EASTERN REGION TECHNICAL ATTACHMENT
NO 94-4A
APRIL 1994

A STUDY OF THIRTY YEARS OF THUNDERSTORMS AT BUFFALO, NEW YORK

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1. INTRODUCTION

It is widely perceived that thunderstorms most often occur during the late afternoon and evening in the Northeastern United States. However, Buffalo, NY residents may differ with that assumption as sleep is often interrupted by overnight thunderstorms.

Does Buffalo really have a climatic anomaly for the Northeast and have more nocturnal thunderstorms than the late afternoon-early evening peak so notable elsewhere (Kessler 1986)? The purpose of this study was to analyze the diurnal distribution of thunderstorms at Buffalo, for the 30 year period of 1961-90. This period coincides with the long-term averages currently in use for all major climatological parameters. In addition, thunderstorms associated with snow as well as those reaching severe criteria were also tabulated and studied.

2. METHODOLOGY

Thunderstorm data is available on the monthly Local Climatological Data Summaries (LCDs) for Buffalo, NY in the category of "Days with thunderstorms". For the 30 year period of study, Buffalo had thunderstorms on 950 days, which yielded an average of 31.7 days per year (Table 1). Data concerning the actual number of thunderstorms is not tabulated in the LCD's. Therefore, a detailed study of the daily weather observation sheets archived at WSFO Buffalo, for this 30 year period was undertaken to determine the actual times of occurrence for all thunderstorms. While collecting these data, it soon became apparent that a possible discrepancy existed, which could lead to a double-count of some thunderstorms. Specifically, a number of thunderstorms that were recorded as starting at exactly midnight LST (0000 LST) on a given day, were actually continuations of storms which began before midnight the previous day and were therefore listed twice. For the purposes of this study, it was assumed that any thunderstorm which started within 2 hours prior to midnight, and was followed by a recorded midnight start on the following day was the same storm. The 0000 LST storm was then dropped from the data sample as it was already counted on the previous day. For example, if a thunderstorm was shown to have begun at 0000 LST on June 15, and another thunderstorm was listed to have started at 2235 LST on June 14, then it was considered the same storm and was dropped. However, if the first thunderstorm had begun at 1930 LST, the two storms would be considered to be separate and both would be counted. By use of this method, a total of 56 thunderstorms were found to have a 0000 LST starting time. Consequently, 44 of these storms were dropped, leaving only 12 to be added to the data sample. Thunderstorms with snow, and severe thunderstorms were also tabulated (Table 2).

3. RESULTS

A total of 1153 thunderstorms were tabulated for the 30 year period yielding an average of 38.4 per year(Table 2). Six hundred and seventy one storms, or 59% of the total, occurred during the 3 summer months of June, July, and August, with a slight maximum evident in August. September and May followed, with over 100 storms in each month. The frequency of storm occurrence lowered substantially in October, dropping to just 34 during the 3 month winter season of December through February.

a. Diurnal Distribution

The thunderstorm frequency at Buffalo clearly exhibited a double-diurnal maximum (Fig.1). As expected, there is a late afternoon-early evening peak, with a maximum of 65 storms occurring between 1600 and 1700 LST. Figure 1 also shows that there is a distinct maximum of thunderstorm occurrence shortly after midnight, with 130 storms occurring between midnight and 0200 LST. The frequency of occurrence dropped off considerably during the morning hours, reaching a minimum of 30 storms between 1100 and 1200 LST. There was no distinct seasonality with these starting times (Figs. 2 and 3), except for a slight tendency for more afternoon/evening storms in May and June, and more nocturnal storms in August (Table 2).

b. Snow Thunderstorms

Thunderstorm climatology (Kessler 1986) has shown that it is fairly unusual to have thunder associated with snow, but the results of this study show a different scenario for Buffalo, New York. Thunderstorms were observed with snow on 43 occasions during the 30 year period of study at Buffalo. This yields an average of about three occurrences every 2 years. Nearly all of these cases involved Lake Effect snow, with its associated extreme convection. Nineteen of these cases occurred in November, with 10 more occurring in December, the peak of the Lake Effect season in Buffalo.

c. Severe Thunderstorms

All 1153 thunderstorms that occurred in the 30 year period of study were analyzed for severe (T+) characteristics (i.e., wind gusts of 58 mph or higher, and hail 3/4 inch in diameter or greater). Interestingly, only 12 thunderstorms obtained this criteria, seven of which occurred during the 3 summer months. All 12 cases involved reports of high winds. Severe criteria hail was never recorded at Buffalo during the 30 year study period.

