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DIRECT OBSERVATIONS OF THE LEEUWIN CURRENT AT 22°S (AUGUST 1994 – JUNE 1996)

A Data Report from the WOCE Indian Ocean Current Meter Array 6

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ABSTRACT

The World Ocean Circulation Experiment Current Meter Array 6 (ICM6) was deployed in August 1994 to estimate the transport, structure and variability at 22°S of the anomalous poleward eastern boundary current of the Indian Ocean, the Leeuwin Current. The six moorings of the ICM6 array comprised four acoustic Doppler current profilers, five acoustic current meters and thirteen recording current meters deployed along a line extending 110 km westwards off the southern end of the Northwest Shelf of Australia, spanning water depths between 250 and 3050 m. Not all instruments were recovered in June 1996 (as scheduled) due to the failure of the acoustic releases on moorings 4 and 5. Although the upper portion of mooring 5 and the deepest instrument on mooring 4 were retrieved by trawling, the upper four instruments on mooring 4 were lost altogether. The remaining instruments on mooring 5 were recovered by trawling during a subsequent cruise in September 1996. The recorded data (speed, direction, temperature and pressure) were subjected to standard error detection, spike removal and interpolation. The valid data were subsequently low-pass filtered to exclude inertial, tidal and other higher frequency signals. The low-pass filtered data are described in the form of tables of simple statistics and time-series plots. Hydrographic data were also obtained along the ICM6 array, but are only summarised for reference.

1 INTRODUCTION

The Indian Ocean current meter array ICM6 is part of the Australian contribution to the World Ocean Circulation Experiment (WOCE). It was deployed to estimate the seasonal variability of the Leeuwin Current near 22°S and thus its meridional heat flux. The Leeuwin Current is well known as the anomalous eastern boundary current that flows poleward into the prevailing equatorward winds (Church et al., 1989).

The array was deployed during RV *Franklin* Cruise FR 08/94 (23 August – 14 September 1994). Six moorings with a total of twenty two instruments were deployed along a line extending 110 km westwards off the southern end of the Northwest Shelf of Australia, spanning water depths between 250 and 3050 m (Figure 1; Table 1). The instruments included four RDI upward-looking acoustic Doppler current profilers (ADCPs), five Neil Brown acoustic current meters (ACM2s) and thirteen Aanderaa recording current meters (RCMs). Their depth distribution and hardware configuration are respectively depicted in Figures 2 and 3.

All moorings were successfully recovered during RV *Franklin* Cruise FR 06/96 (1 – 11 June 1996), except for moorings 4 and 5, whose acoustic releases failed. The upper two instruments on mooring 5 and the deepest instrument on mooring 4 were retrieved by trawling, but the upper four instruments on mooring 4 were lost altogether. The three remaining instruments on mooring 5 were recovered by trawling during a subsequent cruise in the area (RV *Franklin* Cruise FR 07/96) from 14 August to 11 September 1996. In total, eighteen of the twenty-two current meters were recovered.

Detailed information on the recovered instruments is listed in Table 2; the temporal length of the data recorded by each current meter in Table 3; comments on the treatment and quality of individual data records in Table 4.

Both deployment and recovery cruises included hydrographic sections. Opportunistic surveys were also completed during RV *Franklin* Cruises FR 03/95 (1 – 24 April 1995) and FR 05/96 (7 – 31 May 1996), and RV *Knorr* Cruise 145/8 (23 April – 5 June 1995). Appendix A lists the Conductivity-Temperature-Depth (CTD) sections completed along the ICM6 array for each cruise. Dissolved oxygen and nutrients (nitrate, phosphate and silicate) were also collected on some cruises.

2 DATA PROCESSING

Speed, direction, temperature and pressure (the latter only from some instruments) records were obtained as shown in Figures 2 and 3 and detailed in Table 2. Although different instruments were used along the array, the series could largely be quality controlled and filtered using the same techniques. Additional data quality parameters available from the ADCPs were used to determine the reliability of these data.

The raw physical binary data of all current meters were converted from the number of counts to the appropriate physical unit, using the coefficients obtained in the sensor calibrations, performed at CSIRO Marine laboratory in 1997/98 or supplied by the manufacturer (K. Miller and H. Beggs, *pers. comm.*). Velocity data were corrected for the local magnetic deviation at 1 June 1995 (−0.46°E; 0.04 SV yr^{-1}), using the Australian Geological Survey Organisation's software package based on the 1995 revision of the International Geomagnetic Reference Field (Barton, 1997).

All data records were individually examined to detect errors and to remove spikes before filtering. Common errors are listed in Table 4, as well as any data interpolation applied. In general, gaps up to 3 h were filled linearly and gaps of up to 24 h were interpolated using a cubic spline. For longer gaps (up to 12 days)[1], spectral interpolation was applied as described in Ulrych et al. (1973), Smylie et al. (1973) and Andersen (1974), using the EPIC software[2]. In addition, when only good direction but no speed data were available an *ad hoc* constant speed was inserted to help display the recorded information.

A cosine-Lanczos "Lancz-6" low-pass filter[3], with a cut-off period of 40 h, was applied to suppress inertial (32 h at 22°S), tidal and other higher-frequency signals. At different sampling intervals (Table 2), different cosine windows were used: 60+1+60 points for a sampling interval of 60 min (ADCPs); 30+1+30 points for 120 min and 20+1+20 points for 180 min (RCMs); and 360+1+360 points for 10 min (ACM2s).

For the purpose of display, the original **u** (positive east) and **v** (positive north) coordinate system was retained. The principal angles of variance for each current data were calculated and are listed in Appendix B. The valid low-pass filtered records of current, temperature and pressure were decimated to a 6-hourly series, with values at 0300, 0900, 1500 and 2100 UTC.

Further data processing details are given in the following sections, according to each type of record. Figures and tables are presented at the end of the last section. The low-pass filtered time-series plots are grouped by mooring and include **u** and **v** components; current vectors (**V**); temperature (**T**); depth; pitch and roll (these latter two for ADCPs) for each respective instrument nominal/cell depth (**z**).

1 Although longer gaps were spectrally interpolated, they are not included in the statistics tables nor shown in the plots.
2 EPIC software is developed by NOAA/PMEL laboratories.
3 Lancz-6 filter's energy response is 25% at 40 h (0.6 cpd) and 0.01% at 32 h (0.744 cpd).

3 CURRENT DATA

3.1 ADCP

ADCPs were placed at the top of the four inner moorings (Figure 1) to provide horizontal and vertical velocity data in ensembles. Each ensemble consists of an average of 15 pings (1 ping per second) with ensembles sampled every 60 min. Velocity estimates are available for 40 regularly spaced depth cells (or bins), each bin 8 m long. The ADCPs operated at a frequency of 153 kHz. The instrument on mooring 4 was lost (RDI narrowband upward-looking ADCP), but the others (RDI broadband upward-looking ADCPs) were successfully recovered. Vertical velocities were discarded because they are usually slow and cannot be measured with useful accuracy (E. Firing, *pers. comm.*). The data from the upper 15-20% bins were excluded, as the data return was weak (% pings good ≤ 20)[4]. On mooring 2, the ADCP data from the bin at 219 m were disregarded as they were inconsistent when compared to the data from the adjacent bin at 211 m and an RCM just below at 240m. On mooring 3, the ADCP stopped recording data earlier than scheduled, as shown in the timeline of the current meter observations (Table 3). The valid depth cells from moorings 1 to 3 are shown in Table 5, but only five bins (highlighted in Table 5) are presented in this report. Internal calculations yielded instrument inclination (pitch and roll) and orientation (heading) against magnetic north.

3.2 ACM2

Five Neil Brown acoustic current meters were used in the array (Table 2). All five ACM2s stopped recording data well before scheduled (June 1996), as shown in the timeline of the current meter observations (Table 3). Except for the ACM2 at 535 m on mooring 6, which stopped in September 1994, the other four ACM2s stopped in December 1995 due to limited battery life. In addition, after 14 September 1995, the ACM2 at 515 m on mooring 5 did not record valid velocity data (only temperature), for unknown reasons.

3.3 RCM

Thirteen instruments were Aanderaa recording current meters, RCMs models 4 and 5 (Table 2). Common problems are described in Table 4. Before low-pass filtering, an *ad hoc* constant speed (15 cm s^{-1}) was used to display the directional information from the RCMs at 285 m (entire record) and at 785 m (after 27 August 1995 15:00 h) on mooring 6.

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[4] The echo from the sidelobe facing the surface will return to the ADCP at the same time as the echo from the main lobe at ~85% of the distance to the surface. This means that data from the last ~15% of the range to the surface will usually be contaminated and should be normally rejected (RD Instruments, 1989).

4 TEMPERATURE DATA

All instruments appear to have good temperature records, except for one RCM at 248 m on mooring 3. Its temperature values were consistently lower than those recorded by the ADCP only 4 m above it. In addition, its time-series showed a significant drift (Figure 4a). This behaviour could not be explained by poor calibration as it was checked in the laboratory. The fault was most likely in the RCM's temperature sensor. Nevertheless, the data appeared to accurately measure the temperature variability. Hence we deemed the record useful for extending the nearby ADCP record, which stopped recording on 18 December 1995. Both low-pass filtered temperature time-series (ADCP at 244 m and RCM at 248 m) were linearly detrended before being differenced. The resultant time-series showed two distinct trends before and after June 1995 (Figure 5). With the help of a scatter plot, we could verify that the RCM's temperature response was non-linear in time (Figure 6): that is the slope between the two temperature measurements remains constant, but the offset changes with time. To determine the correct slope we repeated the detrending procedure but to the common period after mid-June, when the offset appeared constant. We then calculated the regression (slope) between the detrended data series over that period and used this regression to extend the original ADCP temperature time-series forward in time (Figure 4b).

5 PRESSURE DATA

Pressure records were only available at 265 m and 765 m on mooring 5 and at 285 m, 785 m and 1535 m on mooring 6 (Table 2). The top sensor on mooring 5 showed a clear drift but with no associated temperature drift to suggest real sinking. Therefore we assumed a sensor drift and removed it. The pressure data were converted to depth and processed in exactly the same way as the other records. Their simple statistics are shown in Table 6. There were no significant vertical displacements of the instruments, with maximum excursions reaching only 40 m. However, the pressure data looked suspect: the records have long periods of constant pressure separated by shorter periods of variable pressure. The nominal depths of each instrument grossly agrees with their depth placements as checked against CTD data (depth and temperature) from cruises which bracketed the ICM6 array.

ACKNOWLEDGEMENTS

The authors wish to thank the staff and crew of the RV *Franklin* for their considerable cooperation during the deployment, recovery and opportunistic cruises as well as all the people involved in the ICM6 array organization and collection of data. In particular we thank Ian Helmond, Kevin Miller and Danny McLaughlan for their work on the mooring hardware. We also thank Anna Lebedeva, Bernadette Heaney, Kevin Miller and Terry Byrne for their contributions to data acquisition and processing. C.M. Domingues is sponsored by Brazilian Research Council CNPq (Process n° 200412/97-3). Susan Wijffels and John Church were supported by the CSIRO's Climate Change Research Program funded by Environment Australia.

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Smylie, D.E., G.K.C. Clarke and T.J. Ulrych (1973) Analysis of irregularities in the earth's rotation. *Methods in Computational Physics*, 13, 391-430.

Ulrych, T.J., D.E. Smylie, O.G. Jenssen and G.K.C Clarke (1973) Predictive filtering and smoothing of short records by using maximum entropy. *Journal of Geophysical Research*, 78, 4959-4964.

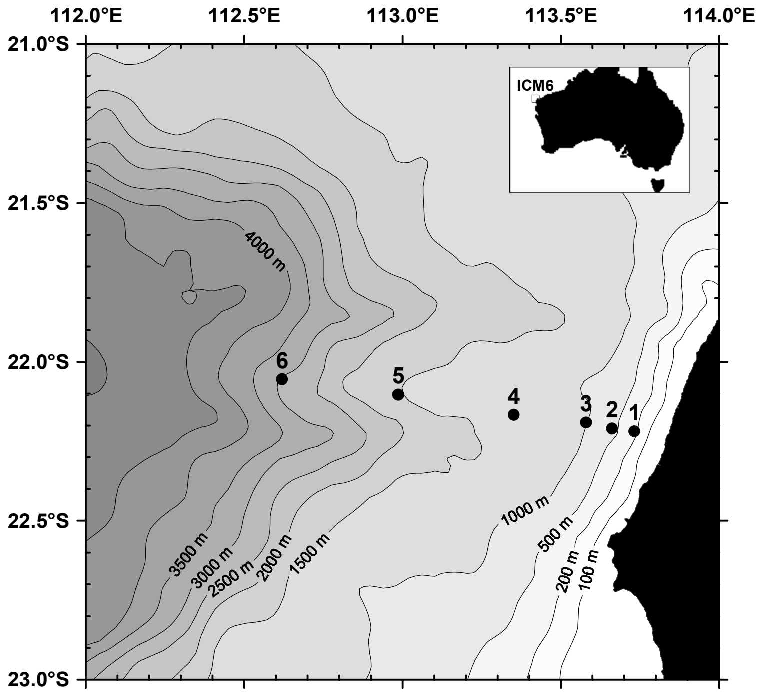

Figure 1: ICM6 array geographic location (bathymetric data sourced from GEBCO).

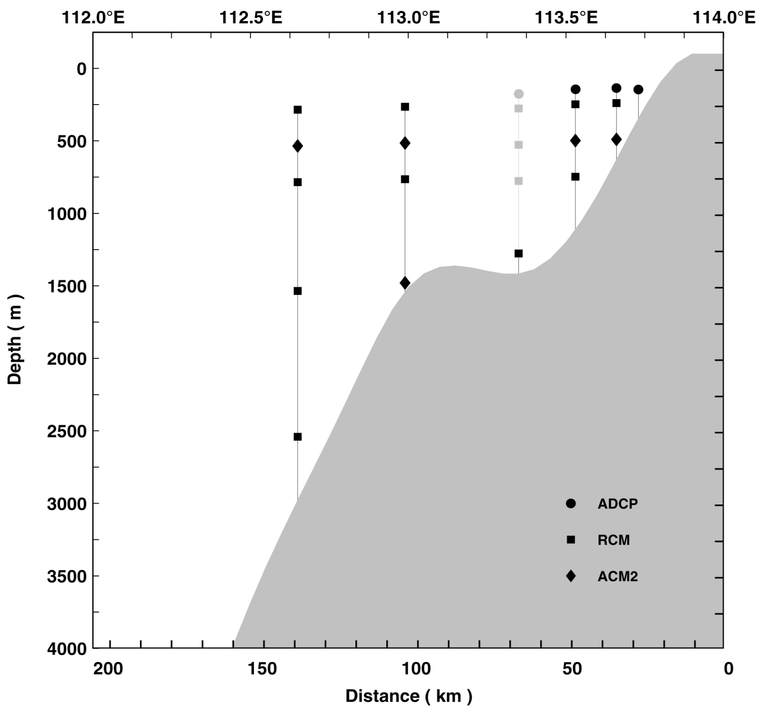

Figure 2: ICM6 current meter depth distribution. Black symbols denote recovered instruments.

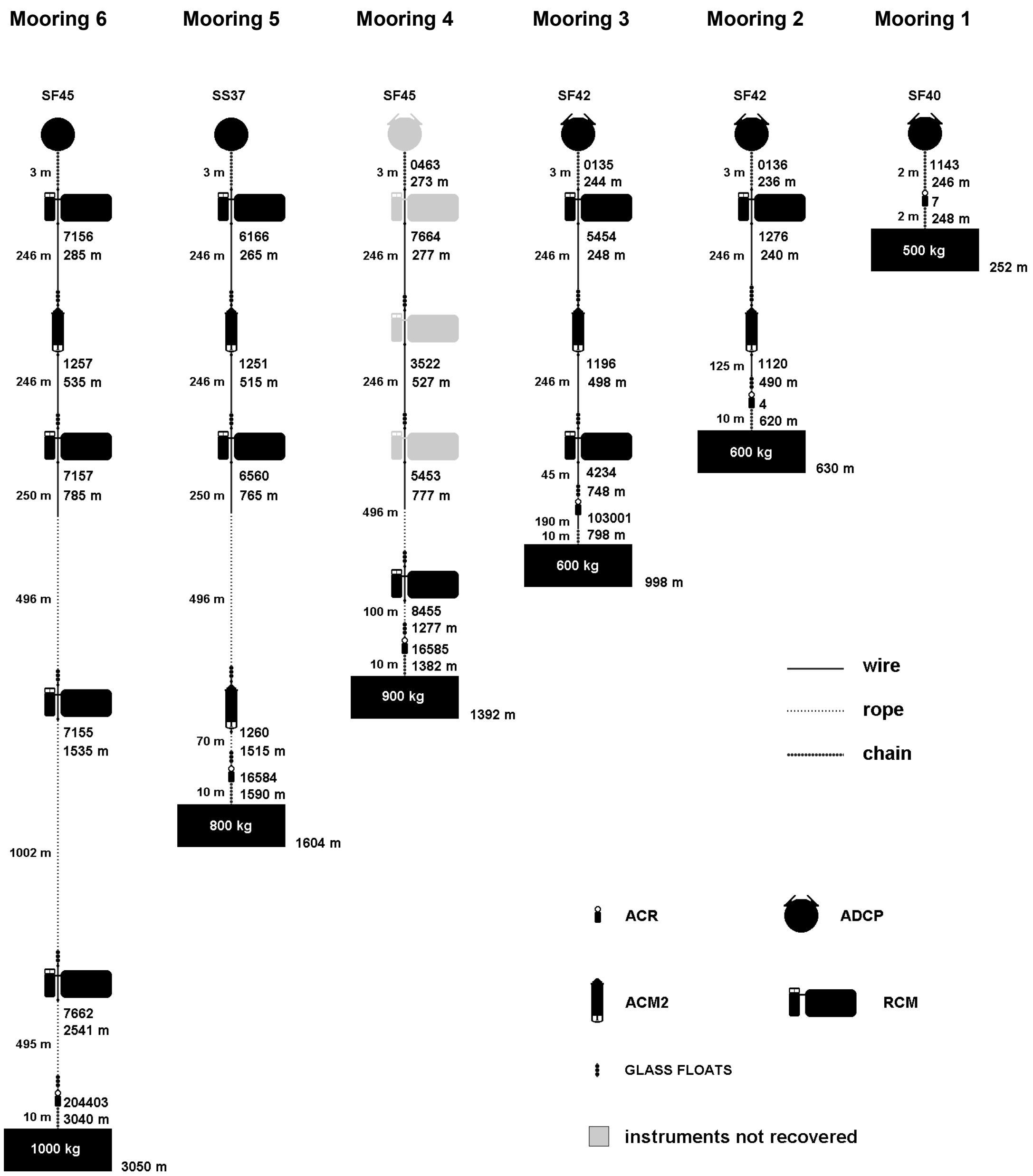

Figure 3: ICM6 hardware configuration. On the left of each mooring, wire, rope and chain lengths are indicated in meters. On the right and below each mooring instrument are the identification numbers and depths respectively. Instrument depths are based on the hardware configuration. Water depths are given at the base of each mooring line.

