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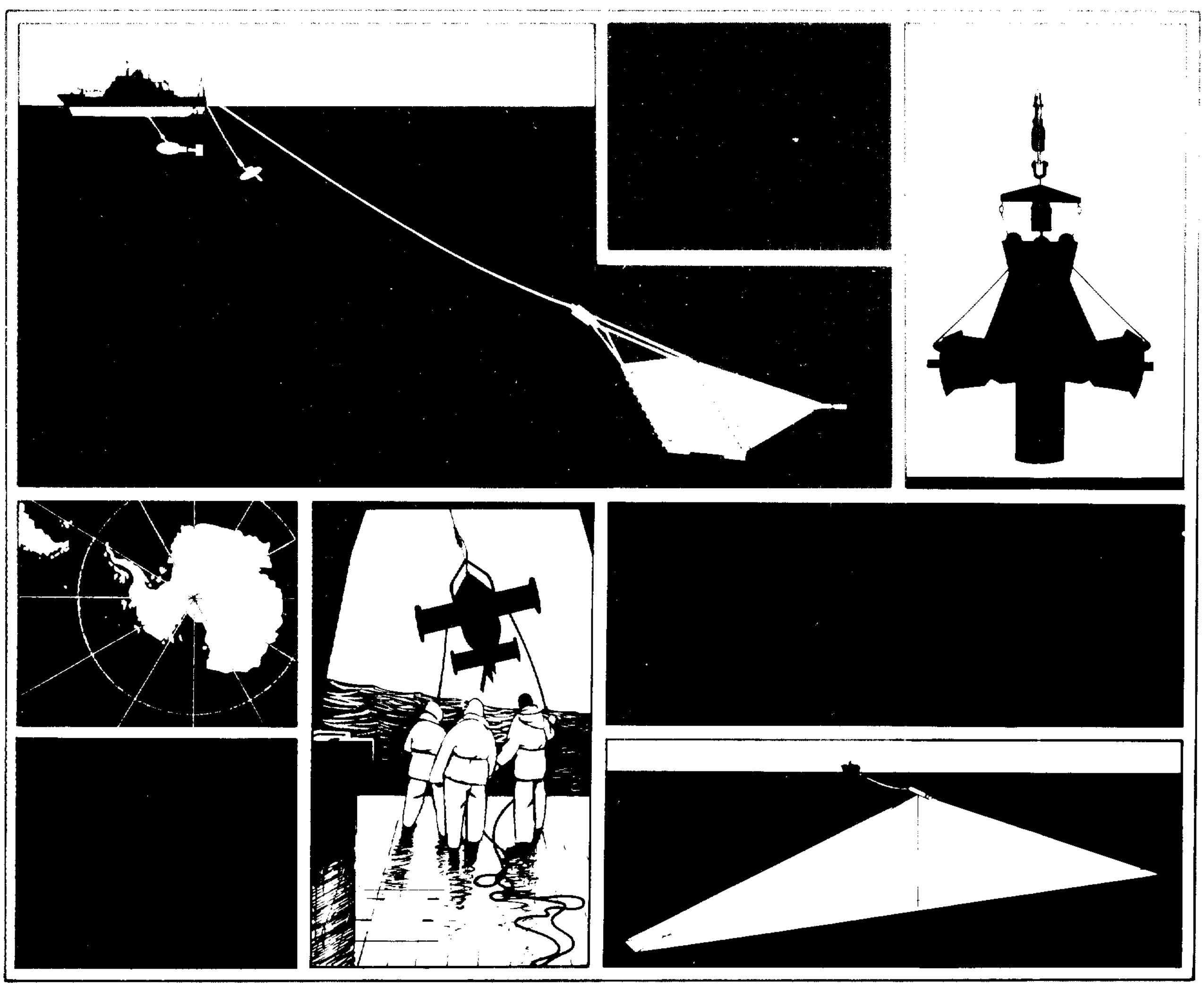
G Griffiths, N A Crisp & L A Povey

Report No 286 1991



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ABSTRACT

This report presents current measurements made in July - August 1990 at a fixed location (64°23.8N, 11°55.7W) just off the Iceland shelf near the Iceland Faeroes Front.

A moored, upward looking, self-contained ADCP recorded a 300 metre profile of the current. Additional data, including temperature and pressure, were recorded by an S4 current meter and an Aanderaa rotor vane instrument.

Data from all instruments were recovered error-free, and the consistency of the data is supported by good correlation of the statistical analyses performed on each data set.

During the deployment, a large change in the mean current was observed. This may be associated with the Iceland Faeroes Front meandering over the mooring.

KEYWORDS

ACOUSTIC DOPPLER CURRENT PROFILER(ADCP)
"CHARLES DARWIN"/RRS - cruise(1990)(50)(51)
CURRENT DATA
CURRENT MEASUREMENT
HOB DRIFTER
ICELAND FAEROES FRONT

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1. INTRODUCTION

In July and August 1990 the Marine Physics Department led two cruises of the *RRS Charles Darwin* to investigate the flow of water masses in the Iceland Faeroes region. Whilst the spatial variations of density and currents were observed using lowered CTDs, the towed SeaSoar vehicle, and the shipboard Acoustic Doppler Current Profiler (ADCP), there was a need for data on temporal variations at a fixed location. To obtain the current profile, a mooring was designed based on the 150 kHz self-contained ADCP manufactured by RD Instruments Inc., San Diego, that had been acquired by Research Vessel Services (RVS). Two conventional current meters, an Interocean S4 electromagnetic instrument (loaned by RVS), and an Aanderaa RCM4 rotor vane instrument were used to provide comparison velocity data and to provide data on pressure and temperature.

The mooring formed part of a current measurement array, the other six moorings were deployed by *RV Alliance* for the SACLANT Undersea Research Centre, La Spezia. The IOSDL ADCP mooring was positioned on the southern edge of the expected position of the Iceland Faeroes Front at 64° 23.8'N 11° 55.7'W in 425 m of water (Figure 1). The mooring was deployed at 1600 on 18 July 1990 (Gould 1990) and recovered at 0827 on 16 August 1990 (Griffiths 1990). There was no means on board ship of checking whether the ADCP had worked correctly. Staff at RVS copied the data from the EPROM logger in the instrument onto IBM-PC floppy disks, using programs supplied by RD Instruments, and sent them to IOSDL for further processing. Data from the S4 current meter were examined and plotted at sea, whilst the Aanderaa data were decoded at IOSDL.

To assist in the interpretation of the spatial pattern of currents obtained from the shipboard ADCP a drogued drifting buoy was released in the vicinity of the mooring. This HOB buoy, kindly loaned by Dr R Pingree of PML, was equipped with an ARGOS PTT and a Novatech radio direction finding transmitter. The drogue extended from 10 m to 20 m and comprised several parallel lengths of polypropylene rope.

Excellent data were obtained from each of the instruments, for which a large part of the credit must go to Mr W Miller of RVS and his staff, for preparing the ADCP and S4. The smoothness of the mooring deployment and recovery were due to the expertise of Mr K Goy of IOSDL and Mr M Harrison, bosun of the *RRS Charles Darwin*.

2. MOORING DESIGN

2.1 ADCP mooring

The mooring (Figure 2) was based on the need to provide the ADCP with a clear transmission path from its transducers. This required the use of a purpose-made buoyancy collar, hired by RVS from Wimpey Environmental. This collar provided a net buoyancy of 100 Kg. The S4 current meter was mounted immediately beneath the ADCP tube, followed by a 10 m wire to the back-up buoyancy spheres and then a further 10 m of wire to the Aanderaa to allow for handling at the stem during recovery. Two acoustic releases were used for security, with either unit capable of releasing the mooring.

Table 1 provides deployment and recovery information for the current meters.

2.2 HOB drifter

The design of the HOB drifter (Figure 3a) was based on previous experience with the buoy and drogue combination. Shock loads on the surface buoyancy and fittings were reduced by using a 10 m length of nylon line between the buoyancy and the upper attachment point of the drogue. The drogue itself, made from 6 parallel lengths of 39 mm polypropylene rope had proved by experience to be reliable and to result in a minimal slip velocity.

The drifter was recovered easily using a combination of ARGOS fixes passed to the ship by IOSDL and homing-in on the buoy using the VHF radio beacon that was received on board at a range of 5 km.

Table 2 gives the deployment and recovery information for the buoy.

3. CURRENTS FROM THE HOB BUOY

The position data from the HOB were obtained from R Barrett at PML. The ASCII data file on a PC disk was transferred to the UNIX system and read in to Pstar using PASCIN. The data at that stage consisted purely of time (in seconds), and positional information (Lat. and Long.). To calculate average speed and direction from this data, the Pstar program POSSPD was used. Speeds exceeding 3 m/s were replaced with absent data.

The calculated current vectors are shown at their respective positions in Figure 4 and the buoy's track is shown on a Mercator map in Figure 3(b).

TABLE 1

IOSDL Mooring 508

		First Measurement		Last Measurement	
Aanderaa		1630	17/7/90	1540	3/9/90
S4		1200	4/7/90	1400	19/8/90
ADCP		1200	4/7/90	1555	17/8/90
Position		64°23.8'N	11°55.7'W	(water depth 435 m uncorr.)	
Deployment:	Rotor Free	1547	18/7/90		
	Commenced	1554			
	Anchor away	1600			
	On bottom	1603			
Recovery:	Acoustic contact	0628	16/8/90		
	Mooring release	0726			
	Sighted on surface	0730			
	Begin recovery	0759			
	ADCP + S4 out of water	0806			
	Aanderaa out of water	0814			
	Aanderaa rotor taped	0827			

TABLE 2

HOB Drifter

Deployment:	Time	0948	8/8/90
	Position	64°18'N	12°38'W
Recovery:	Time	1539	16/8/90
	Position	64°59'N	9°38'W

4. ADCP DATA QUALITY

The moored ADCP was a 150 kHz R.D. Instruments Self-Contained unit incorporating a 20M byte eprom logger for data storage. The required data interval, accuracy, and profiling range were taken into account when setting up the instrument, as resources such as memory and battery power were limited. The necessary trade-offs between these factors and the duration of the deployment were optimised with RDI's Deployment Software, and the instrument was set up at RVS to give a 300 m profiling range consisting of 75 4-metre depth cells, and an ensemble average (over 300 pings) every five minutes. This information allows the random error (standard deviation) of the horizontal velocity components to be calculated using a formula in RDI's ADCP primer (RDI 1989):

$$\text{random error (cm/s)}, \sigma = \frac{1.6 \times 10^7}{153 \times 10^3 \times 4 \times \sqrt{N}} = 1.5 \text{ cm/s} \qquad (1)$$

where N is the pings per ensemble

Whereas the random error is 1.5 cm/s for the 5 minute ensembles, it is reduced to less than 0.5 cm/s by subsequent averaging of the data to a one hour interval. The total error estimate is the sum of the random error and the bias error (a long-term and unavoidable error) which is typically 0.5 - 1.0 cm/s (RDI 1989). The error in our results is, therefore, mostly due to bias error.

The data extracted from the ADCP eprom logger were found to be entirely free of recording errors. This exemplifies the integrity of solid state storage compared to magnetic tape which is much more susceptible to corruption.

The data quality is monitored by the ADCP itself, enabling unreliable data, both single pings and ensembles to be automatically ignored if required. This quality measure is achieved by counting the number of good pings within an ensemble, and recording this as a percentage in the variable 'pgood'. A ping is marked as good only if the received signal exceeds a (user selectable) signal to noise ratio of 6 dB. Past practice with ADCP data has shown that data can be taken as reliable if it is associated with a 'pgood' value of 25% or more. This value also marks the point at which the data has a random error twice that of 100% good data (see Equation 1). Eight profiles of the 'pgood' variable are shown in Figure 5. Each of these is an average over $^1/_8$th of the data set, and the 25% thresholds are indicated for clarity. An estimated 97% of the data had a 'pgood' value of over 25%.

RD Instruments recommend that data from depth cell 1 is ignored since it is usually contaminated due to its close proximity to the transducers. With our set-up, however, this depth cell started 3 m away from the transducers, and data from the first cell appeared to be consistent with that from neighbouring cells.

5. DATA PROCESSING

5.1 Interocean S4 Current Meter

The S4 current meter data were downloaded from the instrument to a binary file. An Interocean utility program then converted the binary file to ASCII format. A program (formconv) was written in Turbo-Basic on a PC to extract the relevant records from the ASCII file and to format the data. This data was then read into a Pstar binary file by the use of the program PASCIN. A new file was created for the east and north components of the current and time as Julian days.

Unwanted values obtained whilst the instrument was being lowered into the water were detected by looking through listings of the file, and subsequently removed.

Using the program PCMCAL, the speed and direction of the current were calculated from the values of the east and north components. The direction was converted from degrees magnetic to degrees true by subtracting the magnetic variation (17.66°). This enabled the calculation of the true east and north components from the true direction and the speed. The data quality was very high, no errors were present in the data, again because of the use of a solid state data logger.

5.2 Aanderaa current meter

The Aanderaa current meter data contained the variables temperature, pressure, fine temperature, speed and direction. This data underwent much the same processing as that from the S4 instrument, however, the data were first converted into engineering units.

Pressure and temperature calibrations were applied using the slope and intercept of the regression lines which were least-squares fitted to the calibration data, Table 3. The conversion of speed from counts to cm/s was achieved using the following equation :-

$$\text{speed(cm/s)} = \frac{a \times (\text{revs/count})}{(\text{count interval})} + \text{offset} \qquad (2)$$

where :-

a = the slope of the rotor calibration

offset = the intercept of the rotor calibration

revs/count = the setting of the instrument (in this case 8 rpc)

count interval = recording period of instrument in seconds (600s)

TABLE 3

Calibration values for Aanderaa

VARIABLE	SLOPE		INTERCEPT	
	Estimate	Std. Error	Estimate	Std. Error
rotor	0.00224314	3.7134E-5	0.0077508	0.0248876
pressure	0.7587547	3.60412E-3	-42.4903	1.97077
temp ch.2	0.0224497	2.49628E-5	-2.61839	0.0102133
temp ch.4	0.0133063	2.7978E-5	-1.35274	0.0167906

The compass direction was corrected by entering values from a 'look-up' table to account for compass non-linearities. This can be a problem since these compass errors can show an extraction of energy from the periodic component of an oscillating current, which can later re-appear in the mean current (Gould 1972). The compass errors are shown in Figure 6.

A few data spikes were edited from the pressure channel. These were replaced by estimates based on surrounding data records.

A plot of fine temperature against time is given in Figure 7. This shows a sudden change from 0°C to over 2°C for a few days about halfway through the deployment period, suggesting the presence of a different water mass.

Common Processing for S4 and Aanderaa

Statistical analyses of the current meter data are given in Tables 5 and 6, whilst Table 4 contains data from the tidal analyses of all instruments, including the ADCP. Time series plots of east, north and speed were obtained and these are shown in Figures 8 and 9. Following this, the time series were both averaged over 24 hrs to eliminate the semi diurnal tidal components, and plots of the average east and north currents were generated in time series and vector formats (Figures 10, 11 and 12). These figures also contain plots of the differences between the two sets of current components, which were obtained after merging the two averaged files. The vector plot of this difference shows a persistent shear throughout the deployment, which is discussed in the next section. Progressive vector plots of distance east against distance north are also given (Figure 13).

