NATIONAL HURRICANE CENTER ANNUAL SUMMARY

2014 EASTERN PACIFIC HURRICANE SEASON

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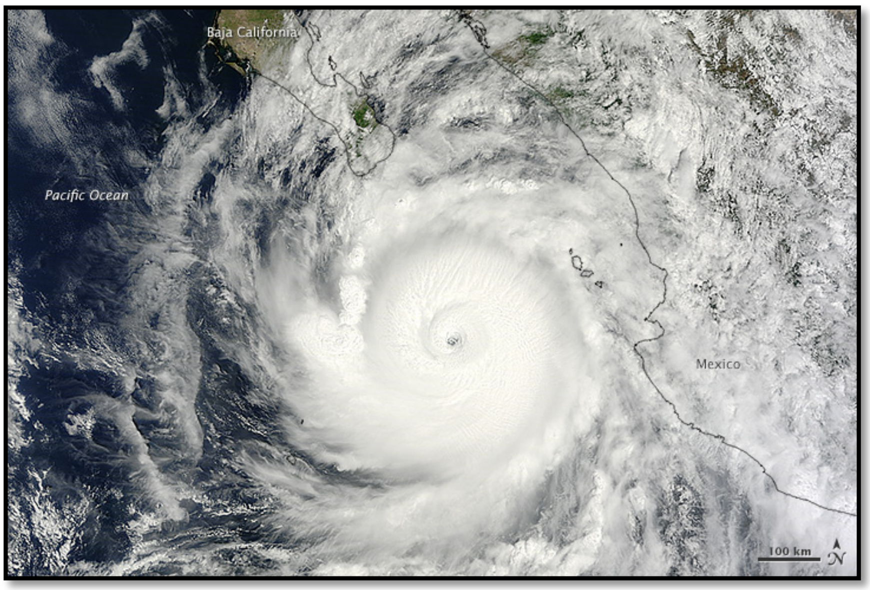
15 April 2015[1]



NASA MODIS IMAGE OF MAJOR HURRICANE ODILE AROUND 1800 UTC 14 SEPTEMBER 2014.

ABSTRACT

Tropical cyclone activity during the 2014 eastern North Pacific hurricane season was well above normal, and by several measures was the highest since the early 1990s. Of the 20 tropical storms that formed, 14 became hurricanes, and 8 reached major hurricane strength (category 3 or higher on the Saffir-Simpson Hurricane Wind Scale). The hurricane total was tied for the second highest on record for the basin, and the number of major hurricanes ties the previous record. For comparison, the 1981-2010 seasonal averages are 15 tropical storms, 8 hurricanes and 4 major hurricanes. The Accumulated Cyclone Energy (ACE) index, a measure that takes into account both the strength and duration of the season's tropical storms and hurricanes, was 162% of the long-term median value.

Mexico was affected by several tropical cyclones. Hurricane Odile devastated portions of the Baja California peninsula, making landfall as a major hurricane near Cabo San Lucas, the first in that region in 25 years. Hurricanes Marie, Norbert, and Simon passed southwest of the Baja California peninsula but produced

[1] Updated 2 May 2016 to reflect final best track information for Hurricane Genevieve.

significant impacts from western Mexico to southern California. Tropical Storms Boris and Trudy brought flooding rains to southeastern Mexico and portions of Guatemala, causing some loss of life.

OVERVIEW

The 2014 eastern North Pacific hurricane season was well above normal in activity. Twenty tropical storms formed, 14 of which became hurricanes and 8 of which reached major hurricane strength (category 3 or higher on the Saffir-Simpson Hurricane Wind Scale) within the basin[2]. These numbers were all above the long-term (1981-2010) averages of 15 tropical storms, 8 hurricanes, and 4 major hurricanes. In fact, the 14 hurricanes ties 1992 as the second highest on record for the basin during the satellite era, and the number of major hurricanes ties the previous record set three other times (in 1983, 1992, and 1993). One tropical depression that did not reach tropical storm strength also formed during the season. The Accumulated Cyclone Energy (ACE) index (Bell et al. 2000), a measure that accounts for the frequency, intensity, and duration of the season's cyclones, was 162.8×10^4 kt^2 for the 2014 season, which is about 162% of the long-term (1981-2010) median value of 100.4×10^4 kt^2. Figures 1a, 1b, and 1c show the

[2] Genevieve reached hurricane and major hurricane strength while in the Central Pacific Hurricane Center area of responsibility, so it does not contribute to the numbers of hurricanes and major hurricanes in the eastern North Pacific basin.

tracks of the 2014 eastern North Pacific tropical storms and hurricanes, and Table 1 lists basic statistics for each cyclone.

Oceanic conditions were unusually conducive for tropical cyclone development and intensification during the 2014 hurricane season. Sea surface temperatures were at or above normal over the entire eastern North Pacific basin and averaged 29°C or warmer off the coast of Mexico as far north as the southern tip of the Baja California peninsula (Fig. 2). Waters were 1.5°C to 2.5°C warmer than normal along the west coast of the Baja California peninsula, likely due to weaker-than-normal coastal upwelling. Sea level pressures west of California were 1.5 mb to 2.0 mb lower than normal (Fig. 3), which effectively decreased the pressure gradient and northwesterly surface winds that typically exist along the west coast of the Baja California peninsula. The lighter winds thus limited the amount of upwelling that occurred.

Atmospheric conditions were also generally favorable for tropical cyclone development and strengthening. Vertical wind shear was lower than average in the western part of the basin (west of 120°W) and generally near normal in the eastern part of the basin (not shown). In addition, upper-level divergence was stronger than normal, especially within the deep tropics, which supported the development of deep convection. Deep convection was also supported by plenty of ambient moisture, with total precipitable water near or above normal over the entire eastern North Pacific Ocean (Fig. 4). Southerly flow feeding into developing disturbances and tropical cyclones supplied copious amounts of moisture, with mean precipitable water anomalies running as much as 7 mm above normal in the equatorial region.

The season's tropical cyclones took tracks that were climatological for the time of year in which they developed. In May and June, a mean mid-tropospheric high was centered over northwestern Mexico and the southern Baja California peninsula, with a ridge axis extending westward to about 125°W (Fig. 5a). The cyclones that formed in May and June all developed and stayed within the eastern part of the basin, either moving slowly in weak steering currents south of the ridge or being steered northwestward and dissipating over cold water southwest of the Baja California peninsula. By July and August, the mid-tropospheric high had shifted northward and strengthened over the southwestern United States, with ridging extending west-southwestward toward the Hawaiian Islands (Fig. 5b). As a result, the July and August cyclones had longer tracks in the deep tropics, with Genevieve, Iselle, and Julio venturing west of 140°W into the Central Pacific Hurricane Center area of responsibility. A weak mid-level high became established over central Mexico in September and October while a break developed in the ridge between 120°W and 135°W (Fig. 5c). The late-season cyclones, therefore, moved northwestward near and just offshore the Pacific coast of Mexico, with Odile moving up the spine of the Baja California peninsula in mid-September.

Twenty-seven people are known to have lost their lives in Mexico and the United States as a direct[3] result of the season's tropical cyclones. Hurricane Odile was the most deadly cyclone, taking the lives of 11 people in Mexico. It was also the most destructive tropical cyclone, with

[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.

preliminary estimated losses around 12 billion Mexico pesos (~1 billion USD). In addition to Odile's deaths, four people died from Marie, three from Norbert, two from Polo, and seven from Trudy. Large waves from Marie caused an estimated 20 million USD in damages along the coast of southern California.

SELECTED STORM SUMMARIES

This section highlights the most significant cyclones of the 2014 eastern North Pacific hurricane season. More detailed information on these storms, as well as information on the other tropical cyclones of 2014, can be found at http://www.nhc.noaa.gov/2014epac.shtml.

