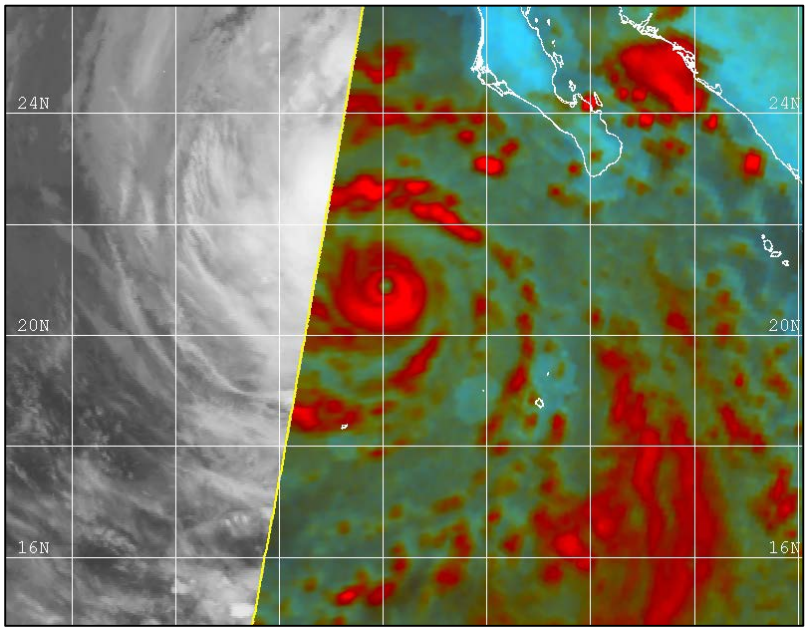
NATIONAL HURRICANE CENTER
TROPICAL CYCLONE REPORT

HURRICANE LINDA

(EP152015)

5 – 10 September 2015

Daniel P. Brown
National Hurricane Center
12 November 2015



SPECIAL SENSOR MICROWAVE IMAGER/SOUNDER (SSMIS) IMAGE OF HURRICANE LINDA NEAR PEAK INTENSITY AT 1354 UTC 8 SEPTEMBER. IMAGE COURTESY OF THE NAVAL RESEARCH LABORATORY.

Linda was a hurricane that passed between Socorro and Clarion Islands before rapidly intensifying to category 3 strength (on the Saffir-Simpson Hurricane Wind Scale) while it moved offshore of but parallel to the west coast of the southern Baja California peninsula.

Hurricane Linda

5 – 10 SEPTEMBER 2015

SYNOPTIC HISTORY

The disturbance from which Linda formed, the same tropical wave that spawned Tropical Storm Erika over the tropical Atlantic Ocean on 25 August, departed the west coast of Africa on 21 August. The southern portion of the wave continued westward and crossed Central America on 30 August, and a couple of days later, showers and thunderstorms associated with the wave began to increase in coverage as the system passed to the south of the Gulf of Tehuantepec. On 2 September, an eastward-moving convectively coupled Kelvin wave approached the system, causing the shower and thunderstorm activity to increase, and a broad area of low pressure formed several hundred n mi south of Manzanillo, Mexico. Despite moderate northeasterly shear, the broad low gradually became better defined and acquired a well-defined center of circulation by 1200 UTC 4 September. The next day deep convection associated with the system became better organized, marking the formation of a tropical depression at 1800 UTC 5 September, about 425 n mi southwest of Manzanillo. 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[1].

The tropical depression moved northwestward around the southwestern portion of a strong mid-level ridge that was centered over northern Mexico. Over warm water and within an environment of moderate northeasterly vertical wind shear, the depression strengthened and became a tropical storm by 0600 UTC 6 September while located about 450 n mi southwest of Manzanillo. The vertical wind shear decreased around that time, and a period of rapid strengthening ensued. Satellite imagery during the daylight hours of 6 September showed an increase in convective banding and the development of a central dense overcast by 0000 UTC 7 September. Linda became a hurricane early on 7 September and microwave satellite data showed the development of an eye by 0600 UTC that day (Fig. 4).