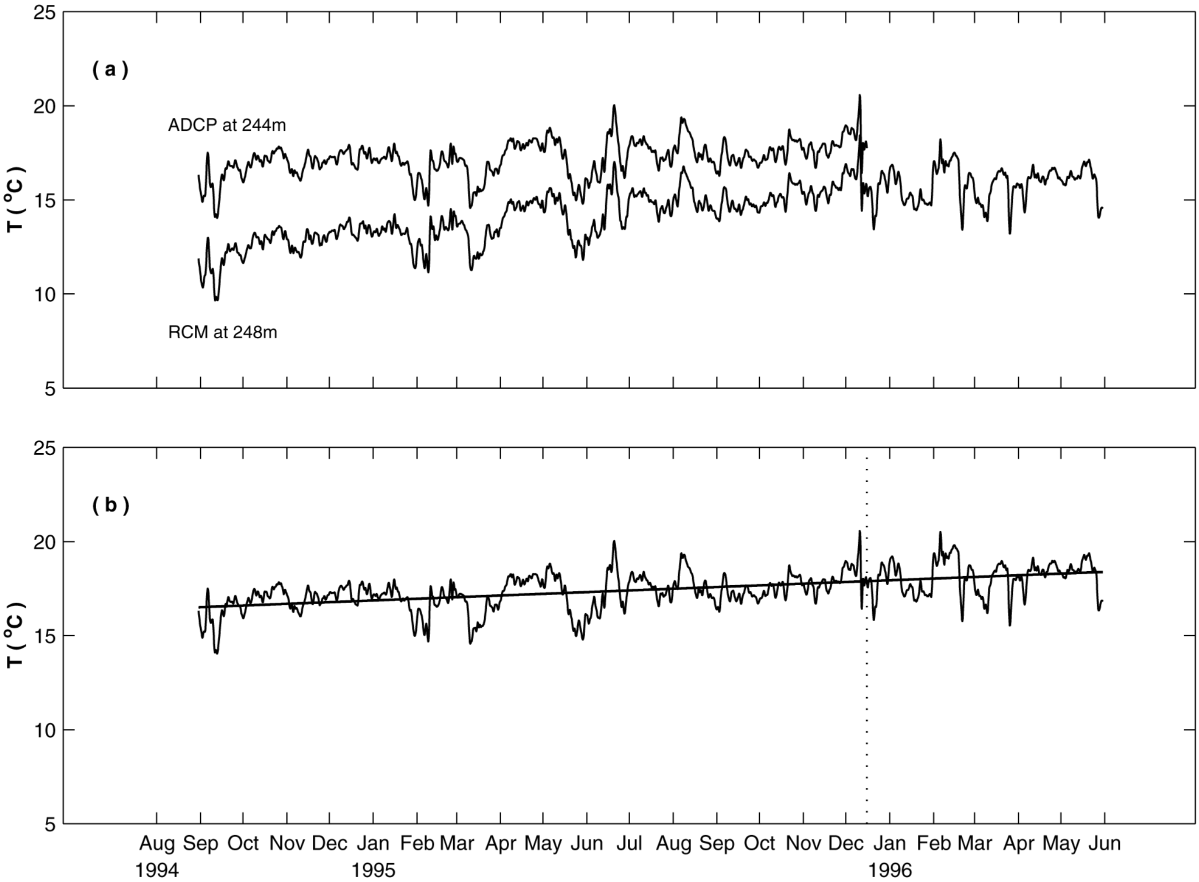

Figure 4: Low-pass filtered temperature time-series from mooring 3 at 244 m (ADCP) and at 248 m (RCM). **(a)** Original data. **(b)** Extended time-series at 244 m (ADCP); the full line shows the linear trend of the original record extended into May 1996.

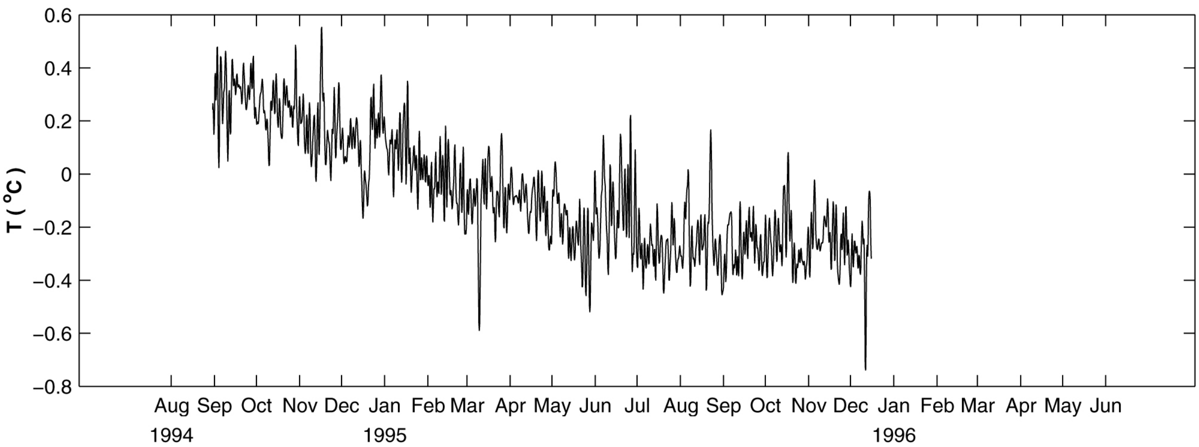

Figure 5: Temperature difference time-series obtained from the linearly detrended low-pass filtered ADCP data at 244 m and RCM data at 248 m on mooring 3 in their commom period (August 1994 – December 1995). Note the two distinct trends before and after June 1995.

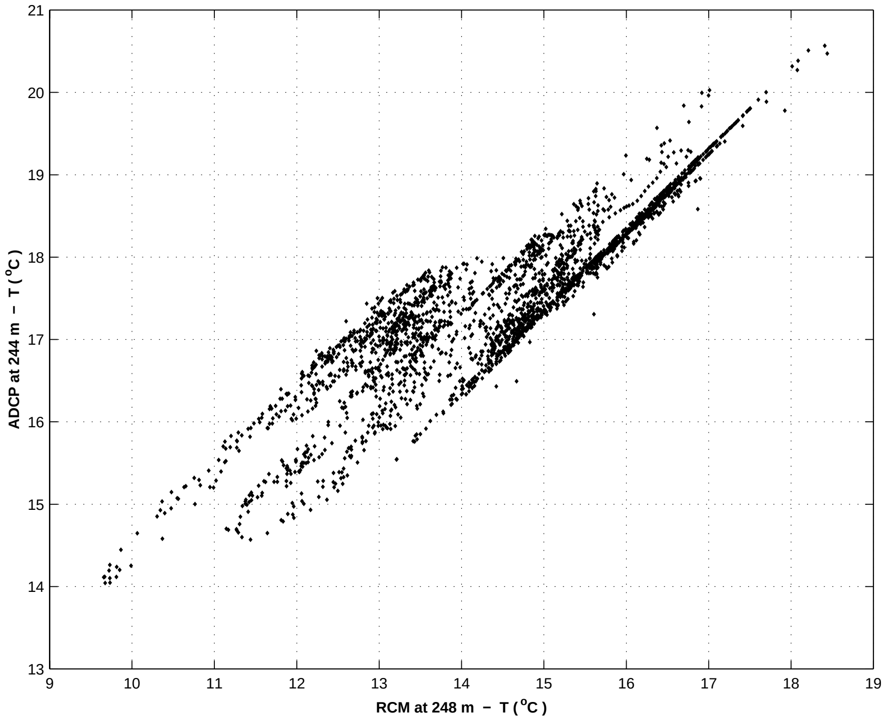

Figure 6: Temperature scatter plot of the uncorrected data – ADCP at 244 m against RCM at 248 m.

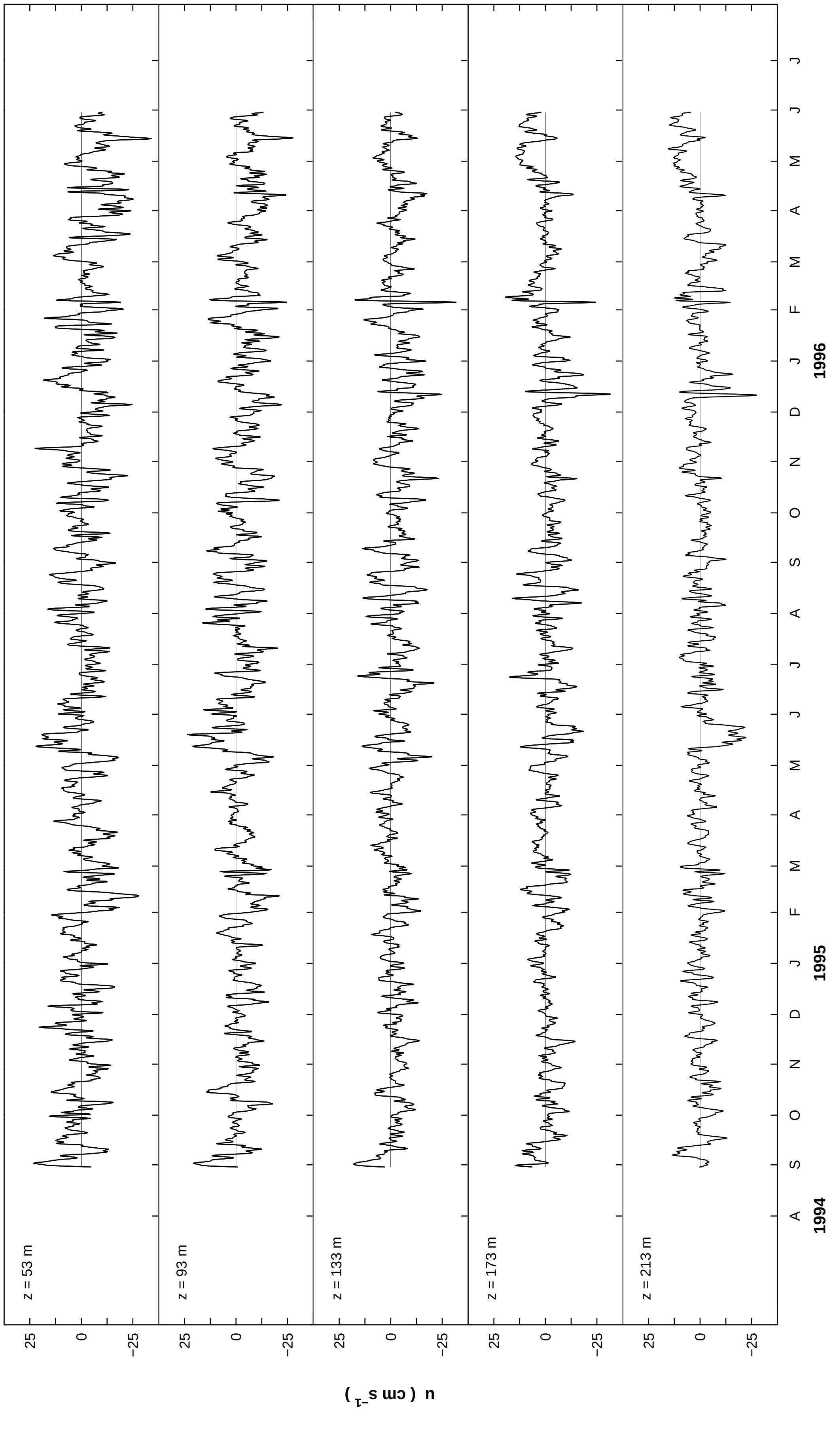

Figure 7: Mooring 1 – **u** component (positive east).

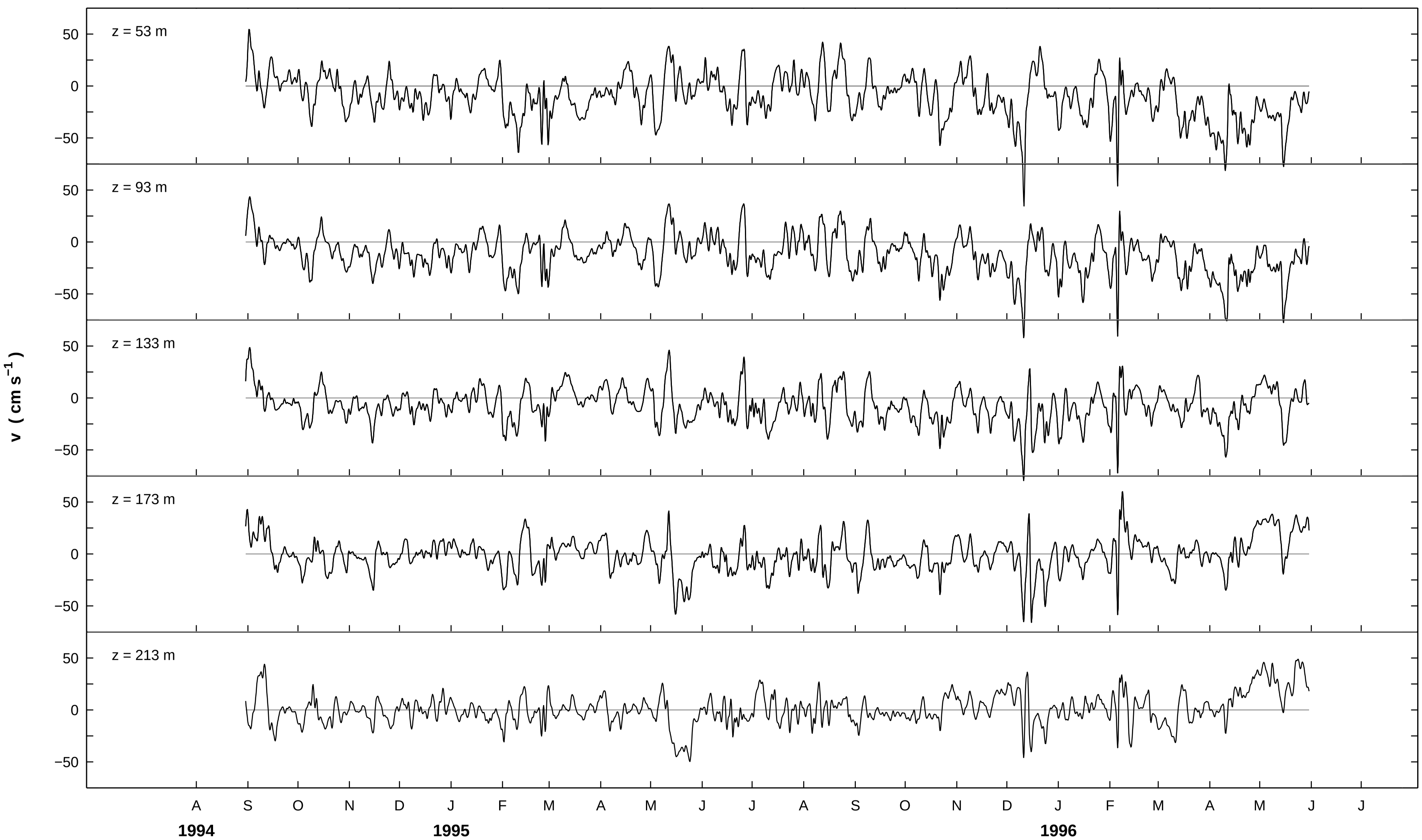

Figure 8: Mooring 1 – **v** component (positive north).

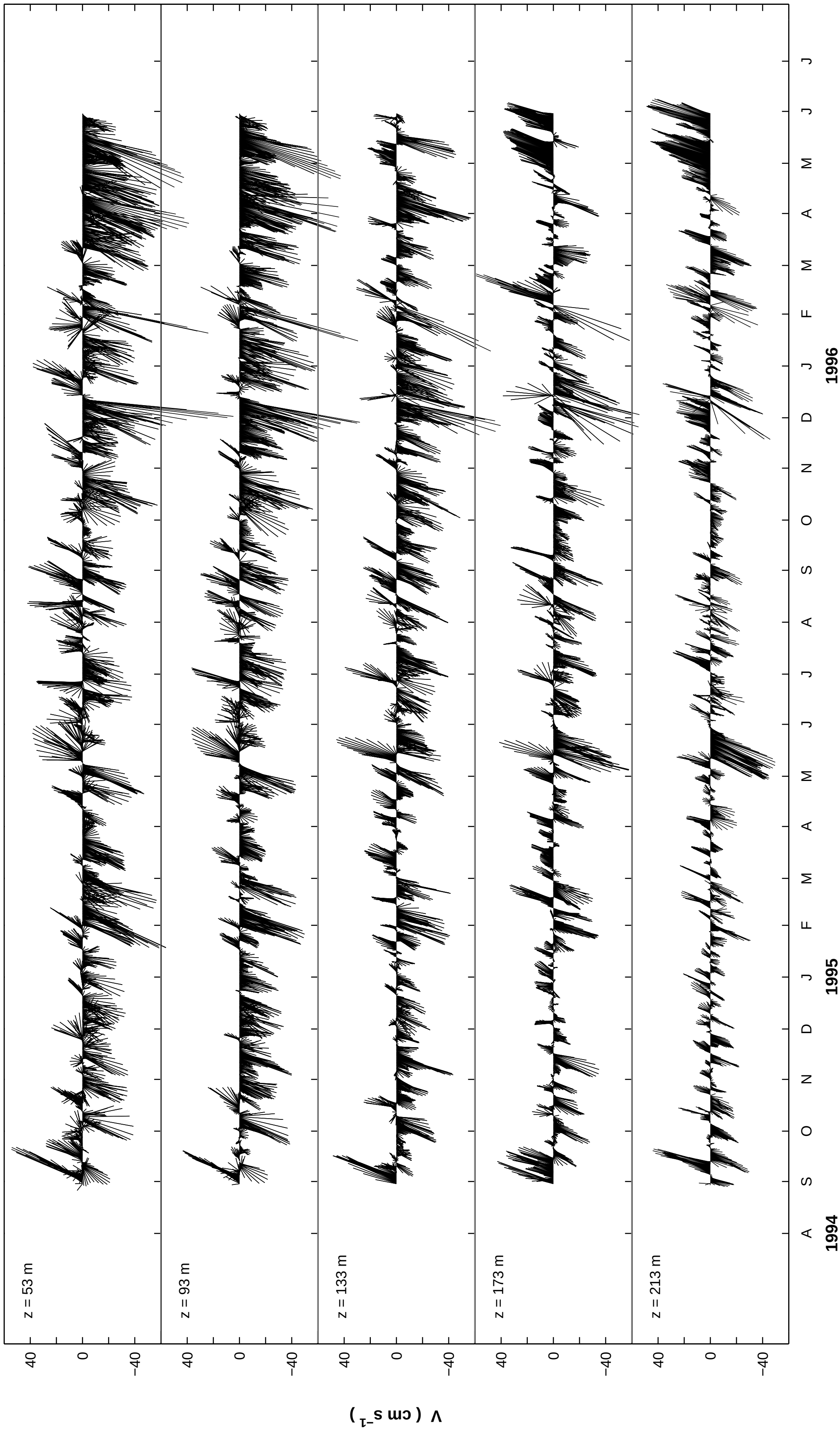

Figure 9: Mooring 1 – **V** current vectors.

