Data Management System (DMS) Plan

CARICOOS Data Management System (DMS) Plan

I. Executive Summary

The Caribbean Coastal Ocean Observing System (CARICOOS) Data Management and Cyberinfrastructure (DMAC) system long-term goals are aligned with the stated IOOS DMAC Mission: "To promote broad access to and use of ocean and coastal data for the benefit of stakeholders, NOAA, and other IOOC agencies" (IOOS DMAC Vision Document Draft as of March 3, 2016). Our regional mandate makes us the stewards of ocean observations in the US-Caribbean-EEZ while our unique geographical location allows us to look beyond the US-EEZ and seek the additional long-term mission/goal of providing a leadership DMAC role in the international Caribbean domain. Our role in NOAA as the Caribbean Regional Information Coordination Entity, or RICE, formalizes our status among non-federal observing organizations who are recognized as meeting federal standards for data gathering and management. The CARICOOS DMAC subsystem is now fully integrated into the IOOS-DMAC Service Oriented Architecture (SOA) and operating as the Regional Data Assembly Center (DAC).

This document provides an overview of one of the major components of CARICOOS, as required by the NOAA IOOS – the Data Management and Cyberinfrastructure (DMAC) System. The CARICOOS DMAC currently operates as the Caribbean Regional Data Assembly Center (DAC). The fundamental function of the DMAC is to aggregate multiple data streams from the sensors and models that comprise CARICOOS as well as from independent data providers into a central archive and provide these data to users

via standard services. The CARICOOS DMAC is involved with all aspects of data flow including archive, discovery, and transport with efforts primarily geared toward: 1) obtaining and distributing a variety of quality data from external partners; 2) managing model data output (WRF, SWAN, FVCOM); 3) maintaining the flow of data into the Data Access Services and web products; and 4) enhancing product development. It archives and serves data and model output for the entire U.S. Caribbean geographical region and facilitates discovery, access, and understanding of regional, relevant in-situ and model data. CARICOOS data servers are registered and listed in the IOOS catalog, allowing them to be discovered. Data can be accessed via WMS, THREDDS/OpenDAP, ncSOS, ERDDAP, and visualized in the CARICOOS portal (https://www.caricoos.org/). Data may also be provided to stakeholders in several standard formats (such as csv, xls, txt, mat, ASCII or NetCDF) upon request.

CARICOOS has been enhancing and expanding the DMAC system for archiving and serving data and model output with grants from NOAA IOOS. These efforts require substantial information technology support in the form of system administration of the various computers and networking between instruments, models, and the data server systems.

The DMS Plan focuses on the management and delivery of CARICOOS-related data. CARICOOS will implement recommended and standard practices as defined by the IOOS Data Management and Communications (DMAC) committee and more specifically those in the *Guide for IOOS Data Providers, version 1.0* (2006). These practices apply to data archive, data discovery, data service (web-based browsing), data transport (access to data), metadata, IT security, and data QA/QC.

CARICOOS adheres to the NOAA Data Sharing Procedural Directive. All real-time data collected by CARICOOS are freely available through open services, without delay or restriction. Avenues for accessing the data are available through the CARICOOS website: https://www.caricoos.org/data-download. At present, CARICOOS does not maintain any data streams that are restricted, either to specific users or after delays.

Whenever guidance is provided by the U.S. IOOS Program Office on data management protocols, CARICOOS will respond within 1 week with an assessment of the relevance of such guidance to our DMAC procedures and if appropriate, an estimate of the time it will take us, given resources and capacity, to reach compliance. Once the data management lead receives the recommended protocol, he takes the necessary steps towards its implementation in a reasonable and timely manner. Implementation of new services is only limited by personnel time and expertise.

CARICOOS often consults outside DMAC expertise from our sister RAs (or RICEs).

Additionally, CARICOOS DMAC personnel maintain regular communication with the U.S. IOOS Program Office through in-person and virtual meetings, phone calls, webinars, and emails. This continuous communication ensures that CARICOOS is aware of all new practices and protocols, as promulgated by the IOOC and the IOOS Program Office, and understands how to implement them.

CARICOOS seeks to comply with IOOS-DMAC data server and services specifications provided in:

DMAC Implementation Plan

The latest version of the DMAC Plan (2011), describing DMAC requirements, architecture, planned implementation, etc can be found here: DMAC Plan 1.0 (.pdf)

IOOS DMAC Subsystem Implementation Guidance

NOAA IOOS® Program Office White Paper designed to advance community discussion about the national/regional IOOS® enterprise, specifically with a focus on implementation of DMAC subsystem elements: IOOS DMAC Subsystem Implementation Guidance

Concept of Operations for the DMAC subsystem

The initial high-level concept of operations (ConOps) for the DMAC subsystem: IOOS DMAC Concept of Operation (.pdf)

IOOS DMAC FAQ

The live DMAC question and answer web page can be found here: IOOS DMAC FAQ (.pdf)

II. System Components / Data Streams

CARICOOS is a unique Regional Association in that much of its data collection, operations, and data management are conducted through contracting arrangements. Individuals and/or organizations are sub-contracted by CARICOOS to provide operations and maintenance for the various system components of CARICOOS. There is a system in place to check and evaluate the contracting agreements. Contractors provide semi-annual reports to the Caribbean Coastal Ocean Observing System Inc (CARICOOS). to demonstrate that they are meeting the agreed-upon scope of work. Both the Executive and Technical Director review the reports and approve disbursements to the contractors based on the services rendered. Additionally,

CARICOOS staff perform daily checks to assure all data streams are active. Uptime and response time in case of interrupted data streams are criteria weighted in the performance assessment of the data-serving contractors.

This section describes each CARICOOS data source individually. The descriptions include the data flow and quality control procedures. Existing or planned archiving procedures for each data stream are described in a separate document.

1. UMaine Meteorological and Oceanographic Data Coastal Buoys

Dr. Neal Pettigrew's lab at the University of Maine operates and maintains 5 buoys for CARICOOS (PR1=Ponce; PR2=San Juan; PR3=Vieques; VI1=St. John; VI2=St. Thomas). The standard measurements on these buoys include near-surface winds (Gill Windsonic anemometer and RMYoung propeller-vane wind sensor), air temperature (Campbell Scientific air temperature), barometric pressure (Setra pressure sensor), directional waves (Axys Triaxys wave sensor), ocean surface temperature and salinity (Seabird 37SM), and ocean currents throughout the water column (Nortek Aquadopp current profiler). An in-house (UMaine-built) directional wave sensor is installed on PR3 (no Axys Technologies sensor); the same sensor is installed on the other buoys as a redundant directional wave sensor. A third non-directional wave sensor (based on single axis accelerometer data) is installed on all buoys as a redundant data source and comparison check. Wave data reported to NDBC are from the Ayxs sensor if available, and from the UMaine-built directional wave sensor if not.

Data Flow

Under contract to CARICOOS, UMaine acquires the buoy data through two redundant communication systems: 1) mobile cellular service (primary) and 2) satellite transmission (backup). The data from all instruments are connected to a Campbell Scientific CR1000 data logger in each buoy for collection and transmission via cellphone IP data transfers. Backup transmissions are also received via NOAA's GOES satellite systems. The data streams are ingested into their system, where all real-time data are processed and quality controlled by UMaine, and distributed to CARICOOS and to NDBC. Note that the data loggers in the buoys transmit at hourly intervals so buoy data are updated hourly, despite the shorter measurement time step for some parameters.

