increases, but intersects the limit line for a value of t a little over one million, which satisfied the equation

$$0.0001025t = 0.0166t^{80.635}$$

As regards the data as a whole, the agreement between the line ADE and the plotted points is very good, the curve even reproducing the flat portion of the plotted data for time-intervals between 1,000 and 5,000 minutes. The discordant points for time-intervals of 21,000 and 43,000 minutes, respectively, are probably due to rain intensities for these time-intervals having occurred "out of their order," or with greater frequency during the 25 years of observations than would be the case on the average. It appears that the equation for the line ADE given on the diagram represents with considerable accuracy the maximum amounts of precipitation having average exceedance intervals of about 25 years at New Orleans for time-intervals ranging all the way from 1 minute to 1 year.

CLOUDBURST RAINFALL AT TABORTON, N. Y., AUGUST 10, 1920.

551.577.3 (747)

By ROBERT E. HORTON and GEORGE T. TODD.

[Albany, N. Y., Oct. 15, 1920.]

SYNOPSIS.

An extremely heavy rainfall occurred at Taborton, N. Y., on the afternoon and night of August 10, 1920. The catch as measured in a bucket, gave a total measurement for 24 hours as 11.62 inches, of which 8.95 inches fell during the main storm in late afternoon. Experiments were tried to determine the magnitude of errors owing to splash from a near-by roof and eddies about the pail. Deductive studies were made on the rise of water in Big Bowman Pond, the washing of roads, and dislodging of boulders, and all the evidence tends to the conclusion that the rainfall certainly amounted to 8 inches. The extent of the heavy downpour was very small, being most intense at Taborton and falling off markedly in all directions, towns 15 to 20 miles distant receiving only 1 or 2 inches of rain. In August, 1891, there was a similar heavy downpour in this locality, in which it is probable that more rain fell than on this occasion.

The record of rainfall depth was reported by Prof. Thos. R. Lawson, of the Rensselaer Polytechnic Institute, who was at his summer cottage, located at the point marked "A" on figure 1, at the time the storm occurred.

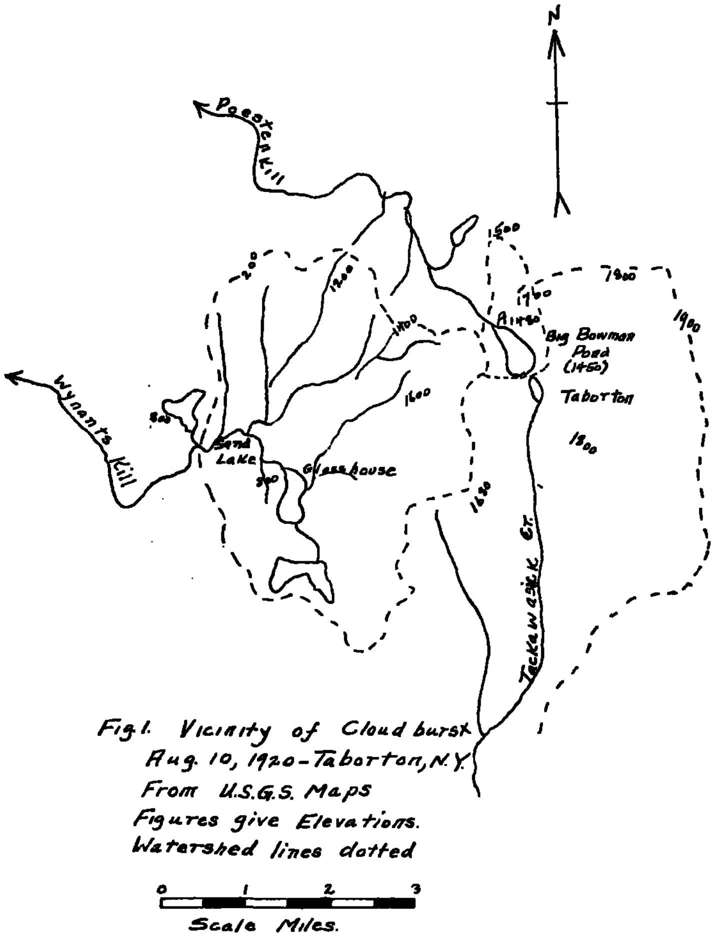

Fig. 1. Vicinity of Cloudburst Aug. 10, 1920—Taborton, N.Y. From U.S.G.S. Maps Figures give Elevations. Watershed lines dotted

There was an ordinary tin pail with flaring sides standing on the ground 8 feet from the south corner of the house, as shown in figure 2. Where the pail stood the grass was short and the ground hard, and the pail stood level.

