2024 NATIONAL REPORT
Submitted by United States

BASIC INFORMATION

1. ICG/CARIBE EWS Tsunami National Contact (TNC)

Name: Gregory M. Schoor
Title: Branch Chief, Marine, Tropical, and Tsunami Service Program
Organization: National Oceanic and Atmospheric Administration/National Weather Service (NOAA)
Postal Address: 1325 East West Highway, SSMC2 13148, Silver Spring, Maryland 20910 USA
E-mail Address: gregory.m.schoor@noaa.gov
Telephone Number: +1 301-427-9848 Fax Number: +1 301-713-1520
Cellular Telephone Number: +1 301-367-1063

Alternate ICG/CARIBE EWS Tsunami National Contact (TNC)
Name: Christa G. von Hillebrandt-Andrade
Title: Manager
Organization: National Oceanic and Atmospheric Administration/National Weather Service/International Tsunami Information Center Caribbean Office (ITIC-CAR)
Postal Address: 259 Boulevard Alfonso Valdés, Building D, University of Puerto Rico at Mayagüez, Mayagüez, Puerto Rico 00680 USA
E-mail Address: christa.vonh@noaa.gov
Telephone Number: +1 787-833-8433
Fax Number: +1 787-265-1684
Cellular Telephone Number: +1 787-249-8307

2. ICG/CARIBE EWS Tsunami Warning Focal Point (TWFP)

Tsunami Warning Focal Point (TWFP)—Puerto Rico
Name: Nino Correa Filomeno
Title: Commissioner
Responsible Organization: Puerto Rico Bureau for Emergency Management
Postal Address: P.O. Box 194140, San Juan, Puerto Rico 00919-4140 USA
E-mail Address: ncorrea@dsp.pr.gov, wgonzalez@dsp.pr.gov
Emergency Telephone Number: +1 787-724-0124 ext. 20001-40075 (24 hours); Office Telephone Number: +1 787-721-3596
Emergency Fax Number: +1 787-523-0823
Emergency Cellular Telephone Number: +1 939-640-6150

Tsunami Warning Focal Point (TWFP)—Puerto Rico (Alternate)
Name: Ernesto Morales (WCM) and Ernesto Rodriguez (MIC, Alternate)
Title: Warning Coordination Meteorologist (WCM) and Meteorologist in Charge (MIC)
Responsible Organization: National Oceanic and Atmospheric Administration/National Weather Service/San Juan Weather Forecast Office
Postal Address: Nº 4000 Road 190, Carolina, Puerto Rico 00979 USA
E-mail Address: sr-sju.mets@noaa.gov, ernesto.morealesl@noaa.gov, ernesto.rodriguez@noaa.gov
Emergency Telephone Number: +1 787-253-4501; +1 787-253-4586 x222
Emergency Fax Number: +1 787-253-7802

Emergency Cellular Telephone Number: +1 787 662-2275, +1 787-4475487

Tsunami Warning Focal Point (TWFP)—Puerto Rico (Alternate)
Name: Víctor Huérfano Moreno
Title: Director
Responsible Organization: Puerto Rico Seismic Network (PRSN)
Postal Address: 259 Boulevard Alfonso Valdés, Building D, University of Puerto Rico at Mayagüez, Mayagüez, Puerto Rico 00680 USA
E-mail Address: staff@prsnmail.uprm.edu; victor@prsnmail.uprm.edu
Emergency Telephone Number: +1 787-833-8433
Emergency Fax Number: +1 787-265-1684
Emergency Cellular Telephone Number: +1 787-615-3645

Tsunami Warning Focal Point (TWFP)—US Virgin Islands
Name: Daryl Jaschen
Title: Director
Responsible Organization: Virgin Islands Territorial Emergency Management Agency/911
Postal Address: 2164 King Cross Street, Christiansted, Virgin Islands 00820 USA
E-mail Address: daryl.jaschen@vitema.vi.gov
Emergency Telephone Number: Mon-Fri, 0800 - 1700 hrs 340-773-2244 – Main Line (St. Croix); 340-774-2244- Main Line (St. Thomas); 340-776-2244 - Main Line (St. John)
Emergency Fax Number: +1 340-713-2075 (911 St. Croix); +1 340-713-2075 (Main Office St. Croix); +1 340-715-6726 (911 St. Thomas), +1 340-778-8980 (Main Office St. Thomas)
Emergency Cellular Telephone Number: 340-690-9264 Liberty Mobile/FirstNet or 340-277-4253 T-Mobile

Tsunami Warning Focal Point (TWFP) - US Virgin Islands (Alternate)
Name: Regina Browne
Title: Deputy Director Planning & Preparedness
Responsible Organization: Virgin Islands Territorial Emergency Agency / 911
Postal Address: 2164 King Cross Street, Christiansted, Virgin Islands 00820 USA
E-mail Address: regina.browne@vitema.vi.gov
Emergency Telephone Number: Mon-Fri, 0800-1700 hrs 340-773-2244-Main Line (St. Croix); 340-774-2244-Main Line (St. Thomas); 340-776-2244-Main Line (St. Join)
Emergency Fax Number: +1 340-713-2075 (911 St. Croix), +1 340-778-8980 (Main Office St. Croix); +1 340-715-6726 (911 St. Thomas), +1 340-715-6847 (Main Office St. Thomas)
Emergency Cellular Telephone Number: 340-422-1350 Liberty/FirstNet

National Tsunami Warning Centre
Person in Charge: Dr. Charles McCreery
Title: Director
Responsible Organization: National Oceanic and Atmospheric Administration/National Weather Service/Pacific Tsunami Warning Center (PTWC)
Postal Address: 1845 Wasp Boulevard, Building 176, Honolulu, Hawaii 96818 USA
E-mail Address: charles.mccreery@noaa.gov
Emergency Telephone Number: +1 808-725-6300
Emergency Fax Number: +1 808-725-6332
Emergency Cellular Telephone Number: +1 808-392-4416

Backup
Person in Charge: James Gridley
Title: Director
Responsible Organization: National Oceanic and Atmospheric Administration/National Weather Service/National Tsunami Warning Center (NTWC)

Postal Address: 910 S. Felton Street, Palmer, Alaska 99645 USA
E-mail Address: James.Gridley@noaa.gov
Emergency Telephone Number: +1 907-745-4212
Emergency Fax Number: +1 907-745-6071

3. **Tsunami Advisor**

Name: Christa G. von Hillebrandt-Andrade
Title: Manager
Organization: National Oceanic and Atmospheric Administration/National Weather Service/International Tsunami Information Center Caribbean Office (ITIC-CAR)
Postal Address: 259 Boulevard Alfonso Valdés, Building D, University of Puerto Rico at Mayagüez, Mayagüez, Puerto Rico 00680 USA
E-mail Address: christa.vonh@noaa.gov
Emergency Telephone Number: +1 787-833-8433
Emergency Fax Number: +1 787-265-1684
Emergency Cellular Telephone Number: +1 787-249-8307

4. **U.S. Domestic Tsunami Standard Operating Procedures for Local (< 1 hour travel time), Regional (1-3 hour travel time), and Distant Tsunamis (> 3 hour travel time)**

The standard operating procedures for tsunamis in the United States are largely the same for local, regional, and distant tsunamis. Where there are differences, they are noted here.

What organization identifies and characterizes tsunamigenic events?

The National Oceanic and Atmospheric Administration's (NOAA) Pacific Tsunami Warning Center (PTWC) in Hawaii provides domestic tsunami alert services for Hawaii, American Samoa, Guam and the Commonwealth of the Northern Mariana Islands (CNMI), and Puerto Rico and the U.S. and British Virgin Islands. The NOAA U.S. National Tsunami Warning Center (US NTWC) in Alaska provides domestic tsunami alert services for the continental United States, Alaska, and Canada. Each center serves as the other center's backup.

Both NOAA centers independently characterize potential tsunamigenic events that occur in the Caribbean and Atlantic. To avoid conflicting information, each center is assigned tsunami source regions for which they are authoritative in tsunami warning center products. In this way, the preliminary earthquake parameters that appear in PTWC and US NTWC products are always the same.

What is the threshold or criteria for declaring a potential tsunami emergency?

PTWC issues initial messages based solely on an earthquake's preliminary location, depth, and magnitude determined from a rapid seismic analysis as well as the distance of the earthquake from Puerto Rico and the Virgin Islands in terms of tsunami travel time or kilometers.

<u>Puerto Rico and the Virgin Islands</u>
For earthquakes located further than three hours tsunami travel time from Puerto Rico and the Virgin Islands, PTWC uses the seismic criteria in Table 1 to determine initial products.

Table 1. Criteria for PTWC initial tsunami products for Puerto Rico/Virgin Islands for distant earthquakes

Earthquake					Alert Level
Sea	**Land**	**Depth**	**Magnitude**	**ETA**	
Yes	Yes	< 62 miles (100 km)	6.5 - 7.8	> 3 hr	Information statement No threat
Yes	Yes	≥ 62 miles (100 km)	≥ 6.5	> 3 hr	Information statement No threat
Yes	Near Sea	< 62 miles (100 km)	≥ 7.9	> 6 hr	Information statement Potential threat
Yes	Near Sea	< 62 miles (100 km)	≥ 7.9	3–6 hr	Watch

Source: Users' Guide Tsunami Warning Products for Puerto Rico, U.S. Virgin Islands, and British Virgin Islands Version 1.21, December 8, 2023

For earthquakes located within three hours of tsunami travel time of Puerto Rico and the Virgin Islands, PTWC uses the earthquake's proximity to polygons created for populated islands of Puerto Rico and the Virgin Islands and the preliminary seismic parameters in Table 2 to determine initial products.

Table 2. Criteria for PTWC initial tsunami products for Puerto Rico and the Virgin Islands for nearby earthquakes

Earthquake			Alert Level
Source Location	**Depth**	**Magnitude**	
Within 186 miles (300 km) of Puerto Rico/Virgin Islands	< 62 miles (100 km)	4.5-6.4	Information Statement
	≥ 62 miles (100 km)	≥ 4.5	
	< 62 miles (100 km)	≥ 7.1	Warning
	< 62 miles (100 km)	6.5–7.0	Advisory
Between 186 miles (300 km) and 621 miles (1000 km) of Puerto Rico/Virgin Islands	< 62 miles (100 km)	≥ 7.6	Warning
	< 62 miles (100 km)	7.1–7.5	Advisory
> 621 miles (1000 km) of Puerto Rico/Virgin Islands	< 62 miles (100 km)	≥ 7.9	Warning
	< 62 miles (100 km)	7.6-7.8	Advisory

Notes:

- *If the earthquake has a preliminary depth less than 62 miles (100 km) with preliminary magnitude of 6.5 or greater but does meet location criteria above for an advisory or warning, then only an information statement will be issued indicating no tsunami threat.*
- *If the preliminary earthquake depth is greater than or equal to 62 miles (100 km) and the preliminary earthquake magnitude is greater than or equal to 6.5, then only an information statement will be issued indicating no tsunami threat from a deep earthquake.*

Source: Users' Guide Tsunami Warning Products for Puerto Rico, U.S. Virgin Islands, and British Virgin Islands Version 1.21, December 8, 2023

Once PTWC generates a forecast for an event, alert levels may be revised in supplemental messages to reflect forecast wave heights as shown in Table 3 or based on observed wave heights.

Table 3. Criteria for PTWC supplemental text products for Puerto Rico/Virgin Islands

Maximum Expected Rise of Sea Level above the Tide	**Alert Level**
0–1 feet (0–0.3 m)	None
1–3.3 feet (0.3–1 m)	Advisory
> 3.3 feet (> 1 m)	Warning

Source: Users' Guide Tsunami Warning Products for Puerto Rico, U.S. Virgin Islands, and British Virgin Islands Version 1.21, December 8, 2023

PTWC may increase alert levels if new information justifies such an increase. They will not lower alert levels before impact unless an updated evaluation has a very high level of confidence and there is a clear benefit to lowering the alert. They may lower alert levels after impact as conditions warrant until cancellation.

What organization acts on the information provided by the agency responsible for characterizing the potential tsunami threat?

Puerto Rico and the Virgin Islands

- Puerto Rico Emergency Management and Disaster Administration Bureau (also a CARIBE-EWS Tsunami Warning Focal Point)
- U.S. National Weather Service San Juan, Puerto Rico, Weather Forecast Office (also a CARIBE-EWS Tsunami Warning Focal Point, Alternate)
- Puerto Rico Seismic Network, University of Puerto Rico at Mayaguez (also a CARIBE-EWS Tsunami Warning Focal Point, Alternate)
- Virgin Islands Territorial Emergency Management Agency (also a CARIBE-EWS Tsunami Warning Focal Point)
- British Virgin Islands Department of Disaster Management (also a CARIBE-EWS Tsunami Warning Focal Point)
- British Royal Police Force (also a CARIBE-EWS Tsunami Warning Focal Point, Alternate)

How is the tsunami information (warning, public safety action, etc.) disseminated within your country? Who is it disseminated to?

In general, tsunami information is disseminated from PTWC to the officially designated responsible government agencies in each jurisdiction through a variety of channels as depicted in Figure 1.