Linda turned north-northwestward and became a category 2 hurricane with winds of 85 kt by 1200 UTC 7 September. Later that day, a slight increase in shear and possible intrusion of dry mid-level air caused a temporary erosion of the inner-core convection (Fig. 4), and Linda's intensity levelled off during the afternoon of 7 September while the center passed about midway between Socorro and Clarion islands. By 0600 UTC the next day, Linda began to quickly intensify once again, and microwave satellite data indicated that a banded eye developed (Fig. 4). The eye continued to become better defined and it became apparent in infrared satellite pictures around 0900 UTC. The eye became more distinct in geostationary satellite images during the next few hours, and Linda reached its estimated peak intensity of 110 kt around 1200 UTC 8

[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 *btk* directory, while previous years' data are located in the *archive* directory.

September (cover photo) while located about 250 n mi west-southwest of the southern tip of the Baja California peninsula. Later that day, Linda turned northwestward and began to weaken while moving over slightly cooler waters. Rapid weakening commenced early on 9 September when the hurricane encountered a drier and more stable air mass, and moved over sea surface temperatures below 26° C. Linda weakened to a tropical storm by 1800 UTC 9 September as the convection decreased in coverage The diminishing area of convection became displaced from the low-level center by early on 10 September, and Linda degenerated to a post-tropical cyclone by 1200 UTC that day.

The post-tropical cyclone moved slowly west-northwestward and continued to weaken over the next couple of days, becoming nearly stationary on 13 September. The next day, a low- to mid-level trough approaching the west coast of the United States caused the low to turn eastward before it degenerated into a trough by 1800 UTC 14 September about 400 n mi west of the west-central coast of the Baja California peninsula.

METEOROLOGICAL STATISTICS

Observations in Linda (Figs. 2 and 3) include subjective satellite-based Dvorak technique intensity estimates from the Tropical Analysis and Forecast Branch (TAFB) 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. 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 Linda.

Winds and Pressure

Linda's estimated peak intensity of 110 kt is based on a blend of subjective Dvorak estimates of 115 kt (T6.0) from TAFB and 102 kt (T5.5) from SAB. Objective ADT T-numbers reached T6.5 (127 kt) at 1800 UTC, but appear to be too high. It is possible that Linda was a little stronger than 110 kt around 1500 UTC, when the satellite presentation of the tropical cyclone was its best.

There were no reports of sustained tropical-storm-force winds over land. An automated weather station on Socorro Island reported peak winds of 24 kt with a gust to 36 kt at 0515 UTC 8 September. When the center of Linda passed about 85 n mi west of Socorro Island late on 7 September, a minimum pressure of 996.9 mb was reported around 2230 UTC, but a historical low bias has been noted in the pressure observations from that station.

Drifting buoy 43546 reported a minimum pressure of 1001.4 mb at 0000 UTC 6 September; this observation was helpful in estimating the minimum pressure of the tropical cyclone shortly after its formation.

There were no ship reports of winds of tropical storm force associated with Linda.

Rainfall and Flooding

Outer rain bands from Linda moved over portions of the southern Baja California peninsula on 8-9 September, producing some locally heavy rain. No official rainfall reports, however, have been received from Mexico.

Mid- to high-level moisture, some of which originating with the tropical cyclone, was advected northward around the eastern portion of Linda's large circulation and caused locally heavy rainfall over portions of northern Mexico, southern California, and the southwestern United States for several days. This heavy rainfall was responsible for the single deadliest flash flood event on record in Utah on 14 September (discussed below).

On 15 September, a strong mid- to upper-level trough and the remnants of Linda moved eastward into southern California and produced 2.39 inches of rain in Los Angeles. This was the second-wettest September day since records began in that city in 1877. A rainfall total of 1.15 inches was observed in San Diego that same day, which was also that city's second-wettest September day on record.

CASUALTY AND DAMAGE STATISTICS

Linda and its remnants caused no casualties or damage in either Mexico or the United States.

Moisture that partially originated with the tropical cyclone, however, was advected into the southwestern United States producing heavy rainfall and deadly flash floods on 14 September. Media reports indicate that 7 hikers died in a narrow canyon in Utah's Zion National Park when it filled with rushing water during the flash flood. That same day 12 other people, including nine children, died in Hildale, Utah, when two vehicles were swept away in flash flooding. A 6-year old child in one of the vehicles remains missing and is presumed to have perished. The 20 fatalities that occurred in Utah that day makes it the deadliest flood event in the state's history.