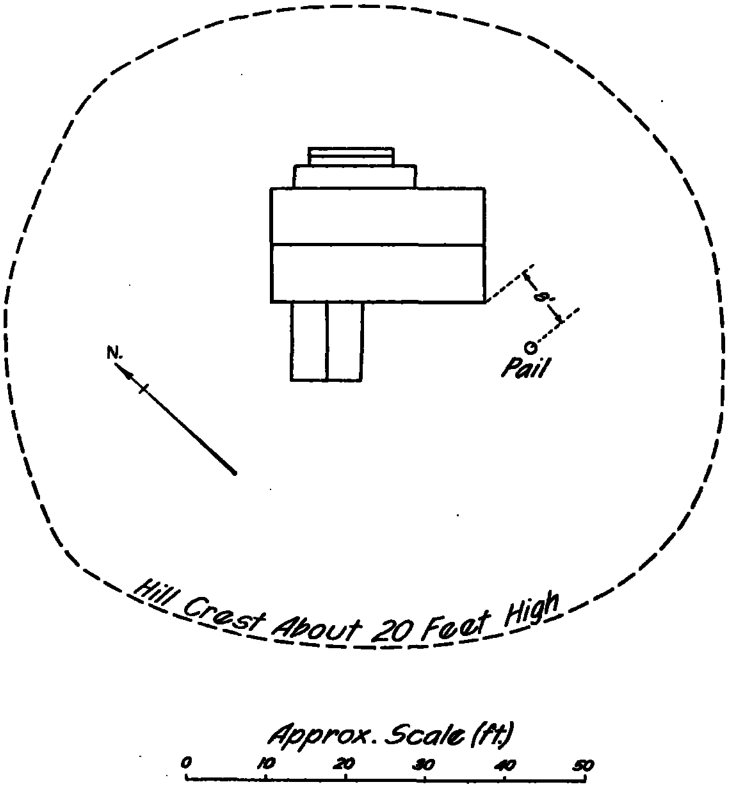

FIG. 2.—Details of location of pail near house.

The mean top diameter inside was 10 inches—mean bottom diameter 7¼ inches—and depth 8⅜ inches. Prof. Lawson reports that the pail was empty before the rain. The rain began about 4 p. m., fast ["summer"] time, and the heaviest storm ended about 6 p. m. There was a lull between 5 and 6 p. m., at which time he found the pail full. He then emptied and replaced it, and at the end of the rain it was again half full or nearly so.

The surface area, or catchment of the pail, is 78.54 square inches. The pail being a truncated cone, the true depth of rainfall caught has been obtained by determining the height of a cylinder of equal volume and having a diameter of 10 inches. This amounts to 6.28 inches. The volume in the bottom half of the pail caught after the lull, reduced to the same basis is equivalent to a cylinder 10 inches in diameter and 2.67 inches high, making the total rainfall caught in the main storm equivalent to 8.95 inches.

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In the second storm, about midnight, the same day, nearly one-half a pailful, or around 2.67 inches, was caught, making the total depth by pail measurement for 24 hours 11.62 inches.

The only question which can be raised regarding these measurements is whether they were affected by wind or by wash from the eaves of the house, which was without eave troughs. Prof. Lawson reports that there was very little wind. It seems impossible to the writer [R. E. H.] that so heavy a rainfall could occur locally without wind, as the apparent precipitation by the pail measurement several times exceeds the total or normal moisture content of the atmosphere; however, it might be possible that the air was quiet near the ground and that the ascending moist air currents which produced the rain slid up the slopes of a virtual air mountain. It would take but little wind with the rain gage located as was the pail in this instance to produce eddies likely to affect seriously the catch of rainfall.

