Snowmaking—Great Lakes Style

Students living near the Great Lakes often feel the chill of lake-effect snowstorms. Students who have been introduced to weather basics can become familiar with the lakes' effect on winter storms through this mapping exercise. This activity compliments a weather and climate unit.

Grades: 5-8
Subject Areas: Weather, Science, Social Studies

The Great Lakes create a weather pattern nearly unique in the world. Lake-effect snowstorms occur in only three places in the world: around the Great Lakes (see map of snow belts), the east shore of Hudson Bay in Canada, and along the west coast of the Japanese islands of Honshu and Hokkaido.

Snowbelts caused by the lakes have a profound effect on people. Winter sports like skiing and snowmobiling are major industries in the snow areas. Snow removal costs in the cities have a high impact on taxes. Heavy snows affect transportation, retail businesses and individual lifestyles.

Procedure

1. Locate a large map of the Great Lakes area to pin on a bulletin board or tape to a wall. Make enough copies of the snowfall and snowbelt maps included in this exercise so that individual students or groups of students can refer to them.

2. Review what students learned about air temperature cooling rates over land and water in Activity 19, "How the Great Lakes Modify the Growing Season." Ask the students for their ideas on how the temperature difference between land and water might affect lake-edge snowfalls.

3. Have students complete the snowbelt worksheet individually or as a group.

4. Tape strips of masking tape on the wall to represent each of the snow depths as they appear on the map. Mark the strips of tape 20", 40", 60", 80", 100", 120", 140", 160" (or the equivalent in metric) and place at the appropriate heights, using the ceiling if necessary. Then help students use their Great Lakes maps to label each level with the names of cities and towns whose average snowfall come under each level. Be sure to include your own area's average snowfall (For the precise average contact the nearest weather service office or your provincial or state climatologist).

5. Read or present the information on "Causes of Lake Effect Snowstorms" and "Clues for Predicting Lake-Effect Snowstorms" found on the following pages. Students should have some preliminary information on how weather systems form and move.

6. Have students complete the Snowstorm Forecaster Worksheet.

7. Discuss the worksheet and their answers.

8. Discuss the impact of heavy snowfalls on people who live in snowbelt communities. The following questions might help:

- What kinds of businesses profit from snowstorms?
- What kinds of businesses lose money because of snowstorms?
- What do you think might be the consequences of lake effect snowstorms caused by city and industry pollution?
- What kinds of food crops can be grown in snowbelt areas? (Consult a world atlas and

agriculture resources maps for help with this one. North latitude will also have an effect).
- What do you suppose the Indians and Fur Traders did when they lived in these snow-belt areas before snowplows, furnaces and international food transportation? Use your imagination or search for answers at the library.
- What kinds of things do you do in a snow-storm that are different from what you do on a sunny day in May?
- What is good weather? What is bad weather?
- What difference does it make when the weather is bad? Is good?
- Have you ever heard someone predicting the weather with a rhyme? (Like: "Red sky in the morning, sailors take warning. Red sky at night, sailors' delight.") What kinds of information do people use in predicting the weather? How would you find out which kinds of information are most helpful? Least helpful?

Taking It Further

1. Have your students collect daily weather maps showing the movements of fronts for one month. Discuss how forecasts may be made. Collect the daily high and low temperatures for lakeshore and inland cities for March and April and show them on a graph. (Daily newspapers are a good source for this information.)

2. Television researchers have said that the local weather report on the 6 p.m. news is the most watched program of the entire day. Discuss this with your students and ask them to suggest reasons why this is so.

3. Ask students to list on the blackboard as many descriptive words for kinds of snow as they can think of. Compare this to the list of Ojibway terms for weather below. * Discuss the differences and ask students to suggest why there are differences.

Mājizōgipon - It starts to snow.

Bīsipon - The falling snow is in fine, tiny flakes.

Nokāgonagā - The falling snow is in very large clusters of flakes.

Zhakāgonagā - The falling snow is soft.

Zhākipon - The falling snow is watery.

Bikokwābīsipon - The falling snow is in round balls.

Gawagonaga - Frozen ice pellets falling.

Bīwan - The falling snow is in flurries.

