NATIONAL HURRICANE CETNER
CENTRAL PACIFIC HURRICANE CENTER
TROPICAL CYCLONE REPORT

HURRICANE LANE

(EP142018)

15-28 August 2018

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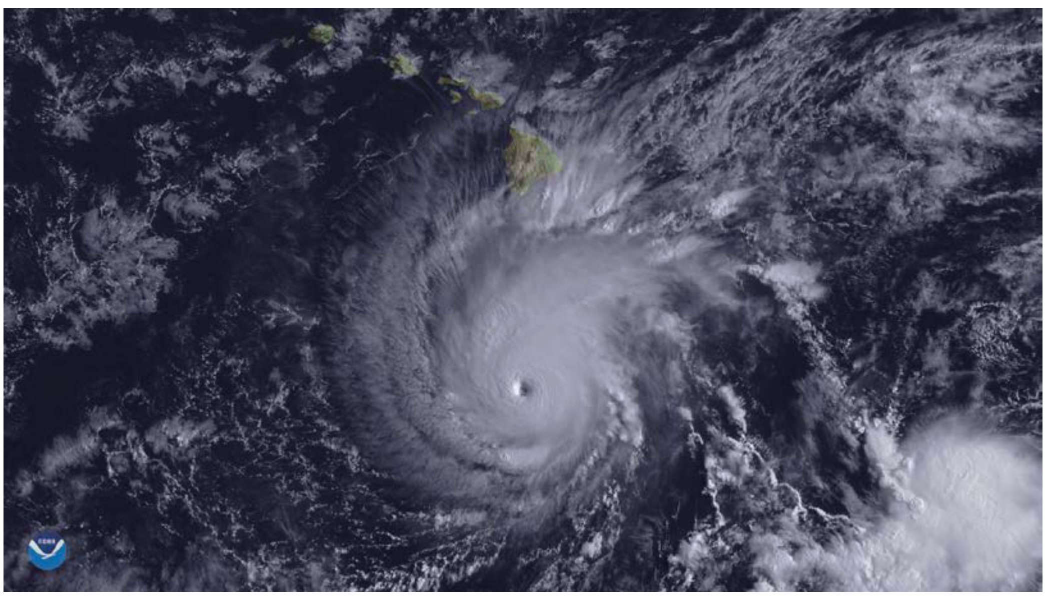

GOES WEST VISIBLE IMAGE OF LANE AT 0000 UTC 23 AUGUST NEAR MAXIMUM INTENSITY.

Lane was a long-lived tropical cyclone that moved across the eastern and central Pacific as a major hurricane for six days, becoming only the fifth category 5 hurricane (on the Saffir-Simpson Hurricane Wind Scale) on record in the central Pacific basin. Lane produced significant flooding and fanned devastating wildfires across the Hawaiian Islands.

[1] Original report released 2 April 2019. Updated 16 December 2019 to include best track analysis, summary, verification, impacts, and damages from the Central Pacific Hurricane Center.

Hurricane Lane

15-28 AUGUST 2018

SYNOPTIC HISTORY

Lane was spawned by a tropical wave that emerged from the coast of Africa on 31 July. The wave moved steadily westward across the Atlantic with little or no convection for the next several days, and eventually reached the eastern Pacific on 8 August. Once over the Pacific, the associated convection gradually increased, and the system first showed signs of organized convection on 11 August. Thereafter, the convection became intermittent for the next few days, which slowed development. Despite the lack of persistent convection, a low pressure area formed in association with the disturbance on 13 August about 765 n mi south-southwest of the southern tip of the Baja California Peninsula. Convective banding gradually increased over the western semicircle of the low as the system moved generally westward, and this led to the formation of a tropical depression by 0000 UTC 15 August about 935 n mi southwest of the southern tip of the Baja California peninsula. The "best track" chart of the tropical cyclone's path is given in Fig. 1, with the wind and pressure histories shown in Figs. 2 and 3, respectively. The best track positions and intensities are listed in Table 1[2].

The cyclone was moving just south of west at the time of genesis, steered by a large subtropical ridge to the north. The ridge weakened slightly during the next 2 to 3 days, which caused the system to turn westward and then west-northwestward. Gradual strengthening occurred during the first 36 h or so after genesis, and the depression became a tropical storm around 1200 UTC 15 August. As Lane moved over warm sea surface temperatures in an environment of light shear and high atmospheric moisture, rapid intensification began late on 16 August, with Lane becoming a hurricane near 0000 UTC 17 August and a major hurricane 24 h later while centered about 1575 n mi west-southwest of the southern tip of the Baja California peninsula. It reached a first estimated peak intensity of 120 kt at 1200 UTC 18 August, just under 12 h before it crossed into the central Pacific basin.

Lane entered the central Pacific basin just before 0000 UTC 19 August, just as a brief period of weakening commenced. A broad upper-level trough centered near the Hawaiian Islands produced southwesterly vertical wind shear in excess of 15 kt across the hurricane. The outflow aloft in the northwest and southwest quadrants of Lane became restricted, causing the eye to become cloud-filled and obscured not long after 0000 UTC. The resulting weakening trend was short-lived, as the intensity of Lane settled at 105 kt by 1200 UTC that day.

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[2] A digital record of the complete best track, including wind radii, can be found on line at ftp://ftp.nhc.noaa.gov/atcf. Data for the current year's storms are located in the *btk* directory, while previous years' data are located in the *archive* directory.

Little change in intensity and forward motion occurred during the next 24 hours as aircraft reconnaissance conducted the first missions to sample Lane. The hurricane continued to move on a general west to west-northwestward track along the southwest flank of a large subtropical surface high. Vertical wind shear relaxed slightly by 1200 UTC 20 August, but the eye remained cloud-filled with restricted outflow persisting in the western quadrant.

Lane intensified during the second half of 20 August through early 22 August. The upper-level trough near the Hawaiian Islands retreated northward and weakened, causing the southwesterly vertical wind shear across Lane to decrease below 15 kt. As a result, the hurricane's outflow aloft steadily improved, and a well-defined eye reemerged in geostationary satellite imagery just before 0000 UTC 21 August. Under this environment of low vertical wind shear and sea surface temperatures of nearly 28°C, aircraft reconnaissance detected continued intensification, and at 0000 UTC 22 August, Lane became the fifth system in recorded history to attain category 5 strength on the Saffir-Simpson Hurricane Wind Scale in the central Pacific basin. During this time, Lane continued on a general westward to west-northwestward motion with a slight decrease in forward speed as the subtropical ridge to the northeast eroded.

From late 22 August into early 24 August, Lane gradually weakened and took a turn toward the north-northwest. Vertical wind shear slowly increased to 15 to 20 kt as Lane advanced toward the upper-level trough parked northwest of Hawaii. As Lane weakened, it rounded the western periphery of the mid-level ridge. This weakness in the ridge aloft became more pronounced with time, causing Lane to shift toward a more northward motion.

Under persistent strong vertical wind shear, Lane rapidly weakened late 24 August through 25 August as it made its closest approach to the State of Hawaii, within 130 n mi south and west of most islands. Lane had been a major hurricane for a six-day period ending early 24 August, but between 0600 UTC 24 August and 0600 UTC 25 August, Lane rapidly weakened to a tropical storm. Under relentless vertical wind shear, Lane continued to lose strength during the second half of 25 August. The primary steering feature for the increasingly shallow cyclone became the low-level subtropical ridge to the north, causing Lane to make a sharp turn toward the west as the tropical storm came within 120 n mi of the Island of Oahu.

