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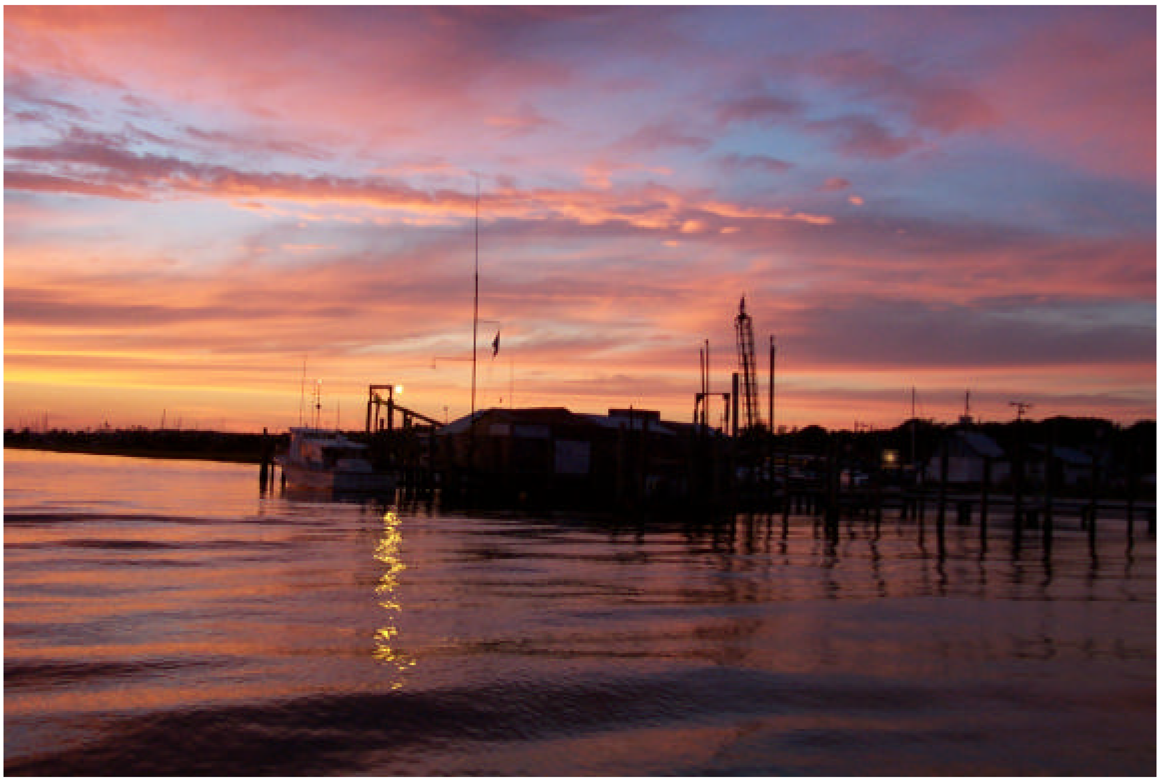
Pre-Deployment Calibration
Of OBS and ADV Sensors Deployed for
Mound Study Project 6000-21
Cape Fear, NC

June/July 2001



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By

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1. SUMMARY

This work was conducted in support of an ongoing investigation on sediment dispersal and evolution of a mixed-sediment disposal mound by the US Army Corps of Engineers (USACE) in Cape Fear, NC: Mound Study Project Number 6000-21. Two Sontek Acoustic Doppler Velocimeter (ADV) arrays equipped with three Seapoint Optical Backscatter Sensors each were calibrated at the Virginia Institute of Marine Science in specialized calibration chambers to verify the instruments' response range to water velocity (ADVs) or suspended sediment concentration (OBSs) before deployment. Calibrations showed stable OBS response to suspended sediment with linear curves at low concentrations and quadratic curves at high concentrations. ADV response to current speed was stable and linear with gains and offsets consistent with the factory calibration.

