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Development of a coastal data hub for stakeholder access in the Caribbean region

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NOC led project "Climate Change Impact Assessment: Ocean Modelling and Monitoring for the Caribbean CME states", 2018-2019; under the Commonwealth Marine Economies (CME) Programme in the Caribbean.

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Summary

The Caribbean islands encompass some of the most vulnerable coastlines in terms of sea level rise, exposure to tropical cyclones, changes in waves and storm surges. Climate in the Caribbean is already changing and sea level rise impacts are already being felt. Considerable local and regional variations in the rate, magnitude, and direction of sea-level change can be expected as a result of thermal expansion, tectonic movements, and changes in ocean circulation. Governments in the Caribbean recognise that climate change and sea level rise are serious threats to the sustainable development and economic growth of the Caribbean islands and urgent actions are required to increase the resilience and make decisions about how to adapt to future climate change (Caribbean Marine Climate Change Report Card 2017; IPCC 2014). Although the level of vulnerability will vary from island to island, it is expected that practically all small island states will be adversely affected by sea level rise.

In this report we present our initial design of a coastal data hub with sea level information for stakeholder access in St. Vincent and Grenadines, Grenada and St Lucia, with potential development of the hub for the Caribbean region.

The work presented here is a contribution to the wide range of ongoing activities under the Commonwealth Marine Economies (CME) Programme in the Caribbean, falling within the work package 2.8 *"Development of a coastal data hub for stakeholder access in the Caribbean region"*, under the NOC led project "Climate Change Impact Assessment: Ocean Modelling and Monitoring for the Caribbean CME states", 2018-2019.

1. Background, aim and objectives of the study

The work presented here is a contribution to the wide range of ongoing activities under the Commonwealth Marine Economies (CME) Programme in the Caribbean, falling within the work package 2.8 "Development of a coastal data hub for stakeholder access in the Caribbean region", under the NOC led project "Climate Change Impact Assessment: Ocean Modelling and Monitoring for the Caribbean CME states", 2018-2019.

The aim of the Work Package 2.8 is to provide a preliminary design of a data portal for sea level information with the main focus on St. Vincent and Grenadines. However, we also provide sea level information for Grenada and St Lucia.

The work in this work package will contribute to the development of strategies for decision making about adaptation in coastal areas, integrated coastal zone management, and the development of infrastructure on the islands.

While the study (portal) is focused on sea level information for the St Vincent and Grenadines (SVG), Grenada and St Lucia, the framework developed here is transferable and can be applied in other locations subject to data availability.

Specific objectives are:

- To contribute to capacity building on the Caribbean islands (St. Vincent and Grenadines).
- To initiate the pilot project with a focus on design of the data portal, providing valuable information about sea level information in the region (e.g. a description of tide gauge data available for the St Vincent, Grenada and the wider region; information about historical tide gauge data sets; list of data centres, locations for the data.)
- To generate future sea level projections by 2100 under four future climate scenarios (RCP4.5, RCP8.5 climate scenarios and scenarios under warming of 1.5 ˚C and 2 ˚C) for St. Vincent and Grenadines, Grenada and St. Lucia.
- To explore opportunities for application of research within a wide range of environmental research disciplines (e.g. sediment processes, ecosystem evolution, salinity intrusion and subsidence) and contribute to the integrated assessment of future changes in the Caribbean region.

2. Sea level rise by 2100

For small islands and fast growing coastal cities (Hallegate et al. 2013; Jevrejeva et al. 2014) sea level rise is one of the most dangerous aspects of climate change (IPCC 2013). The Fifth Assessment Report of Intergovernmental Panel on Climate Change (AR5 IPCC), published in 2013, finds that "It is very likely that the mean rate of global averaged sea level rise was 1.7 [1.5 to 1.9] mm/yr between 1901 and 2010, 2.0 [1.7 to 2.3] mm/yr between 1971 and 2010 and 3.2 [2.8 to 3.6] mm/yr between 1993 and 2010.

Global sea level rise is an integral measure of warming climate (Church et al. 2013), reflecting alterations in the dynamics and thermodynamics of the atmosphere, ocean and cryosphere as a response to changes in radiative forcing. The primary climate related contributors to the 20th century sea level rise are ice loss of land-based glaciers and ice sheets in Greenland and Antarctica; and the thermal expansion of the oceans (Church et al. 2013). In addition, there is a non-climatic contributor - changes in water storage on land due to groundwater mining and the construction of reservoirs (Church et al. 2013).

The AR5 IPCC (Church et al. 2013) gives a likely range (66%) for sea level rise by 2100 (Table 1), implying there is a 34% chance that sea level rise may lie outside this range - largely due to difficulties assessing ice loss from Greenland and Antarctica.

Table 1 (based on Table 13.5 in AR5 IPCC): Median values and likely ranges for projections of global mean sea level rise in meters) at 2100 relative to 1986–2005 for the four Representative Concentration Pathway (RCP) scenarios.

Climate scenario	**Median (m)** **50%**	**Likely Range (m)** **17-83%**
RCP2.6	0.43	[0.28 to 0.60]
RCP4.5	0.52	[0.35 to 0.70]
RCP6.0	0.54	[0.37 to 0.72]
RCP8.5	0.73	[0.53 to 0.98]

A notable development in global mean sea level projections since IPCC AR5 is the use of a probabilistic approach to explore uncertainties in sea level projections beyond the likely range, suggesting a possible sea level rise of up to 1.8 m by 2100 (Jevrejeva et al. 2014; Kopp et al. 2014; Grinsted et al. 2015).

Figure 1 shows regional sea level rise by the end of the 21st century with a high emission scenario (RCP8.5), with global sea level rise of 0.9 m as median (50%, top panel) and a low-probability (95%) global sea level rise of 1.8 m (bottom panel). For the most of the coastline sea level rise will exceed the global low-probability estimate of 1.8 m.

Sea level rise has significant implications to low-lying coastal areas and beyond. The coastal zone contains valuable ecosystems and typically has higher population densities than inland areas (Small and Nicholls 2003; McGranahan et al. 2007). It generates significant amounts of economic activity contributing to national wealth (Bijlsma et al. 1996; Sachs et al. 2001). In physical terms the major direct impacts of sea-level rise include inundation of low-lying areas, shoreline erosion, coastal wetland loss, saltwater intrusion, higher water tables and higher extreme water levels leading to coastal flooding (Ibe and Awosika, 1991). Human-induced pressures on the coastal zone (such as a growing population, water abstraction, and alteration of the hydrological regime including the damming of sediments) will exacerbate the effects of sea-level rise (Nicholls et al. 2007).

