Package 'rintcal'

May 9, 2026

Type Package

Title Radiocarbon Calibration Curves

Version 1.4.0

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

Description The IntCal20 radiocarbon calibration curves (Reimer et al. 2020 <doi:10.1017/RDC.2020.68>) are provided as a data package, together with previous IntCal curves (IntCal13, IntCal09, IntCal04, IntCal98), other curves (e.g., NOTCal04 [van der Plicht et al. 2004], Arnold & Libby 1951, Stuiver & Suess 1966, Pearson & Stuiver 1986) and postbomb curves. Also provided are functions to copy the curves into memory, and to read, query and plot the data underlying the IntCal20 curves.

License GPL (>= 2)

RoxygenNote 7.3.3

Suggests knitr, rmarkdown, utf8

VignetteBuilder knitr

Encoding UTF-8

NeedsCompilation no

Imports data.table, jsonlite

Language en-GB

Depends R (>= 3.5.0)

LazyData true

Author Maarten Blaauw [aut, cre] (ORCID: <https://orcid.org/0000-0002-5680-1515>), Christopher Bronk Ramsey [ctb] (ORCID: <https://orcid.org/0000-0002-8641-9309>)

Repository CRAN

Date/Publication 2026-03-13 18:00:02 UTC

Contents

`ccurve` *Copy a calibration curve*

Description

Copy one of the calibration curves into memory.

Usage

```
ccurve(
  cc = 1,
  postbomb = FALSE,
  cc.dir = NULL,
  resample = 0,
  glue = FALSE,
  as.F = FALSE,
  as.pMC = FALSE,
  as.Delta = FALSE,
  decimals = 8
)
```

Arguments

`cc`	Calibration curve for 14C dates: `cc=1` for IntCal20 (northern hemisphere terrestrial), `cc=2` for Marine20 (marine), `cc=3` for SHCal20 (southern hemisphere terrestrial). Alternatively, one can also write, e.g., "IntCal20", "Marine13". Historical curves (Arnold & Libby 1951, Stuiver and Suess 1966, Pearson and Stuiver 1986) are also provided. One can also make a custom-built calibration curve, e.g. using `mix.ccurves()`, and load this using `cc=4`. In this case, it is recommended to place the custom calibration curve in its own directory, using `cc.dir` (see below).

postbomb	Use postbomb=TRUE to get a postbomb calibration curve (default postbomb=FALSE). For monthly data, type e.g. ccurve("sh1-2_monthly")
cc.dir	Directory of the calibration curves. Defaults to where the package's files are stored (system.file), but can be set to, e.g., cc.dir="ccurves".
resample	The IntCal curves come at a range of 'bin sizes'; every year from 0 to 5 kcal BP, then every 5 yr until 15 kcal BP, then every 10 yr until 25 kcal BP, and every 20 year thereafter. The curves can be resampled to constant bin sizes, e.g. resample=5. Defaults to FALSE.
glue	If a postbomb curve is requested, it can be 'glued' to the pre-bomb curve. This feature is currently disabled - please use glue.ccurves instead
as.F	Return the F values, calculated from the C14 ages (columns 2 and 3). Defaults to as.F=FALSE.
as.pMC	Return the pMC values, calculated from the C14 ages (columns 2 and 3). Defaults to as.pMC=FALSE.
as.Delta	If loading a curve that contains 2 additional columns containing the D14C values, then these can be returned instead of the curve's C14 ages and errors. Defaults to as.Delta=FALSE.
decimals	Number of decimals to report when as.F=TRUE. Defaults to 8.

Details

Copy the radiocarbon calibration curve defined by cc into memory.

Value

The calibration curve (invisible).

References

Emmenegger, L., Leuenberger, M., Steinbacher, M. 2024. ICOS ATC 14C Release analysed by ICOS CRL from Jungfraujoch (6.0 m), 2015-09-21–2023-10-02, ICOS RI, https://hdl.handle.net/11676/6c_RZ7NHc2dnZv7d84BMY_YY

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

Heaton, T.J., Köhler, P., Butzin, M., Bard, E., Reimer, R., Austin, W., Bronk Ramsey, C., Grootes, P, Hughen, K.A., Kromer, B., Reimer, P.J., Adkins, J., Burke, A., Cook, M., Olsen, J., Skinner, L. 2020. Marine20 - the marine radiocarbon age calibration curve (0–55,000 cal BP), doi:10.1017/RDC.2020.68

Hogg, A.G., Hua, Q., Blackwell, P.G., Mu, N., Buck, C.E., Guilderson, T.P., Heaton, T.J., Palmer, J.G., Reimer, P.J., Reimer, R., Turney, C.S.M., Zimmerman, S.R.H. 2013. SHCal13 Southern Hemisphere Calibration, 0-50,000 Years cal BP. Radiocarbon 55, 1889-1903, doi:10.2458/azu_js_rc.55.16783

Hogg, A., Heaton, T.J., Hua, Q., Palmer, P.J., Turney, C.S.M., Southon, J., Bayliss, A., Blackwell, P., Boswijk, G., Bronk Ramsey, C., Petchey, F., Reimer, P.J., Reimer, R., Wacker, L. 2020. SHCal20 Southern Hemisphere calibration, 0-55,000 years cal BP. Radiocarbon 62, 759-778, doi:10.1017/RDC.2020.59

