

Age depth modelling and EPD chronologies

EPD chronologies:

Go to PANGAEA <https://www.pangaea.de/> and search for “EPD Ages” and you should find: Validated sample ages from 823 EPD sites. doi:10.1594/PANGAEA.804597.

Have a look at the different datasets and download EPDAgeCut. You can open it in Excel as tab-delimited and delete the first 842 rows.

ID numbers are easy to confuse and the EPD is using a unique identifier “Sigle” here “Event”. To locate a site it may be easiest to look it up in Table 2 Entity. This table is shorter so all of it is displayed in PANGAEA. Here we can search for a site name e.g. my master thesis site Großer Treppensee (just search for “Treppel”). You find some metadata for that site and see that the Sigle is TREPPEL, so we can find it in Excel, copy and paste it into a new sheet and make an age depth model.

Starting Clam:

Set the “Clam” folder as your working directory when using clam as the calibration function is looking for the calibration curve that is in the same folder.

```
> setwd("path to clam ../clam") # set the path or navigate and set it to working directory
> source("clam.R")
```

To calibrate a single date in Clam you type e.g.:

```
> calibrate(5875, 35) # the first number is the age and the second the error
```

By default, you will use the northern hemisphere terrestrial curve IntCal13.14C (cc=1) from Reimer et al. (2013) and ages for the 95% confidence intervals will be calculated. You can change that e.g. using the southern Hemisphere and 68% confidence intervals:

```
> calibrate(5875, 35, cc=2, prob=0.68)
```

Clam will plot the full probability but forget the data unless you specify “storedat=TRUE”

```
> calibrate(5875, 35, storedat=TRUE)
```

This produces a list with the name “dat”. If we are only interested in the description of the probability distribution for the date, we can extract that by:

```
> date1<-dat$calib
```

Let’s first look at the data we extracted:

```
> plot(date1)
```

Now let’s explore how different measures describe this dates. The weighted average can be calculated by multiplying the probability of each year with the numerical value of the year and sum over all years:

```
> w.av=sum(date1[,1]* date1[,2])
```

```
> abline(v=w.av)
```

The classical intercept is the year with the highest probability:

```
> t<-which(date1[,2] == max(date1[,2]))
```

```
> abline(v= date1[t,1], col="red")
```

To find the midpoint of the 95% cal age range, we first need to define the range:

```
> pp<-cumsum(date1[,2])
```

```
> pl<-which(pp > 0.025 & pp < 0.975)
```

```
> abline(v= date1[median(pl),], col='green')
```

Calib can also handle postbomb dates. If these are reported as percentage modern carbon (pMC) or F14C (normalised to 1) they need to be converted back to a radiocarbon date. E.g.:

```
> pMC.age(143.45, 0.37)
```

```
[1] -2898 21
```

Now that date can be calibrated, which need to have a calibration curve specified:

```
> calibrate(-2898, 21, postbomb=1)
```

Age depth modelling with CLAM

Inside the “Clam” folder you find a folder called “Cores” which has already some examples inside. Create another folder within “Cores” and name it “treppel”. Move the files treppel.csv and treppel_depth.txt into that folder and look at the files.

```
> clam("treppel", type=4, smooth=0.1) # creates a model for Großer Treppelsee using a smoothing spline with a smoothing parameter of 0.1
```

Look at the data in the core folder required to run Clam and at the different output files.

How do you get the estimated ages? There is a text file with ages provided but clam is not using it. How can you tell clam to use these ages? Run different age models for the Treppelsee data set and note down the different ages for the depth 1785 cm. How do they differ? What happens if you assume a hiatus at a depth of 1785 cm.

```
> clam("treppel", type=4, smooth=0.3, hiatus=1785, depths.file=TRUE)
```

Try also to remove individual dates which you suspect to be outliers and explore how you can deal with a slump.

```
> clam("treppel", type=4, smooth=0.3, outliers=c(6,7), slump=c(100, 200, 900, 950), depths.file=TRUE)
```

You can also include modern dates into your age model. Create an age depth model given the below dates:

14C age	% modern	error	depth
	106	0.5	5
	117	0.5	12
	115	0.4	17
184		30	22
253		30	30

Convert the ages reported as % modern carbon to a negative radiocarbon age and create a new folder with ‘*.csv’ file in the cores folder and run it.

```
> clam("post", postbomb=1, type=4)
```

Try with your own data or get some from the web.

