Low Frequency Currents Observed Off Southern Vancouver Island, 1979-1981

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ABSTRACT

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The purpose of this report is to archive the low frequency current meter data that was obtained by the Coastal Zone Oceanography Group of the Institute of Ocean Sciences on the west coast of Vancouver Island between May 1979 and June 1981. Our effort on the west coast was part of a larger research program called CODE (*C*oastal *O*cean *D*ynamics *E*xperiment). These data are receiving wide circulation and it is necessary to make a summary of the entire data set available to the users.

KEYWORDS: Vancouver Island; Low frequency currents; CODE.

RÉSUMÉ

Freeland, H.J. 1983. Low frequency currents observed off southern Vancouver Island, 1979-1981. Can. Data Rep. Hydrogr. Ocean Sci. 7 : 80p.

Le présent rapport constitue une collection des données sur les courants à basse fréquence mesurés par le Groupe d'océanographie de la zone côtière de l'Institut des sciences océaniques sur la côte ouest de l'île Vancouver, de mai 1979 à juin 1981. Ce travail sur la côte ouest faisait partie d'un programme de recherche appelé CODE (*C*oastal *O*cean *D*ynamics *E*xperiment). Comme ces données font l'objet d'une grande diffusion, il est nécessaire de résumer la collection offerte aux usagers.

MOTS-CLES: L'île Vancouver; Courants à basse fréquence; CODE.

INTRODUCTION

The purpose of this note is to bring to the attention of the oceanographic community the existence of a high quality set of current meter data observed at 5 locations across the continental shelf and slope off southern Vancouver Island. Scientific results derived from various parts of this data set have been published elsewhere (see for example Freeland and Denman (1982), Thomson and Crawford (1982) and Crawford and Thomson (1982). However, these publications each disclose only part of the entire data set. This note responds to several requests for a published record of the entire low-frequency data set that will permit a detailed examination of the low frequency currents.

It seemed impractical to list the observations in the usual way for a data report, hence in this report a few statistics on each mooring location will be given and the data will be displayed graphically only.

COMMENTARY

Between May of 1979 and June of 1981 current meter observations were acquired from 5 locations as part of a larger experiment called CODE or the *C*oastal *O*cean *D*ynamics *E*xperiment. The study off southern Vancouver Island constituted part of the contribution of the Coastal Zone Oceanography Group to the overall CODE program. Initially 4 moorings were deployed in a line across the continental shelf and slope as follows: CZ1 and CZ2 on the continental shelf itself, CZ3 at the shelf break and CZ4 about half way down the continental slope. These moorings were all deployed in May 1979 and maintained until June 1981, though the time series do contain gaps. The gaps in the time series are evident in plots and arose for two reasons, instrument failure, and fishing pressure. The latter was a much more serious problem particularly for CZ1 and CZ2. At one time or another the three shallow moorings CZ1, CZ2 and CZ3 were moved, damaged, released or picked up by fishermen. In most cases the instruments were eventually recovered with their tapes but the inevitable delay involved in returning the mooring caused gaps to appear in the time series.

In early June 1980 a fifth mooring location was started because we perceived a need to try to relate events observed on the continental shelf to events in Alberni Inlet. The new location was close inshore near Cape Beale and is designated CBL.

Figure 1 shows a map of the southern Vancouver Island shelf with the mooring locations identified. The location CBL is in a narrow channel connecting two basins on the continental shelf. The currents at 100m appear to be ducted by the channel, however, those at 50m are above the top of the channel and take part in the general shelf circulation.

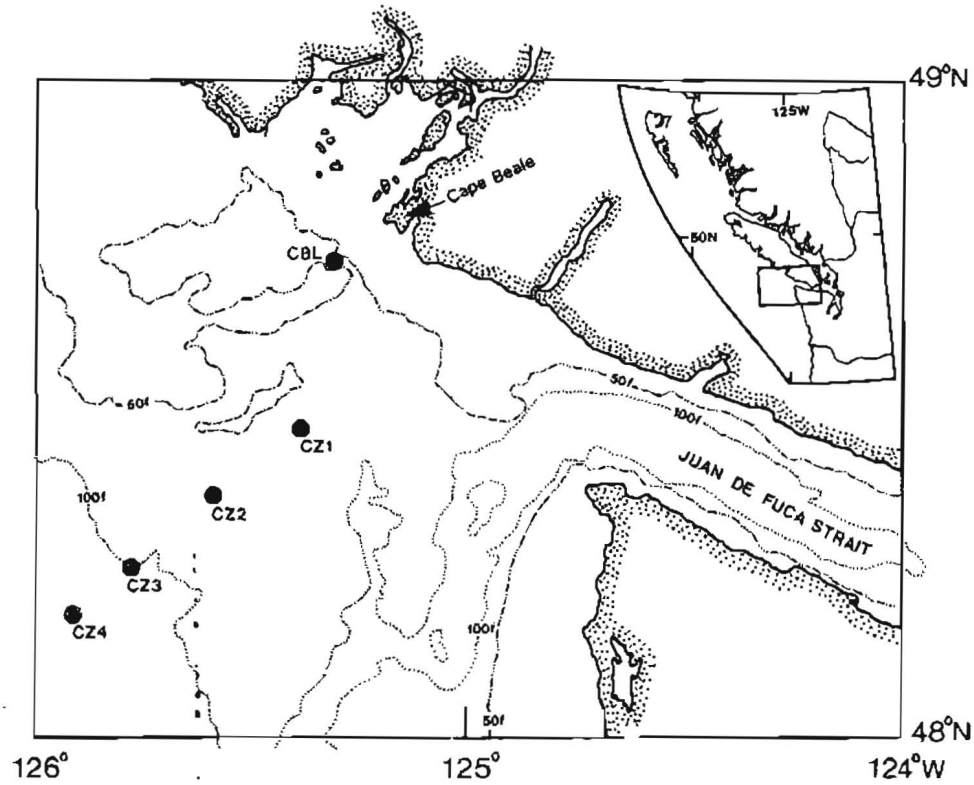

Figure 1: Map of the study location off Southern Vancouver Island. The inset map locates the main chart relative to the rest of the B.C. coastline. The dots indicate the mooring locations discussed here. Two depth contours have been added for reference, 50 fathoms (91m) and 100 fathoms (182m). The latter contour defines the edge of the continental shelf.

Standard depths of 50m and 100m were used on all moorings. In addition a current meter was placed on CZ3 5 metres above the bottom in June 1980 and current meters were placed at nominal depths of 250m and 500m on the deep mooring CZ4. Table 1 lists some statistics for the mooring locations:-

TABLE 1

Mooring	CBL	CZ1	CZ2	CZ3	CZ4
Latitude	48°43.3N	48°28.1N	48°22.0N	48°15.7N	48°11.3N
Longitude	125°18.8W	125°22.7W	125°35.4W	125°46.0W	125°55.2W
Water depth	150m	150m	140m	210m	800m
First date	14/6/80	18/5/79	18/5/79	19/5/79	19/5/79
Last date	4/6/81	3/6/81	4/6/81	4/6/81	4/6/81
Instrument depths	50, 100	50, 100	50,100	50, 100, 205	50, 100, 250, 500.

In all cases the current meters used were Aanderaa RCM4s sampling at either 30 minute or 60 minute intervals. Buoyancy was supplied by spherical ORE buoys at a depth of 45 metres and at an intermediate depth part way down each mooring.

PROCESSING

The raw data tapes were processed following the methods described by Yee and Stucchi (1979). This produced files, one for each current meter deployment, containing data measured at 30 minute or 60 minute intervals. This high frequency portion of the data has been analyzed for tidal content and the results will be published by Tidal and Current Surveys at the Institute of Ocean Sciences. The tides dominate the signals and it is necessary to filter the tides out before the low frequency currents can be displayed. This was done as follows:-

1. The individual high frequency calibrated data files were subsampled to 1 hour intervals if the original sampling interval was 30 minutes.

2. Files corresponding to sequential deployments at a single depth at a particular location were concatenated to produce a single file for a particular location, e.g. CZ3 at 50m, with data extending over a two year period at 1 hour intervals. Data gaps were filled at this stage by dummy records.

3. Data gaps were inspected. Some gaps were large (corresponding to some type of failure) but some were short, only a few hours, corresponding to the interval between recovering a mooring and then replacing it. Data gaps shorter than 40 hours were filled by linear interpolation.

4. The time series were then filtered by a Lanczos-Cosine filter, and subsampled at 12 hour intervals. The resulting series were written on magnetic tape and used as a master source of low-passed current meter data. It is this data that is displayed in this report.

THE LANCZOS-COSINE FILTER

No presentation of data is complete without a discussion of the filter employed. The Lanczos-Cosine filter is a popular filter employed when a need occurs to eliminate tides and higher frequencies leaving all low frequencies untouched. Figure 2 shows the amplitude response function as a function of frequency. As can be seen it has a sharp cut-off, the response is 0.5 at a period of 34 hours, 0.9 at 48 hours and extremely close to 1.0 at 3 days. The filter removes all semi-diurnal tidal signals completely but does allow about 1% of the K_1 tidal amplitude to pass. The 1% of K_1 is the principal defect of this filter. For comparison the amplitude response of Godin's tide reject filter $A_{24}{}^2A_{25}$ is plotted for comparison. It is equally effective at eliminating the semi-diurnal tides, much better at removing the diurnal tides, but has a very slow approach to unity at low frequencies. The amplitude response is 0.5 at 2.8 days and only 0.75 at 5 days, and is still removing a significant part of the signal at a period of 14 days. Because of this the Godin filter cannot be recommended for use on current meters in the coastal zone where low frequencies driven by storm cycles may dominate. In summary, the Lanczos-Cosine filter is effective at removing diurnal and semi-diurnal period signals from current meter data where the tidal and low-frequency currents are similar in magnitude. It is ineffective for filtering of sea level records in which the tides dominate overwhelmingly, then the 1% of the amplitude at K_1 that is passed is still too large.

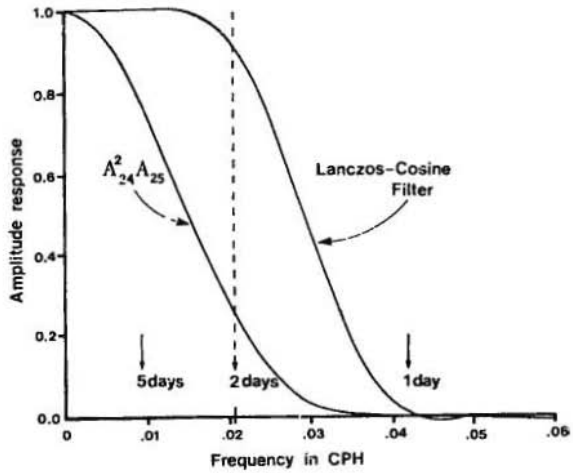

Figure 2: The amplitude response plotted against frequency for two filters, the Lanczos-Cosine filter and the Godin "tide killer".

The Lanczos-Cosine filter is defined as follows:-

1. C_i is a series of filter coefficients which is convolved with a data time-series D_i to produce a filtered time-series $\hat{D}_i$

$$\hat{D}_i = C_o D_i + \sum_{j=1}^{N} C_j (D_{i+j} + D_{i-j})$$

2. The filter coefficients are defined by

$$C_o = 1/Q$$

$$C_i = (0.5/Q)(1 + \cos(ia))\sin(ib)/(ib)$$

for $1 \leqslant i \leqslant N = 60$

and $Q = 17.132$.

REFERENCES

Crawford, W.R. and R.E. Thomson. 1982. Continental shelf waves of diurnal period along Vancouver Island. J. Geoph. Res. 87 (C12), 9516-9522.

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Thomson, R.E. and W.R. Crawford. 1982. The generation of diurnal period shelf waves by tidal currents. J. Phys. Oceanogr. 12, 635-643.

Yee, S.C. and D.J. Stucchi. 1979. User guides for the processing of Aanderaa recording instrument data. (Unpublished manuscript) IOS Note #9 Institute of Ocean Sciences, P.O. Box 6000, Sidney, B.C., Canada, 48 pp.

THE DIAGRAMS

On each page is plotted part of a time series from each current meter site. At the bottom of each page is a time base showing a sequential day number (day #1 = January 1st, 1979) and associated date. Day numbers and tic marks are at 31 day intervals. The next two series are u' and v', on-offshore and alongshore components of current velocity, respectively, with u' positive for offshore (westward) flow and v' positive for northward flow. To compute these a rotation angle of 40° (counter-clockwise) was used. The third series is the vector (u, v) displayed in the standard stick-plot form. As usual north is up the page, east to the right etc., and the length of a stick is directly proportional to current speed. The final three plots are of temperature, salinity (in parts per thousand) and sigma-t. Note that the scales (to the left hand side on each page) vary from one site to another.

The final two pages show the entire set of velocity observations plotted in as compact a fashion as possible to give the reader an overview of the entire data set. In order to compress the data and still leave patterns of variation still visible an additional step of filtering with a six day running mean filter was added to smooth the vectors. Also, a plot of the Bakun Upwelling Index computed at 48°N 125°W is included to give an overview of the wind field and its relationship to the low frequency current field. The units on each time series are cm/sec, for the current meter data and m^3/sec/100m coastline length for the Bakun Upwelling Indices.

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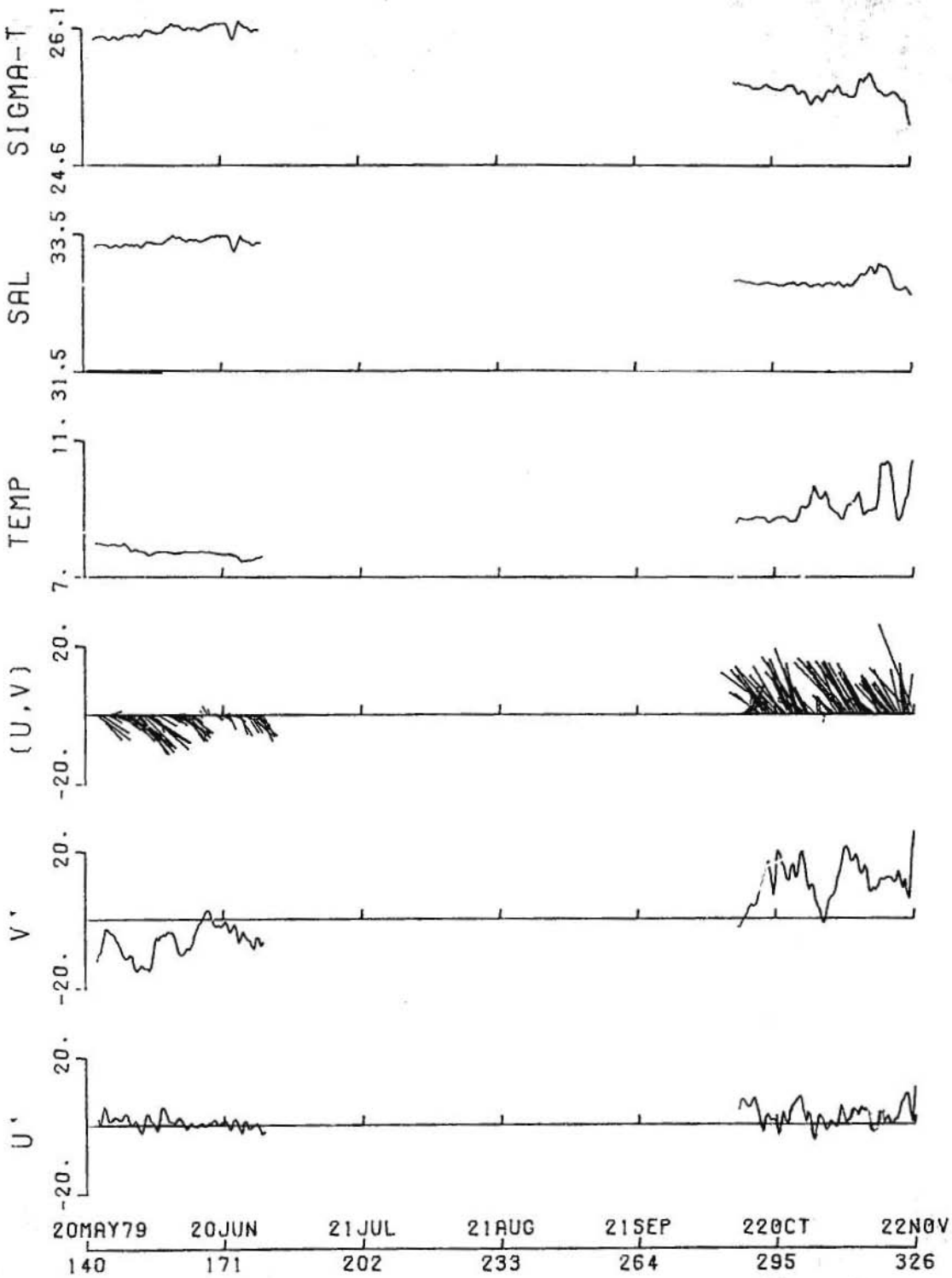
Depth: 50m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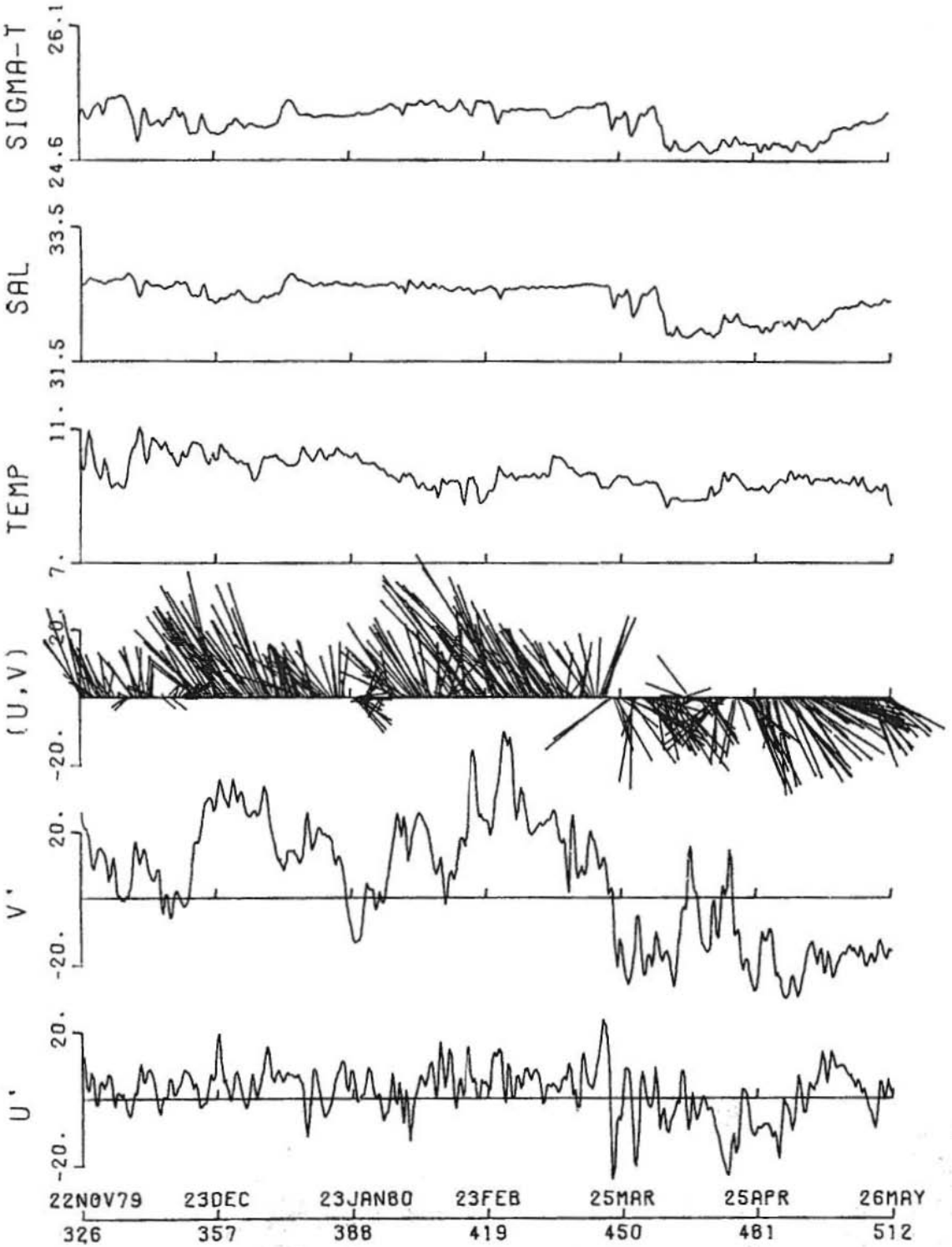
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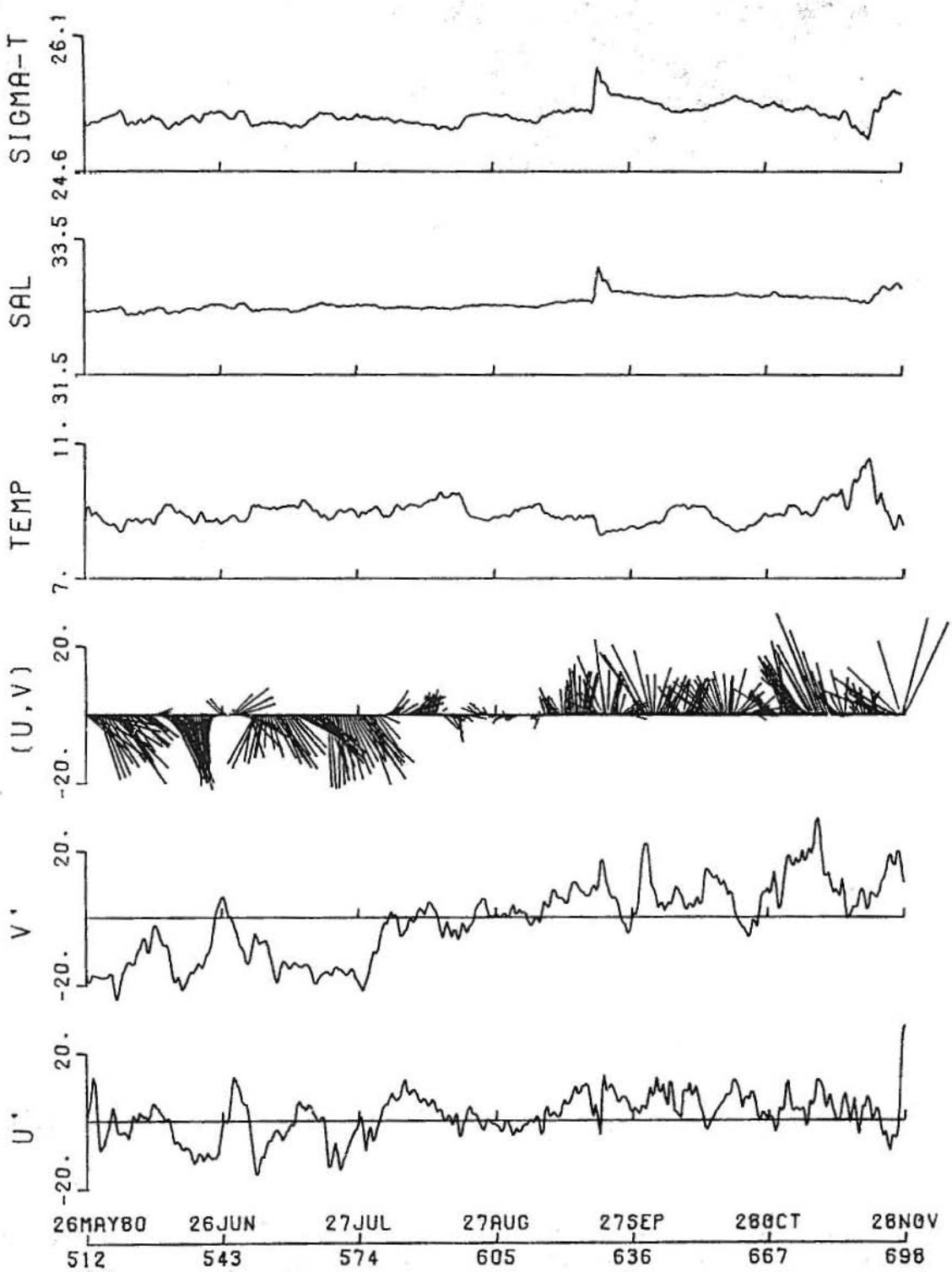
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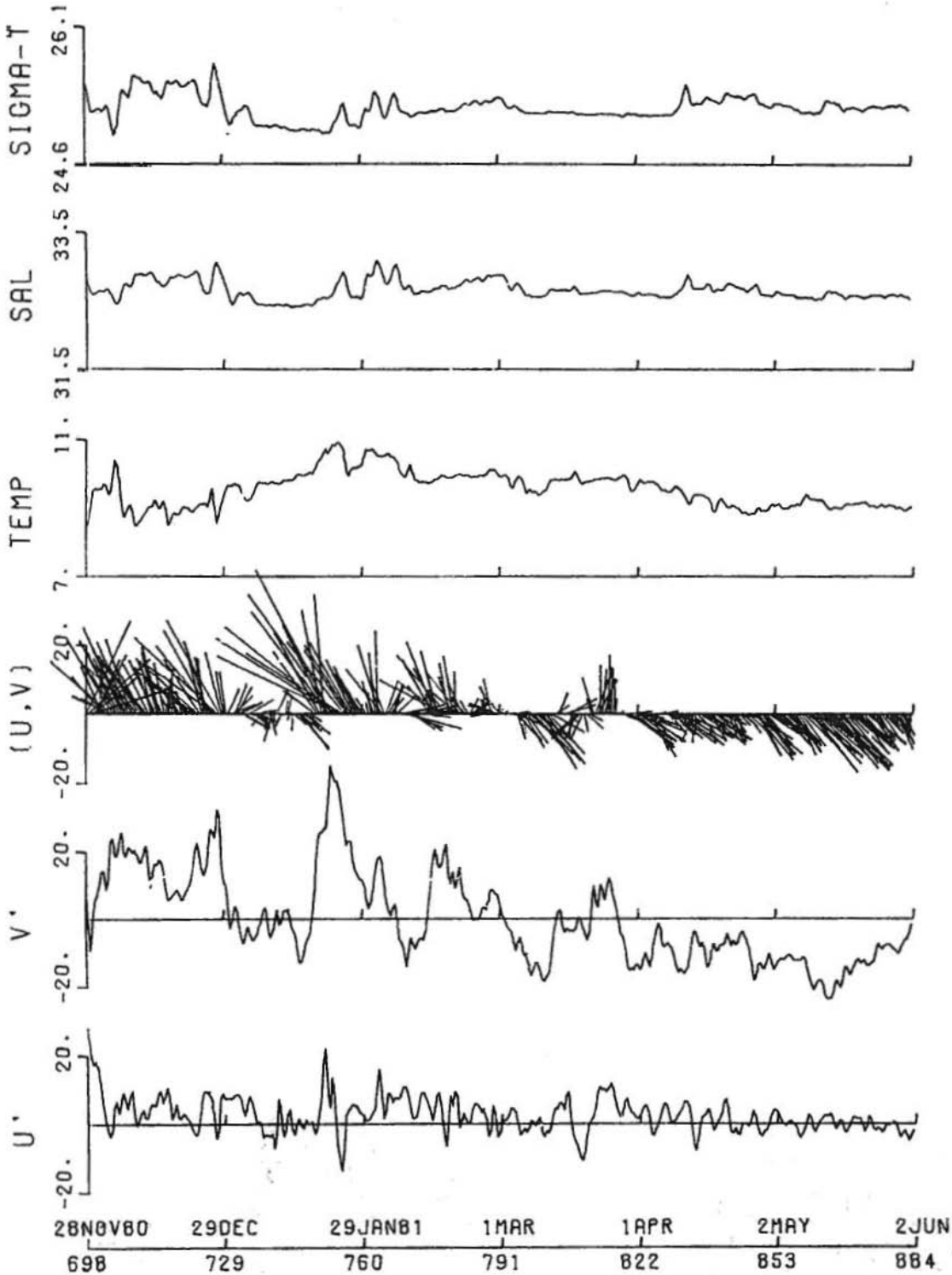
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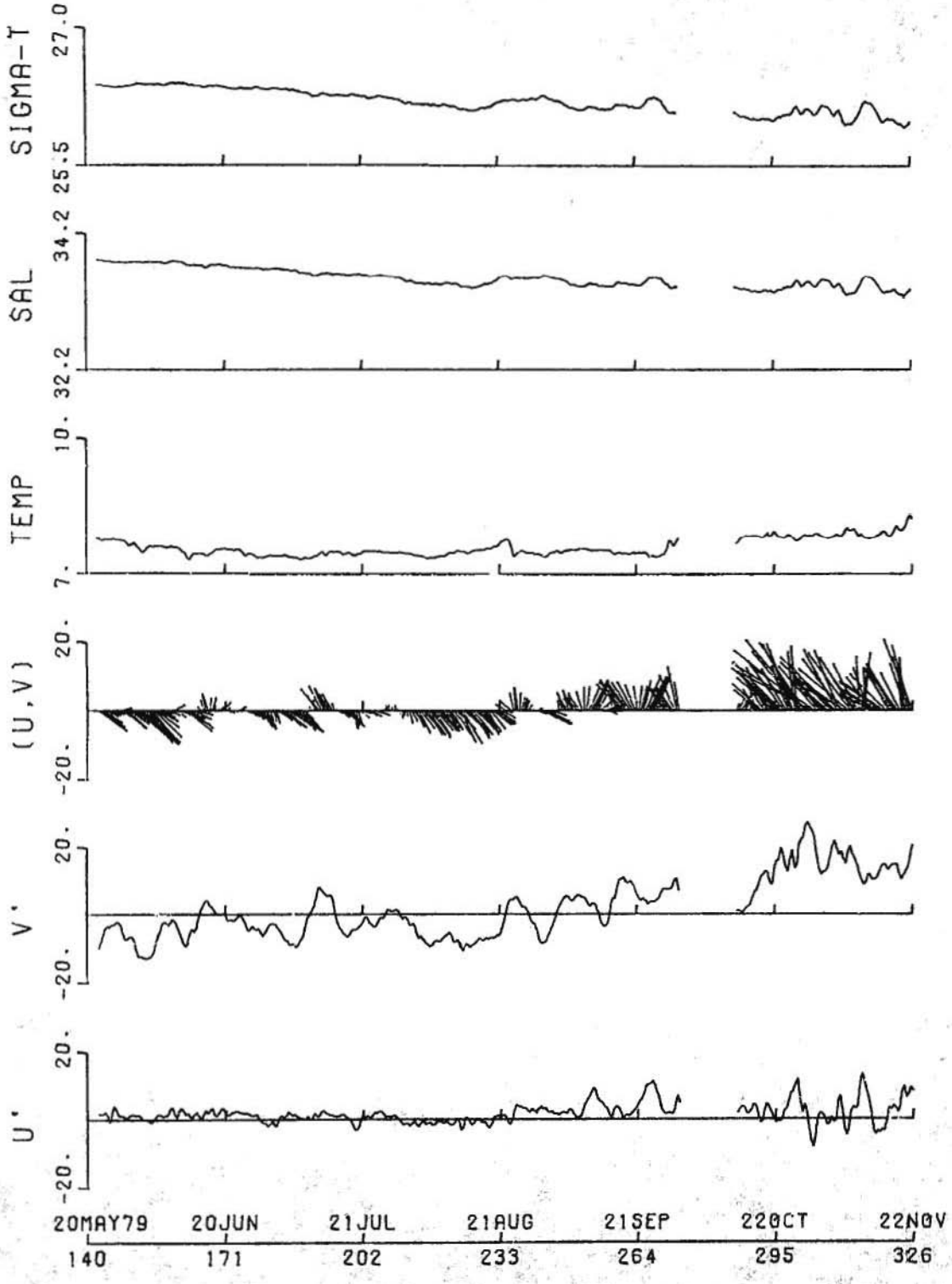
Site: CZ4

