Eastern North Pacific Hurricane Season of 1996

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(Manuscript received 8 November 1997, in final form 2 March 1998)

ABSTRACT

The National Hurricane Center (a component of the Tropical Prediction Center) tracked nine tropical storms, five of which became hurricanes, during the 1996 eastern North Pacific hurricane season. Five tropical storms or hurricanes made landfall in Mexico. An overview of the 1996 hurricane season is presented.

1. Introduction

For the era of routine meteorological satellite coverage that began in 1966, the average numbers of tropical storms and hurricanes per year in the eastern North Pacific (from 140°W eastward and from the equator northward) are 16 and 9, respectively. In 1996, the National Hurricane Center (NHC, a component of the Tropical Prediction Center) identified nine tropical storms, of which five became hurricanes. For the 1966–95 period, only 1969, 1970, and 1977 had fewer hurricanes (four), and only 1977 had fewer tropical storms (eight). Not only were fewer eastern North Pacific tropical storms and hurricanes than average tracked in 1996, there were, uncharacteristically, fewer than observed in the Atlantic basin. Also, the tracks of most of the cyclones, as in 1995, were short and clustered near the southwest coast of Mexico. Five tropical cyclones, Hurricanes Alma, Boris, Fausto, and Hernan, and Tropical Storm Cristina, made landfall on the coast of Mexico. Two hurricanes, Douglas and Fausto, reached category 3 or higher status on the Saffir-Simpson Hurricane Scale (SSHS) (Simpson 1974) with estimated 1-min sustained winds of at least 50 m s^{-1}. A summary of 1996 tropical storm and hurricane statistics is shown in Table 1.

Section 2 briefly describes the database available to the NHC. Section 3 evaluates 1996 NHC forecast quality. Section 4 describes the season's cyclones and section 5 recaps the highlights.

2. Best tracks

The NHC tropical cyclone ''best-track'' database consists of a center position and two measures of intensity (the maximum 1-min sustained surface wind speed and the minimum sea level pressure).[1] The parameters are estimated at 6-h intervals. They are based on a poststorm analysis of data conducted by the NHC. The primary sources for the analysis are the National Oceanic and Atmospheric Administration (NOAA) Tropical Analysis and Forecast Branch (TAFB), the NOAA Synoptic Analysis Branch (SAB), and the Air Force Global Weather Center (AFGWC). These centers provided to the NHC real-time estimates of position and intensity by applying the Dvorak (1984) tropical cyclone analysis technique to imagery from the Geostationary Operational Environmental Satellites (*GOES-8* and *GOES-9*) and polar-orbiting satellites. A limited number of observations from ships and land stations supplemented these data. Radar reflectivity images provided to the NHC by the Servicio Meteorologico Nacional de Mexico proved to be another useful source of data. These radar images were received in near real time and were extremely useful in tracking storms near the coast.

Because best-track intensity values are mainly obtained from satellite analysis, there is greater uncertainty in estimating maximum wind speeds and minimum central pressures for tropical cyclones in the eastern North Pacific than in, say, the Atlantic basin. In the latter basin, measurements from aerial reconnaissance and more abundant surface reports are often available.

Figure 1 shows the 1996 tropical storm and hurricane tracks and indicates where these systems were located

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[1] Track and ''fix'' data are contained in the Annual Hurricane Diskette Data Tabulation, available from the National Climatic Data Center, Federal Building, Asheville, NC 28801. Additional observations are contained in NHC Preliminary Reports found on the NHC Internet home page at address http://www.nhc.noaa.gov.

TABLE 1. Eastern North Pacific hurricane season statistics for 1996.

Number	Name	Class[a]	Dates[b]	Maximum 1-min wind (m s^{-1})	Minimum sea level pressure (mb)
1	Unnamed	T	13–16 May	23	1000
2	Alma	H	20–27 Jun	46	969
3	Boris	H	27 Jun–1 Jul	41	979
4	Cristina	T	1–3 Jul	31	991
5	Douglas	H	29 Jul–6 Aug	59	946
6	Elida	T	30 Aug–6 Sep	28	994
7	Fausto	H	10–14 Sep	54	955
8	Genevieve	T	27 Sep–9 Oct	23	999
9	Hernan	H	30 Sep–4 Oct	39	980

[a] T: tropical storm, wind speed 17–32 m s^{-1}. H: hurricane, wind speed 33 m s^{-1} or higher.
[b] Dates begin at 0000 UTC and include tropical depression stage.

at tropical depression, tropical storm, and hurricane intensity.

3. NHC forecast accuracy

The NHC began operational forecasting of eastern North Pacific tropical cyclones in 1988. Every 6 h the NHC issues its ''official'' tropical cyclone track and intensity forecasts for periods extending to 72 h. The forecasts are evaluated using the track and intensity (5-kt resolution) dataset derived from NHC's poststorm analysis of all available information.

