# Environmental Monitoring of Lake Michigan Using CoastWatch Data and JAVA GIS

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## Abstract

CoastWatch is a nationwide National Oceanic and Atmospheric Administration (NOAA) program within which the Great Lakes Environmental Research Laboratory (GLERL) functions as the Great Lakes regional node. In this capacity, GLERL obtains, produces, and delivers environmental data and products for near real-time observation of the Great Lakes to support environmental science, decision making, and supporting research. This is achieved by providing Internet access to near real-time and retrospective satellite observations, in-situ Great Lakes data, and derived products to Federal, state, and local agencies, academic institutions, and the public via the Great Lakes CoastWatch web site (http://coastwatch.glerl.noaa.gov). The goals and objectives of the CoastWatch Great Lakes Program directly support NOAA's statutory responsibilities in estuarine and marine science, living marine resource protection, and ecosystem monitoring and management. Great Lakes CoastWatch data are used in a variety of ways including monitoring of algal blooms, plumes, ice cover, and water temperatures, two and three dimensional modeling of Great Lakes physical parameters such as wave height and currents, damage assessment modeling, research, and for educational and recreational activities. New utilities such as JAVA based interactive retrieval of physical parameters such as surface temperature, ice cover, winds, and bottom depth at a given location enhance the accessibility and utility of Great Lakes CoastWatch data. Plans include enhancing the present product suite with image products from new satellite sensors such as Synthetic Aperture Radar (SAR) and ocean color sensors.

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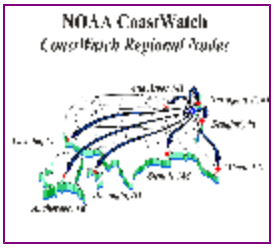
# Introduction

In response to an occurrence of "Red Tide" off the coast of North Carolina in late 1987, a program was developed within NOAA's National Environmental Satellite, Data and Information Service (NESDIS) to provide the NOAA National Marine Fisheries Service Laboratory at Beaufort, North Carolina with satellite-derived sea surface temperature (SST) maps of the Gulf Stream and other types of data so that future occurrences of this phenomenon or other coastal environmental events could be better anticipated and monitored (Pyke, 1989). Within the NOAA Coastal Ocean Program, this program was extended to other coastal regions of the U.S., including the Great Lakes, to become the NOAA CoastWatch Program, now a part of NESDIS (Leshkevich et al., 1997, Leshkevich et al, 1993, Schwab et al., 1992). The original goal of the CoastWatch Program, to develop and deliver environmental data and products for near real-time monitoring of U.S. coastal waters to support environmental science and decision making, has expanded to include research, educational, and recreational uses.




**NOAA CoastWatch Regional Nodes**

The CoastWatch Great Lakes Node is currently receiving a suite of 33 enhanced digital image products including satellite-derived surface temperature, visible and near-infrared reflectance, brightness temperatures, cloud masks, and satellite/solar zenith angle data from the NOAA/AVHRR (Advanced Very High Resolution Radiometer) series of satellites, as well as GOES (Geostationary Operational Environmental Satellites) visible, near infrared, and water vapor imagery. These near real-time products are acquired at GLERL from NESDIS via the Internet.

The Great Lakes environmental data received at the CoastWatch Great Lakes Node are processed within 30 minutes after download. Several types of the products are produced and stored on the CoastWatch Great Lakes Node web site, including AVHRR imagery in GIF, PostScript, and CoastWatch raw data format, AVHRR interactive SST imagery (SatView), Great Lakes Surface Environmental Analysis (GLSEA), subtraction or histogram equalized reflectance imagery, and GOES imagery (see Figure 1). Currently, the AVHRR imagery on the web site are updated continually as the imagery becomes available. GLSEA, subtraction and histogram equalized reflectance imagery are updated once a day. AVHRR satellite data and products are kept on the web site for two weeks. Access to a retrospective archive beginning in 1990 via the NOAA CoastWatch Active Access System (NCAAS) is also available.

The CoastWatch Great Lakes Node also receives raw marine observations for the Great Lakes region via satellite transmission from the NOAAPORT broadcast system. The information extracted from NOAAPORT observations includes: air temperature, dew point, wind direction, wind speed, maximum wind gust, cloud cover, air pressure, water temperature, wave height, and wave period. The raw marine observations are available on the CoastWatch Great Lakes Node web site and are updated hourly. In addition, other in-situ data and modeled data including marine and meteorological observations, NDBC buoy observations, water level gauge measurements received from the National Ocean Service (NOS),

and Great Lakes Forecasting System (nowcast and forecast) products are made available to Great Lakes CoastWatch data users via links on the CoastWatch Great Lakes web site.

Access to near real-time AVHRR satellite imagery received at GLERL is available at no cost after submitting an electronic registration form via the CoastWatch Great Lakes web site. Other data and products (with the exception of the proprietary RADARSAT data) do not require registration for access.

In a cooperative project with the Great Lakes Sea Grant Network, CoastWatch AVHRR imagery is downloaded from the CoastWatch Great Lakes Node by Michigan Sea Grant and the Michigan State University (MSU) Institute of Water Research and processed to produce a contoured surface water temperature product of regional areas on the Great Lakes. This product is available on the CoastWatch Great Lakes web site via a link to the Michigan Sea Grant web site at Michigan State University.

**Figure 1. NOAA CoastWatch Great Lakes Node Web Site (http://coastwatch.glerl.noaa.gov)**

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# AVHRR Imagery (NOAA 14 & NOAA 16 AVHRR Imagery)

CoastWatch image products, i.e., water surface temperature imagery, visible (Ch.1) and near-infrared (Ch.2) reflectance data, cloud mask, and satellite/solar zenith angle data are obtained from NOAA polar-orbiting weather satellites. There are currently two operational polar-orbiting weather satellites (NOAA 14 and NOAA 16) which each carry (among other sensors) the Advanced Very High Resolution Radiometer (AVHRR). Each satellite passes over a given area twice a day (about 5 AM and 4:30 PM local time for NOAA 14 and about 2 AM and 1:30 PM local time for NOAA 16) The AVHRR scans a swath of approximately 2700 km on the earth's surface beneath the satellite in five radiometric bands, Ch.1 - visible (0.58-0.68 µm), Ch.2 - reflected infrared (0.725-1.0 µm), and three thermal infrared channels (Ch.3 - 3.55-3.93 µm, Ch.4 - 10.3-11.3 µm, Ch.5 - 11.5-12.5 µm) (Koczor, 1987). AVHRR data are processed at two resolutions, 4 km Global Area Coverage (GAC) and 1 km High Resolution Picture Transmission (HRPT). The HRPT data are used for Great Lakes CoastWatch imagery. These data are downloaded to a satellite receiving station then transmitted to NESDIS facilities in Suitland, Maryland where they are calibrated, geo-located, quality controlled, and made available as AVHRR level 1b data sets (see Kidwell, 1991 and Pichel et al., 1991 for details of this process). For the CoastWatch program, the level-1b data are mapped to a Mercator projection and resampled to a 512x512 pixel grid. Four scenes or "windows" are extracted for the Great Lakes region as listed in Table 1. One synoptic scene covers all five lakes at a 2.56 km resolution. The other three scenes focus on Lake Superior, Lakes Michigan and Huron, and Lakes Erie and Ontario at twice the resolution of the five-lake scene. Actual resolution is determined by d cos f, where d is the spatial resolution at the equator, and f is the latitude. The grid spacing for the three high resolution Great Lakes scenes ranges from 1.24 to 1.30 km as indicated in Table 1.

**Table 1. CoastWatch Windows for the Great Lakes**

| | Latitude Range (° N) | Longitude Range (° W) | Pixel Size (km) (at mid-latitude) |
|---|---|---|---|
| **Full Region** | 38.89 - 50.58 | 75.88 - 92.41 | 2.56 |
| **Superior** | 43.59 - 49.28 | 84.19 - 92.45 | 1.24 |
| **Michigan-Huron** | 40.76 - 46.73 | 79.78 - 88.05 | 1.30 |
| **Erie-Ontario** | 40.76 - 46.73 | 75.88 - 84.16 | 1.30 |

Full resolution (1.3 km) synoptic scenes on a 1024x1024 pixel grid are currently being received and are available in the JAVA GIS utility.

In the AVHRR Imagery section, users can:

- select the synoptic scene or one of the three subscenes (see Figure 2).

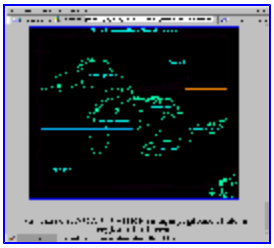

**Figure 2. The Laurentian Great Lakes**

- select daytime or nighttime SST or Ch.1 (visible) or Ch.2 (near-infrared) scenes from the thumbnail images of the past two weeks. (see Figure 3).

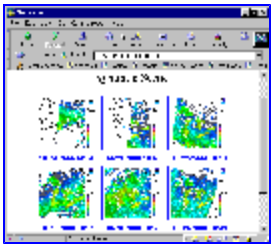

**Figure 3. Thumbnail Images of the Past Two Weeks**

- view or download selected images (see Figure 4).

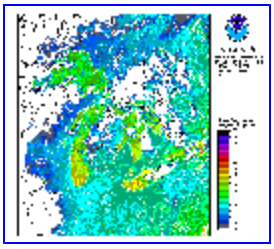

**Figure 4. Selected Image**

- run a Java applet program to interactively retrieve temperature (C or F) and Lat/Long at the cursor position (see Figure 5).

**Figure 5. Run a Java Satview program**

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# GLSEA (Great Lakes Surface Environmental Analysis)

The Great Lakes Surface Environmental Analysis (GLSEA) is a daily, cloud free digital map of the Great Lakes surface water temperature (with ice cover overlay during the winter) produced at the NOAA CoastWatch Great Lakes Node. The GLSEA is stored as a 512x400 pixel map in GIF format, suitable for viewing on PCs and workstations (see Figure 6). Software for accessing and viewing CoastWatch image data and products is available for download from the "Software" page on the CoastWatch Great Lakes web site.

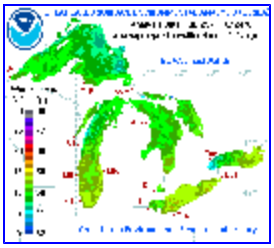

**Figure 6. Great Lakes Surface Environmental Analysis (GLSEA)**

The lake surface temperatures are derived from the near real-time AVHRR satellite imagery obtained by the Great Lakes CoastWatch program. The addition of ice cover concentration information provided by the National Ice Center (NIC) was implemented in late 1997 (see Figure 7). Lake surface temperatures are updated daily with information from the cloud-free portions of the previous day's satellite imagery. If no imagery is available, a smoothing algorithm is applied to the previous day's map (see Schwab et al., 1999). During the winter season, ice concentration information is then added, using the most recent Great Lakes Ice Analysis produced by the NIC, nominally three times per week during the ice season.

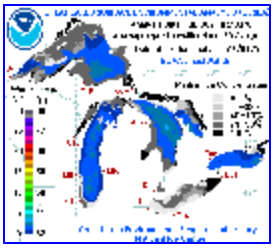

**Figure 7. Great Lakes Surface Environmental Analysis with Ice Cover (GLSEA)**

Yearly and previous 365 day animations of the daily GLSEA chart in QT, FLC, and AVI formats are also available (see Figure 8).

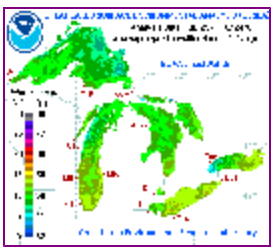

**Figure 8. Previous 365 days GLSEA animation (AVI format)**

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# GOES Imagery (GOES 8 Imagery)

The GOES spacecraft is designed to operate in geosynchronous orbit, 35,790 km (22,240 statute miles) above the earth, thereby remaining stationary relative to the earth's surface. The spacecraft continuously views the continental U.S., neighboring environs of the Pacific and Atlantic Oceans, and Central and South America. The three-axis, body stabilized spacecraft design (GOES-8, onward) enables the sensors to image clouds, monitor earth's surface temperature and water vapor fields, and sound the atmosphere for its vertical thermal and water vapor structures.

The main mission is carried out by the primary payload instruments, the Imager and the Sounder. The Imager is a multichannel instrument that senses radiant energy and reflected solar energy from the earth's surface and atmosphere. The Sounder provides data for vertical atmospheric temperature and moisture profiles, surface and cloud top temperature, and ozone distribution.

Two advanced GOES satellites are in use: GOES-8, and -10 (Series I-M). Currently the CoastWatch Great Lakes Node recieves four types of GOES-8 satellite imagery: Visible Channel (Ch.1) (see Figure 9), Infrared Channel (Ch.2) (see Figure 10), Water Vapor (see Figure 11) (hourly - 3 km resolution), and a recently added GOES sea surface temperature product for the Great Lakes (3 hourly - 6 km resolution) (see Figure 11b).

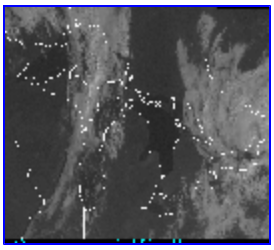

**Figure 9. GOES-8 Satellite Imagery (Visible Channel 1)**

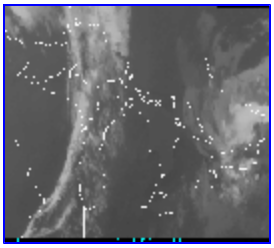

**Figure 10. GOES-8 Satellite Imagery (Infrared Channel 2)**

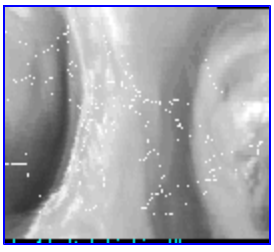

**Figure 11. GOES-8 Satellite Imagery (Water Vapor)**

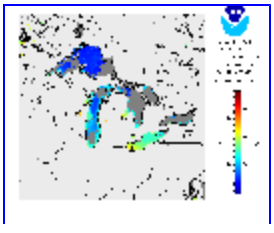

**Figure 11b. GOES SST 3-hour Composite Imagery**

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# RADARSAT (RADARSAT Imagery)

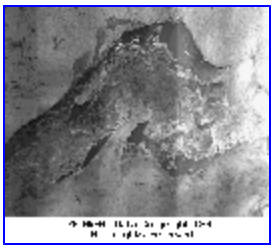

**Figure 12a. RADARSAT Imagery**

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# Image Products (Channel 1 / Channel 2 Reflectance Products)

Great Lakes CoastWatch visible reflectance products are produced using two types of Advanced Very High Resolution Radiometer (AVHRR) satellite data. AVHRR Channel 1 (visible, 0.58-0.68 µm) and Channel 2 (reflected infrared, 0.725-1.0 µm) from daytime passes of NOAA polar orbiting satellites.