Oxcal

You can download Oxcal and run it on your computer, but if your computer is slow some tasks may run a long time and can slow your computer. Running it online provides the same functionality and may thus be more convenient.

Online or on your computer take calibrate a few radiocarbon dates and explore the graphical outputs

In Oxcal on the left panel press “File>>New”. To enter the dates for calibration click on the “Insert” item in the left hand pane and you will be prompted for the details of a date to be entered. When you have entered these details press the button in the upper right corner. Again explore the different output options.

Now start Bayesian and try a Uniform Phase Model (example from Ramsey 2009; RADIOCARBON 51, 337–360):

The dates are for antlers used to dig the main enclosure ditch at Stonehenge. The assumption here is that the construction is dated by the upper boundary “E” of all ages as the antlers are most likely just predating this event, some possibly being somewhat older. An exponential distribution has been assumed with an unknown time constant τ , which is estimated in the analysis.

You can enter the below information as before using “Insert” and the drop down menu to find the terms and enter the dates or you can click the fourth button above the right panel and enter the script directly into the yellow box.

```
Plot()
{
Sequence("Stonehenge")
{
Tau_Boundary("T");
Phase("ditch antlers")
{
R_Date("UB-3788", 4381, 18);
R_Date("UB-3787", 4375, 19);
R_Date("UB-3789", 4330, 18);
R_Date("UB-3790", 4367, 18);
R_Date("UB-3792", 4365, 18);
R_Date("UB-3793", 4393, 18);
R_Date("UB-3794", 4432, 22);
R_Date("BM-1583", 4410, 60);
R_Date("BM-1617", 4390, 60);
};
Boundary("E");
};
Tau=E-T;
};
```

Oxcal age-depth

Oxcal is also able to do age depth models. Under: File>>New >> Tools>>Models>>Deposition model

You can use the tools to help enter your data and prepare a table in Excel with a set of radiocarbon dates (e.g. from Treppelsee) in the format with the youngest sample on top and the oldest on the bottom:

Name age error depth

Paste the cells from Excel into the yellow box. Check the box for the Poisson deposition review the parameters and change them if necessary. Press >> beside Deposition models to copy your data over and continue editing the code manually, which I find easiest in the yellow box, which you get by pressing the fourth button above the main panel.

The “Interpolation rate” parameter will calculate ages for these intervals throughout the core which can be retrieved later. Note that the unit is 1/depth so if your depth is in centimetres and you want a sample every 50 cm set the parameter to 0.02. You can also put in specific depth for which you want to know the age e.g. 440 cm or 1785 cm. If you have some information on the possible oldest and youngest ages you should add that to the boundary information and/or add samples at the bottom or top: Boundary("Bottom", U(-11000,-10500)) in combination with a depth for the lowest sample. I often have trouble with entering data in OxCal using the program facilities and find it easier to copy past the CQL code:

```
Plot()
{
P_Sequence("P", 1, 0.01, U(-2,2))
{
Boundary("Bottom", U(-11000,-10500));
Date("Low_Sample")
{
z=2550;
};
R_Date("KIA6965",9692,75)
{
z=2389;
};
R_Date("KIA6964",7837,54)
{
z=2222;
};
R_Date("KIA6963",6868,39)
{
z=2142.1;
};
Date("D")
{
z=1785;
};
R_Date("KIA6960",2861,36)
{
z=1450;
};
Date("E")
{
z=440;
};
R_Date("KIA6962",758,39)
{
z=439;
```

```

};
Date("F")
{
z=410;
};
R_Date("KIA6961",485,40)
{
z=395;
};
Boundary("Top",N(1995,5))
{
z=0;
};
};
};
};

```

Explore the different outputs. First look at the “Depth plot” and “Multiple plot”, where you can zoom in and investigate if the modelled probability distribution is any different from the original calibration. Inspect the Table. In the previous to the last column you can select individual dates that you want to investigate in the “Multiple plot”. Note that also ages have been produced for the dates that we specified as well as for depth at specified intervals. If you click on the symbol in the second column you will be able to download the data. You have the option to save a *.csv file to your computer or copy and paste directly.

