

## ANNUAL SUMMARY

### Eastern North Pacific Hurricane Season of 2004

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#### ABSTRACT

The 2004 eastern North Pacific hurricane season is reviewed. It was a below-average season in terms of number of systems and landfalls. There were 12 named tropical cyclones, of which 8 became hurricanes. None of the tropical storms or hurricanes made landfall, and there were no reports of deaths or damage. A description of each cyclone is provided, and track and intensity forecasts for the season are evaluated.

#### 1. Overview

Two notable aspects of the 2004 season in the eastern North Pacific hurricane basin (from 140°W eastward and from the equator northward) were that none of the tropical storms or hurricanes made landfall and that there were no reports of deaths or damage attributed to tropical cyclones. In general, three or four named tropical cyclones strike the coast of Mexico each year. Tropical cyclone activity was below average in the basin compared with the mean totals for the 1966–2003 period of 15 named storms and 8 hurricanes. Of the 12 tropical storms that formed during the 2004 season, 6 became hurricanes (Table 1; Fig. 1). Three of the hurricanes in 2004 became “major,” that is, maximum 1-min average winds of at least 96 kt [category 3 or higher on the Saffir–Simpson hurricane scale (SSHs); Saffir (1973); Simpson (1974)]. The season started early with Agatha on 22 May and ended with Lester in mid-October. Historically, the median day for formation of the first eastern North Pacific tropical storm is 2 June. Javier was the strongest hurricane of the season with peak winds of 130 kt. In addition to the 12 named cyclones in 2004, there were four tropical depressions that did not reach tropical storm status. One of them, Sixteen-E, made landfall in Baja California, Mexico.

The formation of tropical cyclones from tropical

waves in the eastern North Pacific has been documented in numerous occasions, for example, Avila et al. (2003). Most of the tropical cyclones in 2004 originated from tropical waves that moved westward from Africa across the Atlantic basin before entering the eastern North Pacific. These waves became convectively active and spawned tropical cyclones in the waters to the south and southwest of Mexico.

Most of the tropical cyclones this season were steered westward and west-northwestward away from the coast of Mexico, around a 500-mb ridge extending from the Atlantic westward across northern Mexico. This feature (Fig. 2) persisted through most of the active portion of the season and was stronger than normal, as indicated by positive 500-mb height anomalies over Mexico through the period (not shown).

One possible explanation for the below-average number of tropical storms and hurricanes in 2004 is that although the ocean was a little warmer than normal in the genesis region south and southwest of Mexico, many of the developing tropical depressions and disturbances were steered west-northwestward toward a region of cooler than normal waters. The anomalous cool water persisted during the season just north of 16°N and west of 112°W as indicated in Fig. 3. The cool water most likely inhibited additional development of the incipient cyclones. In fact, the average lifetime of the tropical cyclones during this season was only about 4 days, about 2 days shorter than normal. In addition, the atmosphere in the genesis region was more stable than normal during the entire season, as shown in Fig. 4. Stable conditions are considered a negative factor for

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TABLE 1. Eastern North Pacific basin hurricane season statistics for 2004.<sup>a</sup>

Name	Class <sup>b</sup>	Dates <sup>c</sup>	Max 1-min wind (kt)	Min pressure (mb)
Agatha	H	22–24 May	50	997
Blas	T	12–15 Jul	55	991
Celia	H	19–25 Jul	75	981
Darby	H	26 Jul–1 Aug	105	957
Estelle	T	19–24 Aug	60	989
Frank	H	23–26 Aug	75	979
Georgette	T	26–30 Aug	55	995
Howard	H	30 Aug–5 Sep	120	943
Isis	H	8–16 Sep	65	987
Javier	H	10–19 Sep	130	930
Kay	T	4–6 Oct	40	1005
Lester	T	11–13 Oct	45	1000

<sup>a</sup> There were no direct deaths associated with Eastern North Pacific tropical cyclones in 2004.

<sup>b</sup> (T) Tropical Storm: wind speed of 34–63 kt. (H) Hurricane: wind speed of 64 kt or higher.

<sup>c</sup> Dates begin at 0000 UTC and include tropical depression stage.

tropical cyclone genesis since deep convection becomes limited. Stability is one of the input variables to the National Environmental Satellite, Data, and Information Service (NESDIS) tropical cyclone formation parameter as described by De Maria et al. (2004). Another factor that should be considered in explaining the level of tropical cyclone activity is the vertical wind shear. It was found, however, that the magnitude of the

vertical wind shear was near average during the season (figure not shown). Therefore, vertical shear was not likely a cause for the low number of tropical cyclones in 2004.

**2. Storm and hurricane summaries**

The National Hurricane Center (NHC) produces a tropical cyclone “best track” database that consists of center positions (latitude and longitude), intensity (maximum 1-min average sustained wind at 10 m), and surface pressure every 6 h. In the eastern North Pacific basin, the best-track data are derived mostly from estimates using satellite data and applying the Dvorak (1984) technique. Aerial reconnaissance is rare in this basin. In fact, the only reconnaissance flight in 2004 was conducted by the 53rd Weather Reconnaissance Squadron, the “Hurricane Hunters” of the U.S. Air Force Reserve Command (AFRC) during Tropical Storm Lester when the cyclone was near land. A description of the various observational data sources utilized to track tropical cyclones in this basin is given by Avila et al. (2003). More information about each named tropical cyclone as well as the complete best track is located on the NHC Internet home page (<http://www.nhc.noaa.gov/pastall.shtml>).

