NATURAL DISASTER SURVEY REPORT 75-1

Hurricane Eloise: The Gulf Coast

A REPORT TO THE ADMINISTRATOR

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration

Rockville, Maryland
December 1975

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U.S. DEPARTMENT OF COMMERCE
Rogers C. B. Morton, *Secretary*

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
ROBERT M. WHITE, ADMINISTRATOR

FOREWORD

Every time a major storm threatens widespread loss of life and property in the United States, our disaster warning system undergoes a crucial test. Each storm is different, and in response to its unique characteristics the warning system--which includes many elements of NOAA, other Federal, State and local agencies, the communications media, and the public itself--has to react in a decisive way that meets the very specific challenge that is thrust at it. We have examined the response of the warning system to Hurricane Eloise, as we have looked previously at other situations, to determine how we can be prepared better, in general, to deal with other future specific storms.

Because of the attention that has been paid in recent years to protection from natural disasters, our warning system appears to be working well. We can be pleased that there was no loss of life directly attributable to this violent act of nature that was fully capable of taking many lives. The warning system can certainly be improved, and will always require careful attention. This report offers several recommendations for improvement of the system, but I believe it is of significance, and gratifying, that none of the recommendations are major or problematic. They are much more in the vein of how we may systematically and incrementally improve on a successful program of vital national importance.

Edward S. Epstein
Associate Administrator for
Environmental Monitoring and
Prediction

PREFACE

The center of Hurricane Eloise reached the Gulf Coast about ten miles east of Fort Walton Beach, Fla., at 7:00 a.m. CDT on Tuesday, September 23, 1975.

Eloise had moved off the coast of Africa as a weak disturbance on September 6th. It then followed a steady westward path across the Atlantic becoming a tropical depression 400 miles east of the Leeward Islands on the 13th, a named tropical storm and subsequently a hurricane north of Puerto Rico on the 16th. The westward track carried the center or eye over eastern Cuba and as it moved out over the water Eloise became a tropical storm once again. After crossing the northeastern tip of the Yucatan Peninsula, Eloise turned northward into the Gulf of Mexico on the 21st reaching hurricane force once more on the morning of the 22nd. By that evening, Eloise turned rather abruptly northeastward towards the Florida coastline.

In anticipation of the potential need for conducting a NOAA Disaster Survey, a team had been formed and placed on standby on Monday, the 22nd. Based upon the damage reports being received on Tuesday, the decision was made to move the team into the Gulf Coast area on Tuesday evening. The NOAA Disaster Survey Team consisted of: Gerald A. Petersen, Director, Office of Meteorological and Hydrological Services, NOAA; John C. Davies, Office of Meteorological and Hydrological Services, NOAA; Herbert Lieb, Community Preparedness Office, NWS; Allen Flanders, Office of Hydrology, NWS; Vincent Oliver, Applications Group, NESS; and Harold S. McCrabb, Meteorological Services Division, Southern Regional Headquarters, NWS.

The team arrived in New Orleans Tuesday night and after visiting the WSFO Wednesday morning, drove eastward through the hardest hit coastal sections. At Panama City, the team split up, with members traveling to Apalachicola, De Funiak Springs, Atlanta, Miami, Tallahassee, and Montgomery. In addition to contacting NOAA offices at Slidell (RFC and Radar), Mobile, Pensacola, Apalachicola, Tallahassee, Montgomery, Atlanta (RFC) and Miami (SFSS), visits were made with Civil Defense officials at Gulfport, Fort Walton Beach, Panama City, and De Funiak Springs. Contacts were also made with a newspaper in Panama City. Numerous contacts with the public were made, especially in the more severely damaged coastal area extending from Fort Walton Beach to Panama City.

The survey convinced team members that the warning system did the job it was intended to do. Some problems were noted, and improvements can be made, but the fact that no deaths were directly attributed to the storm bears witness to the success of the system and the efforts of countless individuals. The team appreciates the help it received in completing this survey.

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FINDINGS AND RECOMMENDATIONS

The team found that the total warning system performed very effectively along the Gulf Coast, and that commendations are in order for many state and local officials, the staffs of radio and television stations, and several NOAA field offices. Some improvements are needed, particularly in the area of forecast preparation, but specific team findings and recommendations are primarily concerned with continued emphasis on effective preparedness, monitoring, and dissemination.

Finding 1: NOAA offices were ready for the storm. Particularly noteworthy were the advance actions taken by NWS Southern Region Headquarters to augment the staffs at several warning offices and the contingency forecasts prepared and distributed to field offices by the River Forecast Centers in Slidell and Atlanta. It was also evident that all warning offices visited by the team had benefited by the preparedness meetings held before the season and the effective workshops conducted by the National Hurricane Center.

Recommendation: A "well done" should be sent to all involved. Such readiness reflects favorably on all concerned and must continue.

Finding 2: While the Florida panhandle had not been struck by a major hurricane for many years, public response was outstanding. No deaths were directly caused by the storm, although the American Red Cross survey reflects four deaths associated with the storm. The team attributed this to: (a) preparedness and education efforts by NOAA in cooperation with DCPA, the American Red Cross, local civil defense, and many other organizations, (b) the actions of local officials in invoking preparedness plans, manning operations centers, recommending evacuation and opening shelters, and (c) an exceptional job by the mass media in dissemination.

Recommendation: NOAA's preparedness and education efforts must be continued and even expanded if we are to maintain interest, cooperation, and response from the public, local officials, and the media. The educational materials should be reviewed periodically to ensure current and complete information on hurricanes.

Finding 3: Overall monitoring of the hurricane in the Gulf of Mexico was considered excellent, with complementary information provided by aircraft reconnaissance, satellite, buoys, and land-based radars. Some problems were noted with obtaining river and rainfall reports after the storm moved inland.

Recommendation: NOAA should continue with its plans to extend and automate its hydrologic data networks, including the collection of data via GOES and the provision of rainfall estimates from radar. Enhanced infrared data from satellites will soon become available to WSFOs and should also be explored as a means of obtaining rainfall estimates.

Finding 4: The 24-hour landfall forecast of the storm center was in error by 63 miles (101 km), and the coastal area placed under hurricane warnings was much larger than the area which actually experienced hurricane conditions. Changes in forward movement of the storm created problems in timing landfall. An estimated 100,000 people evacuated coastal sections between Grand Isle, La., and Cedar Key, Fla. Subsequent newspaper accounts and personal interviews indicated a predominant feeling of relief, rather than criticism, with "unnecessary" evacuation.

Recommendation: Efforts to improve hurricane forecasts and reduce overwarning must be continued. We must also continue to keep the public and local action officials aware of our capabilities and the advantages of "rather safe than sorry" policies and actions.

Finding 5: Significant wind damage occurred near the storm center as it moved well inland. Public forecasts gave little or no warning of these damaging winds in eastern Alabama and northwest Georgia. Investigation reveals both a need for (a) better techniques to forecast storm movement and rate of weakening, and (b) increased consistency between products issued by NHC for marine/aviation use and the WSFOs for public use.

Maximum rainfall received in the southeastern states was fairly accurately predicted, but it fell in a much narrower belt than expected.

Recommendation: NWS and ERL should study these forecast problems with a view toward improved predictions of these storm parameters. In addition, efforts should continue to insure consistency of forecast products.

Finding 6: The storm surge forecasts issued were significantly below the peak tides which occurred.

Recommendation: Efforts in storm surge forecasting research should be given more priority to include more fully the complexities of wind waves and bottom structure off the coast.

Finding 7: Our advisories and local action statements did not always place the most emphasis upon the destructive areas of the storm; rather, they tended to highlight the eye's location. Furthermore, the wording describing this location sometimes implied more accuracy in both monitoring and forecasting capabilities than the facts warranted.

Recommendation: The composition and structure of hurricane advisories and local action statements should be reviewed. The emphasis on the extent of destructive potential of the storm should be highlighted in the advisories and repeated in the local action statements. In addition, educational efforts must continue to stress (a) the areal effects of the storm in contrast to a particular point being hit on the coast, and (b) our monitoring and forecast limitations and their effect upon the size of the area being warned.

Finding 8: Conference calls over the hurricane hot line telephone were invaluable in the effective coordination between NHC, NMC, and the several Eastern and Southern Region WSFOs involved. (This also afforded Eastern and Southern Region Headquarters the opportunity to monitor the situation.) In contrast, there was no direct contact between NHC and the Storm Coordination Center in Chicago when the storm was passed off from one office to the other. This lack of coordination between NHC and SCC Chicago had no adverse effect during this storm but shows a weakness in the system which may cause problems in the future.

Recommendation: Consideration should be given to expanding the hot line telephone system to all SCCs and Regional Headquarters. Direct contact between offices is essential for effective coordination.

Finding 9: Power and communications channels were disrupted by hurricane winds, rain, and tides. Several NWS offices had to switch to emergency power. NOAA Weather Wire Service (NWWS) was interrupted for a limited number of users, including the Fort Walton Beach Emergency Operations Center. NOAA Weather Radio (NWR) performed well in Pensacola but the slave-station at Panama City was inoperative for several hours on Monday due to landline problems and went out again on Tuesday morning due to both power and landline outage.

Recommendation: Other than alternate routing, there seems to be little we can do now to promote better NWWS operations. Outages of NWR must be kept to a minimum, particularly in view of the expansion now planned for this dissemination system. Emergency power should be provided for all NWR transmitter sites. Alternate means of feeding these transmitters should be studied, such as relay through GOES satellite and the provision of standby broadcasting equipment in remote locations for use by local officials during emergency conditions.

Finding 10: Television and radio broadcasters as well as local officials indicated they would find hourly trend statements valuable especially as the hurricane nears the area to be affected. Such messages would fill the gap between scheduled release times and would be beneficial to the concerned public.

Recommendation: The possibility of local offices issuing hourly local trend statements especially when the hurricane is under radar surveillance should be considered. These statements need not be long and may do no more than confirm previous indications. They should be confined to wind and rain associated with the storm and not the storm itself as an entity.

Finding 11: Storm evacuation maps were not available for the area warned, but the team found no evidence that this adversely affected the evacuation. Completion of the program to provide evacuation maps for all potential evacuation areas is not planned until about 1987. If such maps are vital to the preparedness effort, this is too slow.

Recommendation: NOAA should work with other agencies involved with disaster preparedness to assess the need for the program and if appropriate devise a program that will meet the need in a reasonable time.