Madjipo - The falling snow is driven by the wind.

Bimipo - The snow is ending.

Ishkwāzōgipon - The snow is ended.

Each type of snow was associated with particular weather and conditions and could be used to predict the weather to follow. According to the Weather Almanac 1975 from which these terms are reproduced, probably the most competent meteorologist today could not out-forecast the Ojibwe of old, if both were forced to rely only on signs available locally.

Source:
* Bruce F. Watson, *Minnesota and Environs Weather Almanac*, Freshwater Biological Research Foundation, Navarre, MN, 1974, pp. 5-7.

Snowbelt Worksheet

Comparing the snowfall map and the snowbelt map of the Great Lakes to a map of the Great Lakes Region, answer the following questions:

1. Estimate the average snowfall in the following places:
Erie, Pennsylvania _____
Toronto, Ontario _____
Calumet, Michigan (Upper Penn.) _____
Peterborough, Ontario (N. of Lake Ontario) _____
Boonville, N.Y. (east end of Lake Ontario) _____
Mancelona, Michigan (east end of Grand Traverse Bay) _____
Toledo, Ohio _____

2. Find your home town on the snowfall map and estimate the annual average snowfall _____

3. Using the snowbelt map, determine if your town falls within the lake-effect snowbelt? ___Y___N

Answers:

1. 60 in., 152 cm.
2. 60 in., 152 cm.
3. 160 in., 406 cm.
4. 60-80 in., 152-203 cm.
5. 130-160 in., 330-406 cm.
6. 120 in., 305 cm
7. 20-40 in., 51-102 cm

The Causes of Lake-Effect Snowstorms

by Val Eichenlaub *

The period from mid-August to the first of March is the "unstable season" on the Great Lakes. During this season the mean (average) temperature of the land is lower (colder) than the mean temperature of the water. The largest differences between the two occur from mid-November to mid-January. The differences may average over 15˚ F (-9˚ C) in the southern lakes and 30˚ F (-1˚ C) in the northern lakes.

When northerly winds bring Arctic air down across the lakes the contrasts in temperature can become much greater, as much as 40˚ F (4˚ C) in the south and 50˚ F (10˚ C) in the north. Such large temperature differences are the source of "weather."

As the cold air streams across the warm lakes, it is warmed and becomes more humid. As the air warms, it becomes less dense and rises. As it rises it cools. Whenever moist air rises, clouds may form and precipitation may result. After the air passes for some distance over the lake, convection and turbulent exchange have transported the moisture aloft to form clouds. Then snow might fall. (Figure 41)

As the warmed air reaches the shoreline, additional lifting may occur as the air begins to "pile up." The friction of land is higher than that of water, so winds slow as they move over land. Where there are hills and high lands on the down-wind shores of the lakes, air is forced upward, cooling it further and encouraging cloud formation and greater snowfall.

Usually the Arctic air necessary for large amounts of lake-effect snow to fall comes after a deep low pressure center (cyclone) has passed through or near the Great Lakes area. When the low moves through it opens the way for cold air to rush southward, usually in the form of a high-pressure area behind a cold front. Thus the snowfall usually occurs in conjunction with a rising barometer which measures air pressure.

Citieis may influence lake-effect storms too. Even small cities are warmer than their surrounding

areas. The air passing over large urban areas becomes warmed. This warmth may add to the heat acquired from the lakes and may occasionally provide a stimulus for development of lake-effect snowstorms.

Industries like steel mills may emit particles that act as ice-forming nuclei into the atmosphere. These may encourage snowstorms. The southern Great Lakes area is one of the world's leading centers for making iron and steel. Lead from automobile exhausts combines with the nautral iodine in the air to form lead-iodine compounds. These may also make it possible for ice crystals to grow. You can see that the large urban areas along the shores of the Great Lakes may, at times, play a role in creating or intensifying downwind lake-effect snowstorms through the additional heat and ice-forming nuclei which they supply.

Source:

* Val L Eichenlaub, *Weather and Climate of the Great Lakes Region*, University of Notre Dame Press, Notre Dam, Indiana, 1979, pp. 145-153. (Adapted and quoted by permission.)

