flood

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A MESO-SCALE ANALYSIS OF THE FLOOD-PRODUCING RAINFALL IN NEW JERSEY ON 27 AUGUST 1971

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Abstract

An analysis of surface observations in New Jersey on 27 August 1971 revealed that heavy rains were associated with a quasi-stationary front over the state. An oscillation of the front seemed to be associated with outbreaks of heavier convection. This oscillation was apparent only in the meso-scale analysis.

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1. INTRODUCTION

The heavy rains of 27 and 28 August 1971, produced some of the most disastrous local flooding in the history of central New Jersey to that date. Twenty-four hour rainfall amounts set many records throughout the state, and the resulting floods caused several deaths and damage estimated in excess of one hundred million dollars. Rainfall late on the 27th and early in the morning of the 28th was attributable directly to Tropical Storm DORIA that moved northward through the state. Totals up to 5 inches were recorded in this period; these rains would have caused only minor flooding, had it not been for the very heavy rainfall earlier on the 27th that had filled many of the streams and rivers to bankful or over. This rainfall occurred while DORIA was still off the North Carolina coast and amounted to over 9 inches in some places (See Figure 1). Groper and Dunlap (1972) have investigated the overall aspects of this event.

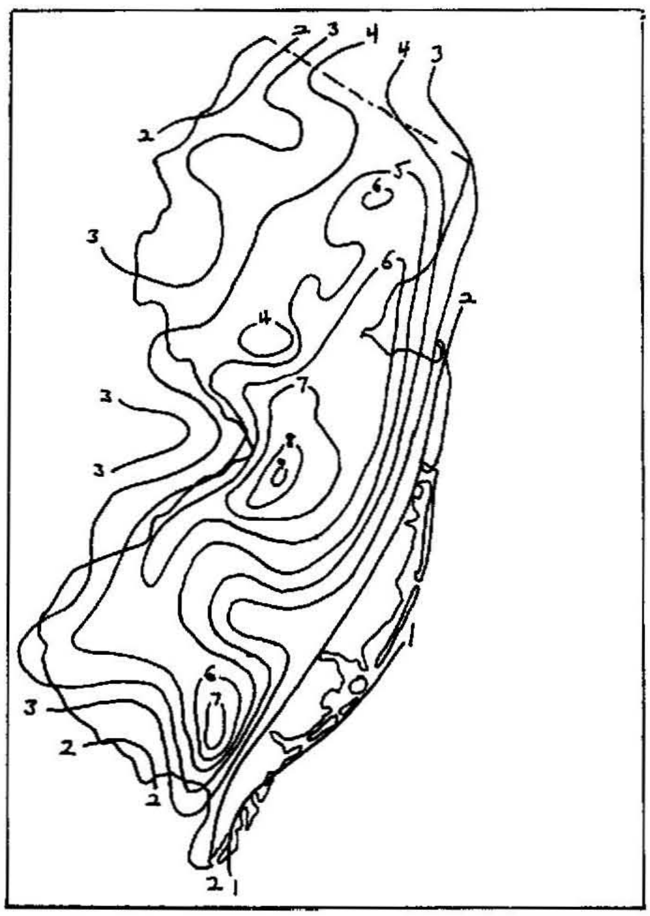

Figure 1. Precipitation in Inches from 0400 to 2000Z 27 August 1971

Browning and Harrold (1969), Harrold (1973), and Browning et al. (1973) have pointed out that within an area of widespread precipitation, there is often a banded pattern of embedded convective precipitation which seems to be the result of mesoscale effects. Browning, Harrold, and their colleagues made extensive use of specialized radar equipment and dealt with systems which moved across Great Britain from the Atlantic ocean. The present investigation was carried out to determine if the locally heavy rainfall could be related to mesoscale weather patterns, with the hope that similar situations might be forecast more accurately in the future.

2. WEATHER PATTERNS BEFORE THE HEAVY RAINS

During the four days prior to 27 August, the weather patterns were more typical of fall than summer. The 50 kPa (500 mb) chart was dominated by sharp troughs and cut-off lows; the surface maps reflected this with intense pressure systems and vigorous fronts.

The surface map for 1200 GMT on the 27th (Figure 2) shows the synoptic situation for the eastern part of the United States. DORIA is shown off the Carolina coast. A stationary front was located just south of New Jersey. A high over the Canadian Maritimes was pumping cool, moist air off the North Atlantic to the north of the front. Warm, moist tropical air was found to the south. Precipitation extended from the Carolinas to New England.

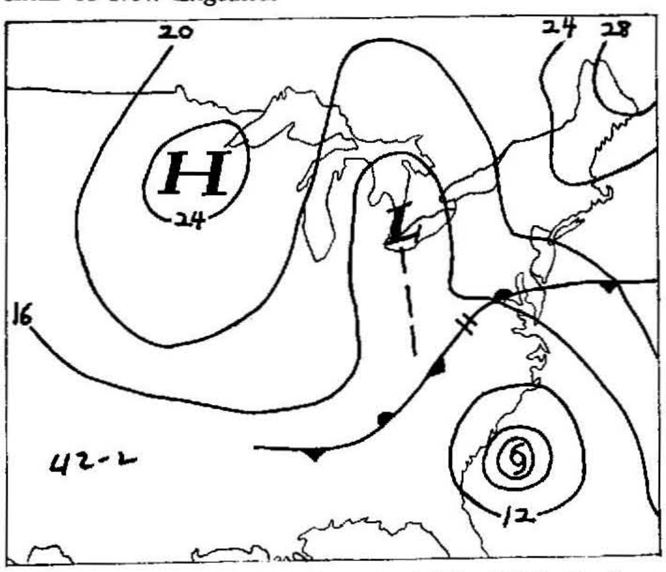

Figure 2. 1200Z 27 August 1971 NMC Surface Analysis

The 85 kPa (850 mb) chart (Figure 3) shows a pronounced flow from the south-southeast along the East Coast. Thus, there was warm advection and much moisture advection from the Atlantic at this level.

