U.S. National Sea Level Report

Contributions to the Global Sea Level Observing System

NOAA NWLON Station in San Juan, Puerto Rico with both acoustic (in back) and microwave sensors installed

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1.0 Introduction

The 2017 United States National Report to the Global Sea Level Observing System (GLOSS) Group of Experts (GE) XV serves as a summary of various ongoing U.S. programs and activities that support GLOSS goals and objectives as outlined in the 2012 GLOSS Implementation Plan. While programs and activities addressing sea level in the U.S. extend from federal to academic, this report focuses on four primary U.S. contributions to GLOSS:

- The NOAA National Ocean Service (NOS) National Water Level Observation Network (NWLON), managed by the Center for Operational Oceanographic Products and Services (CO-OPS)
- The University of Hawaii Sea Level Center (UHSLC)
- U.S. support for satellite altimeter operations and research
- Caribbean regional center

The information in this report is not intended to be exhaustive but rather provides an overview of the topic. When possible, web URLs point the reader to more in-depth discussions. The first section describes the mission of the major organizations as they relate to supporting the sea level observations both in in U.S. waters, regionally, and globally. The second section describes components of the U.S. sea level observing network and provides an update on its operating status since the 2015 report. The third section provides a short synopses on the technology used within the observing systems and describes improvements to those networks over the past few years. The fourth section provides updates to data availability and product delivery systems that have occurred, while the fifth section gives points of contact for each of the organizations described in this report. Appendices list additional water level observing stations and satellite altimetry systems not listed in the main report.

The U.S. program for sea level observations continues to work toward increasing its capabilities through improving infrastructure and methodologies within the network and assisting in building capacities of our regional partners external to the U.S. network. The U.S. looks forward to a future of collaborative sea level monitoring and product dissemination efforts with the international community.

2.0 Organizational Components of the U.S. Sea Level Observing System

2.1 NOAA Center for Operational Oceanographic Products and Services

CO-OPS provides the U.S. national infrastructure, science, and technical expertise to collect and distribute observations and predictions of water levels to protect life, property, and the environment. Businesses, communities, and people's daily lives rely on this information for decisions affecting such things as safe and efficient transportation and commerce, coastal planning and marine conservation, and protecting and restoring habitats and ecosystems.

To collect this information, CO-OPS operates NWLON, a network of 210 continuously operating real time water level stations that provides the national standards for tide and water level reference datums used for nautical charting, coastal engineering, international treaty regulation, and boundary determination. NWLON water level data is supplied to numerous international sea level data archives including the Permanent Service for Mean Sea Level (PSMSL) and the Joint Archive for Sea Level (JASL).

2.2 NOAA Ocean Observing and Monitoring Division

The NOAA Ocean Observing and Monitoring Division (OOMD) supports the ocean component of the Global Climate Observing System (GCOS) and provides long-term, high quality, timely, global observational data, information and products in support of climate, Arctic, weather, and ocean research communities, forecasters, and other service providers and users, for the benefit of society (http://cpo.noaa.gov/ClimateDivisions/OceanObservingandMonitoring.aspx).

A global observing system by definition crosses international boundaries, with potential for both benefits and responsibilities to be shared by many nations. All of NOAA's contributions to global ocean observations are managed in cooperation with the Joint World Meteorological Organization - Intergovernmental Oceanographic Commission (IOC) Technical Commission for Oceanography and Marine Meteorology (JCOMM). NOAA has historically funded nearly half of the *in situ* elements of the international ocean climate observing system. Much of this work is accomplished through the OOMD.

OOMD supports the networks that make up the sustained ocean observing system for climate. They are: tide gauge stations, dedicated ships, ships of opportunity, ocean reference stations, Arctic observing systems, tropical moored buoys, surface drifting buoys, Argo profiling floats, data and assimilation subsystems, product delivery, and continuous satellite missions for sea surface temperature, sea surface height, surface vector winds, ocean color, and sea ice.

Tide gauge stations are necessary to the climate program for accurately measuring long-term trends in sea level change and for calibration and validation of the measurements from satellite altimeters, which are assimilated into global climate models for predicting climate variability and change. Many tide stations need to be upgraded with modern technology, particularly in less developed countries.

The UHSLC is a NOAA partner that assists in the coordination of tide gauge operations within the international community. NOAA provides long-term support for the climate work at the UHSLC. Sea level stations within the U.S. are primarily operated by CO-OPS.

2.3 NOAA Tsunami Warning Program

The NOAA Tsunami Program is a cross-NOAA cooperative effort to minimize the impacts of tsunamis. Administered by NOAA's National Weather Service (NWS), the program leverages the capabilities of other NOAA operational line offices, including the Office of Oceanic and Atmospheric Research, NOS, and the National Environmental Satellite, Data, and Information Service (NESDIS).

The NWS operates two tsunami warning centers, which are staffed 24 hours a day, 7 days a week. The two centers monitor for tsunamis and the earthquakes that may cause them, as well as forecast tsunami impacts statements and tsunami messages. The Pacific Tsunami Warning Center (PTWC) in Hawaii serves the Hawaiian Islands, the U.S. Pacific and Caribbean territories, and the British Virgin Islands. It is the primary international forecast center for the warning centers of the UNESCO Intergovernmental Oceanographic Commission (IOC) in the Pacific and Caribbean and Adjacent Regions. The second center is the U.S. National Tsunami Warning Center (NTWC) in Alaska. The NTWC serves the continental United States, Alaska and Canada.

In support of international partners, the NOAA Tsunami Program operates the Caribbean Tsunami Warning Program (CTWP) which works to improve tsunami observations, provides training and outreach and educational assistance and facilitates data exchange to regional partners in the Caribbean and adjacent regions. The CTWP supports activities of the IOC's Intergovernmental Coordination Group for Tsunamis and Other Coastal Hazards Warning System for the Caribbean and Adjacent Regions.

2.4 NOAA Laboratory for Satellite Altimetry

The NOAA Laboratory for Satellite Altimetry (LSA) specializes in the application of satellite altimetry to a broad array of climate and weather related issues, including global and regional sea level rise, coastal and open-ocean circulation, weather prediction — from hurricane intensity forecasting to El Niño and La Niña events -- and monitoring the changing state of the Arctic Ocean.

2.5 NOAA National Geodetic Survey

The National Geodetic Survey (NGS), an office of NOS, is responsible for defining, maintaining and providing access to the National Spatial Reference System (NSRS). The NSRS is used by all civilian federal agencies and most of the public to establish coordinates for legal purposes. In the last 12 years, the geometric component of the NSRS, latitude, longitude and ellipsoidal heights (NAD 83) has been defined via space geodetic techniques, especially GPS.

2.6 University of Hawaii Sea Level Center

The UHSLC collects, processes, and distributes tide gauge measurements from around the world in support of various climate research activities. Primary support for the UHSLC is provided by the NOAA OOMD. UHSLC datasets are used for a variety of research and operational activities, including assessments of sea level rise and variability, the calibration of altimeter data, and storm surge and tsunami monitoring. In support of satellite altimeter calibration and for absolute sea level rise monitoring, the UHSLC and the Pacific GPS Facility maintain co-located GPS systems at select tide gauge stations (GPS@TG). The UHSLC currently is a designated IOC GLOSS data archive center. The UHSLC distributes data directly from its own website and through a dedicated OPeNDAP server. The data are redistributed by the National Centers for Environmental Information (NCEI), the PSML, the British Oceanographic Data Centre, and the Asia-Pacific Data-Research Center.

The UHSLC collaborates in the operation of 84 tide gauge stations in the global sea level network; 55 of these stations are in the GLOSS Core Network. All of these sites meet GLOSS standards for tsunami monitoring and are currently providing data to appropriate warning centers. The UHSLC in collaboration with the Pacific GPS Facility operates co- located continuous GPS (GPS@TG) receivers at 10 tide gauges, which constitute to the NASA/CNES Science Working Team for altimeter calibration, and provide local estimates of absolute sea level rise.

The UHSLC distributes two sea level data sets: JASL and Fast Delivery Database.

2.7 University of South Florida

The University of South Florida maintains a suite of products available to users. Specifically, a set of time series describing the differences of the various altimeter datasets relative to the global tide gauge network is available.

3.0 Global Sea Level Observing Network Components and Operating Status

3.1 Sea Level Networks

3.1.1 NOAA National Water Level Observation Network (NWLON)

NOAA has operated and maintained a network of coastal and Great Lake water level stations for over 160 years, and is the legal authority for sea level in the U.S. The CO-OPS operates 210 long-term sea level stations, called the National Water Level Observation Network. CO-OPS sea level stations are multi-purpose, supporting diverse applications with both real-time and long-term data, from safe and efficient navigation and coastal hazard mitigation to coastal zone management and climate observation. CO-OPS provides an “end-to-end” system of data collection, quality control, data management, and product delivery. In near real time, CO-OPS distributes data directly from its own website, through the Global Telecommunication System (GTS), through OPeNDAP and SOS servers, and through some specialized methods, such as ftp server. CO-OPS maintains a rigorous set of standards and methodologies and is recognized for the high level of accuracy and reliability in data delivery. Information on CO-OPS standards and protocols can be found at: http://tidesandcurrents.noaa.gov/pub.html

Several NWLON stations have been identified as critical components of GLOSS (See Appendix 1 for a full listing). Twenty-eight of the 210 NOAA NWLON stations are considered GLOSS stations and are available through the GLOSS Website. Ninety-two NWLON stations (including the 28 GLOSS NWLON stations) are contributing to the JASL.

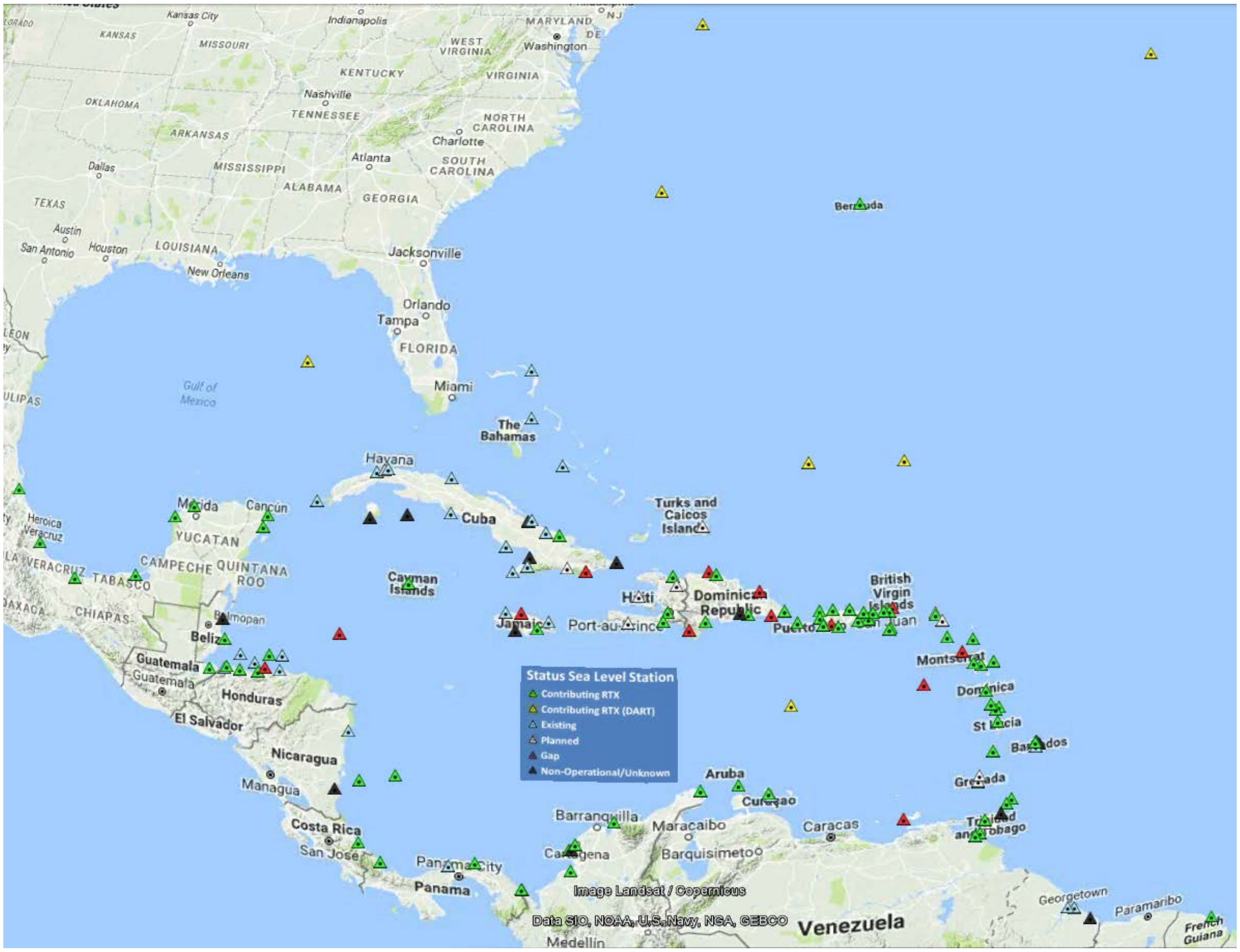
3.1.2 University of Hawaii Sea Level Center

