Description of International Tree Ring Data Bank (ITRDB) Data Files and Procedures

Contents

I. Site Selection and Sample Collection

Tree ring samples are collected in the field by using a hand-held increment borer to remove a cylinder of wood roughly 5mm in diameter along the radius of a tree. The investigator selects the site in order to maximize a particular signal. For example, a steep, rocky, south facing slope may be selected to find trees under maximum water stress, such that growth rates can become a strong proxy for precipitation. Therefore, it is essential to be familiar with the characteristics of the site, as well as the factors regulating tree growth, in order to correctly interpret the results. For reliable statistical analysis, a rule of thumb is 20 trees per site, but this will vary according to the strength of the climate signal in the trees and the purpose of the collection. Two samples are generally collected per tree to facilitate cross-correlation and accurate dating of the annual rings.

The samples are returned to the laboratory, where they are mounted and finely sanded to allow cross-dating and measurement of the widths of the annual rings. In some cases, wood density is also measured, which may provide a more reliable growth signal and additional information. The ring widths are measured to the nearest 0.01mm or .001mm and recorded in computerized data files.

A statistical evaluation of the cross-dating has been conducted for most ITRDB sites using the COFECHA program contained in the ITRDB Program Library available from the University of

Arizona Laboratory of Tree-Ring Research. The output is contained in "additional information" text files named SITECODE*.txt, located in https://www.ncei.noaa.gov/pub/data/paleo/treering/measurements/correlation-stats/. All data must pass minimum COFECHA thresholds of less than 40% "problem segments", and greater than 0.35 Mean Series Intercorrelation in order to be included in the ITRDB.

Note: In the Southern Hemisphere, all collections are dated such that the calendar year represents the year in which tree growth began.

II. Standardization

The raw ring width data from the samples collected at one site are standardized and the results are averaged into a site chronology. The standardization process involves fitting a curve to the ring-width series, and then dividing each ring-width value by the corresponding curve value (or calculating the difference between the ring-width values and the curve value) to generate a series of growth indices. This process allows samples with large differences in growth rates to be combined, and can be used to remove any undesired growth trends present. For example, a typical sample might display exponentially declining growth with age, as a result of the increasing size of the trunk cylinder over time. Standardizing this sample using a negative exponential function results in data values which represent the departure from the "expected" value for a given year. The series of standardized growth indices is then used to interpret a proxy environmental signal in the data.

Many of the chronologies in the ITRDB were created with Program ARSTAN, developed by Dr. Edward R. Cook at the Tree-Ring Laboratory, Lamont-Doherty Earth Observatory of Columbia University, Palisades, New York (Cook 1985). Program ARSTAN produces chronologies from tree-ring measurement series by detrending and indexing (standardizing) the series, then applying a robust estimation of the mean value function to remove effects of endogenous stand disturbances. Three versions of the chronology are produced, intended to contain a maximum common signal and a minimum amount of noise. The standard chronology, designated sitecode.crn, is processed as above without autoregressive modeling. The residual ("whitened") chronology, designated sitecodeR.crn, is additionally processed using autoregressive modeling to remove autocorrelation. The third version, or ARSTAN chronology, designated sitecodeA.crn, is calculated by reincorporating the pooled autoregression (persistence) into the residual chronology.

The index values are unitless, with a nearly stable mean and variance, allowing indices from numerous trees to be averaged into a site chronology. The statistical methods for accomplishing the standardization can be complex. For a more complete discussion of methods, see References below.

The chronology represents the departure of growth for a given year vs. the series mean, and is expressed as a 3 or 4 digit integer with 1.000 (listed without the decimal point as 1000 or 100 in

the data files) representing the long term mean. Higher or lower values for a given year represent proportionally higher or lower tree growth for that year. A researcher can combine knowledge of the individual site and tree species to interpret the growth variations in terms of climate or other environmental factors.

The chronologies archived in the ITRDB are those computed by the original investigator. Chronologies are OPTIONAL for ITRDB contributors, and therefore are not included with every data set in the archive. This is because they are not measured raw data, but instead are standardized averages computed from the raw ring width data. Users may compute their own chronologies for any of the ITRDB raw measurements data. The raw measurements data are required for inclusion in the ITRDB, and all data must pass minimum COFECHA thresholds of less than 40% "problem segments" and greater than 0.35 Mean Series Intercorrelation.