A track error is defined as the great-circle distance between a forecast position and a best-track position of the tropical cyclone center. Table 2 shows that the 1996 average official track errors were a little larger than the 1990–95 averages at 12 and 24 h, presumably because 1996 storms followed relatively erratic tracks rather than the more usual heading toward the west-northwest at near 5 m s^{-1} noted in other years. This is consistent with the observation that the CLImatology and PERsistence Model (CLIPER) had large departures for these forecast periods as well. The relatively few 48- and 72-h official forecasts had errors that were, on average, smaller than in 1990–95.

There are two intensity errors. One error is the difference between the forecast maximum 1-min wind speed and the best-track wind speed. A positive error means that the forecast wind speed is higher than observed and a negative error means that the forecast is lower than observed. The second intensity error is the absolute value of the error without regard to its sign. The sign of the error might be considered as a bias, whereas the absolute value represents the magnitude of its error. Table 3 shows that both the mean and the mean absolute average intensity forecast errors were close to the 1990–95 averages.

4. Tropical storms and hurricanes of 1996

a. Unnamed tropical storm (formerly Tropical Depression One-E), 13–16 May

The tropical storm formed about 1400 km to the south of the southern tip of Baja, California, likely from a tropical wave analyzed to have crossed Central America and northern South America on 8 May. The associated thunderstorm activity was limited and sporadic until early on the 13th when it expanded and became more persistent. A band of deep convection developed on the northwest side of the system that morning. Based on satellite analyses, it is estimated that the system became a tropical depression at 0600 UTC on 13 May. The cyclone moved toward the west-northwest at about 5 m s^{-1} during its 3-day existence and did not affect land.

There is uncertainty about the maximum intensity reached by this tropical cyclone. Operational estimates of 15 m s^{-1} were based on application of the Dvorak technique. Those analyses of satellite pictures showed little variation, ranging from 15 m s^{-1} by the AFGWC and the TAFB, to 18 m s^{-1} by the SAB. These maxima generally occurred on the early hours of 14 May, when a small core of deep convection developed in an environment with a southerly component of vertical wind shear. Subsequently, the U.S. Coast Guard relayed reports to the NHC from the vessel *Solar Wind* suggesting that the cyclone had maximum winds of tropical storm strength on the 14th.

Analysis of satellite pictures early on the 14th suggests that the *Solar Wind* was located in the general vicinity of an isolated thunderstorm cluster seen just north of the circulation center. The *Solar Wind* observed a wind speed of 18–22 m s^{-1} for an unspecified period near 0400 UTC on the 14th, and the anemometer showed its maximum capability, 31 m s^{-1}, for an unknown duration near 0600 UTC. The 0400 UTC report from that ship also included an observation of 1.2–1.8-m seas, which would be generally consistent with either localized, transitory winds of the magnitude reported or lower wind speeds than noted. The maximum 1-min wind speed for this storm is now estimated to have been 23 m s^{-1} at 0600 UTC on the 14th.

Communications with the *Solar Wind* were lost after 0600 UTC on the 14th. The Coast Guard began, but later suspended, a search for the vessel and its two-man crew. The fate of the crew remains unknown.

