curve uncertainty is indeed taken into account during calibration). If known, the calibration curve's error can be added.
asymmetric	Whether or not to plot the C14 distribution asymmetric. If asymmetric=TRUE (default), the underlying calculations are done in the F14C timescale, then converted to C14 ages for plotting the C14 distribution.
...	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, bombalert=FALSE)
cal <- calibrate(2550, 20, reservoir=100)
cal; plot(cal[[1]])
calibrate(130, 10, prob=0.68, bombalert=FALSE)
calibrate(age=130, error=10, BCAD=TRUE, bombalert=FALSE)
calibrate(4450, 40, reservoir=c(100, 50))
```

---

clean *Simulate removing contamination from a radiocarbon age*

Description

Given an observed radiocarbon age, remove the impact of contamination (for example, 1% contamination with modern carbon) to estimate the true/target age

Usage

```
clean(
  y,
  er = 0,
  percentage,
  percentage.error = 0.001,
  F.contam = 1,
  F.contam.er = 0.001,
  MC = TRUE,
  seed = NA,
  its = 10000,
  roundby = 1,
  decimals = 5,
  visualise = TRUE,
  talk = TRUE,
  eq.x = 5,
  eq.y = c(),
  eq.size = 0.75,
  true.col = "darkgreen",
  observed.col = "blue",
  contamination.col = "red",
  true.pch = 20,
  observed.pch = 18,
  contamination.pch = 17,
```

```
  true.name = "true",
  xlab = "contamination (%)",
  ylab = "F14C",
  ylim = c(),
  C14.axis = TRUE,
  bty = "u"
)
```

Arguments

y	The observed radiocarbon age
er	The error of the observed radiocarbon age
percentage	Relative amount of contamination. Must be between 0 and 100 (%)
percentage.error	Uncertainty of the contamination. Assumed to be normally distributed (which fails close to 0% or 100% contamination levels). Defaults to a very small but >0 value, 0.001%.
F.contam	The F14C of the contamination. Set at 1 for carbon of modern radiocarbon age, at 0 for 14C-free carbon, or anywhere inbetween.
F.contam.er	The error of the contamination. Defaults to a very small but >0 value, 0.001%.
MC	Whether or not to use Monte Carlo iterations to estimate the values. Defaults to TRUE, because it treats uncertainties better than if set to FALSE.
seed	For reproducibility, a seed can be set (e.g., seed=123). Defaults to NA, no seed set.
its	Amount of iterations to use if MC=TRUE. Defaults to 10,000.
roundby	Rounding of the output for C14 ages. Defaults to 1 decimal.
decimals	Rounding of the output. Since details matter here, the default is to provide 5 decimals.
visualise	By default, a plot is made to visualise the target and observed F14C values, together with the inferred contamination.
talk	Whether or not to report the calculations made. Defaults to talk=TRUE.
eq.x	Leftmost location of the equation. Defaults to eq.x=5. Can be set to values outside of (0,100) to make the equation invisible.
eq.y	Vertical location of the equation. Defaults to the top of the graph.
eq.size	Size of the font of the equation. In case the equation gets jumbled up upon resizing of a graphical device, just issue the previous ‘clean‘ command again. Defaults to eq.size=0.8.
true.col	Colour for the target/true values. Defaults to "darkgreen".
observed.col	Colour for the observed values. Defaults to blue.
contamination.col	Colour for the contamination values. Defaults to red.
true.pch	Icon for the true/target date. Defaults to a filled circle.
observed.pch	Icon for the observed. Defaults to a diamond

`contamination.pch`
: Icon for the contamination. Defaults to a triangle.

`true.name`
: Name of the label of the true/target date

`xlab`
: Name of the x-axis. Defaults to 'contamination (%)'.

`ylab`
: Name of the y-axis. Defaults to 'F14C'.

`ylim`
: Limits of the y-axis. Calculated automatically by default.

`C14.axis`
: Whether or not to draw a secondary vertical axis for C14 ages. Defaults to `C14.axis=TRUE`.

`bty`
: Draw a box around a box of a certain shape. Defaults to `bty="u"`.

Details

Whereas the function takes C14 ages and percentage contamination as input, internal calculations are done in the F14C timescale and using fractions (between 0 and 1). The central calculation is 'F_true = ((1-frac)*F_obs) - (frac*F_contam)', where 'F_true' is the true or target age in F14C, 'frac' is the fraction of contamination, 'F_obs' is the F14C of the observed C14 age, and 'F_contam' is the F activity of the contamination. In some extreme cases, the calculations will spit out unexpected results. Messages will be provided in most of these cases.

Value

The true/target radiocarbon age and error

Author(s)

Maarten Blaauw

Examples

```
# 1% contamination with modern carbon (no uncertainties in contamination's percentage or F)
clean(5000, 20, 1, 0, 1, 0)
# now with errors:
clean(5000, 20, 1, 0.1, 1, 0.1)
```

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

Description

Given a true/target radiocarbon age, calculate the impact of contamination (for example, 1% contamination with modern carbon) on the observed age. Can optionally include contamination uncertainties, but then Monte Carlo iterations should be used (option MC=TRUE).

Usage

```
contaminate(
  y,
  er = 0,
  percentage,
  percentage.error = 0.001,
  F.contam = 1,
  F.contam.er = 0.001,
  MC = TRUE,
  seed = NA,
  its = 10000,
  decimals = 5,
  roundby = 1,
  visualise = TRUE,
  talk = TRUE,
  eq.x = 5,
  eq.y = c(),
  eq.size = 0.7,
  true.col = "darkgreen",
  observed.col = "blue",
  contamination.col = "red",
  true.pch = 20,
  observed.pch = 18,
  contamination.pch = 17,
  true.name = "true",
  xlab = "contamination (%)",
  ylab = "F14C",
  ylim = c(),
  C14.axis = TRUE,
  bty = "u"
)
```

Arguments

y	The 'true' radiocarbon age
er	The error of the 'true' radiocarbon age
percentage	Relative amount of contamination. Must be between 0 and 1
percentage.error	Uncertainty of the contamination. Assumed to be normally distributed (which fails close to 0% or 100% contamination levels). Defaults to a very small but >0 value, 0.001%.
F.contam	the F14C of the contamination. Set at 1 for carbon of modern radiocarbon age, at 0 for 14C-free carbon, or anywhere inbetween.
F.contam.er	error of the contamination. Defaults to a very small but >0 value, 0.001%.
MC	Whether or not to use Monte Carlo iterations to estimate the values. Defaults to TRUE, because it treats uncertainties better than if set to FALSE.

seed	For reproducibility, a seed can be set (e.g., seed=123). Defaults to NA, no seed set.
its	Amount of iterations to use if MC=TRUE. Defaults to 10,000.
decimals	Rounding of the output for F values. Since details matter here, the default is to provide 5 decimals.
roundby	Rounding of the output for C14 ages. Defaults to 1 decimal.
visualise	By default, a plot is made to visualise the target and observed F14C values, together with the inferred contamination.
talk	Whether or not to report the calculations made. Defaults to talk=TRUE.
eq.x	Leftmost location of the equation. Defaults to eq.x=5. Can be set to values outside of (0,100) to make the equation invisible.
eq.y	Vertical location of the equation. Defaults to the top of the graph.
eq.size	Size of the font of the equation. In case the equation gets jumbled up upon resizing of a graphical device, just issue the previous 'contaminate' command again. Defaults to eq.size=0.8.
true.col	Colour for the target/true values. Defaults to "darkgreen".
observed.col	Colour for the observed values. Defaults to blue.
contamination.col	Colour for the contamination values. Defaults to red.
true.pch	Icon for the true/target date. Defaults to a filled circle.
observed.pch	Icon for the observed. Defaults to a diamond.
contamination.pch	Icon for the contamination. Defaults to a triangle.
true.name	Name of the label of the true/target date
xlab	Name of the x-axis. Defaults to 'contamination (%)'.
ylab	Name of the y-axis. Defaults to 'F14C'.
ylim	Limits of the y-axis. Calculated automatically by default.
C14.axis	Whether or not to draw a secondary vertical axis for C14 ages. Defaults to C14.axis=TRUE.
bty	Draw a box around a box of a certain shape. Defaults to bty="u".

Details

Whereas the function takes C14 ages and percentage contamination as input, internal calculations are done in the F14C timescale and using fractions (between 0 and 1). The central calculation is 'F_obs = ((1-frac)*F_true) + (frac*F_contam)', where 'F_obs' is the observed C14 age as F14C, 'frac' is the fraction of contamination, 'F_true' is the F14C of the true/target C14 age, and 'F_contam' is the F activity of the contamination. In some extreme cases, the calculations will spit out unexpected results. Messages will be provided in most of these cases.

Value

The observed radiocarbon age and error

Author(s)

Maarten Blaauw

Examples

