

**NOAA Technical Memorandum NWSTM PR-54**

2006 Tropical Cyclones Central North Pacific

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**Overview of the 2006 Central North Pacific Tropical Cyclone Season**

The central Pacific tropical cyclone season had near normal activity despite the development of a relatively weak El Niño in September 2006. A total of five tropical cyclones occurred during the season, including two hurricanes. One of the hurricanes, Ioke, reached category 5 intensity and set several central Pacific tropical cyclone records. The other three systems only reached tropical depression intensity. Two signals of El Niño was that 4 of the 5 systems developed within the central Pacific basin where ocean waters were warmer than normal and the three depressions occurred from mid-September to mid-October. Based on long-term averages, the typical season has 4.4 total tropical cyclones, 1.6 being hurricanes, 1.3 tropical storms and 1.5 tropical depressions.

Ioke struck Johnston Island with peak winds estimated to be in the 95 to 115 knots range. This resulted in significant damage to vegetation and coastal erosion. The native bird population was also affected, however no injuries occurred despite a survey crew being on the otherwise uninhabited island at the time. Remnants of both Hurricane Daniel and TD-04C helped fuel locally heavy rains across the Big Island.

Table 1. Summary table (Daniel and Ioke data only for the Central Pacific)

<b>Name</b>	<b>Dates</b>	<b>Max Wind</b>	<b>Est. Minimum Pressure</b>
Hurricane Daniel	Jul 24-26	80 kt/ 90 mph	980 mb/28.94 in

Hurricane Ioke	Aug 19-26	140 kt/160 mph	915 mb/27.02 in
TD two-c	Sep 18-20	30 kt/ 35 mph	1007 mb/29.74 in
TD three-c	Sep 26	30 kt/ 35 mph	1008 mb/29.77 in
TD four-c	Oct 13-14	30 kt/ 35 mph	1007 mb/29.74 in

**Table 2. Overall Track Verification.** Table entries are track forecast errors, measured in nautical miles. Values in parentheses indicate the number of forecasts. Values in bold represent guidance forecast errors equal to or less than the official CPHC forecast.

Forecast	12 hr	24 hr	36 hr	48 hr	72 hr	96 hr	120 hr
CPHC	32.6	51.5	73.0	89.6	111.9	157.3	227.5
CLP5	45.3	86.0	135.5	198.0	290.0	317.9	367.2
BAMD	34.6	54.1	73.4	<b>83.7</b>	<b>73.5</b>	<b>98.1</b>	<b>132.7</b>
BAMM	<b>31.6</b>	<b>49.1</b>	<b>65.5</b>	<b>81.8</b>	<b>75.1</b>	<b>100.9</b>	<b>135.2</b>
BAMS	43.1	75.6	115.9	162.5	240.0	313.5	377.2
GFDL	<b>29.1</b>	<b>45.7</b>	<b>64.2</b>	<b>82.2</b>	<b>101.5</b>	<b>140.3</b>	<b>202.3</b>
AVNO	42.5	63.8	84.7	94.7	<b>109.9</b>	<b>143.0</b>	<b>176.8</b>
GUNS	<b>28.4</b>	55.5	86.0	105.5	131.1	182.8	253.8
GUNA	<b>28.6</b>	<b>50.9</b>	75.4	91.3	<b>109.9</b>	158.0	<b>223.1</b>
CONU	<b>27.1</b>	<b>48.3</b>	<b>70.9</b>	<b>88.0</b>	112.1	<b>155.1</b>	<b>221.4</b>
UKMET	45.3	98.9	91.5	103.8	118.0	<b>149.2</b>	<b>204.3</b>
NOGAPS	33.2	55.8	88.7	109.7	140.4	185.1	253.4

**Table 3. Overall Wind Verification.** Table entries are errors in maximum sustained wind speed forecasts, measured in knots. Values in the parentheses indicate the number of forecasts. Values in bold represent guidance forecast errors equal to or less than the official CPHC forecast.

Forecast	12 hr	24 hr	36 hr	48 hr	72 hr	96 hr	120 hr
CPHC	9.7	17.5	22.8	23.5	25.0	34.3	43.4

GFDL	<b>9.2</b>	<b>14.4</b>	<b>17.0</b>	<b>18.4</b>	<b>16.9</b>	<b>20.4</b>	<b>19.4</b>
AVNO	52.2	62.3	72.4	83.2	94.4	99.6	100.7
SHF5	12.9	22.8	31.7	39.3	88.8	106.9	93.7
SHIP	11.5	26.6	38.5	50.3	65.0	81.4	90.2
ICON	<b>9.2</b>	<b>19.7</b>	26.4	32.8	34.8	44.0	51.6
NOGAPS	46.4	52.8	58.2	62.6	69.7	74.8	76.1

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**HURRICANE DANIEL**  
**24-26 July 2006**

**OVERVIEW.** Tropical Depression (TD) 5-E formed south of Baja California near 12.4N 109.9W at 0000 UTC 17 July then quickly intensified and became Tropical Storm Daniel 12 hours later near 12.4N 112.2W. Development continued unabated until Daniel became a hurricane at 1800 UTC 18 July near 11.9N 117.6W. Thanks to favorable SSTs and low shear environment, Hurricane Daniel continued to strengthen as it moved west, reaching its peak of 130 knots on 22 July. Hurricane Daniel exhibited a relatively rare structure, with very little convection outside of a nearly perfectly symmetrical eye wall. This type of hurricane, known as an annular hurricane, has been shown to maintain its intensity longer than the average hurricane, and Daniel was no exception.

However as it moved westward, Daniel began to slowly weaken and CPHC estimated the mean sustained winds to be 80 knots when it crossed 140W and moved into CPHC area of responsibility shortly before 1200 UTC 24 July. Although initially forecasted to maintain its intensity, Hurricane Daniel became a tropical storm within 18 hours of crossing 140W and a tropical depression within 36 hours. By the time it reached 16.2N 144.4W, CPHC classified it as a remnant low.

**SYNOPTIC HISTORY.** On 24 July when Daniel crossed 140W, most track and intensity guidance suggested that Daniel would continue to slowly weaken and reach the main Hawaiian Islands as a strong tropical storm in roughly 96 hours. At that time, the vertical wind shear in the vicinity of Daniel remained relatively low (9 knots from the east). The upper level easterlies south of a ridge to the north were projected to spread eastward. The strong southwesterly upper level flow across the Hawaiian Islands associated with an upper trough to the northwest was forecast to decrease as the trough receded northwestward. This would have resulted in reduced vertical shear as Daniel approached the Hawaiian Islands. However by 25 July at 0000 UTC, satellite loops showed Daniel was suffering the effects of unfavorable easterly shear estimated at 25 knots from the strong high to the north. Much of the cumulonimbus (convection) activity was pushed west of the low level circulation center (LLCC) and cloud tops had warmed. In addition, Daniel moved over 25 degrees C sea-surface temperatures and the low level northeast flow advected cooler and drier boundary layer air into Daniel's circulation. By 25 July 0600 UTC, Daniel became a tropical storm located near 16.2N 143.1W and by 1200 UTC Daniel became nearly stationary in response to the weak environmental steering. The combination of the weak easterly shear and the ingestion of relatively cool and dry air at low levels caused Daniel to weaken to a tropical depression by 0000 UTC 26 July with the LLCC exposed and well defined and no active convection near the center.

CPHC issued the last bulletin on Daniel at 2100 UTC 26 July and classified it as a dissipating remnant low with maximum sustained winds of 30 knots located about 800 miles east southeast of Hilo, Hawaii.

**IMPACTS:** The remnant circulation of Daniel passed just south of the island of the Big Island of Hawaii on 28 July. Radar and rain gages recorded two to five inches of rainfall across windward areas of the Big Island and Maui on 28 and 29 July. The remnants also brought gusty easterly winds to the main Hawaiian Islands. For a brief period during the afternoon on 28 July, a wind gage at South Point on the Big Island recorded sustained winds of approximately 30 knots with gusts to 40 knots.

**Table 4. Best Track Data**

<b>Date/Time (UTC)</b>	<b>Latitude (°N)</b>	<b>Longitude (°W)</b>	<b>Pressure (mb)</b>	<b>Wind Speed (kt)</b>	<b>Stage/Notes</b>
24 / 1200	16.2	140.4	980	80	Hurricane
24 / 1800	16.2	141.3	985	75	"
25 / 0000	16.2	141.8	994	65	"
25 / 0600	16.2	142.3	999	55	Tropical Storm
25 / 1200	16.2	142.4	1003	45	"
25 / 1800	16.2	142.6	1004	35	"
26 / 0000	16.2	142.8	1006	30	Tropical Depression
26 / 0600	16.2	142.9	1008	30	"
26 / 1200	16.2	143.1	1009	25	"
26 / 1800	16.1	143.6	1009	25	"
27 / 0000	16.2	144.4	1009	25	remnant low
27 / 0600	16.3	145.1	1009	25	"
27 / 1200	16.9	146.6	1009	25	"
27 / 1800	17.2	147.4	1009	25	"
28 / 0000	17.4	148.8	1010	25	"
28 / 0600	17.6	150.1	1010	25	"
28 / 1200	17.8	151.8	1010	25	"