5.3 ADCP

The processing of the data from the ADCP can be split into two main stages. The first stage involved extracting and translating the data from the ADCP, editing and calibrating the data, from $3^{1}/_{2}$" disks, and reduction in size of the data set by averaging in time. Subsequent processing was to produce tabulated and graphic output, the results of which are presented later in this report.

A Turbo-Pascal program (Griffiths and Crisp 1990), incorporating routines from RDI's ADCP data decode package, was used to translate the data and perform some processing before outputting it to a file in a rudimentary ASCII format. The processing performed was for data reduction and involved taking averages of the variables 'pgood' and 'Echo Amplitude' over the four beams, converting velocities from counts to mm/s by multiplying by 5, and averaging over 3 data intervals to give a new interval of 15 minutes. In its ASCII form, the data were transferred to the UNIX network via the ethernet from a PC using TCP/IP and subsequently converted to a Pstar format file using PASCIN.

Unwanted data outside the deployment period were removed and absent data values (-999) inserted using the following criteria:

1. In place of data with a 'pgood' of less than 25.

2. Where data lay outside the ranges:

   -1500 to +1500 mm/s for east, north
   -500 to +500 mm/s for error velocity, vertical velocity.

The data were then averaged over hourly intervals, again to reduce the size of the data set since 15 minute resolution was not required. Calibration of the east and north velocities was achieved by creating speed and direction variables from them, then calibrating these to cm/s and °True by multiplying by 0.1 and subtracting the magnetic variation (17.66°) respectively. True east and north components were then recreated from the speed and direction variables.

All velocities were corrected for temperature and salinity (0°C and 35 psu) taken from the Aanderaa instrument. The velocity of sound in water using the above figures is 1449 m/s, whereas the velocity assumed by the ADCP (RDI 1989) is 1536 m/s, so correction of the velocities was achieved by multiplying by 1449/1536.

Finally, the depth cell values were converted to true bin depth with the aid of the mooring information (Figure 2) and the pressure recorded by the Aanderaa sensor below the ADCP.

Difficulties in presentation, due to the size and the nature of the data, make it impractical to provide detailed information for all of the 75 depth cells. It is, therefore, necessary to choose a set of levels which will reasonably represent the whole set. Depth cells 2, 20, 40, 60 and 70 (at depths of 379, 307, 227, 147 and 107 m respectively) achieve this aim without being coloured by unreliable data.

For the above depths, time series plots of east, north and speed (Figures 14 - 18) were obtained, together with progressive vector plots (Figure 19), and tidal analysis for the M2, S2, K1 and O1 components (Table 4). A plot of the major and minor axes of the M2 component against depth is given in Figure 20. This includes data from the S4 and Aanderaa, whose depths are clearly indicated on the plot. Both this plot and the listings of table 6 show a small discrepancy between the data from the S4 and that of its neighbouring data points (the Aanderaa and depth cell 2). This discrepancy is also consistent with the shear apparent in the difference plot of Figure 12. An analysis of the bias errors in each instruments' readings, from manufacturers and calibration data reveal figures of about ±1 cm/s, ±0.8 cm/s, and ±0.5 cm/s for the S4, Aanderaa and ADCP respectively. The effect that they have on the entire data set is indicated on a plot of the mean current speeds against depth (Figure 21), which includes error bars for the S4 and Aanderaa. Data for this plot are taken from the statistical analysis Tables 5-11. The plot shows that the inconsistencies observed are within the instruments' error specifications, hence the 'shear' shown in Figure 12 may well be spurious.

The effects of compass bias errors on the mean east and north speeds have been deemed negligible, since (observing Figure 12) in the first half of the deployment period, the mean direction was approx south-west, and in the second half, north east.

The sudden drop in the major axis component of the M2 tidal component in Figure 21 is due to the large number of absent data values present in the depth cells furthest from the transducers. Evidence of such absent data is apparent in Figure 18, the time series plots for depth cell 70.

To produce contour maps of the low frequency current speeds against depth and time, (Figures 22 and 23), a 24 hour filter was applied to remove the semi-diurnal tidal information. This filtered data set was also used to produce a gridded vector plot (Figure 24), which shows the magnitude and direction of the current with depth and time. For clarity, and since there are no sudden changes of velocity with depth, this plot only shows every fifth depth cell.

6. RESULTS

All the current meters gave excellent records. The differences between the current meters were consistent with their error specifications. Both the S4 and Aanderaa instruments were within the bottom boundary layer, where some current shear would be expected.

The contour and gridded vector plots for the ADCP low frequency currents show a large increase in speed about halfway through the deployment period. Speeds in excess of 80 cm/s at ~ 130 m and 50 cm/s at ~240 m depth were recorded. A clear indication of the direction of this high speed flow is given in the progressive vector plots of Figure 19 and in the gridded vector plot of Figure 24.

A temperature rise from 0°C to about 2°C, measured by the Aanderaa sensor during days 216-219 corresponded with the speed increase mentioned above. At the depth of the Aanderaa, this flow was north-easterly at a speed of about 20 cm/s. Without salinity and temperature profiles of the water above the ADCP, it is difficult to determine precisely the water masses present. The following is, however, offered to the reader as one possible scenario: Either side of the temperature/speed increase the waters are East Icelandic Intermediate Water (EIIW) and Arctic Intermediate Water (AIW). The former overlying the latter, the front at these times being to the south of the mooring. Then, during the increase, modified EIIW is present, drawn down to the depth of the Aanderaa (~400 m) by the mixing in the front, as the front meandered north to pass over the mooring.

Due to the satisfactory recovery of the ADCP and HOB buoy, it is concluded that the moorings proved to be of sound design and worthy of future use.

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TABLE 4

Tidal analysis for the ADCP

M2 Semi-diurnal component

Depth cell	depth metres	ax.maj. cm/s	ax.min. cm/s	ellip.	dirn. degrees	phase degrees
****	********	********	********	********	********	********
Aand	413.0	24.231	-5.283	-0.218	39.7	-133.4
S4	391.0	27.769	-8.623	-0.311	39.3	-136.2
2.	379.3	29.434	-10.678	-0.363	39.5	-129.3
20.	307.3	32.136	-13.443	-0.418	46.3	-122.6
40.	227.3	31.255	-12.198	-0.390	52.1	-117.2
60.	147.3	30.972	-11.076	-0.358	57.0	-113.9
70.	107.3	31.213	-11.677	-0.374	59.9	-109.2

S2 Semi-diurnal component

Depth cell	depth metres	ax.maj. cm/s	ax.min. cm/s	ellip.	dirn. degrees	phase degrees
****	********	********	********	********	********	********
Aand	413.0	11.866	-4.458	-0.376	53.3	-69.7
S4	391.0	13.313	-4.922	-0.370	50.0	-71.4
2.	379.3	13.692	-5.804	-0.424	48.3	-67.1
20.	307.3	13.691	-5.353	-0.391	50.3	-64.6
40.	227.3	10.881	-4.074	-0.374	51.0	-69.6
60.	147.3	9.026	-2.795	-0.310	54.4	-64.0
70.	107.3	6.713	-1.119	-0.167	62.7	-51.5

K1 Diurnal component

Depth cell	depth metres	ax.maj. cm/s	ax.min. cm/s	ellip.	dirn. degrees	phase degrees
****	********	********	********	********	********	********
Aand	413.0	3.293	-1.157	-0.351	14.0	-122.9
S4	391.0	3.269	-1.188	-0.363	3.6	-127.9
2.	379.3	3.417	-1.383	-0.405	5.6	-127.2
20.	307.3	3.466	-1.173	-0.338	10.4	-124.8
40.	227.3	3.936	-1.316	-0.334	0.8	-110.1
60.	147.3	3.795	-1.623	-0.428	-1.4	-101.3
70.	107.3	2.043	-0.927	-0.454	-24.2	-75.6

O1 Diurnal component

Depth cell	depth metres	ax.maj. cm/s	ax.min. cm/s	ellip.	dirn. degrees	phase degrees
****	********	********	********	********	********	********
Aand	413.0	2.397	-0.156	-0.065	-9.0	-49.5
S4	391.0	1.954	-0.068	-0.035	-16.9	-49.4
2.	379.3	2.175	-0.299	-0.137	-19.4	-51.2
20.	307.3	2.296	-0.443	-0.193	-19.2	-49.9
40.	227.3	2.717	-0.426	-0.157	-14.1	-35.6
60.	147.3	3.108	-0.438	-0.141	-6.8	-23.7
70.	107.3	3.834	0.102	0.027	-3.7	-11.2

TABLE 5

Record-long statistics for S4

LAT, °N 64 23.8		LON, °W 11 55.7	NUMBER OF DATA CYCLES 4124
INTERVAL 1/6 HR		FROM 199.656	TO 228.288
INSTRUMENT S4		DEPTH 391	DEPTH OF WATER 435 m
UNITS	cm/s	cm/s	cm/s
VARIABLE	EAST	NORTH	SPEED
MEAN	-0.60	-2.76	23.86
UNCERTAINTY			
STD. DEVIATION	20.61	18.34	14.39
SKEWNESS	0.017	-0.261	0.523
KURTOSIS			
MINIMUM	-49.643	-50.628	0.2
MAXIMUM	55.082	40.281	63.712

UNITS	cm^2/s^2
VARIABLES	EAST-NORTH
COVARIANCE	258.114
CORREL. COEFF.	0.676

DIRECTION AND VARIABILITY

DIRECTION OF	(MEAN	192.3	°T	AND ITS MAGNITUDE	2.82	cm/s
	(MAX. VARIABILITY	49.5		AND STD. DEVIATION	25.4057	
	(MIN. VARIABILITY	139.5		AND STD. DEVIATION	11.0867	

TABLE 6

RECORD-LONG STATISTICS FOR Aanderaa

LAT, °N 64 23.8	LON, °W 11 55.7	NUMBER OF DATA CYCLES 4124	
INTERVAL 1/6 HR	FROM 199.674	TO 228.306	
INSTRUMENT ACM	DEPTH 413	DEPTH OF WATER 435 M	

UNITS	cm/s	cm/s		deg. C
VARIABLE	EAST	NORTH		TEMPERATURE
MEAN	-2.88151	0.18997		0.25472
UNCERTAINTY				
STD. DEVIATION	18.78373	17.68861		0.73762
SKEWNESS	-0.171	-0.088		2.577
KURTOSIS				
MINIMUM	-47.534	-43.554		-0.171
MAXIMUM	38.494	44.228		3.092

UNITS	cm^2/s^2	°C cm/s	°C cm/s
VARIABLES	EAST-NORTH	EAST-TEMP	NORTH-TEMP
COVARIANCE	206.3804	3.30133	4.04415
CORREL. COEFF.	0.6211	0.2383	0.31

DIRECTION AND VARIABILITY

	(MEAN	273.8	°T	AND ITS MAGNITUDE	2.89	cm/s
DIRECTION OF	(MAX. VARIABILITY	47.8		AND STD. DEVIATION	23.2423	
	(MIN. VARIABILITY	137.8		AND STD. DEVIATION	11.2033	

TABLE 7

Record-long statistics for depth cell 2

LAT, °N 64 23.8	LON, °W 11 55.7	NUMBER OF DATA CYCLES 688	
INTERVAL 1 HR	FROM 199.67	TO 228.295 (JDAYS)	
INSTRUMENT SC-ADCP	DEPTH 379	DEPTH OF WATER 435 m	

UNITS	cm/s	cm/s	cm/s
VARIABLE	EAST	NORTH	SPEED
MEAN	-0.95496	-1.56706	25.12390
UNCERTAINTY			
STD. DEVIATION	21.40754	19.16114	14.05665
SKEWNESS	-0.254	-0.055	0.665
KURTOSIS			
MINIMUM	-54.285	-46.704	0.833
MAXIMUM	51.588	43.363	66.238

UNITS	cm^2/s^2
VARIABLES	EAST-NORTH
COVARIANCE	276.50371
CORREL. COEFF.	0.6741

DIRECTION AND VARIABILITY

DIRECTION OF	(MEAN	211.4 °T	AND ITS MAGNITUDE	1.84	cm/s
	(MAX. VARIABILITY	49.7	AND STD. DEVIATION	26.3239	
	(MIN. VARIABILITY	139.7	AND STD. DEVIATION	11.5101	

TABLE 8

Record-long statistics for depth cell 20

LAT, °N 64 23.8	LON, °W 11 55.7	NUMBER OF DATA CYCLES 688	
INTERVAL 1 HR	FROM 199.67	TO 228.295 (JDAYS)	
INSTRUMENT SC-ADCP	DEPTH 307 m	DEPTH OF WATER 435 m	

UNITS	cm/s	cm/s	cm/s
VARIABLE	EAST	NORTH	SPEED
MEAN	2.69939	-0.50186	28.18537
UNCERTAINTY			
STD. DEVIATION	22.55014	22.20314	14.64963
SKEWNESS	-0.337	-0.030	0.662
KURTOSIS			
MINIMUM	-56.249	-53.563	2.133
MAXIMUM	53.236	55.210	71.660

UNITS	cm^2/s^2
VARIABLES	EAST-NORTH
COVARIANCE	333.00365
CORREL. COEFF.	0.6651

DIRECTION AND VARIABILITY

	(MEAN	100.5 °T	AND ITS MAGNITUDE	2.75	cm/s
	(				
DIRECTION OF	(MAX. VARIABILITY	45.7	AND STD. DEVIATION	28.8763	
	(				
	(MIN. VARIABILITY	135.7	AND STD. DEVIATION	12.9480	

TABLE 9

Record-long statistics for depth cell 40

LAT, °N 64 23.8	LON, °W 11 55.7	NUMBER OF DATA CYCLES 688
INTERVAL 1 HR	FROM 199.67	TO 228.295 (JDAYS)
INSTRUMENT SC-ADCP	DEPTH 227 m	DEPTH OF WATER 435 m

UNITS	cm/s	cm/s	cm/s
VARIABLE	EAST	NORTH	SPEED
MEAN	11.26025	1.68078	32.94705
UNCERTAINTY			
STD. DEVIATION	26.89616	23.04216	17.27583
SKEWNESS	0.034	0.027	0.814
KURTOSIS			
MINIMUM	-53.693	-54.143	0.557
MAXIMUM	85.023	69.141	89.126

UNITS	cm^2/s^2
VARIABLES	EAST-NORTH
COVARIANCE	405.3241
CORREL. COEFF.	0.6540

DIRECTION AND VARIABILITY

DIRECTION OF	(MEAN	81.5	°T	AND ITS MAGNITUDE	11.39	cm/s
	(MAX. VARIABILITY	51.7		AND STD. DEVIATION	32.3073	
	(MIN. VARIABILITY	141.7		AND STD. DEVIATION	14.5114	

TABLE 10

Record-long statistics for depth cell 60

LAT, °N 64 23.8	LON, °W 11 55.7	NUMBER OF DATA CYCLES	688
INTERVAL 1 HR	FROM 199.67	TO 228.295 (JDAYS)	
INSTRUMENT SC-ADCP	DEPTH 147 m	DEPTH OF WATER	435 m

UNITS	cm/s	cm/s	cm/s
VARIABLE	EAST	NORTH	SPEED
MEAN	17.93267	2.64323	37.28956
UNCERTAINTY			
STD. DEVIATION	30.77199	24.53246	22.06384
SKEWNESS	0.345	0.174	0.998
KURTOSIS			
MINIMUM	-54.017	-47.852	1.331
MAXIMUM	111.686	82.508	118.016