If you are running this on the server, it may take some time and you could jump ahead and try Bacon while you wait for your results. Experiment by changing parameters like the variation of k to $U(-1,1.6)$ which together with $k_0=1$ means that we allow between 40 events (years) per 1 cm and 10 cm deposition in one event (year). This is a reasonable assumption since no slumps were detected while we have a relatively high sedimentation rate throughout.

Bacon

As with Clam, get Bacon from the same website and put the folder named “treppel” into the folder “Cores”. Bacon reads the input from a “.csv” file which has a similar structure to the “.csv” file used in Clam. Open an example file and create one for Großer Treppelsee.

Note: Bacon creates complex plots and changes the settings. In order to be able to get back to a default setting save the default before by typing `> op <- par(no.readonly = TRUE)` and use `par(op)` to reset it.

Run the Treppelsee core in Bacon by typing:

```
> Bacon("treppel", 100 acc.mean=10)
```

The core is very long so the number “100” indicates the thickness of a section gives a high number of steps – you can try lower numbers (e.g. 50) but do not get too low as Bacon will run for a long time. The second input gives a starting point for Bacon to try different accumulation rates. You find this plotted in the monitor as well as a resulting distribution of variables used by Bacon. You can and should change the priors and explore the effect. I always prefer to see age-depth plots the other way around. Bacon has options to change the graphical display:

```
> Bacon("treppel", 100, acc.mean=5, depths.file=TRUE, rotate.axes=TRUE, rev.yr=TRUE,
yr.max=13500)
```

You can now also display the sediment accumulation rate of the core by age or depth (use `par(op)` to reset plot default):

```
> plot.accrate.age()
```

You can obtain the probability distribution of the age for a particular depth (e.g. 1785) by:

```
> Bacon.hist (1785)
```

The data or better all MCMC-derived ages for a given depth can be obtained by:

```
> ages.d1785 = Bacon.Age.d(1785)
```

Have a look what you got there:

```
> hist(ages.d1785, breaks = 50)
```

Remember that we inserted the same depth in the QxCal model and we can copy the probability distribution for that depth in OxCal and past it into 'R' using the following function:

```
> x<-read.table("clipboard", sep="\t") # when executed this function reads the data on the clipboard into the variable "x" and assumes that the data on the clipboard is tab separated.
```

Have a look if the data is there:

```
> head(x)
```

If the last thing you did was to run Bacon you can compare the modelled age for depth 1785:

```
> par(mfrow=c(2, 1)) # sets up the plot as two panels
```

```
> Bacon.hist (1785, xlim=c(3000, 7000))
```

```
> plot(abs(x[,1])+1950,x[,2], type="l" , xlim=c(3000, 7000)) # remember Oxcal works in AD/BC as default so we add 1950
```

Try the same for the age of the depth 440 cm. Here we are also really interested in understanding the age probabilities of that depth since it documents a major clearance event around the lake and we know that a monastery was founded in the area in the year 1268.

In the original folder I supplied pollen proportions for selected taxa in the file `treppel_proxies.csv`. With a file `*_proxies.csv` is present BACON can produce 'proxy-ghost' graphs against calendar time while taking into account chronological uncertainties, e.g. to illustrate the uncertainty for the timing of the *Ulmus* decline:

```
> proxy.ghost(4)
```

At least on my computer I am having problems when using all other options with `proxy.ghost()` under 'R-Studio' and if you want to explore further you need to switch to basic 'R'. At this point you may also add another date since we know that the 30 years' war was devastating and we find this reflected in the NAP curve with a dip at 270 cm = 310 cal. BP. Now run Bacon under 'R' and try

```
> proxy.ghost(5, proxy.res=200, rotate.axes=TRUE, yr.res=2000, rev.yr=TRUE, yr.lim=c(-50,1000))
```

Bchron (*extra activity*)

Bchron already comes as an R package so you can install it by going to install Packages in R or Rstudio and type "Bchron".

Once it is installed and the library loaded type:

```
> help(Bchron) # explore the help file and run the examples. Prepare a new dataset according to the example and run it.
```