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Climatology and Weather Services of the St. Lawrence Seaway and Great Lakes

Prepared by

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INTRODUCTION

Completion of the St. Lawrence Seaway opens the Great Lakes to deep-draft, oceangoing vessels for the first time. This publication is intended to familiarize masters, mates, and steamship company officials of vessels now plying the waterway and those who will, in the future, come to use the expanded facilities, with weather conditions and available weather services in the area. The elements described are primarily those affecting ship operations.

The area covered includes the St. Lawrence River from Quebec to Lake Ontario and all the Great Lakes. Climatology of the sea approaches to the St. Lawrence River and from the mouth of the river to Quebec can be found in U. S. Navy Hydrographic Office Publications No. 73 "Sailing Directions for Newfoundland" and No. 100 "Sailing Directions for the Gulf and River St. Lawrence".

Climatological tables for major ports and a list of warning display stations appear in the appendix. A station location chart is shown in figure 1.

ACKNOWLEDGMENTS

This climatic summary of the Great

Lakes and the St. Lawrence River area was compiled in the Marine Section of the Office of Climatology, U. S. Weather Bureau by Messrs. A. Cooperman, G. Cry, and H. Sumner. The compilers are indebted to Dr. H. E. Landsberg who was instrumental in initiating the project and who has provided guidance during preparation of the material.

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GENERAL DESCRIPTION

The St. Lawrence River system, composed of an estuary and a chain of five major interconnected lakes, forms a natural transportation route from the sea almost 2000 mi. into the middle of the North American continent. The entire system has a water surface area of over 95,000 sq. mi., more than 8300 mi. of shoreline, and a drainage area of some 325,000 sq. mi. The region bordering this great inland waterway is notable for its industrial development and for the magnitude of its natural and agricultural resources.

The estuary of the St. Lawrence begins at the western end of Anticosti Island, near 64°30'W. The river here is

some 70 mi. wide, narrowing to 24 mi. at Point des Monts, to 8 mi. at the foot of Orleans Island, and to 1/4 mi. near Quebec. The lower portion of the river, below Quebec, is bounded on both sides by mountain ranges. From Quebec to Montreal the river averages 2 1/3 mi. wide, reaching a maximum of 7 1/4 mi. in Lake St. Peter. This lake is shallow but by dredging here and in other shoal sections a 35-ft. channel is maintained from Montreal to the sea. The shores in this area are comparatively low [2].

From Montreal to Lake Ontario the natural river consists of a series of relatively shallow lakes connected by rapids and shallows. The St. Lawrence Seaway

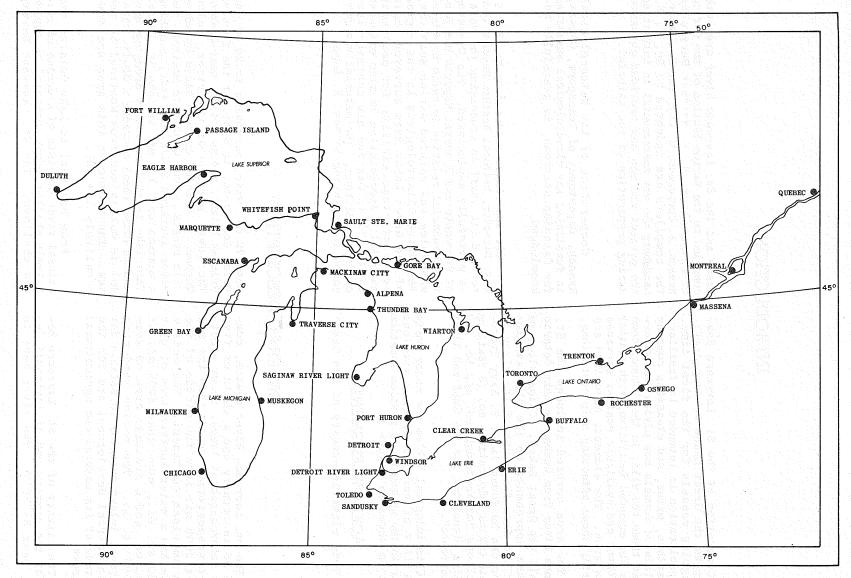


Figure 1. Station location chart of the St. Lawrence Seaway and Great Lakes.

Project, undertaken jointly by the governments of the United States and Canada has provided a navigation control channel at least 450 ft. wide and 27 ft. deep, with a series of 7 locks 800 ft. x 80 ft. x 30 ft., giving a total lift of 225 ft. through this section into the Great Lakes. The major works constructed to provide this access depth, which will make possible operation of some 80 percent of the cargo ships of the world in the Seaway are: 1) Lachine Canal and Locks; 2) Beauharnois Canal and Locks; 3) Wiley-Dondero Ship Channel and Locks, Long Sault Dam and St. Lawrence Power Dam; 4) Iroquois Dam and Lock.

Lakes St. Louis and St. Francis have also been dredged and some shoal areas in the river cleared [14].

The upper St. Lawrence, west of Iroquois, provides a natural channel of deep water through which navigation is unrestricted to Lake Ontario. This easternmost lake of the Great Lakes chain is also the smallest, with a water surface area of 7520 sq. mi. and a drainage basin of 34,800 sq. mi.[11].

The Welland Canal provides the navigation connection between Lakes Ontario and Erie across the Niagara Peninsula. This canal is 27.6 mi. long with 7 locks 800 ft. x 80 ft. x 30 ft. totaling 327 ft. of lift. As a part of the St. Lawrence Seaway project the Canadian government has dredged the canal to the 27-ft. standard depth [14].

Lake Erie is the second smallest of the Great Lakes, with a water surface area of 9930 sq. mi. and a drainage basin of 32,490 sq. mi. In contrast to the other Lakes, which have depths of at least 750 ft., Lake Erie is shallow, reaching a maximum depth of only 210 ft., and over half the area is less than 100 ft. in depth.

The connection between Lakes Erie and Huron is through the Detroit River, Lake St. Clair, and the St. Clair River. The lower Detroit River is broad, with many islands and shallow expanses, while the upper portion is generally deep. Lake St. Clair is an extensive (490 sq. mi.) shallow basin having a maximum depth of about 21 ft. The St. Clair River is generally shallow with several shoal and rapid areas [11].

Extensive rock excavation and dredging have been completed and more work is pro-

ceeding under the direction of the U. S. Army Corps of Engineers to provide a 27-ft. channel throughout this entire area between Lakes Erie and Huron [14].

Lakes Huron and Michigan are, in effect, only one lake. The connection through the Straits of Mackinac is so broad and deep that no flow is perceptible between the two lakes and their surfaces stand at the same level [12]. Lake Huron with a surface area of 23,010 sq. mi. and drainage area of 72,620 sq. mi. is the connecting link in the chain of the Great Lakes. It receives the waters of Lake Superior through the St. Marys River and those of Lake Michigan through the Straits of Mackinac. Lake Michigan has a surface area of 22,400 sq. mi. and a drainage area 67,860 sq. mi. and is the only one of the lakes completely within the United States.

The St. Marys River provides the connection between Lakes Huron and Superior. There are five locks, known as the Soo (or St. Marys Falls Ship Canal) Locks in the river. Extensive dredging and construction are being done in this region to provide a 27-ft. channel.

Lake Superior, with a surface area of 31,820 sq. mi. and a drainage area of 80,000 sq. mi. is the largest and deepest (1302 ft.) of the Great Lakes, and, in fact, is one of the largest expanses of fresh water in the world [11].

The edges of the present Great Lakes embrace almost every type of shoreline feature. Lake Superior is characterized by high and rocky shores along a large portion of its coast. The shorelines of the other lakes are, in general, bordered by flat plains which were portions of their bottoms during the time when the great continental glaciers formed their northern or northeastern shores. Sands of glacial origin, later modified by wave action, have been redeposited by the winds in large sand dunes, especially on the eastern and southern shores of Lake Michigan.

In various areas waves have undercut steep cliffs, worn terraces in the rock or glacial drift, and built terraces of loose material on the beaches. In other sections undertow and shoreline currents have deposited and redeposited sands in the shape of sandbars, spits, hooks, and barrier beaches [1].

CLIMATOLOGY

CYCLONES

The location of the Great Lakes in the interior of the North American continent between the source regions of contrasting polar and tropical air masses gives the region more rapidly changing and complex weather patterns than those of more maritime locations. The interaction of the air masses along the polar front produces LOWS or cyclonic storms which usually move toward the Great Lakes under the influence of the general westerly circulation. Over the oceans, areas of cyclogenesis or storm formation remain in relatively fixed locations. Larger seasonal changes in the heat and moisture characteristics of the land surface, and consequently greater modification of air mass properties as compared with the oceans, produce more variable areas of cyclogenesis over land. In addition, the complex relationships of, and sharper contrasts between, southward moving polar air and northward moving tropical air over the continent can produce extremely rapid deepening of LOWS over the Middle West. The development of a storm of major proportions sometimes occurs within less than 24 hr. Such rapid developments have resulted in extreme alertness on the part of the forecaster to provide adequate warning for shipping in the Great Lakes. Severe weather is made more serious on the Great Lakes by a lack of maneuvering room for vessels.

The Great Lakes area is at the junction of the paths of LOWS from several areas of cyclogenesis in the western portion of the continent. Figures 2 to 7 depict the tracks of a selected group of severe storms designed to illustrate the various paths followed by the more intense LOWS during the navigation season. The complete frequency of LOWS in the Great Lakes area is not portrayed.

November is usually the month of the most frequent severe weather during the season. The energy required for the development of large intense storms is released as sharper contrasts between the polar and tropical air over the continent develop. A secondary factor in the intensity of November storms is the heat energy supplied by the relatively warm open waters of the Great Lakes.

The usual sequence of weather conditions associated with the passage of a LOW depends greatly upon the location of

the observer with respect to the path of the center. For vessels located south of the path the approach of the LOW is indicated by a falling barometer, a wind shift to south or southeast, a gradually lowering cloud level, and drizzle, rain, or snow. The wind veers at the warm front and precipitation diminishes as the temperature rises. During passage of the warm sector, temperatures and pressure remain about the same. The skies are clear to partly cloudy and the warm air is moist, with haze or fog often present.

The passage of the cold front is generally marked by the approach from the west of a bank of convective clouds, a rapid veering of the wind to west or northwest, sometimes sudden squalls and heavy showers often accompanied by thunder and lightning. After the passage of the cold front the pressure rises quite rapidly, visibility improves, and the clouds usually diminish.

North of the center the rapid changes in the weather sequence found south of the center do not occur. The winds in front of the LOW back from easterly through north to northwest but changes in direction are not sudden. The weather conditions vary gradually from those found ahead of the warm front to those behind the cold front.

The more destructive storms on the Great Lakes usually come from a southwesterly direction. These LOWS originally form in three areas: 1) Texas and New Mexico (figure 2); 2) the Central Rocky Mountains and Great Plains (figure 3); and 3) the Pacific Southwest (figure 4). The movement of storms from all three regions is similar, from the Middle West to the Great Lakes. The season for storms from these regions is generally from October through May.

East and northeast winds usually begin from 12 to 24 hr. prior to the approach of a storm center moving from the southwest. As the storm moves into the middle Mississippi Valley, the barometer falls rapidly, and winds over the lakes increase gradually to gale force. With the closer approach of the LOW, winds continue to increase in speed, backing to the left and veering to the right of the storm track. With the passage of the LOW center and cold front, winds shift suddenly to the northwest and

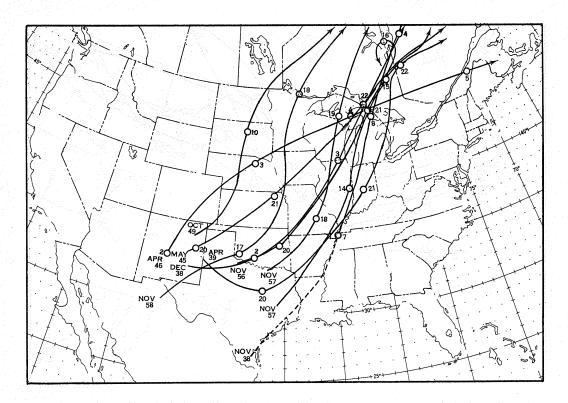


Figure 2. Great Lakes storms originating in the Texas-New Mexico region. Circles give location of storm center at 7:00 a.m. EST of date shown.

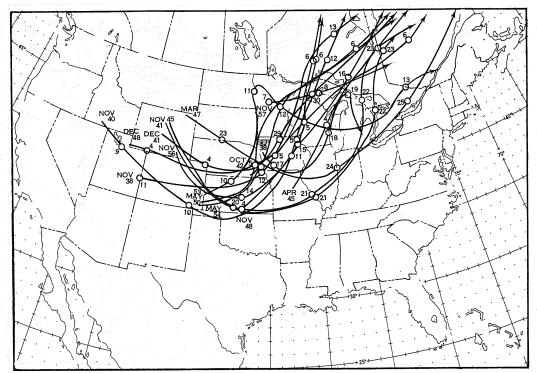


Figure 3. Great Lakes storms originating in the Central Rocky Mountains and Great Plains region. Circles give location of storm center at 7:00 a.m. EST of date shown.

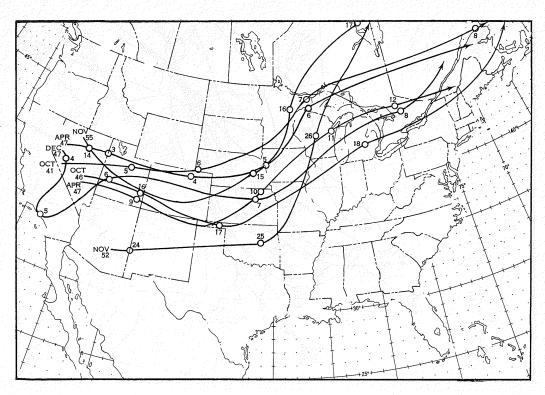


Figure 4. Great Lakes storms originating in the Pacific Southwest region. Circles give location of storm center at 7:00 a.m. EST of date shown.

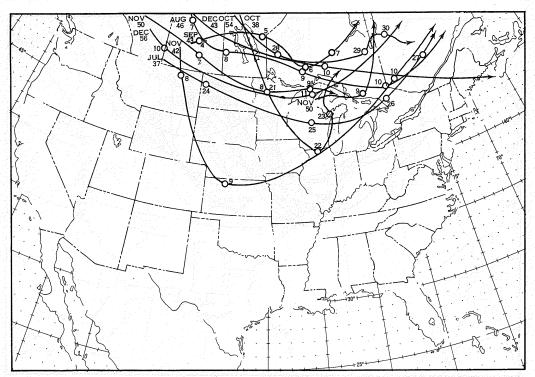


Figure 5. Great Lakes storms originating in the Western Canada region. Circles give location of storm center at 7:00 a.m. EST of date shown.

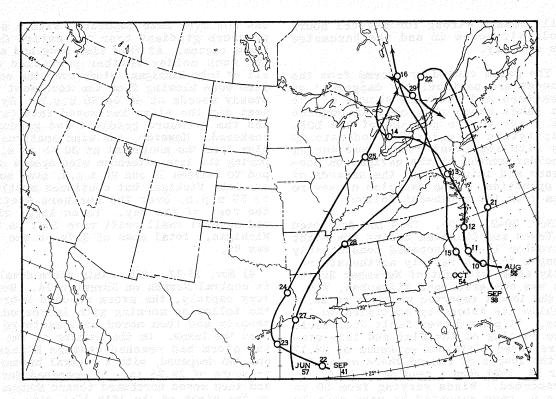


Figure 6. Great Lakes storms of tropical origin. Circles give location of storm center at 7:00 a.m. EST of date shown.

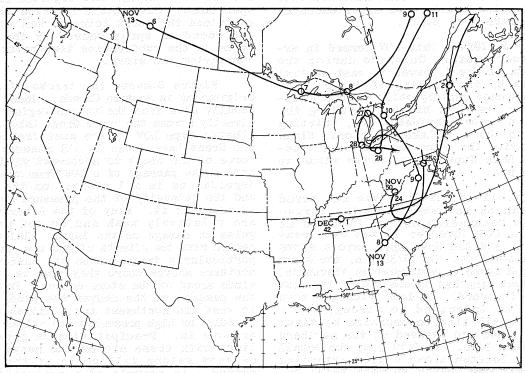


Figure 7. Great Lakes storms originating in the Eastern United States.

Circles give location of storm center at 7:00 a.m. EST of date shown.

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usually remain strong for several hours as cold air moves in and the barometer rises rapidly.

The gales caused by storms from the southwest are particularly dangerous on the western and southern shores of the Great Lakes where they come as onshore winds prior to the passage of the LOW. Precipitation is generally moderate to heavy with southwest storms and during the colder months of the navigation season snow and icing add to the hazards of ship operation. Some examples of severe storms from the southwest follow:

- 1) Nov. 20-21, 1956. This LOW developed over Texas and Oklahoma during the night of November 19-20, deepened considerably and began to move rapidly northeastward. Shortly after midnight of November 20 the storm was centered near Milwaukee, Wis., with the lowest reported pressure as 29.29 in. while its intensity continued to increase. It passed over Sault Ste. Marie on the morning of the 21st and this station reported a minimum pressure of 28.77 in., the lowest of record there since December 14, 1920 when a reading of 28.67 in. was recorded. Winds varying from 50 to 60 m.p.h. were reported by many vessels underway on the lakes. High waves resulting from the strong winds made navigation difficult on eastern Lake Superior and low water levels were experienced at western Lake Erie ports.
- 2) May 5, 1950. This LOW formed in extreme southeastern Colorado during the afternoon of May 4, moved to east-central Nebraska by the morning of May 5. The storm deepened rapidly while moving northward over Iowa and Minnesota during the 5th, then turned northeastward, skirting the north shore of Lake Superior. Winds accompanying the storm were severe. Vessels in Lake Superior reported winds up to 62 m.p.h.
- 3) Nov. 11-12, 1940. This LOW moved from Utah on November 9 to the Texas-Oklahoma Panhandles on the 10th and at 6:30 a.m. CST November 11 was over central Iowa and had developed into a storm of great severity. By 12:30 p.m. the storm center had moved to southwestern Wisconsin, and at that time had become one of the most severe of record. On Lake Michigan wind speeds had increased to strong, and a severe squall line accompanied by winds of gale force had arrived at the southern end of this lake. At 6:30 p.m. the squall line was located along a line extending from Sault Ste. Marie to near Erie, Pa. It had moved 350 mi. in 6 hr., being rotated around the severe storm center that

was now over Lake Superior, with a steep pressure gradient over the entire Great Lakes region. At this time snow and sleet and much colder weather prevailed over all of Lake Michigan; winds over the entire lake were blowing from the southwest with steady speeds of 40 to 60 m.p.h. By the next day the storm had moved into Canada and the pressure gradient had gradually weakened. However, the wind continued to blow from the southwest at 30 to 50 m.p.h. During the late afternoon wind speeds dropped to between 18 and 25 m.p.h. over southern Lake Michigan but continued mostly 25 to 35 m.p.h. over the northern sections the rest of the day. Three large ships and several small craft were lost on Lake Michigan. Total loss of life on the lake was 69.

4) Nov. 16-17, 1955. This storm developed in central Nevada on November 14. Moving very rapidly, the storm reached Nebraska the following morning with increased intensity and then moved northeastward toward the lakes. On the morning of the 16th the storm had reached eastern Minnesota and had deepened, with a central barometric pressure of 29.24 in. It deepened further and then moved northward toward Hudson Bay on the night of the 16th-17th with a central pressure reported as 28.89 in. During the night of the 16th-17th winds varying from 50 to 70 m.p.h. were reported from the open lakes. One Captain reported his ship sustained the worst icing he had ever experienced as spray caused by the winds froze in the subfreezing temperatures accompanying the storm.

Figure 5 shows the tracks of storms originating in western Canada. These storms usually move from the source region almost directly across the upper Great Lakes. This Alberta type LOW is the most frequent in the Great Lakes area in all seasons. force of the south to southwest winds preceding the passage of a LOW from this area depends, as in all storms, on the depth and the intensity of the pressure gradient surrounding it. Many of the Alberta LOWS are relatively weak and do not produce gales or damage on the lakes. Gales connected with the Alberta storms are, however, particularly dangerous on the eastern and northern shores where they come as onshore winds ahead of the storm center. Following the passage of the center the winds shift to west and northwest and diminish rather rapidly, as high pressures and colder weather move in. Precipitation is generally light with these storms and heavy rains or snow seldom fall south of the storm center. An example of a severe Alberta storm is that of October 28-29, 1954. LOW was centered over northern Manitoba

TABLE 1

STORM DATES WINDS AND REMARKS

TEXAS AND NEW MEXICO (FIG	THE 2) THE PROPERTY OF A PARTY OF A EWILTHORN THOOR WHETERS .
November 17-18, 1958	CARL D. BRADLEY lost in storm, 33 lives lost. 60 m.p.h. over Lakes Michigan and Superior - gusts to 75 m.p.h.
November 14-15, 1957	40 to 45 m.p.h. over Lake Superior, 55 to 60 m.p.h. over Lake Erie.
November 18-19, 1957	45 to 55 m.p.h. over Lake Michigan, over 40 m.p.h. over Lake Ontario.
November 20-21, 1956	50 to 60 m.p.h. over all lakes. Pressure 28.77 in. at Sault Ste. Marie - lowest since 1920. Low water in western Lake Erie.
October 9-10, 1949	60 to 70 m.p.h. general over Lakes Superior and Michigan. Reported 102 m.p.h. and 12-ft. waves at Superior, Wis.
April 4, 1946	50 m.p.h. on Lake Michigan and 40 to 50 m.p.h. on Lake Erie.
May 21-22, 1945	In excess of 50 m.p.h. reported by vessels in the upper lakes.
April 1, 1939	40 to 55 m.p.h. over Lake Erie.
November 7-8, 1938	40 to 50 m.p.h. over Lakes Michigan and Huron.
December 2-3, 1938	40 to 50 m.p.h. over Lakes Huron, Erie, and Ontario.
CENTRAL ROCKY MOUNTAINS	AND GREAT PLAINS (FIGURE 3)
November 8, 1957	Above 60 m.p.h. at Duluth and Buffalo, 40 to 50 m.p.h. on all the lakes.
November 15-16, 1956	40 to 50 m.p.h. on all the lakes.
May 10-11, 1953	HARRY STEINBRENNER sank with 17 lives lost. 45 to 60 m.p.h. over Lake Superior.
May 5, 1950	Dock facilities destroyed at Superior, Wis. Winds at Superior were 62 m.p.h., gusts to 92 m.p.h., at Milwaukee 72 m.p.h., at Green Bay 109 m.p.h.
November 4-6, 1948	40 to 50 m.p.h. over the upper lakes.
	45 to 50 m.p.h. over lower lakes, 60 m.p.h. over upper lakes.
March 25, 1947	Up to 55 m.p.h., above gale force for 20 hr. on Lake Erie.
	Above 60 m.p.h. over central lakes.
November 22, 1945	45 to 50 m.p.h. over Lake Superior, 35 to 40 m.p.h. over the lower lakes.
	45 to 50 m.p.h. over Lake Michigan, 30 to 35 m.p.h. over the lower lakes.
November 21-22, 1941	

TABLE 1 (cont.)

STORM DATES

WINDS AND REMARKS

CENTRAL ROCKY MOUNTAINS AND GREAT PLAINS (FIGURE 3) (cont.)

December 5, 1941 40 to 50 m.p.h. over the upper lakes, 50 to 60 m.p.h. over the lower lakes.

November 11-12, 1940

One of most severe storms. Winds 60 m.p.h. over a large area, up to 80 m.p.h. over Lakes Michigan and Huron. Severe snow and cold wave. Three large ships and several small craft lost on Lake Michigan, 69 lives lost.

September 18-19, 1938 35 to 40 m.p.h. over the upper lakes.

November 12-13, 1938 35 to 45 m.p.h. over Lake Michigan, 40 to 55 m.p.h. over Lake Erie.

PACIFIC SOUTHWEST (FIGURE 4)

November 16-17, 1955 Above 60 m.p.h. over Lakes Michigan, Huron, and Erie. Severe icing.

November 26, 1952 Up to 60 m.p.h. over Lakes Michigan, Huron, and Erie.

April 5-6, 1947 Up to 60 m.p.h. over Lake Michigan, 50 m.p.h. over Lake

Erie.

April 11, 1947 35 to 40 m.p.h. over the eastern lakes.

December 7-8, 1947 35 to 45 m.p.h. over all the lakes.

October 18, 1946 35 to 40 m.p.h. over Lake Erie.

October 7, 1941 35 to 50 m.p.h. over all the lakes.

ALBERTA (FIGURE 5)

December 11, 1956 40 to 50 m.p.h. reported by many ships on all lakes.

October 28-29, 1954 45 to 60 m.p.h. on Lake Superior, over 50 m.p.h. on Lake Michigan.

November 8-9, 1950 40 to 50 m.p.h. over Lake Superior.

August 9-10, 1946 35 to 45 m.p.h. over the lower lakes.

September 6-7, 1943 50 to 55 m.p.h. over the upper lakes.

December 10-11, 1943 55 to 60 m.p.h. over the upper lakes.

November 9-10, 1942 40 to 50 m.p.h. over Lakes Erie and Ontario.

October 22, 1938 35 to 40 m.p.h. over Lakes Michigan and Superior.

July 25-26, 1937 One of the most severe summer storms, Up to 65 m.p.h. over Lakes Michigan, Huron, and Erie.

TROPICAL CYCLONES (FIGURE 6)

June 28-29, 1957 50 to 60 m.p.h. over Lakes Erie and Ontario.

August 13-14, 1955 45 to 60 m.p.h. over Lakes Erie and Ontario. 40 m.p.h. on Lake Huron.

TABLE 1 (cont.)

STORM DATES

WINDS AND REMARKS

TROPICAL CYCLONES (FIGURE 6) (cont.)

October 15-16, 1954 50 to 65 m.p.h. over Lakes Erie and Ontario. 35 to 50 m.p.h. on Lake Huron. September 25, 1941 40 to 70 m.p.h. over the lower lakes, 35 to 45 m.p.h.

over Lakes Michigan and Huron.

September 21-22, 1938 Small boats driven ashore, large vessels unable to leave port. 50 to 60 m.p.h. over Lakes Erie and Ontario.

EASTERN UNITED STATES (FIGURE 7)

50 to 60 m.p.h. with gusts to 90 m.p.h. over Lakes Erie November 25-26, 1950 and Ontario.

December 1-2, 1942 40 to 60 m.p.h. over Lakes Erie and Ontario.

November 7-10, 1913 One of the most severe lake storms. 50 to 60 m.p.h. western lakes and above 80 m.p.h. over Lakes Erie and Ontario. Over 200 seamen and at least 8 large ships lost.

on the evening of October 27. It then deepened with a central pressure of 29.20 in. and moved southeastward to approximately 100 mi. north of Lake Superior on the 28th and then moved slowly northeastward. South-westerly winds of 35 to 40 m.p.h. were reported on the upper Great Lakes on October 28, later shifting to northwesterly 45 to 60 m.p.h. over Lake Superior and 50 m.p.h. over Lake Michigan. Winds of 50 m.p.h. were also reported over Lake Michigan on October 29.

Some severe Great Lakes storms, especially over Lakes Ontario and Erie, have been of tropical origin (figure 6). These storms have, however, been very rare, and nearly all had lost their tropical characteristics by the time they reached the lakes. The increased friction between the land surface and the moving storm, and the reduction of the energy supplied by the warm ocean cause a diminution of intensity. The tropical storms which have been most severe in the Great Lakes were those modified and reintensified by the energy processes which form the cyclonic One of storms of the middle latitudes. the more severe tropical storms in the Great Lakes was "Hazel" on October 15-16, 1954. As the storm moved over the eastern United States on the 15th a cold front from the west moved into the circulation and the added energy from this interaction of the warm and cold air kept the storm intense and fast moving on a path from North Carolina to Canada. As "Hazel" crossed Lake Ontario, winds over the Great Lakes increased to southwesterly gales and speeds of 45 to 60 m.p.h. were reported over Lakes Erie and Ontario and 32 to 50

m.p.h. over the other lakes.

LOWS developing in the eastern States usually do not seriously affect weather over the Great Lakes. The normal movements of storms from the states east of the Appalachians is eastward or northeastward over the Atlantic. However, on rare occasions the general circulation is favorable for the movement of intense LOWS developed in the coastal region into the eastern Great Lakes. Precipitation is usually quite heavy and widespread because of the inflow of very moist air off the Atlantic.

The outstanding example of this storm type (figure 7) is the storm of November 7-10, 1913. An Alberta LOW moved into the Lake Superior region on November 7 and 8, causing gale winds over the upper lakes. A secondary circulation developed in central Georgia on the morning of November 8 and moved to central Virginia within 24 hr. as it deepened very rapidly, forming a very tight pressure gradient. The original Alberta LOW in the meantime drifted northeastward and the new storm moved north-northwestward and was centered between Lakes Huron and Erie on the morning of the 10th. High winds and heavy snow covered the entire lakes region. Over the eastern lakes winds were above 60 m.p.h. for 16 hr. At least eleven steamers were lost and several others driven ashore with a loss of life estimated at more than 250.

Table 1 gives information on the area of formation, region affected, highest winds, and damages for the storms shown in figures 2 to 7.

WINDS

The numerous shifts in wind and changes in weather encountered along the waterway are due to the many moving cyclones and anticyclones which traverse the area. Although winds from the westerly quadrants generally prevail, winds from any direction are likely to be encountered, shifting in relation to the vessel's position from the center of the moving LOW or HIGH. If a LOW is predicted to pass north of the vessel the winds can be expected to veer and if to the south, to back.

During the spring and fall months of the navigation season strong winds are most likely to be encountered in rapidly deepening and fast moving LOWS or in steep gradient HIGHS. In the summer months strong winds are rare but may be encountered in thunderstorms or squall lines.

In general winds experienced by vessels operating on the lakes are stronger than those recorded at shore stations bordering the lakes. This is due primarily to differences in surface friction between land and water. Recent work [4] on Lake Erie indicates that to convert land winds to over water winds the multiplication factor varies from 0.76 to 2.35 depending on the air mass (determined by air-water temperature differences) and the station location. Nearly all of the factors, however, are over 1.0.

Lake breezes are experienced on all the Great Lakes during the warmer months on clear days with weak pressure gradients. These breezes are similar in origin to the sea breeze experienced on oceanic coasts but they rarely extend more than 1 or 2 miles inland.

Table 2 gives the highest 1-minute winds reported from anemometer-equipped vessels on Lakes Erie, Huron, Michigan, and Superior for each year since 1941. Observations on Lake Ontario have been too limited in number to establish a reasonable maximum velocity. The highest velocity listed is 93 m.p.h. from the northwest, recorded on Lake Superior in a squall line on June 25, 1950. The velocities given in the table were recorded only at 6-hour intervals (1 and 7 a.m. and p.m. EST) during the navigation season. Higher values may and probably have occurred during the winter months and at times other than those given.

For the U. S. stations listed in the climatological tables appearing in the appendix Green Bay recorded the highest wind velocity with a fastest mile of 109 from the southwest in May of 1950. For the Canadian stations listed Quebec (Ancienne Lorette Airport) had the highest recorded maximum hourly mileage with 60 from the southwest in February of 1956.