Hua, Q., Barbetti, M., Rakowski, A.Z. 2013. Atmospheric radiocarbon for the period 1950-2010. Radiocarbon 55(4), doi:10.2458/azu_js_rc.v55i2.16177

Hua, Q., Turnbull, J.C., Santos, G.M., Rakowski, A.Z., Ancapichún, S., De Pol-Holz, R., Hammer, S., Lehman, S.J., Levin, I., Miller, J.B., Palmer, J.G., Turney, C.S.M. 2022. Atmospheric radiocarbon for the period 1950-2019. Radiocarbon 64(4), 723-745, doi:10.1017/RDC.2021.95

Levin, I., Kromer, B. 2004. The tropospheric 14CO2 level in mid latitudes of the Northern Hemisphere. Radiocarbon 46, 1261-1272, doi:10.1017/S0033822200033130

Pearson, G.W., Stuiver, M., 1986. High-precision calibration of the radiocarbon time scale, 500–2500 BC. Radiocarbon 28, 839–862, doi:10.1017/S0033822200060173

Reimer, P.J., Baillie, M.G., Bard, E., Bayliss, A., Beck, J.W., Bertrand, C.J., Blackwell, P.G., Buck, C.E., Burr, G.S., Cutler, K.B., Damon, P.E., Edwards, R.L., Fairbanks, R.G., Friedrich, M., Guilderson, T.P., Hogg, A.G., Hughen, K.A., Kromer, B., McCormac, G., Manning, S.W., Ramsey, C.B., Reimer, R.W., Remmele, S., Southon, J.R., Stuiver, M., Talamo, S., Taylor, F.W., Plicht, J.V., Weyhenmeyer, C.E. 2004. Intcal04 terrestrial radiocarbon age calibration, 0–26 cal Kyr BP. Radiocarbon 46, 1029-1058, doi:10.1017/S0033822200032999

Reimer, P.J., Baillie, M.G., Bard, E., Bayliss, A., Beck, J., Blackwell, P.G., Bronk, C., Ramsey, Buck, C.E., Burr, G.S., Edwards, R., Friedrich, M., Grootes, P., T., P., Guilderson, Hajdas, I., Heaton, T.J., Hogg, A.G., Hughen, K.A., Kaiser, K.F., B., Kromer, McCormac, F.G., Manning, S.W., Reimer, R.W., Richards, D.A., Southon, J., S., Talamo, Turney, C., Plicht, J.V., Weyhenmeyer, C.E. 2009. IntCal09 and Marine09 radiocarbon age calibration curves, 0-50,000 years cal BP. Radiocarbon 51, 1111-1150, doi:10.1017/S0033822200034202

Reimer, P.J., Bard, E., Bayliss, A., Beck, J.W., Blackwell, P.G., Ramsey, C.B., Buck, C.E., Cheng, H., Edwards, R.L., Friedrich, M., Grootes, P.M., Guilderson, T.P., Haflidason, H., Hajdas, I., Hatté, C., Heaton, T.J., Hoffmann, D.L., Hogg, A.G., Hughen, K.A., Kaiser, K., Kromer, B., Manning, S.W., Niu, M., Reimer, R.W., Richards, D.A., Scott, E.M., Southon, J.R., Staff, R.A., Turney, C.S., van der Plicht, J. 2013. IntCal13 and Marine13 radiocarbon age calibration curves 0-50,000 years cal BP. Radiocarbon 55, 1869-1887, doi:10.2458/azu_js_rc.55.16947

Reimer, P.J., Austin, W.E., Bard, E., Bayliss, A., Blackwell, P.G., Bronk Ramsey, C., Butzin, M., Cheng, H., Edwards, R.L., Friedrich, M., Grootes, P.M., Guilderson, T.P., Hajdas, I., Heaton, T.J., Hogg, A.G., Hughen, K.A., Kromer, B., Manning, S.W., Muscheler, R., Palmer, J.G., Pearson, C.L., van der Plicht, J., Reimer, R.W., Richards, D.A., Scott, E.M., Southon, J.R., Turney, C.S., Wacker, L., Adolphi, F., Büntgen, U., Capano, M., Fahrni, S.M., Fogtmann-Schulz, A., Friedrich, R., Köhler, P., Kudsk, S.G., Miyake, F., Olsen, J., Reinig, F., Sakamoto, M., Sookdeo, A., Talamo, S. 2020. The IntCal20 northern hemisphere radiocarbon age calibration curve (0–55 cal kBP). Radiocarbon 62, 725-757, doi:10.1017/RDC.2020.41

Stuiver, M., Reimer, P.J., Bard, E., Beck, J.W., Burr, G.S., Hughen, K.A., Kromer, B., McCormac, G., Plicht, J.V., Spurk, M. 1998. INTCAL98 radiocarbon age calibration, 24,000–0 cal BP. Radiocarbon 40, 1041-1083, doi:10.1017/S0033822200019123

Stuiver, Suess, H., 1966. On the relationship between radiocarbon dates and true samples ages. Radiocarbon 8, 534-540, doi:10.1017/S0033822200000345

van der Plicht, J., Beck, J.W., Bard, E., Baillie, M.G.L., Blackwell, P.G., Buck, C.E., Friedrich, M., Guilderson, T.P., Hughen, K.A., Kromer, B., McCormac, F.G., Bronk Ramsey, C., Reimer, P.J., Reimer, R., Remmele, S., Richards, D.A., Southon, J.R., Stuiver, M., Weyhenmeyer, C.E., 2004. NotCal04—comparison/calibration 14C records 26–50 cal Kyr BP. Radiocarbon 46, 1225-1238, doi:10.1017/S0033822200033117

Examples

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

`copyCalibrationCurve` *Copy a calibration curve*

Description

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

Usage

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

Arguments

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

Details

Copy the radiocarbon calibration curve defined by cc into memory.