CARICOOS accesses UMaine buoy data in 3 ways:

a. Through the CARICOOS Buoy Monitoring web page that was set for us by UMaine (http://gyre.umeoce.maine.edu/caricoos/). The last 10 days of data from each buoy are provided in text format. Meteorological

parameters (labeled "Surface") at the height indicated for the corresponding station sensor are reported at 10 minute intervals (wind direction, wind speed, wind gust, atmospheric pressure, atmospheric pressure tendency and air temperature) whereas sea surface parameters (labeled "Ocean") at the depth indicated for the corresponding sensor are reported at 1 hour intervals (water temperature, salinity, wave height, wave direction, wave period, surface current speed and surface current direction). Water velocity profiles (labeled "Currents") are reported at 1-hour intervals. These are data listings with no imbedded metadata records. These data have been submitted to UMaine's standard QARTOD procedures. Note data logger transmission caveat above.

b. UMaine provides historical (up to the previous buoy deployment) and near realtime (current buoy deployment) data in NetCDF format. These files are downloaded from http://gyre.umeoce.maine.edu/GoMoos/php/mooring_file_info.php?report=histo rical_files and http://gyre.umeoce.maine.edu/GoMoos/php/mooring_file_info.php?report=activ e_files, run through Python routines by CARICOOS to ensure NCSOS compatibility and are then uploaded to the THREDDS and ERDDAP server; these files contain extensive metadata records and QA/QC flags.

c. From NDBC in csv and NetCDF formats.

The data processing system for data generated by the UMaine buoys consists of both field and shoreside components. A programmable datalogger inside the buoy well timestamps data received from sensors, aggregates it, and transmits the data to UMaine via two methods, cellphone modem and NOAA GOES satellite. This results in two streams of largely redundant data.

The two streams of buoy telemetry received at UMaine are processed by a near-real time processing system that has been in operation since approximately 2001, and extensively modified since then. The system comprises a UNIX-based application server and a UNIX-based web server, and is driven by a number of unix shell scripts, python scripts, and MATLAB scripts. Data are stored in NetCDF format, following CF and COARDS conventions in effect when the system was built. Additional metadata for NetCDF files and directory structure is accessed via MySQL databases.

In the text-based data feed to CARICOOS, data from the two redundant data streams (GOES and cellphone) as well as data from redundant sensors (wind and wave data) are

combined and reconciled. QC is carried out on both data streams independently as the data arrive. The text (ASCII) reports are updated as incoming data are processed, and may be "backfilled" as missing data or data sampled at a higher temporal resolution become available later in time.

As buoy data are processed and updated, associated NetCDF files are immediately replicated from the application server to the web server. Both servers are backed up nightly, and full backups of the NetCDF archive are retained off-premises periodically.

The system description at: http://gyre.umeoce.maine.edu/data/gomoos/buoy/doc/buoy_system_doc/buoy_system/book1.html is the most current version available, (roughly 2003).

Quality Control

UMaine performs data stream QA/QC according to best practices and standards. All data variables reported to CARICOOS in real-time NetCDF files have an ancillary QC flag. A non-zero flag represents an invalid data value for that record. Initial quality control checks tailored to the separate data streams (similar to "Timing/Gap" and "Syntax" checks in QARTOD manuals) are performed on all of the cellphone and GOES satellite telemetry. After this point in the processing, the same processing routines are used for both streams.

A range check ("Gross Range Test" per QARTOD manual) is carried out for all reported data variables processed through the system. The "valid_range" NetCDF variable attribute is used for this purpose at an early stage in processing, and QC flags are set to a non-zero value. The ranges employed for testing are selected by buoy personnel and most are tighter than the maximum "sensor span" for a given data variable.

A "Location Check" is also performed for each reported data variable in the system – as GPS positions are updated, the distance from the updated position to the nominal deployment position is calculated and if this is larger than a watch circle radius, alarms immediately notify data management personnel. Data from a confirmed position outside the watch circle are not reported and a QC flag is set to a non-zero value.

In addition to the real-time automated QC checks, data are reviewed by data management personnel on a daily basis using a variety of diagnostic tools. This operator-supervised data review includes the comparison of buoy data to data from neighboring platforms and to climatology data, serving a similar function to the QARTOD "Neighbor Test" and "Climatology Test". A number of email alarms are configured to indicate gaps in data, unusual or anomalous sensor data, or system processing issues and notify data management personnel within a timeframe that

minimizes downtime or gaps in data. Additional automated and operator- supervised QC is carried out on when sensors with onboard storage are recovered post deployment.

Automated QC checks for the in-situ current measurements (Nortek ADCPs) are limited and are targeted for improvement. UMaine is working to implement In-Situ Current QARTOD guidelines (released in October 2015) to the extent possible using current telemetry and instrument configuration by the late 3rd quarter or 4th quarter calendar 2017.

Status of required QC tests for the data variables listed in the QARTOD manuals are listed in Table 1. Data that fail a test are flagged with a non-zero QC flag.

UMaine data management personnel certify that as of October 2016, QC is being applied at a level equal to or greater than QARTOD standards, given that:

a) Most of the required QARTOD checks are already in place. (Please see Table 1)

b) Daily operator-supervised manual review of data supplements the QARTOD checks in place as described above.

c) A number of in-house automated QC checks for data other than those described in QARTOD standards have been developed over time and are currently in use. Examples include comparison of barometric pressure standard deviation with wind speed, comparison of data from redundant sensors, examination of minimum wind speeds and wind sample counts, and gradient checks for air temperature and barometric pressure.

We have the following plan for more complete implementation of QARTOD standards by the late 3rd quarter or 4th quarter calendar 2017.

a) Enhance real-time QC of Nortek ADCP data by implementing Sensor Tilt QC test, and other tests based on orientation data, Error byte, and Status byte;

b) Implement a gridded model-based comparison check for Wind, Air Temperature, Barometric Pressure, based on NOAA RTMA or Rapid Refresh short term forecasts for Puerto Rico;

c) Implement climatology tests for QARTOD (and other) variables based historical observations we have on hand and a “storm recognition” algorithm to recognize extreme events;

d) Implementation of a “1-based” set of QC flags for buoy data. This will be

implemented in parallel with and in addition to the existing zero-based QC flagging field in the existing NetCDF files;

In-situ temperature and Salinity		**Temperature**	**Salinity**	**Conductivity**
Test 1	Timing/Gap test	*yes*	*yes*	*yes*
Test 2	Syntax Test	*yes*	*yes*	*yes*
Test 3	Location Test	*yes*	*yes*	*yes*
Test 4	Gross Range	*yes*	*yes*	*yes*
Test 5	Climatology Test	*no*	*no*	*no*
Test 7	Rate of change test	*yes*	*yes*	*no*

Wind Data		**Wind Speed**	**Wind Direction**	**Wind Gust**
Test 1	Timing/Gap test	*yes*	*yes*	*yes*
Test 2	Syntax Test	*yes*	*yes*	*yes*
Test 3	Location Test	*yes*	*yes*	*yes*
Test 4	Gross Range	*yes*	*yes*	*yes*
Test 5	Climatology Test	*no*	*no*	*no*

In-situ Surface	**Wave Data**	**Significant Wave Height**	**Dominant Wave Period**	**Avg Wave Direction**
Test 16	Stuck Sensor	*no*	*no*	*no*
Test 17	Operational Frequency	*no*	*no*	*yes*
Test 18	LF Energy	*no*	*no*	*no*
Test 19	Bulk Wave Params	*yes*	*yes*	*yes*
Test 20	Rate of Change	*no*	*no*	*no*

In-situ Current Observations		**Current Speed**	**Current Direction**	**Current u**	**Current v**
Test 2	Check Sum	*no*	*no*	*no*	*no*
Test 3	Sensor Tilt	*no*	*no*	*no*	*no*
Test 4	Speed of Sound	*no*	*no*	*no*	*no*
Test 6	Signal Strength	*no*	*no*	*no*	*no*
Test 10	Current Speed	*yes*	*yes*	*yes*	*yes*
Test 11	Current Direction	*yes*	*yes*	*yes*	*yes*
Test 12	Horizontal Velocity	*no*	*no*	*no*	*no*
Test 15	Stuck Sensor	*no*	*no*	*no*	*no*
Test 16	Echo Intensity	*no*	*no*	*no*	*no*

Table 1. UMaine QC tests for buoy data as of November 2016. Applicable QARTOD tests and NetCDF flags will be added in parallel starting by the late 3rd quarter or 4th quarter calendar 2017.

e) Update QA plan and QC process documentation.

