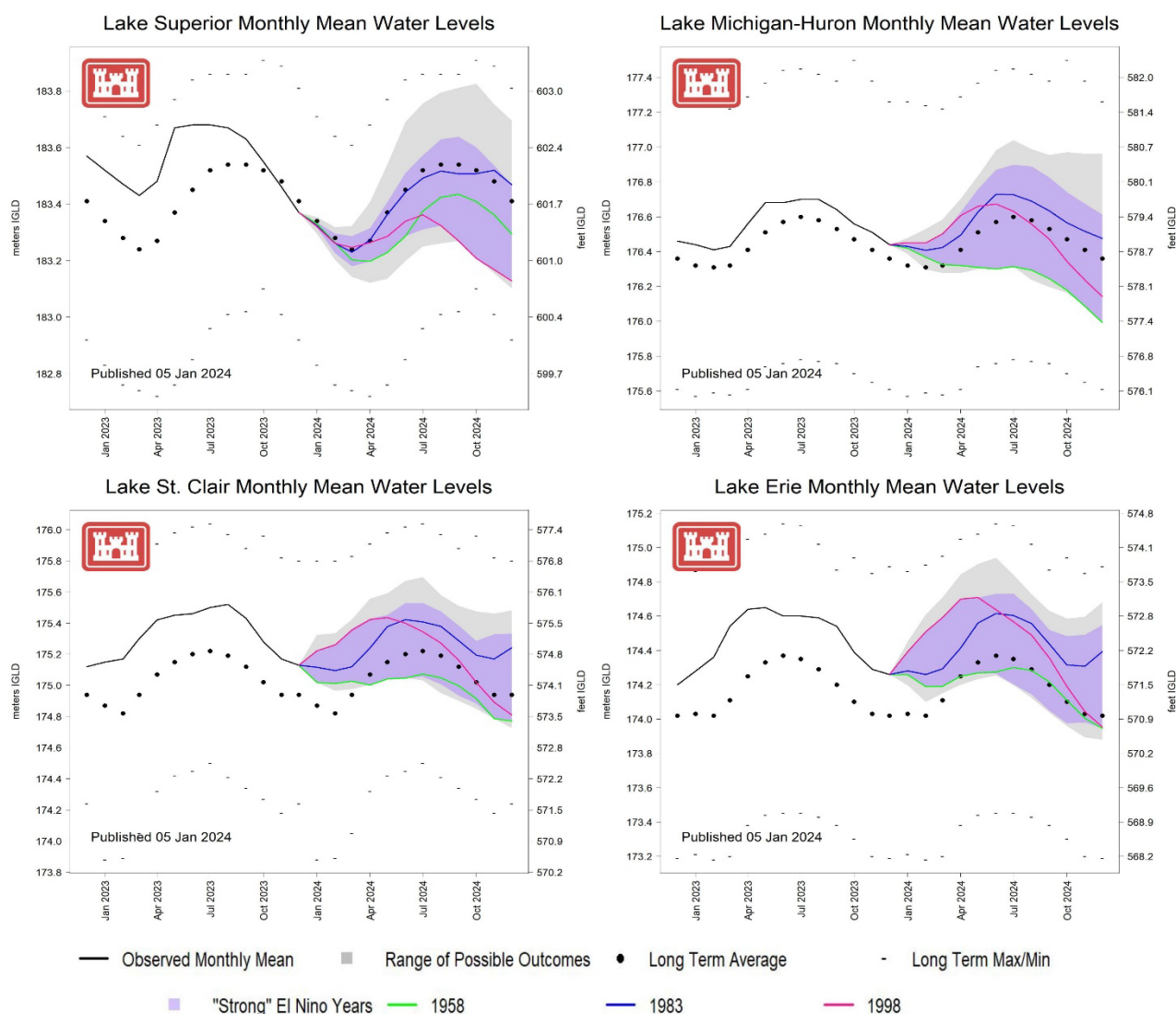




US Army Corps
of Engineers®
Detroit District

Great Lakes Water Level Future Scenarios

Volume 34 January 2024: Effects of Strong El Niño Events



*At this time, water level outlooks for Lake Ontario are still under development due to complexities of its weekly regulation process. An experimental version is shown later in this report. For the official 6-month forecast of all lakes, including Lake Ontario, see the [Monthly Bulletin of Great Lakes Water Levels](#).

Overview

The October 2023 Water Level Future Scenario Product explored ‘Strong’ El Niño years due to the likelihood that the ongoing El Niño would develop into a ‘Strong’ El Niño this season. In the November release of the ENSO Diagnostic Discussion from the Climate Prediction Center (CPC), conditions were indicative of a ‘Strong’ El Niño. Given the ongoing ‘Strong’ El Niño, the January 2024 release will continue with this scenario of highlighting ‘Strong’ El Niño events.

