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Los Angeles and Long Beach Harbors Model Enhancement Program: Prototype Wave Data Summary

by James Rosati III, James P. McKinney, Paul T. Puckette

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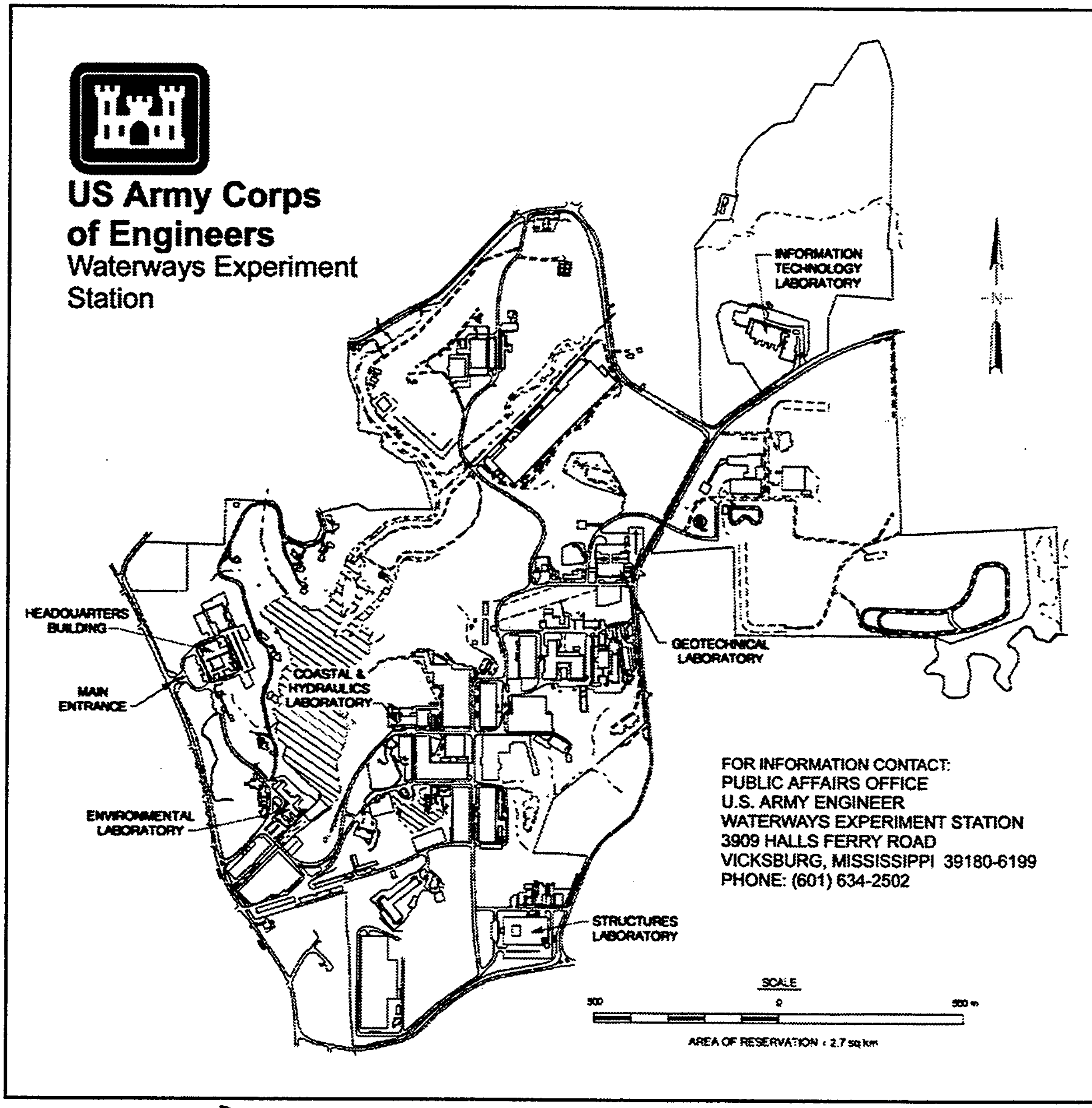

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Preface

This report was prepared by the Coastal and Hydraulics Labratory (CHL), U.S. Army Engineer Waterways Experiment Station (WES), and is a product of the Los Angeles and Long Beach Harbors Model Enhancement (HME) Program. The HME program has been funded by the Los Angeles District and has been conducted jointly by the Ports of Los Angeles and Long Beach (LA/LB); U.S. Army Engineer District, Los Angeles (SPL); and WES. The purpose of the HME Program has been to provide state-of-the art engineering tools to aid in port development. In response to the expansion of oceanborne world commerce, LA/LB has conducted planning studies for harbor development with SPL. Ports are a natural resource, and enhanced port capacity is vital to the nation's economic well-being. LA/LB is expanding to accommodate predicted needs. The Corps of Engineers is responsible for providing deeper channels and determining effects of this construction on the local environment.

This investigation involved the collection of prototype wave and tide data to support other efforts in the HME. These data were used in the physical model and tidal circulation studies. Data summarized in this report cover the time period of the model enhancement program. This study was conducted in the Prototype Measurement and Analysis Branch (PMAB) in the Coastal Sediments and Engineering (CS&ED) at CHL. Overall conceptual design of the measurement system was performed by Mr. Gary L. Howell, PMAB, who also developed the wave gauge hardware and software. Mr. James Rosati, PMAB, created the analysis software and data acquisition system exclusive of the wave gauges. System integration and design of instrument mountings were performed by Messrs. William M. Kucharski and William E. Grogg, Equipment Specialists, PMAB. Current PMAB personnel involved in data collection are Messrs. Ralph E. Ankeny, Larry Caviness, and Charles J. Mayers. Messrs. J. P. McKinney and W.D. Corson, and Mses. Rhonda Lofton and Wendy Thompson, PMAB; and Dr. A. Morang, Coastal Structures and Evaluation Branch, CHL, performed the majority of the data analysis, quality control, and reporting.

Mr. Charles S. Dwyer, Chief, Operations Branch, provided administrative support at the Los Angeles District, with technical management provided by Mr. Steve Fine, Chief, Coastal Resources Branch from 1984-1991, and Ms. Jane Grandon under the supervision of Mr. Arthur Shak, Chief, Coastal Engineering Section since 1991.

Messrs. John Warwar, Richard Wittkop, John Foxworthy, and Ms. Lisa Sales were points of contact for the Port of Los Angeles, and Messrs. Daniel Allen and Angel Fuertes were points of contact for the Port of Long Beach.

General supervision was provided by Dr. James R. Houston and Mr. Charles C. Calhoun, Jr., Director and Assistant Director, respectively, CHL; direct supervision of the project was provided by Messrs. Thomas W. Richardson, Chief, CS&ED, and William L. Preslan, Chief, PMAB.

During the publication of this report, Director of WES was Dr. Robert W. Whalin. COL Robin R. Cababa, EN, was Commander.

Conversion Factors, Non-SI to SI Units of Measurement

Non-SI units of measurement used in this report can be converted to SI units as follows:

Multiply	By	To Obtain
degrees (angle)	0.01745329	radians
feet	0.3048	meters
inches	2.54	centimeters
miles (nautical)	1.852	kilometers
pounds (force) per square inch absolute	6.894757	kilopascals
pounds (mass)	0.4535924	kilograms

1 Introduction

In order to improve U.S. ability to conduct efficient and profitable international shipping, it will be necessary in the coming years to improve and enlarge present port systems throughout the United States. In response to the need for expansion, the Ports of Los Angeles and Long Beach are involved in ongoing studies in cooperation with the U.S. Army Corps of Engineers.

The Corps of Engineers has been given the responsibility of providing deeper channels and determining the effects of construction on the local environment. One major task of the Corps is to investigate how changes in harbor channel depth and configuration affect a harbor's resonance characteristics. Wave oscillations within harbors may have a serious impact on ship loading/unloading and/or ship mooring.

As part of this investigation, wave data from 1984 through 1991 have been collected and analyzed from several different sites in and around Los Angeles and Long Beach Harbors. This wave information has been and continues to be used in modifying and improving tools developed to study potential expansions to the harbors (Seabergh and Rosati 1992). The collected data support physical model studies of harbor response. This study helped support numerical hydrodynamic flow studies as well as prototype ship motion data collection and modeling efforts. The emphasis of the wave data collection effort was to support the harbor resonance analysis task (HME task A.3).

This report presents data products from the analysis of seven different wave gauges in Los Angeles and Long Beach Harbors and a directional wave gauge at a nearby offshore site (Figure 1). These data products have the goal of summarizing all the wave data gathered during the Model Enhancement Program. These data products are the first to be produced using the entire data set of the Model Enhancement Program. In addition to the data contained in the main text, five appendices provide additional information.

Appendix A is a dictionary of parameters used in the relational database. Appendix B contains the plots of total energy for each site tested over the entire data collection period. Tables of percent occurrence for given total energy and period are contained in Appendix C. Appendix D contains data plots for

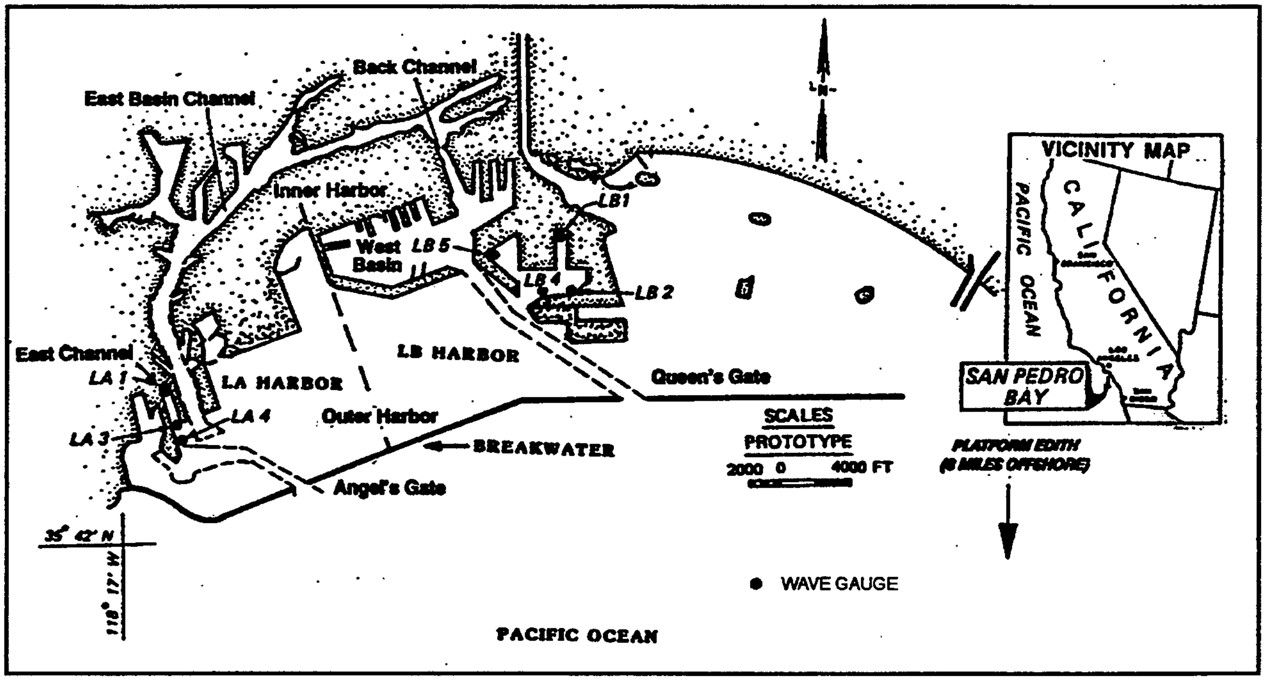


Figure 1. Los Angeles and Long Beach Harbors

Platform Edith, an oil platform 9 miles[1] offshore of the harbors. Pressure sensor specifications are given in Appendix E.

The wave gauge sites selected were a compromise between geographical diversity sufficient for physical model calibrations, ease of installation and maintenance, and cost. Some selected sites are not well-suited for the measurement of short-period (less than 8 sec) wind waves due to their sheltered locations. However, these sites are capable of the measurement of the wind-generated ocean swell (8-25 sec) that exists inside the harbors. Analysis procedures were developed that optimized the calculation of energy spectra for long-period (400-25 sec) waves in the harbors. A directional wave gauge was placed on Platform Edith to measure incident wind waves as well as long-period waves. As mentioned above, Appendix D contains plots of significant wave height, period, and direction for Platform Edith.

[1] A table of factors for converting non-SI units of measurement to SI units is presented on page ix.

2 Methods

Results from this project are to be used in conjunction with the other tools developed for the Model Enhancement Program to identify the resonance characteristics of Los Angeles - Long Beach Harbors and possible changes to these characteristics with harbor modifications. Two types of analysis are required, long-period wave analysis to determine the wave characteristics of selected sites within the harbors, and directional wind-wave analysis for Platform Edith data to help provide incident wave conditions for the harbors. Relational database technology was utilized to help identify conditions that influence harbor resonance.

Harbor Pressure Data

The first and most crucial part of valid wave information is measuring the height of the water at a given point over time. There are various methods for measuring water height, with one of the most successful methods being placement of a pressure gauge in the water at a depth lower than the lowest expected water level. As the amount of water vertically over the pressure sensor varies, the pressure measured by the sensor varies according to known formulas. Therefore, a time series of pressure measured by the sensor can be directly related to the height of waves passing over the sensor. Through the use of various data-processing methods, it is possible to convert the pressure time series into statistically valid parameters describing the energy distribution of the waves.

Each data record starts as a 4,096-sec time series of pressure sampled at 1 Hz. Averaging over 4-sec intervals results in a time series of the same duration, but with a sampling rate of 0.25 Hz.

Data are run through a numerical data-editing routine, which eliminates records containing points outside of the expected pressure range of 14.0 - 31.0 psia. Other data quality checks include checks for spikes and for flat spots longer than 20 sec in the raw time series. Data are also visually inspected to check for any abnormalities that may not be detected by standard quality control analysis. Only data records that pass both visual observation and the numerical data-editing routine are used in the analysis.

All records that are determined to contain good data are zero-meaned in order to comply with the Gaussian assumption for stochastic data. Influences of extremely low-frequency energy, such as tides, are removed from pressure records by linear detrending and a zero frequency rejection filter (Durham et al. 1976). This type of filter takes the form:

$$x_i = A(n_i - n_{i-1} + x_{i-1}) \tag{1}$$

where

A = adjustable coefficient

n_i = ith discrete sample of an input series

x_i = ith discrete sample of the filtered output series

In order to eliminate phase distortion in the filtered signal, it is necessary to pass the series through the filter twice, once in the forward time direction and once in the reverse time direction. The total response function of the filter will therefore be completely described by only the power response function. The z-transform representation of the filter $F(z)$ is :

$$F(z) = \frac{A(1 - z)}{1 - Az} \tag{2}$$

where

$z = e^{iw}$

$\omega = 2\pi f / f_s$ = normalized circular frequency

f = discrete Fourier frequency

f_s = sampling frequency

The response function resulting from passing the series through the filter twice is :

$$|F(z)|^2 = F(z)\tilde{F}(z) = \frac{2A^2(1 - \cos\omega)}{1 - 2A\cos\omega + A^2} \tag{3}$$

where

$|\tilde{F}(z)|$ = complex conjugate of $F(z)$.