The roof of the house is steep, well shingled, and relatively smooth. In order to determine how far rain swashing off from such a roof would be projected before reaching the ground I performed an experiment by pouring water near the ridge of a similar roof so that it flowed off in a sheet, such as is not infrequently observed in swashing storms. I found that the largest drops struck the ground at distances 4 to 5 feet from the building, and produced some splash and mist from rebound at even greater distances. The washing of roads and flooding of fields in the vicinity affords abundant evidence that this was an extraordinary rainfall. A rough check on the amount of precipitation is afforded by Prof. Lawson's own observations of the rise in Big Bowman Pond (see fig. 1). Prof. Lawson stated that on August 18, at the time of my visit, this pond was 1 foot higher than it was before the rain of August 10. The high-water mark of the morning of August 11, as pointed out by Prof. Lawson, was about 14 inches above the stage of the lake August 18; however, it was Prof. Lawson's opinion that the lake rose a total of about 2½ feet in the night of August 10 and 11.

The water surface area of the lake is 0.15 square mile, or 4,180,000 square feet. It has a drainage area, as shown on the topographic map, of 0.95 square mile, or, in other words, the land surface is 0.80 square mile, or 5.3 times the water surface. The outflow rate August 10 was 2 or 3 cubic feet per second. With the lake raised 1.5 feet higher, the outflow rate might be 10 to 15 cubic feet per second. The excess outflow during the night of August 10, in excess of the amount which would have occurred at the initial stage of the lake, would amount to about 10 cubic feet per second for 12 hours, or roundly 0.1 foot or 1¼ inches, so that the rainfall on the lake surface plus inflow to the lake must be equivalent to a total of 27 to 31 inches.

The ground was previously moist, the slopes are steep, averaging about 350 feet per mile. The area is forested, and the rock very close to the surface. The rain occurred at night, and under these conditions the interception loss would be a minimum, as the evaporation rate was low and rainfall rate intense. While it is an ususually high rate of run-off for a wooded area in the summer time, yet it seems certain that under these conditions not more than 3 or 5 inches of precipitation at the most could have been lost by interception or absorbed by the shallow soil. Using 4 inches as the total loss in detention, these considerations lead to the equation:

$$P+5.33\ (P-4)=30 \text{ inches}$$

from which it appears that a total precipitation of about 8 inches during the night of August 10 and 11 is sufficient to account fully for the observed conditions. Of this apparently about 78 per cent fell in the first storm, making an indicated rainfall of 6.24 in two hours. It is possible that the rain was not as heavy over the whole area as at Lawson's.

The drainage basin of Wynantkill lies immediately west of that of Big Bowman Pond, as shown in figure 1. Roads in this basin were washed out, the entire soil cover being removed down to the rocks in many places. A small dam was destroyed, and flats were generally flooded. The rainfall was very intense at Sand Lake village. The dam of Charles A. Brookner's mill at Sand Lake has a level crest 65 feet long. The water rose to a maximum depth about midnight on the evening of August 10 of 33½ inches above the crest of this dam. The dam has a flat crest about 16 inches wide, with an upstream slope of about one on three, to which a discharge coefficient in the weir formula of 3.50 would apply. During the storm two water wheels having capacities of about 40 c. f. s. were blocked open in the mill. The calculated discharge over the dam is 1,066 c. f. s., and with the water-wheel discharge added the maximum rate of discharge at this location was 1,106 c. f. s. The contributary drainage area is 10.7 square miles. The easterly two-thirds is mostly wooded, and the slopes average about 400 feet per mile. The above figures indicate a maximum run-off rate of 103.3 cubic feet per second per square mile. This is by no means an unusual maximum run-off rate for