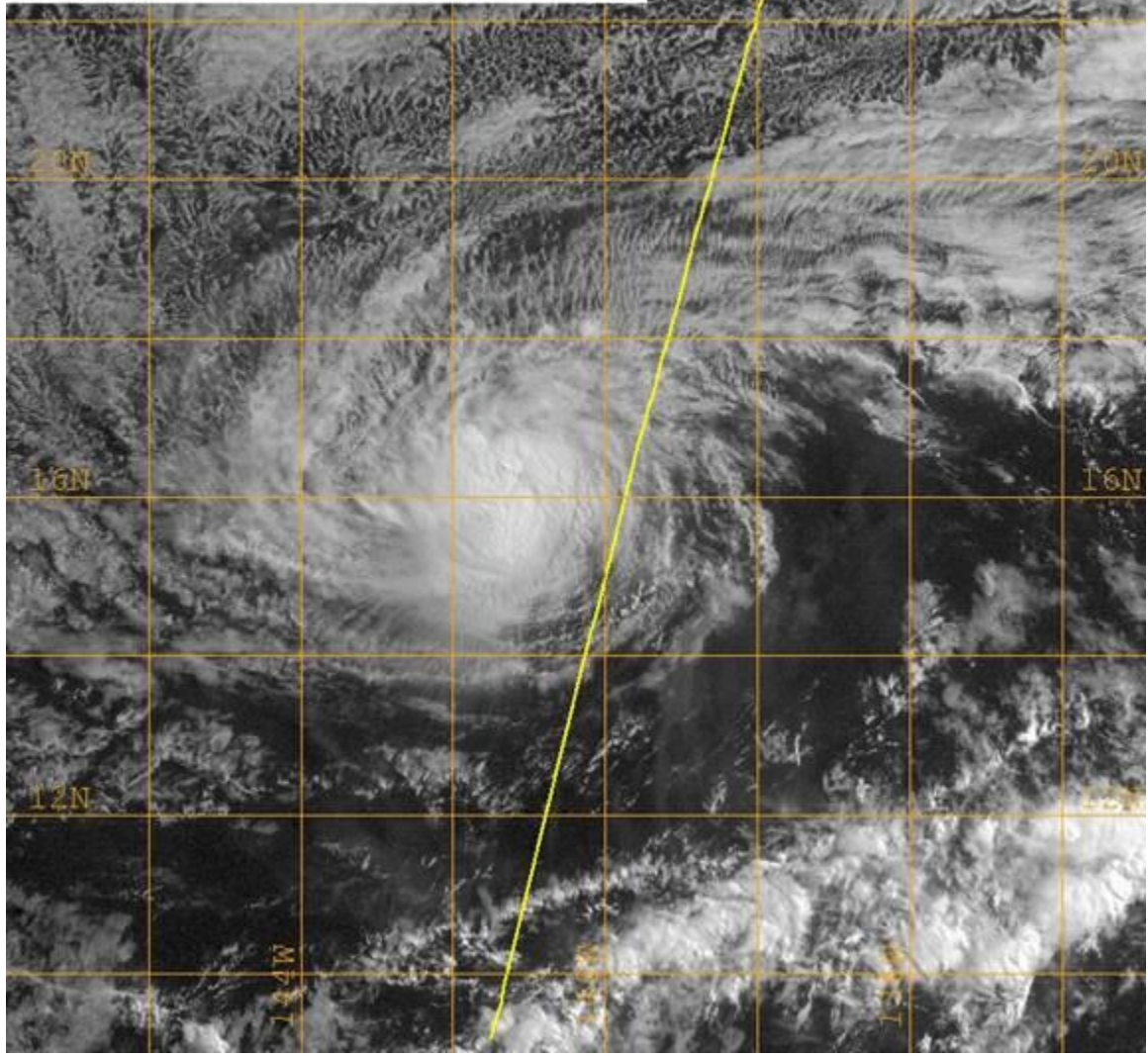
**Table 5. Overall Track Verification.** Table entries are track forecast errors, measured in nautical miles. Values in parentheses indicate the number of forecasts. Values in bold represent guidance forecast errors equal to or less than the official CPHC forecast.

Forecast	12-hr	24-hr	36-hr	48-hr	72-hr	96-hr	120-hr
CPHC	42 (8)	103 (6)	201 (4)	283 (2)	n/a	n/a	n/a
CLP5	45 (8)	114 (6)	218 (4)	354 (2)	n/a	n/a	n/a
BAMD	44 (8)	<b>96 (6)</b>	<b>195 (4)</b>	308 (2)	n/a	n/a	n/a
BAMM	<b>38 (8)</b>	<b>65 (6)</b>	<b>109 (4)</b>	<b>176 (2)</b>	n/a	n/a	n/a
BAMS	<b>25 (8)</b>	<b>39 (6)</b>	<b>66 (4)</b>	<b>110 (2)</b>	n/a	n/a	n/a
GFDL	<b>36 (8)</b>	<b>37 (6)</b>	<b>49 (4)</b>	<b>136 (2)</b>	n/a	n/a	n/a
AVNO	<b>34 (8)</b>	<b>51 (6)</b>	<b>65 (4)</b>	<b>76 (2)</b>	n/a	n/a	n/a
GUNS	<b>41 (8)</b>	<b>97 (6)</b>	<b>177 (4)</b>	<b>267 (2)</b>	n/a	n/a	n/a
GUNA	<b>36 (8)</b>	<b>79 (6)</b>	<b>139 (4)</b>	<b>216 (2)</b>	n/a	n/a	n/a
CONU	<b>34 (8)</b>	<b>78 (6)</b>	<b>142 (4)</b>	<b>231 (2)</b>	n/a	n/a	n/a
UKMET	61 (4)	149 (3)	211 (2)	348 (1)	n/a	n/a	n/a
NOGAPS	<b>35 (8)</b>	<b>90 (6)</b>	<b>177 (4)</b>	286 (2)	n/a	n/a	n/a

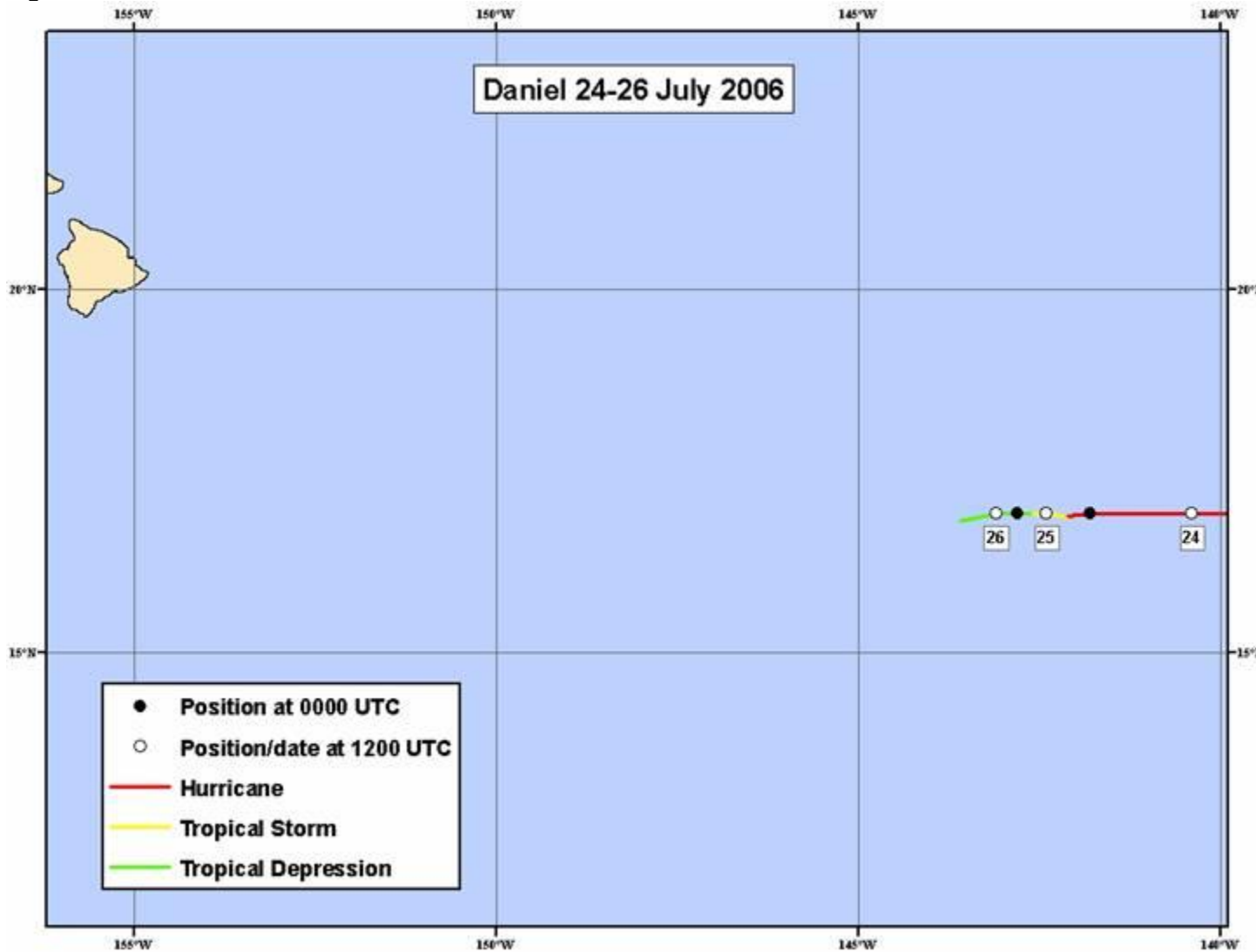
**Table 6. Overall Wind Verification.** Table entries are errors in maximum sustained wind speed forecasts, measured in knots. Values in the parentheses indicate the number of forecasts. Values in bold represent guidance forecast errors equal to or less than the official CPHC forecast.

