

Relationships Between Cyclonic Characteristics and Precipitation in Western Indiana During the Summers of 1953, 1956 and 1957

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An extremely dry summer occurred in southwestern Indiana during 1953. Total rainfall was subnormal in most of the eastern part of the United States. In the latter half of August, 1953, the entire state of Indiana had the least percentage of normal rainfall of any state in the Nation (1). During September, little or no relief was received from the drouth, especially in southwestern Indiana.

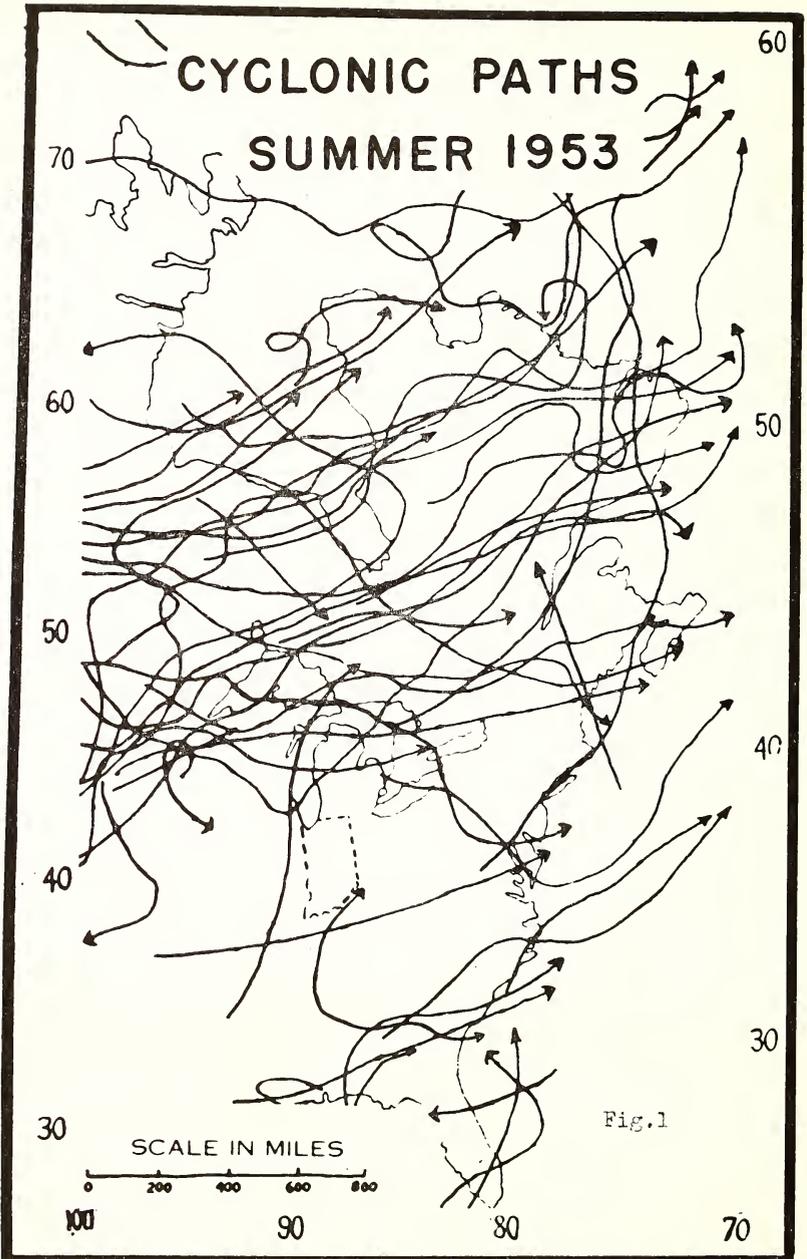
Most areas in Indiana received about the long-term average summer precipitation in 1956. Above normal amounts of precipitation were received in the northern part of the United States with sections of the eastern Great Lakes region receiving twice their normal summer precipitation. In contrast, most of the southern part of the United States received considerably less than the long-term average.

