Eastern North Pacific Hurricane Season of 1993

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ABSTRACT

The National Hurricane Center tracked 14 tropical storms, 10 of which became hurricanes, during the 1993 eastern North Pacific hurricane season. Four named tropical cyclones and one tropical depression made landfall in Mexico. A general overview of the 1993 hurricane season is presented.

1. Introduction

The eastern North Pacific basin extends from 140°W eastward, from the equator northward. In this basin, the long-term annual averages (calculated since 1966, when routine satellite surveillance began) are 16 named tropical cyclones and 9 hurricanes. In 1993, the number of named tropical cyclones was near the average with 14 tropical storms, 10 of which became hurricanes. The 1993 season’s number of tropical cyclones represents a marked decrease from the record-breaking 24 named storms in 1992. Eight hurricanes reached category 3 or higher status on the Saffir–Simpson hurricane scale (SSHs) (Simpson 1974). A summary of 1993 tropical storm and hurricane statistics is shown in Table 1.

Most of the 1993 eastern North Pacific tropical cyclones originated within the climatologically favorable area for development between southern Mexico and 10°N. Their origin was, in most of the cases, related to tropical waves moving generally westward across that region.

The majority of the tropical cyclones followed the climatological west-northwest track away from land and also toward relatively cool waters near 25°N where they dissipated. However, an anomalous 500-mb area of low pressure over the western United States and Mexico during a portion of the season set up a flow that steered some of the tropical cyclones northward. This pattern caused four named tropical cyclones and one tropical depression to make landfall in Mexico, resulting in 42 deaths. On average, three named eastern North Pacific tropical cyclones strike land every year. Calvin, the largest and most destructive hurricane of the season, killed 34 people and caused millions of dollars in damage. Lidia, one of the most powerful hurricanes of 1993, fortunately weakened before moving ashore but still killed two people. Beatriz, although weak, brought copious rains that resulted in six deaths. Hilary and Tropical Depression Three-E also affected land, with the main impact being heavy rains. In addition, Tropical Storm Irwin did not make landfall but it brought high winds and heavy rains to the southwest coast of Mexico as it passed nearby. Tropical Depression Fourteen-E, formerly Atlantic Hurricane Gert, skirted the south coast of Mexico producing scattered rains. Of the tropical cyclones that remained at sea, Hurricane Kenneth was the strongest, matching Hurricane Lidia’s maximum winds of 67 m s⁻¹.

2. Best tracks

Tropical cyclone best tracks consist of a center position and two measures of intensity (the maximum 1-min sustained surface wind speed and the minimum sea level pressure). The parameters are estimated at 6-h intervals and they are based on a postanalysis of data. The primary data sources for the postanalysis are the National Hurricane Center (NHC) Tropical Satellite Analysis and Forecast Unit, the Synoptic Analysis Branch of the National Environmental Satellite Data and Information Service, and the Air Force Global Weather Central (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 Satellite (GOES-7), Meteosat, and polar-orbiting satellites. In addition, information from ships and land stations is included in the postanalysis. Figure 1 shows the 1993 tropical cyclone tracks and indicates where these systems were located at tropical depression, tropical storm, and hurricane intensity.

3. Statistics on forecast accuracy

Every 6 h the NHC issues official tropical cyclone track and intensity forecasts for periods extending to
Table 1. Eastern North Pacific hurricane season statistics for 1993.

