Tropical Cyclone Report
Tropical Storm Arlene
(AL012011)
28 June – 1 July 2011

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National Hurricane Center
Updated for death toll 8 August 2012

Arlene was a tropical storm over the southwestern Gulf of Mexico that made landfall along the coast of Mexico in the state of Veracruz.

a. Synoptic History

Arlene formed from a tropical wave that emerged from the coast of Africa on 13 June. The wave moved westward with little distinction until it reached the western Caribbean Sea on 25 June, when the associated shower activity increased as the wave interacted with an upper-level trough. Little change in organization occurred the next day as the wave crossed Central America and the Yucatan Peninsula of Mexico. As the wave moved into the Bay of Campeche on 27 June, a broad area of low pressure formed. The wind circulation became better defined on 28 June, accompanied by a slight increase in the convective organization. An Air Force Reserve Hurricane Hunter aircraft investigated the system on the afternoon of 28 June and found tropical-storm-force winds to the north of the center of the low. Based on this, it is estimated that the low developed into a tropical storm near 1800 UTC 28 June about 260 n mi east-southeast of Tampico, Mexico. The "best track" chart of Arlene'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].

Arlene moved unsteadily west-northwestward until it turned westward early on 30 June. Little change in strength occurred during the first 12 h after genesis. Steady development occurred after that, and the maximum sustained winds reached an estimated peak intensity of 55 kt as the center of storm made landfall near Cabo Rojo, Mexico around 1300 UTC 30 June. Arlene turned west-southwestward and weakened after landfall, and the cyclone dissipated over the mountains of Central Mexico early on 1 July.

b. Meteorological Statistics

Observations in Arlene (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 Dvorak estimates from the Cooperative Institute for Meteorological Satellite Studies/University of Wisconsin-Madison. Observations also include

[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.

flight-level and Stepped-Frequency Microwave Radiometer (SFMR) observations from flights of the 53rd Weather Reconnaissance Squadron of the U. S. Air Force Reserve Command. Data and imagery from NOAA polar-orbiting satellites (including the Advanced Microwave Sounding Unit), the NASA Tropical Rainfall Measuring Mission (TRMM) and Aqua, 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 Arlene.

The 53rd Weather Reconnaissance Squadron made three flights into Arlene. The maximum flight-level winds at 1500 ft were 64 kt at 2027 UTC 29 June. There was an estimate of 66 kt surface winds from the SFMR a few minutes later, however, this estimate was accompanied by high rainfall rates and its reliability is suspect. The minimum pressure reported by the aircraft was 996 mb on two occasions on 29 June.

An automated station at Isla Lobos, Mexico (just east of Cabo Rojo) reported sustained winds of 36 kt and a peak gust of 48 kt at 1115 UTC 30 June. The station also reported a minimum pressure of 993.1 mb at 1015 UTC that day, although comparison with nearby stations in non-storm periods suggests this value may be 1-3 mb too low.

NOAA buoy 42055 near 22.2N 94.0W reported 1-min mean winds of 37 kt and a peak wind gust of 41 kt at 1809 UTC 29 June. The buoy also reported a minimum pressure of 1003.9 mb at 1144 UTC that day. There were no other marine observations of tropical-storm-force winds.

Arlene brought heavy rain to eastern Mexico. While comprehensive storm totals are not available, data from the National Meteorological Service of Mexico shows widespread daily rainfall totals in excess of 6 inches for 29-30 June and 30 June – 1 July. Tamesi, in the state of Tamaulipas, reported 13.73 inches of rain in 24 h from 30 June – 1 July. Locally heavy rains also occurred over extreme southern Texas.

Although the center of Arlene stayed well south of the United States, an outer rain band spawned an EF-1 tornado near Hidalgo, Texas on 30 June.

Aircraft, satellite, and surface data indicate that Arlene never became a classically-organized tropical cyclone. Aircraft data on 28-29 June showed that the system had an elongated central area of light winds, and this feature possibly contributed to the somewhat erratic forward speed. In addition, microwave satellite imagery at 1242 UTC 30 June (Figure 4) showed that the mid-level eye seen in 91 GHz data was over land some 35 n mi south-southwest of the over-water low-level center seen in 37 GHz data. The low-level center position was confirmed by the data from the Mexican station at Isla Lobos, which reported westerly winds as the center passed to the north.

c. Casualty and Damage Statistics

The National Meteorological Service of Mexico reports that Arlene caused 22 deaths in Mexico. Most of the deaths seem to have been due to freshwater floods and mudslides in eastern

Mexico. However, it is unclear from the available data how many of the deaths were directly due to the effects of the storm. One death reported by the media was clearly indirect - an electrocution due to the touching of a downed power line.