The 50 kPa (500 mb) chart (Figure 4) shows a cut-off low over the southern Great Lakes with a deep trough west of the Appalachians. This produced vorticity advection over the East Coast. The approximate vorticity increase over New Jersey from 1200 GMT on the 27th to 0000 GMT on the 28th was calculated as $+ 3.2 \times 10^{-4}$ sec^{-1}. During the same period, the lifted index at John F. Kennedy Airport, New York dropped from 7.5 to 0.0, indicating decreasing stability.

The advections of warmth, moisture, and positive vorticity would account for the widespread cloudiness and precipitation along the East Coast. However, the spatial variability of the rainfall could not be attributed to orographic effects alone, so some further study of the circulation seemed appropriate. The entire frontal pattern

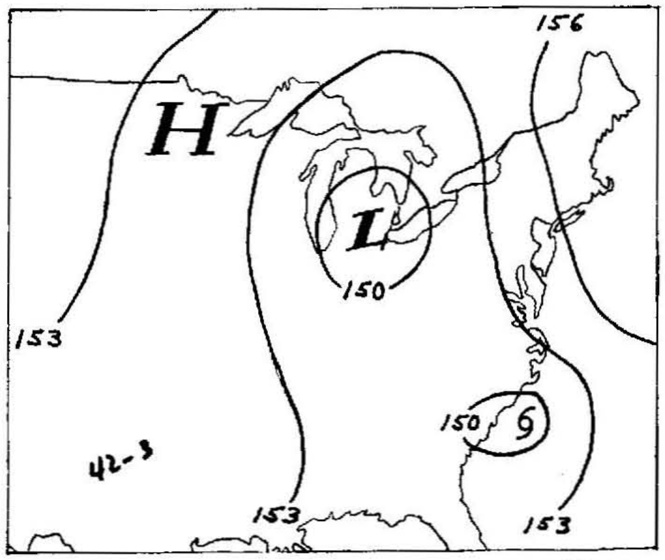

Figure 3. 1200Z 27 August 1971 NMC 85 kPa (850 mb) Analysis

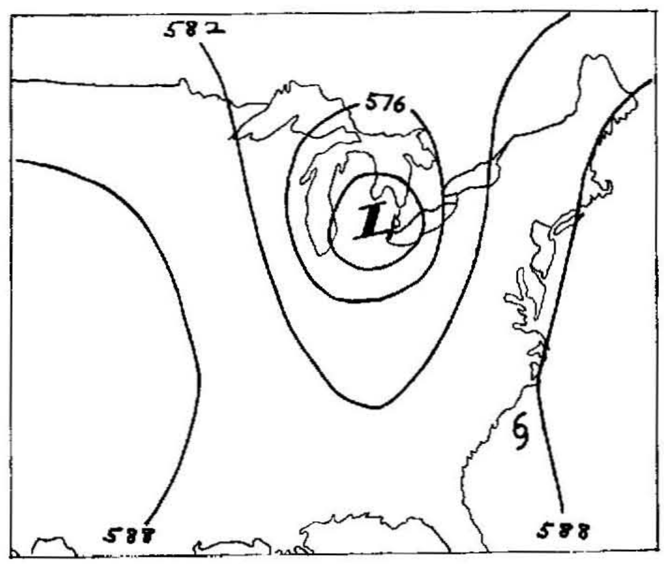

Figure 4. 1200Z 27 August 1971 NMC 50 kPa (500 mb) Analysis

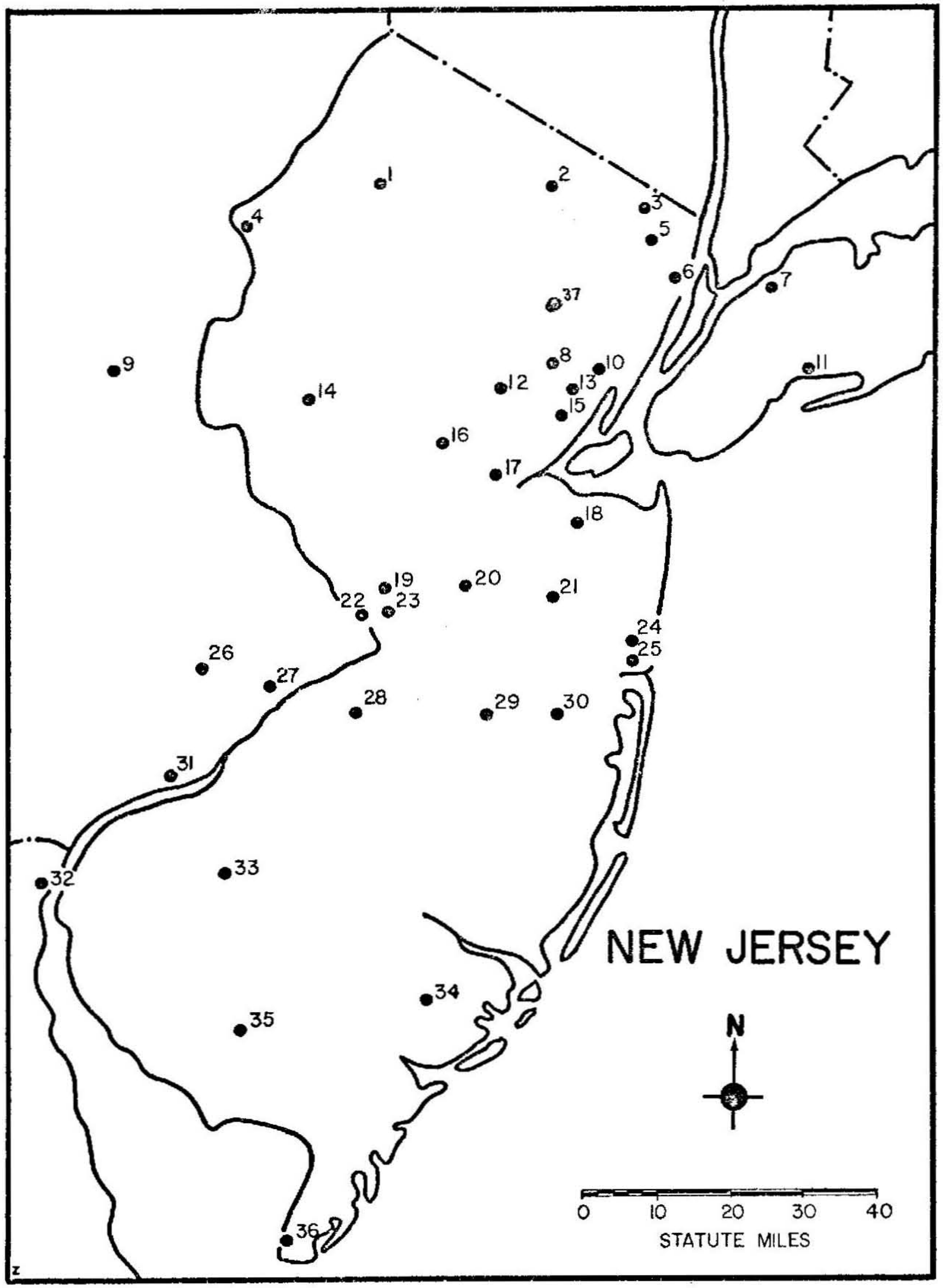

Figure 5. Station Locator Map

indicated on the NMC facsimile charts was quite complex until the passage of DORIA on the 28th. Since the primary interest was to study the flooding in New Jersey, it was decided to perform a mesoscale analysis of the surface data in New Jersey and the immediate surrounding area.

3. MESOSCALE ANALYSIS OVER NEW JERSEY

