

## Lake Ice

*This indicator measures the amount of time that ice is present on lakes in the United States.*

### Background

The formation of ice cover on lakes in the winter and its disappearance the following spring depends on climate factors such as air temperature, cloud cover, and wind. Conditions such as heavy rains or snowmelt in locations upstream or elsewhere in the watershed also affect the length of time a lake is frozen. Thus, ice formation and breakup dates are key indicators of climate change. If lakes remain frozen for longer periods, it can signify that the climate is cooling. Conversely, shorter periods of ice cover suggest a warming climate.

Changes in ice cover can affect the physical, chemical, and biological characteristics of a body of water. For example, ice influences heat and moisture transfers between a lake and the atmosphere. Reduced ice cover leads to increased evaporation and lower water levels, as well as an increase in water temperature and sunlight penetration. These changes, in turn, can affect plant and animal life cycles and the availability of suitable habitat. Additionally, ice cover affects the amount of heat that is reflected from the Earth's surface. Exposed water will absorb and retain heat, making the Earth's surface warmer, whereas an ice- and snow-covered lake will reflect more of the sun's energy and absorb less. (For more information on ice and snow reflecting sunlight, see the Snow Cover indicator)

The timing and duration of ice cover on lakes and other bodies of water can also affect society—particularly in relation to shipping and transportation, hydroelectric power generation, and fishing. The impacts can be positive or negative. For example, reduced ice cover on a large lake could extend the open-water shipping season but require vessels to reduce their cargo capacity, as increased evaporation leads to lower water levels.

### About the Indicator

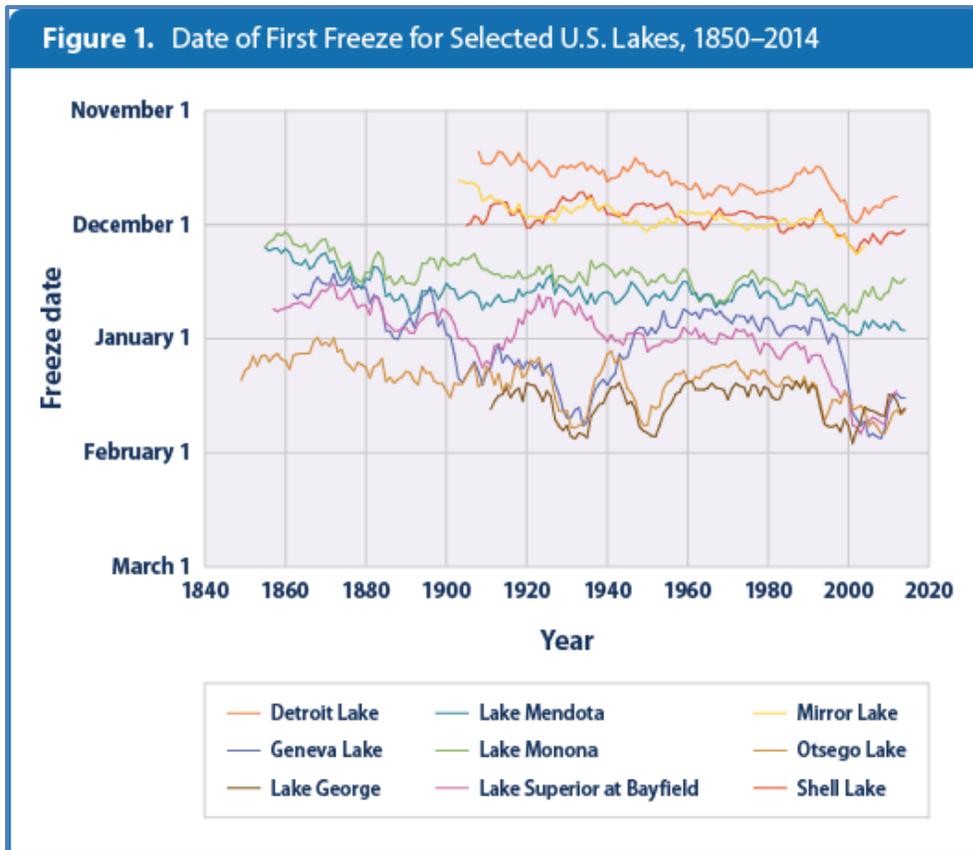
This indicator analyzes the dates at which lakes freeze and thaw. Freeze dates occur when a continuous and immobile ice cover forms over a body of water. Thaw dates occur when the ice cover breaks up and open water becomes extensive.

