An Evaluation of Data from the Prototype, ADSMEX buoy

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Introduction

Occasionally, extended outages occur at National Data Buoy Center (NDBC) deep ocean moored buoys because of a lengthy period of bad weather or the lack of United States Coast Guard (USCG) resources to provide transportation for servicing. To provide some observations in these cases, NDBC has developed an Air-Deployed, Self-Moored, Expendable (ADSMEX) buoy, which could be a "gap filler" until the permanent, moored buoy is repaired. The concept is to adapt a proven drifting buoy design into a cost-effective, stationary or slow-moving buoy, capable of taking the most important measurements, and deployable by aircraft or ship of opportunity. Like a drifting buoy, an ADSMEX buoy reports six to eight times each day through National Oceanic and Atmospheric Administration (NOAA) polar orbiting satellites and data are processed by Service Argos, Inc. Because of this limited reporting capability and its design service life of one year an ADSMEX buoy is more suitable as temporary replacement for moored buoys located well offshore. It is also possible to deploy an ADSMEX in front of a hurricane or near an oil spill as part of an adaptive, short lead time measurement strategy. A photo of an ADSMEX buoy which measures wind direction, speed, gust, sea level pressure, air temperature, and sea surface temperature is shown in Figure 1. Measurement characteristics are identical to those given for the wind-measuring drifting buoys (Gilhousen, 1993).

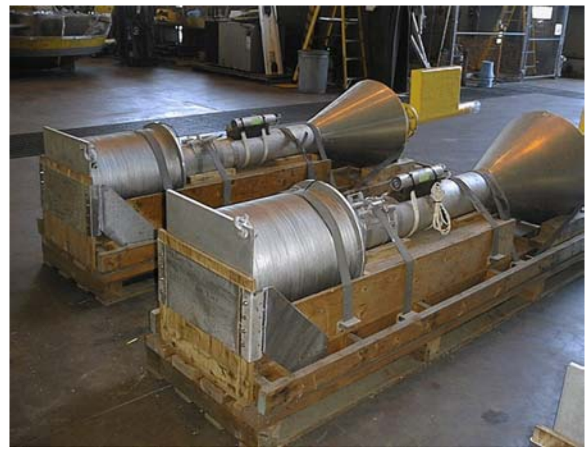

Figure 1. A photograph of the ADSMEX buoy with its spool of mooring line.

Because the buoy is attached to 1/8"diameter, braided, spectra line, the drift rate will be greatly reduced or even eliminated. They may be deployed in water up to 14,000 feet deep. The buoyant line mimics the effect of an inverse catenary mooring, the type used at NDBC's deep water moorings. The amount of line used will be a function of the water depth.

Field Evaluation

Three (3) prototype buoys were deployed in 2003 in the Gulf of Alaska, the Bering Sea, and the Gulf of Mexico. We will examine the observations collected from the system deployed in the Gulf of Mexico near an NDBC moored buoy.

