Weather and Climate in the GREAT LAKES

Lake Levels and the Hydrologic Cycle

Water moves sequentially through the Great Lakes (Lake Superior to Lake Michigan/Lake Huron to Lake Erie to Lake Ontario) before draining to the Atlantic Ocean through the St. Lawrence River (Figure 1). Lake Ontario, with a mean surface elevation of 243 feet above sea level (Figure 1), is the last lake in the hydrologic series of Great Lakes. Water levels on Lake Ontario are the result of how much water enters and leaves the lake system (Figure 2) through the hydrologic cycle, which is the continuous movement of water between the Earth and the atmosphere.

Lake Ontario's primary source of inflowing water is the Niagara River, which drains Lake Erie. Water also enters Lake Ontario via precipitation and drainage from the lake's watershed. Lake Ontario's watershed.

Watershed drainage into the lake includes precipitation that runs over the land into the lake as well as outflows from tributaries (e.g., the Oswego River and the Genesee River). Water leaves the lakes via evaporation and outflows into the St. Lawrence River.

The combination of precipitation, runoff, and evaporation make up the net basin supply (NBS). The NBS plus inflow, outflow, diversions, and consumptive use make up the net total supply (NTS). Changes in the NTS can eventually lead to changes in lake water levels.

A watershed, or basin, is an area of land that drains into the same place.

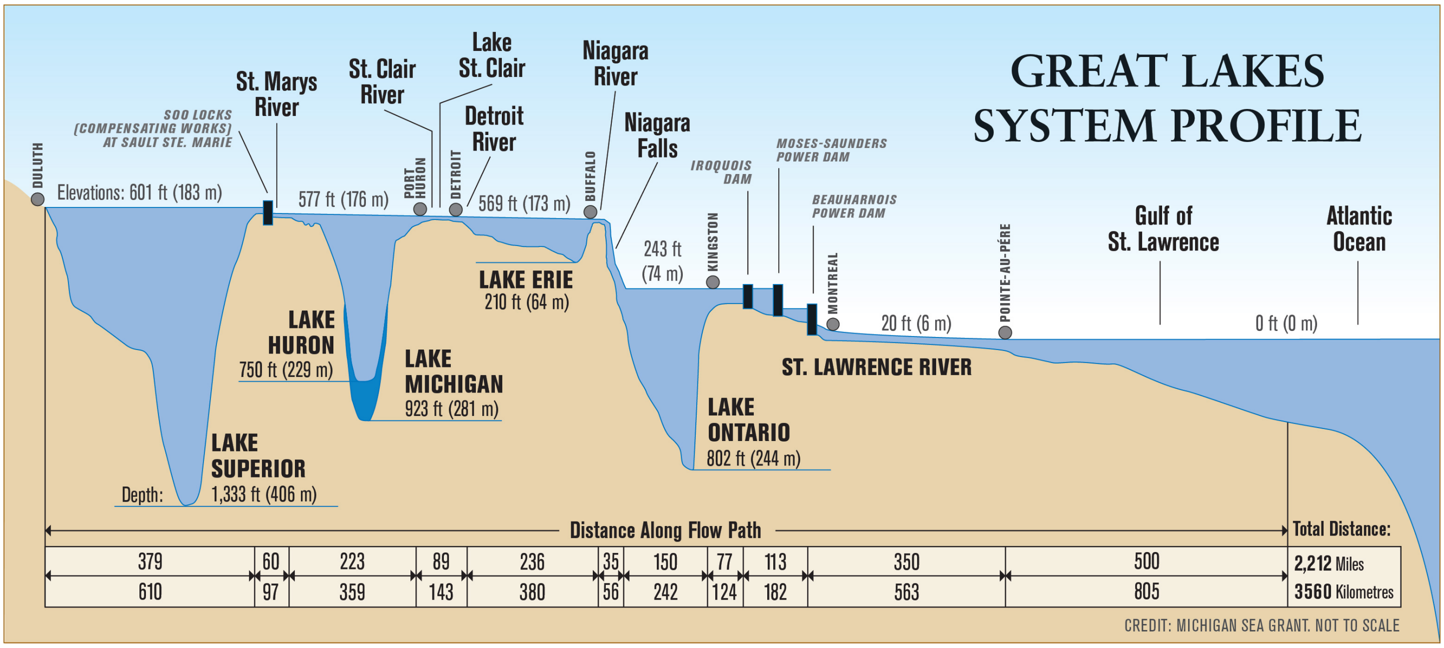


Figure 1: The Great Lakes system profile. Credit: Michigan Sea Grant.

