

defined jet from the eastern Atlantic to central Asia. Wind speeds were as much as 9 m. p. s. above normal over central Europe (fig. 4B.)

The weather associated with the deep trough and negative anomaly center was unseasonably cool and rainy with much storminess. Cyclonic activity entering Europe from the Atlantic was unusually intense for summer, with sea level pressures averaging from 7 mb. below the August normal in Great Britain to 11 mb. below normal in northwestern Russia. Throughout most of the British Isles there was a considerable deficiency of sunshine, and thunderstorms were unusually frequent. New August precipitation records were established in some districts. Persistent northeasterly flow at sea level swept cool Arctic air masses into Europe, where, in the layer from 700 mb. to 1000 mb., mean virtual temperatures averaged 12° F. below normal (corresponding to a thickness anomaly of -210 ft.) over Great Britain (fig. 5). Note also the strong northeasterly anomalous flow at 700 mb. (fig. 1). This month's cool, rainy regime throughout most of Europe was in sharp contrast to the summer of 1955 when anticyclonic conditions produced warm, dry weather [5, 7].

In the Pacific at least five typhoons were observed in August, with a tendency for these storms to move farther westward before recurving, than is usual for this time of year. Presumably this was related in part to the +90-ft. height anomaly center south of Japan (fig. 1). One of the worst of these storms, typhoon Wanda, smashed into the China coast south of Shanghai early in the month. Two thousand persons were reported killed and millions were made homeless before the storm blew itself out deep in the interior of China.

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Weather Notes

BETSY'S ROVING EYE

Between 1700-1900 GMT on August 11, 1956, Hurricane Betsy's eye passed north of the island of Dominica in the northernmost Windward Islands of the Lesser Antilles. After entering the Caribbean Sea the hurricane's eye had a diameter of 10 nautical miles on the Navy reconnaissance aircraft radar as observed by Lt. A. N. Fowler. The eye was continuing what appeared to be a sinusoidal path west-northwestward toward Puerto Rico. (See fig. 1.) The amplitude of its curve averaged about 15 nautical miles and during its initial movement into the Caribbean Sea showed a wave length of 130 nautical miles. From the beginning of its Caribbean trajectory across the Windward Islands until it reached 64° W., the curve crossed its axis on the average of every 5 hours with a period of 10 hours.

At 0400 GMT on August 12, as the eye approached its last well-defined swing to the right, it was 16 nautical miles in diameter with moderate echoes in several spiral bands extending 70 nautical miles north and 40 west. However after it reached 65° W., the track of the eye lost its sinusoidal character. This might be explained by the slight change in direction from west-northwest to northwest. In addition, the storm's proximity to the Virgin Islands and Puerto Rico may have somewhat distorted its rhythmic movement.

Precipitation bands around the circulation eye continued to vary the diameter and at 0830 GMT the center was 18 nautical miles across located about 75 nautical miles to the southeast of Puerto Rico. Somewhere in this location the storm inflicted its first loss of life inside the Caribbean. The *Elena*, a 91-ton vessel en route through the Virgin Islands, broke up so fast that the crew was unable to radio for help and two seamen were drowned. Another larger ship, the 4,381-ton tanker *Michael J.*, was more fortunate. On Saturday morning it heeded the hurricane warnings and when it was south of St. Croix, it began fleeing southward. Several days later it was located 200 miles south of Puerto Rico adrift with engine trouble and without radio contact.

By 0845 GMT the hurricane was located on the San Juan radar but because of local obstructions and terrain to the southeast of the station the eye could not be fixed.* Between 1200 and 1230 GMT a closed circulation was observed with a diameter of 8 to 10 nautical miles. This was one of the smallest diameters so far reported along the track and indicated that precipitation had closed the eye with concentric bands as it neared the land. As it approached the southeastern coastline its movement between 1200 and 1230 GMT oscillated back and forth and was so erratic that it seemed to be deflected by the terrain. (Perhaps an analysis of the radar film will show somewhat less oscillation than is shown in the radar track plotted on figure 1.) The terrain in the southeastern coastal area slopes abruptly from the coastline to about 1,500 feet with a peak of 2,890 feet in the Sierra de Cayey chain. The eye entered the coastline near Maunabo and moved near Yabucoa, then curved erratically westward toward Guayama. Calm winds were reported at Maunabo as well as at Patillas indicating the eye's passage through these towns.

