LUMCON Environmental Monitoring Station
Standard Operating Procedures and Quality Assurance Plan

Project Overview

Environmental Monitoring Stations operated by the Louisiana Universities Marine Consortium (LUMCON) provide continuous observations year round at key stations in salt marshes around southern Louisiana (Table 1). These monitoring efforts began in 2000 with the establishment of a monitoring station at the Marine Center located at LUMCON and have expanded since. LUMCON's active stations are approximately located within 5 to 30 miles of each other. There are 30.48 miles separating the Marine Center and the Port Fourchon station. The Marine Center and Terrebonne Bay have 5.66 miles between them. The Terrebonne Bay and Port Fourchon station have 26.14 miles separating them.

The overall objective of the monitoring stations is to record general meteorological and hydrographical conditions to establish a long term data set for researchers with projects in the area. However, since these data are publicly available in real time, these stations also serve as a public tool to monitor current and historic weather and water conditions.

Station Name	Lat/Long	Location Desc	Years Active	Site Motivation
Marine Center	29°15.200'N 90°39.800'W	LUMCON's West back dock	2000-Present	Provides observations of the hydrographic and meteorological conditions near the center.
Terrebonne Bay	29°11.200'N 90°36.560'W	Coast Guard range marker platform	2000-Present	Coast Guard allowed for the placement instrumentation on its platform
Wisner	29°06'50.0"N 90°11'03.5"N	LUMCON Port Fourchon camp dock	2018-Present	The Wisner Foundation awarded LUMCON a grant to build a station at Port Fourchon
Audubon	29°55.260'N 90°8.070'W	Floating dock behind Audubon Zoo on the Mississippi River	2003-2012	In support of a study of nutrient loading in the Mississippi River.
Southwest Pass	28°55.931'N 89°24.414'W	Pilot House; mouth of Mississippi River	2005-2007	To record environmental conditions near the mouth of the Mississippi River.
Lake Pontchartrain	30°18.894'N 90°16.831'W	Platform installed by LUMCON	2004-2012	Constructed in 2000 to study sediment re-suspension during storms.
Tambour Bay	29°11.242'N 90°39.925'W	Existing platform	2002-2011	Requested by Dr. Soniat (NSU,UNO) performing oyster research in the immediate area.

Table 1. Locations of Environmental Monitoring Locations.

Each monitoring station is equipped with its own power source to ensure that data is collected 24/7. Stations are designed to endure extreme weather events such as hurricanes. Logging of observations is

synchronized across stations. All stations are set to collect data every 15 minutes and all data logger clocks are synced with the same computer.

Site Determination

Station locations are based on a number of factors. The primary goal of these stations is to aid researchers conducting research in the area; the focus of research in an area heavily influences where stations are located. Stations must be at least 150 meters away from any structure that is the same height as the wind monitor. Additionally, in order to properly maintain and service these locations they must all be easily accessible; current stations require boats, cars, and short walks.

Funding also plays a key role in location selection. The cost of a new monitoring station can vary based on the scope of installation required and can depend on whether there is an existing structure in place. The price can range from $50,000-$60,000. With a limited amount of funding, LUMCON often partners, or receive permission to deploy instrumentation off of existing platforms or structures. At these locations an effort is made to place stations at sites that do not require authorization or an escort to ensure that stations can be serviced at short notice.

Data Collection and Storage

Each station contains the same suite of sensors and measure a variety of parameters (Table 2), including the following parameters: water height, water temperature, salinity, specific conductivity, dissolved oxygen (mg/L and %), chlorophyll, wind direction and speed, air temperature, humidity, barometric pressure, rainfall, and solar radiation. Note that dissolved oxygen percent is internally calculated from oxygen mg/L, water temperature, and salinity. At each station, hydrographic data are collected 18 inches above the sediment and meteorological data are collected 30 ft above ground level.