Since finite-length data records are used to simulate an infinite random process, each time series is windowed with a 10-percent cosine bell taper to simulate a stationary periodic time series for the calculation of spectral estimates (Bendat and Piersol 1971). The problems of decreased resolution, negative energy, and spectral leakage due to side lobes are minimized by the windowing process. The 10-percent cosine bell taper window used $W(n)$ is described by:

$$W(n) = \frac{1}{2}\left[1.0 - \cos\left(\frac{10\pi(n - 1)}{N - 1}\right)\right] \qquad n = 1, 2, \ldots N \tag{4}$$

where N is the total number of points being analyzed (512 in this case).

Windowed pressure time series are transformed from the time domain to the frequency domain by using a Welch method (Welch 1967) of analysis with 50-percent overlapping segments of 128 points each. This method utilizes a Fast Fourier Transform (FFT) algorithm. The relationship of Fourier transform pairs for a modified pressure time series is given by:

$$\begin{aligned} p'(n) &= \sum_{m=0}^{N-1} (a_p(m) - ib_p(m)) \times \\ &\quad \exp\left(\frac{i2\pi mn}{N}\right) \quad n = 0, 1, 2, \ldots N - 1 \end{aligned} \tag{5}$$

$$\begin{aligned} P(m) &= (a_p(m) - ib_p(m)) \\ &= \frac{1}{N}\sum_{n=0}^{N-1} p'(n) \exp\left(\frac{i2\pi mn}{N}\right) \end{aligned} \tag{6}$$

$$m = 0, 1, 2, \ldots N - 1 \tag{7}$$

where

$p'(\mathrm{n})$ = modified pressure time series

N = total number of data points (128)

m = discrete time reference for $m\Delta t$

Δt = time increment between data points (0.25 Hz)

$a_p(m)$ = real FFT coefficients for pressure

$i = \sqrt{-1}$

$b_p(m)$ = imaginary FFT coefficients for pressure

$P(m)$ = pressure Fourier transform

Fourier coefficients represent the discrete energy at each spectral line frequency, $f(m) = m\Delta f$, where $\Delta f = 1=(N\Delta t)$, the spectral bandwidth. The $a_p(m)$ and $b_p(m)$ coefficients are symmetric functions about the Nyquist frequency, $f(m) = (N/2)\Delta f$, and are, respectively, even and odd functions. For this analysis, the $a_p(0)$ coefficient is zero, as well as the $a_p(N/2)$ term at the Nyquist frequency. Since the time series is real valued, $b_p(0)$ and $b_p(N=2)$ are also zero. Magnitude and phase components of the line spectra for each $f(m)$ are computed as follows:

$$P_s(m) = \left[a_p^2(m) + b_p^2(m)\right]^{1/2} \tag{8}$$

$$\phi_p(m) = \arctan\left(\frac{b_p(m)}{p_p(m)}\right) \tag{9}$$

Pressure spectral estimates $P_s(m)$ are transformed into equivalent energy spectral estimates at the surface $E(m)$ using the relationship

$$E(m) = \frac{P_s(m)}{K_p^2} \tag{10}$$

where K_p is the pressure response function given by:

$$K_p(m) = \gamma \frac{\cosh[k(m)B_p]}{\cosh[k(m)d]} \tag{11}$$

where

$K_p(m)$ = pressure response factor

γ = specific weight of seawater

$k(m) = 2\pi/L(m)$, wave number

$L(m)$ = wave length, determined from the linear dispersion relationship

B_p = distance of pressure sensor above bottom

d = water depth

The windowing process reduces the energy contained within the time series. This effect is compensated for by multiplying the spectral magnitudes of the pressure by the inverse of the area of the 10-percent cosine taper window.

The energy density spectrum $E(f)$ is computed from the spectral estimates $E(m)$ by the relationship

$$E(mf_1) = E(m) / \Delta f \tag{12}$$

where Δf is the spectral bandwidth and $f_1 = \frac{1}{T}$. The resulting energy density spectrum has units of length^2/frequency.

This method of analysis results in 22.4 equivalent degrees of freedom (Welch 1967).

Directional Wave Data Analysis

A PUV directional wave sensor measures three independent variables: pressure p, u-velocity, and v-velocity at the gauge. Each of these variables is sampled over a 2,048-sec time period at a sampling rate of 1 Hz to produce three separate time series.

Samples of the recorded u-velocity, v-velocity, and pressure are visually inspected for each gauge to ensure the quality of the data. Data are also run through a numerical data editing routine, which locates spikes in the measured time series and corrects them using linear interpolation. If more than 10 percent of a pressure time series are determined to be spikes, the record is rejected for analysis. However, if the pressure channel passes the editing routine and either velocity channel fails, then nondirectional analysis is continued. Only data records that pass both visual observation and the numerical data editing routine are used in the analysis.

All records that are determined to contain good data are zero-meaned in order to comply with the Gaussian assumption for stochastic data. Influences of extremely low-frequency energy, such as tides, are removed from u-velocity, v-velocity,and pressure records by linear detrending and a zero frequency rejection filter as described earlier.

Windowed (as described previously) u-velocity, v-velocity, and pressure time series are transformed from the time domain to the frequency domain by using the Welch FFT algorithm.

The windowing process reduces the energy contained within the time series. This effect is compensated for by multiplying the spectral magnitudes of the pressure, u-velocity, and v-velocity by the inverse of the area of the 10-percent cosine taper window.

The pressure spectra $P(m)$ and velocity spectra ($U(m)$ and $V(m)$) are corrected for depth attenuation using the previously defined response function Kp and the velocity response function given by:

$$K_\mu(m) = \sigma(m)\frac{\cosh[k(m)B_c]}{\sin h[h(m)d]} \tag{13}$$

where

$K_\mu(m)$ = velocity response factor

$\sigma(m) = 2\pi / f(m)$, circular frequency

$k(m) = 2\pi / L(m)$, wave number

$L(m)$ = wave length, determined from the linear dispersion relationship

B_c = distance of current sensor above bottom

d = water depth

$$L(m) = \frac{g}{2\pi f^2(m)} \tan h(dk(m)) \tag{14}$$

where

g = acceleration due to gravity and $f(m)$ represents frequency

Directional wave coefficients are determined by calculating and relating the cross-spectra between the pressure and the velocity time series. Since the pressure and velocity data are in phase, the auto- and cross-spectral estimates (Jenkins and Watts 1968) are expressed by:

$$S_{pp}(m) = P(m)^2 \tag{15}$$

$$S_{uu}(m) = U(m)^2 \tag{16}$$

$$S_{vv}(m) = V(m)^2 \tag{17}$$

$$S_{pu}(m) = P(m)U(m)\cos(\phi_u(m) - \phi_p(m)) \tag{18}$$

where

$S_{xx}(m)$ = the auto-spectral estimate and $S_{xy}(m)$ = the cross-spectral estimate.

The first five directional Fourier coefficients are determined using a method of analysis similar to that of Longuet-Higgins (Longuet-Higgins, Cartwright, and Smith 1963). Using the previously defined single-sided auto-spectral estimates, coincident spectral estimates, pressure estimates, and pressure and velocity response factors, the five real and imaginary directional coefficients are expressed by :

$$A_0(m) = \frac{G_{pp}(m)}{2\pi\, K_p^2(m)} \tag{19}$$

$$A_1(m) = \frac{S_{pu}(m)}{\pi K_p(m)\, K_\mu(m)} \tag{20}$$

$$A_2(m) = \frac{G_{uu}(m) - G_{vv}(m)}{\pi\, K_\mu^2(m)} \tag{21}$$

$$B_1(m) = \frac{S_{pv}(m)}{\pi\, K_p(m) K_\mu(m)} \tag{22}$$

$$B_2(m) = \frac{2S_{uv}(m)}{\pi\, K_\mu^2(m)} \tag{23}$$

where $A_n(m)$ and $B_n(m)$ are the real and imaginary coefficients, respectively, and where $G_{xx} = 2S_{xx}$.

At the center frequency m the frequency spectral estimate (energy density in m^2 / Hz) is calculated by:

$$\text{energy density}(m) = \frac{TG_{pp}(m)}{K_p^2(m)} = 2\pi A_0(m) \tag{24}$$

where T is the record length in seconds.

In general, directional wave spectra are represented by the theoretical infinite Fourier series:

$$S(m, Q) = W_0 A_0(m) + \sum_{n=1}^{\infty} W_n (A_n(m) \cos(nQ) = B_n(m) \sin(nQ)) \tag{25}$$

where Q is the radian angle in 5-deg increments from 0 to 355 deg and W_n are the weighting coefficients for a particular weighting function. If an infinite number of directional coefficients could be calculated, each W_n would be unity. Since only five directional coefficients are available, the infinite series is truncated to three terms. The use of unity for each W_n would result in a loss of resolution and energy, negative side lobes, and a broadened spectrum. In this study a binomial distribution weighting function (Longuet-Higgins, Cartwright, and Smith 1963) was employed to minimize the loss of resolution and eliminate the negative side-lobes. The weights are:

$$W_0 = 1$$
$$W_1 = \frac{2}{3} \qquad (26)$$
$$W_2 = \frac{1}{6}$$

Therefore the truncated Fourier series representation of the directional wave spectrum is expressed by:

$$\begin{aligned} S(m,Q) = {} & A_0(m) + \frac{2}{3}[A_1(m)\cos(Q) + B_1(m)\sin(Q)] + \\ & \frac{1}{6}[A_2(m)\cos(2Q) + B_2(m)\sin(2Q)] \end{aligned} \qquad (27)$$

Values for the wave direction are adjusted to give degrees measured from true north.

Based on the assumptions made in this analysis, the significant wave height for any one record is determined by:

$$H_{m_0} = 4.0\sqrt{M_0} \qquad (28)$$

where M_0 is the sum of the energy in all the frequency and direction bands (zeroth moment) and is equivalent to the integration of the directional spectral density function to the high-frequency cutoff of 0.25 Hz.

The mean wave direction is determined by calculating the mean direction of waves in each band of frequencies and is defined by:

$$Q(m) = \arctan\left(\frac{B_1(m)}{A_1(m)}\right) \qquad (29)$$

where $A_1(m)$ and $B_1(m)$ are the directional coefficients which correspond to a particular center frequency. This value is adjusted to give the direction from which the waves are coming, expressed as an angle in degrees measured clockwise from true north. The directional spread is an estimate of the spread of energy about the mean wave direction at a center frequency and is given by:

$$Q(m) = \left|2 - \left[\frac{A_1^2(m) + B_1^2(m))^{1/2}}{A_0(m)}\right]\right|^{1/2} \qquad (30)$$

where $A_0(m)$, $A_1(m)$; and $B_1(m)$ are the directional Fourier coefficients of a particular band (Cartwright 1963). This analysis results in 22.4 equivalent degrees of freedom.

Platform Edith Harbor Equivalent Analysis

The Platform Edith data were analyzed using the same methods as the harbor pressure in order to enhance comparsions between these pressure data. Platform Edith pressure data are sampled over a 2,048-sec time period at a sampling rate of 1 Hz. The harbor pressure data are sampled at a rate of 0.25 Hz. The Platform Edith pressure data were decimated to the same sample rate as the harbor pressure data. In order to avoid aliasing, the Edith pressure data were first smoothed through a symmetric Finite Impulse Response (FIR) low pass filter (Digital Signal Processing Committee 1979).

The filtered output data y_n are calculated from the original input data x_n as

$$
\begin{aligned}
y_n &= B(1)x_n + B(2)(x_{n+1} + x_{n-1}) + B(3)(x_{n+2} + x_{n-2}) \\
&\quad + \cdots + B(N_p)(x_{n+N_{P-1}} + x_{n-N_{P+1}})
\end{aligned}
\tag{31}
$$

where B is the array of filter coefficients and $N_P = N_T + 1$ and $N_T =$ filter order / 2.

For this filter, values of $\beta = 0.15$ and $\gamma = 0.1$ were used (Figure 2). These values gave a filter order of 34. The filter coefficients were calculated using the design program found in *Programs for Digital Signal Processing* (Digital Signal Processing Committee 1979).

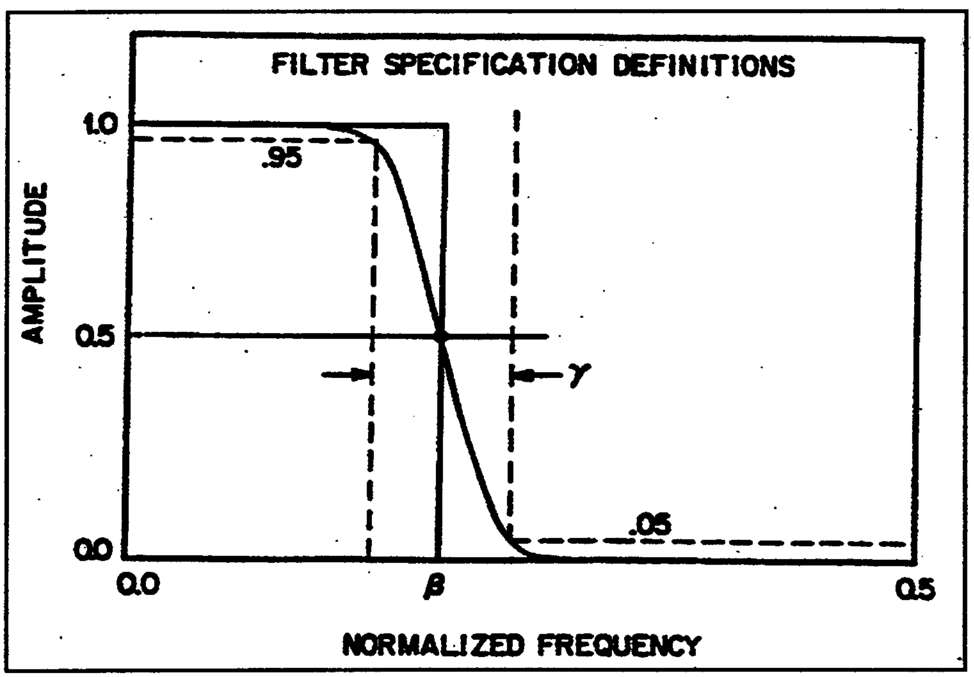


Figure 2. Definitions of β and γ used for maximally flat FIR filters

After filtering, these Platform Edith pressure data were analyzed in the same manner as the harbor gauge pressure data. The results from these harbor equivalent calculations are presented in Chapter 4.

Relational Database

Due to the large amount of wave information currently and historically collected by the U.S. Army Engineer Waterways Experiment Station (WES), a relational wave data access and management system has been created, with the needs of the Los Angeles - Long Beach data collection effort influencing its design. Relational technology was employed for several reasons.

First, a tool was needed to manage and archive raw sample data and analysis results from several sites for several years as well as the related information needed to transform these data into a usable form.

Second, data accessibility was a major consideration in the decision to use a relational database. Related information is maintained within a framework which provides for routine cross-referencing between data objects. For example, if mean spectra for Platform Edith are required for periods when *Hmo* is between 1 and 2 m, a query can quickly be formulated to retrieve the appropriate information. Such a query was used to develop Figure 50, which shows the most frequent wave direction per frequency for Platform Edith for times when significant wave heights for Platform Edith were between 1 and 2 m.

Finally, the utility of relational database design allows for the continued development of the database, and the addition of fields and relations without impacting existing software, resulting in reduced programming costs.

