

## **Program ARSTAN**

### **A Tree-Ring Standardization Program Based on Detrending and Autoregressive Time Series Modeling, with Interactive Graphics**

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### **Introduction**

Program ARSTAN is the personal research project of Dr. Edward R. Cook, evolved from his graduate work at the University of Arizona in the 1980s when the science of dendrochronology was struggling with extracting meaningful tree-ring information from closed canopy forest trees. The ARSTAN methodology (**A**uto**R**egressive **STAN**dardization) was developed to deal with a certain class of problems that is common to trees growing in closed-canopy forest environments: the "endogenous disturbance" problem and its downstream affect on the independence of tree-ring measurements.

Obviously, a detailed description of the ARSTAN methodology (not this program) is contained in Cook's PhD Dissertation "A Time-Series Analysis Approach to Tree-Ring Standardization and will not be repeated here. Rather, a copy of Ed's dissertation is enclosed in this folder for those who wish to learn more.

### **Disclaimer**

What you do with this program is ultimately up to you, but be advised that specialized software is only as valuable to the user as the user's understanding of what the software does. As a matter of programming convention, ARSTAN comes with a ready made default configuration. This is simply a token convenience of publically distributed software to give the first time user a sense for the types of responses the program is

expecting, and to provide a degree of streamlining a program run. Do not think the program has any built-in intelligence that will choose all the correct options for your data. You most certainly will find option combinations that better comport with your data and provide the information you desire. At almost every point of a run ARSTAN can make a plot. We recommend one use this feature to inform your experiments and help you interpret results.

Finally, what you do with the program and how you do it, is your business. We assume no responsibility for the use and support of this program. That being said, of course we would want to know about any routine, or combination of options that produces an incorrect or an impossible result, so we can immediately make the necessary corrections and continue improving this program.

### **System Requirements and Installation**

Program ARSTAN was developed almost entirely on Macintosh computers. This means we know more about the behaviour of this program on a Mac than on other platforms. Since 2005 we have worked hard to find the means to create nearly 100% identical programs, in terms of the interface, analyses, and upgradability (is that even a word?), that can also run on Windows machines, however the port to Windows is not perfect. There still remain a few nuanced differences, almost entirely related to window manager's operation, that distinguishes the two versions. Consequently, since we are constantly using the program, and operating systems are continually being upgraded, updates are regularly produced, and with each update the differences that exist become less and less. Subsequently, for the sake of efficiency, we provide only our most recent versions for download. If you are experiencing problems getting the current version program to run on your computer write us and we will try our best to find or produce a version you can use. If you do write us please provide as many details of the problem you are experiencing, details about your computer's operating system, the point at which the program fails, the steps taken to install the program, and a sample of the input file you are using.

Be advised this program can tax your computers abilities resulting in what may appear as a crash. It is not unusual, when calculating bootstrapped confidence limits on a dataset with 100's of series, spanning hundreds of years of common coverage, to take time. Be patient before reaching for the reset button or ctrl\_alt\_delete-ing. It is a good idea to run the program on machines with at least 1GB of available RAM.

### **Macintosh OSX 10.6 and greater**

The AWE version of ARSTAN is a fully 64 bit compliant program, specifically built for multi processor machines running OSX 10.12 or greater. MRWE versions of the program are 32 bit applications and can run on earlier operating systems post 10.6. ARSTAN can produce high resolution vector graphics saved in Postscript files. For the program to display these images on your Mac you must first download and install XQuartz, an open source vector graphic window manager. The installation steps are;

1. Install the XQuartz window management tools (<https://www.xquartz.org/index.html>). This package is free to download and use under the Apple Public Source License Version 2.
2. Put the folder "PLPLOT\_DATA", with all its contents, in your computer's "/Applications" folder.
3. Copy or move the application (executable) to wherever it is on your computer where you want to work with the program.
4. OSX 10.8 and greater machines will require you relax the quarantine lock on any non-Apple certified program. Earlier operating systems allow you to do this via your System Preferences control panel, the most recent OSX versions require an additional step.

Open a terminal window (/Applications/Utilities/Terminal) and navigate to the folder with the program using the shell command "cd"

Example:

```
> cd /Users/pjk/TRprgms/SignalFree  
Then enter the following command.  
> xattr -d com.apple.quarantine  
RCSsigFree_49_v1_2020MRWE.app
```

### **Windows 7 and greater**

1. Install the Cygwin window management tools (<https://cygwin.com/index.html>). This package is free to download and use
2. Copy the folder "PLPLOT\_DATA", with all its contents, to your computer's C:\ directory.
3. Copy or move the application (executable) to wherever it is on your computer where you want to work with the program.