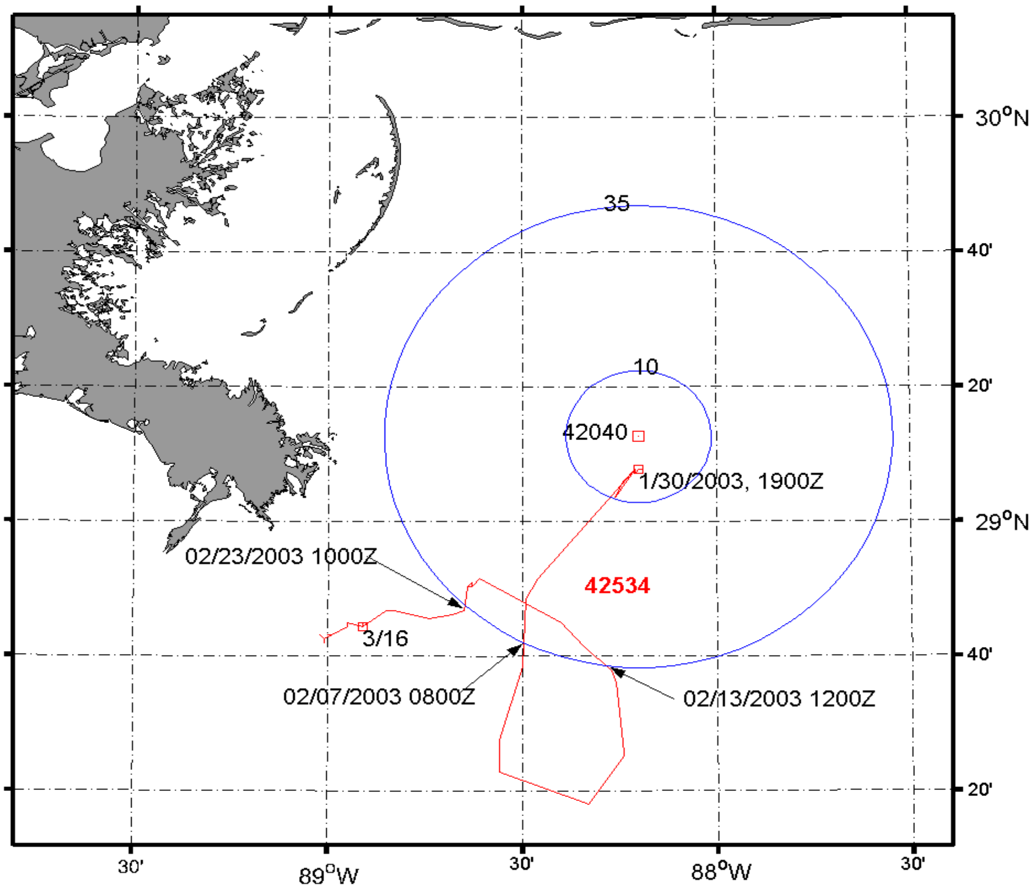

Figure 2. The track of ADSMEX buoy 42534 in relation to moored buoy 42040. Wind direction, speed, sea level pressure, air and sea surface temperature from the ADSMEX buoy were compared against the NDBC moored buoy to assess the quality of the ADSMEX data (Gilhousen 1987).

More specifically, the ADSMEX buoy, identified as 42534, was deployed 50 miles east of the mouth of the Mississippi River in January 2003 near NDBC moored buoy station 42040 (Figure 2).

Figure 2 (above), shows the track of 42534 as it drifted from 42040 to the southwest passing near the mouth of the Mississippi River.

Other deployments featured longer strings of line and drifter much more slowly.

Figure 3 (below), shows a plot comparing the observed 4.7-m wind speed at 42040, which is the continuous trace, with the observed 1-m wind speeds of 42534.

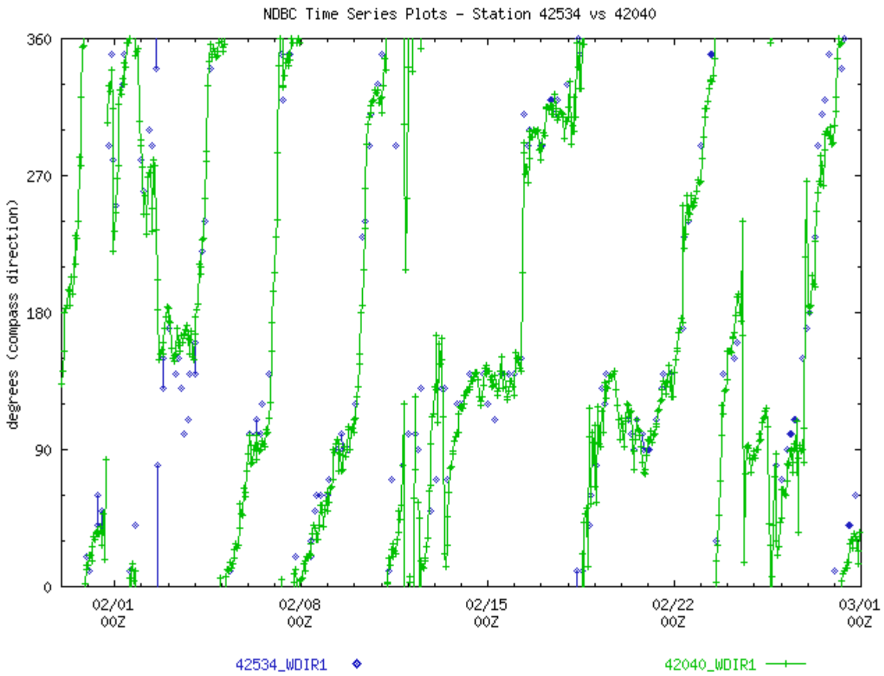

Figure 3. A time series plot comparing the wind speeds from the ADSMEX buoy, 42534, with a moored buoy, 42040. The anemometer height of the ADSMEX buoy is 1 meter compared with a height of 4.7 m for 42040.

