Evaluating the time-dependent behavior of ecological models using dendrochronological data
Or: What if we know climate but not its large-scale ecological response?

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Results (I)

- Relevance of terrestrial biosphere for land-atmosphere carbon exchange, e.g. Kyoto protocol
- Dynamic models of ecosystem structure & function address these questions, e.g. VEMAP project (cf. VEMAP 1995)
- Spatially explicit climate data set covering the US available for 1895-1993
- HOW REALISTIC IS THE SIMULATED RESPONSE?
  - Few long-term data sets available to characterize ecosystem response to climate variability
  - Use dendro data!
- Objectives of this study:
  - To develop a methodology for comparing simulated variables against dendro data
  - To evaluate the simulated model response against independent dendro data (Fig. 1)

Results (II)

- 'Conservative' re-processing of ITRDB data revealed ecosystem response to climate variability
- Ecosystem models possible for the US, available for 1895-1993
- Spatially explicit climate data set covering the US, e.g. VEMAP project (cf. VEMAP 1995)
- Dynamic models of ecosystem structure & function
- Relevance of terrestrial biosphere for land-use management

Material & Methods

- VEMAP climate reconstruction based on measured weather station data only, temporal and spatial interpolation algorithms (Fig. 2)
- Focus on case studies along steep climate gradients
  - Mountain regions
  - Front Range of Colorado, Sierra Nevada
- Newt Ridge Long-Term Ecological Site has four weather stations
  - Check of accuracy of VEMAP climate possible (cf. Fig. 3)
- Tree-ring data from International Tree-Ring Data Bank: Data sets from Kienast & Schweingruber (1996)
- Ecosystem index: Net Primary Productivity (NPP)
- Tree ring index: Ring width

Results (III)

- Correlation between simulated and measured indices appears to be very low (Fig. 6)
  - but closer inspection shows reasonable match of patterns, at least for several periods (Fig. 7)
- Simulated NPP index suggests different properties of measured vs. simulated data (Fig. 5)
- "Standardization" methods in tree-ring research need to be documented better for every chronology (otherwise ITRDB is of limited use: need for re-processing from raw data)

Discussion

- The VEMAP project (with its climate data base) allows us to adopt a new perspective on using tree-ring data: interest shifts from climate reconstruction to reconstruction of ecosystem dynamics using mathematical models
- VEMAP climate database provides accurate long-term climate data sets for any location (within the US) = available for other studies!
- "Standardization" methods in tree-ring research need to be documented better for every chronology (otherwise ITRDB is of limited use: need for re-processing from raw data)
- Simulated NPP indices have different statistical properties compared to measured ring-width indices:
  - autocorrelation
  - spectral characteristics
  - correlation with bioclimatic indices

Conclusions

- Models of long-term vegetation dynamics are important tools for assessing anthropogenic impacts on ecosystems (e.g., carbon cycling questions)
- Tree-ring data could play a major role in the testing (validation) of ecosystem models, which is a critical but difficult issue
- NPP index as simulated by the CENTURY model captures measured ring width patterns reasonably well, but differs in some respects from measured properties
- Tree-ring data are a rich data source:
  - ring widths
  - densities
  - isotopic composition
  - whose ecological potential has not been fully explored yet:
    - evaluation of ecological process understanding (via dynamic models): this study
    - improvement of existing models of vegetation dynamics: e.g. mortality patterns
    (cf. Bigler et al. 2001)

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References

VEMAP Members, 1995. Vegetation/ecosystem modeling and analysis project.