



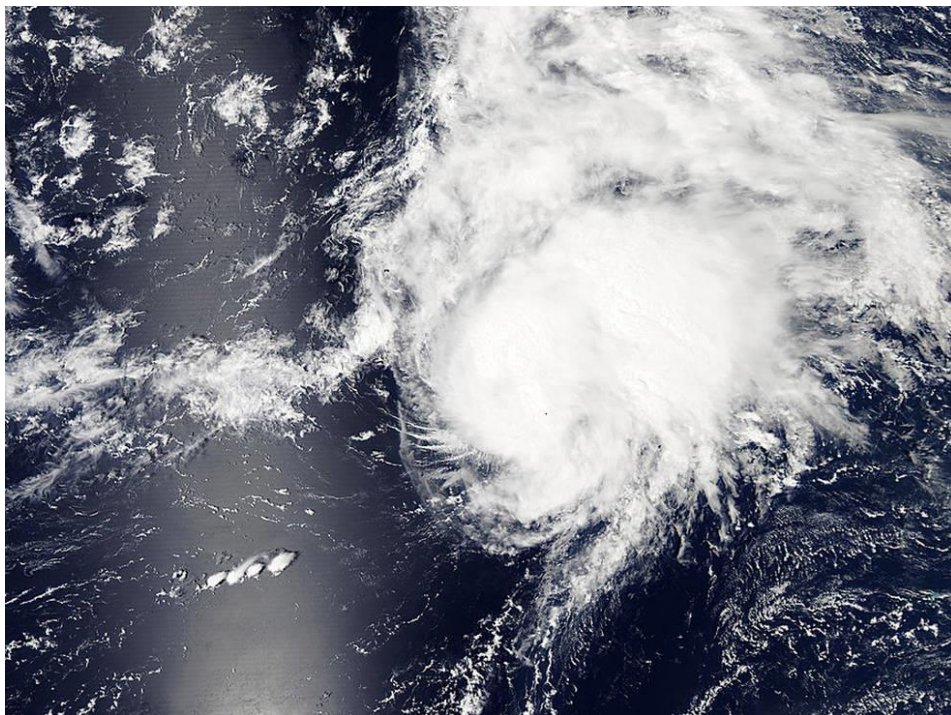
CENTRAL PACIFIC HURRICANE CENTER TROPICAL CYCLONE REPORT



HURRICANE LOKE (CP042015)

21 – 26 August 2015

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MODIS IMAGE OF LOKE AT 0110 UTC 25 AUGUST FROM THE NASA AQUA SATELLITE. IMAGE COURTESY OF NASA.

Loke was a category one hurricane (on the Saffir-Simpson Hurricane Wind Scale) that followed a unique northward track over the western portion of the central North Pacific.

Hurricane Loke

21 – 26 AUGUST 2015

SYNOPTIC HISTORY

Loke was a unique central Pacific tropical cyclone in that it formed in the western portion of the basin then moved along an undulating and general northward-moving track through its life. Loke remained largely over open waters, though it passed over the Papahānaumokuākea Marine National Monument as a hurricane between Lisianski Island and Pearl and Hermes Atoll.

The origins of Loke can be traced back to low-level trough that developed on 13 August along the intertropical convergence zone to the southeast of the main Hawaiian Islands. For several days, this broad feature travelled toward the west around 15 kt, at approximately the same speed as, but lagging several hundred n mi to the southeast of, the compact remnant circulation of former tropical cyclone Hilda. On 17 and 18 August, the broad trough merged with the ill-defined remnants of Hilda roughly 1,000 n mi southwest of the main Hawaiian Islands, becoming the western end of an east-to-west oriented monsoon trough that extended across the entirety of the deep tropics of the central Pacific.

By 0000 UTC 19 August, a weak low-level cloud circulation was observed travelling westward in the monsoon trough with pulses of deep convection confined to the northern quadrant. Late on 19 August, collapsing deep convection revealed an exposed low-level circulation stalling within the monsoon trough more than 1,200 n mi west-southwest of the main Hawaiian Islands. When deep convection redeveloped to the north early on 20 August, the low-level center was drawn northeastward. As the consolidating system separated from the monsoon trough, it continued on a slow northeastward track toward a break in the subtropical ridge created by an unusually deep and low-latitude extratropical low between 30N and 40N just west of the International Date Line. Deep convection became sufficiently organized by 0000 UTC 21 August for the system to be designated Tropical Depression Four-C while centered about 1,100 west-southwest of the main Hawaiian Islands and 745 n mi west-southwest of Johnston Island. The “best track” chart of the tropical cyclone’s path is given in Fig. 1. The best track positions and intensities are listed in Table 1¹.

