# SURFACE STREAMLINES ASSOCIATED WITH THE TORRENTIAL RAINS OF AUGUST 18-19, 1955, IN THE NORTHEASTERN UNITED STATES

CONRAD P. MOOK

U. S. Weather Bureau, Washington National Airport, Washington, D. C.

This report deals with a preliminary effort toward applying a technique advocated for use in the Tropics to a middle-latitude situation wherein the weather of the Tropics seemed for a time to have been lifted bodily to middle latitudes. Namias and Dunn [1] have shown how the floods, which occurred in the wake of the passage of the remnants of hurricane Diane in August 1955, occurred in a homogeneous tropical air mass with its associated high moisture content. The analysis of Chapman and Sloan [2] indicates the lack of fronts in the area. The temporary rejuvenation of the dying hurricane and the sudden eastward turn of the storm as it reached the 40th parallel of latitude must therefore be studied using techniques applicable under such circumstances, namely the techniques used successfully in tropical meteorology.

C. E. Palmer [3] has proposed that the analysis of tropical situations be undertaken using the streamline analysis technique of Bjerknes and collaborators [4]. Using this technique Palmer was able to locate, on day-to-day low-level weather maps in the Tropics, lines of convergence which were associated with convective cloud patterns. His lines of convergence, however, were definitely not lines separating air masses of differing densities, though, like fronts, they occurred in regions of horizontal velocity convergence. However, he pointed out that such velocity convergence must also occur in a region where there is convergence in the streamlines along an asymptote.

In the present instance a preliminary examination of the surface wind field on the map for 0730 EST of August 18 suggests a marked velocity convergence in a narrow zone extending northward from the dying storm center located in western Virginia, the zone of convergence curving thence eastward through Pennsylvania into central Connecticut. One may note in particular that southerly winds were being observed at Allentown, Pa., LaGuardia Field, N. Y., New Haven, Conn., and Block Island, R. I., at the same time that easterly winds were being reported a short distance farther north at Scranton, Pa., Poughkeepsie, N. Y., and at Hartford (Bradley Field), Conn. The chart for 0730 EST in figure 1 shows a heavy line delineating this zone of convergence between the southerly and easterly winds. The heavy line is extended westward to show how it joins with a similar zone of convergence extending northward from the storm center separating easterly from northerly flow.

The observation that this zone was later to be a line north of which the devastating flood rains occurred (and in fact had already begun [1]) and a line which roughly outlined the subsequent path of the low pressure center, which had been identified previously as hurricane Diane, prompted this more thorough analysis of the streamline patterns shown in figure 1. The analyses were constructed at 6-hour intervals beginning with the chart for 0730 EST of August 18.

The method of analysis used in the preparation of the charts shown in figure 1 was that which is customarily used in the analysis of streamlines in the Tropics; namely, the construction of isogons. Numerous short lines are then sketched on each isogon parallel to the wind direction. These lines are then used as additional "winds" in the construction of the streamlines. An example of this technique is given by Riehl [5]. Riehl's example includes both a cyclonic indraft point and a hyperbolic point. The necessity for a hyperbolic point to accompany a cyclonic indraft point has been described recently by Sherman and LaSeur [6]. Similar reasoning applies in dealing with an anticyclonic "outdraft" wind system as sketched in the Adirondack Mountain area of New York State on the 0730 EST chart in figure 1. The accompanying hyperbolic point is located in south central Massachusetts.[2]

---

[1] At the time of this chart some of the heaviest hourly amounts were occurring in areas subsequently to be struck by the flood rains, such as Honesdale, Pa., situated northeast of Scranton, and Norfolk, Conn., both within the two dominant rainfall areas associated with the floods. At Honesdale 0.72 and 1.08 inches of rainfall fell during the hours ending at 0700 and 0800 EST, respectively. During the hour ending at 0700 EST, 0.80 inch of rain fell at Norfolk, Conn. However, in addition to this, a rainfall pattern which developed independently of the two rainfall areas of Pennsylvania and Connecticut was beginning in the Boston, Mass., area where heavy rain was occurring at 0730 EST. There 0.95 inch of rain fell during the hour which ended at 0800 EST. Outside of these immediate areas, heavy rains were occurring in the Blue Ridge Mountains of Virginia, but otherwise hourly rainfall amounts were of considerably lesser magnitude.