The floods and mudslides in Mexico likely caused property damage, although no monetary estimates are available, however. There are also no estimates of the numbers of structures damaged. The Texas tornado caused minor damage.

d. Forecast and Warning Critique

The genesis of Arlene was generally well forecast. The precursor disturbance was first mentioned in the Tropical Weather Outlook about 72 h before genesis occurred, at which time it was given a low chance (less than 30%) of development. This was subsequently raised to a medium chance (30-50%) about 24 h before genesis. However, the chance of development was not raised to a high chance (greater than 50%) until the time of genesis.

A verification of NHC official track forecasts for Arlene is given in Table 2. Official forecast (OFCL) track errors were lower than the mean official errors for the previous 5-yr period, and lower than those of the corresponding climatology/persistence forecasts (OCD5). It is noted that the number of forecasts is small even at 12 h. The official track forecasts caught the general direction of Arlene's motion very well, although the erratic forward speeds caused some along-track errors.

A verification of NHC official intensity forecasts for Arlene is given in Table 3. Official forecast intensity errors were also lower than the mean official errors for the previous 5-yr period. The errors were also lower than those of the corresponding climatology/persistence forecasts at 12, 24, and 48 h, but slightly larger than the climatology/persistence forecast error at 36 h. Once again, the number of forecasts is small.

Watches and warnings associated with Arlene are given in Table 4.

Acknowledgements

The National Meteorological Service of Mexico provided the data on Arlene's rainfall in Mexico. The National Weather Service Forecast Office in Brownsville, Texas provided the information on the Hidalgo tornado.

Table 1. Best track for Tropical Storm Arlene, 28 June – 1 July 2011.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
28 / 0600	19.9	92.8	1007	25	low
28 / 1200	20.3	93.1	1006	30	"
28 / 1800	20.7	93.5	1006	35	tropical storm
29 / 0000	21.0	93.9	1005	35	"
29 / 0600	21.2	94.5	1003	35	"
29 / 1200	21.3	95.3	1000	45	"
29 / 1800	21.4	95.6	998	50	"
30 / 0000	21.6	96.1	996	50	"
30 / 0600	21.6	97.0	994	55	"
30 / 1200	21.6	97.3	993	55	"
30 / 1800	21.5	98.1	998	45	"
01 / 0000	21.1	98.7	1002	30	tropical depression
01 / 0600					dissipated
30 / 1300	21.6	97.4	993	55	Landfall near Cabo Rojo, Mexico
30 / 1200	21.6	97.3	993	55	minimum pressure and maximum winds

Table 2. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Tropical Storm Arlene, 28 June – 1 July 2011. Mean errors for the 5-yr period 2006-10 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	**28.8**	**31.7**	**20.6**	**34.2**			
OCD5	32.3	58.1	107.3	154.5			
Forecasts	8	6	4	2			
(AL) OFCL (2006-10)	31.0	50.6	69.9	89.5	133.2	174.2	214.8
(AL) OCD5 (2006-10)	47.7	98.3	156.4	218.1	323.3	402.2	476.1

Table 3. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) intensity forecast errors (kt) for Tropical Storm Arlene, 28 June – 1 July 2011. Mean errors for the 5-yr period 2006-10 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	**4.4**	**6.7**	**5.0**	**5.0**			
OCD5	3.9	10.2	2.5	19.0			
Forecasts	8	6	4	2			
(AL) OFCL (2006-10)	7.2	11.0	13.2	15.1	17.2	17.9	18.7
(AL) OCD5 (2006-10)	8.5	12.3	15.4	17.8	20.2	21.9	21.7

Table 4. Watch and warning summary for Tropical Storm Arlene, 28 June – 1 July 2011.