Hurricane Marie

Marie was the strongest hurricane of the season and the only one to reach category 5 strength over the eastern North Pacific basin[4]. It was the first category 5 hurricane in the basin since Celia of 2010. Marie developed from a tropical wave that crossed the coast of Africa and entered the eastern tropical Atlantic on 10 August. The wave crossed Central America around 19 August and subsequently moved into an environment in the eastern North Pacific that was conducive for development. Widespread convection led to the development of a large but disorganized area of low pressure by early 20 August. Deep convection gradually became better organized during the next two days, resulting in the development of curved bands of showers and thunderstorms late on 21 August. A well-defined low-level circulation became apparent around 0000 UTC 22 August, marking the formation of a tropical depression centered about 320 n mi south-southeast of Acapulco, Mexico.

The newly formed depression remained embedded within a very favorable environment of low vertical wind shear, high moisture, and sea surface temperatures (SSTs) near 30°C. This led to a remarkable 66-h period of rapid intensification between 0000 UTC 22 August and 1800 UTC 24 August, during which the intensity increased by an estimated 110 kt. Marie strengthened by 60 kt during the final 24 h of this period, reaching an estimated peak intensity of 140 kt around 1800 UTC 24 August, while centered about 500 n mi south-southwest of Cabo San Lucas, Mexico (Fig. 6).

An eyewall replacement that began on 24 August ended the rapid intensification and induced a steady weakening trend. Marie developed concentric eyewalls on 25 and 26 August, which likely led to the weakening of the cyclone during that time. By late on 26 August, the inner eyewall began to open up in the northeast quadrant, indicative of further weakening. In addition, Marie began moving toward much lower SSTs and into a more stable thermodynamic environment. By 1800 UTC 27 August, Marie weakened to tropical storm intensity, and the inner core became devoid of deep convection shortly thereafter. Although shower activity persisted in bands over the southern portions of the circulation for another day, by 1800 UTC 29 August the

[4] Marie and Genevieve both reached category 5 status with estimated 140 kt sustained winds, but Genevieve did so as a supertyphoon over the western North Pacific just west of the International Date Line.

system lacked sufficient deep convection to be classified as a tropical cyclone. On 30 August the remnant low became embedded within weaker low-level easterly flow and slowed considerably while spinning down over the course of several days. A well-defined low-level center was no longer present after 0600 UTC 2 September.

Marie is believed to have caused four direct deaths. Although Marie remained well offshore, large swells generated by the hurricane affected portions of the Mexican and southern California coastlines for several days (Fig. 7). In Malibu, California, a surfer drowned in the high surf. In Mexico, a vessel with seven fishermen aboard capsized when it was hit by high waves near Cabo San Lucas. Although four of the fishermen were able to swim to shore, three went missing and are presumed to have drowned.

In the United States, damage totaled close to $20 million. Media reports indicated that nearly $16 million in damage occurred in and around the Port of Long Beach, where waves breached a major breakwater in multiple locations. Catalina Island was estimated to have sustained at least $3 million in damage. In addition, waves of 10 to 15 feet damaged boatyards and caused the shutdown of the Malibu Pier after several pilings were damaged. Figure 8 shows some examples of the large waves along the coast of southern California and the resulting damage. Elsewhere, mid- and high-level moisture advected northward by Marie contributed to heavy rains, flooding, and mud slides in several Mexican states.

Hurricane Odile

Odile made landfall on the southern tip of the Baja California peninsula as a category 3 hurricane—the first major hurricane to strike the region in 25 years. Odile is tied with Hurricane Olivia of 1967 as the strongest landfalling hurricane on the Baja California peninsula in the historical record.

Odile began from a tropical wave that moved off of the west coast of Africa on 28 August. The wave moved into the eastern Pacific on 4 September, and a surface low pressure area eventually formed around 0000 UTC 9 September about 230 n mi south-southeast of Acapulco, Mexico. The low became better defined that day while deep convection increased further and became better organized, resulting in the formation of a tropical depression about 200 n mi southeast of Acapulco by 0000 UTC 10 September. The depression strengthened into a tropical storm 6 h later.

Moderate to strong northeasterly to northerly vertical wind shear limited the pace of intensification for awhile, but Odile was able to reach hurricane strength by 0600 UTC 13 September, when it was centered about 200 n mi south-southwest of Manzanillo. On 14 September, Odile accelerated north-northwestward toward the Baja California peninsula. Rapid intensification coincided with the acceleration, and the tropical cyclone strengthened from an estimated 65 kt at 0600 UTC 13 September to its peak intensity of 120 kt 24 h later.

Odile developed concentric eyewalls by 14 September (Fig. 9), and by the time an Air Force Reserve Hurricane Hunter aircraft investigated the hurricane around 1900 UTC, the maximum sustained winds were estimated to have decreased to 110 kt. Data from the aircraft also indicated an expansion of the wind field, with the tropical-storm-force wind radii nearly doubling in size over the 36 h that Odile had been a hurricane. Odile made landfall with 110-kt winds (category 3 on the Saffir-Simpson Hurricane Wind Scale) on the southern tip of the Baja California peninsula at 0445 UTC 15 September, just to the east of Cabo San Lucas. The Cabo San Lucas International Airport reported a maximum 1-min sustained wind of 78 kt with a gust to 101 kt, while a 108-kt gust was measured farther north at Bahía de Loreto.

The cyclone moved north-northwestward over Baja California Sur throughout the day and slowly weakened. Due to gradually increasing southwesterly shear and the cyclone's passage over more rugged terrain, Odile weakened to a tropical storm around 0600 UTC 16 September while centered about 25 n mi south-southwest of Santa Rosalía in northeastern Baja California Sur. The weakening tropical storm turned northward and then northeastward on 16 and 17 September, in response to an approaching mid-latitude trough, and entered the northern Gulf of California. Odile then moved inland over the northern part of the Mexican state of Sonora and weakened to a tropical depression. The depression dissipated by 0600 UTC 18 September over the high terrain of the northern Sierra Madre Occidental mountain range.

Odile was the most destructive hurricane on the Baja California peninsula in the historical record. The hurricane caused widespread destruction in Baja California Sur, toppling trees and power lines, causing severe structural damage to buildings and homes, as well as badly damaging the electrical infrastructure of the region. Some of the worst destruction occurred to luxury high-rise condominiums in Cabo San Lucas, where storm surge and wind gutted many of these buildings. Heavy rains and flooding occurred along the Baja California peninsula and in portions of northwestern Mexico, washing out bridges and inundating several primary roadways. Over 90% of the population of Baja California Sur was left without electricity, and many of the state's rural communities became completely isolated. Some residents in the state lost everything they owned. Media accounts indicated 11 direct deaths related to Odile. The total damage is estimated to be 12 billion pesos (~1 billion USD). Figure 10 provides some examples of damage caused by Odile around the Cabo San Lucas area.

The remnants of Odile also brought heavy rains to portions of the southwestern and south-central United States, with 5 to 10 inches of rain occurring across extreme southeastern Arizona, southern New Mexico, and western Texas. Over 15 inches of rain was reported in Gail, Texas, and more than 10 inches was measured in Carlsbad, New Mexico. Two deaths were reported in Texas and New Mexico as a result of flash flooding from Odile's remnants.

FORECAST VERIFICATION

There were 439 official forecasts issued in the eastern North Pacific basin in 2014, although only 136 of these verified at 120 h. This level of forecast activity was considerably above average. Records for track accuracy were set from 12 to 72 h in 2014. The official forecast was very skillful, but it was outperformed by the Florida State Superensemble (FSSE) and the multi-model consensus (TVCE) at all times. The European Centre for Medium-range Weather Forecasting Model (EMXI) was the best individual model, which also beat the official forecast at 96 and 120 h, but it had a little less skill than TVCE and FSSE. The NWS/Global Forecast System (GFSI), the NWS/Global Ensemble Forecast System mean (AEMI), and the NWS/Hurricane

Weather Research and Forecasting Model (HWFI) performed fairly well and made up the second tier of models.