4. DISCUSSION/CONCLUSION

Results of this study indicate that there is a high frequency of overnight thunderstorms in Buffalo, NY. There are several possible explanations for this seemingly unusual phenomenon. Local radar observations and

GOES satellite imagery illustrate the strong stabilizing effect downwind from the prevailing southwest wind off the cool Lake Erie waters during the spring and early summer, with the associated suppression of convective activity in the immediate Buffalo area. Showers and thunderstorms often develop along the lake-breeze convergence boundaries located to the north, east, and southeast of Buffalo by early afternoon. However, as is often the case with lake-sea breeze convection, the activity usually dissipates shortly after sunset without affecting the immediate Buffalo area (Stout and Wilk 1962). This stabilizing effect is a factor in the relative infrequency of severe weather at Buffalo (Grazulis 1993).

Radar observations and climatological records also indicate a higher frequency of late-afternoon thunderstorm activity upstream from western New York over lower Michigan and southern Ontario (Kessler 1986). This activity often remains quasi-stationary to the west of Buffalo during the afternoon and is inhibited from moving eastward by the cool lake breezes. During the evening as the onshore lake breeze circulation weakens, the activity has been observed by Buffalo network weather radar to move eastward into the Buffalo area.

Conversely, Lake Erie can enhance convection and associated thunderstorm activity in autumn and early winter when it is substantially warmer than the surrounding air masses (Mundschenk 1993). This instability is also reflected in the relatively high frequency of thunderstorms associated with snow at Buffalo (Kessler 1986; Moore and Orville 1990). The Lake can also enhance overnight thunderstorms late in summer, when the surface water temperature typically reaches 73°F or higher (Fig. 4). In these cases, sensible heat and moisture from the lake can act to intensify existing thunderstorms as they move along the north shore of Lake Erie into the Buffalo area. The slight increase in nocturnal thunderstorms late in summer (August) is in agreement with this hypothesis. These conditions do not occur earlier in the season as Lake Erie is much cooler, attributing to the fewer number of overnight thunderstorms, and the corresponding slight afternoon peak in spring (Fig. 2).

Finally, mesoscale convective systems (MCS) reach their northernmost extent in July and August, often affecting the northern Plains and upper Great Lakes states(Kessler 1986). Several of these systems can be expected move southeast across western New York from the upper Great Lakes region during the average year. These systems are almost always nocturnal (Maddox 1980; Fritch 1988).

Buffalo's nocturnal maximum is also common to a more "marine-type" climate. Radiational cooling at the top of the clouds typically produces steeper lapse rates and a corresponding increase of instability at night (Kessler 1986). Lake Erie, and to a lesser degree all of the Great Lakes, are located upwind from most of Buffalo's weather and add a definite marine influence to its climate. This effect destabilizes the atmosphere from late summer into early winter when the lake temperature is warmer than the average air temperature (Fig. 4), but serves to stabilize conditions in spring and early summer when the opposite is true (Niziol 1987).

Similar climatological studies of thunderstorms on Lake Michigan (Stout and

Wilk 1962) concluded that summertime airmass convective storms are definitely suppressed by the Lake. Satellite studies (Parmenter 1976) have also shown similar suppression of organized convection downwind of the Great Lakes during spring and early summer. Studies of thunderstorms for cities at approximately the same longitude as Buffalo would serve to confirm or rebut the premise of the direct effect of Lake Erie on Buffalo thunderstorms. Studies for Pittsburgh, Rochester and Toronto would be most helpful. In addition, the frequency of severe thunderstorms, and thunderstorms with snow, for these cities would be most interesting for comparative purposes.