TABLE 2
HIGHEST 1-MINUTE WIND (M.P.H.) REPORTED AT 1 & 7 a.m. and p.m. (EST)

Year	<u>Lake</u>	Erie	Lake	Huron	Lake M	ichigan	Lake S	uperior
1941	was a same a war was a war war was a war war war war war war war war w	7 4 8	WSW	57	NW	50	DERI SVATO	<u></u>
1942	WSW	60	WSW	64	WNW		NNW	
1943	WSW	65	WNW	47 T	SSW			71
1944	NE	44		43	WSW		WSW	
1945		60	SSW				NNE	
1946		58		53	WNW		NW	
1947		59	SSE		.,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	51	NW	
1948		46		과 구조하는 이 글	ESE		WSW	50
1949	"S" W		NNW		NW		WSW	55
1950			NNE	1 Tue 5 4	NNW		N	60
1951		80		55	NW	56	NW	93
- Marin 190 + No. 1 e 1850 feet	WSW	Strain and Strain	WSW	4 7 7 7 7	SW	56	WSW	62
1952		53	SW	65	SSW	51		
1953	WSW	194 T 197 HO 44	NW	52	NNW	53		
1954	W	52	NW	52		55	N	50
1955	W	60	SW	66		67	NW.	
1956	WSW	53	W	50	SSW			
1957	WSW	83	SW		WSW			57
					"D"	9 0	togistabay.	54
Highest	WSW 83	(1957)	SW 66 ((1955)	WSW 67	(1955)	NW 93	(1950)

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The description of the wind regimes for the St. Lawrence Seaway and Great Lakes will be general as detailed monthly information on percentage frequencies of direction and Beaufort force are contained in figures 8 through 19 for representative stations along the waterway. The wind roses for Quebec, Montreal, and Toronto were tabulated from airport data. The following description is based on data from land stations surrounding the lakes. Actual wind conditions on the lakes may vary from those described.

The winds encountered along the St. Lawrence River between Quebec and Lake Ontario tend to parallel the northeastsouthwest axis of the river. Except for the spring months at Quebec when the winds are predominantly from the northeast, the prevailing winds at Quebec and Montreal are from the southwest with high percentages of northerlies and northeasterlies. At Massena the regime is slightly different with southwesterly winds predominating during most of the navigation season. During the winter and early spring months northeasterly winds are frequently encountered at Massena and may at times prevail over the southwesterlies. The mean wind speed on this section of the river averages between 7 and 11 kt. with the higher speeds occurring in the colder months. The mean number of days per year with winds of 28 kt. or over is 30 and 17 for Quebec and Montreal, respectively. During the navigation season strong winds are not likely to be encountered except in the early spring and late fall. Table 3 gives the mean number of days winds of 28 kt. or greater were encountered at Quebec and Montreal and of 34 kt. or greater at Massena.

A characteristic common to all the Great Lakes is that the effects of high winds are generally most serious when the winds blow parallel to the long axis of the lake for any considerable length of time. These winds have a long fetch and can build up a considerable sea.

On Lake Ontario the prevailing winds during the navigation season are generally from the southwest, almost paralleling the long axis of the lake. At the east end of the lake a funneling effect has been noted with west and west-southwest winds. These winds, on encountering the land on either side of the lake in the vicinity of the Thousand Islands, are accelerated, and what would be a strong blow in midlake often becomes a disastrous gale in this restricted area. Mexico Bay, north of Oswego in the extreme eastern part of the lake, used to be called "the graveyard of Lake Ontario" because ships foundered there in strong northwest, north, and northeast winds. The average wind speed on the lake varies from 6 to 9 kt. in the summer and from 9 to 11 kt. in the winter. Rochester recorded a fastest mile of 73 from the west in January 1950 and a maximum hourly mileage of 56 from the southwest was recorded in Toronto in March 1942. The maximum hourly mileage is the total wind flow for one hour and does not represent gusts which were probably much higher.

Lake Erie, which is comparatively shallow, is oriented in a northeast-southwest direction and strong winds from these directions raise a dangerous sea. Prevailing winds, in the sense of being more frequent than other directions, are from the southwest. Due to the orientation of the lake the strongest winds come most frequently from the westerly quadrants with a secondary maximum from the northeast. In the western end of Lake Erie and in the lower Detroit River where lack of water may restrict navigation, high easterly or westerly winds may raise or lower the water level. Changes as great as 6 ft. have occurred within 8 hr. average monthly wind speed varies from about 7 kt. to 16 kt. with the higher averages occurring during the winter months in the eastern part of the lake. Of the shore stations reporting on Lake Erie, Buffalo, which has a 3 to 4 kt. greater average wind speed than the other stations due to a funneling effect at the eastern

TABLE 3

MEAN NUMBER OF DAYS WITH WINDS OF 28 KT. OR GREATER

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year	No. of Years
Quebec	5	3	5	4	3	1	0.4	0.4	0.7	1	3	4	30	10
Montreal	14	2	2	2	1	+	0	+	1	ī	2	$\bar{2}$	17	10
Massena*	* 1	1	1 1	1	. 1	2	0.4	0.4	0.4	1	ī	$\overline{2}$	12	5

⁺ Amount less than 1

^{* 34} kt. or greater

extremity of the lake, recorded a fastest mile of 91 from the southwest in January 1950. Clear Creek, Ont. recorded a high maximum hourly mileage of 58 from the southwest in March 1955.

Due to the configuration of Lake Huron strong winds from any direction may build up a considerable sea. The long fetch, for high northeast and east winds over the waters from Georgian Bay to the Michigan shore, develops high seas which run athwart the normal traffic pattern on the lake. In the northern part of the lake where the shores converge winds from the south may be dangerous becuase of the funneling effect. Similarly, winds from the north may be dangerous in the pointed southern end of the lake, especially near the mouth of the St. Clair River [11]. On Lake Huron the winds vary considerably in direction, however, in general the prevailing winds are from the western quadrants usually between southwest and northwest. The range of the mean wind speed does not have as large a variation as the mean wind speeds on Lake Erie. It generally varies from about 8 kt. in the summer months to 11 kt. in the winter months. For the stations reporting on Lake Huron, Alpena recorded a fastest mile of 61 from the southwest in November 1940 and Gore Bay had a high maximum hourly mileage of 49 from the southwest in February 1953.

On Lake Michigan, dangerous seas are generally experienced with strong northerly and southerly winds due to the long fetch these winds have over the north-south oriented lake. Thus, in the southern part of the lake northerly winds are the most dangerous, while in the northern part of the lake southerly winds are most likely to hinder navigation. These winds may also create strong currents which make conditions hazardous at harbor entrances. The stronger winds of the early spring, fall, and winter are usually from the western quadrants, making entrance to the restricted harbor channels on the east shore especially difficult. Although the predominant wind directions are generally from the western quadrants, there is a considerable variation in direction, some stations during the warmer months reporting prevailing winds from the easterly quadrants. The mean wind speed on Lake Michigan varies from about 8 kt. in the summer to about 13 kt. in the winter and spring. On this lake Green Bay recorded a fastest mile of 109 from the southwest in May 1950, which is the highest velocity recorded on all the lakes. The high wind was the result of an extratropical LOW which was unusually intense for that time of the year.

Lake Superior is large enough so that strong winds from any direction have sufficient fetch to build up a sea. Although the long axis of the lake is east-west its southern shore is nearly divided in two by the Keweenaw Peninsula. This tends to diminish the seas created by strong easterly or westerly winds for those vessels navigating in the southern part of the lake. On the western half of the lake the winds are predominantly from the west and the northwest during the fall, winter, and early spring, and during the warmer months from the east and northeast. On the eastern half of the lake, as represented by Sault Ste. Marie, there is a complete reversal with easterly winds in the colder months and westerly winds in the summer months. This effect is due, in part, to lake breezes. Duluth, located on the western end of the lake, experiences easterlies during the warmer months and Sault Ste. Marie on the eastern extremity of the lake experiences westerlies during these months. The mean wind speed on Lake Superior varies between 7 kt. and 13 kt. with the higher speeds occurring in the winter and spring. Marquette which is well protected has the lowest average wind speeds ranging from about 7 to 9 kt. On Lake Superior, a maximum fastest mile of 91 from the south, was recorded at Marquette in May 1934. It occurred during a severe local thunderstorm. For the Canadian stations Caribou Island recorded a high maximum hourly mileage of 71.

The predominant winds in figures 8 through 19 may differ slightly from the prevailing directions contained in the climatological tables in the appendix because different periods of record were used.

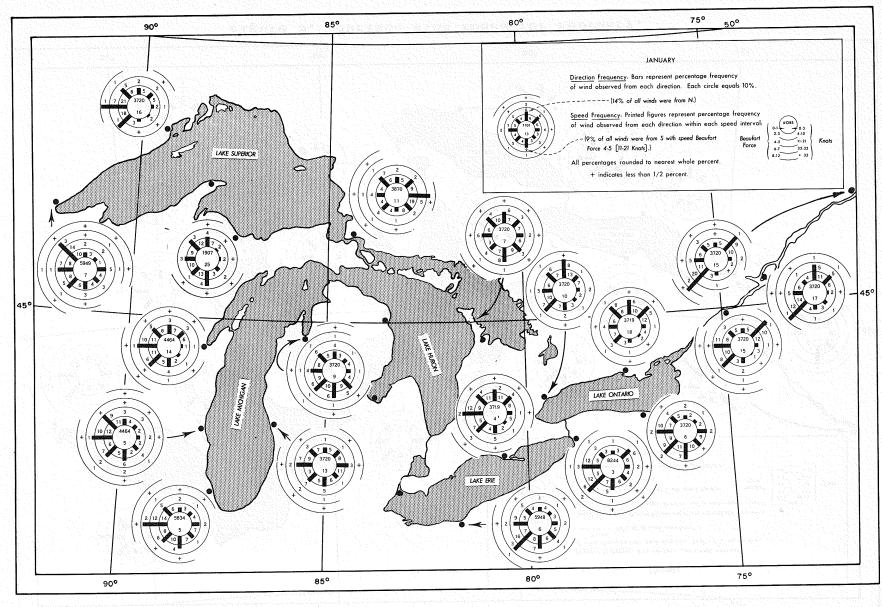


Figure 8. Surface wind roses for January.

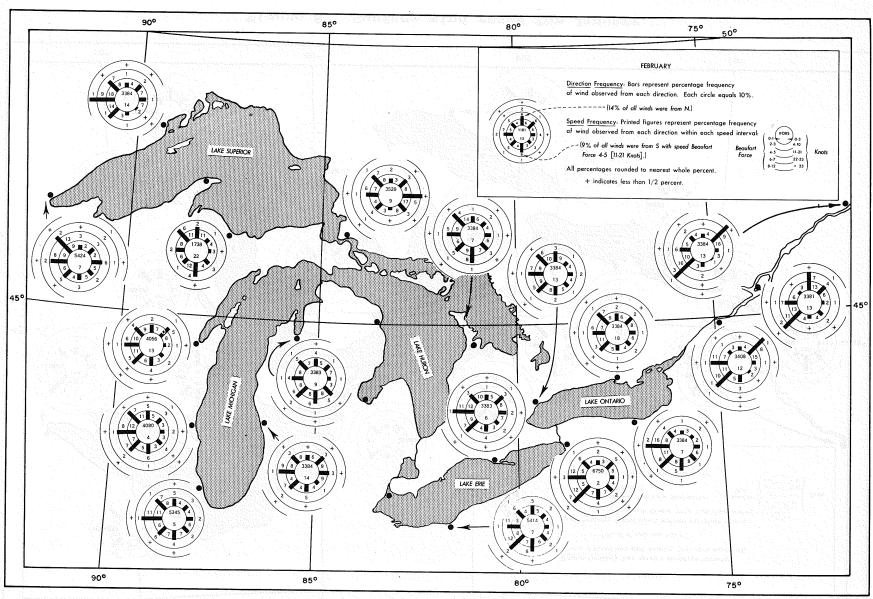


Figure 9. Surface wind roses for February.

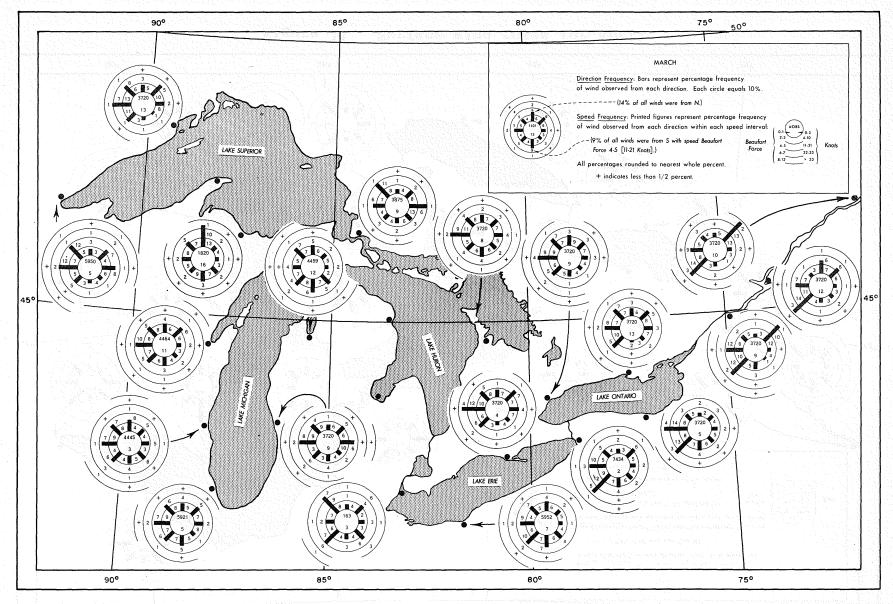


Figure 10. Surface wind roses for March.

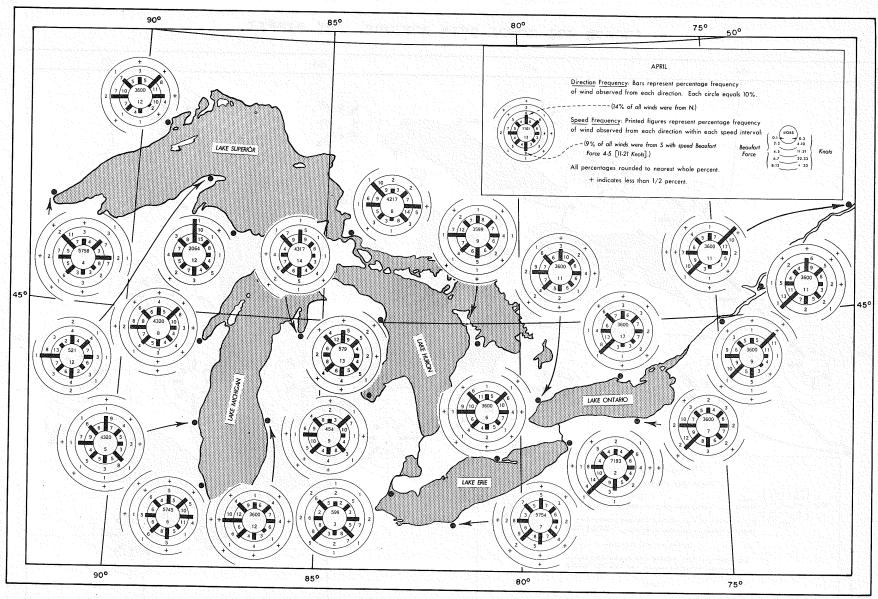


Figure 11. Surface wind roses for April.

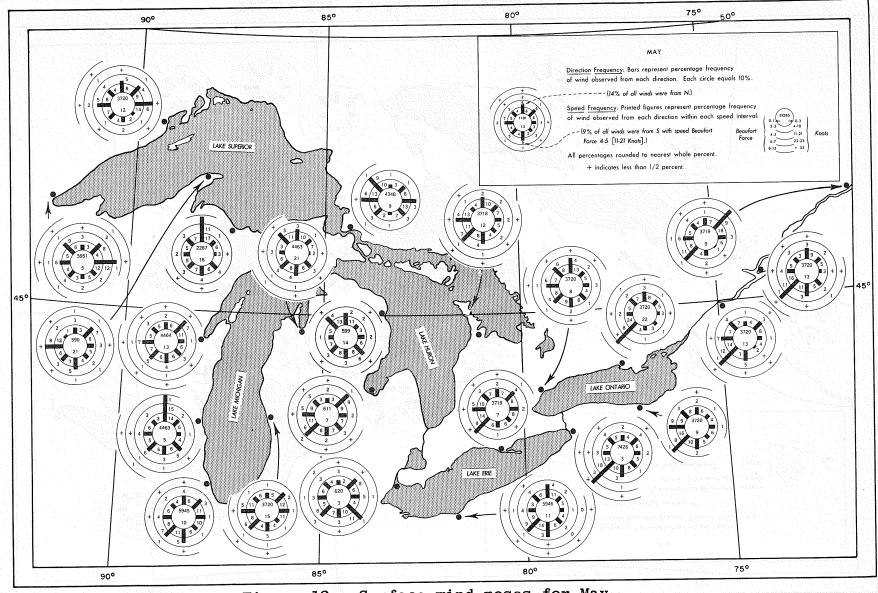


Figure 12. Surface wind roses for May.

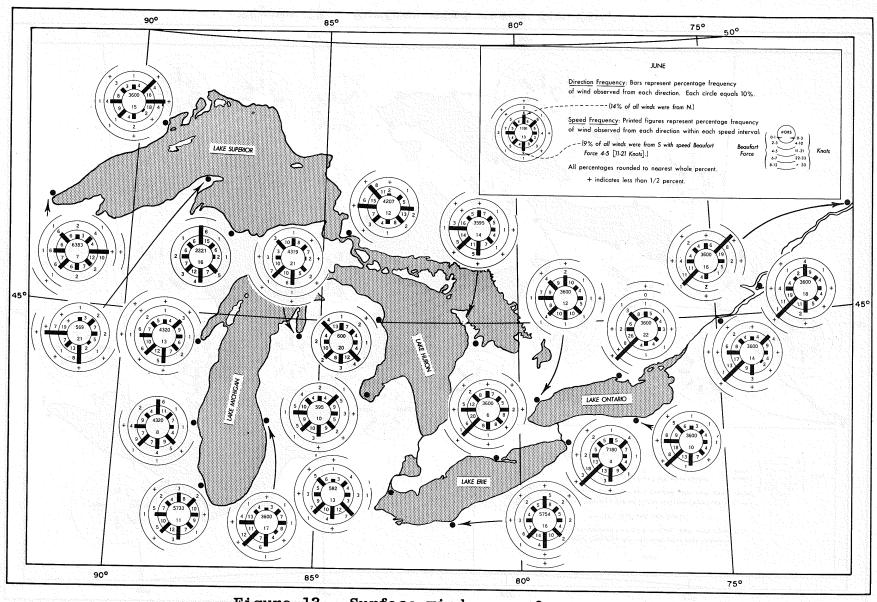


Figure 13. Surface wind roses for June.

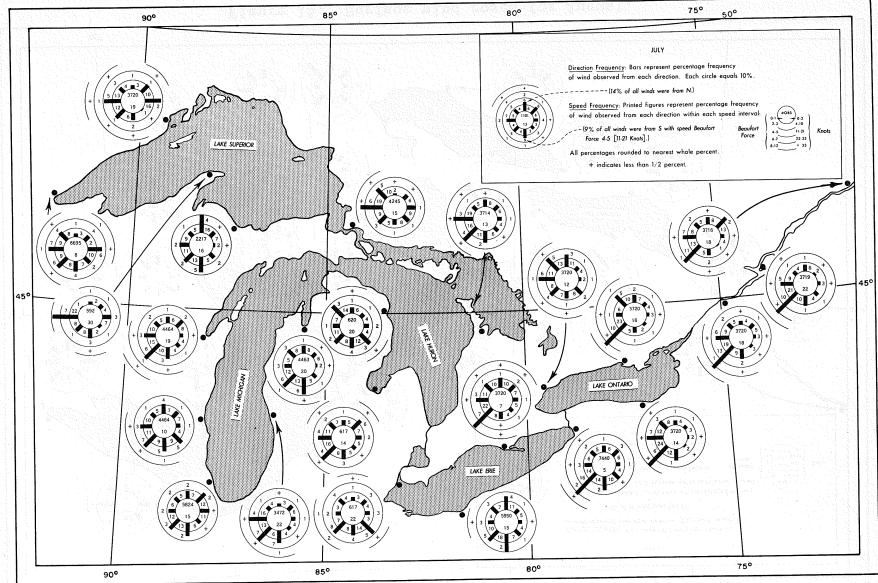


Figure 14. Surface wind roses for July.

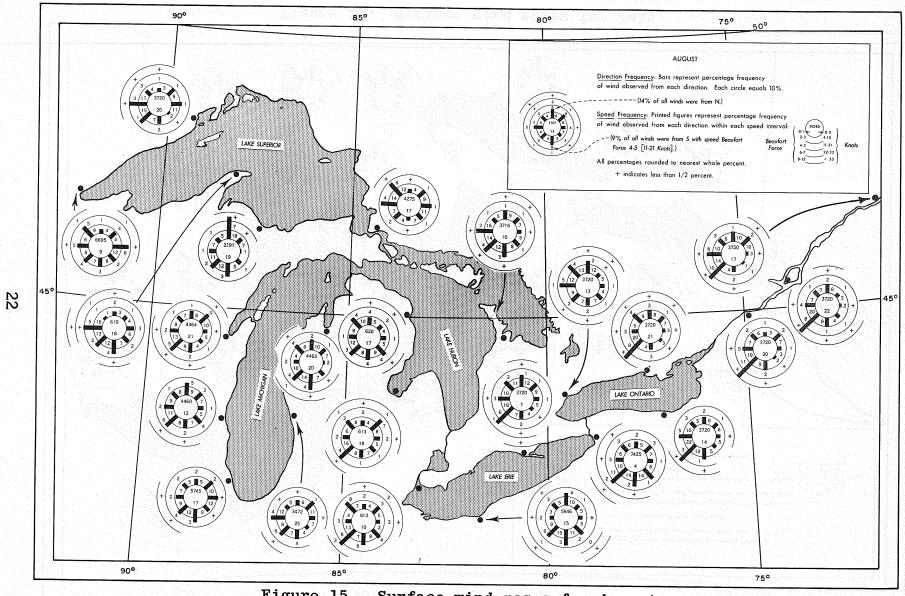


Figure 15. Surface wind roses for August.

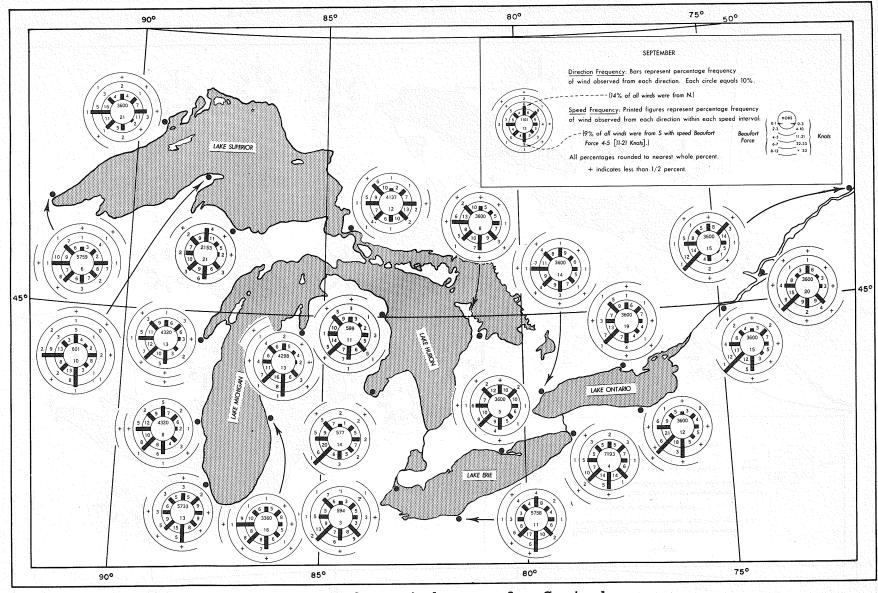


Figure 16. Surface wind roses for September.

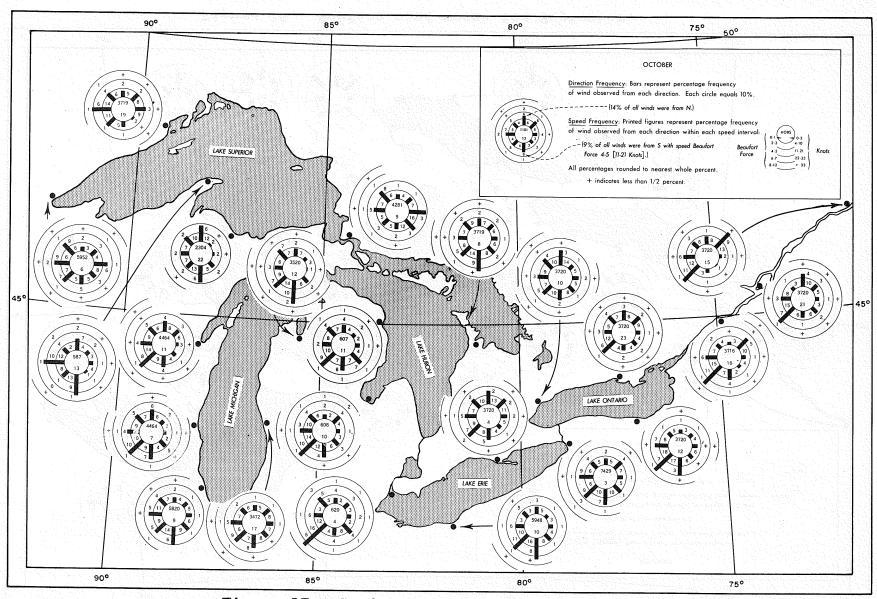


Figure 17. Surface wind roses for October.

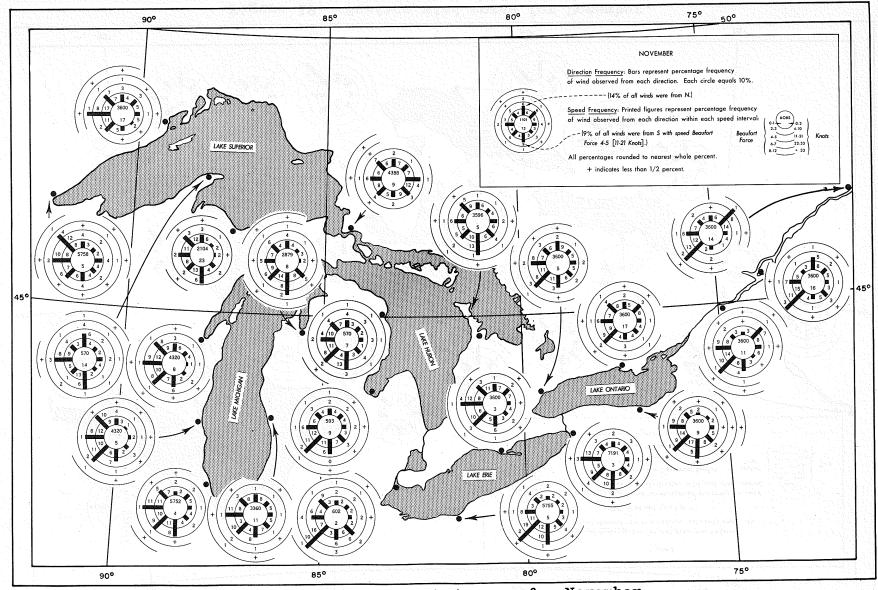


Figure 18. Surface wind roses for November.

From the entrance of the Gulf of St. Lawrence to Quebec the frequency of fog decreases rapidly from 103 days and a summer maximum at Belle Isle to 24 days and a winter maximum at Quebec. At Quebec, Montreal (Dorval) (figure 20) and Massena (table 5) the highest frequency of fog occurs during the winter months. principal cause of this winter maximum along the St. Lawrence River above Quebec is the cooling of maritime air by the cold ground [8].

Radiation fog also occurs along the seaway and is most likely to be encountered on clear nights in the spring and fall. These fogs are of a local nature, their frequency depending greatly on the topography. They generally occur in the early morning hours dissipating with the heat of the day. During the dry season in September, and the first half of October, prolonged spells of thick weather are caused by the smoke of brush fires [2].

On the lakes the principal cause of fog is the temperature difference between the lakes and the surrounding atmosphere. A pronounced temperature lag occurs in the spring and early summer when the lakes are slow to lose their winter chill and the surrounding land is rapidly becoming warmer. From the spring to early fall the water is, on the average, colder than the air and therefore conditions are favorable for advection fog [10] which occurs when warm land breezes are cooled by the comparatively cold lake surfaces. In the fall steam fog also occurs when the first cold air outbreaks come down from the north and the lakes still retain the warmth of the summer.

Figure 20 shows by month the mean num-

ber of days with heavy fog (visibility 1/4 mi. or less) for the major ports. The trend of a maximum in spring or early summer is not readily noticeable on this figure because many of the statistics were compiled for airports some distance from the lakes. At Duluth and Marquette, however, where city office figures were used, distinct maxima of 7 and 4 days of heavy fog, respectively, occur in June.

Table 4 is more representative of the conditions encountered on the lakes. It contains a 5-yr. monthly summary of the mean number of days visibility was less than 2 nautical miles at key stations (mostly Coast Guard) along the waterway. These figures generally indicate a maximum in the spring and early summer and an increase again in late fall. Observations at these lake stations are taken only during the navigation season.

The mean number of days visibility was reduced to less than 2 1/2 mi. at Canadian stations is given in table 5. These figures were generally recorded at airports some distance from the lakes and are not truly representative of lake conditions. Most of them show the maximum in the winter which was probably caused by a combination of smoke and stable meteorological conditions.

In general the three western lakes are foggier than the two eastern ones. Lake Superior is the foggiest and of the stations reporting Sault. Ste. Marie has the highest number of days per year with heavy fog (46 days) with a maximum of 7

TABLE 4 MEAN NUMBER OF DAYS WITH VISIBILITY LESS THAN 2 NAUTICAL MILES

Stations	Jan. Feb.	Mar.	Apr.	May	June	July Aug.	Sept.	Oct.	Nov.	Dec.
Massena	9 9	8	5	2	2	1 2	3	6	7	9
Oswego			4	3	1	1 1	0	2	1	2
Detroit River Light		1	1	2	1	0 1	1	0.4	2	4
Port Huron			3	1	2	0.4 0.2	1	0.4	2	2
Saginaw River Light			2	1	1	3 2	2	3	3	2
Thunder Bay			4	5	6	3 2	1	3	4	1
Mackinaw City			8	5	6	4 3	1	4	5	4
Whitefish Point			5	4	10	6 3	2	2	3	5
Eagle Harbor			3	4	8	5 4	1	0.4	3	2
Passage I. (4 yrs.)				1	9	7 3	1	2	4	3

¹In the figures that follow data for Quebec and Toronto were taken from the city offices; for Montreal from the airport.