The stations that recorded hourly weather and rainfall amounts are shown in Table 1 and Figure 5. The surface observations and hourly rainfall amounts for stations in New Jersey and surrounding areas are shown in Figues 6 to 19. The 1300 GMT map (Figure 6) shows the quasi-stationary front bisecting central New Jersey. This is north of the position shown on the 1200 GMT NMC surface map (Figure 2). As shown in Figure 7,

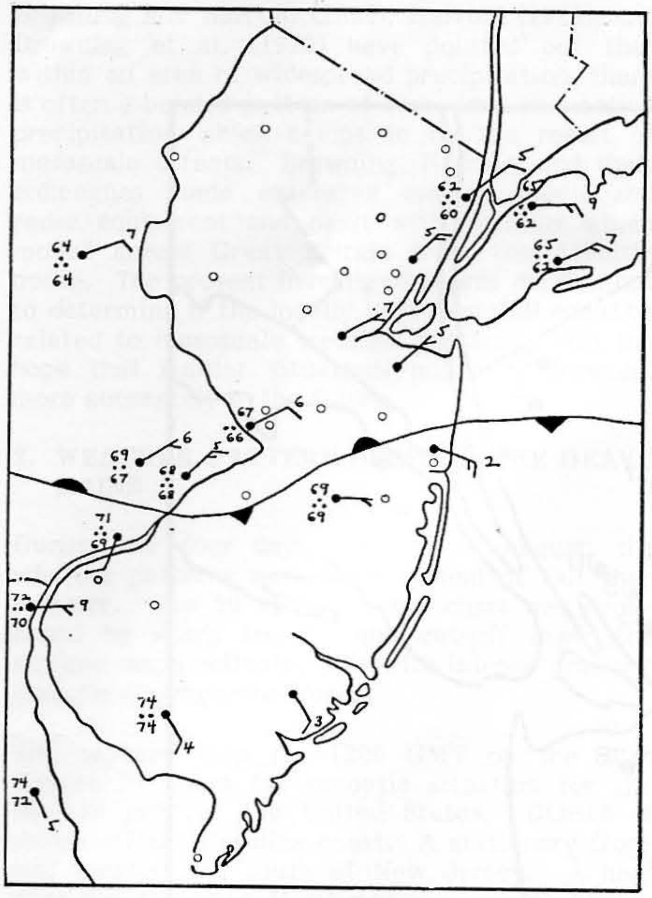

Figure 6. 1300Z Local Area Analysis

during the next hour, the heaviest rainfall occurred along and generally just to the north of the front. By 1400 GMT (See Figure 8), the western portion of the front appeared to begin dropping south as a cold front. At this time, the downtown Philadelphia station reported a wind shift from south to north. It is likely the eastern portion of the front had begun to move northward as a warm front, a point that becomes more obvious later. Heaviest rainfall (See Figure 9) remained just to the north of the front through central New Jersey. The 1500 GMT sectional map (Figure 10) definitely shows a wave in what is still probably a quasi-stationary front. The 1500 GMT NMC surface map (Figure 20) shows a warm front through the south central part of the state. The rainfall map (Figure 11) shows the axis of heaviest rainfall to be slanted from the south-southwest to the north-northeast, fairly parallel to the kink in the front. The 1600 GMT map (Figure 12) shows definite frontal movement. Wilmington, Delaware had a frontal passage with a wind shift from southwest to west and a 2°F temperature drop. On the east side, the warm front has just passed the Bell Labs at Holmdel with a wind shift from northeast to east-southeast. Precipitation amounts (See Figure 13) had also increased. The

