Poster 18, AMS 27th WAF/23rd NWP

The Results of the Field Evaluation of NDBC's Prototype Self-Contained Ocean Observations Payload (SCOOP)

Richard H. Bouchard[1], Rex V. Hervey[1], Walt McCall[2], Ryan Beets[3], Michael D. Robbie[3], Chris Wills[3], John Tancredi[3], Michael Vasquez[4], Steven DiNapoli[4]

[1]NOAA's National Data Buoy Center (NDBC), Stennis Space Center, MS 39529 USA

[2]University of Southern Mississippi, Stennis Space Center, MS 39529 USA

[3]PAE at NDBC, [4]NVision Solutions, Inc. at NDBC

Abstract: The National Oceanic and Atmospheric Administration's (NOAA) National Data Buoy Center (NDBC) is undertaking a fundamental and broad transformation of its ocean observing systems on moored buoys. This transformation is necessary to gain efficiencies in maintaining operational ocean observation networks and to increase their reliability. The Self-Contained Ocean Observations Payload (SCOOP) takes advantage of the advances in communications and small, efficient, multi-purpose sensors to reduce the size and costs of systems and expand the suite of available real-time ocean observations. NDBC has successfully completed a 180-day field evaluation of three prototype systems in the Gulf of Mexico (Table 1). The field evaluations indicate that SCOOP generally meets or exceeds NDBC's established criteria for the accuracy of its marine measurements and the detailed results will be presented. The advances in communications allow NDBC to increase the precision and decrease the latency of the observations from its moored buoys. SCOOP will provide an expanded suite of observations to include subsurface ocean temperature measurements to assist in determining hurricane energy potential and includes visual camera systems to provide daytime horizontal visibility estimations. The camera images can also serve to corroborate many of the automatic observations. The results of the successful field evaluation pave the way for the operational deployments of SCOOP in the Atlantic Ocean in time to provide the expanded suite of ocean observations during the 2015 hurricane season.

Table 1: Evaluation Locations

Prototype Payload	Location (See Figure 1)	Evaluation Start Date	Evaluation End Date	Comment
SCP01	11 km West of 42003	11/7/2014	5/5/2015	*Vaisala misaligned
SCP03	6 km North of 42003	11/7/2014	5/5/2015	Waves Failed 11/20/2014
SCP02	12 km South-Southwest of 42039	11/9/2014	5/7/2015	

Figure 1: Gulf of Mexico Test Locations

THE PLAN

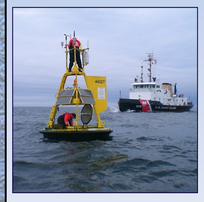
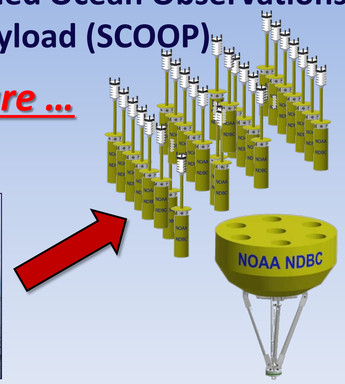
The Weather Buoy – Today


- 600 + hrs Labor to Construct
- Complex, Multiple Systems
- Weighs 3800 lbs
- Can't Field a 100% Tech Refresh in a Realistic Timeframe
- Vulnerable Electronics Opened in Field for Maintenance
- Requires Large, Expensive Ships to Service (≥ 175 ft)
- Minimum 6-8 hrs per Service Visit – Mission Aborts
- Lots of Opportunities for Mistakes & Failures

Self-Contained Ocean Observations Payload (SCOOP)

