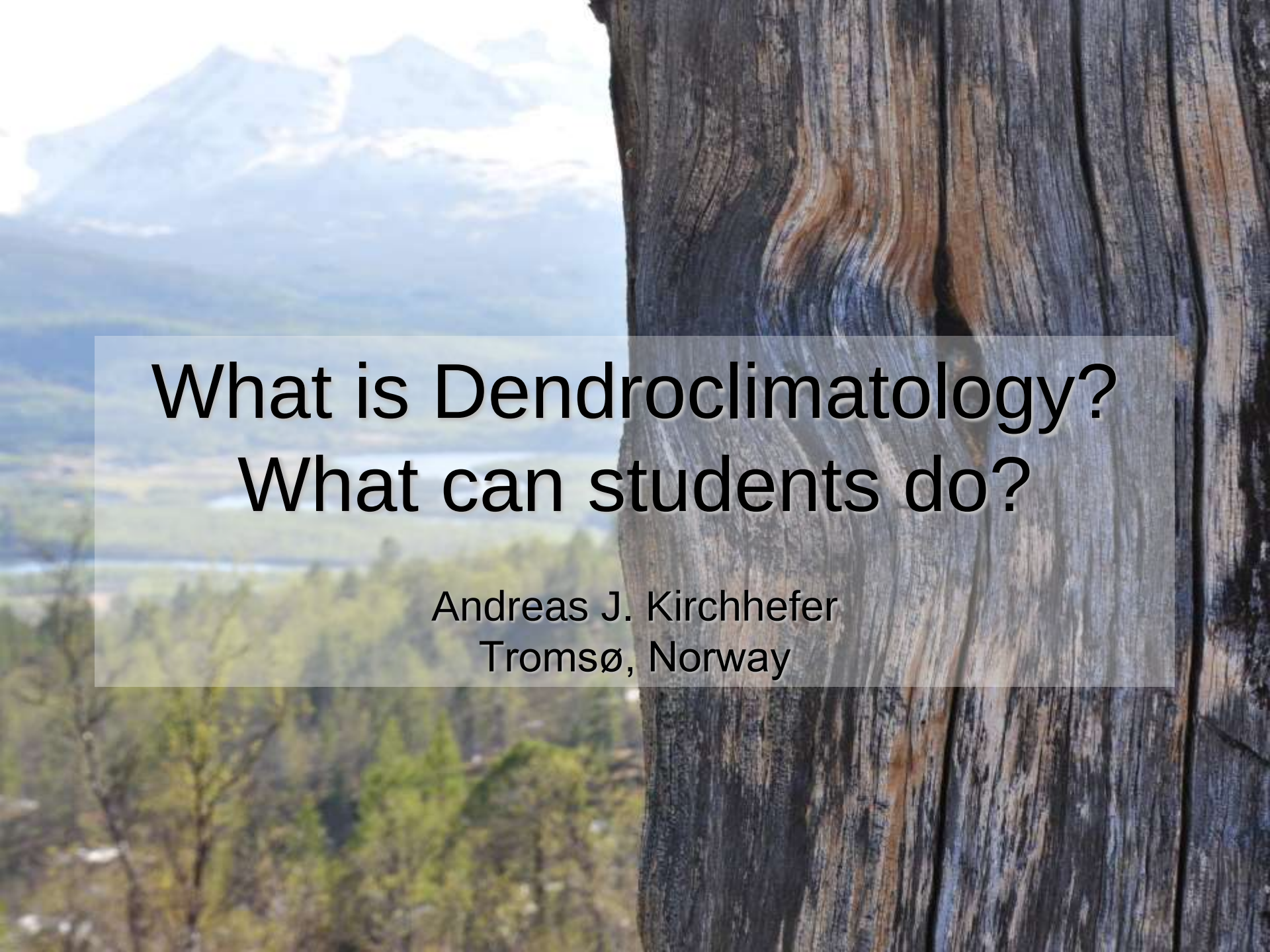


What is Dendroclimatology? What can students do?

Andreas J. Kirchhefer
Tromsø, Norway

What is dendroclimatology?

”*The tree as a weather station*”

Aims:

- Understanding the trees responses to climate
- Reconstructing climate
- Understanding modern climate

- Simple basic steps,
  but increasingly sophisticated methods

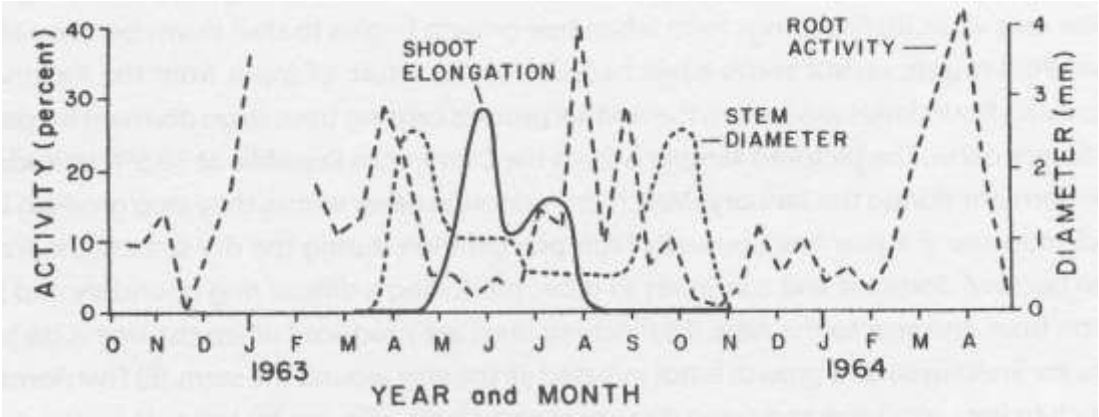
Principals and concepts of dendrochronology

- Prerequisit: An annual ring
- Limiting factors & ecological amplitude
- Crossdating

- Aggregate tree growth model
- Standardisation
- Autocorrelation
- Replication
- Site selection
- Uniformitarianism

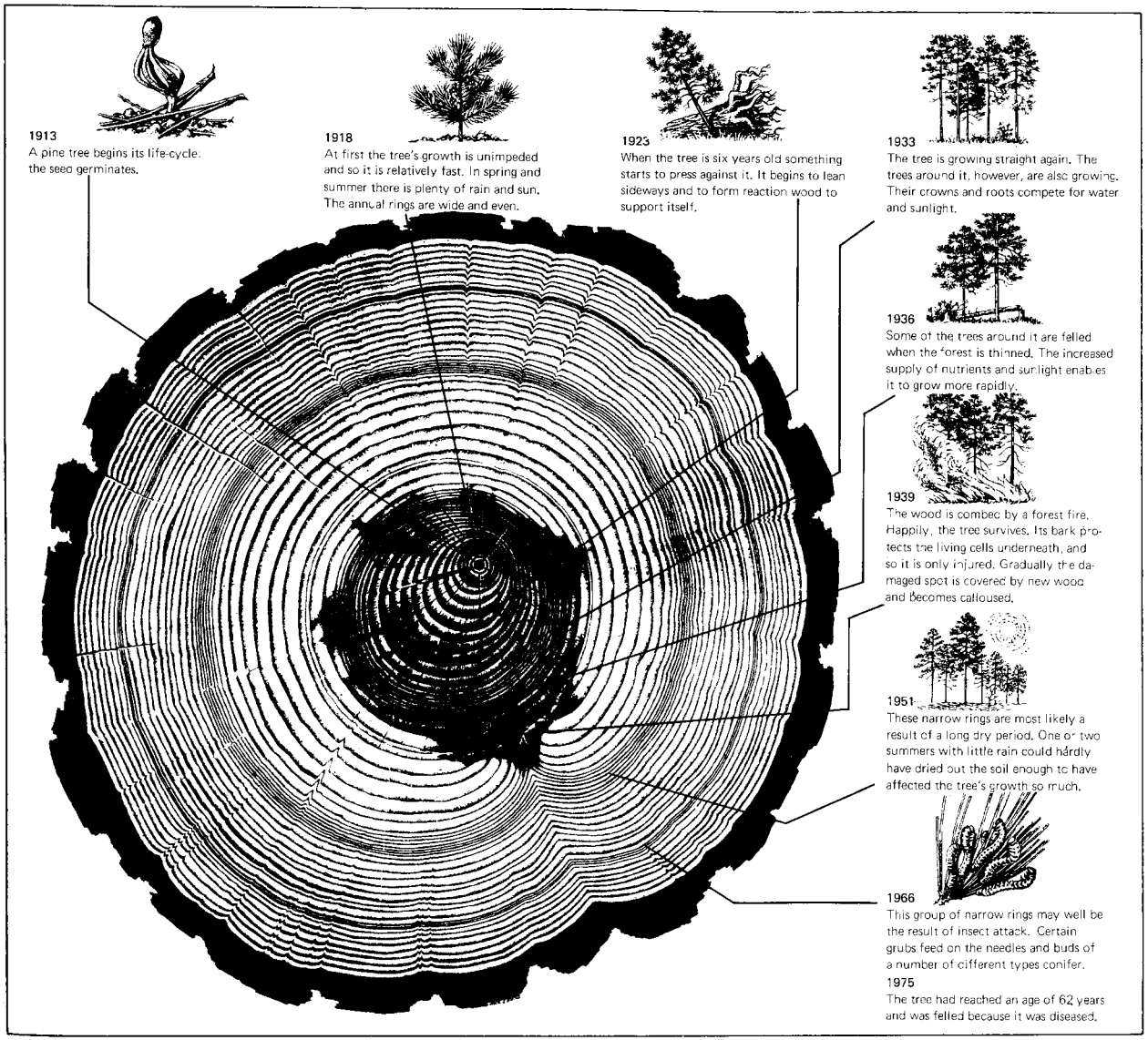
Tree rings

- Seasonal climate with one dormant season
  - Too cold
  - Too dry



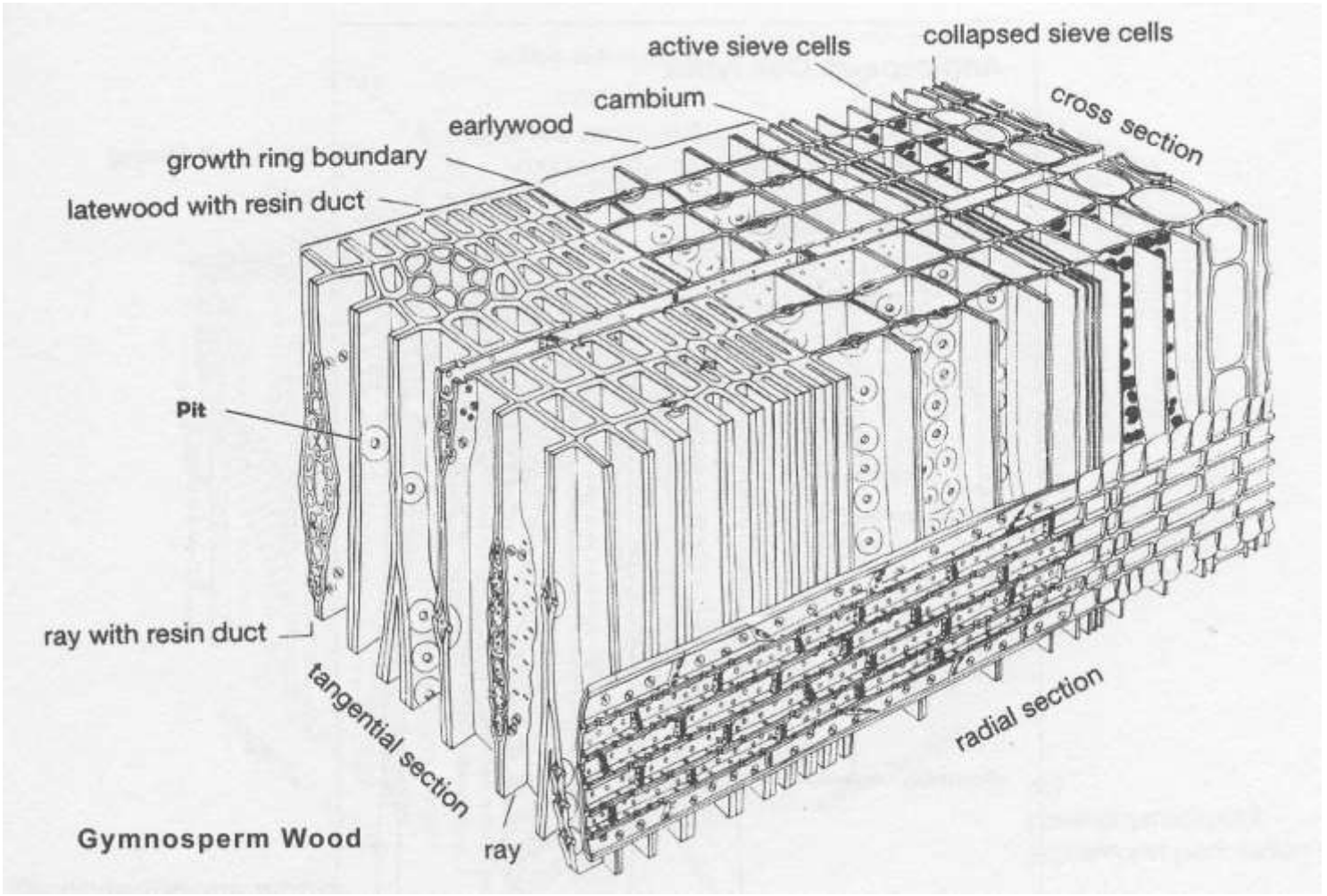
- Challenging: mediterranean climates
- Extremely difficult: tropical climate

