Standardization I

Standardization

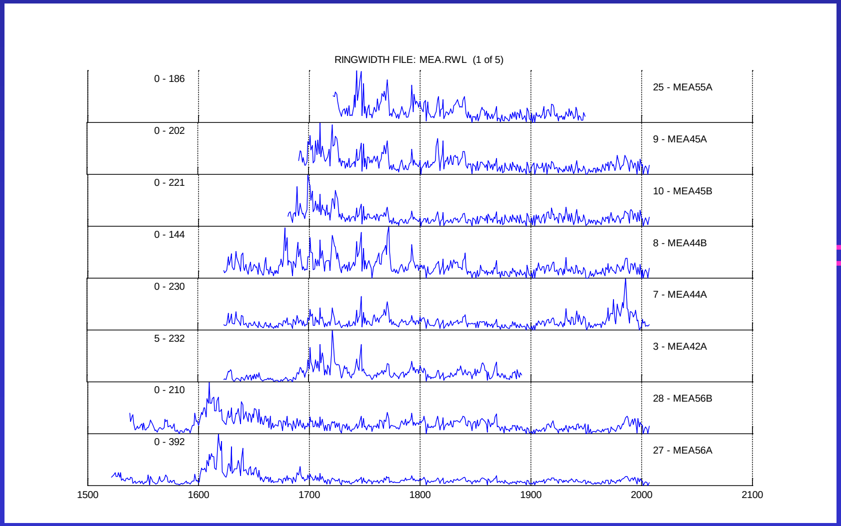
1. Objective
2. Alternative approaches
3. Detrending
4. Averaging

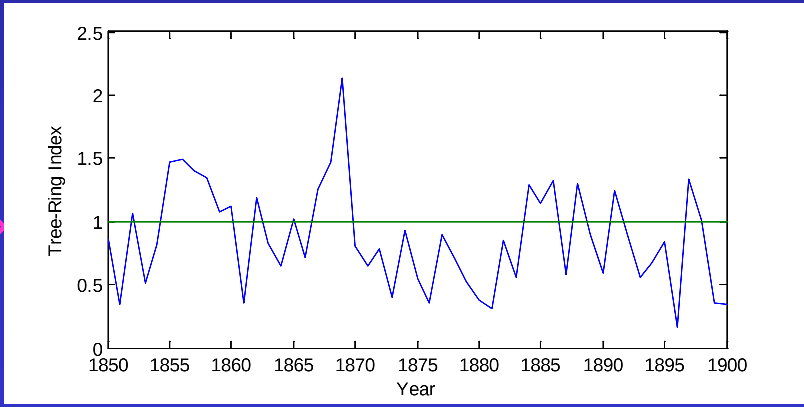
Covered in context of ARSTAN

5. Common signal
6. Variance stabilization
7. Adjusting for persistence

1. Objective

- Start with ring-width series from many trees
- Want a single time series to reconstruct some climate variable (e.g., annual precipitation)
- Must adjust for :
    - Different growth rates (tree vigor)
    - Trends unrelated to climate
    - Temporal changes in sample size





2. Approaches to Detrending in Standardization

1. No detrending
   - Interpret directly from ring widths
   - Usually restricted to very long (multi-millennial length) series
2. Identify and detrend with curve of expected ring width as function of ring age
   - Regional curve standardization (RCS)
   - Align series by biological age and derive generally applicable curve of expected ring-width vs tree age
   - Requires 1) huge sample size covering all age classes, 2) pith or near-pith hit in sampling
3. Empirical curve fitting

   We use this approach in course

   - Describe trend by fitting smooth curve to each ring-width series independently
   - Remove the trend, typically by ratio method

3. Detrending (empirical curve-fitting method)

Goal: remove gradual trends that are not associated with the climate variable or other environmental variable being studied

