Chesapeake Bay Maryland (CBM) **NERR Meteorological Metadata**
January 2022 –December 2022
Latest Update: August 10, 2023

I. Data Set and Research Descriptors

1) Principal investigator(s) and contact persons –

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2) Entry verification –

Data are uploaded from the CR1000 data logger to a personal computer with a Windows 7 or newer operating system. Files are exported from LoggerNet in a comma-delimited format and uploaded to the CDMO where they undergo automated primary QAQC and become part of the CDMO's online provisional database. During primary QAQC, data are flagged if they are missing or out of sensor range. The edited file is then returned to the reserve where it is opened in Microsoft Excel and processed using the CDMO's NERRQAQC Excel macro. The macro inserts station codes, creates metadata worksheets for flagged data and summary statistics, and graphs the data for review. It allows the user to apply QAQC flags and codes to the data, append files, and export the resulting data file to the CDMO for tertiary QAQC and assimilation into the CDMO's authoritative online database. For more information on QAQC flags and QAQC codes, see Sections 11 and 12. Processing, data verification, and data upload to the CDMO server was performed by Lauren Cunningham.

3) Research objectives –

The principal objectives are to record meteorological information for the Chesapeake Bay National Estuarine Research Reserve in Maryland in support of the National Estuarine Research Reserve's (NERR) System Wide Monitoring Program (SWMP). This information is available for the following: 1) to track and record atmospheric and meteorological conditions useful to help understand and explain additional data collected concurrently, 2) to create a database capable of detecting long-term changes in weather patterns, and 3) to record and identify the impact of storms, hurricanes, heavy rain and other episodic weather events capable of influencing other environmental conditions such as water quality (as monitored by the SWMP effort) and to collect ancillary data in support of other research efforts.

4) Research methods –

Campbell Scientific data telemetry equipment was installed at the Chesapeake Bay Maryland NERR Jug Bay station in August 2000 and transmits data to the NOAA GOES satellite, NESDIS ID #3B0071EA. The transmissions are scheduled hourly at 0:40:20 after the hour and contain four (4) data sets reflecting fifteen minute data sampling intervals. Upon receipt by the CDMO, the data undergoes the same automated primary QAQC process detailed in Section 2 above. The "real-time" telemetry data become part of the provisional dataset until undergoing secondary and tertiary QAQC and assimilation in the CDMO's authoritative online database. Provisional and authoritative data are available at http://cdmo.baruch.sc.edu.

The Campbell Scientific weather station samples every 5 seconds continuously throughout the year. Data are used by the CR1000 to produce 15 minutes averages, maximums, minimums, and totals. Data are manually downloaded on site, or is telemetered via cellular technology to a desktop PC at the MD DNR Annapolis Field Office. Typically, data are transferred or uploaded once monthly throughout the year. The reports, graphs and queries of meteorological data are reviewed and any errors or anomalous data are further investigated and the data are corrected, deleted (if necessary), or commented on and left unchanged. Data are collected in Eastern Standard Time (EST) for the entire year.

The 15-minute data are collected in the following formats for the CR1000:

- Averages from 5-second data:
  - Air Temperature (°C), Relative Humidity (%), Barometric Pressure (mb), Wind Speed (m/s), Wind Direction (degrees), Battery Voltage (volts)
- Maximum and Minimum Air Temperature (°C) and their times from 5-second data (these data are available from the reserve)
- Maximum Wind Speed (m/s) and time from 5-second data
- Wind Direction Standard Deviation (degrees)
- Totals:
  - Precipitation (mm), PAR (millimoles/m^2), and Cumulative Precipitation (mm) (Cumulative precipitation is no longer available via export from the CDMO. Please contact the reserve or the CDMO for more information or to obtain these data.)