Clues for Predicting Lake-Effect Snowstorms

The following are necessary conditions for lake-effect snowstorms. "Necessary" means they must be present for a storm to occur (except only one of 3 and 3A must be present).

1. **Large temperature difference between the lake and the air.** The greater the difference, the larger the potential for lake effect snow.

2. **High pressure cell (rising barometer) following a low pressure cell (falling barometer).** This situation provides favorable conditions for lifting the warm, moisture-filled air up for cooling and ice crystal formation.

3. **A long "fetch."** "Fetch" is the distance the wind travels over the open water surface. The longer the fetch, the greater the amount of heat and moisture which may be acquired from the lake. This results in a greater potential for lake effect snow. For example:

> NW wind travels almost 130 miles (210 km) across Lake Superior, 150 miles (242 km) across Lake Huron, but only about 30 miles (48 km) across Lake Erie.
>
> WSW wind travels 30 miles (48 km) across Lake Michigan, 60 miles (97 km) across Lake Huron, and nearly 130 miles (210 km) across Lake Erie.

OR

3A. **A "fetch" which passes over large industrial areas.** The air receives additional heat and ice-forming nuclei from the particulate matter in smoke and exhaust.

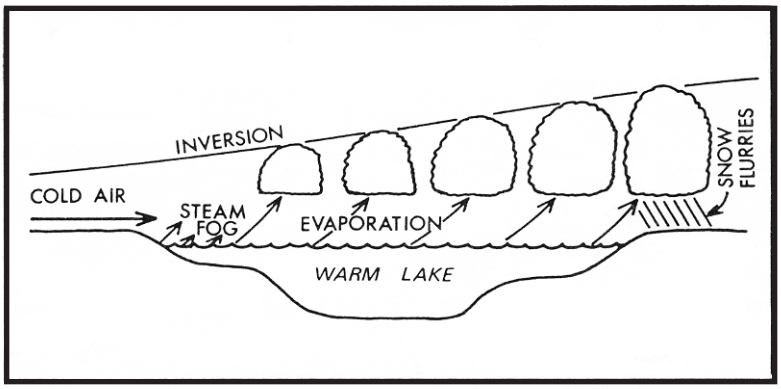


Figure 41 Modifications of Cold Air Crossing a Warm Lake

As the cold air streams across the warm lakes, it is warmed and becomes more humid. As the air warms, it becomes less dense and tends to rise, cooling [as it rises]. Whenever moist air rises, as previously noted, clouds may form and precipitation may result. Fog results from the intense evaporation or transfer of moisture from the warm water to much colder air when the cold air initially makes contact with the warm water. After the air passes for some distance over the lake, convection and turbulent exchange have transported the acquired moisture aloft to form clouds, and snowfall may occur.

