Description of the GTM-NERR Beachfront Data Collection Facility

Overview of the Facility

Referring to Figure 1 below, high-quality nearshore directional wave information and current data are collected at the GTM-NERR site using a Teledyne RD Instruments Workhorse Sentinel Acoustic Doppler Current Profiler (ADCP). The ADCP is located approximately 640 m (2100 ft) from the beach at a nominal depth of 8.5 m (28 ft) and is mounted to the top of a 4 m (13 ft) stainless-steel pipe that is imbedded approximately 3 m (10 ft) into the seafloor. Wind data are collected with a RM Young Marine Anemometer that is mounted to a 3 m (10 ft) tower on the top of the nearby dune which is nominally 9 m (30 ft) tall. Local atmospheric pressure is measured with an RM Young Model 61402 Barometric Pressure Sensor.

All instruments are hard-wired to a Shore Station that supplies continuous power and contains a Data Acquisition System (DAS). The Shore Station allows data to be collected in "real-time" as opposed to instruments that rely on internal batteries and internally recorded memory that must be physically retrieved, serviced, and reinstalled periodically. The DAS logs a file of raw data (*i.e.*, unprocessed) each hour that is then sent using a directional wireless Ethernet communications system to the Data Processing Station DPS). The DPS, located in the parking lot of the GTM Central Beach Access, is housed in a surplus office trailer provided by NOAA and outfitted with a 6m (20 ft) antenna tower. The raw data are processed and plotted by a computer and the updated results are uploaded each hour to the BDCF website via cell modem.

Figure 1 - General layout of the Beachfront Data Collection Facility.

The Acoustic Doppler Current Profiler (ADCP)

The bottom-mounted ADCP (Figure 2, left panel) is equipped with four acoustic transducers, a single pressure sensor, and a thermistor that measures the local water temperature. It also contains an internal compass and a 2-axis tilt sensor for accurately determining the orientation of the instrument. The ADCP is equipped with internal memory cards and a lithium battery pack; however, these are used only for back-up in the event there is an interruption in communication or power via the cable from the Shore Station.

The acoustic transducers, each oriented 20 degrees oblique from vertical, transmit a pulse or "ping" at a frequency of 1.2 MHz. The pings, which propagate all the way to the sea surface, also bounce off any fine particles suspended in the water (*e.g.*, plankton, turbidity). Because the water is moving, the echoes that return to the instrument possess a shift in frequency known as a Doppler shift. Particles moving toward the instrument return sound with a frequency that is higher than 1.2 MHz, while those moving away produce echoes that are lower than 1.2 MHz. Assuming that the suspended particles are moving at the same speed and direction as the water, the difference in frequency of the transmitted and the received pings is used to calculate the speed of the water in the direction along each beam. By separating the return along each beam into segments (Figure 2, right panel), multiple cells are defined, creating individual layers throughout the water column, with four cells in each layer. The ADCP deployed at the BDCF is programed to create cells that are 0.5 m (1.64 ft) in thickness.

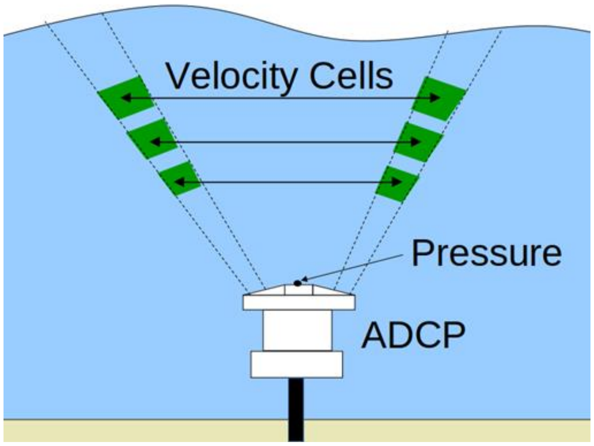

Figure 2 – Left: An Acoustic Doppler Current Profiler (ADCP) directional wave gauge mounted to a seafloor-imbedded pipe, similar to that installed at the BCDF. Right: The oblique acoustic beams and the cells from which the along-axis water speeds are determined from the Doppler-shifted echoes.

