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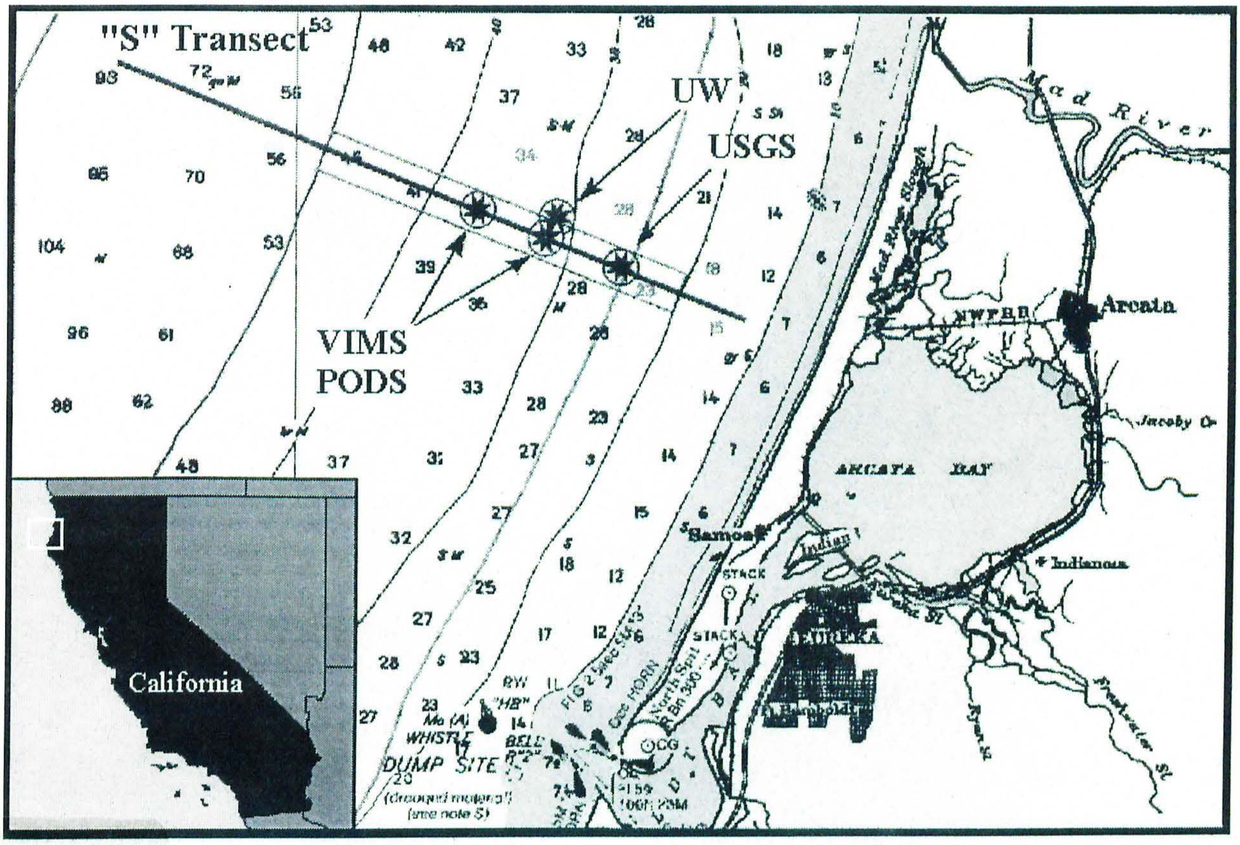

Special Report in Applied Marine Science and Ocean Engineering No. 345

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1. Introduction

During the period December 6, 1995-March 7, 1996 six VIMS scientists and technicians participated in STRATAFORM cruises aboard the R/V Pacific Hunter. The objectives of these cruises were: 1) To obtain regional measurements of bottom roughness at the STRATAFORM shelf sites via side-scan sonar surveys and to obtain more quantitative, localized measurements using plan-view and sediment-water interface-profiling cameras. 2) To deploy and recover two instrumented tripods, one at the S-60 site and one at the S-70 site. The participants in the VIMS component were: Randy Cutter, Franklin Farmer, Robert Gammisch, Debra Mondeel, (Humboldt Marine Lab), Todd Nelson, Wayne Reisner, L. Donelson Wright. Fig 1 shows the site location.

2. Side-Scan Sonar and Benthic Camera Surveys

Methodology

The survey instruments included an EG&G model 260 TH Side-Scan Sonar system with a model 272 TD tow fish operated at 105 KHz. A digital magnetic tape system recorded the raw data so that the images could be analyzed digitally in the laboratory. This system was interfaced with a Magellan Global Positioning System equipped to provide real time differential corrections broadcast by the United States Coast Guard and stored on a laptop field computer for post-processing.

The benthic camera survey employed a Benthos model 3731 Sediment Profiling Camera and a Benthos model 372A Edgerton Deep-Sea Standard Camera. Color slide film was used in both cameras. Both cameras were attached to a single frame. As the frame approaches the bottom, the standard camera fires and provides a close-up image of the sediment surface in plan-view. After the frame lands on the bottom, the profiling camera slices vertically into the sediment and fires to provide a vertical cross-section image of the sediment surface and sub-surface features. Sample site positions were recorded and stored with the image analysis data. Fig 2 shows an example of a sediment profiling camera image.

Ship's log

On December 6, 1995 at 0700 PST the R/V Pacific Hunter departed Woodley Island Marina for the STRATAFORM "S" transect. At 1000 PST the side-scan sonar survey commenced. Three lines were run. Due to the large number of crab pots along the transect however, the captain could not maintain a straight course. This prevented overlap of the survey lines and kept the sonar fish on a short tether. The result was that the system could not be operated at 500 KHz as proposed, and had to be operated at 105 KHz instead. The data quality was sufficient to determine bottom features and ten sites were selected for profile camera ground truth. At 1300 PST the side-scan sonar survey was completed and the profile camera survey began. Five camera stations were occupied with five camera drops at each site. The survey was terminated due to tide and current conditions at the inlet bar. The ship returned to the marina at 1900 PST.

On December 7 the ship was turned over to Dave Cacchione for the deployment of his tripod. At 0700 PST the USGS equipment was loaded at "A" dock. At 1000 PST the pod was deployed on the "S" transect in 50 meters of water. The ship's operation was turned over to VIMS personnel at 1130 PST, and the second profile camera survey was started. Five additional stations were occupied with five camera drops taken at each station. The ship returned to "A" dock at 1900 PST.

Data Return

1) The side-scan surveys produced five lines of data on the "S" transect between the 40 meter and 75 meter isobath. This provided the data necessary to select ten sites representing bed roughness along the "S" transect line including the area around the tripod deployment sites.

2) The camera survey sampled ten stations with both plan and profile photographs at each station. This provided ground truth for the side-scan and delineated the nature of the bottom roughness.

Data Availability

Both the side-scan site records and the scanned photographs will be available on CD-ROM after August 1996. A nominal charge for the cost of the medium will be applied to all data requests.

3. Tripod Deployments

The primary objectives of the VIMS tripod deployments were to obtain estimates of time-varying bed stress over contrasting bottom types at two sites and to evaluate sediment resuspension in response to those stresses. Secondarily, the instruments were intended to add data on waves and mean currents for use by all STRATAFORM investigators.