3 Instrumentation and Gauge Site Description

History of Wave Gauging Systems

Internally recording gauges

In February 1984, wave gauging was initiated for the Los Angeles/Long Beach Harbors Model Enhancement Program (HME). SeaData 635-11 (remote) self-recording wave gauges were initially installed in the harbors. A highly accurate Paroscientific quartz crystal pressure sensor (Appendix E) was strapped to pier pilings at the gauge sites. Initially, the pressure sensors were cabled to the SeaData instruments, which were also strapped to pier pilings but above the water line. Later the remote gauges were placed in electrical enclosure boxes dockside, which negated the requirement to use a boat to service the wave gauges for tape changes (Figure 3). The gauges were configured to record 2,048 sec of wave data every 2 hr, sampling once each second. The self-recording instrument's internal tape drive reached capacity after 1 month when recording data at this rate. This rather frequent tape changing and checkout interval was labor-intensive and, therefore, expensive. Gauge reliability was also less than desired.

New technology gauges

To reduce costs and improve data recovery from the existing wave gauges, a wave data collection system utilizing new technology was designed. The new gauge system was installed in February of 1988 to work in parallel with the SeaData gauge system. In October of 1988 the SeaData tape recording system was removed. At each wave gauge location, a Remote Transmission Unit (RTU) computer system was installed. The RTUs acquired and stored the data from the existing pressure sensors. A computer system located in the Port of Long Beach (POLB) administration building interrogates the RTU at each wave gauge site via UHF radio link. All system computers use a communications protocol to ensure error-free data transmission. The central computer, named the real-time server or RT-server, analyzes the raw data acquired from each RTU and stores the results. A Digital Equipment Corporation VAX computer at WES in turn calls up the

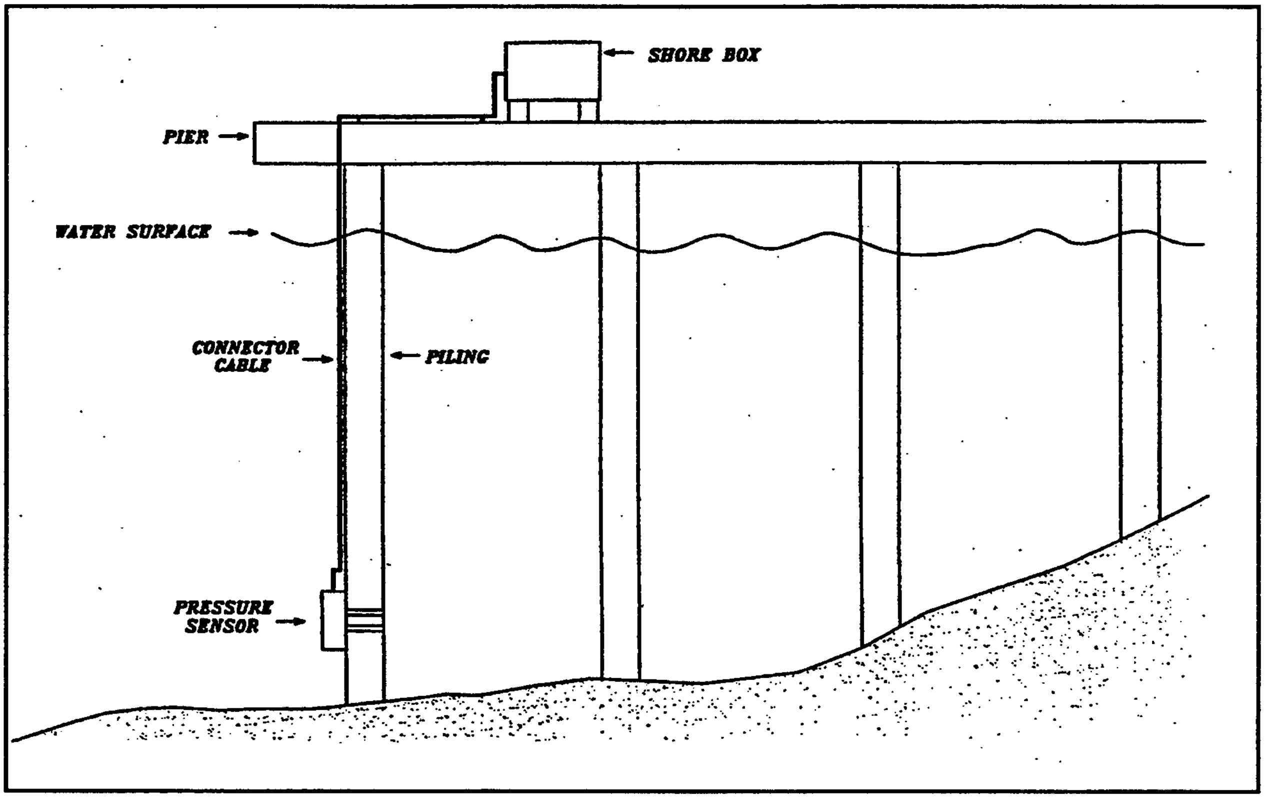


Figure 3. Gauge mounted on pier piling with connection to shore box

central computer and transfers the analyzed data by an error-free network communications protocol over a standard telephone line.

System design details reconciled several competing concerns. The amount of available memory in the RTUs, storage capability of the RT-Server, data link bandwidth limitations, system cost, and capability to develop and test the required software all contributed to the overall design and capabilities of the system.

Remote transmission unit (RTU)

At each wave gauge location, an RTU is used to acquire, store, and send the raw data to the central station, with all of these operations possibly occurring simultaneously. Each RTU consists of low-power consumption components, which are placed in a sealed electrical enclosure that protects the electronic components. The RTU is based upon an STD-bus, single-board computer utilizing a Z-80 microprocessor. The system also consists of a custom-designed module to interface with the quartz crystal pressure sensor. Additionally the system consists of modules for additional system memory and communications to radio frequency modems which allow transmission of the data to the RT-server. Batteries allow data storage for several hours without loss of data when power outages occur.

The RTU continuously accumulates frequency output from the pressure sensor and stores each 4-sec average in a file existing in solid-state memory. Every hour, a new data file is created; however, each file contains 4,096 sec of data; therefore, there is an overlap between data files. The RTU has sufficient memory to store five files before having to erase the data sampled earliest to avoid overflowing its storage buffer. The RTU based at platform Edith can only store three files before the system memory capacity is reached because u and v velocity information is also stored with the pressure data.

The RTU implements KERMIT (daCruz 1987) communications protocol to ensure error-free transmission of raw data to the central system. All RTUs listen on the same radio frequency to the central system. Each RTU has a unique three-letter identifier, LA4, PLF, etc. When a login sequence with the matching identifier is heard, that RTU can then receive further commands in order to transfer stored data via radio to the RT-server. After file transfer is complete, a logout message is sent to the RTU.

RT-server

The data storage and analysis system consisted of a Digital Equipment Corporation Micro PDP 11/23 computer with a DEC RX-50 floppy drive and RD-51 10-Mb disk drive. It was programmed with the Micropower/Pascal real-time executive. The real-time executive allows for the coordination of several independent tasks within the computer without the overhead associated with an entire general-purpose operating system. The RT-server was located in the POLB Administration Building.

The RT-server has four major functions to perform. First, it must communicate with each RTU system. KERMIT server commands are sent to first log in, then check the current time (update if found in error), and request a directory of current files in memory. If the central station has not yet acquired any files resident in the RTU, a request is sent for the file contents. After all files are acquired, a logout is performed. This sequence of commands is sent to each RTU for which the RT-server has a record stored in its status and configuration file. KERMIT implements data checking by sending the data in "packets." If a packet is not received in the correct condition, an error is signaled, and the packet is resent up to the retry limit (usually five times). If the retry limit is exceeded, then the KERMIT protocol is aborted. The RT-server stores the time and result of each KERMIT operation in order to compute statistics of communication performance.

The second major function for the RT-server is to analyze the harbor data. This function is detailed in the data analysis section. Platform Edith data are not analyzed by the RT-server and are stored and transferred in raw form. Platform Edith data are analyzed at the Coastal and Hydraulics Laboratory (CHL) at WES after they are transferred there.

The third major function of the RT-server is to respond to data requests from the CHL VAX computer at any time. A telephone link is used to establish a connection between the two computers. Both systems run the DECnet software protocol and the RT-server in Long Beach becomes a node on the CHL computer network. Only analyzed data from the harbors are transferred to CHL; however, raw data from the platform are transferred from the RT-server to the CHL VAX. In addition to the analyzed data, the system also can send compilations of system performance to the host computer. Various reports include the performance of the KERMIT data acquisition versus time of day, the system time, the data directory, and the last 20 system errors due to analysis or communication failures. Raw, unanalyzed data are not normally saved after analysis, but the RT-server attempts to write the data to the floppy disk drive before deletion. If a floppy disk is in the drive, write enabled, and has sufficient free space, raw data will automatically be copied to the floppy disk.

The fourth function performed by the RT-server is to provide a local interface to a single user on a computer terminal locally attached to the RT-server. The terminal interface performs many of the same functions as the network interface. Additionally, the terminal interface allows a user to type out raw and analyzed data, reconfigure analysis and sensor parameters, and display disk directories. Progress messages indicating the current state of the RT-server are scrolled at the bottom of the computer terminal which serves as the operator interface station.

Host and development facility

The CHL VAX is used to develop programs for and acquire data from the RT-server. On at least a daily basis, the RT-server is polled for data that have not already been acquired. Data obtained by the RT-server subsequent to the last polling by the CHL VAX are transferred via the DDCMP DECnet protocol to the CHL VAX computer. Additionally, the VAX computer is used to create data reports, analyze the Platform Edith data, and produce data plots.

Los Angeles and Long Beach Site Selection and Description

The seven gauges in the Los Angeles - Long Beach Harbor are positioned throughout the harbor, with each location chosen to monitor a specific aspect of the wave field in the harbor. A primary purpose of the prototype data is to calibrate and verify the physical model and other tools for the HME Program. Wave gauge sites were determined with the needs of the physical model in mind. Also, areas where the ports were interested in the wave climate from a ship-operations perspective were considered for wave gauge sites.

Since the emphasis of the study is on long-period waves, interference of the pier pilings with the waves did not present a problem since the wavelength is very large compared to the diameter of a pile for the waves (periods greater than 8 sec) reported here. Mounting the pressure sensors on piers allows the structure to protect the pressure sensor and allows for easier maintenance by divers of the underwater components. Shore box siting considerations were:

- Availability of 110VAC power.
- Ease of running the pressure sensor cable to the shore box.
- Desire to be environmentally sheltered, if possible.
- Line-of-sight view to the POLB administration building for UHF radio communication.
- Ease of access by maintenance personnel.
- Protection from theft or vandalism.
- Minimal interference with port operations.

Gauge locations in the Los Angeles - Long Beach Harbor are designated LA1, LA3, LA4, LB1, LB2, LB4, and LB5, and are shown in Table 1. Information on pressure sensors is as follows:

Table 1
Gauge Position and Depth in LA/LB Harbors

Gauge	Water Depth, ft	Latitude	Longitude
LA1	22	33°43.4'	118°00.0'
LA3	32	33°43.2'	118°16.3'
LA4	50	33°43.0'	118°16.4'
LB1	30	33°45.0'	118°11.8'
LB2	29	33°44.5'	118°00.0'
LB4	35	33°44.4'	118°12.0'
LB5	22	33°44.8'	118°12.7'
Pl. Ed.	165	33°35.8'	118°08.5'

- LA1 is mounted on a piling at the west side of the north end of the East Channel in the Port of Los Angeles (POLA). This gauge was sited to measure long waves at a reflective boundary (antinode) in that area of POLA.
- LA3 is mounted on a piling on the southeast corner of the East Channel. This location at the entrance of the East Channel is intended to provide information on wave energy entering the channel.

- LA4 is mounted on a piling located at the coal-terminal. This gauge is relatively exposed to wave energy incident from the Angel's Gate entrance.

- LB1 is mounted on a piling in the northeast corner of the POLB between berths 232 and 231. This corner location was selected to measure long waves at a reflective boundary (antinode).

- LB2 is mounted on a piling on pier 244/245 in the southeast basin of POLB.

- LB4 is mounted on a piling located on pier J adjacent to the west side of berth 247 within the southeast basin of POLB.

- LB5 is mounted on a piling adjacent to berth 207 in the westernmost corner of the southeast basin of POLB.

- Platform Edith is located in 165 ft of water about 9 miles offshore of POLB in the Santa Catalina Channel. The PUV sensor is located about 20 ft below the surface.

In Table 1, water depths are approximate mean low water depths. The depths given are directly under pressure sensors at the gauge sites, not in the adjacent channels, and are not representative for determining the characteristics of the harbors.

4 Results

A variety of analyzed products are currently available in the historical Los Angeles/Long Beach database (data descriptions are listed in Appendix A). Data products have been produced that attempt to summarize the properties of the collected prototype data. A "month" data field has been included in the analyzed data relations to allow determination of characteristic spectra and statistics for each site for each month or season of the year.

Long-period analysis products include frequency of occurrence tables for both inshore and Platform Edith gauges. Three types of tables were created, total energy (E_t) versus peak frequency (FT_p) and total low-frequency (periods greater than 25.6 sec) energy (E_l) versus peak low frequency (Fl_p). Peak frequency refers to the frequency that contains the most energy for each sampling period. The resulting tables, which are stored in the database, have 80 energy rows in 1-cm^2 increments for the inshore gauges and 50-cm^2 increments for Platform Edith. For publication purposes, the E_t versus FT_p and E_l versus Fl_p tables have been compressed into tables containing 16 energy bands with 9 or 11 frequency bands, depending on the type of data displayed (Appendix C). Individual elements of these tables have been expressed as a decimal portion of the total number of records.

Harbor Gauges

For each of the sites in the Los Angeles/Long Beach Harbors, there are five plots of long-period analysis results (Figures 4-38). The first plot (Figure 4, for example) indicates the periods during which data are available for a particular site (LA1 in this case). The second plot (Figure 5) is of the average wave energy versus frequency (f) for each month. This plot was produced by averaging the spectra from each sampling period during a particular month to produce a monthly average spectrum. Existing monthly average spectra from the different years (1984-1991) were then averaged to produce an average spectrum for each month. In a similar way, the following plots represent average values by month, with all of the measured data included. The origin of the energy axis of these plots is not always zero in order to show the energy spectra in greater detail. Energy values that fall below the origin value are set equal to the origin value.

