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NATIONAL DATA BUOY CENTER: A PORTAL FOR MARINE MESONET DATA

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1.0 Introduction

Many valuable oceanic observations taken in the coastal zone in realtime by universities and laboratories are not used by the National Weather Service (NWS) and other meteorologists. In 2001, about a dozen universities were collecting environmental data from buoys and fixed stations near the U.S. coast and posting them on various Web sites. However, in order to appear on meteorological workstations and be assimilated into numerical prediction models, the measurements must be coded into a World Meteorological Organization (WMO) code form and transmitted to or collected by the NWS. This encoding and transmission has not occurred because many research agencies lack this knowledge or the resources, and the NWS does not have a single focal point for these issues. This paper describes how the National Data Buoy Center (NDBC) has taken steps to help solve this problem.

In early 2002, NDBC developed C language software that could be used to place reports into two WMO realtime codes and distributed them to many of these universities. Then, later in 2002, NDBC began to serve as a collection point where universities sent observations via FTP for quality control and distribution on the various meteorological circuits. This capability benefitted the universities in many ways:

- Their program gained much better visibility because their observations were posted on NDBC's Web site which receives about 14 million hits each month.
- Their observations were distributed to the entire meteorological community, including NWS forecast offices, the Tropical Prediction Center (a.k.a. The National Hurricane Center), the National Centers for Environmental Prediction (NCEP), the Weather Channel, the Federal Emergency Management Agency, and local TV meteorologists.
- Their observations helped fill in the gaps between stations in the National Oceanic and Atmospheric Administration's (NOAA) national backbone and provided critical realtime information on smaller scale weather or oceanographic features.
- Their observations were monitored, and any obviously degraded data were removed from real time distribution. Data providers were notified of such actions.

As of May 2003, NDBC has partnered with four universities or consortiums as data providers. Three additional universities are actively working with NDBC and should begin providing data during the summer of 2003. Table 1 provides the names, number, and types of stations of these providers. Coastal stations are located on beaches or on a variety of fixed structures in the coastal zone.

TABLE 1. A list of present and future university data providers.

Provider	Program Name	Moored Buoys	Coastal Stations
Providers as of May 1, 2003			
Gulf of Maine Ocean Observing System	GoMOOS	8	0
Texas A&M	TABS	5	0
Skidaway Institute	SABSOON	0	1
University of South Florida	COMPS	4	8
Future Providers			
Louisiana University Marine Consortium	LUMCON	0	4
Texas A&M	TCOON	0	40
University of Connecticut	MYSOUND	1	1

2.0 Preliminary Information

Preliminary discussions with these providers centered around station locations; the station's exposure to the marine environment; the types of measurements made and the sensors used; the acquisition frequency (e.g. hourly) and averaging times; and other metadata. The

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NWS is primarily interested in hourly or half-hourly observations from stations whose sensors have good exposure to the marine environment. NDBC reviewed photographs, sensor elevation, and other documentation to determine if any obstructions present serious problems to wind measurement. Measurements are transmitted to NDBC within 15 minutes of their acquisition time. Wind measurements should be averaged for at least one minute, but for no more than 15 minutes.

NDBC has supplied the data providers with:

- Station identifiers that permit routing of observations into the NDBC/NWS processing and dissemination system.
- Software that facilitates encoding of the observations into a WMO message format, or code, to be used for each station. FM-13 code is used for observations from moored buoys, while the C-MAN code is used for land-based stations or those located on offshore platforms.
- A routing or communications header that uniquely identifies each provider's input to our system.