FORECAST AND WARNING CRITIQUE

The genesis of Linda was not particularly well forecast. The disturbance from which Linda formed was first mentioned in the Tropical Weather Outlook at 0000 UTC 3 September, about 66 h before formation occurred. At that time, the disturbance was assigned a low chance (<40%) of formation during the next 5 days. The 5-day probability of development was increased to the medium (40-60%) and high categories (>60%) 36 h and 18 h before formation, respectively. The 48-h probability of formation did not reach the medium category until 18 h before genesis, and

the high category 12 h before development occurred. The global forecast models did a poor job in predicting the genesis of Linda, which caused the shorter-than-typical lead time of NHC medium- and high-category genesis forecasts.

A verification of NHC official track forecasts for Linda is given in Table 3a. Official forecast track errors were lower than the mean official errors for the previous 5-yr period at verifying times between 24 and 72 h. The track errors at 96 h were higher than the long-term mean, but there are only 2 verifying track forecasts for Linda at that time. A homogeneous comparison of the official track errors with selected guidance models is given in Table 3b. The track models performed quite well for Linda, which resulted in the lower than long-term mean track errors through 72 h. The best-performing track model was the European Center for Medium Range Weather Forecasting global model (EMXI), which had mean track errors lower than the official forecasts at all verifying times except 24 h. The GFEX (GFS and ECMWF) consensus had the lowest mean track errors of all of the various consensus aids, and was slightly better than the official forecast at each forecast lead time.

A verification of NHC official intensity forecasts for Linda is given in Table 4a. Official forecast intensity errors were greater than the mean official errors for the previous 5-yr period through 72 h, and lower than the long-term mean at 96 h. A homogeneous comparison of the official intensity errors with selected guidance models is given in Table 4b. The NHC intensity forecasts had slightly lower mean errors than much of the guidance, except for the LGEM and FSSE models that outperformed the official forecasts at most verifying lead times. The first few NHC forecasts accurately predicted that Linda would attain hurricane strength, but they did not anticipate the tropical cyclone's intensification to major hurricane status. The relatively large NHC intensity errors at 12 and 24 h are the result of the two periods of rapid strengthening. The second period of rapid intensification, to category 3 strength on 8 September, was not well anticipated since the hurricane was nearing less favorable thermodynamic conditions and a temporary decrease in inner-core structure was observed just prior to that period of intensification.

There were no watches or warnings issued in association with Linda.

Table 1. Best track for Hurricane Linda, 5-10 September 2015.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
04 / 1200	10.0	104.0	1007	25	low
04 / 1800	10.4	104.4	1007	25	"
05 / 0000	10.8	104.8	1006	25	"
05 / 0600	11.3	105.3	1006	25	"
05 / 1200	11.7	105.8	1005	25	"
05 / 1800	12.1	106.3	1003	25	tropical depression
06 / 0000	12.6	107.0	1001	30	"
06 / 0600	13.2	107.8	999	35	tropical storm
06 / 1200	13.8	108.6	997	40	"
06 / 1800	14.5	109.3	995	50	"
07 / 0000	15.4	110.1	990	60	"
07 / 0600	16.3	111.0	984	75	hurricane
07 / 1200	17.2	111.7	976	85	"
07 / 1800	17.9	112.1	974	85	"
08 / 0000	18.6	112.5	971	85	"
08 / 0600	19.6	113.0	964	90	"
08 / 1200	20.6	113.6	950	110	"
08 / 1800	21.5	114.5	950	110	"
09 / 0000	22.2	115.3	955	105	"
09 / 0600	22.8	115.9	965	90	"
09 / 1200	23.4	116.4	976	75	"
09 / 1800	24.0	117.0	986	60	tropical storm
10 / 0000	24.6	117.5	990	55	"
10 / 0600	25.2	118.0	996	45	"
10 / 1200	25.7	118.4	1002	35	low
10 / 1800	26.1	118.8	1002	30	"
11 / 0000	26.4	119.2	1003	30	"
11 / 0600	26.6	119.6	1003	30	"
11 / 1200	26.8	120.0	1003	30	"

