

Package ‘seasonalclumped’

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Title Toolbox for Clumped Isotope Seasonality Reconstructions

Version 0.3.2

Description

Compiles a set of functions and dummy data that simplify reconstructions of seasonal temperature variability in the geological past from stable isotope and clumped isotope records in sub-annually resolved carbonate archives (e.g. mollusk shells, corals and speleothems). For more information, see de Winter et al., 2020 (Climate of the Past Discussions, <[doi:10.5194/cp-2020-118](https://doi.org/10.5194/cp-2020-118)>).

Imports ggplot2, gridExtra, TTR, magrittr

License GPL-3

URL <https://github.com/nielsjdewinter/seasonalclumped>

BugReports <https://github.com/nielsjdewinter/seasonalclumped/issues>

Encoding UTF-8

LazyData true

RoxygenNote 7.1.1

Depends R (>= 3.5.0)

Suggests knitr, rmarkdown

NeedsCompilation no

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binning_seasonality	<i>Function for monthly binning based clumped isotope seasonality reconstruction.</i>
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Description

Combines records of stable oxygen isotope ratios ($\delta^{18}O_c$) and clumped isotope ratios (Δ_{47}) through subannually resolved carbonate archives (e.g. mollusk shells or corals) to reconstruct monthly variability in temperature and salinity (through the $\delta^{18}O$ composition of the precipitation fluid), using the monthly binning method detailed in de Winter et al., 2020 (Climate of the Past).

Usage

```
binning_seasonality(
  d180c,
  D47,
  ages,
  SD_d180c = 0.1,
  SD_D47 = 0.04,
  N = 1000,
  binsize = "month",
  d180_fun = "KimONeil97",
  D47_fun = "Bernasconi18",
  export = FALSE
)
```

Arguments

d180c	Vector containing subannually resolved $\delta^{18}O_c$ data
D47	Vector containing subannually resolved Δ_{47} data
ages	Vector containing ages for of all samples in years relative to the shell chronology
SD_d180c	Error on the $\delta^{18}O_c$ measurements. Either a single value (constant uncertainty) or a vector of length equal to the period in SST data (365 days by default) containing information about the error of each datapoint (1 standard deviation; default = 0.1 permille).
SD_D47	Error on the Δ_{47} measurements. Either a single value (constant uncertainty) or a vector of length equal to the period in SST data (365 days by default) containing information about the error of each datapoint (1 standard deviation; default = 0.04 permille).
N	Number of datapoints for Monte Carlo simulation (defaults to 1000)
binsize	Size of the bins in which records are subdivided. month and season (period of three months) is currently supported.
d180_fun	String containing the name of the transfer function used to convert temperature and $\delta^{18}O_w$ to $\delta^{18}O_c$ data (for example: "KimONeil97" or "GrossmanKu86"). Defaults to Kim and O'Neil (1997).
D47_fun	String containing the name of the transfer function used to convert temperature to Δ_{47} data (for example: "Bernasconi18" or "Jautzy20"). Defaults to Bernasconi et al., 2018).
export	Export table summary of result (CSV format)? TRUE/FALSE

Value

A data frame containing monthly reconstructions of Δ_{47} , temperature, $\delta^{18}O$ of the precipitation fluid and $\delta^{18}O_c$.

References

- Grossman, E.L., Ku, T., Oxygen and carbon isotope fractionation in biogenic aragonite: temperature effects, *Chemical Geology* **1986**, *59.1*, 59–74. <https://doi.org/bvpzws>
- Kim, S., O’Niel, J.R., Equilibrium and nonequilibrium oxygen isotope effects in synthetic carbonates, *Geochimica et Cosmochimica Acta* **1997**, *61.16*, 3461–3475. <https://doi.org/c7bwbp>
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- Kele, S., Breitenbach, S. F., Capezzuoli, E., Meckler, A. N., Ziegler, M., Millan, I. M., Kluge, T., Deák, J., Hanselmann, K. and John, C. M., Temperature dependence of oxygen– and clumped isotope fractionation in carbonates: a study of travertines and tufas in the 6–95 C temperature range, *Geochimica et Cosmochimica Acta* **2015**, *168*, 172–192. <https://doi.org/f7sgn6>
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- Jautzy, J. J., Savard, M. M., Dhillon, R. S., Bernasconi, S. M. and Smirnov, A., Clumped isotope temperature calibration for calcite: Bridging theory and experimentation, *Geochemical Perspectives Letters* **2020**, *14*, 36–41. <https://doi.org/fpc3>
- de Winter, N. J., Agterhuis, T., Ziegler, M., Optimizing sampling strategies in high–resolution paleoclimate records, *Climate of the Past Discussions* **2020**, 1–52. <https://doi.org/fpc4>

Examples

```
# find attached dummy data
Case1 <- seasonalclumped::Case1
d180c <- Case1[, 29]
d180c <- d180c[-which(is.na(d180c))]
D47 <- Case1[, 30]
D47 <- D47[-which(is.na(D47))]
ages <- Case1[, 27]
ages <- ages[-which(is.na(ages))]
# Run function
binned <- binning_seasonality(d180c,
D47,
ages,
```

```

0.1,
0.04,
100, # Use small amount of samples for quick testing (recommended N = 1000)
"month",
"KimONeil97",
"Bernasconi18",
FALSE)

```

carbmodel

Function that produces $\delta^{18}O$ and Δ_{47} records

Description

Takes vectors of time, temperature, growth rate and $\delta^{18}O$ of the fluid and converts them into a $\delta^{18}O$ and Δ_{47} record. The $\delta^{18}O$ and Δ_{47} values are calculated for every depth value provided in the D vector. By default, the empirical transfer function by Kim and O'Neil (1997) is used to produce the $\delta^{18}O$ record, but other transfer functions (e.g. Grossman and Ku, 1986) are also supported. The default transfer function for converting temperature data to Δ_{47} data is based on Bernasconi et al. (2018), but other transfer functions (e.g. Jautzy et al., 2020) are also supported.

Usage

```

carbmodel(
  time,
  SST,
  GR,
  d180w,
  D,
  d180_fun = "KimONeil97",
  D47_fun = "Bernasconi18",
  AV = FALSE,
  plot = FALSE
)

```

Arguments

time	Time vector (values in years)
SST	A vector containing temperature data (values in degrees C; length must be equal to that of time)
GR	Growth rate vector (values in same time unit as time (years); length must be equal to that of time)
d180w	A vector containing data on the $\delta^{18}O$ value of the precipitation fluid (values in permille VSMOW; length must be equal to that of time)
D	Depth vector (values in same depth unit as GR)
d180_fun	String containing the name of the transfer function used to convert temperature and $\delta^{18}O_w$ to $\delta^{18}O_c$ data (for example: "KimONeil97" or "GrossmanKu86"). Defaults to Kim and O'Neil (1997).

D47_fun	String containing the name of the transfer function used to convert temperature to Δ_{47} data (for example: "Bernasconi18" or "Jautzy20"). Defaults to Bernasconi et al., 2018).
AV	Should the subsampling take into account the mean value within the sample interval? TRUE/FALSE If FALSE, the interpolated value corresponding to the exact position is used instead of the mean of the interval
plot	Should the result be plotted? TRUE/FALSE

Value

A matrix containing subsampled time, depth, $\delta^{18}O_c$ and Δ_{47} values: "Tnew"): New time vector after subsampling "D"): New depth vector after subsampling "d18Oc"): Vector listing $\delta^{18}O_c$ values for each sample "D47"): Vector listing Δ_{47} values for each sample

References

- package dependencies: ggplot2, gridExtra function dependencies: subsample, subsample_mean
 Grossman, E.L., Ku, T., Oxygen and carbon isotope fractionation in biogenic aragonite: temperature effects, *Chemical Geology* **1986**, 59.1, 59–74. <https://doi.org/bvpzws>
- Kim, S., O’Niel, J.R., Equilibrium and nonequilibrium oxygen isotope effects in synthetic carbonates, *Geochimica et Cosmochimica Acta* **1997**, 61.16, 3461–3475. <https://doi.org/c7bwbp>
- Dettman, D.L., Reische, A.K., Lohmann, K.C., Controls on the stable isotope composition of seasonal growth bands in aragonitic fresh-water bivalves (Unionidae), *Geochimica et Cosmochimica Acta* **1999**, 63.7–8, 1049–1057. <https://doi.org/cbb7zc>
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- Jautzy, J. J., Savard, M. M., Dhillon, R. S., Bernasconi, S. M. and Smirnov, A., Clumped isotope temperature calibration for calcite: Bridging theory and experimentation, *Geochemical Perspectives Letters* **2020**, 14, 36–41. <https://doi.org/fpc3>

Examples

```

# Create test data (= ideal case)
# Set boundary conditions
Td <- seq(1, 12 * 365, 1) # Create timeline of 12 years in days
Ty <- Td / 365 # Convert to years
MAT <- 20 # Set mean annual temperature
Amp <- 10 # Set seasonal amplitude
Sext <- 2 * Amp # Calculate extent of seasonal variability
TSD <- 1.5 # Set the degree of random non-annual seasonal noise on the SST curve
# ("weather")
SST <- rnorm(length(Ty), MAT + Amp * sin(2 * pi * Ty), TSD) # Create virtual
# daily SST data
GR <- rep(10 / 365, length(Ty)) # Set growth rate to 10 mm/yr and create daily
# GR vector
DSD <- 0.6 # Set the degree of random non-annual seasonal noise on the d180sw curve
# ("salinity fluctuations")
d180sw <- rnorm(length(Ty), rep(0, length(Ty)), DSD) # Set d180sw to 0 permille
# VSMOW, create daily d180sw vector
SR <- 0.75 # Set sampling resolution to 0.75 mm
# Create vector for all samples along entire shell length by applying constant
# sampling resolution
D <- seq(SR, sum(GR), SR)
# Calculate virtual data
newdata <- carbmodel(Ty, SST, GR, d180sw, D, AV = TRUE)

```

Case1

*Virtual dataset Case 1***Description**

A dataset containing ages (Tnew), depth values (D), stable oxygen isotope values ($\delta^{18}O$) and clumped isotope values Δ_{47} of a simulated carbonate record based on environmental parameters following Case 1 and employing a sampling resolution of 0.1 mm, 0.2 mm, 0.45 mm, 0.75 mm, 1.55 mm and 3.25 mm.