Instrumentation

The two tripods deployed by VIMS were similar in configuration and rigged primarily to collect benthic boundary layer profiles of velocity and suspended sediment concentration as well as to provide general information on waves and mean currents. The three main instruments on each tripod were designated as the 635, 626, and OBS. The S-60 tripod carried a 635 with a single point electro-magnetic Marsh-McBirney velocity sensor and a Paroscientific pressure gage located at elevations of 126 and 138 cm above the bed respectfully. The 626 collected velocity profiles using four Marsh-McBirney sensors at 10, 41, 71, and 101 cm above the bed. The OBS used five Downing infrared optical backscatter sensors for suspended sediments profile determination at 15, 42, 71, 104, and 131 cm above the bed. AT S-70, the 635 velocity sensor was at 138 cm (no pressure gage). The 626 sensors were at 18, 48, 78, and 108 cm and OBS sensors at 27, 49, and 102 cm above the bed. All of these instruments were programmed to start sampling every 3 hours and collect 2048 samples at 1 second intervals (approx. 34 minutes of data).

Ship's Log

The VIMS tripod was assembled and ready for deployment on December 11, 1995. Due to weather conditions and sea state, the deployment was delayed until January, 1996. On January 5, 1996 the *R/V Pacific Hunter* arrived at "A" dock to load VIMS pod. Around 1030 PST the ship departed for the S-60 site. Upon arrival, 2 hours later, a marker buoy was deployed at

Sternberg's S-60 pod site (40° 53.28' North, 124° 15.27' West). The VIMS pod was deployed about 100 meters southeast of the marker buoy (40° 53.27' N, 124° 15.19 W). At 1330 PST two side-scan survey lines were run to document roughness changes subsequent to the December 1995 storm. Again, crab pots interfered with the survey track lines. At 1900 PST the ship returned to Woodley Island marina.

On January 6 the *Pacific Hunter* arrived at "A" dock to load VIMS second tripod. At 1130 PST the ship departed and 2 hours later, this pod was deployed at the S-70 site (40° 57.78' N, 124° 17.03' W). During deployment the acoustic release fired and the recovery buoy returned to the surface. Rearming the release required that the pod be recovered and returned to the deck. At 1430 PST the tripod was redeployed; however the ship had drifted and as a result the tripod's deployment site changed (40° 53.65 N, 124° 16.99 W). The water depth at this site was 71.8 meters. The ship returned to the marina at 1830 PST.

On March 4 the *Pacific Hunter* departed at 0700 PST to pick up the tripods. The seas at the site were in excess of fifteen feet with a 16 sec. period and the pick up had to be canceled. By March 6 the seas had dropped to 8 feet at 12 sec. with fair weather conditions. Both pods were recovered without incident and returned to "A" dock where they were stripped and data were downloaded.

Data Return and Preliminary Processing

In spite of some equipment problems, most of the data were of good quality. At the 60 m site we retrieved roughly 2 months (at 8 bursts a day) of pressure and suspended sediment data in addition to a slightly shorter period for all 5 velocity sensors. Problems at this site included the failure of a sonar altimeter and an Acoustic Doppler Velocity sensor (ADV). At the 70 m site suspended sediment concentrations were observed at 3 elevations for 2 months. The 635 velocity sensor collected over 1 month of data, but the 626 failed after about a day because of a leaking pressure housing. No data were recovered from a sonar altimeter or an upward looking acoustic water column profiler.

Preliminary processing focused on calibrations and overall data quality. Early processing efforts were focused on interpretation of internal compass data, zero flow offsets, and details of pod configurations. Some spurious velocity spikes were removed from the data. All of the data are now available in both raw and pre-processed forms for use by other STRATAFORM investigators.

4. Data Analyzes and Preliminary Results

Only sensors from the S-60 tripod have been analyzed as of July, 1996. We use an EW-NS coordinate. The direction varies clockwise from 0 at north.

Sea surface elevation measured by a Paroscientific pressure sensor from the 635 data unit showed both diurnal and semi-diurnal tidal signals (Fig 3a). All 4 EMCM's from the 626 unit and an EMCM from the 635 behaved consistently (Fig 3b and Fig 3c). Non-tidal signals were apparent in the burst mean currents.

By log-fit of vertical arrays of 4 Marsh-McBirney sensors from the 626 unit, we calculated current friction velocity, u_{*b} (Fig 4a) and apparent roughness, z_0 (Fig 4b). Out of 387 recovered profiles, 372 showed $r^2 > 0.5$. The average Fisher's Z transform is 2.62 and the corresponding average r^2 is 0.98. The 95 % confidence interval is ± 44.43 % for u_{*b} and $\times\div$ 5.47 for z_0. Two significant events with strong shear with high roughness values were the most visible for the periods between burst 110 and burst 130 and between burst 245 and burst 280.

Directional variances of bottom orbital velocities were calculated from one EMCM on the 635 unit (Fig 5). Onshore-directed waves (15° - 195°) were more organized compared to offshore-directed (195° - 15°). High energy events between bursts 110 to 160 and between 245 and 330 showed veering of the dominant wave directions from WSW to WNW.

Spectral variances of sea surface elevations were calculated from a pressure sensor data of 635 unit (Fig 6). Dominant wave frequencies were between 0.12 and 0.15 Hz. Infragravity waves were apparent between bursts 110 and 130 and between bursts 245 and 275.

Fig 7 shows the calculated wave characteristics. It is apparent that high waves were related with high current friction velocities. We calculated the friction velocity and roughness length using a wave-current boundary layer model modified from Grant and Madsen (1986). The bottom sediment characteristics were obtained by grain-size analyzes of sediment samples near the deployment sites. Modal size was about 10 μm and median grain diameter was about 5.5 μm. Stratification effects of suspended sediments were not significant from the model. Overestimation for both u_{*b} and z_0 was seen during low wave events (Fig 8).

The National Weather Service provided surface pressure and winds for 41° N and 124° W (Fig 9). The event between bursts 110 and 130 was associated with a generally onshore wind with a speed of 10 m/sec. The event around burst 250 was associated with wind from the south (up coast) at about 10 m/sec.

Fig 10 shows the converted suspended sediment concentrations from the OBS sensors at the inshore site (S-60). The most prominent high concentration period between bursts 245 and 275 coincides with high winds and waves.

We are now extending the analyzes to the S-70 data and analyzing the recovered OBS data set. Future efforts will focus on defining bottom roughness.

The burst averaged values of currents, waves, and suspended concentrations at the inshore site are on the attached disc. Also included are the estimated current friction velocities and apparent roughness from log-fit. The format of the data is shown on the next page. All data collected from the tripods will be fully processed and available on CD-ROM or by FTP by early fall 1996.

