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Tree growth dynamics in relation to changing climate and hydrology at Lake Hinnensee, NE Germany

Ingo Heinrich, Theresa Blume, Andreas Güntner, Sonia Simard, Gerhard Helle

Helmholtz Centre Potsdam

GFZ German Research Centre for Geosciences

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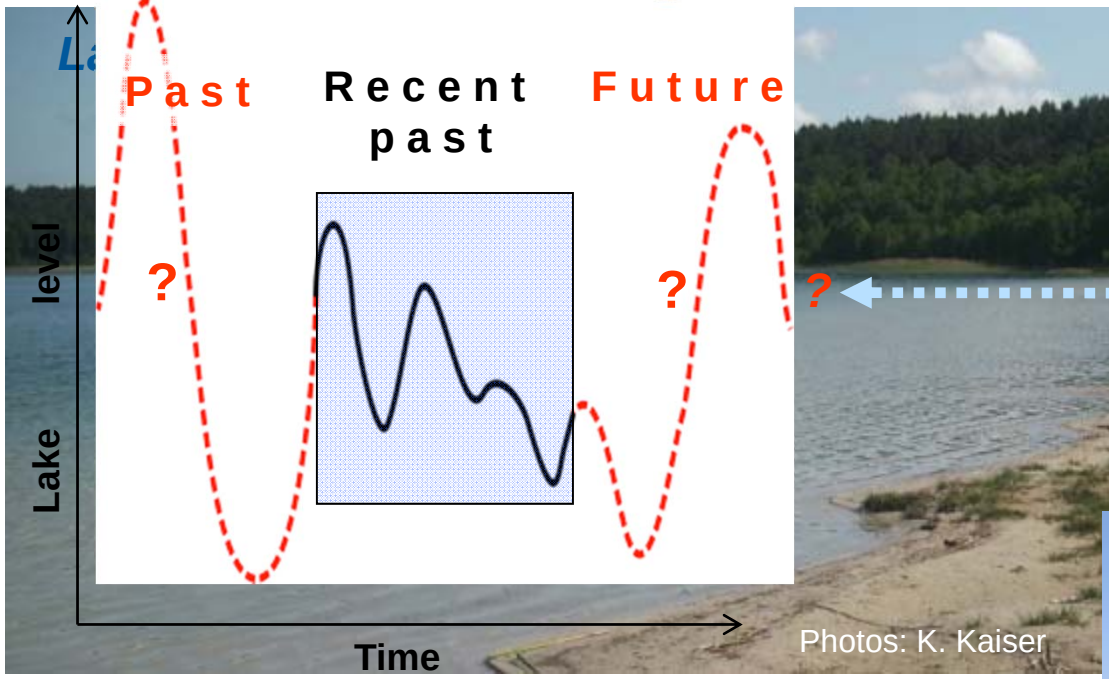
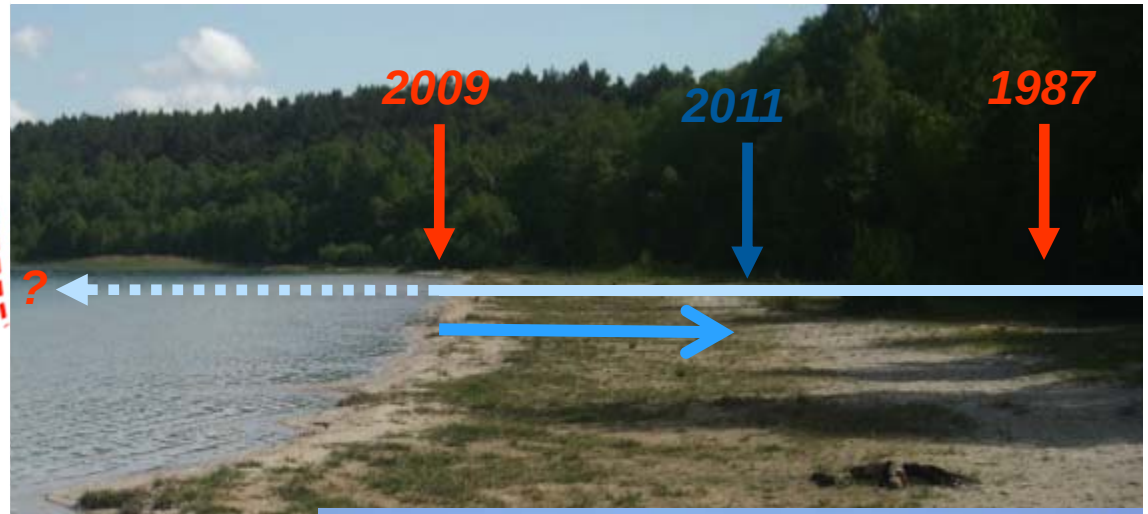
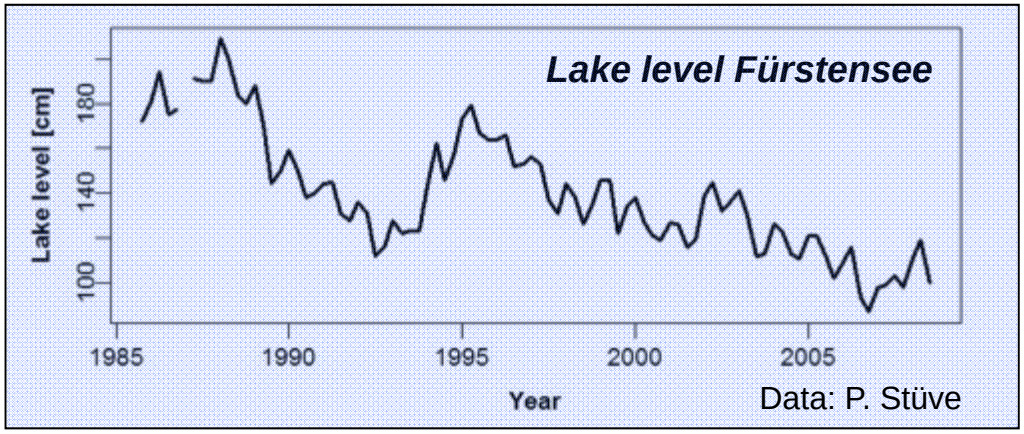
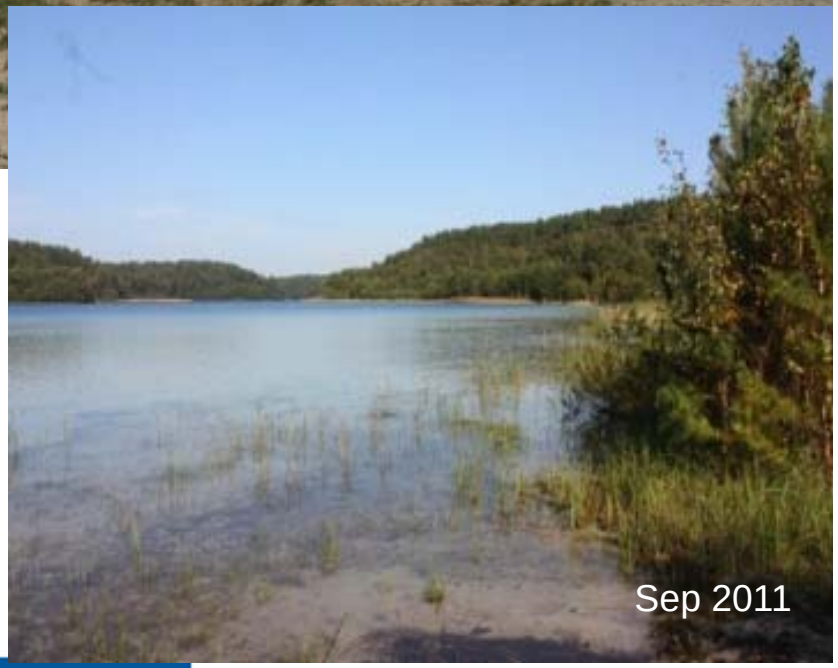
Lake Level Changes in NE Germany





Photos: K. Kaiser





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The landscape we are faced with