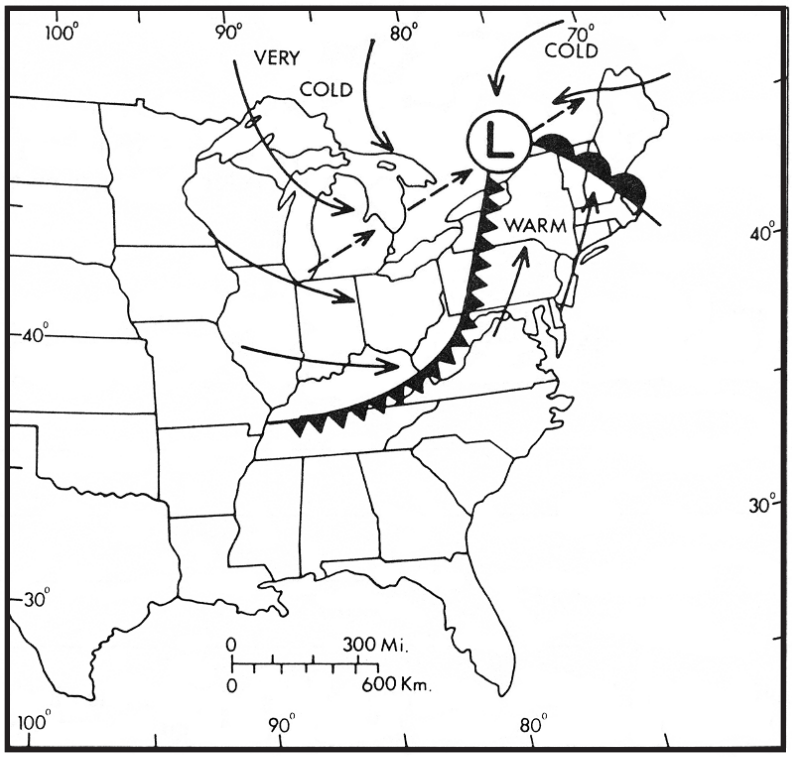
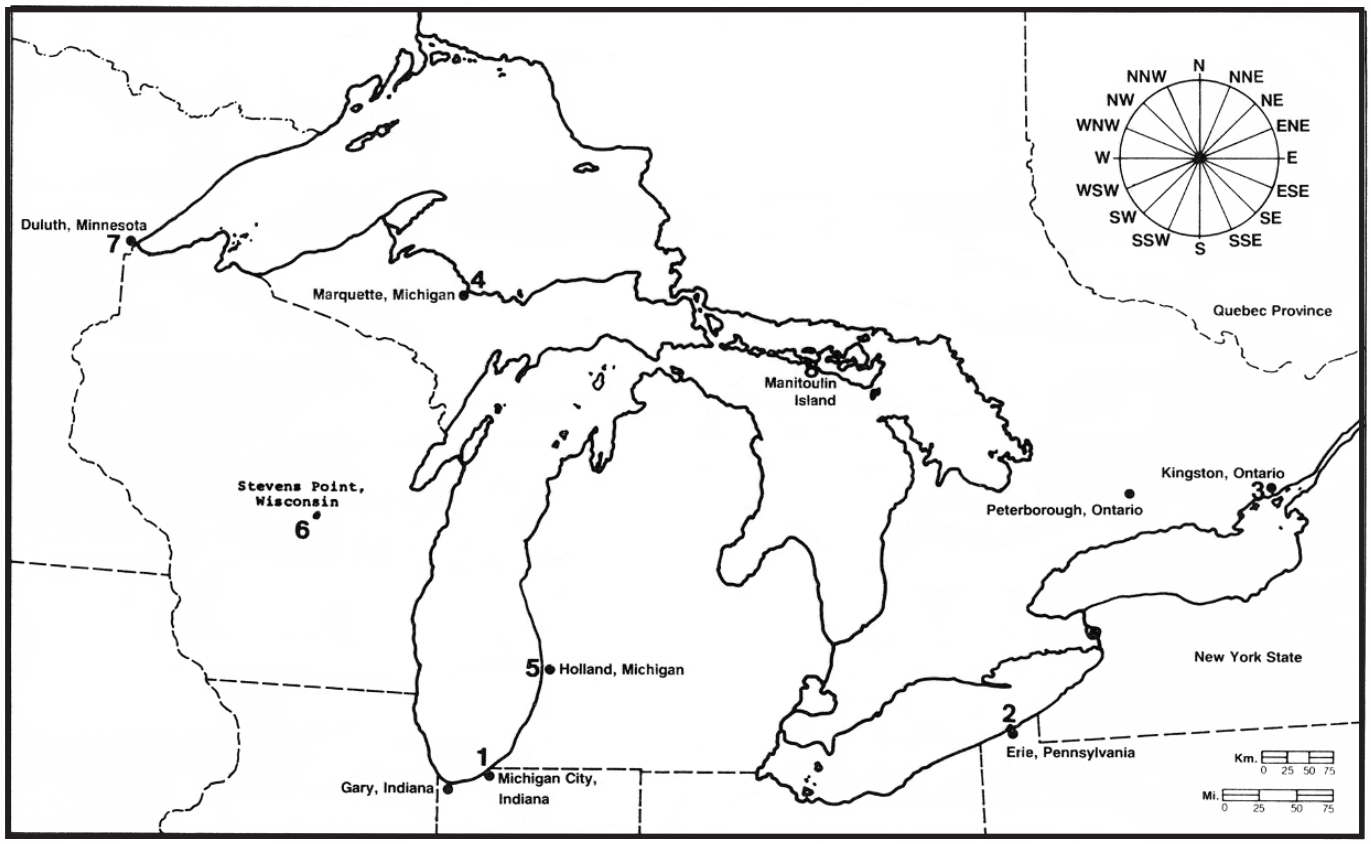