<table>
<thead>
<tr>
<th>Number</th>
<th>Name</th>
<th>Class*</th>
<th>Dates**</th>
<th>Maximum 1-min wind (m s⁻¹)</th>
<th>Minimum sea level pressure (mb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Adrian</td>
<td>H</td>
<td>11–19 Jun</td>
<td>39</td>
<td>979</td>
</tr>
<tr>
<td>2</td>
<td>Beatriz</td>
<td>T</td>
<td>18–20 Jun</td>
<td>28</td>
<td>995</td>
</tr>
<tr>
<td>3</td>
<td>Calvin</td>
<td>H</td>
<td>4–9 Jul</td>
<td>49</td>
<td>966</td>
</tr>
<tr>
<td>4</td>
<td>Dora</td>
<td>H</td>
<td>14–21 Jul</td>
<td>59</td>
<td>945</td>
</tr>
<tr>
<td>5</td>
<td>Eugene</td>
<td>H</td>
<td>15–25 Jul</td>
<td>57</td>
<td>948</td>
</tr>
<tr>
<td>6</td>
<td>Fernanda</td>
<td>H</td>
<td>9–19 Aug</td>
<td>64</td>
<td>934</td>
</tr>
<tr>
<td>7</td>
<td>Greg</td>
<td>H</td>
<td>15–28 Aug</td>
<td>59</td>
<td>948</td>
</tr>
<tr>
<td>8</td>
<td>Hilary</td>
<td>H</td>
<td>17–27 Aug</td>
<td>54</td>
<td>957</td>
</tr>
<tr>
<td>9</td>
<td>Irwin</td>
<td>T</td>
<td>21–22 Aug</td>
<td>31</td>
<td>999</td>
</tr>
<tr>
<td>10</td>
<td>Jova</td>
<td>H</td>
<td>29 Aug–6 Sep</td>
<td>59</td>
<td>948</td>
</tr>
<tr>
<td>11</td>
<td>Kenneth</td>
<td>H</td>
<td>5–18 Sep</td>
<td>67</td>
<td>932</td>
</tr>
<tr>
<td>12</td>
<td>Lidia</td>
<td>H</td>
<td>8–14 Sep</td>
<td>67</td>
<td>930</td>
</tr>
<tr>
<td>13</td>
<td>Max</td>
<td>T</td>
<td>30 Sep–4 Oct</td>
<td>21</td>
<td>1000</td>
</tr>
<tr>
<td>14</td>
<td>Norma</td>
<td>T</td>
<td>2–6 Oct</td>
<td>23</td>
<td>1000</td>
</tr>
</tbody>
</table>

* T: tropical storm, wind speed 17–32 m s⁻¹.
H: hurricane, wind speed 33 m s⁻¹ or higher.
** Dates begin at 0000 UTC and include tropical depression stage.

72 h. The forecasts are evaluated using the best-track dataset derived from NHC’s postanalysis of all available track and intensity information (see section 2). Table 2 shows the 1993 average official track errors. These errors are slightly smaller than the 1988–92 average at all forecast periods.

Official maximum 1-min wind speed forecast errors are given in Table 3. Official intensity errors show a negative bias in 1993 that is somewhat larger than the average of the previous 5 years. The mean absolute error is larger than the previous 5-yr average in the early forecast periods (12–48 h).

4. Tropical cyclone summaries

a. Hurricane Adrian, 11–19 June

Adrian, the first tropical cyclone of the year, formed on 11 June about 1500 km south-southwest of the southern tip of Baja California.¹ The cyclone meandered, well away from land, embedded in a weak steering flow, during its entire 9 days of existence.

Adrian developed within a rather organized and large area of disturbed weather in the intertropical convergence zone. It became a tropical depression on 11 June and reached hurricane status on 15 June. In the initial stage, there were some cloud-band features on satellite imagery along with a well-defined low-level circulation but there was little convection concentrated near the center. By 14 June, an outflow pattern aloft developed, followed by the appearance on infrared satellite imagery of a warm spot near the center. Visible imagery during 15 June revealed a tiny eye embedded in a small area of convection. This was the basis for upgrading the storm to a hurricane on that day.

Adrian reached a maximum intensity² of 39 m s⁻¹ and a minimum pressure of 979 mb on 16 June. Soon after, there was an increase in the vertical wind shear. This began the weakening process that continued until 19 June, when the system was reduced to a swirl of low clouds over cooler waters.

b. Tropical Storm Beatriz, 18–20 June

Beatriz was a short-lived tropical storm that brought copious rainfall to portions of southern Mexico. Cloudiness associated with a broad area of low pressure increased to the south of the Gulf of Tehuantepec on 14 June. Convective banding increased, and analysis of satellite data indicated that a tropical depression formed from the activity early on 18 June about 280 km south-southeast of Huatulco, Mexico.

