



**General Updates: Annex 9
Climate Change Impacts
Great Lakes Water Quality Agreement**

Tuesday, November 14, 2023

**Presented by Alisa Young
Annex 9 Co-Chairs
ALISA YOUNG (NOAA)
and SEAN BACKUS (ECCC)**

**GLP on Aquatic Nuisance Species
Session: Invasive Species and Climate
Change Risk**

Annex 9 Leadership Transition

Outgoing Chairs

Shaffina Kassam (ECCC)



Years Active (2018-2023)



Jennifer Day U.S. Co-Chair (NOAA)



Years Active (2018-2023)

Thank you for your service!

Incoming Chairs

Sean Backus (ECCC)



Alisa Young (NOAA)



Annex 9 Key Commitments

Canada and the United States agree to:

- Develop/improve regional-scale climate models and link them to GL chemical, physical and biological models to better understand and predict the impacts of climate change on GL water quality/ecosystem
- Enhance monitoring of relevant climate and GL variables to validate model predictions and understand current climate changes and its impacts;
- Develop and improve analytical tools to understand and predict the impacts, risks and vulnerabilities associated with climate change; and
- Coordinate binational climate change science activities to quantify, understand and publicly share information to proactively address climate change impacts.



Annex 9 Co-Chair Goal: Add Support Across Annex Themes

Climate Change Cuts Across Most Annex Themes	
Annex	Climate Change References in other Annexes
Lakewide Management (2)	Through the nearshore framework, climate change, among other factors, will be considered as a source of stress to the nearshore
Chemicals of Mutual Concern (3)	Recognition that climate change might affect the use, release, transport, and fate of chemicals of mutual concern.
Nutrients (4)	Climate change, among other factors, will be taken in account when establishing phosphorus concentrations and loading targets
	The influence of climate change on nutrient inputs to the great lakes and the formation of algae will be studied.
Aquatic Invasive Species (6)	The potential impact of climate change on the introduction survival, establishment and spread of AIS will be assessed.
Habitat and Species (7)	Science to support implementation of prevention methods to improve the resilience of native species and habitat will consider climate change impacts among other stressors
Groundwater (8)	Climate changes's affect of groundwater's impact on the quality of Waters in the Great Lakes will be analyzed.

Updates: 2023 - 2025 Priorities for Science

1. Collaborate with Annex 2 to enhance Lakewide Action and Management Plans (LAMP) by including current climate trends and best available information of projected future change and impacts.

Deliverables:

1. Provide climate-related expertise to the LAMP writing teams in development of each new LAMP

Status:

LE LAMP is currently in the stage of a red flag review w/comments due by November 24.

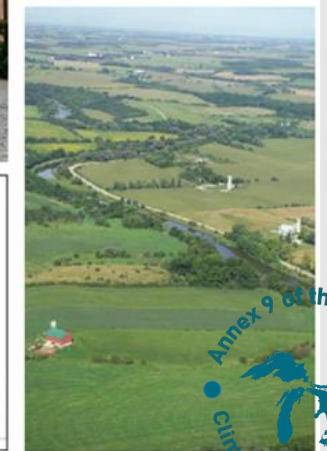
Upcoming:

2024 Lake Michigan LAMP



Lake Erie

2019-2023 LAKEWIDE ACTION & MANAGEMENT PLAN



Updates: 2023 - 2025 Priorities for Action



1. Enhance knowledge exchange and discussions of GL climate projections, integrated modeling, and downscaling approaches for resource managers.

Deliverables:

- Convene an expert climate modelling workshop
- Update *Climate Change in The Great Lakes Basin* report
- Host Annex 9 *Climate Change Webinar Series* and *Extended Subcommittee Calls*

2. Produce and share relevant climate information with the Great Lakes community, (including regularly issuing the binational Quarterly Climate Impacts and Outlook report and the Annual Climate Trends and Impacts Summary for the Great Lakes Basin.

Deliverables:

- Publish *Quarterly Climate Impacts and Outlook* reports
- Publish *Annual Climate Trends and Impacts* reports

Quarterly Climate Impacts and Outlook

Great Lakes Region
March 2023

Great Lakes Significant Events – December 2022 - February 2023

Great Lakes ice cover averaged 11.4% in February, which was the 6th lowest February on record since 1973. As of March 15, the seasonal average ice cover was tied for 3rd lowest on record at 5.7%.