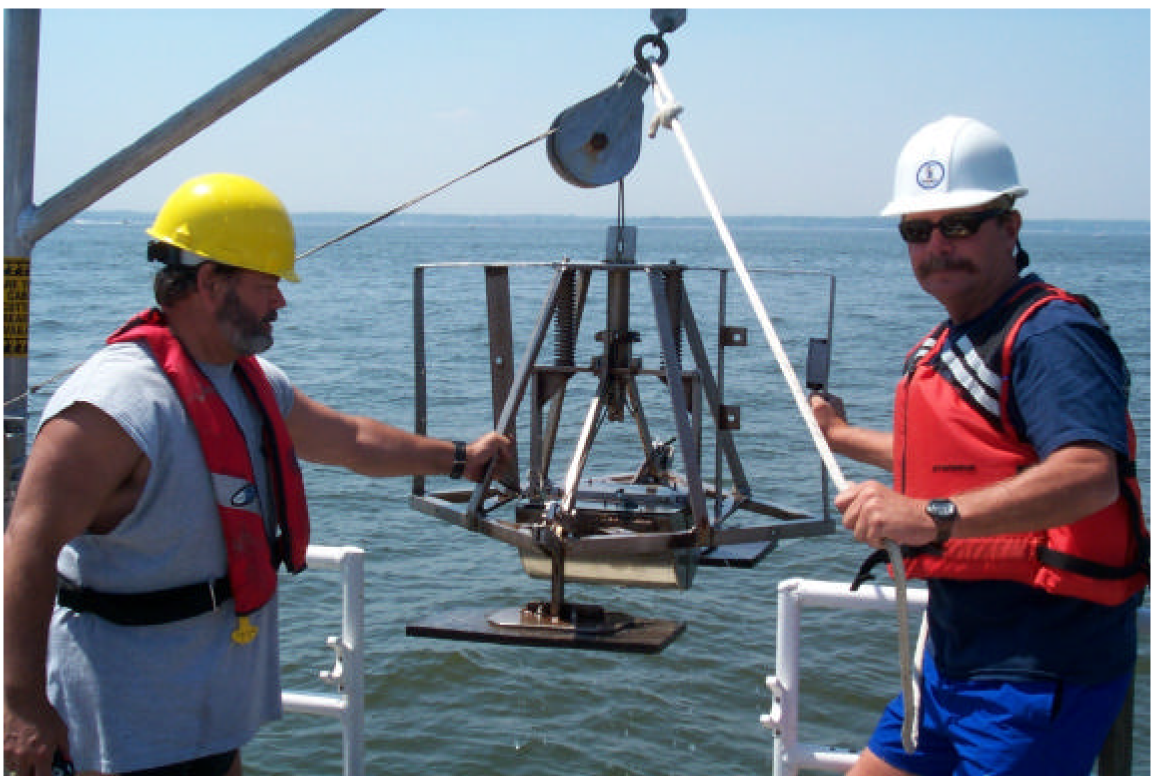

Figure 1. Smith-Mac bottom sediment grab used to collect the top approximately 10 cm with the sediment-water interface left relatively intact.

2. METHOD

The Sontek array case G187 was equipped with ADV B211 and OBS sensors 1 through 3 (S/N 1761, 1762 and 1763 respectively). Array case G181 was equipped with ADV B205 Sensors and OBS sensors 1 through 3 (S/N 1764, 1768 and 1769). June 2001 calibrations were attempted for all sensors. Array G187 calibrations were successful. Array G181 had connector problems and was sent back to Evans-Hamilton, Inc., after failed attempts to communicate with the ADV and OBS sensors. July 2001 calibrations for Array G181 sensors were successful.

Sontek "Sonterm" software was used to communicate with the instruments. The June calibrations were hurried due to delay in shipment of the instrument Arrays to VIMS and the tight deadline for deployment of the instruments. Thus in June there was not enough time to become familiar with the Sonterm software. Therefore 10 records were recorded by hand and averaged for each OBS sensor at each concentration, and 7 records were recorded and averaged for each water velocity used to calibrate the ADV sensors. In July, familiarization with the Sonterm software allowed log files of over 100 records each to be collected and averaged for each calibration point in the second attempt to calibrate the G181 sensor.

2.1 Sediment Collection

Sediment for calibration was collected in May 2001 using a Smith-Mac bottom grab (see Figure 1) from the proposed bipod site on the western end of the Mound Crest (33^{o}8.2574 N, 78^{o}8.1427 W). Sediment Entrapment Devices were to be deployed to collect suspended sediment for calibration purposes. Because the bipods were not functional at the time of calibration, bottom sediment had to be used for the pre-deployment calibrations. Wet sieve methods were used to separate the bottom sediment into mud (< 63 microns), sand (63 – 2 mm), and gravel (> 2mm) fractions. The West Pod bottom sediment contained 26.5, 72.96, and 0.46 percent mud, sand, and gravel, respectively.

The mud fraction was separated further into clay (< 20 micron) and silt (20 – 63 microns) using pipette analysis. The mud fraction consisted of 72% clay and 28% silt. Rapid Sand Analysis (RSA) results showed a peak sand grain size of approx 2.5 phi (180 microns).

Figure 2. Modified Downing-Beach OBS calibration chamber use to calibrate OBS Sensors. During calibration, sensors are mounted on the inner wall of the inner chamber.

2.2 OBS Calibration

OBS sensors were mounted to the inner wall of the inner chamber of the modified 69 liter Downing-Beach calibration chamber (Figure 2). Sediment was separated into two fractions, mud (< 63 microns) and sand (63 microns – 2mm) to provide the end user two calibration curves to compensate for the OBS's known sensitivity to grain-size. Due to the hurried nature of the June calibrations, there was not enough time to separate sufficient mud and sand sediment that when added to the calibration chamber the final concentration of either fraction would saturate the sensors. Addition of the primary mud sediment solution to the calibration chamber provided nine mud concentrations for the June calibrations ranging from 0 to 0.48 g/L. (The maximum suspended sediment concentration sampled during the May 2001 survey was 0.28 g/L.). Twelve mud concentrations were obtained by adding the primary mud sediment solution to the calibration chamber in July, resulting in a range of 0 to 4 g/L. Even at the highest mud concentration of 4 g/L, the sensors never reached saturation. Sand sediment added to the calibration chamber resulted in twelve sand concentrations ranging from 0 to 40 g/L for both the June and July calibrations. Zero readings were taken for all calibrations first without stirring (0* in Tables 1 and 2). All the rest of the concentrations were recorded with stirring by the propeller visible in Figure 2.