The CoastWatch Great Lakes Node currently provides two types of reflectance imagery products: Subtraction (Ch.1 - Ch.2) (see Figure 12) which is useful in the detection of suspended solids (plumes) and algal blooms in the Great Lakes, and Histogram Equalized Ch.1 (see Figure 13) which is useful for ice cover detection and monitoring during the winter season.

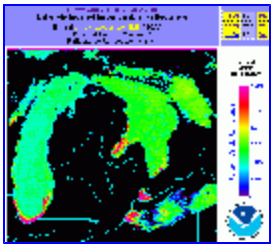

**Figure 12. Subtraction (Ch.1 - Ch.2)**

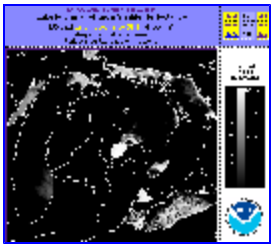

**Figure 13. Histogram Equalized Ch.1**

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# In Situ Data (Great Lakes NOAAPORT Marine Observation Data)

Marine observations for the Great Lakes region are obtained via satellite transmission from the NOAAPORT broadcast system. The NOAAPORT broadcast system provides a one-way broadcast

communication of NOAA environmental data and information in near real-time to NOAA and external users. This broadcast service is implemented by a commercial provider of satellite communications utilizing C-band.

These NOAAPORT observations, acquired hourly by the CoastWatch Great Lakes node, are decoded and processed to produce various data files, timeseries plots, and interactive imagemaps (see Figure 14).

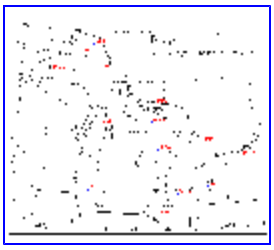

**Figure 14. Interactive Image Map - Buoy Data**

The Great Lakes surface observation network is comprised of 205 fixed stations including 18 moored buoys, 11 Coastal Marine Automated Network (CMAN) stations, 35 US Coast Guard stations, 21 Other Marine Reports (OMR) stations, and 120 surface airways stations. In addition, many commercial cargo ships and Coast Guard vessels provide regular meteorological reports. Frequency of observational reporting ranges from about once every 3 hours to 3-5 times per hour depending on the type of station.

The Great Lakes CoastWatch data base includes the following information extracted from NOAAPORT observations: air temperature, dew point, wind direction, wind speed, maximum wind gust, cloud cover, air pressure, water temperature, wave height, and wave period. During a typical summer day, the marine observation data includes about 300 buoy observations, 3500 observations from land stations, and about 300 reports from vessels.

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# Statistics (Great Lakes Average Surface Water Temperature)

Great Lakes average surface water temperature derived from the daily Great Lakes Surface Environmental Analysis (GLSEA) is displayed in three formats:

- Previous 365 day GLSEA Average Surface Water Temperature for each lake.
- Average GLSEA Surface Water Temperature Graphs (see Figure 16) for each lake for the previous 5 years and for all lakes for each of the previous 5 years.
- Average GLSEA Surface Water Temperature Data for each lake for the previous 5 years.

The average GLSEA surface water temperature graphs and data will help data users compare Great Lakes surface water temperatures for the past 5 years.

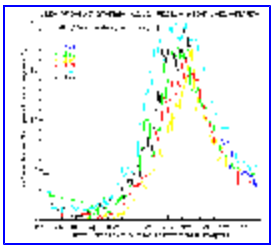

**Figure 16. GLSEA Average Surface Water Temperature Graph**

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# JAVA GIS

A new utility, based on a JAVA applet, allows interactive retrieval of physical parameters such as surface temperature, ice cover, winds, and bottom depth at a given location in an image, which enhances the accessibility and utility of Great Lakes CoastWatch data (see Figure 17) . The applet is initiated using the JAVA GIS buttom on the Great Lakes CoastWatch home page. A window will appear in which you can specify an image type and date, overlay (shapefile) data, or the URL of a custom shapefile to be viewed. Current image data includes near real-time NOAA AVHRR surface temperature data, Channel 1 visible reflectance data, and GLSEA (Great Lakes Surface Environmental Analysis) cloud-free composited surface temperature data. Ice concentration data is available during the winter season. Shapefiles include shoreline, bathymetry, and state boundary/land mask overlays. Once the image type and date are chosen, select and load desired shapefiles, then press the start button. Three new windows (Panner window, Image window, and Control Panel window) will appear on your screen. Scroll and zoom options are available using the Panner and Image windows. Overlays (shapefiles) are turned on and off using the Control Panel. Overlay colors can be changed to enhance visibility. In addition, near real-time NOAAPort marine observation data at buoy, CMAN, and Coast Guard shore station locations and/or nowcast gridded winds (at the hour of the displayed satellite image) can be displayed and observed values obtained by moving the cursor over the station or wind vector of interest.

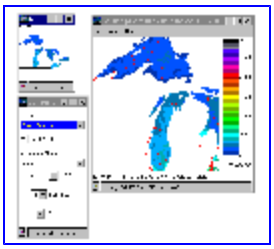

**Figure 17. Great Lakes CoastWatch Java GIS**

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# CDAT (CoastWatch Data Analysis Tool)

The CoastWatch Data Analysis Tool (CDAT) is a data visualization program with a graphical interface that allows users to view and perform simple analysis on CoastWatch and other satellite data such as applying cloud masks (Maturi and Pichel, 1993) to the imagery and querying and obtaining statistics for a user defined regional area of interest. CDAT is currently under development, but versions for Unix and Windows platforms are available for download from the "Software" page on the CoastWatch Great Lakes web site.

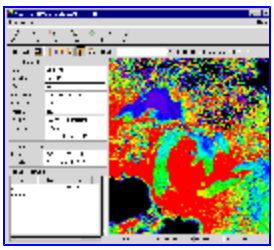

**Figure 18. Imagery and Information Panel**

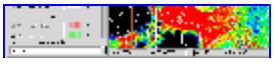

**Figure 19. Imagery with Grid and Geography Overlay**

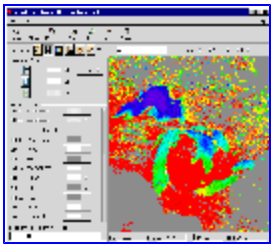

**Figure 20. Imagery with Cloud Mask Overlay**

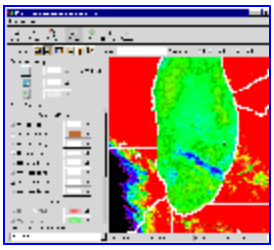

**Figure 21. Imagery Zoom In**

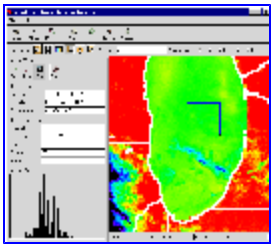

**Figure 22. Imagery Survey (regional area of interest) and Statistics**

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# Future Plans

Plans include enhancing the present product suite with products derived from new satellite sensors such as synthetic aperture radar (SAR) (see example in Figure 12a ) and ocean color sensors. Figure 23 is an example of a chlorophyll map derived from the SeaWiFS ocean color sensor. Image viewing and analysis tools will be improved and other image and in situ data will be added. In addition, a new CoastWatch file naming convention will soon be implemented. The new file names contain additional information about the image data and will be in the form: **YYYY_JJJ_HHMM_SSS_NR_PP.TYP** where

| | |
|---|---|
| **YYYY** | Year |
| **JJJ** | Julian Day |
| **HH** | Hour |
| **MM** | Minute |
| **SSS** | Satellite Code (N14, N16, etc.) |
| **NR** | CoastWatch Node and Regional Scene (l, m, s, e) |
| **PP** | Product Data Type (d1, s7, etc.) |
| **TYP** | File Format Type (cwf, gif, hdf, etc) |

For example, a file with the name 2001_310_1740_n16_gl_d1.cwf contains image data for year 2001,

julian day 310, hour 17 minute 40 (GMT), and was acquired by NOAA-16, covers the Great Lakes region, synoptic (all lakes) scene, and is a daytime image in CoastWatch format.

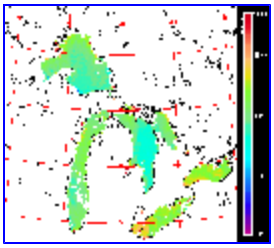

**Figure 23. Chlorophyll Map Derived from SeaWiFS Image. Provided by the SeaWiFS Project, NASA/Goddard Space Flight Center and ORBIMAGE**

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Satellite measurements of surface water temperature in the Great Lakes - Great Lakes CoastWatch. *Journal of Great Lakes Research* 18(2):247-258(1992).

Schwab, D.J., Leshkevich, G.A., and Muhr, G.C., 1999. Automated Mapping of Surface Water Temperature in the Great Lakes. Journal of Great Lakes Research 25(3):468-481.

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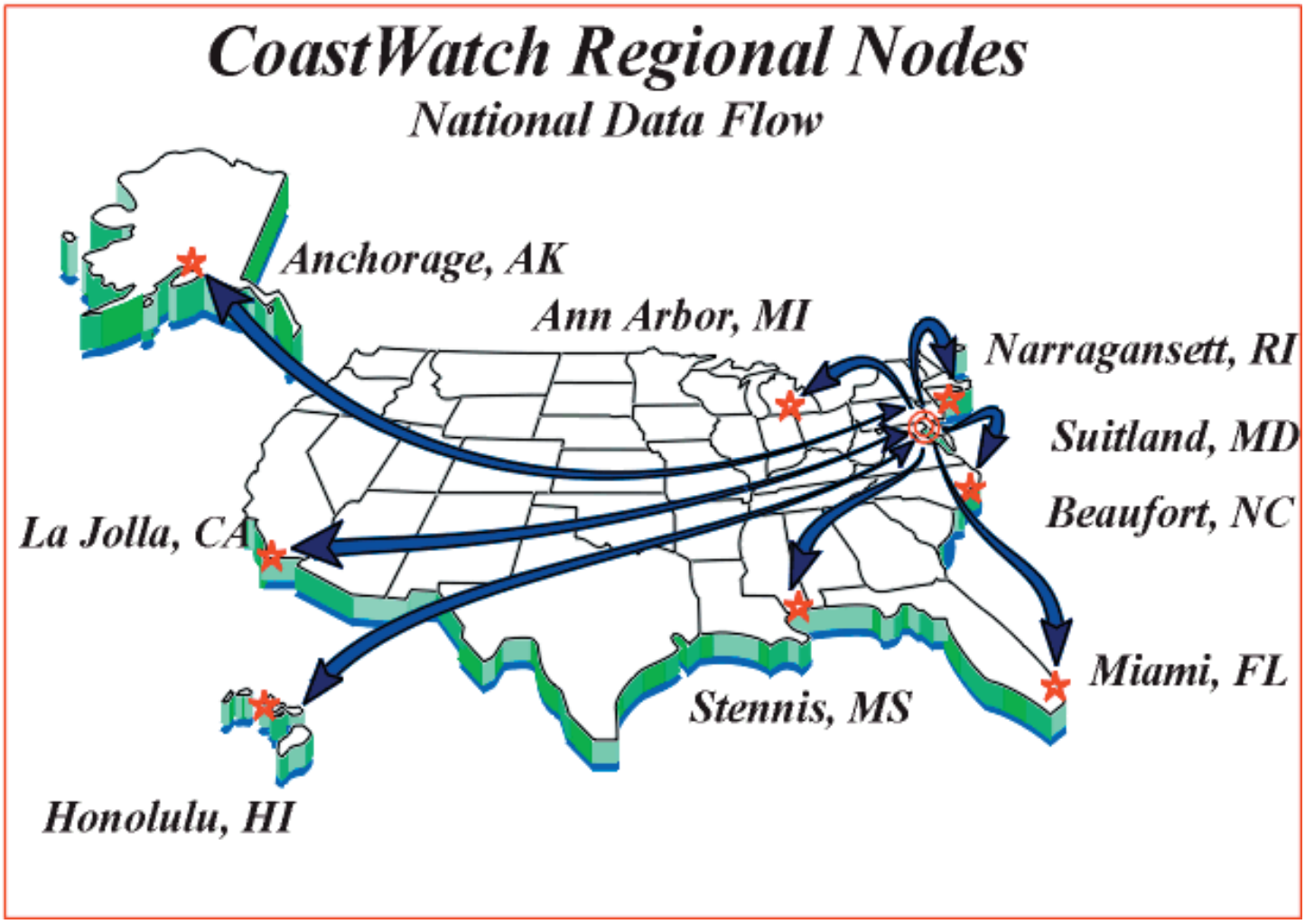
LESHKEVICH, G.A., and S.V. LIU. Environmental Monitoring of Lake Michigan using CoastWatch data and JAVA GIS. Proceedings, Lake Michigan: State of the Lake 2001, Muskegon, MI, November 6-7, 2001. U.S. EPA Lake Michigan Forum, Grand Valley State University, Annis, Water Resources Institute (2002).

# NOAA CoastWatch




What's New
CW Overview
REGISTRATION
AVHRR Imagery
GLSEA
Contour Maps
GOES Imagery
RADARSAT
Ocean Color
Image Products
In Situ Data
GLFS
Statistics
JAVA GIS
NCAAS
Software
Documentation
Validation
Other Links
Welcome to the NOAA CoastWatch
Great Lakes Node
CoastWatch
Great Lakes CoastWatch Node
NOAA/Great Lakes Environmental
Research Laboratory
2205 Commonwealth Blvd.
Ann Arbor, MI 48105-1593
Fax: (734) 741-2055
http://coastwatch.glerl.noaa.gov
George A. Leshkevich,
Manager
leshkevich@glerl.noaa.gov
SongJi Liu,
Operations Assistant
sliu@glerl.noaa.gov

Figure 1.