UHSLC technicians and data analysts collaborate directly with international partners to maintain >80 high profile tide gauge stations that are essential for the global sea level observing effort. UHSLC gauges are located in all three major ocean basins (Atlantic, Pacific, and Indian), comprising approximately 19% of the GLOSS Core Network (GCN) and 36% of the GCN at tropical latitudes (20°S-20°N). UHSLC's contribution to the global tide gauge network ensures that invaluable, multi-decade time series are maintained in otherwise sparsely sampled areas of the global ocean. These time series are required to properly resolve historical sea level change and connect past variability to current and future change. Data from UHSLC stations receive rigorous quality control and are freely available from the UHSLC website (http://uhslc.soest.hawaii.edu/) and other GLOSS data centers.

A subset of UHSLC gauges are supported by funds from the NOAA Tsunami Program for maintaining sea level stations in the Pacific Ocean (Quepos, Costa Rica; Acajutla, El Salvador; Callao, Matarani, and Talara, Peru; La Libertad, Ecuador; Hiva Oa, and Nuku Hiva, Fr. Polynesia; Legaspi, Philippines; and French Frigate Shoals, U.S.) and the Caribbean (Limon, Costa Rica; Punta Cana and Puerto Plata, Dominican Republic; Bullen Bay, Curacao; Roseau, Dominca; Prickly Bay, Grenada; El Porvenir, Panama; and Santa Marta and San Andres, Colombia). Maintenance in the Caribbean is provided in collaboration with the Puerto Rico Seismic Network (PRSN). The data from these stations are made available to the Tsunami Warning Centers and can also be accessed through the website of the UHSLC (http://uhslc.soest.hawaii.edu/) and the IOC Sea Level Monitoring Facility (http://www.ioc-sealevelmonitoring.org/).

3.1.3 Caribbean Regional Network

Through NOAA's CTWP, the United States supports an extensive sea level network in the Pacific, Atlantic, and the Caribbean. In Puerto Rico and the U.S. Virgin Islands, data is used for a variety of purposes including climate change, navigation, coastal management, storm surge warning, and tsunami detection and measurement. Gauges are operated by many regional entities including: NOS, NOAA's National Data Buoy Center (NDBC), PRSN, the UHSLC, UNAVCO and nations in the region. Many of these stations are part of GLOSS, coordinated by UNESCO's IOC. The figure below illustrates the locations of the sea level stations in the Caribbean. A brief synopsis of the various gauges follows:



Map of existing sea level gauges in the Caribbean as of April 2017 . (http://caribewave.info)

NOAA NWLON

NOS's Center for Operational Oceanographic Products and Services (CO-OPS) operates most of the U.S. coastal stations including 210 long-term stations comprising the National Water Level Observation Network (NWLON). These multi-purpose gauges each 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 6 minutes over one of the two U.S. meteorological satellites (GOES-E or GOES-W) with telephone, IP modem, or Iridium communications capabilities as backup. Data are also sent to the NOAA's Tsunami Warning Centers (TWCs). NOAA operates eleven NWLON stations located in Puerto Rico and the U.S. Virgin Islands, Barbuda and Bermuda, as well as many stations along the U.S. Gulf and East Coast.

GLOSS

GLOSS introduced tsunami requirements for their tide gauges after the 2004 Indian Ocean Tsunami. Many non-operational stations in the GLOSS Core Network in the Caribbean have been upgraded/reinstalled as part of CARIBE EWS. The CTWP is working with GLOSS and other sea level partners to update the GLOSS Core Network as defined for the CARIBE EWS region.

University of Hawaii Sea Level Center

With financial support from NWS and with PRSN support, the UHSLC has upgraded/provided maintenance to all nine tsunami capable stations in the Caribbean (Costa Rica, Dominican Republic (2), Curacao, Colombia (2), Panama, Dominica and Grenada) in the inter-sessional period. All these stations transmit every 5 minutes and also meet GLOSS standards for sea level observations and are currently providing data to appropriate Warning Centers, Weather Service Offices and the IOC Sea Level Monitoring Facility.

NOAA National Data Buoy Center (NDBC)

The U.S. operates 32 tsunameter stations in the Pacific Ocean and seven in the Atlantic, Gulf of Mexico, and the Caribbean Sea. The tsunameters employ the second-generation Deep-ocean Assessment and Reporting of Tsunamis (DART® II) technology. The technology uses a recorder on the seafloor that samples the pressure at 15-s intervals and communicates with a surface buoy. The technology has two-way communication between the TWCs or NDBC and the pressure recorder on the seafloor. These tsunameters have a standard mode that communicates every 6 hours with a 15-minute subsampling of the full 15-sampling intervals. All tsunameters have a triggered mode that replaces the standard mode. The triggering can be initiated by the tsunami detection algorithm either embedded with the seafloor recorder or externally, using two-way communications. The triggered mode provides a few minutes of the 15-s full resolution data and then approximately three hours of one-minute averages that are sent every few minutes. The tsunameter will return to standard mode of operations after three hours of triggered mode unless re-triggered. NDBC receives the data via Iridium from the tsunameters and reformats the data into messages for distribution on the GTS and NOAAPORT under the GTS bulletin header SZNT01 KWNB for the Atlantic, Caribbean, and Gulf of Mexico tsunameters. NDBC also posts the data to its website. NDBC's Data Assembly Center continuously monitors the tsunameters and validates triggers with the designated TWC. Data from these stations are critical for constraining tsunami forecast models. As of this report of 7 DARTs in the Caribbean and Western Atlantic, 5 were operational and NOAA is seeking to repair the DARTs in Northeast Castle Rock Seamount and in the central Caribbean.

NOAA's Pacific Marine Environmental Lab and Chile's Navy entered into a Joint Project Agreement in 2015 to test 4G (fourth Generation) DART in the Chilean Trench. These DART 4G are capable of sensing and reporting directly over the seismic source thus provide information to the TWCs more quickly than earlier generation DARTS. This project will continue for 5 years. Two additional sensors were deployed in 2016 and though the project is moving forward, there has not yet been an event to fully test the capabilities of these new generation DARTs.

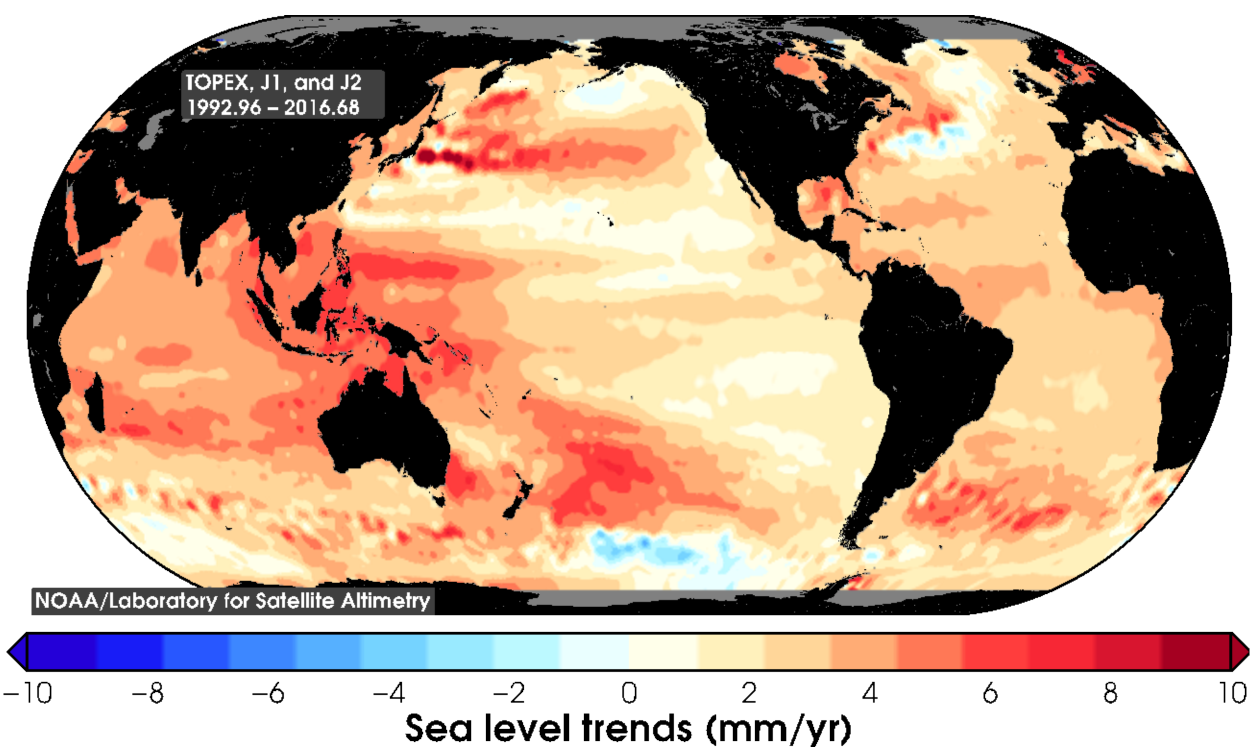
Puerto Rico Seismic Network (PRSN)

The PRSN of the University of Puerto Rico at Mayagüez (UPRM) operates 6 sea level stations in Puerto Rico. These stations are NOAA NOS compliant and were funded initially by the U.S. Federal Emergency Management Agency and the UPRM, and installed with the support and guidance of NOS between 2006 and 2008. All of these stations also meet GLOSS standards for sea level observations and are currently providing data to appropriate Warning Centers and

Weather Service offices. The data are transmitted every 6 minutes on GOES. The data can be accessed on the homepage of the PRSN, the CO-OPS website, and the IOC Sea Level Data Facility. The PRSN sea level network is currently supported by NOAA and contributions from the government of Puerto Rico. With funds provided by NOAA, the PRSN also is providing support for the operations of a sea level station in Tortola (British Virgin Islands) and Puerto Caucedo (east of Santo Domingo) and Barahona in the Dominican Republic, as well as the station installed in Cap-Haitien, Haiti. In 2015-2016 PRSN provided guidance and support to the meteorology agency of Aruba to install a GOES communications platform. In addition to GOES, the PRSN is receiving near real time data at 1spm (one sample per minute) which help to improve the sea level monitoring around Puerto Rico.