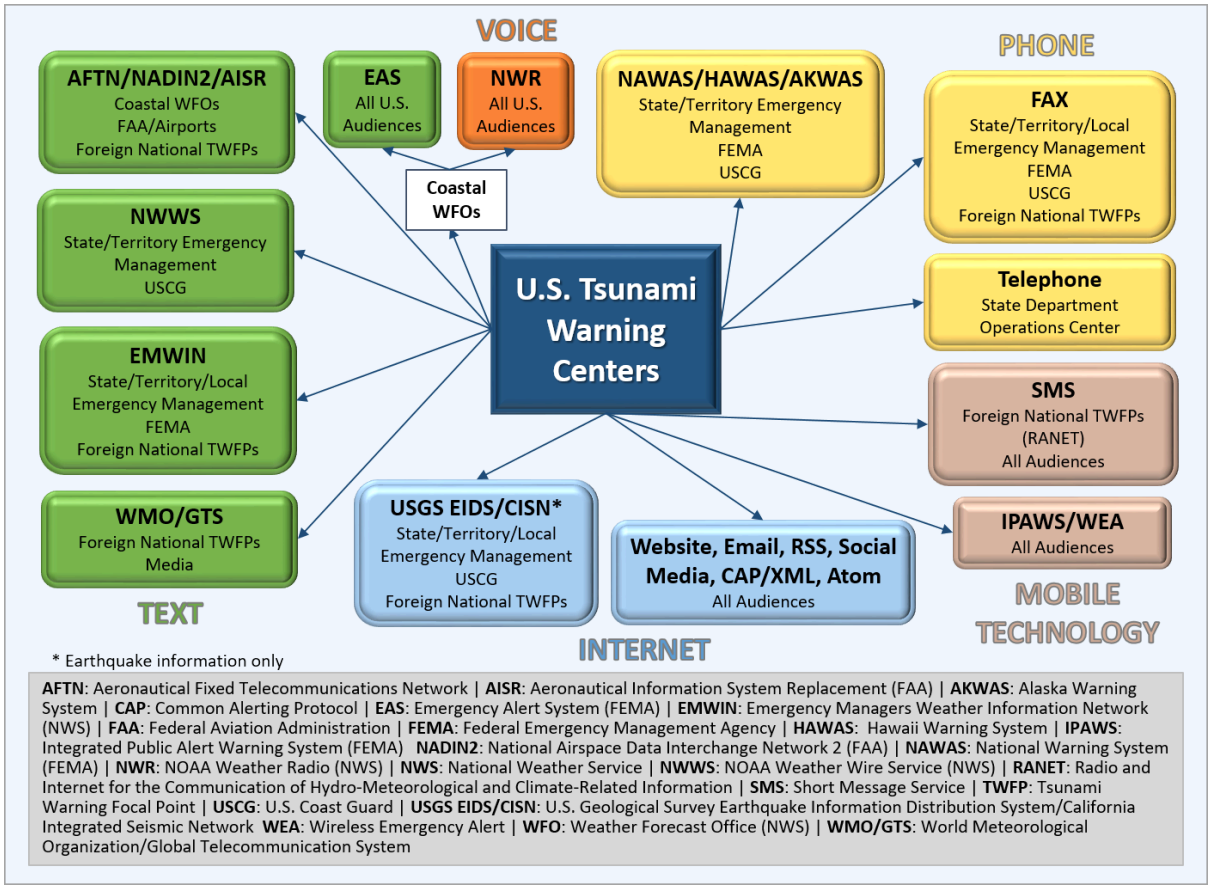


Figure 1. NOAA tsunami warning center dissemination methods.

Puerto Rico and the Virgin Islands

- The Puerto Rico Emergency Management and Disaster Administration Bureau alerts the public (through interoperability systems, sirens, and other means); police, fire, rescue, and other response agencies; and media outlets (Figures 2 and 3)
- The Wireless Emergency Alert (WEA), through FEMA's Integrated Public Alert amd Warning System (IPAWS) capability was tested in Puerto Rico on March 21, 2024 as part of CARIBE WAVE 24 exercise.
- The U.S. Virgin Islands Territorial Emergency Management Agency alerts the public (through interoperability systems, sirens, and other means); police, fire, rescue, and other response agencies; and media outlets
- The US Virgin Islands utilizes Alert VI - mass message notification / Everbridge which reaches 21% of the population (2020 US Census). VITEMA uses WEA/IPAWS which requires FCC approval during training and drills.
- The Puerto Rico Seismic Network (PRSN) provides guidance to the emergency management agencies in Puerto Rico and the Virgin Islands, the media, and the San Juan Weather Forecast Office as well as the Dominican Republic National Meteorological Office (ONAMET). The PRSN further disseminates official tsunami messages through RSS, email, SMS, web page, social media, phone calls, radio, and more (Figure 3).
- The U.S. National Weather Service San Juan Weather Forecast Office as TWFP Alternate activates the Emergency Alert System (EAS) for Puerto Rico and the U.S. Virgin Islands to interrupt commercial radio and television with a message and broadcasts tsunami information over NOAA Weather Radio (Figure 3)
- Upon receipt, the media may also interpret and re-disseminate tsunami information.
- Upon receipt, NOAA's Caribbean Office of the International Tsunami Warning Center (ITIC) may also interpret and re-disseminate tsunami information.

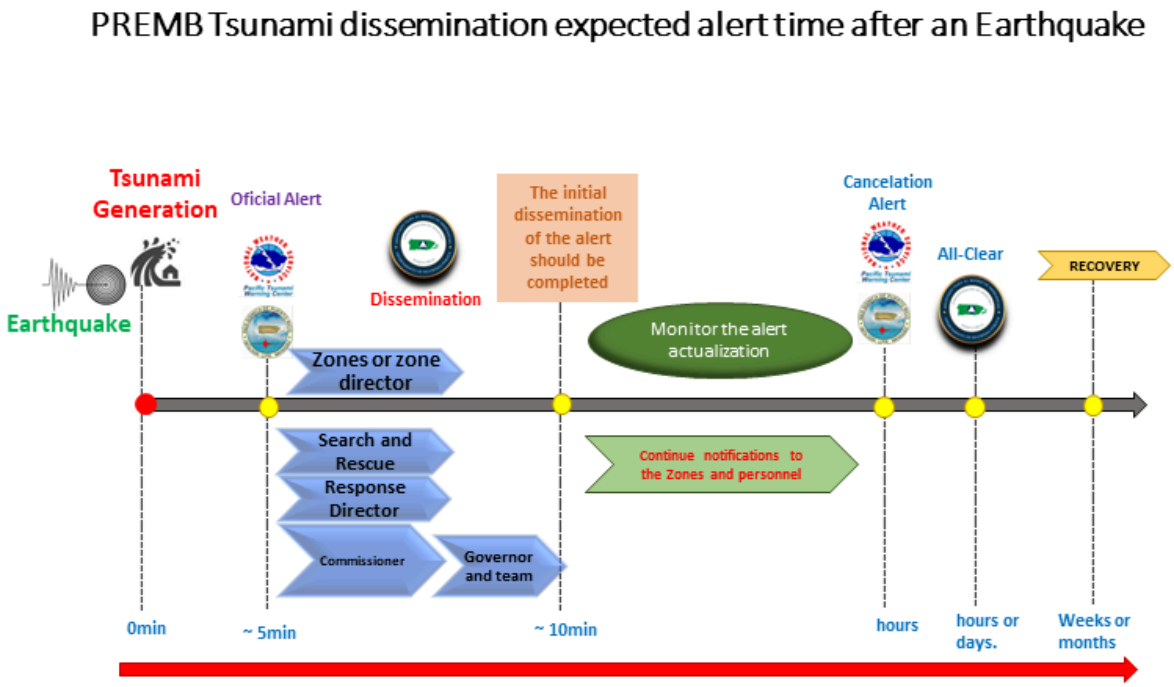
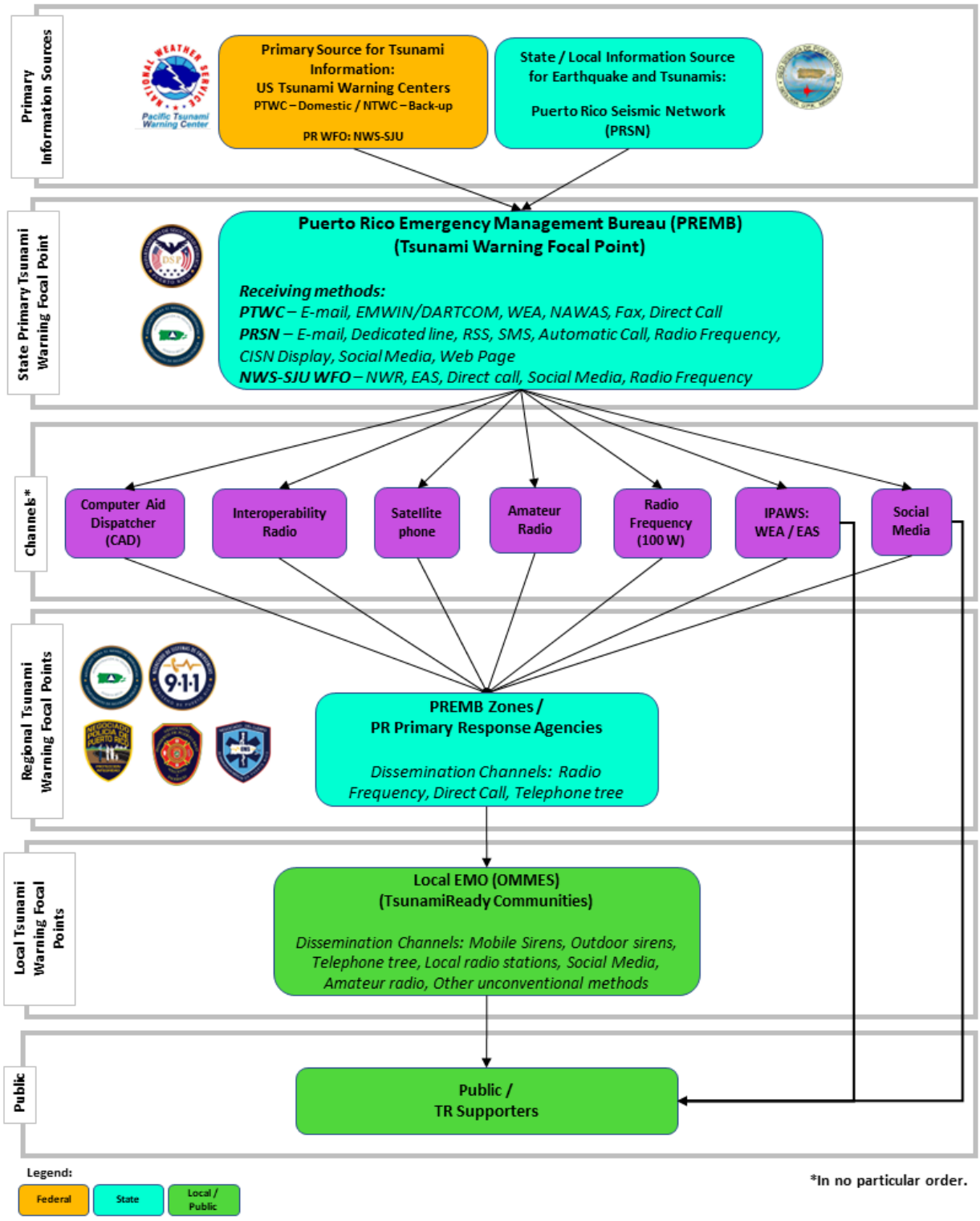
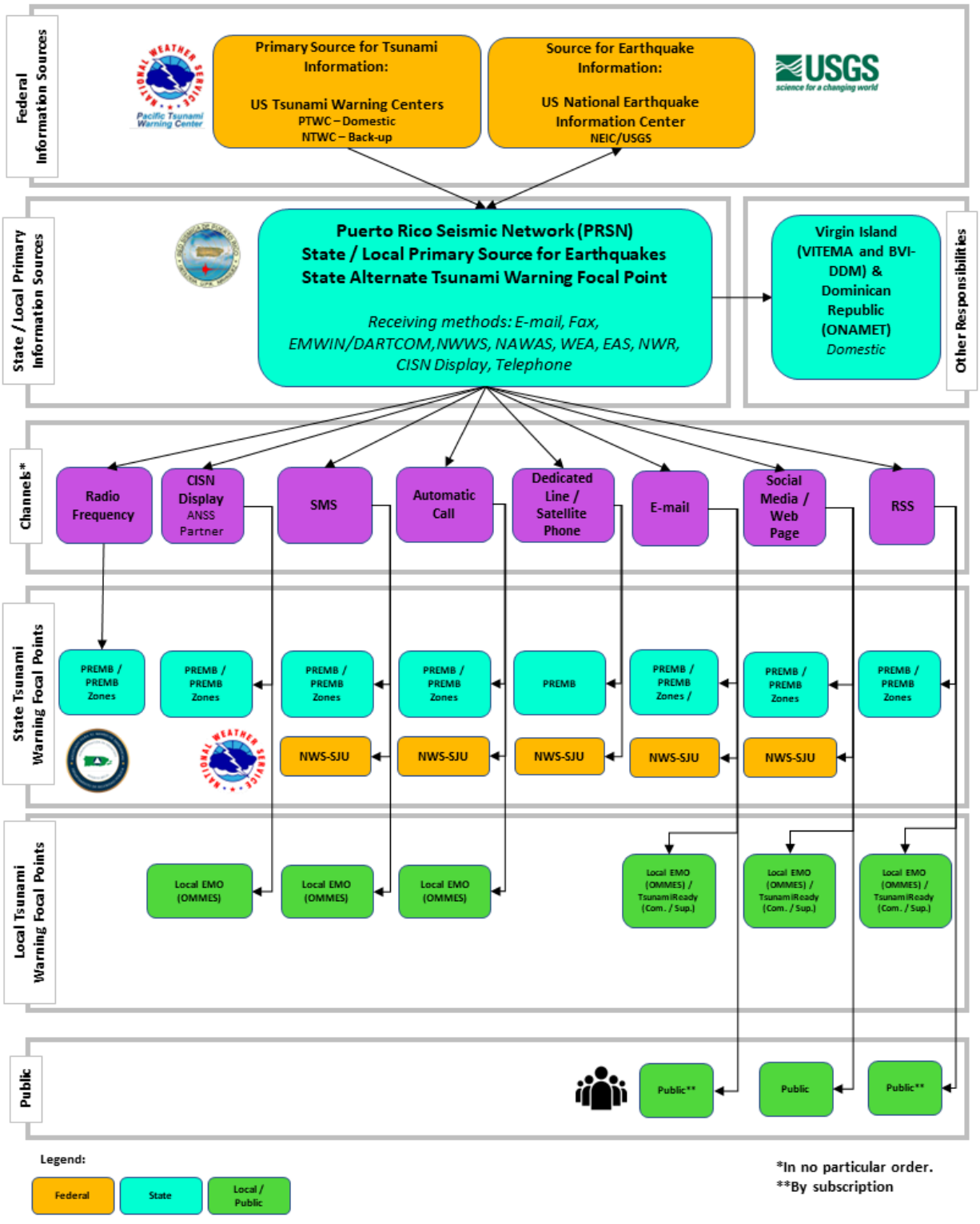