Depth: 100m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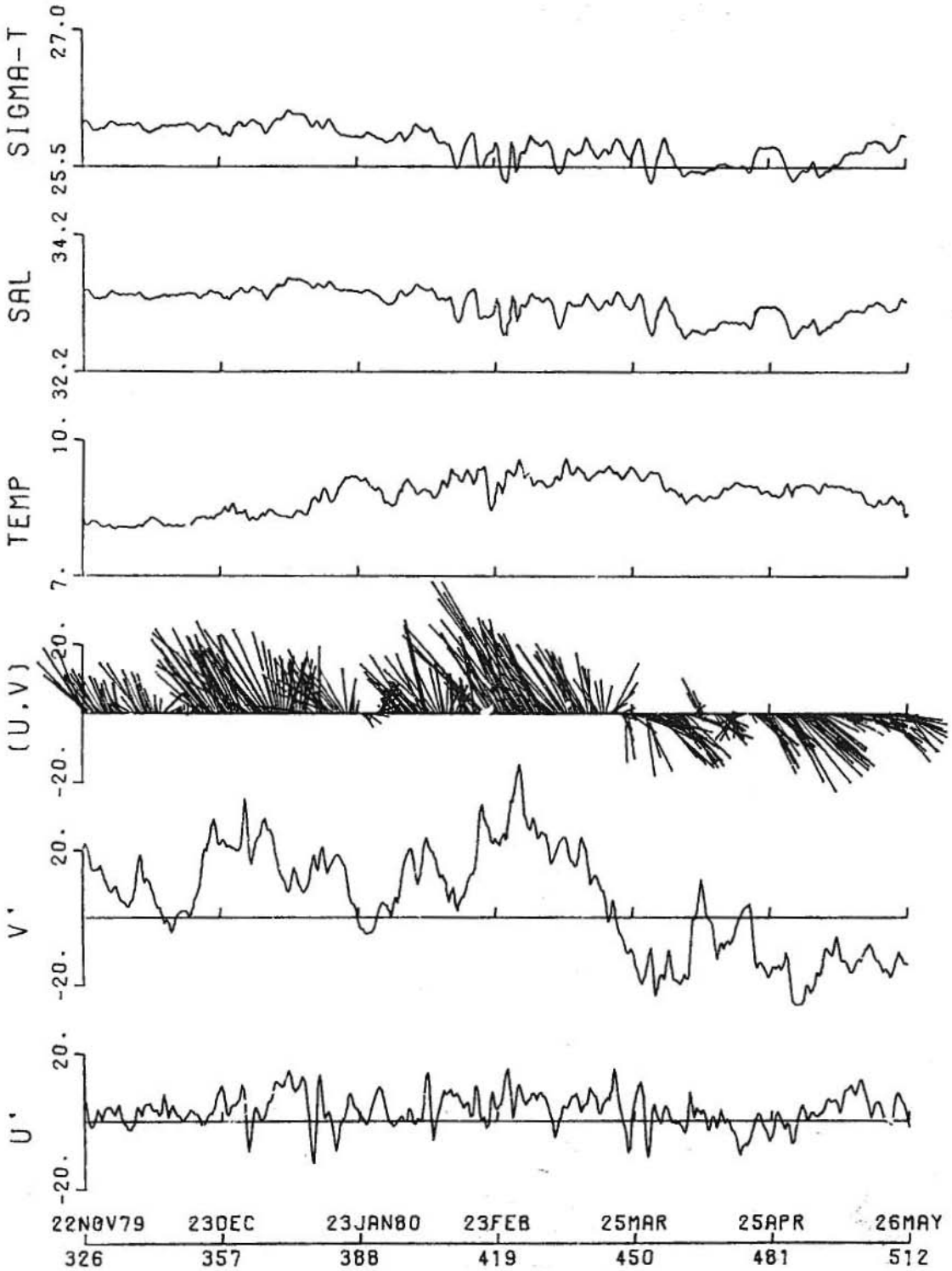
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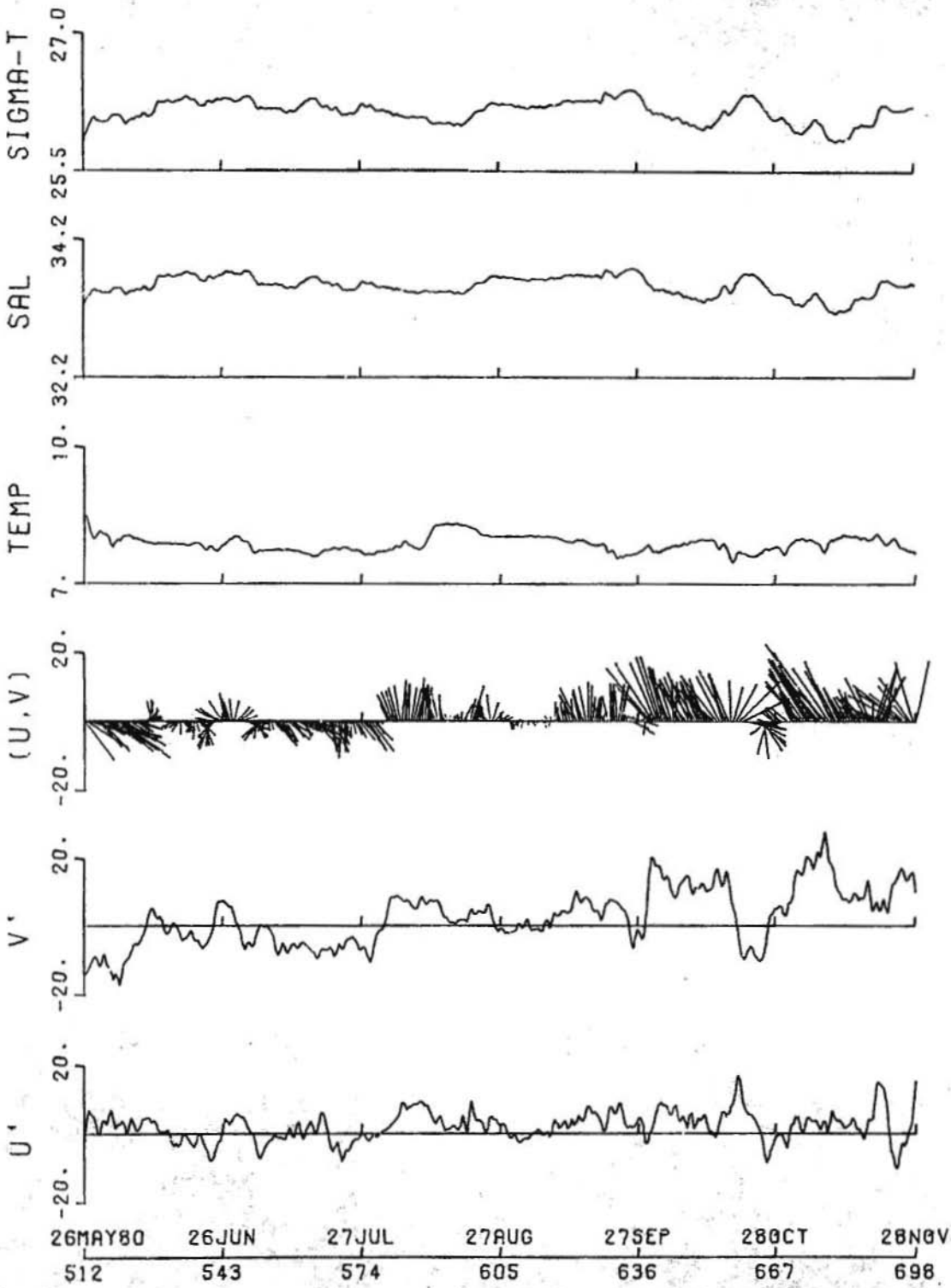
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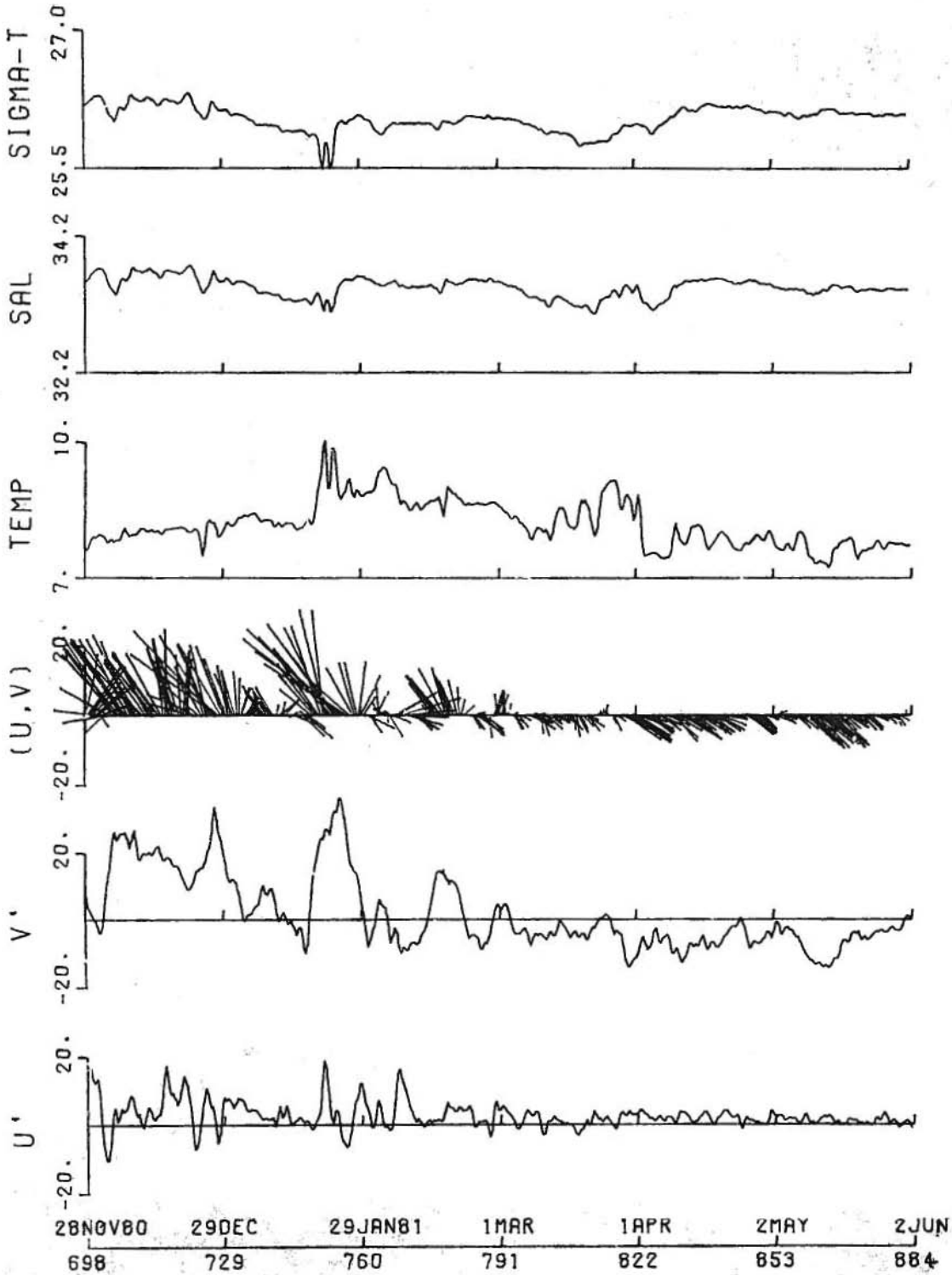
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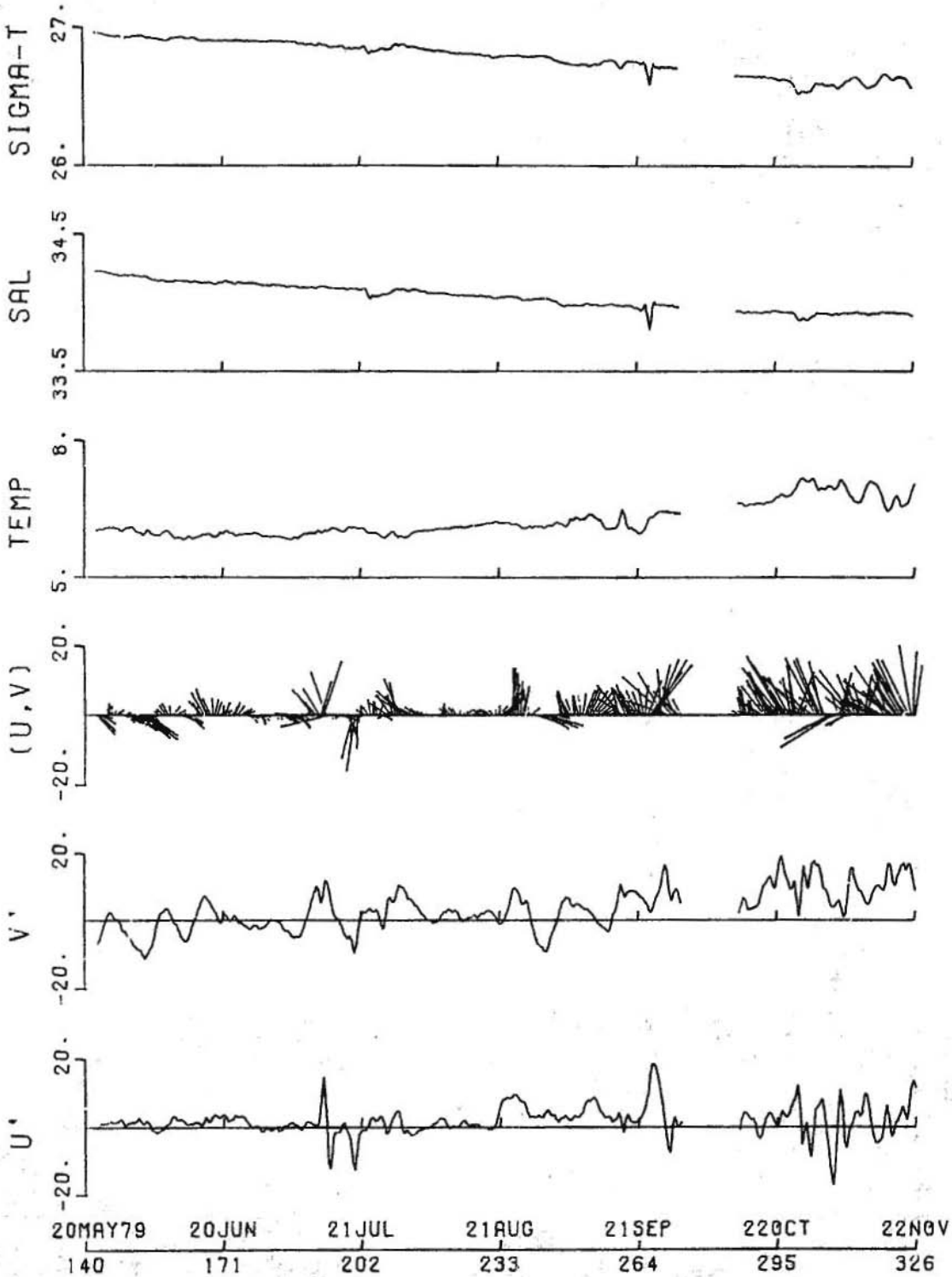
Site: CZ4