```
contaminate(5000, 20, 5, 0, 1) # 5% contamination with modern carbon
# dino bone with 1% contamination, shouldn't be dated as way beyond the dating limit:
contaminate(66e6, 1e6, 1, 0, 1)
```

---

coverage *To be retired - coverage of one distribution by another.*

Description

To be retired - Samples n random points from distribution A (with higher likelihoods proportionally more likely to be sampled), and for each point checks whether distribution B covers that point. Then the proportion of points where A is covered by B is returned. Can also calculate the coverage of distribution B by distribution A (if both=TRUE). The value of the coverage can range between 0 (distribution A is not covered by distribution B) to 1 (B covers A completely).

Usage

```
coverage(
  distA,
  distB,
  n = 10000,
  k = 10,
  nameA = "A",
  nameB = "B",
  decimals = 4,
  seed = NA,
  visualise = TRUE,
  xlab = "cal BP"
)
```

Arguments

distA	Distribution A. Expects two columns: values and their probabilities (e.g., caldist(130,10, cc=1)).
distB	Distribution B. Expects two columns: values and their probabilities (e.g., caldist(130,10, cc=1)).
n	The number of random points to be sampled (proportionally to the density of distribution A).
k	The number of points to be sampled for each iteration n from distribution B. After this, the range of these samples values is calculated to obtain a width of distribution B within which the sampled values of distribution could fall (the more, the higher the coverage).

nameA	The name of distribution A (for the plot's legend).
nameB	The name of distribution B (for the plot's legend).
decimals	Number of decimals to report - rounding is to 4 decimals by default.
seed	For reproducibility, a seed can be set (e.g., seed=123). Defaults to NA, no seed set.
visualise	Whether or not to plot the distributions. Defaults to TRUE.
xlab	Label of the horizontal axis. Defaults to xlab="cal BP".

Value

The coverage of distribution A within distribution B.

Examples

```
distA <- caldist(130, 20, cc=0) # normal distribution
distB <- caldist(130, 20, glue=1) # calibrated distribution
plot(distB, type="l")
lines(distA, col=2)
coverage(distA, distB)
```

CtoF *Calculate F14C values from C14 ages*

Description

Calculate F14C values from radiocarbon ages

Usage

```
CtoF(y, er = NULL, roundby = Inf, lambda = 8033, botherrors = FALSE)
```

Arguments

y	Reported mean of the 14C age.
er	Reported error of the 14C age. If left empty, will translate y to F14C.
roundby	Amount of decimals required for the output. Defaults to roundby=Inf, no rounding.
lambda	The mean-life of radiocarbon (based on Libby half-life of 5568 years).
botherrors	Since going from C14 to F14C involves a logarithmic transformation (F=exp(-y/lambda)), errors that are symmetric on the C14 scale will become asymmetric on the F14C scale. By default, only the largest error is reported, but if botherrors=TRUE, both errors are reported.

Details

Post-bomb dates are often reported as F14C or fraction modern carbon. Since software such as Bacon expects radiocarbon ages, this function can be used to calculate F14C values from radiocarbon ages. The reverse function of F14C.age. This function is a shortcut to C14toF14C.

Value

F14C values from C14 ages.

Examples

```
CtoF(-2000, 20)
```

Delta14CtoC14 *Transform Delta14C into C14 age*

Description

Transform Delta14C into C14 age

Usage

```
Delta14CtoC14(Delta14C, er = NULL, t, roundby = Inf)
```

Arguments

Delta14C	The Delta14C value to translate
er	Reported error of the Delta14C. Returns just the mean if left empty.
t	the cal BP age
roundby	Amount of decimals required for the output. Defaults to roundby=Inf, no rounding.

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 C14 ages. Note that per convention, this function uses the Cambridge half-life, not the Libby half-life.

Value

The corresponding C14 age

Examples

```
Delta14CtoC14(-10, 1, 238)
```

`Delta14CtoF14C` *Transform Delta14C into F14C*

Description

Transform Delta14C into F14C

Usage

```
Delta14CtoF14C(Delta14C, er = NULL, t, roundby = Inf, lambda = 5730/log(2))
```

Arguments

`Delta14C`	The Delta14C value to translate
`er`	Reported error of the Delta14C. Returns just the mean if left empty.
`t`	the cal BP age
`roundby`	Amount of decimals required for the output. Defaults to `roundby=Inf`, no rounding.
`lambda`	Radiocarbon's mean-life, based on the Cambridge half-life

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

```
Delta14CtoF14C(-10, 1, 238)
```

Delta14CtopMC *Transform Delta14C into pMC*

Description

Transform Delta14C into pMC

Usage

```
Delta14CtopMC(Delta14C, er = NULL, t, roundby = Inf)
```

Arguments

Delta14C	The Delta14C value to translate
er	Reported error of the Delta14C. Returns just the mean if left empty.
t	the cal BP age
roundby	Amount of decimals required for the output. Defaults to roundby=Inf, no rounding.

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

```
Delta14CtoF14C(-10, 1, 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(),
  cc = c(),
  cc1 = "IntCal20",
  cc2 = NA,
  cc1.postbomb = FALSE,
  cc2.postbomb = FALSE,
  BCAD = FALSE,
  timescale = "C14",
  as.F = FALSE,
  as.pMC = FALSE,
  as.Delta = FALSE,
  timescale2 = c(),
  cal.lab = c(),
  cal.rev = FALSE,
  c14.lab = c(),
  cc2.lab = c(),
  c14.lim = c(),
  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",
  mar = c(),
  mgp = c(),
  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.
cc	synonym for cc1.
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 cal BC/AD using BCAD=TRUE.
timescale	Which timescale of radiocarbon to use. Defaults to timescale="C14" but can also be set to timescale="F14C", timescale="pMC" or timescale="Delta14C". Can be shorted to, respectively, "C", "F", "P" or "D" (or their lower-case equivalents). Alternatively, the timescale can be defined using 'as.F=TRUE' or 'as.pMC=TRUE'.
as.F	Plot as F14C values. Defaults to as.F=FALSE. Alternative to 'timescale'.
as.pMC	Plot as pMC values. Defaults to as.pMC=FALSE. Alternative to 'timescale'.
as.Delta	Plot as Delta14C values. Defaults to as.Delta=FALSE.
timescale2	Which timescale to use for the second calibration curve (if used). Defaults to timescale2="C14" but can also be set to timescale2="F14C", timescale2="pMC" or timescale2="Delta14C". 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. Defaults to FALSE.
c14.lab	Label for the C-14 axis. Defaults to 14C BP (or 14C kBP if ka=TRUE).
cc2.lab	Label for the righthand axis (if present). Defaults to the chosen timescale.
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".
mar	Plot margins (amount of white space along edges of axes 1-4). Defaults to give more white space if a second y-axis is to be plotted.
mgp	Axis text margins (where should titles, labels and tick marks be plotted).
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.CF *Draw the asymmetric relationship between 14C and F14C*

Description

Whereas distributions on the F14C scale are symmetric, this is not the case for distributions on the 14C scale. Indeed, errors are skewed toward older ages, especially for dates with large uncertainties (e.g., older dates). This function takes a C14 date, calculates its distribution on the F scale (which is a value much closer to what is actually measured in AMS or radiometric dating), then takes that distribution and for each F value calculates the corresponding C14 age, and reports both the plus and minus errors.

Usage

```
draw.CF(
  y,
  er,
  normal = TRUE,
  t.a = 3,
  t.b = 4,
  height = 1,
  extend.axes = 0.1,
  dist.res = 5000,
  C14.lim = c(),
  F.lim = c(),
  x.pos = c(),
  y.pos = c(),
  C14.col = rgb(0, 0, 1, 0.2),
  F.col = rgb(0, 0.5, 0, 0.2),
  draw.date = TRUE,
  date.col = "red",
  legend.pos = "top",
  legend.size = 0.7,
  roundby = 0
)
```

Arguments

y	The mean of the radiocarbon age (on the 14C scale).
er	The error of the radiocarbon age (on the 14C scale).
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 b of the t distribution (defaults to 4).
height	Heights of the distributions. Defaults to 1.
extend.axes	Multiplication factor by which the axes should be extended. Defaults to 0.1, 10%.
dist.res	Number of bins of the distributions (defaults to 5000).
C14.lim	Limits for the C-14 axis. Calculated automatically by default.
F.lim	Axis limits for the F14C axis. Calculated automatically by default.
x.pos	Amount by which the C14 distribution floats on the y-axis.
y.pos	Amount by which the F14C distribution floats on the x-axis.
C14.col	Colour of the C14 distribution. Defaults to semi-transparent blue, `rgb(0,0,1,.2)`.
F.col	Colour of the F14C distribution. Defaults to semi-transparent green, `rgb(0,.5,0,.2)`.
draw.date	Whether or not to also draw the original date (as dot and 1 sigma error bars).
date.col	Colour of the date. Defaults to red.
legend.pos	Position of the legend. Defaults to "top".
legend.size	Size of the font of the legend. Defaults to 0.7.
roundby	Rounding of the reported values.

