
```
title: "Dendrochronology in R"
author: "Jeff Atkins"
date: 'r format(Sys.time(), "%B %d, %Y)"
output:
word_document: default
pdf_document: default
html_document: default
```

Working with ring-width data

dplR version 1.7.2 is available on CRAN

Here we show how to import tree-ring data.

We are using data downloaded from the NOAA XXXX, specifically the Cook - Kelsey Tract TSCA-ITRDB NC005 [url - <https://www.ncdc.noaa.gov/paleo-search/study/2987?siteId=15463>]

Installation of dplR

```
# install the package if not already installed and call it via library()
if(!require(dplR)){install.packages("dplR")}

## Loading required package: dplR

library(dplR)
library(tidyverse)

## -- Attaching packages ----- tidyverse 1.3.1 --

## v ggplot2 3.3.5     v purrr   0.3.4
## v tibble  3.1.3     v dplyr    1.0.7
## v tidyr   1.1.3     v stringr  1.4.0
## v readr   2.0.0     vforcats 0.5.1

## -- Conflicts ----- tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()   masks stats::lag()
```

Importing ring-width data

The vignette included with dplR provides a thorough walkthrough (<https://cran.r-project.org/web/packages/dplR/vignettes/intro-dplR.pdf>) here we show some highlights based on the independent dataset we have downloaded.

```
## Attempting to automatically detect format.
## Assuming a Tucson format file.
## There does not appear to be a header in the rwl file
## There are 31 series
```

```

## 1      102061    1653    1983   0.01
## 2      102062    1649    1983   0.01
## 3      102081    1707    1983   0.01
## 4      102101    1634    1983   0.01
## 5      102102    1637    1983   0.01
## 6      102121    1675    1976   0.01
## 7      102141    1638    1983   0.01
## 8      102142    1665    1983   0.01
## 9      102171    1623    1983   0.01
## 10     102172    1654    1983   0.01
## 11     102181    1695    1983   0.01
## 12     102182    1684    1983   0.01
## 13     102241    1654    1983   0.01
## 14     102261    1694    1983   0.01
## 15     102271    1737    1983   0.01
## 16     102272    1678    1983   0.01
## 17     102291    1594    1983   0.01
## 18     102292    1594    1983   0.01
## 19     102301    1673    1932   0.01
## 20     102302    1628    1977   0.01
## 21     102311    1623    1983   0.01
## 22     102312    1645    1983   0.01
## 23     102321    1689    1983   0.01
## 24     102322    1738    1983   0.01
## 25     102341    1560    1983   0.01
## 26     102342    1573    1983   0.01
## 27     102431    1692    1983   0.01
## 28     102432    1663    1983   0.01
## 29     102451    1617    1983   0.01
## 30     102452    1581    1983   0.01
## 31     102491    1612    1983   0.01

## [1] 424 31

## [1] "rwl"       "data.frame"

```

Data descriptions

dplR has a function, `rw.report()` that provides a fairly detailed description of the data set(s) you are working with.

```

## Number of dated series: 31
## Number of measurements: 10281
## Avg series length: 331.6452
## Range: 424
## Span: 1560 - 1983
## Mean (Std dev) series intercorrelation: 0.5316996 (0.05975429)
## Mean (Std dev) AR1: 0.8697419 (0.04867715)
## -----
## Years with absent rings listed by series
##   Series 102182 -- 1877 1888
##   Series 102291 -- 1644