Wood structure: conifers

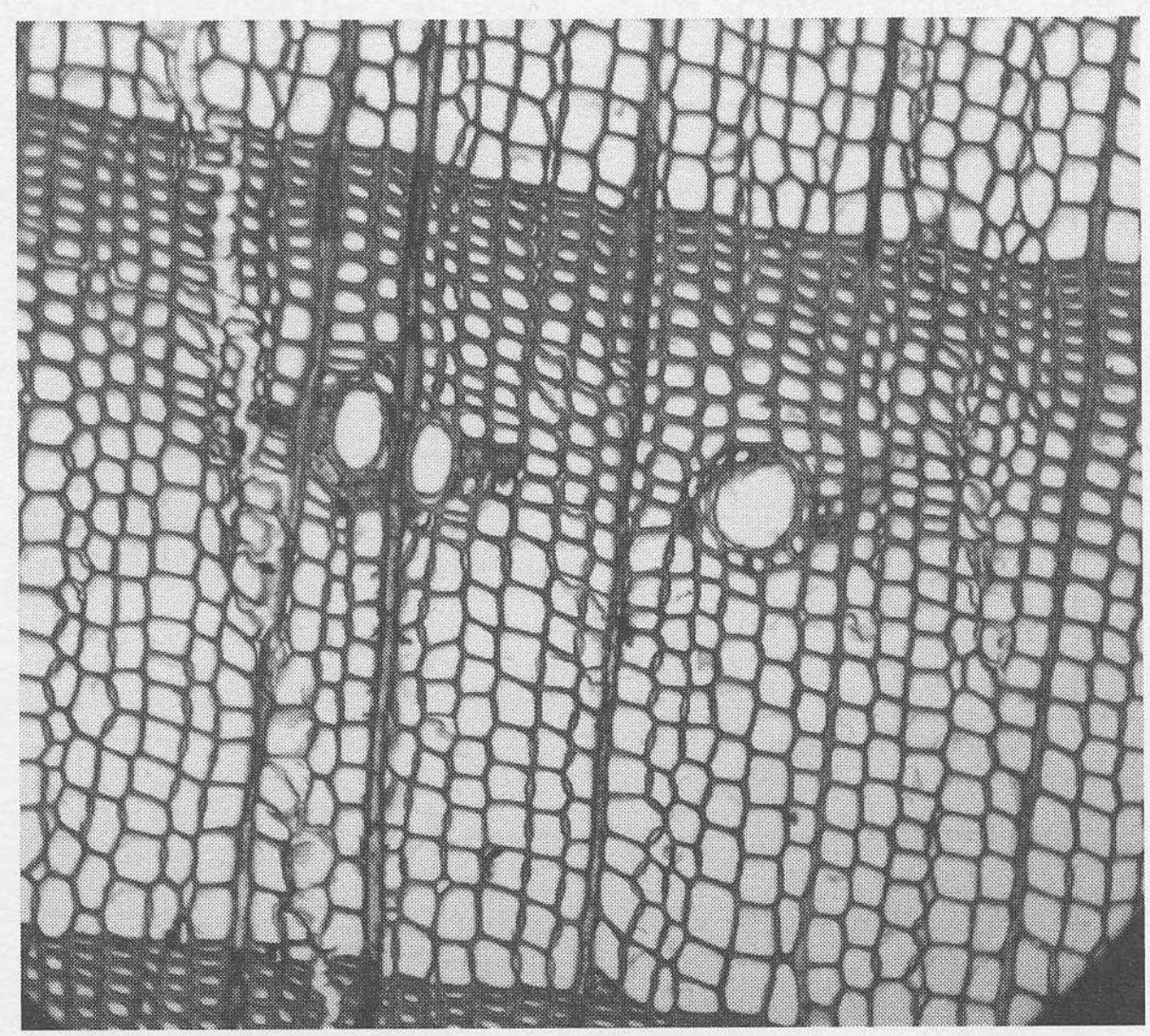


The reaction of an individual tree to different environmental factors (Wald and Umwelt).

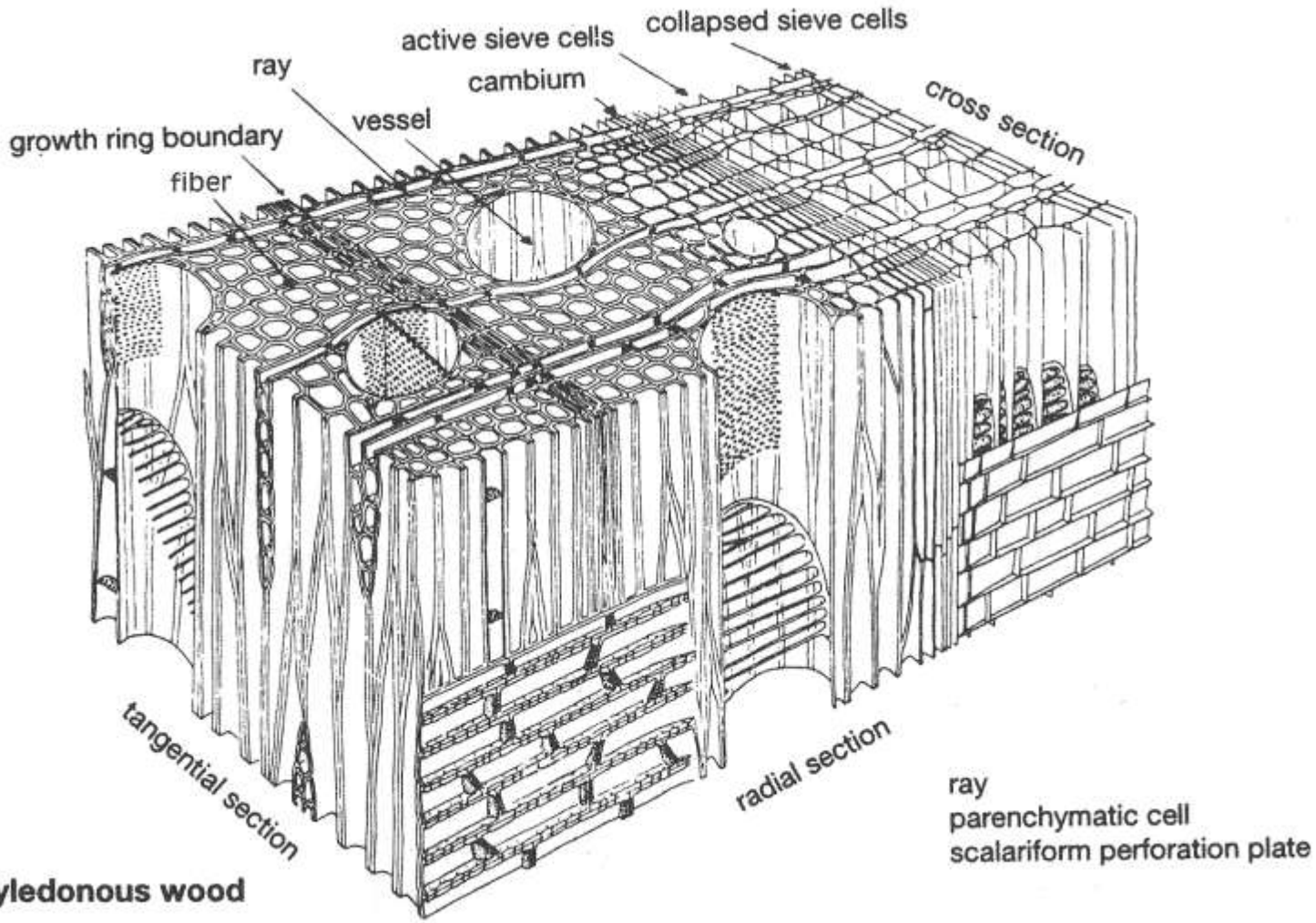
Wood structure: conifers



Wood structure: conifers

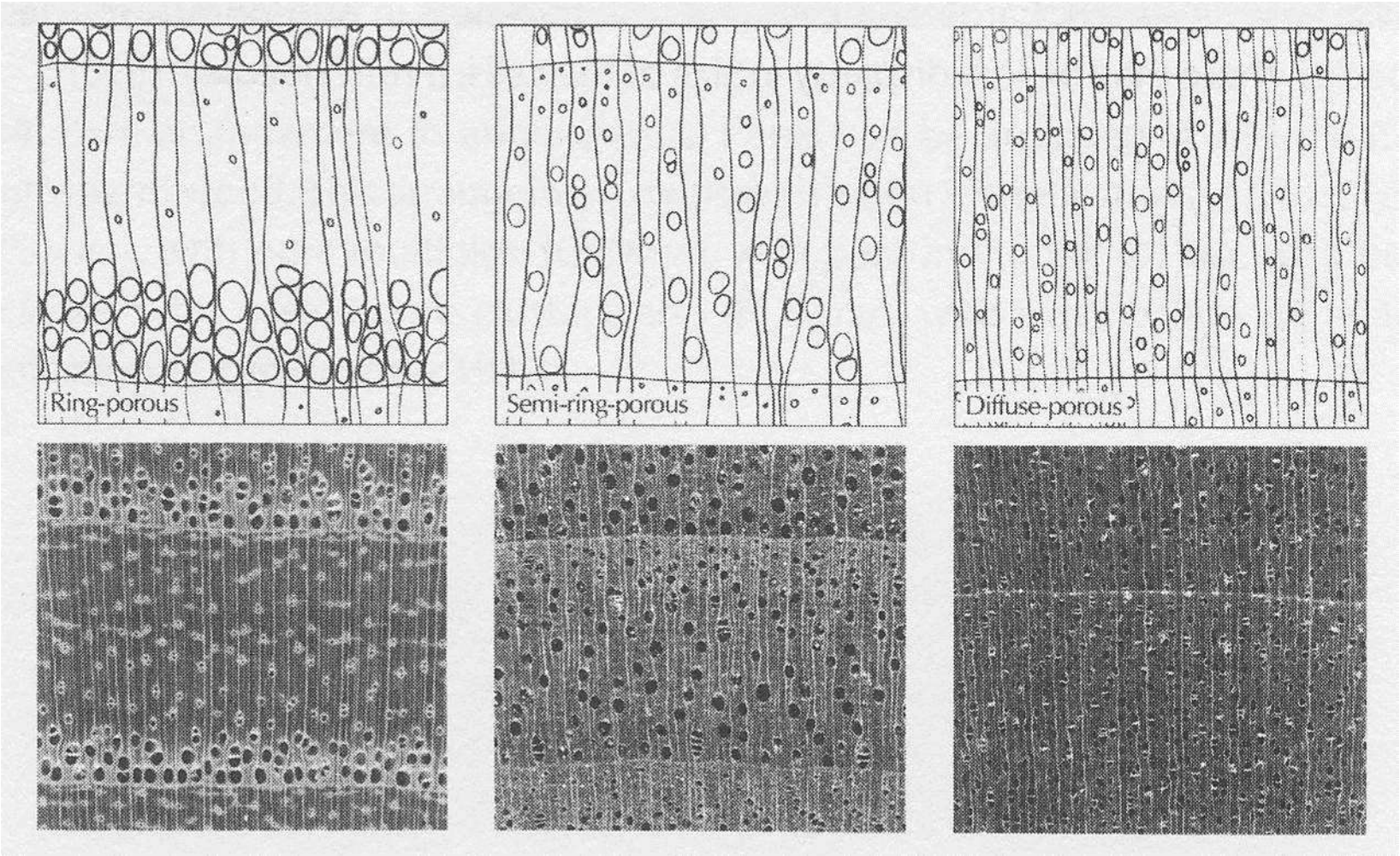


Wood structure: broadleaved trees



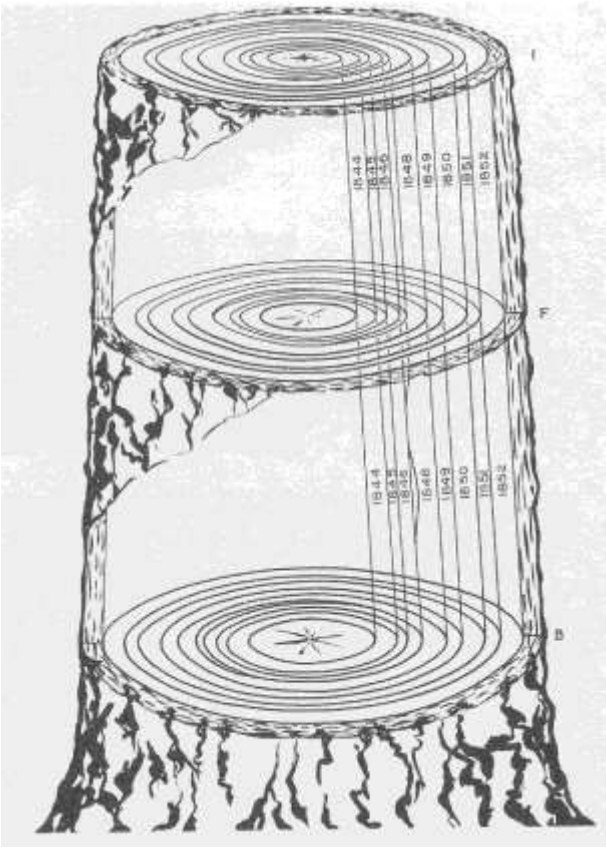
Dicotyledonous wood

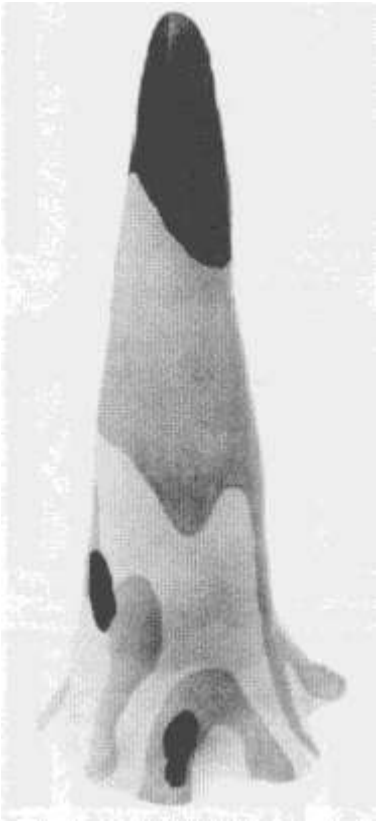
Wood structure: broadleaved trees



Wood structure

Think three-dimensional !