Figure 2. Timeline of Puerto Rico for issuance and dissemination of tsunami alert and updates from event origin time

PREMB: Tsunami Warning Focal Points Dissemination Channels Diagram



PRSN Dissemination Channels Diagram



NWS-SJU WFO Dissemination Channels Diagram

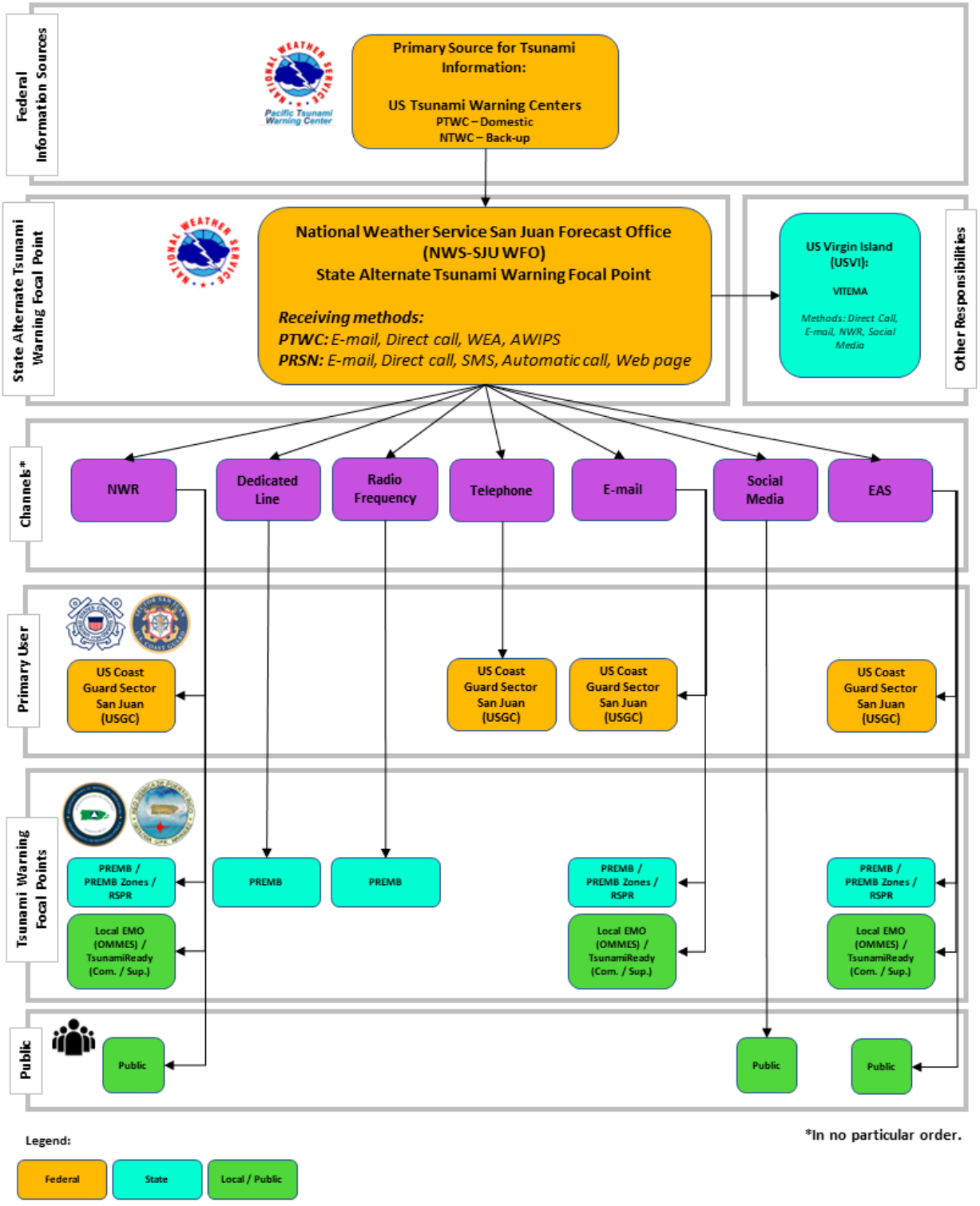


Figure .3 Tsunami dissemination channels for Puerto Rico Emergency Management and Disaster Administration Bureau, Puerto Rico Seismic Network and the US National Weather Service San Juan Weather Forecast Office (Rev 2024).

Communication Testing
As shown in Figure 2, PTWC confirms communication links with each of the key recipient agencies in Puerto Rico and the Virgin Islands following the issuance of each product – typically about once a month. Agencies also receive the monthly CARIBE-EWS communication tests and the test associated with each year's CARIBE WAVE Exercise. PRSN also tests communication lines monthly and annually as part of the CARIBE WAVE and ShakeOut earthquake exercises. VITEMA tests their Tsunami Sirens territory wide the third Thursday of each month at 11am. During the weekly meetings of the Tsunami Working Group the results are analyzed and gaps and success are noted.

How is the emergency situation terminated?

Puerto Rico and the Virgin Islands
PTWC issues a cancellation after an evaluation of water-level data confirms that a destructive tsunami will not impact an area under an alert (warning, advisory, or watch) or that a tsunami has diminished to a level where additional damage is not expected. This does not mean it is safe to return to evacuated areas. Local authorities determine when it is safe (issued all clear) to return based on local information about continuing wave conditions and related hazards such as fires or downed power lines.

For distant tsunamis, what actions were taken in response to warnings issued by PTWC and/or US NTWC during the intersessional period?

There were no warnings for U.S. Caribbean, Gulf of Mexico, or Atlantic coasts issued by PTWC or US NTWC during the intersessional period.

5. Seismic Monitoring Network

The United States supports an extensive network of seismic sensors in the Pacific, Atlantic, Caribbean, and Gulf of Mexico. A number of other entities also support earthquake monitoring activities in the Caribbean and adjacent regions.

- The U.S. Geological Survey (USGS) National Earthquake Information Center (NEIC) and Albuquerque Seismological Laboratory coordinate field and monitoring operations to ensure reliable mission-critical data to the tsunami warning centers. One hundred and fifty of these stations are part of the Global Seismographic Network (GSN) and are jointly operated by the USGS, University of California San Diego (IDA) and the EarthScope Consortium. An additional 97 stations in the U.S. are part of the Advanced National Seismic System (ANSS). Seismic station details are provided at the GSN and ANSS URLs listed in Section 9.
- The PRSN, with the support from the Puerto Rico Strong Motion Program (PRSMP), and in partnership with the ANSS, monitors the seismic activity in Puerto Rico and the U.S. and British Virgins Islands. The stations operated by the PR network include more than 100 free field ground motion stations (75 in Puerto Rico and the Virgin Islands and 12 in nearby countries, including Anguila and Aruba as well as the Dominican Republic); the broadband stations are equipped with velocity and acceleration sensors. Some stations are equipped with GNSS displacement sensors.
- In response to the damage caused by 2017 hurricanes, USGS ASL worked with PRSN to upgrade a total of 25 seismic stations. Each site was upgraded with new sensors (posthole broadband seismometer and accelerometer), digitizers, and solar power backups. Twelve (12) of these sites have VSAT connections to PRSN and

NEIC to maintain monitoring capability if island wide power and internet go down again. The backbone network of strong motion stations were updated as well, and the communications improved mostly with cell phone circuits and telemetry. The VSAT radio firmware is going to be updated.

- In response to the 2020 southwestern Puerto Rico earthquake the PRSN in partnership with the USGS installed 11 temporary real time seismic stations (GS.PR01-GS.PR06) in southwestern Puerto Rico to monitor the sequence. The stations have been removed but the data is openly available as part of the GS network via EarthScope data services (DS).
- The PRSN, with the support from the Puerto Rico Science Trust, installed a network of type-C accelerometers (100 in the first stage), these equipment, together with the Raspberry Shake network, and the permanent networks of the Island, are being used to study the feasibility of developing an earthquake early warning in Puerto Rico.

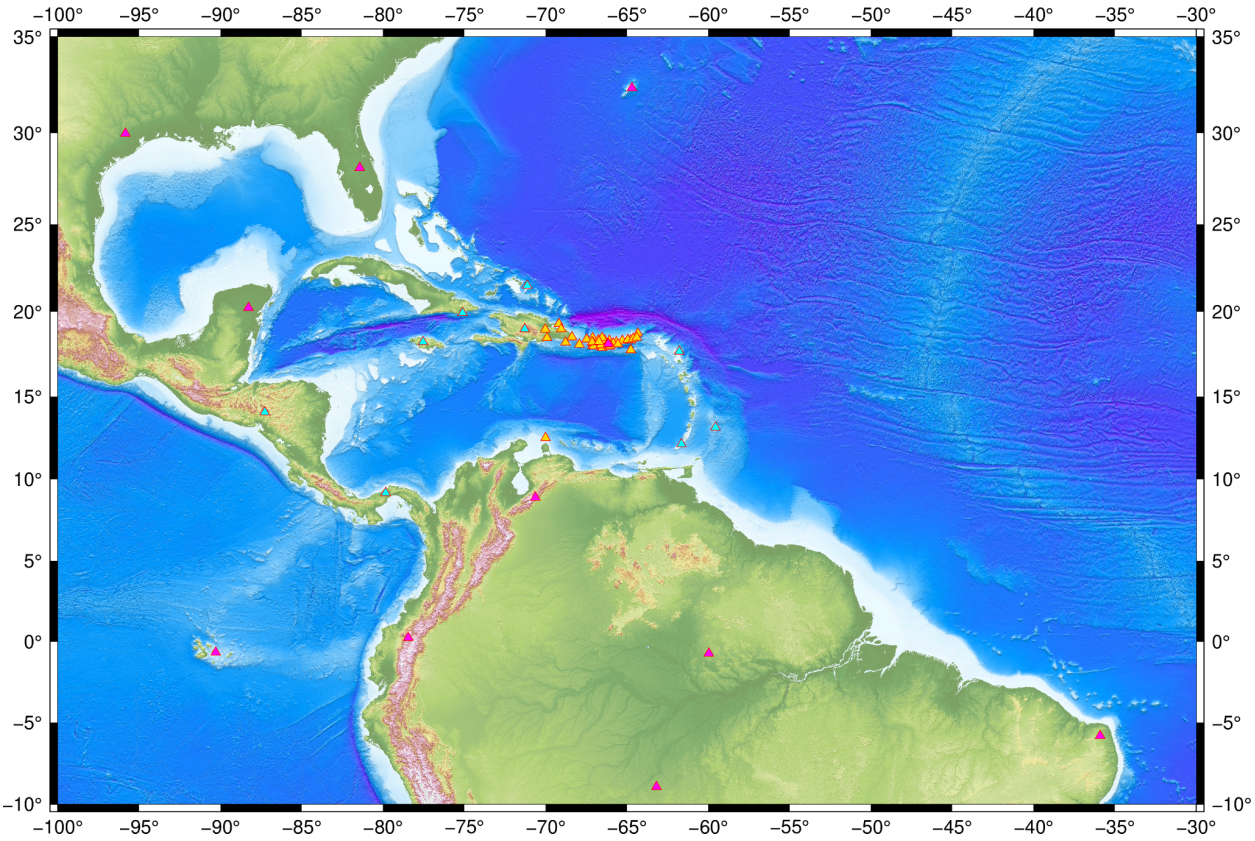


Figure 3.Distribution of seismic instruments supported or operated by PRSN/PRSMP (PR-gold and the USGS (IIU - magenta, CU-cyan) in the CARIBE-EWS region. A table of these instruments is available as Appendix A (below).

6. National Sea Level Network

The United States supports an extensive sea level network in the Pacific, Atlantic, Caribbean, and Gulf of Mexico. In the Caribbean, this includes coastal water-level stations and Deep-ocean Assessment and Reporting of Tsunami (DART) systems as described below and cataloged in Table 5.

U.S. Caribbean Coastal Water-Level Stations

Coastal water-level stations in the United States are operated by a variety of entities. Many of these stations are part of the international Global Sea-Level Observing System (GLOSS), which is coordinated by UNESCO/IOC. The data from these stations are made available to the NOAA tsunami warning centers and can be viewed on the UNESCO/IOC Sea Level Data Facility and through programs like Tide Tool, which is run in many CARIBE EWS tsunami warning centers.