Depth: 250m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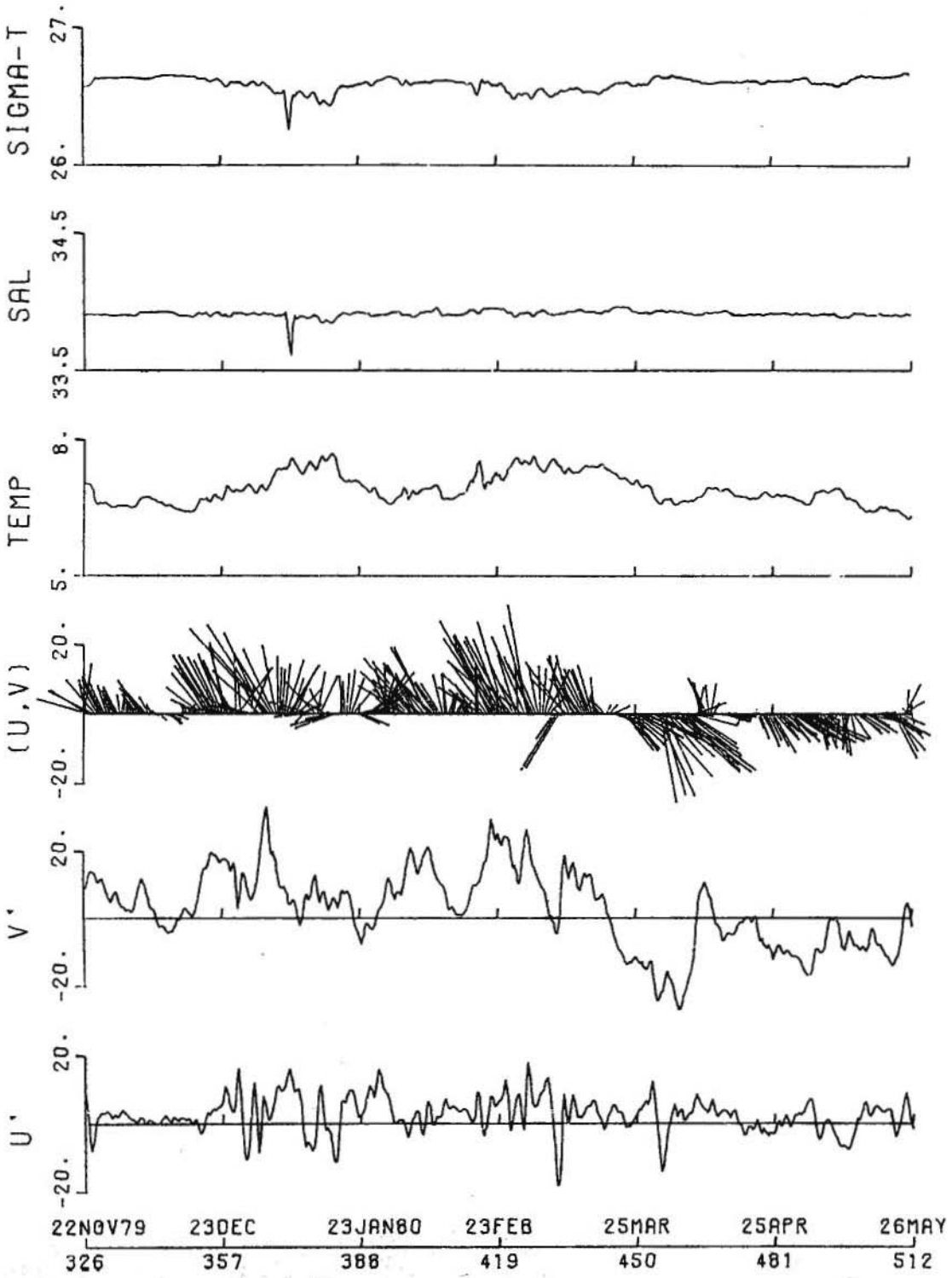
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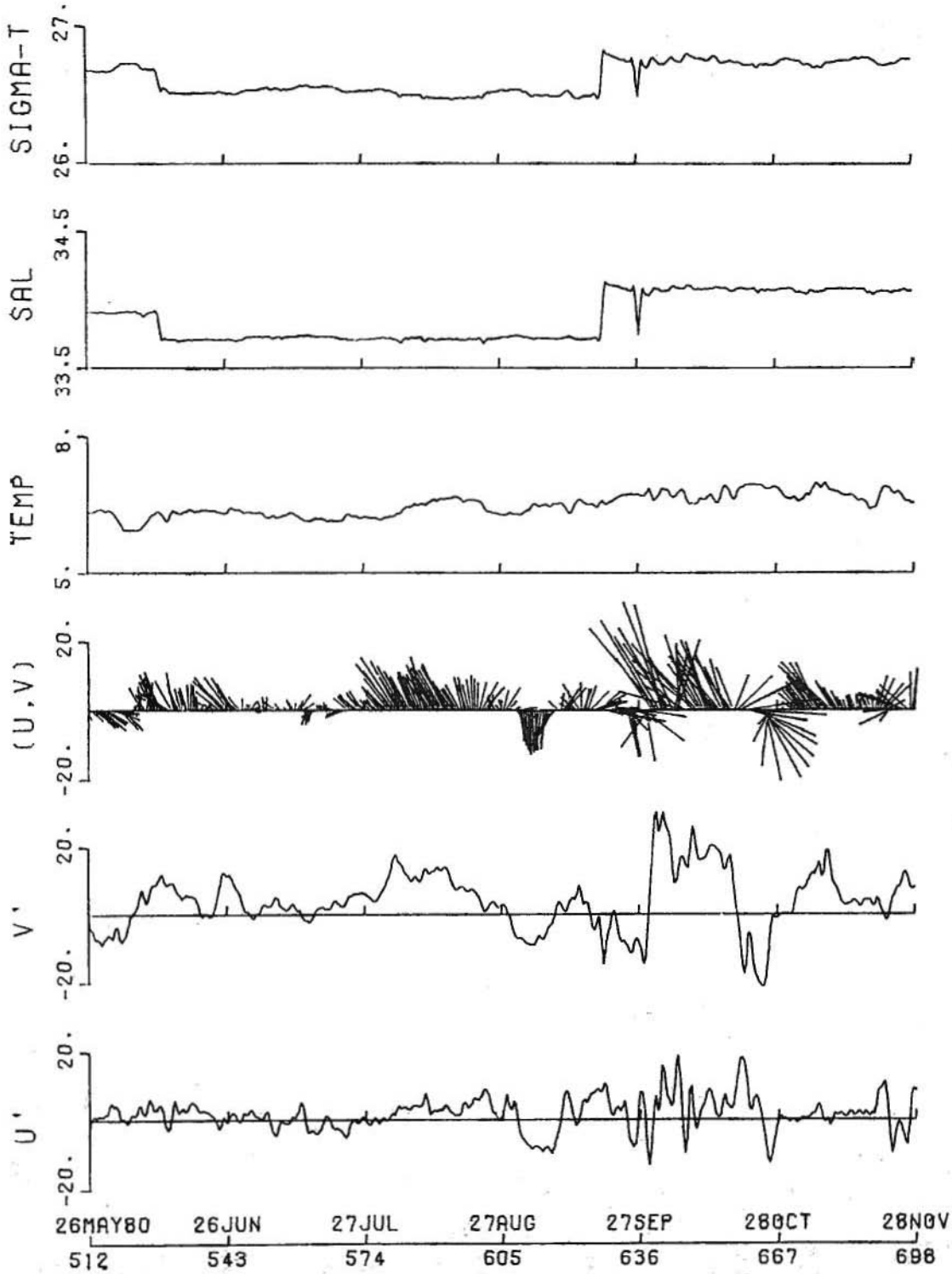
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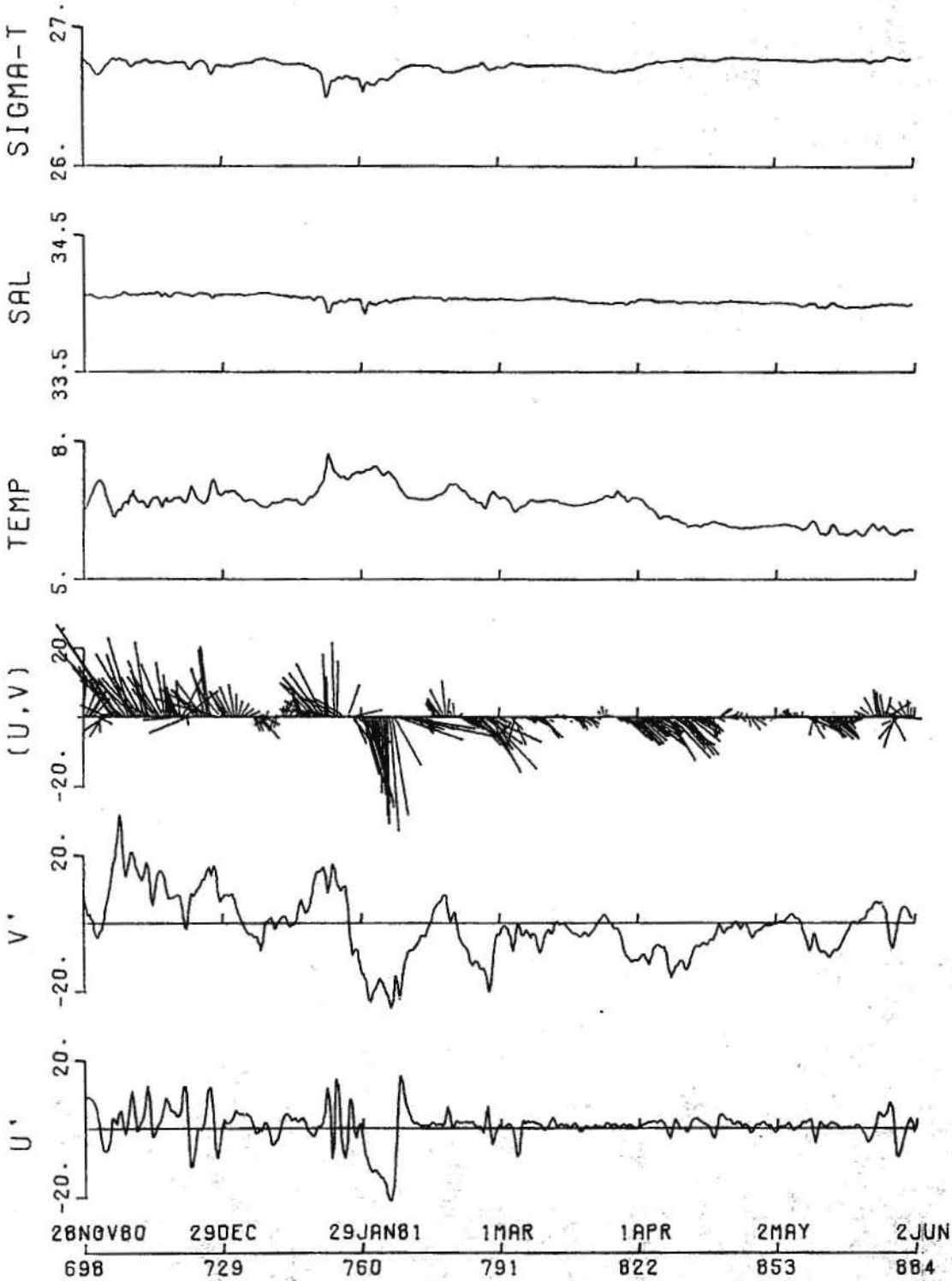
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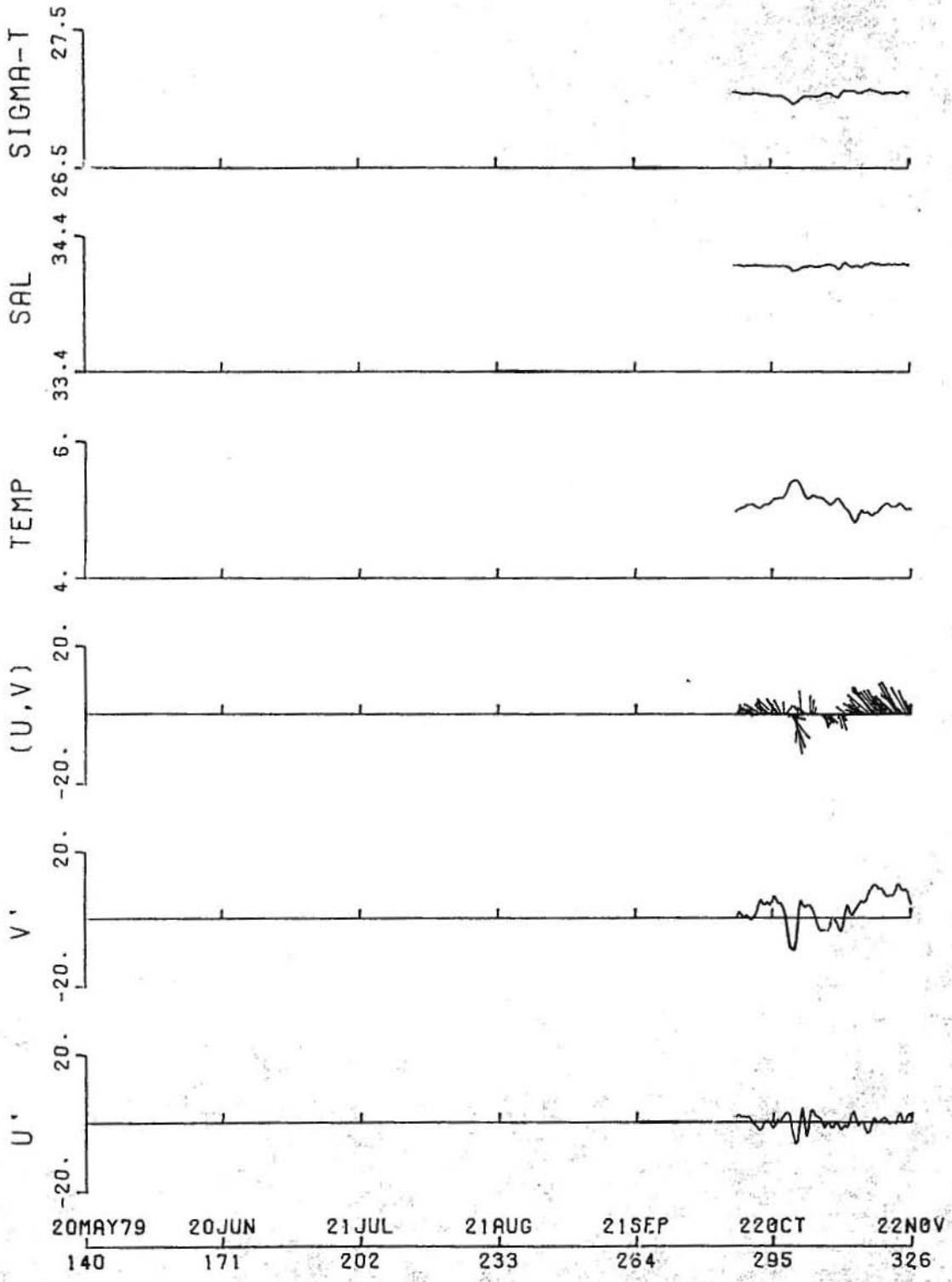
Site: CZ4

Depth: 500m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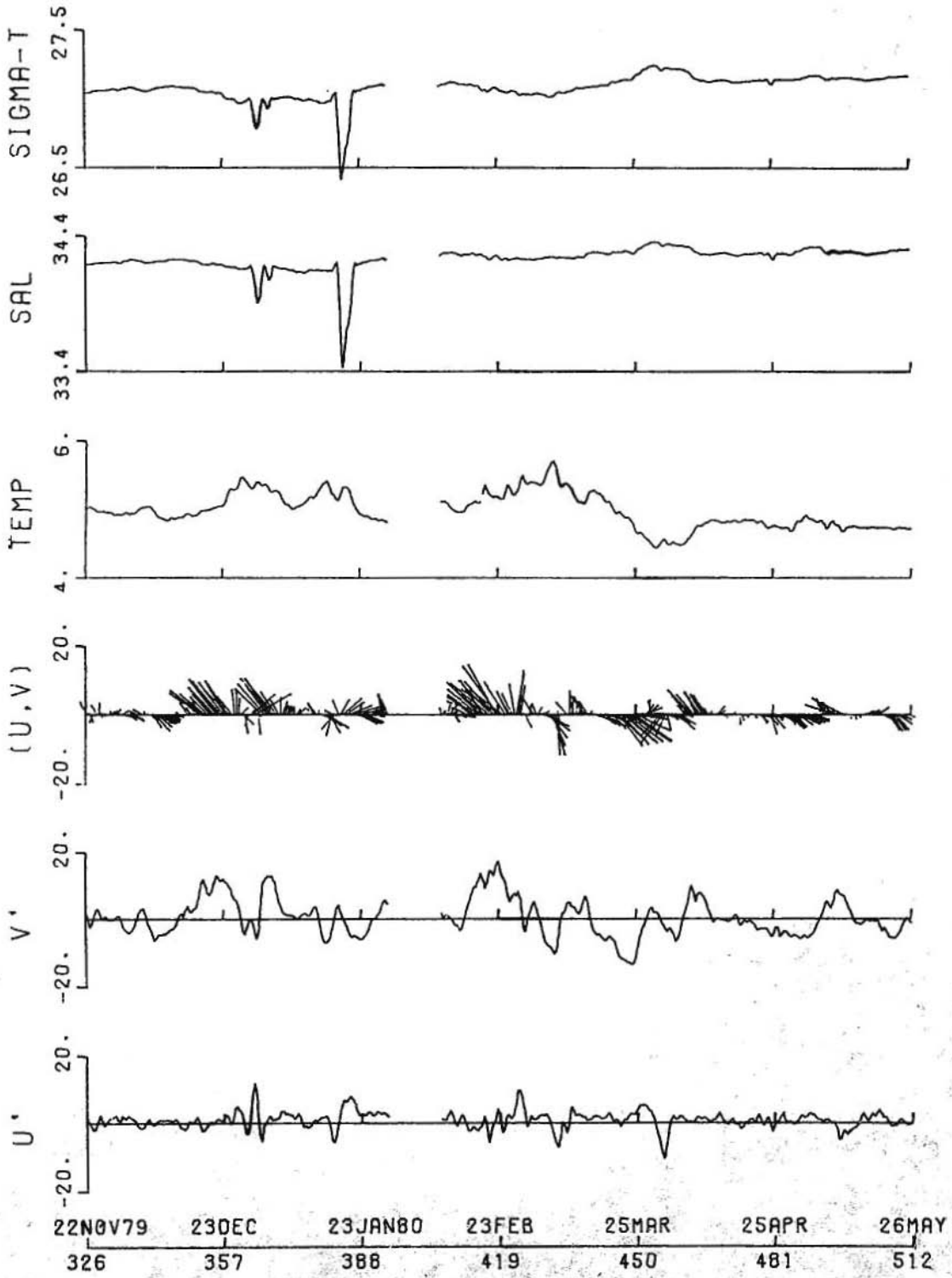
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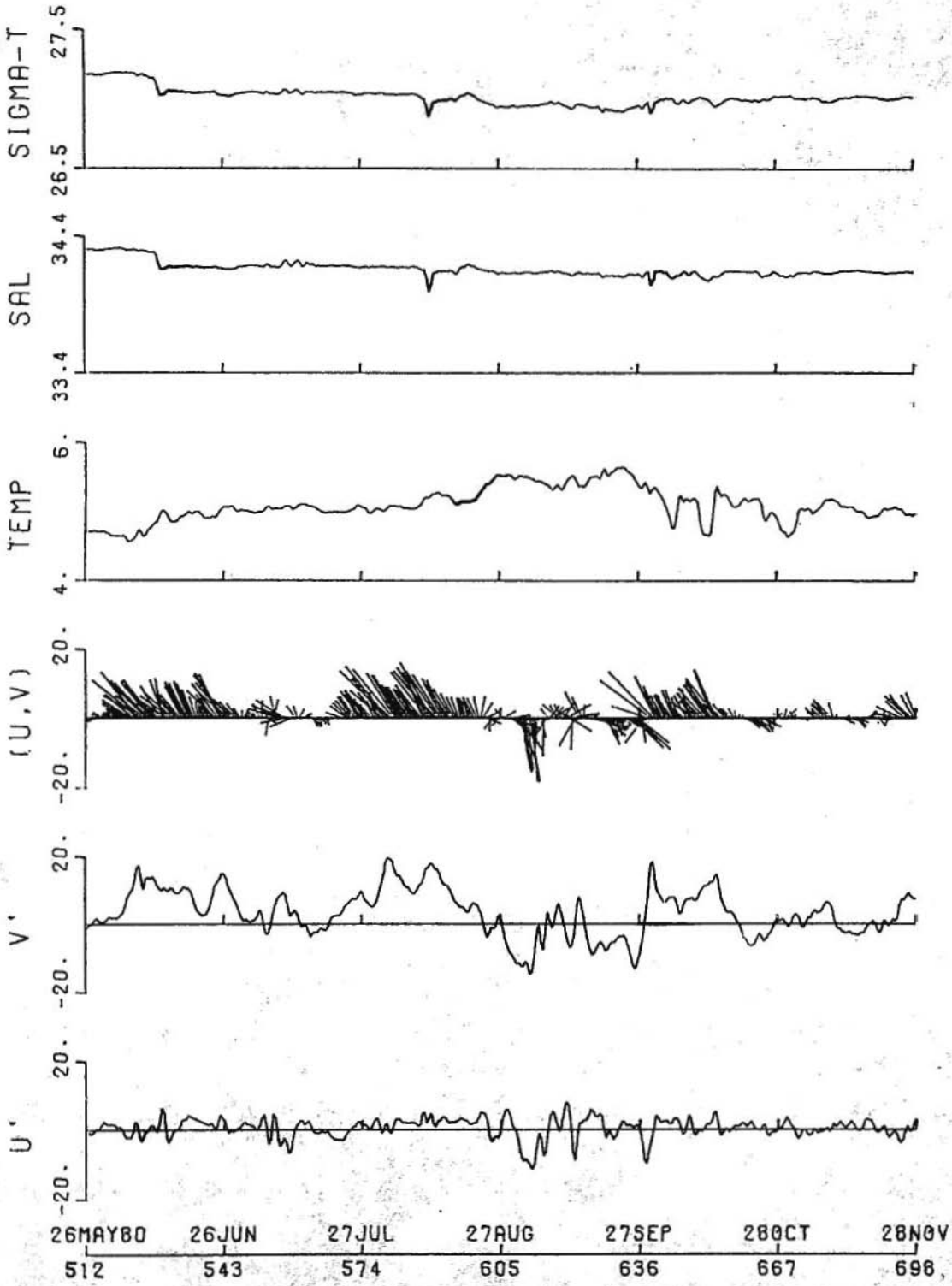
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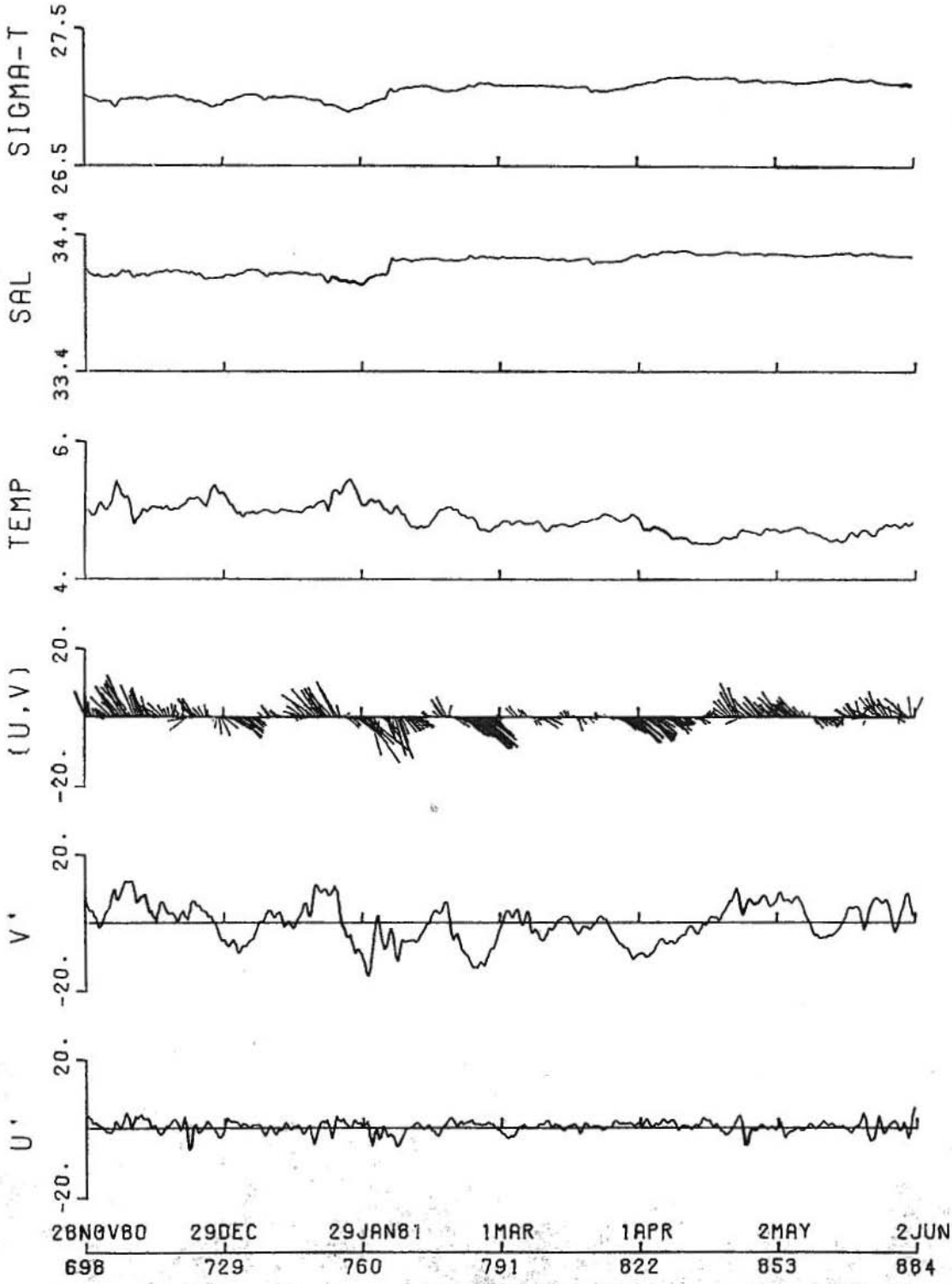
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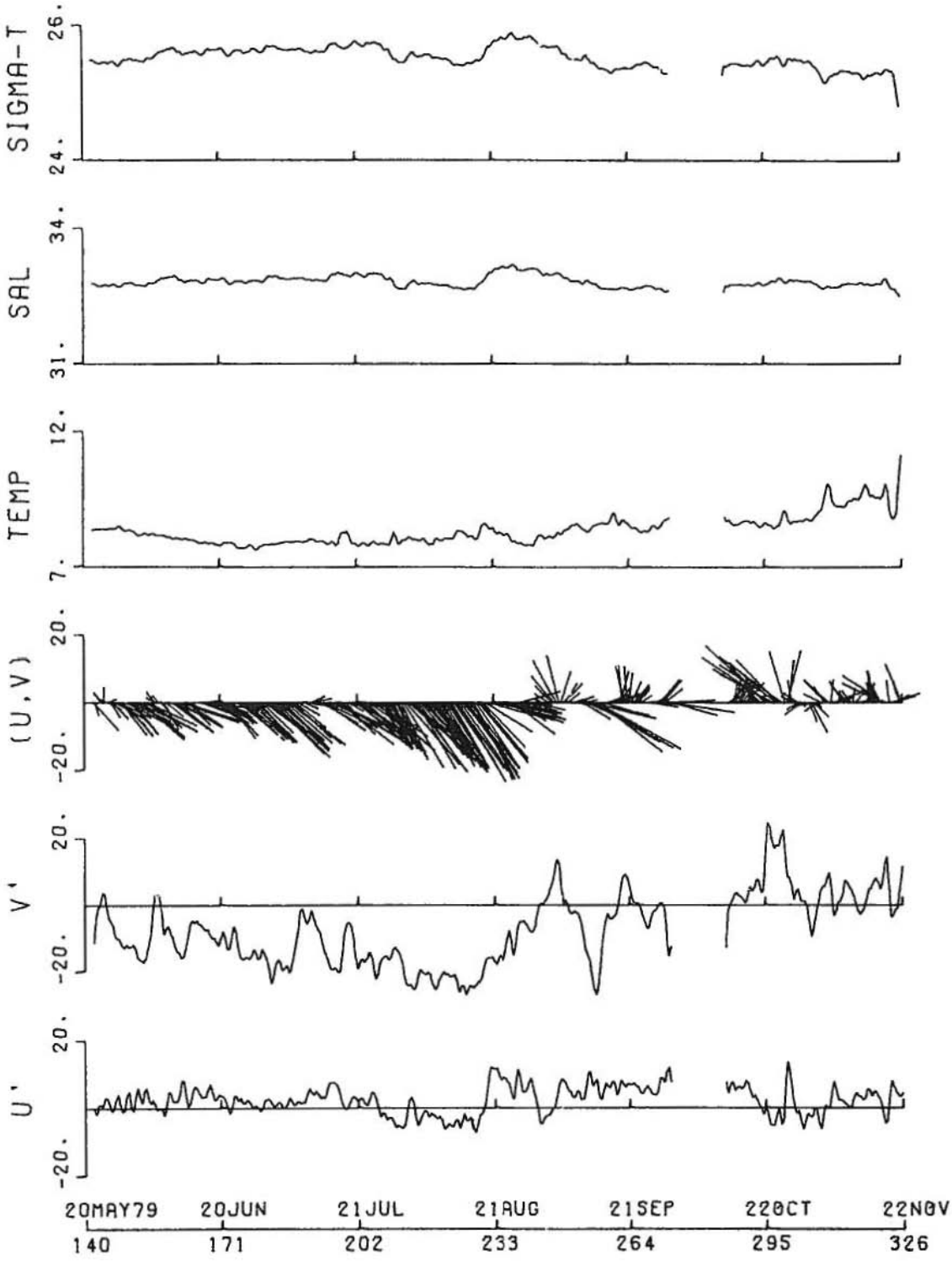
Site: CZ3