Duluth had its snowiest December and 7th snowiest winter on record.

Hamilton, Ontario recorded its 2nd warmest winter dating back to 1870.

Rochester, New York had its 5th least snowy winter.

A massive lake-effect snow event from December 23-27 dumped 51.9 inches (1313 cm) of snow on Buffalo, New York.

A winter storm on February 22 brought widespread ice accumulations of a tenth-inch (2.5 mm) to a half-inch (13 mm) from Grand Rapids to Detroit.

A rapidly intensifying storm traversed the Great Lakes region in late December bringing strong winds, high waves, and snow to the eastern basin. A seiche developed on Lake Erie from December 23-24 resulting in an 18.4-foot (5.6-meter) lake level difference between Toledo and Buffalo. Buffalo recorded its 4th all-time snowiest day with 22.3 inches (56.6 cm) on December 23. Lake-effect snow persisted for nearly a week, dropping over 50 inches (127 cm) of snow in localized areas downwind of Lakes Erie and Ontario. Snowfall in southern Ontario ranged from about 20-40 inches (50-100 cm).

Only a few deep cold periods affected the Great Lakes, and long warm stretches were widespread. This resulted in persistently low lake ice extent, much above-normal water temperatures, and below-normal snowfall. Winter weather advisories spanned the region on February 22 as a strong storm brought rain, ice, and snow. The Green Bay area had about 6-10 inches (15-25 cm) of snowfall while the Detroit area had over a half-inch (13 mm) of ice. A lack of snow and warm temperatures contributed to drought intensification in southeast Michigan and southern Ontario across the winter months.

Regional Climate Overview – December 2022 - February 2023

Winter Temperature Departure from Normal

Air Temperature and Precipitation

Winter was up to 4°C (7°F) above normal. December ranged from 2°C (4°F) below normal in the west to 3°C (5°F) above in the east. January was up to 6°C (11°F) above normal across the basin. February ranged from near normal in the west to 5°C (9°F) above normal in the east.

Winter precipitation ranged from 75-200% of normal across the basin. December precipitation was over 150% of normal in the far western and eastern ends of the basin, with 50-150% in between. January ranged from 50-125% of normal in the west up to 200% in the east. February ranged from 75% of normal in the eastern end of the basin to over 150% of normal in the western lakes.

Michigan had its 6th warmest winter. In Ohio, Cleveland had its 2nd warmest winter and Toledo had its 8th least snowy. Watertown, New York has its 2nd wettest winter.

Current Water Levels

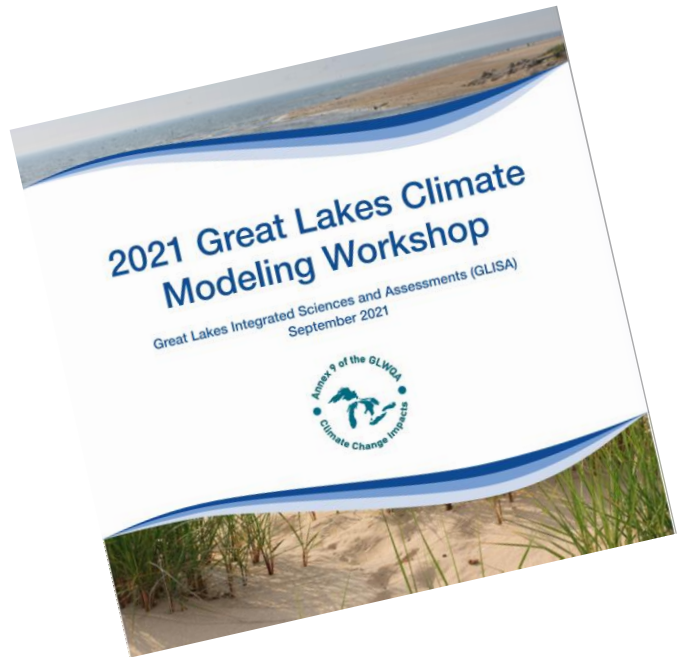
Lake	End of Feb 2023 Level Compared to:		Change in Level from beg. of Dec. to end of Feb:	
	Average for Feb	Feb 2022	2022-23 Change in Level	Average Change in Level
Sup.	+21 cm	+30 cm	-16 cm	-10 cm
Mich-Huron	+11 cm	-12 cm	-9 cm	-17 cm
Erie	+42 cm	-3 cm	+26 cm	+3 cm
Ont.	+19 cm	-11 cm	+39 cm	+10 cm