The early summer months of 1957 were the wettest on record in certain parts of Indiana (2). The average rainfall for three stations in Western Indiana (Gary, Terre Haute, and Evansville) was 17.0 inches from June 1 to September 30. This is 21 per cent above the long-term average of the three stations. At the same time, the summer of 1957 was characterized by less than 50 per cent of normal rainfall in various regions of the Atlantic Seaboard (3).

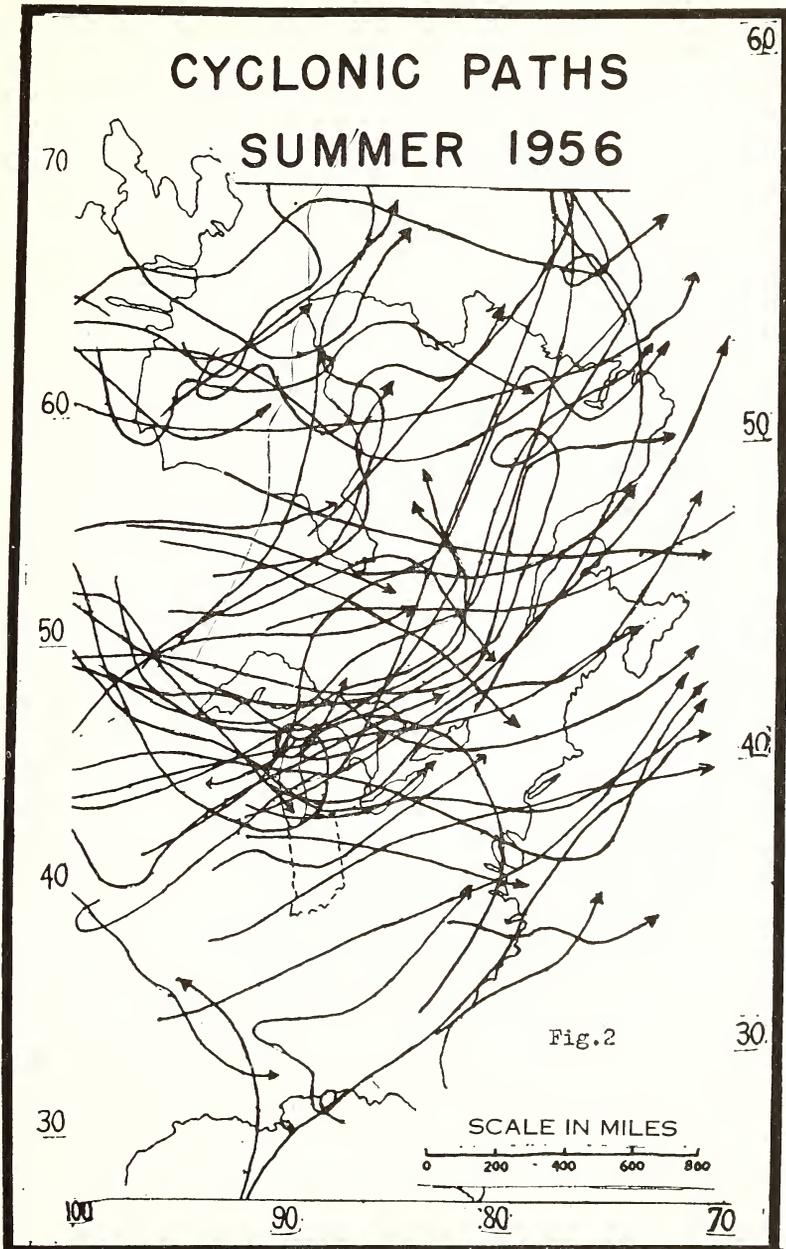
In an attempt to better understand the above contrasting summer precipitations, this study attempts to compare cyclonic characteristics during three recent summers: dry (1953), normal (1956), and wet (1957). A cross section of western Indiana's summer precipitation was gathered by using surface weather data for Gary, Terre Haute, and Evansville. Data were obtained from Daily Synoptic Maps, Monthly Weather Reviews, and Climatological Data for June, July, August, and September during 1953, 1956, and 1957. These data were then analyzed for relationships of cyclonic paths, cyclonic frequencies, precipitation sources, cyclonic velocities, and relative depths of cyclones during the three summers noted.