From 26 August through dissipation, Lane mostly moved westward, away from the main Hawaiian Islands. Lane weakened to a tropical depression at 1200 UTC 26 August, and despite remaining under very strong vertical wind shear, organized deep convection returned long enough for the system to briefly become a tropical storm again from 1200 UTC to 1800 UTC 27 August. At 0000 UTC 29 August, Lane degenerated to a post-tropical remnant low while centered approximately 160 n mi north-northeast of Johnston Atoll. The remnant low drifted northward and dissipated by 1200 UTC 29 August.

METEOROLOGICAL STATISTICS

Observations in Lane (Figs. 2 and 3) include subjective satellite-based Dvorak technique intensity estimates from the Tropical Analysis and Forecast Branch (TAFB), the Satellite Analysis Branch (SAB), the Central Pacific Hurricane Center (PHFO), and the Joint Typhoon Warning

Center (JTWC), as well as objective Advanced Dvorak Technique (ADT) estimates and Satellite Consensus (SATCON) estimates from the Cooperative Institute for Meteorological Satellite Studies/University of Wisconsin-Madison. Data and imagery from NOAA polar-orbiting satellites including the Advanced Microwave Sounding Unit (AMSU), the NASA Global Precipitation Mission (GPM), the European Space Agency's Advanced Scatterometer (ASCAT), and Defense Meteorological Satellite Program (DMSP) satellites, among others, were also useful in constructing the best track of Lane.

Lane was the most aircraft-reconnoitered tropical cyclone in history within the central Pacific basin. Aircraft observations include flight-level, stepped frequency microwave radiometer (SFMR), and dropwindsonde observations from five flights (including 14 center fixes) by the 53rd Weather Reconnaissance Squadron of the U.S. Air Force Reserve Command and four flights (including 13 center fixes) by the NOAA Aircraft Operations Center (AOC) Lockheed WP-3D Hurricane Hunter aircraft. The NOAA AOC G-IV aircraft flew four synoptic surveillance flights around Lane, and a NASA DC-8 aircraft conducted a mission around Lane under the High Ice Water Content Field Program. It is worthy to note that this was the first instance where the NOAA AOC Hurricane Hunters surveilled a central Pacific tropical cyclone, and all of these missions were coincident with missions by the Air Force Reserve.

National Weather Service WSR-88D Doppler radar data from the Island of Hawaii and the Island of Molokai were aided in center location while Lane was near the State of Hawaii.

Selected surface observations from land stations and data buoys are given in Table 2. Six land stations across the State of Hawaii reported sustained tropical-storm-force winds, and the eye of Lane passed over and damaged NOAA buoy 51002, which measured sustained winds to 72 kt. No ship reports of tropical-storm-force winds or greater were received in associated with Lane.

Winds and Pressure

Lane's estimated peak intensity of 140 kt from 0000 UTC to 0600 UTC 22 August is based on a blend of multiple SFMR surface wind estimates and flight-level winds observed by the Air Force Reserve and NOAA Hurricane Hunters, as well as two dropwindsondes released in the eyewall around that time period. The highest unflagged SFMR surface wind estimate from the Air Force Reserve was 146 kt at 0517 UTC, and the highest 700-mb flight-level winds from missions around that time were 140–146 kt, which corresponds to about 126–131 kt at the surface. The NOAA Hurricane Hunters measured maximum flight-level winds of 145 kt, which correspond to about 130 kt at the surface, and peak SFMR winds of 154 kt. Two dropwindsondes released in the eyewall around these times suggested surface winds to 128 kt. It should be noted that this intensity estimate is somewhat uncertain, given the disparity of the peak SFMR winds and the intensity supported by the flight-level winds and dropwindsondes.

Lane's estimated minimum central pressure of 926 mb at 0600 UTC 22 August is based on a dropwindsonde surface pressure measurement of 927 mb at 0357 UTC 22 August, which was accompanied by a surface wind of 13 kt.

The center of Lane passed within 130 n mi of the State of Hawaii on 24 and 25 August. While it was determined that radii of tropical-storm-force winds did not extend to the state, the proximity of Lane combined with the effects of the high island terrain caused some land-based stations to measure sustained winds of 34 kt or greater (Table 2). All of the observations occurred on 24 August, with four reports from the Island of Hawaii, one from Maui, and one from Oahu.

Rainfall and Flooding

Although Lane did not make landfall in the State of Hawaii, record-breaking rainfall (Fig. 4) occurred as the slow-moving tropical cyclone passed near the islands. On the Island of Hawaii, the Kahuna Falls Cooperative Observer Program station measured 58.00 inches of total rainfall from Lane. This total sets a new State of Hawaii record for tropical cyclone storm total rainfall, breaking the mark previously set during Hurricane Hiki in 1950. It is also the second highest storm total rainfall from a tropical cyclone in the United States. The record is 60.58 inches set by Hurricane Harvey in 2017.

The eastern portion of the State of Hawaii endured the longest duration of heavy rainfall. Initial rain bands reached the eastern slopes of Maui and the Island of Hawaii late 21 August, and heavy rainfall persisted over portions of these islands through 25 August, leading to many sites recording in excess of 25 inches of storm total rainfall (Table 2). This triggered numerous mudslides along Highway 19 on the eastern coast of the Island of Hawaii and along the Hana Highway on Maui. In addition, a severe road washout occurred on western slopes of Maui.

A second period of intense rainfall occurred across the western portion of the State of Hawaii on 27 and 28 August. As a weakened Tropical Depression Lane was moving away from the islands, a trailing rain band was enhanced by the upper-level trough that had disrupted the tropical cyclone. Storm total rainfall in excess of 9 inches occurred at a handful of stations on Kauai and Oahu, with one site on Kauai measuring more than 36 inches (Table 2). Significant damage occurred on northern Kauai in the same areas affected by the record-breaking flooding in April 2018. On Oahu, flash flooding led to road closures in Honolulu.

CASUALTY AND DAMAGE STATISTICS

Lane caused one direct death[3] in the State of Hawaii. On 28 August, a man drowned after jumping into a rain-swollen stream on Kauai in an attempt to save a dog.

The most severe flooding and damage occurred on the Island of Hawaii. Flooding affected more than 100 structures (Fig. 5), and public infrastructure suffered at least $20 million in damage. On Maui, initial estimates for infrastructure repair exceeded $2 million.

As rain bands from Lane were moving onto portions of Maui and the Island of Hawaii, gusty winds fanned a series of wildfires in western Maui. The steep, mountainous terrain of the islands and the prevailing trade wind flow typically produce extreme rainfall gradients that often lead to dry conditions along western slopes in the summer months. At the time of Lane's approach

[3] Deaths occurring as a direct result of the forces of the tropical cyclone are referred to as "direct" deaths. These would include those persons who drowned in storm surge, rough seas, rip currents, and freshwater floods. Direct deaths also include casualties resulting from lightning and wind-related events (e.g., collapsing structures). Deaths occurring from such factors as heart attacks, house fires, electrocutions from downed power lines, vehicle accidents on wet roads, etc., are considered indirect" deaths.

to the islands, western Maui was under moderate drought conditions (as defined by the United States Drought Monitor). On 23 August, with strong high pressure to the north of the state and Lane advancing from the south, sustained winds of around 30 mph and gusts in excess of 50 mph blew across western Maui. Driven by these winds, three wildfires rapidly charred 2,000 acres and destroyed 21 residential structures, causing over $4 million in reported damage.

