NATIONAL HURRICANE CENTER TROPICAL CYCLONE REPORT

HURRICANE IOTA

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13–18 November 2020

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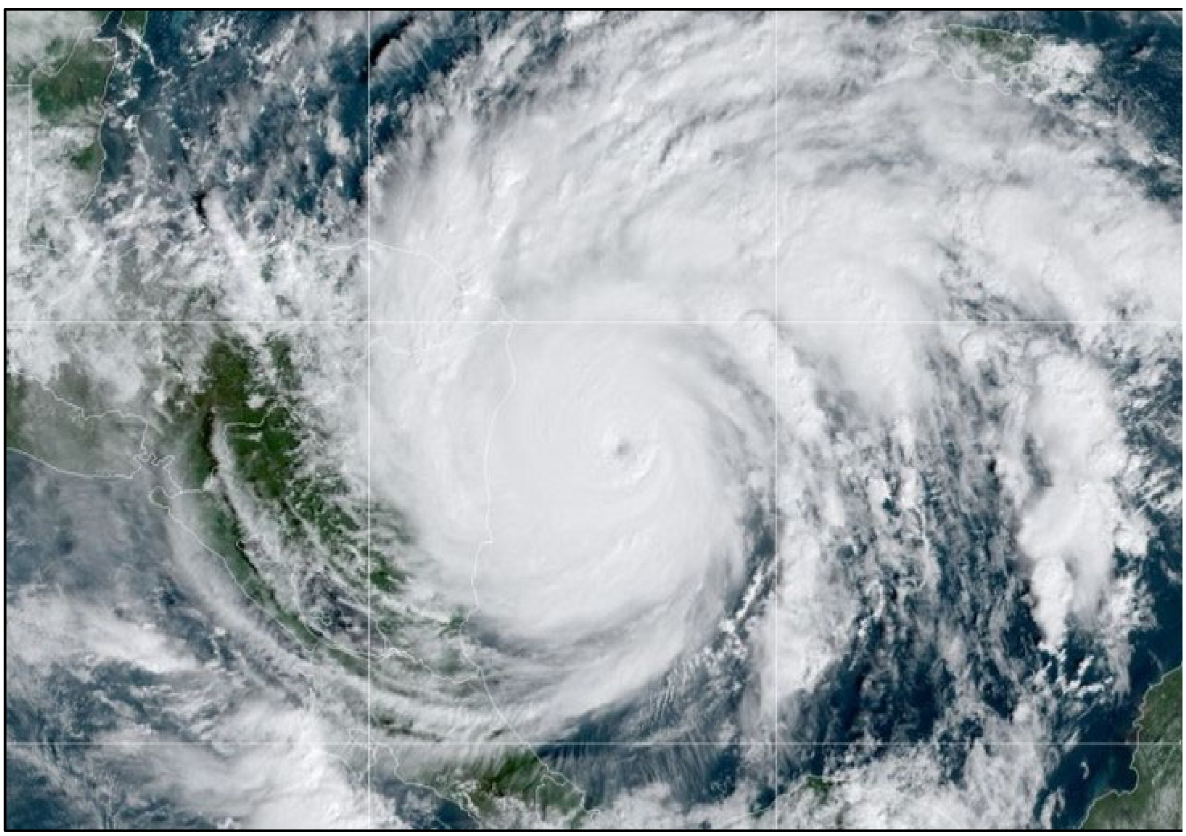

GOES-16 TRUE COLOR VISIBLE SATELLITE IMAGE OF IOTA WHEN IT WAS A STRONG CATEGORY 4 HURRICANE APPROACHING NORTHEASTERN NICARAGUA AT 1430 UTC 16 NOVEMBER 2020. IMAGE COURTESY NOAA/NESDIS/STAR.

Iota was a strong category 4 hurricane that made landfall along the coast of Nicaragua where Hurricane Eta had devastated the same area less than two weeks earlier. Widespread freshwater flooding, exacerbated by pre-existing flood conditions caused by Eta, resulted in 67 deaths and 41 people missing across portions of Central America.

Table of Contents

Hurricane Iota

13–18 NOVEMBER 2020

SYNOPTIC HISTORY

The incipient disturbance from which Iota developed was a low-latitude tropical wave that moved off the coast of Africa on 30 October. The wave moved westward for the next several days, remaining well south of 10°N latitude and producing only disorganized convection mainly east of the wave axis. By early 7 November, a pronounced, southeasterly cross-equatorial wind surge of 20–25 kt along and just offshore of northeastern South America steered the wave northwestward across Guyana, northeastern Venezuela, and the Windward Islands. The wave continued its northwestward trek across the reminder of the Lesser Antilles and over the extreme eastern Caribbean Sea on 8 November, followed by a slower westward motion across the Virgin Islands, Puerto Rico, and the eastern Caribbean on 9 October. After turning westward, the wave began to interact with the diffluent southern portion of a broad mid- to upper-level trough located over much of the central and southwestern Atlantic Ocean, which caused a sharp increase in both the depth and areal coverage of the associated convection, resulting in several inches of locally heavy rainfall occurring across the Virgin Islands and Puerto Rico.

Although the upper-level flow was both diffluent and divergent, the tropical wave was experiencing strong vertical wind shear of more than 30 kt from the north and northwest, which prevented the convection from becoming better organized. The system moved westward at an even slower pace across the north-central Caribbean Sea on 10–11 November, just skirting the southern coast of Hispaniola. Early on 12 November, deep convection increased while the wave turned uncharacteristically toward the west-southwest, resulting in the development of a broad low-pressure system by 1200 UTC that day centered over the central Caribbean Sea about 180 n mi south of Barahona, Dominican Republic. Early the next day, the low made yet another unusual turn and began moving southwestward while deep convection increased and became better organized owing to a decrease in the vertical wind shear. Based on the improved convective structure, it is estimated that a tropical depression formed over the south-central Caribbean Sea around 1200 UTC 13 November when the system was located about 160 n mi northwest of Aruba. The depression continued to strengthen, becoming a tropical storm 6 h later. 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].

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[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.

Under the influence of a strong northeast-to-southwest-oriented subtropical ridge situated to the north over the southwestern Atlantic, Tropical Storm Iota began and maintained its aclimatological southwestward motion of 5–8 kt for the next 24 h, while only gradually strengthening during that time due to modest southwesterly vertical wind shear (Fig. 4). By 1800 UTC 14 November, however, when the cyclone was located over the southwestern Caribbean Sea, the inner-core convection became much better defined and the radius of maximum winds (RMW) began to decrease, which resulted in Iota beginning a period of both explosive deepening (≥42 mb/24 h) and rapid intensification (≥30 kt/24 h) while the cyclone turned slowly northwestward and then westward. Figure 4 indicates that environmental and oceanic conditions were ideal for rapid strengthening to occur, owing to the very low vertical shear, warm sea-surface temperatures near 29°C, and deep moisture in the low- and mid-levels of the troposphere. In fact, between 1200 UTC 15 November and 0000 UTC 16 November, the eye and inner core of Iota passed near the center of a large-scale, upper-level anticyclone when the winds shifted from a northwesterly direction to a more easterly component (see SHRDIR/10 plot in Fig. 4). During the 42-h period from 1800 UTC 14 November to 1200 UTC 16 November, data from an Air Force Reserve reconnaissance aircraft indicated that Iota strengthened 90 kt and that the central pressure fell an amazing 80 mb, culminating in the powerful hurricane reaching a peak intensity of 135 kt when it was located about 20 n mi northwest of the Colombian island of Providencia (Isla de Providencia y Santa Catalina).

After the 12-n-mi-wide eye of Iota passed over the islands of Providencia and Santa Catalina, the hurricane maintained a motion slightly north of due west for the next 15 h until landfall. During that time, the hurricane gradually weakened due to passing over the relatively cool wake created by Hurricane Eta almost two weeks earlier (Figs. 5, 6, and 7), which allowed for cold upwelling to occur beneath Iota. The hurricane made landfall with an intensity of 125 kt around 0340 UTC 17 November along the eastern coast of Nicaragua about 20 n mi south-southwest of Puerto Cabezas near the village of Haulover. Shortly after landfall, Iota turned due west and rapidly weakened over the mountainous terrain of Nicaragua, becoming a tropical storm by 1800 UTC that day while located over western Nicaragua near the Honduras-Nicaragua border. Further weakening followed as the cyclone moved across the rugged terrain of southern Honduras early on 18 November, and become a tropical depression by 1200 UTC 18 November when the broad system was moving across east-central El Salvador. Iota dissipated over western El Salvador 6 h later.

METEOROLOGICAL STATISTICS

Observations in Iota (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), objective Advanced Dvorak Technique (ADT) estimates and Satellite Consensus (SATCON) estimates from the Cooperative Institute for Meteorological Satellite Studies/University of Wisconsin-Madison. Observations also include flight-level and stepped frequency microwave radiometer (SFMR) observations from eight flights conducted by the 53rd Weather Reconnaissance Squadron of the U.S. Air Force Reserve Command, which resulted in 19 center fixes. 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 Iota.

There was only one buoy or ship report of tropical-storm-force winds associated with Hurricane Iota. NOAA buoy 42057, located about 195 n mi west-southwest of Negril, Jamaica (16.91°N 81.42°W), or about 200 n mi north of Iota's track, reported a sustained wind of 37 kt at 1400 UTC and 1410 UTC 16 November at a height of 3.8 meters. Those winds covert to a 41-kt wind speed at a standard 10-meter elevation. A wind gust to 43 kt was also measured earlier that day at 1120 UTC.

Winds and Pressure

Peak Intensity

Iota's estimated peak intensity of 135 kt at 1200 UTC 16 November is based on a blend of a 1218 UTC reconnaissance aircraft 700-mb flight-level wind speed of 147 kt, which results in an equivalent surface wind speed estimate of 132 kt, and an SFMR surface wind speed estimate of 140 kt. Although there was a subsequent SFMR wind speed estimate of 143 kt observed at 1324 UTC, that value was associated with a 700-mb flight-level wind speed of only 129 kt (116-kt equivalent surface wind speed). Furthermore, that SFMR wind estimate was obtained from the southern semicircle (i.e., left side), which is typically the weakest portion of a westward-moving hurricane such as Iota. Due to the small RMW of approximately 8 n mi, significant undersampling of Iota's peak winds was not considered to be a factor.

Operationally, Iota was assessed as a 140-kt category 5 hurricane. However, ongoing research suggests there is a high bias of SFMR wind speeds in these high wind regimes, and the final best track peak intensity was adjusted downward by 5 kt, closer to the standard reduction of the peak flight level winds. While a 5-kt change is typical for post-analysis best track intensity changes, this decrease in Iota's peak intensity crosses the threshold from Category 5 to Category 4. This change is well within the typical range of uncertainty in NHC's post-storm intensity analyses, but the discrepancy between dropsonde-based reductions of peak flight-level winds and SFMR-derived surface winds leads to greater-than-normal uncertainty in the peak intensity of Iota, as has been noted in previous intense hurricanes such as Matthew in 2016, Irma, Jose, and Maria in 2017, and Dorian in 2019. Future adjustments may be needed to Iota's estimated peak intensity once SFMR data at high wind speeds are recalibrated.

Also, the sampling of SFMR winds near coastlines or sharp ocean current gradients where significant breaking waves occur can result in a high bias of SFMR wind speed estimates (Uhlhorn and Black 2003, p. 102). The interaction of Iota's wind field with the islands of Providencia and Santa Catalina likely caused complex wave interactions to the lee or west side of the archipelago, producing constructive interference, wave steepening, and subsequent breaking waves. These breaking waves could have resulted in some high bias in the SFMR surface winds in that area.

Minimum Pressure

The estimated minimum central pressure of 917 mb at 1200 UTC 16 November is based on a 1323 UTC reconnaissance aircraft center dropsonde report of 920 mb. The dropsonde measured a south-southwesterly surface wind of 33 kt, which yields an estimated minimum pressure of 917 mb based on a reduction of the pressure by 1 mb for every 10-kt of surface wind speed measured.

Explosive Deepening and Rapid Intensification

Hurricane Iota underwent an incredible period of explosive deepening between 1800 UTC 14 November and 1200 UTC 16 November, during which the central pressure fell an incredible 80 mb in 42 h. Coincident with the explosive deepening was a period of rapid intensification when Iota strengthened 90 kt from 45 kt to 135 kt.

Explosive or rapid deepening is defined by the National Hurricane Center as a decrease in the minimum sea-level pressure of a tropical cyclone of 42 mb/24 h. Such extreme rates of deepening are rare, with this atmospheric phenomenon having only occurred with 25 North Atlantic basin hurricanes since 1965, and only two hurricanes – Wilma (-105 mb/42 h) and Rita (-93 mb/42 h) in 2005 – have exceeded Iota's -80 mb/42 h deepening rate.

Although favorable atmospheric and oceanic conditions consisting of very low vertical wind shear ($\leq$ 5kt), a moist lower-to-middle troposphere ($\geq$70% relative humidity), and sea-surface temperatures near 29°C (Fig. 4) contributed to Iota's rapid strengthening phase, the explosive deepening process may have been hastened by the presence of multiple eyewall mesovortices (EMV) – small-scale low-pressure areas embedded within the eyewall that can protrude into the eye. These vortices or 'air pumps' (also known as a ''vortical hot tower'' or VHT in some literature) have been hypothesized to transport mass out of the eye more rapidly than what occurs during typical eyewall mixing processes [Stewart et al 1997, (see their Figs 2 and 3); Hogsett and Stewart 2014], thus, causing a greater rate of pressure falls in the eye and a subsequent rapid increase in the eyewall wind speeds. This greater mass outflow from the eye is due to the existence of much stronger updrafts associated with some of the more vertically deep EMVs.

During the penetration of Hurricane Iota by an Air Force Reserve Reconnaissance aircraft on 15 November, the onboard aerial reconnaissance weather officer (ARWO) reported in the 2347 UTC vortex data message (VDM) remarks section — "HEXAGONAL EYEWALL". This is an indication that possibly six EMVs were present at the time of the ARWO's report. One encounter with an EMV appears to have occurred shortly thereafter at 0617 UTC 16 November (Figs. 8a and 8b) when the aircraft was exiting the northwestern portion of the eyewall. The aircraft flew near through a perturbation 13 n mi northwest of the center of the eye at an altitude of 9,347 ft, which contained a surface pressure (931 mb) that was at least 4 mb lower than the central pressure (935 mb) in the eye (Fig. 8b). The pressure perturbation was also accompanied by a pronounce directional wind shift from northwest to northeast along that outbound flight leg (Fig. 8a).

Hurricane Iota was already experiencing RI at the time that the multiple EMVs were observed at 0000 UTC 16 November, with the intensity having increased 45 kt during the previous 30-h period. However, during the ensuing 12-h period, Iota's intensity increased another 45 kt. By 1200 UTC 16 November, it appears the multiple EMVs devolved into just one quasi-stationary intense convective cell that had migrated into the southern semicircle of the eyewall (Fig. 9). This convective asymmetry continued for the next 15 h until Iota made landfall. Although this persistent cell contained frequent lightning flashes (Fig. 10), subsequent reconnaissance aircraft passes near and through this feature revealed a steady decrease in pressure with no abrupt pressure changes or perturbations that would suggest a deep EMV was collocated with this intense thunderstorm.

Landfall Intensity and Pressure

Iota's intensity of 125 kt and pressure of 921 mb at landfall along the coast of Nicaragua near Haulover are based on extrapolation of the weakening trend indicated in reconnaissance aircraft data after the hurricane had reached its peak intensity at 1200 UTC 15 November. This trend is also supported by the erosion of Iota's eyewall, which was evident in both infrared and passive microwave (Fig. 9d) satellite imagery. However, given the lack of aircraft data in the final hours before landfall and the lack of wind observations near where Iota made landfall (noted below), uncertainty in the landfall intensity estimate is higher than usual.

Wind Reports

There was a dearth of land-based wind reports associated with Hurricane Iota owing to Hurricane Eta's traversal of the same general area nearly two weeks prior to Iota's arrival, which resulted in damage or complete destruction of weather observing systems across the western Caribbean Sea and portions of Central America. Also, some reporting stations ceased operations as Iota approached the coast, while other observing sites only reported partial observations.

