Daily Great Lakes Ice Concentration, 1973 Onward, Version 1

USER GUIDE

How to Cite These Data

As a condition of using these data, you must include a citation:

NOAA Great Lakes Environmental Research Laboratory. 2020. *Daily Great Lakes Ice Concentration, 1973 Onward, Version 1*. [Indicate subset used]. Boulder, Colorado USA. NSIDC: National Snow and Ice Data Center. https://doi.org/ 10.7265/krkb-f591. [Date Accessed].

FOR QUESTIONS ABOUT THESE DATA, CONTACT NSIDC@NSIDC.ORG

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/G10029

National Snow and Ice Data Center

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1 DATA DESCRIPTION

1.1 Summary

This data set consists of daily gridded lake ice concentration for the Laurentian Great Lakes from the NOAA Great Lakes Environmental Research Laboratory (GLERL). The data are provided as gridded ASCII text files along with corresponding browse image files in .jpg format and GIS shapefiles beginning in the 2003 ice season.

GLERL conducts research of the Great Lakes and coastal regions in order to "provide information for resource use and management decisions that lead to safe and sustainable ecosystems, ecosystem services, and human communities" (NOAA GLERL).

Mapping lake ice for the daily use of those operating on the Great Lakes is not part of the GLERL mission. The agencies mandated with that mission are the U.S. National Ice Center (USNIC) and the Canadian Ice Service (CIS), under the mantel of the North American Ice Service (NAIS). However, GLERL uses these ice maps from the NAIS to build products that assist GLERL researchers and others in understanding how, when, and where lake ice forms and breaks up.

This data set is the product of a project conducted by NOAA GLERL and the Cooperative Institute for Great Lakes Research (CIGLR) at the University of Michigan. That project is fully described in the GLERL manuscript titled *A Consistent Great Lakes Ice Cover Digital Data Set for Winters 1973-2019* (Yang et al., 2020). This user guide is largely based on that report. Users seeking more detailed information on methods and background on the data that contributed to this reprocessed data set should refer to Yang et al.

This product, *Daily Great Lakes Ice Concentration, 1973 Onward*, at NSIDC (data set ID G10029), is the long-term archive for GLERL's Historical Great Lakes Ice Cover Database. However, these data may also be obtained from the GLERL site.

The database has grown and changed over the years. *Daily Great Lakes Ice Concentration, 1973 Onward* holds data that have been reprocessed at GLERL to make a consistent, daily, 1.8 km gridded product. Yang et al. describe how the older data were reprocessed to create this product.

GLERL distributes several related products. These include a digital Great Lakes ice atlas that summarizes ice conditions between 1973 and 2002 called *An Electronic Atlas of Great Lakes Ice Cover, Winters 1973-2002*. That product is not archived at NSIDC but has an entry in the NOAA@NSIDC catalog with information on how to access the data from GLERL. In addition, the NOAA@NSIDC catalog includes several historical Great Lakes data collections. These are no longer being updated but are listed in section 4 Related Data Sets of this document for reference.

1.2 Parameters

The parameter of this data set is lake ice concentration with values ranging from 0 to 100 percent.

1.3 File Information

1.3.1 Format

The data files are provided in gridded ASCII text format, GIS shapefile format, and browse image charts in .jpg format are also provided. In addition, two ancillary ASCII data files with the latitude and longitude coordinates of the grid are also provided.

1.3.2 File Contents

1.3.2.1 ASCII Files

The first seven rows of the ASCII data files are header rows followed by the data in a grid of 1024 columns by 1024 rows. The first six header rows will be the same for all data files. The seventh row, `source`, can have three different values: `Canadian Ice Services`, `US National Ice Center`, or `GLERL Temporal Interpolation`. Figure 1 shows a sample of the first ten rows of the ASCII data file for 10 March 2019, and Figure 2 shows the browse image chart for that date.

```
ncols         1024
nrows         1024
xllcorner     -10288021.9553
yllcorner     4675974.1583
cellsize      1800
NODATA_value  -99
source        US National Ice Center
-1  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1
-1  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1
-1  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1
```

Figure 1. First ten rows of the ASCII data file for 10 March 2019 (g20190310.ct)

Grid cells for files before winter 1983 have values for ice concentration ranging from 0 to 100 in steps of 5. Grid cells for files from winter 1983 onward have one of 13 values: 0, 5, 10, 20, 30, 40, 50, 60, 70, 80, 90, 95, or 100. In all files, *land* grid cells have a value of -1, and *missing* data are assigned a value of -99. See Table 6, Column 3, for a list of all allowed values and to see how these compare with WMO SIGRID-3 codes.