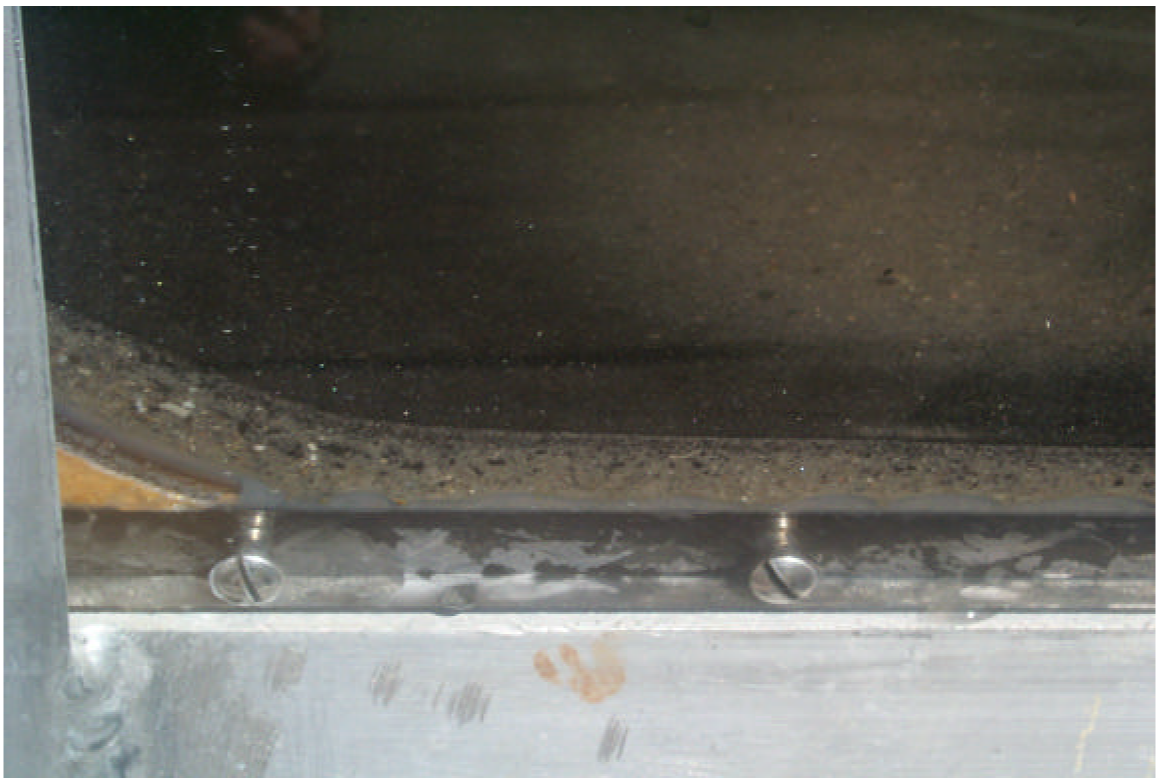

Figure 3. Visible organic matter on surface of sand in OBS calibration chamber at end of June sand calibration run.

It was noticed at the end of the June sand calibration run that a fine layer of organic matter settled on top of the sand when the motor was turned off (Figure 3). This organic matter should cause the OBS to have a greater response for each concentration than muffled sand would have, and the resultant calibration curve will tend to somewhat over estimate the sand concentration in suspension. Sand used for the July sand calibration was muffled at 550 deg C to remove this organic matter before adding to the calibration chamber.

Figure 4. ADV calibration in re-circulating flume at VIMS.

2.3 ADV Calibration

ADV calibrations were conducted in the 80 ft, 6000 gallon re-circulating flume at VIMS. An AC motor and impeller controlled the water speed. The actual water velocity was verified using a weighted straw that passed two laser beams 50 centimeters apart. The lasers started and stopped an electronic timer which records time to 1/1000 of a second.

The ADV sensor, mounted on a cross bar so that it was recording the velocities of the water in the center of the flow, was rotated so that each co-ordinate (X+, X-, Y+, Y-) was sequentially facing directly into the flow. For each co-ordinate, the water velocity was adjusted so 3 or 4 calibration points could be recorded. In June, water velocities of approximately 15 cm/sec, 30 cm/sec and 45 cm/sec were used. In June, the water in the flume was not clean enough to allow for a calibration point at approximately 60 cm/sec, as particles in the water erroneously tripped the laser timer. In July water velocities of 15, 30, 45 and 60 cm/sec were used.

3. **RESULTS**

Table 1 contains the averaged results and the standard deviation of the raw data from the mean for the Array G181 three OBS sensors' mud and sand calibrations. Figure 5 displays graphs of the quadratic fit of the data along with their corresponding coefficients. Figures 5 (a, c, and e) are the mud calibrations and Figures 5(b, d, and f) are the sand calibrations. Figure 6 displays graphs of the linear fit of the data along with their corresponding coefficient. Figures 6 (a, c, and e) are the mud calibrations (concentrations less than 0.4 g/L) and Figures 5(b, d, and f) are the sand calibrations (concentrations less than 1.0 g/L).

Table 2 contains the averaged results and the standard deviation of the raw data from the mean for the Array G187 three OBS sensors' mud and sand calibrations. Figure 7 displays graphs of the quadratic fit of the data along with their corresponding coefficients. Figures 7 (a, c, and e) are the mud calibrations and Figures 7(b, d, and f) are the sand calibrations. Figure 8 displays graphs of the linear fit of the data along with their corresponding coefficient. Figures 8 (a, c, and e) are the mud calibrations (concentrations less than 0.4 g/L) and Figures 8(b, d, and f) are the sand calibrations (concentrations less than 1.0 g/L).

Tables 3 and 4 contain the averaged results and the standard deviation of the raw data from the mean for the Array G181 ADV B205 and Array G187 ADV B211, respectively. Figures 9 and 10 are the linear fit of the data along with their corresponding coefficients.

Table 5 is a summary of the best fit coefficients and an estimate of their errors for all the sensors.

Table 1. Array G181 OBS Pre-deployment Calibration Data **July 2001**

Calibration using bottom sediment from West Mound Crest site collected May 2001
Mud separated using wet sieve method has 72% clay and 28% silt.
Sand has a peak grain size of approx 2.5 phi (180 micron). See May report for RSA.
0* -- zero concentration without stirring Sand was muffled for this calibration

Sensor 1 S/N 1764

Conc (g/L)	MUD OBS Response mean	MUD OBS Response std dev	Conc (g/L)	SAND OBS Response mean	SAND OBS Response std dev
0*	275	34	0*	338	28
0	279	77	0	322	95
0.01	858	94	0.05	340	95
0.02	1028	117	0.1	87	41
0.04	1913	52	0.2	512	114
0.08	2553	169	0.4	475	145
0.16	5756	174	0.8	1286	229
0.4	13108	264	1	1310	244
0.8	24204	332	5.6	7712	885
1.2	33085	395	10.6	13549	1372
1.6	40731	476	15.6	18959	1759
2.4	53181	545	20.6	22356	2241
3.2	63205	632	40.6	29878	2522
4	65520	680			

Sensor 2 S/N 1768

Conc (g/L)	MUD OBS Response mean	MUD OBS Response std dev	Conc (g/L)	SAND OBS Response mean	SAND OBS Response std dev
0*	215	48	0*	488	18
0	245	52	0	477	44
0.01	460	43	0.05	467	40
0.02	647	58	0.1	540	38
0.04	940	32	0.2	484	38
0.08	1663	52	0.4	782	76
0.16	2937	30	0.8	993	90
0.4	7378	64	1	1160	130
0.8	13062	98	5.6	4584	423
1.2	17690	104	10.6	7333	703
1.6	21829	131	15.6	10473	852
2.4	28658	147	20.6	12522	1061
3.2	34078	158	40.6	16957	1549
4	38540	166			

