Age profile of pine megafossils at Lake Vallijärvi.
A closer view over the supra-long Scots pine tree-ring record for Finnish Lapland.
GROWTH VARIATION OF SCOTS PINE IN DIFFERENT TIME SCALES

[Graphs showing growth variation over different time scales from 1700 to 2000]
SCOTS PINE, TIMBERLINE, 11-YR FFT SMOOTHED TREE-RING INDICES
Depending on the method, different results appear. In the upper figure only annual (high-frequency) and decadal (medium-frequency) variation are exposed, whereas the lower figure includes also long-term variation (low-frequency variation). The dataset is from the timberline of Scots pine, Northern Finland.
Scots pine on its highest position about 5000 years ago

Norway spruce reaches its present position 3000 years ago

Holocene Climate Optimum (5500-2200 BC)

Medieval Warm Period (700-1300 AD)

Little Ice Age (1400-1910 AD)

The red and blue areas indicate Bradley's or Eddy's temperature model (1991). The white curve is a FFT smoothed 100-year average of Scots pine tree-ring index.
Annual variation in tree growth according to Cook’s (1992) conceptual aggregate model depends on environmental factors as follows:

\[ R_t = A_t + C_t + \delta D_{1t} + \delta D_{2t} + E_t \]

- \( R_t \): Observed growth
- \( A_t \): Trend in ring width caused by biological age of tree
- \( C_t \): Climate effect on growth
- \( D_{1t} \): Internal (endogenous) factors affecting growth
- \( D_{2t} \): External (exogenous) factors affecting growth and unexplained effect on growth
- \( E_t \): Unexplained effect on growth
- \( t \): Time (year)
I. CHRONOLOGY BUILDING
1. Selection of proper tree species
2. Validity and reliability
3. What parts of tree to study?
4. Selection of the research area
5. Stand sampling
6. Criteria for tree sampling
7. Tree sampling
8. Sample depth
9. Field work
10. Sample documentation
11. Measurements
12. Dating, crossdating, quality analysis
13. Chronology building

II. CLIMATE MODELLING
13. Standardisation methods
14. RCS modelling
15. Data accumulation
16. Box Filling Procedure
17. Data resampling
18. Signal-free standardisation
19. Indexing
20. Transfer models
21. Replicated climate modelling
22. Generalisation of results
It is evident that careful pre-sampling improves the validity of results. What exclusions should we use?

- The growth environment of a sample tree should be unchanged: no endogenous or exogenous disturbances in the proximity.
- Choose semidry sites and sparse stand structure.
- Choose sample trees from a flat site.
- Choose trees of all ages, in good shape and health.
- Sample at breast height if possible. Disks are better than cores.
DEFINING SAMPLE SIZE

WHAT IS THE RIGHT SAMPLE SIZE?

- There is no final common answer!
- Defining the proper sample size for each case is a challenging task!
- Minimum accuracy in dendrolimatic studies at least 10% at 5% risk?
- According to the table, 10% accuracy requirement at 5% risk level in the Finnish pine timberline counts at least 50 observations per year!
- We can ask whether the 10% accuracy is adequate for correlating the indices with instrumental measurements.
- Well, it is worth discussing!

Collecting even larger data sets should be considered!
Boosting the RCS method into a better performance
Three important approaches in signal exposing:

1. Single Tree Standardization (STS)
2. Regional Curve Standardization (RCS)
3. Age Banding (AB).
DATA SELECTION IN RCS ANALYSIS: "FILL-THE-BOX"

Sample size depends on accuracy request
PROGRAM SAMPLER

A Fortran Program called Sampler, developed by the author, creates homogenous signal-free* data sets for RCS modelling projects. The program asks the following parameters (example answers follow):

1. Chronology index data for signal-free data transformation (0=No 1=Cronol 2=Arstan) >
2. Correction data for signal-free data (0=No) >
3. Define calendar years > 1200, 2000
4. Define cambial years > 40, 80
5. Classify calendar and cambium years > 10, 10
6. Sample size: no of rings in each calendar-age class > 30
7. Randomising (1=no 2=series 3=tree-rings) > 3
8. Number of iterations > 5
9. Sample data type (1=all data 2=independent) > 2
10. Data output (N,xmean,sdev,coeffvar) > 1111

The program writes in each iteration an RCS analysis file and 7 statistical description files for data qualifying. A run with these parameters would produce five fully randomised and independent data sets.

RCS (Regional Curve Standardisation)

Climatic influence on growth = Observed - modeled growth

Calibrated growth
Average growth during the period
CONVERTING RING WIDTHS TO TEMPERATURES

Residual variation of growth model

Temperature proxy

Temperature °C

RCS index

0 500 1000 1500 2000
A look at the Finnish growth trends
V. Chronology building
ANCIENT PINE TIMBERLINES

HOW TO ESTIMATE PAST JULY TEMPERATURES BASED ON SITE LOCATIONS BEYOND THE PRESENT PINE?

METLÀS’S GROWTH TREND STUDIES

- Samples collected 2007-2008
- More than 700 cores from 25 sampling areas in Northern Finland
- More than 400 cores from 11 sampling areas in Southern Finland.
METLA’S GROWTH TREND PROJECT (PRELIMINARY RESULTS)
SOUTHERN FINLAND
Conclusions
WHAT SHOULD WE DO FOR BETTER PERFORMANCE IN RCS?

- Modelling techniques at high level in Dendrochronology

- More attention should be paid to data validity and reliability questions:
  → Data selection methods need developing
  → Sampling depth is insufficient in many cases

- More consideration in generalisation of results.
Thank you.

More to read here!