UNITS	cm^2/s^2
VARIABLES	EAST-NORTH
COVARIANCE	469.86168
CORREL. COEFF.	0.6224

DIRECTION AND VARIABILITY

DIRECTION OF	(MEAN	81.6	°T	AND ITS MAGNITUDE	18.13	cm/s
	(MAX. VARIABILITY	55.1		AND STD. DEVIATION	35.7060	
	(MIN. VARIABILITY	145.1		AND STD. DEVIATION	16.5481	

TABLE 11

Record-long statistics for depth cell 70

LAT, °N 64 23.8	LON, °W 11 55.7	NUMBER OF DATA CYCLES 688	
INTERVAL 1 HR	FROM 199.67	TO 228.295 (JDAYS)	
INSTRUMENT SC-ADCP	DEPTH 107 m	DEPTH OF WATER 435 m	

UNITS	cm/s	cm/s	cm/s
VARIABLE	EAST	NORTH	SPEED
MEAN	23.2248	4.0508	41.2099
UNCERTAINTY			
STD. DEVIATION	32.70724	25.17978	23.69238
SKEWNESS	0.283	0.123	0.765
KURTOSIS			
MINIMUM	-53.365	-48.594	1.981
MAXIMUM	110.194	85.25	117.343

UNITS	cm^2/s^2
VARIABLES	EAST-NORTH
COVARIANCE	464.50081
CORREL. COEFF.	0.5640

DIRECTION AND VARIABILITY

	(MEAN	80.1 °T	AND ITS MAGNITUDE	23.58	cm/s
DIRECTION OF	(MAX. VARIABILITY	57.6	AND STD. DEVIATION	36.9452	
	(MIN. VARIABILITY	147.6	AND STD. DEVIATION	18.4074	

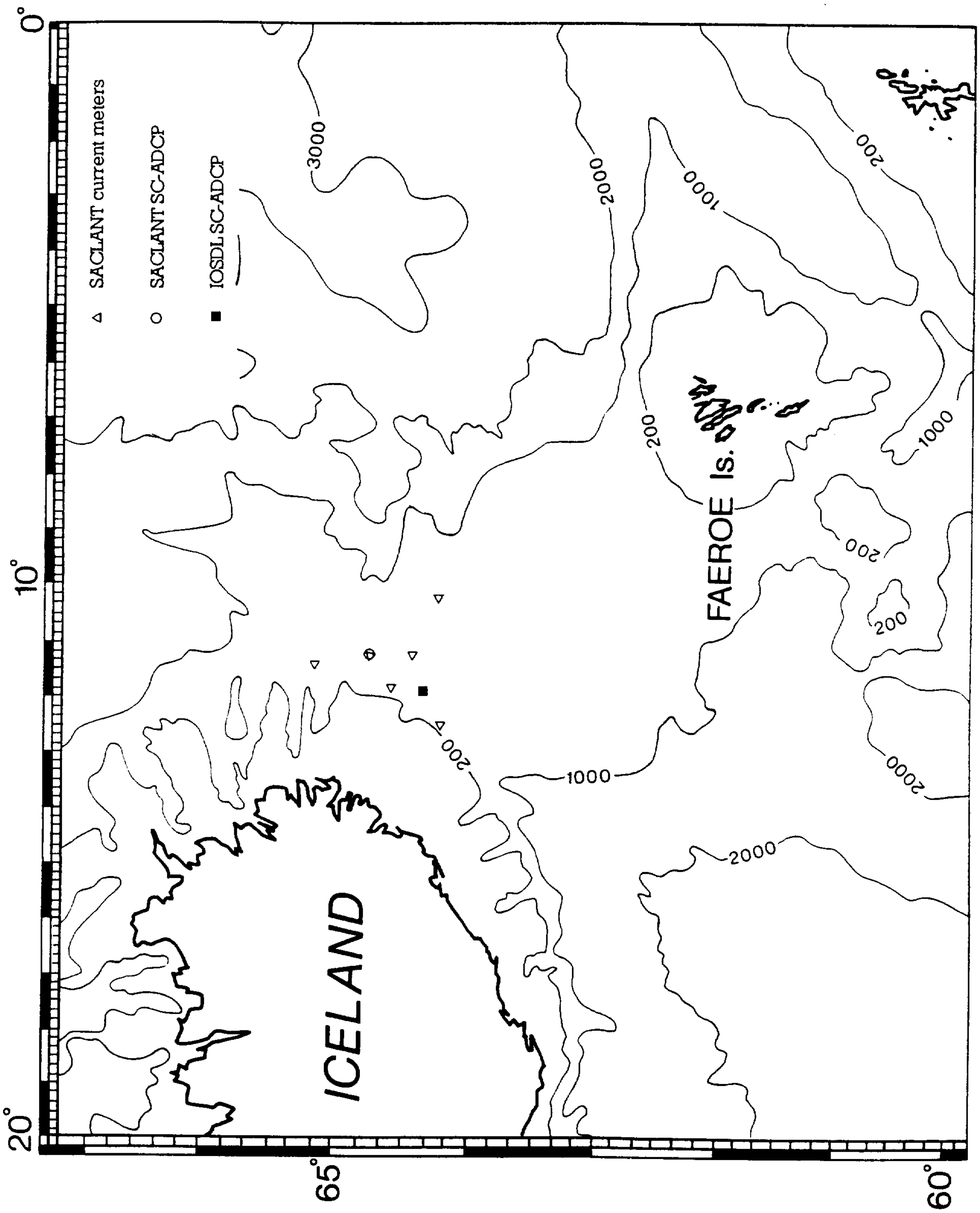
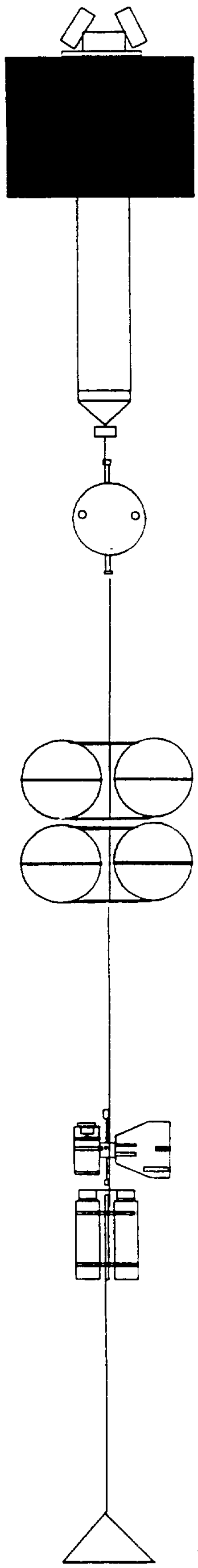


Figure 1. SACLANT and IOSDL Mooring sites.

Figure 2. ADCP Mooring Information.



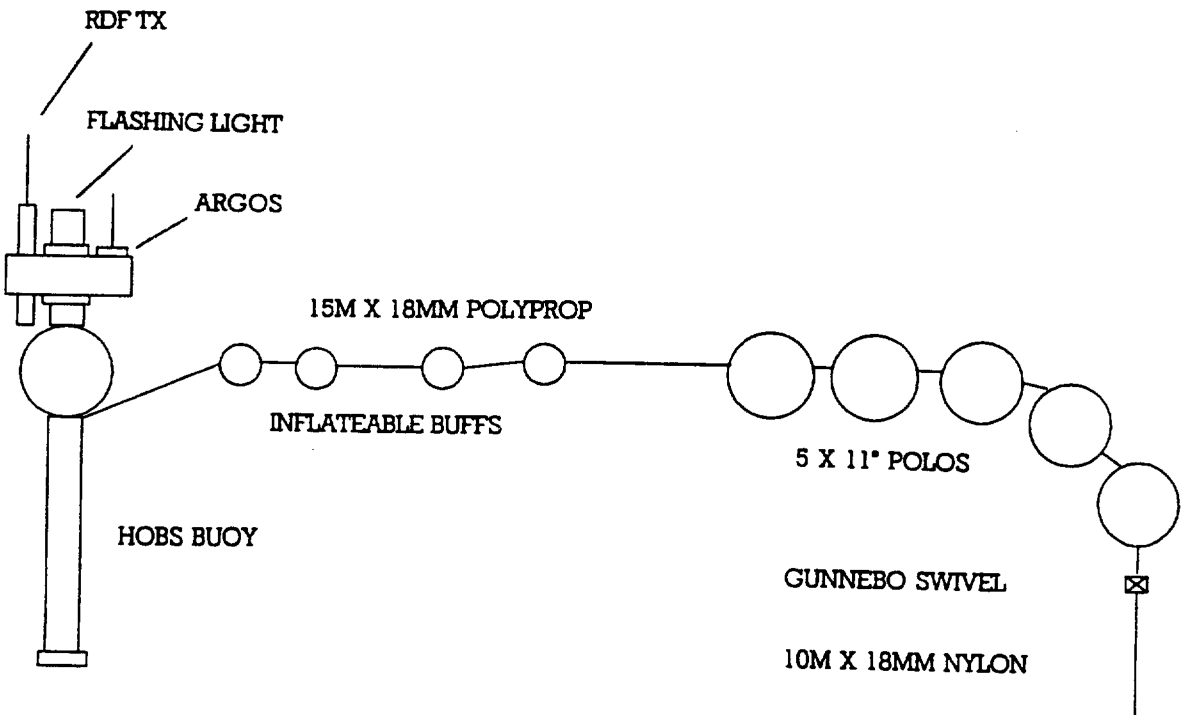
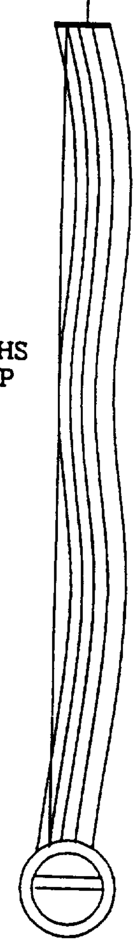



Figure 3(a). HOB drifter assembly.

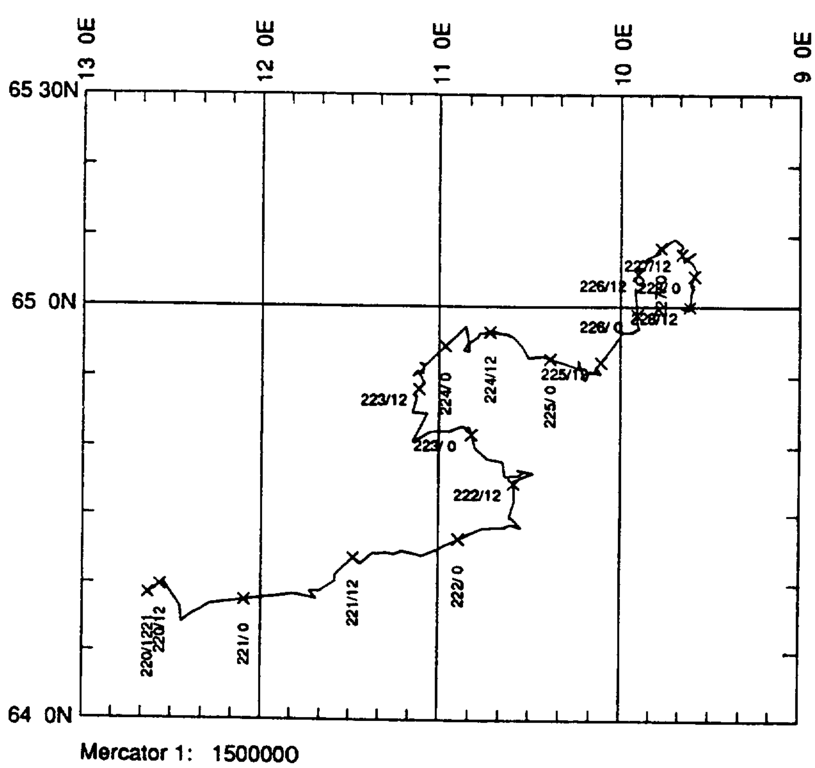


Figure 3(b). HOB buoy track.

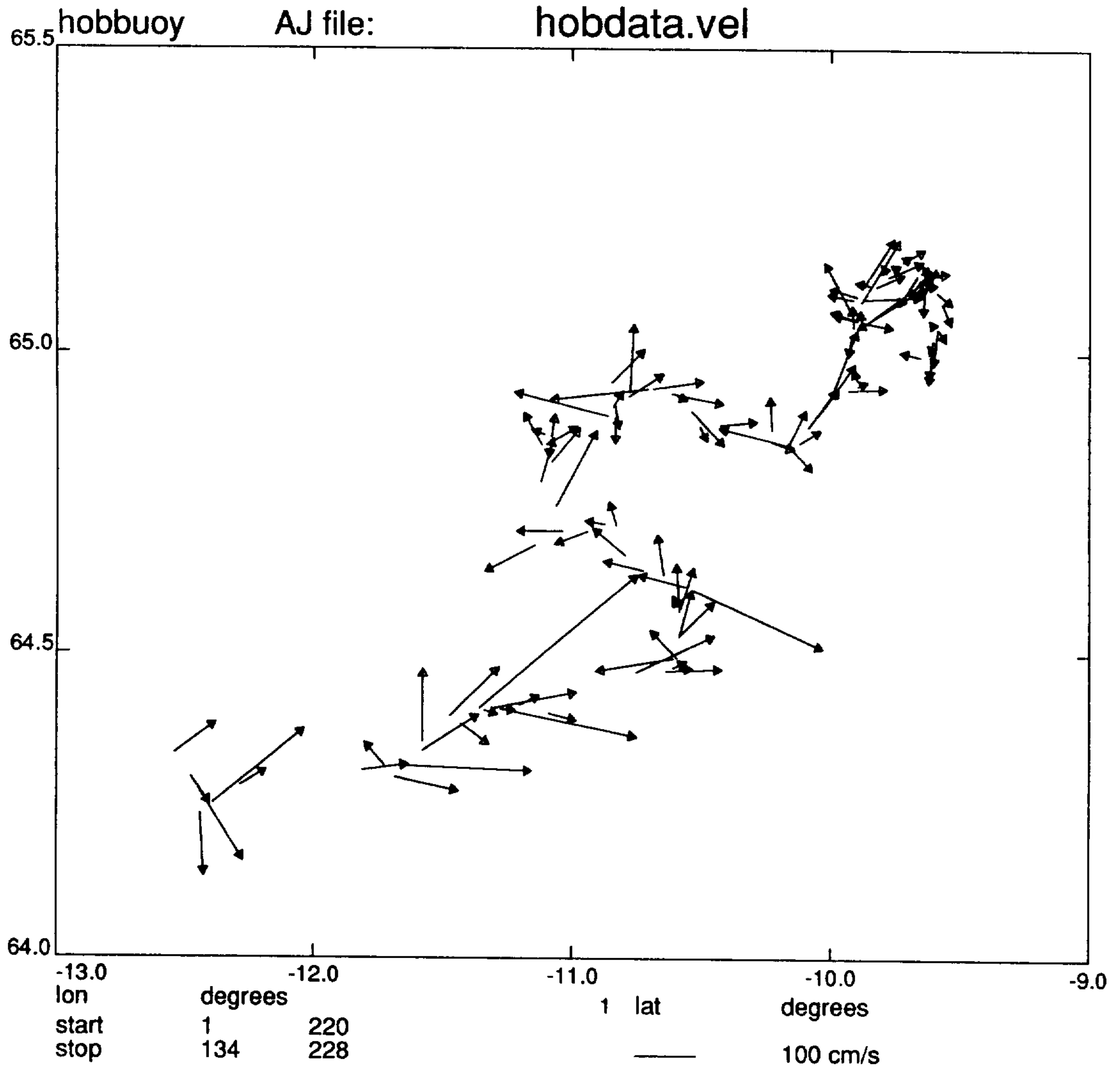


Figure 4. HOB buoy current vectors.