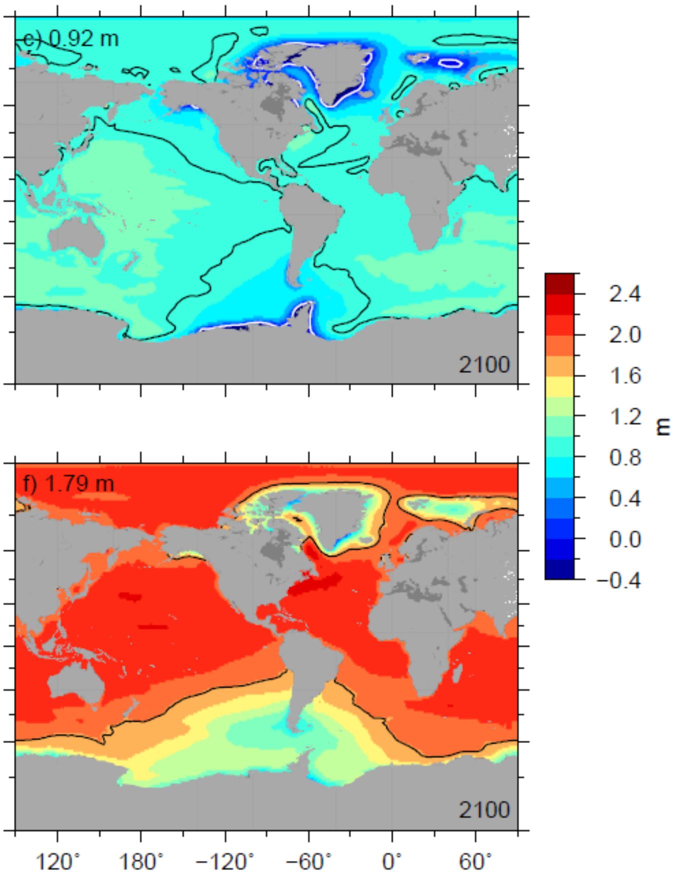


Figure 1. Regional sea level projections in metres: median (50% probability, top panel) and low-probability (95% probability, bottom panel) by 2100 with RCP8.5 scenario.

However, due to uncertainties in future regional sea level projections and a lack of information about erosion, coastal flooding, water abstraction and sediment transport, most of these factors are not considered in available studies (e.g. Dasgupta et al. 2007, 2009). In most studies, some simplistic assumptions are made (e.g. 1 m sea level rise by 2100, without uncertainties; Dasgupta et al. 2009).

3. Sea level rise and its impact on St Vincent and Grenadines

The Caribbean islands encompass some of the most vulnerable coastlines in terms of sea level rise, exposure to tropical cyclones, changes in waves and storm surges (IPCC, 2014). Climate in the Caribbean is already changing and sea level rise impacts are already being felt (IPCC 2014). Considerable local and regional variations in the rate, magnitude, and direction of sea-level change can be expected as a result of thermal expansion, tectonic movements, and changes in ocean circulation. Governments in the Caribbean recognise that climate change and sea level rise are serious threats to the sustainable development and economic growth of the Caribbean islands. They recognise that urgent actions are required to increase resilience and make decisions about how to adapt to future climate change (Caribbean Marine Climate Change Report Card 2017; IPCC 2014). Although the level of vulnerability will vary from island to island, it is expected that practically all small island states will be adversely affected by sea level rise.

However, compared to the other parts of the world, the potential impacts of sea level rise on Caribbean islands have been little studied at the national and sub-national levels. This is mainly due to lack of sea level observations; understanding of sea level rise and variability;

coastal geomorphology of the coast; and detailed studies about sea level rise impact in coastal areas.

St. Vincent and the Grenadines is an archipelagic state that forms part of the Windward Islands in the southern part of the Caribbean. Located at 13^0 15'N and 61^0 15'W, it is neighboured by St Lucia to the North, Barbados to the East and Grenada to the South (Figure 2). The state covers a total land area of approximately 150.3 square miles (388 sq. km.) and a larger marine area including a shallow coastal shelf encompassing an area of approximately 690 square miles. The capital, Kingstown, is located on St. Vincent - commonly referred to as the mainland.

The Grenadines cover a total land area of 16.5 sq. miles (44 sq. km), and stretch a distance of 45 miles to the southwest of St. Vincent toward Grenada. The land area of the Northern Grenadines totals 9 sq. miles, and the Southern Grenadines 7.5 sq. miles.

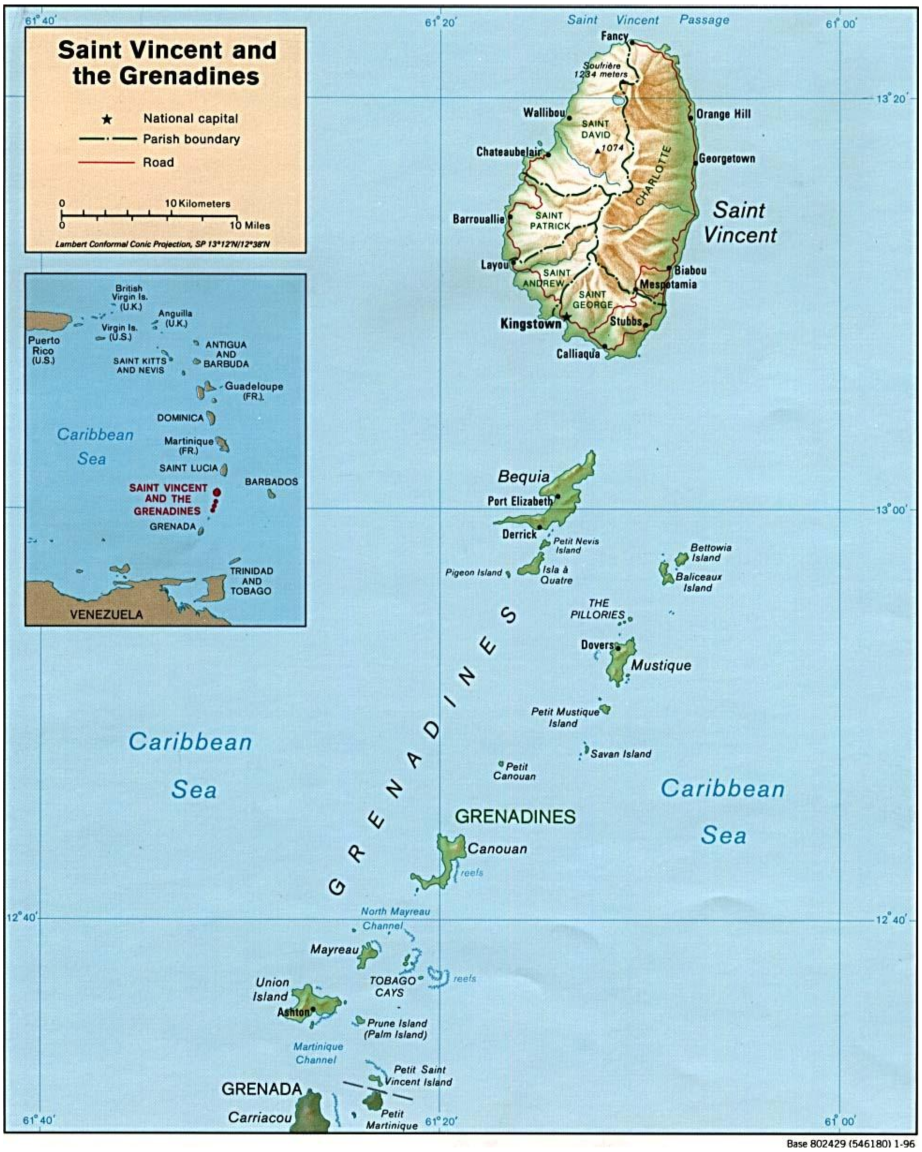


Figure 2. Location of St. Vincent and the Grenadines.