3.0 Encoded Measurements

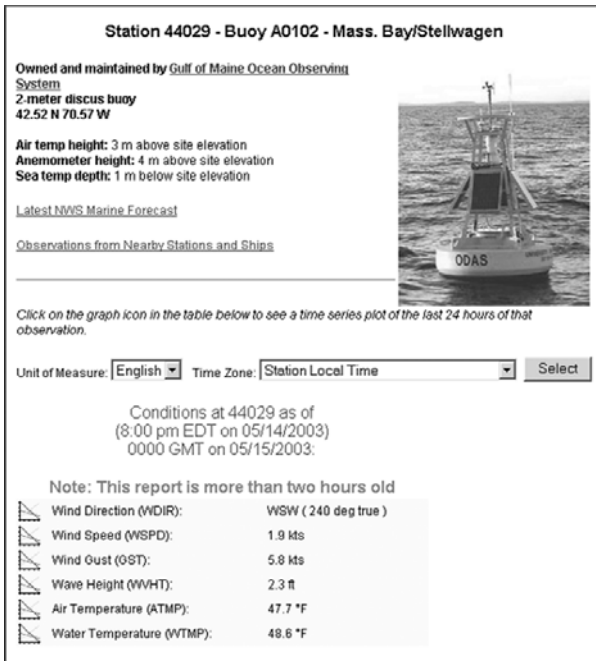
The following information has been encoded for moored buoys in FM-13: observation date-time; station identifier; latitude; longitude; average wind speed; wind direction; wind gust; air temperature; sea surface temperature; dew point; sea level pressure; station pressure; visibility; significant wave height; and dominant wave period. For fixed stations reporting in C-MAN code, our software encodes observation date-time; station identifier; average wind speed; wind direction; wind gust; air temperature; sea surface temperature; dew point; sea level pressure; station pressure; visibility; water level; significant wave height; and dominant wave period.

A provider typically does not take all of these measurements; however, the observation date-time; station identifier; routing identifier; message format; and the wind speed units are mandatory. Wind speeds can be in either knots or meters per second, and wind direction is in degrees true. Temperatures are in degrees Celsius, and pressure is in hectoPascals (mb). Water level is in feet above Mean Lower Low Water (MLLW), which may be estimated; wave height is in meters, and wave period is in seconds. MLLW is an average of the lowest daily water levels observed over at least a month. Time is encoded in UTC.

Several derived quantities are calculated and transmitted, such as three hour pressure tendency, winds adjusted (extrapolated) to 10- and 20-meter reference heights, and dew point, given the relative humidity and air temperature. The wind adjustment helps forecasters to more properly interpret the wind speeds from a tall platform. The adjustment method requires sensor heights, and an air temperature and water temperature since the calculation is stability-dependent.

4.0 The Software Kit

The data providers tailored the NDBC-supplied encoding software, called the Meteorological and Oceanographic Data Exchange Module (MODEM), so that it worked for their observations. This required a junior-level programmer experienced in C or C++. The modifications needed were fairly minor and centered around changing assignment statements to read data from the provider's input files. Output messages were in the FM-13 and C-MAN codes, as given in http://www.ndbc.noaa.gov/decode.shtml. When the messages were transmitted to NDBC, they were verified through quality control and posted on NDBC's Web site.



Station 44029 - Buoy A0102 - Mass. Bay/Stellwagen

Owned and maintained by Gulf of Maine Ocean Observing System
2-meter discus buoy
42.52 N 70.57 W

Air temp height: 3 m above site elevation
Anemometer height: 4 m above site elevation
Sea temp depth: 1 m below site elevation

Latest NWS Marine Forecast

Observations from Nearby Stations and Ships

Click on the graph icon in the table below to see a time series plot of the last 24 hours of that observation.

Unit of Measure: English | Time Zone: Station Local Time | Select

Conditions at 44029 as of
(8:00 pm EDT on 05/14/2003)
0000 GMT on 05/15/2003:

Note: This report is more than two hours old

Wind Direction (WDIR):	WSW (240 deg true)
Wind Speed (WSPD):	1.9 kts
Wind Gust (GST):	5.8 kts
Wave Height (WVHT):	2.3 ft
Air Temperature (ATMP):	47.7 °F
Water Temperature (WTMP):	48.6 °F