Value

The calibration curve (invisible).

`glue.ccurves` *Glue calibration curves*

Description

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

Usage

```
glue.ccurves(
  prebomb = "IntCal20",
  postbomb = "NH1",
  thisprebombcurve = c(),
  thispostbombcurve = c(),
  as.F = FALSE,
  as.pMC = FALSE,
  as.Delta = FALSE,
  cc.dir = c(),
  decimals = 8
)
```

Arguments

prebomb	The prebomb curve. Defaults to "IntCal20"
postbomb	The postbomb curve. Defaults to "NH1" (Hua et al. 2013)
thisprebombcurve	As an alternative to using existing curves, a tailor-made curve can be provided for the prebomb curve (as three columns: cal BP, C14 age, error)
thispostbombcurve	As an alternative to using existing curves, a tailor-made curve can be provided for the postbomb curve (as three columns: cal BP, C14 age, error)
as.F	The glued curve can be returned as F14C values instead of the default C14. Make sure that if as.F=TRUE and you are using thisprebombcurve and/or thispostbombcurve, that these curves are in F14C space already.
as.pMC	The curves can be returned as pMC values instead of the default C14. Make sure that if as.pMC=TRUE and you are using thiscurve1 and/or thiscurve2, that these curves are in pMC space already.
as.Delta	The curves can be returned as D14C values instead of the default C14. Make sure that if as.Delta=TRUE and you are using thiscurve1 and/or thiscurve2, that these curves are in Delta14C space already.
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"`.
decimals	Number of decimals to report when as.F=TRUE. Defaults to 5.

Value

The custom-made curve (invisibly)

Examples

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

intcal *IntCal20 json file*

Description

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

Usage

```
intcal
```

Format

'intcal' A list with six main entries:

json_application IntChron project name

records a list with 139 entries for each IntCal dataset

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

parameters an empty list

bibliography a list with 141 bibliography entries

options a list of 17 options (not used)

Source

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

intcal.data *plot the IntCal20 data*

Description

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

Usage

```
intcal.data(
  cal1,
  cal2,
  cc1 = "IntCal20",
  cc2 = NA,
  calcurve.data = "IntCal20",
  select.sets = c(),
```

```
  timescale = "C14",
  BCAD = FALSE,
  cal.lab = NA,
  cal.rev = FALSE,
  c14.lab = NA,
  c14.lim = NA,
  c14.rev = FALSE,
  ka = FALSE,
  cc1.col = rgb(0, 0, 1, 0.5),
  cc1.fill = rgb(0, 0, 1, 0.2),
  cc2.col = rgb(0, 0.5, 0, 0.5),
  cc2.fill = rgb(0, 0.5, 0, 0.2),
  data.cols = c(),
  data.pch = c(1, 2, 5, 6, 15:19),
  pch.cex = 0.5,
  legend.loc = "topleft",
  legend.ncol = 2,
  legend.cex = 0.7,
  cc.legend = "bottomright",
  bty = "l",
  ...
)
```

Arguments

cal1	First calendar year for the plot
cal2	Last calendar year for the plot
cc1	Name of the calibration curve. Can be "IntCal20", "Marine20", "SHCal20", or for the previous curves "IntCal13", "Marine13" or "SHCal13".
cc2	Optional second calibration curve to plot. Can be "IntCal20", "Marine20", "SHCal20", or for the previous curves "IntCal13", "Marine13" or "SHCal13". Defaults to nothing, NA.
calcurve.data	Which dataset to use. Defaults to calcurve.data="IntCal20", but can also be calcurve.data="SHCal20". Note that Marine20 is based on IntCal20 and a marine carbon cycle model.
select.sets	Which datasets to plot. Defaults to all datasets within the selected period.
timescale	Which 'timescale' of radiocarbon to use. Defaults to timescale="C14" but can also be set to timescale="F14C", timescale="pMC" or timescale="D14C". Can be shorted to, respectively, "C", "F", "P" or "D" (or their lower-case equivalents).
BCAD	The calendar scale of graphs and age output-files is in cal BP (calendar or calibrated years before the present, where the present is AD 1950) by default, but can be changed to BC/AD using BCAD=TRUE.
cal.lab	The labels for the calendar axis (default age.lab="cal BP" or "BC/AD" if BCAD=TRUE), or to age.lab="kcal BP" etc. if ka=TRUE.
cal.rev	Reverse the calendar axis.