- NOAA's Center for Operational Oceanographic Products and Services operates 11 stations in the Caribbean (Puerto Rico, U.S. Virgin Islands, Bermuda) as part of its National Water Level Observation Network (NWLON). These multi-purpose stations have, at a minimum, a primary and backup sensor and data collection platform. High-frequency 1-minute water-level data are collected and transmitted every six minutes over GOES-East, telephone, IP modem, or Iridium to the tsunami warning centers. The NWLON also includes stations along the U.S. East and Gulf Coasts.
    - Tide gauge data from the NOAA-operated stations are quality controlled (for research), de-tided, and archived at NOAA's National Centers for Environmental Information (NCEI). Data is available for download from an interactive timeline at https://www.ngdc.noaa.gov/hazard/tide/.
- The University of Hawaii Sea Level Center (UHSLC) operates 10 stations in the region and assists with installation and maintenance of additional stations when necessary. The UHSLC stations have a primary and backup sensor and sample once per minute. Data is sent over GOES-East or Iridium with a five-minute transmission interval at most locations with no longer than ten-minute intervals. Data transmission at all stations will be migrated to Iridium over coming years with data flow to GTS maintained.
- With support from NOAA, the government of Puerto Rico and the University of Puerto Rico, the PRSN operates ten stations in Puerto Rico and the Dominican Republic. These stations transmit data every six minutes over GOES-HRIT, and some of them each minute via internet through an earthworm module using the seedlink protocol. CO-OPS displays the 1 minute data. PRSN will be reinstalling station in Caja de Muertos and installing new stations in Anegada (BVI) and Samana (Dominican Republic). With NOAA funds, the PRSN also supports sea level station operations in the British Virgin Islands. PRSN is no longer supporting the sea level station in Haiti.
- The Smithsonian Institution has installed, operates, and maintains two tsunami-capable water-level stations in Belize and Panama that transmit data every five minutes. The station in Belize is back online as of October 2023.
- UNAVCO (now Earthscope) installed two stations (Port Royal, Jamaica, in 2014 and Puerto Morelos, Mexico, in 2015) as part of the National Science Foundation-funded Continuously Operating Caribbean GPS Observational Network (COCONet) project. The Morelos station is now under ownership and management of UNAM in Mexico. The Jamaica is no longer operational (decommissioned).

U.S. Caribbean Deep-ocean Assessment and Reporting of Tsunami (DART) Systems

NOAA's National Data Buoy Center (NDBC) operates 32 DART systems in the Pacific Ocean and 7 in the Atlantic Ocean (including 1 in the Gulf of Mexico and 3 in the Caribbean and adjacent seas region). The DART system technology uses a bottom pressure recorder (BPR), samples the pressure at 15-second intervals and communicates via acoustic link with a surface buoy, and has two data reporting modes, standard and event. In standard mode, DART systems transmit data every six hours with a 15-minute subsampling of the full 15-second sampling intervals.

DART systems will enter event mode if tsunami detection algorithm identifies an event in the BPR or manually by a tsunami warning center. NDBC's Mission Control Center continuously monitors the DART systems and validates triggers with the tsunami warning centers. In event mode, a DART system delivers several minutes of full resolution data at 15-second intervals followed by one-minute averages. If no further events are detected or if it is not manually reset to event mode, the system reverts to its standard transmission mode after four hours.

NDBC receives DART data via Iridium and reformats it into messages for distribution on the Global Telecommunication System (GTS) and NOAAPORT. Data from the seven Atlantic DART systems goes out under the GTS bulletin header SZNT01 KWNB. NDBC also posts the data to its website. The high-resolution 15-second data is sent to NCEI for, quality control, tidal analysis, and long-term archive. Data is available from an interactive timeline at https://www.ngdc.noaa.gov/hazard/dart/.

Vandalism or unintentional interference to DART systems and other sensors in the region has impacted their operations over the past decade. NOAA is working with international partners under the IOC and World Meteorological Organization to educate members of the fishing community and others to combat the incidence of vandalism and interference. Regional marine fisheries organizations are also collaborating to address the issue. All members are encouraged to share the importance of these sensing systems for accurately forecasting tsunamis and vandalism can make vulnerable communities even more at risk.

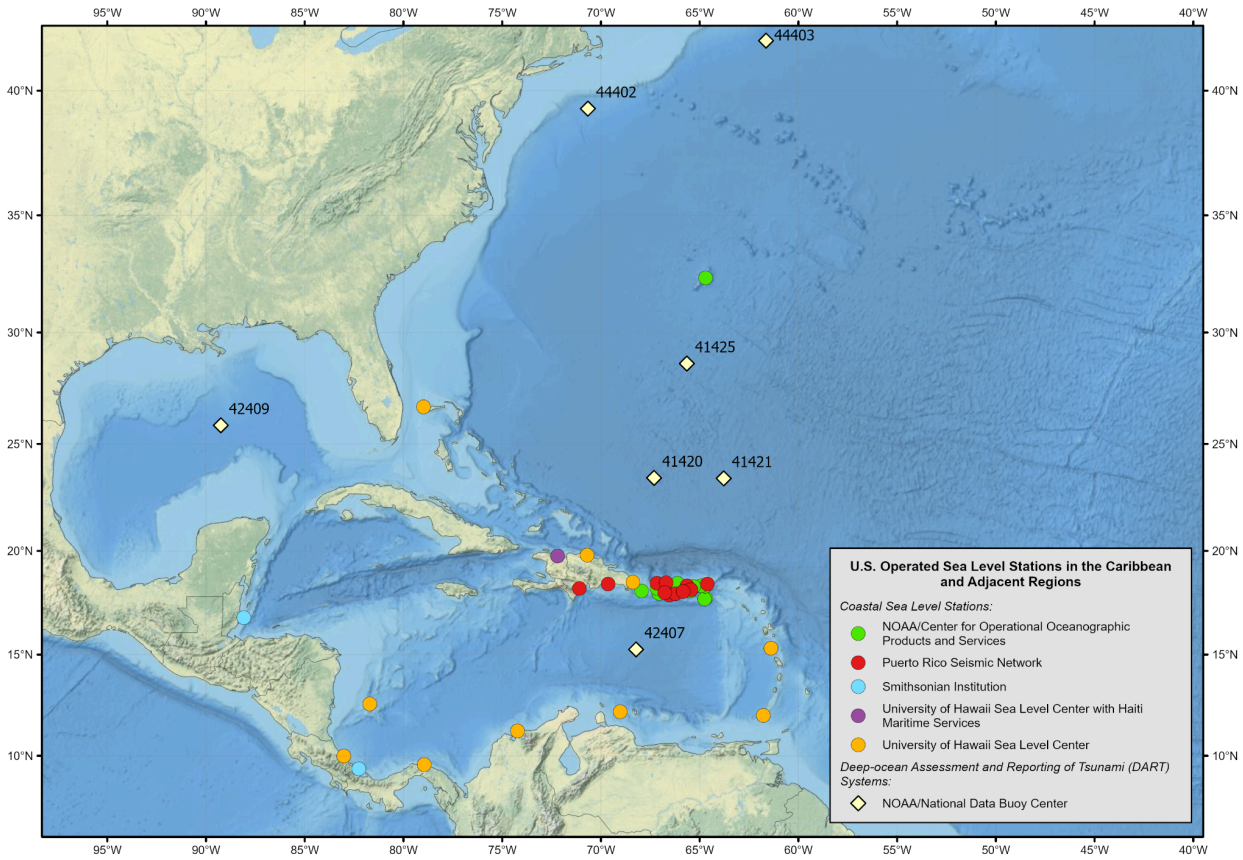


Figure 4: U.S.-operated sea level stations in Caribbean and adjacent regions.

Table 4: U.S.-operated sea level stations in Caribbean and adjacent regions.

Location	Latitude	Longitude	Status*	Operator
Coastal Water-Level Stations**				
Christiansted Harbor, St. Croix, U.S. Virgin Islands	17.75 N	64.70 W	Fully Operational	NOAA/Center for Operational Oceanographic Products and Services[1]
Lime Tree Bay. St. Croix, U.S. Virgin Islands	17.70 N	64.75 W	Fully Operational	
Lameshur Bay, St. John, U.S. Virgin Islands	18.32 N	64.72 W	Fully Operational	
Charlotte Amalie, St. Thomas, U.S. Virgin Islands	18.34 N	64.92 W	Fully Operational	
Culebra, Puerto Rico	18.30 N	65.30 W	Fully Operational	
Esperanza, Vieques Island, Puerto Rico	18.09 N	65.47 W	Fully Operational	
Magueyes Island, Puerto Rico	17.97 N	67.06 W	Fully Operational	
Mayagüez, Puerto Rico	18.22 N	67.16 W	Fully Operational	
Mona Island, Puerto Rico	18.09 N	67.94 W	Fully Operational	
San Juan, La Puntilla, San Juan Bay, Puerto Rico	18.46 N	66.12 W	Fully Operational	
Bermuda, Biological Station	32.37 N	64.70 W	Fully Operational	
San Andres, Colombia	12.58 N	81.70 W	Fully Operational	University of Hawaii Sea Level Center
Santa Marta, Colombia	11.24 N	74.22 W	Fully Operational	
Limon, Costa Rica	9.99 N	83.02 W	Fully Operational	
Bullen Bay, Curacao	12.19 N	69.02 W	Fully Operational	
Roseau, Dominica	15.31 N	61.39 W	Fully Operational	
Puerto Plata, Dominican Republic	19.80 N	70.70 W	Fully Operational	
Punta Cana, Dominican Republic	18.51 N	68.38 W	Fully Operational	
Prickly Bay, Grenada	12.01 N	61.77 W	Fully Operational	
El Porvenir, Panama	9.56 N	78.95 W	Fully Operational	
Settlement Point, Bahamas	26.69 N	78.98 W	Fully Operational	

Aguadilla, Puerto Rico	18.46 N	67.16 W	Fully Operational	Puerto Rico Seismic Network *operated with the support of ONAMET (Oficina Nacional de Meteorologia de la RD) and Globalmatrix eng. **PRSN and DDM
Arecibo, Puerto Rico	18.48 N	66.70 W	Fully Operational	
Caja de Muertos, Puerto Rico	17.89 N	66.53 W	Damaged [Not Operational]	
Salinas, Puerto Rico	17.949 N	66.226 W	Fully Operational	
Guayanilla, Puerto Rico	18.01 N	-66.77 W	Fully Operational	
Fajardo, Puerto Rico	18.338 N	65.631 W	Fully Operational	
Isabel Segunda, Vieques Island, Puerto Rico	18.15 N	65.44 W	Fully Operational	
Yabucoa Harbor, Puerto Rico	18.06 N	65.84 W	Fully Operational	
Tortola, British Virgin Islands**	18.42 N	64.61 W	Operational	
Barahona, Dominican Republic*	18.21 N	71.09 W	Operational [with gaps]	
Puerto Caucedo, Dominican Republic*	18.42 N	69.63 W	Not Operational	
Cap-Haitien, Haiti	19.76 N	72.19 W	Radar and Bubbler Operational, Pressure Sensor Not Operational	UH Sea Level Center with Haiti Maritime Services
Bocas del Toro, Panamá	9.35 N	82.26 W	Fully Operational	Smithsonian Institution
Carrie Bow Cay off Belize	16.80 N	88.08 W	Operational [with gaps]	
Deep-ocean Assessment and Reporting of Tsunami Systems				
South Puerto Rico—230 nautical miles southwest of San Juan, Puerto Rico (42407)	15.25 N	68.22 W	Fully Operational	NOAA/National Data Buoy Center
North Santo Domingo—328 nautical miles north northeast of Santo Domingo, Dominican Republic (41420)	23.43 N	67.31 W	Fully Operational	
North St. Thomas—300 nautical miles north of St Thomas, Virgin Islands (41421)	23.41 N	63.78 W	Fully Operational	
Southwest Bermuda—200 nautical miles south southwest of Hamilton, Bermuda (41425)	28.63 N	65.65 W	Fully Operational	

Southeast Block Canyon—130 nautical miles southeast of Fire Island, New York (44402)	39.30 N	70.66 W	Fully Operational (restored 04/17/24)	
Sable Island Bank, Canada (44403)	41.91 N	61.64 W	Fully Operational (restored 04/25/24)	
Gulf of Mexico–247 nautical miles south of New Orleans, Louisiana (42409)	25.85 N	89.25 W	Fully Operational	

** Status as of April 12, 2023*
*** To see other NOAA/Center for Operational Oceanographic Products and Services coastal water-level stations in the Atlantic Ocean, visit https://tidesandcurrents.noaa.gov/tsunami/.*

7. National GNSS Networks

The United States is actively pursuing techniques that will enable real-time, dynamic characterization and modeling of earthquake-generated tsunami sources. One of the most promising emerging datasets to accomplish this is the displacement vectors measured by the GNSS (Global Navigation Satellite System). While the United States does not currently have the capability to perform this type of characterization in an operational setting, we continue to support the deployment and maintenance of the underpinning networks. Continuously operating real-time GNSS stations in the United States and the Caribbean region are operated by a number of entities, including EarthScope Consortium that operates the GAGE Facility and Network of the Americas for NSF, NOAA, and the PRSN.

Table 5.. U.S.-operated GNSS Networks in the Caribbean and adjacent regions.

GNSS Network Name	Region	Number of GNSS stations	Number of Stations Providing 1-Hz Data Streams in Real Time to Enhance Caribbean Tsunami Early Warning	Operator
Network of the Americas (NOTA)	U.S./Alaska/ Caribbean/Mexico	1147	67	GAGE Facility/ EarthScope Consortium
PRSN	Puerto Rico/Virgin Islands	26	21	Puerto Rico Seismic Network
CORS	Worldwide	42 stations: 3 in Caribbean region	0	National Geodetic Survey (NOAA)

Figure 5. Caribbean regional GNSS assets within the Network of the Americas (NSF-GAGE Facility operated by the EarthScope Consortium). This includes 67 stations that are currently operational and streaming 1-Hz data which could be utilized for tsunami hazard monitoring.

