Package 'clam'

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Type Package

Title Classical Age-Depth Modelling of Cores from Deposits

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Description Performs 'classical' age-depth modelling of dated sediment deposits - prior to applying more sophisticated techniques such as Bayesian age-depth modelling. Any radiocarbon dated depths are calibrated. Age-depth models are constructed by sampling repeatedly from the dated levels, each time drawing age-depth curves. Model types include linear interpolation, linear or polynomial regression, and a range of splines. See Blaauw (2010). <doi:10.1016/j.quageo.2010.01.002>.

License GPL (>= 2)

Imports grDevices, graphics, stats, utils

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R topics documented:

`add.dates` *Add dates to age-depth plots*

Description

Add dated depths to plots, e.g. to show dates that weren't used in the age-depth model

Usage

```
add.dates(
  mn,
  sdev,
  depth,
  cc = 1,
  above = 0.001,
  exx = 50,
  normal = TRUE,
  normalise = TRUE,
  t.a = 3,
  t.b = 4,
  age.res = 100,
  times = 20,
  col = rgb(1, 0, 0, 0.5),
  border = rgb(1, 0, 0, 0.5),
  rotate.axes = FALSE,
  mirror = TRUE,
  up = TRUE,
  BCAD = FALSE
)
```

Arguments

`mn`	Reported mean of the date. Can be multiple dates.
`sdev`	Reported error of the date. Can be multiple dates.
`depth`	Depth of the date.
`cc`	The calibration curve to use: `cc=1` for IntCal20 (northern hemisphere terrestrial), `cc=2` for Marine20 (marine), `cc=3` for SHcal20 (southern hemisphere terrestrial), `cc=0` for none (dates that are already on the cal BP scale).

above	Threshold for plotting of probability values. Defaults to above=1e-3.
exx	Exaggeration of probability distribution plots. Defaults to exx=50.
normal	By default, Bacon uses the student's t-distribution to treat the dates. Use normal=TRUE to use the normal/Gaussian distribution. This will generally give higher weight to the dates.
normalise	By default, the date is normalised to an area of 1 (normalise=TRUE).
t.a	The dates are treated using the student's t distribution by default (normal=FALSE). The student's t-distribution has two parameters, t.a and t.b, set at 3 and 4 by default (see Christen and Perez, 2010). If you want to assign narrower error distributions (more closely resembling the normal distribution), set t.a and t.b at for example 33 and 34 respectively (e.g., for specific dates in your .csv file). For symmetry reasons, t.a must always be equal to t.b-1.
t.b	The dates are treated using the student's t distribution by default (normal=FALSE). The student's t-distribution has two parameters, t.a and t.b, set at 3 and 4 by default (see Christen and Perez, 2010). If you want to assign narrower error distributions (more closely resembling the normal distribution), set t.a and t.b at for example 33 and 34 respectively (e.g., for specific dates in your .csv file). For symmetry reasons, t.a must always be equal to t.b-1.
age.res	Resolution of the date's distribution. Defaults to date.res=100.
times	The extent of the range to be calculated for each date. Defaults to times=20.
col	The colour of the ranges of the date. Default is semi-transparent red: col=rgb(1,0,0,.5).
border	The colours of the borders of the date. Default is semi-transparent red: border=rgb(1,0,0,0.5).
rotate.axes	The default of plotting age on the horizontal axis and event probability on the vertical one can be changed with rotate.axes=TRUE.
mirror	Plot the dates as 'blobs'. Set to mirror=FALSE to plot simple distributions.
up	Directions of distributions if they are plotted non-mirrored. Default up=TRUE.
BCAD	The calendar scale of graphs is in cal BP by default, but can be changed to BC/AD using BCAD=TRUE.

Details

Sometimes it is useful to add additional dating information to age-depth plots, e.g., to show outliers or how dates calibrate with different estimated offsets.

Value

A date's distribution, added to an age-depth plot.

Author(s)

Maarten Blaauw, J. Andres Christen

Examples

```
clam(coredir=tempfile())
add.dates(5000, 100, 60)
```

age.pMC *Calculate pMC values from C14 ages*

Description

Calculate pMC values from radiocarbon ages

Usage

```
age.pMC(mn, sdev, ratio = 100, decimals = 3)
```

Arguments

mn	Reported mean of the 14C age.
sdev	Reported error of the 14C age.
ratio	Most modern-date values are reported against 100. If it is against 1 instead, use 1 here.
decimals	Amount of decimals required for the pMC value.

Details

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

Value

pMC values from C14 ages.

