ETH **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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What's the problem? Material & Methods Annual Tatal Precisi Relevance of terrestrial biosphere for land-VEMAP climate reconstruction based on measured weather station data only, temporal and spatial interpolation algorithms (Fig. 2) atmospere carbon exchange, e.g. Kyoto protocol Dynamic models of ecosystem structure & function address these questions, e.g. VEMAP project (cf. VEMAP 1995) Focus on case studies along steep climate gradients In marked ⇒ mountain regions
⇒ Front Range of Colorado, Sierra Nevada Spatially explicit climate data set covering the US available for 1895-1993 In have been been Tree ring Transfer Funct Weather Niwot Ridge Long-Term Ecological Site has four cerpt from the VEMAP climate database, Exploration of spatio-temporal response of ecosystem models possible Fig. 2: E> ⇒ Check of accuracy of VEMAP climate possible (cf. Fig. 3) HOW REALISTIC IS THE SIMULATED RESPONSE? B) Tree-ring data from International Tree-Ring Data Bank: Data sets from Kienast & Schweingruber (1986) T LTER
 T VEMAP Few long-term data sets available to characterize ecosystem response to climate variability \Rightarrow use dendro data! Ecosystem model: CENTURY (Parton et al. 1987, Schimel et al. 1994) Objectives of this study: . Tree ring index 'Ecosystem index': Net Primary Productivity (NPP) To develop a methodology for comparing simu-lated variables against dendro data 1: he 'classica'l approach in dendroclimatology, where ther is reconstructed from tree-ring data using a tra tion (i.e., a model). The approach taken in the present study, where were a re used to drive a dynamic ecosystem model, wh ulates an 'ecosystem index'. The simulated index is upompared anglest measured tree-ring indices. Tree ring index: Ring width trison of VEMAP te function (i.e. To evaluate the simulated model response against independent dendro data (Fig. 1) m temperature data m data from the Niw ns and the met stati g. 3: Compariso its) vs. measure dge LTER wea ingmont. CO (g Results (III) Results (I) Results (II)

'Conservative' re-processing of ITRDB data revealed that published chronologies are appropriate for use in this project (Fig. 4) mmmmM žeg 10 M

Fig. 4: Result of the re-standardization of the Boulder ITRDB chronology (Pseudotsuga menziesi)

Simulated NPP index suggests different properties of measured vs. simulated data (Fig .5)



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 indices are characterized by lack of significant temporal autocorrelation (AC; Fig. 8): – AC of VEMAP weather < AC of measured weather problem of model structure (allocation of carbon)



reason unknown

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) \Rightarrow 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

Reasons

- 2) loss of information when moving from site-specific met data to interpolated VEMAP data
- Studies along strong environmental (i.e. altitudinal) gradients have large potential Further investigations (beyond the present one) are required
- · Ultimate aim is to perform regional- to continental-scale evaluation of simulated patterns

- 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 al. 2001)

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VEMAP Project Website: <u>http://www.cpd.ucar.edu/cwp</u> Schweingruber, F.H., 2001. Growth-dependent tree mortality processes in confers. wence "Tree rings and poople", Davos, Switzerkind, Spenneter 2007. er, F.H. 1986. Dendheocobgical studies in the Front Range, Colorado, U.S.A. Arct ch 18: 277-288. 7-288.
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