THE IMPACT

American Red Cross statistics show four deaths and 19 injuries were associated with Hurricane Eloise in Florida and Alabama. The two deaths in Florida were from heart attacks in shelters (one occurred the day of the storm, the other the following day). The deaths in Alabama occurred after the storm, with one caused by a tree-fall during clean-up operations and the other due to electrocution by a downed power line. Estimates of property loss, including extreme tree and crop damage, are in the 200 million dollar range. Over 8,000 families suffered losses and more than 500 small businesses were destroyed or had major damage. (See table at the end of this section.)

Without almost total evacuation of the 55-mile (89 km) strip of coastline between Ft. Walton Beach and Panama City, there is little question that numerous deaths and injuries would have occurred as the storm pushed ashore. Coastal damage was severe as storm tides and accompanying wind waves left water marks over 18 feet (5.5m) above mean sea level at two locations on the coast (given in preliminary measurements by the Corps of Engineers). Professional Engineer Herbert Saffir estimated that winds in excess of 120 mph (193 km/hr) caused the structural wind damage he observed. This correlates fairly well with a private barometer reading of 28.2 inches of mercury (95.5 kPa) measured at Destin, which saw a part of the 40-mile (64 km) diameter eye of the storm. Wind measurements aren't too plentiful in that portion of the Gulf Coast, but a wind of 109 mph (175 km/hr) was reported at Crestview, Fla., located 21 miles (34 km) inland, and the wind recorder at Eglin Air Force Base failed at 92 mph (148 km/hr). An anemometer located 38 feet (11.6 m) above the ground at the Naval Coastal Laboratory in Panama City registered a gust to 156 mph (251 km/hr) about 6:30 a.m. on the 23rd.

In the area of greatest coastal destruction, running primarily from Grayton Beach to Panama City Beach, tidal and wind damage was extremely severe on the seaward side of U.S. Highway 98. Seawalls, most of which were built by private owners, were wiped out and sections of highway were eaten away. Beaches were destroyed, dunes undermined, vacation and permanent homes demolished, and both large and small motels built "on the beach" sustained severe wind and tide damage. Structural damage occurred in some high-rise buildings*. Power and telephone lines were extensively

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*Such damage to high-rises is of particular concern, since some communities utilize these as emergency hurricane shelters.

damaged. Piers were washed away and several marinas were damaged. While many owners had moved their boats to safe harbor, others were not so fortunate. More than 30 boats moored in Destin, including large yachts, were reported destroyed, sunk, or washed ashore. In Ft. Walton Beach, a yacht valued at $250,000 was driven ashore and sailboats were reportedly "stacked like toys." Signs were knocked down and, in some cases, blown around by the wind to cause additional damage.

Elsewhere on the coast, Eloise was kinder, but there were significant effects. In Mexico Beach, about 25 miles (40 km) southeast of Panama City, nearly 30 beach homes were destroyed or extensively damaged. A section of Highway 98 was eaten away in the Highland View area and extensive street flooding occurred in Port St. Joe, where a city dock was washed away. The water damaged section of U.S. Highway 98 between Apalachicola and St. Teresa Beach, and State Route 370 leading to Alligator Point was washed away in one location. Some flooding occurred in St. Teresa Beach, in Panacea, and in sections of Apalachicola. Flooding was also reported in Gulf Breeze, just southeast of Pensacola. Farther west, newspaper accounts told of 80 mph (129 km/hr) winds on Monday evening at Venice, La., on the delta, while winds of 62 mph (100 km/hr) were reported at Buras, La. The road to Grand Isle was reportedly closed by high water. To the north, flooding between the seawall and the protection levee at the lakefront caused an estimated 50 to 100 thousand dollars damage in New Orleans.

Eloise moved inland fairly rapidly. It is believed this lessened the impact right on the coast (the main effects of the storm were over in just a few hours in the Panama City area), but damaging winds were associated with the storm well inland, reaching northward into east-central Alabama and northwest Georgia. Trees, crops, and utility lines were damaged through this area. The Florida communities of De Funiak Springs, Chipley, and Bonifay were hard-hit. In Bonifay, the National Guard Armory, being used to shelter about 200 refugees from the beaches, lost part of its roof and several injuries were reported. In Alabama, Dothan reported 85 mph (137 km/hr) winds and Ft. Rucker had damage to hangars and other base facilities. Maximum official wind at Ft. Rucker was a gust to 72 mph (116 km/hr), although the anemometer on top of an 80-foot (24 m) tower at a satellite field did register an unofficial gust to 120 mph (193 km/hr) during the passage of a suspected tornado at that location. The Alabama towns of Florala, Sampson, Geneva, and Hartford received damage. A trailer park near Enterprise, Ala., was demolished and the fall term was ushered in with a power outage at Auburn

University, where winds estimated at 75 mph (121 km/hr) downed many trees to cause damage to homes, automobiles, and utility lines. In Georgia, winds damaged roofs, uprooted trees, and blew branches onto businesses, cars, homes, and power lines in a wide area between Columbus and the Tennessee border. 100,000 homes were reported without electricity at one time. The gymnasium was damaged at Central High School in Carrollton and some injuries were reported in Bremen, where considerable roof damage occurred.

Tornado activity preceded and accompanied the hurricane. On Monday evening, the 22nd, a funnel aloft was reported by the Okaloosa County (Fla.) Sheriff's department and a waterspout was seen in St. Andrews Bay near Panama City. Shortly after midnight CDT, a tornado destroyed a house and severely damaged a mobile home near Westbay, 10 miles (16 km) northwest of Panama City. About 3:00 a.m. CDT a deputy sheriff observed a funnel aloft over Mobile Bay. Brief tornado touchdowns occurred the morning of the 23rd in Panama City, Ft. Walton Beach, and Chipley, Fla. During the afternoon of the 23rd, a funnel aloft was sighted over Winter Park, Fla., and a tornado injured 8 persons in Savannah, Ga.

While Eloise was an extremely "wet" hurricane as she moved westward through the Caribbean, her rapid speed of movement in the southeastern states worked to reduce the rainfall totals and flooding from rainfall was limited. Some rapid flooding was noted in the Pensacola area early on the 23rd, as rains over nine inches (229 mm) hit that area, and later flooding occurred on the Yellow River near Milligan, Fla. Storm totals of 2 to 6 inches (50 to 150 mm) were the rule in the southeastern states (see Figure 1 for storm totals in this area).

Marine interests were also affected by the hurricane. Coast Guard helicopters reportedly rescued at least 25 persons from three drilling rigs and several dozen more from pleasure boats, fishing vessels, and oil company supply and crew boats. While only minor damage was reported to oil industry facilities, the threat was sufficient to cause operators to shut down production and evacuate thousands of employees. This temporary shutdown of facilities caused a reported reduction in production of one million barrels of oil per day for one company alone.

The extent and severity of the damage to power and telephone lines in the southeast necessitated a massive repair effort, and some areas were still without service several days after the storm. Cable television lines were also hard hit in some areas.

Tree and crop losses were extensive in the Florida panhandle and southeast Alabama. In Alabama alone, the State Civil Defense estimated agricultural losses in excess of 100 million dollars. In Florida, a shrimp raising facility at Westbay lost shrimp valued at 1.5 to 2 million dollars.

The American Red Cross provided the following statistics for the three state area:

	FLORIDA	ALABAMA	GEORGIA	TOTALS
PERSONS				
Dead	2	2	0	4
Injured	14	5	0	19
Hospitalized	5	3	0	8
DWELLINGS				
Destroyed	87	45	0	132
Major Damage	617	628	1	1246
Minor Damage	2671	3313	26	6010
MOBILE HOMES				
Destroyed	67	170	3	240
Major Damage	179	203	5	387
APARTMENTS, CONDOMINIUMS, ETC.				
Family Units Destroyed	3	0	0	3
Family Units with Major Damage	79	0	0	79
Family Units with Minor Damage	90	13	0	103
SMALL BUSINESSES				
Destroyed or with Major Damage	195	340	0	537
TOTAL FAMILIES SUFFERING LOSS	3860	4486	35	8381