A deep trough to the northwest of Tropical Depression Four-C inhibited outflow within the northwest quadrant of the depression through much of 21 August and caused the system to make a gradual turn toward the north. Late on 21 August, deep convection increased around the center, and by 1800 UTC, the system strengthened to Tropical Storm Loke. Loke increasingly interacted with the deep trough to the northwest on 22 August, leading to a gradual acceleration and turn toward the northwest. This interaction eventually led to a disruption to the outflow in the northwest quadrant, decreasing the amount of deep convection around the system during the overnight

¹ 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 *bt* directory, while previous years’ data are located in the *archive* directory.

hours of 22 August. A pair of ASCAT passes at 0846 UTC and 0931 UTC showed no tropical-storm-force winds, and Loke was downgraded to a tropical depression at 1200 UTC 22 August. As Loke continued to interact with the deep trough to the northwest, Loke made a gradual turn toward the north and continued a slow acceleration. Though outflow remained restricted in the northwest quadrant, increasing deep convection pulsed around the low-level center during late 22 August. An ASCAT-B pass at 2116 UTC revealed a small area of 35 kt winds just east of the center, and Loke was once again designated a tropical storm at 0000 UTC 23 August.

Starting late 23 August and continuing through 24 August, Loke gained significant strength. Continued interaction with the deep trough to the northwest caused an acceleration toward the northeast and an enhancement of the outflow aloft, leading to an increase in deep convection around the center. An ASCAT-A pass at 0852 UTC 24 August contained wind retrievals of 55 kt in the southeast quadrant. A 37 GHz Coriolis pass at 1757 UTC (Fig. 2) revealed an eye wall structure, and a cloud-filled eye was noted on morning GOES-15 visible satellite imagery. As a result, Loke became a hurricane at 1800 UTC 24 August.

The deep trough to the northwest intensified and moved closer on 25 August, causing Loke to decelerate and turn toward the north. Vertical wind shear increased late in the day, allowing the southern edge of the low-level circulation to become partially exposed, and as Loke passed north of 30N latitude, sea surface temperatures began to decrease. These factors caused Loke to weaken to a tropical storm at 1800 UTC 25 August. On 26 August, Loke began extratropical transition as it was rapidly drawn northwestward into the circulation of a large and deep extratropical storm low that was comprised of former west Pacific Typhoon Atsani. As Loke crossed the International Date Line, the tropical cyclone dissipated as it was absorbed by the extratropical storm low by 0000 UTC 27 August.

METEOROLOGICAL STATISTICS

Observations in Loke include subjective satellite-based Dvorak technique intensity estimates from CPHC, the Joint Typhoon Warning Center (JTWC), and the Satellite Analysis Branch (SAB), and objective Advanced Dvorak Technique (ADT) estimates from the Cooperative Institute for Meteorological Satellite Studies/University of Wisconsin-Madison (CIMSS). Data and imagery from NOAA polar-orbiting satellites including the Advanced Microwave Sounding Unit (AMSU), 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 Loke.

The peak intensity of 65 kt is based on Dvorak satellite estimates from CPHC and SAB, with supporting data from ADT produced by CIMSS. No ship reports of tropical-storm-force winds associated with Loke were received.

CASUALTY AND DAMAGE STATISTICS

There were no reports of damage or casualties² associated with Loke.

FORECAST AND WARNING CRITIQUE

The genesis of Loke was poorly anticipated (Table 2). Note that in 2015, CPHC only produced genesis forecasts for a 48 h period. The focus for tropical cyclogenesis for numerous days had been on a persistent, well-defined disturbance embedded within the monsoon trough to the south and southeast of the main Hawaiian Islands. The poorly defined, incipient disturbance of Loke was first mentioned in CPHC's Tropical Weather Outlook only 24 h prior to development to a tropical depression. This feature was assigned a "low" (< 30%) probability of genesis and was only raised to the "medium" (40-60%) category just prior to actual development to a tropical depression.