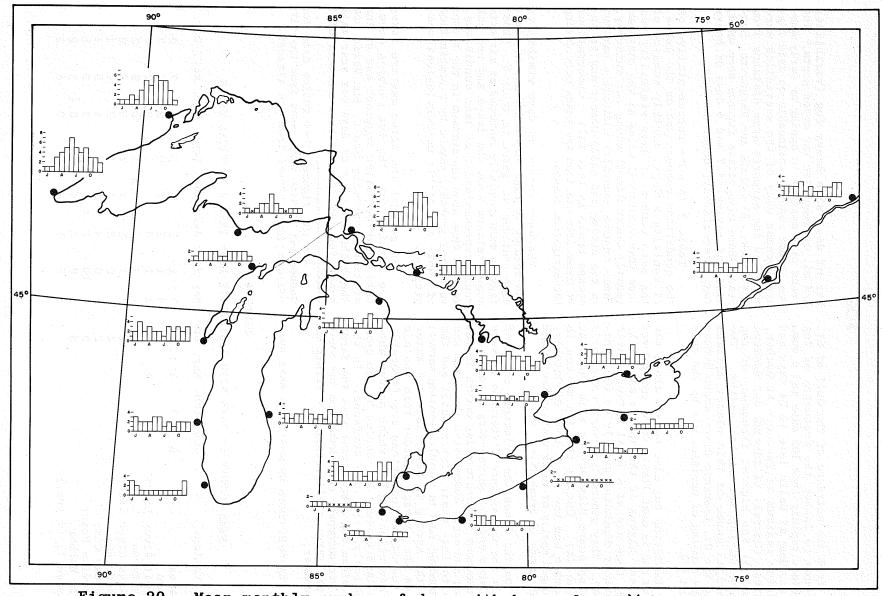


Figure 20. Mean monthly number of days with heavy fog. X indicates average frequency less than 1/2 day.

days per month in August and September. Duluth is close behind with a total of 43 days a year.

In areas where upwelling is present (usually along northwestern shores of the lakes) the cold water is likely to increase the possibility of advection fog in the spring and summer. Chances of this type of fog are not as great along the southeastern shores of the lakes where sinking occurs and the water temperatures are higher. These areas are most likely to experience steam fogs in the late fall and winter months.

On Lake Ontario prolonged periods of rain and foggy weather are quite common when frontal systems moving into New York become stationary. Of the stations reporting heavy fog on this lake, Trenton, Ont. with 25 days has the highest frequency.

Fog is more prevalent along the northern shore of Lake Erie than along the southern shore. Over the western part of Lake Erie fogs are rare though they do occur in the early fall and late spring. The average annual number of dense fogs is 5 per year

while approximately 15 days are classified as "partly foggy" [16]. Steam fogs occur in the late fall and winter while advection fogs are confined to spring months. Visibility is sometimes reduced by haze during the late summer.

On the southern shores of Lake Michigan, in the Chicago-Gary area, shipping may be affected by extensive smoke. With a light offshore wind, visibility over the lake is reduced considerably. This is especially true when the water temperature is lower than the air temperature. Along the Indiana shoreline of Lake Michigan it is estimated that about five fogs occur during the colder months which are severe enough to slow down lake traffic.

Fog on Lake Superior usually occurs during the months of July, August, and September. Yearly occurrences average about 30 with more in the Duluth area due to industrial smoke. The area of greatest fog frequency on Lake Superior is east of Keweenaw Point and northward of Au Sable Point. Less fog is reported on the coast from Au Sable Point to Marquette and Portage Entry [11].

TABLE 5

MEAN NUMBER OF DAYS WITH VISIBILITY REDUCED TO LESS THAN
2 1/2 MILES DURING AT LEAST ONE OF THE FOUR SYNOPTIC HOURS

				an nanê					ere de telepro- Olegie er gan i	e e e e e e e e e e e e e e e e e e e			<u> </u>	No. of	
Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year	Years	
Quebec (Ancienne Lorette Airport)	12	9	9	7	3	3	4	3	6	6	9	12	83	15	
Montreal (Dorval Airport)	14	13	12	6	4	4	4	6	12.5 7 175 2 5 7 1.5 3 5 7 1.5	adel g Događaja Sestov	jaro ģ ili Vilkara Svensilis	13	101	17	
Trenton (Airport)	12	10	10	7	7	5.	4	. 1, a 6 5 1, a 7 5 1 7	6	10	11	11	99	15	
Toronto (Malton Airport)	13	10	10	8	7	5	5	6	8 	10	.10	11	103	17	
Clear Creek	14	15	15	7	6	4	5	6	6	7	8	11	104	16	
Windsor (Airport)	15	16	15	11	8	8	3 64 8 0 550 (3	12	10	15	13	15°	146	17	
Wiarton (Airport)	17	12	12	8	5	7	4	6	4	7	11	14	107	11	
Gore Bay (Airport)	12	9. // 9.	9	6	3	60 11 15 5 1	4	3	4	5	8	11	79	11	
Fort William (Airport)	9	7	8	6	5	7	6	8	8	7	76 7	8	86	17	

AIR TEMPERATURE

Mariners accustomed to operating over oceans under maritime climatic conditions will note that there is a wide difference between those conditions and those prevailing over a mid-continent body of water. These differences are noticeable in air temperatures which, over the waterway, change much more quickly from day to day and hour to hour, and reach greater extremes, than they do over stretches of open ocean. Extremes of temperature are greatest in areas near land and under conditions of offshore winds.

While the area bounding the Great Lakes is considered to have a continental climate the lake waters have a stabilizing effect and bring to the area influences of a marine climate that are apparent in such elements as temperature and humidity, and in the usual effects of land and lake breezes.

During cold periods stations along the shores of the Great Lakes benefit from the heat surplus of the lake waters and as a result temperatures are somewhat warmer than those in the surrounding area. These are the conditions under which steam fogs develop. Beginning in the spring when air temperatures at land stations rise above the still frozen surfaces of the lakes, locations along the shore may, for a period of a few weeks, remain colder than areas not strongly affected by the ice covered lakes. Such conditions end when the ice melts and the lake waters have had time to warm [6].

For stations having a pronounced prevailing wind direction, those with offshore winds have a more continental type climate than those with onshore winds. Winds coming in off the water bring greater cloudiness and humidity, heavier precipitation, and are stronger than those prevailing on the opposite shore. During the colder part of the year, with waters remaining open, the temperatures are higher on those shores with breezes off the lake.

Subject to some variation, the normal ranges of air temperature at stations along the Great Lakes are somewhat greater during the summer months than in the winter. In most cases the mean daily maximum temperatures for the various months and for the year are about 20 degrees higher than the daily minumum temperatures. Duluth, one of the colder stations, has an annual normal daily maximum of 47.9° and a daily minimum of 30.4°, and at Chicago (Midway

Airport), one of the warmer locations, the annual normal daily maximum is 59.3° and the daily minimum 40.8° .

Lake Erie, the shallowest and most southerly lake, has the highest and earliest maximum air temperatures and Lake Superior, the deepest and most northerly, has the lowest and latest maxima. The lowest minimum temperatures are recorded along the north and west shores of Lake Superior. The extremes occur under the winter regime of prevailing westerly and northwesterly winds when the area receives the least heating effect from the lake waters. Duluth with an extreme minimum of -38° and Fort William with -42°, both in January, are representative of the area. Such temperatures are not experienced during the navigation season but do indicate why ships cannot operate on the Great Lakes throughout the year.

Intense cold spells in the area of the Great Lakes and the St. Lawrence River result from the spreading southward of Arctic air masses. With the arrival of these cold air masses, temperatures may drop as much as 50° to 60° over a period of 24 hr.

The modifying effect of lake waters is particularly noticeable when severe cold waves sweep down from Canada. Under such conditions the temperatures along the northern shores of Lake Ontario have been as much as 20 degrees colder than those on the southern shores [5].

The winter freeze-up, ending the season of navigation, does not ordinarily take place until December, when temperatures are considerably below those that prevail in spring when ports are first opened to navigation, in most instances in March or April. During spring break-up maximum temperatures considerably above freezing must prevail for a number of days before any notable deterioration of the ice takes place. Honeycombing of the ice does take place with high daytime temperatures even though mean temperatures for the day are near freezing and minimum temperatures at night considerably below freezing. Such deterioration leaves the ice in a porous state so that it may be easily broken and moved about by winds and currents. Slush ice of this type, drifting to the eastern end of Lake Erie, jams the approaches to Buffalo harbor and often delays the opening of that port until after the opening date at Duluth where temperatures, during that period of the year, average about 5 degrees colder than those at Buffalo.

The following paragraphs summarize air temperatures along the St. Lawrence River and the shores of the Great Lakes beginning at Montreal and moving westward to Duluth. Figures 21a and b graphically represent the temperature distribution along the waterway.

Average monthly temperatures along the St. Lawrence River, as represented by Montreal (McGill), range between a maximum of 70° in July and a minimum of 15° in January. The average daily maximum and minimum reach a high of 79° and 62° minimum reach a high of 79° and 62°, respectively, in July and fall to 23° and 8°, respectively, in January. At Montreal an extreme high of 97° occurred in July and the extreme low of -29° was recorded in both February and December. is late and cold along the St. Lawrence, being delayed till the snow and ice melt, after which temperatures often rise quickly and occasionally reach into the eighties. Changes in temperature can be large and Warm air masses in the front of sudden. depressions bring in abnormally warm tropical air and this can quickly be displaced by cold polar air moving in behind the cold front.

Temperatures at Buffalo may be considered representative of locations on Lakes Erie and Ontario. Here the average monthly range is between a high of 71° in July

and a low of 25° in February. The average daily maximum and minimum reach highs of 81° and 60° in July and fall to 32° and 17° in February. The extremes for an 84-yr. period of record are a high of 99° in August and a low of -21° in February.

The long axes of Lakes Michigan and Huron are oriented north and south with the result that there is considerable temperature variation for locations at different latitudes. This difference is apparent when data for Chicago are compared with data for Escanaba, where temperatures average some 8° to 10° lower. At Chicago (Midway Airport) the average monthly temperatures range between a high of 75° in July and a low of 25° in January. Average daily maxima and minima range between 85° and 64° in July and 33° and 17° in January. Extreme values are 104° in June and -15° in both January and February.

For Lake Superior, Duluth may be considered representative. Here the range in average monthly temperatures is between a high of 66° in July and a low of 10° in January. Average daily maxima and minima are high at 76° and 56° in July and low at 19° and 2° in January. The extreme maximum recorded was 106° in July and the extreme minimum -38° in January.

Climatological tables covering temperature normals, means, and extremes for most stations, included in the station location chart, are given in the appendix.

HUMIDITY

The marine influence exerted by the lakes results in higher and more stable humidity values over the Great Lakes area than might be expected at mid-continent locations. Prevailing winds, which often vary with the season, and the strength of shore and lake breezes are important in raising or lowering humidity values. Overall values are highest at ports along the shores of Lakes Superior, Huron, and northern Michigan where the marine influences of the lakes are most clearly marked, and are, in general, lowest at more southerly locations along Lakes Erie and Ontario and the St. Lawrence River.

At most locations average relative humidity values during the early morning hours are uniform, ranging between about 75 and 80 percent. During the winter the afternoon readings are generally 5 to 10 percent lower than the morning readings and during the summer about 15 to 20 per-

cent lower. During afternoon hours, there is more variation throughout the year, with highest values during the winter season and lower humidities in the summer months. During July and August early afternoon values, at the 1:00 p.m. observation, may be 20 to 25 percent lower than corresponding values for the winter months. At Cleveland (Hopkins Airport) this difference in the average monthly relative humidity at 1:00 p.m. ranges from a high of 73 percent in January to a low of 52 percent in July. At nearly all stations there is a rise of 5 to 10 percent in average monthly relative humidity between the 1:00 p.m. and 7:00 p.m. readings.

CARGO CARE - Relatively high humidity values and extremes of temperature encountered on the Great Lakes make protection of cargoes from sweat an important consideration. Critical conditions are most likely to develop when cargoes

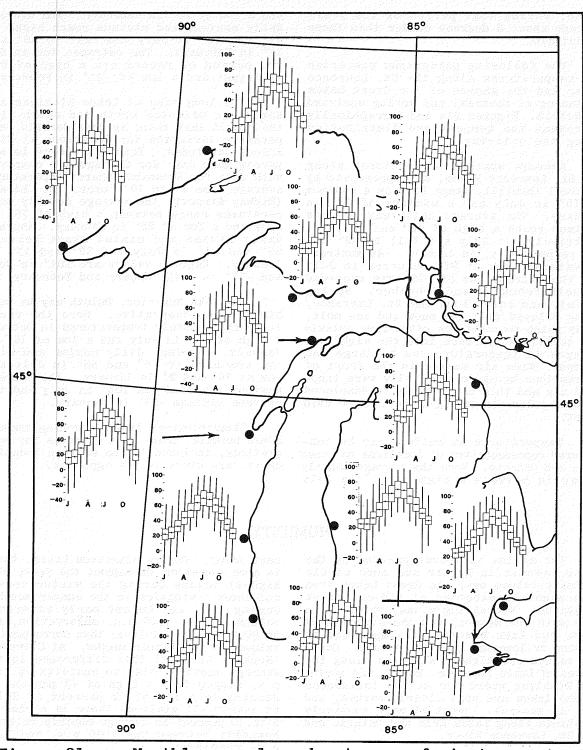


Figure 21 a. Monthly normals and extremes of air temperature - Western Great Lakes.

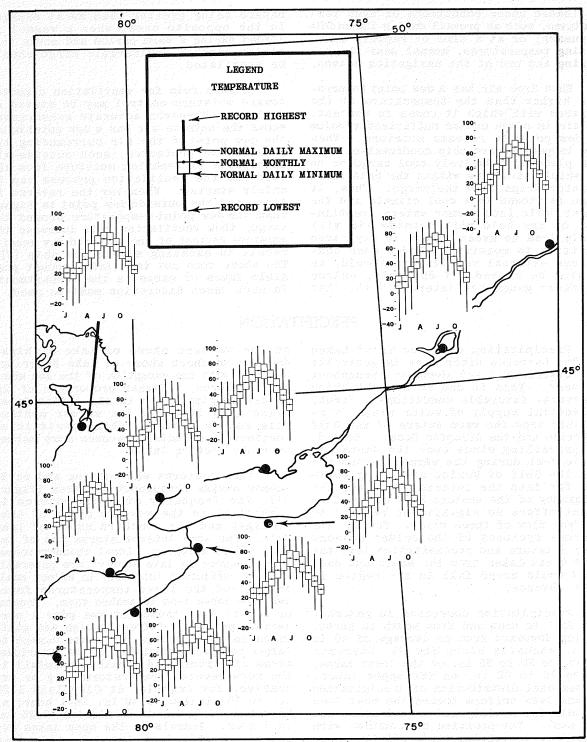


Figure 21 b. Monthly normals and extremes of air temperature - Eastern Great Lakes and St. Lawrence River.

are loaded under conditions of high temperatures, such as prevail during the middle of summer, or at a time of rapidly fluctuating temperatures, normal near the beginning and end of the navigation season.

When free air has a dew point temperature higher than the temperature of the surfaces with which it comes in contact, the air is often cooled sufficiently below its dew point to release moisture. When this happens aboard ship condensation will take place on relatively cool cargo or on the ship's structure within the hold where it later drips onto the cargo. Thus, if cargo is stowed in a cool climate and the vessel sails into warmer waters, ventilation of the hold with outside air will likely lead to sweat damage in any cargo sensitive to moisture. Under such conditions external ventilation should, as a rule, be closed off entirely, unless the cargo generates internal heat, that

hazard being greater than sweat damage. In the opposite case, when a vessel is loaded during a warm period and moves into cooler weather, vulnerable cargo should be ventilated.

A safe rule for ventilation directed toward moisture control may be stated as follows: Whenever accurate measurement shows the outside air has a dew point below the dew point of the air surrounding the cargo to be protected, such outside air is capable of removing moisture from the hold and the ventilation process can be safely started. Whenever the reverse is true, and the outside dew point is higher than the dew point temperature around the cargo, then ventilation will increase the moisture content of the hold and may readily result in sweating within the ship [7]. The above does not take into account possible fumes or gases in the compartment. In such cases discretion must be used.

PRECIPITATION

Precipitation over the Great Lakes and St. Lawrence River area is generally well distributed and abundant throughout the year. This is due to a combination of several favorable conditions. First, a plentiful supply of water vapor is available from the warm waters of the Gulf of Mexico and the Atlantic Ocean. Second, the prevailing winds over the South and Middle West during the warmer months are from the Gulf of Mexico and bring moisture far into the interior. Third, the topography of the eastern half of the Continent offers no significant barrier to the free flow of these winds. Fourth, the numerous cyclones of the colder seasons bring moisture and precipitation into the lower Great Lakes from the south and east which would never fall in the region in their absence.

Precipitation decreases, in general, from east to west and from south to north, varying downward from an average of 40 to 45 in. annually along the St. Lawrence Valley, to 30 to 35 in. on the lower lakes, and to 25 to 30 in. on the upper lakes. The seasonal distribution of precipitation becomes less uniform toward the west (see appendix for monthly and annual means and extremes). The position of a station with respect to prevailing winds off the large water areas of the lakes appears to affect its total precipitation and the seasonal distribution. On the Canadian side of Lake Huron there are increases in the mean annual precipitation, winter maxima in the amount of precipitation, and the number of rainy days. Over the other lakes winter maxima of rainy days also occur except

on the western shore of Lake Michigan and the northern shore of Lake Superior. However, with the exception of the lee shore of Lake Huron, a larger proportion of the annual precipitation in the entire Great Lakes area falls in the warmer months. This summer maximum, characteristic of continental climates, becomes more marked over the western lakes.

Thunderstorms show spring and early summer maxima throughout the area (figure 22). The frequency of thunderstorms is highest along the western shore of Lake Michigan and the southern shore of Lake Erie. The more intense storms are of importance to shipping. Local thunderstorms, more frequent in late summer, are generally only of sufficient intensity to affect small craft, and the lower temperatures found over the lakes tend to weaken them. Frontal or squall line thunderstorms pose a more serious problem. Extremely high and gusty winds in these storms may cause damage to larger vessels, especially in the restricted areas of harbors and canals. Rainfall in the more severe thunderstorms may be excessive, for example: at Cleveland 1.20 in. in 10 minutes, 2.09 in. in 1 hour; at Milwaukee, 1.11 in. in 10 minutes, 2.25 in. in 1 hour. Vessels in the open lakes are generally safe from the rare tornadoes observed in the region. These intense local storms tend to dissipate and to develop waterspout characteristics over the open lakes. Early and late season navigation may be severely hampered for limited times by freezing precipitation and by spray icing conditions.

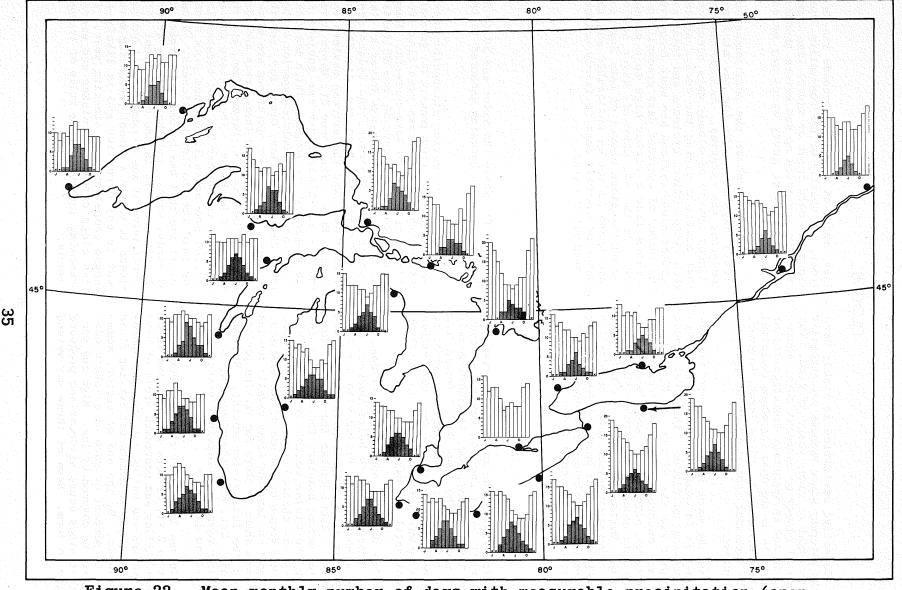


Figure 22. Mean monthly number of days with measurable precipitation (open bars) and thunderstorms (shaded). X indicates average frequency less than 1/2 day.

CLOUDS

Celestial navigation is rarely used on the waterway since vessels are generally within sight or radar range of land. The number of cloudy or overcast days, therefore, is not as important operationally as it would be on the open sea where celestial sights are required. Cloud forms, however, can be important indicators of an approaching cyclone.

As the warm front of a cyclone approaches it is usually heralded by a regular sequence of clouds. The first clouds to appear are the cirrus, which in turn give way successively to cirrostratus, altostratus, altocumulus, and nimbostratus. Steady rain usually accompanies the nimbostratus. During the early and late part of the navigation season this precipitation may fall as sleet or snow and severe icing may occur. The cloud forms which are associated with the cold front and squall

line, which at times may precede the cold front, are usually of the convective type. Along the cold front or squall line cumulonimbus may build up and severe thunderstorms and high gusty winds may be encountered.

Figure 23 shows the mean number of cloudy days by month for the stations bordering the waterway. As expected the highest number of cloudy days occurs at most stations during the cooler months when extratropical cyclones and their attendant cloud systems are most frequent. The number of overcast days gradually decreases from a winter high to a summer low. On the St. Lawrence River and on the northwestern shores of Lake Superior this trend is not as noticeable and the number of overcast days is fairly uniform throughout the year.

ICE

Ice limits the navigation season on the Great Lakes and St. Lawrence River above Three Rivers, Que. to approximately eight months. The lakes do not freeze from shore to shore with the rare exception of Lake Erie. Ice begins to form in northern waters by early November and may still be present until mid-May.

The St. Lawrence River seldom, if ever, freezes across below Quebec, but it is almost always filled with ice that fluctuates with wind and current from shore to shore. Above Quebec ice bridges form and jams occur; however, for short periods during the winter months it is possible to keep the channel open between Quebec and Three Rivers by the use of ice breakers. The upper St. Lawrence River usually freezes over from shore to shore for varying periods during the late winter months. Between Prescott, Ont. and Ogdensburg, N. Y. ice breaking ferries maintain a passage the year round [2].

In the lakes, ice ranging from a few inches to 3 ft. or more in thickness forms in the shallow and protected areas of bays and harbors and builds out from the shoreline. Much of it breaks off forming floes and fields. By the end of winter, sometimes 60 percent or more of a lake's surface may be covered by ice. High and persistent winds cause windrows and pressure ridges to form. Some of these may extend

10 to 20 ft. above the water and 30 to 35 ft. below, often becoming anchored to the lake bottom.

From a navigation standpoint there are certain areas which present the greatest difficulty from windrows resulting from prevailing winds and lake currents. These areas, shown in figure 24, are Whitefish Bay, the upper St. Marys River at the foot of Lake Superior, the island area of northern Lake Michigan, the Straits of Mackinac, and the extreme eastern end of Lake Erie. The lower St. Marys River and the St. Clair River are subject to the dangers of ice gorges. Thick ice forms in Thunder Bay, the Duluth-Superior harbor area, Chequamegon Bay, Green Bay, and the De Nocs. Ice breaker operations are almost invariably required in these areas and also in Whitefish Bay, St. Marys River, and the Straits of Mackinac. The eastern end of Lake Erie is another bad spot because the current and prevailing winds pack slush ice into the shallow bottleneck. Slush ice is ice that has become well broken up by winds, waves, and the crushing effect of pressure. It is one of the most difficult forms of ice to combat as it quickly closes in around a vessel preventing movement in any direction and is likely to damage propellers and steering gear. It also clogs condenser intakes and exerts tremendous pressure on the hulls of trapped vessels.

Figure 23. Mean monthly number of cloudy days (8 to 10 tenths clouds).

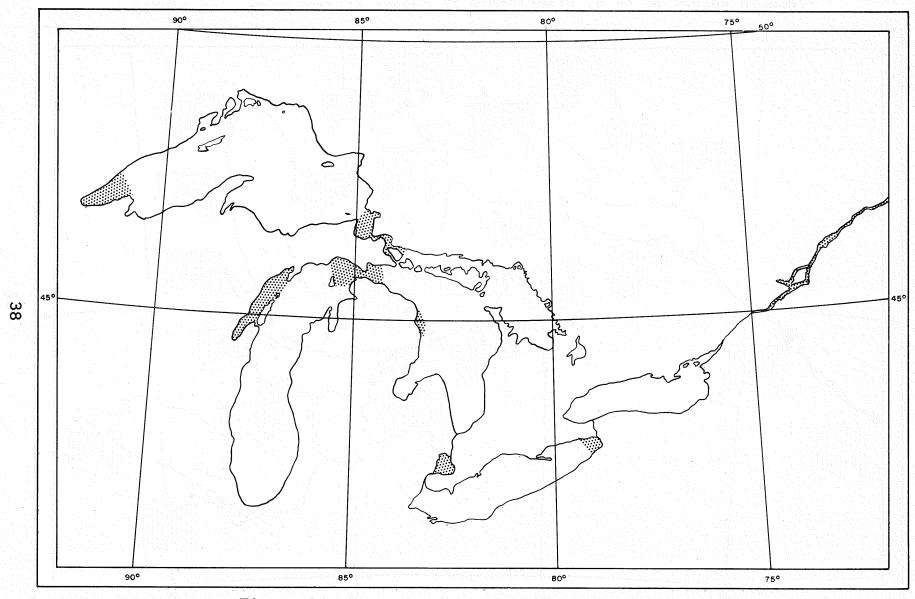


Figure 24. Critical early and late season ice areas.

TABLE 6
OPENING AND CLOSING DATES OF NAVIGATION SEASON

	No.of		OPENING			LOSING	경찰 하나 나
	Years	Earlies		Average	<u>Earliest</u>	Latest	Average
	65	Apr. 7	May 24	Apr. 24	Nov. 21	Dec.19	Dec. 4
Montreal, Que.	5	Apr. 6	Apr.19	Apr. 15	Dec. 5	Dec'.13	Dec. 9
Lachine Canal	5	Apr. 6	Apr.19	Apr. 15	Dec. 5	Dec.12	Dec. 9
Soulanges Canal	5	Apr. 6	Apr.19	Apr. 15	Dec. 5	Dec.11	Dec. 9
Cornwall Canal	5	Apr. 6	Apr.19	Apr. 15	Dec. 5	Dec.12	Dec. 9
Williamsburg Canal	5	Apr. 4	Apr.16	Apr. 12	Dec. 4	Dec.14	Dec. 9
Prescott, Ont.		Mar. 2	mpr • 20	P- •	Dec. 15		
Kingston, Ont.		mar . 2		Apr. 4			Dec. 25
Cape Vincent, N. Y		Apr. 2	Apr.28	Apr. 16	Dec. 1	Dec.26	Dec. 15
Oswego, N. Y.		Apr. 2	npr •20	Mar. 21			Dec. 19
Toronto, Ont.			green for the state	Apr. 15			Dec. 10
Welland Canal		Mar. 1	2 May 11	Apr. 11	Dec. 16	Dec.31	Dec. 23
Buffalo, N. Y.		Mar. 19		Apr. 14	Dec. 7	Jan.5	Dec. 26
Erie, Pa.		Mar. 2		Mar. 31	Nov. 28	Dec.31	Dec. 13
Cleveland, Ohio		Mar. 1	· •	Mar. 28	Dec. 1	Dec.31	Dec. 8
Sandusky, Ohio		Jan. 6			Dec. 3	Dec.31	Dec. 20
Toledo, Ohio		Jan. U	mar . 10	. 138°, 57			
Detroit (Rouge	10	Jan. 8	Mar.27	Mar. 3	Dec. 6	Dec.31	Dec. 19
River), Mich.		Feb. 3		Feb. 28	Dec. 1	Dec.31	Dec. 1
Lower Detroit Rive	r 10	ren. o	mar . 10				
Lake St. Clair	10	Apr. 4	Apr.7	Apr. 5	Nov. 27	Dec.14	Dec. 5
Ship Channel		Apr. 4	Thr.	*****			
St. Clair River (Po	ort Jo	Jan. 2	5 Mar.29	Mar. 19	Nov. 25	Dec.29	Dec. 1
Huron), Mich.	10	Jan. 2	J Mar.23				
South End, Lake	10	Mar. 2	9 Apr. 7	Apr. 3	Nov. 25	Dec.29	Dec. 1
Huron	10	Jan. 2	-		Nov. 28	Dec.19	Dec. 5
Saginaw River, Mic	:n.10				Nov. 1	Dec.31	
Alpena, Mich.	10		0 May 1	Apr. 12	Nov. 16	Dec . 29	
Cheboygan, Mich.	10	mar. 3	U May 1	Apr. 12	1101.		Dec. 1
Straits of Mackina	.C			npr. 12			
St. Marys Falls		vr 0	1 1 1 26	Apr. 5	Dec. 15	Jan.14	Dec. 1
Canals	20	Mar. 2			Nov. 9	Dec 25	
Marquette, Mich.	36	Mar. 2	6 May 26	Apr. 20	1,0,,,		
Duluth-Superior,			C Wow 15	Apr. 22	Nov. 15	Jan.13	Dec. 1
Minn.,Wis.*	85	Mar. 2	6 May 15	npr. 22	1,04. 10		
Duluth-Superior,	0.5		V 10	Apr. 10	Nov. 24	Feb.28	Jan. 4
Minn.,Wis.+	85	Mar. 1	. May 12	whr. 10	1104. 21	100,00	

^{*}Interlake

Ice strong enough to halt navigation is generally encountered in the key channels about December 15. Navigation resumes about April 15 when the channels are sufficiently clear of ice to allow operations. These dates vary considerably from place to place and from season to season. Table 6 shows the earliest, latest, and mean dates of navigation for some of the key ports, canals, and locks [11]. Forecasts of opening days for major lake ports are made

by the U. S. Weather Bureau and are explained on page 53 under Weather Services.

Ice is also a major hazard in the locks during the spring and fall season. Ice not thick enough to obstruct navigation may be carried into the lock by the motion of a vessel. It collects behind the lock gates and prevents full opening or closing until the accumulation is removed [14].

⁺Local

LAKE LEVELS

During periods of low water levels on the Great Lakes, millions of tons of pay load annually may be dependent on each inch of navigable water under the hulls of vessels operating on the waterway. In a single bulk carrier the tons of cargo per inch of immersion varies from 38 tons in the older and smaller vessels to 100 tons in the newer additions to the fleet [12].

The depths of the lakes proper are, with the exception of Lake St. Clair and western Lake Erie, beyond the needs of navigation. The critical points appear in the numerous reaches of the dredged channels in the harbors and in the connecting rivers.

A systematic measurement of lake and river stages in the Great Lakes system began in 1860 and continues to the present day. These data indicate that lake levels fluctuate from year to year and also from month to month depending upon the volume of water in the lakes. In addition, the stages at specific locations vary from day to day and even from hour to hour because of unbalance or tilting of the lake surfaces resulting primarily from strong sustained winds and fluctuating barometric pressures.

The annual and seasonal variations in the measured levels may amount to a number of feet and the short term hourly or daily variations may range from a few inches to several feet depending on the particular location on the lake. Variations in lake levels are of major importance to navigation interests but also seriously increase shore erosion, destroy property, and disrupt or slow down the output of power installations. Developments along the shoreline that fail to take into account the wide natural range in surface elevations indicated by the record are subject to periodically increased losses and occasional heavy damage.

RANGES IN LAKE LEVELS Long Period Fluctuations

Table 7 shows the long range variation of levels of the Great Lakes as indicated by the highest and the lowest monthly average levels for the 98 years of record. The maximum fluctuation in the monthly average levels ranges from 4 ft. on Lake Superior to over 6 ft. on Lakes Michigan, Huron, and Ontario.