It is difficult to believe that hurricane Betsy could be deflected by terrain of such dimensions. If the radar positions of the eye were eliminated between 1200 and 1230 GMT, the extrapolated track from the southeastern coast of Puerto Rico to the northwestern coast would assume a more symmetrical line and would even tend toward a quasi-sine curve. Unfortunately there were no pressure readings while the hurricane was in this area. The eye was distorted and seemed to be breaking up over land at 1300 GMT. At 1315 GMT the eye was in the vicinity of Cayey and calm winds were reported there. At that time the eye's diameter was around 6 nautical miles with a sharp tilt toward the northwest. Cayey is located in a valley in the Central Cordillera bounded by peaks of 2,500 to 3,000 feet on the east and 2,200 to 2,800 feet on the west. At one time the eye was observed to take a "square" shape on the scope. Mr. Rockney momentarily fixed the radar antenna at 5,000 feet and the eye was observed to take a more circular shape.

*The radar observer during this period was Mr. Vaughn Rockney.

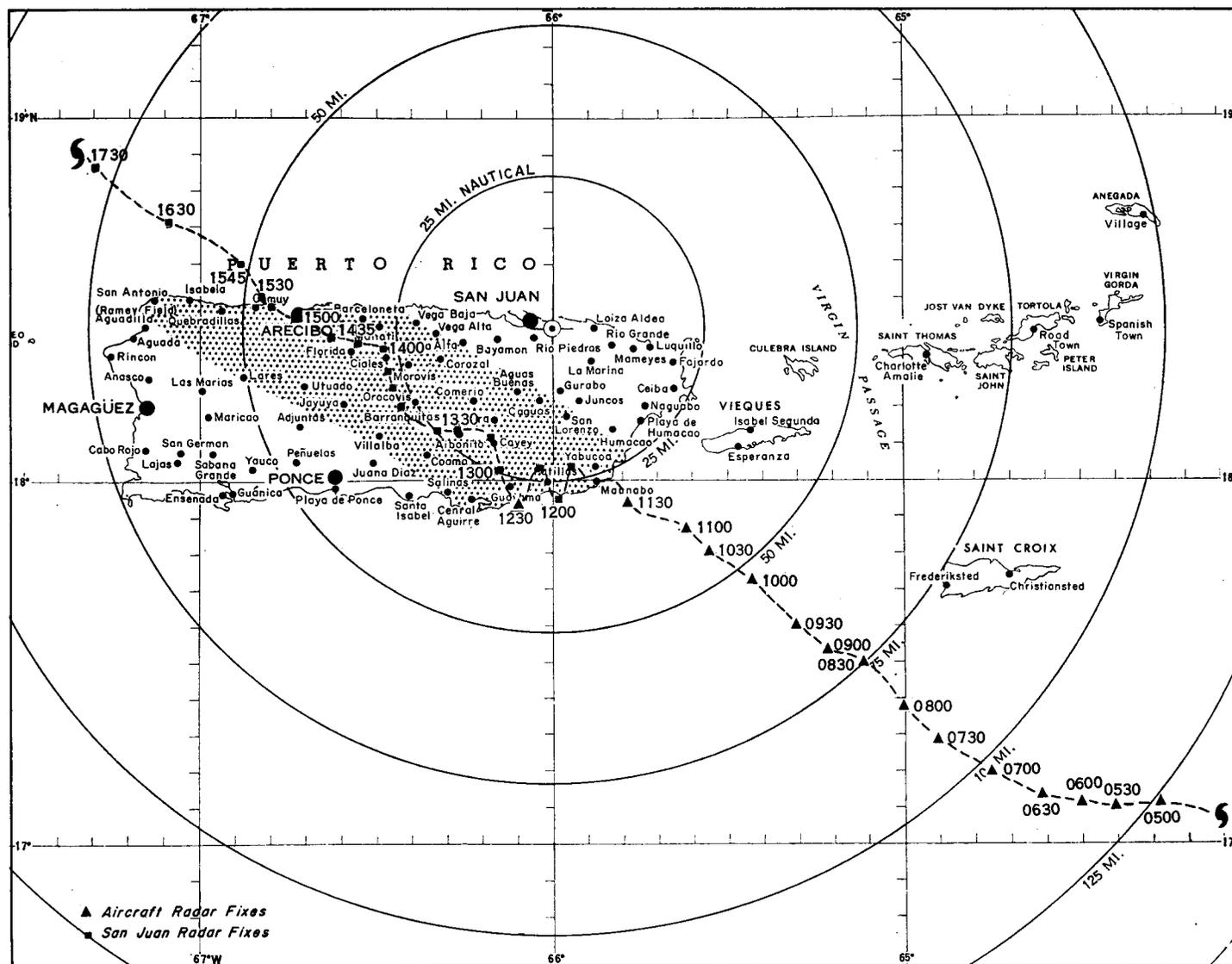


FIGURE 1.—Radar track of hurricane Betsy across the island of Puerto Rico, August 12, 1956. Plotted numbers give time of radar fixes in Greenwich Mean Time. Stippled area is path of greatest damage.

Tilting of the antenna showed that the upper and lower positions of the eye did not coincide as the lower part was being held back by the friction of the terrain.

The movement of the eye from Cayey to Aibonito through the Central Cordillera was west-northwestward and caused considerable damage. An eye witness account of the valleys in the area southwest of Cayey reports that the lower valleys were practically denuded of trees while trees on the ridges were relatively intact. This phenomenon might be explained by the funnelling effect of high winds. Aibonito reported calm winds with the passage of the eye. This town is about 2,000 feet above sea level with peaks of 2,400 feet to the immediate south and 2,780 feet 10 miles to the west. The high winds at Aibonito resulted in more than 1,000 homes being destroyed and 500 partially demolished. The movement of the eye northward from Aibonito to west of Orocovis is over some of the