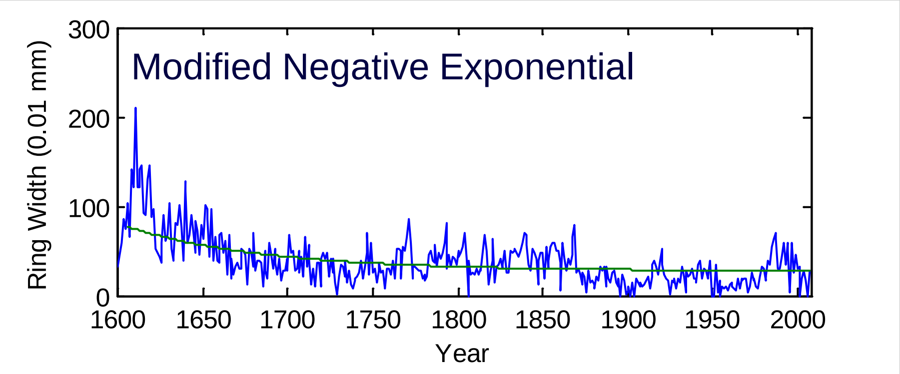
Step 1: fit a smooth curve to the ring widths

Step 2. remove the fitted trend line from the ring widths

Step 3. Average detrended series over cores

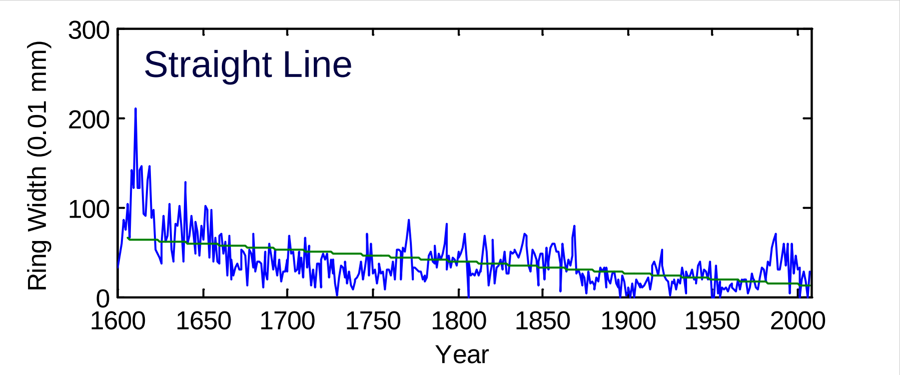
Step 1. fit a smooth curve to the ring-widths