Seasonal Fluctuations

In the usual pattern of seasonal varia-

TABLE 7
COMPARISON OF LAKE LEVELS*

Lake	Average level for period of Record 1860-1957	one	ghest -month erage Month and Year	One	west -month erage Month and Year	Range between high and low one-month average (feet)
ONTARIO	246.05	249.20	June 1952	242.68	November 1934	6.52
ERIE	572.36	574.70	May 1952	569.43	February 1936	5.27
ST. CLAIR**	925	577.52	July 1952	571.68	January 1936	5.84
MICHIGAN- HURON	7. – 7 ažese ja Štate 580.58 01 ap Galanda – 17 km ap	583.68	June 1886	577.35	February 1926	6.33
SUPERIOR	602.21	604.05	August 1876	599.98	April 1926	4.07

^{*} All levels are in feet above mean tide at New York, 1935 Datum. ** Period of record for Lake St. Clair is 1898-1957.

tions of levels of the Great Lakes the high levels occur in summer or early fall and the low levels in late winter. Lakes Ontario and Erie usually reach their highest level in June, Lakes Michigan and Huron in July and Lake Superior in September. The lowest level is usually reached on Lake Ontario in January, on Lakes Erie, Michigan, and Huron in February, and on Lake Superior in March. The average seasonal range in level between the low monthly average and the high monthly average is 1.8 ft. for Lake Ontario, 1.6 ft. for Lake Erie, 1.1 ft. for Lakes Michigan and Huron, and 1.2 ft. for Lake Superior. There have been years in which the highest and lowest levels have occurred in months at a considerable variance from the established pattern.

Short Period Fluctuations

As indicated previously, short period fluctuations or seiches may occur daily or even hourly and are caused by unbalance or tilting of the lake surfaces. variations are caused by winds, varying barometric pressures, and tides. Small scale differences in pressures and tides are usually unimportant but high winds, particularly of storm force, and sharp gradients in barometric pressure cause large changes in lake levels. Any short period fluctuations are superimposed on the general levels prevailing and may cause excessive highs in periods of generally high levels and excessive lows during periods of generally low levels. Fluctuations in level are, in general, more significant in shallow areas such as Green Bay, Saginaw Bay, and the western reaches of Lake Erie. Short period fluctuations as great as 10 ft., and existing as long as 12 hr., have occurred on Lake Erie where the maximum fluctuations are most frequently felt. A difference in water level as high as 13.5 ft. has been recorded between the extremities of Lake Erie along its long axis, Buffalo and Toledo [4]. These fluctuations affect the depths in the channel of the lower Detroit River where changes of as much as 6 ft. in 8 hr. have occurred.

During recent years extreme fluctuations up to 7 ft. above the monthly mean have occurred on Lake Erie on an average of once in every seven or eight years. Variations in level of several feet lasting for periods of several hours are common on all of the lakes.

RANGES IN STAGES ON THE ST. LAWRENCE RIVER

The mean level of the river falls gradually from a high stage in the spring to a low stage in the autumn. The fall from May to September ranges downward from an average of 5 ft. at Three Rivers through 1 3/4 ft. at Newville, and below St. Augustin Bar it is negligible. At Quebec and above, the range of the tide is reduced by the high stage of the river. The range increases during the season that the river is gradually falling so that the available depth at high water is not decreased as much as the fall in the stage of the river would indicate [2].

CURRENTS

On the St. Lawrence River below Quebec the currents are caused primarily by the rise and fall of the tide which has a mean range of 13.7 ft. at Quebec [13]. Between Montreal and Lake Ontario flow-through is the principal cause of currents while on the Great Lakes wind is the major factor governing the current regime.

At Quebec the ebb current which reaches a speed of 4 1/2 kt. is strongest along the southeastern shore, and the flood current which attains a speed of 3 1/2 kt. along the northwestern shore. At Batiscan, about 55 mi. above Quebec, there is no reversal and the current sets continuously downstream at a speed of about 2 1/2 kt. [15]. Between Batiscan and Lake St. Peter the speed of the downstream or flow-through current is either increased or decreased depending on the stage of the tide. At Montreal the current is constantly downstream with

speeds in the main channel ranging from 1.7 to 6.3 kt. Generally the current follows the reaches of the channel, but at turns or bends in the river, in most instances it sweeps obliquely across the channel and must be guarded against. St. Mary's Current is the name of the current found in the 1,300-ft. passage between Ronde and Montreal through which the bulk of the St. Lawrence River water passes on its way to sea. The average speed of the current in this section of the river is about 4 1/2 kt.

The St. Lawrence Seaway is designed in such a manner that the average current speed will not exceed 2.4 kt. [14].

Currents in the Great Lakes are principally wind driven. In addition to the wind, other factors such as the rotation of the earth, density differences, shape

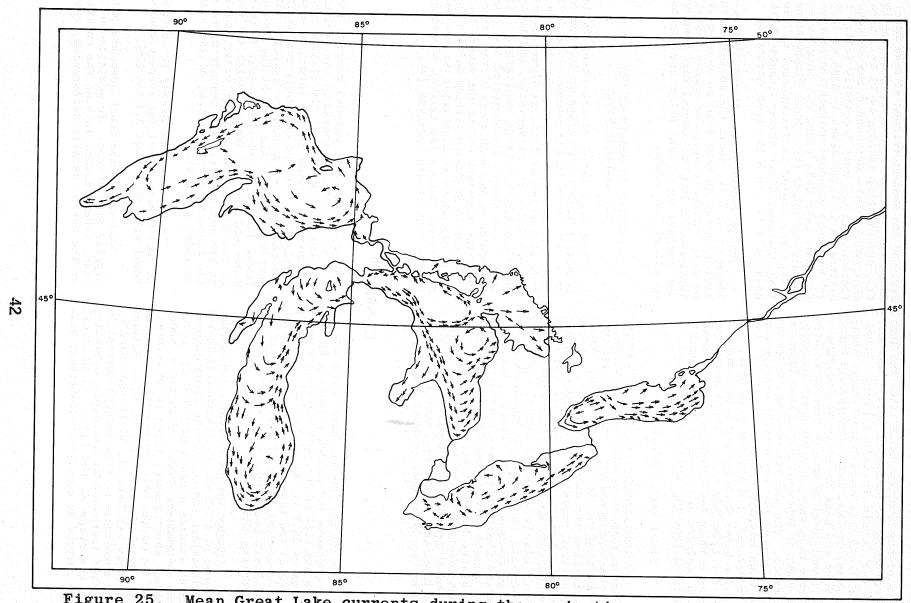


Figure 25. Mean Great Lake currents during the navigation season (after Millar).

of the basin, depths of water, and flow-through all have secondary effects on the horizontal currents of the lakes.

Figure 25 depicts the general current regime on the lakes as found by Harrington [3] and drawn by Millar [9]. The configuration was found by Harrington by means of drift bottles which were released during the navigation season. The figure, therefore, represents the mean pattern during the warmer months. However, there is nothing in the original data suggesting different patterns in the spring or fall months.

On the lakes, especially the large and deep basins, the currents tend to circulate in a cyclonic or anticlockwise direction with upwelling in the west and northwest and sinking in the east or southeast. The general pattern of the primary currents seems to persist with little change. Temporary changes do occur in connection with seiches and, in the case of secondary or weaker currents, with wind direction. Even the well marked currents are modified when strong winds blow for an extended period from a direction other than the prevailing one.

In general the currents on the lakes vary in speed from .2 to .4 kt. Over short distances, however, much higher speeds may be encountered. The most clearly marked currents have speeds of about 1 kt.

On Lakes Ontario and Erie the eastward drift due to the prevailing winds is predominant and extends from the middle of the lakes to their southern shores. There are small cyclonic whirls in the western sections of both lakes and the currents along their northern shores appear to be weak.

In the Welland Canal the current has an average velocity of about .9 kt. between Lock 8 and the Power Commission intake north of Bridge 11. A cross current towards the west exists 500 ft. south of Bridge 11 and also at the entrance to the Third Welland Canal Channel north of Bridge 11. Masters are warned to guard against being drawn over to the west at these locations [11].

The Detroit River which connects Lake Erie to Lake St. Clair has an average current speed of about 1.7 kt. with a maximum speed of 3.5 kt. at Limekiln Crossing. The

St. Clair River, which connects Lake Huron with Lake St. Clair has a current speed near its upper end of about 4.3 kt. through the rapids section extending from about 1,000 ft. above to 200 to 300 ft. below the Blue Water Bridge at Port Huron, and a speed of about 1.7 kt. through the canal entering Lake St. Clair. At intermediate points the speed varies irregularly between these limits. During periods of sustained high north-northeast winds on Lake Huron, speeds in the upper St. Clair River are increased [11].

In Lake Huron the currents are divided into two cyclonic cells. One is located near the center of the lake close to the eastern shore and the other in the northern part of the lake. A comparatively strong southward to southeastward current parallels the entire length of the west coast. Weak northward and westward return currents flow along the east and north shores, respectively.

The currents in Lake Michigan are also divided into two cyclonic cells. A well-developed cell is located in the southern part of the lake with a marked southward drift on its western side and a northward drift on its eastern side. The northern cell is not as intense and the currents along the northwestern shores of the lake are weak. A well-defined northward current parallels the entire east shore of the lake.

In the Strait of Mackinac during intense storms with strong easterly winds the normal current from Lake Michigan to Lake Huron has occasionally been reversed.

The St. Marys River forms the outlet for Lake Superior, connecting it with Lake Huron. The swiftest currents in the navigable channels of the St. Marys River are found at the Middle Neebish dike, the West Neebish rock cut, and the Little Rapids cut. The strength of the current depends largely upon the discharge of the river and the elevation of the water surface at the mouth of the river. The speed of the current averages between 1.3 and 2.2 kt. and varies between a probable low of 0.9 kt. and a probable high of 3 kt. [11].

The currents in Lake Superior generally parallel the shoreline with an eastward drift along the southern shore and a westward drift along the northern shore.

LAKE TEMPERATURES

Aside from the geographical factor of latitude and its obvious effect on temperature distribution, there are additional considerations that are important to an understanding of the variations of water temperatures over the Great Lakes area. These factors include depth of lake and drift of surface water as a result of currents.

The influence of water depths in the lakes on surface temperatures is so strong that the depth contours resemble a blurred image of the water isotherms [9]. Outstanding instances of these resemblances are evident over the shallow reaches of Lake Erie and the unusual depths of Lake Superior.

The distribution of water temperatures in the Great Lakes is also related to currents. Observations show that the surface water over the southeastern portions of the lakes is relatively warm in summer due to the drift of warm surface water to these areas under the influence of prevailing westerly winds. As a result convergence and sinking occurs in these areas, and a compensating upwelling must result elsewhere and is evident in the western and northern portions of several of the lakes. In an area of upwelling the surface

water is relatively cold during the warming season and during the early cooling stage until the mass of floating surface water has been cooled to the temperature of the bottom water.

On Lake Ontario there is a cyclonic circulation due to upwelling at the western end. Along the northern shore from Hamilton to east of Cobourg, during the period mid-June through August, the rather narrow band of cold waters resulting from upwelling is well known to ships' engineers, as it affects the operation of condensers. Similar patterns are apparent at the northern ends of Lakes Michigan and Huron while on Lake Superior the south-southwest set of the current along the northwestern shore is reinforced by upwelling. Cyclonic circulation is less marked on Lake Erie, probably because of the shallow nature of the lake with bottom friction acting as a brake.

Figures 26 through 30, prepared by Millar [9], indicate bimonthly (April through December) surface water temperatures of the Great Lakes. As would be expected Lake Superior, the deepest and most northerly lake, has throughout the year the lowest water temperatures, and Lake Erie, the shallowest and most southerly, has the highest temperatures. Temperature

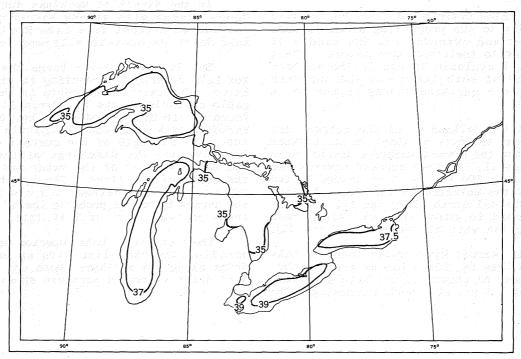


Figure 26. Mean Great Lakes water temperatures, April (after Millar).

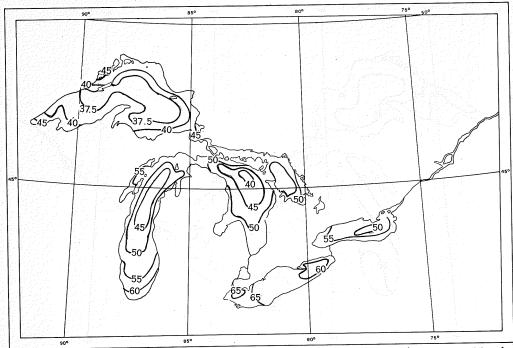


Figure 27. Mean Great Lakes water temperatures, June (after Millar).

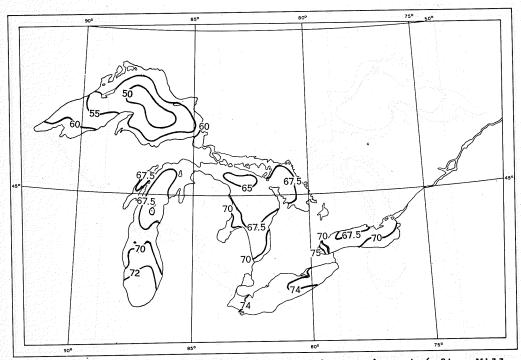


Figure 28. Mean Great Lakes water temperatures, August (after Millar).

variations over a single lake and between lakes are much greater during the warm season, as indicated by the chart for June, than they are during the colder months, as represented by the chart for December. During the spring and early summer periods of maximum thunderstorm activity, the temperature of the water in the lakes is low, so that convective storms tend to weaken over the lakes. During autumn when

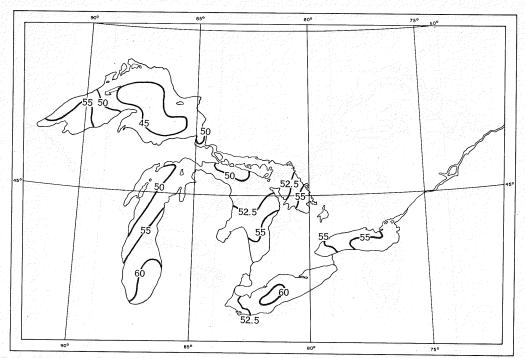


Figure 29. Mean Great Lakes water temperatures, October (after Millar).

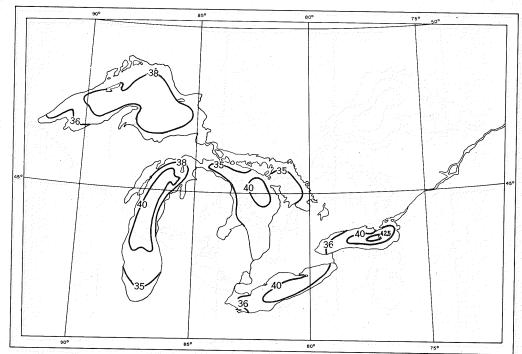


Figure 30. Mean Great Lakes water temperatures, December (after Millar).

the lakes become a heat source there is a tendency for cyclone centers and active cold fronts to intensify over the water. The conservative nature of water temperature

causes a lag in reaching the temperature of the air above. This difference in airwater temperatures results in fog, discussed on page 27.

WEATHER SERVICES

The Great Lakes and St. Lawrence River form the world's most important and longest inland waterway for the movement of heavy cargoes. Ships engaged in this trade are vulnerable to the weather, mostly because the location of the waterway on the North American continent places it in the path of some of the most vicious of inland storms. Many of these storms, especially in the winter half of the year, develop quickly and move with alarming rapidity toward the Great Lakes and St. Lawrence River. The warning service must be alert, resourceful, and swift in its decisions and in the issuance of warnings.

For nearly two decades, waterborne cargoes on the Great Lakes alone have been not only of such hugh proportions as to surpass all previous records, but also of vital character, with weight and bulk such that no other means of transporation would have been capable of giving much assistance. Iron ore, limestone, and coal

for the steelmaking industry, as well as grain and oil and many other commodities, are hauled cheaply and steadily over a water route, which, due to climatic conditions, is open only 8 1/2 months each year. During the other 3 1/2 months, ice on the lakes and in the connecting waterways makes navigation very difficult, and at times impossible.

Demands for extraordinary cargo movements in the past have resulted in forcing the opening of navigation on this waterway to the earliest possible date in the spring and delaying the closing of navigation until the latest possible date in early winter. Consequently, shipping is exposed to some of the worst storms which occur over this waterway. Thus the information services including weather contribute to the successful handling of an enormous amount of marine traffic on the waterway with a minimum of casualties due to storms and violent weather.

FORECASTING AND WARNING SERVICES

As a rule, navigation on this water-way from Montreal inland to the lakes, commences around the middle of April and continues until the middle of December each year. In some years these dates may be as much as two weeks or more earlier and extend past the end of December when demands for continuous movement of cargoes is essential to meet the needs of nations on the North American as well as on other continents.

To provide shipping on the Great Lakes with daily weather services, the U. S. Weather Bureau, through the Weather Bureau District Forecast Center at Chicago, Ill., issues forecasts, and warnings when necessary, for broadcast every 6 hr. during the navigation season by several U. S. Coast Guard and commercial marine radiotelephone stations along the lakes. Broadcasts by a limited number of U. S. radio stations are continued throughout the winter months. Similarly, the Canadian Meteorological Service, through the Dominion Public Weather Office at Toronto, issues forecasts and warnings for the Great Lakes and St. Law-

rence River for broadcast to ships by the Canadian radio stations. Details of the U. S. and Canadian broadcasts to ships are shown in tables 8 and 9, respectively. Warnings whenever issued, are broadcast to ships on separate schedules as shown in the tables.

Forecasts for each lake (LAFOT) prepared for broadcast by U. S. and Canadian radio stations listed in the tables employ a simple number code, supplemented by plain language. An explanation of the LAFOT forecast code is given underneath tables 8 and 9.

In addition, a bulletin containing weather reports from vessels and stations located in harbors and other points in the Great Lakes Region (LAWEB) is also broadcast at 6-hourly intervals during the navigation season. The broadcast schedules for the LAWEB Bulletin are shown in table 10, together with a list of station reports included therein. Weather data for each station in the bulletin are given in plain language.

TABLE 8

U. S. LAFOT RADIOTELEPHONE BROADCASTS-MARINE WAVELENGTHS

Great Lakes coded weather forecasts (LAFOTS) issued by the U. S. Weather Bureau District Forecast Center, Chicago, Illinois, and broadcast by U. S. radiotelephone stations every six hours during the navigation season. Schedules, frequencies, call signs and LAFOTS included in broadcasts by each radio station are as follows:

<u>City</u>	Station	<u>Kc.</u>]	Forecasts†	Broadcast times, E.S.T.
Lorain, Ohio	WMI	2514 4420.7 8797.3*	SMHEO	12:02 & 6:02 a.m. & p.m.
Chicago, Ill. (Lake Bluff)	WAY	2514 4420.7 8797.3#	SMHEO	12:09 & 6:09 a.m. & p.m.
Rogers City, Mich.	WLC	2514 4420.7 8797.3+	SMHEO	12:16 & 6:16 a.m. & p.m.
Buffalo, N. Y. (Martinsville)		2514ø 4420.7	HEO	12:23 & 6:23 a.m. & p.m.
Duluth, Minn.	WAS	2514@ 4420.7*	SMH	12:27 a.m. & 6:27 a.m. & p.1
Port Washington Wis.	WAD	2514	SMH	12:23, 6:23 a.m., 12:27 p.m

NOTE: LAFOTS for Lakes Superior and Michigan are broadcast on 2514 kc., and 4420.7 kc., during the winter months by Radio WAY at 12:02 and 6:02 a.m. & p.m., and Radio WAD at 12:06 and 6:06 a.m. and p.m. Broadcasts continue until regular LAFOT schedules are resumed in the spring.

- † Forecast abbreviations: S-Lake Superior: M-Lake Michigan: H-Lake Huron: E-Lake Erie: O-Lake Ontario
- * Not used at 12:02 a.m.

- # Not used at 12:09 a.m. + Not used at 12:16 & 6:16 a.m. Ø Not used at 12:23 & 6:23 a.m. @ A+ 12:23 p.m.
- ° At 12:27 p.m.

U. S. RADIOTELEPHONE BROADCASTS OF WARNING MESSAGES (All broadcasts on 2182 kc.)

Gale and Whole Gale warnings are broadcast on receipt of the message by U.S. radiotelephone station, on the first warning schedule and at 2-hour intervals thereafter until 5 hours from the "Hoist" time given in the message, unless superseded or cancelled. Cancellation of a warning is broadcast once only on the next warning schedule following receipt of the message at the station. Schedules given in the table are in minutes past EVEN or ODD hours, E.S.T.

City	Station	<u>La kes</u>	Broadcast times-E.S.T.
Buffalo, N. Y.	WBL	EO	On receipt & odd HH+55
Chicago, Ill.	WAY	SM	On receipt & odd HH+45
Duluth, Minn.	WAS	S	On receipt & odd HH+55
E. Tawas, Mich.	NMD-24	H	On receipt & odd HH+55
Erie, Pa.	NMD-11*	E	On receipt & even HH+55
Lorain, Ohio	WMI	SMHEO	On receipt & odd HH+35
Marquette, Mich.	NOG-5*	S	On receipt & even HH+55
Plum Island, Wis.	NMP-15	M Silver	On receipt & even HH+35
Portage, Mich.	NOG-17	S	On receipt & even HH+35
Port Huron, Mich.	NMD-22	H	On receipt & even HH+35
Port Washington, Wis.	WAD	M	On receipt & odd HH+55
Rogers City, Mich.	WLC	SMH	On receipt & even HH+45
Sault Ste. Marie, Mich	. NOG*	SH	On receipt & odd HH+45

NOTE: Radiotelegraph Stations, WLC and WBL also make broadcasts of warnings on receipt. Broadcasts are made on 482 kc. after initial call on 500 kc.

^{*} Daylight hours only

TABLE 9

CANADIAN LAFOT RADIOTELEPHONE BROADCASTS (All broadcasts on 2514 kc.)

LAFOTS for Lakes Superior, Huron, Erie and Ontario and Georgian Bay are issued by the Dominion Public Weather Office, Toronto, Canada.

<u>City</u>	Statio	<u>n</u>	Broadcast times-E.S.T.
Kingston, Ont.	VBH		4:40 & 10:40 a.m. & p.m.
Midland, Ont.	VBC		4 & 10 a.m. & p.m.
Port Arthur, Ont.	VBA		4:30 & 10:30 a.m. & p.m.
Port Burwell, Ont.	$\mathbf{v}\mathbf{B}\mathbf{F}$		3:50 & 9:50 a.m. & p.m., in-
	t Shoal	Island	reports; Long Point 9:50 only.
Sarnia, Ont.	VBE		4:10 & 10:10 a.m. & p.m.
Sault Ste. Marie, Ont.	VBB		4:20 & 10:20 a.m. & p.m.
Toronto, Ont.	VBG		3:40 & 9:40 a.m. & p.m.

Station VBH broadcasts local weather reports from Main Duck Island at 9:10 a.m., 2 and 8 p.m.; VBA reports from Caribou and Slate Islands at 9:10 a.m., 1:40 and 7:40 p.m.; VBB reports from Caribou and Slate Islands at 9:20 a.m., 1:50 and 7:50 p.m.; VBC reports from Cove Island at 10 a.m., 4 and 10 p.m. All broadcasts being made on 2514 kc.

Urgent reports of dangers to navigation and revisions to current weather forecasts are transmitted immediately on receipt by each station shown in the table above. These reports are repeated on 2514 kc. during the following schedules: 7-7:30; 8-8:30; 9-9:30; 10-10:30; 11-11:30 a.m., 1-2; 3-3:30; 4-4:30; 5:30-6; 7-9; 9:30-10 p.m. E.S.T.

CANADIAN RADIOTELEGRAPH (A1) AND RADIOTELEPHONE BROADCASTS

St. Lawrence River forecasts and warnings are issued by the Dominion Public Weather Office, Toronto, Canada, and broadcast in plain language by the following radio stations:

<u>Station</u>	Call Sign	<u>Frequency</u>	Broadcast times, E.S.T.
*Father Point, P.Q.	VCF	2582	7:20 a.m. & p.m.; 12:30 & 11:30 p.m.
		446(A ₁)	7:30 a.m. & p.m.; 12:40 & 11:40 p.m.
*Fox River, P.Q.	VCG	2582 (1994) (1994) (1994)	7:30 a.m. & p.m.; 12:40 & 11:20 p.m.
Santana da		434(A ₁)	7:40 a.m. & p.m.; 12:50 & 11:30 p.m.
#Montreal, P.Q.	VCA	2582 420(A ₁)	7 a.m. & p.m., 12 noon 7:10 a.m. & p.m.; 12:10 p.m.
*Quebec, P.Q.	VCC	2582 434(A ₁)	7:10 a.m. & p.m.; 12:10 p.m. 7:20 a.m. & p.m.; 12:20 p.m.
øThree Rivers, P.Q.	VBK	2582	7:20 a.m. & p.m.; 12:20 p.m.

^{*} All year

EXPLANATION OF GREAT LAKES WEATHER FORECAST (LAFOT) CODE

Great Lakes weather forecasts (LAFOTS) are issued in code and broadcast by U. S. and Canadian radiotelephone stations (marine wavelengths) on schedules as published above.

The LAFOT code consists of groups of five figures represented by the letter symbols "DDffW", supplemented by plain language words. The first two digits, "DD", indicate the wind direction according to Table A. When the two figures for "DD" are the same, this means that the wind is expected to hold steady from that direc-

[#] Winter 7 a.m. to 7 p.m. E.S.T.

ø Navigation season only

tion during the forecast period indicated in the LAFOT. If the figures for "DD" are different, this means that the winds will vary between the two directions indicated.

Figures for the third and fourth digits, "ff", give the wind speed expected in actual miles per hour. Variations from the forecast wind speed may be anticipated. For winds below 16 m.p.h., variations from the forecast speed will usually run as high as 40 percent and occasionally 70 percent; for speeds 16 m.p.h. and above, variations will run as high as 20 percent and occasionally 30 percent. The figure for the last digit "W", gives the average weather expected according to Table B.

Table A
Symbol D - Wind
Direction

Table B
Symbol W - Weather

Code Figure	Direction	Code Figure	Weather
0	Calm	0	Fine (mostly clear)
1	Northeast	1	Cloudy (or overcast)
2	East	2	Thundersqualls
3	Southeast	3	Showers
4	South	4	Rain Pain Pain
5	Southwest	5	Fog (visibility 1/2 mile or less)
6	West	6	Lake steam (visibility 1/2 mile or less)
7	Northwest	7	Light to moderate snow
8	Nor th	8	Freezing rain
9	Variable	9	Heavy snow (visibility 1/2 mile or less)

LAFOTS cover 24 hours divided into two 12-hour periods; the periods in LAFOTS being identified by the words "FIRST" and "SECOND". In LAFOTS transmitted by U. S. Radiotelephone stations commencing shortly after midnight, the "FIRST" period begins at 1 a.m., and the "SECOND" 12 hours later at 1 p.m., E.S.T. For LAFOTS broadcast a few minutes after 6 a.m., 12 noon and 6 p.m.,E.S.T., the "FIRST" period starts at 7 a.m., 1 p.m., and 7 p.m., E.S.T., respectively. In LAFOTS issued by the Dominion Public Weather Office, at Toronto for broadcast by Canadian radiotelephone stations, the "FIRST" period commences at the time of broadcast and the "SECOND" 12 hours later.

Examples of U. S. LAFOTS issued for broadcast shortly after midnight E.S.T.: Superior: First 18347 west half 11189 east half. Second 87240 west half 88277 east half. Much colder with temperature falling to 15 by late evening. Michigan: First 99113 becoming 11193 middle period and 18301 end period Second 87310.

Examples of above LAFOTS as translated: Lake forecasts for two 12-hour periods, the first commencing at 1 a.m. and the second starting at 12 hours later or at 1 p.m., E.S.T. Lake Superior: First period, northeast to north winds, 34 m.p.h. with light to moderate snow west half of Lake and northeast 18 m.p.h. with heavy snow east half of Lake. Second period, north to northwest winds 24 m.p.h., fine weather west half and north 27 m.p.h. with light to moderate snow east half of Lake. Much colder with temperature falling to 15 degrees by late evening. Lake Michigan: First period, variable winds, 11 m.p.h. with showers becoming northeast 19 m.p.h. with showers middle of period and northeast to north winds, 30 m.p.h. and cloudy end of period. Second period, north to northwest winds, 31 m.p.h. with fine weather. Synopsis: Each LAFOT Bulletin also contains a brief weather summary giving positions of Lows, Highs, Fronts, and other features on the weather map within a radius of 600 miles of the Lake Region. NOTE: When Small Craft, Gale, or Whole Gale Warnings have been issued for any Lake, the appropriate U. S. LAFOTS will also contain a statement indicating the type of display and the area along the Lakes where warning displays are in effect.

TABLE 10

U. S. LAWEB BROADCASTS

Great Lakes Weather Bulletins(LAWEB) are issued for radiotelephone broadcast by the U. S. Weather Bureau every six hours during the navigation season. Schedules of LAWEB broadcasts are as follows:

City Station	Kc.	Broadcast	times-E.S.T.
	053.4	0.20 0 0.2	20 2
Lorain, Ohio WMI	2514 4420.7	* not use	30 a.m. & p.m. 1 at 2:30
	8797.3*	a.m. after	r October 1

EXPLANATION OF GREAT LAKES WEATHER BULLETIN (LAWEB)

LAWEB Bulletins are issued in two parts. Part I contains plain language reports of wind direction and speed and/or barometer reading data from land stations in the Lake Region as follows:

Oswego Harbor, N. Y. (Wind only)
Rochester Harbor, N. Y. (Wind only)
Fort Niagara, N. Y. (Wind only)
Buffalo Harbor, N. Y. Erie Harbor, Pa. (Wind only) Ashtabula Harbor, Ohio (Wind only) Cleveland Lighthouse, Ohio Marblehead, Ohio (Wind only) Toledo Lighthouse, Ohio Port Huron Lighthouse, Mich. (Wind only) Bay City, Mich. (Wind only) Tawas Point, Mich. (Wind only) Alpena, Mich. (Barom. only) Thunder Bay Island, Mich. (Wind only) Point Betsie, Mich. (Wind only) Muskegon Harbor, Mich. St. Joseph, Mich. (Wind only) Chicago, Ill. (Barom. only) Dunne Crib, Ill. (Wind only) Milwaukee Lighthouse, Wis. (Wind only) Green Bay, Wis.
Escanaba, Mich. (Wind only) Lansing Shoals, Mich. (Wind only)

Mackinaw City, Mich. (Wind only)
Sault Ste. Marie, Mich.
Whitefish Point, Mich. (Wind only)
Grand Marais, Mich. (Wind only)
Stannard Rock, Mich. (Wind only)
Marquette, Mich. (Wind only)
Passage Island, Mich. (Wind only)
Manitou Island, Mich. (Wind only)
Eagle Harbor, Mich. (Wind only)
Keeweenaw, Upper Entrance, Mich.
(Wind only)
Houghton, Mich. (Barom. only)
Superior Harbor, Wis. (Temperature when below 32°F.)
Fargo, N. Dak. (Barom. only)
Lakehead, Ont.
Gore Bay, Ont. (Wind only)
Wiarton, Ont.
Clear Creek, Ont. (Wind only)
Toronto, Ont. (Wind only)
Trenton, Ont.
Montreal, Que. (Barom. only)

Part II comprises reports from ships underway on the Lakes when more than 4 miles off shore. Positions of ships are given in distance in miles and direction from well-known landmarks; wind direction to 16 points of the compass and speeds in miles per hour. Ice data, in season, are added when reported by ships.

Visibility and weather are included in both land and ship station reports when visibility is less than 5/8 of a mile. Observations are taken one hour and 30 minutes prior to the time of each broadcast.