Hydrology dominated by groundwater and lakes and their interactions

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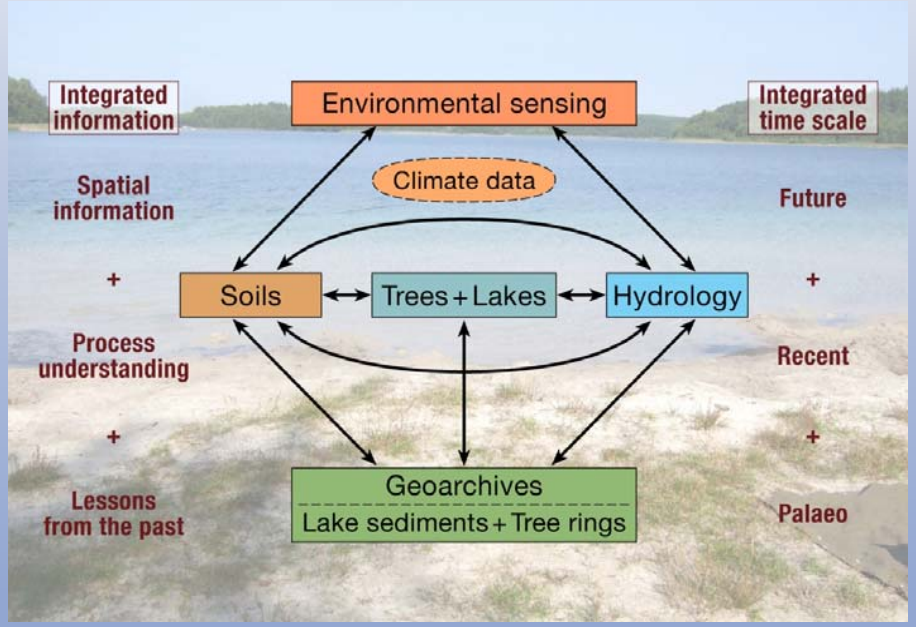
Scientific concept

- Combine data from a network of geoarchives, monitoring sites and environmental sensing
- Assess climate dynamics and hydrological fluctuations on various time scales



- Distinguish between anthropogenic and natural influences
- Verify models for improved future projections

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Dendrochronology – Challenges we can help with

- How have lake levels changed in historical times?
- How has the climate changed in historical times?
- How much of the lake level changes are man-made?
- How large is the influence of trees/forests on the hydrological cycle?

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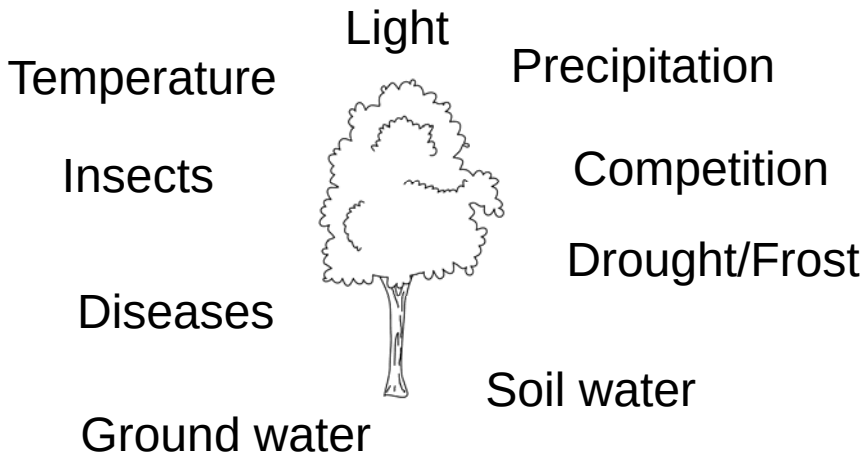
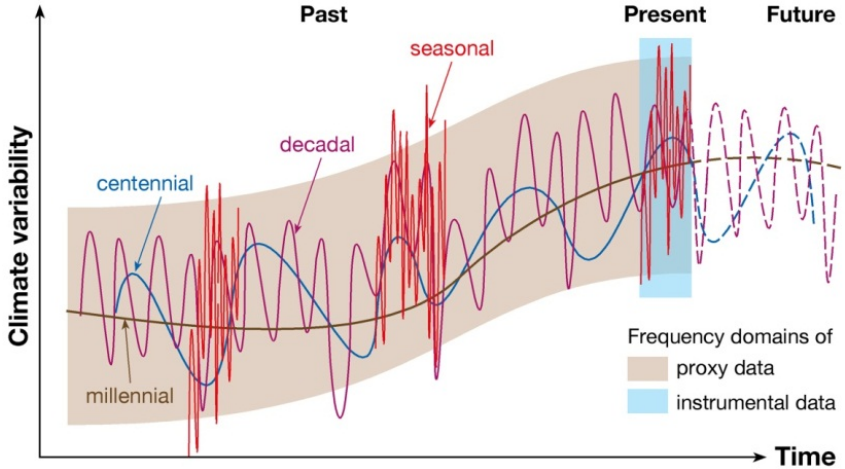
Two major challenges

- Mixture of climatic, hydrological and other environmental signals in the tree rings need to be decoded
- Mixture of low- to high-frequency signals (incl. anthropog. influences) encoded in the tree-ring parameters need to be extracted step by step statistically





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Main activities

- Comprehensive joint monitoring of hydrology, climate and tree growth
- Dating of old stumps in lakes
- Sampling the main species (pine, oak and beech) along transects at selected lakes
- Applying a multi-parameter approach (tree ring width, tree ring density, stable isotopes, cell dimensions)
- Sampling old living trees of the main species and combine them with archaeological wood material

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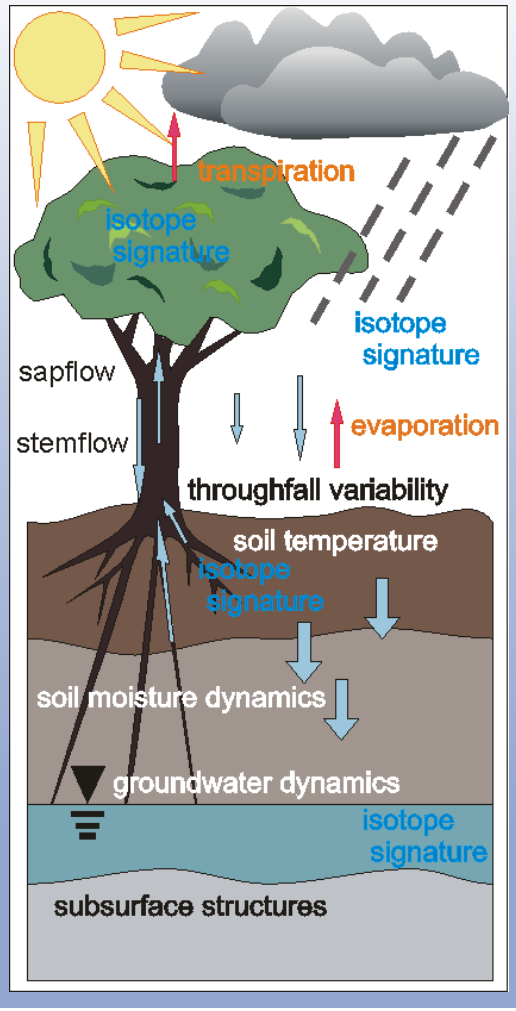
Monitoring – research questions



- How do different tree species and forest structures alter the hydrology, e.g. young vs old – pines vs oaks?
- How is tree growth related to climate and groundwater / soil water?
- How do different tree species behave under various forms of water stress (too much & too little)?
- From where do the trees receive their water, i.e. groundwater vs. soil water?