Data Sharing

CARICOOS provides buoy data to clients:

a. CARICOOS THREDDS/OPeNDAP/ERDDAPservers (THREDDS: http://dm1.caricoos.org/thredds/ , http://dm2.caricoos.org/thredds/; ERDDAP: http://dm3.caricoos.org/:8002/erddap/) provide whole NetCDF files and subset queries. Cron jobs in the THREDDS server are scheduled to download the Historical and Realtime NetCDF data files from UMaine, run ncSOS compliance scripts and aggregate the buoy data.

b. CARICOOS Data Download web page https://www.caricoos.org/data-download feeds from NDBC and UMaine csv data files.

c. A dedicated CARICOOS web page for each buoy (for visualization) may be accessed through https://www.caricoos.org/#!?detail=SelectBuoys.

CARICOOS provides buoy products to clients:

a. The map at https://www.caricoos.org the main entryway to the CARICOOS web portal, feeds from the 10-day data through an intermediate MySQL database.

b. A dedicated CARICOOS web page for each buoy may be accessed https://www.caricoos.org/#!?detail=SelectBuoys station metadata, most recent data, time series plots and data download links are available from these pages.

2. Mesonet Weather Stations / Meteorological

WeatherFlow owns and operates 13 Coastal Mesonet weather stations for CARICOOS. The standard measurements for these stations include surface winds (R.M. Young wind sensor), air temperature, and barometric pressure. Under contract to CARICOOS, Weatherflow installs, maintains and collects the data from the Mesonet network of meteorological stations.

Data Flow

The data processing system for data generated by the WeatherFlow weather stations for CARICOOS consists of both field components and shoreside components. Programmable dataloggers, built by WeatherFlow, are mounted on various locations.

The dataloggers timestamp data received from sensors, aggregate it, and transmit it to WeatherFlow via GPRS radio signal. A brief description of the data flow can be found here: WF Data and Coms

The system comprises a UNIX-based application server and a UNIX-based web server, and is driven by a number of unix shell scripts, python scripts, and MATLAB scripts. Data are stored and archived in NetCDF format, following CF metadata and COARDS NetCDF conventions in effect when the system was built. Additional metadata for NetCDF files and directory structure are accessed via MySQL databases.

Data are transferred to CARICOOS with QA/QC; Weatherflow retains ownership of the hardware.

a. The last 24 hours of data from each station are provided in text format at https://datascope.weatherflow.com/externalDataView.cfm?special=UPR2. Wind direction, atmospheric pressure, air temperature and mean, lull and gust speeds are included.

b. These 24-hour data are ingested to web server for data visualization and from here to the caricooos.org map (https://www.caricoos.org) and products. They are also used to create the NetCDF real-time files for the THREDDS/OPeNDAP servers. CARICOOS operates duplicate THREDDS servers for Mesonet data at: Amazon Web Services (AWS) and UPR-Mayaguez facilities (http://dm1.caricoos.org/thredds/catalog/content/Mesonet/catalog.html) and redundancy at (AWS) (http://dm2.caricoos.org/thredds/catalog/content/Mesonet/catalog.html); note these servers are located at different geographical locations. ERDDAP server for Mesonet data at Amazon Web Services (http://dm3.caricoos.org:8002/erddap)

c. Once a month data from the previous month is manually downloaded from Weatherflow's DataScope server. Monthly NetCDF are then created and added to the THREDDS/OPeNDAP servers, ERDDAP, and the real-time files are reset.

d. Data are submitted to the GTS system by CARICOOS.

e. Some old historical csv data files are available through Data Download but the main distribution source is our THREDDS/OPeNDAP server.

f. Mesonet data are not ingested by NDBC and are not archived at NCEI

due to restrictions in the contractual agreement between WeatherFlow and CARICOOS.

Quality Control

WeatherFlow currently conducts a set of QC checks on all of its operational data (wind speed and direction, air temperature, and air pressure). The full scope of the details of this collection of tests is proprietary, but all include a Timing/Gap check, a Syntax check, a Location test, and a Gross Range test. WeatherFlow QC procedures are equivalent to or greater than the minimum standards identified by QARTOD.

Data Sharing:

CARICOOS provides Mesonet data and products to its clients through its publicly accessible OPeNDAP/THREDDS data servers.

3. WindNet and Wind Stations / Meteorological

Dr. Patricia Chardón-Maldonado of CARICOOS operates and maintains one WindNet and four Davis land-based coastal weather stations for CARICOOS. The standard measurements for these stations include wind speed, wind direction, barometric pressure, and air temperature. The NDBC station code (PTRP4 for Puntas, Rincon) and the Gladstone Family station codes (F2397 for Magueyes, E7791 for Ponce, E7866 for Cabo Rojo and E9889 for Tres Palmas, Rincon), are used through the data flow / data processing pipeline.

Data Flow

WindNet data flow proceeds as follows:

a. CARICOOS acquires the station data via internet through mobile cellular service or through direct internet connection depending on a station's location. The WindNet station are equipped with Sutron Xlite 9210B data loggers.

b. Near-realtime data are disseminated from a CARICOOS server to NDBC via ftp following NDBC's data messaging protocols.

c. NDBC sends the data to GTS, performs QA/QC and makes these data available through near-realtime and historical csv data files, and also in NetCDF format through its THREDDS/OPeNDAP server.

d. CARICOOS pulls the NDBC near-realtime csv data and generates NetCDF

files that are distributed through our THREDDS servers. Cron jobs are scheduled in our DMAC servers to download the NDBC csv files, generate aggregated NetCDF files with augmented metadata and upload these aggregated data files to the CARICOOS THREDDS/OPeNDAP servers. The data are made available through our duplicate servers.

e. Our web products use the NDBC csv data.

Davis data flow proceeds as follows:

a. CARICOOS acquires the station data via internet through mobile cellular service or through direct internet connection depending on a station's location. All Davis stations are equipped with DAVIS VantagePro 2 data loggers.

b. Near-real time data are disseminated from Gladstone Family server to CARICOOS via URL.

c. Gladstone Family services perform QA/QC and makes these data available through near-realtime and historical csv data files. CARICOOS generates the NetCDF and disseminates it through its THREDDS/OPeNDAP server.

d. CARICOOS pulls the near-real-time csv data and generates NetCDF files that are distributed through our THREDDS servers. Cron jobs are scheduled in our DMAC servers to download the csv files, generate aggregated NetCDF files with augmented metadata and upload these aggregated data files to the CARICOOS THREDDS/OPeNDAP servers. The data are made available through our duplicate servers.

Quality Control

CARICOOS staff procedures and practices comply with Appendix A of the QARTOD manual in the commission of the current station. The WindNet stations is equipped with Sutron Xlite 9210B data logger and the Davis weather stations are equipped with VantagePro2 data loogers. The data logger performs an internal QC check to flag the average data. The quality can be G=GOOD, B=BAD or U=UNDEFINED. A quality status of UNDEFINED means that the system has not yet tried to measure the sensor. Data with B or U are removed; the other data are disseminated to NDBC.