Date/Time (UTC)	Action	Location
29 / 0000	Tropical Storm Warning issued	Barra de Nautla to Bahia Algodones
29 / 1500	Hurricane Watch issued	Tuxpan to La Cruz
29 / 1800	Hurricane Watch modified to	Barra de Nautla to La Cruz
29 / 1800	Tropical Storm Warning discontinued	La Pesca to Bahia Algodones
29 / 1800	Tropical Storm Warning issued	Barra de Nautla to Palma Sola
29 / 2230	Hurricane Warning issued	Barra de Nautla to La Cruz
29 / 2230	Tropical Storm Warning modified to	Palma Solo to Barra de Nautla and La Cruz to La Pesca
30 / 0000	Tropical Storm Warning issued	Veracruz to Palma Sola
30 / 1500	Hurricane Warning discontinued	All
30 / 1500	Tropical Storm Warning discontinued	Veracruz to Barra de Nautla
30 / 1500	Tropical Storm Warning modified to	La Pesca to Palma Sola
30 / 2100	Tropical Storm Warning discontinued	North of Tampico and south of Barra de Nautla
1 / 0000	Tropical Storm Warning discontinued	All

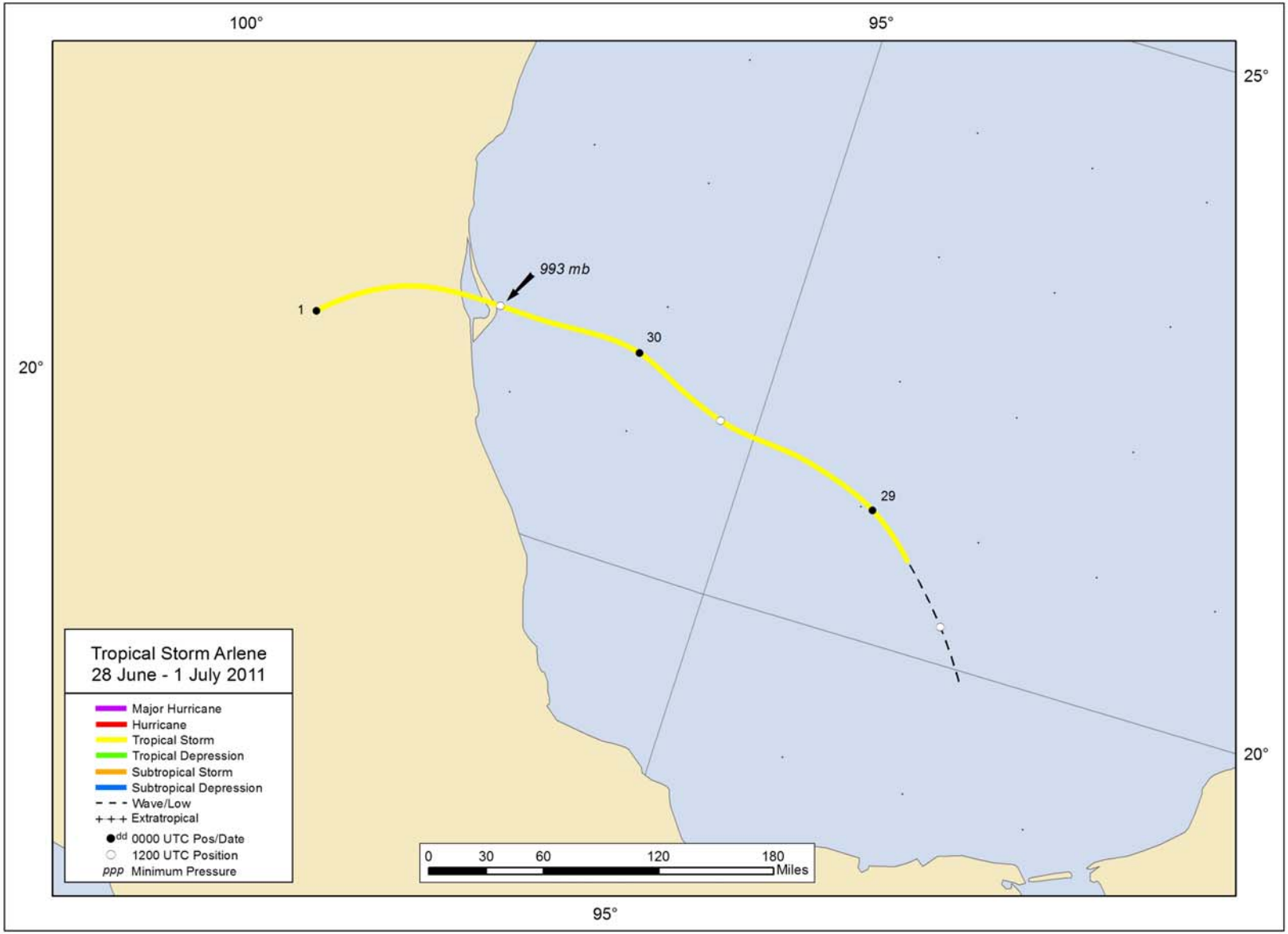

Figure 1. Best track positions for Tropical Storm Arlene, 28 June – 1 July 2011.