FORECAST AND WARNING CRITIQUE

The genesis of Lane was adequately forecast at long range, but had some issues in the short range. In the 5 day development period, the disturbance from which Lane developed was introduced in the Tropical Weather Outlook 96 h prior to genesis (Table 3) with a low chance of development (<40%). The probability was raised to medium (40–60%) 78 h and high chances (>60%) 24 h before genesis, respectively. In the 2-day development period, the disturbance was introduced with a low chance of development 84 h before genesis. The probability was raised to medium 24 h before genesis and high 6 h before genesis. One issue with the 2-day genesis forecasts was the slow development that occurred after the initial organization on 11 August, which was not well anticipated.

A verification of NHC official track forecasts for Lane is given in Table 4a. Official forecast track errors were lower than the mean official errors for the previous 5-yr period. A homogeneous comparison of the official track errors with selected guidance models is given in Table 4b. The NHC track forecasts were better than the vast majority of the guidance, but were beaten by the HCCA and Florida State Superensemble (FSSE) consensus models at several forecast times and the European Center model (EMXI) from 48–96 h.

A verification of NHC official intensity forecasts for Lane is given in Table 5a. Official forecast intensity errors were lower than the mean official errors for the previous 5-yr period through 48 h and significantly higher than the mean official errors for the previous 5-yr period at 72–120 h. A homogeneous comparison of the official intensity errors with selected guidance models is given in Table 5b. The official intensity forecasts were better than all of the guidance at all forecast times. Examination of the individual forecasts (Fig. 6) shows that the NHC forecasts correctly anticipated Lane's rapid intensification into a major hurricane over the eastern Pacific, followed by some weakening as the hurricane entered the central Pacific. However, the NHC forecasts did not at all anticipate Lane's re-intensification in the central Pacific. This may have been due to track forecasts that were a little to the north of where the hurricane tracked, which led to an expectation of stronger shear and cooler water temperatures than what Lane actually encountered.

A verification of the CPHC official track forecasts for Lane is given in Table 6a. CPHC official forecast track errors were lower than the CPHC mean official errors for the previous 5-yr period. A homogeneous comparison of the CPHC official track errors with selected guidance models is given in Table 6b. FSSE, TVCE, and AEMI outperformed CPHC at all forecast times, and EGRI and HCCA had lower errors at all but one forecast time compared to the CPHC official forecasts.

A verification of the CPHC official intensity forecasts for Lane is given in Table 7a. CPHC official forecast intensity errors were greater than the CPHC mean official errors for the previous 5-yr period at all times except for 12 h and 120 h. A homogeneous comparison of the CPHC official intensity errors with selected guidance models is given in Table 7b. HCCA and IVCN outperformed CPHC at all but one forecast time, as did HWFI at all but two times. The CPHC intensity errors were largest at 72 and 96 h, likely due uncertainty in the timing of weakening when Lane was near the State of Hawaii.

Watches and warnings associated with Lane are given in Table 8. A Hurricane Watch was issued for the Island of Hawaii and Maui County (Maui, Molokai, Lanai, and Kahoolawe) at 1500 UTC 21 August, when Lane was centered approximately 320 n mi southeast of the State of Hawaii. At 0300 UTC 22 August, the Hurricane Watch was expanded to Oahu, and the watch was upgraded to a Hurricane Warning for the Island of Hawaii. As Lane turned northwestward toward the State of Hawaii, the watch was expanded to Kauai and Niihau at 1500 UTC 22 August and was upgraded to a Hurricane Warning for Maui County. The watch was upgraded to a Hurricane Warning for Oahu at 0300 UTC 23 August.

As confidence in the timing and location of Lane's long awaited turn toward west gradually increased, the Hurricane Warning for the Island of Hawaii was changed to a Tropical Storm Warning at 0300 UTC 24 August. The Hurricane Watch for Kauai and Niihau was changed to a Tropical Storm Watch at 2100 UTC 24 August, and the Hurricane Warning for Oahu and Maui County was changed to a Tropical Storm Warning at 0300 UTC 25 August. The Tropical Storm Warning for the Island of Hawaii was discontinued at 1500 UTC 25 August. At 2100 UTC 25 August, the Tropical Storm Warning for Oahu and Maui County was discontinued, and the Tropical Storm Watch for Kauai and Niihau was discontinued.

Table 1. Best track for Hurricane Lane, 15–28 August 2018.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
13 / 1200	10.9	114.7	1009	20	low
13 / 1800	11.0	115.7	1009	20	"
14 / 0000	11.1	116.6	1009	25	"
14 / 0600	11.1	117.4	1009	25	"
14 / 1200	11.1	118.4	1009	25	"
14 / 1800	11.1	119.4	1009	25	"
15 / 0000	11.0	120.6	1008	30	tropical depression
15 / 0600	10.8	121.7	1007	30	"
15 / 1200	10.7	122.8	1006	35	tropical storm
15 / 1800	10.5	123.9	1005	40	"
16 / 0000	10.4	124.9	1003	45	"
16 / 0600	10.4	125.9	1003	45	"
16 / 1200	10.4	126.9	1001	50	"
16 / 1800	10.5	127.9	999	55	"
17 / 0000	11.0	129.2	992	65	hurricane
17 / 0600	11.2	130.7	990	70	"
17 / 1200	11.2	132.1	982	85	"
17 / 1800	11.3	133.6	977	90	"
18 / 0000	11.6	134.9	969	100	"
18 / 0600	11.9	136.2	956	115	"
18 / 1200	12.1	137.5	950	120	"
18 / 1800	12.4	138.9	950	120	"
19 / 0000	12.6	140.3	956	115	"
19 / 0600	12.8	141.6	961	110	"
19 / 1200	13.0	142.9	966	105	"
19 / 1800	13.3	144.1	966	105	"
20 / 0000	13.5	145.3	966	105	"
20 / 0600	13.6	146.5	966	105	"
20 / 1200	13.6	147.7	966	105	"
20 / 1800	13.6	148.7	964	110	"
21 / 0000	13.7	149.8	959	115	"
21 / 0600	13.9	150.8	953	120	"

21 / 1200	14.0	151.8	941	130	"
21 / 1800	14.1	152.7	941	130	"
22 / 0000	14.3	153.6	929	140	"
22 / 0600	14.5	154.3	926	140	"
22 / 1200	14.8	155.0	938	130	"
22 / 1800	15.1	155.6	938	130	"
23 / 0000	15.6	156.3	942	125	"
23 / 0600	16.0	156.8	942	125	"
23 / 1200	16.5	157.2	946	120	"
23 / 1800	17.0	157.5	950	115	"
24 / 0000	17.5	157.8	959	105	"
24 / 0600	17.9	158.0	962	100	"
24 / 1200	18.3	158.1	969	90	"
24 / 1800	18.6	158.1	977	80	"
25 / 0000	18.9	158.2	987	65	"
25 / 0600	19.2	158.3	995	55	tropical storm
25 / 1200	19.4	158.5	998	50	"
25 / 1800	19.5	159.1	1001	45	"
26 / 0000	19.5	159.8	1003	40	"
26 / 0600	19.4	160.7	1005	35	"
26 / 1200	19.3	161.6	1006	30	tropical depression
26 / 1800	19.1	162.4	1006	30	"
27 / 0000	18.9	163.3	1006	30	"
27 / 0600	18.8	164.1	1006	30	"
27 / 1200	18.7	165.0	1005	35	tropical storm
27 / 1800	18.5	165.9	1005	35	"
28 / 0000	18.4	166.4	1006	30	tropical depression
28 / 0600	18.4	167.0	1006	30	"
28 / 1200	18.5	167.6	1006	30	"
28 / 1800	18.6	168.1	1006	30	"
29 / 0000	19.1	168.3	1007	25	remnant low
29 / 0600	19.5	168.3	1007	25	"
29 / 1200					dissipated
22 / 0600	14.5	154.3	926	140	maximum wind and minimum pressure

Table 2. Selected surface observations for Hurricane Lane, 15–28 August 2018.