Deep convection near the circulation center became

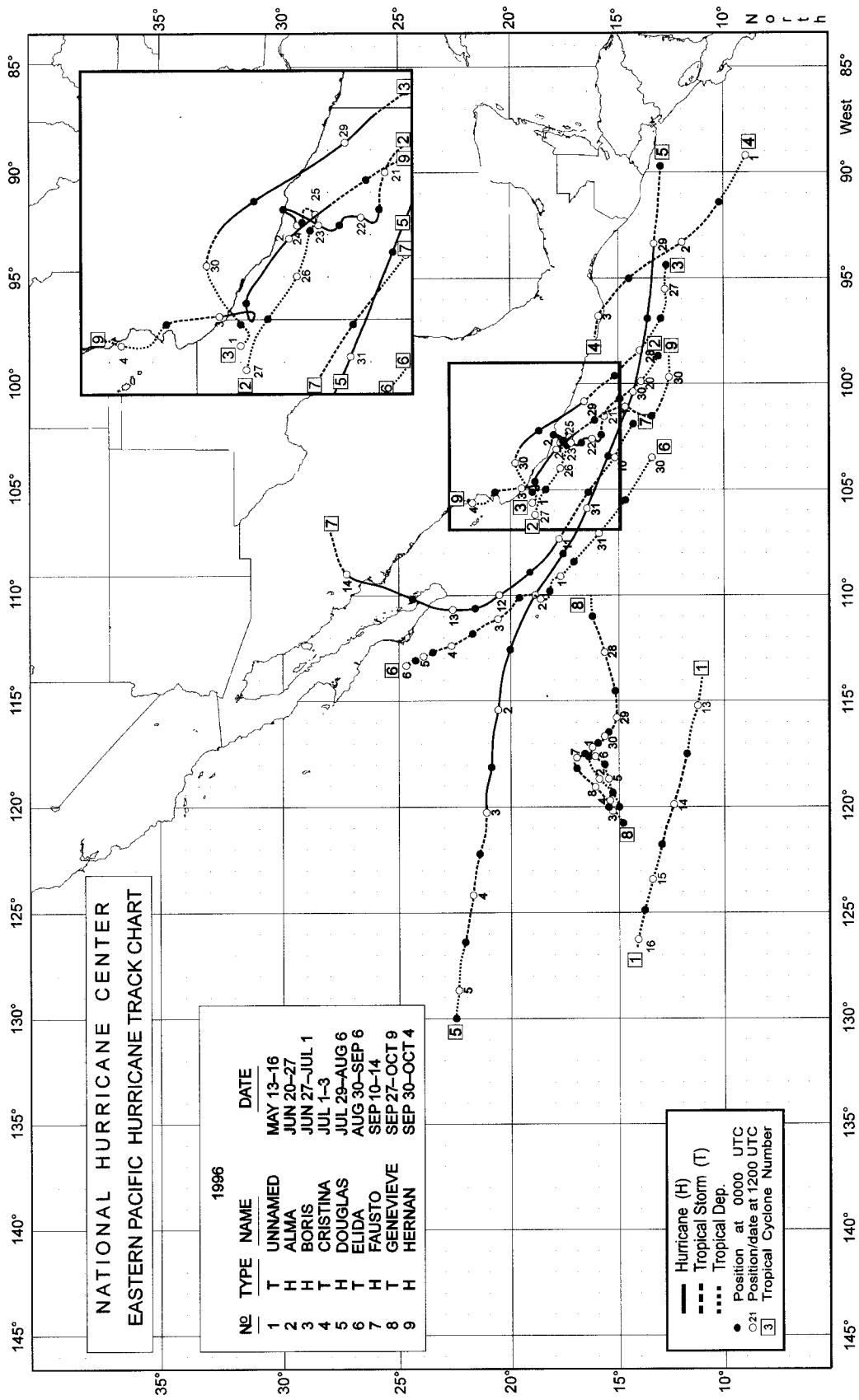

FIG. 1. Eastern North Pacific tropical storm and hurricane tracks for 1996.

TABLE 2. Official average track forecast errors (km), eastern North Pacific, 1996, excluding extratropical, subtropical, and tropical depression stages.

	Forecast period (h)					
	0	12	24	36	48	72
1996 average	28	79	144	191	222	245
(number of cases)	(108)	(108)	(88)	(70)	(54)	(30)
1988–95 average	24	71	132	195	257	363
1996 departure from 1988–95 average	+16%	+10%	+08%	−02%	−13%	−33%
1996 error range	0–170	0–328	0–476	33–585	15–740	22–819

intermittent by late on the 14th and then disappeared completely on the night of the 15th–16th. The system dissipated on the 16th.

The observations and analyses of this tropical cyclone serve as reminders of the large uncertainty often associated with tropical cyclone intensity estimates. They also call attention to the great importance and scarcity of reliable surface weather observations in the vicinity of tropical cyclones.

b. Hurricane Alma, 20–27 June

Alma, the first named tropical cyclone of the 1996 eastern North Pacific hurricane season, developed about 450 km south of Acapulco, Mexico. Although it is difficult to identify the origin of this disturbance, it appears to be related to the southern extension of the same tropical wave that triggered Tropical Storm Arthur in the Atlantic. Upper-air observations from Central America and satellite images indicate that the incipient disturbance crossed from the southwestern Caribbean to the eastern Pacific between the 17th and the 18th of June.

The disturbance moved into the eastern Pacific, over 0.5°–1.0°C warmer than normal waters. During June, an unusual atmospheric circulation pattern also prevailed in this area, with an 8–10 m s^{-1} 200-mb northeasterly wind anomaly, and a 10–15 m s^{-1} 850-mb southwesterly wind anomaly occurring, on average. This pattern was in place when Alma formed and resulted in a shearing environment with a low-level center located to the northeast of the convection. However, the shear was not strong enough to prevent strengthening and the deep convective activity gradually became aligned with the low-level center. Intensity estimates from satellite pictures imply that a tropical depression formed from the system at 0000 UTC 20 June and reached tropical storm intensity by 1800 UTC.