There were no surface observation or official wind reports from Providencia, Colombia. However, the center of Iota's eye passed less than 5 n mi (10 km) north of Santa Catalina Island and northern Providencia Island around 1045 UTC 16 November. Interpolation of Air Force Reserve reconnaissance aircraft data between the 0613 UTC and 1221 UTC fixes indicate that the diameter of Iota's eye at the time of closest approach was about 13 n mi (24 km). This means that while the center of Iota did not cross Providencia, the southern portion of the eyewall and associated RMW did cross the island, still resulting in a "direct hit" on Providencia (see Glossary of NHC Terms). Based on reliable reconnaissance SFMR surface winds located in Iota's southern eyewall, there is a high probability that sustained, category-4 wind speeds of at least 115 kt winds occurred on Providencia and Santa Catalina islands, and that sustained hurricane-force winds persisted for approximately 7 h between 0700 UTC and 1400 UTC on 16 November.

On San Andrés island (Colombia), the highest winds measured at the Gustavo Rojas Pinilla International Airport (**SKSP**) were a 10-minute average wind speed of 33 kt and a gust to 44 kt at 1300 UTC 16 November. Based on the SKSP observations, tropical-storm-force wind gusts occurred on the island for at least 14 h between 0900 UTC and 2300 UTC 16 November.

In Nicaragua, the strongest winds observed were at the Puerto Cabezas-Bilwi Airport (**MNPC**) where a 10-minute average wind speed of 72 kt and a gust to 98 kt at 0253 UTC 17 November. On the south side of Puerto Cabezas, an unofficial wind gust to 108 kt was reported at 0133 UTC by the amateur radio group *Club de Radio-Experimentadores de Nicaragua* (CREN). Both of these wind reports occurred just outside of Iota's estimated landfall RMW of 15 n mi, which is based on the last reconnaissance aircraft data approximately 3 h prior to landfall and passive microwave satellite data. Therefore, there is a high probability that sustained, category-4 wind speeds of at least 115 kt winds occurred farther south along the coast of Nicaragua where the eyewall of Iota made landfall.

Along the northern coast of Honduras, the highest winds reported were a 10-minute average wind speed of 25 kt and a gust to 50 kt at 0110 UTC 18 November that were observed at the Goloson International Airport (**MHLC**) located near La Ceiba. There were a couple of other stations along the northern coast of Honduras that briefly reported tropical-storm-force wind gusts; however, there were no official reports of sustained tropical-storm-force winds along the coast of Honduras.

Rainfall and Flooding

Iota's precursor tropical wave produced locally heavy rainfall and some flooding across U.S. and British Virgin Islands, Vieques, and Puerto Rico when the northern portion of the system passed over those areas on 10–11 November. St. Thomas in the U.S. Virgin Islands measured a total of 4.37 inches during that 2-day period, while San Juan, Puerto Rico, recorded a total of 3.51 inches during that same period. A record daily maximum rainfall record for San Juan was set for 10 November when a rainfall total of 2.44 inches was recorded, which broke the old record of 2.43 inches set in 1927.

The southern portion of the pre-Iota disturbance also produced heavy rains across northwestern Venezuela, causing flash floods and mudslides. However, no official rainfall totals were available at the time of this report.

As a precursor disturbance and a tropical cyclone, Iota brought heavy rainfall to parts of northern Colombia, causing flash floods, river flooding, and mudslides. However, no official rainfall totals were available at the time of this report.

Iota's heavy rains fell on already saturated ground caused by Hurricane Eta, producing widespread flash floods and river flooding across most of Central America and extending into extreme southeastern Mexico (Figs. 11-15). The following are specific rainfall totals and river stages:

Nicaragua – Puerto Cabezas, 9.80 inches (250 mm); Wewa Bar, 9.80 inches (250 mm); San Marcos, 7.80 inches (200 mm).

Honduras – La Ceiba, 11.85 inches (301 mm); Santa Barbara, 8.90 inches (225 mm); northern half of Honduras received > 3.00 inches (75 mm) of rainfall along and north of Iota's track.

Belize – Gales Point, 12.27 inches (312 mm); C & C Farms, San Ignacio, 10.75 inches (273 mm); Philip S. W. Goldson International Airport, 10.32 inches (262 mm); San Pedro, ≥175 mm (6.80 inches); Baldy, 8.44 inches (241 mm); rainfall amounts of 4-5 inches (100-125 mm) generally occurred over the southern and northern thirds of the country.

El Salvador – Las Pilas, 6.61 inches (168.0 mm); Volcan San Miguel, 5.38 inches (137 mm); Los Naranjos, 3.75 inches (95.2 mm).

Costa Rica – Ojochal, 9.75 inches (248 mm); Salitral, 9.02 inches (229 mm); Ostional, 7.78 inches (198 mm).

Guatemala – Las Vegas, 20.08 inches (510 mm), with 3.70 inches (94 mm) falling during a 6-h period on 18 November; Puerto Barrios, 13.26 inches (337 mm); Esquipulas, 12.00 inches (305 mm); Santa María Cahabón, 9.68 inches (246 mm), with 2.48 inches (63 mm) falling during a 6-h period on 18 November; the southern third of the country generally received rainfall amounts of 2–3 inches (50–75 mm). Guatemala's INSIVUMEH (Instituto Nacional de Sismología, Vulcanología, Meteorología e Hidrología) reported that rivers exceeded flood stage in at least 12 locations across the country, with the rivers La Pasión, Usumacinta, and Rio Grande Camotán cresting at more than 10 ft (3 m) above flood stage.

Mexico – there were no official rainfall reports received from Mexico; however, rainfall data from Belize, Guatemala, and El Salvador indicate that the eastern portions of the Mexican border states of Quintana Roo, Campeche, Tabasco, and Chiapas likely received rainfall amounts of 2–3 inches (50–75 mm).

Storm Surge[2]

Due to the damage caused by Hurricane Eta, which made landfall in the same general area two weeks prior, accurate storm surge values associated with Hurricane Iota were very difficult to ascertain. However, the *Instituto Nicaraguënse de Estudios Territoriales* (Nicaraguan Institute of Territorial Studies) estimated that a storm surge of at least 26 ft (8 m) occurred several n mi north and south of the village of Haulover, Nicaragua, and also farther north up the coast near Wawa Bar (Fig. 16). The high storm surge combined with the scouring action of the associated large and battering waves eroded a significant portion of the barrier island upon which Haulover was located, resulting in the formation of a large cutout right through the center of the village (Fig. 17). Fortunately, the village was evacuated before Iota made landfall, and no deaths were reported in Haulover.

[2] Several terms are used to describe water levels due to a storm. **Storm surge** is defined as the abnormal rise of water generated by a storm, over and above the predicted astronomical tide, and is expressed in terms of height above normal tide levels. Because storm surge represents the deviation from normal water levels, it is not referenced to a vertical datum. **Storm tide** is defined as the water level due to the combination of storm surge and the astronomical tide, and is expressed in terms of height above a vertical datum, i.e. the North American Vertical Datum of 1988 (NAVD88) or Mean Lower Low Water (MLLW). **Inundation** is the total water level that occurs on normally dry ground as a result of the storm tide, and is expressed in terms of height above ground level. At the coast, normally dry land is roughly defined as areas higher than the normal high tide line, or Mean Higher High Water (MHHW).

CASUALTY AND DAMAGE STATISTICS

As of the time of this report, Hurricane Iota was responsible for causing 67 direct[3] deaths, 17 indirect deaths, and 41 people missing due to the cyclone's strong winds and inland freshwater flooding. It is estimated that more than 7 million people across the Caribbean region and Central America were affected by Iota and its pre-cursor disturbance, with hundreds of thousands of people having been displaced from their homes across much of Central America.

According to *Global Catastrophe Impact* (November 2020 — Aon Benfield Analytics), total damage estimates for the Hurricane Iota are $1.4 billion (USD). Damage in Nicaragua alone was $564 million (USD), comprising nearly half of Iota's total damage estimate. This damage estimate is less than what would typically be expected with a category 4 hurricane due to Iota having made landfall where Hurricane Eta caused extensive damage just two weeks prior.

Some specific damages and deaths by country are as follows:

Venezuela

Heavy rains caused freshwater flooding across the extreme northwestern portion of the country that damaged 288 homes, mainly across the Paraguaná Peninsula in the state of Falcón. Damage to homes was reported in the communities of El Cayude and El Tranquero, while the town of Santa Ana lost electrical service. Some minor flooding also occurred in the state of Miranda, but no significant damage to any infrastructure or deaths were reported. No loss of life was reported.

Colombia

Iota caused 10 direct deaths, 8 on the mainland and 2 on the Colombian archipelago of San Andrés-Providencia-Santa Catalina, along with 8 persons missing.

<u>Mainland</u>

Heavy rains associated with Iota's pre-cursor tropical wave and the outer circulation of the cyclone caused extensive damage across the northern portion of the country, especially on the Guajira Peninsula, resulting in significant damage in the Mohán area of Dabeiba, a town and

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[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.

municipality in the Antioquia Department, where mudslides killed three people, left eight persons missing, and injured 20 others. The landslides destroyed 67 homes and damaged 104 others, and also damaged three schools. A total of nearly 500 people were affected in the community, with eight people having been rescued from the rubble. Rockfalls along a road between Dabeiba and Urabá trapped 100 vehicles but caused no injuries. Freshwater flooding affected 28,000 people in 10 municipalities within the Chocó Department, including isolating the town of Lloró after the only bridge into the community collapsed. A man was killed in the municipality of El Carmen de Atrato when his home was buried by a mudslide. Two people disappeared and are presumed dead when a mudslide dragged their van into the Rio Atrato. In the Santander Department, multiple rivers topped their banks. Several families had to be evacuated from Cimitarra due to rising water along the Carare River. About 1,000 people were isolated in the municipalities of Carcasí and Enciso after a bridge collapsed over the Chicamocha River. The extensive flooding resulted in states of emergency declared for 29 municipalities. In the Atlántico Department, 693 residences were damaged in Malambo, 200 in Candelaria, and 150 in Carreto.

About 70 percent of the city of Cartagena experienced significant freshwater flooding. Numerous homes were damaged or destroyed by floods and landslides, affecting approximately 155,000 people. Two people died in the San Pedro neighborhood when the motorcycle that they were riding was swept off the road and into a canal. As a result of the extensive flooding, the Combat Coliseum and Gymnastics (Coliseo de Combate) fitness center in Cartagena was converted into a shelter to accommodate 200 people. According to TECHO Colombia, an anti-poverty NGO that operates in Latin America, barrios in Cartagena, Barranquilla, and the communities of Nuevo Magdalena and El Chocó were significantly affected by Iota's heavy rainfall and associated flooding.

Providencia, Santa Catalina, and San Andrés

Although the center of the hurricane's eye passed just north of Providencia, the southern eyewall containing category-4 winds made a direct hit on the islands of Providencia and Santa Catalina, causing extensive damage (Fig. 18) and an island-wide power outage after Iota destroyed the island's electricity plant. According to *The Bogata Post* newspaper, the 5,000 inhabitants of Providencia had no electricity and no way to communicate with the rest of the world for about 24 h. According to Providencia officials, 98 percent of Providencia's infrastructure was destroyed, including provincial buildings constructed in the 15th century. Many people were left without electricity or drinking water after Hurricane Iota reached its full strength in the early on 16 November. Every home on the island suffered sort of damage, with about 80 percent having been destroyed with the remaining 20 percent incurring extensive damages. At least two evacuation shelters lost their roofs. According to *El Espectador*, the hospital was too damaged to use, making it difficult to treat those individuals who had been injured during the hurricane's passage. For several hours after Iota's winds had subsided, debris covered runways at El Embrujo Airport, preventing aircraft from arriving or leaving. By 17 November, the airport was operational enough to allow Colombian President Duque to visit and assess the damage on the island. A 47-year old man was killed and six people were injured on Providencia.

On San Andrés, torrential rains and large swells caused extensive flooding, with the storm surge reaching almost 3 m (10 ft) above normal tide levels. Iota's intense winds uprooted numerous trees, some of which fell on homes, and damaged or blew away the roofs on several homes. Communications with San Andrés were temporarily lost during the storm and approximately 60 percent of the island lost power. Storm surge flooding produced about 6 inches of saltwater inundation that washed over the Gustavo Rojas Pinilla International Airport, temporarily shutting down the runways. One person was killed on the island.

According to Aon Plc Insurance Company, total economic losses for Colombia were estimated to be at least $100 million USD, most of which will be uninsured.

Nicaragua

At the time of this report, there were at least 39 direct deaths in Nicaragua, with 29 people still missing. Before Iota's arrival, large portions of the country were still recovering from freshwater flooding, storm surge flooding, and wind damage caused by Hurricane Eta just two weeks prior. In particular, areas around and south of Puerto Cabezas were devastated by Eta and cleanup operations had to be suspended in order for preparations and evacuations to commence prior to Iota's landfall in basically the same location. As a result, separating the damage caused by the two powerful hurricanes was quite difficult for local emergency managers. Wind damage caused by Hurricane Iota was very limited due to damage that the area sustained previously from Hurricane Eta. The *Club de Radio-Experimentadores de Nicaragua* (CREN) — an amateur radio group — reported that many homes in the Puerto Cabezas area incurred roof damage. They also indicated that the roof had been torn off of a makeshift hospital that had been serving as a replacement to an older hospital, which required the evacuation of patients being treated there. A total of 160,233 homes lost power, 47,638 families lost water service, and 35 communities lost telephone service. According to witnesses and Nicaraguan officials, many roofs were blown off buildings and numerous power lines had been knocked down in Bilwi, resulting in the loss of telephone and internet service.

Iota's heavy rains falling on already saturated soil caused by Hurricane Eta led to widespread flooding and mudslides (Figs. 19–20). Two children died when they were swept away by a river in Santa Teresa, Carazo, while three other members of their family are still missing. A mudslide killed two people in the town of Wiwilí de Jinotega located in the Jinotega Department, and another person died in Quilalí, which is located in the Nueva Segovia Department. According to the newspaper *Confidencial*, dozens of homes were destroyed in Wiwilí de Jinotega, causing hundreds of people to seek refuge in Catholic churches and evangelical temples. At least 30 people were killed, including a small boy, when they were buried by a mudslide late on 17 November in Macizo de Penas Blancas in Jinotega Department. The next day, four more bodies, including a baby, were recovered from the mud. A week later on 23 November, a passenger truck slid off of a rain-damaged mountainous road and into a valley, resulting in 17 indirect deaths and injuring 25 people.

Honduras

Widespread mudslides and downed trees were reported in portions of the country, especially near and to the north of Iota's track (Fig. 21). Iota is responsible for at least 13 direct deaths in the country, with one person still missing, owing to freshwater flooding caused by the hurricane. Mudslides were the primary cause of the deaths, with one mudslide killing eight people in San Manuel Colohete and another mudslide killing five people in Los Trapiches. Many concrete and wooden houses were completely destroyed by rushing flood waters and mudslides, with

COPECO reporting more than 366,000 people were directly affected by the hurricane. Eighty percent of the roads in Copán Ruinas were rendered impassible due to mudslides and flash flooding. The Ramón Villeda Morales International Airport complex was completely submerged under flood waters more than 1 m (3 ft) deep for than a month (Fig. 22), resulting in severe damage to the passenger terminal experienced severe damage. Approximately 80,000 people were evacuated from flood-prone areas across the country.

According to Aon Plc Insurance Company, combined total economic losses for Honduras and Nicaragua are estimated to be at least $1.25 billion USD, most of which will be uninsured.

El Salvador

The southern portion of Iota's circulation tapped into deep moisture over the eastern Pacific Ocean, and southwesterly wind flow forced over the mountains produced heavy rains and flooding, which resulted in two deaths and significant damage to agriculture in the country. The Government of El Salvador opened 1,000 shelters with a total capacity for 30,000 people. There was no damage estimate available at the time of this report.