Figure 43 An Outbreak of Very Cold Air May Follow the Passage of a Cyclone through the Great Lakes

Source:

Val L. Eichenlaub, *Weather and Climate of the Great Lakes Region*, University of Notre Dame Press, Notre Dame, Indiana, 1979, p. 148, p. 150. (Used by permission.)

Snowstorm Forecaster Worksheet



Refer to the conditions for lake effect snowstorms and predict whether they will occur in the following situations. Give your evidence. (Hint: place a ruler on the compass line parallel to the wind direction given in the problem. Without changing its angle, slide it over until the ruler edge rests on the city given in the problem.)

1. You are in Michigan City, Indiana (1). The lake temperature is 33˚ F (.6˚ C). The air temperature is 2˚ F (-17˚ C). Winds are from the north at 12 mph (19kmph). A low pressure cell has moved east into New York State. The barometer is rising. Is a lake effect snowstorm likely ____ yes ____ no. Why or why not?

2. You are in Erie, Pennsylvania (2). The lake temperature is 33˚ F (.6˚ C). The air temperature is 30˚ F (-1˚ C). Winds are from the south, light and variable. A high pressure cell has just moved east into New Jersey. Barometer is steady. Is a lake effect snowstorm likely ____ yes ____ no. Why or why not?

3. You are in Kingston, Ontario (3). The lake temperature is 33˚ F (.6˚ C). The air temperature is 20˚ F (-7˚ C). Winds are from the Southwest, 9 mph (15 kmph). The barometer is falling and a low pressure cell is located just west of you over Peterborough, Ontario. Is a lake effect snowstorm likely? ____ yest ____ no. Why or why not?

4. You are at Marquette, Michigan (4). The lake temperature is 33˚ F (.6˚ C). The air temperature is -10˚ F (-30˚ C). Winds are out of the north, 20 mph (32 kmph). The barometer is rising. Is a lake effect snowstorm likely? ____ yes ____ no. Why or why not?

Would you expect light, moderate. or heavy snowfall? Why?

5. You are at Holland, Michigan (5). The lake temperature is 32˚ F (0˚ C). The air temperature is 12˚ F (-11˚ C). Winds are out of the southwest. They carry arctic air due to the position of a large high pressure cell over central Michigan. The winds pass over Gary, Indiana. The barometer is rising. Is a lake effect snowstorm likely? ____ yes ____no. Why or why not?

6. You are at Stevens Point, Wisconsin (6). The lake temperature is 32˚ F (0˚ C). The air temperature is 10˚ F (-12˚ C). Winds are out of the northwest at 8 mph (13 kmph). Barometer is rising. Is a lake effect snow storm likely? ____ yes ____ no. Why or why not?

7. You are at Duluth, Minnesota (7). The lake temperature is 32˚ F (0˚ C). The air temperature is -8˚ F (-31˚ C). The winds are out of the northwest at 18 mph (29 kmph). Barometer is steady. Is a lake effect snowstorm likely? ____ yes ____ no. Why or why not?

8. You are on Manitoulin Island. The lake temperature is 60˚ F (16˚ C). The air temperature is 75˚ F (24˚ C). Low pressure has just moved east over Quebec Province. High pressure is over Lake Michigan. Winds are from the west north west at 5 mph (8 kmph). Is a lake effect snowstorm likely? ____ yes ____ no. Why or why not?

9. Add a question using your own city or town:

Answers:

1. Yes. High temperature difference, rising barometer, long fetch.
2. No. Winds from the south would not cross a lake to reach Erie, PA. The temperature range is too narrow.
3. No. Low pressure is west of Kingston. It must be east and followed by high pressure.
4. Yes. There is a very wide temperature difference and a long fetc. Expect heavy snow for the same reasons.
5. Yes. The fetch over the lake is not long but there is a fetch over the industrial area of Gary, Indiana. This adds heat and ice-forming nuclei to the air.
6. No. Stevens Point, Wisconsin, is not on a lake.
7. No. Winds don't pass over water to reach Duluth.
8. No. It's summer, silly!

