How Does the Temperature of the Great Lakes Change Over Time?

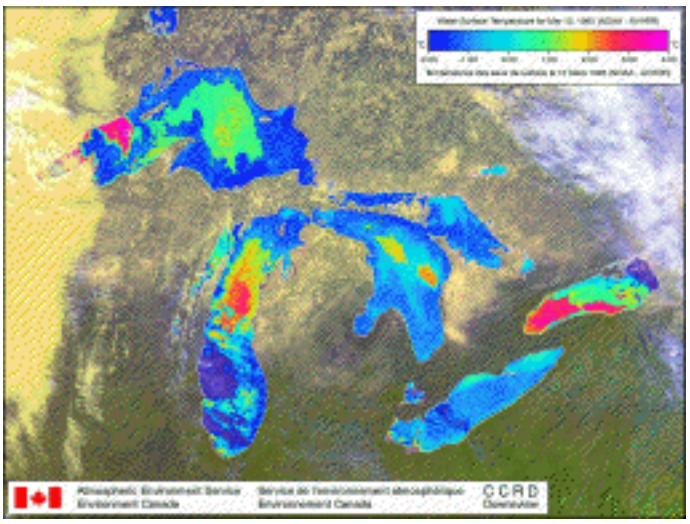
Preface

Can you predict the changes in temperature of the surface water of the Great Lakes? This activity will have participants examine satellite images and collect data. Please feel free to use this activity while on-line (at http://www.ag.ohio-state.edu/~earthsys/ese/GLtemperature/lesson.html).

If you decide that you want to use the activity with a class or group, please use software such as WebWhacker (Mac or Win) to download the entire activity. You can also order the CD-ROM—GLSeeker which has this activity (older version: images are larger and more detailed) and many more activities, software and resources about the Great Lakes for $10 from Ohio Sea Grant Publications.

By downloading, you will have the entire set of material needed for the activity and you will not have to wonder if you will have access to the activity at the time you want to use it.

An alternate version of this activity utilizing quicktime movie data can be found at the following URL: http://www.ag.ohio-state.edu/~earthsys/ese/GLtemperature/lessonm.html. The movies are large files, between 10-20 MB. If your browser does not recognize and play the movie, you may have to edit the application settings (found under "preferences") to recognize the suffix (qt) used by these movies.



Sources of other images/data

- Operational Significant Event Imagery from NOAA: http://www.osei.noaa.gov/.
- Archived Sea Surface Temperature Images: http://dcz.gso.uri.edu/avhrr-archive/archive.html
- Modern Average Global Sea-Surface Temperature: http://geochange.er.usgs.gov/pub/magsst/magsst.html
- Sea Surface Temperature- Month or weekly averages: http://www.nodc.noaa.gov/dsdt/oisst/index.html

In the spring the water is very cold and only a few brave (or crazy) people will go swimming in a lake, but by July and August many people will go swimming. The Great Lakes even with their huge size, have temperature changes. In this activity you will examine how they change and compare the five lakes to each other to see how they are the same and how they might be different.

Student Material Needed:
- Access to a web browser (Netscape)
- Computer with CD-Rom or with the file loaded onto the hard drive
- Student Handout to record information
- Graph paper

Earth Systems Understandings: This activity deals with Understandings #1, 3, 4 (Aesthetics, Scientific Study, and Interacting Subsystems)

Objectives:
- Students will use satellite images to make observations about temperature changes in the Great Lakes.
- Students will hypothesize the causes of some of their observations and then use more data to support or reject their hypothesis.

Procedure:

1. Make predictions about the following before beginning to explore the images. Record your predictions on the student worksheet. The worksheet is numbered to match the procedure instructions.

- a. Which lake is the coldest, warmest?
- b. What lake will warm up the fastest, slowest?
- c. What conditions affect the temperature change of the lakes?

2. In this activity you will be looking at satellite images that have been color coded to show surface temperatures. Use the "Satellite Image Introduction" section to answer the questions on your handout. Look at a couple of water surface temperature images linked in that section so that you have an idea about the information that they contain.

3. Select five locations on the lake that you have been assigned. At least two of the locations should be near land and at least two should be in open water. Sketch the outline of your lake and mark the locations that you are going to collect data at. Label them A, B, C, D and E. Your teacher may have a large map available, or you can use the location map. (See Figure 1.)