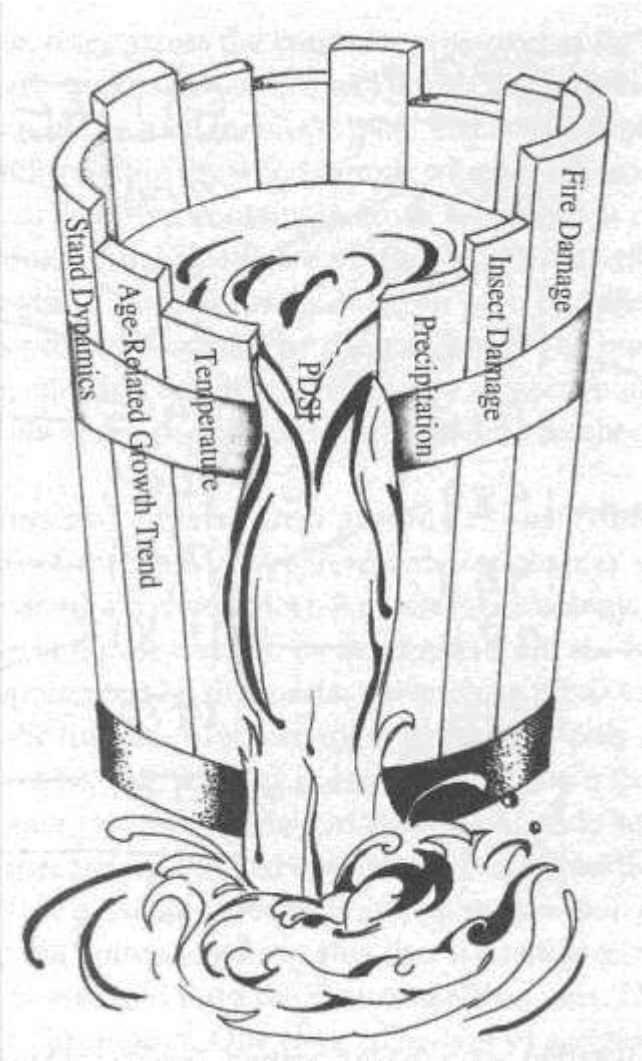


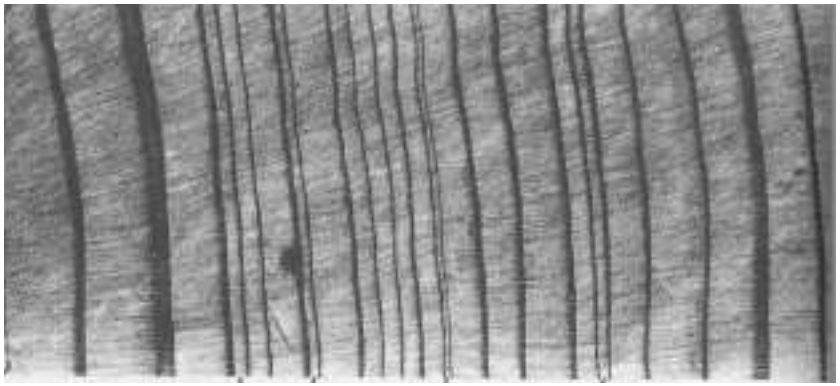


Auxin model of tree growth
=> Partial missing rings

Limiting factors

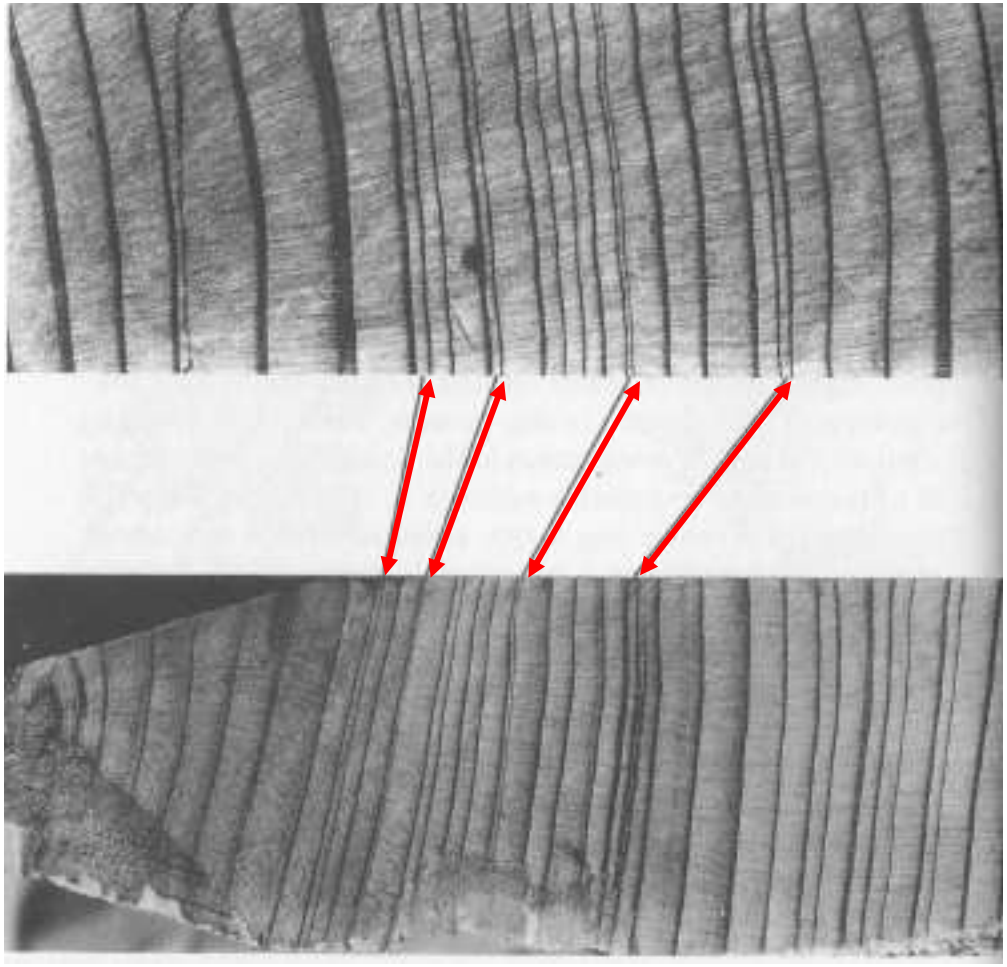
- Liebig's Law of the Minimum -





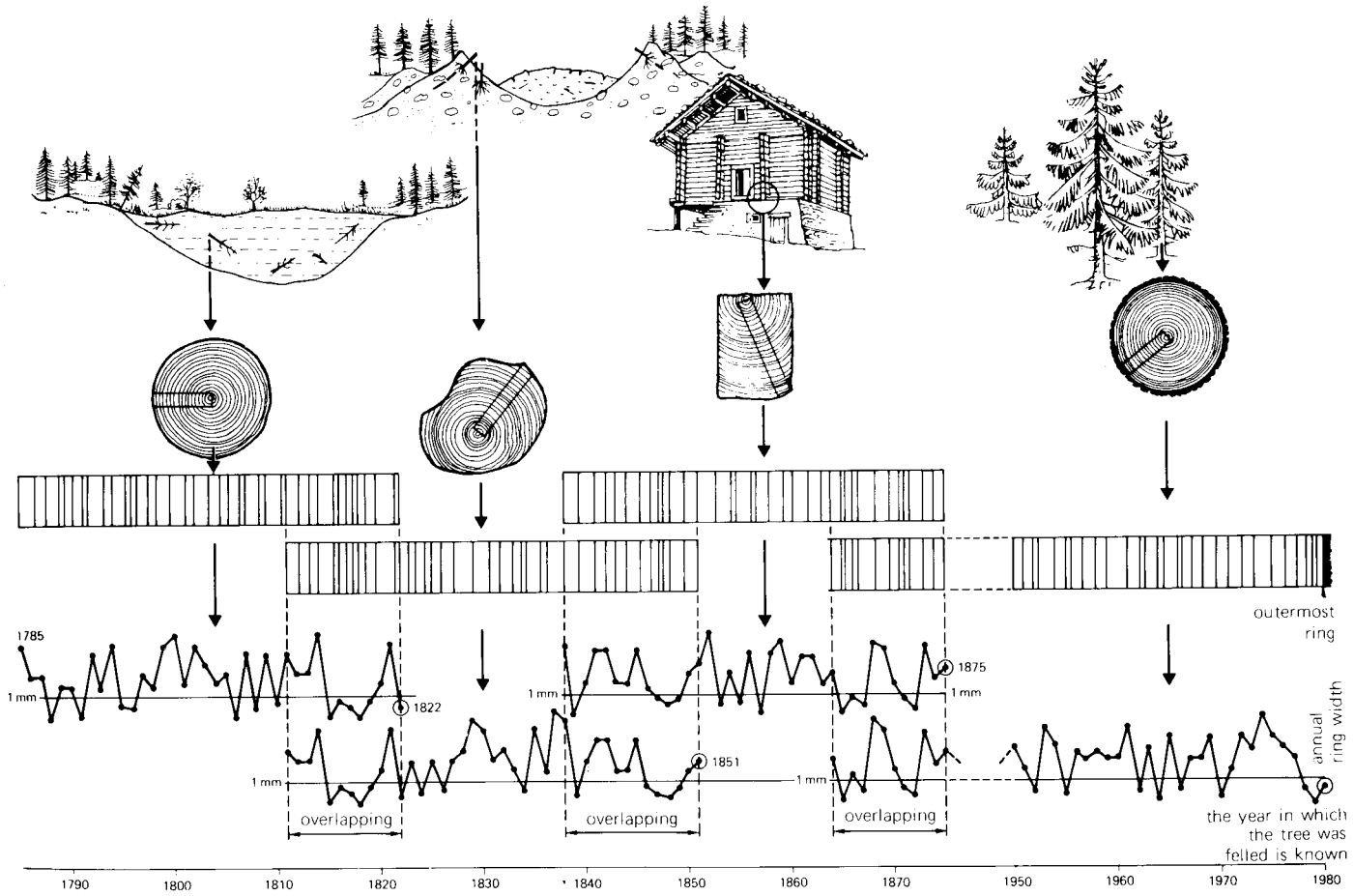
Droughts

Cross-dating



➢Dendrochronology

Dating of wood by means of tree-rings

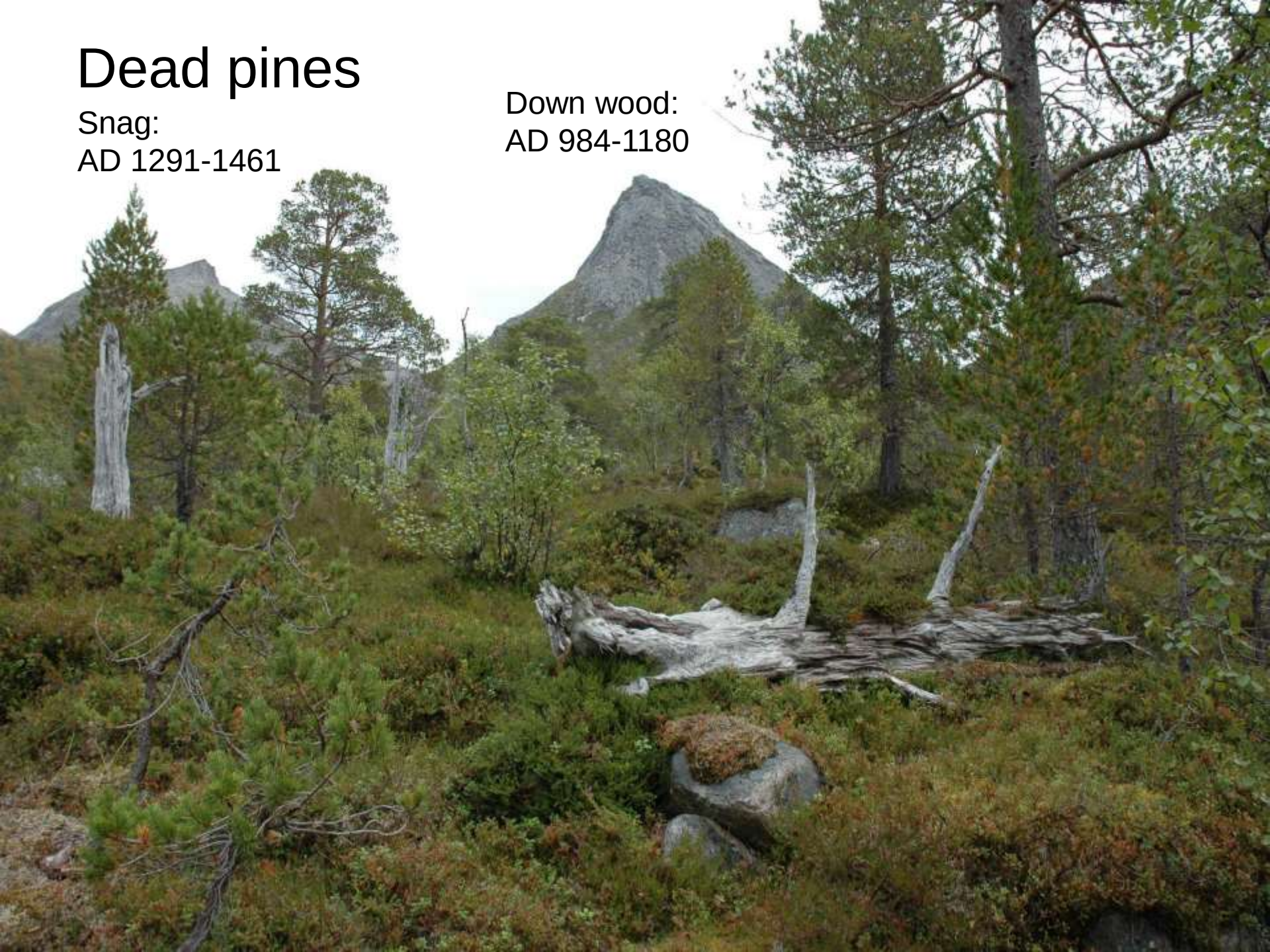


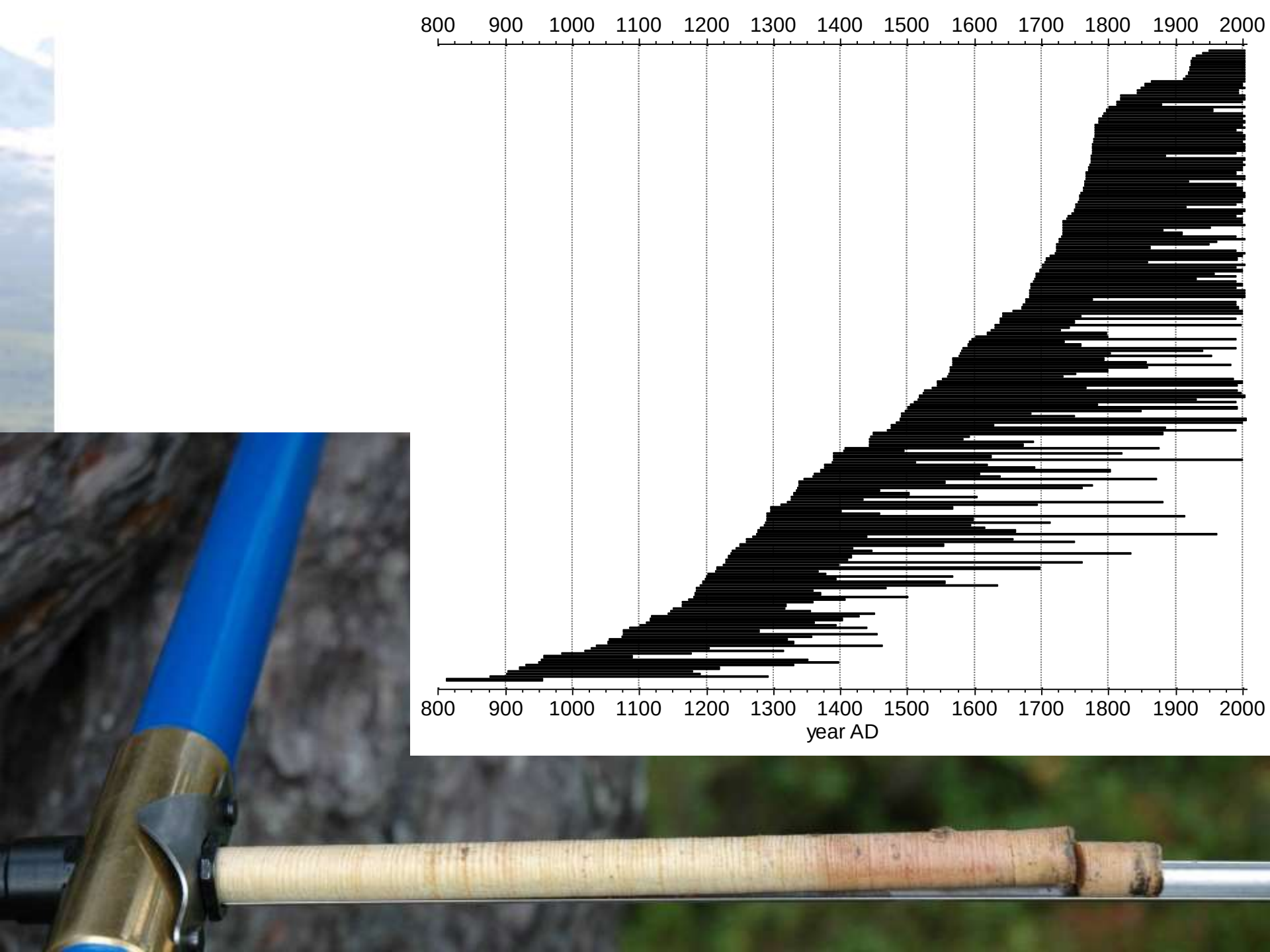

80 yrs
Living pines
300 yrs
>680 yrs