The calculated speed from each cell in the water column and the measurement from the pressure sensor are transmitted along the cable to the Shore Station DAS and also saved internally in the ADCP memory as back-up. To measure waves, the ADCP pings and samples at a rate of 2 Hz for 20-minutes (2,400-point records) once per hour, starting at the top of the hour. The instrument also delivers a vertical profile of the mean current and a mean pressure at the head of the instrument every 10 minutes, or six times per hour.

The Wave Gauge Cable and Conduits

The ADCP is connected to the Shore Station via a single, double-armored steel cable that encapsulates the multiple leads required for transmitting power and communicating with the instrument. The seaward end of the cable is epoxy-potted to a custom-fabricated flexible "pigtail" that plugs into an underwater connector at the base of the instrument. To install the cable, its seaward end is pulled offshore with a suitable vessel, aiming for the intended location of the ADCP. However, given the weight of 2,100 ft of the cable even when submerged (more than 550 lbs), its drag along the seabed, and especially any lateral drag on the cable due to wave or wind-driven longshore currents, renders this task extremely challenging.

In addition, a trench must be excavated across the dry beach so that the landward section of the cable can be buried. The trench must be sufficiently deep so that the cable does not become exposed and damaged during extreme beach erosion events. As is mandated throughout Florida, such excavations cannot be performed during sea turtle nesting season. In anticipation of having to repair or replace the cable during a future turtle nesting season, the idea of burying a semi-flexible plastic conduit in the trench was adopted, so that the landward end of a cable could be pulled up through the conduit at any time of year. Also, with the possibility of adding additional underwater instruments to the facility in the future, a total of three conduits were buried in the trench (Figure 3).

Figure 3 – Left: Excavating the trench across the dry beach and installing the three conduits. Right: Backfilling the trench and burying the conduits.

The Anemometer

The anemometer selected for use at the facility (RM Young Wind Monitor-SE-MA model 09106) (Figure 4) uses a helicoid impeller that turns a multipole magnet to provide wind speed and a swiveling vane with an optical encoder to provide direction. This model is environmentally hardened to withstand intense sun exposure and wind-blown salt aerosols. Although modern sonic anemometers are more responsive and accurate and have no moving parts to wear out, they generally are rated for wind speeds less than 168 mph (75 m/s) whereas the RM Young SE-MA instrument is rated to 224 mph (100 m/s) and so can measure the wind gusts experienced during even the strongest hurricanes.

Figure 4 – Left: Marine-grade anemometer used at the BDCF. Right: Anemometer (and Ethernet antenna) mounted to the dune tower erected near the Shore Station (photo taken from A1A).

The anemometer is mounted to a 3 m (10 ft) tall dune tower (located in Figure 1) that is bolted to the top of a stainless-steel pipe that is imbedded in the dune. The tower is protected by a grounded lightning rod. The anemometer's optical encoder is aimed such that True North produces an output of 0/360 degrees. Power is supplied via cable from the Shore Station, and wind speed and direction are sampled continuously at 1 Hz, time-stamped, and saved in daily data files in ASCII format by the DAS.

The Barometer

Local atmospheric pressure is measured with a RM Young Model 61402 Barometric Pressure Sensor. The barometer is housed inside the DAS enclosure and is seen in the lower left-hand corner of the left panel of Figure 5. Data are sampled at 0.2 Hz (5 s) and saved in monthly ASCII files.

The Shore Station and Data Acquisition System (DAS)

As indicated in Figure 1, the Shore Station is located on the landward side of the dune near FDEP range monument R-057 (St. Johns County). The DAS system (Figure 5, left panel) is contained in a weather-tight environmental enclosure (Figure 5, right panel) along with the solar panel used to provide power. Both the enclosure and the solar panel are mounted to a 3 m (10 ft) tower section, attached to the top of a stainless-steel pipe that is imbedded in the ground, much like the dune tower.