For intensity, the official forecast errors in the eastern North Pacific basin were slightly lower than the 5-yr means at most times. Climatology and persistence (Decay-SHIFOR) errors in 2014 were similar to their 5-yr means at most forecast times, indicating the season's storms were about of average difficulty to predict. The official forecast was as good as or better than all of the guidance early, but it was outperformed by the intensity consensus aid IVCN at 72 h and beyond. HWFI was a good performer for all lead times, while the NWS/Geophysical Fluid Dynamics Laboratory Model (GHMI) showed increased skill at the longer forecast times. The Statistical Hurricane Intensity Prediction Scheme model (DSHP) and the Logistic Growth Equation Model (LGEM) were skillful as well, except at 120 h. All of the guidance and the official forecast had a low bias in 2014.

A total of 716 quantitative probabilistic forecasts of tropical cyclogenesis were issued for the eastern North Pacific basin for the 48- and 120-h forecast periods, expressed in 10% increments and in terms of categories ("low", "medium", or "high"). A slight under-forecast bias was present at most ranges in the 48- and 120-h probabilistic forecasts.

Acknowledgments

The cyclone summaries are based on Tropical Cyclone Reports written by the author and Lixion Avila, John L. Beven II, Eric Blake, Daniel Brown, John Cangialosi, Todd Kimberlain, Christopher Landsea, Richard Pasch, Stacy Stewart, and David Zelinsky. These reports are available online at http://www.nhc.noaa.gov/2014epac.shtml. The verification summary is based on the annual verification report written by John Cangialosi and available online at http://www.nhc.noaa.gov/verification/pdfs/Verification_2014.pdf.

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Table 1. 2014 Eastern Pacific hurricane season statistics.

Storm Name	Class[a]	Dates[b]	Max. Winds (kt)	Min. Pressure (mb)	Direct Deaths	U.S. Damage ($million)
Amanda	MH	May 22 – 29	135	932		
Boris	TS	June 2 – 4	40	998		
Cristina	MH	June 9 – 15	130	935		
Douglas	TS	June 28 – July 5	45	999		
Elida	TS	June 30 – July 2	45	1002		
Fausto	TS	July 7 – 9	40	1004		
Genevieve	MH	July 25 – August 13	140[c]	918[c]		
Hernan	H	July 26 – 29	65	992		
Iselle	MH	July 31 – August 9	120	947		
Julio	MH	August 4 – 15	105	960		
Karina	H	August 13 – 26	75	983		
Lowell	H	August 17 – 24	65	980		
Marie	MH	August 22 – 28	140	918	4	20
Norbert	MH	September 2 – 8	110	950	3	
Odile	MH	September 10 – 18	120	918	11	
Sixteen-E	TD	September 11 – 15	30	1005		
Polo	H	September 16 – 22	65	979	2	
Rachel	H	September 24 – 30	75	980		
Simon	MH	October 1 – 7	115	946		
Trudy	TS	October 17 – 19	55	998	7	
Vance	H	October 30 – November 5	95	964		

[a] TD - tropical depression maximum sustained winds 33 kt or less; TS - tropical storm, winds 34-63 kt; H - hurricane, winds 64-95 kt; MH - major hurricane, winds 96 kt or higher.

[b] Dates based on UTC time and include tropical depression stage

[c] Peak intensity and minimum pressure reached outside of the eastern North Pacific hurricane basin

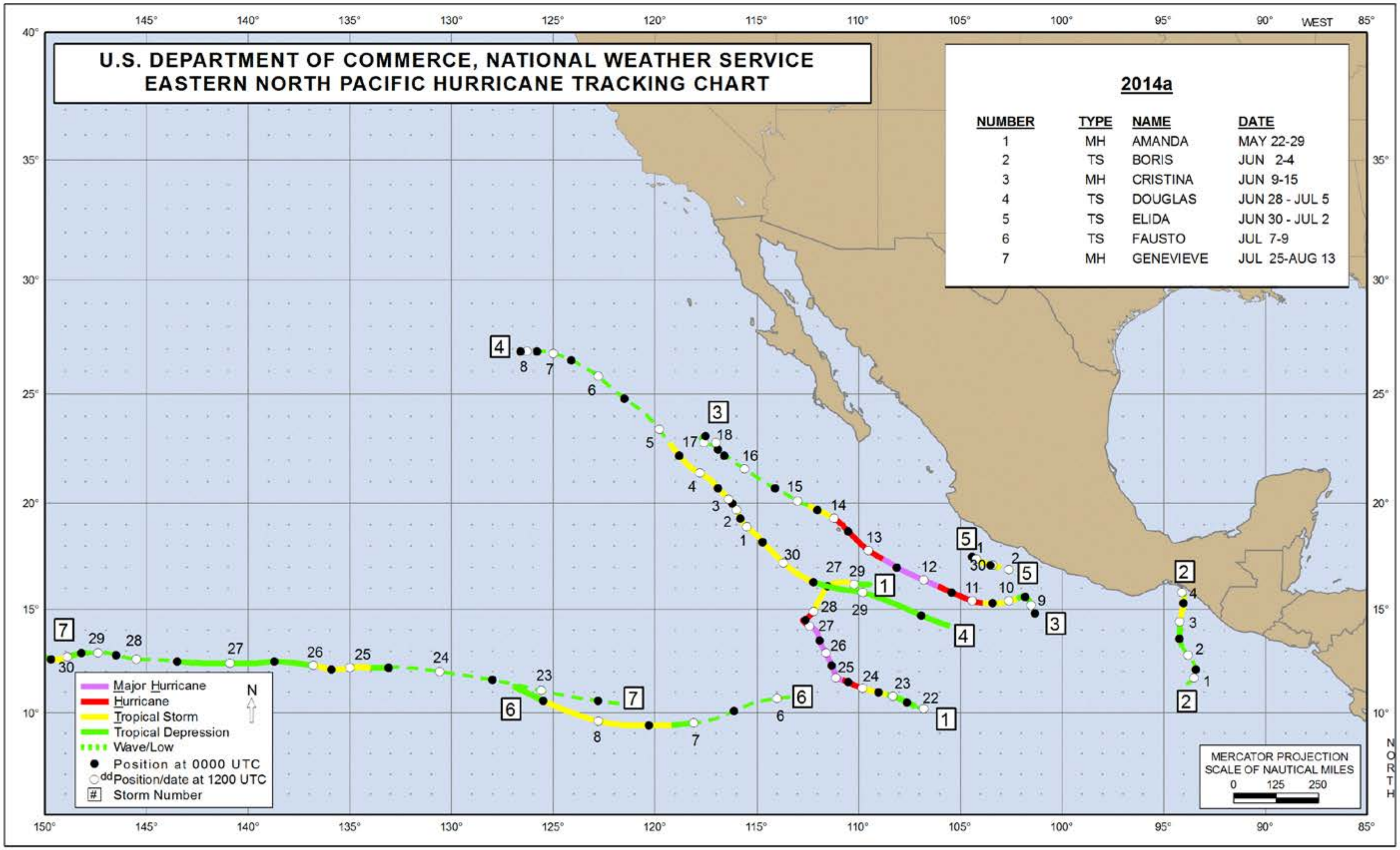

Figure 1a. Tracks of 2014 eastern North Pacific tropical storms and hurricanes from Amanda to Genevieve.