The majority of infrastructure and settlements in SVG, Grenada and St Lucia, like most SIDS (Small Island Developing States), are located on, or near the coast, including government, health, commercial and transportation facilities. High-density tourism development on the coast is particularly vulnerable to climate change and sea level rise. It also tends to increase the degradation of coastal and marine biodiversity, thereby reducing resilience to climate change impacts such as sea level rise, waves and storm surge.

In our study, we provide the new projections for future sea level rise for St. Vincent, Grenada and St. Lucia that will provide a scientific estimate of future sea level rise and address the challenges of adapting to sea level rise in the region. Only when the current conditions are known can adaptation planning begin in earnest, with sea level rise integrated into government insurance policies, design of coastal structures, and most importantly land use development plans.

Although St. Vincent and the Grenadines lies to the south of the main hurricane storm track, the islands are occasionally impacted by tropical storms, hurricanes and heavy rainfall events. Most recently, heavy rainfall during April 11-12, 2011 caused rivers to overflow and landslides in the north-eastern section of St. Vincent. An assessment by the National Emergency Management Office (NEMO) revealed that the sectors most affected were water and agriculture. Accelerated sea level rise is expected to increase the likelihood of the inundation of low-lying coastal areas, increase the salinity of surface and ground water and result in higher water tables.

The impact of sea level rise is likely to exacerbate the damage caused by existing anthropogenic impacts, such as coastal pollution and over-fishing. Improving the management of biodiversity and fisheries will become increasingly important to the welfare of Vincentians and to the sustainability of the country’s main economic activities – fishing, tourism and agriculture.

In common with many small island states globally, St Vincent’s coastal areas are experiencing erosion arising from a variety of causes, including hurricanes, sea level rise, reef damage and human activity. An understanding of wave processes and energy along the island’s coastline and in surrounding waters, combined with geographical knowledge of natural and man-made features and human activity within coastal areas, can aid the assessment of current and future risk of damage and inundation from storm surge and sea level rise.

Beaches and mangroves are particularly vulnerable to sea level rise, more intense storm surges and changes in waves. In the small islands of the Grenadines, protecting fisheries will be important for maintaining healthy populations of herbivores and hence the resilience of coral reefs, as well as for safeguarding the sustainability of artisanal fisheries.

Examples of vulnerable coastlines in St Vincent:

1) 1 m sea level rise places 10% of the major tourism properties at risk, along with 1% of road networks, 50% and 67% of airport and sea port lands respectively.
2) With 2 m sea level rise, 24% of major tourism resorts will be impacted and 75% of airport lands.
3) With 100 m of erosion (resulting from approx. 1 m sea level rise), 76% of the major tourism resorts will be impacted.
4) Annual losses in tourism resulting from the reduced amenity value from beach loss is estimated to be between US $46 million by 2050 to US $174 million by 2080 for an estimate of sea level rise of 20-50 cm.

Historic data (Figure 3) on sea level rise in Caribbean region are limited compared to other regions, which hinders the assessment of coastal impacts and vulnerability. The lack of sea level rise data on the coast is especially striking and this is a major barrier to better analysis of socio-economic impacts of sea level rise. Missing data includes information on present rates of sea-level change and coastal geomorphology through to good data on socio-economic trends. Good coastal environmental management depends on this type of information, and it should be a priority to improve collection.

This suggests a need for national and regional efforts to collect data, as well as international efforts, using remote sensing techniques and interpretation of already available data, to identify the main mechanisms for sea level rise and variability in coastal areas of St Vincent and Grenadines and other islands in the Caribbean region.

4. Monitoring of sea level rise in the Caribbean region

(See additional file, https://psmsl.org/cme/availableStations.xlsx).

This section contains information about the tide gauge data available in the Caribbean, what websites hold the data, and how to obtain it. This information has been summarized in an accompanying Excel file, availableStations.xlsx.

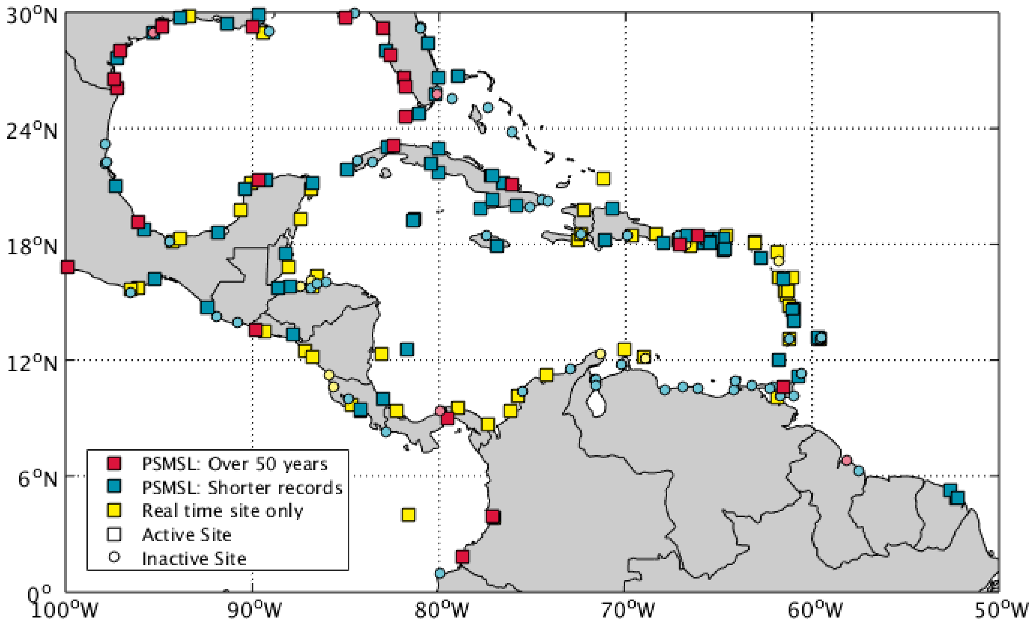


Figure 3. Map of the locations for tide gauge observations in the Caribbean region. Data availability is marked by colour.

4.1 Monthly mean sea level data from PSMSL (Permanent Service for Mean Sea Level)

The PSMSL holds quality controlled monthly and annual mean sea level from tide gauges. PSMSL has two classes of data, RLR (Revised Local Reference) and Metric. The names for the classes may be somewhat obscure, but as explained on the https://psmsl.org/data/obtaining/rlr.php, the vertical reference frame of records is monitored by recording the height of the data relative to a local physical benchmark, and monitoring the stability of the benchmark through frequent geodetic levelling campaigns. The benchmark should be sited on stable ground, so any vertical movement is representative of larger-scale movement of the area. Where all this has been done, the record can be included in the RLR dataset.

Stations in the Metric dataset do not have this guarantee of long term vertical stability, so may contain sudden jumps or long term drifts that are not the result of changes in sea level, or vertical movement in the height of the tide gauge benchmark. As a result, they cannot be used to estimate long term changes in sea level, but could be used in limited cases, e.g. studying seasonal cycles.

Data is available in a simple ASCII format, see https://psmsl.org/data/obtaining/notes.php, and data can be obtained from individual sites (RLR sites, Metric sites). Alternatively, the entire dataset can be downloaded in a zip file via link https://psmsl.org/data/obtaining/complete.php. The dataset can be explored through an interactive map, using https://psmsl.org/data/obtaining/map.html. Each station has a dedicated metadata page giving more information about that site (e.g. Newlyn).