*a. Tropical Storm Agatha: 22–24 May*

A nearly stationary trough of low pressure became established from the eastern Pacific east-northeastward

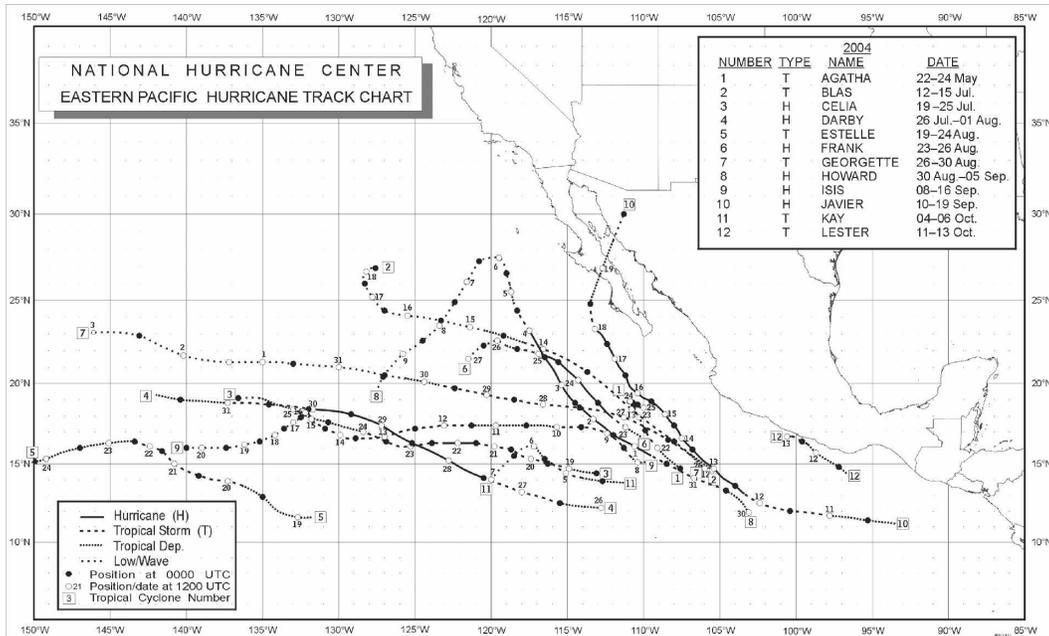


FIG. 1. Eastern North Pacific tropical storm and hurricane tracks for 2004.

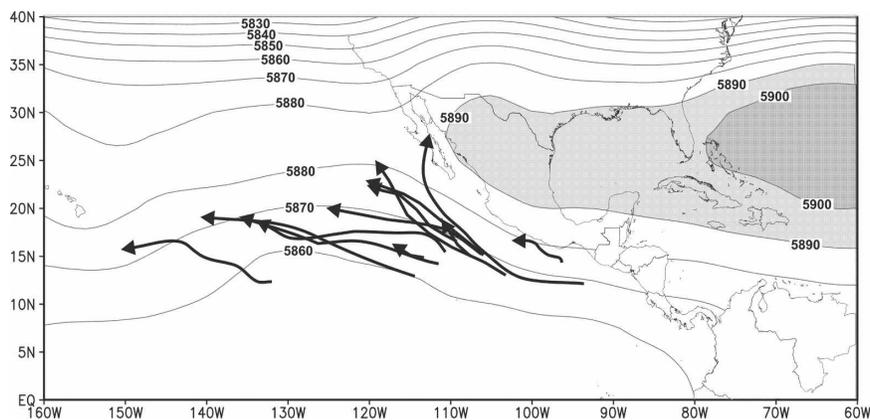


FIG. 2. Mean 500-mb heights for June–September 2004. Arrows mark the track of the 2004 named tropical cyclones.

across Central America and portions of the Caribbean Sea during mid-May. This pattern resulted in a large area of moist southwesterly monsoon-like flow over the region. A poorly defined westward-moving tropical wave became convectively active over the eastern Caribbean Sea on 13 May and crossed Central America two days later accompanied by limited cloudiness and thunderstorms. Once the wave reached the eastern Pacific and combined with the trough, the convection associated with the wave gradually became organized, and on 20 May, the system showed signs of cyclonic rotation. As the wave continued westward, the thunderstorm activity became concentrated to the southwest of a developing low-level circulation center and it is estimated that a tropical depression formed at 0000 UTC 22 May about 500 n mi south-southeast of Cabo San Lucas, Mexico. The depression moved slowly toward the northwest, and under light shear, the cyclone intensified and became a tropical storm by 1200 UTC

on that day. It is estimated that the cyclone reached its peak intensity of 50 kt at 0000 UTC 23 May. Thereafter, lower sea surface temperatures and stable air caused the cyclone to weaken gradually, and it degenerated to a remnant low by 1200 UTC 24 May. The low moved little and dissipated by 0000 UTC 26 May.