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Storm surge (ft)[c]	Storm tide (ft)[d]	Estimated Inundation (ft)[e]	Total rain (in)
	Date/ time (UTC)	Press. (mb)	Date/ time (UTC)[a]	Sustained (kt)[b]	Gust (kt)				
Hawaii									
International Civil Aviation Organization (ICAO) Sites									
Lanai City Airport (PHNY) (20.79N 156.95W)	24/1356	1008.2	25/1105	30	37				
Kahului Airport (PHOG) (20.89N 156.44W)	25/0300	1008.8	24/1010	28	43				
Hilo International Airport (PHTO) (19.72N 155.06W)	25/0053	1009.9	25/0040	19	28				
Keahole Airport Kona (PHKO) (19.74N 156.05W)	24/1453	1006.3	24/1805	17					
Honolulu International Airport (PHNL) (21.33N 157.94W)	24/1453	1009.4	24/0845	29	39				
Lahaina West Maui (PHJH) (20.96N 156.67W)	24/1600	1007.8	24/1600	34	50				
Lihue Airport (PHLI) (21.98N 159.34W)	25/0253	1011.5	25/0955	26	34				
Molokai Airport Kaunakakai (PHMK) (21.15N 157.10W)	24/1454	1009.0	24/0410	28	48				
Kalaeloa Airport (PHJR) (21.31N 158.07W)	24/1453	1010.5	25/0040	16	40				
Kaneohe Marine Corps Air Station (PHNG) (21.45N 157.77W)	25/1257	1009.6	24/1204	21	30				
Barking Sands Kekaha (PHBK) (22.04N 159.79W)	25/0156	1010.0	25/0456	13					
Wheeler Air Force Base (PHHI) (21.48N 158.03W)	24/1453	1011.2	24/0655	15	27				
Hydrology-Surface Observing Instrumentation System (H-SOIS) Site									
Hana Airport (HNAH1) (20.79N 156.02W)									10.57
Maalaea Harbor (P36) (20.79N 156.51W)			24/0738	33	47				

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Storm surge (ft)[c]	Storm tide (ft)[d]	Estimated Inundation (ft)[e]	Total rain (in)
	Date/ time (UTC)	Press. (mb)	Date/ time (UTC)[a]	Sustained (kt)[b]	Gust (kt)				
Hydrometeorological Automated Data System (HADS) Sites (NWS)									
Kohala Ranch (KHRH1) (20.09N 155.83W)			24/0935	35	59				
Kawaihae (KWHH1) (20.04N 155.83W)			24/1036	37	56				
Waikoloa (WKVH1) (19.92N 155.79W)			24/0935	28	50				
PTA West (PKWH1) (19.77N 155.70W)			24/1056	36	52				
Kamuela (PHMU) (20.00N 155.67W)			24/1034	39	49				
Kahuku Ranch (KRCH1) (19.23N 155.78W)			24/2329	24	40				
Kaneloa (KAOH1) (20.52N 156.57W)			24/1253	28	51				
Hakioana (HKIH1) (20.58N 156.57W)			24/1724	31	47				
Lanai 1 (LNIH1) (20.87N 157.01W)			24/0637	27	41				
Molokai 1 (MLKH1) (21.12N 156.95W)			24/1637	15	42				
Oahu Forest NWR (OFRH1) (21.48N 157.94W)			24/0836	40	64				
Kuaokala (KKRH1) (21.57N 158.26W)			24/1936	32	47				
Kawailoa Training Area (KWLH1) (21.59N 158.01W)			24/0749	22	44				
Palehua (PLHH1) (21.38N 158.10W)			24/0436	23	40				
Mountain View (MTVH1) (19.52N 155.14W)									52.82
Waiakea Uka (WKAH1) (19.66N 155.13W)									49.48
Saddle Road Quarry (SDQH1) (19.69N 155.29W)									48.52
Piihonua (PIIH1) (19.71N 155.14W)									48.13
Waiakea Exp Station (WEXH1) (19.65N 155.08W)									47.37

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Storm surge (ft)[c]	Storm tide (ft)[d]	Estimated Inundation (ft)[e]	Total rain (in)
	Date/ time (UTC)	Press. (mb)	Date/ time (UTC)[a]	Sustained (kt)[b]	Gust (kt)				
Pahoa (PHAH1) (19.54N 155.31W)									38.09
Glenwood (GLNH1) (19.51N 155.17W)									35.83
Kulani NWR (KNWH1) (19.55N 155.31W)									28.71
Keaumo (KKUH1) (19.47N 155.36W)									24.65
Puu Mali (PMLH1) (19.93N 155.44W)									13.78
Haiku (AIKH1) (20.93N 156.32W)									10.56
Hanalei (HANAL) (22.19N 159.50W)									18.27
Princeville Airport (PRIH1) (22.21N 159.44W)									9.27
Haiku (AIKH1) (20.93N 156.32W)									10.56
Haiku (AIKH1) (20.93N 156.32W)									10.56
Haiku (AIKH1) (20.93N 156.32W)									10.56
Haiku (AIKH1) (20.93N 156.32W)									10.56
US Geological Survey (USGS)									
Kawainui Stream USGS (KWSH1) (20.10N 155.70W)									16.70
West Wailuaiki USGS (WWKH1) (20.82N 156.14W)									25.58
Puu Kukui USGS (PKKH1) (20.89N 156.59W)									17.48
Mt Waialeale USGS (WLLH1) (22.07N 159.50W)									34.78
North Wailua Ditch USGS (WLDH1) (22.06N 159.47W)									19.60
Kilohana USGS (KLOH1) (22.15N 159.59W)									9.62
Moanalua Rain Gage USGS (MOAH1) (21.37N 157.88W)									9.81

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Storm surge (ft)[c]	Storm tide (ft)[d]	Estimated Inundation (ft)[e]	Total rain (in)
	Date/ time (UTC)	Press. (mb)	Date/ time (UTC)[a]	Sustained (kt)[b]	Gust (kt)				
Tunnel Rain Gage USGS (TNLH1) (21.40N 157.85W)									7.13
Offshore									
NOAA Buoys									
Southwest Hawaii (51002) (17.04N 157.56W)	23/1930	956.6	23/1820	72	93				
Southeast Hawaii (51004) (17.60N 152.40W)	24/0210	1003.7	24/0140	33	49				
Western Hawaii (51003) (19.29N 160.57W)	26/0450	1005.0	26/0100	22	25				

[a] Date/time is for sustained wind when both sustained and gust are listed.
[b] Except as noted, sustained wind averaging periods for land-based reports are 2 min; buoy averaging periods are 8 min.

Table 3. For Hurricane Lane, number of hours in advance of formation associated with the first NHC Tropical Weather Outlook forecast in the indicated likelihood category. Note that the timings for the "Low" category do not include forecasts of a 0% chance of genesis.

	Hours Before Genesis	
	48-Hour Outlook	**120-Hour Outlook**
Low (<40%)	84	96
Medium (40%-60%)	24	78
High (>60%)	6	24

Table 4a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Hurricane Lane, 15–28 August 2018. Mean errors for the previous 5-yr period are shown for comparison. Official errors that are smaller than the 5-yr means are shown in boldface type.