Gladstone Family servers perform full QA/QC on the data provided by the Davis while NDBC performs full QA/QC on the data provided by WindNet.

Data Sharing NDBC web links:

- https://www.ndbc.noaa.gov/station_page.php?station=ptrp4
- https://www.ndbc.noaa.gov/station_page.php?station=imgp4
- https://dods.ndbc.noaa.gov/thredds/dodsC/data/stdmet/imgp4/imgp4h2017.nc.html
- https://dods.ndbc.noaa.gov/thredds/dodsC/data/stdmet/ptrp4/ptrp4h2017.nc.html

CARICOOS THREDDS server links:

- http://dm1.caricoos.org/thredds/catalog/content/WindNet/catalog.html?dataset=wi ndnet/ptrp4_realtime_ndbc_qc.nc
- http://dm1.caricoos.org/thredds/catalog/content/WindNet/catalog.html?dataset=windnet/f2397_img_realtime.nc
- http://dm1.caricoos.org/thredds/catalog/content/WindNet/catalog.html?dataset=windnet/e9889_tpr_realtime.nc
- http://dm1.caricoos.org/thredds/catalog/content/WindNet/catalog.html?dataset=windnet/e7866_fcr_realtime.nc
- http://dm1.caricoos.org/thredds/catalog/content/WindNet/catalog.html?dataset=windnet/e7791_pyc_realtime.nc

4. Rincon and Arecibo Datawell WaveRider Buoy / Surface Wave

The Datawell WaveRider buoys (2 operational, 1 spare) are owned and maintained by CARICOOS. The Coastal Data Information Program (CDIP) provides data management services. The parameters measured include wave height, wave direction, wave period, and water temperature.

Data Flow

a. The Waverider buoy transmits directly to CDIP via the Iridium satellite constellation

b. CDIP sends the data to NDBC, both CDIP and NDBC QC the data stream

c. CARICOOS web products and data download options use the 45-day csv data from NDBC

d. The CARICOOS THREDDS carries copies of the CDIP historical and real-time NetCDF data files.

Quality Control

CDIP handles the acquisition and dissemination of the WaveRider buoy data from UC San Diego- SCRIPPS. CDIP performs QA/QC and archival procedures on all data collected by the Rincon Waverider Buoy.

Data Sharing

The CARICOOS THREDDS servers provide copies of the CDIP NetCDF data files to all stakeholders at:

http://dm1.caricoos.org/thredds/catalog/content/Rincon_Waverider/catalog.html

http://dm2.caricoos.org/thredds/catalog/content/Rincon_Waverider/catalog.html

http://dm3.caricoos.org/thredds/catalog/content/Rincon_Waverider/catalog.html

Arecibo buoy data will be publicly available in the following months.

5. High Frequency Radar (HFR) / Surface Water Velocity

HFR technology provides real-time surface current velocities. There are 5 HFR antennas in the CARICOOS region (Ponce, North Cabo Rojo, South Cabo Rojo, Ponce, Maunabo and Añasco), owned and operated by CARICOOS. CARICOOS currently provides coverage for the west coast, southwestern coast, and much of the southern coast (including the ports of Ponce and Guayanilla) of Puerto Rico.

Data Flow, Quality Control

a. Data from the 5 HFR antennas are treated the same. The antenna raw data are sent via internet to the CARICOOS Amazon Web Service interfaces. Rutgers and the IOOS HF Radar DAC pull the raw data from Amazon Web Services and process, QA/QC, archive and distribute them.

b. The HFR DAC consists of developmental servers at Scripps which also serve as the primary operational server. Backup operational servers are located at NDBC, and at Rutgers for fail-over security.

c. CARICOOS has full data archives and processes new data at hourly intervals (for internal use only at the moment).

Data Sharing

a. Once the HFR radial data are quality controlled, total vectors are calculated and displayed on the National HFR Network, hosted by Scripps, CORDC: (http://cordc.ucsd.edu/projects/mapping/maps/)

b. Data are made available via the CORDC THREDDS Server (https://hfrnet.ucsd.edu/thredds/catalog.html) and the NDBC OpeNDAP/THREDDS Server (https://dods.ndbc.noaa.gov/thredds/catalog.html)

c. Links to Scripps (CORDC) graphical web products for the Caribbean are provided in the CARICOOS web page (see https://www.caricoos.org/hf-radar).

d. Scripps (CORDC) total vectors are also re-plotted and animated locally. The vector movies for our region are found ats https://www.caricoos.org/currents/observation/hfradar/regional/6km

6. MAPCO2 Buoy / Atmospheric and Water Chemistry

NOAA, Pacific Marine Environmental Laboratory (PMEL) provides operations and data management for the MAPCO2 buoys in the CARICOOS region. The MAPCO2 buoys measures atmospheric CO2 concentration, water CO2 concentration, water pH, salinity, and sea surface temperature.

a. Collaboration with NOAA, Pacific Marine Environmental Labs (PMEL)

b. Data available from NOAA Ocean Acidification Data Stewardship (OADS) (https://www.ncei.noaa.gov/access/ocean-carbon-data-system/oceans/Moorings/La_Parguera.html) and from PMEL https://www.pmel.noaa.gov/co2/)

c. CARICOOS downloads PMEL data and constructs trend plots that are displayed in http://www.caricoos.org/oceans/acidification/seawater.

d. PMEL performs all QA/QC on data from the MAPCO2 Buoy. Details of general instrument QA/QC process for each deployment are found at: https://www.ncei.noaa.gov/access/ocean-carbon-data-system/oceans/Moorings/La_Parguera.html.

e. Preliminary data are transmitted to PMEL daily by the iridium satellite data transmission system. Junk data are flagged and removed by PMEL.

An internal QC process for atmospheric CO2 concentration, water CO2 concentration, and water pH is conducted by CARICOOS. This process consists in a MATLAB subroutine that updates daily and identifies values outside of ±3 standard deviations of the mean to subsequently post it at CARICOOS website at https://www.caricoos.org/oceans/acidification/seawater.

f. PMEL preliminary data are submitted to NOAA OADS for final QA/QC process and archival. This process follows the NOAA OADS standard QA/QC process (more details at https://www.ncei.noaa.gov/access/ocean-carbon-data-system/oceans/DOE_94.pdf)

Metadata are provided by:

- Sutton, Adrienne J.; Sabine, Christopher L.; Morell, Julio M.; Musielewicz, Sylvia; Maenner Jones, Stacy; Dietrich, Colin; Bott, Randy; Osborne, John (2014). High-resolution ocean and atmosphere pCO2 time-series measurements from mooring La_Parguera_67W_18N in the Caribbean Sea. https://doi.org/10.3334/cdiac/otg.tsm_la_parguera_67w_18n

7. Gliders / Conductivity-Temperature-Depth Profiles

CARICOOS owns and operates one underwater glider, as well assist NOAA, Atlantic Oceanographic & Meteorological Laboratory (AOML), who owns and provides operations and data management for several gliders in the CARICOOS region (four as of November 2021). CARICOOS also provides field support to the gliders in the form of ship time for deployments and retrievals plus local students and crews in collaboration with AOML. The gliders measure vertical profiles of temperature and salinity.

a. Gilder data are received by AOML and forwarded to the Glider DAC who performs the appropriate data management and QC procedures.

b. "Glider DAC: In 2013 the U.S. IOOS Program Office established a prototype national glider DAC, developed by MARACOOS, as a central access point for this rapidly emerging technology. The glider DAC's initial rapid deployment was possible because IOOS has focused on data standards, the large number of glider missions flown by IOOS and academic partners, and leveraging of other platforms data standards, e.g. ARGO (https://gliders.ioos.us)". From http://www.iooc.us/ioos-dmac-frequently-asked-questions.

c. Data and products are available through AOML. CARICOOS serves glider

data via the AOML link found in our glider web pages (see below): https://www.aoml.noaa.gov/phod/goos/gliders/observations.php.

d. CARICOOS serves value-added glider products generated in-house in its webpage https://www.caricoos.org/gliders.