Sensor 3   S/N 1769

	MUD				SAND	
Conc	OBS Response			Conc	OBS Response	
	mean	std dev			mean	std dev
(g/L)				(g/L)		
0*	389	40		0*	280	44
0	276	68		0	150	85
0.01	454	87		0.05	167	92
0.02	658	83		0.1	284	57
0.04	1090	73		0.2	227	43
0.08	1779	68		0.4	598	40
0.16	3326	74		0.8	883	76
0.4	7446	100		1	1008	130
0.8	13055	166		5.6	4770	424
1.2	17709	222		10.6	7664	592
1.6	21849	256		15.6	11244	703
2.4	28486	309		20.6	13131	1047
3.2	33933	335		40.6	17851	1357
4	38299	338				

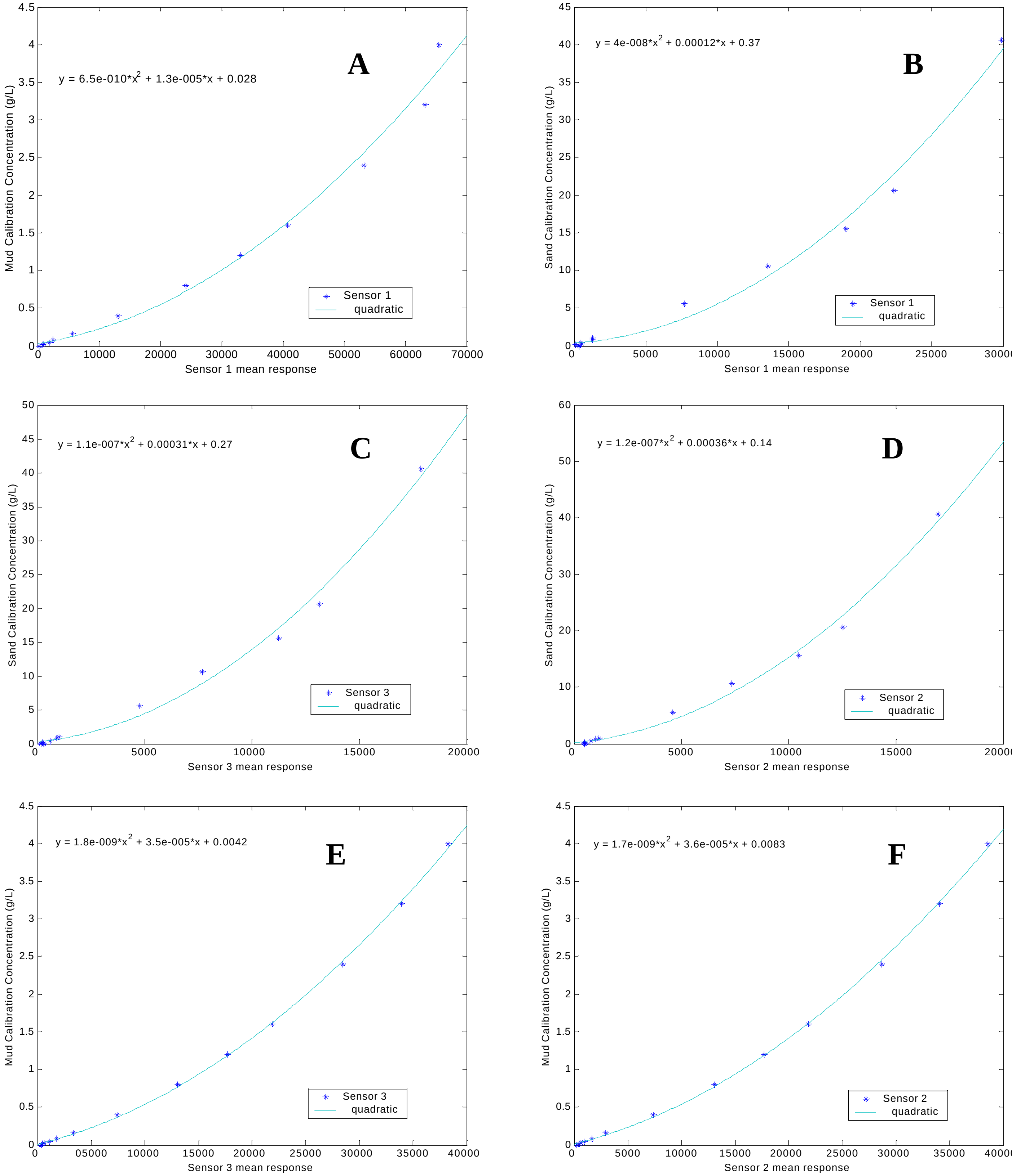

Figure 5. Array G181 OBS sensor calibration graphs. A, C, and E are quadratic fits of the mud calibrations for sensors 1, 2, and 3, respectively. B, D, and F are the quadratic fits of sand calibrations for sensors 1, 2, and 3, respectively.