```

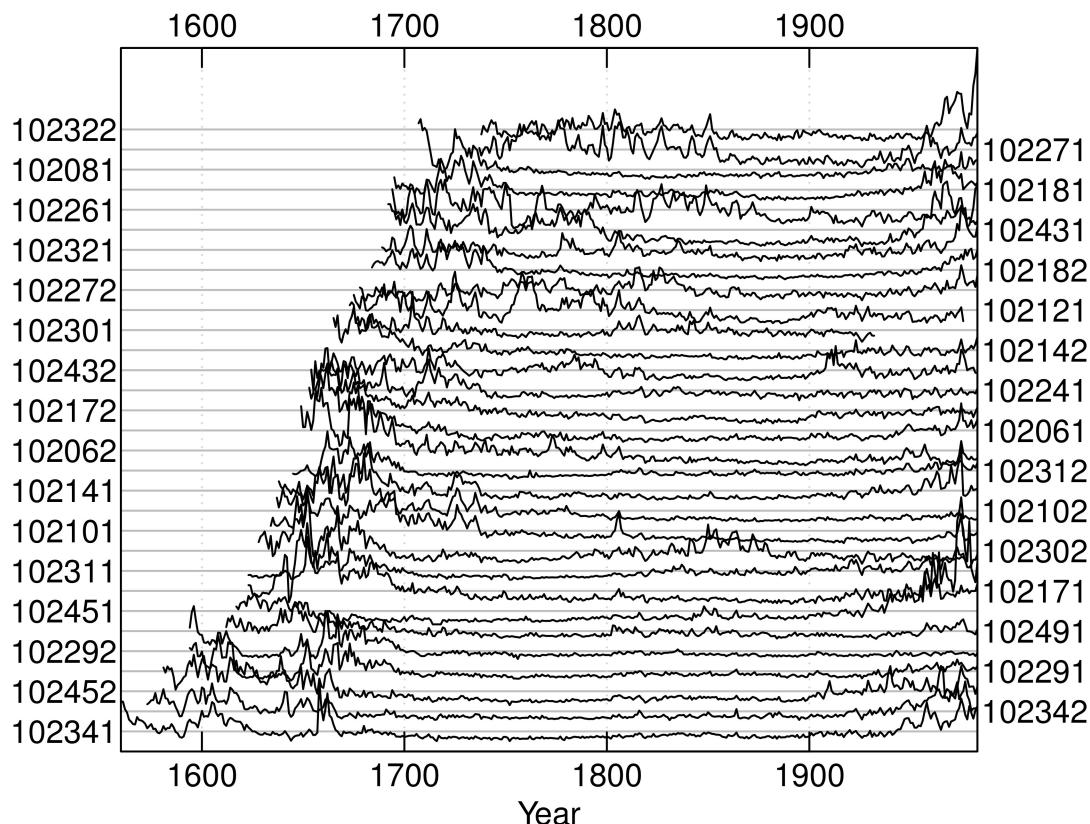
```

##      Series 102292 -- 1756
##      Series 102311 -- 1752 1753
##      Series 102312 -- 1752 1753
##      Series 102321 -- 1876
##      Series 102341 -- 1716 1752
##      Series 102451 -- 1714 1715 1716 1717 1718
##      Series 102452 -- 1752
## 17 absent rings (0.165%)
## -----
## Years with internal NA values listed by series
##     None

```

Plotting data (Spaghetti Plots)

We can now plot these data.



Note that the `echo = FALSE` parameter was added to the code chunk to prevent printing of the R code that generated the plot.

Detrending

```

## Detrending example, albeit brief.
rw.detrend <- detrend(rwl = rw, method = "ModNegExp", verbose = TRUE)

```

```

## Verbose output: 102061
##
## Options
## make.plot      FALSE
## method(s)     "ModNegExp"
## nyrs          NULL
## f              0.5
## pos.slope     FALSE
## constrain.nls never
## verbose       TRUE
## return.info   FALSE
## wt             default
## span           cv
## bass           0
## difference    FALSE
##
## ~~~~~
## No zeros in input series.
##
## ~~~~~
## Detrend by ModNegExp.
## Trying to fit nls model...
## nls coefs
## a:  3.44413903
## b: -0.03434367
## k:  0.44902961
## Verbose output: 102062
##
## Options
## make.plot      FALSE
## method(s)     "ModNegExp"
## nyrs          NULL
## f              0.5
## pos.slope     FALSE
## constrain.nls never
## verbose       TRUE
## return.info   FALSE
## wt             default
## span           cv
## bass           0
## difference    FALSE
##
## ~~~~~
## No zeros in input series.
##
## ~~~~~
## Detrend by ModNegExp.
## Trying to fit nls model...
## nls coefs
## a:  2.82001527
## b: -0.01668015
## k:  0.46014773
## Verbose output: 102081
##

```

```

## Options
## make.plot      FALSE
## method(s)      "ModNegExp"
## nyrs           NULL
## f              0.5
## pos.slope      FALSE
## constrain.nls never
## verbose        TRUE
## return.info   FALSE
## wt             default
## span           cv
## bass           0
## difference    FALSE
##
## -----
## No zeros in input series.
##
## -----
## Detrend by ModNegExp.
## Trying to fit nls model...
## nls coefs
## a:  2.02801478
## b: -0.04568062
## k:  0.34733182
## Verbose output: 102101
##
## -----
## Options
## make.plot      FALSE
## method(s)      "ModNegExp"
## nyrs           NULL
## f              0.5
## pos.slope      FALSE
## constrain.nls never
## verbose        TRUE
## return.info   FALSE
## wt             default
## span           cv
## bass           0
## difference    FALSE
##
## -----
## No zeros in input series.
##
## -----
## Detrend by ModNegExp.
## Trying to fit nls model...
## nls coefs
## a:  1.877257142
## b: -0.007058882
## k:  0.043304971
## Verbose output: 102102
##
## -----
## Options
## make.plot      FALSE