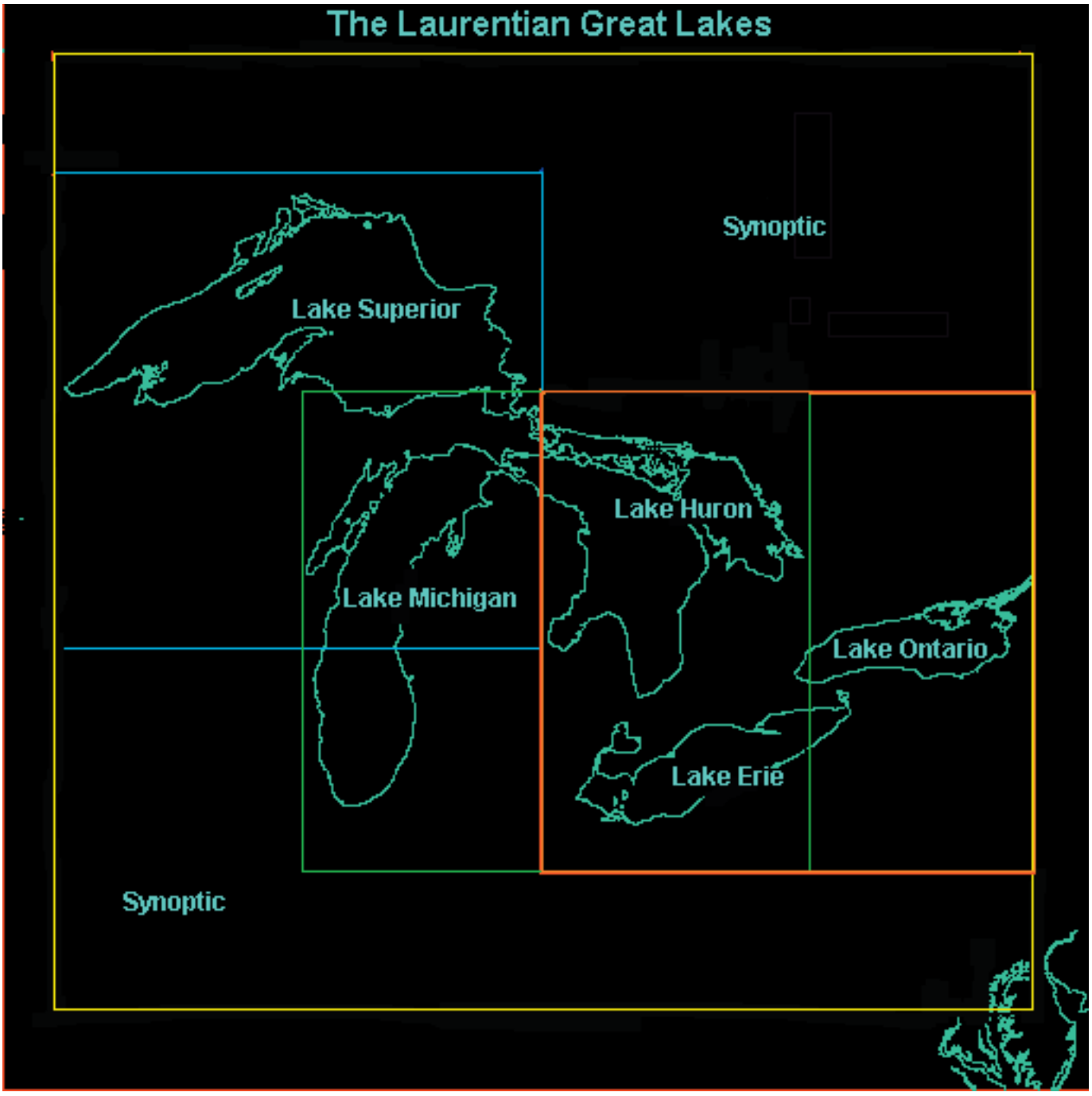

The Laurentian Great Lakes
Synoptic
Lake Superior
Lake Huron
Lake Michigan
Lake Ontario
Lake Erie
Synoptic

Figure 2.

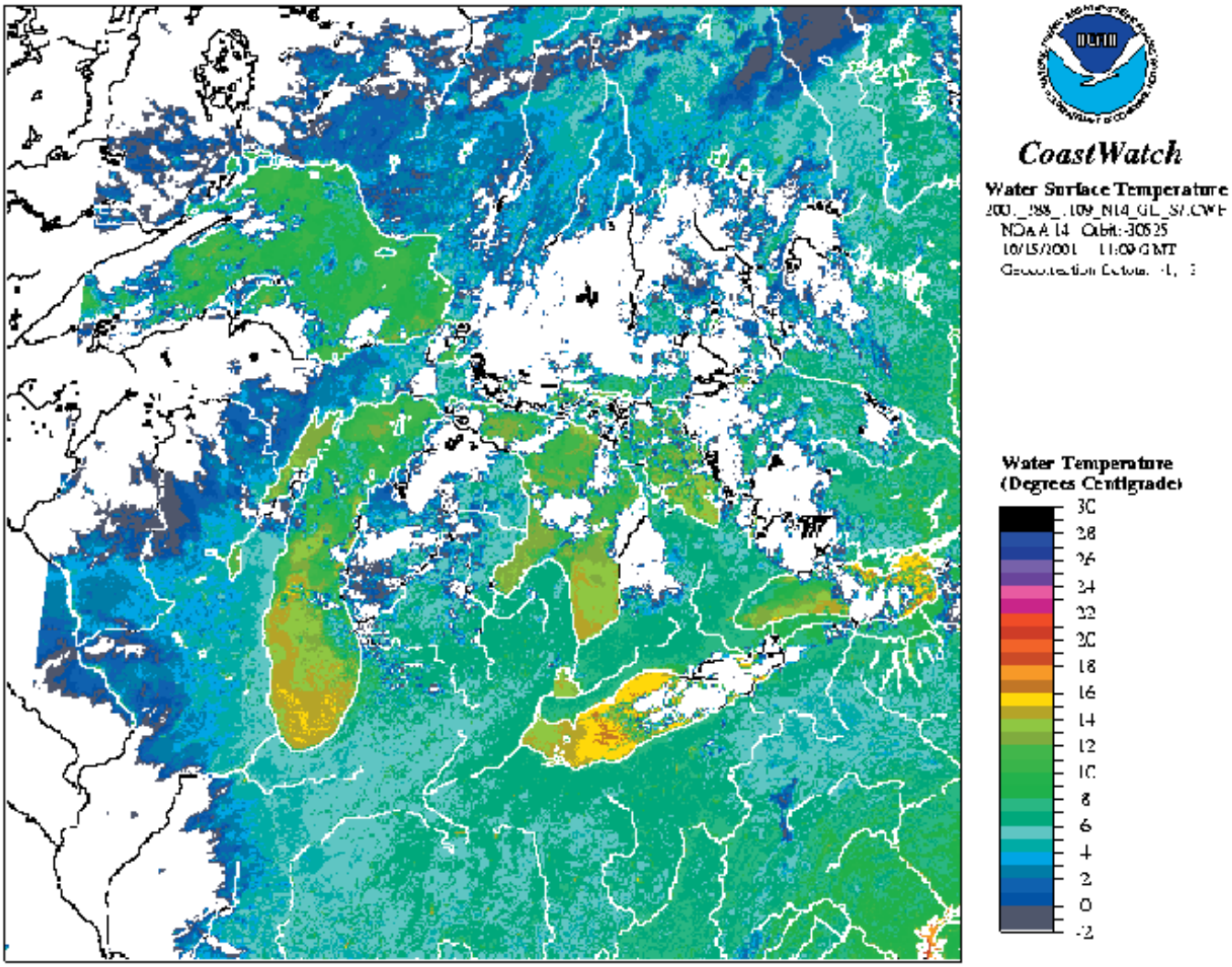

CoastWatch
Water Surface Temperature
NOAA 14 Orbit: 30525
10/15/2001 11:09 GMT
Water Temperature
(Degrees Centigrade)
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
-2

Figure 4.

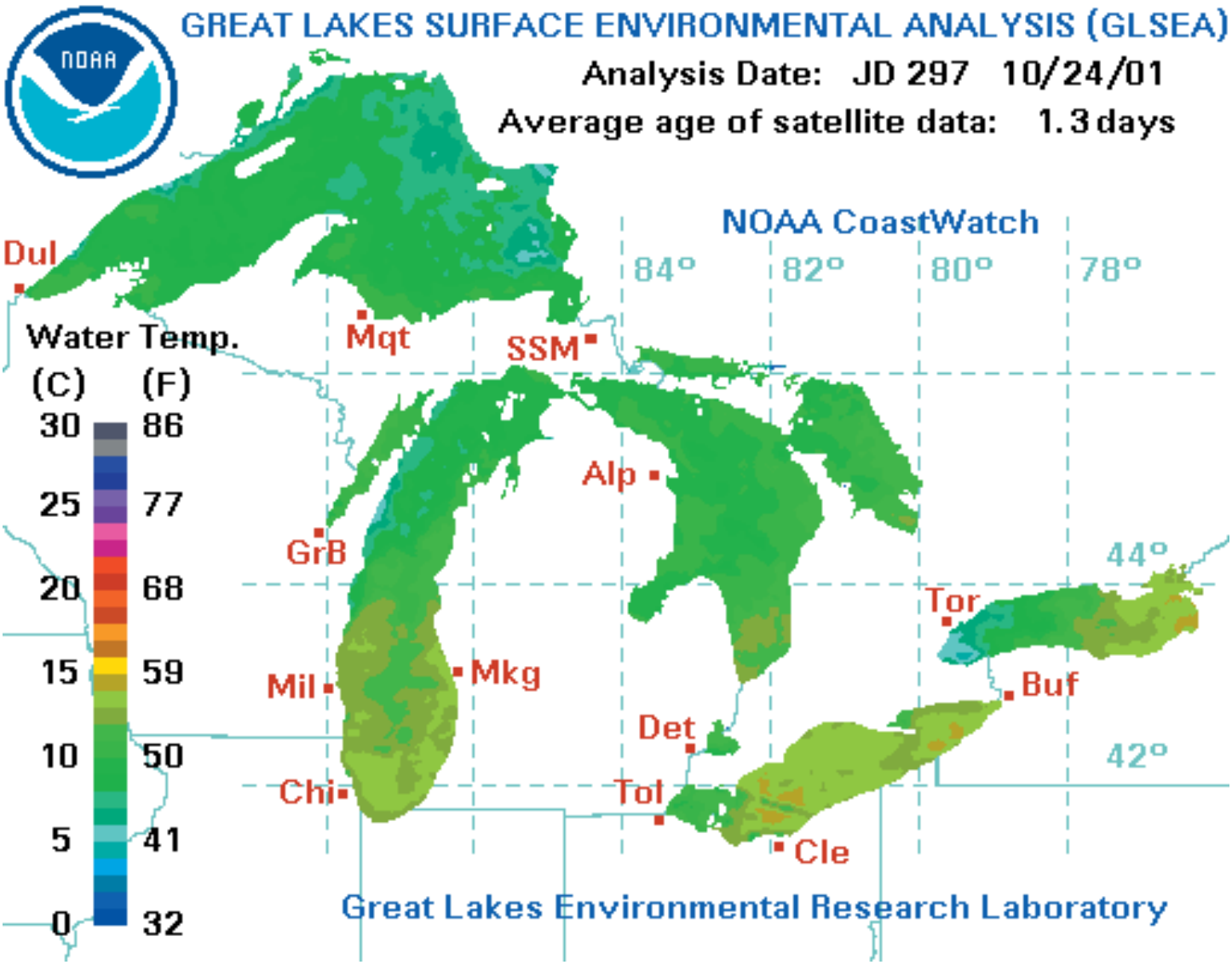

GREAT LAKES SURFACE ENVIRONMENTAL ANALYSIS (GLSEA)
Analysis Date: JD 297 10/24/01
Average age of satellite data: 1.3 days
NOAA CoastWatch
Water Temp.
(C) (F)
30 86
25 77
20 68
15 59
10 50
5 41
0 32
Dul
Mqt
SSM
Alp
GrB
Tor
Mil
Mkg
Buf
Det
Chi
Tol
Cle
84°
82°
80°
78°
44°
42°
Great Lakes Environmental Research Laboratory

Figure 6.