A midlevel trough located in the vicinity of Baja, California in combination with a mid- to upper-level low over the southwestern Gulf of Mexico steered Alma slowly northward and then northwestward, toward the southwest coast of Mexico. The government of Mexico issued a tropical storm warning from Acapulco to Manzanillo at 0300 UTC 21 June. The shear then relaxed. Alma intensified and became a hurricane at 0000 UTC 22 June. The portion of coastline from Zihuatanejo to Manzanillo was then upgraded to a hurricane warning at 2100 UTC 22 June. Alma reached its estimated maximum intensity of 46 m s^{-1} and minimum pressure of 969 mb at 1200 UTC 23 June.

The steering flow collapsed and Alma began to drift near the coast. Alma made landfall close to maximum intensity near the town of Lazaro Cardenas around 0000 UTC 24 June, but it did not move farther inland. The center moved back over water but meandered near the coast for another 36 h. A portion of the circulation remained over land and Alma never reintensified. Apparently, the inner core circulation was severely disrupted by the steep topography of Mexico. It gradually weakened until it dissipated not far from the coast.

Newspaper reports from Mexico stated that three people were killed by Alma when their house collapsed in a small town near Lazaro Cardenas. Numerous houses were damaged and power failed in various coastal towns where roads were covered by debris and water. In Zihuatanejo, several houses and trees were also damaged. There are unconfirmed reports (*The Miami Herald*, 25 June 1996) that at least 17 people were killed by flooding in Puebla, about 550 km to the east of the landfall point. These rains were probably related to Alma.

TABLE 3. Official wind speed forecast errors (m s^{-1}) eastern North Pacific, 1996. Error = forecast − observed.

	Forecast period (h)					
	0	12	24	36	48	72
1996 mean	−1.2	−1.0	−1.5	−2.5	−3.2	−3.2
1996 mean absolute	1.7	3.9	6.7	7.6	9.1	9.8
(no. of cases)	(108)	(108)	(88)	(70)	(54)	(30)
1990–95 mean	−0.5	−0.8	−1.2	−2.0	−2.7	−3.0
1990–95 mean absolute	1.5	3.6	6.1	8.2	9.5	11.1
1996 departure from 1990–95 mean absolute	+10%	+07%	+10%	−07%	−05%	−12%
1996 error range	−8 to +5	−15 to +10	−18 to +18	−21 to +15	−26 to +21	−39 to +23

c. Hurricane Boris, 27 June–1 July

Boris could have originated from a tropical wave that moved from Africa to the eastern Atlantic Ocean on 8 June and crossed Central America on 23 June. This is based on continuity, as the wave was poorly defined on satellite imagery for many days.

The first signs of a low-level circulation on satellite imagery appeared on the 26th, centered about 450 km south of the Gulf of Tehuantepec. The system became a tropical depression on the 27th when convective banding increased around the center. A tropical storm warning was issued at 1500 UTC on the 28th, from Puerto Escondido to Manzanillo, and a hurricane warning was issued at 2100 UTC from Punta Maldonado to Manzanillo. The tropical cyclone moved northwestward at 4–5 m s^{-1} on the 28th and 29th and its winds strengthened from 13 to 41 m s^{-1} during a 36-h period. A ragged eye appeared on satellite imagery just before landfall at 1800 UTC on the 29th. The center crossed the south coast of Mexico midway between Lazaro Cardenas and Acapulco. Maximum winds at landfall are estimated near 41 m s^{-1}.

Boris quickly weakened to a depression and turned southwestward in response to a building ridge to its north. The system was disrupted by the mountainous terrain of Mexico and dissipated on 1 July after moving back over water just south of Puerta Vallarta.

The only significant surface wind observation available is an east wind of 21 m s^{-1} sustained and gusts to 25 m s^{-1} from Acapulco at 1145 UTC on the 29th. This was the time of closest approach of the center to Acapulco, when the center was 110 km southwest of the city. The heaviest rainfall occurred in the state of Guerrero and ranged to a maximum of 283 mm at Coyuga de Benitez, located on the coast just west of Acapulco.

A report from an amateur radio operator indicated one death at Tecpan, near the landfall location. The *El Finaciero* newspaper reported at least three other persons drowned near Tecpan and another five fishermen missing. An Associated Press report stated that a child was killed in Acapulco when a roof collapsed. The total death estimate from the Servicio Meteorologico Nacional de Mexico stands at seven.

It was reported that the San Jeronimo River caused flood damage to 40% of the municipality of Coyuca, affecting at least 5000 people. Countless homes were also washed away at Tecpan.

d. Tropical Storm Cristina, 1–3 July

Satellite imagery showed an increase in cloudiness and showers just to the south of Central America early on 30 June. This activity was moving generally toward the west-northwest and was likely associated with a tropical wave that crossed over Panama on the previous day. Deep convection became more concentrated and analysts from both the SAB and the TAFB began Dvorak classifications near 1800 UTC on the 30th.