Usage

Case1

Format

A data frame with 1200 rows and 30 variables:

SR_0.1 Empty column denoting the start of the record sampled at a sampling resolution of 0.1 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d180c stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_ 0.2 Empty column denoting the start of the record sampled at a sampling resolution of 0.2 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_ 0.45 Empty column denoting the start of the record sampled at a sampling resolution of 0.45 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_ 0.75 Empty column denoting the start of the record sampled at a sampling resolution of 0.75 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_ 1.55 Empty column denoting the start of the record sampled at a sampling resolution of 1.55 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_ 3.25 Empty column denoting the start of the record sampled at a sampling resolution of 3.25 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille ...

Details

Case 1 describes an ideal temperature sinusoid without distortion by either changes in growth rate or changes in $\delta^{18}O_w$.

Generated using the code in "Generate_Case1.r" in dataraw

Source

See code to generate data in dataraw Details on how these example cases are defined is provided in:

de Winter, N. J., Agterhuis, T., Ziegler, M., Optimizing sampling strategies in high-resolution paleoclimate records, *Climate of the Past Discussions* **2020**, 1–52. <https://doi.org/fpc4>

Case10

*Virtual dataset Case 10***Description**

A dataset containing ages (Tnew), depth values (D), stable oxygen isotope values ($\delta^{18}O$) and clumped isotope values Δ_{47} of a simulated carbonate record based on environmental parameters following Case 10 and employing a sampling resolution of 0.1 mm, 0.2 mm, 0.45 mm, 0.75 mm, 1.55 mm and 3.25 mm.

Usage

Case10

Format

A data frame with 1200 rows and 30 variables:

SR_0.1 Empty column denoting the start of the record sampled at a sampling resolution of 0.1 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.2 Empty column denoting the start of the record sampled at a sampling resolution of 0.2 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.45 Empty column denoting the start of the record sampled at a sampling resolution of 0.45 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.75 Empty column denoting the start of the record sampled at a sampling resolution of 0.75 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_1.55 Empty column denoting the start of the record sampled at a sampling resolution of 1.55 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_3.25 Empty column denoting the start of the record sampled at a sampling resolution of 3.25 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille ...

Details

Case 10 describes an ideal temperature sinusoid without distortion by changes in growth rate, but a negative peak in $\delta^{18}O_w$ during spring season.

Generated using the code in "Generate_Case10.r" in dataraw

Source

See code to generate data in dataraw Details on how these example cases are defined is provided in:

de Winter, N. J., Agterhuis, T., Ziegler, M., Optimizing sampling strategies in high-resolution paleoclimate records, *Climate of the Past Discussions* **2020**, 1–52. <https://doi.org/fpc4>

Case11

Virtual dataset Case 11

Description

A dataset containing ages (Tnew), depth values (D), stable oxygen isotope values ($\delta^{18}O$) and clumped isotope values Δ_{47} of a simulated carbonate record based on environmental parameters following Case 11 and employing a sampling resolution of 0.1 mm, 0.2 mm, 0.45 mm, 0.75 mm, 1.55 mm and 3.25 mm.

Usage

Case11

Format

A data frame with 1200 rows and 30 variables:

SR_0.1 Empty column denoting the start of the record sampled at a sampling resolution of 0.1 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.2 Empty column denoting the start of the record sampled at a sampling resolution of 0.2 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.45 Empty column denoting the start of the record sampled at a sampling resolution of 0.45 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.75 Empty column denoting the start of the record sampled at a sampling resolution of 0.75 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_1.55 Empty column denoting the start of the record sampled at a sampling resolution of 1.55 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_3.25 Empty column denoting the start of the record sampled at a sampling resolution of 3.25 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille ...

Details

Case 11 describes an ideal temperature sinusoid without distortion by changes in growth rate, but a positive peak in $\delta^{18}O_w$ during the warm season.

Generated using the code in "Generate_Case11.r" in dataraw

Source

See code to generate data in dataraw Details on how these example cases are defined is provided in:

de Winter, N. J., Agterhuis, T., Ziegler, M., Optimizing sampling strategies in high-resolution paleoclimate records, *Climate of the Past Discussions* **2020**, 1–52. <https://doi.org/fpc4>

Case12

Virtual dataset Case 12

Description

A dataset containing ages (Tnew), depth values (D), stable oxygen isotope values ($\delta^{18}O$) and clumped isotope values Δ_{47} of a simulated carbonate record based on environmental parameters following Case 12 and employing a sampling resolution of 0.1 mm, 0.2 mm, 0.45 mm, 0.75 mm, 1.55 mm and 3.25 mm.

Usage

Case12

Format

A data frame with 1200 rows and 30 variables:

SR_0.1 Empty column denoting the start of the record sampled at a sampling resolution of 0.1 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.2 Empty column denoting the start of the record sampled at a sampling resolution of 0.2 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.45 Empty column denoting the start of the record sampled at a sampling resolution of 0.45 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.75 Empty column denoting the start of the record sampled at a sampling resolution of 0.75 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_1.55 Empty column denoting the start of the record sampled at a sampling resolution of 1.55 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_3.25 Empty column denoting the start of the record sampled at a sampling resolution of 3.25 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille ...

Details

Case 12 describes a temperature sinusoid without distortion by changes in growth rate or $\delta^{18}O_w$, but with a multi-annual trend in temperature superimposed on the seasonality.

Generated using the code in "Generate_Case12.r" in dataraw

Source

See code to generate data in dataraw Details on how these example cases are defined is provided in:

de Winter, N. J., Agterhuis, T., Ziegler, M., Optimizing sampling strategies in high-resolution paleoclimate records, *Climate of the Past Discussions* **2020**, 1–52. <https://doi.org/fpc4>

Case13

*Virtual dataset Case 13***Description**

A dataset containing ages (Tnew), depth values (D), stable oxygen isotope values ($\delta^{18}O$) and clumped isotope values Δ_{47} of a simulated carbonate record based on environmental parameters following Case 13 and employing a sampling resolution of 0.1 mm, 0.2 mm, 0.45 mm, 0.75 mm, 1.55 mm and 3.25 mm.

Usage

Case13

Format

A data frame with 1200 rows and 30 variables:

SR_0.1 Empty column denoting the start of the record sampled at a sampling resolution of 0.1 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.2 Empty column denoting the start of the record sampled at a sampling resolution of 0.2 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.45 Empty column denoting the start of the record sampled at a sampling resolution of 0.45 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.75 Empty column denoting the start of the record sampled at a sampling resolution of 0.75 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_1.55 Empty column denoting the start of the record sampled at a sampling resolution of 1.55 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_3.25 Empty column denoting the start of the record sampled at a sampling resolution of 3.25 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille ...

Details

Case 13 describes a temperature sinusoid without distortion by changes in growth rate but with a multi-annual trend in $\delta^{18}O_w$ superimposed on the seasonality.

Generated using the code in "Generate_Case13.r" in dataraw

Source

See code to generate data in dataraw Details on how these example cases are defined is provided in:

de Winter, N. J., Agterhuis, T., Ziegler, M., Optimizing sampling strategies in high-resolution paleoclimate records, *Climate of the Past Discussions* **2020**, 1–52. <https://doi.org/fpc4>

Case14

Virtual dataset Case 14

Description

A dataset containing ages (Tnew), depth values (D), stable oxygen isotope values ($\delta^{18}O$) and clumped isotope values Δ_{47} of a simulated carbonate record based on environmental parameters following Case 14 and employing a sampling resolution of 0.1 mm, 0.2 mm, 0.45 mm, 0.75 mm, 1.55 mm and 3.25 mm.

Usage

Case14

Format

A data frame with 1200 rows and 30 variables:

SR_0.1 Empty column denoting the start of the record sampled at a sampling resolution of 0.1 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.2 Empty column denoting the start of the record sampled at a sampling resolution of 0.2 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.45 Empty column denoting the start of the record sampled at a sampling resolution of 0.45 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.75 Empty column denoting the start of the record sampled at a sampling resolution of 0.75 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_1.55 Empty column denoting the start of the record sampled at a sampling resolution of 1.55 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_3.25 Empty column denoting the start of the record sampled at a sampling resolution of 3.25 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille ...

Details

Virtual case simulating open marine conditions: Seasonal change in growth rate in phase with temperature with linear growth decrease and dynamic growth threshold. Multi-annual cyclicity in $\delta^{18}O_w$ (NAO-style).