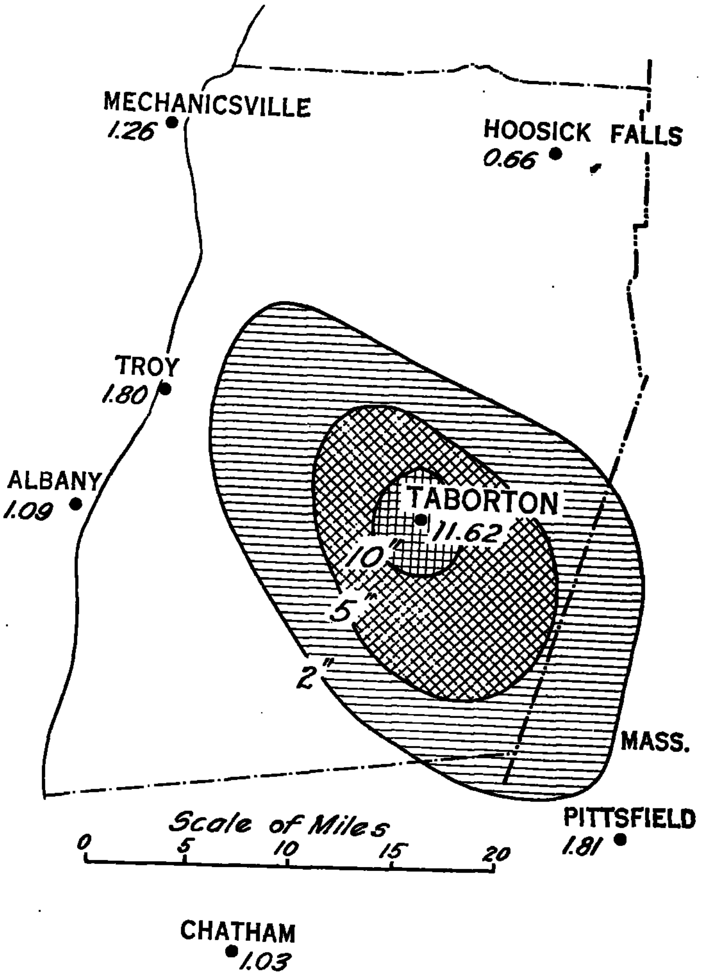

Fig. 3.—Distribution of rainfall near Taborton, N. Y., Aug. 10, 1920.

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such a drainage area. It amounts to a run-off depth of only 0.16 inch per hour. There are, however, two lakes in this basin, and the amount of stream channel storage is relatively large, so that from the same rainfall a run-off rate much larger would naturally be expected from the land area tributary to Bowman Pond.

Observers both at Sand Lake and Taborton state that 29 years ago, in August, roads were washed out and streams were slightly higher than on the recent occasion. Probably the intense rainfall of August 10 covered only the higher easterly portions of the Sand Lake Drainage Basin. (See fig. 3.)

CORRELATION OF WIND VELOCITY AND CONVECTIVE RAINS AT HOUSTON, TEX.

551.55 : 551.578.1 (764)

By I. R. TANNEHILL, Observer.

[Weather Bureau, Houston, Tex., Apr. 16, 1921.]

SYNOPSIS

In the vicinity of Houston, Tex., convective rains are frequent during the summer months. These rains result from expansion and consequent cooling of air rising in a nearly vertical column. The air can not rise in a continuous convection column if the wind is of more than moderate velocity nor can it rise through or even well into a stratum of strong winds.

From a study of wind movement and rainfall at Houston, Tex., it is apparent that there is a strong relationship between these two elements. The lighter the surface wind movement the greater is the probability of local convective rains in summer.

In the vicinity of Houston there is sufficient moisture on nearly all days in summer; the necessary condition for the formation of convective rains is local heating in relatively quiet air.

The majority of the rains which occur at Houston, Tex., in summer are of a type peculiar to the territory bordering the Gulf of Mexico. The southeasterly monsoon is a source of abundant moisture on the coast. Toward the interior the rainfall diminishes. In other portions of the State the precipitation of this moisture may be due to cyclonic action or to forced ascent. In the coast section cyclonic disturbances in summer are limited mostly to rather infrequent tropical storms and since that section is practically flat, little of the rainfall can be ascribed to the forced ascent of air currents. Nearly all of the rains which do occur in the vicinity of Houston are undoubtedly convective in origin.