The ancillary data files, `1024_latgrid.txt` and `1024_longrid.txt`, contain the latitude and longitude coordinates for all 1024 x 1024 grid cells.

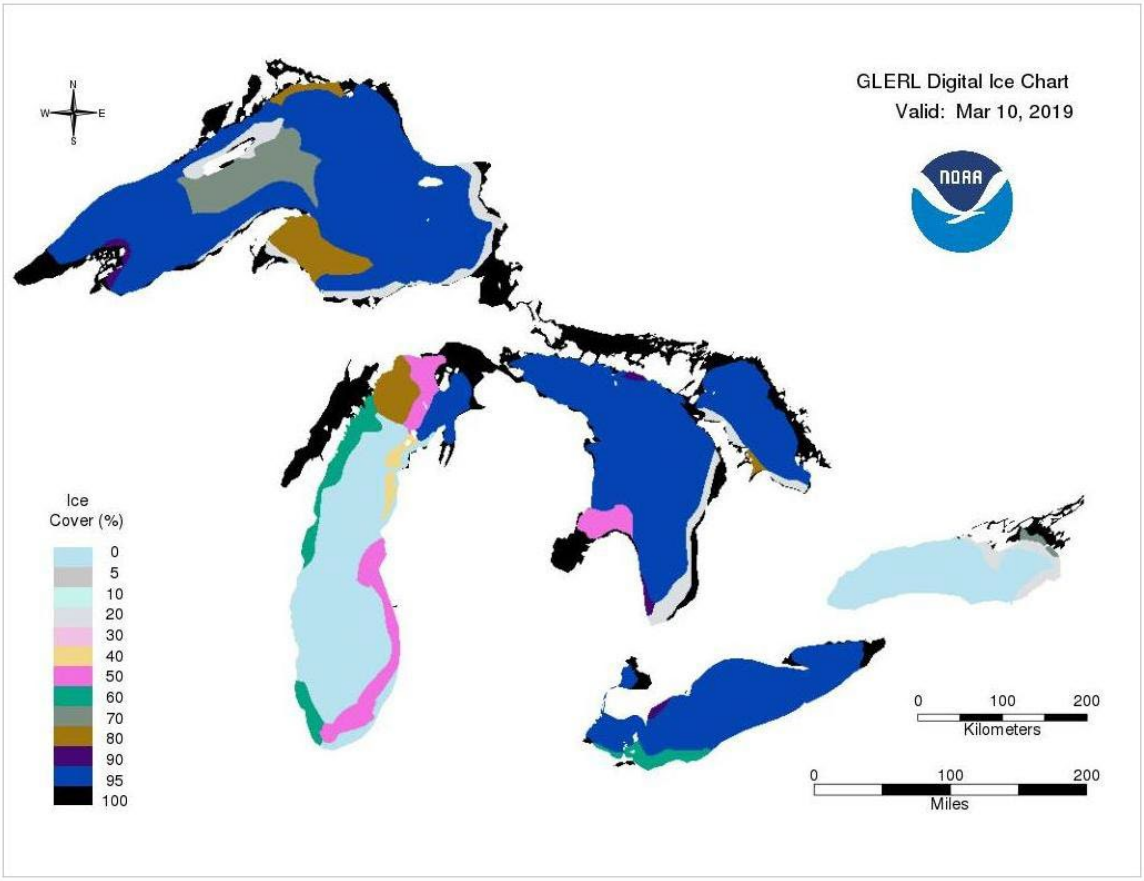

Figure 2. Browse image for 10 March 2019 (20190310.jpg).