Curve fits, example 1

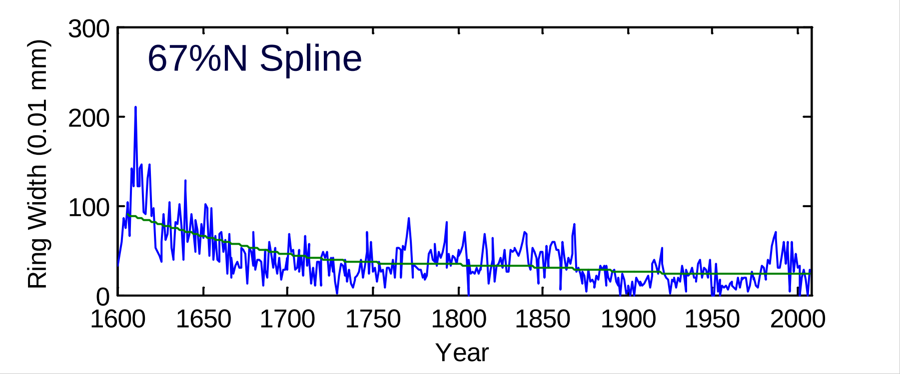


$$g = ae^{-bt} + k$$

"modified": curve approaches k as $t \rightarrow \infty$

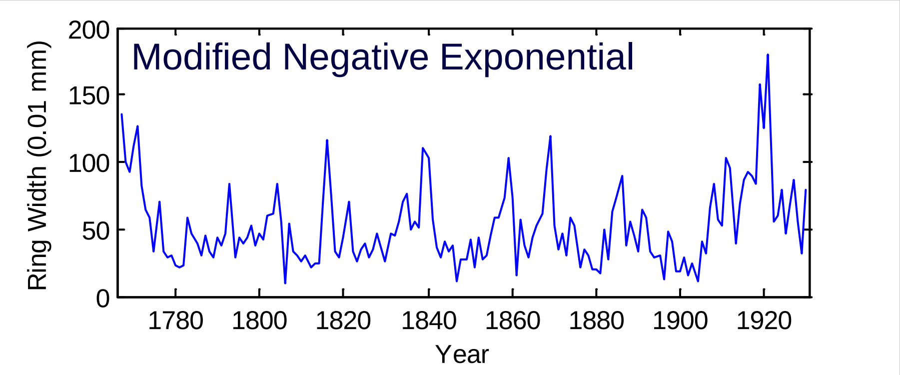


$$g = a + bt$$

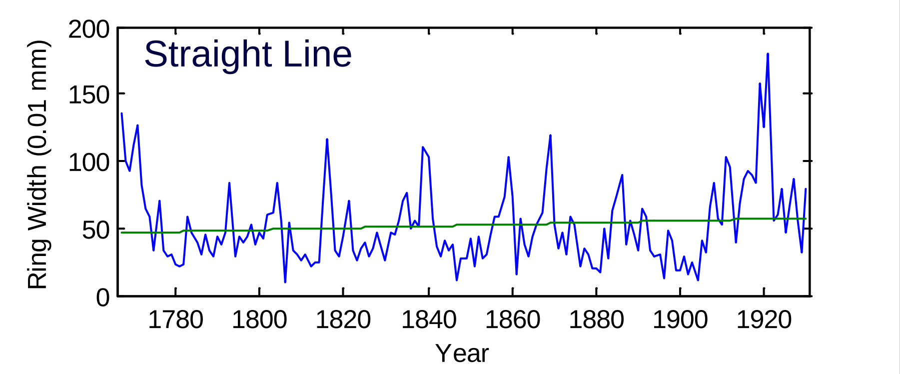


- Spline is compromise of smoothness and variance explained
- Spline parameter controls "stiffness":
  - p=0: straight line (maximum smoothness)
  - p=1: goes through every data point
  - p can be set according to desired wavelength range to retain and remove

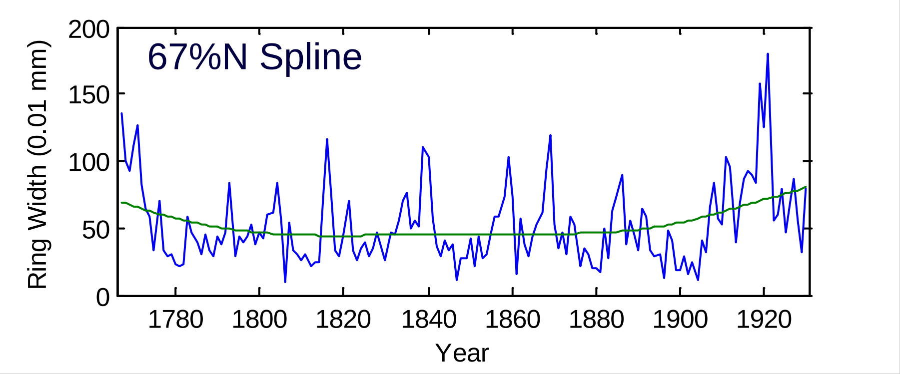
Curve fits, example 2



Negative exponential cannot be fit



Straight line has positive slope



Spline tracks wavelengths on order of the series length, and will remove those and longer wavelengths when used as a detrending curve