ACKNOWLEDGMENTS

The author wishes to thank Tom Niziol of WSFO Buffalo, and Stephan Kuhl of Eastern Region Headquarters, Scientific Services Division, for their helpful suggestions and review of this paper.

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Table 1. Annual frequency of thunderstorms at Buffalo, New York

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1961			2	1	2	5	8	11	2	1			32
1962		1	1	1	4	7	7	10	4	3			38
1963			2	4	2	4	5	5	2		1		25
1964			4	1	4	3	6	6	3	2	1		30
1965				3	3	4	4	8	3	3	5		33
1966			2		1	6	6	5	5	4	4	1	34
1967		1		5	1	3	7	7	2	2	2	2	32
1968			2	2	3	6	3	11	7	4		1	39
1969	2			1	2	7	8	4	3		1		28
1970				2	7	5	7	6	6	4		4	41
1971		2		1		13	6	9		1	4		36
1972				2	6	4	2	7	2		1		24
1973			2	3	3	5	5	7	3	4	2	2	36
1974				4	2	7	5	3	3	1	4		29
1975	1			2	5	5	7	10		1	1	1	33
1976		1	4	4	1	8	8	4	3	1			34
1977			3	2	1	6	7	7	7	1	2	1	37
1978				1	1	3	2	4	6	2			19
1979			1	1	1	4	3	7	2	2			21
1980				1	2	7	10	7	10	3	1		41
1981				5	2	8	8	7	3				33
1982			2	1	4	3	5	5	3		2		25
1983				3	1	3	5	6	7	2	2	1	30
1984		2	1		2	8	4	10	3	1			31
1985			2	4	6	3	6	7	4		1	1	34
1986			2	2	4	6	8	9	6	1		1	39
1987	1		1	1	1	10	7	2	6	1	2	1	33
1988	2	1	2	2	2	5	6	6	5	4	1		36
1989	1		2		4	6	2	5		1	1		22
1990		1		1	3	4	6	3	4	2	1		25
SUM	7	9	35	60	80	168	173	198	114	51	39	16	950
AVG	0.2	0.3	1.2	2.0	2.7	5.6	5.8	6.6	3.8	1.7	1.3	0.5	31.7

Table 2. Diurnal frequency of thunderstorms at Buffalo, New York.

HOUR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOT	SNW	SVR
00		2*	5	4	7	12	9	17	9		1*	1	67	2	
01	2**		3	4*	7+	11	9	13+	9	2	3*		63	4	2
02		1*		4	1	8	10	15	5	2	2*		48	2	
03			2*	2	2	9	9	9	1	3			37	1	
04	1+	1*	4	4	2	4	11	9	5	1	2*		44	2	1
05				8	1	12	10	7	8	4	1*		51	1	
06			1*	3**	2	10	6	12	2	1			37	3	
07			1	3	3	6	9	2	2	4	3	1*	34	1	
08				2	3	8	2	8	3	4		2**	32	2	
09			2	1	2	3	14	6	5	1	1*	1*	36	2	
10			1		2	6	10	3	4	2	4***		32	3	
11	1		1	3	5	8	6	3	2		1		30		
12				4	3	8	11	10	4	1	2	1	44		
13				3	4	5	15	10	6	2	2		47		
14	1*	1	2+	2	5	5	14	12	9	2	2	1*	56	2	1
15		1	2+	1	7	11	9	17+	9	2	2*		61	1	2
16		1	7**	5	8	16	10	8	6	3		1	65	2	
17	2*	1	2	3	2	13	8+	11	9+	5	2*		58	2	2
18			1	3	8	12+	3	14+	6	4	2*	4***	57	4	2
19			1		12	11+	9	13	11	1			58		1
20			1	3	4	13+	7	14	8	2	3**	3*	58	3	1
21				7	4	6	5	9	8	2	1		42		
22		1	2	3	4	8	11	11	3	6	2*	1	52	1	
23				3	2	7	8	11	5	2	4****	2*	44	5	
TOTAL	7	9	38	75	100	212	215	244	139	56	40	18	1153	43	12
AVG	0.2	0.3	1.3	2.5	3.3	7.1	7.2	8.1	4.6	1.9	1.3	0.6	38.4	1.4	0.4
Snow *	4	3	4	3							19	10		43	
Svr +	1		2		1	3	1	3	1						12