Depth: 50m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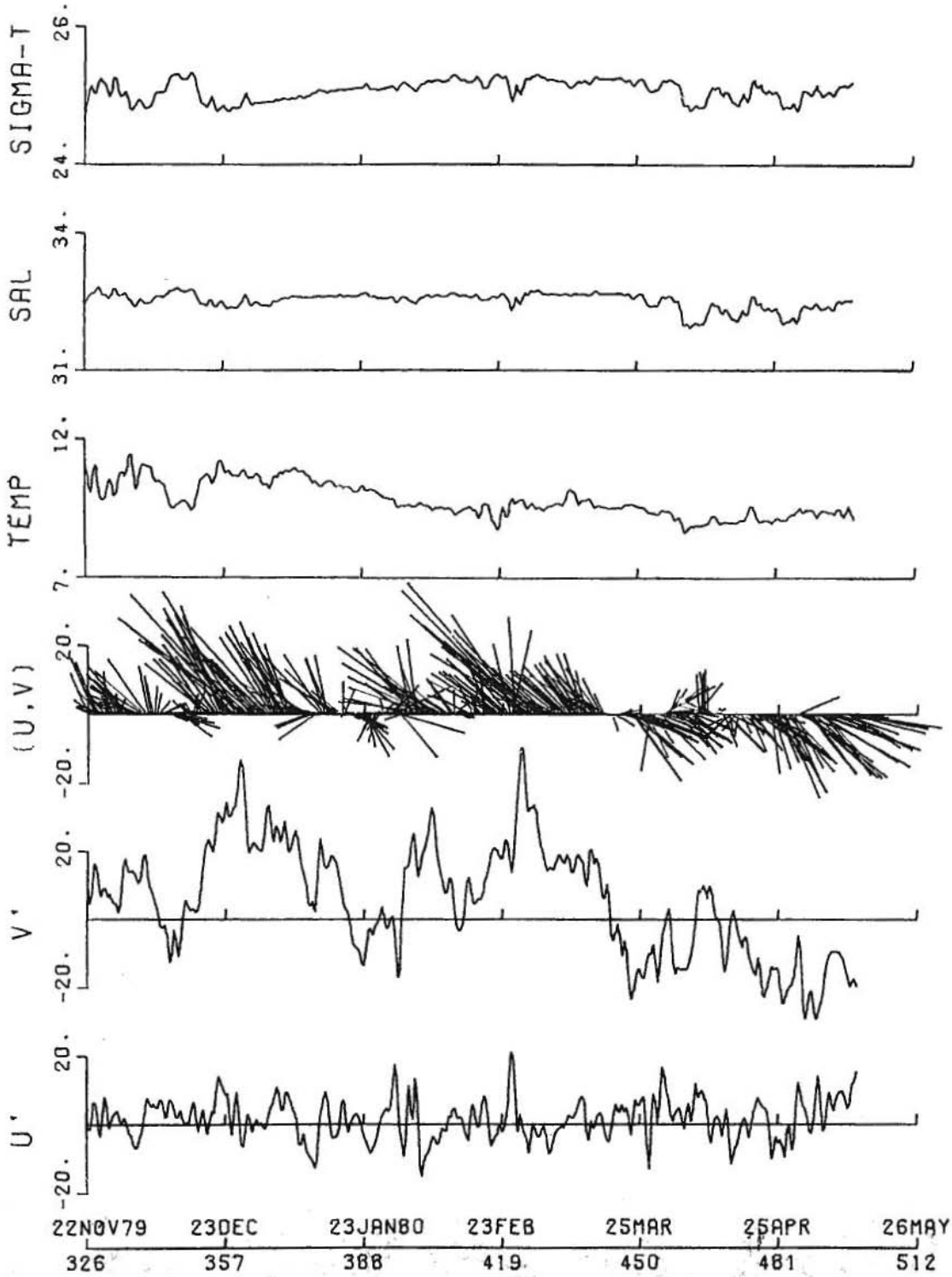
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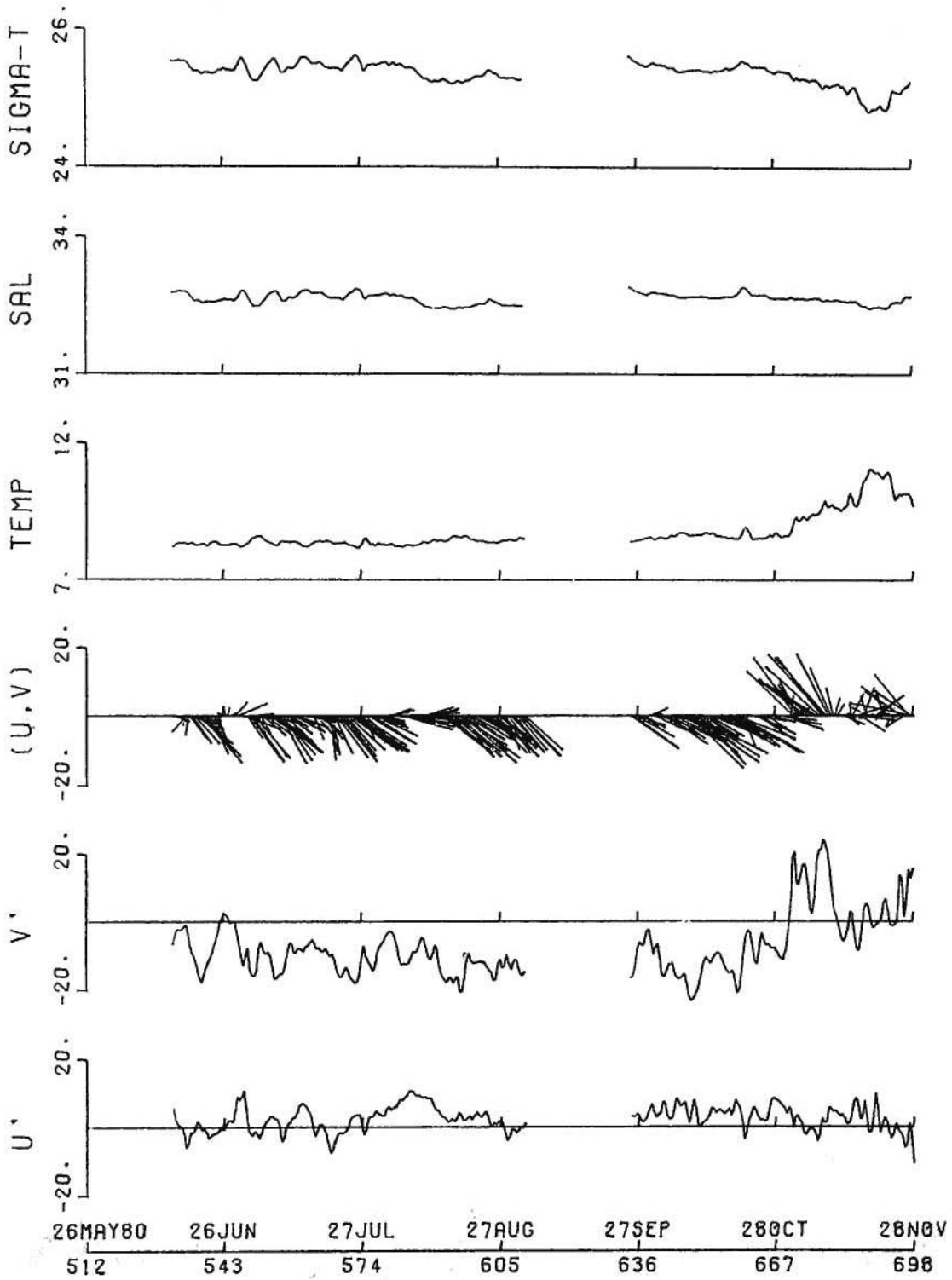
SIGMA-T
26.
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SAL
34.
31.
TEMP
12.
7.
(U,V)
20.
-20.
V'
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U'
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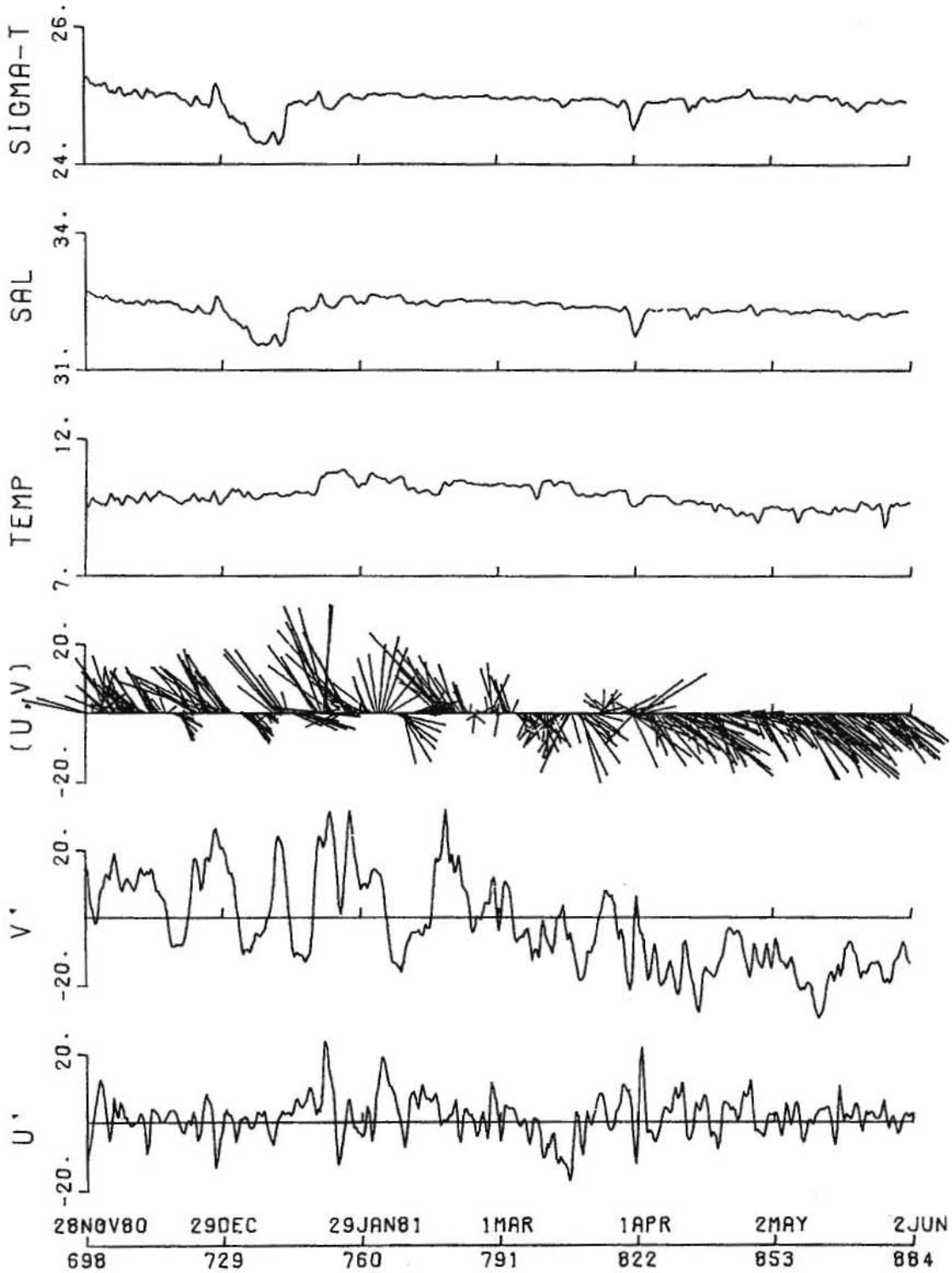
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SAL
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TEMP
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(U,V)
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-20.
V'
20.
-20.
U'
20.
-20.
28NOV80
29DEC
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2MAY
2JUN
698
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791
822
853
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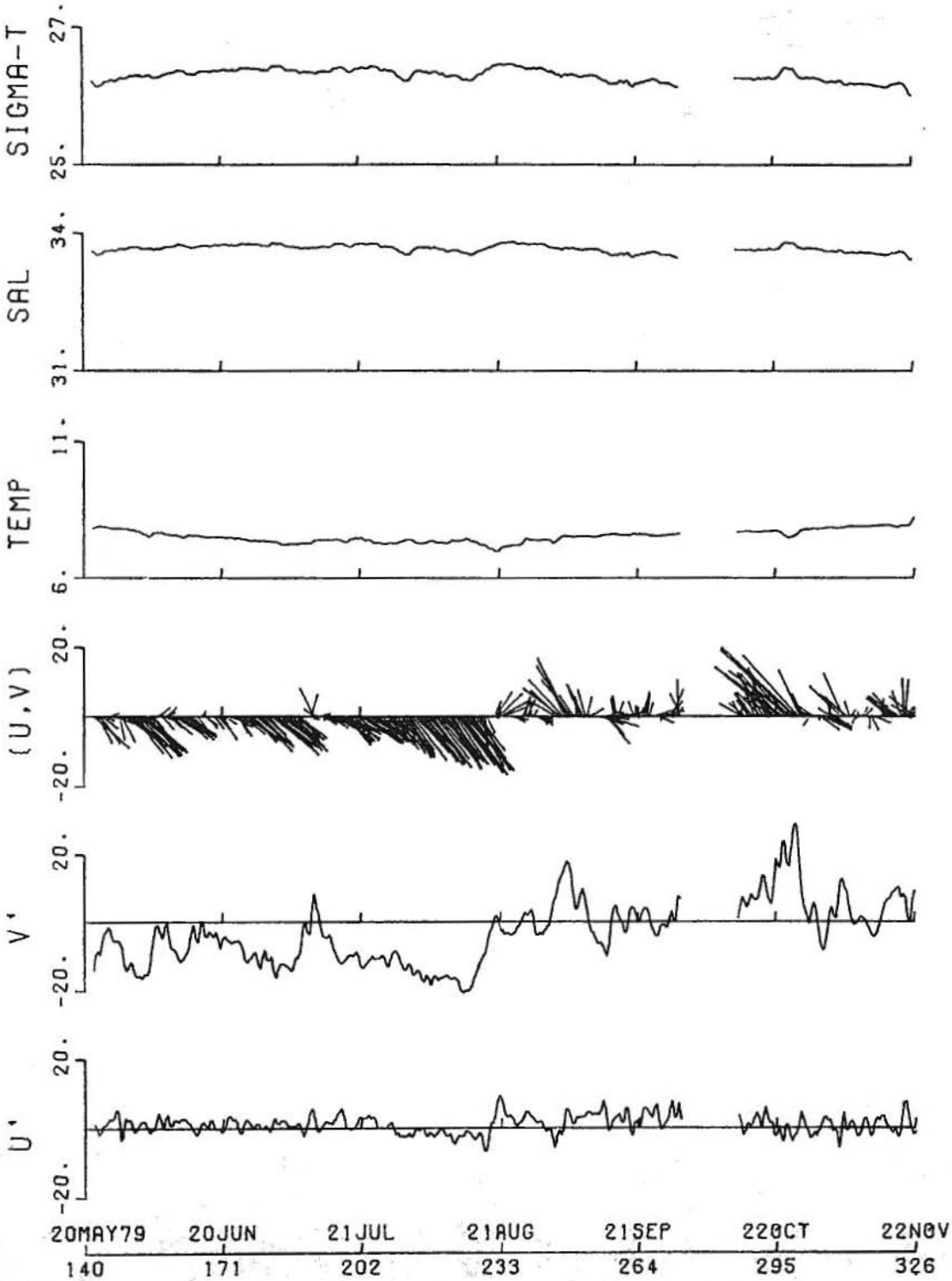
Site: CZ3