Author(s)

Maarten Blaauw, J. Andres Christen

Examples

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

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

Description

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

Usage

```
calBP.14C(
  yr,
  cc = 1,
  cc1 = "IntCal20.14C",
  cc2 = "Marine20.14C",
  cc3 = "SHCal20.14C",
  cc4 = "mixed.14C",
  ccdir = "",
  postbomb = FALSE,
  pb1 = "postbomb_NH1.14C",
  pb2 = "postbomb_NH2.14C",
  pb3 = "postbomb_NH3.14C",
  pb4 = "postbomb_SH1-2.14C",
  pb5 = "postbomb_SH3.14C"
)
```

Arguments

yr	The cal BP year.
cc	calibration curve for C14 dates (1, 2 or 3).
cc1	For northern hemisphere terrestrial C14 dates.
cc2	For marine C14 dates.
cc3	For southern hemisphere C14 dates.
cc4	A custom calibration curve
ccdir	Directory where the calibration curves for C14 dates cc are allocated. By default ccdir="". Use ccdir="." to choose current working directory. Use ccdir="Curves/" to choose sub-folder Curves/.
postbomb	Which postbomb curve to use for negative 14C dates
pb1	For Northern hemisphere region 1 postbomb C-14 dates.
pb2	For Northern hemisphere region 2 postbomb C-14 dates.
pb3	For Northern hemisphere region 3 postbomb C-14 dates.
pb4	For Southern hemisphere regions 1-2 postbomb C-14 dates.
pb5	For Southern hemisphere region 3 postbomb C-14 dates.

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.

Author(s)

Maarten Blaauw

Examples

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

`calibrate` *Calibrate individual 14C dates.*

Description

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

Usage

```
calibrate(
  cage = 2450,
  error = 50,
  reservoir = 0,
  prob = 0.95,
  cc = 1,
  cc1 = "IntCal20.14C",
  cc2 = "Marine20.14C",
  cc3 = "SHCal20.14C",
  cc4 = "mixed.14C",
  ccdir = "",
  postbomb = FALSE,
  pb1 = "postbomb_NH1.14C",
  pb2 = "postbomb_NH2.14C",
  pb3 = "postbomb_NH3.14C",
  pb4 = "postbomb_SH1-2.14C",
  pb5 = "postbomb_SH3.14C",
  yrsteps = 1,
  pbsteps = 0.01,
  hpdsteps = 1,
  calibt = FALSE,
  yrmin = NULL,
  yrmax = NULL,
  minC14 = NULL,
  maxC14 = NULL,
```

```
  times = 5,
  calheight = 0.3,
  expand = 0.1,
  threshold = 1e-06,
  storedat = FALSE,
  graph = TRUE,
  xlab = NULL,
  ylab = NULL,
  BCAD = FALSE,
  mar = c(3.5, 3, 2, 1),
  mgp = c(1.7, 0.8, 0),
  bty = "l",
  xaxs = "i",
  yaxs = "i",
  title = NULL,
  date.col = "red",
  cc.col = rgb(0, 0.5, 0, 0.7),
  dist.col = rgb(0, 0, 0, 0.3),
  sd.col = rgb(0, 0, 0, 0.5)
)
```

Arguments

cage	Mean of the uncalibrated C-14 age.
error	Error of the uncalibrated C-14 age.
reservoir	Reservoir age, or reservoir age and age offset.
prob	Probability confidence intervals (between 0 and 1).
cc	Calibration curve for C-14 dates (1, 2, 3, or 4).
cc1	For northern hemisphere terrestrial C-14 dates.
cc2	For marine C-14 dates.
cc3	For southern hemisphere C-14 dates.
cc4	For mixed marine/terrestrial C-14 dates.
ccdir	Directory where the calibration curves for C-14 dates cc are located. By default ccdir="". Use ccdir="." to choose current working directory. Use ccdir="/Curves" to choose sub-folder /Curves.
postbomb	Calibration curve for postbomb dates.
pb1	For Northern hemisphere region 1 postbomb C-14 dates.
pb2	For Northern hemisphere region 2 postbomb C-14 dates.
pb3	For Northern hemisphere region 3 postbomb C-14 dates.
pb4	For Southern hemisphere regions 1-2 postbomb C-14 dates.
pb5	For Southern hemisphere region 3 postbomb C-14 dates.
yrsteps	Temporal resolution at which C-14 ages are calibrated (in calendar years).
pbsteps	Temporal resolution at which postbomb C-14 ages are calibrated (in calendar years).