c14.lab	Label for the C-14 axis. Defaults to 14C BP (or 14C kBP if ka=TRUE).
c14.lim	Axis limits for the C-14 axis. Calculated automatically by default.
c14.rev	Reverse the C-14 axis.
ka	Use kcal BP (and C14 kBP).
cc1.col	Colour of the calibration curve (outline).
cc1.fill	Colour of the calibration curve (fill).
cc2.col	Colour of the calibration curve (outline), if activated (default cc2=NA).
cc2.fill	Colour of the calibration curve (fill), if activated (default cc2=NA).
data.cols	colours of the data points. Defaults to R's colours 1 to 8 (black, red, green, darkblue, lightblue, purple, orange, and grey)
data.pch	Symbols of the data points. Defaults to R's symbols 1, 2, 5, 6, and 15 to 19 (open circle, open upward triangle, open diamond, open downward triangle, closed square, closed circle, closed upward triangle, closed diamond)
pch.cex	Size of the data symbols. Defaults to 0.5.
legend.loc	Location of the data legend. Defaults to topleft. Set to NA for no plotting.
legend.ncol	Number of columns of the data legend.
legend.cex	Size of the legend. Defaults to 0.7.
cc.legend	Location of the legend for the calibration curve(s).
bty	Box type around the plot. Defaults to "l"-shaped.
...	Any additional optional plotting parameters.

Details

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

Value

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

References

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

[2] Stuiver, M., Reimer, P.J., Braziunas, T.F. 1998. High-precision radiocarbon age calibration for terrestrial and marine samples. Radiocarbon 40, 1127-1151.

[3] McCormac, F.G., Bayliss, A., Baillie, M.G.L., Brown, D.M. 2004. Radiocarbon calibration in the Anglo-Saxon period: AD 495-725. Radiocarbon 46, 1123-5.

[4] McCormac, F.G., Hogg, A.G., Higham, T.F.G., Lynch-Stieglitz, J., Broecker, W.S., Baillie, M.G.L., Palmer, J., Xiong, L., Pilcher, J.R., Brown, D., Hoper, S.T., 1998. Temporal variation in the interhemispheric C-14 offset. Geophysical Research Letters 25, 1321-1324.

[5] Pearson, G.W., Pilcher, J.R., Baillie, M.G.L., Corbett, D.M., Qua, F. 1986. High-precision C-14 measurement of Irish Oaks to show the natural C-14 variations from AD 1840 to 5210 BC. Radiocarbon 28, 911-934.

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

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

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

[9] de Jong, A.F.M., Becker, B., Mook, W.G. 1989. Corrected calibration of the radiocarbon time scale. Radiocarbon 31, 201-210.

[10] Kuitems, M., van der Plicht, J., Jansma, E., 2020. Wood from the Netherlands around the time of the Santorini eruption dated by dendrochronology and radiocarbon. Radiocarbon 62, 963-967, doi:10.1017/RDC.2020.23

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

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

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

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

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

[16] Vogel, J.C., and van der Plicht, J. 1993. Calibration curve for short-lived samples, 1900-3900 BC. Radiocarbon 35, 87-91.

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

[18] Hogg, A., Southon, J., Turney, C., Palmer, J., Ramsey, C.B., Fenwick, P., Boswijk, G., Buentgen, U., Friedrich, M., Helle, G. 2016. Decadally resolved lateglacial radiocarbon evidence from New Zealand kauri. Radiocarbon 58, 709-733.

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

[20] Fahrni, S.M. Southon, J., Fuller, B.T., Park, J., Friedrich, M., Muscheler, R., Wacker, L., Taylor, R.E. 2020. Single-year German oak and Californian bristlecone pine 14C data at the beginning of the Hallstatt plateau from 856 BC to 626 BC; Radiocarbon 62, 919-937. doi:10.1017/RDC.2020.16

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

[22] Friedrich, R., Kromer, B., Wacker, L., Olsen, J., Remmele, S., Lindauer, S., Land, A., Pearson, C. 2020. A new annual 14C dataset for calibrating the Thera eruption. Radiocarbon 62, 953-961. doi:10.1017/RDC.2020.33

[23] Sookdeo, A., Kromer, B., Buentgen, U., Friedrich, M., Friedrich, R., Helle, G., Pauly, M., Nievergelt, D., Reinig, F., Treydte, K., Synal, H.A., Wacker, L. 2020. Quality dating: A well-defined protocol implemented at ETH for high-precision 14C dates tested on Late Glacial wood. Radiocarbon 62, 891-899. doi:10.1017/RDC.2019.132

[24] Friedrich, R., Kromer, B., Sirocko, F., Esper, J., Lindauer, S., Nievergelt, D., Heussner, K., Westphal, T. 2019. Annual 14C tree-ring data around 400AD: mid and high-latitude records. Radiocarbon 61, 1305-1316. doi:10.1017/RDC.2019.34

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

[26] Capano, M., Miramont, C., Guibal, F., Kromer, B., Tuna, T., Fagault, Y., Bard, E. 2018. Wood 14C dating with AixMICADAS: Methods and application to tree-ring sequences from the Younger Dryas event in the Southern French Alps. Radiocarbon 60, 51-74.

[27] Capano, M., Miramont, C., Shindo, L., Guibal, F., Marschal, C., Kromer, B., Tuna, T., Bard, E. 2020. Onset of the Younger Dryas recorded with 14C at annual resolution in French subfossil trees. Radiocarbon 62, 901-918.