Freeze and thaw dates have been recorded through human visual observations for more than 150 years. The National Snow and Ice Data Center maintains a database with freeze and thaw observations from more than 700 lakes and rivers throughout the Northern Hemisphere. This indicator focuses on 14 lakes within the United States that have the longest and most complete historical records. The lakes of interest are located in Minnesota, Wisconsin, New York, and Maine.

### Key Points

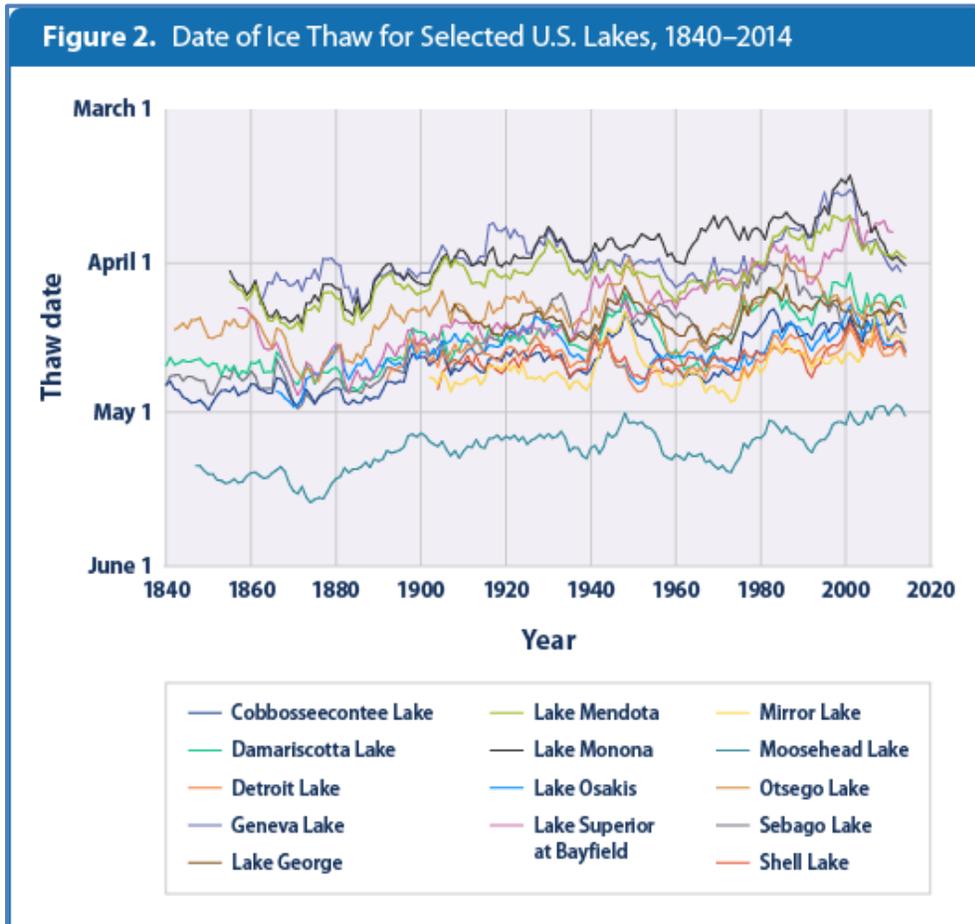
- The lakes covered by this indicator are generally freezing later than they did in the past. Freeze dates have shifted later at a rate of roughly half a day to one day per decade (see Figure 1).

- Thaw dates for most of these lakes show a general trend toward earlier ice breakup in the spring (see Figure 2). Thaw dates have grown earlier by up to 23 days in the past 109 years, except for two lakes that remained unchanged (see Figure 3). None of these lakes were found to be thawing later in the year.
- The changes in lake freeze and thaw dates shown here are consistent with other studies. For example, a broad study of lakes and rivers throughout the Northern Hemisphere found that since the mid-1800s, freeze dates have occurred later and thaw dates have occurred earlier, both shifting at an average rate of 0.8 days to one day per decade.<sup>1</sup>



This figure shows the “ice-on” date, or date of first freeze, for nine U.S. lakes. The data are available from as early as 1850 to 2014, depending on the lake, and have been smoothed using a nine-year moving average.