Recommended calibration frequency for the MET station sensors:

- Temperature/Humidity- yearly recalibration
- Precipitation Gauge- yearly recalibration
- Wind Speed/Direction- every 2 years
- Barometric Pressure- every 2 years recalibration
- PAR- every 2 years recalibration
- CR1000-every 5 years

A minimum of monthly maintenance is conducted on the sensors, probes, and weather station in accordance with NERR guidelines. At this time, sensors on the weather station are inspected for damage, debris, and or/fouling and

cleaned as needed. Monthly maintenance log sheets are also completed, and sensors are checked with a handheld Kestrel 4000 or a local National Weather Station to ensure comparative readings. Additional checks are often done bi-weekly specifically to check the rain gauge for fouling. The rain gauge frequently tends to collect debris and is, therefore, checked as often as possible, with suggested checks prior to onset of storm events. Simultaneous rain data are also recorded by the Jug Bay Wetlands Sanctuary daily, providing supplemental rain data. Old sensors are sent back to Campbell Scientific for calibration and are rotated every year or two years to maintain current calibration requirements.

5) Site location and character –

The Chesapeake Bay National Estuarine Research Reserve in Maryland consists of three components; Otter Point Creek on the Bush River along the upper western shore of the Chesapeake Bay, Jug Bay along the Patuxent River in the middle Bay, and Monie Bay on the lower eastern shore of the Chesapeake Bay. The weather station is located at the Jug Bay Component of the Reserve, specifically at the Jug Bay Wetlands Sanctuary. The station is situated on the north end of the Jug Bay marsh, along a tidal creek that feeds the Patuxent River. The weather station is situated at 38° 46.846 N and 76° 42.492 W. The station is housed in a small bird blind situated at the end of a boardwalk in the Jug Bay marsh. The boardwalk extends about 50m from an elevated old railroad track out into the marsh. The CR1000 and BP sensor are in a weatherproof box situated on the inside of the building, while the other probes are fixed to the roof or side of the building so as not to be impacted by the structure. The probes are approximately 5m above mean water and are not shaded. The wind speed and direction sensor and PAR sensors are mounted directly to the roof of the blind. The temperature/relative humidity sensor is mounted directly below those sensors on the side of the building. The tipping rain gauge is mounted on the boardwalk railing, a few meters from the other sensors.

Sensor heights from the marsh surface (meters):
Temperature/humidity: 3.9
PAR: 5.2
Wind speed/direction: 5.4
Rain bucket: 3.9
BP: 3.4

Wind speed may be slightly altered at the site due to proximity of the historic railroad bridge that splits the marsh. The old railroad bridge is on an elevated berm that sits about 2-2.5m above mean water. The berm runs east to west and the boardwalk that houses the weather station runs perpendicular to the berm in the north/south direction. From 1995-2002, the weather station was also the site of a YSI datalogger that recorded water quality at the site. Due to problems with the shallow nature of the site, the water quality component was moved in 2003, approximately 500m westward, from the tidal creek to the mainstem of the Patuxent River.

SWMP Station Timeline

Station Code	SWMP Status	Station Name	Location	Active Dates	Reason Decommissioned	Notes
CBMJBMET	P	Jug Bay	38°46.846 N 76°42.492 W	07/01/2003 – present	NA	NA

6) Data collection period –
Meteorological data have been collected at the Chesapeake Bay Maryland NERR Jug Bay site since August 2000. The current weather station has been operational since this time. Weather data at the JUG Bay site for 2022 was collected from 01/01/2022 00:00:00 to 12/31/2022 23:45:00.

Start and end date and times of 2022 raw data files submitted to the CDMO:
CBMJBMET102221.csv : 10/22/2021 10:30:00 – 01/21/2022 09:15:00
CBMJBMET012122.csv : 01/21/2022 09:30:00 – 04/20/2022 09:00:00
CBMJBMET042022.csv : 04/20/2022 09:15:00 – 07/01/2022 06:45:00
CBMJBMET070122.csv : 07/01/2022 07:00:00 – 07/27/2022 07:15:00
CBMJBMET072722.csv : 07/27/2022 07:30:00 – 10/19/2022 07:15:00
CBMJBMET101922.csv : 10/19/2022 07:30:00 – 10/31/2022 09:45:00
CBMJBMET103122.csv : 10/31/2022 10:00:00 – 01/30/2023 09:00:00

7) Distribution –

NOAA retains the right to analyze, synthesize and publish summaries of the NERRS System-wide Monitoring Program data. The NERRS retains the right to be fully credited for having collected and processed the data. Following academic courtesy standards, the NERR site where the data were collected should be contacted and fully acknowledged in any subsequent publications in which any part of the data are used. The data set enclosed within this package/transmission is only as good as the quality assurance and quality control procedures outlined by the enclosed metadata reporting statement. The user bears all responsibility for its subsequent use/misuse in any further analyses or comparisons. The Federal government does not assume liability to the Recipient or third persons, nor will the Federal government reimburse or indemnify the Recipient for its liability due to any losses resulting in any way from the use of this data.