3.2 Satellite Altimeter Observations

The launch of the Jason-3 on January 17, 2016, marked an important turning point in the evolution of satellite radar altimetry from research to operations. Jason-3 is a joint effort led for the first time by operational agencies, NOAA and the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT), in partnership with NASA and France's Centre National d'Etudes Spatial (CNES). The primary goal of Jason-3 is to maintain continuity of the more than two-decade record of ocean surface topography measurements established by the TOPEX/Poseidon, Jason-1, and Jason-2 altimeter missions. The observations from Jason-3 and the earlier missions have proven invaluable in the study of sea level change, showing global mean sea level rising at approximately 2.8 mm/yr between 1993 and 2016, nearly 50% faster than over the past century, but in a strikingly non-uniform spatial pattern of regional sea level changes. Jason sea surface height observations are also used to study eddy variability and large-scale circulation changes in the ocean.



Sea level trends measured between 1993 and 2017 from TOPEX, Jason-1, and Jason-2/OSTM observations.

During the first seven months of operation, known as the Tandem Mission, Jason-3 was flown along the same repeat orbit as Jason-2/OSTM, but separated by about 1 minute. In October, 2016, Jason-2/OSTM was moved to an orbit that interleaves and lags Jason-3 by 5 days, effectively doubling the resolution of observations (157 km versus 315 km track spacing at equator, 5 day versus 10 day repeat period), thereby greatly improving the ability to monitor mesoscale sea level variability. The two satellites continued this mode of operation, known as the Interleaved Mission, until July 2017, when Jason-2/OSTM was put in a new orbit with a repeat cycle of 371 days to improve the resolution of the marine geoid and mean sea surface.

NOAA, working with CNES, is providing ground system support for Jason-2/OSTM and Jason-3, operating both altimeters simultaneously. This includes command and control of the satellite, downloading telemetry, producing near-real time data products (OGDRs) and archiving and distributing all data products. EUMETSAT is sharing with NOAA the responsibility for downloading telemetry and producing OGDRs. CNES is producing all interim and final science data products (IGDRs and GDRs), as well as archiving and distributing them.

Jason-3 marks the last of the series conventional, low-rate altimeters. A series of Jason follow-on missions is being developed to maintain continuity of the sea level climate data record and will employ high-rate, delay-Doppler/SAR altimeters. This technology, demonstrated on Cryosat-2 and used operationally on Sentinel-3A, produces more accurate and higher resolution sea level observations, and will potentially improve altimeter observations near coasts. The follow-on to Jason-3 that will use delay-Doppler/SAR is Sentinel-6/Jason-CS, a joint 5-partner mission, involving the European Space Agency, as well as NOAA, EUMETSAT, NASA, and CNES. The first mission, Sentinel-6A/Jason-CS-1, is scheduled for launch in 2020. After a 9-month tandem mission for calibration and validation with Sentinel-6A/Jason-CS-1, Jason-3 is expected to move to an interleaved orbit. The next mission in the series, Sentinel-6B/Jason-CS-2, will be launched in 2026. For Sentinel-6/Jason-CS, NOAA and EUMETSAT will exchange roles; EUMETSAT will be responsible for satellite command and control, as well as producing all science data products. NOAA will downlink data and disseminate near-real time data products.

3.3 Geodesy and Positioning

NOAA’s NGS manages the U.S. network of Continuously Operating Reference Stations (CORS) that provide Global Navigation Satellite System (GNSS) data consisting of carrier phase and code range measurements in support of three dimensional positioning, meteorology, space weather, and geophysical applications throughout the United States, its territories, and a few foreign countries. The CORS network is a multi-purpose cooperative endeavor involving government, academic, and private organizations many of the sites are independently owned and operated. Each agency shares their data with NGS, and NGS in turn analyzes and distributes the data free of charge. As of August 2015, the CORS network almost 2,000 stations, contributed by over 200 different organizations, and the network continues to expand.

Precise determination of vertical land motion at tide stations continues to be a priority area of investigation for NOAA. Using funding provide by NOAA OOMD, new CORS will continue to be established near NWLON stations that are part of the GLOSS network as budgets allow. The table in the following section provides the current listing of co-located CORS and NWLON stations and their distance between the two. Work on leveling between the two systems has started and will be updated in the next U.S. report.

3.4 US GLOSS Sea Level Stations

The Table below lists the U.S. GLOSS stations along with the nearest GPS station as reported by SONEL

Table 1 – US GLOSS Water Level Stations

GLOSS ID	Station Name	Lat.	Long.	Country/State	Organization	Nearest GPS	Distance to WL station (m)	GPS Latitude	GPS Longitude
26	Diego Garcia Is.	-7.2833	72.4000	United Kingdom	U Hawaii	DGAR	2900	-7.2903	72.3938
27	Gan	-0.7000	73.1667	Maldives	U Hawaii	ADDU	467	-0.6906	73.1501
28	Male	4.1667	73.5000	Maldives	U Hawaii	HULE	1179	4.1927	75.5281
65	Rabaul	-4.2000	152.1833	Papua New Guinea	U Hawaii	None			
74	Nome	64.5000	-165.4400	Alaska	NOAA	AB11	8317	64.5645	-165.3734
100	Sand Point	55.3333	-160.5000	Alaska	NOAA	AB07	2584	55.3493	-160.4768
102	Unalaska	53.8833	-166.5333	Alaska	NOAA	AV09	950	53.8756	-166.5418
105	Wake Is.	19.2833	166.6167	Marshall Is.	NOAA	WQSL	32	19.2905	166.6174
106	Midway Is	28.2167	-177.3667	Hawaii	NOAA	MQSI	10	28.2150	-177.3609
107	French Frigate Shoals	23.8667	-166.2833	Hawaii	U Hawaii	None			
108	Honolulu	21.3000	-157.8667	Hawaii	NOAA	HNLC	1	21.3032	-157.8645
109	Johnston Is.	16.7333	-169.5333	Hawaii	U Hawaii	None			
111	Kwajalein	8.7333	167.7333	Marshall Is.	NOAA	KWJI	1175	8.7222	167.7302
112	Majuro	7.1000	171.3667	Marshall Is.	U Hawaii	MAJU	1719	7.1191	171.3645
116	Chuuk Atoll, Caroline Is.	7.4500	151.8500	Fed. Micronesia	NOAA	TRUK	5128	7.4470	151.8870
117	Kapingamarangi, Caroline Is.	1.1000	154.7833	Fed. Micronesia	U Hawaii	None			
118	Saipan	15.2333	145.7333	North Mariana Is.	U Hawaii	CNMR	600	15.2297	145.7431
119	Yap, Caroline Is.	9.5167	138.1333	Fed. Micronesia	U Hawaii	None			
120	Malakal	7.3333	134.4667	Belau	U Hawaii	PALA	3125	7.3409	134.4755
125	Tongatapu	-21.1667	-175.2500	Tonga		TONG	779	-21.1450	-175.1790
0	Penrhyn	-8.5900	-158.0667	Cook Islands	U Hawaii	None			
144	Pago Pago, American Samoa	-14.2833	-170.6833	A. Samoa	NOAA	ASPA	7082	-14.3261	-170.7224
145	Kanton Is., Phoenix Is.	-2.4900	-171.4300	Kiribati	U Hawaii	None			
146	Christmas Is., Line Is.	1.9833	-157.4833	Kiribati	U Hawaii	None			
149	Apra Hbr, Guam, Marianas	13.4333	144.6500	Marianas	NOAA	GUUG	16700	13.4332	144.8030
150	Seward	60.1167	-149.4333	Alaska	NOAA	None			
151	Prudhoe Bay	70.4000	-148.5267	Alaska	NOAA	DSL1	7684	70.3334	-148.4727
154	Sitka	57.0500	-135.3333	Alaska	NOAA	BISS	24921	56.8540	-135.5390
157	South Beach	44.3800	-124.0300	Oregon	NOAA	ORSB	450	44.6253	-124.0488
158	San Francisco	37.8000	-122.4667	California	NOAA	TIBB	9551	37.8909	-122.4476

159	La Jolla (Scripps Pier)	32.8667	-117.2667	California	NOAA	SIO5	2990	32.8406	-117.2497
206	San Juan	18.4667	-66.1167	Puerto Rico	NOAA	BYSP	9472	18.4079	-66.1609
211	Settlement Point	26.7167	-78.9833	Bahamas	U Hawaii	BHMA	3411	26.6899	-78.9670
216	Key West	24.5500	-81.8000	Florida	NOAA	CHIN	400	24.5505	-81.8071
217	Galveston (Pier 21)	29.3167	-94.8000	Texas	NOAA	TXGA	2856	29.3279	-94.7726
219	Duck	35.1833	-75.7500	North Carolina	NOAA	NCDU	190	36.1817	-75.7513
220	Atlantic City	39.3500	-74.4167	New Jersey	NOAA	NJGT	16342	39.4745	-74.5308
221	Bermuda, St. Georges Is.	32.3667	-64.7000	Bermuda	NOAA	BRMU	686	32.3704	-64.6963
287	Hilo	19.7333	-155.0667	Hawaii	NOAA	HILR	2529	19.7174	-155.0494
288	Pensacola	30.4000	-87.2167	Florida	NOAA	PCLA	7500	30.1894	-87.1893
289	Fort Pulaski	32.0333	-80.9000	Georgia	NOAA	GASK	12470	31.9876	-81.0229
290	Newport	41.5000	-71.3333	Rhode Island	NOAA	NPRI	500	41.5098	-71.3275
302	Adak	51.8667	-176.6333	Alaska	NOAA	AB21	2034	51.8642	-176.6626
332	Virginia Key	25.7317	-80.1617	Florida	NOAA	None			

4.0 Technology Overview and Network Updates

4.1 Sea Level Networks

4.1.1 Microwave Water Level Transition at NOAA NLWON Stations

Starting in 2012, CO-OPS has been working on replacing its acoustic and pressure water level sensors with the Design Analysis WaterLog® microwave sensor as the primary sensor throughout its observational network. Previous national reports have detailed the testing and evaluation of different microwave sensors as potential candidates for use as its primary water sensor.

Transitioning to the new sensor technology at a station involves multiple years of work to ensure that the data record is continuous, high quality and without any biases. The process starts with an engineering field reconnaissance to develop a site plan for location of the microwave water level sensor (MWWL) and data collection platform near the existing acoustic sensor. Once the system has been designed, installed and leveled, a minimum one year simultaneous data comparison between the existing primary sensor and the MWWL commences. Data from both sensors are processed every month using CO-OPS' operational system. During this time, the existing acoustic or pressure sensor is still considered the primary sensor for all derived products. During the comparison period, CO-OPS oceanographers work closely with CO-OPS' chief scientist to identify concerns or investigate problems with the data comparisons in order validate MWWL sensor technology is working for the new location. If problems are found, the comparison period may be extended until the problem is fixed and adequate data is collected to validate the MWWL.

When the one-year comparison period is complete and field crews conduct an annual visit to the station to ensure proper operation of the MWWL system, conduct leveling and verify sensor stability on site for both sensors involved in comparison. All the steps are documented on a checklist that certify sensor configuration documentation, full data comparison analysis, bracketing levels from the start and end of the comparison period, sensor offset checks, vertical stability checks and datum tabulations. Each item on the checklist has certain criteria bounds in order to pass for full transition. The completion of the checklist is certified by the chief scientist and the field operations division chief. Only at this point is dissemination of the station's data switched from the acoustic to the MWWL sensor and the acoustic sensor can be removed. Ten stations have been designated for long-term intercomparisons. At these stations, the acoustic sensor is maintained, though the MWWL is the primary sensor, and comparisons continue for a 5 year period.

Table 2 - NOAA NWLON MWWL Installations

Note: Honolulu, HI, Newport, RI, Crescent City, CA, and Friday Harbor, WA are long term intercomparison stations but MWWL sensors have not been installed yet.