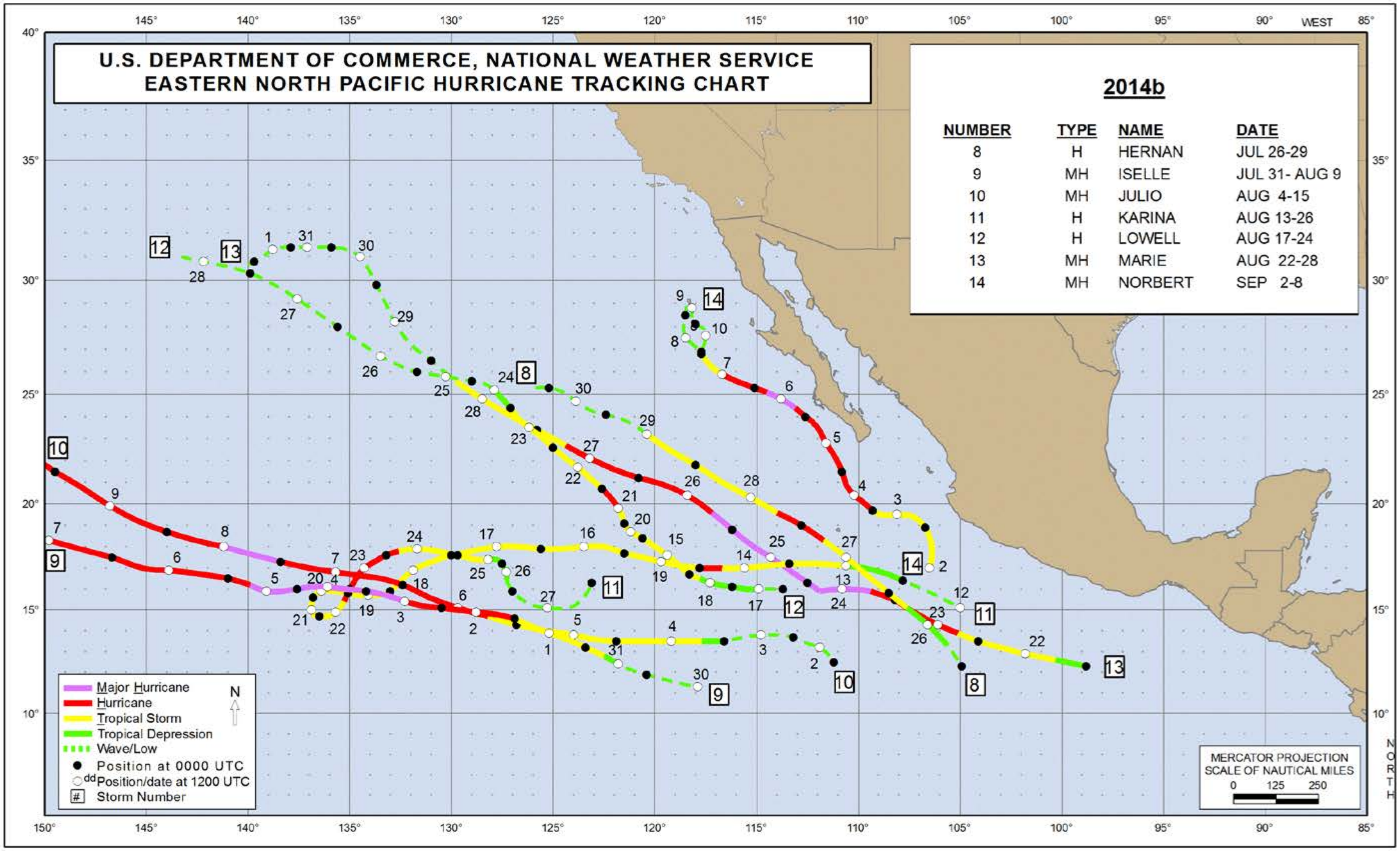

Figure 1b. Tracks of 2014 eastern North Pacific tropical storms and hurricanes from Hernan to Norbert.

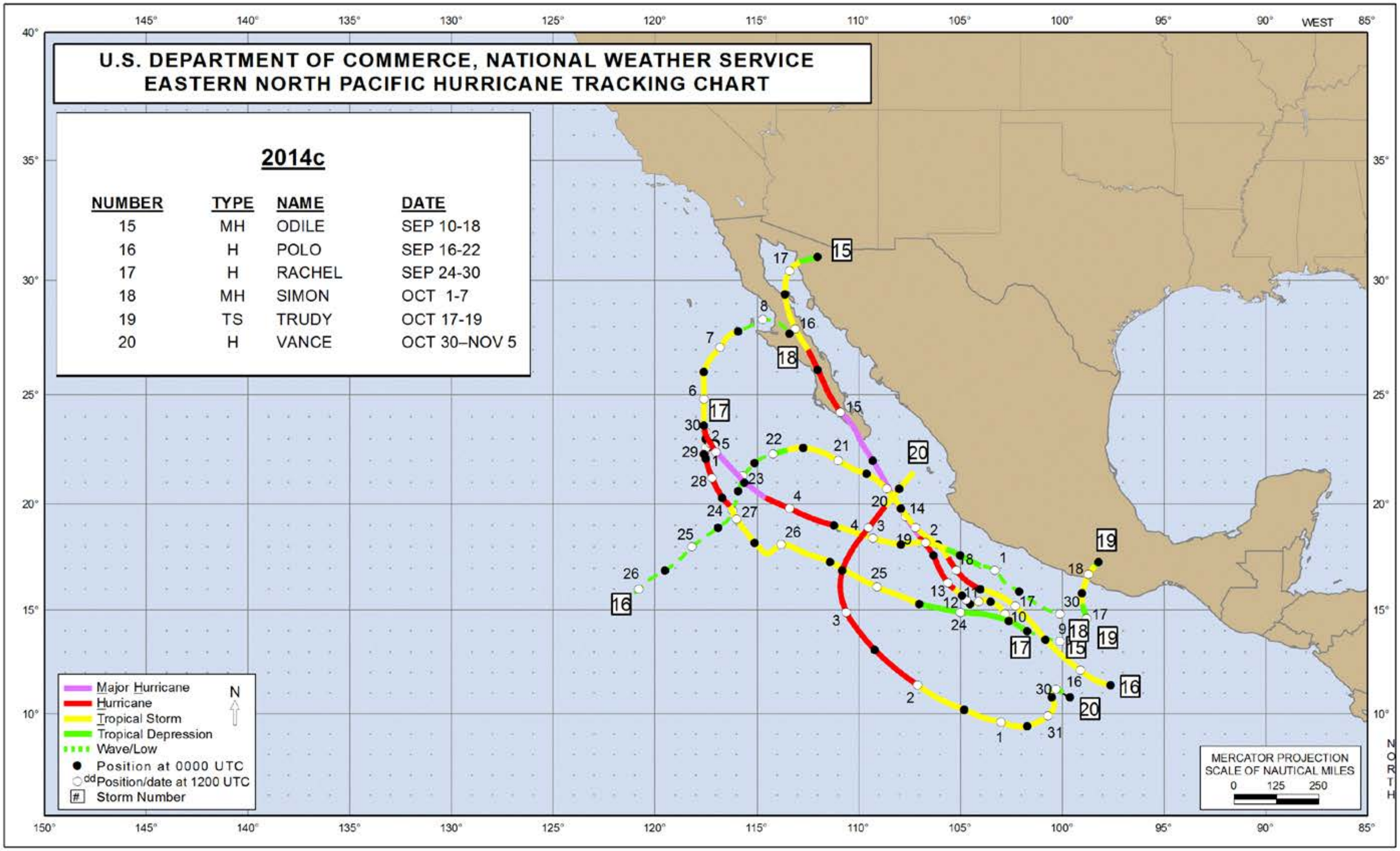

Figure 1c. Tracks of 2014 eastern North Pacific tropical storms and hurricanes from Odile to Vance.