8. Drifters

The NOAA, Atlantic Oceanographic & Meteorological Laboratory (AOML) owns and provides operations and data management for the Global Drifter Program surface drifters in the CARICOOS region. The drifters measure horizontal trajectories.

a. CARICOOS provides field support to our disposable drifters in the form of ship time for deployments plus local students and crews in collaboration with AOML.

b. Data and products are available through AOML. CARICOOS serves GDP drifter data through its Data Download webpage via the AOML link: https://www.aoml.noaa.gov/phod/dac/gdp_doc.php.

c. AOML provides all QA/QC for CARICOOS drifters: https://www.aoml.noaa.gov/phod/dac/Training_CD.pdf.

9. Citizen Science Data / Beach Water Quality

Surfrider Water Quality Data.

Water quality tests for beach water Enterococcus and bacteria concentrations in Puerto Rico and the US Virgin Islands are performed by the Surfrider Foundation-Rincon, by the Puerto Rico Environmental Quality Board, and by the CARICOOS team following EPA-approved Enterolert® QA protocols. The results show the Most Probable Number (MPN) of colony-forming units (CFU) of Enterococcus in 100ml of seawater. These data are at least two days old by the time they reach CARICOOS. The equipment and protocols used by Surfrider are included in the Standard Operating Procedures document.

Data Flow

CARICOOS grabs the data directly from the Surfrider Blue Water Task Force site and from the Environmental Quality Board via API. Enterococcus data and time series plots are made available through CARICOOS.

Quality Control

No quality control procedures are performed on these data so user discretion is advised. CARICOOS provides a disclaimer on these data.

Data Sharing

The geographical distribution of sampled beaches is displayed in the CARICOOS webpage https://www.caricoos.org/map/beach-water-quality. Through the interactive map a user may quickly scan the levels of enterococcus contamination in the region and also access the most recent concentration values as well as past time series at each sampled location.

III. Data Servers, Services and Flow / Common to Many Data Streams

The backbone of the CARICOOS data system is the data service. On the back-end of this system is an OPeNDAP-based architecture. In this section, the data transport and discovery tools are described.

The data system can be envisioned as a tiered system, with data at one end and client tools, including web page displays, at the other. Connecting these two are databases and file systems, data servers, and data services. Figure 1 shows this schematically.

CARICOOS maintains duplicate/redundant THREDDS/OPeNDAP servers: 1) dm1.caricoos.org is hosted instance server at Amazon Web Services (AWS, in the Cloud) and 2) dm2.caricoos.org is hosted at the UPR–Mayaguez campus server data center. These two server facilities are geographically separated by over a thousand miles and constitute a duplicate/redundant pair in terms of their data holdings (but may differ in terms of model output). Users may access either server for their data needs.

The THREDDS server hardware at UPR consists of generic rack-mounted, multi-processor, multi- core linux systems with ample storage space on which the appropriate Java-Apache-THREDDS-OPenDAP software scaffold is installed. Software versions and upgrades are recommended by IOOS and Unidata while several github locales and the ioos_tech usergroup provide a certain degree of technical support. AWS provides virtual server instances tailored to our hardware and operating system specifications; server OS configuration and software installation are performed by CARICOOS.

All data accessible via the THREDDS servers resides within local storage in each server. Scripts running at periodic intervals in the servers (aka cron jobs) manage the acquisition of observational data from the various server providers and modeling output from either local high performance computing servers or from community-

model output repositories. The data fetching process has been tuned to balance optimal data latency versus network access limitations.

On-site storage is distributed among our various servers and dedicated NAS. Most of the storage space is dedicated to model output. AWS S3 storage buckets provide additional storage space in the Cloud and are used for a variety of purposes.

All data served by CARICOOS moves through to the CARICOOS THREDDS server and may or may not be available through all the data services (WMS/WCS, ncSOS, OPenDAP, HTTP. Not all data are suited for each of the four data services CARICOOS provides. From there, the data are made available to viewers and clients through the following platforms:

- Web Portal
    - The CARICOOS web portal, https://www.caricoos.org, serves as the main window for viewing and accessing all data served.
- CARICOOS Explorer
    - The CARICOOS Explorer is a user-friendly graphical interface that combines model output with observations and forecasts. It allows the user to explore various data levels at a time. http://assets.maracoos.org/?config=cari
- ERDDAP
    - ERRDAP is an interface for the graphical output of model data in 2D and 3D. ERRDAP runs on the OPeNDAP servers.
- Data Download
    - User-friendly method for users to download entire datasets. Datasets are provided in ASCII format for ease of use. https://www.caricoos.org/data-download

CARICOOS operates one OPeNDAP/THREDDS, one ERDDAP, the scripts server and several computational servers to the Cloud in the third quarter of FY 2016-2017. Our web page database, the scripts server and the OPeNDAP/THREDDS server are operational as Amazon Web Services (AWS) EC2 containers while the ftp server was reconfigured as AWS S3 buckets.

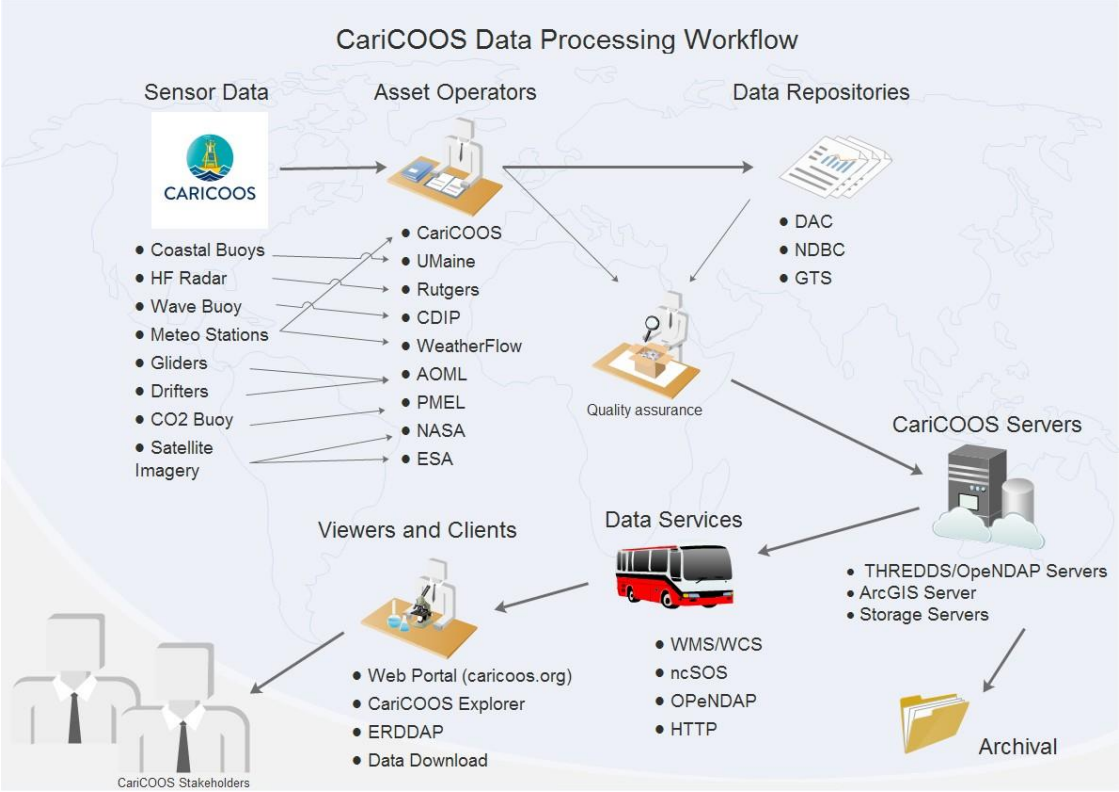

Figure 1: General schematic of CARICOOS data flow.

