12.4 OPERATIONAL FIELD TEST AND EVALUATION OF NDBC'S COMPACT OCEAN OBSERVING SYSTEM, CONFIGURED FOR OCEAN WAVE, METEOROLOGICAL, AND OCEAN CURRENT PROFILING MEASUREMENTS

R.L. Crout, R.V. Hervey, and R.H. Bouchard
NOAA/NWS/National Data Buoy Center (NDBC)
Stennis Space Center, MS

1. INTRODUCTION

NOAA's National Data Buoy Center (NDBC) has developed a new, low-cost, easy-to-deploy, multi-purpose ocean observing system. The observing platform is a 1.8-meter foam discus hull buoy. The new electronic data acquisition system is called the Wave and Marine Data Acquisition System (WAMDAS). The system is intended to augment observations from existing NDBC observing stations, or serve as a temporary or even permanent observing system. Originally developed primarily for the measurement of ocean waves, WAMDAS has the capability to interface with additional sensors.

After two test and evaluation deployments in a waves-only configuration, an Acoustic Doppler Current Profiler and a compact meteorological sensor package were added to the system and deployed in the Florida Straits as 42080 for evaluation. NDBC, in conjunction with the staff of the Weather Forecast Office, Key West, FL conducted the evaluation. This paper describes the field test and the results of the evaluation of the meteorological, oceanographic, and wave observations.

2. SENSORS

2.1 Waves

Wave observations from the compact buoy system (Teng, *et al.*, 2005) are done using a strapped-down MicroStrain® 3DMG-X1®***,*** Gyrocompass Enhanced Orientation Sensor. The output from the time series of the vertical accelerometer is processed on-board the buoy to generate the wave spectrum that is transmitted to NDBC and processed into wave heights and periods.

2.2 Meteorology

The small size of the 1.8-meter buoy makes it impractical to equip it with the standard suite of NDBC meteorological sensors. The Climatronics TACMET II seemed a good fit for the small buoy having external dimensions of 30-cm by 10-cm and weighing 1.5 kg. The TACMET package includes sensors to measure wind speed and direction, barometric pressure, air temperature and humidity.

2.3 Current Profiles

A 300 kHz Teledyne RD Instruments (TRDI) Acoustic Doppler Current Profiler (ADCP) was selected for the Sand Key 1.8- m buoy. The ADCP is mounted in the bridle with the transducers approximately 1.8 meters below the water line. The first bin began at ten meters below the water surface. Twenty, eight-meter bins were selected to collect the profile data. While the bins below 90 meters were not useable due to acoustic losses and the upper bins were occasionally not useable due to fish contamination of the acoustic signal, there was still a large amount of data to analyze.

3. PROCESSING

3.1 Waves

The processing is similar to NDBC's Wave Processing Module (WPM) (National Data Buoy Center, 2003) except the band averaging. Because of the shorter 20-minute sampling duration, the WAMDAS band-averaging includes overlapping of the Fourier frequencies to maintain the same degrees of freedom as 40-minute WPM. Three orthogonal magnetometers are used to calculate buoy heading similar to WPM except that mean values of the horizontal and vertical magnetometers are used as the Earth's magnetic flux constants instead of geomagnetic model output for the location. Directional wave information is derived using NDBC's Angular Rate System (Steele, *et al*., 1998) except that a separate tilt sensor is not used to obtain mean pitch and roll.

3.2 Meteorology

The test compared measurements from the TACMET with that of the nearby Coastal Meteorological Automated Network (C-MAN) station at Sand Key, FL, 6-nm to the northeast of the buoy's location. The evaluation was conducted with observations collected from 20 June 2007 through 15 August 2007.

* *Corresponding author address*: Richard L. Crout, National Data Buoy Center, 1007 Balch Blvd. Stennis Space Center, MS 39529; e-mail: Richard.Crout@noaa.gov

The TACMET uses a Climatronics sonic anemometer to compute wind speed and direction. It was mounted approximately 2-m above the buoy's waterline. The C-MAN station is equipped with dual R. M. Young mechanical anemometers mounted 45-m above the sea surface. The TACMET hourly winds were sampled over a period of 8-minutes, ending at 6-minutes after the top of the hour. The C-MAN hourly winds were sampled over a 2-minute period, ending at the top of the hour. Wind speeds from both stations were adjusted to 10-meters for the comparison using the standard NDBC method (Liu, et al., 1979).