Forecast	12-hr	24-hr	36-hr	48-hr	72-hr	96-hr	120-hr
CPHC	10 (8)	18 (6)	28 (4)	30 (2)	n/a	n/a	n/a
GFDL	<b>4 (8)</b>	<b>8 (6)</b>	<b>16 (4)</b>	<b>18 (2)</b>	n/a	n/a	n/a
AVNO	15 (8)	<b>8 (6)</b>	<b>6 (4)</b>	<b>3 (2)</b>	n/a	n/a	n/a
SHFR5	<b>6 (8)</b>	<b>12 (6)</b>	<b>19 (4)</b>	<b>27 (2)</b>	n/a	n/a	n/a
SHIP	<b>6 (8)</b>	<b>12 (4)</b>	<b>14 (4)</b>	<b>26 (2)</b>	n/a	n/a	n/a
ICON	<b>5 (8)</b>	<b>13 (4)</b>	<b>15 (4)</b>	<b>26 (2)</b>	n/a	n/a	n/a
NOGAPS	<b>5 (8)</b>	<b>6 (6)</b>	<b>9 (4)</b>	<b>17 (2)</b>	n/a	n/a	n/a

07/24/06 1200Z U5E DANIEL  
07/24/06 1809Z F-15 OVERPASS  
07/24/06 1700Z GOES-11 VIS



**Figure 2.** Track of Daniel



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### HURRICANE IOKE 20-27 August 2006

**OVERVIEW.** CPHC started tracking a tropical disturbance at 1200 UTC 16 August located near 10.7N 144.7W or 925 nm southeast of Hilo, Hawaii. The disturbance moved due west over the next four days becoming Tropical Depression 01-C at 0000 UTC 20 August near 10.4N 158.7W or 675 nm south of Honolulu, Hawaii.

Tropical Depression 01-C rapidly intensified becoming Tropical Storm Ioke near 10.6N 159.0W six hours later at 0600 UTC 20 August. Ioke was the first named tropical cyclone to develop within the Central Pacific since 2002. The system continued to strengthen and at 0000 UTC 21 August, only 24 hours after becoming a depression, Ioke became a hurricane. CPHC estimated maximum sustained winds at 65 knots with a center near 11.5N 163.8W or 685 nm southwest of Honolulu.

Twenty-four hours after becoming a hurricane, Ioke, on a northwest course towards Johnston Island, had estimated maximum sustained winds of 115 knots at 0000 UTC 22 August. After the previous rapid increase in intensity, Ioke began to weaken and at 1800 UTC 22 August had winds estimated near 90 knots about 40 miles south-southeast of Johnston Island. Ioke passed approximately 30 miles south of Johnston Island as a Category 2 hurricane during the 6 hours from 1800 UTC 22 August to 0000 UTC 23 August.

After 36 hours as a Category 2 hurricane, Ioke once again started to intensify. CPHC hurricane specialists estimated the maximum sustained winds to be near 100 knots at 0600 UTC 24 August. Twenty-four hours later at 0600 UTC 25 August, CPHC placed the maximum sustained winds at 140 knots, a category 5 hurricane, centered near 19.1N 174.2W moving to the west-northwest at 6 knots. Ioke crossed the International Dateline near 17.7N between 0300 and 0600 UTC 27 August with winds estimated at 140 knots. With the crossing of the International Dateline, Hurricane Ioke became Super Typhoon Ioke and took aim at Wake Island.

**SYNOPTIC HISTORY.** Low Level. Convection which developed and dissipated on a diurnal cycle for several days prior to 20 August was associated with a persistent tropical disturbance embedded in the Intertropical Convergence Zone (ITCZ) near 10N and 155W. The disturbance was embedded in the deep easterly flow south of the north Pacific subtropical ridge which extended from a high near 43N 140W to 30N 154W and 24N 180. The ridge kept the system on a westward course within the ITCZ and shifted westward in tandem with the system.

When the disturbance became more organized and a LLCC was evident, CPHC identified it as Tropical Depression One-C on 20 August at 0000 UTC near 10.4N 158.7W. Conditions were ideal for further development with warm sea surface temperatures near 28 degrees C and a non-shearing environment (vertical wind shear between 850 hPa and 200 hPa was well below 10 meters per second).

On 22 August, Hurricane Ioke separated from the ITCZ and assumed a northwest course towards a weakness in the subtropical ridge northwest of the system. A surface low that formed near 28N 178E and a frontal trough that extended south of the low produced this weakness. Though weakened by the low and trough, the ridge to the north maintained sufficient strength to prevent Ioke from recurving into the mid-latitude westerlies. By August 26, the low and frontal trough moved west to near 25N 159E which allowed the subtropical ridge to extend west to southwestward ahead of Ioke. With the extension of the ridge, Ioke turned to the west then southwest as it crossed the International Dateline.

Middle and Upper Levels. A broad ridge extended east to west over the tropics along 10N from 16 August through 21 August. As mentioned above, vertical wind shear was practically non-existent due to light winds associated with the flat ridge. The ridge also provided good diffluence aloft. In a 24 hour period from 0000 UTC 20 August to 0000 UTC 21 August, Ioke rapidly developed from a tropical depression into a hurricane.

On 22 August, a north/south oriented upper level trough formed along 180 north of 30N. High pressure centers were located to the east of the trough near 28N 168W and to the west near 20N 160E. The trough aloft weakened the subtropical ridge which allowed Ioke to turn to the northwest away from the ITCZ.

During the next two days from 22 August to 23 August, the trough assumed a northeast to southwest orientation and weakened slightly. The resulting southwesterly wind shear of 10 to 15 meters per second was sufficient to weaken the approaching Ioke from 115 knots to 90 knots.

By 25 August, the upper level trough weakened further and moved westward to near 170E. The vertical wind shear decreased to below 10 meters per second. This along with warmer waters strengthened Hurricane Ioke to a very intense 140 knots. The hurricane maintained this intensity as it crossed the International Dateline and moved to the west.



**IMPACTS.** Hurricane Ioke passed just southwest of Johnston Island on 22 August. The island is a wildlife refuge and normally uninhabited. However, a survey ship and 12 crew members were on the island when Ioke hit. After securing their ship, the crew took shelter in a sturdy concrete building and rode out the storm. There were no injuries, and the ship received only minor damage.

No meteorological instruments were on the island. However based on the crew's eyewitness accounts, tropical storm force winds lasted nearly 27 hours, from about 1200 UTC August 22 until 1500 UTC August 23. Hurricane force winds began shortly before 2200 UTC and lasted 6 to 8 hours. The crew visually estimated the peak winds at 95 to 115 knots. The hurricane washed away a portion of a sea wall and adjacent road. Also, Ioke blew off the tops of an estimated 15 percent of the island's palm trees, and blew down some ironwood trees. The crew estimated the majority of the bird life on the island made it through the hurricane unscathed.

Ioke was:

- The first named tropical cyclone to form in the central Pacific since 2002 when there was Alika, Ele and Huko;
- The fifth Category 5 hurricane on record in the central Pacific;
- The first Category 5 hurricane with origins in the central Pacific since record keeping began in the early 1960s. In 1994, Emilia, Gilma and John strengthened to Category 5 hurricanes in the central Pacific, but these hurricanes originated in the east Pacific. Patsy, also a Category 5 hurricane, was a rarity because it came into the central Pacific from the west across the Dateline in September 1959;
- The hurricane which set a new record for the lowest estimated surface pressure for any hurricane within the central Pacific;
- A Category 4 or higher hurricane for 198 consecutive hours which was the longest continuous time period at that intensity observed for any tropical cyclone anywhere on earth.

**Figure 3.** This satellite picture was taken on August 31 with Super Typhoon Ioke well west of the International Dateline in the RSMC Tokyo area of responsibility. It is included here because if you look

very closely at the inner edge of the south eyewall you can see one white pixel. That pixel is Wake Island.