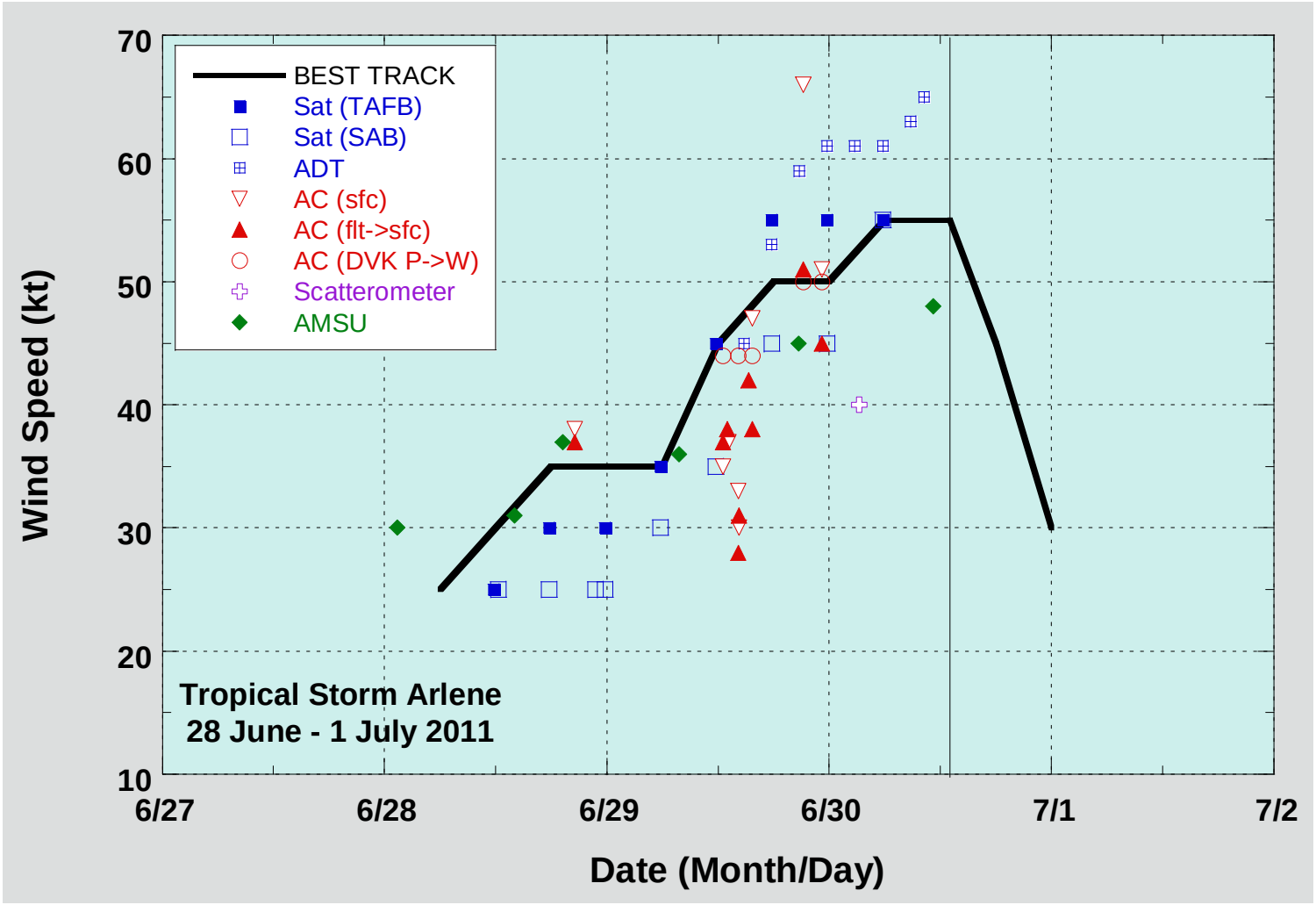

Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Tropical Storm Arlene, 28 June – 1 July 2011. Aircraft observations have been adjusted for elevation using 90%, 80%, and 80% adjustment factors for observations from 700 mb, 850 mb, and 1500 ft, respectively. Advanced Dvorak Technique estimates represent linear averages over a three-hour period centered on the nominal observation time. AMSU intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies technique. Dashed vertical lines correspond to 0000 UTC. Solid vertical black line denotes landfall.