3.3 Current Profiles

The ADCP provides horizontal and vertical current speeds collected on-board the ADCP. There is no corresponding current profile information for comparison purposes. A description of the characteristics of the flow during the deployed period is provided. The current profile data are collected using 5 minute samples consisting of 300 one-second pings. Housekeeping data transmitted with the signal include: echo amplitudes for each of the four beams; percent good three and/or four beams; and error velocities.

4. RESULTS

4.1 Waves

During the deployment, NDBC monitored the wave reports from 42080 and compared them with the output of NOAA's WaveWatch III model (Tolman, 2002) for the virtual buoy, EYW01, located about 45 kilometers southeast of NDBC Buoy 42080 in 1000 m of water. Statistical comparisons were made only when the model data showed significant wave heights of 0.8 m or greater. This criterion resulted in two episodes for comparison June 26-27, 2007 (table 1) and July 18-20, 2007 (table 2). The parameters evaluated where the significant wave height, peak (or dominant) period, and mean wave direction at the peak period. Bias and Root Mean Square Difference (RMSD) were computed for the limited data sets.

The RMSDs for significant wave height, peak period, and mean wave direction at the peak period are in approximate agreement with the NDBC Accuracy Statements of 0.2m, 1 s, and 10 degrees True for (National Data Buoy Center, 2006) those respective parameters, when making allowances for the 45-km separation distance, model limitations, and possible shoaling effects for 42080 in much shallower water than the model output point.

The comparison results are encouraging, but are limited by a small range of values for the parameters. Maximum buoy wave height was 1.1 m during those periods.

4.2 Meteorology

4.2.1 Wind Speed and Direction

All wind comparisons were made with the C-MAN station's primary anemometer. There were no significant differences noted in the performance of the primary and secondary C-MAN anemometers during the course of the evaluation. The TACMET has a built-in magnetic compass. The buoy payload accounted for the local magnetic variation of -5 deg and reported wind direction referenced to true north. Wind speed and direction measured by the TACMET compared very favorably with that form the C-MAN station. The mean difference in wind speeds when adjusted to 10-m was 0.04 m/sec with a standard deviation of 0.96 m/s. The mean difference in wind direction was 3.5 deg with a standard deviation of 26.7 deg. Wind speeds were generally light through the period of the evaluation, averaging 3.7 m/s, with no periods of sustained high winds. An evaluation of the TACMET's performance under more severe wind a sea conditions is needed to judge its suitability for wind measurements on small buoys.

4.2.2 Barometric Pressure

The TACMET barometric pressure tracked well with the C-MAN pressure adjusted to sea level, but there was a -1.5 hPa bias. The C-MAN pressure appeared to read high since the TACMET pressure agreed more favorably with model pressure analyses and other nearby stations. The C-MAN barometer may be improperly calibrated, or the height of the barometer (38-m) that is used to adjust pressure to sea level may be in error.

4.2.3 Air Temperature and Humidity

TACMET air temperatures were unrealistically high during the day. This was particularly true during periods of light winds where they at times read as much as 4-deg C above temperatures reported by the C-MAN station. It is apparent that the sensor's shielding does not vent well. The poor venting may have also caused the humidity sensor to become saturated soon after buoy deployment and remain so through the evaluation.

4.3 Current Profiles

Current profiles were transmitted by the ADCP from deployment (23 June 2007) until after the buoy went adrift and was retrieved. The flow was initially out of the Straits of Florida (west to east) at between 75 to 100 cm/s. Flow decreased until mid-July and then became east to west or negligible for about two weeks. At the beginning of August, flow at 34 m and 90 m became somewhat separated with flow west to east at 90 m and negligible flow at 34 m (figure 1). Flow became uniform for short period of time thereafter and then flow increased rapidly from west to east in the upper layers (34 m) and east to west in the lower layers (90 m), with a strong tidal component. Flow between the two layers (74 m) oscillated strongly from +/- 20 cm/s (figure 2). Between 02 and 03 Z 17 August, the mooring separated and the buoy moved eastward along with the surface current. It was retrieved within twelve hours of going adrift.

The buoy was redeployed at the beginning of December 2007 and performed well during the following month. Initial currents during this period exceed 140 cm/s during the first week after re-deployment. There was some separation in flow, but it indicated slower currents with depth and no reversing flow.

