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The Gulf Stream Dynamics Experiment: Inverted Echo Sounder Data Report for the July 1982 to April 1983 Deployment Period

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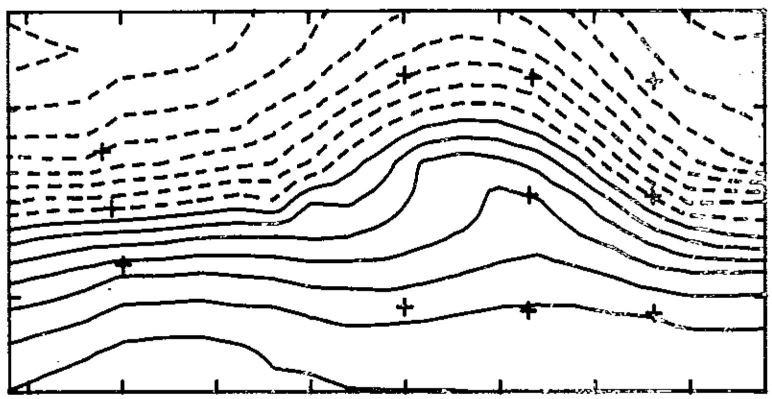

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ABSTRACT

The Gulf Stream Dynamics Experiment was conducted in the region just northeast of Cape Hatteras to study the propagation and growth characteristics of Gulf Stream meanders. This report documents the inverted echo sounder data collected during the July 1982 to April 1983 deployment period. Time series plots of the half-hourly travel time and low-pass filtered thermocline depth measurements are presented for eleven instruments. Basic statistics are given for all the data records shown. Maps of the thermocline depth field in a 200 km by 400 km region are presented at daily intervals.

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SECTION 1

Experiment Description and Data Processing

1.1 Introduction

This report documents data collected using inverted echo sounders (IESs) in the Gulf Stream northeast of Cape Hatteras from July 1982 to April 1983, as part of the Gulf Stream Dynamics Experiment. The measurements were made under the support of an NSF project entitled "The Dynamics of Gulf Stream Meanders". Other data collected as part of the program conducted by the University of Rhode Island (D. R. Watts, P. I.) included two current meter moorings with instruments at three levels (under ONR sponsorship) and closely spaced CTD casts along two transects. These other data have been documented by W. E. Johns (1984) and E. Johns (1984), respectively.

The principal objectives of the experiment were:

1) determining the propagation and growth characteristics of Gulf Stream meanders and how these vary downstream,

2) determining the vertical structure of the current and temperature fluctuations associated with Gulf Stream meanders in the study area,

3) determining the potential vorticity distribution of the Gulf Stream, and

4) determining if the current is in geostrophic balance.

Additionally, these data are being used in cooperation with other investigations of the Gulf Stream in the same region. Collaboration with P. Cornillon's satellite imagery project (NSF supported) and H. T. Rossby's Pegasus project (ONR supported) is currently underway to obtain detailed descriptions of the meander characteristics.

To address these objectives, an array of inverted echo sounders was deployed in the Gulf Stream approximately 200 km downstream of Cape Hatteras. The study area, shown in Figure 1, was occupied from July 1982 to April 1983. The IESs were located on four lines in an approximately rectangular grid 130 km cross-stream by 300 km downstream. The instrument sites are shown in Figure 1 and listed in Table 1. Deployment of the twelve IESs took place from 5 to 25 July 1982 on a cruise aboard the R/V ENDEAVOR (EN087). The three instruments along line B were recovered on a cruise aboard the R/V ENDEAVOR (EN092) from 20 to 29 November 1982. The remaining recoveries took place from 16 to 27 April 1983 aboard the R/V COLUMBUS ISELIN (CI8304).

1.2 Site and Record Naming Conventions

In this report, each instrument site and the associated data record are referred to by both a line letter and a site number. The four cross-stream lines are designated from west to east by the letters B, D, E, and F. The IES sites along each line are numbered consecutively from 1 through 3, with site 1 located at the northwestern end of the line. This designator has a prefix of IES, indicating that the instrument is a standard type of inverted echo sounder (i.e., without any optional sensors). Additionally, a two-digit code, 83, indicates the reference year of the time base and (except for line B) the year in which the instruments were recovered. (The three instruments along line B were recovered in 1982.) For example, IES83E2, the second site from the northwestern end of line E, was recovered during 1983.

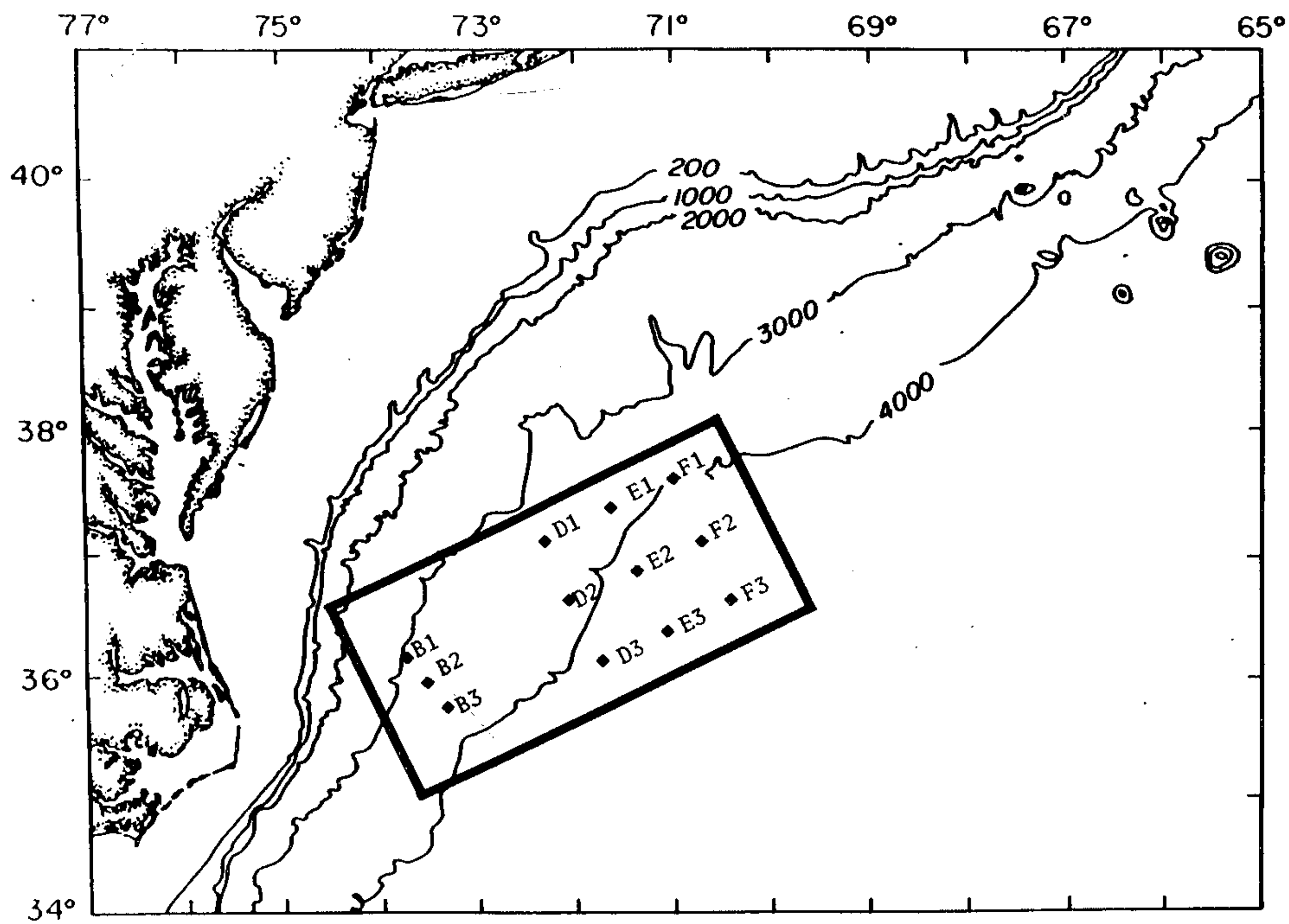


Figure 1. The Gulf Stream Dynamics Experiment Study Area. IES sites (solid squares) along lines B through F were occupied during 1982-1983. The box outlines the 200 km by 400 km region (the combined areas 1 and 2 in the inset of Figure 5), which was mapped by objective analysis (Figure 7).

Table 1. Instrument Site Locations and Data Returns.

SITE	LATITUDE (N)	LONGITUDE (W)	1982 1983 JASONDJFMA
IES83B1	36°10.48	73°43.80	XXXXX
IES83B2	35°57.18	73°32.23	XXXXX
IES83B3	35°44.07	73°19.97	XXXXX
IES83D1	37°08.03	72°19.40	XXXXXXXXXX
IES83D2	36°38.14	72°04.32	
IES83D3	36°08.55	71°44.29	XXXXXXXXXX
IES83E1	37°23.10	71°38.90	XXXXXXXXXX
IES83E2	36°53.01	71°22.00	XXXXXXXXXX
IES83E3	36°23.13	71°04.67	XXXXXXXXXX
IES83F1	37°37.49	71°00.10	XXXXXXXXXX
IES83F2	37°08.02	70°43.06	XXXXXXXXXX
IES83F3	36°38.10	70°24.81	XXXXXXXXXX

1.3 Inverted Echo Sounder Description

A detailed description of the IES is presented in Chaplin and Watts (1984) and will not be repeated here. Briefly, the IES is an instrument which is moored one meter above the ocean floor and which monitors the depth of the main thermocline acoustically. A sample burst of acoustic pulses is transmitted every half hour and the round trip travel times to the surface and back are recorded on a digital cassette tape within the instrument. For the standard IES, a sample burst typically consists of twenty 10-kHz pings. Additionally, bottom pressure and temperature can be measured and recorded; however, during this deployment period, none of the instruments were equipped with these optional sensors.

1.4 Data Processing

The raw data are recorded within the IES on Sea Data model 610 recorders. The cassette tape contains the counts associated with travel time measurements as a series of integer words of varying lengths. All processing was done on a PRIME 750 computer, except for the initial dumping of the data from the cassette tapes onto a 9-track magnetic tape. This was performed on the Hewlett Packard 2000 series computer maintained by the URI Marine Technicians. The basic processing steps, which include transcription, editing, and conversion into scientific units, are illustrated by the flowchart in Figure 2. The data processing is accomplished by a series of routines specifically developed for the IES (Tracey and Watts, 1986a) and these are outlined below.

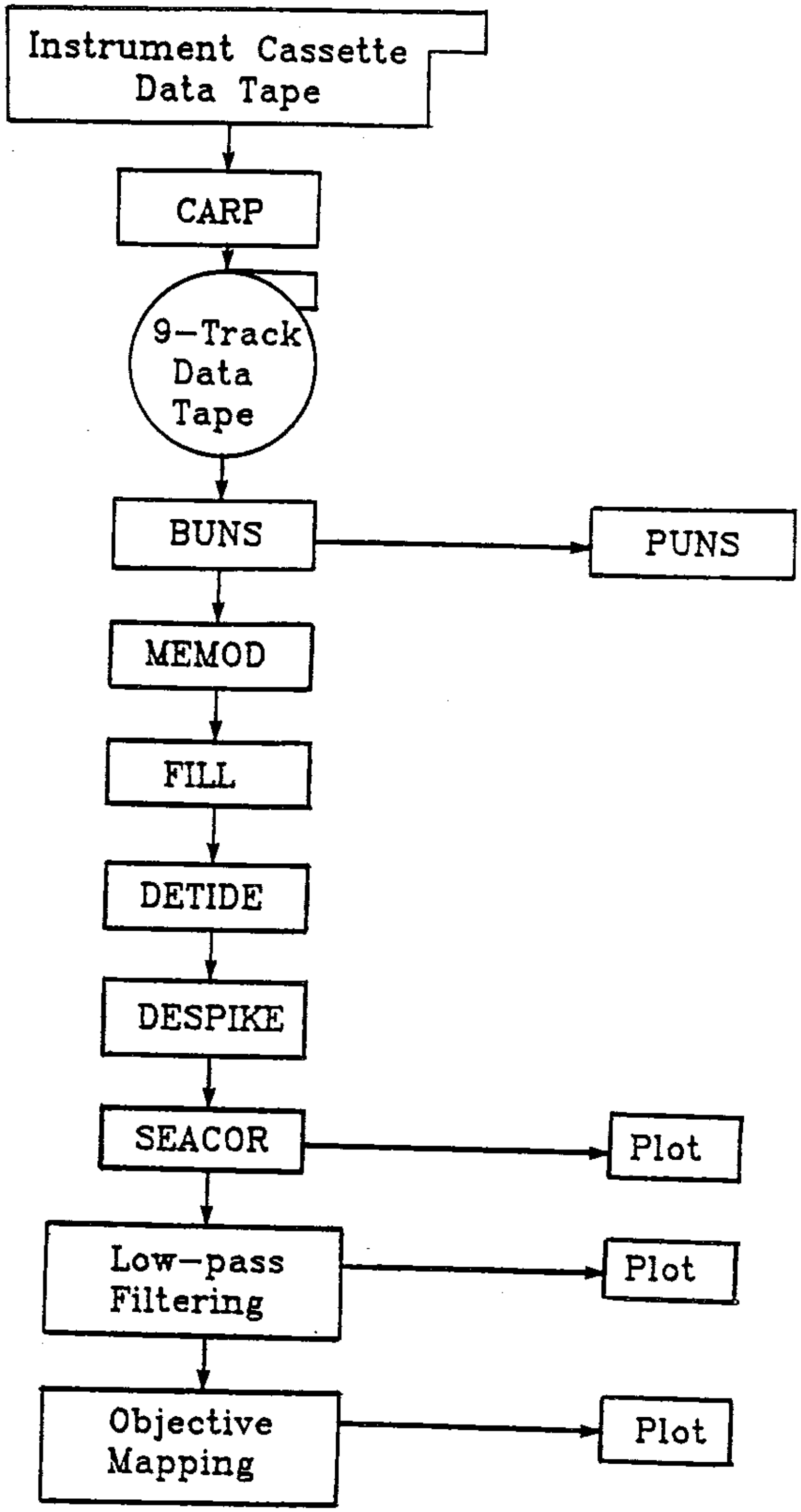


Figure 2. IES Data Processing Flowchart.

CARP: Transfers the data from cassettes to 9-track magnetic tape for subsequent processing.

BUNS: Converts the series of integer words of varying lengths into standard length 32-bit integer words.

PUNS: Produces integer listings and histograms of the travel time sample bursts. Provides an initial look at data quality and travel time distributions. Used to determine the first (after launch) and last (before recovery) 'on bottom' samples.

MEMOD: Establishes the time base. Determines either the median or modal value (at the user's option) of the travel time burst as the representative measurement. Converts all travel time counts into scientific units of seconds.

FILL: Checks for proper incrementing of the time base. Missing data points are filled by inserting interpolated values.

DETIDE: From user-supplied tidal constituents specific to each site, determines the tidal contribution to the travel times and removes it from the measured values.

DESPIKE: Identifies and replaces travel time spikes with interpolated values.

SEACOR: Removes the effects of seasonal warming and cooling of the surface layers from the travel times. Plots of the half-hourly travel times are generated.

LOW-PASS FILTERING: Convolves the travel times with a 40-hour low-pass Lanczos filter. The smoothed series are subsampled at six-hour intervals and plotted.

OBJECTIVE MAPPING: Produces daily maps of the depth of the 12°C isotherm.

The <u>FESTSA</u> time series analysis package (Brooks, 1976), modified for the PRIME 750, was used to remove the higher frequency (tidal and inertial) motions from those with periods of several days or longer, which are the main focus of this project. The symmetric filter, with a Lanczos taper, was designed with the quarter-power point at 0.025 cph and the tidal cycle attenuated by 60 db. The half-hourly travel time data (plotted in Figures 3.1-11) were low-pass filtered and the smoothed output series (40 HRLP) had sampling intervals of six hours.

1.4.1 Travel Time Calibration

Variations in the travel times have been shown to be proportional to variations in the thermocline depth (Watts and Rossby, 1977; Watts and Wimbush, 1981). Calibration XBTs were taken at each IES site in order to convert the travel times (τ) into thermocline depths (ξ) according to the relation: $\xi = M\tau + B$, where M is a scale factor and the intercept B depends on the depth of the instrument. Regressions of τ versus ξ, performed for several instruments, show that the constant value, M = -19.0 m/sec, is appropriate for all these Gulf Stream sites. The values of B used for each instrument are listed in the tables in Section 2.

For practical purposes the main thermocline depth can be represented by the depth of an individual isotherm. For this work, we have chosen the 12°C isotherm since it is situated near the highest temperature gradient of the main thermocline and correlates well with τ (Rossby, 1969; Watts and Johns, 1982). The low-pass filtered travel time records were scaled to the thermocline depths (Z_{12}) and these records are shown in Figures 4.1-4. Since τ is resolved to 0.1 msec, the 40 HRLP Z_{12} scaled values are therefore resolved to ± 2 m. However, there is a constant offset of ± 25 m for most records, which is the estimated accuracy of the intercept B. This is determined from the several calibration XBTs taken at each site.

1.4.2 Thermocline Depth Mapping

Objective maps of the thermocline (Z_{12}) field in the array region have been produced at daily intervals from these records. The boxed region in Figure 1, oriented 064°T, is the region which has been mapped.

The objective mapping techniques were developed by E. Carter (1983); special adaptations for their application to the Gulf Stream frontal zone are discussed in Watts and Tracey (1985). Two results presented in this latter work are of particular importance to the objective mapping performed here: 1) If the mean field is removed, the perturbations have essentially isotropic correlation fields. 2) The space-time correlation functions used for the objective analysis are shown.

The objective analysis is performed on the "perturbation fields", which are obtained by removing the mean field from the input data set and normalizing by the standard deviation. To represent the mean field, $\overline{Z_{12}}(x,y)$, a third order polynomial was fitted to the mean thermocline depth values observed during the July 1982 to April 1983 deployment period. The function form of the polynomial was:

$$\overline{Z_{12}}(x,y) = B_0 + B_1 x + B_2 y + B_{11} x^2 + B_{12} xy + B_{22} y^2 + B_{111} x^3 + B_{112} x^2 y + B_{122} xy^2 + B_{222} y^3$$

where (x,y) is the position in kilometers from the origin at 36°00'N, 73°30'W, B_0 is 4.555453E+02, B_1 is 7.737683E-01, B_2 is -4.613387E+00, B_{11} is -2.845196E-03, B_{12} is 1.188891E-03, B_{22} is 2.173707E-03, B_{111} is 4.411177E-06, B_{112} is -2.999912E-06, B_{122} is -3.097973E-05, and B_{222} is 1.408226E-04. The standard deviation field, $\sigma(x,y)$, was defined as a function of the mean field depth, from a Gaussian form representative of all IES records:

$$\sigma(x,y) = A + B \exp - \left[\frac{\overline{Z_{12}}(x,y) - Z_0}{C} \right]^2$$

where A is 50 m, B is (200 m - A), C is 200 m, Z_0 is 470 m, and $\overline{Z_{12}}(x,y)$ is the mean thermocline depth at that (x,y) location. Figure 5 shows both the mean and standard deviation fields in plan view.

For each output grid point, the objective mapping technique selects, from all the input data within a specified maximum time lag (T) and radial distance (R), the number of points (N) which have the highest correlations. The output fields in Figures 6 and 7 result from specifying N = 8, T = ±4 days, and R = 120 km, and using the idealized correlation function (Watts and Tracey, 1985) with an assumed noise level E = 0.05.

The output of the objective mapping is the perturbation field (Figure 7) on a full grid of points, with 20-km grid spacing, within the mapped region. The thermocline depth maps (also shown in Figure 7) are obtained by renormalizing the perturbation field by the standard deviation and restoring the mean. In this report, two different sizes of regions are mapped, depending on the locations of the instrument sites (see inset of Figure 5). These are: 1) For the period from July to November 1982, the region mapped is 200 km cross-stream by 400 km downstream. 2) From November 1982 to April 1983, it is 200 km by 240 km. The accuracy of these output fields can be obtained from the estimated error fields, which are shown in Figure 6. A detailed discussion of the accuracy is given in Watts and Tracey (1986).

1.4.3 Time Base

The date and time were assigned to each sampling period. The tables in Section 2 report the hour, minutes, and seconds associated with the first and last sampling period as a six-digit number. All times are given as Greenwich Mean Time (GMT). For processing convenience, the times were converted into yearhours. Table 2 lists the yearhour which corresponds to 0000 GMT of each day for non-leap years. (For leap years, the yearhours can be determined by adding 24 to each day after February 28.) There are a total of 8760 hours in a standard (non-leap) year and 8784 hours in a leap year. The yearhours given in this report are referenced to 0000 GMT on January 1, 1983, with measurements occurring between January and April 1983 assigned positive yearhours. Negative values correspond to sampling periods occurring during July through December 1982.

1.5 Data Recovery

Table 1 summarizes the data returns from each of the inverted echo sounders. Of the twelve instruments deployed, all but one, IES83D2, were recovered, giving an instrument recovery rate of 92%. The travel time detectors on the eleven recovered instruments performed successfully, resulting in a 92% data return rate.

Table 2. Yearhour Calendar for Non-Leap Years. Only the yearhour corresponding to 0000 GMT is listed for each day.

JAN			FEB			MAR			APR			MAY			JUNE		
DATE	YEAR DAY	HOUR (0000Z)	DATE	YEAR DAY	HOUR (0000Z)	DATE	YEAR DAY	HOUR (0000Z)	DATE	YEAR DAY	HOUR (0000Z)	DATE	YEAR DAY	HOUR (0000Z)	DATE	YEAR DAY	HOUR (0000Z)
1	1	0	1	32	744	1	60	1416	1	91	2160	1	121	2880	1	152	3624
2	2	24	2	33	768	2	61	1440	2	92	2184	2	122	2904	2	153	3648
3	3	48	3	34	792	3	62	1464	3	93	2208	3	123	2928	3	154	3672
4	4	72	4	35	816	4	63	1488	4	94	2232	4	124	2952	4	155	3696
5	5	96	5	36	840	5	64	1512	5	95	2256	5	125	2976	5	156	3720
6	6	120	6	37	864	6	65	1536	6	96	2280	6	126	3000	6	157	3744
7	7	144	7	38	888	7	66	1560	7	97	2304	7	127	3024	7	158	3768
8	8	168	8	39	912	8	67	1584	8	98	2328	8	128	3048	8	159	3792
9	9	192	9	40	936	9	68	1608	9	99	2352	9	129	3072	9	160	3816
10	10	216	10	41	960	10	69	1632	10	100	2376	10	130	3096	10	161	3840
11	11	240	11	42	984	11	70	1656	11	101	2400	11	131	3120	11	162	3864
12	12	264	12	43	1008	12	71	1680	12	102	2424	12	137	3144	12	163	3888
13	13	288	13	44	1032	13	72	1704	13	103	2448	13	133	3168	13	164	3912
14	14	312	14	45	1056	14	73	1728	14	104	2472	14	134	3192	14	165	3936
15	15	336	15	46	1080	15	74	1752	15	105	2496	15	135	3216	15	166	3960
16	16	360	16	47	1104	16	75	1776	16	106	2520	16	136	3240	16	167	3984
17	17	384	17	48	1128	17	76	1800	17	107	2544	17	137	3264	17	168	4008
18	18	408	18	49	1152	18	77	1824	18	108	2568	18	138	3288	18	169	4032
19	19	432	19	50	1176	19	78	1848	19	109	2592	19	139	3312	19	170	4056
20	20	456	20	51	1200	20	79	1872	20	110	2616	20	140	3336	20	171	4080
21	21	480	21	52	1224	21	80	1896	21	111	2640	21	141	3360	21	172	4104
22	22	504	22	53	1248	22	81	1920	22	112	2664	22	142	3384	22	173	4128
23	23	528	23	54	1272	23	82	1944	23	113	2688	23	143	3408	23	174	4152
24	24	552	24	55	1296	24	83	1968	24	114	2712	24	144	3432	24	175	4176
25	25	576	25	56	1320	25	84	1992	25	115	2736	25	145	3456	25	176	4200
26	26	600	26	57	1344	26	95	2016	26	116	2760	26	146	3480	26	177	4224
27	27	624	27	58	1368	27	86	2040	27	117	2784	27	147	3504	27	178	4248
28	28	648	28	59	1392	28	87	2064	28	118	2808	28	148	3528	28	179	4272
29	29	672				29	88	2088	29	119	2832	29	149	3552	29	180	4296
30	30	696				30	89	2112	30	120	2856	30	150	3576	30	181	4320
31	31	720				31	90	2136				31	151	3600			

JULY			AUG			SEPT			OCT			NOV			DEC		
DATE	YEAR DAY	HOUR (0000Z)	DATE	YEAR DAY	HOUR (0000Z)	DATE	YEAR DAY	HOUR (0000Z)	DATE	YEAR DAY	HOUR (0000Z)	DATE	YEAR DAY	HOUR (0000Z)	DATE	YEAR DAY	HOUR (0000Z)
1	182	4344	1	213	5088	1	244	5832	1	274	6552	1	305	7296	1	335	8016
2	183	4368	2	214	5112	2	245	5856	2	275	6576	2	306	7320	2	336	8040
3	184	4392	3	215	5136	3	246	5880	3	276	6600	3	307	7344	3	337	8064
4	185	4416	4	216	5160	4	247	5904	4	277	6624	4	308	7368	4	338	8088
5	186	4440	5	217	5184	5	248	5928	5	278	6648	5	309	7392	5	339	8112
6	187	4464	6	218	5208	6	249	5952	6	279	6672	6	310	7416	6	340	8136
7	188	4488	7	219	5232	7	250	5976	7	280	6696	7	311	7440	7	341	8160
8	189	4512	8	220	5256	8	251	6000	8	281	6720	8	312	7464	8	342	8184
9	190	4536	9	221	5280	9	252	6024	9	282	6744	9	313	7488	9	343	8208
10	191	4560	10	222	5304	10	253	6048	10	283	6768	10	314	7512	10	344	8232
11	192	4584	11	223	5328	11	254	6072	11	284	6792	11	315	7536	11	345	8256
12	193	4608	12	224	5352	12	255	6096	12	285	6816	12	316	7560	12	346	8280
13	194	4632	13	225	5376	13	256	6120	13	286	6840	13	317	7584	13	347	8304
14	195	4656	14	226	5400	14	257	6144	14	287	6864	14	318	7608	14	348	8328
15	196	4680	15	227	5424	15	258	6168	15	288	6888	15	319	7632	15	349	8352
16	197	4704	16	228	5448	16	259	6192	16	289	6912	16	320	7656	16	350	8376
17	198	4728	17	229	5472	17	260	6216	17	290	6936	17	321	7680	17	351	8400
18	199	4752	18	230	5496	18	261	6240	18	291	6960	18	322	7704	18	352	8424
19	200	4776	19	231	5520	19	262	6264	19	292	6984	19	323	7728	19	353	8448
20	201	4800	20	232	5544	20	263	6288	20	293	7008	20	324	7752	20	354	8472
21	202	4824	21	233	5568	21	264	6312	21	294	7032	21	325	7776	21	355	8496
22	203	4848	22	234	5592	22	265	6336	22	295	7056	22	326	7800	22	356	8520
23	204	4872	23	235	5616	23	266	6360	23	296	7080	23	327	7824	23	357	8544
24	205	4896	24	236	5640	24	267	6384	24	297	7104	24	328	7848	24	358	8568
25	206	4920	25	237	5664	25	268	6408	25	298	7128	25	329	7872	25	359	8592
26	207	4944	26	238	5688	26	269	6432	26	299	7152	26	330	7896	26	360	8616
27	208	4968	27	239	5712	27	270	6456	27	300	7176	27	331	7920	27	361	8640
28	209	4992	28	240	5736	28	271	6480	28	301	7200	28	332	7944	28	362	8664
29	210	5016	29	241	5760	29	272	6504	29	302	7224	29	333	7968	29	363	8688
30	211	5040	30	242	5784	30	273	6528	30	303	7248	30	334	7992	30	364	8712
31	212	5064	31	243	5808				31	304	7272				31	364	8736

SECTION 2

Individual Site and Record Information Tables

The following tables provide information about the location, dates, and basic statistics of the data records. Each table documents a single instrument site.

General site information, such as position, bottom depth, and launch and recovery times, are given first. Subsequently, details about the travel time and thermocline depth records plotted in Sections 3 and 4 are tabulated. For each plot, the times associated with the first and last data point are supplied. All yearhours are referenced to 0000 GMT on January 1, 1983 as indicated by the two-digit number, 83, of the site name. Measurements made during the calendar year prior to the reference date are given as negative yearhours.

The first order statistics (minimum, maximum, mean, and standard deviation) were calculated for the half-hourly travel time and the 40 HRLP Z_{12} records. These are also presented in the following tables.

Table 3. Site and Record Information for IES83B1

Serial Number: 023
Type of Travel Time Detector: TTB
Number of Pings per Sampling: 20
Additional Sensors: None

Position: 36°10.48 N, 73°43.80 W   Depth: 3055 m

	DATE	GMT	CRUISE
LAUNCH:	Jul 16, 1982	0550	EN087
RECOVERY:	Nov 24, 1982	1110	EN092

TRAVEL TIME RECORDS
(Fig. 3.1)

	DATE	GMT	YEARHOUR
1st DATA POINT:	Jul 16, 1982	070626	-4048.8929
LAST DATA POINT:	Nov 24, 1982	110323	-900.9436

Number of Points: 6297
Sampling Interval: 0.49999195 hrs

Minimum τ = 4.06140 s
Maximum τ = 4.07756 s
Mean = 4.07042 s
Standard deviation = 0.00303 s

40 HRLP THERMOCLINE DEPTH RECORDS
(Fig. 4.1)

Z_{12} Conversion equation: $Z_{12} = (-19000 ms^{-1}) (\tau_d) + B$
where B = 77598.82 m
τ_d = Travel Time (sec) with tide removed

	DATE	GMT	YEARHOUR
1st DATA POINT:	Jul 17, 1982	180000	-4014.00
LAST DATA POINT:	Nov 23, 1982	000000	-936.00

Number of Points: 514
Sampling Interval: 6.00 hrs

Minimum Z_{12} = 160.63 m
Maximum Z_{12} = 419.01 m
Mean = 260.81 m
Standard Deviation = 55.79 m

Table 4. Site and Record Information for IES83B2

Serial Number: 017
Type of Travel Time Detector: TTB
Number of Pings per Sampling: 20
Additional Sensors: None

Position: 35°57.18 N, 73°32.23 W   Depth: 3380 m

	DATE	GMT	CRUISE
LAUNCH	Jul 18, 1982	0057	EN087
RECOVERY:	Nov 24, 1982	0800	EN092

TRAVEL TIME RECORDS
(Fig. 3.2)

	DATE	GMT	YEARHOUR
1st DATA POINT:	Jul 18, 1982	015626	-4006.0594
LAST DATA POINT:	Nov 24, 1982	075626	-904.0594

Number of Points: 6205
Sampling Interval: 0.50 hrs

Minimum τ = 4.51400 s   Mean= 4.52148 s
Maximum τ = 4.53285 s   Standard Deviation = 0.00317 s

40 HRLP THERMOCLINE DEPTH RECORDS
(Fig. 4.1)

Z_{12} Conversion equation: $Z_{12} = (-19000 ms^{-1})(\tau_d) + B$
where B = 86375.86 m
τ_d = Travel Time (sec) with tide removed

	DATE	GMT	YEARHOUR
1st DATA POINT:	Jul 19, 1982	120000	-3972.00
LAST DATA POINT:	Nov 23, 1982	000000	-936.00

Number of Points: 507
Sampling Interval: 6.00 hrs

Minimum Z_{12} = 292.42 m   Mean = 466.81 m
Maximum Z_{12} = 595.13 m   Standard Deviation = 59.16 m

Table 5. Site and Record Information for
IES83B3

Serial Number: 014
Type of Travel Time Detector: TTB
Number of Pings per Sampling: 20
Additional Sensors: None

Position: 35°44.07 N Depth: 3695 m
73°19.97 W

	DATE	GMT	CRUISE
LAUNCH:	Jul 17, 1982	2238	EN087
RECOVERY:	Nov 24, 1982	0456	EN092

TRAVEL TIME RECORDS
(Fig. 3.3)

	DATE	GMT	YEARHOUR
1st DATA POINT:	Jul 17, 1982	232122	-4008.6440
LAST DATA POINT:	Nov 24, 1982	045122	-907.1440

Number of Points: 6204
Sampling Interval: 0.50 hrs

Minimum τ = 4.93478 s
Maximum τ = 4.94447 s

Mean = 4.93817 s
Standard Deviation = 0.00145 s

40 HRLP THERMOCLINE DEPTH RECORDS
(Fig. 4.1)

Z_{12} Conversion equation: $Z_{12} = (-19000\text{ms}^{-1})(\tau_d) + B$
where B = 94483.66 m
τ_d = Travel Time (sec) with tide removed

	DATE	GMT	YEARHOUR
1st DATA POINT:	Jul 19, 1982	060000	-3978.00
LAST DATA POINT:	Nov 22, 1982	180000	-942.00

Number of Points: 507
Sampling Interval: 6.00 hrs

Minimum Z_{12} = 570.52 m
Maximum Z_{12} = 712.43 m

Mean = 658.03 m
Standard Deviation = 26.49 m

Table 6. Site and Record Information for IES83D1

Serial Number: 022
Type of Travel Time Detector: TTB
Number of Pings per Sampling: 20
Additional Sensors: None

Position: 37°08.03 N, 72°19.40 W — Depth: 3350 m

	DATE	GMT	CRUISE
LAUNCH:	Jul 13, 1982	1528	EN087
RECOVERY:	Apr 19, 1983	0530	CI8304

TRAVEL TIME RECORDS
(Fig. 3.4)

	DATE	GMT	YEARHOUR
1st DATA POINT:	Jul 13, 1982	162352	-4111.6022
LAST DATA POINT:	Apr 19, 1983	052352	2597.3978

Number of Points: 13419
Sampling Interval: 0.50 hrs

Minimum τ = 4.44954 s
Maximum τ = 4.47715 s
Mean = 4.46807 s
Standard Deviation = 0.00687 s

40 HRLP THERMOCLINE DEPTH RECORDS
(Fig. 4.2)

Z_{12} Conversion equation: $Z_{12} = (-19000 \text{ms}^{-1})(\tau_d) + B$
where B = 85165.29 m
τ_d = Travel Time (sec) with tide removed

	DATE	GMT	YEARHOUR
1st DATA POINT:	Jul 15, 1982	000000	-4080.00
LAST DATA POINT:	Apr 18, 1983	000000	2568.00

Number of Points: 1109
Sampling Interval: 6.00 hrs

Minimum Z_{12} = 124.42 m
Maximum Z_{12} = 606.17 m
Mean = 272.47 m
Standard Deviation = 129.77 m

Table 7. Site and Record Information for **IES83D3**

Serial Number: 020
Type of Travel Time Detector: TTB
Number of Pings per Sampling: 20
Additional Sensors: None

Position: 36°08.55 N, 71°44.29 W   Depth: 4120 m

	DATE	GMT	CRUISE
LAUNCH:	Jul 13, 1982	0636	EN087
RECOVERY:	Apr 18, 1983	1618	CI8304

TRAVEL TIME RECORDS
(Fig. 3.5)

	DATE	GMT	YEARHOUR
1st DATA POINT:	Jul 13, 1982	074559	-4120.2336
LAST DATA POINT:	Apr 18, 1983	161559	2584.2664

Number of Points: 13410
Sampling Interval: 0.50 hrs

Minimum τ = 5.47855 s
Maximum τ = 5.51288 s
Mean = 5.48876 s
Standard Deviation = 0.00456 s

40 HRLP THERMOCLINE DEPTH RECORDS
(Fig. 4.2)

Z_{12} Conversion equation: $Z_{12} = (-19000 \mathrm{ms}^{-1})(\tau_d) + B$
where B = 105002.78 m
τ_d = Travel Time (sec) with tide removed

	DATE	GMT	YEARHOUR
1st DATA POINT:	Jul 14, 1982	180000	-4086.00
LAST DATA POINT:	Apr 17, 1988	060000	2550.00

Number of Points: 1107
Sampling Interval: 6.00 hrs

Minimum Z_{12} = 274.22 m
Maximum Z_{12} = 892.29 m
Mean = 717.38 m
Standard Deviation = 84.10 m

Table 8. Site and Record Information for
IES83E1

Serial Number: 019
Type of Travel Time Detector: TTB
Number of Pings per Sampling: 20
Additional Sensors: None

Position: 37°23.10 N, 71°38.90 W   Depth: 3580 m

	DATE	GMT	CRUISE
LAUNCH:	Jul 7, 1982	0745	EN087
RECOVERY:	Apr 23, 1983	0051	CI8304

TRAVEL TIME RECORDS
(Fig. 3.6)

	DATE	GMT	YEARHOUR
1st DATA POINT:	Jul 7, 1982	084254	-4263.2850
LAST DATA POINT:	Apr 23, 1983	004254	2688.7150

Number of Points: 13905
Sampling Interval: 0.50 hrs

Minimum τ = 4.75087 s
Maximum τ = 4.77657 s

Mean = 4.76790 s
Standard Deviation = 0.00598 s

40 HRLP THERMOCLINE DEPTH RECORDS
(Fig. 4.3)

Z_{12} Conversion equation: $Z_{12} = (-19000 ms^{-1})(\tau_d) + B$
where B = 90855.44 m
τ_d = Travel Time (sec) with tide removed

	DATE	GMT	YEARHOUR
1st DATA POINT:	Jul 8, 1982	180000	-4230.00
LAST DATA POINT:	Apr 21, 1983	180000	2658.00

Number of Points: 1149
Sampling Interval: 6.00 hrs

Minimum Z_{12} = 117.29 m
Maximum Z_{12} = 575.92 m

Mean = 265.93 m
Standard Deviation = 112.34 m

Table 9. Site and Record Information for
IES83E2

Serial Number: 016
Type of Travel Time Detector: TTB
Number of Pings per Sampling: 20
Additional Sensors: None

