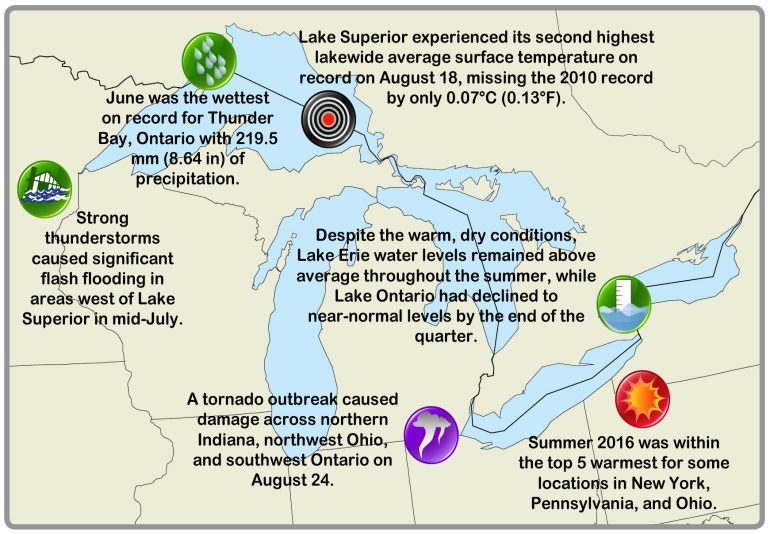
Quarterly Climate Impacts and Outlook

Great Lakes Region

September 2016

Great Lakes Significant Events - *for June - August 2016*

The Great Lakes basin experienced a wide range of extreme weather this summer. Temperatures in the basin this summer were above normal, with the greatest departures from normal occurring in August. Summer 2016 was within the top 5 warmest for Rochester (NY), Buffalo (NY), and Erie (PA) (records began in the 1870s). High minimum temperatures were a large contributor to the warmth this summer. Ohio's summer minimum temperatures were the warmest on record since records began in 1895.



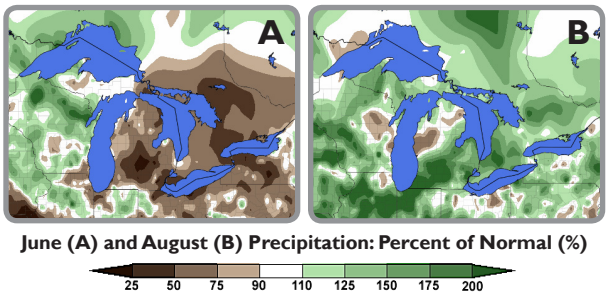
Precipitation varied from drier-than-normal in the eastern Great Lakes to wetter-than-normal in the western Great Lakes. The dry conditions, which were predominant in the early summer, led to drought development in New York, Pennsylvania, Ohio, Michigan, and portions of Ontario. On the other hand, Thunder Bay, Ontario recorded 219.5 mm (8.64 in) in June, making this their wettest June on record since records began in 1877.

Strong thunderstorms in mid-July caused significant flash flooding in areas west of Lake Superior in Minnesota and Wisconsin. Rainfall amounts totaled 102 to 254 mm (4 to 10 inches) in a 24-hour period, with much actually falling within an 8-hour period. Gurney, Wisconsin recorded 245 mm (9.65 in) on the morning of July 12, making it their highest one-day precipitation total on record since records began in 1952.

A tornado outbreak on August 24 caused substantial damage in portions of Indiana, southwest Ontario, and northwest Ohio, which is unusual for this time of year. The 25-year average for August tornadoes in Indiana and Ohio is only two, but these states had over 21 combined on August 24. In fact, the 21 tornadoes reported in Indiana and Ohio ranks in the top 10 list for the largest number of tornadoes in a single August day across the U.S. (since 1950).