Sensors	Calibration Tools	Support Equipment
EXO2 Sonde	Probe Tool	Desiccant Canister
Dissolved Oxygen Probe	Conductivity Solution	Vented Cable
Salinity Probe	Bucket	Cell Modem
Chlorophyll Probe	Air Bubbler	Solar Panel
Wiper	Distilled Water	Solar Panel Regulator
WXT 520 or 530*	KOR EXO Software	12v Rechargeable Battery
Li 200 Li 190 Solar Radiation Sensors*		Boat
CR1000 Data Logger		

*Table 2. List of sensors, calibration tools, and support equipment. * Indicates Meteorological Sensors.*

Data are collected at each station every 15 minutes. Once an observation is made, the instrument sends that information to a CR100 data logger, connected by cables, where it is stored internally. From the data logger, data are sent to the weather station server located at LUMCON by cellular modem. From the LUMCON servers, data are displayed on the LUMCON Environmental Monitoring website via Loggernet software. Data are backed up from the servers to synology, a cloud based storage system used by LUMCON that can be accessed anywhere with a username and password. Synology ensures that if the

servers, computers, and any paper copies of the data were destroyed, a backup dataset would still exist. If there is an issue with communication between the data logger and cell modem, the data are directly downloaded from the data logger upon retrieval. The CR1000 data loggers have 4MB of storage to house data; this is enough storage to hold approximately 2 to 3 months worth of data.

Sensor Calibration, Deployment, and Maintenance

EXO2 sondes are calibrated in the laboratory by Amanda Fontenot using KorEXO software and EXO2 calibration procedures found in the synology folder under "Protocols" and Appendix A. Calibrations are done on the chlorophyll, dissolved oxygen, specific conductivity/ salinity, depth, and wiper probes. Each probe has special considerations during its calibration:

- The pressure sensor is located on the sonde body and can be seen as four small holes located on the bulkhead of the sonde. To calibrate the depth these four holes need to be out of any water and the dummy plugs for the cable attachment should be removed.
- Chlorophyll is calibrated using a one point "zero" calibration with distilled water.
- Dissolved oxygen is calibrated in 100% O2 saturated water. Oxygen membranes are changed once a year.
- Specific conductivity/salinity is calibrated in a potassium chloride solution purchased from YSI.
- The wiper probe is calibrated to move left or right to ensure it is sitting in the correct position.

After each probe is calibrated the KorEXO software provides a quality control score. A green check means the sensor calibrated and is fully functional. A yellow or red check means that there is something wrong with the probe and it needs to be sent back to YSI for inspection. EXO2 calibration records are automatically saved on the KorEXO software; records are also saved on the environmental monitoring synology.

Calibrated sondes are stored in the laboratory inside a calibration cup with an inch of water at the bottom screwed onto the sonde until deployment.

Batteries are replaced every 4 to 5 deployments. When the sondes are deployed at the stations they receive power from the data logger, which allow its batteries to last longer than 1 deployment. The data logger is powered from a 12v battery and solar panel.

Prior to deployment, sondes are removed from storage and tested in a bucket of tap water with a bubbler. Readings from this pre-deployment test are documented on the pre-deployment portion of the Pre/Post deployment form. (see Appendix B).

Sondes are replaced at each station monthly. During these maintenance visits, the old sonde is removed and a newly calibrated sonde is deployed. During this switch, if possible, a separate handheld YSI is lowered into the water next to the station to take several readings for comparison. Additionally, when possible, water samples are taken for winkler titrations and chlorophyll readings on a fluorometer.

After the "old" sonde is retrieved, it is prepared for travel by screwing on the calibration cup with distilled water. Sondes are transported back to the lab by either boat or truck. Travel time can range from 20 minutes to 2 hours. Once back in the laboratory, the sonde is connected to the KorExo software for post calibration. Post calibrations are done while the sonde is submerged in a bucket of water with an air bubbler. Post-deployment readings are recorded on the post section of the same form used during pre-

deployment for that instrument (tracked by serial number). After each post-deployment test, the sonde is cleaned of any biofouling and fresh copper tape is applied to the probes. After cleaning the sondes are calibrated and ready for redeployment.