Depth: 100m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TEMP
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(U,V)
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-20.
V'
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U'
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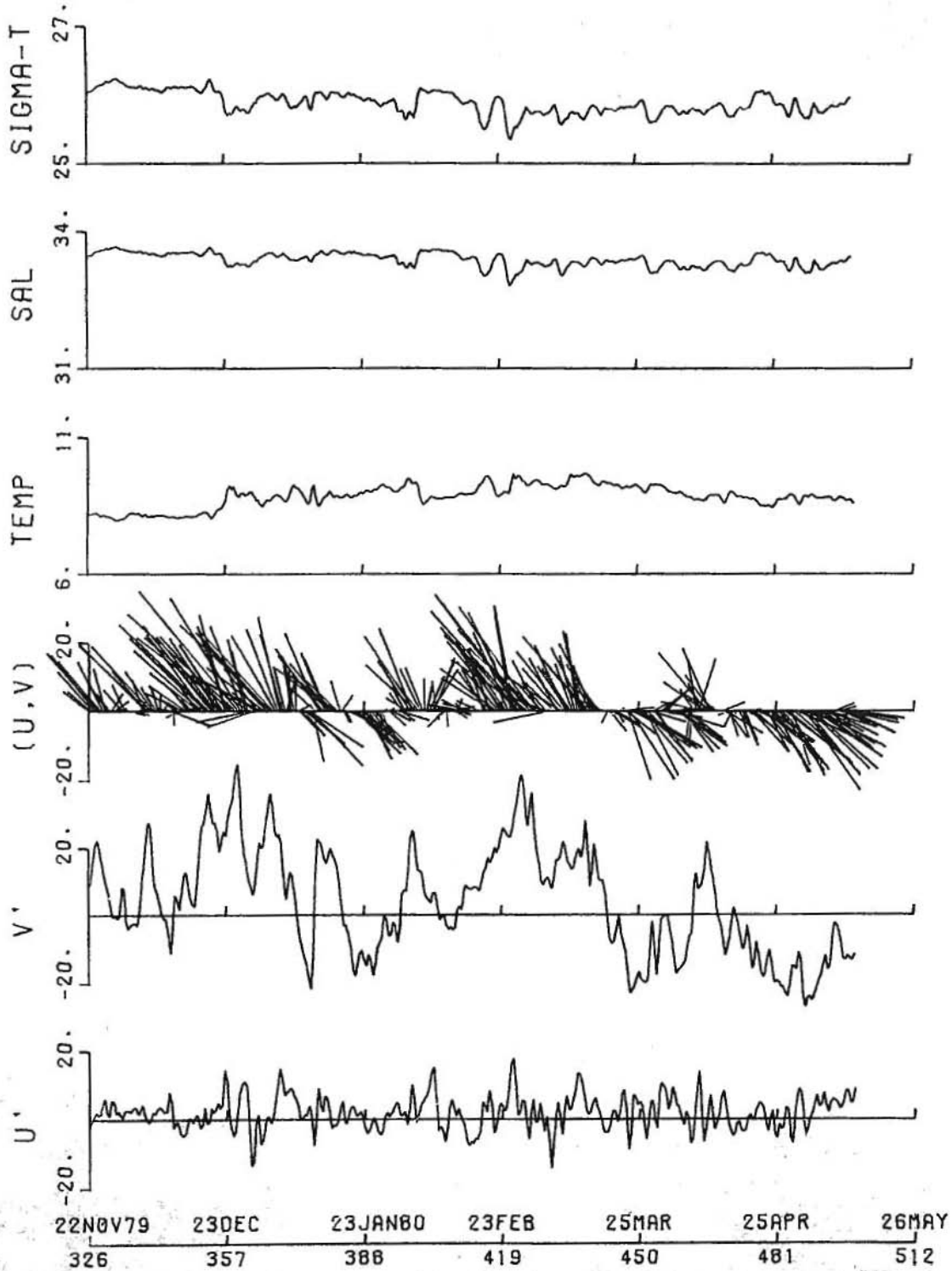
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V'
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U'
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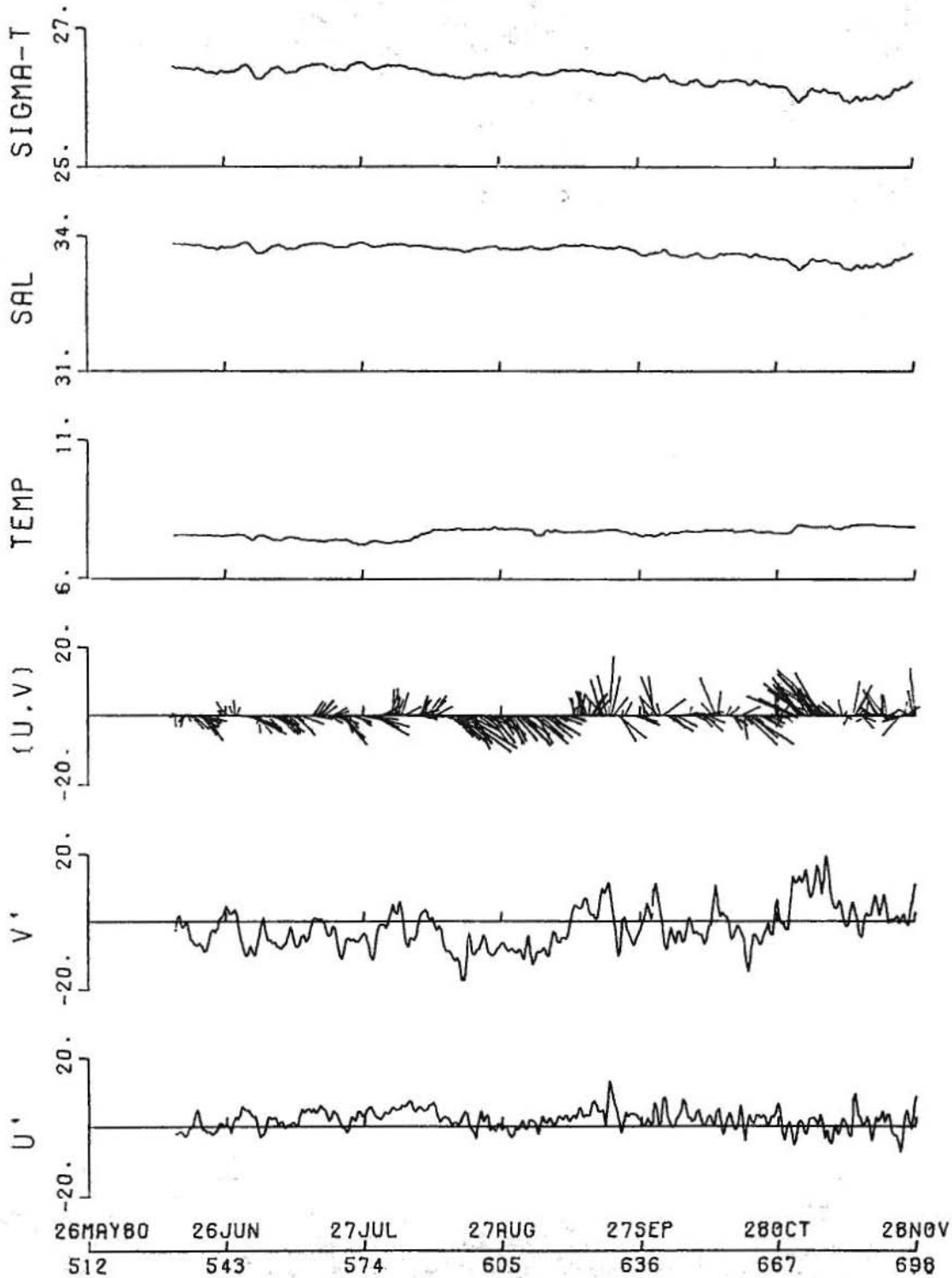
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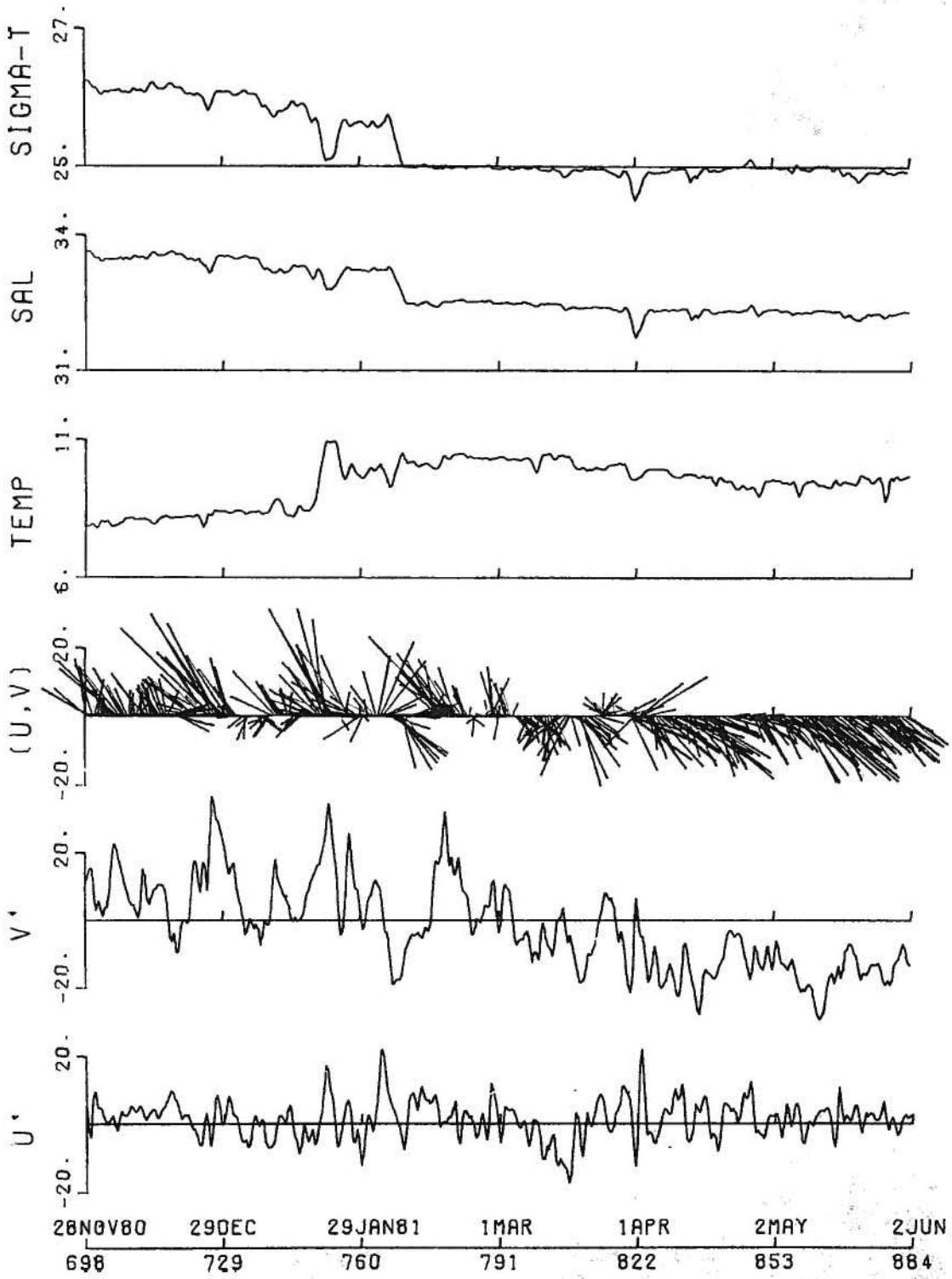
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V'
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-20.
U'
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-20.
28NOV80
29DEC
29JAN81
1MAR
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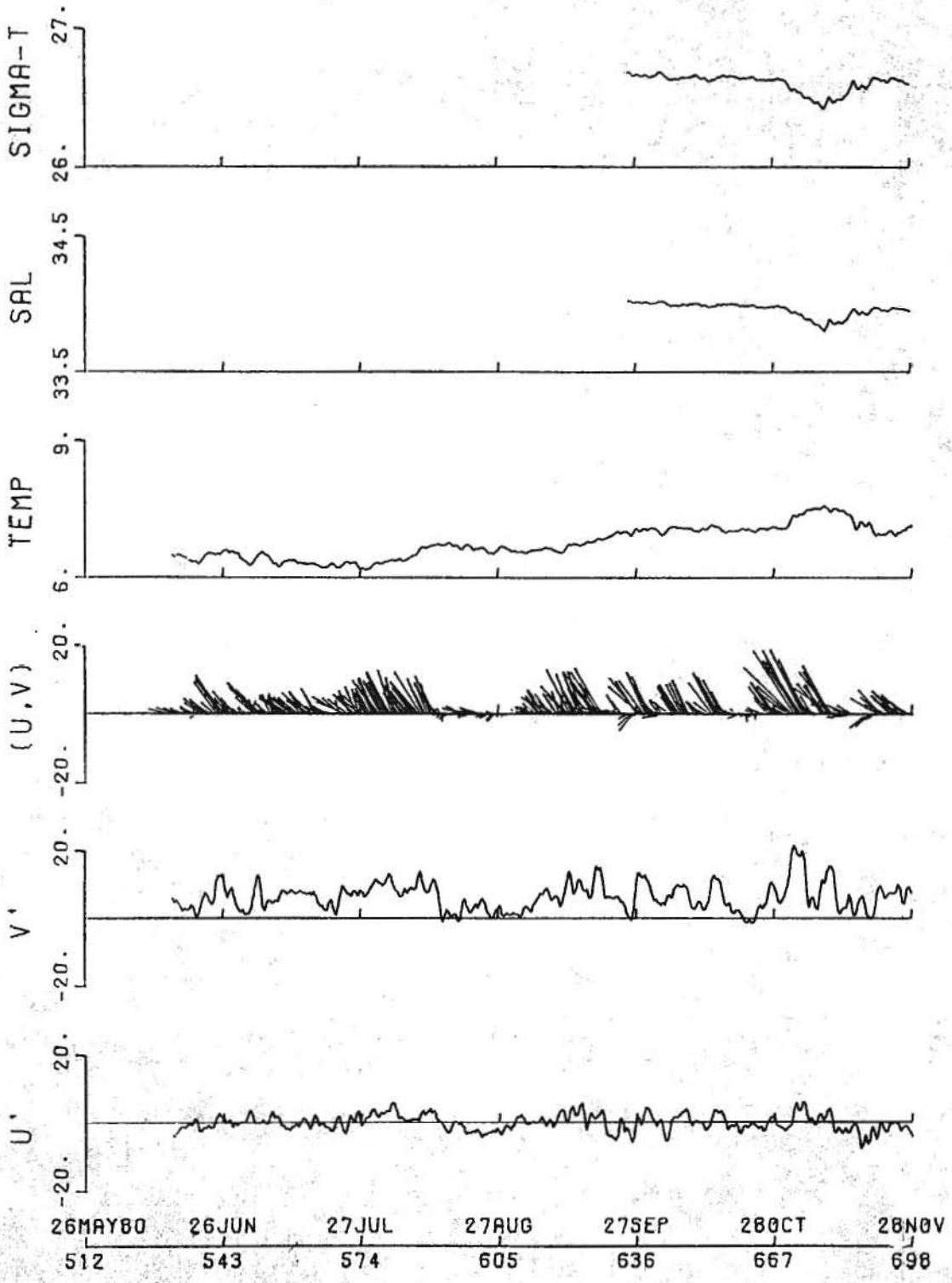
2MAY
2JUN
698
729
760
791
822
853
884

Site: CZ3

Depth: Bottom minus 5m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SAL
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TEMP
9.
6.
(U,V)
20.
-20.
V'
20.
-20.
U'
20.
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28NOV
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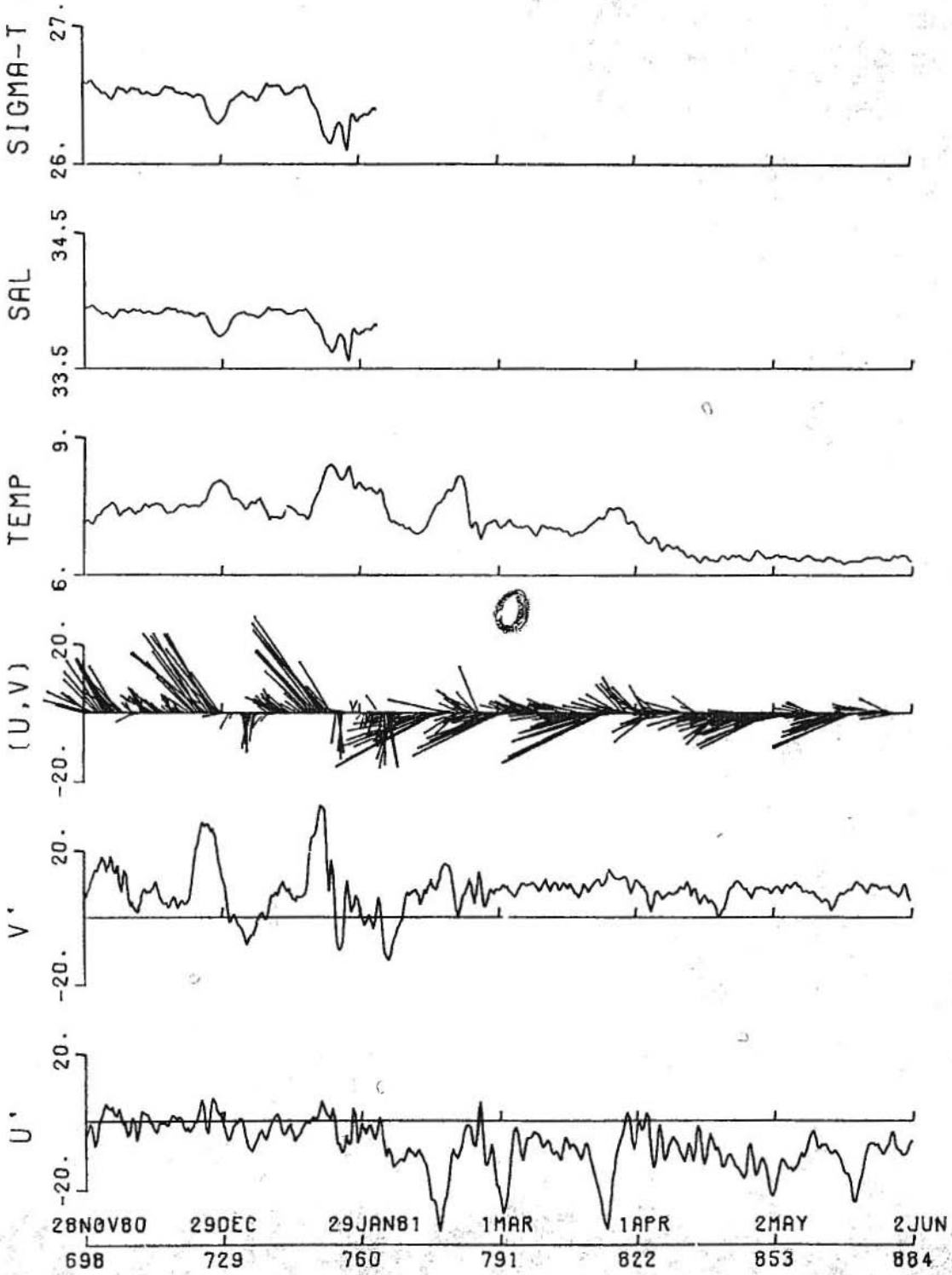
605
636
667
698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SAL
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TEMP
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6.
(U,V)
20.
-20.
V'
20.
-20.
U'
20.
-20.
28NOV80
29DEC
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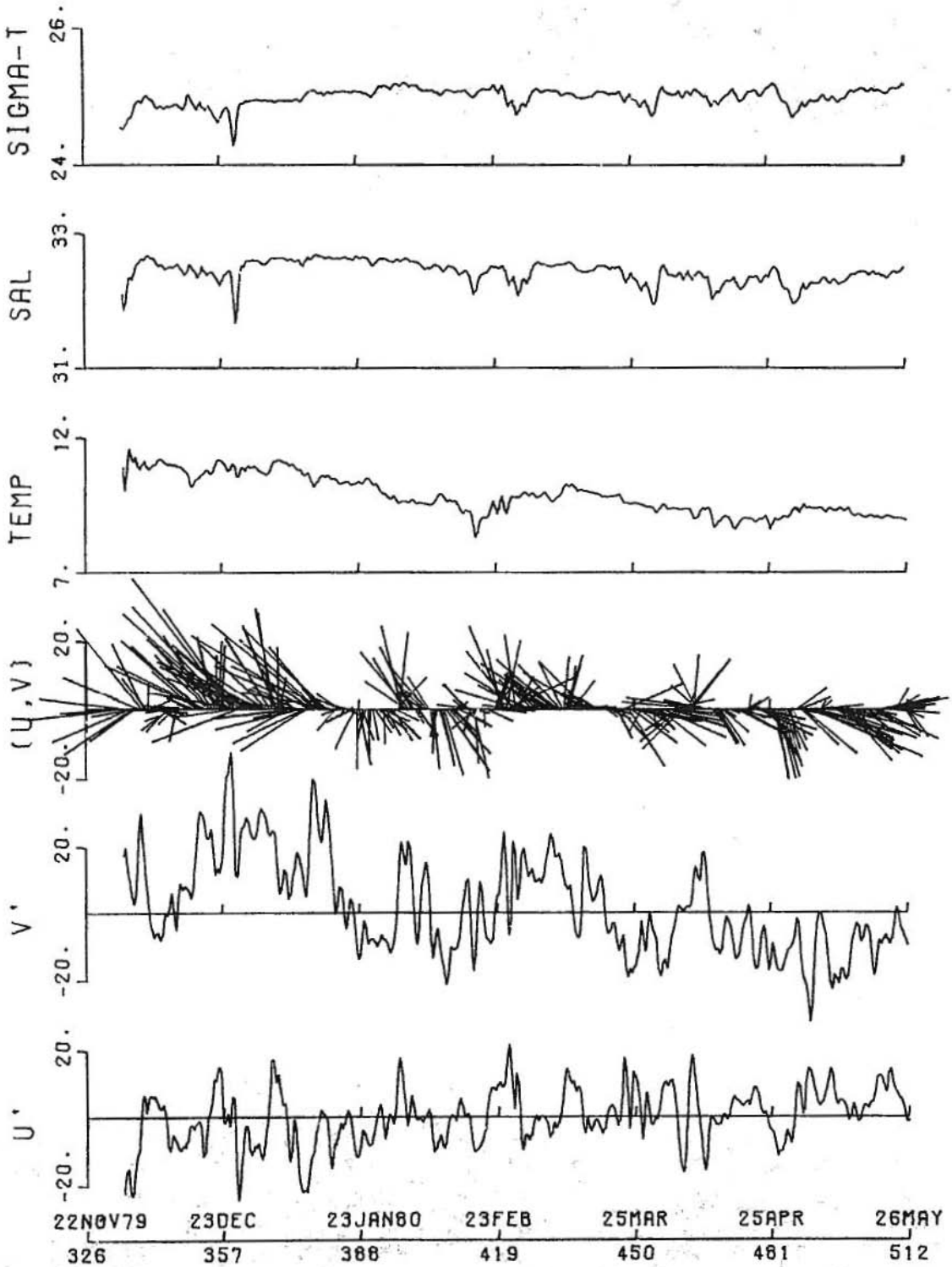
1MAR
1APR
2MAY
2JUN
698
729
760
791
822
853
884