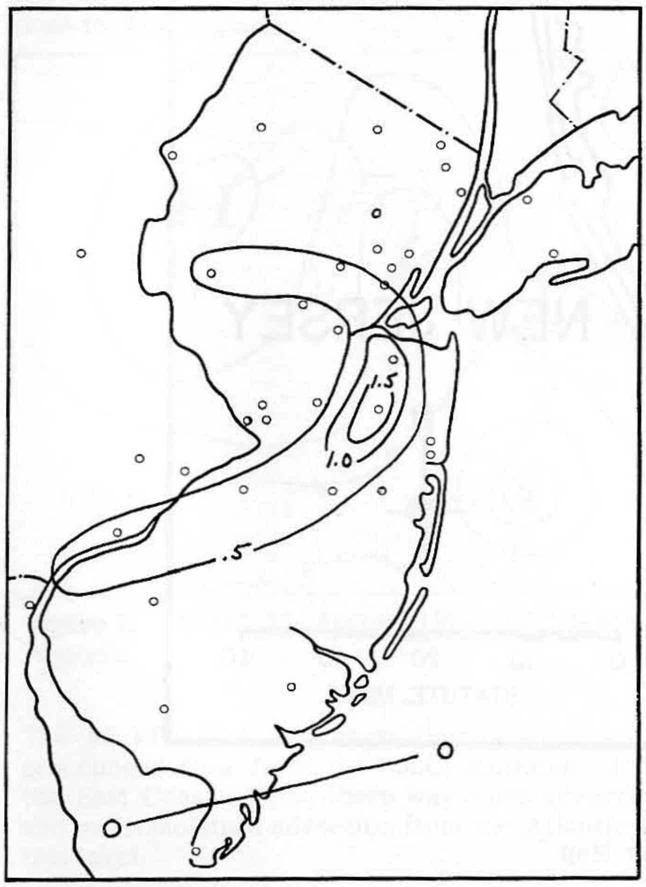

Figure 7. 13-1400Z Precipitation in Inches

area of heaviest rainfall, just west of Trenton, was occurring just north of what could be considered an occlusion point. The 1700 GMT map (Figure 14) shows slight frontal movements. Now, the area of heaviest rainfall (See Figure 15) had shifted northeastward to the Newark area. The 1800 GMT sectional map (Figure 16) shows the next significant evidence of frontal movement. The western cold front has passed through Dover, Delaware and Millville and Wrightstown in New Jersey. All three stations showed wind shifts to the west-northwest and drops in temperature and dewpoint. Meanwhile, the warm front to the east

	STATION	WEATHER	PRECIPITATION
1.	Newton		X
2.	Wanaque Raymond Dam		X
3.	Woodcliff Lake		X
4.	Columbia		X
5.	New Milford		X
6.	Teterboro Airport	X	
7.	La Guardia Airport	X	
8.	Springfield		X
9.	Allentown-Bethlehem-Easton Airport	X	X
10.	Newark Airport	X	X
11.	J.F. Kennedy International Airport	X	
12.	Watchung		X
13.	Elizabeth		X
14.	Clinton		X
15.	Rahway		X
16.	Bound Brook		X
17.	New Brunswick (Rutgers University	X	X
18.	Holmdel (Bell Telephone Laboratories)	X	
19.	Mercer County Airport	X	
20.	Hightstown		X
21.	Freehold		X
22.	Trenton		X
23.	Windsor		X
24.	Belmar (Evans Signal Laboratory)	X	
25.	Laurelton		X
26.	Willow Grove Naval Air Station	X	
27.	North Philadelphia Airport	X	
28.	Mt. Holly		X
29.	McGuire Air Force Base	X	
30.	Lakehurst Naval Air Station	X	
31.	Philadelphia International Airport	X	X
32.	Greater Wilmington Airport	X	X
33.	Glassboro		X
34.	Atlantic City Airport	X	X
35.	Millville Airport	X	
36.	Cape May		X
37.	Essex Fells		X