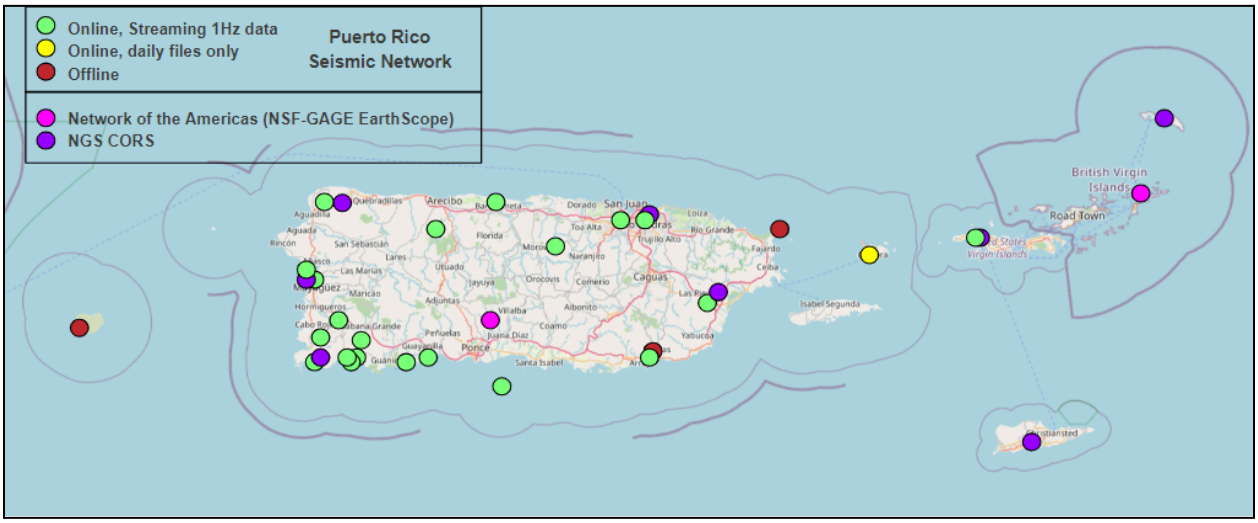


Figure 6. GNSS reference stations within Puerto Rico, the US Virgin Islands, and British Virgin Islands. The majority of these stations are operated by the Puerto Rico Seismic Network, with some from the Network of the Americas and the NGS CORS network.

EarthScope Contribution: The Network of the Americas

UNAVCO and IRIS merged to form the EarthScope Consortium, Inc. on January 1, 2023. The NSF-funded SAGE Facility, formerly operated by IRIS, and the NSF-funded GAGE Facility, formerly operated by UNAVCO, are now operated by the EarthScope Consortium. The EarthScope Consortium, Inc., a non-profit university-governed consortium funded by the National Science Foundation (NSF), the National Aeronautics and Space Administration (NASA), and the United States Geological Survey (USGS), manages three large GNSS networks in the western hemisphere. These three networks, known collectively as the Network of the Americas (NOTA), consist of the earthscope Plate Boundary Observatory (PBO), the Continuously Operating Caribbean GPS Observational Network (COCONet), and the Trans-boundary Land and Atmospheric Long-term Observational and Collaborative Network (TLALOCNet) in Mexico.

NSF has awarded UNAVCO a 5-year Cooperative Agreement (Geodesy Advancing Geosciences - GAGE) Facility, which started Oct. 1, 2018 and was originally scheduled to continue through Sep. 30, 2023. The GAGE Facility was recently extended through September 30, 2025. Most of the RT-GNSS resources that national, regional, or state EEW and TWS will use once fully operational, are cGNSS assets that were funded primarily by the NSF through the previous earthscope MREFC and GAGE Facility CAs. UNAVCO also received funding through USGS as part of the ShakeAlert program (during 2017-2021) to upgrade and modernize a subset of Network of the Americas cGNSS stations in Northern California, Oregon, and Washington. These stations continue to be operated by the EarthScope Consortium with NSF funding as part of NOTA.

The construction phase of NOTA is finished, with stations producing high-quality, low-latency GNSS data and data products from 1,147 continuously operating GNSS stations, over 900 of which provide both 1-Hz raw GNSS code and phase data and ambiguity-resolved precise point positions in real time, which are required for tsunami warning. Sixty (60) of these real-time stations are located in the Caribbean Basin, of which 57 are currently operational.

UNAVCO, and now the EarthScope Consortium, has tested real-time algorithms to determine Peak Ground Displacement (PGD) from RT-GNSS position estimates (Hodgkinson et al., 2020). For events greater than ~M7, the system worked well and has been able to estimate the “final” magnitude with high accuracy and in a timely way (<300 s) for several events in Alaska, Mexico, and the Caribbean (Hodgkinson et al., 2020).

Puerto Rico Seismic Network Contribution

The PRSN also operates a GNSS network of 36 real-time/high-rate stations (originally) funded by NSF. Ten of them are equipped with alloy receivers. NOAA’s National Geodetic Survey (NGS) also has non-real-time GPS stations in Puerto Rico, the Virgin Islands, Bermuda, and Barbados. All the permanent GPS stations are equipped with Trimble receivers and antennae. All PRSN stations receive 1-Hz position corrections through Trimble's RTX service, and data are shared through the EarthScope server or PRSN earthworm/seedlink system and caster.

At the PRSN, continuous data are simultaneously logged to three sessions with different sampling rates depending on their designated usage. Data is transferred from field sites to the data-collection server on a daily basis and is made available for download through UNAVCO's Data Archive. Real-time data is available through a dedicated NTRIP caster. An Earthworm module actively receives RTX (corrected) positions from PRSN remote sites and serves those streams via EW export or seedlink.

8. Information on Tsunami Occurrences/Tsunami Exercises

Tsunami Occurrences. Since the last ICG/CARIBE-EWS meeting in April of 2023 there have been no significant tsunamis impacting the U.S. in the Caribbean or Atlantic region. However, PTWC issued 14 Tsunami Information Statements to Puerto Rico and the Virgin Islands for nearby potentially felt earthquakes ranging in magnitude from 4.5 to 5.7, and two for two larger non-tsunamigenic Caribbean and Atlantic events that also prompted PTWC TSP products to the CARIBE-EWS.

Exercises

The US helped coordinate and participated in the annual CARIBE WAVE Exercises which are further discussed in the narrative.

9. National Tsunami-related Websites

General Resources

- U.S. Tsunami Warning System: https://www.tsunami.gov
- International Tsunami Information Center (ITIC) http://www.tsunamiwave.org; http://itic.ioc-unesco.org
- International Tsunami Information Center Caribbean Office (ITIC-CAR), has been transitioned to ITIC website http:/iticcar.org
- National Centers for Environmental Information (NCEI) Tsunami Data and Information: https://www.ngdc.noaa.gov/hazard/tsu.shtml
- NOAA Center for Tsunami Research/Pacific Marine Environmental Laboratory (PMEL): https://nctr.pmel.noaa.gov/index.html
- U.S. Agency for International Development (USAID): https://www.usaid.gov/ https://www.usaid.gov/what-we-do
- Office of U.S. Foreign Disaster Assistance (OFDA): https://www.usaid.gov/who-we-are/organization/bureaus/bureau-democracy-conflict-and-humanitarian-assistance/office-us

Warning Center User's Guides

PR and USVI receive both the domestic and international products from the PTWC. While the domestic products establish the alert levels for PR and USVI, the international products support IDSS with additional text and graphical products.

- Users' Guide Tsunami Warning Products for Puerto Rico, U.S Virgin Islands, and British Virgin Islands (Version 1.22, April 28, 2024) https://tsunami.gov/operations/PRVIUserGuide.pdf
- Communication Plan for the Interim Tsunami Advisory Information Service to the Caribbean Sea and Adjacent Regions 23 July 2006 Version. https://www.weather.gov/media/ctwp/PDF/CommunicationsPlanICG-CARIBE_EWS-II-11.pdf
- User's Guide for the Pacific Tsunami Warning Center Enhanced Products for the Tsunami and other Coastal Hazards Warning System for the Caribbean and Adjacent Regions (CARIBE EWS, 2017). https://www.weather.gov/media/ctwp/PDF/Users%20guide%202017.pdf

Seismic Information

- U.S. Geological Survey (USGS) Earthquakes Hazard Program: https://earthquake.usgs.gov/earthquakes/
- Puerto Rico Seismic Network (PRSN): http://redsismica.uprm.edu
- Earthscope CARIBE EWS Virtual Seismic Network: http://ds.iris.edu/gmap/#network=_CARIBE EWS&planet=earth
- Earthscope Data Management Center (DMC) https://ds.iris.edu/ds/nodes/dmc/
- International Tsunami Information Center Caribbean Office - Caribbean Tsunami Warning Program (Seismic Stations Reports and Maps): http://iticcar.org

Sea Level Tools/Information

- Center for Operational Oceanographic Products & Services Tsunami website https://tidesandcurrents.noaa.gov/tsunami/
- International Tsunami Information Center (Tide Tool) http://itic.ioc-unesco.org/index.php?option=com_content&view=article&id=1573:tsunami-warning-operations-sea-level-monitoring-tide-tool-and-ioc-sea-level-monitoring-facility&catid=2141&Itemid=2565
- International Tsunami Information Center Caribbean Office (Sea Level Stations Reports and Maps): http://caribewave.info
- National Data Buoy Center (NDBC) DART Program: https://www.ndbc.noaa.gov/dart/dart.shtml
- Puerto Rico Seismic Network Station Monitoring System: http://www.prsn.uprm.edu/English/EstacionesV3/gauges.php
- University of Hawaii Sea Level Center (UHSLC): https://uhslc.soest.hawaii.edu/network/
- National Centers for Environmental Information (NCEI) Long-term Archive of NOAA Water-level Data: https://www.ngdc.noaa.gov/hazard/tide/ https://www.ngdc.noaa.gov/hazard/dart/

10. Summary Plans for Future Tsunami Warning and Mitigation System Improvements

Tsunami detection and measurement. The United States continues to work toward a near-real-time, direct tsunami detection and measurement capability. If realized, we expect this will yield significant improvement in tsunami forecast accuracy. We expect this capability will consist of analyzing and integrating a number of discrete real-time data inputs, including traditional seismic waveforms and w-phase CMT calculations, but also place increasing emphasis on direct deep ocean and coastal sea-level readings, and added emphasis on determining coseismic deformation through GNSS offset data.

DART 4G: NOAA's 4th generation of DART is currently being deployed. It provides a more robust communications and mooring capability, and through the use of seismic band-pass filters, allows the bottom pressure recorder to be placed much closer to the seismic source than was possible with previous generations. This presents the opportunity to make direct tsunami detections within 10s of minutes as opposed to 1 hour, provided the instruments are properly relocated and densified. Final upgrades to firmware are necessary to activate 4G filtering, but NOAA is exploring a revised DART deployment grid to take advantage of the 4G capability to include the CARIBE EWS region.

GNSS Update: To facilitate incorporation of GNSS into TWC operations, NOAA's National Center for Tsunami Research has built a test-bed at the Pacific Marine Environmental Laboratory (PMEL) in Seattle WA for testing algorithm development done at various academic institutions into a prototype operational analysis system. As of Q3 of fiscal year 2022 the testbed has been detecting and characterizing small events. The GFAST system has been installed at NOAA's Tsunami Warning Centers and testing and training continues. Funding to the EarthScope Consortium for the operation of GAGE Facility, including the Network of the Americas, will end at close of Fiscal Year 2025. The future funding of NOTA by NSF is uncertain after September 30, 2025, although the EarthScope Consortium expects that NSF will be releasing a solicitation sometime in Summer 2023 for an integrated seismological and geodetic facility after the close-out of

the current SAGE and GAGE Facility Cooperative Agreements. While the scope that would be included in the NSF solicitation is unknown at this time, EarthScope Consortium senior management believe that NOTA will continue to be supported at some level after the close-out of the GAGE Facility. The UPRM, PRSN and PMEL are also working to study the use of the Ionospheric Total Electron Content (see Research section, below).

SMART Cables: Science Monitoring And Reliable Telecommunications (SMART) Cables are sensor-enabled subsea fiber optic cables that will be equipped with seismic, pressure, and temperature sensors. The goal of SMART Cables is to provide enhanced capabilities for Tsunami Early Warning (TEW), Earthquake Early Warning (EEW), climate monitoring, and telecommunications resiliency. These sensors are emplaced in and near cable repeaters, which are spaced 60-120 km apart and amplify cable signals. SMART Cable technological developments are ongoing, including hardware development by Subsea Data Systems, a U.S. startup supported by several foundations, including National Science Foundation, Schmidt Marine Technology Partners, and the Gordon and Betty Moore Foundation. Subsea Data Systems has also developed a SMART Cable data management system to facilitate low-latency data feeds for seismic and pressure data to earthquake and tsunami warning centers, as well as a SMART Cable data products line that leverages the SMART system for cable security purposes. A significant recent development is that several SMART Cable initiatives have made substantial progress toward implementation. Two SMART Cables are currently moving toward the construction phase: 1) TAM-TAM, a short (~150 km) cable connecting New Caledonia and Vanuatu with 4-6 SMART systems, and 2) Atlantic CAM in Portugal, a ring system connecting Lisbon, Azores, and Madeira with 20 SMART systems. Several other SMART Cable projects are in various stages of development. In the CARIBE EWS region, SMART Cables could provide a cost-effective solution to substantially improve earthquake and tsunami warning for the region, while simultaneously providing enhanced cable security for commercial subsea fiber cable systems.

U.S. Tsunami Warning Center (TWC) Alignment. The U.S. National Weather Service is undertaking a comprehensive re-design of the US Tsunami Warning System in order to both improve capabilities and ensure 100% failover capability between TWCs. This includes designing and building a comprehensive and common analytic system that will ensure both TWCs are working from the same scientific and procedural baseline when a tsunami event occurs, and ensuring common hardware and software infrastructure between PTWC and US NTWC to improve and align data ingestion and analysis, tsunami forecast model guidance, and message creation and dissemination, in a way that advances a seamlessly coordinated backup between the two tsunami warning centers. The first major milestone is the transition of legacy TWC messaging generation software to NWS supported architecture by early CY25.