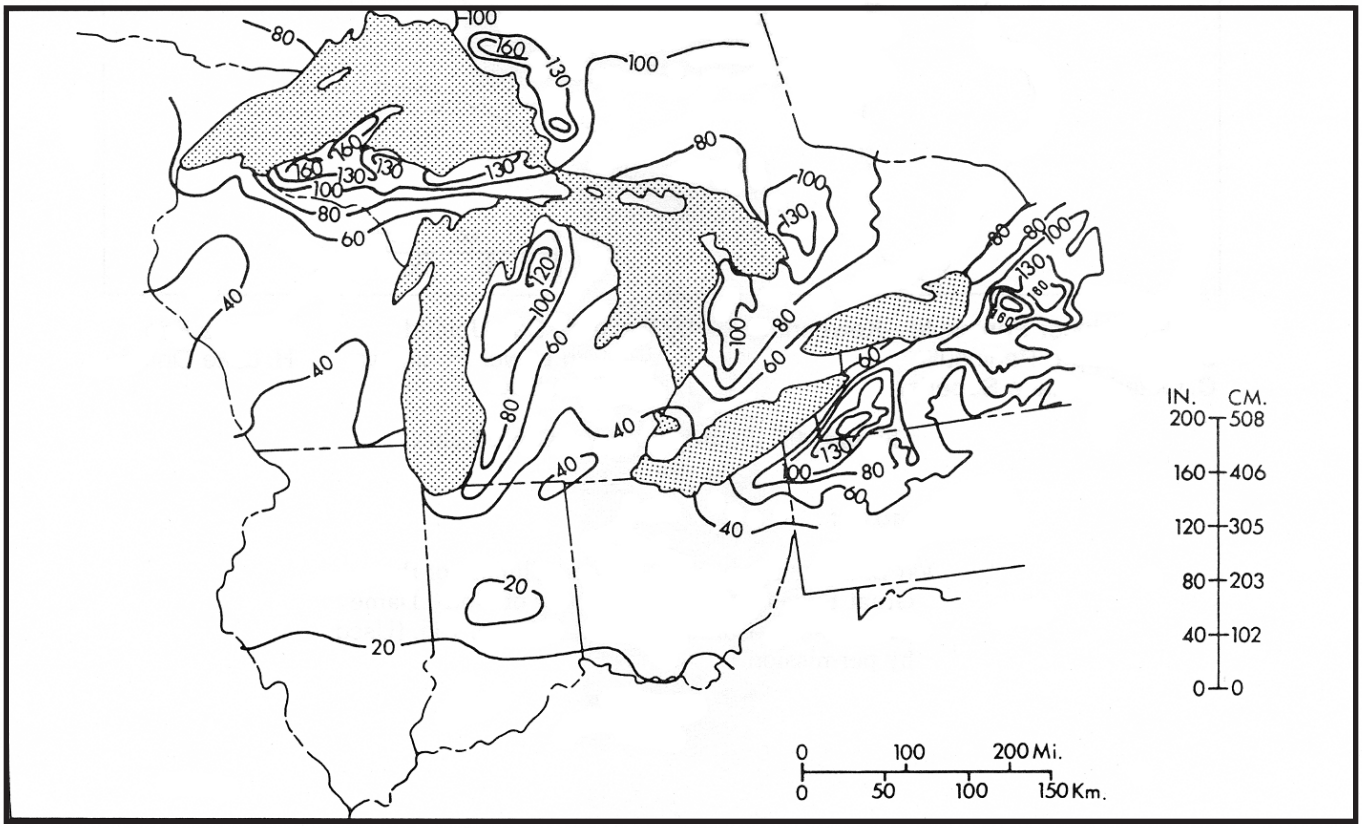
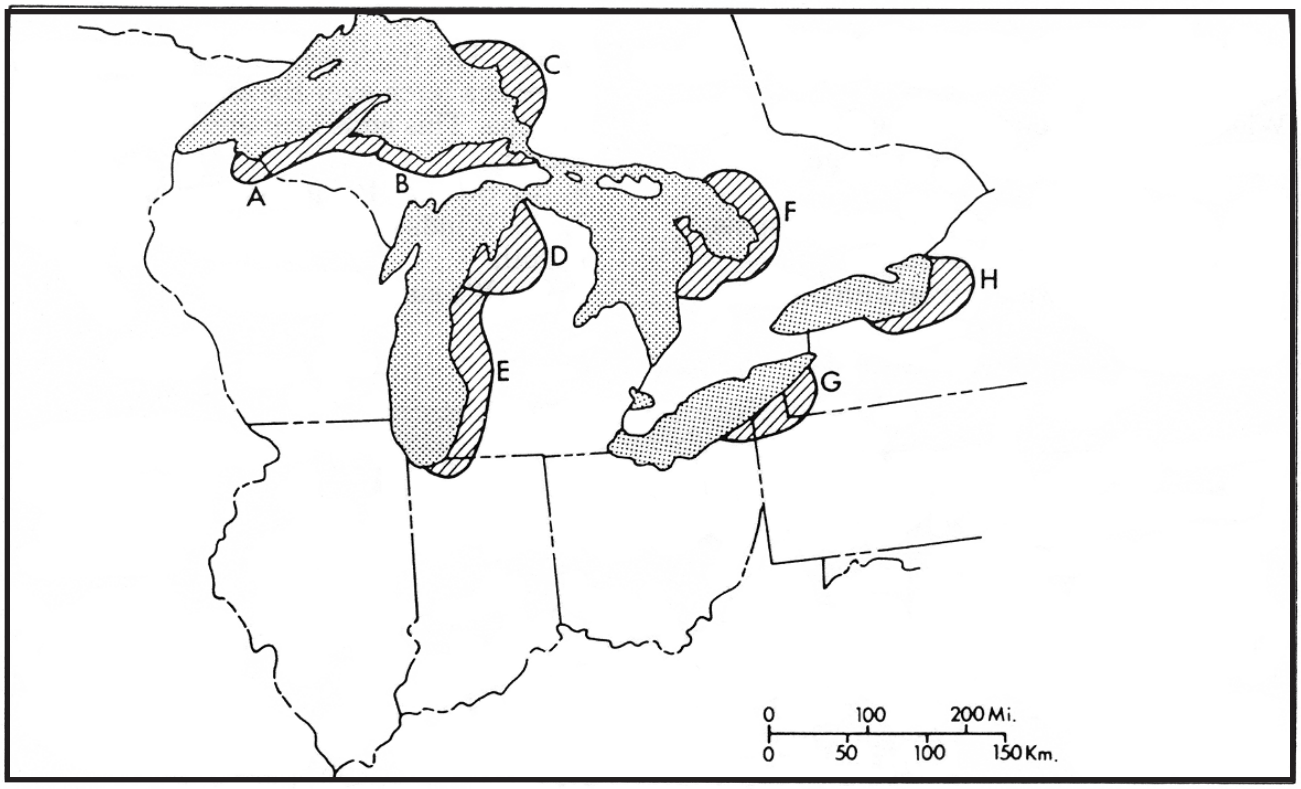


Figure 47 Mean Annual Snowfall in the Great Lakes Area (in inches)

Source:

Val L. Eichenlaub, *Weather and Climate of the Great Lakes Region*, University of Notre Dame Press, Notre Dame, Indiana, 1979, p. 162. (Used by permission.)



A. West Upper Peninsula—Keweenaw
B. East Upper Peninsula
C. Ontario—Lake Superior
D. Traverse Bay Upland
E. Western Lower Peninsula
F. Georgian Bay
G. Lake Erie
H. Lake Ontario

Figure 48 Snowbelts of the Great Lakes

Source:

Val L. Eichenlaub, *Weather and Climate of the Great Lakes Region*, University of Notre Dame Press, Notre Dame, Indiana, 1979, p. 165. (Used by permission.)