### **Program Notes:**

1. All input files must reside in the same folder as the application.
2. Remember, the default end-of-line character for Mac input files is a simple LF (LineFeed); File-type = "Unix". On Windows machines the default end-of-line characters is CRLF (CarriageReturn/LineFeed); file-type "Windows" or "Dos". Historically, ignoring this requirement

is responsible for 60% of all emails we receive reporting a problem. The remaining 40% are solved by correctly completing steps 1 & 2 in the above directions.

## **Running ARSTAN.**

Program ARSTAN is a FORTRAN program without a lot of amenities like drop and drag mouse control, or pull down windows, all the great stuff we expect from software today. It's a top down program, meaning you set it up to do what you want first, then you let it run. There are three principle modes for running the program, interactive, command and batch. In the "interactive" mode you enter the name of a file containing ring-width data, you configure all the options to perform, hit return for "no more options" and watch what happens.

During an interactive mode run ARSTAN produces a logfile, or command file. The log file records all the options you have used in the most recent interactive run, including the name(s) of the input file used. The log file may be used as input for any subsequent runs of the program, repeating the exact same instructions that were used when the log file was created. This is called command mode. Command mode is useful for a) keeping a record of previous setting configurations and b) to apply the same chronology building options on different data file. Simply changing the data input file name(s) in the log file will apply stored option set on a different data file. BTW, throughout this document we will use the following convention, numbers or text within a pair of less-than and greater-than symbols < >, to denote a program option response. To apply a default option, or skip a particular option, where appropriate, simply hit return <ret>. All input and output files are simple ASCII text files. They should only be viewed and/or modified using a text editor like BBedit (mac), Notepad (Windows).

ARSTAN can also open a text file containing a list of ring-width file names (one name/line) and perform all the selected detrending and chronology building options on the contents of each file in the list (e.g, examplelistfile.txt). This is called "batch" mode and useful for building chronology networks.

To demonstrate how to use program ARSTAN in interactive mode we will run the ring-width data in file Torn1.raw (Grudd, 2008) that was included with the distribution to produce the Standard (std), Residual (res) and ARSTAN (ars) chronologies. Accompanying the example are a few screen shots to get you going.

1. Loading file: torn1raw. (an increment file in decade format 0.01mm precision).

```
ARSTAN_49v1a_AWE

*****
***          Program ARSTAN          ***
***          Creation Date:         ***
***          12/02/19               ***
***          ***                     ***
***          Dr. Edward R. Cook     ***
***          Tree-Ring Laboratory   ***
***          Lamont-Doherty Earth Obs. ***
***          Palisades, N.Y. 10964  ***
***          drdendro@ldeo.columbia.edu ***
***          Paul J. Krusic         ***
***          Department of Geography ***
***          University of Cambridge ***
***          pk466@cam.ac.uk        ***
***          ***                     ***
*****

*** ARSTAN Version: 49v1_Mac adds the Melvin age-dependent ***
*** spline to the detrending options (curve fit opt. -6) with ***
*** non-increasing end fitting similar to the neg exp curve ***
*** and is set now as the default method of detrending. You can ***
*** still change the detrending method to whatever option you ***
*** prefer, but the age-dependent spline works well in general. ***
*** ARSTAN 49v1_Mac also adds three user-selected thresholds ***
*** for detecting and optionally removing autoregressive (AR) ***
*** outliers to make the method more useful for chronology ***
*** building and disturbance detection applications. The ring ***
*** width series minus the AR outlier effects can also be ***
*** saved now. But as always we suggest CAVEAT UTILITOR. ***
*****

          MAXIMUM tree-ring chronology length:          5001
          MAXIMUM number of tree-ring series:           1501

          <ret> to run, / to exit, h for more info:

open the file listing the data file names
type h for help or <ret> to enter them ==>

okay, so enter your data file name(s)
which will be stored in the new file: arstan_files.txt
when done, hit <ret> to process the data file(s).

file name # 1: torn1.raw
```