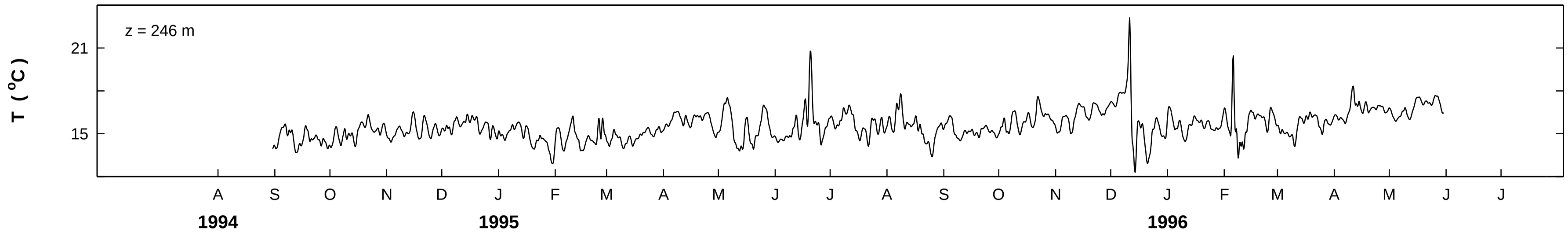

Figure 10: Mooring 1 – Temperature.

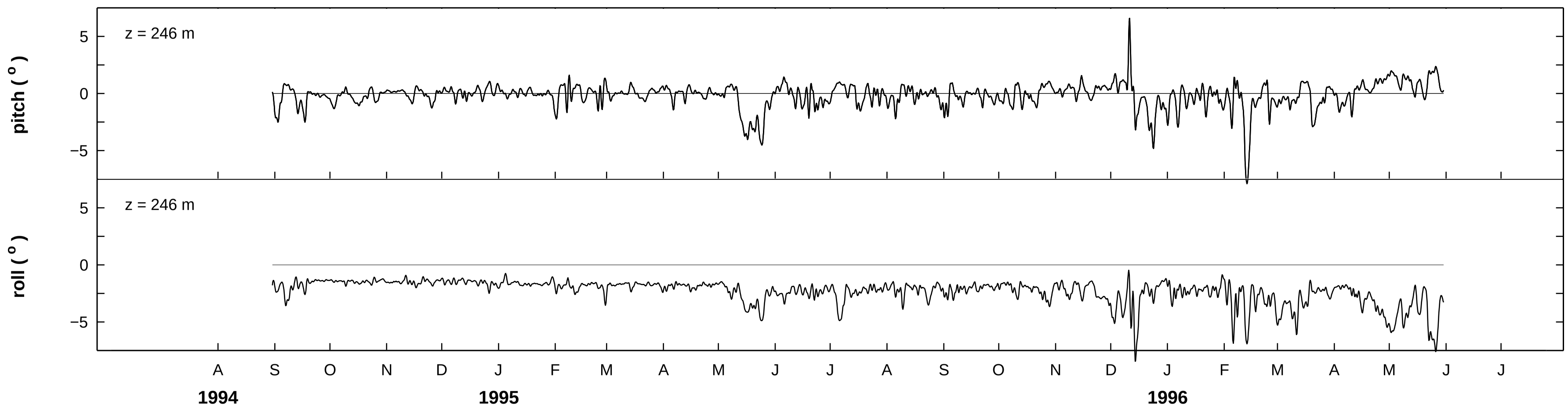

Figure 11: Mooring 1 – Pitch (above) and roll (below).

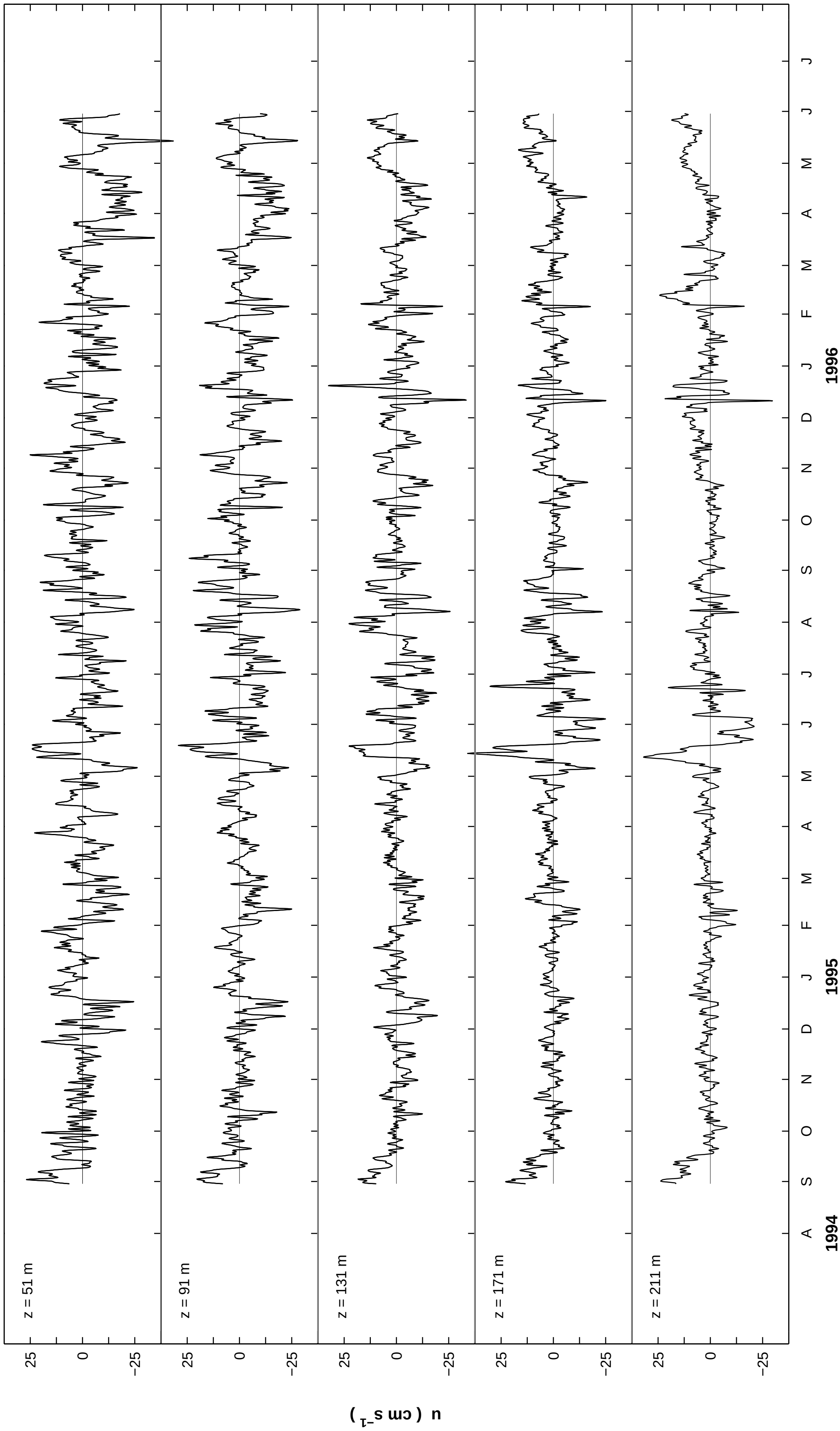

Figure 12a: Mooring 2 – **u** component (positive east).

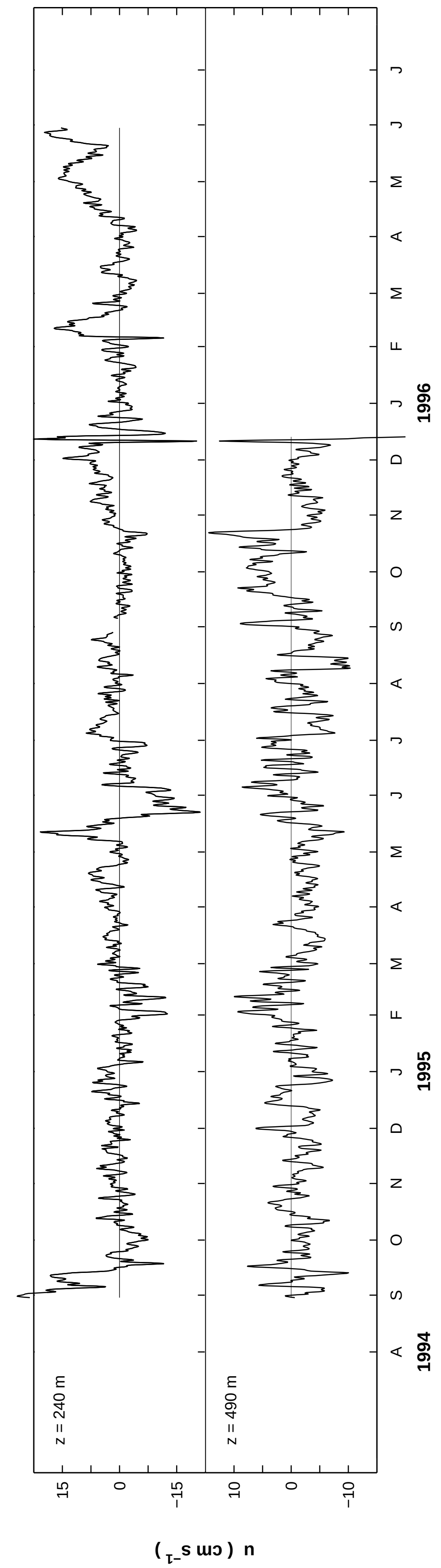

Figure 12b: Mooring 2 – **u** component (positive east).

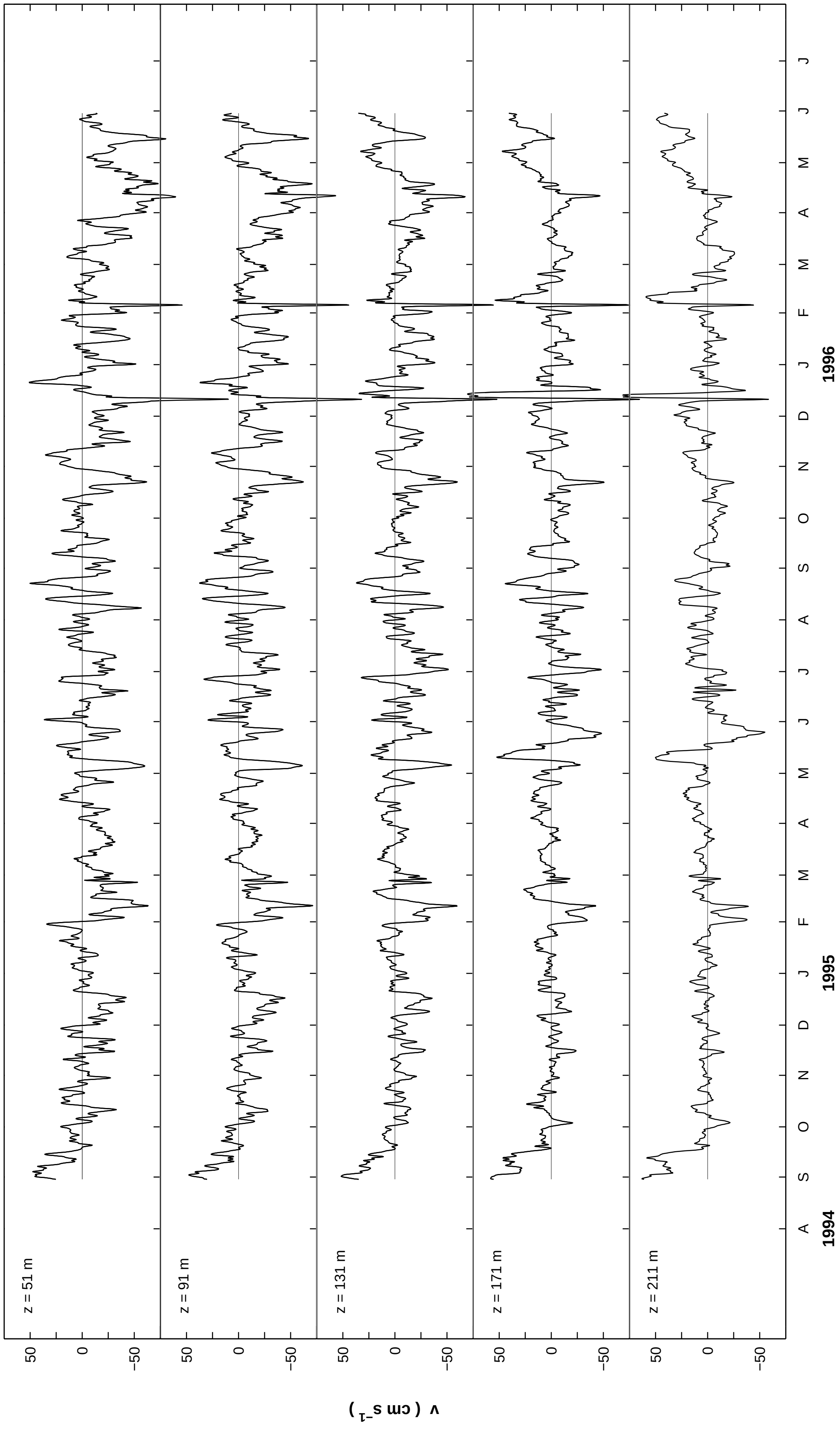

Figure 13a: Mooring 2 – **v** component (positive north).

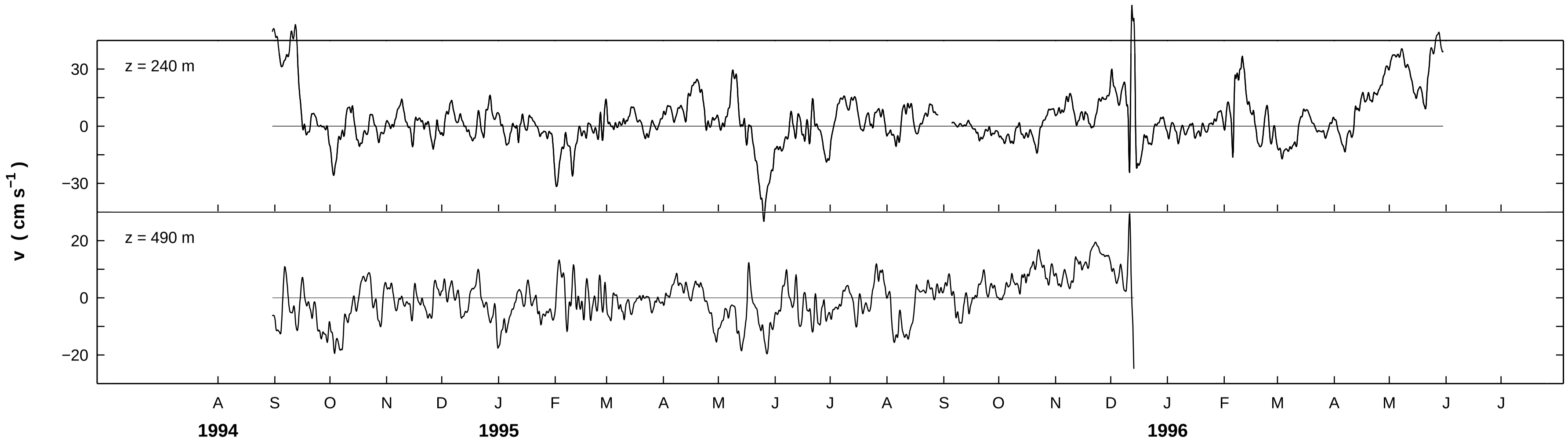

Figure 13b: Mooring 2 – **v** component (positive north).

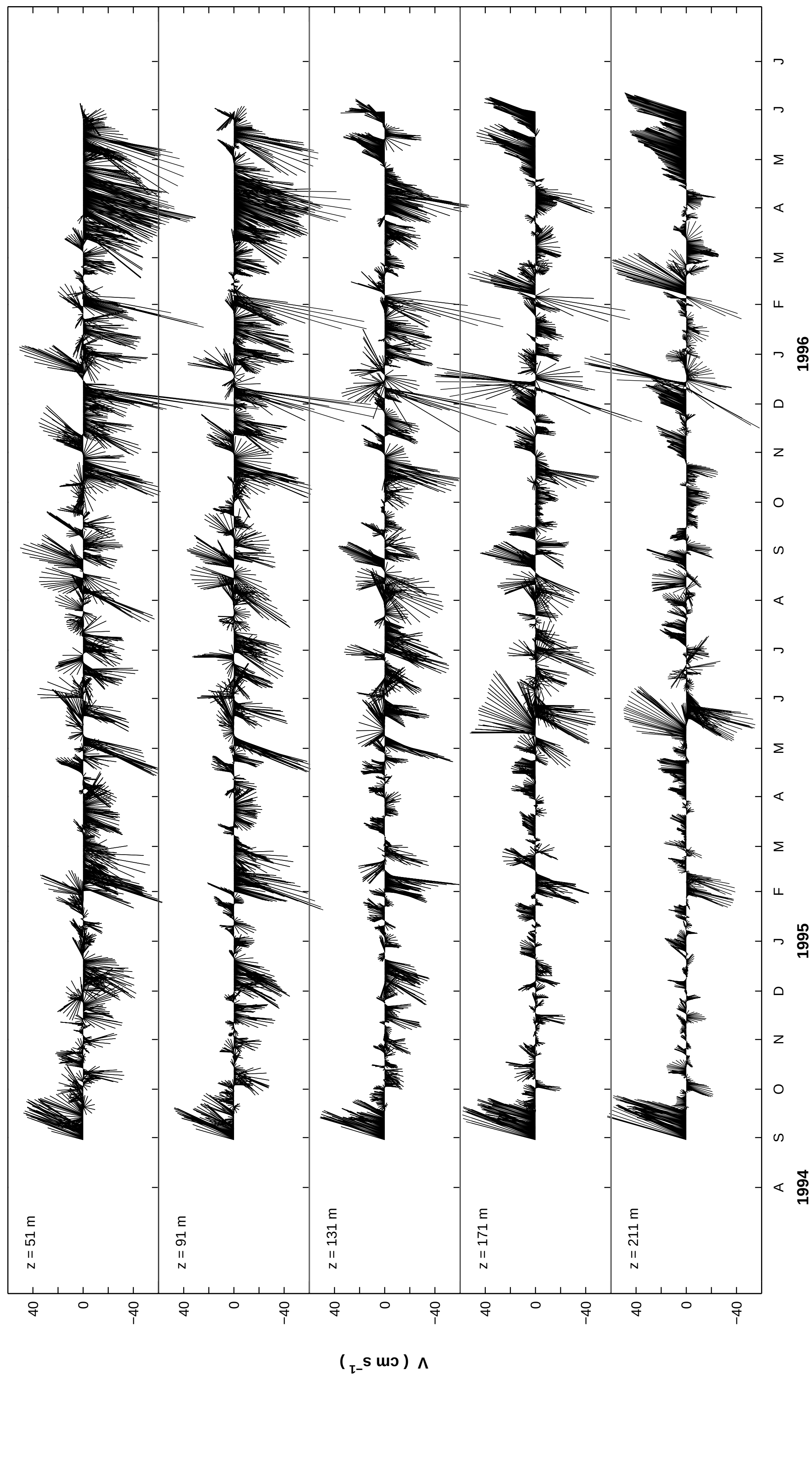

Figure 14a: Mooring 2 – **V** current vectors.