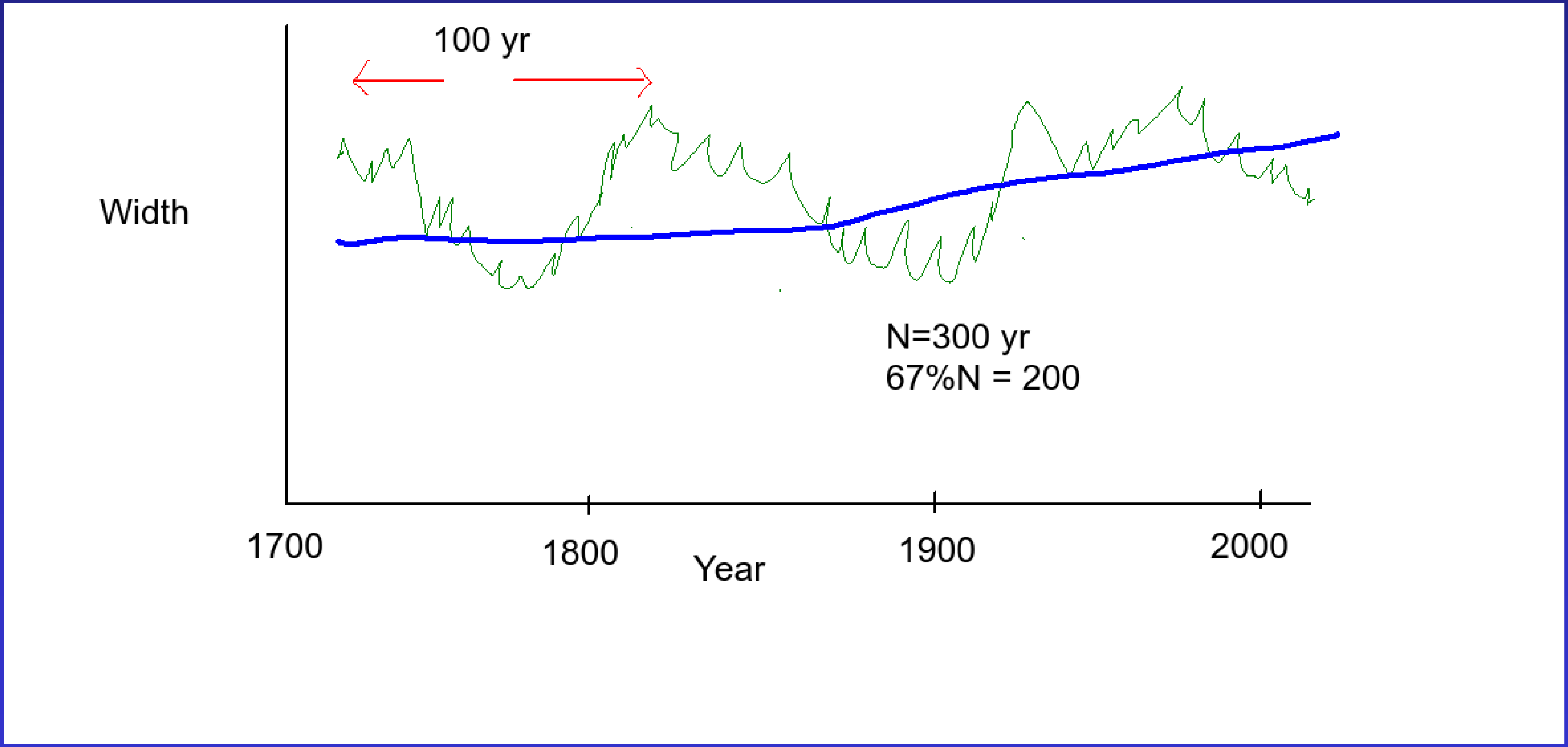
What is a 67%N spline?

1. N is the length of the ring-width series
2. The 67%N spline closely follows gradual variations in the ring width at wavelengths longer than two-thirds, or 67%, of the length of the series
3. Those long-wavelength variations are tracked by the spline, but are removed in detrending because the index is computed as the ratio of the measured widths to the spline curve.