4. Make predictions about your five locations.

- a. Which of the five sites will warm up the fastest, slowest?
- b. Which of the five sites will get the warmest? How warm do you predict (0-30 degrees Celsius)?
- c. Where will the lake change the fastest, slowest? (north, south, shore, bays, deep, open areas...)

5. Examine ten of the satellite weather maps and use the temperature scale at the top right of the image to estimate the temperature for each of your sites. Record the temperature for each site on your handout. Make sure that you look at the scale. Each map has its own scale. If your lake is cloud covered, use a different image.

6. Graph the temperature data that you have collected (noted in step 6 on student worksheet). Use a different color or symbol for each site

7. What observations can you make from your graphs? What predictions in #4 were correct? Incorrect? Record your observations.

8. Compare the temperature changes to the bathymetry (bottom depth) data for your lake. (See Figure 2.) Approximately how deep was each of your sites? Did this appear to affect the temperature changes? (Refer to the bathymetry maps listed later in this activity.)

9. Did you observe any anomalies (data that did not fit the pattern)? Describe any observed anomalies.

10. Take a look at the weather maps you chose earlier for any days that you have anomalies. Does the weather map help you come up with a possible explanation of the anomaly? What is your explanation? (Refer to the weather maps listed later in this activity.)

11. Decide as a group what is the most important information to share with your base groups (1 person from each lake). You will be the expert on your lake.

12. What are some other questions that you might investigate about the Great Lakes using the type of data in this activity?

Meet in base groups as assigned. Share what you have learned about your lake with each other. Discuss the following:

13. How were the lakes alike?
14. How were they different from each other?
15. What were the conditions that affected the temperature on all of the lakes?

Your base group will be asked to share your discussion with the class.

Extension:
Make predictions of the current temperatures of your sites. Go on-line and locate current temperature maps and compare them to your predictions. Report to the class your results and possible explanations of any differences between your predictions and the actual temperatures.

STUDENT WORKSHEET

How Does the Temperature of the Great Lakes Change Over Time?

Student(s): _____ Date: _____

1. Predictions:

a. coldest: _____ warmest: _____

b. _____

c. _____

2. How accurate are the temperatures represented on the images?

What things might threaten the accuracy of the images?

3. Sketch the outline of your lake and mark the five locations on the sketch (A-E).

4. Predictions

a. _____

b. _____

c. _____

5. Data Table

Date.....	Site A	Site B	Site C	Site D	Site E
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

6. Graph your data. Use a different color or symbol for each site. Include a key for your colors or symbols. Your teacher will have graph paper, or use a spreadsheet program on the computer to make a graph. Attach your graph to this paper when you are asked to turn it in.

7. What observations can you make from your graph? What predictions in #4 were correct? Incorrect?

8. What was the depth of each of your sites? How did this affect the temperature changes?

A = _____ B = _____ C = _____ D = _____ E = _____

9. Did you observe any anomalies (data that did not fit the pattern)? Describe them.

10. What are some possible explanations for the anomalies? Did the weather account for any of the anomalies?

11. What is the most important information to share in asking the question: How does the temperature of your lake change over time?

12. What are some other questions that you might investigate about the Great Lakes using the type of data in this activity?

Satellite Image Introduction

Great Lakes Water Surface Temperature Images

Please read the following note carefully. It explains how the Great Lakes Temperature and Composite Maps are produced and how to read them properly. It is recommended that these images be used for general interest and educational purposes only!

The Great Lakes Maps are computed from NOAA polar orbiting satellite data on a weekly basis by the Climate Research Branch of Atmospheric Environment Service. The maps are actual navigated (georeferenced) digital images, registered by five visible and infrared channels of the Advanced Very High Resolution Radiometer (AVHRR) mounted on aboard the satellites. The original signal is processed to produce either false color Composite or Temperature maps.

Composite images are created by assigning three seperate colors (red, green and blue) to three AVHRR channels and subsequently combining them to create an image that resembles a color picture from an ordinary camera. Only one black and white infrared channel is applied for nighttime passes when visible channels become unusable. This type of image can be useful in determination of ice extent and movement, detection of certain particles suspended in the water, presence of fog, etc.