The strength of this southeasterly wind is variable. With the passage of high-pressure areas to the northward this monsoon becomes feeble and sometimes there occur distinct land and sea breezes. On a typical summer day, however, the southeasterly wind continues throughout the 24 hours, becoming stronger after midday. The formation of cumulus clouds is an almost daily occurrence. Yet day after day passes in summer with no rainfall at Houston if the southeasterly wind is strong.

On some days the convective column builds upward to great heights in quiet air. On other days the tops of the cumuli appear to be torn away and to dissolve on entering a stratum with a higher velocity of wind movement. It is obvious that a strong wind, by mixing unsaturated air with the air in the column, tends to prevent further growth of the cloud mass. Quiescence of the upper air is therefore an aid if it is not on some occasions essential to the formation of convectional columns to great altitudes.

Similarly, quiescence of the surface air favors the starting of convections, since it permits, as strong winds do not, appreciable local inequalities of temperature.

From observation it therefore appears that the prevailing southeasterly wind at Houston is productive of abundant rainfall when conditions are favorable for convection and that the important consideration is the strength of this southeasterly current.

Concerning convective rains, Prof. A. J. Henry, in Weather Forecasting in the United States, says:

> There are two districts in which convective rains occur during the warm season. The first of the districts is along the Gulf coast, including the Florida peninsula, and extending back into the interior probably not more than 50 miles, the exact border not being as yet determined. Its east-west length is approximately 700 miles, or from the Atlantic in the neighborhood of Jacksonville. Fla., to about Houston, Tex. The pressure conditions associated with these rains are about as follows:
>
> A high, with pressure 30.15 to 30.20 inches, overlies the southern portion of the middle Atlantic, with an extension over the Florida peninsula, in which the pressure is 30.08 to 30.10 inches. Pressure diminishes in a westerly direction to a region of indifferent gradients over southeastern Louisiana. The gradients are for gentle southeast winds along the coast and over the narrow fringe of the interior.

In the foregoing quotation it is pointed out that the pressure distribution is such as to give rise to gentle southeast winds.

The temperature of the air does not differ materially from one summer day to another in this section. On nearly all days there is an abundance of moisture. The important consideration seems to be the velocity of the southeast wind. When the wind is strong, rain is prevented by mixing, and the moisture is carried farther into the interior.

The records at Houston, Tex., covering a period of 11 years, 1910 to 1920, inclusive, were examined in an effort to determine any relationship that exists between rainfall and wind. During this period the anemometer and the rain gage have not been moved.

TABLE 1.—*Average wind velocity, miles per hour, and the number of rainy days, 0.01 inch or more, for each of the months June, July, and August.*

Year.	June.		July.		August.	
	Average wind movement (miles per hour).	Number of days with 0.01, or more, rainfall.	Average wind movement (miles per hour).	Number of days with 0.01, or more, rainfall.	Average wind movement (miles per hour).	Number of days with 0.01, or more, rainfall.
1910	7.4	9	7.4	11	7.1	6
1911	7.1	9	6.7	13	6.8	9
1912	8.5	9	6.3	12	6.9	11
1913	8.1	9	7.5	5	6.3	10
1914	6.7	7	6.7	5	6.7	18
1915	8.2	2	7.9	5	8.3	17
1916	8.3	7	5.9	13	6.6	14
1917	8.7	3	7.6	7	6.8	4
1918	6.9	5	6.7	6	6.6	9
1919	7.4	13	5.0	12	5.8	11
1920	6.7	10	6.1	12	5.5	17

For the values in Table 1, the coefficient of correlation[1] has been computed by the method of least squares. The equation used was

$$r=\frac{\Sigma(xy)}{\sqrt{\Sigma x^2 \Sigma y^2}}$$

for the correlation coefficient and

$$E_r=0.674\,\frac{1-r^2}{\sqrt{n}}$$

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[1] See: The Effect of Weather upon the Yield of Corn, Mo. WEATHER REV., Feb., 1914, 42: 78-87; also Elementary Notes on Least Squares, etc., ibid., Oct., 1914, 42: 551-568.

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