Position: 36°53.01 N, 71°22.00 W   Depth: 4105 m

	DATE	GMT	CRUISE
LAUNCH:	Jul 7, 1982	0344	EN087
RECOVERY:	Apr 22, 1983	1824	CI8304

TRAVEL TIME RECORDS
(Fig. 3.7)

	DATE	GMT	YEARHOUR
1st DATA POINT:	Jul 7, 1982	044123	-4267.3103
LAST DATA POINT:	Apr 22, 1983	181123	2682.1897

Number of Points: 13900
Sampling Interval: 0.50 hrs

Minimum τ = 5.44679 s
Maximum τ = 5.48201 s
Mean = 5.45876 s
Standard Deviation = 0.01003 s

40 HRLP THERMOCLINE DEPTH RECORDS
(Fig. 4.3)

Z_{12} Conversion equation: $Z_{12} = (-19000 ms^{-1}) (\tau_d) + B$
where B = 104257.16 m
τ_d = Travel Time (sec) with tide removed

	DATE	GMT	YEARHOUR
1st DATA POINT:	Jul 8, 1982	120000	-4236.00
LAST DATA POINT:	Apr 21, 1983	120000	2652.00

Number of Points: 1149
Sampling Interval: 6.00 hrs

Minimum Z_{12} = 119.75 m
Maximum Z_{12} = 752.99 m
Mean = 542.99 m
Standard Deviation = 187.89 m

Table 10. Site and Record Information for
IES83E3

Serial Number: 015
Type of Travel Time Detector: TTB
Number of Pings per Sampling: 20
Additional Sensors: None

Position: 36°23.13 N   Depth: 4315 m
71°04.67 W

	DATE	GMT	CRUISE
LAUNCH:	Jul 6, 1982	2349	EN087
RECOVERY:	Apr 22, 1983	1139	CI8304

TRAVEL TIME RECORDS
(Fig. 3.8)

	DATE	GMT	YEARHOUR
1st DATA POINT:	Jul 6, 1982	003643	-4271.3881
LAST DATA POINT:	Apr 22, 1983	113643	2675.6119

Number of Points: 13895
Sampling Interval: 0.50 hrs

Minimum τ = 5.69466 s   Mean = 5.70510 s
Maximum τ = 5.73179 s   Standard Deviation = 0.00692 s

40 HRLP THERMOCLINE DEPTH RECORDS
(Fig. 4.3)

Z_{12} Conversion equation: $Z_{12} = (-19000 ms^{-1})(\tau_d) + B$
where B = 109132.51 m
τ_d = Travel Time (sec) with tide removed

	DATE	GMT	YEARHOUR
1st DATA POINT:	Jul 8, 1982	060000	-4242.00
LAST DATA POINT:	Apr 21, 1983	060000	2646.00

Number of Points: 1149
Sampling Interval: 6.00 hrs

Minimum Z_{12} = 237.74 m   Mean = 736.82 m
Maximum Z_{12} = 918.35 m   Standard Deviation = 129.19 m

Table 11. Site and Record Information for IES83F1

Serial Number: 005
Type of Travel Time Detector: TTB
Number of Pings per Sampling: 20
Additional Sensors: None

Position: 37°37.49 N, 71°00.10 W   Depth: 3970 m

	DATE	GMT	CRUISE
LAUNCH:	Jul 6, 1982	0817	EN087
RECOVERY:	Apr 21, 1983	1258	CI8304

TRAVEL TIME RECORDS
(Fig. 3.9)

	DATE	GMT	YEARHOUR
1st DATA POINT:	Jul 6, 1982	092612	-4286.5633
LAST DATA POINT:	Apr 21, 1983	122612	2652.4367

Number of Points: 13879
Sampling Interval: 0.50 hrs

Minimum τ = 5.27554 s
Maximum τ = 5.30192 s
Mean = 5.29418 s
Standard Deviation = 0.00548 s

40 HRLP THERMOCLINE DEPTH RECORDS
(Fig. 4.4)

Z_{12} Conversion equation: $Z_{12} = (-19000\text{ms}^{-1})(\tau_d) + B$
where B = 100840.10 m
τ_d = Travel Time (sec) with tide removed

	DATE	GMT	YEARHOUR
1st DATA POINT:	Jul 7, 1982	180000	-4254.00
LAST DATA POINT:	Apr 20, 1983	060000	2622.00

Number of Points: 1147
Sampling Interval: 6.00 hrs

Minimum Z_{12} = 127.73 m
Maximum Z_{12} = 583.26 m
Mean = 250.88 m
Standard Deviation = 102.89 m

Table 12. Site and Record Information for **IES83F2**

Serial Number: 011
Type of Travel Time Detector: TTB
Number of Pings per Sampling: 20
Additional Sensors: None

Position: 37°08.02 N, 70°43.06 W — Depth: 4220 m

	DATE	GMT	CRUISE
LAUNCH:	Jul 6, 1982	1236	EN087
RECOVERY:	Apr 21, 1983	2054	CI8304

TRAVEL TIME RECORDS
(Fig. 3.10)

	DATE	GMT	YEARHOUR
1st DATA POINT:	Jul 6, 1982	130050	-4281.9861
LAST DATA POINT:	Apr 21, 1983	203050	2660.5139

Number of Points: 13886
Sampling Interval: 0.50 hrs

Minimum τ = 5.58430 s
Maximum τ = 5.61933 s
Mean = 5.59733 s
Standard Deviation = 0.00984 s

40 HRLP THERMOCLINE DEPTH RECORDS
(Fig. 4.4)

Z_{12} Conversion equation: $Z_{12} = (-19000 ms^{-1})(\tau_d) + B$
where $B = 106884.81$ m
τ_d = Travel Time (sec) with tide removed

	DATE	GMT	YEARHOUR
1st DATA POINT:	Jul 8, 1982	000000	-4248.00
LAST DATA POINT:	Apr 20, 1983	120000	2628.00

Number of Points: 1147
Sampling Interval: 6.00 hrs

Minimum Z_{12} = 134.69 m
Maximum Z_{12} = 769.85 m
Mean = 536.83 m
Standard Deviation = 185.82 m

Table 13. Site and Record Information for
IES83F3

Serial Number: 012
Type of Travel Time Detector: TTB
Number of Pings per Sampling: 20
Additional Sensors: None

Position: 36°38.10 N   Depth: 4380 m
70°24.81 W

	DATE	GMT	CRUISE
LAUNCH:	Jul 6, 1982	1826	EN087
RECOVERY:	Apr 22, 1983	0408	CI8304

TRAVEL TIME RECORDS
(Fig. 3.11)

	DATE	GMT	YEARHOUR
1st DATA POINT:	Jul 6, 1982	193331	-4276.4414
LAST DATA POINT:	Apr 22, 1983	040331	2668.0586

Number of Points: 13890
Sampling Interval: 0.50 hrs

Minimum τ = 5.83357 s   Mean = 5.84270 s
Maximum τ = 5.86739 s   Standard Deviation = 0.00562 s

40 HRLP THERMOCLINE DEPTH RECORDS
(Fig. 4.4)

Z_{12} Conversion equation: $Z_{12} = (-19000\text{ms}^{-1})(\tau_d) + B$
where B = 111763.74 m
τ_d = Travel Time (sec) with tide removed

	DATE	GMT	YEARHOUR
1st DATA POINT:	Jul 8, 1982	060000	-4242.00
LAST DATA POINT:	Apr 20, 1983	180000	2634.00

Number of Points: 1147
Sampling Interval: 6.00 hrs

Minimum Z_{12} = 329.05 m   Mean = 752.75 m
Maximum Z_{12} = 916.64 m   Standard Deviation = 105.80 m

SECTION 3

Half-hourly Travel Time Data For Each Instrument

Plots of the travel time records from each instrument are presented. The time scale is the same for all plots, with each increment corresponding to 5 days. The axis begins on 0000 GMT of the first date labelled.

The vertical scale is consistent between instruments, with each increment corresponding to 5 msec for the travel time records.

The sampling interval is nominally 0.5 hours; the actual interval for each instrument is given in the tables of Section 2. The length and the start and end times of the data records are also given in these tables.

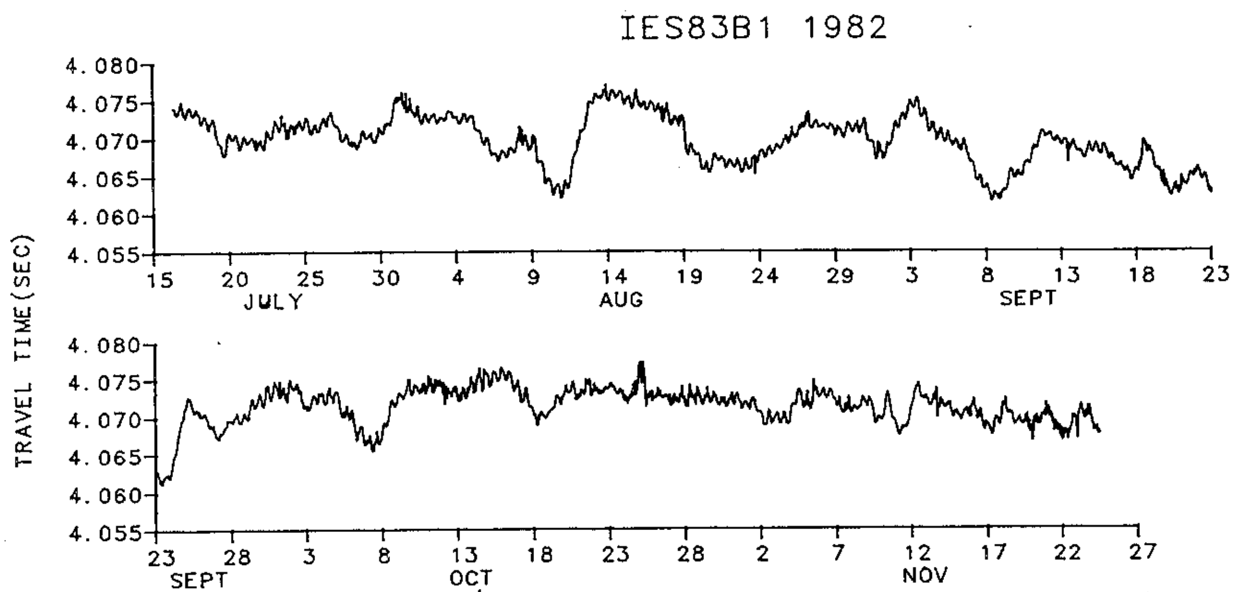


Figure 3.1

Figure 3.1-11. Full travel time records for each IES at half-hourly intervals.

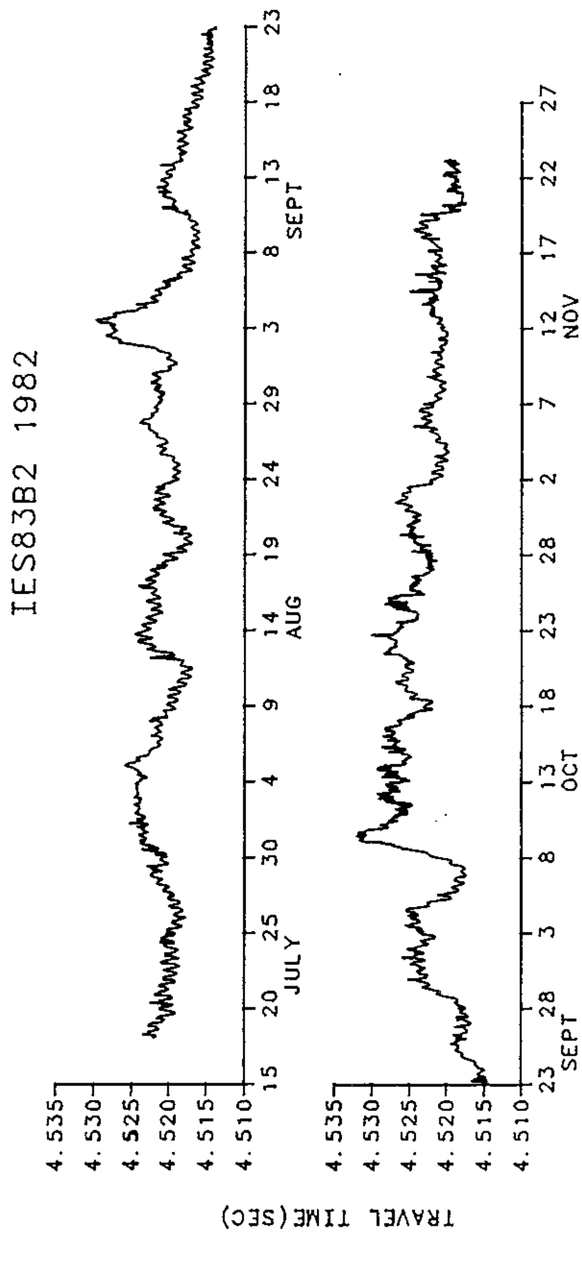

IES83B2 1982
TRAVEL TIME(SEC)
4.535
4.530
4.525
4.520
4.515
4.510
15 20 25 30 4 9 14 19 24 29 3 8 13 18 23
JULY
AUG
SEPT
23 28 3 8 13 18 23 28 2 7 12 17 22 27
SEPT
OCT
NOV

Figure 3.2

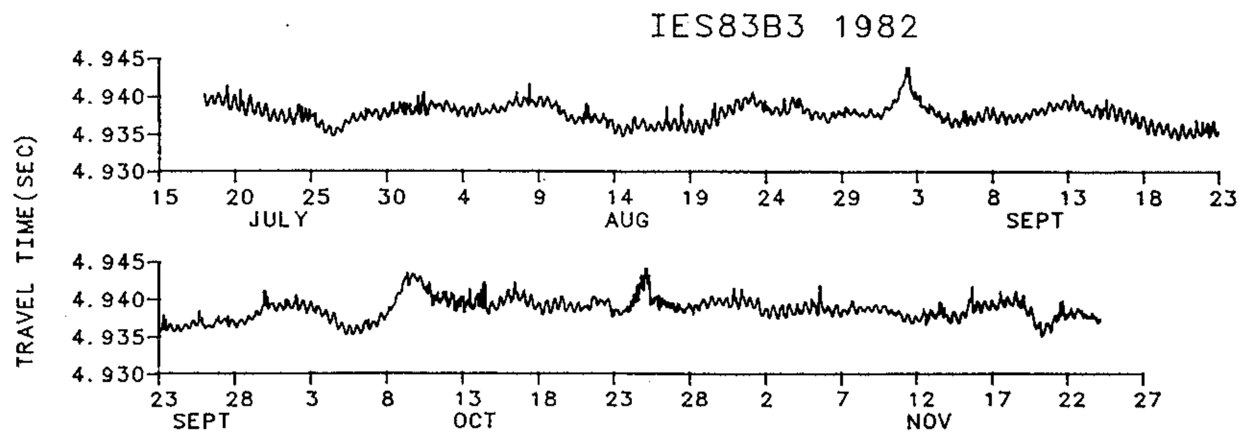

IES83B3 1982
TRAVEL TIME (SEC)
4.945
4.940
4.935
4.930
15
20
25
30
4
9
14
19
24
29
3
8
13
18
23
JULY
AUG
SEPT
4.945
4.940
4.935
4.930
23
28
3
8
13
18
23
28
2
7
12
17
22
27
SEPT
OCT
NOV

Figure 3.3

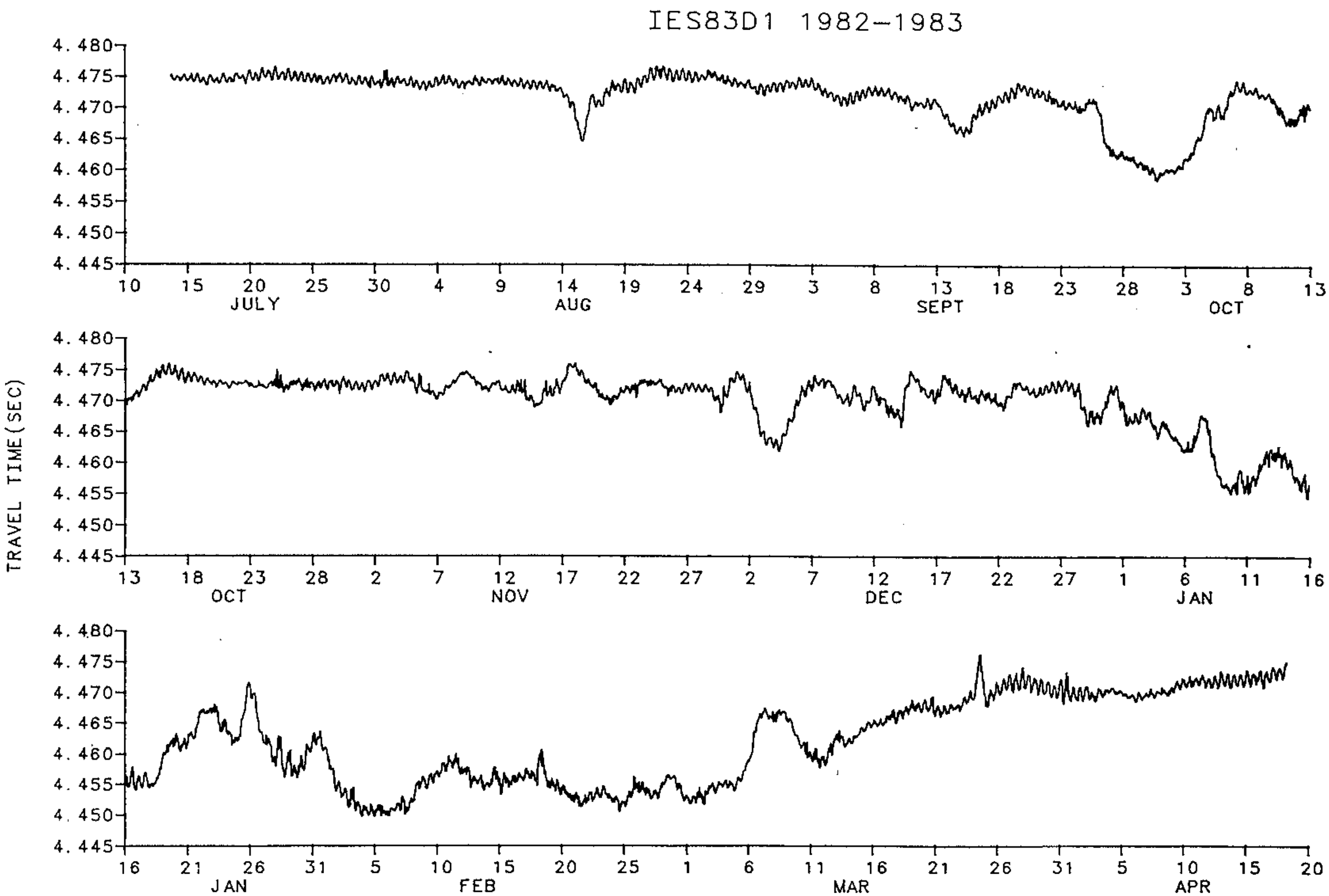

IES83D1 1982–1983
TRAVEL TIME (SEC)
4.480
4.475
4.470
4.465
4.460
4.455
4.450
4.445
10 15 20 25 30 4 9 14 19 24 29 3 8 13 18 23 28 3 8 13
JULY AUG SEPT OCT
13 18 23 28 2 7 12 17 22 27 2 7 12 17 22 27 1 6 11 16
OCT NOV DEC JAN
16 21 26 31 5 10 15 20 25 1 6 11 16 21 26 31 5 10 15 20
JAN FEB MAR APR

Figure 3.4

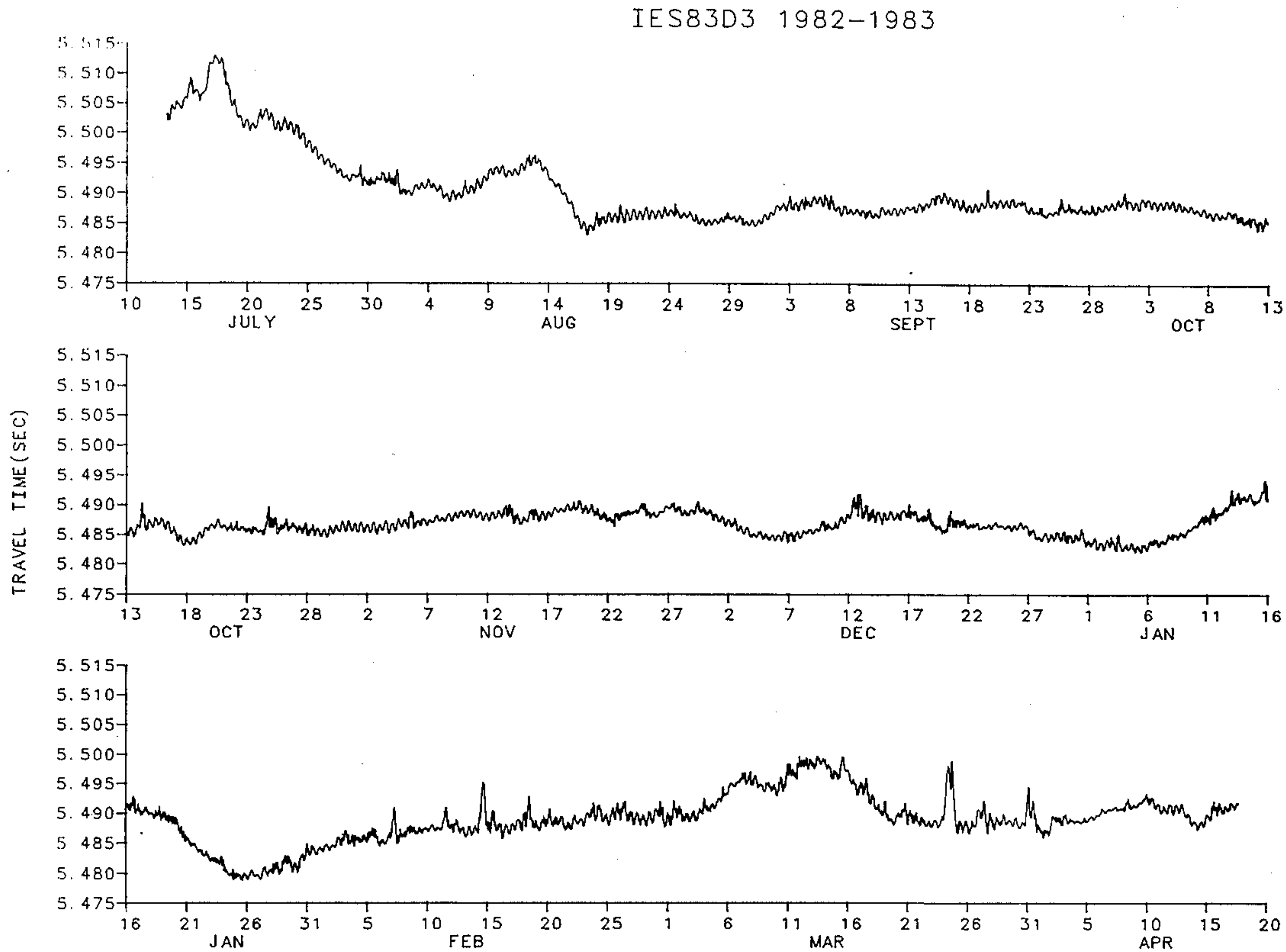

IES83D3 1982-1983
TRAVEL TIME(SEC)
5.515
5.510
5.505
5.500
5.495
5.490
5.485
5.480
5.475
10 15 20 25 30 4 9 14 19 24 29 3 8 13 18 23 28 3 8 13
JULY
AUG
SEPT
OCT
13 18 23 28 2 7 12 17 22 27 2 7 12 17 22 27 1 6 11 16
OCT
NOV
DEC
JAN
16 21 26 31 5 10 15 20 25 1 6 11 16 21 26 31 5 10 15 20
JAN
FEB
MAR
APR

Figure 3.5

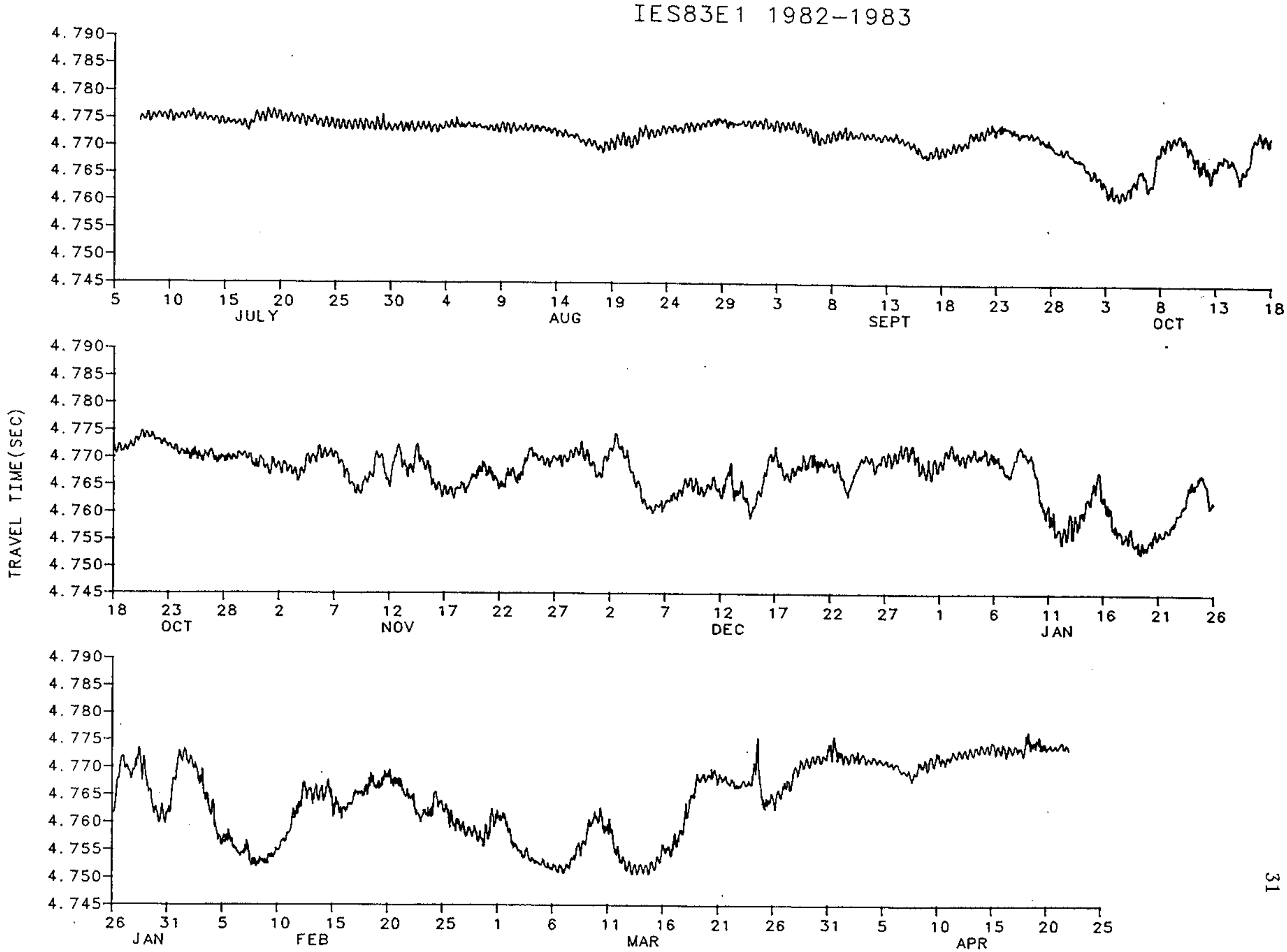
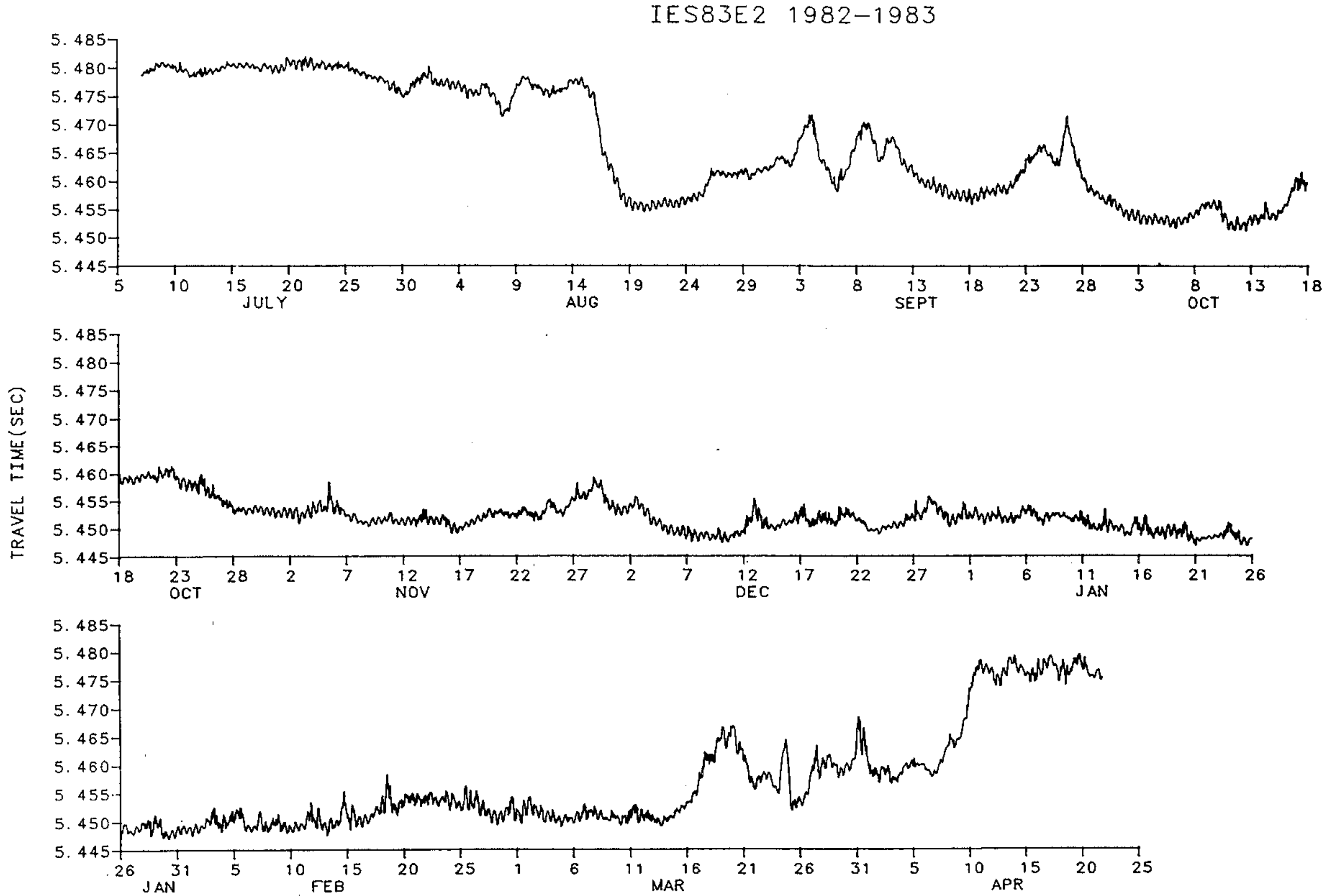

IES83E1 1982-1983
TRAVEL TIME(SEC)
4.790
4.785
4.780
4.775
4.770
4.765
4.760
4.755
4.750
4.745
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
MAR
APR

Figure 3.6



IES83E2 1982–1983
TRAVEL TIME(SEC)
5.485
5.480
5.475
5.470
5.465
5.460
5.455
5.450
5.445
5 10 15 20 25 30 4 9 14 19 24 29 3 8 13 18 23 28 3 8 13 18
JULY
AUG
SEPT
OCT
18 23 28 2 7 12 17 22 27 2 7 12 17 22 27 1 6 11 16 21 26
OCT
NOV
DEC
JAN
26 31 5 10 15 20 25 1 6 11 16 21 26 31 5 10 15 20 25
JAN
FEB
MAR
APR

Figure 3.7

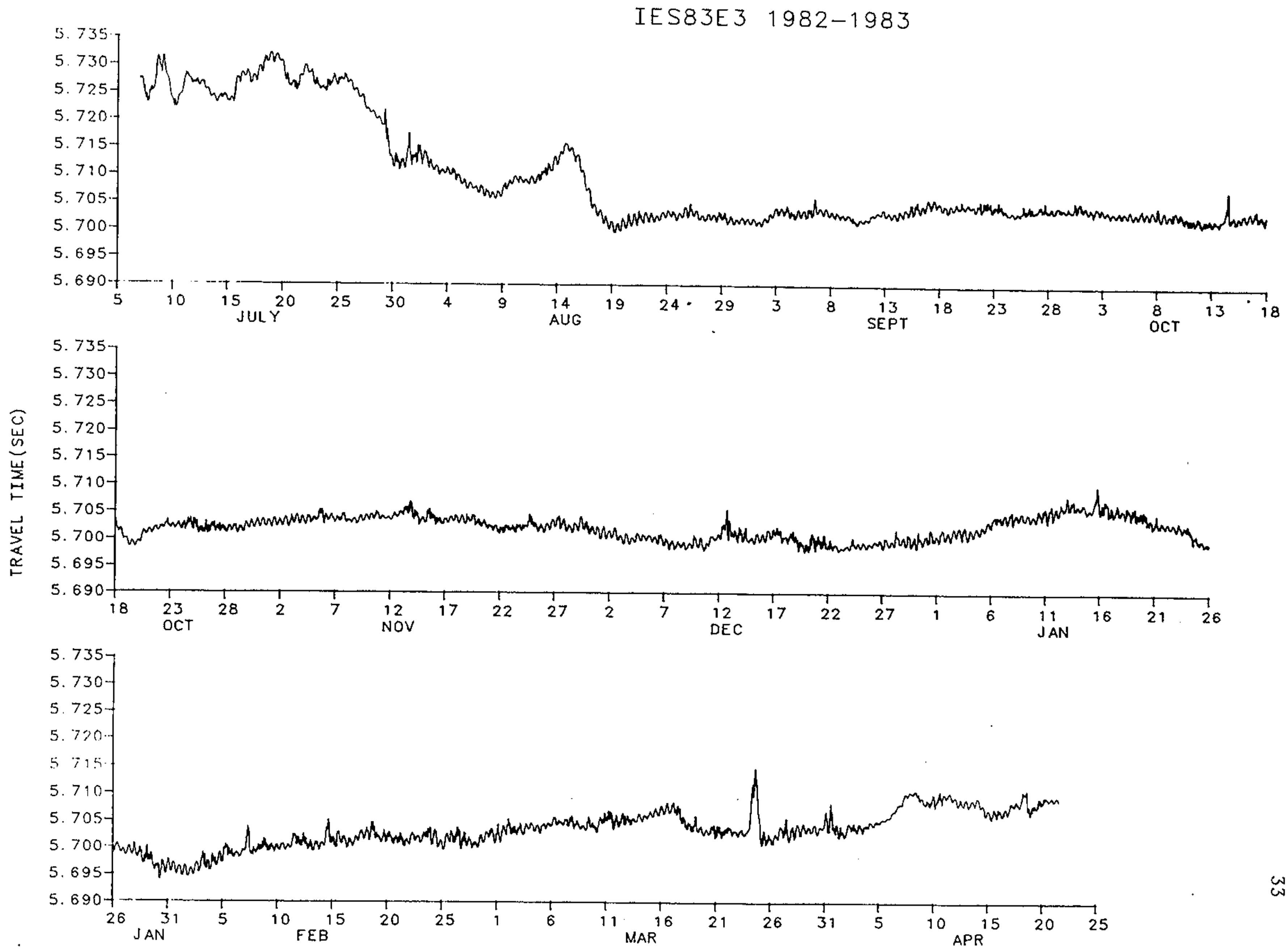

IES83E3 1982–1983
TRAVEL TIME(SEC)
5.735
5.730
5.725
5.720
5.715
5.710
5.705
5.700
5.695
5.690
5 10 15 20 25 30 4 9 14 19 24 29 3 8 13 18 23 28 3 8 13 18
JULY
AUG
SEPT
OCT
18 23 28 2 7 12 17 22 27 2 7 12 17 22 27 1 6 11 16 21 26
OCT
NOV
DEC
JAN
26 31 5 10 15 20 25 1 6 11 16 21 26 31 5 10 15 20 25
JAN
FEB
MAR
APR