Water temperature maps are rpoduced from two infrared AVHRR channels, which are calibrated and applied in statistically modeled equations to account for atmospheric attenuation. In most cases the final result shows the temperature of the "skin" of the water surface usually with +/- 1 degree Celsius accuracy. For better visualization the temperature is ehhanced in a full range of colors and the scale is displayed in the upper right corner. Land and clouds are portrayed in a similar manner as in the Composite images and do not correspond to temperatures!

Cloud patches over the water destroy the validity of temperature estimates but usually can be easily distinguished. Sometimes however the presence of fog or low cloud is not so obvious from these images alone. If the temperature seems locally somewhat too low and fog/cloud was indeed identified from other sources like a concurrent Composite image, these readings should be discarded. This is most probable in Spring, but is not a frequent occurence, because most of the time such images are screened and rarely processed. Another situation to be aware of is the formation of ice late in Fall and in Winter that again can render somewhat lower readings.

Because of other priorities, there is usually a few days delay between the time of a satellite pass and the time of actual processing. Additional delays are possible during prolonged periods of cloudy conditions over the lakes, since thermal infrared radiation cannot penetrate through clouds. On average one pass, either temperature, composite or both, a week is produced and gives a good representation of the situation on the day the data were collected (refer to the date in the upper right corner). Since water surface temperatures normally do not fluctuate that much on a daily basis, these maps usually give an adequate overall pattern even a few days later. Locally, however, themperatures might be already dramatically different, especially if significant changes in weather have occurred in the meantime. For example strong Northwest winds after the passage of a cold front can quickly push the surface water on Lake Ontario towards the Southeast shore and bring much colder water from deeper layers to the surface along the Northwest shore.

All Water Surface Temperature Images can be downloaded from the following URL:

http://www.ag.ohio-state.edu/~earthsys/ese/GLtemperature/image.page.html#image.

Bathymetry maps can be downloaded from the following URLS:

Lake Erie: http://www.ag.ohio-state.edu/~earthsys/ese/GLtemperature/bathymetry/eriebath.gif
Lake Huron: http://www.ag.ohio-state.edu/~earthsys/ese/GLtemperature/bathymetry/huronbath.gif
Lake Michigan: http://www.ag.ohio-state.edu/~earthsys/ese/GLtemperature/bathymetry/michiganbath.gif
Lake Ontario: http://www.ag.ohio-state.edu/~earthsys/ese/GLtemperature/bathymetry/ontariobath.gif
Lake Superior: http://www.ag.ohio-state.edu/~earthsys/ese/GLtemperature/bathymetry/superiorbath.gif
Lake St. Clair: http://www.ag.ohio-state.edu/~earthsys/ese/GLtemperature/bathymetry/clairbath.gif

Weather Maps can be downloaded from the following URLS:

March 12, 1995: http://www.ag.ohio-state.edu/~earthsys/ese/GLtemperature/weather.maps/95031212.gif
March 24, 1995: http://www.ag.ohio-state.edu/~earthsys/ese/GLtemperature/weather.maps/95032412.gif
April 15, 1995: http://www.ag.ohio-state.edu/~earthsys/ese/GLtemperature/weather.maps/95041512.gif
April 23, 1995: http://www.ag.ohio-state.edu/~earthsys/ese/GLtemperature/weather.maps/95042312.gif
May 6, 1995: http://www.ag.ohio-state.edu/~earthsys/ese/GLtemperature/weather.maps/95050612.gif
May 13, 1995: http://www.ag.ohio-state.edu/~earthsys/ese/GLtemperature/weather.maps/95051312.gif
May 20, 1995: http://www.ag.ohio-state.edu/~earthsys/ese/GLtemperature/weather.maps/95052012.gif
May 26, 1995: http://www.ag.ohio-state.edu/~earthsys/ese/GLtemperature/weather.maps/95052612.gif
June 4, 1995: http://www.ag.ohio-state.edu/~earthsys/ese/GLtemperature/weather.maps/95060412.gif
June 15, 1995: http://www.ag.ohio-state.edu/~earthsys/ese/GLtemperature/weather.maps/95061512.gif
June 21, 1995: http://www.ag.ohio-state.edu/~earthsys/ese/GLtemperature/weather.maps/95062112.gif
July 13, 1995: http://www.ag.ohio-state.edu/~earthsys/ese/GLtemperature/weather.maps/95071312.gif
August 19, 1995: http://www.ag.ohio-state.edu/~earthsys/ese/GLtemperature/weather.maps/95081912.gif
Sept. 10, 1995: http://www.ag.ohio-state.edu/~earthsys/ese/GLtemperature/weather.maps/95091012.gif
Sept. 18, 1995: http://www.ag.ohio-state.edu/~earthsys/ese/GLtemperature/weather.maps/95091812.gif
Sept. 28, 1995: http://www.ag.ohio-state.edu/~earthsys/ese/GLtemperature/weather.maps/95092812.gif
October 13, 1995: http://www.ag.ohio-state.edu/~earthsys/ese/GLtemperature/weather.maps/95101312.gif
October 17, 1995: http://www.ag.ohio-state.edu/~earthsys/ese/GLtemperature/weather.maps/95101712.gif
October 26, 1995: http://www.ag.ohio-state.edu/~earthsys/ese/GLtemperature/weather.maps/95102612.gif