	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	**18.9**	**25.9**	**28.4**	**30.3**	**50.2**	**71.7**	**82.1**
OCD5	22.1	41.2	59.1	77.5	124.2	176.5	223.2
Forecasts	16	16	16	16	16	16	16
OFCL (2013-17)	21.8	33.2	43.0	53.9	80.7	111.1	150.5
OCD5 (2013-17)	34.9	70.7	109.1	146.1	213.8	269.0	339.7

Table 4b. Homogeneous comparison of selected track forecast guidance models (in n mi) for Hurricane Lane for forecasts made in the eastern North Pacific basin. Errors smaller than the NHC official forecast are shown in boldface type. The number of official forecasts shown here will generally be smaller than that shown in Table 4a due to the homogeneity requirement.

Model ID	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	18.3	23.0	26.2	34.6	55.1	66.7	61.9
OCD5	22.0	38.2	59.5	82.1	129.9	177.8	219.9
GFSI	20.7	33.2	48.5	72.9	127.5	153.9	141.1
HWFI	21.9	37.2	51.9	72.4	120.7	136.9	124.5
HMNI	**17.8**	26.7	36.0	56.4	97.8	109.2	131.0
EGRI	26.3	46.8	68.1	93.0	123.0	133.1	117.5
EMXI	19.8	27.2	26.9	**29.7**	**42.2**	**60.0**	116.9
NVGI	23.7	33.4	47.1	65.7	110.1	141.8	150.2
CMCI	27.7	40.0	52.2	67.3	91.3	103.0	141.8
CTCI	20.8	29.1	35.1	52.9	88.3	96.5	88.0
TCON	19.3	27.8	35.2	44.1	73.3	92.0	84.5
TVCE	**17.9**	24.0	27.7	36.6	61.3	66.9	68.0
HCCA	**17.2**	24.8	27.9	**33.8**	**52.1**	**56.9**	65.8
FSSE	19.0	**20.7**	22.8	**31.0**	62.1	79.3	93.6
AEMI	18.9	27.7	27.9	38.5	79.4	98.7	94.2
TABS	32.2	59.5	81.0	90.0	92.9	95.7	114.9
TABM	**17.7**	**22.2**	35.4	56.4	115.1	135.2	117.8
TABD	18.8	38.0	66.5	103.7	184.5	218.1	199.2
Forecasts	12	12	12	12	12	12	12

Table 5a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) intensity forecast errors (kt) for Hurricane Lane, 15–28 August 2018. Mean errors for the previous 5-yr period are shown for comparison. Official errors that are smaller than the 5-yr means are shown in boldface type.

	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	**3.4**	**6.9**	**7.8**	**7.5**	15.9	26.9	35.9
OCD5	7.0	11.3	14.9	19.2	30.8	48.4	55.8
Forecasts	16	16	16	16	16	16	16
OFCL (2013-17)	5.8	9.6	11.8	13.2	15.1	15.1	14.6
OCD5 (2013-17)	7.6	12.4	15.6	17.7	19.8	20.8	19.6

Table 5b. Homogeneous comparison of selected intensity forecast guidance models (in kt) for Hurricane Lane for forecasts made in the eastern North Pacific basin. Errors smaller than the NHC official forecast are shown in boldface type. The number of official forecasts shown here will generally be smaller than that shown in Table 5a due to the homogeneity requirement.

Model ID	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	4.2	7.5	8.8	7.9	12.5	30.8	45.0
OCD5	8.2	14.6	18.5	20.8	27.2	51.6	61.4
HWFI	8.7	14.9	15.9	15.5	17.1	37.8	55.4
HMNI	7.9	10.2	9.8	11.9	17.5	49.6	60.3
DSHP	6.9	12.7	18.8	24.6	30.8	43.1	53.3
LGEM	7.7	15.2	22.4	26.1	30.5	46.5	62.4
ICON	7.4	11.1	14.7	17.5	23.2	43.6	57.4
IVCN	7.4	11.5	14.8	17.2	21.8	40.9	55.2
CTCI	9.2	15.5	17.6	17.4	16.4	35.0	47.4
GFSI	10.8	17.9	23.8	26.0	29.4	44.2	57.2
EMXI	13.5	24.5	34.0	41.4	50.8	67.4	79.4
HCCA	7.0	12.2	14.8	13.4	16.8	35.2	52.8
FSSE	6.9	10.9	12.3	13.8	23.9	45.0	61.9
Forecasts	12	12	12	12	12	12	12

Table 6a. CPHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Hurricane Lane, 15-28 August 2018. CPHC mean errors for the previous 5-yr period are shown for comparison. CPHC official errors that are smaller than the 5-yr means are shown in boldface type.

	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	**20.7**	**37.0**	**53.5**	**67.5**	**88.4**	**111.5**	**148.3**
OCD5	25.9	60.4	108.6	168.4	292.5	392.6	489.0
Forecasts	35	33	33	32	28	24	20
OFCL (2013-17)	28.2	43.2	58.0	75.6	121.0	163.2	208.4

Table 6b. Homogeneous comparison of selected track forecast guidance models (in n mi) for Hurricane Lane for forecasts made in the central North Pacific basin. Errors smaller than the CPHC official forecast are shown in boldface type. The number of official forecasts shown here will generally be smaller than that shown in Table 6a due to the homogeneity requirement.

Model ID	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	20.9	37.9	54.3	67.0	88.4	112.2	149.5
OCD5	25.8	61.6	112.0	176.4	300.0	395.0	493.9
GFSI	27.4	52.5	76.1	95.3	114.7	**111.3**	**120.0**
HWFI	31.2	58.1	82.6	99.9	115.4	124.6	150.3
HMNI	23.2	**37.8**	56.0	68.5	89.2	**98.2**	**125.4**
EGRI	21.5	**37.0**	**49.1**	**57.7**	**65.2**	**69.7**	**126.8**
EMXI	**18.6**	**27.5**	**40.3**	**54.1**	**86.0**	139.5	219.3
NVGI	32.0	59.7	83.5	108.2	146.8	188.3	216.9
CMCI	**19.3**	**33.2**	**52.6**	81.9	138.0	210.9	297.7
CTCI	28.7	57.6	80.8	96.4	129.7	133.4	167.8
TVCE	**19.8**	**36.0**	**51.7**	**62.6**	**75.2**	**88.6**	**129.9**
HCCA	**19.1**	**35.3**	**51.5**	**64.4**	**80.0**	**98.9**	150.6
FSSE	**19.7**	**35.8**	**51.4**	**65.6**	**72.0**	**62.5**	**97.8**
AEMI	**20.6**	**35.2**	**49.5**	**62.6**	**83.7**	**85.7**	**94.9**
TABS	23.2	**34.0**	**41.7**	**58.2**	106.2	146.5	150.4
TABM	32.1	68.4	114.7	164.0	248.2	305.6	310.0
TABD	49.3	118.1	204.0	279.3	396.2	503.7	522.9
Forecasts	29	28	28	27	24	21	17

Table 7a. CPHC official (OFCL) and climatology-persistence skill baseline (OCD5) intensity forecast errors (kt) for Hurricane Lane, 15–28 August 2018. CPHC mean errors for the previous 5-yr period are shown for comparison. CPHC official errors that are smaller than the 5-yr means are shown in boldface type.