Dead pines

Snag:
AD 1291-1461

Down wood:
AD 984-1180




800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000
800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000
year AD

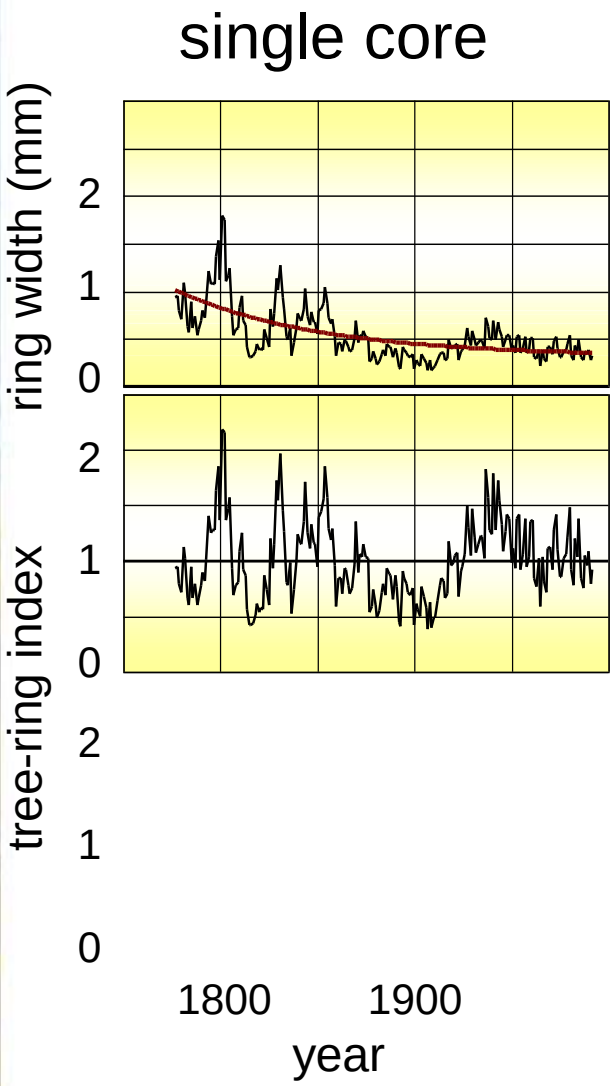
Brennskogtjern, 311 m

Aggregate model of tree growth

Ring width is function of

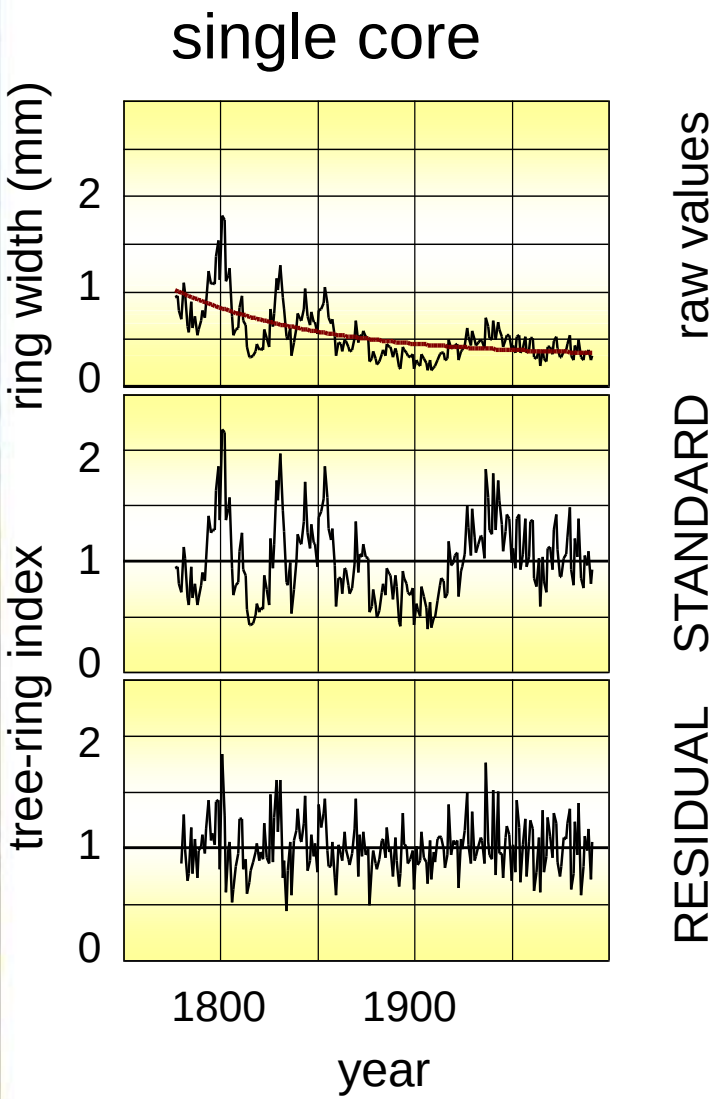
- Age related growth trend
- Climate
- Endogeneous disturbance (within stand)
- Exogeneous disturbance (from outside)
- error