Site: CZ2

Depth: 50m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-20.
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25APR
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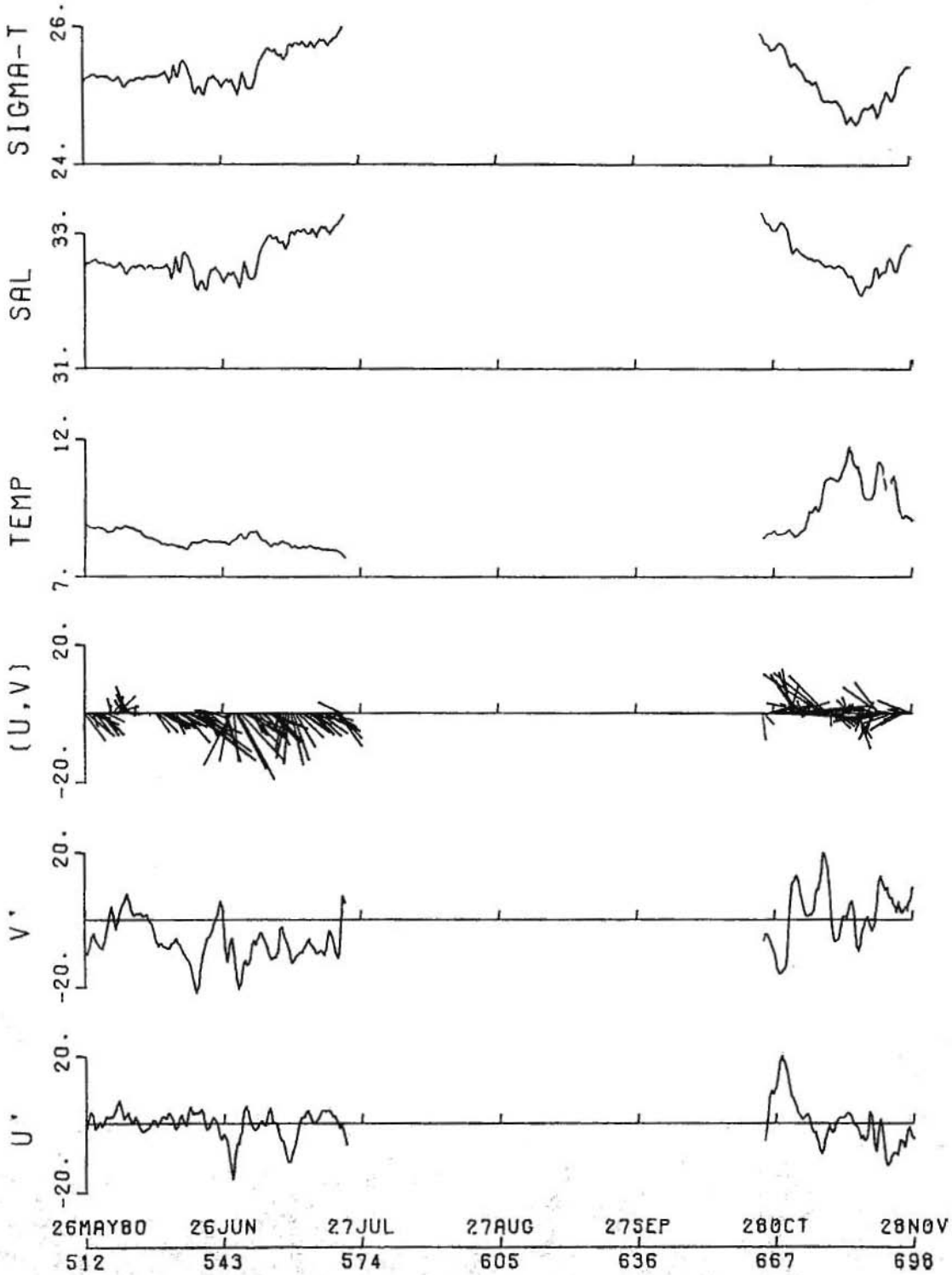
512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TEMP
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V'
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-20.
U'
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28OCT
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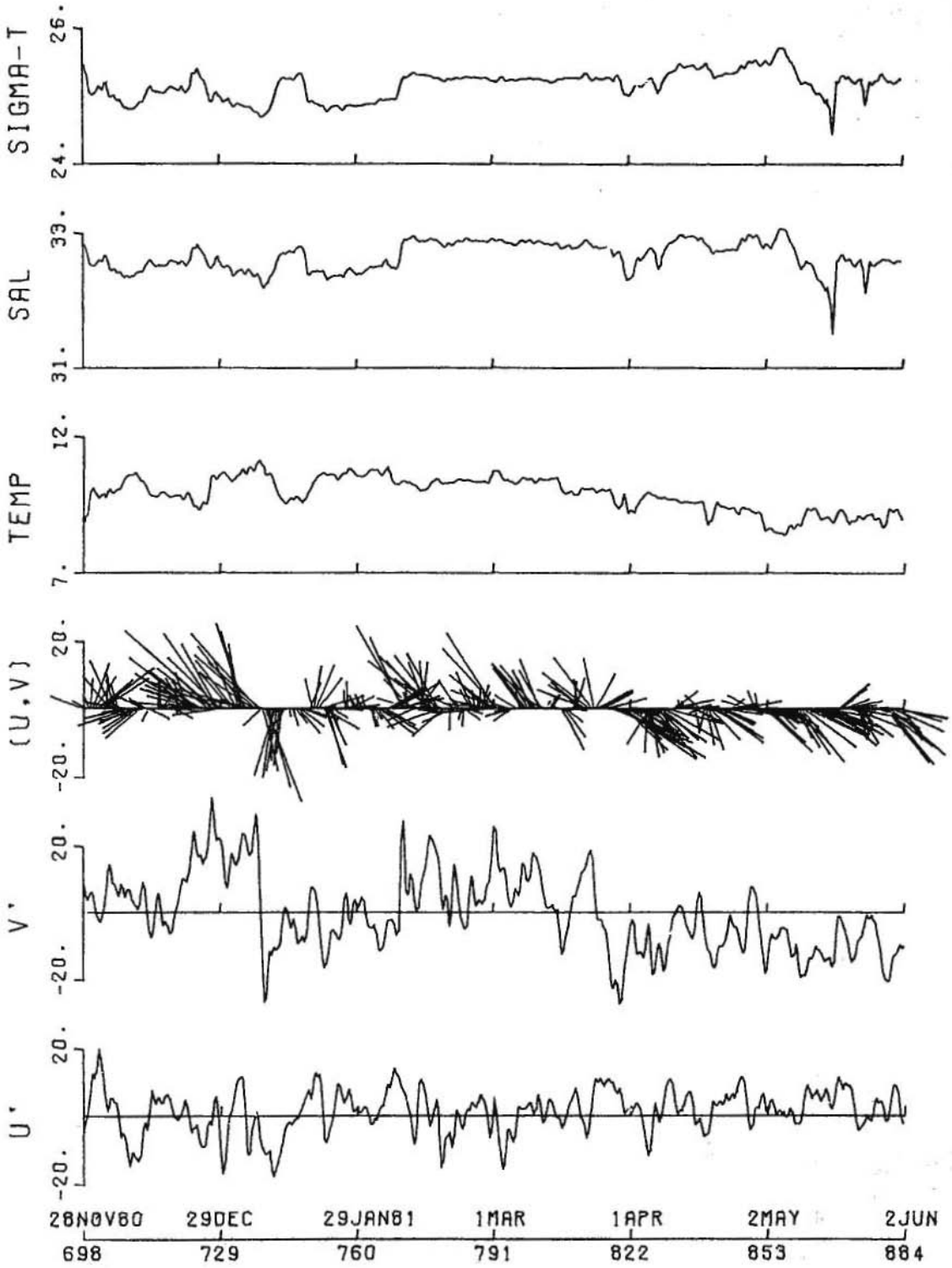
698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TEMP
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-20.
28NOV80
29DEC
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2JUN
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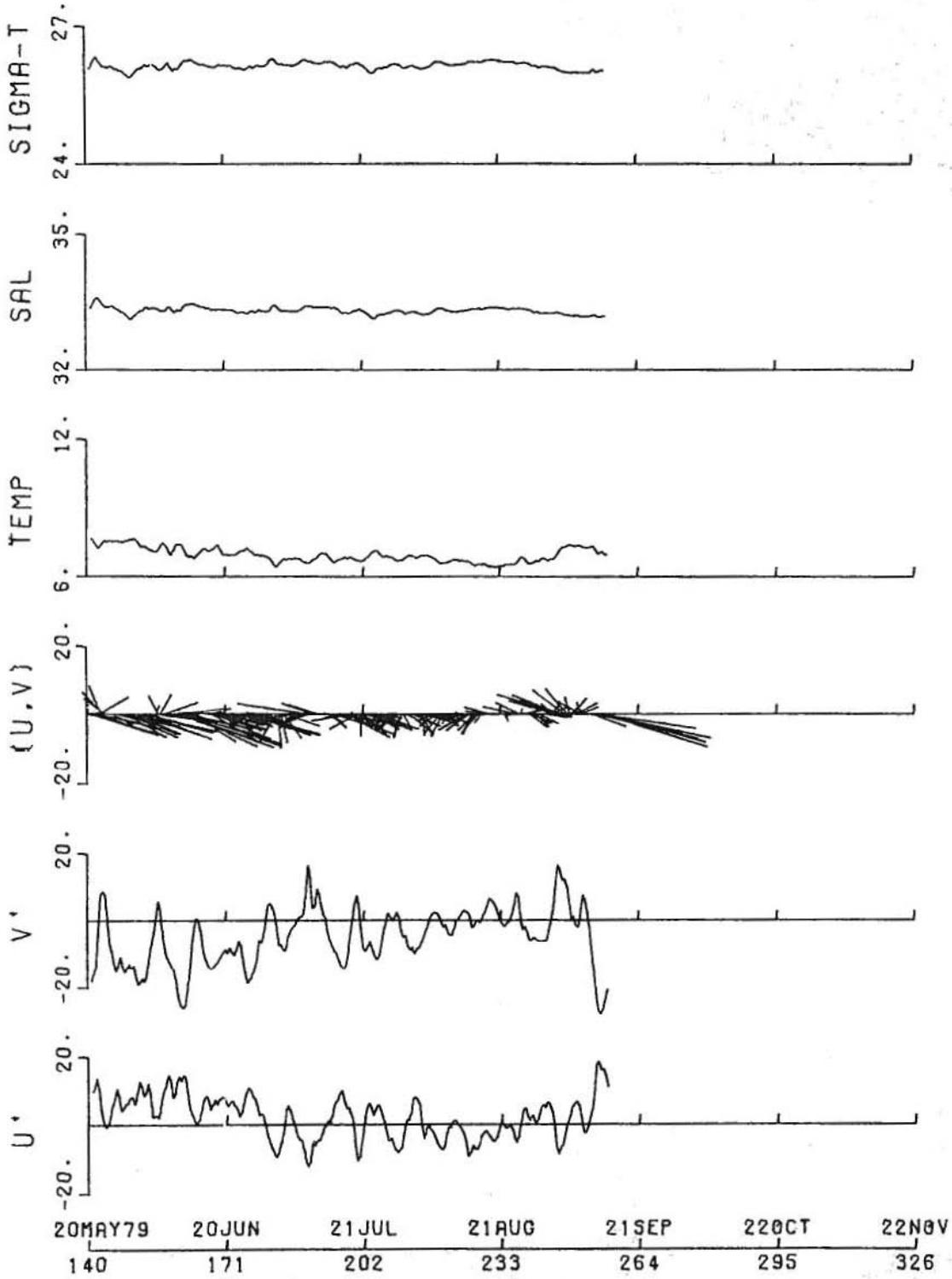
884

Site: CZ2

Depth: 100m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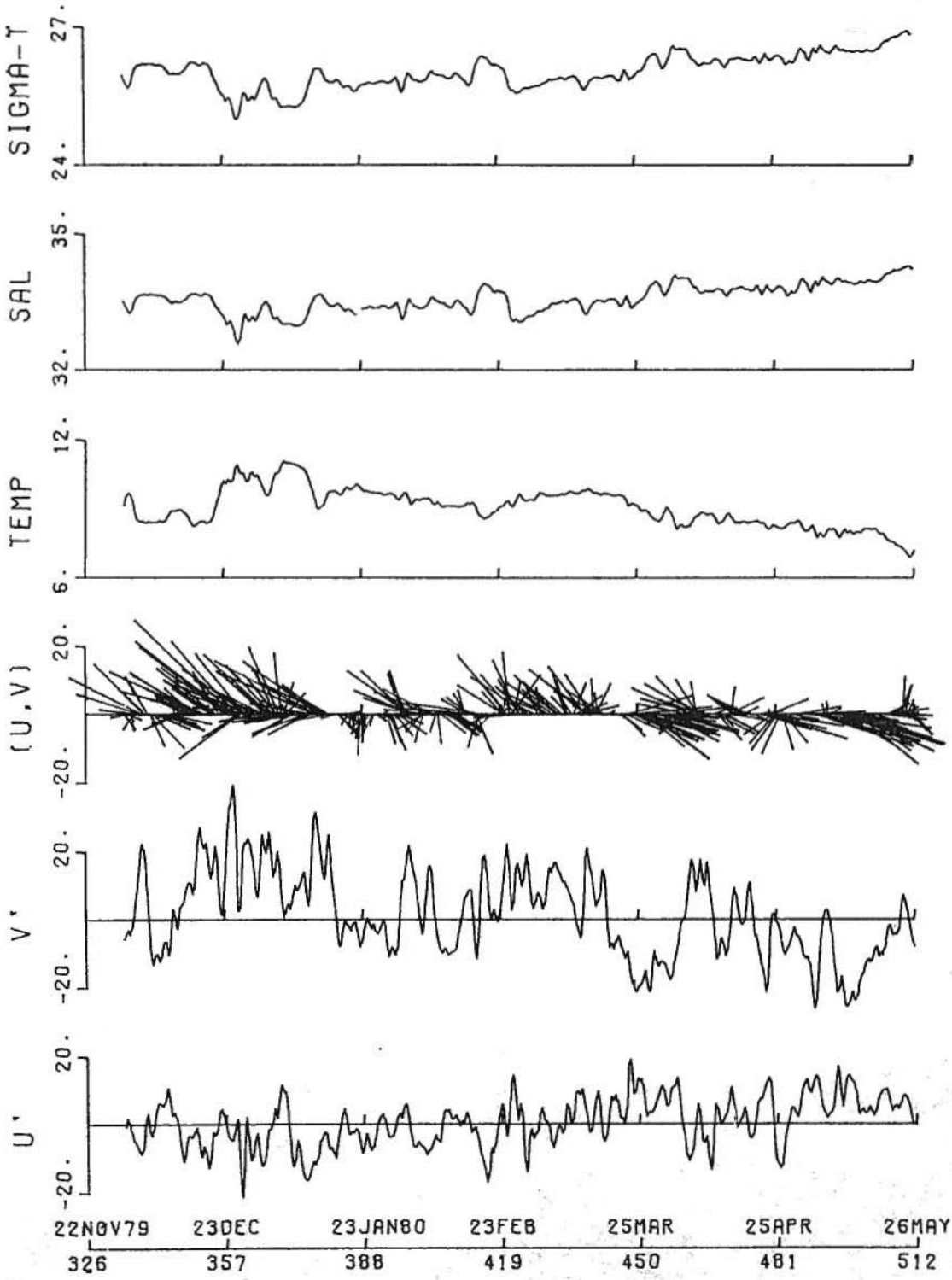
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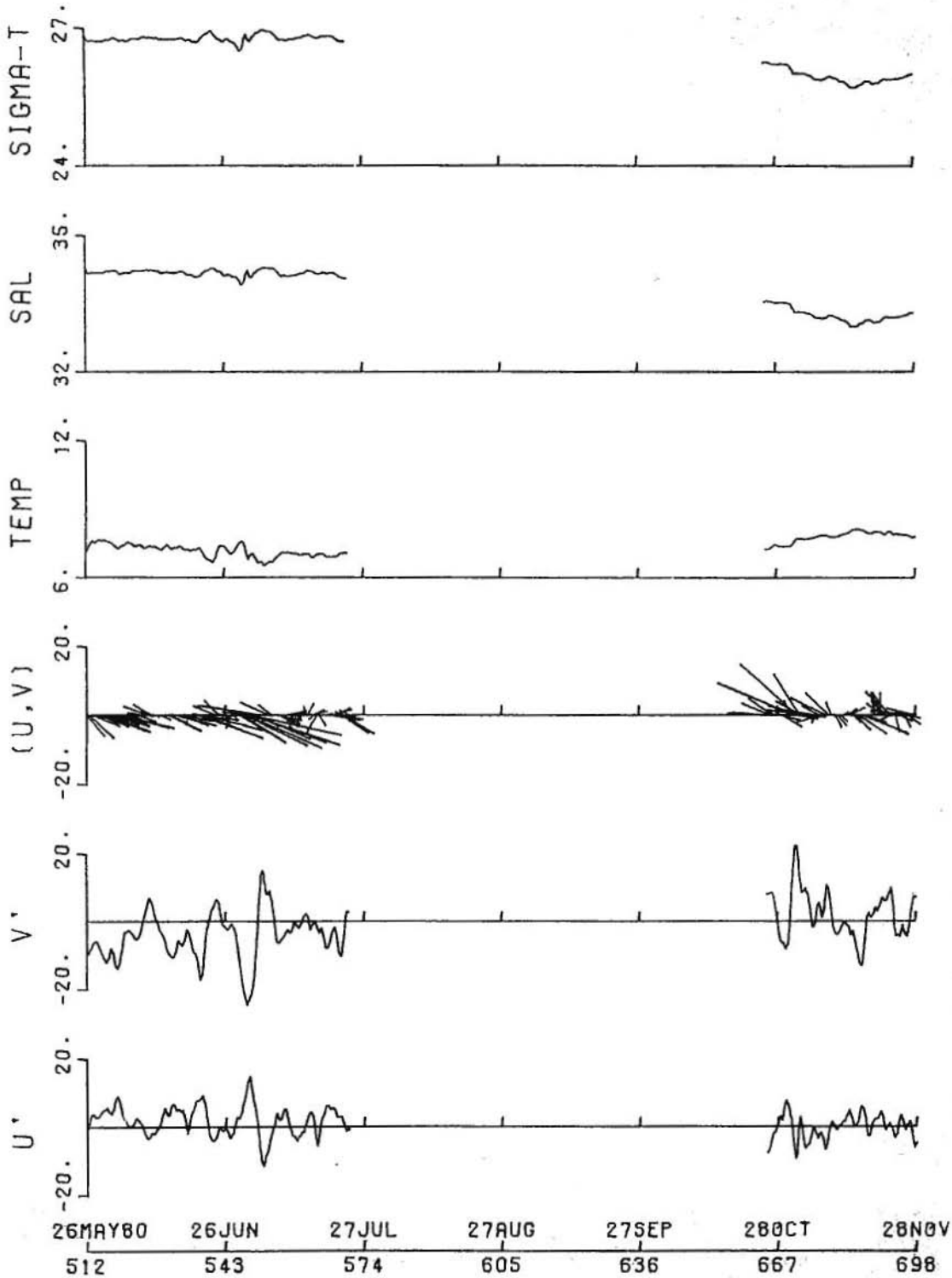
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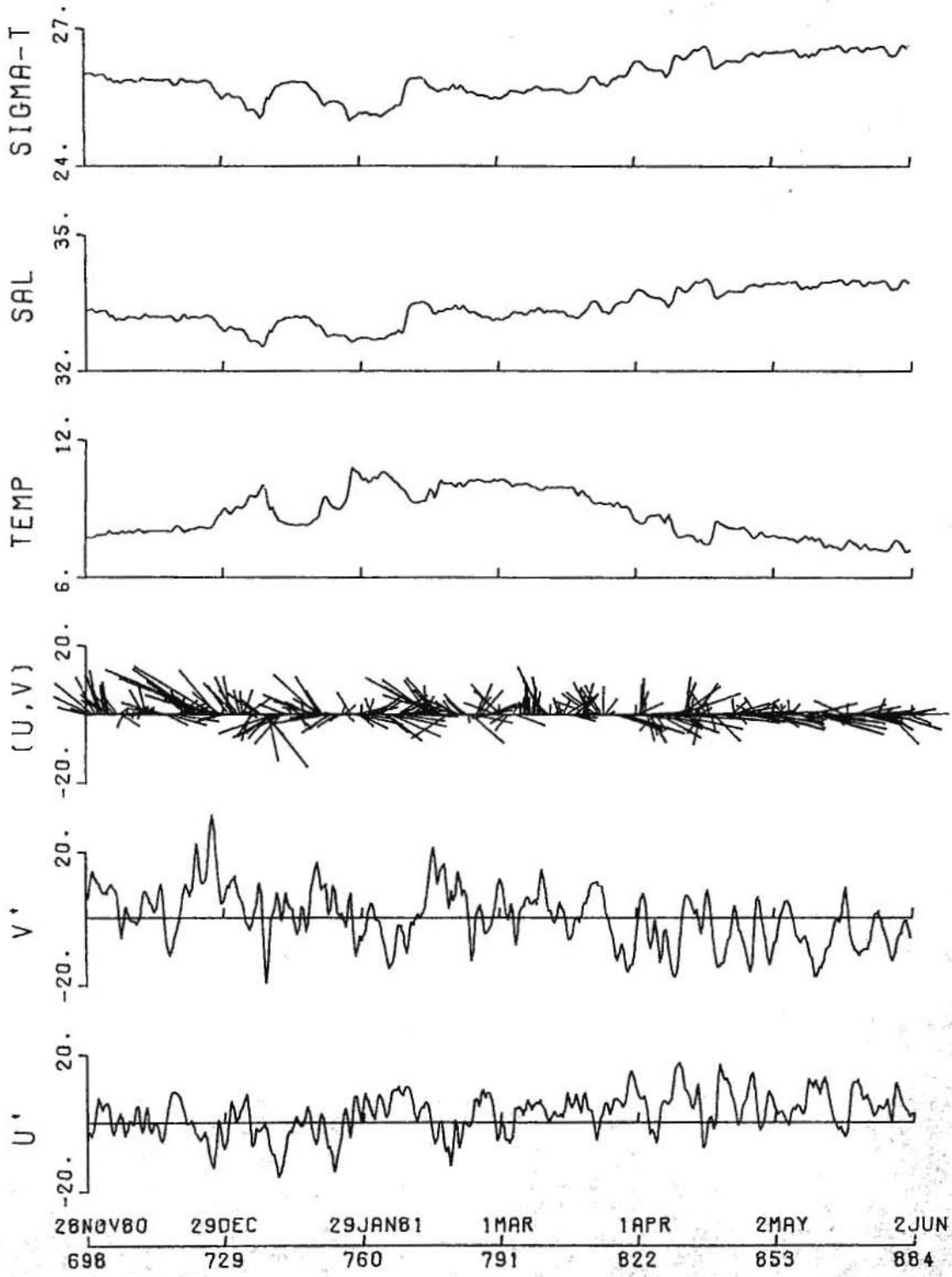
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28NOV80
29DEC
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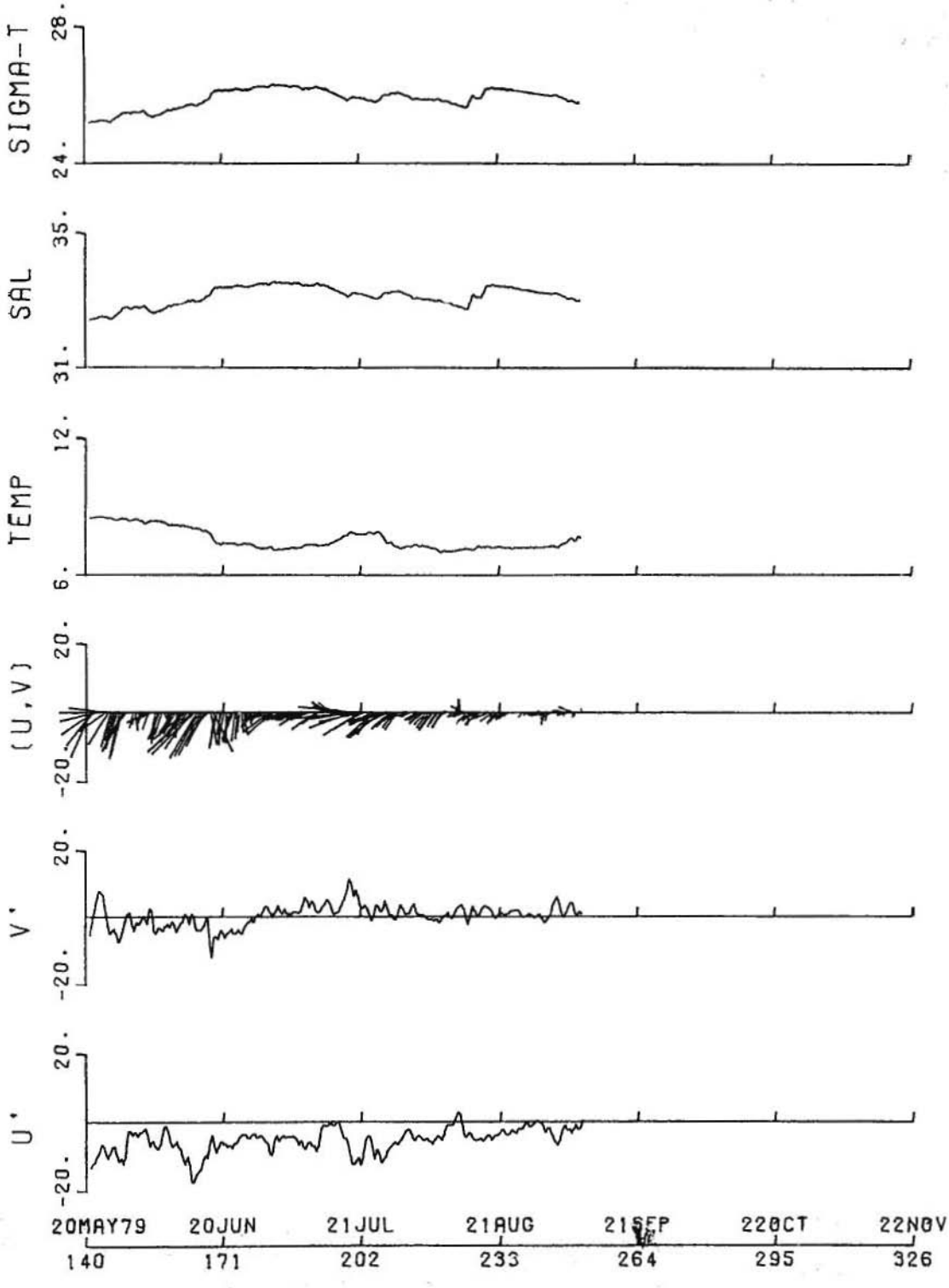
884