* = Thunder occurrence with snow (one each)
+ = Severe thunderstorms (one each)

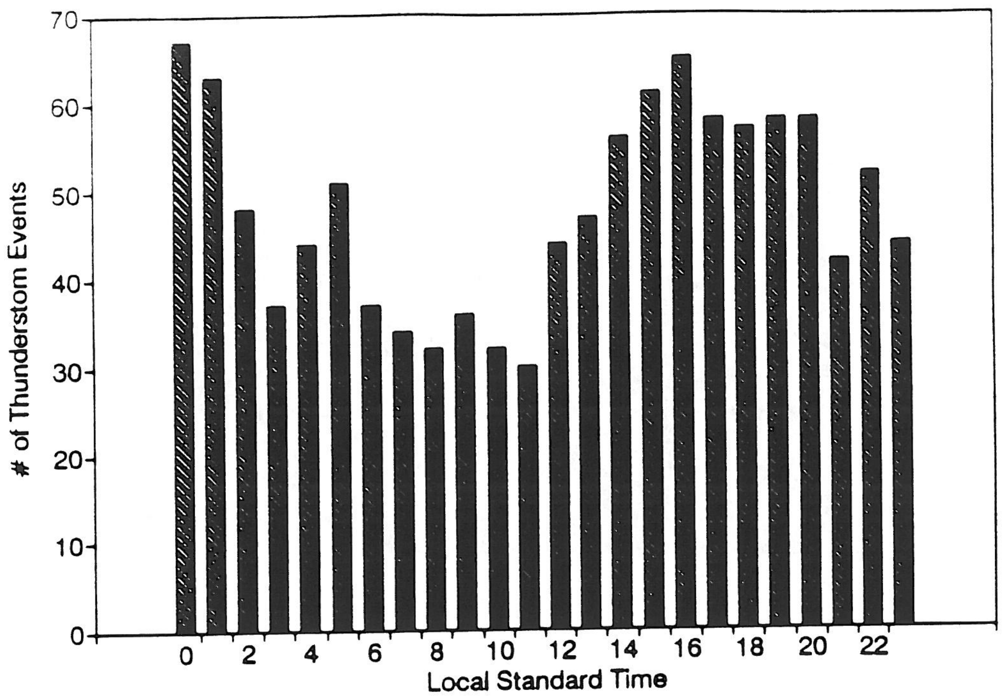
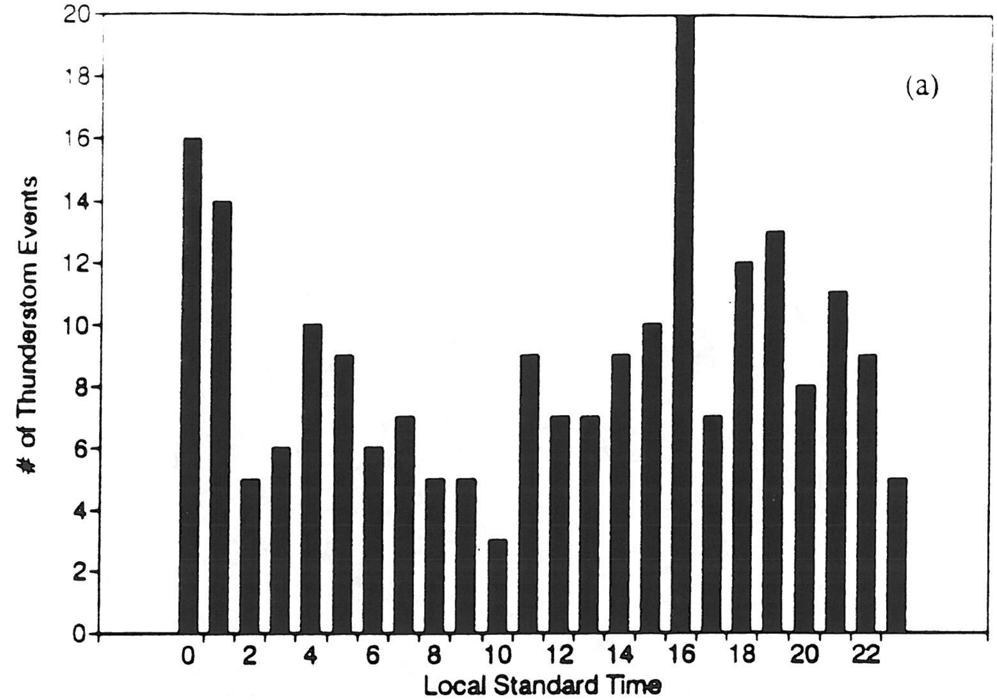