Costa Rica

Similar to the southwest-flow rainfall event that occurred in El Salvador, heavy rains were concentrated along the mountainous Pacific coast of Costa Rica, especially in Guanacaste Province. Widespread flooding and mudslides occurred nationwide, causing water levels to rise above flood stage on 12 rivers. The flash flooding and river flooding required 26 people to be evacuated from the municipality of Corredores, located in Puntarenas Province near the Panama-Costa Rica border, and in the town of and Parrita, which is located southwest of the capital San José. No deaths were reported.

The damage estimate at the time of this report was $16.5 million USD.

Panama

Government officials reported that floodwaters killed one person in Nole Duima in the county (comarca) of Ngäbe-Buglé, located in the western portion of the country. A person was reported missing in nearby Soloy, with the status of that individual still unknown at the time of this report.

There was no specific damage estimate available at the time of this report.

Guatemala

Two people died and two more were reported missing due to a mudslide that occurred in the village of El Carmen Jalauté de Purulhá in Baja Verapaz department on 18 November (Fig. 23). Severe flooding was reported in the Río Hondo municipality in the department of Zacapa. Numerous swift water rescues occurred across the eastern portion of the country.

There was no specific damage estimate available at the time of this report.

Mexico

The states of Chiapas, Tabasco, and Veracruz, located in the extreme southeastern portion of the country, incurred appreciable effects from Iota's heavy rainfall. Freshwater flooding and mudslides damaged nearly 59,000 homes, which affected 297,000 people, and also blocked roads and cut off access to 135 communities for a few days. No fatalities were reported.

There was no specific damage estimate available at the time of this report.

FORECAST AND WARNING CRITIQUE

Genesis

The genesis of Hurricane Iota was forecast exceptionally well. The disturbance from which tropical cyclone developed was first introduced in the Tropical Weather Outlook in the low (<40%) category 114 h and 66 h in the 120-h and 48-h periods, respectively, prior to genesis (Table 2). The 5-day and 2-day probabilities were raised to the medium category (40%–60%) 102 h and 36 h before genesis occurred and were increased to the high category (>60%) 72 h and 30 h, respectively, before Iota formed. The robust genesis forecasts were, in large part, the result of the favorable environmental conditions forecast by the GFS- and ECMWF-based SHIPS intensity model forecasts, which were indicating sea-surface temperatures near 30°C, low vertical wind shear conditions of generally <10 kt (Fig. 4), a moderate upper-level divergence pattern, and a relatively slow forward speed <10 kt.

Track and Intensity

A verification of NHC official track forecasts for Iota is given in Table 3a. Official forecast (OFCL) track errors were lower than the mean official errors for the previous 5-yr period at all forecast times. This is surprising, given that the first four forecasts had a pronounced right-of-track bias (Fig. 24). However, by the fifth forecast cycle at 1200 UTC 14 November, NHC forecasters had determined that the atypical southwestward motion was likely coming to an end fairly soon, and the OFCL forecasts began to zero in on the eventual landfall location along the east-central coast of Nicaragua. Although the OFCL track errors were better than average, so were the OCD5 climatology track errors, which is an indication that Iota wasn't a particularly difficult hurricane to forecast for track. A homogeneous comparison of the official track errors with selected guidance models is given in Table 3b. OFCL track forecasts outperformed most of the model guidance at all forecast times except for the ECMWF (EMXI) and the NOAA HFIP Corrected Consensus model (HCCA). Although there was only one homogenous forecast available for verification at the 120-h period, the EMXI, HCCA, and the GFS-ECMWF simple-average (GFEX) models also outperformed OFCL.

A verification of NHC official intensity forecasts (OFCL) for Iota is given in Table 4a. OFCL forecast intensity errors were lower than the mean official errors for the previous 5-yr period at the 24-, 36-, 72-, 96-, and 120-h forecast periods. NHC forecasters performed admirably in predicting the first 30 h of Hurricane Iota's remarkable 42-h rapid intensification phase that occurred between 1800 UTC 14 November and 1200 UTC 16 November, and came within about 12 h of predicting when Iota would reach its peak intensity (Fig. 25). OFCL forecasts also correctly captured the rapid weakening trend at and after Iota's landfall. A homogeneous comparison of the official intensity errors with selected guidance models is given in Table 4b. OFCL intensity errors were generally lower than all of the available intensity guidance.

Watches and Warnings

Coastal tropical cyclone watches and warnings associated with Iota are listed in Table 5. Tropical Storm Watches and Warnings were issued well in advance of Iota for the Colombian archipelago of Providencia, Santa Catalina, and San Andrés, and for portions Central America, which resulted in lead times of about two days in each instance. A Tropical Storm Warning was issued for Providencia-Santa Catalina and San Andrés at 1500 UTC 14 November, resulting in a lead time of 46 h before the onset of sustained tropical-storm-force winds occurred at San Andrés, and about a 39-h lead time for Providencia-Santa Catalina. A Hurricane Watch was issued for Providencia-Santa Catalina and San Andrés at 1800 UTC and 2100 UTC 14 November, respectively, and the Hurricane Watch was upgraded to a Hurricane Warning for Providencia-Santa Catalina at 2100 UTC 14 November. The Hurricane Watch for Providencia-Santa Catalina verified with a lead time of at least 36 h, while the Hurricane Warning lead time was approximately 33 h. The Hurricane Watch for San Andrés did not verify since no hurricane-force winds were observed on that island.

Tropical Storm Watches and Warnings were issued for the portions of the coasts of Nicaragua and Honduras at 1800 UTC 14 November and 0300 UTC 15 November, respectively, while a Hurricane Watch and a Hurricane Warning were issued for the east-central coast of Nicaragua (Sandy Bay Sirpi to Punta Patuca) at 1800 UTC 14 November and 0300 UTC 15 November, respectively. Based on surface observations from the Puerto Cabezas Airport in Nicaragua and reliable reconnaissance aircraft SFMR surface wind data, it is estimated that the Tropical Storm Watch and Tropical Storm Warning verified with lead times of at least 51 h and 42 h, respectively, while the Hurricane Watch and a Hurricane Warning verified with lead times of approximately 54 h and 45 h, respectively.

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ACKNOWLEDGEMENTS

Special thanks to Senior Hurricane Specialist John Cangialosi for producing the Iota "best track" map (Fig. 1). Rainfall data and maps were provided by the national meteorological services of Belize, Costa Rica, El Salvador, Honduras, and Nicaragua.

Table 1. Best track for Hurricane Iota, Hurricane Iota, 13–18 November 2020.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
12 / 1200	15.5	70.9	1009	25	low
12 / 1800	15.3	71.9	1009	25	"
13 / 0000	15.0	72.7	1008	25	"
13 / 0600	14.7	73.3	1007	25	"
13 / 1200	14.4	73.7	1006	30	tropical depression
13 / 1800	14.0	74.1	1005	35	tropical storm
14 / 0000	13.6	74.5	1005	35	"
14 / 0600	13.3	75.0	1004	35	"
14 / 1200	12.9	75.7	1002	40	"
14 / 1800	12.5	76.4	997	45	"
15 / 0000	12.6	76.7	992	55	"
15 / 0600	13.0	77.1	988	65	hurricane
15 / 1200	13.1	78.0	982	70	"
15 / 1800	13.2	78.9	974	75	"
16 / 0000	13.2	79.8	961	90	"
16 / 0600	13.4	80.7	935	120	"
16 / 1200	13.5	81.5	917	135	"
16 / 1800	13.5	82.3	918	130	"
17 / 0000	13.6	83.0	918	130	"
17 / 0340	13.6	83.5	922	125	"
17 / 0600	13.7	83.8	935	110	"
17 / 1200	13.7	84.7	965	75	"
17 / 1800	13.7	85.7	988	55	tropical storm
18 / 0000	13.8	86.7	1000	40	"
18 / 0600	13.8	87.8	1005	35	"
18 / 1200	13.7	89.0	1006	25	tropical depression
18 / 1800					dissipated
17 / 0340	13.6	83.5	921	125	landfall near Haulover, Nicaragua
16 / 1200	13.5	81.5	917	135	minimum pressure & maximum wind

Table 2. Number of hours in advance of formation of Iota 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%)	66	114
Medium (40%-60%)	36	102
High (>60%)	30	72

Table 3a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Hurricane Iota, 13–18 November 2020. 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	60	72	96	120
OFCL	**23.3**	**30.8**	**39.8**	**54.5**	**72.0**	**88.2**	**109.2**	**72.5**
OCD5	34.5	57.8	81.4	124.7	186.5	244.5	311.9	349.7
Forecasts	19	17	15	13	11	9	5	1
OFCL (2015-19)	24.1	36.9	49.6	65.1	80.7	96.3	133.2	171.6
OCD5 (2015-19)	44.7	96.1	156.3	217.4	273.9	330.3	431.5	511.9

Table 3b. Homogeneous comparison of selected track forecast guidance models (in n mi) for Hurricane Iota, 13–18 November 2020. 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	60	72	96	120
OFCL	23.9	31.6	41.1	56.6	74.5	88.2	109.2	72.5
OCD5	34.3	56.3	77.6	119.8	178.3	225.6	311.9	349.7
GFSI	28.8	40.5	53.4	68.4	87.0	101.4	127.0	98.8
EMXI	26.2	**30.4**	**38.4**	**41.5**	**52.1**	**56.4**	**60.9**	**49.4**
NVGI	34.9	52.0	67.2	74.7	106.2	136.4	166.5	254.5
CMCI	31.0	39.0	57.2	73.8	84.2	91.1	**107.3**	90.7
AEMI	24.7	34.7	45.9	66.6	86.5	102.7	140.9	138.1
HWFI	35.6	56.8	77.8	105.6	139.2	159.6	216.6	308.8
HMNI	31.5	44.8	57.7	82.2	108.6	136.2	179.9	293.3
CTCI	25.9	39.2	50.5	68.4	**74.2**	89.9	112.1	131.9
TVCA	25.3	36.1	46.7	63.3	78.0	90.1	113.0	100.9
TVCX	26.2	36.1	44.6	60.1	**74.4**	**84.1**	**102.1**	88.0
GFEX	26.4	33.5	44.0	**54.9**	**68.1**	**75.2**	**88.0**	**29.7**
HCCA	24.8	**28.8**	**35.9**	**45.5**	**58.8**	**65.3**	**73.4**	**39.4**
TABS	37.6	75.9	124.1	168.0	195.7	206.1	214.2	163.5
TABM	26.7	45.2	76.9	115.8	145.4	158.1	173.6	140.0
TABD	28.1	46.0	68.3	100.5	132.1	154.0	153.8	81.4
Forecasts	18	16	14	12	10	8	5	1

Table 4a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) intensity forecast errors (kt) for Hurricane Iota, 13–18 November 2020. 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	60	72	96	120
OFCL	6.6	**7.4**	**9.0**	13.5	15.5	**12.2**	**13.0**	**0.0**
OCD5	9.1	18.2	25.5	32.8	44.8	54.2	11.4	32.0
Forecasts	19	17	15	13	11	9	5	1
OFCL (2015-19)	5.2	7.7	9.4	10.7	11.9	13.0	14.4	15.5
OCD5 (2015-19)	6.8	10.8	14.1	17.0	18.8	20.6	22.5	24.6

Table 4b. Homogeneous comparison of selected intensity forecast guidance models (in kt) for Hurricane Iota, 13–18 November 2020. 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	60	72	96	120
OFCL	6.7	7.8	7.5	12.9	16.5	13.1	13.0	0.0
OCD5	9.2	18.1	22.9	30.9	48.9	57.2	**11.4**	32.0
HWFI	8.7	12.4	15.9	25.6	24.1	28.1	59.8	82.0
HMNI	9.4	12.9	16.3	18.7	20.2	20.1	46.2	82.0
DSHP	8.6	10.2	10.7	16.0	24.8	25.0	**12.8**	3.0
LGEM	8.1	11.9	14.9	19.6	27.7	26.6	13.2	2.0
ICON	8.1	11.3	13.4	17.2	24.3	21.1	23.0	42.0
IVCN	8.2	11.8	13.9	16.3	22.8	20.6	19.8	38.0
CTCI	10.3	14.2	17.4	15.3	**16.2**	19.4	**8.2**	20.0
GFSI	14.5	26.6	32.0	28.9	30.8	29.0	**7.6**	9.0
EMXI	15.8	29.6	37.1	40.7	46.7	49.8	14.4	3.0
HCCA	8.4	10.7	11.3	**12.5**	20.0	18.9	25.6	47.0
Forecasts	18	16	14	12	10	8	5	1

Table 5. Summary of wind watches and warnings for Hurricane Iota, 13–18 November 2020.

Date/Time (UTC)	Action	Location
14 / 1500	Tropical Storm Warning issued	San Andres to Providencia (Colombian Islands)
14 / 1800	Tropical Storm Watch issued	Punta Patuca, Honduras to Punta Castilla, Honduras
14 / 1800	Hurricane Watch issued	Sandy Bay Sirpi, Nicaragua to Punta Patuca, Honduras
14 / 1800	Hurricane Watch issued	Providencia
14 / 2100	Tropical Storm Warning changed to Hurricane Watch	San Andres
14 / 2100	Tropical Storm Warning changed to Hurricane Warning	Providencia
14 / 2100	Tropical Storm Warning issued	San Andres
14 / 2100	Hurricane Watch discontinued	Providencia
15 / 0300	Tropical Storm Watch changed to Tropical Storm Warning	Punta Patuca to Punta Castilla
15 / 0300	Hurricane Watch changed to Hurricane Warning	Sandy Bay Sirpi to Punta Patuca
15 / 0300	Tropical Storm Warning issued	Bluefields, Nicaragua to Sandy Bay Sirpi, Nicaragua
16 / 1500	Tropical Storm Warning modified to	Punta Patuca to Guatamala/Honduras Border
16 / 2100	Hurricane Watch changed to Tropical Storm Warning	San Andres
16 / 2100	Hurricane Warning changed to Tropical Storm Warning	Providencia

17 / 0900	Tropical Storm Warning discontinued	San Andres
17 / 0900	Tropical Storm Warning discontinued	Providencia
17 / 1500	Tropical Storm Warning modified to	Bluefields, Nicaragua to Guatemala/Honduras Border
17 / 1500	Tropical Storm Warning modified to	Bluefields to Guatemala/Honduras Border
17 / 1500	Hurricane Warning discontinued	All
17 / 2100	Tropical Storm Warning modified to	Nicaragua/Honduras Border to Guatemala/Honduras Border
18 / 0300	Tropical Storm Warning modified to	Punta Castilla, Honduras to Guatemala/Honduras Border
18 / 0900	Tropical Storm Warning discontinued	All