Generated using the code in "Generate_Case14.r" in dataraw

Source

See code to generate data in dataraw Details on how these example cases are defined is provided in:

de Winter, N. J., Agterhuis, T., Ziegler, M., Optimizing sampling strategies in high-resolution paleoclimate records, *Climate of the Past Discussions* **2020**, 1–52. <https://doi.org/fpc4>

Example of natural NAO oscillation:

Sarafanov, A., On the effect of the North Atlantic Oscillation on temperature and salinity of the subpolar North Atlantic intermediate and deep waters *ICES Journal of Marine Science* **2009**, 66.7, 1448–1454. doi: [10.1093/icesjms/fsp094](https://doi.org/10.1093/icesjms/fsp094)

Case15

Virtual dataset Case 15

Description

A dataset containing ages (Tnew), depth values (D), stable oxygen isotope values ($\delta^{18}O$) and clumped isotope values Δ_{47} of a simulated carbonate record based on environmental parameters following Case 15 and employing a sampling resolution of 0.1 mm, 0.2 mm, 0.45 mm, 0.75 mm, 1.55 mm and 3.25 mm.

Usage

Case15

Format

A data frame with 1200 rows and 30 variables:

SR_0.1 Empty column denoting the start of the record sampled at a sampling resolution of 0.1 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.2 Empty column denoting the start of the record sampled at a sampling resolution of 0.2 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_ 0.45 Empty column denoting the start of the record sampled at a sampling resolution of 0.45 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_ 0.75 Empty column denoting the start of the record sampled at a sampling resolution of 0.75 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_ 1.55 Empty column denoting the start of the record sampled at a sampling resolution of 1.55 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_ 3.25 Empty column denoting the start of the record sampled at a sampling resolution of 3.25 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille ...

Details

Case simulating a coastal ecosystem: Seasonal change in growth rate with fast growth in spring and linear growth decrease. Pulse of light $\delta^{18}O_w$ in spring and multi-annual cyclicality in SST.

Generated using the code in "Generate_Case15.r" in dataraw

Source

See code to generate data in dataraw Details on how these example cases are defined is provided in:

de Winter, N. J., Agterhuis, T., Ziegler, M., Optimizing sampling strategies in high-resolution paleoclimate records, *Climate of the Past Discussions* **2020**, 1–52. <https://doi.org/fpc4>

Case16

*Virtual dataset Case 16***Description**

A dataset containing ages (Tnew), depth values (D), stable oxygen isotope values ($\delta^{18}O$) and clumped isotope values Δ_{47} of a simulated carbonate record based on environmental parameters following Case 16 and employing a sampling resolution of 0.1 mm, 0.2 mm, 0.45 mm, 0.75 mm, 1.55 mm and 3.25 mm.

Usage

Case16

Format

A data frame with 1200 rows and 30 variables:

SR_0.1 Empty column denoting the start of the record sampled at a sampling resolution of 0.1 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.2 Empty column denoting the start of the record sampled at a sampling resolution of 0.2 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.45 Empty column denoting the start of the record sampled at a sampling resolution of 0.45 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.75 Empty column denoting the start of the record sampled at a sampling resolution of 0.75 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_1.55 Empty column denoting the start of the record sampled at a sampling resolution of 1.55 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_3.25 Empty column denoting the start of the record sampled at a sampling resolution of 3.25 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille ...

Details

Case simulating a lagoonal ecosystem – Seasonal change in growth rate with slower growth in summer and linear growth decrease. Pulse of increased $\delta^{18}O_w$ in summer (evaporation).

Generated using the code in "Generate_Case16.r" in dataraw

Source

See code to generate data in dataraw Details on how these example cases are defined is provided in:

de Winter, N. J., Agterhuis, T., Ziegler, M., Optimizing sampling strategies in high-resolution paleoclimate records, *Climate of the Past Discussions* **2020**, 1–52. <https://doi.org/fpc4>

Case17

Virtual dataset Case 17

Description

A dataset containing ages (Tnew), depth values (D), stable oxygen isotope values ($\delta^{18}O$) and clumped isotope values Δ_{47} of a simulated carbonate record based on environmental parameters following Case 17 and employing a sampling resolution of 0.1 mm, 0.2 mm, 0.45 mm, 0.75 mm, 1.55 mm and 3.25 mm.

Usage

Case17

Format

A data frame with 1200 rows and 30 variables:

SR_ 0.1 Empty column denoting the start of the record sampled at a sampling resolution of 0.1 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_ 0.2 Empty column denoting the start of the record sampled at a sampling resolution of 0.2 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_ 0.45 Empty column denoting the start of the record sampled at a sampling resolution of 0.45 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_ 0.75 Empty column denoting the start of the record sampled at a sampling resolution of 0.75 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_ 1.55 Empty column denoting the start of the record sampled at a sampling resolution of 1.55 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_ 3.25 Empty column denoting the start of the record sampled at a sampling resolution of 3.25 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille ...

Details

Case simulating a tropical ecosystem – Slight seasonal change in growth rate with slower growth in summer and linear growth decrease. Confined temperature seasonality, relatively strong multi-annual trend. Strong $\delta^{18}O_w$ seasonality, light in summer, multi-annual trend in antiphase with multi-annual SST (ENSO-style)

Generated using the code in "Generate_Case17.r" in dataraw

Source

See code to generate data in dataraw Details on how these example cases are defined is provided in:

de Winter, N. J., Agterhuis, T., Ziegler, M., Optimizing sampling strategies in high-resolution paleoclimate records, *Climate of the Past Discussions* **2020**, 1–52. <https://doi.org/fpc4>

Example of modern ENSO variability: Iijima, H., Kayanne, H., Morimoto, M., Abe, O. Interannual sea surface salinity changes in the western Pacific from 1954 to 2000 based on coral isotope analysis, *Geophysical research letters*, **2005**, 32.4, 1–4. <https://doi.org/bhv8dn>

Case18

Virtual dataset Case 18

Description

A dataset containing ages (Tnew), depth values (D), stable oxygen isotope values ($\delta^{18}O$) and clumped isotope values Δ_{47} of a simulated carbonate record based on environmental parameters following Case 18 and employing a sampling resolution of 0.1 mm, 0.2 mm, 0.45 mm, 0.75 mm, 1.55 mm and 3.25 mm.

Usage

Case18

Format

A data frame with 1200 rows and 30 variables:

SR_0.1 Empty column denoting the start of the record sampled at a sampling resolution of 0.1 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.2 Empty column denoting the start of the record sampled at a sampling resolution of 0.2 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_ 0.45 Empty column denoting the start of the record sampled at a sampling resolution of 0.45 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_ 0.75 Empty column denoting the start of the record sampled at a sampling resolution of 0.75 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_ 1.55 Empty column denoting the start of the record sampled at a sampling resolution of 1.55 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_ 3.25 Empty column denoting the start of the record sampled at a sampling resolution of 3.25 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille ...

Details

Case simulating a high-latitude shallow marine ecosystem: Spring freshening and growth only during summer half of season

Generated using the code in "Generate_Case18.r" in dataraw

Source

See code to generate data in dataraw Details on how these example cases are defined is provided in:

de Winter, N. J., Agterhuis, T., Ziegler, M., Optimizing sampling strategies in high-resolution paleoclimate records, *Climate of the Past Discussions* **2020**, 1–52. <https://doi.org/fpc4>

Case19

*Virtual dataset Case 19***Description**

A dataset containing ages (Tnew), depth values (D), stable oxygen isotope values ($\delta^{18}O$) and clumped isotope values Δ_{47} of a simulated carbonate record based on environmental parameters following Case 19 and employing a sampling resolution of 0.1 mm, 0.2 mm, 0.45 mm, 0.75 mm, 1.55 mm and 3.25 mm.

Usage

Case19

Format

A data frame with 1200 rows and 30 variables:

SR_0.1 Empty column denoting the start of the record sampled at a sampling resolution of 0.1 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.2 Empty column denoting the start of the record sampled at a sampling resolution of 0.2 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.45 Empty column denoting the start of the record sampled at a sampling resolution of 0.45 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.75 Empty column denoting the start of the record sampled at a sampling resolution of 0.75 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_1.55 Empty column denoting the start of the record sampled at a sampling resolution of 1.55 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_3.25 Empty column denoting the start of the record sampled at a sampling resolution of 3.25 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille ...

Details

Case 19 describes an ideal temperature sinusoid without distortion by either changes in growth rate or changes in $\delta^{18}O_w$ but with a smaller temperature amplitude.

Generated using the code in "Generate_Case19.r" in dataraw

Source

See code to generate data in dataraw Details on how these example cases are defined is provided in:

de Winter, N. J., Agterhuis, T., Ziegler, M., Optimizing sampling strategies in high-resolution paleoclimate records, *Climate of the Past Discussions* **2020**, 1–52. <https://doi.org/fpc4>

Case2

Virtual dataset Case 2

Description

A dataset containing ages (Tnew), depth values (D), stable oxygen isotope values ($\delta^{18}O$) and clumped isotope values Δ_{47} of a simulated carbonate record based on environmental parameters following Case 2 and employing a sampling resolution of 0.1 mm, 0.2 mm, 0.45 mm, 0.75 mm, 1.55 mm and 3.25 mm.

Usage

Case2

Format

A data frame with 1200 rows and 30 variables:

SR_ 0.1 Empty column denoting the start of the record sampled at a sampling resolution of 0.1 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_ 0.2 Empty column denoting the start of the record sampled at a sampling resolution of 0.2 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_ 0.45 Empty column denoting the start of the record sampled at a sampling resolution of 0.45 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_ 0.75 Empty column denoting the start of the record sampled at a sampling resolution of 0.75 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_ 1.55 Empty column denoting the start of the record sampled at a sampling resolution of 1.55 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_ 3.25 Empty column denoting the start of the record sampled at a sampling resolution of 3.25 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille ...