Station ID	Name	MWWL Installed	Status	Long Term intercomparison Station
8631044	Wachapreague, VA	1-Jul-2012	MWWL Operational	
8722670	Lake Worth Pier, FL	12-Jul-2013		
9410230	La Jolla, CA	14-Sep-2013	MWWL Operational	
8516945	Kings Point, NY	10-Jul-2014	MWWL Operational	
8518750	The Battery, NY	16-Sep-2014		
9461380	Adak Island, AK	19-Sep-2014	MWWL Operational	
9444900	Port Townsend, WA	29-Oct-2014	MWWL Operational	
8747437	Bay Waveland, MS	9-Feb-2015		
8766072	Freshwater Canal Locks, LA	20-Feb-2015		
8764227	Amerada Pass (LAWMA), LA	23-Feb-2015		
9759394	Mayaguez, PR	18-Mar-2015	MWWL Operational	
8531680	Sandy Hook, NJ	20-Apr-2015	MWWL Operational	
8577330	Solomons Island, MD	18-May-2015	MWWL Operational	
9450460	Ketchikan, AK	22-May-2015		
9442396	La Push, WA	12-Jun-2015		
8726520	St. Petersburg, FL	13-Jul-2015	MWWL Operational	
8720030	Fernandina Beach, FL	14-Jul-2015	MWWL Operational	
9497645	Prudhoe Bay, AK	1-Aug-2015	MWWL Operational	
9443090	Neah Bay, WA	27-Aug-2015		
8467150	Bridgeport, CT	17-Sep-2015	MWWL Operational	
8760922	Pilots Station East, SW Pass	29-Sep-2015	MWWL Operational	
9440422	Longview, WA	16-Oct-2015	MWWL Operational	
9415144	Port Chicago, CA	19-Oct-2015		

1820000	Kwajalein, Marshall Islands	8-Dec-2015		
8762482	West Bank, LA	15-Dec-2015		
8771450	Galveston Pier 21, TX	12-Jan-2016		Yes
9755371	San Juan, PR	12-Mar-2016	MWWL Operational	Yes
9410840	Santa Monica, CA	23-Mar-2016		Yes
9751401	Lime Tree Bay, VI	29-Mar-2016	MWWL Operational	
8761305	Shell Beach, Lake Borgne, LA	5-Apr-2016		
8771341	Galveston Bay Entrance, N. Jetty	24-Apr-2016		
8772447	Freeport, TX	30-Jun-2016		
9440910	Toke Point, WA	10-Aug-2016		
8443970	Boston, MA	14-Sep-2016	MWWL Operational	
8461490	New London, CT	22-Sep-2016		
8638901	CBBT, VA	19-Oct-2016		
1619910	Sand Island, Midway	15-Nov-2016		
9414290	San Francisco, CA	8-Dec-2016		Yes
8720218	Mayport, FL	18-Jan-2017		
8725520	Fort Myers, FL	23-Jan-2017		
8721604	Trident Pier, FL	24-Jan-2017		
8723214	Virginia Key, FL	3-Apr-2017		
9410170	San Diego, CA	4-Apr-2017		
8571892	Cambridge, MD	12-Apr-2017	MWWL Operational	
8651370	Duck, NC	20-Apr-2017		Yes
9452400	Skagway, AK	3-May-2017		
9431647	Port Orford, OR	14-May-2017		
8724580	Key West, FL	12-Jun-2017		Yes
8775870	Corpus Christi (Bob Hall Pier), TX	12-Jun-2017		

4.1.2 University of Hawaii Sea Level Center

The GLOSS Implementation Plan identifies the addition of GPS at GLOSS Core Network and GCOS stations as the primary sea level observing system need. The focus of ongoing updates to the UHSLC network is to install collocated GPS (cGPS) instruments at tide gauge sites. Current support provides for the installation of one new cGPS at an island tide gauge during each of the next 5 years.

4.1.3 Caribbean Regional Network

The United Kingdom (UK) has provided funds to its National Oceanography Centre (NOC) to install a station in Saint Lucia. NOAA provided slot for transmission over GOES and has routed the data of Saint Lucia thru the GTS. CTWP provided support and guidance for the station installation. This station went online in October 2016. The NOC also organized the fifth ICG CARIBE EWS sea level operators training course in Saint Lucia. The CTWP helped with the organization and conduct of the course.

The Smithsonian Institution has installed, operates and maintains sea level stations in Bocas del Toro, Panama (near the border with Costa Rica) and in Carrie Bow Cay off Belize. They are tsunami capable stations transmitting every 5 minutes and can be viewed on the IOC Sea Level Monitoring Facility. These data are available to the PTWC.

The UK provided funds in 2015 for NOAA's NWS to install stations in Anguilla and Turks and Caicos. CTWP is working with a contractor, governments and experts from UHSLC and MeteoFrance to finish the project soon. The Anguilla station was installed in April 2017 and is expected to go online and be available to the CARIBE EWS community by late May 2017. The Turks and Caicos station is expected to be set for the beginning of Fall 2017.

5.0 Data Availability and Product Delivery

5.1 Sea Level Networks

5.1.1 NOAA National Water Level Observation Network

CO-OPS maintains a comprehensive website, which allows users full access to all data and products on a 24 X 7 basis (http://tidesandcurrents.noaa.gov). All raw observed data (6-minute data with quality control flags attached) are automatically available over the website after the data collection systems receive each hourly transmission and after they undergo the quality control checks. Derived data products are made available through the website after verification. Starting in 2017, CO-OPS is beginning to send a copy of its water level data and product holdings to NCEI as part of its archiving strategy and to increase the availability of the data.

5.1.2 University of Hawaii Sea Level Center

The UHSLC website hosts a variety of products, in addition to providing access to raw sea level data. Products include: global sea level deviations, tide gauge- altimeter analysis (deviations and anomalies), upper ocean volume, current indices, and topography. http://uhslc.soest.hawaii.edu/

UHSLC maintains three databases for sea level data. They are:

Joint Archive for Sea Level (JASL)

JASL is a collaborative arrangement between NCEI, the World Data Center for Oceanography, Silver Spring, and the UHSLC. The JASL is responsible for the collaborative archive referred to as the Research Quality Data Set.

The JASL data set is designed to be user friendly, scientifically valid, well-documented, and standardized for archiving at international data banks. JASL data are provided internally by the UH Sea Level Network and by over 60 agencies representing over 70 countries. In the past year, the UHSLC increased its JASL holdings to 14,515 station-years of hourly quality assured data. The JASL set now includes 8166 station years of data in 328 series at 248 GLOSS sites.

Fast Delivery Database

The Fast Delivery Database supports various international programs, in particular CLIVAR and GCOS. The database has been designated by the IOC as a component of the GLOSS program. The fast delivery data are used extensively by the altimeter community for ongoing assessment and calibration of satellite altimeter datasets. The fast delivery sea level dataset now includes 277 stations, 214 of which are located at GLOSS sites.

High Frequency Data

Near Real-Time Data (collection + up to a three hour delay, H-3 delay) and daily filtered values (J-2 delay) are provided, primarily for stations that UHSLC directly operates and maintains. UHSLC has committed to hosting the GLOSS High Frequency database in collaboration with the Institute of Flanders (VLIZ).

The UHSLC provides monthly maps of the Pacific sea level fields through the JCOMM. UHSLC also produces quarterly updates of an index of the tropical Pacific upper layer volume and annual updates of indices of the ridge-trough system and equatorial currents for the Pacific Ocean. The analysis includes tide gauge and altimeter sea surface elevation comparisons.

5.1.3 Caribbean Regional Network

The CTWP has been providing monthly reports on the sea level data availability to the operators and stakeholders and has organized a bi-monthly conference call/webinars to review sea level data issues. With PTWC, it coordinates with NESDIS the assignment of GOES IDs for new stations in the region. CTWP also follows up with NOAA, PTWC and the IOC to ensure that stations that are transmitting over GOES are also made available to the IOC Sea Level Data Facility and to the U.S. Tsunami Warning Centers. As new stations have become available the PTWC updates the Tide Tool system which is used at many water and warning centers for the monitoring and reporting of tsunamis.

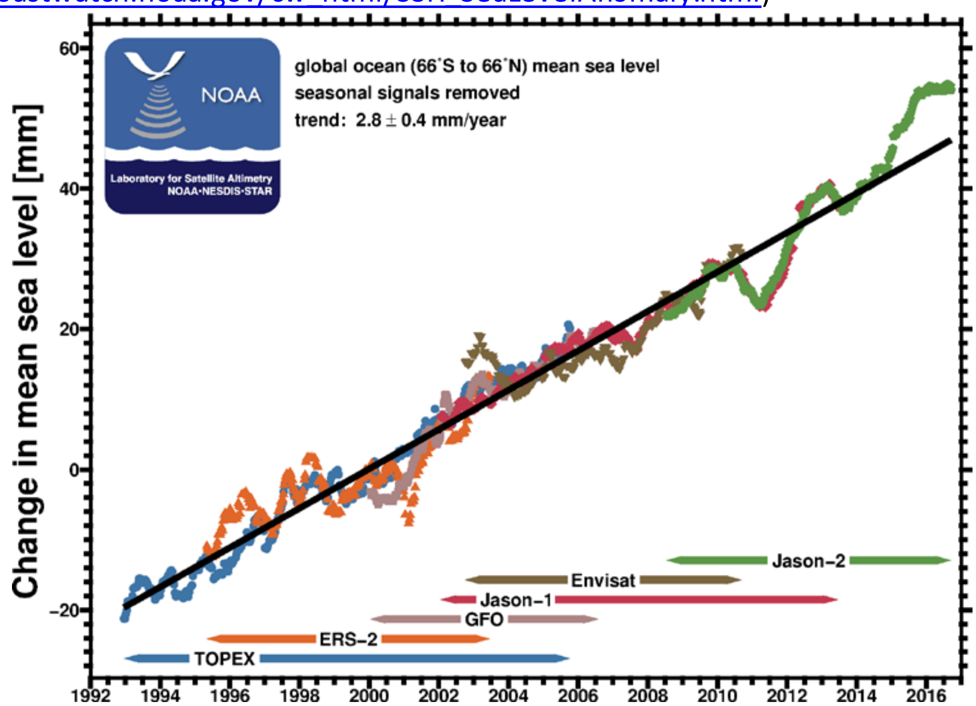
- The latest Tide Tool available at: ftp://ftp.soest.hawaii.edu/ptwc/TideTool_ftp/
- The PTWC with the International Tsunami Information Center has developed Tide Tool, which is a tool for monitoring and analyzing sea level data. http://itic.ioc-unesco.org/index.php?option=com_content&view=article&id=1573:tsunami-warning-operations-sea-level-monitoring-tide-tool-and-ioc-sea-level-monitoring-facility&catid=2141&Itemid=2565
- The CTWP provides a KML file that customers can download and extract to review the inventory of the Sea Level Stations in the Caribbean. The interactive map uses the Google Earth platform: http://www.weather.gov/source/ctwp/stations.zip
- The monthly sea level station reports, as well as sea level operators meeting reports can be accessed on the CTWP website at http://www.weather.gov/ctwp/stations
- The IOC Sea Level Monitoring Facility has an interactive map of most of the sea level stations operational in the Caribbean with remote communication systems (GOES, FTP, etc.): http://www.ioc-sealevelmonitoring.org/

- The followings links provide a connection to an interactive map (with time series) of the tide stations in the NOS system: http://tidesonline.nos.noaa.gov/monitor.html and http://co-ops.nos.noaa.gov/
- The NDBC provides a map of the tsunameter (DART) stations: http://www.ndbc.noaa.gov/dart.shtml
- The following link provides information on the sea level stations operated by the PRSN or regional stations received via GOES: http://redsismica.uprm.edu