IV. General Comments on Data Quality Assurance and Control, and Data Archiving

With the exception of a couple of assets, all of the data served through CARICOOS are provided by external sources, including subcontracted organizations, partners, and Federal data servers.

CARICOOS serves observational Near Real-Time Data which we define as being transferred from a sensor package to the respective asset providers at the same frequency the data are collected, with minimal latency for any given observation, where latency is being defined as the time interval between the moment an observation is taken and the moment when it becomes available to our stakeholders. The asset provider performs QA/QC on these data and they become available for download into the CARICOOS data servers. Our goal is to minimize latency times to the full extent as possible.

CARICOOS manages Citizen Science data from Surfrider. These water quality data are collected by members of the general public who are not trained scientists. These data are collected by volunteers and have limited quality control.

1. Quality Assurance

CARICOOS relies on subcontracted partners and established partner programs (i.e. CDIP) to provide the best possible QA/QC on instruments. Each asset provider operates and maintains their equipment in compliance with manufacturer guidelines (see CARICOOS Equipment Standard Operating Procedures and Inventory document).

CARICOOS serves near real-time data provided by federal agencies, IOOS Data Assembly Centers (e.g. CDIP, HFR, gliders), and external groups (WeatherFlow, UMaine). These entities perform their own QA/QC according to best practices and standards. CARICOOS does not serve near real-time data from external partners who do not perform QA/QC.

2. Quality Control

CARICOOS does not apply near real-time quality control procedures to the data it distributes, but all data made available by CARICOOS are quality controlled by the data originators.

All of the near real-time data received and served by CARICOOS are quality controlled. The quality control methods vary with each provider. However, each provider is contractually required to implement QARTOD procedures (if applicable) or provide QA/QC at a level equal to or greater than QARTOD standards.

All data available through CARICOOS are either provided by:

Federal Agencies:

- MAPCO2 buoys
- Drifters
- Data from the WindNet stations, operated by CARICOOS, are ingested and served through NDBC, and run through the NDBC QC procedures.
- NWS Doppler Radar
- NASA Ocean Color
- NOAA-NOS tide gauge

CARICOOS, via a functioning National Data Assembly Center (DAC) who performs QA/QC:

- HFR
- Wave Buoy
- Gliders

By a partner with documented QA/QC procedures:

- UMaine buoys
- Weatherflow meteo stations
- Windnet stations (NDBC & Gladstone meteo stations)

3. Data Archiving

The CARICOOS Data Archiving Plan is included in a separate document.

CARICOOS Data Archival Procedures

CARICOOS is working with the National Centers for Environmental Information (NCEI) in Silver Spring towards the long-term archival of applicable CARICOOS data holdings. The NCEI IOOS representative is advising us on the recently implemented, applicable, data submission procedures. Documentation of the archival process for our coastal data buoy network has been established in the Advanced Tracking and Resource tool for Archive Collections (ATRAC) system, project ID 8774. Attached is the Request to Archive documentation in its current state as of 2017-02-21 (Request2Archive_2017-02-17T18-29-04.pdf). CARICOOS has started the development archival procedures with NCEI for the WindNet data.

CARICOOS serves five data sets that already have an archive mechanism in place. These include: 1) wave data that are processed via CDIP, 2) glider data that are processed by the Glider DAC, 3) HFR data that are processed by the HFR DAC, 4) drifter data that are processed by AOML (the functional drifter DAC) and 5) meteo station data that are processed by WeatherFlow. Model output and data-derived products are not included in the archival process.

The Mesonet meteorological stations (currently numbering 13 as of September 2017) are owned and operated by WeatherFlow under contract to CARICOOS. Data from the station network are not submitted to NDBC and are not archived at NCEI under the current contractual agreement with CARICOOS. WeatherFlow data are collected at the station, stored in the station's data logger, and transmitted to the WeatherFlow central database (typically every five minutes). In the event the data cannot be transmitted (due to a loss of cell, Internet, or phone connectivity, etc.) the data are stored locally until transmitted, at which point all data collected since the last successful transmission is uploaded so no data is lost.

Observation data are retained permanently in the WeatherFlow database, and observation values are also pushed to Synoptic Data Corp., which also keeps a permanent archive.

Finally, all observations are pushed to the National Weather Service's (NWS) Meteorological Assimilation Data Ingest System (MADIS) by CARICOOS, where they are available for use within NOAA and NWS in near real time. These data are also stored and made freely available through two redundant CARICOOS THREDDS/OPeNDAP servers, one of which is located at an AWS instance and the other resides in a server bunker at the University of Puerto Rico at Mayaguez.

Thus, the data that CARICOOS will be submitting for long-term archival to NCEI are therefore limited to: 1) oceanographic and atmospheric data from our coastal buoy

network comprised of five UMaine buoys and 2) meteo station data that are processed by NDBC. The archive process is done via a Request to Archive procedure through NCEI's ATRAC system (https://www.ncdc.noaa.gov/atrac/index.html). CARICOOS has procured the fore mentioned ATRAC account for data archival purposes, and with Mr. Biddle's (IOOS Data Management Analyst) assistance this account has been configured accordingly.

UMaine in collaboration with NCEI is bringing the NetCDF buoy data files to full compliance with all applicable CF Conventions and Metadata standards (currently CF 1.6) and with NetCDF Attribute Conventions for Data Discovery (ACDD) through the use of IOOS and NCEI compliance checkers. UMaine's QC variables are also being updated through the addition of QARTOD flag conventions. In order to expedite the data archival process, it has been agreed upon that UMaine will directly submit data files from CARICOOS and NERACOOS to a secure data upload access point at UMaine for archival by NCEI. A secondary, or backup, secure data upload access point, enabled for cyclic redundancy checks of the files to be uploaded, has also been created in one of CARICOOS' data servers.

The site we have established (http://dm2.caricoos.org/BROWSE/files/) was tested by NCEI and declared as perfect for automation. NCEI was able to copy test files over and validate using the sha384 algorithm.

The Request to Archive documentation in CARICOOS's ATRAC account includes the following:

1. list of parameters/observations being collected.
2. processing steps/quality control including final format.
3. timing of data submissions and approximate sizes.
4. development of data documentation (metadata).
5. data disposition (path to archive center).
6. data affiliations, including both institutions and individual persons whose names will be associated with the data set in some way, *e.g.*, where did it come from, where does it go, etc.

These items are outlined in the following sections for the two datasets we will be submitting for long-term archival to NCEI.

A. Coastal data buoy network

CARICOOS currently supports two different coastal data buoy types: five UMaine oceanographic data buoys. Dr. Neal Pettigrew of the Physical Oceanography Group at the University of Maine Ocean Observing System (UMOOS) is responsible for operating the UMaine oceanographic data buoys. This program is funded by IOOS through the CARICOOS. The data from the buoy system is managed by UMOOS and distributed to NDBC.