2. Select an initial detrending option with interactive graphical display. This combination of options permits you to change in real the default method to another should you find the default option does not meet your detrending requirement.

```

ARSTAN_49v1a_AWE
which will be stored in the new file: arstan_files.txt
when done, hit <ret> to process the data file(s).

file name # 1: torn1.raw
file name # 2:

number of files to be processed: 1

okay, enter your overall run title:
==>

run in batch mode from log file? y/<n>/h ==>

|***** arstan run time menu and current options settings *****|

      opt      plt
[1] tree-ring data type      1      0 !tucson ring-width format
[2] missing data in gap     -9      0 !missing values estimated (no plots)
[3] data transformation      0      0 !no data transformation (no plots)
[4] first detrending        -6     50  0 !1st-age-dependent spline, init spline
[5] second detrending        0      0  0 !2nd-no detrending performed
[6] robust detrending        1      0  0 !non-robust detrending methods used
[7] interactive detrend      0      0  0 !no interactive detrending
[8] index calculation        1      0  0 !tree-ring indices or ratios (rt/gt)
[9] ar modeling method       1      0  0 !non-robust autoregressive modeling
[10] pooled ar order         0      0  0 !minimum aic pooled ar model order fit
[11] series ar order         0      0  0 !pooled ar order fit to all series
[12] mean chronology         2      0  0 0 !robust (biweight) mean chronology
[13] stabilize variance      1      0  0 !rbar weighted stabilization method
[14] common period years     0      0  0 !no common period analysis performed
[15] site-tree-core mask     SSSITCC !site-tree-core separation mask
[16] running rbar            50     25  0 !running rbar window/overlap (no plots)
[17] printout option         2      0  0 !summary & series statistics printed
[18] core series save        0      0  0 !no individual core series saved
[19] summary plots           0      0  0 !no spaghetti and mean chronology plots
[20] stand dynamics stuff    0      0  0 !no stand dynamics analyses done
      running mean window 0
      percent growth change 0
      std error threshold 0

enter the option to change (<ret> = go) ==> 4

input control parameters from keyboard

hit <ret> for any specified default <parameters>

first tree-ring detrending options:
  enter (/ to exit, h for help):

age dependent spline      <-6>
friedman variable span smoother -5
lowess robust smoothing method -4
median filter sharpening/smoothing -3
regional curve (rcs) detrending -2
first differences         -1
no detrending applied      0
neg expon curve (k>0), no = opt 4 1
neg expon curve (k>0), no = opt 5 2
neg expon curve (any k)    3
linear regression (any slope) 4
linear regression (neg slope) 5
horizontal line (arithmetic mean) 6
hugershoff growth curve    7
general negative exponential curve 8
smoothing spline (fixed n cutoff) >9
smoothing spline (pct n cutoff) <-9 ==> 7

plot data with curve fits? y/<n> ==> y|

```

Here we have chosen to change the first detrending default method (option -6: Age Dependent Spine), to option #7 (hugershoff growth curve). At the same time we request the program to plot the individual series curve fits, thereby evoking the program's interactive detrending option.

After entering 'y'es to display curve fits the program returns us to the main options windows. At this point you could continue customizing the run, by selection options from the list or hit <ret> to run. However, in this example there is one more option to choose.

If you open the file torn1raw with a text editor you will see in the first two series there are ring-width measurements = -888. The number -888 is used as a placeholder for missing rings or, when more than one, a gap. Consistently using the same negative value, something **other than** -9999, as a missing value placeholder lets you to use ARSTAN's gap filling routine to interpolate missing values ("Whooah Snowy, that sounds like a reach"). Well, maybe it is but the program gives you the choise, and you can choose not to use it. If you do not want ARSTAN to interpolate missing values then change all -888's to 0 or the min. resolution of your measurements (ie 1). Be careful not to destroy the format of the data in the file, which is (a8,i4,10i6). Note: characters are left justified, numbers right justified.