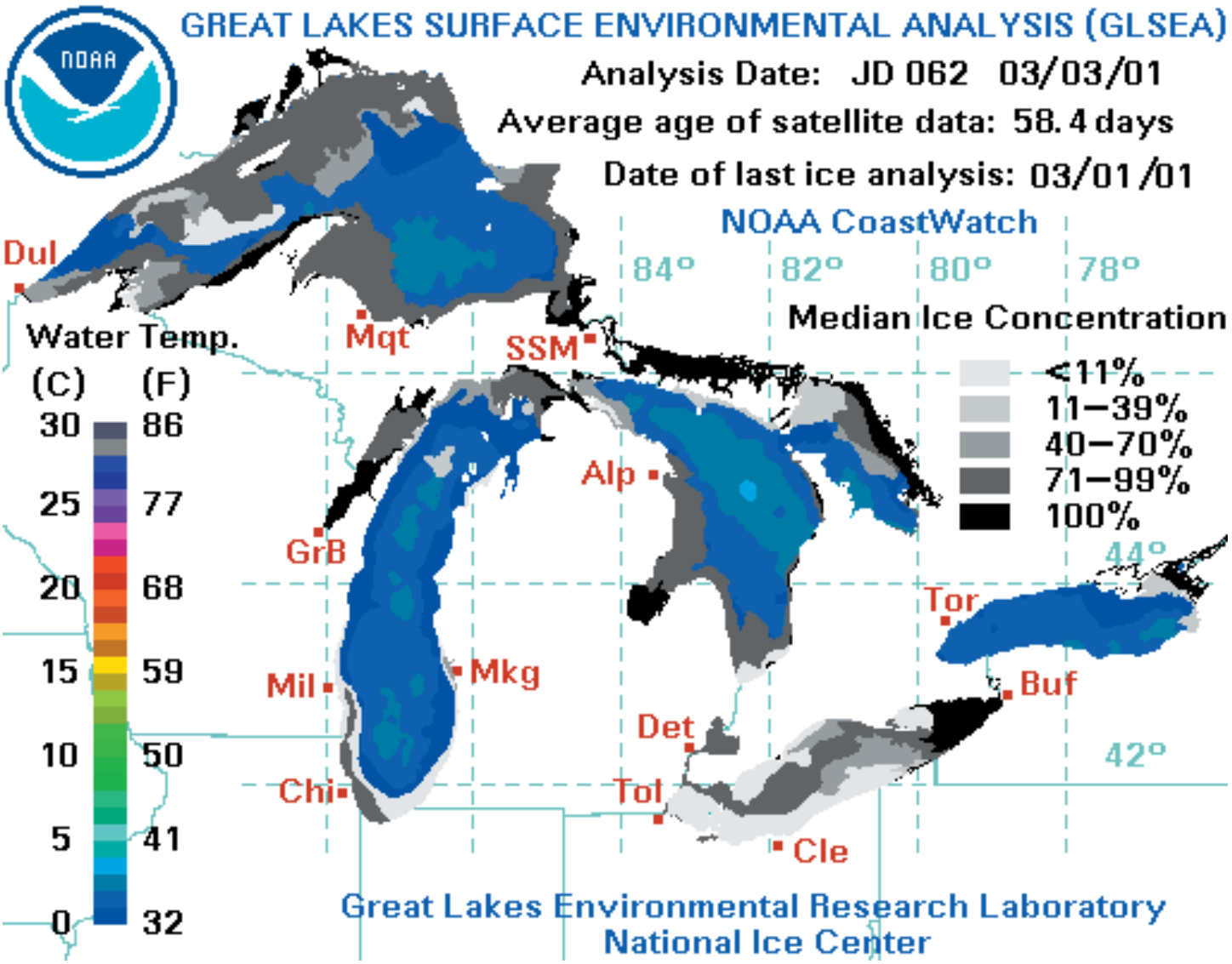

GREAT LAKES SURFACE ENVIRONMENTAL ANALYSIS (GLSEA)
Analysis Date: JD 062 03/03/01
Average age of satellite data: 58.4 days
Date of last ice analysis: 03/01/01
NOAA CoastWatch
84°
82°
80°
78°
Median Ice Concentration
<11%
11–39%
40–70%
71–99%
100%
Water Temp.
(C) (F)
30 86
25 77
20 68
15 59
10 50
5 41
0 32
Dul
Mqt
SSM
Alp
GrB
Tor
Mil
Mkg
Buf
Det
Chi
Tol
Cle
44°
42°
Great Lakes Environmental Research Laboratory
National Ice Center

Figure 7.

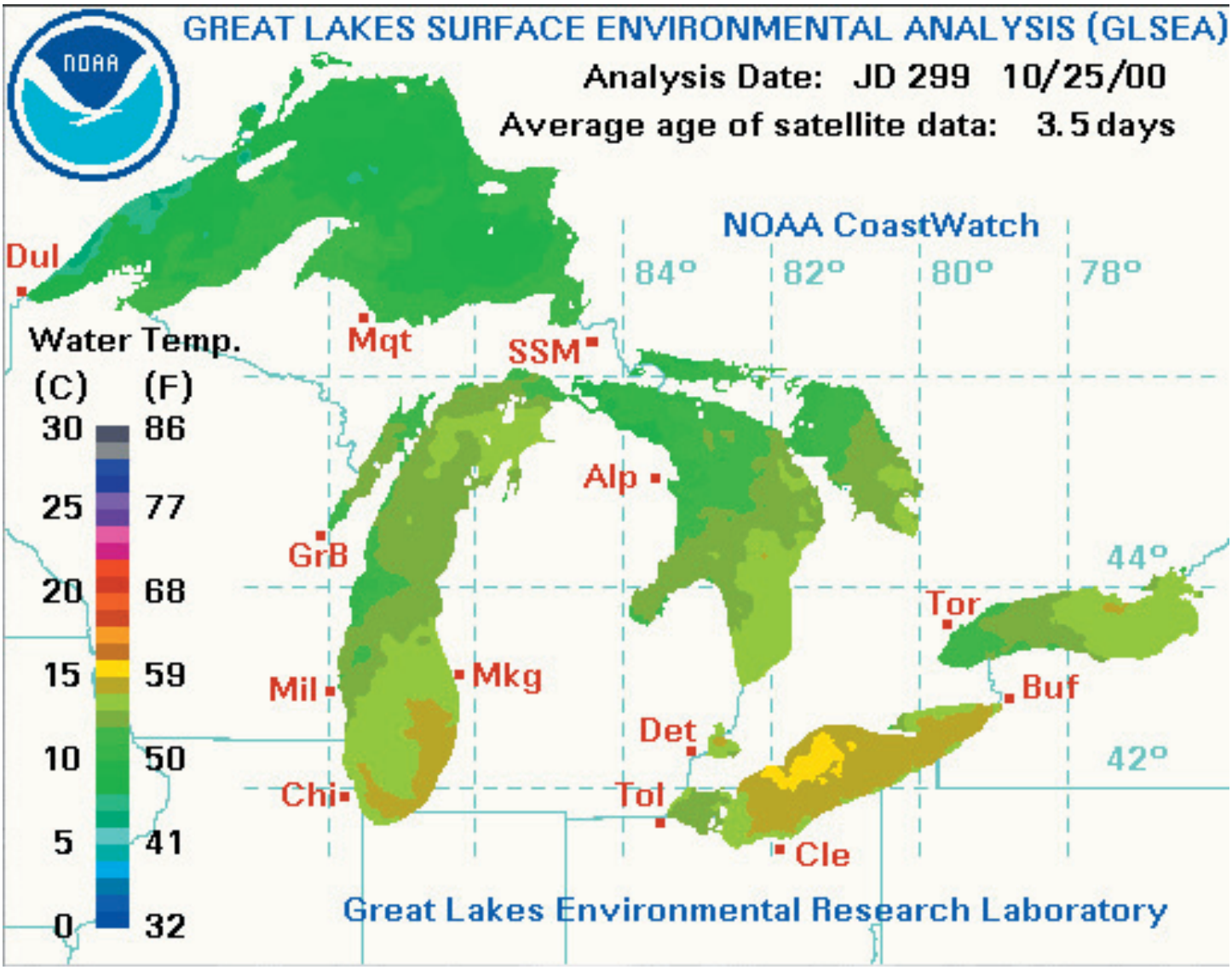

GREAT LAKES SURFACE ENVIRONMENTAL ANALYSIS (GLSEA)
Analysis Date: JD 299 10/25/00
Average age of satellite data: 3.5 days
NOAA CoastWatch
Water Temp.
(C) (F)
30 86
25 77
20 68
15 59
10 50
5 41
0 32
Dul
Mqt
SSM
Alp
GrB
Tor
Mil
Mkg
Buf
Det
Chi
Tol
Cle
84°
82°
80°
78°
44°
42°
Great Lakes Environmental Research Laboratory

Figure 8.

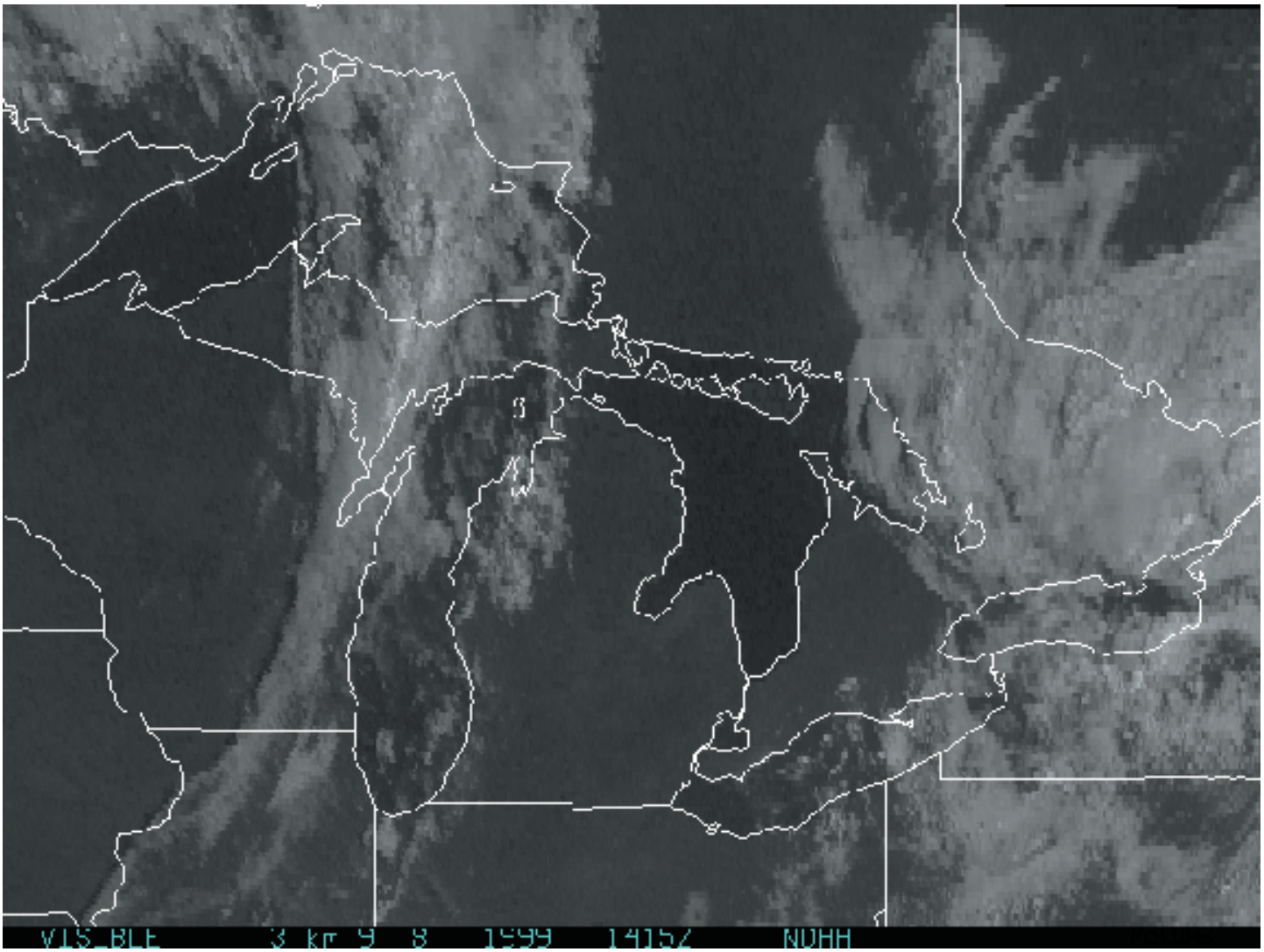



Figure 9.

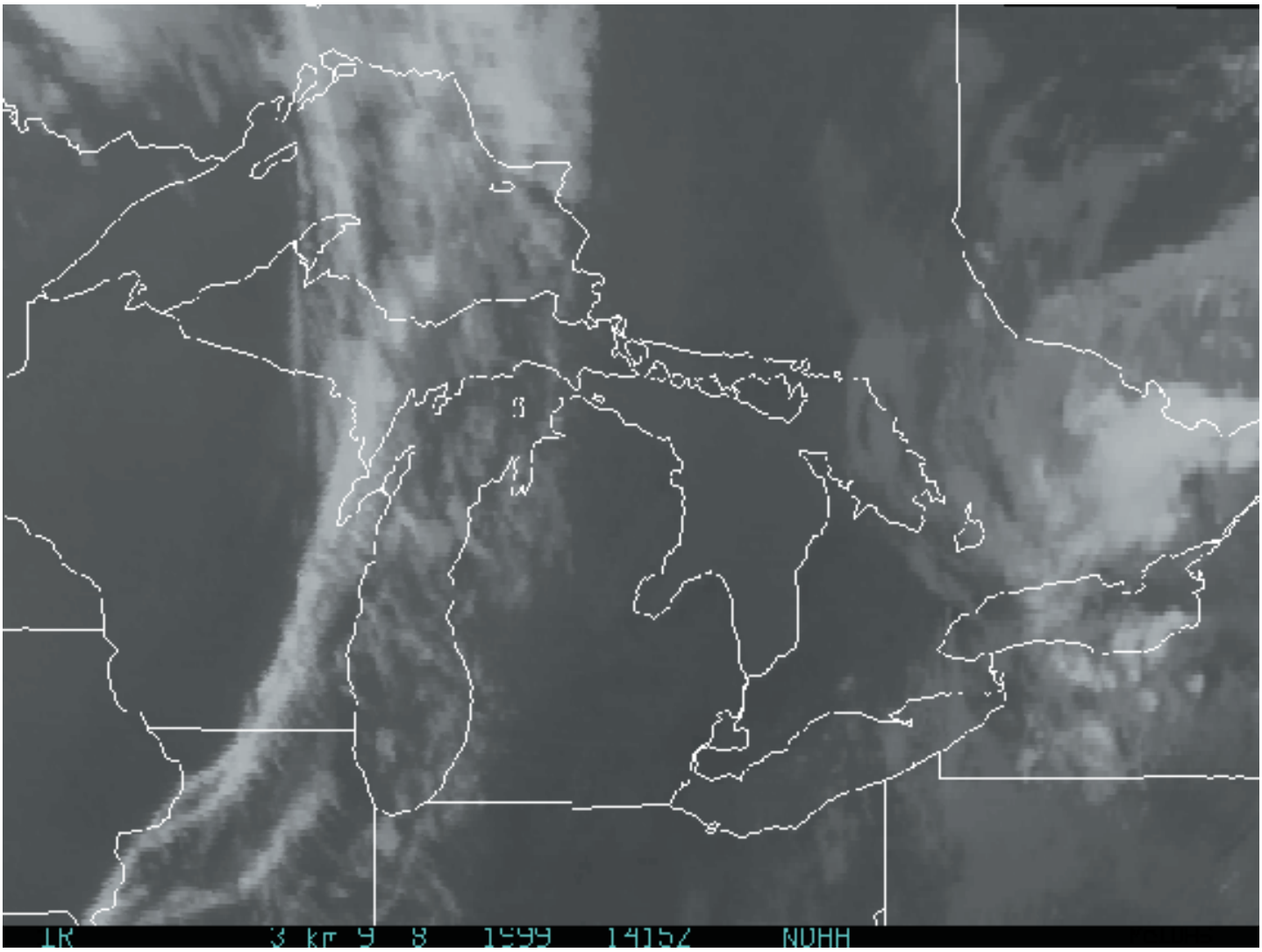


Figure 10.