PSMSL data for the Caribbean region are shown on Figures 4-5.

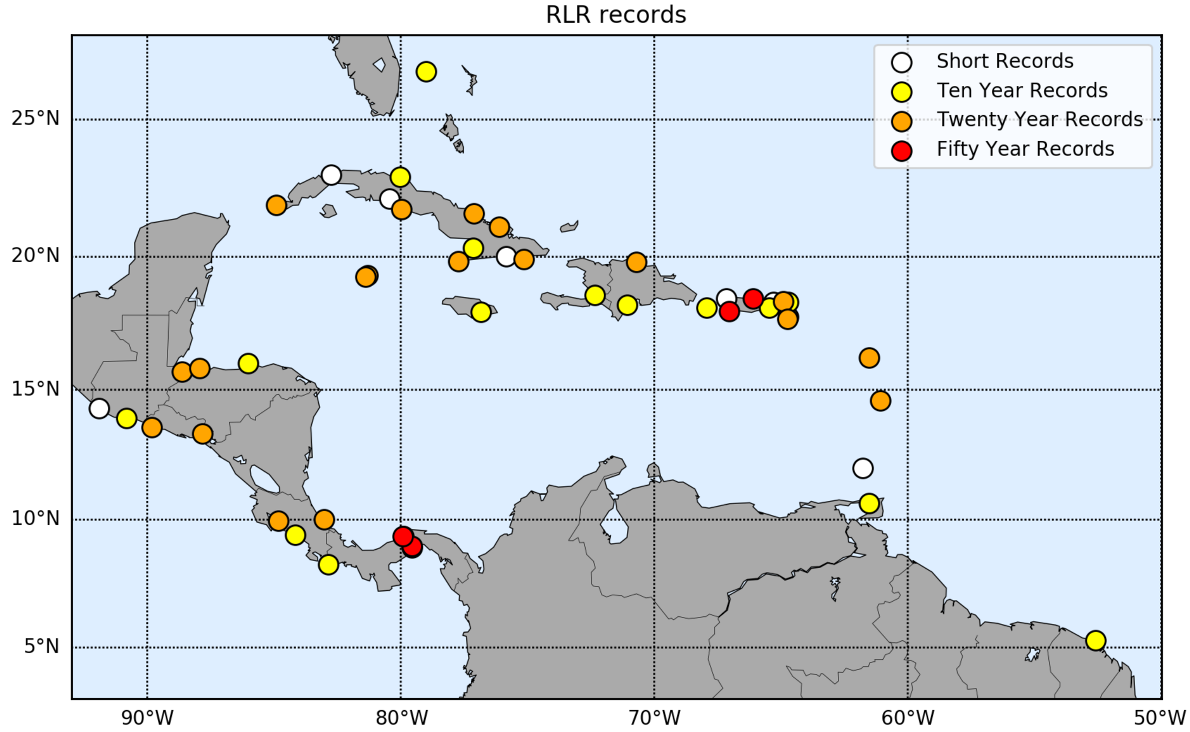


Figure 4. Locations of tide gauge records (historical monthly mean sea level data with revised local reference) available from the Permanent Service for Mean Sea Level (PSMSL)

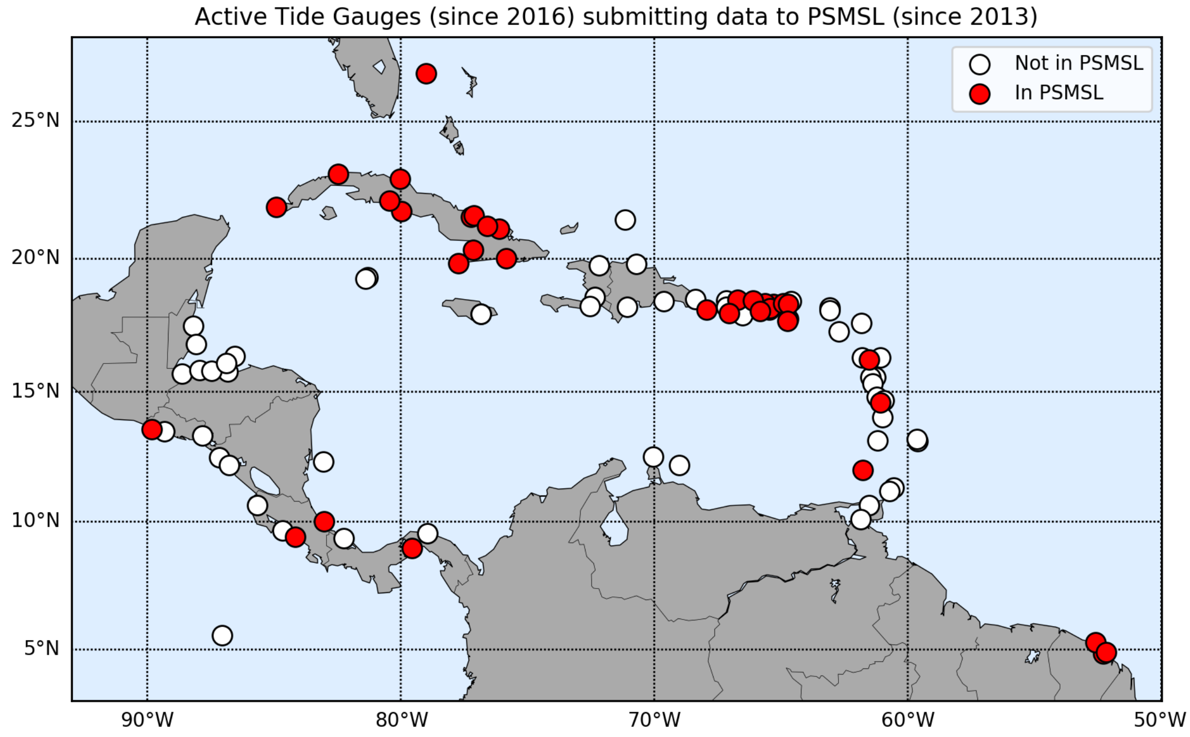


Figure 5. Active tide gauges and limited processed data (red dots) for the Caribbean region available from the PSMSL.

4.2 High frequency data availability

4.2.1 University of Hawaii Sea Level Center (UHSLC)

The University of Hawaii Sea Level Center makes daily and hourly sea level data available. They publish two separate data streams:

- 'Fast-delivery' data: data released within 1-2 months of collection, receiving only basic quality control, which only removes spikes, large level shifts and obvious outliers.
- 'Research-quality' data, archived in the Joint Archive for Sea Level (JASL). This is fully quality controlled, with vertical reference frames monitored throughout the length of the series.

Data can be obtained in ASCII and netCDF format (for fast-delivery or research quality), or via a THREDDS or OPenDAP data servers.

4.2.2 GESLA (Global Extreme Sea Level Analysis)

The GESLA dataset of high-frequency (hourly or more frequent) data was collated in 2009 and updated in 2017. It is the combination of hourly records from the JASL data set distributed by UHSLC and other data obtained from operators of tide gauge networks. The curators of the GESLA dataset have not done any quality control of their own on the data, but data should have been quality controlled by the supplying authority.

Data is distributed in an ASCII format, and can be obtained from the GESLA website, http://gesla.org/.