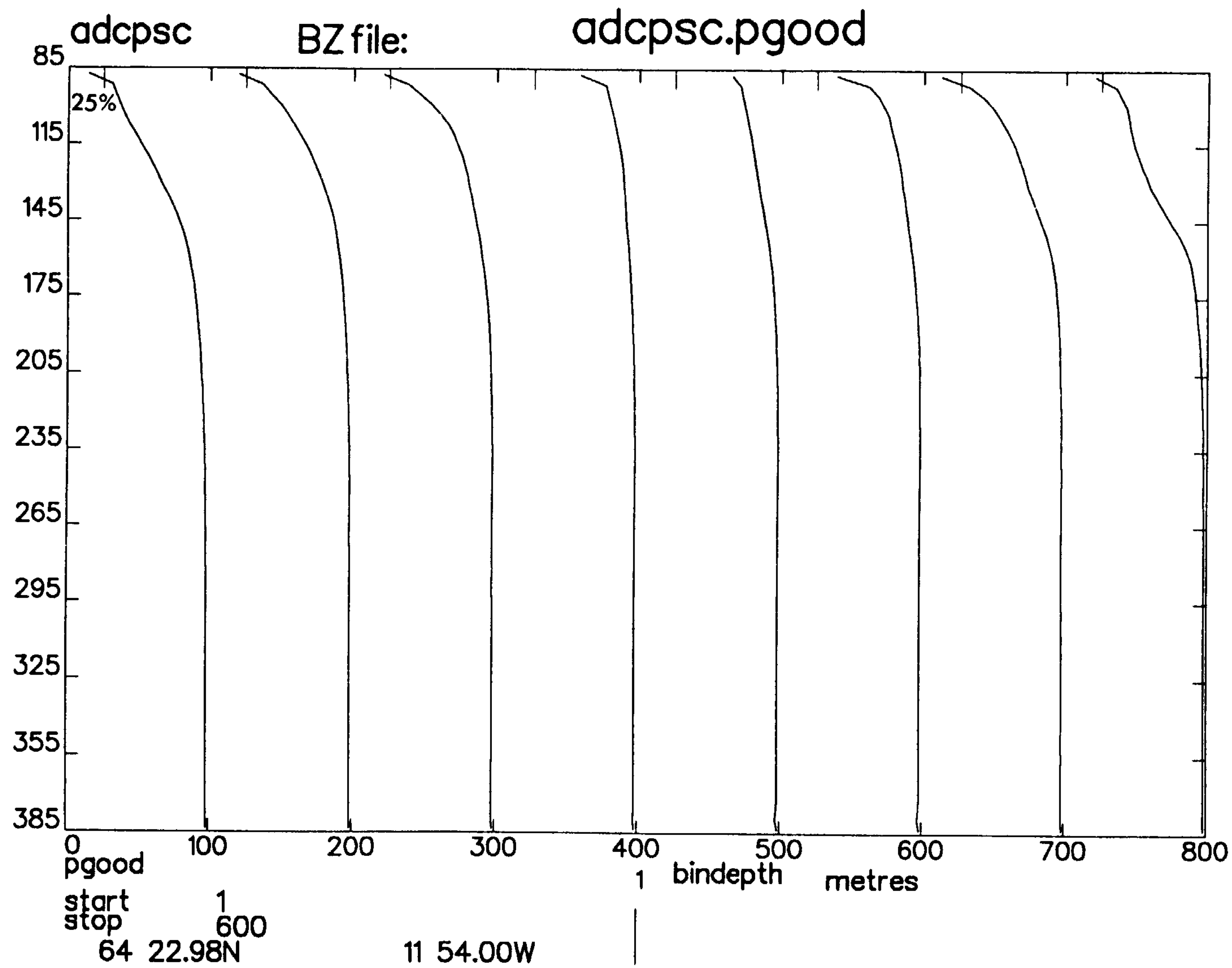


Figure 5. profiles of 'pgood' (ADCP).

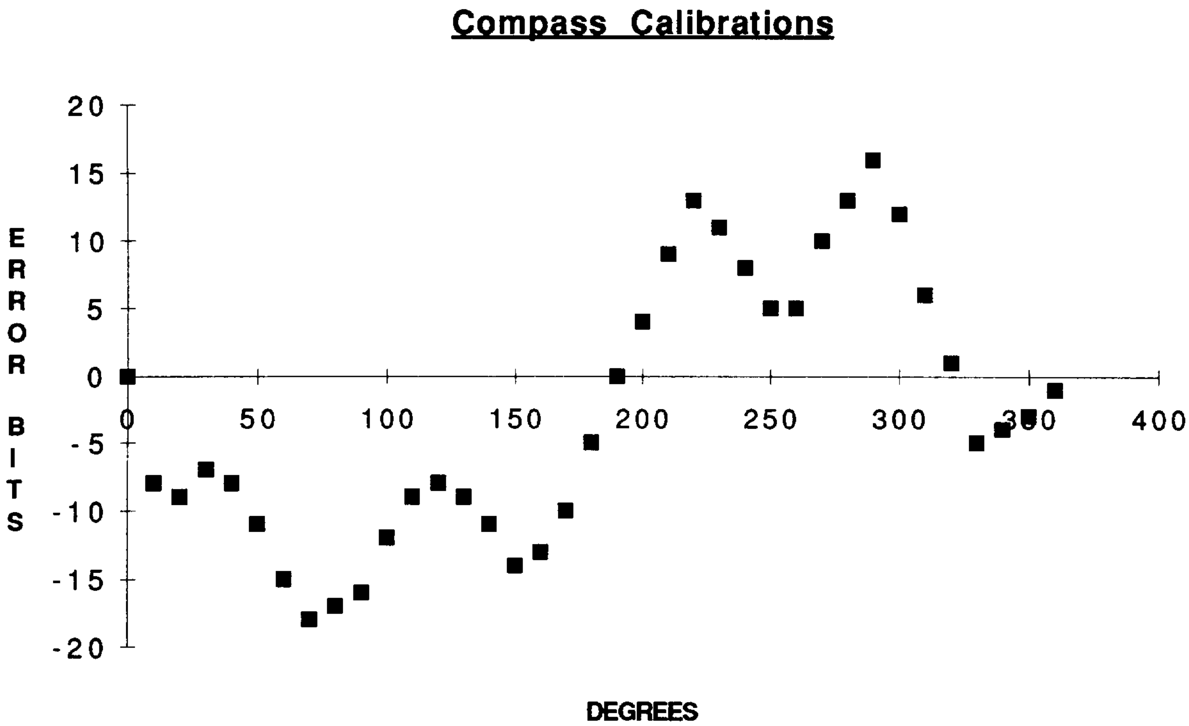


Figure 6. Aanderaa compass calibrations.

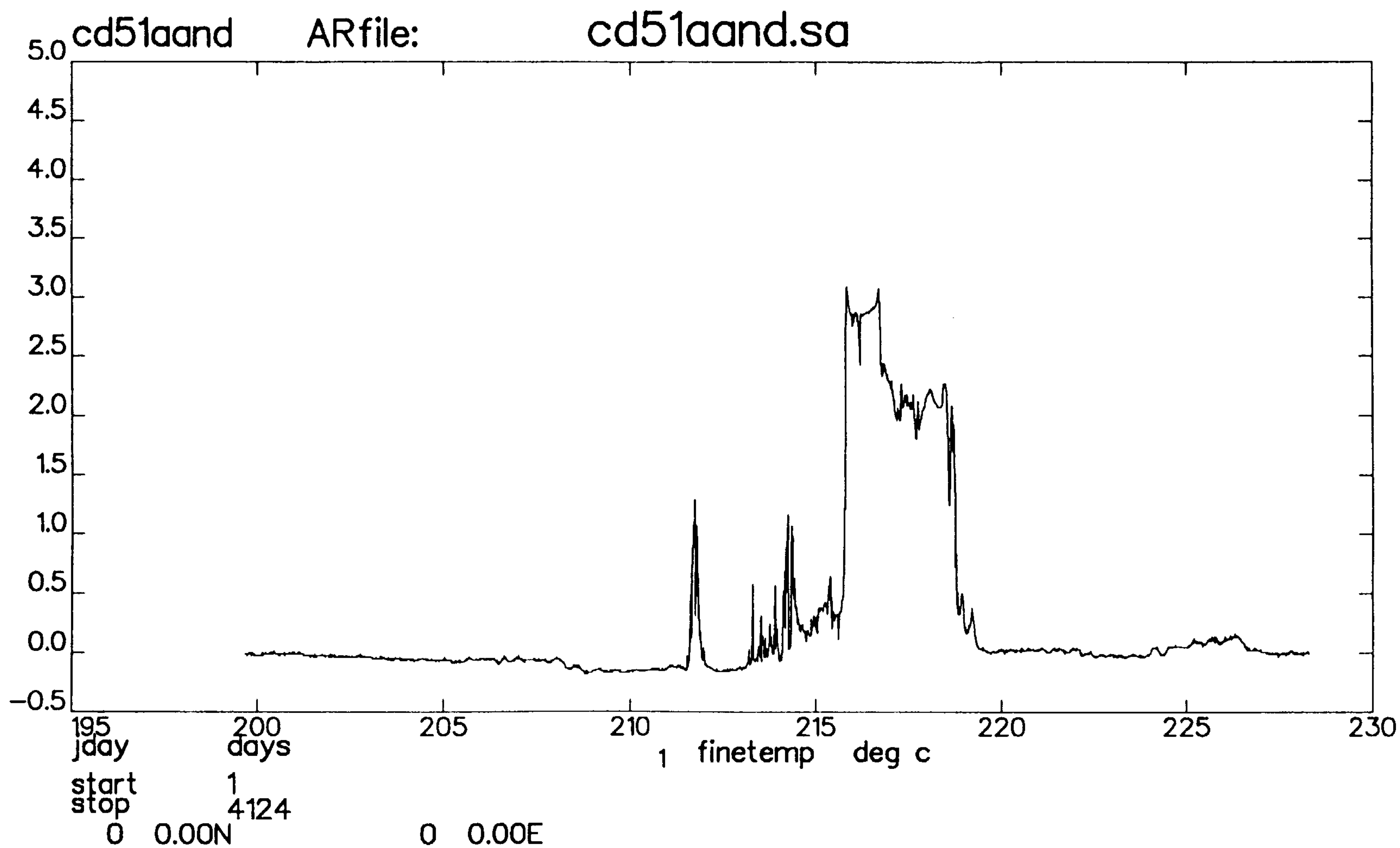


Figure 7. Aanderaa fine temperature.

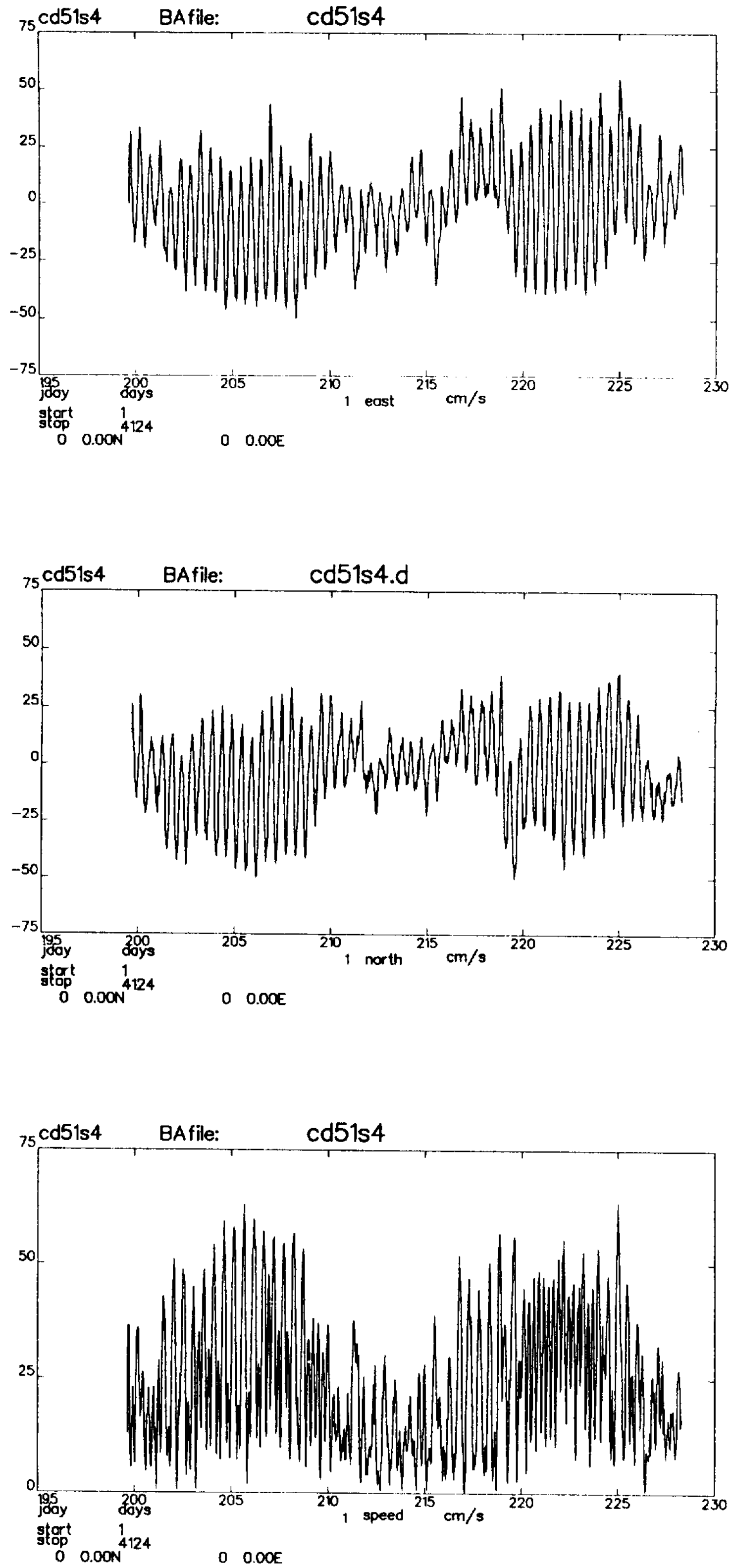


Figure 8. S4 time series.