1. **List of parameters**: (see Section II.1 in the DMS Plan)

2. **Processing steps**: (see Section II.1 in the DMS Plan).

3. **Timing of submission**: UMaine generates near-real time NetCDF files for each buoy's current deployment (referred to as Realtime) and aggregated NetCDF files for past deployments (referred to as Historical). For archival purposes we propose submitting the updated Historical data files after the latest buoy maintenance cycle; these files will contain all buoy data up to the end of the last full deployment. The Historical data files would be updated annually upon completion of the buoy maintenance cycle, usually in June-July but may vary.

4. **Data documentation**: Submitted NetCDF files contain metadata records of buoy location, instrumentation, points of contact, QC flags, etc.. Other documentation is provided on the CARICOOS web site (http://caricoos.org).

5. **Data disposition**: The NCEI approved secure data upload access points at UMaine (URL to be provided by UMaine) and at CARICOOS http://dm2.caricoos.org/BROWSE/files/, Cwhich are enabled for cyclic redundancy checks of the files to be uploaded by NCEI.

6. **Data affiliations**:

   - *Submitting institution*: CARICOOS
   - *Data point of contact*: Dr. Patricia Chardón-Maldonado (patricia.chardon@upr.edu)
   - *Instrument technical point of contact*: Dr. Neal Pettigrew (nealp@maine.edu)
   - *Data technical points of contact*: Mr. Bob Fleming (bfleming@umeoce.maine.edu) and Dr. Patricia Chardón-Maldonado (patricia.chardon@upr.edu)

7. **Schedule:** A conversation has been initiated with NCEI and UMaine and initial

transfer of the data collected can happen as early as the 3rd calendar quarter of 2017

B. WindNet network of meteorological observations

In addition to the WeatherFlow-operated Mesonet CARICOOS currently operates and maintains two land-based meteorological stations in its WindNet.

Dr. Patricia Chardón-Maldonado of CARICOOS is responsible for operating the meteorological stations. The data from both stations are acquired by CARICOOS and distributed to NDBC for near-real-time processing.

1. **List of parameters**: (see Section II.4 in the DMS Plan)

2. **Processing steps**: (see Section II.4 in the DMS Plan).

3. **Timing of submission**: Near-realtime NetCDF files for each station are generated at 15-minute intervals and are updated at the **Data disposition** URL accordingly. A single NetCDF containing all aggregated data will be submitted for each station; current file sizes are smaller than 3 Mb.l

4. **Data documentation**: Submitted NetCDF files contain metadata records of station/sensor location, instrumentation, points of contact, QC flags, etc.. Other documentation is provided on the CARICOOS web site (https://caricoos.org).

5. **Data disposition**: The NCEI approved a secure data upload access point at CARICOOS http://dm2.caricoos.org/BROWSE/files/, which is enabled for cyclic redundancy checks of the files to be uploaded by NCEI; i.e., a CARICOOS push / NCEI pull configuration.

6. **Data affiliations**:

   - *Submitting institution*: CARICOOS
   - *Data point of contact*: Mr. Jose Torres (jose.torres111@upr.edu)
   - *Instrument technical point of contact*: Dr. Patricia Chardon-Maldonado (patricia.chardon@upr.edu)
   - *Data technical points of contact*: Mr. Jose Torres(jose.torres111@upr.edu)

7. **Schedule:** A conversation has been initiated with NCEI and initial transfer of the data collected can happen as early as the 3rd calendar quarter of 2017.

CARICOOS Equipment: Standard Operating Procedures

CARICOOS instructs all subcontractors and employees to follow industry best practices and manufacture guidelines where applicable, and to be prepared to provide documentation upon request.

Below are descriptions of the standard operating procedures for calibrating, validating, operating, and maintaining equipment within CARICOOS. A description of the inventory, shipping, and maintenance log requirements are also included on p.7.

WIND

1) WeatherFlow Coastal Mesonet Stations

WeatherFlow owns and operates 13 Coastal Mesonet weather stations for CARICOOS. The standard measurements for these stations include surface winds (R.M. Young wind sensor), air temperature, and barometric pressure.

WeatherFlow Inc. calibrates, operates, and maintains the equipment in accordance with the manufacture's guidelines and/or industry standards, when available. The following specific sensors are included in the weather station:

Surface Winds:

R.M. Young aero-vane wind sensor, model number RMY 05133-58. WeatherFlow personnel use the operations and maintenance guidelines provided in the following manual:

https://about.caricoos.org/wp-content/uploads/2022/01/rm_young_05103.pdf

Air Temperature

Sensirion model SHT75 housed in a Stevenson radiation shield.

WeatherFlow personnel follow the operations and maintenance guidelines provided in the following manual:

https://about.caricoos.org/wp-content/uploads/2022/01/Sensirion_Humidity_SHT7x_Datasheet_V5.pdf

Barometric Pressure

Bosche barometric pressure transducer, model number BMP085/183. WeatherFlow personnel use the operations and maintenance guidelines provided in the following

manual:

https://about.caricoos.org/wp-content/uploads/2022/01/BOSCH_BMP085.pdf

2) WindNet Meteorological Stations

Dr. Patricia Chardon-Maldonado operates and maintains one WindNet and four Davis land-based coastal weather stations for CARICOOS. CARICOOS and the University of Puerto Rico at Mayaguez staff provide operations and maintenance as recommended in the following manuals:

RM Young Wind Monitor - Model 05103

https://about.caricoos.org/wp-content/uploads/2022/01/rm_young_05103.pdf

RM Young Temperature Probe - Model 41342VC

https://about.caricoos.org/wp-content/uploads/2022/01/rm41342V.pdf

RM Young Relative Humidity/Temperature Probe - Model 41382VC
https://about.caricoos.org/wp-content/uploads/2022/01/rm41382VC.pdf

RM Young Barometric Pressure Sensor - Model 61302V https://about.caricoos.org/wp-content/uploads/2022/01/rm_press_61302V-90.pdf

Davis Vantage Pro2

https://about.caricoos.org/wp-content/uploads/2022/01/Davis-Vantage-PRo2-USerManual.pdf

Davis Vantage Pro2 Console

https://about.caricoos.org/wp-content/uploads/2022/01/Davis-Console_Manual.pdf

Davis Anemometer – Model 6410

https://about.caricoos.org/wp-content/uploads/2022/01/Davis-Anemometer-User-manual.pdf

BUOYS

1) UMaine Meteorological and Oceanographic Data Buoys

The University of Maine operates and maintains 4 buoys for CARICOOS (PR1=Ponce; PR2=San Juan; PR3=Vieques; VI1=St. John, VI2=St. Thomas).