Regional Climate Overview - *for June - August 2016*

Precipitation



June (A) and August (B) Precipitation: Percent of Normal (%)

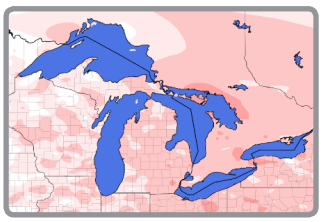
June was dry for all lake basins except Superior, with the Great Lakes basin receiving 83% of normal precipitation. The July storm track brought near- to above-normal precipitation to the upper lakes, while the lower lakes had below-normal precipitation. The overall basin received 91% of normal in July. In August, all lakes received above-normal precipitation, with the overall basin receiving 138% of normal. Summer averaged out to be drier than normal for Lake Ontario, wetter than normal for Lake Superior, and near normal for the other lake basins. Overall, the Great Lakes basin received 104% of normal summer precipitation.

June and August 2016 graphics are shown to display the range in precipitation this summer. Precipitation normals based on 1981-2010.

Temperature

Air Temperature: June temperatures ranged from 1°C (2°F) below normal to 2°C (4°F) above normal, while July temperatures ranged from near normal to 3°C (5°F) above normal. The entire region was warmer than normal in August, with temperatures ranging from 1°C (2°F) to 5°C (9°F) above normal. New York and Pennsylvania were record warm, while Ohio had its 3rd warmest August. The eastern Canadian basin observed August mean temperatures that were extremely above normal (90th-98th percentile). Summer temperatures ranged from near normal to 3°C (5°F) above normal.

Water Temperature: All Great Lakes surface water temperatures were above the long-term average for June, July, and August. Some temperatures were as much as 3.5°C (6.3°F) above average for the period.



June-Aug 2016: Dep. from Normal

Air temperature normals based on 1981-2010. Water temperature long-term average is 1995-2015.

Great Lakes Water Levels

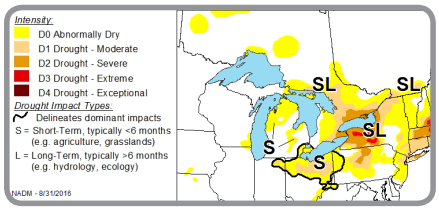
With the exception of Lake Superior, all lakes generally experienced dry conditions during the past three months, yet levels on all but Lake Ontario remained above average throughout the quarter. At the end of August, Lake Superior was 16 cm (6.3 in) above average, Lake Michigan-Huron was 28 cm (11.0 in) above average, and Lake Erie was 24 cm (9.45 in) above normal. The past three months were especially dry on Lake Ontario, and it finished the quarter 2 cm (0.8 in) below average, 20 cm lower than last year.

Water level statistics based on 1918-2015.

Regional Impacts - *for June - August 2016*

Drought

After persistent dry conditions, drought developed in the eastern Great Lakes basin. Several counties in New York experienced extreme drought conditions for the first time since at least 2000, when the U.S. Drought Monitor data began.



North American Drought Monitor as of 8/31/16 (www.drought.gov)

Agriculture

The yields of corn, soybeans, and hay are expected to be lower than average in some drought areas. Dried up pastures forced farmers in New York to supplement with feed, which is usually saved for the winter. Despite the drought conditions in New York, grape growers indicated berries were ripening faster than usual and may be smaller in size, but higher quality. Areas to the west that were wetter are expecting above-average yields this summer.

Seasonal growing degree day accumulations were above average for much of the basin. This may reduce the risk for fall freeze damage since crops may reach maturity before the first killing freeze.

Water Resources

As a result of drought conditions, streamflow and groundwater levels were at record or near-record low levels in parts of New York, with some private wells going dry. In late July, Ithaca, New York's water supply was critically low, with an estimated 30 days of water left without significant rain or reduction in use.

Transportation & Infrastructure

The mid-July flash flooding around western Lake Superior resulted in many road closures, including major interstates. In Lake Superior, numerous vessels were affected by downburst winds. Six vessels became adrift and some were overturned. Preliminary damage estimates for eight Wisconsin counties totaled over $28 million to public infrastructure.