Site: CZ1

Depth: 50m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(U,V)
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U'
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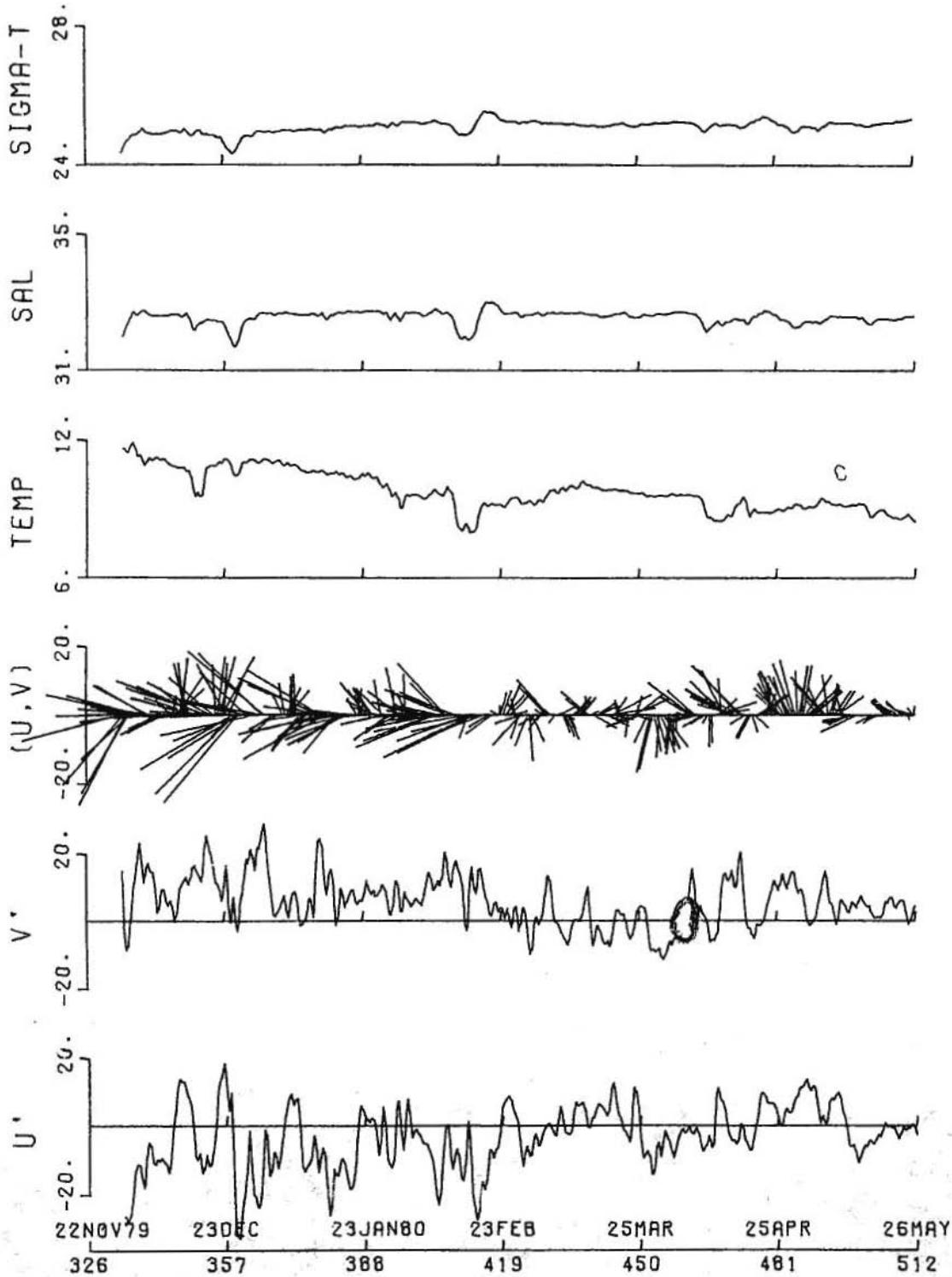
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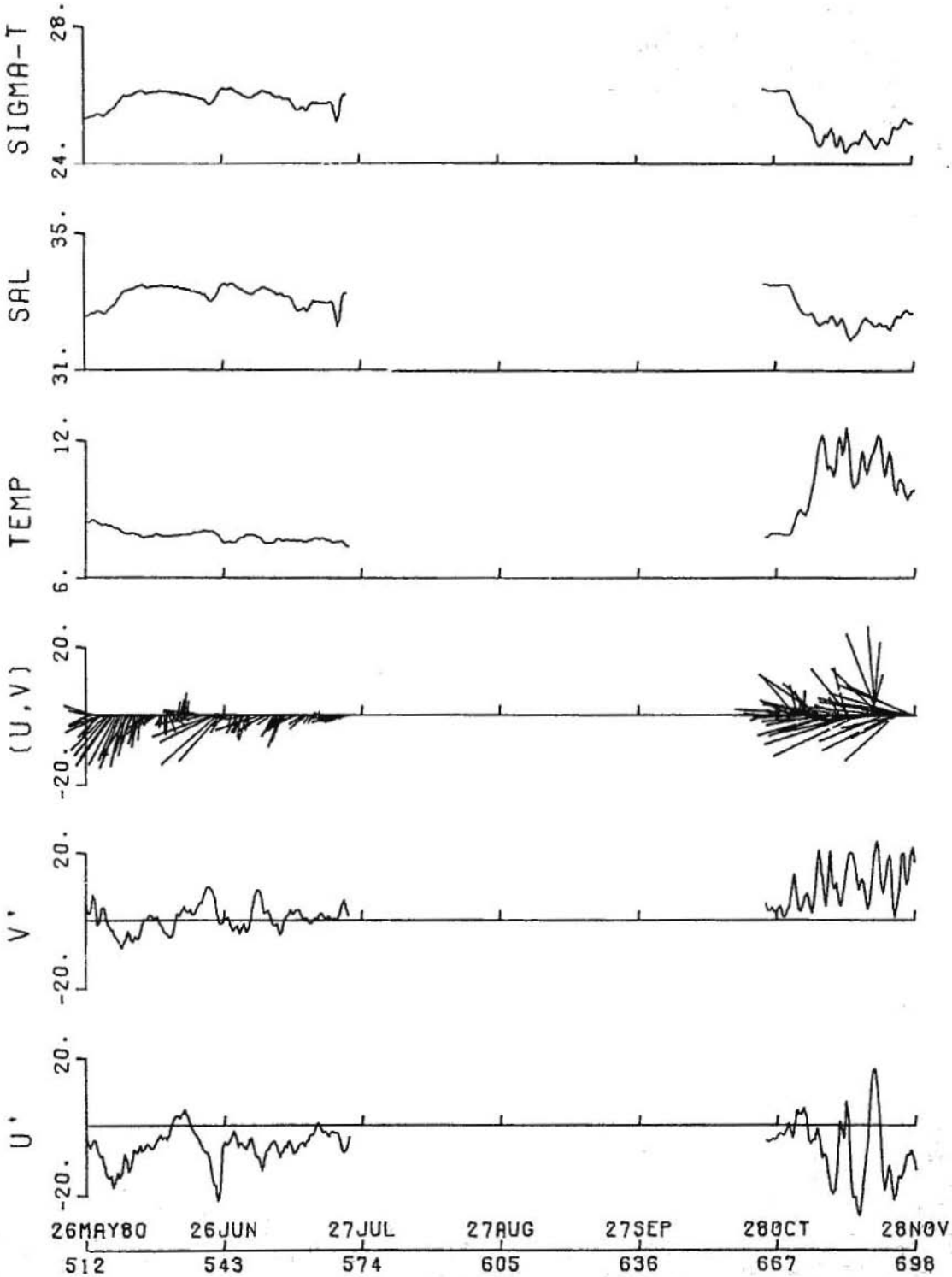
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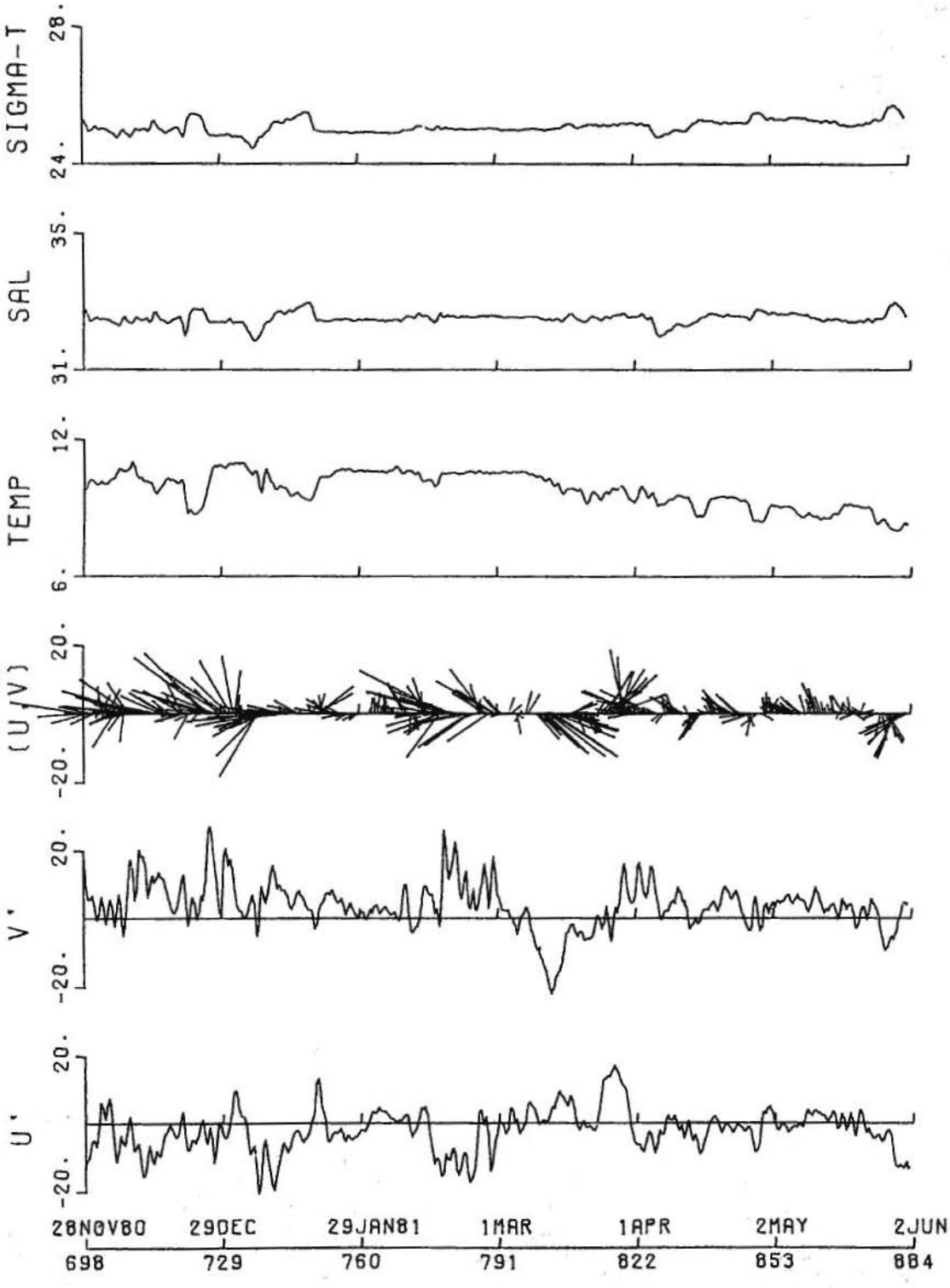
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28NOV80
29DEC
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1MAR
1APR
2MAY
2JUN
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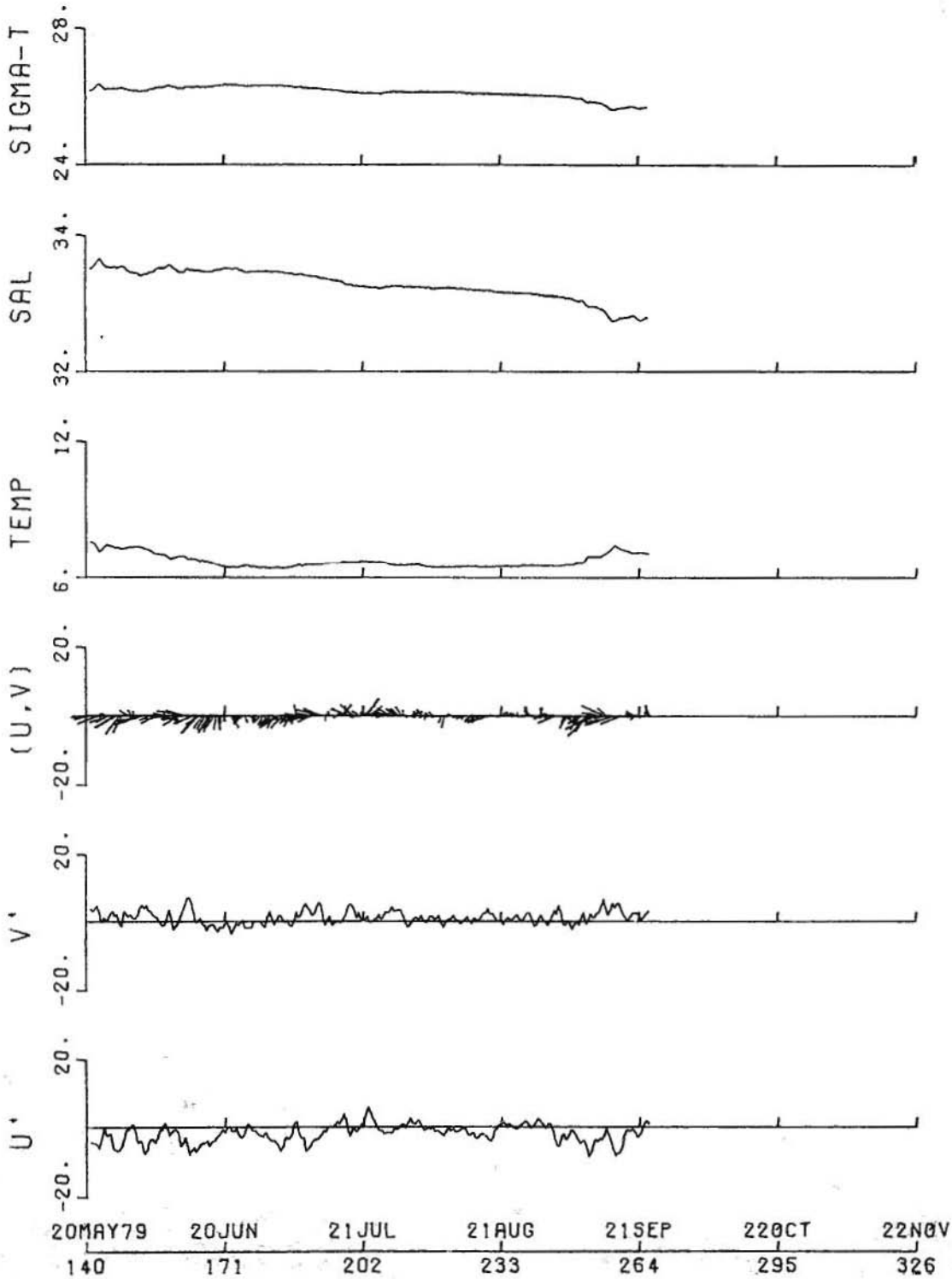
853
884

Site: CZ1

Depth: 100m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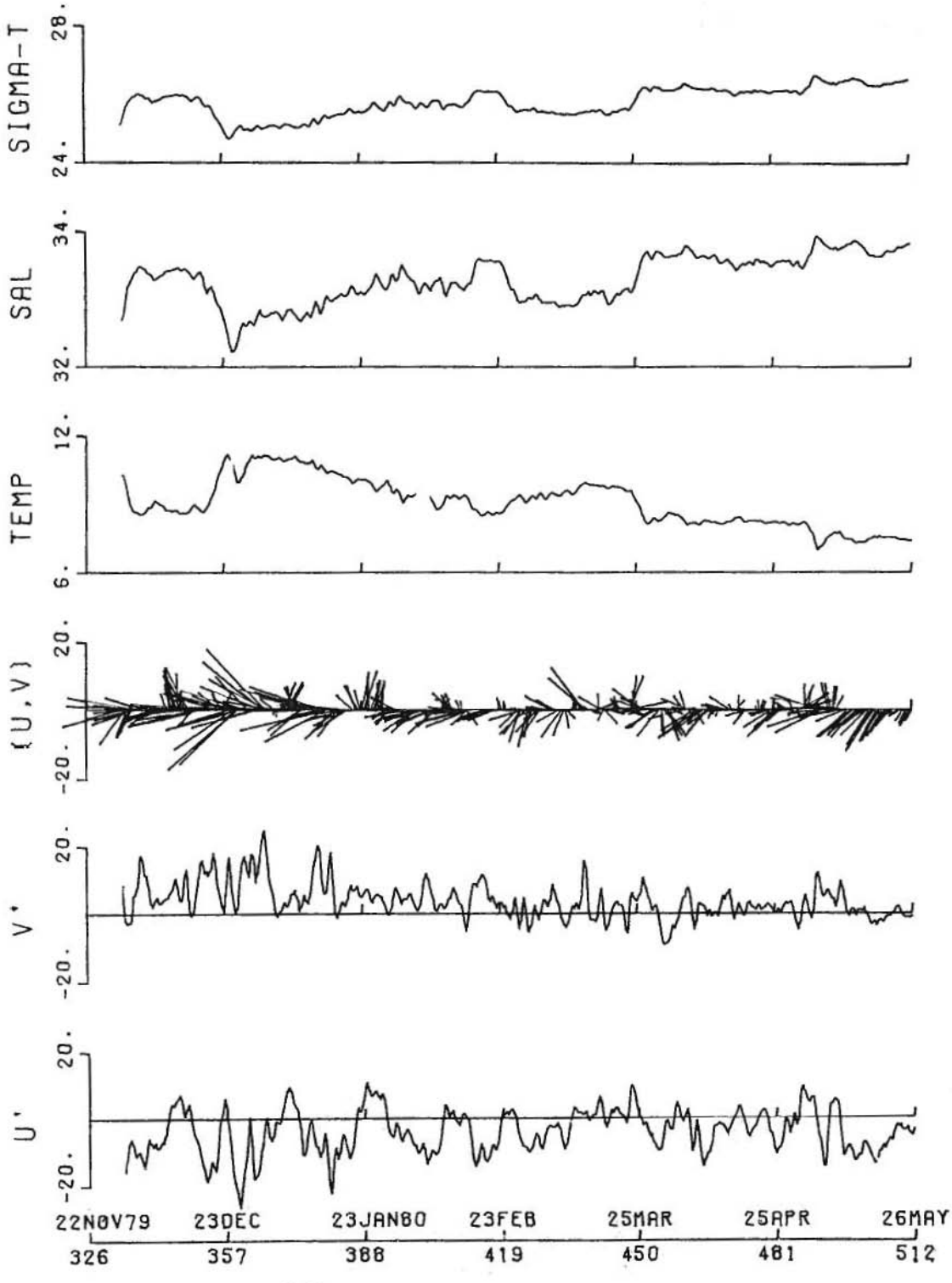
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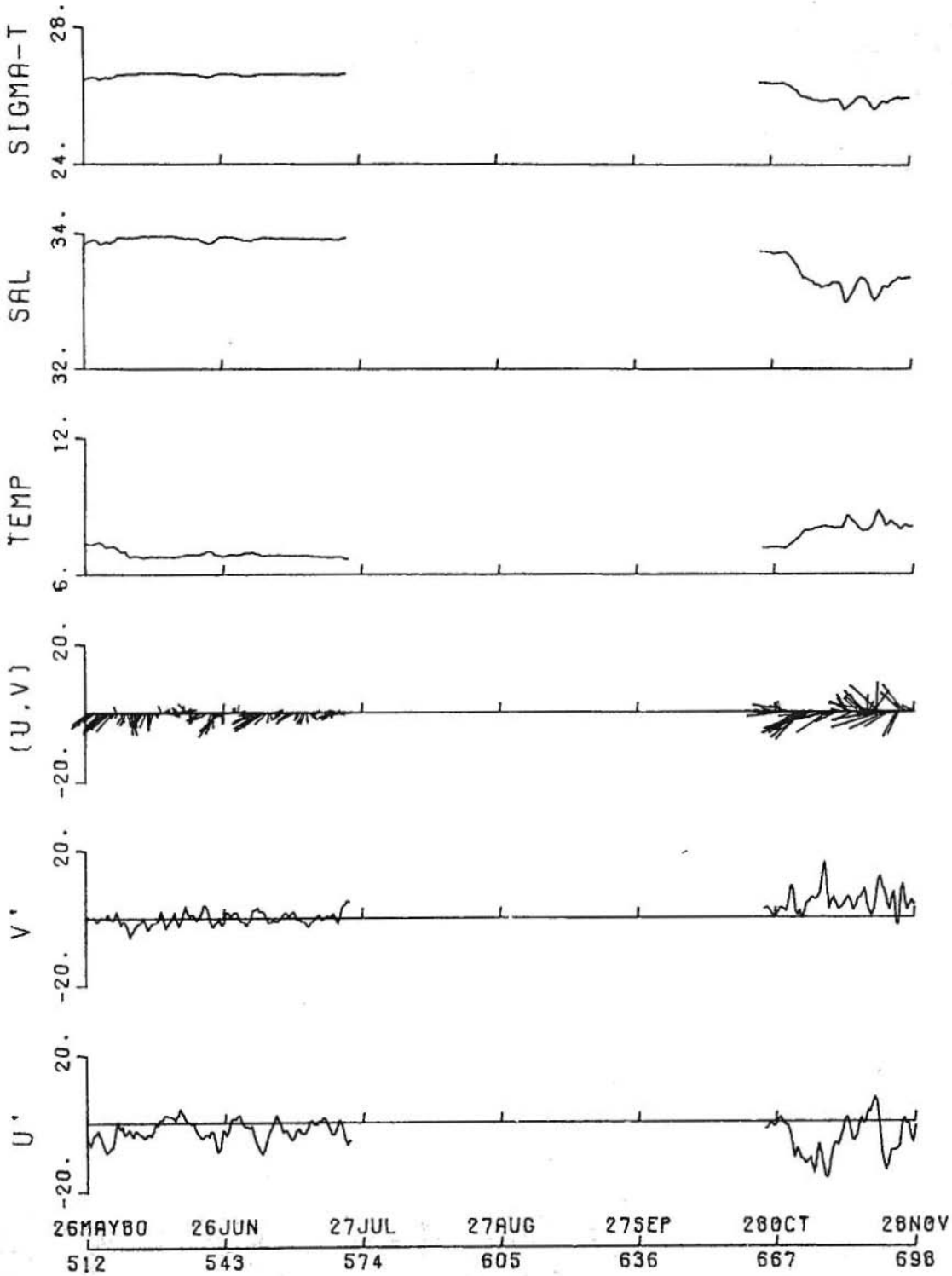
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U'
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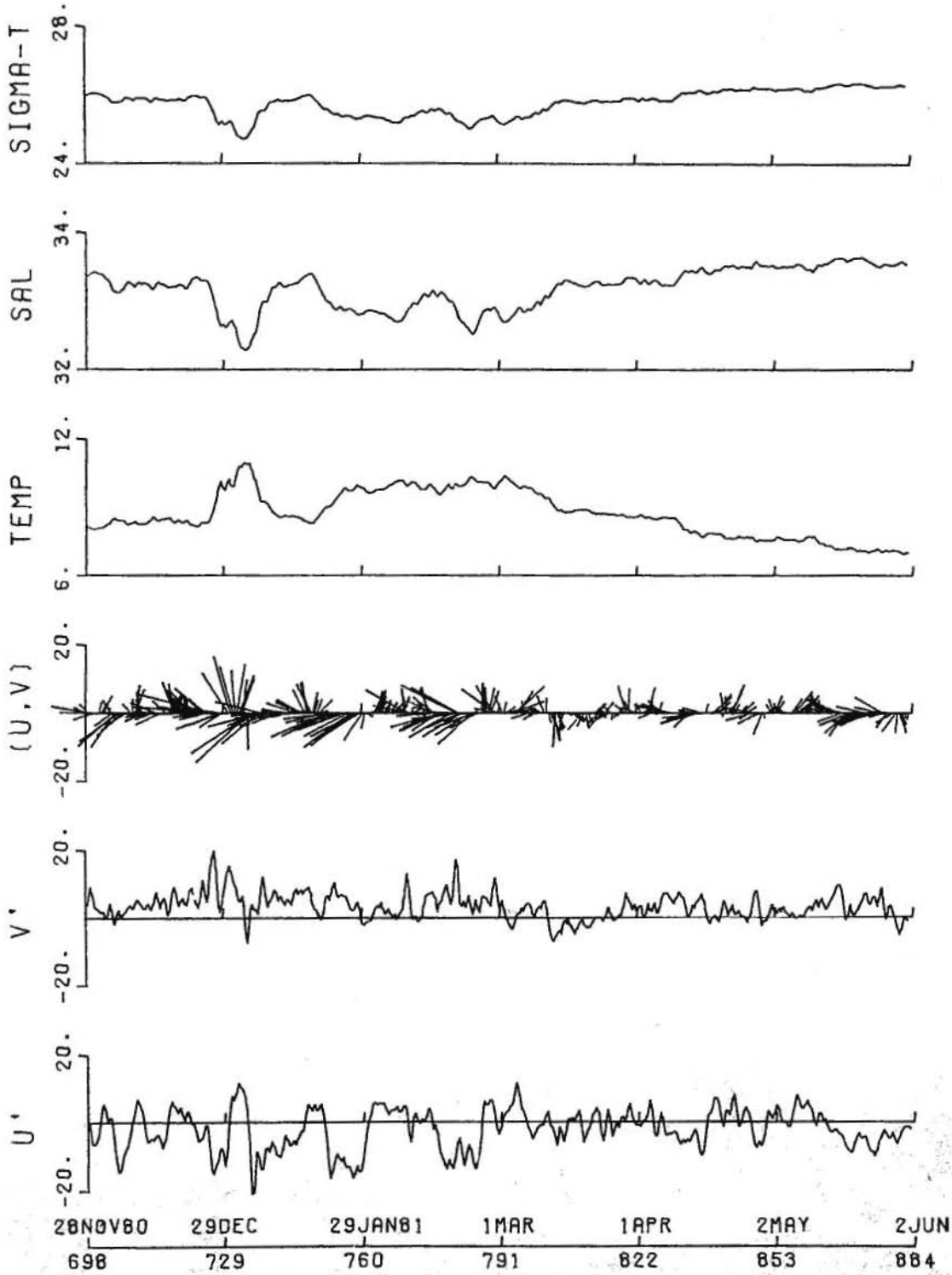
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-20.
28NOV80
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1MAR
1APR
2MAY
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729
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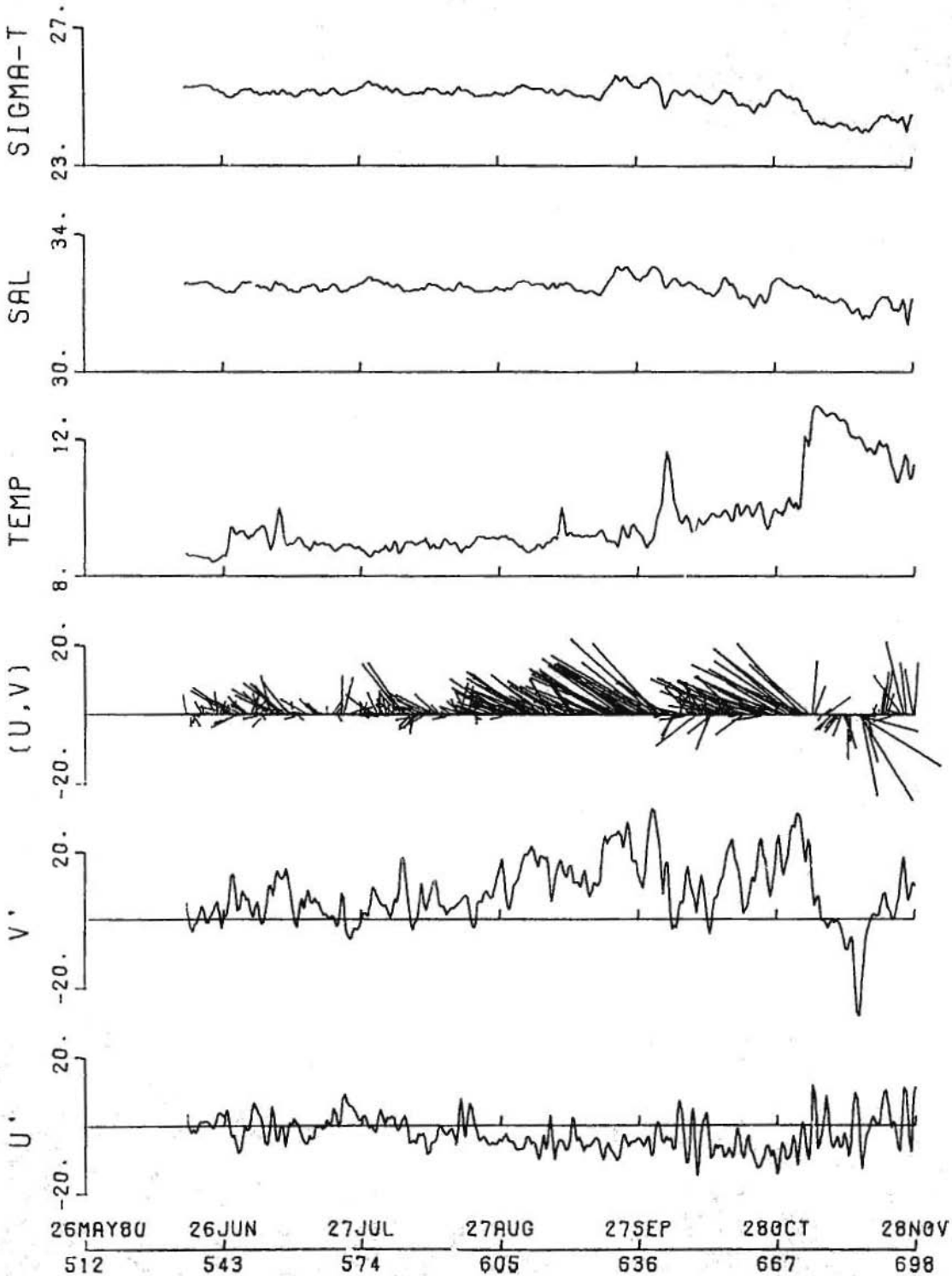
791
822
853
884