Details

Case 2 describes an ideal temperature sinusoid without distortion by changes in $\delta^{(18)}O_w$, but with a growth stop in the cold season.

Generated using the code in "Generate_Case2.r" in dataraw

Source

See code to generate data in dataraw Details on how these example cases are defined is provided in:

de Winter, N. J., Agterhuis, T., Ziegler, M., Optimizing sampling strategies in high-resolution paleoclimate records, *Climate of the Past Discussions* **2020**, 1–52. <https://doi.org/fpc4>

Case20

Virtual dataset Case 20

Description

A dataset containing ages (Tnew), depth values (D), stable oxygen isotope values ($\delta^{18}O$) and clumped isotope values Δ_{47} of a simulated carbonate record based on environmental parameters following Case 20 and employing a sampling resolution of 0.1 mm, 0.2 mm, 0.45 mm, 0.75 mm, 1.55 mm and 3.25 mm.

Usage

Case20

Format

A data frame with 1200 rows and 30 variables:

SR_0.1 Empty column denoting the start of the record sampled at a sampling resolution of 0.1 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.2 Empty column denoting the start of the record sampled at a sampling resolution of 0.2 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.45 Empty column denoting the start of the record sampled at a sampling resolution of 0.45 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_ 0.75 Empty column denoting the start of the record sampled at a sampling resolution of 0.75 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_ 1.55 Empty column denoting the start of the record sampled at a sampling resolution of 1.55 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_ 3.25 Empty column denoting the start of the record sampled at a sampling resolution of 3.25 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille ...

Details

Case 20 describes an ideal temperature sinusoid without distortion by either changes in growth rate or changes in $\delta^{18}O_w$ but with an even smaller temperature amplitude.

Generated using the code in "Generate_Case20.r" in dataraw

Source

See code to generate data in dataraw Details on how these example cases are defined is provided in:

de Winter, N. J., Agterhuis, T., Ziegler, M., Optimizing sampling strategies in high-resolution paleoclimate records, *Climate of the Past Discussions* **2020**, 1–52. <https://doi.org/fpc4>

Case21

*Virtual dataset Case 21***Description**

A dataset containing ages (Tnew), depth values (D), stable oxygen isotope values ($\delta^{18}O$) and clumped isotope values Δ_{47} of a simulated carbonate record based on environmental parameters following Case 21 and employing a sampling resolution of 0.1 mm, 0.2 mm, 0.45 mm, 0.75 mm, 1.55 mm and 3.25 mm.

Usage

Case21

Format

A data frame with 1200 rows and 30 variables:

SR_0.1 Empty column denoting the start of the record sampled at a sampling resolution of 0.1 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.2 Empty column denoting the start of the record sampled at a sampling resolution of 0.2 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.45 Empty column denoting the start of the record sampled at a sampling resolution of 0.45 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.75 Empty column denoting the start of the record sampled at a sampling resolution of 0.75 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_1.55 Empty column denoting the start of the record sampled at a sampling resolution of 1.55 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_3.25 Empty column denoting the start of the record sampled at a sampling resolution of 3.25 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille ...

Details

Case 21 describes an ideal temperature sinusoid without distortion by either changes in growth rate or changes in $\delta^{18}O_w$ but with an the smallest temperature amplitude.

Generated using the code in "Generate_Case21.r" in dataraw

Source

See code to generate data in dataraw Details on how these example cases are defined is provided in:

de Winter, N. J., Agterhuis, T., Ziegler, M., Optimizing sampling strategies in high-resolution paleoclimate records, *Climate of the Past Discussions* **2020**, 1–52. <https://doi.org/fpc4>

Case22

Virtual dataset Case 22

Description

A dataset containing ages (Tnew), depth values (D), stable oxygen isotope values ($\delta^{18}O$) and clumped isotope values Δ_{47} of a simulated carbonate record based on environmental parameters following Case 22 and employing a sampling resolution of 0.1 mm, 0.2 mm, 0.45 mm, 0.75 mm, 1.55 mm and 3.25 mm.

Usage

Case22

Format

A data frame with 1200 rows and 30 variables:

SR_ 0.1 Empty column denoting the start of the record sampled at a sampling resolution of 0.1 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_ 0.2 Empty column denoting the start of the record sampled at a sampling resolution of 0.2 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_ 0.45 Empty column denoting the start of the record sampled at a sampling resolution of 0.45 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_ 0.75 Empty column denoting the start of the record sampled at a sampling resolution of 0.75 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_ 1.55 Empty column denoting the start of the record sampled at a sampling resolution of 1.55 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_ 3.25 Empty column denoting the start of the record sampled at a sampling resolution of 3.25 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille ...

Details

Case 22 describes a natural environment with temperature and $\delta^{18}O_w$ records from a tidal inlet (Texel harbor). data from `inst/extdata/Texel_data.csv`.

Generated using the code in "Generate_Case22.r" in `dataraw`

Source

See code to generate data in `dataraw` Details on how these example cases are defined is provided in:

de Winter, N. J., Agterhuis, T., Ziegler, M., Optimizing sampling strategies in high-resolution paleoclimate records, *Climate of the Past Discussions* **2020**, 1–52. <https://doi.org/fpc4>

Case23

Virtual dataset Case 23

Description

A dataset containing ages (Tnew), depth values (D), stable oxygen isotope values ($\delta^{18}O$) and clumped isotope values Δ_{47} of a simulated carbonate record based on environmental parameters following Case 23 and employing a sampling resolution of 0.1 mm, 0.2 mm, 0.45 mm, 0.75 mm, 1.55 mm and 3.25 mm.

Usage

Case23

Format

A data frame with 1200 rows and 30 variables:

SR_0.1 Empty column denoting the start of the record sampled at a sampling resolution of 0.1 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.2 Empty column denoting the start of the record sampled at a sampling resolution of 0.2 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.45 Empty column denoting the start of the record sampled at a sampling resolution of 0.45 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_ 0.75 Empty column denoting the start of the record sampled at a sampling resolution of 0.75 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_ 1.55 Empty column denoting the start of the record sampled at a sampling resolution of 1.55 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_ 3.25 Empty column denoting the start of the record sampled at a sampling resolution of 3.25 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille ...

Details

Case 23 describes an natural environment with temperature and $\delta^{18}O_w$ records from a tropical sea (Great Barrier Reef). data from `inst/extdata/GBR_data.csv`.

Generated using the code in "Generate_Case23.r" in `dataraw`

Source

See code to generate data in `dataraw` Details on how these example cases are defined is provided in:

de Winter, N. J., Agterhuis, T., Ziegler, M., Optimizing sampling strategies in high-resolution paleoclimate records, *Climate of the Past Discussions* **2020**, 1–52. <https://doi.org/fpc4>

Case24

*Virtual dataset Case 24***Description**

A dataset containing ages (Tnew), depth values (D), stable oxygen isotope values ($\delta^{18}O$) and clumped isotope values Δ_{47} of a simulated carbonate record based on environmental parameters following Case 24 and employing a sampling resolution of 0.1 mm, 0.2 mm, 0.45 mm, 0.75 mm, 1.55 mm and 3.25 mm.

Usage

Case24

Format

A data frame with 1200 rows and 30 variables:

SR_0.1 Empty column denoting the start of the record sampled at a sampling resolution of 0.1 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.2 Empty column denoting the start of the record sampled at a sampling resolution of 0.2 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.45 Empty column denoting the start of the record sampled at a sampling resolution of 0.45 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.75 Empty column denoting the start of the record sampled at a sampling resolution of 0.75 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_1.55 Empty column denoting the start of the record sampled at a sampling resolution of 1.55 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_3.25 Empty column denoting the start of the record sampled at a sampling resolution of 3.25 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille ...

Details

Case 24 describes an natural environment with temperature and $\delta^{18}O_w$ records from an evaporation-dominated sea (Red Sea) data from `inst/extdata/Red_sea_data.csv`.

Generated using the code in "Generate_Case24.r" in `dataraw`

Source

See code to generate data in `dataraw` Details on how these example cases are defined is provided in:

de Winter, N. J., Agterhuis, T., Ziegler, M., Optimizing sampling strategies in high-resolution paleoclimate records, *Climate of the Past Discussions* **2020**, 1–52. <https://doi.org/fpc4>

Case25

Virtual dataset Case 25

Description

A dataset containing ages (Tnew), depth values (D), stable oxygen isotope values ($\delta^{18}O$) and clumped isotope values Δ_{47} of a simulated carbonate record based on environmental parameters following Case 25 and employing a sampling resolution of 0.1 mm, 0.2 mm, 0.45 mm, 0.75 mm, 1.55 mm and 3.25 mm.

Usage

Case25

Format

A data frame with 1200 rows and 30 variables:

SR_0.1 Empty column denoting the start of the record sampled at a sampling resolution of 0.1 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.2 Empty column denoting the start of the record sampled at a sampling resolution of 0.2 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.45 Empty column denoting the start of the record sampled at a sampling resolution of 0.45 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.75 Empty column denoting the start of the record sampled at a sampling resolution of 0.75 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_1.55 Empty column denoting the start of the record sampled at a sampling resolution of 1.55 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_3.25 Empty column denoting the start of the record sampled at a sampling resolution of 3.25 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille ...