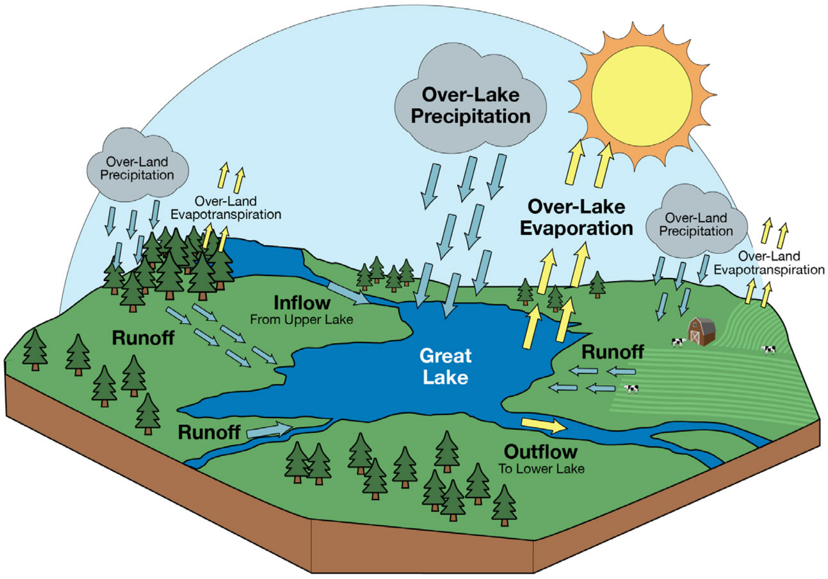
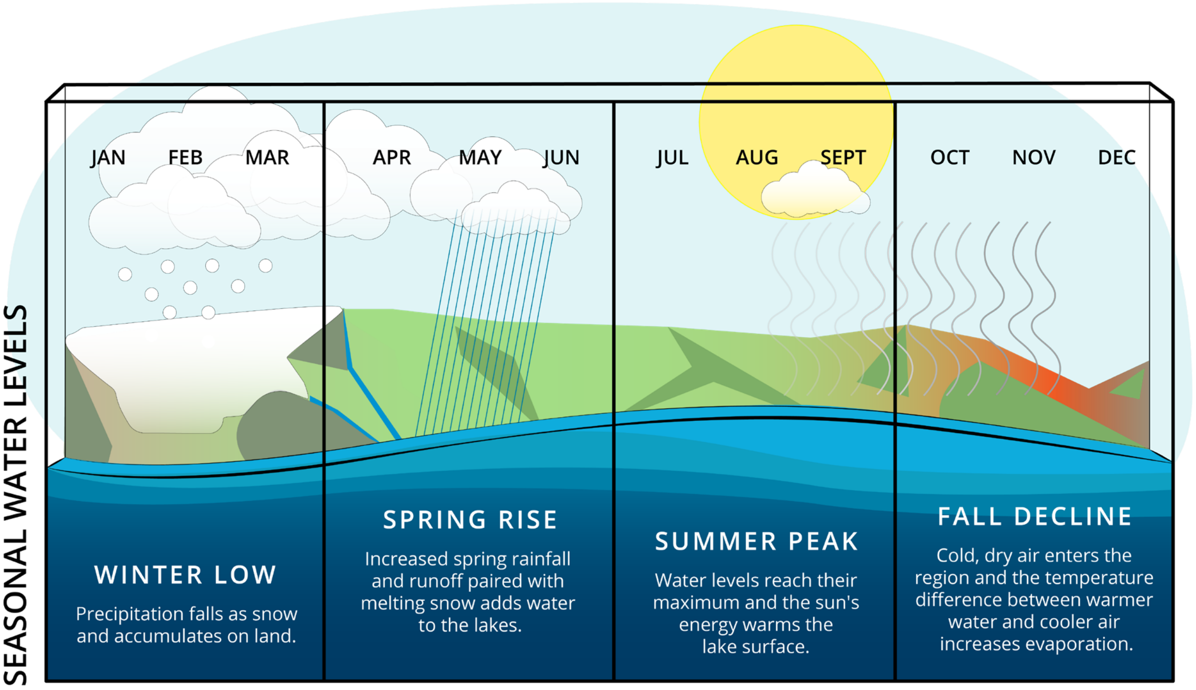