Convective banding became organized and the system became a tropical depression at 1200 UTC 1 July about 550 km south of San Salvador, El Salvador. The depression initially moved toward the northwest near 6 m s^{-1}, apparently in response to a weakness in the ridge to the north over the southwest Gulf of Mexico.

Based on ship reports, the depression became Tropical Storm Cristina at 0000 UTC 2 July while centered about 500 km south of Guatemala City, Guatemala. Deep convection increased near the center of the tropical cyclone, and gradual further intensification occurred. Forward motion increased to near 8 m s^{-1}. The government of Mexico issued a tropical storm warning for the coast of Mexico from Tapachula (near the border of Guatemala and Mexico) to Punta Maldonado (about midway between Puerto Escondido and Acapulco) at 1500 UTC 2 July. Cristina made landfall near the middle of the warning area about 18 h later.

It is estimated that Cristina almost reached hurricane strength just before making landfall near Puerto Angel, Mexico, around 0900 UTC 3 July. Although no reports of damage have been received, storm surge flooding of near 1 m above normal tide levels near and just to the east of the landfall point likely occurred. It is expected that wind and rain also resulted in some damage. According to the news agency Notimex, one person drowned when his fishing boat was caught out at sea off the southern state of Oaxaca. Another man aboard the boat was missing, and another was found alive. The news agency also reported that 11 fishing vessels were missing with some 22 people aboard after they set out to sea the day before the storm made landfall. Fishermen in this area frequently seek refuge from bad weather on remote stretches of shoreline and information on their fate often remains incomplete. The official number of total deaths estimated from the Servicio Meteorologico Nacional de Mexico is five.

Cristina was the third named tropical cyclone to strike the southern coast of Mexico within a 10-day span.

The tropical cyclone weakened rapidly as the circulation moved over the mountainous terrain of Mexico, and it dissipated by 0000 UTC 4 July.

e. Hurricane Douglas, 29 July–6 August

Hurricane Cesar, from the Atlantic basin, moved westward over Central America for about 18 h and emerged into the Pacific with tropical storm strength. It was then designated Tropical Storm Douglas. Such a name change for tropical cyclones crossing from the Atlantic to the eastern North Pacific is based on a World Meteorological Organization regional agreement. Once centered over the Pacific, the tropical cyclone intensified rapidly and was upgraded to a hurricane based on observations from the vessel *Tritonhighway*, which reported winds of 36 m s^{-1} at 1500 UTC 29 July. The

vessel was located just north of the center of the tropical cyclone. Douglas continued moving on a general west and then west-northwest track around the periphery of a high pressure system centered over the western United States. On this track, Douglas reached its estimated maximum intensity of 59 m s^{-1} and minimum pressure of 946 mb at 1200 UTC 1 August when located about 450 km south of the southern tip of Baja, California. Objective T-numbers (based on the warmest temperature in the cyclone center and the coldest surrounding temperature at 55-km radius from the cyclone center) were oscillating around 6.3 on the Dvorak (1984) scale during that time. Figure 2 is a visible satellite picture near the time of peak intensity. Thereafter, Douglas moved over cooler waters and a gradual weakening began. It was no longer a tropical depression by 0000 UTC 6 August. However, the remnants of Douglas, represented by a swirl of low clouds, moved westward for several more days.

Due to the large extent of tropical storm force winds associated with Douglas and its proximity to the south coast of Mexico, tropical storm watches and warnings were issued by the government of Mexico for portions of the coast. However, the damage associated with this tropical cyclone occurred over Central America and was attributed to Cesar (Avila and Pasch 1997).

f. Tropical Storm Elida, 30 August–6 September

Tropical Storm Elida formed from a tropical wave that generated a small area of deep convection between 10° and 15°N nearly every day on its crossing of the Atlantic Ocean and Caribbean Sea from 16–26 August 1996. The convection became more concentrated on 30 August over the eastern North Pacific Ocean a few hundred kilometers to the south-southwest of Acapulco. It is estimated that the system became a tropical depression at 1200 UTC on the 30th.

During its one-week lifespan, the tropical cyclone's forward motion decelerated from 7 to 1 m s^{-1} as it moved generally toward the northwest, except for a 24-h period of erratic movement when the center was located just east of Socorro Island on 2 September. Bands of thunderstorms became more prominent and, despite some northeasterly wind shear, the depression became Tropical Storm Elida on the 2d. Elida reached its estimated peak intensity of 28 m s^{-1} on the night of the 3d–4th while centered about 200 km west-southwest of the southern tip of the Baja, California peninsula. The government of Mexico issued a tropical storm warning for the Baja, California peninsula from Cabo San Lazaro southward at 2100 UTC on the 3d.