1.3.2.2 Shapefiles

The shapefiles contain points of ice concentration in percent from 0 to 100 at specific latitudes and longitudes. The attribute table is described in Table 1.

Table 1. Shapefile Attribute Description

Attribute	Description
icecon	The ice concentration in percent from 0 to 100 at the latitude and longitude indicated by the lat and lon attributes.
lat	Latitude of the ice concentration point in degrees.
lon	Longitude of the ice concentration point in degrees.

1.3.3 Directory Structure

All files reside on HTTPS in https://noaadata.apps.nsidc.org/NOAA/G10029/. The files reside in four separate subdirectories underneath the main directory: `ancillary`, `ascii`, `browse`, and

`shapefiles`. Within each of the `ascii`, `browse`, and `shapefiles` subdirectories, the data are further subdivided by the ice-season year.

Note that an ice season crosses two years. It begins in the fall of one year and then ends in the spring of the next year. The ice-season year is defined by the year that the ice season ended. For example, the 2019 ice season began in fall 2018 and ended in spring 2019. Therefore, an ice-season year directory contains data files from two years. For example, the ice-season year directory, `2019`, holds files from the fall of 2018 through the spring of 2019.

1.3.4 Naming Convention

The naming convention for the data files is described below and in Table 2:

`[g]YYYYMMDD.ext`

Table 2. File Naming Convention

Variable	Description
g	Indicates these data have been processed by GLERL. Only applicable to ASCII data files.
YYYY	4-digit year
MM	2-digit month
DD	2-digit day of month
.ext	File extension (.ct: ASCII data files, .jpg: browse image files, .zip: shapefile zip archive that contains a .shp, .prj, .shx, and .dbf file)

1.4 Spatial Information

1.4.1 Coverage and Resolution

These data are on a 1024 x 1024 1.8 km grid that covers the Great Lakes region. The grid extends within the following latitude/longitude bounding coordinates:

Northernmost Latitude: 50.60° N
Southernmost Latitude: 38.86° N
Easternmost Longitude: 75.86° W
Westernmost Longitude: 92.42° W

1.4.2 Geolocation

Table 3 provides information for geolocating this data set and Table 4 provides grid details.

Table 3. Geolocation Details

Geographic coordinate system	WGS 1984
Projected coordinate system	Mercator
Longitude of true origin	0
Latitude of true origin	0
Scale factor at longitude of true origin	1
Datum	WGS84
Ellipsoid/spheroid	WGS84
Semi major Axis	6378137
Semi minor Axis	6356752.314
Inverse Flattening	298.2572236
Units	meter
False easting	0
False northing	-24
PROJ4 string	'+proj=merc +lon_0=0 +k=1 +x_0=0 +y_0=-24 +datum=WGS84 +units=m +no_defs'

Table 4. Grid Details

Grid cell size (x, y pixel dimensions)	1800
Number of rows	1024
Number of columns	1024
Geolocated lower left point in grid	38.87440° N, 92.41060 ° W
Nominal gridded resolution	1.8 m
XLLCORNER	-10288021.9553
YLLCORNER	4675974.1583

1.5 Temporal Information

1.5.1 Coverage

For the ASCII data files and browse images, the temporal coverage begins 20 December 1972 and goes through the most recent update. For the shapefiles, the temporal coverage starts on 02 December 2002 and goes through the most recent update. Normally an update will occur after the end of the current ice season. An ice season begins in late fall in November or December and runs through spring, ending in April or May. The ice season is always identified with the year the ice season ends. For example, the 2019 ice season began in November 2018 and ended in May 2019. GLERL has used this method of identifying the ice season consistently in publications dating back to the 1980s.

1.5.2 Resolution

The temporal resolution of the ASCII data files is daily. For the shapefiles, the temporal resolution is sporadic from 2002 until late 2010 with approximately only eight files per month. From 2011 to 2017, the number of shapefiles more closely matches the number of ASCII files with only a few missing files per year. Beginning in 2018, there is a shapefile for each ASCII file with only a few exceptions. The temporal resolution of the browse images also changed over time. See Table 5 for details.