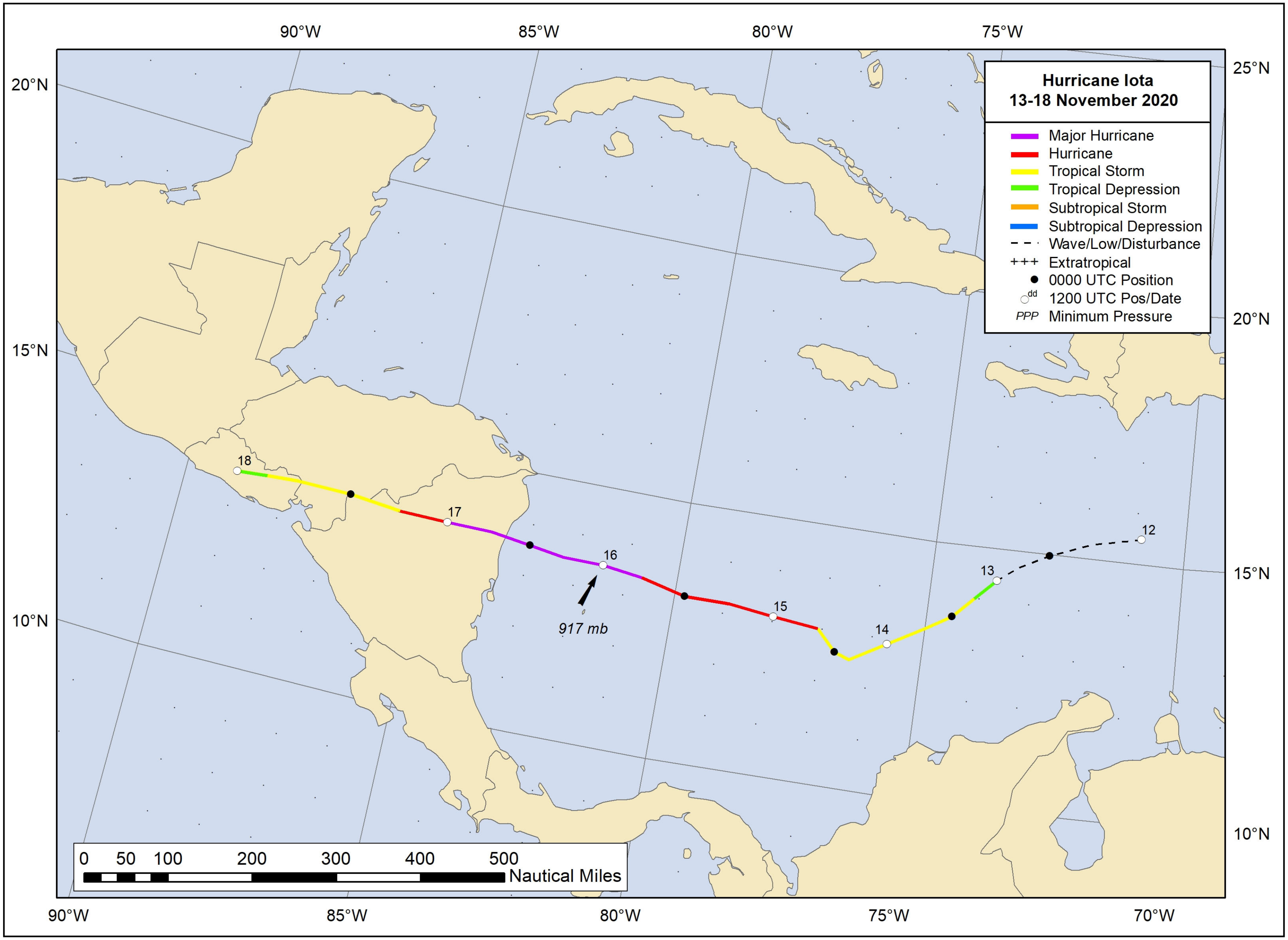

Figure 1. Best track positions for Hurricane Iota, 13–18 November 2020.

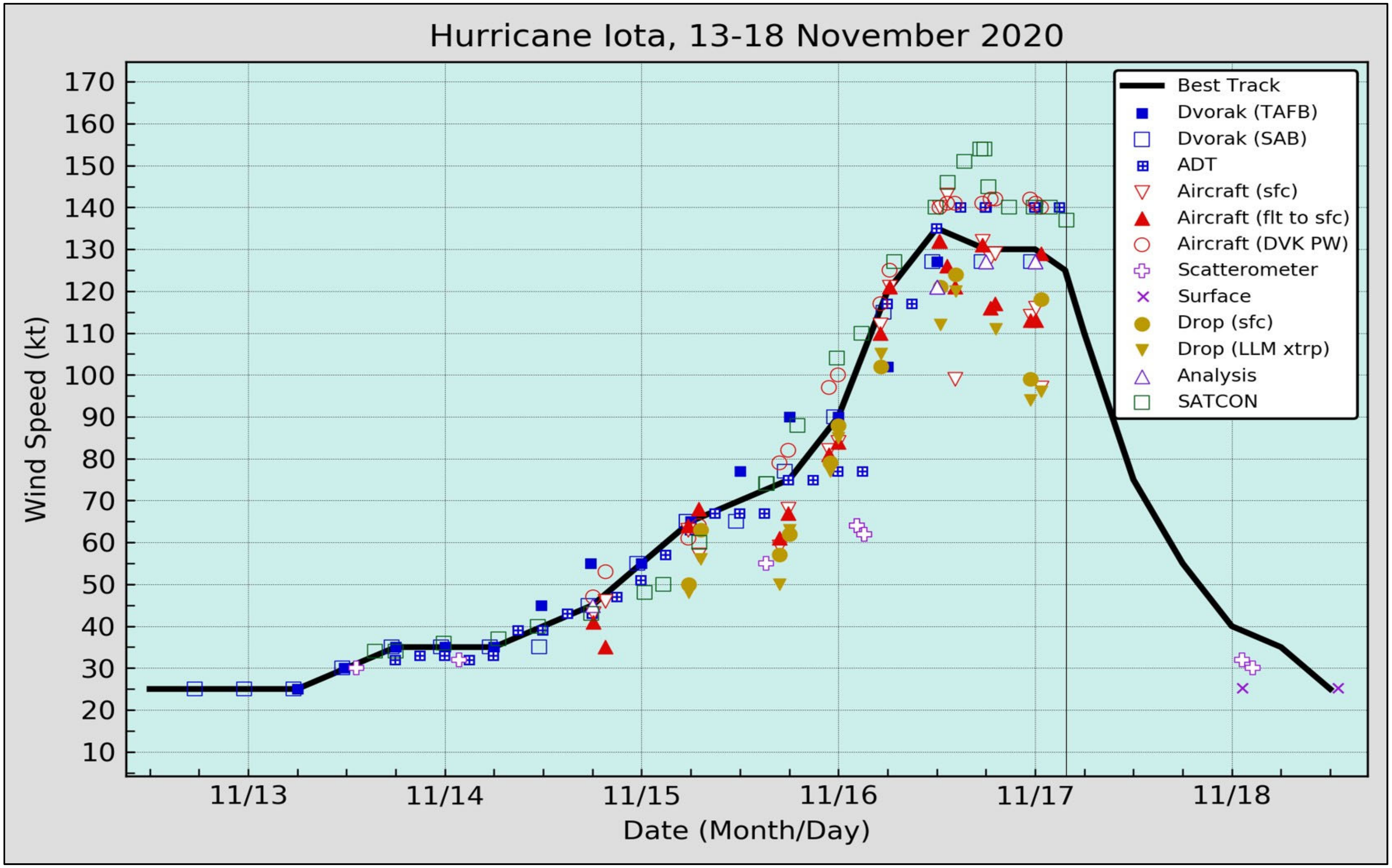

Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Hurricane Iota, 13–18 November 2020. Aircraft observations have been adjusted for elevation using 90%, 80%, and 80% adjustment factors for observations from 700 mb, 850 mb, and 1500 ft, respectively. Dropwindsonde observations include actual 10 m winds (sfc), as well as surface estimates derived from the mean wind over the lowest 150 m of the wind sounding (LLM). Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. SATCON intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies. Dashed vertical lines correspond to 0000 UTC. Solid vertical line indicates landfall.

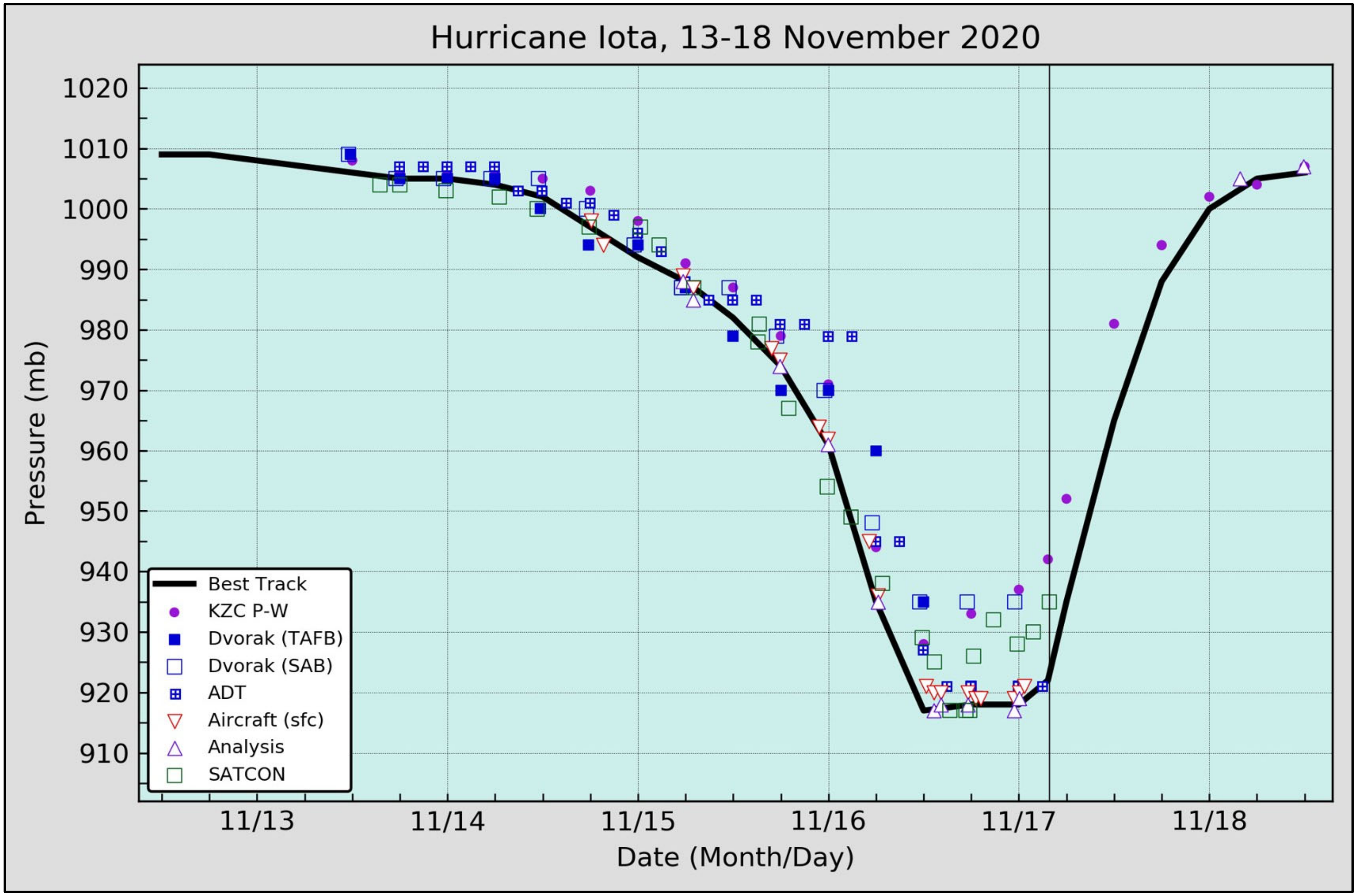

Figure 3. Selected pressure observations and best track minimum central pressure curve for Hurricane Iota, 13–18 November 2020. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. SATCON intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies. KZC P-W refers to pressure estimates derived using the Knaff-Zehr-Courtney pressure-wind relationship. Dashed vertical lines correspond to 0000 UTC. Solid vertical line indicates landfall.

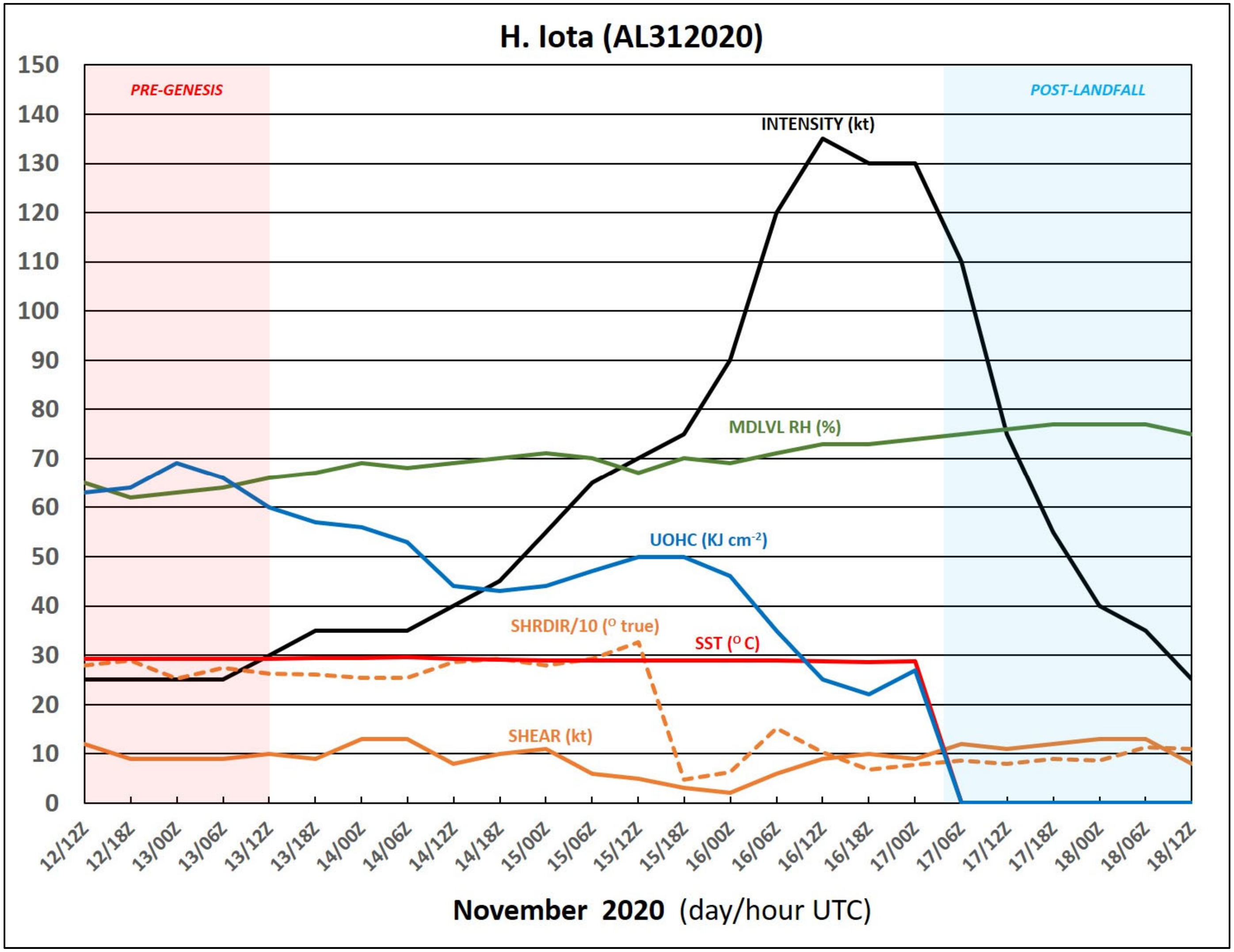

Figure 4. Graph of the **INTENSITY** (kt) versus GFS-based SHIPS model parameters for Hurricane Iota during the period 12–18 November 2020. **SHEAR** is 850–200–mb vertical wind shear (kt); **SHRDIR/10** is the actual shear direction (dashed line; degrees true) divided by 10; **SST** is sea-surface temperature (°C); **UOHC** is upper ocean heat content (KJ cm^{-2},); **MDLVL RH** is 700–500–mb average relative humidity (%). Light-red shaded region represents the pre-genesis period (left) and the light-blue shaded region represents the post-landfall period (right).