Table 1. Station Index

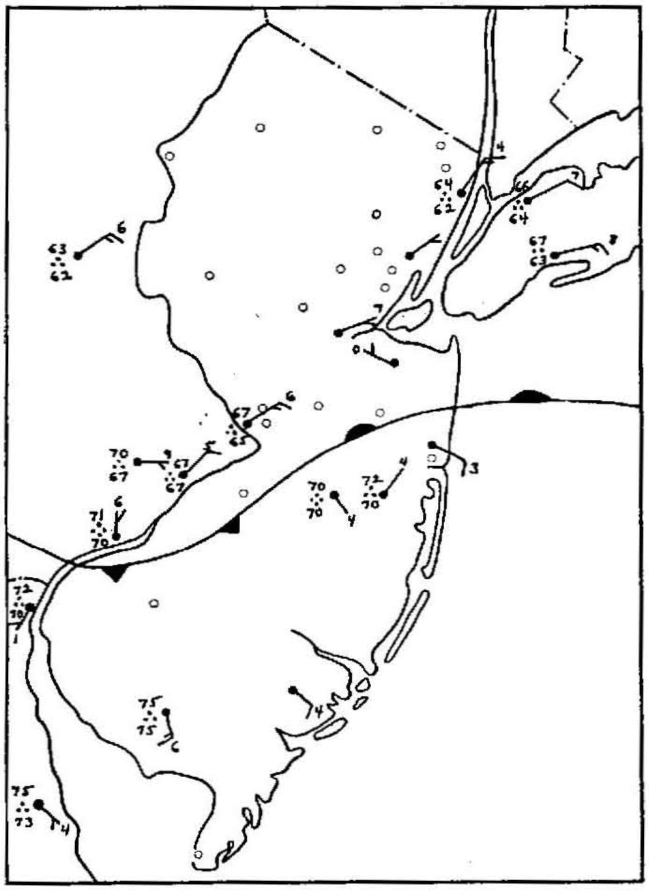

Figure 8. 1400Z Local Area Analysis

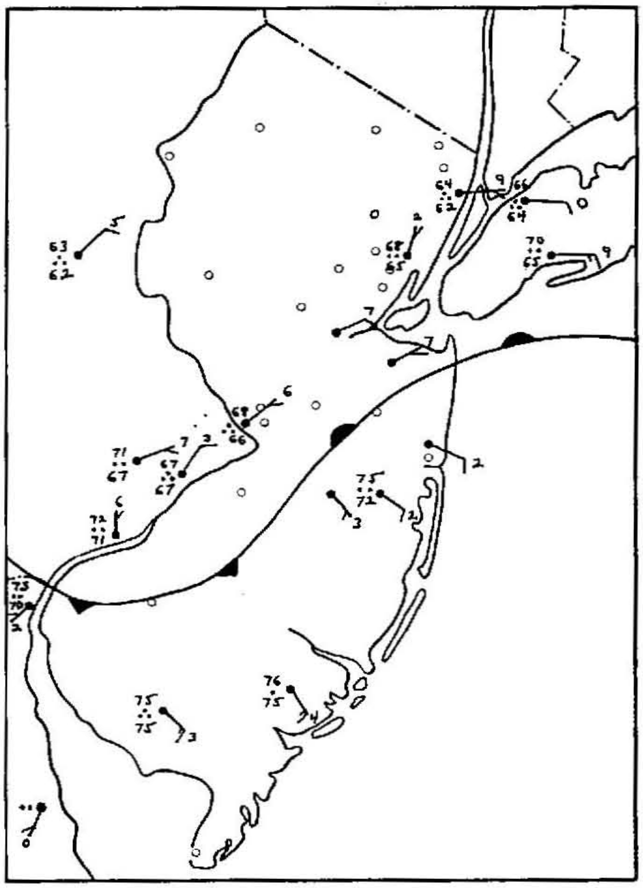

Figure 10. 1500Z Local Area Analysis

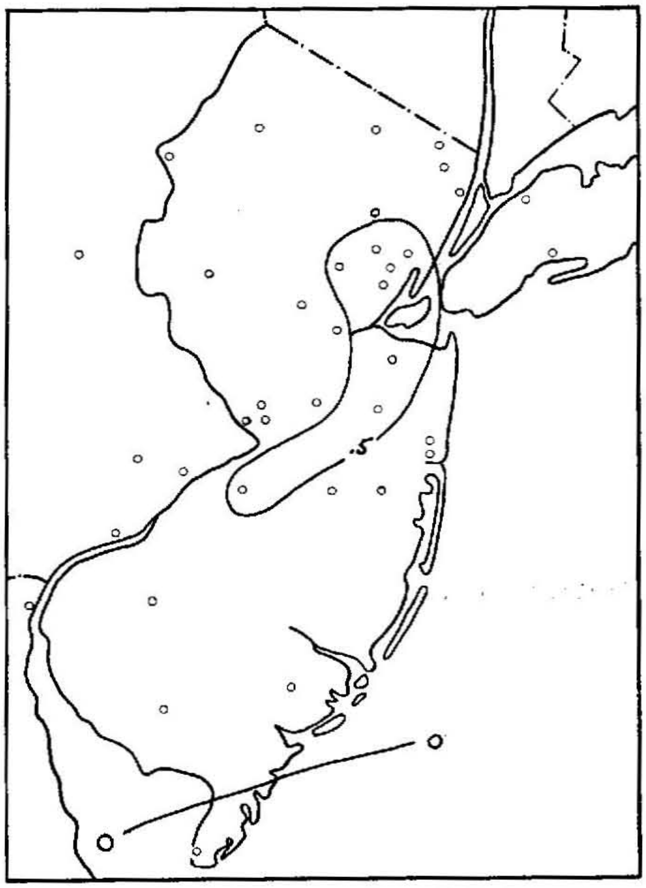

Figure 9. 14-1500Z Precipitation in Inches

Figure 11. 15-1600Z Precipitation in Inches

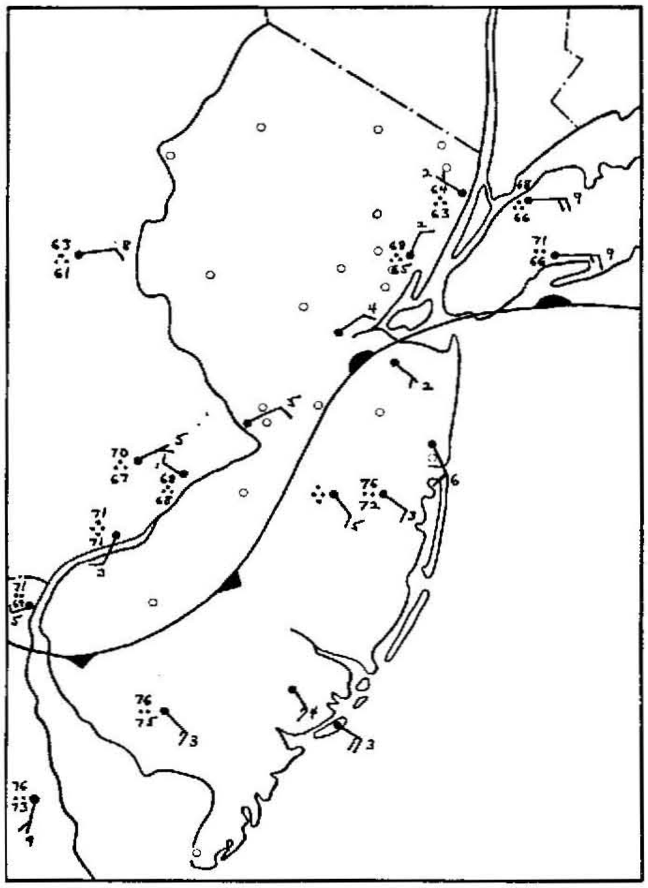

Figure 12. 1600Z Local Area Analysis

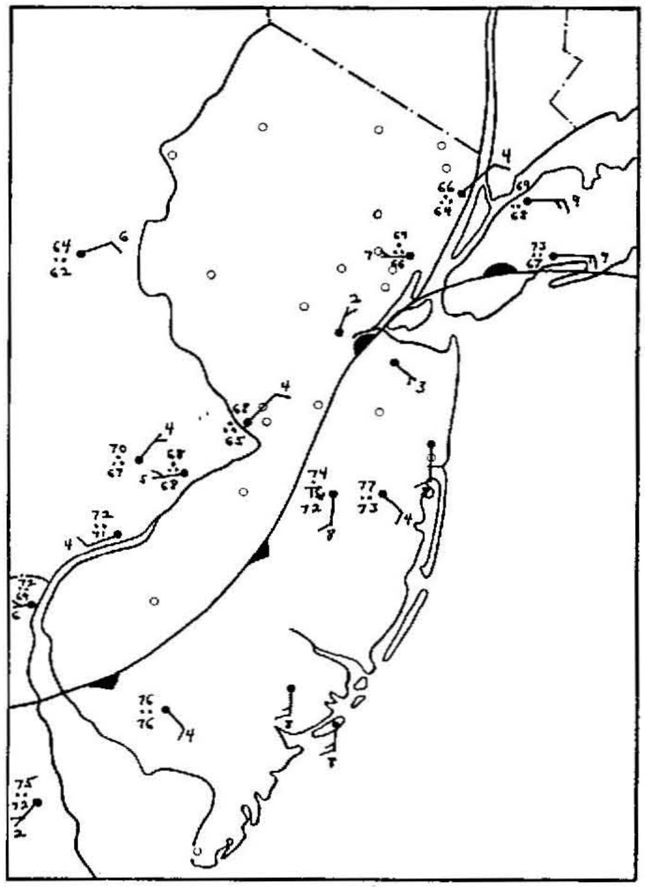

Figure 14. 1700Z Local Area Analysis

Figure 13. 16-1700 Precipitation in Inches

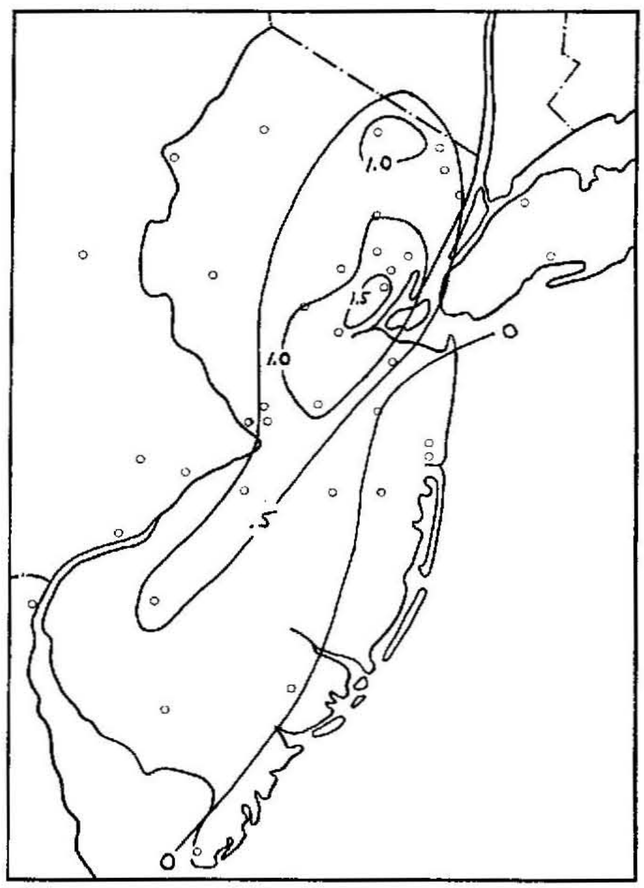

Figure 15. 17-1800Z Precipitation in Inches

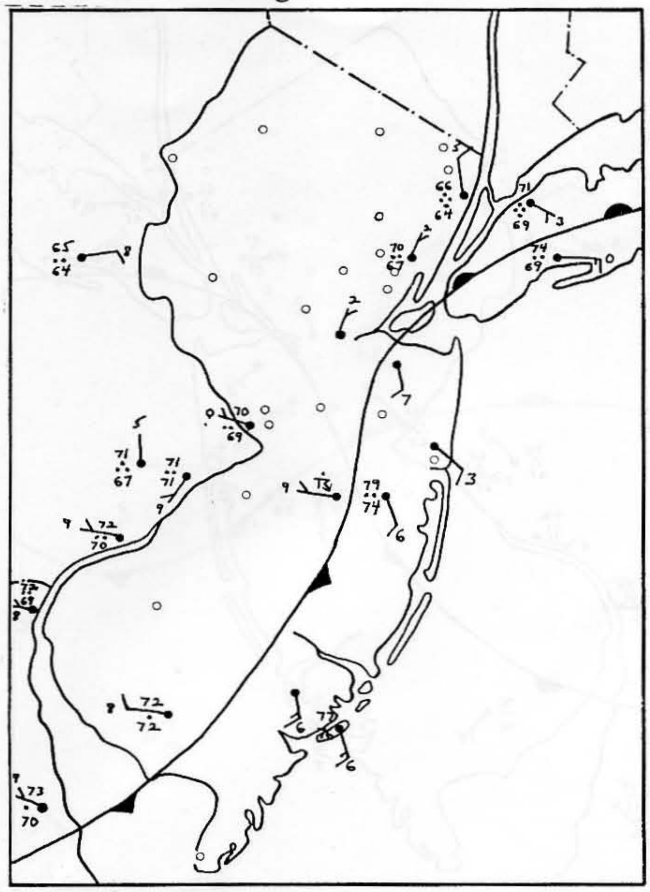

Figure 16. 1800Z Local Area Analysis