Based on a report of sustained winds of 18 m s⁻¹ from the German ship Caroline II, the depression was upgraded to tropical storm strength on 18 June. Beatriz moved generally toward the northwest, partly under the influence of the large-scale circulation associated with developing Tropical Storm Arlene in the western Gulf of Mexico. Beatriz reached its maximum sustained winds of 28 m s⁻¹ and minimum central pressure of 995 mb near the time of landfall on the coast of Mexico just west of Puerto Escondido on 19 June.

The Japanese ship New York Highway reported sustained winds of 28 m s⁻¹ while located about 85 km to the southwest of the center at 1800 UTC 19 June. At the same time, the American ship USCGC Mellon re-

¹ Specific locations and distances normally refer to the center of the tropical cyclone. It should be noted that tropical cyclones generally cover thousands of square kilometers around that point.
² Wind and pressure information are estimates based on the Dvorak technique unless otherwise indicated.
FIG. 1. Tropical storm and hurricane tracks for 1993.

- - - - Tropical depression stage
- - - - Tropical storm stage
- - Hurricane stage
++ Extratropical stage
◆ Position and date at 0000 UTC
O Position at 1200 UTC
980 Lowest central pressure in millibars
6 Cyclone "Number 6"
H Hurricane
T Tropical storm
ported 20 m s\(^{-1}\) winds while located about 425 km to the south-southeast of the center.

Several rainfall amounts of between 125 and 250 mm were reported from observing sites in the state of Oaxaca. Even higher storm total amounts of 390 and 300 mm were reported from Salina Cruz and Las Pilas, respectively. News sources reported six people killed in the Mexican states of Morelos and Veracruz due to flooding and falling trees attributed to Beatriz. Damage statistics from flooding are not available. Beatriz dissipated quickly after interacting with the mountains of southwest Mexico. A circulation center was no longer identifiable during 20 June, although some of the cloudiness associated with the remnants of Beatriz spread over portions of the western Gulf of Mexico.

Analyses of U.S. National Meteorological Center (NMC) aviation model data and satellite pictures suggested that the hurricane was embedded in a large, deep-layer-mean cyclonic circulation. Within that environment, the system grew to become a large tropical cyclone with 15 m s\(^{-1}\) surface winds reported nearly 370 km from the circulation center. The cyclone’s upper-level outflow dominated the circulation pattern over Central America, southern Mexico, and the eastern North Pacific Ocean to the east of about 110\(^\circ\)W. Although the center of the cyclone was then several hundred kilometers offshore, widespread rains were falling over southern Mexico. Calvin’s circulation was also broad enough to sweep a trailing disturbance northwestward into eastern Mexico, enhancing the precipitation there.

Calvin turned toward the northwest on a track that brought the center to only 165 km south-southwest of Acapulco. The Acapulco sounding at 1200 UTC 6 July showed 40 m s\(^{-1}\) southeasterly winds near the 2-km level. This motion toward land occurred while water vapor imagery showed a developing mid- to upper-level low just south of Baja California, and a second low aloft moving westward across northern Mexico. These features are generally consistent with a northwestward motion for Calvin. Also, Calvin’s forward motion could also have been affected by interactions between the steering flow, the cyclone’s large circulation, and the nearby mountainous terrain of Mexico.

The Pacific Sandpiper reported sustained winds of 44 m s\(^{-1}\) and 13.4-m waves at 1500 UTC 6 July, when Calvin was centered only 55 km to the southwest of the ship. About 90 min later, a poorly defined eye of...