Figure 3.8

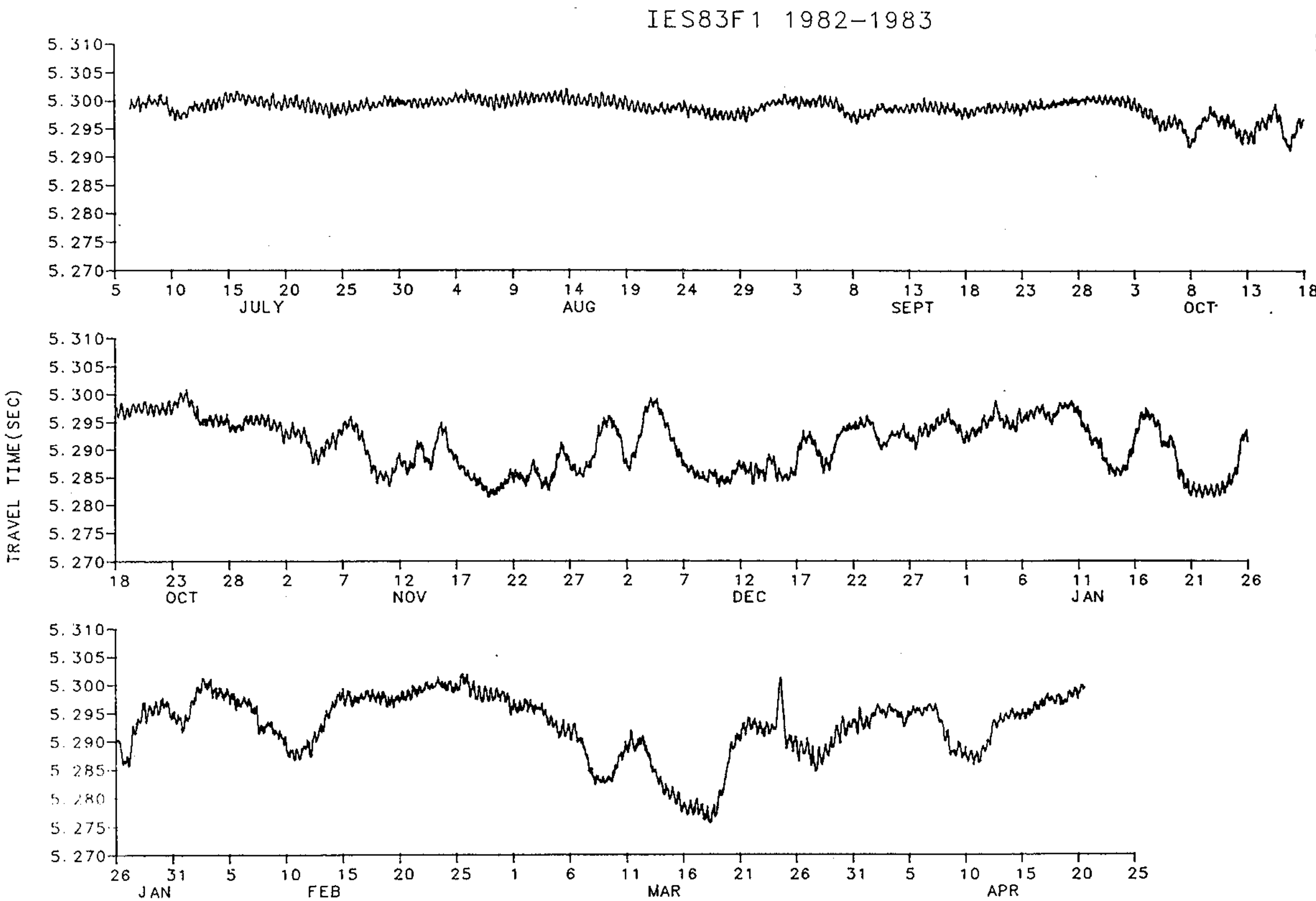

IES83F1 1982–1983
TRAVEL TIME(SEC)
5.310
5.305
5.300
5.295
5.290
5.285
5.280
5.275
5.270
5 10 15 20 25 30 4 9 14 19 24 29 3 8 13 18 23 28 3 8 13 18
JULY
AUG
SEPT
OCT
18 23 28 2 7 12 17 22 27 2 7 12 17 22 27 1 6 11 16 21 26
OCT
NOV
DEC
JAN
26 31 5 10 15 20 25 1 6 11 16 21 26 31 5 10 15 20 25
JAN
FEB
MAR
APR

Figure 3.9

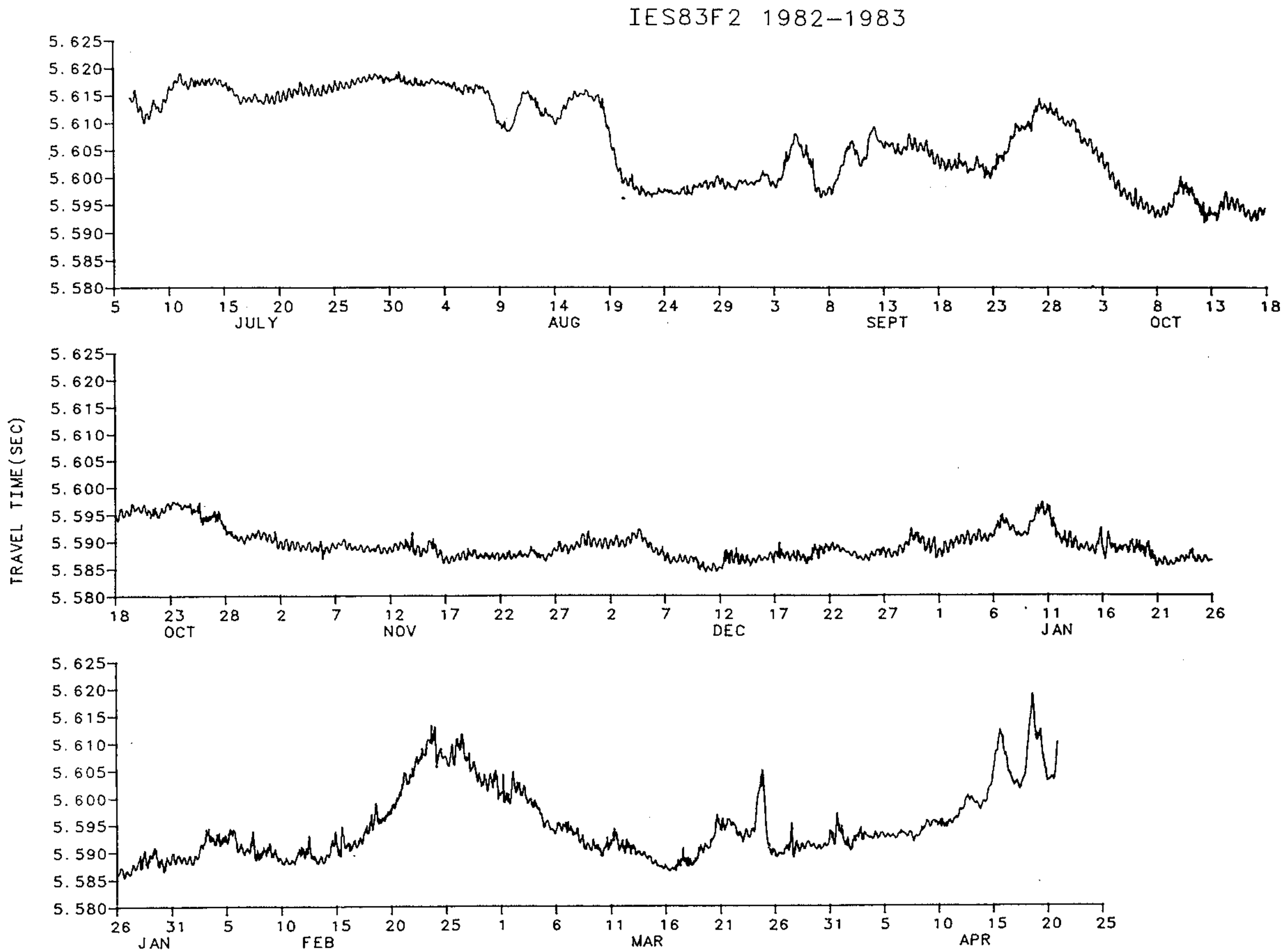

IES83F2 1982–1983
TRAVEL TIME(SEC)
5.625
5.620
5.615
5.610
5.605
5.600
5.595
5.590
5.585
5.580
5 10 15 20 25 30 4 9 14 19 24 29 3 8 13 18 23 28 3 8 13 18
JULY
AUG
SEPT
OCT
18 23 28 2 7 12 17 22 27 2 7 12 17 22 27 1 6 11 16 21 26
OCT
NOV
DEC
JAN
26 31 5 10 15 20 25 1 6 11 16 21 26 31 5 10 15 20 25
JAN
FEB
MAR
APR

Figure 3.10

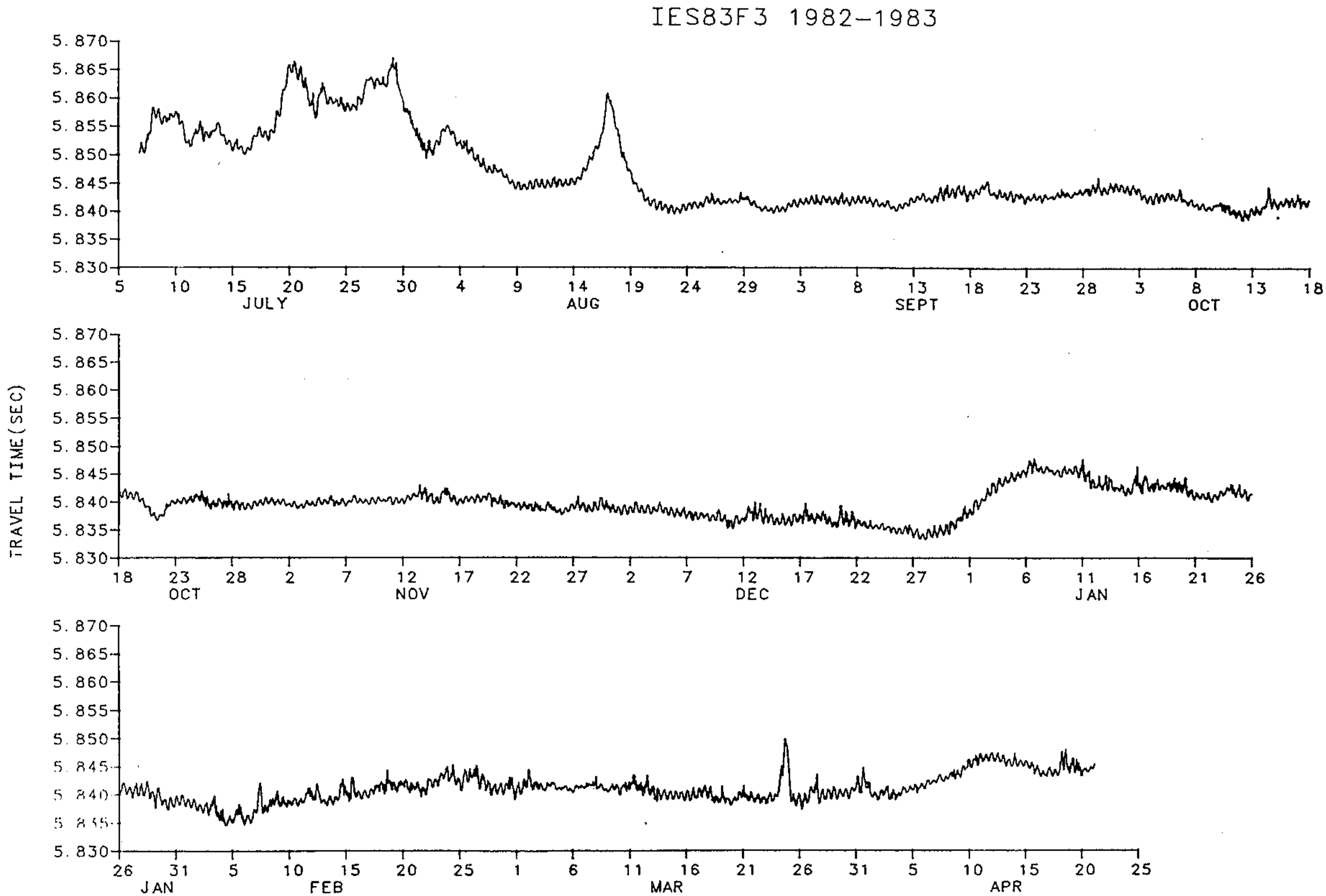

IES83F3 1982–1983
TRAVEL TIME(SEC)
5.870
5.865
5.860
5.855
5.850
5.845
5.840
5.835
5.830
5 10 15 20 25 30 4 9 14 19 24 29 3 8 13 18 23 28 3 8 13 18
JULY
AUG
SEPT
OCT
18 23 28 2 7 12 17 22 27 2 7 12 17 22 27 1 6 11 16 21 26
OCT
NOV
DEC
JAN
26 31 5 10 15 20 25 1 6 11 16 21 26 31 5 10 15 20 25
JAN
FEB
MAR
APR

Figure 3.11

SECTION 4

40 HRLP Thermocline Depth Data For Each Cross-Stream Line

The 40 HRLP thermocline depths (Z_{12}) are plotted for each instrument. These are grouped by cross-stream line, with the northwesternmost IES on each line plotted at the top of the figure. Each plot is labelled with the instrument name in the upper or lower left corner.

The time scale is the same for all plots, with each increment corresponding to 10 days. The axis begins on 0000 GMT of the first date labelled.

Vertical scale for the Z_{12} records is consistent for all the plots; each increment corresponds to 100 m.

The sampling interval is 6 hours. The length and the start and end times of the data records are tabulated in Section 2.

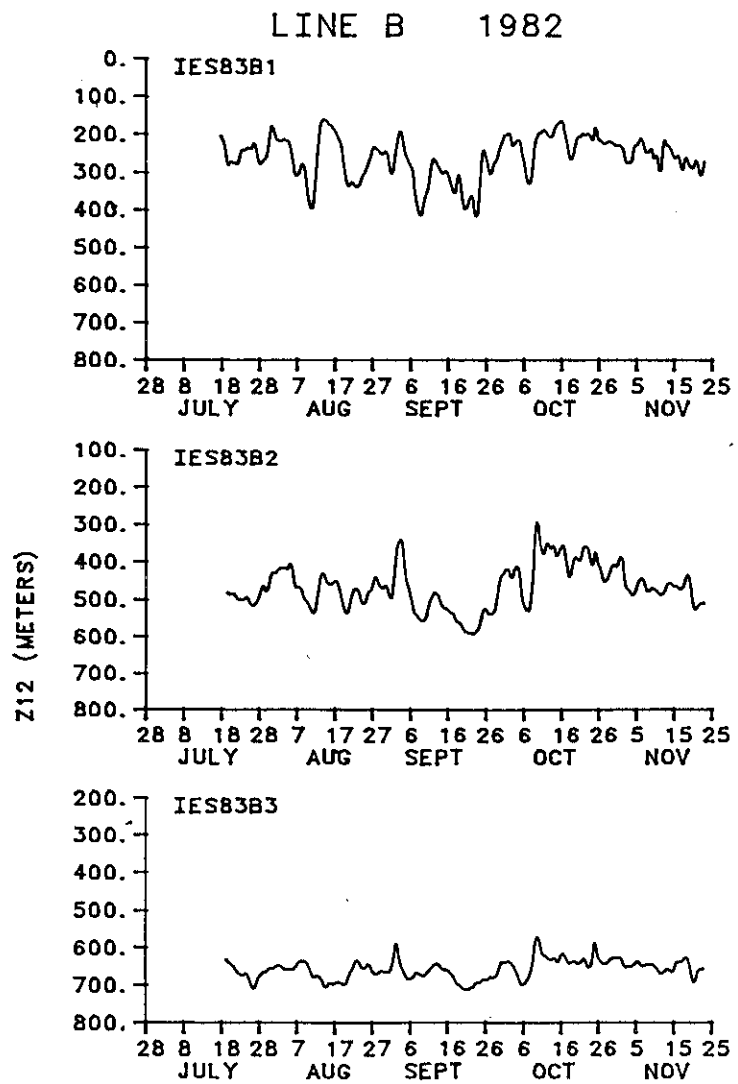


Figure 4.1

Figure 4.1-4 40 HRLP thermocline depth data along lines B to F.

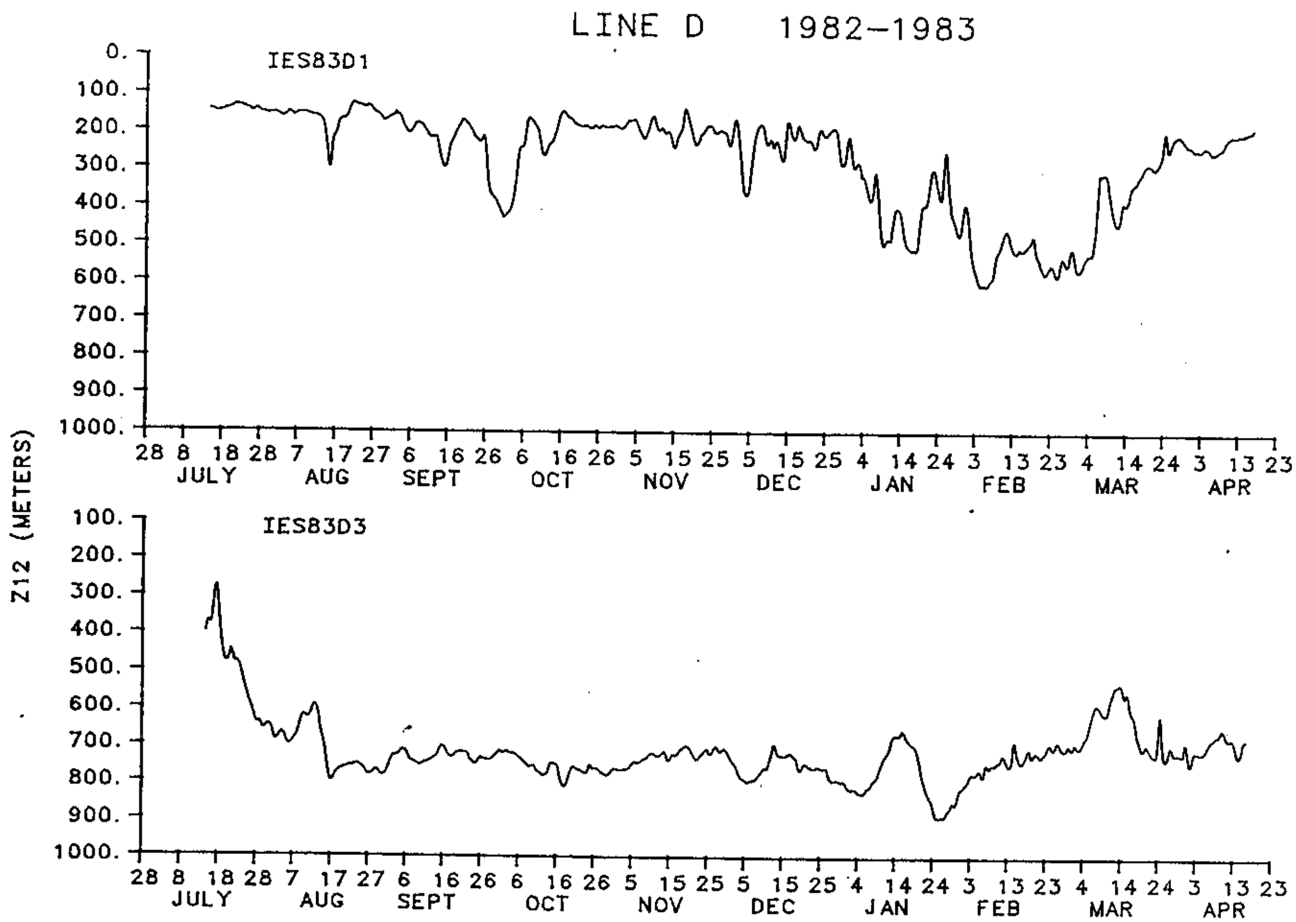

LINE D 1982–1983
IES83D1
IES83D3
Z12 (METERS)
0.
100.
200.
300.
400.
500.
600.
700.
800.
900.
1000.
28 8 18 28 7 17 27 6 16 26 6 16 26 5 15 25 5 15 25 4 14 24 3 13 23 4 14 24 3 13 23
JULY AUG SEPT OCT NOV DEC JAN FEB MAR APR

Figure 4.2

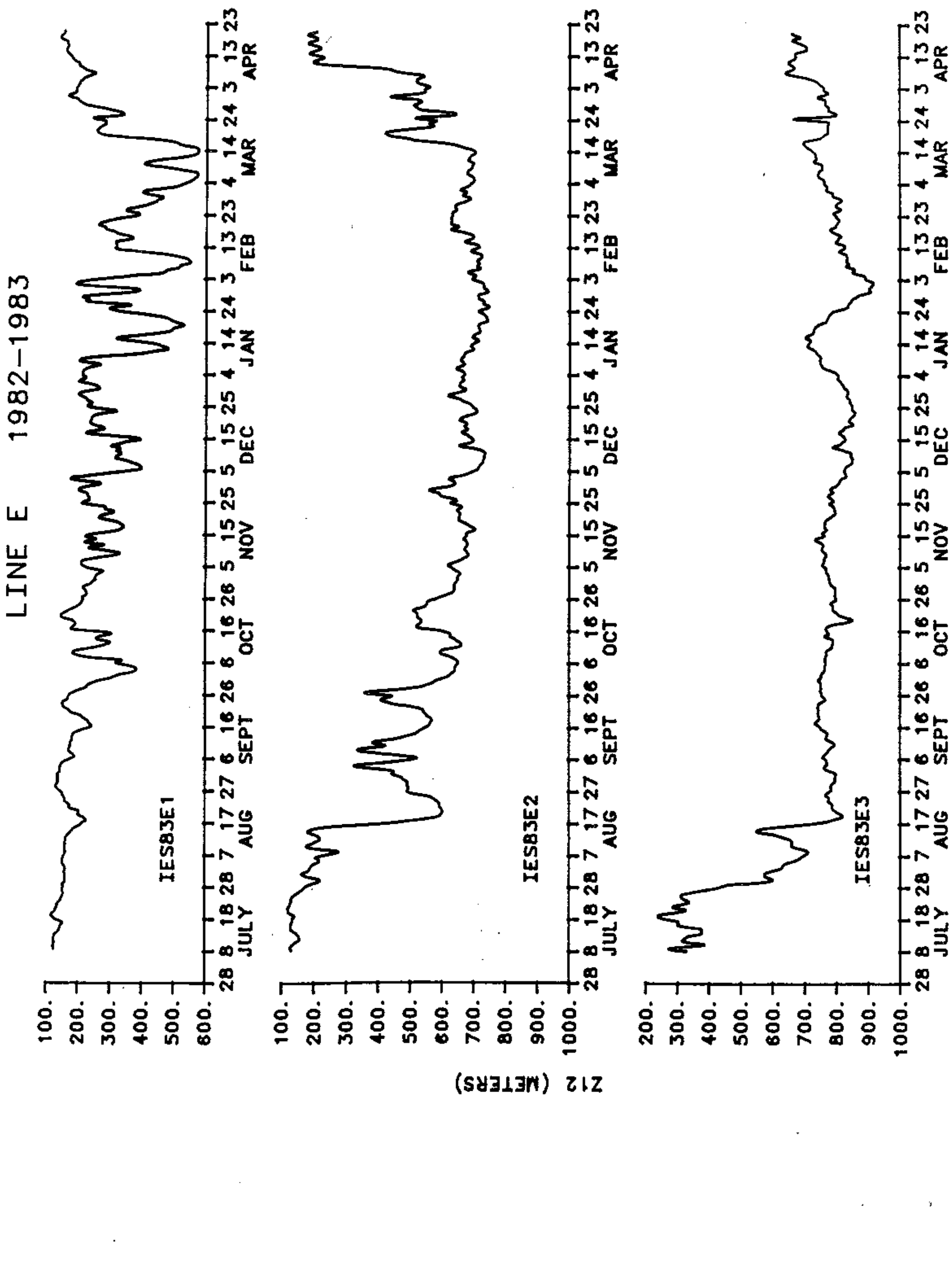

LINE E 1982–1983
IES83E1
IES83E2
IES83E3
Z12 (METERS)
100. 200. 300. 400. 500. 600.
100. 200. 300. 400. 500. 600. 700. 800. 900. 1000.
200. 300. 400. 500. 600. 700. 800. 900. 1000.
28 8 18 28 7 17 27 6 16 26 6 16 26 5 15 25 5 15 25 4 14 24 3 13 23 4 14 24 3 13 23
JULY AUG SEPT OCT NOV DEC JAN FEB MAR APR

Figure 4.3

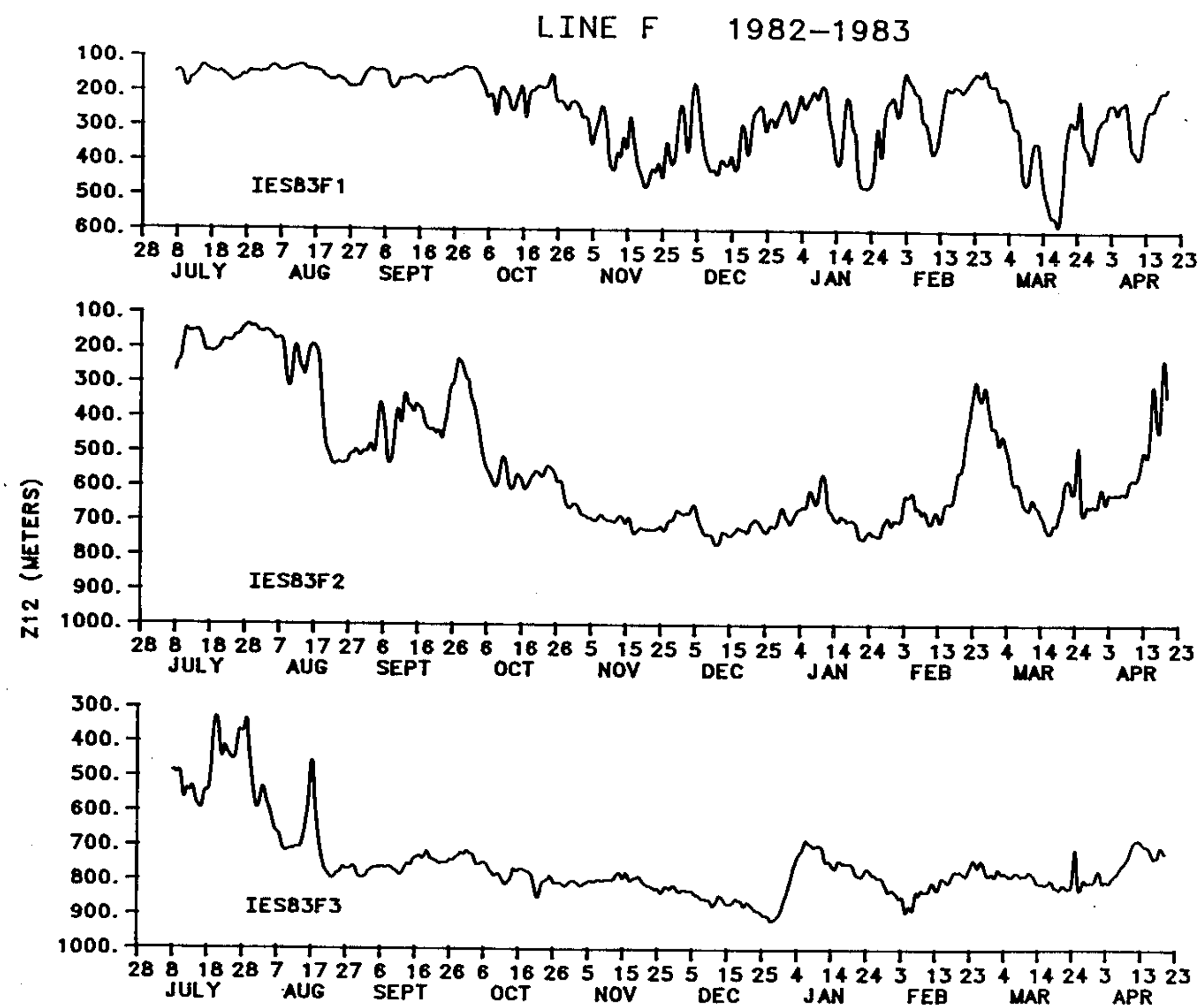

LINE F 1982–1983
IES83F1
IES83F2
IES83F3
Z12 (METERS)
100. 200. 300. 400. 500. 600.
100. 200. 300. 400. 500. 600. 700. 800. 900. 1000.
300. 400. 500. 600. 700. 800. 900. 1000.
28 8 18 28 7 17 27 6 16 26 6 16 26 5 15 25 5 15 25 4 14 24 3 13 23 4 14 24 3 13 23
JULY AUG SEPT OCT NOV DEC JAN FEB MAR APR

Figure 4.4

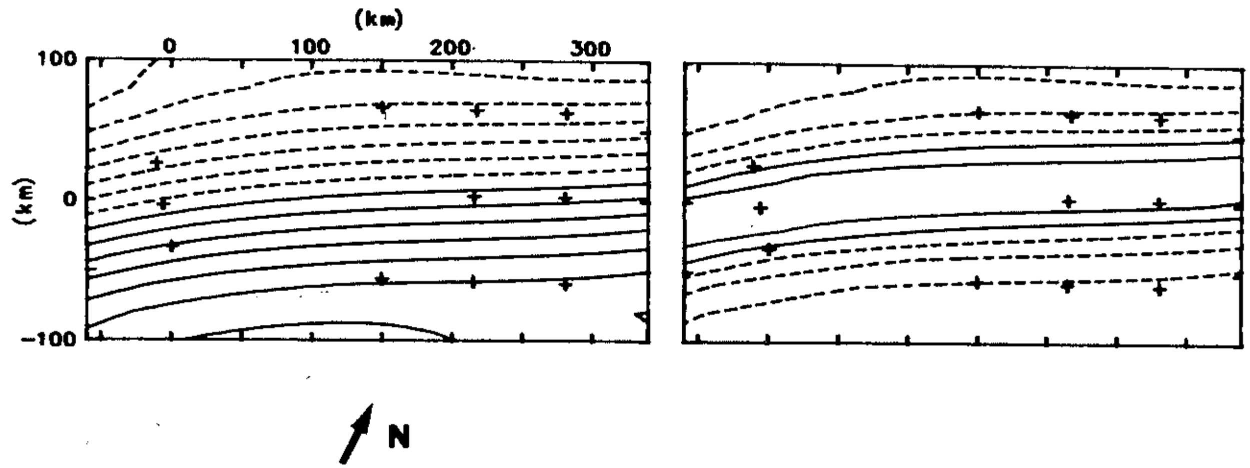
SECTION 5

Thermocline Depth Maps: Mean and Standard Deviation Fields, Error Fields, and Daily Thermocline Depth and Perturbation Fields

Contour plots of the mean thermocline depth and standard deviation fields, the error fields, the thermocline depth (Z_{12}) fields, and the perturbation fields are presented.

Two different sizes of regions are mapped, depending on the number and location of the instrumented sites. These are: a) From July to November 1982, the region is 200 km cross-stream by 400 km downstream. b) From November 1982 to April 1983, it is 200 km by 240 km. The inset in Figure 5 shows the relationship of these regions to each other; the upper right-hand corner of both regions corresponds to the same location. In Figures 5-7, each of the contoured frames corresponds to either the full boxed region in Figure 1 (areas 1 and 2 in the inset of Figure 5) or a portion of it (area 2 in Figure 5). The boxed region is oriented 064°T, and north is indicated by the arrow in Figure 5. The horizontal scales in Figure 5 apply also to the frames in Figures 6 and 7.

Each frame consists of a grid of points at 20 km spacing. The actual IES sites are indicated by the + marks and the positions are listed in Table 1. During April 1983, most of the IESs documented in this report were recovered and redeployed at the same locations. Thus for 17-27 April 1983, the most accurate Z_{12} maps were obtained by combining the data records from this deployment period and the next one. The positions of the instruments and their data records from the April 1983 to June 1984 deployment are presented in Tracey and Watts (1986b).



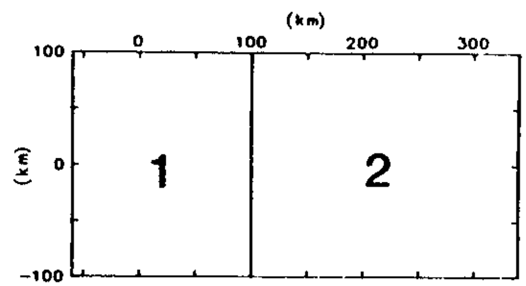


Figure 5. Mean field (above left) for the July 1982 to April 1983 data and the root-mean-square standard deviation field (above right) are contoured in plan view. Contour interval of the mean field is 50 m, with dashed lines indicating $Z_{12} \lesssim 500$ m. Contour interval of the standard deviation field is 25 m, with the dashed region corresponding to standard deviation $\lesssim 150$ m rms. North is indicated by the arrow. The inset (right) shows the two regions which are mapped in Figures 6 and 7: a) The combined areas 1 and 2 were mapped from 19 July to 23 November 1982 (200 x 400 km). b) Area 2 corresponds to the region mapped from 24 November 1982 to 27 April 1983 (200 x 240 km).

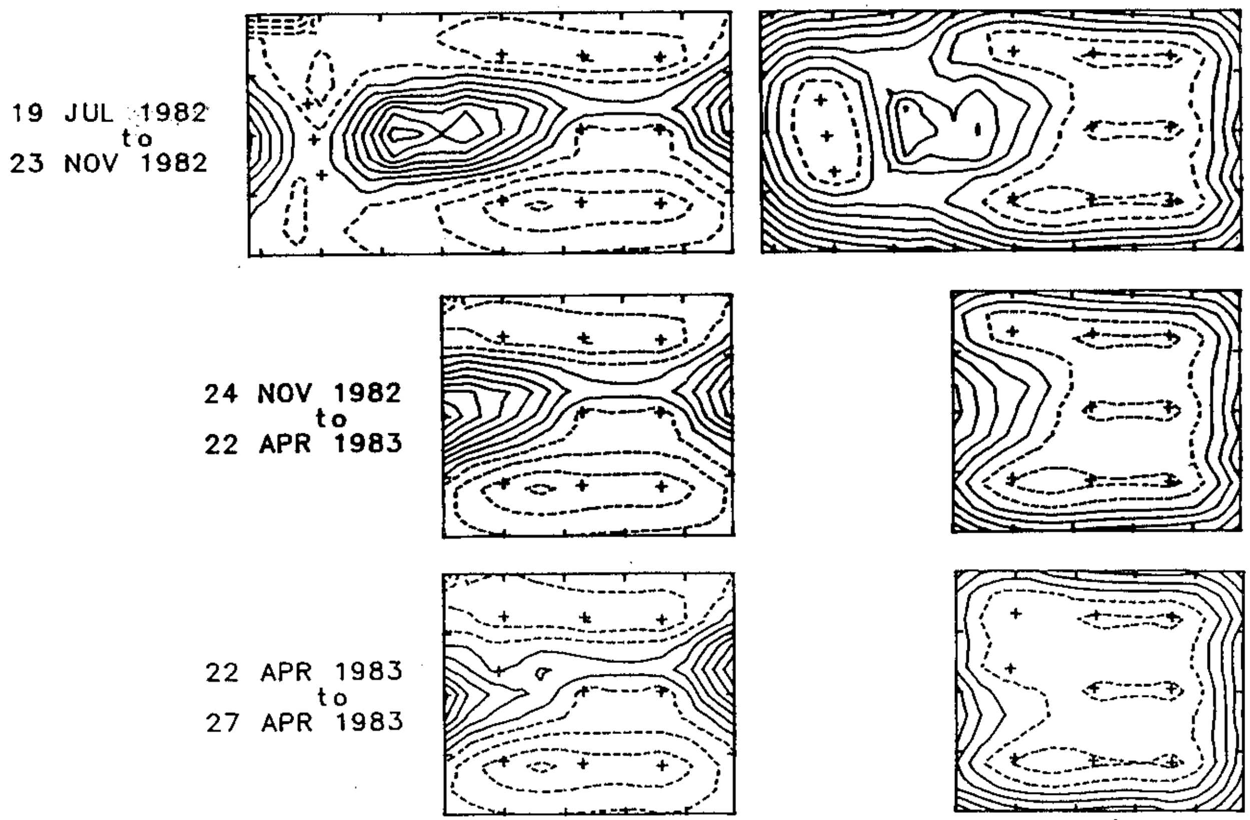
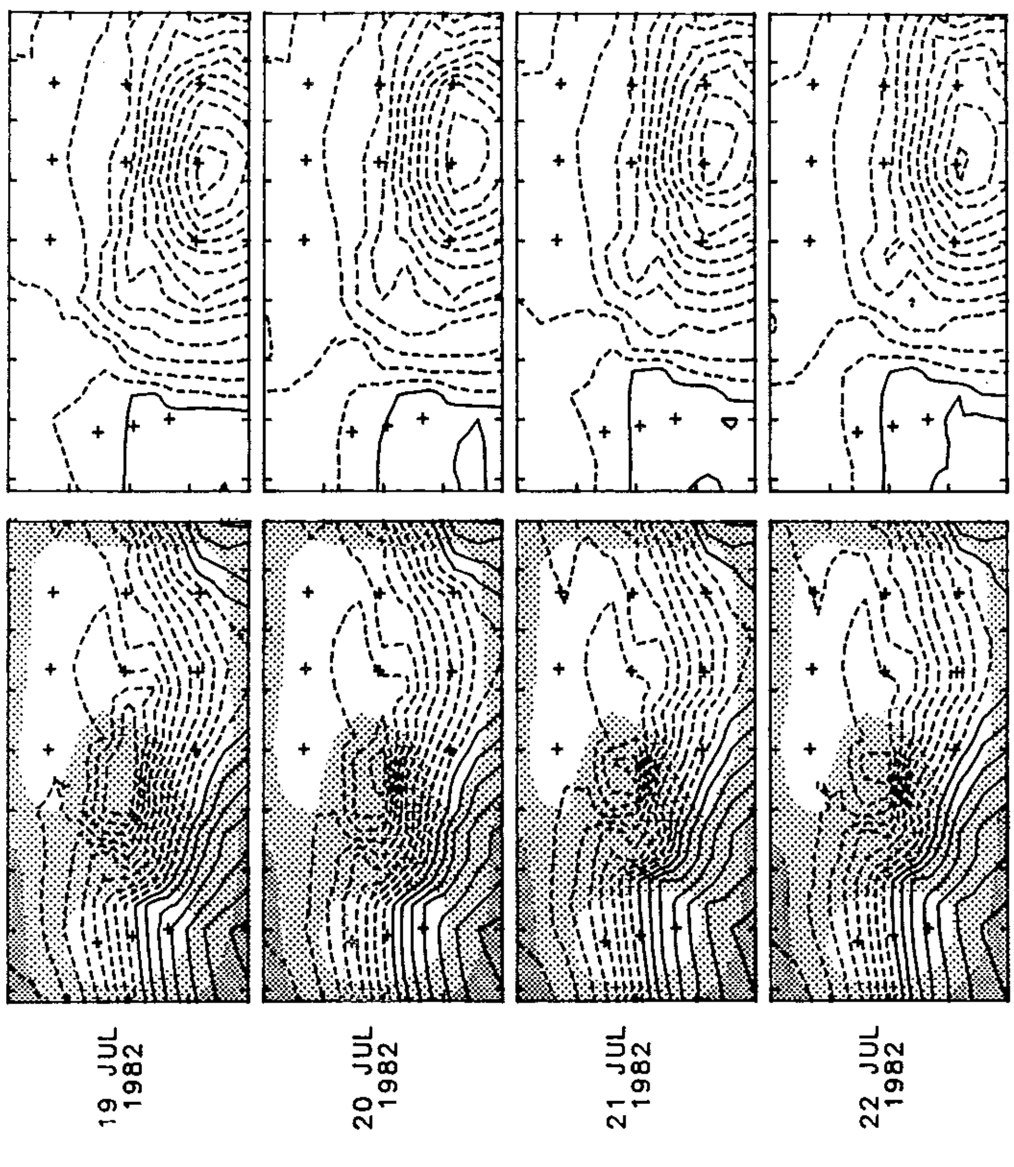


Figure 6. The error (percent standard deviation) fields, shown at right, are contoured at 5% intervals, with the dashed region corresponding to < 15% error. The error-bar fields (left) have a contour interval of 10 m and the dashed region corresponds to errors < 50 m. The three sets of error maps apply to the Z_{12} and perturbation fields in Figure 7 for the dates shown. The horizontal scales are the same as those labelled in Figure 5, with the upper right-hand corner of all frames corresponding to the same location.