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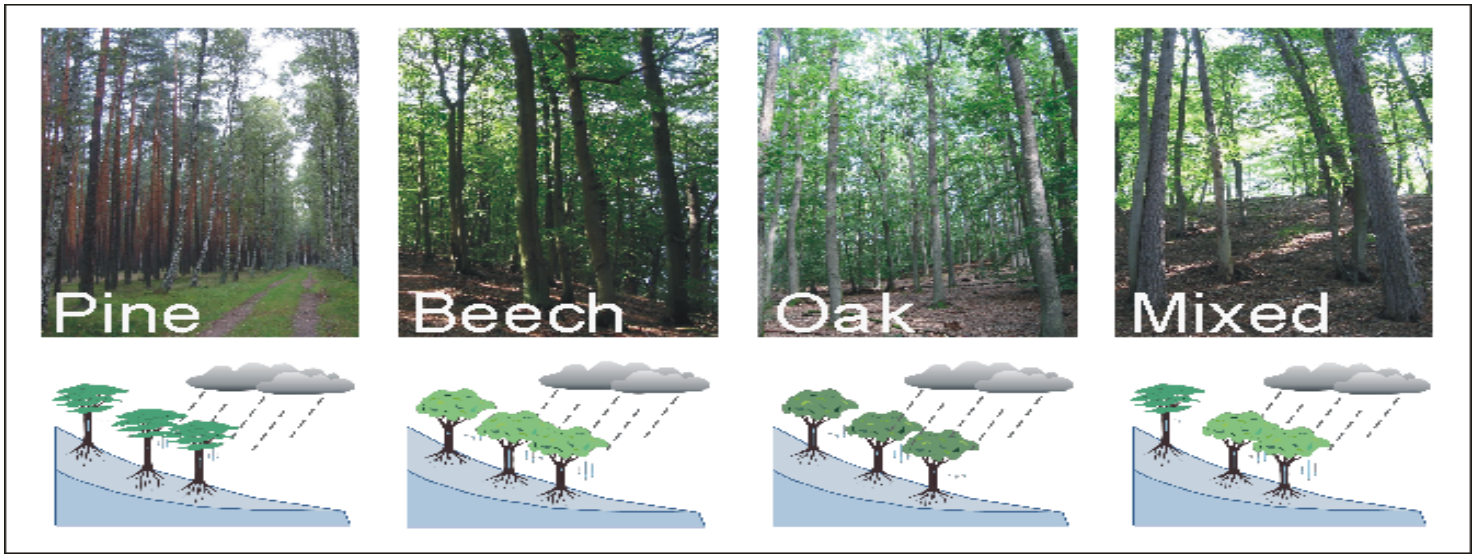
Monitoring approach

- **Joint monitoring of tree physiology and root zone water storage dynamics**
- **Sensor clusters along transects of different tree species**



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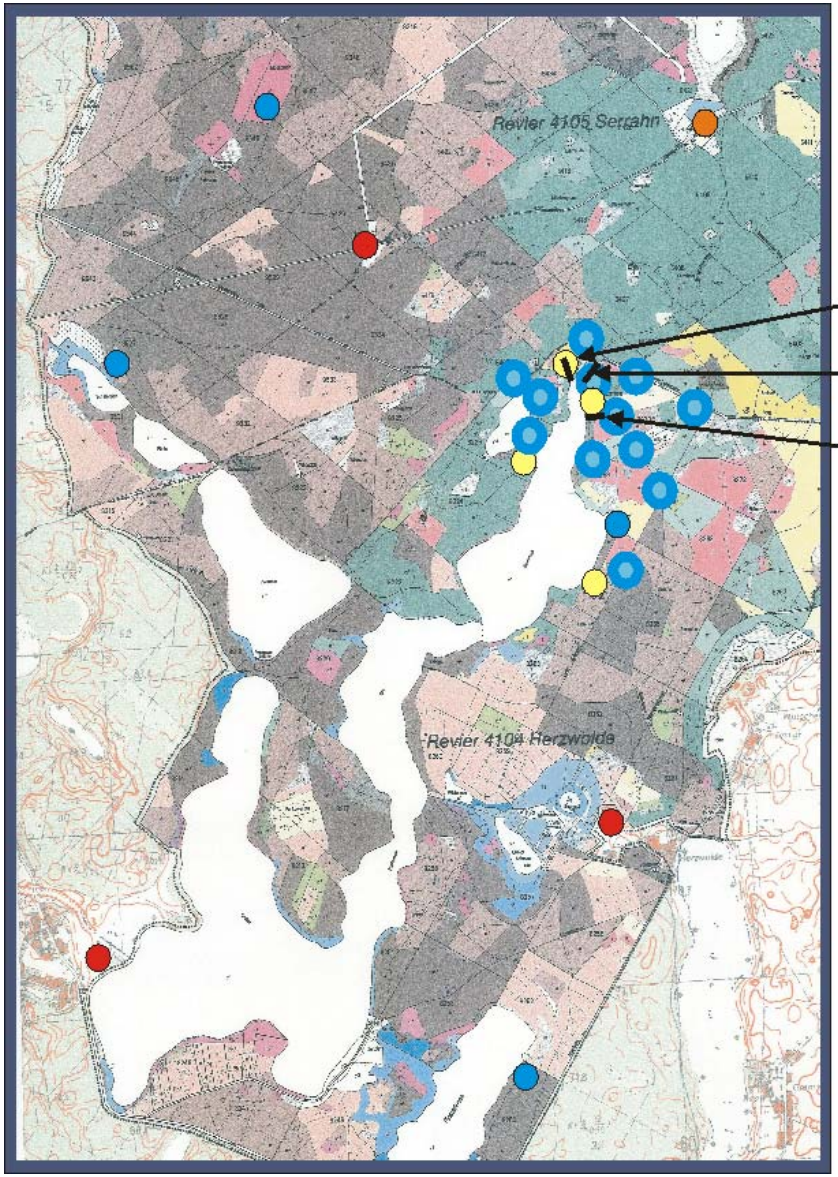
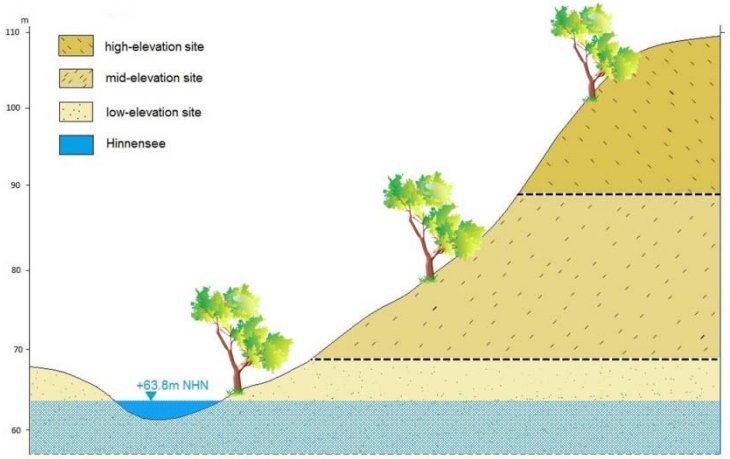
Lake Hinnensee - Experimental design