Figure 1. Diurnal distribution of thunderstorms at Buffalo, NY from 1961 to 1990.



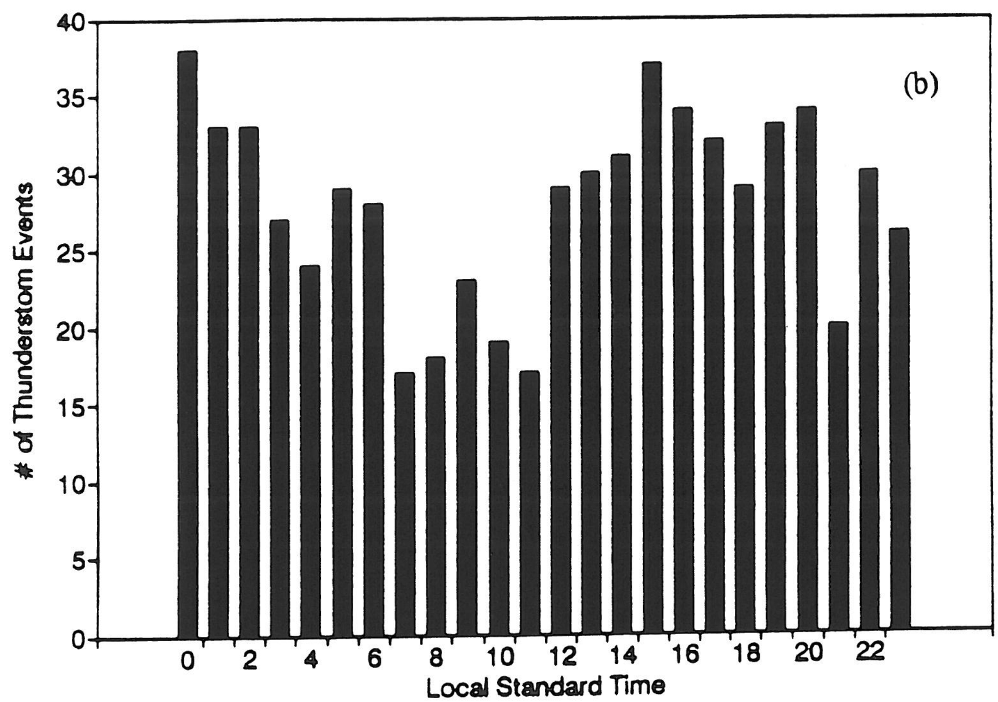
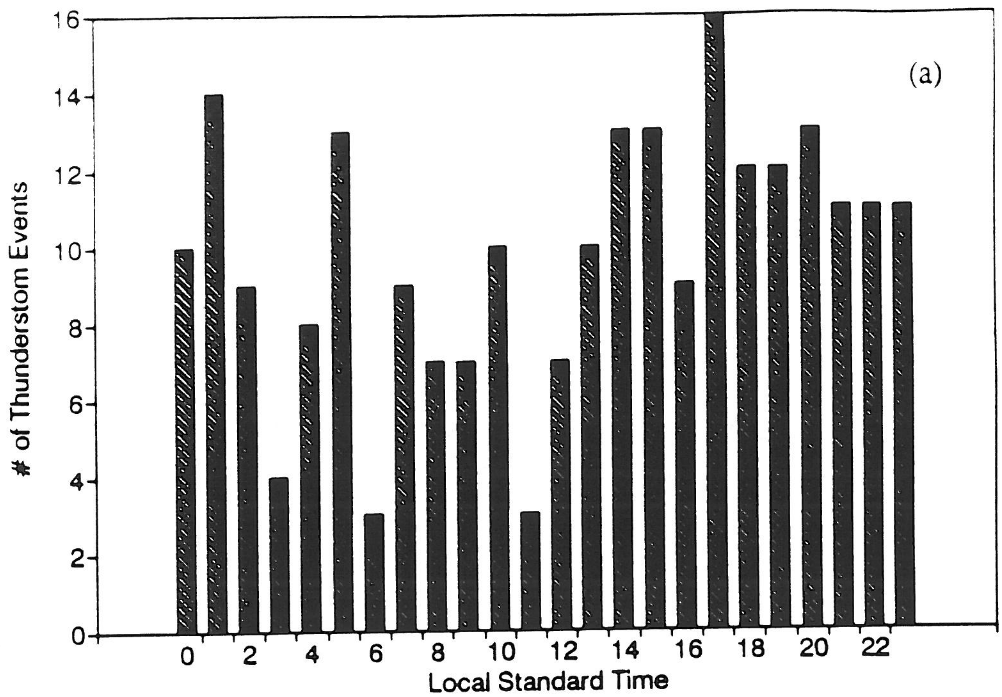