```

```

##  method(s)      "ModNegExp"
##  nyrs          NULL
##  f              0.5
##  pos.slope     FALSE
##  constrain.nls never
##  verbose       TRUE
##  return.info   FALSE
##  wt             default
##  span           cv
##  bass            0
##  difference    FALSE
##
## ~~~~~
## No zeros in input series.
##
## ~~~~~
## Detrend by ModNegExp.
## Trying to fit nls model...
## nls coefs
## a:  1.98975444
## b: -0.01029991
## k:  0.08925286
## Verbose output: 102121
##
## ~~~~~
## Options
## make.plot     FALSE
## method(s)      "ModNegExp"
## nyrs          NULL
## f              0.5
## pos.slope     FALSE
## constrain.nls never
## verbose       TRUE
## return.info   FALSE
## wt             default
## span           cv
## bass            0
## difference    FALSE
##
## ~~~~~
## No zeros in input series.
##
## ~~~~~
## Detrend by ModNegExp.
## Trying to fit nls model...
## nls coefs
## a:  2.368258903
## b: -0.001827476
## k: -0.856734422
## Verbose output: 102141
##
## ~~~~~
## Options
## make.plot     FALSE
## method(s)      "ModNegExp"
## nyrs          NULL

```

```

## f           0.5
## pos.slope   FALSE
## constrain.nls never
## verbose     TRUE
## return.info FALSE
## wt          default
## span        cv
## bass        0
## difference  FALSE
##
## -----
## No zeros in input series.
##
## -----
## Detrend by ModNegExp.
## Trying to fit nls model...
## nls coefs
## a:  0.8676739
## b: -0.0139668
## k:  0.3768793
## Verbose output: 102142
## -----
## Options
## make.plot   FALSE
## method(s)   "ModNegExp"
## nyrs        NULL
## f           0.5
## pos.slope   FALSE
## constrain.nls never
## verbose     TRUE
## return.info FALSE
## wt          default
## span        cv
## bass        0
## difference  FALSE
##
## -----
## No zeros in input series.
##
## -----
## Detrend by ModNegExp.
## Trying to fit nls model...
## nls coefs
## a:  1.83194012
## b: -0.02752817
## k:  0.31690910
## Verbose output: 102171
## -----
## Options
## make.plot   FALSE
## method(s)   "ModNegExp"
## nyrs        NULL
## f           0.5
## pos.slope   FALSE

```

```

## constrain.nls never
## verbose      TRUE
## return.info FALSE
## wt           default
## span         cv
## bass         0
## difference  FALSE
##
## ~~~~~
## No zeros in input series.
##
## ~~~~~
## Detrend by ModNegExp.
## Trying to fit nls model...
## nls coefs
## a: 1.77511561
## b: -0.01150277
## k: 0.39930169
## Verbose output: 102172
##
## ~~~~~
## Options
## make.plot    FALSE
## method(s)    "ModNegExp"
## nyrs        NULL
## f            0.5
## pos.slope   FALSE
## constrain.nls never
## verbose      TRUE
## return.info FALSE
## wt           default
## span         cv
## bass         0
## difference  FALSE
##
## ~~~~~
## No zeros in input series.
##
## ~~~~~
## Detrend by ModNegExp.
## Trying to fit nls model...
## nls coefs
## a: 2.47420695
## b: -0.02358822
## k: 0.44310224
## Verbose output: 102181
##
## ~~~~~
## Options
## make.plot    FALSE
## method(s)    "ModNegExp"
## nyrs        NULL
## f            0.5
## pos.slope   FALSE
## constrain.nls never
## verbose      TRUE