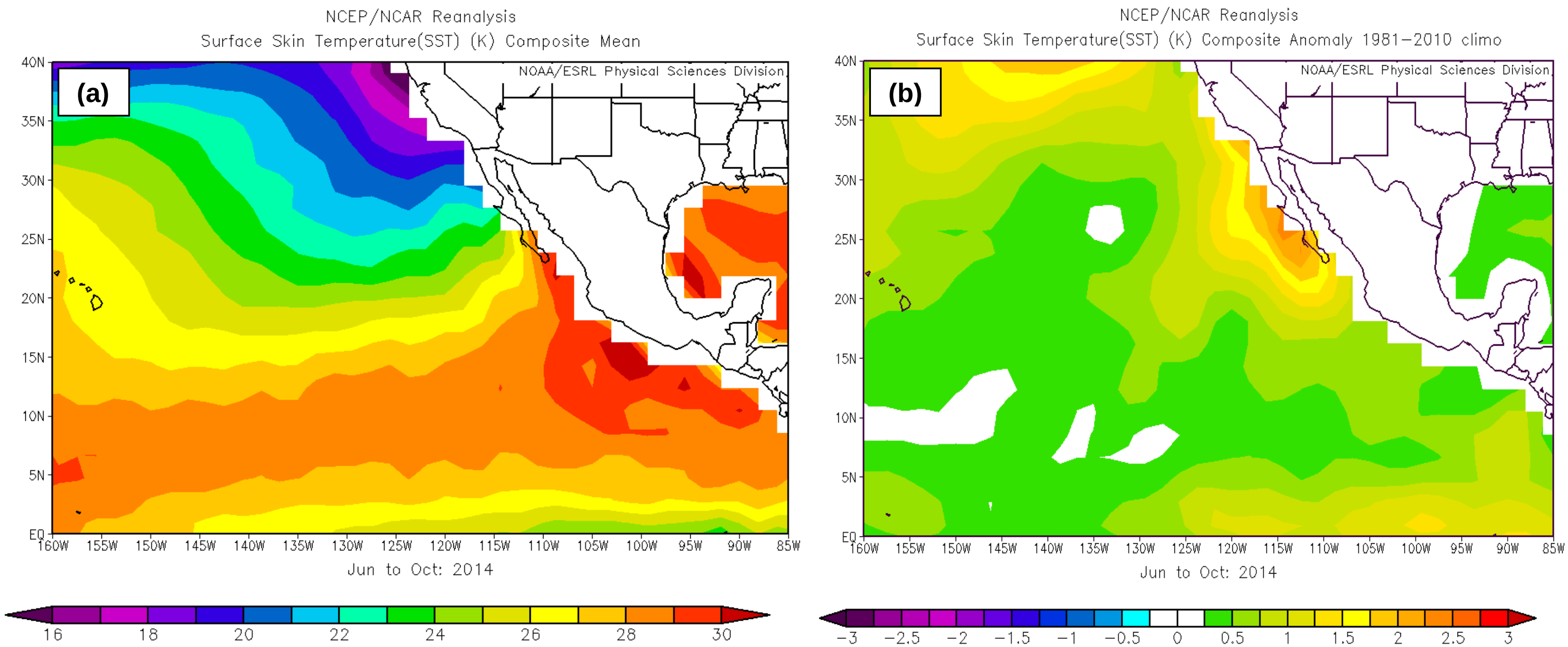

Figure 2. (a) Sea surface temperature composite mean (°C) from the NCEP reanalysis for June through October 2014 over the eastern North Pacific basin. (b) Sea surface temperature composite anomalies (°C) from the NCEP reanalysis for June through October 2014 over the eastern North Pacific basin relative to the 1981-2010 climatology. Images courtesy of the NOAA Earth System Research Laboratory.

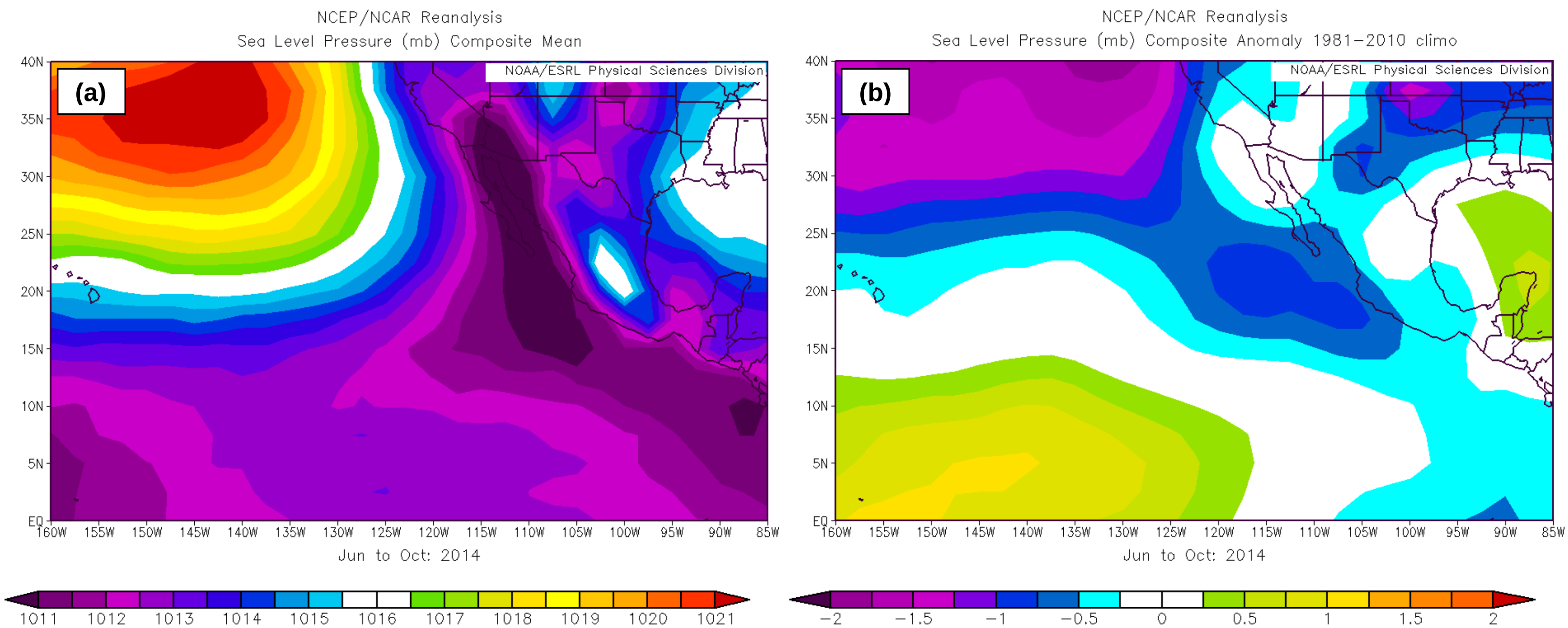

Figure 3. (a) Sea level pressure composite mean (mb) from the NCEP reanalysis for June through October 2014 over the eastern North Pacific basin. (b) Sea level pressure composite anomalies (mb) from the NCEP reanalysis for June through October 2014 over the eastern North Pacific basin relative to the 1981-2010 climatology. Images courtesy of the NOAA Earth System Research Laboratory.