Figure 7. The 12°C isotherm depth (Z_{12}) field (left) and the perturbation field (right) are shown at daily intervals from 19 July 1982 to 27 April 1983. The maps are shown for 1200 GMT on the date indicated at the left. Contour interval of the perturbation field is 0.5 with the dashed region corresponding to negative values. The Z_{12} field is contoured at 50 m intervals and depths shallower than 500 m are dashed. The lighter shaded area corresponds to regions of ≥15% estimated error and the darker shading to errors of ≥35%, as shown in the error maps in Figure 6.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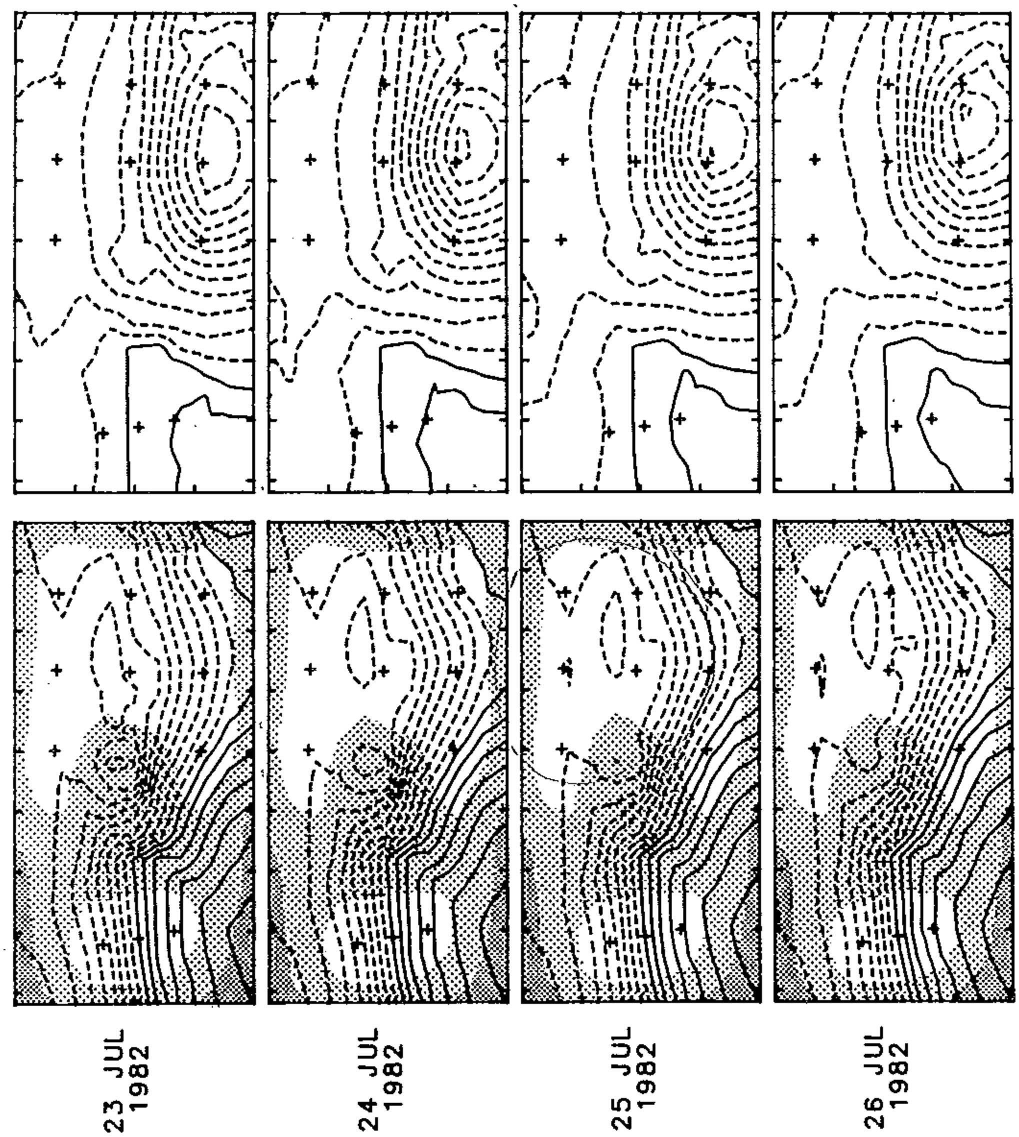
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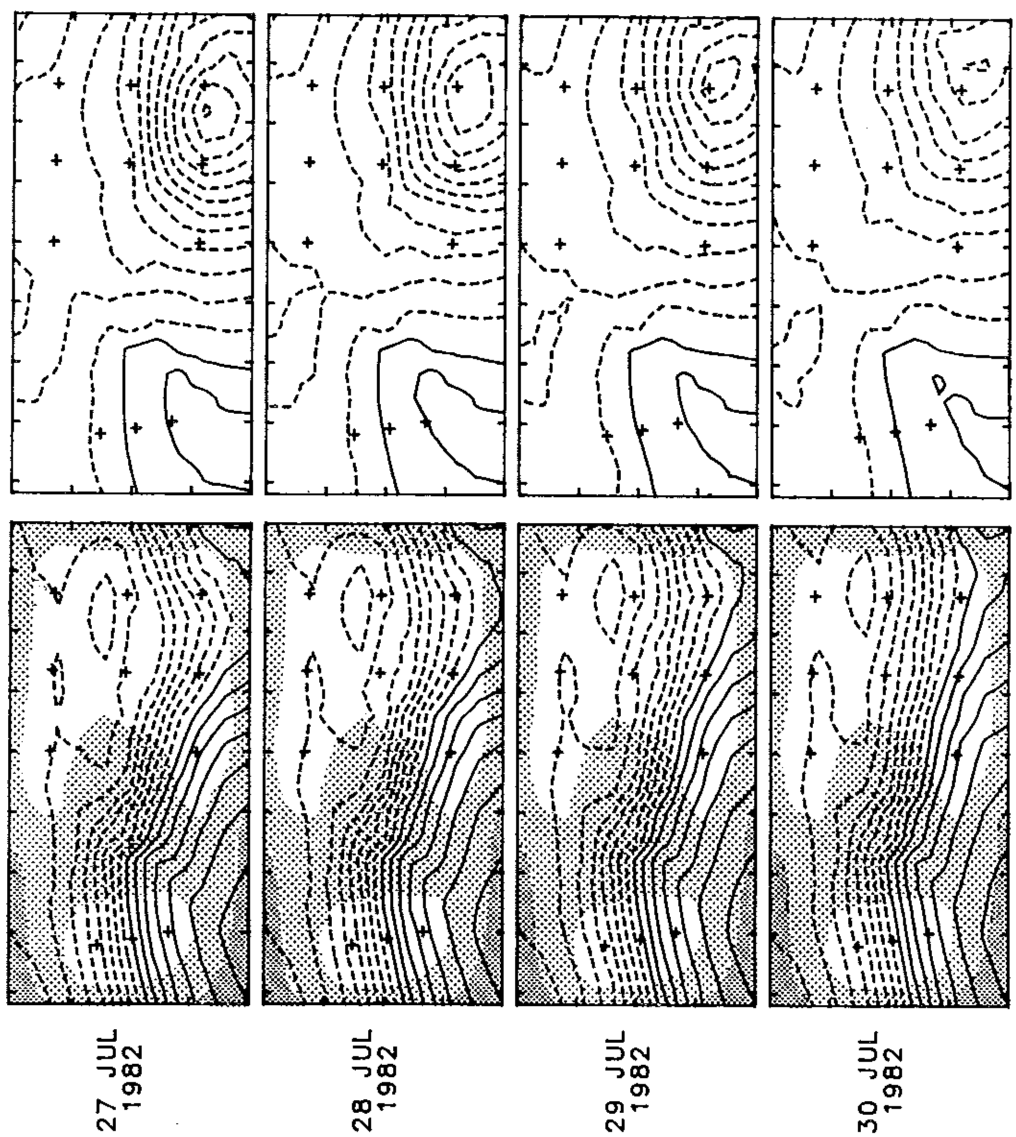
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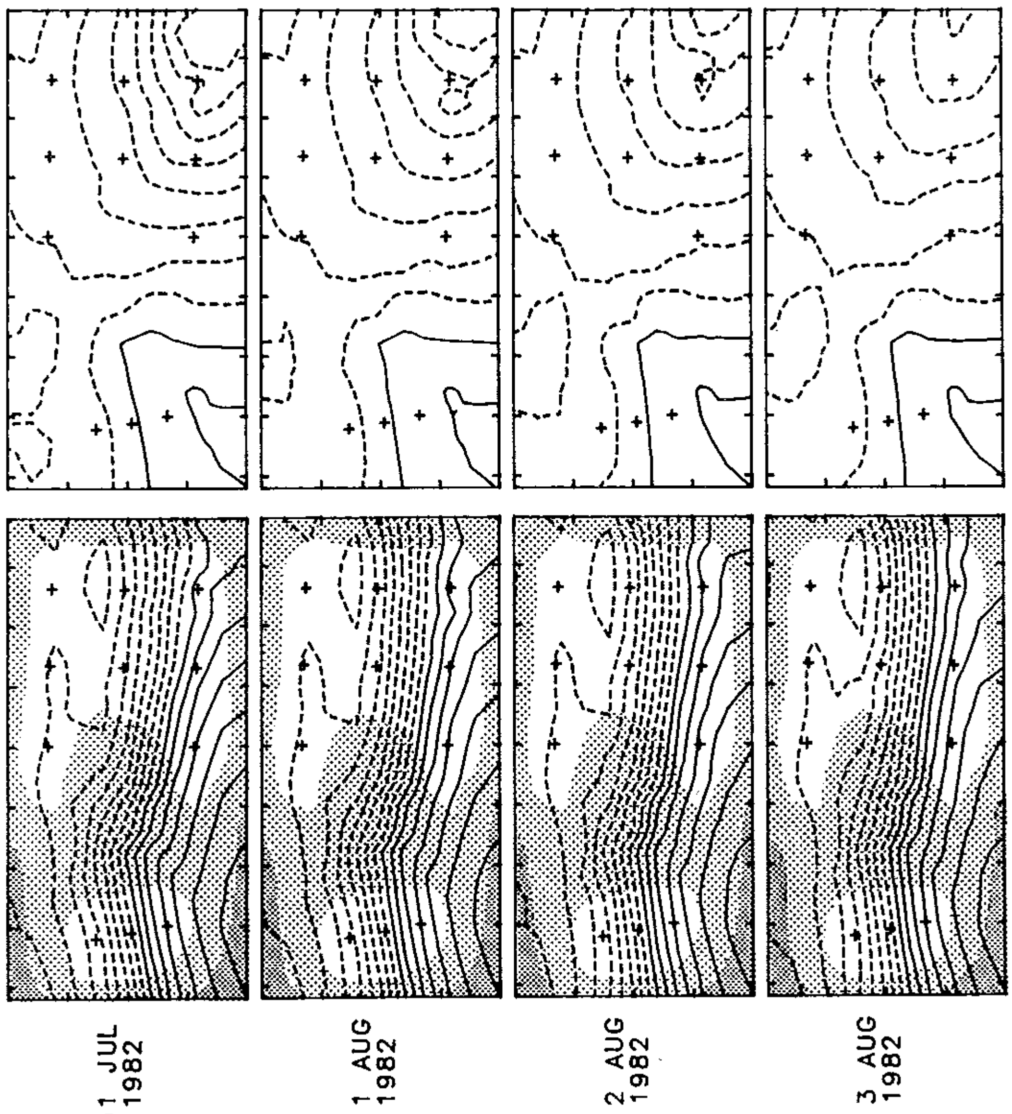
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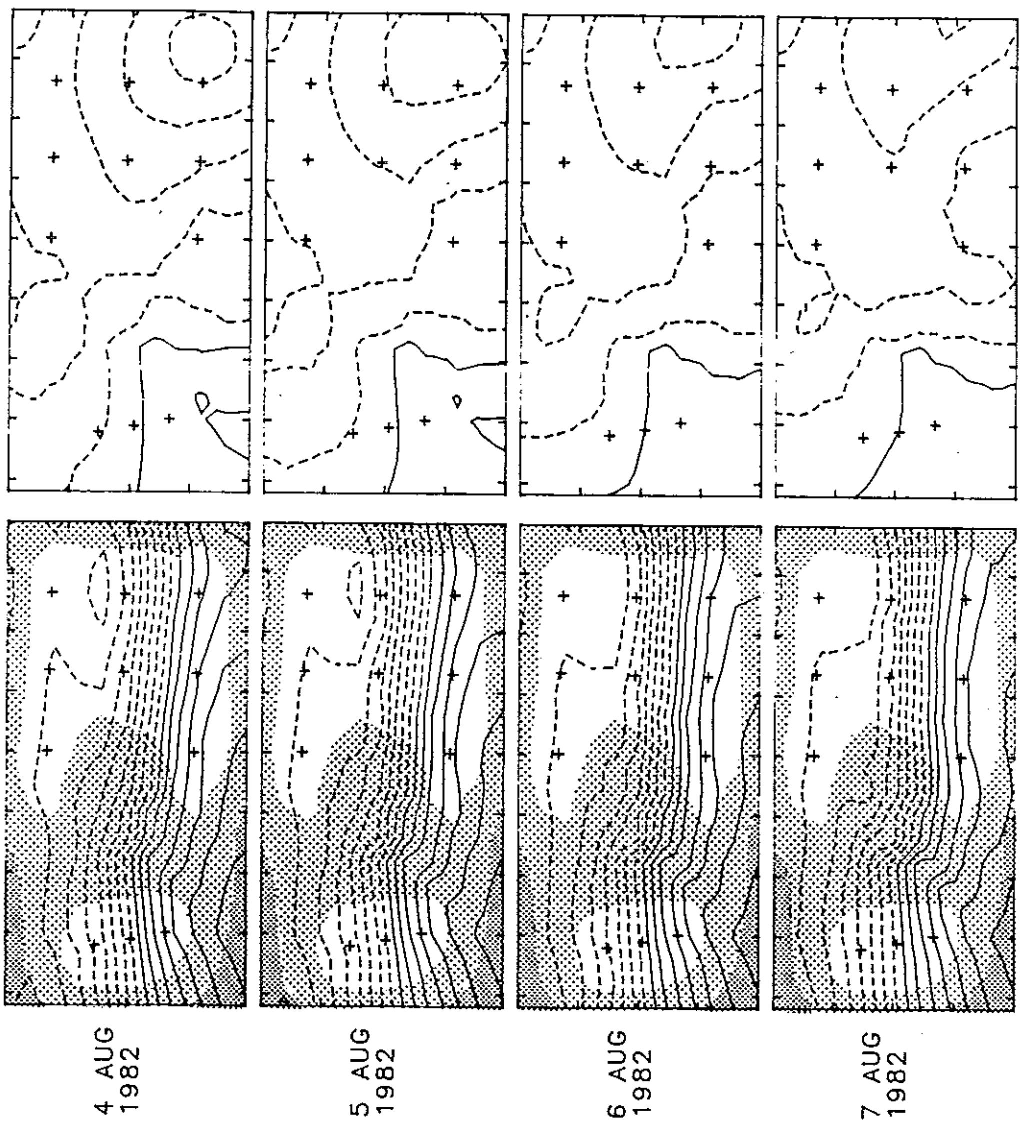
1982
2 AUG
1982
3 AUG
1982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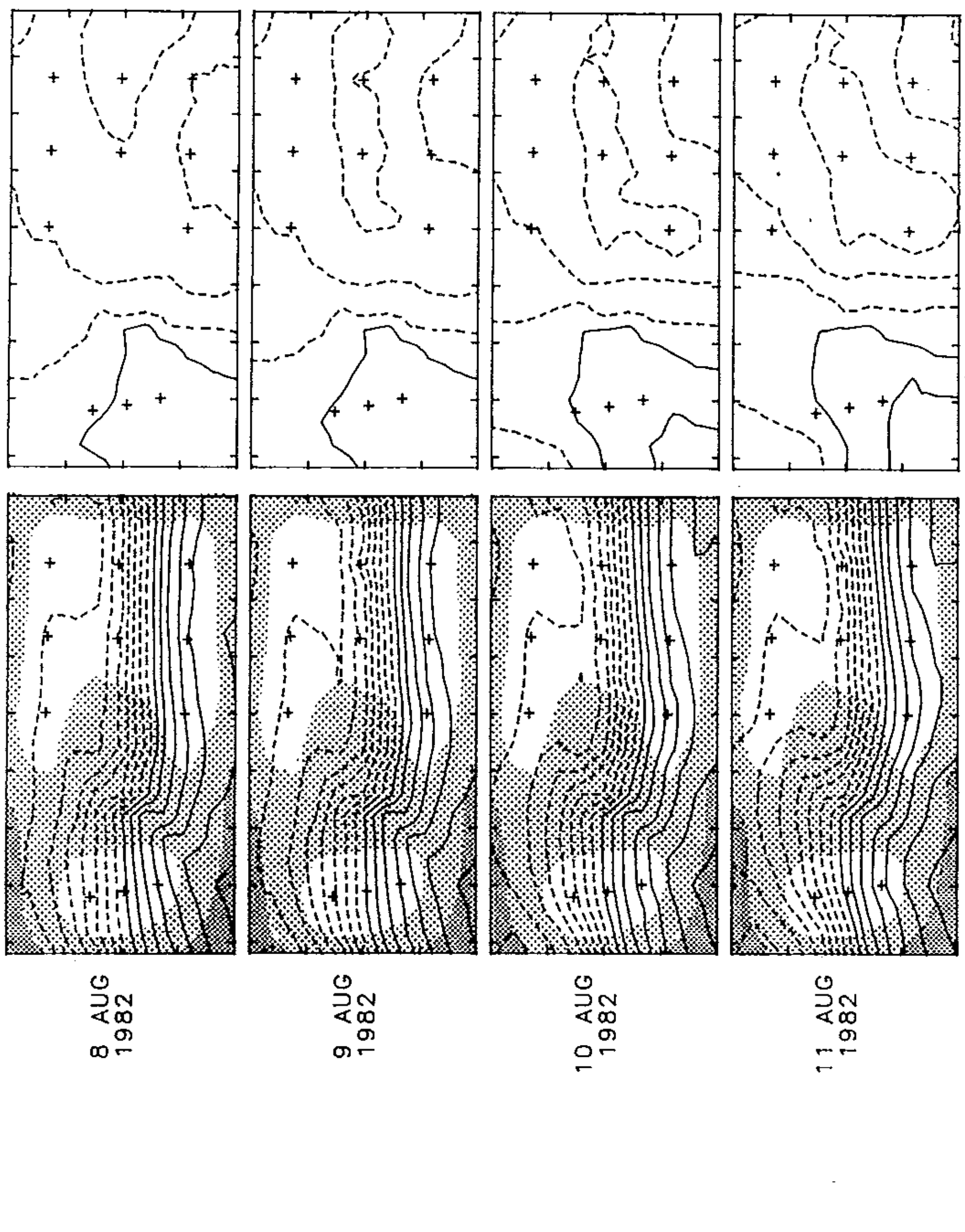
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1982
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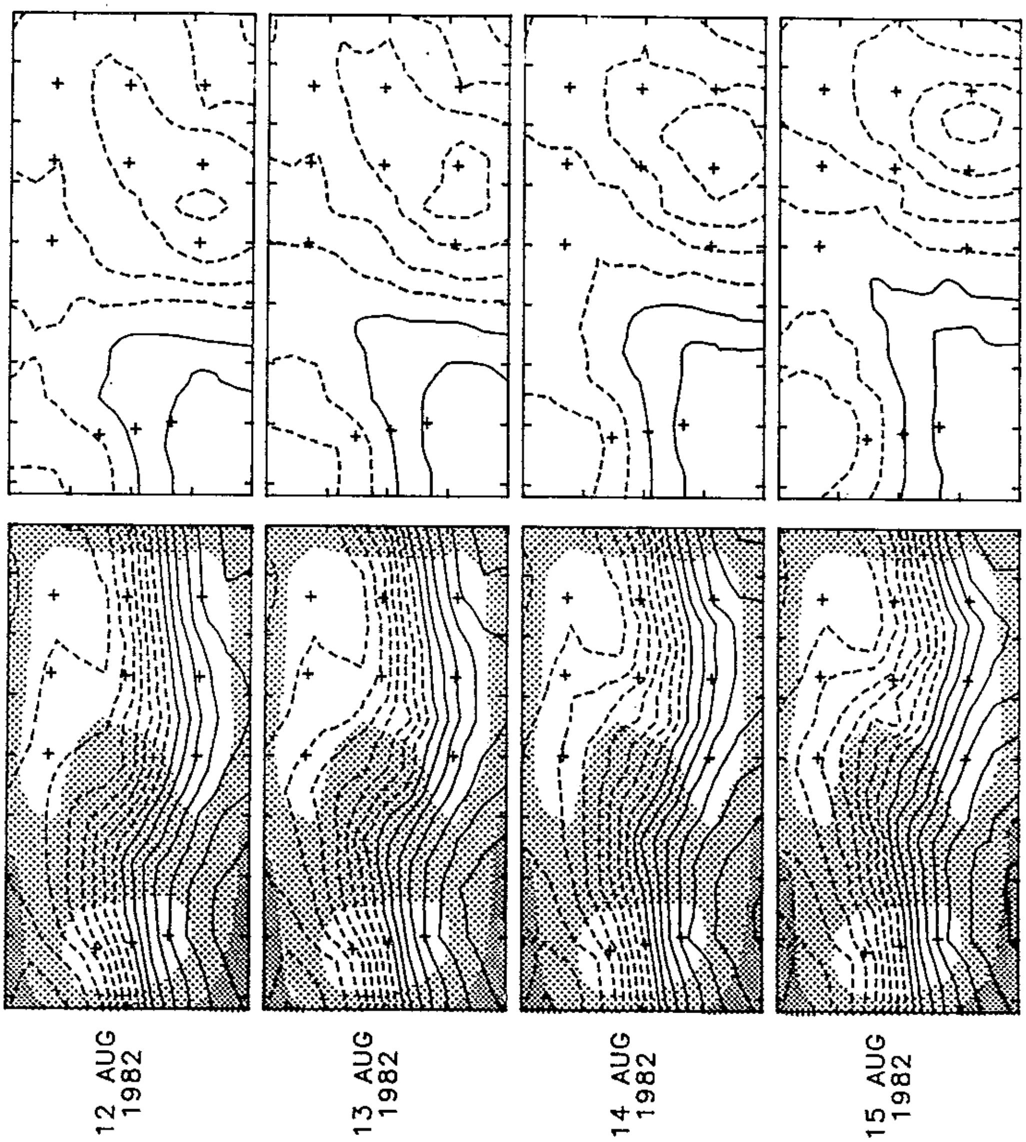
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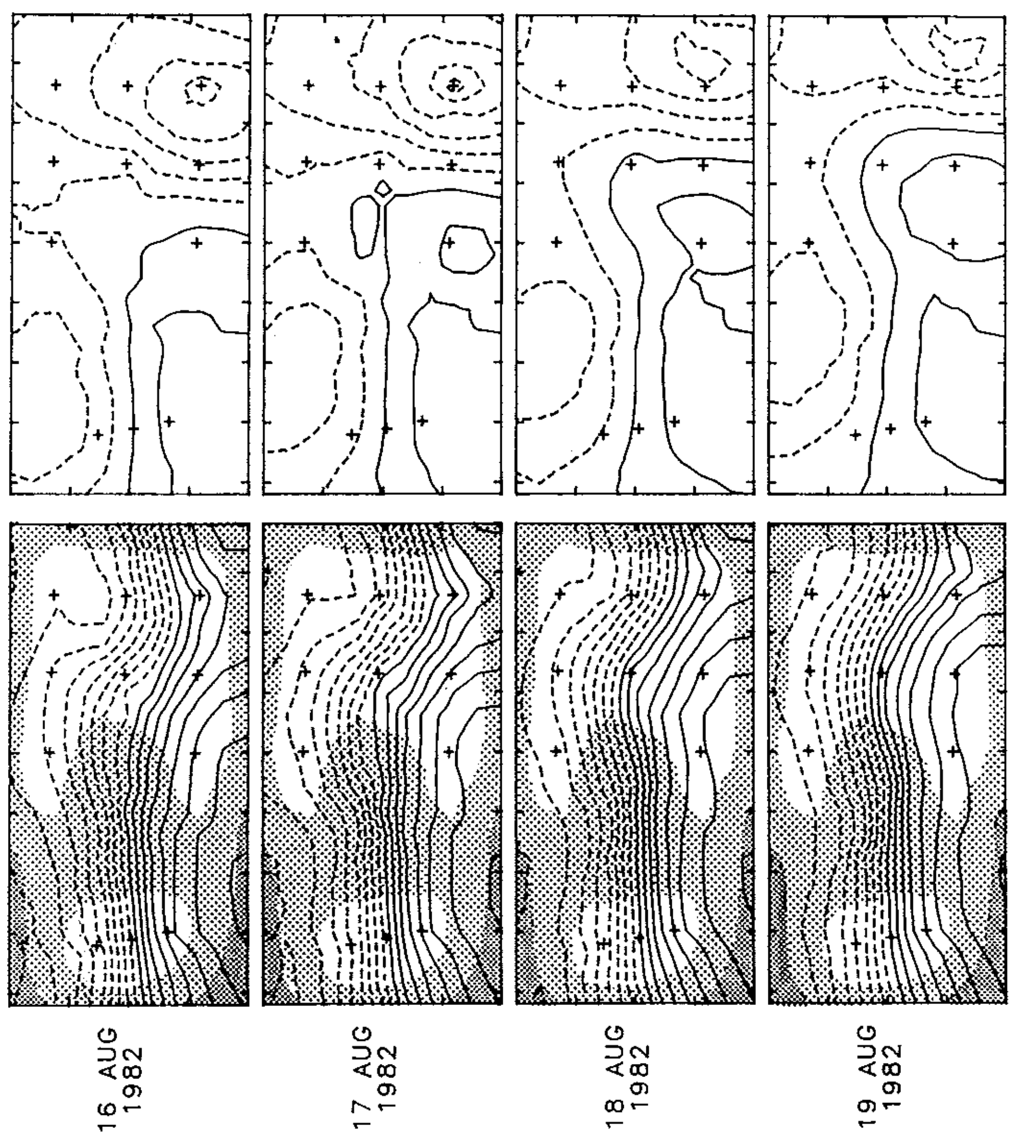
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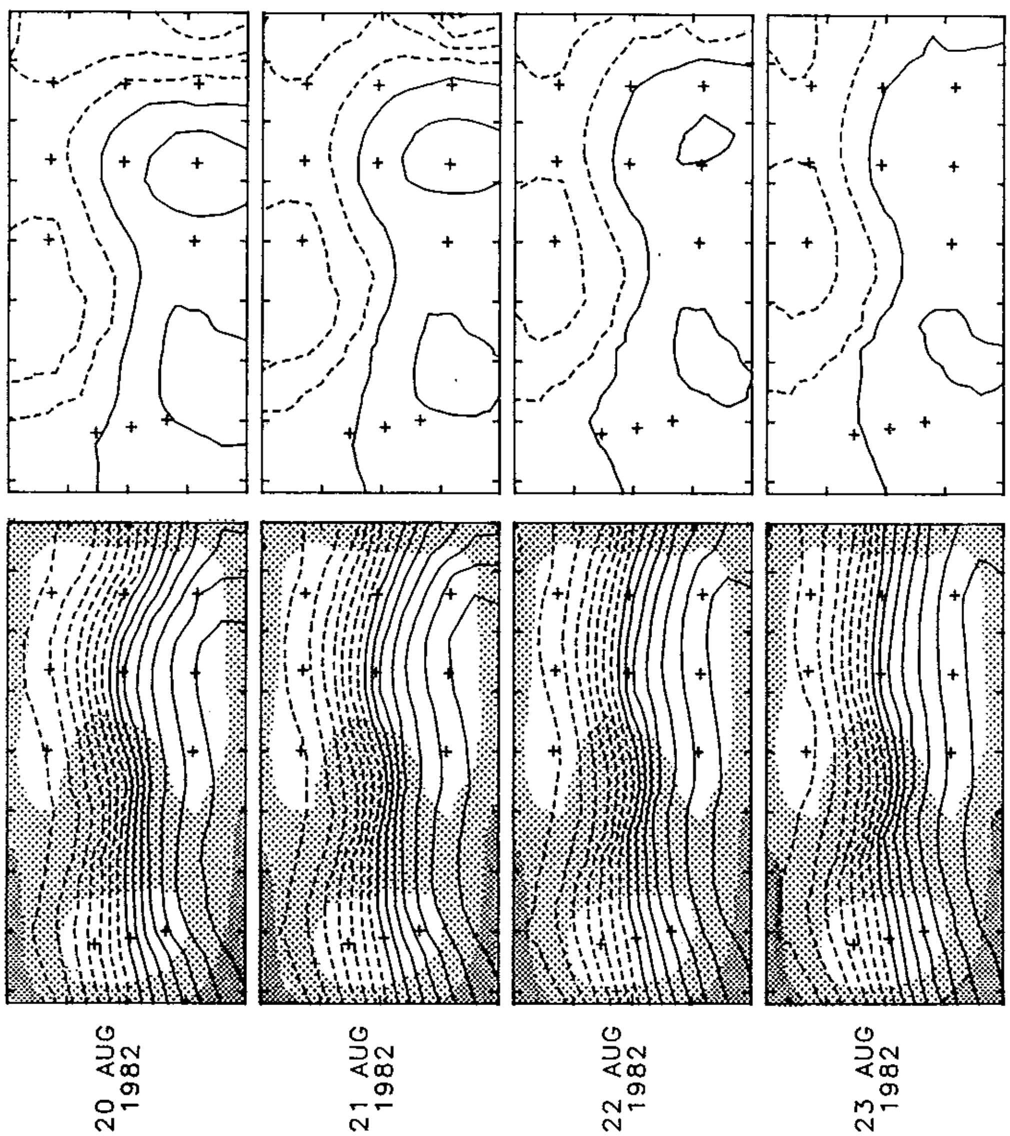
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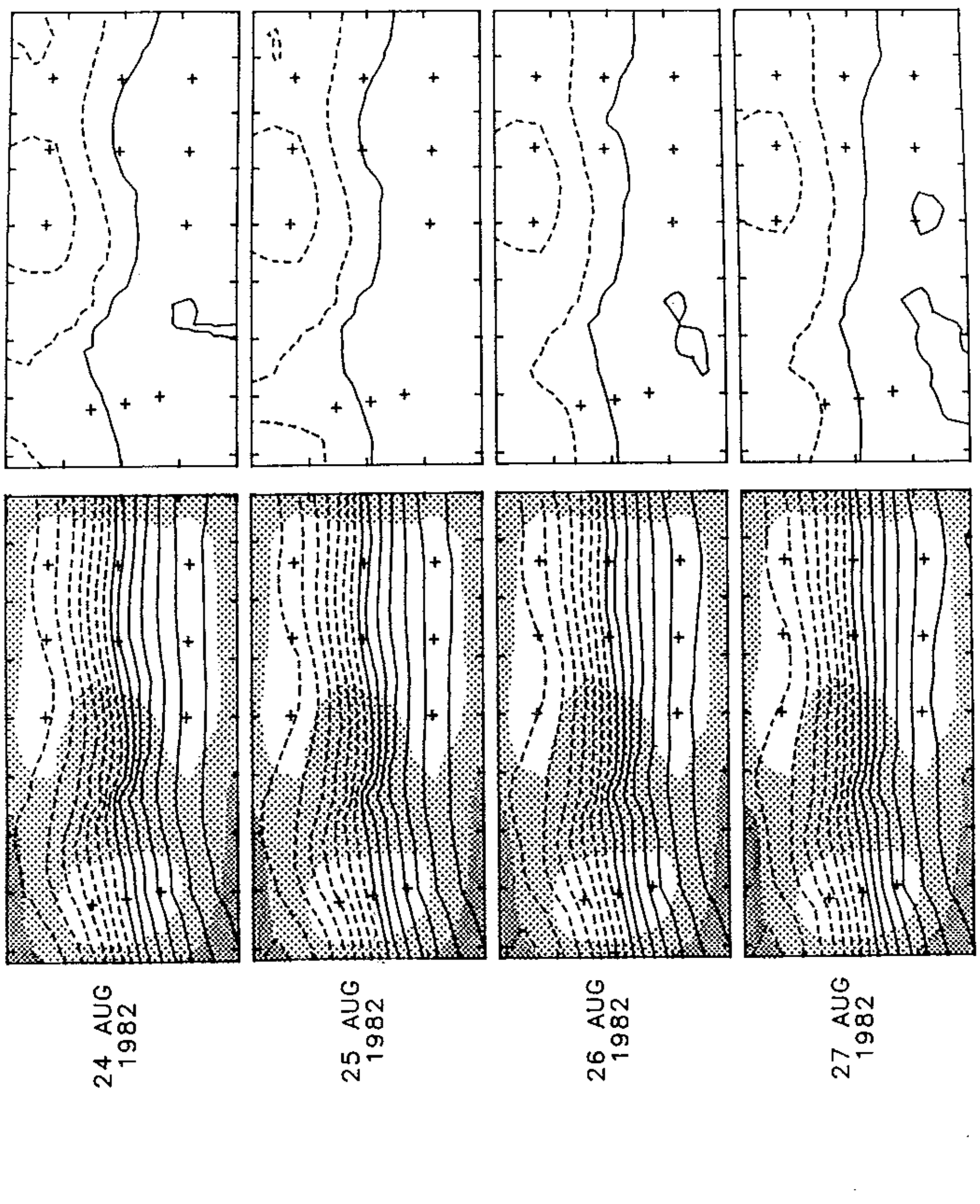
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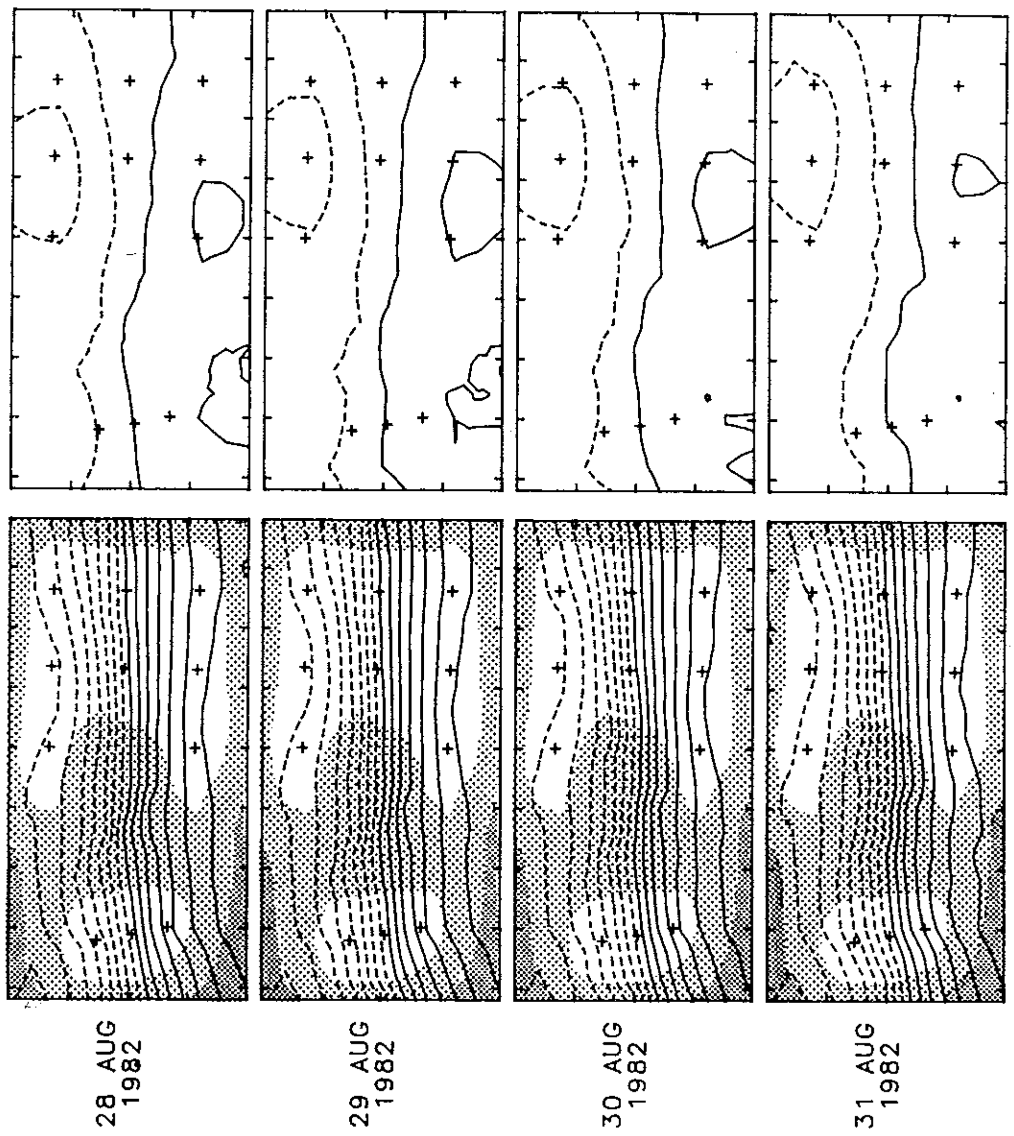
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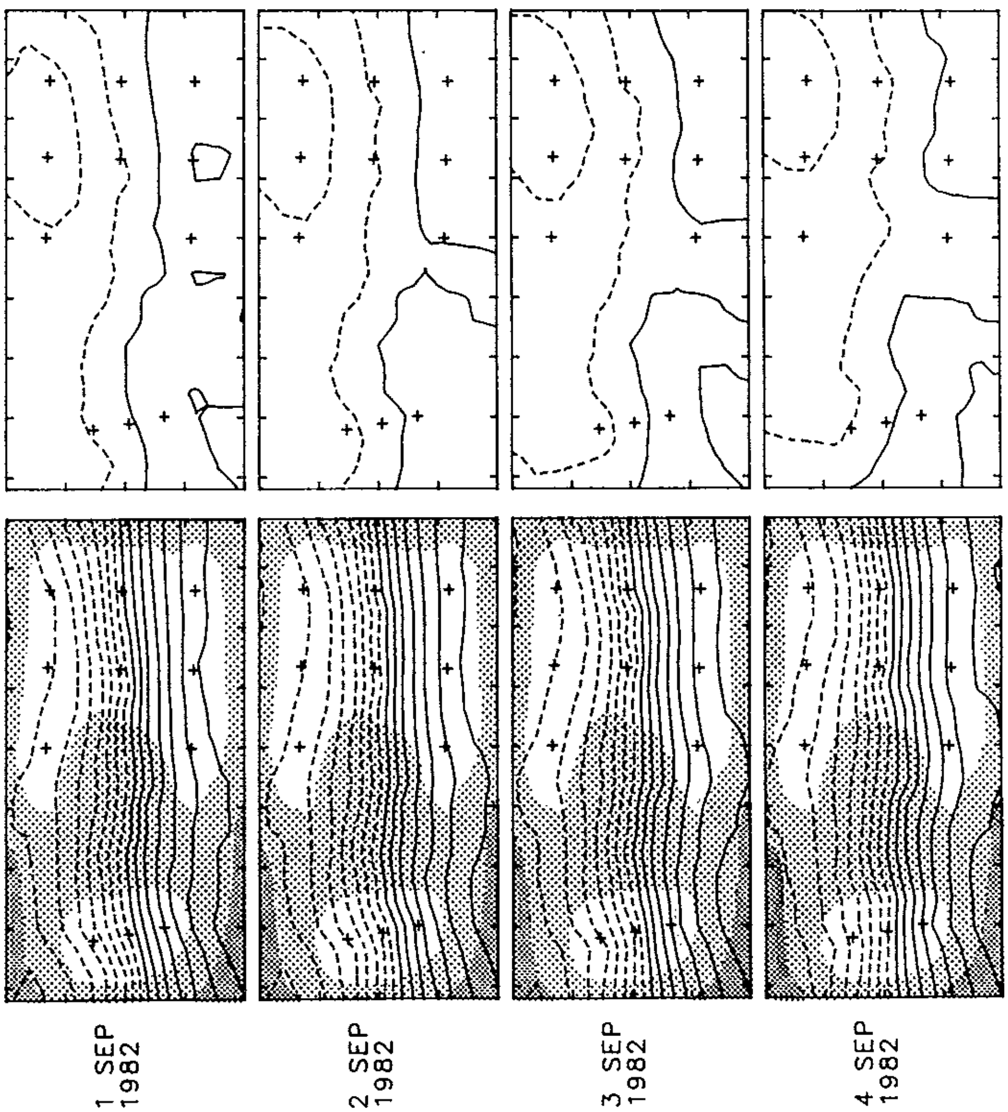
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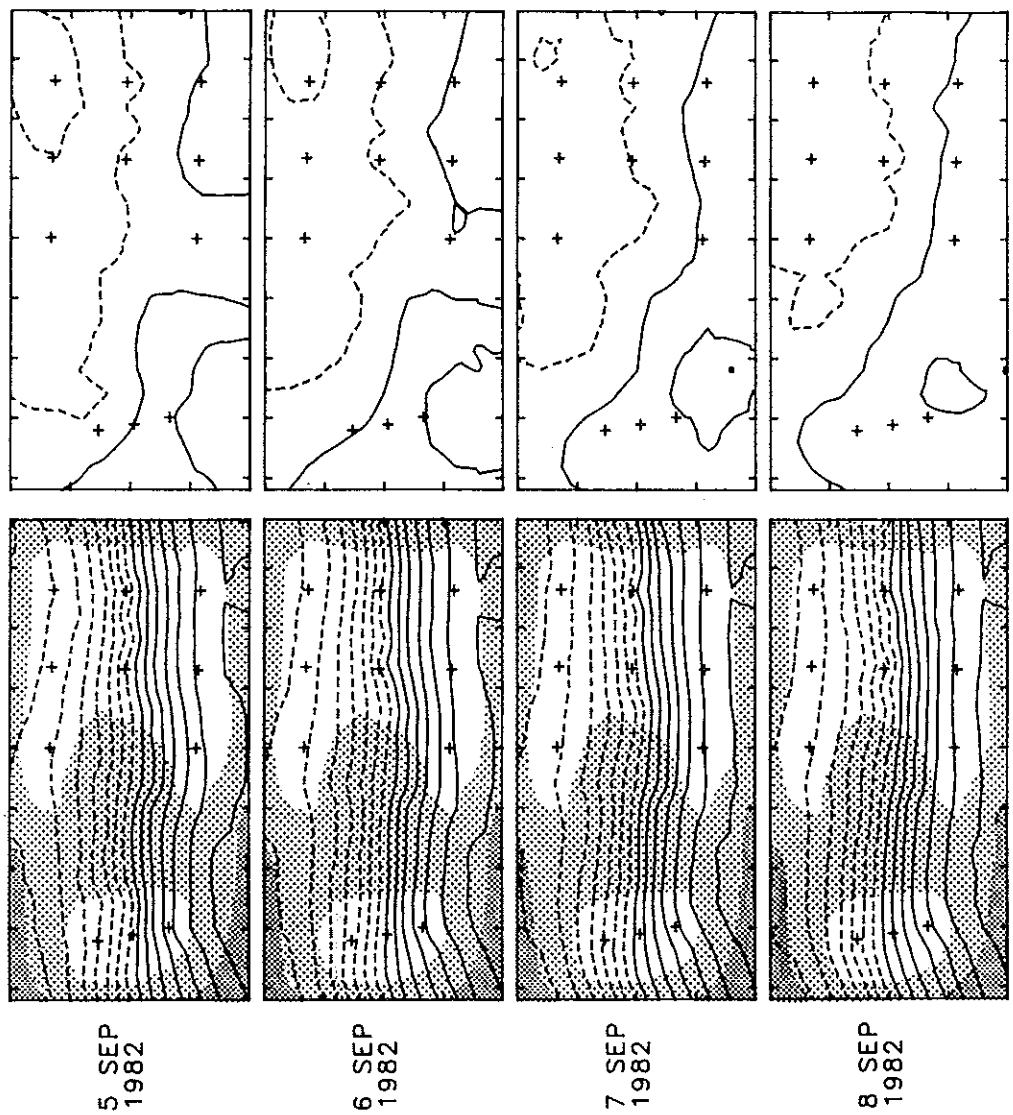
1982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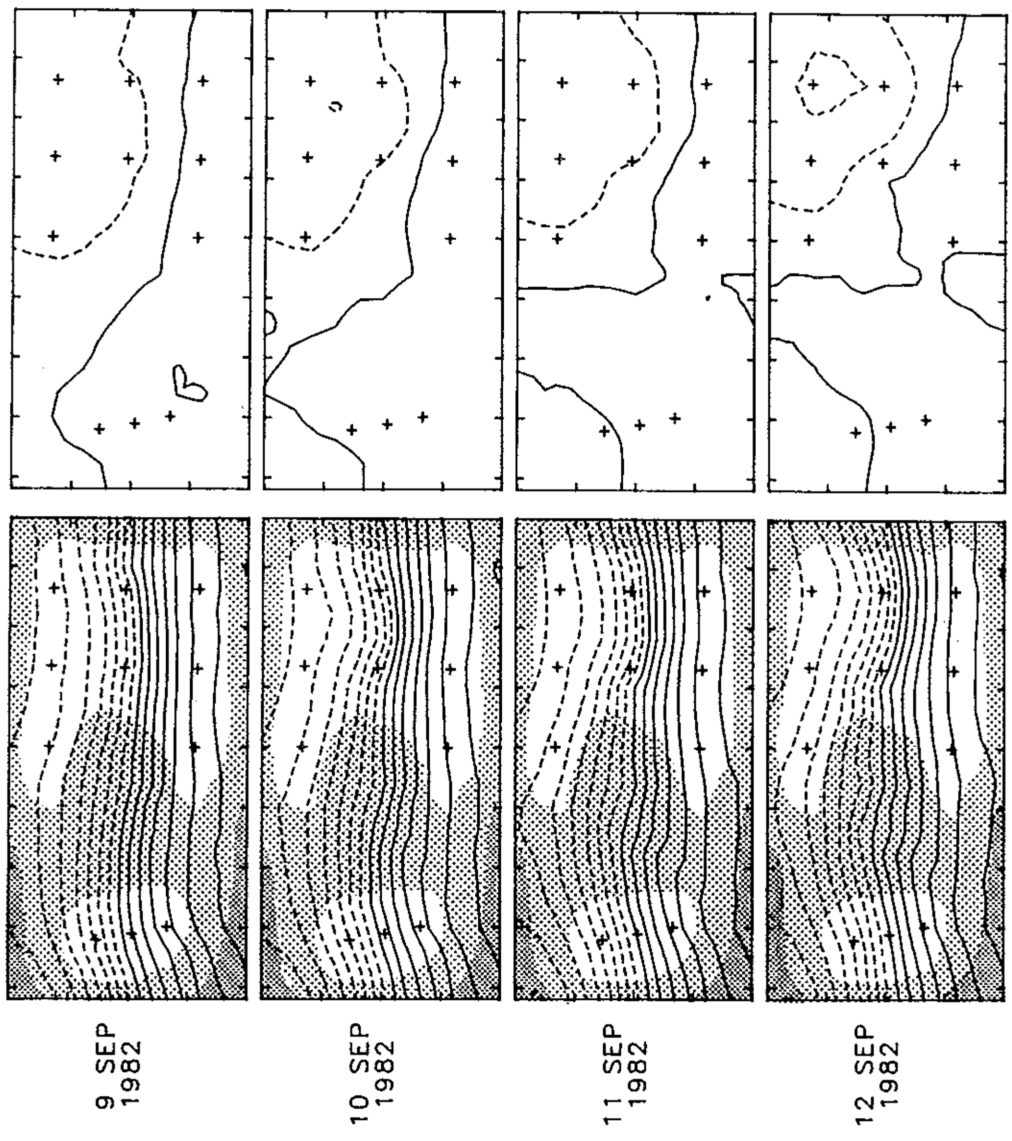
1982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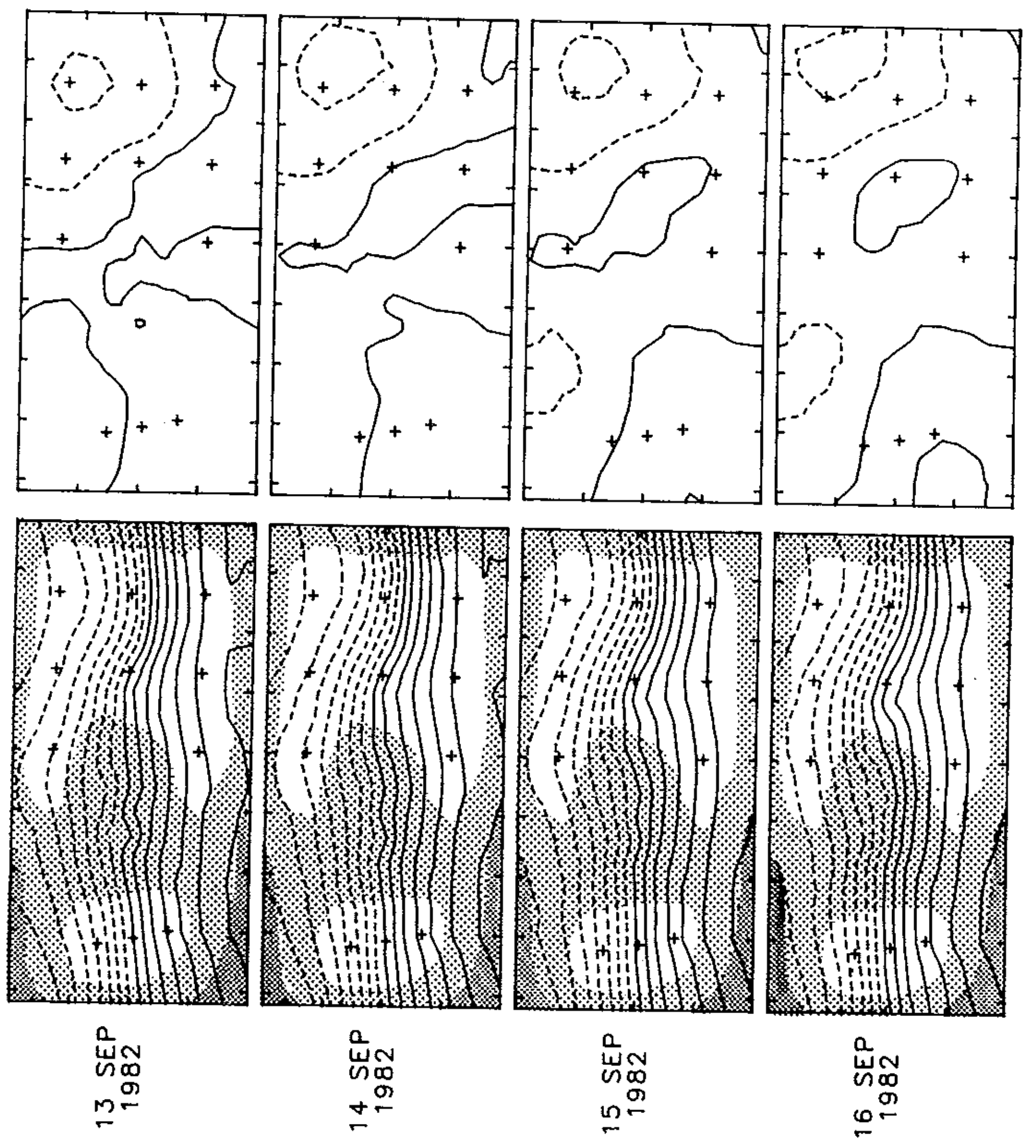
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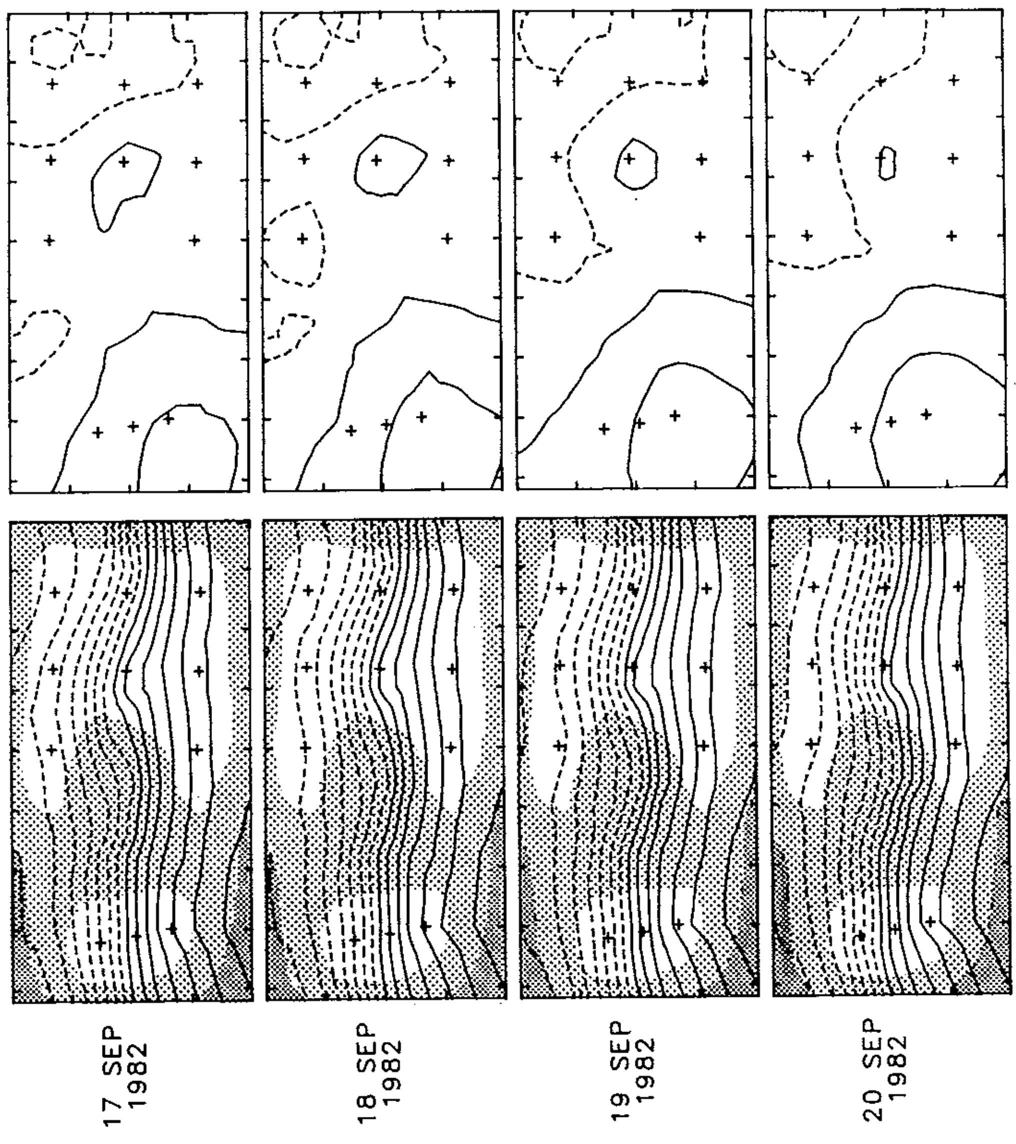
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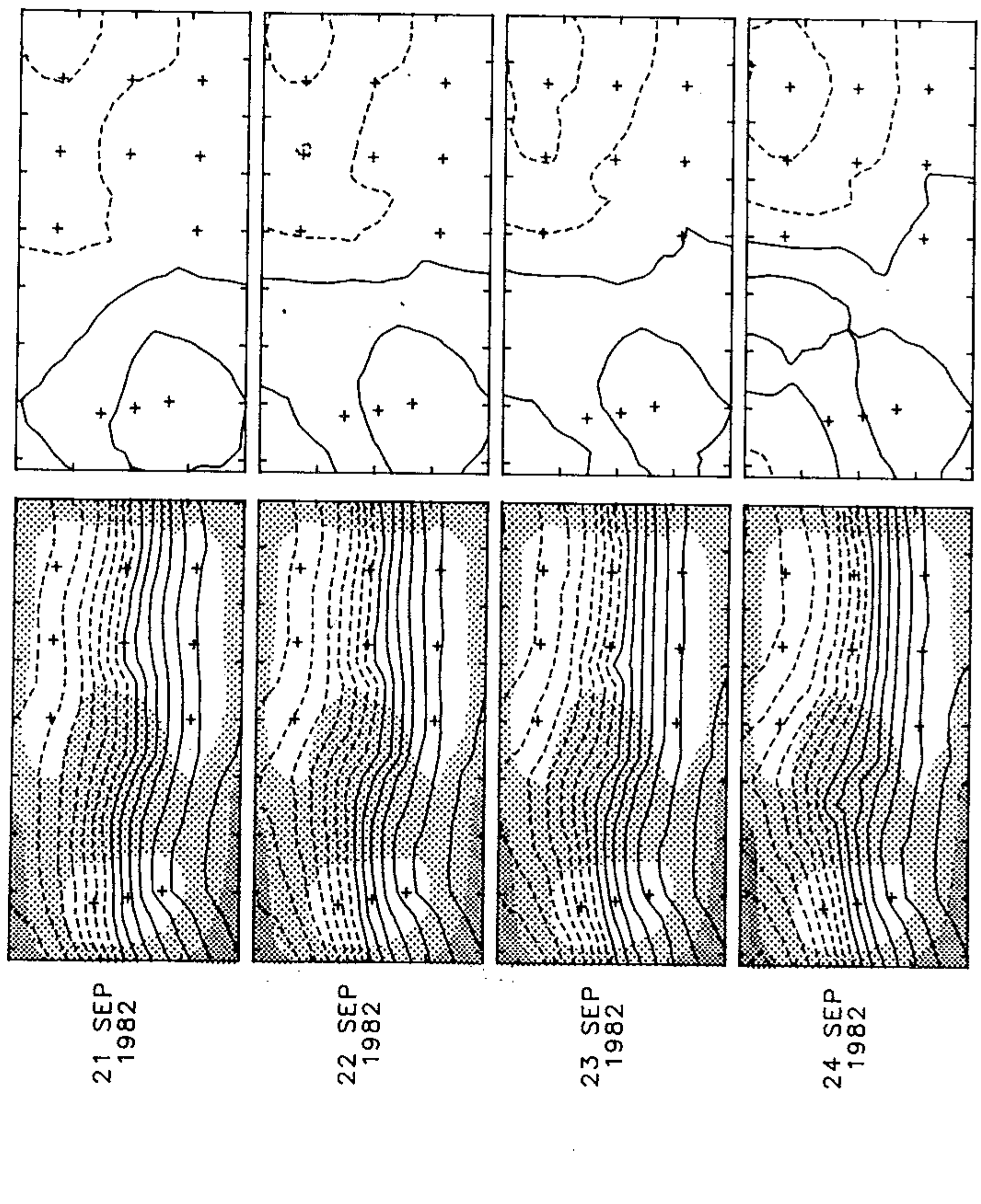
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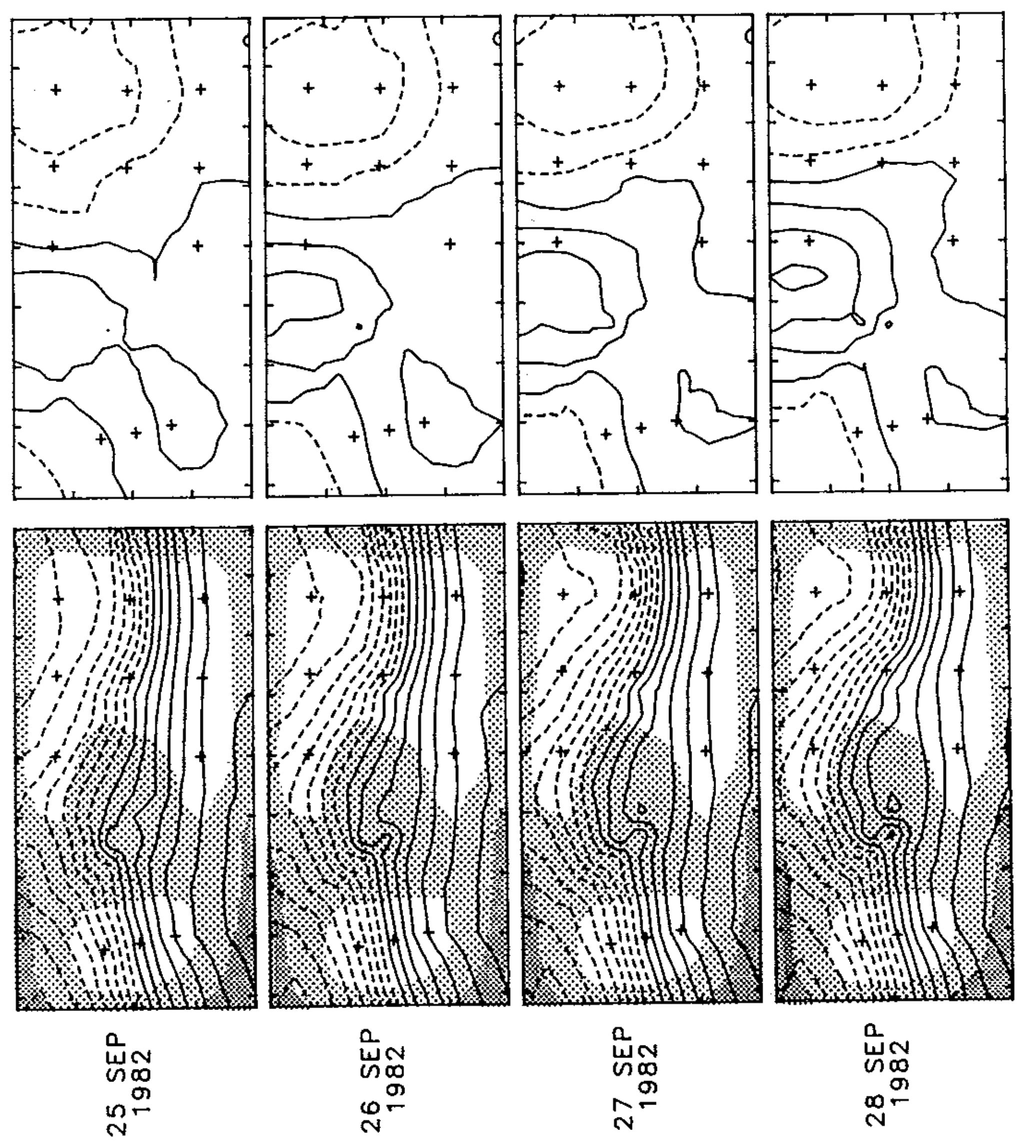
1982