Table 5. Browse Image Temporal Resolution

Ice Season	Frequency
1973 - 1988	1 per week
1989 - 1996	2-4 per week
1997 - 2010	2 per week
2011 - present	daily

2 DATA ACQUISITION AND PROCESSING

2.1 Background

Analysis of the Great Lakes ice concentration has evolved over time; beginning in 1973 at the CIS. The following list provides a timeline of the progression of Great Lakes ice charting by the CIS and USNIC:

- 1973: The CIS began producing a weekly Great Lakes ice analysis on paper charts.

- 1989: USNIC (then called the Joint Ice Center) began producing two or three analyses per week, thereby increasing Great Lakes coverage to 3 to 4 times per week when included with the CIS charts.
- 1996: The CIS and USNIC began generating digital ice concentration fields on a 510 x 516 2.55 km resolution grid, twice per week. The gridded product was in addition to the full analysis charts.
- 2008: The CIS and USNIC began generating digital ice concentration fields on a 1024 x 1024 1.8 km resolution grid, once per day, in addition to the full analysis charts.

The CIS and USNIC, as NAIS, report ice conditions using a World Meteorological Organization (WMO) vector format called SIGRID-3. Figure 3 shows a Great Lakes West analysis for 25 January 2020, acquired from the USNIC site. Ice conditions within polygons are described in accompanying attribute tables that follow SIGRID-3 alphanumeric encoding. In addition to ice concentration given in tenths or range of tenths, SIGRID-3 allows conditions like ice form and stage of development to be encoded.