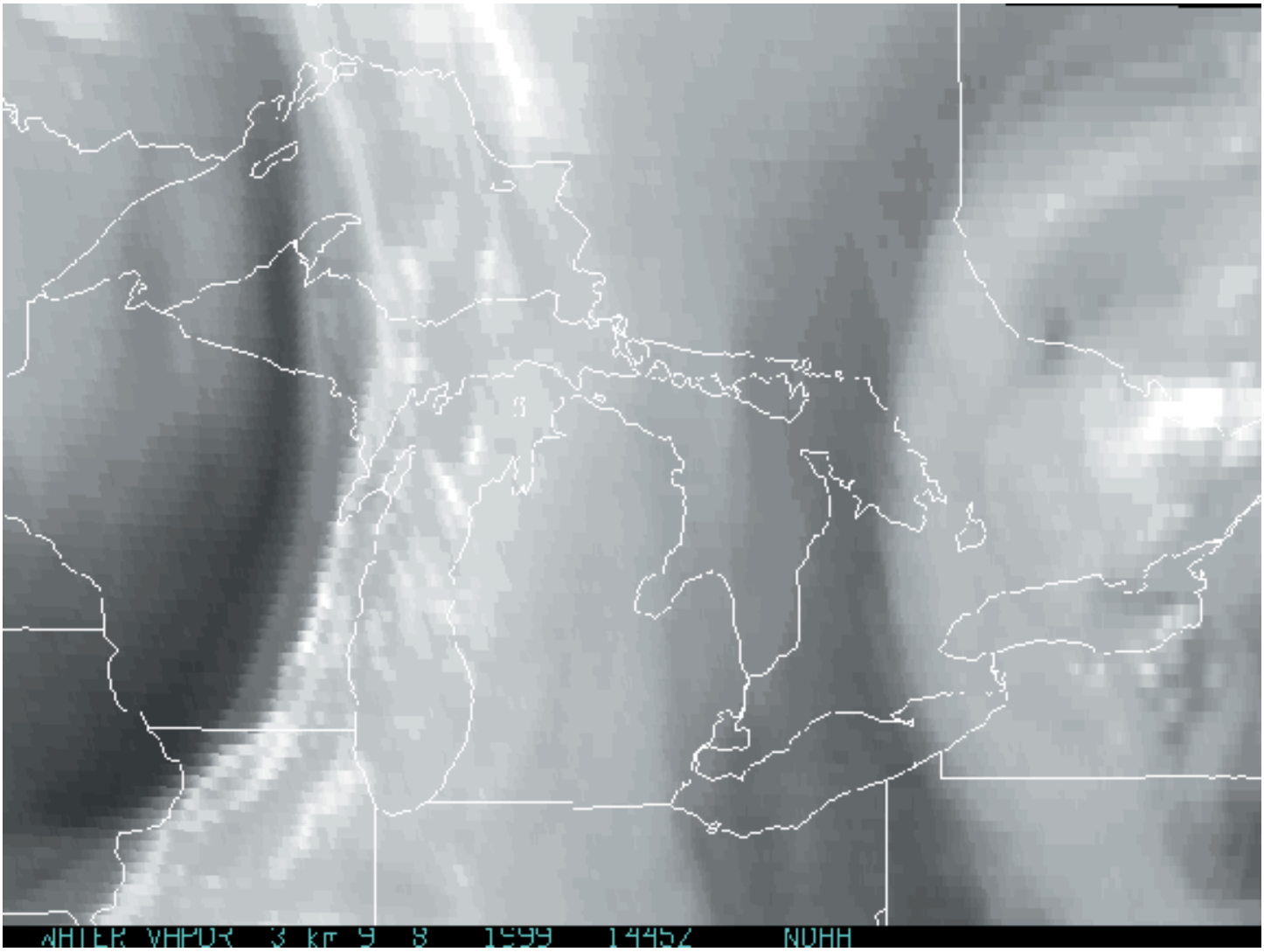


Figure 11.

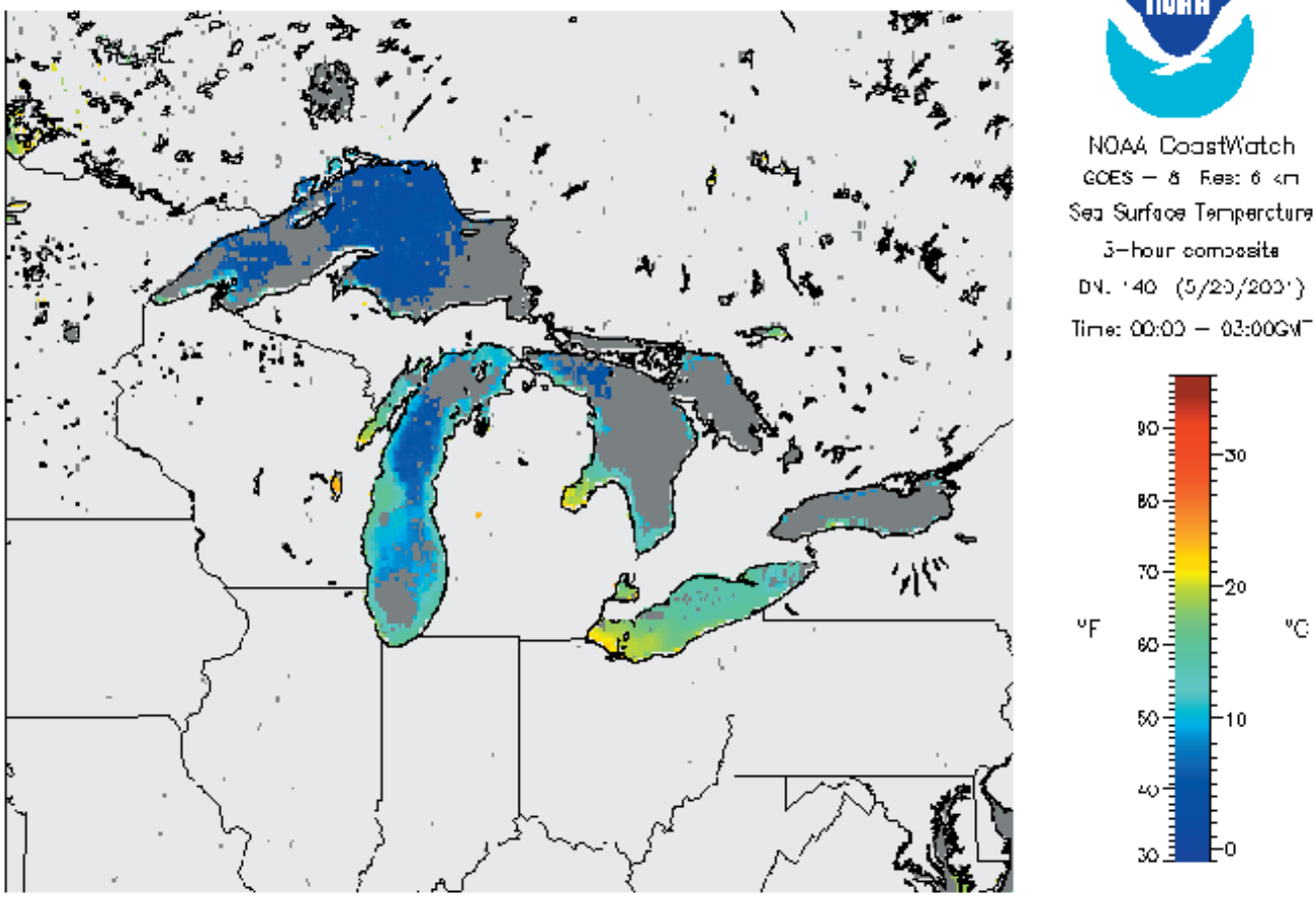

NOAA CoastWatch
GOES – 8 Res: 6 km
Sea Surface Temperature
3-hour composite
DN. '40 (5/20/200')
Time: 00:00 – 03:00GMT
90
80
70
60
50
40
30
°F
30
20
10
0
°C

Figure 11b.

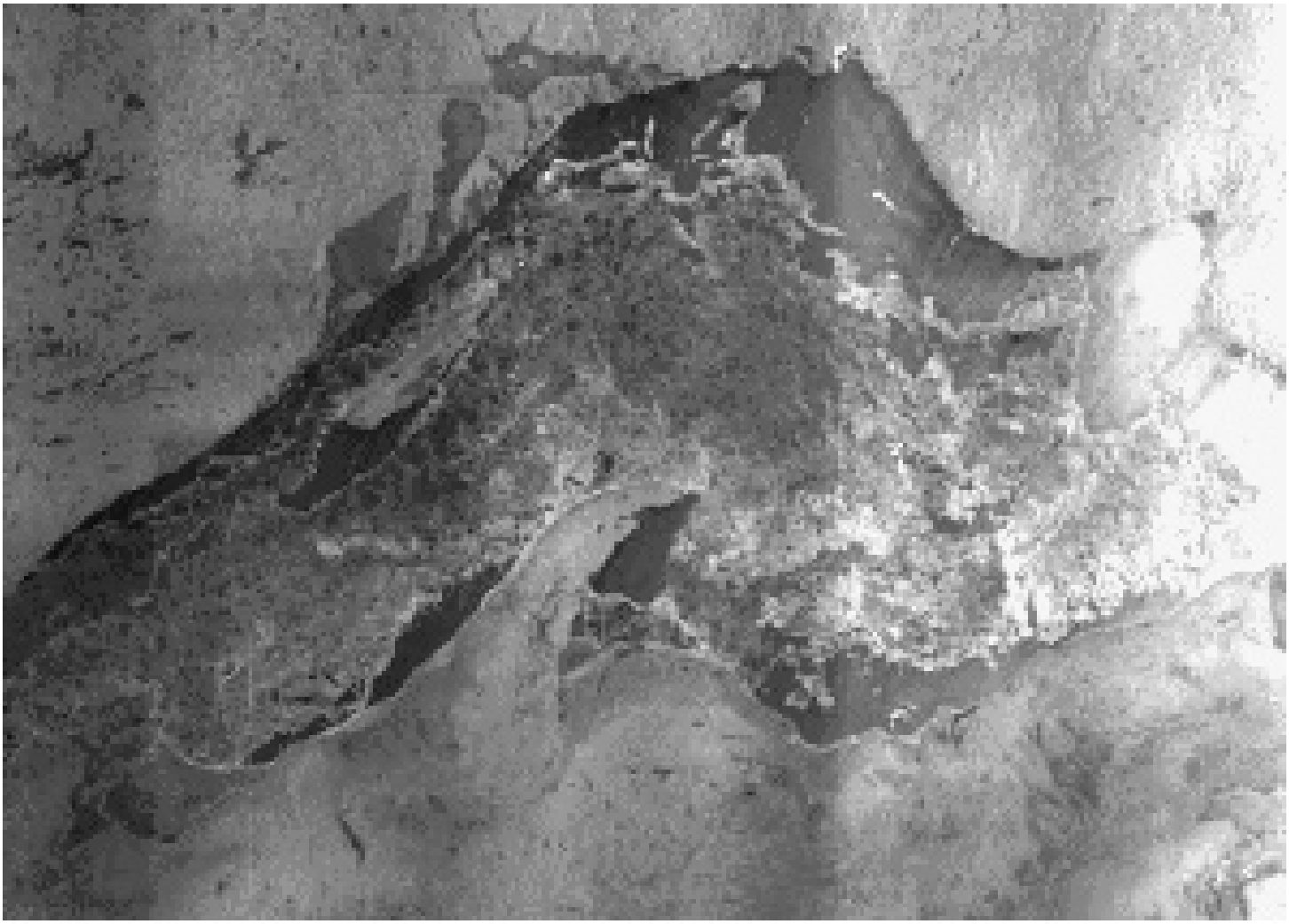




Figure 12a.