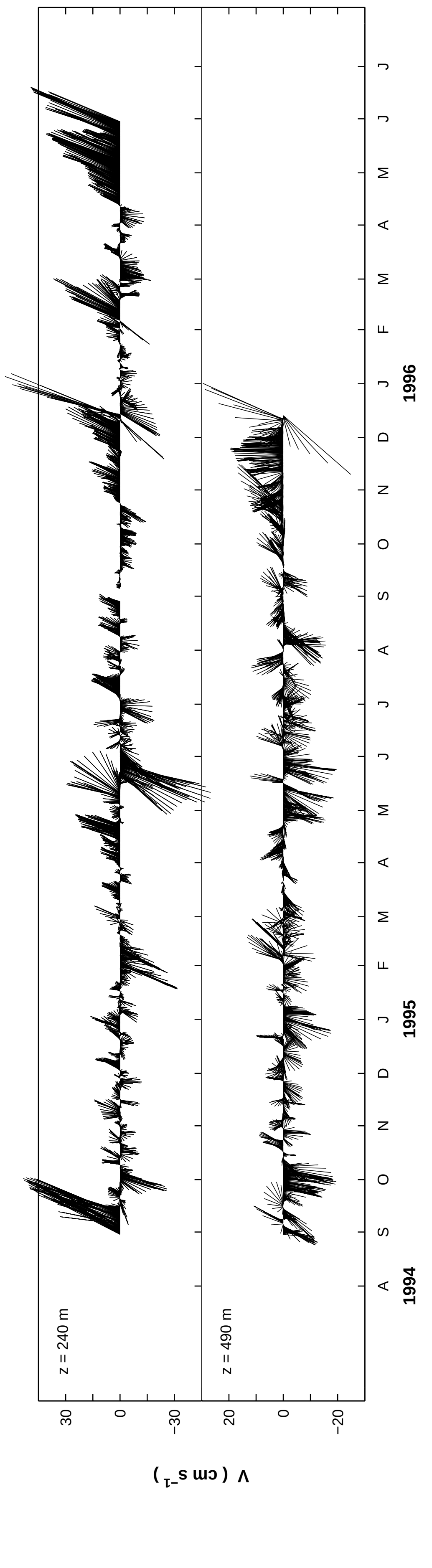

Figure 14b: Mooring 2 – **V** current vectors.

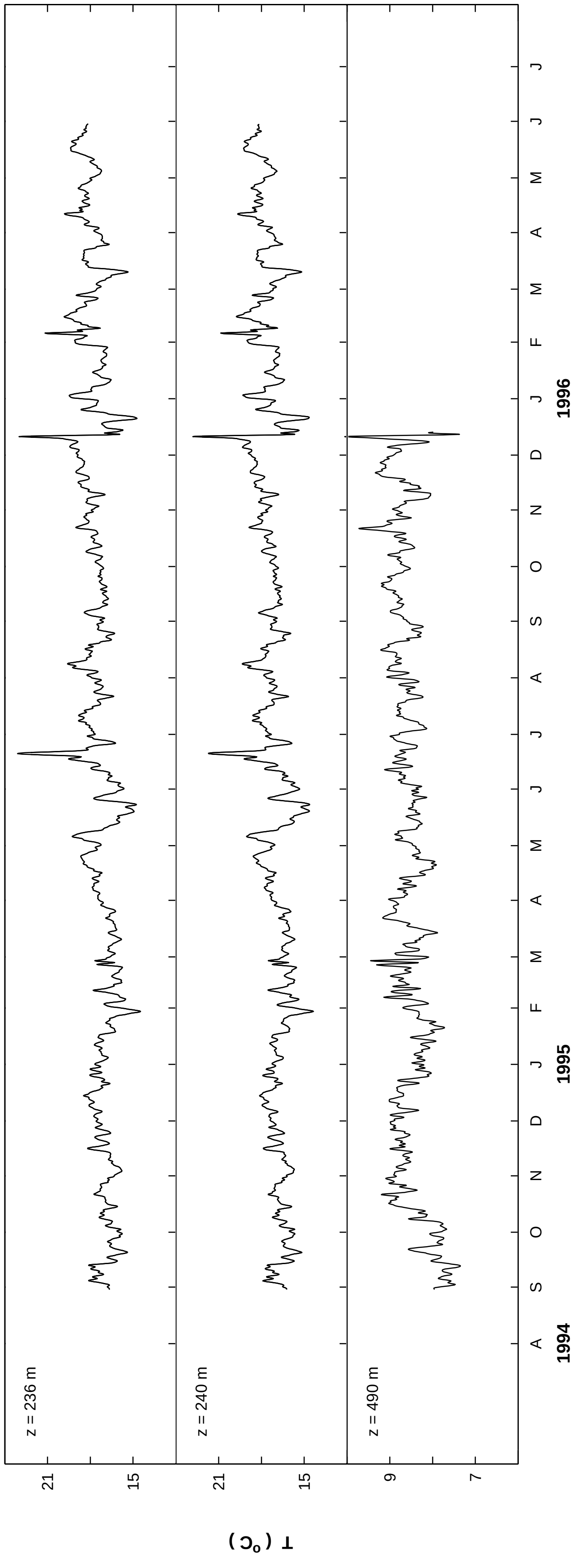

Figure 15: Mooring 2 – Temperature.

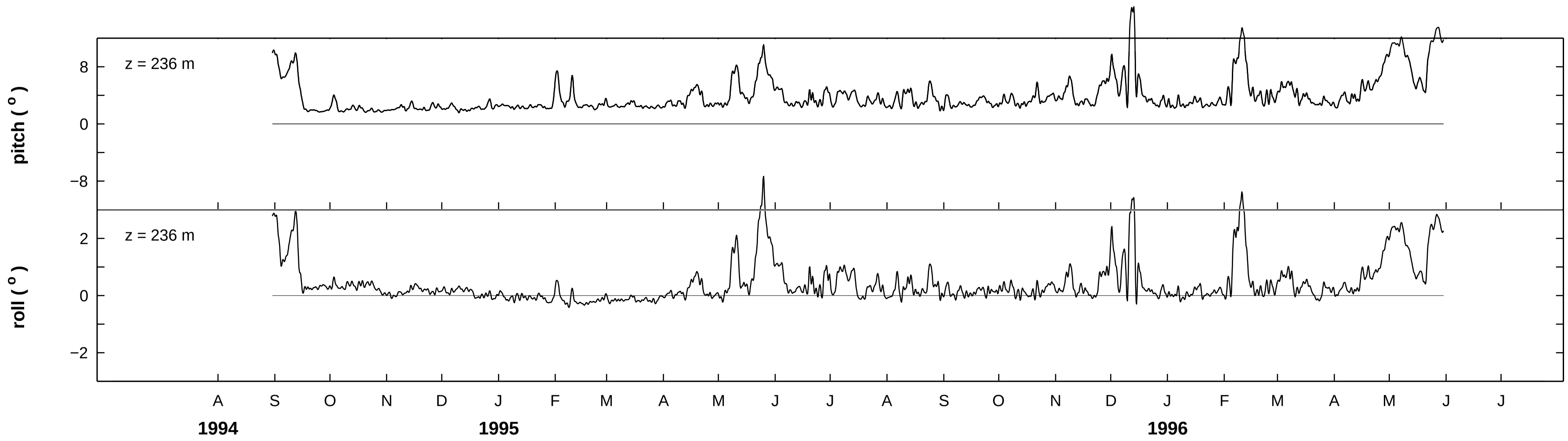

Figure 16: Mooring 2 – Pitch (above) and roll (below).

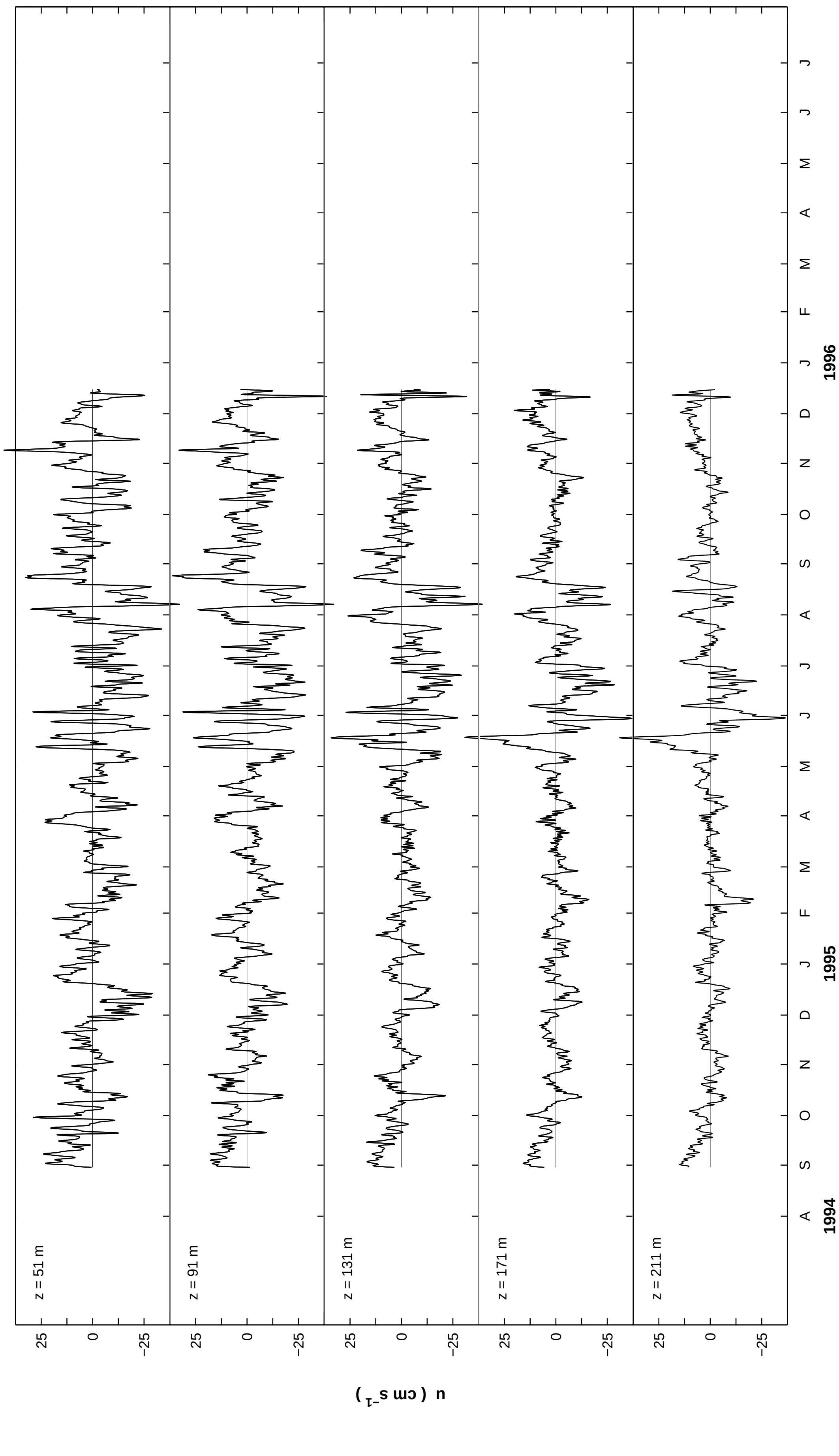

Figure 17a: Mooring 3 – **u** component (positive east).

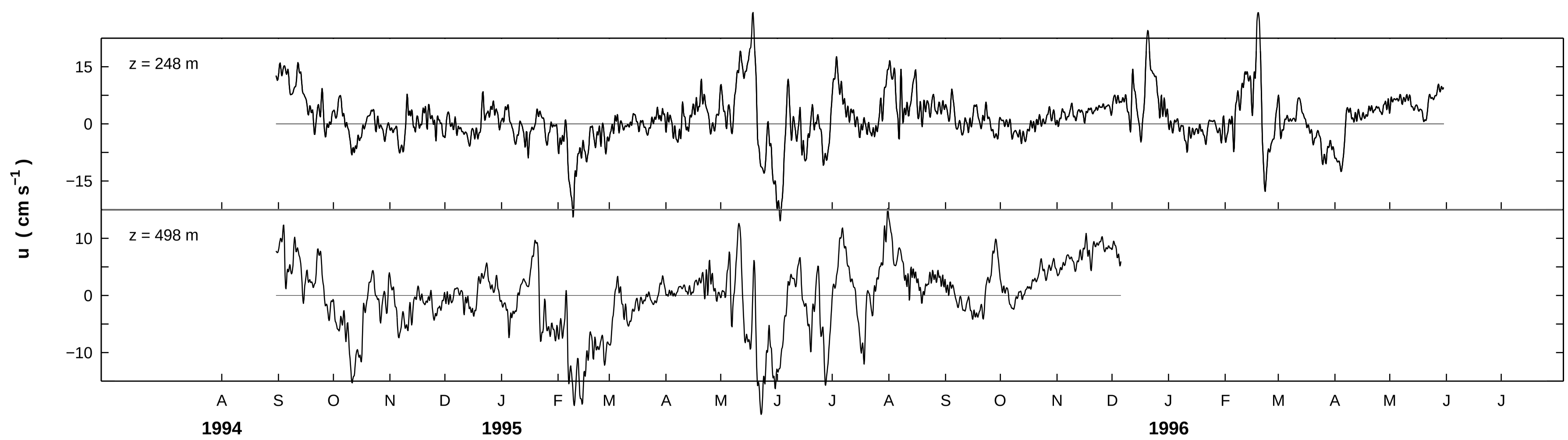

Figure 17b: Mooring 3 – **u** component (positive east).

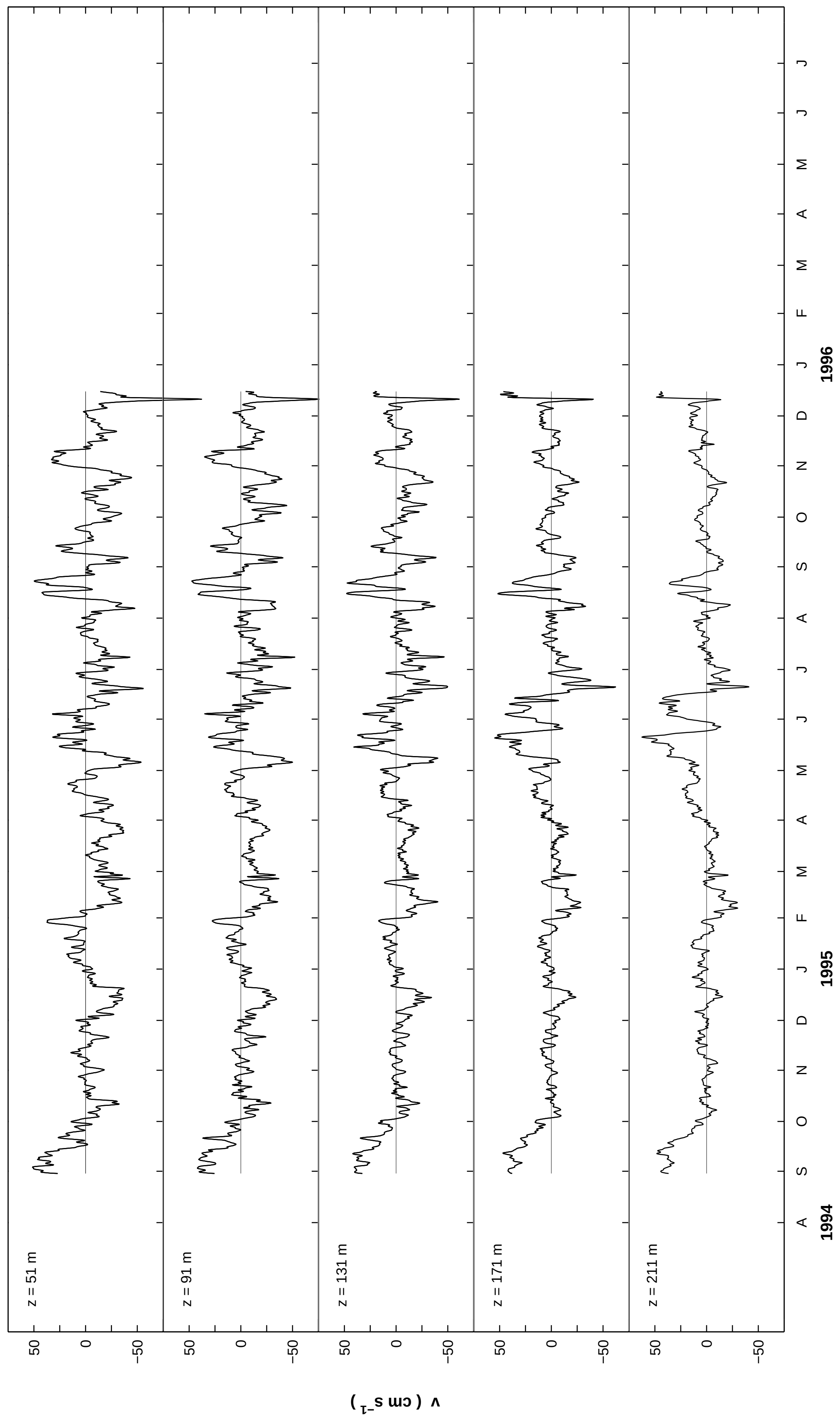

Figure 18a: Mooring 3 – **v** component (positive north).

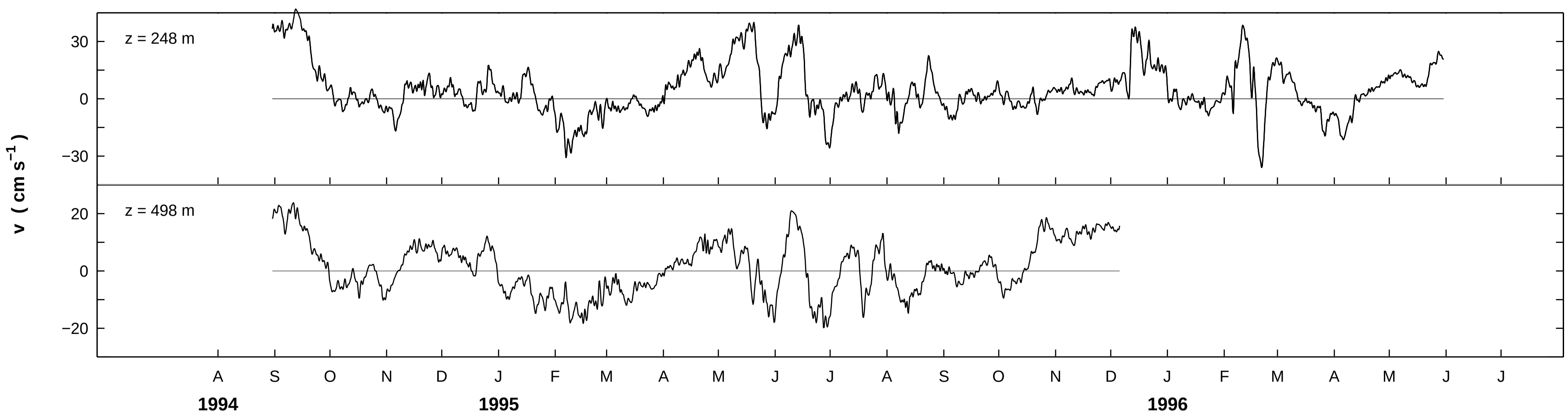

Figure 18b: Mooring 3 – **v** component (positive north).