NWS Hazard Simplification (Tsunami Focus). The U.S. National Weather Service (NWS) began a contract for internal and stakeholder engagement and connections on the possible removal of the term “Advisory” from domestic alerts from tsunami. The contract is for a Social, Behavioral, and Economic Science (SBES) study to evaluate the effectiveness and clarity of the current NWS Tsunami headline terms (Watch, Advisory, and Warning) and the body of the alert messages. In addition, the study will test new potential terminology and messaging with the public, core partners, and stakeholders in order to recommend changes to the alerting system while clearly describing the hazard, risks to maritime or land interests. Headlines and messages tested in this study must be compatible with established dissemination and communications methods. Specifically, the study is designed to examine how well the product suite operates as a whole (i.e. each product works in concert with the others to effectively show the dynamic nature of the threat). Interviews have begun with internal stakeholders, with the public and partner stakeholder survey period occurring in the Summer of 2024. From those survey results,

recommendations will be produced, providing the NWS with valuable information on possible changes to tsunami services from the two U.S. Tsunami Warning Centers (TWC). While this does not affect the CARIBE EWS products, the U.S. is aware that many countries have followed and adopted U.S. domestic messages.

Seismic Monitoring. The PRSN is working with the Dominican Republic to maintain the four seismic stations operated there. In Puerto Rico, the PRSN is planning the installation of two new broadband seismic stations.

- The PRSN released two new software modules to feed a central Earthworm system with real-time data streams from tide gauge satlink data servers and RTX GNSS corrected data messages. There are plans to install one GNSS - IR station.
- The ITIC-CAR in coordination with the PTWC, PRSN, Earthscope, network operators and CARIBE EWS Working Group 2, will continue to prepare and share monthly maps on seismic data availability at PTWC and biannual reports on status of CARIBE EWS stations through the intersessional period. During this time ITIC-CAR looks forward to reviewing the reports, their effectiveness and way forward with Working Group 2.

Sea level monitoring. The ITIC-CAR in coordination with the PTWC, PRSN and the IOC Sea Level Monitoring Facility, network operators and CARIBE EWS Working Group 2 will continue to prepare and share monthly maps on sea level data availability at PTWC and biannual reports on CARIBE EWS sea level stations through the intersessional period. ITIC-CAR looks forward to reviewing the reports with the WG 2 and the way forward.

- The PRSN is working with the Dominican Republic to maintain two tsunami-capable tide gauges. Plans are to install a new Tide Gauge station in the province of Samana. Also, a new tsunami-capable tide gauge will be installed in the British Virgin Island of Anegada.

Map Viewers

- NCEI continues to update the Caribbean and Adjacent Regions Tsunami Sources and Models (CATSAM) map viewer.
- NCEI enhanced the Tsunami Events (1850 to present) interactive time-lapse animation to include tsunami runup observations.
- The PRSN Tsunami Map Tool.
- NOS operates a Coastal Flood Exposure Mapper. The information in this product is based on the Roadmap for Adapting to Coastal Risk approach to assessing coastal hazard risks and vulnerabilities. The mapper enables users to explore maps that show people, places, and natural resources exposed to coastal flood hazards (including tsunamis) and create a collection of maps to share and communicate about flood exposure.

Seismic Hazard Map for Puerto Rico and the U.S. Virgin Islands

- The USGS National Seismic Hazard Model Project (NSHMP) has been working on the 2025 Puerto Rico and the U.S. Virgin Islands (PRVI) National Seismic Hazard Model (NSHM) update. The plan is to have the draft model completed, reviewed by the public and our review panels, and submitted for review to a journal by the end of 2024. A public workshop to present the draft model components and results is being planned for late August, 2024 in Puerto Rico.

Digital Elevation Models (DEM).

- NCEI updated regional-scale coastal relief models (CRMs) for the Atlantic Coast, Gulf Coast, Puerto Rico, and Hawaii. Similar to the high-resolution CUDEM and global ETOPO datasets, the mid-resolution CRMs combine a variety of airborne, shipborne, and satellite-derived datasets from U.S. and global sources into seamless

gridded topography and bathymetry extending inland from the coast to out beyond the continental shelf. The CRMs provide a key nested dataset for coastal hazard modelers to accurately simulate and predict hazards originating offshore.
- NCEI developed the ICESat-2 Validation of Elevations Reporting Tool (IVERT). The IVERT assesses the accuracy of DEMs against spaceborne lidar data collected by the NASA Ice, Cloud, and Land Elevation Satellite 2 (ICESat-2), and its ATLAS instrument.

US TsunamiReady® Program

- Through the National Tsunami Hazard Mitigation Program (NTHMP), NOAA will continue to support renewals of 49 communities recognized by the US National Weather Service in Puerto Rico and the US Virgin Islands, including the strengthening of local and territorial capabilities.

UNESCO IOC Tsunami Ready Programme

- ITIC-CAR is finalizing the USAID supported ($500,000) Tsunami Ready projects in Barbados, Saint Vincent and The Grenadines, Saint Lucia and Dominica. Communities in Saint Lucia and Dominica should be recognized in July 2024.
- ITIC-CAR receive an additional $500,000 from USAID to support TR renewal of Anguilla and 3 communities in Honduras (2 in Caribbean and 1 in Pacific) and new recognitions in Antigua and Barbuda and Belize.
- The Tsunami Ready page hosted by the International Tsunami Information Center (ITIC) (TsunamiReady.org) is being continuously updated. This page includes documentation on Tsunami Ready, as well as a map and the documentation of Tsunami Ready communities.
- ITIC-CAR will provide an intern (Lapenta Scholar) to conduct the TR survey of stakeholders that have been recognized since 2019. This is being coordinated with CTIC and WG IV sub group on TR.
- Dr. Laura Kong, Director of ITIC, is the Chair of the UNESCO/IOC Tsunami Ready Coalition. The purpose of the Coalition is to create awareness of the program and identify contributions to support TR initiatives.

Capacity Enhancement and IDSS

- ITIC will be co-organizing with SHOA/Chile the International Tsunami Training Program in Chile August 19-30, 2024. It will be open to attendees from CARIBE EWS.
- ITIC, as an IOC Ocean Teacher Global Academy Specialized Training Center (OTGA STC), will continue to develop online and hybrid training courses, to be available to all CARIBE-EWS Member States, and globally. The courses are being done in coordination with the IOC Tsunami information Centers (CTIC, IOTIC, NEAMTIC), Member State practitioner experts, and the Indonesia OTGA STC, Courses planned are:
    - Tsunami Awareness (6-hr online), in final stages
    - Tsunami Ready (6-hr online) - (led by Indonesia), in final stages
    - Tsunami Early Warning Systems (40-hr online/blended) to be started
    - Tsunami Warning Center and Emergency Response Standard Operating Procedures (40-hr online/blended) - planned
    - Tsunami Maps, Plans, and Procedures, including inundation mapping (TEMPP) (160-hr online/blended) - planned
    - Tsunami Hazard and Risk Assessment (40-hr course) - (led by Indonesia)
    - Tsunami Warning Center Staff Basic Competencies (120-hr online/blended) - planned and funded 2024

- The USGS has developed a tool for Pedestrian Evacuation Modelling - which has been used by Puerto Rico to help determine the best routes for evacuation and the selection and placement of vertical evacuation structures. Subject to funding availability the USGS/PRSN may be able to provide training on these tools.

CARIBE WAVE Exercise. The ITIC-CAR and PTWC will continue to coordinate and support this annual tsunami exercise, including the development of simulated products, handbook and reports, the conduct of webinars, survey, website (caribewave.org) and registration system (tsunamizone.gov)

World Tsunami Awareness Day (WTAD)

- ITIC will continue to support World Tsunami Awareness Day by hosting a page on its website, providing still and moving visuals and documentation, and subject matter expertise.
- Using all available social media platforms, the PRSN and the PR Bureau for Emergency Management (PR BEM) will participate and promote the participation in the WTAD.

UN Decade of Ocean Science

- NOAA will continue to support and be actively engaged in the UN Decade of Ocean Science for Sustainable Development through Programmes, Projects, and Contributions which have been proposed, or are under the IOC's Ocean Decade Tsunami Programme (ODTP)
- NOAA will continue to advocate for the development and implementation of SMART Cables, and other emerging technologies that support direct detection and measurement in support of tsunami early warning
- NOAA will continue to advocate and support (as funding permits) the implementation and maintenance of UNESCO/IOC Tsunami Ready Recognition Programme, including the Chairing of UNESCO/IOC Tsunami Ready Coalition by Dr. Laura Kong, Director of ITIC.
- ITIC-CAR will continue to engage in the coordination of the UN Decade of Ocean Science for Sustainable Development in the Western Atlantic (WTA), including participation in the WTA Working Group for Safe Ocean and the endorsed Decade Project, Integrating Coastal Hazards Early Warning Systems (iCHEWS) and its parent program, Coast Predict.

Outreach, Education, and Communications

- ITIC and ITIC-CAR will continue to distribute educational and decision support resources. A Google Form has been created for Member States to request materials: https://docs.google.com/forms/d/1Ohu8sKBT9JbMVOS5FAGnSfZt1ABkweepUw6KtH3oGDs/edit
- ITIC-CAR will continue to support the IOC Caribbean Tsunami Information Center (CTIC) mission activities, including collaborating for tsunami training in warning, response, and evacuation planning and warning decision support tools, Tsunami Ready, and outreach and awareness building.
- ITIC-CAR will continue to distribute Tsunami Rules Brochure in Braille and seek feedback from the Blind community and present findings at ICG CARIBE EWS XVIII.

Technology Warning Communications

- NOAA will continue to support the GEONET CAST Americas as an additional method to receive Tsunami products from the Pacific Tsunami Warning Center.
- NOAA will continue to support the EMWIN as an additional method to receive Tsunami products from the Pacific Tsunami Warning Center.

- ITIC-CAR will continue to support ICG CARIBE EWS WG 3 and the Inventory of Tsunami Warning Dissemination and Communication Systems.

NATIONAL PROGRAMMES AND ACTIVITIES INFORMATION

11. Executive Summary

The US continues to advance and strengthen its national thru local capabilities to assess, detect, analyze and forecast, issue and disseminate warnings and prepare and mitigate for future tsunamis in addition to advancing international and regional capacity enhancement initiatives including the UN Ocean Decade Tsunami Programme, the UNESCO-IOC Tsunami Ready Programme and CARIBE WAVE exercise and international training.

To accomplish its domestic and international missions, there is active ongoing collaboration between and thru NOAA line offices and programs (NWS, PTWC, ITIC, including its Caribbean Office, PMEL, NCEI, NCEP, NOS, NTHMP, San Juan Weather Forecast Office (WFO)), other US Agencies (USGS, FEMA), Puerto Rico and USVI academic and government agencies (PRSN, PREMB, VITEMA, UVI), UNESCO-IOC bodies (CARIBE-EWS, IOCARIBE, OD) and CARIBE EWS Member States. While funding for the domestic efforts comes from agency budgets, activities, those in and territories are funded by territorial budgets, NTHMP and FEMA.

Through the Caribbean Office of the International Tsunami Information Center, the US has continued to support the CARIBE EWS in response to the requests of the ICG and CTIC and through funding provided by the USAID for Tsunami Ready implementation. The website of ITIC-CAR was recently transitioned from a NWS site to UNESCO/IOC site within the ITIC Website (http://iticcar.org).

Tsunami forecast and warning operations continued as normal with no alert-level events. PTWC confirms communications over all circuits and with key partner agencies following each message issuance. Puerto Rico and the U.S. Virgin Islands also participate in international CARIBE EWS tsunami communication tests with PTWC, including CARIBE WAVE 24 exercise. For CARIBE WAVE 24, in addition to testing of communications between PTWC and local TWFPs drills, exercises and orientation events were conducted. 136,010 participants were registered from Puerto Rico and 23,672 from USVI on the USG supported TsunamiZone.org.

The United States continues to work toward a near-real-time, direct tsunami detection and measurement capability. If realized, we expect this will yield significant improvement in tsunami forecast accuracy. We expect this capability will consist of analyzing and integrating a number of discrete real-time data inputs, but also place increasing emphasis on direct deep ocean (SMART and DART) and coastal sea-level readings, and added emphasis on determining coseismic deformation through GNSS offset data. The U.S. National Weather Service is also undertaking a comprehensive re-design of the US Tsunami Warning System in order to both improve capabilities and ensure 100% failover capability between TWCs.

The US is also committed to advancing the understanding of tsunami risk and hazard assessments from all sources of tsunamis, ensuring that all people at risk from a tsunami are alerted (EW4ALL) and maintaining and augmenting the number of communities in the US and globally that are recognized by the US National Weather Service or UNESCO as Tsunami Ready.

Both Puerto Rico and the USVI maintain their Tsunami Ready status with the National Weather Service with 49 TsunamiReady communities, and 16 TsunamiReady supporters. The US looks forward to a mechanism by which the US TR communities can also be recognized as contributing to the goal of 100% of communities prepared for and resilient to tsunamis by 2030.

With funding from USAID, ITIC-CAR and in collaboration with CTIC and national and local authorities and stakeholders supported the UNESCO/IOC Tsunami Ready recognitions of Christ Church West, Barbados and the Parish of Saint George, Saint Vincent and The Grenadines in September 2023. It has ongoing TR projects in Dominica, Saint Lucia, Anguilla, Antigua and Barbuda, Belize and Honduras. USAID funded the Mayor of Portsmouth, Dominica and the Director of NEMO, Saint Vincent and the Grenadines to share their TR testimonies in the Ocean Decade Conference Side Event held in Barcelona in April, 2024 along with Christa von HIllebrandt and Dr. Laura Kong of ITIC. ITIC-CAR and PMEL/NCTR also presented the results of a Tsunami Ready tsunami hazard assessment in the Cayman Islands and Anguilla.

The US also supports multi-hazard early warning alignment by linking hazard-specific systems together. Equally important is the priority to apply an inclusive approach by providing a balanced platform for capacity, gender and generational participation. It is delighted to announce it produced and is distributing a tsunami brochure in Braille. It is the first such initiative in the globe.

Through these and two endorsed contributions, the US fully supports the implementation of the IOC Tsunami Ocean Decade Framework developed by the UN Ocean Decade Tsunami Programme (ODTP) Scientific Committee, which includes the membership of Christa von Hillebrandt and Dr. Laura Kong (as Chair of the UNESCO/IOC Tsunami Ready Coalition).