hpdsteps	Temporal resolution at which highest posterior density ranges are calibrated (in calendar years).
calibt	Calibration based on the student-t distribution. By default, the Gaussian distribution is used (calibt=FALSE). To use the student-t distribution, provide two parameters such as calibt=c(3,4).
yrmin	Minimum of calendar axis (default calculated automatically).
yrmax	Maximum of calendar axis (default calculated automatically).
minC14	Minimum age of the C-14 age axis (default calculated automatically).
maxC14	Maximum of the C-14 age axis (default calculated automatically).
times	Half-range of calibration curve used to calibrate dates (multiplication factor for the date's errors).
calheight	Maximum height of the C14 and calibrated distributions (as proportion of the invisible secondary axes).
expand	By which ratio should the calendar axis be expanded to fit the calibrated distribution.
threshold	Below which value should probabilities be excluded from calculations.
storedat	Store the dates within the R session after a clam run.
graph	Plot a graph of the calibrated date. If set to FALSE, only the hpd ranges will be given.
xlab	Label of the horizontal axis. Defaults to the calendar scale, but alternative names can be provided.
ylab	Label of the vertical axis. Defaults to the 14C scale, but alternative names can be provided.
BCAD	Use BC/AD or cal BP scale (default cal BP).
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).
bty	Draw a box around the graph ("n" for none, and "l", "7", "c", "u", "]" or "o" for correspondingly shaped boxes).
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.
title	Title of the graph. Defaults to the values of the uncalibrated date.
date.col	Colour of the "dot-bar" plot of the C14 date. Defaults to date.col="red".
cc.col	Colour of the calibration curve. Defaults to semi-transparent dark green; cc.col=rgb(0,.5,0,0.7).
dist.col	Colour of the calibrated distribution.
sd.col	Colour of calibrated range.

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 +- 20 14C BP, type `calibrate(cage=130,error=20)` or, shorter, `calibrate(130,20)`. As this date will fall partly beyond the younger extreme of the calibration curve, a warning will be given (similar warnings will be given for too old dates).

In case the date has a reservoir effect or age offset, e.g. of 100 14C years, provide this as follows: `calibrate(130,20,reservoir=100)`. If you want to include an uncertainty for this offset, provide this as follows, e.g., for an uncertainty of 50yr, `calibrate(130,20,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.calibrationcurves` mix.calibrationcurves, and calibrate the date using that custom-built curve.

If you prefer to work with, e.g., 68 % as opposed to the default 95 % confidence intervals, type: `calibrate(130,20,prob=0.68)` or `calibrate(130,20,,0.68)` (the commas between the brackets indicate the position of the option; the standard deviation is the fourth option of the `calibrate` function). Clam calculates the calibrated distribution for every single calendar year (`yrsteps=1`) within a wide range of the 14C date (default but adaptable `times=5` standard deviations or 99.999999 % of its probability distribution). This range can also be adapted by changing the option expand (default `expand=0.1`). Probabilities below a threshold (default `threshold=1e-6`) will be neglected.

By default the northern hemisphere terrestrial calibration curve is used (`cc=1,cc1="IntCal20.14C"`). To use alternative curves, use `cc=2` (`cc2="Marine20.14C"`), `cc=3` (`cc3="SHCal20.14C"`), `cc=4` (`cc4="mixed.14C"`), or change the file names of `cc1,cc2,cc3` or `cc4`.

Clam 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 student-t distribution instead, provide two sensible values, e.g., `calibt=c(3,4)`.

Calibrated distributions are usually reduced to their 68% or 95% calibrated ranges, taking into account the asymmetric and multi-peaked shape of these distributions. In clam, this is done by calculating the highest posterior density (hpd) ranges:

- i) the probability distribution (see above) is normalised to 100%
- ii) the calendar years are ranked according to their probabilities
- iii) those calendar ages with a cumulative sum at or above the desired probability threshold (default 95%) are retained, and
- iv) the extremes and probabilities of any sub-ranges within these calendar ages are reported.

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 in clam. The hpd ranges are calculated at yearly resolution by default (`hpdsteps=1`).

Negative radiocarbon ages are calibrated with postbomb curves, but the user needs to tell clam which curve to use. For example, to use the first of the three northern hemisphere curves, provide the

option postbomb=1, while for southern hemisphere samples, use postbomb=4 or postbomb=5. Default curves can be changed; currently they are pb1="postbomb_NH1.14C", pb2="postbomb_NH2.14C", pb3="postbomb_NH3.14C", pb4="postbomb_SH1-2.14C" and pb5="postbomb_SH3.14C"; see http://calib.org/CALIBomb/. If no postbomb option is provided for negative radiocarbon ages, clam will report an error and refuse to calibrate the date. Given the sub-year resolution of postbomb-curves, hpd ranges are calculated at high resolution by default (pbsteps=0.01). Choose alternative values with care as they may cause unexpected results.