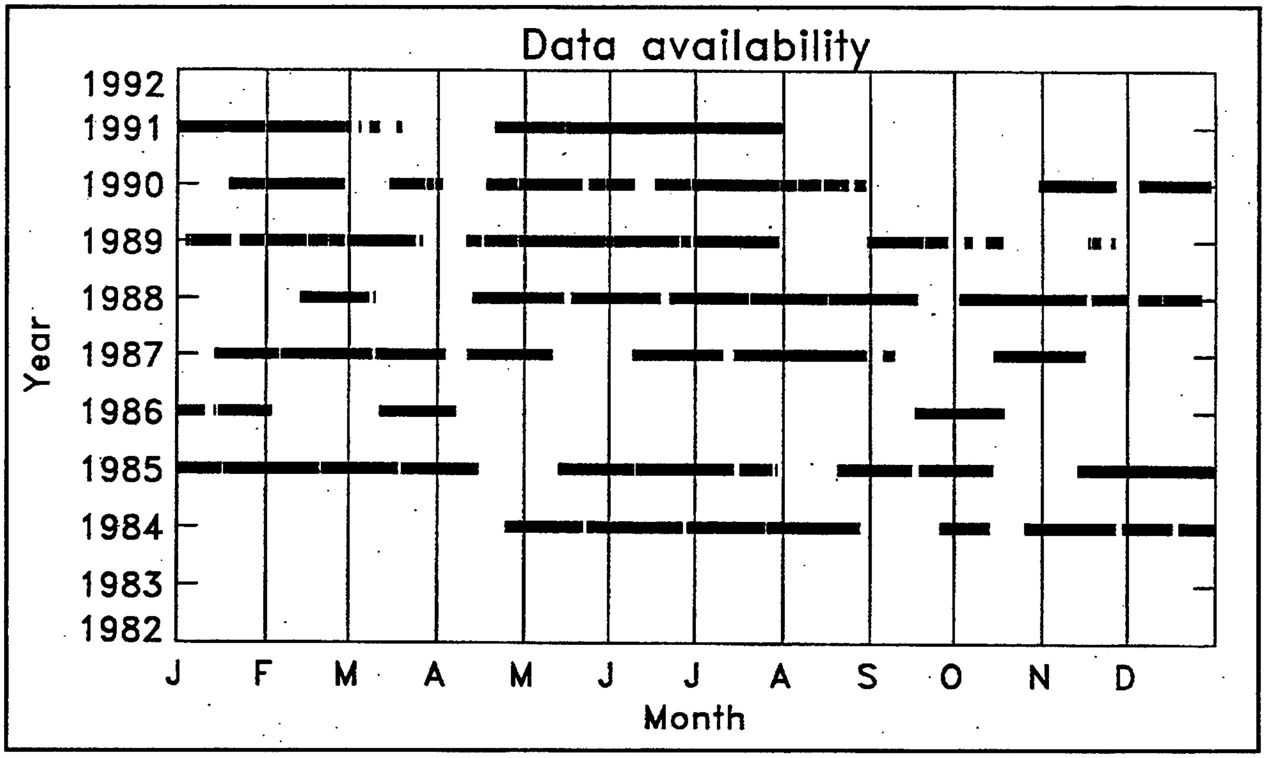


Figure 4. Data availability for Los Angeles station 1

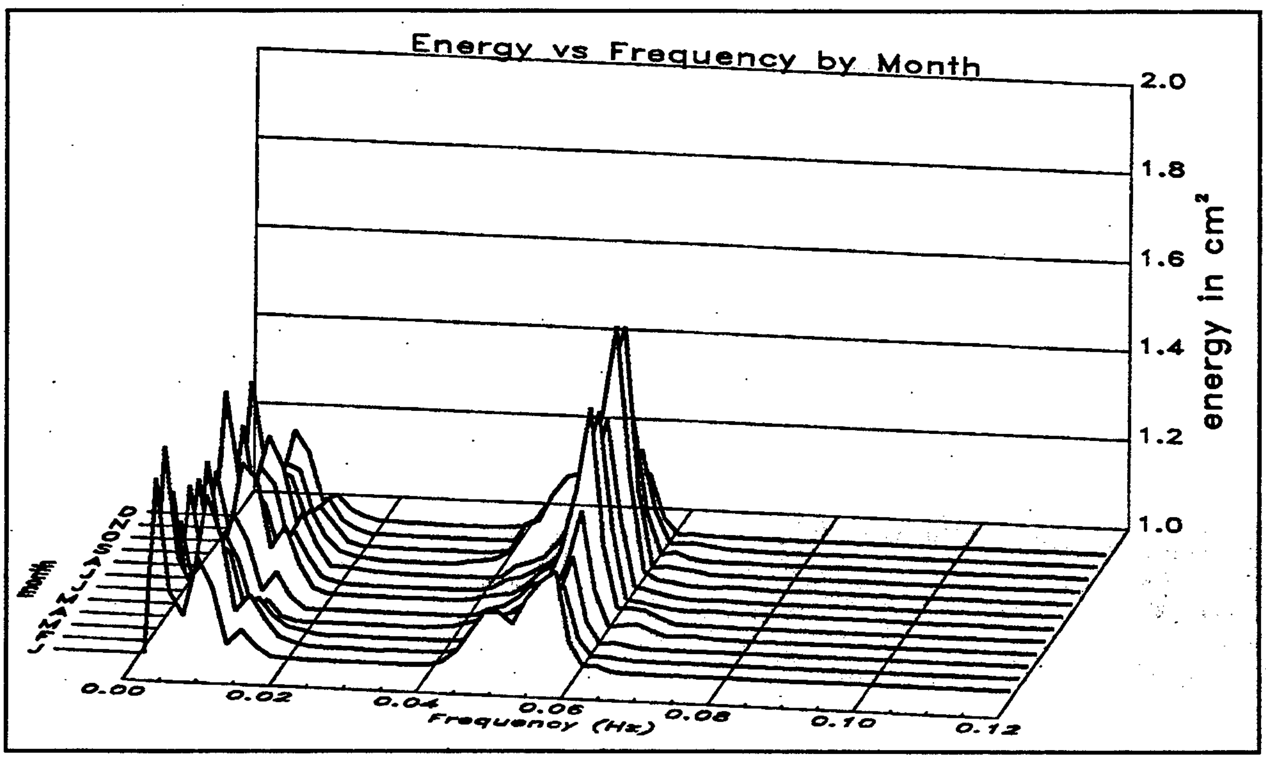


Figure 5. Average energy versus frequency, by month, for Los Angeles station 1

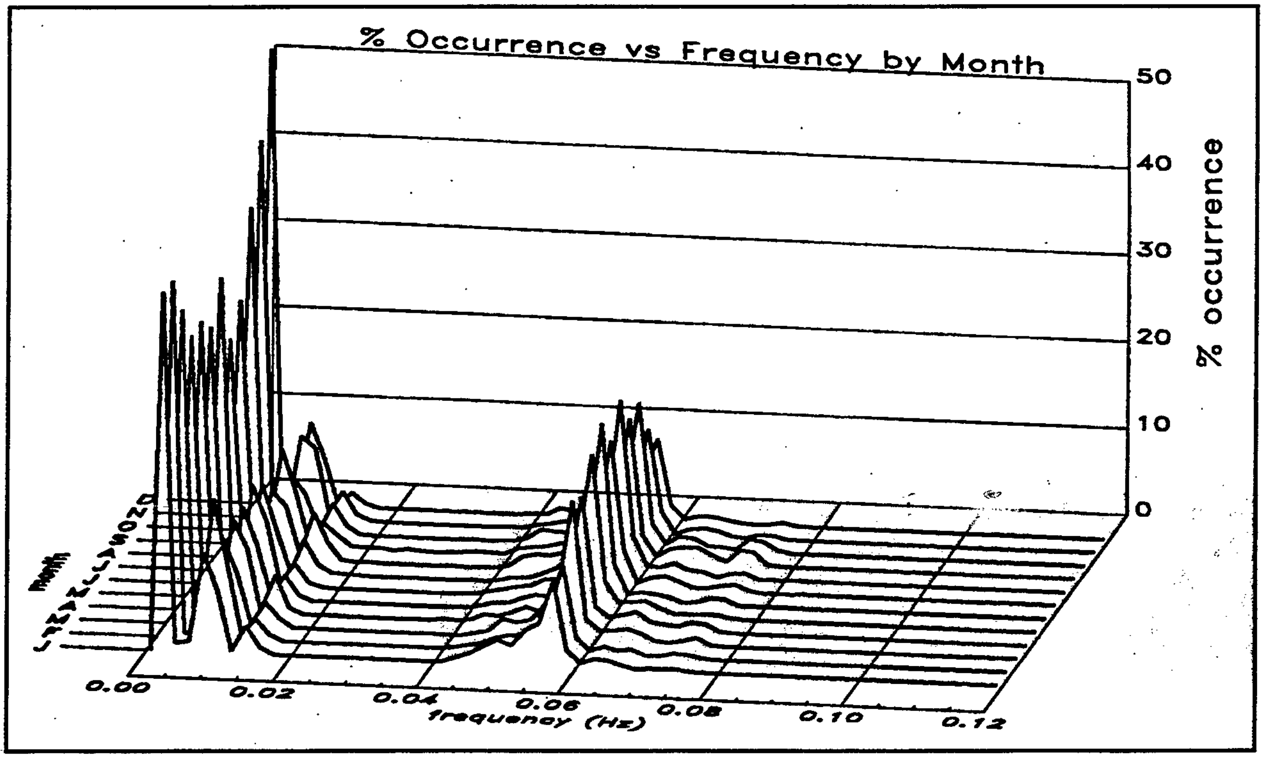


Figure 6. Percent occurrence versus peak frequency, by month, for Los Angeles station 1

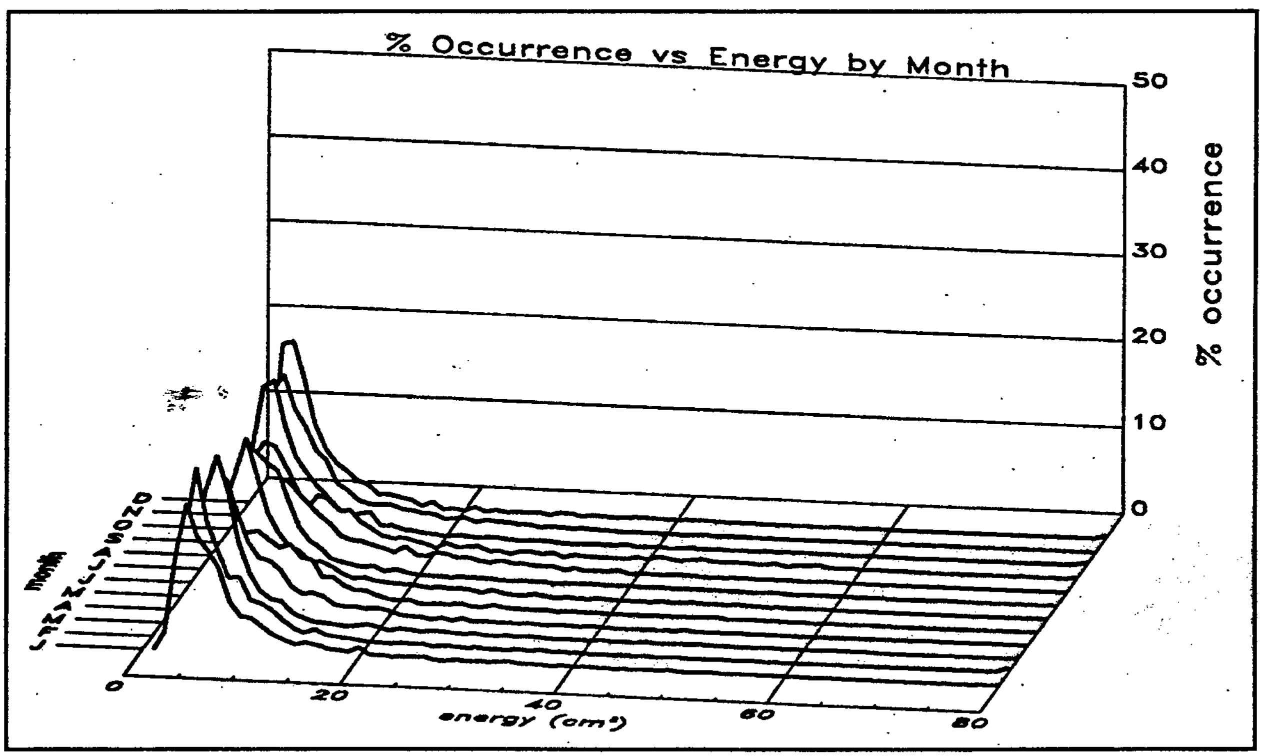


Figure 7. Percent occurrence versus total energy, by month, for Los Angeles station 1