Note: This section on Great Lakes Water Surface Temperature originated from Environment Canada. The links above can be accessed electronically from http://www.ag.ohio-state.edu/~earthsys/ese/GLtemperature/image.page.html.

Great Lakes Ice Atlas, July 1983, Great Lakes Environmental Research Laboratory, Ann Arbor, Michigan 48104

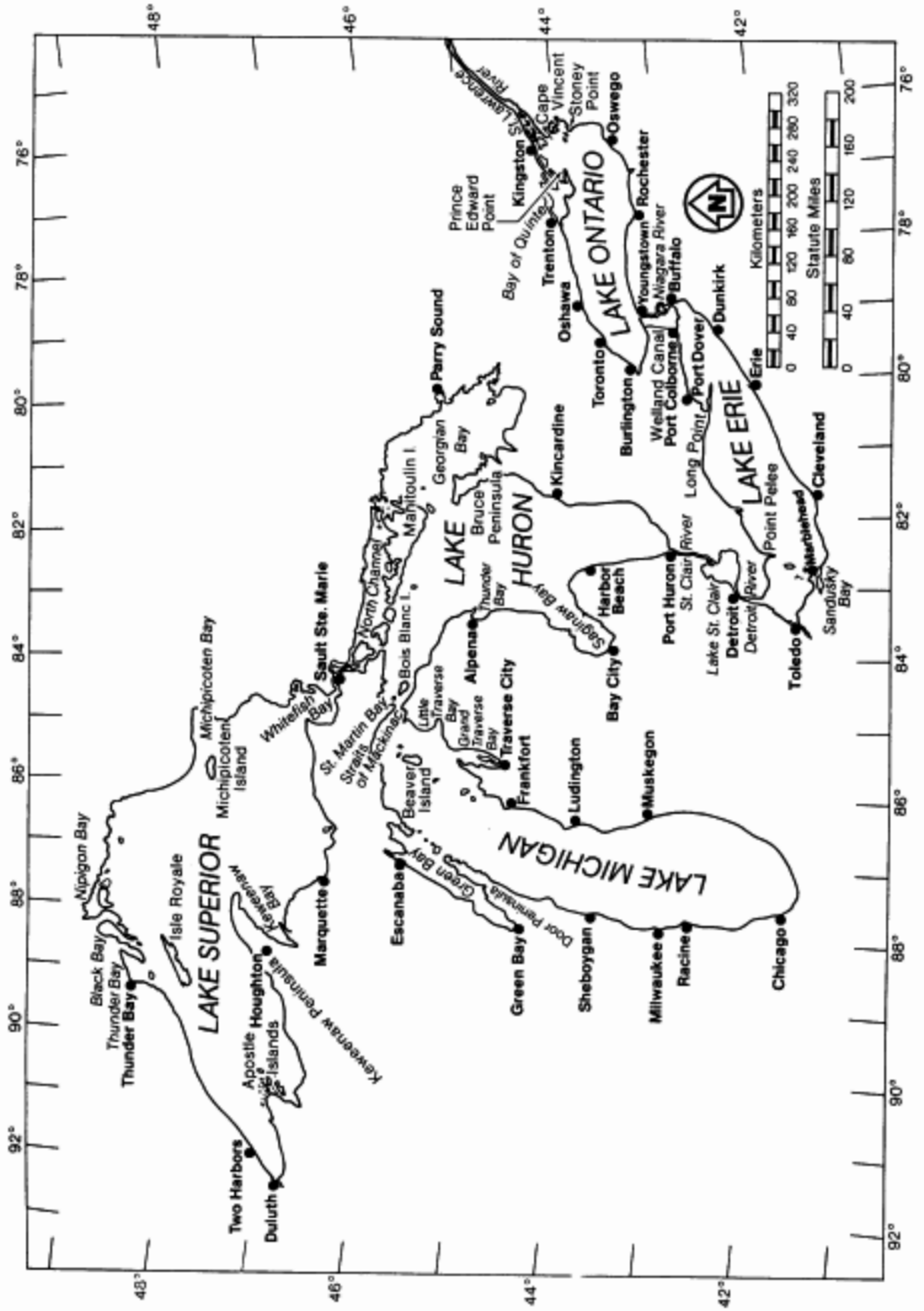


FIGURE 1. Place names on the Great Lakes.

Physical Data

Lake Erie

	Metric	Standard
Low water datum (LWD)	173.3 m	568.6 ft
Length	388 km	241 mi
Breadth	92 km	57 mi
Shoreline length	1,377 km	856 mi
Total surface area	25,657 km^2	9,910 mi^2
Surface area in U.S.	12,893 km^2	4,980 mi^2
Volume at LWD	483 km^3	116 mi^3
Average depth below LWD	19 m	62 ft
Maximum depth below LWD	64 m	210 ft
Average surface elevation (IGLD)	173.96 m	570.37 ft
Maximum surface elevation (IGLD)	174.69 m	572.76 ft
Minimum surface elevation (IGLD)	173.08 m	567.49 ft

Lake Huron

	Metric	Standard
Low water datum (LWD)	175.8 m	576.8 ft
Length	331 km	206 mi
Breadth	294 km	183 mi
Shoreline length	5,120 km	3,180 mi
Total surface area	59,500 km^2	23,000 mi^2
Surface area in U.S.	23,600 km^2	9,100 mi^2
Volume at LWD	3,537 km^3	849 mi^3
Average depth below LWD	59 m	195 ft
Maximum depth below LWD	229 m	750 ft
Average surface elevation (IGLD)	176.50 m	578.68 ft
Maximum surface elevation (IGLD)	177.49 m	581.94 ft
Minimum surface elevation (IGLD)	175.48 m	575.35 ft

Lake Michigan

	Metric	Standard