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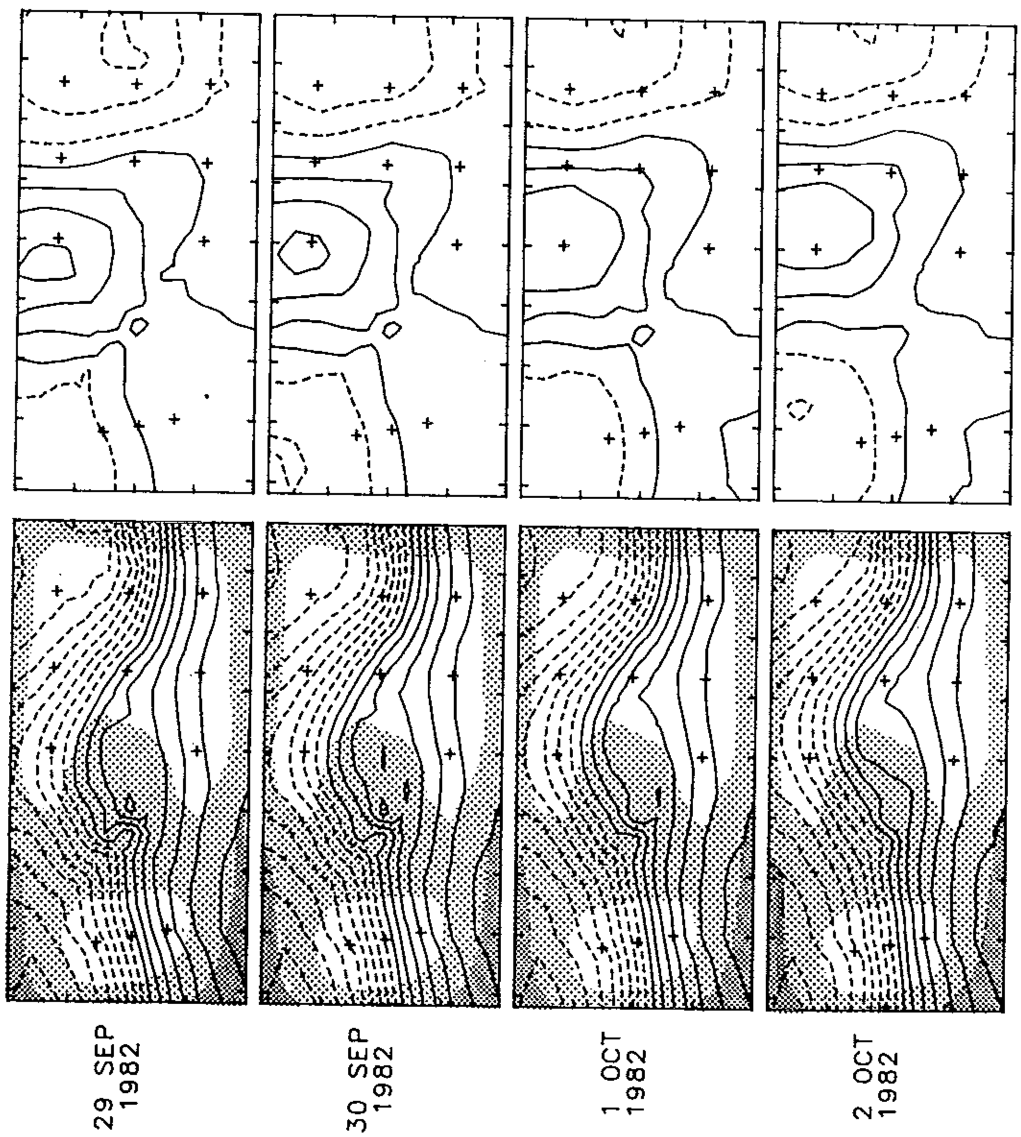
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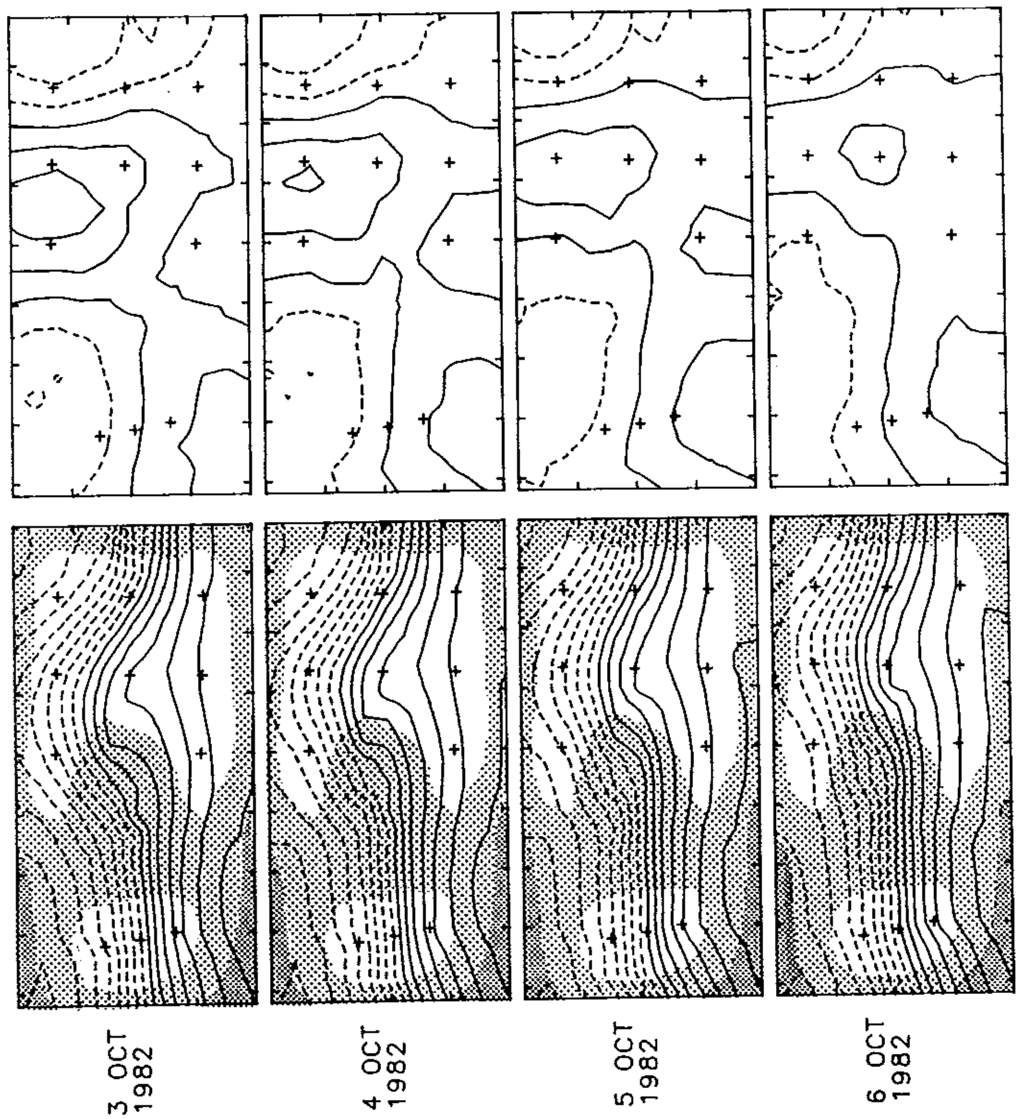
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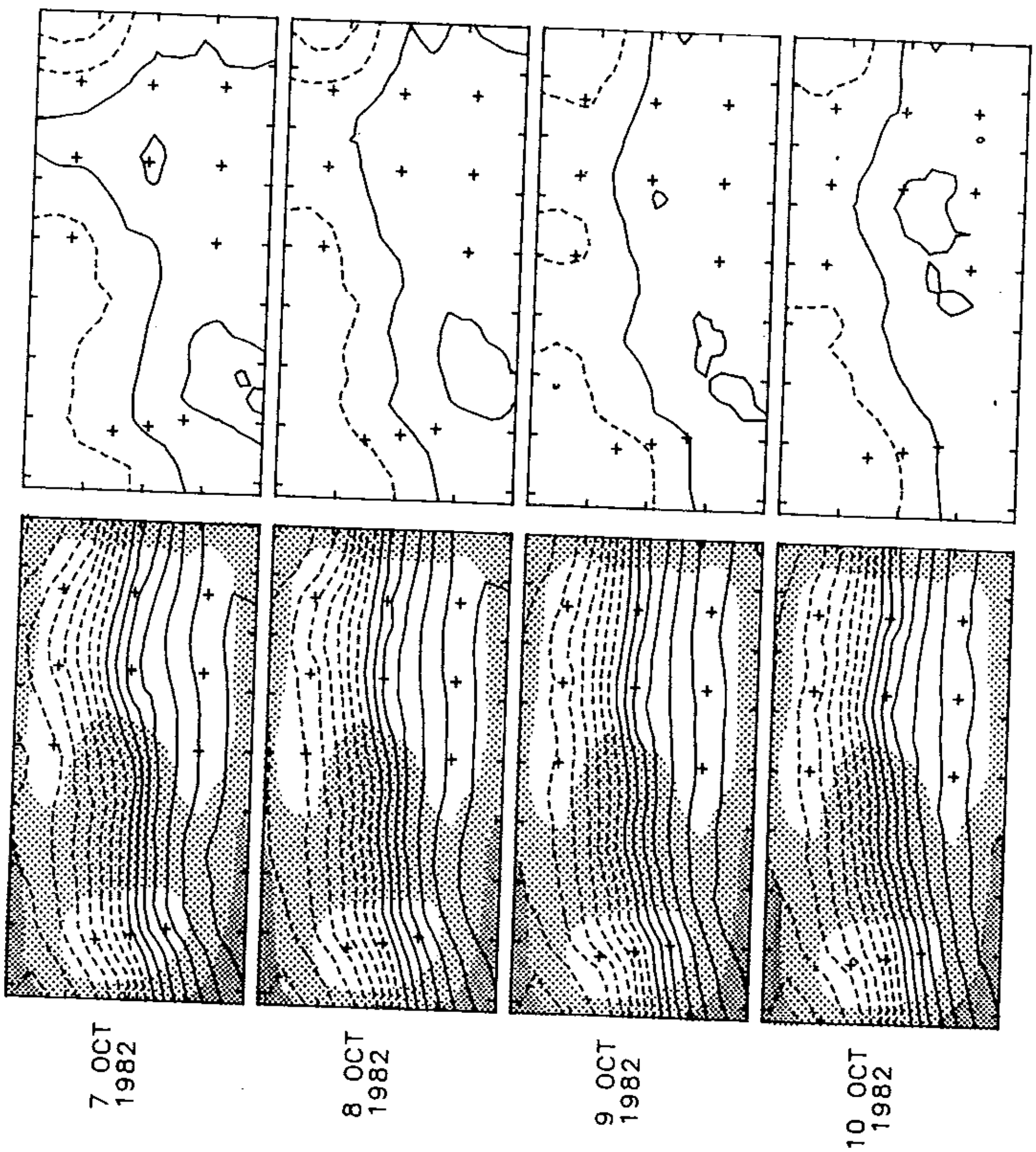
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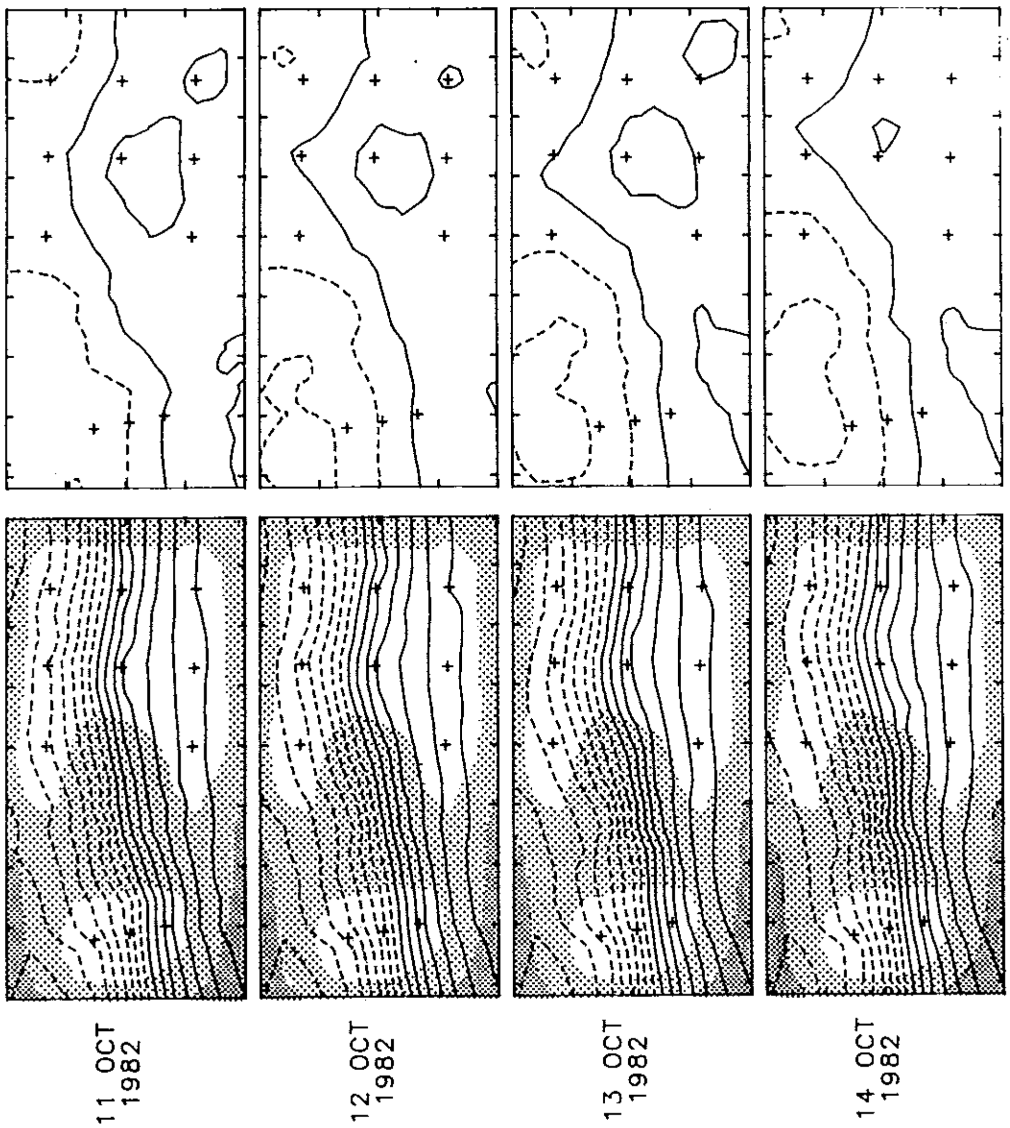
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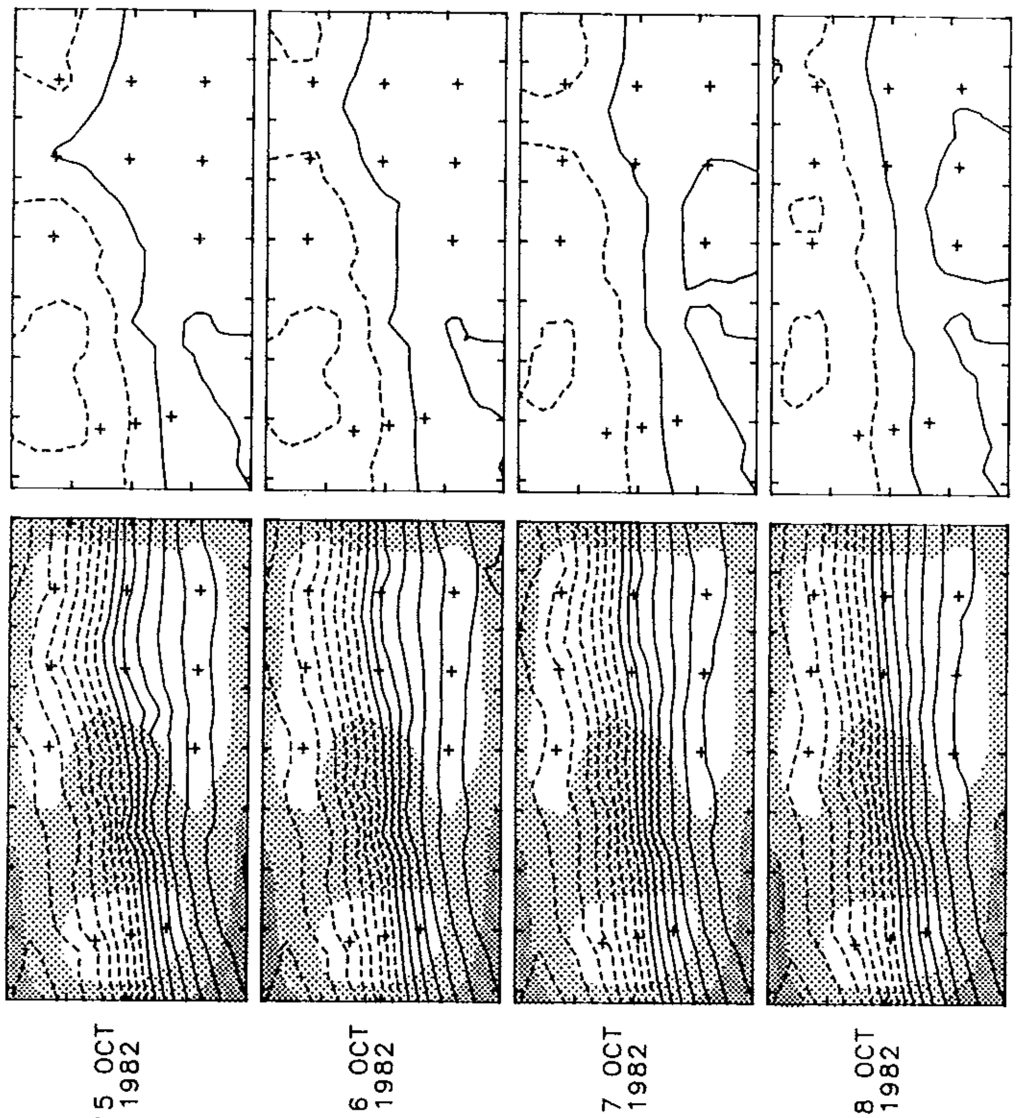
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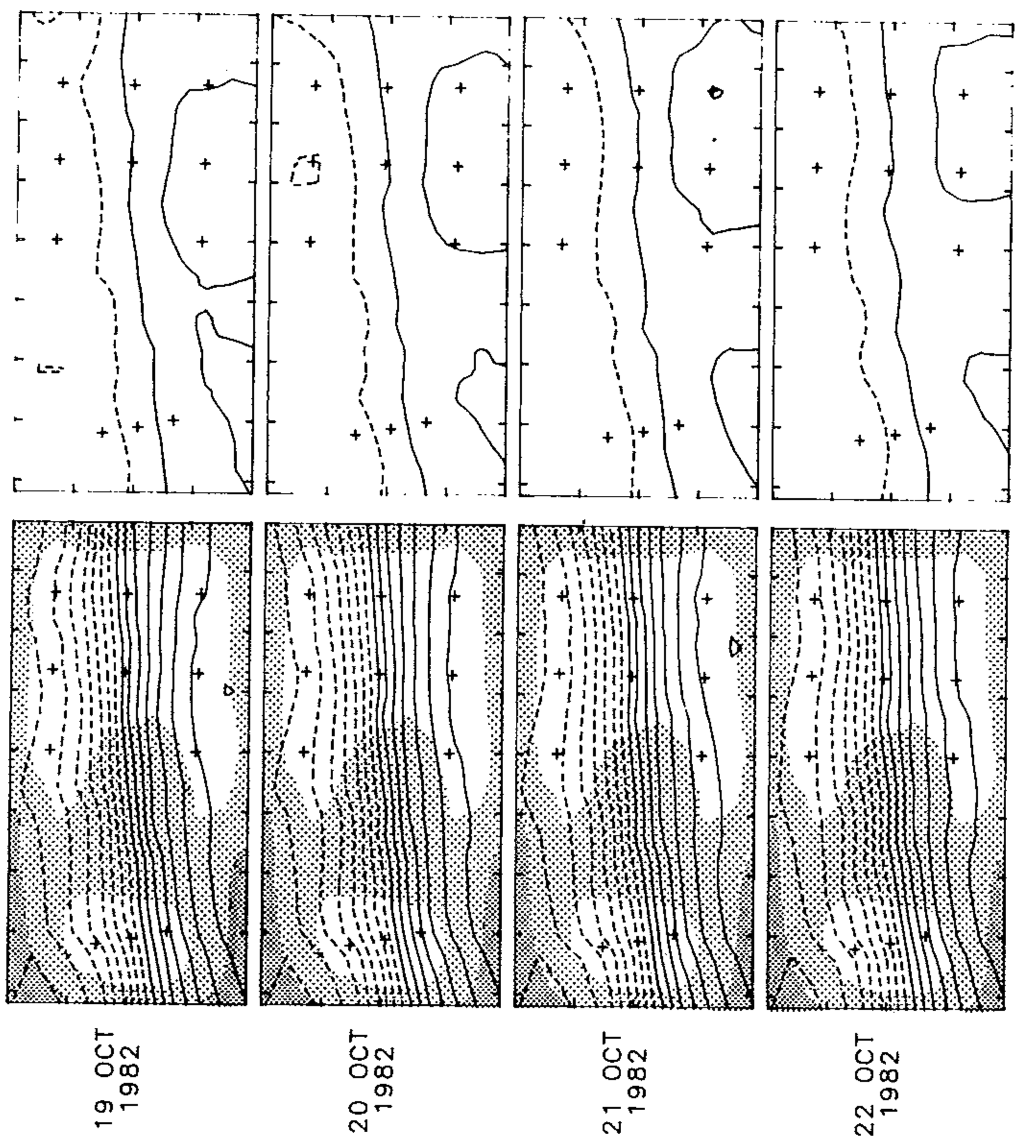
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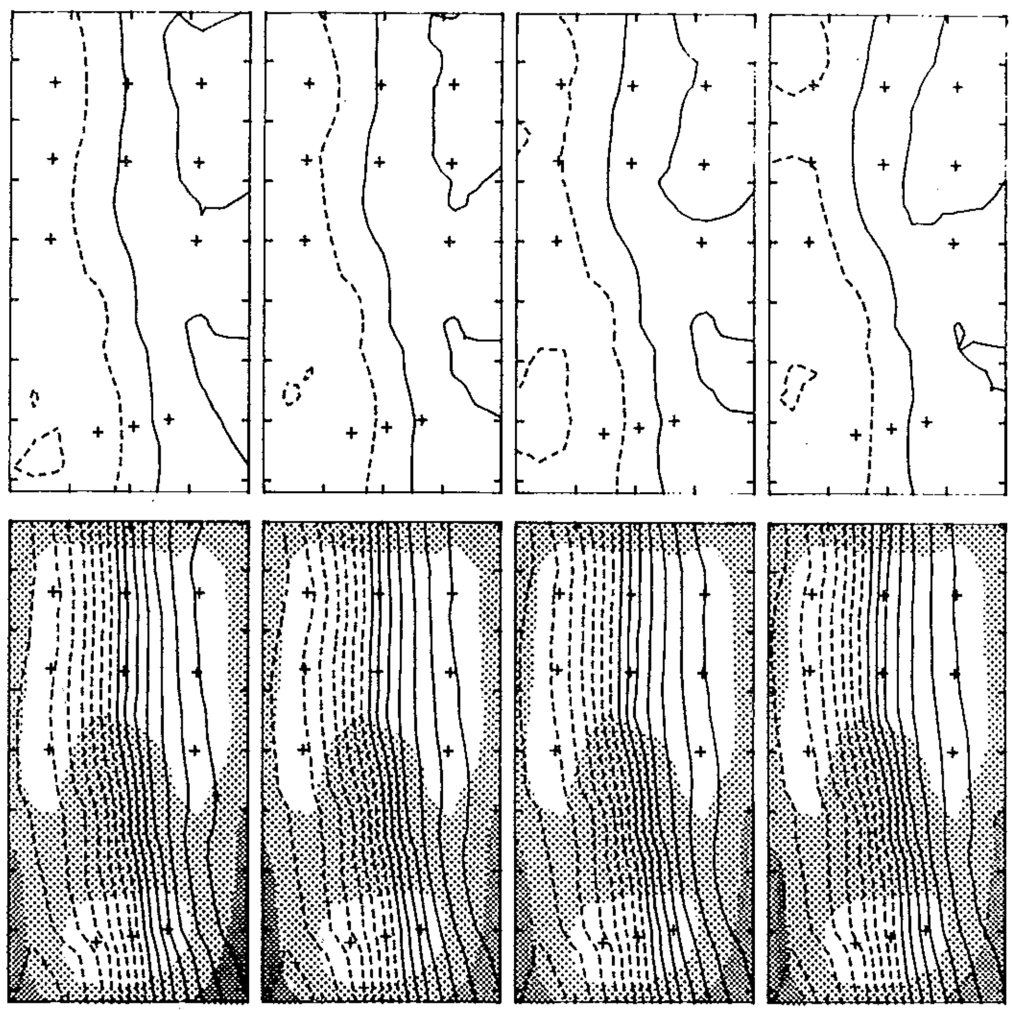