So what is meant by a ‘Strong’ El Niño? El Niño is characterized by Sea Surface Temperatures (SST) in the Tropical Pacific Ocean being over 0.5°C above normal for 5 consecutive months. NOAA uses the Oceanic Niño Index (ONI) index to classify El Niño and La Niña events. The ONI is 3-month running mean of SST anomalies in the Niño 3.4 region (5°N-5°S Latitude, 120°-170°W Longitude).

Strong El Niño Events are defined by an ONI between 1.5°C and 1.9°C, while a ‘Very Strong’ El Niño Event is defined by an ONI $\geq 2.0^\circ\text{C}$. The CPC notes that a strong El Niño does not necessarily equate to strong impacts regionally. The probability of related climate anomalies are often lower than the chances of El Niño itself. However, above average temperatures in winter occurred in the Great Lakes basin during all 3 ‘Very Strong’ El Niños, as shown below (Figure 1) in the climate maps from NOAA’s Climate.gov website:

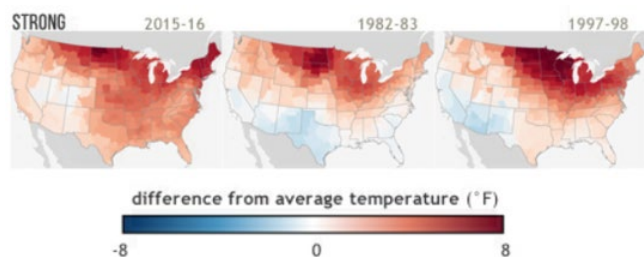


Figure 1: USA Winter Climate Maps for the 3 ‘Very Strong’ El Niño. From Climate.gov

Usually, the United States begins to see significant impacts of El Niño in the late fall and early winter. El Niño events are associated with above average temperatures in the Great Lakes region, and below average winter precipitation in the Lake Erie and southern Lake Michigan-Huron basins (Figure 2).

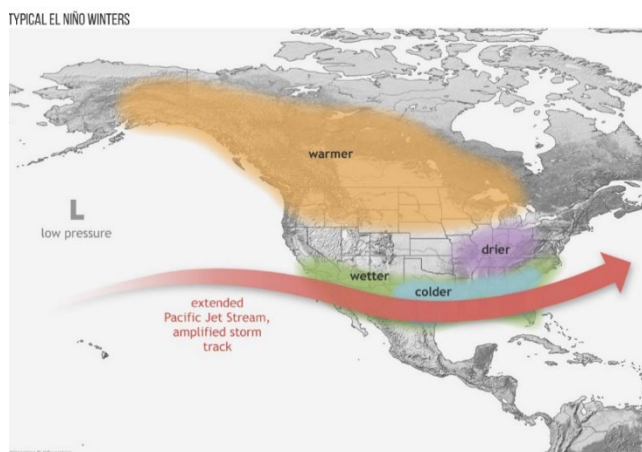


Figure 2: Typical conditions in an El Niño winter state. From: NOAA Climate

Above average temperatures in winter in the Great Lakes region will generally result in lower snowpack, higher lake surface temperatures, and lower ice coverage. These all have an impact on the Net Basin Supply (NBS), which consists of evaporation that takes water from the lakes, and precipitation and runoff that add water to the lakes. NBS is the main impetus for Great Lakes static water level changes.

This edition of the Water Level Future Scenarios incorporates the projection of water levels if NBS values are like those experienced in the years in which the ‘strongest’ El Niño events occurred. Eight NBS sequences are incorporated into this analysis and are represented by the purple plume shown in the plots on Page 1. The NBS sequences represent 5 years in which ‘Strong’ El Niño conditions occurred and the 3 years of ‘Very Strong’ El Niño conditions.

In addition, three of the years within the purple plume have been called out to show the difference in hydroclimate conditions that could occur over the next 12 months – 1958, 1983, and 1998. The

1958 El Niño is categorized as a ‘Strong’ El Niño, while the 1983 and 1998 El Niño events were classified as ‘Very Strong’. The 1958, 1983, and 1998 water level scenarios are represented by the green, blue, and pink lines, respectively. Also, the gray shaded area on the plot represents the full range of possible outcomes using historical sequences of NBS from 1900 through 2022. This analysis also incorporates an experimental version of a Lake Ontario graphic. For Lake Ontario, the range of possible outcomes (gray shaded area) is based on historical NBS from 1900 through 2019 (Figure 3).