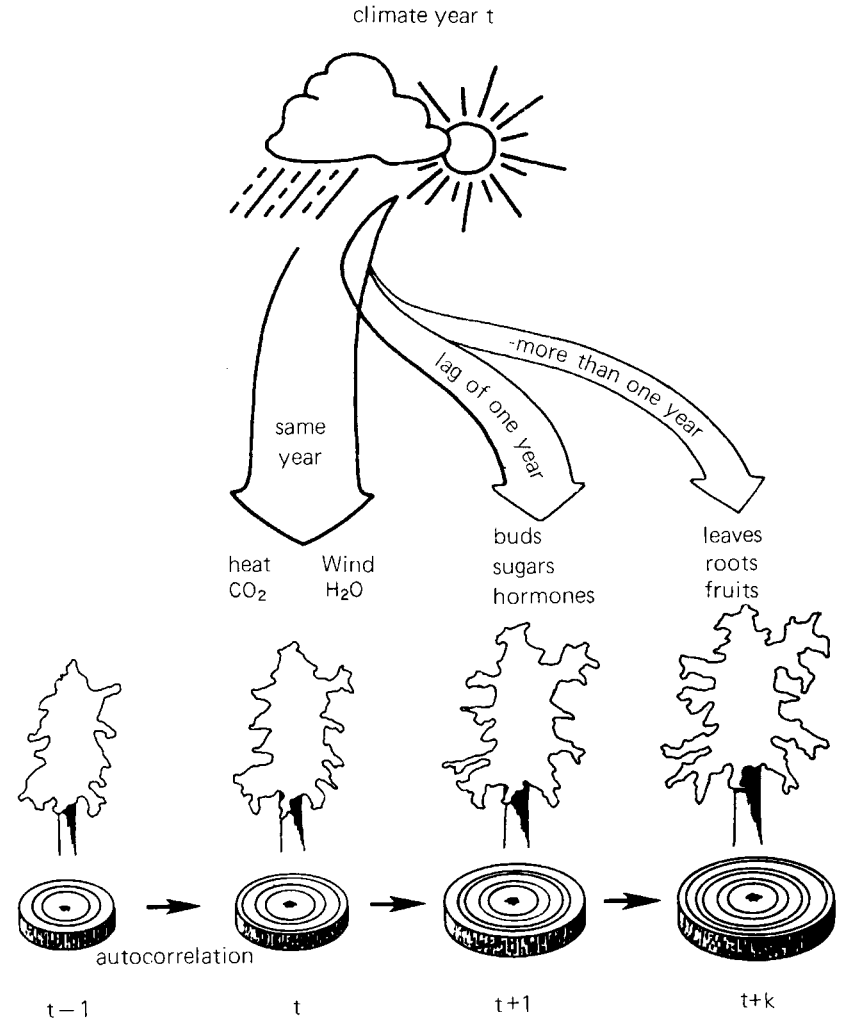
Standardisation – removing age trend



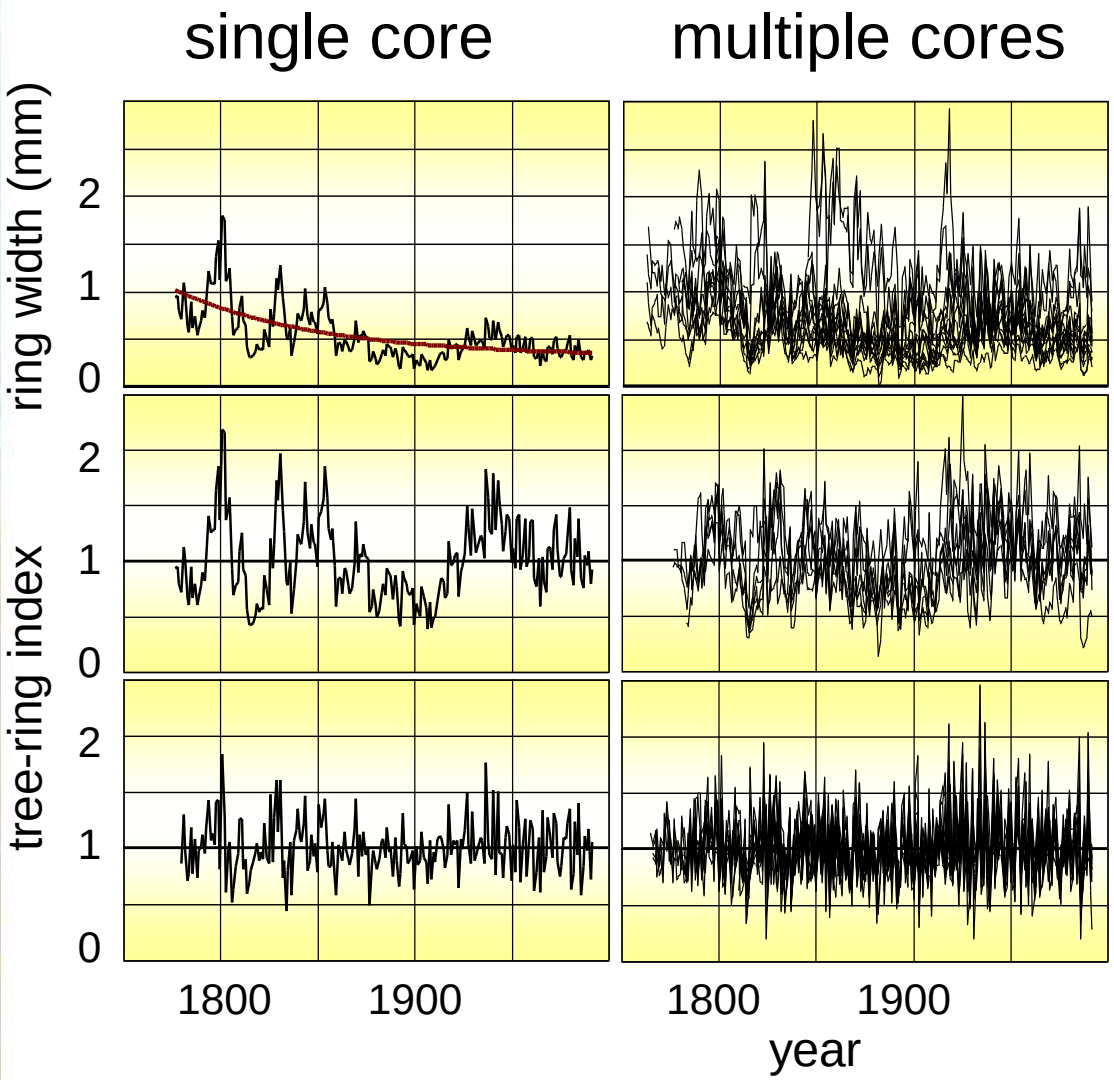
RESIDUAL STANDARD raw values

Autocorrelation



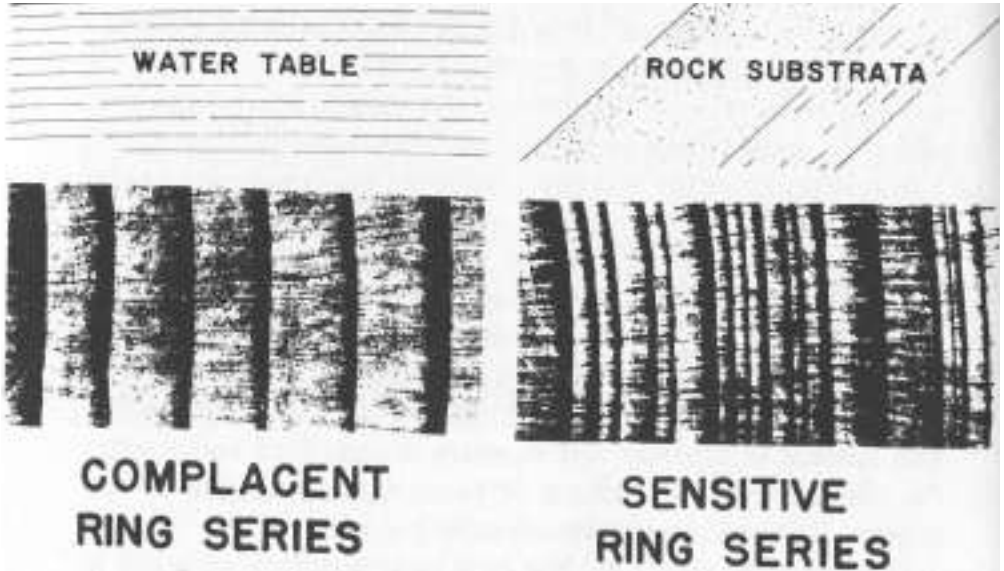


Replication



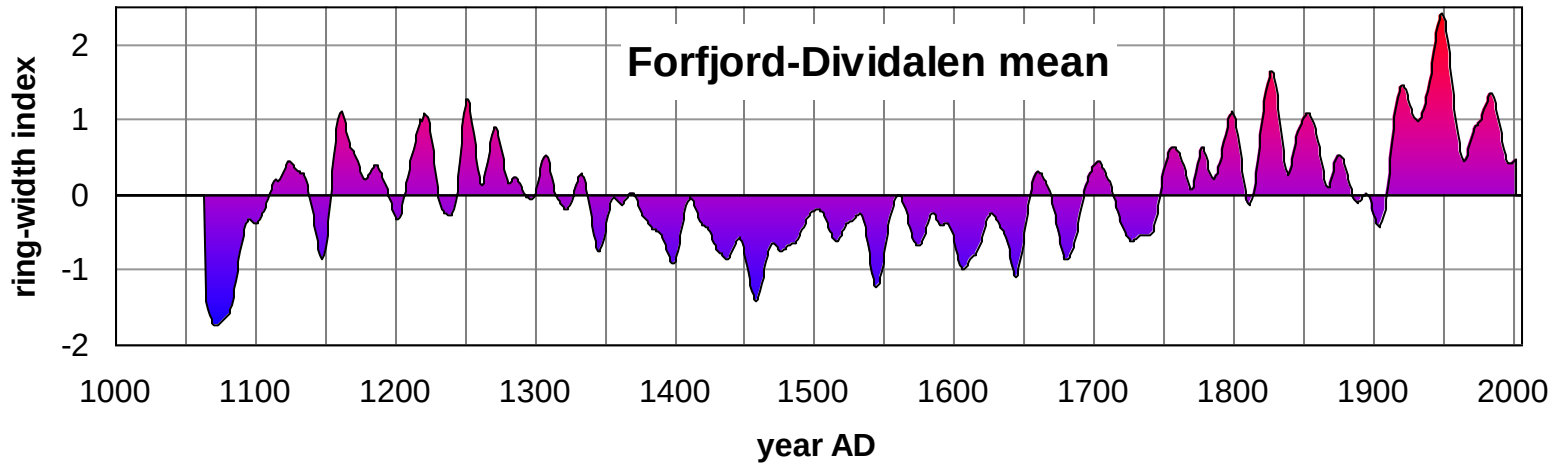
raw values STANDARD RESIDUAL

Site selection



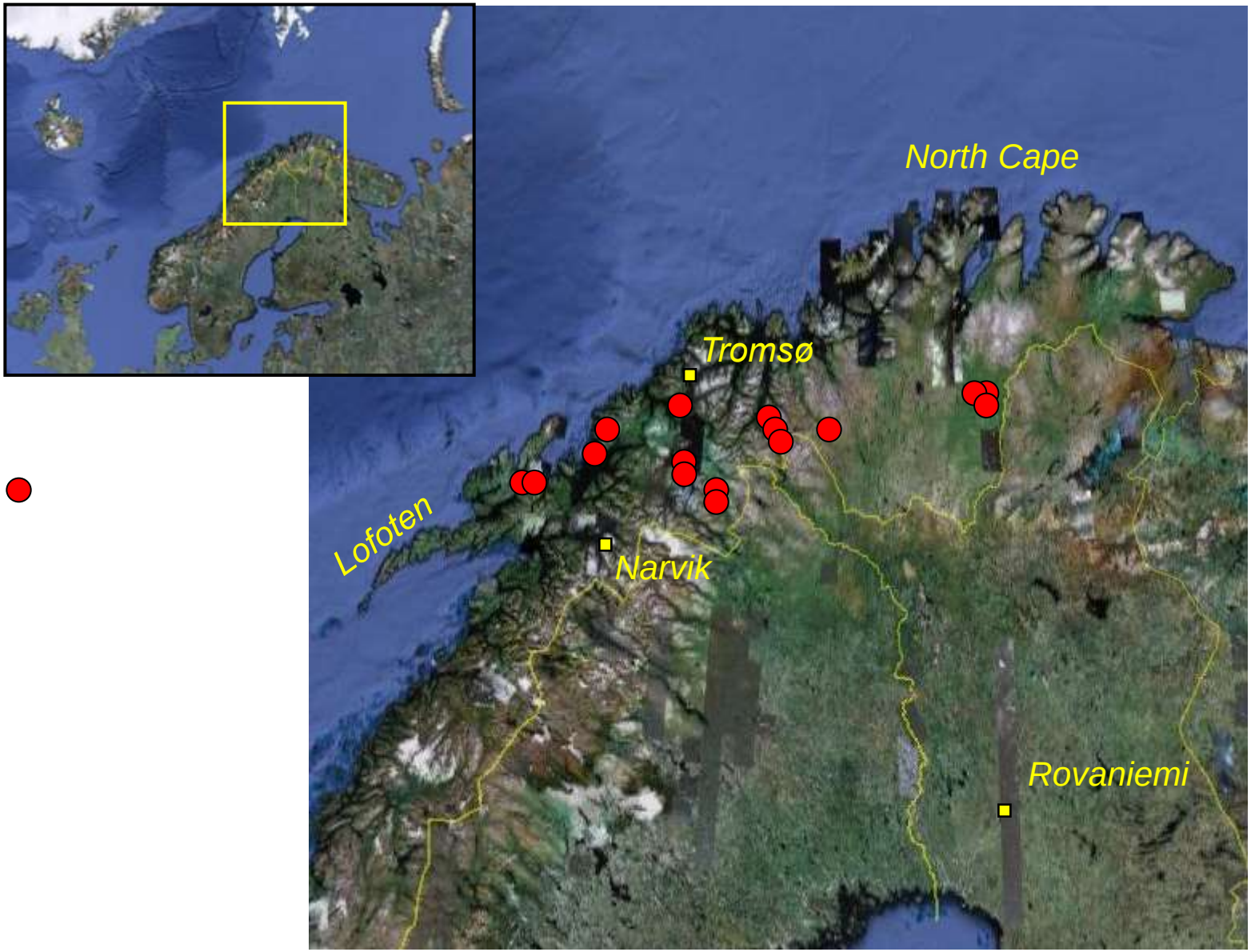
Uniformitarianism

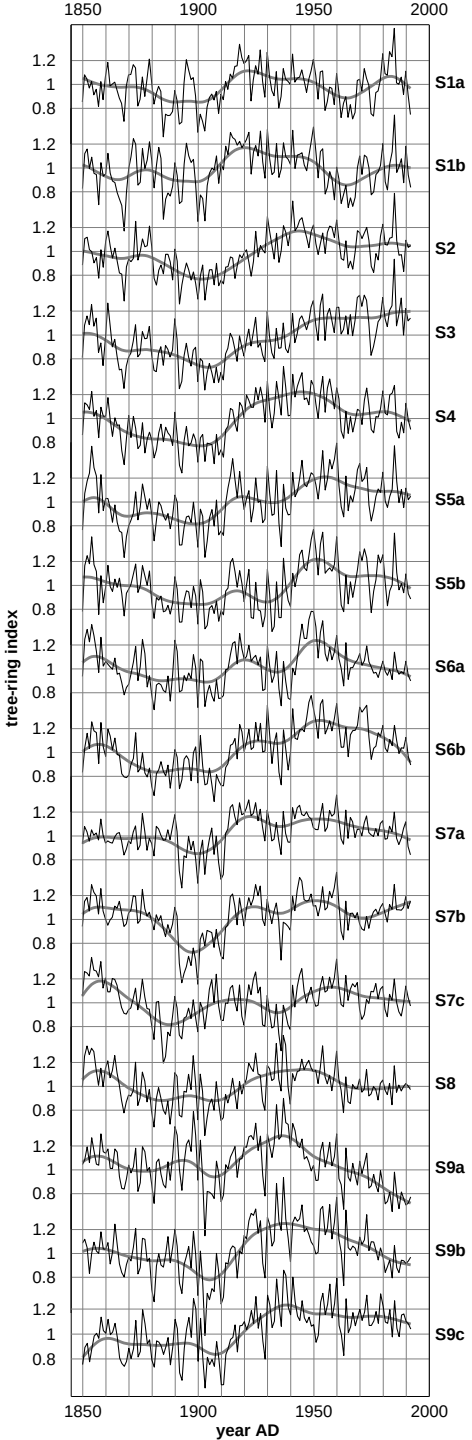
- The present is the key to the past



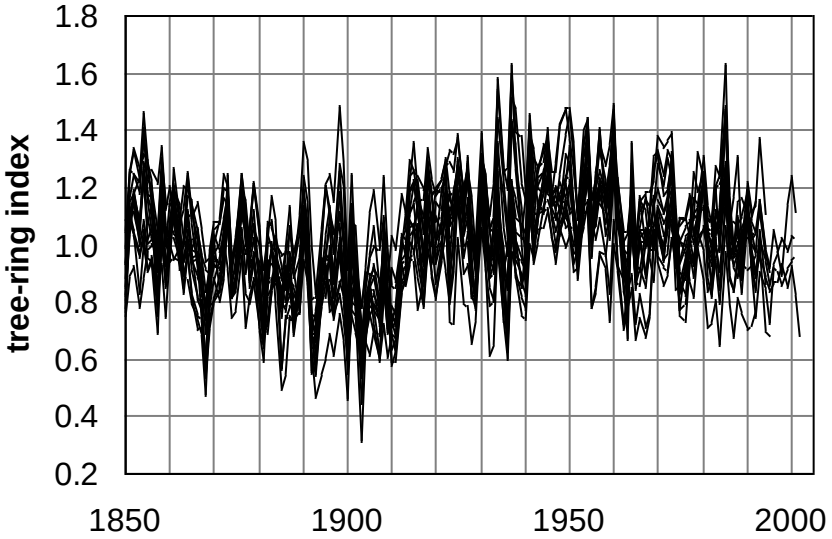