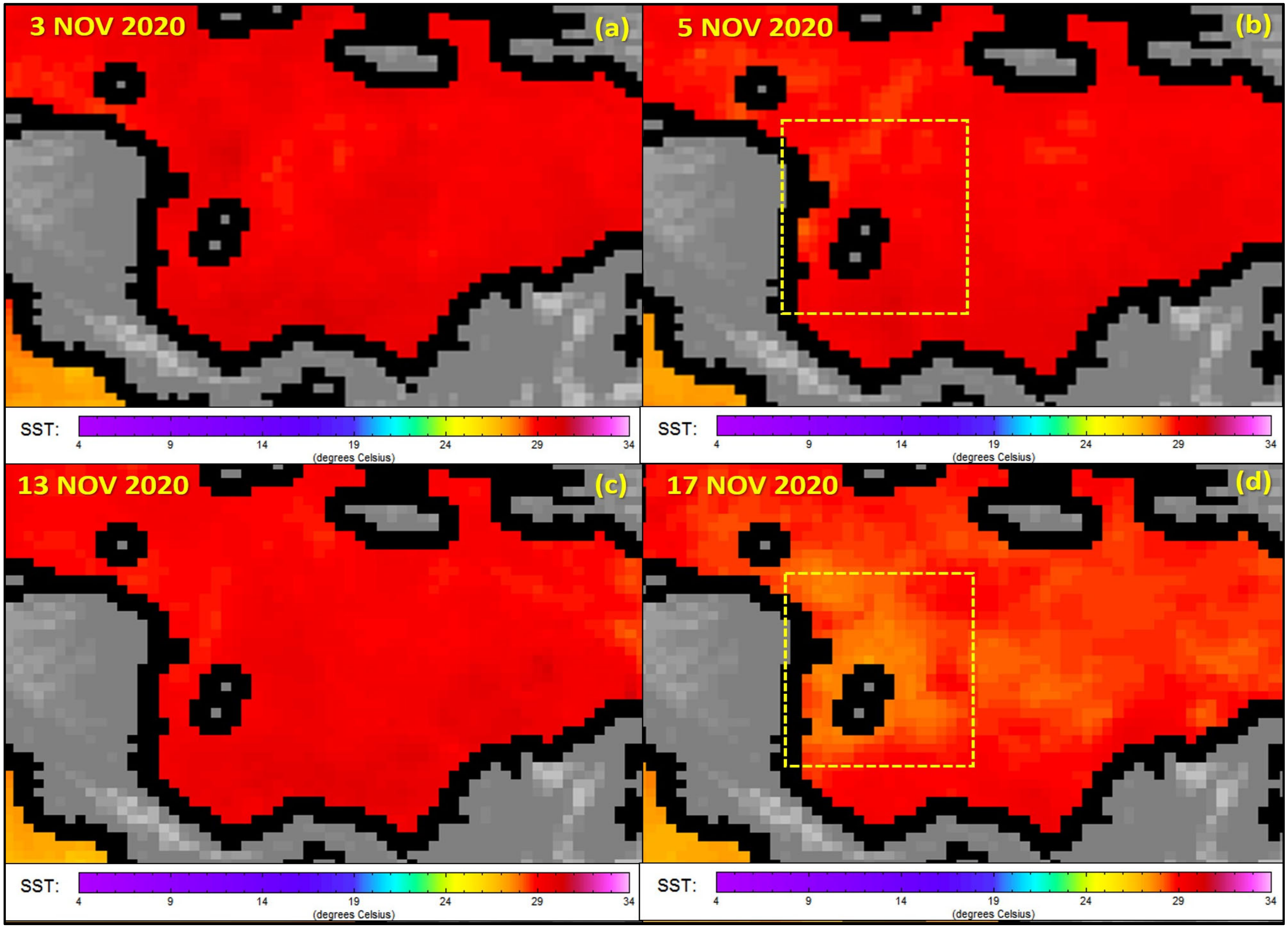

Figure 5. Sea-surface temperature (°C) analyses for Hurricane Eta on 3 November before landfall (a) in Nicaragua and on 5 November 2020 after landfall (b), and for Hurricane Iota on 13 November before landfall (c) in Nicaragua and on 17 November 2020 after landfall (d). The yellow-dashed rectangle indicates area of affected by both Eta and Iota; note area of significant cooling caused by upwelling generated by Hurricane Iota on 17 November. Images courtesy of Remote Sensing Systems, Santa Rosa, CA.

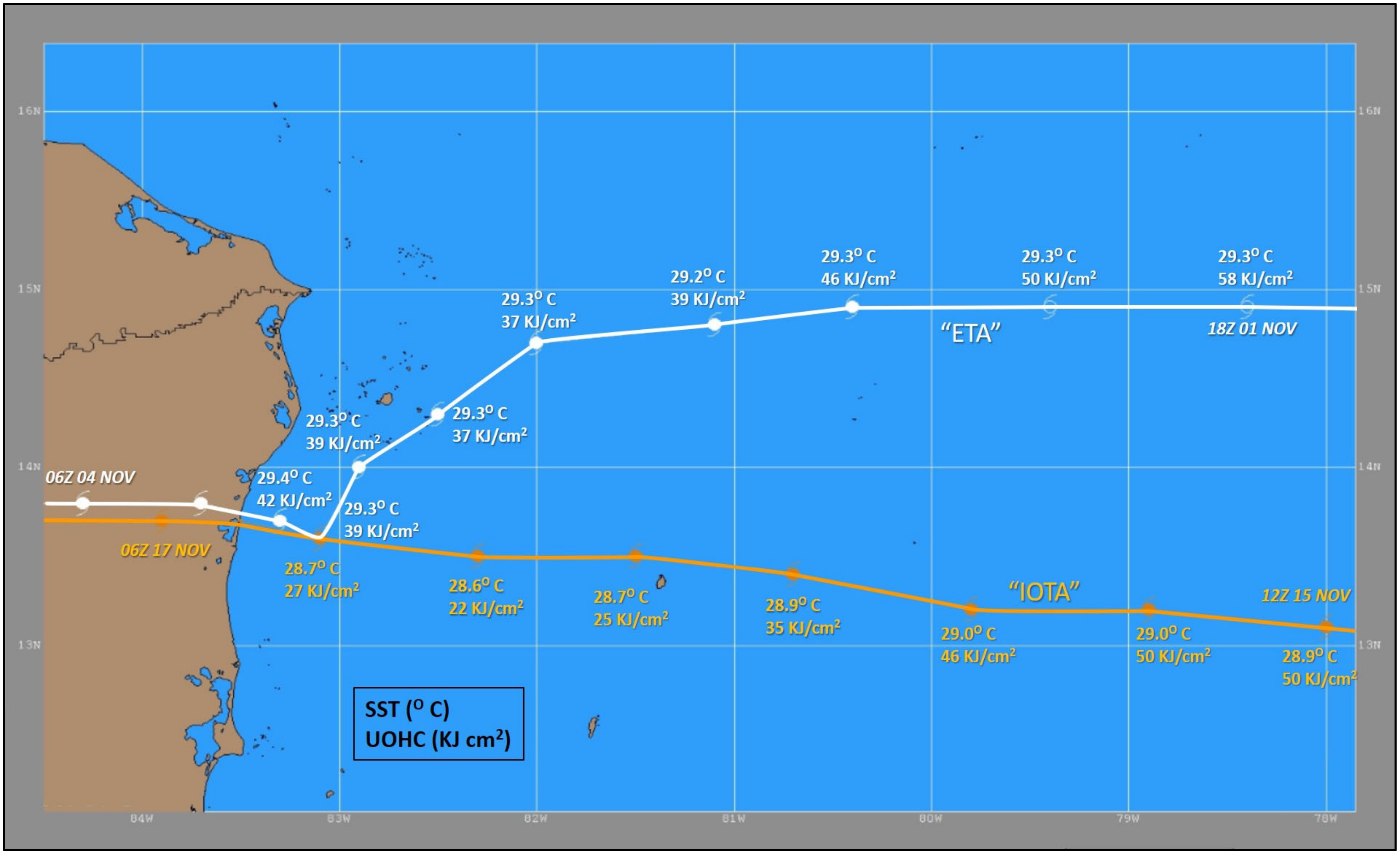

Figure 6. Plots of the 'best tracks' for Hurricane Eta, 1–4 November 2020, and Hurricane Iota, 15–17 November 2020. Sea-surface temperatures (SST °C) and Upper-Ocean Heat Content (UOHC KJ cm^{-2}) values are superimposed along the tracks at the respective 6-h synoptic times. The southern portion of Eta's circulation generated mixing and upwelling around Providencia as indicated by the slightly lower SSTs and by the 30% lower UOHC values along Iota's track.

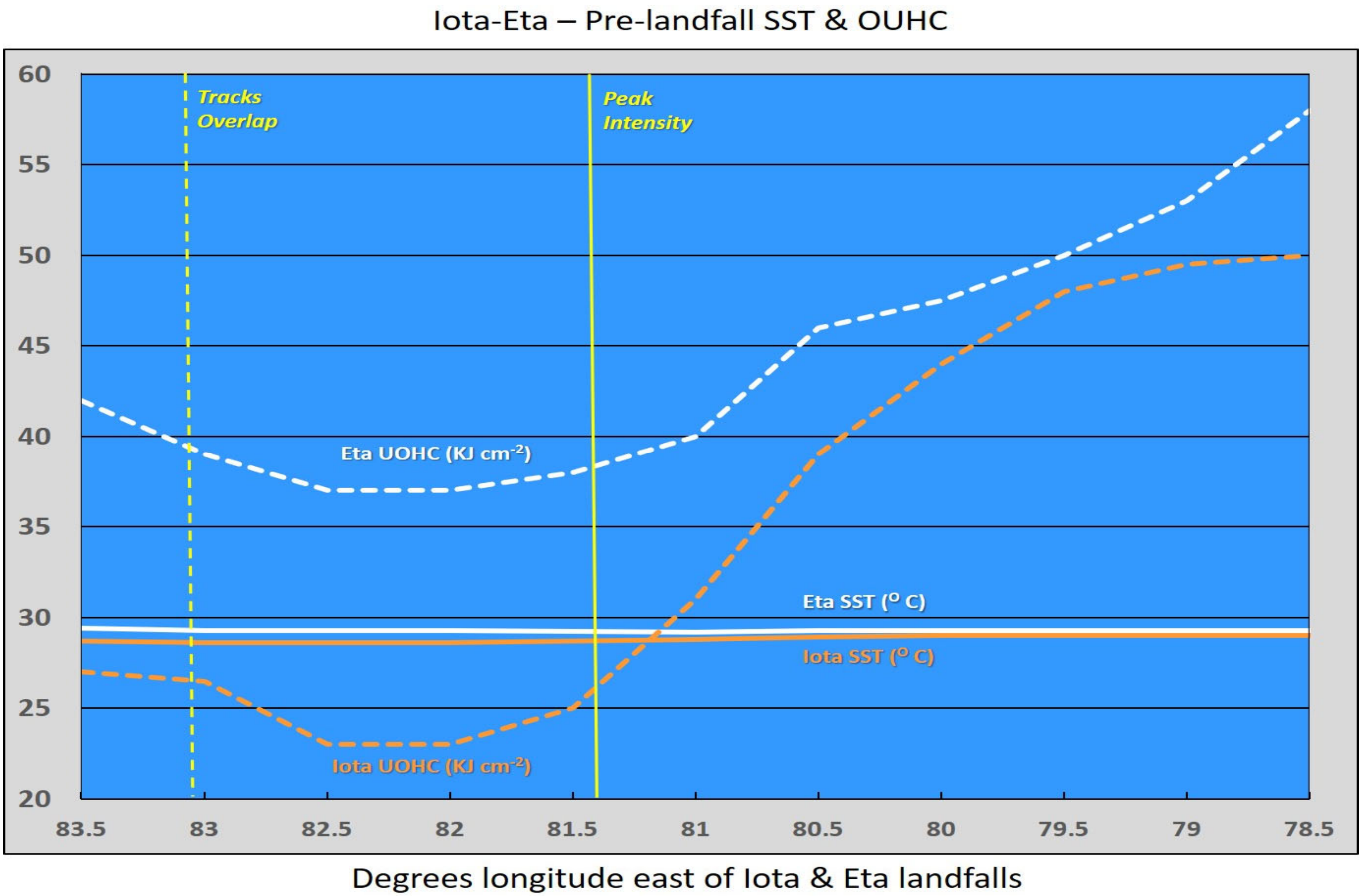

Figure 7. Graphs of the Sea-Surface Temperatures (SST °C) and Upper-Ocean Heat Content (UOHC KJ cm-2) values for Hurricane Eta and Hurricane Iota contained in Figure 7. Data values are plotted along the longitudes east of the landfall longitude (approx. 83.5° W) for each hurricane. Solid-yellow line indicates longitude of Iota's peak intensity and dashed-yellow line indicates the longitude where the tracks of Hurricanes Iota and Eta overlapped leading up to the two landfalls along ~83.5W longitude.

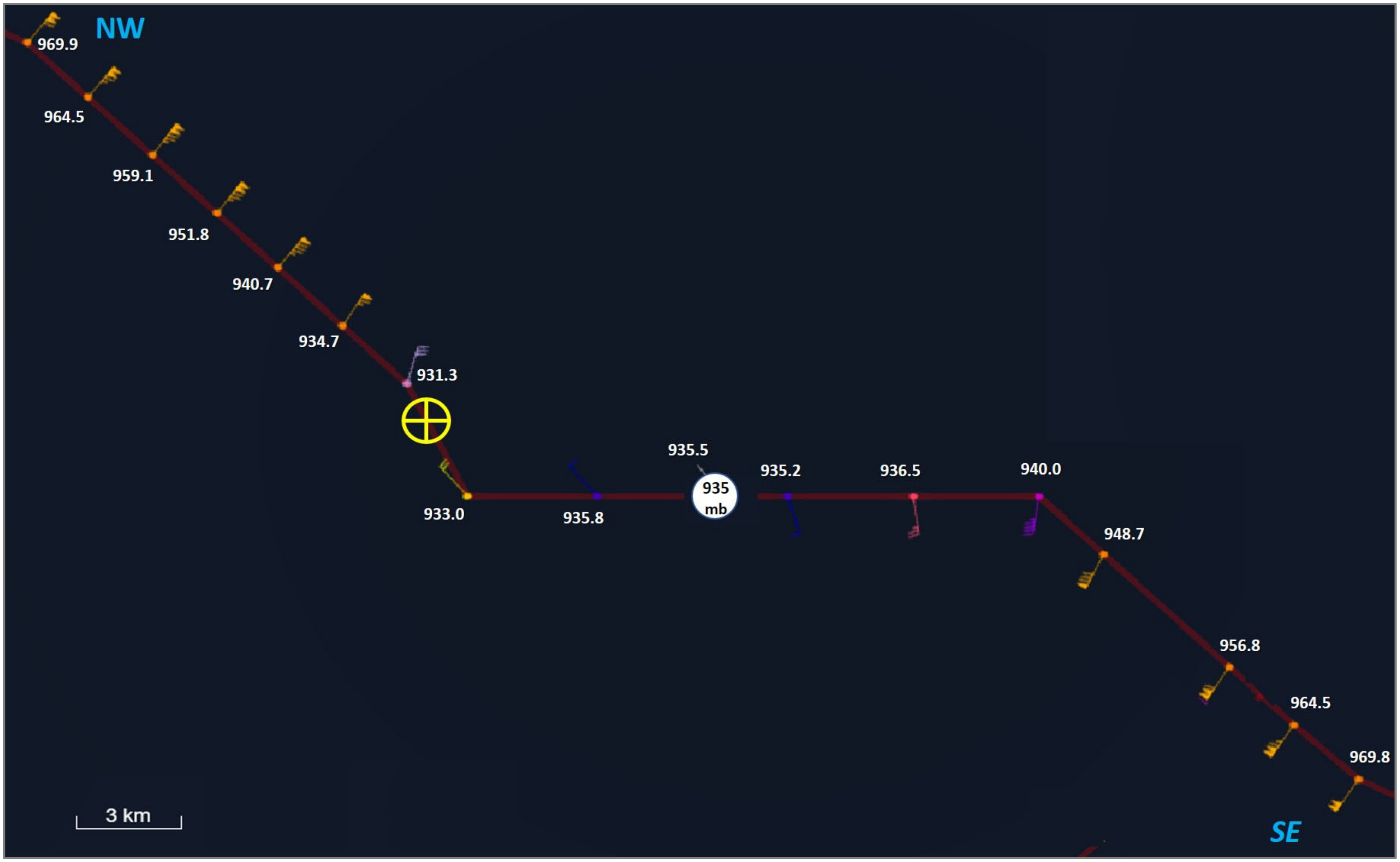

Figure 8a. USAFR reconnaissance flight track with excerpts of wind (kt, standard notation) and extrapolated surface pressure (mb, white numerals) plots between 0609:00 UTC and 0628:30 UTC on 16 November 2020. The data reveal that a pronounced mesovortex (yellow circled-cross) existed in the northwestern portion of Hurricane Iota's eyewall, which was also coincident with a localized increase in lightning activity. The pressure of the eyewall mesovortex was approximately 931 mb, which was at least 4 mb lower than the eye dropsonde-estimated central pressure of 935 mb (solid-white circle). Data plot courtesy of *tropicalatlantic.com*.