BURST-MEAN SUMMARY FROM EURK96A 40 53.70 N 124 15.91 W S60 POD

Time is GMT

Depth in meters

Velocities in cm/sec

Directions in degrees True

Wave periods in seconds

				Mean Current at 126cm							Velocity Profile							
						Wave	Wave				at 10cm	41cm	71cm	101cm	10cm	41cm	71cm	101cm
Burst	Time	Date	Depth	Mag	Direction	Direction	Period	Ub	u*	z0	Mag1	Mag2	Mag3	Mag4	Dir1	Dir2	Dir3	Dir4
1	22:00	01/05/96	60.03	23.55	294.8	102.2	15.40	17.30	1.0089	0.0155	16.42	19.55	21.36	22.25	288.6	293.5	294.6	298.3
2	01:00	01/06/96	58.98	17.52	301.3	103.0	15.52	17.57	0.8333	0.0315	12.09	14.69	16.13	16.93	290.1	296.7	297.9	303.5
3	04:00	01/06/96	59.66	14.54	69.4	118.0	15.63	13.37	0.5882	0.0113	10.23	11.53	12.52	13.98	70.3	65.5	66.9	66.6
4	07:00	01/06/96	60.77	13.06	218.8	105.0	15.28	13.99	0.4862	0.0033	9.79	11.22	12.35	12.49	228.7	225.9	222.7	222.5
5	10:00	01/06/96	60.57	9.97	247.3	106.8	14.63	11.58	0.3156	0.0003	8.31	9.27	9.96	10.07	249.5	250.6	249.4	252.2
6	13:00	01/06/96	60.10	11.35	313.5	98.3	13.93	9.47	0.5657	0.0336	8.16	9.78	10.81	11.50	297.0	307.6	308.8	314.6
7	16:00	01/06/96	60.70	12.18	75.6	99.3	14.12	8.07	0.2691	0.0000	8.72	9.22	10.04	10.27	83.6	80.9	77.1	72.4
8	19:00	01/06/96	61.29	9.23	84.7	101.5	14.52	8.36	0.2404	0.0001	7.17	8.00	8.53	8.45	92.5	90.9	90.3	85.9
9	22:00	01/06/96	60.34	12.14	235.0	103.6	13.47	6.88	0.4582	0.0022	9.66	11.15	12.05	12.22	239.3	237.6	235.9	238.6
10	01:00	01/07/96	59.08	17.34	278.8	97.0	12.88	6.31	0.4282	0.0000	13.44	14.95	15.58	15.89	273.5	276.8	277.6	280.1

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OBS BURST-MEAN SUMMARY FROM EURK96A 40 53.70 N 124 15.91 W S60 POD

Time is GMT

Concentrations in g/l

			Suspended Sediment Concentrations				
Burst	Time	Date	at 15cm	42cm	71cm	104cm	131cm
1	22:00	01/05/96	0.127	0.082	0.067	0.050	0.054
2	01:00	01/06/96	0.136	0.084	0.071	0.053	0.058
3	04:00	01/06/96	0.118	0.065	0.056	0.045	0.048
4	07:00	01/06/96	0.077	0.022	0.020	0.020	0.015
5	10:00	01/06/96	0.077	0.018	0.018	0.019	0.013
6	13:00	01/06/96	0.068	0.012	0.012	0.015	0.009
7	16:00	01/06/96	0.083	0.025	0.023	0.022	0.017
8	19:00	01/06/96	0.069	0.011	0.011	0.014	0.006
9	22:00	01/06/96	0.065	0.007	0.009	0.013	0.006
10	01:00	01/07/96	0.062	0.007	0.007	0.012	0.005

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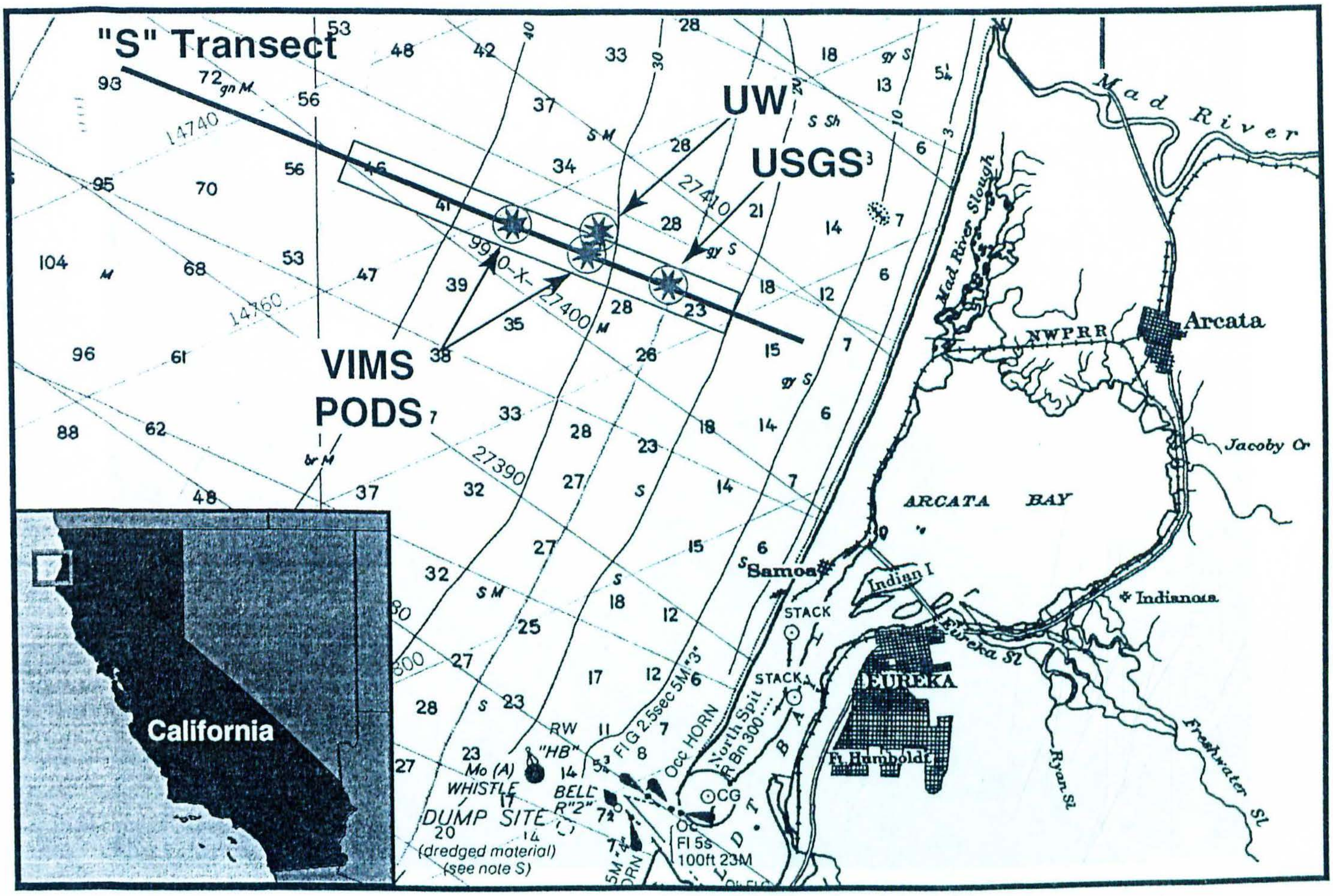

Fig 1. Location map of Side Scan Transect (box) and tripod deployment sites.