Dendroclimatology

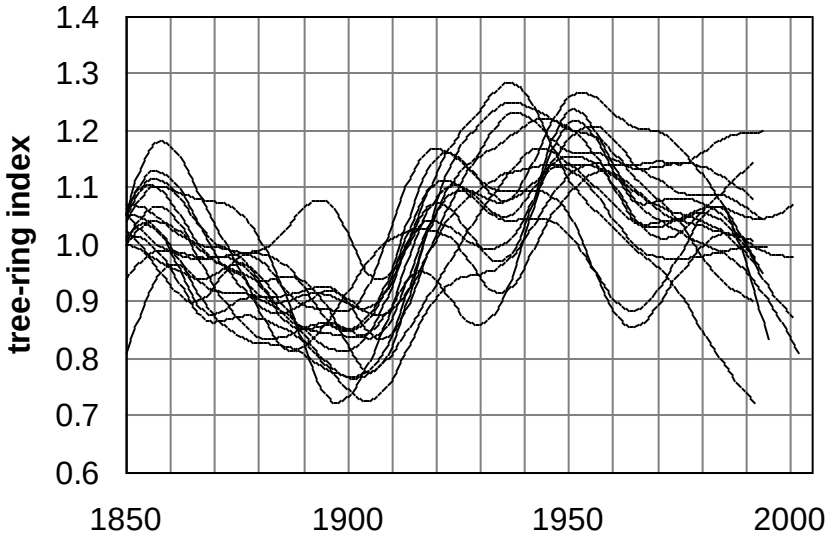
- Stabile chronology
- Climate data
- Climate-response analysis
- Calibration / verification
- Reconstruction


North Cape
Tromsø
Lofoten
Narvik
Rovaniemi

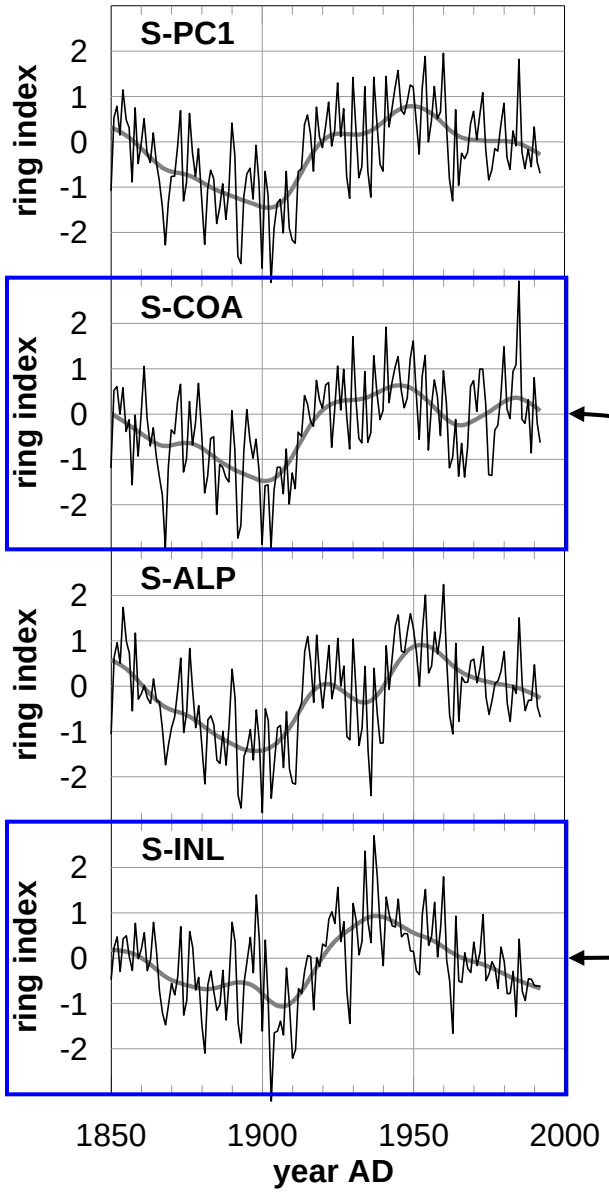


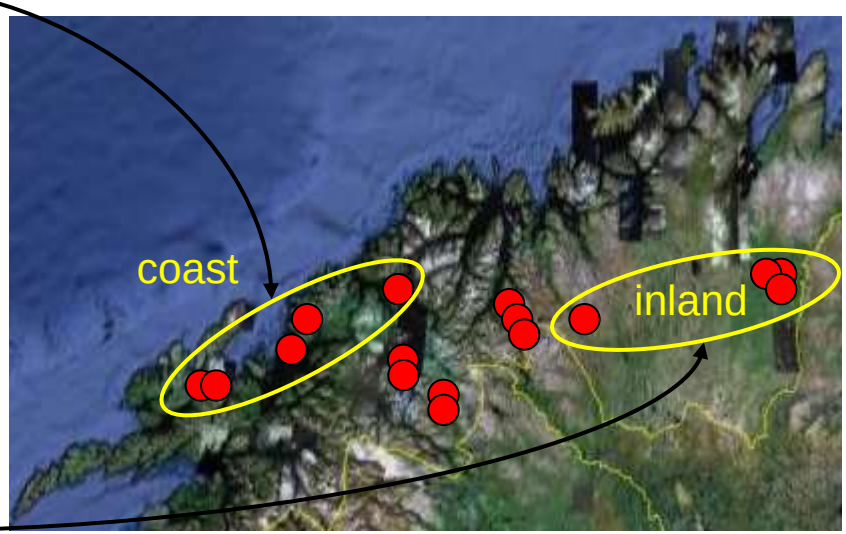
Standard chronologies 1850-1992



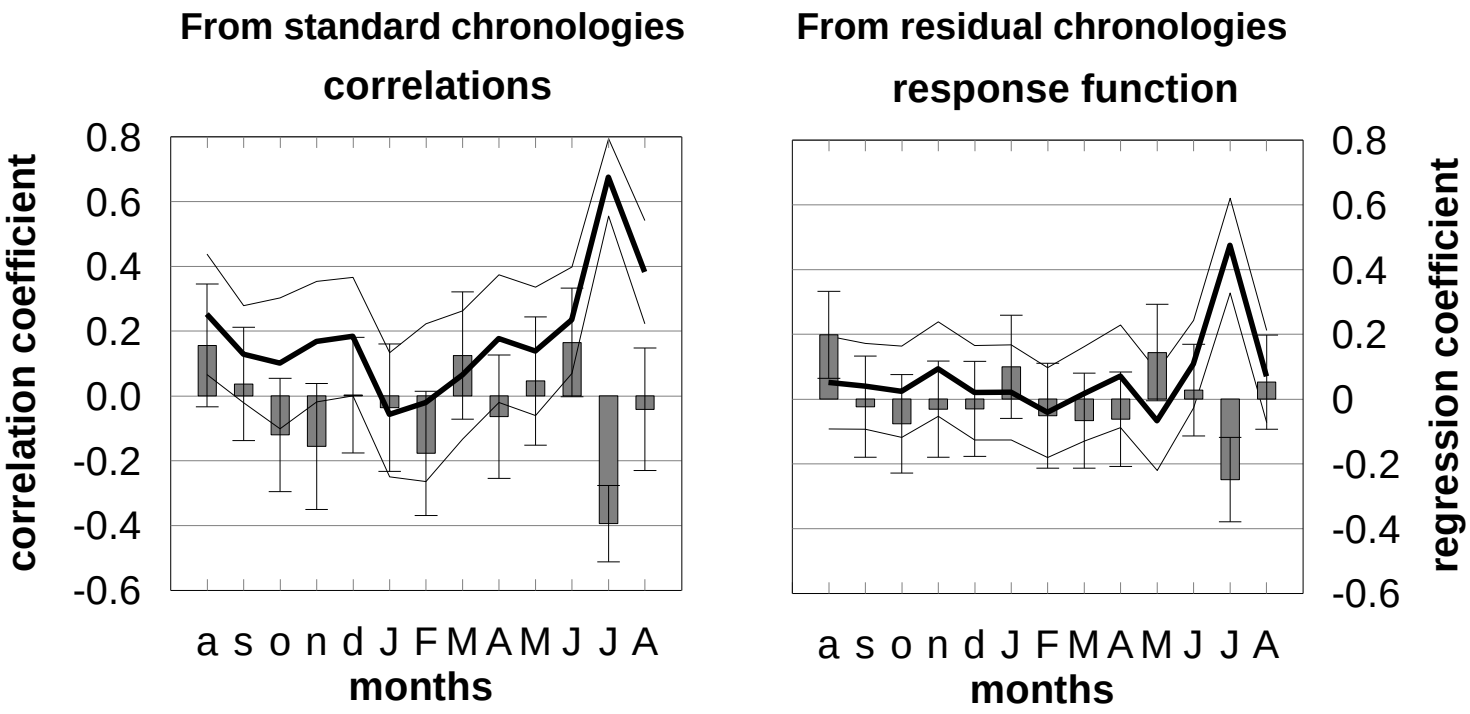


Regional standard chronologies 1850-1992



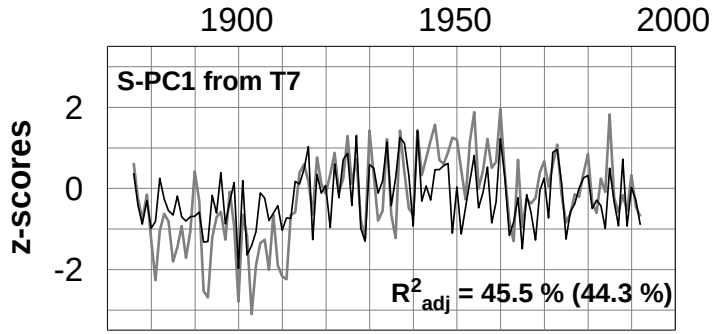


General growth response (PC1)