4.2.3 IOC Sea Level Monitoring Facility

The IOC Sea Level Monitoring Facility (http://www.ioc-sealevelmonitoring.org/, operated by the Flanders Marine Institute, VLIZ) is a web portal that receives and distributes data from tide gauges in real time. Originally developed for tsunami monitoring, the facility now hosts data from sites across the world. Data arrives in real time, and has absolutely no quality control.

Data is available in a variety of text formats, including JSON and XML formats. Data can be obtained using a REST web service, details of which are available at http://www.ioc-sealevelmonitoring.org/service.php?query=help. A maximum of 30 days can be obtained in a single call. For example, to obtain the real time data recorded at Stornoway in January 2012 in a text format, visit
http://www.ioc-sealevelmonitoring.org/service.php?query=data&code=stor&timestart=2012-01-01&timeend=2012-01-31&format=ascii.

4.3 National Data Suppliers

In addition to the above global data banks, data is also available from the Caribbean in the islands that are US and French territories.

4.3.1 Puerto Rico, US Virgin Islands and Barbuda – NOAA

Data from the US tide gauge network in the Caribbean can be downloaded from https://tidesandcurrents.noaa.gov/stations.html?type=Historic+Water+Levels#Caribbean/CentralAmerica. Data for each individual site can be downloaded in text format as 6 minute, hourly, daily or monthly data (select Tides / Water Levels; Water Levels). Data is initially available as 'preliminary data', and is replaced by verified data after quality control has been completed. Fitted harmonic constituents are also available at each site (e.g. for Lime Tree Bay, St. Croix), along with information about tidal datums and benchmarks.

Data is also available from a station in Barbuda operated by the Antigua & Barbuda Meteorological Services in conjunction with NOAA, although this data is not quality controlled.

All data can also be downloaded via the CO-OPS API, https://tidesandcurrents.noaa.gov/api/: this option also allows for the download of data at a frequency of one minute.

4.3.2 Guadeloupe, Martinique, St Martin and French Guiana

Data from all French overseas departments can be downloaded from the SHOM (Service Hydrographique et Océanographique de la Marine) data portal: https://data.shom.fr. This portal contains all data produced by SHOM. To find the tide gauge data, follow these instructions (which assume you are using the English version of the portal):

- Click the "Access to Shom catalog" button
- Click the "Coastal Observations" tab
- Click "REFMAR"
- Select both the "RONIM" and "Partners" tide-gauge check boxes.
- Pan the map to the Caribbean.
- Select a site to view / download, and follow instructions.

Data is available in the original sampling frequency (typically 1 minute), or hourly. Further instructions are available (in French) from https://services.data.shom.fr/static/help/Aide-en-ligne_DATA-SHOM-FR.pdf, see Chapter 8 for information specific to tide gauges. This also describes methods of downloading data via SHOM's web services.

4.4 GNSS Data from SONEL

SONEL (Système d'Observation du Niveau des Eaux Littorales) are a data bank distributing information about the rate of land movement at or near tide gauges as measured by GNSS (GPS and other similar systems) receivers. Daily data can be downloaded in text format via the interactive map or via the SONEL FTP server (ftp.sonel.org). SONEL also provide estimates of the vertical land movement at each site.

Tide gauge data at each site is measured relative to a local vertical reference frame, whereas GNSS receivers measured heights above a reference ellipsoid. Where a GNSS receiver is located at or near a tide gauge, and the two reference frames are connected by levelling, the tide gauge data can be expressed relative to the ellipsoid, which can allow comparison between tide gauge data and satellite altimetry. Further explanation is available on the PSMSL website. A list of stations where this link has been made is also available.

SONEL also distribute tide gauge data from the French network at daily, monthly and annual timescales.

4.5 Summary Table

Source	Website	Data Type
PSMSL	https://psmsl.org	Quality controlled monthly and annual data
UHLSC	https://uhslc.soest.hawaii.edu/	Research Quality (JASL): Quality controlled hourly and daily data Fast Delivery: Hourly and daily data with minimal quality control
GESLA	https://gesla.org/	Hourly and higher frequency data – assumed to be quality controlled by supplier
VLIZ	http://www.ioc-sealevelmonitoring.org/	Real time data high frequency data with no quality control
NOAA	https://tidesandcurrents.noaa.gov/	Data from USA, US territories, and some other NOAA-operated sites. Six-minute to monthly quality controlled data.
SHOM	https://data.shom.fr	Data from France, including Overseas territories. One minute and hourly quality controlled data.
SONEL	http://www.sonel.org/	Daily GNSS (GPS) data, and information about land movement at or near tide gauges.

4.6 Accompanying Spreadsheet

The accompanying spreadsheet summarises the data available at each of the sites in the region, subject to the following:

- Stations within the window 0 – 30° North, 100 – 50 ° West are included.
- Stations from larger nations have been omitted, as they are mostly on the edges of the window. Nations omitted: Brazil, Colombia, Ecuador, Mexico, United States (expect for Puerto Rico and US Virgin Islands), and Venezuela. French overseas departments are also included.
- Sites close to each other have been combined into one row – with 'close' meaning within approximately 10 km. As a result, the name used may not match the name used on the data supplier's website.
- The 'Local' column refers to data available from the NOAA or SHOM websites described above.

5. CME Web Portal

As part of the CME programme, we have produced a prototype web portal to visualise and provide access to some of the programme's outputs. This document describes where to find the web portal, and what it contains.

The web portal has been created as a subsection of the Permanent Service for Mean Sea Level (PSMSL) website: https://psmsl.org, and is located at https://psmsl.org/cme.

5.1 Portal webpages

Homepage *https://psmsl.org/cme/index.php*

The homepage of the portal contains information about the CME programme and links to other parts of it, along with a list of the other pages available on the site.

5.1.1 Sea level data catalogue *https://psmsl.org/cme/catalogue.php*

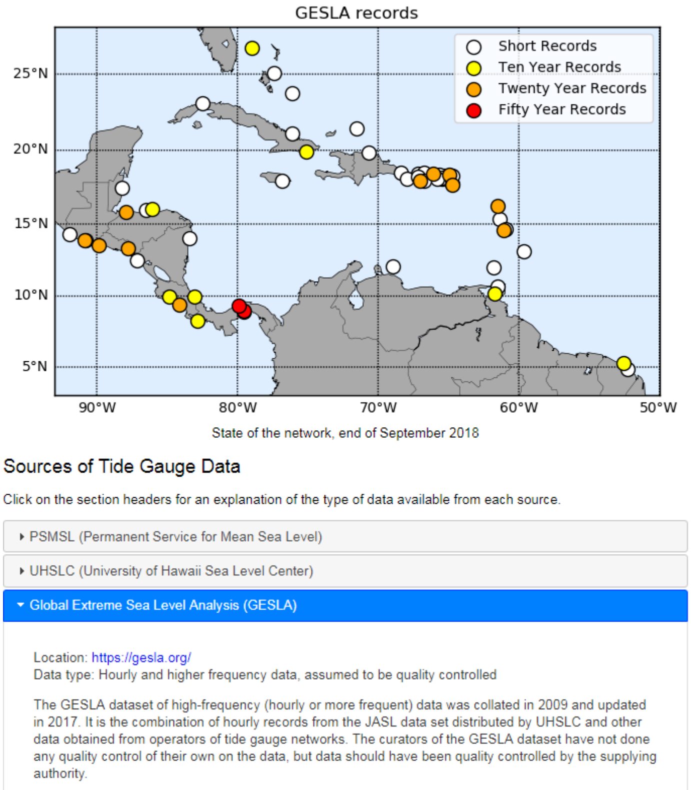
A catalogue of sea level data from tide gauges available in the Caribbean was created as part of the programme.