11 / 1800	27.1	120.4	1004	25	"
12 / 0000	27.4	120.9	1004	25	"
12 / 0600	27.5	121.4	1004	25	"
12 / 1200	27.6	121.8	1004	25	"
12 / 1800	27.6	122.2	1004	25	"
13 / 0000	27.7	122.4	1005	20	"
13 / 0600	27.7	122.6	1005	20	"
13 / 1200	27.8	122.8	1005	20	"
13 / 1800	27.8	123.0	1006	15	"
14 / 0000	27.8	123.0	1007	15	"
14 / 0600	27.8	122.9	1008	15	"
14 / 1200	27.8	122.7	1008	15	"
14 / 1800					dissipated
08 / 1200	20.6	113.6	950	110	maximum winds and minimum pressure

Table 2. 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%)	42	66
Medium (40%-60%)	18	36
High (>60%)	12	18

Table 3a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Hurricane Linda, 5-10 September 2015. 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	25.7	**33.0**	**38.4**	**31.4**	**59.1**	161.4	
OCD5	38.7	68.6	104.4	139.8	247.3	353.3	
Forecasts	16	14	12	10	6	2	
OFCL (2010-14)	23.4	36.4	47.2	59.4	89.0	123.6	159.5
OCD5 (2010-14)	36.6	74.2	116.5	159.7	245.6	331.1	427.4

Table 3b. Homogeneous comparison of selected track forecast guidance models (in n mi) for Hurricane Linda, 5-10 September 2015. 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 3a due to the homogeneity requirement.

Model ID	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	25.1	35.4	38.0	29.8	40.7		
OCD5	40.1	68.7	100.6	134.4	230.4		
GFSI	26.3	43.8	52.1	40.1	52.0		
GHMI	26.3	46.1	61.3	63.7	66.1		
HWFI	31.6	55.7	72.0	66.8	69.5		
EGRI	27.2	50.2	81.8	95.8	93.3		
EMXI	**25.0**	36.8	**31.0**	**19.2**	**20.5**		
CMCI	34.2	50.6	60.4	61.0	72.7		
NVGI	27.5	**34.3**	47.6	67.7	127.1		
GFNI	30.3	40.1	44.9	51.7	73.5		
AEMI	28.5	45.7	51.2	38.8	**26.6**		
FSSE	**24.9**	40.8	46.6	37.3	**20.3**		
TCON	25.8	42.2	53.5	45.5	**37.8**		
TVCE	**24.1**	38.2	46.9	36.9	**31.7**		
GFEX	**23.5**	**34.0**	**35.5**	**24.4**	**30.9**		
TVCX	**23.7**	35.7	42.7	34.0	**25.9**		
LBAR	35.0	57.1	76.6	87.9	148.6		
BAMD	35.4	56.9	79.1	80.9	95.4		
BAMM	32.2	51.6	63.6	59.8	71.7		
BAMS	**24.7**	36.6	48.9	53.4	75.8		
Forecasts	14	12	10	8	4		

Table 4a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) intensity forecast errors (kt) for Hurricane Linda, 5-10 September 2015. 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	10.9	16.8	14.6	16.0	16.7	**7.5**	
OCD5	12.5	21.3	21.0	20.9	21.2	8.5	
Forecasts	16	14	12	10	6	2	
OFCL (2010-14)	5.9	9.8	12.5	14.0	15.5	16.3	14.9
OCD5 (2010-14)	7.7	12.8	16.4	18.8	21.1	20.9	19.7

Table 4b. Homogeneous comparison of selected intensity forecast guidance models (in kt) for Hurricane Linda, 5-10 September 2015. 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	11.4	16.3	12.0	14.4	8.8		
OCD5	13.4	21.3	18.8	18.9	14.3		
GHMI	14.0	21.3	23.0	26.4	13.0		
HWFI	**11.1**	20.2	24.6	23.6	10.0		
GFNI	16.4	28.5	33.7	35.4	15.3		
GFSI	15.1	24.4	24.5	25.0	11.3		
EMXI	18.6	30.7	31.6	33.9	16.3		
DSHP	11.6	**15.3**	13.4	14.8	11.0		
LGEM	**11.1**	**15.1**	**11.8**	**10.8**	**7.0**		
ICON	**10.7**	17.3	17.6	17.6	**7.0**		
IVCN	**10.7**	17.3	17.6	17.6	**7.0**		
FSSE	**10.5**	**13.7**	14.0	**13.4**	**7.0**		
Forecasts	14	12	10	8	4		