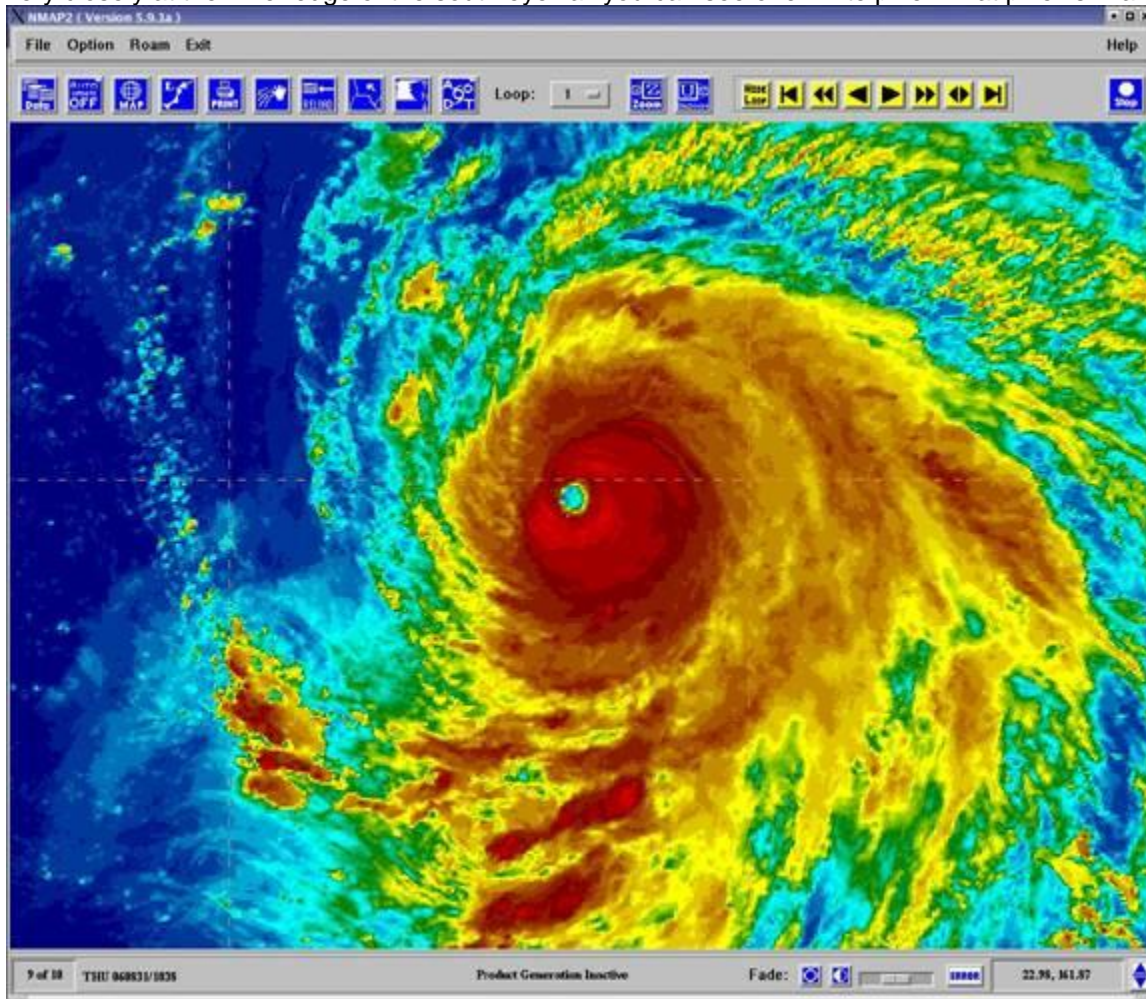


Table 7. Best Track Data

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage/Notes
20 / 0000	10.4	158.7	1012	30	Tropical Depression
20 / 0600	10.5	159.4	1012	30	"
20 / 1200	10.7	160.2	1007	40	Tropical Storm
20 / 1800	11.0	161.7	1005	45	"
21 / 0000	11.2	163.2	995	65	Hurricane
21 / 0600	11.5	164.4	990	70	"

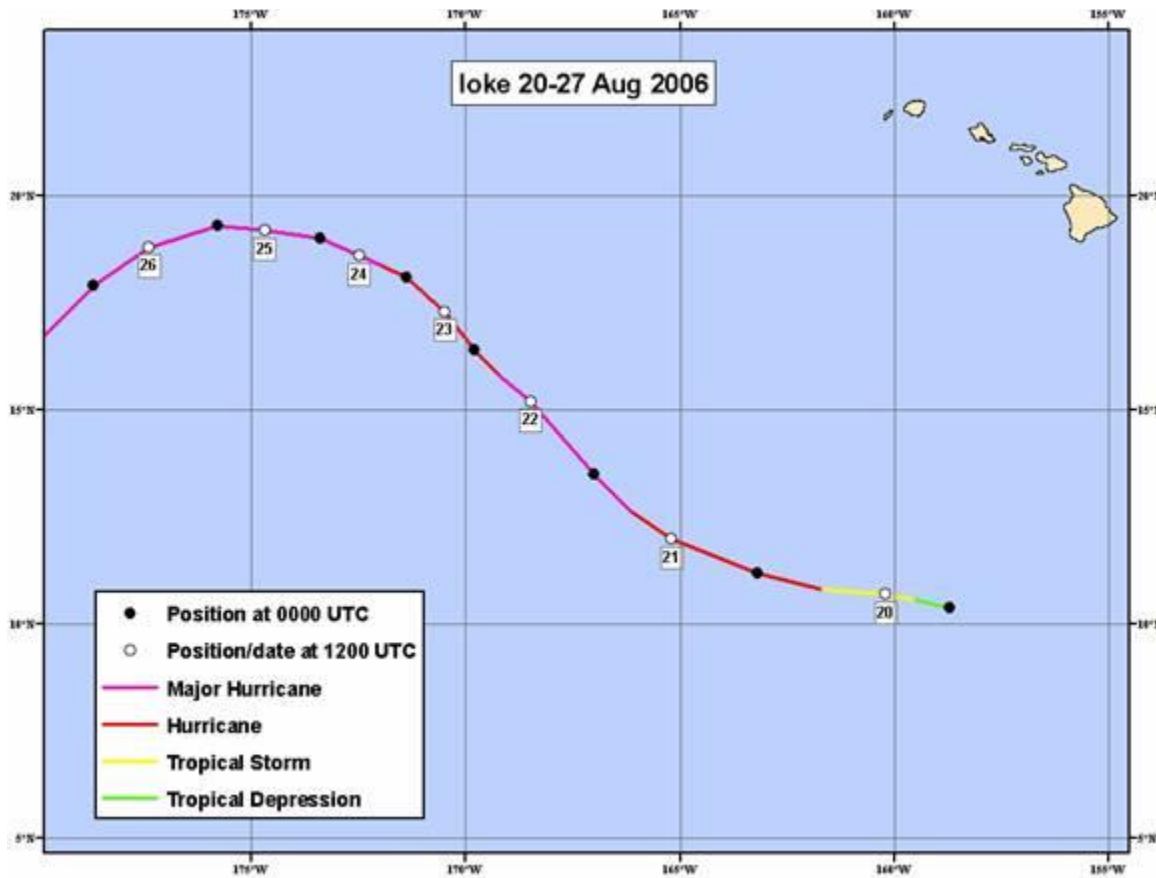
21 / 1200	12.0	165.2	985	75	"
21 / 1800	12.7	166.0	960	100	"
22 / 0000	13.5	167.0	945	115	"
22 / 0600	14.5	167.7	945	115	"
22 / 1200	15.2	168.5	945	115	"
22 / 1800	15.8	169.3	964	90	"
23 / 0000	16.4	169.8	971	90	"
23 / 0600	16.9	170.2	971	90	"
23 / 1200	17.3	170.5	971	90	"
23 / 1800	17.6	170.9	971	90	"
24 / 0000	18.1	171.4	971	90	"
24 / 0600	18.5	172.0	960	100	"
24 / 1200	18.6	172.5	945	115	"
24 / 1800	18.8	172.9	935	125	"
25 / 0000	19.0	173.4	935	125	"
25 / 0600	19.1	174.2	920	140	"
25 / 1200	19.2	174.7	920	140	"
25 / 1800	19.2	175.1	920	140	"
26 / 0000	19.3	175.8	935	130	"
26 / 0600	19.1	176.5	935	130	"
26 / 1200	18.8	177.4	920	140	"
26 / 1800	18.3	178.0	920	140	"
27 / 0000	17.9	178.9	920	140	"
27 / 0600	17.6	179.8	915	140	"

**Table 8. Overall Track Verification.** Table entries are track forecast errors, measured in nautical miles. Values in parentheses indicate the number of forecasts. Values in bold represent guidance forecast errors equal to or less than the official CPHC forecast.

Forecast	12 hr	24 hr	36 hr	48 hr	72 hr	96 hr	120 hr
CPHC	24.3 (29)	44.3 (29)	57.7 (29)	76.3 (29)	111.9 (29)	157.3 (29)	227.5 (29)
AVNO	42.7 (27)	64.8 (27)	85.1 (27)	96.1 (27)	<b>109.9</b> <b>(27)</b>	<b>143.0</b> <b>(27)</b>	<b>176.8</b> <b>(27)</b>
BAMD	29.3 (29)	48.1 (29)	60.2 (29)	68.2 (29)	73.5 (29)	<b>98.1</b> <b>(29)</b>	<b>132.7</b> <b>(29)</b>
BAMM	29.1 (28)	47.8 (28)	62.5 (28)	<b>75.1</b> <b>(28)</b>	75.1 (28)	<b>100.9</b> <b>(28)</b>	<b>135.2</b> <b>(28)</b>
BAMS	48.3 (28)	90.8 (28)	129.6 (28)	166.3 (28)	240.0 (28)	313.5 (28)	377.2 (28)
CLP5	40.4 (29)	82.8 (29)	129.8 (29)	187.2 (29)	290.0 (29)	317.9 (29)	367.2 (29)
CONU	<b>23.3</b> <b>(29)</b>	<b>42.0</b> <b>(29)</b>	60.9 (29)	78.1 (29)	112.1 (29)	<b>155.1</b> <b>(29)</b>	<b>221.4</b> <b>(29)</b>
GFDL	<b>24.0</b> <b>(27)</b>	45.2 (27)	64.6 (27)	78.2 (27)	<b>101.5</b> <b>(27)</b>	<b>140.3</b> <b>(27)</b>	<b>202.3</b> <b>(27)</b>
GUNA	24.7 (18)	<b>42.9</b> <b>(18)</b>	61.3 (18)	77.4 (18)	<b>109.9</b> <b>(18)</b>	158.0 (18)	<b>223.1</b> <b>(18)</b>
GUNS	<b>22.7</b> <b>(18)</b>	<b>42.7</b> <b>(18)</b>	65.8 (18)	87.6 (18)	131.1 (18)	182.8 (18)	253.8 (18)
NOGAPS	31.8 (29)	49.4 (29)	76.6 (29)	97.6 (29)	140.4 (29)	185.1 (29)	253.4 (29)
UKMET	32.2 (15)	58.5 (15)	75.6 (15)	87.5 (15)	118.0 (15)	<b>149.2</b> <b>(15)</b>	<b>204.3</b> <b>(15)</b>

**Table 9. Overall Wind Verification.** Table entries are errors in maximum sustained wind speed forecasts, measured in knots. Values in the parentheses indicate the number of forecasts. Values in bold represent guidance forecast errors equal to or less than the official CPHC forecast.