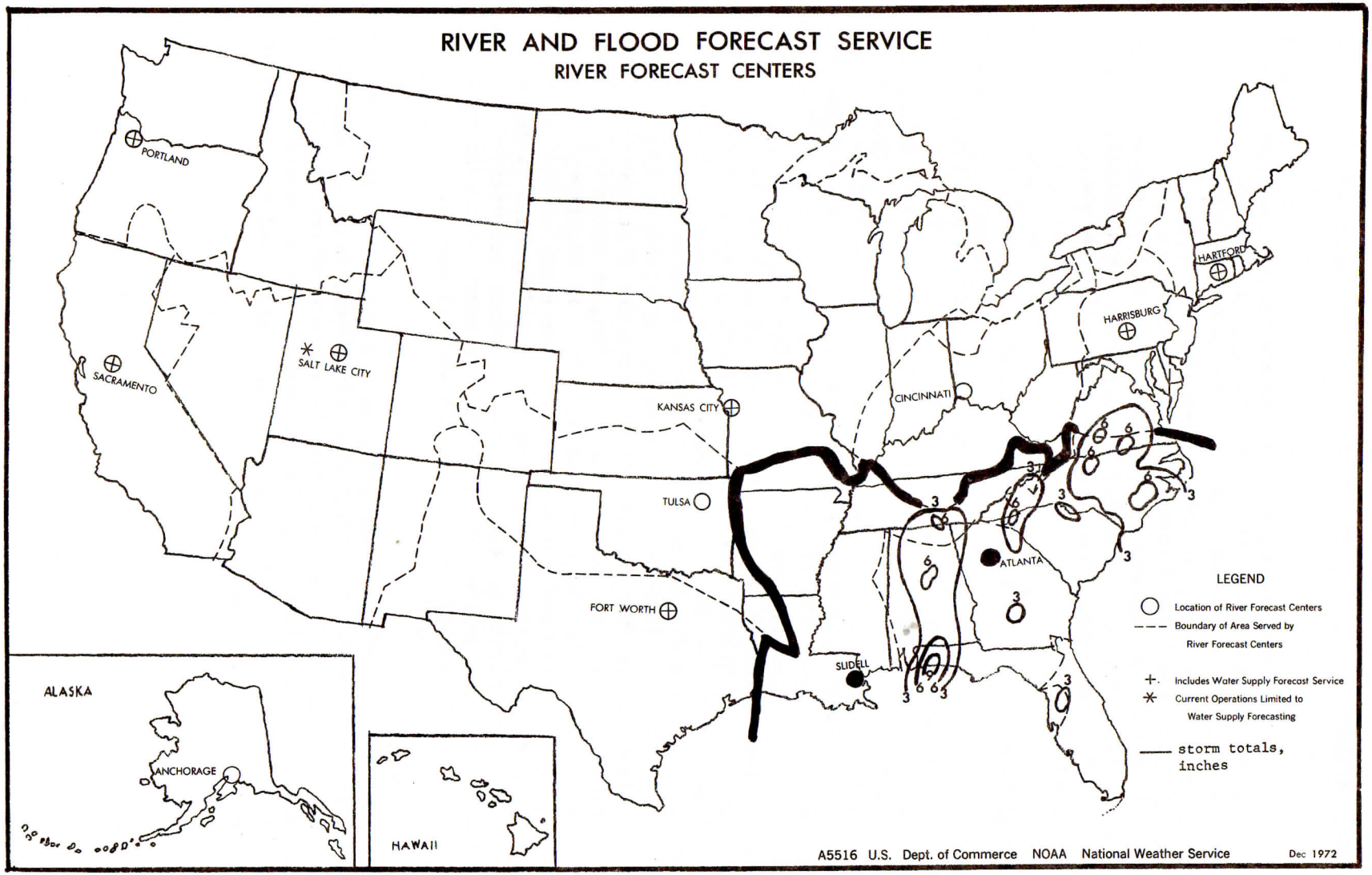

FIGURE 1--PRELIMINARY STORM TOTALS FROM ELOISE IN SLIDELL AND ATLANTA RFC AREAS FOR PERIOD 22 - 26 SEPTEMBER 1975

THE WARNING SYSTEM

An evaluation of the total hurricane warning system must include an assessment of several vital links, extending from effective monitoring through forecast and advisory preparation to dissemination and, finally, to a proper public response to the threat. Cementing the first three of these links are such internal NWS factors as readiness, communications, and coordination. Public education and community preparedness are necessary factors to fasten the final link. This section will discuss these links and factors.

NWS Readiness, Communications, and Coordination

Recognizing the need for readying the NWS offices for a hurricane threat, the Southern Region Headquarters took a number of decisive early steps. Among these were the temporary assignment of personnel to augment staffs at Pensacola (2), Apalachicola (2), Mobile (2), Birmingham (1), and New Orleans (1). These assignments were made early on September 22 and personnel were on the job by late that afternoon. (Earlier in the life of the hurricane, electronic technicians had been dispatched to San Juan and to Key West.) The River Forecast Centers in Slidell and Atlanta went to a 24-hour operation, starting at 10:00 p.m. Sunday, September 21, at Slidell and 10:00 p.m. Monday, September 22, at Atlanta. These offices made advance preparation to cope with a storm which had already taken lives by flood in the Caribbean. At Slidell, this preparation amounted to running through the computer (for field office guidance) varying amounts of rainfall, ranging up to 12 inches (305 mm), for 12- and 24-hour periods. In addition, the Slidell RFC had made advance arrangements for transfer of computer forecast operations to the NASA facility (Marshall Space Flight Center) at Huntsville, Ala., should it become necessary. At Atlanta, data files on the IBM 1130 computer were updated so that the 1130 could be used in case the IBM 360/195 was not available.

Both the Southern Region and Eastern Region Headquarters began manning of round-the-clock Hurricane Operations Centers to coordinate the flow of hurricane information among the various offices and the National Headquarters. Central Region Headquarters made several coordinating calls to its offices as the storm approached the eastern sections of its area.

Internal communications worked very well during the storm threat. No problems were noted with the RAWARC circuit, the other teletypewriter circuits (Service A and C), or the facsimile circuits. Particularly important in the coordination function was the hurricane hot line telephone which connects NHC, NMC, and key WSFOs in the south and east. This hot line also gives Southern Region and Eastern Region Headquarters the opportunity to monitor the situation. Coordination was quite effective through most of the storm period. The only possible exception occurred when the storm became extratropical on Tuesday afternoon, the 23rd. In this instance, the NHC passed off the responsibility for the storm to the Storm Coordination Center in Chicago without speaking directly with that office. Chicago was ready and no apparent problems resulted, on this occasion. The only additional function a WSFO has as an SCC is to prepare the storm summary.

Monitoring

Aircraft reconnaissance, satellite imagery, buoys, land-based radars, and surface reports all contributed to excellent monitoring of Hurricane Eloise in the Gulf of Mexico. Figure 2 shows the center positions as determined by the various monitoring systems. Table 1 gives the times and positions of the center fixes from reconnaissance and satellite. (Satellite positions given are those provided the NHC forecaster by the SFSS*; in addition, half-hourly satellite pictures were available to the forecaster through the life of the storm.) The difference in positions comes about because the reconnaissance positions are generally centers of lowest pressure, the satellite centers are either circulation centers or eye centers as seen from the cloud tops, and the radar centers are the centers of the precipitation echoes in the wall cloud surrounding the eye. These centers, which may or may not coincide, provide the hurricane forecaster with a set of complementary indicators for monitoring the location, intensity, movement, and structure of the storm.

As noted in Figure 2, one reconnaissance position was in error and later corrected. The erroneous position was transmitted from the aircraft in a preliminary data message and contributed to some problems, as will be discussed in the next section, before the complete observation was sent with the correct position. Except for this bad position, aircraft reconnaissance was considered excellent as the storm moved from Yucatan to the Florida panhandle.

There are sometimes uncertainties in satellite center positions due to the structure of the storm at any given time or to occasional problems with picture registration (the alignment of the satellite

*Satellite Field Service Stations

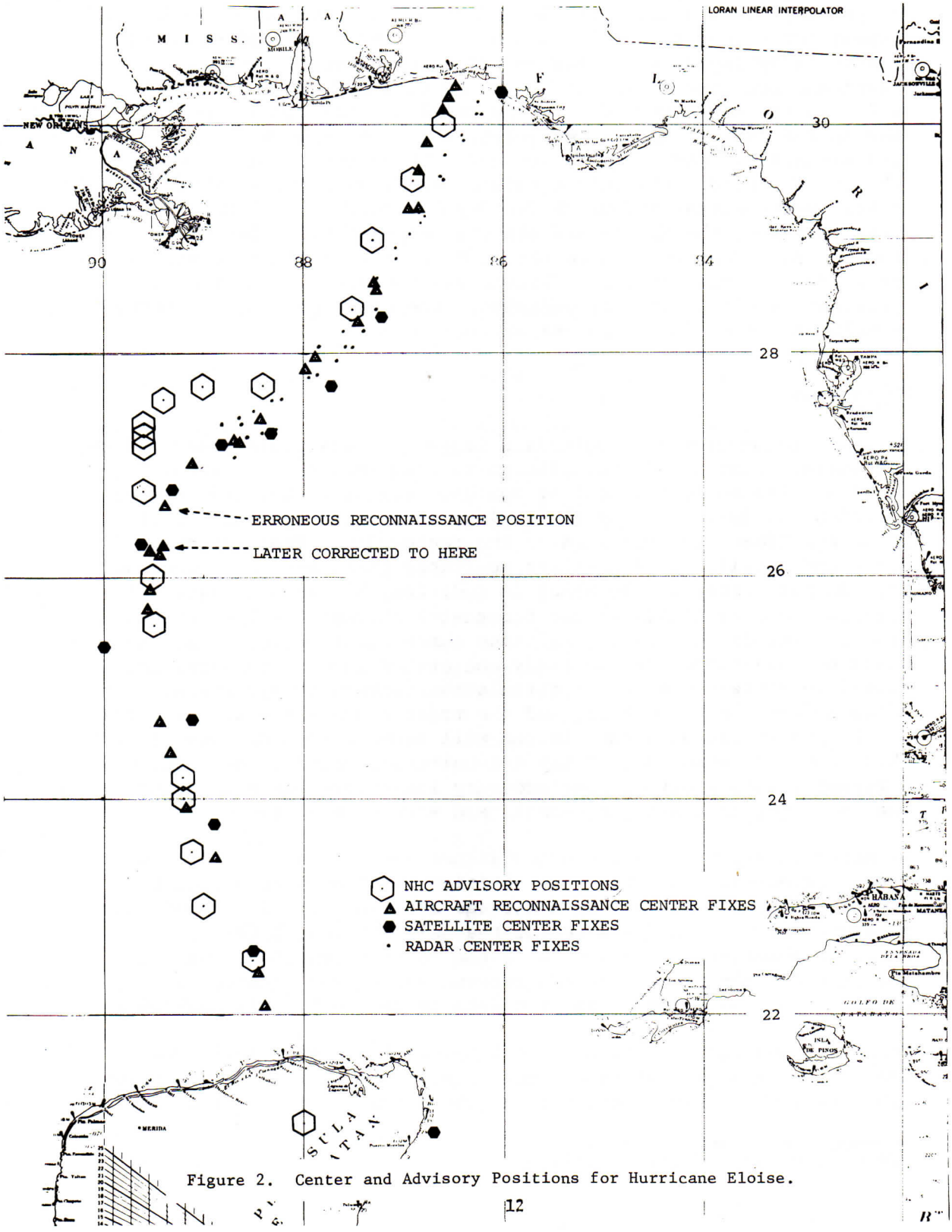

Figure 2. Center and Advisory Positions for Hurricane Eloise.

	RECONNAISSANCE		SATELLITE			
TIME	POSITION		POSITION		CONFIDENCE LEVEL	ESTIMATED MAX WIND
21/0730CDT			20.9N	86.7W	5	35K
1102	22°04'N	88°23'W				
1235	22 23	88 28				
1330			22.6	88.5	3	40
1915	23 27	88 53				
1930			23.7	88.9	3	45
2037	23 55	89 10				
2230	24 25	89 20				
22/0005	24 40	89 25				
0130			24.7	89.1	5	55
0533	25 44	89 33				
0700	25 54	89 32				
0730			25.4	90.0	3	65
0900	26 12	89 27				
1000	26 14	89 37				
1030			26.3	89.6	1	77
1210	26 45	89 22 (Erroneous)				
1210	26 17	89 25 (Corrected)				
1330			26.8	89.3	1	83
*1553	27 02	89 06				
1730			27.2	88.8	1	83
*1817	27 14	88 38				
*1845	27 15	88 41				
1930			27.3	88.3	1	90
*2004	27 26	88 26				
2145	27 51	87 58				
2220	27 58	87 53				
2230			27.7	87.7	1	102
23/0002	28 17	87 27				
0106	28 33	87 15				
0130			28.3	87.2	2	102
0155	28 38	87 17				
0321	29 15	86 56				
0404	29 15	86 50				
0439	29 36	86 50				
0519	29 51	86 45				
0604	30 08	86 36				
0634	30 14	86 32				
0702	30 20	86 27				
0730			30.3	86.0	1	102

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*NOAA Aircraft, remainder of reconnaissance performed by Air Force

CONFIDENCE LEVEL FOR SATELLITE FIXES

1 Well defined eye; certain picture registration
2 Well defined eye; uncertain picture registration
3 Well defined circulation center; certain picture registration
4 Well defined circulation center; uncertain picture registration
5 Poorly defined circulation center, certain picture registration
6 Poorly defined circulation center; uncertain picture registration

TABLE 1 . Reconnaissance and Satellite Center Positions

imagery with the proper location on the earth's surface). As seen in Table 1, most of the satellite positions were assigned a high degree of confidence while the storm was in the Gulf of Mexico.