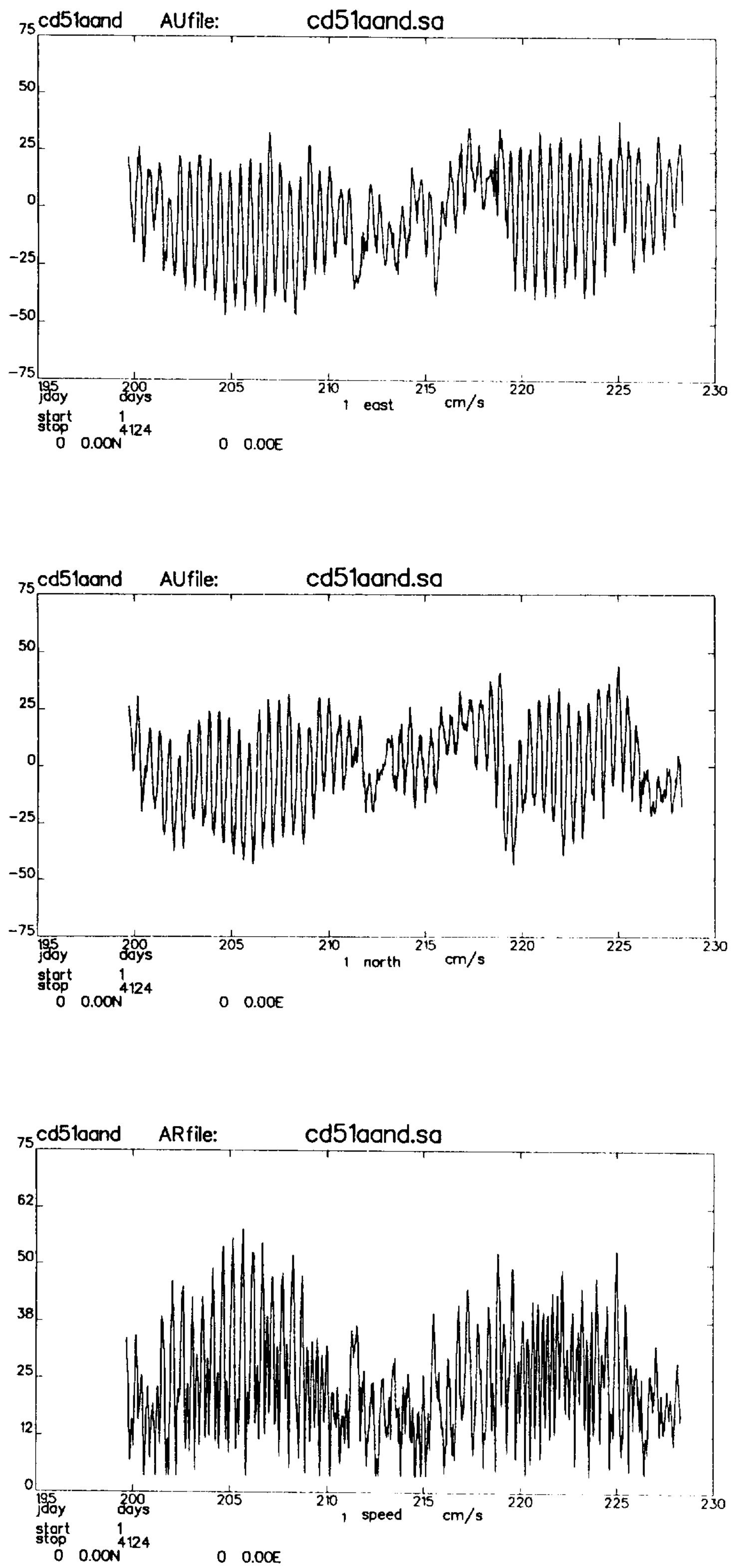


Figure 9. Aanderaa time series.

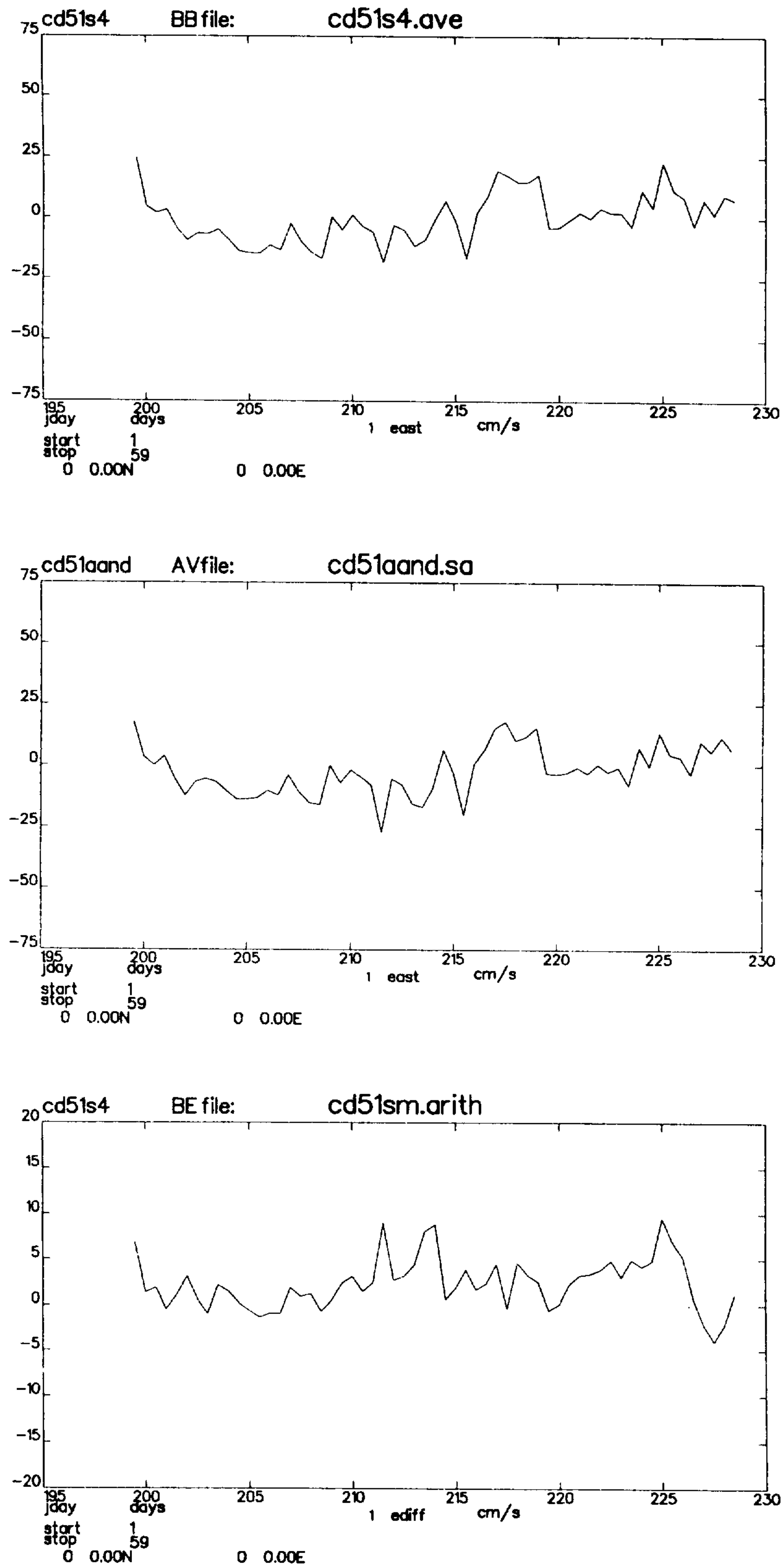


Figure 10. S4 and Aanderaa east component and difference (averaged time series).

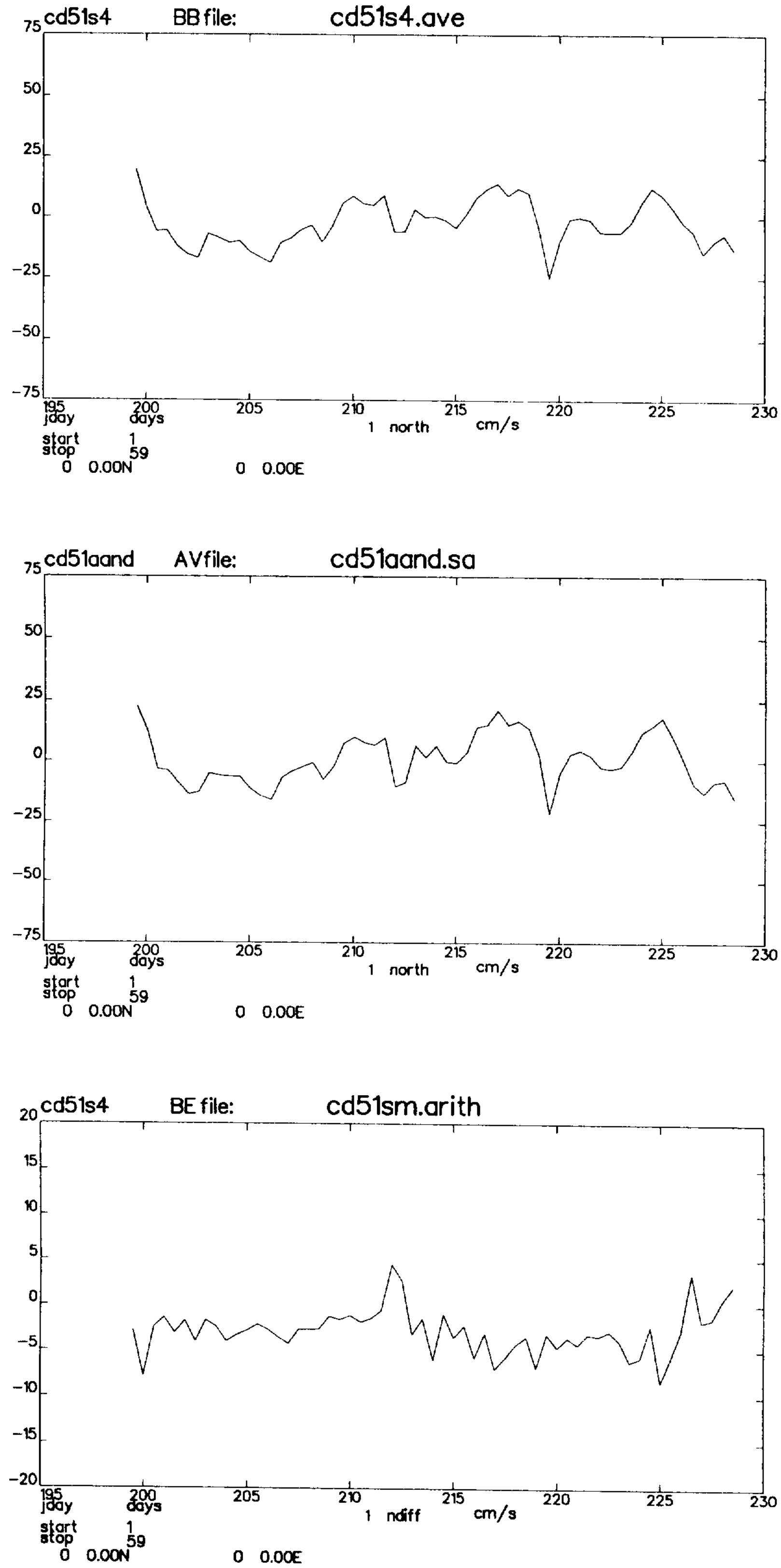


Figure 11. S4 and Aanderaa north component and difference (averaged time series).

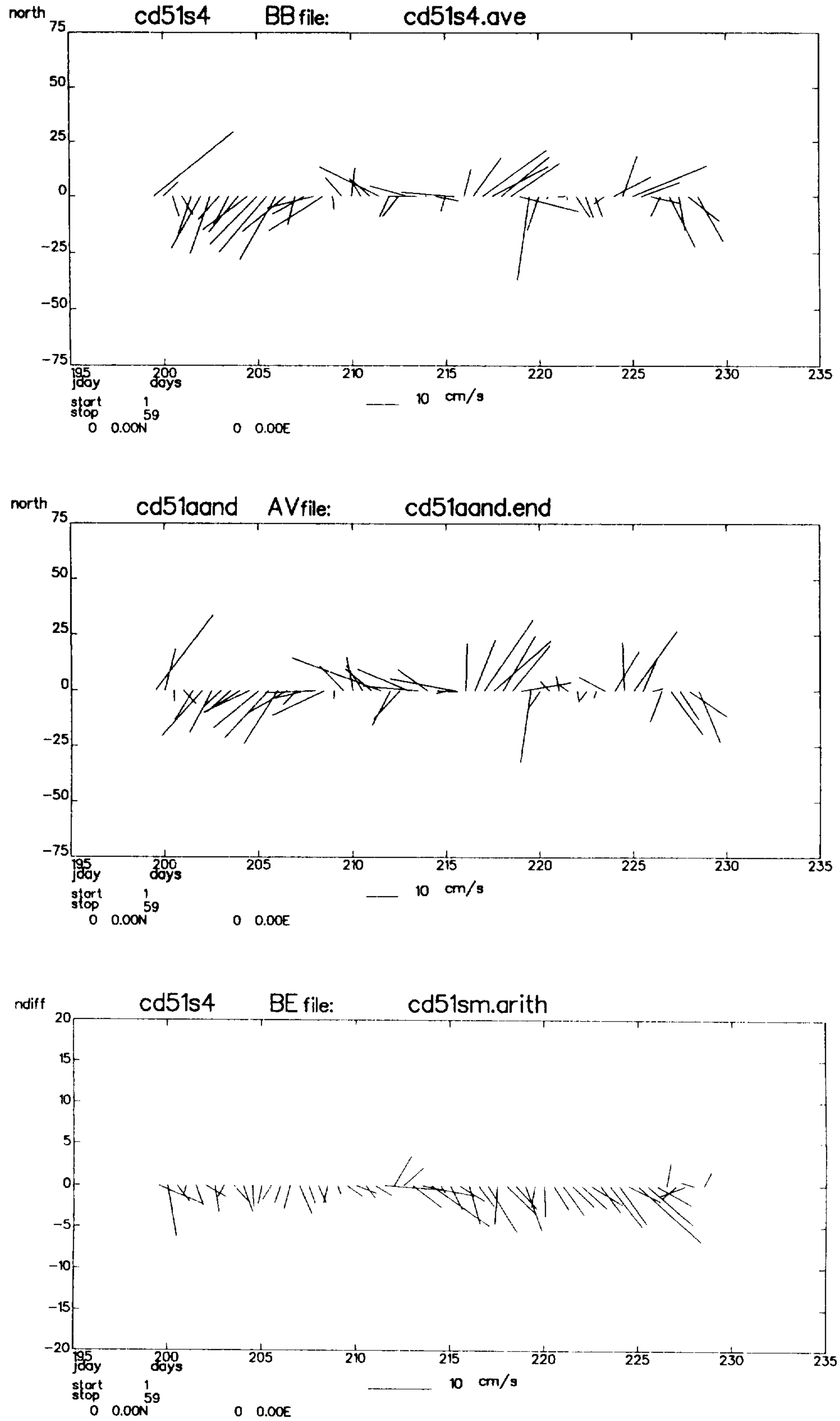
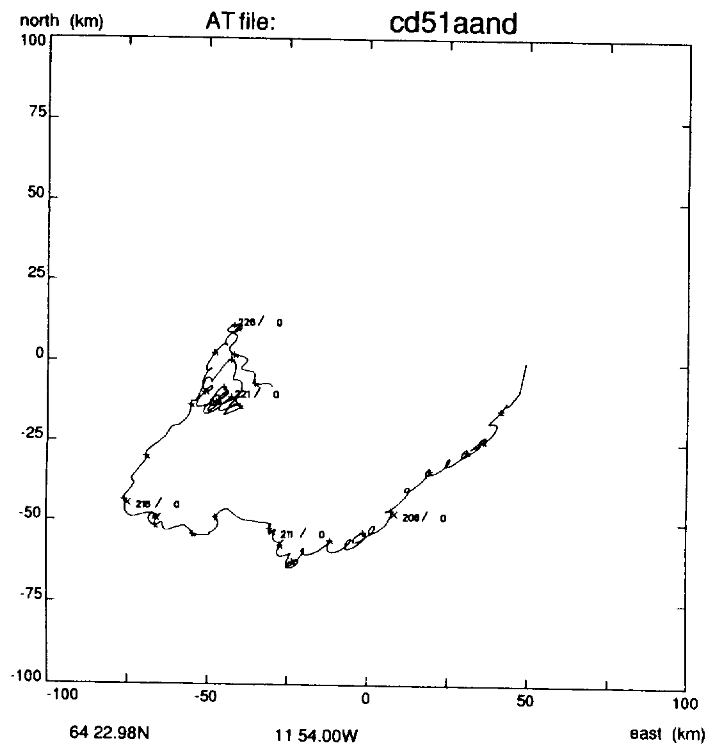


Figure 12. S4 and Aanderaa vectors and difference (averaged time series).