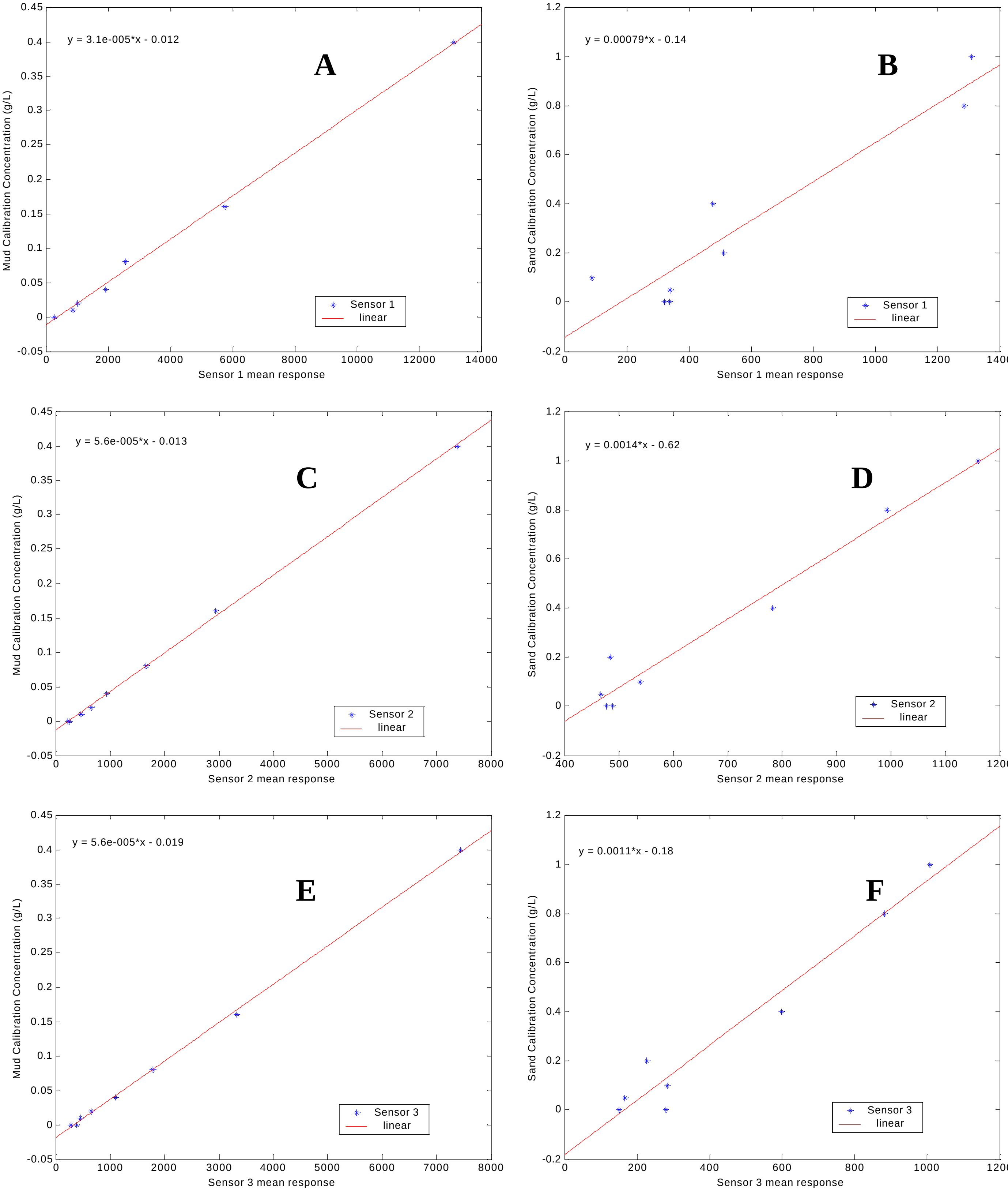

Figure 6. Array G181 OBS sensor calibration graphs. A, C, and E, are linear fits of the mud calibrations for sensors 1, 2, and 3, respectively. B, D and F, are linear fits of the sand calibrations for sensors 1, 2, and 3, respectively.

Table 2. Array G187 OBS Pre-deployment Calibration Data   June 2001

Calibration using bottom sediment from West Mound Crest site collected May 2001
Mud separated using wet sieve method has 72% clay and 28% silt.
Sand has a peak grain size of approx 2.5 phi (180 micron). See May report for RSA.
0* -- zero concentration without stirring

Sensor 1 S/N 1761

Conc (g/L)	MUD OBS Response mean	std dev
0*	498	12
0	560	65
0	429	26
0.01	853	35
0.02	1540	22
0.04	2027	130
0.08	3796	171
0.16	7492	199
0.24	10709	133
0.32	14312	201
0.4	17232	165
0.48	19370	186

Conc (g/L)	SAND OBS Response mean	std dev
0*	85	16
0	603	38
0.05	669	71
0.1	339	57
0.2	1146	111
0.4	1389	143
0.8	2451	131
1	2761	122
5	12922	392
10	23054	1328
15	29358	1546
20	35536	1897
30	47681	2623
40	56109	3304

Sensor 2 S/N 1762

Conc (g/L)	MUD OBS Response mean	std dev
0*	326	19
0	232	58
0	450	30
0.01	435	26
0.02	1542	39
0.04	2078	53
0.08	4038	78
0.16	6814	118
0.24	9725	111
0.32	15370	385
0.4	17245	230
0.48	21299	260

Conc (g/L)	SAND OBS Response mean	std dev
0*	123	30
0	605	40
0.05	386	49
0.1	459	37
0.2	726	107
0.4	1414	193
0.8	2011	186
1	2286	134
5	11675	1344
10	18406	2010
15	25330	2433
20	33082	2615
30	40280	3758
40	49046	4034

Sensor 3 S/N 1763

Conc (g/L)	MUD OBS Response mean	MUD OBS Response std dev
0*	74	11
0	243	13
0	192	20
0.01	520	14
0.02	470	38
0.04	2167	3233
0.08	2262	24
0.16	4366	183
0.24	6568	115
0.32	6403	164
0.4	8859	421
0.48	11443	137

Conc (g/L)	SAND OBS Response mean	SAND OBS Response std dev
0*	348	19
0	648	20
0.05	408	14
0.1	524	36
0.2	853	52
0.4	914	122
0.8	1290	104
1	1659	105
5	6326	558
10	10702	992
15	14486	1629
20	16551	1168
30	24962	1979
40	30992	3377