Details

Case 25 describes an natural environment with temperature and $\delta^{18}O_w$ records from a high-latitude marine site (Iceland). data from `inst/extdata/Iceland_data.csv`.

Generated using the code in "Generate_Case25.r" in dataraw

Source

See code to generate data in dataraw Details on how these example cases are defined is provided in:

de Winter, N. J., Agterhuis, T., Ziegler, M., Optimizing sampling strategies in high-resolution paleoclimate records, *Climate of the Past Discussions* **2020**, 1–52. <https://doi.org/fpc4>

Case26

Virtual dataset Case 26

Description

A dataset containing ages (Tnew), depth values (D), stable oxygen isotope values ($\delta^{18}O$) and clumped isotope values Δ_{47} of a simulated carbonate record based on environmental parameters following Case 26 and employing a sampling resolution of 0.1 mm, 0.2 mm, 0.45 mm, 0.75 mm, 1.55 mm and 3.25 mm.

Usage

Case26

Format

A data frame with 1200 rows and 30 variables:

SR_0.1 Empty column denoting the start of the record sampled at a sampling resolution of 0.1 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.2 Empty column denoting the start of the record sampled at a sampling resolution of 0.2 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.45 Empty column denoting the start of the record sampled at a sampling resolution of 0.45 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.75 Empty column denoting the start of the record sampled at a sampling resolution of 0.75 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_1.55 Empty column denoting the start of the record sampled at a sampling resolution of 1.55 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_3.25 Empty column denoting the start of the record sampled at a sampling resolution of 3.25 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille ...

Details

Case 26 describes an ideal temperature sinusoid without distortion by either changes in growth rate or changes in $\delta^{18}O_w$ but with a shorter (6 yr) record length.

Generated using the code in "Generate_Case26.r" in dataraw

Source

See code to generate data in dataraw Details on how these example cases are defined is provided in:

de Winter, N. J., Agterhuis, T., Ziegler, M., Optimizing sampling strategies in high-resolution paleoclimate records, *Climate of the Past Discussions* **2020**, 1–52. <https://doi.org/fpc4>

Case27

*Virtual dataset Case 27***Description**

A dataset containing ages (Tnew), depth values (D), stable oxygen isotope values ($\delta^{18}O$) and clumped isotope values Δ_{47} of a simulated carbonate record based on environmental parameters following Case 27 and employing a sampling resolution of 0.1 mm, 0.2 mm, 0.45 mm, 0.75 mm, 1.55 mm and 3.25 mm.

Usage

Case27

Format

A data frame with 1200 rows and 30 variables:

SR_0.1 Empty column denoting the start of the record sampled at a sampling resolution of 0.1 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.2 Empty column denoting the start of the record sampled at a sampling resolution of 0.2 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.45 Empty column denoting the start of the record sampled at a sampling resolution of 0.45 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.75 Empty column denoting the start of the record sampled at a sampling resolution of 0.75 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_1.55 Empty column denoting the start of the record sampled at a sampling resolution of 1.55 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_3.25 Empty column denoting the start of the record sampled at a sampling resolution of 3.25 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille ...

Details

Case 27 describes an ideal temperature sinusoid without distortion by either changes in growth rate or changes in $\delta^{18}O_w$ but with a shorter (3 yr) record length.

Generated using the code in "Generate_Case27.r" in dataraw

Source

See code to generate data in dataraw Details on how these example cases are defined is provided in:

de Winter, N. J., Agterhuis, T., Ziegler, M., Optimizing sampling strategies in high-resolution paleoclimate records, *Climate of the Past Discussions* **2020**, 1–52. <https://doi.org/fpc4>

Case28

Virtual dataset Case 28

Description

A dataset containing ages (Tnew), depth values (D), stable oxygen isotope values ($\delta^{18}O$) and clumped isotope values Δ_{47} of a simulated carbonate record based on environmental parameters following Case 28 and employing a sampling resolution of 0.1 mm, 0.2 mm, 0.45 mm, 0.75 mm, 1.55 mm and 3.25 mm.

Usage

Case28

Format

A data frame with 1200 rows and 30 variables:

SR_0.1 Empty column denoting the start of the record sampled at a sampling resolution of 0.1 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.2 Empty column denoting the start of the record sampled at a sampling resolution of 0.2 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.45 Empty column denoting the start of the record sampled at a sampling resolution of 0.45 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.75 Empty column denoting the start of the record sampled at a sampling resolution of 0.75 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_1.55 Empty column denoting the start of the record sampled at a sampling resolution of 1.55 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_3.25 Empty column denoting the start of the record sampled at a sampling resolution of 3.25 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille ...

Details

Case 28 describes an ideal temperature sinusoid without distortion by either changes in growth rate or changes in $\delta^{18}O_w$ but with a shorter (1 yr) record length.

Generated using the code in "Generate_Case28.r" in dataraw

Source

See code to generate data in dataraw Details on how these example cases are defined is provided in:

de Winter, N. J., Agterhuis, T., Ziegler, M., Optimizing sampling strategies in high-resolution paleoclimate records, *Climate of the Past Discussions* **2020**, 1–52. <https://doi.org/fpc4>

Case29

Virtual dataset Case 29

Description

A dataset containing ages (Tnew), depth values (D), stable oxygen isotope values ($\delta^{18}O$) and clumped isotope values Δ_{47} of a simulated carbonate record based on environmental parameters following Case 29 and employing a sampling resolution of 0.1 mm, 0.2 mm, 0.45 mm, 0.75 mm, 1.55 mm and 3.25 mm.

Usage

Case29

Format

A data frame with 1200 rows and 30 variables:

SR_0.1 Empty column denoting the start of the record sampled at a sampling resolution of 0.1 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.2 Empty column denoting the start of the record sampled at a sampling resolution of 0.2 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.45 Empty column denoting the start of the record sampled at a sampling resolution of 0.45 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_ 0.75 Empty column denoting the start of the record sampled at a sampling resolution of 0.75 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_ 1.55 Empty column denoting the start of the record sampled at a sampling resolution of 1.55 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_ 3.25 Empty column denoting the start of the record sampled at a sampling resolution of 3.25 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille ...

Details

Case 29 describes an ideal temperature sinusoid without distortion by changes in growth rate, but with seasonal variability in $\delta^{18}O_w$ with a minimum in spring season and a tiny (1 days SD) error on age model

Generated using the code in "Generate_Case29.r" in dataraw

Source

See code to generate data in dataraw Details on how these example cases are defined is provided in:

de Winter, N. J., Agterhuis, T., Ziegler, M., Optimizing sampling strategies in high-resolution paleoclimate records, *Climate of the Past Discussions* **2020**, 1–52. <https://doi.org/fpc4>

Case3

*Virtual dataset Case 3***Description**

A dataset containing ages (Tnew), depth values (D), stable oxygen isotope values ($\delta^{18}O$) and clumped isotope values Δ_{47} of a simulated carbonate record based on environmental parameters following Case 3 and employing a sampling resolution of 0.1 mm, 0.2 mm, 0.45 mm, 0.75 mm, 1.55 mm and 3.25 mm.

Usage

Case3

Format

A data frame with 1200 rows and 30 variables:

SR_0.1 Empty column denoting the start of the record sampled at a sampling resolution of 0.1 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.2 Empty column denoting the start of the record sampled at a sampling resolution of 0.2 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.45 Empty column denoting the start of the record sampled at a sampling resolution of 0.45 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.75 Empty column denoting the start of the record sampled at a sampling resolution of 0.75 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_1.55 Empty column denoting the start of the record sampled at a sampling resolution of 1.55 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_3.25 Empty column denoting the start of the record sampled at a sampling resolution of 3.25 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille ...

Details

Case 3 describes an ideal temperature sinusoid without distortion by changes in $\delta^{18}O_w$, but with a growth stop in the warm season.

Generated using the code in "Generate_Case3.r" in dataraw

Source

See code to generate data in dataraw Details on how these example cases are defined is provided in:

de Winter, N. J., Agterhuis, T., Ziegler, M., Optimizing sampling strategies in high-resolution paleoclimate records, *Climate of the Past Discussions* **2020**, 1–52. <https://doi.org/fpc4>

Case30

Virtual dataset Case 30

Description

A dataset containing ages (Tnew), depth values (D), stable oxygen isotope values ($\delta^{18}O$) and clumped isotope values Δ_{47} of a simulated carbonate record based on environmental parameters following Case 30 and employing a sampling resolution of 0.1 mm, 0.2 mm, 0.45 mm, 0.75 mm, 1.55 mm and 3.25 mm.

Usage

Case30

Format

A data frame with 1200 rows and 30 variables:

SR_ 0.1 Empty column denoting the start of the record sampled at a sampling resolution of 0.1 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_ 0.2 Empty column denoting the start of the record sampled at a sampling resolution of 0.2 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_ 0.45 Empty column denoting the start of the record sampled at a sampling resolution of 0.45 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_ 0.75 Empty column denoting the start of the record sampled at a sampling resolution of 0.75 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_ 1.55 Empty column denoting the start of the record sampled at a sampling resolution of 1.55 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_ 3.25 Empty column denoting the start of the record sampled at a sampling resolution of 3.25 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille ...