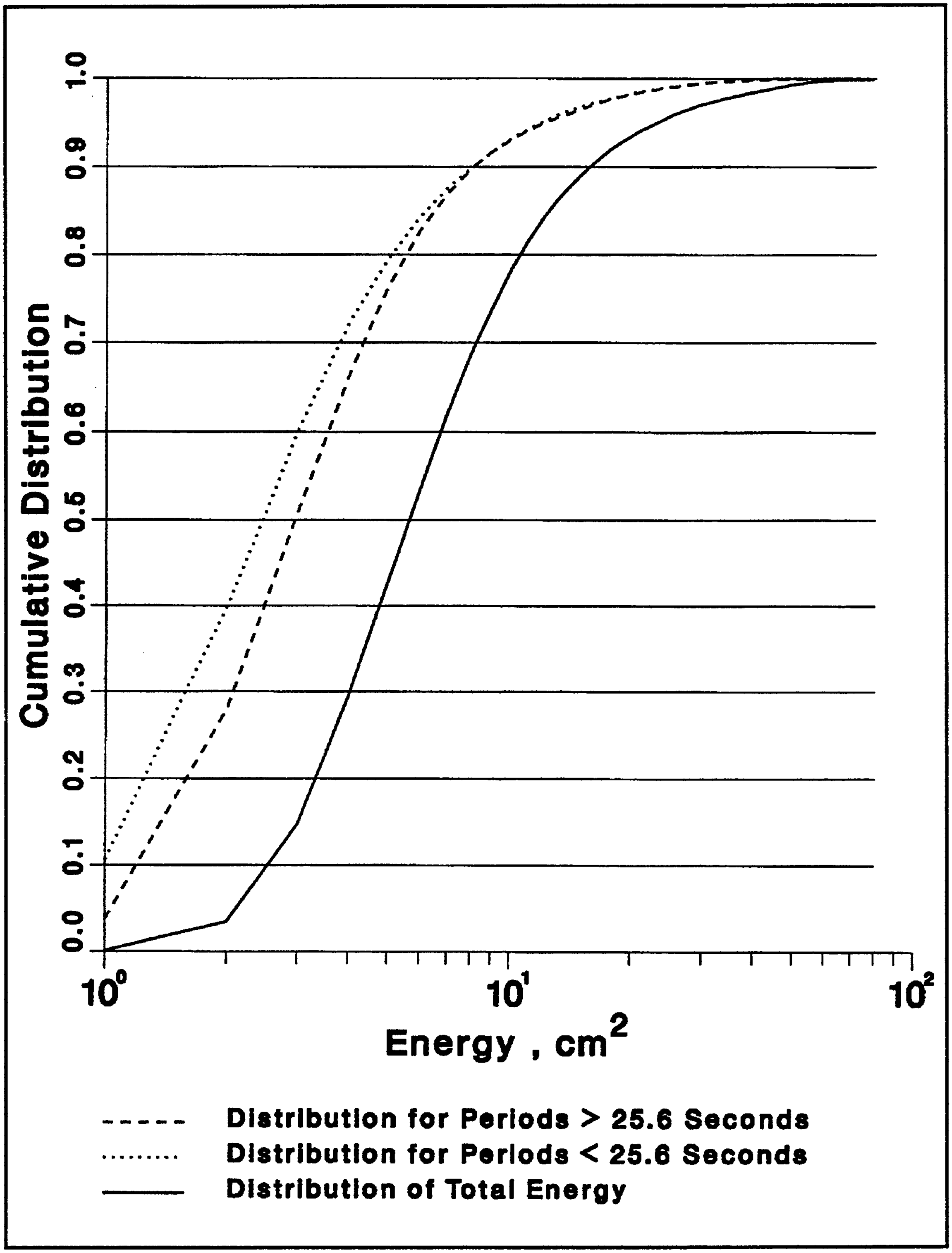


Figure 8. Energy CDF, by frequency ranges, for Los Angeles station 1

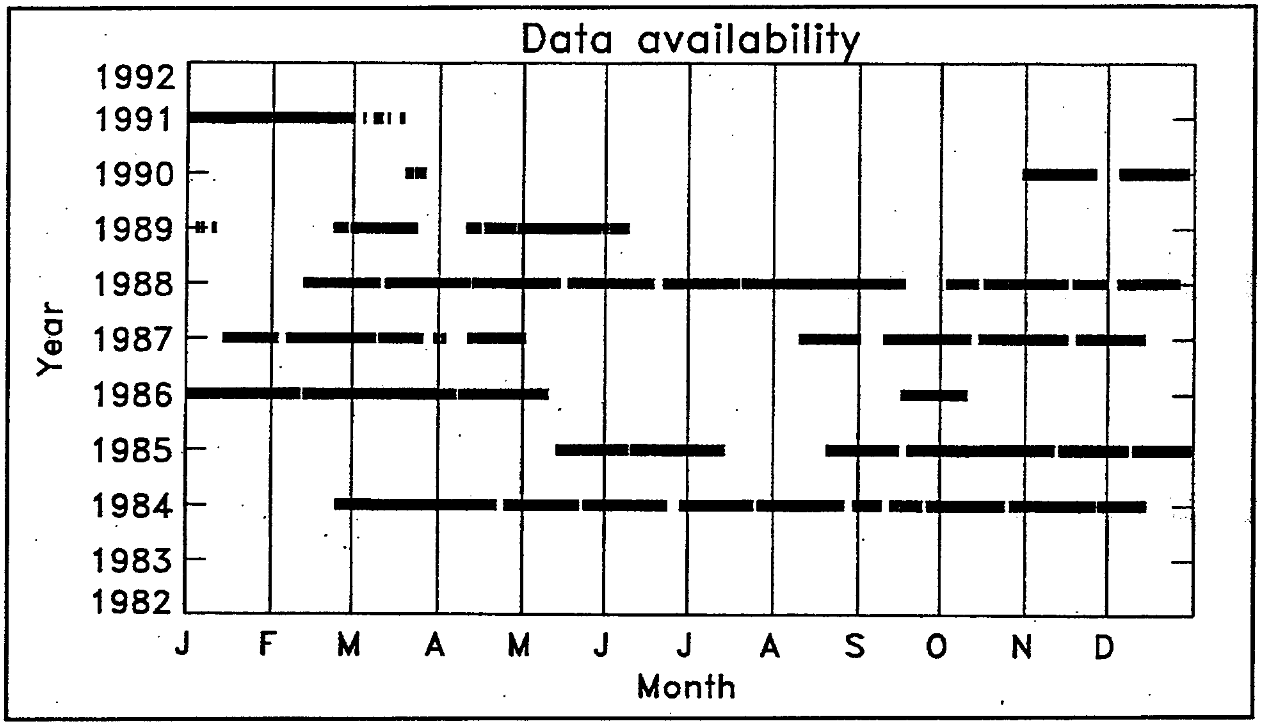


Figure 9. Data availability for Los Angeles station 3

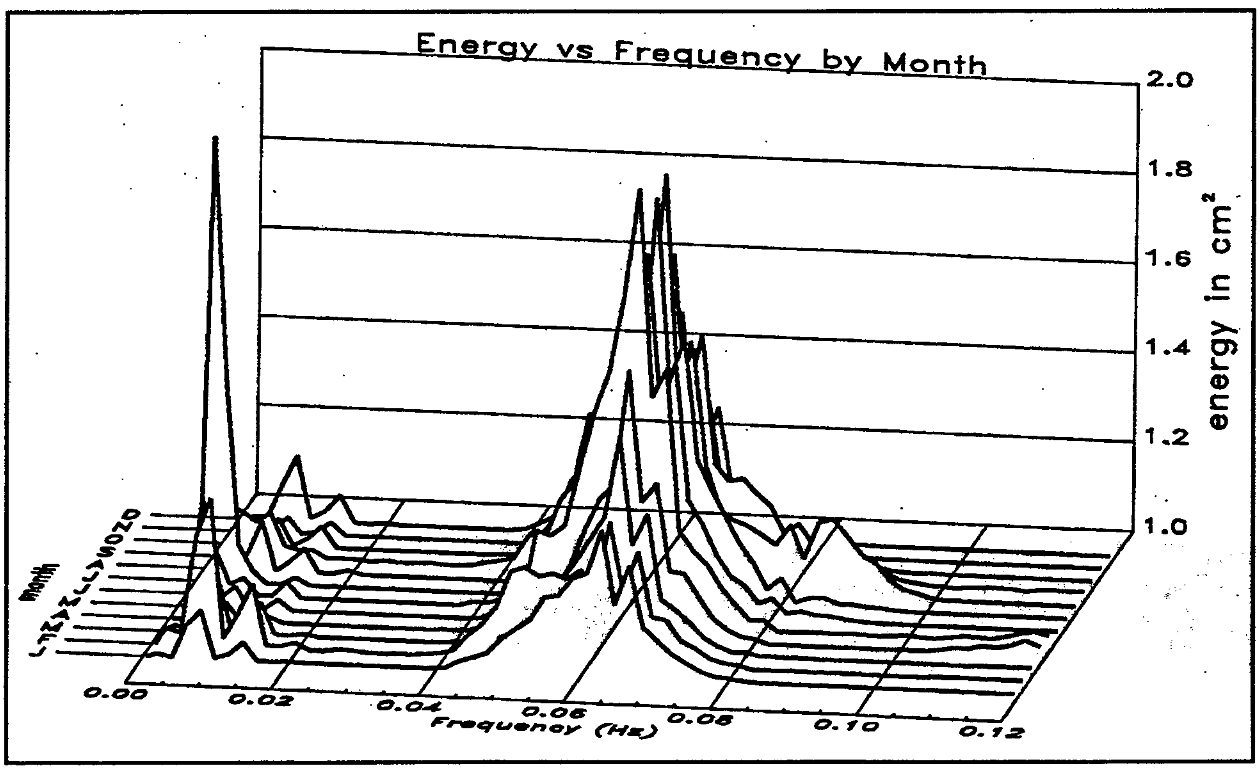


Figure 10. Average energy versus frequency, by month, for Los Angeles station 3

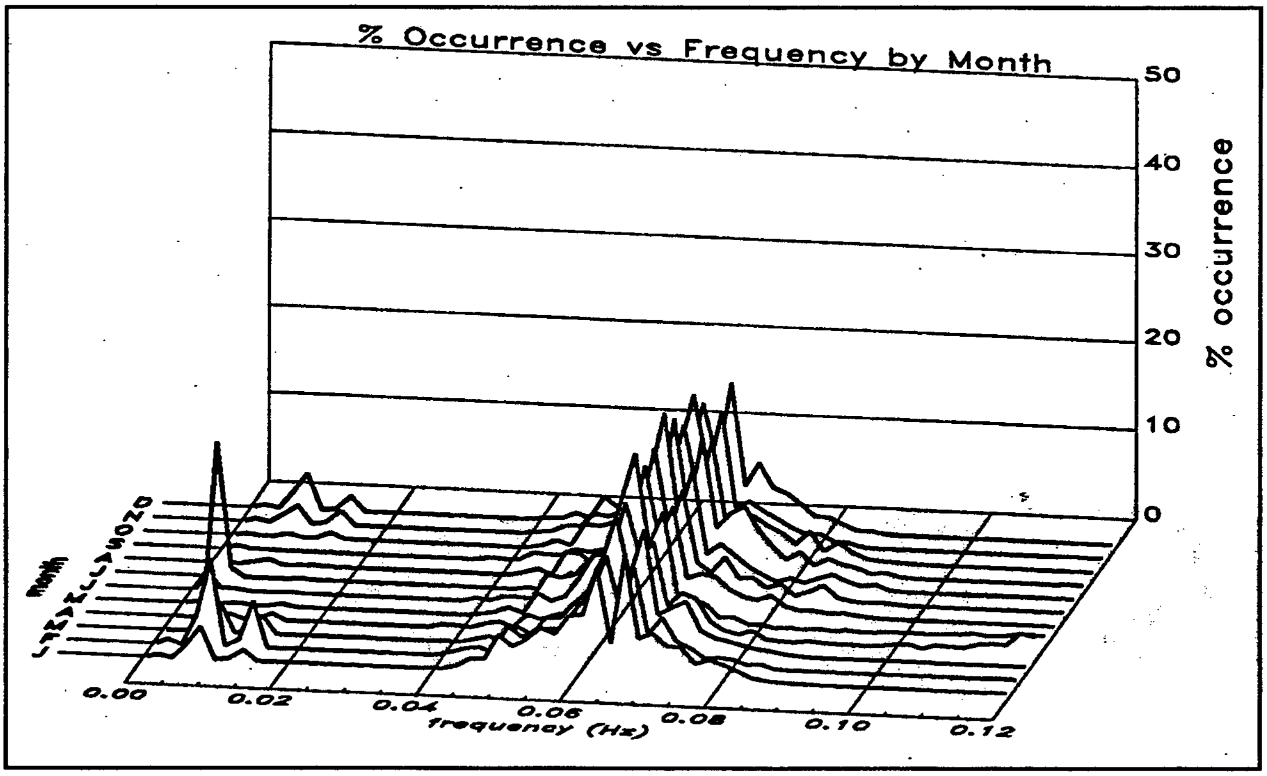


Figure 11. Percent occurrence versus peak frequency, by month, for Los Angeles station 3

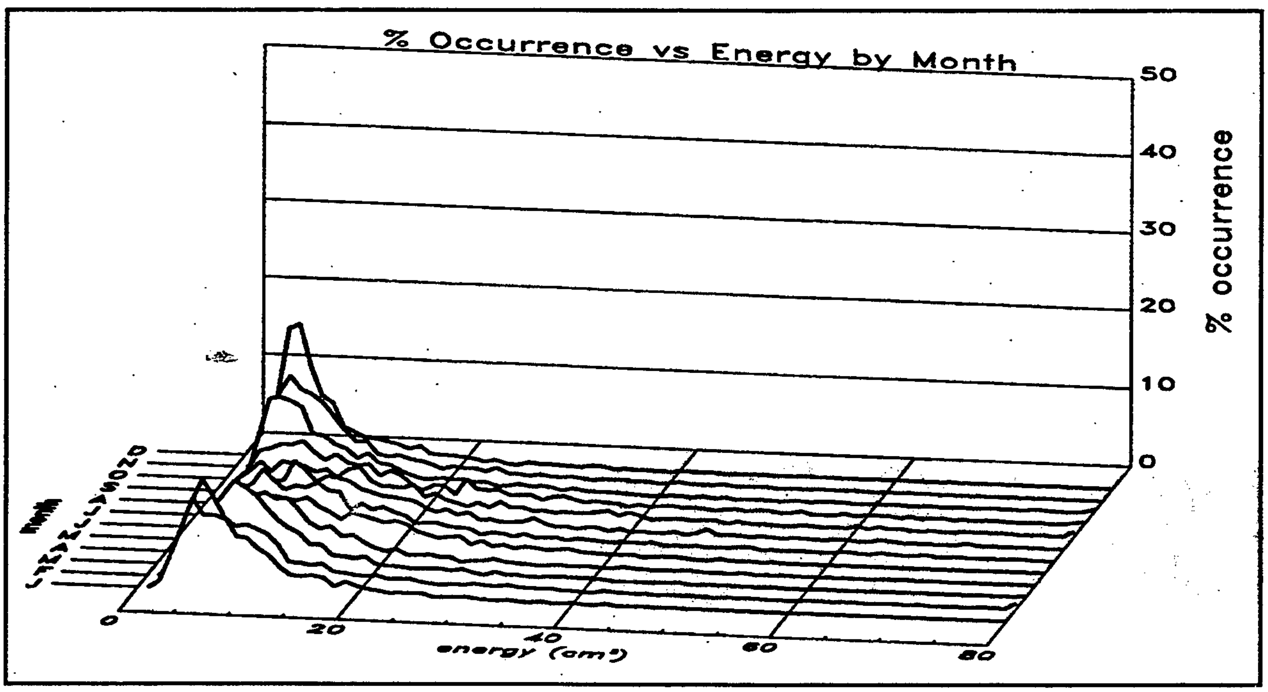


Figure 12. Percent occurrence versus total energy, by month, for Los Angeles station 3