Generally the calculations are removed from memory after calibration; if you want to have them stored (say for subsequent manipulations), provide the option storedat=TRUE.

A graph of the calibration is produced by default (graph=TRUE), 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 yrmin,yrmax,minC14 and maxC14, respectively. The titles of both axis can be changed by providing alternative titles to xlab and/or ylab, and also the top title can be adapted using title. The heights of the distributions of the 14C and calibrated ages can be set to alternative values using calheight (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 entire distributions, as well as of the highest posterior density (hpd) ranges, can be changed by providing an alternative colour in date.col, cc.col, dist.col, and/or sd.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 ranges and probabilities.

Author(s)

Maarten Blaauw

Examples

```
calibrate()
calibrate(130, 20)
cal <- calibrate(2550, 20, reservoir=100)
cal; plot(cal$calib)
calibrate(130, 20, prob=0.68)
calibrate(cage=130, error=20)
calibrate(4450, 40, reservoir=c(100, 50))
```

clam *clam*

Description

clam is R code for classical (non-Bayesian) age-depth modelling.

Produce age-depth models for cores with dated depths.

Usage

```
clam(
  core = "Example",
  type = 1,
  smooth = NULL,
  prob = 0.95,
  its = 1000,
  coredir = NULL,
  ask = TRUE,
  wghts = 1,
  cc = 1,
  cc1 = "IntCal20.14C",
  cc2 = "Marine20.14C",
  cc3 = "SHCal20.14C",
  cc4 = "mixed.14C",
  postbomb = FALSE,
  pb1 = "postbomb_NH1.14C",
  pb2 = "postbomb_NH2.14C",
  pb3 = "postbomb_NH3.14C",
  pb4 = "postbomb_SH1-2.14C",
  pb5 = "postbomb_SH3.14C",
  ccdir = "",
  outliers = NULL,
  ignore = NULL,
  youngest = NULL,
  extradates = NULL,
  slump = NULL,
  est = 1,
  calibt = FALSE,
  mixed.effect = FALSE,
  dmin = NULL,
  dmax = NULL,
  every = 1,
  yrmin = NULL,
  yrmax = NULL,
  yrsteps = 1,
  pbsteps = 0.01,
  hpdsteps = 1,
```

```
  BCAD = FALSE,
  decimals = 0,
  cmyr = FALSE,
  ageofdepth = NULL,
  depth = "cm",
  depthseq = NULL,
  depths.file = FALSE,
  thickness = 1,
  hiatus = NULL,
  remove.reverse = 0.5,
  times = 5,
  sep = ",",
  ext = ".csv",
  runname = NULL,
  storedat = TRUE,
  threshold = 1e-06,
  proxies = FALSE,
  revaxes = FALSE,
  revd = TRUE,
  revyr = TRUE,
  calhght = 0.3,
  maxhght = 0.01,
  mirror = TRUE,
  plotrange = TRUE,
  bty = "l",
  mar = c(3.5, 3, 2, 1),
  mgp = c(2, 1, 0),
  plotpdf = TRUE,
  plotpng = TRUE,
  greyscale = NULL,
  yrlab = NULL,
  dlab = NULL,
  calcol = rgb(0, 0.5, 0.5, 0.5),
  C14col = rgb(0, 0, 1, 0.5),
  outcol = "red",
  outlsize = 1,
  bestcol = "black",
  rangecol = rgb(0, 0, 0, 0.3),
  slumpcol = grey(0.75),
  plotname = TRUE,
  ash = FALSE
)
```

Arguments

`core`	Name of the core, given using quotes. Defaults to the core provided with clam, `core="Example"`.
`type`	The type of age-depth model. Five different types are provided:

1. linear interpolation between neighbouring levels (1, "int", "inter" or "interp")
2. linear or higher polynomial regression (2, "reg", "regr", "poly" or "polyn", default linear)
3. cubic spline (3, "spl" or "spline")
4. smooth spline (4, "sm" or "smooth", default smoothing 0.3)
5. locally weighted spline (5, "loess" or "lowess", default smoothing 0.75, cannot extrapolate)

`smooth` Degree of smoothing. Gives polynomial degree for model type 2. Not relevant for `type=1` or `type=3`.

- for type=2: `smooth=1` (linear), `smooth=2` second-order polynomial, `smooth=3` for third-order polynomial, etc.
- for type=4: `smooth=0.3`
- for type=5: `smooth=0.75`

`prob` Confidence intervals (between 0 and 1), default `prob=0.95` or 95%.