Elida's subsequent progression into colder waters led to gradual weakening and a final disappearance of deep convection on the afternoon of the 5th. The warning was discontinued on the 5th, when the threat to the peninsula ended. No reports of casualties or damages were received. The surface circulation dissipated on the 6th.

g. Hurricane Fausto, 10–14 September

The origin of Fausto can be traced using satellite imagery to an area of disturbed weather that was located over Venezuela on 31 August. It is possible that this disturbed weather was the southern part of a tropical wave that became Hurricane Fran over the Atlantic Ocean. The disturbed weather moved westward across Central America on 4 September and to a position centered about 375 km south of Acapulco, Mexico on 9 September, where it began to develop a low-level circulation and considerable organized convection. It became a tropical depression on the 10th while located about 375 km south-southeast of Manzanillo.

Guided by a weak ridge near Baja, California, the depression moved northwestward at about 5 m s^{-1} on a course parallel to the coast of Mexico for the next 3 days. It intensified, with a well-established outflow pattern, well-organized banding features, and, ultimately, it developed an eye. It became a hurricane on the 11th, reached its maximum intensity with sustained winds estimated at 54 m s^{-1} midday on the 12th, and turned northward while centered about 275 km south of the southern tip of Baja, California. This northward turn and the accompanying decrease in forward speed to about 3 m s^{-1} was caused by an approaching and deepening shortwave trough in the westerlies, which eroded the weak ridge.

Fausto was weakening when it made landfall near Todos los Santos on Baja, California at 2000 UTC 13 September. Its track had become north-northeastward when it made landfall on the mainland of Mexico near Los Mochis 10 h later. The estimated sustained wind speed was 39 m s^{-1} at the first landfall and 33 m s^{-1} at the landfall on the mainland. Fausto quickly weakened and dissipated over the Sierra Madre mountains.

The only report of tropical storm force winds from an official weather station, either on Baja, California or on the mainland, was sustained winds of 18 m s^{-1} with gusts to 23 m s^{-1} from La Paz International Airport at 1800 UTC on the 13th, just prior to landfall. However, there were numerous observations of tropical storm force winds received via amateur radio operators from La Paz and San Jose del Cabo. The highest of these was a report of 31 m s^{-1} with gusts to 39 m s^{-1} from San Jose del Cabo at 1700 UTC on the 13th.

Radar data from Guasave, Mexico, depicted the well-defined eye for about a 12-h period as it made landfall on Baja, California and on the mainland of Mexico. This greatly assisted in the tracking of the hurricane.

The Servicio Meteorologico Nacional de Mexico reported two deaths in association with Fausto. One death was the electrocution of a San Diego vacationer from a downed power line in a trailer park near Cabo San Lucas. The Associated Press reported that Fausto ''bat-

