Paleoclimate perspectives on future climate change in Great Lakes of the world: new approaches promise new insights

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Model Projections for 2080-2099

Regional Climate Projections

Chapter 11
Looking at past climate change to test climate models and identify patterns (spatial and temporal) of climate variability.
Vegetation boundaries today and 6,000 years ago

Figure 1 Present-day biomes reconstructed from surface pollen

Figure 3 Reconstructed biomes at 6000 yr BP. The biomes are plotted

Prentice et al., 1998
An interesting paleoclimate record from western Minnesota
The sodium content of the Elk Lake core reflects abundance of wind-blown silt - high concentration indicating arid conditions.
Scanning X-Ray Fluorescence - new technology!
Drilling on Lake Malawi, East Africa 2005
Scanning XRF: A breakthrough in sediment core analyses
Comparison of % biogenic silica in a piston core from the north basin and the XRF measure of Si/Ti in the Malawi drill site near the same location

Chemical digestion technique - required about 300 hours of lab work

XRF scan results - required about 2 hours
Abrupt climate change - making the ties between the tropics and the poles

Brown, Johnson et al., PNAS, 2007
TEX$_{86}$ - A new quantitative indicator of past temperature

A TetraEther index of lipids with 86 carbon atoms

\[
TEX_{86} = \frac{[2]+[3]+[4]}{[1]+[2]+[3]+[4]}
\]

(numbers indicate no. cyclopentane rings)
\( \text{TEX}_86 \) works in lakes!

\[ \text{TEX86} = 0.015T + 0.29 \]

\( R^2 = 0.93 \)

Powers et al., Geology, 2004, and additional data
Reconstructing the temperature of Lake Malawi since the last ice age using $\text{TEX}_{86}$
Lake Malawi temperature history for the past 700 years

Powers et al., submitted
Comparison of TEX\textsubscript{86} and instrumental temperature history for the past 50 years

\begin{align*}
y &= 0.0303x - 33.375 \\
y &= 0.0231x - 20.361
\end{align*}

Powers et al., submitted
Western juniper, about 1000 years old

Bristlecone pine in White Mountains of Arizona - oldest trees in N. America
Near Duluth

Tree-ring PDSI Cell Id: 98 Lat: 47 Lon: 92.5

Instrumental PDSI Cell Id: 98 Lat: 47 Lon: 92.5

West central MN

Tree-ring PDSI Cell Id: 88 Lat: 47 Lon: 95.5

Instrumental PDSI Cell Id: 88 Lat: 47 Lon: 95.5

PDSI

Drought reconstruction from tree rings for the United States, 1863

Palmer Drought Severity Index

from Cook et al. 1996
High-resolution records from corals in the eastern tropical Pacific
Conclusions:

• While climate models predict wetter conditions in the Great Lakes basin with future warming, paleoclimate data from the mid-Holocene warm period indicate drier conditions prevailed, at least near the prairie-forest boundary of central Minnesota.

New advances in the technology of lake sediment core analyses will enable us to generate quantitative records of past temperature trends and very high resolution records of past climate variability.

• New high resolution records based on tree ring and coral analyses from as far away as the tropical Pacific Ocean may shed insight into global climate patterns that will allow us to better predict what is in store for not only the Great Lakes basin but also for the other great lakes of the world.