highest terrain along the track. In this area peaks range from 3,127 feet to the east of track to as high as 3,442 feet to the west of track. Between 1330 and 1400 GMT calm winds were reported at Barranquitas, Orocovis, and Ciales. At Comerio, a small town in the Cordillera just east of the eye's path, 579 houses were totally destroyed and 706 were in uninhabitable condition.

The terrain from the Central Cordillera to east of Camuy where the eye left Puerto Rico is gradually downslope with minor hills near the coast. Calm winds were reported at Florida, Arecibo, and Camuy between 1400 and 1530 GMT. There seems to have been a slight acceleration of Betsy after it crossed the Cordillera and by 1545 GMT the hurricane

had intensified off the coast north of Camuy with the diameter of the eye now larger over water at 25 nautical miles. Ramey Field on the extreme northwestern coast of the island reported wind gusts of 115 m. p. h. between 1606 and 1612 GMT. The lowest pressure observed over Puerto Rico was at Ramey Field, 28.88 in. This compared to 29.62 in. at San Juan International Airport and 29.56 at the San Juan Naval Station.

It was estimated that the path of greatest damage extended about 20 miles north of the track and a little less to the south. A preliminary report furnished by Civil Defense showed that the two towns nearest the eye's point of entry, Maunabo and Yabucoa, were the hardest hit. Between 12,000 and 15,000 people were reported homeless at Yabucoa alone, with \$8 million worth of agricultural and property damage. Betsy's roving eye was estimated to have cost Puerto Rico \$25 million in overall damage. The hurricane caused severe damage to all crops in the Jayuya area: bananas were a 100 percent loss, and the coffee crop will take several years to recover. At Camuy, the eye's track dealt its last effective blow to crops—100 percent of the corn, 95 percent of the avocado, 65 percent of the breadfruit and 50 percent of the coffee crop ruined.

In spite of these heavy property and agricultural losses, it is amazing that the total death toll was only 9. The small casualty list is indicative of the large number of people who heeded the warnings and took cover in Civil Defense shelters.—Robert J. Grace, WRAS, San Juan, Puerto Rico.