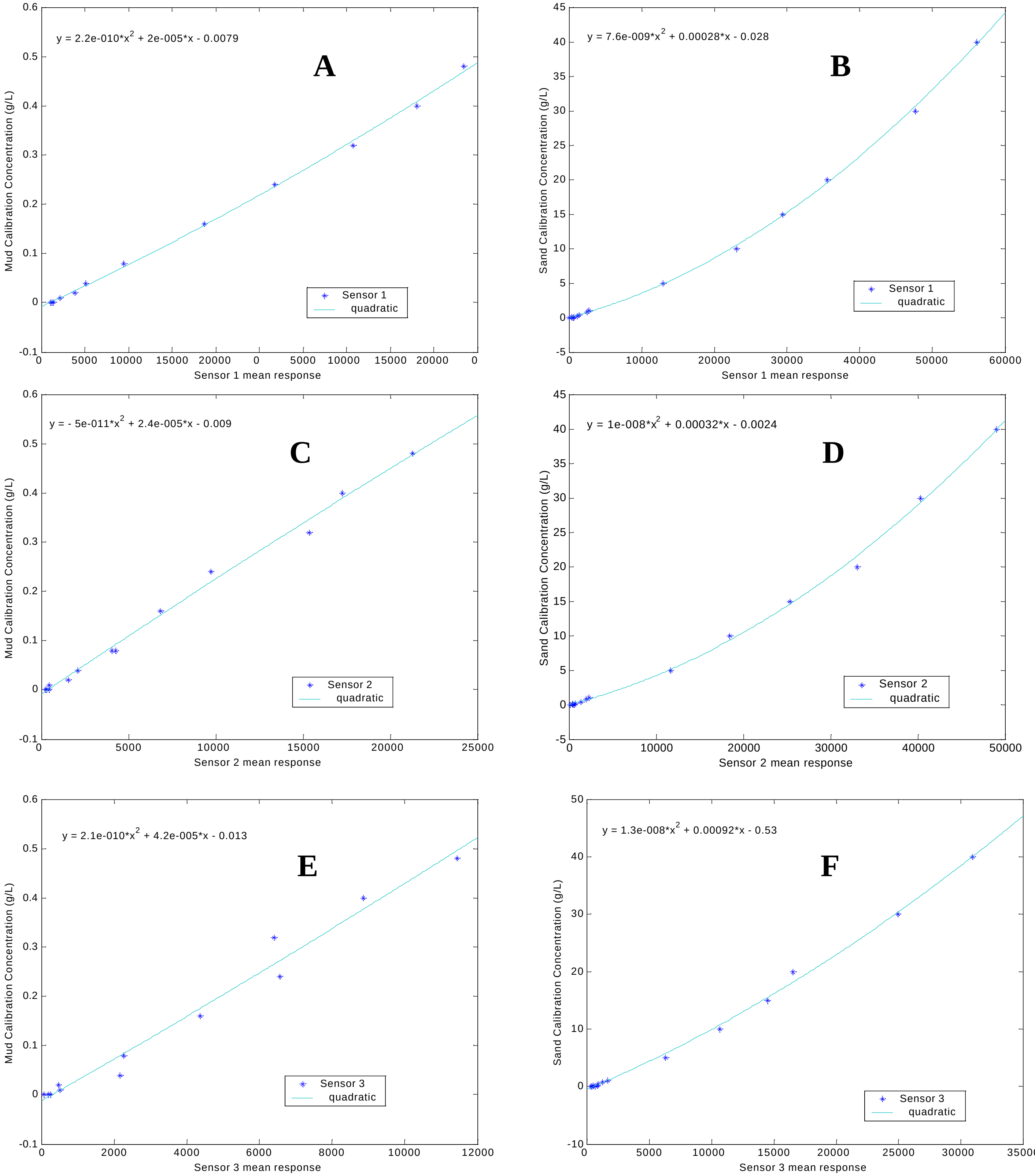

Figure 7. Array G187 OBS sensor calibration graphs. A, C, and E are quadratic fits of the mud calibrations for sensors 1, 2, and 3, respectively. B, D, and F are quadratic fits of sand calibrations for sensors 1, 2, and 3, respectively.