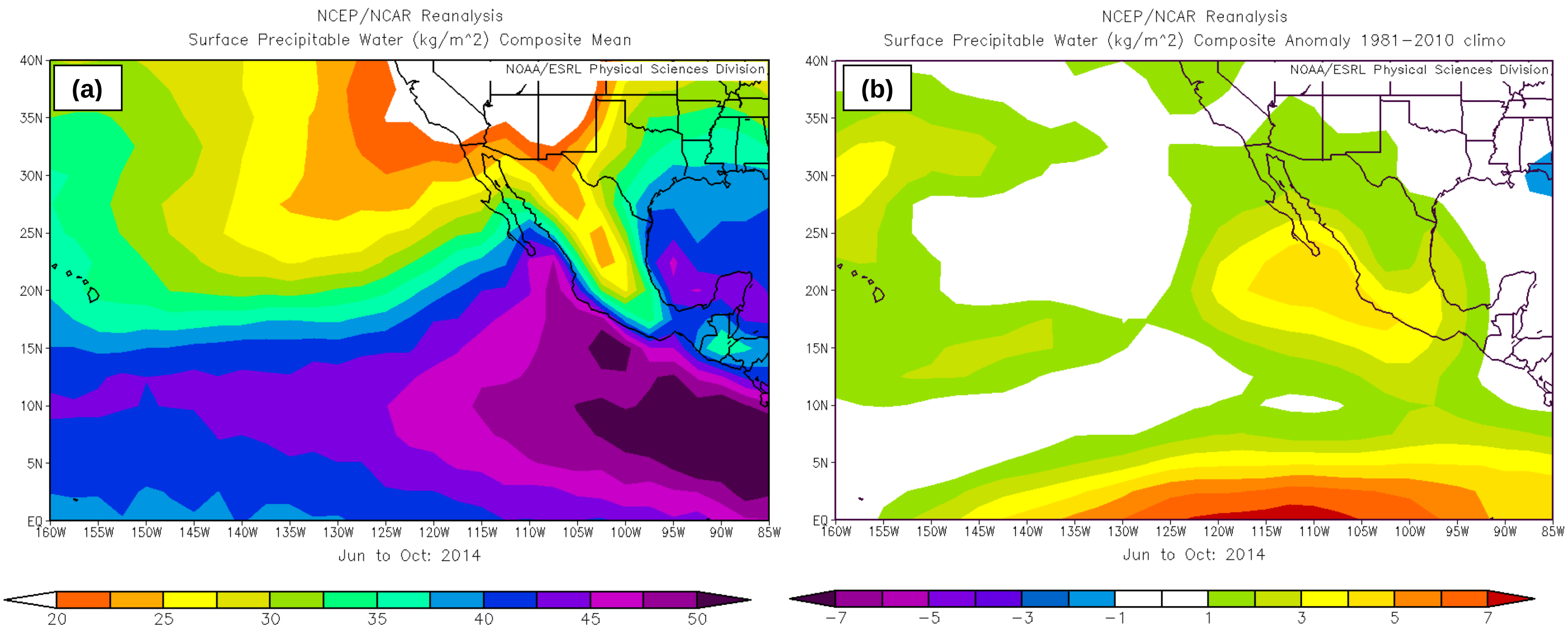

Figure 4. (a) Composite mean of total precipitable water (kg/m^2, or mm) from the NCEP reanalysis for June through October over the eastern North Pacific basin. (b) Composite anomaly of total precipitable water (kg/m^2, or mm) from the NCEP reanalysis for June through October over the eastern North Pacific basin relative to the 1981-2010 climatology. Images courtesy of the NOAA Earth System Research Laboratory.

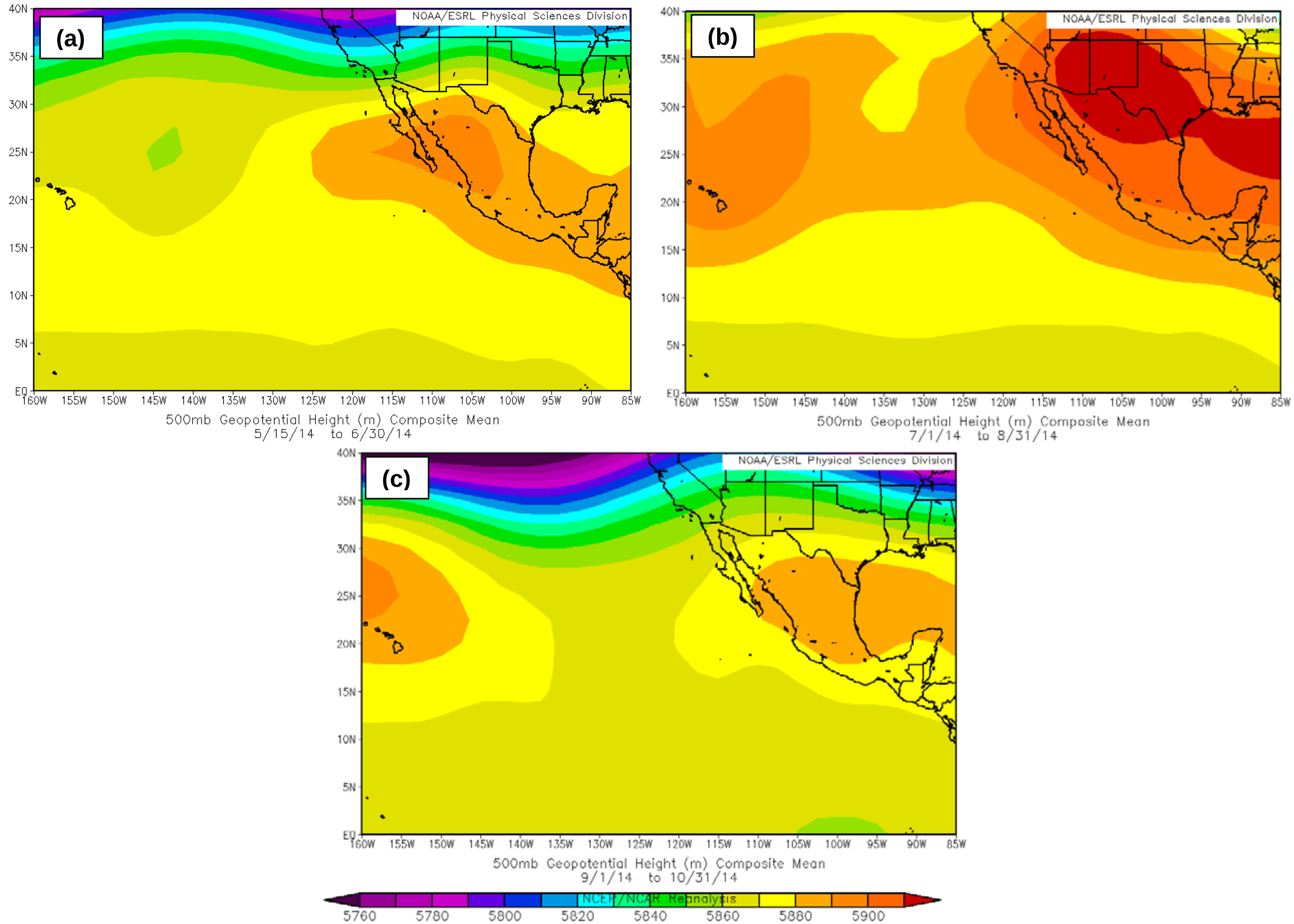

Figure 5. Composite of daily 500 mb geopotential heights (m) from the NCEP reanalysis for (a) May 15 through June 30, (b) July 1 through August 31, and (c) September 1 through October 31 over the eastern North Pacific basin. Images courtesy of the NOAA Earth System Research Laboratory.