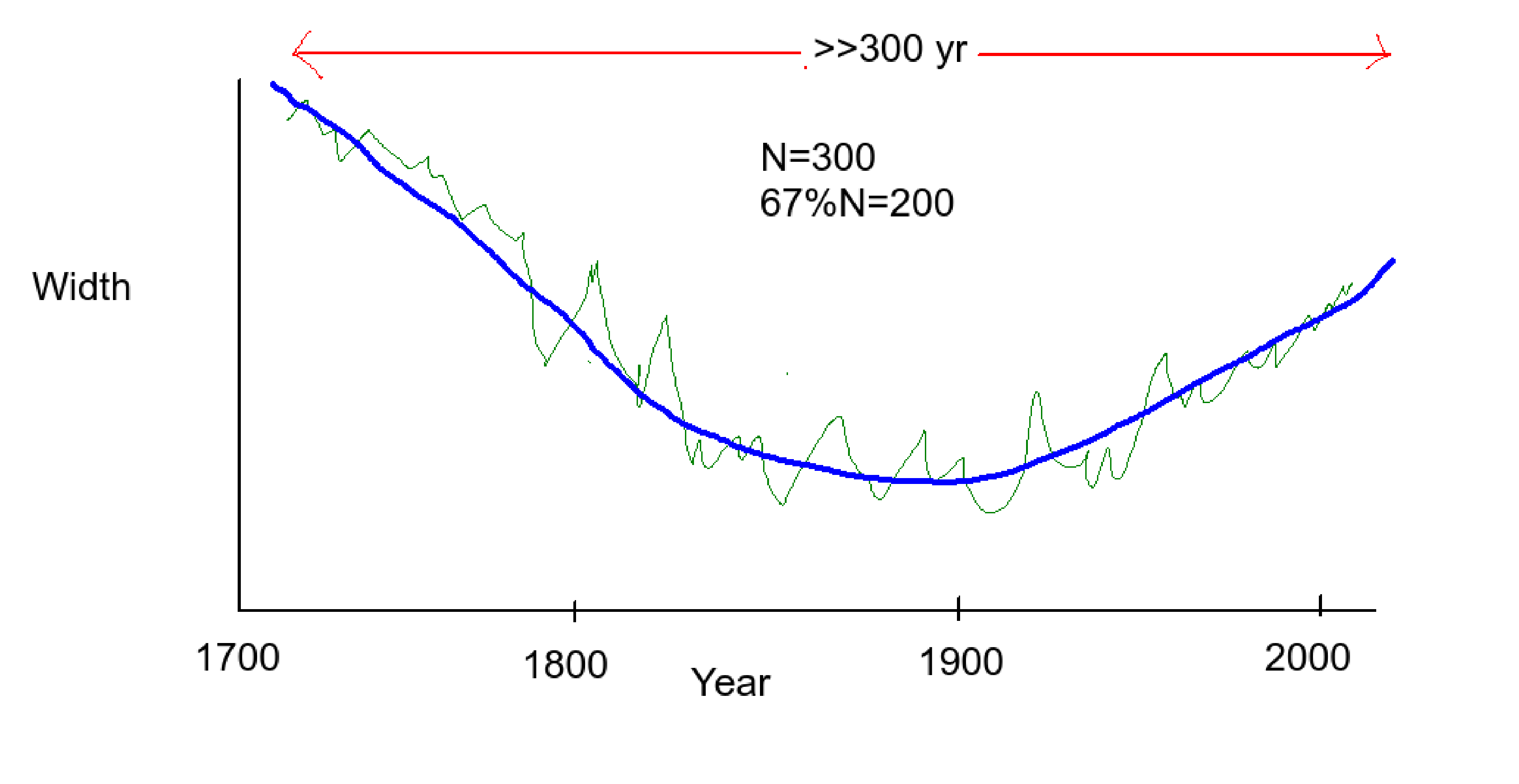
Some hypothetical examples:

300-year ring width series

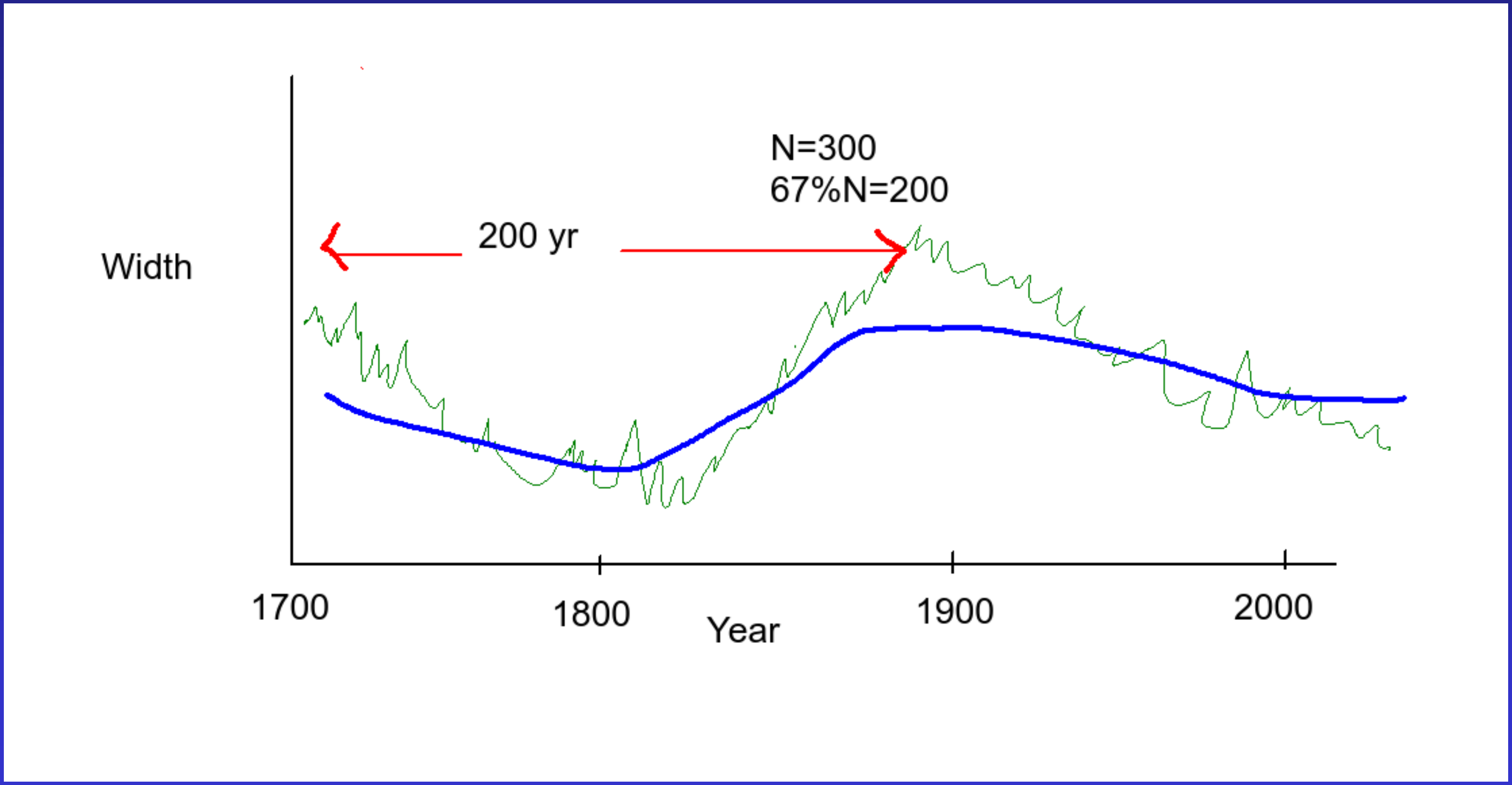
- Ring width below (green line) has wave with wavelength about 100 yr
- That wavelength is much shorter than 67%N
- The spline (blue) does not track the wave
- In detrending, the wave is not removed from the ring widths