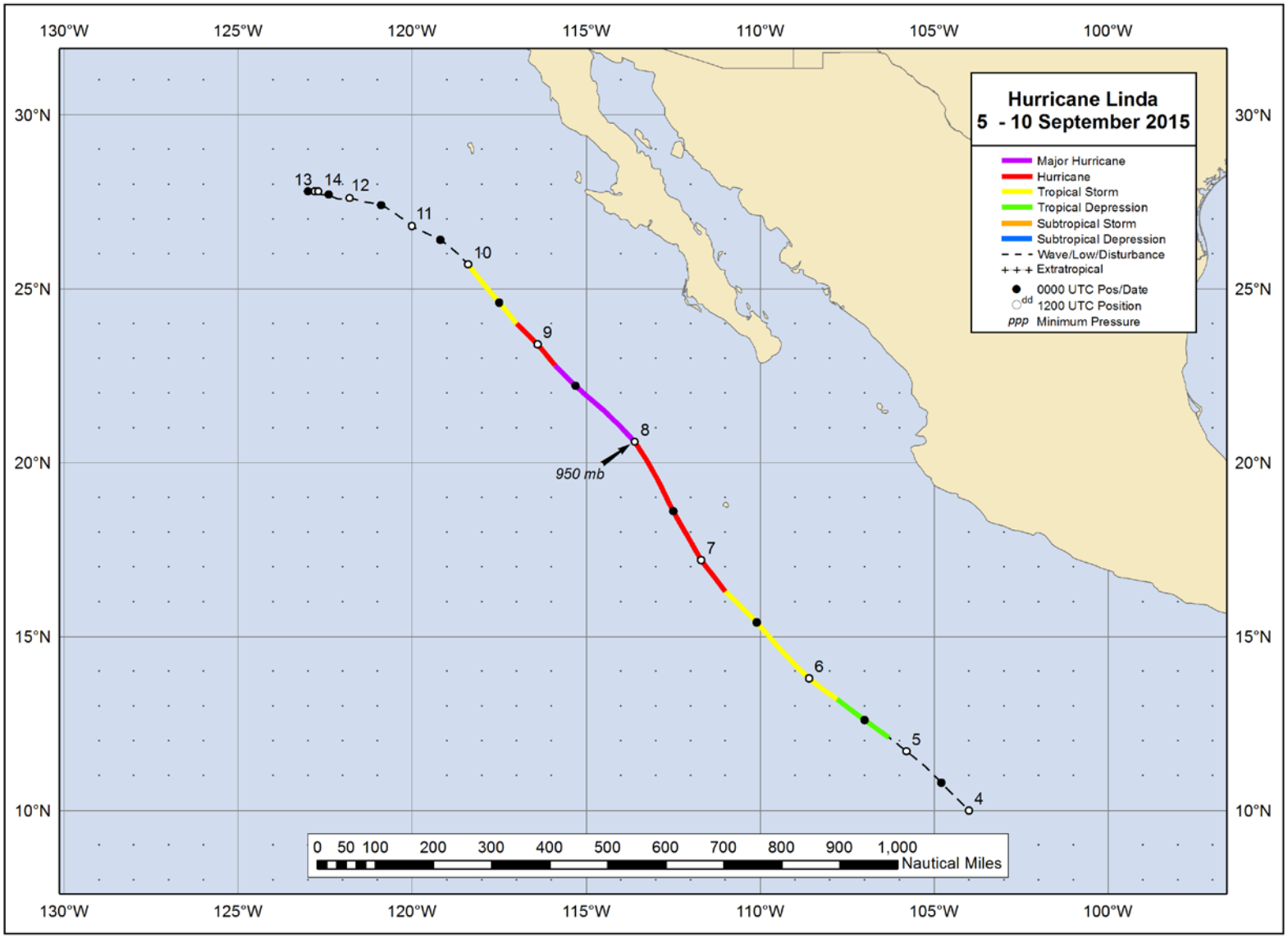


Figure 1. Best track positions for Hurricane Linda, 5-10 September 2015.