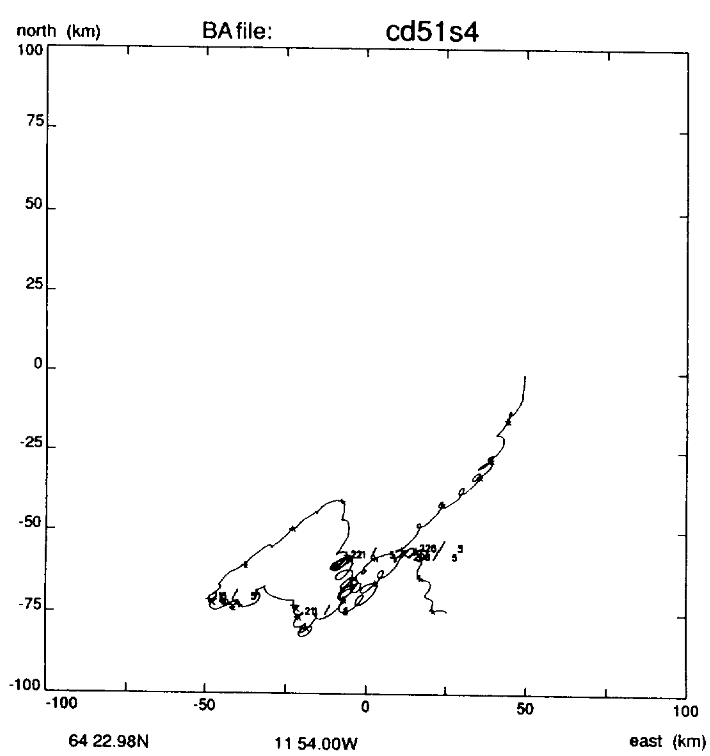
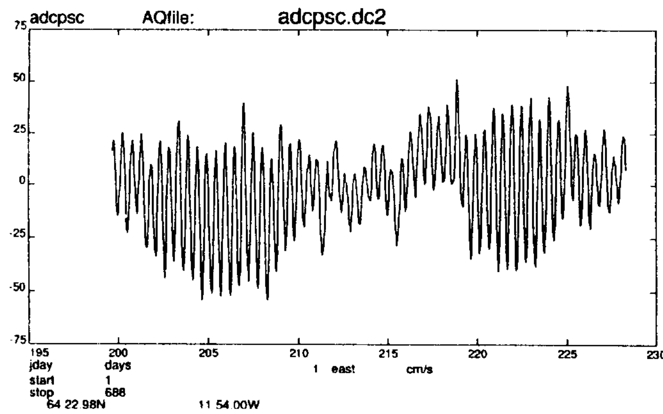
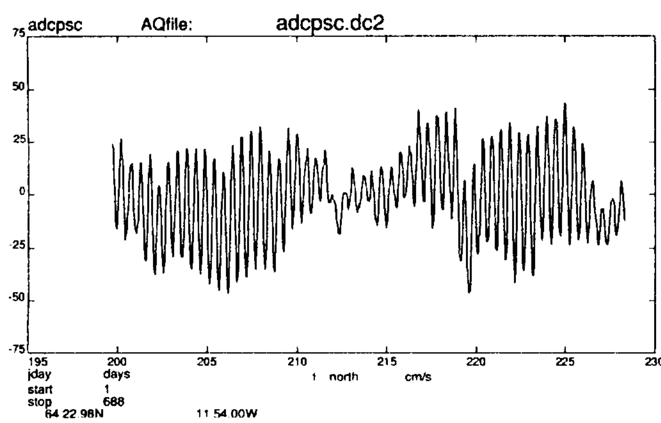


Figure 13. S4 and Aanderaa progressive vectors (to the same scale as the enlargements of ADCP progressive vectors in figure 19).





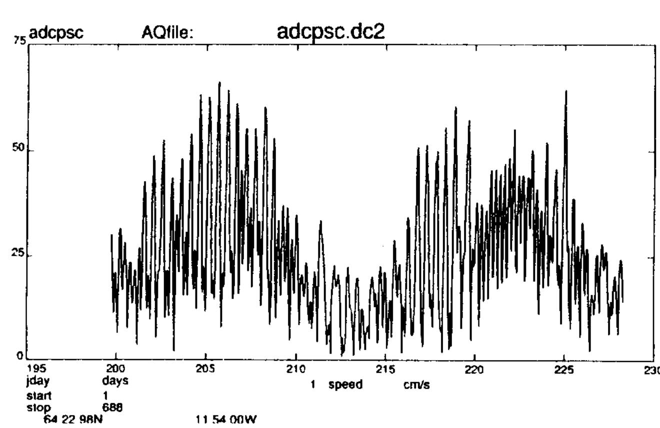
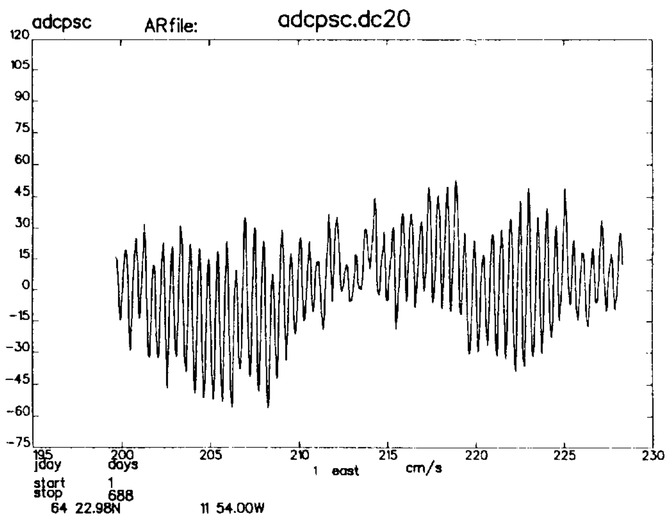
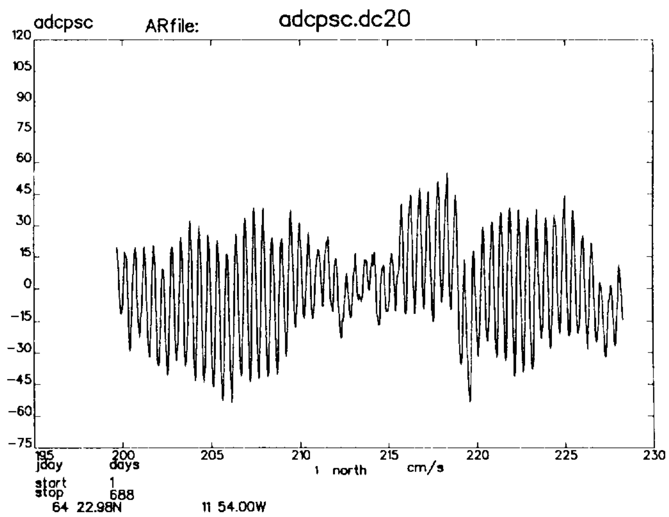


Figure 14. ADCP time series (depth cell 2).





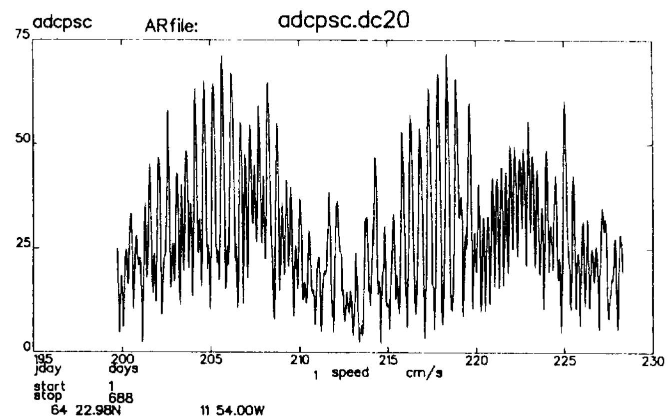


Figure 15. ADCP time series (depth cell 20).

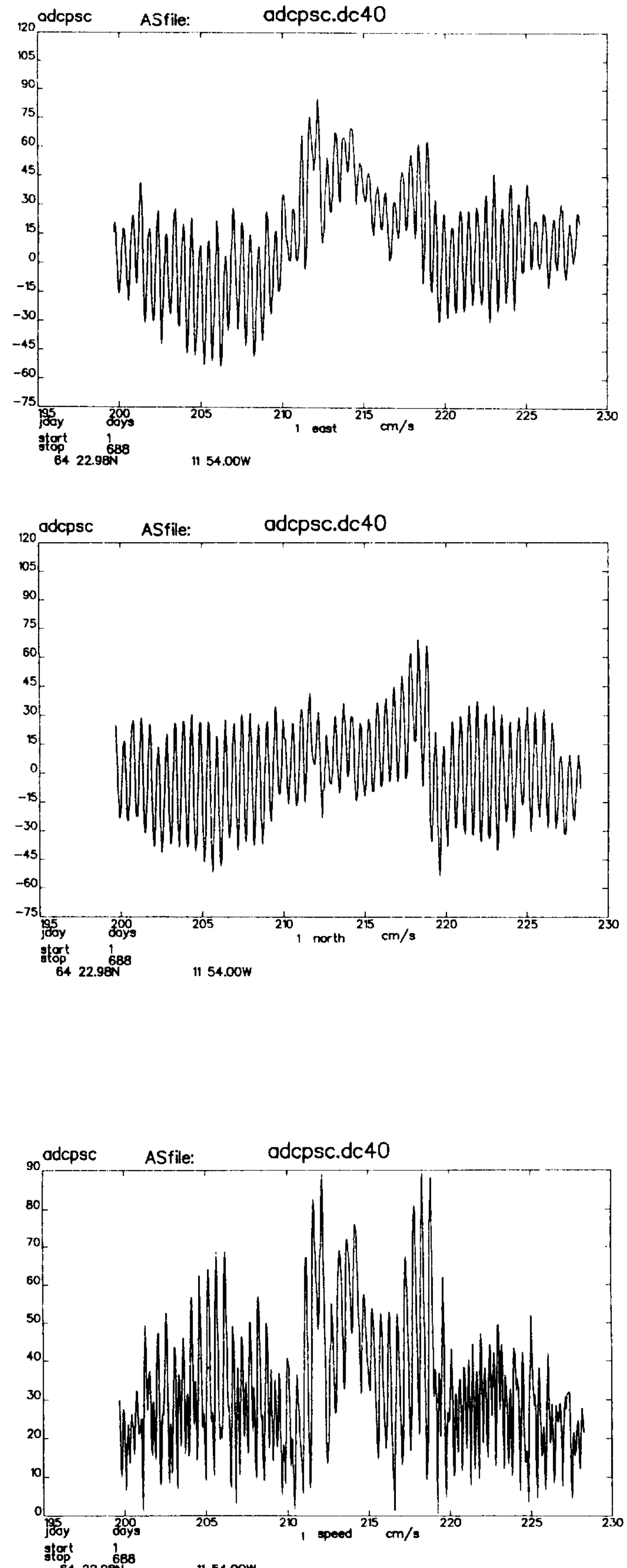
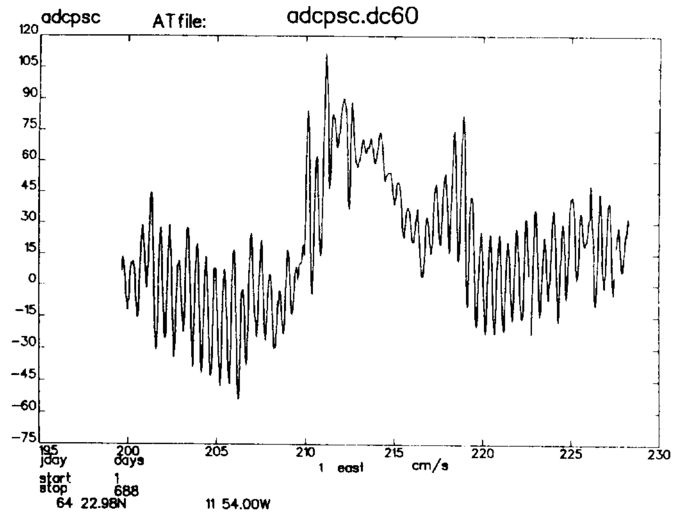
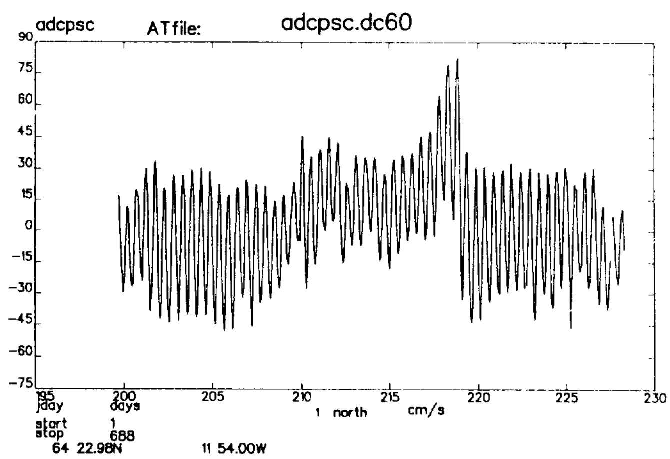


Figure 16. ADCP time series (depth cell 40).