Details

Case 30 describes an ideal temperature sinusoid without distortion by changes in growth rate, but with seasonal variability in $\delta^{18}O_w$ with a minimum in spring season and a small (5 days SD) error on age model (roughly +/- one week)

Generated using the code in "Generate_Case30.r" in dataraw

Source

See code to generate data in dataraw Details on how these example cases are defined is provided in:

de Winter, N. J., Agterhuis, T., Ziegler, M., Optimizing sampling strategies in high-resolution paleoclimate records, *Climate of the Past Discussions* **2020**, 1–52. <https://doi.org/fpc4>

Case31

Virtual dataset Case 31

Description

A dataset containing ages (Tnew), depth values (D), stable oxygen isotope values ($\delta^{18}O$) and clumped isotope values Δ_{47} of a simulated carbonate record based on environmental parameters following Case 31 and employing a sampling resolution of 0.1 mm, 0.2 mm, 0.45 mm, 0.75 mm, 1.55 mm and 3.25 mm.

Usage

Case31

Format

A data frame with 1200 rows and 30 variables:

SR_0.1 Empty column denoting the start of the record sampled at a sampling resolution of 0.1 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.2 Empty column denoting the start of the record sampled at a sampling resolution of 0.2 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.45 Empty column denoting the start of the record sampled at a sampling resolution of 0.45 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.75 Empty column denoting the start of the record sampled at a sampling resolution of 0.75 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_1.55 Empty column denoting the start of the record sampled at a sampling resolution of 1.55 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_3.25 Empty column denoting the start of the record sampled at a sampling resolution of 3.25 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille ...

Details

Case 31 describes an ideal temperature sinusoid without distortion by changes in growth rate, but with seasonal variability in $\delta^{18}O_w$ with a minimum in spring season and a larger (15 days SD) error on age model (roughly +/- one month)

Generated using the code in "Generate_Case31.r" in dataraw

Source

See code to generate data in dataraw Details on how these example cases are defined is provided in:

de Winter, N. J., Agterhuis, T., Ziegler, M., Optimizing sampling strategies in high-resolution paleoclimate records, *Climate of the Past Discussions* **2020**, 1–52. <https://doi.org/fpc4>

Case32

*Virtual dataset Case 32***Description**

A dataset containing ages (Tnew), depth values (D), stable oxygen isotope values ($\delta^{18}O$) and clumped isotope values Δ_{47} of a simulated carbonate record based on environmental parameters following Case 32 and employing a sampling resolution of 0.1 mm, 0.2 mm, 0.45 mm, 0.75 mm, 1.55 mm and 3.25 mm.

Usage

Case32

Format

A data frame with 1200 rows and 30 variables:

SR_0.1 Empty column denoting the start of the record sampled at a sampling resolution of 0.1 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.2 Empty column denoting the start of the record sampled at a sampling resolution of 0.2 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.45 Empty column denoting the start of the record sampled at a sampling resolution of 0.45 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.75 Empty column denoting the start of the record sampled at a sampling resolution of 0.75 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_1.55 Empty column denoting the start of the record sampled at a sampling resolution of 1.55 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_3.25 Empty column denoting the start of the record sampled at a sampling resolution of 3.25 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille ...

Details

Case 32 describes an ideal temperature sinusoid without distortion by changes in growth rate, but with seasonal variability in $\delta^{18}O_w$ with a minimum in spring season and a large (45 days SD) error on age model (roughly +/- three months)

Generated using the code in "Generate_Case32.r" in dataraw

Source

See code to generate data in dataraw Details on how these example cases are defined is provided in:

de Winter, N. J., Agterhuis, T., Ziegler, M., Optimizing sampling strategies in high-resolution paleoclimate records, *Climate of the Past Discussions* **2020**, 1–52. <https://doi.org/fpc4>

Case33

Virtual dataset Case 33

Description

A dataset containing ages (Tnew), depth values (D), stable oxygen isotope values ($\delta^{18}O$) and clumped isotope values Δ_{47} of a simulated carbonate record based on environmental parameters following Case 33 and employing a sampling resolution of 0.1 mm, 0.2 mm, 0.45 mm, 0.75 mm, 1.55 mm and 3.25 mm.

Usage

Case33

Format

A data frame with 1200 rows and 30 variables:

SR_0.1 Empty column denoting the start of the record sampled at a sampling resolution of 0.1 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.2 Empty column denoting the start of the record sampled at a sampling resolution of 0.2 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.45 Empty column denoting the start of the record sampled at a sampling resolution of 0.45 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.75 Empty column denoting the start of the record sampled at a sampling resolution of 0.75 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_1.55 Empty column denoting the start of the record sampled at a sampling resolution of 1.55 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_3.25 Empty column denoting the start of the record sampled at a sampling resolution of 3.25 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille ...

Details

Case 33 describes an ideal temperature sinusoid without distortion by changes in growth rate, but with seasonal variability in $\delta^{18}O_w$ with a minimum in spring season and a enormous (90 days SD) error on age model (roughly +/- half year)

Generated using the code in "Generate_Case33.r" in dataraw

Source

See code to generate data in dataraw Details on how these example cases are defined is provided in:

de Winter, N. J., Agterhuis, T., Ziegler, M., Optimizing sampling strategies in high-resolution paleoclimate records, *Climate of the Past Discussions* **2020**, 1–52. <https://doi.org/fpc4>

Case4

Virtual dataset Case 4

Description

A dataset containing ages (Tnew), depth values (D), stable oxygen isotope values ($\delta^{18}O$) and clumped isotope values Δ_{47} of a simulated carbonate record based on environmental parameters following Case 4 and employing a sampling resolution of 0.1 mm, 0.2 mm, 0.45 mm, 0.75 mm, 1.55 mm and 3.25 mm.

Usage

Case4

Format

A data frame with 1200 rows and 30 variables:

SR_0.1 Empty column denoting the start of the record sampled at a sampling resolution of 0.1 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.2 Empty column denoting the start of the record sampled at a sampling resolution of 0.2 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.45 Empty column denoting the start of the record sampled at a sampling resolution of 0.45 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.75 Empty column denoting the start of the record sampled at a sampling resolution of 0.75 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_1.55 Empty column denoting the start of the record sampled at a sampling resolution of 1.55 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_3.25 Empty column denoting the start of the record sampled at a sampling resolution of 3.25 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille ...

Details

Case 4 describes an ideal temperature sinusoid without distortion by changes in $\delta^{18}O_w$, but with a linearly decreasing growth rate.

Generated using the code in "Generate_Case4.r" in dataraw

Source

See code to generate data in dataraw Details on how these example cases are defined is provided in:

de Winter, N. J., Agterhuis, T., Ziegler, M., Optimizing sampling strategies in high-resolution paleoclimate records, *Climate of the Past Discussions* **2020**, 1–52. <https://doi.org/fpc4>

Case5

*Virtual dataset Case 5***Description**

A dataset containing ages (Tnew), depth values (D), stable oxygen isotope values ($\delta^{18}O$) and clumped isotope values Δ_{47} of a simulated carbonate record based on environmental parameters following Case 5 and employing a sampling resolution of 0.1 mm, 0.2 mm, 0.45 mm, 0.75 mm, 1.55 mm and 3.25 mm.

Usage

Case5

Format

A data frame with 1200 rows and 30 variables:

SR_0.1 Empty column denoting the start of the record sampled at a sampling resolution of 0.1 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.2 Empty column denoting the start of the record sampled at a sampling resolution of 0.2 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.45 Empty column denoting the start of the record sampled at a sampling resolution of 0.45 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.75 Empty column denoting the start of the record sampled at a sampling resolution of 0.75 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_1.55 Empty column denoting the start of the record sampled at a sampling resolution of 1.55 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_3.25 Empty column denoting the start of the record sampled at a sampling resolution of 3.25 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille ...

Details

Case 5 describes an ideal temperature sinusoid without distortion by changes in $\delta^{18}O_w$, but with seasonal variability in growth rate which is in phase with the temperature seasonality.

Generated using the code in "Generate_Case5.r" in dataraw

Source

See code to generate data in dataraw Details on how these example cases are defined is provided in:

de Winter, N. J., Agterhuis, T., Ziegler, M., Optimizing sampling strategies in high-resolution paleoclimate records, *Climate of the Past Discussions* **2020**, 1–52. <https://doi.org/fpc4>

Case6

Virtual dataset Case 6

Description

A dataset containing ages (Tnew), depth values (D), stable oxygen isotope values ($\delta^{18}O$) and clumped isotope values Δ_{47} of a simulated carbonate record based on environmental parameters following Case 6 and employing a sampling resolution of 0.1 mm, 0.2 mm, 0.45 mm, 0.75 mm, 1.55 mm and 3.25 mm.

Usage

Case6

Format

A data frame with 1200 rows and 30 variables:

SR_0.1 Empty column denoting the start of the record sampled at a sampling resolution of 0.1 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.2 Empty column denoting the start of the record sampled at a sampling resolution of 0.2 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.45 Empty column denoting the start of the record sampled at a sampling resolution of 0.45 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.75 Empty column denoting the start of the record sampled at a sampling resolution of 0.75 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_1.55 Empty column denoting the start of the record sampled at a sampling resolution of 1.55 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_3.25 Empty column denoting the start of the record sampled at a sampling resolution of 3.25 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille ...

Details

Case 6 describes an ideal temperature sinusoid without distortion by changes in $\delta^{18}O_w$, but with seasonal variability in growth rate which is in phase with maxima in the spring season.