Figure 2. The Great Lakes hydrologic cycle. Credit: Great Lakes Integrated Sciences and Assessments (GLISA).

Seasonality of the Hydrologic Cycle and Lake Levels

Local weather conditions, including factors like temperature and precipitation, drive the hydrologic cycle. As weather changes seasonally, so does its effect on the hydrologic cycle (Figure 3). During the winter, precipitation accumulates as snow, and lake levels are typically at their lowest. In the spring, temperatures increase and melt accumulated snow. Rainfall also increases during the springtime. Increased rainfall and snow melt increases runoff into the lake, causing lake levels to rise and eventually peak during the summer. Throughout the summer, the lake is warmed by higher air temperatures, creating a large temperature difference between the warm lake surface and cool air in the fall, leading to increased evaporation rates. As evaporation increases, lake levels decrease, which persists into wintertime.



Precipitation falls as snow and accumulates on land.

Increased spring rainfall and runoff paired with melting snow adds water to the lakes.

Water levels reach their maximum and the sun's energy warms the lake surface.

Cold, dry air enters the region and the temperature difference between warmer water and cooler air increases evaporation.

Figure 3. The seasonality of Great Lakes water levels. Credit: National Oceanic and Atmospheric Administration (NOAA).

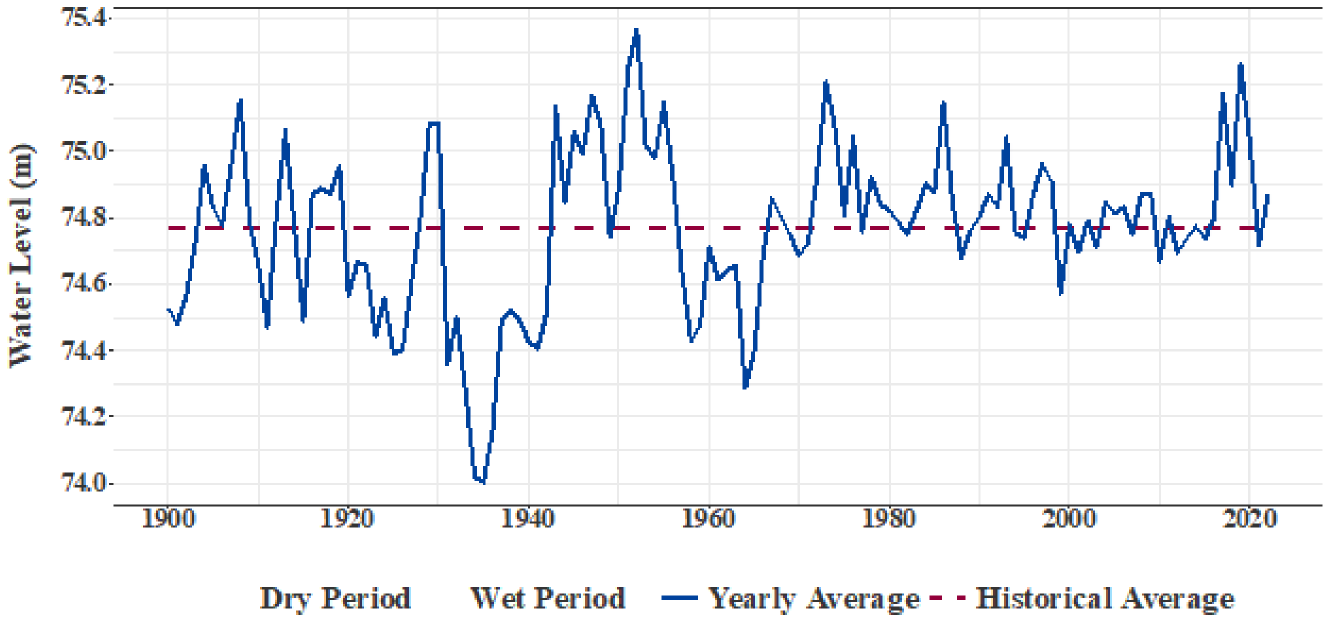


Figure 4. Annual average and long-term average historical water levels. Credit: Great Lakes Integrated Sciences and Assessments (GLISA).

Long Term Trends in Lake Levels

In addition to the seasonality of weather and lake levels, lake levels follow long-term (e.g. decades-long) cycles. Climate is the long-term pattern of weather for a particular area. Long-term variations in water levels are caused by fluctuations away from climate normal. When the weather is "wetter than usual" or "warmer than usual," we could expect water levels to be "higher than usual" or "lower than usual". However, these changes in lake levels are the result of many different competing processes and change ultimately occurs when certain conditions dominate over others. For example, there was a dry period which resulted in extremely low lake levels on Lake Ontario during late 1950s through the 1960s (Figure 4). This dry period was followed by a period of high water levels in the 1970s, which led to significant flooding for several years (Figure 4) [https://glisa.umich.edu/sustained-assessment/ontario-climatology/].

Scientists can forecast lake water levels by considering historical data, present conditions, and possible future scenarios. It is important to remember that there is a lot of uncertainty when making these kinds of projections. The U.S. Army Corps of Engineers (USACE) produces 6-month forecasts for Great Lakes water levels projecting a range of potential lake levels that are dependent on variations in weather. Projections of low or high water level periods, even though uncertain, assist in the mitigation of various risks (e.g. flooding during high water periods and navigational hazards during low water periods). In addition to short-term forecasts, long-term forecasts project lake levels through the end of the 21st century using a combination of global and regional climate models, as well as hydrologic models. These long-term forecasts project a range of possibilities, rather than specific periods of low or high water levels. On the historic record, periods of low and high water levels have typically persisted on a multi-decadal time period. However, the time between fluctuations of low and high periods is generally expected to decrease as the climate changes [https://www.glerl.noaa.gov/data/dashboard/info/ltForecasts.html], meaning extreme low and high water levels will likely occur at a greater frequency than they have historically.