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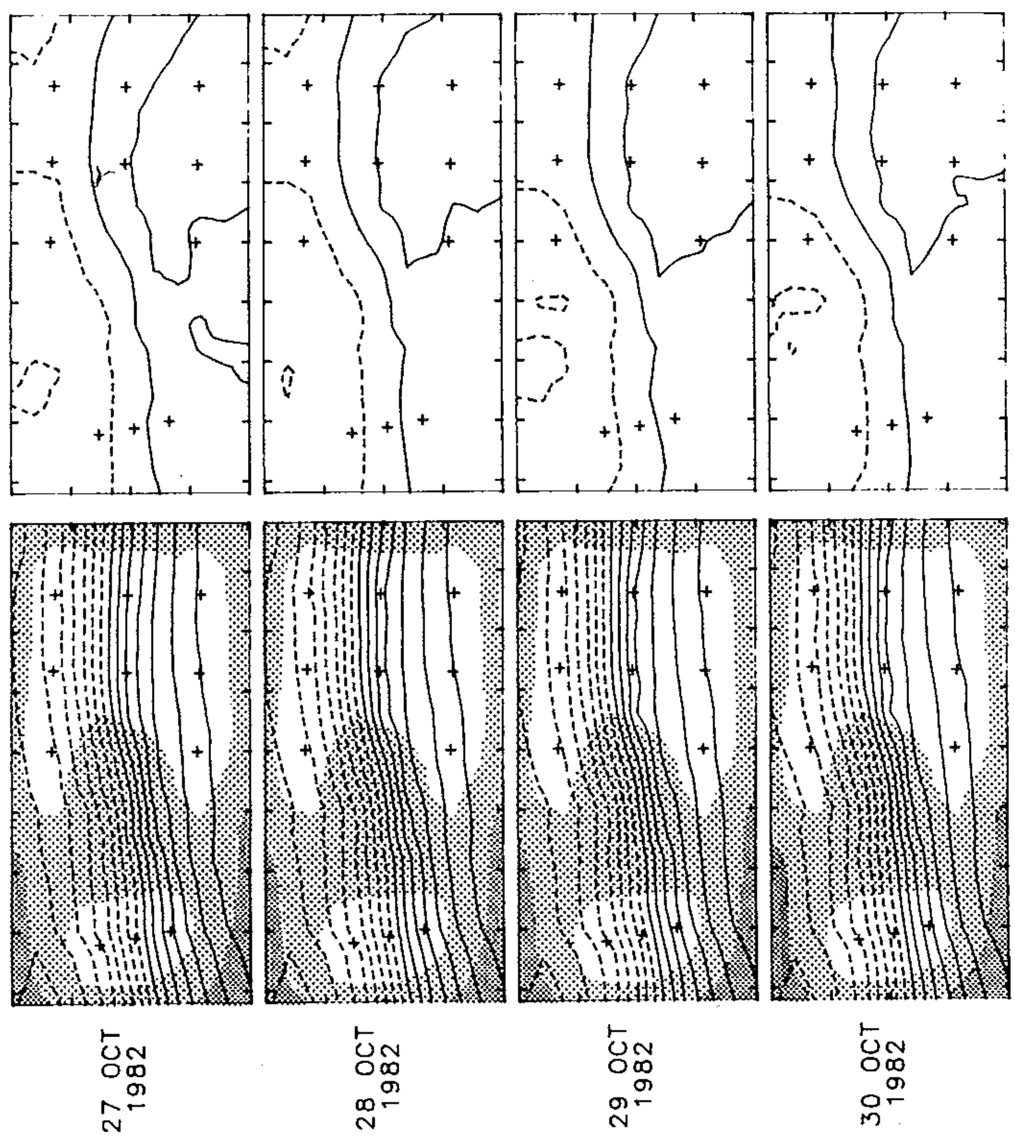
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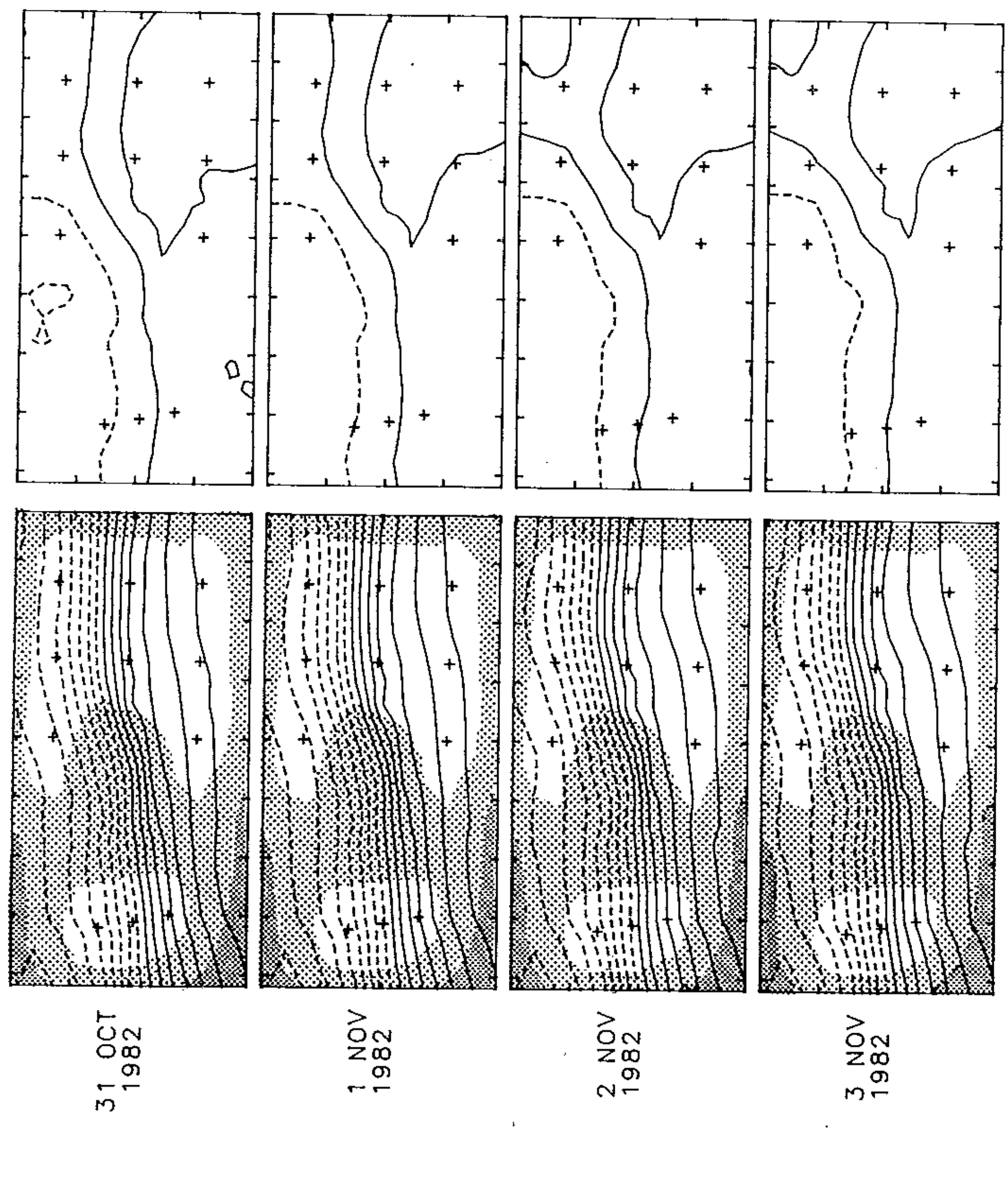
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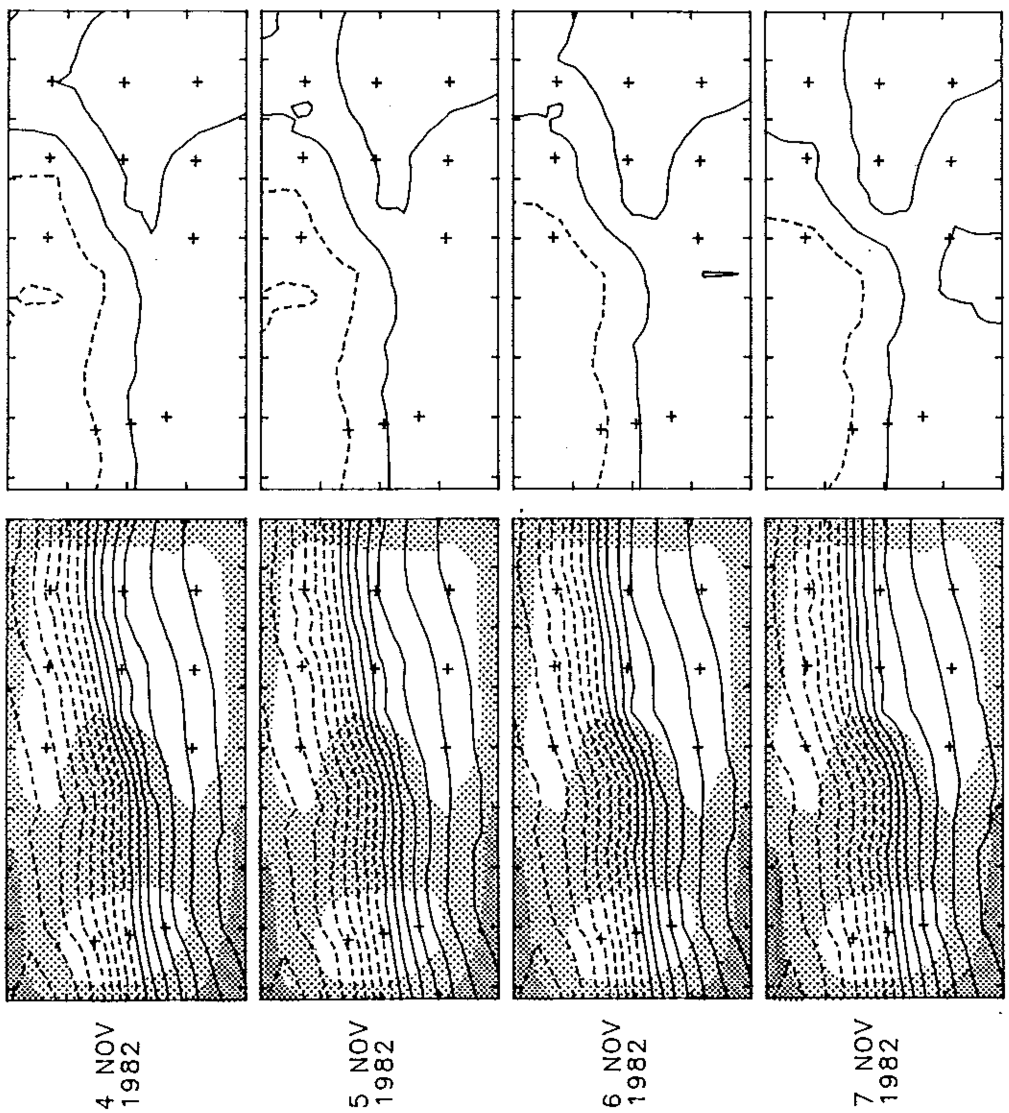
1982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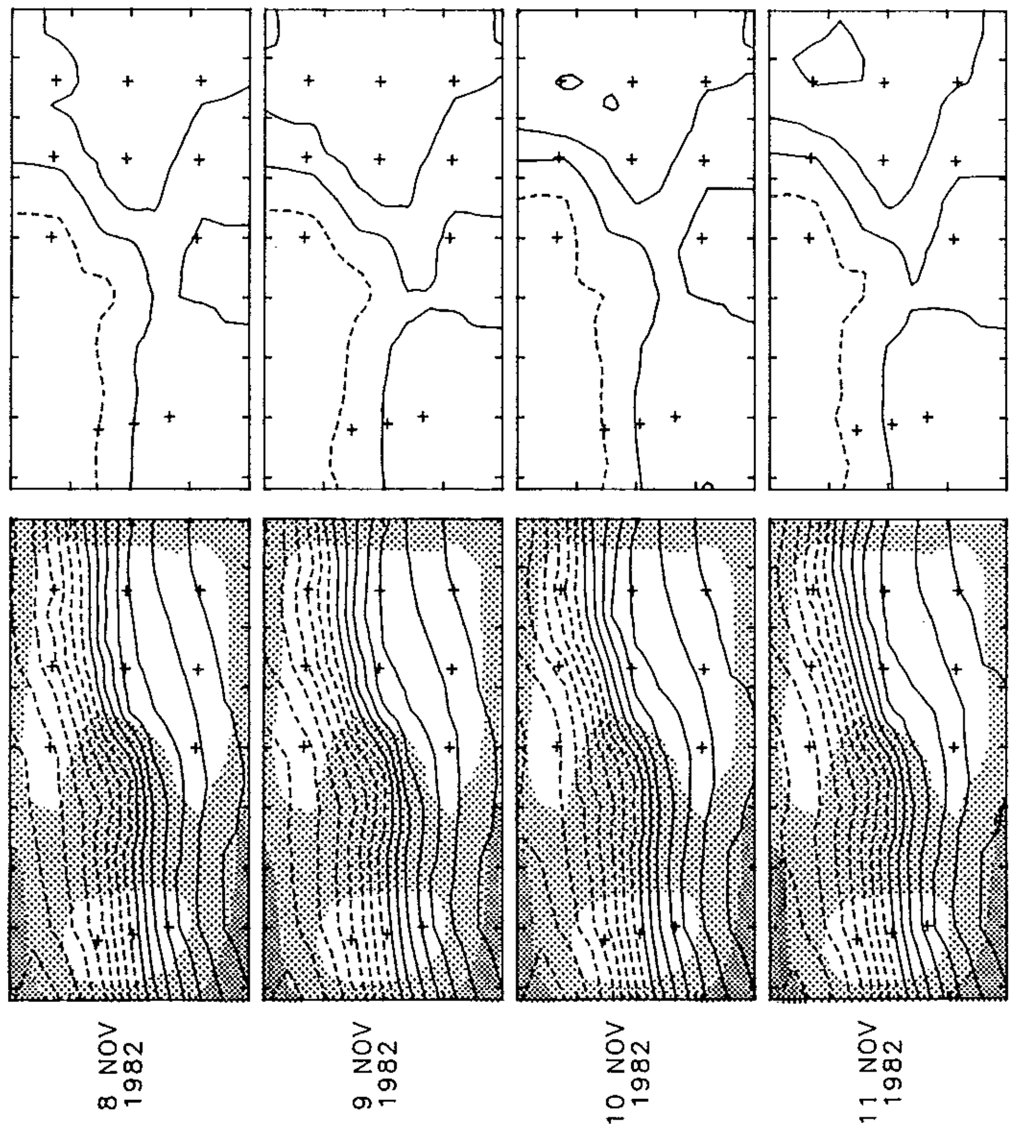
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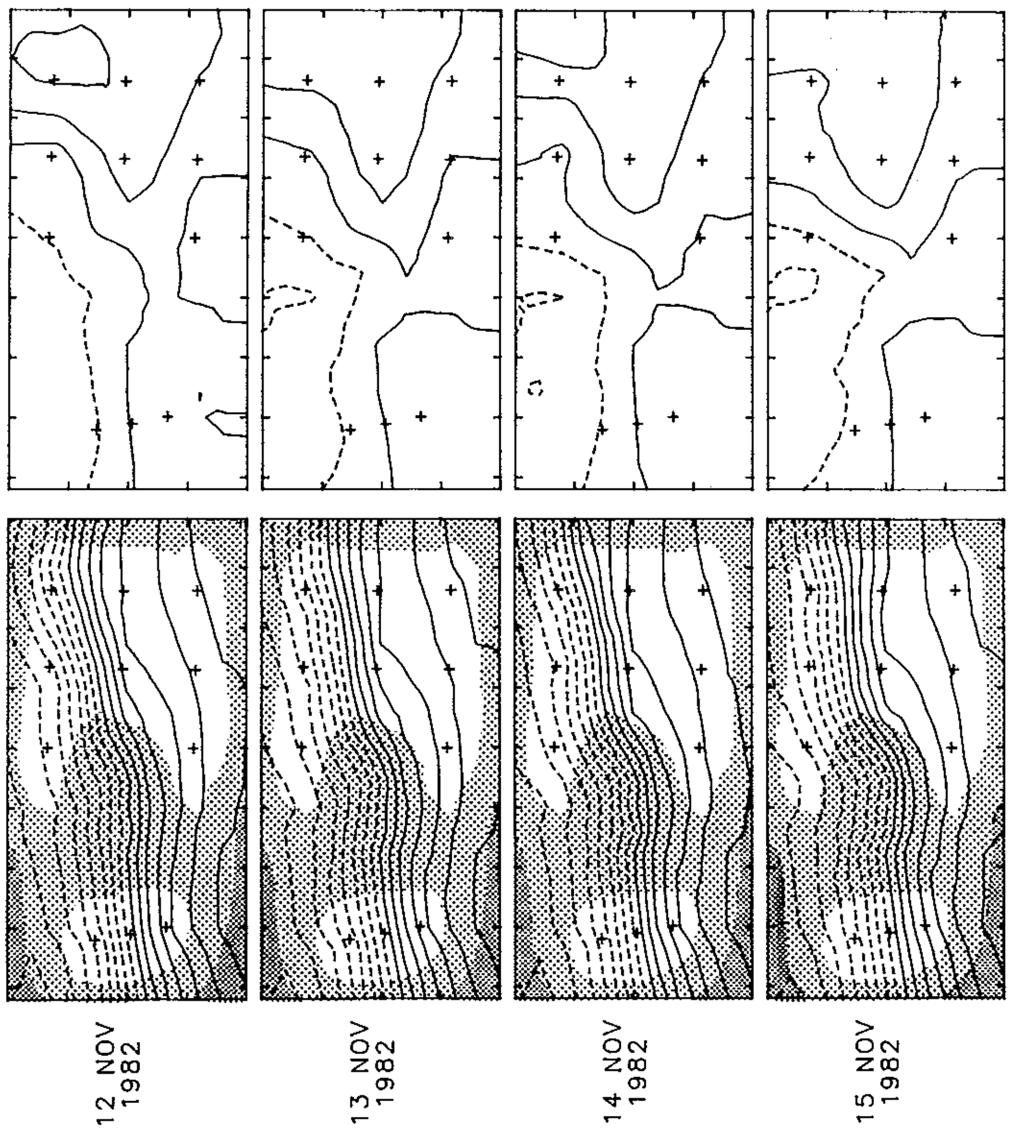
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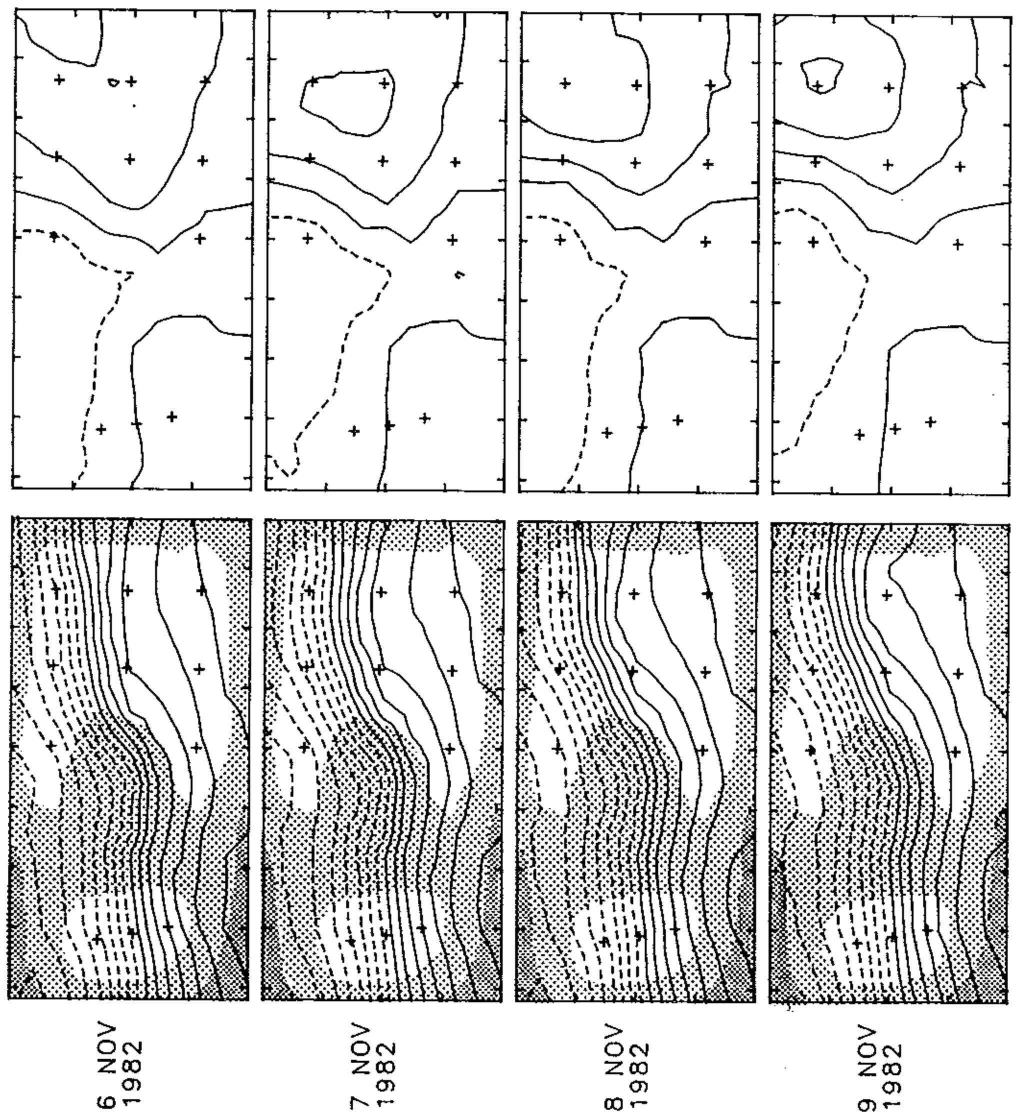
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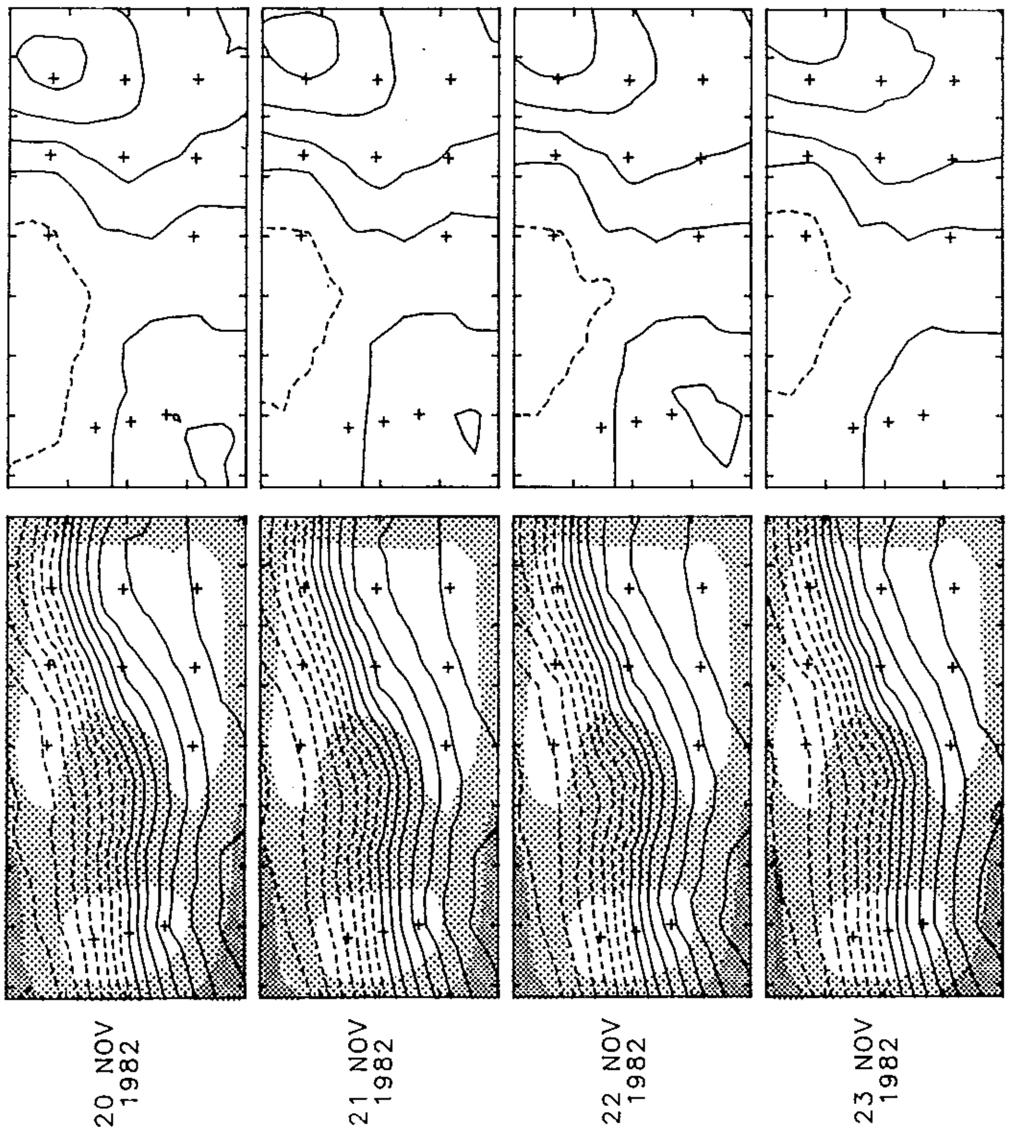
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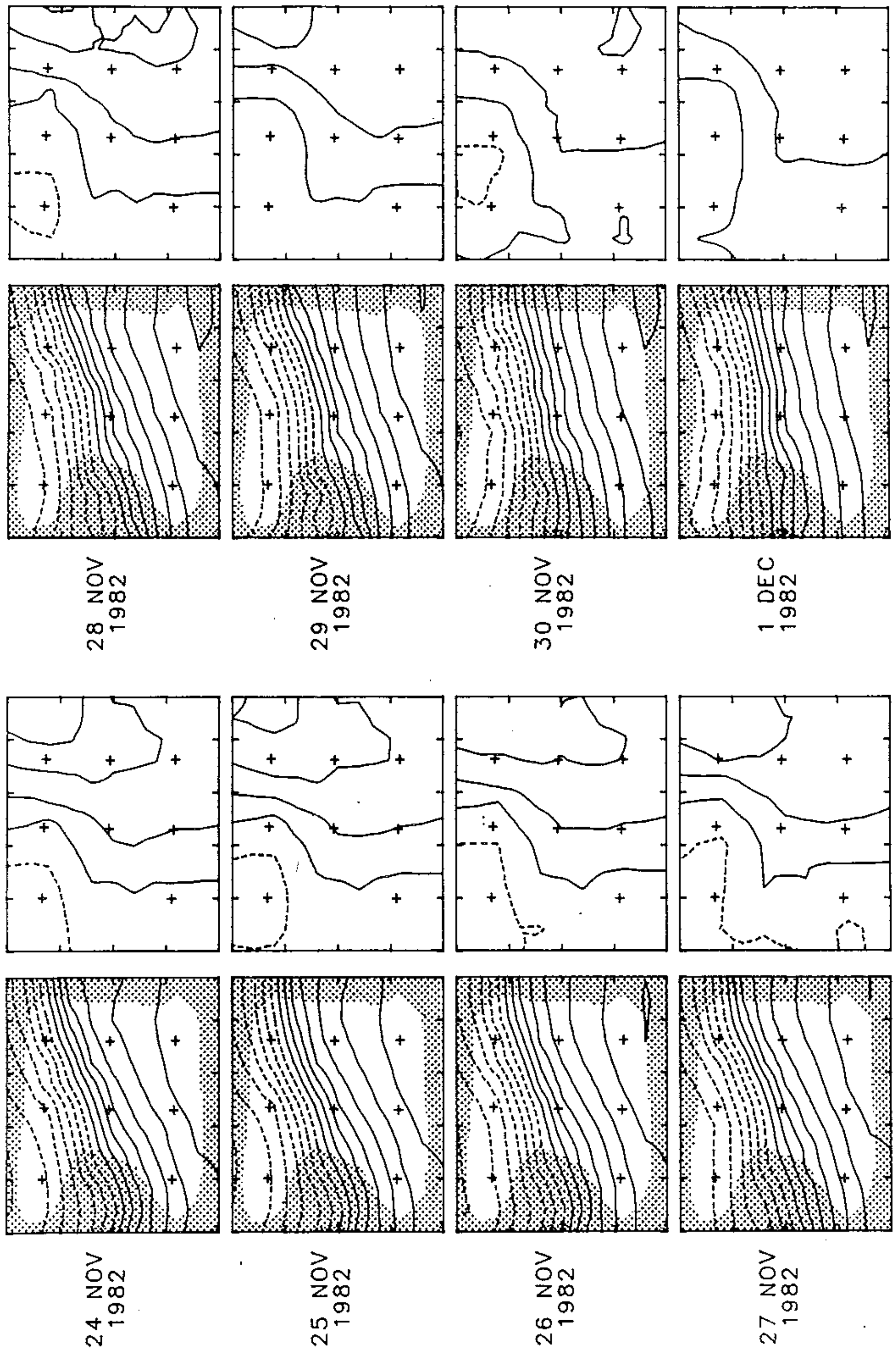