The US looks forward to celebrating 20 years of achievements and advances of the CARIBE -EWS. Together with the Member States and Observer organizations it is also committed to addressing challenges to achieve the goal of 100% of communities are warned and prepared for and resilient to tsunamis by 2030.

12. **Narrative**

Focus Areas

The US is focused on facilitating implementation of the IOC Tsunami Ocean Decade Framework developed by the UN Ocean Decade Tsunami Programme (ODTP) Scientific Committee. This will focus on two primary areas: (1) exploration and development of instrumentation and techniques to more rapidly detect and measure tsunamis independent of generating source; and, (2) ensuring capacities lifted across the region to enable the ODTP goal of *100% communities at risk are prepared for and resilient to tsunamis* through programs like the UNESCO IOC Tsunami Ready Recognition Programme. More specifically we will strive to accomplish this by:

1. Detection and Measurement
    a. Advocate full sharing of available data at time and space resolutions necessary for tsunami detection and measurement
    b. Determine spatial and temporal resolutions necessary to detect and measure tsunamis from all sources
    c. Identify candidate new capabilities to be tested and possibly deployed within the region
    d. Consider new research initiatives to add detection and measurement capabilities not current developed (eg Ionospheric TEC)
    e. Identify instrumentation and or communications investments can make in order to contribute to the CARIBE EWS Rapid Tsunami Detection and Measurement initiative
2. Risk Assessment, Warning Communications and Preparedness and Response
    a. Advance the understanding of tsunami risk and hazard assessments from all sources of tsunamis.

   b. Ensure that all people at risk from a tsunami are alerted and reinforce the warning messages.
   c. Maintain and augment the number of communities in the US and globally that are recognized by the US National Weather Service or UNESCO as Tsunami Ready.
3. Support multi hazard early warning alignment by linking hazard-specific systems together.
4. Apply an inclusive approach by providing a balanced platform for gender and generational participation.

The US is committed to Improved tsunami detection and source characterization. These efforts include:

a. Continued testing of the 4th Generation of DART with advanced seismic noise filtering to allow for near-field placement.
b. Continued testing and development of advanced **geodetic analysis** in tsunami source estimation using GNSS station static offsets. We expect to field and initial capability to use this technique in operations within 2 years.
c. The PRSN completed a regional study toward the implementation of a rapid tool to compute the focal mechanism via the W-phase method, and will also support research regarding the Tsunami detection using the ionospheric total electron content (TEC) methodology.

Warning Center Operations

There were no significant changes to PTWC's domestic procedures or operations. However, there were some minor product changes to add Universal Geographic Codes with corresponding area descriptions to the headers of all PTWC's products for Puerto Rico and the Virgin Islands, and to have the area description given in Spanish in all the Spanish-language versions of the products. A summary of products issued is contained in Section 8.

US DART Systems

DART station 44403 near Sable Island Bank and station 44402, 130 nautical miles southeast of Fire Island, NY, are operational as of April 2024l. NDBC repaired DART 42409, which is 247 nautical miles south of New Orleans, LA; station 41421, which is located 300 nautical miles north of Saint Thomas, Virgin Islands; and station 42407, 230 nautical miles southwest of San Juan, PR, as part of their regular maintenance and repair schedule in 2024.

GNSS Training in Puerto Rico

In summer 2023 (August 7-11), the PRSN with the support from EarthScope and ICG/CARIBE EWS held a short course in GNSS titled: "*Improving the Geodetic Component in Monitoring Agencies for the Earthquake and Tsunami Warning del Intergovernmental Coordination Group for the Tsunami and other Coastal Hazards Warning System for the Caribbean and Adjacent Regions."* The course was funded by NOAA and the course was given in Aguadilla, Puerto Rico. The course was organized to include theoretical talks and a field trip to visit one of the PRSN GNSS stations. The main objective was to learn about the use of GNSS data for earthquake characterization and applications in tsunami warning centers. That includes a detailed description from the station installation to the data quality control. The topics were: NTRIP Casters, RTX, the GSOF2EW module, G-FAST, TEC and IR. Fifteen (15) countries were represented, and keynote speakers were from EarthScope, PRSN, UW, NOAA, USGS and ICG/CARIBE EWS. Each network operator presented a short talk regarding their particular network.

https://drive.google.com/drive/folders/1mbGAcXlhbbPC0UolmFsF5C8OkOa_0TEW?usp=sharing

Technology and Warning Communications

GEONETCAST-AMERICAS (GNC-A)

- GEONETCast Americas (GNC-A) is a near real time, global network of satellite broadcasts that disseminate meteorological and environmental data, products, and emergency communications to users. Because it is a standalone system that can be powered by a portable generator, GNC-A does not require internet service or commercial power to provide data to users and can be a reliable, timely way to receive information, especially during emergency situations.
- NOAA-NESDIS maintains the GNC-A broadcast. Data, products and information on the broadcast are provided for transmission by various countries, organizations, and users. Tsunami and other weather warning products take priority and are broadcast first.
- ITIC CAR in preparation and in support of CARIBE Wave 24 exercise hosted a webinar on this system. To address the need for repairs and troubleshooting on stations, the GNC-A Forum was highlighted as a resource. In addition a WhatsApp Group for users to discuss things was created. Another resource is INPE GNC-A Website (Brazil)
- Information on GNC-A was made available during CW 24 webinar 2
- CARIBE WAVE 24 Dummy Message was transmitted successfully over GNC-A
- The PRSN was not able to get the GNC A operational in its facilities
- NOAA-NESDIS is collaborating with the Caribbean Institute for Meteorology and Hydrology (CIMH) to distribute 24 DVB-S2 receivers, a key component of GNC-A ground stations, to user's standing up GNC-A programs in the Caribbean. Requests for receivers will be reviewed and approved collectively by NOAA and CIMH.

Emergency Managers Weather Information Network (**EMWIN**).

- High Rate Information Transmission/Emergency Managers Weather Information Network (HRIT/EMWIN) – HRIT/EMWIN is a NOAA-provided broadcast available from either GOES-R series East/West satellites. Both satellite broadcasts are limited in bandwidth, thus products available are limited or in lower resolution compared to GNC-A.
- The NWS EMWIN satellite broadcast and FTP file server services fully transitioned to the US NWS Enterprise Architecture at College Park, MD and Boulder, CO in December 2020. This transition enabled the EMWIN broadcast stream to be transmitted via the GOES-East (GOES-16, 75.2° West) and GOES-West (GOES-17, 137.2° West) satellites through the NESDIS HRIT/EMWIN broadcast service (1694.1 MHz) using Virtual Channels 20, 21 and 22.
- With the introduction of the GOES-16/17 HRIT/EMWIN modified broadcast format, EMWIN users had to replace their legacy EMWIN receivers with HRIT receivers if they desired to continue receiving products over a satellite broadcast. Unfortunately, the major EMWIN legacy satellite receiver manufacturers did not pursue the manufacture of affordable HRIT/EMWIN receiving systems due in part to the reported likelihood of interference from new G5 cell phone service upstarts in the recently auctioned adjacent radio frequency spectrum. Existing EMWIN users were left with a limited number of alternatives: (1) investing in a high-end commercial HRIT/EMWIN receiver costing upwards of 10x the price of the previous receiver, (2) constructing a hobbyist EMWIN receiving systems from parts and software and support the systems locally, or (3) looking elsewhere for

dissemination services to meet the local information requirements. Consequently, a large segment of the EMWIN user community transitioned to alternate systems and services to receive timely alerts and warnings including, among others, the NWS NOAA Weather Wire Service (NWWS) and its associated internet dissemination service, and the NESDIS GEONetcast-Americas satellite broadcast service.

- The NWS continues to investigate alternatives for the legacy EMWIN ByteBlaster Internet dissemination service which could not transition into the US NWS Enterprise Architecture at College Park, MD and Boulder, CO due to an inability to meet IT operational compliance requirements.
- Many users now only have access to EMWIN over internet, not satellite. The PRSN has installed several satellite based systems purchased from DARTCOM.
- Information on EMWIN was made available during CW 24 webinar 2
- CARIBE WAVE 24 Dummy Message was transmitted successfully over EMWIN
- More HRIT/EMWIN Broadcast Information (https://www.noaasis.noaa.gov/ and https://www.weather.gov/emwin/)
- Questions regarding the content of the EMWIN data service, including the selection and addition of products should be addressed to nws.emwin.support@noaa.gov
- Questions regarding the GOES HRIT/EMWIN Broadcast, for example apparent outages or missing products, can be addressed to hrit.manager@noaa.gov
- For HRIT/EMWIN broadcast issues impacting user operations, especially outside of work hours, please contact the ESPC 24/7 Helpdesk at ESPCOperations@noaa.gov or (301) 817-3880

Inventory of Tsunami Warning Dissemination and Communication systems.

- ITIC-CAR supported ICG CARIBE EWS WG 3 in the preparation of an Inventory of Tsunami Warning Dissemination and Communication systems.

Tsunami Research Projects and Publications

GNSS

- A collaboration between the NOAA Center for Tsunami Research and NASA Jet Propulsion Lab was formed to study the feasibility of utilizing GNSS Total Electron Content (TEC) ionospheric measurements to aid in tsunami forecasting. The JPL GUARDIAN project produces TEC waveforms for events within 1200km of GNSS stations, with transfer functions to estimate oceanic waveforms and locations.
- The NOAA Center for Tsunami Research continues to conduct research and develop software to incorporate the GNSS technology into the SIFT Tsunami Forecast System. The GFAST system was installed at NOAA Tsunami Warning Centers, with Fastlane data feeds from Central Washington University. Peak Ground Displacement magnitude estimates are fed into SIFT within 90 seconds of origin time, and Finite Fault estimates within 3 minutes.
- The UPRM and the PRSN are working in an effort to study the use of the GNSS - Interferometric Reflectometry (GNSS-IR).

Other

- Along with lead author Dr. Valerie Clouard and other co-authors, Christa von Hillebrandt, Charles McCreery and Jelis Sostre of the US published the scientific paper Implementation of tsunami warning procedures in the Caribbean in case of a volcano crisis: Use of a Volcano Notice for tsUnami Threat (VONUT), in the Bulletin of Volcanology.
- In addition to archiving and processing preliminary 1-minute water level data from CO-OPS tide gauge stations in the Caribbean, NCEI continues to archive preliminary

and verified 6-minute, verified highs and lows, verified hourly, and verified monthly mean water levels for these same stations. NCEI quality-controlled and de-tided 1-minute water level data from the NOAA tide station at Clearwater Beach, FL, on the Gulf Coast of Florida showing evidence of a meteotsunami on June 21, 2023. See the figure provided in the September 2023 edition of the "NCEI Water Level Update - Tsunami." 100 new images across 4 events were added to the Natural Hazards Image Database and archived at NCEI. These images include recently acquired tsunami survey team images from the 2022 Tonga eruption and tsunami event.

- The PRSN completed a regional study toward the implementation of a rapid tool to compute the focal mechanism via the W-phase method. Their results show the performance of the algorithms and the capability to improve the regional detection of larger tsunamigenic earthquakes. Also, two new software modules were developed to feed a central Earthworm system with real-time streams from tide gauge satlink data servers and RTX GNSS corrected data messages.
- PTHA: With the support of the NTHMP Puerto Rico is currently developing a Probabilistic Tsunami Hazard Analysis for the island concentrating on the off-shore fault sources. The ultimate aim is to include the PTHA in future ASCE building codes.
- PRISTINA Experiment: Puerto RIco Subduction Tectonics seismic INvestigAtion: In November-December 2023 an NSF supported seismic survey across the PRT, its outer rise, and across the island of Puerto Rico using the RV Langseth (cruises MGL2315 and MGL2316) was performed along with the deployment of Nodal and Broadband instrumentation on-shore. Data from these cruises are currently being analyzed with the aim to better characterize the Puerto Rico Subduction Zone.

Improved tsunami documentation.

- 100 new images across 4 events were added to the Natural Hazards Image Database and archived at NCEI. These images include recently acquired tsunami survey team images from the 2022 Tonga eruption and tsunami event.

Tsunami Mitigation Activities and Best Practices in Puerto Rico and the USVI

- Puerto Rico and the US Virgin Islands have been recognized as TsunamiReady® by the National Weather Service since 2016 and 2014, respectively. Within Puerto Rico there are 46 TsunamiReady communities, while for the USVI the total number is 3. The renewal cycle is 4 years. https://www.weather.gov/TsunamiReady/communities
- In addition to the TsunamiReady communities, there are sixteen TsunamiReady supporters in Puerto Rico. https://www.weather.gov/tsunamiready/communities
- NOAA, through the National Tsunami Hazard Mitigation Program (NTHMP), provides funding to the Puerto Rico Seismic Network (UPRM), the Puerto Rico Emergency Management Bureau and VITEMA for the TsunamiReady renewal activities.
- FEMA, through hurricane recovery and mitigation funding, has also supported activities associated with the TsunamiReady guidelines.
- As a result of the hurricanes of 2017, a significant number of tsunami signs, EMWIN systems and sirens were destroyed in Puerto Rico and the U.S. Virgin Islands. The replacement effort has almost been completed.
- Puerto Rico has held meetings and prepared a guidance document on vertical evacuation for tsunamis and is updating the tsunami guidelines for the maritime community.
- PRSN, PREMB, VITEMA and ITIC-CAR have resumed in-person outreach activities in which tsunami guidance was provided.

- PRSN with NOAA/NTHMP funding is currently updating its Tsunami Media tool kit (Spanish) http://www.prsn.uprm.edu/mediakit/ PRSN with NOAA/NTHMP funding updated the tsunami maritime guidance (in Spanish). http://redsismica.uprm.edu/Spanish/tsunami/programatsunami/prc/documentos/Maritima/GuiadeTsunamis_Comunidad_Maritima_Final2019.pdf
- PRSN with NOAA/NTMP funding is updating the TsunamiMap tool for online access to tsunami inundation, community pedestrian models, evacuation and signage information http://prddst.uprm.edu/apps/prtmp/
- PRSN with NOAA/NTHMP funding is coordinating a protocol and a pilot effort to include the Amateur Radio associations into the tsunami alerting system.