[28] Fogtmann-Schulz, A., Kudsk, S.G.K., Trant, P.L.K., Baittinger, C., Karoff, C., Olsen, J., Knudsen, M.F. 2019. Variations in solar activity across the Spoerer Minimum based on radiocarbon in Danish Oak. Geophysical Research Letters 46, 8617-8623.

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

[30] Kudsk, S., Philippsen, B. Baittinger, C., Fogtmann-Schulz, A., Knudsen, M., Karoff, C. Olsen, J. 2020. New single-year radiocarbon measurements based on Danish oak covering the periods AD 692-790 and 966-1057 AD. Radiocarbon 62, 969-987. doi:10.1017/RDC.2019.107

[31] Manning, S.W., Kromer, B. 2012. Considerations of the scale of radiocarbon offsets in the East Mediterranean, and considering a case for the latest (most recent) likely date for the Santorini Eruption. Radiocarbon 54, 449-474.

[32] Manning, S.W., Griggs, C., Lorentzen, B., Bronk Ramsey, C., Chivall, D., Jull, A.J.T., Lange, T.E. 2018. Fluctuating radiocarbon offsets observed in the Southern Levant and implications for archaeological chronology debates. Proceedings of the National Academy of Sciences of the United States of America 115, 6141-6146.

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

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

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

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

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

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

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

[40] Jull, A.T., Panyushkina, I., Miyake, F., Masuda, K., Nakamura, T., Mitsutani, T., Lange, T.E., Cruz, R.J., Baisan, C., Janovics, R. 2018. More rapid 14C excursions in the tree-ring record: a record of different kind of solar activity at about 800 BC? Radiocarbon 60, 1237-1248.

[41] Miyake F., Jull A.J.T., Panyushkina I.P., Wacker L., Salzer M., Baisan C., Lange T., Cruz R., Masuda K., Nakamura T. 2017. Large 14C excursion in 5480 BC indicates an abnormal sun in the mid-Holocene. Proceedings of the National Academy of Sciences 114, 881-884. doi:10.1073/pnas.161314411

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

[43] Pearson, C.L., Wacker, L., Bayliss, A., Brown, D.M., Salzer, M., Brewer, P.W., Bollhalder, S., Boswijk, G., Hodgins, G.W.L. 2020. Annual variation in atmospheric 14C between 1700 BC and 1480 BC. Radiocarbon 62, 939-952. doi:10.1017/RDC.2020.14

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

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

[46] Wacker et al. in prep

[47] Sookdeo, A., Kromer, B., Adolphi, F., Beer, J., Brehm, N., Buntgen, U., Christl, M., Eglinton, T.I., Friedrich, M., Guidobaldi, G., Helle, G., Nievergelt, D., Pauly, M., Reinig, F., Tegel, W.,

Treydte, K., Synal, H.-A., Wacker, L., submitted. There Goes the Sun: 14C in trees reveals reduced solar activity during the Younger Dryas. Nature Geoscience.

[48] Büntgen, U., Wacker, L., Galván, J.D., Arnold, S., Arseneault, D., Baillie, M.G., Beer, J., Bernabei, M., Bleicher, N., Boswijk, G., Bräuning, A., Carrer, M., Ljungqvist, F.C., Ljungqvist, F.C., Cherubini, P., Christl, M., Christie, D.A., Clark, P.W., Cook, E.R., D'Arrigo, R., Davi, N., Davi, N., Eggertsson, Ó., Esper, J., Fowler, A.M., Gedalof, Z., Gennaretti, F., Grießinger, J., Grissino-Mayer, H.D., Grudd, H., Gunnarson, B.E., Hantemirov, R.M., Herzig, F., Hessl, A.E., Heussner, K.U., Jull, A.J., Kukarskih, V.V., Kirdyanov, A.V., Kirdyanov, A.V., Kirdyanov, A.V., Kolář, T., Krusic, P.J., Krusic, P.J., Kyncl, T., Lara, A., LeQuesne, C., Linderholm, H.W., Loader, N.J., Luckman, B.H., Miyake, F., Myglan, V.S., Nicolussi, K., Oppenheimer, C., Palmer, J.G., Panyushkina, I.P., Pederson, N., Rybníček, M., Schweingruber, F.H., Seim, A., Sigl, M., Churakova, O.V., Churakova, O.V., Speer, J.H., Synal, H., Tegel, W., Treydte, K., Villalba, R., Wiles, G.C., Wilson, R., Wilson, R., Winship, L.J., Wunder, J., Yang, B., Young, G.H. 2018. Tree rings reveal globally coherent signature of cosmogenic radiocarbon events in 774 and 993 CE. Nature Communications, 9.

[49] Bayliss et al. in prep

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

[51] Turney, C.S., Palmer, J., Ramsey, C.B., Adolphi, F., Muscheler, R., Hughen, K.A., Staff, R.A., Jones, R.T., Thomas, Z.A., Fogwill, C.J. 2016. High-precision dating and correlation of ice, marine and terrestrial sequences spanning Heinrich Event 3: Testing mechanisms of interhemispheric change using New Zealand ancient kauri (Agathis australis). Quaternary Science Reviews 137, 126-134.