Hurricane Eloise marked the first time that two of NOAA's large experimental data buoys were located in or near the path of the eye of a hurricane. The center of the storm passed near EB-04 (anchored at 26.0N 90.0W) about 9:00 a.m. on September 22, and over EB-10 (27.5N 88.0W) at 9:00 p.m. the same day. Both buoys continued to operate satisfactorily through the passage of the storm and furnished valuable surface meteorological data on an hourly basis to NHC and NMC. Figures 3 and 4 show plots of preliminary measurements made by these buoys. It can be seen that EB-10 measured wind speeds of over 35 m/sec (78 mph) with a decided lull at eye passage.

Long-range weather radars at Slidell, La., and the Florida offices at Pensacola and Apalachicola provided a continuous monitoring of the "precipitation eye" center as the storm neared the coast. No problems were noted with this equipment. However, the NHC did report trouble obtaining a telephone line into the remote read-out (WBRR) from these sets. The outdated WSR-3 local warning radar at WSO Mobile was out of commission from 7:00 p.m. CDT on September 20 until 3:30 p.m. CDT on the 23rd. The electronics technician was called back to the station from a course being given on the new radar scheduled for installation at Mobile. He arrived back on station early Monday afternoon and repairs to the equipment required more than 12 man-hours of labor. Conceivably, this could have led to problems had the storm moved into the Mobile area. In addition, Mobile's WBRR receiver went out of operation at 12:30 a.m. on the 21st, but was repaired by 11:00 p.m. on the 22nd.

There also were some deficiencies noted in reporting from the river and rainfall network during the hurricane. Not all reasons for this have been determined, but in one instance illness in the home of the observer was cited. Only partial data was received from Eglin Air Force Base after the rainfall measuring equipment became inoperative. Other reports were missing or incomplete because of telephone line outage from winds.

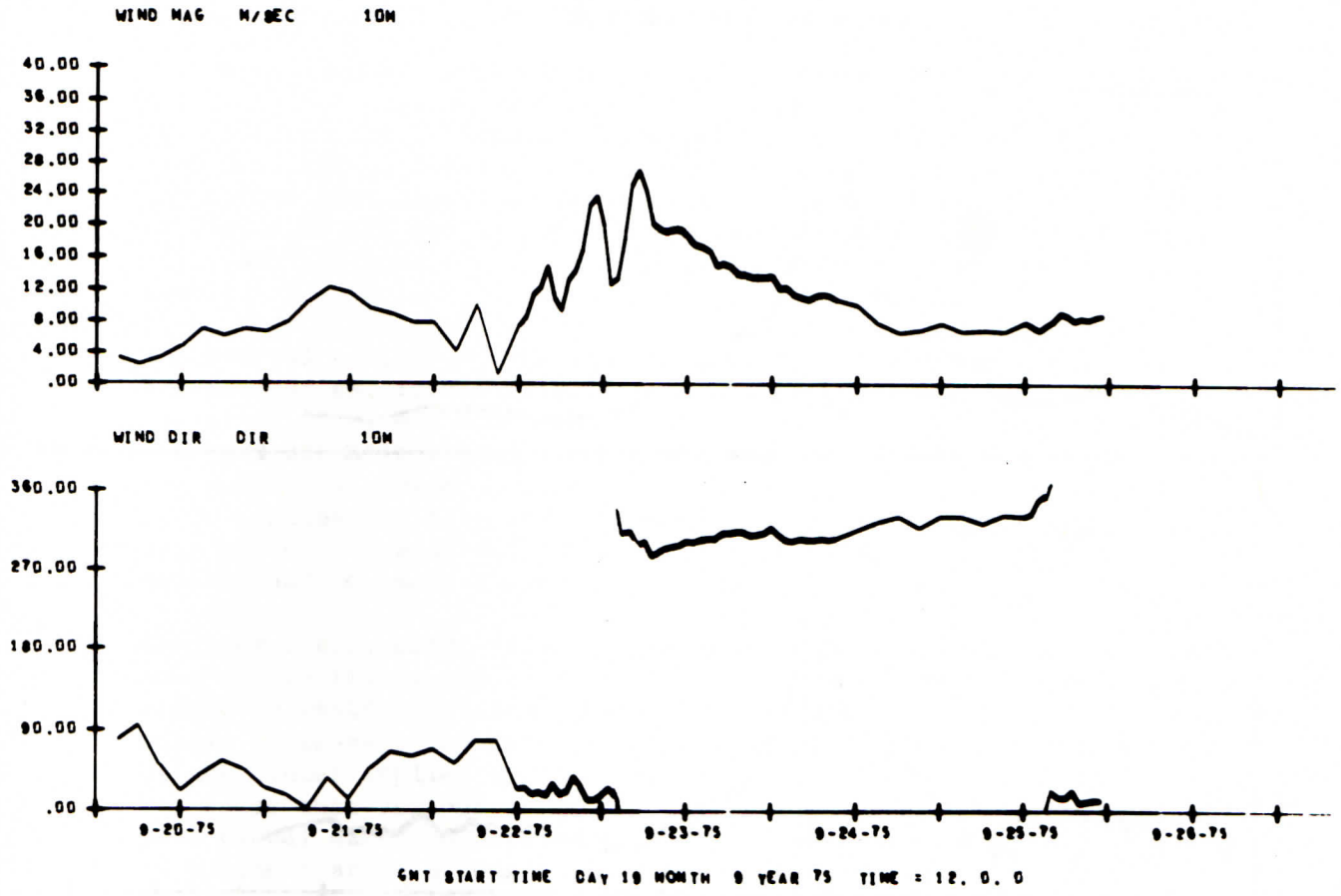


Figure 3. Ocean Data Station - EB04

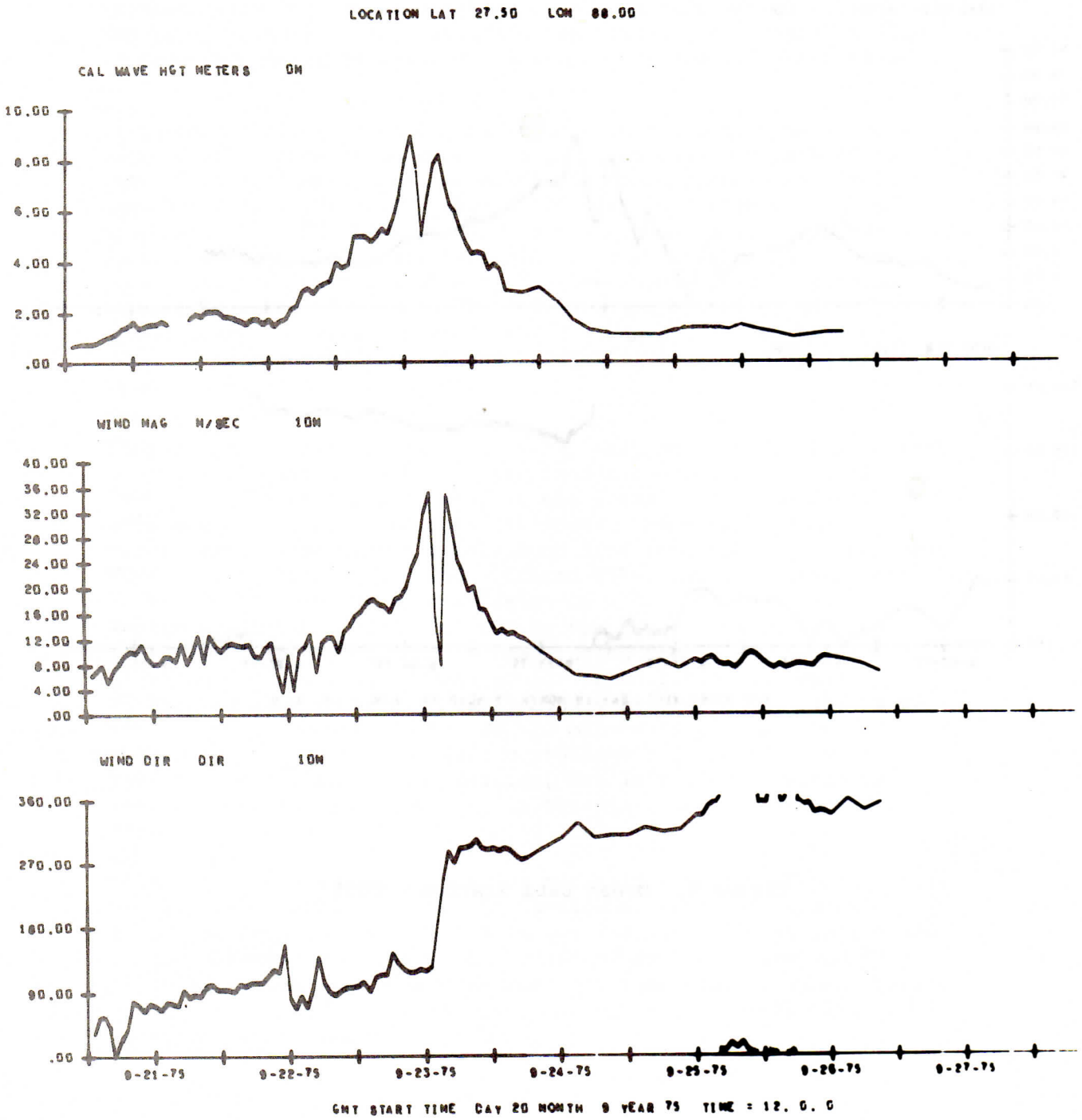


Figure 4. Ocean Data Station - EB10

Forecast and Advisory Preparation

The NHC issued 33 numbered advisories over the life of the storm. In addition, intermediate 2-hourly messages were sent beginning at 9:00 a.m. CDT on Monday, September 22 and continuing until 9:00 a.m. CDT on Tuesday, the 23rd. Hurricane warnings were issued for the coast from Grand Isle, La., to Apalachicola, Fla., at 7:00 a.m. CDT on the 22nd, and extended eastward to Cedar Key, Fla., at 1:00 a.m. CDT on the 23rd. No hurricane watches were issued.