<table>
<thead>
<tr>
<th>Forecast period (h)</th>
<th>0</th>
<th>12</th>
<th>24</th>
<th>36</th>
<th>48</th>
<th>72</th>
</tr>
</thead>
<tbody>
<tr>
<td>1993 mean</td>
<td>-0.4</td>
<td>-0.7</td>
<td>-1.4</td>
<td>-2.2</td>
<td>-2.9</td>
<td>-3.6</td>
</tr>
<tr>
<td>1993 mean absolute</td>
<td>1.4</td>
<td>4.0</td>
<td>7.0</td>
<td>9.0</td>
<td>9.6</td>
<td>10.1</td>
</tr>
<tr>
<td>(Number of cases)</td>
<td>(291)</td>
<td>(265)</td>
<td>(242)</td>
<td>(220)</td>
<td>(199)</td>
<td>(163)</td>
</tr>
<tr>
<td>1988–92 mean</td>
<td>-0.7</td>
<td>-0.9</td>
<td>-1.4</td>
<td>-1.9</td>
<td>-1.6</td>
<td>-1.6</td>
</tr>
<tr>
<td>1988–92 mean absolute</td>
<td>3.2</td>
<td>5.8</td>
<td>7.6</td>
<td>9.0</td>
<td>10.3</td>
<td></td>
</tr>
<tr>
<td>1993 departure from 1988–92 mean absolute</td>
<td>+26%</td>
<td>+21%</td>
<td>+18%</td>
<td>+7%</td>
<td>-2%</td>
<td></td>
</tr>
<tr>
<td>1993 error range</td>
<td>-10 to +8</td>
<td>-40 to +18</td>
<td>-26 to +23</td>
<td>-28 to +26</td>
<td>-31 to +31</td>
<td>-33 to +39</td>
</tr>
</tbody>
</table>
37-km radius was noted in data from the Special Sensor Microwave/Imager (SSM/I) on board a Defense Meteorological Satellite Program (DMSP) satellite as reported by the AFGWC. Satellite data over the following 18 h indicated that convective cloud tops grew around an eye of increasing clarity while SSM/I data indicated a circular eye of 19-km radius. In addition, the average objective intensity estimates reached a maximum between 0600 and 1200 UTC on 7 July. These objective intensity estimates were based on a 3-h average of the difference between the warm eye temperature and the coldest temperatures surrounding the eye (a modification of the official Dvorak technique). Calvin was at its peak intensity of 49 m s\(^{-1}\) and 966-mb pressure, centered about 140 km southwest of Manzanillo early on 7 July. Some weakening occurred prior to the center of Calvin making landfall about 75 km west-northwest of Manzanillo.

The observers at Manzanillo recorded a minimum pressure of 986.5 mb and sustained winds of 38 m s\(^{-1}\) as the center of Calvin passed by a little to their west late on 7 July. The Instituto Oceanográfico del Pacífico in Manzanillo had a minimum pressure of 994 mb. Colima (located about 95 km east-northeast of Manzanillo) observed sustained winds of 26 m s\(^{-1}\) at 1300 UTC 7 July.

The center of Calvin reentered the Pacific early on 8 July. However, Calvin’s interaction with the mountainous terrain weakened the cyclone to a rather poorly organized tropical storm. Nevertheless, it was still generating seas in excess of 3.6 m as far away as 550 km to the south of the center. Calvin was a tropical depression with a few clusters of deep convection when the center moved ashore just south of La Paz, on the Baja California peninsula during the afternoon of 8 July. Calvin dissipated about 12 h later over the colder waters that lie west of the peninsula.

Reports of 3.9–4.9-m water heights near the northwest coast of Mexico were received by the NHC and likely represent a superposition of storm surge and waves. Waves 4.6 m tall reportedly rolled through some Acapulco streets. Rainfall totals of between 125 and 250 mm occurred in several states. Las Pilas, in Oaxaca, had the largest reported accumulation, 415 mm.

Reports from Miami Herald and the West Hawaii Today indicated that Calvin took the lives of 34 people (This count is believed to include some “indirect” deaths: e.g., an unknown number from traffic accidents on wet roads.) Most of the fatalities were related to flooding that occurred prior to Calvin making landfall. The available partial totals of deaths by state are San Luis Potosí (11), Mexico (5), Guerrero and Oaxaca combined (9), and Colima (1). At least two fatalities occurred offshore. According to the West Hawaii Today, the Mexico Coast Guard found the bodies of two
people aboard the Sultan, a 16-m trimaran, that capsized about 500 km southwest of Acapulco.