[2] Although the location of a hyperbolic point that was associated with Diane cannot be firmly established without extending the analysis to a larger area, such a point may be the one found on the chart for 1330 EST over eastern Lake Ontario as shown in figure 1. It is not shown on the chart for 0730 EST but it is probable that it existed along a northwestward extension of the asymptote of divergence located over Lake Ontario.

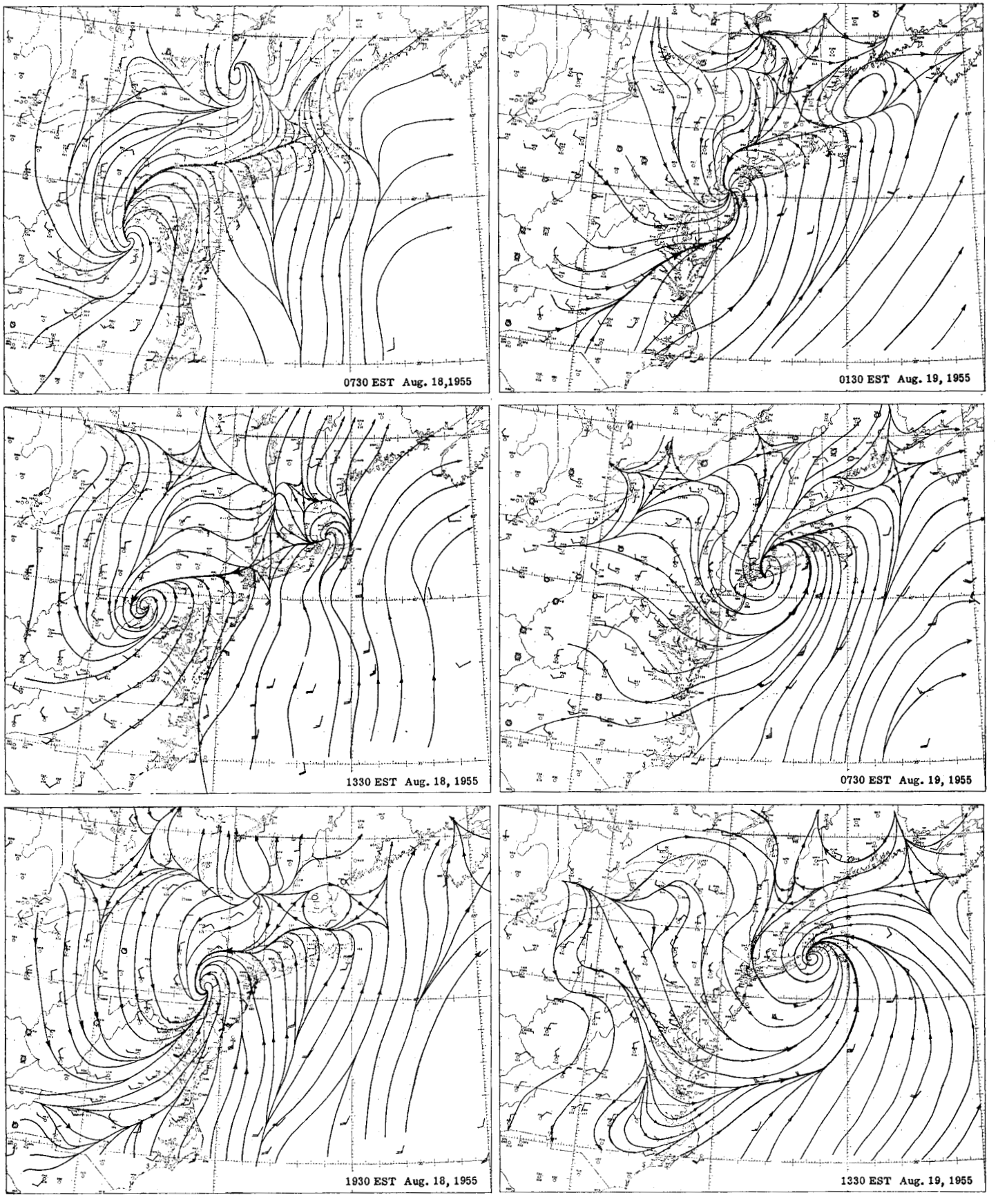


FIGURE 1.—Surface streamlines at 6-hour intervals, August 18–19, 1955.