Forecast	12 hr	24 hr	36 hr	48 hr	72 hr	96 hr	120 hr
CPHC	10.7 (29)	17.9 (29)	21.6 (29)	23.1 (29)	25.0 (29)	34.3 (29)	43.4 (29)
GFDL	<b>10.6 (27)</b>	<b>15.6 (27)</b>	<b>17.3 (27)</b>	<b>18.4 (27)</b>	<b>16.9 (27)</b>	<b>20.4 (27)</b>	<b>19.4 (27)</b>
AVNO	76.8 (27)	82.9 (27)	87.5 (27)	89.2 (27)	94.4 (27)	99.6 (27)	100.7 (27)
SHF5	16.9 (29)	26.2 (29)	34.1 (29)	40.1 (29)	88.8 (29)	106.9 (29)	93.7 (29)
SHIP	14.6 (27)	30.3 (27)	42.7 (27)	52.1 (27)	65.0 (27)	81.4 (27)	90.2 (27)
ICON	11.4 (26)	21.5 (24)	28.4 (24)	33.4 (24)	34.8 (24)	44.0 (24)	51.6 (22)
NOGAPS	57.8 (29)	62.5 (29)	65.0 (29)	65.7 (29)	69.7 (29)	74.8 (29)	76.1 (29)



### TROPICAL DEPRESSION 02-C 18-20 September 2006

**OVERVIEW.** Tropical Depression 02-C developed from a tropical disturbance embedded within the ITCZ south of Hawaii. First identified as a tropical disturbance on 14 September near 10.6N 145.3W, the system persisted as an organized cluster of thunderstorms. Through 17 September, QuikSCAT satellite winds and other data did not indicate a closed circulation. TD 02-C became a tropical depression on the morning of 18 September when a 1623 UTC QuikSCAT pass displayed a closed circulation at the surface. This same QuikSCAT data indicated maximum sustained winds of 45 knots near the center of TD 02-C, but these data were rain flagged (contaminated due to heavy rain). Thus based largely in part on agency fixes of 1.0 to 1.5 Dvorak numbers, CPHC set the initial intensity at 25 knots. Over the next 36 hours, TD 02-C failed to reach tropical storm strength with winds remaining at 25 to at 30 knots from 0600 UTC 19 September to 0600 UTC 20 September. By early on 21 September, persistent convective activity had ceased and TD 02-C lost its low level circulation.

**SYNOPTIC HISTORY.** Initial analyses indicated TD 02-C formed from the remnants of former Hurricane Kristy. Kristy formed in the Eastern Pacific on 30 August as a tropical depression and quickly reached hurricane strength on 31 August. By 8 September, Kristy had weakened to a remnant low. The final best track position from the Tropical Prediction Center (TPC) placed the remnant low near 15.0N 132.5W at 0600 UTC 9 September. The remnant low continued to move slowly westward until 0600 UTC 13 September when it dissipated near 10N 140W. Subsequent QuikSCAT passes and satellite imagery did not indicate an identifiable feature (either a closed circulation or open wave) which was discernible from

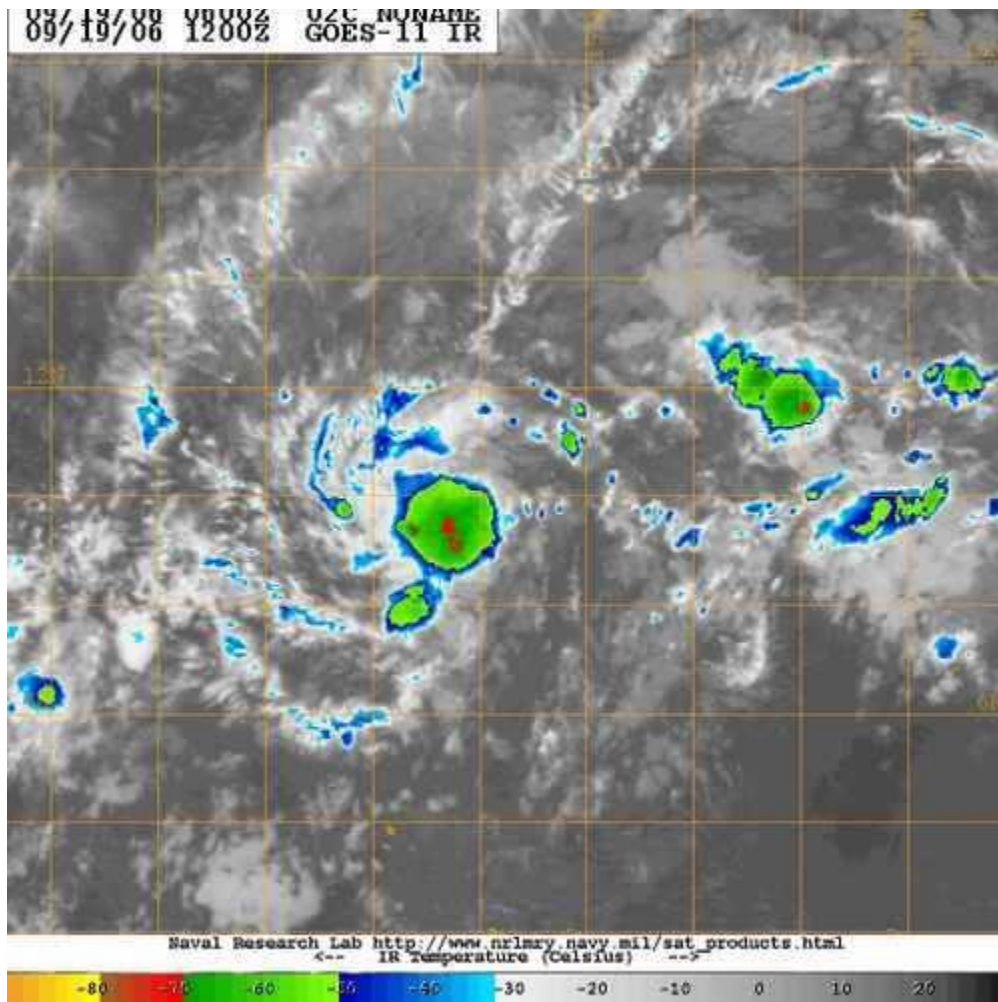
the ITCZ. Therefore, CPHC hurricane specialists determined in the post analysis the disturbance which eventually became TD 02-C formed west of where the remnant low from Hurricane Kristy dissipated, and thus they concluded, TD 02-C was a separate system.

TD 02-C formed within the seasonal east to west surface trough associated with the ITCZ around 1600 UTC 18 September near 9.8N 151.5W. Little to no vertical wind shear, sufficient outflow aloft, and sea surface temperatures of 28-29 degrees C indicated continued development which was supported by both statistical and dynamic model guidance at the time. A strong 1032 hPa surface high located near 38N 144W and the upper atmosphere's deep layer mean easterly winds steered TD 02-C toward the west northwest. Between 0000 and 0600 UTC on 19 September, TD 02-C's maximum winds increased to 30 knots, the system showed signs of better organization, and the convection near the center intensified. However by 1800 UTC on 19 September, the building high pressure system at mid- and upper-levels located to the northeast of TD 02-C slightly increased the vertical wind shear. While vertical wind shear values remained weak overall, generally 10 knots or less, it was apparently sufficient to push convection west of the low level circulation center. At 1200 UTC 20 September, infrared imagery showed a completely exposed low level circulation center with disorganized convection west of the center. The 1711 UTC QuikSCAT pass confirmed there was no longer a low level circulation center.

**IMPACTS.** TD 02-C remained over water and away from any significant or otherwise populated Pacific islands.

**Table 10. Best Track Data**

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage/Notes
19 / 0000	9.9	156.6	1007	25	Tropical Depression
19 / 0600	9.9	157.5	1007	30	"
19 / 1200	9.9	158.4	1007	30	"
19 / 1800	10.1	160.0	1007	30	"
20 / 0000	10.3	161.2	1007	30	"
20 / 0600	10.6	162.3	1007	30	"
20 / 1200	10.9	163.6	1008	25	"
20 / 1800	11.2	165.0	1008	25	"
21 / 0000	11.9	166.4	1009	20	Tropical Disturbance



**Table 11. Overall Track Verification.** Table entries are track forecast errors, measured in nautical miles. Values in parentheses indicate the number of forecasts. Values in bold represent guidance forecast errors equal to or less than the official CPHC forecast.