- Ring width below has fluctuation with wavelength greater than 300 yr
- That wavelength is much longer than 67%N
- The spline closely tracks the wave
- In detrending, the wave would be completely removed



- Ring width below has fluctuation with wavelength about 200 yr
- That wavelength is about 67%N
- The spline tracks the wave, but not perfectly
- In detrending, some of the fluctuation due to the wave would remain



Step 2. remove trend

Alternative ways to remove trend: 1) Difference, 2) Ratio

x_t = time series

g_t = fitted trend line

$y_t = x_t - g_t$ DIFFERENCE DETRENDING

In same units
as original data

$y_t = x_t / g_t$ RATIO DETRENDING

Units dimensionless

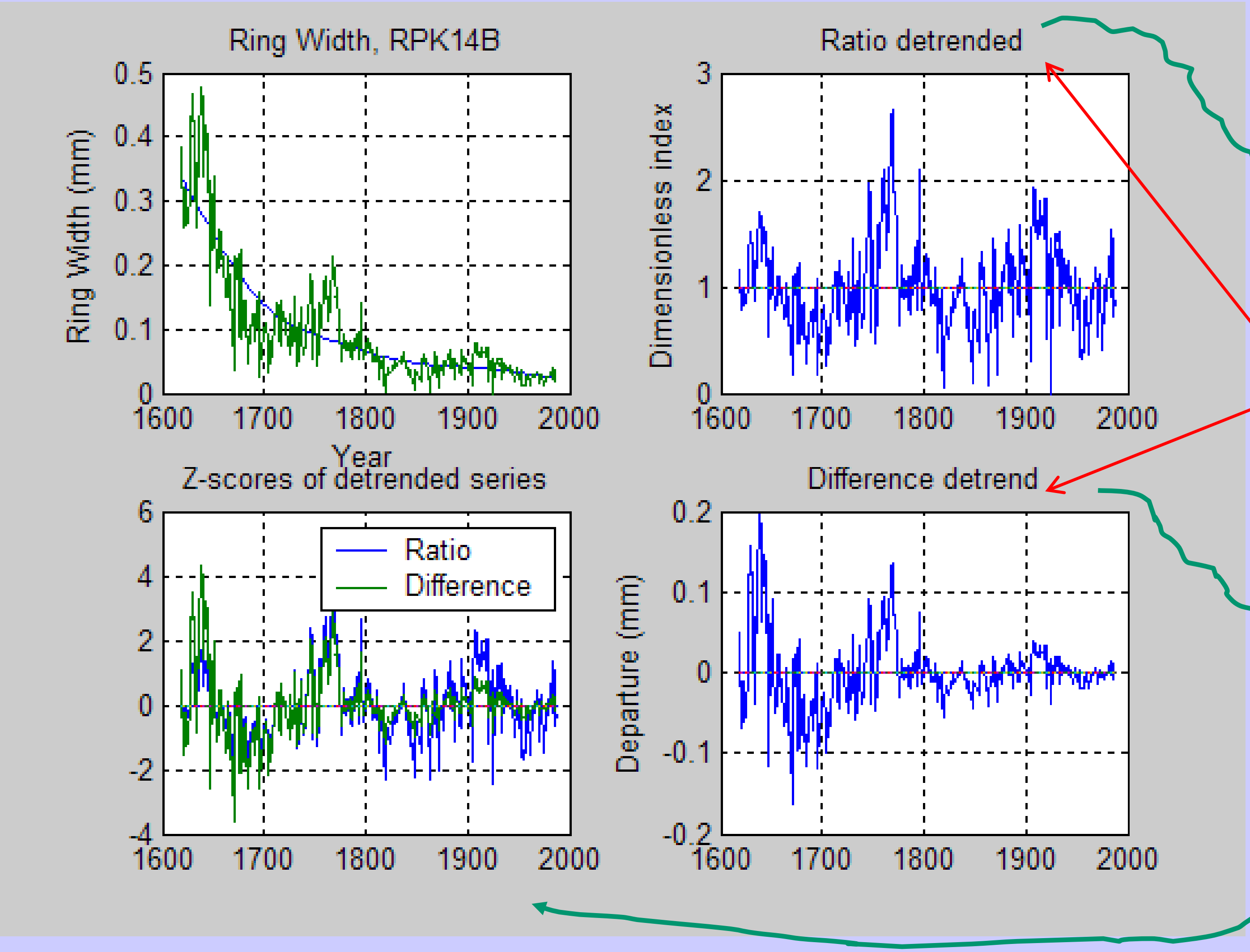
1.0 is "normal"