3. After invoking ARSTAN's gap-filling routine, Option <2> from the main menu, you will be prompted to enter the missing value sentinel used to identify missing values and gaps (-888 in this example), and whether or not you would like to see the result.

```

ARSTAN_49v1a_AWE

opt          plt
[1] tree-ring data type 1          !tucson ring-width format
[2] missing data in gap -9         0          !missing values estimated (no plots)
[3] data transformation 0          0          !no data transformation (no plots)
[4] first detrending    7         50         1          !1st-hugershoff growth curve
[5] second detrending   0          0          0          !2nd-no detrending performed
[6] robust detrending   1          0          0          !non-robust detrending methods used
[7] interactive detrend 0          0          0          !no interactive detrending
[8] index calculation   1          0          0          !tree-ring indices or ratios (rt/gt)
[9] ar modeling method  1          0          0          !non-robust autoregressive modeling
[10] pooled ar order    0          0          0          !minimum aic pooled ar model order fit
[11] series ar order    0          0          0          !pooled ar order fit to all series
[12] mean chronology    2         0         0         0          !robust (biweight) mean chronology
[13] stabilize variance 1          0          0          !rbar weighted stabilization method
[14] common period years 0         0         0          !no common period analysis performed
[15] site-tree-core mask SSSTTCC    !site-tree-core separation mask
[16] running rbar       50        25        0          !running rbar window/overlap (no plots)
[17] printout option     2          0          0          !summary & series statistics printed
[18] core series save    0          0          0          !no individual core series saved
[19] summary plots      0          0          0          !no spaghetti and mean chronology plots
[20] stand dynamics stuff 0          0          0          !no stand dynamics analyses done
      running mean window 0          0          0          !running mean window width
      percent growth change 0         0          0          !percent growth change threshold
      std error threshold 0          0          0          !standard error limit threshold

enter the option to change (<ret> = go) ==> 2

input control parameters from keyboard

hit <ret> for any specified default <parameters>

missing data fill-in capability is automatic.
any number .lt. 0, except -9999, is regarded
as a missing datum. if your missing data flag
is not negative, or it equals -9999, quit the
program and change your missing data flag!
enter <ret> to continue or / to quit ==> -888

plot the in-filled data? y/<n> ==> y

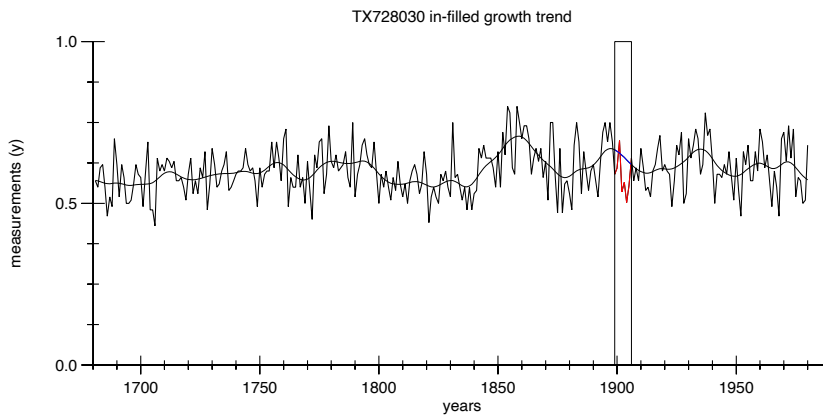
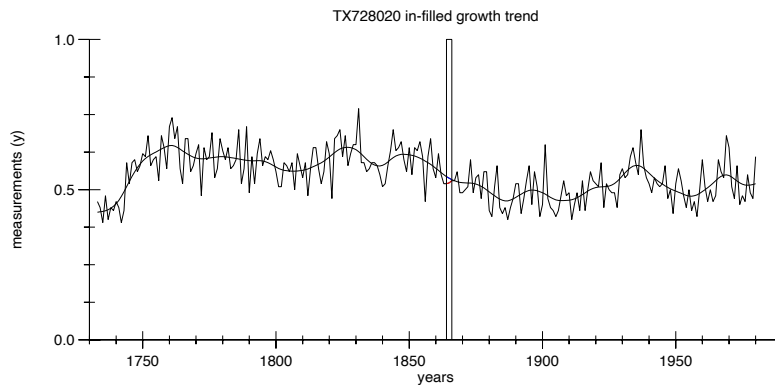
|***** arstan run time menu and current options settings *****|

opt          plt
[1] tree-ring data type 1          !tucson ring-width format
[2] missing data in gap -888       1          !missing values estimated (w/ plots)
[3] data transformation 0          0          !no data transformation (no plots)
[4] first detrending    7         50         1          !1st-hugershoff growth curve
[5] second detrending   0          0          0          !2nd-no detrending performed
[6] robust detrending   1          0          0          !non-robust detrending methods used
[7] interactive detrend 0          0          0          !no interactive detrending
[8] index calculation   1          0          0          !tree-ring indices or ratios (rt/gt)
[9] ar modeling method  1          0          0          !non-robust autoregressive modeling
[10] pooled ar order    0          0          0          !minimum aic pooled ar model order fit
[11] series ar order    0          0          0          !pooled ar order fit to all series
[12] mean chronology    2         0         0         0          !robust (biweight) mean chronology
[13] stabilize variance 1          0          0          !rbar weighted stabilization method
[14] common period years 0         0         0          !no common period analysis performed
[15] site-tree-core mask SSSTTCC    !site-tree-core separation mask
[16] running rbar       50        25        0          !running rbar window/overlap (no plots)
[17] printout option     2          0          0          !summary & series statistics printed
[18] core series save    0          0          0          !no individual core series saved
[19] summary plots      0          0          0          !no spaghetti and mean chronology plots
[20] stand dynamics stuff 0          0          0          !no stand dynamics analyses done
      running mean window 0          0          0          !running mean window width
      percent growth change 0         0          0          !percent growth change threshold
      std error threshold 0          0          0          !standard error limit threshold

enter the option to change (<ret> = go) ==>

```

Example: Gap filled measurement series.