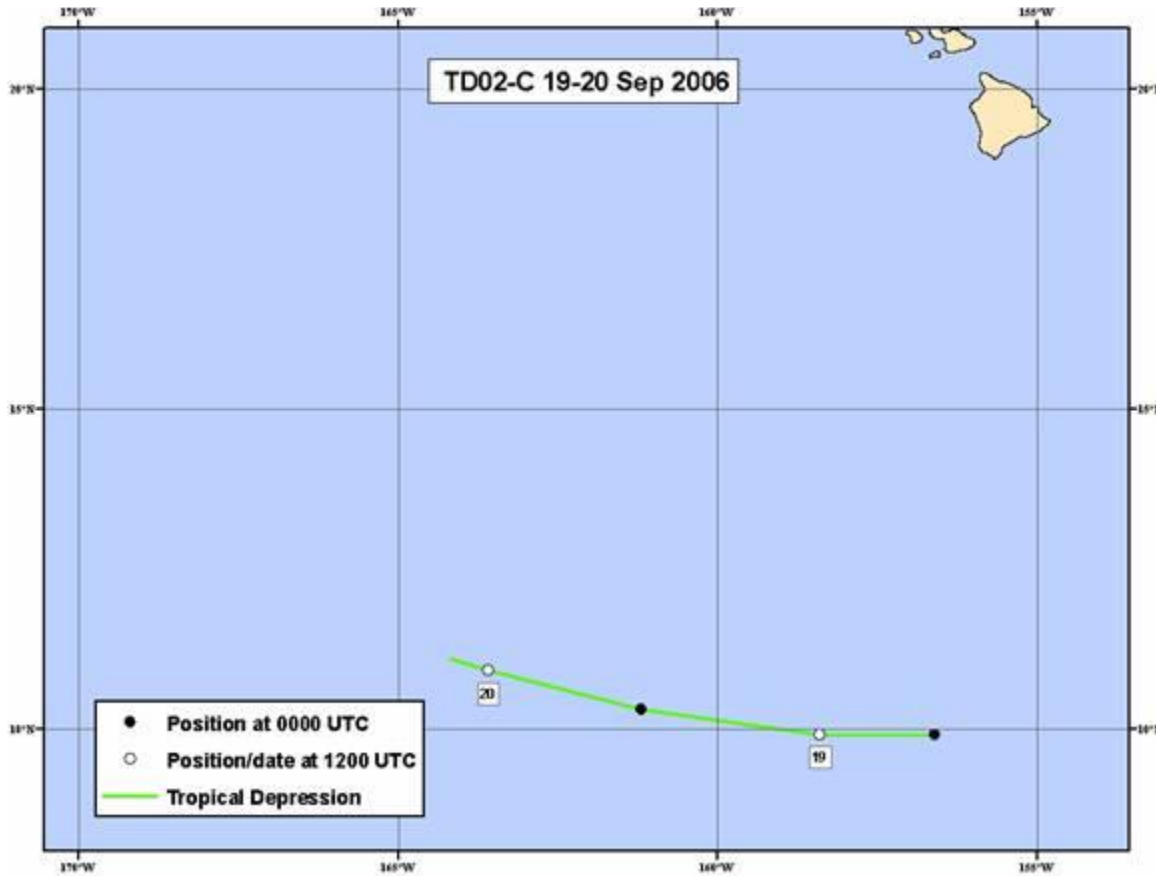
Forecast	12 hr	24 hr	36 hr	48 hr	72 hr	96 hr	120 hr
CPHC	29.9 (6)	26.8 (4)	39.1 (2)	n/a	n/a	n/a	n/a
AVNO	54.6 (6)	76.8 (4)	120.3 (2)	n/a	n/a	n/a	n/a
BAMD	<b>24.7 (6)</b>	34.8 (4)	<b>21.5 (2)</b>	n/a	n/a	n/a	n/a
BAMM	<b>24.7 (6)</b>	34.8 (4)	<b>21.5 (2)</b>	n/a	n/a	n/a	n/a
BAMS	30.0 (6)	<b>24.8 (4)</b>	<b>24.5 (2)</b>	n/a	n/a	n/a	n/a
CLP5	36.0 (6)	67.2 (4)	51.7 (2)	n/a	n/a	n/a	n/a



CONU	30.3 (5)	48.9 (3)	76.7 (1)	n/a	n/a	n/a	n/a
GFDL	44.9 (4)	67.7 (3)	113.4 (1)	n/a	n/a	n/a	n/a
GUNA	32.3 (3)	<b>25.2 (1)</b>	n/a	n/a	n/a	n/a	n/a
GUNS	<b>29.3 (3)</b>	34.5 (1)	n/a	n/a	n/a	n/a	n/a
NOGAPS	38.8 (4)	46.6 (2)	n/a	n/a	n/a	n/a	n/a
UKMET	74.6 (3)	325.9 (2)	n/a	n/a	n/a	n/a	n/a

**Table 12. Overall Wind Verification.** Table entries are errors in maximum sustained wind speed forecasts, measured in knots. Values in the parentheses indicate the number of forecasts. Values in bold represent guidance forecast errors equal to or less than the official CPHC forecast.

Forecast	12 hr	24 hr	36 hr	48 hr	72 hr	96 hr	120 hr
CPHC	7.5 (6)	15.0 (4)	30.0 (2)	n/a	n/a	n/a	n/a
GFDL	8.5 (4)	16.0 (3)	<b>13.0 (1)</b>	n/a	n/a	n/a	n/a
AVNO	<b>4.5 (6)</b>	<b>4.0 (4)</b>	<b>2.0 (2)</b>	n/a	n/a	n/a	n/a
SHF5	<b>5.8 (6)</b>	<b>13.8 (4)</b>	<b>22.0 (2)</b>	n/a	n/a	n/a	n/a
SHIP	<b>6.5 (6)</b>	16.5 (4)	30.5 (2)	n/a	n/a	n/a	n/a
ICON	<b>6.2 (5)</b>	<b>14.3 (3)</b>	<b>24.0 (1)</b>	n/a	n/a	n/a	n/a
NOGAPS	<b>3.8 (4)</b>	<b>1.5 (2)</b>	n/a	n/a	n/a	n/a	n/a



### TROPICAL DEPRESSION 03-C 26-27 September 2006

**OVERVIEW.** Tropical Depression 03-C developed over the open tropical ocean near the International Dateline far to the west southwest of the Hawaiian Islands. This system which formed within a cluster of thunderstorms within the ITCZ was the second weak tropical cyclone (first was TD 02-C) to develop in the southwestern portion of the central Pacific Ocean after the occurrence of powerful Hurricane Ioke in August 2006. On 25 September, CPHC began tracking the cluster of disorganized, but persistent deep convection, which spawned TD-03C. Based upon the appearance of significant cold cloud tops in infrared satellite imagery, a low level circulation center evident in early morning visible satellite imagery, and a somewhat ambiguous QuikSCAT pass, CPHC declared the system TD 03-C at 2100 UTC 26 September (Figure 7). At that time, the center of TD 03-C was near 11.2N 177.8W or about 1530 miles west-southwest of Honolulu, Hawaii and 710 miles west-southwest of Johnston Island. CPHC estimated the maximum sustained wind speed at the time to be 30 knots, and the tropical depression was moving toward the west-northwest at slightly less than 8 knots. However, TD-03C struggled to maintain its identity during the next several hours. QuikSCAT data from 0827 UTC 27 September indicated TD-03C no longer had an identifiable closed low level circulation center. As a result, CPHC issued the final advisory for dissipating TD-03C at 0900 UTC 27 September as it was crossing the International Dateline.

**SYNOPTIC HISTORY.** El Nino conditions started to develop during the central Pacific hurricane season according to NOAA scientists<sup>1</sup>. These scientists linked the El Nino's rapid development and intensification to a series of large subsurface oceanic waves in the equatorial Pacific Ocean which began in June 2006.

The result was progressive warming of the tropical Pacific Ocean during the summer months of 2006. A particularly strong subsurface wave led to a significant warming of the entire eastern half of the equatorial Pacific in early September 2006. As a result, NOAA reported in early September that an El Niño had developed. The warmer than normal tropical ocean waters produced enhanced deep convection and increased rainfall near the Dateline during much of the central Pacific hurricane season. These El Niño conditions likely contributed to the development of TD-03C near the Dateline as well as the genesis of the other tropical cyclones that formed in the central Pacific from August through October 2006. However, only intense Hurricane Ioke developed beyond tropical depression stage, despite the fact the other systems formed in approximately the same region of the central Pacific Ocean.

In the case of TD 03-C, significant westerly vertical wind shear in the vicinity of the system likely inhibited further development beyond the tropical depression stage. In addition, there was evidence of dry mid-level air just west of the system after it developed. These hostile conditions likely overwhelmed any positive role that anomalously warm ocean temperatures may have played in the maintenance of TD-03C as a viable tropical cyclone. As a result of these adverse environmental elements, the CPHC forecast indicated TD 03-C would maintain its status as tropical depression as it tracked west northwestward at approximately 8 knots towards the west Pacific.

<sup>1</sup>NOAA, 2006: "Return of El Niño Yields Near Normal 2006 Atlantic Hurricane Season". <http://www.noaanews.noaa.gov/stories2006/s2748.htm>.

**IMPACTS.** TD 03-C remained over water and away from any significant or otherwise populated Pacific islands.

**Table 13. Best Track Data**

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage/Notes
26 / 1800	11.2	177.8	1008	30	Tropical Depression
27 / 0000	11.5	178.4	985	30	"
27 / 0600	11.8	179.3	994	25	Dissipating

**Table 14. Overall Track Verification.** Table entries are track forecast errors, measured in nautical miles. Values in parentheses indicate the number of forecasts. Values in bold represent guidance forecast errors equal to or less than the official CPHC forecast.