Resources

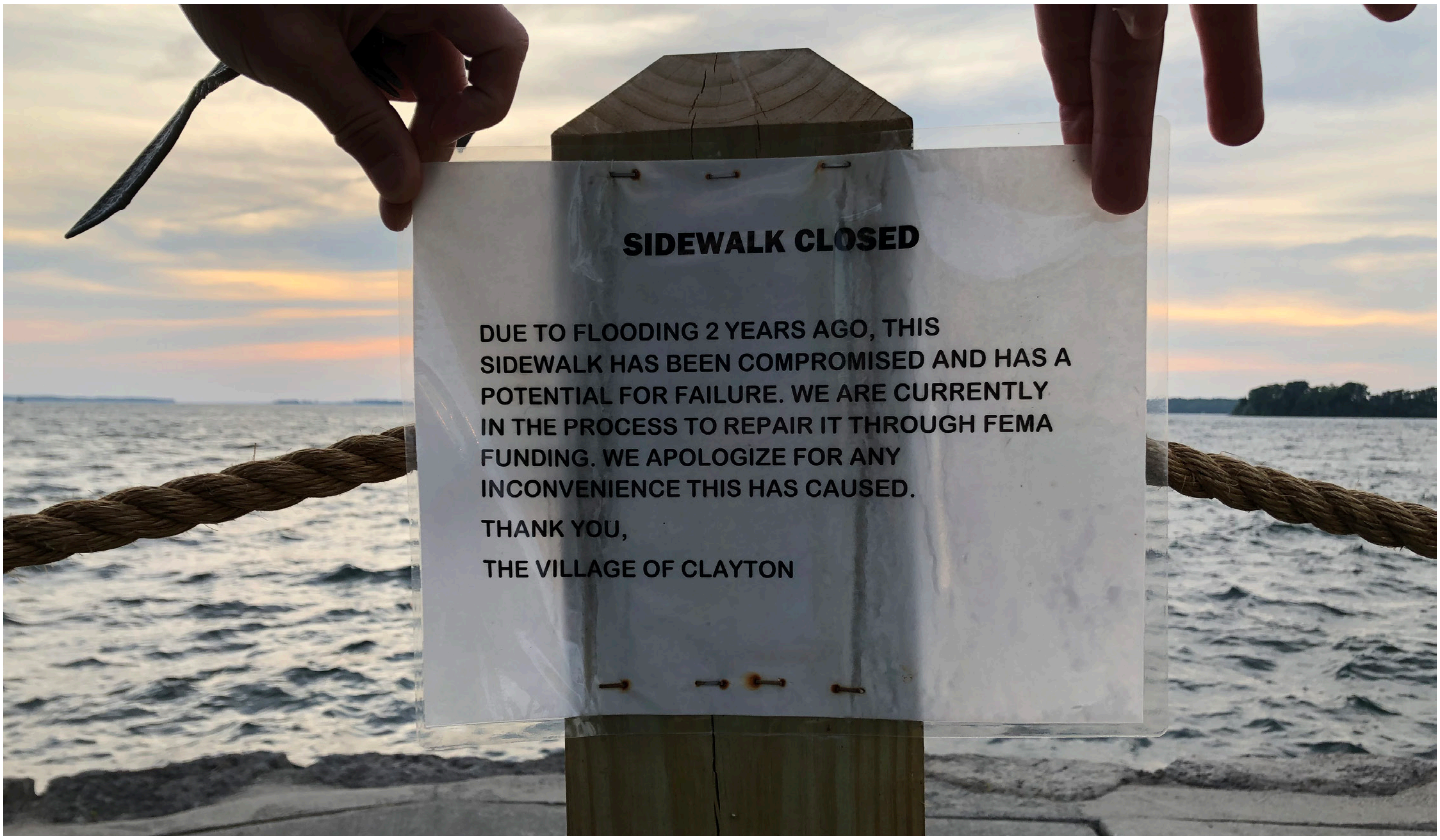
For additional resources about short-term water level forecasts and long-term climate projections, please visit the link provided or scan the QR code using your phone camera.

linktr.ee/weatherandclimate

New York Sea Grant
202 Jarvis Hall
SUNY at Buffalo
SGBuffal@cornell.edu

Authors:
Kyla Semmendinger
PhD Candidate
Cornell University

Megan Kocher
Great Lakes Outreach Coordinator
New York Sea Grant


SIDEWALK CLOSED

DUE TO FLOODING 2 YEARS AGO, THIS SIDEWALK HAS BEEN COMPROMISED AND HAS A POTENTIAL FOR FAILURE. WE ARE CURRENTLY IN THE PROCESS TO REPAIR IT THROUGH FEMA FUNDING. WE APOLOGIZE FOR ANY INCONVENIENCE THIS HAS CAUSED.

THANK YOU,

THE VILLAGE OF CLAYTON

Image depicting a sidewalk closure as a result of flooding on the St. Lawrence River. Credit: Jayme Breschard

www.nyseagrant.org

New York Sea Grant is part of a nationwide network of 34 university-based programs working with coastal communities through the National Oceanic Atmospheric Administration (NOAA). Sea Grant research and outreach programs promote better understanding, conservation, and use of America's coastal resources. Sea Grant is funded in New York through SUNY and Cornell University and federally through NOAA. New York's Sea Grant Extension Program provides Equal Program and Equal Employment Opportunities in association with Cornell Cooperative Extension, U.S. Department of Agriculture and U.S. Department of Commerce and cooperating County Cooperative Extension Associations. Funding for the printing of this document was provided by the New York State Environmental Protection Fund under the authority of the New York Ocean and Great Lakes Ecosystem Conservation Act.

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