Cyclonic Paths

Of primary importance in any analysis of cyclonic characteristics are the prevailing paths of cyclones. The main object of this section is to portray the principal paths of cyclones for the three summers noted. Figures 1, 2, and 3 were based upon the maps of the storm tracks published in the Monthly Weather Review and the Synoptic Weather Maps. They include all areas of North America east of 100° West and between 26° North and 62° North. The general procedure was to first plot the paths on a work map. Then the frequencies were obtained by making a grid and placing it over the map and counting the number of cyclones which crossed each grid. The location of each cyclone which

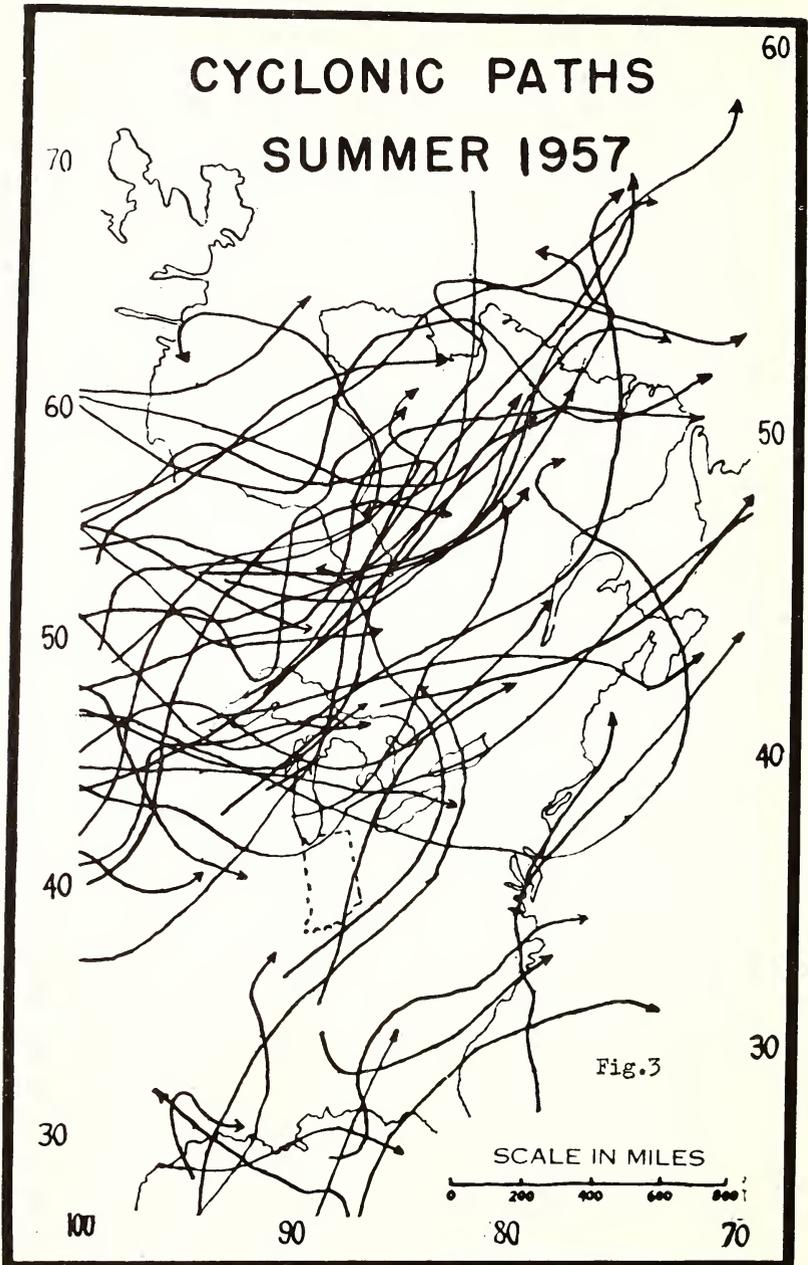


produced any precipitation during the three summers in Gary, Terre Haute or Evansville was pinpointed every six hours in order to calculate the velocity of each precipitation-producing cyclone. In addition, a reading of the barometric pressure was recorded and the mean calculated



since the Daily Synoptic Maps and Monthly Weather Reviews indiscriminately lump together all types and magnitudes of cyclones.