Details

Large positive errors (e.g., much larger than the minus error) indicate a highly skewed age, with the upper tail essentially extending to infinite ages. Note that for older and uncertain ages, the F14C distribution will be truncated at 0 (since negative F14C values can't happen). C14 ages are turned into F using exp(-y/8033), whereas they are turned back into C14 ages using y = -8033 * ln(F). For more details, e.g. on how errors/uncertainties are treated, see F14CtoC14 and C14toF14C.

Value

A plot of the F14C and C14 distributions together with a black curve showing the F/C relation, and estimates of the + and - errors (invisible).

Examples

```
draw.CF(2450,50) # precise C14 ages are essentially symmetric
draw.CF(50000,2000) # but lower-precision ones aren't!
```

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

Description

Add individual or multiple calibrated dates to a plot.

Usage

```
draw.dates(
  age,
  error,
  depth = c(),
  cc = 1,
  postbomb = FALSE,
  bombalert = TRUE,
  glue = 1,
  as.F = TRUE,
  is.F = FALSE,
  is.pMC = FALSE,
  deltaR = 0,
  deltaSTD = 0,
  thiscurve = c(),
  oncurve = FALSE,
  timescale = "C",
  reservoir = c(),
  normal = TRUE,
  peak = 1,
  ex = c(),
  as.unit = FALSE,
  t.a = 3,
  t.b = 4,
```

```
  prob = 0.95,
  threshold = 0.001,
  BCAD = FALSE,
  draw.hpd = TRUE,
  hpd.border = NA,
  rounded = 0.1,
  every = 1,
  mirror = TRUE,
  up = TRUE,
  draw.base = TRUE,
  col = rgb(0, 0, 1, 0.3),
  border = col,
  hpd.col = col,
  cal.col = rgb(0, 0.5, 0.5, 0.35),
  cal.border = cal.col,
  cal.hpd.col = cal.col,
  add = FALSE,
  ka = FALSE,
  rotate.axes = FALSE,
  normalise = TRUE,
  cc.col = rgb(0, 0.5, 0, 0.5),
  cc.border = cc.col,
  cc.resample = 5,
  age.lab = c(),
  age.lim = c(),
  age.rev = FALSE,
  cal.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 = col,
  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). Defaults to their relative positions if no depths are pro-

	vided.
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.
bombalert	Warn if a date is close to the lower limit of the IntCal curve. Defaults to postbomb=TRUE.
glue	Glue postbomb and prebomb curves together. Defaults to 0 (none), can be 1 (IntCal20 + NH1), 2 (IntCal20 + NH2), 3 (IntCal20 + NH3), 4 (SHCal20 + SH1-2) or 5 (SHCal20 + SH3). Note that this will override the value of cc.
as.F	Whether or not to calculate ages in the F14C timescale. Defaults to as.F=TRUE, since it takes better care of asymmetric distributions and older dates close to the dating limit. If set as as.F=FALSE, the C14 timescale will be used.
is.F	Use is.F=TRUE if the date and error are entered as F14C.
is.pMC	Use is.pMC=TRUE if the date and error are entered as pMC.
deltaR	Age offset (e.g. for marine samples). Can also be provided as option 'reservoir'.
deltaSTD	Uncertainty of the age offset (1 standard deviation). Can also be provided within option 'reservoir'.
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 c().
oncurve	Whether or not to plot the calibration curve and then plot the dates onto this curve. Defaults to FALSE.
timescale	If oncurve is used, by default the calibration curve is plotted in the C14 age timescale. Alternatively, it can be provided as timescale="F14C" or timescale="pMC"
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).
peak	Height multiplier for the distributions. Defaults to peak=1.
ex	synonym for peak
as.unit	If set to TRUE, the peak of the highest distribution is set to 1. Otherwise, it is set to a fraction of the axis limits (default, see 'fraction')
t.a	Value a of the t distribution (defaults to 3).
t.b	Value b 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 cal BC/AD or cal BP scale (default cal BP).
draw.hpd	Whether or not to draw the hpd ranges as a line
hpd.border	Colour of the border of the hpd intervals. Not drawn by default. Defaults to the colour of 'col'.
rounded	Rounding for probabilities of reported hpd ranges. Defaults to 1 decimal.

every	Yearly precision of hpds (defaults to every=1).
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 facing upwards or downwards.
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. Defaults to the colour of 'col'.
hpd.col	Colour of the hpd rectangle for all dates or radiocarbon dates. Defaults to the colour of 'col'.
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. Defaults to the colour of 'cal.col'.
cal.hpd.col	Colour of the hpd rectangle for cal BP dates. Defaults to the colour of 'cal.col'.
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.
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.col	Colour of the calibration curve. Default semi-transparent darkgreen.
cc.border	Colour of the edges of the calibration curve. Default semi-transparent dark-green.
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
cal.rev	Synonym for age.rev
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 that 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, bombalert=FALSE)
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), bombalert=FALSE)
# or draw on the calibration curve
draw.dates(y, er, y, d.lab="Radiocarbon age (BP)", bombalert=FALSE)
draw.ccurve(add=TRUE, cc1.col=rgb(0,.5,0,.5))
```

---

draw.Delta14C *Draw Delta14C and the calibration curve.*

Description

Draw a proxy of the atmospheric 14C concentration (Delta14C) as well as the calibration curve.

Usage

```
draw.Delta14C(
  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),
  Delta14C.lab = c(),
  Delta14C.lim = c(),
  Delta14C.col = rgb(0, 0, 1, 0.5),
  Delta14C.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 cal 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).
Delta14C.lab	Label for the Delta14C axis.
Delta14C.lim	Axis limits for the Delta14C axis. Calculated automatically by default.
Delta14C.col	Colour of the Delta14C curve (fill).
Delta14C.border	Colour of the Delta14C curve (border).

Value

A plot of Delta14C and the calibration curve

Examples

```
draw.Delta14C()
draw.Delta14C(30e3, 55e3, ka=TRUE)
draw.Delta14C(cc=rintcal::ccurve("NH1_monthly"), BCAD=TRUE)
```

F14C.age *Deprecated. Use F14CtoC14instead*

Description

Deprecated. Use F14CtoC14instead

Usage

```
F14C.age()
```

Value

A deprecation message

F14CtoC14 *Calculate C14 ages from F14C values.*

Description

Calculate C14 ages from F14C values of radiocarbon dates.

Usage

```
F14CtoC14(F14C, er = NULL, roundby = Inf, lambda = 8033, botherrors = FALSE)
```

Arguments

F14C	Reported mean of the F14C
er	Reported error of the F14C. Returns just the mean if left empty.
roundby	Amount of decimals required for the output. Defaults to roundby=Inf, no rounding.
lambda	The mean-life of radiocarbon (based on Libby half-life of 5568 years).
botherrors	Since going from C14 to F14C involves a logarithmic transformation (F=exp(-y/lambda)), errors that are symmetric on the C14 scale will become asymmetric on the F14C scale. By default, only the largest error is reported, but if reportbotherrors=TRUE, both errors are reported. #' @return The radiocarbon ages from the F14C values. If F14C values are above 100%, the resulting radiocarbon ages will be negative.

Details

Post-bomb dates are often reported as F14C (between 0 at c. 55 kcal BP and 1 at c. AD 1950). Since software such as Bacon expects radiocarbon ages, this function can be used to calculate radiocarbon ages from F14C values. The reverse function is age.F14C.

Examples

```
F14CtoC14(1.10, 0.005) # a postbomb date, so with a negative C14 age
F14CtoC14(.80, 0.005) # prebomb dates can also be calculated
```

F14CtoDelta14C *Transform F14C into Delta14C*

Description

Transform F14C into Delta14C

Usage

```
F14CtoDelta14C(F14C, er = NULL, t, roundby = Inf, lambda = 5730/log(2))
```

Arguments

F14C	The F14C value to translate
er	Reported error of the F14C. Returns just the mean if left empty.
t	the cal BP age
roundby	Amount of decimals required for the output. Defaults to roundby=Inf, no rounding.
lambda	Radiocarbon's mean-life, based on the Cambridge half-life

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 Delta14C value

Examples

```
F14CtoDelta14C(0.89, .001, 900)
```

F14CtopMC *Calculate pMC ages from F14C values.*

Description

Calculate pMC values from F14C values of radiocarbon dates.

Usage

```
F14CtopMC(F14C, er = NULL, roundby = Inf)
```

Arguments

F14C	Reported mean of the F14C
er	Reported error of the F14C. Returns just the mean if left empty.
roundby	Amount of decimals required for the output. Defaults to roundby=Inf, no rounding.

Details

Post-bomb dates are often reported as F14C (between 0 at c. 55 kcal BP and 1 at c. AD 1950). Since software such as Bacon expects radiocarbon ages, this function can be used to calculate radiocarbon ages from F14C values. The reverse function is age.F14C.

Value

The pMC values from the F14C values. Basically the original values multiplied by 100.

Examples