Special Sensor Microwave Imager (SSM/I) and Tropical Rainfall Measuring Mission (TRMM) images of Agatha from around 1400 UTC 22 May through 0230 UTC 23 May revealed a ring of precipitation resembling an eyewall. One of these images is shown in Fig. 5. The presence of the convective ring suggests that Agatha’s peak intensity was probably higher than indicated by the 35–45-kt winds suggested by the Dvorak estimates, although no technique is available at this

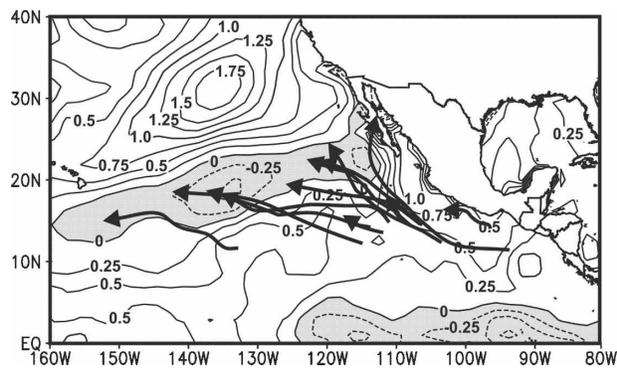


FIG. 3. SST departures from the 1968–96 long-term mean for the June–September 2004 period. Shaded areas denote cold anomalies and arrows mark the track of the 2004 named tropical cyclones.

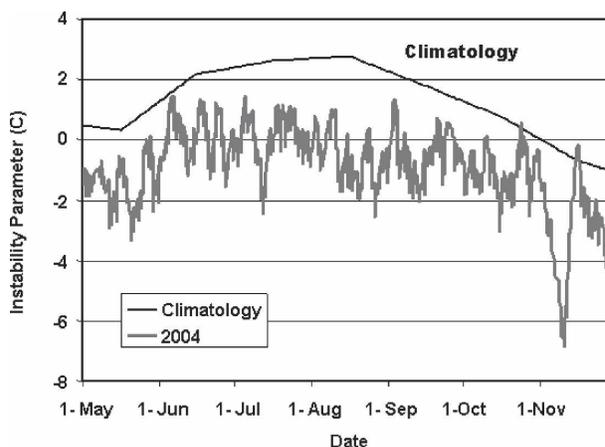


FIG. 4. Vertical instability parameter for the eastern North Pacific east of 110°W, for the May–November 2004 period. This is one of the inputs to the tropical cyclone formation parameter as described by DeMaria et al. (2004). Note that the atmosphere was more stable than normal throughout the season in the genesis region.

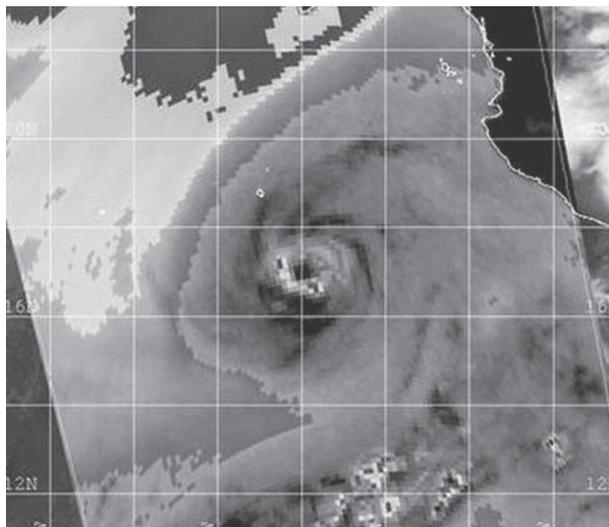


FIG. 5. SSM/I microwave data for Agatha at 0235 UTC showing a ring of convection resembling an eyewall. This image is courtesy of Naval Research Laboratory, Monterey, CA.

time to estimate tropical cyclone intensity from such features observed on microwave images. The peak intensity of Agatha is estimated to be 50 kt—but this estimate is particularly uncertain.

#### *b. Tropical Storm Blas: 12–15 July*

Blas was a large tropical storm whose outer bands produced gusty winds over extreme southern Baja California. Its formation is associated with a tropical wave that emerged from western Africa on 1 July. This wave was accompanied by a large swirl of low clouds over the far eastern tropical Atlantic, but the system generated little deep convection as it traversed the tropical Atlantic and the Caribbean Sea. The wave crossed Central America on 8 July, and over the next several days deep convection increased and slowly became organized to the south of Mexico. The pace of development increased around 0600 UTC 12 July, and by 1200 UTC that day, the organization and amount of deep convection was sufficient to designate the system a tropical depression. Banding features became more pronounced during the day, and it is estimated that the tropical cyclone strengthened into a tropical storm by around 1800 UTC that day.

On 12–13 July, Blas moved northwestward at a relatively fast forward speed of 15–18 kt, on the southwest side of a midlevel anticyclone centered over the southwestern United States. The storm reached its estimated peak intensity of 55 kt around 1200 UTC 13 July, at which time it exhibited a large convective overcast with very cold cloud tops. Thereafter, deep convection de-

creased and Blas gradually weakened due to lower sea surface temperatures. The weakening storm turned toward the west-northwest on 14 July. Although the circulation remained large and well defined, cool waters continued to take their toll on Blas and the cyclone weakened to a tropical depression by 1800 UTC 14 July. Blas degenerated to a large remnant low around 0600 UTC 15 July and moved generally west-northwestward for a couple of days while continuing to slowly spin down. As its forward speed slowed to a drift, the remnant low turned northward, then northeastward on 18 July. Early on 19 July, the low turned eastward and dissipated well to the west of central Baja California.

