Proposed session plan: Tree rings and speleothems

- Introduction to tree rings as climate proxies (30 min)
- Break (5 min)
- Introduction to speleothems as climate proxies (30 min)
- Reintroduce discussion questions (5 min)
- Break (5 min)
- Discussion (20 min)
- Formulation of discussion summary (20 min)

Discussion questions

- What are the major uncertainties in high resolution proxy data? Which are most critical?
- How do they compare between the various proxies?
- What is the best way to merge different proxies (and their errors) for paleoclimate field reconstruction, climate modeling 'targets', and climate modeling initial/boundary conditions?
Sources of uncertainty in tree-ring proxy data and reconstructions based on them with some notes on ways forward

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Thanks: R. Wilson, P. Fenwick, N. McKay, H.D. Grissino-Mayer, C. Woodhouse

Outline

- Data: Sources, distribution, critical jargon.
- Generalized interpretative model of the proxy.
- Uncertainties: proxy and reconstruction levels.

What are the major uncertainties in this proxy archive? How are they reflected in climate reconstructions?
Key References

- **More background and principles**
  - Laboratory of Tree-Ring Research, 2008, www.ltrr.arizona.edu

- **Generalized theory of tree ring formation**

- **Data sources**
Data: the archive

Data: the archive

Data: the archive

Data: measurements

Data: chronology development

Source: LTRR/UA, Extending a chronology based on living trees further back in time through crossdating; image from Woodhouse and Bauer, NOAA Paleoclimatology, Paleo Slide Set: Tree Rings: Ancient Chronicles of Environmental Change, www.ncdc.noaa.gov/paleo/slides/slideset/18/18_357_slide.html
Generalized model: tree ring widths

\[ R(t) = A(t) + C(t) + \delta E(t) + \delta D(t) + \varepsilon(t) \]

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\[ R(t) = A(t) + C(t) + \delta E(t) + \delta D(t) + \epsilon(t) \]
Uncertainty: data standardization procedure

Data series

Spectral properties as a function of standardization

Power spectral density

Unpublished data contributed by Pavla Fenwick
Uncertainty: multivariate controls on ring width formation

Tree ring width (year $\tau$): $TRW(\tau) = N(\tau)/\langle N(\tau) \rangle_\tau$

Cambial model (year $\tau$): $N(\tau) = N[V(G(t))]$

Environmental growth rate (day t): $G(t) = g_E(t) \min[g_T(t), g_W(t)]$

Solar Radiation

*$g_T* depends on:
- Latitude
- Day length
- Declination angle

Temperature

Precipitation

$f(P) = \min[c_1 P, P_{\text{max}}]$ $E = c_2 G(t) \exp(c_3 T)$ $Q = c_4 W$

$dW = f(P) - E - Q$

Evans, Reichert et al. (2006) following Vaganov et al. (2006a, b)
Sources of uncertainty: climate field reconstruction from high resolution proxy data networks

- Definition of $C, E, A, \alpha$ (Climate Field Reconstruction)
- Calibration
- Proxy records
- Proxy data characterization
- Verification
- Reconstruction of fields, indices, theoretical errors
- Analysis procedure
- Instrumental data
- Target field characterization
- Study of climate dynamics

E.g. Evans et al., 2001
Uncertainty: proxy-dependent frequency response

Evans et al. (2002)
Uncertainty: dependence on observing network

J.E. Smerdon (2006, unpublished); F. Gonzalez-Rouco et al., 2006}
Uncertainty: sparse multivariate proxy networks

*ECHO-G simulated T and P from http://chubasco.fis.ucm.es/~fi/simul.html; Reconstructions by J Smerdon (LDEO)*
Summary

- Principal uncertainties in the interpretation of tree-ring data for paleoclimate reconstruction are:
  - Heterogeneous coverage in time and space
  - Competing multivariate dependencies (non-static calibration)
  - Calibration error (artificial skill)
  - Assumption of frequency-independent calibration
  - Influence of standardization choices on low frequency behavior
Notes on ways forward

- Improving replication and spatial coverage will still help.
- Reconciliation of statistical modeling with biological / chemical / physical modeling may help resolve proxy calibration uncertainties, and may represent a nexus between paleoclimate reconstruction and climate modeling.
- Pseudoproxy experiments suggest that as long as our proxies have some connection to the target field, large-scale reconstruction averages may be robust in time and frequency. But the results may depend on the sampling network.
- Intercomparison between proxies is a powerful means for assessment of uncertainties, especially at low frequencies not directly calibrated against the instrumental record.
Discussion

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