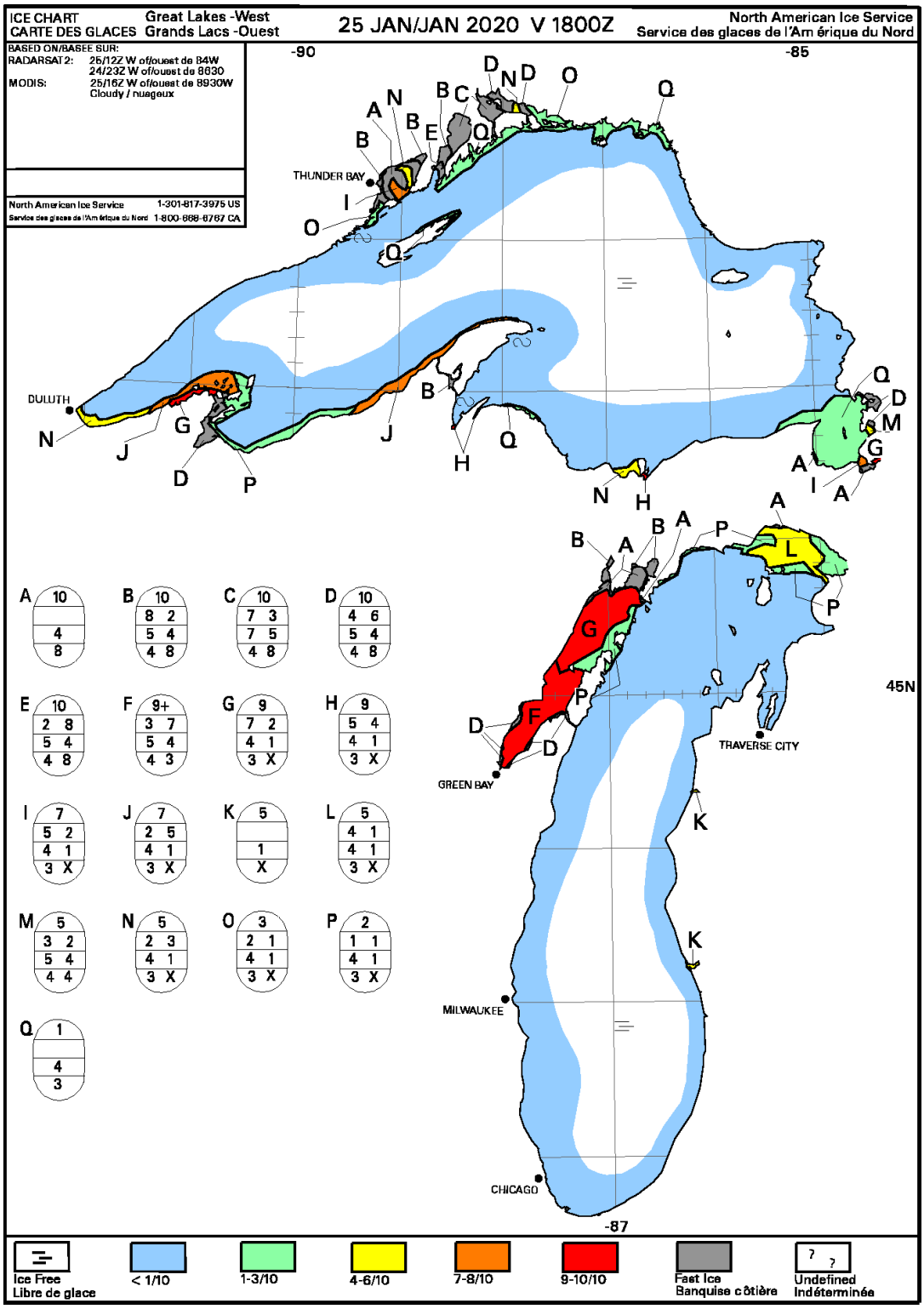

Figure 3. An analysis of ice in the western Great Lakes on 25 January 2020. Ice conditions in polygons are encoded using the WMO egg code. Accompanying attribute tables have the coded information in SIGRID-3 alphanumeric format.

From the full analysis, the CIS and USNIC produce an ASCII format grid holding only total ice concentration information. This information is given in the WMO SIGRID-3 code. Table 6 gives the equivalent between ice concentration information charted as in Figure 3, the WMO SIGRID code, and the ice concentration value used by GLERL in this product.

Table 6. Data File Values

Charted Ice Concentration	WMO SIGRID-3 Code	G10029 Product Value for % Concentration
Ice Free	00	0
Less than 1/10 (Open water)	01	5
Bergy water*	02	10
1/10	10	10
2/10	20	20
3/10	30	30
4/10	40	40
5/10	50	50
6/10	60	60
7/10	70	70
8/10	80	80
9/10	90	90
1/10 - 3/10	13	20
4/10 - 6/10	46	50
7/10 - 9/10	79	80
9/10-10/10	91	95
10/10	92	100
		-1 (marks Land)
		-99 (marks Missing)

Charted Ice Concentration is the total ice concentration from polygons on a full analysis chart, reported using the *egg code*. See Environment Canada (2005) for a full explanation.

*Note that for sea ice, the WMO SIGRID code 02 indicates *Bergy water*, where ice is in concentrations of less than 10%. Icebergs do not occur in the Great Lakes. When code 02 appears in Great Lakes charts, it indicates ice at about 10% concentration, according to GLERL scientist R. Assel (from L. Mason, personal communication, February 2020).

2.2 Acquisition

From 1973 through 1988, GLERL's source for ice concentration data was the CIS. Beginning in 1989, GLERL obtained data from the USNIC. GLERL now uses the daily NAIS 1024 x 1024 ASCII format grid, obtained from the USNIC, to keep its Great Lakes Ice Cover Database current. Each day, GLERL acquires WMO SIGRID-3 ice code ASCII data files from the USNIC web site and then processes them for their research purposes. Section 2.3 Processing provides details on this procedure. These files are updated daily during the ice season and are available on the GLERL website: https://www.glerl.noaa.gov/data/ice/#historical.