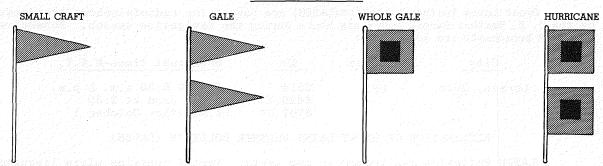
SMALL CRAFT, GALE, AND WHOLE GALE WARNING DISPLAYS

In addition to issuing warnings for broadcast, the U. S. Weather Bureau also makes visual displays of Small Craft, Gale, and Whole Gale Warnings by means of flags and pennants by day, and lights at night, at approximately 100 stations at U. S.

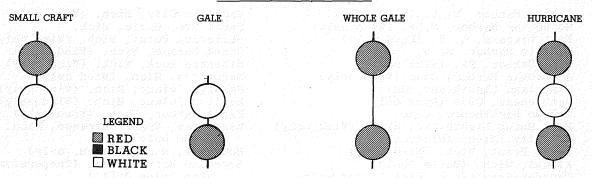
points along the lakes. An illustration, together with an explanation, of each of these warning signals is given in figure 31. A list of the locations of these stations is contained in the appendix.

SMALL CRAFT, GALE, WHOLE GALE AND HURRICANE WARNINGS

DAYTIME SIGNALS



NIGHT (LIGHT) SIGNALS



EXPLANATION OF WARNING DISPLAYS

SMALL CRAFT WARNING: One RED pennant displayed by day and a RED light OVER a WHITE light at night to indicate winds and seas, or sea conditions alone, considered dangerous to small craft operations are forecast. Winds may range as high as 38 mph (33 kt.).

GALE WARNING: Two RED pennants displayed by day and a WHITE light ABOVE a RED light at night to indicate winds within the range 39 to 54 mph (34 to 47 kt.) are forecast for the area.

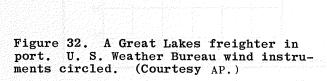
WHOLE GALE WARNING: A single square RED flag with a BLACK center displayed during daytime and two RED lights at night to indicate winds within the range 55 to 73 mph (48 to 63 kt.) are forecast for the area.

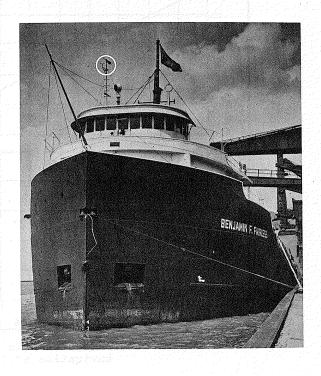
HURRICANE WARNING: Two square RED flags with BLACK centers displayed by day and a WHITE light between two RED lights at night to indicate that winds 74 mph (64 kt.) and above are forecast for the area. As a rule, hurricane warning signals may be ordered displayed at points along U. S. shores of the Great Lakes only on very rare occasions. For example, in the event a hurricane moves inland over the U. S. Gulf or Atlantic coast states and continues with marked intensity as it approaches or passes near the Lake Region, hurricane warnings may be ordered displayed along the lakes to be affected. Hurricane warning signals may also be ordered displayed on occasions during fall, winter, or early spring months when severe storms other than those of tropical origin are expected to affect the lakes. In such cases, warning messages issued for press and radio broadcast distribution will specify that the storm is not a hurricane, but winds of 74 mph (64 kt.) and above are expected.

NOTE: The above warning display signals are supplementary to, and can not replace the Small Craft, Gale, Whole Gale and Hurricane Warning messages issued for broadcast. Important details as to time, intensity, duration, direction of movement of the storm needed for navigation purposes are included in warning messages and lake forecasts broadcast by radio stations.

WEATHER REPORTS FROM GREAT LAKES VESSELS

To supplement surface and upper air data received from stations throughout North America, which form the basis for issuing Great Lakes and other forecasts, the U.S. Weather Bureau has equipped a number of vessels with anemometers to furnish wind and weather reports by radio every six hours while the ships are underway on the lakes. The Canadian Meteorological Service has made similar arrangements with vessels registered under the flag of that country relative to furnishing reports for forecasting and warning purposes. A typical wind equipment installation aboard a vessel is shown in figure 32.





PREDICTING OPENING OF NAVIGATION

Before the opening of navigation each year, the U.S. Weather Bureau at Detroit, Mich., provides an ice reporting and forecasting bulletin service to marine interests along the Great Lakes. Beginning during the middle or latter part of February, bulletins are issued weekly and contain reports of ice conditions from U.S. and Canadian weather reporting stations along the Great Lakes and the St. Lawrence River as far as Prescott, Ont. Reports of ice conditions on lakes furnished by airline pilots and U. S. Coast Guard aircraft are also included. The bulletin, issued during the last week of February or early in March, also contains a forecast of the dates when a number of major Great Lakes ports are expected to be free of ice and navigation can commence. As a rule, this service continues until the middle of April or when ice conditions are no longer a menace to navigation.

A knowledge of the dates when the major ports will be open to navigation is vital to marine interests. To fit out the U.S. Great Lakes fleet of carriers prematurely would entail an unnecessary

operating expense ranging perhaps as much as \$400,000 to \$500,000 a day. On the other hand, it has been estimated that a million tons of iron ore alone can be gained per week, if the lake ore vessels can commence operation as soon as navigation is feasible.

The techniques employed for predicting a month or more in advance the dates when ports are expected to be free of ice have been evolved from an attempt to correlate winter months' temperatures with opening dates of the ports to navigation. A significant correlation was obtained from a study of December, January, and February mean temperature summations but better results were obtained from February temperatures alone. From these data, curves and standard errors were developed for eight major lake ports. Examples of the curves developed are shown in figure 33. Thus on March 1, if the February mean temperature for Duluth was 16.5°F., the probable opening date indicated by the graph is 98 days after January 1, or April 8, with a tolerance of plus or minus 13 days.

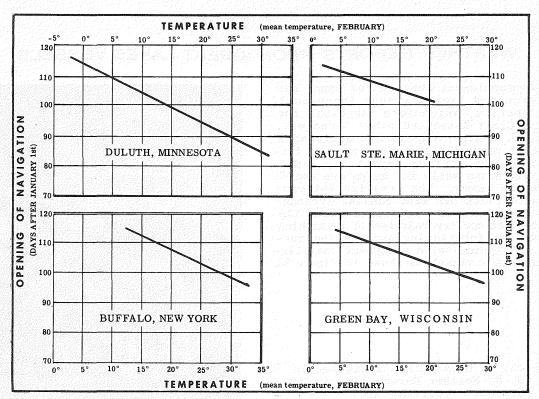


Figure 33. Curves used in prediction of opening date of navigation at four Great Lakes ports.

It should be noted that predictions from the graph are approximate dates and not exact. However, on several occasions the opening dates as forecast by the U.S. Weather Bureau coincided with or were very near to the actual port opening dates. Of course, economic conditions, as well as ice conditions, are important factors in determining when early season navigation on the Great Lakes is to commence.

All of these weather services now provided to shipping on this waterway have

been arranged in cooperation with the U.S. Lake Carriers, the International Shipmasters, and the Dominion Marine Associations. These organizations hold their annual meetings, usually in January of each year, with representatives of the U.S. Weather Bureau and the Canadian Meteorological Service participating. At these meetings, the weather services provided to shipping are reviewed for the purpose of making improvements in line with suggestions offered by shipmasters and others interested in marine transport.

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APPENDIX

CLIMA	TOL	OGICA	L TAI	BLES	
	7'				

NORMALS, MEANS, AND EXTREMES

QUEBEC (CITY) P.Q.

LATITUDE 46° 48' N LONGITUDE 71° 13' W ELEVATION (ground) 2961

Теп	perature		_	ays.						Precip	itation							lative nidity			Wi	nd		shine	İ			Mean	num)	ber of	days		
Normal	Ext	remes		91786 d	_								Sı	ow			١.,		F. 15		Ho	Maxi	num Hileage	le sur	nset	A1 1330	E	9101	Hore	8		empe	eratu
Daily maximum Daily minimum Monthly	Record highest Year	Record	Year	Normal de	Normal tota	Maximum monthly	Year	Minimum monthly	Year	Maximum in 24 hrs.	Year	Mean total	Maximum monthly	Year	Maximum in 24 hrs.		0130 E.S.T.	84	Meen hourly	speed Prevailing	ed etton	8	ä	Pet. of possib	Mean sky co sunrise to sur	Clear	cloudy	Precipitation 01 inch or n	Snow, Sleet	Thunderstor Heavy fog	90° and	7	g
64.7 49.0 56.8 52.0 38.8 45.4 37.2 26.9 32.0	91 52 1950. 53 1953 64 1945. 80 1945. 91 1911. 94 1947. 97 1953 96 1876 88 1895 82 1949 71 1938 59 1951	-32 18 -23 18 -2 18 18 18 31 18	888 886 882 880 881 957+ 957+ 875 887	30 1640 1460 1250 810 400 100 20 70 250 610 990 1470	30 3.63 2.80 2.95 3.29 3.55 4.50 4.40 4.41 4.21 3.72 4.00 3.30	8.77 6.17 6.49 7.64 9.31 10.11 11.87 9.43 7.54 8.95	1877 1920 1947 1957 1935 1938 1918 1937 1927	0.93 0.42 0.70 0.27 0.80 0.53 0.99 0.84 0.84	1941 1915 1883 1887 1955 1877 1953 1922 1947	1.30 1.81 1.36 4.11 2.95 5.17 2.86 1.76	1955 1943 1947 1937 1942 1935 1937 1946 1942 1950	0 0 0 1.2 13.0	82.4 51.7 33.6 6.0 T 0 0 T 9.8 40.0	1877 1874 1943 1930 1888 1952 1875	16.9 13.0 8.0 6.0 0	1941 1955 1943 1945 1943+ 1952 1952 1954	10 80 79 74 73 78 80 81 84 82 79		8 7 1 7 5 7 3 8 8 9	.0 W .3 W .8 NI	49 52 E 41 E 42 W 41 W 40 42 41 54	NE NE NE NE	1938 1939 1947 1947+ 1944 1948 1954 1953 1953 1950 1948					20 17 15 15 13 12 14 14 12 12 12 13	20 1 16 14 12 6 * 0	10 10 10 0 2 0 2 1 3 2 1 4 2 5 1 1 2 2 0 3 0 3	30	17 27 24 14 1 0 0 0 0 0	10 31 28 28 18 2 0 0 0 4 20 31

The Quebec Observatory was in Battlefield Park overlooking the St. Lawrence River.

- (a) Length of Record, years.
 (b) Normal values are based on the period 1921-1950, and are means adjusted to represent observations taken at the present standard location.
 (c) No vind data available.
 (d) No observations taken at 1330 E.S.T.
 (d) No observations taken able.
 (f) Means and extremes are from the existing location. Extremes listed may have been exceeded at prior locations.

- * Less than one-half
- T Trace, an amount too small to measure
- + Also on earlier dates, months, or years

 Also on earlier dates, months, or years

NOTES: Unless otherwise indicated, dimensional units used are: temperature in degrees F; precipitation and snowfall in inches; wind movement in miles per hour; and relative humidity in percent.

Sky cover is expressed in a range of 0 for no clouds or obscuring phenomena to 10 for complete say cover. The number of clear days is based on cloudi-ness 0.3 tenther partly cover. The number of clear days is based on cloud-tenths. For United States stations the numbers hand cloudy days on 8-10 from sunrise to sunset; for Canadian stations on average cloudiness at 1330 E.S.T.

Monthly degree day totals are the sums of the negative departures of average daily temperatures from $65^{\circ}\text{F}_{\star}$

Heavy fog also includes data referred to at various times in the past as "dense" or "thick". The upper visibility limit for heavy fog is 1/4 mile.

Below zero temperatures are preceeded by a minus sign.

NORMALS, MEANS, AND EXTREMES

LATITUDE 46° 48' N LONGITUDE 71° 23' W ELEVATION (ground) 245'

QUEBEC (ANCIENNE LORETTE AIRPORT) P.Q.

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74.7 83.6 64.2 93 1947 37 1946 90 5.58 6.14 1943 0.61 1953 1.81 1950 0 0 0 0 0 0 87 18 157 72 8.5 5W 25 WSW 19 55.4 45.4 55.4 93 1947 26 1947 29 0 3.47 8.13 1945 0.68 1945 0.68 1945 T T 1957 T 1957 86 85 60 77 9.1 5W 35 WSW 19	1956 1955 1957 1957	0 SW 2 SW 5 SW 5 SW	60 S 42 S 35 S	SW SW SW SW	SW SW SW	S# S# S#	SW SW SW	SW 19: SW 19: SW 19: SW 19:	1956 1955 1957	1956 1955 1957 1957+	956 955 957 957+	5 7			Section of the Section		6 8 9 7 6 3		4 5 5 5 6 7	15 17 18 19 20	5 7 8 9	16 13 13 12 12 12	10	2 (0)		3 3 3 2 2	0 0 0 0 1	2 2 1	4	31 28 29 19 4	
	1957	5 WS	35 ¥	WN WS	WSW WNW WSW	WSW WNW WSW	WSW WNW WSW	YSW 19: FNW 19: FSW 19:	195	1957 1957 ₊ 1957+	957 957+ 957+	7+		-			4 7 7 7 .7		0 9 7 6	17 15 16 18	5 6 8	13 10 12 11	T	0 3 T 1	4 3 1	2 2 3 3	1 *		0 0 0	0 0 1	
1.6 10.8 17.7 57 1951 -25 1943 1530 3.61 6.37 1957 1.30 1947 1.40 1946 26.0 51.9 1946 14.0 1946 87 89 82 87 12.0 WSW 45 WSW 194	1955 1957 FEB	0 SW 5 WS	40 S 45 W	SW WS	WSW	SW WSW	SW WSW	TSW 19	1957	1957	957	-	-	+	_	+	5		5	23	3	13 16	14	4 0	0	3	0	2		22 30	4

Ancienne Lorette Airport is 8 miles W of Quebec in the St. Lawrence River valley, 4 miles N of the river

LATITUDE 45° 30' N
LONGITUDE 73° 34' W
ELEVATION (ground) 187'

MONTREAL (McGILL) P.Q.

- 7			Ten	perat	ure		170			11 (-1				Precip	oitation		1 1	N		1 11 1		lative midity				Wind	37		shine	T			Mean	numl	oer of	days	1.7		=-
	1 A.	Norma	1		Ext	remes		Tee da	_					100	The state of the s		Sı	10W			F F	· ·					ximu y Mi	m leage	le sun	uneet	133	t DE	nore	more	e e	1	mper	rature:	
Month	Daily	Daily	Monthly	Record	Year	Record	Year	Normal deg	Normal total	Maximum monthly	Year	Minimum monthly	Year	Maximum in 24 hrs.	Year	Mean total	Maximum monthly	Year	Maximum in 24 hrs.	Year	0130 E.S.	83	E . S.		direction	Speed	Direction	Your	Pet. of possik	sunrise to st	Partly	Cloudy	Precipitation Ol inch or	Snow, Sleet	fog fog	90° and above	32° and below	32° and below	O'and below
F A H	30 22.7 23.6 34.6 49.5 64.3 74.2	8.2 9.3 21.3 33.8 46.9	30 15.4 16.4 28.0 41.6 55.6 65.6	89 55 51 77 86 94 94	1950 1880 1945 1941 1871 1925	-29 -20 2 23	1914 1943 1872 1923 1880 1945	30 1540 1370 1150 700 300 50	30 3.54 2.72 3.26 3.37 3.30 3.76	96 6.84 7.38 7.32 6.10 7.38 8.62	1869 1901 1924 1945	96 1.13 0.49 0.81 0.35 0.11 0.49	1877 1915 1870 1903	24 1.75 1.20 1.67 1.62 2.04 2.68	1947 1944 1955 1954 1945 1957	30 23.8 21.5 18.0 6.5 T	73.8 46.4 29.8	1898 1869 1900 1885 1869	17 10.0 12.0 11.7 9.2 T	1944	10 80 77 76 74 74 76	2	4 9 8 5	(e)	The state of the s	(c)				(,	D		20 13 15 15 13 13 13	20 1	7 17 * 1 0 1 * 2 1 1 2 1 5 1	30 0 0 0 0 *	17 23 20 11 * 0	10 30 28 25 10 1	
SON	78.7 76.3 67.1 54.9 40.6 26.7	62.1 60.1 52.0 41.2 29.7 14.7	70.4 68.2 59.6 48.0 35.2 20.7	97 96 91 84 72 59	1931 1917 1871 1949 1950 1951	43 32 19 -18	1891 1903 1914 1933 1875 1933	10 40 180 530 890 1370	3.97 3.48 3.72 3.40 3.92 3.36	7.72 8.68 8.44 7.77 12.04 8.72	1869 1866 1885 1927	0.96 0.08 0.79 0.42 1.44 1.12	1957 1948 1924 1904	2.71 2.98 1.94 3.39 2.08 1.96	1940 1933 1946 1932 1950+ 1952	0 T 0.7 9.2 21.1	22.1 36.1	1946 1892 1886 1908	1.1	1946 1945 1944 1951+	77 80 83 83 81 80	7777	0 4 3 7			10 To							13 10 12 12 15 16	0 0 * 1 6	6 * 3 1 1 1 1 1 1 2 2	1 * 0 0 0	0 0 0 0 5 19	0 0 0 3 17 29	0 0 0 0 4
Ē A R	51.1	36.3	43.7	97	JULY 1931	-29	DEC 1943	8130	41.80	12.04	NOV 1927	0.08	AUG 1957	3,39	OCT 1932	100.8	73.8	FEB 1869	12.0	DEC 1951+	78	7	0						-				160	63 2	0 13	1	78	143	18

The Montreal City Observatory is located at McGill University on the SE slope of Mount Royal in downtown Montreal slightly more than a mile from the St. Lawrence River.

NORMALS, MEANS, AND EXTREMES

LATITUDE 45° 28' N
LONGITUDE 73° 45' W
ELEVATION (ground) 98'

MONTREAL (DORVAL AIRPORT) P.Q.

	i									
ar e		woled bas*0	10	18			00	0.0) + v	26
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ap jo		Pur 06	16	00	01 01	- 6		101	nnn	24
per	SULL	DISTADURE	91	* 0		OJ 44	9 4	101	٠	12
num	erom	Snow, Slee 0, 1 inch or	2	22	20	• 0	00	•	• 9 5	59
Mean number of days	more	Precipitation To doni IO.	ខ្ព	15	25	45	22	123	299	162
×	1	Cloudy	2	19	19	18	2.5	191	13 72	207
	At 330E	cjongk	ន	60 60	io ro	r- 6	H.	0 1~ 1	- 4 0	17
	2	Clear	9	6.	0.0	9 10	90	0 1-1	- 60 1-	18
-	19sun	e of earinus	-		_				_	- 80
		Меап вку с	-	2.00						
enide		Pet. of possi	-	+					+	1
	lmum Mileage	тем		1950	942	947	948	949	1950	DEC 1950+
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Wind	Max urly		16	SW			-			
*	<u></u>	direction	ļ	64.5					844	1
		Prevailing	2	S is			N S	S o	S S N	S
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		1930 E.S.	6	76	68	62			23.5	
Relative		7330 E'S'	6	74					69 47	
Rek		0730 E.S.	6			7.5			888	
	т.	0130 E.S.	6	88	77	8.8	80	8 8	8 8 2	1
		тен		1954	955	945		946	1945	FEB 1954
		in 24 hrs.	16			00			4.05	
	200	mumixeM	Ľ.	120	27 9	00	00	0 01	122	15.5
å ä	Snow	Теех		1954	1955	1945		1946	1945	FEB 1954
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ď.	A- 11	mimixey		E 4	4 0			5 (4		- 7
g Electric	Ŀ	Mean total	ន	23.7	4.6	H-0	00		0.0.5	2.96
recipitation	3 G	тю.		1945	1955	1945	1951	1946	1930	AUG 1952
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Å.		mumixeM			7.7	7.2	810	× %	- 010	2.71
		Year				1944	1942		1956	4 -
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	5	or i granda	1		•	.,	100	_		20
333	1.3	Year		194	195	1945	194	194	1941	JUN 1943
		monthly	16	86	20	8 6	80	61	5.53	8.49
	-	mumixeM		4 10	φ.4	ဖထ	ı, ı	0 10	4.0,4	
langa.) I	Istot IsmroM	27	2.8	2.2	188	299	23	3.76	38.41
	<u> </u>		-	- m m	00	0.00				
9.6	sb ee1	Normal deg	æ	1590	1180	270	2	196	910	8350
17.7		Year		5.2	9.7	9 4	9	2.2	÷ 6 6	3 5 5
187	197.5	Jowest	<u> </u>			1956-			1949	
	Extremes	Record	97	-38	2,2	38.	4.	88	25.5	136
	1	тем	11.	53	5 4	1953+	55+	53	1949	AUG
fare	PÚ	highest	16			93 19			71 19	
emperature		Record	ř	277						+
Ten		Monthly	æ	10.00	8.7	55.1	1.0	9.7	7.45	43.3
587	3	muminim	1-				- 6	4 to	191	-
919	Norma	Delly	€	9 1	200	55.3	60	8 8	38.3	
	[-	mumixem	æ	41	w w	40	m.	N 0	4.5	9 (0
	100	Daily	12	200	120	2.5	62	23	8 6 8	5
200	-	Month	3	_	*		···		0 = 6	

Dorval Airport is located 7 miles #SW of the center of Montreal in flat open country. The St. Lawrence river is 1 mile south,

LATITUDE 44° 07 N LONGITUDE 77° 32' W ELEVATION (ground) 266'

TRENTON (AIRPORT) ONT.

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ę	Тепр	above	17	00000*	HH+000	N
Mean number of days		bas *08	-	папапан	101400	
, o		Heavy fog	11		040H**	25
- qu	800	Thundersto	17	* * HHO4		22
ä		Snow, Sleet to don! I.0	13	002000	-000001	34
Sear	01011	Precipitation To don't IO.	20	22121%	- r e e 2 2	- 61
^		Cloudy	97	123 123 123 123 123 123 123 123 123 123	844728	208
	At 1330E	cjondy	2	4000-0	118848	79
7 '	13	Partly	_	1897-21 1 7 1897-21 1 7		
		Clear	ដ	rorror	000047	78
	jesur	a of esingue	7.1	6004000	Automotion (
		Pct. of possil Mean sky o		12.00 pt - 12		
uide	uiia 6/c	figure to tod	-		2000	
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ě 4		1330 E.S.	10	88 88 88 88 88 88 88 88 88 88 88 88 88	62 7 62 7 74 8 77 8	69
Relative numidity	-1		1 2	88 88 88 88 88 88 88 88 88 88 88 88 88	79 6 88 6 88 6 89 7 7	. 84
ă H		0130 E.S.	0	7.18888 3.212888	288888 288888 7888888	85
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		fatot naeM	7	16.1 14.2 17.8 17.8 0	0000	60.1
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dip		in 24 hrs.	17	222122	22222	823
Æ	2 40	mumixeM	-	11.35	2 2 2 2 3 4 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5	<u></u>
	100	Хем		1935 1935 1935 1936	1936 1935 1953 1953 1953 1953	0CT
	1	monthly	8	1025589		32
	10	muminiM	~	0.10 0.45 0.60 0.60 0.60	004040	
	100	мод	17	1950 1955 1955 1943 1947	1951 1955 1957 1955 1951 1941	OCT 1955
		### #	L	222222	44444	
	200	monthly	20	5.06 3.71 5.49 5.38	235558	19
	-	mumixeM	~	0.04.00.0	7.00 4.89 10.61 5.75 6.23	2
	F	mo muc:	14	33118848	282	47
	3.2	Into! IsmroM	ី	23.22.22	3.02.50	31,74
				1400 1280 1080 670 670 70	28 10 10 10 10 10 10 10 10 10 10 10 10 10	7630
87	op ee	Normal deg	9	425 p.g.	44.92	163
	aring and a	Year		1945 1943 1943 1943 1945	1940+ 1940+ 1935 1940 1942	FEB
		lowest	-		444444	
	Extremes	Proced.	8	385585	2882545	-26
	1	Хеях	116	1950 1954 1946 1941 1944	1936 1953 1955 1956 1956	3ULY 1936
er.	47	70.70	10			
eratı	Γ.	Record highest	20	26 73 83 83 83	102 97 78 72 57	102
emperature		100 Sec. 9		200000	0.8.0.0.4	
ů	7.	Monthly	9	888448	68. 68. 37. 24.	45.3
47	7	muminim	12		444004	. (0
	Normal	Dadly	9	111.8 222.0 34.1 55.4	51. 30. 17.	36.6
	- 2	mumixam	1		က်ယ်တွက်ထွဲထ	
		Delly	3	28.8 28.3 38.5 51.5 74.5	2487841	5

Trenton Airport is 2 miles east of town on the north shore of the Bay of Quinte. The immediate country is flat and open.

<u>6</u>

NORMALS, MEANS, AND EXTREMES

LATITUDE 43° 07' N LONGITUDE 77° 40' W ELEVATION (ground) 543 feet

ROCHESTER (AIRPORT) N.Y.

				Tem	perati	ire	(84) (4)	WW.			188	Nucl.		10 (10 T) VENT	Precip	dtation	100						Relati humid		1 3 4 1 3 4 5		Win	1		hine		13		м	ean n	umb	er of	days	A.	
	500	No	rmal	\$ 5		Ex	reme	1945	Tree day								15 to	S	now, Sle	ret	60 - An						F	nstest	mile	uple sun	over		inrise to unset		Bore	more	T		mpe ax.	Min.
Month	Delly	Delly	minimum	Monthly	Record	Year	Record	Year	Normal des	Normal total	Maximum monthly	Year	Minimum monthly	Year	Maximum in 24 hrs.	Year	Meen total	Maximum monthly	Year	Maximum in 24 hrs.	Year	1:00 a.m.,	4 1	7:00 p.m.	Mean hourl	Prevailing	Speed	Direction	Year	要	Mean sky o	Clear	cloudy	Cloudy	Ol inch or	Thundernor	Heavy log	90° and above	32° and below	32° and below O'and below
F A A	(b) 32.7 32.5 41.8 54.7 67.8 78.2	16 15 24 34 45	.5 .1 .2	(b) 24.7 24.0 33.0 44.5 56.4 66.6	70 86 90 93	1950 1932 1905 1885 1895 1953	-2	8 1957 2 1934 7 1885+ 7 1923 7 1911 5 1949+	(b) 1249 1148 992 615 289 54	(b) 2,36 2,42 2,96 2,64 2,64 2,85	5.40 7.02 6.13 6.87	1878 1876 1873 1857 1894	0.21 0.55 0.50 0.52	1834 1841 1936 1837 1934 1929	2.43 2.98 1.99 2.95	1878 1950 1900 1943 1916 1950	73 18.0 18.1 13.5 3.5 0.2 0.0	42.7 54.0 25.1 3.3	1884 1910 1900 1874 1909	18.5 29.8 10.0	1879 1910 1900 1885 1909	81 80 80 79 81	17 1 81 7 81 6 81 6 79 5 77 5	3 79 9 78 4 75 7 66 4 63	11.0 11.1 10.9 10.1 8.9	WSW WSW WSW SW	1	W W W SW	1956+ 1956 1946 1950	64 32 41 47 53 60 67	8.1 7.8 7.2 6.7	2 3 6 8 9	8 9 9	87 21 17 16 13 11	87 7 19 17 17 14 13 11	4 73 6 4 5 4 1 1 2 4 0	1 1 1	86 0 0 0 * *	86 16 14 9 1 0	86 86 29 2 26 2 23 * 10 0 1 0 0 0
8 O N	82.7 80.3 73.0 61.1 47.4 35.4	57 50 40 32	.9	71.2 68.9 62.0 50.8 39.7 28.2	99 98 91 81	1938 1948 1881 1951 1950 1875	11	1945 1957+ 1947 1879 1875 1942	9 34 133 440 759 1141	3.09 2.48 2.66 2.50 2.74 2.40	7.26 7.41 8.67 7.12	1886 1868 1873	0.36 0.46 0.08 0.33	1854 1876 1897 1924 1904 1835	4.19 2.47 3.77 3.13	1897 1893 1925 1873 1945 1901	0.0 0.0 T 0.3 6.4 15.2	0.0 T 6.1 22.2	1956+ 1880 1886 1944	5.8	1956+ 1880 1886 1 944	86 87 84 81	80 5 83 5 86 5 86 5 83 6 81 7	2 65 5 73 7 75 6 78	7.0 7.6 8.4 9.9	SW SW SW	56 59 59 55 59 57	NE SW SW E	1955 1949 1937 1950	70 66 60 50 32 26	5.6 5.6 6.1 8.0	11 11 10 8 3	13 12 10 9 7 6	14	10 12 15	0 7 0 5 0 9 1 2 *	1 1 2 1 1	3 2 1 * 0	0 0 * 3 12	0 0 0 0 * 0 3 0 15 0 25 1
Year	57.3	37	.7	47.5	102	July 1936	-2:	Feb. 2 1934	6863	31.74	9.70	July 1947	0.08	Oct. 1924	4.19	Aug. 1893	75.2	54.0	Mar. 1900	29.8	Mar. 1900	82	81 6	0 71	9.2	WSW	73		Jan. 1950	50	6,8	83 1	13 1	69 1	167 2	3 28	14	8	55	132 5

The Rochester Airport is located some 11 miles south of the shore of Lake Ontario in level to gently rolling terrain with a slight inclination toward the Lake.

LATITUDE 42° 56' N LONGITUDE 78° 44' W ELEVATION (ground) 693 Feet BUFFALO (AIRPORT) N. Y.

| Relative | Moranal | Ratremes | Factorine | Relative | Moranal | Ratremes | Factorine | Relative | Moranal | Ratremes | Factorine | Fact

The Buffalo Airport is located about nine miles northeast of the eastern end of Take Erie and 25 miles south of Lake Ontario. The surrounding country is low and level to the west, gently rolling to the east and south, rising to pronounced hills within 12 to 18 miles.

NORMALS, MEANS, AND EXTREMES

LATITUDE 43° 40' N LONGITUDE 79° 24' W ELEVATION (ground) 379'

TORONTO (CITY) ONT.