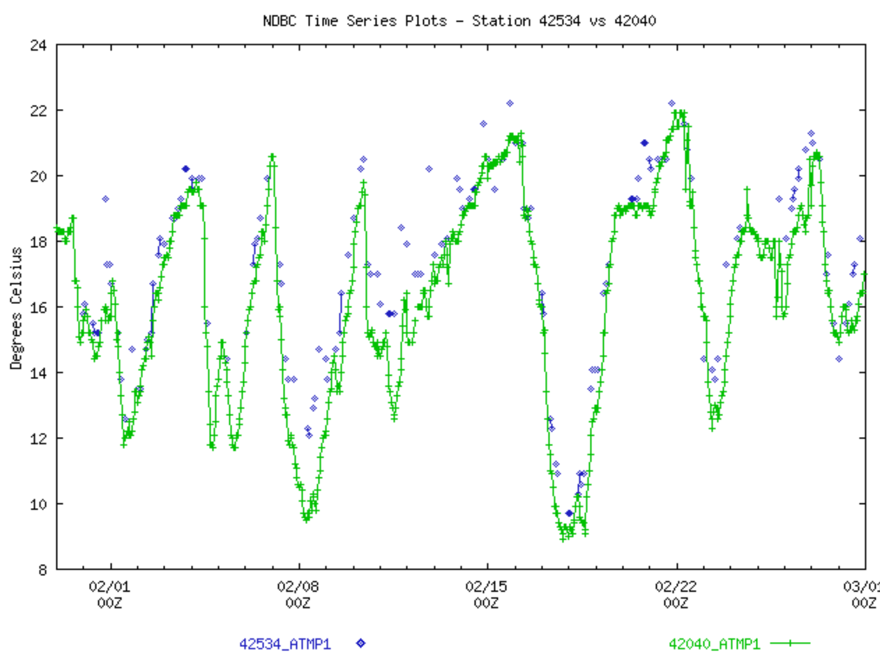

Figure 4. Same as Figure 3, except for wind direction.

Figure 4 (above), shows a similar comparison for wind directions. A statistical comparison follows a brief qualitative discussion below, in a qualitative sense, the speeds track together well, especially during the beginning part of the time series where the buoys were closer together. Particularly impressive were the observations during a storm on Feb. 23, 2003. The wind waves reached 3.5 m with 2.5 m swell at 42040 without any obvious degradation in the comparison. This indicates that buoy motion or sheltering does not influence the wind measurement, at least at these wave heights.

Figure 5 (below), shows a plot comparing the observed 3-m air temperatures at 42040 with those observed by the ADSMEX buoy, 42534. 42534's air temperatures tends to be higher than 42040's, especially later in the period. Some of this difference could be caused by the difference in sensor height (1 vs. 3 m) since the Gulf tends to be warmer than the air temperature at this time of the year. Also, part of this difference could be caused by legitimate spatial differences as ADSMEX encountered warmer waters as it drifted south off the continental shelf.

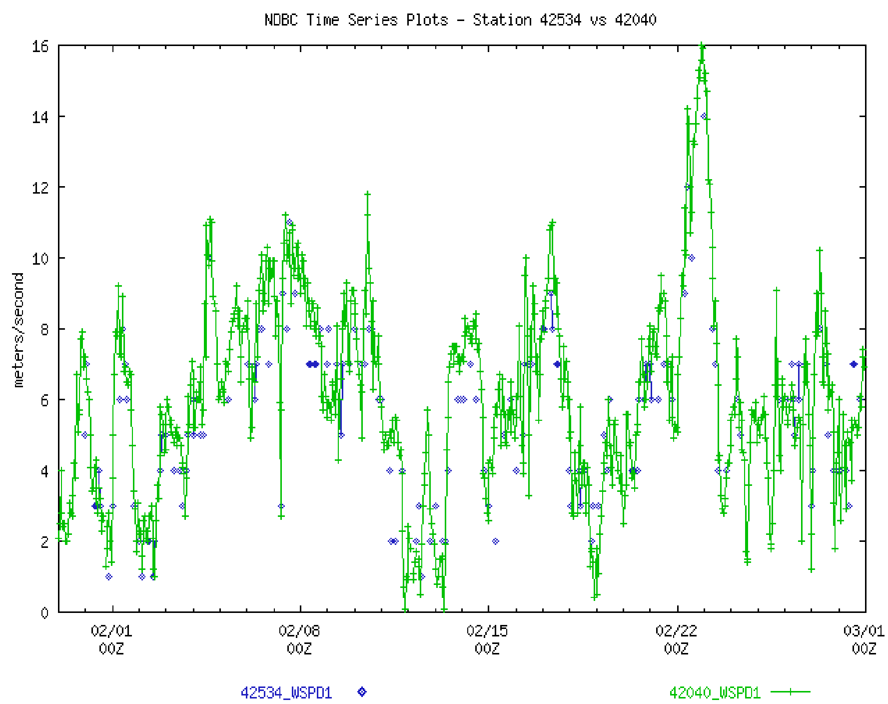

Figure 5. Same as Figure 3, except for air temperature.