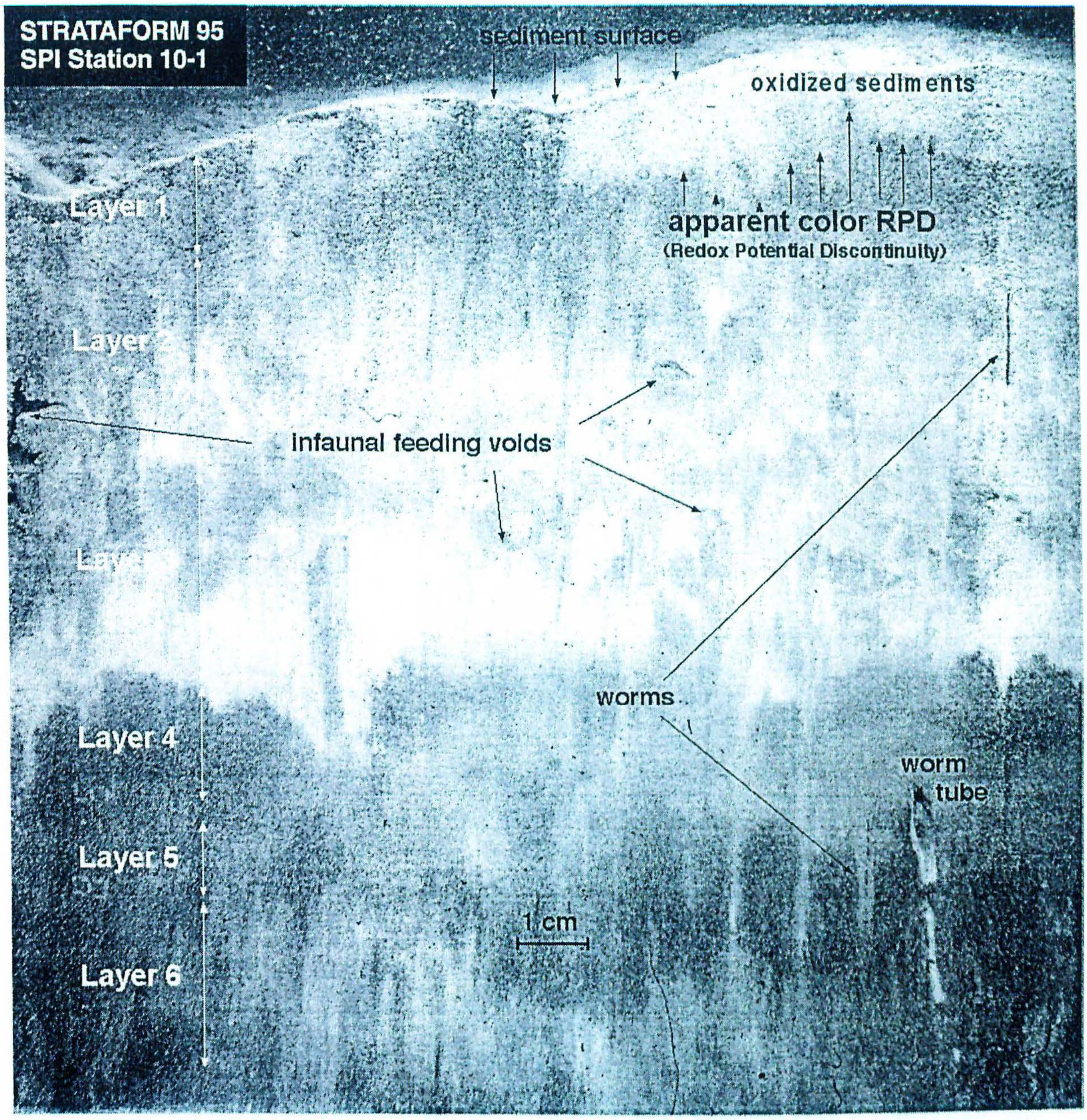

Fig 2. Sediment profile camera image near the S60 tripod.

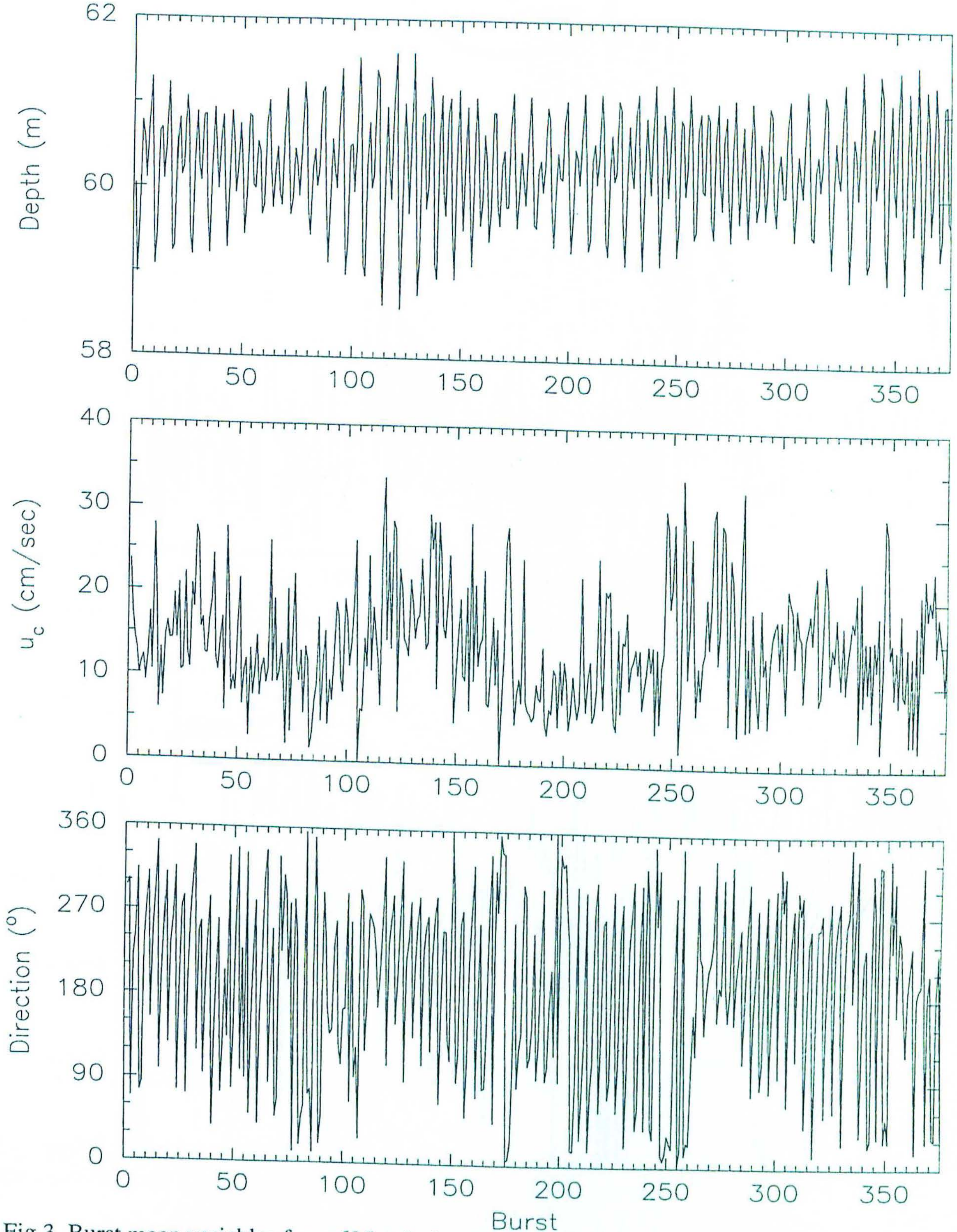

Fig 3. Burst mean variables from 635 at inshore station, S-60: (a) water depth in m; (b) current magnitude in cm/sec; and (c) current direction in degree clockwise from north. Burst interval is 3 hours.