```

```

##  return.info      FALSE
##  wt              default
##  span            cv
##  bass            0
##  difference     FALSE
##
## -----
## No zeros in input series.
##
## -----
## Detrend by ModNegExp.
## Trying to fit nls model...
## nls coefs
## a:  0.77170590
## b: -0.02142554
## k:  0.41657207
## Verbose output: 102182
##
## -----
## Options
## make.plot      FALSE
## method(s)      "ModNegExp"
## nyrs           NULL
## f               0.5
## pos.slope      FALSE
## constrain.nls never
## verbose        TRUE
## return.info    FALSE
## wt              default
## span            cv
## bass            0
## difference     FALSE
##
## -----
## Zero indices in input series:
## 318 329
##
## -----
## Detrend by ModNegExp.
## Trying to fit nls model...
## nls coefs
## a:  1.02193357
## b: -0.01735269
## k:  0.27466582
## Verbose output: 102241
##
## -----
## Options
## make.plot      FALSE
## method(s)      "ModNegExp"
## nyrs           NULL
## f               0.5
## pos.slope      FALSE
## constrain.nls never
## verbose        TRUE
## return.info    FALSE

```

```

## wt           default
## span         cv
## bass         0
## difference   FALSE
##
## ~~~~~
## No zeros in input series.
##
## ~~~~~
## Detrend by ModNegExp.
## Trying to fit nls model...
## nls coefs
## a: 1.21881979
## b: -0.01844401
## k: 0.50931582
## Verbose output: 102261
##
## Options
## make.plot    FALSE
## method(s)    "ModNegExp"
## nyrs         NULL
## f             0.5
## pos.slope    FALSE
## constrain.nls never
## verbose       TRUE
## return.info   FALSE
## wt            default
## span          cv
## bass          0
## difference    FALSE
##
## ~~~~~
## No zeros in input series.
##
## ~~~~~
## Detrend by ModNegExp.
## Trying to fit nls model...
## nls failed... fitting linear model... Linear model fit
## Intercept: 1.510529
## Slope: -0.003410913
## Verbose output: 102271
##
## Options
## make.plot    FALSE
## method(s)    "ModNegExp"
## nyrs         NULL
## f             0.5
## pos.slope    FALSE
## constrain.nls never
## verbose       TRUE
## return.info   FALSE
## wt            default
## span          cv
## bass          0

```

```

## difference      FALSE
##
## -----
## No zeros in input series.
##
## -----
## Detrend by ModNegExp.
## Trying to fit nls model...
## nls coefs
## a:  1.12591921
## b: -0.01085169
## k:  0.83246748
## Verbose output: 102272
##
## -----
## Options
## make.plot      FALSE
## method(s)      "ModNegExp"
## nyrs           NULL
## f               0.5
## pos.slope      FALSE
## constrain.nls never
## verbose        TRUE
## return.info    FALSE
## wt              default
## span            cv
## bass            0
## difference     FALSE
##
## -----
## No zeros in input series.
##
## -----
## Detrend by ModNegExp.
## Trying to fit nls model...
## nls failed... fitting linear model... Linear model fit
## Intercept: 0.6787952
## Slope: 0.0001062071
## lm has a positive slope
## pos.slope = FALSE
## Detrend by mean.
## Mean = 0.695098
## Verbose output: 102291
##
## -----
## Options
## make.plot      FALSE
## method(s)      "ModNegExp"
## nyrs           NULL
## f               0.5
## pos.slope      FALSE
## constrain.nls never
## verbose        TRUE
## return.info    FALSE
## wt              default
## span            cv

```

```

## bass      0
## difference FALSE
##
## ~~~~~
## Zero indices in input series:
## 85
##
## ~~~~~
## Detrend by ModNegExp.
## Trying to fit nls model...
## nls coefs
## a: 0.98465235
## b: -0.02122522
## k: 0.34636554
## Verbose output: 102292
##
## ~~~~~
## Options
## make.plot FALSE
## method(s) "ModNegExp"
## nyrs NULL
## f 0.5
## pos.slope FALSE
## constrain.nls never
## verbose TRUE
## return.info FALSE
## wt default
## span cv
## bass 0
## difference FALSE
##
## ~~~~~
## Zero indices in input series:
## 197
##
## ~~~~~
## Detrend by ModNegExp.
## Trying to fit nls model...
## nls coefs
## a: 0.89227265
## b: -0.01100944
## k: 0.18795069
## Verbose output: 102301
##
## ~~~~~
## Options
## make.plot FALSE
## method(s) "ModNegExp"
## nyrs NULL
## f 0.5
## pos.slope FALSE
## constrain.nls never
## verbose TRUE
## return.info FALSE
## wt default
## span cv