		Ten	perati	ire		V.V	2						Precipi	tation							elativ midi				Wind			shine				Mean	numl	ber c	í days	i	
	Norma	i S		Ext	emes		ree da									S	ow			e t			¥			ly Mi	m leage	ble sur	nuset	133		nore	more	8	tall said	empe iax.	eratu M
maximum	Dally minimum	Monthly	Record	Year	Record	Year	Normal deg	Normal tota	Maximum monthly	Year	Minimum monthly	Year	Maximum in 24 hrs.	Year	Mean total	Maximum monthly	Year	Maximum in 24 hrs.	Year	0130 E.S.		30 E.	aan sed	Prevailing direction	pee	Direction	1	Pet. of possil Mean sky c	Sunrise to s	Partly	Cloudy	Precipitatio .01 inch or	Snow, Sleet 0.1 inch or	Thundersto	90° and	32° and	32° and
30	30	30	114		114		30	30	116		116		116	813	30	116		116		10 1	0 10	10	18	18	18	18			1	3 18	18	50	50 2	25 1	30	17	7 10
1.1 0.8 9.1 2.0 4.5 5.4	17.9 17.2 25.4 35.6 45.7 55.6	24.5 24.0 32.2 43.8 55.1 65.5	57 80 90 93	1950 1954 1946 1842 1895 1901	-25 -16 5 25	1859 1855 1868 1923 1854 1843	1249 1147 1018 646 316 73	2.72 2.31 2.58 2.55 2.65 2.70	6.84 5.21 7.00 6.21 9.36 8.09	1932 1900 1870 1929 1894 1870	0.29 0.51 0.10 0.39	1871 1877 1905 1881 1920 1949		1843 1855 1881 1850 1894 1957	14.1 13.6 9.4 3.1 0.1	43.6 46.1 62.4 12.9 3.1 T	1871 1846 1870 1857 1875 1859	16.2	1863 1876 1901 1875	80 8 78 8 69 7 67 6 70 7 70 7	2 57 8 50 0 53	72 63 56 58	14.7 14.4 13.9 13.0 10.4 9.1	W NW NW NE		SW] SW] Y]	1943+ 1946 1942 1940 1945			5 5 7 6 6 6	20 18 20 17 19 14	13 14 12 12	12 11 8 3 *	* 1 1 3 4	1 0 1 0 1 0 1 0 1 *	17 14 7 *	7 25
1.1	60.9 59.5 52.7 42.3 33.2 22.5	70.8 69.0 61.6 50.2 39.2 28.4	102 100 85 75	1936 1918 1953 1916- 1950 1875	40 28 16 -5	1843 1855 1844+ 1844 1875 1932	8 29 154 465 777 1126	3.23 2.39 2.67 2.29 2.55 2.29	8.15 8.14 9.76 6.10 5.84 6.60	1841 1915 1843 1954 1846 1841	T 0.40 0.52 0.11	1954 1876 1897 1944 1904 1845	3.88 3.68 3.46 3.79 3.13 2.05	1897 1908 1843 1954 1861 1944	.0 .0 T 0.2 4.3 9.8	.0 .0 T 12.0 22.5 38.0	1956+ 1845 1950 1872		1956+ 1875 1950 1944	79 7 80 7 80 8 77 8 76 8 76 7	9 53 3 56 4 58 0 64	62 70 72 73		SW E,NW SW	37 32 47 5 38 46 1 50 50 5	r) sw) r)	1940 1951 1941 1941 1940 1938	State of the state	1	8 6	14 13 14 15 20 21	10 9 11 10 13 14	0 0 0 • 4	6 3 2 1 1	2 1 2 0 1 0	0 0 0 2 1	1 2
.0	39.0	47.0	105	JULY 1936	-26	JAN 1859	2000	30.93	9.76	SEPT 1843		AUG 1876	3.88	JULY 1897	54.6	62.4	MAR 1870		DEC 1944	LL	7 59	66		SW	56		MAR 942	생	1,	81	20	100	47	221	1.	51	12

Toronto (City) observations are taken at the Headquarters of the Meteorological Branch in downtown Toronto, 2 1/4 miles from Lake Ontario.

LATITUDE 43° 41' N LONGITUDE 79° 38' W ELEVATION (ground) 578' TORONTO (MALTON AIRPORT) ONT.

Ł			Ten	perati	re			3,8						Precip	itation							elativ midit				Wind			shine				м	oan r	umb	er of	days		
E		Norma	1	13	Ex	remes		ree da							100		S	now	\$3.41	ZW.			27.5				axim	um ileage	ole sun	over		At 1330	Е	nore	nore		1000	empe: lax.	rature Mi
Month	maximum	Daily	Monthly	Record	Year	Record	Year	Normal deg	Normal total	Maximum monthly	Year	Minimum monthly	Year	Meximum in 24 hrs.	Year	Mean total	Maximum monthly	Year	Maximum in 24 hrs.	Year	0130 E.S.T	30 E.	1930 E.S.T.	an pos	Prevailing direction	pee	Direction	Year	Pct. of possib	san sky o nrise to s	Clear	Partly cloudy	fg.	Precipitation Ol inch or 1	nch or a	Heavy fog	90° and	32° and below	32° and below
a)	(b)	(b)	(b)	20		20	Special Control	(b)	20	20	1908	20		20	1,11	20	20		20		10 10	10	10	16	16	16					18	18	18	20	20 1	7 17	7 10	17	10
28 38 52 65	5.1	13.9 12.6 21.7 33.1 43.7 53.4	21.7 20.6 30.0 42.6 54.4 64.6	62 54 78 85 91 98	1956 1956 1946 1938 1945 1952	-24 -20 10 25	1939 1943 1950 1954 1947 1949	1360 1260 1090 700 370 100		3.87 3.47 4.61 3.60 5.71 4.61	1947 1939 1942 1954 1945 1947	1.07 1.10 0.67 0.37	1957	2.31 1.04 1.64 1.64 3.65 1.73	1946 1943 1943 1951 1944 1957	14.2 13.2 9.0 3.8 T	22.8 21.4 12.8	1939	11.2	1950	86 86 82 83 81 83 79 79 82 79 84 78	5 74 1 66 9 57 9 58	81 74 67 66	12.3 12.1 12.0 9.9	H H SW N,W	49 52 54 46 45 36	SW 3 SW 3 SW 3	1949 1946 1942 1947 1945			656655	5 6 6 7	20 18 19 18 19 15	17 1 12 1 13 11 12 9	3 0 8 2	* 4 * 3 2 3 3 3 4 3	0 0 0 0 0 0 0 0 0	12 16 8 1 0	30 28 26 15 3 0
78 70 58	3.9 3.6 3.6	57.7 56.3 49.8 38.7 30.0 19.2	69.3 67.6 60.2 48.7 37.2 26.2	97 101 98 87 77 66	1936 1946 1953 1951 1950	37 28 21 -1	1942 1947 1944	30 40 180 540 840 1220		4.65 5.27 6.08 8.42 4.50 4.33	1945 1949 1948 1954 1940 1942	1.13 0.87 0.28 1.08	1957 1942 1950 1938 1956 1943	1.83 2.31 4.25 4.78 2.20 1.51	1956 1955 1948 1954 1943 1942	.0 .0 .0 T 7.0 8.9	0.3 24.0	1956 1952 1940 1951	12.0	1956 1952 1950 1944	84 75 83 83 87 87 86 85 86 85 84 85	2 53 7 59 9 61 3 73	65 76	8.5 9.3 9.5	X, W W W W W		W D	1940 1942 1941 1954 1947+			6 5 7 9 4 5	12 10 6 5	14 13 16	10 9 10 9 12 15 1	4	5 2 4 2 3 4 1 5 1 4	2 2 1 3 0 0 0	0 0 0 0 3 14	0 0 1 5 18 28
54	.7	35.8	45,3	101	AUG 1948	-24	DEC 1942	7730	30,52	8.42	OCT 1954	0,16	JUNE 1949	4.78	OCT 1954	56.1	34.1	DEC 1951	12.0	NOV 1950	B4 B2	8 64	74	0.5		54		MAR 1942			69	87	209	139	47 2	3 40	5	54	154

Malton Airport is located 15 miles NW of the center of Toronto, about 10 miles N of Lake Ontario. The surrounding country is flat.

NORMALS, MEANS, AND EXTREMES

ERIE (PORT ERIE AIRPORT) PA.

Г			Tem	peratu	LT®			1000							Precip	dtation						10.00	Relativ umidi		18		Wind	1		ahtne					dean.	numl	ber o	i day	•	<u> </u>	
		Normal			Extr	eme			ree day		N.		137.5				148	Sı	10w, Sle	e t	118	EST	EST	EST			F	ustosi	mile	ible sun	nnset	144.0	unris to runse	t .	in more	шохе	THE STREET		Tempe Max.		Min
Delly	maximum	Dally minimum	Monthly	Record	Year	Record	lowest	Year	Normal deg	Normal total	Maximum monthly	7.	Minimum monthly	Year	Maximum in 24 hrs.	Year	Meen total	Maximum monthly	Year	Maximum In 24 hrs.	Text	1:30 8.8.	7:30 s.m.,		Mean hourl	Prevailing	Speed	Direction	Year	Pet. of possi	Mean sky c	Clear	Partly cloudy	Cloudy		Snow, Slee 1,0 inch or	Thundersto	bus 08	32° and	32° and	pelow
34 34 42	4.1 2.6 3.9 5.5	18.9	(b) 27.2 26.5 34.1 44.3 55.1 65.5	72 82 86 91	1876 1932 1910 1883 1879 1934	-1 -1 -	5 18 6 18 5 19 7 19 0 19	975 916 923 926	(b) 1172 1078 958 621 324 78	(b) 2.34 2.07 2.79 3.50 3.19 2.87	8.50 7.36 8.88 8.05	1950 1887 1913 1947 1892	0.33 0.53 0.74 0.55	1910 1915	3.35 3.06 3.16	1913 1947 1893	73 12.6 10.3 8.2 2.8 0.1 0.0	36.9 20.9 19.3	1945 1947 1896 1901 1923	10.7 16.1 15.4	1951 1936 1901 1923	84 84 81 79 82	12 12 84 76 85 76 81 77 78 65 78 66 80 66	73 83 79 71	12.4 11.4 11.7 10.2	WSW SSE WSW S	42 56 57 60 56 51 47	SW	1918 1923 1917 1922 1925 1916	35 44 51 58	8.4 7.9 7.0 6.6 6.2 5.4	10	82 8 10 10 11 11	82 21 16 15 12 10 6	84 17 15 15 14 13 11	63 1 3 2 1 *	74 7 * 1 2 5 6	4 84 • 0 • 0 1 0 1 0 1 *	13 13 13	3 2 3 2 7 2	4 7 5 3 8 *
75 75 61 48	9.0 2.9 1.2 8.2	33.7	70.4 69.0 63.2 52.3 41.0 30.7	96 99 89 82	1936 1918 1953 1951 1950 1941	3 2	7 18 2 19 3 19 3 18 6 19 1 18	957 957 895 929	7 33 105 399 720 1063	3.19 2.48 3.39 3.01 3.26 2.39	9.28 8.48 9.87 8.93	1947 1915 1876 1954 1950 1881	0.54	1899 1897	3.40 3.24 2.86	1947 1915 1882 1912 1956 1944	0.0 0.0 T 1.2 7.5 12.2	14.7 46.9	1954+ 1925 1950 1944	0.0 0.0 T 8.5 23.0 26.5	1954+ 1913 1956	85 82 80 78	79 64 82 63 82 63 82 63 80 70 82 73	74 79 78 77	7.5 8.6 9.0	S	51 58 56 51 60 53	SE SE SE	1916 1926 1921 1916 1915 1927	63 55 44	5.5 8.0	12 11 10 9 4	13	6 7 9 13 19 23	10 10 11 13 15 17	0 0 0 * 2 4	7 5 4 2 1	* 2 * 1 * 0 * 0	000	8	0 0 1 0 23
57	7.1	39.4	48.3	99	Sept.	-1	6 18	eb. 875	6558	34.48	13.27	July 1947	0.02	Oct. 1924	10.42	July 1947	54.9	53.6	1944	26.5	1944	82	81 61	75	9.8	s	60	SW	Mar. 1917-	45	6.6	90	118	157	161	15	33	3 4	4!	5 11	.7

The Port Eric Airport is located six miles southwest of the center of the City and about one mile from the lake shore. The terrain rises gradually in a series of ridges, parallel to the shore to 500 feet above lake level 3 to 4 miles inland.

LATITUDE 42° 35' N LONGITUDE 80° 34' W ELEVATION (ground) 624'

LATITUDE

LONGITUDE

42° 05' 80° 12'

CLEAR CREEK, ONT.

	Γ		Ter	nperat	ure		100	2	100	40 1. 34 3	335		K.C.	Precip	itation		35 1	14.17	10 3	1913		elative	- 1	15		Wind	14	W.	shine	T		T t	Mean	numl	oer of	days	ŦŞ.	
		Norma	al .		Extr	emes		ree da	130		MA			As I			Sn	10W		Will.		F F	Ę.	у.	1	Ma Hour 1	ximu y Ni	m leage	ble sur	sunset	133	At 30E	nore	eet or more	su.		emper lax.	Min.
Month	Daily	Daily	Monthly	Record	Year	Record	Year	Normal deg	Normal total	Maximum monthly	Year	Minimum monthly	Year	Maximum in 24 hrs.	Year	Mean total	Maximum monthly	Year	Maximum in 24 hrs.	Year	8.0	0730 E.S.		3 8	Prevailing direction	peq	Direction	Year	Pct. of possil	sunrise to s	Partly	cloudy	Precipitatio	Snow, Slee 0, 1 inch or	Thundersto Heavy for		32° and below	32° and below O'and below
Ī	8	8	. 8	8		8	4 1	(e)	8	8	\	8 .	34	8	200	8	8	44	8	44.5	(e)	1 0		3	3	3	3	3	-3	(е) (6	a) (e) 8	8 (e) (e) 8	8	8 '8
M	30.9 33.1 37.9 51.4 60.4 71.5	21.0 26.2 36.5 44.5	27.1 32.1 44.0 52.4	47 50 59 76 78 85	1953 1954 1952 1957 1955 1957+	-15 5 7 28	1957 1955 1954 1954 1957 1956	Y T	3.41 3.02 3.56 3.61 3.06 2.10	4.83 4.32 6.85 5.86 5.59 4.43	1954	1.12 1.84 0.28	1956 1957 1957 1953 1954 1952	2.32 1.63 1.80 1.55 1.83 2.00	1957 1954 1954 1957 1956 1957	14.8 8.6 7.2 2.1 *	23.2 12.8 24.4 7.7 0.1	1954 1957	10.9 7.0 18.0 4.0 0.1	1955 1951 1954 1956 1956			180	12.4 10.4 13.0 11.5 10.3 9.0	H H SH	36 H 35 H 58 S 48 S 30 H 42 M	W I	955 957 956	2000				16 12 13 13 10 7	6		0 0 0 0 0	16 12 8 • 0	29 1 26 1 26 0 9 0 2 0 0 0
A S O N	77.4 75.8 69.2 59.8 45.8 36.5	58.8 51.2 42.8 32.6	67.3 60.2 51.3 39.2	88 93 78 69	1952 1955+ 1953 1951 1956 1953	38 30 21 6	1954 1950 1951 1952 1950 1951		2.34 2.77 2.80 2.78 3.52 3.11	4.75 4.90 5.50 7.27 4.93 4.38	1956 1957 1954	1.65 0.27 1.85	1952 1951 1953 1953 1952 1953	1.74 1.90 2.83 2.39	1951 1956 1955 1954 1951 1952	0 0 0.4 12.1 7.3	0 0 3.0 50.1 25.7	1952 1950 1951	0 0 3.0 13.0 5.5	1952 1950 1951				9.2 9.4 10.2 11.3 15.2 13.8	WSW WSW WSW	30 % 40 S 35 % 40 % 56 % 42 %	SW 1	957+ 956 957 955 955 957					8 9 8 8 13 14	0 0 • 5 6	A 2	0 0 * 0 0	0 0 0 0 3 9	0 0 0 0 * 0 4 0 15 0 25 *
E	54.1	39.5	46.8	93	SEPT 1953	-15	FEB 1955		36.09	7.27	OCT 1954	0.27	ОСТ 1953	2.83	OCT 1954	52.5	50.1	NOV 1950	18.0	MAR 1954				11.3	w	58 8		MAR 955				1	131	38			48	136 2

The Clear Creek telecommunications station is located near the base of the Long Point peninsula less than a mile from Lake Eric

NORMALS, MEANS, AND EXTREMES

CLEVELAND (CLEVELAND HOPKINS AIRPORT) OHIO

LATITUDE	41°	24'	N	
LONGITUDE	81°	51'	Ħ	
PI PURTION (mound)	707			

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		1.3	Ten	npera	ture		100	2		1.3			\$1 F	Precip	itation	H-X	100	3 (03	1 11	94 - 33 44 - 4		lative midity			,	Vind	-4 316 p -4 316 p	shine	65 411			м	lean :	numb	er of	days		9 1 2 4 1 1
		Norma	d		Ext	reme	•	ree da	_	1 1	- 47		114				Sr	ow, Sle	eet .		RST	EST	EST			Fas	test mile	ble ann	cover		unrise to unset	- 1	nore	nore	ă		ampera	atures Min.
Month	Deilly	Daily	Monthly	Record	Year	Record	Year	Normal deg	Normal tota	Maximum monthly	Year	Minimum monthly	Year	Maximum in 24 hrs.	Year	Mean total	Maximum monthly	Year	Maximum in 24 hrs.	Year	1:00 a.m.,	1:00 p.m.,	7:00 p.m.	speed a	direction	X I	Direction	Pet of possib	en sky	Clear	Partly cloudy	Cloudy	Precipitation Ol inch or r	Snow, Sleet 1.0 inch or	Heavy fog	90° and	32° and balow	32" and below : 0" and below
H A M	(b) 36.0 36.4 45.2 57.1 69.9 80.4	20.9 20.8 28.3 37.5 48.2	28.6 36.8 47.3 59.1	83 88 92	1950 1957 1945 1942 1944 1944	- 8 - 5 19 29	1942 1951+ 1948 1954 1954 1947	(b) 1132 1019 874 531 223 46	(b) 2.38 2.12 2.89 2.73 2.73 3.05	4.64 6.07 5.90 6.04	1950 1950 1954 1950 1947	16 0.79 0.75 1.50 1.18 1.04 1.38	1946 1947 1957 1946	16 1.74 1.77 2.76 1.92 3.73 2.79	1950 1948 1950 1955	16 10.6 9.7 10.9 3.1 0.0 0.0	20.7 26.3 14.3	1943 1957+	7.5 14.9 7.6	1952 1944 1954 1957 1957+	77 7	2 73 1 69 0 62 8 56 6 55	79 1 76 1 72 1 65 1 66 1	2.5 3.0 2.0	8 8 NW 8	59 65 74 65	16 SW 1950 W 1956 W 1948 W 1951 SW 1957 S 1953	34 45 50 57	8.1 7.7 7.1 6.9 6.6	16 3 3 6 5 5	16 5 6 7 8 11 13	23 19 18 17 15	16 15 16 15 14 11	16 16 4 4 4 1 0 0	6 16 * 2 * 2 2 1 4 2 6 1 8 1	0	12	16 16 27 2 24 1 21 * 8 0 * 0 0 0
SON	49,2	61.1 55.1 44.5	71.9 65.5 54.4 41.7	102 103 90 82	1941 1948 1953 1946 1950 1941	32 25	1946+ 1952 1942 1942 1942 1950 1951	0 10 75 340 699 1057	3.04 2.64 3.13 2.42 2.66 2.29	5.19 6.37 9.50 6.44	1947 1945 1954 1950	1.61 1.57 0.61 1.14	1953 1952	2.73 3.07 1.85 3.44 1.94 1.26	1947 1945 1954 1950	0.0 0.0 0.0 0.6 6.5 11.1	0.0 0.0 0.0 6.4 22.3 28.9	1954 1950	15.0	1	78 8 77 8	2 53 3 53 2 55 0 64	63 67 70 1 73 1	2.8	8 8 8	65 61 45 43 59	W 1956 W 1956 S 1953- W 1946 W 1948 W 1949	67 63 56 33	5.3 5.2 5.3 5.6 7.7 8.0	10 10 10 11 3 3	12 13 10 8 7 6	9 8 10 12 20 22	10 9 9 10 15 16	0	7 1 5 1 3 * 2 1 1 1	7 6 2 * 0	0 0 0 0 2 10	0 0 0 0 * 0 1 0 13 0 25 1
Year	59.9	41.3	50.6	103	July 1941	- 8	Dec. 1951+	6006	32.08	9.50	Oct. 1954	0.61	Oct. 1952	3.73	May 1955	52.5		Dec. 1944	15.0	Nov. 1950	79 8	60	69 1	1.1	s	74	War. 1948	49	6.6	75	106	184	156	20 36	8 14	20	38	119 4

The Cleveland Hopkins Airport is located about 10 miles southwest of the downtown area and about 5 miles south of Lake Erie. The surrounding terrain is generally level except for a ridge to the southeast which rises some 500 feet above the shore terrain.

LATITUDE 41° 27' N LONGITUDE 82° 43' W ELEVATION (ground) 603 feet

SANDUSKY (CITY) OHIO

T	1 1		Tem	perat	ure .		1.8		3.54					Precip	itation						1000	ative aidity	1.04			Wind			shine				b	dean :	numb	er of	days		
		Norma	d'Ali	0.8	Ext	reme	188	ree day	15117	183	6.00			GV 1		100	S	now, Si	eet		,EST	EST	EST			Fa	test :	mile	thle sun	runset		unrise to sunset	1994	nore	nore	ă	5.0	empe ax.	Min.
Month	maximum	Daily minimum	Monthly	Record	Year	Record	Year	Normal deg	Normal total	Maximum monthly	Year	Minimum monthly	Year	Maximum in 24 hrs.	Year	Meen total	Maximum monthly	Your	Maximum in 24 hm.	Year	7:00 a.m.,	1:80 p.m.,	m.d.	Mean hourly speed	Prevailing	Speed	Direction	Year	Pet. of possil	Meen sky o	Clear	Partly cloudy	Cloudy	Precipitation .01 inch or 1	Snow, Sleet 1.0 inch or	Heavy fog	90° and	32° and	32° and below
(a) (b)	(b)	(b)	80	100	80	- 5.5	(b)	(b)	81		81	100	81	100	73	73		73	- 4 1	53	25	20	80	80	80	80	nan,	47	69	80	80	80	81	66 7	4 74	80	80	80 8
35 36 45 45 68 79	. 2 . 3	22.4 29.8 39.4 50.2	28.8 29.4 37.5 47.9 59.3 69.9	72 85 90 93	1950 1944 1910 1942 1941 1934	-15 - 3 14 32	1879 1899 1885 1923 1923+ 1894	1122 997 853 513 217 41	2.29 1.92 2.89 2.96 3.32 3.73	6.58 8.53 8.69 6.24 9.04 12.51	1887 1913 1910 1943	0.27	1902 1920 1910 1915 1934 1919	1.71 2.98 2.96 2.21 3.83 5.95	1887 1913 1929 1938	8.2 6.5 4.5 1.2 0.0 0.0	29.8 22.1 16.1 12.0 0.0 0.0	1893 1893 1916 1957	8.7	1910 1900 1955 1886	81 79 73 72	68 70 64 61 59 58	76 74 68 67	10.9	SW SW SW SW SW SW	64 56 58 48	NE NW SW	1918	62	7.4 7.0 6.7 6.3 5.8 5.3	5 6 7 8 9	8 9 9 11 13	18 15 16 14 12 8	14 12 13 12 13 11	4 3 2 0 0	0 1 0 1 2 1 3 0 5 0 7 0	0 0 0 0 3	13 11 5 0 0	26 24 21 5 0 0
83 81 75 63 49	.7	63.9 57.5 46.5	74.6 72.8 66.5 55.0 42.2 31.5	105 99 93 82	1936 1918 1953 1953 1950 1899	45 34 22	1918 1946 1956+ 1925 1880	0 66 327 684 1039	3.45 2.81 3.26 2.10 2.27 2.16	9.71 8.02 7.72 6.22 6.43 6.27	1882 1950 1917 1927	0.23	1904	3.87 4.20 4.28 2.76 2.26 1.74	1906 1950 1920 1927	0.0 0.0 0.0 T 1.9 6.1	0.0 0.0 0.0 1.6 12.3 20.2	1917 1950 1951	12,3	1917 1950 1886	74 74 77 79	57	67 68 70 73	7.6 7.6 8.4 9.3 10.9	24 24 24 24 24 24 24	54 68	NE NW N	1897 1885 1919	71 68 63 55 37 29	4.7 4.8 5.0 5.5 7.1 7.7	11 11 11 10 5	14 13 11 9 8 8	6 7 8 12 17 20	10 9 9 10 12 13	0 0 0 0 1 3	7 0 5 0 3 0 1 1 1 1 0 1	5 3 2 0 0	0 0 0 2 10	0 0 0 1 11 23
59	.3	43.2	51.3	105	July 1936+	-16	Jan. 1879	5859	33.16	12.51	June 1937	0.09	Nov. 1904		June 1937	28.2	29.8	Jan. 1893		Nov. 1950	76	62	71	9,6	87	77		June 1924	53	6.1	91	121	153	138	13 3	4 6	13	41	111

Sandusky is located at the open end of Sandusky Bay on the South Shore of Lake Erie. Terrain is level here and for a considerable distance inland from the lake shore.

NORMALS, MEANS, AND EXTREMES

TOLEDO (TOLEDO EXPRESS AIRPORT) OHIO

LATITUDE		41°	361	H	
LONGITUDE		83°	48'	w	
PIPUSTION	(mound)	676	Pag	ŧ i	

-	. 11		Tem	perati	ıre	ALC: Care		e e	1.5		1334	lank it Wata s	ÇEH	Precip	itation		14.			14 M. 144		Relativ				Wind			shine			h	ъ	loan n	umbe	er of	days		
	14.5	Norma	150		Ext	emes	TA N	nee da	1.5	3 1		183.5	VAN.		\$54.0 2.00		S	ow, Sl	pat	. 184	EST	EST	EST.	h	-	Fa	steet	mile .	dble sun	pover nunset		unrise to unset		900	a more		To Ma	mper	Min.
Month	Daily meximum	Detly	Monthly	Record	Year	Record	Your	Normal deg	Normal total	Mordmum monthly	Year	Minimum monthly	Year	Maximum in 24 hrs.	Year	Mean total	Maximum monthly	Year	Mardmum in 24 hrs.	Year		7:00 a.m.	7:00 p.m.	Mean hourly speed	Prevailing direction	Speed	Direction	Year	Pct. of possil	Meen sky o	Clear	Partly	#	Precipitatio Ol inch or	19 8	Heavy fog	90° and above	32° and below	32 and below
r H K	(b) 34.7 36.0 45.6 58.0 70.4 80.7	18.6	(b) 26.4 27.3 35.8 46.5 58.2 68.6	71 83 89 95	1950+ 1944 1910 1942+ 1911 1934	-16 -10 12 28	1897 1885 1948 1875 1945 1945	(b) 1197 1056 905 555 245 60	(b) 2.25 1.86 2.86 3.25 2.95 3.55	6.84	1887 1913 1929 1943	87 0.51 0.08 0.05 0.55 0.45 0.12	1877 1910 1876 1881	87 1.56 2.26 2.69 2.93 3.57 3.44	1883 1913 1929 1913	73 8.0 6.9 5.1 1.3 0.1 0.0	17.1	1918 1900 1916 1957 1923	19.0 8.4 9.8	1888 1957 1923	80 79 79 81	78 68 78 62 76 56	76 3 73 70 64 5 63	12.6 12.5 13.0 12.8 11.0	9 WSW SW WSW ENE SW	46 66 69 87 72 58 56	SW SW SW	1949 1919 1948 1956 1917 1930	58 33 40 47 50 59 65	87 7.0 6.5 6.2 5.7 5.2 4.8	87 6 6 8 9 10	87 8 8 9 9 11 12	87 17 14 14 12 10 7	12 12	7 87 3 * 2 * 2 2 * 3 * 5	86 1 1 1 *	84 0 0 0 0	84 14 12 5 0 0	84 8 27 2 25 2 22 4 7 0
3	85.3 83.0 75.9 63.9 48.9 36.9	60.9 58.9 52.5 41.5 30.7 20.9	73.1 71.0 64.2 52.7 39.8 28.9	100 92 80	1936 1918 1953+ 1951 1950 1889	41 29 21 2	1945 1946 1942 1952+ 1947+ 1872	0 12 102 387 756 1119	2.65 2.69 3.02 2.32 2.15 2.29	7.64 8.07 8.49 5.58	1926 1926 1881	0.37 0.32 0.04	1894 1946 1892 1904	2.47 4.58 5.98 3.10 2.68 2.04	1920 1918 1881 1871	0.0 0.0 0.0 T 2.0 7.0	12.0	1925 1932 1951	0.0 0.0 1.1 11.5 10.8	1925 1932 1909	85 84 83 81	76 54 80 54 82 55 82 56 81 66 82 72	63 67 68 73	8.8 9.7 10.5	SW SW SW SW SW SW	76 76 62 57 76 69	S SW SW	1919 1916 1919	71 67 62 55 36 30	4.4 5.1 6.6	14 14 13 12 7 5	12 11 10 8 8 8	5 6 7 11 15 18	9 9	0 7 0 5 0 3 * 2 1 1 2 *	* 1 1 1	5 4 1 * 0 0	0 0 0 2 10	0 0 0 0 2 0 14 0 24 1
1	59.9	38.8	49.4	105	July 1936	-16	Jan. 1897+	6394	31.84	8.49	Oct. 1881		Nov. 1904	5.98	Sept. 1918	30.4		Jan. 1918	19.0	Feb. 1900	82	79 80	68	11.2	8#	87		Mar. 1948	53	5.6	115	114	136	131 1	0 35	7	13	43	121 5

The Airport Office is located at Toledo Express Airport. The terrain is generally level with only a slight slope toward the Maumee River and Lake Eric.

LATITUDE 42° 17' N LONGITUDE 82° 58' W LLEVATION (ground) 637'

WINDSOR (AIRPORT) ONT.

-			Тег	nperat	ure		4 4	5.	3313	14.11	4.	N.		Precip	itation		. 1	1112	3 -	400		elativ		4		Wind	e Se		shine		a M		Mean	numb	er of	days	- 41		
		Norma	1	1	Ext	reme	10 19 1 10 19 1	ree da	_		34	8				- 1	S	ow						b		Ma Hourl	ximum y Mil	eage	ible sun	unset	133	t OE	n nore	more	1	1	ampe	Min.	
Month	Daily	Daily	Monthly	Record	Year	Record	Year	Normal deg	Normal total	Maximum m nthly	Year	Minimum monthly	Year	Maximum in 24 hrs.	Year	Mean total	Maximum monthly	Year	Maximum in 24 hrs.	Yea	3.1			Mean hourl speed	Prevailing direction	8	Direction	2	Pet. of possil Mean sky c	nrise to	Partly	Cloudy	Precipitatio .01 inch or	5 ~ 1 €	Heavy fog	90° and	32° and below	32° and below	O'and below
Р А М	(b) 30.8 32.2 42.3 55.2 67.2 77.9	(b) 18.2 19.4 26.7 36.2 47.8 58.3	(b) 24.5 25.8 34.5 45.7 57.5 68.1	65 79 87	1950 1954 1943 1942 1942 1942	-8 -3 15 29	1943 1951 1943 1954 1954 1954	(b) 1220 1100 950 580 270 70	10 2.12 2.17 2.90 3.03 4.43 2.98	18 5.28 4.18 5.66 6.78 7.67 4.90	1954 1954 1947 1943	18 0.80 0.80 0.34 0.58 1.11 0.49	1958 1946	18 0.94 1.34 1.56 1.65 2.16 1.94	1957 1949 1954 1947 1953 1946	10 8.6 9.8 4.4 1.6 T	18 20.8 20.2 20.5 5.4 0.2		18 9.4 8.0 7.1 2.7 0.2	1957 1944 1954 1947 1954	85 8 86 8 80 8 79 8	8 72 4 66 2 56	81 80 74 66	12.7 13.2 12.1 9.5	SW. H	41 W	W 1 E 1 W,S 1	942 943 942 944 943+		1	4 4 5 5 7 4 7	18 23 20 20 19 18 16	14 13 13 12 12	18 18 11 0 9 * 6 1 2 3 0 5 0 6	1 2 2 3 2 2 5 2	0000*	18 16 13 6 *	18 28 27 22 10 1	18 1 1 0 0 0 0
ON	83.1 80.6 73.7 61.1 45.5 34.5	62.9 61.0 54.5 42.9 32.9 22.7	73.0 70.8 64.1 52.0 39.2 28.6	98 99 87 79	1941 1944 1954+ 1951 1950 1956+	44 30 25	1954+ 1950 1942 1952 1955+ 1951+	10 120 410 780	2.61 3.31 2.44 2.70 2.43 2.31	9.09 6.22 6.00 6.42 4.96 3.94	1940 1945 1954 1950	1.01 1.42 0.80 0.23 0.97 0.55	1944 1948 1956 1945 1953 1943	2.70 1.80 1.82 2.82 2.01 0.98	1957 1953 1950 1949 1951 1945	.0 T T 4.2 7.2	.0 .0 T 0.4 11.4 25.0	1949 1952 1950 1951	.0 T 0.4 6.1 7.7	1949 1952 1951 1951	86 8 86 9 85 8 85 8	9 60 7 70	66 73 75 80	6.6 8.0 8.8 11.0	SW SW SW	29 N 29 N 41 W 34 W 38 S 39 S	E 1	941 944 941 941 952 943		10	10 8 6	14 13 14 15 22 22	10 9 9 12 14	0 6 0 5 0 3 * 2 5 *	2 2 4 2	5 3 1 0 0	0 0 0 0 3 11	0 0 * 3 14 27	0 0 0
E	57.0	40.3	48.7	101	JULY 1941	-9	JAN 1943	6650	33.43	9.09	JULY 1957	0.23	OCT 1945	2,82	OCT 1949	35.8	25.0	DEC 1951	9.4	JAN 1957	84 8	6 63	72	10.0	SW.	44 S		JAN 942		74	75	216	137	41 31	30	12	49	132	3

The airport is located 5 miles SE of the city center and the Detroit River, 5 miles SW of Lake St. Clair and 17 miles N of Lake Eric. The surrounding country is quite flat

NORMALS, MEANS, AND EXTREMES

LATITUDE 42° 24' N
LONGITUDE 83° 00' W
ELEVATION (ground) 619 FEET

DETROIT (DETROIT CITY AIRPORT) MICH.