ARSTAN can produce a lot of figures, both at the level of the individual series, and at the chronology. The a suite of summery figures are invoked by selction one of the three choices under Option <19>. In the figure below we have selected to veiw a subset of those figures that summerize the chronology attributes of the data in the file torn1.raw.

```

ARS370SXwin_5c output

|***** arstan run time menu and current options settings *****|

      opt      plt
[1] tree-ring data type      1      !tucson ring-width format
[2] missing data in gap     -9      0      !missing values estimated (no plots)
[3] data transformation      0      0      !no data transformation (no plots)
[4] first detrending         7      1      !1st-hugershoff growth curve
[5] second detrending        0      0      !2nd-no detrending performed
[6] robust detrending        1      !non-robust detrending methods used
[7] interactive detrend      0      !no interactive detrending
[8] index calculation        1      !tree-ring indices or ratios (rt/gt)
[9] ar modeling method       1      0      !non-robust autoregressive modeling
[10] pooled ar order         0      0      !minimum aic pooled ar model order fit
[11] series ar order         0      !pooled ar order fit to all series
[12] mean chronology         2      0      0      !robust chronology (w/ biweight plots)
[13] stabilize variance      0      !no variance stabilization performed
[14] common period years     0      0      !no common period analysis performed
[15] site-tree-core mask     ssstcc !site-tree-core separation mask
[16] running rbar            50 25 0      !running rbar window/overlap (no plots)
[17] printout option         2      !summary & series statistics printed
[18] core series save        0      !no individual core series saved
[19] summary plots           0      !no spaghetti and mean chronology plots
[20] stand dynamics stuff    0      0      !no stand dynamics analyses done
      running mean window    0      !running mean window width
      percent growth change  0      !percent growth change threshold
      std error threshold    0      !standard error limit threshold

enter the option to change (<ret> = go)   ==> 19

input control parameters from keyboard
hit <ret> for any specified default <parameters>

summary hi-res plot options (/ to exit, h for help):
no summary hi-res plots          <0>
spaghetti plots of all series    1
various summary plots (try it!)  2
all of the above (lots!!!)      3   ==> 2

|***** arstan run time menu and current options settings *****|

```

Here we have chosen to view various chronology summery plots first by selecting option <19> from the Main Program Menu, then option <2> from the Summery Plot Sub-Menu.