End of February water levels were above average on all lakes, while Lake Superior was the only lake above its level from last February. Lakes Superior and Michigan-Huron experienced a net decrease in water levels from the beginning of December to the end of February, which is typical for this time period. In contrast, lakes Erie and Ontario experienced well above average rises in water level over the same time horizon due to warm and wet conditions throughout January and February.

Contact: Melissa Widholm (mwidholm@purdue.edu) | Great Lakes Region Quarterly Climate Impacts and Outlook | March 2023
<https://www.drought.gov/drought/resources/reports>

Implementation of the Priority For Action #1

Foster and enhance knowledge exchange and discussions on Great Lakes climate projections, integrated modeling, and downscaling approaches for Great Lakes resource managers.



Deliverable	Timeframe
<p>Planning for the next climate modelling workshop is in progress. We expect registration to open in February with plans for the workshop to convene in spring.</p> <p><i>GLEC member agency and organization modelers are invited to attend and present</i></p>	<p>Scheduled for 2023 - 24</p>

2021 Recap: 66 participants

Themes: 1) Physical climate modeling 2) Bias & bias correction 3) Lake level impact modeling 4) Translating climate information

Activities: 1) Review existing climate modeling efforts, share work, identify gaps, develop recommendations

Implementation of the Priority For Action #1

Foster and enhance knowledge exchange and discussions on Great Lakes climate projections, integrated modeling, and downscaling approaches for Great Lakes resource managers.

2. Deliverable	Timeframe
<p>Update The Climate Change in the Great Lakes Report to reflect te a greater understanding of climate modelling.</p> <p><i>GLEC member agency experts are invited to provide comment and review the report</i></p>	<p>Scheduled for 2024</p>



Implementation of the Priority Action #1: Climate Change in the Great Lakes Report

The Climate Change in the Great Lakes Report presents many opportunities to address climate change impacts across the various Annex themes.