Low water datum (LWD)	175.8 m	576.8 ft
Length	494 km	307 mi
Breadth	190 km	118 mi
Shoreline length	2,670 km	1,660 mi
Total surface area	57,750 km^2	22,300 mi^2
Surface area in U.S.	57,750 km^2	22,300 mi^2
Volume at LWD	4,920 km^3	1,180 mi^3
Average depth below LWD	85 m	279 ft
Maximum depth below LWD	282 m	923 ft
Average surface elevation (IGLD)	176.50 m	578.68 ft
Maximum surface elevation (IGLD)	177.49 m	581.94 ft
Minimum surface elevation (IGLD)	175.48 m	575.35 ft

Lake Ontario

	Metric	Standard
Low water datum (LWD)	74.0 m	242.8 ft
Length	311 km	193 mi
Breadth	85 km	53 mi
Shoreline length	1,168 km	726 mi
Total surface area	19,000 km^2	7,340 mi^2
Surface area in U.S.	8,960 km^2	3,460 mi^2
Volume at LWD	1,637 km^3	393 mi^3
Average depth below LWD	86 m	283 ft
Maximum depth below LWD	245 m	802 ft
Average surface elevation (IGLD)	74.65 m	244.77 ft
Maximum surface elevation (IGLD)	75.66 m	248.06 ft
Minimum surface elevation (IGLD)	73.64 m	241.45 ft

Lake Superior

	Metric	Standard
Low water datum (LWD)	182.9 m	600 ft
Length	563 km	350 mi
Breadth	259 km	160 mi
Shoreline length	4,795 km	2,980 mi
Total surface area	82,100 km^2	31,700 mi^2
Surface area in U.S.	53,350 km^2	20,600 mi^2
Volume at LWD	12,230 km^3	2,935 mi^3
Average depth below LWD	149 m	480 ft
Maximum depth below LWD	407 m	1,333 ft
Average surface elevation (IGLD)	183.11 m	600.37 ft
Maximum surface elevation (IGLD)	183.63 m	602.06 ft
Minimum surface elevation (IGLD)	179.23 m	598.23 ft