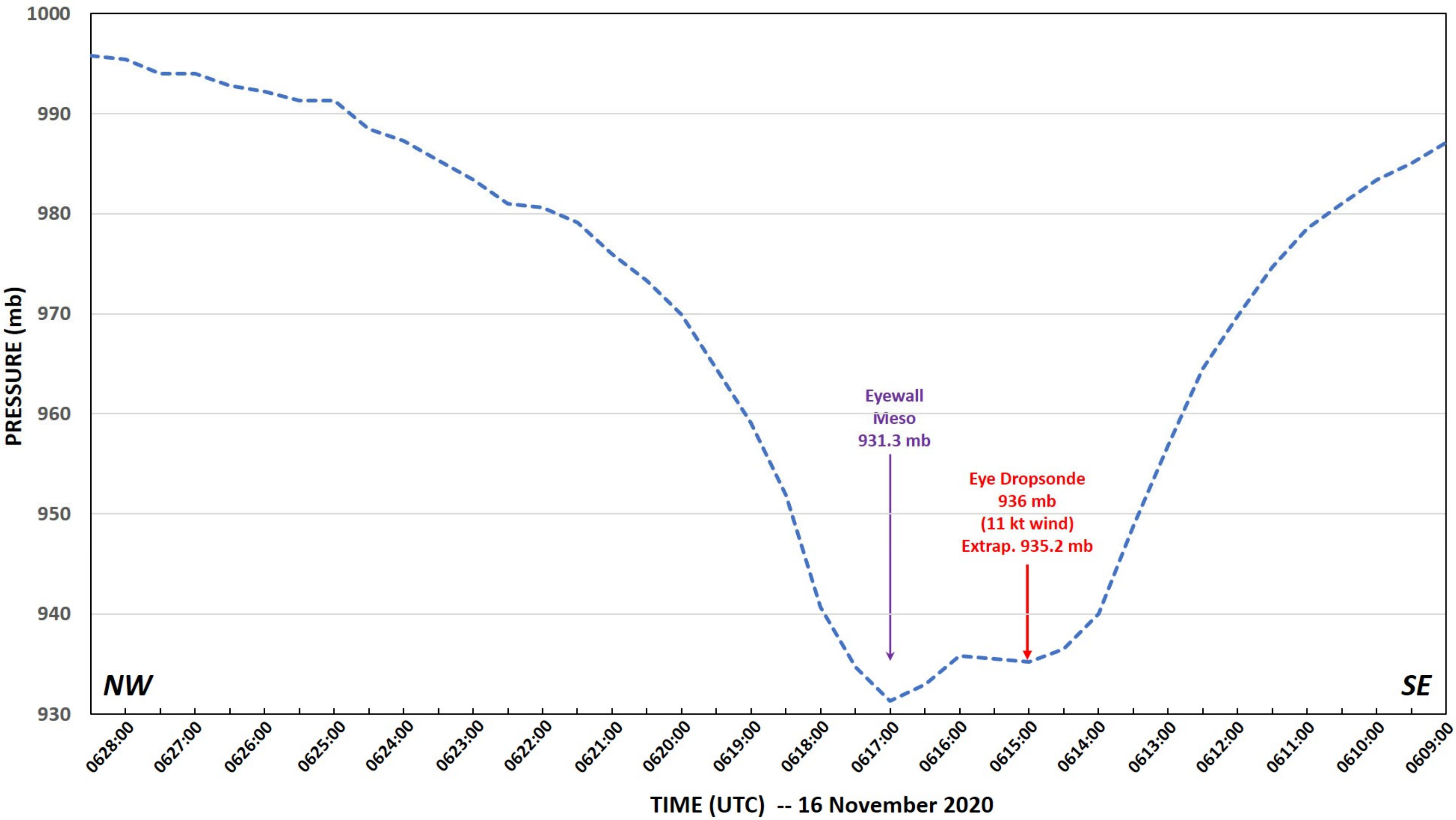

Figure 8b. Aircraft-extrapolated surface pressure plot from 0609:00 UTC to 0628:30 UTC 16 November 2020 (in 30-second time intervals) along flight track shown in Figure 8a. Time increases from right to left to coincide with the southeast-to-northwest (*SE-NW*) track of the reconnaissance aircraft. The central pressure in the eye as measured by a dropwindsonde was estimated to be 935 mb based on a pressure measurement of 936 mb and an associated 11-kt surface wind, which correlates with the 935.2-mb aircraft-extrapolated surface pressure at 0615:00 UTC. An eyewall mesovortex associated with a pressure perturbation of approximately -4 mb was located northwest of the center of the eye at 0617:00 UTC.

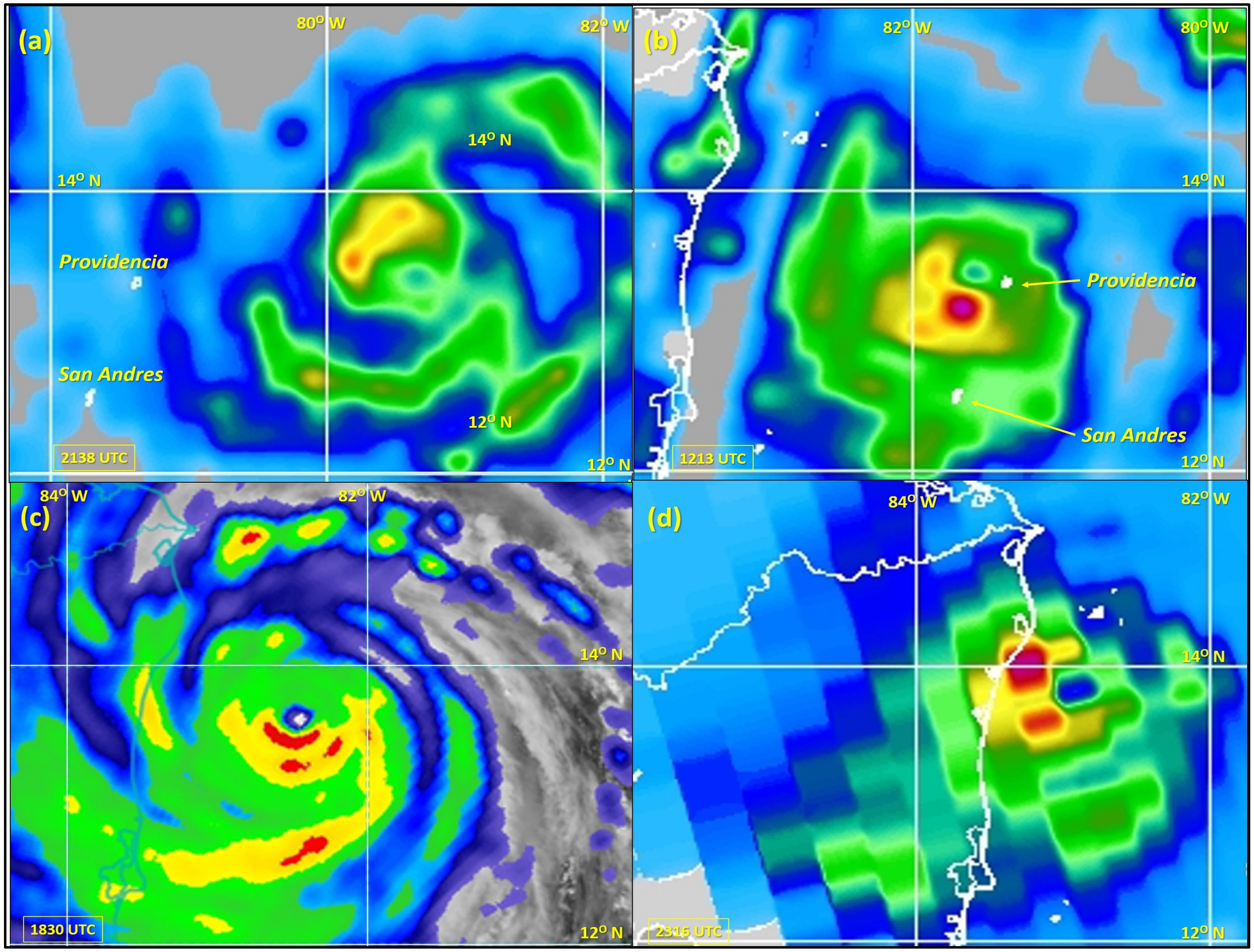

Figure 9. Passive microwave satellite imagery showing the evolution of Hurricane Iota's asymmetrical inner-core convection: (a) 2138 UTC 15 November SSMI/S Rain Rate product showing rainfall rates of about 1.0 in hr^{-1} in the band located in the northern semicircle; (b) 1213 UTC 16 November SSMI/S Rain Rate product with rainfall rates of >1.4 inch hr^{-1} in the band in the southern semicircle; (c) 1830 UTC 16 November AMSR-2 89 GHz PCT image showing persistent, intense convection in the southern semicircle; (d) 2316 UTC 16 November AMSU Rain Rate product showing intense convection southwest and west of the eye that contained rainfall rates of >1.4 inch hr^{-1} along the coast of Nicaragua just east of Puerto Cabezas.

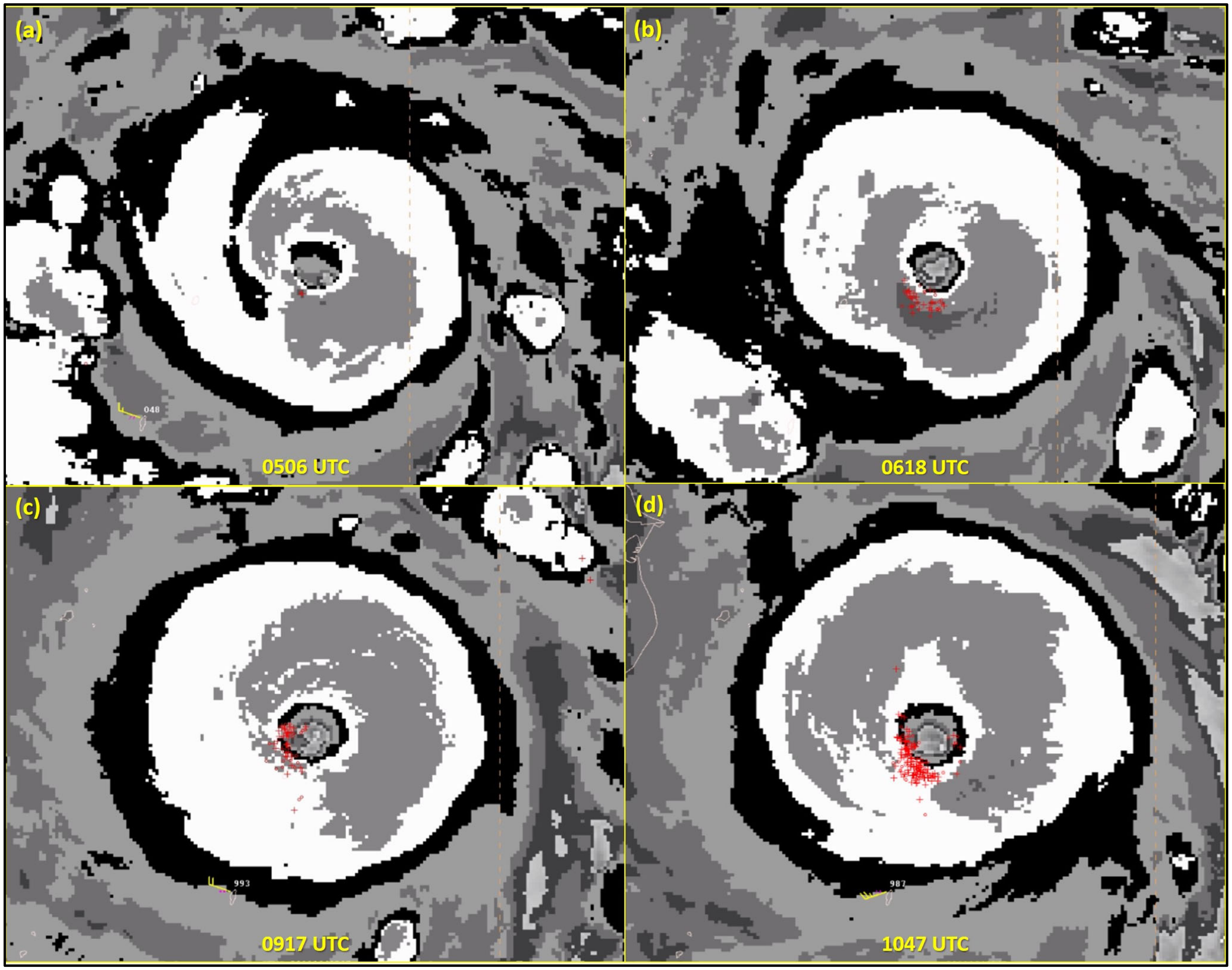

Figure 10. GOES-16 infrared satellite imagery with superimposed 5-minute lightning data (red X's and circles) during Hurricane Iota's rapid intensification (RI) period on 16 November: (a) 0506 UTC, (b) 0618 UTC, (c) 0917 UTC, and (d) 1047 UTC. Lightning began about 0500 UTC in the southwestern quadrant of Iota's eyewall and persisted in that quadrant until RI ended around 1200 UTC later that day.

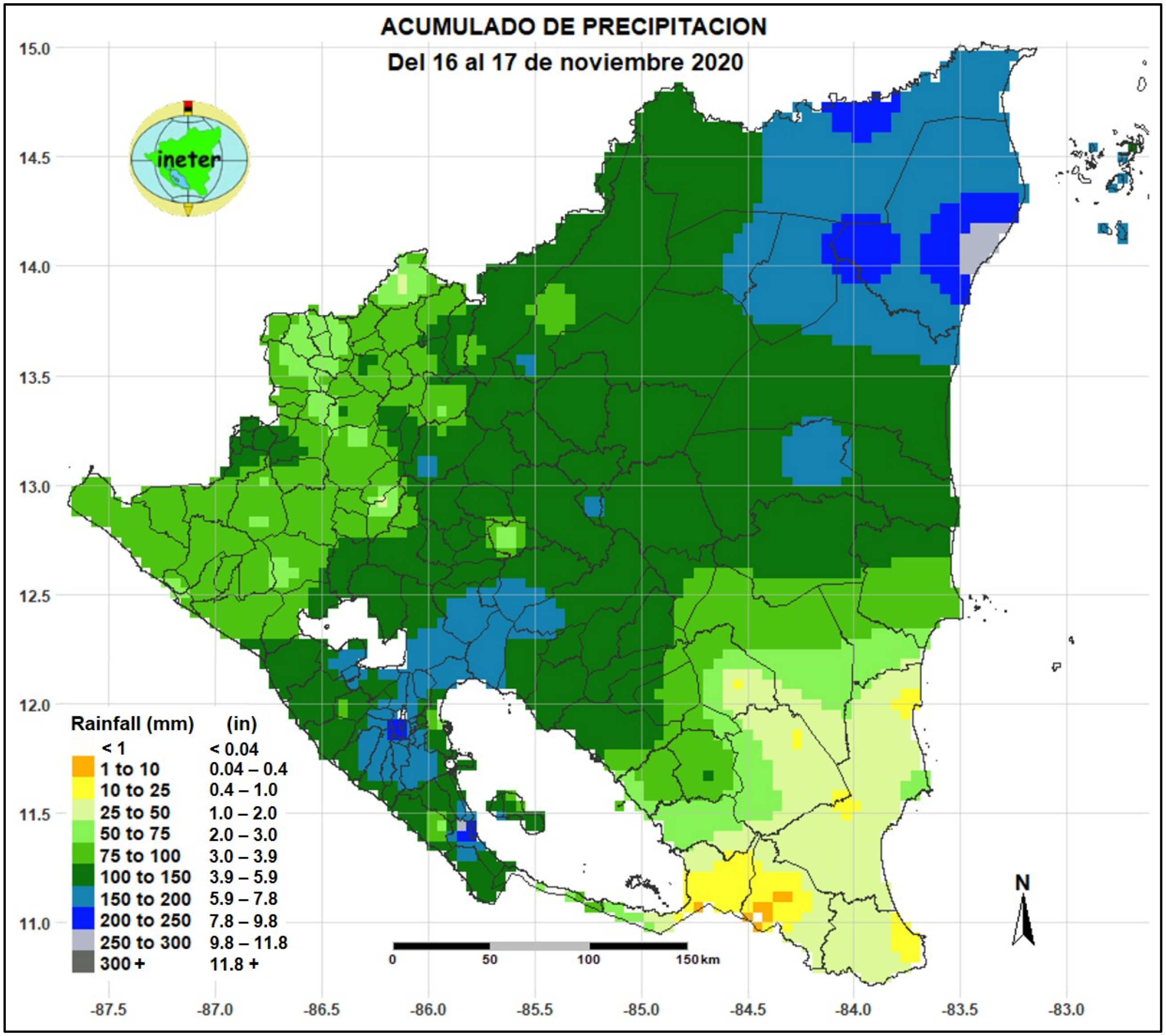

Figure 11. Nicaragua rainfall totals associated with Hurricane Iota during the period 16-17 November 2020. Graphic courtesy of Instituto Nicaraguënse de Estudios Territoriales/INETER (Nicaraguan Institute of Territorial Studies).