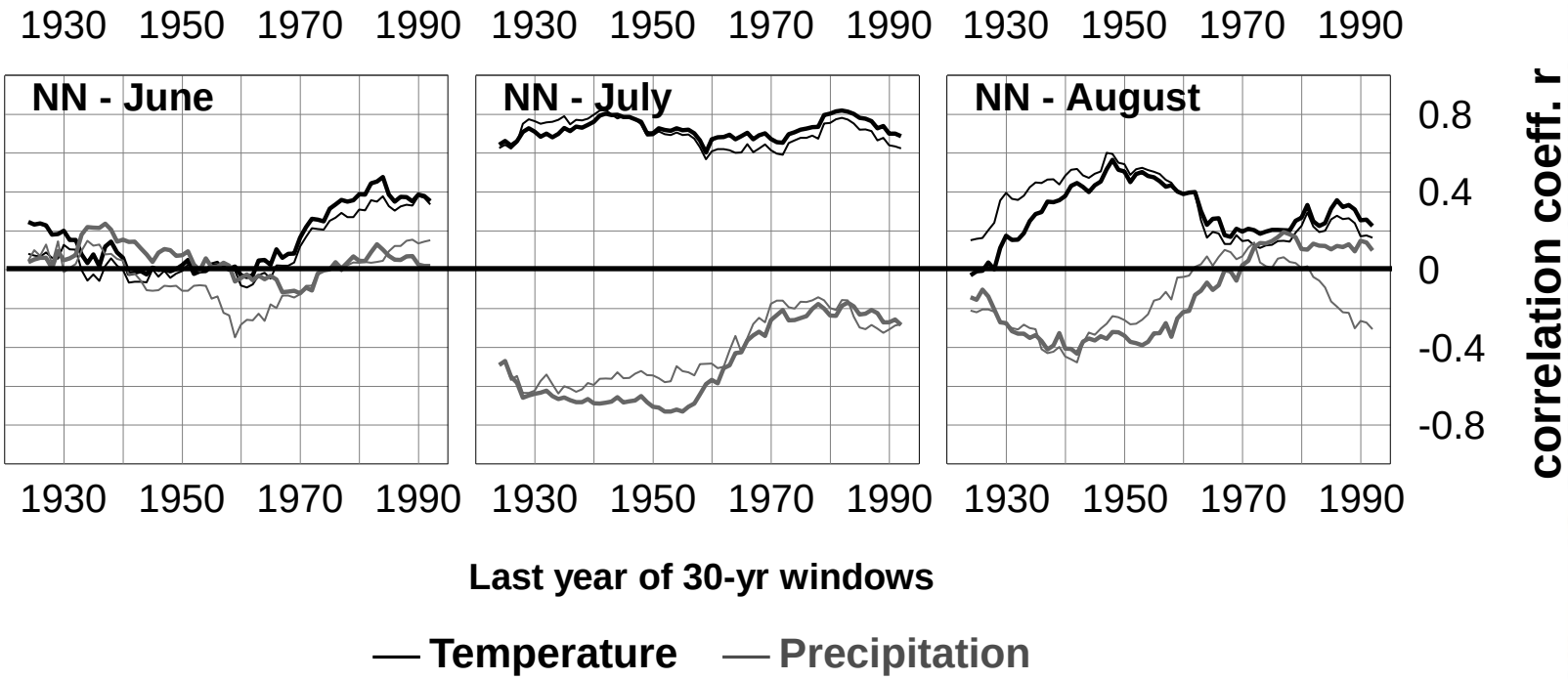


Tree-growth from July temperatures

1875-1992 (1895-1992), standard chronologies



A mid-20th century response shift

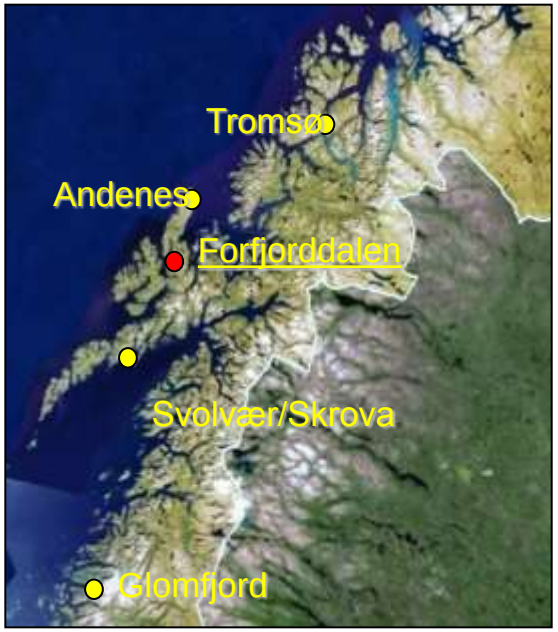


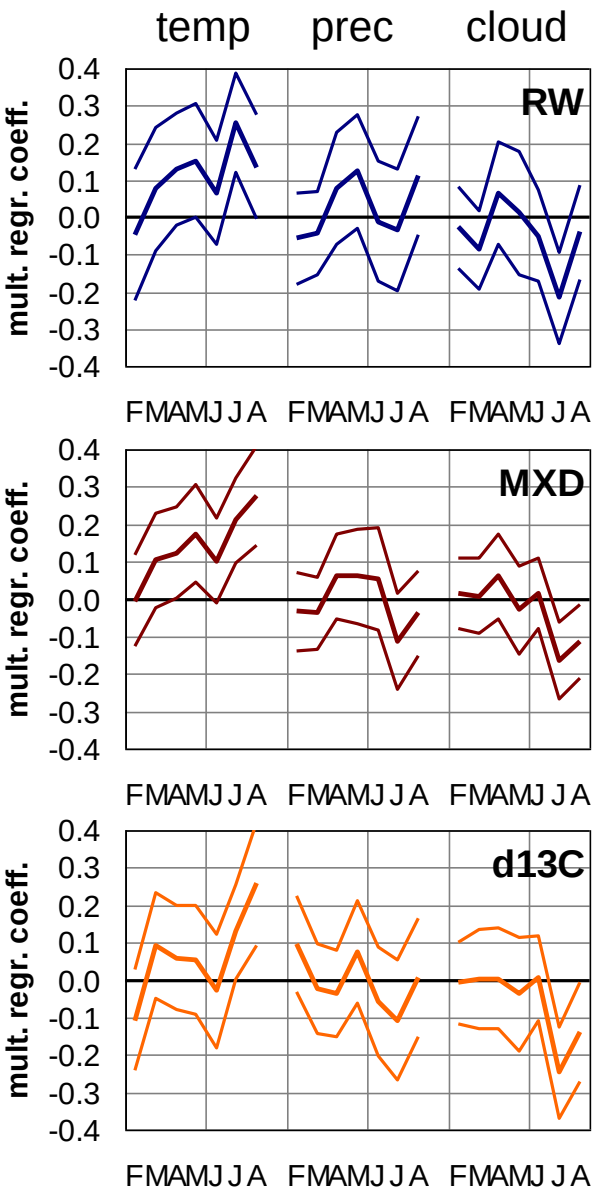
Multiproxy dendroclimatology

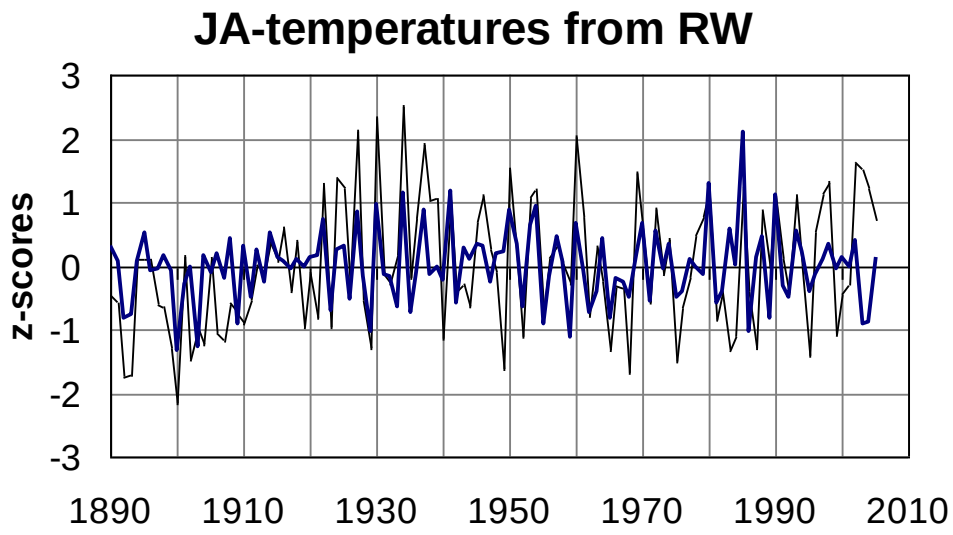
- Ring width
- Early- and latewood width
- Latewood density
- Stabile isotopes
- Cell morphology
- Other high-resolution climate archives:
  - Ice cores, speleotems, sediments
  - Corals, molluscs

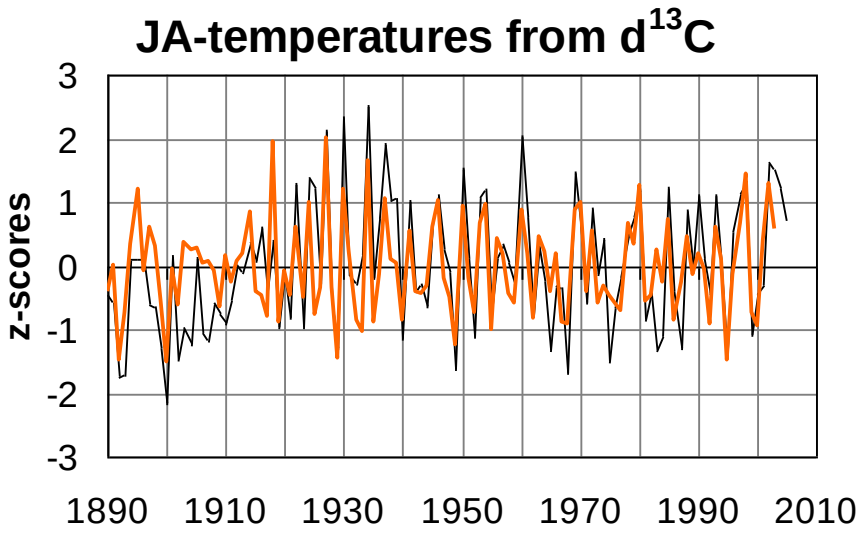
Growth responses:

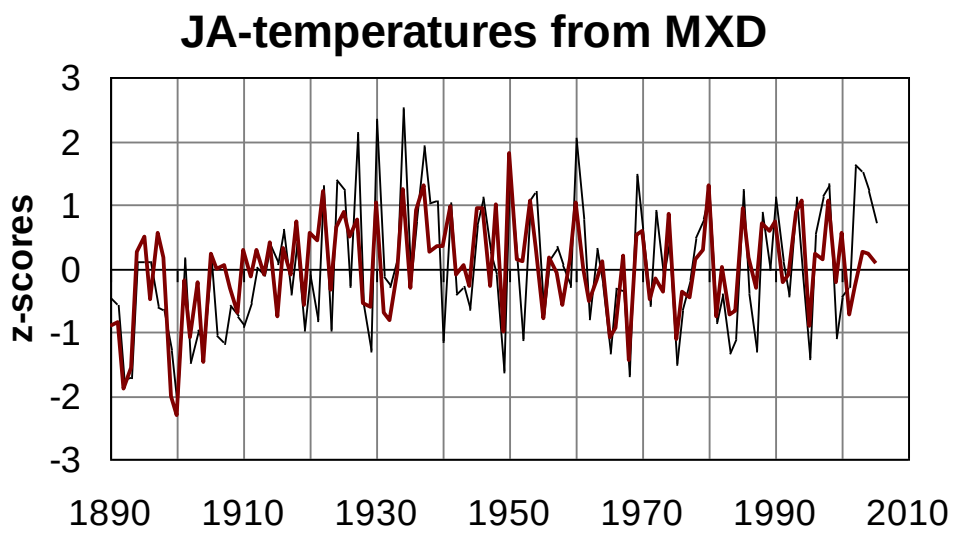
- temperature (left)
- precipitation (mid)
- cloud cover (right)