Blas was a larger-than-normal-sized tropical cyclone. Based on data from the SeaWind scatterometer on board the National Aeronautics and Space Administration's (NASA) Quick Scatterometer (QuikSCAT) (Tsai et al. 2000) and a few ship observations, tropical-storm-force winds extended about 200 n mi to the northeast and northwest of the center by 0000 UTC 13 July. Even though Blas' center remained well offshore of Baja California, strong gusty winds of the storm's outer circulation affected the extreme southern Baja California peninsula. On 13 July, an automated station just north of Cabo San Lucas at an elevation of 225 m above sea level reported a maximum sustained wind of 41 kt at 1630 UTC and a peak gust of 57 kt at 1750 UTC. There were no reports of death or damages associated with Blas.

#### *c. Hurricane Celia: 19–25 July*

A fairly vigorous tropical wave crossed the west coast of Africa on 5 July. The wave moved westward across the tropical Atlantic and northern South America for the next week before it emerged over the northeastern Pacific near Panama on 13 July. Upon reaching the warm waters of the Pacific, thunderstorms developed near a weak low-level circulation that had formed along the wave axis according to data from QuikSCAT, as well as surface and upper-air observations.

By 15 July, the low-level circulation and the convection became better organized about 400 n mi south-southwest of Acapulco, Mexico. However, unfavorable upper-level winds inhibited additional development for the next 3 days. By late 18 July, the upper-level environment became more favorable and convective banding features became better defined. The system became a tropical depression by 0000 UTC 19 July about 540 n mi south-southwest of Cabo San Lucas.

The cyclone moved west-northwestward at 8–10 kt around the southern periphery of a subtropical ridge and became a tropical storm at 1200 UTC 19 July, when

the cyclone was centered about 570 n mi southwest of Baja California. Under a favorable upper-level environment, deep convection gradually developed. While not apparent in conventional satellite imagery, a well-defined eye did develop in the center of a cold central dense overcast (CDO) cloud mass observed at 0928 UTC 22 July in an Advanced Microwave Scanning Radiometer for the Earth Observing System (AMSR-E) microwave imagery from the NASA *Aqua* satellite. It is estimated that Celia's intensity reached a peak value of 75 kt around 0600 UTC 20 July. Thereafter, Celia began a slow weakening trend as the cyclone moved over cooler water. Celia eventually weakened back to a tropical storm late on 22 July and to a tropical depression on 24 July. It degenerated into a nonconvective low pressure system at 0000 UTC 26 July. Shortly thereafter, the remnant circulation dissipated about 1500 n mi west-southwest of Cabo San Lucas.

*d. Hurricane Darby: 26 July–1 August*

Darby formed from a tropical wave that moved westward across the coast of Africa on 12 July. The wave crossed the Atlantic and Caribbean with no development and reached the eastern North Pacific on 20 July. Moving westward, the system first showed signs of organization on 23 July. Continued slow development resulted in the formation of a tropical depression around 1200 UTC 26 July about 660 n mi south-southwest of Cabo San Lucas.

The depression moved westward on the south side of the subtropical ridge and became a tropical storm early on 27 July. It turned west-northwestward later that day and continued to strengthen. Darby became a hurricane early on 28 July, and then reached an estimated peak intensity of 105 kt on 29 July. The hurricane started to weaken later that day due to a combination of lower sea surface temperatures and increasing westerly wind shear. It became a tropical storm again on 30 July as it turned westward, and it weakened to a depression on 31 July. The depression crossed 140°W into the central North Pacific hurricane basin later that day. Darby dissipated as a tropical cyclone on 1 August about 740 n mi east of the Hawaiian Islands. Darby's remnants continued westward in the low-level trade winds and caused heavy rains and flooding over portions of the Hawaiian Islands on 3–4 August. No damage was reported.

*e. Tropical Storm Estelle: 19–24 August*

A tropical wave exited the west coast of Africa on 4 August and moved westward across the Atlantic, the Caribbean Sea, and entered the eastern North Pacific

with little convective activity. It was not until 18 August that the shower activity associated with the wave began to increase between 120° and 130°W, as the wave interacted with a nearly stationary disturbance associated with the intertropical convergence zone (ITCZ). The cloud pattern became more organized and a few curved convective bands developed rather quickly. It is estimated that a tropical depression formed at 0600 UTC 19 August about 1250 n mi east-southeast of Hilo, Hawaii. However, after the formation of the depression, there was no significant change in organization for the next 12–18 h. Thereafter, convection redeveloped and it is estimated that the system had reached tropical storm status at 0600 UTC 20 August. Estelle moved toward the west-northwest along the periphery of the subtropical ridge and gradually strengthened. It then crossed 140°W into the central Pacific hurricane basin where Estelle reached its estimated maximum intensity of 60 kt and a minimum pressure of 989 mb at 1200 UTC 21 August. Thereafter, the cyclone began to move toward the west and west-southwest, and weakened due to strong shear. It became a nonconvective remnant low at 1800 UTC 24 August and dissipated by 0000 UTC 26 August.