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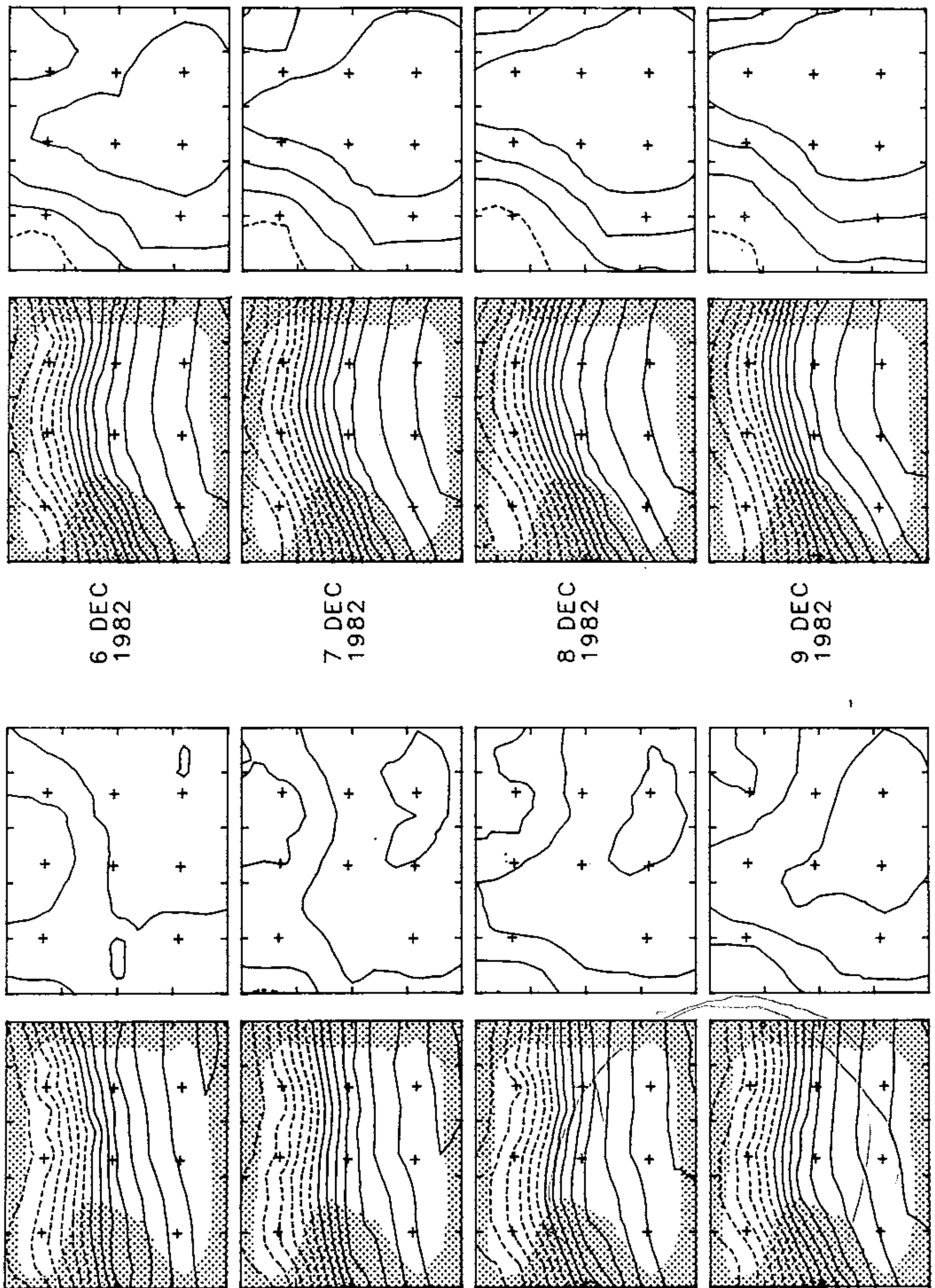

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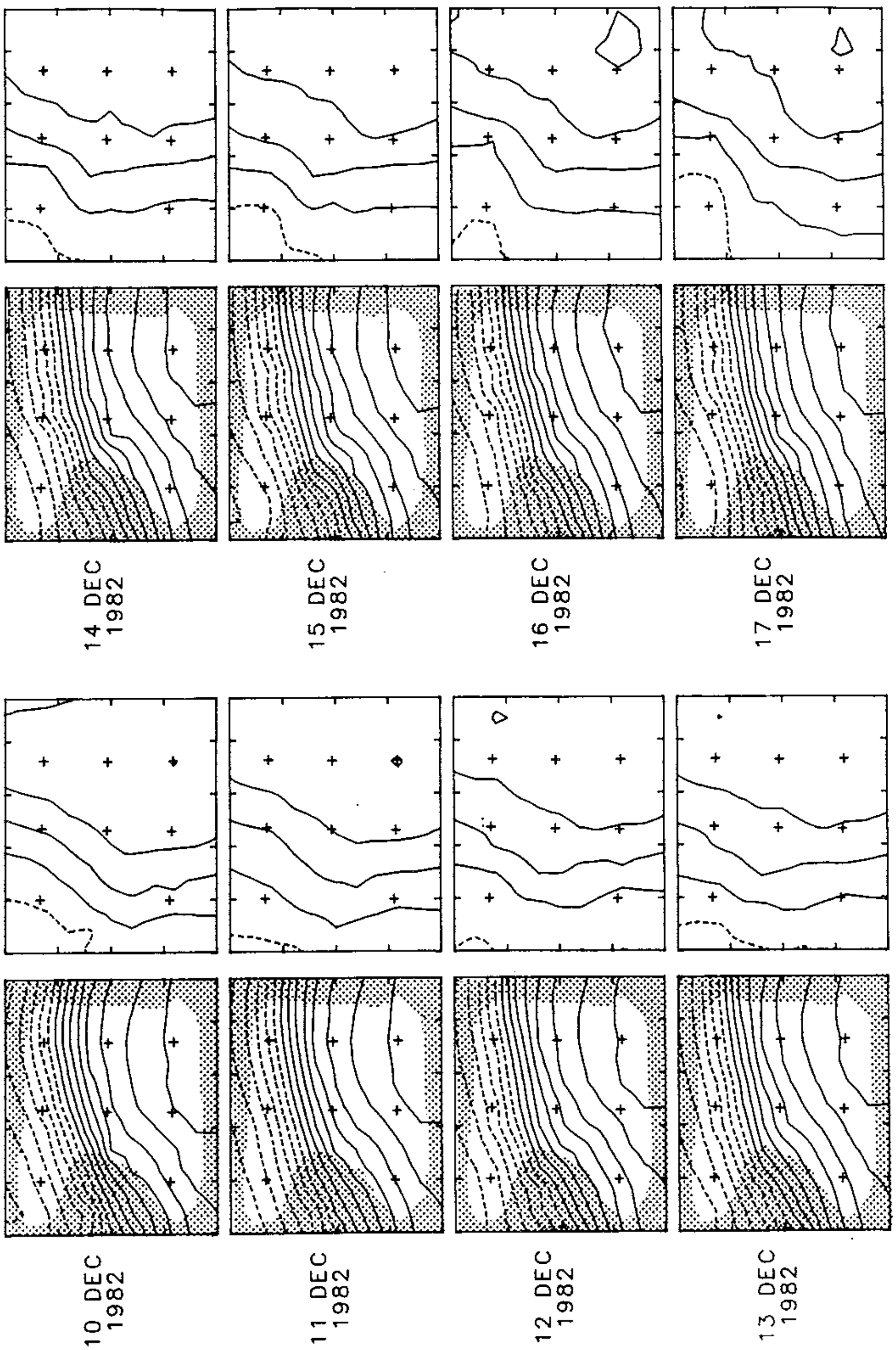