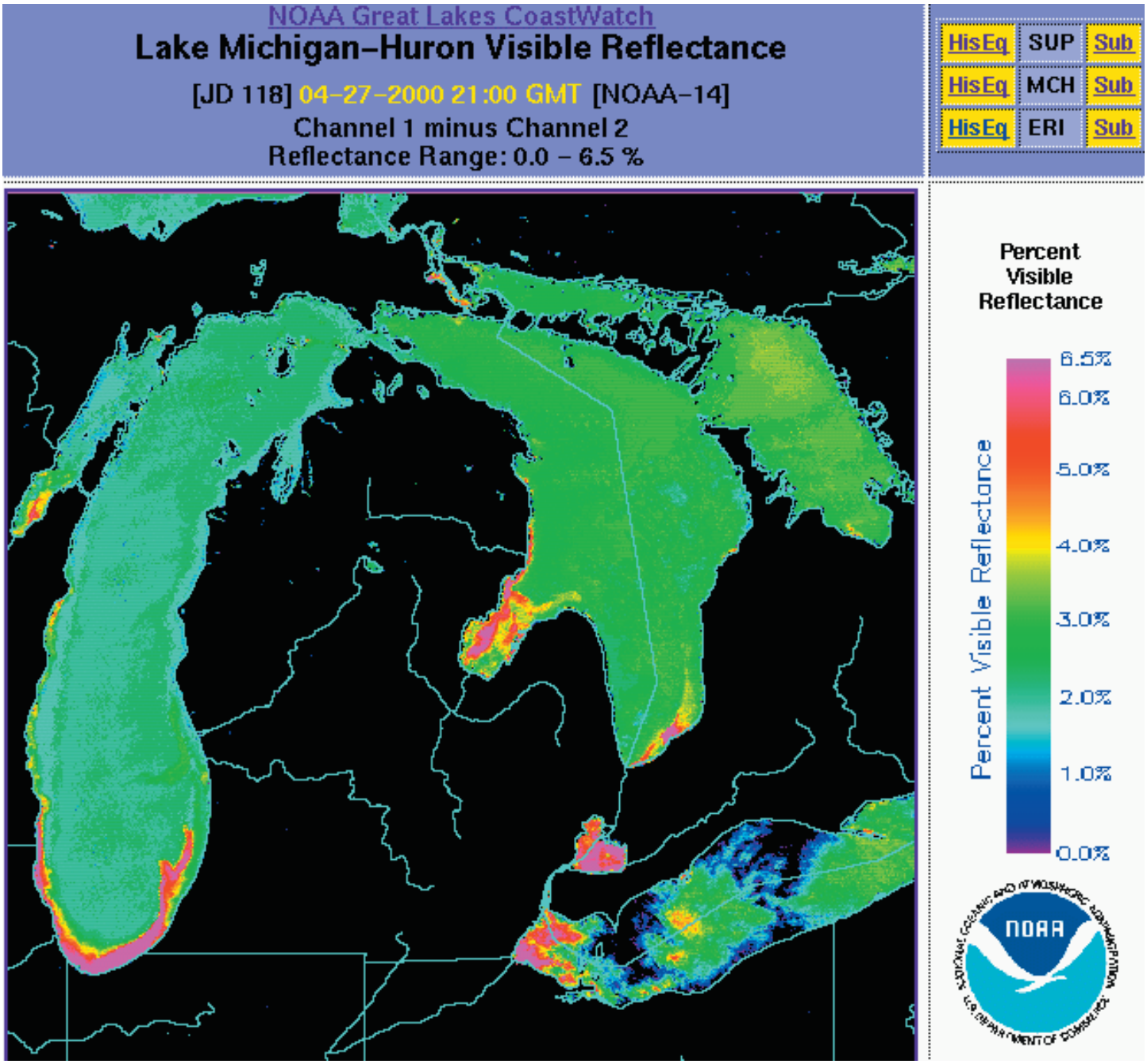

NOAA Great Lakes CoastWatch
Lake Michigan–Huron Visible Reflectance
[JD 118] 04–27–2000 21:00 GMT [NOAA–14]
Channel 1 minus Channel 2
Reflectance Range: 0.0 – 6.5 %
HisEq SUP Sub
HisEq MCH Sub
HisEq ERI Sub
Percent Visible Reflectance
Percent Visible Reflectance
6.5%
6.0%
5.0%
4.0%
3.0%
2.0%
1.0%
0.0%
NOAA

Figure 12.

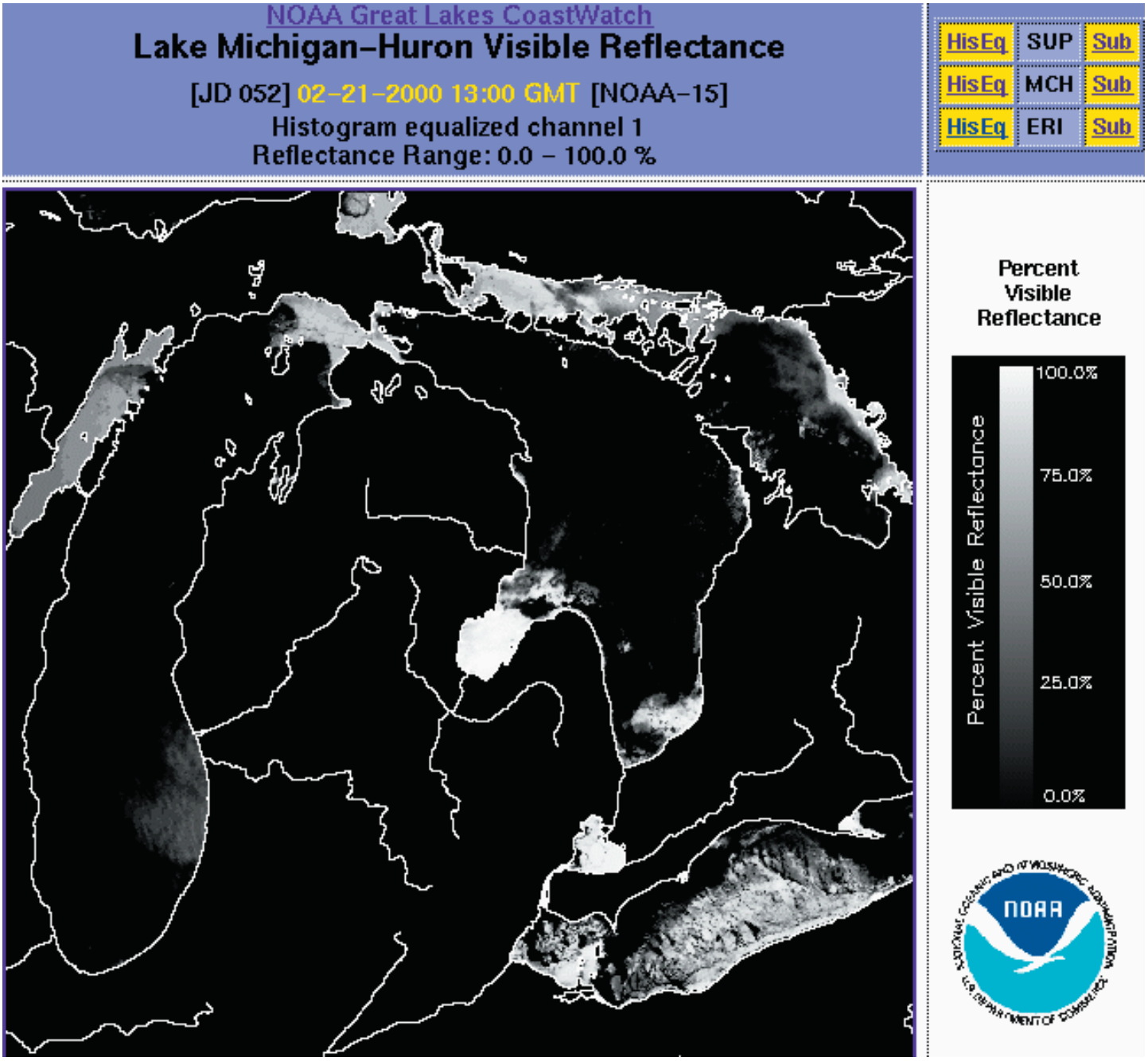

NOAA Great Lakes CoastWatch
Lake Michigan–Huron Visible Reflectance
[JD 052] 02-21-2000 13:00 GMT [NOAA-15]
Histogram equalized channel 1
Reflectance Range: 0.0 – 100.0 %
HisEq SUP Sub
HisEq MCH Sub
HisEq ERI Sub
Percent Visible Reflectance
Percent Visible Reflectance
100.0%
75.0%
50.0%
25.0%
0.0%
NOAA

Figure 13.

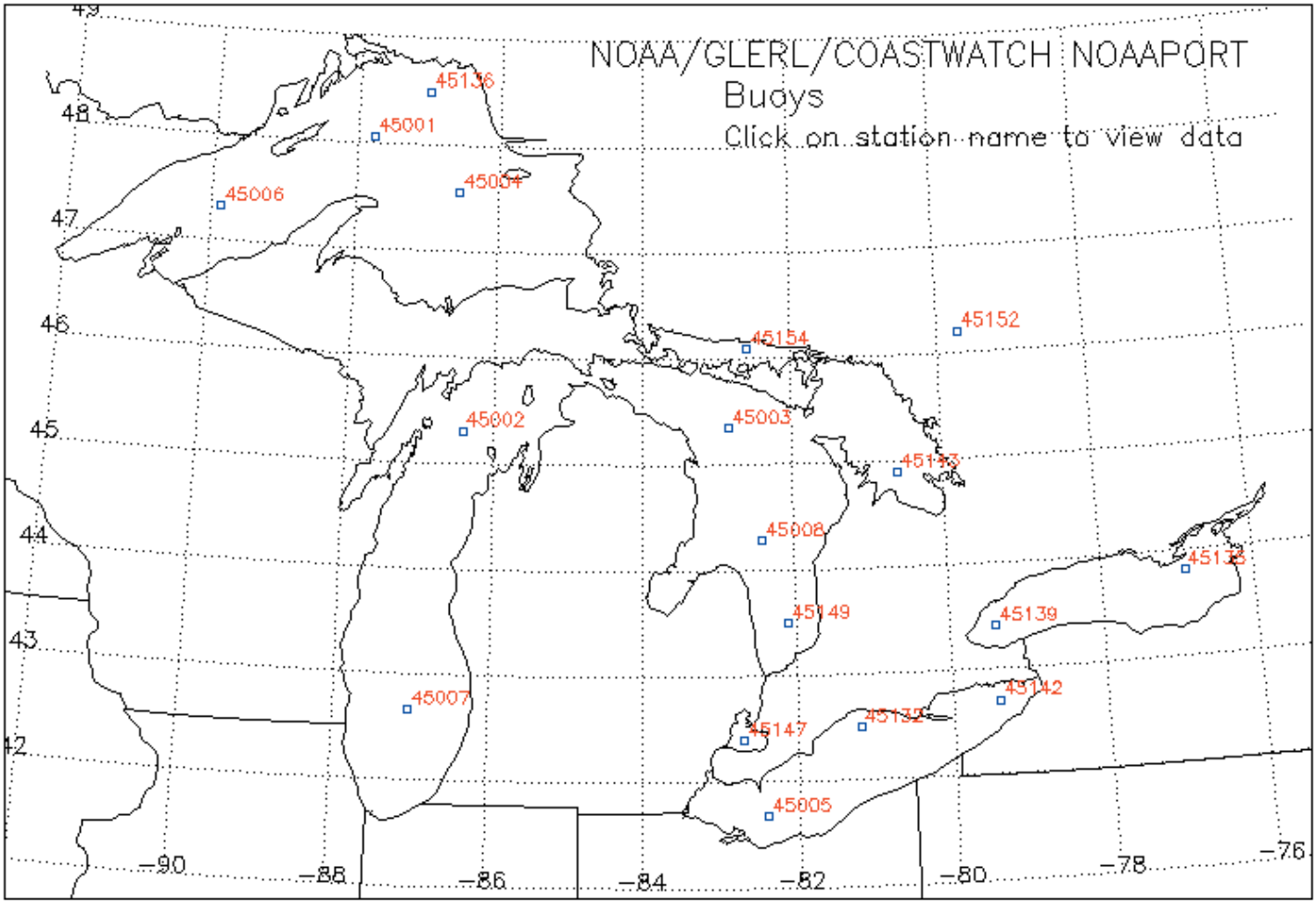

NOAA/GLERL/COASTWATCH NOAAPORT
Buoys
Click on station name to view data
45136
45001
45004
45006
45154
45152
45002
45003
45143
45008
45149
45139
45007
45142
45147
45005
49
48
47
46
45
44
43
42
-90
-88
-86
-84
-82
-80
-78
-76

Figure 14.

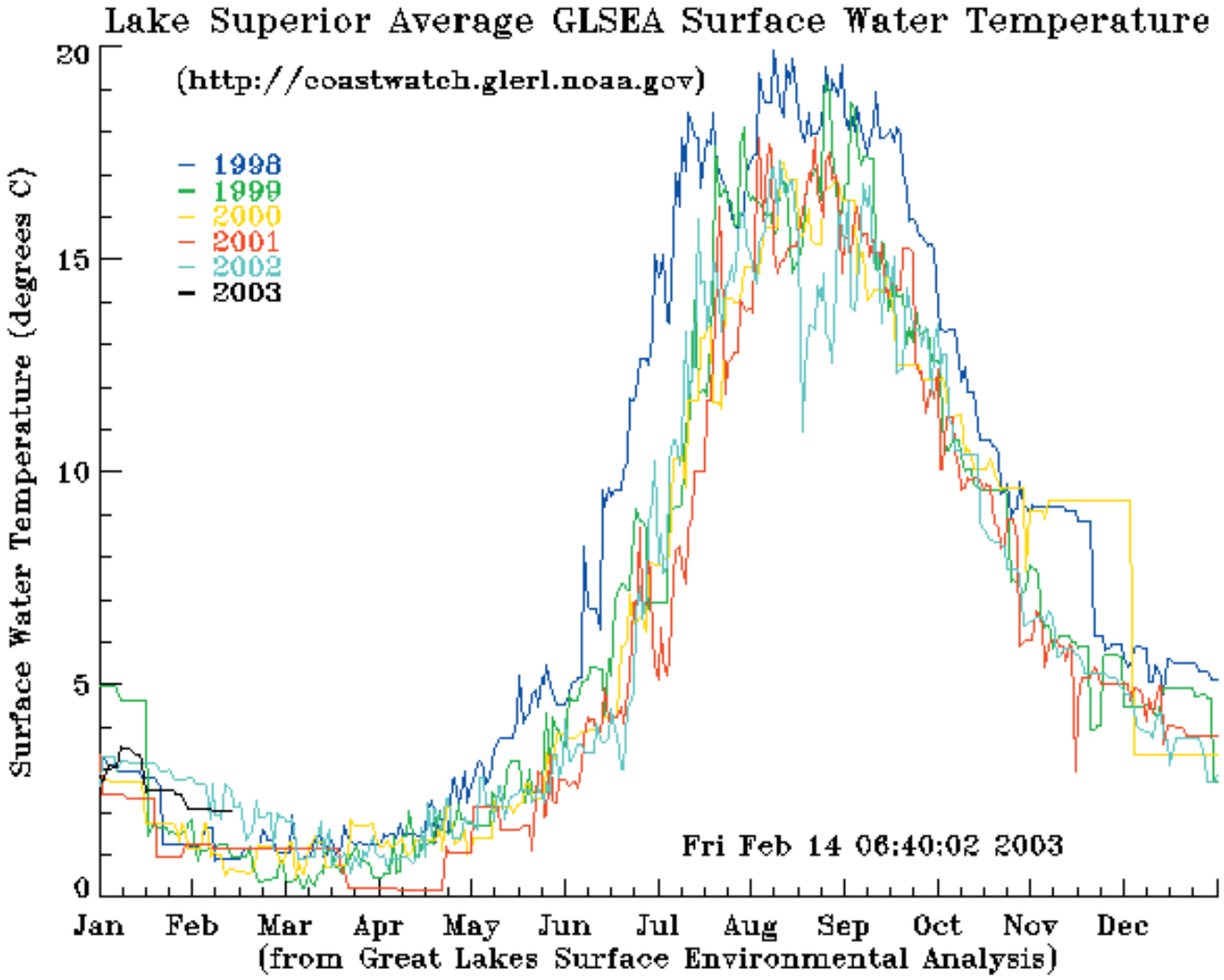

Lake Superior Average GLSEA Surface Water Temperature
(http://coastwatch.glerl.noaa.gov)
1998
1999
2000
2001
2002
2003
Surface Water Temperature (degrees C)
0
5
10
15
20
Fri Feb 14 06:40:02 2003
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
(from Great Lakes Surface Environmental Analysis)

Figure 16.