*f. Hurricane Frank: 23–26 August*

Frank developed from the remnants of Atlantic Tropical Storm Earl, which had degenerated into a tropical wave over the eastern Caribbean Sea. This wave crossed Central America on 18 August, and on 22 August the thunderstorm activity began to increase in organization. By 0600 UTC 23 August, the symmetry and quantity of deep convection was sufficient to designate the system as a tropical depression about 360 n mi south of Cabo San Lucas, and it is estimated that the tropical cyclone strengthened into a tropical storm 6 h later. Frank intensified rapidly during the day and strengthened into a hurricane around 1800 UTC while an eye became apparent in visible and microwave imagery. Frank was then centered about 300 n mi south-southwest of Cabo San Lucas. It is notable that Frank strengthened from a tropical depression to a hurricane in only 12 h.

From 23 to 25 August, Frank moved northwestward at a forward speed of 9–12 kt, on the southwestern side of a midlevel anticyclone centered over the southwestern United States and northwestern Mexico. Frank reached its estimated peak intensity of 75 kt around 0600 UTC 24 August, at which time it exhibited a ragged 20 n mi-wide eye. Thereafter, deep convection decreased and Frank gradually weakened over lower sea surface temperatures. The system turned back toward the west-northwest on 25 August and weakened

to a tropical depression by 0000 UTC 26 August. Frank became a remnant low several hours later and drifted toward the southwest for another day. It degenerated into an open trough on 27 August about 650 n mi west-southwest of Cabo San Lucas.

*g. Tropical Storm Georgette: 26–30 August*

The tropical wave that spawned Georgette moved across the west coast of Africa on 15 August. The wave moved westward across the tropical Atlantic Ocean with little associated shower activity until it reached the Gulf of Tehuantepec in the northeastern Pacific Ocean on 24 August. By early on 25 August, deep convection increased and became better organized. A QuikSCAT overpass indicated that a weak surface low pressure area had formed along the wave axis and by 1200 UTC 26 August, the cloud pattern was sufficiently well organized to designate the system as a tropical depression centered about 525 n mi south-southeast of Cabo San Lucas.

Deep convection continued to become organized, and it is estimated that the tropical cyclone strengthened into a tropical storm by around 1800 UTC 26 August. Georgette moved northwestward at 12–15 kt and reached its peak intensity of 55 kt at about 1200 UTC 27 August. Shortly thereafter, northeasterly wind shear caused weakening as the cyclone moved west-northwestward over cooler waters. It is estimated that Georgette became a depression again by 0600 UTC 30 August about 770 n mi west of Cabo San Lucas. Weakening continued and the tropical cyclone quickly degenerated into a nonconvective low pressure system by 1800 UTC that day. The remnant low remained devoid of significant convection as it moved west-northwestward over progressively colder water for the next 4 days. It dissipated early on 3 September about 520 n mi northeast of Hawaii.

*h. Hurricane Howard: 30 August–5 September*

Howard formed from a tropical wave that moved westward across the coast of Africa on 18 August. While there was no development as the wave crossed the Atlantic, an increase in the associated shower activity occurred on 26 August when the system reached the western Caribbean Sea and the eastern North Pacific. The resulting disturbed weather then moved west-northwestward parallel to the coast of Central America and Mexico. Deep convection increased in both coverage and organization on 29 August, and continued development resulted in the formation of a tropical depression around 1200 UTC 30 August about 350 n mi south-southwest of Acapulco.

The depression moved west-northwestward on the southwest side of a midlevel ridge over Mexico and strengthened. It became a tropical storm early on 31 August and a hurricane on 1 September. Howard then strengthened rapidly and reached an estimated peak intensity of 120 kt on 2 September. This was followed by weakening as Howard moved northwestward over decreasing sea surface temperatures. Howard weakened to a tropical storm on 4 September and to a tropical depression early on 5 September. The cyclone became a nonconvective remnant low later that day about 230 n mi west-southwest of Punta Eugenia, Baja California.

The remnant low continued slowly northwestward until 6 September when it turned southwestward on the southeast side of a low-level ridge. A general southwestward motion continued until 10 September, when the low dissipated about 1000 n mi west-southwest of Cabo San Lucas.

The only observation of tropical-storm-force winds in Howard was from the ship *Strong Virginian* (call sign KSPH), which reported winds of 37 kt at 0600 UTC 4 September.

*i. Hurricane Isis: 8–16 September*

The disturbance that developed into Isis was a tropical wave that entered into the eastern North Pacific basin on 3 September. Although the wave is difficult to follow prior to that point, this wave may have also spawned Hurricane Frances in the Atlantic basin. The system began to organize near 0000 UTC 7 September a few hundred miles southwest of Manzanillo, Mexico. By 0600 UTC 8 September, when the disturbance was located about 460 n mi south of Cabo San Lucas, Mexico, it had sufficient circulation and convective organization to be considered a tropical depression.