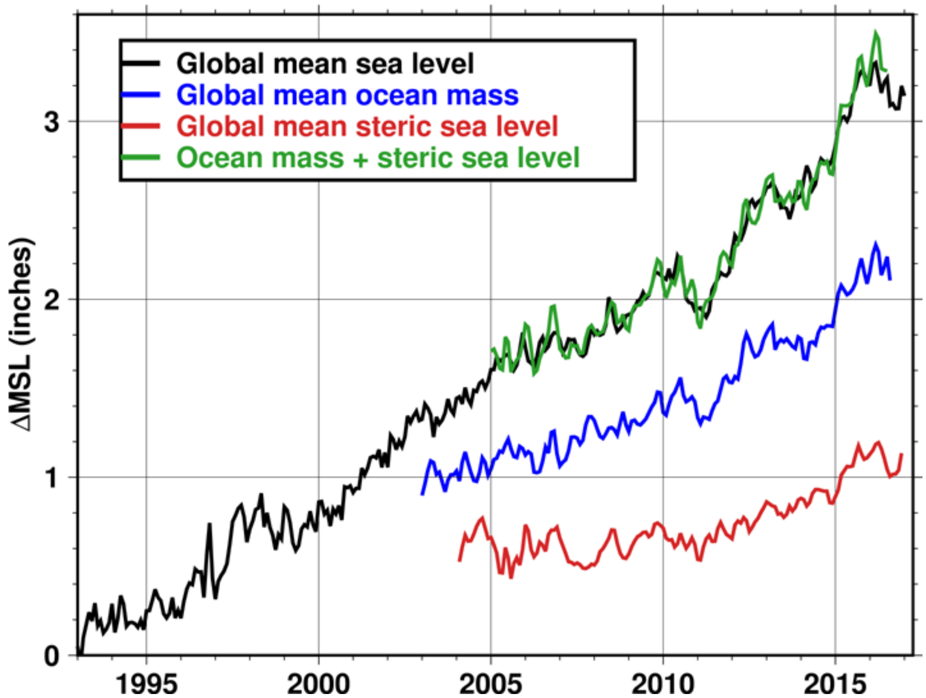
5.2 Satellite Altimetry

The LSA website includes resources and links to a variety of satellite altimeter products. Projects on the site include: satellite altimeter sea level rise data, near real-time processed analysis, historical sea level, sea-ice research, geophysics research, and sea floor topography. It also provides updates on new research and access to partner agency websites (https://www.star.nesdis.noaa.gov/sod/lsa/).

Monthly, the LSA produces global and regional time series and maps of mean sea level. The altimetry data is from the joint NOAA/EUMETSAT Radar Altimeter Database System (https://github.com/remkos/rads), which includes data from the reference series of TOPEX/POSEIDON, Jason-1, Jason-2, Jason-3 and other missions suitable for sea level change studies (Geosat, Geosat Follow-On, ERS-1, ERS-2, Envisat, CryoSat-2, SARAL/AltiKa, and Sentinel-3A). At LSA, the data are used with GRACE and Argo observations to monitor the sea level rise budget. For operational users, LSA produces daily near-real time maps of sea level anomalies from an optimal interpolation from multiple altimeter missions, which is distributed through NOAA CoastWatch.
(https://coastwatch.noaa.gov/cw_html/SSH_SeaLevelAnomaly.html)



Variations in global mean sea level from altimetry (seasonal signals have been removed and no correction for glacial Isostatic adjustment has been applied.)



Closure of the sea level budget using the global ocean observing system. Monthly averaged global mean sea level observed by satellite altimeters from 1993–2016 (black). Monthly averaged global ocean mass (2003–August 2016) from the Gravity Recovery and Climate Experiment (blue). Monthly averaged global mean steric sea level (2004–2016) from the Argo profiling float array (red). The global sea level change inferred from the sum of GRACE and Argo (green) is in excellent agreement with Jason altimetry (black).

APPENDIX 1: NOAA NWLON Stations in the United States

The table below lists all currently installed NOAA NWLON water level stations along with their GLOSS, PSMSL, and JASL IDs. For completeness, this list includes NWLON stations installed in the U.S. portion of the Great Lakes and St. Lawrence River. Below this table is a second table containing NOAA stations that are not part of the NWLON but are transmitted to one of sea level data archive centers. More information on these stations can be obtained at the following website: https://tidesandcurrents.noaa.gov/

Active NOAA NWLON Water Level Stations							
Station ID	Station Name	Year Installed	Latitude	Longitude	GLOSS ID	PSMSL ID	JASL ID
1611400	Nawiliwili, HI	1954	21.9544	-159.3561		756	058a
1612340	Honolulu, HI	1905	21.3067	-157.867	108	155	057b
1612480	Mokuoloe, HI	1957	21.4331	-157.79		823	061a
1615680	Kahului, Kahului Harbor,	1946	20.895	-156.4767		521	059a

	HI						
1617433	Kawaihae, HI	1988	20.0366	-155.8294		2128	552a
1617760	Hilo, Hilo Bay, Kuhio Bay, HI	1946	19.7303	-155.0556	287	300	060a
1619910	Sand Island, Midway Islands	1947	28.2117	-177.36	106	523	050a
1630000	Apra Harbor, Guam	1948	13.4431	144.6556	149	540	053a
1770000	Pago Pago, American Samoa	1948	-14.2767	-170.6894	144	539	056a
1820000	Kwajalein, Marshall Islands	1946	8.7317	167.7361	111	513	055a
1890000	Wake Island	1950	19.2907	166.6176	105	595	051a
8311030	Ogdensburg, NY	1900	44.7017	-75.494			
8311062	Alexandria Bay, NY	1983	44.331	-75.9345			
8410140	Eastport, ME	1929	44.9033	-66.985		332	740a
8411060	Cutler Farris Wharf, ME	1963	44.657	-67.2047		1524	
8413320	Bar Harbor, ME	1947	44.3922	-68.2043		525	
8418150	Portland, ME	1910	43.6567	-70.2467		183	252a
8443970	Boston, MA	1921	42.355	-71.0517		235	741a
8447930	Woods Hole, MA	1932	41.5236	-70.6711		367	742a
8449130	Nantucket Island, MA	1963	41.2853	-70.0964		1111	743a
8452660	Newport, RI	1930	41.5044	-71.3261	290	351	253a
8454000	Providence, RI	1938	41.8067	-71.4006		430	
8461490	New London, Thames River, CT	1938	41.355	-72.0867		429	744a
8467150	Bridgeport, CT	1932	41.1758	-73.184		1068	
8510560	Montauk, NY	1947	41.0483	-71.9594		519	279a
8516945	Kings Point, NY	1998	40.8103	-73.765		2322	
8518750	The Battery, NY	1920	40.7006	-74.0142		12	745a
8531680	Sandy Hook, NJ	1910	40.4669	-74.0094		366	
8534720	Atlantic City, NJ	1911	39.3567	-74.4181	220	180	264a
8536110	Cape May, NJ	1965	38.968	-74.9597		1153	746a
8545240	Philadelphia, PA	1989	39.93	-75.1417		135	
8551910	Reedy Point, DE	1956	39.5583	-75.5733		786	
8557380	Lewes, DE	1919	38.7828	-75.1192		224	747a
8570283	Ocean City Inlet, MD	1978	38.3283	-75.0911		2292	
8571421	Bishops Head, MD	2005	38.2206	-76.0386			
8571892	Cambridge, MD	1980	38.5742	-76.0722		481	
8574680	Baltimore, MD	1902	39.2669	-76.5793		148	
8575512	Annapolis, MD	1978	38.9833	-76.4816		311	
8577330	Solomons Island, MD	1937	38.3172	-76.4508		412	
8594900	Washington, DC	1924	38.873	-77.0217		360	
8631044	Wachapreague, VA	1978	37.608	-75.6858		2293	
8632200	Kiptopeke, VA	1951	37.1652	-75.9884		636	
8635027	Dahlgren, VA	1970	38.3198	-77.0366			

8635750	Lewisetta, VA	1970	37.9954	-76.4646		2324	
8637689	Yorktown USCG Training Center, VA	2004	37.2265	-76.4788			
8638610	Sewells Point, VA	1927	36.947	-76.33		299	
8638863	Chesapeake Bay Bridge Tunnel, VA	1975	36.9667	-76.1133		1635	749a
8651370	Duck, NC	1977	36.1833	-75.7467	219	1636	260a
8652587	Oregon Inlet Marina, NC	1974	35.795	-75.5481		2325	
8654467	USCG Station Hatteras, NC	2010	35.2086	-75.7042		2294	
8656483	Beaufort, NC	1964	34.72	-76.67		2295	
8658120	Wilmington, NC	1908	34.2275	-77.9536		396	750a
8658163	Wrightsville Beach, NC	2004	34.2133	-77.7867			
8661070	Springmaid Pier, SC	1976	33.655	-78.9183		1444	
8665530	Charleston, Cooper River Entrance, SC	1899	32.7808	-79.9236		234	261a
8670870	Fort Pulaski, GA	1935	32.0367	-80.9017	289	395	752a
8720030	Fernandina Beach, FL	1898	30.6714	-81.4658		112	240a
8720218	Mayport (Bar Pilots Dock), FL	1995	30.3982	-81.4279		316	753a
8721604	Trident Pier, FL	1994	28.4158	-80.5931		2123	774a
8722670	Lake Worth Pier, FL	1970	26.6128	-80.0342		1696	
8723214	Virginia Key, FL	1994	25.7317	-80.1617	332	1858	755a
8723970	Vaca Key, FL	1970	24.711	-81.1065		1701	
8724580	Key West, FL	1913	24.6	-81.8079	216	188	242a
8725110	Naples, FL	1965	26.1317	-81.8075		1107	757a
8725520	Fort Myers, FL	1965	26.648	-81.871		1106	
8726520	St Petersburg, Tampa Bay, FL	1946	27.7606	-82.6269		520	759a
8726724	Clearwater Beach, FL	1973	27.9783	-82.8317		1638	773a
8727520	Cedar Key, FL	1914	29.1336	-83.0309		428	
8728690	Apalachicola, FL	1967	29.7244	-84.9806		1193	760a
8729108	Panama City, FL	1973	30.1523	-85.7		1641	
8729210	Panama City Beach, FL	1989	30.2133	-85.8783			761a
8729840	Pensacola, FL	1923	30.4044	-87.21	288	246	762a
8735180	Dauphin Island, AL	1966	30.25	-88.075		1156	763a
8737048	Mobile State Docks, AL	1980	30.7046	-88.0396		2327	
8741533	Pascagoula NOAA Lab, MS	2005	30.368	-88.5631			
8747437	Bay Waveland Yacht Club, MS	1978	30.325	-89.325		2215	
8760922	Pilots Station East, SW Pass, LA	2004	28.932	-89.4075			
8761305	Shell Beach, LA	1979	29.8683	-89.673		2296	
8761724	Grand Isle, LA	1979	29.263	-89.957		526	765a
8761927	New Canal Station, LA	1982	30.0272	-90.113		2328	
8762482	West Bank 1, Bayou Gauche, LA	2003	29.7886	-90.4203			