III. Format for Tree-Ring Data Files

NOTE: From 2019 forward, NCEI Paleoclimatology has produced NOAA Template versions of the original "Tucson Decadal" format described below. The NOAA Template versions are text files with metadata headers over tab-delimited data columns. Filenames are SITECODE*-noaa.rwl or SITECODE*-noaa.crn, and contain the same data as the original Tucson decadal files named SITECODE*.rwl or SITECODE*.crn.

Raw Data Files (File Extension .rwl)

These are measurements in units of .01mm or .001mm of the thickness of tree ring width for each year. Each file consists of all the measurements for a given site. Fifty or more Core ID numbers and data series may comprise one (site) file. The end of record code is 999 (for 0.01 mm measurements) or -9999 (for 0.001 mm measurements). The 10 values following the decade are the 10 annual measurements for the 10 years of that decade. First and last decade rows for each core may contain less than 10 values.

Example .rwl file:

```
spp2_r 1 Sheep Pen Canyon                                          PIED
spp2_r 2 Colorado     Pinyon Pine       1580M +3704-10316          __     1837 1998
spp2_r 3 Connie A. Woodhouse and Peter M. Brown
spp011  1934   277   642   476   739  1065   903
spp011  1940  1060  2820  2496  2001  3026  2447  1546  2018  2386  2236
spp011  1950  1488  1701  1621  1175  2488  2890  2227  3342  3588  2593
spp011  1960  1494  1983  1812   978  1265  1808  1826  2288  2179  2676
spp011  1970  2605  3708  2327  1884  1575  1430  1334  1583  1054  1525
spp011  1980   930  1162  1525  1777  1736  1397  1350  1945  1019  1308
spp011  1990  1060   765  1657  1542  1454  1101   760  2717   825 -9999
```

Format for .rwl header records:

Line #	Column # and Description
1	1-6 Site ID, 10-61 Site Name, 62-65 Species Code, optional ID #'s
2	1-6 Site ID, 10-22 State/Country, 23-30 Species, 41-45 Elevation, 48-57 Lat-Long, 62-63 measurement type code*, 68-76 1st & last Year Note: lat-lons are in degrees and minutes, ddmm or dddmm
3	1-6 Site ID, 10-72 Investigators, 73-80 optional completion date

* If no measurement type code is listed, data are total ring width measurements. Otherwise, refer to Measurement Type Codes in Section V.

Format for .rwl data row:

Column #	Description
1-6	Core ID Number
9-12	Decade
13-73	Data Values, 6 columns per measurement, fortran format code: 10(I6)
74-78	Optional Site ID

Processed Data Files (Site Chronologies, File Extension .crn)

These are the standardized tree-growth indices from a stand of trees, representing the mean growth observed for each year over the entire stand. Site chronologies are used in climate analysis. Data are stored as 3 or 4-digit numbers, with a value of 1000 representing mean growth, a minimum value of 0 (no growth), and no defined maximum. There is only one time series per file, in contrast to the raw data files. Missing value code is 9990. Site information is stored in the first 3 records of the file.

Example .crn file:

```
CGD    1 Cienega de Nuestra Senora de Guadalupe              PIPO
CGD    2 Mexico       Ponderosa Pine    2000M  2504-10618    EA    1676 1993
CGD    3 Peter Fule
CGDARS16769990  09990  09990  09990  09990  09990  0 894  11155  11550  1 965  1
CGDARS1680 650  11424  1 418  1 806  11001  11003  1 635  11178  11222  1 566  1
CGDARS16901310  1 998  11860  11119  11380  1 947  1 452  11115  1 862  11270  1
CGDARS17001044  11189  1 844  11169  1 883  11136  11377  21407  21197  2 786  2
CGDARS17101533  21213  31187  3 638  31079  3 797  3 698  3 954  31254  31296  3
CGDARS1720 827  3 922  3 891  3 985  3 915  3 961  31505  41242  41037  41103  4
CGDARS1730 667  41040  41000  4 788  4 898  41340  41105  41090  41237  4 717  4
```

Format for .crn header records:

Line #	Column # and Description
1	1-6 Site ID, 10-61 Site Name, 62-65 Species Code, optional ID#'s
2	1-6 Site ID, 10-22 State/Country, 23-30 Species, 41-45 Elevation, 48-57 Lat-Long, 62-63 chronology type code*, 68-76 1st & last Year Note: lat-lons are in degrees and minutes, ddmm or dddmm
3	1-6 Site ID, 10-72 Investigators, 73-80 optional completion date

* Refer to Chronology Type Codes in Section V.