The depression strengthened and became a tropical storm at 1800 UTC 18 September, about 525 n mi south of Cabo San Lucas. Isis moved generally westward for the next several days but did not develop due to easterly shear, and weakened back to a depression on 10 September when its deep convection temporarily evaporated. Isis restrengthened to a tropical storm on 12 September about 725 n mi west-southwest of Cabo San Lucas, and its maximum winds reached 45 kt later that day. There was little change in strength until 14 September, when the convection again sputtered and Isis's winds dropped to 35 kt. However, the easterly shear had been decreasing, and late in the day Isis again restrengthened—this time rapidly. Isis developed a ragged eye, and reached hurricane strength at 1200 UTC 15 September, about 1260 n mi west of Cabo San Lucas.

As quickly as the eye had developed, it disappeared. During its rapid development, Isis had turned north-westward over cooler waters (roughly 25°C) and a more stable low-level environment before becoming stationary. Within 24 h of becoming a hurricane, Isis had weakened to a depression, and by 1800 UTC 16 September it had lost all deep convection and become a remnant low, about 1300 n mi west of Cabo San Lucas. The remnant low drifted southwestward and then westward for a few days, generating intermittent convection before dissipating on 21 September about 875 n mi east of the Hawaiian Islands.

Isis is assumed to have become a hurricane at 1200 UTC 15 September, based on Dvorak classifications. However, given that the satellite appearance immediately and rapidly began to deteriorate, it is quite possible that Isis never reached that threshold.

#### *j. Hurricane Javier: 10–19 September*

Javier, the strongest hurricane of the season, originated from a tropical wave that crossed the west coast of Africa 29 August. The wave was devoid of deep convection for several days during its westward trek across the tropical Atlantic. The wave encountered an upper-level low near the Lesser Antilles, and both systems moved westward across the Caribbean Sea. The low weakened and the wave continued westward, crossing Central America on 9 September with an increase in convection. Once the wave entered the eastern Pacific, the cloud pattern became better organized with a limited upper-level outflow. It is estimated that a tropical depression formed from this system at 1800 UTC 10 September about 300 n mi south-southeast of Salina Cruz, Mexico. Satellite images showed that a CDO developed over the circulation center, and intensity estimates based on this cloud pattern indicate that the cyclone became a tropical storm at 1200 UTC 11 September.

Under light wind shear, Javier continued to strengthen and reached hurricane status at 1800 UTC 12 September. It then moved slowly west-northwestward around the periphery of a subtropical ridge centered over Mexico. Thereafter, Javier rapidly intensified and developed a distinct eye. The hurricane reached its estimated peak intensity of 130 kt and a minimum pressure of 930 mb at 0000 UTC 14 September, when the cyclone was located about 270 n mi south-southwest of Manzanillo (Fig. 6). Figure 6 shows Hurricane Javier at the time of the cyclone's peak intensity. Microwave data showed the formation of concentric eyewalls and Javier weakened, but the hurricane maintained category 3 intensity for the next 3 days. Javier moved northwestward over cool waters

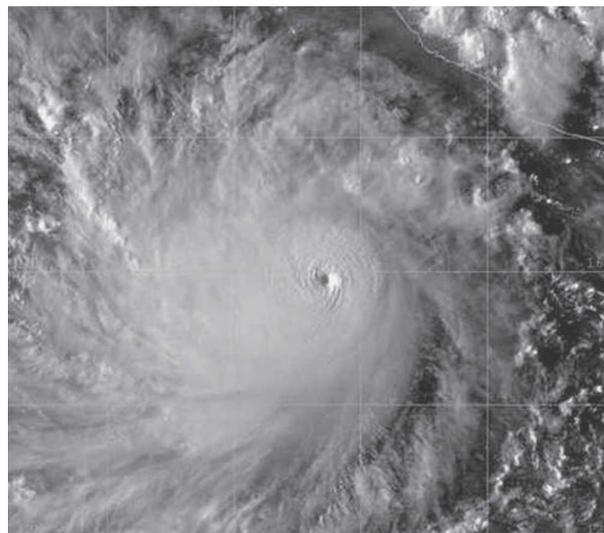


FIG. 6. Visible *Geostationary Operational Environmental Satellite-10 (GOES-10)* image of Hurricane Javier at 0000 UTC 14 Sep 2004, near the time of the hurricane's maximum intensity of 130 kt. This image is courtesy of Naval Research Laboratory, Monterey, CA.

and under strong southwesterly shear resulting in weakening. Javier then turned northward and north-northeastward and the government of Mexico issued of a tropical storm watch for portions of Baja California from Bahia Magdalena to La Paz, including San Carlos at 2100 UTC 15 September and a portion of the watch, from Bahia Magdalena to Punta Eugenia, was replaced by a tropical storm warning at 2100 UTC 16 September. All watches and warnings were discontinued at 0300 UTC 19 September when Javier weakened and was no longer a threat. Javier crossed Baja California between Cabo San Lazaro and Punta Abreojos as a weakening tropical depression around 1100 UTC 19 September. The depression continued toward the north-northeast over the Sea of Cortez and degenerated to a remnant low at 1800 UTC 19 September. The low moved inland near Guaymas, Mexico, and dissipated over the high terrain of the state of Sonora. Midlevel moisture from Javier spread northeastward over northern Mexico and the southwestern United States.