The overall quality of these advisories was considered excellent. Two advisories, issued after the turn from north to northeast, contained incorrect distances of the center position from Pensacola, and some attention should be paid to such details in the future. One scheduled advisory (1:00 a.m. CDT on the 23rd) was delayed 25-30 minutes due to changes resulting from the latest available data which indicated relocation of the position, storm intensification, and movement toward the Panama City area.

The team feels, after talking with many people in the hardest hit area and reviewing the advisories, that too much emphasis is being placed on center positions (both observed and forecast) in our public releases. The wording describing the "current" position of the center implies a pin-point accuracy which doesn't exist. The facts that various types of centers (pressure, wind circulation, wall cloud) exist in hurricanes and have hour-by-hour irregularities in movement argue strongly against such accuracy. In addition, the "current" position given in our advisories is frequently a one to two hour forecast since lag times do exist in getting observed positions to the forecaster.

The 24-hour landfall forecast for the center of the storm was 63 miles (101 km) in error, which is within current capabilities. We warned an extensive area of coastline to expect hurricane conditions 24 hours in advance, and yet emphasized in advisory after advisory that a smaller section would get the center. This apparently lulled part of the public into a false sense of security.

As noted in Figure 2, advisory center positions strayed a significant distance from the track as observed by reconnaissance and satellite on Monday afternoon, the 22nd. The erroneous reconnaissance position contributed to this, but it may be that existing practices in regard to highlighting the center position also played a part. The forward movement of the storm, which had been about

15 mph (24 km/hr) for a number of hours, slowed considerably on Monday morning. It was felt by the forecaster that the storm would resume a faster northward speed, and when the bad position report was received, it appeared that this had begun. When the corrected report arrived, about 10 minutes after the advisory was released, the forecaster was faced with a dilemma. It was decided that it would be better to slow the northward speed on subsequent advisories and "wait for the storm to catch up" than to relocate the center and risk confusing the public with an apparent southward movement of the storm. This strategy failed when the storm changed course. Eventually the advisories came closer to reflecting the observed positions. (The deceleration noted above also contributed to uncertainty in timing the landfall of the center. Advisories released through most of the day on Monday indicated landfall could occur as early as the evening hours.)

As mentioned earlier in the report, the storm tide and wave action caused much of the damage with Eloise. Our advisories forecast tides of 10 feet (3.0 m) above normal. Estimated peak tides around 12 feet (3.7 m) above mean sea level occurred with wave action on top of these tides leaving evidence of debris over 18 feet (5.5 m) above mean sea level at two locations on the coast. The SPLASH model computations performed by NHC during the storm gave a maximum surge of only 5.8 feet (1.77 m). In post-analysis runs of the model used during the storm and more advanced models, the maximum was still less than 10 feet (3.0 m). The reasons for the discrepancies between forecast and observed conditions appear at this time to be related to the complexity of the bottom topography and the lack of consideration of the wave run-up effects. Further work on forecasting storm surge is needed.

Public forecasts gave little or no warning of the damaging winds which persisted near the storm center as it moved into eastern Alabama and northwest Georgia. Examination of the marine/aviation advisories issued by NHC on September 23 indicates a need for better techniques to predict the movement and rate of weakening of tropical storms as they move inland. However, the advisory issued at 5:00 a.m. that morning did forecast the storm center to be 60 miles (97 km) east of Montgomery, Ala., at 1:00 p.m. CDT with maximum sustained winds of 90 mph (145 km/hr). This was much higher than the winds included in the public forecasts. Efforts should continue to insure consistency between forecast products. The maximum rainfall predicted following landfall was 5 to 10 inches (127 to 254 mm) and this verified fairly well. However, it fell over a much smaller area than expected and flooding in the southeastern states was minimal.

The river forecasts issued by the RFCs at Slidell and Atlanta were reasonably good, except the initial forecast for flood crest at Milligan, Fla., was 3 feet (.9 m) too low due to lack of data. However, this forecast was revised by Atlanta 36 hours before the crest and verified within three-tenths of a foot (.09 m). A five-foot (1.52 m) overflow on the South Chickamauga Creek in southeast Tennessee was forecast within one-half foot (.15 m) by Slidell RFC.

Local action statements were issued by Pensacola (12 plus one tornado warning), Apalachicola (15), Mobile (13 plus one tornado warning), New Orleans (10), Tampa (six plus a special marine warning bulletin), Montgomery (three plus three tornado warnings, two severe thunderstorm warnings, and a special weather statement), and Tallahassee (five plus a severe weather statement). The overall quality of these products was outstanding and reflected the readiness drills which these offices had conducted.

As a rule, local action statements also reflected close coordination with local Civil Defense directors as to areas in which evacuation or relocation was recommended. Such recommendations came as early as 7:30 a.m. CDT on Monday in Louisiana's St. Bernard Parish and by early Monday afternoon such actions were underway as far east as Escambia and Santa Rosa Counties in Florida. Relocation from the coastal sections of Okaloosa, Walton, and Bay Counties in Florida was recommended in a local action statement at 9:45 p.m. CDT on Monday evening. Similar recommendations were made for portions of Gulf County at 9:00 p.m. EDT and for Franklin County at 11:00 p.m. EDT. Following extension of the hurricane warning eastward to Cedar Key, evacuation was advised at 3:30 a.m. EDT for coastal sections of Wakulla, Jefferson, Taylor, and Dixie Counties.

Not all offices followed directives requiring special handling of tornado threat during hurricane situations. This problem was discussed at the NWS Severe Local Storms Conference in October. Existing directives seem adequate and should be followed.

Dissemination

Dissemination channels in use by our warning offices were the NOAA Weather Wire Service (NWWS); NOAA Weather Radio (NWR) in New Orleans, Mobile, Pensacola, Panama City, and Atlanta; and DCPA's National Warning System (NAWAS). Investigation revealed these systems were operative except for (a) line outages on the NWWS at Pensacola

(briefly after landfall) and Ft. Walton Beach Emergency Operations Center (power loss at 5:00 a.m. CDT on the 23rd), and (b) outage of the NWR remote transmitter at Panama City between 1:30 p.m. and 8:00 p.m. on Monday, the 22nd, and from 5:30 a.m. CDT Tuesday until Wednesday evening, the 24th. The Monday outage was attributed to land-line problems between our Pensacola office and the transmitter in Panama City. The outage beginning on Tuesday was due to both power and land-line outage. The problem with land-lines is reportedly recurrent in that area. As mentioned later in the report, NAWAS proved invaluable during the hurricane.

With the exceptions noted above, the NWWS and NWR contributed significantly to the dissemination. Drops on the Florida NWWS in the coastal area include four in Panama City (Civil Defense, two television stations, one radio station--other radio stations rebroadcast NWR); five in Ft. Walton Beach (City Civil Defense, County Civil Defense, Cable TV station, two radio stations); and ten in Pensacola (including Civil Defense, Gulf Power, six radio stations, and a newspaper).

The citizens of the area were better informed by the news media than ever before. Radio and television kept up a steady barrage of information--the bulletins, advisories, notification of available shelters, school closings, hurricane safety rules, interviews, film clips of Camille, and a constant flow of local action statements and updates from NWS offices at New Orleans, Mobile, Pensacola, and Apalachicola. Television and radio crews worked out of Weather Service Offices and Emergency Operating Centers all along the upper Gulf Coast. Interviews with key weather and safety officials provided the latest authoritative advice.

The tremendous role broadcasters played in informing and educating the public can't be stressed enough. Radio was relentless all day Monday. And when the viewing public switched to television in the late afternoon and evening, it was TV's time to shine. Those who claim television hasn't lived up to its informational and educational potential will get the strongest arguments from the residents of the Gulf Coast. Television's role as a news medium in covering the hurricane as a spot news event was unequaled. Its handling of Eloise was done with great effectiveness. It informed. It educated. It motivated. It got people to believe and to act. It was "prime time" for TV when advisories began stressing the growing threat for the eastern section of the Florida panhandle. There were three major broadcast television stations serving the

Panhandle: Channel 3 in Pensacola; Channel 7 in Panama City Beach; and Channel 13 in Panama City. Channel 6, a Cable TV station located in Ft. Walton Beach and a program-originating station of the Warner Cable Company, also played a key role. These stations had most of the population watching. Monday night football was on ABC's Channel 7. About 15-20 minutes of every hour was devoted to the weather advisories, interviews, and updates. Announcements that a decision was forthcoming on whether total evacuation would be ordered kept viewers from going to sleep and tuned to TV or radio.

Even with the outages noted with NWWS and NWR, it must be concluded that dissemination was very effective with this storm.

In our discussions with the TV interests, the need for more frequent statements of some kind between scheduled releases became evident. As the storm approaches, the media wants to have as much up-to-date and authoritative information as possible even, for example, if it's only confirmation of the storm's movement based on the latest radar indications or other available data.

Public Education and Community Preparedness

Before the hurricane season, preparedness conferences are held by National Weather Service Offices with warning responsibilities along the hurricane-vulnerable Gulf and Atlantic coasts. All county/city officials with responsibilities in public safety take part in the conferences as well as news directors representing radio and television in the multi-county areas.

The meetings are called to update preparedness plans and coordinate communications systems. They are also presented to create public awareness of the hurricane threat and to enlist the help of the news media in a continuing educational effort.

One of the several such conferences held this year was a joint Mobile-Pensacola meeting held June 18, 1975, at Mobile. More than 100 officials and broadcasters representing all the coastal counties in Alabama, Mississippi, and western Florida attended this meeting. Interest and enthusiasm ran high. Ray Barnes, Meteorologist in Charge of the Mobile Weather Service Office opened the meeting by declaring:

"The most sophisticated warning systems are of no benefit if the users are not aware of the meaning of the warning and the measures that must be taken to protect themselves. A community is never better prepared than its individual citizens. Public awareness and education is the keystone to hurricane preparedness."

Phyllis Polland, MIC of the Pensacola WSO, described local procedures and communications to be employed during the coming season.