	W.		Temp	eratu	re	N.			. 1 6				ş l Aç	Precipi	itation	1	ile i		413			Relat	ive dity			Win	d		hine		4		Mea	n nur	mbe	of d	lays	
		Norma		. 3	Ext	emos	1 1	ap da							1		Sno	w, Slee		- 10	EST	EST	EST		T	Fe	stest	mile	1	ver		nrise to nset	1	e i				eratures
Month	Daily maximum	Daily minimum	Monthly	Record	Year	Record	Year	Normal degr	Normal total	Meximum monthly	Year	Minimum monthly	Year	Maximum in 24 brs.	Year	Mean total	Maximum monthly	Year	Maximum in 24 hrs.	Year	1:30 A.M.	30 A.M.	Z 2	ž	Prevailing direction	Speed	Direction	Year	ct. of possible	Mean sky co sunrise to sur		Į,	Precipitation 01 inch or me	Snow, Sleet	Thunderstorm	Heavy fog	32°and above	32*and below G
DZOWPC CAPETE	(b) 33.1 33.8 43.1 55.9 68.1 78.3 83.5 81.4 74.0 62.2 47.1 35.7	61.2	(b) 26.2 26.7 35.1 46.4 57.8 68.1 73.1 71.3 64.3 52.9 40.1 29.5	82 87 93 104 105 101 100 89 81	1945 1942 1942 1934 1934 1936	14 30 38 48 43 32 25 7	1940 1934 1934 1954 1954 1945 1945 1934 1936 1936 1950	60	3.61 2.90 2.91 2.62 2.78 2.29 2.18	23 4.38 4.95 4.40 6.89 8.05 4.70 7.03 7.51 5.90 7.80 4.14 3.51	1950 1938 1938 1947 1943 1939 1937 1940 1936 1954 1948	.38 .59 .74 .58 1.06 .81 1.07 .58 .61	1936 1936 1956 1956 1939		1950 1949 1947 1948 1939 1937 1956 1945 1954	7.6 5.3 1.3 7 .0 .0 .0	21.1 14.7 15.5 6.8 .1 .0 .0	1936 1954 1943 1954	5.6 9.8 4.2 .1 .0 .0 .0 .0	1939 1950# 1934 1942 1954	19 78 78 77 73 75 77 80 80 79 78	23 82 82 80 76 72 75 74 80 83 83 81	19 2: 71 7: 68 7: 63 6: 53 6: 53 6: 54 5: 50 5: 52 6: 53 6: 53 6: 53 6: 53 6: 53 6: 53 6: 53 6: 53 6: 54 5:	23 7 11. 11. 11. 11. 9 . 11. 11. 9 . 8 . 7 .	7 3 N 2 NW 4 NW 5 S 9 S 1 S 8 N 9 S 2 SW	23 57 49 68 56 61 56 57 50 52 56 66 59	SW SW N NW SW N NW SW SW SW SW SW SW	1953# 1943 1949 1942 1951	23 31 43 51 53 59 65 71 67 61	23 8.0 7.3 6.9 6.8 6.4 6.1 5.2 5.2 5.3	23 3 4 6 6 7 6	23 2: 6 2: 7 1: 8 1: 8 1: 10 1: 13 1: 13 1:	3 23 2 13 7 12 7 13 6 12 4 12 1 11 1 11 8 9 8 8 0 9 9 12	23 : 3 : 1 : 0 : 0 : 0 : 0 : 0 :	23 2 * 1 2 2 5 6 7 5 3 1	23 2 2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1		23 23 28 1 26 1 22 *
Year	58.0	40.5	49.3	105	JULY 1934	-16	FEB 1934	6404	31.03	8.05	MAY 1943		FEB 1947	3.72	OC T 1954	28.7	24.0	DEC 1951	9.8	MAR 1934	78	79	59 66	10.	s	68	SW	MAR 1943	54	6.5	81 1	0817	6133	10	34 1	2 1	6 48	126 2

(f) The Detroit City Airport is located about 5 miles north of the Detroit River and 6 miles from Lake St. Clair, which lies to the east and northeast. The terrain is generally level with rising ground toward the northwest.

LATITUDE 44° 45' N LONGITUDE 81° 06' W ELEVATION (ground) 720'

WIARTON (AIRPORT) ONT.

		Ten	perat	are		91.5	, a		A112				Precipi	tation			5 (1)	VIII.		2017/06	elativ umidit			4 34	Wind	1		shine				Mean	numl	ber of	days		
	Normal			Ext	remes	43.	пее сау	4					450A			Sn	ow	2.	16.4							aximu ly Mi	ım Lleage	ible sun	nnset	A 133	t OE	more	more	S C		ax.	atures Min.
Daily	Daily minimum	Monthly	Record	Year	Record	Year	Normal dec	Normal tota	Maximum monthly	Year	Minimum monthly	Year	Maximum in 24 hrs.	Year	Mean total	Maximum monthly	Year	Maximum in 24 hrs.	Year			100	3 8	Prevailing direction	Speed	Direction	Year	poss	Clear	Partly	Cloudy	Precipitatio .01 inch or	Snow, Sleet inch or	Thundersto Heavy fog	90° and above	32° and below	32 and below
) (b)	(b)	(b)	11		11		(e)	30	11	- 1.4	11		11	1.3	10	11		11	740	4	4 4	4	(c)		(c)		34	1	1	1 11	11	11	11 1	11 11	11	11	11
27.8 27.5 34.3 47.0 59.9 70.2		21.0 20.3 27.3 38.9 50.3 60.5		1950 1954 1957 1957 1951 1957	-22 -19 2 26	1948 1948 1948 1954 1957 1949		4.45 3.42 3.48 2.74 2.50 2.92	6.70 4.17 4.71 6.12 3.33 4.40	1949 1948 1951 1955	1.80 2.11 1.05 1.37 0.48 1.45	1956 1955 1958 1958 1951 1951	1.53 1.16 1.42 1.54 0.96 2.67	1955 1951 1948 1951 1955 1950	29.5 23.8 17.6 3.5 0.1	32.9 29.2 7.5	1955 1949 1951 1951 1954	2.9	1955 1951 1951 1950 1958+	88 93 9 87 8 85 8 84 8	92 82 38 76 35 68	88 87 82 76 71 73			254445					3 4 5 5 3 4 9 6	25 21 20 18 16 15	18 15 12 9	16 12 4 *	0 3 0 2 * 2 2 3 2 3 5 4	0 0 0	21 18 14 1 0 0	30 27 29 15 4
75.0 74.2 66.7 56.0 42.2 31.2	57.1 56.2 50.0 39.8 30.6 19.9	66.1 65.2 58.4 47.9 36.4 25.6	83 74	1952 1947 1953 1947 1950 1951	40 27 25 5	1954 1957+ 1947 1957+ 1949 1954		2.44 1.63 2.74 2.81 4.01 4.35	4.26 5.63 7.53 7.32 4.93 7.36	1956 1957 1954 1947	0.80 1.27 0.54 0.62 2.14 2.05	1950 1947 1955 1952 1953 1948	2.95 1.81 1.54 2.73 1.12 0.98	1955 1953 1953 1954 1955 1949	.0 T 1.3 17.5 25.5	7.7 35.3	1958+ 1957 1947 1951	5.6	1958+ 1957 1955 1957	88 8	99 71 91 71 91 83	76 83 83 88		18.8					1	7 6	13 13 17 17 25 26	9 11 11 18	0 1	4 3 3 3 2 2 3 0 1 2	1 * 0 0	0 0 0 0 4 15	0 0 4 18 27
51.0	35.3	43.2	96	SEPT 1953	-22	FEB 1948		37.49	7.53	SEPT 1957	0.48	MAY 1951	2,95	JULY 1955	118.8	62.1	JAN 1955	15.3	JAN 1955	88 8	38 74	81							7	61	226	161	78 2	31	1	73	154

Wiarton Airport is located NE of the town beside, but 200 ft. above, Colpoy's Bay on Georgian Bay.

NORMALS, MEANS, AND EXTREMES

GORE BAY (AIRPORT) ONT.

LATITUDE 45° 53' N LONGITUDE 82° 34' W ELEVATION (ground) 624'

| Relative | Normal | Extremes | Show
Gore Bay Airport is located 5 miles SW of town on the N side of Manitoulin Island. It is about 2 miles from open water in the north channel of Lake Huron.

LATITUDE 45° 04' N LONGITUDE 83° 26' W

ALPENA (CITY) MICH.

100		Тетр	eratur					11 60	714.5		- 1	151	Precipit	ation							lelati umid				Win	1	Aurily A	shine		ejas, el	Mea	n nun	aber o		
	Normal			Extre	mes		ee days	-			14.5	1.4.4				Snov	w, Sleet		Designation of the second seco	EST	EST	EST	70		Fa	stest 1	mile	ible sun	sunset	Sunrise to sunset	-85	r more	forms	Me	nperatu
Deily	Daily Infinum	fonthly	Record	Year	Record lowest	Year	Normal degr	Vormal total	Maximum monthly	Year	Minimum monthly	Year	Maximum in 24 hrs.	Year	Mean total	Maximum monthly	Year	Maximum in 24 hrs.	Year	1:00 A.M.	.00 A.	1:00 P.W. 7:00 P.W.	Mean hourly spec	Prevailing direction	Speed	Direction	Төаг	Pct. of poss			-	Show, Sle	Thunderst Heavy for		32 and below
	E (1)	(b)	44	~	44	-	(b)	(b)	- 44	•	44	1 1 1	44		44	44	- 1	44	17	18	44 4	0 44	44	44	44	100		44	44	44 44	4 44	14	44 4	44	44 44
(b) 28.1 27.8 35.3 47.7 59.9 70.8 76.8 75.0	(b) 14.2 12.0 20.1 31.4 41.9 52.1 57.9 56.6	21.2 19.9 27.7 39.6 50.9 61.5 67.4	62 58 79 88 93 100	1915 1937 1933	-19 -28 -16 - 2 25 34 41	1920 1934 1943 1923 1947# 1949#	1358 1263 1156 762 437 135	2.59	3.09 4.28 4.73 4.99 6.05	1922 1921 1954 1927 1930 1951 1938	.63 .24 .63 .44 .76	1944 1957 1937 1935 1925 1955 1955	1.67 1.82 1.70 2.25 2.42 2.28 3.09	1916 1952 1954 1915 1951 1941	12.6	27.2 33.8 13.7 9.7	1926	11.1 16.7 10.4 9.4 .0	1922 1947 1949 1929	78 78 77 78 82 82 83	79 8 80 8 77 8 74 7 76 8	57 74 56 72 51 68 51 67	12.4 12.1 10.5 9.5 9.2	NW NW SE SE NW NW	56 50 56 52 47 50 44 52 49	E NW E NW NW S S	1918 1944 1946 1921 1931 1921 1952 1932	43 52 56 59 64 70 64 52	6.4 6.0 5.8 5.5 4.8 5.1 5.8	5 8 7 10 8 10 9 11 9 12 11 13 10 13 8 11	14 12 12 12 11 1 9 1 7 8 16 11 1	5 2 3 1 1 1 0	* 1 2 4 5 7 5	1 0 1 0 2 0 2 0 2 * 2 1 1 2 1 1 2	20 30 19 28 12 28 1 16 0 2 0 0 0 0 0 0
66.9 55.7 42.2 31.3	49.8 40.0 30.1 20.0	58.4 47.9 - 36.2	99 87 77	1953 1928 1950	29 16 - 2	1916 1925 1929 1933	215 530 864 1218	3.20 1.98 2.18 1.75	5.44	1932 1926	•26 •54	1955 1952 1939 1919	4.40 2.72 1.75 2.51	1929	6.1	19.4		5.0 8.0	1930	82 82	85 84	65 76	5 10.8	B NW 9 NW	50 61 49	NW SW NW	1954# 1940 1939	24	6.3 7.9 8.1	3 7	14 1. 20 1 22 1	2 * 5 2 5 4	1 *	3 0 2 0 2 0	4 18 17 28
51.5		_	-	111 Y	1	FFR	8073	26.63		SEPT 1937	•16	SEPT 1955	4.40	SEPT 1937	64.8	41.8	JAN 1943	16.7	MAR 1947	80	80	66 7:	3 11.	O NW	61	S₩	NOV 1940	51	6.4	82 20	63 4	6 20	29 2	1 4	73155

⁽f) Alexer is located at the head of Thunder Bay on the western shore of Lake Huron. The terrain is level to gently rolling.

NORMALS, MEANS, AND EXTREMES

LATITUDE 46° 28' N
LONGITUDE 84° 22' W
ELEVATION (ground) 721 Feet

SAULT STE. MARIE (AIRPORT) MICH.

	41.5		Temp	eratu	re									Precipi	tation							Relati umid				Wind		hine	100		N	dean n	umb	er of	days	
		Normal	un i	13.4 11.2 11.2	Ext	ошес		ee day		10.15			A 27 1			100	Sno	w, Slee		1905 1905	BBT	EST	EST	100		Faster	t mile	e suns	over	Sunri		20	an an			eratures Min.
Month	Deily maximum	Daily minimum	Monthly	Record	Year	Record	Year	Normal degr	Normal tota	Maximum monthly	Year	Minimum monthly	Year	Maximum in 24 hrs.	Year	Meen total	Maximum monthly	Year	Maximum in 24 hrs.	Year	1:00 A.M.	.A 00	7:00 P.M.	Mean hourly speed	Prevailing direction	Speed	۱ ا	Pet. of possib	Mean sky or sunrise to su	Partigondy		Precipitation Olinch or m Snow, Sleet	I.O incn or n Thunderston	8	above	alow elow
(a)	(p)	(b)	(p)	16	10	16		(b)	(b)	16		16	1111	16	9 -	16	16		16	3.	16	16 1	6 16	16	5	16		16	16	16 16	1-1	10 107	_	-	16 1	6 16 16
CXVX	21.9 22.7 31.7 45.7 59.7 69.7	4.3 14.2 27.8 38.1	13.8 13.5 23.0 36.8 48.9 58.1	45 75 82 85	1954	-25 -24 1 23	1948 1943 1943 1950 19544 1949	499	2.55	4.37 2.67 3.22 5.16 5.27 6.66	1951 1943 1954 1945	.59 1.13 .60 1.23	1949		1953 1943 1954 1945	16.3	32.2 14.7 4.6	1949	10.9 11.3 8.3 4.6	1949 1951 1943 1943 1947 1951#	84 82 81 82	85 6 85 6 79 5	5 82 9 77 1 69	11.1 11.3 10.5	ANA ANA E	52 SM	1942	50 53 53	8.0 7.5 7.0 6.5 6.6 6.4	4 6 7 6 7 8	18 15 16	18 16 14 12 11 12	7 * 6 * 5 1 2 1 2 3 0 7	1 2 3 3 3 4	0 2 0 2 0 1	
JASOND	75.4 73.5 64.4 52.4 37.9 26.7	52.3 45.9 36.4 25.1	63.9 62.9 55.2 44.4 31.5 19.9	98 93 80 66	1947 1953 1950 1953	32 25 20 - 5	1950 1950 1947 1949 19568 1946	109 126 298 639 1005 1398	3.49 2.98 3.26	5.62 4.39 5.62	1944 1942 1951 1948	.50 .86 .25 1.55	1954 1947 1943 1947 1954 1954	2.20 1.59 1.59 1.50	1944 1957 1951 1957	204 14.8 25.5	2.7 12.5 27.7	1956 1943 1943 1944	10.1	1956 1943 1943 1932	92 91 88 86	92 6 89 6 87	2 73 7 81 5 80	9.2 9.8 10.6	SE ANA	48 SW 47 W 55 W	1944	58 43 46 21	5.9 6.9 6.6 8.6	9 10 5 9 7 8 2 5	12	9 14 11 18	0 6 0 5 * 4 1 2 5 *	5 7 7 6 2 3	1 1 0 0 0 2	0 0 0 4 0 1 * 8 7 22 2 30
Year	48.5	30.1	39.3	98	AUG 1947	-25	FEB 1943	9475	30.19	6.66	JUNE 1949		OCT 1947	2.67	APR 1957	202.1	39.1	JAN 1950		NOV	П	П			П	58 NW	DEC			67 91	П		4 29	46		4178 2

(f) Sault Ste. Marie Airport is located about 3 miles east-northeast of the City on a plateau overlooking Whitefish Bay.

LATITUDE 43° 10' N LONGITUDE 86° 14' W ELEVATION (ground) 627 Feet

MUSKEGON (AIRPORT) MICH.

			Temp	eratu	re			2	- 100	, Selv	14			Precipi	tation		100		***		I h	Relativ	76 it y) 1	Win	d		hine		2 1		Mean	num	ber of	f days		
	1. 1	Normal	1 y -4 1 1 1 1 1	1484	Extr	emes		ree day	7	75-143- 73-53-1 73-53-1	50					5.5	Sno	w, Sleet	3455 ×		EST		EST	11, 101 21, 124 31, 24		Fe	stest :	mile	le suns	cover	su	rise to aset	lore	nore		Temp		
Month	Daily	Daily minimum	Monthly	Record highest	Year	Record	Year	Normal degr	Normal total	Maximum monthly	Year	Minimum monthly	Year	Maximum in 24 hrs.	Year	Mean total	Maximum monthly	Year	Maximum in 24 hrs.	Year	1:00 A.M.	:00 A		Mean hourly speed	Prevailing direction	Speed	Direction	Year	Pct. of possible	Mean sky co	Clear	Cloudy	Precipitation Olinch or m	Physical or r	Heavy fog	above	below	3 8
(a)	(b)	(b)	(b)	16	10	16		(b)	(b)	16		16		16		16	16		16		9	14 1	4 14						П	1	_		16	16 16	-	16 1		_
J F M A M	31.4 31.8 40.3 53.1 64.8 74.8	18.3 17.1 24.4 34.1 43.7 53.9	24.9 24.5 32.4 43.6 54.3 64.4	57 77 84 86	1950 1954 1945 1942 1950 1953	-11 -10 15	1948	1243 1134 1011 642 350 116	1.95 1.64 2.18 2.34 2.82 2.87	3.88 2.74 5.10 7.12 5.26 4.83	1957 1948 1947 1945	.94 1.48 .86 1.43		1.39 1.98 2.23	1957 1948 1947 1955	12.5	6.0		7.3 7.7 5.4	1947 1946 1954 1956 1954	80 78 77 80	82 7 81 7 81 6 80 5 78 5 81 6	4 78 6 72 9 64 7 62							8.7 8.1 7.2 6.7 6.4 5.9	2 3 5 7 7 8	4 25 5 20 7 19 7 16 10 14	13 14 12 13	4 3 1	* 2 1 1 2 2 3 2 5 3 6 2	0 1 0 0	7 2 * 1	7 1
J A S O N D	80.5 78.7 71.1 59.3 45.2 34.9	59.2 58.1 51.5 41.3 31.7 23.4	69.9 68.4 61.3 50.3 38.5 29.2	97 95 83 73	19554 19474 19544 19534 1950 1951	40 28 22 -14	1942 1950# 1952 1950	48	2.12 2.66 3.34 2.52 2.64 1.93	6.63 4.22 5.85 6.36 4.43 5.42	1945 1947 1954 1955	•96 •97	1953	2.00 3.51 3.21 1.91	1945 1947 1954 1952	.0 T .1 8.4 15.9	2.0 21.5 30.5	1949# 1952 1951 1951	7.6	1955	87 84 82 79	83 5 87 5 87 5 86 6 81 7 82 7	9 65 9 72 0 74 0 76							4.8 4.9 5.2 5.5 8.3 8.7	11 11 10 11 3	12 8 12 8 10 10 7 13 4 23 4 25	14	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	6 1 5 2 5 1 2 3 1 2	2 2 1 0 0 0	0 0 0 3 1 2 2	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
Year	55.5	38.1	46.8		JUNE 1953		NOV 1950	7089	29.01		APR 1947		OCT 1944		SEPT 1947	68.3	33.9	JAN 1954	12.5	JAN 1947	82	82 6	5 70							6.7	80	92193	41	24 3	7 23	6 :	114	6 2

(f) The Muskegon Airport is located about seven miles southeast of the City and Lake Michigan. The terrain is generally level, with several sand dunes along the shore line.

NORMALS, MEANS, AND EXTREMES

LATITUDE 41° 47' N LONGITUDE 87° 45' W ELEVATION (ground) 610 Feet

CHICAGO (MIDWAY AIRPORT) ILL.

			Temp	eratu	re		NVA S	100	Prijaj					Precipi	tation							Relati numic				Wind	1		hine			М	lean n	umbe	er of	days	
t		Norma		1 27	Extr	eme	TESTA STATE	se day		2122						783 2743	Sno	w, Slee			CBT	CST	CBT			Fas	test r	nile	le sum	over	Sunri to suns	100	azor	ms ms	1 1 1 1	Tem; Max	peratures . Min.
Monte	Daily maximum	Daily minimum	Monthly	Record	Year	Record	Year	Normal degr	Normal total	Maximum monthly	Үөаг	Minimum monthly	Year	Maximum in 24 hrs.	Хоаг	Mean total	Maximum monthly	Үөм	Maximum in 24 hrs.	Year	Midnight	¥.	Noon CST 6:00 P.M.		Prevailing direction	Speed	Direction	Year	Pct. of possib	Mean sky c sunrise to s	Clear Partly	1 . 12	Olinch or n Show, Sleet	Thunderstor	Heavy fog	32 and	32 and below
a)	(b)	(b)	(b)	15		15		(b)	(b)	15	- 3	15		15		15	15		15		15	15	15 15	15	13	15	-	1.3	15	15	15 15	15	15 1	5 15	15	15 1	5 15 1
J F M A M J	32.7 35.0 45.0 57.6 69.7 80.0	17.1 19.8 29.0 38.6 48.7 58.8	24.9 27.4 37.0 48.1 59.2 69.4	69 82 84 94	1950 1954 1945 1952 1949 1953	-15 - 7 19 30	1951 1951 1943 1954 1947# 1945	1243 1053 868 507 229 58	1.84 1.41 2.85 2.82 3.66 4.15	3.77 3.35 5.00 8.33 7.59 5.94	1950 1954 1947 1945	.38 1.10 1.28 .78	1946 1950	1.25 2.50 4.08 2.93	1949 1948 1947 1951	7.0	20.8 16.6 19.9 2.4 .2	1950	8.3 11.8 2.4	1957 1956 1954 1951 1954	77 74 72 74	80 78 76 75	67 73 60 66			50 54	W NW NW S	1951	53 52 58	6.9	6 6 6 8 6 8 7 9 7 10	16 17 16 15	10 10 12 13 12 10	2 * 2 1 2 3 * 4 0 5 0 7	3 2 1 1 1	0 1 0 0 0 1 7	4 29 9 24 5 20 * 6 0 * 0 0
1	85.3 83.0 75.9 64.3 47.6 35.3	63.9 62.3 55.2 43.9 31.3 20.6	72.7 65.6 54.1 39.5	101 101 91 81	1947 1953 1954 1950	46 36 20 - 2	1947 1950 1943 1948 1950 1951	0 90 350 765 1147	3.23 2.56 2.33	8.98 5.91 6.01 12.06 3.74 6.67	1954 1945 1954 1951	1.00 .46 .30	1953 1956 1956 1949	2.55 5.63 1.79	1955 1951 1954 1946	.0 .0 .3 3.5 10.0	•0 •0 3•0	1952 1951 1951	0 0 3.0 8.0 10.0	1952 1951	79 76 73 75	82 81 80 79	51 63 62 69	7.3	S	54 47 45 60	NW N S	1949 1947 1949 1952	70 68	5 • 2 4 • 9 5 • 1 7 • 1	11 12 11 11 11 10 12 8 6 7 6 7	9 9 11	9 6 8 6 7 9 10 1	0 6 0 5 0 3 * 1 1 1	1 1 1 1 3	9 8 3 8 0 0	0 0 0 0 0 0 0 2 3 16 1 26
t	59.3	40.8	50.1	104	JUNE 1953	-15	FEB 1951#	6310	32.72		OC T 1954		OCT 1956		JULY 1957	34.6	33.3	DEC 1951		MAR 1954	76	79	58 64	9.8	SSW	60		NOV 1952	59	6.2	95102	681	19 10	0 36	17	28 4	2123

(f) The Midway Airport is located 10 miles southwest of Chicago's "Loop" area. The Lake Michigan shoreline lies in a northwest-southeast line 8 miles to the east and approximately 20 miles to the north of the airport. The terrain is generally level. A series of low hills parallels the lake shore some 15 to 20 miles inland.

LATITUDE 42° 57' N LONGITUDE 87° 54' W ELEVATION (ground) 672 Feet

MILWAUKEE (GENERAL MITCHELL FIELD) WIS.

	LEVAT	ON (gre	ound)	672 1	eet																_			_				_								_		
	ern i	4.84	Temp	eratu	(e	44.0		į.						Precipit	ation					100		Relati numid		1		Wind			une			М	lean r	ıumb	er of	days		
	111	Normal	44.	24	Extr	emes		9e day						14 A			s	now, Sl	et	100g	cST	CST			100	Fast	est mile	1 !	e 8	21	Sunris to sunse		nore	nore		Temp Max	eratu . M	
Month	Daily maximum	Daily minimum	Monthly	Record	Year	Record	Year	Normal degr	Normal total	Maximum monthly	Year	Minimum monthly	Year	Maximum in 24 brs.	Year	Mean total	Maximum monthly	Year	Maximum in 24 hrs.	Year	12:30 A.M.	6:30 A.M.	9 8	Mean hourly speed	Prevailing direction	Speed	Direction	Total of tod	an sky	sunrise to si	Partly	Cloudy	Olinch or n Spow, Sleet	LO inch or r Thunderstor	6	, 00 v	and	0° and below
(a)	(b) 29.2 31.8 40.8 52.8 63.9	(b) 14.5 16.6 25.7 35.8 44.7	(b) 21.9 24.2 33.3 44.3 54.3	60 81 82 90	1944 1954 1945 19524	-19 - 7 13 28	1951 1941 1953 1947	(b) 1336 1142 983 621 351	1.27 2.19 2.39 2.98	3.67 4.91 5.27	1951 1952 1951 1945	1.05 .81 1.72	1945 1947 1955 1942 1949	1.32 1.63 2.11 2.06	1948 1943 1956 1948	16.5 6.5 8.0 .6	28.4 9.9 19.8	1943 1956 1952 1950 1954#	5.8 7.9 3.4 T	1956 1950 1953 1954#	76 74 76 75 77	76 6 78 6 77 5 77 6	0 73 8 72 5 71 8 64 0 64	13.3 13.2 14.1 13.8 12.5	WNW WNW NNE NNE	50 S 73 S 66 S	H 194 W 195 W 194 W 195	0 4 4 5 5	8 7. 2 6. 8 6. 3 6. 1 6.	1 8 8 5	6 16	16 19 16 16 15	16 1 10 9 11 11			16 1 0 1 0 1	6 16 7 30 3 26 7 23 9 0 1	3
DZONDL L	75.1 81.2 79.2 71.8 60.3 44.7 32.7	54.7 61.4 60.5 53.3 42.4 29.9 18.7	71.3 69.9 62.6 51.4 37.3 25.7	101 100 98 86 77	1955 19554 1953 1947 1947	45 44 28 21	1945 1950 1942 1948# 1950 1950#	831	2.43 2.62 3.33 1.97 2.11	8.28 6.69 4.34 9.87 4.42 3.36 2.64	1952 1953 1941 1951 1952	.46 .30 .15	1943 1946 1948 1956 1956 1949 1943	3.30 4.05 5.28 1.39 2.18	1950 1953 1941 1954 1943	.0 .0 T T 3.2 9.6		1942 1955# 1951 1951	1 6.3	1942	82 83 80 77	81 5 84 5 83 5 82 5 80 6	8 64 9 68 8 69 7 70 5 73	9.9 11.4 12.1 13.8	NNE SW SW SW	59 W 50 W 62 S 60 S 72 W	195 194 194 194	2 7 9 6 1 6 9 5	0 5. 6 5. 9 5.	.2 1 .2 1 .3 1 .2 1	0 12 1 11 0 10 2 8 6 6	9 9 10 11	9 9 8 8	0 7 0 6 0 4 0 1 1 1 3 =	1 2 1 2 2 2 2	4 1 0 0 0 1	0 0 0 0 0 3 0 3 4 17 4 28	0 0 0 * 2
Year	55.3	38.2	46.8	101	JULY 1955	-24	JAN 1951	7205	27.57	9.87	SEPT 1941		OC T 1956		SEPT 1941	39.4	28.4	JAN 1943		JAN 1947	78	79 6	2 69	12.3	SW	73 S	MAR W 195		4 6.	.2 9	3104	1681	191	2 36	25	11 5	57.37	11

(f) General Mitchell Field is located six miles south of the City and about three miles west of the Lake Michigan shore. The field is located in the NNE sector of a very shallow circular depression about four miles in diameter.

NORMALS, MEANS, AND EXTREMES

LATITUDE 44° 29' N LONGITUDE 88° 08' W ELEVATION (ground) 689 Feet

GREEN BAY (AUSTIN STRAUBEL AIRPORT) WIS.