> Requested citation format:
> NOAA National Estuarine Research Reserve System (NERRS). System-wide Monitoring Program. Data accessed from the NOAA NERRS Centralized Data Management Office website: http://www.nerrsdata.org/; *accessed* 12 October 2022.

NERR meteorological data and metadata can be obtained from the Research Coordinator at the individual NERR site (please see Principal Investigators and Contact Persons), from the Data Manager at the Centralized Data Management Office (please see personnel directory under the general information link on the CDMO home page) and online at the CDMO home page www.nerrsdata.org. Data are available in comma delimited format.

8) Associated researchers and projects –

As part of the SWMP long-term monitoring program, CBM NERR also collects 15-minute water quality data and monthly grab and diel samples for nutrient/pigment data which may be correlated with this meteorological dataset. These data are available at www.nerrsdata.org.

Meteorological data are most commonly used in support of the SWMP and to help explain the relationships between water quality, nutrients, and meteorological conditions. Three of the five CBM SWMP water quality sites are located at the Jug Bay component of the Reserve and, therefore, the collection of meteorological data provides additional information helpful for analyzing and detecting trends in water quality and nutrient data that are collected by the Reserve.

Additional research and data that is available at the Jug Bay component of the Reserve is sediment erosion data and water quality data collected by Jug Bay Wetlands Sanctuary staff. Various sediment erosion tables (SET) are installed and monitored at the site annually to track changes in sedimentation levels. These can be obtained through the Research Coordinator.

II. Physical Structure Descriptors

9) Sensor specifications –

Parameter: Temperature
Units: Celsius
Sensor type: Platinum resistance temperature detector (PRT)
Model #: HMP45C Temperature and Relative Humidity Probe
Operating Temperature: -40°C to +60°C
Range: -40°C to +60°C
Accuracy: ± 0.2 °C @ 20°C

Serial Number: Z4020126
Date of Calibration: 03/05/2021
Dates of Sensor Use: 04/19/2021 – current as of 12/31/2022

Parameter: Relative Humidity
Units: Percent
Sensor type: Vaisala HUMICAP© 180 capacitive relative humidity sensor
Model #: HMP45C Temperature and Relative Humidity Probe
Range: 0-100% non-condensing
Accuracy at 20°C: +/- 2% RH (0-90%) and +/- 3% (90-100%)
Temperature dependence of RH measurement: +/- 0.05% RH/°C

Serial Number: Z4020126
Date of Calibration: 03/05/2021
Dates of Sensor Use: 04/19/2021 – current as of 12/31/2022

Parameter: Barometric Sensor
Units: millibars (mb)
Sensor type: Vaisala Barocap © silicon capacitive pressure sensor
Model #: CS-106
Operating Range: Pressure: 500 to 1100 mb; Temperature: -40°C to +60°C;
Humidity: non-condensing
Accuracy: ± 0.3 mb at +20°C, ± 0.6 mb at 0°C to 40°C, ± 1 mb at -20°C to +45°C, ± 1.5 mb at -40°C to +60°C
Stability: ± 0.1 mb per year

Serial Number: R0440840
Date of Calibration: 01/24/2019
Dates of Sensor Use: 10/18/2019 – 04/20/2022

Serial Number: U0250315
Date of Calibration: 01/17/2022
Dates of Sensor Use: 04/20/2022 – current as of 12/31/2022

Parameter: Wind speed
Units: meter per second (m/s)
Sensor type: 18 cm diameter 4-blade helicoids propeller molded of polypropylene
Model #: R.M. Young 05106 Wind Monitor
Range: 0 to 100m/s (224mph)
Accuracy: +/- 0.3 m/s