The Future …

Present

The *OceanOBS* Buoy - Tomorrow

SCOOP Payloads

Modular "Empty" Buoy

Basic Unit (NDBC MET-1) Includes MET, Cameras, AIS, and SATCOM

- ~ 40 hrs Labor to Construct
- Simple, Modular Sealed Systems
- Weight – One Person can Lift and Emplace on a Buoy
- Deploy Immediately on old & New Buoys – 100% Tech Refresh in a few Years
- Units Leave NDBC Sealed and Calibrated – Never Opened in Field
- With Smaller "Empty" Buoy Family – More Options for Deployment with Many Vessels
- Service Visit in Less than 30 min – Significant Reduction in Mission Aborts
- Lack of Opportunities for Mistakes & Failures – due to Sealed Units
- Same Unit goes Anywhere – on Legacy or New Buoys, C-MAN Towers, Ships, Land,……

SCOOP PROVIDES:

- Low O&M / Low Cost Impact to Host "Guest Sensors" on NOAA Observing Platforms
- Easy to Expand NOAA Sensor & Ocean Measurement Types
- Facilitate Affordable Partnerships with Industry & Academia, IOOS,…
- Achieve Robust *In-Situ* Ocean Observation Density & Rapid Deployment Capability

SCOOP IMPROVES:

- Reporting intervals decreased from one hour to 10 minutes
- All measurements except waves now available at 10 minute intervals. Previously only winds were available at 10 minutes
- Increased precision (> 2%) of wave spectral density data
- For the first time, NDBC Weather Buoys will provide routine, operational subsurface temperature measurements

RESULTS and CONCLUSIONS

1. Configurations of each SCOOP prototype included an Extended Meteorological Package and one of the two multi-sensor instruments (Table 2).
2. Operating Conditions: Winter and Spring (Table 3)
3. Accuracy Results are presented in Tables 4, 5, and 6. Generally the prototypes achieved the accuracy goals, stated with each table, based on the Root Mean Square Differences (RMSD) with the exception of the Wind Directions (Table 5) and the Wave Directions for SCP01 (Table 6). A misalignment of the anemometer contributed to the larger differences for wind direction (Table 5) for SCP01-Vaisala comparison.
4. Data Availability was exceptional achieving greater than 98% for all measurements except for SCP02 Vaisala, which became intermittent after 30 days (Table 5) and the SCP03 Waves, which failed after 10 days (Table 6). Subsurface oceanographic measurements failed at or shortly after deployment.
5. Encouraging Results of the prototype evaluations have led to further deployments within NDBC's weather buoy network.

Table 2: Meteorological Configurations

	Reference Stations 42003 and 42039	Extended Meteorological SCP01, SCP02, & SCP03	Vaisala SCP01 and SCP02	Gill SCP03
Winds				
Anemometer Height (meters)	5	4	4	4
Anemometer Make and Model	42003: R.M. Young 05108 42039: R.M. Young 05103	R.M. Young 05108, heavy duty propeller	Multi-sensor Vaisala WXT520	Gill MetPak Pro
Type	**Propeller/Vane**		**Ultrasonic**	
Sampling Frequency (Hz)	42003: 1.7066 42039: 2.00	1.0		
Averaging Period (minutes):	10			
Pressure				
Barometer Make and Model	Setra Inc 270	R.M. Young 61302V	Multi-sensor Vaisala WXT520	Gill MetPak Pro
Sampling Frequency (Hz)	42003: 1.7066 42039: 2.00	1.0		
Averaging Period (minutes)	8	10		

Mention of commercial products and companies is not intended as an endorsement by the U.S. Department of Commerce, NOAA, or NDBC.