- **Monitoring transects for main tree species (pine, oak and beech)**





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Monitoring instruments

- Throughfall and stemflow

- Soil moisture and matrix potential
- Piezometer
- Sapflow and Dendrometer

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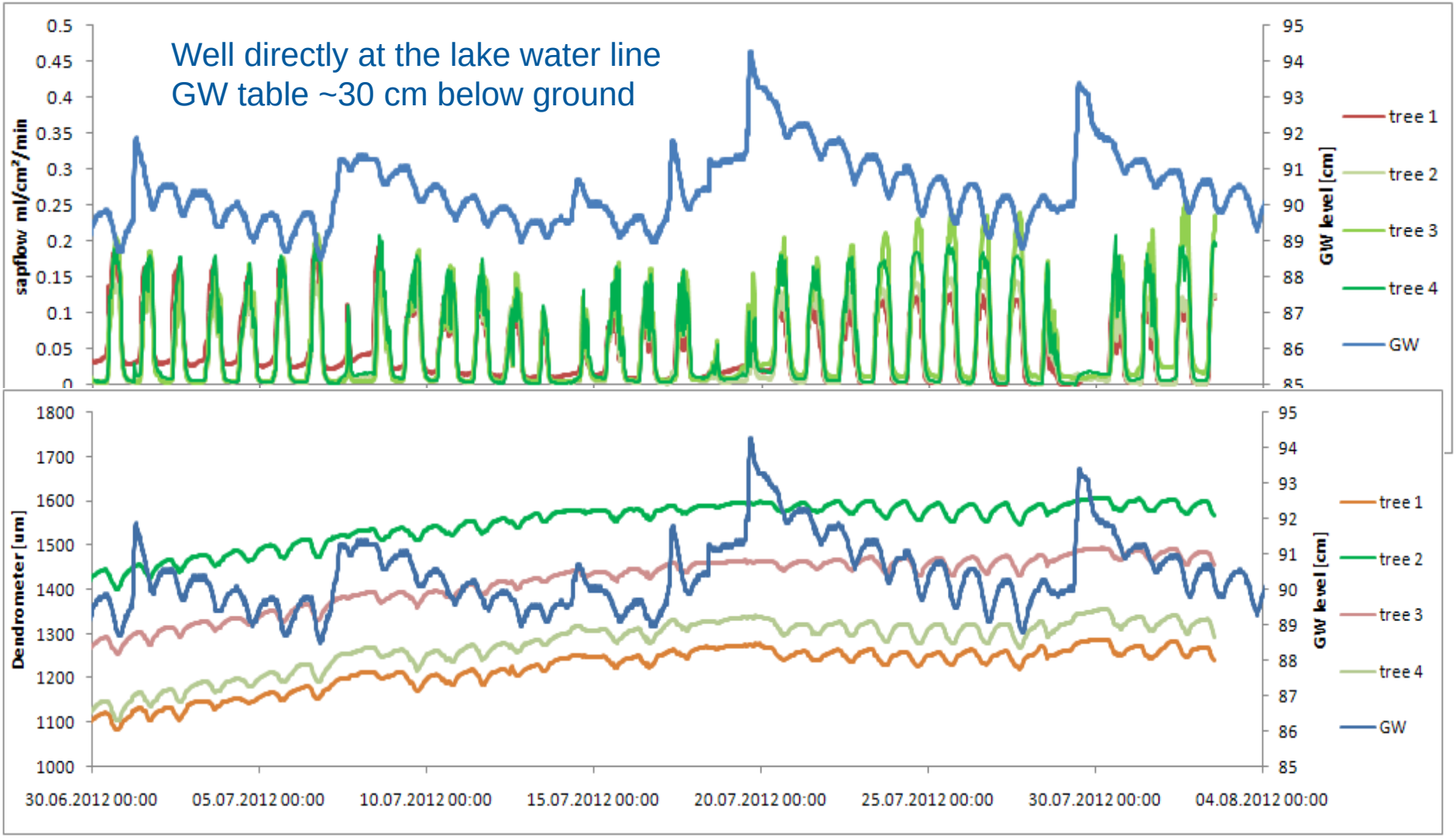
Sapflow, Dendrometer and Groundwater Dynamics



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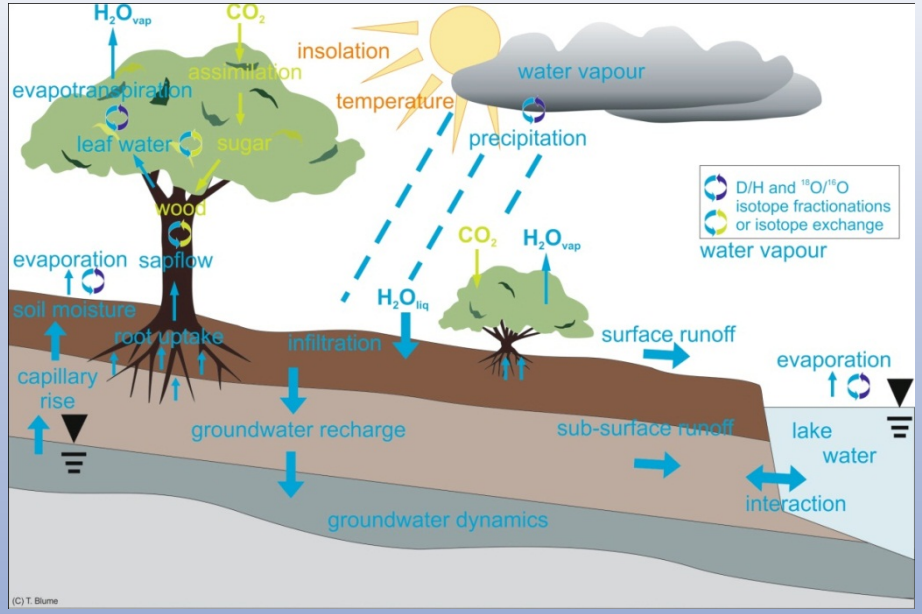
Monitoring – Stable isotope analysis



- Trees: at the junction between surface and sub-surface runoff
- Leaves: meeting point of the hydrological and the carbon cycle

- Tree-ring stable isotopes record changes in temperature, precipitation, soil moisture content, transpiration and water-use efficiency (carbon gain vs. water loss) of trees

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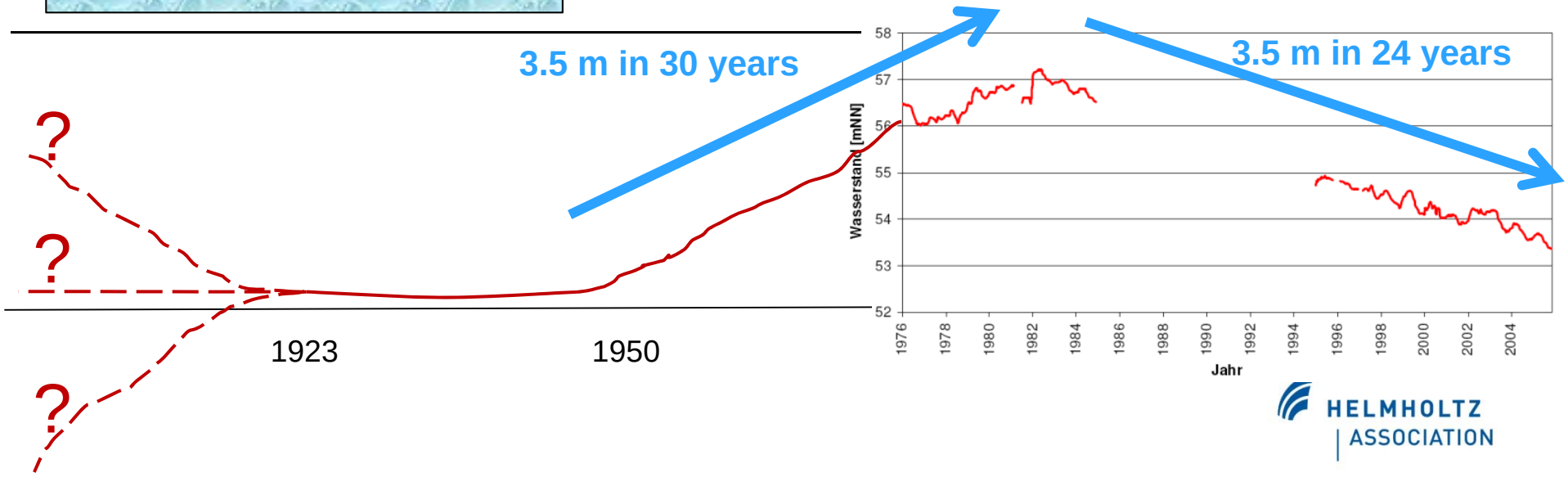
Dating of Alder stumps at Redernswalder See => 1923 – 1952

Lake level 2-3 m higher than in the 1980s
(Example Redernswalder See)