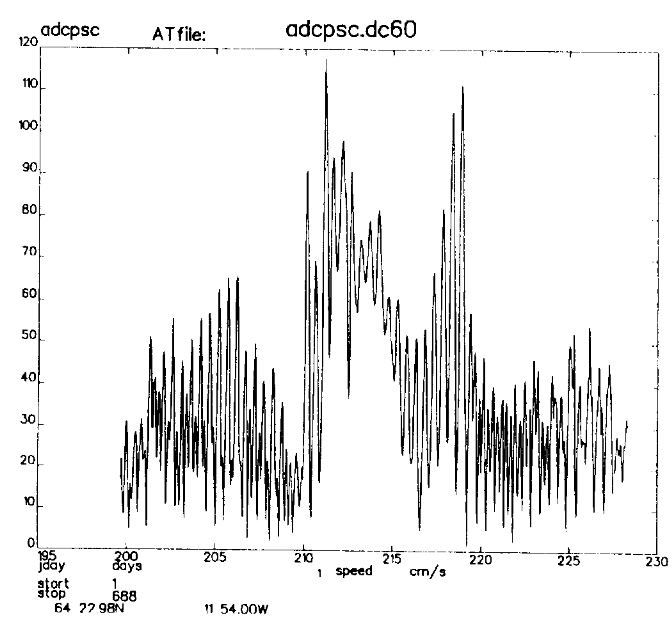


Figure 17. ADCP time series (depth cell 60).

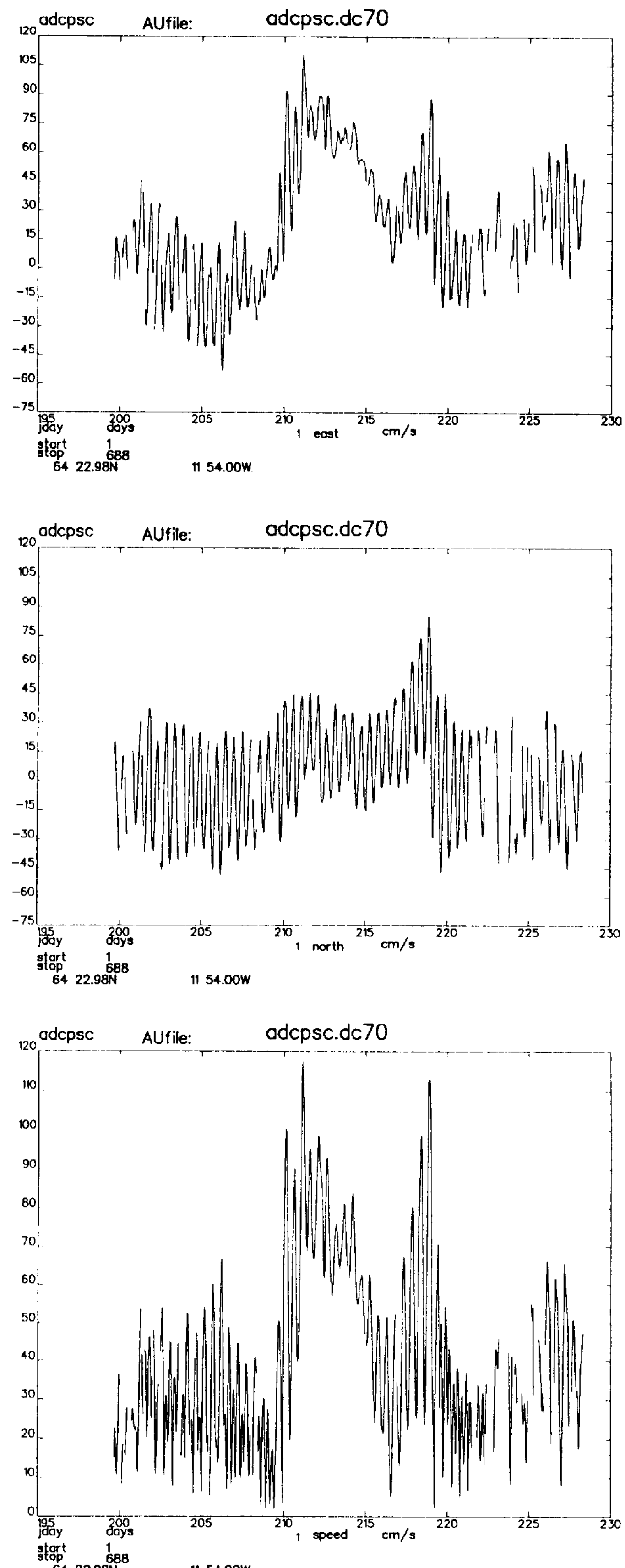
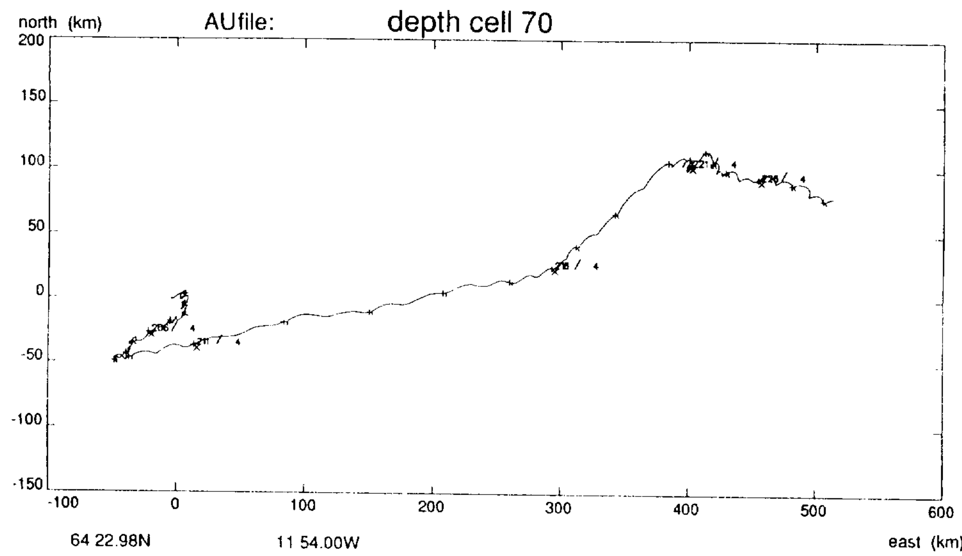
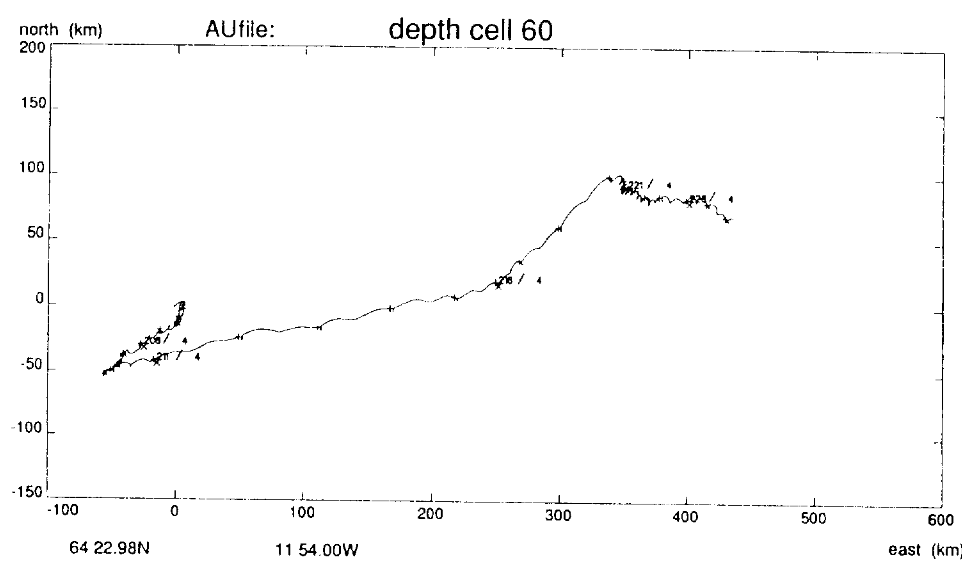
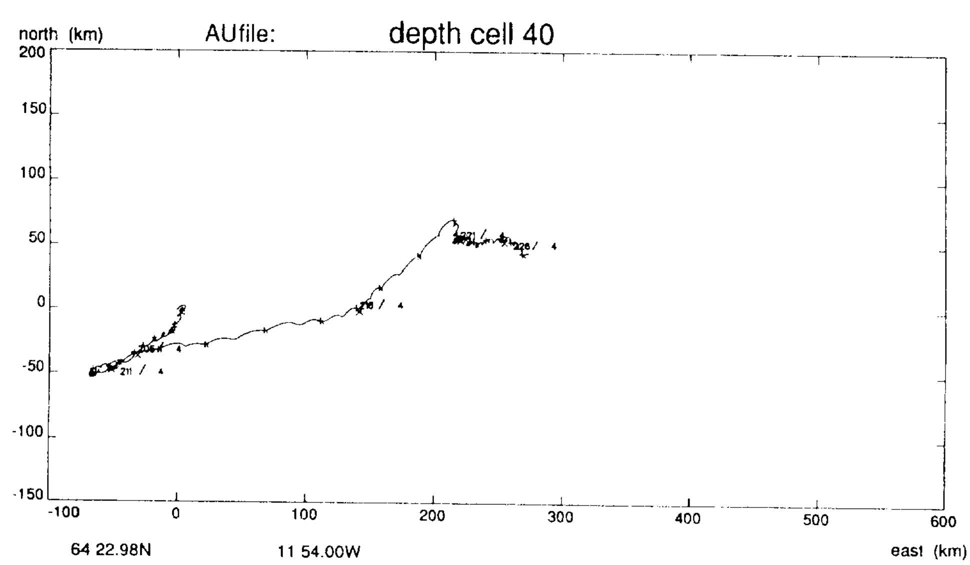
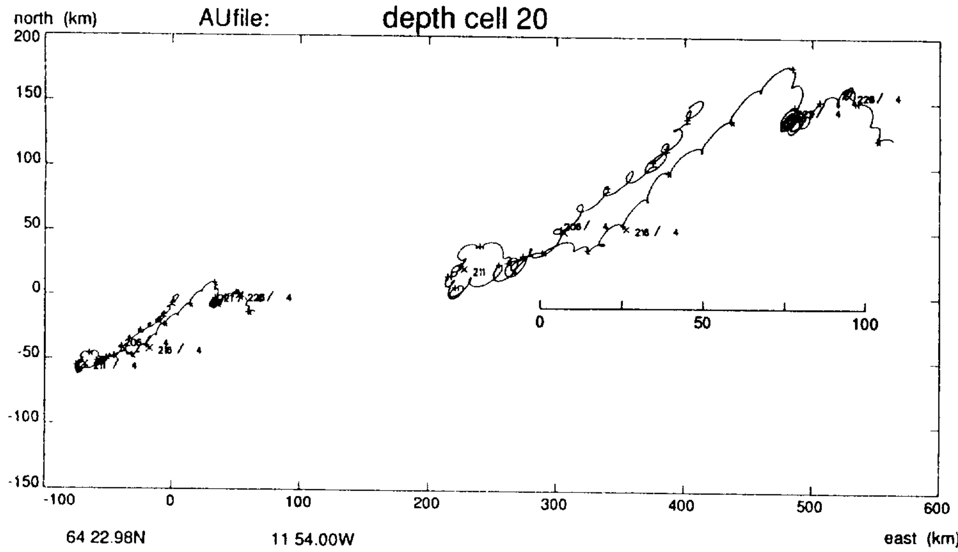


Figure 18. ADCP time series (depth cell 70).


north (km)
AUfile:
depth cell 70
200
150
100
50
0
-50
-100
-150
-100
0
100
200
300
400
500
600
64 22.98N
11 54.00W
east (km)


north (km)
AUfile:
depth cell 60
200
150
100
50
0
-50
-100
-150
-100
0
100
200
300
400
500
600
64 22.98N
11 54.00W
east (km)


north (km)
AUfile:
depth cell 40
200
150
100
50
0
-50
-100
-150
-100
0
100
200
300
400
500
600
64 22.98N
11 54.00W
east (km)



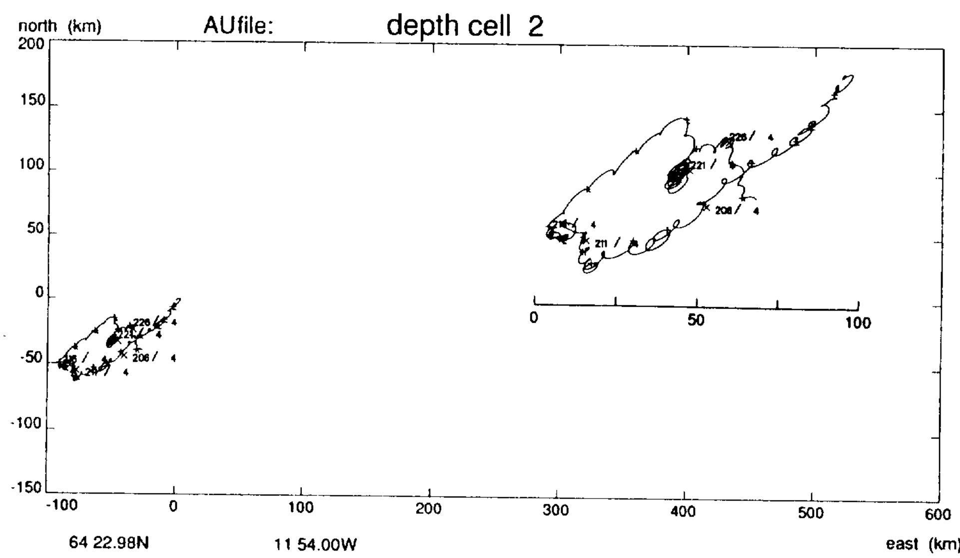


Figure 19. ADCP Progressive vectors.
The above 2 plots contain enlargements to the same scale as the S4 and Aanderaa progressive vector plots.

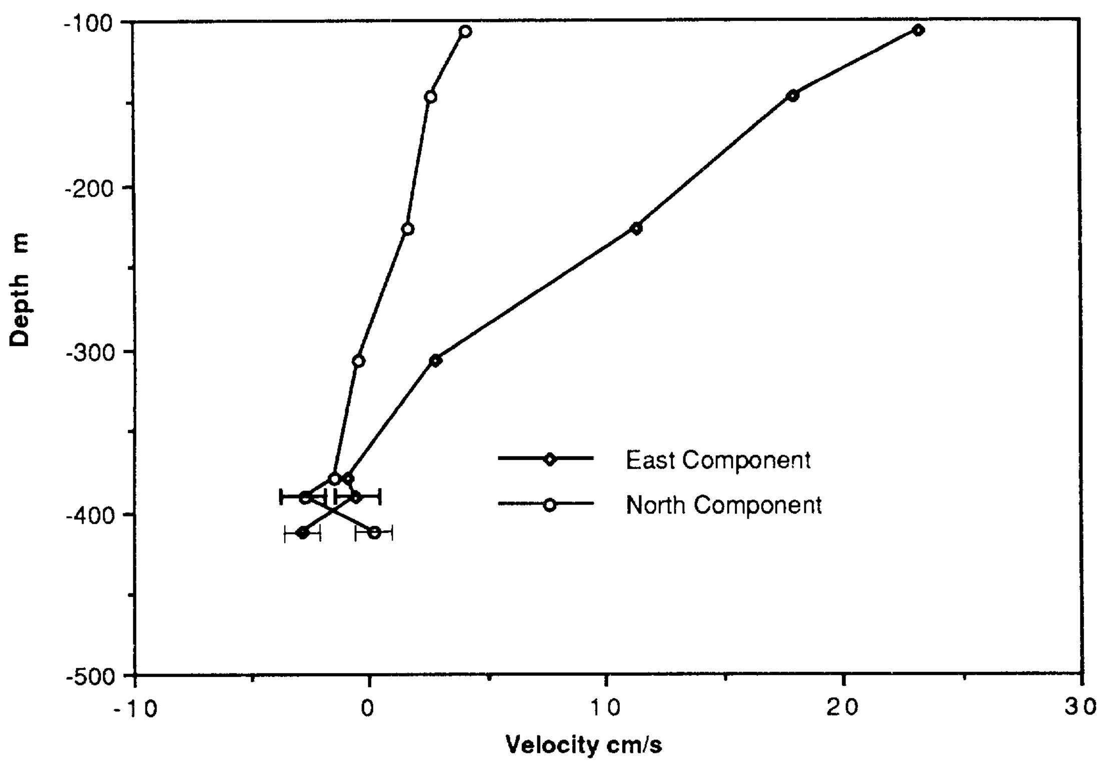


Figure 20. Mean east & north components for all instruments.
Error bars for the S4 (391m) & Aanderaa (413m) included
(±1cm/s and ±0.8 cm/s respectively). ADCP error is ±0.5 cm/s.