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

[53] Bronk Ramsey, C., Staff, R.A., Bryant, C.L., Brock, F., Kitagawa, H., van der Plicht, J., Schlolaut, G., Marshall, M.H., Brauer, A., Lamb, H.F., Payne, R.L., Tarasov, P.E., Haraguchi, T., Gotanda, K., Yonenobu, H., Yokoyama, Y., Tada, R., Nakagawa, T., 2012. A complete terrestrial radiocarbon record for 11.2 to 52.8 kyr BP. Science 338, 370-374.

[54] Schlolaut, G., Staff, R.A., Marshall, M.H., Brauer, A., Bronk Ramsey, C., Lamb, H.F., Nakagawa, T. 2018. An extended and revised Lake Suigetsu varve chronology from ~50 to ~10 ka BP based on detailed sediment micro-facies analyses. Quaternary Science Reviews 200, 351-366.

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

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

[57] Fairbanks, R.G., Mortlock, R.A., Chiu, T.C., Cao, L., Kaplan, A., Guilderson, T.P., Fairbanks, T.W., Bloom, A.L., Grootes, P.M., Nadeau, M.J. 2005. Radiocarbon calibration curve spanning 0 to 50,000 years BP based on paired Th-230/U-234/U-238 and C-14 dates on pristine corals. Quaternary Science Reviews 24, 1781-96.

[58] Cutler, K.B., Gray, S.C., Burr, G.S., Edwards, R.L., Taylor, F.W., Cabioch, G., Beck, J.W., Cheng, H., and Moore, J. 2004. Radiocarbon calibration to 50 kyr BP with paired 14C and 230Th dating of corals from Vanuatu and Papua New Guinea. Radiocarbon 46, 1127-1160.

[59] Hughen, K.A., Southon, J.R., Lehman, S.J., Overpeck, J.T. 2000. Synchronous radiocarbon and climate shifts during the last deglaciation. Science 290, 1951-1954.

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

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

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

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

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

[65] Bard, E., Ménot, G., Rostek, F., Licari, L., Böning, P., Edwards, R.L., Cheng, H., Wang, Y., & Heaton, T.J. 2009. Radiocarbon calibration/comparison records based on marine sediments from the Pakistan and Iberian Margins. Radiocarbon 55, 1999-2019.

[66] Southon, J., Noronha, A.L., Cheng, H., Edwards, R.L., Wang, Y.J. 2012. A high-resolution record of atmospheric C-14 based on Hulu Cave speleothem H82. Quaternary Science Reviews 33, 32-41.

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

[68] Hoffmann, D., Beck, J.W., Richards, D., Smart, P., Singarayer, J.S., Ketchmark, T., & Hawkesworth, C.J. 2010. Towards radiocarbon calibration beyond 28 ka using speleothems from the Bahamas. Earth and Planetary Science Letters, 289, 1-10.

[69] Beck, J.W., Richards, D.A., Lawrence, R.D., Edwards, Silverman, B.W., Smart, P.L., Donahue, D.J., Hererra-Osterheld, S., Burr, G.S., Calsoyas, L., Timothy, A., Jull, & Biddulph, D. 2001. Extremely large variations of atmospheric 14C concentration during the Last Glacial Period. Science 292, 2453-2458.

[70] Vogel, J.C., Fuls, A., Visser, E., Becker, B. 1993. Pretoria calibration curve for short-lived samples, 1930–3350 BC. Radiocarbon 35, 73-85.

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

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

[73] McCormac, F.G., Hogg, A.G., Higham, T.F.G., Lynch-Stieglitz, J., Broecker, W.S., Baillie, M.G.L., Palmer, J., Xiong, L., Pilcher, J.R., Brown, D., Hoper, S.T. 1998. Temporal variation in the interhemispheric C-14 offset. Geophysical Research Letters 25, 1321-1324.

[74] Hogg, A.G., Palmer, J.G., Boswijk, G., Turney, C.S. 2011. High-precision radiocarbon measurements of tree-ring dated wood from New Zealand: 195 BC-AD 995. Radiocarbon 53, 529-542.

[75] Hogg, A., Turney, C., Palmer, J., Cook, E., Buckley, B. 2013 Is there any evidence for regional 14C offsets in the Southern Hemisphere? Radiocarbon 55, 2029-2034. doi:10.2458/azu_js_rc.v55i2.16104

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

[77] McCormac, F.G., Hogg, A.G., Higham, T.F.G., Lynch-Stieglitz, J., Broecker, W.S., Baillie, M.G.L., Palmer, J., Xiong, L., Pilcher, J.R., Brown, D., Hoper, S.T. 1998. Temporal variation in the interhemispheric C-14 offset. Geophysical Research Letters 25, 1321-1324.

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

[79] Hua, Q., Barbetti, M., Zoppi, U., Fink, D., Watanasak, M., Jacobsen, G. 2004. Radiocarbon in tropical tree rings during the Little Ice Age. Nuclear Instruments and Methods in Physics Research B 223-224, 489-494.