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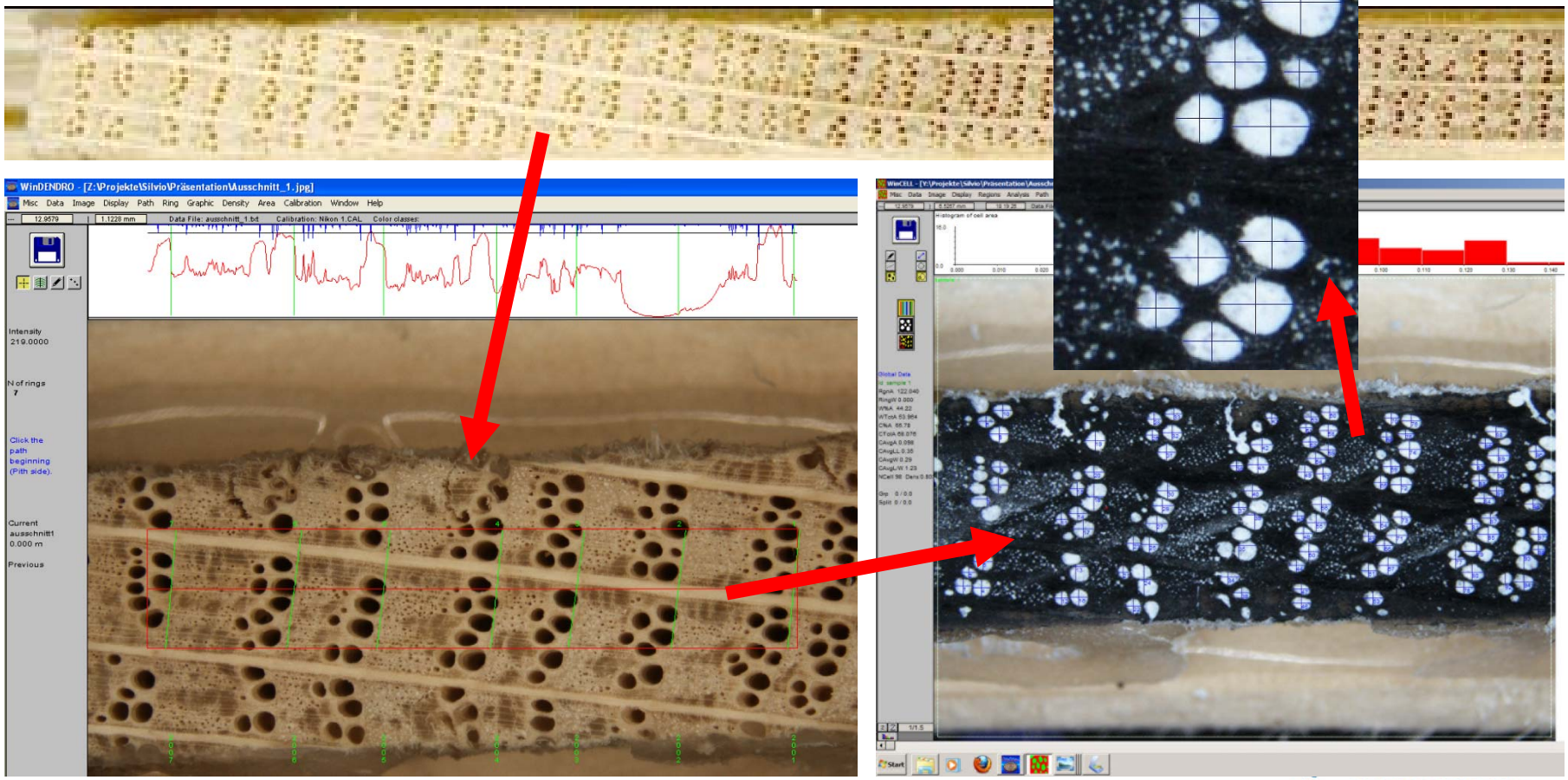
Quantitative wood anatomy

Poster by Silvio Pohlmann et al.

- Example: measuring vessels in oaks



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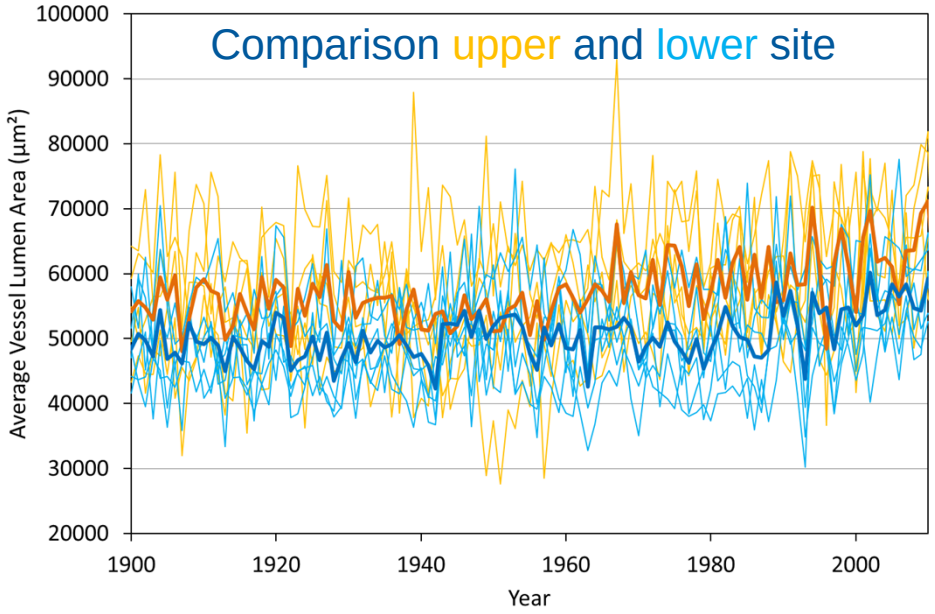
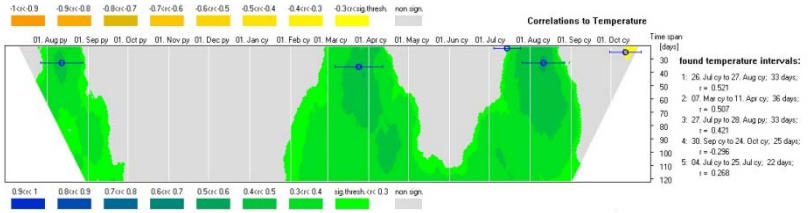
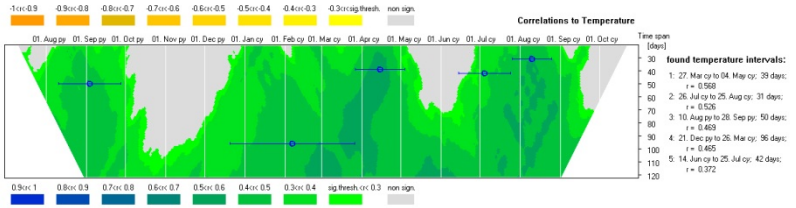
Quantitative wood anatomy

Example: measuring vessels in oaks along an altitudinal transect





Correlation Temp - upper & lower site



- ALA at upper site generally higher than at the lower
- Only during the 40s and 50s are they on a similar level -> drier period ?
- Correlations with temperature are stronger and more stable at the lower site
- Correlation (r=0.57) better than for tree ring widths

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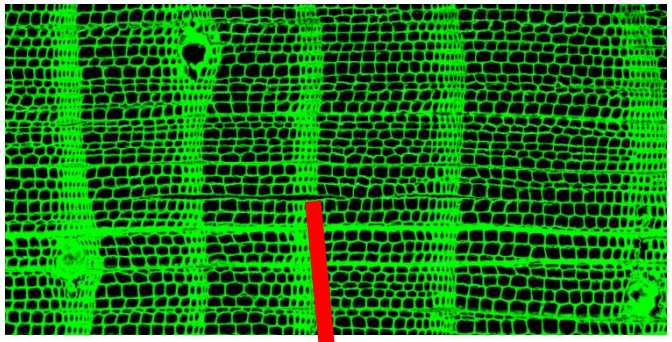
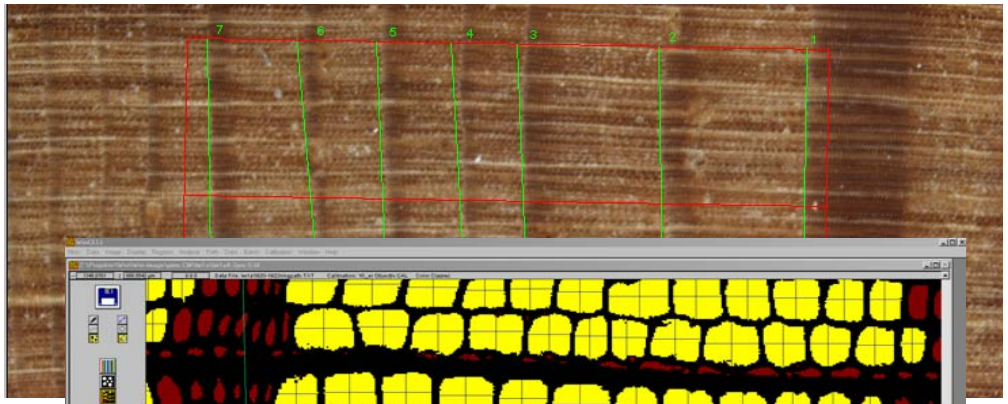
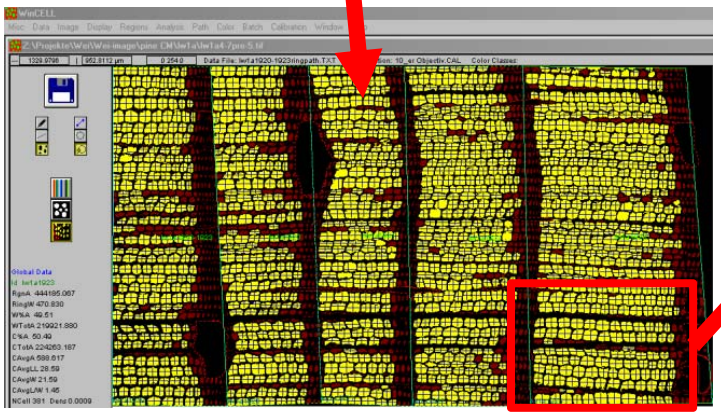
Quantitative wood anatomy