A verification of CPHC official track forecasts for Loke is given in Table 3a. Official forecast track errors through 48 h were comparable to the mean official errors for the previous 5-yr period. Beyond 48 h, CPHC official track errors increased steadily and significantly, reaching nearly double the 120 h mean official error for the previous 5-yr period. The large errors beyond 48 h were likely due to the undulating track of Loke. A homogeneous comparison of the official track errors with selected guidance models is given in Table 3b. The GFSI and its ensemble mean (AEMI) were the only dynamical models to consistently outperform the official CPHC forecast, and the consensus models outperformed the CPHC official forecast at nearly all times.

A verification of CPHC official intensity forecasts for Loke is given in Table 4a. Official forecast intensity errors through 48 h were comparable to the mean official errors for the previous 5-yr period. Beyond 48 h, CPHC official intensity errors followed a decreasing trend and were significantly superior to the mean official errors for the previous 5-yr period. A homogeneous comparison of the official intensity errors with selected guidance models is given in Table 4b. The official CPHC intensity forecast outperformed or was comparable to any single model at most times. However, the consensus guidance provided some improvement to the official CPHC forecast from 24 to 72 h.

Watches and warnings associated with Loke are given in Table 5. It should be noted that Loke passed over Papahānaumokuākea Marine National Monument, which contains numerous small islands and atolls. The only location within the monument with a permanent settlement and a weather observation is Midway Island, and several locations contain small seasonal

² 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.

camps, mainly for resource management and scientific research. When Loke was approximately 450 n mi southwest of the monument, a Tropical Storm Watch was issued for Midway Island and for the region from Pearl and Hermes Atoll to Lisianski Island to Maro Reef at 1500 UTC 23 August. The watch was upgraded to a Tropical Storm Warning from Pearl and Hermes Atoll to Lisianski Island later that day at 2100 UTC. Due to an unexpected intensification of Loke, the Tropical Storm Warning was upgraded to a Hurricane Warning for the region from Pearl and Hermes Atoll to Lisianski Island at 0300 UTC 24 August. At the same time, the Tropical Storm Watch was upgraded to a Tropical Storm Warning for Midway Island and for the region from Pearl and Hermes Atoll to Lisianski Island. As Loke neared the monument, confidence in the track increased, and at 2100 UTC 24 August, the Tropical Storm Warning was discontinued for Midway Island and for the region from Lisianski Island to Maro Reef. Loke passed over the Papahānaumokuākea Marine National Monument as a hurricane during the first part of 25 August, and as the cyclone lifted toward the north-northeast, the Hurricane Warning for the region from Pearl and Hermes Atoll to Lisianski Island was discontinued at 0900 UTC August 25.

Table 1. Best track for Hurricane Loke 21 – 26 August 2015.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
19 / 0000	13.4	176.8	1007	20	low
19 / 0600	13.5	177.8	1007	20	"
19 / 1200	13.7	178.6	1007	20	"
19 / 1800	13.4	179.3	1007	20	"
20 / 0000	13.4	179.0	1007	20	"
20 / 0600	13.6	178.6	1007	20	"
20 / 1200	13.9	178.3	1006	25	"
20 / 1800	14.3	177.9	1005	25	"
21 / 0000	14.8	177.5	1004	30	tropical depression
21 / 0600	15.3	177.3	1003	30	"
21 / 1200	15.7	177.2	1003	30	"
21 / 1800	16.1	177.2	1002	35	tropical storm
22 / 0000	16.5	177.3	1002	35	"
22 / 0600	16.8	177.5	1002	35	"
22 / 1200	17.2	177.9	1004	30	tropical depression
22 / 1800	17.8	178.5	1004	30	"
23 / 0000	18.4	179.0	1003	35	tropical storm
23 / 0600	19.1	179.3	1003	35	"
23 / 1200	20.0	179.6	1003	35	"
23 / 1800	21.2	179.7	1002	40	"
24 / 0000	22.4	179.4	1000	45	"
24 / 0600	23.5	178.8	995	55	"
24 / 1200	24.4	177.9	991	60	"
24 / 1800	25.3	176.7	986	65	hurricane
25 / 0000	26.4	175.4	986	65	"
25 / 0600	27.6	173.9	986	65	"