[80] Hogg, A.G., Hua, Q., Blackwell, P.G., Niu, M., Buck, C.E., Guilderson, T.P., Heaton, T.J., Palmer, J.G., Reimer, P.J., Reimer, R.W., Turney, C.S., Zimmerman, S.R. 2013. SHCal13 Southern Hemisphere calibration, 0–50,000 years cal BP. Radiocarbon 55, 1889-1903.

[81] Zimmerman, S.R., Guilderson, T.P., Buckley, B.M., Cook, E.E. 2010. Extension of the Southern Hemisphere atmospheric radiocarbon curve, 2120-850 years BP: results from Tasmanian Huon Pine. Radiocarbon 52, 203: 887-94.

[82] Büntgen, U., Wacker, L., Galván, J.D., Arnold, S., Arseneault, D., Baillie, M.G., Beer, J., Bernabei, M., Bleicher, N., Boswijk, G., Bräuning, A., Carrer, M., Ljungqvist, F.C., Ljungqvist, F.C., Cherubini, P., Christl, M., Christie, D.A., Clark, P.W., Cook, E.R., D'Arrigo, R., Davi, N., Davi, N., Eggertsson, Ó., Esper, J., Fowler, A.M., Gedalof, Z., Gennaretti, F., Grießinger, J., Grissino-Mayer, H.D., Grudd, H., Gunnarson, B.E., Hantemirov, R.M., Herzig, F., Hessl, A.E., Heussner, K.U., Jull, A.J., Kukarskih, V.V., Kirdyanov, A.V., Kirdyanov, A.V., Kirdyanov, A.V., Kolář, T., Krusic, P.J., Krusic, P.J., Kyncl, T., Lara, A., LeQuesne, C., Linderholm, H.W., Loader, N.J., Luckman, B.H., Miyake, F., Myglan, V.S., Nicolussi, K., Oppenheimer, C., Palmer, J.G., Panyushkina, I.P., Pederson, N., Rybníček, M., Schweingruber, F.H., Seim, A., Sigl, M., Churakova, O.V., Churakova, O.V., Speer, J.H., Synal, H., Tegel, W., Treydte, K., Villalba, R., Wiles, G.C., Wilson, R., Wilson, R., Winship, L.J., Wunder, J., Yang, B., Young, G.H. 2018. Tree rings reveal globally coherent signature of cosmogenic radiocarbon events in 774 and 993 CE. Nature Communications 9, 3605. doi:10.1038/s41467-018-06036-0.

[83] Sookdeo, A., Kromer, B., Büntgen, U., Friedrich, M., Friedrich, R., Helle, G., Pauly, M., Nievergelt, D., Reinig, F., Treydte, K., Synal, H., & Wacker, L. 2020. Quality Dating: A well-defined protocol implemented at ETH Zurich for high-precision 14C dates tested on Late Glacial wood. Radiocarbon 62, 891-899. doi:10.1017/RDC.2019.132

Examples

```
intcal.data(100, 200)
intcal.data(40e3, 55e3, ka=TRUE)
# plot Suigetsu and Cariaco data only
```

```
dat <- intcal.data(20e3, 25e3)
unique(dat$set) # ordered against their appearance in the plot's legend
dat <- intcal.data(20e3, 25e3, select.sets=c(109, 120), data.cols=c(1,2))
```

---

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

Description

Extract items from the intcal json file.

Usage

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

Arguments

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

Examples

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

---

intcal.extract.record *Extract an IntCal20 record*

Description

Extract one of the 140 records contributing to the IntCal20 calibration curves

Usage

```
intcal.extract.record(i)
```

Arguments

i	The IntCal record, in the order as they appear in the IntCal20 json file (140 entries). Must be a single integer between 1 and 140.

Value

The most relevant information for each record (where available, the record and site names, intcal series and division number, country, longitude, latitude, taxon, dois of publications, notes, calendar information (e.g., dendrochronology) and radiocarbon data)

Examples

```
record_1 <- intcal.extract.record(1)
```

`intcal.plot.record` *Plot an IntCal20 record*

Description

Plot the calendar and radiocarbon data of an IntCal20 record

Usage

```
intcal.plot.record(
  i,
  col = rgb(0, 0, 1, 0.5),
  pch = 19,
  pch.cex = 0.3,
  lwd = 1,
  lty = 1,
  cal.lim = c(),
  C14.lim = c(),
  add = FALSE,
  cal.lab = c(),
  C14.lab = c(),
  ka = FALSE,
  as.F = FALSE,
  as.pMC = FALSE,
  as.Delta = FALSE,
  draw.z = TRUE,
  draw.calsigma = TRUE,
  grid = FALSE,
  grid.lty = 2,
  grid.col = rgb(0, 0, 0, 0.5),
  draw.cc = 1,
  cc.col = rgb(0, 0.5, 0, 0.5),
  legend.loc = "topleft",
  legend.cex = 0.5,
  mgp = c(2.5, 0.8, 0)
)
```