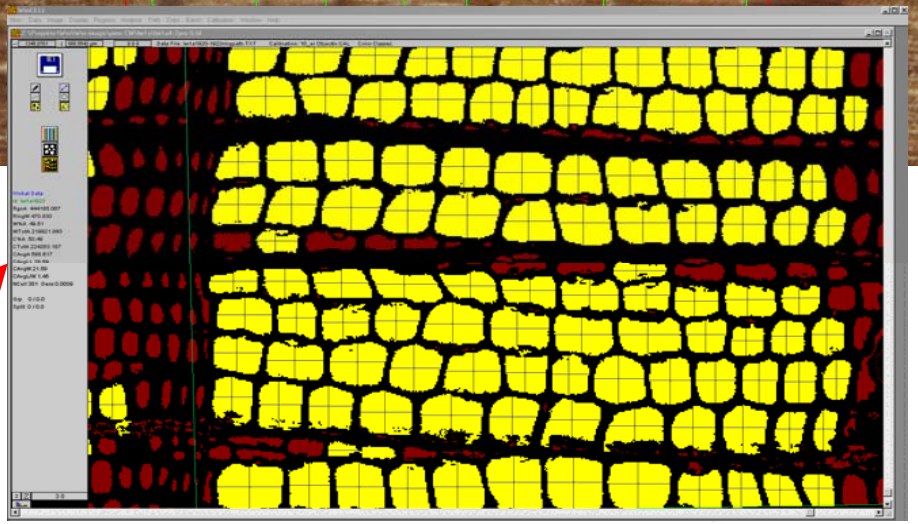
Poster by Wei Liang et al.

- Example: measuring tree rings and tracheids in pines









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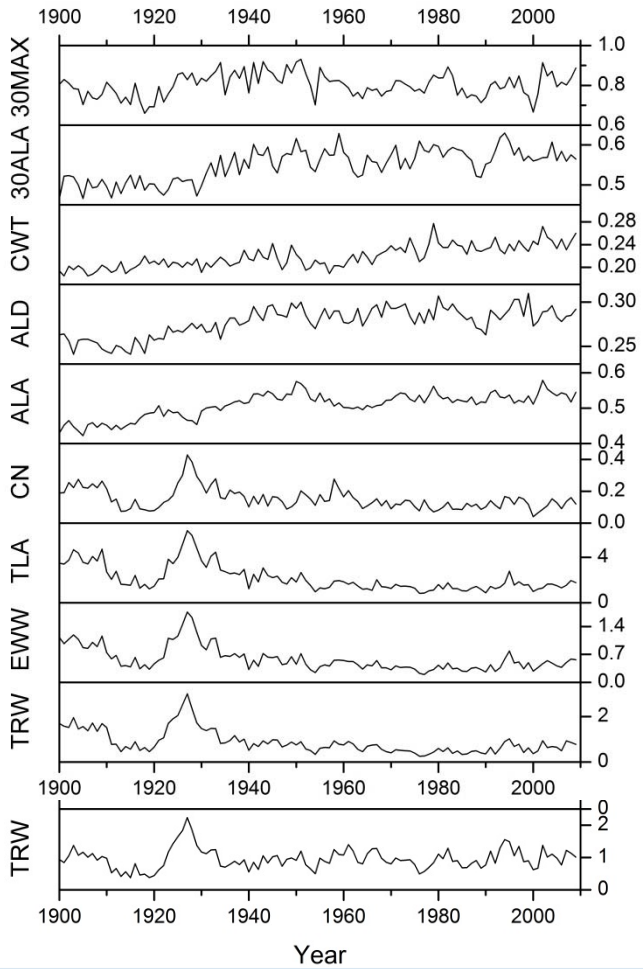
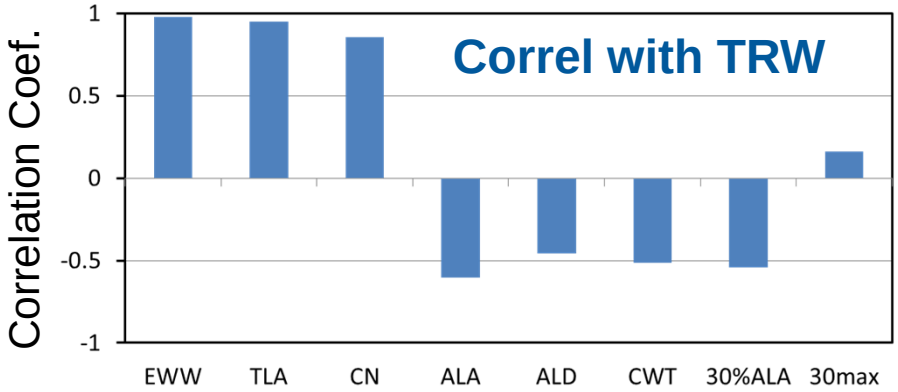
Quantitative wood anatomy

Example: measuring tree rings and tracheids in pines

Raw values





- Significant positive correlations between TRW and EWW, TLA and CN
- Less significant negative correlations between TRW and ALA, ALD, CWT and 30%ALA
- No significant correlations between TRW and 30MAX

➢ ALA, ALD, CWT, 30%ALA and 30MAX contain additional information

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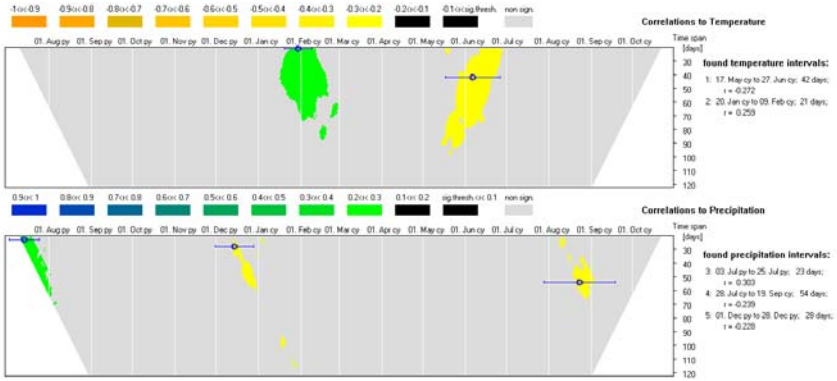
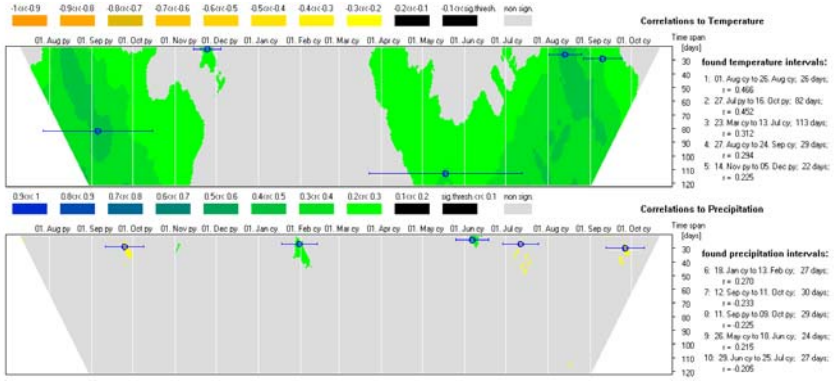
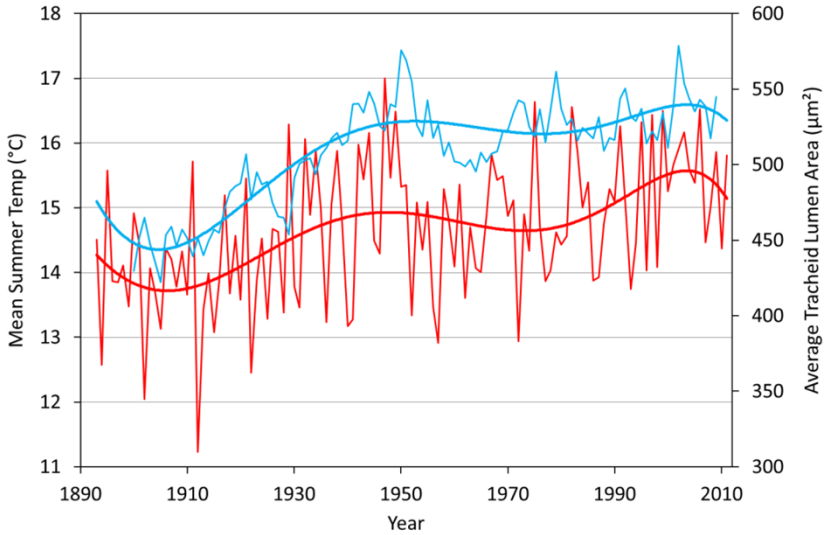
Quantitative wood anatomy