8764044	Berwick, Atchafalaya River, LA	2003	29.6675	-91.2376			
8764227	LAWMA, Amerada Pass, LA	2005	29.4496	-91.3381			
8766072	Freshwater Canal Locks, LA	2005	29.5517	-92.3052			
8767816	Lake Charles, LA	1932	30.2236	-93.2217			
8768094	Calcasieu Pass, LA	1933	29.7682	-93.3429			
8770570	Sabine Pass North, TX	1985	29.7284	-93.8701		1835	766a
8771341	Galveston Bay Entrance, North Jetty, TX	2000	29.3573	-94.7248			
8771450	Galveston Pier 21, TX	1904	29.31	-94.7933	217	161	775a
8772447	Freeport, TX	2006	28.9433	-95.3025		2297	
8773146	Matagorda City, TX	2012	28.71	-95.9139			
8774770	Rockport, TX	1937	28.0217	-97.0467		538	769a
8775870	Bob Hall Pier, Corpus Christi, TX	1983	27.5808	-97.2164		1903	770a
8779770	Port Isabel, TX	1944	26.0612	-97.2155		497	772a
9014070	Algonac, MI	1926	42.621	-82.527			
9014080	St Clair State Police, MI	1971	42.812	-82.486			
9014087	Dry Dock, MI	1899	42.9453	-82.443			
9014090	Mouth of the Black River, MI	1900	42.9747	-82.4189			
9014096	Dunn Paper, MI	1955	43.0033	-82.4217			
9014098	Fort Gratiot, MI	1970	43.0069	-82.4225			
9034052	St Clair Shores, MI	1968	42.4732	-82.8792			
9044020	Gibraltar, MI	1989	42.0917	-83.1867			
9044030	Wyandotte, MI	1930	42.2023	-83.1475			
9044036	Fort Wayne, MI	1970	42.2983	-83.0933			
9044049	Windmill Point, MI	1897	42.3575	-82.93			
9052000	Cape Vincent, NY	1916	44.1303	-76.332			
9052030	Oswego, NY	1990	43.4642	-76.5118			
9052058	Rochester, NY	1860	43.269	-77.6258			
9052076	Olcott, NY	1967	43.3384	-78.7273			
9063007	Ashland Ave, NY	1957	43.1	-79.0599			
9063009	American Falls, NY	1900	43.0811	-79.0614			
9063012	Niagara Intake, NY	1963	43.0769	-79.0139			
9063020	Buffalo, NY	1860	42.8774	-78.8905			
9063028	Sturgeon Point, NY	1989	42.6913	-79.0473			
9063038	Erie, PA	1959	42.1539	-80.0925			
9063053	Fairport, OH	1935	41.7598	-81.2811			
9063063	Cleveland, OH	1860	41.5409	-81.6355			
9063079	Marblehead, OH	1959	41.5436	-82.7314			
9063085	Toledo, OH	1904	41.6936	-83.4723			
9063090	Fermi Power Plant, MI	1963	41.96	-83.257			

9075002	Lakeport, MI	1955	43.1417	-82.4933			
9075014	Harbor Beach, MI	1860	43.8464	-82.6431			
9075035	Essexville, MI	1977	43.6404	-83.8468			
9075065	Alpena, MI	2006	45.063	-83.4286			
9075080	Mackinaw City, MI	1900	45.8	-84.7211			
9075099	De Tour Village, MI	1977	45.9925	-83.8982			
9076024	Rock Cut, MI	2001	46.2648	-84.1912			
9076027	West Neebish Island, MI	2006	46.2833	-84.205			
9076033	Little Rapids, MI	2008	46.4858	-84.3017			
9087023	Ludington, MI	1895	43.9474	-86.4416			
9087031	Holland, MI	1894	42.773	-86.2128			
9087044	Calumet Harbor, IL	1905	41.7297	-87.5383			
9087057	Milwaukee, WI	1989	43.002	-87.8876			
9087068	Kewaunee, WI	1974	44.464	-87.501			
9087072	Sturgeon Bay Canal, WI	1905	44.7956	-87.3143			
9087079	Green Bay, WI	1980	44.541	-88.0072			
9087088	Menominee, MI	2005	45.0959	-87.5899			
9087096	Port Inland, MI	1964	45.9699	-85.8715			
9099004	Point Iroquois, MI	1930	46.4845	-84.6309			
9099018	Marquette C.G., MI	1991	46.546	-87.3786			
9099044	Ontonagon, MI	1959	46.874	-89.3242			
9099064	Duluth, MN	1860	46.7758	-92.092			
9099090	Grand Marais, MN	1966	47.7486	-90.3413			
9410170	San Diego, CA	1906	32.7142	-117.1736		158	569a
9410230	La Jolla, CA	1924	32.8669	-117.2571	159	256	554a
9410660	Los Angeles, CA	1923	33.7199	-118.2729		245	567a
9410840	Santa Monica, CA	1932	34.0083	-118.5		377	578a
9411340	Santa Barbara, CA	1974	34.4031	-119.6928		2126	
9412110	Port San Luis, CA	1933	35.1688	-120.7542		508	565a
9413450	Monterey, CA	1973	36.605	-121.8881		1352	555a
9414290	San Francisco, CA	1854	37.8063	-122.4659	158	10	551a
9414750	Alameda, CA	1939	37.7717	-122.3		437	
9415020	Point Reyes, CA	1975	37.9961	-122.9767		1394	
9415144	Port Chicago, CA	1976	38.056	-122.0395		2330	
9416841	Arena Cove, CA	1978	38.9146	-123.7111		2125	573a
9418767	North Spit, CA	1977	40.7663	-124.2172		1639	576a
9419750	Crescent City, CA	1933	41.7456	-124.1844		378	556a
9431647	Port Orford, OR	1924	42.739	-124.4983		1640	557a
9432780	Charleston, OR	1964	43.345	-124.322		1269	575a
9435380	South Beach, OR	1967	44.6254	-124.0449	157	1196	592a
9437540	Garibaldi, OR	1866	45.5545	-123.9189		1285	
9439040	Astoria, OR	1853	46.2073	-123.7683		265	572
9440422	Longview, WA	1985	46.1061	-122.9542			

9440910	Toke Point, WA	1922	46.7075	-123.9669		1354	564a
9441102	Westport, WA	1982	46.9043	-124.1051			
9442396	La Push, WA	1924	47.9133	-124.637		2298	
9443090	Neah Bay, WA	1934	48.3703	-124.6019		385	558a
9444090	Port Angeles, WA	1975	48.1247	-123.4411		2127	
9444900	Port Townsend, WA	1971	48.1129	-122.7595		1325	
9447130	Seattle, WA	1899	47.6026	-122.3393		127	
9449424	Cherry Point, WA	1971	48.8633	-122.758		1633	
9449880	Friday Harbor, WA	1932	48.5453	-123.0129		384	
9450460	Ketchikan, AK	1919	55.3319	-131.6261		225	571a
9451054	Port Alexander, AK	1924	56.2466	-134.6477		2299	
9451600	Sitka, AK	1938	57.0517	-135.3417	154	426	559a
9452210	Juneau, AK	1936	58.2988	-134.4106		405	
9452400	Skagway, AK	1943	59.4508	-135.328		495	
9452634	Elfin Cove, AK	1938	58.1947	-136.3469		2300	
9453220	Yakutat, Yakutat Bay, AK	1940	59.5483	-139.733		445	570a
9454050	Cordova, AK	1949	60.5583	-145.755		566	583a
9454240	Valdez, AK	1964	61.1242	-146.3631		1353	562a
9455090	Seward, AK	1925	60.12	-149.4267	150	266	560a
9455500	Seldovia, AK	1964	59.4405	-151.7199		1070	561a
9455760	Nikiski, AK	1971	60.6833	-151.398		1350	
9455920	Anchorage, AK	1964	61.2375	-149.8904		1067	
9457292	Kodiak Island, AK	1984	57.7303	-152.5139		567	039a
9457804	Alitak, AK	1929	56.8974	-154.248		2301	
9459450	Sand Point, AK	1972	55.3317	-160.5043	100	1634	574a
9459881	King Cove, AK	1917	55.0599	-162.3261		2302	
9461380	Adak Island, AK	1943	51.8633	-176.632	302	487	040a
9461710	Atka, AK	2006	52.232	-174.1726		2303	
9462450	Nikolski, AK	2006	52.9406	-168.8713			
9462620	Unalaska, AK	1955	53.8792	-166.5403	102	757	041b
9463502	Port Moller, AK	1960	55.9857	-160.5739			
9464212	Village Cove, St Paul Island, AK	1977	57.1253	-170.2852		2304	
9468333	Unalakleet, AK	1977	63.8714	-160.7843			
9468756	Nome, Norton Sound, AK	1944	64.4946	-165.4396	74	1800	595a
9491094	Red Dog Dock, AK	2003	67.5758	-164.0644			
9497645	Prudhoe Bay, AK	1990	70.4114	-148.5318	151	1857	579a
9751364	Christiansted Harbor, St Croix, VI	1981	17.7477	-64.6984		2118	
9751381	Lameshur Bay, St John, VI	1983	18.3182	-64.7242		2119	
9751401	Lime Tree Bay. St. Croix, VI	1977	17.6947	-64.7538		1447	254a
9751639	Charlotte Amalie, VI	1975	18.3358	-64.92		1393	255a
9752235	Culebra, PR	2005	18.3009	-65.3025		2120	
9752695	Esperanza, Vieques Island,	2005	18.0939	-65.4714		2209	

	PR						
9755371	San Juan, La Puntilla, San Juan Bay, PR	1962	18.4592	-66.1164	206	1001	245a
9759110	Magueyes Island, PR	1954	17.97	-67.0464		759	246a
9759394	Mayaguez, PR	1975	18.2176	-67.1588			
9759938	Mona Island, PR	2006	18.0899	-67.9385		2122	

Additional Active NOAA Water Level Stations							
Station ID	**Station Name**	**Year Installed**	**Latitude**	**Longitude**	**GLOSS ID**	**PSMSL ID**	**JASL ID**
1631428	Pago Bay, Guam	2004	13.4283	144.7967		2130	037a
2695540	Bermuda, St. Georges Island	1988	32.3733	-64.7033	221	363	259b
9411406	Platform Harvest, CA	1992	34.4683	-120.6817			594a

APPENDIX 2: University of Hawaii Sea Level Center GLOSS Stations

The stations listed are GLOSS Stations operated by or in collaboration with UHSLC. More information on these stations can be found at the following website: http://uhslc.soest.hawaii.edu/

GLOSS	STATION	COUNTRY	LAT	LONG	GPS?
182	Acajutla	El Salvador	13°35'N	089°50'W	
068	Ambon	Indonesia	03º41'S	128º11'E	
169	Baltra	Ecuador	00º26'S	090º17'W	GLPS
049	Benoa	Indonesia	08º46'S	115º13'E	BNOA
069	Bitung	Indonesia	00º27'N	125º12'E	BTNG
173	Callao	Peru	12°03'S	077°09'W	CALL
036	Chittagong	Bangladesh	22º20'N	091º38'E	
146	Christmas	Rep. of Kiribati	01º59'N	157º28'W	
291	Cilacap	Indonesia	07º45'S	109º00'E	CLCP
033	Colombo	Sri Lanka	06º57'N	079º51'E	SGOC
253	Dakar	Sénégal	14º41'N	017º25'W	DAKA
071	Davao	Philippines	07º50'N	125º38'E	
026	Diego Garcia	United Kingdom	07º17'S	072º24'E	DGAR
245	Fortaleza	Brazil	03º43'S	38º28'W	CEFT
107	French Frigate S	USA	23º52'N	166º17'W	
027	Gan	Rep. of Maldives	00º41'S	073º09'E	ADDU
109	Johnston	USA Trust	16º44'N	169º32'W	
145	Kanton	Rep. of Kiribati	02º49'S	171º43'W	
117	Kapingamarangi	Fd St Micronesia	01º06'N	154º47'E	
042	Ko Taphao Noi	Thailand	07º49'N	098º25'E	
172	La Libertad	Ecuador	02°12'S	080°55'W	
072	Legaspi	Philippines	13°09'N	123°45'E	
120	Malakal	Rep. of Belau	07º20'N	134º28'E	PALA
028	Male (Hulhule)	Rep. of Maldives	04º11'N	073º32'E	HULE
073	Manila	Philippines	14º38'N	121º05'E	MANL
163	Manzanillo	Mexico	19º03'N	104º20'W	MANZ
192	Mar Del Plata	Argentina	38º02'S	057º32'W	MPL2
008	Mombasa	Kenya	04º04'S	039º39'E	
141	Moulmein	Myanmar	16º29'N	097º37'E	
142	Nuku Hiva	French Polynesia	08º55'S	140º06'W	
045	Padang	Indonesia	00º57'S	100º22'E	IPA0
329	Palmeira	Cape Verde	16º45'N	022º59'W	TGCV
140	Papeete	French Polynesia	17º32'S	149º34'W	PAPE
143	Penrhyn	Cook Islands	08º59'S	158º03'W	
245	Ponta Delgada	Portugal	37º44'N	025º40'W	PDEL
018	Port Louis	Mauritius	20º09'S	057º30'E	
273	Pt. La Rue	Seychelles	04º40'S	055º32'E	SEY1
190	Puerto Deseado	Argentina	47°45'S	065°55'W	PDES
191	Puerto Madryn	Argentina	42°46'S	065°02'W	
167	Quepos	Costa Rica	09°24'N	084°10'W	
075	Qui Nhon	Vietnam	13º47'N	109º15'E	
138	Rikitea	French Polynesia	23º08'S	134º57'W	RKTG
019	Rodrigues	Mauritius	19º40'S	063º25'E	RDRG
347	Sabang	Indonesia	05º50'N	095º20'E	