		2.87	Temp	eratu	е .	10		R.			A Section			Precipi	itation				T Y			Relativ umid				Wind	1	177	hine	2.1	4.0		Mean	num	ber o	of da	ув	
		Norma	1	100 100	Extr	emes	Mary Salar	ree da	ন				90 V W 90 V V 90 V V				Sno	w, Slee			CST	CST	CST		100	Fas	stest 1	mile	e suns	cover	Sun	0 .	920	more	<u></u>		mper lax.	rature
Month	Daily maximum	Daily minimum	Monthly	Record highest	Хөх	Record lowest	1 3	Normal deg	Normal total	Maximum monthly	Year	Minimum monthly	Year	Maximum in 24 hrs.	Year	Mean total	Maximum monthly	Year	Maximum in 24 hrs.	Year	idnight	A. M.	8 8	Me	Prevailing direction	Speed	Direction	Year	Pct. of possibl	Mean sky co sunrise to su		<u>N</u>	Precipitation Olinch or m	8 H S	Heavy fog	and	woled	Z and below IN
a)	(p)	(b)	(b)	8	3.3	8		(p)	(b)	8	2	В	11	8	1	8	8	11.	- 8		8	8	8 8	8	8	8			- 4	В					}~	٦	6	33
7.5 4.5.	24.5 26.0 36.7 51.7 65.2 75.2	7.7 8.6 20.2 31.9 43.6 54.1	16.1 17.3 28.5 41.8 54.4 64.7	50 63 84 90	1954 1952 1952	-24 -10 7 25	1951 1951 1950 1954 1950 1956	1516 1336 1132 696 347 107		3.56	1957	.35 .43 .46 1.45 .89 1.90	1957 1957 1956 1951	1.05 1.51 .96 1.75 2.73 1.56	1953 1950 1953 1956	9.2		1953	8.2 9.3 3.5	1950 1956 1956 1954	77 76 77 79	79 6 78 6 78 5	9 74 3 70 7 62 4 59	10.6 10.1 11.6 11.8 11.0	SW NE NE NE	109	W NE SW	1950 1951 1951 1952 1950 1953#	51 56 51 58	6.7 6.5 6.3 6.7 6.4 6.0	7 9 7 7	7 17 7 14 7 15 7 16 0 14 2 11	9 11 11 12	3 3 2 1 0	* 2 * 4 1 2 3 3 4 2 9 2	0 0 0 * 1	18	31 28 29 16 3
	81.1 78.5 69.9 57.5 40.6 27.1	58.7 57.1 50.4 39.3 26.4 13.0	69.9 67.8 60.2 48.4 33.5 20.1	99 95 83 72-	1955 1955 1955 1953 1953 1951	38 27 16	1952# 1950 1956 1952 1950 1950	32 58 183 515 945 1392	3.03	6.50 5.50 5.78 5.00 3.52 1.84	1951 1954 1954 1957	•76	1955 1955 1952 1953	2.62 1.60 3.68 1.25	1951 1954 1954	.0 .0 .0 T 4.2 7.8	.0 .0 .0 T 8.9 14.1	1957# 1951 1950	3.8	1.0	89 86 81 77	80 6	9 68 7 70 6 71 5 73	7.5 9.4 9.9	SW	50 66	SW W SW	1957 1950 1951 1951 1955 1957#	62 60 57 40	5.6 5.4 5.6 7.2	9 1	1 1·1 0 10	10 9 8 9	0 0 0 0 1 3	8 1 5 3 3 2 3 3	2 2 0 0	0 0 0 0 7	0 0 2 7 23
	52.8	34.3	43.6		AUG 1955		JAN 1951	8259	26.51		JUL Y 1950		OCT 1952		OCT 1954	40.3		MAR 1956		MAR 1956				11.				MAY				-	\Box	2 2	7 20	0		

(f) The Green Bay Airport is about eight miles west of the City which is located at the mouth of the Fox River. The terrain is slightly higher to the north, south, and westward.

LATITUDE 45° 45' N LONGITUDE 87° 03' W ELEVATION (ground) 594 Feet

ESCANABA (CITY) MICH.

	NT.				1000	9 1 2	\$1.197		11111	19.19	0.54	1.00	Same	Precipi	tation							Relat				Wix	ıd		hine	5.0		• •	Mean	numb	oer of	days	
	No	rmal		13.9	Extr	:eme		e da	-							11.3	Sno	w, Slee			EST	EST	EST			Fe	etest	mile	ang	nset	Sunr	44	920	ore us		Temp	eratu. Mi
Daily	Dedly	minimum	Monthly	Record highest	Year	Record	Year	Normal deg	Normal total	Maximum monthly	Year	Minimum monthly	Year	Maximum in 24 hrs.	Year	Meen total	Maximum monthly	Year	Maximum in 24 hrs.	Year	1:00 A.K.	.00 A.	1:00 P.M. 7:00 P.M.		Prevailing direction	Speed	Direction	Year	Pot. of possible	Mean sky co sunrise to sur	Clear Partly ondy	Cloudy	Precipitation Olinch or m Snow Sleet	L'O inch or m Thunderstorn	avy fog	and shove	and below
(p)	(ъ	b)	(p)	48	8.7	48	100	(b)	(b)	48	7100	48		48	. a . ja	48	48	100	48	200	10	48	40 48	26	534	26			48	5. 7	48 48	1		-	+1	o, j.,	
25. 26. 34. 45. 57. 69.	0 18 8 30 8 41 0 52	9.1 8.4 0.6 1.8 2.3	17.5 17.6 26.2 38.2 49.8 60.7	52 79 82 91 95	1943 1946 1957 1925 1931	-31 -20 - 1 22 32	1911 1927	1327 1203 804 471 166	1.37 1.78 2.10 2.60 2.80	3.88 3.83 5.23 5.77 7.91	1937 1950 1954 1918 1953	•35 •11 •39 •76 1•06	1910	2.14 4.83	1937 1950 1932 1949 1953	10.8	26.6 32.4 21.2	1929 1953 1916 1923 1954	14.5 11.1 14.0	1915 1938 1916 1910 1954	77 76 77 77 78	78 79 79 79	70 75 68 73 66 73 63 69 64 66	10.2 10.5 11.1 11.1 10.8 9.6		47 43 68 47 57	N N N N N SE	1942 1941 1948 1949 1957 1946	42 50 55 56 58	6.6 6.2 5.9 5.7	7 7 8 7 9 9 10 8 10 10	17 13 13 12 11	12 10 10 10 10	5 * 4 3 1 1 2 4 0 6	1 2 2 2 2 2 1	0 24	4 31 0 28
75. 73. 65. 54. 39. 28.	2 56 2 49 2 39 9 27	6.6 9.5 9.9 7.9	66.9 64.9 57.4 47.1 33.9 22.4	100 96 86 69 56	1955 1953 1922 1953	35 26 10	1912 1915 1926 1925 1950 1927	62 95 247 555 933 1321	3.22 2.89 3.12 2.04 2.20 1.43	7.46 7.58 4.70 5.69	1912 1937 1919 1948	.69 1.03 .07	1939 1930 1948 19524 1930 1943	1.98	1921 1937 1911 1945	.0 T .2 5.3 10.4	2.2	1933	1.5	1942 1933	84 85 81 80	84 86 83 81	67 72 68 76 67 75 70 76	9.1 9.3 10.0 10.7 11.2		49 43 47 49 56 47	N N N N N N N	1949 1945 1939 1947 1950 1939	62 54 49 34	4.8 5.1 5.6 6.0 7.3 7.1	9 10 9 9 5 6	9 11 13	10 12 10 11	0 7 0 6 0 4 * 2 2 1 4 *	1 2 2 2 2 2	****	0 0 0 1 1 6 6 20 9 29

Escanaba is located along the west shore of Little Bay De Noquet, an arm of Green Bay. The terrain is flat to slightly rolling.

NORMALS, MEANS, AND EXTREMES

LATITUDE 46° 34' N LONGITUDE 87° 24' W MARQUETTE (CITY) MICH.

		Temp	eratu	•		40,165	10000	14.5					Precipi	tation							telativ umid		3.7		Wind	1		hine	40.00			Mean	ı nun	mber	of da	(ys :	
	Normal			Extr	emes		ee days		17 A.	9 (4 th)	228 (6) 50 (5)	70 (Vs)	wasini Nama	- 140 d - 500 d	100.001	Sno	w, Sleet		alk (AA) usa es	EST	RBT	RBT	(610) (610) (810)		Fa	stest :	mile	ole sum	over unset	sur	o uset	anom	more	1	М	mpe fax.	1
Daily	Daily ninimum	Monthly	Record highest	Year	Record	Year	Normal degr	Normal total	Maximum monthly	Year	Minimum monthly	Year	Maximum in 24 hrs.	Year	Mean total	Maximum monthly	Year	Maximum in 24 hrs.	Year	1:00 A.M.	4	1:00 P.K. 7:00 P.K.	Mean hourly spee	Prevailing direction	Speed	Direction	Year	Pet. of possil	Mean sky or sunrise to su	Clear	Cloudy	Precipitatio Olinch or	Show, Slee I.O inch or	Thunderstor Heavy for	90° and	32 and below	32°and
(b)	(b)	(b)	20		20		(b)	(b)	20		20		20		20	20		20		11	20 2	0 20	20	20	20			20	20	20 2	0 20	0 20	20	20 2	0 20	20	20
25.2 26.0 33.7 46.2 58.3 69.0	12.1 11.8 20.0 31.2 40.8 50.2	18.7 18.9 26.9 38.7 49.6 59.6	54 76 86 93	1943 1946 1938 1941	-12 -13 -4 22	1938 1943 1954 1954	1435 1291 1181 789 477 189	2.17 1.72 2.05 2.51 2.64 3.46	3.93 3.29 3.16 5.28 4.37 8.86	1947 1955 1947 1940	•31 •30 •64	1949 1948	1.39 1.18 1.56 2.43 2.22 4.65	1951 1939 1947 1955	16.6	32.8	1947	11.5 16.1 16.0 11.7 7.8 T	1947	73 73 70 72	76 6 75 6 73 6 73 6	9 73 7 72 66 72 62 66 63 63 66 68	8.6 8.6 8.6	NW NW	57 42 50	SW SW S S S	1938 1939 1938 1948 1943 1946	38 48 53 54	8 • 1 7 • 8 7 • 2 6 • 6 6 • 6 6 • 5	5 6	6 2: 6 1: 8 1: 9 1: 10 1:	9 14 8 12 5 11	5 4 2 #	0 # 1 2 3 7	* 0	0 24 0 20 0 15 0 3 * *	28
75.1 73.6 65.7 54.8 39.3 28.8	57.1 56.9 49.9 40.2 28.4 17.4	65.3 57.8 47.5 33.9	102 98 86 73	1947 1939 1950 1944	41 31 21 0	1956# 1950# 1942 1942 1955 1938	87 236 543 933	3.13 2.71 3.43 2.26 3.12 2.04	5.40 5.73 4.15 5.08	1951 1942 1941 1948	1.69 1.21 .21 .79	1940 1948 1956 1939	3.94 2.34 1.90 2.41 2.29 1.23	1951 1949 1938 1943	.0 .1 2.2 15.7 20.1	2.0 9.1 35.2	1942 1939 1949 1950	6.0	1942 1939# 1948 1952	79 80 76 79	79 6 81 6 77 6 80 7	54 66 54 70 54 75 52 71 71 77 70 74	7.4 8.4 8.8 9.0	W S	38 45 47 49	SE S NW S	1943 1943 1951#	59 50 47 24	5.7 5.9 6.6 6.6 8.3 8.3	8 6 7 2	12 1	2 16	1 5	6 6 3 1 *	2 2 1 2 * 1 1 0 1 0	2 0 1 0 0 7 0 19	7 2 9 2
49.6	_				-	2.70	8529	31.24	10.20	JULY 1949	•21	0CT 1956	4.65	JUNE 1939	98.4	43.7	JAN 1950	16.1	FEB 1947	75	77	56 71	8.4	w	57	SW	MAR 1938	48	7.0	62	05 9	8155	29	29 1	.6	6 88	3 5

(f) Marquette is located on the south shore of Lake Superior. The terrain is generally level.

LATITUDE 48° 22' N LONGITUDE 89° 19' W ELEVATION (ground) 644' FORT WILLIAM/PORT ARTHUR (LAKEHEAD AIRPORT) ONT.

		Теп	perati	ıre				- 527		1000	1760		Precipi	tation						-	ative			Wine	4	1 2 2 2	shine			3 1	Mean	numb	er of		(1)	411
	Norma	1		Extr	emes	100	ree day			1 1 A			4 1 45 975		125	Sne	οw	in h N	/ A 35	E E		. A			axim ly M	um ileage	possible sur	sunset	At 1330	Е	on r more	r more		Ma	1	Min.
Daily	Daily	Monthly	Record	Year	Record	/ear	Normal deg	Normal total	Maximum monthly	Year	Minimum monthly	Year	Maximum in 24 hrs.	Year	Mean total	Maximum monthly	Year	Maximum in 24 hrs.	Year	0130 E.S	i mi	, B	Prevailing	Speed	Direction	Year	Pet. of poss	1 4	Clear	Cloudy .	Precipitati	Snow, Sleet 0, linch or m	Heavy for	90° and above	32° and below	32° and below.
(b) 15.2 17.5 29.5 44.1 57.7	(b) -3.5 -2.7 10.2 25.7 36.9	(b) 5.9 7.4 19.8 34.9 47.3	55 48 50 73 83 91	1908 1935 1946 1942 1953	55 -42 -40 -34 -10 16	1943 1936 1958+	(b) 1830 1580 1380 890 540 230	30 1.67 1.18 1.37 1.81 2.37 3.29	78 6.66 4.36 3.52 4.31 4.82 7.12	1937 1955 1938 1944	78 0.17 0.04 0.05 0.07 0.28 0.50	1944 1894 1915 1898 1924 1889	17 2.03 1.32 1.65 2.73 2.13 1.94	1956 1951 1957 1954 1953 1947	30 16.0 11.4 10.8 6.6 0.9	78 66.6 32.9 34.5 31.2 13.7	1937 1938 1955 1950 1954	17 20.3 13.2 14.9 9.5 8.5	1956 1951 1956 1956 1954	87 8 83 8	3 80 2 73 8 68 4 60	85 9.5 81 9.3 7410.0	*	40 34 37 41	N. NW NE NW NW	1946 1949 1950 1946 1947 1953			7 17 9 4 8 4 9 6 8 5 6 7 4 7	18 16 16 17 18 19	14 10 9 9	20 1 13 10 8 5	7 17 0 1 0 1 * 2 1 1 2 3 5 5	0	27 24 16	31 28 30 24 13 2
67.8 74.5 71.9 62.5 50.1 33.2 20.4	52.6 50.9 43.5 33.1	57.2 63.6 61.4 53.0 41.6 26.2 12.2	104 96 89 83 69	1936 1949 1921 1943 1903 1941	35 31 17 4 -22		90 140 370 740 1170 1680	3.26 3.18 3.34 2.52 2.17 1.46	9.21 6.77 8.34 7.80 5.65	1887 1900 1941 1931	0.74 0.35 0.77 0.21 0.13 0.02	1953 1921 1940 1947 1916	1	1944 1958 1941 1950 1948 1948	1.0 9.6 12.5	.0 0.3 18.5 43.2 37.6	1942 1880 1940 1956	6.4 13.5 12.2	1956- 1954 1950 1947	94 9 92 9 89 9	5 63 4 66 1 64 8 73	69 8.3 72 7.8 79 8.6 79 9.2 81 9.6 84 9.5	H H H	38 34 38 42 45 42	NA A A NA	1948 1950 1943 1945 1946 1943			5 11 5 10 4 7 7 6 3 5 7	15 16 19 18 18 22 1 20	13 11 11 13	0 0 * 1 8 12	5 4 6 6 3 5 1 5 • 3 0 1	4 * 5 0 5 0 3 0 1 0	0 0 * 1 12 24	0 * 7 16 26 31
	26.4		1	JULY	+	JAN	10640		9.21	JULY 1887	0.02	DEC 1888	2.75	AUG 1958	68.8	66.6	JAN 1937	20.3	JAN 1956	89 9	67	75 9.2	w	45	HA	NOV 1946		٠,	75 76	5 214	139	58 2	23 37	(1)	106	208

The airport is located just west of Fort William and 5 miles west of Lake Superior in locally flat country. Prior to 1942 the observing station was located near the waterfront in Port Arthur.

NORMALS, MEANS, AND EXTREMES

Latitude 46° 47' N Longitude 92° 06' W Elevation (ground) 1162 Feet

DULUTH (CITY) MINN.

		3	Temp	erature			P.			1000		1043	Precipi	ation	3.5					Rel	ative	2/	3	Win	ıd	2 PG 1545 -	shine	3/		10	Mear	num	ber c	f days	
-2.	Nor	rmal		Ext	reme	a 1/	ap ser	7	1/	- 105	1/	9.4	1/		W11	Snor	w, Sleet		1/	CST	CST	3.	/ 3/	Fa	stest :	mile	ang.	cover	1 1	rise o 3	14	6/03	/ 3/	Tem	perature
Dadly	Deily	minimum	Monthly	Record highest Year	Record	Year	Normal deg	Normal tota	Maximum monthly	Year	Minimum monthly	Year	Maximum in 24 hrs.	Year	Mean total	Maximum monthly	Year	Maximum in 24 hrs.	Year	6:30 A.M.	:30 P.M.	P. H.	Prevailing	Speed	Direction	Oer	Pct of possible	Mean sky cor sunrise to sun		doudy loudy	Precipitation	Show, Sleet 10 inch or mo Thunderstorm	Heavy fog	Marg	and below
18. 22. 32. 46.8 59.0	7 1. 2 4. 7 16. 8 29. 0 39.	.9 10 .3 13 .4 24 .7 36	(b) 0.3 3.3 4.6 8.3 9.3 8.7	55 1942 56 1931 81 1946 88 1952 95 1939 97 1910	-3: -2:	1935 1936 1913 1954 1954 1907	1252 801 487	1.02 1.54 2.21 2.95	54 3.48 4.24 4.97 4.57 7.12 8.75	1916 1922 1917 1948 1944 1905	54 .18 .27 .30 .48 .64	1912 1930 1926 1948	54 0.98 1.08 2.04 2.41 2.56 2.78	1922 1917 1954 1944	11.4	34.4 48.2 19.1 6.2	1922	54 10.5 10.9 21.0 9.1 5.0	1917 1933	90 89 85 77 75	25 3 79 8 76 8 69 7 62 6	17 46 14 13. 10 13. 13 13. 15 13. 10 11.	46 4 NW 5 NW 8 NE 6 NE 0 NF	31 65 63 75	282282	1941	39 46 55 60 59 58	46 6.0 5.5 5.6 5.5	46 4 10 10 10 10	6 46 8 13 7 11 9 12 9 11 0 12	54 10 8 10 9		5 46	0	7 31 1 3 28 1 5 29 2 19
75.8 74.1 64.9 53.1 35.4 22.1	1 55. 9 47. 5 36. 4 21.	5 64 3 56 8 49	5.8 4.8 5.1 5.2 8.6 5.0	106 1936 97 1930 92 1931 85 1953 70 1904 56 1939	36 25 -18	1953 1941 1926 1951 1919 1917	66 91 277 614 1092 1550	3.31 3.19 3.05 1.96 1.67 1.00	10.83 9.04 7.72 5.40 3.89 3.02	1909 1953 1905 1946 1931 1950	.63 1 .29 1 .27 1 .23 1 .09 1	1930	5.35 3.38 4.10 2.33 1.93 1.80	1939 1955 1950#		1.5 14.0 28.7	1908 1933 1919 1950	.0 1.5 11.5 9.5 23.0	1908 1933 1949 1950	84 87 85 87	63 7 67 7 66 7	9 13.	5 NE 6 NE 6 NE 4 NW	54 68 60 59 63 72	NW NW NW NW	1949 1934 1924 1918 1940 1946	63 54 46 36	5.0 5.4 5.9 6.8	12 1	2 7	11	0 7 0 6 * 3 * 1 2 * 3	. -	1 0 1 1 0 1 1 0 1 1 0 1 1 1 0 1 1 1 1 1	0 0 0 0 0 1 1 10 1 25 4 30
47.9	9 30.	4 39	9.2	JULY 106 1936	-38	JAN 1935	9574	26.63	10.83	JULY 1909	.07	DEC 1905	5.35	JULY 1909	56.2		MAR 1917	23.0	DEC 1950	84	69.7	4 12.	5 NE	75	NW	MAR			1616	97.61		16 30			3177 4

- (a) Length of Record, years.

 (b) Normal values are based on the period 1921-1990, and are means adjusted to represent observations taken at the present standard location.

 (c) No wind data available.

 (d) No wind data available.

 (e) Insufficient data available.

 (f) Means and extremes are from the existing location. Extremes listed may have been exceeded at prior locations.

 1 Data covers period 1904-1957 incl.

 2 Relative Bunddity observations to airport in June 1941

 6:30 a.m. and 6:30 p.m. data cover period 1904-1940.

 12:30 p.m. data covers period 1916-1940.

 3 Data covers period 1904-1949.

 4 Data covers period 1904-1949.

 5 Data covers period 1905-1949.

- T Trace, an amount too small to measure

- + Also on earlier dates, months, or years # And also in earlier months or years.
- Sky cover is expressed in a range of 0 for no clouds or obscuring phenomena to 10 for one to the cover. The number of clear days is based on cloudi-ness 0.3 templets of the cover on 4.7 tenths; and cloudy days on 8.10 tenths. For United States stations on 4.7 tenths; and cloudy days on 8.10 from sunrise to sunset; for Canadian stations on average clouditions at 1350 E.S.T.

Monthly degree day totals are the sums of the negative departures of average daily temperatures from $65^{\circ}\mathrm{F}_{\cdot}$

NOTES: Unless otherwise indicated, dimensional units used are: temperature in degrees F; precipitation and snowfall in inches; wind movement in miles per hour; and rolative hundlity in percent.

Heavy fog also includes data referred to at various times in the past as "dense" or "thick". The upper visibility limit for heavy fog is 1/4 mile.

Below zero temperatures are preceded by a minus sign.

GREAT LAKES SMALL CRAFT, GALE, AND WHOLE GALE WARNING DISPLAY STATIONS

			Type
Station	Latitude	Longitude	Display*
하다 요즘 중요한 것이 말하는 것이 없는 것이 하다는 것이다. 기가 하는 것이 나무를 가지 않는 것이 없는 것이 없는 것이 없는 것이 되었다. 이 사람들은 것이 되었다.	The same of the sa	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	ahaaa0
BUFFALO, N. Y Supervising Office			
Oswego (Fort Ontario), N. Y.	43°27.9'	76°30.6'	D&N
Clayton, N. Y.	44 14.3	76 05.3	D
Sodus Point, N. Y.	43 16.0	76 59.6	D&N
Sodus Bay (Leroy Island), N. Y.	43 15.7	76 56.6	D
Books day (Lefty Island), N. 1.	43 15.4	77 36.2	D&N
Rochester LBSTA, N. Y. (CG)	43 15.8	79 03.9	D&N
Niagara LBSTA, N. Y. (CG)	42 52.6	78 53.2	D&N
Buffalo LBSTA, N. Y. (CG)	42 49.9	78 51.7	D&N
Lackawanna, N. Y.	42 29.0	79 20.5	D&N
Dunkirk, N. Y.	42 23.0		223 E T
ERIE, PENN Supervising Office	40.00 2	90 0E E	D&N
Erie Public Dock, Penn.	42 08.3	80 05.5	D&N
[2] (1) (1) (1) (1) (1) (1) (1) (1) (1) (1)			
CLEVELAND, OHIO - Supervising Office		00 00 0	er balance
Conneaut, Ohio	41 58.1	80 33.2	$\tilde{\mathbf{D}}$
Ashtabula LBSTA, Ohio (CG)	41 54.1	80 48.1	D
Fairport LBSTA, Ohio (CG)	41 45.6	81 16.9	D
Mentor Harbor Yachting Club, Ohio	41 43.6	81 21.2	D
Willoughby (Chagrin Lagoons Yacht Club), Oh	io 41 40.6	81 26.3	D
Cleveland (Northeast Yacht Club), Ohio	41 34.4	81 35.1	D
Cleveland (Lakeside Yacht Club), Ohio	41 31.6	81 39.9	D
Cleverand (Lakeside lacit Club), Onio	41 30.2	81 42.7	D&N
Cleveland LBSTA, Ohio (CG)	41 29.2	81 50.1	D
Rocky River (Cleveland Yacht Club), Ohio	41 28.3	82 10.7	D&N
Lorain LBSTA, Ohio (CG)	41 20.0		
SANDUSKY, OHIO - Supervising Office		00 01 5	D
Vermilion, Ohio	41 25.6	82 21.5	
Huron, Ohio	41 24.1	83 32.9	D&N
Sandusky (WB City), Ohio	41 27.4	82 42.9	D&N
Sandusky Boat Works, Ohio	41 27.4	82 41.9	D
Sandusky (Meigs Street), Ohio	41 27.6	82 42.1	D
Marblehead LBSTA, Ohio (CG)	41 32.2	82 42.7	D&N
Kelleys Island, Ohio	41 35.6	82 42.7	D
Put-in-Bay, Ohio	41 39.3	82 49.1	D
Catawba Cliffs Beach, Ohio	41 35.3	82 50.5	D
	41 31.2	82 56.2	D
Port Clinton, Ohio			
To The Oute			
TOLEDO, OHIO - Supervising Office	41 41.6	83 28.3	D
Toledo Coast Guard Depot, Ohio (CG)	41 43.7	83 28.0	$\tilde{\mathbf{D}}$
Toledo (Ottawa River), Ohio			rogezátő,
AND AND THE CONTRACT OF THE PARTY OF THE PAR			
DETROIT, MICH Supervising Office	41 50 9	02 02 N	\mathbf{D}
Monroe, Mich.	41 52.3	83 23.0	
Rockwood, Mich.	42 02.2	83 12.0	Decree
Gibralter, Mich.	42 05.3	83 11.4	D
Detroit Boat Club, Mich.	42 20.5	82 59.7	D
Belle Isle LBSTA, Mich. (CG)	42 20.4	82 57.7	D&N
Grosse Pointe (Crescent Sail Yacht Club), Mi	ich. 42 24.1	82 53.1	D
Grosse Pointe Farms Municipal Pier, Mich.	42 24.4	82 53.2	D
Jefferson Beach Marina, Mich.	42 26.0	82 52.5	D
	42 38.5	82 46.7	D
New Baltimore, Mich.	42 36.2	82 47.3	D
Mount Clemens (Romicks Boatyard), Mich.	42 36.1	82 46.8	i gransky p o blyk a si
Mount Clemens, Mich.		82 48.7	Ď
Selfridge Air Force Base, Mich.	42 36.6		
Port Huron LBSTA, Mich. (CG)	43 00.4	82 25.4	Agoan D io
Port Sanilac, Mich.	43 25.9	82 32.4	D
Harbor Beach LBSTA, Mich. (CG)	43 51.0	82 38.6	D
Bay City, Mich.	43 38.5	83 50.8	D
Saginaw, Mich.	43 26.0	83 56.5	D
이 등 어디, 하지 않는 생생님들이 들어 되었다. 그는 아이를 하는 것이 되었다. 그는 사람들이 되었다. 그는 그는 그는 그는 그는 그를 하는 것이 없다.			

GREAT LAKES SMALL CRAFT, GALE AND WHOLE GALE WARNING DISPLAY STATIONS

<u>Station</u>	<u>Latitude</u>	Longitude	Type Display*
ALPENA, MICH Supervising Office			
Oscoda, Mich.	44°25.0'	83°19.0'	D
Tawas IBSTA, Mich. (CG)	44 15.0		D&N
East Tawas, Mich.	44 16.7		D
Thunder Bay Island LTSTA, Mich. (CG)	45 02.2	83 11.7	D
Alpena (WB City), Mich.	45 03.8	83 25.8	D
SAULT STE. MARIE - Supervising Office			
Detour, Mich.	45 59.4	83 54.0	D&N
St. Ignace, Mich.	45 52.0	84 43.0	D
Mackinac Island LBSTA, Mich. (CG)	45 51.1	84 37.1	D&N
Mackinaw City, Mich.	45 47.1	84 43.4	D&N
Beaver Island LBSTA, Mich. (CG) Harbor Springs, Mich.	45 44.6	85 30.2	D
Charlevoix LBSTA, Mich. (CG)	45 25.7 45 19.1	84 59.3	D
Whitefish Point LTSTA, Mich. (CG)	46 46.3	85 15.7 84 57.4	D Dont
Grand Marais LBSTA, Mich. (CG)	46 40.6	85 58.0	D&N D
MUSKEGON, MICH Supervising Office			
Northport, Mich.	45 07.8	85 36.7	D&N
Leland, Mich.	45 01.4	85 45.7	D
Frankfort LBSTA, Mich. (CG)	44 37.8	86 14.7	D&N
Manistee LBSTA, Mich. (CG)	44 15.0	86 20.4	D
Ludington LBSTA, Mich. (CG)	43 57.2	86 27.7	D
Pentwater Moorings, Mich. (CG)	43 46.9	86 26.5	D&N
Muskegon LBSTA, Mich. (CG)	43 13.7	86 20.4	D&N
Grand Haven LBSTA, Mich. (CG)	43 03.6	86 14.9	D&N
CHICAGO, ILL Supervising Office			
Holland CG Moorings, Mich. (CG)	42 46.4	86 12.5	D
Saugatuck, Mich.	42 39.0	86 12.0	$ar{ extbf{D}}$
South Haven LBSTA, Mich. (CG)	42 24.2	86 17.0	D
St. Joseph LBSTA, Mich. (CG)	42 06.8	86 29.1	D
New Buffalo, Mich.	41 48.1	86 44.9	D
Michigan City LBSTA, Ind. (CG)	41 43.4	86 54.1	D
Gary Marquette Park, Ind.	41 37.4	87 13.6	D
Gary (Miller), Ind.	41 37.2	87 15.9	D
Gary Steel Works, Ind. Gary Buffington Harbor, Ind.	41 37.4	87 19.6	D
Chicago LBSTA, Ill. (CG)	41 38.7	87 24.7	D
South Chicago LBSTA, III. (CG)	41 53.3	87 36.6	D
Jackson Park LBSTA, III. (CG)	41 43.1 41 46.7	87 31.5	D
Chicago Yacht Club (Monroe Street), Ill.	41 52.9	87 34.5 87 36.9	D
Chicago Yacht Club (Belmont Harbor), Ill.	41 55.4	87 38.2	D D
Wilmette Harbor LBSTA, Ill. (CG)	42 04.7	87 41.0	D
MILWAUKEE, WIS Supervising Office			
Waukegan, Ill.	42 21.7	87 49.3	D&N
Racine LBSTA, Wis. (CG)	42 44.1	87 46.2	D&N
Milwaukee, Wis.	43 01.5	87 54.1	D&N
Sheboygan LBSTA, Wis. (CG)	43 45.0	87 42.2	D&N
GREEN BAY, WIS Supervising Office			
Ephraim, Wis.	45 09.4	87 10.0	D&N
- 1 - 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	ropezagá Talábk	apiti kalasati	n guyaak (di)
MARQUETTE, MICH Supervising Office			
Marquette LBSTA, Mich. (CG)	46 32.8	87 22.5	D
Ontonogan LTSTA, Mich. (CG)	46 52.5	89 19.3	D
사는 동생 아이들은 사람들이 나는 것이 되었다면 하면 어떻게 되었다. 그 사람들은 바다에 가지 않는데 나는 사람들이 가지 않는데 하는데 하는데 함께 가지 않는데			

GREAT LAKES SMALL CRAFT, GALE AND WHOLE GALE WARNING DISPLAY STATIONS

Station	Latitude	Longitude	Type <u>Display</u> *
DULUTH, MINN Supervising Office Black River Park, Mich. Ashland, Wis. Superior, Wis. Duluth Yacht Basin, Minn. Two Harbors, Minn. North Superior LBSTA, Minn. (CG)	46°40.0°	90°02.8°	D
	46 35.5	90 53.1	D&N
	46 42.2	92 01.4	D&N
	46 46.5	92 05.5	D&N
	47 00.8	91 40.5	D&N
	47 44.8	90 20.1	D&N

^{*} D Day Displays D&N Day and Night Displays

Note:

Stations listed from east to west following the Great Lakes Coastline. Displays are made during the Great Lakes Navigation Season.

(CG) Coast Guard