Example: measuring tree rings and tracheids in pines

Correlation Temp (top) / Precip (bottom) with detrended TRW (left) and raw ALA values (right)







- Little correlations for tree ring widths
- Significant posit. correl. (r=0.47) between raw ALA and summer-temp
- Good agreement between raw ALA and summer-temp in the low-frequency domain which is only possible with cell data but not with tree ring widths!

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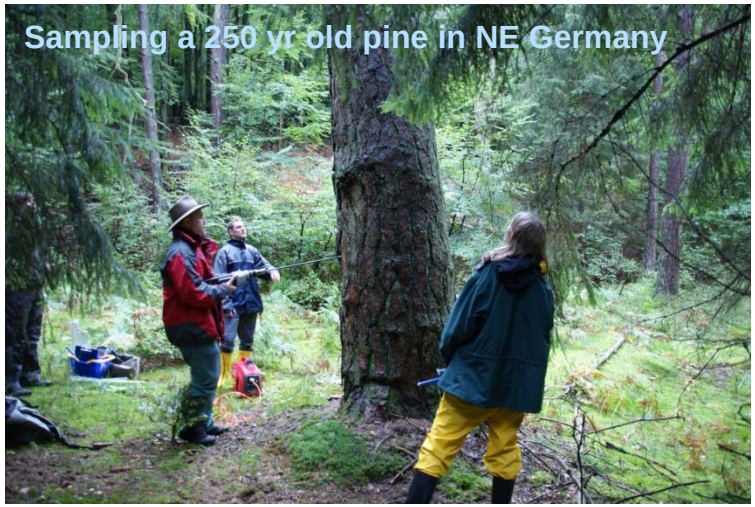
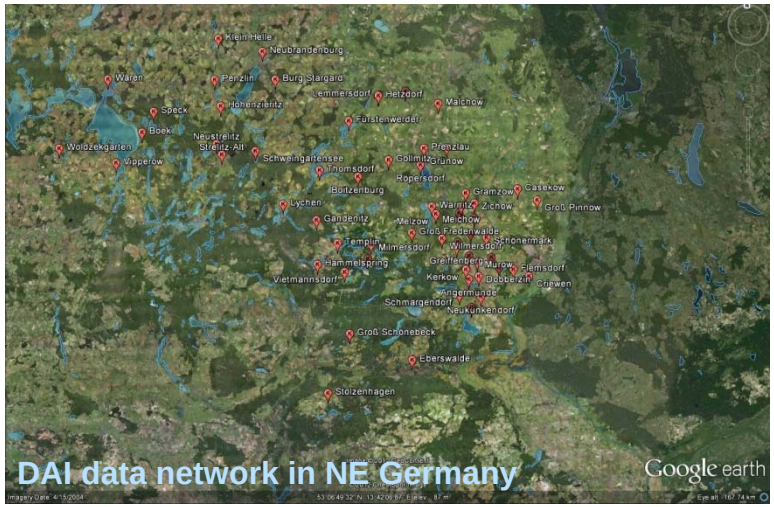
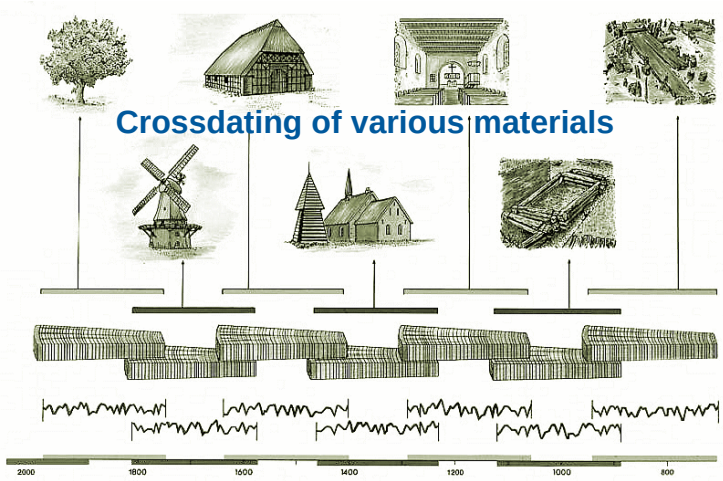
First Pine Chronology (~1000 ys)

- Sampling old living trees
- Crossdating with archaeological wood from network in NE Germany







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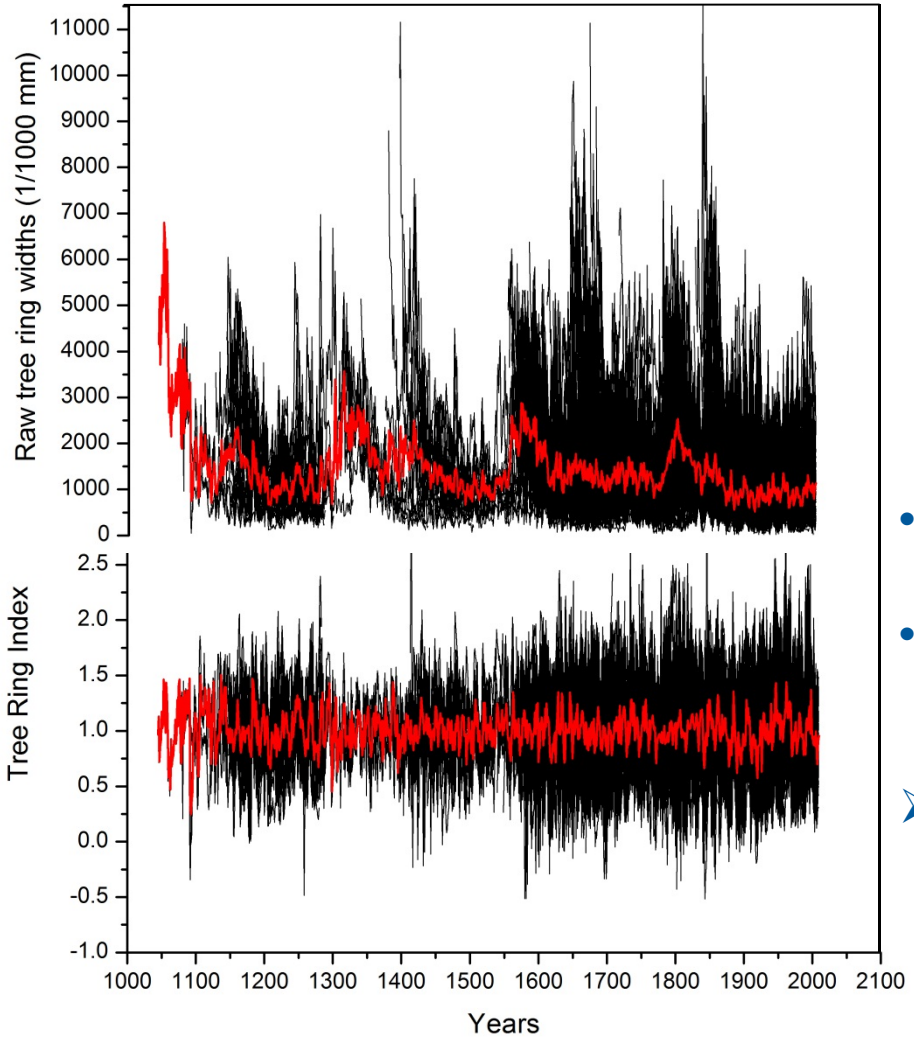
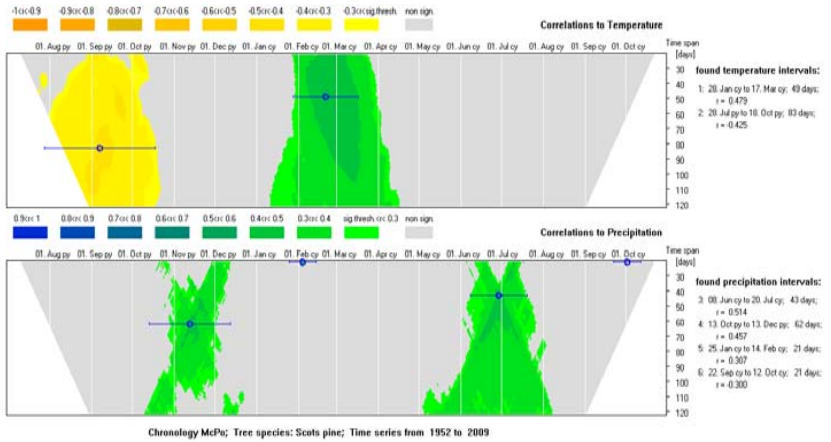
First Pine Chronology (~1000 ys)