Previous 24 observations

MM	DD	HH EDT	WDIR	WSPD kts	GST kts	WVHT ft	DPD sec	APD sec	MWD	PRES in	PTDY in	ATMP °F	WTMP °F	DEWP °F	SAL	VIS mi	TIDE ft
05	14	6 pm	-	0.0	3.9	2.0	-	-	-	-	-	48.6	50.2	-	-	-	-
05	14	5 pm	-	0.0	3.9	2.0	-	-	-	-	-	49.5	51.8	-	-	-	-
05	14	4 pm	WSW	7.8	9.7	2.3	-	-	-	-	-	48.6	52.0	-	-	-	-
05	14	3 pm	WSW	11.7	13.6	2.6	-	-	-	-	-	47.5	48.7	-	-	-	-
05	14	2 pm	WSW	7.8	13.6	3.0	-	-	-	-	-	46.4	47.1	-	-	-	-
05	14	1 pm	SSE	1.9	5.8	2.6	-	-	-	-	-	45.3	46.2	-	-	-	-
05	14	12 pm	-	0.0	1.9	2.0	-	-	-	-	-	47.8	48.0	-	-	-	-
05	14	10 am	-	0.0	0.0	1.6	-	-	-	-	-	46.4	46.6	-	-	-	-
05	14	9 am	-	0.0	0.0	2.0	-	-	-	-	-	45.5	45.9	-	-	-	-
05	14	8 am	-	0.0	1.9	2.0	-	-	-	-	-	44.8	45.3	-	-	-	-
05	14	7 am	-	0.0	1.9	2.3	-	-	-	-	-	44.4	45.0	-	-	-	-
05	14	6 am	-	0.0	1.9	3.0	-	-	-	-	-	44.6	45.0	-	-	-	-
05	14	5 am	-	0.0	1.9	3.0	-	-	-	-	-	44.8	45.3	-	-	-	-
05	14	4 am	-	0.0	1.9	3.0	-	-	-	-	-	44.8	45.3	-	-	-	-
05	14	3 am	-	0.0	1.9	-	-	-	-	-	-	44.6	45.0	-	-	-	-
05	14	2 am	-	0.0	1.9	2.3	-	-	-	-	-	44.8	45.1	-	-	-	-
05	14	1 am	-	0.0	1.9	2.0	-	-	-	-	-	44.8	45.1	-	-	-	-
05	14	12 am	-	0.0	1.9	2.0	-	-	-	-	-	45.9	46.0	-	-	-	-
05	13	11 pm	-	0.0	1.9	2.0	-	-	-	-	-	47.3	47.3	-	-	-	-
05	13	10 pm	SW	1.9	3.9	-	-	-	-	-	-	46.8	47.3	-	-	-	-
05	13	9 pm	NNW	1.9	1.9	2.0	-	-	-	-	-	46.6	47.5	-	-	-	-
05	13	8 pm	NE	3.9	3.9	2.0	-	-	-	-	-	46.6	47.7	-	-	-	-

Figure 1. NDBC's Web page showing observations from buoy station 44029, operated by GoMOOS. Observations for only the last 24 hours are given on NDBC's Web site.

When they were transmitted to other meteorologists, they were mixed with NDBC stations under routing headers that NDBC already uses. This made the communication process transparent to the meteorological community. Realtime reports for the previous 24 hours are posted on NDBC's Web site. A link was created to the providing organization's web page for details about their measurement program, metadata, and possibly historical data. NDBC does not archive these observations. Figure 1 shows an example of how university observations appear on the NDBC Web site.

5.0 Data Monitoring

Gross range and time continuity checks are performed in realtime by NDBC processing, including a check to see that the dew point does not exceed the air temperature. These checks are designed to stop the obviously bad measurements, but NDBC supplements them with other after-the-fact checks and manual review.