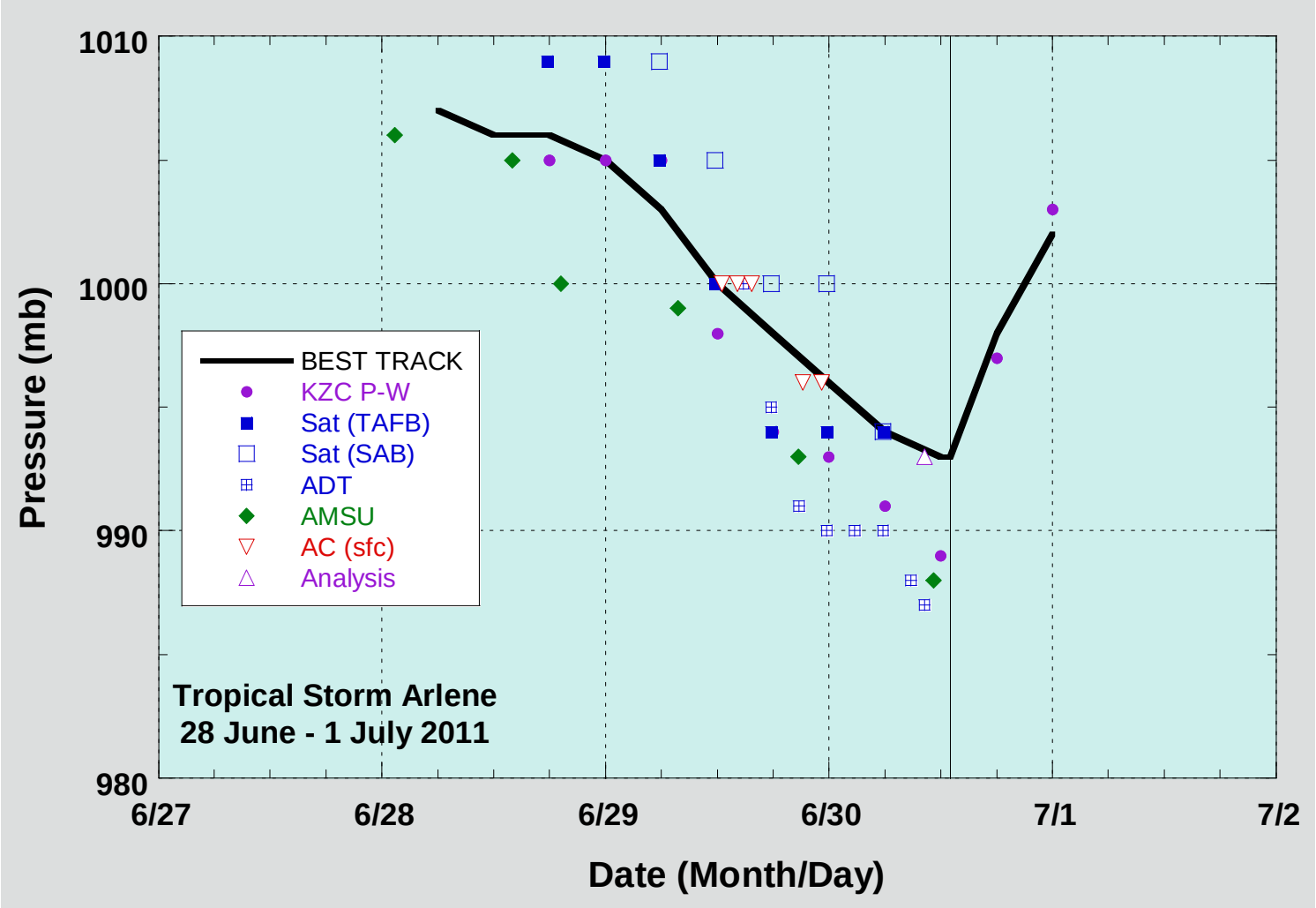

Figure 3. Selected pressure observations and best track minimum central pressure curve for Tropical Storm Arlene, 28 June – 1 July 2011. Advanced Dvorak Technique estimates represent linear averages over a three-hour period centered on the nominal observation time. AMSU intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies technique. Dashed vertical lines correspond to 0000 UTC. Solid vertical black line denotes landfall.