4. Each time options are changed the new changes are displayed in the Main Program Options Menu (two-right columns).

```

|***** arstan run time menu and current options settings *****|
      opt          plt
[1] tree-ring data type 1          !tucson ring-width format
[2] missing data in gap -888      1 !missing values estimated (w/ plots)
[3] data transformation 0          0 !no data transformation (no plots)
[4] first detrending      7      50 1 !1st-hugershoff growth curve
[5] second detrending     0          0 !2nd-no detrending performed
[6] robust detrending     1          0 !non-robust detrending methods used
[7] interactive detrend   0          0 !no interactive detrending
[8] index calculation     1          0 !tree-ring indices or ratios (rt/gt)
[9] ar modeling method    1          0 !non-robust autoregressive modeling
[10] pooled ar order      0          0 !minimum aic pooled ar model order fit
[11] series ar order      0          0 !pooled ar order fit to all series
[12] mean chronology      2      0  0 0 !robust (biweight) mean chronology
[13] stabilize variance   1          0 !rbar weighted stabilization method
[14] common period years  0      0  0 !no common period analysis performed
[15] site-tree-core mask  SSSSTCC !site-tree-core separation mask
[16] running rbar        50  25  0 !running rbar window/overlap (no plots)
[17] printout option      2          0 !summary & series statistics printed
[18] core series save     0          0 !no individual core series saved
[19] summary plots       2          0 !mean chronology plots
[20] stand dynamics stuff 0          0 !no stand dynamics analyses done
      running mean window 0          0 !running mean window width
      percent growth change 0          0 !percent growth change threshold
      std error threshold  0          0 !standard error limit threshold

enter the option to change (<ret> = go) ==> 19

input control parameters from keyboard

hit <ret> for any specified default <parameters>

summary hi-res plot options (/ to exit, h for help):
no summary hi-res plots      <0>
spaghetti plots of all series 1
various summary plots (try it!) 2
all of the above (lots!!!)    3 ==> 2

|***** arstan run time menu and current options settings *****|
      opt          plt
[1] tree-ring data type 1          !tucson ring-width format
[2] missing data in gap -888      1 !missing values estimated (w/ plots)
[3] data transformation 0          0 !no data transformation (no plots)
[4] first detrending      7      50 1 !1st-hugershoff growth curve
[5] second detrending     0          0 !2nd-no detrending performed
[6] robust detrending     1          0 !non-robust detrending methods used
[7] interactive detrend   0          0 !no interactive detrending
[8] index calculation     1          0 !tree-ring indices or ratios (rt/gt)
[9] ar modeling method    1          0 !non-robust autoregressive modeling
[10] pooled ar order      0          0 !minimum aic pooled ar model order fit
[11] series ar order      0          0 !pooled ar order fit to all series
[12] mean chronology      2      0  0 0 !robust (biweight) mean chronology
[13] stabilize variance   1          0 !rbar weighted stabilization method
[14] common period years  0      0  0 !no common period analysis performed
[15] site-tree-core mask  SSSSTCC !site-tree-core separation mask
[16] running rbar        50  25  0 !running rbar window/overlap (no plots)
[17] printout option      2          0 !summary & series statistics printed
[18] core series save     0          0 !no individual core series saved
[19] summary plots       2          0 !mean chronology plots
[20] stand dynamics stuff 0          0 !no stand dynamics analyses done
      running mean window 0          0 !running mean window width
      percent growth change 0          0 !percent growth change threshold
      std error threshold  0          0 !standard error limit threshold

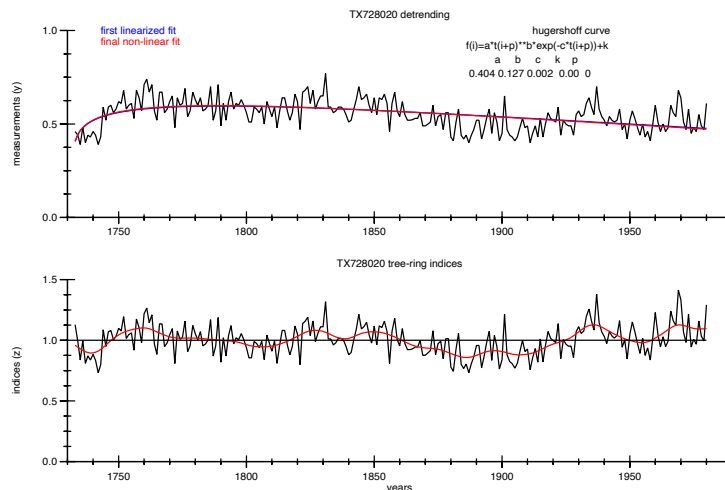
enter the option to change (<ret> = go) ==>

```

Here, in the final set-up screen shot (above), we see all the changes we have made to the program's default settings. Hitting return at this

point launches the program, saving this command set in the log file "torn1.raw\_log".

After filling all the gaps and missing values (if so desired and prepared for), the next plot on the screen is a time series plot of the minimum, median, and 75<sup>th</sup> percentile of the raw measurements for each year. The next figure drawn will be the detrending of the first series in the file, in this example it's TX728020, by the initial Hegershoff curve fit.



5. The program will now prompt you to either chose elements of the plot to change (plot options 1-21), [s]ave the plot to a postscript file, [c]ontinue with interactive detrending, or see [n]o more plots. Entering a "return" or "c" while in the interactive detrending mode gives you the chance to change the detrending option on the series just displayed and see the new result.