25 / 1200	28.8	173.1	985	65	“
25 / 1800	30.1	173.0	986	60	tropical storm
26 / 0000	31.1	173.5	988	55	“
26 / 0600	32.5	174.4	988	55	“
26 / 1200	34.5	176.3	991	50	“
26 / 1800	36.6	179.2	991	50	“
27 / 0000					dissipated
25 / 1200	28.8	173.1	985	65	maximum winds and minimum pressure

Table 2. Number of hours in advance of formation of Hurricane Loke associated with the first CPHC 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 in 48-Hour Outlook
Low ($\leq 30\%$)	24
Medium (40%-60%)	0
High ($\geq 70\%$)	0

Table 3a. CPHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Hurricane Loke. 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	29.2	43.8	57.9	81.4	188.9	340.4	507.0
OCD5	67.0	143.6	202.6	261.1	425.2	626.6	787.4
Forecasts	22	20	18	16	10	8	4
OFCL (2010-14)	27.9	44.1	56.7	73.9	132.3	183.7	258.9

Table 3b. Homogeneous comparison of selected track forecast guidance models (in n mi) for Hurricane Loke. 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 3a due to the homogeneity requirement.

Model ID	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	29.4	46.0	61.0	90.2	177.8	264.7	-
OCD5	64.8	155.8	220.7	296.1	483.9	704.5	-
GFSI	25.0	40.6	56.7	81.8	162.2	205.5	-
HWFI	22.2	41.5	70.9	118.1	262.4	395.8	-
EGRI	38.9	66.6	91.8	118.0	234.7	285.1	-
EMXI	30.7	54.6	75.3	98.3	115.6	137.3	-
CMCI	35.0	72.5	115.9	201.7	414.3	493.2	-
NGXI	41.9	74.9	104.1	121.5	169.5	269.3	-
TCON	23.9	39.5	54.2	75.8	177.9	234.9	-
TVCA/TVCE	25.3	40.2	51.3	71.4	158.0	207.3	-
AEMI	25.5	36.2	52.4	84.3	161.8	212.5	-
Forecasts	19	18	16	13	7	5	0

Table 4a. CPHC official (OFCL) and climatology-persistence skill baseline (OCD5) intensity forecast errors (kt) for Hurricane Loke. 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	5.7	9.0	12.8	13.1	9.5	8.1	7.5
OCD5	10.5	10.6	16.3	12.9	39.2	40.5	20.0
Forecasts	22	20	18	16	10	8	4
OFCL (2010-14)	4.8	8.6	11.6	13.8	18.5	19.3	20.4

Table 4b. Homogeneous comparison of selected intensity forecast guidance models (in kt) for Hurricane Loke. 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 4a due to the homogeneity requirement.

Model ID	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	6.0	9.4	12.5	13.6	10.6	5.8	10.0
OCD5	11.1	10.6	15.3	11.6	44.0	40.2	19.5
HWFI	7.7	12.1	12.7	12.8	6.4	11.7	42.5
DSHP	6.9	10.4	14.6	14.4	13.5	8.5	8.5
LGEM	7.4	10.3	14.4	15.9	18.3	10.7	4.5
ICON	6.5	8.9	11.8	12.6	6.0	7.5	17.0
IVCN	6.5	8.9	11.8	12.6	6.0	7.5	17.0
Forecasts	20	18	16	14	8	6	2

Table 5. Watch and warning summary for Hurricane Loke 21 – 26 August 2015.