This page (see right) contains the results of this catalogue, as of the end of September 2018.

Each source of data has a description of what type data is available (e.g. monthly, real-time), what level of quality control it has been subject to, where to download the data, and what format the data is distributed in.

There is also a map at the top of the page, showing the state of the selected network at the end of September 2018.

To change the displayed network, click on the name of its section in the accordion menu.



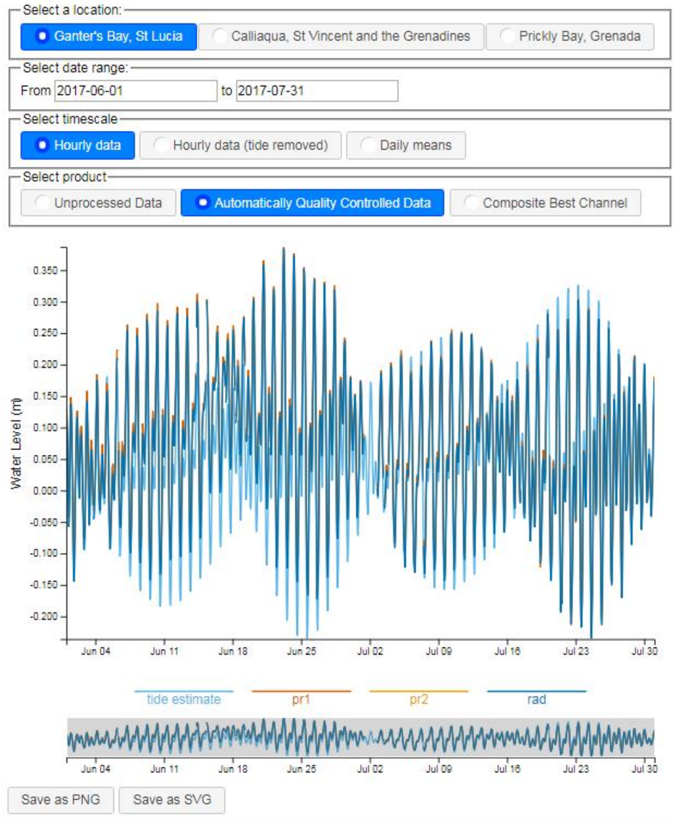
The catalogue contains all stations in the window 0° to 28° North, 95° to 50° West. As the focus is on the Caribbean and Central American, we have not include any tide gauges in Brazil, Colombia, Ecuador, Mexico, the United States (with the exception of Puerto Rico and the US Virgin Islands), and Venezuela. Data from French overseas departments and British overseas territories are included.

5.1.2. Automatic Quality Control Process https://psmsl.org/cme/autoqc.php

This page contains links to a report explaining how the automatic quality control process works, along with a link to the code, which is written using MATLAB (https://www.mathworks.com/products/matlab.html).

5.1.3. Quality Controlled Data Plotter (https://psmsl.org/cme/tidegauge.php)

The data plotter page illustrates the outputs of the quality control process. The user can select output from one of three tide gauges in the Windward Islands, and choose to display hourly data (maximum one year), hourly data with the fitted tide removed, or daily means.



The quality control process is illustrated by changing the displayed product. Options are unprocessed data (data before the quality control is applied), automatically quality controlled data, and a “composite best channel” option, where the algorithm combines output flagged good from all available sensors at a site into a single series.

An estimate of the fitted tide is included if hourly and quality control data options are selected.
The plot can be zoomed and panned using a mouse, or by resizing the grey rectangle in the small overview plot at the bottom of the figure. The image can be saved in raster (.png) or vector (.svg) formats using the buttons at the bottom of the plot.

5.1.4. Automatic Quality Controlled Data Access

https://psmsl.org/cme/downloaddata.php

The automatically quality controlled data can be downloaded from this link. Options are to download the data in the original frequency (usually one observation per minute), as hourly averages, or daily averages. Each downloaded file is in zip format, and contains one file per sensor available at the station, a file containing the composite record, and in the case of the hourly averages, our estimate of the fitted tide at the site.

The output format is described fully on that page, but is a simple comma separated format suitable for import into a spreadsheet package such as Microsoft Excel.

5.1.5. Sea Level Projections https://psmsl.org/cme/projection.php

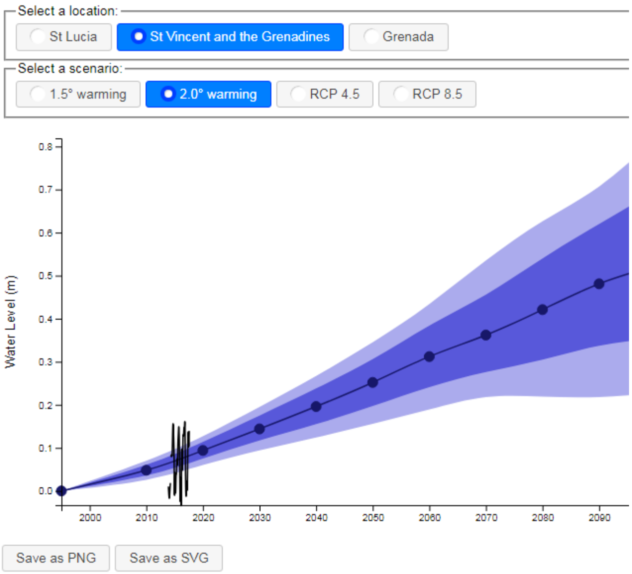
The final page on the portal contains a visualisation of projected sea level rise to 2100 at the three study locations.

The image displayed shows our best estimate of future mean sea level (the central line), along with two envelopes displaying our certainty about the projection. There is a 66% chance that actual sea level lies within the inner envelope, and a 95% chance it lies within the outer envelope. Projected values are also shown in a table beneath the plot.

The projected sea level changes depending on the selected scenario, which can either be based on temperature (1.5° or 2°C above pre-industrial levels at 2100), or on future emissions (the IPCC RCP 4.5 and 8.5 scenarios, described in detail at http://sedac.ipcc-data.org/ddc/ar5_scenario_process/RCPs.html.

The image also monthly data at the tide gauge outputted by the automatic quality control process. This illustrates the monthly variations that are not included in the projection, which only shows the mean sea level.

Again, the image can be saved in raster or vector format.