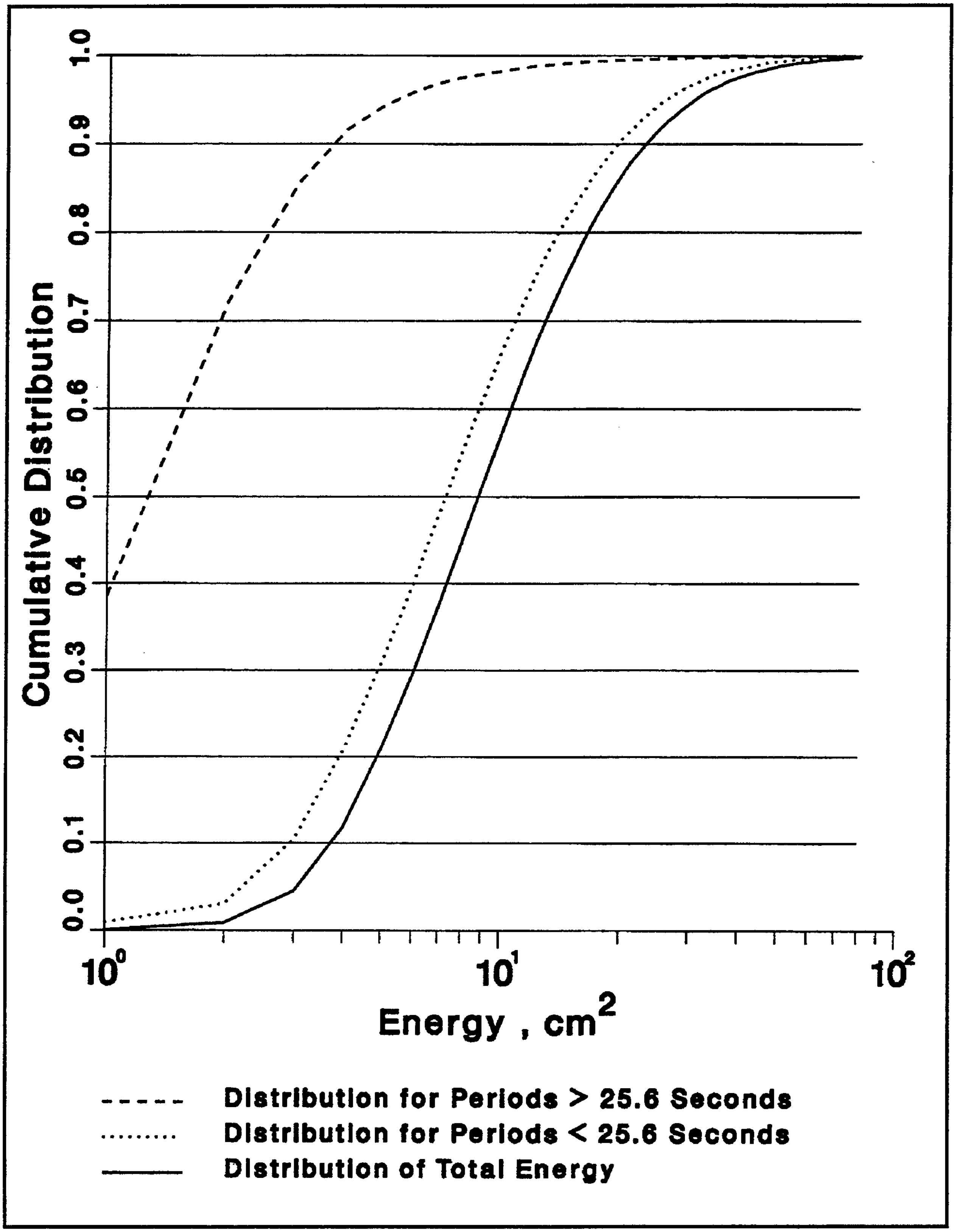


Figure 13. Energy CDS, by frequency ranges, for Los Angeles station 3

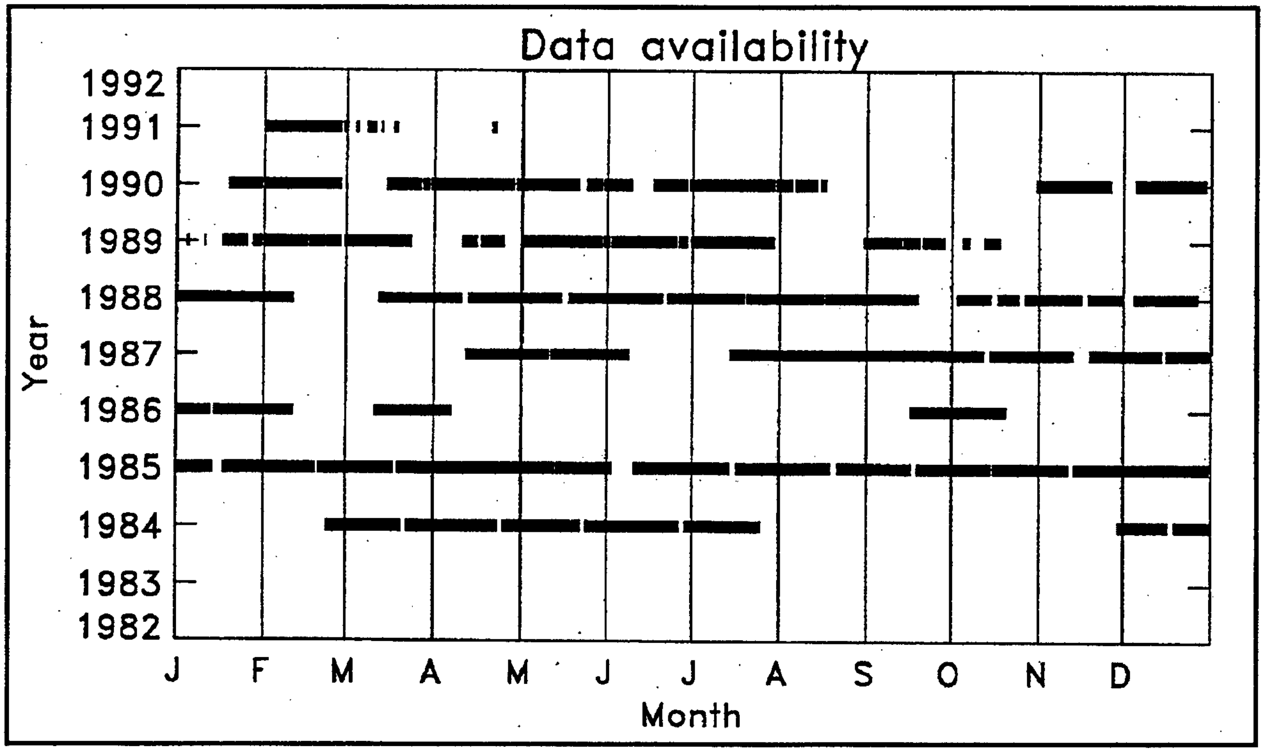


Figure 14. Data availability for Los Angeles station 4

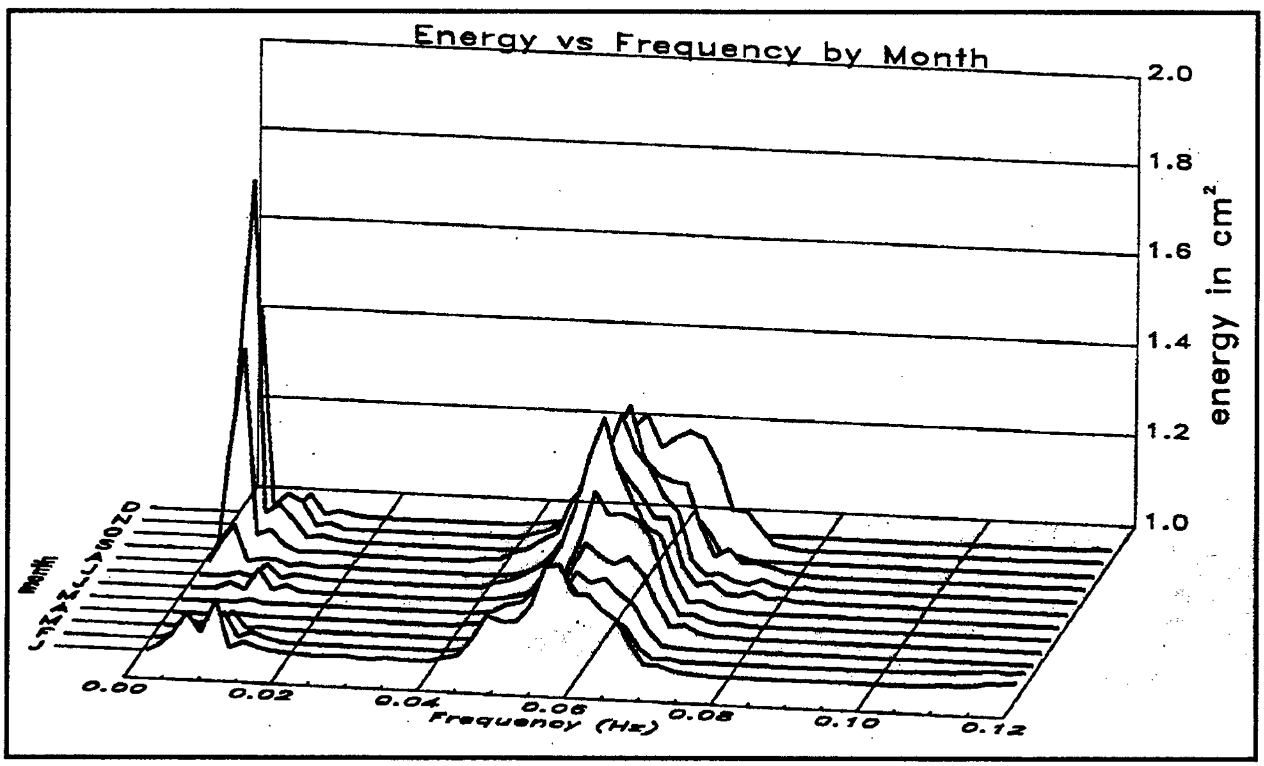


Figure 15. Average energy versus frequency, by month, for Los Angeles station 4

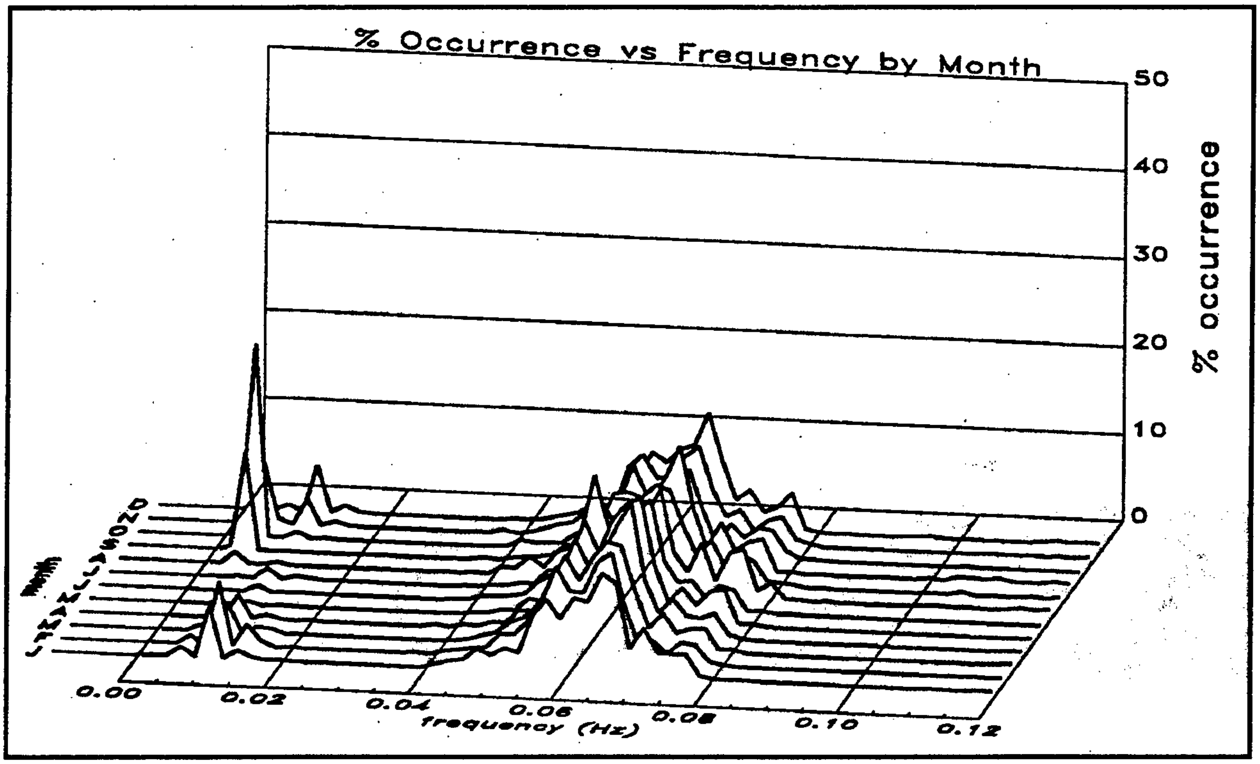


Figure 16. Percent occurrence versus peak frequency, by month, for Los Angeles station 4

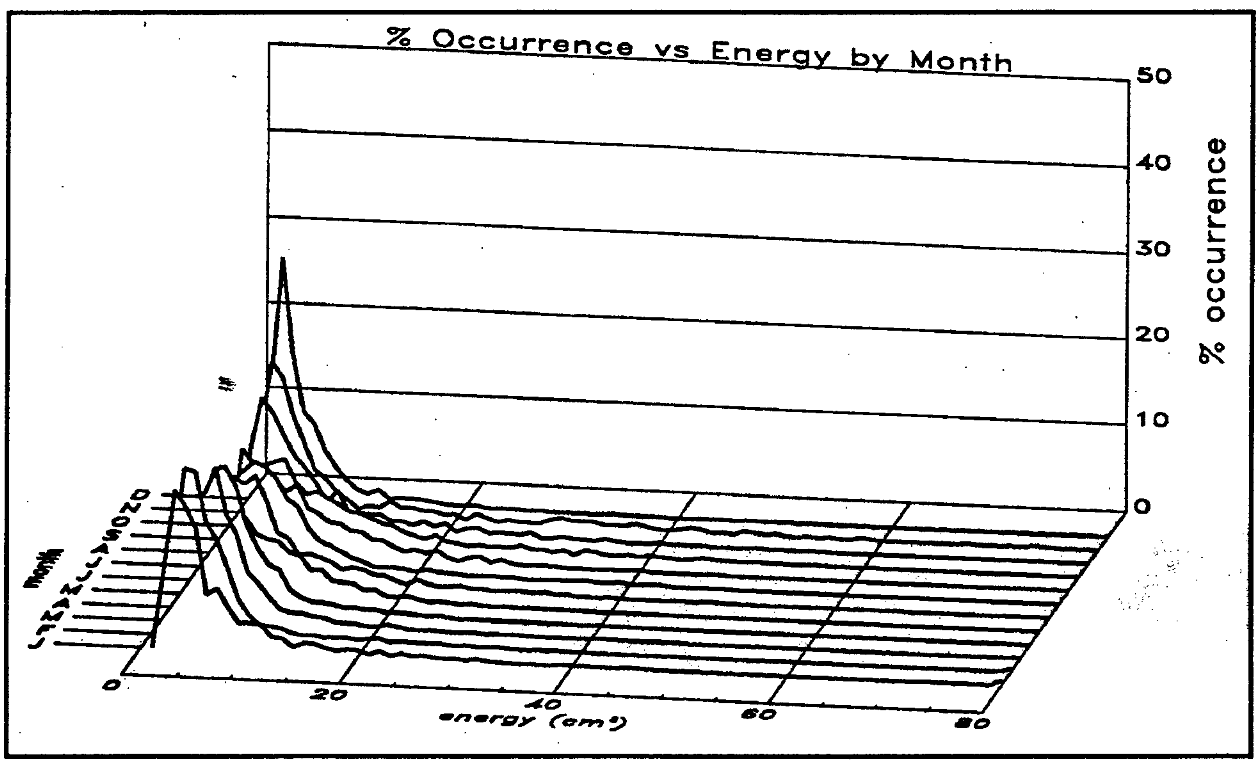


Figure 17. Percent occurrence versus total energy, by month, for Los Angeles station 4