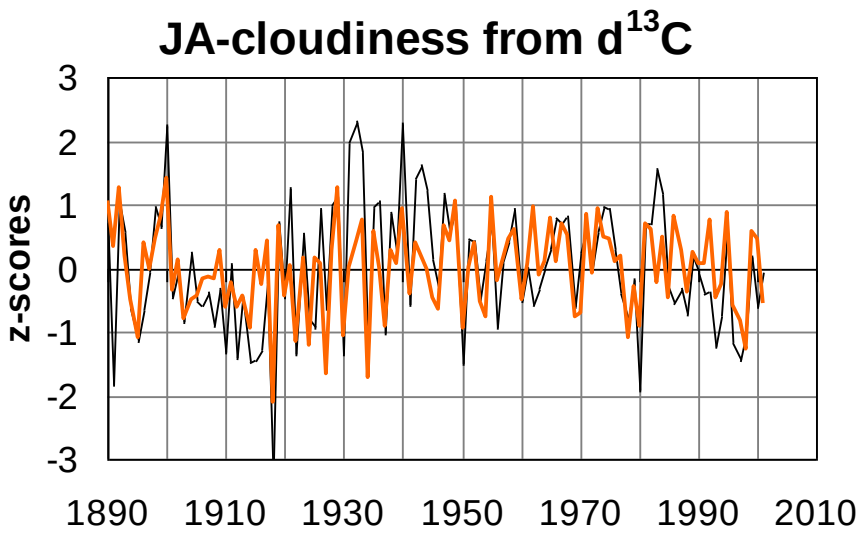





JA-temperatures from RW
z-scores
3
2
1
0
-1
-2
-3
1890
1910
1930
1950
1970
1990
2010


JA-temperatures from d13C
z-scores
3
2
1
0
-1
-2
-3
1890
1910
1930
1950
1970
1990
2010


JA-temperatures from MXD
z-scores
3
2
1
0
-1
-2
-3
1890
1910
1930
1950
1970
1990
2010

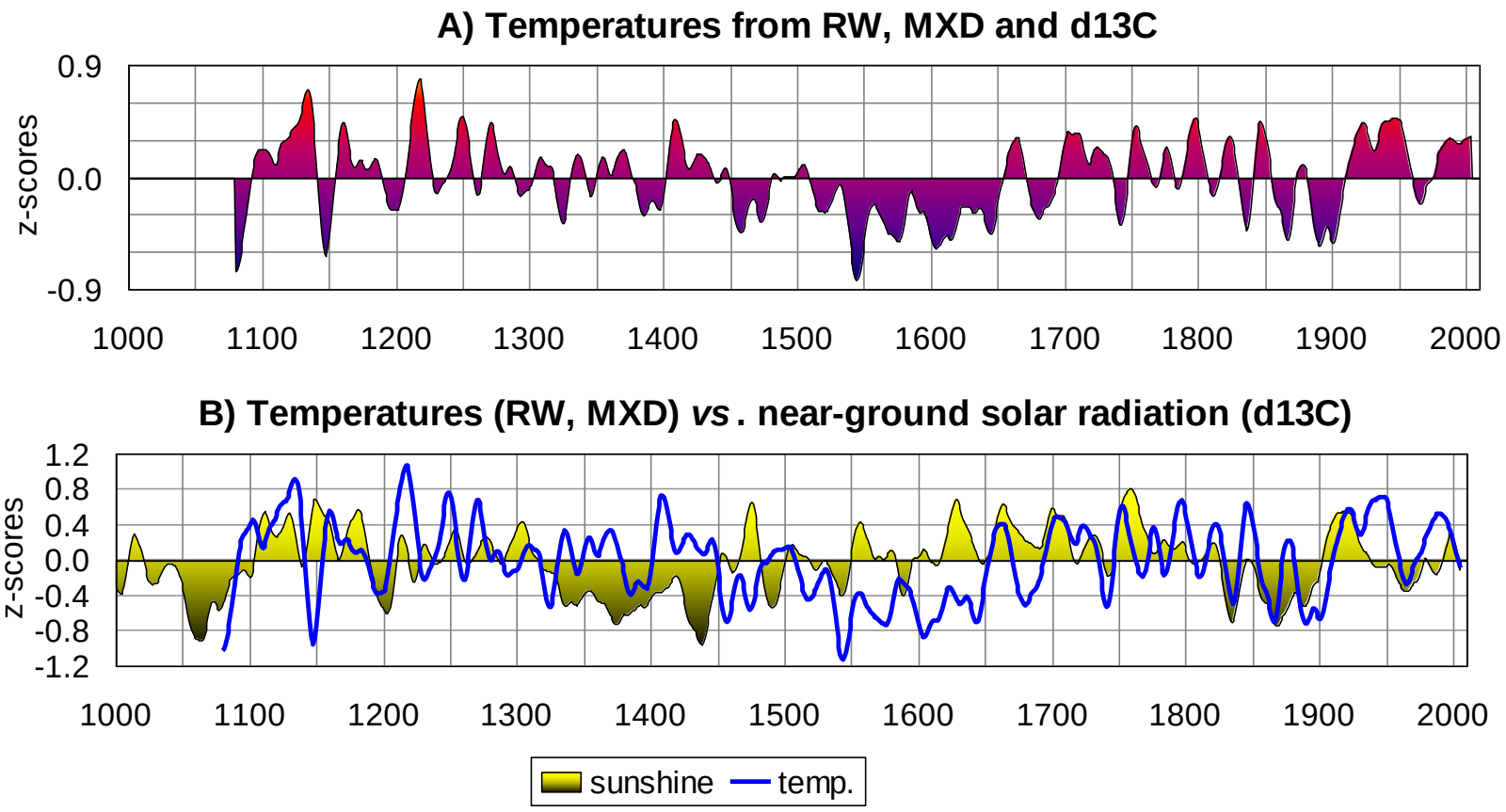

JA-cloudiness from d13C
z-scores
3
2
1
0
-1
-2
-3
1890
1910
1930
1950
1970
1990
2010

Calibration statistics

RE: Reduction of Error, CE: Coefficient of Efficiency

Target <= predictor (model)	Calibration	n	r	R^2_{adj}	Verification	RE	CE
JA temp <= RW (t-1,t,t+1)	1890-2005	116	.58	**.319**			
	1890-1947	58	.73	.502	1948-2005	-.095	-.136
	1948-2005	58	.57	.286	1890-1947	.177	.151

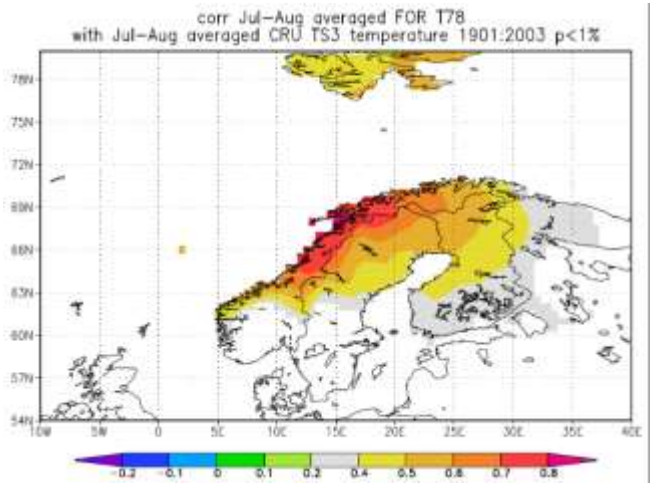
July-August climate from tree-rings



Synoptic dendroclimatology

- Large-scale networks
  - Atmospheric circulation
  - Teleconnections

CRU TS3



Forfjord
3-proxy
JA temp.

What can students do?
- basics -

- Where do we find tree-rings? How do they look?
- Tree

  species, circumference, height, state?
- Site

  geology, slope aspect, soil moisture, vegetation type - what influences tree growth?
- Preparation:

  http://web.utk.edu/~grissino/, http://www.rmtrr.org/
- Tree-ring counts
  - On discs or cores
  - How old is the tree (vs. DBH & height, stand structure)?

What can students do?

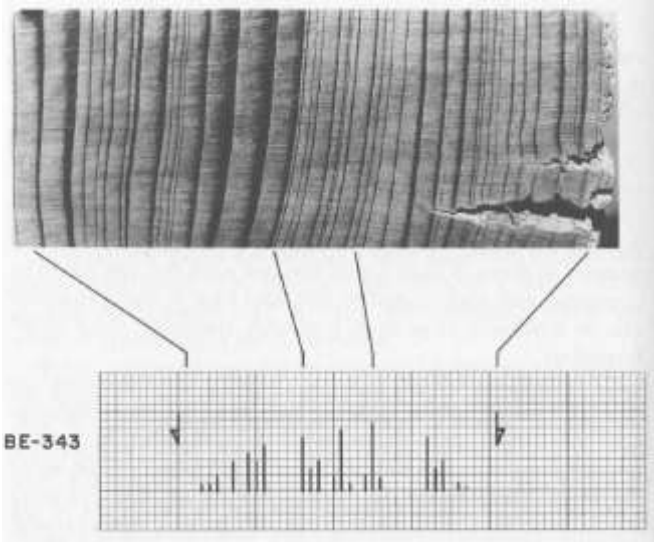
- basics (2) -

- Tree-ring patterns on discs
  - From pith to bark
  - Concentric?
  - Growth discontinuities?
- Young conifers

  branch whirl count & height increment vs. TR

What can students do?
- ring widths -

- Single-year analysis:
  - skeleton plotting
    - exteme rings, abrupt changes
    - particular characteristics: frost rings, resin ducts
  - Cross-dating (pointer years)
  - Comparison with climate



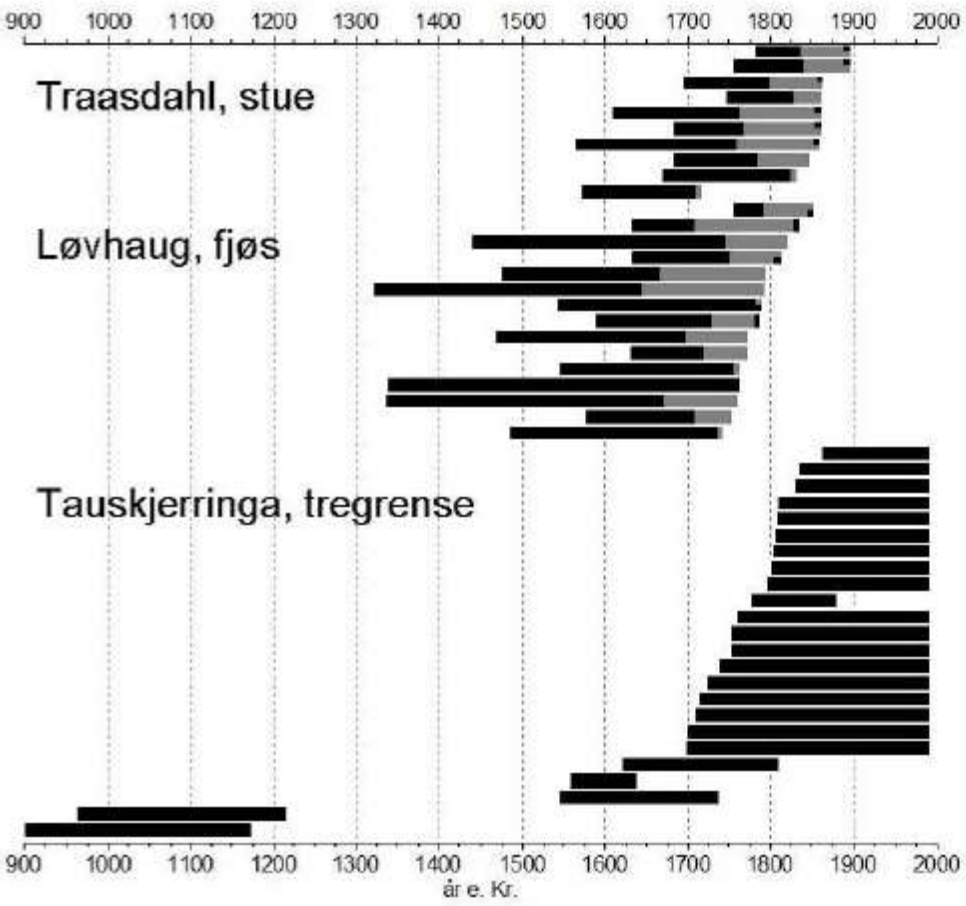
What can students do?

- ring widths (2) -

- Ring-width series:
  - Measuring (measuring scale, scan, digital photography – depending on RW)
  - Cross-dating and chronology
  - Dealing with age trends
  - Comparison with climate
  - Reconstruction excercise?

What can students do?

- dating excercises -



- Stumps?
- Recently died trees?
- Buildings?