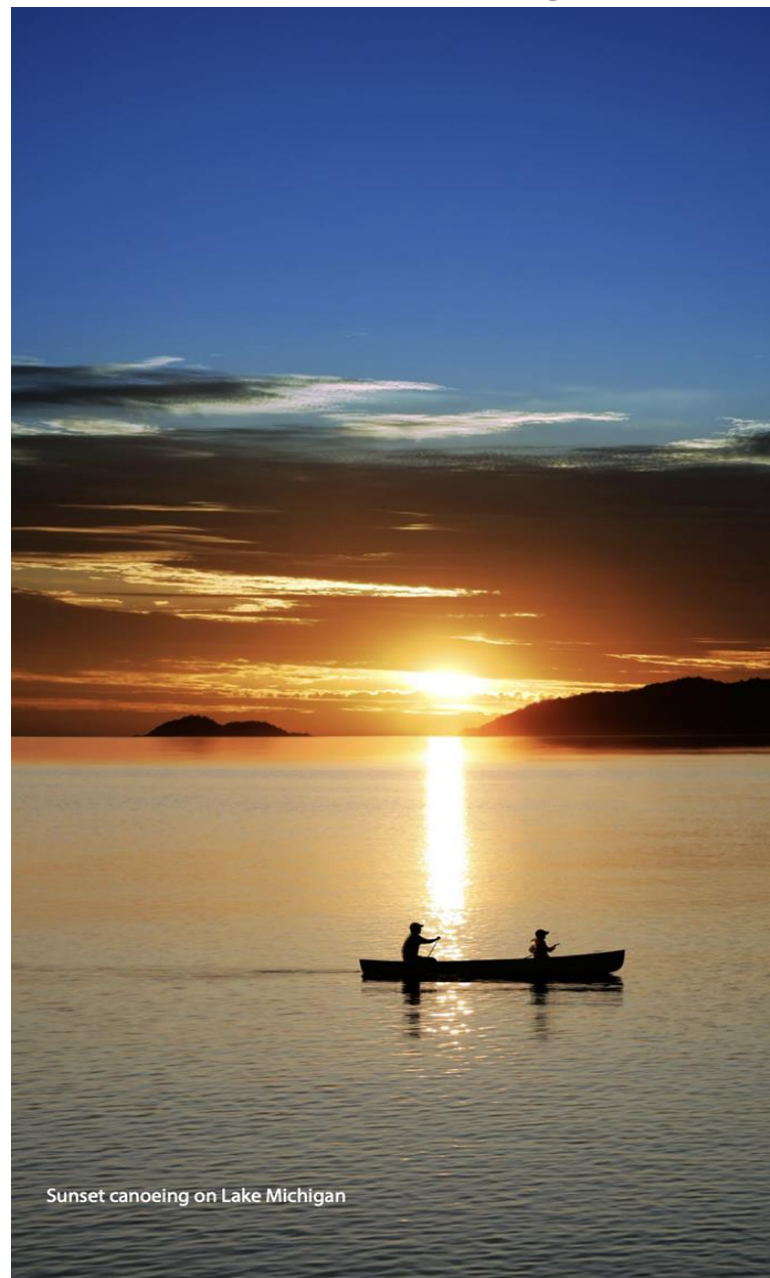


Table of Contents

EXECUTIVE SUMMARY	4
1.0 INTRODUCTION	6
2.0 HISTORICAL AND FUTURE CLIMATE TRENDS	10
2.1 Over-Land Air Temperature (ECCC Projections)	11
2.2 Over-Lake Precipitation (ECCC Projections)	17
2.3 Lake Levels (ECCC Projections)	22
2.4 Ice Cover (CCR Projections)	33
3.0 CLIMATE CHANGE IMPACTS	39
3.1 Impacts of Warmer Water Temperatures	39
3.2 Impacts of Ice Cover Reduction	41
3.3 Impacts of Flooding, Erosion, and Storms	42
3.4 Impacts on Industries and Livelihoods	44
3.5 Impacts on Ecosystems and Biodiversity	45
4.0 LOOKING AHEAD	46
REFERENCES	48
APPENDIX A: Detailed Description of the Methodology Used by Environment and Climate Change Canada to Develop the Climate and Water Level Projections	53
APPENDIX B: Detailed Description of the Methodology Used by the Nelson Institute Center for Climatic Research to Develop the Ice Cover Projections	56

Implementation of the Priority For Action #1

Foster and enhance knowledge exchange and discussions on Great Lakes climate projections, integrated modeling, and downscaling approaches for Great Lakes resource managers.

Deliverable	Timeframe
<p>Annex 9 Climate Change Webinar Series and Extended Subcommittee meetings help share climate change related information</p> <p><i>GLEC member agencies and organizations are invited to attend, participate and learn from invited climate change experts, as well as present their own climate-related work</i></p>	<p>Occur approximately every quarter</p>

Implementation of the Priority For Action #2

Produce and share climate information of relevance to the Agreement with the Great Lakes community, including regularly issuing the binational Quarterly Climate Impacts and Outlook report and the Annual Climate Trends and Impacts Summary for the Great Lakes Basin.

Quarterly Climate Impacts and Outlook
Great Lakes Region
June 2022

Great Lakes Significant Events – March - May 2022

Thunder Bay set a new spring record with a drought-busting 359.1 mm (14 in) of precipitation.

With a 38 cm (15 in) rise, Lake Superior tied for the largest spring water level rise since 1918.

At 116 kph (72 mph), Rochester recorded its 7th highest wind gust on record on March 6.

On May 20, an EF-3 tornado struck Gaylord, MI, becoming only the 5th deadly tornado to affect northern Lower Michigan.

A derecho on May 21 brought deadly and destructive straight-line winds to a large portion of Canada's population.

Nighttime temperatures from May 12-14 averaged a record-warm 22.4°C (72.3°F) in Chicago.

A strong weather system brought warm temperatures, earlier than normal, to the eastern basin on March 6 along with strong winds. Ithaca had its 3rd earliest 21.1°C (70°F) day since 1893. Winds up to 116 kph (72 mph) affected the area, damaging buildings and downing trees.