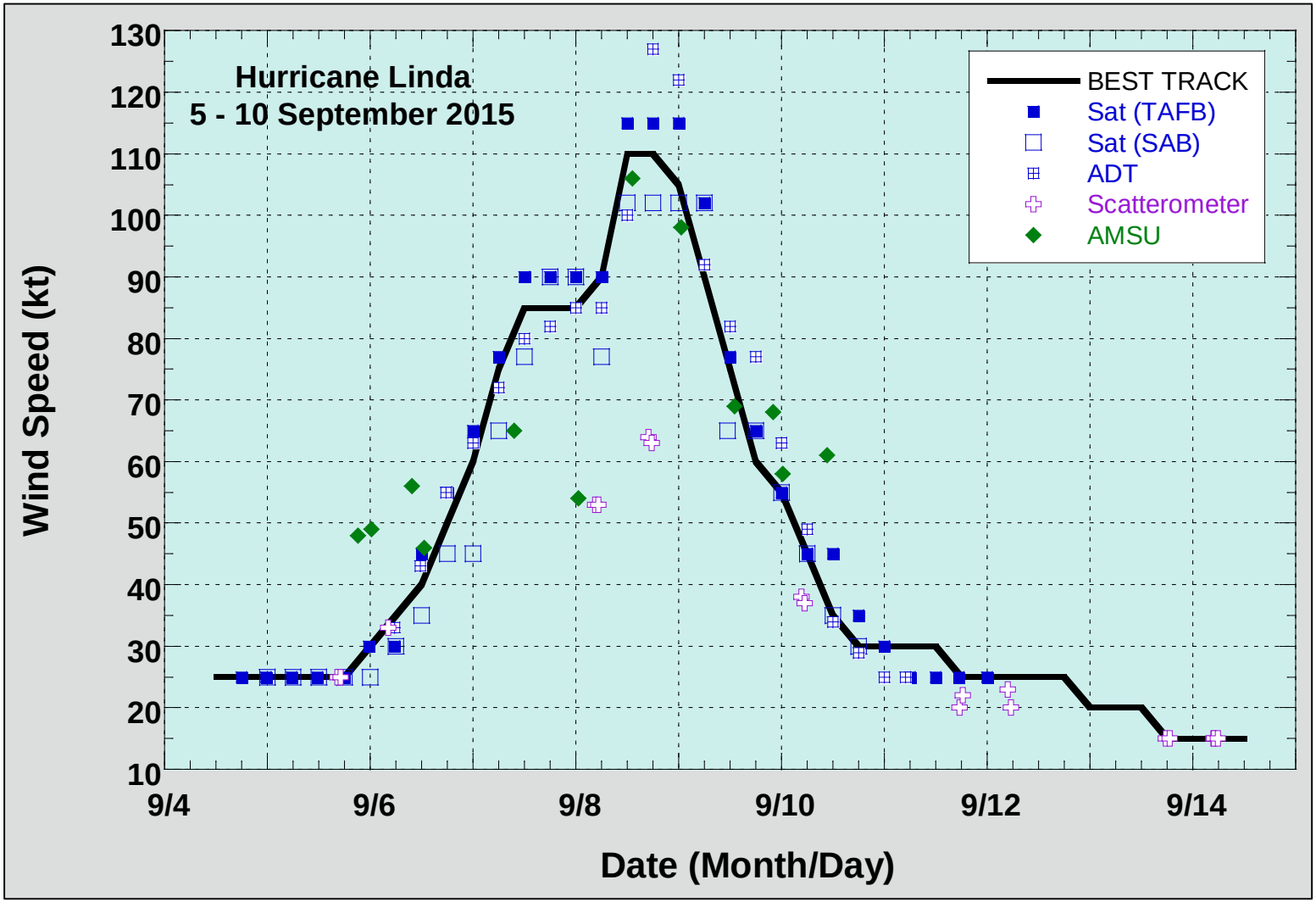


Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Hurricane Linda, 5-10 September 2015. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. AMSU intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies technique. Dashed vertical lines correspond to 0000 UTC.