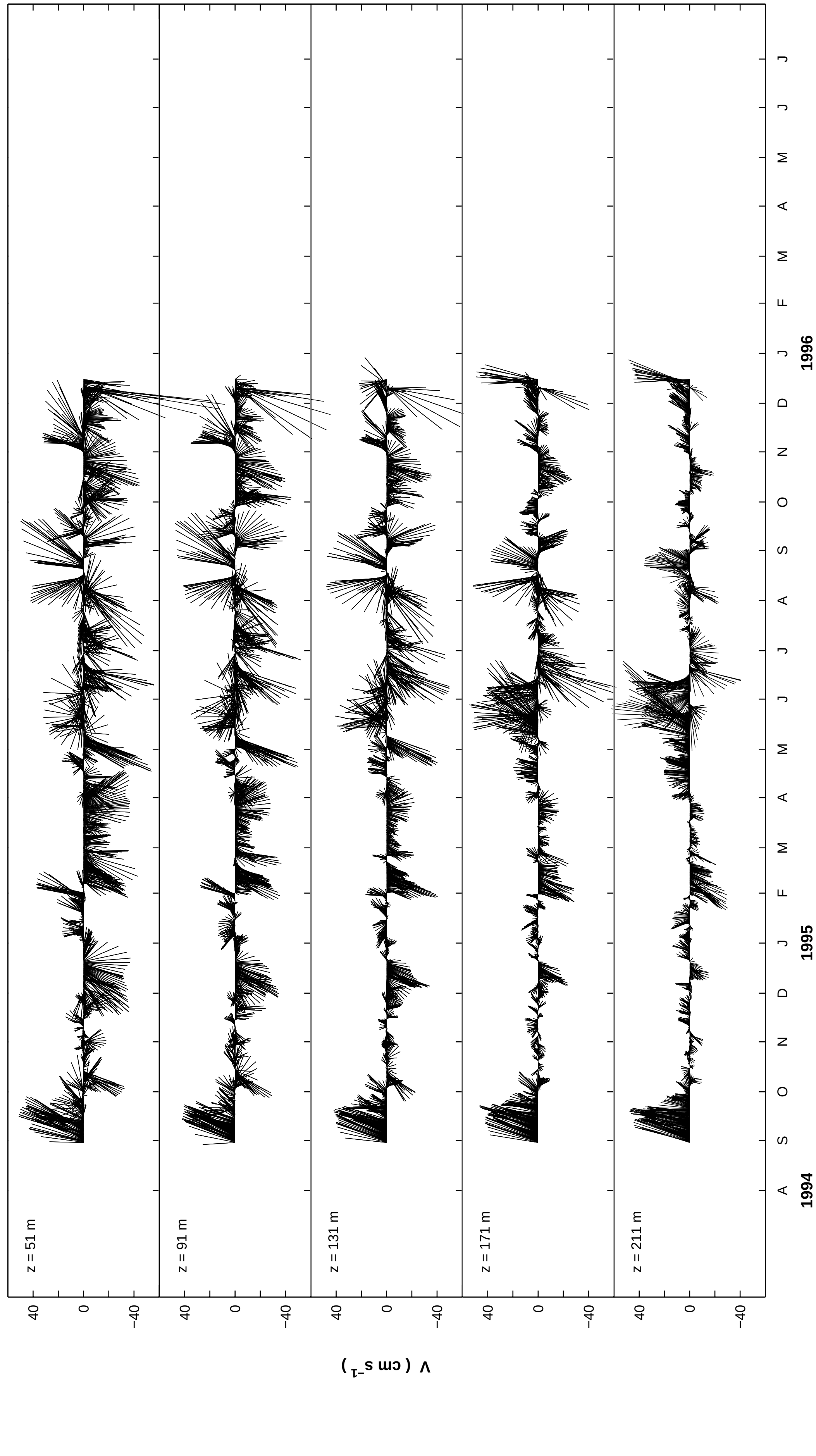

Figure 19a: Mooring 3 – **V** current vectors.

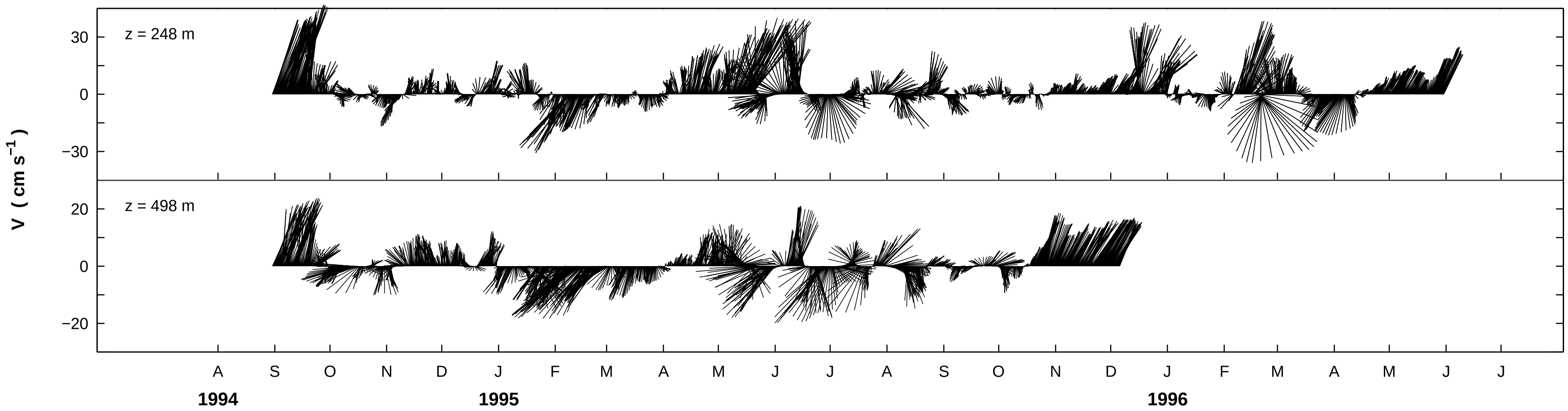

Figure 19b: Mooring 3 – **V** current vectors.

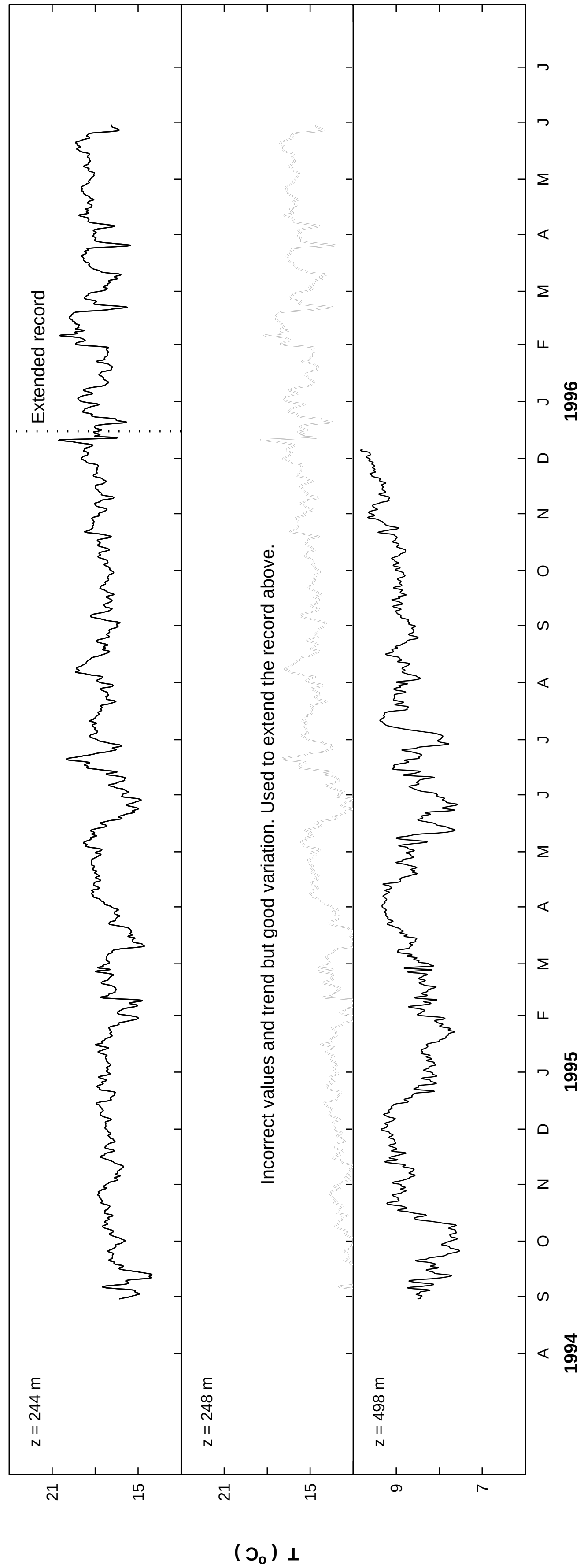

Figure 20: Mooring 3 – Temperature.

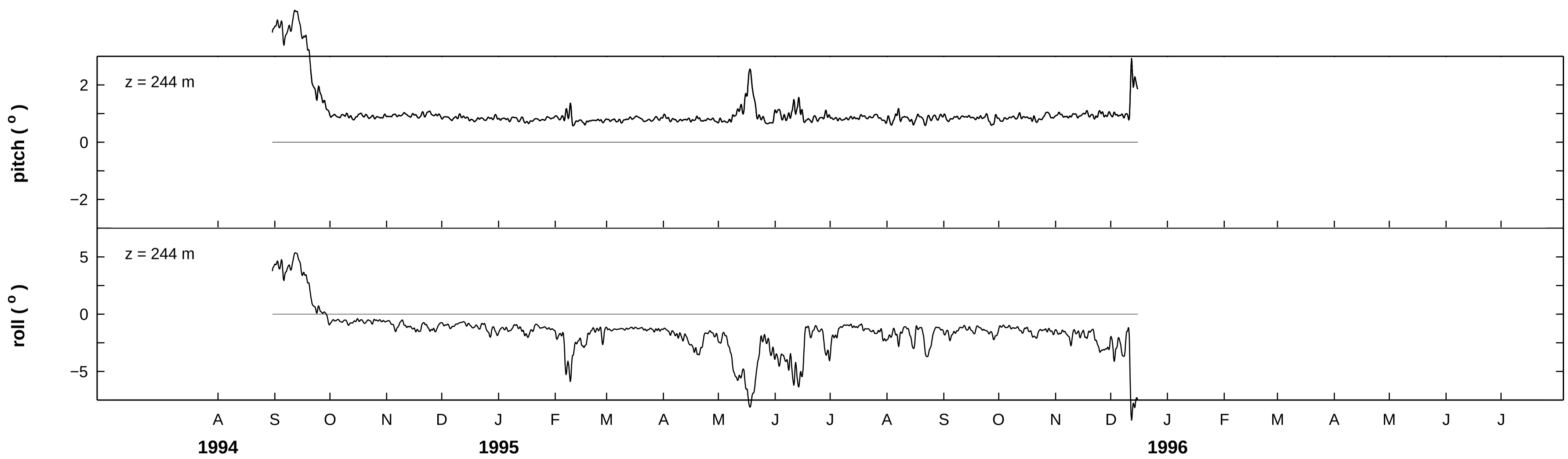

Figure 21: Mooring 3 – Pitch (above) and roll (below).

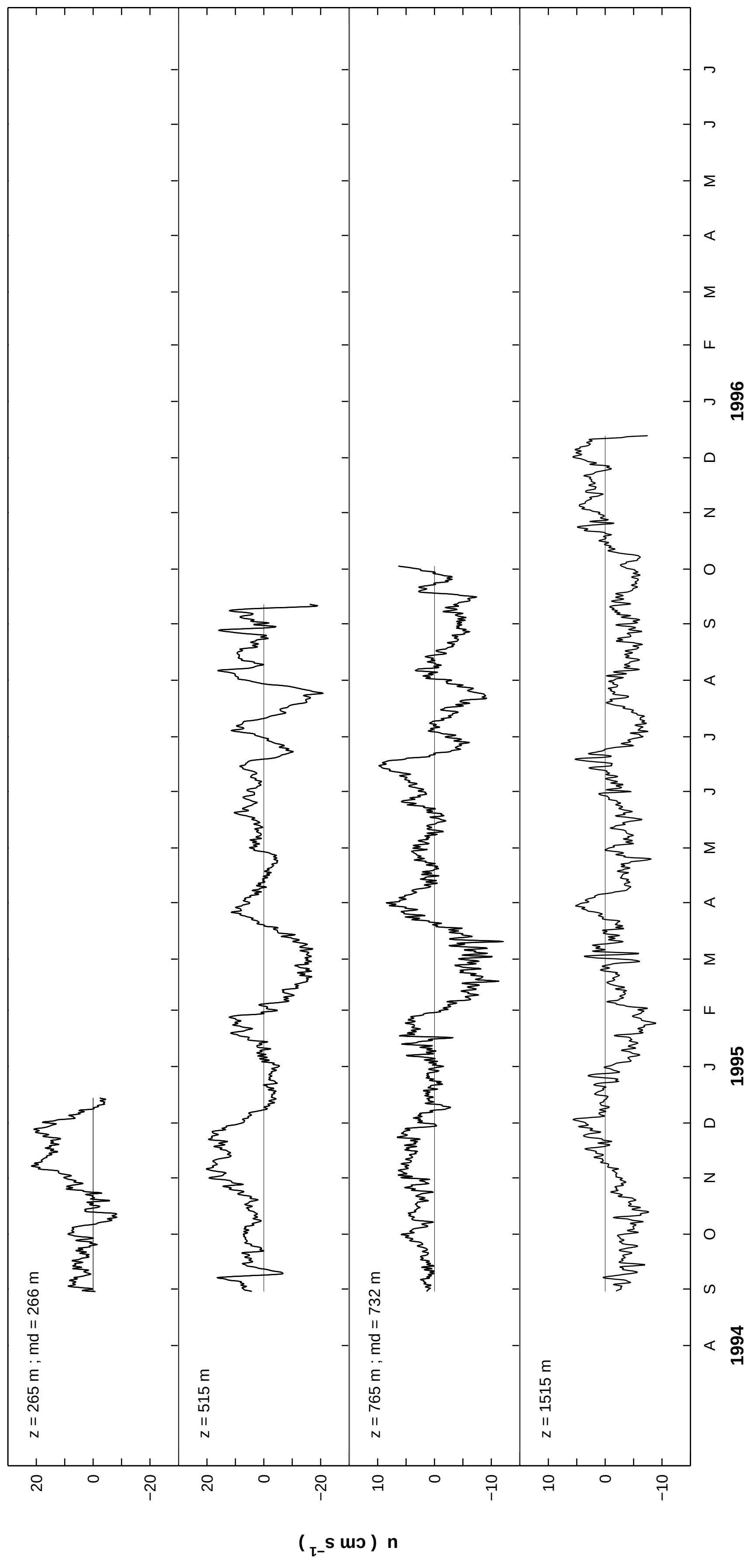

Figure 22: Mooring 5 – **u** component (positive east).

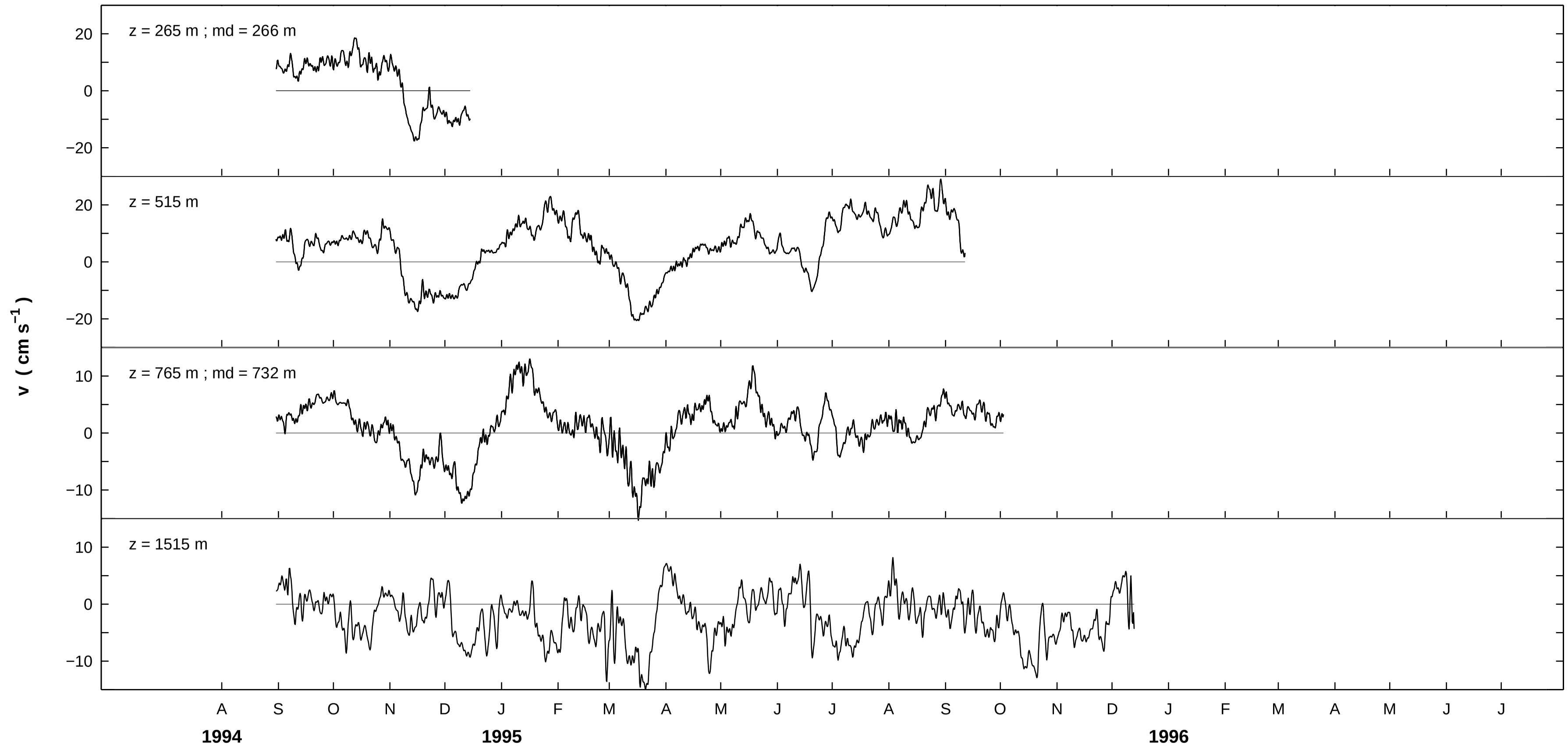

Figure 23: Mooring 5 – **v** component (positive north).