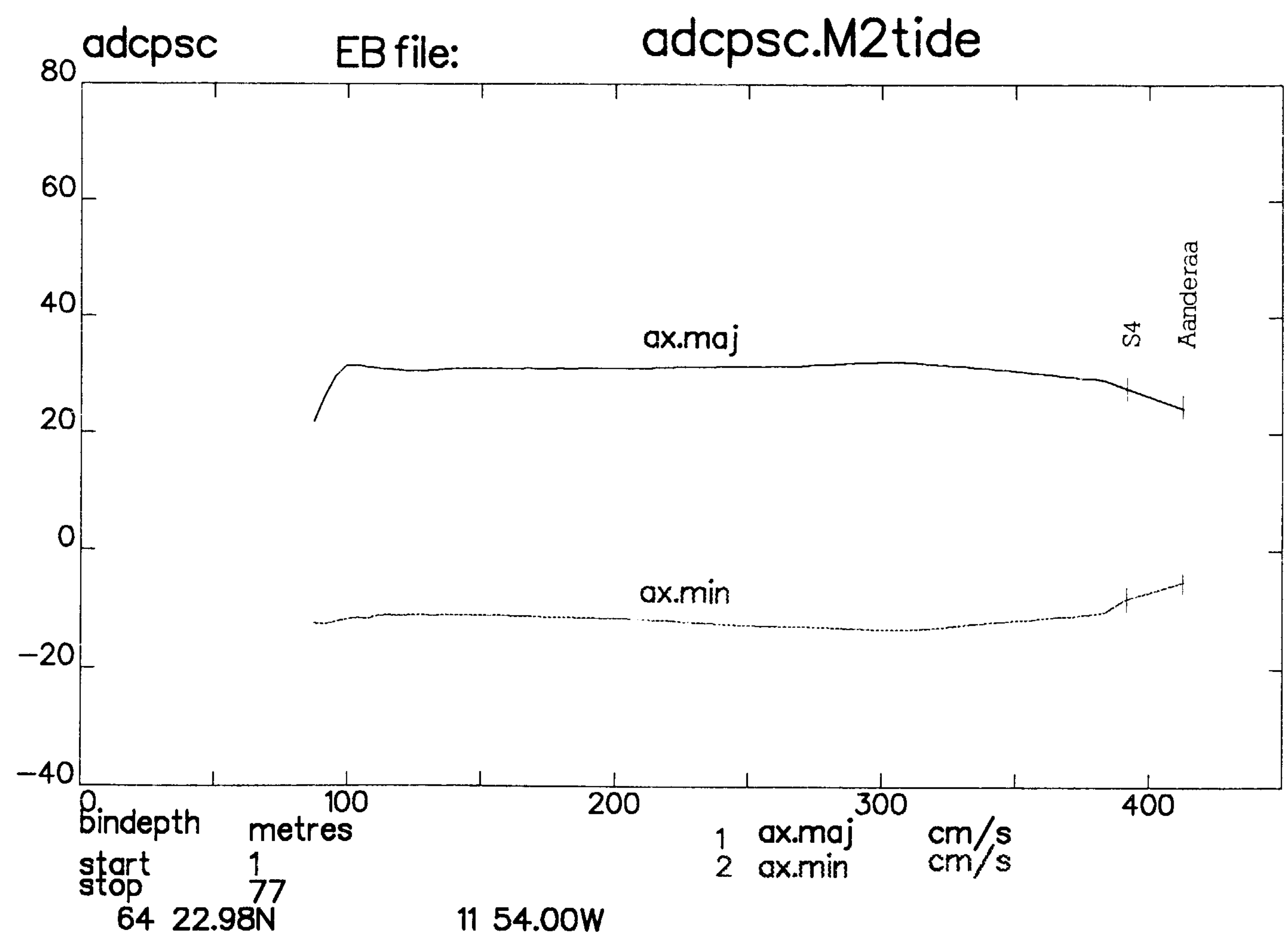


Figure 21. Tidal analysis (M2 component vs depth).

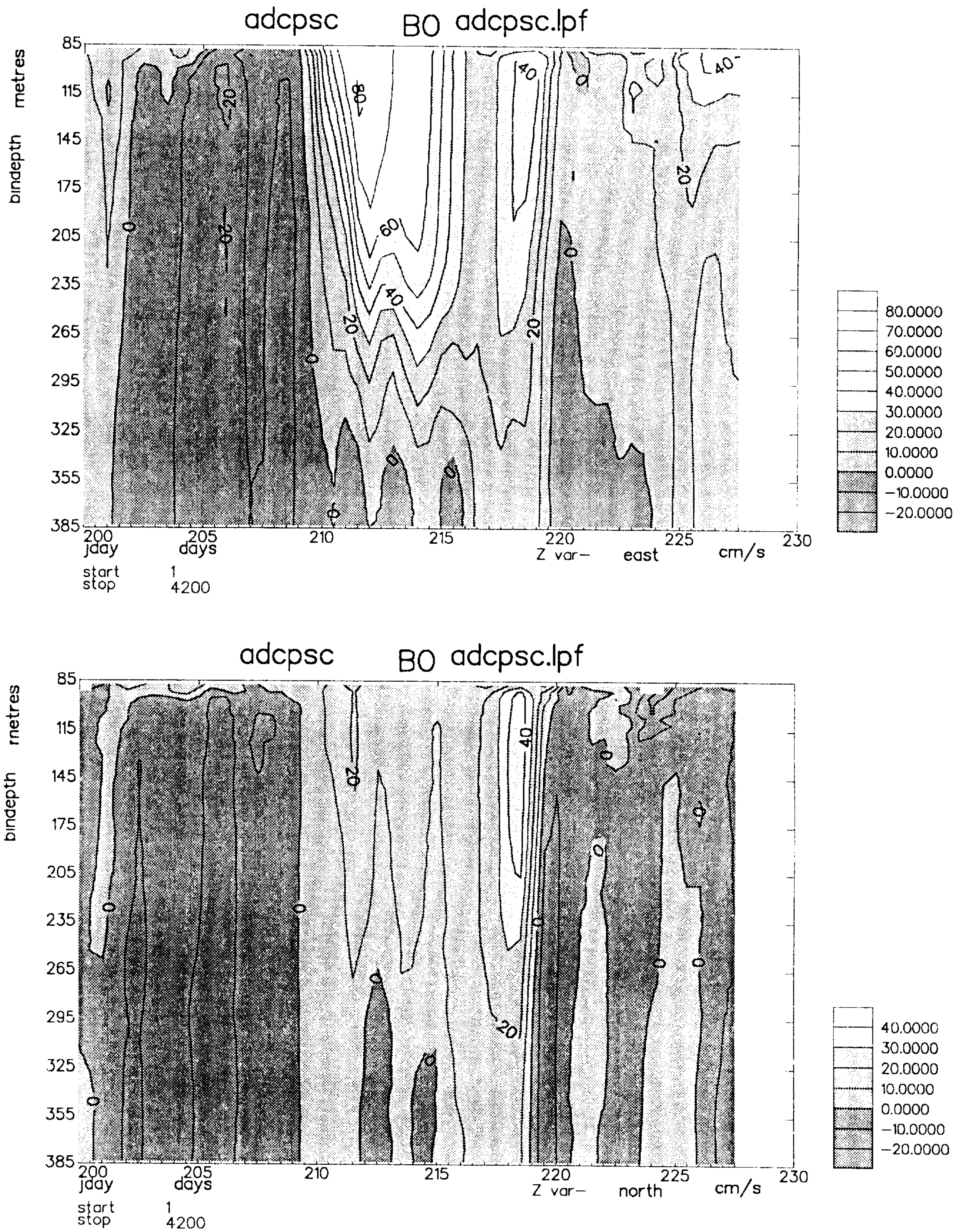
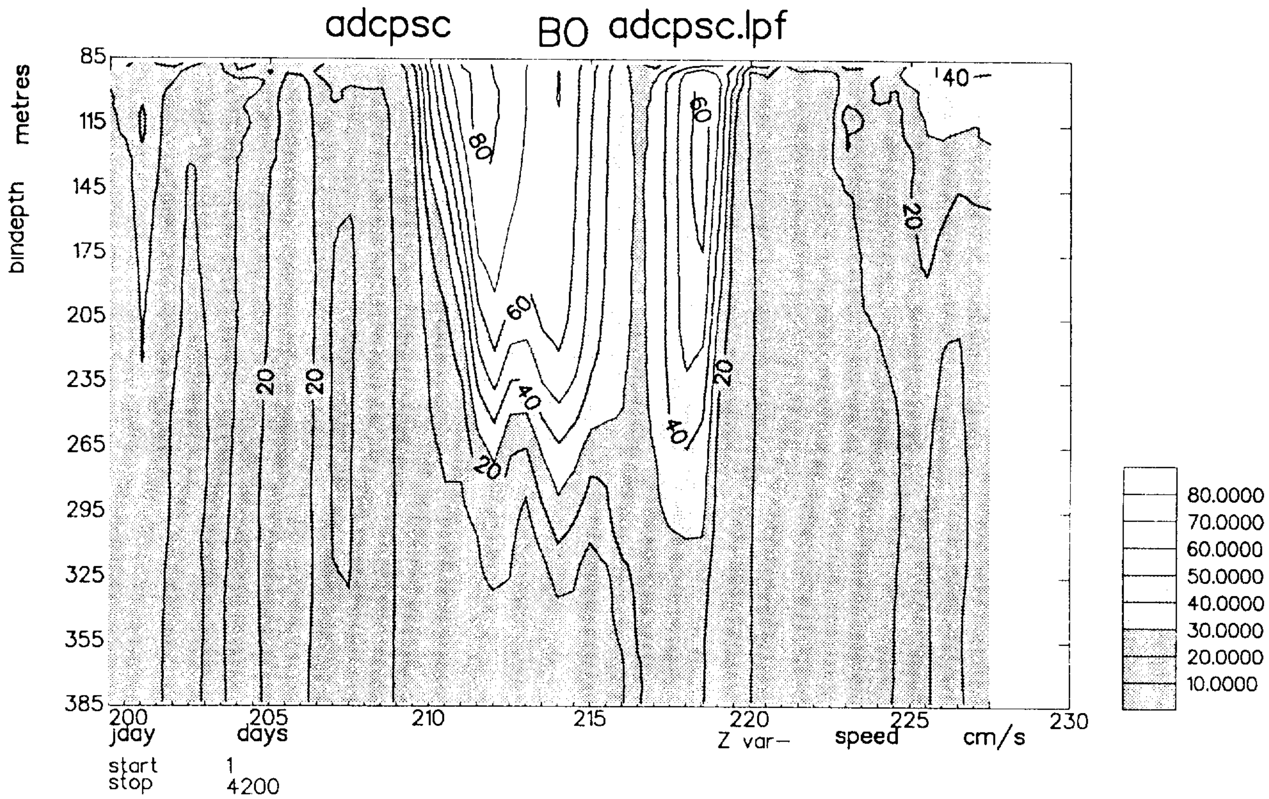


Figure 22. ADCP Contour maps (north and east components).



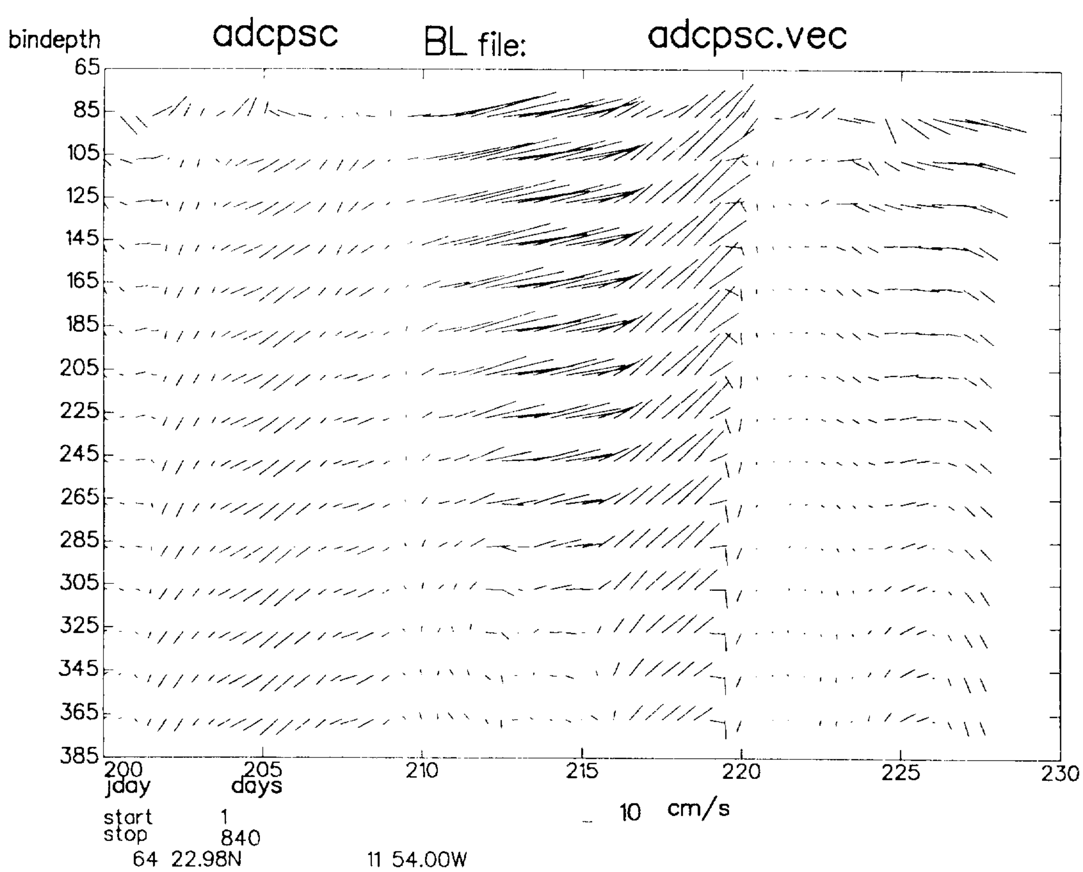


Figure 23. (top) ADCP Contour map of speed.

Figure 24. (above) ADCP gridded vector plot (every fifth cell).