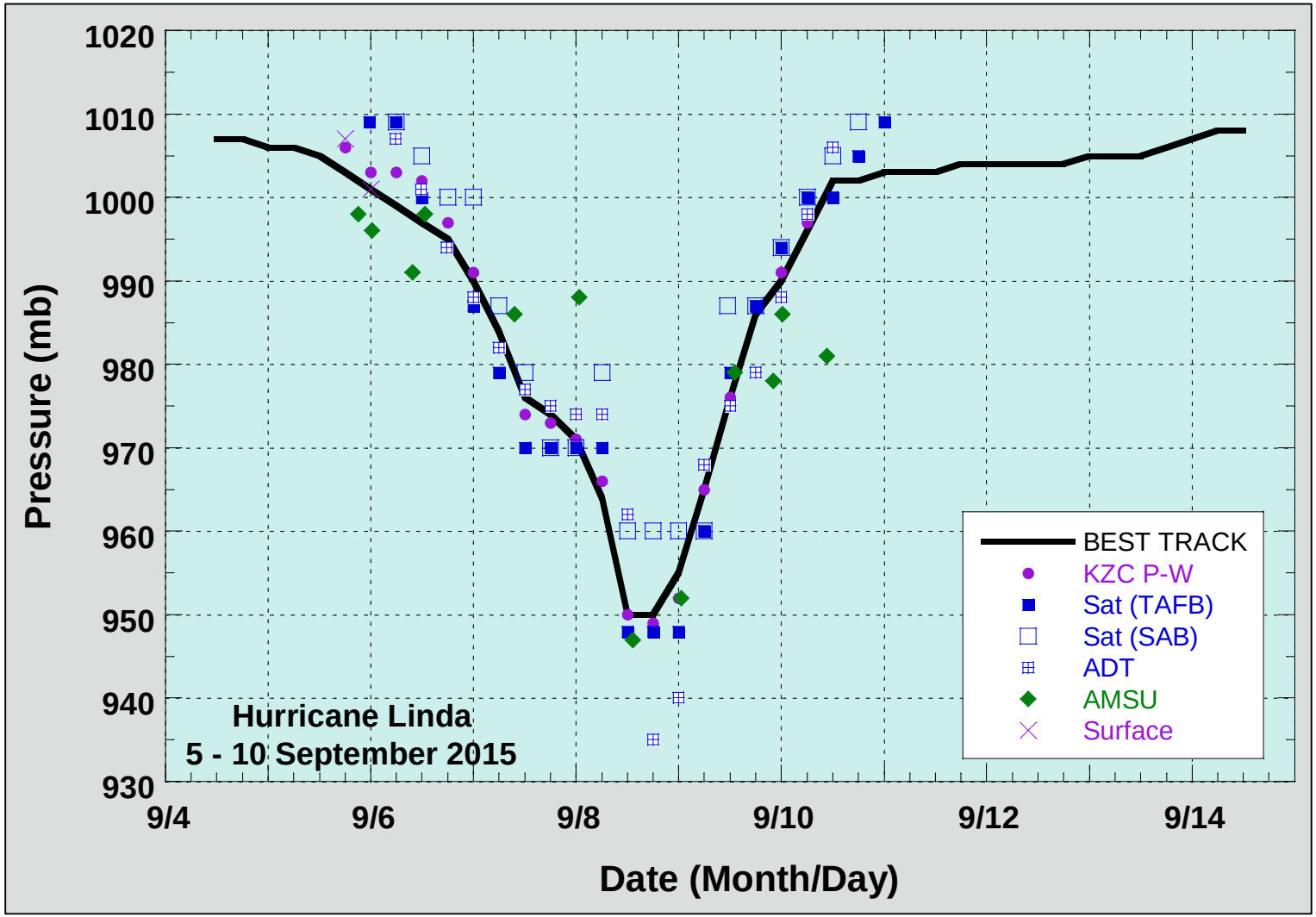


Figure 3. Selected pressure observations and best track minimum central pressure curve for Hurricane Linda, 5-10 September 2015. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. AMSU intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies technique. KZC P-W refers to pressure estimates derived using the Knaff-Zehr-Courtney pressure-wind relationship. Dashed vertical lines correspond to 0000 UTC.