```
F14CtopMC(1.10, 0.5)
```

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,
  browse = FALSE,
  colour = "dR",
  rainbow = FALSE,
  size = 2,
  mapsize = "large",
  mincol = "yellow",
  maxcol = "red",
  feeding = c(),
  symbol = "feeding",
  symbol.legend = TRUE,
  legend.loc = c(0.95, 0.02),
  legend.size = c(0.05, 0.2),
  ocean.col = "aliceblue",
  land.col = rgb(0, 0.5, 0, 0.6),
  padding = 1,
  warn = TRUE,
  currents = TRUE
)
```

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.
browse	Type of map to provide. browse=FALSE (default) plots a static map in R's device (doesn't require Internet access), while browse=TRUE opens a browsable, interactive map in your Internet browser.
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.
mapsize	Resolution of the map. Can be "small" or "large". If the latter, a high-resolution dataset will have to be downloaded using the R package 'rnaturalearthhires'. Since this package is on github but not on CRAN, you will have to download it yourself (using the command remotes::install_github("ropensci/rnaturalearthhires")). Defaults to "small" if 'rnaturalearthhires' is not installed, and to "large" if it is installed.
mincol	Colour for minimum values.
maxcol	Colour for maximum values.

feeding	Optionally, the output of only specific types of feeding ecology (e.g., deposit, suspension, browser) can be selected. Defaults to returning all feeding ecologies.
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.
legend.loc	Location of the legend, if using a basic plot. Defaults to the bottom right corner based on par("usr"), legend.loc=c(0.95, 0.02)
legend.size	Size of the legend, if using a basic plot. Defaults to legend.size=c(0.05, 0.2)
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).
padding	Area around the map if using a basic plot. Avoids strange line features. Defaults to padding=1.
warn	Whether or not to warn if some recommended R packages are not available.
currents	If set to TRUE (the default), the user will be asked if they want to browse a map of ocean currents. If the user responds 'y', an Internet browser window will be opened pointing to a zoomed-in map of ocean currents (at 50 m depth). The ocean currents are from 'earth.nullschool.net' and are based on an ocean circulation model which is updated daily. Owing to limitations of the website, the shell locations cannot currently be added to the page itself.

Details

This function uses the 'rnaturalearth' package for country maps. If the high-resolution maps are desired, the 'rnaturalearthhires' package must be installed from GitHub.

Value

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

Examples

```
UK <- find.shells(0, 55, mapsize="small")
mean(UK$dR)
Caribbean <- find.shells(-70, 20, 30, mapsize="small")
```

`fractions` *Estimate a missing radiocarbon age from fractions*

Description

Estimate a missing radiocarbon age from a sample which has C14 dates on both the bulk and on fractions, but where 1 sample was too small to be dated. This can be used in for example soils separated into size fractions, where one of the samples turns out to be too small to be dated. Requires to have the bulk age, the ages of the dated fractions, and the carbon contents and weights of all fractions.

Usage

```
fractions(
  bulk_age = NULL,
  bulk_er = NULL,
  fractions_percC = NULL,
  fractions_weights = NULL,
  fractions_ages = NULL,
  fractions_errors = NA,
  roundby = 1,
  talk = TRUE
)
```

Arguments

`bulk_age`	The age of the bulk/entire sample
`bulk_er`	The error of the age of the bulk/entire sample
`fractions_percC`	The %carbon contents of the fractions. If unknown, enter estimates (e.g., rep(1,4))
`fractions_weights`	The weights of the fractions. The units are not important here as the weights are used to calculate the relative contributions of carbon within individual fractions to the entire sample.
`fractions_ages`	The radiocarbon ages of the individual fractions. The fraction without a date should be entered as NA.
`fractions_errors`	The errors of the radiocarbon ages of the individual fractions. The fraction without a date should be entered as NA.
`roundby`	Rounding of the reported age
`talk`	Provide feedback

Examples

```
Cs <- c(.02, .05, .03, .04) # carbon contents of each fraction
wghts <- c(5, 4, 2, .5) # weights for all fractions, e.g., in mg
ages <- c(130, 130, 130, NA) # ages of all fractions. The unmeasured one is NA
errors <- c(10, 12, 10, NA) # errors, unmeasured is NA
fractions(150, 20, Cs, wghts, ages, errors) # assuming a bulk age of 150 +- 20 C14 BP
# if all fraction ages are known, model the combined age:
Cs <- c(.02, .05, .03, .04) # carbon contents of each fraction
wghts <- c(5, 4, 2, .5) # weights for all fractions, e.g., in mg
ages <- c(130, 140, 150, 200)
errors <- c(10, 12, 10, 14)
fractions(,, Cs, wghts, ages, errors)
```

---

fromto *translate between timescales*

Description

translate between timescales

Usage

```
fromto(
  x,
  from = "calBP",
  cc = 1,
  postbomb = 1,
  cc.dir = NULL,
  thiscurve = NULL,
  zero = FALSE,
  width = c(),
  digits = 0,
  C14.col = rgb(0, 0, 1, 0.5),
  Delta14C.col = rgb(0, 0.4, 0, 0.4),
  ka = FALSE,
  cal.rev = TRUE,
  legend.size = 0.7
)
```

Arguments

x	The value to be translated into other timescales
from	The timescales of the entered value. Can be "calBP" for cal BP, "BCAD" for BC/AD, "C14" for C14 BP, "F14C" for F14C, or "pMC" for pMC. Delta14C cannot be entered as a value (you could enter the corresponding cal BP or BC/AD ages instead).
cc	calibration curve for C14 (see `caldist()`).

postbomb	Whether or not to use a postbomb curve (see caldist()).
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".
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).
zero	Whether or not zero BC/AD should be included. Defaults to none, FALSE.
width	Width of the righthand plot. Calculated automatically by default (older ages get wider windows).
digits	Rounding of the reported values. Defaults to 0 digits.
C14.col	Colour of the 14C calibration curve. Defaults to semi-transparent blue, C14.col=rgb(0,0,1,.5).
Delta14C.col	Colour of the Delta14C curve. Defaults to semi-transparent green, Delta14C.col=rgb(0,.4,0,.4).
ka	Whether to use years or ka (thousands of years). Defaults to ka=FALSE.
cal.rev	Reverse the age axis (right panel). Defaults to TRUE.
legend.size	Size of the font of the legend. Defaults to 0.7 of R's standard size.

Details

Upon entering a value and its timescale, this function will find the corresponding values in the other timescales. Note that uncertainties are *not* taken into account, and especially going from C14 BP to cal BP and BC/AD ignores many calibration-related uncertainties. Delta14C values are only reported for entered values on the cal BP or BC/AD scale.

Value

A plot and output showing the translations into the different timescales.

Examples

```
fromto(0, "BCAD")
fromto(2450, "C14")
```

FtoC *Calculate C14 ages from F14C values.*

Description

Calculate C14 ages from F14C values of radiocarbon dates. Shorthand for the function F14CtoC14.

Usage

```
FtoC(F14C, er = NULL, roundby = Inf, lambda = 8033, botherrors = FALSE)
```

Arguments

F14C	Reported mean of the F14C
er	Reported error of the F14C. Returns just the mean if left empty.
roundby	Amount of decimals required for the output. Defaults to roundby=Inf, no rounding.
lambda	The mean-life of radiocarbon (based on Libby half-life of 5568 years).
botherrors	Since going from C14 to F14C involves a logarithmic transformation (F=exp(-y/lambda)), errors that are symmetric on the C14 scale will become asymmetric on the F14C scale. By default, only the largest error is reported, but if reportbotherrors=TRUE, both errors are reported. #' @return The radiocarbon ages from the F14C values. If F14C values are above 100%, the resulting radiocarbon ages will be negative.

Details

Post-bomb dates are often reported as F14C (between 0 at c. 55 kcal BP and 1 at c. AD 1950). Since software such as Bacon expects radiocarbon ages, this function can be used to calculate radiocarbon ages from F14C values. The reverse function is age.F14C.

Value

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

Examples

```
FtoC(1.10, 0.005) # a postbomb date, so with a negative C14 age
FtoC(.80, 0.005) # prebomb dates can also be calculated
```

---

howmuchC14 *Amount of C14 particles in a sample*

Description

Calculate the expected amount of remaining C14 atoms in a sample, given its weight and age.

Usage

```
howmuchC14(
  age,
  wght = 1,
  use.cc = TRUE,
  Av = 6.02214076e+23,
  C14.1950 = 1.176e-12,
  current = 2.5e-05,
  format = "g",
```

```
  cc = 1,
  postbomb = FALSE,
  cc.dir = NULL,
  thiscurve = NULL,
  talk = TRUE,
  decimals = 3
)
```

Arguments

age	The age of the sample (in cal BP per default, or in C14 BP is use.cc=FALSE).
wght	The weight of the sample (in mg). Defaults to 1 mg.
use.cc	Whether or not to use the calibration curve. If set to use.cc=FALSE, then we assume that the age is the radiocarbon age (this enables ages beyond the reach of the calibration curves to be used).
Av	Avogadro's number, used to calculate the number of carbon atoms in the sample.
C14.1950	The standard 14C/C ratio back in AD 1950 (1.176e-12, so around 1 in 1 trillion carbon atoms was a 14C atom at that moment in time.
current	The current of 12C+ ions arriving at the Faraday counter. Defaults to current=25e-6, 25 micro-Ampere.
format	The format of the printed numbers. Defaults to either scientific (for large numbers) or as fixed-point, depending on the size of the number.
cc	calibration curve for C14 (see caldist()).
postbomb	Whether or not to use a postbomb curve (see caldist()).
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".
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).
talk	Whether or not to provide feedback (defaults to TRUE).
decimals	Number of decimals to be returned for F and atom counts.