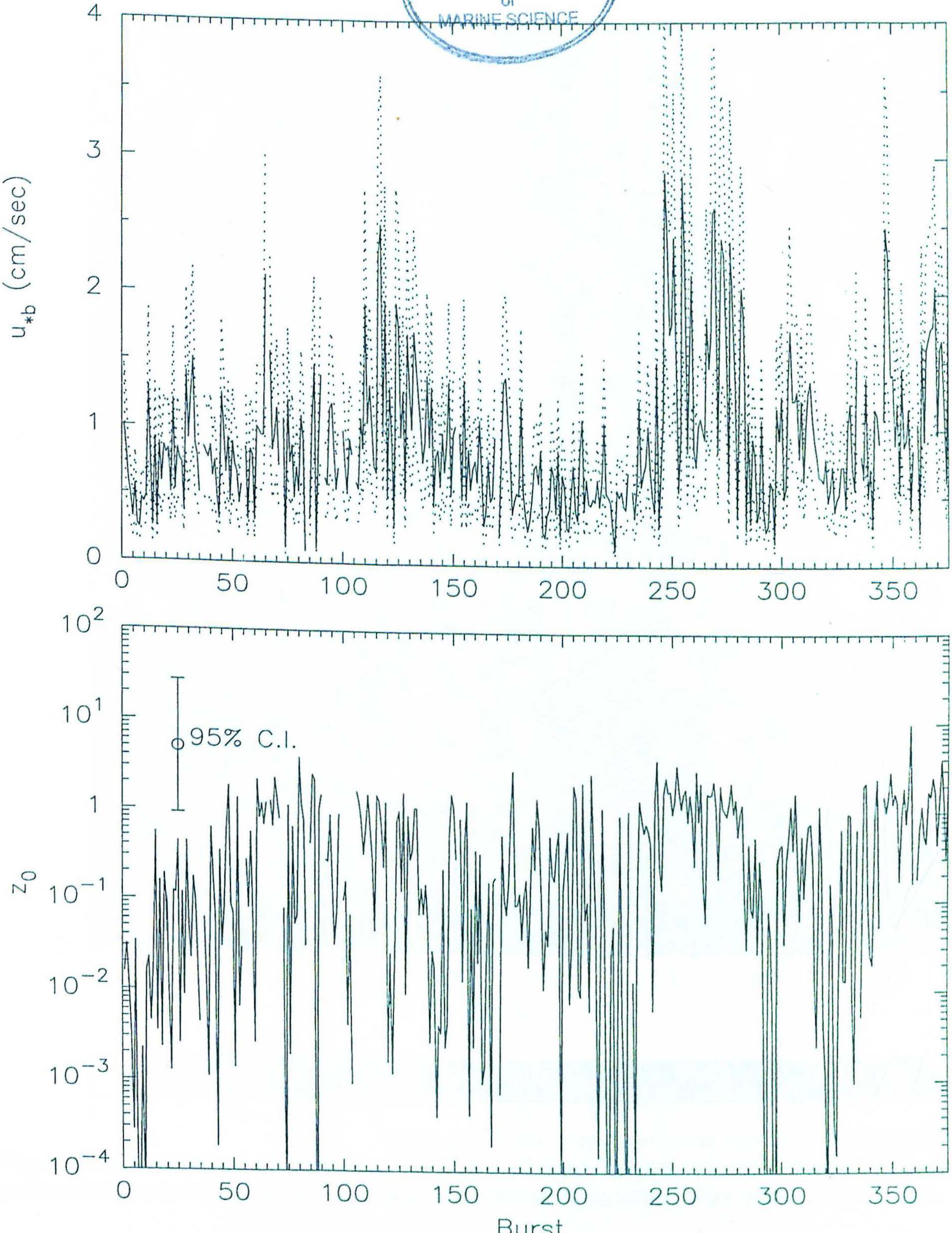

Fig 4. Solid lines are estimated (a) bottom friction velocities in cm/sec and (b) apparent roughness in cm. Dotted lines show envelop of 95 % confidence interval for bottom friction velocities. Burst interval is 3 hours.