Serial Number: WM146506
Date of Calibration: 01/15/2021
Dates of Sensor Use: 01/25/2021 – current as of 12/31/2022

Parameter: Wind direction
Units: degrees
Sensor type: balanced vane, 38 cm turning radius
Model #: R.M. Young 05106 Wind Monitor

Serial Number: WM146506
Date of Calibration: 01/15/2021
Dates of Sensor Use: 01/25/2021 – current as of 12/31/2022

Parameter: Photosynthetically Active Radiation (PAR)
Units: mmoles m-2 (total flux)
Sensor type: anodized aluminum with cast acrylic diffuser
Model #SQ110 Apogee Quantum Sensor
Light spectrum waveband: 410 to 655 nm
Temperature dependence: 0.06+/-0.06% per °C
Stability: <±2% change over 1 yr
Operating Temperature: -40°C to 70°C; Humidity 0 to 100%
Cosine Response: 45° zenith angle: +/- 2%; 75° zenith angle: +/- 5%
Sensitivity: 0.2mV per µmol s-1 m-2
Multiplier: 0.025

Serial Number: SQ-110_22476
Date of Calibration: 09/27/2019
Dates of Sensor Use: 10/18/2019 – 01/21/2022

Serial Number: SQ-110_20223
Date of Calibration: 01/11/2022
Dates of Sensor Use: 01/21/2022 – current as of 12/31/2022

Parameter: Precipitation (specify if heated rain gauge)
Units: millimeters (mm)
Sensor type: Tipping Bucket Rain Gauge
Model #: TE525
Rainfall per tip: 0.01 inch
Operating range: Temperature: 0° to 50°C; Humidity: 0 to 100%
Accuracy: +/- 1.0% up to 1 in./hr; +0, -3% from 1 to 2 in./hr; +0, -5% from 2 to 3 in./hr

Serial Number: N/A
Date of Calibration: 09/06/2018
Dates of Sensor Use: 09/06/2018 – 01/25/2021
Date of Calibration: 01/25/2021
Dates of Sensor Use: 01/25/2021 – current as of 12/31/2022

CR1000:
The CR1000 has 2 MB of Flash EEPROM that is used to store the Operating System. Another 128 K Flash is used to store configuration settings. A minimum of 2 MB SRAM is (4 MB optional upgrade) available for program storage (16K), operating system use, and data storage. Additional storage is available by using a compact flash card in the optional CFM100 Compact Flash Module.

Date CR1000 Installed: 10/31/2006
Date CR1000 Calibrated: unknown

Serial Number: 5080
Date CR1000 Installed: 02/11/2015
Date CR1000 Calibrated: 02/06/2015
Dates CR1000 in use: 02/11/2015 – 04/01/2021
CR1000 Firmware Version (s): Std. 22 Installed 11/04/2007

Date CR1000 Calibrated: 04/07/2021
Dates CR1000 in use: 04/19/2021 – current as of 12/31/2022
CR1000 Firmware Version (s): OS v.32.05 Installed 04/07/2021

CR1000 Program Version(s): CBMJBMET_CR1000_6.0.4_102119.CR1

GOES Transmitter: Campbell Scientific, Inc. HDR GOES Transmitter
Model Number: TX312
Serial Number: 1180
Date Installed: unknown (possibly 2006)

10) Coded variable definitions -

Sampling station:	Sampling site code:	Station code:
Jug Bay	JB	cbmjbmet

11) QAQC flag definitions –

QAQC flags provide documentation of the data and are applied to individual data points by insertion into the parameter's associated flag column (header preceded by an F_). During primary automated QAQC (performed by the CDMO), -5, -4, and -2 flags are applied automatically to indicate data that is above or below sensor range, or missing. All remaining data are then flagged 0, as passing initial QAQC checks. During secondary and tertiary QAQC 1, -3, and 5 flags may be used to note data as suspect, rejected due to QAQC, or corrected.