Details

The number of carbon atoms in the sample is estimated. Given the known C14/C ratio at F=1, and given the sample's age, we can estimate the number of remaining C14 atoms. Given a 12C current at the detector end of an AMS, we can then also calculate how many 14C ions would be counted per second and minute. Note that backgrounds are not modelled (but could be investigated by e.g. typing howmuchC14(45e3) which gives as c. 1 background count per second).

Value

The estimated number of C14 atoms.

Author(s)

Maarten Blaauw

Examples

```
howmuchC14(0) # recent sample
howmuchC14(55e3) # at dating limit
howmuchC14(145e3) # way beyond the dating limit, 1 C14 atom per mg remains
```

---

hpd *Calculate highest posterior density*

Description

Calculate highest posterior density ranges of a calibrated distribution

Usage

```
hpd(
  calib,
  prob = 0.95,
  return.raw = FALSE,
  BCAD = FALSE,
  ka = FALSE,
  age.round = 0,
  prob.round = 1,
  every = 0.1,
  bins = 20
)
```

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.
BCAD	Which calendar scale to use. Defaults to cal BP, BCAD=FALSE.
ka	Whether to report results in years (default) or as ka
age.round	Rounding for ages. Defaults to 0 decimals.
prob.round	Rounding for reported probabilities. Defaults to 1 decimal.
every	Yearly precision (defaults to 0.1, as a compromise between speed and accuracy).
bins	The number of bins required. Any distribution with fewer bins gets recalculated using 100 narrower bins.

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

`hpd.overlap` *Check whether hpds of two distributions overlap*

Description

Checks whether any of the highest posterior densities (hpds) of two distributions overlap.

Usage

```
hpd.overlap(distA, distB, prob = 0.95)
```

Arguments

`distA`	Distribution A. Expects two columns: values and their probabilities (e.g., caldist(130,10, cc=1)).
`distB`	Distribution B. Expects two columns: values and their probabilities (e.g., caldist(130,10, cc=1)).
`prob`	The probability of the highest posterior densities. Defaults to 95%.

Value

TRUE if at least one of the hpds of distA overlaps with that of distB.

Examples

```
distA <- caldist(130, 20, cc=0) # normal distribution
distB <- caldist(130, 20, cc=1, bombalert=FALSE) # calibrated distribution
plot(distB, type="l")
lines(distA, col=2)
hpd.overlap(distA, distB)
```

`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(
  x,
  y,
  er,
  cc = 1,
  postbomb = FALSE,
  deltaR = 0,
  deltaSTD = 0,
  thiscurve = c(),
  cc.dir = c(),
  normal = TRUE,
  as.F = FALSE,
  is.F = FALSE,
  t.a = 3,
  t.b = 4
)
```

Arguments

`x`	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).
`postbomb`	Whether or not to use a postbomb curve. Required for negative radiocarbon ages.
`deltaR`	Age offset (e.g. for marine samples). This assumes that the radiocarbon age is provided as 14C BP (not F14C or pMC).
`deltaSTD`	Uncertainty of the age offset (1 standard deviation).
`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).
`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"`.
`normal`	Use the normal distribution to calibrate dates (default TRUE). The alternative is to use the t model (Christen and Perez 2016).

as.F	Whether or not to calculate ages in the F14C timescale. Defaults to as.F=FALSE, which uses the C14 timescale.
is.F	Use this if the provided date is in the F14C timescale.
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
plot(0:300, l.calib(0:300, 130, 20), type='l')
```

---

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,
  browse = FALSE,
  colour = "dR",
  rainbow = FALSE,
```

```
  size = 2,
  mapsize = "large",
  mincol = "yellow",
  maxcol = "red",
  feeding = c(),
  symbol = "feeding",
  symbol.legend = TRUE,
  ocean.col = "aliceblue",
  land.col = rgb(0, 0.5, 0, 0.6),
  legend.loc = c(0.95, 0.02),
  legend.size = c(0.05, 0.2),
  padding = 0.1,
  warn = TRUE,
  currents = TRUE
)
```

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.
browse	Type of map to provide. browse=FALSE (default) plots a static map in R's device (doesn't require Internet access), while browse=TRUE opens a browsable, interactive map in your Internet browser.
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.
mapsize	Resolution of the map. Can be "small" or "large". If the latter, a high-resolution dataset will have to be downloaded using the R package 'rnaturalearthhires'. Since this package is on github but not on CRAN, you will have to download it yourself (using the command remotes::install_github("ropensci/rnaturalearthhires")). Defaults to "small" if 'rnaturalearthhires' is not installed, and to "large" if it is installed.
mincol	Colour for minimum values.
maxcol	Colour for maximum values.
feeding	Optionally, the output of only specific types of feeding ecology (e.g., deposit, suspension, browser) can be selected. Defaults to returning all feeding ecologies.
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).
legend.loc	Location of the legend, if using a basic plot. Defaults to the bottom right corner based on par("usr"), legend.loc=c(0.95, 0.02)
legend.size	Size of the legend, if using a basic plot. Defaults to legend.size=c(0.05, 0.2)
padding	Area around the map if using a basic plot. Avoids strange line features. Defaults to padding=0.1.
warn	Whether or not to warn if some recommended R packages are not available.
currents	If set to TRUE (the default), the user will be asked if they want to browse a map of ocean currents. If the user responds 'y', an Internet browser window will be opened pointing to a zoomed-in map of ocean currents (at 50 m depth). The ocean currents are from 'earth.nullschool.net' and are based on an ocean circulation model which is updated daily. Owing to limitations of the website, the shell locations cannot currently be added to the page itself.

Details

This function uses the 'rnaturalearth' package for country maps. If the high-resolution maps are desired, the 'rnaturalearthhires' package must be installed from GitHub.

Value

A plot and the relevant dR values.

Examples

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

---

muck *Calculate the amount of muck/contamination to explain an observed C14 age*

Description

Given an observed, a target radiocarbon age and the F14C or amount of contamination, calculate the amount of contamination (or its F14C) required to explain the observed age.

Usage

```
muck(
  y.obs,
  y.obs.er = 0,
  y.target,
  y.target.er = 0,
```

```
  F.contam = 1,
  F.contam.er = 0.001,
  perc.contam = NA,
  perc.contam.er = 0.001,
  MC = TRUE,
  seed = NA,
  its = 10000,
  roundby = 1,
  decimals = 3,
  visualise = TRUE,
  talk = TRUE,
  eq.x = 5,
  eq.y = c(),
  eq.size = 0.8,
  target.col = "darkgreen",
  observed.col = "blue",
  contamination.col = "red",
  target.pch = 20,
  observed.pch = 18,
  contamination.pch = 17,
  true.name = "target",
  xlab = "contamination (%)",
  ylab = "F14C",
  ylim = c(),
  C14.axis = TRUE,
  bty = "u"
)
```

Arguments

y.obs	The observed radiocarbon age
y.obs.er	The error of the observed radiocarbon age
y.target	the target radiocarbon age
y.target.er	The error of the target radiocarbon age. Not taken into account in the calculations.
F.contam	the F14C of the contamination. Set at 1 for carbon of modern radiocarbon age, at 0 for 14C-free carbon, or anywhere inbetween.
F.contam.er	The error of the contamination. Defaults to a very small but >0 value, 0.001%.
perc.contam	The percentage of the contamination. By default (perc.contam=NA), this is the parameter of interest and this is found by setting F.contam to a specified value. If however the value of 'perc.contam' is set, then the function will calculate the F14C of the contamination instead.
perc.contam.er	The error of the percentage of contamination. Defaults to a very small but >0 value, 0.001%.
MC	Whether or not to use Monte Carlo iterations to estimate the values. Defaults to TRUE, because it treats uncertainties better than if set to FALSE.

seed	For reproducibility, a seed can be set (e.g., seed=123). Defaults to NA, no seed set.
its	Amount of iterations to use if MC=TRUE. Defaults to 10,000.
roundby	Rounding of the output for C14 ages. Defaults to 1 decimal.
decimals	Rounding of the output. Since details matter here, the default is to provide 5 decimals.
visualise	By default, a plot is made to visualise the target and observed F14C values, together with the inferred contamination.
talk	Whether or not to report the calculations made. Defaults to talk=TRUE.
eq.x	Leftmost location of the equation. Defaults to eq.x=5. Can be set to values outside of (0,100) to make the equation invisible.
eq.y	Vertical location of the equation. Defaults to the top of the graph.
eq.size	Size of the font of the equation. In case the equation gets jumbled up upon resizing of a graphical device, just issue the previous 'muck' command again. Defaults to eq.size=0.8.
target.col	Colour for the target/true values. Defaults to darkgreen.
observed.col	Colour for the observed values. Defaults to blue.
contamination.col	Colour for the contamination values. Defaults to red.
target.pch	Icon for the target. Defaults to a filled circle.
observed.pch	Icon for the observed. Defaults to a diamond
contamination.pch	Icon for the contamination. Defaults to a triangle.
true.name	Name of the label of the true/target date
xlab	Name of the x-axis. Defaults to 'contamination (%)'.
ylab	Name of the y-axis. Defaults to 'F14C'.
ylim	Limits of the y-axis. Calculated automatically by default.
C14.axis	Whether or not to draw a secondary vertical axis for C14 ages. Defaults to C14.axis=TRUE.
bty	Draw a box around a box of a certain shape. Defaults to bty="u".

Details

Whereas the function takes true/target and observed C14 ages as input and percentage contamination as output, internal calculations are done in the F14C timescale and using contamination fractions (between 0 and 1). The central calculation is 'frac = (F_obs - F_true) / (F_contam - F_true)', where 'frac' is the fraction of contamination to explain how we went from the observed to the true C14 age, 'F_obs' is the observed C14 age in F14C, 'F_true' is the true or target age in F14C, 'F_contam' is the F value of the contamination. In some extreme cases (e.g., if dividing by zero), the calculation will spit out unexpected results. Messages will be provided in most of these cases.

Value

The required contamination (as percentage) or the F14C of the contamination, as well as a plot

Author(s)

Maarten Blaauw

Examples