Data availability in the region

(See additional file https://psmsl.org/cme/availableStations.xlsx, and the Table next page)

Name	Country	Latitude	Longitude	PSMSL RLR	PSMSL Metric	VLIZ	JASL	UHSLC Fast	GESLA	Local	SONEL
Barbuda	Antigua and Barbuda	17.591	-61.821			2012-2018				2011-2015	
Parham (Camp Blizard), Antigua	Antigua and Barbuda	17.15	-61.783			2013-2014					
Blowing Point	Anguilla	18.171	-63.093			2017-2017					
Oranjestad	Aruba	12.517	-70.033			2017-2018					
Lee Stocking Island, Exuma Cays	Bahamas	23.783	-76.1		1992-1993		1992-1993		1992-1993 1992-1993		
Nassau	Bahamas	25.083	-77.367		2001-2001		1904-1905		1904-1905		
Settlement Point	Bahamas	26.71	-78.997	1985-2001 2002-2016	1985-2001 2002-2016	2009-2018	1985-2002 2002-2017	2002-2018	1985-2002 1985-2000 2002-2012		
Bridgetown	Barbados	13.1	-59.617		1968-1970 1990-1996	2013-2018	1968-1970 1990-1991 1993-1996 2008-2010		1968-1970 1990-1991 1993-1996 2008-2010		1997-2001 2004-2013
St. James	Barbados	13.183	-59.65		1957-1960	2012-2018					
Belize City	Belize	17.5	-88.183		1964-1967	2017-2018	1964-1967		1964-1967		
Carrie Bow Cay	Belize	16.803	-88.082			2016-2018					
North Sound	Cayman Islands	19.3	-81.317	1976-1996	1976-2003	2013-2018					2005-2011 2014-2018
South Sound	Cayman Islands	19.267	-81.383	1976-1996	1976-1996	2013-2018					
Puerto Limon	Costa Rica	10	-83.033	1948-1968	1948-1980 2009-2016	2009-2018	1970-1981 2009-2017	2009-2018	1970-1981 2009-2012		
Puntarenas	Costa Rica	9.967	-84.833	1941-1966	1941-1966 1970-1980		1970-1980		1970-1980		2007-2018
Quepos	Costa Rica	9.4	-84.167	1957-1970 2009-2016	1957-1994 2009-2016	2009-2018	1961-1994 2009-2017	2009-2018	1961-1994 1961-1994 2009-2012		
Cocos Island	Costa Rica	5.556	-87.048			2018-2018					
Los Sueños	Costa Rica	9.65	-84.666			2013-2017					
Papagayo Marina	Costa Rica	10.642	-85.656			2014-2016					
Bullen Bay	Curaçao	12.187	-69.02			2013-2018	2013-2017	2013-2018			
Willemstad	Curaçao	12.104	-68.942			2011-2013	2011-2012		2011-2012		

Baracoa	Cuba	20.35	-74.5		1949-1951						
Cabo Cruz	Cuba	19.833	-77.733	1992-2017	1992-2017						
Cabo de San Antonio	Cuba	21.9	-84.9	1971-2017	1971-2017						
Casilda	Cuba	21.75	-79.983	1979-2017	1949-1956 1979-2017						
Cayo Loco	Cuba	22.151	-80.454	2012-2017	2012-2017						
Gibara	Cuba	21.108	-76.125	1974-2017	1949-2017		1985-1992		1985-1992		
Guantanamo Bay	Cuba	19.907	-75.147	1937-1971	1937-1971 1996-1997		1937-1948 1995-1997		1937-1948 1995-1997		
Havana	Cuba	23.15	-82.333		1947-1956						
Isabela de Sagua	Cuba	22.933	-80.017	2000-2017	2000-2017						
La Coloma	Cuba	22.233	-83.567		1949-1950						
Los Arroyos	Cuba	22.35	-84.383		1950-1951						
Maisi	Cuba	20.25	-74.15		2000-2002						
Manzanillo	Cuba	20.333	-77.15	2004-2017	2004-2017						
Mariel Boca	Cuba	23.021	-82.756	2012-2015	2012-2015						
Nuevitas Bufadero	Cuba	21.56	-77.237		2015-2017						
Nuevitas Punta Practico	Cuba	21.591	-77.109	1992-2017	1992-2017						
Puerto Padre	Cuba	21.202	-76.6		2001-2017						
Santiago de Cuba	Cuba	20.02	-75.837	2012-2017	2012-2017						2000-2018
Siboney	Cuba	23.1	-82.467		1966-2017		1990-1990		1990-1990 1990-1991		
Marigot	Dominica	15.548	-61.283			2017-2018					
Portsmouth, Dominica	Dominica	15.559	-61.468			2017-2017 2018-2018					
Roseau	Dominica	15.314	-61.389			2011-2018			2011-2012		
Barahona	Dominican Republic	18.2	-71.083	1954-1969	1954-1969	2012-2018	2011-2015	2011-2018			2011-2018 2015-2018
Ciudad Trujillo	Dominican Republic	18.45	-69.883		1949-1954						
Puerto Plata	Dominican Republic	19.817	-70.7	1949-1969	1949-1969	2010-2018	2010-2017	2010-2018	2010-2012		2012-2017
Punta Cana	Dominican Republic	18.505	-68.376			2010-2018	2010-2017	2010-2018	2010-2012		2014-2018

Santo Domingo	Dominican Republic	18.421	-69.629			2010-2017					
Acajutla	El Salvador	13.567	-89.833	1962-2001 2011-2016	1962-2001 1962-2016	2008-2018	1962-2001 2001-2009 2010-2017	2010-2018	1962-2001 2001-2009 2010-2012		
La Union	El Salvador	13.333	-87.817	1948-1968	1948-1968 1954-1980 2001-2010	2010-2018	1954-1980 2001-2010		1954-1980 2001-2010		
La Libertad	El Salvador	13.485	-89.319			2016-2018					
Cayenne	French Guiana	4.85	-52.283				2006-2007	2006-2011	2006-2007		
Degrad des Cannes	French Guiana	4.853	-52.278		1990-2017					2008-2018	2005-2013
Ile Royale	French Guiana	5.284	-52.587	2006-2017	2006-2017	2012-2012 2018-2018	1989-2007 1989-2016		1989-2007 2006-2012	1989-2007 2006-2018	1991-2018 2013-2018
Ilet La Mere	French Guiana	4.894	-52.19		1978-2017					1989-2018	
Prickley Bay	Grenada	12.005	-61.765	2011-2016	2011-2016	2011-2018	2011-2017	2011-2018	2011-2012		
Pointe-à-Pitre	Guadeloupe	16.224	-61.531	1991-2017	1991-2017	2012-2012 2018-2018	1991-2012		1991-2012	1987-2018	2003-2013 2008-2018 2015-2018
Deshaies	Guadeloupe	16.305	-61.796			2013-2018				1999-2017	
La Desirade Island	Guadeloupe	16.303	-61.072			2010-2018				2010-2017	2003-2014
Champerico	Guatemala	14.283	-91.917	1967-1975	1967-1975		1974-1975		1974-1975		
Puerto Quetzal	Guatemala	13.917	-90.783		1984-1984		1983-1984 1992-1995 2001-2002		1992-1995 2001-2002 1983-1984		
San Jose	Guatemala	13.917	-90.833	1960-1969 1963-1975	1960-1969 1955-1975		1955-1975		1955-1975		
Santo Tomas de Castilla	Guatemala	15.7	-88.617	1964-1983	1964-1983	2013-2018					
Georgetown	Guyana	6.8	-58.167		1927-1981						
Rosignol	Guyana	6.3	-57.517		2001-2001						
Port au Prince	Haiti	18.567	-72.35	1949-1961	1949-1961	2013-2018	2011-2017	2011-2018			2010-2014
Cap-Haïtien	Haiti	19.759	-72.193			2011-2018					
Jacmel	Haiti	18.231	-72.535			2013-2017					
Cochino Pequeno	Honduras	15.953	-86.5		1995-1997		1995-1996		1995-1996		
La Ceiba	Honduras	15.767	-86.833		1960-1968	2015-2018					