`its` Amount of age-model iterations; defaults to `its=1000`.

`coredir` The directory where core runs are stored (each core in its own directory named after the core's name).

`ask` By default, and as per R rules, clam will ask if it is OK to make or write to a directory. Defaults to `coredir="clam_runs"`, or to `coredir="Cores"` if this folder exists where R is working.

`wghts` Weights can be applied to dated depths as follows:

- 0 no weighting
- 1 weighted to calibrated probabilities of sampled calendar years (default, `wghts=1`).
- 2 weighted to (inverse squared) errors of the dates.

`cc` calibration curve for C14 dates (1, 2 or 3).

`cc1` For terrestrial, northern hemisphere C14 dates.

`cc2` For marine C14 dates.

`cc3` For southern hemisphere C14 dates.

`cc4` For mixed terrestrial/marine C14 dates.

`postbomb` Use a postbomb curve for negative (i.e. postbomb) 14C ages. `0 = none, 1 = NH1, 2 = NH2, 3 = NH3, 4 = SH1-2, 5 = SH3`. See http://calib.org/CALIBomb/.

`pb1` For Northern hemisphere region 1 postbomb C14 dates.

`pb2` For Northern hemisphere region 2 postbomb C14 dates.

`pb3` For Northern hemisphere region 3 postbomb C14 dates.

`pb4` For Southern hemisphere regions 1-2 postbomb C14 dates.

`pb5` For Southern hemisphere region 3 postbomb C14 dates.

`ccdir` Directory where the calibration curves for C14 dates `cc` are located. By default `ccdir=""`. For example, use `ccdir="."` to choose current working directory, or `ccdir="Curves/"` to choose sub-folder `Curves/`.

`outliers` The number of any dates to be considered outlying, e.g. `c(5,6)` for the fifth and sixth dated depth counting from the top of a core.

`ignore` The number of any dates that should be ignored, e.g., `c(5,6)` for the fifth and sixth date counting from the top of a core.

`youngest` The age beyond which dates should be truncated (e.g., `youngest=-60` if the core was sampled in -60 cal BP or AD 2010).

`extradates` Depths of any additional dates with their files of ages and probabilities.

`slump` Upper and lower depths of sections of abrupt accumulation that should be excised, e.g., `c(600,550,120,100)` for two sections of 600-550 and 120-100 cm depth.

`est` Which point estimate to use as 'best' age. It is highly recommended to not only use these 'best' point estimates, as chronological uncertainties are often considerable and should not be ignored.

1. averages of age-depth model derived ages (default, `est=1`)
2. midpoints of age-depth model derived age estimates
3. midpoints of calibrated ranges
4. weighted means of calibrated ranges
5. medians of calibrated distributions
6. maximum densities of calibrated distributions
7. midpoints of entire calibrated distributions (including years outside the calibrated ranges)

`calibt` Calibration based on the student-t distribution. By default, the Gaussian distribution is used (`calibt=FALSE`). To use the student-t distribution, provide two parameters such as `calibt=c(3,4)`.

`mixed.effect` Set to `TRUE` to activate mixed-effect modelling.

`dmin` Minimum depth of age-depth model (e.g., extrapolate).

`dmax` Maximum depth of age-depth model (e.g., extrapolate).

`every` Resolution at which (ages for) depths are calculated.

`yrmin` Minimum of calendar axis of age-depth plot (calculate automatically by default).

`yrmax` Maximum of calendar axis of age-depth plot (calculated automatically by default).

`yrsteps` Temporal resolution at which calibrated ages are calculated (in calendar years).

`pbsteps` Temporal resolution at which postbomb C14 ages are calibrated (in calendar years).

`hpdsteps` Temporal resolution at which highest posterior density ranges are calibrated (in calendar years).

`BCAD` Use BC/AD or cal BP scale.

`decimals` Amount of decimals for rounding.

`cmyr` Accumulation rates can be provided as yr/cm (default, `cmyr=TRUE`, more accurately named deposition times) or cm/yr (`cmyr=FALSE`).