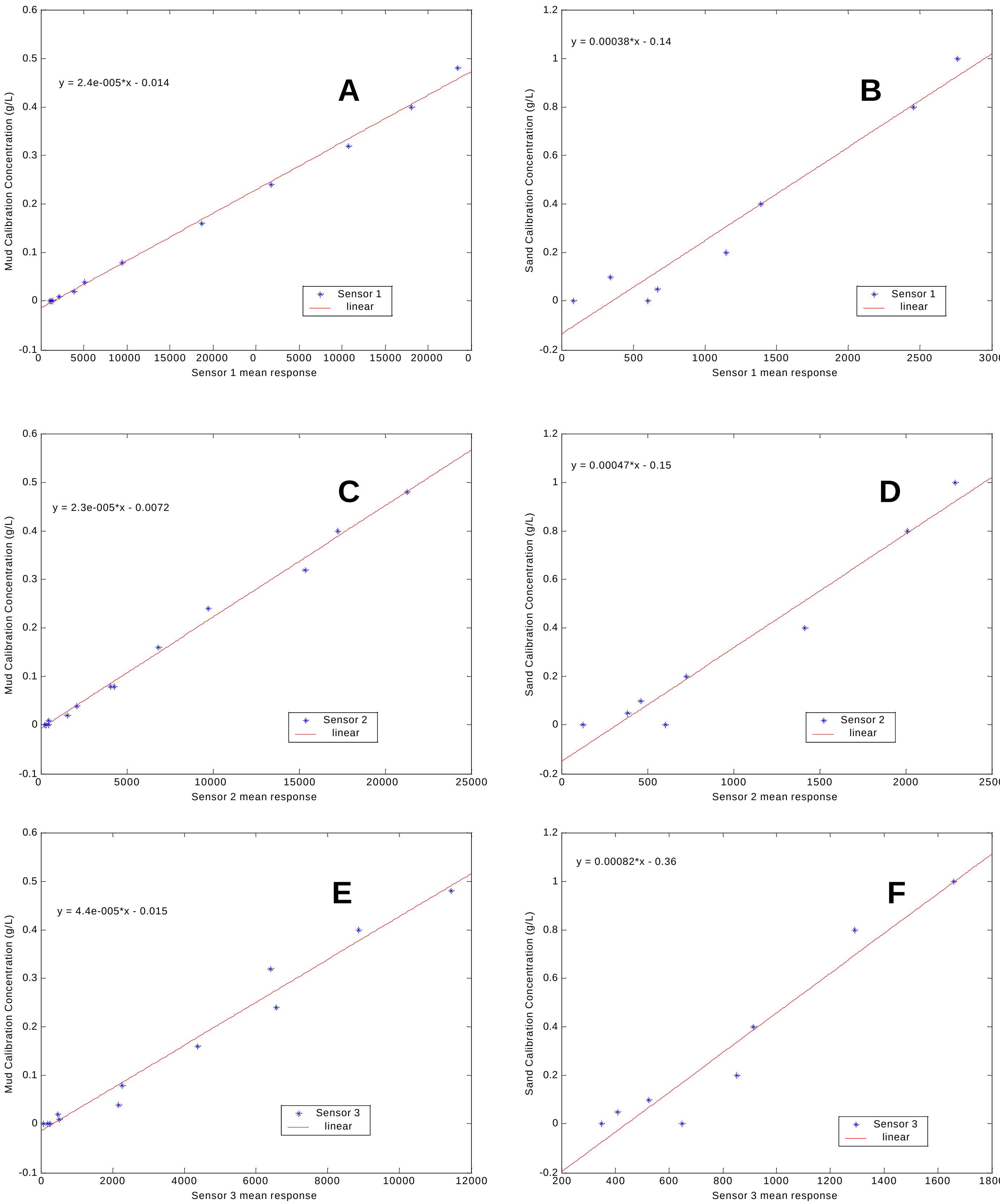

Figure 8. Array G187 OBS sensor calibration graphs. A, C, and E are linear fits of the mud calibrations for sensors 1, 2, and 3, respectively. B, D, and F are linear fits of sand calibrations for sensors 1, 2, and 3, respectively.

Table 3. Array G181 ADV B205 Pre- deployment Calibration DATA

July 2001

X Axis			Y Axis		
	ADV Response			**ADV Response**	
Flume Speed cm/sec	**mean**	**std dev**	**Flume Speed** cm/sec	**mean**	**std dev**
59.14	6289	352	59.22	6243	292
46.52	4765	260	46.79	4677	271
29.63	3120	184	29.49	3003	187
19.94	2099	140	20	1998	142
-20.92	-2031	166	-20.54	-2059	142
-29.83	-3110	184	-29.87	-3140	184
-46.25	-4670	266	-47.33	-4736	235
-63.4	-6335	334	-58.64	-6035	346

Table 4. Array G187 ADV B211 Pre- deployment Calibration Data

June 2001

X Axis			Y Axis		
	ADV Response			**ADV Response**	
Flume Speed cm/sec	**mean**	**std dev**	**Flume Speed** cm/sec	**mean**	**std dev**
45.18	4546	111	45.05	4425	112
29.31	2779	171	28.39	2789	177
17.25	1783	290	17.14	1561	293
-16.78	-1738	299	-16.40	-1781	305
-29.71	-2882	169	-30.04	-3001	167
-44.51	-4427	113	-45.54	-4853	111

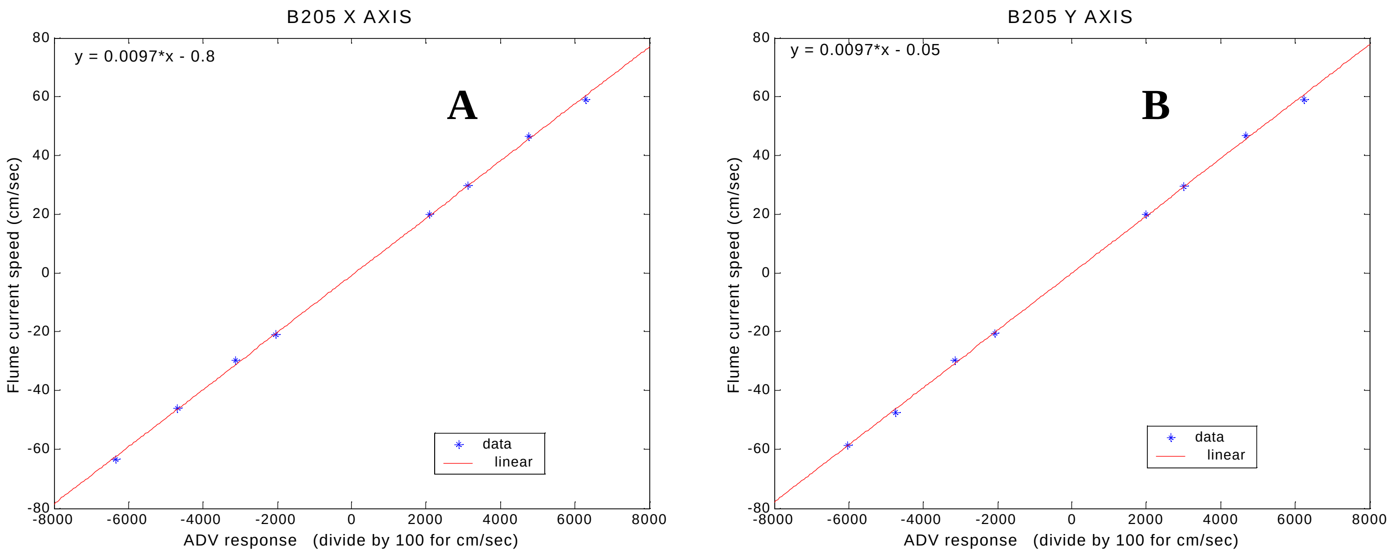

Figure 9. Array G181 ADV B205 sensor calibration graphs. Graph A is the X axis linear fit of the data and B is the Y axis linear fit.