118	Saipan	USA	15º14’N	145º45’E	CNMR
004	Salalah	Oman	16º56’N	054º00’E	
334	Salvador	Brazil	12º58’S	038º31’W	SALV
211	Settlement Pnt.	Bahamas	26º41’N	078º59’W	BHMA
037	Sittwe	Myanmar	20º09’N	092º54’E	
181	Ushuaia	Argentina	54°48'S	068°18'W	AUTF
119	Yap	Fd St Micronesia	09º31’N	138º08’E	
297	Zanzibar	Tanzania	06º09’S	039º11’E	ZNZB

APPENDIX 3: CARIBE-EWE Sea Level Stations

Additional information on these stations can be found at the following website: http://www.weather.gov/ctwp/#

Station location	Station Code (IOC - PTWC)	Type of Sensors	Country	Latitude	Longitude	Status	Operator	GLOSS ID
Blowing Point			Anguilla	18.4569	-67.1649	Planned	Anguilla DDM	
Barbuda	barb	pwl	Antigua and Barbuda	17.5900	-61.8200	Contributing RTX	NOS/NOAA	
	barb2							
Parham (Camp Blizard), Antigua	parh		Antigua and Barbuda	17.1500	-61.7833	Contributing RTX???	Antigua & Barbuda Meteorological Services CPACC/MACC	
Oranjestad	oran	prs	Aruba	12.5167	-70.0333	Contributing RTX	Aruba Department of Meteorology	
		rad						
DART 44D01			Atlantic NE Connecticut, USA - Northeast Castle Rock Seamount	37.5610	-50.0010	Contributing RTX	NOAA NDBC	
DART 44402			Atlantic off New York, USA - Southeast Block Canyon, NY	39.2980	-70.6590	Contributing RTX	NOAA NDBC	
DART 41424			Atlantic off South Carolina, USA - East Charleston, SC	32.9530	-72.4990	Contributing RTX	NOAA NDBC	
Settlement Point	stpt/setp1	prs	Bahamas	26.4200	-79.0100	Contributing RTX	University of Hawaii Sea Level Center	211
		rad						
		ra2						
		ecs						
Lee Stocking Island, Exuma			Bahamas	23.4600	-76.0600	Existing	Bahamas Department of Meteorology CPACC	12

Matthew Town, Inagua			Bahamas	20.0500	-77.2200	Existing (Not Transmitting)	Bahamas Department of Meteorology CPACC	
Nassau Harbour, New Providence			Bahamas	25.0500	-77.2200	Existing	Bahamas Department of Meteorology CPACC/MACC	
Treasure Cay, Abaco			Bahamas	26.6739	-77.2833	Existing	Bahamas Department of Meteorology CPACC	
Bridgetown Port	brid		Barbados	13.1000	-59.6166	Non-operational	Caribbean Institute of Meterology and Hydrology, CPACC/MACC.	
Port St. Charles	ptsc	rad	Barbados	13.2630	-59.6449	Contributing RTX	Coastal Zone Management Unit with ICSECA Funds	
Pelican Fort			Barbados	13.1115	-59.6310	Existing	Coastal Zone Management Unit	
Conset Bay			Barbados	13.2000	-59.5000	Removed CARIBE EWS Implementation Plan Non operational-CZMU	Coastal Zone Management Unit	
Speightstown			Barbados	13.3000	-59.6000	Removed CARIBE EWS Implementation Plan Non operational-CZMU	Coastal Zone Management Unit	
Carrie Bow Cay	cabc	rad	Belize	16.8028	-88.0820	Contributing RTX	Smithsonian Institute	
		prs						
Belize			Belize	17.5000	-88.2000	Non-operational	Belize Dept. Meterology - CPACC/MACC	
St. Georges Island / Esso Pier	bmda	pwl	Bermuda	32.3744	-64.7019	Contributing RTX	NOS/NOAA Station ID: 2695540	221
Road Town Harbor, Tortola	tort		British Virgin Islands	18.4248	-64.6081	Offline	BVI Dept. of Disaster Management as of 2011, previously Dept.	

							Lands and Survey	
DART 42407			Caribbean Sea	15.2520	-68.2170	Contributing RTX	NOAA NDBC	
George Town	geor	rad	Cayman Islands	19.2951	-81.3835	Contributing RTX	UNESCO/Hazard Management Cayman Islands	
		prs						
Cartagena	cart	rad	Colombia	10.3900	-75.5333	Operational	Instituto de Hidrología, Meteorología y Estudios Ambientales de Colombia (IDEAM)	207
San Andres	sana	prs	Colombia	12.5500	-81.7667	Contributing RTX	DIMAR/UHSLC/PRSN	
		rad						
		bub						
Santa Marta	sama	prs	Colombia	11.2352	-74.2216	Contributing RTX	DIMAR/UHSLC/PRSN	
		rad						
		bub						
Capurganá			Colombia	8.5162	-77.3283	Non operational	Instituto de Hidrología, Meteorología y Estudios Ambientales de Colombia (IDEAM)	
Sapzurro	sapz	prs	Colombia	8.6603	-77.3653	Contributing RTX	Dirección General Marítma (DIMAR)	
		rad						
	sapz2	bub						
		prs						
		rad						
Islas del Rosario			Colombia	10.1834	-75.6667	Non operational	Instituto de Hidrología, Meteorología y Estudios Ambientales de Colombia (IDEAM)	
Isla Naval	inav2	bub	Colombia	10.1806	-75.7503	Contributing RTX	DIMAR	
		rad						
	inav	bub						
		prs						
		rad						
Coveñas	cove	bub	Colombia	9.4145	-75.6911	Contributing RTX	DIMAR	
		prs						

		rad						
Puerto Estrella	estr	prs	Colombia	12.3553	-71.3136	Contributing RTX	DIMAR	
		rad						
Limón	limon / limn	prs	Costa Rica	9.9886	-83.0202	Contributing RTX	RONMAC; Upgraded in 2010 NOAA/UHSLC/PRSN	
		rad						
		ra2						
Cabo Cruz			Cuba	19.8400	-77.7283	Existing	Oficina Nacional de Hidrografía y Geodesia	
Cabo San Antonio - Morros de Piedra			Cuba	21.9000	-84.9067	Existing	Oficina Nacional de Hidrografía y Geodesia	214
Gibara			Cuba	21.1083	-76.1250	Existing	Oficina Nacional de Hidrografía y Geodesia	276
Isabela de Sagua			Cuba	22.9400	-80.0133	Existing	Oficina Nacional de Hidrografía y Geodesia	
Manzanillo			Cuba	20.3400	-77.1467	Non-operational	Oficina Nacional de Hidrografía y Geodesia	
Guantanamo			Cuba	19.9103	-75.1900	Gap	National Ocean Service	
Casilda			Cuba	21.7500	-79.9833	Exisitng	Oficina Nacional de Hidrografía y Geodesia	
Maisí			Cuba	20.2333	-74.1333	Non-operational	Oficina Nacional de Hidrografía y Geodesia	
Mariel Boca			Cuba	23.0205	-82.7561	Existing	Oficina Nacional de Hidrografía y Geodesia	
Bahia de la Habana			Cuba	23.1379	-82.3459	Existing	Oficina Nacional de Hidrografía y Geodesia	
Nuevitas Punta de Practicos			Cuba	21.6056	-77.0989	Existing	Oficina Nacional de Hidrografía y Geodesia	
Puerto Padre			Cuba	21.2033	-76.6012	Existing	Oficina Nacional de Hidrografía y Geodesia	
Nuevitas Bufaderos			Cuba	21.5609	-77.2350	Non-operational	Oficina Nacional de Hidrografía y Geodesia	

Siboney			Cuba	23.1000	-82.4667	Planned	Oficina Nacional de Hidrografía y Geodesia	215
Santiago de Cuba			Cuba	20.0196	-75.8383	Non-operational	Oficina Nacional de Hidrografía y Geodesia	
Santa Cruz del Sur			Cuba	20.7025	-77.9823	Existing	Oficina Nacional de Hidrografía y Geodesia	
Carapachibey			Cuba	21.4429	-82.9005	Non-operational	Oficina Nacional de Hidrografía y Geodesia	
Cayo Loco			Cuba	23.1000	-82.4667	Existing	Oficina Nacional de Hidrografía y Geodesia	
Cayo Largo			Cuba	21.6229	-81.5456	Non-operational	Oficina Nacional de Hidrografía y Geodesia	
La Coloma			Cuba	23.1000	-82.4667	Existing	Oficina Nacional de Hidrografía y Geodesia	
Willemstad			Curacao	12.1043	-68.9416	Removed	Meteorological Dept. Curacao NOAA/UHSLC/PRSN	
Bullen Bay (Replaces Willemstad)	bull	prs rad bub	Curacao	12.1043	-68.9416	Contributing RTX	Meteorological Dept. Curacao/UHSLC/PRSN	
Roseau	rose	prs rad bub	Dominica	15.3000	-61.4000	Contributing RTX	UHSLC/PRSN replaced sea level CPACC/MACC;	
Barahona	bara	prs ra2	Dominican Republic	18.2081	-71.0922	Contributing RTX	ONAMET/PRSN	
Puerto Caucedo/San Andres/Santo Domingo	sdom/sdrd	pwl	Dominican Republic	18.4208	-69.6294	Contributing RTX	ONAMET/PRSN	
Puerto Plata	ptpl / ppla	prs rad ra2	Dominican Republic	19.7988	-70.7020	Contributing RTX	UHSLC/PRSN/ONAMET	
Punta Cana	ptca / pcan	prs rad ra2	Dominican Republic	18.5046	-68.3755	Contributing RTX	UHSLC/PRSN/ONAMET	
Bahía de Luperón			Dominican Republic			Gap	ONAMET	

Bahía de Samaná			Dominican Republic	19.2000	-69.2190	Gap	ONAMET	
Bayahibe			Dominican Republic			Gap	INDRHI	
Pedernales			Dominican Republic	17.9264	-71.6551	Gap	INDRHI	
Puerto de Santo Domingo			Dominican Republic	18.4579	-69.9134	Removed CARIBE EWS Implementation Plan; Originally Planned	INDRHI	
Ile Royale	iler iler2	rad	French Guiana	5.2798	-52.8939	Contributing RTX	SHOM / DDE, RONIM	
Prickly Bay	pric	prs rad bub	Grenada	12,05	-61.7333	Contributing RTX	UHSLC/PRSN replaced sea level CPACC/ MACC;	
Sauteurs			Grenada	12.1000	-61.7500	Planned	Seismic Research Center	
The Sisters Island,			Grenada	12.3000	-61.7000	Planned	Seismic Research Center	
Deshaies Harbour	desh	rad	Guadeloupe	16.3053	-61.7959	Contributing RTX	IPGP	
La Désirade Island, Grande Anse Marina Harbour	desi	rad	Guadeloupe	16.3029	-61.0725	Contributing RTX	IPGPFR	
Puerto Barrios	prba	prs rad	Guatemala	15.6946	-88.6220	Contributing RTX	INSIVUMEH	
DART 42409			Gulf of Mexico	26.6570	-85.7910	Planned re-instalation between 27 Sep through 14 Oct by NOAA (relocation 25,9166 -89,2833)	NOAA NDBC	
DART 42429			Gulf of Mexico			Out of Service	NOAA NDBC	
Harbour Master Boathouse	HMB		Guyana	6.8100	-58.1683	Existing	Maritime Administration Department	