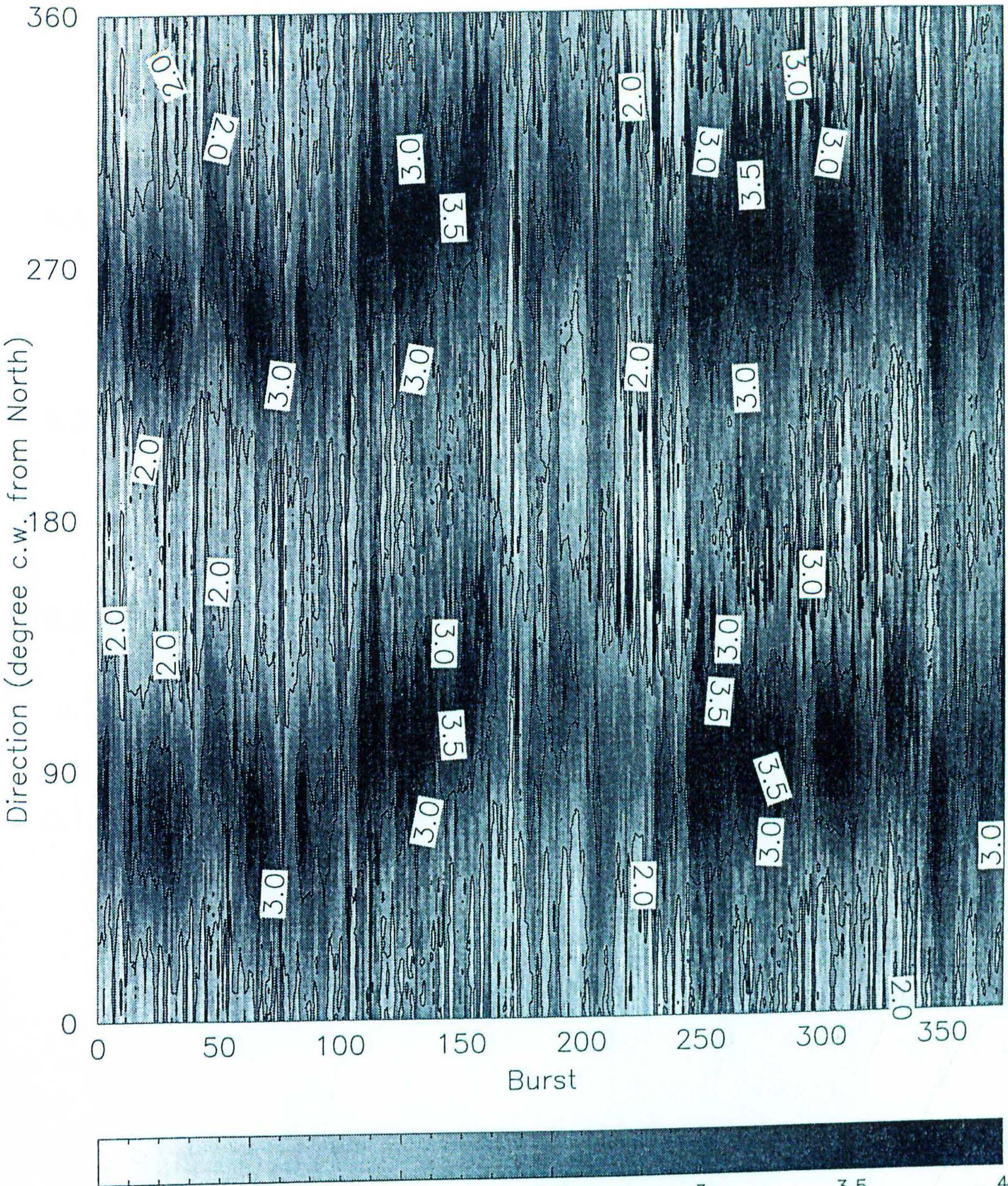

Fig 5. Time variations of directional variances of wave bottom orbital velocities (log of cm^2/sec^2/degree). The direction is in degree clockwise from north. Burst interval is 3 hours.

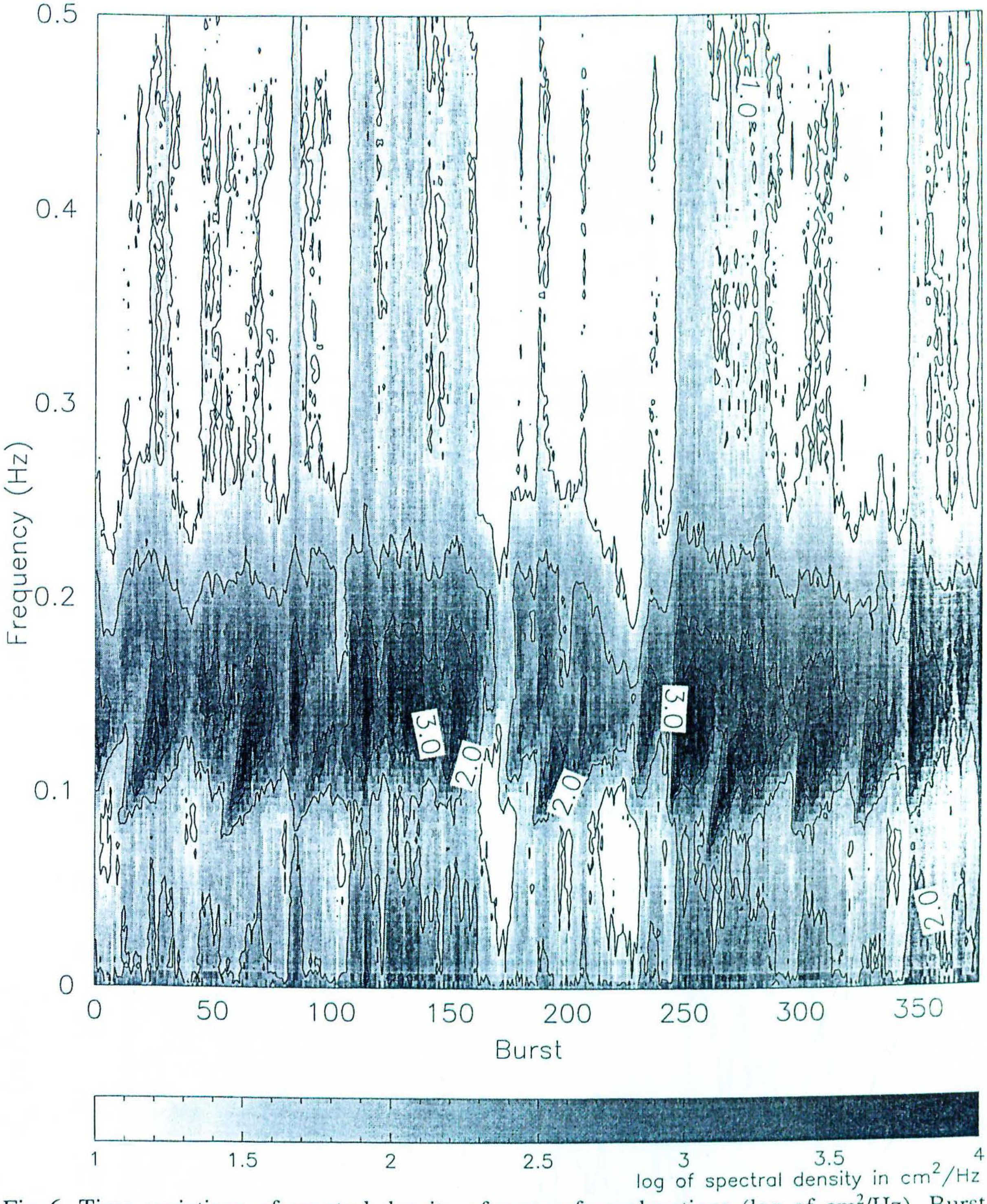

Fig 6. Time variations of spectral density of sea surface elevations (log of cm^2/Hz). Burst interval is 3 hours.