A state of emergency was declared in at least 10 states in Mexico. The Mexico Defense Department said that 42,063 people were evacuated in 11 states. At least 1600 people were made homeless. El Herald of Mexico City reported that preliminary damage estimates were at least 100 million ("new") pesos (about $32 million). Much of the damage was due to flooding from rainfall over several states. In addition, news photographs and reports indicated damage to shoreline structures and boats from Acapulco northwestward through Manzanillo, apparently caused by a combination of wind, storm surge, and ocean waves. Rough seas near Lazaro Cardenas caused the leakage of all 3.6 million kilograms of sulfuric acid aboard the previously beached cargo tanker Betula.

d. Hurricane Dora, 14–21 July

The tropical wave associated with the development of Dora left Africa on 27 June and reached the eastern Pacific on 9 July. However, it was not until early 14 July that the weather system became organized into a tropical depression about 1700 km southwest of the southern tip of Baja California. Dora became a tropical storm later on 14 July and a hurricane the next day. Satellite estimates indicate that Dora reached its maximum intensity of 59 m s\(^{-1}\) and a 945-mb pressure on 17 July.

Dora moved on a general west to west-northwestward track around the periphery of a subtropical high during most of its lifetime. This track brought the tropical cyclone toward cooler waters and into an upper-level strong vertical wind shear environment, resulting in a gradual weakening. It dissipated on 21 July about 925 km east of the Hawaiian Islands. The remnants of Dora produced a few showers in those islands a few days later.

e. Hurricane Eugene, 15–25 July

Eugene was first identified as a low-level circulation on 15 July centered about 1300 km south-southwest of the southern tip of Baja California. It strengthened to a tropical storm on 16 July and to a hurricane on 17 July while moving slowly westward. Eugene turned abruptly northwestward on 18 July, but then the tropical cyclone gradually resumed a westward motion that lasted four days. On that track, Eugene reached its peak winds of 57 m s\(^{-1}\) and a pressure of 948 mb on 19 July. Thereafter, Eugene weakened and accelerated westward until dissipation on 25 July about 300 km southwest of Honolulu, Hawaii. It passed over the big island of Hawaii on 25 July as a weakening tropical depression with no significant wind or rain reported.

Although the overall track was rather smooth, the northwest turn on 18 July was notable. The only available explanation for the abrupt change was found in the water vapor imagery where an upper-level low was located to the north of the hurricane. This feature was not depicted by any of the available numerical guidance.

f. Hurricane Fernanda, 9–19 August

Fernanda formed from a tropical disturbance that first appeared in satellite imagery over the tropical Atlantic southwest of the Cape Verde Islands on 28 July. The disturbance was easily tracked as it moved westward over the Atlantic and into the Caribbean Sea. On 4 August, cloudiness and thunderstorms increased to the south of Panama while gradually becoming better organized. The weather system continued westward and a tropical depression developed on 9 August about 650 km south of Manzanillo. The convective banding increased and the system became Tropical Storm Fernanda late on 9 July, while centered about 1000 km south-southeast of the southern tip of Baja California. Upper-level outflow improved over the developing storm, and Fernanda was upgraded to hurricane status the next day. Based on objective satellite intensity estimates, Fernanda reached a minimum pressure of 934 mb and maximum sustained winds of 64 m s\(^{-1}\) on 12 August. Figure 3 shows Hurricane Fernanda near the time of its maximum strength.

Fernanda moved toward the west or west-northwest while located over the Pacific east of 140\(^\circ\)W and passed into the Central Pacific Hurricane Center’s (CPhC) area of responsibility on 14 August. Fernanda turned northward and produced high surf on the north- and east-facing shores of the Hawaiian Islands before becoming extratropical on 19 August.

g. Hurricane Greg, 15–28 August

Greg formed from the remnants of Atlantic Tropical Storm Bret, which traversed Central America a few days earlier. Greg had a very long track over the open waters of the eastern North Pacific.