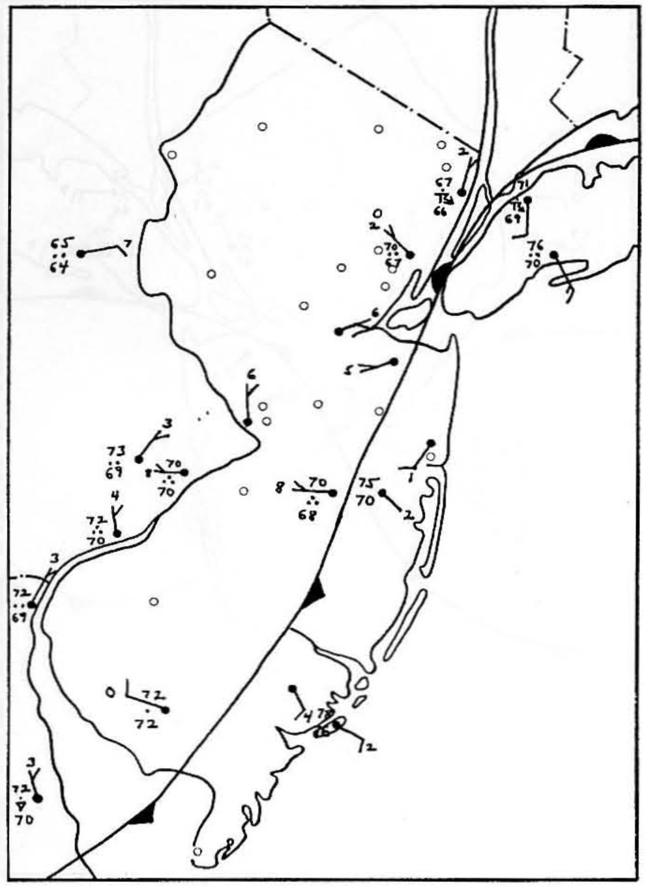

Figure 18. 1900Z Local Area Analysis

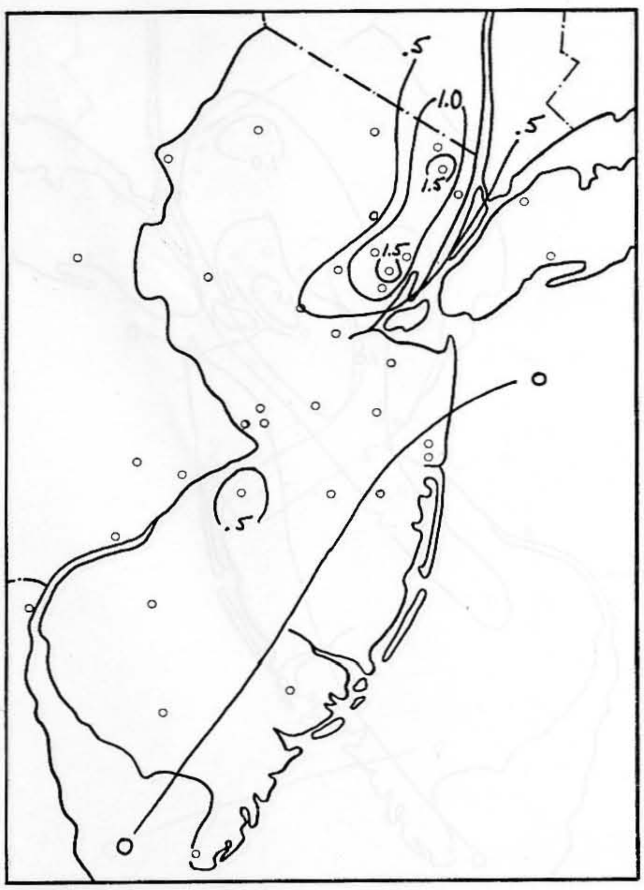

Figure 17. 18-1900Z Precipitation in Inches

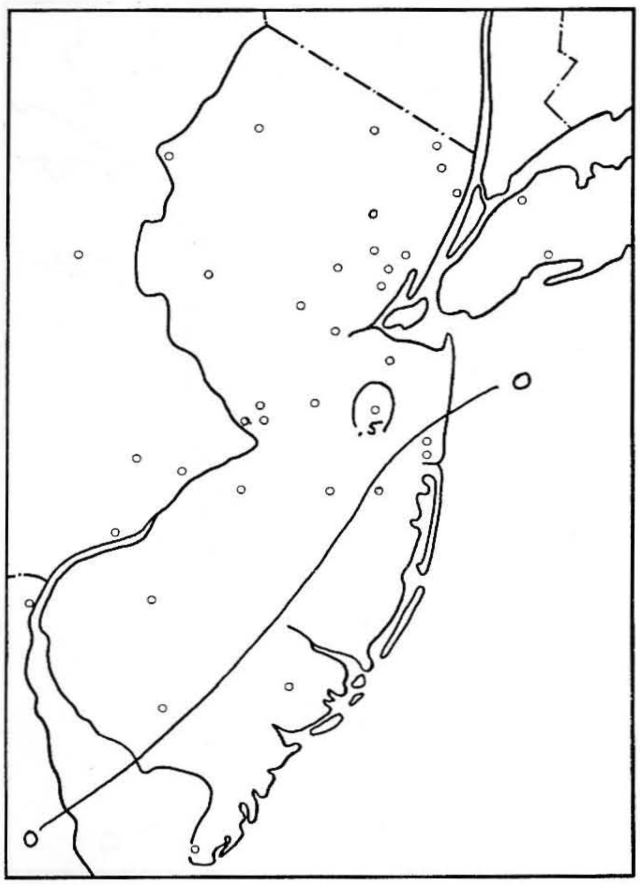

Figure 19. 19-2000Z Precipitation in Inches

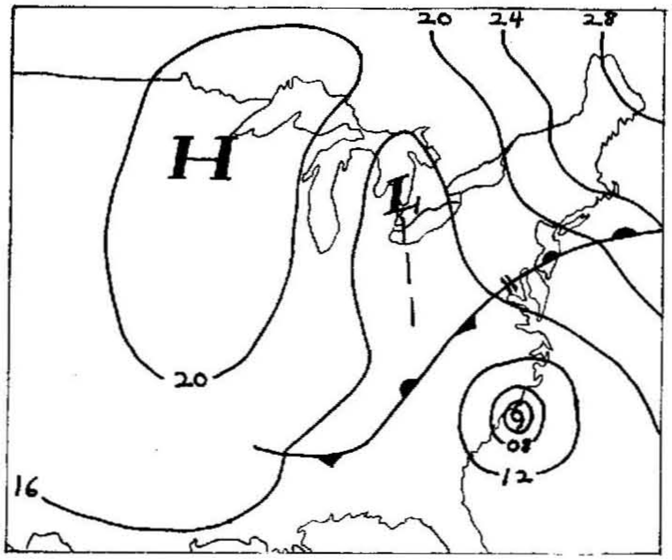

Figure 20. 1500Z 27 August 1971 NMC Surface Analysis

has just passed Kennedy Airport with a windshift to the east-southeast and an increase in temperature and dewpoint. The 1800 GMT NMC surface chart (Figure 21) still shows a warm front through southern New Jersey with little movement during the past three hours. The rainfall map (Figure 17) shows the heaviest precipitation in the extreme