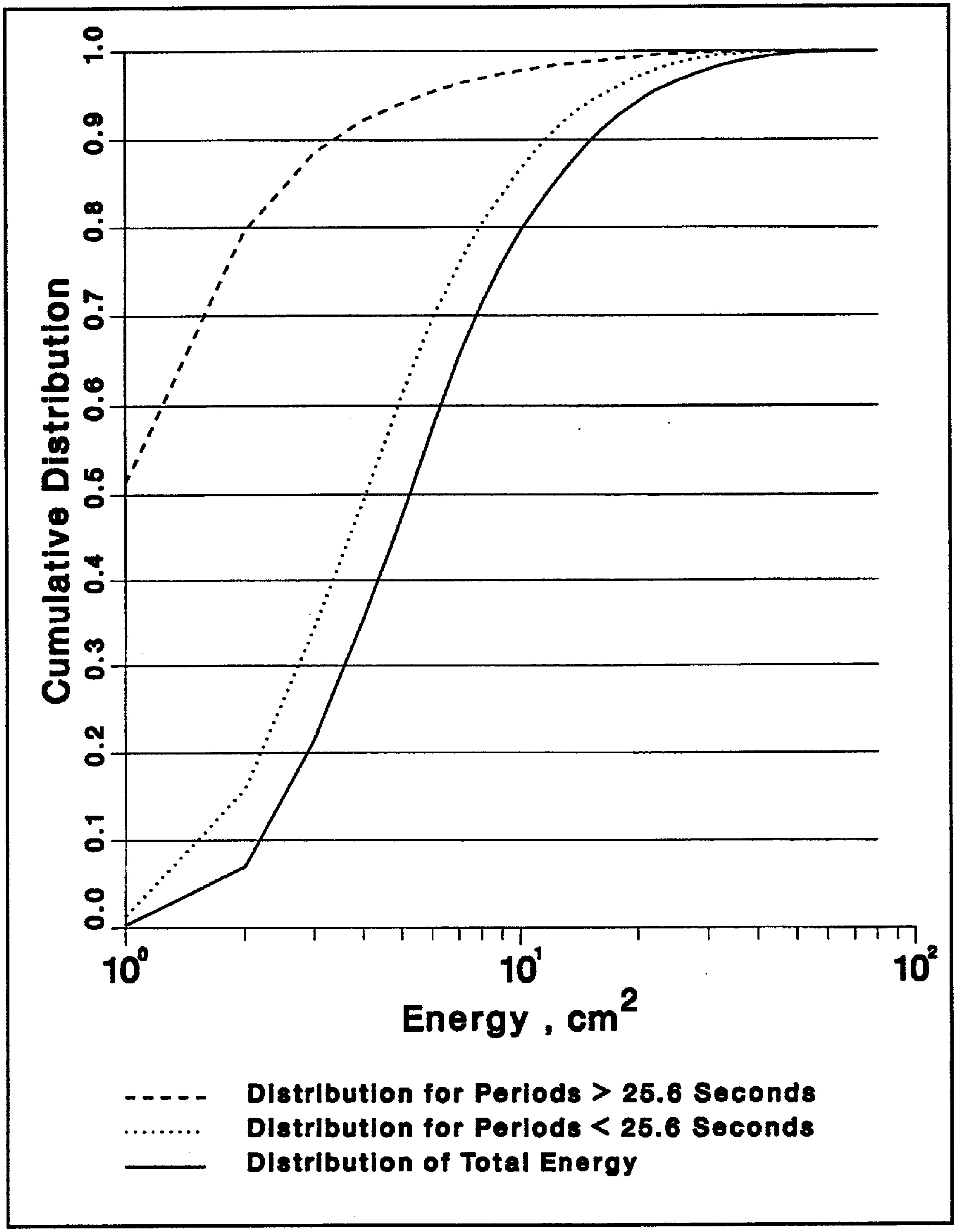


Figure 18. Energy CDF by frequency ranges for Los Angeles station 4

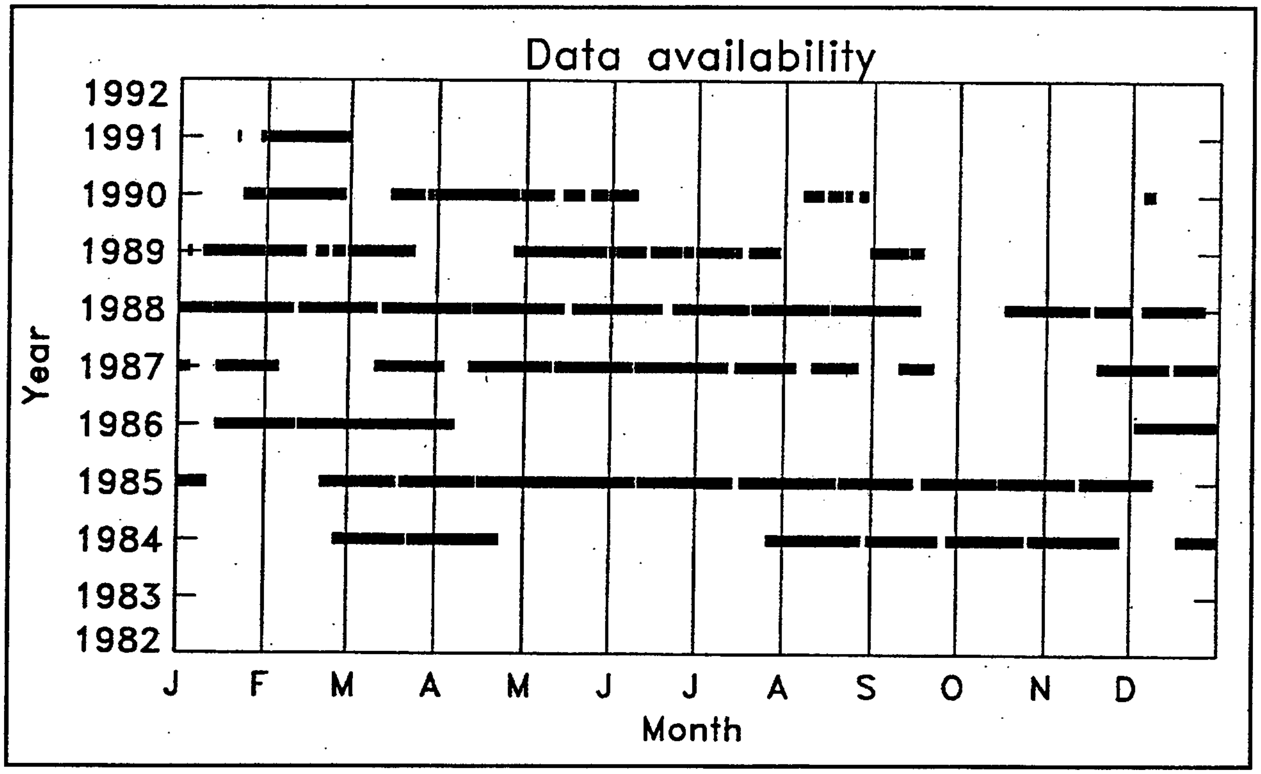


Figure 19. Data availability for Long Beach station 1

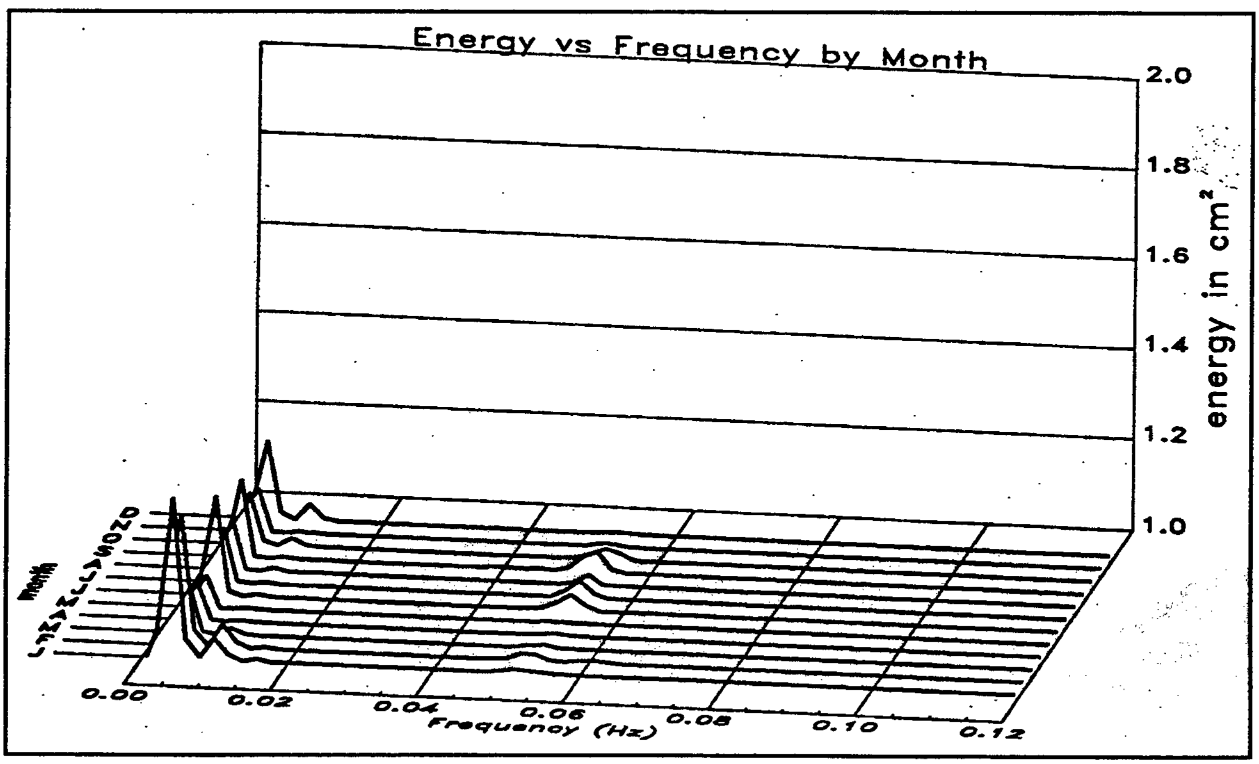


Figure 20. Average energy versus frequency, by month, for Long Beach station 1

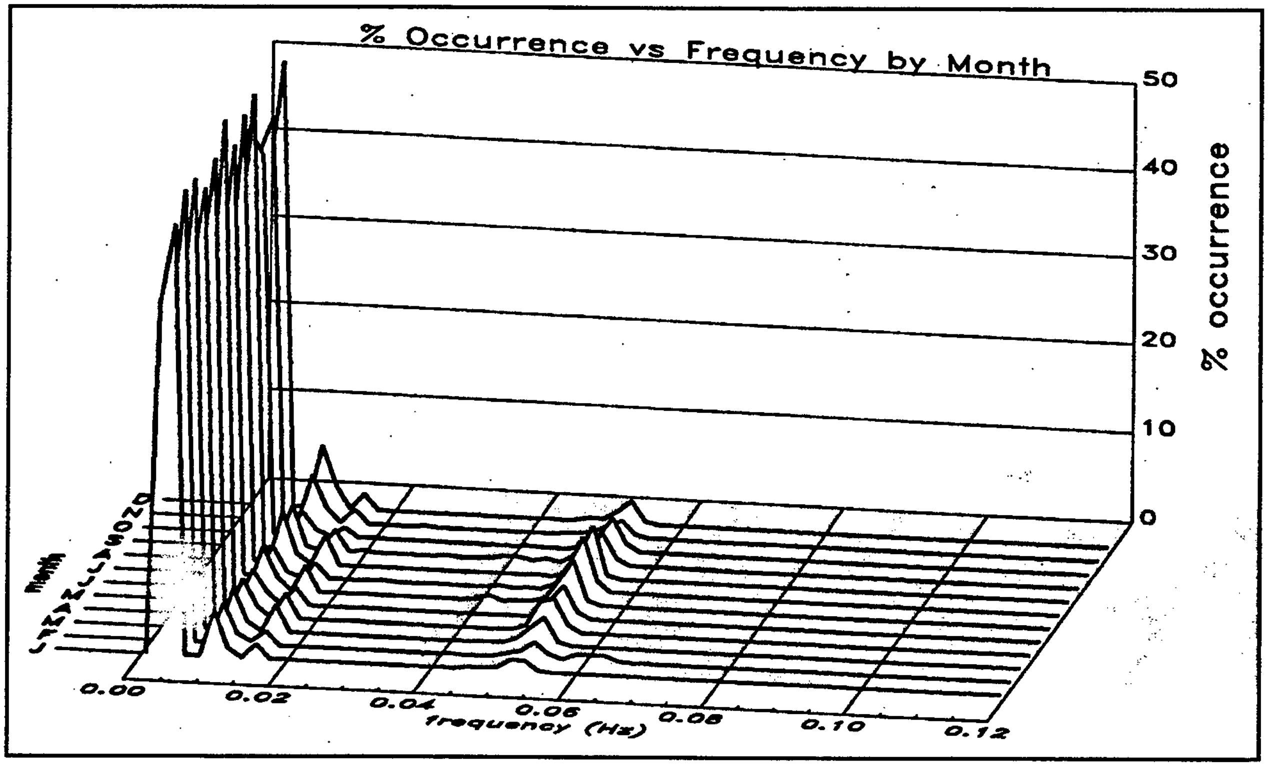


Figure 21. Percent occurrence versus peak frequency, by month, for Long Beach station 1

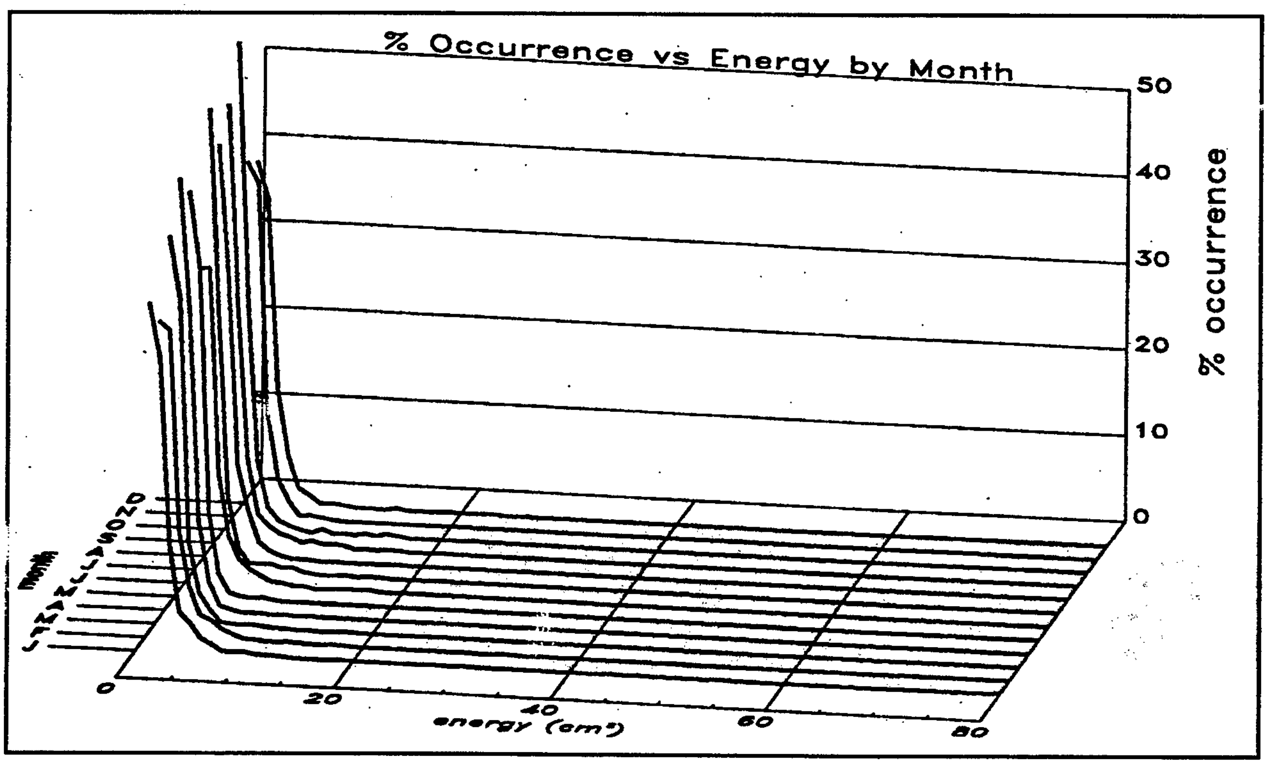


Figure 22. Percent occurrence versus total energy, by month, for Long Beach station 1