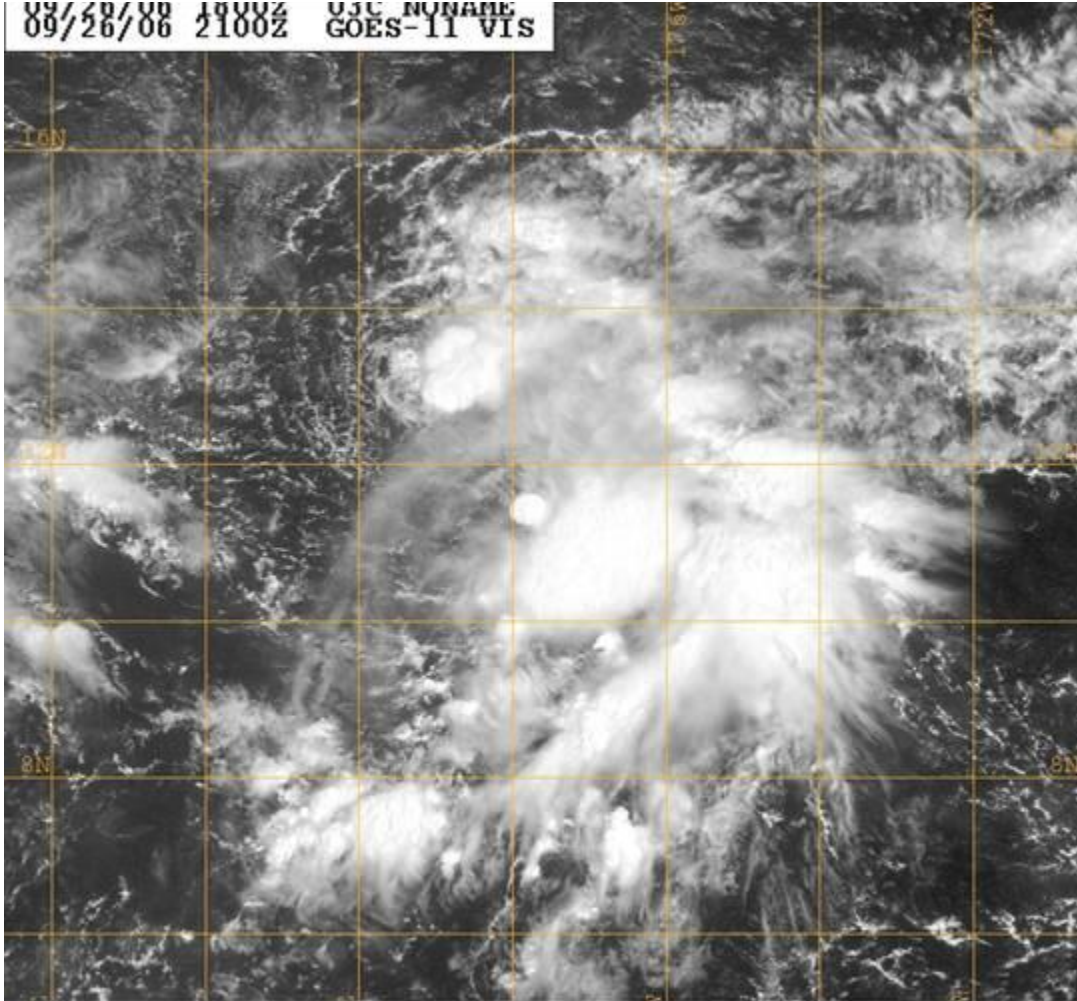
Forecast	12-hr	24-hr	36-hr	48-hr	72-hr	96-hr	120-hr
CPHC	42 (8)	103 (6)	201 (4)	283 (2)	n/a	n/a	n/a
CLP5	45 (8)	114 (6)	218 (4)	354 (2)	n/a	n/a	n/a
BAMD	44 (8)	<b>96 (6)</b>	<b>195 (4)</b>	308 (2)	n/a	n/a	n/a
BAMM	<b>38 (8)</b>	<b>65 (6)</b>	<b>109 (4)</b>	<b>176 (2)</b>	n/a	n/a	n/a

BAMS	<b>25 (8)</b>	<b>39 (6)</b>	<b>66 (4)</b>	<b>110 (2)</b>	n/a	n/a	n/a
GFDL	<b>36 (8)</b>	<b>37 (6)</b>	<b>49 (4)</b>	<b>136 (2)</b>	n/a	n/a	n/a
AVNO	<b>34 (8)</b>	<b>51 (6)</b>	<b>65 (4)</b>	<b>76 (2)</b>	n/a	n/a	n/a
GUNS	<b>41 (8)</b>	<b>97 (6)</b>	<b>177 (4)</b>	<b>267 (2)</b>	n/a	n/a	n/a
GUNA	<b>36 (8)</b>	<b>79 (6)</b>	<b>139 (4)</b>	<b>216 (2)</b>	n/a	n/a	n/a
CONU	<b>34 (8)</b>	<b>78 (6)</b>	<b>142 (4)</b>	<b>231 (2)</b>	n/a	n/a	n/a
UKMET	61 (4)	149 (3)	211 (2)	348 (1)	n/a	n/a	n/a
NOGAPS	<b>35 (8)</b>	<b>90 (6)</b>	<b>177 (4)</b>	286 (2)	n/a	n/a	n/a

**Table 15. Overall Wind Verification.** Table entries are errors in maximum sustained wind speed forecasts, measured in knots. Values in the parentheses indicate the number of forecasts. Values in bold represent guidance forecast errors equal to or less than the official CPHC forecast.

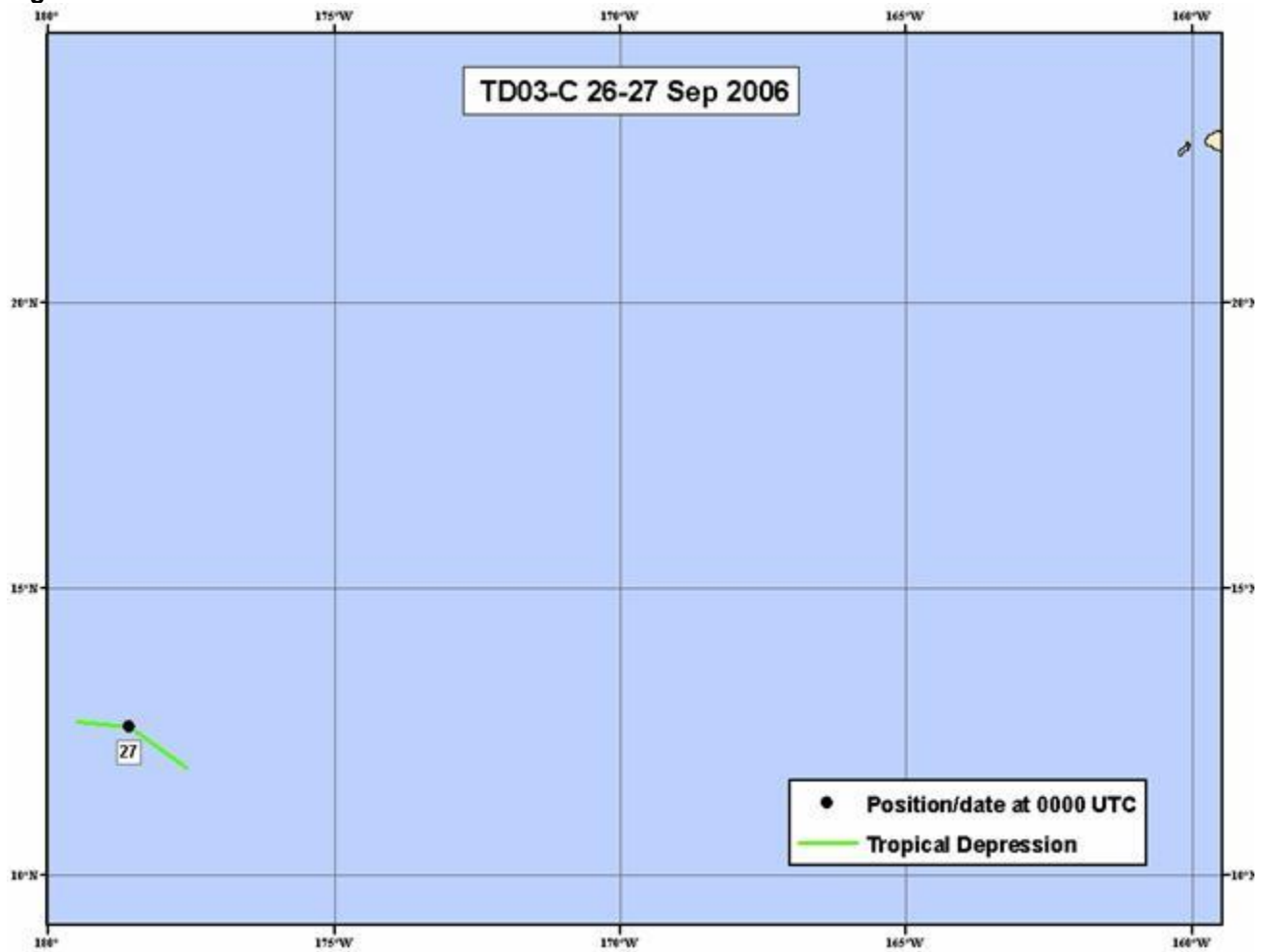
Forecast	12-hr	24-hr	36-hr	48-hr	72-hr	96-hr	120-hr
CPHC	10 (8)	18 (6)	28 (4)	30 (2)	n/a	n/a	n/a
GFDL	<b>4 (8)</b>	<b>8 (6)</b>	<b>16 (4)</b>	<b>18 (2)</b>	n/a	n/a	n/a
AVNO	15 (8)	<b>8 (6)</b>	<b>6 (4)</b>	<b>3 (2)</b>	n/a	n/a	n/a
SHFR5	<b>6 (8)</b>	<b>12 (6)</b>	<b>19 (4)</b>	<b>27 (2)</b>	n/a	n/a	n/a
SHIP	<b>6 (8)</b>	<b>12 (4)</b>	<b>14 (4)</b>	<b>26 (2)</b>	n/a	n/a	n/a
ICON	<b>5 (8)</b>	<b>13 (4)</b>	<b>15 (4)</b>	<b>26 (2)</b>	n/a	n/a	n/a
NOGAPS	<b>5 (8)</b>	<b>6 (6)</b>	<b>9 (4)</b>	<b>17 (2)</b>	n/a	n/a	n/a

09/26/08 1800Z OJC NONAME  
GOES-11 VIS



Naval Research Lab [http://www.nrlmry.navy.mil/sat\\_products.html](http://www.nrlmry.navy.mil/sat_products.html)  
<-- Visible ( Sun elevation at center is 50 degrees) -->