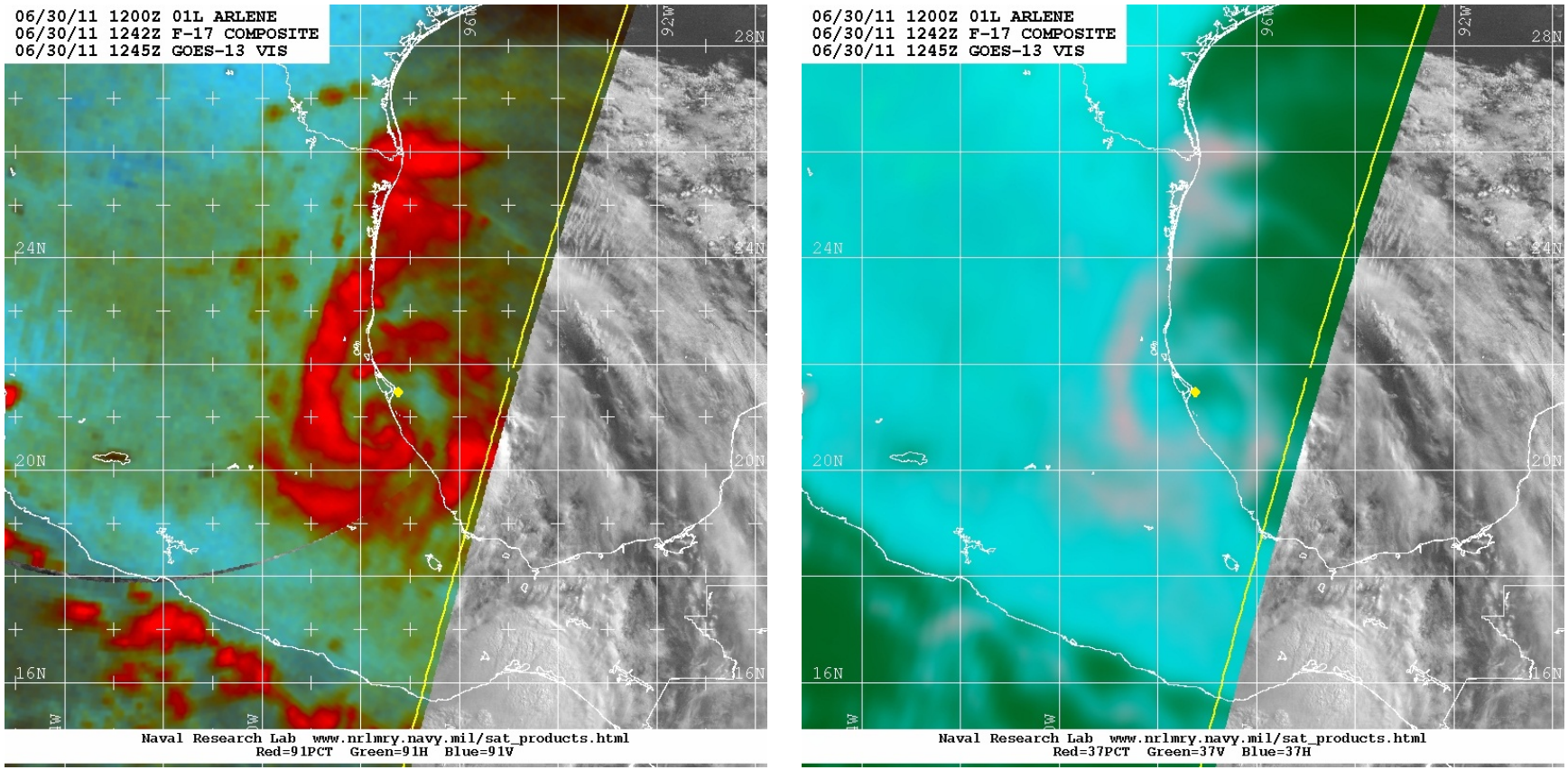

Figure 4. DMSP F-17 SSM/IS microwave images for Tropical Storm Arlene at 1242 UTC 30 June 2011. A 91 GHz composite image is on the left while a 37 GHz composite image is on the right. Small yellow dot is the position of the Isla Lobos, Mexico weather station. Images courtesy of the Naval Research Laboratory, Monterey, CA.