Each day, data analysts view plotted winds, pressures, air temperature, dew points, and water temperatures on meteorological work stations. This ensures consistency with surrounding stations via analyzed contours. They also view a listing of the most recent day's reports via the Web site, looking for sporadic errors as well as consistency between the wind and wave measurements. Measurements are also automatically compared with NCEP's Aviation model initial analysis fields twice daily, and analysts are alerted to any large differences. To help diagnose anything suspicious, analysts often create time series plots comparing measurements with those from nearby buoy, coastal, or airport stations. In addition, NWS field forecasters occasionally contact analysts concerning suspicious data. When degraded measurements are detected, analysts immediately stop the release of individual measurements, while permitting dissemination of other valid measurements. While it is possible for degraded data to be transmitted, any such data will almost certainly be detected within 24 hours and withheld from further release.

For data providers having duplicate, or backup, sensors that also provide measurements in realtime, NDBC can give providers powerful quality control checks that can be used before encoding the data. All NDBC stations have duplicate anemometers, and all buoys have duplicate barometers and air temperature sensors. Not only do duplicate sensors reduce the need for servicing, but an automated check detects when the redundant data are not in agreement and determines which one to transmit.

NDBC quality control has helped each of the university data providers to detect degraded data. Data that did not agree with surrounding observations have been traced to misaligned anemometers, barometers out of calibration, and communication software errors. An example of a time series plot that helped NDBC discover a 4 hPa pressure bias in a Texas Automated Buoy System report is shown in Figure 2. Station 42043 is a TABS buoy located about 20 miles south of NDBC buoy station 42035 near Galveston, Texas. The pressures at station 42035 were compared with those reported by the Galveston Automated Surface Observing System (ASOS) and found

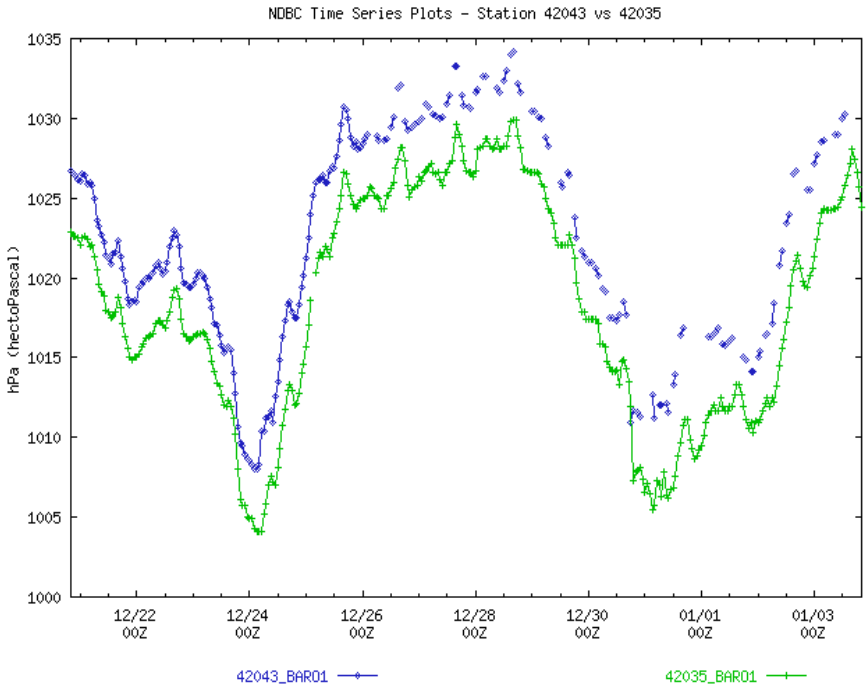


Figure 2. A time series plot showing a pressure bias for TABS buoy station 42043 when compared to NDBC station 42035.

to be in much better agreement.

6.0 Future Work

NDBC has developed the capability to be a portal for incoming marine observations provided by universities, consortiums, or other government agencies. This benefits the universities or agencies by giving greater visibility to their measurement programs and benefits the NWS by providing them easier access to the much-needed observations. NDBC hopes to slowly expand this program, since university meso-networks and regional observing systems will form a vital additional to the NWS observing backbone. In addition, NDBC will offer the capability to disseminate salinity and currents at multiple depths via the WMO FM-64 TESAC code in mid-2003 and to disseminate spectral wave measurements via FM-65 WAVEOB.