Date/Time (UTC)	Action	Location
23/1500	Tropical Storm Watch issued	Midway Island
23/1500	Tropical Storm Watch issued	Pearl and Hermes Atoll to Lisianski Island to Maro Reef
23/2100	Tropical Storm Watch changed to Tropical Storm Warning	Pearl and Hermes Atoll to Lisianski Island
24/0300	Tropical Storm Warning changed to Hurricane Warning	Pearl and Hermes Atoll to Lisianski Island
24/0300	Tropical Storm Watch changed to Tropical Storm Warning	Midway Island
24/0300	Tropical Storm Watch changed to Tropical Storm Warning	Lisianski Island to Maro Reef
24/2100	Tropical Storm Warning discontinued	Midway Island
24/2100	Tropical Storm Warning discontinued	Lisianski Island to Maro Reef
25/0900	Hurricane Warning discontinued	Pearl and Hermes Atoll to Lisianski Island

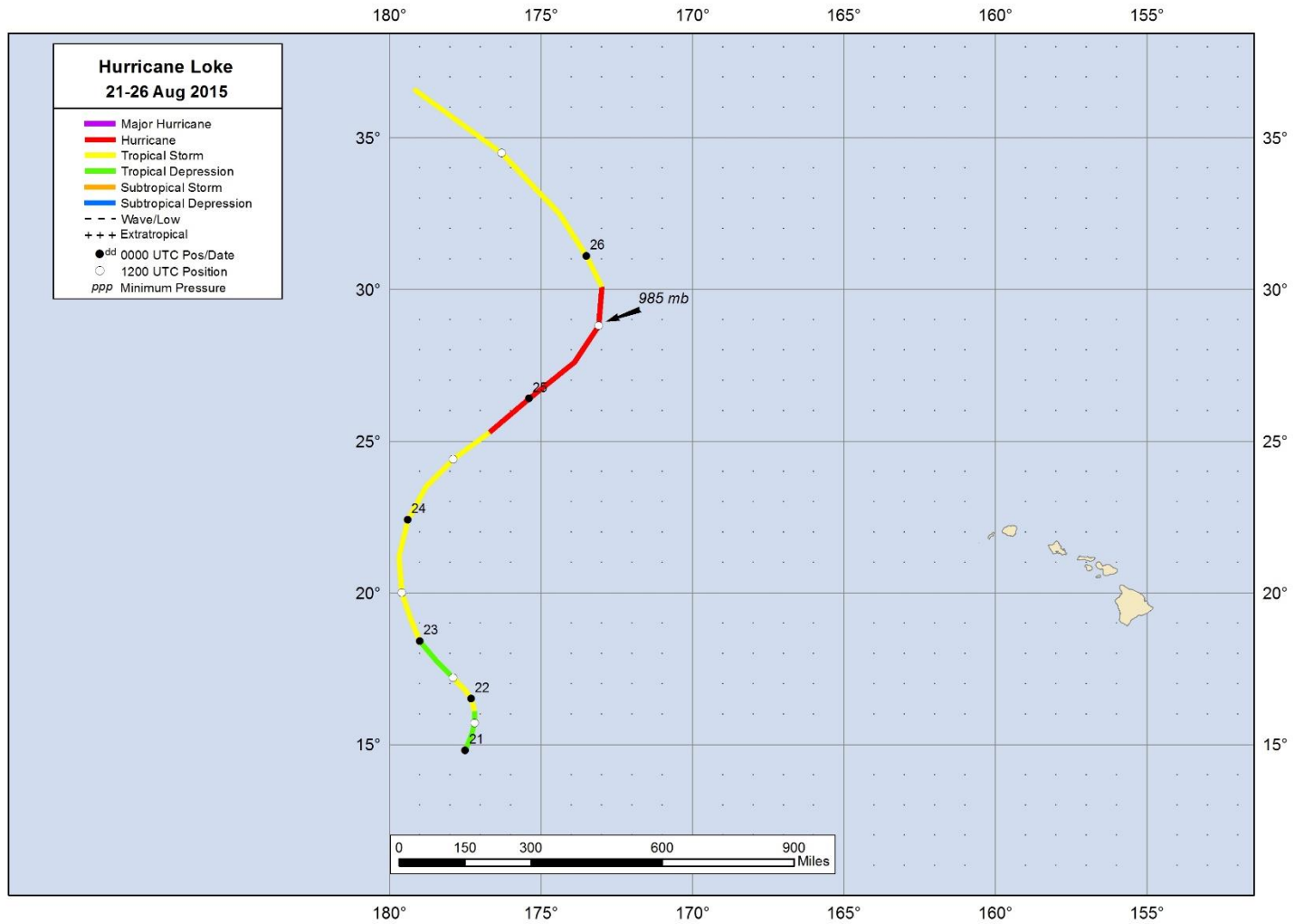


Figure 1. Best track positions for Hurricane Loke, 21 – 26 August 2015.