Here we are asking to change the detrending option from the Hegershoff to the Age-Dependent Spline (Melvin and Briffa, 2008) with an initial spline freq.response of 30 yrs., plot the new result and save the figure in a file called "detrend2.eps".

```

ARSTAN_49v1a_AWE
| replot          [0]  minor ticks y  [11] |
| background color [1]  major ticks z  [12] |
| frame color     [2]  minor ticks z  [13] |
| text color      [3]  max. x          [14] |
| line color      [4]  min. x          [15] |
| curve color     [5]  max. y          [16] |
| line style      [6]  min. y          [17] |
| curve width     [7]  max. z          [18] |
| major ticks x   [8]  min. z          [19] |
| minor ticks x   [9]  symbol type    [20] |
| major ticks y  [10]  symbol color    [21] |
|-----|
| reset options  [99] |
|-----|
| [s]ave  <[c]ontinue>  [n]o more plots |
|-----|

enter option number >

change curve fit? y/<n>          ==> y

you can change the current curve fit with any one of the following options:

-6: age dependent spline
-5: friedman super smoother      lower alpha (0-9) gives more local fit
-4: robust lowess smoother      integer percent or fixed length of n
-3: median smoothing            must have odd window length
1:  neg expon curve, no = opt 4  f(i) = a*exp(-b*t(i)) + d    (d>0)
2:  neg expon curve, no = opt 5  f(i) = a*exp(-b*t(i)) + d    (d>0)
3:  neg expon curve (general)    f(i) = a*exp(-b*t(i)) + d    (any d)
4:  linear regression (any slope) f(i) = +/-c*t(i) + d
5:  linear regression (neg slope) f(i) = -c*t(i) + d
6:  horizontal line through mean f(i) = mean(y(i)) = d
7:  hughershoff growth function  f(i) = a*t(i+p)**b * exp(-c*t(i+p)) + d
8:  general exponential (b = 1)  f(i) = a*t(i+p)**b * exp(-c*t(i+p)) + d
>9: cubic smoothing spline      fixed 50 pct variance cutoff
<-9: cubic smoothing spline     pct n 50 pct variance cutoff

enter new option (h for help)    ==> -6

Age-dependent spline starting stiffness
is needed. Must be .ge. 5. Hit <RET> for
a default of 50 years or enter you own. ==> 30

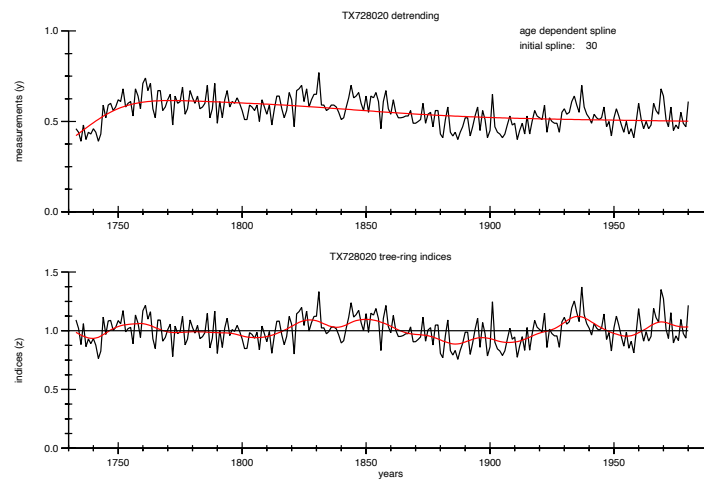
***** plot options menu *****
| replot          [0]  minor ticks y  [11] |
| background color [1]  major ticks z  [12] |
| frame color     [2]  minor ticks z  [13] |
| text color      [3]  max. x          [14] |
| line color      [4]  min. x          [15] |
| curve color     [5]  max. y          [16] |
| line style      [6]  min. y          [17] |
| curve width     [7]  max. z          [18] |
| major ticks x   [8]  min. z          [19] |
| minor ticks x   [9]  symbol type    [20] |
| major ticks y  [10]  symbol color    [21] |
|-----|
| reset options  [99] |
|-----|
| [s]ave  <[c]ontinue>  [n]o more plots |
|-----|

enter option number > s

NOTE: The image file you are about to create is PostScript.
To make this readily apparent to your OS we recommend adding
the extension .ps to the file name.
Enter plot file name > detrend2.eps