Supporting Tsunami Awareness, UNESCO/IOC Tsunami Ready Programme Implementation and other Capacity Enhancement and IDSS efforts in CARIBE EWS

- In 2023 ITIC CAR transcribed the CTIC Tsunami Rules brochure in Braille. It is the first such initiative in the globe to provide educational and awareness materials for visually impaired community. It is currently in the process of distributing the materials and gathering feedback.
- ITIC CAR supported the final translation into spanish of the UNESCO/IOC as Manual and Guide 86 “The Multi-Annual Community Tsunami Exercise Programme: Guidelines for the Tsunami and other Coastal Hazards Warning System for the Caribbean and Adjacent Regions. It had already been translated into French.
- NCEI and ITIC updated its Global Historical Tsunami, Significant Earthquake, and Significant Volcanic Eruption posters to 2023. As well as being general public outreach materials, the posters are used as historical references for experts and as a way to communicate to the media during an event. The posters are distributed to warning and response personnel by the ITIC and are available digitally through both NCEI and the ITIC. Hard copies available on request. http://itic.ioc-unesco.org/index.php?option=com_content&view=article&id=1672&Itemid=2698
- PMEL, ITIC,ITIC-CAR and PTWC continued the development of new features in the TsuCAT software and made it available to some of the training participants. TsuCAT v4.3.2 supports tsunami hazard assessment and tsunami exercises using the PTWC Products; the newest feature adds the option to automatically produce customized exercise injects. http://itic.ioc-unesco.org/index.php?option=com_content&view=category&layout=blog&id=2239&Itemid=2763
- ITIC is developing online and blended training as an IOC Ocean Teacher Global Academy Specialized Training Center for Tsunamis. Courses available in 2023-2024 will be Tsunami Awareness, Tsunami Ready, and Tsunami Early Warning Systems. http://itic.ioc-unesco.org/index.php?option=com_content&view=article&id=2138&Itemid=3207
- The website of ITIC-CAR was transitioned from NWS site to UNESCO/IOC site within the ITIC Website. The easy link for the page is http://iticcar.org
- NCEI and ITIC updated the Historical Tsunami Effects: Caribbean, Central America, Mexico and Adjacent Regions (1530–2023) Poster with event through March 2023. Additional regional maps are available for regions near the Tonga Trench, New Guinea and Bismarck Trenches, and New Hebrides Trenches
- PMEL, ITIC, and PTWC continued training in the use of the TsuCAT software, including a workshop in Anguilla and Cayman Islands and support to Aruba. New features are planned to show focal mechanisms for historic events to support work in IOC Tsunami Source workshops.
- IITIC-CAR produced videos on the TR recognition program in Barbados and another for Saint Vincent and The Grenadines. Both are captioned. These videos, in addition to

others that ITIC has produced can be accessed on theITIC YouTube Channel for sharing of videos https://youtu.be/a6_ZiRItqOM. In addition to PTWC products and staging videos are on the ITIC Vimeo site https://vimeo.com/showcase/8956022, Password: training

- ITIC-CAR held a Tsunami Ready workshop in San Jose, Costa Rica on Apr 24, 2023 for stakeholders from USAID supported projects and interested parties from other countries. The PRSN participated also in this workshop sharing its expertise.
- ITIC-CAR with funding from USAID participated and supported the participation of the Mayor of Portsmouth, Dominica and the Director of NEMO, Saint Vincent and the Grenadines in the Ocean Decade Conference Side Event held in Barcelona on April, 11, 2024. The Director of ITIC and Manager of ITIC-CAR also participated.
- As part of ITIC CAR project, with funding from USAID, Christ Church West, Barbados and Parish of Saint George, Saint Vincent and The Grenadines, were recognized in September 2023.
- ITIC-CAR and PMEL/NCTR presented the results of a Tsunami Ready tsunami hazard assessment in the Cayman Islands September 23-25, 2023, and presented tsunami hazard assessment results in Anguilla March 10-15, 2024
- Christa von Hillebrandt presented on Tsunami Ready in the Tsunami Evacuation Workshop held in San José, Costa Rica – April 22-24, 2024
- Christa von Hillebrandt and Laura Kong presented on Tsunami Ready in the Caribbean and Pacific at AGU, 2023 in San Francisco.
- The International Tsunami Information Center (ITIC) conducted its annual ITIC Training Program in Hawaii (ITP-Hawaii) from 7 to 18 August 2023 on Tsunami Early Warning Systems and the Pacific Tsunami Warning Center (PTWC) Enhanced Products, Tsunami Evacuation Planning and the UNESCO IOC Tsunami Ready Recognition Programme. Thirty-six participants representing tsunami warning centers and emergency response agencies from 26 Pacific and Caribbean countries, including 19 persons from Pacific and 5 from Caribbean Small Island Developing States, attended.
- Between June 2023 and March 2024, ITIC-CAR delivered in person training on Tsunami Early Warning Systems and the Pacific Tsunami Warning Center (PTWC) Enhanced Products, Tsunami Evacuation Planning and the UNESCO IOC Tsunami Ready Recognition Programme in Anguilla, Barbados, Cayman Islands, Dominica, Saint Lucia, Saint Vincent and the Grenadines and US (Puerto Rico and USVI)

Tsunami Exercises and Communication Tests

Caribe Wave 2024

- Puerto Rico and the US Virgin Islands participated in the CARIBE WAVE 24 exercise on March 21. It was both a domestic and international exercise and consisted of two exercise scenarios (Panama and Puerto Rico Trench). The scenario chosen was Puerto Rico Trench. The PTWC prepared simulated domestic messages for this scenario, in addition to the international messages. According to TsunamiZone.org, 475,044 (up from 410,292 in 2023) people from Bermuda through Brazil were registered to participate. From Puerto Rico, 136,010 (up from 117,696) people were registered, while for the USVI, the number was 23,672 (up from 12,351).
- For both exercises, the PTWC issued one dummy message at the start of the exercise that was followed by the simulated products, which were sent according to the scenario each country had selected. In Puerto Rico and the U.S. Virgin Islands, activities included communication tests, activation of the Emergency Alert System (EAS), testing the use of radio operators to disseminate information, and drills. The exercise was coordinated at the regional level by the ICG CARIBE EWS CARIBE WAVE Task Team. The ITIC

Caribbean Office served as exercise coordinator, with documentation, website, communication and webinars. Also, all reports and documentation for the exercise are now posted on the website of the International Tsunami Information Center. Locally the exercise was coordinated by the PRSN, the Puerto Rico Emergency Management Bureau, the San Juan WFO, and the Virgin Islands Territorial Emergency Management Agency. PRSN's contribution included providing support and guidance to local stakeholders to participate in the exercise. The University of Southern California supported the TsunamiZone.org registry web tool, which is funded through the National Tsunami Hazard Mitigation Program.

- The US looks forward to participating in and supporting the CARIBE WAVE 25 exercise and supporting coordination through its Caribbean Office of the ITIC.

Communication Tests

- Puerto Rico and the U.S. Virgin Islands also participated in international CARIBE EWS tsunami communication tests with PTWC.
- PTWC's communication tests with Puerto Rico and the Virgin Islands continue suspended due to problems with third-party distributors of tsunami alerts that inadvertently send out a tsunami warning in response to US NTWC communication tests. This problem is being addressed by mandating a change to the VTEC codes used in the U.S. NTWC has resumed test messages, and PTWC is considering renewing monthly tests with Puerto Rico and the Virgin Islands stakeholders.
- Puerto Rico and the U.S. Virgin Islands participated in international tsunami communication tests with PTWC.
- Puerto Rico Seismic Network has implemented a local monthly test.
- Puerto Rico municipalities conduct a silent test of its sirens every first Wednesday of the month and audible test on the last Wednesday of every month.
- USVI does monthly tests and holds weekly meetings to review the status of its siren systems and coordination of communication tests.

END

Appendix A: *Seismic stations operated by Puerto Rico (PR) including PRSN and PRSMP and the USG (CU (USGS Caribbean Network) and IU (Global Seismic Network) in the CARIBE_EWS region.*

Location	Latitude	Longitude	Operator	Net_Stat	Sensors	Status*
Anegada, British Virgin Islands	18.73 N	64.33 W	PR	ABVI	Velocity + Acceleration + GPS	No Comms
Tortola, British Virgin Islands	18.42 N	64.62 W	PR	TBVI	Velocity + Acceleration	OK
Virgin Gorda, British Virgin Islands	18.49 N	64.40 W	PR	VGBI	Velocity + Acceleration + GNSS	No Comms
Aguadilla, Puerto Rico	18.47 N	67.11 W	PR	AGPR	Velocity + Acceleration + GNSS	OK
Arecibo, Puerto Rico	18.35 N	66.75 W	PR	AOPR	Velocity + Acceleration + GNSS	OK
St. Croix, U.S. Virgin Islands	17.75 N	64.77 W	PR	CDVI	Velocity + Acceleration + GPS (CORS)	OK
Cerillos Dam, Ponce, Puerto Rico	18.07 N	66.58 W	PR	CELP	Velocity + Acceleration	OK
Cabo Rojo, Puerto Rico	18.01 N	67.11 W	PR	CRPR	Velocity + Acceleration + GNSS	OK
Culebra, Puerto Rico	18.31 N	65.281 W	PR	CUPR	Velocity + Acceleration + GNSS	OK
Manati, Puerto Rico	18.48 N	66.53 W	PR	EMPR	Velocity + Acceleration + GNSS	OK
Guanica, Puerto Rico	17.98 N	66.88 W	PR	GBPR	Velocity	OK
Guaynabo, Puerto Rico	18.31 N	66.08 W	PR	GCPR	Velocity + Acceleration	OK
Humacao, Puerto Rico	18.14 N	65.86 W	PR	HUMP	Velocity + Acceleration + GPS	OK
Isla Caja de Muertos, Puerto Rico	17.89 N	66.53 W	PR	ICMP	Velocity + Acceleration + GNSS	OK
Isla Desecheo, Puerto Rico	18.39 N	67.47 W	PR	IDE	Velocity	OK
Guayama, Puerto Rico	17.97 N	66.11 W	PR	IGPR	Velocity + Acceleration + GNSS	OK
Isla Mona, Puerto Rico	18.08 N	67.93 W	PR	IMPR	Velocity + Acceleration + GNSS	OK
Mayagüez, Puerto Rico	18.18 N	67.09 W	PR	LSP	Velocity	OK
Lajas, Puerto Rico	17.97 N	67.04 W	PR	MLPR	Velocity + Acceleration + GNSS	OK
Vieques, Puerto Rico	18.10 N	65.55 W	PR	MTP	Velocity + Acceleration	OK
Obispado, Ponce, Puerto Rico	18.04 N	66.61 W	PR	OBIP	Velocity + Acceleration	OK

Patillas, Puerto Rico	18.02 N	66.02 W	PR	PDPR	Velocity + Acceleration + GNSS	OK
U Puerto Rico Mayagüez, Puerto Rico	18.22 N	67.14 W	PR	PRSN	Velocity + Acceleration + GNSS	OK
St. John, U.S. Virgin Islands	18.33 N	64.77 W	PR	SJVI	Velocity + Acceleration	No Comms
St. Thomas, U.S. Virgin Islands	18.35 N	64.96 W	PR	STVI	Velocity + Acceleration + GPS	OK
Utuado, Puerto Rico	18.25 N	66.72 W	PR	UUPR	Velocity + Acceleration	OK
Corozal, Puerto Rico	18.32 N	66.36 W	PR	ECPR	Velocity + Acceleration + GNSS	OK
Ceiba, Puerto Rico	18.22 N	65.666 W	PR	FAPR	Strong Motion Seismometer	OK
Salinas, PR	18.029 N	66.235 W	PR	ASPR	Velocity & Acceleration	OK
Punta Cana, Dominican Republic	18.51 N	68.38 W	PR	PCDR	Velocity + Acceleration	OK
Miches, Dominican Republic	18.98 N	69.05 W	PR	MIDR	Velocity + Acceleration	OK
Samana, Dominican Republic	19.29 N	69.19 W	PR	SMDR	Velocity + Acceleration	OK
Isla Saona, Dominican Republic	18.19 N	68.78 W	PR	SADR	Velocity + Acceleration	OK
North Barbuda Island	17.67N	61.79 W	CU	ANWB	Velocity	OK
Gun Hill	13.14 N	59.56 W	CU	BBGH	Velocity	OK
Isla Barro Colorado	9.17 N	79.83W	CU	BCIP	Velocity	OK
Grand Turk	21.51 N	71.13W	CU	GRTK	Velocity	OK
Grenville	12.13N	61.65 W	CU	GRGR	Velocity	OK
Guantanamo Bay	19.23N	75.11 W	CU	GTBY	Velocity	OK
Mount Denham, Jamaica	18.23N	77.53W	CU	MTDJ	Velocity	OK
Presa de Sabenta, Dominican Republic	18.98N	71.29W	CU	SDDR	Velocity	OK
Tegucigalpa	14.06N	87.27W	CU	TGUH	Velocity	OK
Bermuda Institute of Ocean Sciences	32.37N	64.70W	IU	BBSR	Velocity	OK
Disney Wilderness Preserve	28.11N	81.43W	IU	DWPF	Velocity	OK
San Pablo	39.54N	4.35W	IU	PAB	Velocity	OK
Riachuelo	5.83S	35.90W	IU	RCBR	Velocity	OK
Samuel	8.95S	63.18W	IU	SAML	Velocity	OK

Santo Domingo	8.88N	70.63W	IU	SDV	Velocity	OK
Cayey	18.11N	66.15W	IU	SJG	Velocity	OK
Tepich	20.23N	88.28W	IU	TEIG	Velocity	OK
Aruba	12.51N	70.01W	PR	ACPR	Velocity	OK