-5 Outside High Sensor Range
-4 Outside Low Sensor Range
-3 Data Rejected due to QAQC
-2 Missing Data
-1 Optional SWMP supported Parameter
0 Passed Initial QAQC Checks
1 Suspect Data
2 *Open - reserved for later flag*
3 *Open - reserved for later flag*
4 Historical Data: Pre-Auto QAQC
5 Corrected Data

12) QAQC code definitions –

QAQC codes are used in conjunction with QAQC flags to provide further documentation of the data and are also applied by insertion into the associated flag column. There are three (3) different code categories, general, sensor, and comment. General errors document general problems with the CR1000, sensor errors are sensor specific, and

comment codes are used to further document conditions or a problem with the data. Only one general or sensor error and one comment code can be applied to a particular data point, but some comment codes (marked with an * below) can be applied to the entire record in the F_Record column.

General Errors

GIM	Instrument malfunction
GIT	Instrument recording error, recovered telemetry data
GMC	No instrument deployed due to maintenance/calibration
GMT	Instrument maintenance
GPD	Power down
GPF	Power failure / low battery
GPR	Program reload
GQR	Data rejected due to QA/QC checks
GSM	See metadata

Sensor Errors

SDG	Suspect due to sensor diagnostics
SIC	Incorrect calibration constant, multiplier or offset
SIW	Incorrect wiring
SMT	Sensor maintenance
SNV	Negative value
SOC	Out of calibration
SQR	Data rejected due to QAQC checks
SSD	Sensor drift
SSN	Not a number / unknown value
SSM	Sensor malfunction
SSR	Sensor removed

Comments

CAF	Acceptable calibration/accuracy error of sensor
CCU	Cause unknown
CDF	Data appear to fit conditions
CML	Snow melt from previous snowfall event
CRE*	Significant rain event
CSM*	See metadata
CVT*	Possible vandalism/tampering
CWE*	Significant weather event

13) Other remarks/notes –

Data are missing due to equipment or associated specific sensors not being deployed, equipment failure, time of maintenance or calibration of equipment, or repair/replacement of a sampling station platform. Any NANs in the dataset stand for "not a number" and are the result of low power, disconnected wires, or out of range readings. If additional information on missing data is needed, contact the Research Coordinator at the reserve submitting the data.

Small negative PAR values and slightly elevated nighttime PAR values measured with the Apogee PAR sensor are flagged and coded as suspect, <1> CSM.

Relative Humidity data greater than 100 are within range of the sensor accuracy of +/-3% and are flagged and coded as suspect, <1> (CAF). Values greater than 103 are rejected <-3>.

Data recorded for all parameters (with the exception of cumulative precipitation) at the midnight timestamp (00:00) are the 15 minute averages and totals for the 23:45-23:59 time period of the previous day. Cumulative precipitation data at the midnight timestamp (00:00) are the sum of raw (unrounded) precipitation data from 00:00 to 23:59 of the previous day. Summing each individual 15-minute total precipitation value from the same period will result in small differences from cumulative precipitation due to rounding. It is especially important to note how data at the midnight timestamp are recorded when using January 1st and December 31st data. **Note: Cumulative precipitation is no longer available via export from the CDMO. Please contact the reserve or the CDMO for more information or to obtain these data.**

Precipitation data collected with rain gauges that are not designed specifically for measuring frozen precipitation (snow/ice/hail), including heated gauges and those that use antifreeze to melt frozen precipitation, may not be measured accurately. Blowing wind, sublimation, and rate of snowfall/ice melt all affect the amount of recorded precipitation. The reserve has made attempts to accurately record dates and times when frozen precipitation and subsequent melting has occurred. Frozen precipitation events at CBM often include transitions between rain, freezing rain, and snow in any combination or order of those precipitation types. Due to the different locations of the weather station and the reserve offices, often times the precipitation type being measured and the timing of melt at the station is unknown. Known frozen precipitation events are documented in the metadata to the best of the reserves ability.

Total precipitation data for the following dates and times were corrected in the data. The associated cumulative precipitation data were also corrected but are not listed. Field personnel were cleaning the rain gauge at these times.