```
# observed age 600 +- 30, target age 2000 +- 0, contamination F 1 +- 0.01
  muck(600, 30, 2000, 0, 1, .01)
# assuming we need to find the F14C of a 10\% contamination
  muck(600, 30, 800, 30, perc.contam=10)
```

`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,
  bombalert = TRUE,
  deltaR = 0,
  deltaSTD = 0,
  normal = TRUE,
  as.F = FALSE,
  is.F = FALSE,
  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()).
bombalert	Warn if a date is close to the lower limit of the calibration curve. Defaults to postbomb=TRUE.
deltaR	Age offset (e.g. for marine samples).
deltaSTD	Uncertainty of the age offset (1 standard deviation).
normal	Use the normal distribution to calibrate dates (default TRUE). The alternative is to use the t model (Christen and Perez 2016).
as.F	Whether or not to calculate ages in the F14C timescale. Defaults to as.F=FALSE, which uses the C14 timescale.
is.F	Use this if the provided date is in the F14C timescale.
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)
```

`overlap` *The overlap between calibrated C14 dates*

Description

Calculates the amount of overlap (as percentage) between two or more calibrated radiocarbon dates. It does this by taking a sequence of calendar dates 'x' and for each calendar date find the calibrated distribution with the minimum height - this minimum height is taken as the overlap between the dates for that age. This is repeated for all 'x'. The sum of these heights is the overlap, which can reach values from 0 to 100%.

Usage

```
overlap(
  y,
  er = c(),
  labels = c(),
  is.F = FALSE,
  res = 1000,
  cc = 1,
  postbomb = FALSE,
  deltaR = 0,
  deltaSTD = 0,
  thiscurve = NULL,
  BCAD = FALSE,
  normal = TRUE,
  t.a = 3,
  t.b = 4,
  cc.dir = NULL,
  threshold = 0,
  xlim = c(),
  cal.rev = TRUE,
  xlab = c(),
  yrby = 1,
  dist.col = rgb(0, 0, 0, 0.2),
  overlap.col = rgb(0, 0, 1, 0.4),
  overlap.border = NA,
  overlap.height = 1,
  talk = TRUE,
  visualise = TRUE,
  prob = 0.95,
  roundby = 1,
  bty = "n",
  yaxt = "n"
)
```

Arguments

y	The set of radiocarbon dates. Alternatively, existing distributions can be provided as a list of distributions, e.g. already-calibrated distributions or distributions derived from age-model estimates.
er	The lab errors of the radiocarbon dates
labels	Labels to be printed for the distributions (optional).
is.F	Set this to TRUE if the provided age and error are in the F14C timescale.
res	The resolution to base the calculations on. Defaults to 1000 steps between the minimum and maximum cal BP (these are calculated from the total calendar age range of all calibrated distributions).
cc	Calibration curve to use. Defaults to IntCal20 (cc=1).
postbomb	Whether or not to use a postbomb curve. Required for negative radiocarbon ages.
deltaR	Age offset (e.g. for marine samples).
deltaSTD	Uncertainty of the age offset (1 standard deviation).
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).
BCAD	Which calendar scale to use. Defaults to cal BP, BCAD=FALSE.
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).
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".
threshold	Report only values above a threshold. Defaults to threshold=1e-6.
xlim	Age limits of the x-axis. Calculated automatically by default.
cal.rev	Reverse the calendar axis. Defaults to TRUE.
xlab	Label of the calendar age, defaults to BCAD or cal BP.
yrby	Resolution in years. Defaults to by=1.
dist.col	The colour of the individual (calibrated) distributions. Defaults to semi-transparent grey. Different colours can also be provided for the individual distributions.
overlap.col	The colour of the overlap distribution.
overlap.border	The colour of the border of the overlap distribution.
overlap.height	The height of the overlap distribution.
talk	Whether or not to report a summary of the spread.
visualise	Whether or not to plot the individual distributions and the overlap.
prob	Probability range to report. Defaults to prob=0.95.
roundby	Number of decimals to report.
bty	Draw a box around a box of a certain shape. Defaults to bty="n".
yaxt	Type of y-axis. Defaults to none drawn (yaxt="n").

Value

The overlap between all calibrated probabilities as percentage, and a plot.

Examples

```
y <- c(3820, 4430) # the C14 ages of a twig and a marine shell from a single layer
er <- c(40, 40) # their lab errors
overlap(y, er, cc=1:2, dist.col=3:4, labels=c("twig", "shell"))
mydists <- list(caldist(130,20, cc=1, bombalert=FALSE), caldist(150, 20, cc=0))
overlap(mydists)
```

`p.range` *Probability of a date lying within a cal BP range*

Description

Find the probability of a calibrated date lying within an age range

Usage

```
p.range(
  x1,
  x2,
  y,
  er,
  cc = 1,
  postbomb = FALSE,
  bombalert = TRUE,
  deltaR = 0,
  deltaSTD = 0,
  normal = TRUE,
  as.F = FALSE,
  is.F = FALSE,
  t.a = 3,
  t.b = 4,
  BCAD = FALSE,
  threshold = 0
)
```

Arguments

`x1`	The start the range of interest.
`x2`	The end of the range of interest.
`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()).
bombalert	Warn if a date is close to the lower limit of the calibration curve. Defaults to postbomb=TRUE.
deltaR	Age offset (e.g. for marine samples).
deltaSTD	Uncertainty of the age offset (1 standard deviation).
normal	Use the normal distribution to calibrate dates (default TRUE). The alternative is to use the t model (Christen and Perez 2016).
as.F	Whether or not to calculate ages in the F14C timescale. Defaults to as.F=FALSE, which uses the C14 timescale.
is.F	Use this if the provided date is in the F14C timescale.
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 lying within a certain calendar age range.

Author(s)

Maarten Blaauw

Examples

```
p.range(2800, 2400, 2450, 20)
```

---

pMC.age *Deprecated. Use pMCtoC14 instead.*

Description

Deprecated. Use pMCtoC14 instead.

Usage

```
pMC.age()
```

Value

A deprecation message

pMCtoC14 *Calculate C14 ages from pMC values.*

Description

Calculate C14 ages from pMC values of radiocarbon dates.

Usage

```
pMCtoC14(pMC, er = NULL, roundby = Inf, lambda = 8033)
```

Arguments

pMC	Reported mean of the pMC.
er	Reported error of the pMC.
roundby	Amount of decimals required for the output. Defaults to roundby=Inf, no rounding.
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 C14.pMC.

Value

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

Examples

```
pMCtoC14(110, 0.5) # a postbomb date, so with a negative 14C age
pMCtoC14(80, 0.5) # prebomb dates can also be calculated
pMCtoC14(.8, 0.005) # throws a warning, use F14C.age instead
```

pMCtoDelta14C *Transform pMC into Delta14C*

Description

Transform pMC into Delta14C

Usage

```
pMCtoDelta14C(pMC, er = NULL, t, roundby = Inf)
```

Arguments

pMC	The pMC value to translate
er	Reported error of the pMC value. Returns just the mean if left empty.
t	the cal BP age
roundby	Amount of decimals required for the output. Defaults to roundby=Inf, no rounding.

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 Delta14C value

Examples

```
pMCtoDelta14C(98.5, 1, 222)
```

pMCtoF14C *Calculate pMC ages from F14C values.*

Description

Calculate pMC values from F14C values of radiocarbon dates.