	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	**5.3**	9.8	13.2	17.3	20.9	19.2	**14.3**
OCD5	7.0	13.9	19.5	26.6	26.3	20.1	20.5
Forecasts	35	33	33	32	28	24	20
OFCL (2013-17)	5.6	9.0	11.3	12.9	15.7	17.4	18.9

Table 7b. Homogeneous comparison of selected intensity forecast guidance models (in kt) for Hurricane Lane for forecasts made in the central North Pacific basin. Errors smaller than the CPHC official forecast are shown in boldface type. The number of official forecasts shown here will generally be smaller than that shown in Table 7a due to the homogeneity requirement.

Model ID	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	5.0	10.0	13.8	18.3	28.9	20.5	14.3
OCD5	7.2	14.3	19.8	27.5	32.7	24.4	18.9
HWFI	5.7	**8.1**	**9.3**	**12.1**	**18.2**	**16.9**	15.8
HMNI	5.6	**5.2**	**7.5**	**10.6**	**18.7**	20.6	25.1
DSHP	6.3	11.1	15.0	19.2	**24.1**	**17.0**	**13.8**
LGEM	6.8	12.6	15.9	19.1	**23.6**	**18.5**	**13.8**
IVCN	**4.7**	**6.5**	**8.3**	**11.9**	**19.3**	**17.7**	15.3
CTCI	7.3	**9.0**	**8.7**	**10.3**	**20.3**	21.9	19.8
GFSI	8.1	11.9	15.1	18.6	**23.5**	**16.9**	18.2
EMXI	6.8	12.7	17.8	21.5	29.4	**19.6**	**11.6**
HCCA	5.3	**8.7**	**11.9**	**14.0**	**15.1**	**11.5**	**11.1**
FSSE	**4.8**	**8.2**	**13.3**	19.7	32.5	35.0	20.1
Forecasts	29	28	28	27	19	19	14

Table 8. Coastal wind watch and warning summary for Hurricane Lane, 15-28 August 2018.

Date/Time (UTC)	Action	Location
21/1500	Hurricane Watch issued	Islands of Hawaii, Maui, Molokai, Lanai, and Kahoolawe
22/0300	Hurricane Watch changed to Hurricane Warning	Island of Hawaii
22/0300	Hurricane Watch issued	Island of Oahu
22/1500	Hurricane Watch changed to Hurricane Warning	Islands of Maui, Molokai, Lanai, and Kahoolawe
22/1500	Hurricane Watch issued	Islands of Kauai and Niihau
23/0300	Hurricane Watch changed to Hurricane Warning	Island of Oahu
24/0300	Hurricane Warning changed to Tropical Storm Warning	Island of Hawaii
24/2100	Hurricane Watch changed to Tropical Storm Watch	Islands of Kauai and Niihau
25/0300	Hurricane Warning changed to Tropical Storm Warning	Islands of Oahu, Maui, Molokai, Lanai, and Kahoolawe
25/1500	Tropical Storm Warning discontinued	Island of Hawaii
25/2100	Tropical Storm Warning discontinued	Islands of Oahu, Maui, Molokai, Lanai, and Kahoolawe
25/2100	Tropical Storm Watch discontinued	Islands of Kauai and Niihau

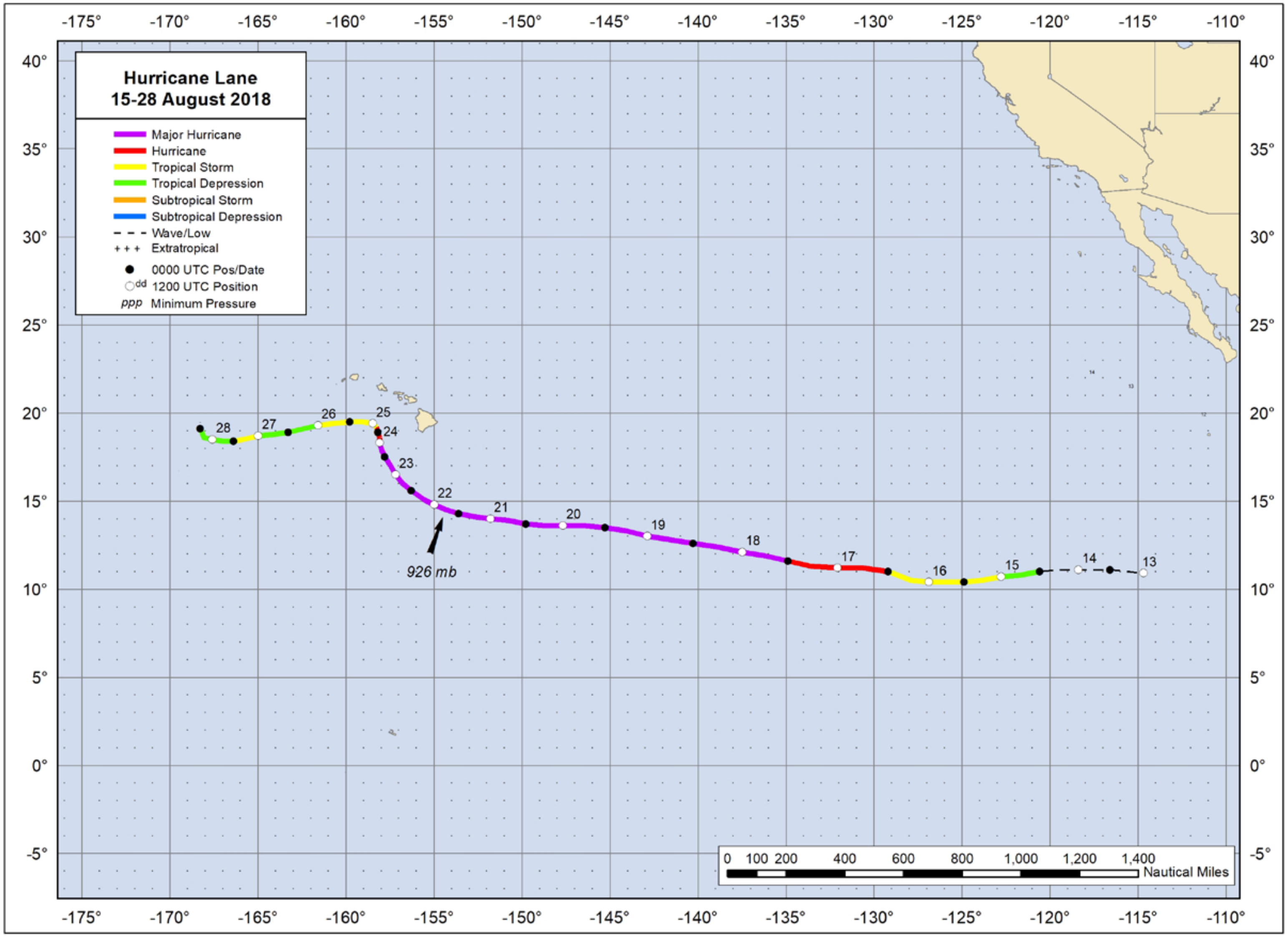

Figure 1. Best track positions for Hurricane Lane, 15–28 August 2018.