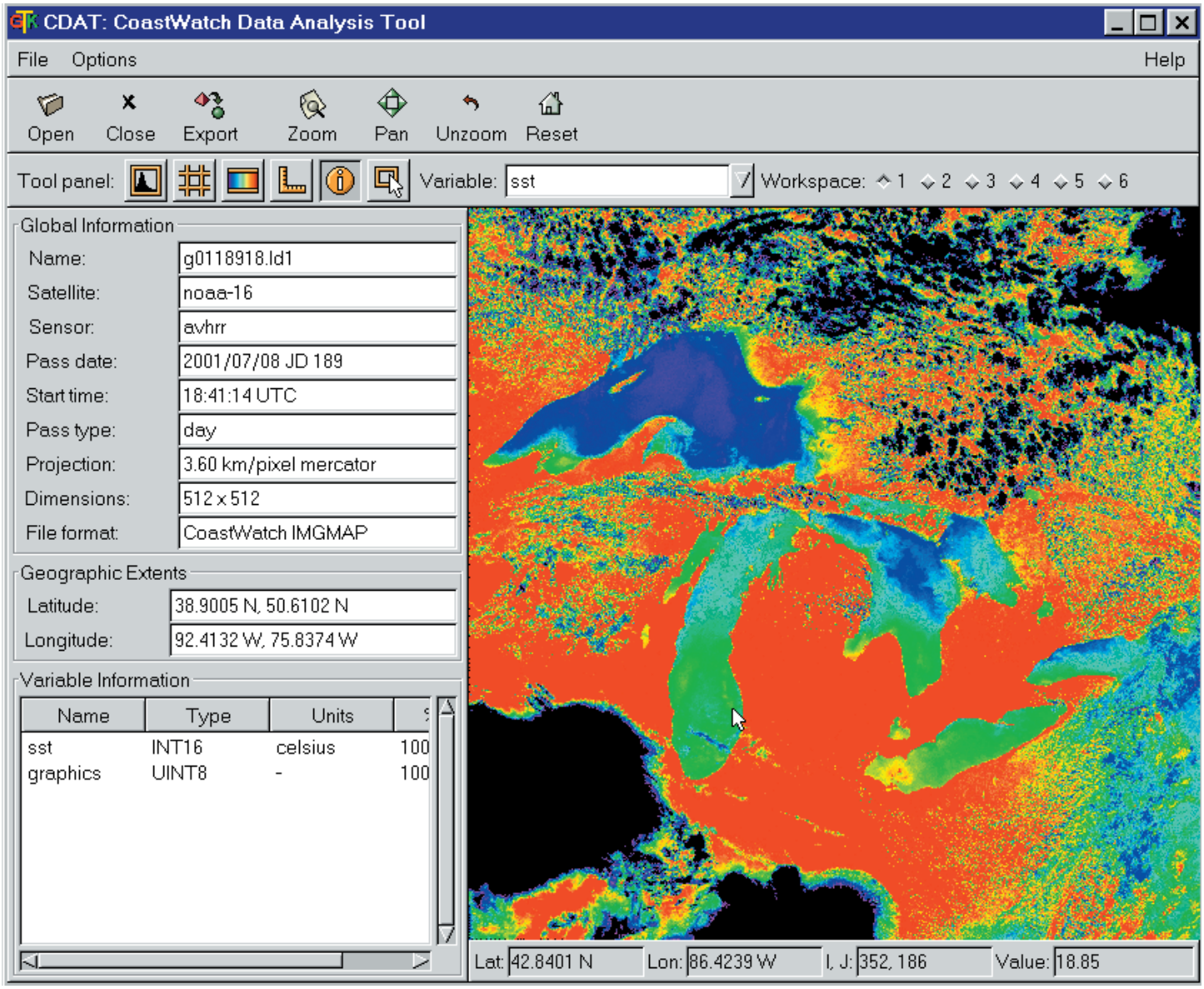

CDAT: CoastWatch Data Analysis Tool
File
Options
Help
Open
Close
Export
Zoom
Pan
Unzoom
Reset
Tool panel:
Variable:
sst
Workspace:
1
2
3
4
5
6
Global Information
Name:
g0118918.ld1
Satellite:
noaa-16
Sensor:
avhrr
Pass date:
2001/07/08 JD 189
Start time:
18:41:14 UTC
Pass type:
day
Projection:
3.60 km/pixel mercator
Dimensions:
512 x 512
File format:
CoastWatch IMGMAP
Geographic Extents
Latitude:
38.9005 N, 50.6102 N
Longitude:
92.4132 W, 75.8374 W
Variable Information
Name
Type
Units
sst
INT16
celsius
100
graphics
UINT8
-
100
Lat:
42.8401 N
Lon:
86.4239 W
I, J:
352, 186
Value:
18.85

Figure 18.

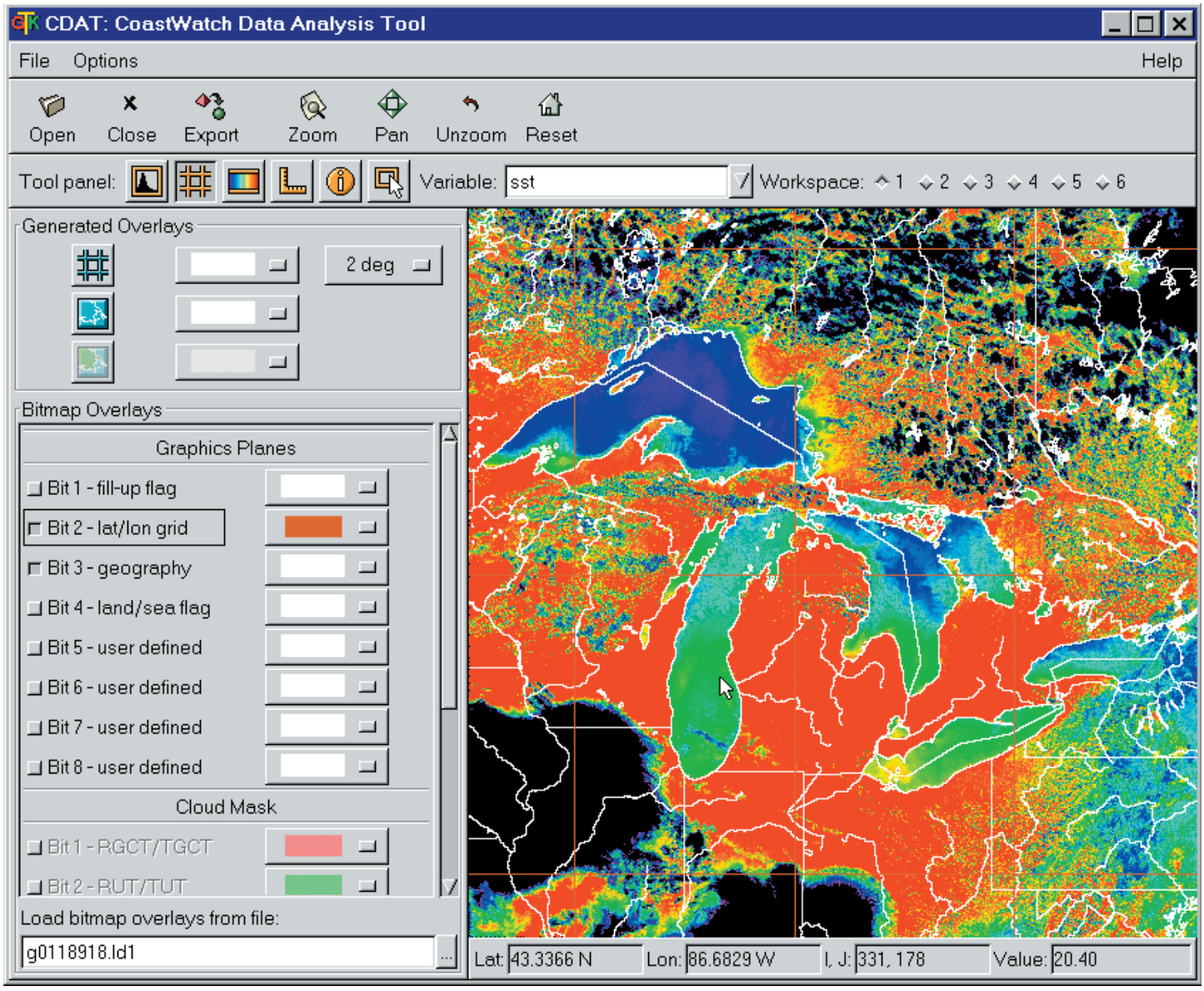

CDAT: CoastWatch Data Analysis Tool
File
Options
Help
Open
Close
Export
Zoom
Pan
Unzoom
Reset
Tool panel:
Variable:
sst
Workspace:
1
2
3
4
5
6
Generated Overlays
2 deg
Bitmap Overlays
Graphics Planes
Bit 1 - fill-up flag
Bit 2 - lat/lon grid
Bit 3 - geography
Bit 4 - land/sea flag
Bit 5 - user defined
Bit 6 - user defined
Bit 7 - user defined
Bit 8 - user defined
Cloud Mask
Bit 1 - RGCT/TGCT
Bit 2 - RUT/TUT
Load bitmap overlays from file:
g0118918.ld1
Lat: 43.3366 N
Lon: 86.6829 W
I, J: 331, 178
Value: 20.40

Figure 19.

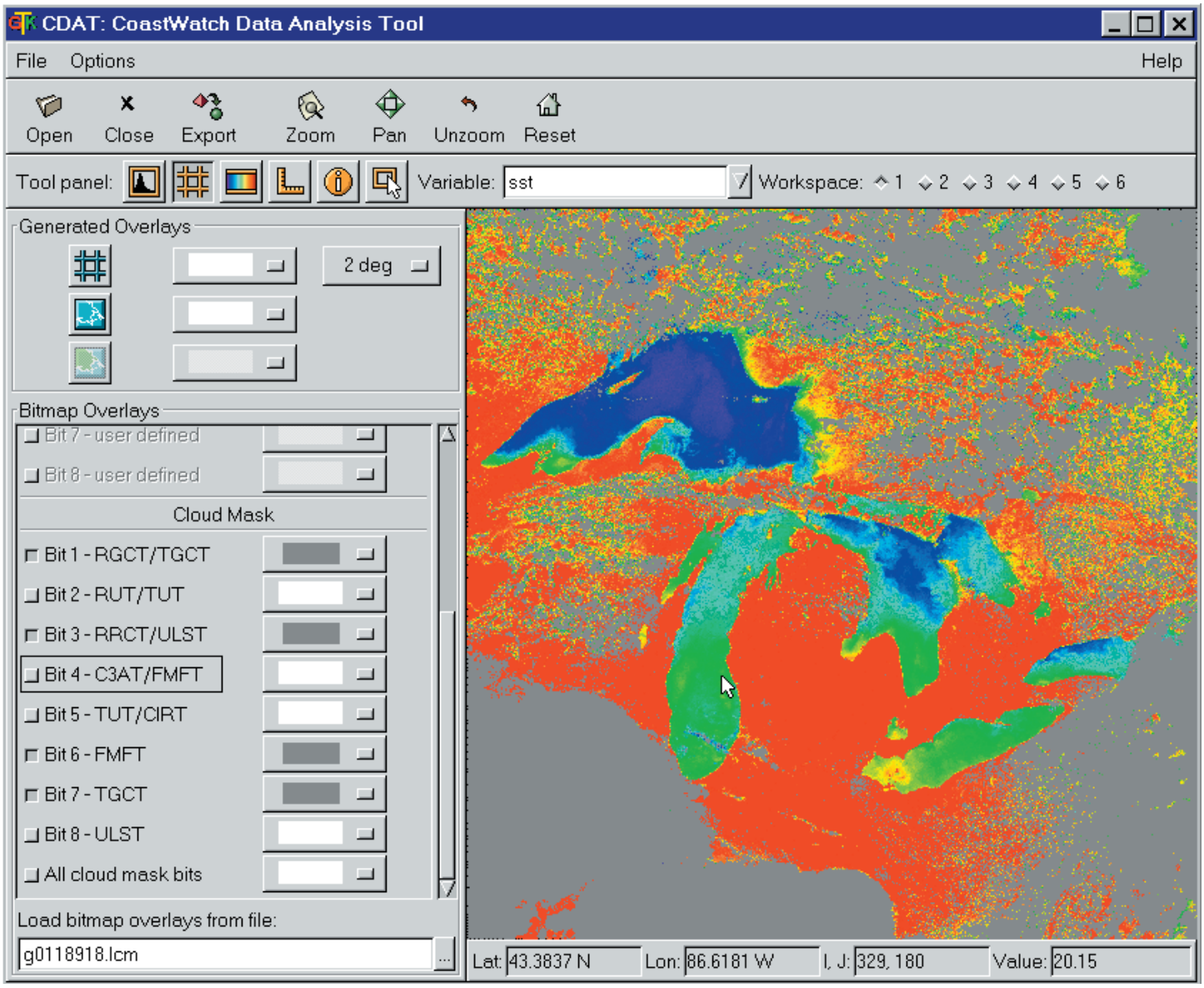

CDAT: CoastWatch Data Analysis Tool
File
Options
Help
Open
Close
Export
Zoom
Pan
Unzoom
Reset
Tool panel:
Variable:
sst
Workspace:
1
2
3
4
5
6
Generated Overlays
2 deg
Bitmap Overlays
Bit 7 - user defined
Bit 8 - user defined
Cloud Mask
Bit 1 - RGCT/TGCT
Bit 2 - RUT/TUT
Bit 3 - RRCT/ULST
Bit 4 - C3AT/FMFT
Bit 5 - TUT/CIRT
Bit 6 - FMFT
Bit 7 - TGCT
Bit 8 - ULST
All cloud mask bits
Load bitmap overlays from file:
g0118918.lcm
Lat: 43.3837 N
Lon: 86.6181 W
I, J: 329, 180
Value: 20.15

Figure 20.