Table 3: Operating Conditions November 2014 – May 2015

Reference Station:	42003 (Southern Gulf of Mexico)			42039 (Northern Gulf of Mexico)		
Measurement	Mean	Minimum	Maximum	Mean	Minimum	Maximum
Air Temperature (°C)	22.6	14.6	28.0	19.5	5.0	25.8
Sea-level Pressure (hPa)	1019.0	1005.1	1028.8	1019.7	1000.3	1032.3
Wind Speed (m/s)	6.1	1.14	17.8	6.1	0.0	17.9
Wave Height (m)	1.14	0.12	4.12	1.05	0.13	4.05

Table 4: Sea-Level Pressure

Goal: RMSD <= 1.0 hPa

Proto-Type Payload	Reference Station	# Samples	Bias (Mean Difference)	Mean Absolute Difference	Absolute Maximum Difference	RMSD
Sea-level Pressure (hPa), Extended Met Evaluation						
SCP01	42003	25891	-0.10	0.19	1.55	0.24
SCP03	42003	25892	-0.27	0.28	2.25	0.33
SCP02	42039	22109	-0.10	0.18	1.25	0.21
Sea-level Pressure (hPa), Vaisala Evaluation						
SCP01	42003	25891	-0.12	0.21	1.77	0.25
SCP02	42039	25891	0.04	0.15	1.37	0.21
Sea-level Pressure (hPa), Gill Evaluation						
SCP03	42003	25890	-0.15	0.27	6.73	0.35

Table 5: Winds

Wind Speed Goal: RMSD <= 1.0 hPa

Wind Direction Goal: RMSD <= 10°

Proto-type Payload	Reference Station	# Samples	Bias (Mean Difference)	Mean Absolute Difference	Maximum Absolute Difference	RMSD
Wind Speed (m/s), Extended Met Evaluation						
SCP01	42003	25891	-0.26	0.47	14.5	0.67
SCP03	42003	25892	-0.11	0.44	9.60	0.52
SCP02	42039	25891	-0.08	0.36	9.40	0.65
Wind Speed (m/s), Vaisala Evaluation						
SCP01	42003	25866	0.16	0.45	15.5	0.65
SCP02	42039	22125	0.29	0.44	9.90	0.60
Wind Speed (m/s), Gill Evaluation						
SCP03	42003	25890	0.14	0.47	9.90	0.67
Wind Direction (degrees True), Extended Met Evaluation						
SCP01	42003	25891	-1.67	7.61	179	14.63
SCP03	42003	25892	2.31	8.41	178	15.49
SCP02	42039	25891	-4.98	8.32	179	14.24
Wind Direction (degrees True), Vaisala Evaluation						
SCP01	42003	25886	15.14	16.94	179	*20.96
SCP02	42039	22109	-6.25	9.77	180	15.42
Wind Direction (degrees True), Gill Evaluation						
SCP03	42003	25890	5.41	9.63	180	16.24

Table 6: Waves

Wave Height Goal: RMSD <= 0.2 m

Wave Period Goal: RMSD <= 1.0 s

Wave Direction Goal: RMSD <= 10°

Proto-type Payload	Reference Station	# Samples	Bias	Mean Absolute Difference	Absolute Maximum Difference	RMSD
Significant Wave Height (meters)						
SCP01	42003	4286	0.020	0.08	0.68	0.12
SCP03	42003	304	0.004	0.07	0.50	0.10
SCP02	42039	4269	-0.004	0.06	0.60	0.09
Dominant or Peak Period (seconds)						
SCP01	42003	4286	0.010	0.45	16.88	0.83
SCP03	42003	304	0.004	0.29	1.71	0.42
SCP02	42039	4269	-0.029	0.42	5.52	0.78
Mean Wave Direction[1] (degrees True)						
SCP01	42003	1346	1.780	10.23	148.00	15.29
SCP03	42003	98	1.220	7.01	62.00	10.46
SCP02	42039	1444	-2.180	7.61	58.00	10.13

Wave Configuration: Sensor: Microstrain 3DM-GX1® using NDBC's Digital Directional Wave Module (DDWM), sampling at 1.7066 Hz for 20-minutes. 42003, 42039, and SCP02 are 3-meter aluminum, discus hulls. SCP01 and SCP03 are 2.4-m foam, discus hulls.

[1]The Mean Wave Direction is only evaluated when the Dominant Periods are equal, waves are greater than or equal to 0.5 m, and then the remaining differences are weighted by wave height.