Figure 2. Diurnal distribution of thunderstorms at Buffalo, NY from 1961 to 1990, for the (a) Spring (March-May) and (b) Summer (June-August).



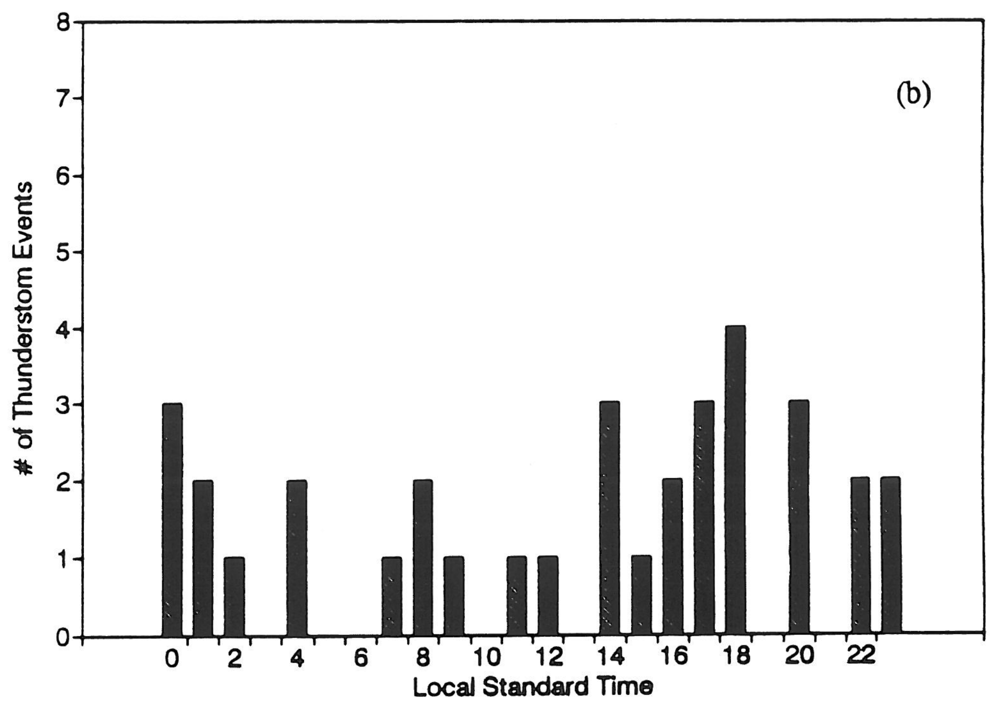


Figure 3. Diurnal distribution of thunderstorms at