**Figure 8.** Track of TD 03-C



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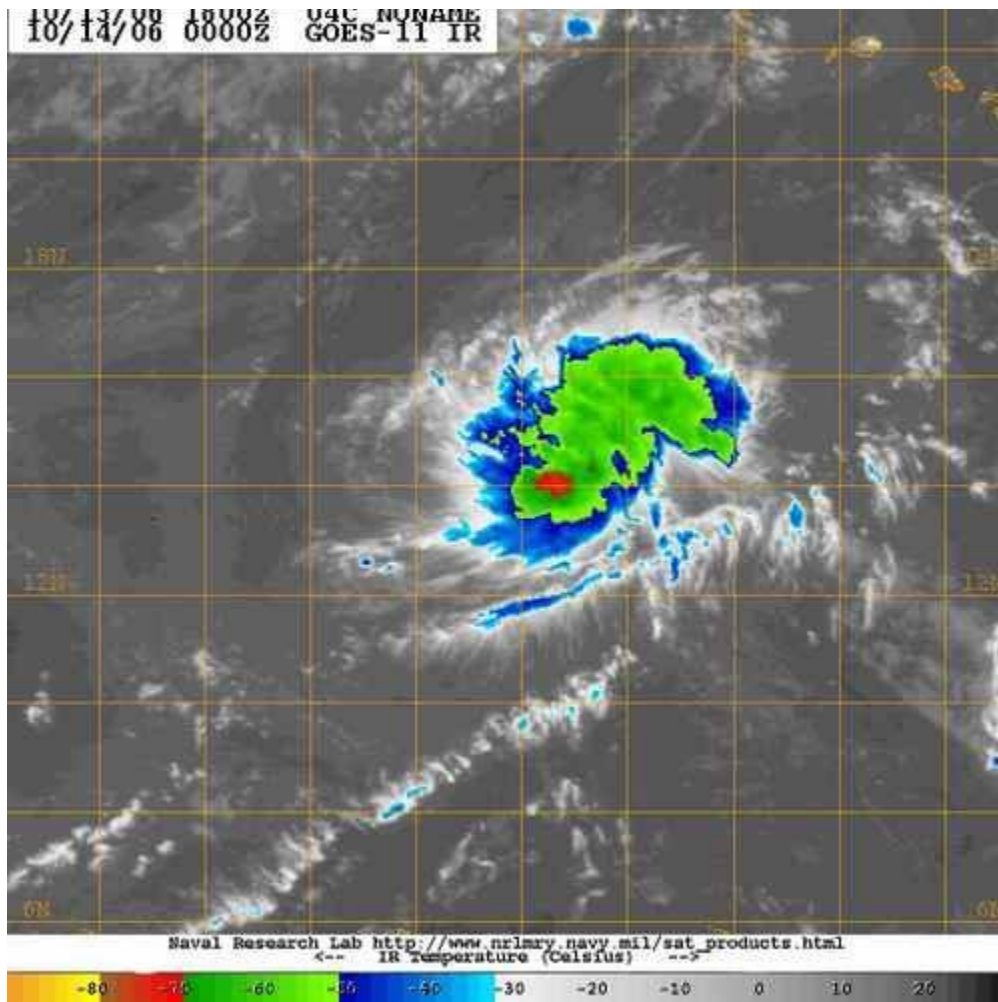
**TROPICAL DEPRESSION 04-C  
13-14 October 2006**

**OVERVIEW:** Tropical depression 04-C formed from a persistent cluster of Thunderstorms nearly 750 miles southwest of Oahu on October 13.

TD04-C moved north and then northeast as it was embedded in a southwesterly steering flow ahead of a mid latitude trough closer to the dateline. As the trough approached, upper level winds increased and caused the convection to shear away from the low level center. By early on October 14, TD04-C was nothing more than a low level cloud swirl. The remnants ultimately moved northeast in advance of the upper level trough and helped fuel heavy rainfall and flooding from thunderstorms across the big island of Hawaii on October 17.

**Table 16. Best Track Data**

<b>Date/Time (UTC)</b>	<b>Latitude (°N)</b>	<b>Longitude (°W)</b>	<b>Pressure (mb)</b>	<b>Wind Speed (kt)</b>	<b>Stage/Notes</b>
13 / 1800	13.7	166.3	1007	30	Tropical Depression
14 / 0000	13.8	166.0	1007	30	"
14 / 0600	13.5	165.7	1007	30	"
14 / 1200	13.0	165.5	1007	25	"
14 / 1800	12.3	165.7	1008	20	Tropical Disturbance
15 / 0000	11.9	165.3	1007	20	"
15 / 0600	11.7	164.8	1007	20	"
15 / 1200	11.8	163.8	1007	20	"
15 / 1800	12.0	162.7	1007	20	"
16 / 0000	12.7	161.3	1007	20	"

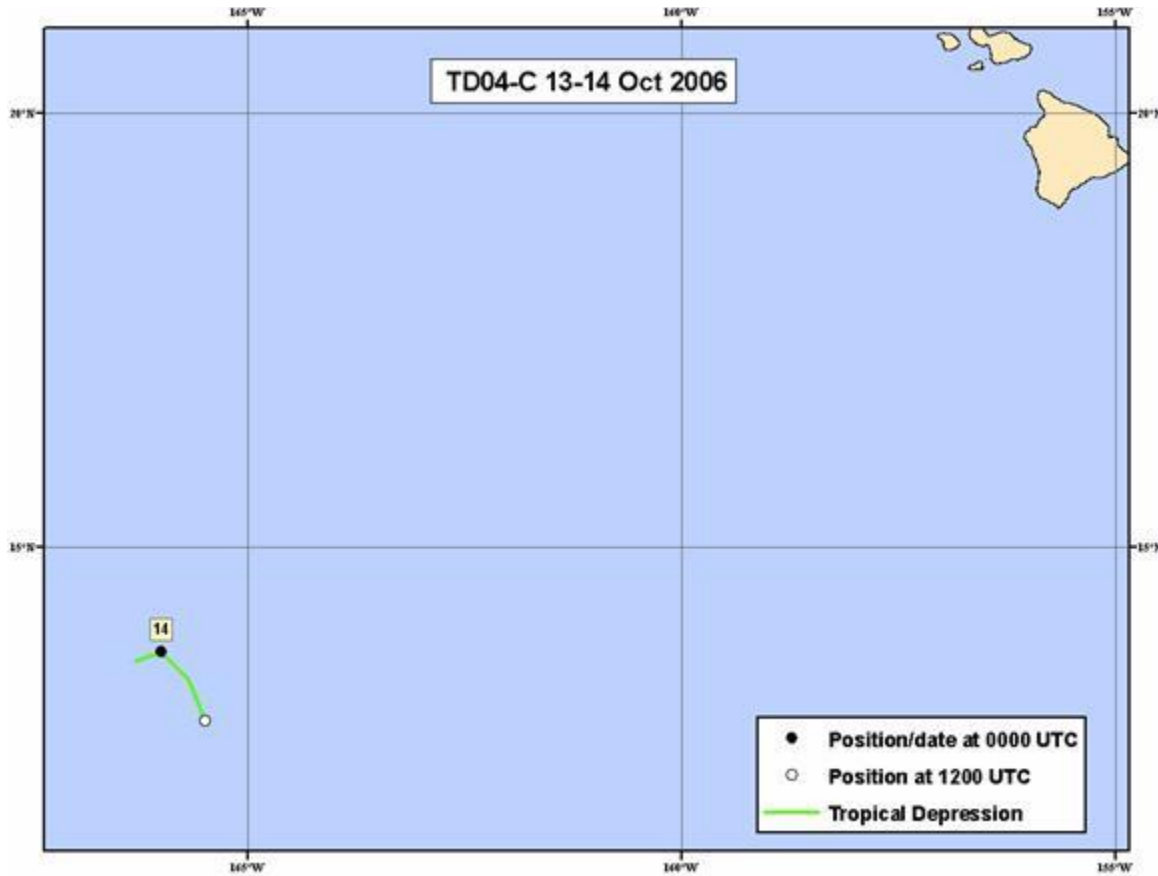


**Table 17. Overall Track Verification.** Table entries are track forecast errors, measured in nautical miles. Values in parentheses indicate the number of forecasts. Values in bold represent guidance forecast errors equal to or less than the official CPHC forecast.

Forecast	12-hr	24-hr	36-hr	48-hr	72-hr	96-hr	120-hr
CPHC	111.1 (2)	n/a	n/a	n/a	n/a	n/a	n/a
AVNO	<b>37.1 (2)</b>	n/a	n/a	n/a	n/a	n/a	n/a
BAMD	<b>99.5 (2)</b>	n/a	n/a	n/a	n/a	n/a	n/a
BAMM	<b>73.8 (2)</b>	n/a	n/a	n/a	n/a	n/a	n/a
BAMS	<b>93.9 (2)</b>	n/a	n/a	n/a	n/a	n/a	n/a
CLP5	140.5 (2)	n/a	n/a	n/a	n/a	n/a	n/a







ACRONYMS that may have been used in this report.

<b>Acronym</b>	<b>Full Spelling/Definition</b>
AOR	Area of Responsibility
AVNO	Operation global forecast system model
BAMD	Deep Layer Beta Advection Model (mean layer averaged between 850 hPa and 250 hPa)
BAMM	Medium Layer Beta Advection Model (mean layer averaged between 850 hPa and 400 hPa)
BAMS	Shallow Layer Beta Advection Model (mean layer averaged between 850 hPa and 700 hPa)
CLIP	Climatology and Persistence
CPHC	Central Pacific Hurricane Center
GFDL	Geophysical Fluid Dynamics Laboratory model
hPa	Hectopascal (formerly millibar)
ITCZ	Inter-tropical Convergence Zone
JTWC	Joint Typhoon Warning Center
kts	knots
LBAR	Barotropic limited area sine transform
mb	millibars

NA	Not Available
NGPS	NOGAPS (Navy Operational Global Atmospheric Prediction System) Vortex Tracking Routine
NHC	National Hurricane Center
nm	nautical miles
P91E	Pacific Statistical Dynamic Model (adapted from NHC90 for the Eastern Pacific)
SHIFR	Statistical Hurricane Intensity Forecast
SHIP	Statistical Hurricane Intensity Prediction
SST	Sea Surface Temperature
TD	Tropical Depression
TPC	Tropical Prediction Center, Miami, FL
TUTT	Tropical Upper Tropospheric Trough
UTC	Universal Time Coordinated
WFO	Weather Forecast Office