Market Place Georgetown			Guyana	6.7667	-58.1667	Existing	MACC/Hydromet Dept.	
Rosignol			Guyana	6.2667	-57.5333	Non-operational	CPACC	
Parika			Guyana	6.8500	-58.4167	Unknown	CPACC	
Cap Haitien	caph	prs bub ra2	Haiti	19.7593	-72.1933	Contributing RTX	UNESCO/SEMANAH/PRSN	
Jacmel	jaca	prs rad	Haiti	18.2310	-72.5354	Contributing RTX	UNESCO/SEMANAH/PRSN	
Port au Prince	ptpr	prs rad	Haiti	18.5345	-72.3800	Contributing RTX	UNESCO/SEMANAH/PRSN	209
Gonaives			Haiti	19.4500	-72.0700	Planned	SEMANAH	
Mole Saint Nicolas			Haiti	19.0800	-73.3667	Planned	SEMANAH	
Les Cayes			Haiti	18.1833	-73.7333	Planned	SEMANAH	
Guanaja Island			Honduras	16.4553	-85.8761	Existing?	COPECO	
Omoa			Honduras	15.7776	-88.0470	Existing?	COPECO	
Puerto Cortes	pcor	prs	Honduras	15.8433	-87.9587	Contributing RTX	COPECO	
Puerto De Castilla, Trujillo			Honduras	15.9231	-85.9508	Existing	COPECO	
Roatan N			Honduras	16.3333	-87.4500	Existing	COPECO	
Punta Gorda Harbor, Roatan S	rtas	prs	Honduras	16.3455	-86.5404	Contributing RTX	COPECO	
Tela Harbor	tela	prs	Honduras	15.7841	-87.4531	Contributing RTX	COPECO	
Utila Island			Honduras	16.0957	-86.8947	Existing	COPECO	
Cabotaje Harbor, La Ceiba	ceib	prs	Honduras	15.7899	-86.7604	Contributing RTX	COPECO	
Cochino Pequeño			Honduras	15.9500	-86.5000	Gap		
Swan Island			Honduras	17.4000	-83.8000	Gap		
Port Royal	ptro	prs rad	Jamaica	17.9258	-76.8458	Contributing RTX	Jamaica Meteorological Service UNAVCO	210
Montego Bay			Jamaica	18.4601	-77.9417	Existing	Meteorological Service P.R. China	
Port Antonio			Jamaica	18.1828	-76.4537	Existing	Meteorological Service P.R. China	

Discovery Bay, Jamaica			Jamaica	18.4500	-77.4000	Gap	Meteorological Service CPACC/MACC	
Alligator Pond			Jamaica	17.8500	-77.6000	Non-operational		
Fort de France Harbour	ftfr2 ftfr	rad	Martinique	14.6017	-61.0636	Contributing RTX	SHOM, RONIM, Meteo-France	338
Le Precheur Harbour	prec	prs	Martinique	14.8076	-61.2266	Contributing RTX	local authorities	
Le Robert	lero	prs rad	Martinique	14.6833	-60.9333	Contributing RTX	General Council of Martinique	
Celestun	clst	flt	Mexico	20.8487	-90.4034	Contributing RTX	UNAM	
Ciudad del Carmen	ccar	flt	Mexico	18.6167	-91.8167	Contributing RTX	UNAM	
Frontera	frtr	flt	Mexico	18.1574	-94.4059	Contributing RTX	UNAM	
Isla Mujeres	imuj		Mexico	21.2167	-86.7167	Contributing RTX	UNAM	
Progreso	prog/prog2	rad	Mexico	21.3033	-89.6667	Contributing RTX	UNAM	213
Puerto Morelos, Q. R.	pumo pumo2 / pum	flt prs rad	Mexico	20.8300	-86.8700	Contributing RTX	UNAM	
Tuxpan	tuxp	flt	Mexico	20.9700	-97.4000	Contributing RTX	UNAM	
Veracruz	vera vera2	rad flt	Mexico	19.1921	-96.1236	Contributing RTX	UNAM	212
Montserrat			Montserrat	16.7420	-62.1900	Gap		
Corn Island	cois	prs	Nicaragua	12.2849	-82.9800	Contributing RTX	INETER	
Blue Fields			Nicaragua	11.8910	-83.8570	Gap/Non operational	RONMAC/INETER	
Puerto Cabezas			Nicaragua	14.0200	-83.3800	Gap/Non operational	RONMAC/INETER	
El Porvenir	elpo	prs rad bub	Panama	9.5589	-78.9680	Contributing RTX	U. Panama, NOAA/UHSLC/PR SN2009-2012 project	

Bocas del Toro	bdto	prs	Panama	9.3352	-82.2455	Contributing RTX	Smithsonian Tropical Research Institute	
		rad						
Galeta Point			Panama	9.4021	-79.8609	Existing	UHSLC/IG-UPA	
Limon Bay (replaced Coco Solo which replaces Portobelo, reccomended initially by IAS, given close location)			Panama	9.3667	-79.8833	Existing		208
Aguadilla	agua	pwl	Puerto Rico	18.4566	-67.1646	Contributing RTX	NOS/NOAA/PRSN	
Arecibo	arac	pwl	Puerto Rico	18.4805	-66.7024	Contributing RTX	PRSN	
	aracS							
Culebra Island	cule	pwl	Puerto Rico	18.3011	-65.3024	Contributing RTX	NOS/NOAA	
	cule2	pwl						
Fajardo	faja	pwl	Puerto Rico	18.3350	-65.6309	Contributing RTX	PRSN	
Isabel II, Vieques	isab/viqu	pwl	Puerto Rico	18.1525	-65.4438	Contributing RTX	PRSN	
La Esperanza, Vieques	vieq	pwl	Puerto Rico	18.0939	-65.4714	Contributing RTX	NOS/NOAA	
	vieq2							
Magueyes Island	magi	pwl	Puerto Rico	17.9701	-67.0464	Contributing RTX	NOS/NOAA	
	magi2							
Mayagüez	maya	pwl	Puerto Rico	18.2176	-67.1589	Contributing RTX	PRSN	
Mona Island	mona	pwl	Puerto Rico	18.0899	-67.9385	Contributing RTX	NOS/NOAA	
	mona2							
San Juan	sanj	wls	Puerto Rico	18.4589	-66.1164	Contributing RTX	NOS/NOAA	206
	sanj2	pws						
Yabucoa	yabu	wls	Puerto Rico	18.0551	-65.8330	Contributing RTX	PRSN	
Peñuelas	penu		Puerto Rico	17.9725	-66.7618	Removed, relocated equipment to Caja de Muertos (2014)	PRSN	
Caja de Muertos	camu	pwl	Puerto Rico	17.8876	-66.5286	Contributing RTX	PRSN	

DART 41421			Puerto Rico Trench East - North St Thomas	23.4090	-63.8880	Contributing RTX	NOAA NDBC	
DART 41420			Puerto Rico Trench West - North Santo Domingo	23.4840	-67.3510	Contributing RTX	NOAA NDBC	
Baseterre (Coast Guard Base)	bass	prs	St. Kitts & Nevis	17.2900	-62.7097	Contributing RTX	CPACC/MACC; Upgraded by UNESCO/ NEMA	
		rad						
Castries			St. Lucia	14.1666	-61.0000	Contributing RTX	CPACC/MACC	
Calliaqua (Coast Guard Base)	calq	prs	St. Vincent & the Grenadines	13.1299	-61.1955	Contributing RTX	CPACC/MACC; Upgraded by UNESCO/ NEMO	
		rad						
Gustavia			St. Barthelemy	17.8833	-62.8500	Planned	Collectivite de St. Barthelemy	
Marigot	stmt	prs	St. Martin	18.0833	-63.0854	Contributing RTX	Collective de St. Martin	
		rad						
Cedros Bay	cdtt	rad	Trinidad and Tobago	10.0946	-61.8654	Contributing RTX	Trinidad and Tobago Hydrographic Unit, Originally CPACC ?	
Charlotteville	chrl	rad	Trinidad and Tobago	11.3238	-66.5490	Contributing RTX	CPACC Trinidad and Tobago Hydrographic Unit	
Point Fortin	pnfo	rad	Trinidad and Tobago	10.1833	-61.7000	Contributing RTX???	Trinidad and Tobago Hydrographic Unit	
Port Of Spain	ptsp	rad	Trinidad and Tobago	10.6500	-61.5167	Contributing RTX	Trinidad and Tobago Hydrographic Unit, CPACC/MACC	203
Scarborough	scar	rad	Trinidad and Tobago	11.1667	-60.7333	Contributing RTX	Trinidad and Tobago Hydrographic Unit	
Toco Trinidad			Trinidad and Tobago	10.8333	-60.9333	Non operational	Trinidad and Tobago	

							Hydrographic Unit	
Point a Pierre			Trinidad and Tobago	10.5167	61.5155	Planned		
Grand Turk			Turks and Caicos	21.4336	-71.1497	Planned	George Maul, Florida Institute of Technology Proposed NOAA/UHSLC/PRSN2009-2011 upgrade, eliminated.	
Charlotte Amalie, St. Thomas	amal amal2	pwl	USVI	18.3349	-64.9197	Contributing RTX	NOS/NOAA	
Christiansted Harbor, St. Croix	stcr stcr2	pwl	USVI	17.7500	-64.7050	Contributing RTX	NOS/NOAA	
Lameshur Bay, St. John	lame lame2	pwl	USVI	18.3183	-64.7242	Contributing RTX	NOS/NOAA	
Lime Tree Bay, St. Croix	lime lime2	pwl	USVI	17.6845	-64.7540	Contributing RTX	NOS/NOAA	
Aves Island			Venezuela	15.7000	-63.6000	Gap		
Punta Arenas, Margarita Island			Venezuela	10.9700	-64.4000	Gap		
La Guaira			Venezuela	10.6167	-66.9333	Unknown	Instituto Geografico de Venezuela Simon Bolivar	328

APPENDIX 4: Acronyms

CLIVAR	Climate variability and predictability
CO-OPS	Center for Operational Oceanographic Products and Services
CORS	Continuously Operating Reference Stations
CNES	Centre National d'Etudes Spatial
CTWP	Caribbean Tsunami Warning Center
DART	Deep-ocean Assessment and Reporting of Tsunamis
EUMETSAT	European Organization for the Exploitation of Meteorological Satellites
GCN	GLOSS Core Network
GCOS	Global Climate Observing System
GLOSS	Global Sea Level Observing System
GTS	Global Telecommunications System
IOC	UNESCO Intergovernmental Oceanographic Commission
JASL	Joint Archive for Sea Level
JCOMM	WMO Technical Commission for Oceanography and Marine Meteorology
LSA	Laboratory for Satellite Altimetry
MWWL	Microwave water level sensors
NDBC	National Data Buoy Center
NCEI	National Centers for Environmental Information
NESDIS	National Environmental Satellite, Data, and Information Service
NGS	National Geodetic Survey
NOAA	National Oceanic and Atmospheric Administration
NOC	United Kingdom National Oceanography Centre
NOS	National Ocean Service
NSRS	National Spatial Reference System
NTWC	U.S. National Tsunami Warning Center
NWLON	National Water Level Observation Network
NWS	National Weather Service
OOMD	Ocean Observing and Monitoring Division
PSMSL	Permanent Service for Mean Sea Level
PRSN	Puerto Rico Seismic Network
PTWC	Pacific Tsunami Warning Center
UHSLC	University of Hawaii Sea Level Center
TWC	Tsunami Warning Center
UPRM	University of Puerto Rico at Mayagüez
UK	United Kingdom
U.S.	United States