Puerto Castilla	Honduras	16.017	-86.033	1955-1968	1955-1968		1955-1967		1955-1967		
Puerto Cortes	Honduras	15.833	-87.95	1948-1968	1948-1968	2015-2018	1948-1968 2001-2002		1948-1968 2001-2002		
Roatan Island Punta Gorda Harbor	Honduras	16.346	-86.54			2015-2018					
Tela Harbor	Honduras	15.784	-87.453			2015-2016					
Utila Island	Honduras	16.096	-86.895			2015-2016					
Discovery Bay	Jamaica	18.433	-77.417		2001-2001						
Kingston	Jamaica	17.95	-76.85		2001-2001	2014-2018					
Port Royal	Jamaica	17.933	-76.85	1954-1969	1954-1969	2014-2018	1965-1971		1965-1971		2000-2007 2011-2018 2014-2016
Fort-de-France	Martinique	14.6	-61.083	1976-2017	1983-1985 1976-2017	2012-2017 2012-2018	1976-2016	1976-2018	1976-2012	2005-2018	2008-2018 2012-2013 2015-2017
Le Prêcheur	Martinique	14.808	-61.227			2013-2018					
Le Robert	Martinique	14.683	-60.933		1976-1984	2013-2018	1976-1984		1976-1984		
Corn Island	Nicaragua	12.327	-83.068			2014-2018					
Puerto Cabezas	Nicaragua	14.042	-83.382				2001-2002		2001-2002		
Puerto Corinto	Nicaragua	12.483	-87.168			2014-2018	1967-1967 2001-2001		1967-1967 2001-2001		
Puerto San Juan del Sur	Nicaragua	11.251	-85.875			2014-2015					
Puerto Sandino	Nicaragua	12.201	-86.764			2014-2018					
Balboa	Panama	8.967	-79.567	1908-2017	1908-2017		1907-2017	1907-2014	1907-2012		2018-2018
Coco Solo	Panama	9.367	-79.883	1991-1996	1981-1996						
Cristobal	Panama	9.35	-79.917	1909-1980	1909-2010 1907-2014		1907-2014	1907-2014	1907-2012		2008-2018
Naos Island	Panama	8.918	-79.55	1949-1968 1991-1995	1949-1968 1991-1998		1961-1965 1991-1997		1991-1997 1961-1965 1991-1997		
Puerto Armuelles	Panama	8.267	-82.867	1951-1968 1983-2001	1951-1968 1983-2001		1955-1968 1983-2001		1955-1968 1983-2001		
Bocas Del Toro	Panama	9.351	-82.258			2014-2018					
El Porvenir	Panama	9.558	-78.949			2012-2018	2012-2017	2012-2018			

Aguadilla	Puerto Rico	18.457	-67.163	2006-2012	2006-2012	2015-2016	2006-2012		2006-2012	2006-2012	1997-2007 1997-2007 2007-2016 2007-2016
Arecibo	Puerto Rico	18.48	-66.702		2008-2017	2009-2010 2018-2018	2008-2016		2008-2012	2008-2017	
Culebra	Puerto Rico	18.302	-65.303	2005-2013	2005-2013	2010-2012 2018-2018	2005-2013		2005-2012	2005-2018	2008-2017
Esperanza, Vieques	Puerto Rico	18.093	-65.472	2005-2017	2005-2017	2010-2012 2018-2018 2010-2018	2005-2016		2005-2012	2005-2018	
Fajardo	Puerto Rico	18.335	-65.63		2008-2017	2010-2017	1921-1923 2008-2016		1921-1923 2008-2012	2008-2017	
Isabel Segunda, Vieques	Puerto Rico	18.152	-65.443		2009-2017	2010-2012 2018-2018	2009-2016		2009-2012	2009-2017	
Magueyes Island	Puerto Rico	17.97	-67.045	1955-2017	1955-2017	2010-2012 2018-2018	1954-2016		1965-2012	1995-2018	2006-2018
Mona Island	Puerto Rico	18.09	-67.938	2006-2017	2006-2017	2010-2010 2018-2018	2006-2016		2006-2012	2006-2018	2008-2016
San Juan	Puerto Rico	18.458	-66.115	1962-2017	1962-2017	2010-2012 2018-2018	1977-2016		1985-2000 1977-2012	1995-2018	2003-2011 2008-2016 2012-2018
Yabucoa Harbor	Puerto Rico	18.055	-65.832		2008-2017	2010-2018	2008-2016		2008-2012	2008-2017	
Caja de Muertos	Puerto Rico	17.888	-66.528			2015-2017					
Mayaguez	Puerto Rico	18.218	-67.159			2010-2018	2008-2016		2008-2012	2008-2018	1996-1999 2010-2017
Penuelas (Punta Guayanilla)	Puerto Rico	17.973	-66.762			2010-2015	2001-2005		2001-2005	2001-2005	
Basseterre	Saint Kitts and Nevis	17.283	-62.717		2001-2001	2013-2018					
Castries	Saint Lucia	14.017	-61		2001-2001	2016-2018					
Saint Martin Island	Saint Martin	18.083	-63.085			2015-2018				2002-2017	2007-2016 2016-2017
Kingstown	Saint Vincent and the Grenadines	13.133	-61.2		2001-2001						

Calliaqua Coast Guard Base	Saint Vincent and the Grenadines	13.13	-61.196			2013-2017					
Charlotteville	Trinidad and Tobago	11.317	-60.55		2001-2001	2013-2016					
Guayaguayare	Trinidad and Tobago	10.133	-61		2001-2001						
Point Fortin	Trinidad and Tobago	10.183	-61.7		1987-1996		1987-1996		1987-1996		
Port of Spain	Trinidad and Tobago	10.65	-61.517	1983-1992	1937-1992	2013-2018	1984-1992		1984-1992		2014-2018
Scarborough	Trinidad and Tobago	11.183	-60.733		1987-1987	2013-2018					
Cedros Bay	Trinidad and Tobago	10.094	-61.865			2013-2018					
Point Galeota	Trinidad and Tobago	10.138	-60.992			2013-2013					
Grand Turk Island	Turks and Caicos Islands	21.434	-71.15			2017-2017					
South Caicos	Turks and Caicos Islands	21.483	-71.533				1992-1992		1992-1992 1991-1992		
Tortola	Virgin Islands, British	18.425	-64.608			2013-2018					
Charlotte Amalie	Virgin Islands, U.S.	18.335	-64.92	1975-2017	1975-2017	2010-2018 2012-2018	1978-2016		1978-2012	1994-2017	2006-2018 2008-2018
Christiansted Harbour	Virgin Islands, U.S.	17.75	-64.705	2006-2017	2006-2017	2010-2010 2012-2012 2018-2018 2018-2018	2006-2016		2006-2012	2006-2018	1994-2018
Lameshur Bay	Virgin Islands, U.S.	18.317	-64.723	2006-2017	2006-2017	2010-2012 2018-2018	2006-2016		2006-2012	2006-2018	
Lime Tree Bay, St. Croix	Virgin Islands, U.S.	17.693	-64.753	1977-2017	1977-2017	2010-2010 2012-2012 2018-2018 2018-2018	1982-2016		1982-2012 1991-2000	1994-2018	2006-2017

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