Remoting sensing explores freshwater lakes' role in global carbon cycle

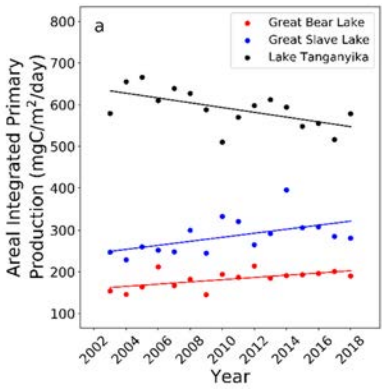
How do freshwater lakes contribute to the global carbon cycle? The vast number and size of these lakes has made answering that question a challenge. Different measurement techniques used in onsite studies also make it difficult to compare production values between lakes, or even to create lakewide assessments.

To address these challenges, researchers at Michigan Tech Research Institute (MTRI) turned to the sky. They used data collected from NASA's satellite-based MODIS sensor from 2003 to 2018 to estimate phytoplankton production in 11 of the world's largest lakes: the five Laurentian Great Lakes, three African Great Lakes, Lake Baikal, Great Bear Lake, and Great Slave Lake. MODIS views every point on Earth every one to two days, which resulted in a rich dataset of 137,161 images of the 11 lakes studied.

"Using these data, we were able to compute how much carbon is being fixed from a particular water body over a given year," says MTRI scientist Gary Fahnenstiel. "This consistent methodology allowed us to compare primary production in the world's largest lakes for the first time ever."

Their analysis revealed that three lakes showed significant trends in production over the study period. Great Bear and Great Slave lakes exhibited significant increases in production, while Lake Tanganyika experienced a significant decline. These changes appear to be related to climate change, including increasing temperatures and solar radiation and decreasing wind speeds.

The absence of climate change impacts on the other eight lakes may be due to the study's limited time period as well as interactions of other variables. For example, the study period largely misses the early mussel invasion phase in the Laurentian Great Lakes when the greatest production trends would be noted.



The study, reported in Water and at the 2021 Conference on Great Lakes Research, demonstrates how remote sensing primary production or carbon fixation models can be used for the world's large lakes. These results can be used to quantify changes in phytoplankton production, in some cases, due to climate change and anthropogenic forcing. The results also provide insights to better understand the contribution of freshwater lakes to the global carbon cycle dynamics. Researchers hope to expand the study to use other satellite platforms with higher spatial resolution so they can look at smaller lakes in the future.

Long-term NOAA GLERL dataset shows warming of Lake Michigan's deepwater temperatures, signaling the loss of winter

A study published in *Nature Communications* from NOAA's Great Lakes Environmental Research Laboratory (GLERL) reveals a warming trend in Lake Michigan's deepwater temperatures that foreshadows profound ecological change on the horizon. Using a 30-year dataset of deepwater temperature measurements, GLERL scientists investigated how Lake Michigan's seasonal mixing patterns are being influenced by climate change.

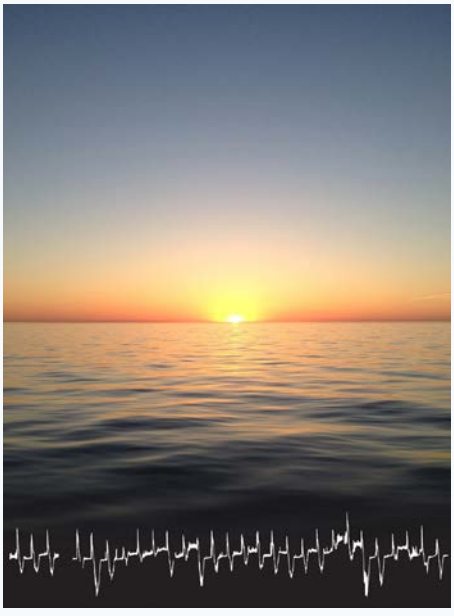
"We found that this long-term dataset not only confirms that Lake Michigan's deep waters are warming, but also shows that winter is vanishing from them," says NOAA GLERL scientist Eric Anderson. As climate change has gradually delayed the onset of cooler autumn weather over the past three decades, Lake Michigan's deep waters have reflected this change by showing shorter winter seasons.

This warming could eventually alter Lake Michigan's rate of primary productivity, which would inevitably disrupt the structure of its entire food web—a change that could have negative impacts on fisheries and recreation. "Without high-frequency long-term monitoring of subsurface waters of the world's deep lakes," says Anderson, "we will be blind to the impacts of climate change on most of Earth's fresh surface water."

Subsurface waters in deep lakes are important because they integrate conditions across years, providing a "climate memory," and can help identify the potential for ecological and physical changes throughout the lake. GLERL's continuous long-term dataset—likely the only one of its kind—was collected using a mooring that has been recording temperatures at different depths in the lake every hour almost continuously for the past three decades.

The deep-water conditions of the Earth's largest lakes are considered a missing piece of the global climate change puzzle. NOAA's work on Lake Michigan will pave the way for gaining a better understanding of this puzzle piece in the future.

Collaborators include the University of Michigan School for Environment and Sustainability and the University of Toledo Department of Environmental Sciences.



The 30-year, deep-water temperature dataset overlaying this Lake Michigan photo reveals a hidden story about how the lake's deep waters are responding to climate change.

By Gabrielle Farina, Jamison Professional Services contractor and science communications specialist at NOAA GLERL