Tropical Storm Bret struck Nicaragua on 10 August, and by 11 August, its remnants emerged over the eastern Pacific, just to the west of coast of Nicaragua. Bret had become so disorganized by its passage over land that a single center of circulation could no longer be detected. However, the convection retained enough organization so that the remnant area of cloudiness and thunderstorms could be followed from Central America westward over the Pacific waters for the next few days.

The convection became better organized and the system reached tropical depression status early on 15 August, while centered about 530 km south-southeast of Manzanillo, and became Tropical Storm Greg later on that day. On 16 August, Greg was upgraded to a hurricane as a hint of an eye was noted on satellite images. Fairly rapid strengthening occurred during that day when Greg showed a small and fairly well-defined eye. Thereafter, there were some fluctuations in intensity while Greg was heading in the general direction of So-
corro Island. The only report from Socorro was a 28 m s$^{-1}$ wind from the northwest at 1800 UTC 17 August, a few hours before the hurricane passed nearest to that island.

Greg accelerated westward and the eye became more distinct. Maximum winds increased to 59 m s$^{-1}$ and the pressure dropped to 948 mb on 19 August when the hurricane was located about 850 km southwest of the southern tip of Baja California. A well-established deep-layer ridge located to the north of Greg kept the hurricane moving generally westward, at a lower speed, and with little change in intensity for a few days. Greg weakened to a tropical storm on 26 August and to a tropical depression a couple of days later, just before crossing 140°W. The tropical cyclone was dissipating at a location about 1750 km to the east of Honolulu 28 August, but a remnant swirl of clouds (having occasional small areas of deep convection) could be seen moving westward on satellite pictures for several more days. No reports of casualties or damage associated with Greg have been received.

h. Hurricane Hilary, 17–27 August

An area of thunderstorm activity, which persisted to the south of the Gulf of Tehuantepec, became organized sufficiently to become a tropical depression on 17 August. Initially, an upper-level low over the southwest Gulf of Mexico inhibited the development of a strong upper-level outflow associated with the tropical cyclone. Nevertheless, convective bands organized close to the circulation center and the system became Tropical Storm Hilary on 18 August about 220 km south of Huatulco.

Hilary moved slowly on a track that was roughly parallel to the southwest coast of Mexico. On that course, Hilary became a hurricane on 19 August and the first hint of an eye on satellite pictures occurred early on 20 August. Ship reports indicated that Hilary had developed a rather large circulation with its tropical storm force winds extending outward as much as about 280 km to near the coastline. Hilary reached its peak intensity of 54 m s$^{-1}$ and minimum pressure of 957 mb early on 21 August, when located a little more than 370 km west of Manzanillo.

Thereafter, Hilary nearly stalled while executing a small cyclonic loop about 280 km to the south of the southern tip of Baja California. Hilary weakened and resumed a track toward the northwest with maximum sustained winds of only 18 m s$^{-1}$. Although the center of circulation moved into cooler waters just west of the southern part of Baja California, the atmospheric environment apparently became more favorable for some strengthening. Hilary reintensified as a 200-mb high developed over the tropical cyclone and deep convection reformed near the circulation center.
Hilary accelerated northward and made landfall on the Baja California peninsula on 25 August with estimated maximum winds of 28 m s⁻¹. It came ashore on mainland Mexico as a tropical depression, to the west of Hermosillo about midday on 26 August. The residual low-level circulation center dissipated early on 27 August in the vicinity of the northern end of the Gulf of California, but Hilary’s mid- and upper-level moisture was then advected over northwestern Mexico and the southwestern United States.