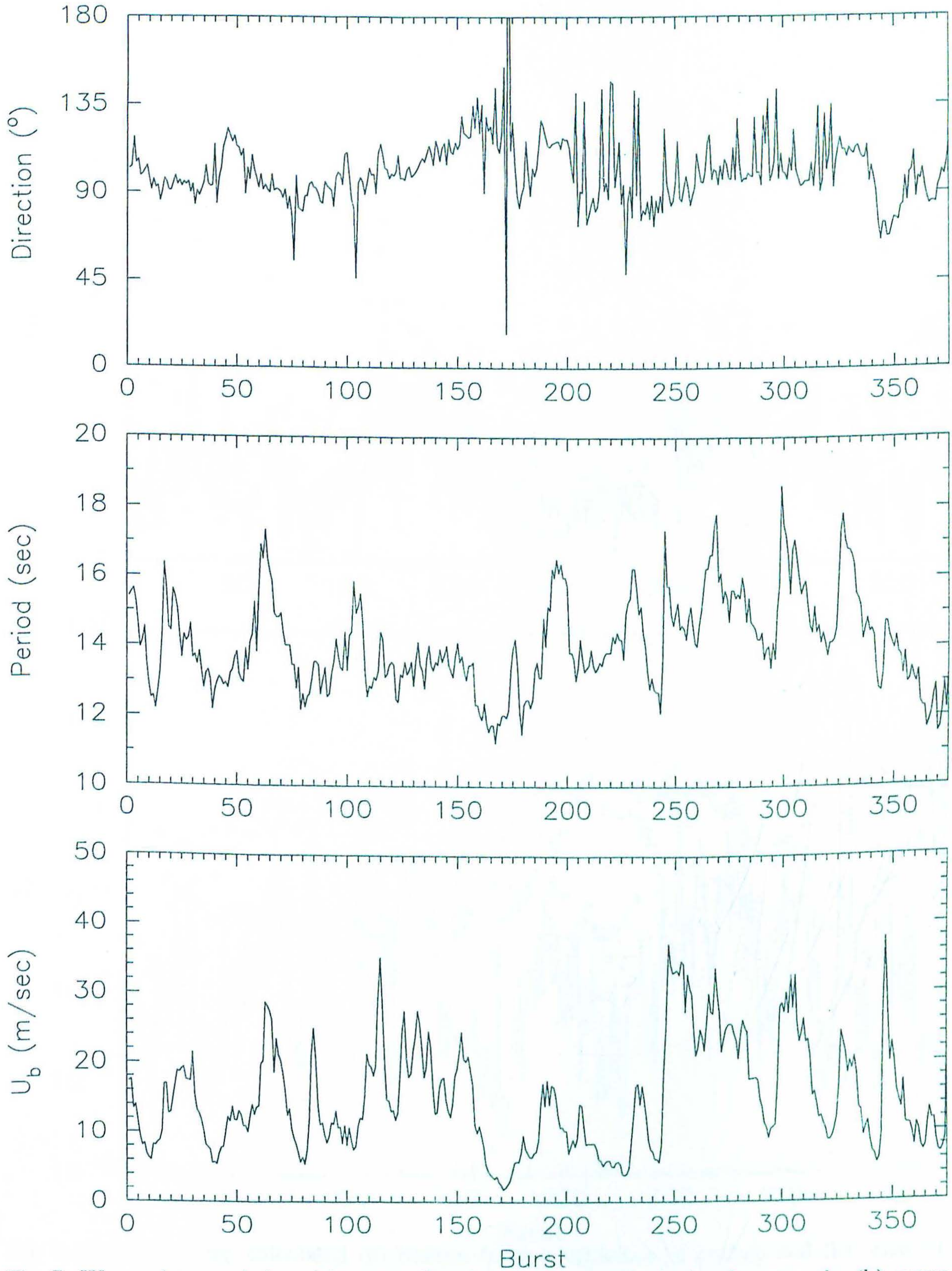

Fig 7. Wave characteristics: (a) wave direction in degree clockwise from north; (b) wave period in seconds; and (c) bottom wave orbital velocity in cm/sec. Burst interval is 3 hours.

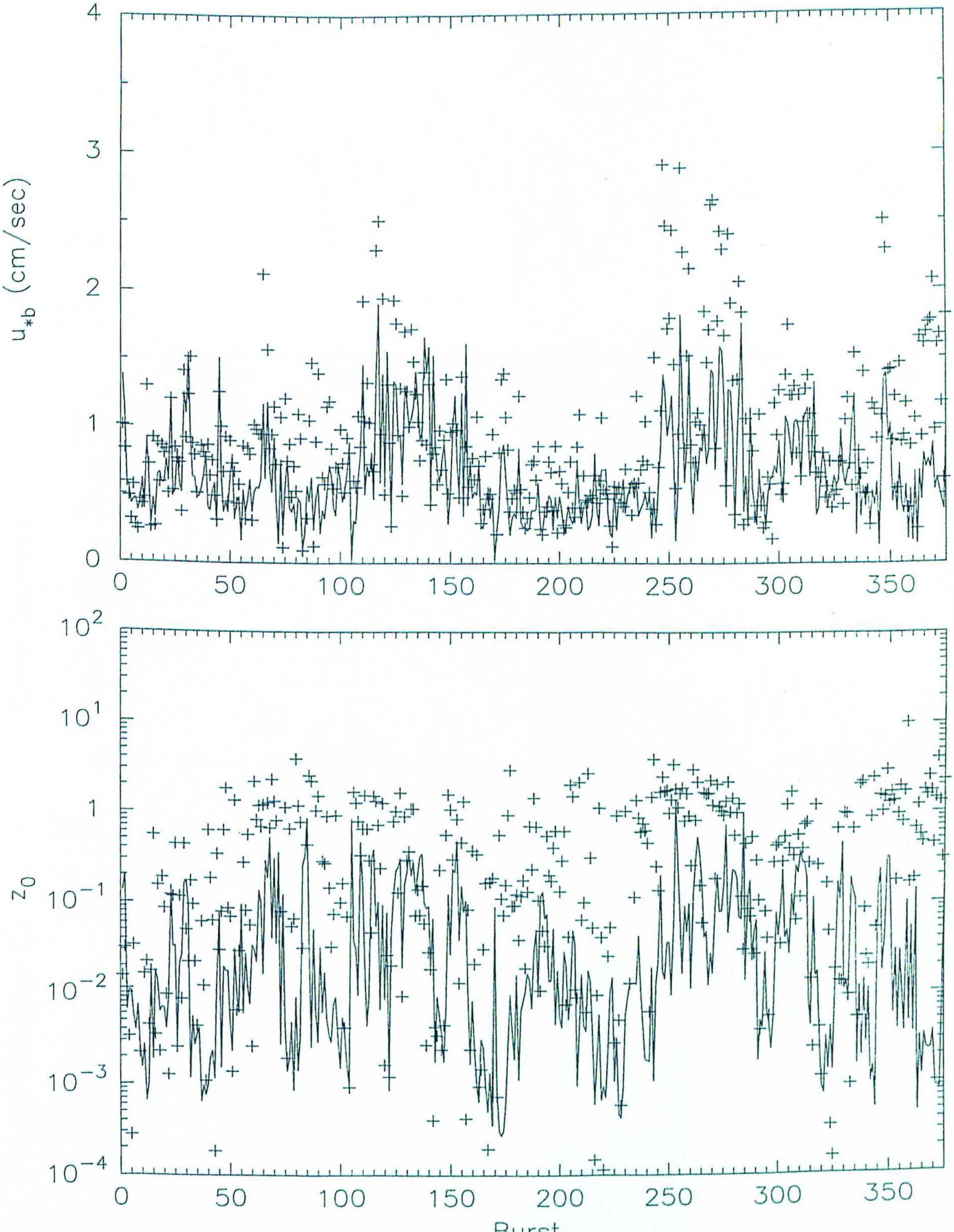

Fig 8. Solid lines are calculated (a) bottom friction velocities in cm/sec and (b) apparent roughness in cm from the Grant-Madsen's (1986) boundary layer model. Plus sign denotes estimation from a vertical profile. Burst interval is 3 hours.