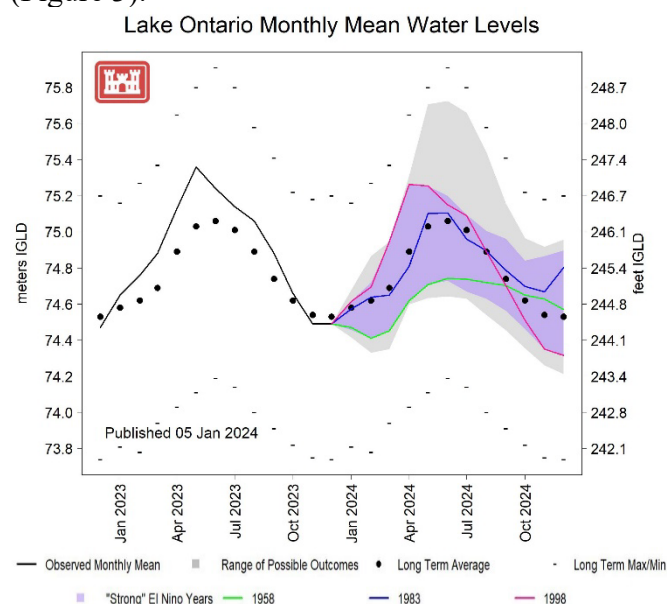


Figure 3: An experimental version Lake Ontario graphic with the new future scenario reflected.

Purple Plume

The purple plume represents the water levels that could occur if NBS conditions were similar to the eight years when either a ‘strong’ or ‘very strong’ El Niño event occurred. Overall, the full range of the purple plume tends to be shifted more towards the bottom of full range of possible outcomes. The purple plume does show possibilities of water levels above and below average on all lakes.

1958 Scenario

The 1958 scenario is shown on the plot by the green line. The green line represents the water levels that could occur if similar NBS conditions are experienced in 2024 that occurred during 1958.

The interesting tie between 1958 to 2024 is that, prior to the ‘Strong’ El Niño event of 1957-58, the three prior years (1954-56) were characterized by La Niña events. Leading into the 2023-24 El Niño event, there were also three prior years of La Niña events between 2020-23. Three years of consecutive La Niña events have happened 4 times in the period of record back to 1950.

The 1958 scenario is a drier scenario, especially in the first 6 months of the calendar year. During this time, precipitation was predominantly below average on all lakes from January to May. This also led to below average runoff during the spring months. These dry conditions led to very minimal spring rises in water level on Lakes Michigan-Huron, St. Clair, and Erie. Lakes Superior and Ontario did have a slight seasonal rise due to wetter conditions during the summer months. The last 4 months of the year (Sept.-Dec.), precipitation was variable between above and below average. The seasonal declines on Lakes Michigan-Huron, St. Clair, and Erie brought water levels to the bottom of the purple plume by December. Lake Michigan-Huron would follow the bottom of the purple plume for the entire 12 months, reaching below average water levels by April. All the lakes, besides Lake Ontario, would finish the year below long-term average water levels.

1983 Scenario

The 1983 scenario is shown on the plot by the blue line. The blue line represents the water levels that could occur if similar NBS conditions are experienced during 2024 that occurred in 1983. The 1982-83 winter was characterized by a ‘Very Strong’ El Niño event and as shown in Figure 1, above normal temperatures were experienced. Temperatures so far in the late fall and early winter of 2023-24 have also been warmer than average. Ice development was also minimal during the beginning of the winter in 1982-83, as it has been so far in 2023-24.

Looking forward into the scenario year of 1983, water levels experienced a typical seasonal rise

and seasonal decline pattern across all lakes, except Lake Superior. The spring rise across all lakes would be influenced by predominantly above average precipitation during April and May. NBS was mainly near to below average for the summer months on Lakes Superior, Michigan-Huron, and Ontario. Lakes St. Clair and Erie experienced slightly above average NBS in the summer months. The last 3 months of the year (Oct.-Dec) would be characterized by precipitation that was well above average. This would contribute to very high NBS in December on Lakes St. Clair, Erie, and Ontario, which would cause lake levels to rise slightly at the end of the simulation period. Lake Superior would have high precipitation in the last 4 months of the year and high NBS in October and November, which would allow the water level to stay relatively stable from August to November.

Overall, if conditions similar to 1983 occurred, water levels would remain above average for all 12 months on Lakes Michigan-Huron, St. Clair, and Erie, while Lakes Superior and Ontario, would finish the 12-month period above average.