Generated using the code in "Generate_Case6.r" in dataraw

Source

See code to generate data in dataraw Details on how these example cases are defined is provided in:

de Winter, N. J., Agterhuis, T., Ziegler, M., Optimizing sampling strategies in high-resolution paleoclimate records, *Climate of the Past Discussions* **2020**, 1–52. <https://doi.org/fpc4>

Case7

Virtual dataset Case 7

Description

A dataset containing ages (Tnew), depth values (D), stable oxygen isotope values ($\delta^{18}O$) and clumped isotope values Δ_{47} of a simulated carbonate record based on environmental parameters following Case 7 and employing a sampling resolution of 0.1 mm, 0.2 mm, 0.45 mm, 0.75 mm, 1.55 mm and 3.25 mm.

Usage

Case7

Format

A data frame with 1200 rows and 30 variables:

SR_0.1 Empty column denoting the start of the record sampled at a sampling resolution of 0.1 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.2 Empty column denoting the start of the record sampled at a sampling resolution of 0.2 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.45 Empty column denoting the start of the record sampled at a sampling resolution of 0.45 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18O_c stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.75 Empty column denoting the start of the record sampled at a sampling resolution of 0.75 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18O_c stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_1.55 Empty column denoting the start of the record sampled at a sampling resolution of 1.55 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18O_c stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_3.25 Empty column denoting the start of the record sampled at a sampling resolution of 3.25 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18O_c stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille ...

Details

Case 7 describes an ideal temperature sinusoid without distortion by changes in growth rate, but with seasonal variability in $\delta^{18}O_w$ in phase with temperature seasonality.

Generated using the code in "Generate_Case7.r" in dataraw

Source

See code to generate data in dataraw Details on how these example cases are defined is provided in:

de Winter, N. J., Agterhuis, T., Ziegler, M., Optimizing sampling strategies in high-resolution paleoclimate records, *Climate of the Past Discussions* **2020**, 1–52. <https://doi.org/fpc4>

Case8

*Virtual dataset Case 8***Description**

A dataset containing ages (Tnew), depth values (D), stable oxygen isotope values ($\delta^{18}O$) and clumped isotope values Δ_{47} of a simulated carbonate record based on environmental parameters following Case 8 and employing a sampling resolution of 0.1 mm, 0.2 mm, 0.45 mm, 0.75 mm, 1.55 mm and 3.25 mm.

Usage

Case8

Format

A data frame with 1200 rows and 30 variables:

SR_0.1 Empty column denoting the start of the record sampled at a sampling resolution of 0.1 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.2 Empty column denoting the start of the record sampled at a sampling resolution of 0.2 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.45 Empty column denoting the start of the record sampled at a sampling resolution of 0.45 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_0.75 Empty column denoting the start of the record sampled at a sampling resolution of 0.75 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_1.55 Empty column denoting the start of the record sampled at a sampling resolution of 1.55 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_3.25 Empty column denoting the start of the record sampled at a sampling resolution of 3.25 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille ...

Details

Case 8 describes an ideal temperature sinusoid without distortion by changes in growth rate, but with seasonal variability in $\delta^{18}O_w$ in antiphase with temperature seasonality.

Generated using the code in "Generate_Case8.r" in dataraw

Source

See code to generate data in dataraw Details on how these example cases are defined is provided in:

de Winter, N. J., Agterhuis, T., Ziegler, M., Optimizing sampling strategies in high-resolution paleoclimate records, *Climate of the Past Discussions* **2020**, 1–52. <https://doi.org/fpc4>

Case9

Virtual dataset Case 9

Description

A dataset containing ages (Tnew), depth values (D), stable oxygen isotope values ($\delta^{18}O$) and clumped isotope values Δ_{47} of a simulated carbonate record based on environmental parameters following Case 9 and employing a sampling resolution of 0.1 mm, 0.2 mm, 0.45 mm, 0.75 mm, 1.55 mm and 3.25 mm.

Usage

Case9

Format

A data frame with 1200 rows and 30 variables:

SR_ 0.1 Empty column denoting the start of the record sampled at a sampling resolution of 0.1 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_ 0.2 Empty column denoting the start of the record sampled at a sampling resolution of 0.2 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_ 0.45 Empty column denoting the start of the record sampled at a sampling resolution of 0.45 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_ 0.75 Empty column denoting the start of the record sampled at a sampling resolution of 0.75 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_ 1.55 Empty column denoting the start of the record sampled at a sampling resolution of 1.55 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille

SR_ 3.25 Empty column denoting the start of the record sampled at a sampling resolution of 3.25 mm

Tnew Age, in years relative to the start of the record

D Depth, in mm along the virtual record

d18Oc stable oxygen isotope value, in permille VPDB

D47 clumped isotope value, in permille ...

Details

Case 9 describes an ideal temperature sinusoid without distortion by changes in growth rate, but with seasonal variability in $\delta^{18}O_w$ with a minimum in spring season.

Generated using the code in "Generate_Case9.r" in dataraw

Source

See code to generate data in dataraw Details on how these example cases are defined is provided in:

de Winter, N. J., Agterhuis, T., Ziegler, M., Optimizing sampling strategies in high-resolution paleoclimate records, *Climate of the Past Discussions* **2020**, 1–52. <https://doi.org/fpc4>

optimization_seasonality

Function for sample size optimization based clumped isotope seasonality reconstruction.

Description

Combines records of stable oxygen isotope ratios ($\delta^{18}O_c$) and clumped isotope ratios (Δ_{47}) through subannually resolved carbonate archives (e.g. mollusk shells or corals) to reconstruct monthly variability in temperature and salinity (through the $\delta^{18}O$ composition of the precipitation fluid), using the sample size optimization method detailed in de Winter et al., 2020 (Climate of the Past).

Usage

```
optimization_seasonality(
  d180c,
  D47,
  ages,
  SD_d180c = 0.1,
  SD_D47 = 0.04,
  N = 1000,
  p = 0.05,
  d180_fun = "KimONeil97",
  D47_fun = "Bernasconi18",
  export = FALSE,
  export_raw = FALSE
)
```

Arguments

d180c	Vector containing subannually resolved $\delta^{18}O_c$ data
D47	Vector containing subannually resolved Δ_{47} data
ages	Vector containing ages for of all samples in years relative to the shell chronology

SD_d180c	Error on the $\delta^{18}O_c$ measurements. Either a single value (constant uncertainty) or a vector of length equal to the period in SST data (365 days by default) containing information about the error of each datapoint (1 standard deviation; default = 0.1 permille).
SD_D47	Error on the Δ_{47} measurements. Either a single value (constant uncertainty) or a vector of length equal to the period in SST data (365 days by default) containing information about the error of each datapoint (1 standard deviation; default = 0.04 permille).
N	Number of datapoints for Monte Carlo simulation (defaults to 1000)
p	Threshold value for the p value of separating summer from winter reconstructions. Defaults to 0.05 (95% confidence level)
d180_fun	String containing the name of the transfer function used to convert temperature and $\delta^{18}O_w$ to $\delta^{18}O_c$ data (for example: "KimO'Neil97" or "GrossmanKu86"). Defaults to Kim and O'Neil (1997).
D47_fun	String containing the name of the transfer function used to convert temperature to Δ_{47} data (for example: "Bernasconi18" or "Jautzy20"). Defaults to Bernasconi et al., 2018).
export	Export table summary of result (CSV format)? TRUE/FALSE
export_raw	Export tables containing all raw model results before being merged into tidy tables? TRUE/FALSE

Value

A data frame containing monthly reconstructions of Δ_{47} , temperature, $\delta^{18}O$ of the precipitation fluid and $\delta^{18}O_c$.

References

- package dependencies: TTR Grossman, E.L., Ku, T., Oxygen and carbon isotope fractionation in biogenic aragonite: temperature effects, *Chemical Geology* **1986**, 59.1, 59–74. <https://doi.org/bvpzws>
- Kim, S., O'Neil, J.R., Equilibrium and nonequilibrium oxygen isotope effects in synthetic carbonates, *Geochimica et Cosmochimica Acta* **1997**, 61.16, 3461–3475. <https://doi.org/c7bwbp>
- Dettman, D.L., Reische, A.K., Lohmann, K.C., Controls on the stable isotope composition of seasonal growth bands in aragonitic fresh-water bivalves (Unionidae), *Geochimica et Cosmochimica Acta* **1999**, 63.7–8, 1049–1057. <https://doi.org/cbb7zc>
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- Kele, S., Breitenbach, S. F., Capezzuoli, E., Meckler, A. N., Ziegler, M., Millan, I. M., Kluge, T., Deák, J., Hanselmann, K. and John, C. M., Temperature dependence of oxygen– and clumped isotope fractionation in carbonates: a study of travertines and tufas in the 6–95 C temperature range, *Geochimica et Cosmochimica Acta* **2015**, 168, 172–192. <https://doi.org/f7sgn6>
- Bernasconi, S.M., Müller, I.A., Bergmann, K.D., Breitenbach, S.F., Fernandez, A., Hodell, D.A., Jaggi, M., Meckler, A.N., Millan, I. and Ziegler, M., Reducing uncertainties in carbonate–clumped

isotope analysis through consistent carbonate based standardization. *Geochemistry, Geophysics, Geosystems* **2018**, 19–9, 2895–2914. <https://doi.org/gfmjrw>