`ageofdepth` Calculate age estimates of a specific depth.

depth	Depth units.
depthseq	Sequence of depths for which age estimates are to be calculated (default: from dmin to dmax with steps of size every)
depths.file	Use a file with depths for depthseq.
thickness	Thickness of the dated samples.
hiatus	Depths of any hiatuses, e.g., c(500,300). Each sub-section must have at least 2 dates (4 for smoothing spline; does not work with loess as it cannot extrapolate).
remove.reverse	Proportion of age-models with reversals that can be removed before prompting a warning. Set at FALSE to avoid removing models with reversals.
times	Half-range of calibration curve used to calibrate dates (multiplication factor for the dates' errors).
sep	Separator between the fields of the plain text file containing the dating information.
ext	Extension of the file containing the dating information.
runname	Text to add to the core name for specific runs, e.g., "MyCore_Test1"
storedat	Store the dates and age-model within R after a clam run. Defaults to storedat=TRUE.
threshold	Below which value should probabilities be excluded from calculations.
proxies	Set to TRUE to plot proxies against age after the run.
revaxes	Set to TRUE to plot ages on the vertical axis and depth on the horizontal axis.
revd	Plot depth axis in reverse.
revyr	Plot age axis in reverse.
calhght	Heights of the calibrated distributions in the age-depth plot.
maxhght	Maximum height of age probability distributions.
mirror	Plot the age distributions in "mirror" style (above and below depth).
plotrange	Plot the confidence ranges of the age-model.
bty	Type of box to be drawn around plots. Draw a box around the graph ("n" for none, and "l", "7", "c", "u", "]" or "o" for correspondingly shaped boxes).
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).
plotpdf	Produce a pdf file of the age-depth plot.
plotpng	Produce a png file of the age-depth plot.
greyscale	Produce a grey-scale representation of all age-models (number gives resolution, e.g., 500 bins; will cancel plotting of the confidence intervals).
yrlab	Label of the calendar axis. Defaults to either cal BP or BC/AD. Alternative names can be provided.
dlab	Label of the depth axis. Defaults to dlab="Depth (cm)" (assuming depth="cm"), but alternative names can be provided.
calcol	Colour of the calibrated distributions in the age-depth plot.
C14col	Colour of the calibrated ranges of the dates.

outcol	Colour of outlying dates.
outlsize	Size of symbols outlying dates.
bestcol	Colour of the "best" age-depth model (based on chosen value for est).
rangecol	Colour of plotted confidence ranges.
slumpcol	Colour of slump.
plotname	Print the core name on the graph.
ash	Plot all distributions at the same height.

Details

Cores containing several 14C and/or other dates can be processed semi-automatically in order to obtain age-depth models. In the process, any 14C dates are calibrated, and age-depth curves are repeatedly drawn through point estimates sampled from the dates. Age-depth models can be based on linear interpolation, linear/polynomial regression, or cubic, smooth or locally weighted splines. For each date, the probability of a calendar year being sampled is proportionate to its calibrated probability (see Blaauw, 2010). Uncertainty ranges as well as a 'best' age-model are calculated.

Additional cores should be put in a comma-separated file in a sub-folder of the directory where the cores are stored. By default this parent folder is called `coredir="clam_runs"` (if no folder called `"Cores"` already exists). If your core is called MyCore1, save MyCore1.csv as `clam_runs/MyCore1/MyCore1.csv`. Ensure that the names of the core's folder and filename's root (the part before .csv) match, e.g., using exactly similar upper- and lower case letters.

Avoid the use of spaces or non-standard (non-ASCII) characters within the file or in folder or file names. The plain text file should consist of 6 or 7 columns (also called fields), containing in the following exact order (see the example below):

1. Identification labels (e.g. 14C lab codes)
2. 14C ages for 14C-dated depths; leave empty for non-14C dated depths
3. cal BP ages (for any non-14C dates such as the core surface; leave empty for levels with 14C dates)
4. errors (reported 1 standard deviation errors. This column should never be left empty. Errors should always be larger than 0)
5. age offsets if known (otherwise leave empty)
6. depths (depths in the sequence were the dated samples were taken, default unit depth="cm"; this column should never be left empty)
7. thicknesses of the sampled slices (optional column; leave empty for default of 1)

Add a final empty line to your core's .csv file by pressing 'Enter' after the file's last value.

These files can be made in spreadsheet software such as MS-Excel, but it is always a good idea to check the file's formatting in a plain-text editor such as WordPad. Remove any lines which contain only commas, and it is also recommended to remove quotes ()`\" or \'`) in the headers or elsewhere.

Age-models for the core can then be produced by typing, e.g., `clam("MyCore1")`.

By default the northern hemisphere terrestrial calibration curve is used (`cc=1`, `cc1="IntCal20.14C"`). To use alternative curves, change `cc` to `cc=2` (`cc2="Marine20.14C"`), `cc=3` (`cc3="SHCal20.14C"`),

cc=4 (cc4="mixed.14C"). You can also provide custom-built calibration curves, indicating its location using ccdir.