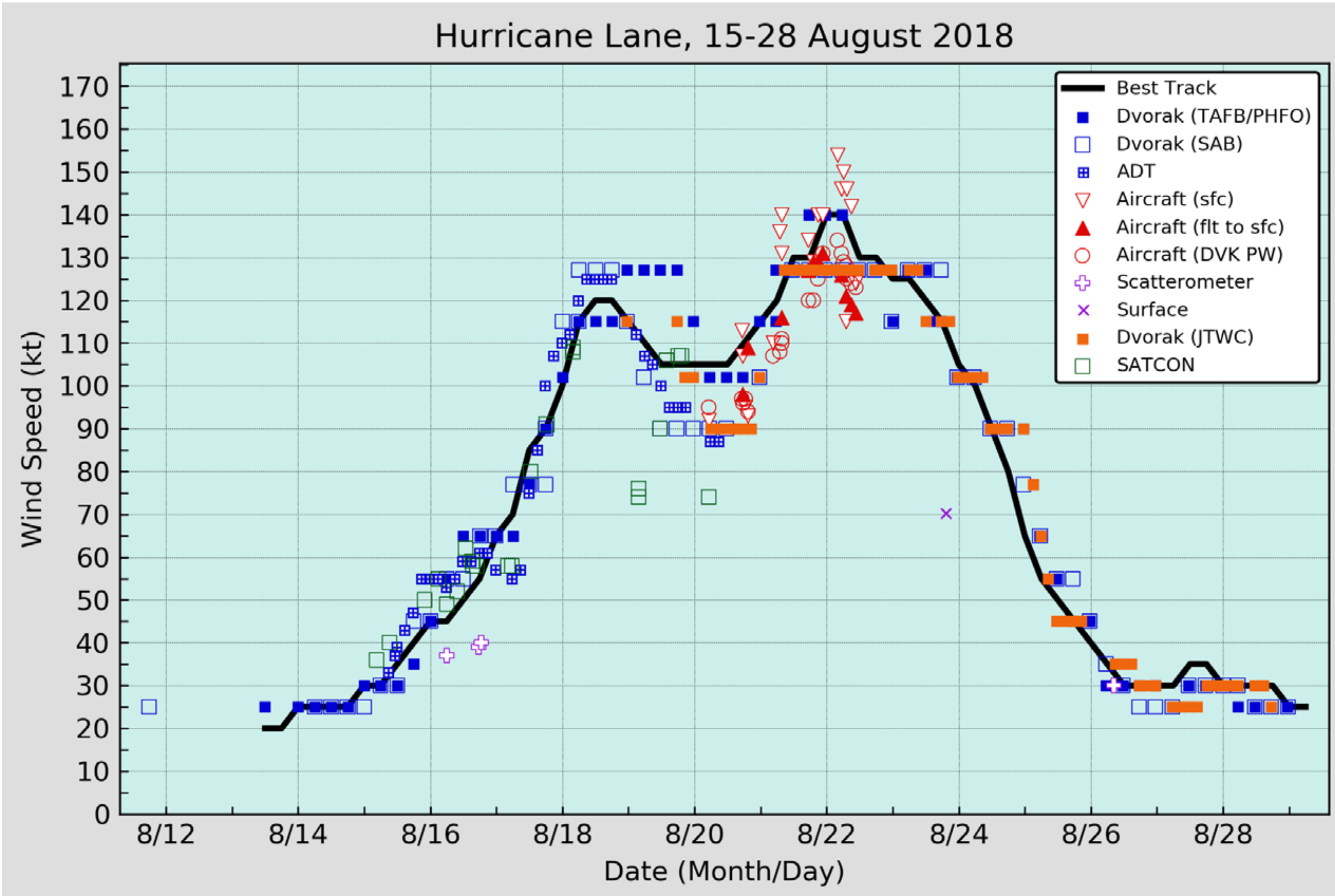

Figure 2. Selected wind observations and best track maximum sustained wind speed curve for Hurricane Lane 15–28 August 2019.

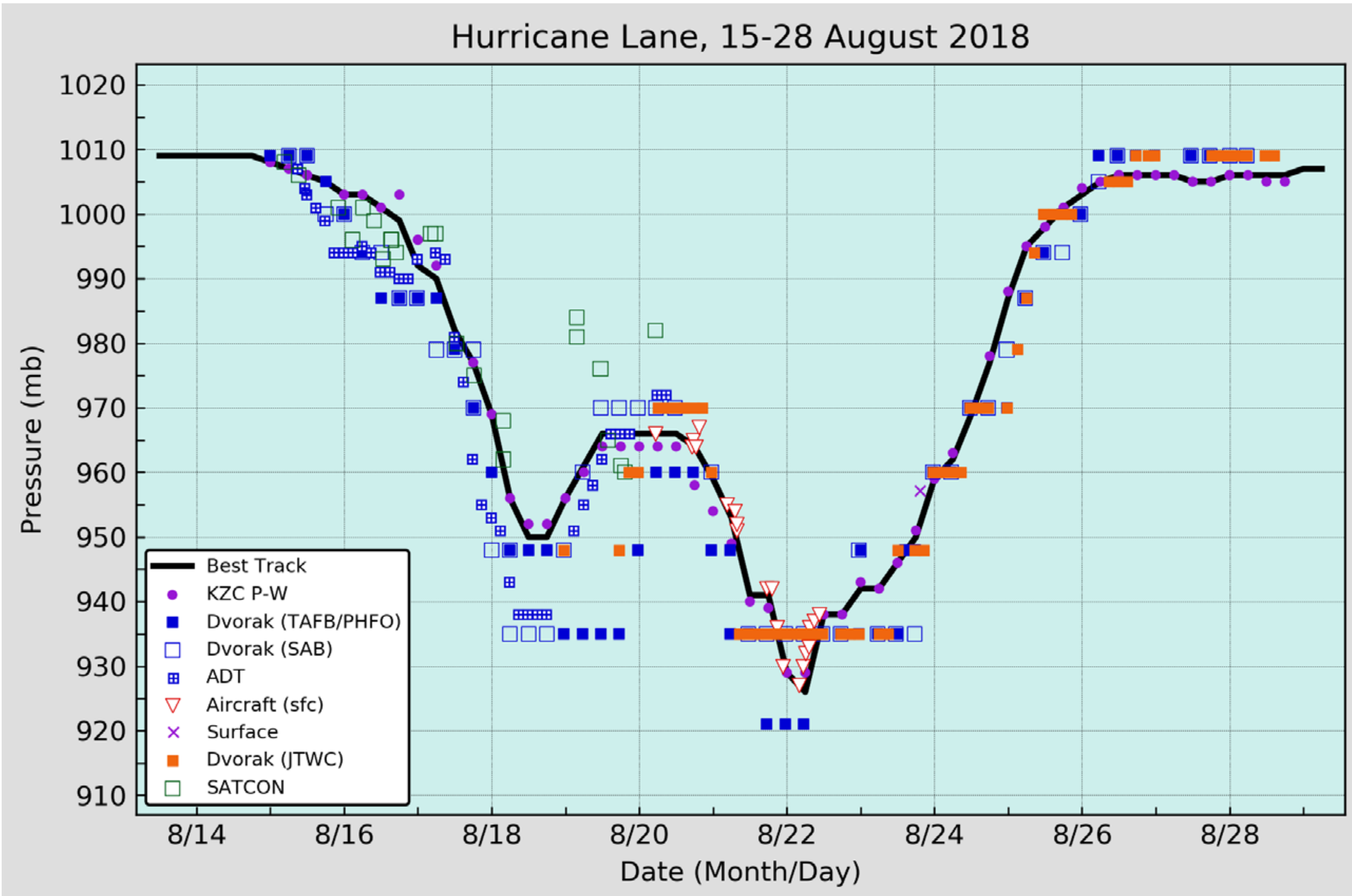

Figure 3. Selected pressure observations and best track minimum central pressure curve for Hurricane Lane 15–28 August 2019.