Record-setting spring precipitation in the northwest basin was widespread after two years of drought. Portions of the Lake Superior basin measured 2-3 times above normal precipitation in April. Thunder Bay received over 69 mm (2.7 in) in 12 hours on April 22-23, in just one of many heavy downpours to affect the region in April and May.

Extremely warm and humid air affected the central Great Lakes region May 9-14, with high temperatures over 11°C (20°F) above normal and low temperatures up to 8°C (15°F) above normal. Green Bay had the earliest occurrence of 34.4°C (94°F) since records began in 1886.

An intense, large-scale wind event (derecho) stretched from Sarnia, ON northeast to Quebec City on May 21 with widespread wind gusts over 120 kph (75 mph). A 132 kph (82 mph) gust was measured at Kitchener, ON. An EF2 tornado with 195 kph (121 mph) winds hit Uxbridge, ON.

Regional Climate Overview – March - May 2022

Spring Temperature Departure from Normal

Air Temperature and Precipitation

March ranged from 2°C (4°F) below normal in the Superior basin to 3°C (5°F) above normal in the Erie and Ontario basins. April ranged from 4°C (7°F) below normal in the Superior basin to 1°C (2°F) above normal in the Ontario basin. May ranged from near normal to 3°C (5°F) above normal. Spring ranged from 2°C (4°F) below normal in the Superior basin to 2°C (4°F) above normal in the Erie and Ontario basins.

During March and April, the Erie and Ontario basins were drier than average while the other basins were wetter, with the overall basin seeing 118% of average in March and 122% of average in April. During May, all basins were drier except Superior, with the overall basins seeing 96% of average. The overall basin saw 111% of average for spring, with Erie and Ontario being drier and the other basins being wetter.

Lake	End of May 2022 Level Compared to:		Change in Level from beg. of Mar. to end of May:	
	Average for May	May 2021	2022 Change in Level	Average Change in Level
Sup.	+12 cm	+2 cm	+38 cm	+17 cm
Mich-Huron	+27 cm	-14 cm	+27 cm	+23 cm
Erie	+32 cm	-1 cm	+18 cm	+31 cm
Ont.	+8 cm	+45 cm	+21 cm	+43 cm

Current Water Levels

End of May water levels were above-average on all lakes, and Lakes Superior and Ontario were above last May's levels. Lake Superior had wet spring conditions that led to a large rise in water level. The lake measured a 38 centimeter increase from the beginning of March to the end of May, which tied for the largest rise on record (1918-2021) during that time frame. Lake Michigan-Huron had a slightly above-average spring rise, while water levels on Lakes Erie and Ontario had a below-average spring rise.

Precipitation normals based on 1991-2020. Temperature normals based on 1991-2020 (U.S) and 1981-2010 (Canada).

Contact: Melissa Widhalm (mwidhalm@purdue.edu)

Great Lakes Region Quarterly Climate Impacts and Outlook | June 2022
<https://www.drought.gov/drought/resources/reports>

Deliverable	Timeframe
<p>Quarterly Climate Impacts and Outlook reports</p> <p><i>Continue to rely on several GLEC member agencies' participation in the compilation and development of these reports</i></p>	<p>Released quarterly in March, June, September and December</p>
<p>Annual Climate Trends and Impacts Summary reports</p> <p><i>Continue to rely on several GLEC member agencies' participation in the compilation and development of these reports</i></p>	<p>Released annually in late spring</p>

Join the Annex 9 Subcommittee



Climate Change Updates

Get updated on climate change news, research, and events happening in the Great Lakes Basin



Connect

Learn from and network with over 90 practitioners in the Great Lakes in both Canada and the U.S.



Strategic Sharing

Participate in our quarterly calls where you can provide input on various research projects and share key insights and findings from your own research or events

Email: Alisa.Young@noaa.gov or Sean.Backus@ec.gc.ca



Annex 9 Webinar Series

CANADA'S NATIONAL ADAPTATION STRATEGY

Briefing on Canada's first National Adaptation Strategy and how it is relevant to the Great Lakes

Friday, November 17, 2023



Vincent Loiselle
Senior Policy Analyst, Climate Change Adaptation Policy, ECCC



Questions?

Sean Backus, Environment and Climate Change Canada

Sean.Backus@ec.gc.ca

Alisa Young, U.S. National Oceanic and Atmospheric
Administration

Alisa.Young@noaa.gov