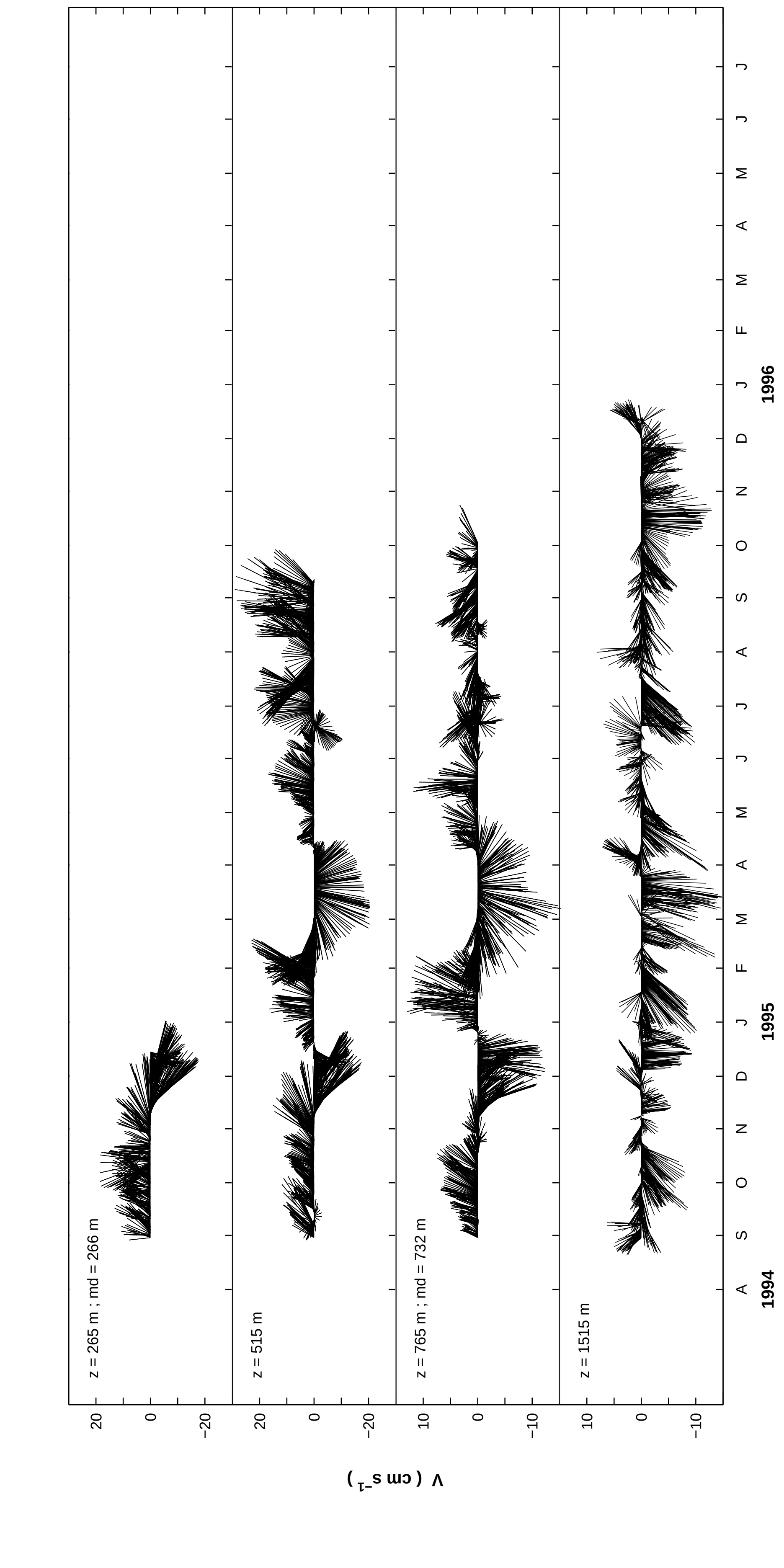

Figure 24: Mooring 5 – **V** current vectors.

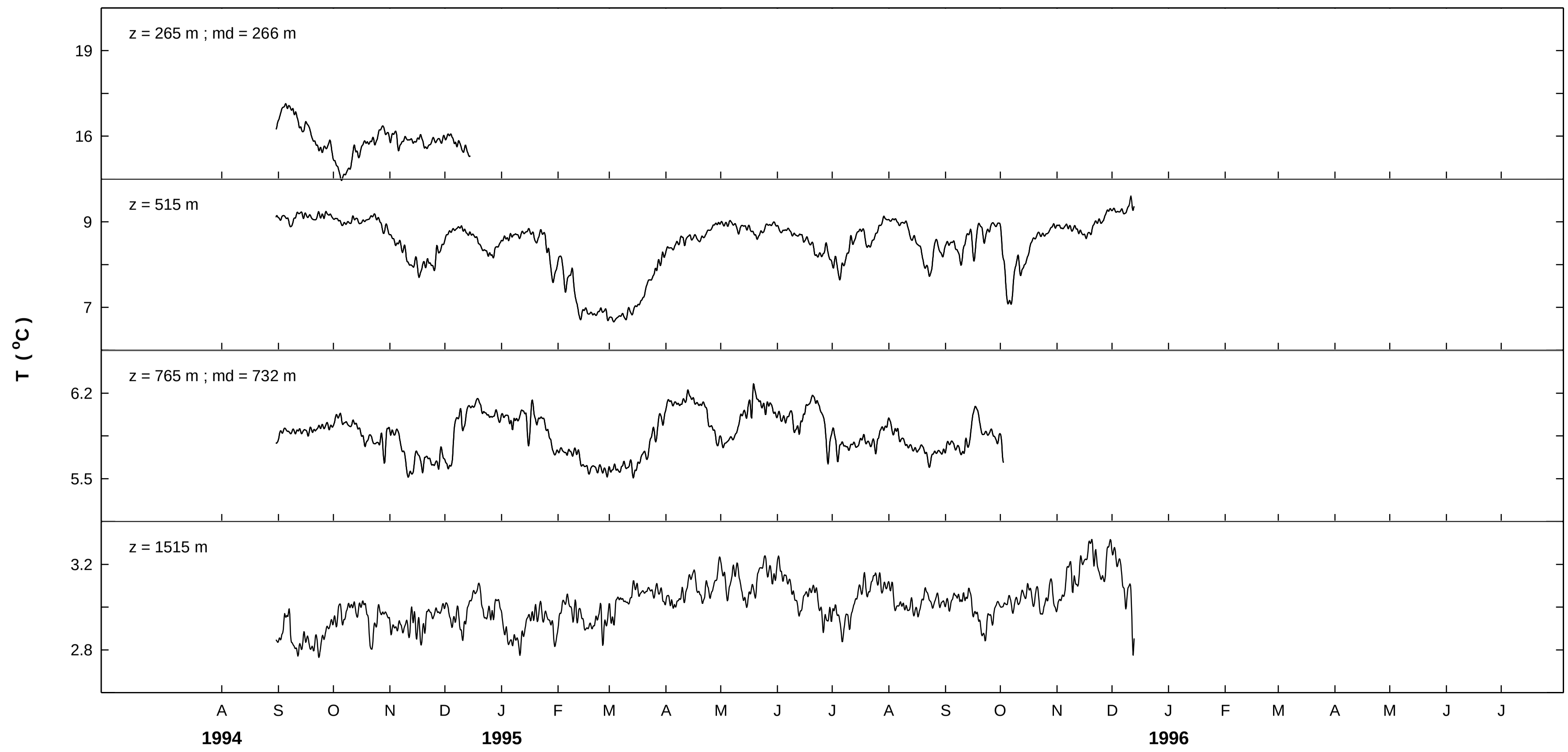

Figure 25: Mooring 5 – Temperature.

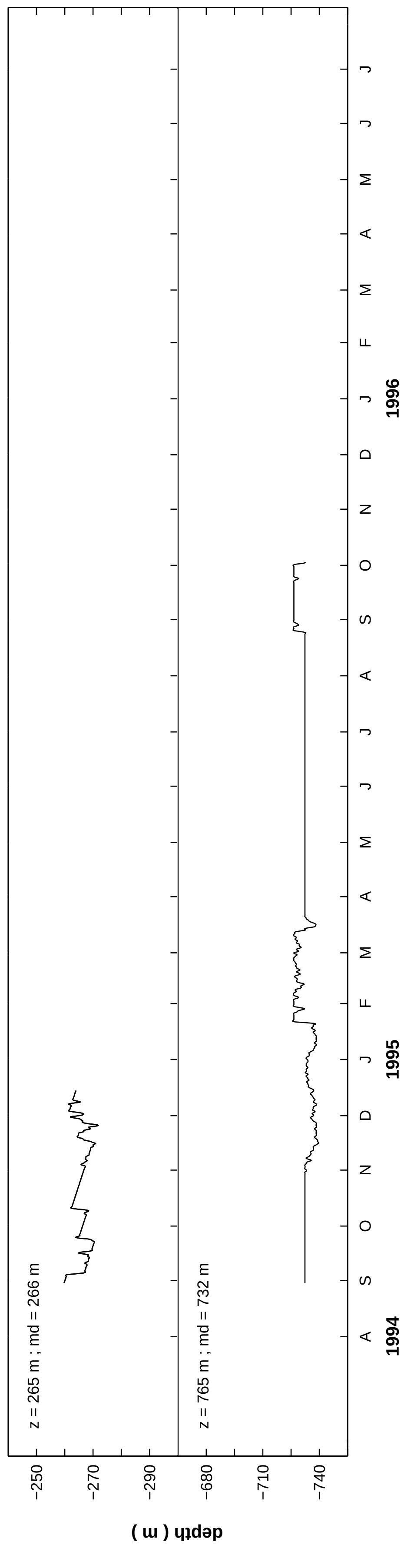

Figure 26: Mooring 5 – Depth (converted from pressure).

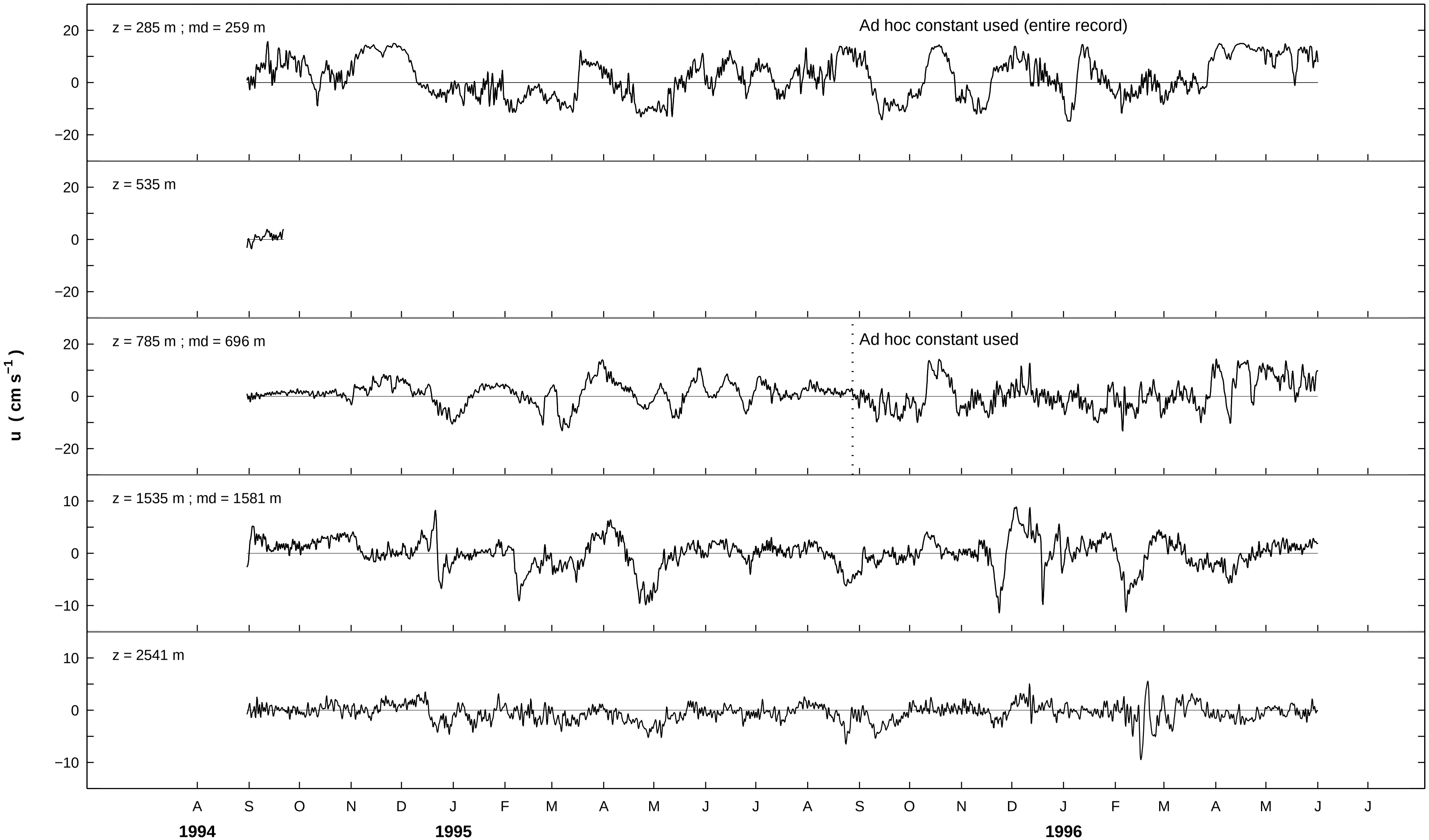

Figure 27: Mooring 6 – **u** component (positive east).

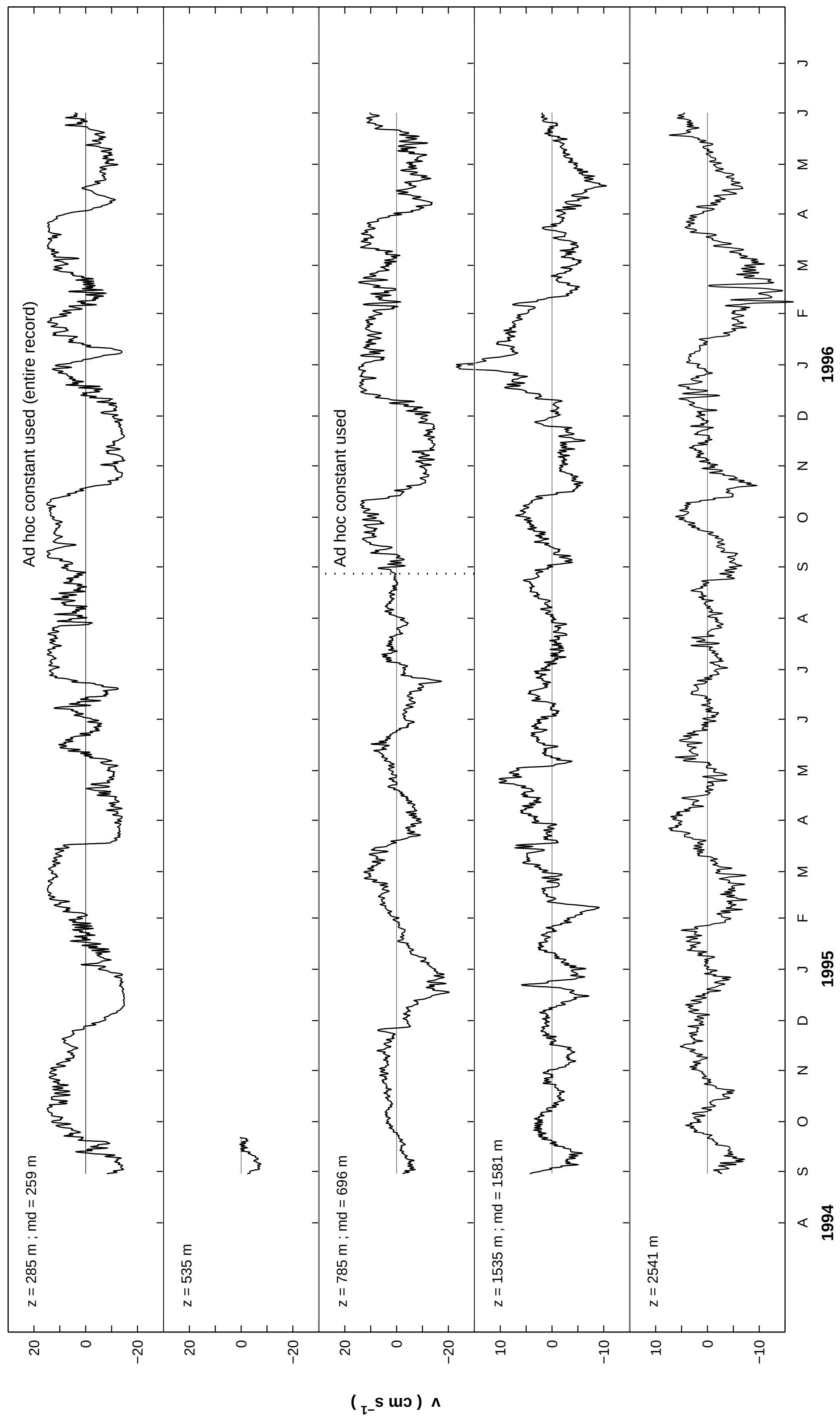

Figure 28: Mooring 6 – **v** component (positive north).