Figure 6 (below), shows a similar comparison of sea surface temperatures.

The temperatures are in general agreement until late in the period when ADSMEX drifts away from 42040 into warmer waters.

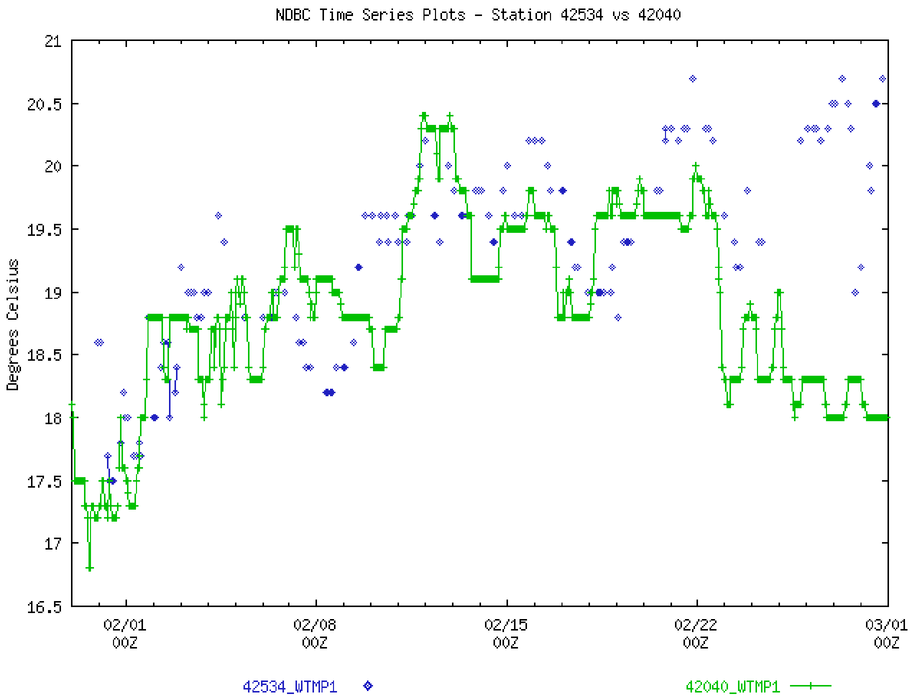

Figure 6. Same as Figure 3, except for sea surface temperature.

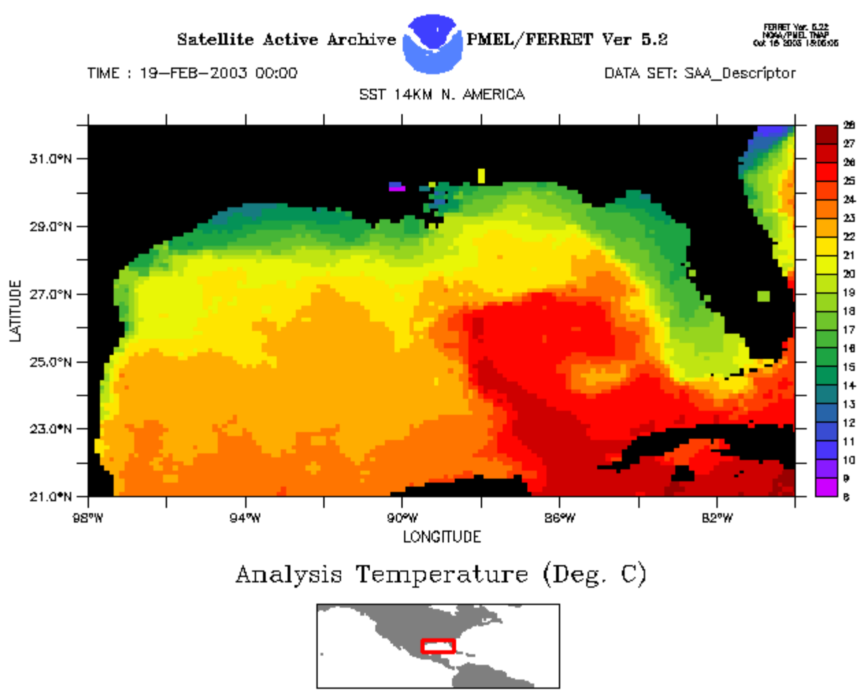

Figure 7. The NESDIS 14-km sea surface temperature analysis based on polar-orbiting AVHRR data on Feb. 19, 2002, 0000 UTC

The 14-km sea surface temperature analysis based on polar-orbiting AVHRR on Feb. 19, shown in Figure 7 (above), shows a strong east-west temperature gradient in this area, supporting the notion that a legitimate temperature difference of several degrees C existed between the two buoys. Unfortunately, the pressure measurement failed a week after deployment. Twenty six observations were collected before failure and 42054's pressure averaged 0.8 hPa higher than 42040's.