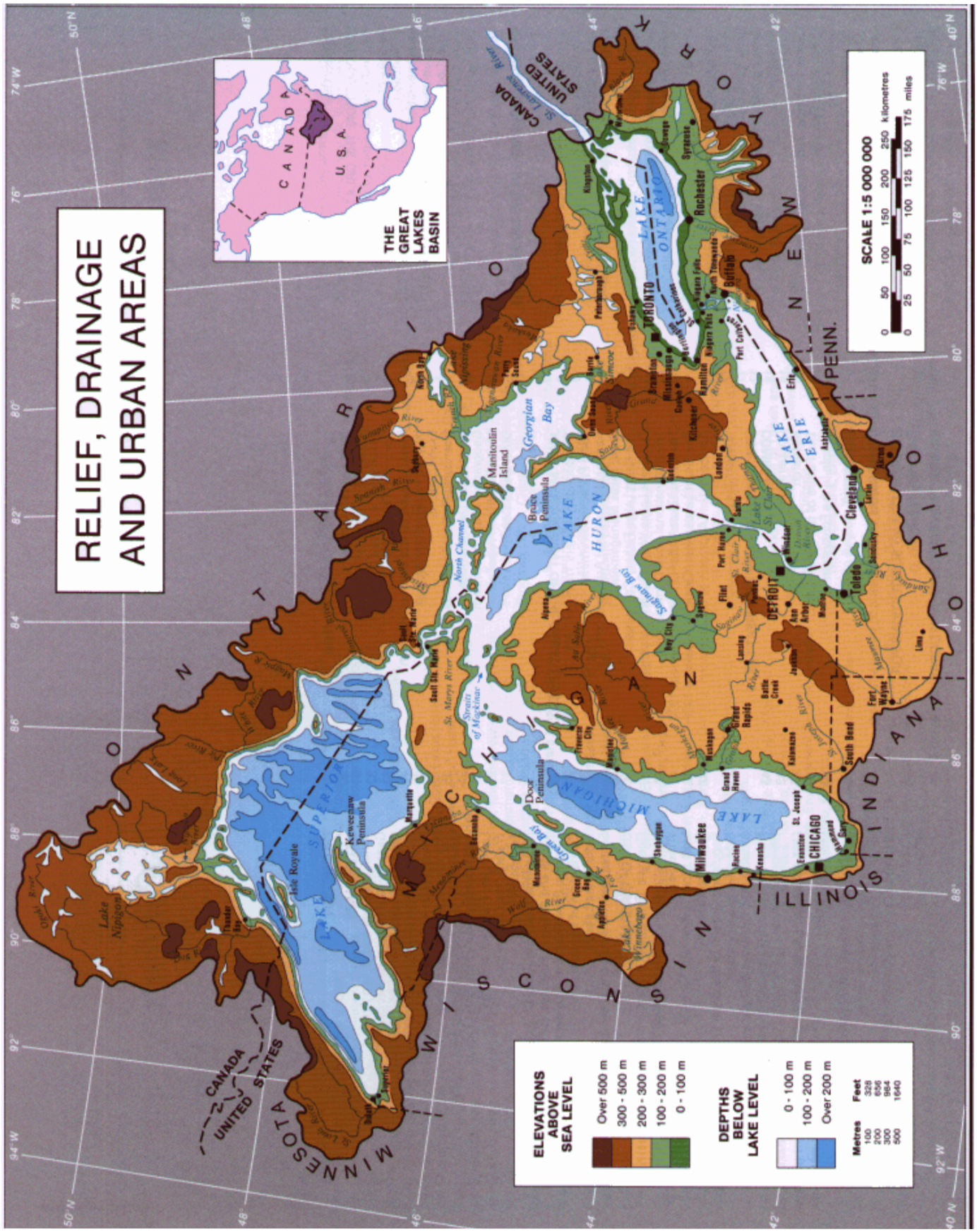


Figure 2. Great Lakes Basin Relief Map