2.3 Processing

The data in GLERL's ice cover database were reprocessed to a common frequency (daily) and resolution (1.8 km) in order to make the database easier to work with and better suited for applications like biological research and long-term weather assessment. For most of the period between 1973 and 2019, Great Lakes ice was charted less frequently and at a lower resolution. Reprocessing used temporal and spatial interpolation to achieve nominal daily, 1.8 km resolution grids. Below are the major steps in that reprocessing. See Yang et al. (2020) for details.

1. Convert the WMO SIGRID-3 ice code for concentration to ice concentration in percent (Table 6) in gridded files.
2. Re-grid the earlier 512 x 516 data to the 1024 x 1024 grid using nearest-neighbor resampling. For files after 2007, this step was is not needed.
3. Check for discrepancies between the NIC-encoded land mask and the Great Lakes CoastWatch land mask. The Great Lakes CoastWatch mask takes precedence.
4. Interpolate linearly between days for which an ice chart was made by USNIC in order to get a daily grid. For files after 2010, this step is not needed. Files that are temporally interpolated are noted in the ASCII header with the source set to GLERL Temporal Interpolation.

2.4 Quality, Errors, and Limitations

See Yang et al. (2020) for information on quality control and technical validation.

2.5 Instrumentation

The CIS and USNIC analyses, that the GLERL data are created from, are mainly based on integration of Synthetic Aperture Radar (SAR), visible and infrared imagery, and meteorological data (temperature and wind data, if there is a lack of SAR and imagery), to represent the ice conditions.

3 VERSION HISTORY

Table 7 provides version history information for this data set.

Table 7. Version History Summary

Version	Release Date	Description of Changes
1.0	March 2020	Initial release of these data

4 RELATED DATA SETS

- GLERL Great Lakes Ice Concentration Data Base, 1960-1979 (doi: 10.7265/N5G44N6G)
- GLERL Great Lakes Ice Thickness Data Base, 1966-1979 (doi: 10.7265/N5KW5CXG)
- GLERL Great Lakes Air Temperature/Degree Day Climatology, 1897-1983 (doi: 10.7265/N5VD6WCJ)
- Great Lakes Surface Ice Reports from U.S. Coast Guard (doi: 10.7265/N5BG2KW2)
- Great Lakes Ice Charts (doi: 10.7265/N5H41PBV)
- Great Lakes Daily Ice Observations at NOAA Water Level Gauge Sites (doi: 10.7265/N5PN93HT)
- Great Lakes Aerial Photos of Ice Conditions (doi: 10.7265/N5CC0XM4)
- Canadian Ice Service Arctic Regional Sea Ice Charts in SIGRID-3 Format (doi: 10.7265/N51V5BW9)
- National Ice Center Arctic Sea Ice Charts and Climatologies in Gridded Format (doi: 10.7265/N5X34VDB)

5 ACKNOWLEDGMENTS

In 2019, GLERL scientist Lacey Mason arranged for NSIDC to archive these data. This data product is maintained at NSIDC with funding from the NOAA National Centers for Environmental Information.

6 REFERENCES

Assel, R. A., Norton, D. C., and Cronk, K. C. (2002). A Great Lakes ice cover digital data set for winters 1973-2000. NOAA Technical Memorandum GLERL-121. NOAA, Great Lakes Environmental Research Laboratory, Ann Arbor, MI. https://repository.library.noaa.gov/view/noaa/11046 (Accessed January 2020).

Environment Canada, 2005. Manual of Standard Procedures for Observing and Reporting Ice Conditions (MANICE). Issuing authority: Assistant Deputy Minister, Meteorological Service of Canada. https://www.canada.ca/en/environment-climate-change/services/weather-manuals-documentation/manice-manual-of-ice.html (Accessed January 2020).

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Yang, T. Y., Kessler, J., Mason, L., Chu, P. Y., Wang, J. (2020). A Consistent Great Lakes Ice Cover Digital Data Set for Winters 1973-2019. *Sci Data* 7:259, 1-12. https://doi.org/10.1038/s41597-020-00603-1.

7 DOCUMENT INFORMATION

7.1 Author

A. Windnagel and F. Fetterer prepared this document from Yang et al. (2020) and from correspondence with L. Mason.

7.2 Publication Date

March 2020