Arguments

i	The IntCal record, in the order as they appear in the IntCal20 json file (140 entries). Must be a single integer between 1 and 140.
col	Colour of the symbols. Defaults to semi-transparent blue, col=rgb(0,0,1,.5).
pch	Symbol of the dates. Defaults to a filled circle, pch=20.
pch.cex	Size of the symbol. Defaults to 0.3.
lwd	Line width of the error bars. Defaults to 1.
lty	Line type of the error bars. Defaults to continuous, 1.
cal.lim	Limits of the horizontal/calendar scale. Calculated automatically by default.
C14.lim	Limits of the C-14 scale. Calculated automatically by default
add	Make a new plot (default, add=FALSE). The alternative is to add to an existing plot.
cal.lab	Label of the calendar axis. Defaults to 'cal BP' or 'kcal BP'.
C14.lab	Label of the C-14 axis. Defaults to '14C BP' or '14C kBP'
ka	Whether or not to use ka (thousands of years). Defaults to FALSE (i.e., cal BP).
as.F	Return the F values, calculated from the C14 ages (columns 2 and 3). Defaults to as.F=FALSE.
as.pMC	Return the pMC values, calculated from the C14 ages (columns 2 and 3). Defaults to as.pMC=FALSE.
as.Delta	Return the Delta14C values, calculated from the C14 ages (columns 2 and 3). Defaults to as.Delta=FALSE.
draw.z	Whether or not to plot the spread in calendar years of blocks of (mostly) tree rings. This is for tree-ring datasets where individual dates were taken on blocks of rings covering e.g. 10 or 20 years.
draw.calsigma	Whether or not to plot the calendar age uncertainties where available.
grid	Whether or not to add a grid to the plot.
grid.lty	Line type of the grid.
grid.col	Colour of the grid.
draw.cc	Whether or not to also plot the calibration curve. Defaults to plotting the IntCal20 calibration curve, but can also be set to 2 (Marine20), 3 (SHCal20), or NA (none).
cc.col	Colour of the calibration curve. Defaults to semi-transparent darkgreen, cc.col=rgb(0,.5,0,.5).
legend.loc	Location of the legend. Defaults to top right. Set to NA if you don't want to plot the legend.
legend.cex	Relative size of the font of the legend. Defaults to 0.5.
mgp	White space around the plot. Defaults to giving a bit more than usual white space around the axis labels.

Value

A plot of the calendar and radiocarbon ages, indicating uncertainties (error bars) and age blocks where relevant (e.g., for trees where blocks of >1 rings were dated).

See Also

intcal.extract.record

Examples

```
record_1 <- intcal.plot.record(1)
record_10 <- intcal.plot.record(10, add=TRUE, col=rgb(1,0,0,.5), legend.loc="bottomright")
```

---

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

Description

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

Usage

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

Arguments

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

Details

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

Examples

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

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

Description

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

Usage

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

Arguments

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

Examples

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

list.ccurves *List the calibration curves*

Description

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

Usage

```
list.ccurves()
```

Value

A list of the available calibration curves

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

Description

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

Usage

```
mix.ccurves(
  proportion = 0.5,
  cc1 = "IntCal20",
  cc2 = "Marine20",
  postbomb1 = FALSE,
  postbomb2 = FALSE,
  as.F = FALSE,
  as.pMC = FALSE,
  name = "mixed.14C",
  cc.dir = c(),
  thiscurve1 = c(),
  thiscurve2 = c(),
  save = FALSE,
  offset = cbind(0, 0),
  round = c(),
  sep = " ",
  decimals = 8
)
```

Arguments

`proportion`	Proportion of the first calibration curve required. e.g., change to `proportion=0.7` if `cc1` should contribute 70% (and `cc2` 30%) to the mixed curve.
`cc1`	The first calibration curve to be mixed. Defaults to the northern hemisphere terrestrial curve IntCal20.
`cc2`	The second calibration curve to be mixed. Defaults to the marine curve IntCal20.
`postbomb1`	Option to provide a postbomb curve for the first curve (defaults to FALSE).
`postbomb2`	Option to provide a postbomb curve for the second curve (defaults to FALSE).
`as.F`	The curves can be returned as F14C values instead of the default C14. Make sure that if as.F=TRUE and you are using thiscurve1 and/or thiscurve2, that these curves are in F14C space already.

as.pMC	The curves can be returned as pMC values instead of the default C14. Make sure that if as.pMC=TRUE and you are using thiscurve1 and/or thiscurve2, that these curves are in pMC space already.
name	Name of the new calibration curve.
cc.dir	Name of the directory where to save the file. Since R does not allow automatic saving of files, this points to a temporary directory by default. Adapt to your own folder, e.g., `cc.dir="~/ccurves"` or in your current working directory, `cc.dir="."`.
thiscurve1	As an alternative to using curves that come with the package, a tailor-made curve can be provided for the first curve (as three columns: cal BP, C14 age, error).
thiscurve2	As an alternative to using curves that come with the package, a tailor-made curve can be provided for the second curve (as three columns: cal BP, C14 age, error).
save	Save the curve in the folder specified by dir. Defaults to FALSE.
offset	Any offset and error to be applied to cc2 (default 0 +- 0). Entered as two columns (possibly of just one row), e.g. `offset=cbind(100,0)`
round	The entries can be rounded to a specified amount of decimals. Defaults to no rounding.
sep	Separator between fields (tab by default, "\t")
decimals	Number of decimals to report when as.F=TRUE. Defaults to 8.

Details

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

Value

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

Examples

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

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

Description

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

Usage

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

Arguments

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

Details

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

Value

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

Examples

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

Index