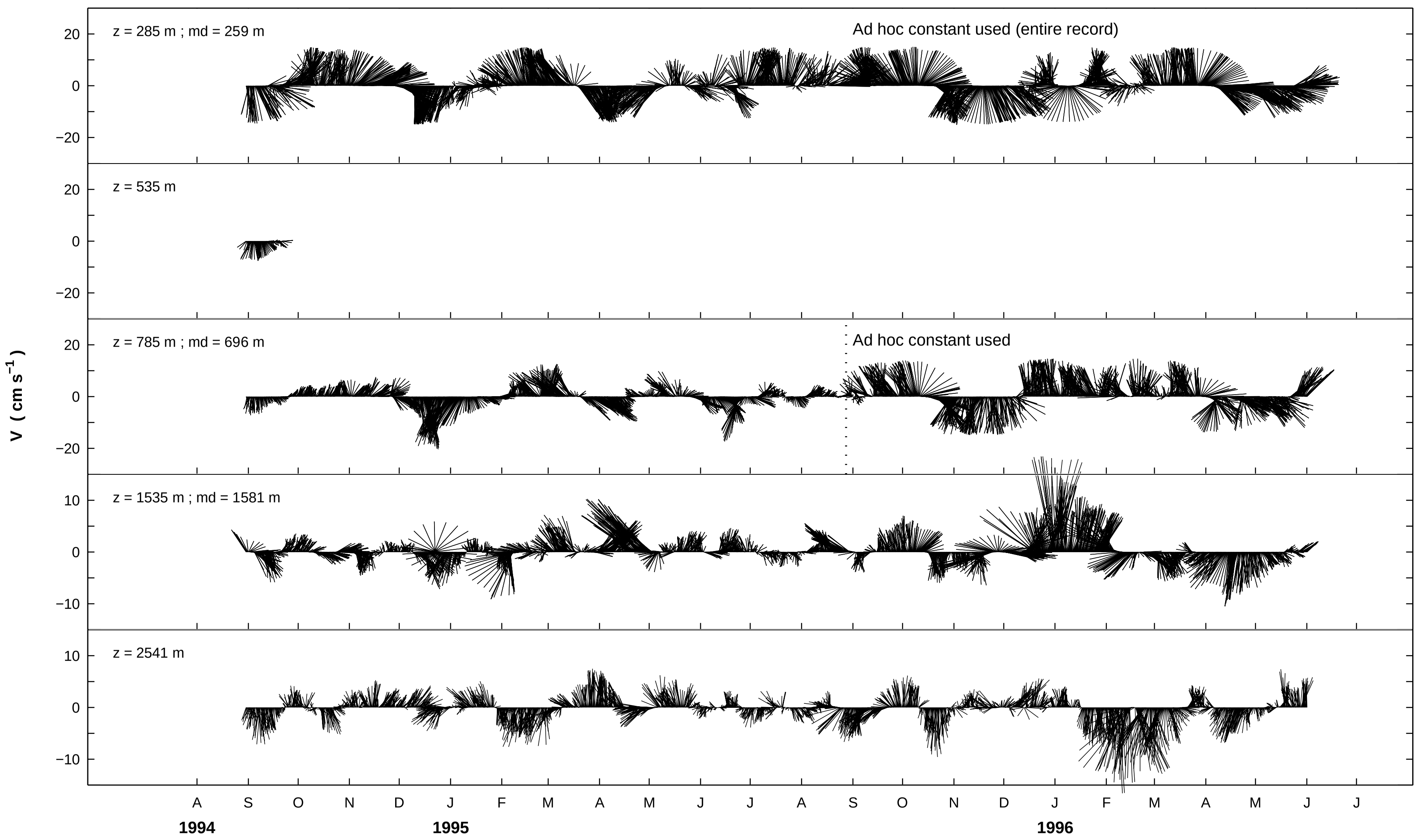

Figure 29: Mooring 6 – **V** current vectors.

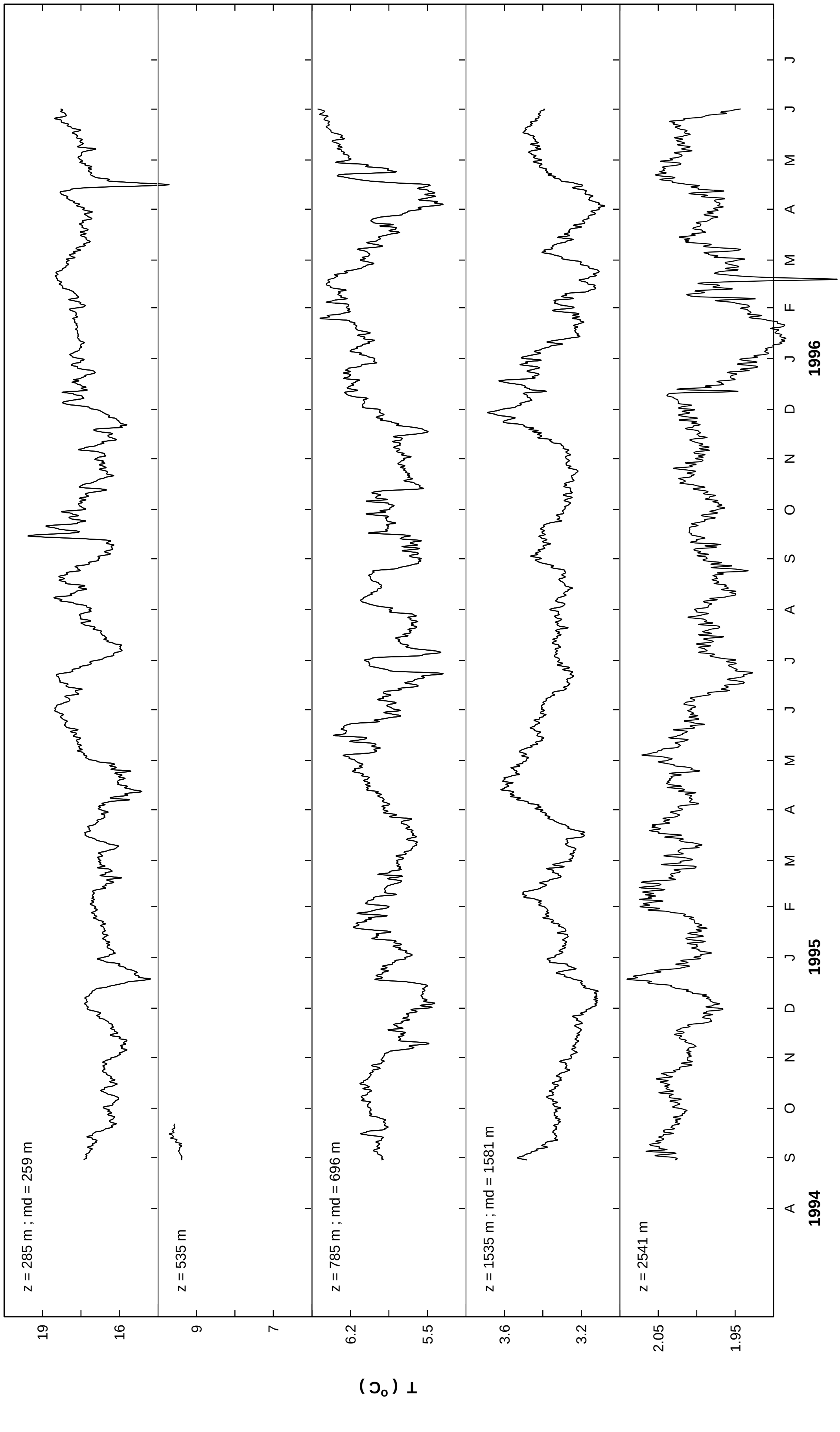

Figure 30: Mooring 6 – Temperature.

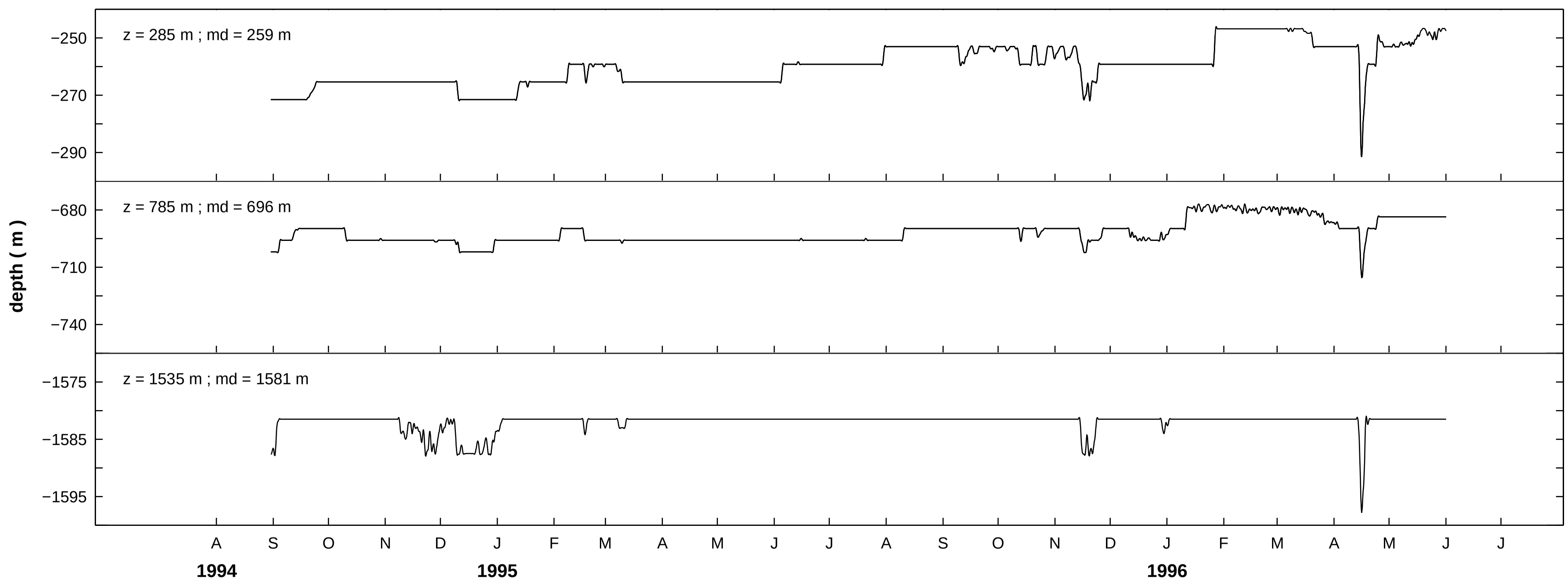

Figure 31: Mooring 6 – Depth (converted from pressure).

Table 1: ICM6 moorings (geographic coordinates, distance from shore and bottom depth).

Mooring	Latitude (°S)	Longitude (°E)	Distance from shore (km)	Water depth (m)
1	22.219	113.733	10.5	252
2	22.210	113.662	17.8	630
3	22.191	113.525	32.0	998
4	22.167	113.352	50.1	1392
5	22.103	112.987	88.3	1604
6	22.055	112.650	123.4	3050

Table 2: ICM6 recovered current meters (nominal depth, identification number, type and sampling interval used).

Mooring	Depth (m)	Instrument number	Instrument type	Sample interval (min)
1	**246**	1143	ADCP	60
2	**236**	0136	ADCP	60
	240	1276	RCM4	120
	490	1120	ACM2	10
3	**244**	0135	ADCP	60
	248	5454	RCM4	180
	498	1196	ACM2	10
	748	4234	RCM4	180
4	**1277**	8455	RCM4 [S]	180
5	**265** [P]	6166	RCM5	180
	515	1251	ACM2	10
	765 [P]	6560	RCM5	180
	1515	1260	ACM2	10
6	**285** [P]	7156	RCM5	180
	535	1257	ACM2	10
	785 [P]	7157	RCM5	180
	1535 [P]	7155	RCM5	180
	2541	7662	RCM5 [S]	180

[P] current meters with pressure sensor
[S] current meters with Savonious rotor (otherwise paddle-wheel rotor)

Table 3: ICM6 timeline of the current meter observations of speed, direction, temperature and pressure. The lengths of speed gaps are shown in days.

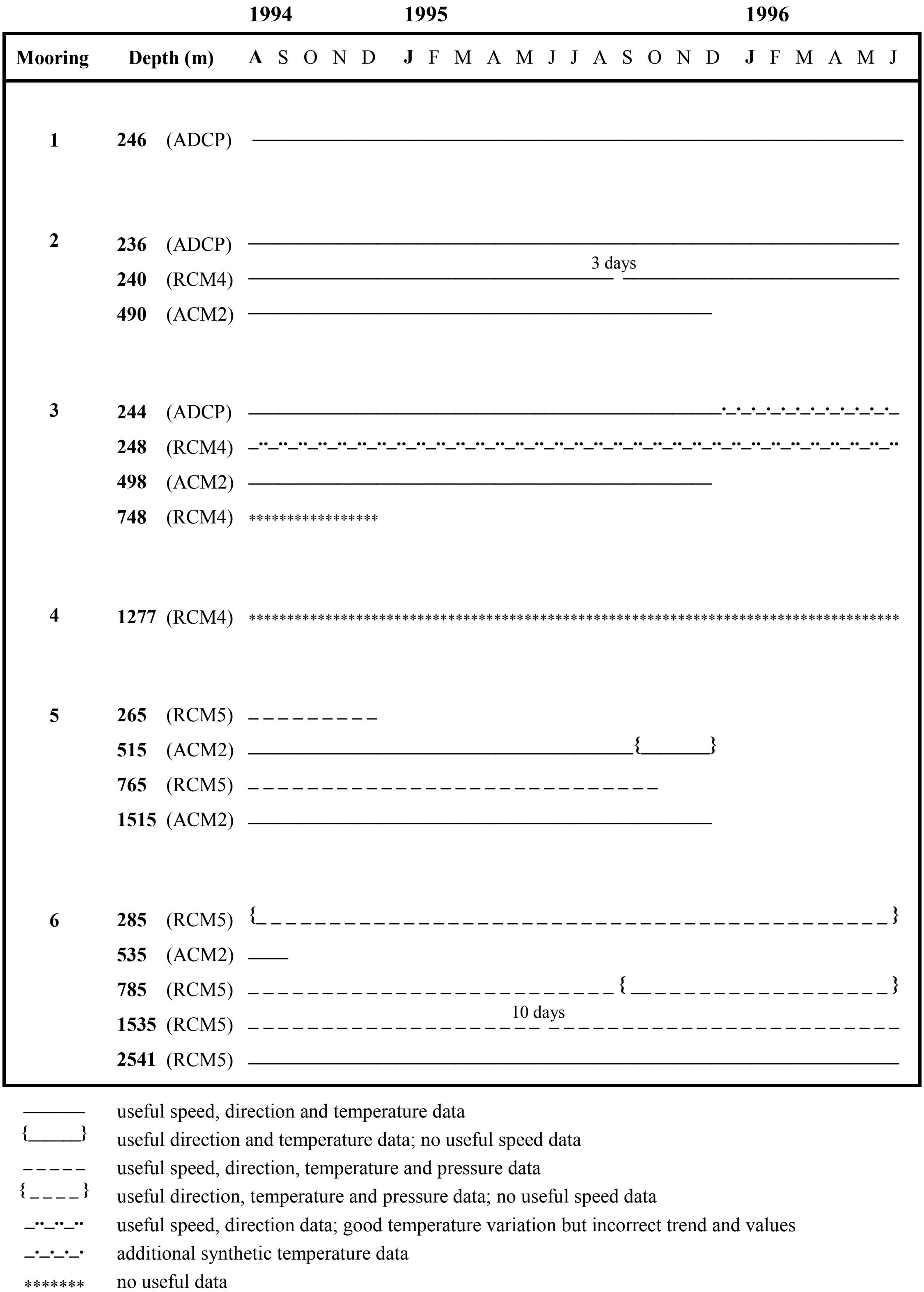

Table 4: Comments on treatment and quality of ICM6 individual data records.

Mooring	Depth (m)	Comments
1	**246**	Good record (speed, direction and temperature). One missing record (25 Jul 1995 20:00 h) was linearly interpolated.
2	**236**	Good record (speed, direction and temperature), except for bin at 219 m depth.
	240	Good record (direction and temperature). Speed data good except between 31 Aug 10:00 h and 02 Sep 1995 16:00 h, when it went to zero.
	490	Good record (speed, direction and temperature).
3	**244**	Good record (speed, direction and temperature). No record after 18 Dec 1995. Additional synthetic low-passed temperature data available between 18 Dec 1995 and 30 May 1996 (obtained by regression of the detrended measured low-passed temperature from the instrument below).
	248	Speed data had intermittent zero values discarded. Cubic spline interpolation was used to fill gaps shorter than 24 h. Good temperature variation but incorrect values and trend. Used to extend the record above.
	498	Good record (speed, direction and temperature).
	748	No useful data (unit flooded and tape damaged).
4	**1277**	No useful data (all channels bad suggesting an unrecoverable problem in the A-D or recording mechanisms).
5	**265**	Short record (~ 4 months, speed, direction and temperature). Pressure data suspect. Data missing due to slight leak causing tape to foul after 17 Dec 1994.
	515	Good record (direction and temperature). Speed data good until 14 Sep 1995 (suspected instrument malfunction after this time).
	765	Good record (speed, direction and temperature). Pressure data suspect. Suspected mechanical malfunction caused the battery to run flat prematurely and hence logging to cease after 02 Oct 95.
	1515	Good record (speed, direction and temperature).
6	**285**	Good record (direction and temperature). Pressure data suspect. No useful speed data. *Ad hoc* constant added (entire record).
	535	Short record (~ 1 month, speed, direction and temperature).
	785	Good record (direction and temperature). Pressure data suspect. Speed data good until 30 Aug 1995. *Ad hoc* constant added after that date.
	1535	Good record (direction and temperature). Pressure data suspect. Speed data good except between 02 Jun 21:00 h and 12 Jun 1995 00:00 h, when it went to zero.
	2541	Good record (speed, direction and temperature data).

Table 5: Valid ADCP depth cells. Data presented here are in bold type.

Mooring	Depth cell (m)																							
1	45	**53**	61	69	77	85	**93**	101	109	117	125	**133**	141	149	157	165	**173**	181	189	197	205	**213**	221	229
2	43	**51**	59	67	75	83	**91**	99	107	115	123	**131**	139	147	155	163	**171**	179	187	195	203	**211**	- - -	- - -
3	- -	**51**	59	67	75	83	**91**	99	107	115	123	**131**	139	147	155	163	**171**	179	187	195	203	**211**	219	227

Table 6: Simple statistics for low-pass filtered depth data. N is the number of 6 hourly data; Md is the median; SD is the standard deviation and Min/Max are the minimum and maximum values respectively, including all following tables.

Mooring	Nominal Depth (m)	Record length			Depth (m)				
		Start time	End time	N	Md	Mean	SD	Min	Max
5	**265**	30 Aug 94 15:00 h	14 Dec 94 21:00 h	426	266	266	2.6	260	272
	765	30 Aug 94 15:00 h	02 Oct 95 15:00 h	1593	732	732	3.1	726	740
6	**285**	30 Aug 94 15:00 h	01 Jun 96 03:00 h	2563	259	260	7.2	246	291
	785	30 Aug 94 15:00 h	01 Jun 96 03:00 h	2563	696	692	6.0	677	715
	1535	30 Aug 94 15:00 h	01 Jun 96 03:00 h	2563	1581	1582	1.6	1581	1598

Table 7: Simple statistics for **u** and **v** ADCP low-pass filtered data on mooring 1.

ADCP Mooring 1	Record length							
	Start time		End time		N			
	30 Aug 94 15:00 h		30 May 96 15:00 h		2557			
Depth cell (m)	u ($cm\ s^{-1}$)				v ($cm\ s^{-1}$)			
	Mean	SD	Min	Max	Mean	SD	Min	Max
45	-1.25	8.53	-34.29	22.69	-8.45	21.05	-120.54	58.56
53	-1.49	8.52	-33.98	23.11	-9.89	20.49	-115.52	54.45
61	-1.79	8.38	-31.03	24.24	-11.01	19.95	-109.97	51.01
69	-2.14	8.12	-29.89	23.76	-11.78	19.43	-103.97	48.52
77	-2.38	7.79	-29.55	23.07	-12.22	18.95	-99.80	46.71
85	-2.51	7.44	-28.75	23.65	-12.31	18.43	-95.77	44.79
93	-2.59	7.16	-27.65	23.55	-12.02	17.82	-92.18	43.47
101	-2.61	6.87	-25.25	21.35	-11.48	17.23	-89.59	43.97
109	-2.54	6.65	-26.93	20.53	-10.75	16.76	-87.22	46.81
117	-2.36	6.42	-29.08	18.48	-9.81	16.37	-84.20	49.29
125	-2.15	6.23	-30.57	18.50	-8.62	16.07	-81.74	49.86
133	-1.97	6.09	-31.70	17.93	-7.29	15.97	-79.68	48.59
141	-1.83	6.06	-31.48	18.87	-5.97	15.93	-77.62	47.30
149	-1.56	6.06	-29.91	19.69	-4.57	15.85	-75.08	48.41
157	-1.19	6.05	-29.39	19.54	-3.32	15.88	-72.16	47.85
165	-0.80	6.03	-30.80	18.57	-2.28	15.88	-68.90	49.76
173	-0.46	5.93	-31.58	19.56	-1.34	15.92	-65.87	59.88
181	-0.16	5.98	-31.27	19.39	-0.49	15.92	-63.41	67.18
189	0.00	6.04	-31.49	20.78	0.23	15.89	-58.70	62.58
197	0.07	5.95	-28.71	18.77	0.71	15.71	-54.81	52.68
205	0.12	5.76	-26.03	16.19	0.92	15.32	-53.01	52.08
213	0.09	5.59	-27.33	15.47	0.75	14.73	-49.72	48.84
221	0.02	5.25	-28.55	13.14	0.38	14.01	-46.33	47.96
229	-0.04	4.53	-28.30	10.78	-0.10	12.43	-46.58	45.25

Table 8: Simple statistics for **u** and **v** ADCP low-pass filtered data on mooring 2.