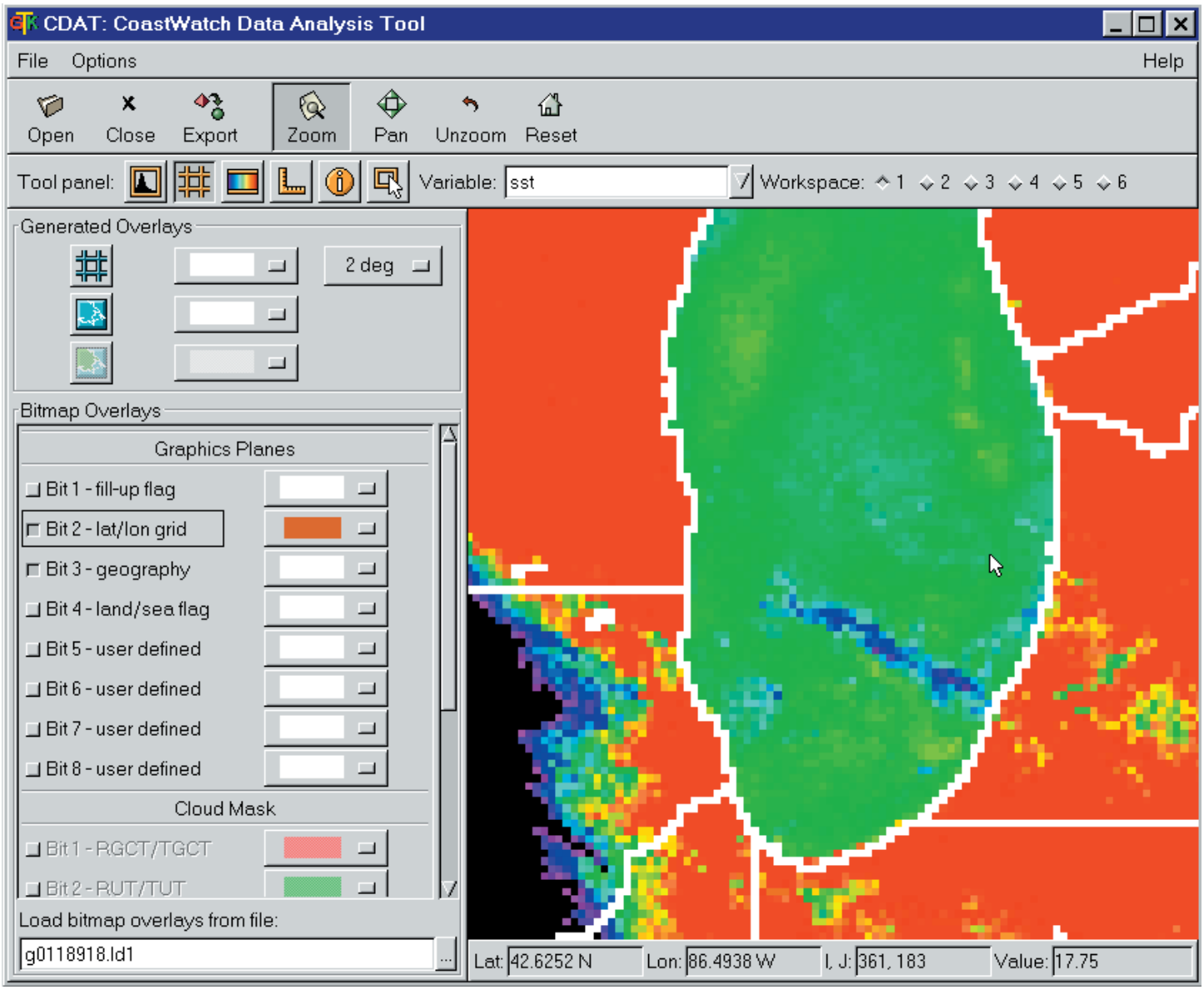

CDAT: CoastWatch Data Analysis Tool
File
Options
Help
Open
Close
Export
Zoom
Pan
Unzoom
Reset
Tool panel:
Variable:
sst
Workspace:
1
2
3
4
5
6
Generated Overlays
2 deg
Bitmap Overlays
Graphics Planes
Bit 1 - fill-up flag
Bit 2 - lat/lon grid
Bit 3 - geography
Bit 4 - land/sea flag
Bit 5 - user defined
Bit 6 - user defined
Bit 7 - user defined
Bit 8 - user defined
Cloud Mask
Bit 1 - RGCT/TGCT
Bit 2 - RUT/TUT
Load bitmap overlays from file:
g0118918.ld1
Lat: 42.6252 N
Lon: 86.4938 W
I, J: 361, 183
Value: 17.75

Figure 21.

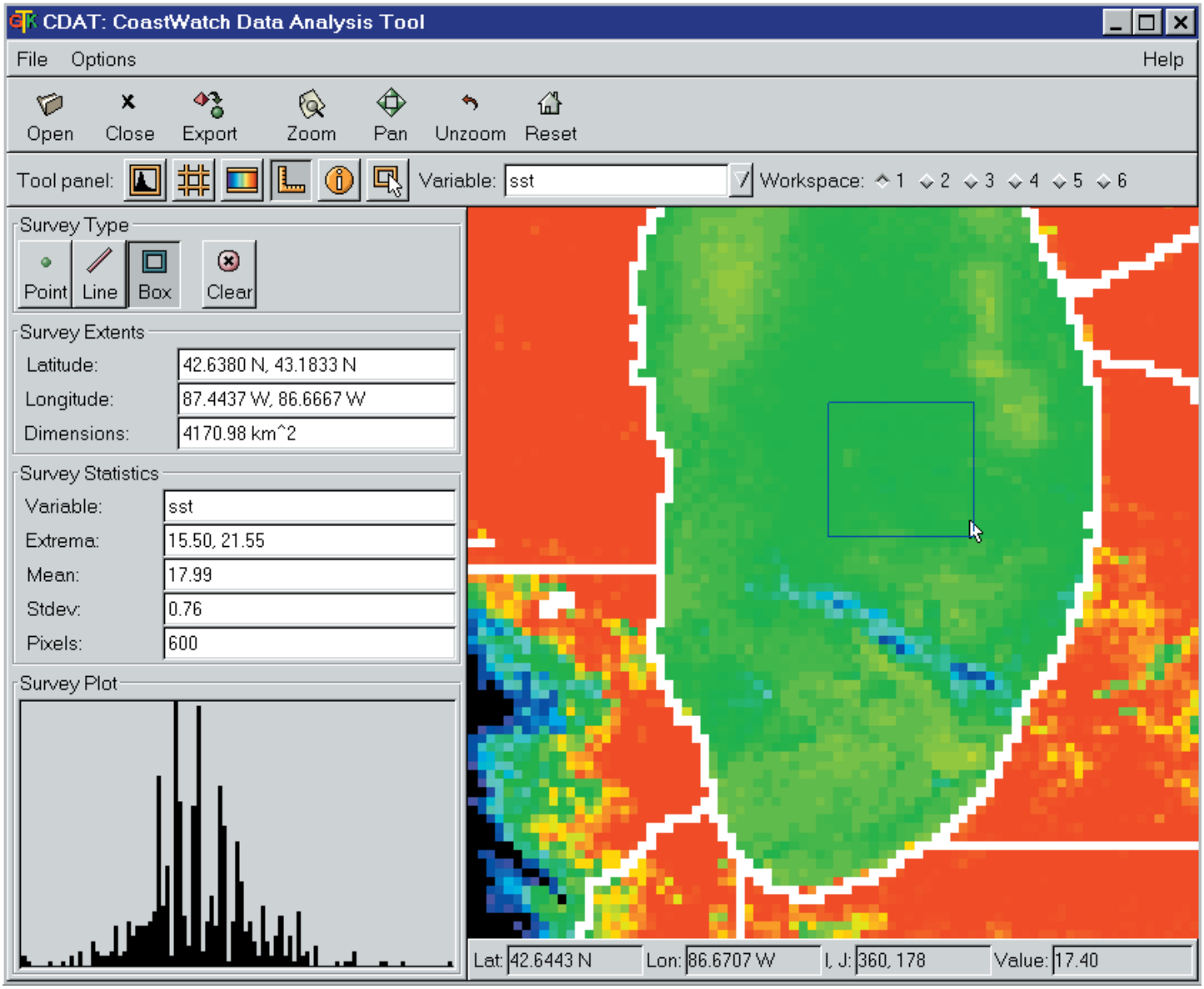

CDAT: CoastWatch Data Analysis Tool
File
Options
Help
Open
Close
Export
Zoom
Pan
Unzoom
Reset
Tool panel:
Variable:
sst
Workspace:
1
2
3
4
5
6
Survey Type
Point
Line
Box
Clear
Survey Extents
Latitude:
42.6380 N, 43.1833 N
Longitude:
87.4437 W, 86.6667 W
Dimensions:
4170.98 km^2
Survey Statistics
Variable:
sst
Extrema:
15.50, 21.55
Mean:
17.99
Stdev:
0.76
Pixels:
600
Survey Plot
Lat:
42.6443 N
Lon:
86.6707 W
I, J:
360, 178
Value:
17.40

Figure 22.

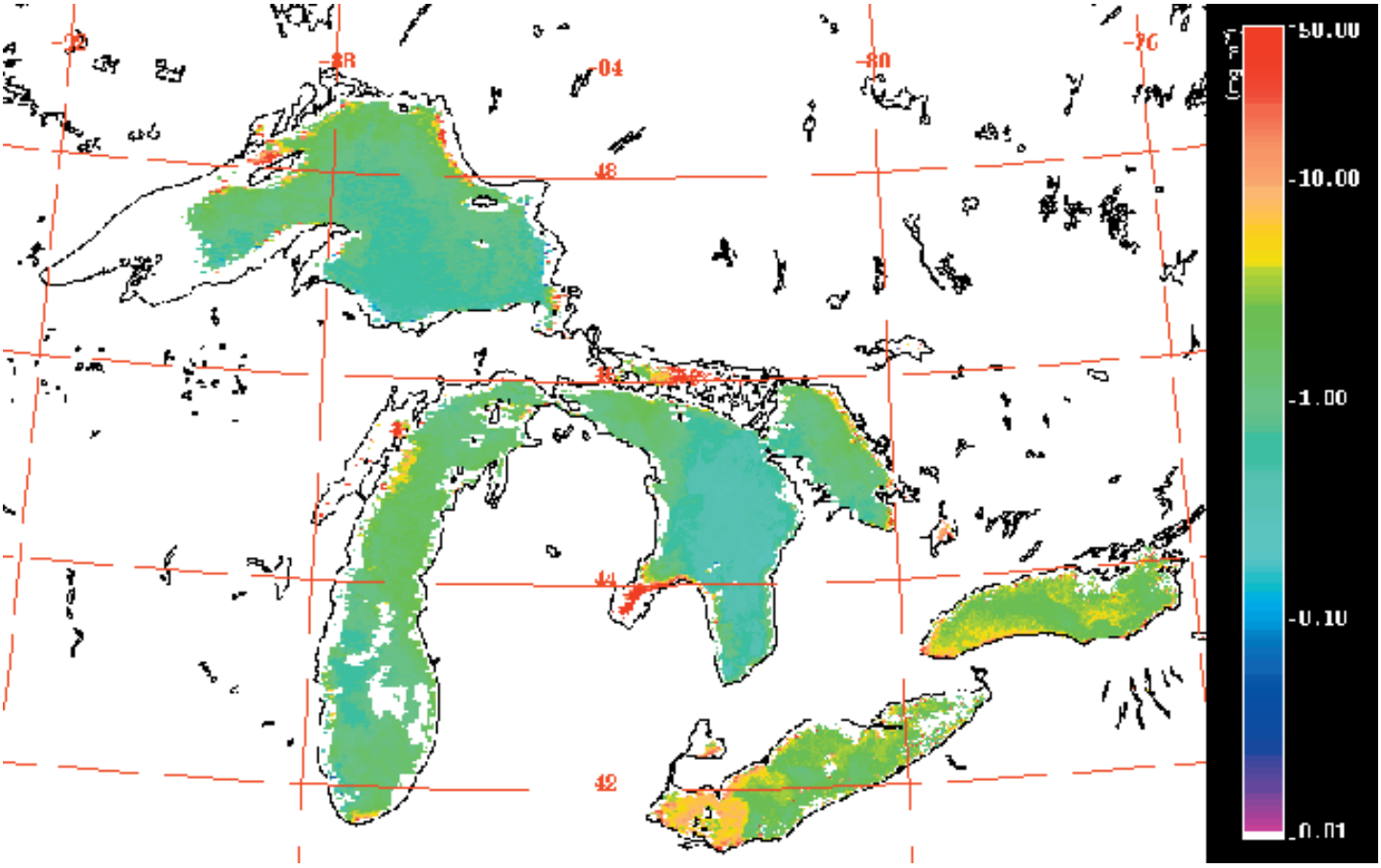



Figure 23.