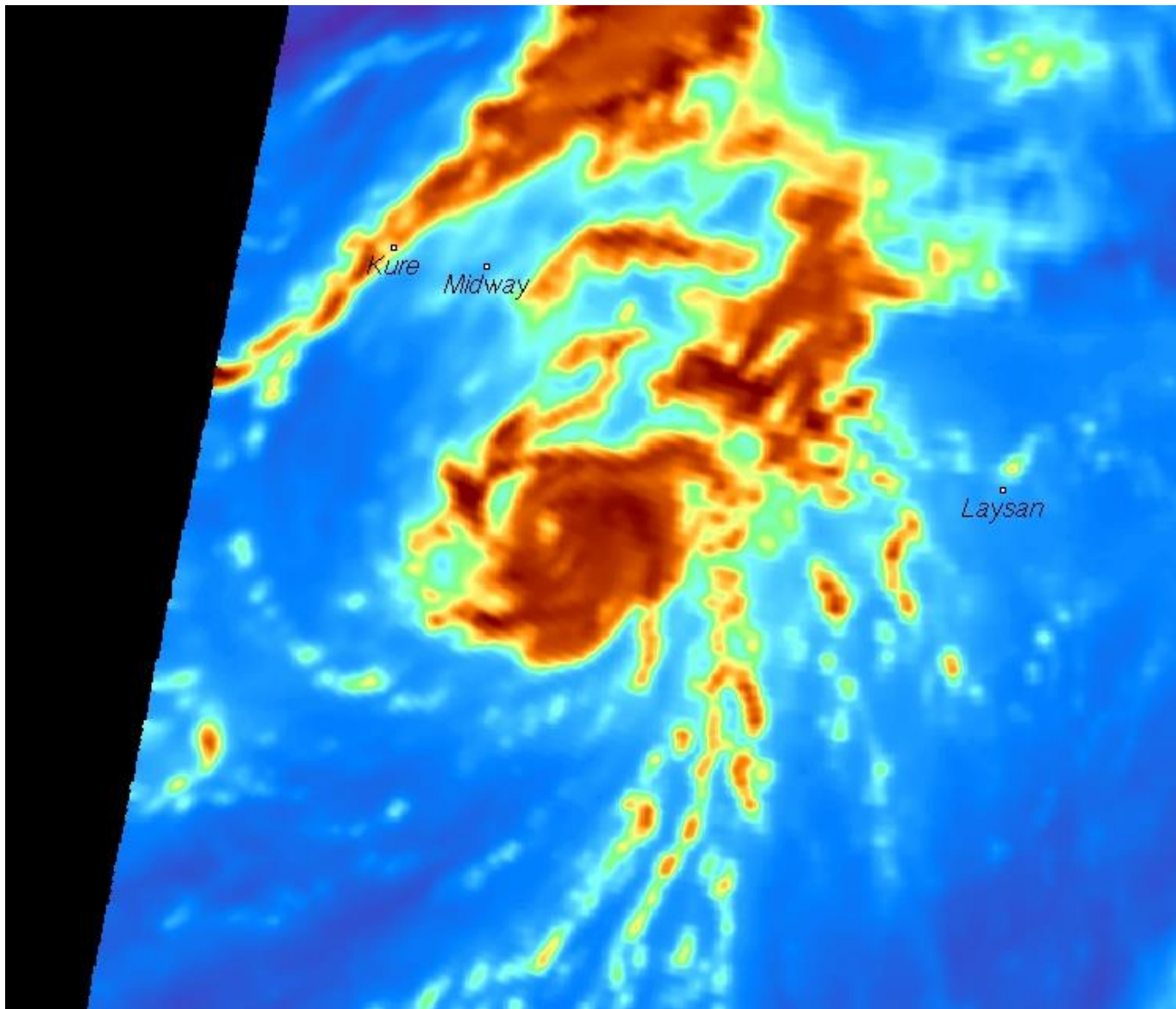


Figure 2. A 37 GHz Windsat image taken by the Coriolis satellite at 1757 UTC 24 August showing an eye wall structure in Loke.