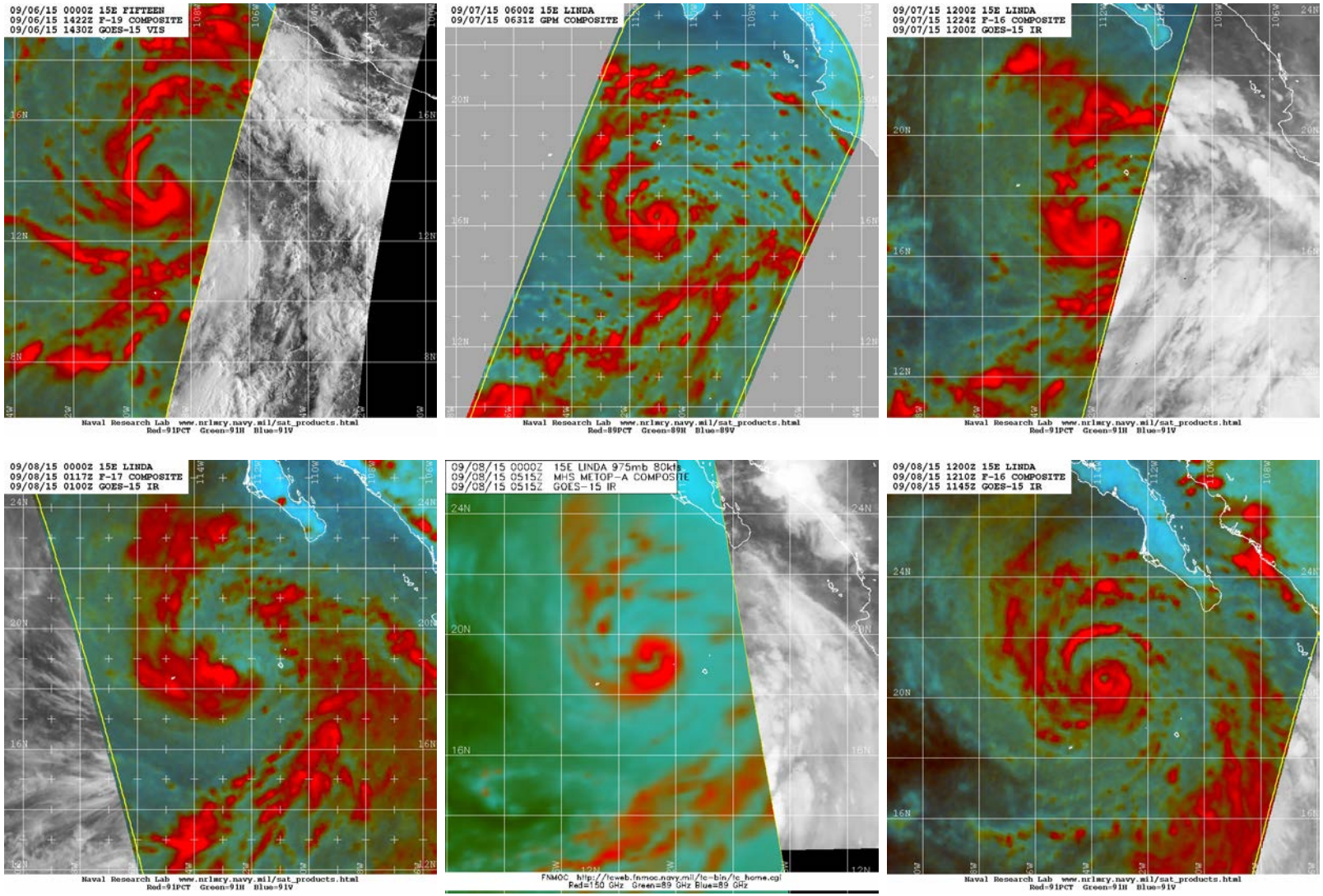


Figure 4. Composite 85- to 91-GHz microwave satellite images showing the evolution of Linda's inner-core structure between 1422 UTC 6 September (top left) and 1210 UTC 8 September (bottom right). Linda's intensification was briefly interrupted late on 7 September (bottom left). However, an eye quickly returned and Linda reached its peak intensity around 1200 UTC 8 September (bottom right). Images courtesy of the Naval Research Laboratory.