Another big factor in the success of the Eloise warning operation was the series of workshops conducted by Dr. Neil Frank and the NHC staff with the coastal WSOs which have warning responsibilities. The teamwork reflected in the issuances of advisories, bulletins, local action statements, and constant updates showed the tremendous value of those workshops.

More than 325,000 NOAA brochures, pamphlets, safety rules, posters, and miscellaneous information on hurricanes were distributed to people along the coasts by NWS and Civil Defense.

Radio and television public service announcements produced by NOAA and the Red Cross received wide distribution before the season. DCPA's film "A Lady Called Camille" continued to receive wide acclaim and was replayed by many TV stations as well as shown to countless community groups.

Dr. Neil Frank spoke at nine of the coastal hurricane preparedness conferences including the Mobile-Pensacola meeting. He ended his slide presentation with these prophetic words and plea:

"There's absolutely no reason for loss of life in hurricanes if proper preparedness plans are developed and people react to the warnings and advice.

We need your help to make the citizens of this community aware of the hurricane threat. Let's substitute a little education for experience."

Governor Reubin Askew of Florida declared the week of July 6, 1975, "Hurricane Preparedness Week." Teams of State and county disaster preparedness and Red Cross officials and Dr. Frank conducted seminars in four key Florida cities including Panama City.

While in Panama City, Dr. Frank was interviewed in depth by the Panama City News Herald and Channels 7 and 13. Channel 13 broadcast the taped interview in five parts, playing it on both the 6:00 p.m. and 10:00 p.m. news slots over a one-week period before the season.

On Monday, the day before Eloise hit, Channel 7 repeated its unedited version of the Dr. Frank interview at noon, at 6:00 p.m., and again at 10:00 p.m.

Another valuable plan that was implemented during Hurricane Eloise is the Emergency Hurricane Information Center (EHIC) concept operated by the National Weather Service. It is a means of augmenting the staffs of the coastal stations to insure continuous flow of hurricane information to press, radio, and TV. Southern Region Headquarters assigned two specialists to both Pensacola and Apalachicola for that purpose.

In the area of community preparedness, it must also be noted that storm evacuation maps were not available for the section of the Gulf coast hit by Eloise. The program to provide these maps to all areas of potential evacuation is not scheduled for completion until around 1987. While the lack of such maps apparently had little adverse effect in this storm, an assessment should be made as to the need for accelerating this program.

Public Response

The public education and community preparedness efforts described above paid off in Eloise. When the NHC posted hurricane warnings over a 325-mile (523 km) stretch of coast from Louisiana to Apalachicola, Fla., early Monday morning, Eloise was still some 200 miles (322 km) and more than 24 hours from landfall. But that was all that was needed for Civil Defense directors, law enforcement agencies, the Red Cross, and other state, county, and local agencies involved in disaster work to go into action. It was a conditioned response, too, for the people along the hurricane-vulnerable Gulf coastline. It's estimated more than 100,000 people from south of New Orleans to Apalachicola left their homes for safer shelter. In Louisiana, Mississippi, and Alabama, people took action early. Evacuation for the most part was completed before sundown on Monday. Shelters had been opened by late morning and most schools had closed.

It had been more than six years since the most devastating North American hurricane of all time rammed into the Mississippi coast with its catastrophic effects felt all along the Gulf Coast. It's the vivid memory of Camille that makes residents along the coast respond today. They take hurricanes seriously. It's the lessons of Camille that dominate the actions of those who have the community warning responsibilities. Last year Hurricane Carmen tested the system and 75,000 people fled from its path. But Carmen, a powerful hurricane, lost its power just before landfall and destruction was fortunately minor. Local Civil Defense officials worried that the experience with Carmen would lead to complacency. It didn't.

It wasn't Louisiana, Mississippi, and Alabama that worried most people. It was the Florida panhandle. When landfall near Fort Walton was forecast Monday night, Wade Guice, head of Civil Defense for Hamilton County, Miss., and often called the "hero of Camille", made this dire prediction: "150 deaths." The Fort Walton area hadn't had a major hurricane in about 40 years. Bay County to the east hasn't had a direct hit by a major hurricane this century. The same respect for a hurricane that grew from experience west of Pensacola was largely absent along the Panhandle.

But the story of Camille told over and over again was apparently effective. Jay Mills, Civil Defense Director for Bay County, said 50 percent of the people had left their homes before Eloise made her turn to the northeast and the remainder of the residents were evacuated. Evacuation was total and orderly.

At Ft. Walton Beach, Okaloosa County Civil Defense Director, Tom Nichols, had opened his Emergency Operating Center as early as the previous Friday when Eloise posed no threat at all. Like Mills, Nichols shared the concern about the reaction "of his people" to the threat of the hurricane. "More than 90 percent of Okaloosa residents never experienced even fringe effects of hurricanes." Yet 80 percent went to designated hurricane shelters early on Monday. "About 10 percent waited until the winds started to blow and yelled, 'Come and get me'.", Nichols said. Nichols was perhaps in the hottest seat along the potential path. He relied almost exclusively on NWWS which performed well until it went out Tuesday morning. At the time, he didn't have NAWAS (it has since been installed). Ft. Walton Beach is over 40 miles (64 km) from the Pensacola NWR transmitter and more than 50 miles (80 km) from the remote transmitter at Panama City. He has been unable to receive NWR broadcasts. He was able to receive telephone calls and information was relayed to him from Florida's Western

Civil Defense Coordinator, Bob Smith. The NAWAS circuit proved to be extremely effective in this emergency since the Civil Defense Directors play such a vital decision-making role all along the coast. Dr. Neil Frank, Director of the National Hurricane Center, discussed aspects of Eloise with Civil Defense officials and NWS meteorologists over the Florida NAWAS line during the storm's critical stages. All found this use of NAWAS to be very effective.

When the survey team talked to people who had returned to their homes along the most devastated area from Ft. Walton Beach to Panama City Beach, we could find evidence of only a scattered few who, for one reason or another, chose to ignore the warnings. All were grateful and had only the highest praise for officials and broadcasters.

But one disturbing aspect kept cropping up in our discussions with the people. Apparently the stress on the location of the center of the storm and a certain point along the coast where the eye will go in leads to complacency among those who aren't exactly at that point. Phyllis Polland, MIC of WSO Pensacola, reached the same conclusion: "Originally the statement was made that the actual eye of the hurricane was going to hit this area (Pensacola). So they (the few who chose not to leave) decided it's not going to hit here (Dune Allen, 55 miles east of Pensacola). They don't listen to the next paragraph that says damaging winds extend a hundred miles eastward. They hear the one word that says the center is expected to hit Pensacola and that's all they hear." The problem may be compounded when a television weatherman indicates the center of the storm by a point reference and the landfall prediction by an arrow. This may cloud the fact that the area of extreme devastation may be about 50 miles in diameter and the entire storm's overall diameter may be 300 miles.

As a follow-up to evaluate public response, the NWS Southern Region is having a sociological survey conducted by the Mississippi State University. A statistical sampling will be made to determine how the public responded to our warnings, e.g., what they heard, where they heard it, what they understood, and what action was taken.

Photo Captions

Photos 1 through 4, PPI scope of radar at Apalachicola, Florida.

1. 0400 EDT, range 250 n.m.
2. 0445 EDT, range 250 n.m.
3. 0515 EDT, range 250 n.m.
4. 0730 EDT, range 125 n.m. (storm over land)

Photos 5, 6, and 7.

Damage along the beaches of Florida from wind and storm surge associated with Hurricane Eloise.

Photo 8

Eloise regains hurricane strength. Shown is half-mile resolution visible image from SMS-1 at 10:30 a.m. CDT on Sept. 22. Land features seen include Yucatan peninsula, Cuba, and portions of Florida and Texas coastlines.

Photo 9

Satellites provided round-the-clock coverage of the storm. This one-mile resolution visible picture was taken at 12 noon CDT on Sept. 22, and shows Eloise centered about 250 miles south of New Orleans.

Photo 10

This infrared image, with equivalent 1-mile resolution, was taken at 1:00 a.m. on Sept. 23 and shows the storm center nearing the Florida panhandle.