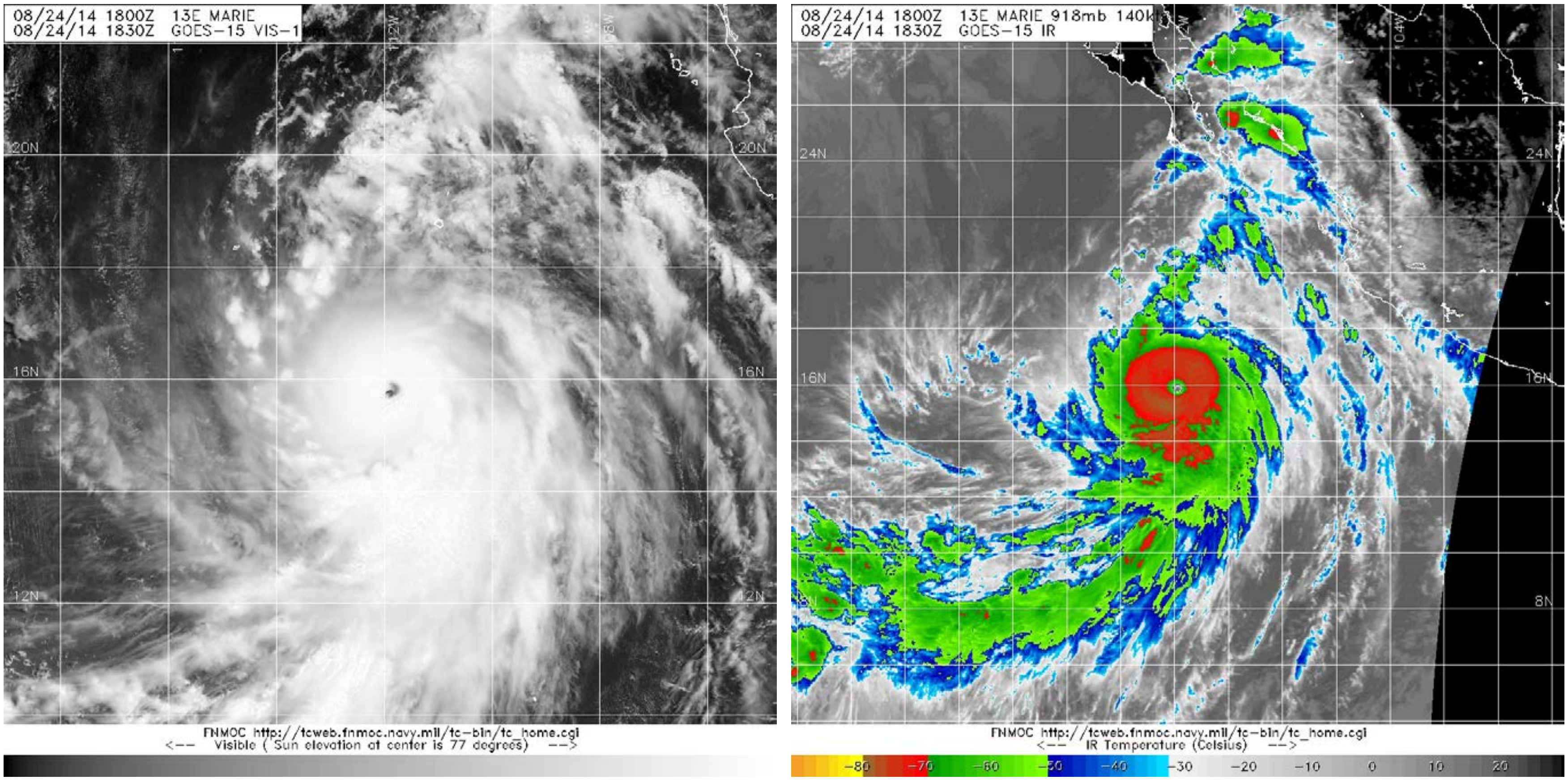

Figure 6. GOES-15 visible (a) and infrared (b) images of Hurricane Marie at 1830 UTC 24 August 2014, near the time of its peak intensity. Images courtesy of the Fleet Numerical Meteorology and Oceanography Center of the U.S. Navy.

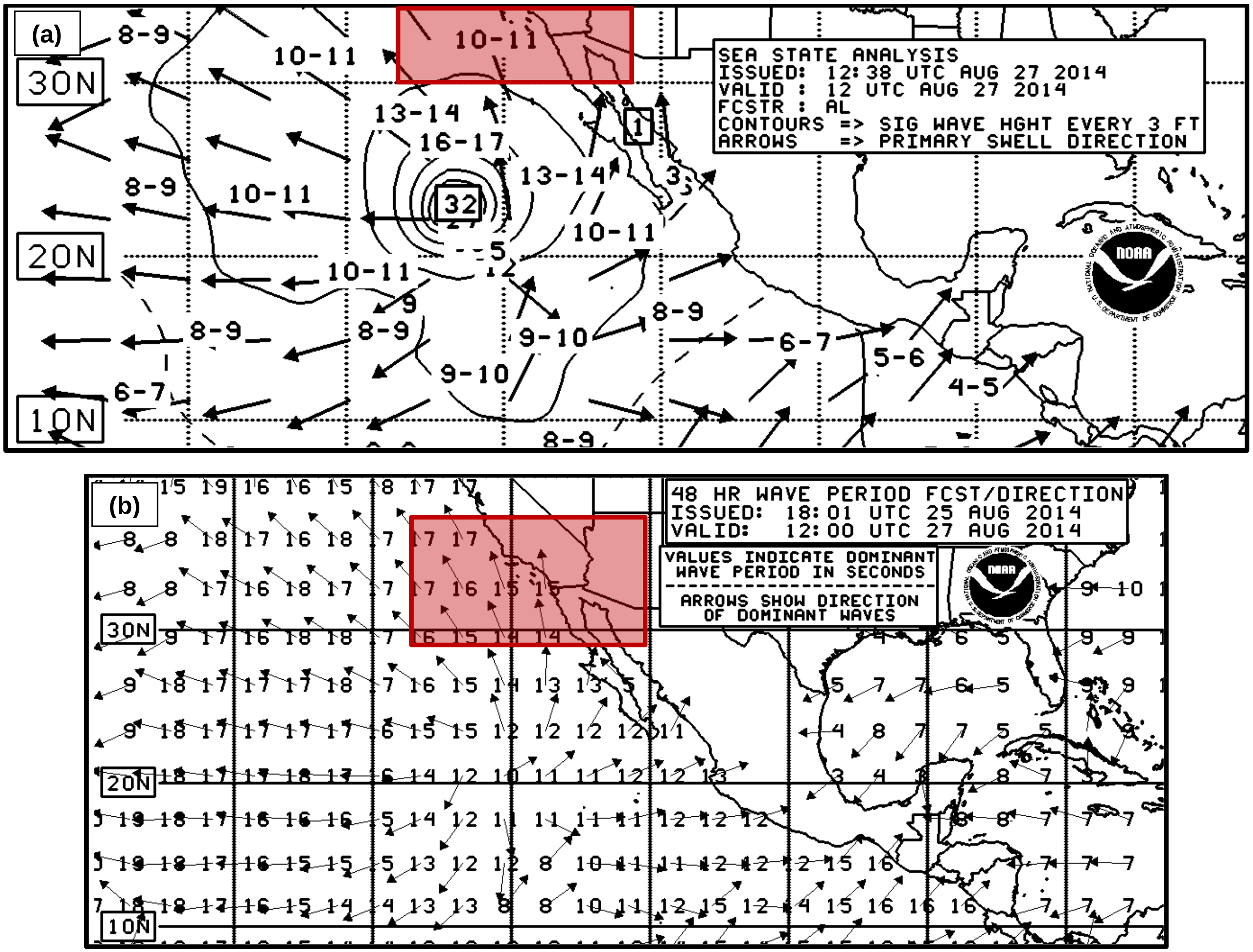

Figure 7. (a) Sea state analysis from the NHC/Tropical Analysis and Forecast Branch (TAFB) at 1200 UTC 27 August 2014, showing waves with significant wave heights of 10-11 ft off the coast of southern California from Hurricane Marie (red box). (b) 48-h wave period forecast from the NHC/TAFB issued at 1801 UTC 25 August 2014, showing 15-second southerly swells forecast to reach the coast of southern California from Marie (red box).