Statistical Comparison

To help quantify the differences, several comparison statistics are shown in Table 1. (below).

Measurement					
	Wind Speed m/s	Adjusted Wind Speed m/s	Wind Direction deg.	Air Temp. Deg. C	Water Temp. Deg. C
Distances < 10 n mi					
N	33	33	0	35	35
Bias	- 0.67	0.12		0.76	0.23
SDE	0.76	0.88		0.68	0.55
FP	1.01	0.90		1.02	0.60
Distances < 30 n mi					
N	47	47	24	50	50
Bias	- 0.82	0.06	1.2	0.73	0.18
SDE	0.95	1.03	14.1	0.68	0.51
FP	1.25	1.03	14.2	0.99	0.54
Distances < 35 n mi					
N	94	94	55	99	97
Bias	- 0.74	0.27	- 3.8	0.74	0.25
SDE	1.17	1.19	12.3	0.69	0.53
FP	1.38	1.22	12.9	1.01	0.76

Table 1. The sample size, N, bias, standard deviation of the differences (SDE), and the functional precision (FP) of the differences between an ADSMEX buoy and a moored buoy (42534 - 42040) at various separation distances.

The statistics were calculated for three ranges of separation distance, less than 10 nm (18.5 km), less than 30 nm (55.6 km), and less than 35 nm (64.7 km) . Statistics are shown for both unadjusted and adjusted wind speeds. ADSMEX wind speeds were adjusted to 4.7 m, the height of the anemometers on 42040, by using the power law with a coefficient of 0.11 (Hsu et. al., 1994).

Wind direction statistics were calculated only when the wind speed was 5 m/s or higher. N refers to the sample size, the bias is the mean difference, SDE is the standard deviation of the differences, and FP is the functional precision (Hoehne, 1977), which is a root-mean square combination of bias and SDE. Once the wind speeds are adjusted to account for the height difference, FP for separation distances less than 10 nm is less than the +/- 1.0 m/s stated accuracy for NDBC moored buoys.

Wind speed differences between two NDBC moored buoys located 3.3 km apart gave an FP of 0.796 m/s and a similar comparison between an adjacent platform and a buoy gave an FP of 1.00 m/s (Gilhousen, 1997). An FP of 0.90 m/s would indicate that wind speeds measured by ADSMEX are of comparable accuracy to a moored buoy.

Conclusions regarding the accuracy of wind direction are somewhat different. When wind directions differences between two NDBC moored buoys were calculated, an FP of 9.27 degrees resulted, which was less than the stated accuracy of 10 degrees (Gilhousen, 1997). However, the FP in this study ranges from 12.9 degrees to 14.1 degrees.
To place this in perspective, Wilkerson and Earle (1990) compared ship wind direction observations with those from moored buoys when the distance was less than 25 km and calculated a FP of 42 degrees. Therefore, the accuracy of wind directions measured by ADSMEX is not quite as good as a moored buoy, but much better than manual ship observations. The increase in FP is not thought to be of any operational significance. The FP between the ADSMEX air temperatures and those measured by 42040 are about 1.0 degree C, which is NDBC's stated accuracy.

Collocated NDBC moored buoys yield an FP of 0.29 degrees C (Gilhousen 1997). However, the thermistor height on the moored buoys was the same, while the ADSMEX thermistor is at 1 m compared to the 3 m elevation on 42040. The FP between the ADSMEX sea surface temperatures and those measured by 42040 range between 0.5 and 0.6 degree C, depending on the separation distance. This is considerably less than NDBC's stated accuracy of +/- 1.0 degree C, but more than an FP of 0.29 degrees C achieved between several pairs of collocated, moored buoys (Gilhousen, 1997). The larger separation distances between ADSMEX and 42040 is the likely cause here.

Conclusions

Based on comparisons with a nearby moored buoy, the accuracy of ADSMEX measurements meets the stated requirements for operational purposes. In particular, the accuracy of ADSMEX wind speed measurements appears comparable to the quality of moored buoy winds once anemometer height differences are accounted for.

References

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