The DAS uses a single-board Linux computer to collect the raw data from the ADCP, anemometer, and barometer, as well as temperature and humidity within the enclosure. Separate files are created for each of these instruments. A copy is kept on the computer, and another is placed in an outgoing directory to be retrieved by the Data Processing Station immediately after the top of each hour.

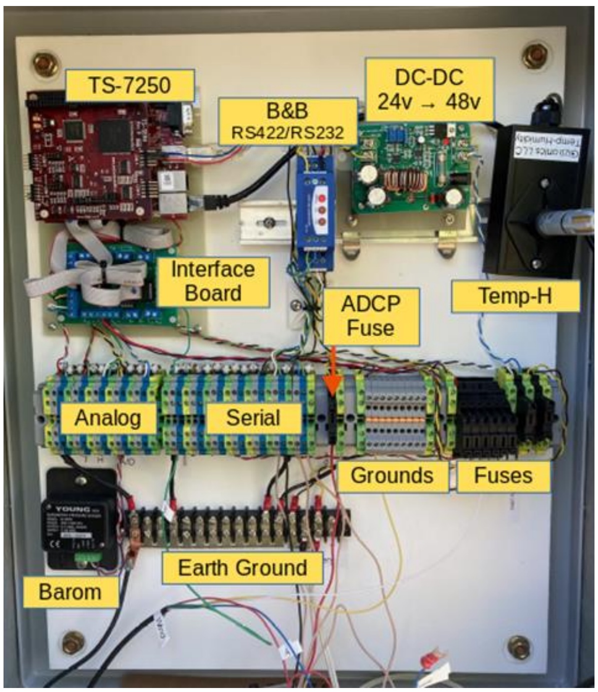

Figure 5 – Left: Shore Station Data Acquisition System; Right: Shore Station enclosure and solar panel, mounted to a tower section that is bolted to the top of a stainless-steel pipe embedded in the ground.

All instruments and the DAS are powered by four 12-volt batteries, also housed in the Shore Station enclosure, that are maintained by the solar panel. The station also has multiple lightning protection features: grounded lightning rod, transient suppression diodes, fuses, and gas-discharge tubes. In the event the Ethernet communications with the Data Processing Station are interrupted, the computer continues collecting and storing the raw data.

The Wireless Ethernet Connection

To circumvent the problematic and expensive task of running a buried armored cable more than 1,300 m (4,300 ft) southward along A1A and into the Central Access parking lot, a matched pair of directional antennas is used to create a wireless Ethernet connection between the Data Acquisition System and the Data Processing Station (ref. Figure 1). The DAS antenna is mounted at the top of the dune tower (Figure 4, right panel), while the antenna for the DPS is mounted at the top of a 6 m (20 ft) tower that is attached to the NOAA-supplied office trailer (Figure 6), where the data processing equipment is housed.

Figure 6 – Ethernet antenna mounted to the tower at the NOAA-supplied office trailer located in the parking lot of the GTM Central Access.

The Data Processing Station (DPS)

Data processing is done with two computer systems housed inside the NOAA trailer - a Linux computer and a Windows laptop. The Linux machine serves multiple roles, including 1) providing GPS time synchronization (Network Time Protocol - NTP) on the local network to keep the collection and analysis properly synchronized and time-stamped, 2) pulling both the raw binary data generated by the ADCP and the ASCII files of the other instruments from the Shore Station DAS via the wireless Ethernet connection, 3) saving a copy of the data in a backup archive, and 4) feeding the raw data to the Windows machine for processing and plotting.

To process the raw binary data from the ADCP, the laptop runs RD Instruments' WavesMon software, creating ASCII files of wave and current measurements. Other software specifically developed for the BDCF also runs on the laptop to create the 24-hour and 7-day plots that are uploaded via cell modem to the Surfbreak Engineering Sciences website for monitoring system performance and for public viewing.