- Significant neg. correl. with previous late-summer-temp (r=-0.42)
- Significant pos. correl. with early-spring-temp (r=0.48) and summer-precip (r=0.51)

➢ Next step: reconstructions of summer-precip / spring-temp but low-frequency signal difficult

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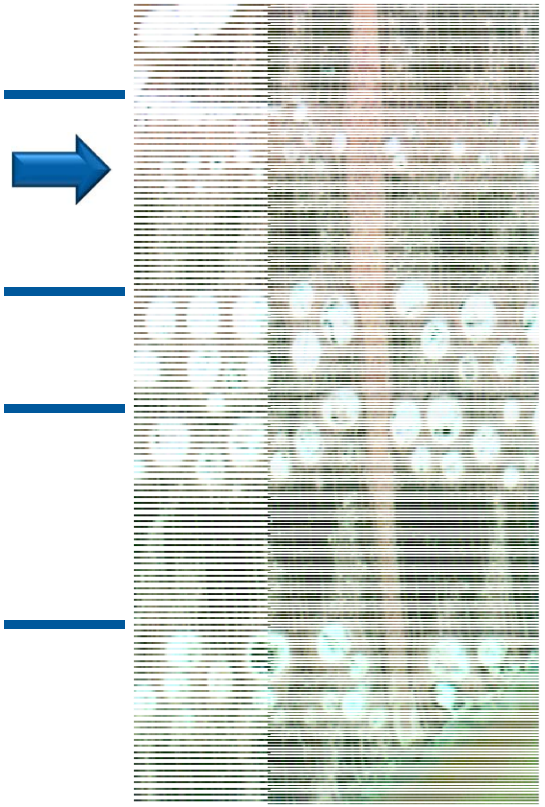
Further dendrohydrological methods

Frequency of flooding events from time series of wood anatomical features

Flood ring



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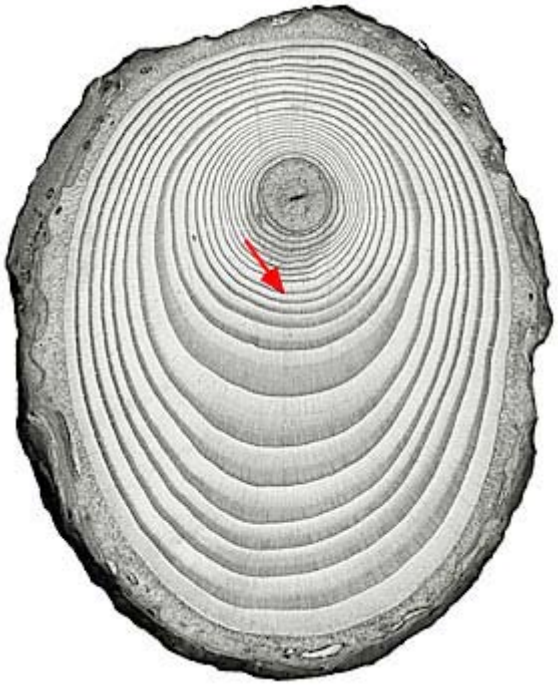
Further dendrohydrological methods

Dating and reconstruction of erosion along shores with stem reaction wood

Red arrow indicates year of beginning of reaction wood formation



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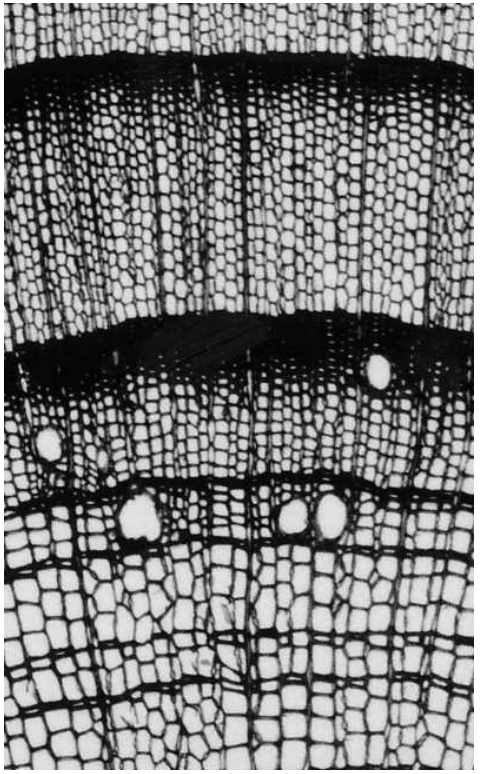
Further dendrohydrological methods

Dating and reconstruction of erosion along shores with root reaction wood

Root exposed



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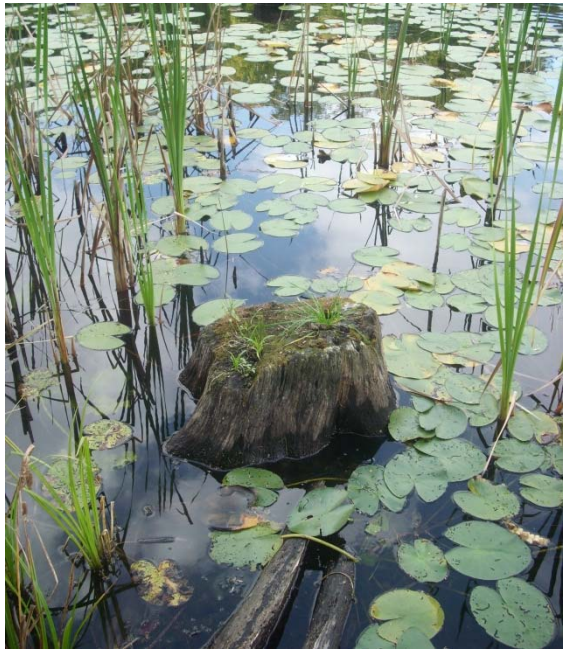
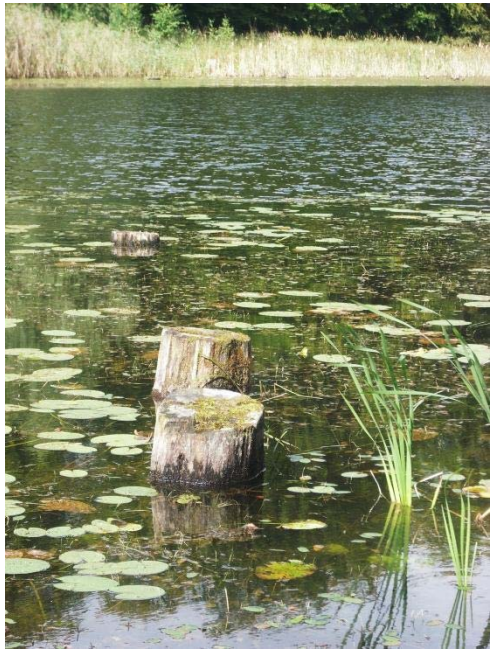
Dating of oak stumps
Lake Krummer See near Melzow
September 2009





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He who comes too late will be punished by life

September 2012 … to be continued!

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Thank You!

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