When one examines the Daily Synoptic Maps for the summer of 1953, it can be readily noted that cyclonic activity frequently moved



across the Great Plains, where precipitation was heavy, but then moved northeastward to the Atlantic Seaboard. Upon moving eastward from 100° West, the belt of maximum cyclone frequency moved north of

Indiana. Only one cyclone moved across the unit box in which Indiana is included. The actual path missed the political limits of Indiana by a few miles; therefore, not one cyclone actually crossed Indiana during the summer of 1953 (Fig. 1). This contrasted sharply with the months of June, July, August, and September during 1956 and 1957. However, during the summer of 1953 cyclones were most frequent in Canada at latitudes 46° North to 50° North (Fig. 7). On the other hand, cyclones were present four or five times in most areas along the Gulf Coast where cyclones are normally less frequent in summer (Fig. 4).

The summer of 1956 was characterized by the most frequent cyclonic activity in Indiana (Fig. 2). From June 1 to September 30, six cyclones moved across Indiana. An exceptionally large number of days were characterized by cyclonic precipitation, yet the monthly totals were about normal since most daily totals were generally meager. The approximate 30 per cent of all cyclones which moved eastward across the Great Lakes at from 42° North to 46° North was clearly an important influence responsible for a cool, moist Indiana summer in 1956 (Fig. 7). In fact, it has been noted that the cyclones over the Great Lakes in July of 1956 were more typical of spring than summer months (4). However, east of Indiana the cyclones took a decided turn northward thence northeastward (Fig. 2).

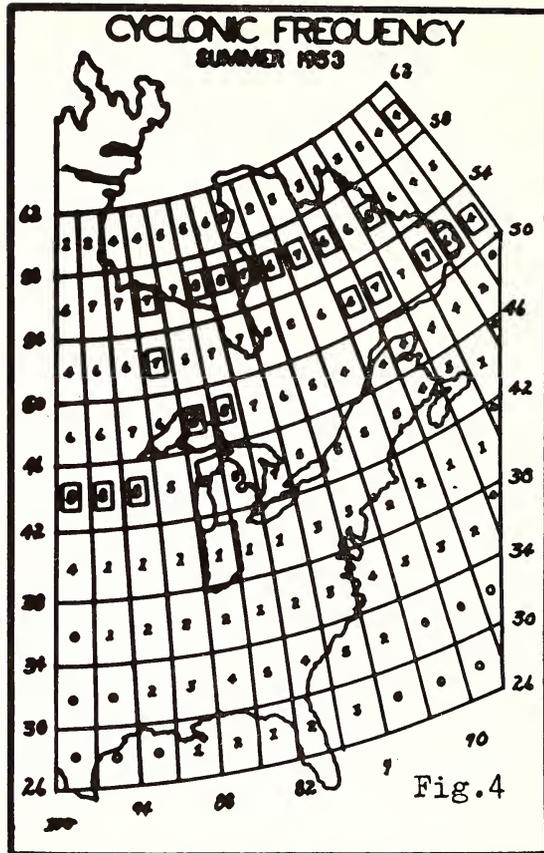
During the summer of 1957, the greatest total number of cyclones moved across eastern North America. June of 1957, in particular, was characterized by the passage of numerous cyclones across latitudes 42° North to 54° North and by abundant cyclonic precipitation which was widespread throughout western Indiana (Fig. 3). During the months of June, July, August, and September of 1957, 20 per cent of all cyclones in eastern North America moved across at latitudes 42° North to 46° North, and more than 50 per cent crossed the 87° West meridian from 42° North to 54° North (Fig. 7).

Cyclonic Frequencies

The number of cyclones crossing unit boxes, which are 4 degrees latitude and 3 degrees longitude in size, was recorded for the three summers. The unit size of the boxes was selected to approximate the extent of Indiana's latitude and longitude. It is recognized that the boxes are not equal area quadrangles, but this tends to reduce the greater cyclone frequency of the higher latitudes rather than exaggerate it.