#### *k. Tropical Storm Kay: 4–6 October*

Kay formed on 3 October from an area of disturbed weather in the ITCZ centered several hundred miles southwest of mainland Mexico. There is little evidence that this development was associated with a tropical wave. The disturbance formed into a tropical depression around 1800 UTC 4 October about 515 n mi southwest of Manzanillo while the low-level circulation be-

came increasingly better defined. The depression strengthened to a tropical storm around 0600 UTC the next day approximately 640 n mi west-southwest of Manzanillo. From 4 to 6 October, Kay moved west-northwestward to northwestward on the southwest side of a strong midlevel anticyclone centered over the southwestern United States. Kay reached its peak intensity of 40 kt at 1200 UTC 5 October. Weakening quickly ensued as the deep convection decreased in moderate northerly shear. On 6 October, Kay, reduced to a remnant low, turned southwestward and dissipated the next day.

#### *1. Tropical Storm Lester: 11–13 October*

An area of disturbed weather persisted a couple hundred nautical miles to the southwest of the Gulf of Tehuantepec from 8 to 10 October. On 10 October, a surface low developed in this area, while the associated deep convection gradually became organized into slightly curved bands, and Dvorak classifications were initiated around 1800 UTC that day. The gradual development trend continued on the following day. By 1800 UTC 11 October, the low-level circulation and cloud pattern were sufficiently well organized to indicate the formation of a tropical depression centered about 80 n mi south of Puerto Escondido, Mexico. Steered by the flow between a weak midlevel ridge to its north, and a broad cyclonic circulation to its southwest, the tropical cyclone moved on a northwestward to west-northwestward track for a couple of days. A weak upper-level anticyclone was centered just east of the system, which resulted in an atmospheric environment that was favorable for intensification. The depression became Tropical Storm Lester around 1800 UTC 12 October, and the storm reached its peak intensity of 45 kt about 6–12 h later.

The Mexican government issued a tropical storm watch for the southern coast of Mexico from Punta Maldonado to Zihuatanejo at 1500 UTC 12 October and upgraded this watch to a tropical storm warning for the same area 6 h later. Radar images indicated that the center passed just to the south of Acapulco around 0400 UTC 13 October. The tropical storm warning was extended westward to Lazaro Cardenas at 0900 UTC 13 October.

The interaction with land, and the influence of a larger low-level cyclonic circulation to the southwest, appeared to have disrupted the tropical cyclone's circulation, and the storm began to weaken rapidly just after 0600 UTC 13 October. Lester weakened to a poorly defined tropical depression by 1200 UTC that day, and observations from a U.S. Air Force Reserve Unit Hurricane Hunter aircraft flying at an altitude of

about 300 m indicated that the system had degenerated into a trough on the northeast side of the larger low pressure area later that day. All tropical storm warnings were discontinued at 2100 UTC 13 October.

Lester produced locally heavy rainfall of around 75 to 125 mm over portions of the Mexican states of Oaxaca and Guerrero. Lester very likely produced at least localized flooding over portions of southern Mexico, but no reports of damages or casualties have been received.

### **3. Nondeveloping tropical depressions**

The origin of Tropical Depression Two-E is a tropical wave that moved from Africa to the eastern tropical Atlantic Ocean on 17 June. It is estimated to have moved over Central America on 25 June accompanied by considerable convection. Continuing westward, the wave reached 110°W longitude and began to show signs of a low-level circulation. The system is estimated to have become a tropical depression at 1200 UTC on 2 July while centered about 650 n mi southwest of Cabo San Lucas. The depression moved west-northwestward to westward during the next 36 h and degenerated to a remnant low by 0000 UTC on 4 July when there was no longer significant convection. The remnant low dissipated about 24 h later.

Tropical Depression Six-E was a short-lived cyclone that remained over open waters about 1250 n mi southwest of Cabo San Lucas. It formed at 0600 UTC 1 August and dissipated 24 h later.

Tropical Depression Nine-E appears to have originated from a tropical wave that exited the African coast on 8 August. The wave crossed Central America on 15 August, and for the next few days, while the system moved westward to the south of Mexico, it generated only sporadic deep convection. A persistent area of disturbed weather associated with the wave developed on 19 August about 725 miles south-southwest of Cabo San Lucas. By 23 August, the convection became organized into a more circular pattern, and it is estimated that a tropical depression formed around 1800 UTC that day about 800 n mi west-southwest of Cabo San Lucas. Cold waters and southerly to southwesterly shear prevented strengthening, and by 26 August, the cyclone had lost all deep convection. The depression became a remnant low and moved west-southwestward for a couple of days. It dissipated on 28 August about 950 n mi east of Hilo, Hawaii.

Tropical Depression Sixteen-E formed from a tropical wave around 0000 UTC 25 October about 275 n mi south-southeast of Cabo San Lucas. The depression began to move northward at about 15 kt around the west-

TABLE 2. Homogeneous comparison of official and CLIPER5 track forecast errors in the eastern North Pacific basin for the 2004 season for all tropical cyclones (including depressions). Longer-term averages for the 10-yr period 1994–2003 are shown for comparison. Averages for 96 and 120 h are for the period 2001–03.