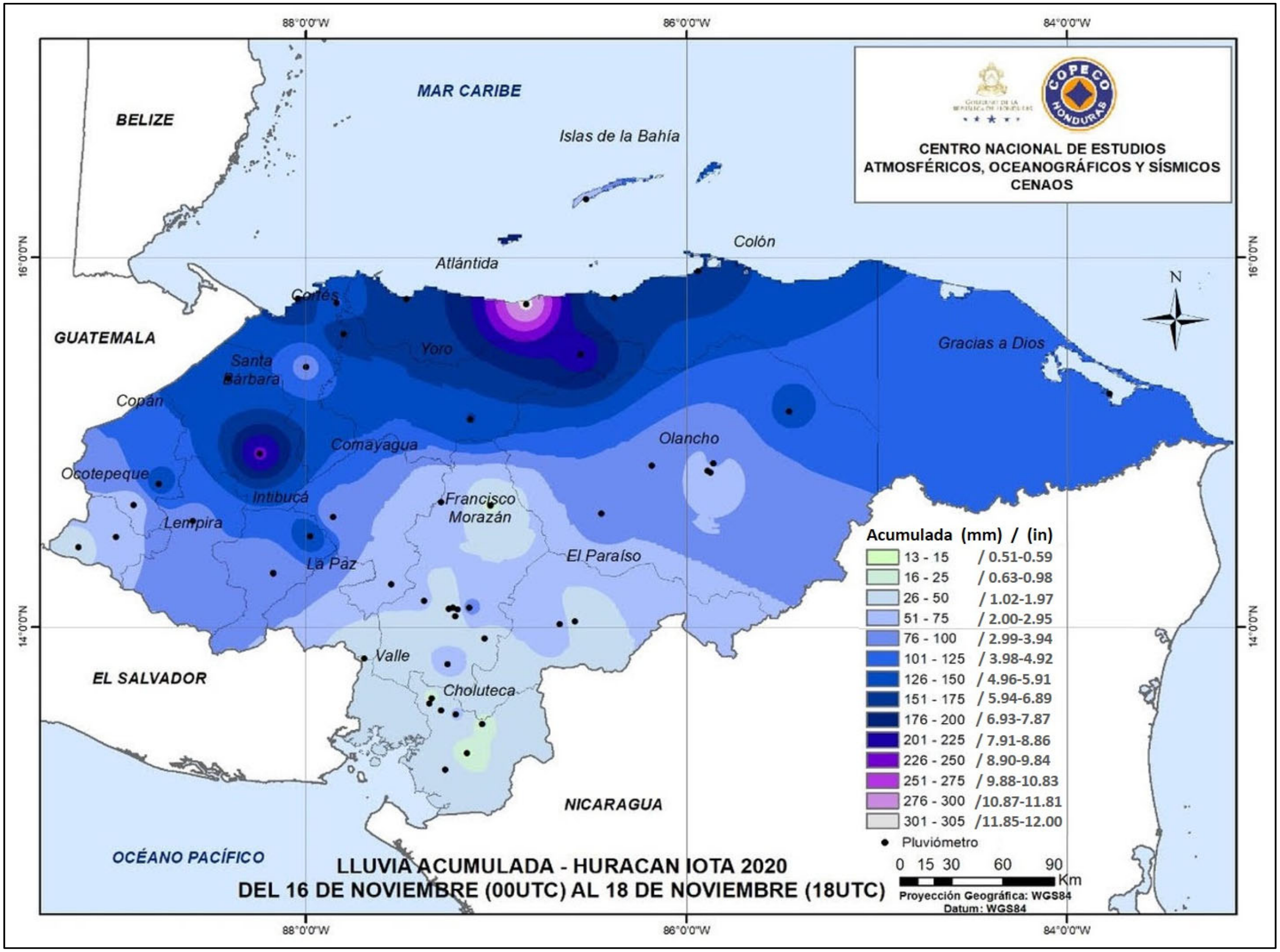

Figure 12. Honduras rainfall totals associated with Hurricane Iota during the period 16–18 November 2020. Graphic courtesy of Centro de Estudios Atmosféricos, Oceanográficos y Sísmicos/CENAOS (Honduras Center for Atmospheric, Oceanographic and Seismic Studies).

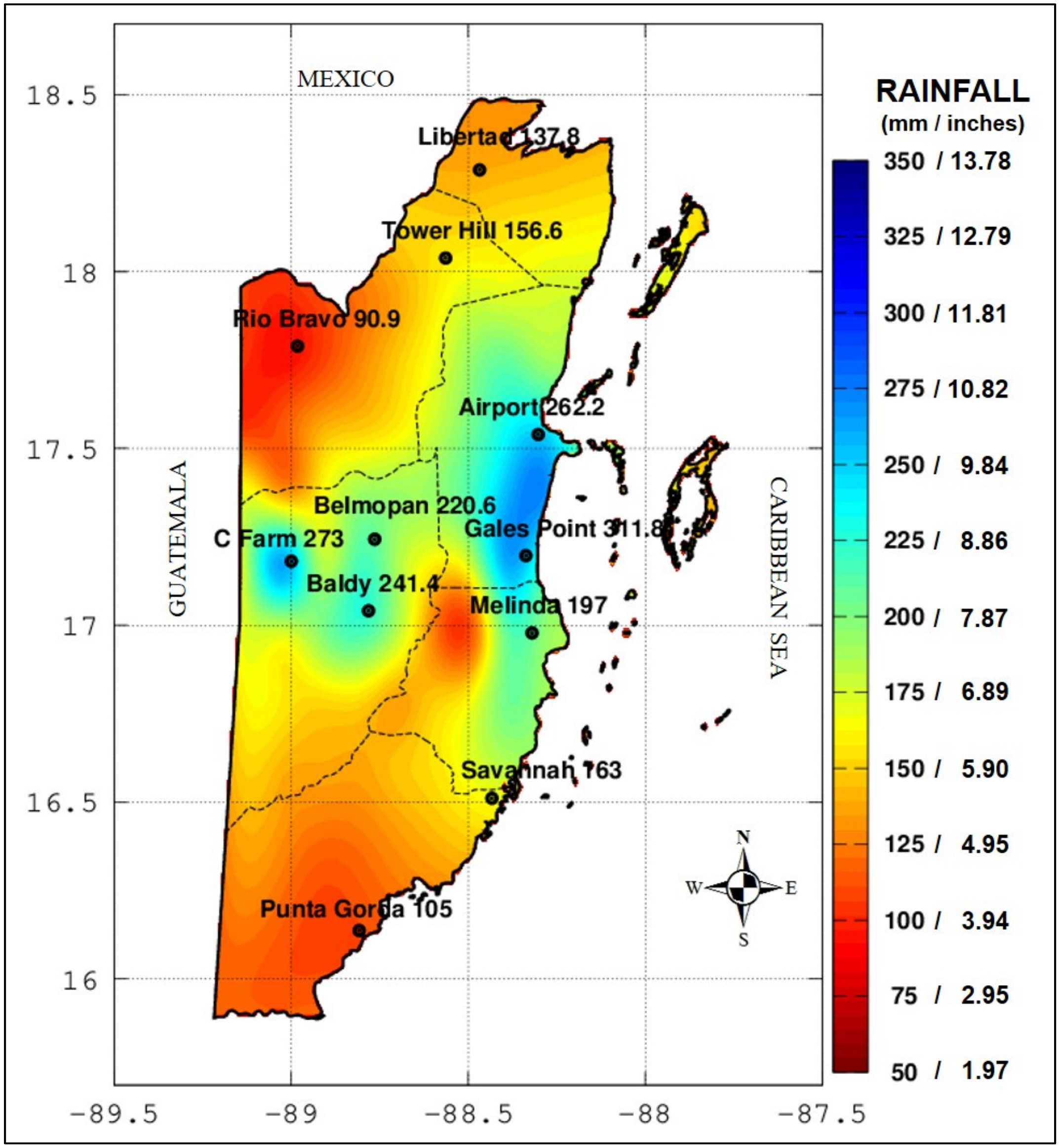

Figure 13. Belize rainfall totals (mm/inches) associated with Hurricane Iota during the period 16–20 November 2020. Graphic courtesy of National Meteorological Service of Belize.

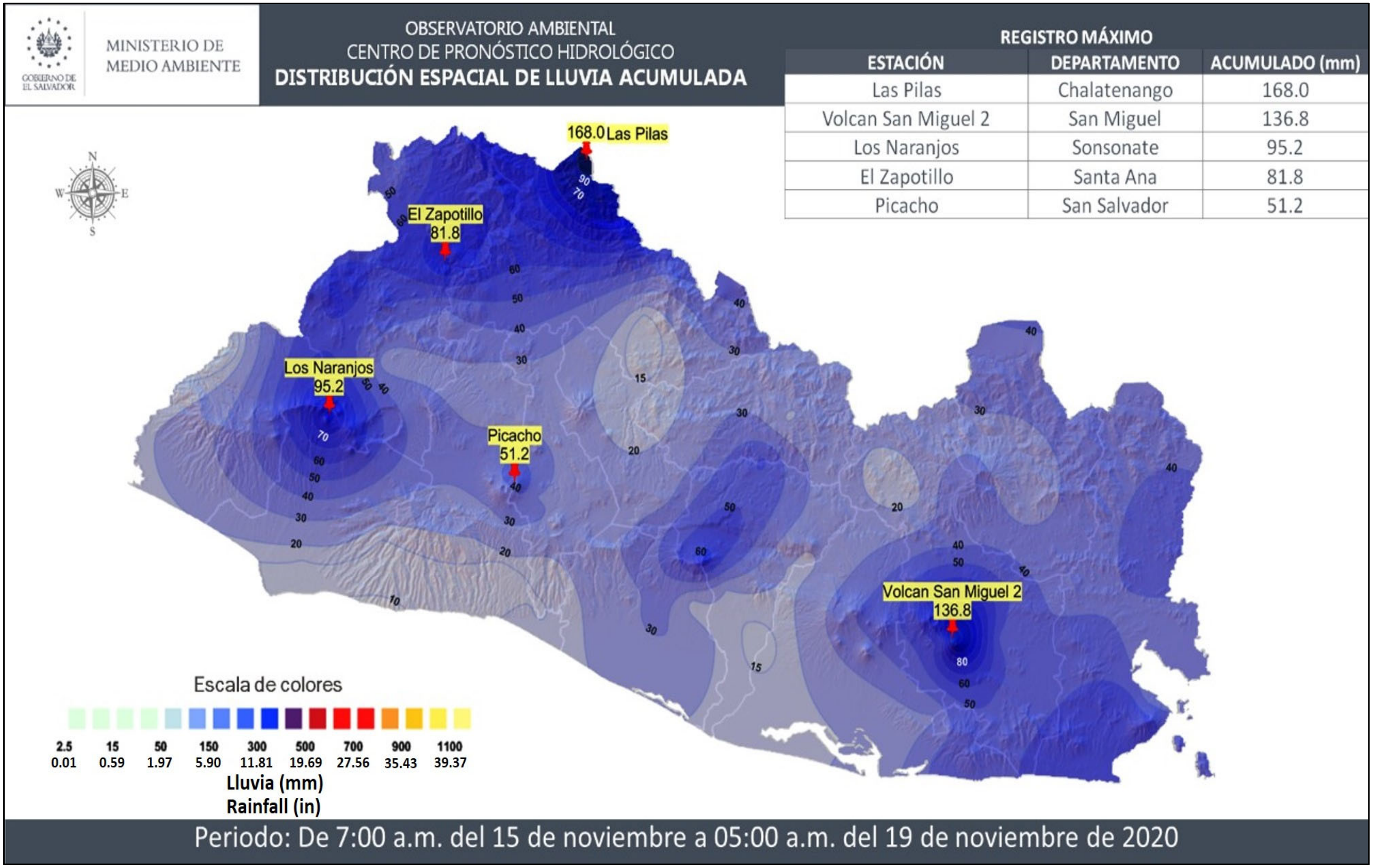

Figure 14. El Salvador rainfall totals associated with Hurricane Iota during the period 15–19 November 2020. Graphic courtesy of Centro De Pronóstico Hidrológico de El Salvador (El Salvador Hydrological Forecast Center).

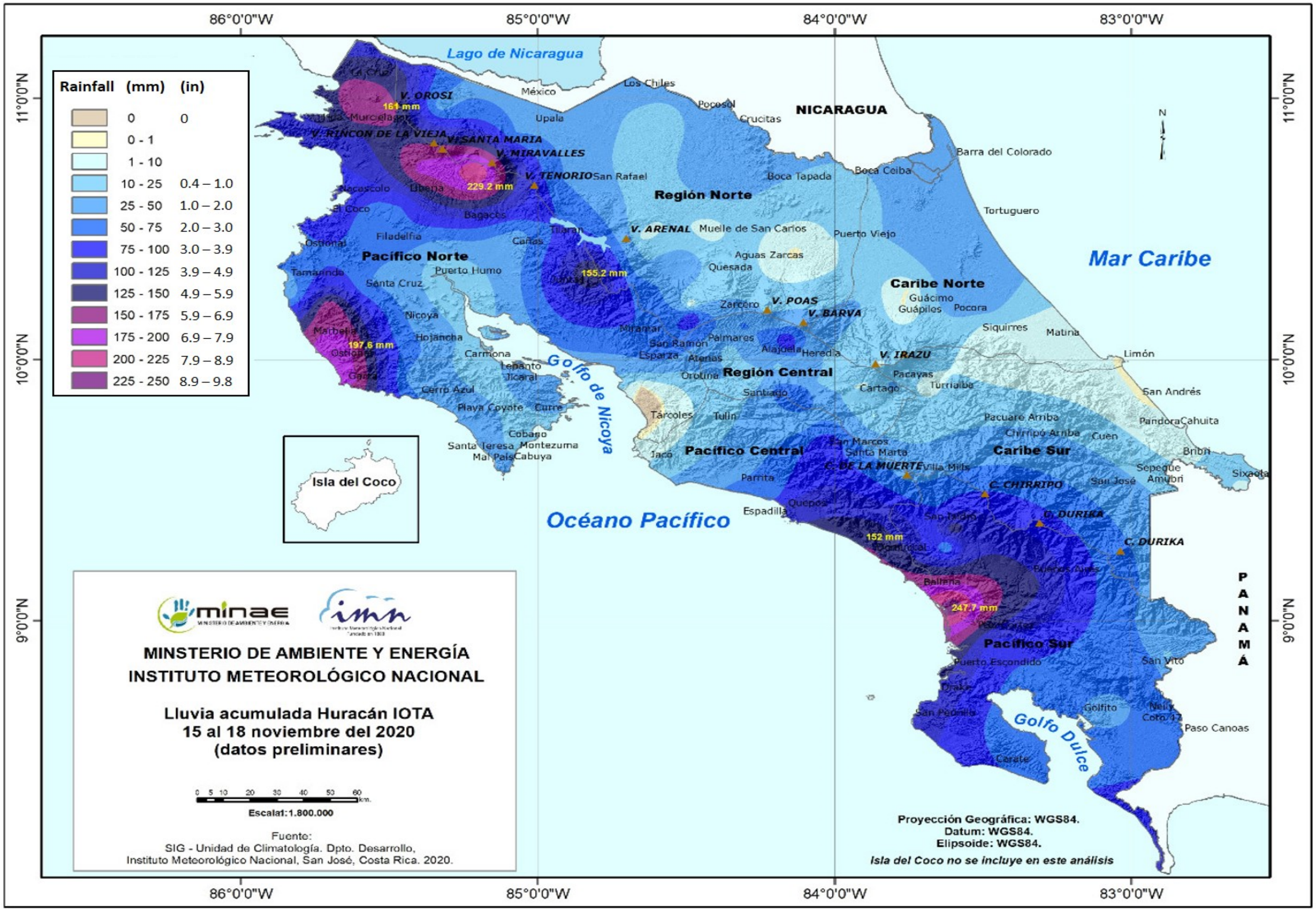

Figure 15. Costa Rica rainfall totals associated with Hurricane Iota during the period 15–18 November 2020. Graphic courtesy of Instituto Meteorológico Nacional de Costa Rica (National Meteorological Institute of Costa Rica).