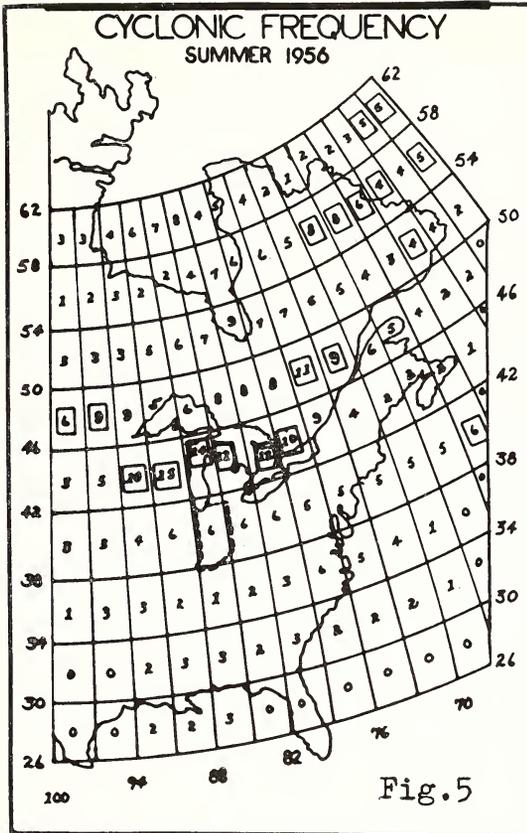
Figures 4, 5, and 6 indicate the number of cyclones which passed through the unit boxes during the three summers. No cyclone was counted more than once within the same box regardless of whether it remained there for a six hour interval or several days. Numbers with a border around them indicate the unit box with the maximum cyclone frequency for each four degrees of latitude. These data, when scrutinized, indicate that in addition to a shift in cyclonic paths, a marked variation in cyclonic frequencies also occurred during the three summers.

In 1953, belts of well-defined maximum cyclonic frequencies were located in boxes from 50° North to 58° North (Fig. 4). All maxima east



of Indiana and in North America, occurred within these latitudes. In 1956 the principal axis of maximum cyclone frequency is the 42° North-46° North unit box at both Indiana's longitude and in eastern North America (Fig. 5). Twenty-one per cent of all cyclones crossing the 87° West Meridian were located within the 42° North-46° North unit box in 1957. However, the latitudinal distribution of 1957 cyclones varied considerably with longitude (Fig. 6). Numerous centers of 1957 maxima cyclonic frequencies vary from the 42° North-46° North unit box to 54° North-58° North unit box. The 1957 chart (Fig. 6) reflects the discontinuous nature and randomness of cyclonic developments during the four summer months of 1957.

Despite several discontinuous axes (Figs. 4, 5, 6, and 7) it is interesting to note that: (1) During the two wettest summers the axes of cyclonic frequencies had their peak within the 42° North-46° North unit box at western Indiana's longitude; (2) All cyclones tended to move northeastward from Indiana each summer with the 54° North-58° North unit box receiving the maximum during each of the three summers in northeastern North America; (3) The total number of cyclones which

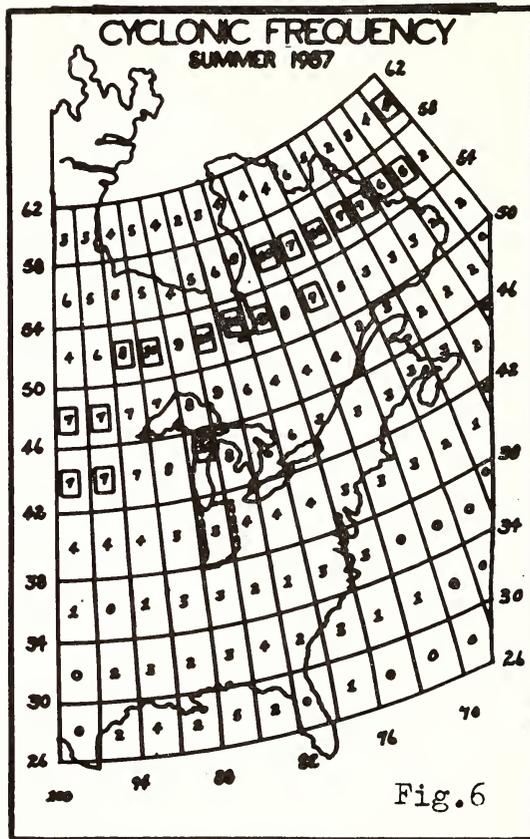


moved across eastern North America increased directly with total amounts of precipitation in western Indiana with 39 in 1953, 48 in 1956, and 49 in 1957; and (4) The frequency of cyclones crossing the 87° West Meridian near Indiana's latitude during the dry summer of 1953 was markedly less than during the two wetter years of 1956 and 1957.