These buoys are serviced yearly and refurbished by its fabricators from the Physical Oceanography group of the U. of Maine led by Dr. Neal Pettigrew. The maintenance is scheduled to ensure it's timely completion before the hurricane season that officially begins June 1. UMaine and CARICOOS personnel service the following instruments annually following instrument manuals and guidelines:

Surface Winds:

The primary wind sensor on the CARICOOS buoys is the Gill Instruments UltraSonic wind sensor (WindSonic). The WindSonic is interfaced to the Campbell data logger for data collection and transmission. UMaine staff follows all operational guidelines as described in the Gill WindSonic manual:

https://about.caricoos.org/wp-content/uploads/2022/01/gill_windsonic-manual.pdf

There is also a backup R.M. Young wind sensor (Marine Wind Monitor model 05106) on each buoy. These are serviced yearly by UMaine personnel in accordance with the operational guidelines for laboratory checks described in the Wind Monitor manual and Wind System Calibration manual:

https://about.caricoos.org/wp-content/uploads/2022/01/rm05106-90%28J%29.pdf

https://about.caricoos.org/wp-content/uploads/2022/01/rm18860-90%28B%29.pdf

Air Temperature:

Each buoy has a Campbell Scientific air temperature sensor (model 107) housed in a Campbell radiation shield as specified by the manufacturer. All operational guidelines as described in the Campbell air temperature manual are followed by UMaine personnel as part of the yearly maintenance: https://about.caricoos.org/wp-content/uploads/2022/01/campbell107.pdf

Barometric Pressure:

A Setra 270 barometric pressure transducer is installed in a vented housing on each

buoy. These are serviced yearly by UMaine personnel in accordance with the operational guidelines described in the pressure transducer manual: https://about.caricoos.org/wp-content/uploads/2022/01/sertra270.pdf

Directional Waves:

The primary directional wave sensor used on the CARICOOS buoys is the AXYS Technology Triaxys directional wave sensor. UMaine personnel service the sensros annually in accordance with the operational guidelines described in the TRIAXYS OEM Directional Wave Sensor User Manual (not found online; copy of manual obtained when instrument was procured). Genera information about the TRIAXYS wave sensor can be found at:

https://about.caricoos.org/wp-content/uploads/2022/01/TRIAXYS-Sensor.pdf

Ocean Temperature/Salinity:

Each buoy has a Seabird SBE37SM mounted at a depth of 1 meter. The University of Puerto Rico sends all recovered SBE37SM back to the manufacturer (Seabird) for recalibration yearly. A freshly calibrated instrument is provided by UPR for each buoy as part of the yearly servicing. All operational guidelines described in the following manual are followed by UPR/UMaine personnel during the yearly servicing: https://about.caricoos.org/wp-content/uploads/2022/01/SBE_37SM_rs232_039.pdf

Ocean Currents:

Each buoy has a Nortek Aquadopp current profiler. All operational guidelines described in the Aquadopp Current Profiler User Guide are followed. If an instrument requires servicing, UPR returns the instrument to the manufacturer:

https://about.caricoos.org/wp-content/uploads/2022/01/aquadopp-profiler_Users-Guide_86pgs.pdf

2) Datawell Waverider Buoys

CARICOOS operates one Waverider Buoy at Rincon and Arecibo. CARICOOS follows the standard operating procedures outline in the National Wave Plan (p. 31) and in the Datawell manual: https://about.caricoos.org/wp-content/uploads/2022/01/datawell_waverider.pdf

HIGH FREQUENCY RADAR (HFR)

NOAA IOOS and the HFR Steering Team developed standard operating procedures for HFR. CARICOOS follows these guidelines: https://about.caricoos.org/wp-content/uploads/2022/01/HF_radar_best.pdf

Deployment & Maintenance of a High Frequency Radar for Ocean Surface Current Mapping: Best Practices, February 2008.

MAPCO2 BUOYS

The buoy maintenance and instrument calibration operations are completed annually. Instrument calibration process is offered by NOAA, Pacific Marine Environmental Laboratory and assisted by CARICOOS. The MAPCO2 buoys include the following equipment:

Infrared CO2 analyzer (LI-COR)

The analyzer is calibrated on a 3hr cycle using a reference CO2 gas mixture. The gas mixture is filled and calibrated at the World Meteorological Organization (WMO) central calibration laboratory at NOAA Earth Systems Research Laboratory in Boulder, Colorado. The description about how standard reference gases are filled is at: https://about.caricoos.org/wp-content/uploads/2022/01/preparation_std_air_mix.pdf

Averaged data and standard deviations for each measurement are transmitted to PMEL daily.

GPS module

GPS information is provided through iridium satellite data transmission system. Data and diagnostic information are transmitted directly to PMEL daily. The software user manual is provided by Battelle Memorial Institute at https://about.caricoos.org/wp-content/uploads/2022/01/pco2_firmware_manual.pdf

SBE16 Microcat

The SBE16 Microcat has temperature, salinity with fluorescence, turbidity and oxygen auxillary sensors. SeaBird provides calibrations and maintenance annually following these manuals:

SBE16 plus:

https://about.caricoos.org/wp-content/uploads/2022/01/sbe_16plusV2.pdf

Dissolved Oxygen optode:

https://about.caricoos.org/wp-content/uploads/2022/01/sbe_DO63_010.pdf

SAMI pH system:

The SAMI pH system is provided by Sunburst Sensors, LLC. The instrument is self-calibrated every cycle using an internal pH standard and operates following the manual:
https://about.caricoos.org/wp-content/uploads/2022/01/phsensor_SAMI.pdf

GLIDERS

CARICOOS owns and operates one underwater glider, as well assist NOAA, Atlantic Oceanographic & Meteorological Laboratory (AOML), who owns and provides operations and data management for several gliders in the CARICOOS region (four as of November 2021). CARICOOS also provides field support to the gliders in the form of ship time for deployments and retrievals plus local students and crews in collaboration with AOML. The gliders measure vertical profiles of temperature and salinity.

AOML and CARICOOS personnel use the following guidelines and manuals to perform calibration, maintenance, and operations: Maintenance Guide:
https://about.caricoos.org/wp-content/uploads/2022/01/Seaglider_Refurbishment_Maintenance_Guide.pdf

Calibration Procedures: https://about.caricoos.org/wp-content/uploads/2022/01/Seagliders_Calibration_Procedures.pdf

DRIFTERS

The NOAA, Atlantic Oceanographic & Meteorological Laboratory (AOML) owns and provides operations and data management for the Global Drifter Program surface drifters in the CARICOOS region. CARICOOS provides field support to the disposable drifters in the form of ship time for deployments, plus local students and crews in collaboration with AOML.

AOML uses the standard guide of David Griffin from NOAA's The Global Drifter Program for the deployment and design of CARICOOS drifters. Many of the documents can be found here: http://www.aoml.noaa.gov/phod/dac/gdp_doc.php

SURFRIDER WATER SAMPLING

Surfrider trains volunteers to use Enterolert for detecting enterococci, using this IDEXX manual: https://about.caricoos.org/wp-content/uploads/2022/01/Enterolert-Procedure-en.pdf

Surfrider trains volunteers to use IDEXX Quanti-Tray*/2000 to determine bacterial counts in 100mL water samples, using this manual: https://about.caricoos.org/wp-content/uploads/2022/01/Quanti-tray-2000-procedure-en.pdf

CARICOOS INVENTORY AND EQUIPMENT LOGS

CARICOOS requires all subcontractors to keep logs, inventory, and maintenance records. Any maintenance details, shipments, and problems observed with the instruments during the deployment, or the yearly servicing period are included in the reports from the subcontractor to CARICOOS. This structure applies to the following subcontractors and associated assets:

- University of Maine: Meteorological and Oceanographic Data Buoys
- WeatherFlow: Mesonet Weather Stations
- Arecibo Datawell WaveRider Buoy

For equipment owned and operated by CARICOOS, the Property Office of the UPR at Mayaguez Oficina de Propiedad UPRM maintains inventories, maintenance details, and shipping logs: https://www.uprm.edu/propiedad/

This structure applies to the following assets:

- WindNet Weather Stations
- Rincon Datawell WaveRider Buoy
- High Frequency Radar antennas

NOAA PMEL keeps a record of the equipment inventories, shipping logs, and instrument history logs for all equipment on the MAPCO2 buoy.

NOAA, Atlantic Oceanographic & Meteorological Laboratory (AOML) keeps a record of the equipment inventories, shipping logs, and instrument history logs for all gliders and drifters operating within CARICOOS.