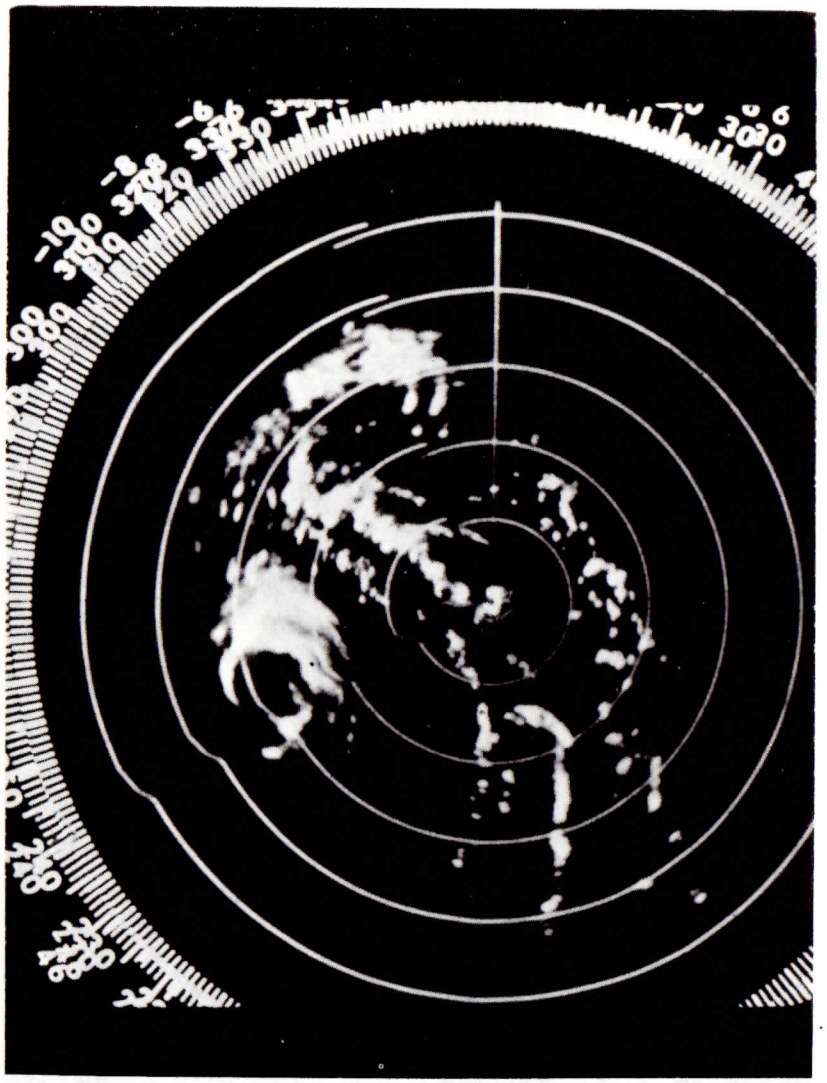


Photo 1

Photo 2

Photo 3

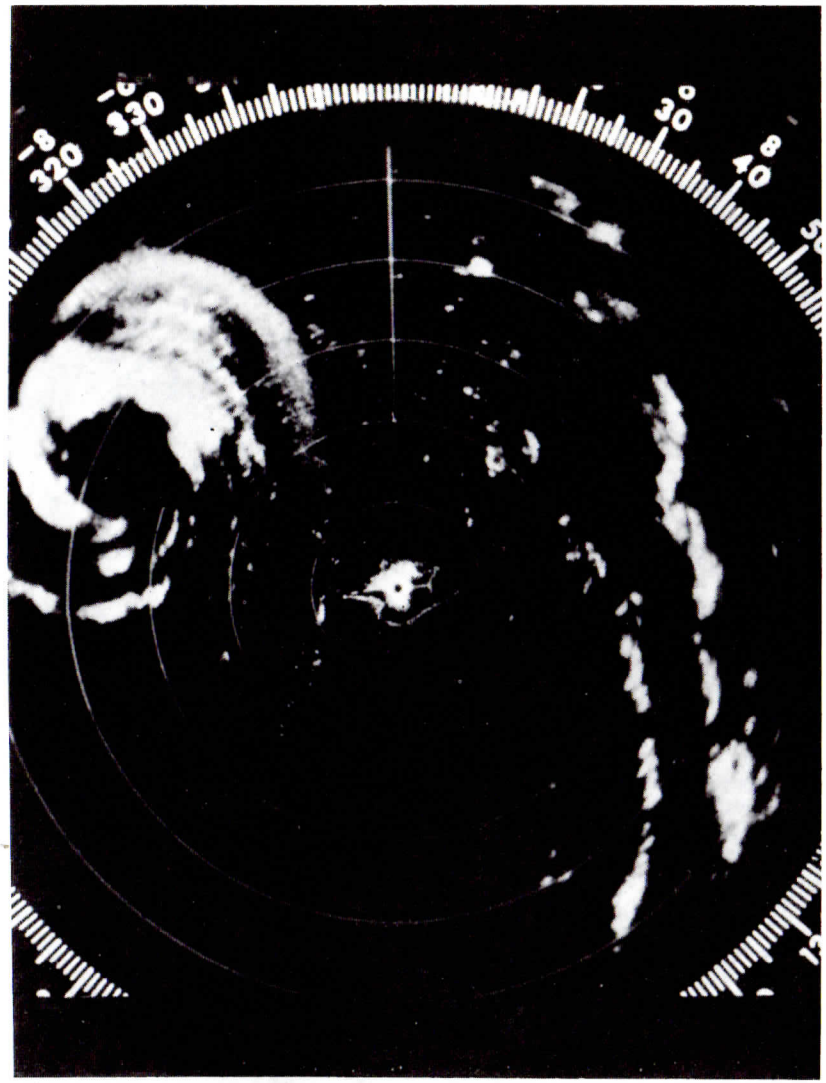
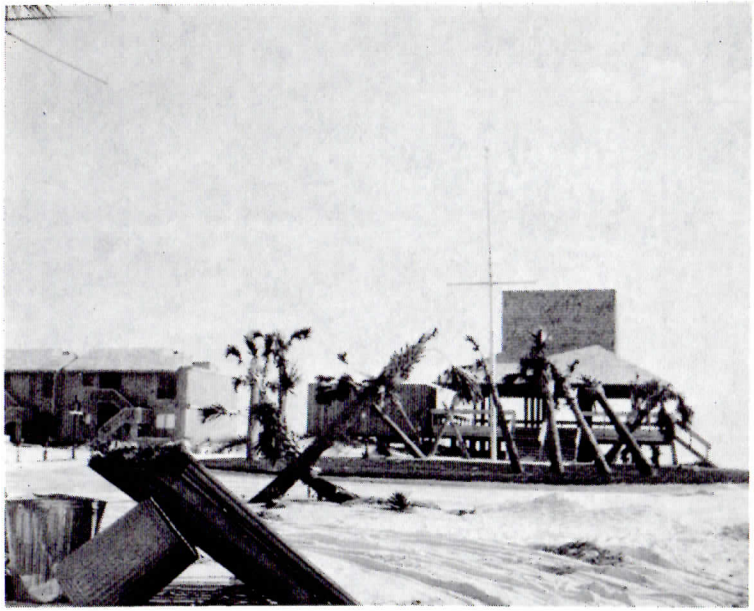
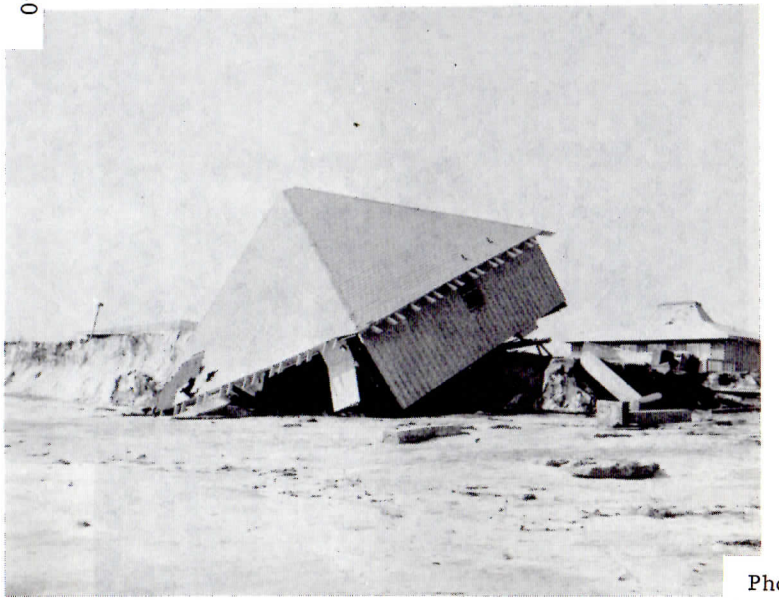


