High-resolution satellite images provide insight into Great Lakes' coastal changes after historical water level Increase



From left, Two Creeks, Wisconsin, author conducting real-time kinematic (RTK) survey at Ogden Dunes, Indiana, and Warren Dunes, Michigan. RTK surveys are used to correct for common errors in satellite navigation systems.

The Great Lakes are known for their significant water level fluctuations. From 2013 to 2020, Lake Michigan-Huron experienced a remarkable two-meter rise in water levels, setting records for both the lowest and highest water levels ever measured in just seven years. This rapid and large increase led to substantial coastal erosion, shoreline retreat, habitat changes, and even damage to infrastructure. However, quantifying and tracking these changes has been challenging due to the extensive length of the Great Lakes shorelines and the logistical difficulty in tracking their movements.

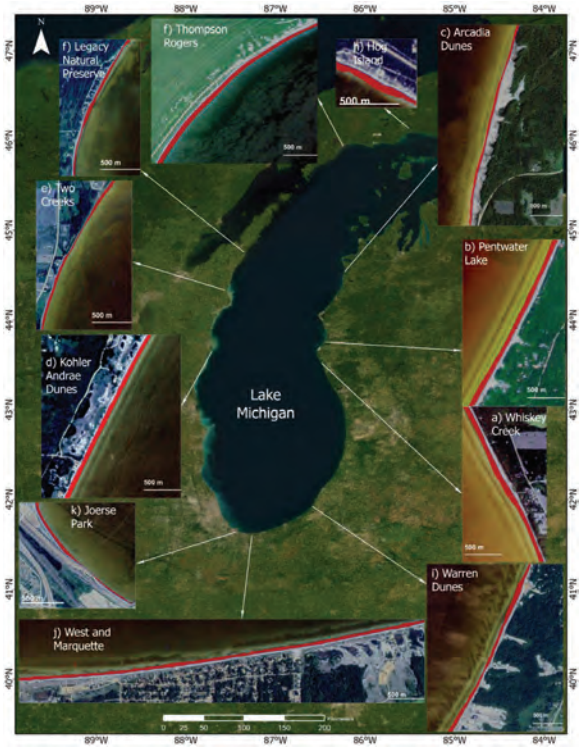
To address this issue, we developed an automated tool to monitor shoreline changes using high-resolution multispectral satellite images. The tool was validated using in-situ surveys. This approach allows us to accurately track shoreline movements over time across any part of the Great Lakes (Abdelhady et. al., 2022). The method relies on imagery from commercial satellites such as PlanetScope, which provide daily multispectral imagery at three–five meter resolution, which is ideal coverage for tracking Great Lakes shoreline positions. This tool is now available for coastal researchers across the Great Lakes.

We applied this shoreline detection tool to 11 natural beaches around Lake Michigan for the water level increase period of 2013 to 2020. Our findings revealed that shorelines retreated between 20 and 62 meters on average (see image below). These differences were primarily due to variations in wave activity and beach shape, highlighting how different factors can influence erosion at Great Lakes beaches despite the same water level increase (Abdelhady et al., 2024).

The shoreline change observations inspired the development of the Great Lakes Shoreline Model. This model uses water level data, wave data, and beach information to predict expected shoreline changes. Importantly, the model explicitly includes the effect of water level changes, which drive shoreline changes in the Great Lakes but have been thus far omitted from ocean shoreline models. We calibrated the model with the shoreline change data obtained from the satellite images, and the calibrated model was able to simulate observed shoreline changes accurately (Abdelhady and Troy, 2023).

Currently, we are expanding this work to other Great Lakes to assess their coastal changes and to compare the similarities and differences in the lakes' responses to water level fluctuations. While the lake levels are currently back to normal, coastal communities need to be prepared for the next high-water period, and understanding how shorelines respond to these extreme events is an important step in helping communities prepare.

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Shoreline changes detected from satellite images at the 11 study sites around Lake Michigan, with the red lines indicating eroded areas.