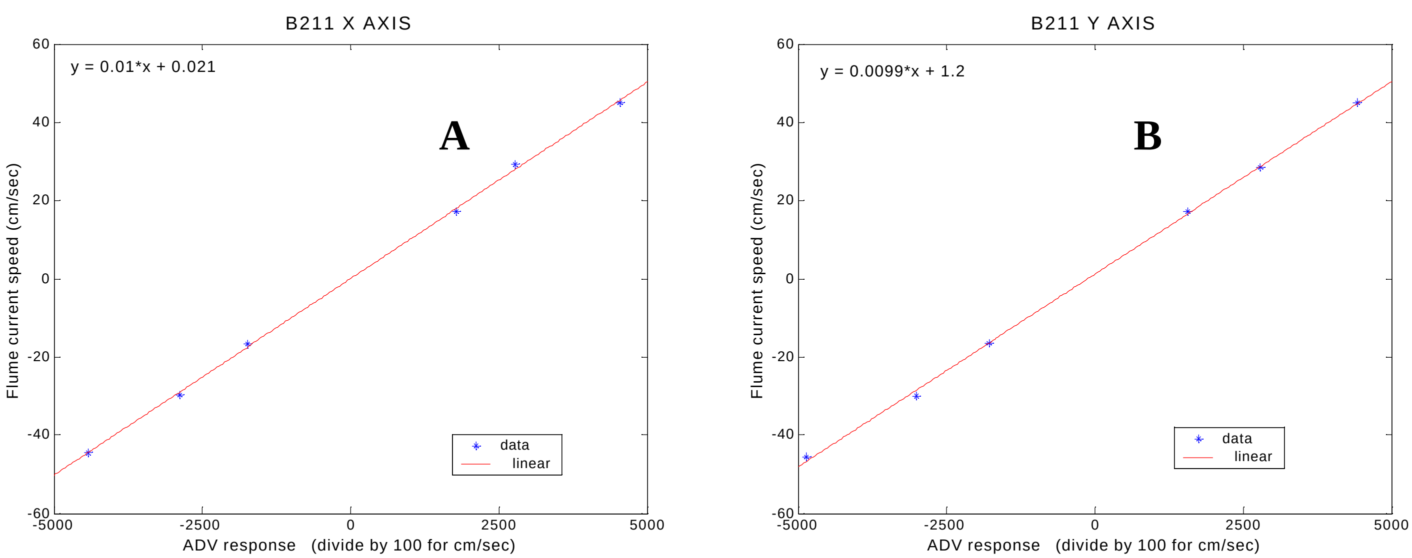

Figure 10. Array G187 ADV B211 sensor calibration graphs. Graph A is the X axis linear fit of the data and B is the Y axis linear fit.

Table 5. Summary of Best Fit Coefficients and Estimates of Their Errors

Concentration = A + B (Response) +C (Response)^2

Array	Sensor	S/N	Calibration Type	A	B	C
G181	OBS 1	1764	MUD	-0.028 ± 0.053	(1.30 ± 0.57) e -5	(6.50 ± 0.91) e -9
				-0.0118 ± 0.0031	(3.1230 ± 0.0069) e -5	
	OBS 2	1768		0.008 ± 0.012	(3.61 ± 0.21) e -5	(1.7173 ± 0.0059) e -9
				-0.0133 ± 0.0021	(5.6382 ± 0.0059) e -5	
	OBS 3	1769		0.004 ± 0.012	(3.55 ± 0.21) e -5	(1.762 ± 0.059) e -9
				-0.0187 ± 0.0017	(5.5837 ± 0.0058) e -5	
G181	OBS 1	1764	SAND	0.37 ± 0.42	(1.2 ± 1.1) e -4	(3.95 ± 0.43) e -8
				-0.145 ± 0.076	(7.9 ± 1.0) e -4	
	OBS 2	1768		0.14 ± 0.41	(3.6 ± 1.9) e -4	(1.15 ± 0.12) e -7
				-0.618 ± 0.070	(1.390 ± 0.097) e -4	
	OBS 3	1769		0.27 ± 0.40	(3.1 ± 1.8) e -4	(1.06 ± 0.11) e -7
				-0.183 ± 0.051	(1.116 ± 0.092) e -4	
G187	OBS 1	1761	MUD	0.0078 ± 0.0030	(2.05 ± 0.11) e -5	(2.16 ± 0.59) e -10
				0.0144 ± 0.0043	(2.438 ± 0.039) e -4	
	OBS 2	1762		-0.0090 ± 0.0055	(2.39 ± 0.18) e -5	(-5.1 ± 9.1) e -11
				-0.0072 ± 0.0046	(2.295 ± 0.048) e -3	
	OBS 3	1763		-0.013 ± 0.012	(4.21 ± 0.67) e -5	(2.1 ± 6.3) e -10
				0.014 ± 0.010	(4.42 ± 0.20) e -3	
G187	OBS 1	1761	SAND	-0.03 ± 0.11	(2.80 ± 0.15) e -5	(7.64 ± 0.30) e -9
				-1.36 ± 0.05	(3.84 ± 0.34) e -4	
	OBS 2	1762		0.00 ± 0.21	(3.21 ± 0.33) e -4	(1.01 ± 0.08) e -8
				-0.151 ± 0.048	(4.687 ± 0.039) e -4	
	OBS 3	1763		0.53 ± 0.24	(9.22 ± 0.58) e -4	(1.26 ± 0.21) e -8
				-0.361 ± 0.078	(8.19 ± 0.84) e -4	

Concentration = A + B (Response) +C (Response)^2

Array	Sensor	S/N	Calibration Type	A	B	C
G181	ADV	B205	X axis	-0.80 ± 0.30	(9.734 ± 0.070) e -3	
			Y axis	-0.05 ± 0.34	(9.748 ± 0.080) e -3	
G187	ADV	B211	X axis	0.02 ± 0.34	(1.007 ± 0.011) e -2	
			Y axis	1.18 ± 0.38	(9.87 ± 0.12) e -3	