ADCP Mooring 2	**Record length**							
	Start time		**End time**		**N**			
	30 Aug 94 15:00 h		30 May 96 15:00 h		2557			
Depth cell (m)	**u ($cm\ s^{-1}$)**				**v ($cm\ s^{-1}$)**			
	Mean	**SD**	**Min**	**Max**	**Mean**	**SD**	**Min**	**Max**
43	-1.34	9.66	-44.30	26.20	-9.39	23.06	-144.24	54.07
51	-1.20	9.63	-43.48	26.86	-9.90	22.62	-140.36	50.81
59	-1.16	9.52	-41.18	26.54	-10.22	22.09	-135.66	48.72
67	-1.27	9.36	-37.44	26.04	-10.38	21.54	-130.40	47.05
75	-1.37	9.15	-34.54	27.27	-10.43	21.02	-125.67	45.98
83	-1.43	8.87	-32.40	28.45	-10.33	20.51	-122.13	46.90
91	-1.46	8.51	-28.91	29.25	-10.01	19.97	-118.25	47.64
99	-1.36	8.17	-27.59	29.55	-9.41	19.39	-114.02	47.34
107	-1.15	7.86	-29.85	28.53	-8.51	18.77	-108.90	47.67
115	-0.98	7.72	-31.84	29.71	-7.44	18.25	-104.27	48.91
123	-0.70	7.62	-32.66	32.57	-6.27	17.90	-100.71	50.16
131	-0.42	7.38	-33.37	32.55	-4.90	17.68	-98.08	51.59
139	-0.14	7.15	-32.71	30.03	-3.45	17.54	-96.13	52.93
147	0.13	6.96	-30.36	25.71	-2.00	17.45	-93.89	54.65
155	0.50	6.82	-26.76	26.53	-0.54	17.49	-91.85	63.17
163	0.97	6.91	-25.70	31.62	0.81	17.65	-88.90	74.49
171	1.40	6.97	-25.06	41.03	1.96	17.80	-84.84	80.46
179	1.76	6.95	-26.56	41.97	2.96	17.88	-80.98	83.66
187	2.02	6.95	-28.13	41.32	3.82	17.79	-76.30	85.88
195	2.19	6.86	-29.41	35.05	4.48	17.62	-70.63	86.20
203	2.32	6.67	-30.14	32.49	4.90	17.47	-64.40	85.25
211	2.38	6.49	-29.70	31.98	5.12	17.27	-58.37	81.48

Table 9: Simple statistics for **u** and **v** ADCP low-pass filtered data on mooring 3.

ADCP Mooring 3	Record length							
	Start time		End time		N			
	30 Aug 94 15:00 h		15 Dec 95 21:00 h		1890			
Depth Cell (m)	u ($cm\ s^{-1}$)				v ($cm\ s^{-1}$)			
	Mean	SD	Min	Max	Mean	SD	Min	Max
51	-0.28	11.83	-42.29	43.11	-5.56	19.53	-112.17	51.39
59	-0.25	11.67	-42.99	41.73	-5.41	19.16	-101.36	49.79
67	-0.26	11.43	-43.02	39.37	-5.18	18.76	-91.29	50.01
75	-0.39	11.18	-43.15	39.17	-4.87	18.32	-84.04	49.81
83	-0.51	10.96	-42.64	39.74	-4.53	17.92	-79.01	48.91
91	-0.63	10.70	-42.17	36.27	-4.18	17.53	-75.70	47.40
99	-0.69	10.38	-42.56	31.34	-3.73	17.15	-73.73	46.30
107	-0.69	10.04	-42.63	31.84	-3.27	16.80	-72.09	46.10
115	-0.65	9.78	-42.44	32.09	-2.81	16.46	-69.17	46.72
123	-0.58	9.64	-41.50	33.67	-2.26	16.14	-65.07	47.44
131	-0.47	9.37	-39.31	34.26	-1.58	15.93	-61.05	47.80
139	-0.30	8.96	-37.43	33.09	-0.78	15.87	-58.45	50.31
147	-0.08	8.62	-33.95	32.99	0.09	15.91	-58.53	51.00
155	0.16	8.43	-32.84	36.52	1.10	15.86	-61.75	50.83
163	0.36	8.35	-35.40	40.85	2.17	15.92	-63.01	50.98
171	0.45	8.25	-37.38	44.31	3.14	16.06	-62.16	54.72
179	0.53	8.06	-35.94	45.85	4.06	16.20	-60.67	58.23
187	0.61	7.88	-34.81	46.44	4.78	16.29	-58.20	60.88
195	0.60	7.68	-35.31	45.24	5.23	16.18	-54.21	65.45
203	0.83	7.55	-36.88	45.68	5.52	15.81	-47.74	65.98
211	0.99	7.30	-36.55	44.16	5.65	15.33	-40.84	62.53
219	1.04	6.82	-31.26	37.87	5.60	14.68	-35.84	55.62
227	1.01	5.87	-22.99	24.62	4.84	12.58	-26.21	43.92

Table 10: Simple statistics for **u**, **v** and temperature low-pass filtered data on moorings 1 to 6.

Mooring	Depth (m)	Record length			u ($cm\ s^{-1}$)				v ($cm\ s^{-1}$)				Temperature (°C)			
		Start time	End time	N	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max
1	**246** ✣	30 Aug 94 15:00 h	30 May 96 15:00 h	2557	see table 7				see table 7				15.57	1.01	12.29	23.13
2	**236** ✣	30 Aug 94 15:00 h	30 May 96 15:00 h	2557	see table 8				see table 8				17.48	1.01	14.47	23.12
	240	30 Aug 94 15:00 h	30 May 96 09:00 h	2556	1.75	5.69	-21.16	26.85	3.54	13.71	-50.01	63.52	17.27	1.00	14.36	22.82
	490	30 Aug 94 15:00 h	13 Dec 95 15:00 h	1881	-0.80	3.77	-19.98	14.42	-0.51	7.43	-24.81	30.21	8.57	0.38	7.35	10.06
3	**244** ✣	30 Aug 94 15:00 h	15 Dec 95 21:00 h 30 May 96 15:00 h♣	1890 2557♣	see table 9				see table 9				17.44 17.20	1.00 0.92	14.04 14.04	20.57 20.57
	248	30 Aug 94 15:00 h	30 May 96 15:00 h	2557	1.40	6.37	-25.48	29.26	4.79	13.05	-35.92	46.95	Bad values but with good variation			
	498	30 Aug 94 15:00 h	05 Dec 95 21:00 h	1850	-0.20	6.00	-20.83	15.22	1.14	9.34	-19.78	23.82	8.71	0.49	7.53	9.84
	748	No useful data recovered														
4	**1277**	No useful data recovered														
5	**265** p	30 Aug 94 15:00 h	14 Dec 94 21:00 h	426	6.53	7.18	-8.34	21.75	2.89	9.48	-17.60	18.56	15.85	0.53	14.44	17.14
	515	30 Aug 94 15:00 h	13 Dec 95 03:00 h 11 Sep 95 15:00 h†	1879 1509†	1.88	8.20	-20.85	20.22	5.34	10.17	-20.59	29.08	8.48	0.63	6.66	9.61
	765 p	30 Aug 94 15:00 h	02 Oct 95 15:00 h	1593	0.31	3.88	-12.08	9.76	0.98	4.75	-15.33	12.98	5.86	0.17	5.51	6.28
	1515	30 Aug 94 15:00 h	13 Dec 95 03:00 h	1879	-1.88	3.02	-8.89	5.67	-2.55	4.06	-14.87	8.17	3.01	0.10	2.76	3.32
6	**285** p	30 Aug 94 15:00 h	01 Jun 96 03:00 h	2563	No speed data recovered				No speed data recovered				17.09	0.76	14.06	19.56
	535	30 Aug 94 15:00 h	21 Sep 94 15:00 h	89	0.80	1.66	-3.60	3.85	-3.59	2.49	-7.63	0.54	9.51	0.10	9.38	9.71
	785 p	30 Aug 94 15:00 h	01 Jun 96 03:00 h 27 Aug 95 15:00 h†	2563 1449†	1.18	4.27	-13.15	13.98	-0.82	5.97	-20.31	12.60	5.92	0.24	5.36	6.50
	1535 p	30 Aug 94 15:00 h	01 Jun 96 03:00 h	2563	-0.01	2.87	-11.40	8.88	0.54	4.02	-10.48	18.49	3.34	0.11	3.08	3.69
	2541	30 Aug 94 15:00 h	01 Jun 96 03:00 h	2563	-0.49	1.61	-9.46	5.58	-0.57	3.64	-16.59	7.47	2.00	0.04	1.82	2.09

✣ ADCPs (see tables 7, 8 and 9 for **u** and **v** statistics)
p RCMs with pressure sensor (see table 6 for depth statistics)
♣ Extended ADCP temperature data (see section 4)
† Shorter speed data record

APPENDIX A

CTD sections conducted on five different WOCE cruises along the ICM6 array:

CTD - FR 08/94 (23 August to 14 September 1994)

Station N°	Date	Time (h)	Latitude (°S)	Longitude (°E)	Water depth (m)
2	26 Aug 94	12:39	22.234	113.795	74
3	26 Aug 94	13:35	22.210	113.737	253
4	26 Aug 94	14:37	22.197	113.664	640
5	26 Aug 94	18:28	22.180	113.530	1043
6	26 Aug 94	20:35	22.153	113.362	1336
7	27 Aug 94	00:04	22.104	112.982	1622
8	27 Aug 94	04:41	22.073	112.787	2330
9	27 Aug 94	09:44	22.056	112.667	2952
10	27 Aug 94	13:10	22.000	112.384	4396

CTD - FR 03/95 (1 April to 24 April 1995)

Station N°	Date	Time (h)	Latitude (°S)	Longitude (°E)	Water depth (m)
65	21 Apr 95	23:16	22.000	112.384	4243
66	22 Apr 95	05:11	22.080	112.818	2211
67	22 Apr 95	09:29	22.135	113.170	1313
68	22 Apr 95	12:17	22.155	113.439	1310
69	22 Apr 95	14:36	22.202	113.596	866
70	22 Apr 95	16:14	22.215	113.699	384
71	22 Apr 95	17:14	22.224	113.759	160

CTD - KN 145/8 (23 April to 5 June 1995)

Station N°	Date	Time (h)	Latitude (°S)	Longitude (°E)	Water depth (m)
444	26 Apr 95	10:06	22.225	113.758	153
445	26 Apr 95	11:10	22.215	113.696	414
446	26 Apr 95	12:42	22.201	113.600	863
447	26 Apr 95	14:51	22.178	113.440	1293
448	26 Apr 95	17:30	22.135	113.168	1311
449	26 Apr 95	20:37	22.079	112.816	2230
450	27 Apr 95	00:30	22.002	112.381	4241

CTD - FR 05/96 (7 May to 31 May 1996)

Station N°	Date	Time (h)	Latitude (°S)	Longitude (°E)	Water depth (m)
83	27 May 96	20:02	22.032	112.471	3972
84	28 May 96	00:19	22.040	112.565	3482
85	28 May 96	03:55	22.065	112.736	2598
86	28 May 96	07:10	22.087	112.859	1978
87	28 May 96	10:31	22.121	113.103	1338
88	28 May 96	12:52	22.145	113.231	1378
89	28 May 96	15:14	22.178	113.444	1290
90	28 May 96	17:31	22.203	113.595	864
91	28 May 96	19:33	22.212	113.697	396
92	28 May 96	21:10	22.212	113.800	66

CTD - FR 06/96 (1 June to 11 June 1996)

Station N°	Date	Time (h)	Latitude (°S)	Longitude (°E)	Water depth (m)
2	02 Jun 96	10:18	22.226	113.755	172
3	02 Jun 96	11:12	22.217	113.694	416
4	02 Jun 96	12:37	22.202	113.594	868
5	02 Jun 96	14:38	22.180	113.439	1280
6	02 Jun 96	17:33	22.139	113.171	1314
7	03 Jun 96	14:58	22.080	112.818	2215
8	03 Jun 96	19:24	22.000	112.383	4244
9	04 Jun 96	13:54	22.226	113.759	150
10	04 Jun 96	15:02	22.216	113.694	428
11	04 Jun 96	16:19	22.205	113.598	859
12	04 Jun 96	18:11	22.180	113.442	1266
13	04 Jun 96	20:53	22.136	113.169	1312
14	05 Jun 96	14:28	22.086	112.820	2208
15	05 Jun 96	14:53	22.005	112.382	4265

For further information on the data collected on WOCE cruises along the ICM6 array refer to:

FR 08/94, FR 03/95 and FR 06/96

⇒ http://www.es.flinders.edu.au/fiams/ocean/database/front.html

FR 05/96

⇒ http://www.marine.csiro.au/datacentre

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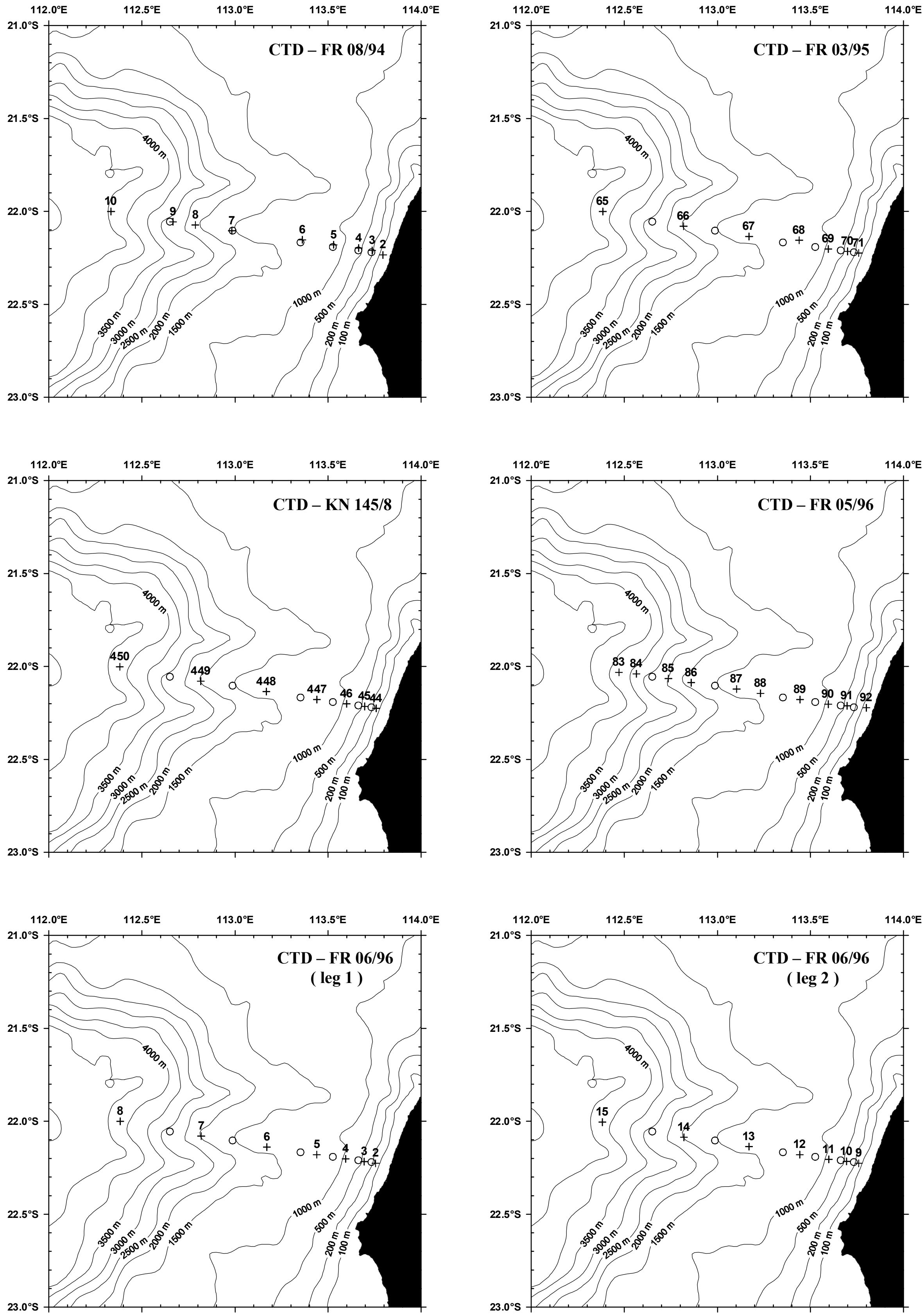
⇒ http://whpo.ucsd.edu/data/Tables/onetime/1tim_ind.htm



(+) Location and number of the stations on different cruises
(o) Location of ICM6 moorings (1 to 6, from right to left)

APPENDIX B

Table of the principal angles of variance for each current record from the ICM6 array. Note, the local orientation of the 200 m isobath is 18°T.

	Mooring	**1**	**2**	**3**	**5**	**6**
	Depth (m)	**Principal angles of variance (°T)**				
ADCP (depth cells)	**43/45**	18	17	---	---	---
	51/53	19	18	18	---	---
	59/61	19	18	19	---	---
	67/69	19	19	19	---	---
	75/77	19	19	20	---	---
	83/85	19	19	20	---	---
	91/93	19	18	20	---	---
	99/101	19	18	20	---	---
	107/109	19	17	20	---	---
	115/117	19	17	20	---	---
	123/125	19	17	20	---	---
	131/133	19	17	20	---	---
	139/141	19	16	18	---	---
	147/149	19	15	17	---	---
	155/157	19	15	16	---	---
	163/165	19	15	16	---	---
	171/173	19	16	15	---	---
	179/181	19	16	14	---	---
	187/189	20	16	13	---	---
	195/197	20	16	14	---	---
	203/205	20	17	14	---	---
	211/213	20	17	14	---	---
	219/221	19	---	14	---	---
	227/229	19	---	14	---	---
ACM2 / RCM	**240/248/265/285**	---	21	17	−31*	−12
	490/498/515/535	---	13	26	−9	21*
	765/785	---	---	---	−2	−13
	1515/1535	---	---	---	18	−4
	2541	---	---	---	---	5

* short record (see timeline in Table 3)