Format for .crn data row:

Column #	Description
1-6	Site ID Number
7-10	Decade
11-80	Index Value-Sample Number* pairs of values, fortran format code: 10(I4+I3)
82-88	TRL ID# (optional)

* Index Values are in columns 11-14, 18-21, 25-28, 32-35, etc. and the number of samples used in calculating the chronology are in columns 15-17, 22-24, 29-31, 36-38, etc. In the last row of the example .crn file above, 1020 is the ring-width index value for year 1850 with a sample size of 24; 1139 is the ring-width index value for year 1851 with a sample size of 25, etc.

Format for chronology statistics in last row of .crn file (Optional):

Column #	Description
1-6	Site ID Number
8-10	Number of Years
13-16	First Order Autocorrelation
19-22	Standard Deviation
25-28	Mean Sensitivity
29-35	Mean Index Value
37-44	Sum of Indices
46-53	Sum of Squares of Indices
62-63	Max# of series

IV. Species Codes

The list of species codes is here:
https://www.ncei.noaa.gov/pub/data/paleo/templates/tree-species-code.csv

V. Data Type Codes

The majority of ring measurements in the ITRDB are of the width of the annual ring. However, some of the series are measurements of portions of the annual ring, namely Earlywood or Springwood, and Latewood. The Earlywood appears light in color due to less dense cell walls, and is formed in the earlier part of the growing season. The Latewood, darker due to more dense cell walls, is formed later in the growing season. Some researchers measure wood density in addition to width, and density measurements can also made on the Earlywood and Latewood portions of the annual ring, as well as the as maximum and minimum density over the entire ring.

Below is a table of the codes used to designate the type of measurement contained within a data file. The filename convention is a site code, optionally followed by a measurement and/or a chronology type. Default values are ring width measurement type and standard chronology (as described above), and these types are not coded into the filenames. For example, the ring width measurement file and standard chronology file for site CO512 are co512.rwl and co512.crn. The earlywood measurements file is co512e.rwl, and the latewood ARSTAN chronology file is co512la.crn.

Tree Ring Measurement Type Codes

Code	Measurement Type	Units
<none>	Total Ring Width	either 0.01 mm or 0.001 mm
b	Blue Intensity	0.1 reflectance intensity
ba	Basal Area Increment	square millimeter
bm	Basal Area Mass Increment	gram
c	Average Cell Wall Thickness	either 0.01 mm or 0.001 mm
d	Total Ring Density	gram per decimeter
e	Earlywood Width	either 0.01 mm or 0.001 mm
f	Average Microfibril Angle	degree
g	Earlywood Tracheid Diameter	either 0.01 mm or 0.001 mm
i	Earlywood Density	gram per decimeter
l	Latewood Width	either 0.01 mm or 0.001 mm
n	Minimum Density	gram per decimeter
p	Latewood Percent	percent
t	Latewood Density	gram per decimeter
w	Tracheid Diameter	either 0.01 mm or 0.001 mm
x	Maximum Density	gram per decimeter

Tree Ring Chronology Type Codes

Code	Chronology Type
<none>	Standard
a	ARSTAN
p	Low Pass Filter
r	Residual
w	Re-Whitened Residual

VI. References

Cook, E.R., and Kairiukstis, L.A., eds. 1990. Methods of Dendrochronology. Kluwer Academic Publishers, 101 Philip Drive, Norwell, MA 02061 USA, or P.O. Box 17, 3300 AA Dordrecht, The Netherlands.

Cook, E.R. 1985. A Time Series Approach to Tree-Ring Standardization. PhD Dissertation. University of Arizona, Tucson, AZ, USA

Esper, J., Cook, E.R., Krusic, P.J., Peters, K., Schweingruber, F.H. 2003. Tests of the RCS method for preserving low-frequency variability in long tree-ring chronologies. Tree-Ring Research 59(2): 81-98.

Fritts, H. C. 1976. Tree Rings and Climate. Academic Press LTD., 24/28 Oval Road, London NW1, or 111 Fifth Avenue, New York NY 10003.

Hughes, M.K. et al. 1982. Climate from Tree Rings. Cambridge University Press, Cambridge, UK.