```

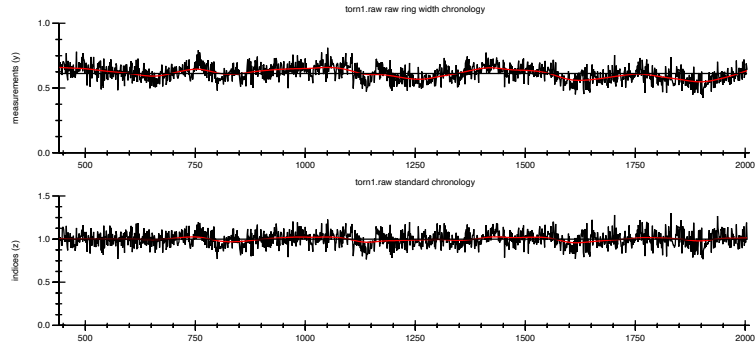
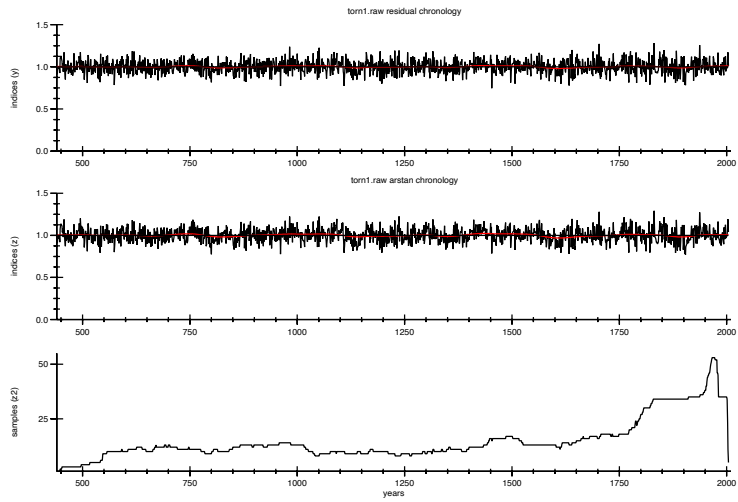
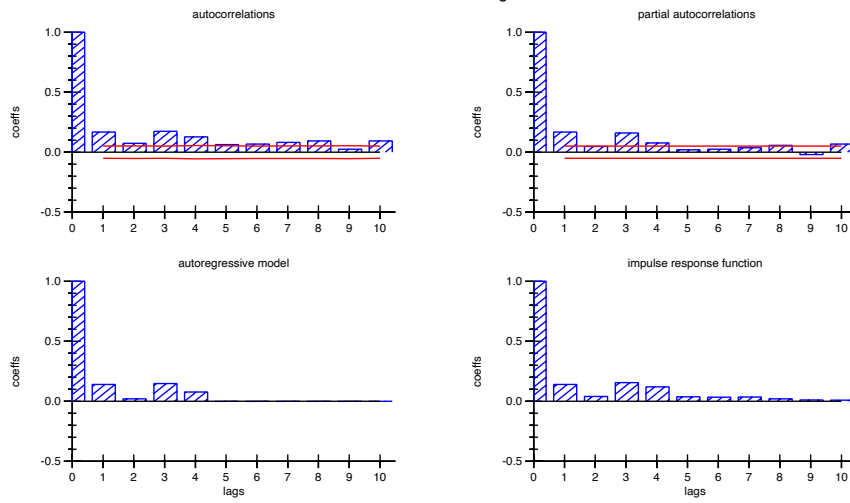
The consequence of this detrending option change is seen here:



Looping within the Plot Options Menu we can change a number of attributes of any plot. As mentioned previously you can save any figure made in PostScript format by entering an <s> after which the program will prompt you for a file name. It is a good idea to add the .eps extension. All figures are vector graphic images that can be handlilly manipulatted in programs such as Adobe's astronomically expensive Illustrator, or the free open source program Gimp (<https://www.gimp.org>)! All the figures in this document have been edited in Illustrator (paid from our own project funds), slightly modified to improve readability when reduced in size, and saved as pdf's before importing to msWord.

6. After all the individual series detrending is done the program, as we have configured this run, begins to display various summery plots including plots of the final chronologies.

### torn1.raw Pooled Autoregression



## Referneces;

Melvin, T.M., and K.R. Briffa A "Signal-Free" approach to dendroclimatic standardisation *Dendrochronologia*, 26 (2008), pp. 71-86

Grudd, H. Torneträsk tree-ring width and density AD 500–2004: a test of climatic sensitivity and a new 1500-year reconstruction of north Fennoscandian summers. *Clim Dyn* 31, 843–857 (2008).  
<https://doi.org/10.1007/s00382-007-0358-2>

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We must also acknowledge the value of institutions like IMSL, Source Forge, GNU and the worldwide community of FORTRAN programmers. Many of the 18,441 lines of code in ARSTAN are either variants or direct inclusions of public access code. By using this software you are directly benefiting from the spirit of intellectual sharing, a philosophy we consider paramount to the advancement of all science.

Finally, we thank Absoft for providing a decent FORTRAN compiler that can accept legacy FORTRAN77 code, include C++ code, and produce executables on both Macs and PC's. We want to especially thank Mr. Scott Campbell, Tony Goelz, Peter Jacobson and Jeremy Smith who over the years have helped us utilize the full power of their Fortran compiler to produce executable programs that we can share. Thanks Absoft!

Good luck!