06/15/2022 08:15 0.762 mm corrected to 0 mm
07/12/2022 08:00 0.508 mm corrected to 0 mm
07/27/2022 07:45 0.254 mm corrected to 0 mm
08/23/2022 08:15 0.254 mm corrected to 0 mm
09/07/2022 10:00 0.254 mm corrected to 0 mm
09/22/2022 10:30 0.508 mm corrected to 0 mm
12/06/2022 09:00 1.27 mm corrected to 0 mm

Total precipitation values and the associated cumulative precipitation totals on 1/16/2022 and 1/17/2022 are from a weather event that began as snow and transitioned into rain/freezing rain and are flagged <1> (CSM). It is unknown when exactly the transition occurred and how much snow had accumulated.

The precipitation event that occurred on 3/12/2022 included both snow and rain throughout the day. All total precipitation values and the associated cumulative precipitation totals are flagged <1> (CSM).

Precipitation recorded on 09/12/2022 at 18:00 exceeded the 15-minute upper limit of the rain gauge. Those data and associated cumulative precipitation totals are considered suspect, <1> [GSM] (CSM).

Field personnel installed a newly calibrated PAR sensor on 1/21/2022. The old PAR sensor (serial # SQ-110_22476) was disconnected from the CR1000 at 09:34. The new PAR sensor (serial # SQ-110_20223) was wired to the CR1000 at 10:04. PAR values from 09:45 to 10:15 are rejected due to the removed sensor <-3> [SSR] (CSM). While removing the old PAR sensor and installing the new PAR sensor, the technician interfered with the wind sensor. All wind speed and direction values are rejected from 09:45 to 10:15. <-3> [GMT] (CSM).

The PAR sensor installed on 1/21/2022 was incorrectly wired to the CR1000 (the jumper wire was not installed in the correct two ports). This resulted in a failure of the sensor to correctly obtain PAR values. All PAR is rejected beginning on 1/21/2022 at 10:30 until 4/20/2022 at 09:15 <-3> [SIW] (CSM). Field personnel corrected the wiring on 4/20/2022 at 09:30.

The station was powered down on 4/20/2022 at 09:30 to correct the PAR wiring and install a newly calibrated BP sensor (serial #U0250315). All data is missing at 09:30 <-2> [GPD] (CSM). Power was returned to the station at

09:37. All data is rejected at 09:45 as it is not a full 15 minutes of data <-3> [GPD] (CSM). While the station was powered down, field personnel cleaned out the tipping buckets of the rain gauge, producing false tips. The total precipitation for the timestamp was not recorded due to the power down, however, the tips were shown in the cumulative precipitation. These values were corrected to zero (1.016mm corrected to 0mm) beginning at 09:45.

The wind sensor began outputting zero values for both speed and direction beginning on 6/18/2022 at 11:15. All zero values rejected <-3> [SSM] (CSM) until 7/1/2022 at 07:45 when field personnel connected to the CR1000 and the wind sensor began working again. The cause of this malfunction is unknown.

Field personnel replaced the wind sensor cable on 07/27/2022. Cable disconnected at 07:38. New cable connected at 08:02. All wind speed and direction values rejected from 07:45 to 08:15 <-3> [SMT] (CSM).

No data was recorded by the station to the CR1000 between 10/19/2022 at 07:30 and 10/31/2022 at 09:45. The cause is unknown. The malfunction began after a technician initiated a data download during a site visit on 10/19/2022 at 07:20. The station had been functioning properly up until the time stamp. Missing records were replaced with data retrieved from telemetry 10/19/2022 07:30 – 10/31/2022 09:45 and are marked as suspect, <1>[GIT](CSM), unless otherwise noted. Max wind speed times are not included in the retrieved telemetry file, although Max wind speed values are. Cumulative precipitation is not available in telemetry files and is flagged as <-2>[GIT](CSM).

The reserve began feeling the effects of Hurricane Ian on 9/30/2022 (downgraded to tropical storm by the time it reached the reserve) and experienced heavy rainfall for several days through 10/5/2022. Record comment code {CWE}{CSM} from 9/30/2022 00:00 to 10/6/2022 00:00