The 1330 EST chart in figure 1 shows that for a brief period a cyclonic circulation developed in the Boston area, it too being accompanied by the development of a new hyperbolic point. This cyclonic indraft was associated with a second peak of hourly precipitation amounts in the Boston area which culminated in the measurement of 1.20 inches of rain there in the hour ending at 1500 EST on the 18th. This precipitation cannot be attributed to topographic lifting and must therefore be associated with a general vertical motion pattern and upper-level divergence which could have influenced the behavior of the over-all storm circulation, including the turning of the storm Diane toward the east as it reached the 40th parallel.

A third peak of precipitation occurred in the Boston area between 0700 and 1100 EST of the 19th as the storm moved eastward to the south of New England.

The occurrence of the heavier amounts of precipitation north of the line of convergence in northeastern Pennsylvania and southwestern New England can be attributed for the most part to orographic lifting of the lowest 5,000 feet of air, the air being saturated with dew points in the 70's [7]. In this connection it should, however, be noted that the orographic effect was *augmenting* a more general vertical motion and precipitation pattern which developed in advance of the storm center and that this more general vertical motion pattern produced 2 to 3 inches of rain at sea-level installations along the coast south and east of the region of topographic lifting. In the lowest 5,000 feet there was considerable horizontal *velocity* convergence in the heavy rain area which is not shown on these streamline charts in which wind speed is not a factor.

In figure 1 the primary lines of convergence are shaded more heavily than ordinary streamlines. Note especially the converging streamlines on the 1930 EST chart for August 18 in the region extending from northeastern Pennsylvania into southern New England and the general tendency for the old hurricane to bring this convergence line into its spiraling circulation in the manner suggested by Wexler [8] as the mechanism which accounts for the spiral-banded structure of hurricanes generally.

The late Dr. Isaac M. Cline [9] noted in his investigations of rainfall associated with tropical hurricanes that the temperature in the different parts of the storms which he studied did not vary greatly. He stated that the causes of the heavy rains in tropical cyclones could not be found in the surface temperature distribution (See page 220 of [9]). Finally, he noted that the region of greatest precipitation intensity was located "50 to 100 miles in front of the region where the winds of the right rear quadrant converge with those of the right front quadrant" and attributed the rainfall to the vertical motion above the zone of convergence.

Briefly summarizing, the streamline patterns shown in figure 1 reveal a marked zone of convergence which lay close to the subsequent path of the storm center and across the region of flood-producing rainfall.

*Note added in proof.*—A paper by Y. Masuda, M. Takeuchi, and M. Hashimoto ("On the Forecasting of the Movement of Typhoon", *Papers in Meteorology*, Meteorological Research Institute, Tokyo, vol. 3, No. 4, 1953, pp. 246–251) has just come to the attention of the author. In the 1953 paper it was suggested that typhoons move toward a point in the streamlines that corresponds to Scherhag's "delta". If on the maps for 0730 and 1330 EST, August 18 (fig. 1) this point is considered to lie in southeastern New England, the subsequent movement of hurricane Diane provides an interesting confirmation of this hypothesis.—*C.P.M.*

REFERENCES

1. J. Namias and C. R. Dunn, "The Weather and Circulation of August 1955—Including the Climatological Background for Hurricanes Connie and Diane," *Monthly Weather Review*, vol. 83, No. 8, August 1955, pp. 163–170.
2. W. T. Chapman and Y. T. Sloan, "The Paths of Hurricanes Connie and Diane," *Monthly Weather Review*, vol. 83, No. 8, August 1955, pp. 171–180.
3. C. E. Palmer, "Tropical Meteorology," *Compendium of Meteorology*, American Meteorological Society, Boston, 1951, pp. 859–880.
4. V. Bjerknes and collaborators, *Dynamic Meteorology and Hydrography, Part II, Kinematics*, Carnegie Institution of Washington, Publication No. 88, Part II, 1911.
5. H. Riehl, *Tropical Meteorology*, McGraw-Hill Book Company, Inc., New York, Toronto, and London, 1954, 392 pp.
6. L. Sherman and N. E. LaSeur, "Reconnaissance of the 'Complete Hurricane'," *Bulletin of the American Meteorological Society*, vol. 36, No. 4, April 1955, pp. 152–158.
7. U. S. Weather Bureau, "Hurricane Rains and Floods of August 1955, Carolinas to New England, Part 1—Meteorological Analysis," *Technical Paper* No. 26. (In preparation.)
8. H. Wexler, "Structure of Hurricanes as Determined by Radar," *Annals of the New York Academy of Sciences*, vol. XLVIII, Art. 8, September 1947, pp. 821–824.
9. I. M. Cline, *Tropical Cyclones*, The Macmillan Company, New York, 1926, 301 pp.