	Forecast period (h)						
	12	24	36	48	72	96	120
Average official error for 2004 (kt)	31	52	73	93	136	201	308
Average CLIPER error for 2004 (kt)	36	69	103	140	211	295	373
Average error relative to CLIPER for 2004 (%)	–16	–24	–29	–34	–36	–32	–17
No. of cases in 2004	212	184	158	135	97	72	45
Average official error for 1994–2003 (n mi)	38	70	100	127	180	210	247
Average CLIPER error for 1994–2003 (n mi)	42	85	130	177	256	341	401
Average error relative to CLIPER for 1994–2003 (%)	–9	–18	–23	–28	–30	–38	–38
No. of cases in 1994–2003	2746	2474	2196	1928	1476	283	179
Official error for 2004 relative to 1994–2003 mean (%)	–18	–26	–27	–27	–24	–4	25
CLIPER error for 2004 relative to 1994–2003 mean (%)	–14	–19	–21	–21	–18	–13	–7

ern periphery of a subtropical ridge over Mexico. Strong convection developed near and to the east of the center around 2000 UTC. However, increasing wind shear prevented additional development. The depression continued its northward motion and crossed the extreme southeastern portion of the Sea of Cortez before moving inland along the northwestern coast of Mexico midway between Guasave and Topolobampo at about 1000 UTC 26 October. After moving inland, the high terrain of the Sierra Madres quickly disrupted the circulation and the cyclone dissipated by 1800 UTC. However, over the next two days the remnant midlevel circulation and its associated moisture moved northeastward across northern Mexico and into the southwestern United States, where it interacted with a frontal system and triggered strong thunderstorms and locally heavy rainfall across portions of eastern New Mexico, western and central Texas, and much of Oklahoma. Locally heavy rain fell along the coastal and mountain regions of west-central and northwestern Mexico, causing some localized floods. There were no reports of damage.

The government of Mexico issued a tropical storm warning for the western coast of Mexico from El Roblito northward to Topolobampo at 2200 UTC 25 October. The warning was discontinued at 0900 UTC 26 October.

#### 4. Forecast verification

For all operationally designated tropical cyclones in its area of responsibility, the NHC issues an “official” tropical cyclone track (latitude and longitude of the circulation center) and intensity (maximum 1-min wind speed at 10 m above the surface) forecast every 6 h. These forecasts are made for the 12-, 24-, 36-, 48-, 72-,

96-, and 120-h periods from the initial synoptic time of the forecast (0000, 0600, 1200, or 1800 UTC). The forecasts are evaluated using the postseason best track database for all tropical and subtropical cyclones, including tropical depressions. The track error is defined as the great-circle distance between forecast and best-track positions of the tropical cyclone center and the intensity error is the absolute value of the difference between the forecast and best-track wind speeds.

Table 2 shows the 2004 and long-term (for the 10-yr period 1994–2003, except for the 3-yr period 2001–03 at 96 and 120 h) mean track errors for the official forecasts and CLIPER5<sup>1</sup> (Neumann 1972 and Aberson 1998) model forecasts. In 2004, the official track forecast errors were 18%–27% lower than the long-term means for the 12–72-h forecast times. However the official forecasts were only 4% better than the long-term mean at 96 h and 25% worse than the multiyear mean at 120 h. The table also shows that the 2004 CLIPER5 errors were lower than the long-term mean CLIPER5 errors at all forecast periods. If one uses the CLIPER5 error as a measure of forecast difficulty, this suggests that the 2004 track forecasts were, in general, less difficult than usual. It should be noted that the number of cases in 2004 is somewhat low in comparison to previous years.

Table 3 shows the 2004 and long-term (averaging periods same as in Table 2) mean intensity errors for the official forecasts and SHIFOR5<sup>1</sup> (Jarvinen and Neumann 1979) model forecasts. SHIFOR5, like CLIPER5, is considered to be a benchmark of forecast skill. It can be seen that the official intensity forecasts had slight skill at all forecast periods, since the mean official er-

<sup>1</sup> CLIPER5 and SHIFOR5 are 5-day versions of the original Climatology and Persistence (CLIPER) and Statistical Hurricane Intensity Forecast (SHIFOR) models.

TABLE 3. Homogeneous comparison of official and SHIFOR5 intensity forecast errors in the eastern North Pacific basin for the 2004 season for all tropical cyclones (including depressions). Longer-term averages for the 10-yr period 1994–2003 are shown for comparison. Averages for 96 and 120 h are for the period 2001–03.

	Forecast period (h)						
	12	24	36	48	72	96	120
Average official error for 2004 (kt)	7	11	14	16	19	18	19
Average SHIFOR error for 2004 (kt)	8	13	16	17	21	21	22
Average error relative to SHIFOR for 2004 (%)	–13	–13	–12	–9	–12	–14	–13
No. of cases in 2004	212	184	158	135	97	72	45
Average official error for 1994–2003 (kt)	8	11	15	17	20	18	19
Average SHIFOR error for 1994–2003 (kt)	7	12	16	19	22	20	19
Average error relative to SHIFOR for 1994–2003 (%)	–33	–8	–1	–11	–9	–10	0
No. of cases in 1994–2003	2736	2457	2186	1919	1478	283	179
Official error for 2004 relative to 1994–2003 mean (%)	16	0	–1	–1	–1	0	0
SHIFOR error for 2004 relative to 1994–2003 mean (%)	14	8	0	–11	–5	5	16

rors were 9%–14% lower than SHIFOR5. The mean official intensity errors for 2004 ranged from 7 kt at 12 h to 19 kt at 120 h, and these errors were not much different than the long-term values. Also, the SHIFOR5 errors for 2004 were about the same as the long-term means.

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