5. CONCLUSIONS

The 1.8m design performed well in the conditions during the first deployment (<1.1 meter waves). More testing is needed during the winter to determine how well waves can be reproduced in higher sea conditions. Wind speed and direction were comparable to nearby data. The humidity sensor failed and the housing for the temperature sensor impacted temperature readings. More testing is necessary. The bridle-mounted ADCP also performed very well. There were very few dropouts in the data stream and loss of data in the near-surface water from interference from fish was expected. The buoy has been redeployed and analysis of the data will continue.

6. REFERENCES

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Parameter	Mean 42080	Mean EYW01	Bias	RMSD
Significant Wave Height (m)	0.9	1.0	-0.1	0.15
Peak Period (s)	5.9	4.8	1.1	1.2
Mean Wave Direction at Peak Period (degrees True)	88	98	-10	14

Table 1: Model-Buoy Comparison June 26-27, Number of comparisons: 8

Parameter	Mean 42080	Mean EYW01	Bias	RMSD
Significant Wave Height (m)	0.59	0.88	-0.29	0.30
Peak Period (s)	5.0	4.6	0.4	0.84
Mean Wave Direction at Peak Period (degrees True)	108	105	3	12

Table 2: Model-Buoy Comparison July 18-20, Number of observations: 10

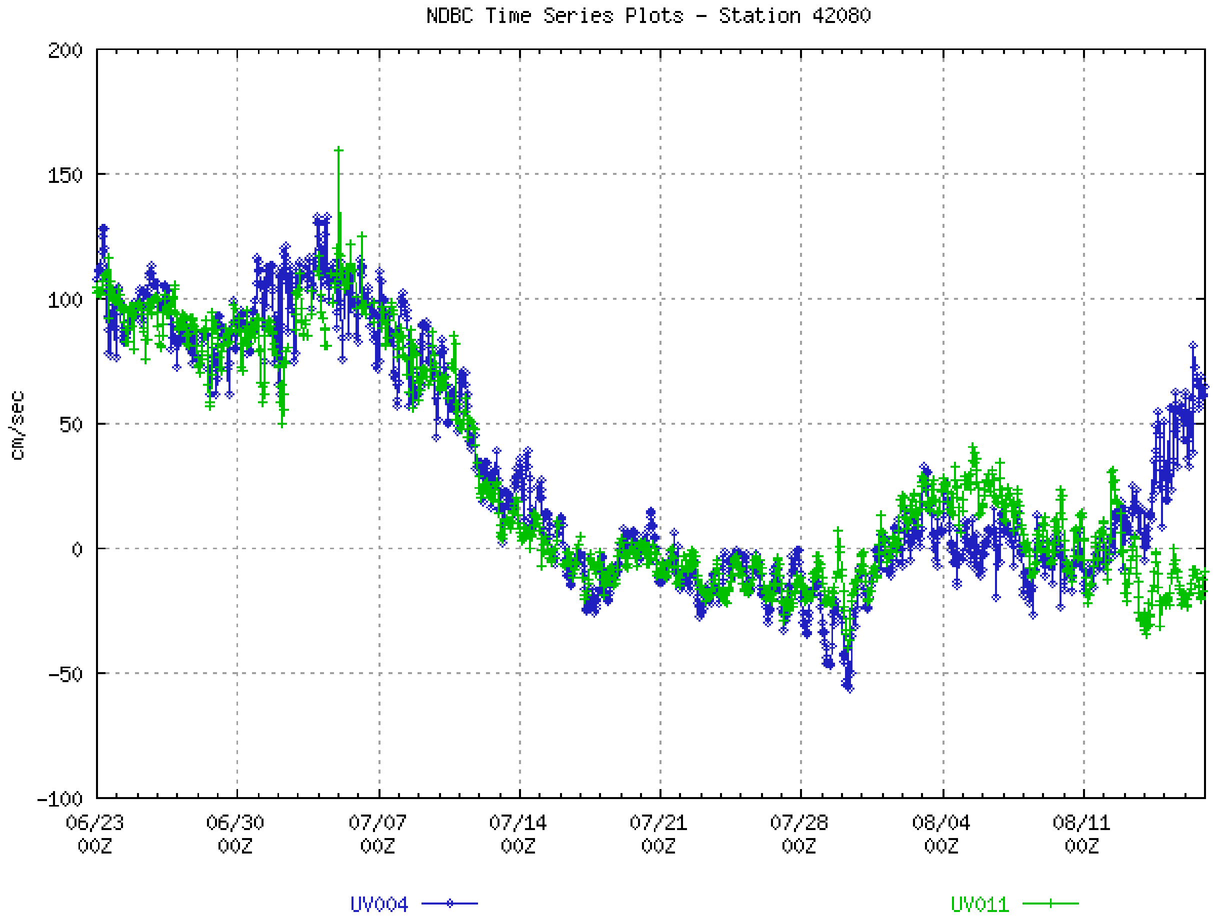

Figure 1. East-west component of velocity at 34 m (uv004) and 90 m (uv011) depths during first deployment.