The provided example (default core="Example") is core Quilichao-1 which was sampled from a Colombian lake (Berrio et al., 2002). This core was chosen because it was dated at a rather high resolution, and appears to contain a hiatus (e.g., try hiatus=450 for a hiatus at 450 cm depth).

Each clam run will produce a range of files within the core's folder. One, ending with "_calibrated.txt" contains the calibrated age ranges of the 14C and other dates. The others will be named according to the core's name followed by the model type, and contain the age estimates for all depths (files ending with "_ages.txt"), settings (files ending with "_settings.txt") and graphs (files ending with ".pdf" and ".png"). The file containing the age estimates has 5 columns; first the depths, then the minima and maxima of the confidence intervals, then a "best" estimate, and finally the reconstructed accumulation rates. The reported values are rounded to 0 decimals by default (decimals=0). Accumulation rates are in yr/cm ("deposition time") by default (cmyr=FALSE), but can be reported in cm/yr (cmyr=TRUE).

see accompanying webpage http://www.qub.ac.uk/chrono/blaauw/clam.html and Blaauw 2010 (Quaternary Geochronology 5: 512-518).

Value

Age model construction together with a text output and files saved to a folder in the coredir/core directory.

Author(s)

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

Maarten Blaauw

References

Berrio, J.C., Hooghiemstra, H., Marchant, R., Rangel, O., 2002. Late-glacial and Holocene history of the dry forest area in the south Colombian Cauca Valley. _Journal of Quaternary Science_ 17, 667-682

Blaauw, M., 2010. Methods and code for 'classical' age-modelling of radiocarbon sequences. Quaternary Geochronology 5, 512-518 http://dx.doi.org/10.1016/j.quageo.2010.01.002

See Also

http://www.qub.ac.uk/chrono/blaauw/clam.html calibrate mix.calibrationcurves pMC.age age.pMC student.t deptime.depth deptime.age plot_proxies

Examples

```
clam(, coredir=tempdir()) # Create the example in Cores/Example folder
clam(, coredir=tempdir(), extradates=470)
```

copyCalibrationCurve *Copy a calibration curve.*

Description

Copy one of the the calibration curves into memory.

Usage

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

Arguments

cc	Calibration curve for 14C dates: cc=1 for IntCal20 (northern hemisphere terrestrial), cc=2 for Marine20 (marine), cc=3 for SHCal20 (southern hemisphere terrestrial).
postbomb	Use postbomb=TRUE to get a postbomb calibration curve (default postbbomb=FALSE).

Details

Copy the radiocarbon calibration curve defined by cc into memory.

Value

The calibration curve (invisible).

Author(s)

Maarten Blaauw, J. Andres Christen

Examples

```
intcal20 <- copyCalibrationCurve(1)
```

deptime.age *Calculates the slope of a straight curve at the desired age.*

Description

Calculates *for each iteration* the slope of a straight curve between depths above and below the desired age. Requires sufficiently dense density of depths, e.g. steps=1.

Usage

```
deptime.age(age, yrcm = TRUE, prob = 0.95)
```

Arguments

age	Age to calculate deposition time (years per cm).
yrcm	Calculate in years per cm, or alternatively in cm per yr.
prob	Probability level at which to calculate the ranges.

Details

To calculate deposition times at an age. Before doing this, run your core in clam and store the data, so, make sure the option `storedat=TRUE`. Renamed from previous accrate.age function to avoid confusion with accrate.age function of rbacon.

Value

Returns (invisibly) the modelled deposition times at a specific age, a histogram and confidence ranges.

Author(s)

Maarten Blaauw

Examples

```
clam(coredir=tempdir(), storedat=TRUE)
dp <- deptime.age(5000)
summary(dp)
deptime.age(5000, yrcm=FALSE) # to calculate sedimentation times in cm/yr, so accumulation rates
```

---

deptime.depth — *Calculates *for each iteration* the slope of a straight curve between depths just above and below the desired point.*

Description

Calculates *for each iteration* the slope of a straight curve between depths above and below the desired point. Requires sufficiently dense density of depths, e.g. `yrsteps=1`.

Usage

```
deptime.depth(depth, yrcm = TRUE, prob = 0.95)
```

Arguments

depth	The depth for which accumulation rate estimates should be calculated.
yrcm	Calculate in years per cm, or alternatively in cm per yr.
prob	Probability level at which to calculate the ranges.

Details

To calculate sedimentation times at a depth. Before running this, run your core in clam and store the data, so, make sure to set `storedat=TRUE`. Renamed from previous accrate.depth function to avoid confusion with accrate.depth function of rbacon.