"Blows up" as $g \to 0$

Most commonly used in ring-width detrending

"variance-stabilizing"

Examples:Difference vs Ratio Detrending



Stabilizes variance

Alternative versions of core index

Does not stabilize variance

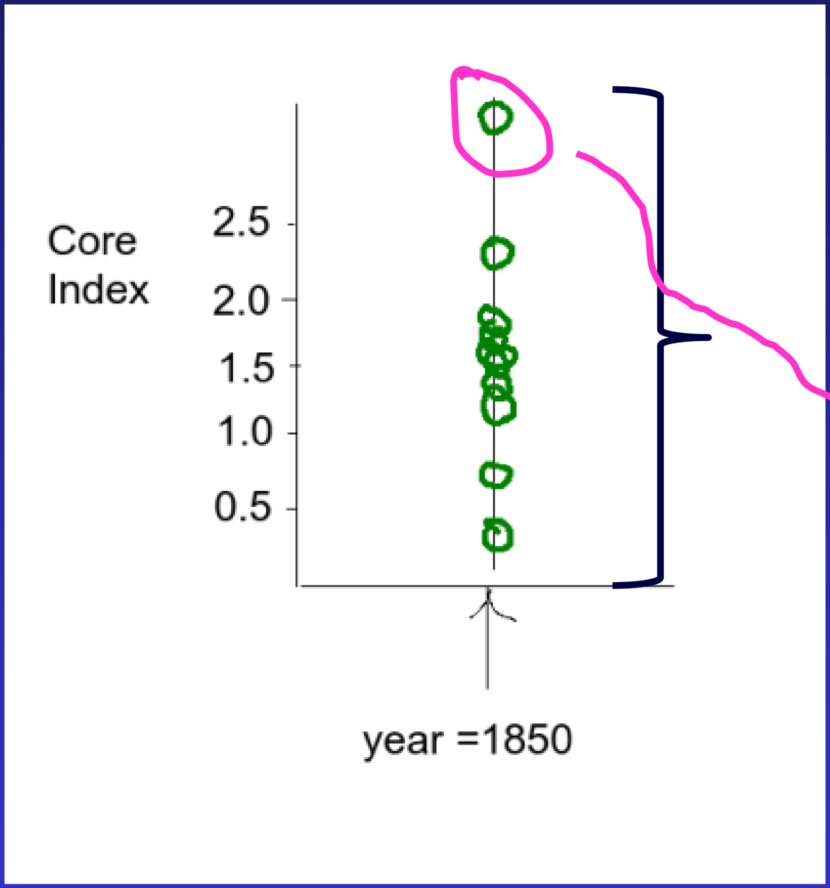
Both versions of core index plotted together

Step 3. Average over cores

Arithmetic and Bi-weight Averaging

1. The site chronology is computed optionally by the arithmetic mean or a biweight mean.
2. The biweight mean applies a weighting function to discount outliers
3. In ARSTAN, the biweight option defaults to the median if fewer than 7 observations in the year (fewer than 7 cores).

Biweight mean



- Say, have 10 cores in 1850
- These yield 10 core index values
- Biweight mean assigns weights to each value, with lower weights on values further from center of values
- Effect is to discount outliers

For example, this core index would receive a relatively low weight

Example: Averaging core Indices into site index