```

```

##  bass      0
##  difference FALSE
##
## ~~~~~
## No zeros in input series.
##
## ~~~~~
## Detrend by ModNegExp.
## Trying to fit nls model...
## nls coefs
## a:  0.98013439
## b: -0.03880089
## k:  0.57402812
## Verbose output: 102302
## ~~~~~
## Options
## make.plot    FALSE
## method(s)    "ModNegExp"
## nyrs         NULL
## f            0.5
## pos.slope    FALSE
## constrain.nls never
## verbose      TRUE
## return.info  FALSE
## wt           default
## span         cv
## bass         0
## difference   FALSE
##
## ~~~~~
## No zeros in input series.
##
## ~~~~~
## Detrend by ModNegExp.
## Trying to fit nls model...
## nls failed... fitting linear model... Linear model fit
## Intercept: 1.224673
## Slope: -0.002383974
## Verbose output: 102311
## ~~~~~
## Options
## make.plot    FALSE
## method(s)    "ModNegExp"
## nyrs         NULL
## f            0.5
## pos.slope    FALSE
## constrain.nls never
## verbose      TRUE
## return.info  FALSE
## wt           default
## span         cv
## bass         0
## difference   FALSE
##

```

```

## ~~~~~
## Zero indices in input series:
## 193 194
##
## ~~~~~
## Detrend by ModNegExp.
## Trying to fit nls model...
## nls failed... fitting linear model... Linear model fit
## Intercept: 0.2906381
## Slope: 0.0008129911
## lm has a positive slope
## pos.slope = FALSE
## Detrend by mean.
## Mean = 0.4377895
## Verbose output: 102312
##
## Options
## make.plot      FALSE
## method(s)      "ModNegExp"
## nyrs           NULL
## f               0.5
## pos.slope      FALSE
## constrain.nls never
## verbose        TRUE
## return.info    FALSE
## wt              default
## span            cv
## bass            0
## difference     FALSE
##
## ~~~~~
## Zero indices in input series:
## 193 194
##
## ~~~~~
## Detrend by ModNegExp.
## Trying to fit nls model...
## nls coefs
## a:  0.81473188
## b: -0.02042174
## k:  0.28838224
## Verbose output: 102321
##
## Options
## make.plot      FALSE
## method(s)      "ModNegExp"
## nyrs           NULL
## f               0.5
## pos.slope      FALSE
## constrain.nls never
## verbose        TRUE
## return.info    FALSE
## wt              default
## span            cv

```

```

## bass          0
## difference    FALSE
##
## ~~~~~
## Zero indices in input series:
## 317
##
## ~~~~~
## Detrend by ModNegExp.
## Trying to fit nls model...
## nls coefs
## a: 0.38350175
## b: -0.03208014
## k: 0.52453774
## Verbose output: 102322
##
## ~~~~~
## Options
## make.plot    FALSE
## method(s)    "ModNegExp"
## nyrs         NULL
## f             0.5
## pos.slope     FALSE
## constrain.nls never
## verbose       TRUE
## return.info   FALSE
## wt            default
## span          cv
## bass          0
## difference    FALSE
##
## ~~~~~
## No zeros in input series.
##
## ~~~~~
## Detrend by ModNegExp.
## Trying to fit nls model...
## nls failed... fitting linear model... Linear model fit
## Intercept: 0.5473924
## Slope: 0.00080779
## lm has a positive slope
## pos.slope = FALSE
## Detrend by mean.
## Mean = 0.6471545
## Verbose output: 102341
##
## ~~~~~
## Options
## make.plot    FALSE
## method(s)    "ModNegExp"
## nyrs         NULL
## f             0.5
## pos.slope     FALSE
## constrain.nls never
## verbose       TRUE
## return.info   FALSE

```

```

##  wt           default
##  span          cv
##  bass          0
##  difference   FALSE
##
## ~~~~~
## Zero indices in input series:
## 157 193
##
## ~~~~~
## Detrend by ModNegExp.
## Trying to fit nls model...
## nls coefs
## a:  0.87817024
## b: -0.02076663
## k:  0.38438272
## Verbose output: 102342
##
## Options
## make.plot    FALSE
## method(s)    "ModNegExp"
## nyrs         NULL
## f             0.5
## pos.slope    FALSE
## constrain.nls never
## verbose      TRUE
## return.info  FALSE
## wt           default
## span          cv
## bass          0
## difference   FALSE
##
## ~~~~~
## No zeros in input series.
##
## ~~~~~
## Detrend by ModNegExp.
## Trying to fit nls model...
## nls coefs
## a:  1.008153
## b: -0.020637
## k:  0.398493
## Verbose output: 102431
##
## Options
## make.plot    FALSE
## method(s)    "ModNegExp"
## nyrs         NULL
## f             0.5
## pos.slope    FALSE
## constrain.nls never
## verbose      TRUE
## return.info  FALSE
## wt           default