Value

Returns (invisibly) the modelled deposition times for a specific depths, a histogram and confidence ranges.

Author(s)

Maarten Blaauw

Examples

```
clam(coredir=tempdir(), storedat=TRUE)
dp <- deptime.depth(20)
summary(dp)
deptime.depth(20, FALSE) # to calculate accumulation rates in cm/yr
```

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

Description

If two curves need to be 'mixed' to calibrate, e.g. for dates of mixed terrestrial and marine carbon sources, then this function can be used.

Usage

```
mix.calibrationcurves(
  proportion = 0.5,
  cc1 = "IntCal20.14C",
  cc2 = "Marine20.14C",
  name = "mixed.14C",
  dirname = ".",
  offset = c(0, 0),
  sep = "\t"
)
```

Arguments

proportion	Proportion of the first calibration curve required. e.g., change to proportion=0.7 if cc1 should contribute 70% (and cc2 30%) to the mixed curve.
cc1	The first calibration curve to be mixed. Defaults to the northern hemisphere terrestrial curve IntCal20.
cc2	The second calibration curve to be mixed. Defaults to the marine curve Marine20.
name	Name of the new calibration curve.
dirname	Directory where the file will be written. If using the default dirname=".", the new curve will be saved in current working directory.
offset	Any offset and error to be applied to cc2 (default 0 +- 0).
sep	Separator between fields (tab by default, "\t")

Details

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

Value

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

Author(s)

Maarten Blaauw, J. Andres Christen

Examples

```
mix.calibrationcurves(dirname=tempdir())
```

---

plot_proxies *Produce a plot of proxy values against calendar age.*

Description

Produce a plot of proxy values against calendar age.

Usage

```
plot_proxies(prox, errors = TRUE, proxcol = grey(0.5), revyr = TRUE)
```

Arguments

prox	Position of the proxy that should be plotted, e.g. 1 for the first proxy in the file.
errors	Plot an error envelope.
proxcol	Colour of the error envelope.
revyr	Direction of the calendar scale (revyr=TRUE will reverse the calendar scale from the default FALSE).

Details

Only works after running clam on the core using `proxies=TRUE`. Requires a file containing the core depths as the first column, and any proxy values on subsequent columns. Values should be separated by comma's. The file should be stored as a .csv file in the core's directory.

Value

A plot of the age model function with proxies.

Author(s)

Maarten Blaauw

Examples

```
clam(coredir=tempdir(), proxies=TRUE)
plot_proxies(3)
plot_proxies(3, revyr=FALSE)
```

---

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

Description

Calculate C14 ages from pmC values of radiocarbon dates.

Usage

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

Arguments

`mn`	Reported mean of the pMC.
`sdev`	Reported error of the pMC.
`ratio`	Most modern-date values are reported against `100`. If it is against `1` instead, use `1` here.
`decimals`	Amount of decimals required for the radiocarbon age.

Details

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

Value

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

Author(s)

Maarten Blaauw, J. Andres Christen

Examples

```
pMC.age(110, 0.5) # a postbomb date, so with a negative 14C age
pMC.age(80, 0.5) # prebomb dates can also be calculated
pMC.age(.8, 0.005, 1) # pMC expressed against 1 (not against 100\%)
```

---

student.t — *Comparison dates calibrated using both the student-t distribution and the the normal distribution.*

Description

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

Usage

```
student.t(
  y = 2450,
  error = 50,
  t.a = 3,
  t.b = 4,
  cc = 1,
  postbomb = NULL,
  cc1 = "IntCal20",
  cc2 = "Marine20",
  cc3 = "SHCal20",
  cc4 = "mixed",
  ccdir = "",
  Cutoff = 1e-05,
  times = 8
)
```

Arguments

y	The reported mean of the date.
error	The reported error of the date.
t.a	Value for the student-t parameter a.
t.b	Value for the student-t parameter b.
cc	calibration curve for C14 dates (1, 2 or 3).
postbomb	Which postbomb curve to use for negative 14C dates
cc1	For northern hemisphere terrestrial C14 dates.
cc2	For marine C14 dates.

cc3	For southern hemisphere C14 dates.
cc4	A custom calibration curve
ccdir	Directory where the calibration curves for C14 dates cc are allocated. By default ccdir="". Use ccdir="." to choose current working directory. Use ccdir="Curves/" to choose sub-folder Curves/.
Cutoff	Threshold above which calibrated probabilities are plotted
times	8 by default.

Details

Radiocarbon and other dates are usually modelled using the normal distribution (red curve). The student-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

```
student.t()
```

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