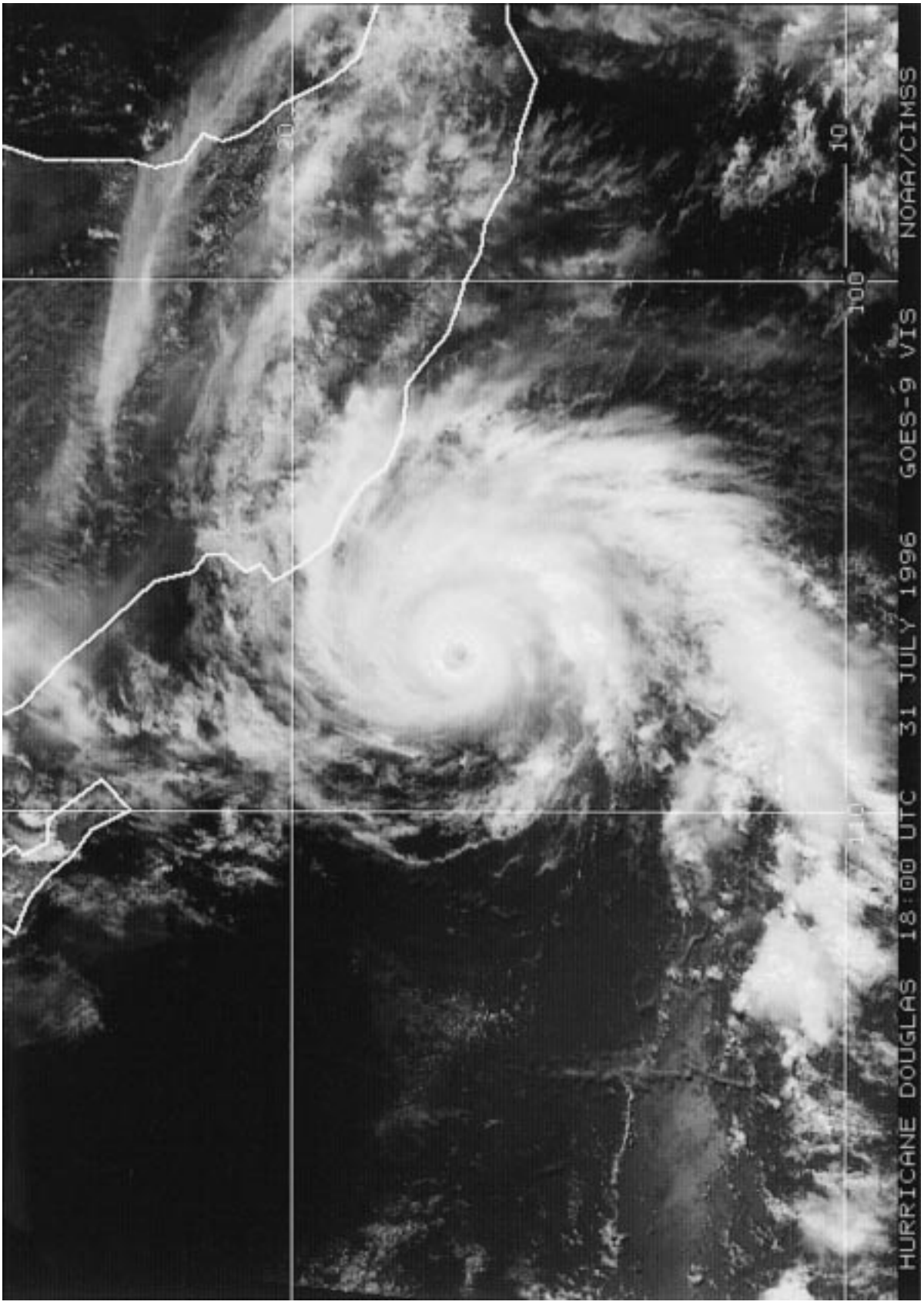

FIG. 2. GOES visible image of Hurricane Douglas at 1800 UTC 31 July 1996, near the cyclone's peak intensity.

tered'' Baja, California, downing power poles, smashing windows, and disrupting the tourist business at Cabo San Lucas and La Paz. Waves of up to 4.5 m walloped Pacific beaches along the southern tip of Baja and yachts were damaged. There was no major damage on the mainland.

There was one report of 100 mm of rainfall at Cabo San Lucas and heavy rains caused mudslides there. Similar amounts of rain may have spread inland over mainland Mexico.

Various watches and warnings were issued by the government of Mexico. The hurricane watch for Baja, California was issued 56 h before landfall and the hurricane warning was issued 29 h before landfall. On the mainland, the hurricane watch and warning were issued 27 and 21 h, respectively, before landfall.

h. Tropical Storm Genevieve, 27 September–9 October

Genevieve was a weak tropical cyclone that meandered over the eastern North Pacific for over 11 days without affecting land. Satellite imagery showed an increase in cloudiness and thunderstorms in the vicinity of the Gulf of Tehuantepec on 23 September. The tropical disturbance moved westward over the next few days without signs of development. Deep convection became more concentrated and a tropical depression formed from the disturbance near 1800 UTC 27 September, centered about 750 km south of the southern tip of Baja, California. The developing cyclone initially moved westward near 5 m s^{-1}.

The tropical depression strengthened into Tropical Storm Genevieve when upper-level outflow became better established and convective banding increased. Maximum winds of 23 m s^{-1} are estimated to have occurred from late on the 28th to early on the 30th.

Genevieve tracked toward the west-southwest and decelerated when steering currents collapsed. The forward motion slowed to less than 3 m s^{-1} by 30 September. A rather erratic motion occurred between 30 September and 8 October, during which time the center of Genevieve moved less than 375 km. Although there is uncertainty in the precise track, visible satellite ''fixes'' indicate that the tropical cyclone executed two loops during this period.

Genevieve weakened to a tropical depression near 0000 UTC 1 October in response to increased easterly shear. Satellite pictures indicate that the shear temporarily diminished on 6 October, and that Genevieve regained and maintained tropical storm strength for about 36 h. This is consistent with the ship *Nedlloyd Dejima* report of a north wind of 18 m s^{-1} at 1800 UTC 7 October about 375 km to the north-northwest of the center of Genevieve. Thereafter, the tropical cyclone again weakened to a tropical depression as it entrained drier air.

Genevieve dissipated on 9 October (less than 1200 km from where it developed 11 days earlier), although occasional flare-ups of convection occurred in association with a low-level swirl for a few more days.

Operationally, advisories were discontinued at 2100 UTC 3 October when the cloud pattern appeared very disorganized; advisories resumed at 2100 UTC 6 October. In contrast, a postanalysis indicates that a weak low-level circulation persisted and that depression status is justified through this period.