Photo 4

Photo 5





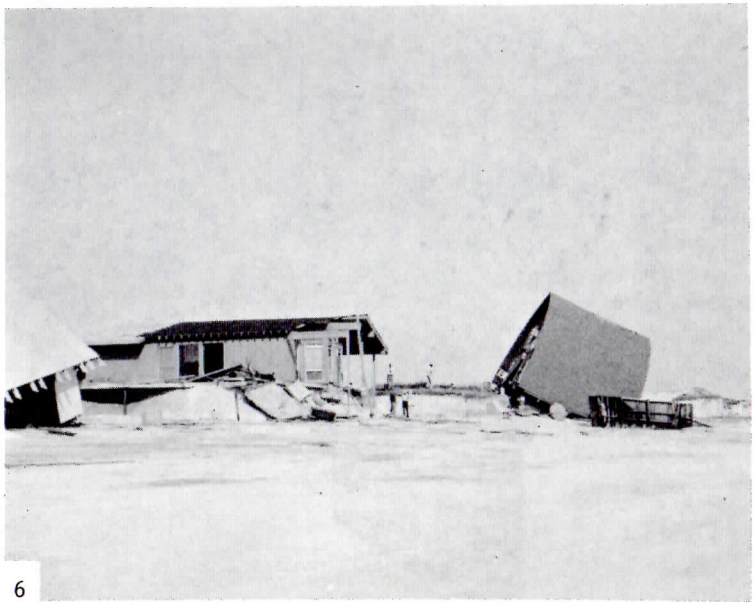


Photo 6

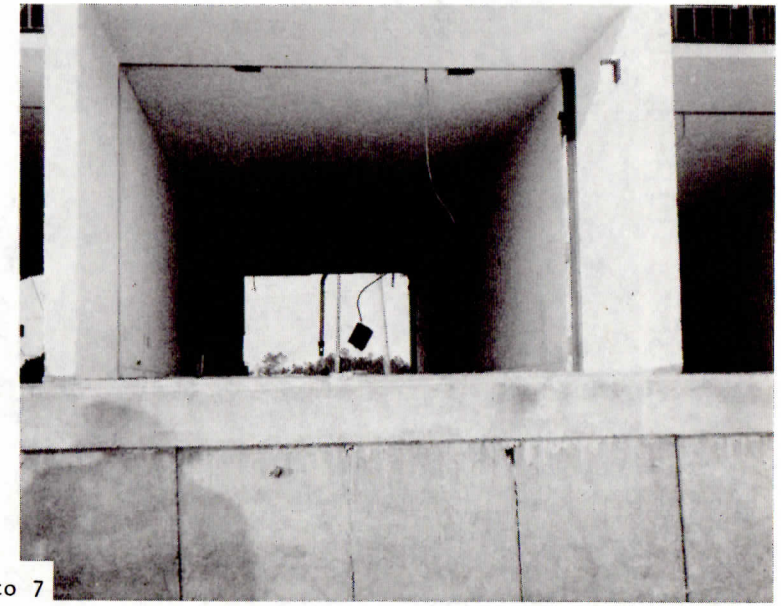
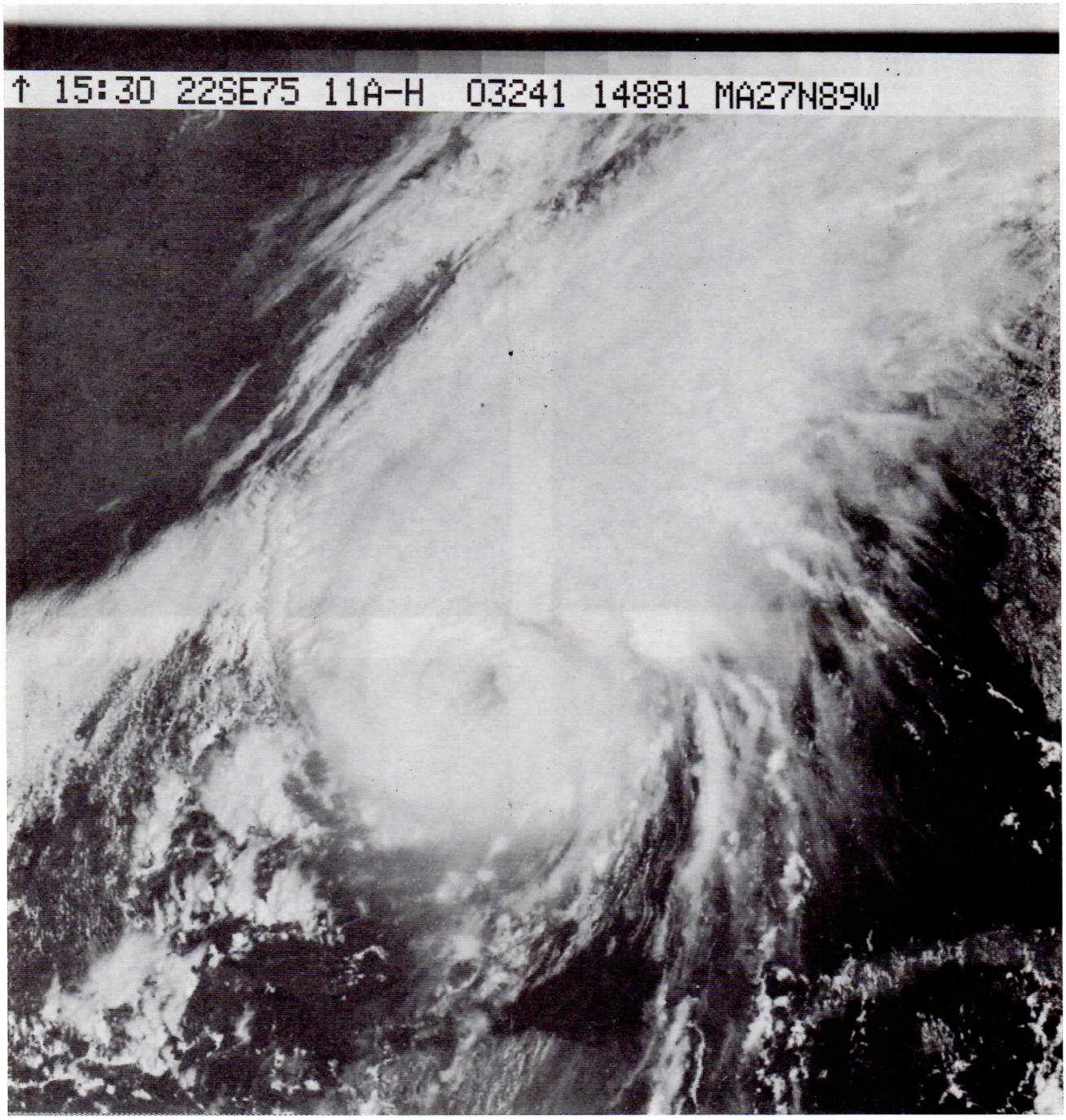


Photo 7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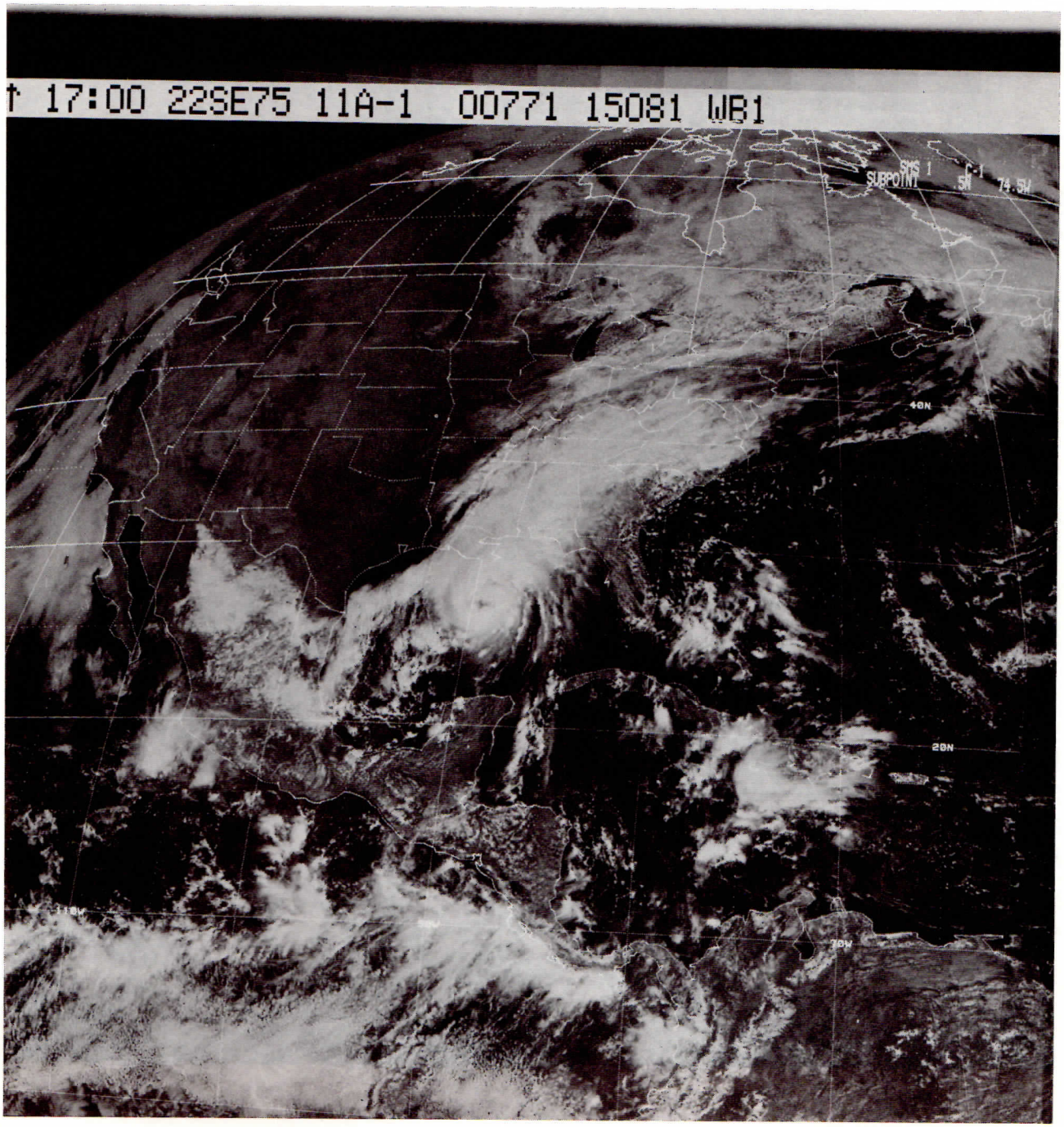
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SUBPOINT
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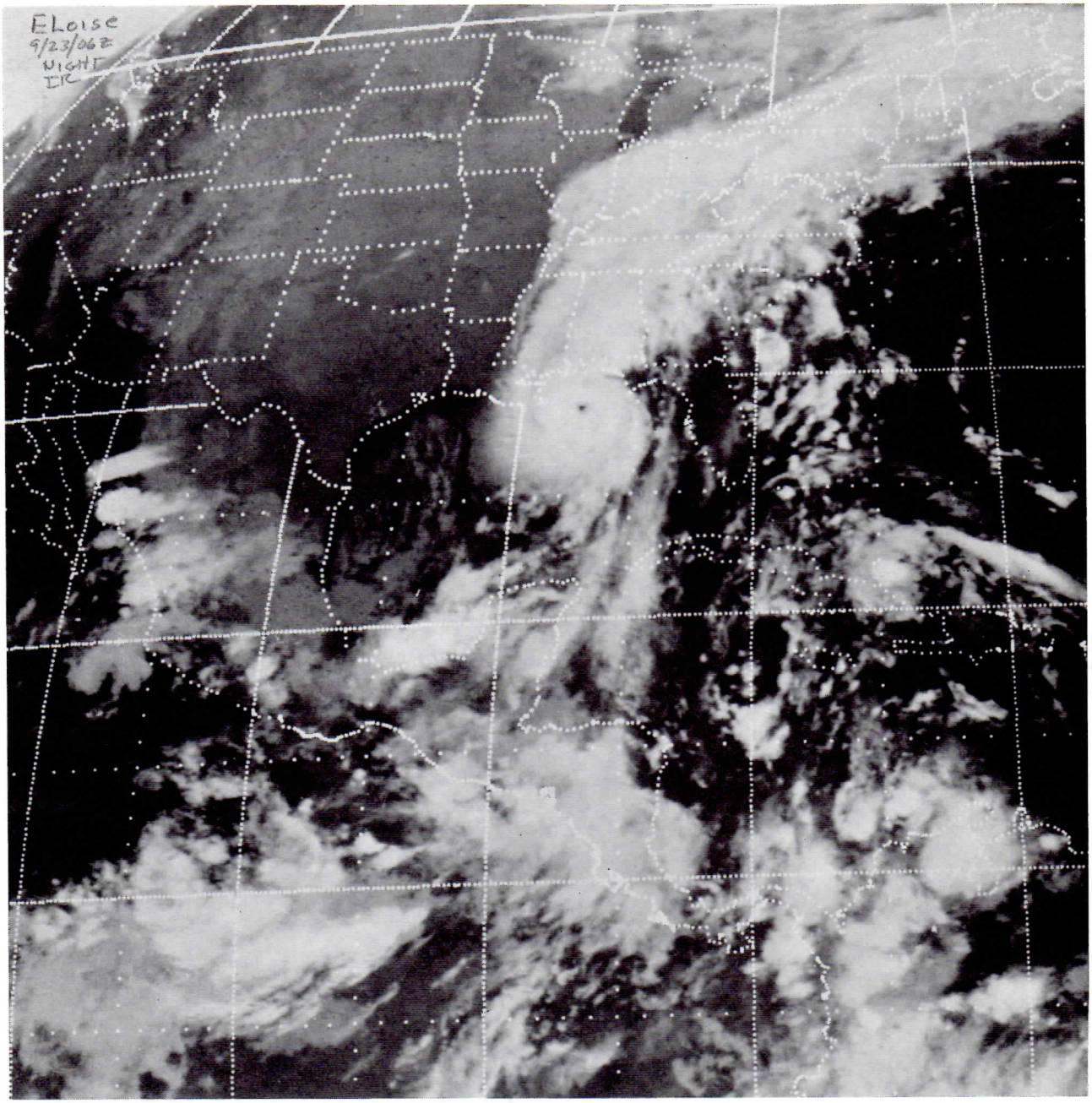
20N


Eloise
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