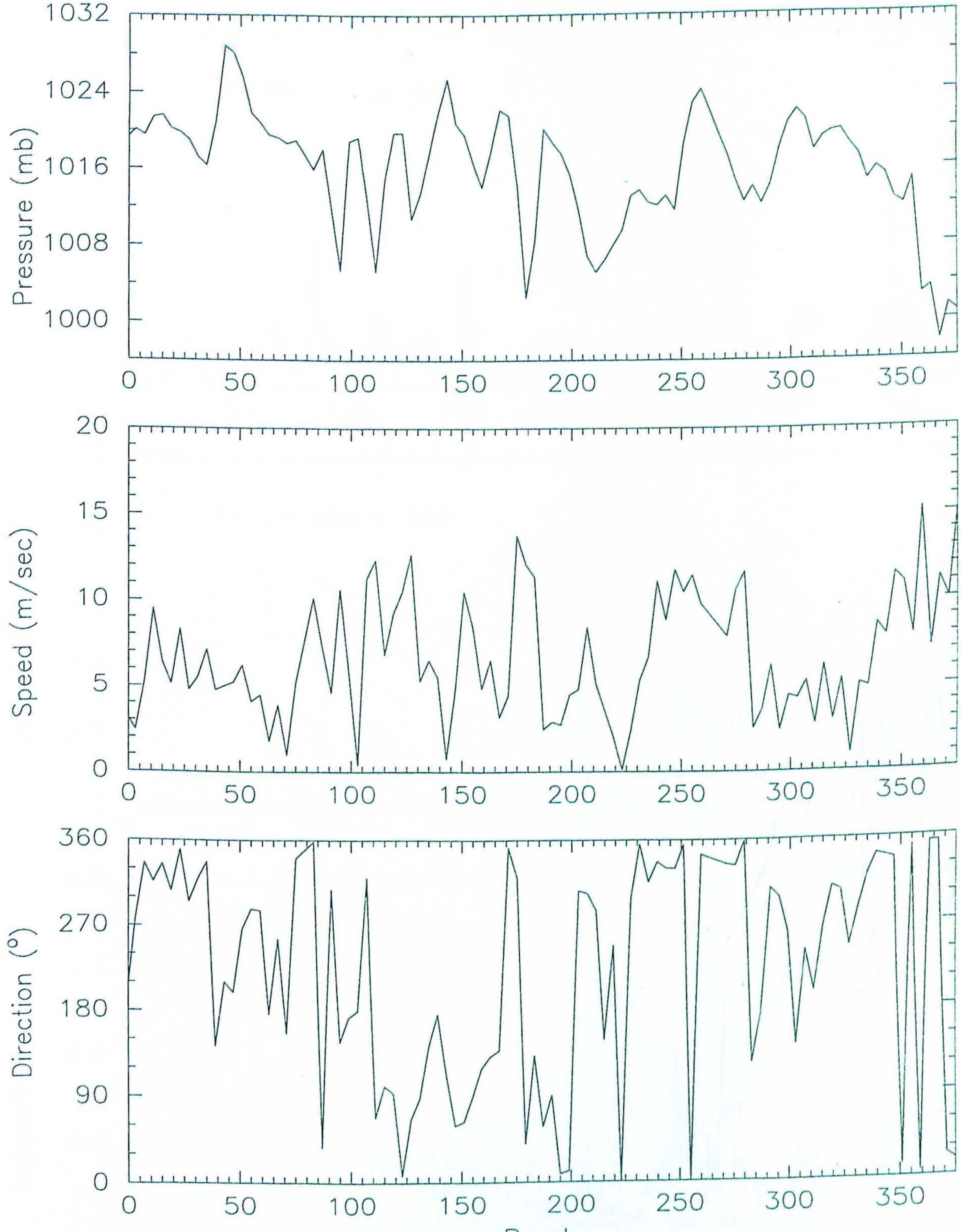

Fig 9. Meteorological conditions extracted from the NWS's AVN analyzed surface winds: (a) sea surface pressure in millibar; (b) surface wind speed in m/sec; and (c) surface wind direction in degree clockwise from north. Burst interval is 3 hours.

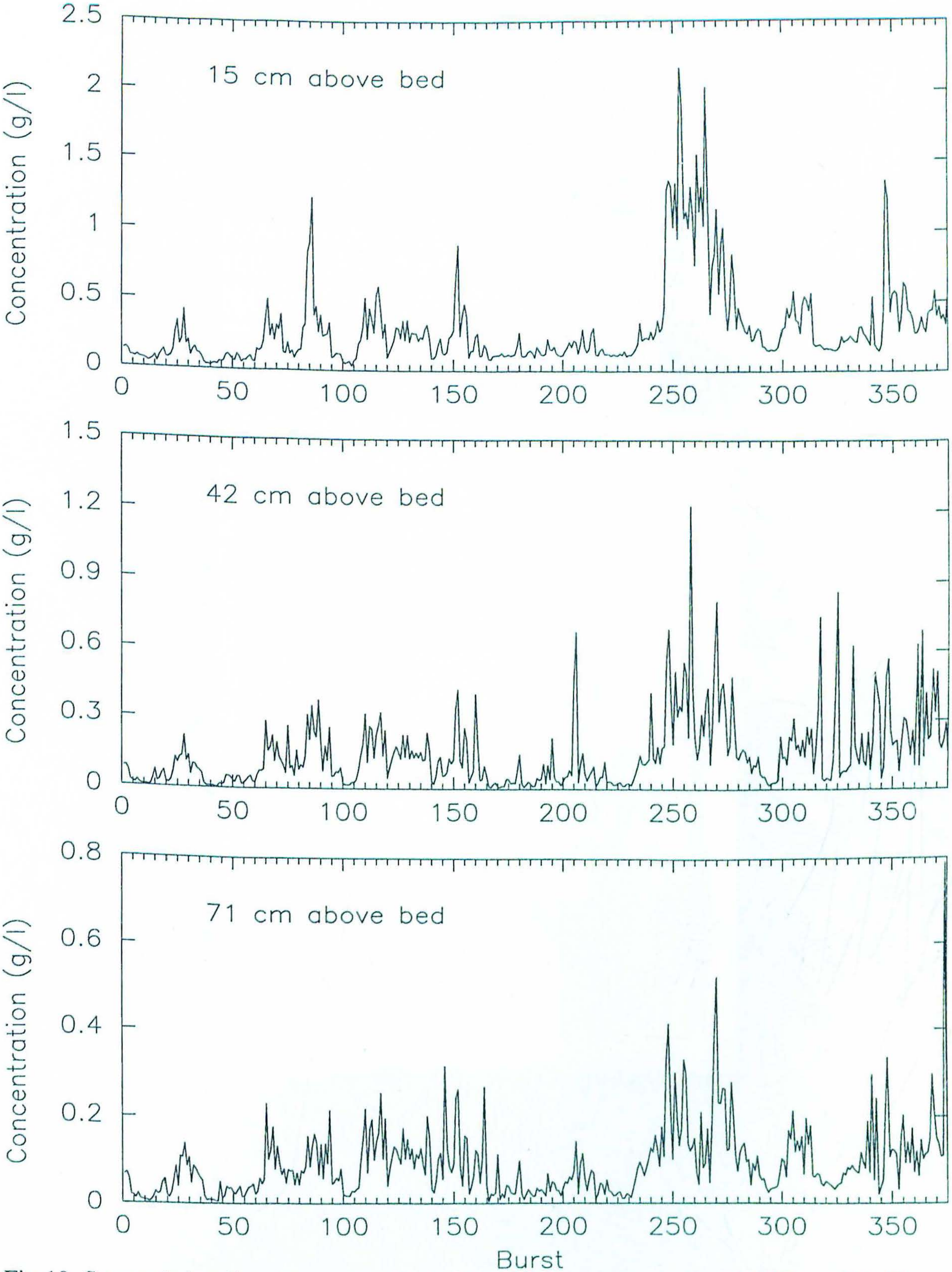

Fig 10. Suspended sediment concentrations from OBS measurements at (a) 15 cm, (b) 42 cm, and (c) 71 cm above bed, respectively. Burst interval is 3 hours.