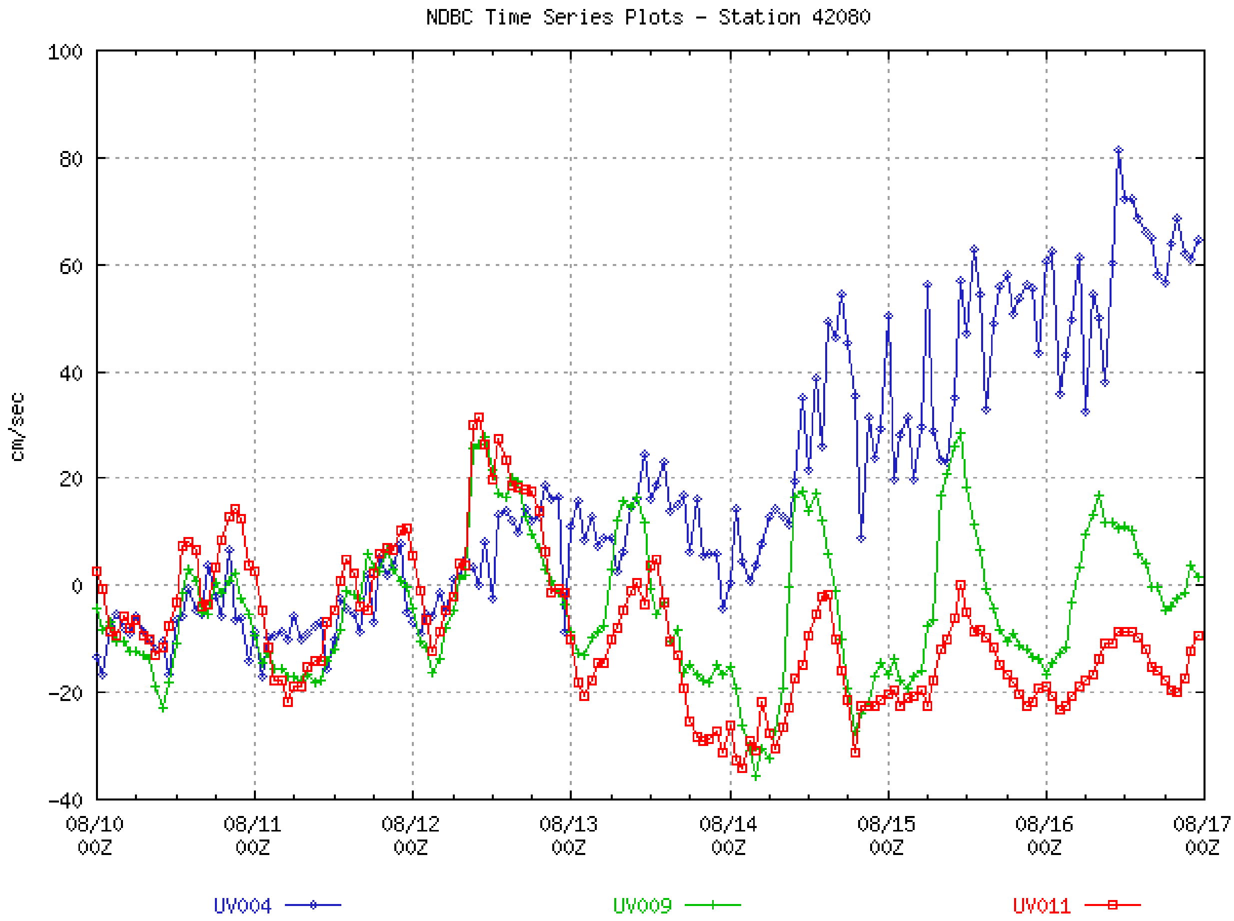

Figure 2. East-west component of velocity at 34 m (uv004), 74 m (uv009) and 90 m (uv011) depths during first deployment.