The largest rainfall totals (mm) along the southwest coast of Mexico reported by the Servicio Meteorológico de México were, by state, Derivadora Jala, Colima (288.2); La Villita, Michoacán (101.0); and Huerta Vieja, Baja California Sur (109.9). Other selected totals were Manzanillo (136.3) and Cabo San Lucas (37.0). The largest rainfall totals in Arizona were Avra Valley Airport (62.9), Organ Pipe Cactus National Monument (59.6), and Kitt Peak Observatory (57.1).

i. Tropical Storm Irwin, 21–22 August

Convection increased south of, and near, the Gulf of Tehuantepec during 20 August, when a tropical wave moved into that region. This wave appeared to be the same wave that spawned Tropical Storm Cindy in the Caribbean Sea a few days earlier. On 20 August, the NHC was issuing advisories on Hurricanes Greg and Hilary. Figure 4 shows Hurricanes Greg and Hilary in progress and Tropical Storm Irwin in its formative stage. The area of disturbed weather became a tropical depression early on 21 August and reached tropical storm status 6 h later while moving northwestward toward the southwest coast of Mexico.

Observations from the ship BT Nestor confirmed the strengthening of the tropical cyclone at that time. The ship reported 27 m s⁻¹ just east of the developing center at 1200 UTC 21 August. A report from Manzanillo, as well as observations from surrounding ships, suggests that the maximum winds associated with Irwin may have been as high as 31 m s⁻¹, with a minimum pressure of 999 mb on 22 August. None of the satellite intensity estimates indicated such winds associated with Irwin at that time. Irwin moved parallel to, and near, the coast of Mexico and was absorbed by the much larger circulation of Hurricane Hilary later on that day.

Manzanillo reported sustained winds of 29 m s⁻¹ and a minimum pressure of 1003.5 mb at 0830 UTC 22 August, when Irwin was about 75 km to the south of that location. At the same time, winds of 44 m s⁻¹ in the Manzanillo harbor were estimated by a manager of a hotel there. In a telephone conversation with the NHC the manager commented: “Winds are certainly strong but not as strong as in Hurricane Calvin” (Calvin hit that area a few weeks before). Those winds appear to be overestimated in comparison to the official data from the Servicio Meteorológico de México in Manzanillo. A maximum rainfall of near 180 mm was recorded at Jala, a dam located in the state of Colima. There were no reports of damage associated with Irwin.

j. Hurricane Jova, 29 August–6 September

Jova was a strong hurricane that remained offshore of the west coast of Mexico. However, some outer rainbands did affect land. Jova formed from a low-level cyclonic circulation that gradually became better organized in the Gulf of Tehuantepec and was upgraded to a tropical depression on 29 August, centered 560 km to the southeast of Acapulco.

The tropical cyclone moved parallel to the coast while strengthening. It reached winds of 59 m s⁻¹ and a 948-mb minimum pressure on 1 September while the center was 230 km southwest of Manzanillo. Thereafter, a gradual weakening began and continued until 6 September when Jova became a swirl of low clouds about 1300 km west of the southern tip of Baja California.

k. Hurricane Kenneth, 5–18 September

Kenneth was a powerful hurricane that fortunately did not hit land. It originated from a disturbance that was tracked from Panama, and it became a tropical depression about 1200 km south-southeast of the southern tip of Baja California on 5 September. It reached tropical storm strength the next day. The storm had a relatively large circulation, as evidenced by a wind report of 18 m s⁻¹ from the SILVIE III, which was located about 430 km southeast of the storm center at 0900 UTC 6 September. Kenneth gradually intensified and reached a minimum pressure of 932 mb and maximum sustained winds of 67 m s⁻¹ on 11 September. Those estimates were based on the highest objective intensity values obtained from digital infrared imagery on that day. A well-defined eye persisted until late on 13 September, but thereafter it gradually became larger and cloud covered. Kenneth weakened to a tropical depression on 18 September and became a low-level cloud swirl that was tracked for a few more days.

l. Hurricane Lidia, 8–14 September

Lidia hit mainland Mexico in the state of Sinaloa, near the city of Culiacan. Its origin was a tropical depression that formed on 8 September from a circularly shaped area of convection noted about 450 km south of the Gulf of Tehuantepec. By late on 8 September the cyclone was already nearing tropical storm intensity, as evidenced by a 17 m s⁻¹ wind report from the ship Pascasia. The cyclone was then centered about 500 km south-southwest of Salina Cruz, moving west-northwestward at 4 m s⁻¹. Lidia reached hurricane strength on 10 September, as very deep convection formed over the center and upper-level outflow became well established.