Usage

```
pMCtoF14C(pMC, er = NULL, roundby = Inf)
```

Arguments

pMC	Reported mean of the F14C
er	Reported error of the pMC value. Returns just the mean if left empty.
roundby	Amount of decimals required for the output. Defaults to roundby=Inf, no rounding.

Details

Post-bomb dates are often reported as F14C (between 0 at c. 55 kcal BP and 1 at c. AD 1950). Since software such as Bacon expects radiocarbon ages, this function can be used to calculate radiocarbon ages from F14C values. The reverse function is age.F14C.

Value

The F14C values from the pMC values. Basically the original values divided by 100.

Examples

```
pMCtoF14C(110, 5)
```

---

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,
  every = 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.
every	Yearly precision (defaults to every=1).

Value

The chosen point estimates

Examples

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

---

pool *Test if a set of radiocarbon dates can be combined*

Description

Calculate the (chi-square) probability that a set of radiocarbon dates is consistent, i.e. that it can be assumed that they all pertain to the same true radiocarbon age (and thus to the same calendar age - note though that sometimes multiple calendar ages obtain the same C14 age). The function calculates the differences (chi2 value) and finds the corresponding p-value. If the chi2 values is sufficiently small, then the p-value is sufficiently large (above the threshold), and the pooled mean is calculated and returned. If the scatter is too large, no pooled mean is calculated.

Usage

```
pool(
  y,
  er,
  deltaR = 0,
  deltaSTD = 0,
  threshold = 0.05,
  roundby = 1,
  talk = TRUE
)
```

Arguments

y	The set of radiocarbon dates to be tested
er	The lab errors of the radiocarbon dates
deltaR	Age offset (e.g. for marine samples).
deltaSTD	Uncertainty of the age offset (1 standard deviation).
threshold	Probability threshold above which chisquare values are considered acceptable (between 0 and 1; default threshold=0.05).
roundby	Rounding of the reported mean, chisquare and and p-value. Defaults to roundby=1.
talk	It's better than staying silent.

Details

This follows the calculations of Ward and Wilson (1978; Archaeometry 20: 19-31 <doi:10.1111/j.1475-4754.1978.tb00208.x>) and should only be used for multiple dates that stem from the same sample (e.g., multiple measurements on a single bone). It cannot be used to test if multiple dates from multiple samples pertain to the same event. Since the assumption is that all measurements stem from the same event, we can assume that they all share the same C14 age (since any calBP age will have an associated IntCal C14 age).

Value

The pooled mean and error if the p-value is above the threshold - a warning if it is not.

Author(s)

Maarten Blaauw

Examples

```
data(shroud)
pool(shroud$y,shroud$er)
Zu <- grep("ETH", shroud$ID) # Zurich lab only
pool(shroud$y[Zu],shroud$er[Zu])
```

---

push.gamma *Add a gamma distribution to a calibrated date*

Description

Push a date to younger or older ages by adding (or subtracting) a gamma distribution (e.g. if a bone is assumed to have a lag or in-built age)

Usage

```
push.gamma(
  y,
  er,
  mean,
  shape,
  add = TRUE,
  subtract = FALSE,
  seed = NA,
  n = 1e+06,
  prob = 0.95,
  cc = 1,
  postbomb = FALSE,
  deltaR = 0,
  deltaSTD = 0,
  thiscurve = NULL,
  cc.dir = NULL,
  is.F = FALSE,
  normal = TRUE,
  t.a = 3,
  t.b = 4,
  BCAD = FALSE,
  cal.lim = c(),
  cal.rev = TRUE,
  calib.col = rgb(0, 0, 0, 0.25),
  pushed.col = rgb(0, 0, 1, 0.4),
  heights = 0.3,
  inset = TRUE,
  inset.col = "darkgreen",
  inset.loc = c(0.6, 0.97, 0.6, 0.97),
  inset.mar = c(3, 0.5, 0.5, 0.5),
  inset.mgp = c(2, 1, 0)
)
```

Arguments

y	The radiocarbon age
er	The error of the radiocarbon age
mean	The mean of the gamma distribution
shape	The shape of the gamma distribution. If setting this to shape=1, it becomes an exponential distribution.
add	The distribution can be added or subtracted. Adding results in ages being pushed to older age distributions, and subtracting to younger ones.
subtract	The distribution can be added or subtracted. Adding results in ages being pushed to older age distributions, and subtracting to younger ones. Defaults to `subtract=FALSE`. If set to TRUE, overrides 'add'.

seed	For reproducibility, a seed can be set (e.g., seed=123). Defaults to NA, no seed set.
n	The amount of random values to sample (from both the calibrated distribution and the gamma distribution) to calculate the push. Defaults to n=1e6.
prob	The probability for the hpd ranges. Defaults to prob=0.95.
cc	Calibration curve to use. Defaults to IntCal20 (cc=1).
postbomb	Whether or not to use a postbomb curve. Required for negative radiocarbon ages. Defaults to postbomb=FALSE.
deltaR	Age offset (e.g. for marine samples).
deltaSTD	Uncertainty of the age offset (1 standard deviation).
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).
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".
is.F	Use this if the provided date is in the F14C timescale.
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.
cal.lim	Calendar axis limits. Calculated automatically by default.
cal.rev	Reverse the calendar axis. Defaults to TRUE.
calib.col	Colour of the calibrated distribution (defaults to semi-transparent light grey).
pushed.col	Colour of the pushed distribution (defaults to semi-transparent blue).
heights	Heights of the calibrated and 'pushed' distributions. Defaults to 0.3 of the device's height.
inset	Whether or not to plot an inset graph showing the shape of the normal/gamma distribution.
inset.col	Colour of the normal/gamma distribution.
inset.loc	Location of the inset graph.
inset.mar	Margins of the inset graph.
inset.mgp	Margin lines for the inset graph.

Details

n random values will be sampled from the calibrated distribution, and a similar amount will be sampled from the gamma distribution. The sampled values will then be added to or subtracted from each other to push the date to younger or older ages.

Value

The resulting calibrated distribution and its hpd ranges, together with a plot of the pushed date with the gamma distribution (and whether it is added or subtracted) as inset

Examples

```
push.gamma(250, 25, 50, 2, add=FALSE) # subtract a gamma distribution
```

`push.normal` *Add a normal distribution to a calibrated date*

Description

Push a date to younger or older ages by adding (or subtracting) a normal distribution (e.g. if a bone is assumed to have a lag or in-built age)

Usage

```
push.normal(
  y,
  er,
  mean,
  sdev,
  add = TRUE,
  subtract = FALSE,
  seed = NA,
  n = 1e+06,
  prob = 0.95,
  cc = 1,
  postbomb = FALSE,
  deltaR = 0,
  deltaSTD = 0,
  thiscurve = NULL,
  cc.dir = NULL,
  normal = TRUE,
  t.a = 3,
  t.b = 4,
  BCAD = FALSE,
  cal.lim = c(),
  cal.rev = TRUE,
  calib.col = rgb(0, 0, 0, 0.25),
  pushed.col = rgb(0, 0, 1, 0.4),
  heights = 0.3,
  inset = TRUE,
  inset.col = "darkgreen",
  inset.loc = c(0.6, 0.97, 0.6, 0.97),
  inset.mar = c(3, 0.5, 0.5, 0.5),
  inset.mgp = c(2, 1, 0)
)
```

Arguments

y	The radiocarbon age.
er	The error of the radiocarbon age.
mean	The mean of the normal or gamma distribution.
sdev	The standard deviation of the normal distribution.
add	The distribution can be added or subtracted. Adding results in ages being pushed to older age distributions, and subtracting to younger ones.
subtract	The distribution can be added or subtracted. Adding results in ages being pushed to older age distributions, and subtracting to younger ones. Defaults to subtract=FALSE. If set to TRUE, overrides 'add'.
seed	For reproducibility, a seed can be set (e.g., seed=123). Defaults to NA, no seed set.
n	The amount of random values to sample (from both the calibrated distribution and the gamma/normal distribution) to calculate the push. Defaults to n=1e6.
prob	The probability for the hpd ranges. Defaults to prob=0.95.
cc	Calibration curve to use. Defaults to IntCal20 (cc=1).
postbomb	Whether or not to use a postbomb curve. Required for negative radiocarbon ages. Defaults to postbomb=FALSE.
deltaR	Age offset (e.g. for marine samples).
deltaSTD	Uncertainty of the age offset (1 standard deviation).
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).
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".
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.
cal.lim	Calendar axis limits. Calculated automatically by default.
cal.rev	Reverse the calendar axis. Defaults to TRUE.
calib.col	Colour of the calibrated distribution (defaults to semi-transparent light grey).
pushed.col	Colour of the pushed distribution (defaults to semi-transparent blue).
heights	Heights of the calibrated and 'pushed' distributions. Defaults to 0.3 of the device's height.
inset	Whether or not to plot an inset graph showing the shape of the normal/gamma distribution.
inset.col	Colour of the normal/gamma distribution.
inset.loc	Location of the inset graph.
inset.mar	Margins of the inset graph.
inset.mgp	Margin lines for the inset graph.