Meteorological instruments are retrieved from stations and sent back to the factory for calibration once a year unless there is an apparent sensor issue prior to its annual maintenance date. The annual maintenance timeline of each station can vary. Exact dates are stored in station log books along with serial numbers of instruments during each deployment and retrieval. All log forms and factory calibration records are scanned and uploaded to the environmental monitoring synology.

A calibrated backup is stored for each instrument on each operational station. This includes a calibrated WXT 530 or 520 all-in-one meteorological sensor including wind, air temperature, air pressure, humidity, and rain, Li200 and Li190 solar radiation sensor, and an EXO2 sonde with all probes (DO,Sal,wiper,and Chl). Spare battery, solar panel, cell modem, data logger, solar panel regulator and vented cable are also on hand at all times.

All hydrographic instrumentation is wrapped in copper tape to prevent fouling. This copper tape should be changed before each deployment. The sonde body is wrapped in a layer of saran wrap and then duct tape. The saran wrap allows for easier removal of the duct tape and ensures fouling organisms will grow on the tape and saran wrap rather than the body of the instrument itself. There is also a wiper installed on the EXO2 sonde that wipes the probes every 15 minutes. The wiper brush can be changed when the bristles become bent or fouled.

Probes may develop issues that cannot be resolved in the laboratory. When this occurs, YSI technical support is called to troubleshoot the issue. If the problem can not be resolved over the phone, the probes are returned to YSI for inspection/ repair. Note that if any deep gashes, breaks, or corrosion are observed on the probes, they are sent in for repair even if they appear to be calibrating correctly. Any defects on the probe body could allow water to breach the sonde when submerged.

Laboratory Supplies and Consumables

The supplies and consumables needed are only for the EXO2 sonde. The sonde requires D batteries to perform the in lab calibration. The dissolved oxygen probe requires a new membrane once a year that is purchased from YSI. Similarly, a YSI specific conductivity calibration solution (50,000 µS/cm²) is used to calibrate specific conductivity and salinity. The spare wiper brushes are also purchased from YSI. Over time the bristles become worn and sometimes the brushes will fall off during deployment. These need to be changed as soon as either one of these issues are observed. All purchases of monitoring supplies are made by LUMCON's monitoring technician, Amanda Fontenot.

Data Quality Control

Data and field notes are organized by Amanda Fontenot. New Excel data files are created for each station and year and are organized within synology under the station name. Files are labeled as "StationName_Year_DateSaved_Version#." Within each file, the first tab contains a filelog with detailed notes of changes made in each version with the date. The second tab contains raw data transmitted from the date labeled "StationName_Year_Raw;" no changes are made to data in this tab. The third tab a copy of the meteorological data and labeled StationName_Year_Met_QAQC. This sheet is used to proof/make

changes to the meteorological data, including wind speed and direction, air temperature, humidity, air pressure, rainfall, and solar radiation. The fourth sheet is a copy of the hydrographical data labeled StationName_Year_HydroQAQC. This sheet is used to proof/make changes to the hydrological data, including water temperature, water height, salinity, specific conductivity, dissolved oxygen, and chlorophyll. The fifth sheet contains graphs of each meteorological parameter labeled Met_Year_Graphs. The sixth sheet contains graphs of the hydrographical data labeled Hydro_Year_Graphs.

Data Quality control is done in three stages 1) routine maintenance and calibration of sensors (see above sections); 2) real-time human in the loop monitoring and testing; and 3) automated testing using QARTOD quality control algorithms via the Gulf of Mexico Coastal Ocean Observing System (GCOOS).