Data source: Various organizations<sup>2</sup>



*This figure shows the “ice-off” date, or date of ice thawing and breakup, for 14 U.S. lakes. The data are available from as early as 1850 to 2014, depending on the lake, and have been smoothed using a nine-year moving average.*

Data source: Various organizations<sup>3</sup>



*This figure shows the change in the “ice-off” date, or date of ice thawing and breakup, for 14 U.S. lakes during the period from 1905 to 2014. All but two of the lakes have red circles with negative numbers, which represent earlier thaw dates. The other two lakes have not experienced a significant change in thaw dates. Larger circles indicate larger changes.*

Data source: Various organizations<sup>4</sup>

### Indicator Notes

Although there is a lengthy historical record of freeze and thaw dates for a much larger set of lakes and rivers, some records are incomplete, with breaks ranging from brief lapses to large gaps in data. This indicator is limited to 14 lakes with sufficiently complete historical records. The four Maine lakes and Lake Osakis only have data for ice thaw, so they do not appear in Figure 1 (first freeze date).

Data used in this indicator are all based on visual observations. While the procedures for making observations of lake ice are consistent over time, visual observations by individuals are open to some interpretation and can differ from one individual to the next. In addition, historical observations for lakes have typically been made from a particular spot on the shore, which might not be representative of lakes as a whole or comparable to satellite-based observations. Considerations for defining the thaw date are specific to each lake.

### Data Sources

Data through 2004 for most lakes were obtained from the Global Lake and River Ice Phenology Database, which is maintained by the National Snow and Ice Data Center. These data are available

at: [http://nsidc.org/data/lake\\_river\\_ice](http://nsidc.org/data/lake_river_ice). More recent data were obtained from state, local, and other organizations that collected or compiled the observations.

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<sup>1</sup> Benson, B.J., J.J. Magnuson, O.P. Jensen, V.M. Card, G. Hodgkins, J. Korhonen, D.M. Livingstone, K.M. Stewart, G.A. Weyhenmeyer, and N.G. Granin. 2012. Extreme events, trends, and variability in Northern Hemisphere lake-ice phenology (1855–2005). *Climatic Change* 112(2):299–323.

<sup>2</sup> [see full list starting on next page]

<sup>3</sup> [see full list starting on next page]

<sup>4</sup> [see full list starting on next page]

## Lake Ice: Citations for Figures 1, 2, and 3

### Figure 1

*Detroit Lake, Minnesota, 2006–2012*

Minnesota Department of Natural Resources. Accessed May 2015. [www.dnr.state.mn.us/ice\\_in](http://www.dnr.state.mn.us/ice_in).

*Geneva Lake, Wisconsin, 2005–2014*

Geneva Lake Environmental Agency Newsletters. Accessed May 2015. [www.genevaonline.com/~glea/newsletters.php](http://www.genevaonline.com/~glea/newsletters.php).

*Lake George, New York, 2005–2014*

Lake George Association. Accessed May 2015. [www.lakegeorgeassociation.org/who-we-are/documents/Ice-In-Ice-Out2014-15.pdf](http://www.lakegeorgeassociation.org/who-we-are/documents/Ice-In-Ice-Out2014-15.pdf).

*Lake Mendota and Lake Monona, Wisconsin, 2011–2014*

North Temperate Lakes Long Term Ecological Research site. Accessed May 2015.  
<http://lter.limnology.wisc.edu/lakeinfo/ice-data?lakeid=ME> and  
<http://lter.limnology.wisc.edu/lakeinfo/ice-data?lakeid=MO>.

*Otsego Lake, New York, 2005–2014*

State University of New York (SUNY) Oneonta Biological Field Station. Annual Reports. Accessed May 2015. [www.oneonta.edu/academics/biofld/PUBS/ANNUAL/2013/29-Otsego-Ice-History-2014.pdf](http://www.oneonta.edu/academics/biofld/PUBS/ANNUAL/2013/29-Otsego-Ice-History-2014.pdf).

*Shell Lake, Wisconsin, 2005–2014*

Washburn County Clerk. 2015. Personal communication.

*All other data*

NSIDC (National Snow and Ice Data Center). 2014. Global lake and river ice phenology. Last updated January 2014. [http://nsidc.org/data/lake\\_river\\_ice](http://nsidc.org/data/lake_river_ice).

### Figure 2

*Cobbosseecontee Lake, Damariscotta Lake, Moosehead Lake, and Sebago Lake, Maine, 1800s–2008*

Hodgkins, G.A. 2010. Historical ice-out dates for 29 lakes in New England, 1807–2008. U.S. Geological Survey Open-File Report 2010-1214.