Highway near Highbridge, WI (Photo: NWS Duluth/Tracy Packingham)

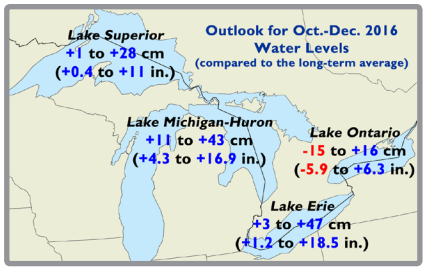
Hot and dry weather and aging infrastructure led to a dozen water main breaks in the Buffalo, New York area in July.

Water Quality

The size of the western Lake Erie harmful algal bloom is smaller this year due to developing and persistent drought conditions in the region. However, NOAA scientists have found that toxic algae is still forming as bloom toxin concentrations are significantly higher than last year. The drivers behind changes in toxicity are still under investigation and areas of algal scum could still present risk and should be avoided.

Regional Outlook - *for October - December 2016*

Water Levels



Potential range for water levels for Oct-Dec 2016 compared to the long-term average (1918-2015).

All of the Great Lakes typically begin or continue their seasonal decline at this time of the year, as lake evaporation rates are at their highest due in large part to declining air temperatures and relatively warm lake water. Water levels are expected to remain above average for lakes Superior, Michigan-Huron, and Erie unless exceedingly dry conditions are experienced. Lake Ontario water levels are expected to remain near average unless exceedingly wet or dry conditions are experienced.

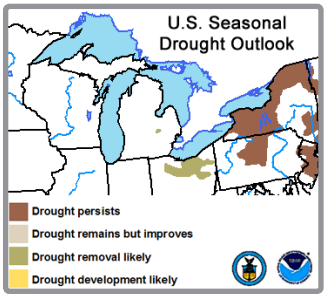
Temperature & Precipitation

The October-December 2016 period is forecasted to have a greater chance of above-normal temperatures for both the U.S. and Canadian Great Lakes basins by the Climate Prediction Center (CPC) and Environment and Climate Change Canada (ECCC). On the other hand, there is no clear signal on whether precipitation will be above, near, or below normal. The current monthly and seasonal outlooks can be found through CPC and ECCC.

Currently, CPC is forecasting neutral conditions for the El Niño Southern Oscillation (ENSO) this fall and winter 2016/17, meaning that ENSO will not likely have a strong influence on North American weather in the coming months.

Drought

For the U.S. Great Lakes basin (pictured), drought is expected to persist in New York into the October-December 2016 period. In Ohio, drought removal is likely. Agriculture and Agri-Food Canada expects that drought conditions will also continue in the Canadian Great Lakes basin into the October-December 2016 period (not pictured).



Valid for Sept. 15-Dec. 31, 2016 (Source: NOAA CPC)

Great Lakes Region Partners

Environment and Climate Change Canada (ECCC)
www.ec.gc.ca
Agriculture and Agri-Food Canada
www.agr.gc.ca
Midwestern Regional Climate Center
mrcc.isws.illinois.edu
Northeast Regional Climate Center
www.nrcc.cornell.edu
Great Lakes Region State Climatologists
www.stateclimate.org
National Oceanic and Atmospheric Administration
www.noaa.gov
- **National Centers for Environmental Information**
  www.ncei.noaa.gov
- **National Operational Hydrologic Remote Sensing Center**
  www.nohrsc.noaa.gov
- **Great Lakes Environmental Research Laboratory**
  www.glerl.noaa.gov
- **NOAA Great Lakes Sea Grant Network**
  www.seagrant.noaa.gov
- **North Central River Forecast Center**
  www.crh.noaa.gov/ncrfc
- **Ohio River Forecast Center**
  www.weather.gov/ohrfc
- **Climate Prediction Center**
  www.cpc.noaa.gov
- **Office for Coastal Management**
  http://coast.noaa.gov/

Great Lakes Integrated Sciences & Assessments
www.glisa.umich.edu
US Army Corps of Engineers, Detroit District
www.lre.usace.army.mil
National Integrated Drought Information System
www.drought.gov

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