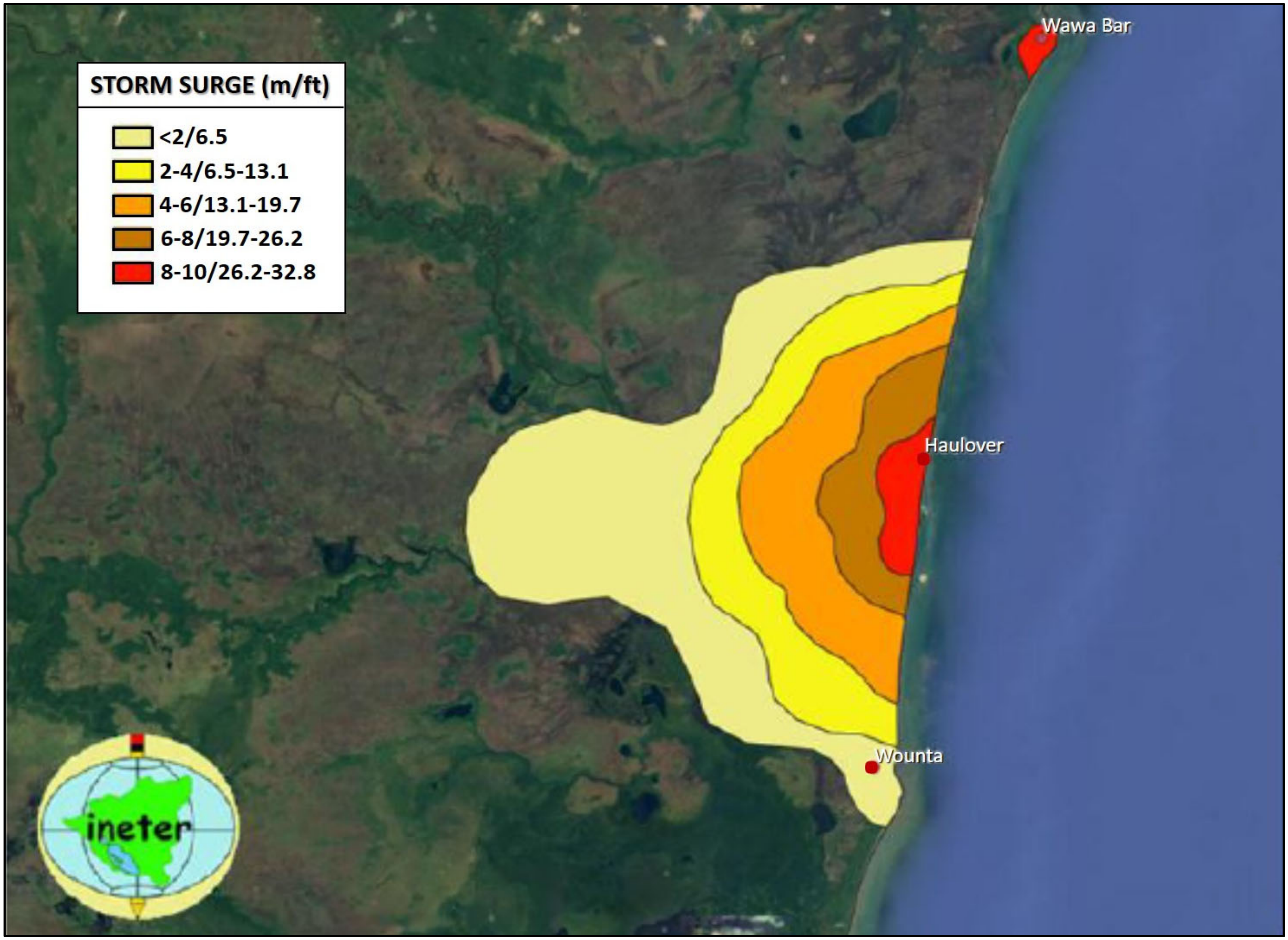

Figure 16. Storm surge values (meters/feet) along the east-central coast of Nicaragua associated with Hurricane Iota. Graphic courtesy of INETER – Instituto Nicaraguënse de Estudios Territoriales (Nicaraguan Institute of Territorial Studies).

Figure 17. Before (top) and after (bottom) overhead pictures depicting erosion of the barrier island and the development of a cutout caused by Hurricane Iota's storm surge at Haulover, Nicaragua, on 17 November 2020. (images courtesy *New York Times*)

Figure 18. Damage caused by Hurricane Iota on Providencia Island, Colombia. (top pictures courtesy *Efran Herrera – Oficina de prensa de la Presidencia de Colombia* via the *Associated Press;* bottom pictures courtesy *TECHO Colombia*)

Figure 19. Cutout of barrier island caused by Hurricane Iota's storm surge at Haulover, Nicaragua. (viewing north -- picture courtesy *New York Times*)

Figure 20. Damage caused by Hurricane Iota’s storm surge at Haulover, Nicaragua. (pictures courtesy *New York Times*).

Road damage at El Florido, Honduras, near the Guatemala border (picture courtesy Guatemala government)

Flooding on the Rio Bermejo in San Pedro Sula, Honduras -- 17 Nov 2020 (picture courtesy AP)

River flooding in central Honduras (picture courtesy Encarni Pindado)

Honduras' largest airport, Ramón Villeda Morales International Airport (MHLM) near San Pedro Sula, submerged by flood waters caused by Hurricane Iota (picture courtesy Orlando Sierra/AFP)

Figure 21. Freshwater flood damage caused by Hurricane Iota's heavy rainfall across Honduras.

Figure 22. Close-up view of submerged Ramón Villeda Morales International Airport near San Pedro Sula, Honduras. The extensive freshwater flooding damage was due to Hurricane Iota's heavy rainfall falling on top of already saturated ground caused by Hurricane Eta's heavy rains just two weeks earlier. (picture courtesy *La Pensa Televisión*)

Mudslide at El Carmen Jalauté de Purulhá, Baja Verapaz, Guatemala, killed two people, 18 November 2020

Figure 23. Mudslide at El Carmen Jalauté de Purulhá, Baja Verapaz, Guatemala, that killed two people on 18 November 2020 (pictures courtesy Sam Chun informa).

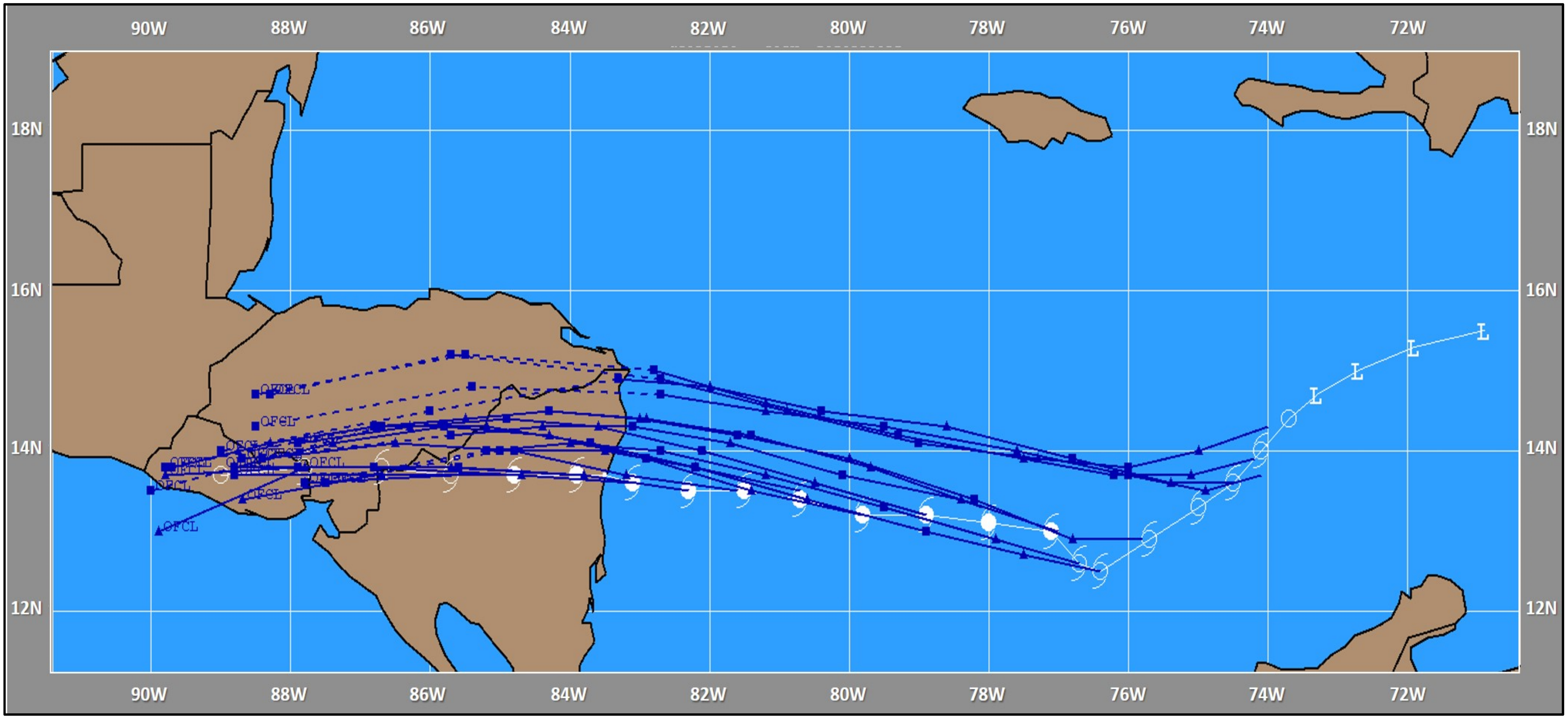

Figure 24. Plot of NHC official 120-h track forecasts (OFCL) during the period 1200 UTC 13 November to 0600 UTC 18 November 2020 (dark blue lines). Solid white line indicates the 'best track', with position estimates at 6-h intervals (white symbols) from 1200 UTC 12 November to 1200 UTC 18 November. The "L" symbols indicate pre-genesis positions.

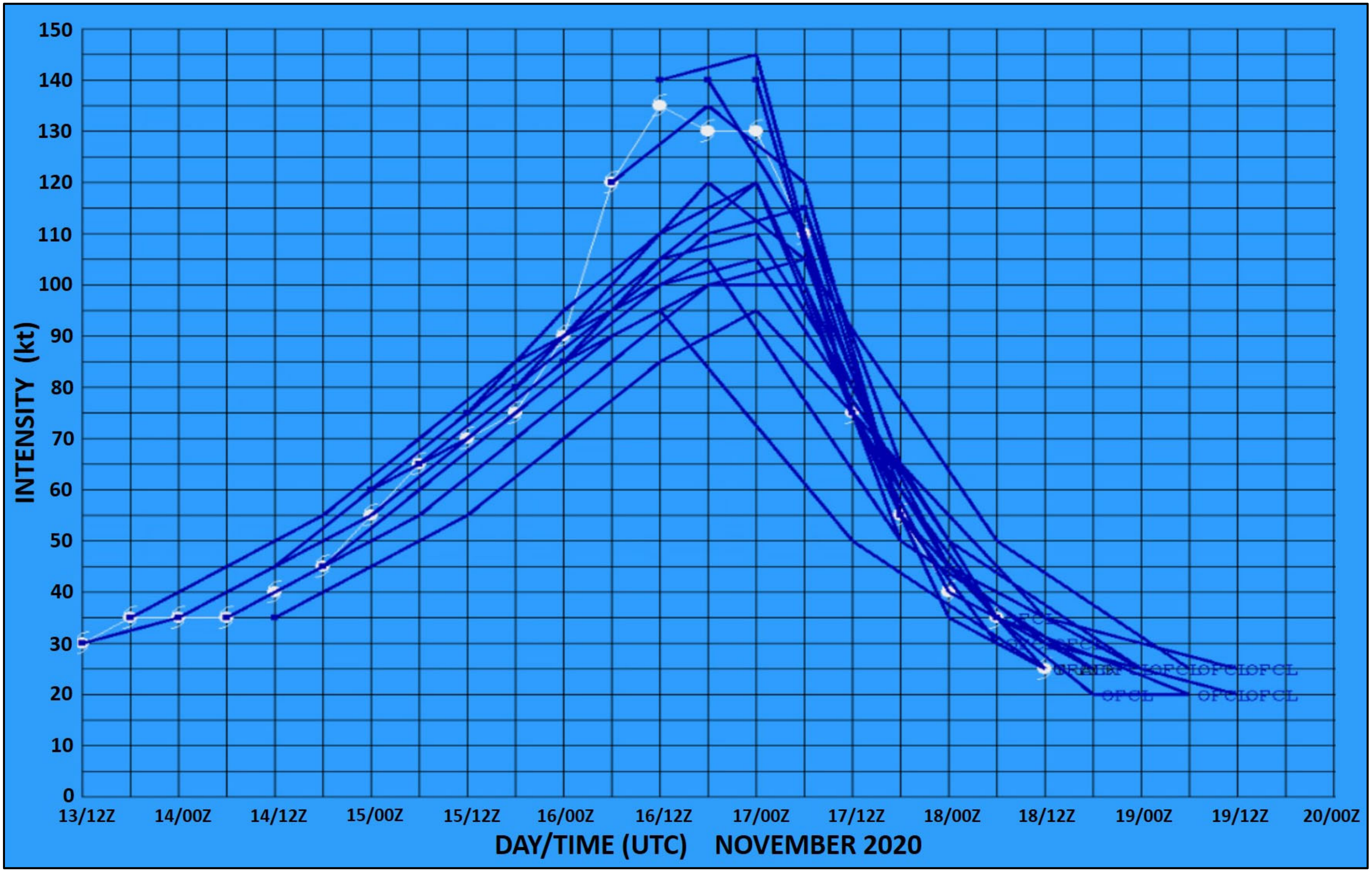

Figure 25. Plot of NHC official intensity forecasts (OFCL, kt) during the period 1200 UTC 13 November to 0600 UTC 18 November 2020. Solid white line indicates the 'best track' intensity estimate (kt) plotted at 6-h forecast intervals (white symbols).