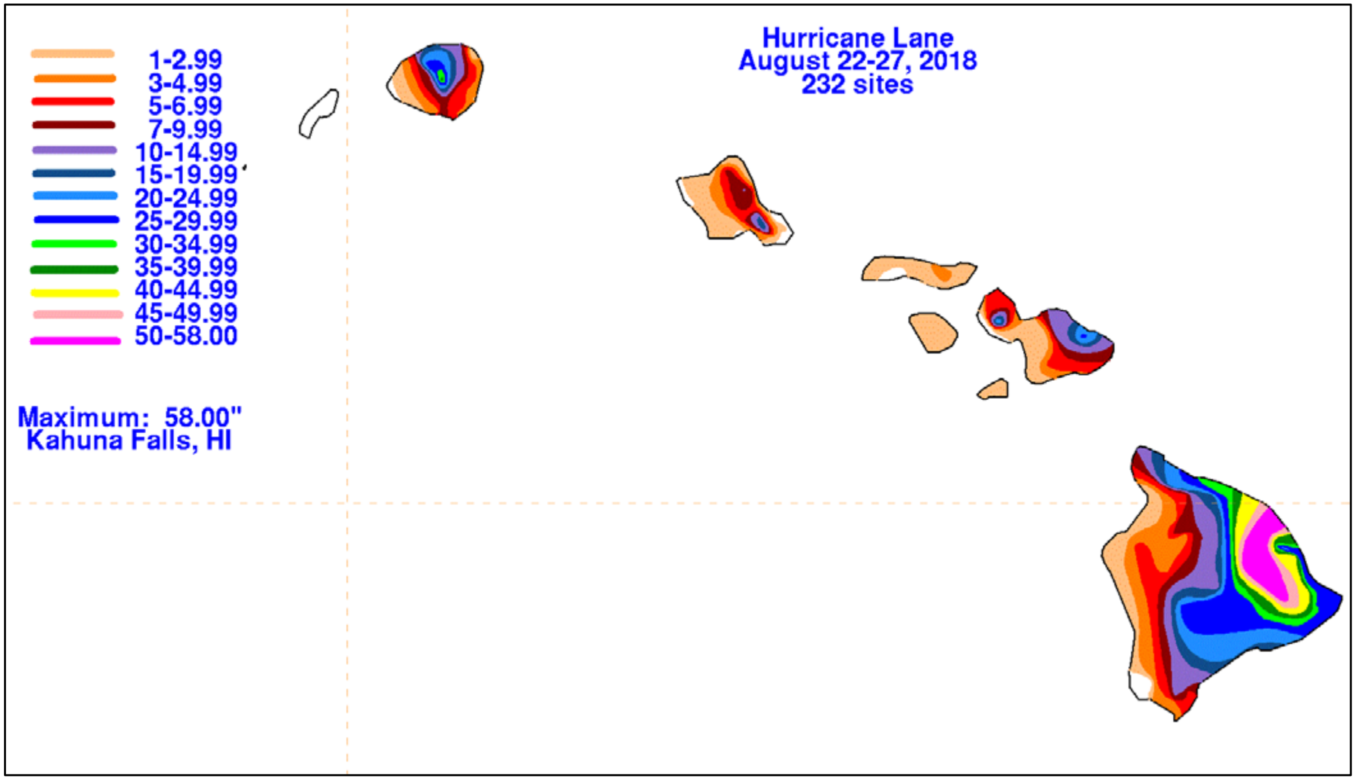

Figure 4. Rainfall analysis (inches) courtesy of the Weather Prediction Center for 22–27 August 2018 over portions of the State of Hawaii where reliable rainfall data were available.

Figure 5. Flood damage to a property in Hilo on the Island of Hawaii.

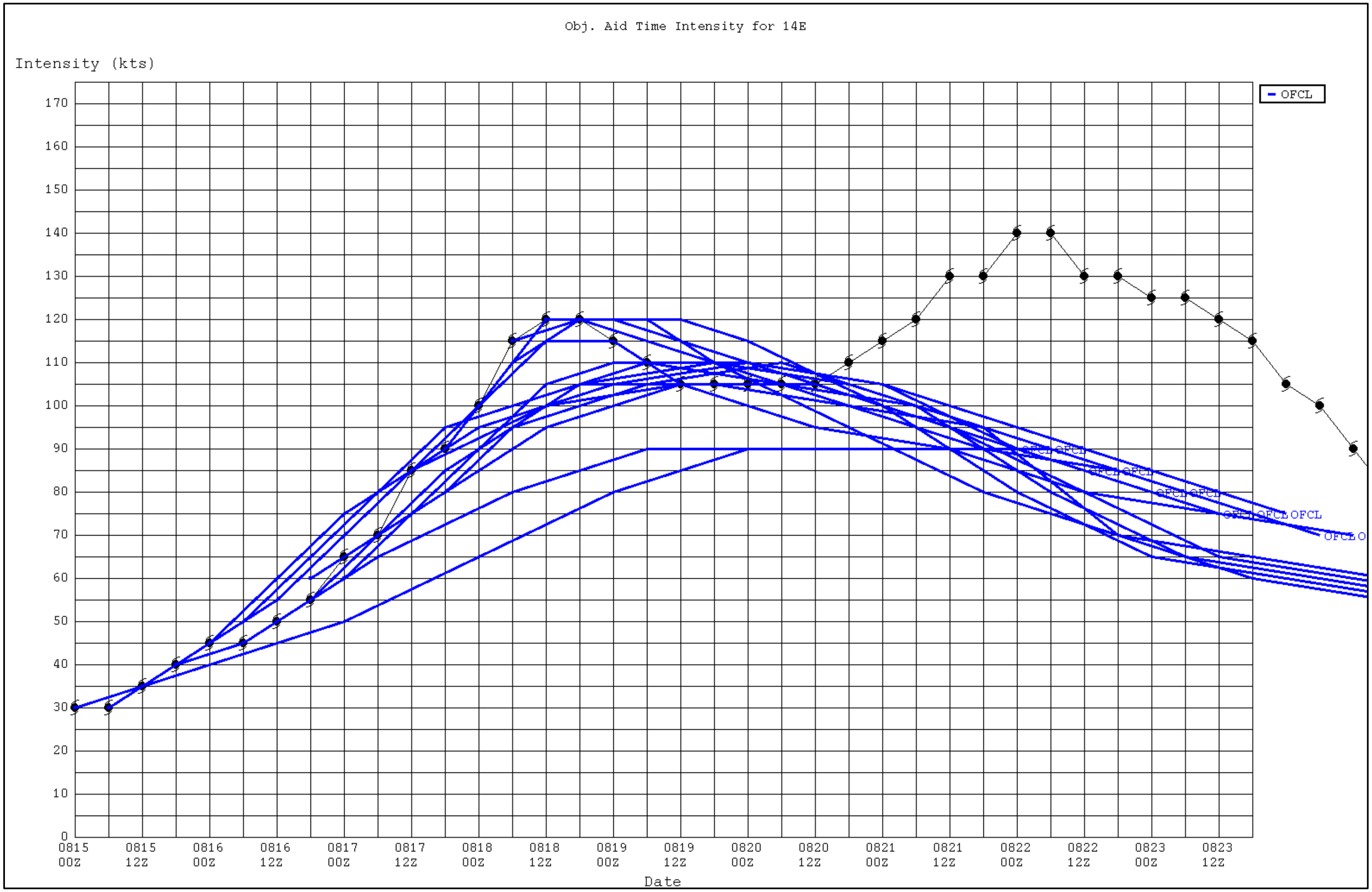

Figure 6. NHC official intensity forecasts (blue lines, kt) for Hurricane Lane from 0000 UTC 15 August through 1800 UTC 18 August 2018. The best track intensity (kt) is given by the black line with intensities (kt) shown at 6 h interval.