*Cobbosseecontee Lake, Damariscotta Lake, Moosehead Lake, and Sebago Lake, Maine, 2009–2014*

U.S. Geological Survey. 2015. Personal communication.

*Detroit Lake, Minnesota, 2006–2014*

*Lake Osakis, Minnesota, 1867–2014*

Minnesota Department of Natural Resources. Accessed May 2015. [www.dnr.state.mn.us/ice\\_out](http://www.dnr.state.mn.us/ice_out).

*Geneva Lake, Wisconsin, 2005–2013*

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[www.genevaonline.com/~glea/newsletters.php](http://www.genevaonline.com/~glea/newsletters.php).

*Lake George, New York, 2005–2013*

Lake George Association. Accessed May 2015. [www.lakegeorgeassociation.org/who-we-are/documents/Ice-In-Ice-Out2014-15.pdf](http://www.lakegeorgeassociation.org/who-we-are/documents/Ice-In-Ice-Out2014-15.pdf).

*Lake Mendota and Lake Monona, Wisconsin, 2011–2014*

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<http://lter.limnology.wisc.edu/lakeinfo/ice-data?lakeid=ME> and

<http://lter.limnology.wisc.edu/lakeinfo/ice-data?lakeid=MO>.

*Mirror Lake, New York, 2007–2012*

Adirondack Daily Enterprise. Accessed December 2013. [www.adirondackdailyenterprise.com](http://www.adirondackdailyenterprise.com).

*Mirror Lake, New York, 2013–2014*

Lake Placid News. Accessed May 2015. [www.lakeplacidnews.com](http://www.lakeplacidnews.com).

*Otsego Lake, New York, 2005–2014*

State University of New York (SUNY) Oneonta Biological Field Station. Annual Reports. Accessed May 2015. [www.oneonta.edu/academics/biofld/PUBS/ANNUAL/2013/29-Otsego-Ice-History-2014.pdf](http://www.oneonta.edu/academics/biofld/PUBS/ANNUAL/2013/29-Otsego-Ice-History-2014.pdf).

*Shell Lake, Wisconsin, 2005–2014*

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*All other data*

NSIDC (National Snow and Ice Data Center). 2014. Global lake and river ice phenology. Last updated January 2014. [http://nsidc.org/data/lake\\_river\\_ice](http://nsidc.org/data/lake_river_ice).

### **Figure 3**

*Cobbosseecontee Lake, Damariscotta Lake, Moosehead Lake, and Sebago Lake, Maine, 1905–2008*

Hodgkins, G.A. 2010. Historical ice-out dates for 29 lakes in New England, 1807–2008. U.S. Geological Survey Open-File Report 2010-1214.

*Cobbosseecontee Lake, Damariscotta Lake, Moosehead Lake, and Sebago Lake, Maine, 2009–2014*

U.S. Geological Survey. 2015. Personal communication.

*Detroit Lake, Minnesota, 2006–2014*

*Lake Osakis, Minnesota, 1905–2014*

Minnesota Department of Natural Resources. Accessed May 2015. [www.dnr.state.mn.us/ice\\_out](http://www.dnr.state.mn.us/ice_out).

*Geneva Lake, Wisconsin, 2005–2013*

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[www.genevaonline.com/~glea/newsletters.php](http://www.genevaonline.com/~glea/newsletters.php).

*Lake George, New York, 2004–2013*

Lake George Association. Accessed May 2015. [www.lakegeorgeassociation.org/who-we-are/documents/Ice-In-Ice-Out2014-15.pdf](http://www.lakegeorgeassociation.org/who-we-are/documents/Ice-In-Ice-Out2014-15.pdf).

*Lake Mendota and Lake Monona, Wisconsin, 2011–2014*

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<http://lter.limnology.wisc.edu/lakeinfo/ice-data?lakeid=ME> and

<http://lter.limnology.wisc.edu/lakeinfo/ice-data?lakeid=MO>.

*Mirror Lake, New York, 2007–2012*

Adirondack Daily Enterprise. Accessed December 2013. [www.adirondackdailyenterprise.com](http://www.adirondackdailyenterprise.com).

*Mirror Lake, New York, 2013–2014*

Lake Placid News. Accessed May 2015. [www.lakeplacidnews.com](http://www.lakeplacidnews.com).

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