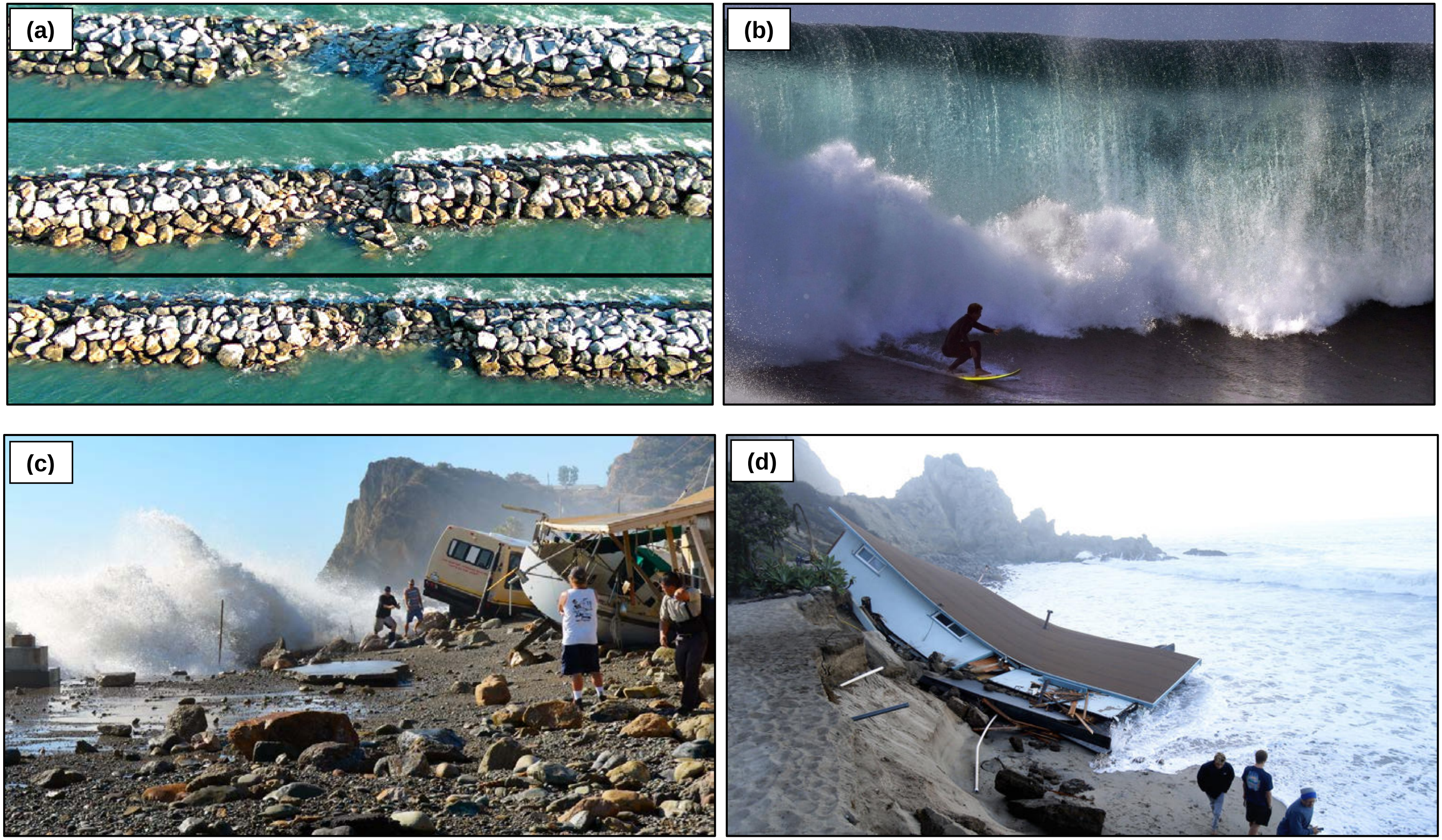

Figure 8. (a) Three sections of middle breakwater damage from Hurricane Marie at the Port of Long Beach, California (courtesy U.S. Army Corps of Engineers) (b) A surfer rides the Wedge in Newport Beach, California, enhanced by swell from Marie (courtesy Don Bartletti/ *Los Angeles Times*) (c) Wave damage on Catalina Island, California (courtesy *Los Angeles Times*) (d) Lifeguard building destroyed by high surf from Marie at Point Mugu State Park, California (courtesy *Los Angeles Times*)

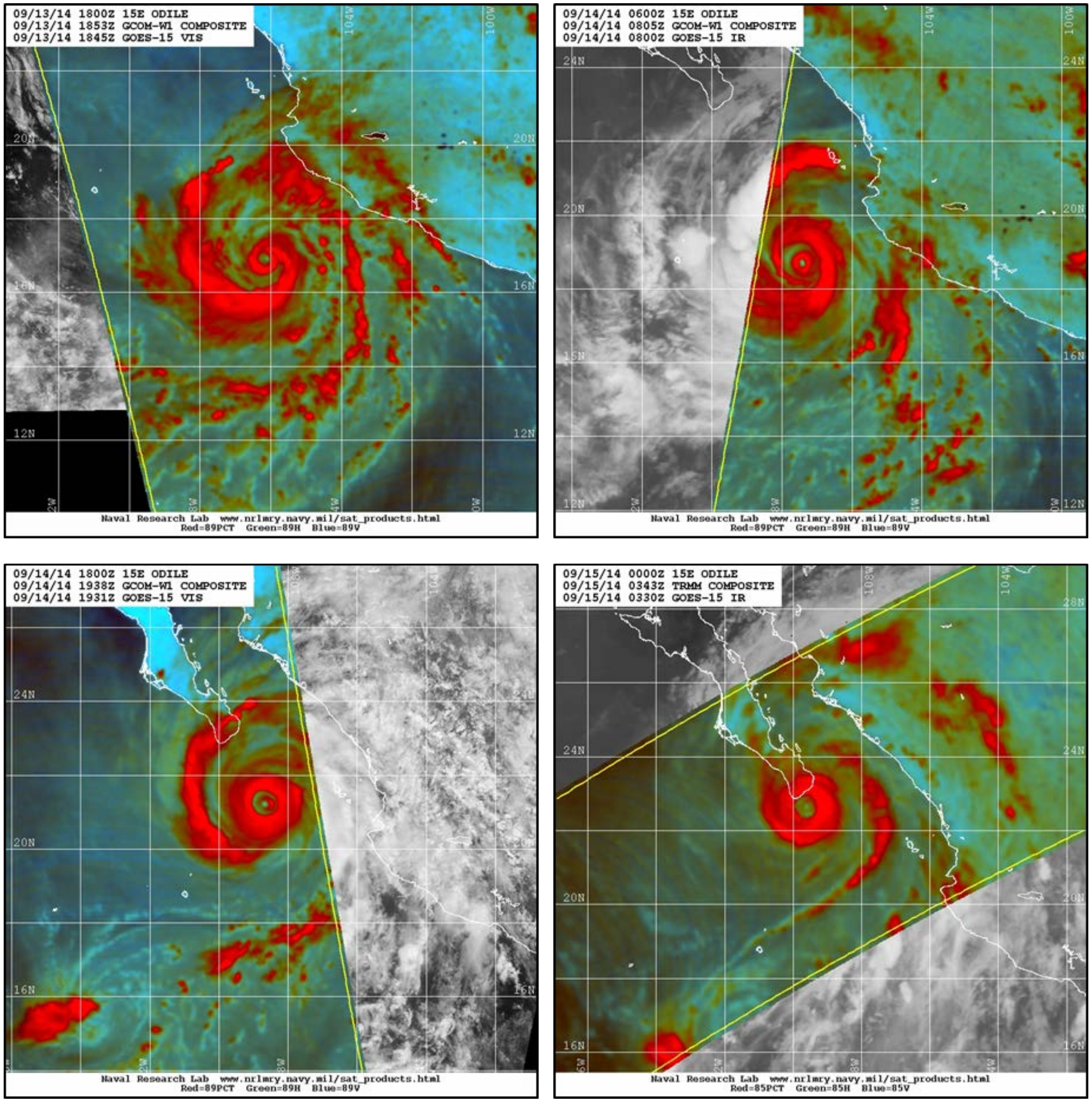

Figure 9. Series of 85-91-GHz microwave images showing the evolution of Odile's eyewall replacement prior to landfall near Cabo San Lucas, Mexico. Images courtesy of the Naval Research Lab.

Figure 10. (a) Damage from Hurricane Odile inside the terminal at Cabo San Lucas International Airport (coutesy Reuters) (b) Houses damaged in Los Cabos from Odile (courtesy the AP) (c) Damaged building in Los Cabos' resort zone (courtesy Alfredo Estrella/AFP/Getty Images) (d) Storm surge and wave damage along the beachfront in Los Cabos (courtesy bajavisitor blog).