northeastern part of the state; again just north of the relative occlusion point. By 1900 GMT (See Figure 18), the eastward moving cold front had passed through most of southern and central New Jersey. The northward moving warm front now appears close to La Guardia Airport in New York. Most of the heavy rainfall has now ended (See Figure 19). The 2100 GMT NMC surface chart (Figure 22) stil shows a warm front through south central New Jersey.

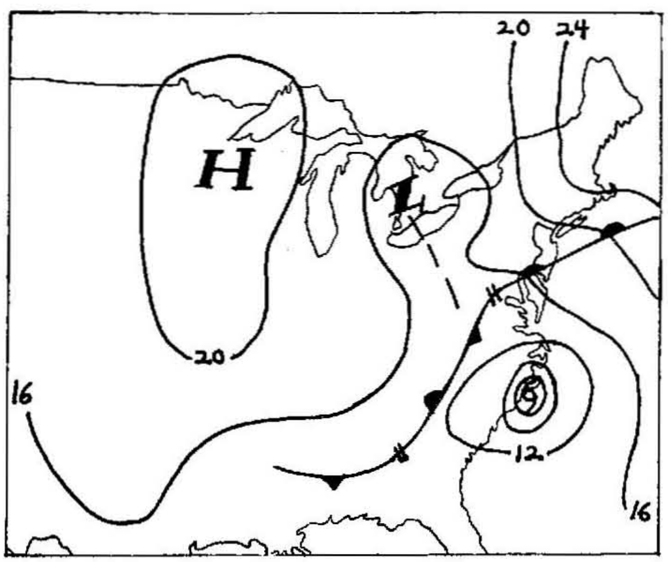

Figure 21. 1800Z 27 August 1971 NMC Surface Analysis

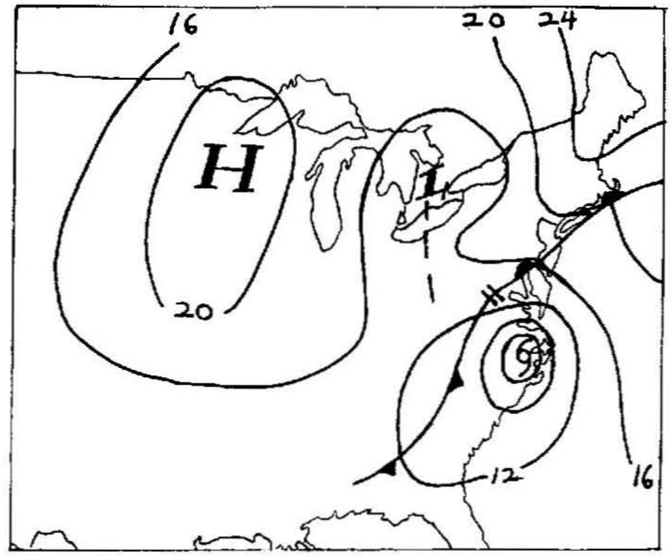

Figure 22. 2100Z 27 August 1971 NMC Surface Analysis

4. CONCLUSIONS

The flood-producing rainfalls in New Jersey on 27 August 1971 seem to be associated with an oscillation of a quasi-stationary front. This oscillation, when viewed on the mesoscale, gave the appearance of a wave with both warm and cold fronts. Of great importance is the fact that this situation was only discernible at the mesoscale. The standard synoptic-scale analysis not only missed this feature but also gave little evidence of unusual weather activity. Since it is becoming more apparent that total precipitation amounts are governed by mesoscale occurrences, this study of an extreme event will hopefully aid the quest for routine mesoscale analysis in the future.

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