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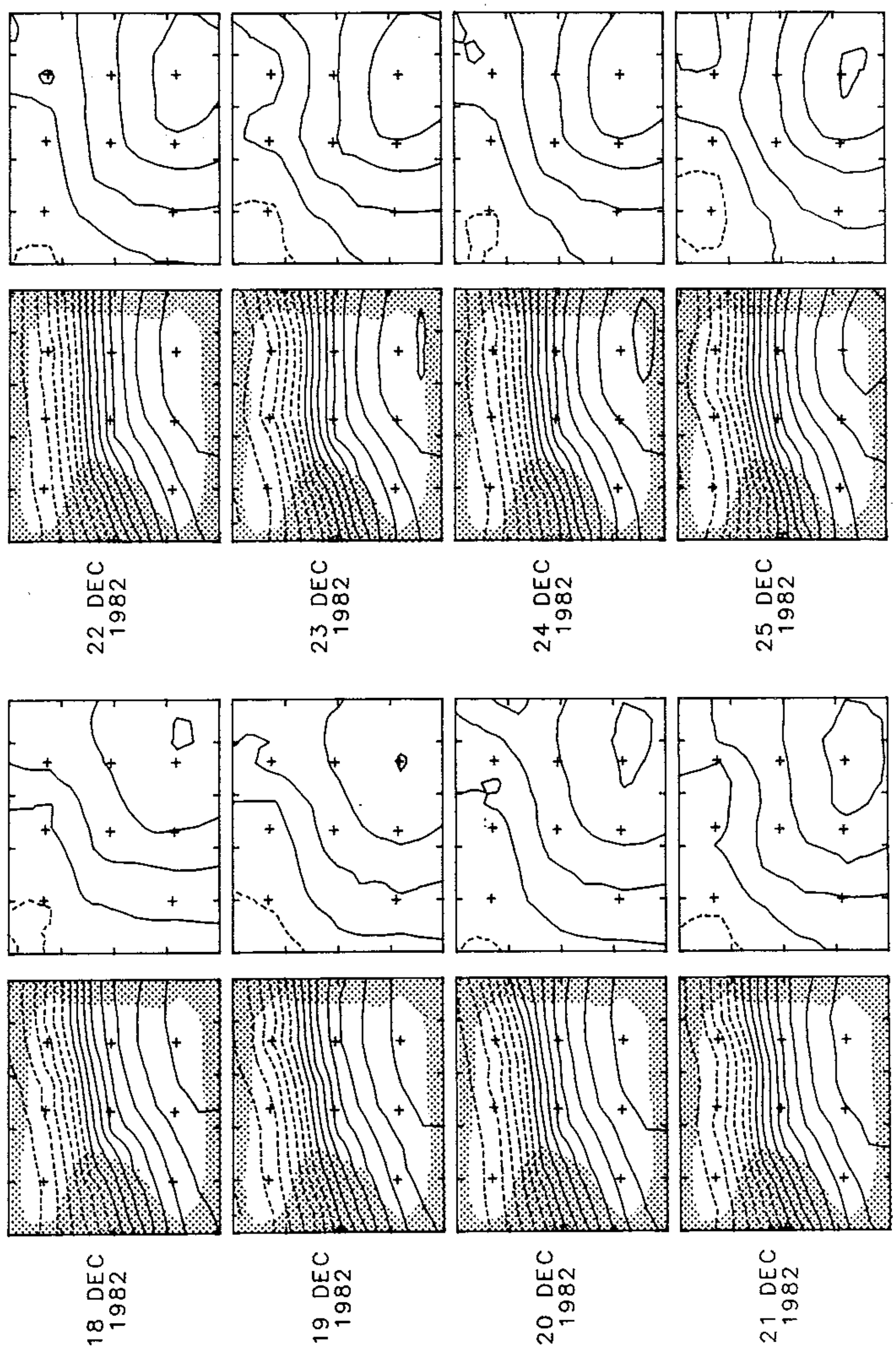
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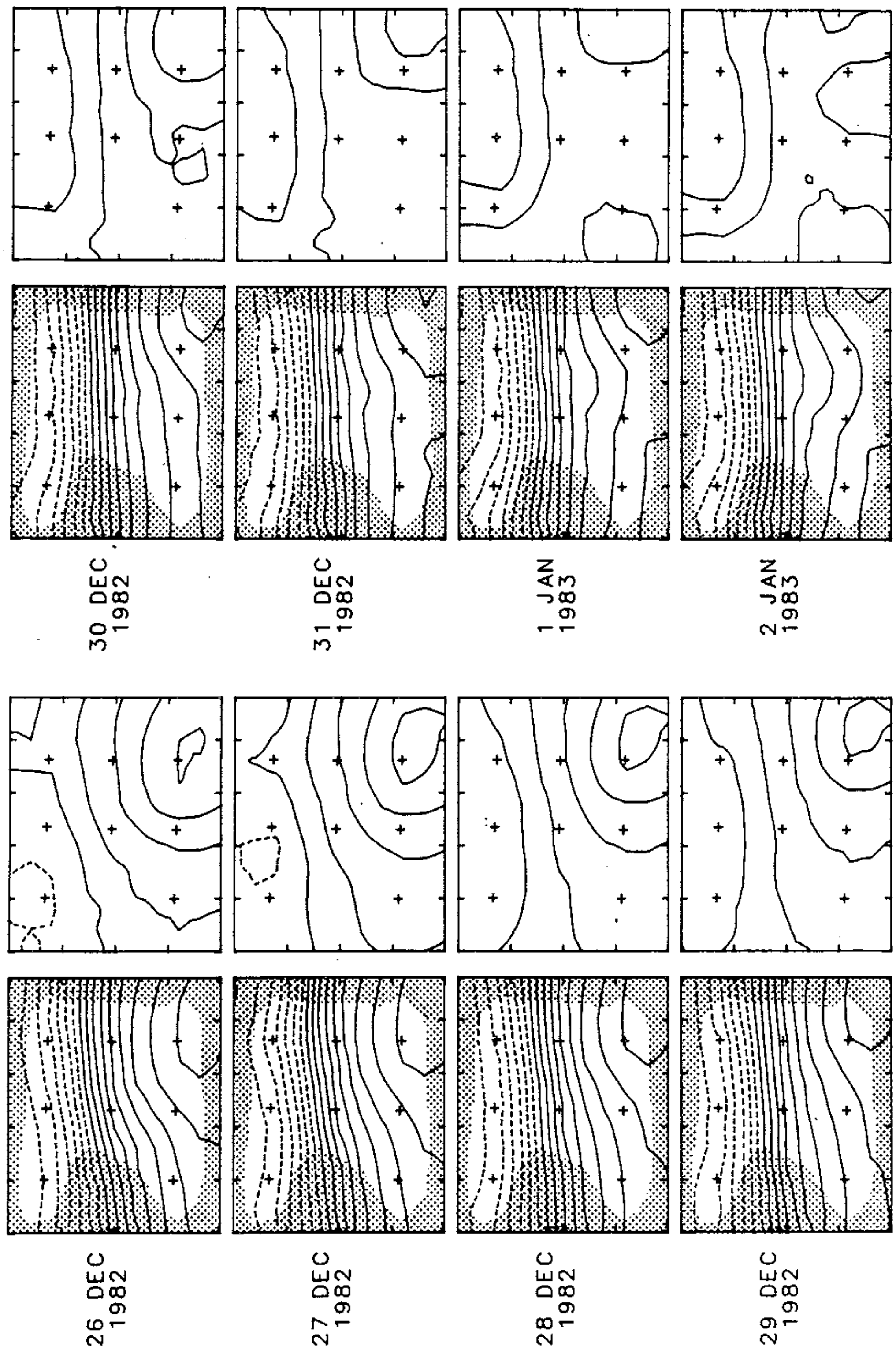
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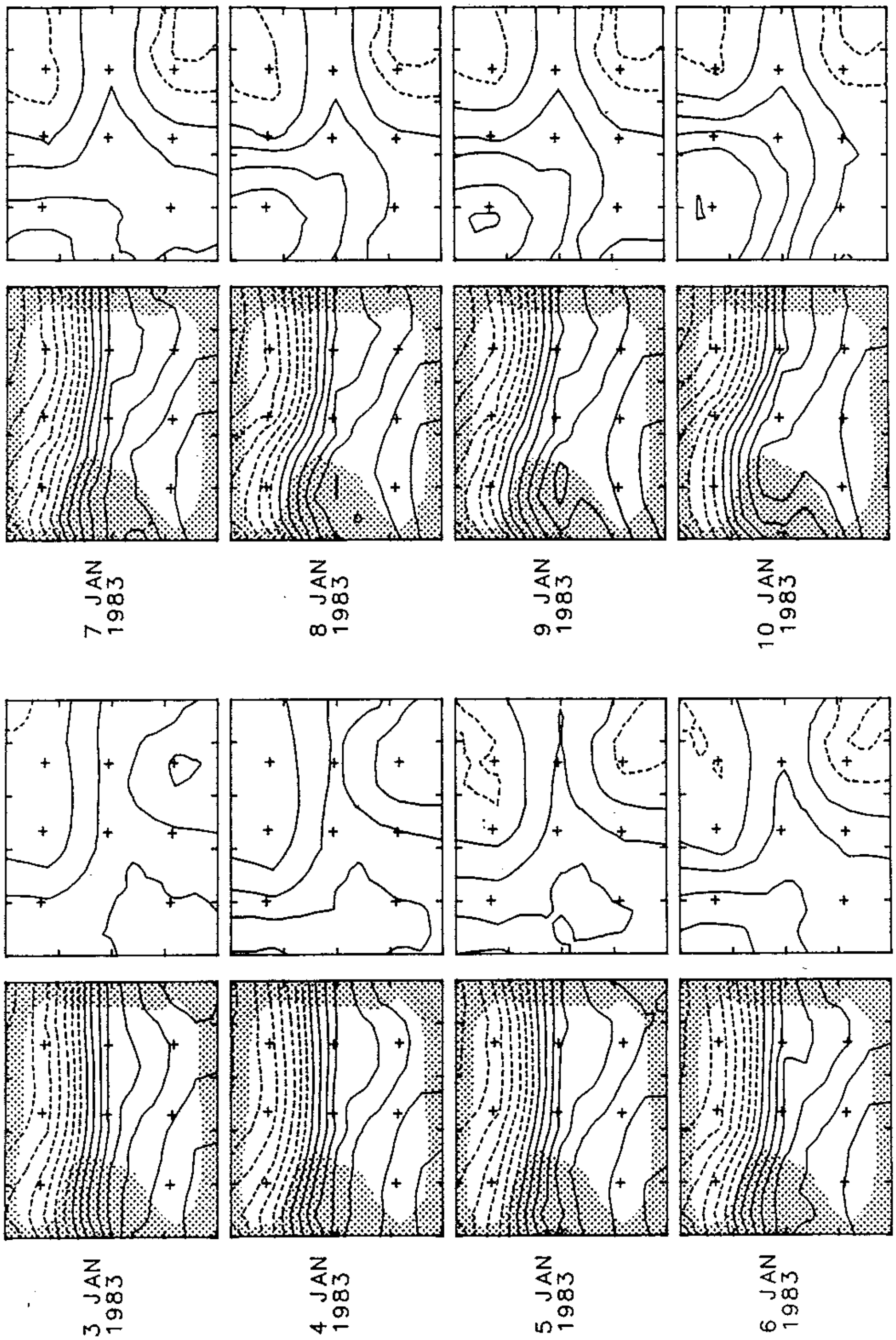
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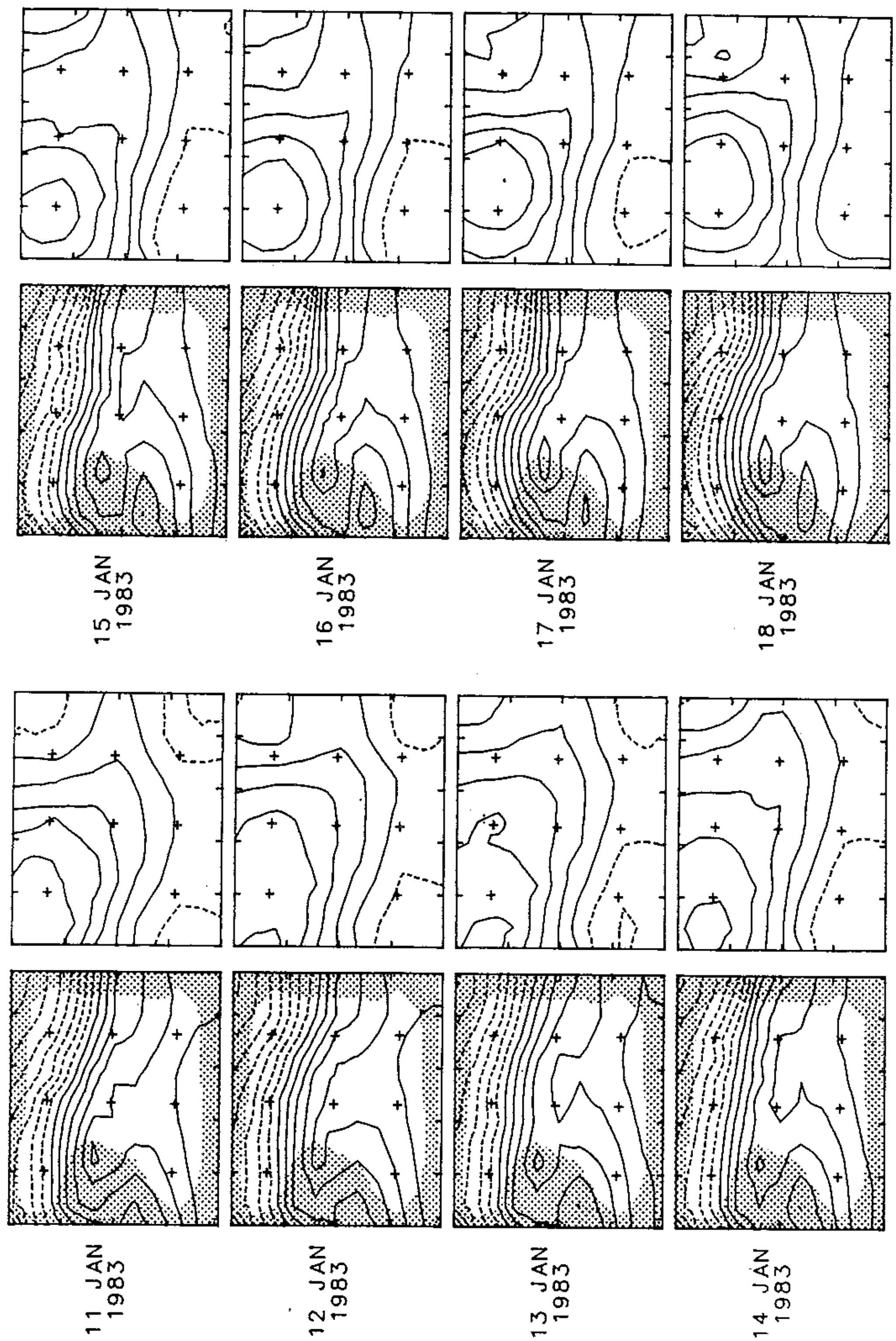
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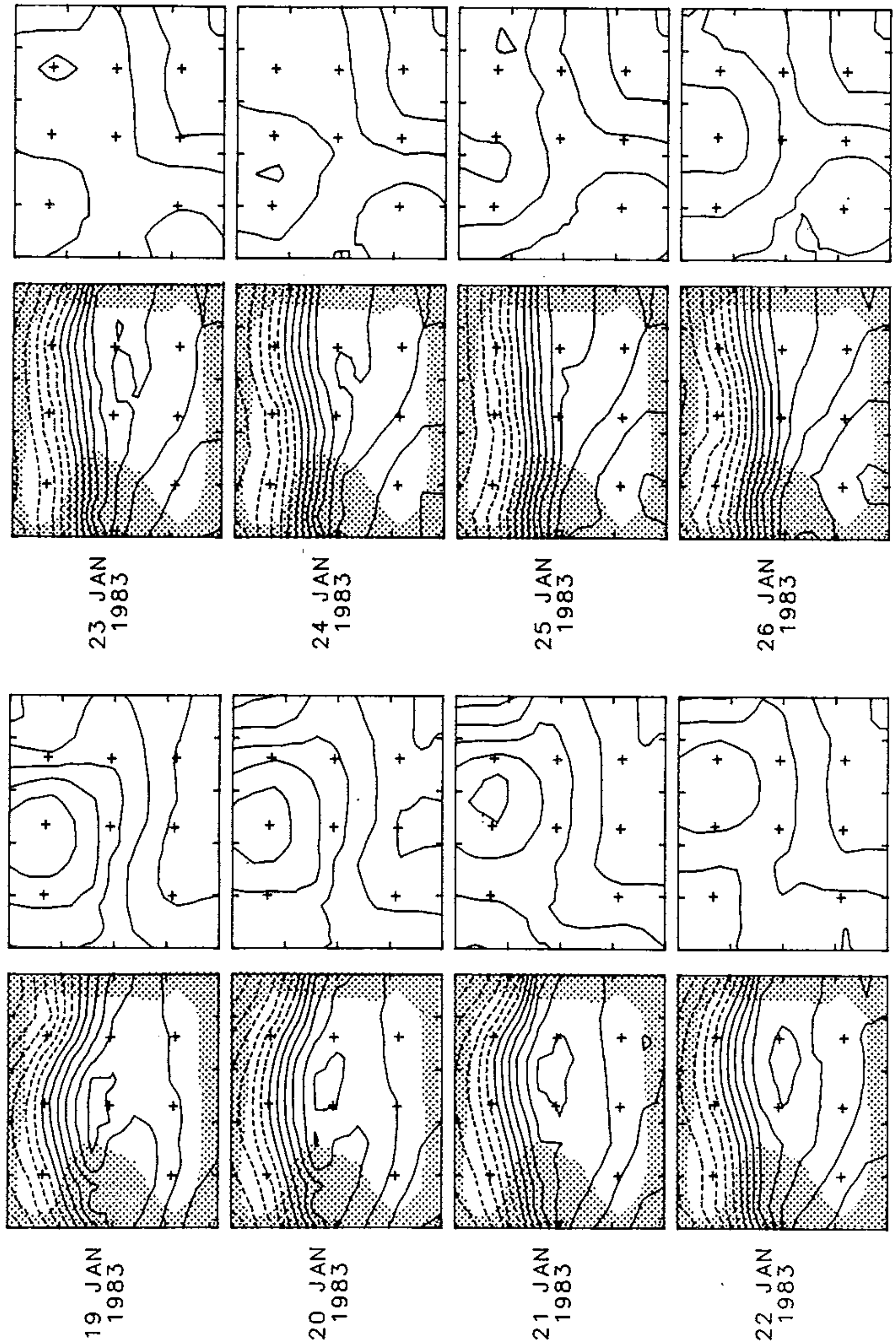
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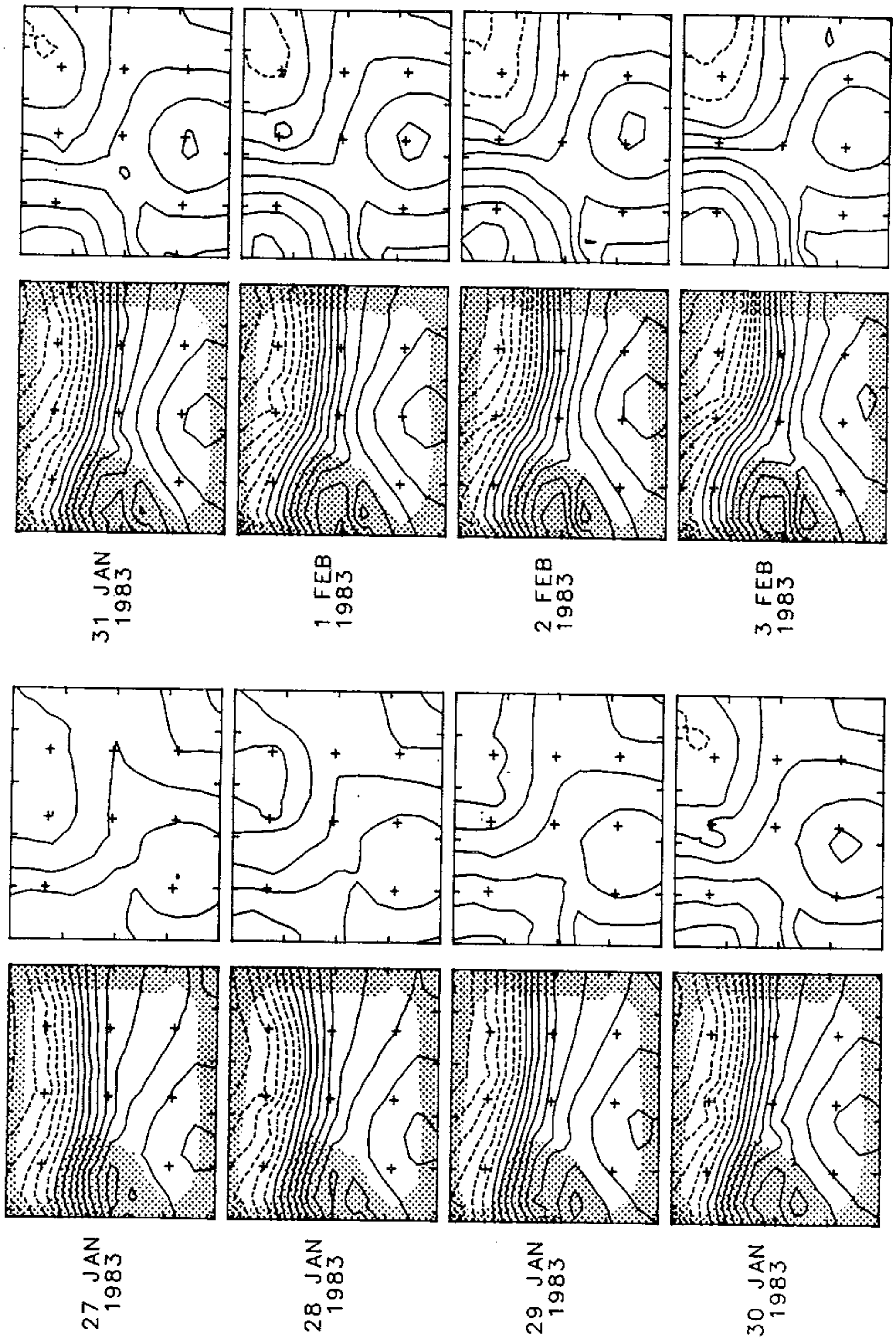
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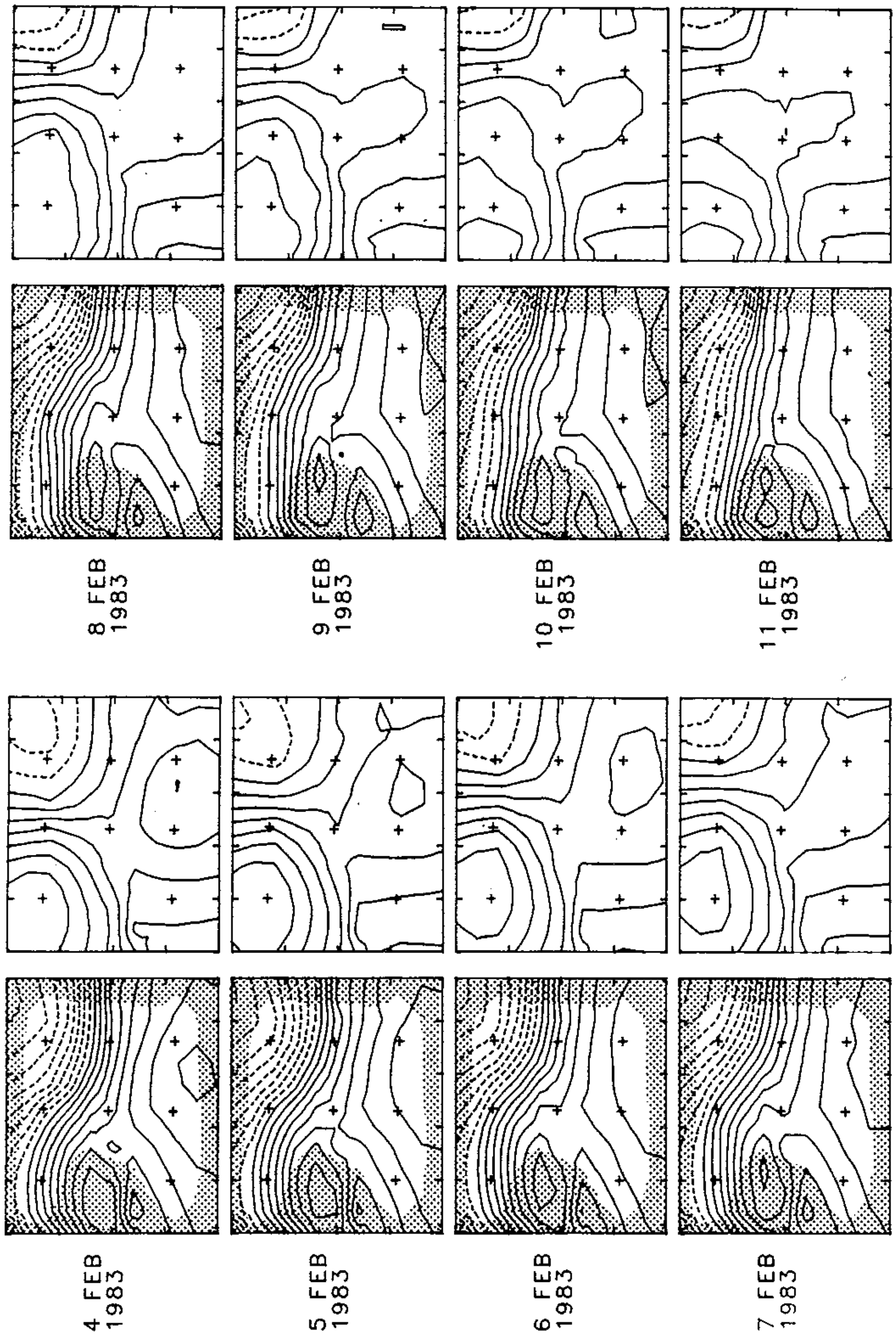
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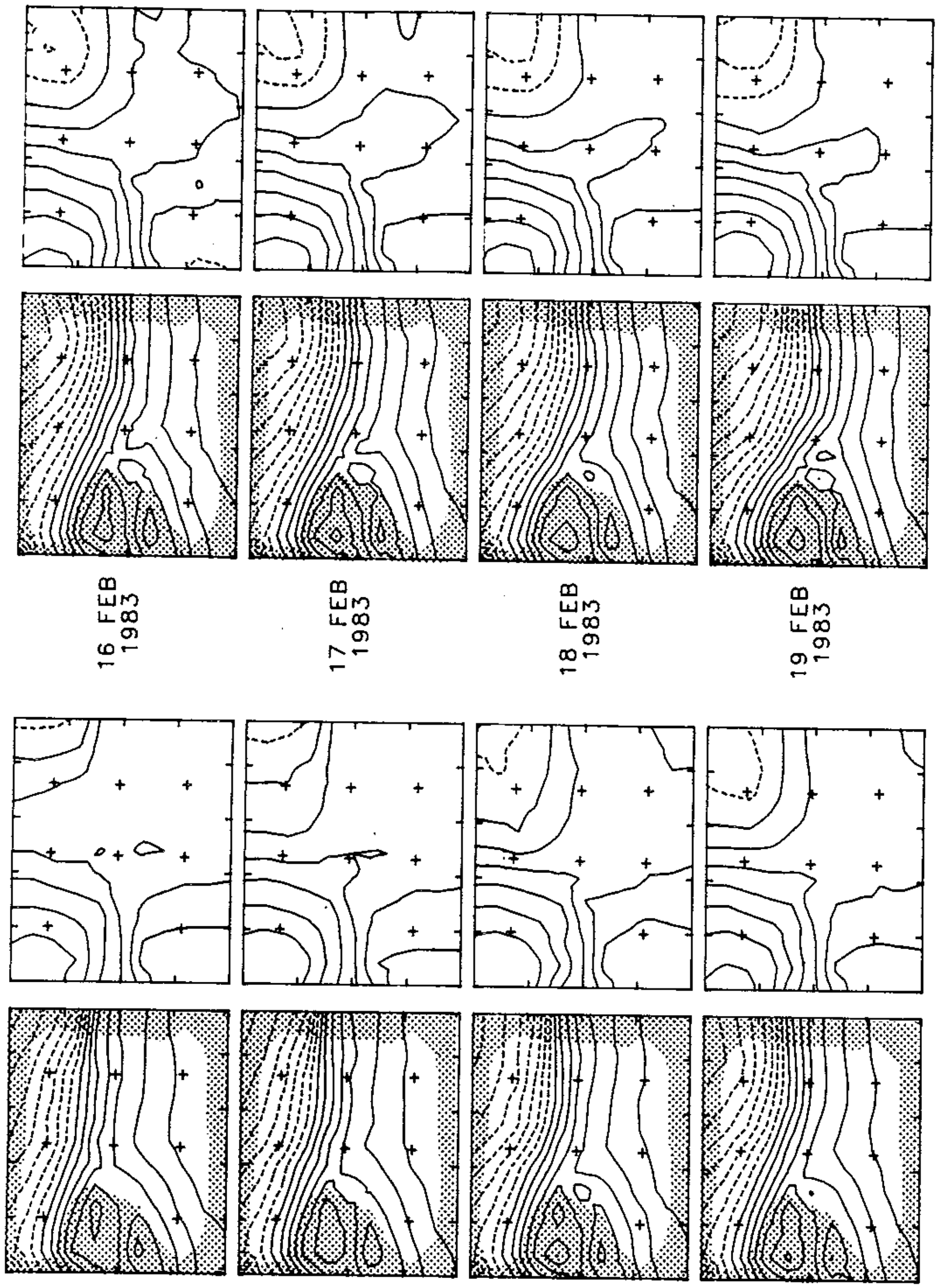
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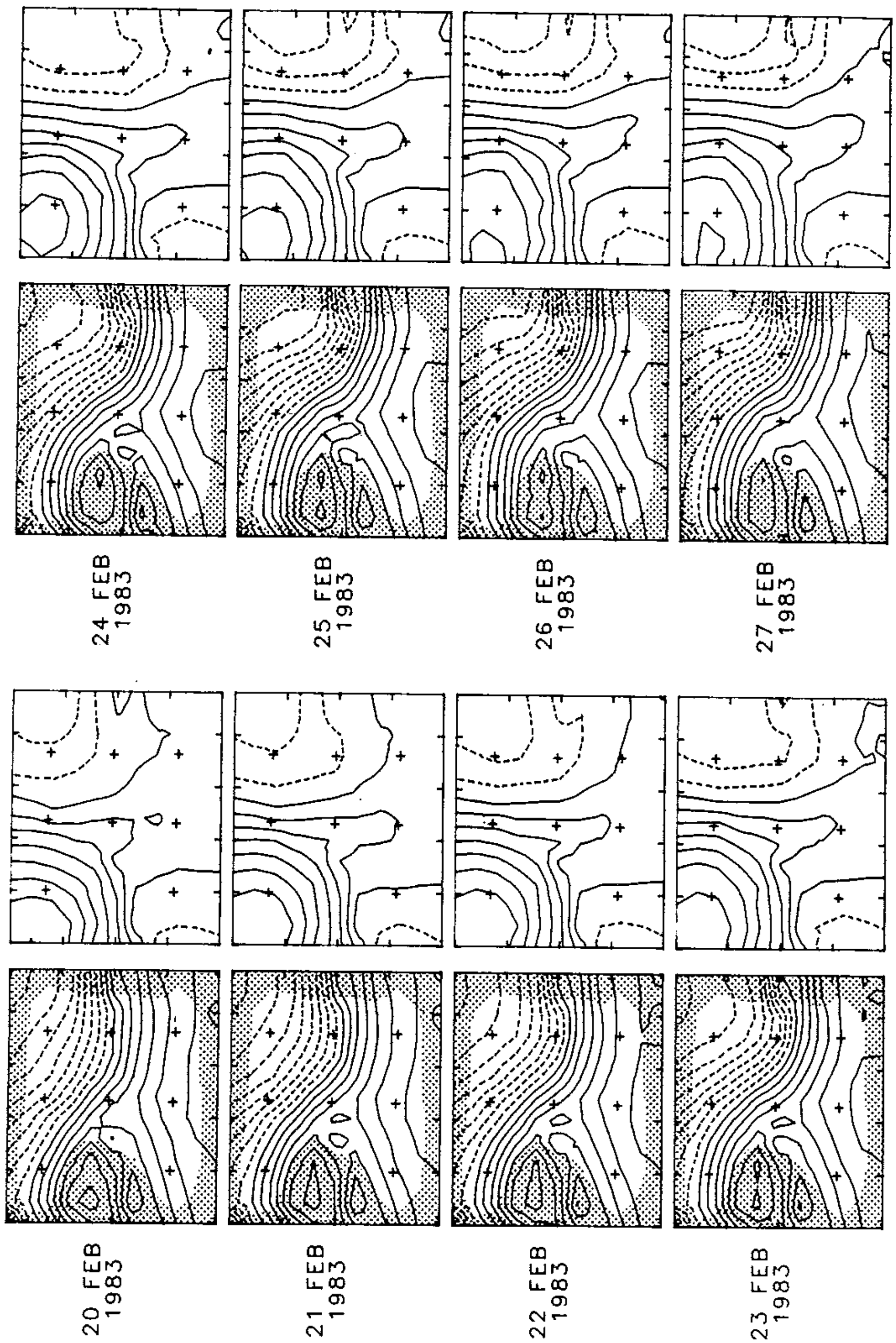
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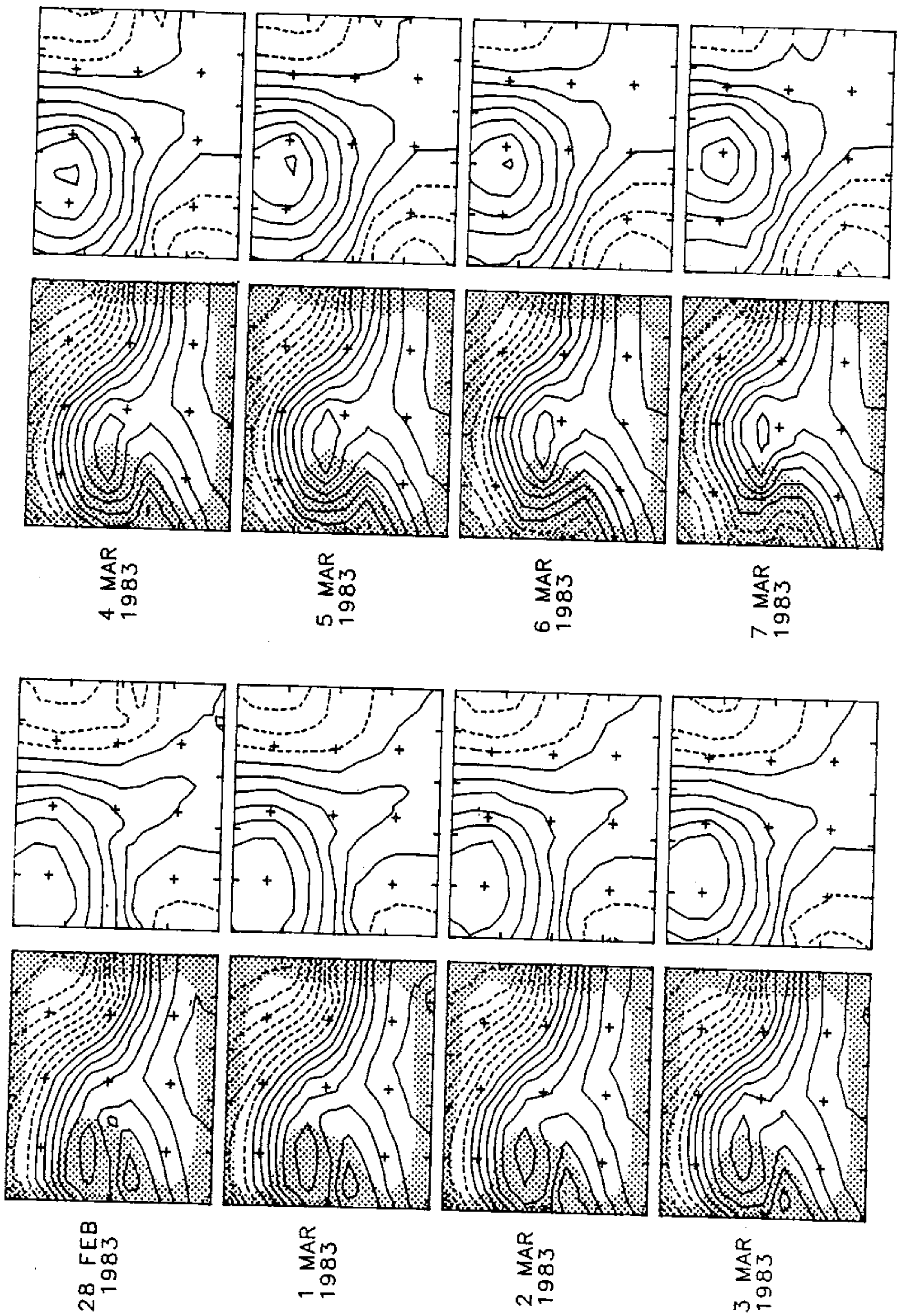
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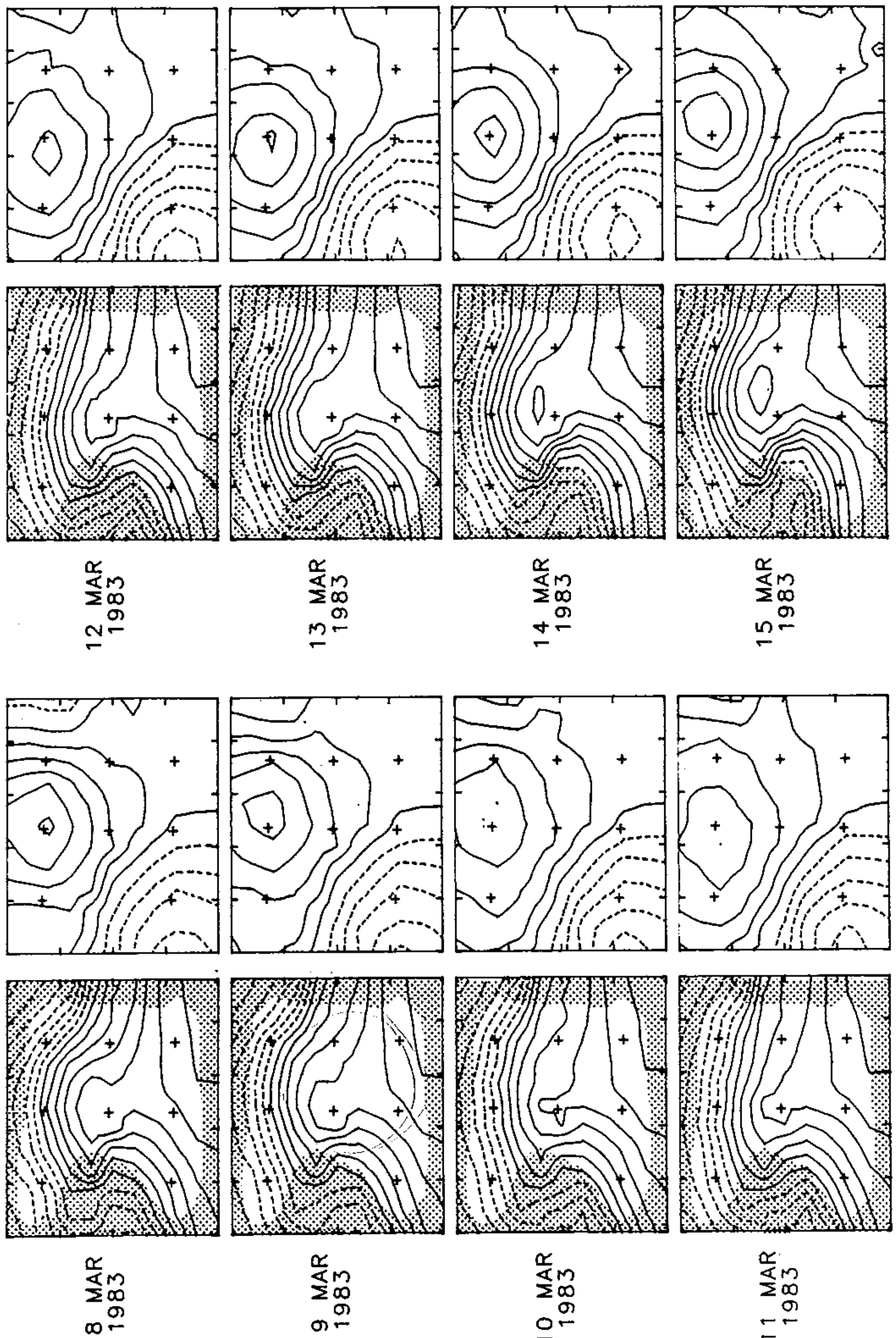
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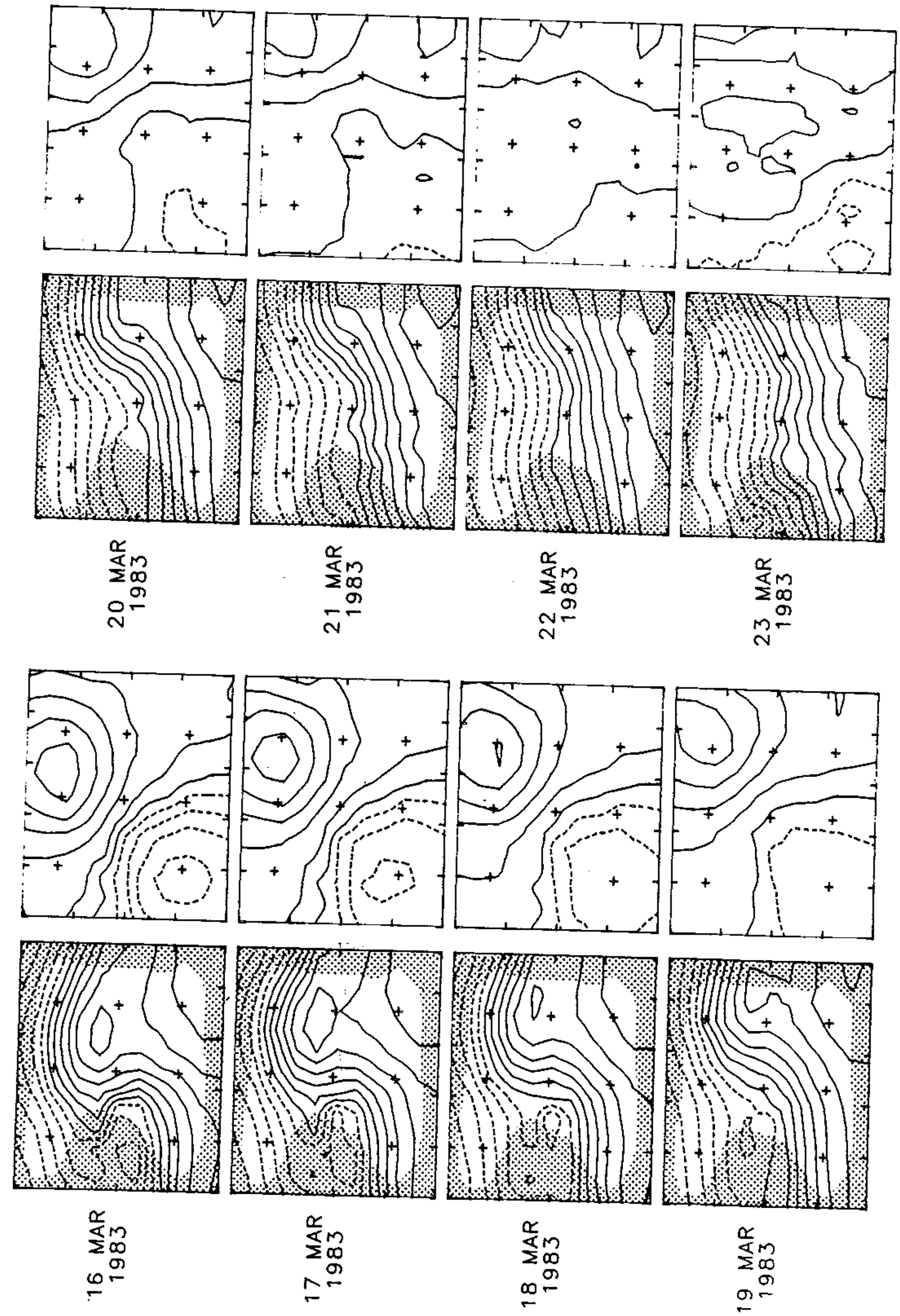
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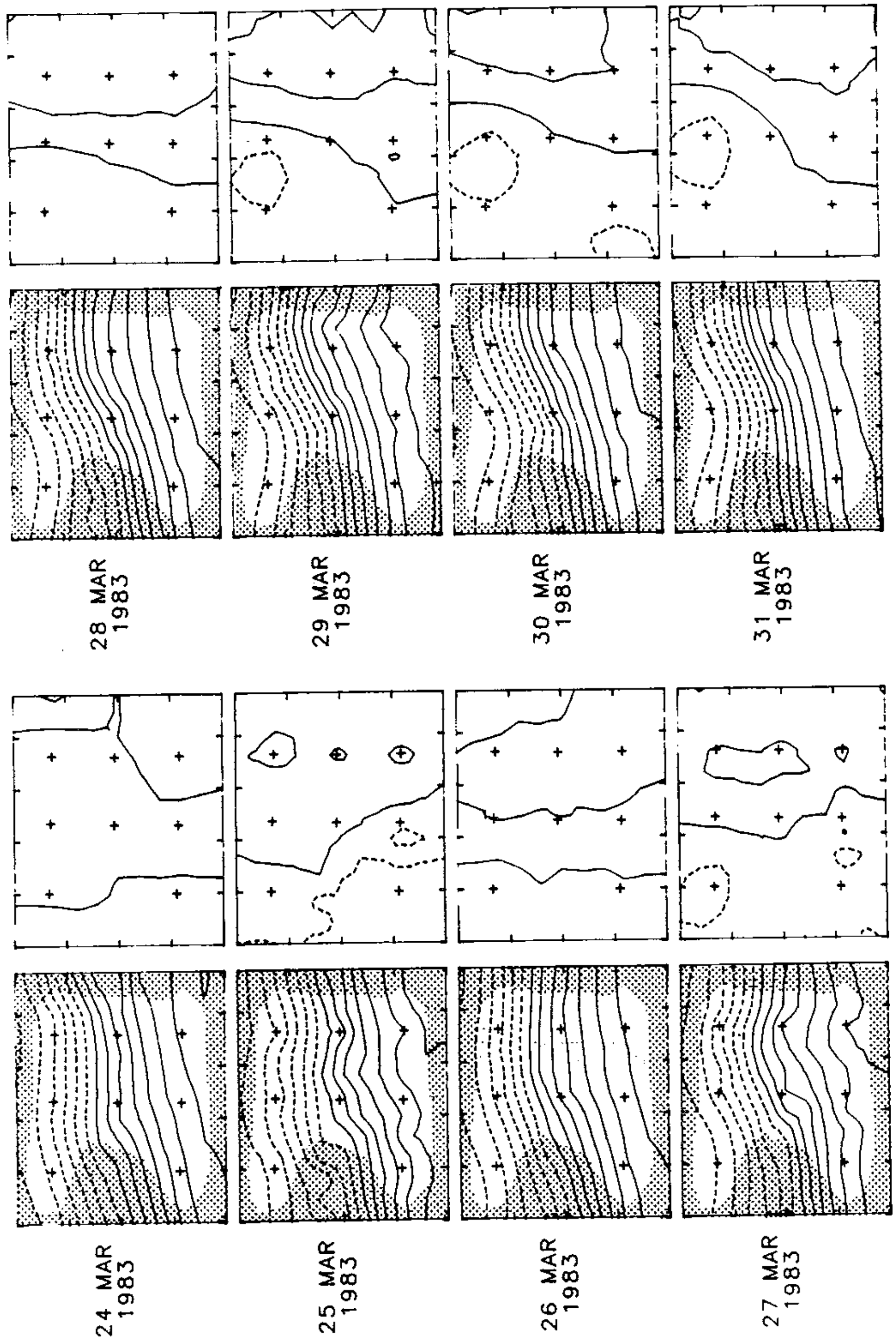
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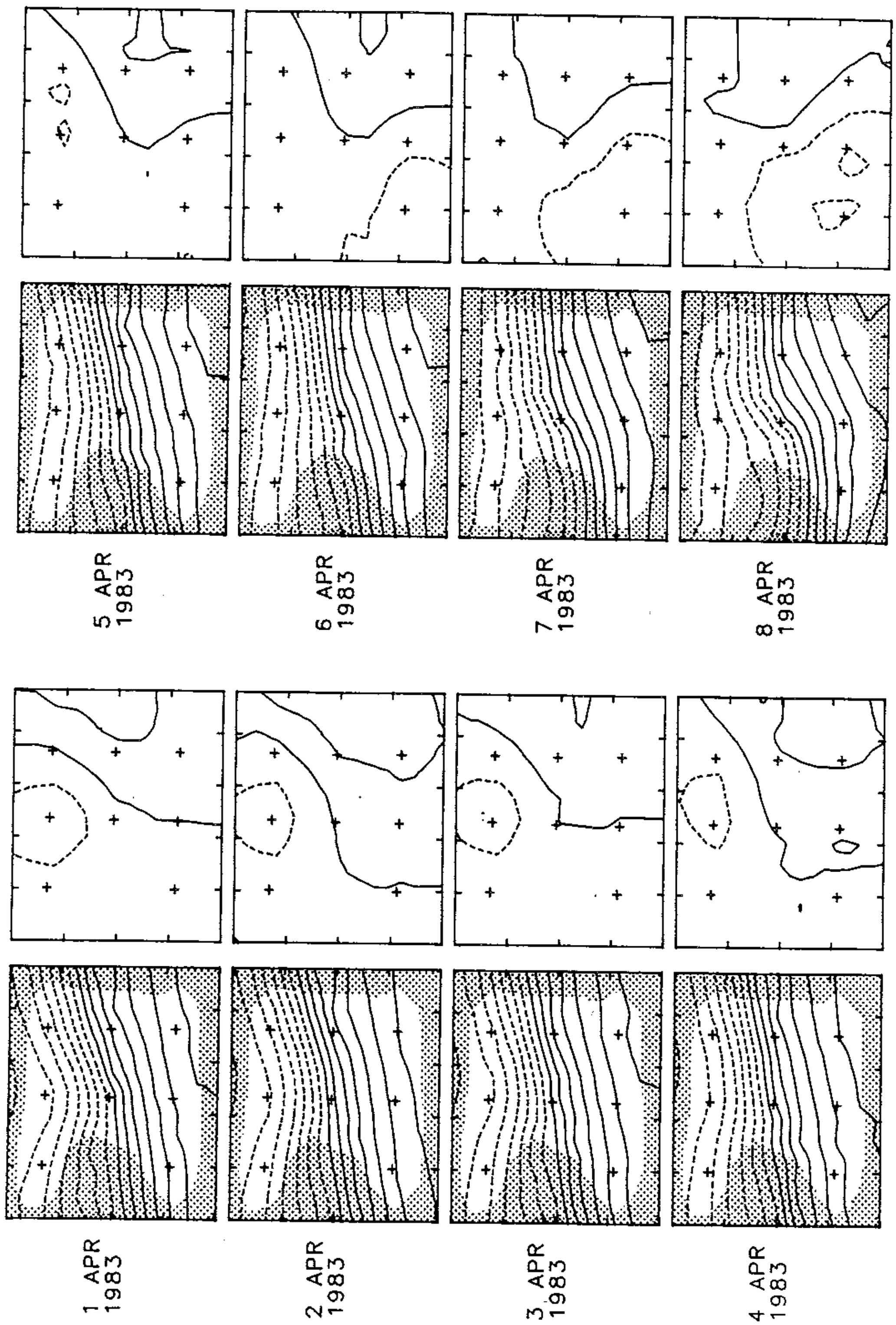
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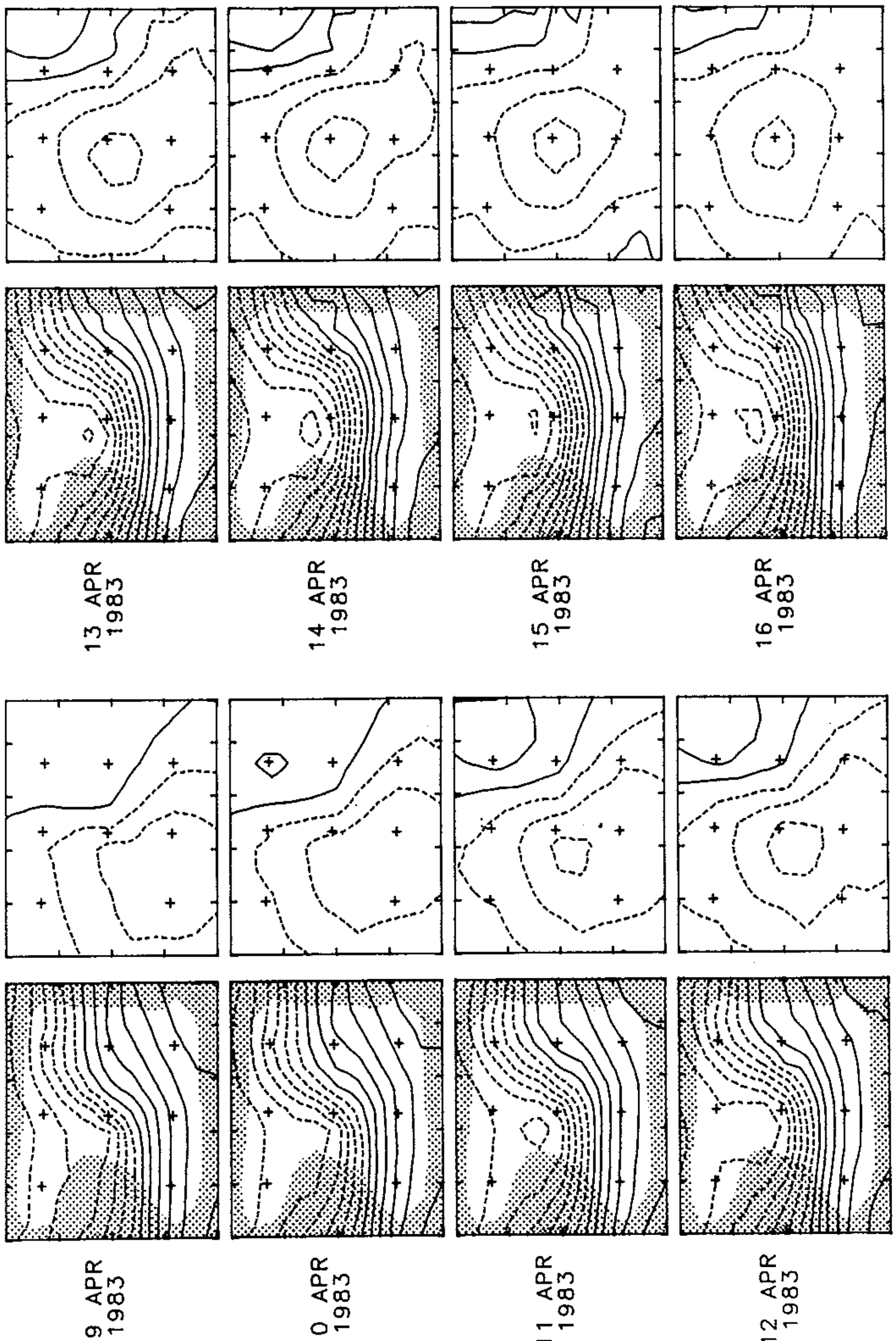
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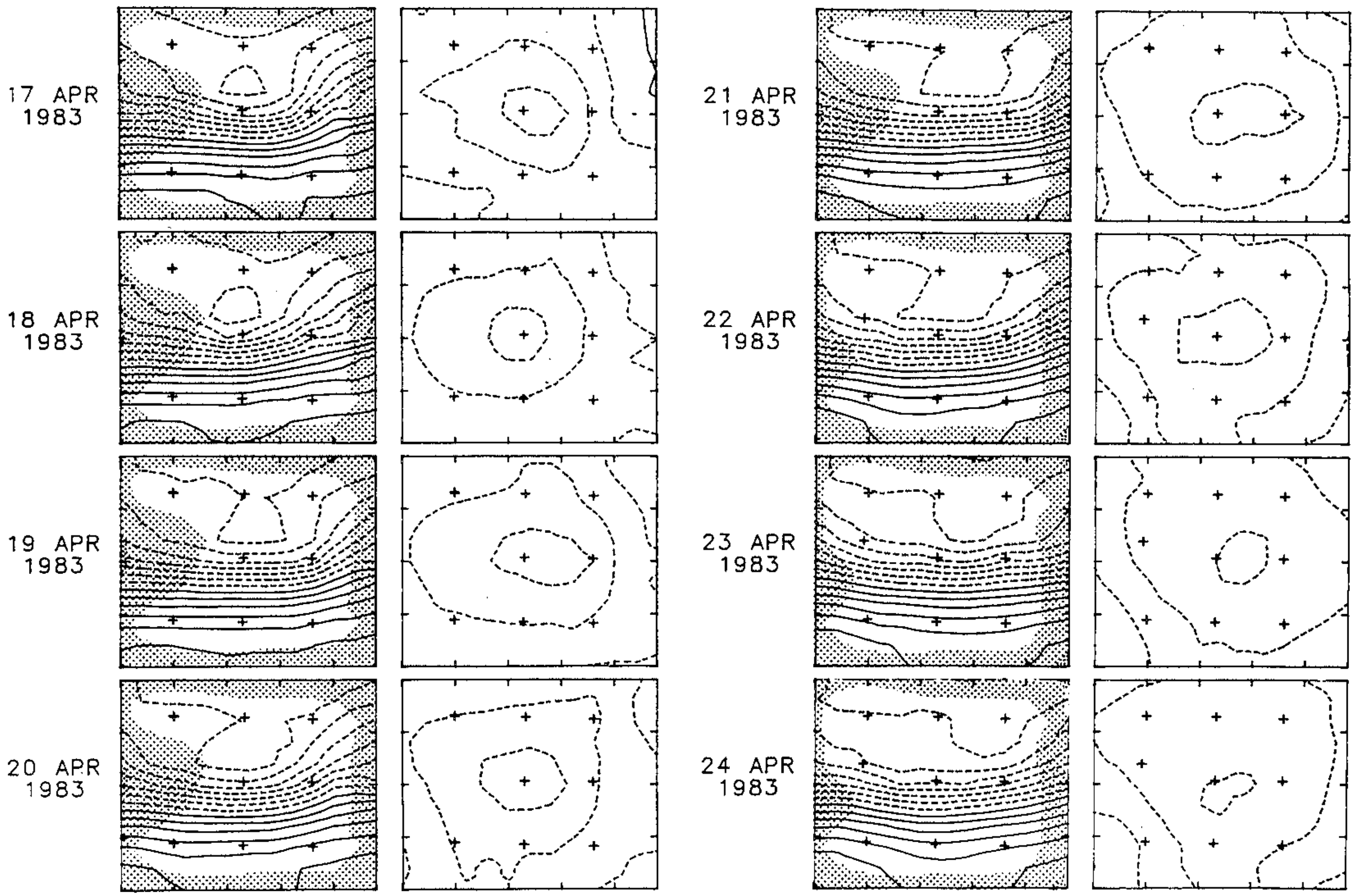
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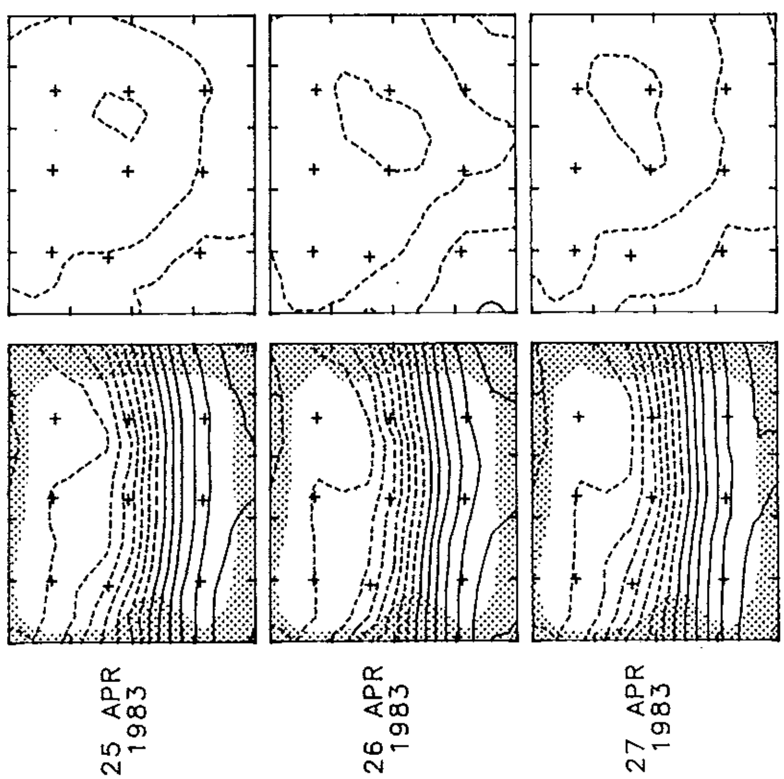
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The Gulf Stream Dynamics Experiment was conducted in the region just northeast of Cape Hatteras to study the propagation and growth characteristics of Gulf Stream meanders. This report documents the inverted echo sounder data collected during the July 1982 to April 1983 deployment period. Time series plots of the half-hourly travel time and low-pass filtered thermocline depth measurements are presented for eleven instruments. Basic statistics are given for all the data records shown. Maps of the thermocline depth field in a 200 km by 400 km region are presented at daily intervals.

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