Details

n random values will be sampled from the calibrated distribution, and a similar amount will be sampled from the normal distribution. The sampled values will then be added to or subtracted from each other to push the date to younger or older ages.

Value

The resulting calibrated distribution and its hpd ranges, together with a plot of the pushed date with the normal distribution (and whether it is added or subtracted) as inset

Examples

```
push.normal(250, 25, 50, 10)
```

---

r.calib *return a random calendar age from a calibrated distribution*

Description

Calculate the cumulative calibrated distribution, then sample n random uniform values between 0 and 1 and find the corresponding calendar ages through interpolation. Calendar ages with higher calibrated probabilities will be proportionally more likely to be sampled.

Usage

```
r.calib(
  n,
  y,
  er,
  cc = 1,
  postbomb = FALSE,
  bombalert = TRUE,
  deltaR = 0,
  deltaSTD = 0,
  as.F = FALSE,
  is.F = FALSE,
  thiscurve = NULL,
  yrsteps = FALSE,
  cc.resample = FALSE,
  threshold = 0,
  normal = TRUE,
  t.a = 3,
  t.b = 4,
  normalise = TRUE,
  BCAD = FALSE,
  rule = 2,
  cc.dir = NULL,
```

```
  seed = NA
)
```

Arguments

n	The number of calendar ages to sample
y	Uncalibrated radiocarbon age
er	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.
bombalert	Warn if a date is close to the lower limit of the calibration curve. Defaults to postbomb=TRUE.
deltaR	Age offset (e.g. for marine samples).
deltaSTD	Uncertainty of the age offset (1 standard deviation).
as.F	Whether or not to calculate ages in the F14C timescale. Defaults to as.F=FALSE, which uses the C14 timescale.
is.F	Use this if the provided date is in the F14C timescale.
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).
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.
threshold	Report only values above a threshold. Defaults to threshold=0.
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).
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".
seed	For reproducibility, a seed can be set (e.g., seed=123). Defaults to NA, no seed set.

Value

n randomly sampled calendar ages

Author(s)

Maarten Blaauw

Examples

```
r.calib(10,130,20, bombalert=FALSE) # 10 random cal BP ages
plot(density(r.calib(1e6, 2450, 20)))
```

---

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),
  talk = TRUE
)
```

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)`.
`talk`	Report details of the found values.

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, mapsize="small")
shells.mean(N_UK)
nearby <- find.shells(0,56,20) # somewhere in Scotland
shells.mean(nearby, distance=TRUE) # distance matters
```

shroud *shroud Data*

Description

A dataset containing the radiocarbon dates on the Shroud of Turin, from three labs

Usage

```
shroud
```

Format

A data frame with the Lab numbers, ages and errors of 12 Shroud dates.

ID Lab numbers. Replicates are indicates with .1, .2, etc.

y Radiocarbon year

er Lab error

Source

Data taken from Damon et al. 1989 [Nature] <doi:10.1038/337611a0>, see also Christen 1994 [Applied Statistics] <doi:10.2307/2986273>

Examples

```
data(shroud)
head(shroud)
```

smooth.curve *Smooth a calibration curve*

Description

Smooth a calibration curve over a time window of a specified width. This to accommodate material that has accumulated over a certain assumed time, e.g. a cm of peat over say 30 years.

Usage

```
smooth.ccurve(
  smooth = 30,
  cc = 1,
  postbomb = FALSE,
  cc.dir = c(),
  thiscurve = c(),
  resample = 0,
```

```
  name = "smoothed.csv",
  save = FALSE,
  sep = "\t"
)
```

Arguments

smooth	The window width of the smoothing. Defaults to smooth=30.
cc	The calibration curve to smooth. 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"'.
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 c().
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.
name	The filename of the curve, if it is being saved. Defaults to name="smoothed.csv".
save	Whether or not to save the curve to cc.dir. Defaults to save=FALSE.
sep	Separator between fields if the file is saved (tab by default, sep="\t").

Details

The smoothing is done by calculating the mean C14 age and error of a moving window (moving along with the cal BP steps of the calibration curve). Something similar is done in the online calibration software CALIB.

Author(s)

Maarten Blaauw

Examples

```
mycurve <- smooth.ccurve(smooth=50)
calibrate(2450,20, thiscurve=mycurve)
```

span *The time span between two calibrated dates*

Description

Calculates the timespan between two calibrated radiocarbon dates. It does this by randomly sampling ages from both calibrated dates, followed by calculating the differences between all samples ages.

Usage

```
span(
  y1,
  er1,
  y2,
  er2,
  n = 1e+05,
  positive = TRUE,
  cc = 1,
  postbomb = FALSE,
  deltaR = 0,
  deltaSTD = 0,
  as.F = FALSE,
  thiscurve = NULL,
  yrsteps = 1,
  cc.resample = FALSE,
  threshold = 0.001,
  normal = TRUE,
  t.a = 3,
  t.b = 4,
  cc.dir = NULL,
  visualise = TRUE,
  talk = TRUE,
  prob = 0.95,
  roundby = 1,
  bty = "l"
)
```

Arguments

y1	The first radiocarbon date.
er1	The lab error of the first radiocarbon date.
y2	The second radiocarbon date.
er2	The lab error of the second radiocarbon date.
n	The number of iterations to base the calculations on. Defaults to 100,000. Different values for n could significantly alter performance and accuracy.

positive	Whether or not to enforce the span to be positive. If set to TRUE, then negative span values are removed. Defaults to TRUE.
cc	Calibration curve(s) to use. Defaults to IntCal20 (cc=1). Can be a vector of length 2.
postbomb	Whether or not to use a postbomb curve. Required for negative radiocarbon ages.
deltaR	Age offset (e.g. for marine samples). Can be a vector of length 2.
deltaSTD	Uncertainty of the age offset (1 standard deviation). Can be a vector of length 2.
as.F	Whether or not to calculate ages in the F14C timescale. Defaults to as.F=FALSE, which uses the C14 timescale.
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).
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.
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). Can be a vector of length 2.
t.b	Value b of the t distribution (defaults to 4). Can be a vector of length 2.
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".
visualise	Whether or not to plot the time span.
talk	Whether or not to report a summary of the span.
prob	Probability range to report. Defaults to prob=0.95.
roundby	Number of decimals to report
bty	Draw a box around a box of a certain shape. Defaults to bty="l".

Value

The time span.

Examples

```
span(2300, 20, 2350, 20)
```

spread *The spread among calibrated dates*

Description

Calculates the spread among multiple calibrated radiocarbon dates. It does this by randomly sampling ages from the calibrated dates, and calculating the difference between one random date and all others for that iteration.

Usage

```
spread(
  y,
  er,
  n = 1e+05,
  cc = 1,
  postbomb = FALSE,
  deltaR = 0,
  deltaSTD = 0,
  as.F = FALSE,
  thiscurve = NULL,
  yrsteps = 1,
  cc.resample = FALSE,
  threshold = 0.001,
  normal = TRUE,
  t.a = 3,
  t.b = 4,
  cc.dir = NULL,
  visualise = TRUE,
  talk = TRUE,
  prob = 0.95,
  roundby = 1,
  bty = "l"
)
```

Arguments

y	The set of radiocarbon dates
er	The lab errors of the radiocarbon dates
n	The number of iterations to base the calculations on. Defaults to 100,000. Different values for n could significantly alter performance and accuracy.
cc	Calibration curve to use. Defaults to IntCal20 (cc=1).
postbomb	Whether or not to use a postbomb curve. Required for negative radiocarbon ages.
deltaR	Age offset (e.g. for marine samples).

deltaSTD	Uncertainty of the age offset (1 standard deviation).
as.F	Whether or not to calculate ages in the F14C timescale. Defaults to as.F=FALSE, which uses the C14 timescale.
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).
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.
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 b of the t distribution (defaults to 4).
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".
visualise	Whether or not to plot the spread
talk	Whether or not to report a summary of the spread
prob	Probability range to report. Defaults to prob=0.95.
roundby	Number of decimals to report
bty	Draw a box around a box of a certain shape. Defaults to bty="l".

Value

The spread of all calibrated probabilities.

Examples

```
data(shroud)
spread(shroud$y,shroud$er)
Zu <- grep("ETH", shroud$ID) # Zurich lab only
spread(shroud$y[Zu],shroud$er[Zu])
```

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, mapsize="small")
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,
  bombalert = TRUE,
  deltaR = 0,
  deltaSTD = 0,
  normal = TRUE,
  as.F = FALSE,
  is.F = FALSE,
  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()).
bombalert	Warn if a date is close to the lower limit of the calibration curve. Defaults to postbomb=TRUE.
deltaR	Age offset (e.g. for marine samples).
deltaSTD	Uncertainty of the age offset (1 standard deviation).
normal	Use the normal distribution to calibrate dates (default TRUE). The alternative is to use the t model (Christen and Perez 2016).
as.F	Whether or not to calculate ages in the F14C timescale. Defaults to as.F=FALSE, which uses the C14 timescale.
is.F	Use this if the provided date is in the F14C timescale.
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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