Lidia continued its west-northwestward motion, paralleling the southwest coast of Mexico for the next day
and a half while continuing to strengthen. Lidia reached its peak intensity of 67 m s⁻¹ and minimum pressure of 930 mb early 11 September. Hurricanes Kenneth and Lidia near the time of their maximum strength are shown in Fig. 5.

Later on 11 September, Lidia’s motion became more northwesterly as a mid- to upper-tropospheric cyclone approached the northern Gulf of California. Thereafter, Lidia began recurving toward mainland Mexico, but it weakened considerably before reaching the coast. Maximum sustained winds were estimated to be near 44 m s⁻¹ when the hurricane made landfall in the state of Sinaloa, a short distance to the southwest of Culiacan early on 13 September. After crossing the coastline, Lidia accelerated northeastward, and then east-northeastward, and weakened rapidly over the high terrain of Mexico. It was reduced to a tropical depression just after crossing the Texas–Mexico border and dissipated over south-central Texas, near Austin, on 14 September. Lidia’s remnants merged with a cold front.

One ship, the BT Alaska, reported 46 m s⁻¹ winds, a 989-mb pressure, and a radar fix indicating the eye of Lidia about 22 km to its south-southwest at 0600 UTC 10 September. No measurements of tropical storm force or stronger winds have been received from Mexico. However, the government of Mexico indicated that winds of “near hurricane force” occurred over the area from near Mazatlan to Culiacan as Lidia was making landfall. Rainfall totals from 100 to 200 mm were reported in the state of Sinaloa.

There were two deaths reported in Mexico, one in Sinaloa (near Culiacan) due to electrocution and another in Durango due to the collapse of a dwelling. One injury was also reported in Durango. The government of Mexico states that at least 10 000 persons were “displaced” in Mexico and that structural damage was extensive in Sinaloa and Durango. There was an Associated Press report of 100 houses destroyed in La Cruz (about 100 km south of Culiacan), and hundreds of shanty-type homes were said to have been demolished by wind and rain in the Mazatlan area. Newspaper reports also stated that 16 homes were destroyed and an additional 4000 damaged in Durango. In the state of Nayarit, agriculture was declared “totally lost” in four counties, due to flooding. There were 1200 head of cattle killed near Culiacan. A 46-m television broadcasting tower in Culiacan was toppled during the hurricane.

m. Tropical Storm Max, 30 September–4 October

Analysis of satellite images suggests that Max developed from an area of convection located near 10°N, 115°W. It became a tropical depression early on 30 September and reached tropical storm intensity the same day. However, strong upper-level winds quickly removed the convection from the low-level center, and
the tropical cyclone weakened to a tropical depression a few hours later. Soon thereafter, the westward extension of a large upper-level anticyclone associated with another disturbance (seedling of Norma) centered about 925 km to the east began to move over the tropical depression. This resulted in a decrease in the vertical wind shear, allowing the convection to become better organized near the low-level circulation. The tropical depression then regained tropical storm strength. Max reached its maximum winds of 21 m s⁻¹ and minimum pressure of 1000 mb early on 2 October.

Because steering currents were weak, Max meandered for a couple of days while weakening. It was absorbed by the much larger circulation of Tropical Storm Norma by 4 October.

n. Tropical Storm Norma, 2–6 October

Norma originated from a large area of disturbed weather that was first identified on 29 September a few hundred kilometers to the south of Acapulco. The disturbed weather gradually developed a surface circulation and was upgraded to a tropical depression on 2 October, while centered about 1100 km south of the southern tip of Baja California. The depression moved toward the northwest at about 5 m s⁻¹ and strengthened to Tropical Storm Norma on 3 October while acquiring a large anticyclone aloft. Norma reached its maximum intensity of 23 m s⁻¹ and a minimum pressure of 1000 mb on 4 October. The storm then moved into an area of southwesterly upper-level flow and weakened for the next couple of days. A swirl of low clouds drifted north-northwestward and then dissipated on 7 October.

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