Site: CBL

Depth: 50m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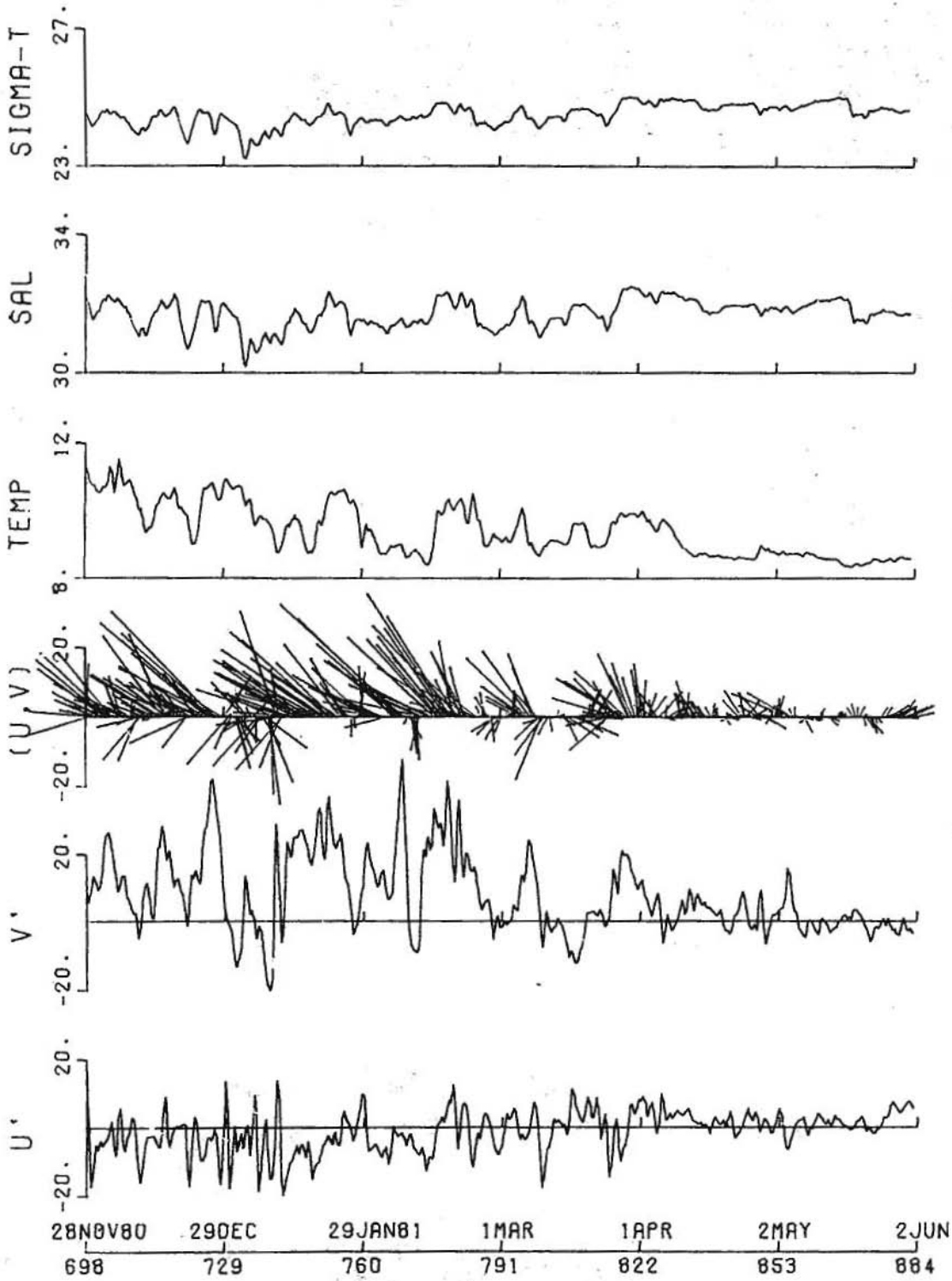
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U'
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28NOV80
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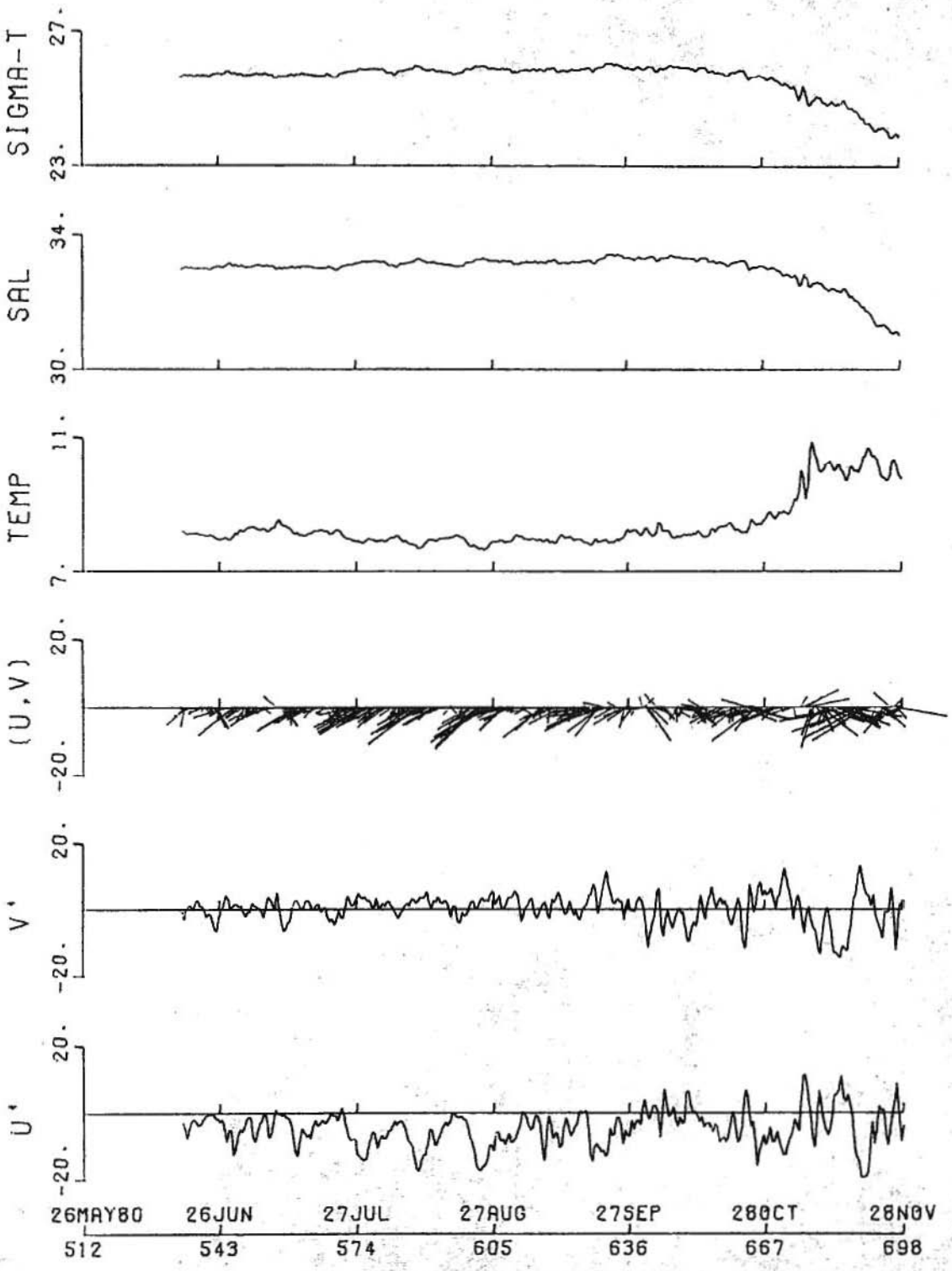
Site: CBL

Depth: 100m


SIGMA-T
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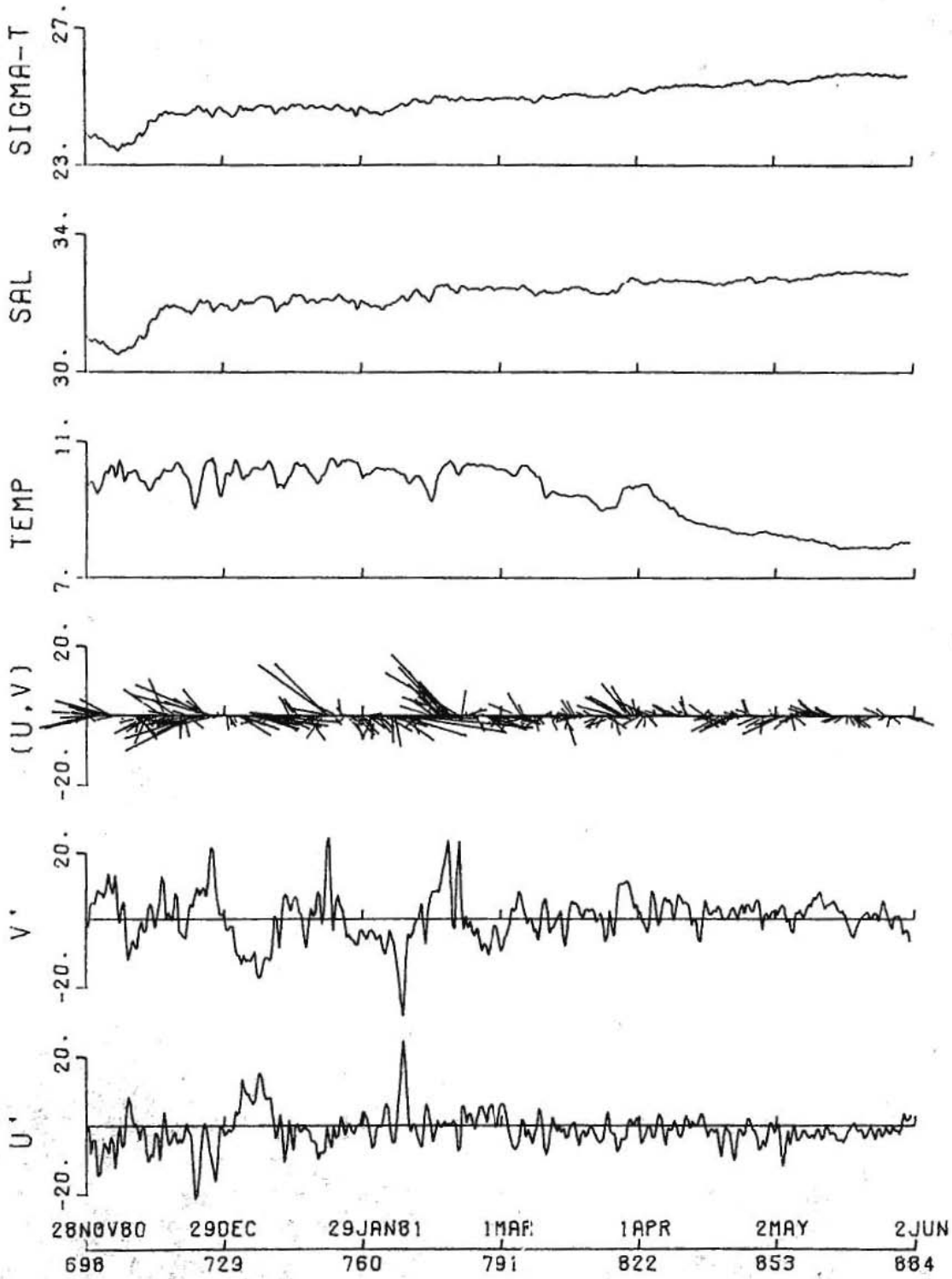
SIGMA-T
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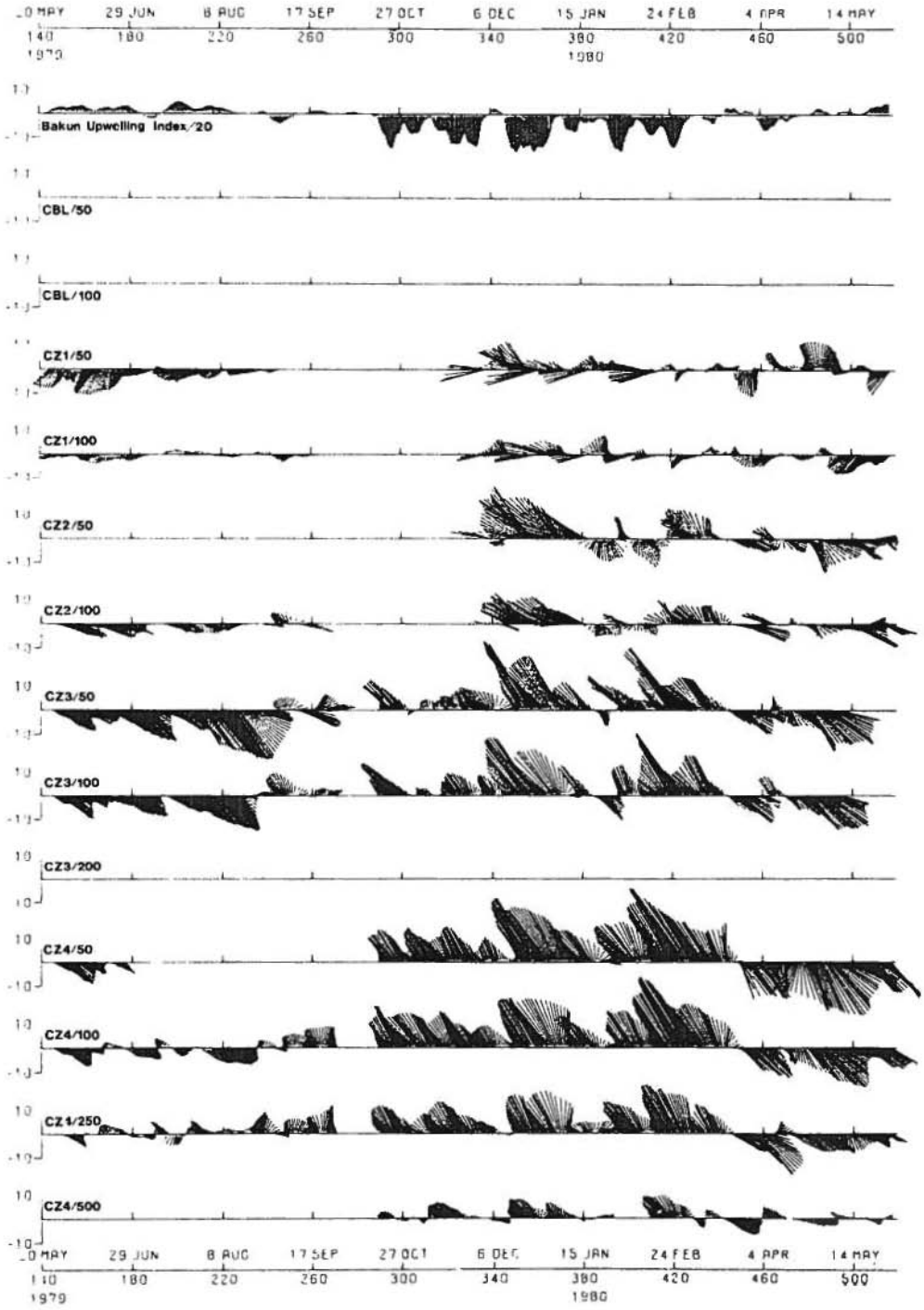
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27 OCT
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14 MAY
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420
460
500
1979
1980
Bakun Upwelling Index/20
CBL/50
CBL/100
CZ1/50
CZ1/100
CZ2/50
CZ2/100
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CZ3/100
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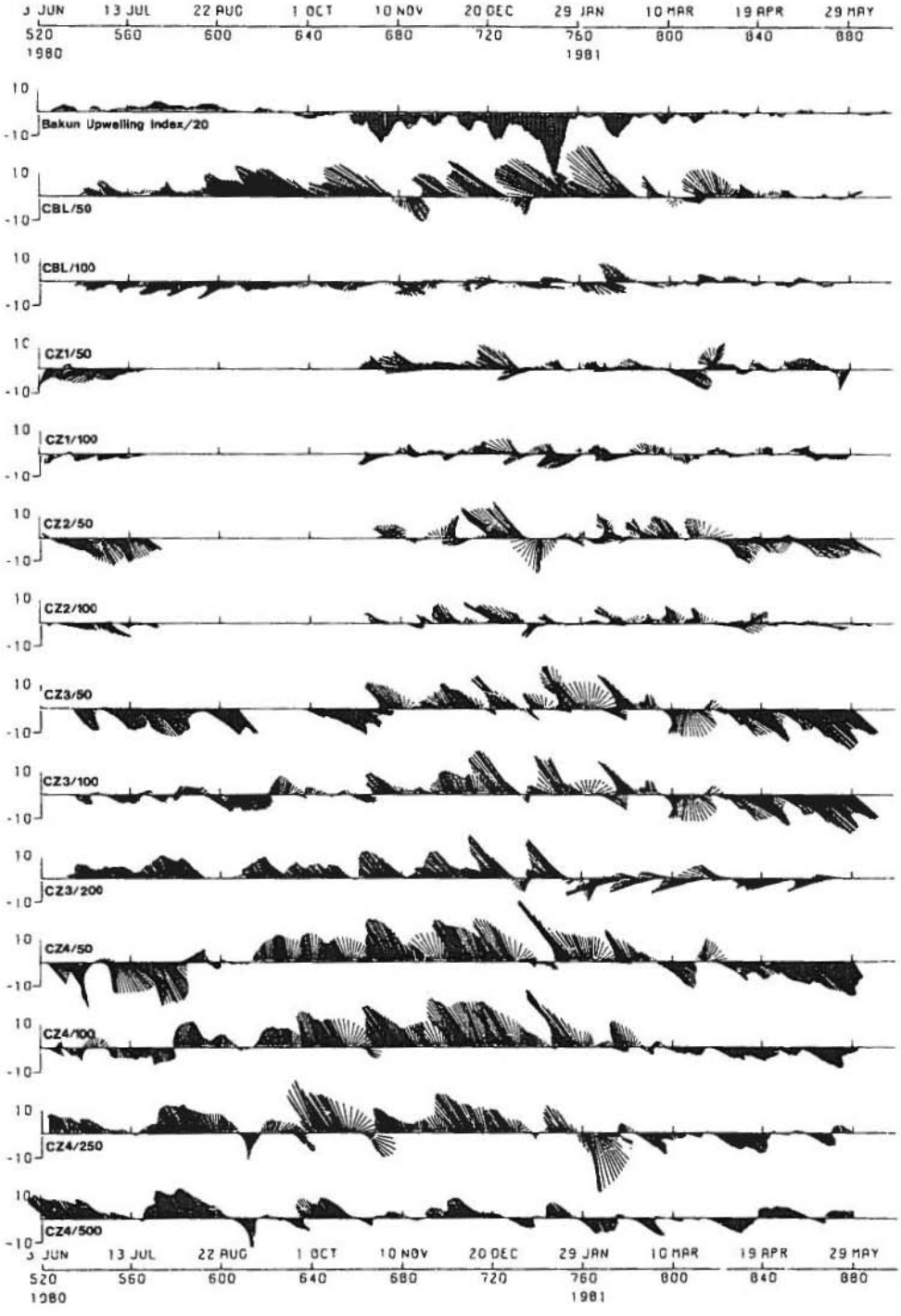
3 JUN
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1 OCT
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20 DEC
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840
880
1980
1981
10
-10
Bakun Upwelling Index/20
CBL/50
CBL/100
CZ1/50
CZ1/100
CZ2/50
CZ2/100
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CZ3/100
CZ3/200
CZ4/50
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