The tropical storm did not threaten land. Therefore, coastal watches or warnings were not necessary.

i. Hurricane Hernan, 30 September–4 October

A tropical wave that emerged from the coast of western Africa in mid-September moved westward across the Atlantic basin during the latter half of the month. Convection associated with the system temporarily increased near the Lesser Antilles on 22 September, and again on 25–27 September while the wave moved across the western Caribbean Sea and Central America. Deep convection associated with the wave became a little more consolidated near the Gulf of Tehuantepec on the 28th. By 1800 UTC on the 29th, when the wave axis was near 97°W, the cloud pattern became even better organized. Satellite data suggest that a tropical depression developed from this disturbance a little over 450 km south-southeast of Acapulco around 0600 UTC 30 September. Gradual development continued, and the cyclone became Tropical Storm Hernan about 12 h later.

Initially, the cyclone was moving westward, but the motion soon became west-northwestward and then northwestward. Early on 1 October, Hernan shifted northward, and then north-northeastward. The storm was still in the developing stage and not yet well-organized; thus, part of this displacement was probably related to a reformation of the center. Later on the 1st, Hernan, then better-organized, turned back toward the north-northwest. Three ships, the *Chevron Colorado,* one with call sign MQWA5, and one of unknown call sign, reported winds of 18 or 21 m s^{-1} from within Hernan's circulation on the 1st. The ship MQWA5 reported the lowest pressure from the vessels, 999.1 mb.

On the 2d, Hernan moved toward the northwest. By 0600 UTC the center was nearing the coast, about 100 km south of Lazaro Cardenas, when Hernan strengthened into a hurricane. Reflectivity presentations from the Mexican weather service radar located at Cuyutlan at around 1000 UTC on the 2d revealed a well-defined, closed eyewall. The maximum intensity of Hernan, 39 m s^{-1}, is estimated to have occurred around that time.

From 1200 UTC on the 2d through 0000 UTC on the 3d, the hurricane moved parallel, but very near, to the coastline. Early on the 3d, the forward motion slowed to a crawl and the center moved in a small counterclockwise loop, just offshore. Hernan then responded to a mid- to upper-tropospheric trough over the southwestern United States and moved northward, making landfall as a category 1 hurricane on the SSHS near

Barra de Navidad, between Manzanillo and Puerto Vallarta, at 1000 UTC 3 October. Because the center had been moving very near to the mountainous landmass of Mexico for about 24 h prior to landfall, the hurricane had weakened somewhat before the center finally crossed the coast.

Hernan struck a relatively sparsely populated area of Mexico. No actual measurements of strong winds from land have been received. Local press reports indicate that waves along the coasts of the states of Colima and Jalisco reached 4 m. The total death estimate from the Servicio Meteorologico Nacional de Mexico is three. Local press reported at least 100 injuries with 1000 homes damaged. There was flooding in the coastal town of Melaque, Jalisco. Washouts were reported on Mexico Route 200, the coastal road between Puerto Vallarta and Manzanillo, and on Mexico Route 80, which runs between Melaque and Guadalajara. Telephone service and electricity were disrupted in various locations.

Hernan weakened to a tropical storm just after landfall. The cyclone moved mostly northward over land, passing just east of Puerto Vallarta while weakening below storm strength by 0000 UTC on the 4th. Although the center briefly moved back out over the waters north of Puerto Vallarta, the system had become so disorganized that it dissipated around 0000 UTC 5 October.

A series of watches and warnings was issued during Hernan's prolonged encounter with the coast. A tropical storm warning was issued for Mexico from Acapulco to Manzanillo at 1800 UTC 1 October. A hurricane watch was put into effect from Zihuatanejo to Manzanillo at 0300 UTC 2 October. This was changed to a hurricane warning at 0900 UTC 2 October. A tropical storm warning was issued north of Manzanillo to San Blas at 1500 UTC 2 October, and the hurricane warning was extended north of Manzanillo to Cabo Corrientes at 2100 UTC 2 October. Hurricane warnings were extended north of Cabo Corrientes to San Blas and tropical storm warnings were extended north of San Blas to Mazatlan at 0300 UTC 3 October. There was a relatively short lead time, roughly 6 h, between the issuance of hurricane warnings and the arrival of the eyewall (not the center) on the coast on 2 October. Hernan's center ultimately crossed the coast (on 3 October) about 13 h after the issuance of hurricane warnings for the landfall area.

5. Summary

Relatively few tropical cyclones formed in the eastern North Pacific Ocean during the 1996 hurricane season. Nevertheless, five of these systems made landfall, including three which struck the southwest coast of Mexico during a 2-week period in late June–early July. The 1996 storms killed 20–40 people in Mexico.

Acknowledgments. Lixion Avila, Miles Lawrence, and Richard Pasch contributed to this report. Stephen Baig produced the track chart. Special thanks to Alberto Hernandez Unzon from the Servicio Meteorologico de Mexico for providing valuable data and to Chris Velden from the University of Wisconsin Space Science and Engineering Center for providing the satellite picture.

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