Sources of Precipitation

Standard geography textbooks often state that much or most of the summer precipitation of the Humid Continental Climates (Dfa, Dwa, Dfb, and Dwb) is convective in origin. This study indicated that cyclonic precipitation (together with associated frontal and squall line precipitation) was clearly the dominant source of summer precipitation during all three summers in Western Indiana. Ninety-two per cent of all precipitation during the wettest summer, 93 per cent in 1956, and 98 per cent during the dry summer of 1953 were cyclonic in origin.

This conclusion is based upon the use of Daily Synoptic Charts and Climatological Data. By using the main weather map and the two smaller maps for all days from June 1 to September 30 of the three



years, a relatively continuous weather record was assembled. By combining the three weather maps, a sequence of summer precipitation was

TABLE I
AMOUNT AND SOURCE OF PRECIPITATION

	1953 Cyclonic		
	Gary	Terre Haute	Evansville
June	2.84	4.45	.98
July	2.64	4.27	2.05
August	3.28	1.19	.26
September	1.90	.77	.70
Total	10.66	10.68	3.99
	1956 Cyclonic		
	Gary	Terre Haute	Evansville
June	2.40	3.42	1.60
July	3.28	1.11	2.14
August	2.73	2.67	1.03
September	.77	1.65	3.61
Total	9.18	8.85	8.38

**LATITUDINAL PERCENTAGE OF CYCLONES
CROSSING THE 87°W MERIDIAN
JUNE 1 - SEPT. 30, 1953, 1956, 1957**

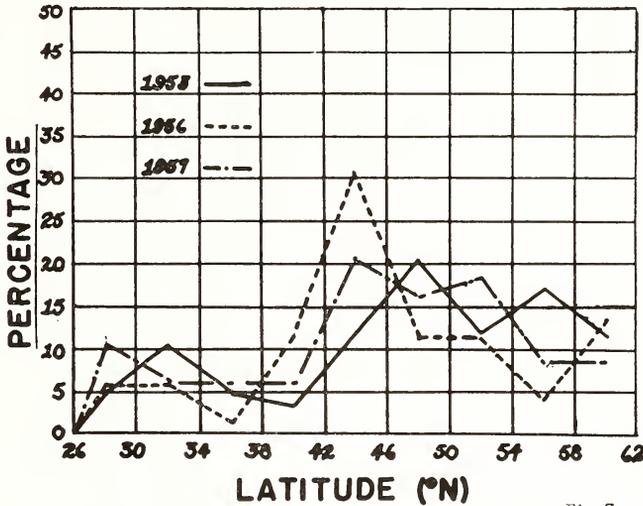


Fig.7

1957 Cyclonic

June	4.19	9.25	6.44
July	4.45	4.03	1.27
August	4.20	4.46	4.70
September	1.30	.90	1.89
Total	14.14	18.64	14.30

1953 Other

June	....	....	....
July	.47	....	.01
August	....	....	....
September	.02	....	....
Total	.49	....	.01

1956 Other

June	.26	.06	.02
July	.34	.22	.57
August	.08	.42	.03
September	....	.05	....
Total	.68	.75	.63

	1957 Other		
June	.05	.79	.93
July	.15	1.41	.30
August	....	.08	....
September	....	.26	....
Total	.20	2.54	1.23

determined. Table I was tabulated by cross-checking the daily precipitation amounts for the three stations in Climatological Data. The precipitation was then classified as *cyclonic* or *other* in origin by its contiguous or noncontiguous position from the cyclone or front. All areas of precipitation which were located within a contiguous area of precipitation from the front or cyclone were arbitrarily classified as cyclonic. All noncontiguous areas, which were nearly always smaller in size and extent, were classified as having received precipitation from other than cyclonic sources (5). By employing these criteria, the final tabulations show that only two per cent in 1953, seven per cent in 1956, and eight per cent of the 1957 total summer precipitation in Gary, Terre Haute, and Evansville were caused by other than cyclonic actions. (Table II.)