Petersen, S. V., Defliese, W. F., Saenger, C., Daëron, M., Huntington, K. W., John, C. M., Kelson, J. R., Bernasconi, S. M., Colman, A. S., Kluge, T., Olack, G. A., Schauer, A. J., Bajnai, D., Bonifacie, M., Breitenbach, S. F. M., Fiebig, J., Fernandez, A. B., Henkes, G. A., Hodell, D., Katz, A., Kele, S., Lohmann, K. C., Passey, B. H., Peral, M. Y., Petrizzo, D. A., Rosenheim, B. E., Tripathi, A., Venturelli, R., Young, E. D. and Winkelstern, I. Z., Effects of Improved ^{17}O Correction on Inter-laboratory Agreement in Clumped Isotope Calibrations, Estimates of Mineral-Specific Offsets, and Temperature Dependence of Acid Digestion Fractionation, *Geochemistry, Geophysics, Geosystems* *2019, 20–7, 3495–3519. <https://doi.org/ggrc39>

Jautzy, J. J., Savard, M. M., Dhillon, R. S., Bernasconi, S. M. and Smirnov, A., Clumped isotope temperature calibration for calcite: Bridging theory and experimentation, *Geochemical Perspectives Letters* **2020**, 14, 36–41. <https://doi.org/fpc3>

de Winter, N. J., Agterhuis, T., Ziegler, M., Optimizing sampling strategies in high-resolution paleoclimate records, *Climate of the Past Discussions* **2020**, 1–52. <https://doi.org/fpc4>

Examples

```
# find attached dummy data
Case1 <- seasonalclumped::Case1
d180c <- Case1[, 29]
d180c <- d180c[-which(is.na(d180c))]
D47 <- Case1[, 30]
D47 <- D47[-which(is.na(D47))]
ages <- Case1[, 27]
ages <- ages[-which(is.na(ages))]
# Run function
monthly <- optimization_seasonality(d180c = d180c,
D47 = D47,
ages = ages,
SD_d180c = 0.1,
SD_D47 = 0.04,
N = 100, # Use small amount of samples for quick testing (recommended N = 1000)
p = 0.05,
d180_fun = "KimONeil97",
D47_fun = "Bernasconi18",
export = FALSE,
export_raw = FALSE)
```

oxygen_isotope_seasonality

Function for oxygen isotope based seasonality reconstructions.

Description

Uses records of stable oxygen isotope ratios ($\delta^{18}\text{O}_c$) through subannually resolved carbonate archives (e.g. mollusk shells or corals) to reconstruct monthly variability in temperature and salinity (assuming user provided variability in $\delta^{18}\text{O}$ composition of the precipitation fluid).

Usage

```
oxygen_isotope_seasonality(
  d180c,
  ages,
  SD_d180c = 0.1,
  d180w = 0,
  d180_fun = "KimONeil97",
  export = FALSE
)
```

Arguments

d180c	Vector containing subannually resolved $\delta^{18}O_c$ data
ages	Vector containing ages for of all samples in years relative to the shell chronology
SD_d180c	Error on the $\delta^{18}O_c$ measurements. Either a single value (constant uncertainty) or a vector of length equal to the period in SST data (365 days by default) containing information about the error of each datapoint (1 standard deviation; default = 0.1 permille).
d180w	Vector containing $\delta^{18}O$ values (in permille VSMOW) of the precipitation fluid used to calculate temperatures. If only a single value is provided, the $\delta^{18}O$ of the fluid is presumed constant at this value. Default = 0 permille VSMOW.
d180_fun	String containing the name of the transfer function used to convert temperature and $\delta^{18}O_w$ to $\delta^{18}O_c$ data (for example: "KimONeil97" or "GrossmanKu86"). Defaults to Kim and O'Neil (1997).
export	Export table summary of result (CSV format)? TRUE/FALSE

Value

A data frame containing monthly reconstructions of temperature, $\delta^{18}O$ of the precipitation fluid and $\delta^{18}O_c$.

References

- Grossman, E.L., Ku, T., Oxygen and carbon isotope fractionation in biogenic aragonite: temperature effects, *Chemical Geology* **1986**, 59.1, 59–74. <https://doi.org/bvpzws>
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Examples

```
# find attached dummy data
Case1 <- seasonalclumped::Case1
d180c <- Case1[, 29]
d180c <- d180c[-which(is.na(d180c))]
ages <- Case1[, 27]
ages <- ages[-which(is.na(ages))]
# Run function
monthly <- oxygen_isotope_seasonality(d180c,
  ages,
  0.1,
  0,
  "KimONeil97",
  FALSE)
```

smoothing_seasonality *Function for sample size optimization based clumped isotope seasonality reconstruction.*

Description

Combines records of stable oxygen isotope ratios ($\delta^{18}O_w$) and clumped isotope ratios (D47) through subannually resolved carbonate archives (e.g. mollusk shells or corals) to reconstruct monthly variability in temperature and salinity (through the $\delta^{18}O$ composition of the precipitation fluid), using the moving average method detailed in de Winter et al., 2020 (Climate of the Past).

Usage

```
smoothing_seasonality(
  d180c,
  D47,
  ages,
  SD_d180c = 0.1,
  SD_D47 = 0.04,
  window = "optimize",
  N = 1000,
  p = 0.05,
  d180_fun = "KimONeil97",
  D47_fun = "Bernasconi18",
  export = FALSE,
  export_raw = FALSE
)
```

Arguments

d180c	Vector containing subannually resolved $\delta^{18}O_w$ data
D47	Vector containing subannually resolved D47 data

ages	Vector containing ages for of all samples in years relative to the shell chronology
SD_d180c	Error on the $\delta^{18}O_w$ measurements. Either a single value (constant uncertainty) or a vector of length equal to the period in SST data (365 days by default) containing information about the error of each datapoint (1 standard deviation; default = 0.1 permille).
SD_D47	Error on the D47 measurements. Either a single value (constant uncertainty) or a vector of length equal to the period in SST data (365 days by default) containing information about the error of each datapoint (1 standard deviation; default = 0.04 permille).
window	Either supply the size of the window used for moving average calculation (integer with values between 2 and the length of the record), or enter the term "optimize" to let the function find the optimum window size for the record through a Monte Carlo approach.
N	Number of datapoints for Monte Carlo simulation (defaults to 1000)
p	Threshold value for the p value of separating summer from winter reconstructions. Defaults to 0.05 (95% confidence level)
d180_fun	String containing the name of the transfer function used to convert temperature and $\delta^{18}O_w$ to $\delta^{18}O_w$ data (for example: "KimONeil97" or "GrossmanKu86"). Defaults to Kim and O'Neil (1997).
D47_fun	String containing the name of the transfer function used to convert temperature to D47 data (for example: "Bernasconi18" or "Jautzy20"). Defaults to Bernasconi et al., 2018).
export	Export table summary of result (CSV format)? TRUE/FALSE
export_raw	Export tables containing all raw model results before being merged into tidy tables? TRUE/FALSE

Value

A data frame containing monthly reconstructions of D47, temperature, $\delta^{18}O$ of the precipitation fluid and $\delta^{18}O_w$.

References

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de Winter, N. J., Agterhuis, T., Ziegler, M., Optimizing sampling strategies in high-resolution paleoclimate records, *Climate of the Past Discussions* **2020**, 1–52. <https://doi.org/fpc4>

Examples

```
# find attached dummy data
Case1 <- seasonalclumped::Case1
d180c <- Case1[, 29]
d180c <- d180c[-which(is.na(d180c))]
D47 <- Case1[, 30]
D47 <- D47[-which(is.na(D47))]
ages <- Case1[, 27]
ages <- ages[-which(is.na(ages))]
# Run function
monthly <- smoothing_seasonality(d180c,
D47,
ages,
0.1,
0.04,
"optimize",
100, # Use small amount of samples for quick testing (recommended N = 1000)
0.05,
"KimONeil197",
"Bernasconi18",
FALSE,
FALSE)
```

subsample *Function used to linearly subsample data at new depth values*

Description

Function used to linearly subsample data at new depth values

Usage

```
subsample(data, old_depth, new_depth, AV = FALSE, plot = FALSE)
```

Arguments

data	A vector of data to be interpolated
old_depth	A vector containing the depth values belonging to data
new_depth	A vector containing depth values at which the data should be interpolated.
AV	Should the subsampling take into account the mean value within the sample interval? TRUE/FALSE If FALSE, the interpolated value corresponding to the exact position is used instead of the mean of the interval
plot	Should the result be plotted? TRUE/FALSE

Value

A vector listing the values interpolated from data at the positions of new_depth

Examples

```
# Create test data (= ideal case)
# Set boundary conditions
Td <- seq(1, 12 * 365, 1) # Create timeline of 12 years in days
Ty <- Td / 365 # Convert to years
MAT <- 20 # Set mean annual temperature
Amp <- 10 # Set seasonal amplitude
Sext <- 2 * Amp # Calculate extent of seasonal variability
TSD <- 1.5 # Set the degree of random noise on the SST curve
# ("weather")
SST <- rnorm(length(Ty), MAT + Amp * sin(2 * pi * Ty), TSD) # Create virtual
# daily SST data
GR <- rep(10 / 365, length(Ty)) # Set growth rate to 10 mm/yr and create daily
# GR vector
SR <- 0.75 # Set sampling resolution to 0.75 mm
# Create vector for all samples along entire shell length by applying constant
# sampling resolution
D <- seq(SR, sum(GR), SR)
D_cum <- cumsum(GR) # Create cumulative depth vector for all values
new_data <- subsample(SST, D_cum, D, AV = TRUE, plot = FALSE) # Interpolate
# SST values at the positions of D while calculating sample averages
```

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