1998 Scenario

The 1998 scenario is shown on the plot by the pink line. The pink line represents the water levels that could occur if similar NBS conditions are experienced in 2024 that occurred in 1998. The 1998 scenario year is also indicative a 'Very Strong' El Niño event that began in 1997. Similar to the 1982-83, the warm winter temperatures experienced (Figure 1) also led to minimal ice coverage to develop early in the winter. Another interesting similarity between the 1997-98 El Niño and the 2023-24 event was a dry Fall period (Sept., Oct., Nov.) leading into the winter months across much of the Great Lakes basin.

In 1998, conditions across all lakes besides Lake Superior, began the year quite wet. Well above average precipitation in January and March propelled runoff to be above average during this time and led to large rises on Lakes Michigan-Huron, St. Clair, Erie, and Ontario, that were at the top of the range of the purple plume. However,

beginning in April for the rest of the year, NBS conditions would be near to below average, especially in the last 4 months of the year, which would lead to very large seasonal declines on these four lakes. All four of these lakes would finish the 12-month period with water levels below average.

Lake Superior's conditions in 1998 were slightly different than the other lakes. It would not start the year as wet as the other lakes and NBS would only be slightly above average in March and November of that year. It would experience NBS well below average in 4 consecutive months between July and October, which would result in an early water level seasonal peak followed by a steep decline in water levels. The pink scenario line would follow along the bottom of the purple plume for the last 5 months of the year and finish well below long-term average levels.

Summary & Climatic Outlook

The purple plume that represents Great Lakes water levels in the 12 months during and after the 8 strongest El Niño events is shifted toward the bottom of the full range of possible outcomes (gray shaded area) for water levels on all the lakes.

Hydrometeorological conditions like those in 1983 (blue line) showed a more typical seasonal cycle and would result in water levels being above average water levels on all lakes by the end of the 12 months. The 1958 scenario (green line) was indicative of drier conditions across the lakes and all lakes would finish the 12-month period below average, except Lake Ontario. The 1998 scenario (pink line) experienced variable conditions throughout the year, but all lakes would end the 12 months with water levels below average.

The current seasonal temperature forecasts for the winter and early spring (January, February, March) shows a likelihood of above normal temperatures across the Great Lakes. The current seasonal precipitation forecast shows a likelihood toward below average precipitation across most of the Great Lakes basin. See Figure 4 on the next page.

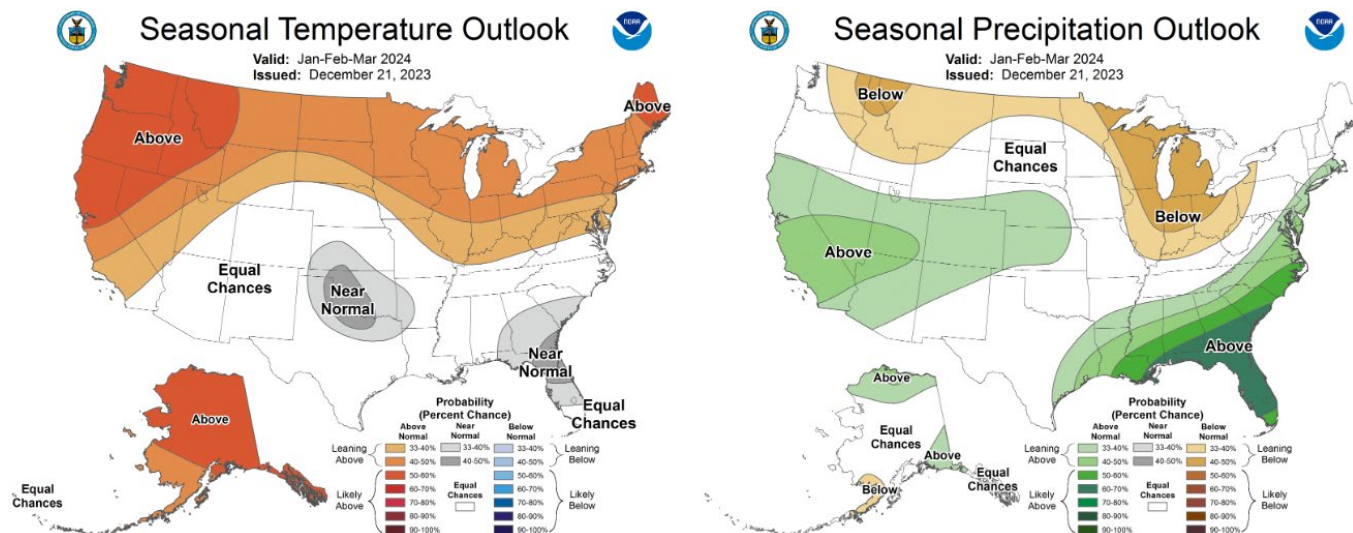


Figure 4. Climate Prediction Center's Seasonal Outlook maps for Temperature and Precipitation for January, February, and March 2024.