```

```

##   span          cv
##   bass          0
##   difference    FALSE
##
## ~~~~~
## No zeros in input series.
##
## ~~~~~
## Detrend by ModNegExp.
## Trying to fit nls model...
## nls coefs
## a:  1.23895466
## b: -0.02085683
## k:  0.71092005
## Verbose output: 102432
##
## ~~~~~
## Options
## make.plot    FALSE
## method(s)     "ModNegExp"
## nyrs         NULL
## f            0.5
## pos.slope    FALSE
## constrain.nls never
## verbose      TRUE
## return.info  FALSE
## wt           default
## span          cv
## bass          0
## difference   FALSE
##
## ~~~~~
## No zeros in input series.
##
## ~~~~~
## Detrend by ModNegExp.
## Trying to fit nls model...
## nls coefs
## a:  0.60218879
## b: -0.01295955
## k:  0.53169545
## Verbose output: 102451
##
## ~~~~~
## Options
## make.plot    FALSE
## method(s)     "ModNegExp"
## nyrs         NULL
## f            0.5
## pos.slope    FALSE
## constrain.nls never
## verbose      TRUE
## return.info  FALSE
## wt           default
## span          cv
## bass          0

```

```

## difference      FALSE
##
## -----
## Zero indices in input series:
## 155 156 157 158 159
##
## -----
## Detrend by ModNegExp.
## Trying to fit nls model...
## nls coefs
## a:  0.75585309
## b: -0.06015716
## k:  0.63053197
## Verbose output: 102452
## -----
## Options
## make.plot      FALSE
## method(s)      "ModNegExp"
## nyrs           NULL
## f               0.5
## pos.slope      FALSE
## constrain.nls never
## verbose        TRUE
## return.info    FALSE
## wt              default
## span            cv
## bass            0
## difference     FALSE
##
## -----
## Zero indices in input series:
## 193
##
## -----
## Detrend by ModNegExp.
## Trying to fit nls model...
## nls coefs
## a:  1.83274980
## b: -0.01756686
## k:  0.43457031
## Verbose output: 102491
## -----
## Options
## make.plot      FALSE
## method(s)      "ModNegExp"
## nyrs           NULL
## f               0.5
## pos.slope      FALSE
## constrain.nls never
## verbose        TRUE
## return.info    FALSE
## wt              default
## span            cv
## bass            0

```

```

## difference      FALSE
##
## -----
## No zeros in input series.
##
## -----
## Detrend by ModNegExp.
## Trying to fit nls model...
## nls failed... fitting linear model... Linear model fit
## Intercept: 0.6962061
## Slope: -0.001302699

# we can look at the col names of the new object
names(rw.detrend)

## [1] "102061" "102062" "102081" "102101" "102102" "102121" "102141" "102142"
## [9] "102171" "102172" "102181" "102182" "102241" "102261" "102271" "102272"
## [17] "102291" "102292" "102301" "102302" "102311" "102312" "102321" "102322"
## [25] "102341" "102342" "102431" "102432" "102451" "102452" "102491"

# and we can look at the means of those individuals
colMeans(rw.detrend, na.rm=TRUE)

##    102061    102062    102081    102101    102102    102121    102141    102142
## 1.0046278 1.0021507 0.9977224 1.0407909 1.0610862 1.0023233 0.9996141 1.0014092
##    102171    102172    102181    102182    102241    102261    102271    102272
## 1.0108265 1.0001056 0.9977949 1.0038460 0.9997856 1.0000540 0.9998278 1.0000000
##    102291    102292    102301    102302    102311    102312    102321    102322
## 0.9979854 0.9990962 0.9996780 1.0112870 1.0000000 1.0007899 0.9996691 1.0000000
##    102341    102342    102431    102432    102451    102452    102491
## 0.9979342 0.9979640 0.9982441 0.9994659 0.9992464 1.0024558 1.0383337

```

Building a Chronology

A chronology can be built from the detrended data.

```

rw.crn <- chron(rw.detrend, prefix = "CAM")

# now we can plot these data
plot(rw.crn, add.spline=TRUE, nyrs=20)

```