Buffalo, NY from 1961 to 1990, for the (a) Autumn (September-November) and (b) Winter (December-February).

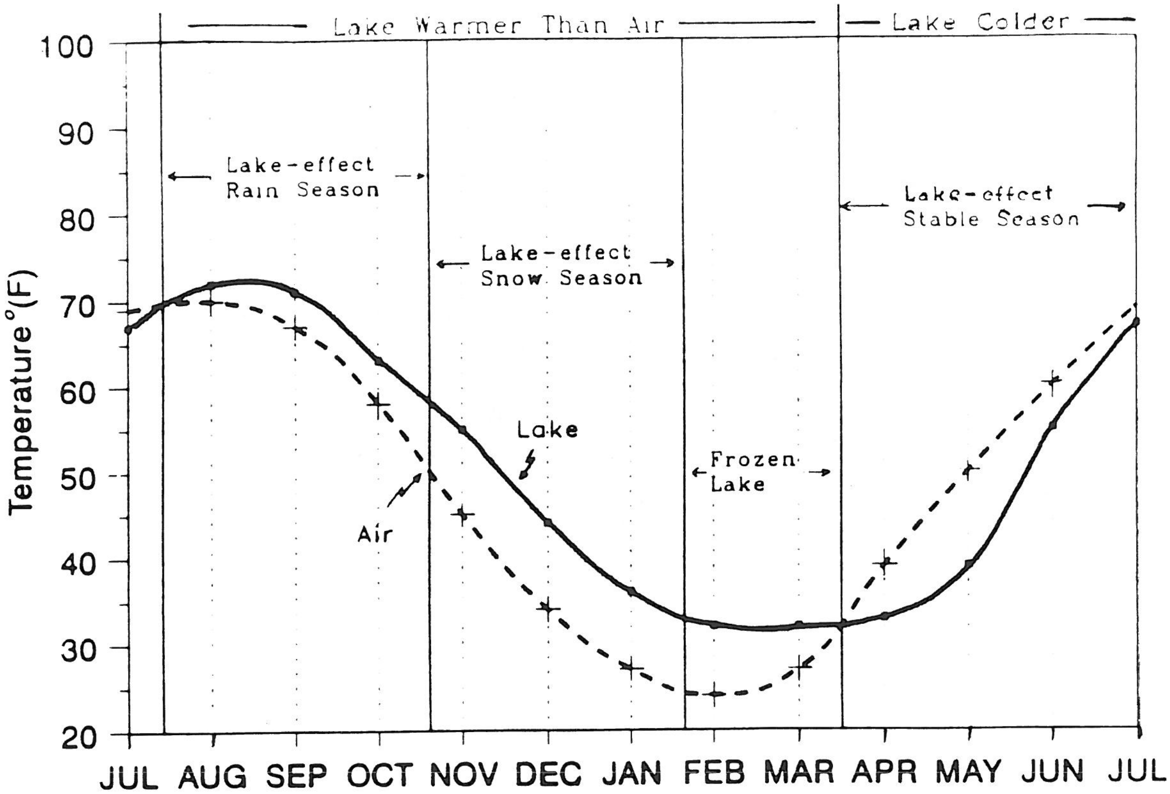


Figure 4. Average land and lake water temperature for Lake Erie at Buffalo, NY. From Niziol, 1987.