TABLE II
TOTAL AMOUNT AND SOURCE OF SUMMER PRECIPITATION

Cyclonic Precipitation for	1953	1956	1957
Gary	10.66	9.18	14.14
Terre Haute	10.68	8.85	18.64
Evansville	3.99	8.38	14.30
Average	8.44	8.80	15.69
Per Cent of Total	98%	93%	92%
Other Precipitation			
Gary	.49	.68	.20
Terre Haute	....	.75	2.54
Evansville	.01	.63	1.23
Average	.17	.69	1.32
Per Cent of Total	2%	7%	8%

The percentage of total summer precipitation (Table II) which was caused by cyclonic activity may appear exaggerated. Certainly most geographers have the impression that more summer precipitation is caused by convection than this study has shown. The basic problem appears to be that variations of precipitation causes and their effects are often combined. For example, during the three summers noted for western Indiana, precipitation resulting from cyclonic action has probably been accentuated by convectonal updrafts. Nevertheless, all precipitation contiguously located with the front or cyclone is here labeled as "cyclonic."

On the other hand, this is a limited study of surface weather conditions. If upper air cyclonic effects were also analyzed, probably some scattered precipitation, here classified as "other," would be truly

cyclonic in origin. Two points are obvious. One is the need for a more thoroughly tested criteria of identifying and classifying precipitation causes. The other is the desirability of more quantified studies of various climate regions over a greater number of years.

Cyclonic Velocities and Depths

Relationships were also determined between the velocities of cyclones and precipitation amounts during the three summers. By using the maps of cyclone tracks in the Monthly Weather Review, the average velocity was computed for each cyclone which brought any precipitation to Gary, Terre Haute, or Evansville during the three summers studied. The tabulations showed an average velocity of 21.4 m.p.h. for the 25 cyclones which caused precipitation during the summer of 1953, 18.33 m.p.h. for the 34 precipitation-producing cyclones during the summer of 1956, and 22.4 m.p.h. for the 31 cyclones of the summer of 1957. Therefore, the summer which was characterized by the greatest cyclonic precipitation (1957) had the greatest number of cyclones moving through eastern North America (47) and they were moving the most rapidly. However, the summer which had the more nearly average total amount of precipitation, rather than the least amount, had the slowest moving cyclones.

The data from the Daily Synoptic Charts were also scrutinized for relationships between relative depths of cyclones and summer amounts of precipitation in the three western Indiana stations. It was found that the cyclones which had the greatest average depth were those of the summer of 1957. However, the average cyclonic depth in 1957 was only 1008.4 millibars as compared to 1009.7 millibars in 1956, and 1010.1 millibars during the dry summer of 1953. Since the average pressure gradient for the cyclones which brought precipitation to western Indiana in 1957 was only 1.7 millibars lower than those precipitation-producing cyclones of 1953, it would seem that little or no significant differences existed in their relative depths. However, it is a fact that the wettest summer in western Indiana was characterized by the greatest number of cyclones which took a southern path. They also moved the fastest, and they were the deepest which occurred during the three summers studied.

Summary

The general conclusions are that: (1) During the dry summer the cyclonic paths were markedly farther north than during the two wetter summers. (2) The cyclonic frequency from 42° North to 46° North seemed to have a most direct bearing on the amount of summer precipitation received in western Indiana during the three years. (3) Cyclonic (and associated frontal and squall line) precipitation was clearly the dominant cause of precipitation during all three summers, and was responsible for 92 per cent of precipitation during the wettest summer, 93 per cent during 1956, and 98 per cent during the dry summer of 1953. (4) Differences in average velocity of all cyclones which brought precipitation to Gary, Terre Haute, and Evansville showed that the fastest moving cyclones occurred during the wettest year, and (5) Relationships to

amounts of summer precipitation and average cyclonic depth in the places and years noted, showed the depth to be lowest during the wettest summer.

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