Human in the Loop Testing

Human in the loop test occurs in three phases: 1) Daily monitoring of the operational status of all deployed sensors; 2) Monitoring of data quality; 3) Identifying issues of sensor function and data quality and work to quickly resolve.

Data streams from all stations are examined daily in order to monitor of the operational status of all deployed sensors. If a station is no longer actively reporting live data, the following steps are taken:

- Attempt to connect to the data logger through the loggernet software. If successful, the issue is with the IT side of the website. Send IT an email requesting that they look into this issue. Most of the time this issue can be resolved by IT restarting the weather station server.
- If you are unable to connect to the data logger through loggernet, this indicates there is a problem with the power supply or the cell modem. The first step is to physically remove the power cord that connects to the data logger, wait 30 seconds then reconnect the power. If this does not fix the issue you can check the battery with a voltmeter to confirm 12VDC. Replace the battery if the voltage is below 12. If the battery has a 12 or above voltage the cell modem should be checked next. The cell modem has LED indicator lights, which can help Campbell Scientific assist over the phone.
- On a rare occasion, the solar panel regulator may go bad and need replacement. This should be done only after ruling out all of the above.

If all stations are reporting data, incoming streams from the last day are reviewed for data quality, specifically focusing on answering the question - are these data reasonable and scientifically valid? In order to test this, data are compared to historical averages for that station, current readings across stations, and as needed compared with nearby stations maintained by other groups to verify values that readings are within normal range (Table 3).

Station Name	GISL 1	AMRL1	07381349 Caillou Lake	Bayou Petit Caillou at Cocodrie (76305)
Maintained by:	NOAA	NOAA	USGS	Army Corps of Engineers
Coordinates	264722 -89.957500	29.450000 -90.33800	29.249167 -90.921111	29.254250 -90.663528
Parameters	Water Temp Wind DIrection/Speed	Water Temp Wind DIrection/Speed	Wind Direction/Speed Gage Height Salinity/Specific Cond	Gage height Water Temp

	AIr Temp AIr Pressure	AIr Temp AIr Pressure	Water Temp	
Used for comparison to station:	Marine Center Terrebonne Bay Port Fourchon	Marine Center Terrebonne Bay	Marine Center Terrebonne Bay	Marine Center

Table 3. Stations used for data quality control comparisons.

When out of range readings are observed on the instrument, those readings are recorded on the weather station log form and the sensor is retrieved as soon as the observations are noticed. Our goal is to identify issues within 24 hours of their occurrence and to be on site at the station within 1-2 days with a replacement sensor. Work will continue to mitigate data errors unrelated to the sensor itself (e.g. biofouling) as fast as possible until the issue is resolved. Note that the sensor may still be collecting and reporting data at this time, but those data will later be flagged and annotated with details of the issue. The most common issues include biofouling, storm damage, and loss of communication to the site.

Below are typical steps taken when out of range readings are observed for an instrument:

- When a meteorological instrument starts reading out of normal ranges this is usually an indication that it has either drifted out of calibration or has been damaged. Hydrographical instruments are very susceptible to biofouling and out of range data is usually an indicator that this has occurred.
- Take the back up calibrated instrument from the lab and replaced the instrument from the field with the new one.
- Make sure to write down date, time, and serial number of the new instrument.
- Make sure to send in the retrieved instrument for calibration or repair, or if possible to repair/ calibrate in lab.

Data are then sent to GCOOS through a scheduled task on the weather stations sever than runs every fifteen minutes starting at five minutes after the hour. The task executes a program (WinSCP) to format the data files to GCOOS's liking and trasnfers then via FTP.
The data is then run through test conducted by GCOOS. The tests consist of the following: timing, syntax, location, gross range, climatology, spike, rate of change, and flat line. Any data that do not pass one of these test receives a flag. Information on data flags are sent to the LUMCON Environmental Monitoring staff daily. For more information on these test please visit
http://data.gcoos.org/certification/GCOOS_DMAC_DMS.pdf