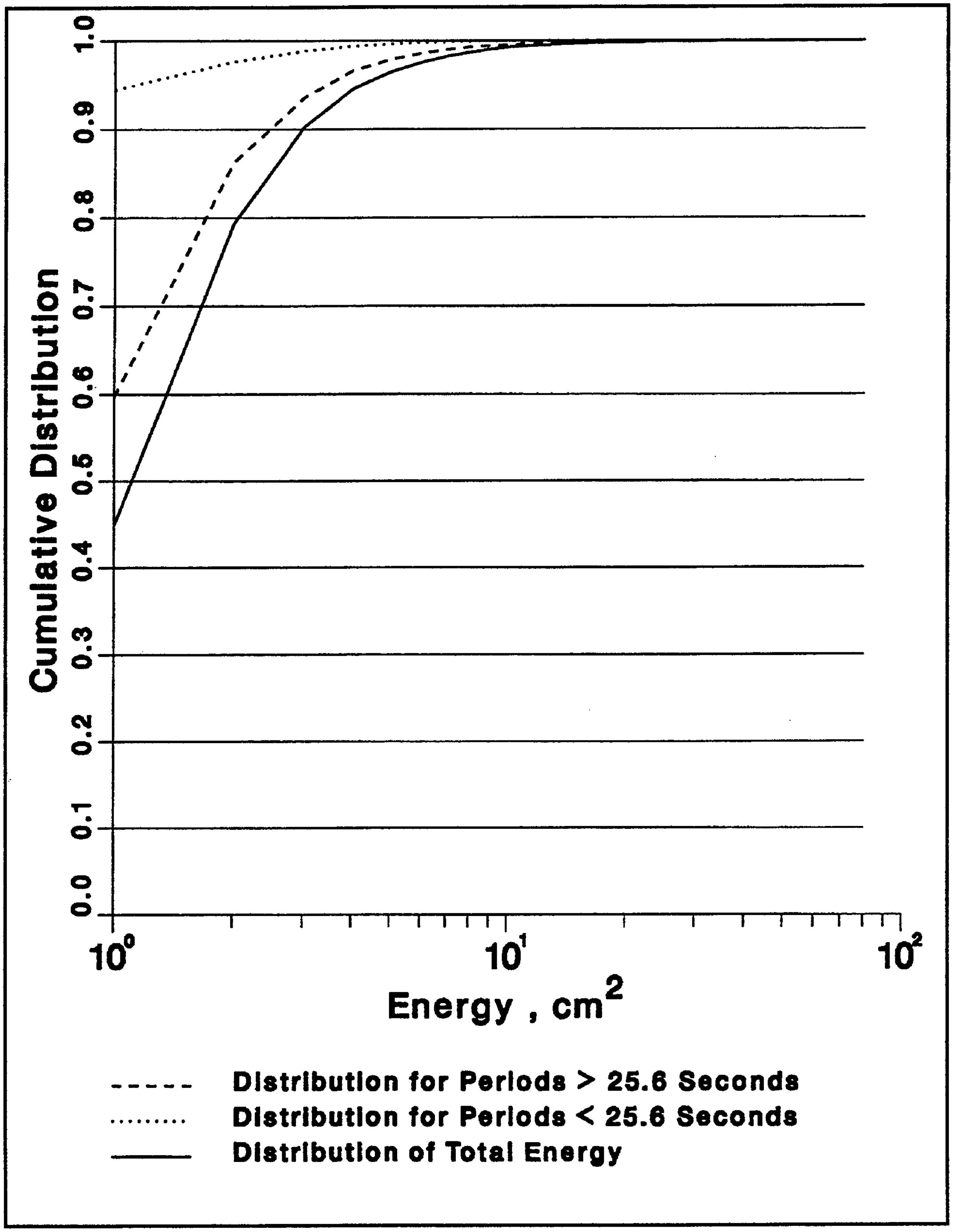


Figure 23. Energy CDF, by frequency ranges, for Long Beach station 1

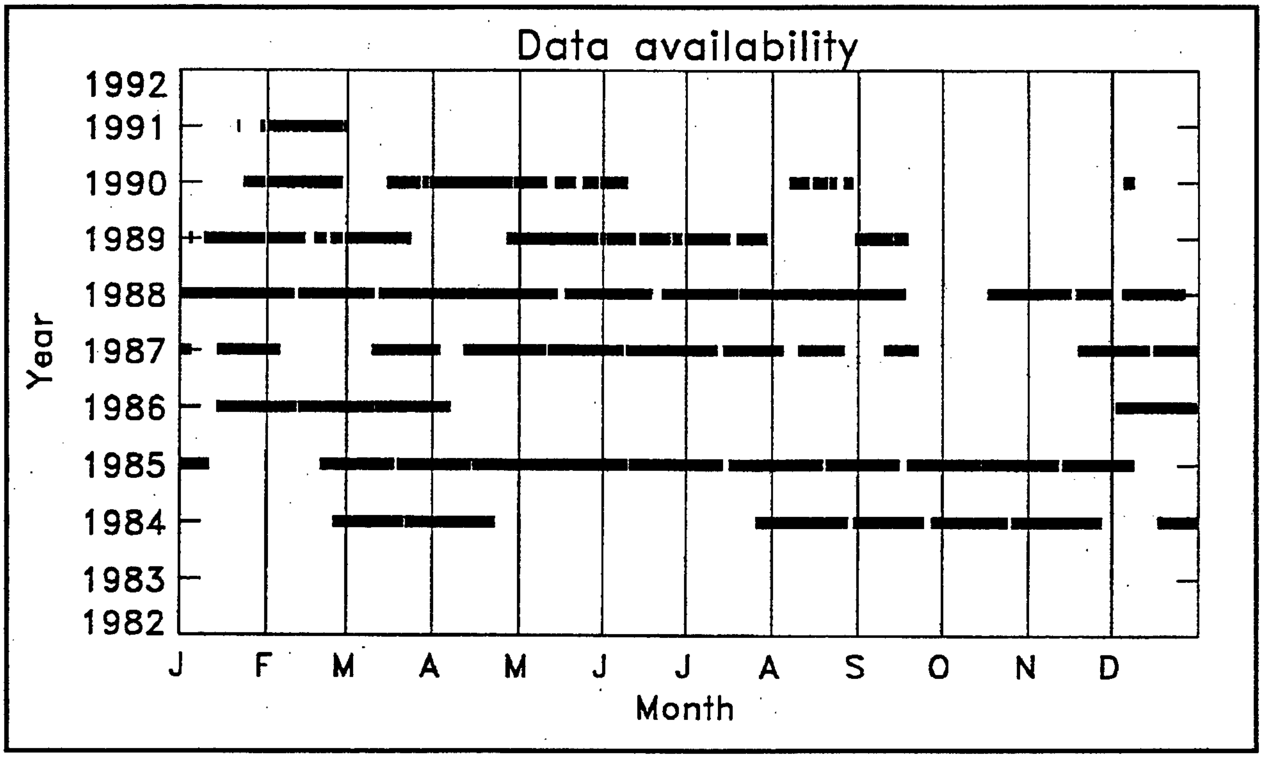


Figure 24. Data availability for Long Beach station 2

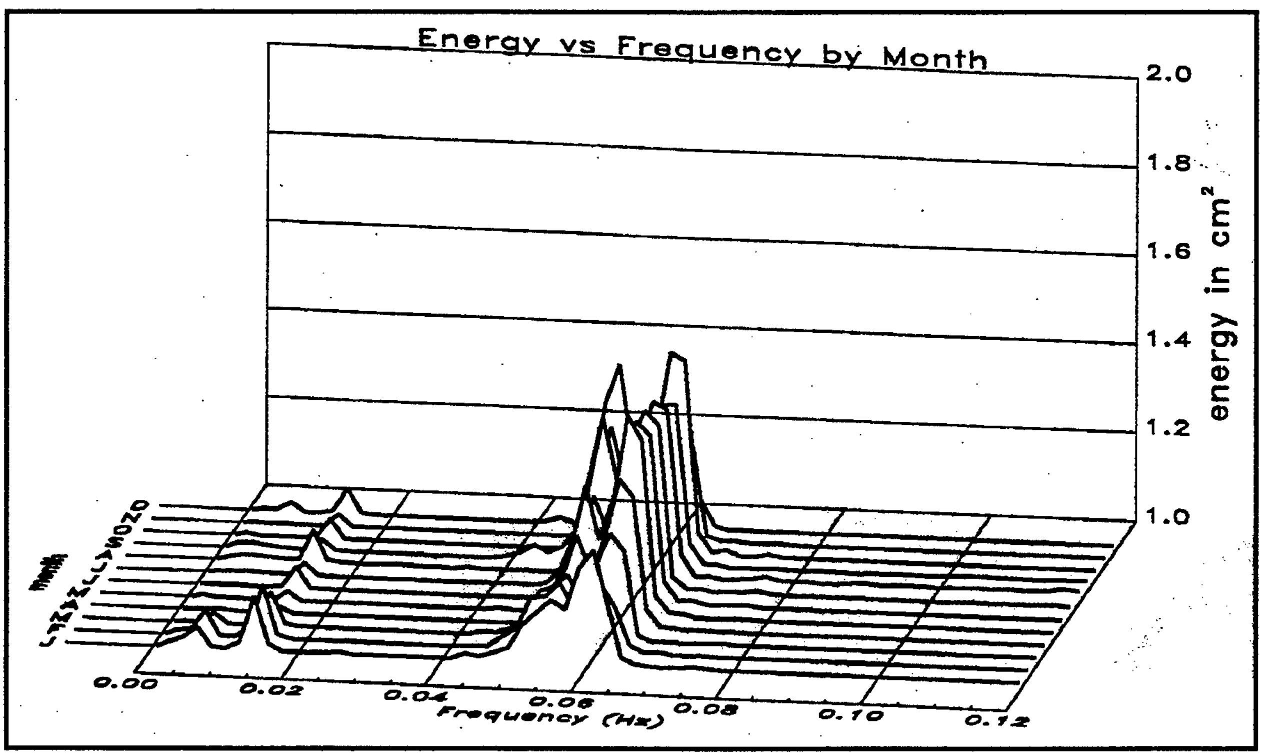


Figure 25. Average energy versus frequency, by month, for Long Beach station 2

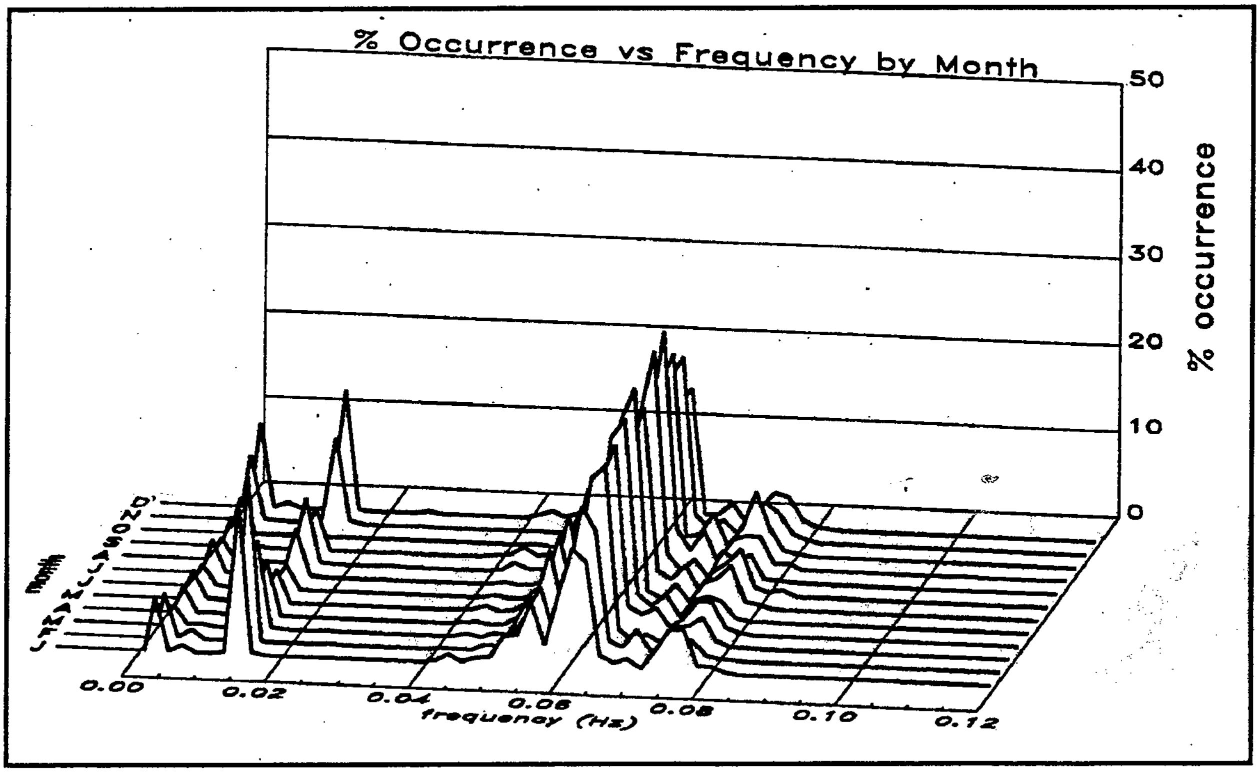


Figure 26. Percent occurrence versus peak frequency, by month, for Long Beach station 2

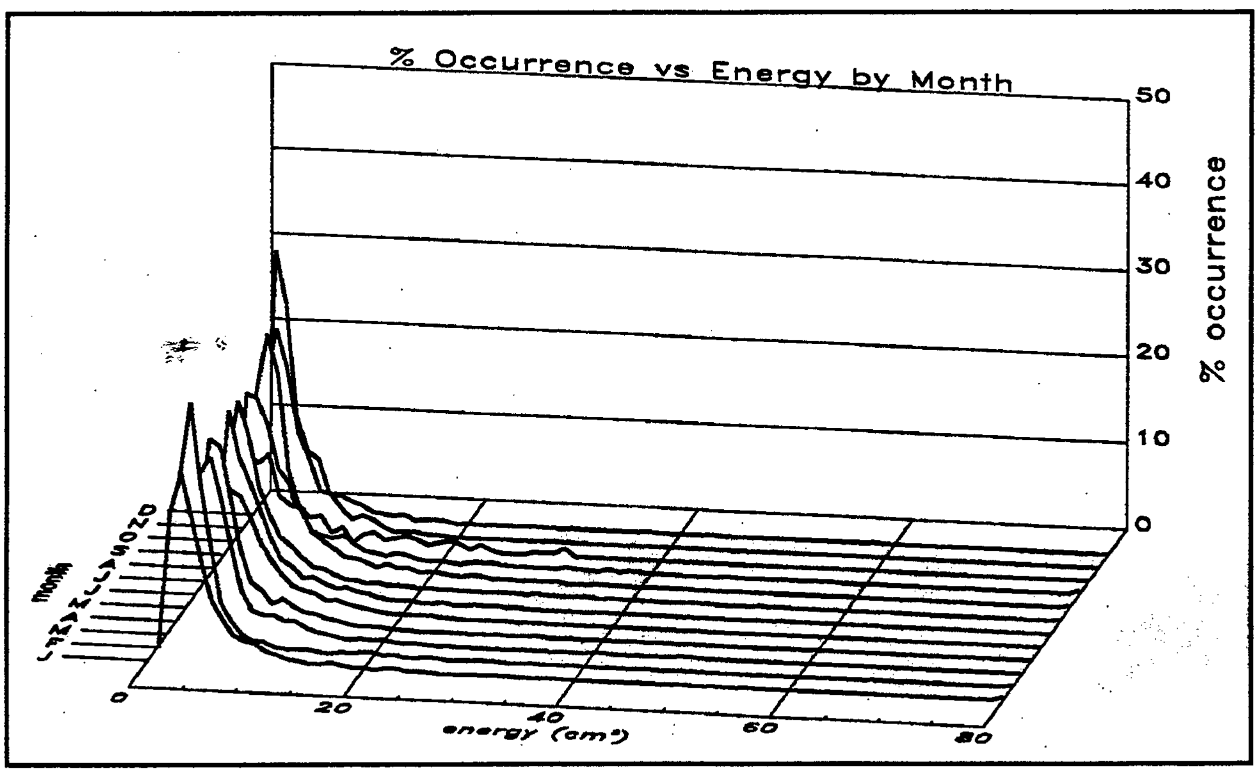


Figure 27. Percent occurrence versus total energy, by month, for Long Beach station 2

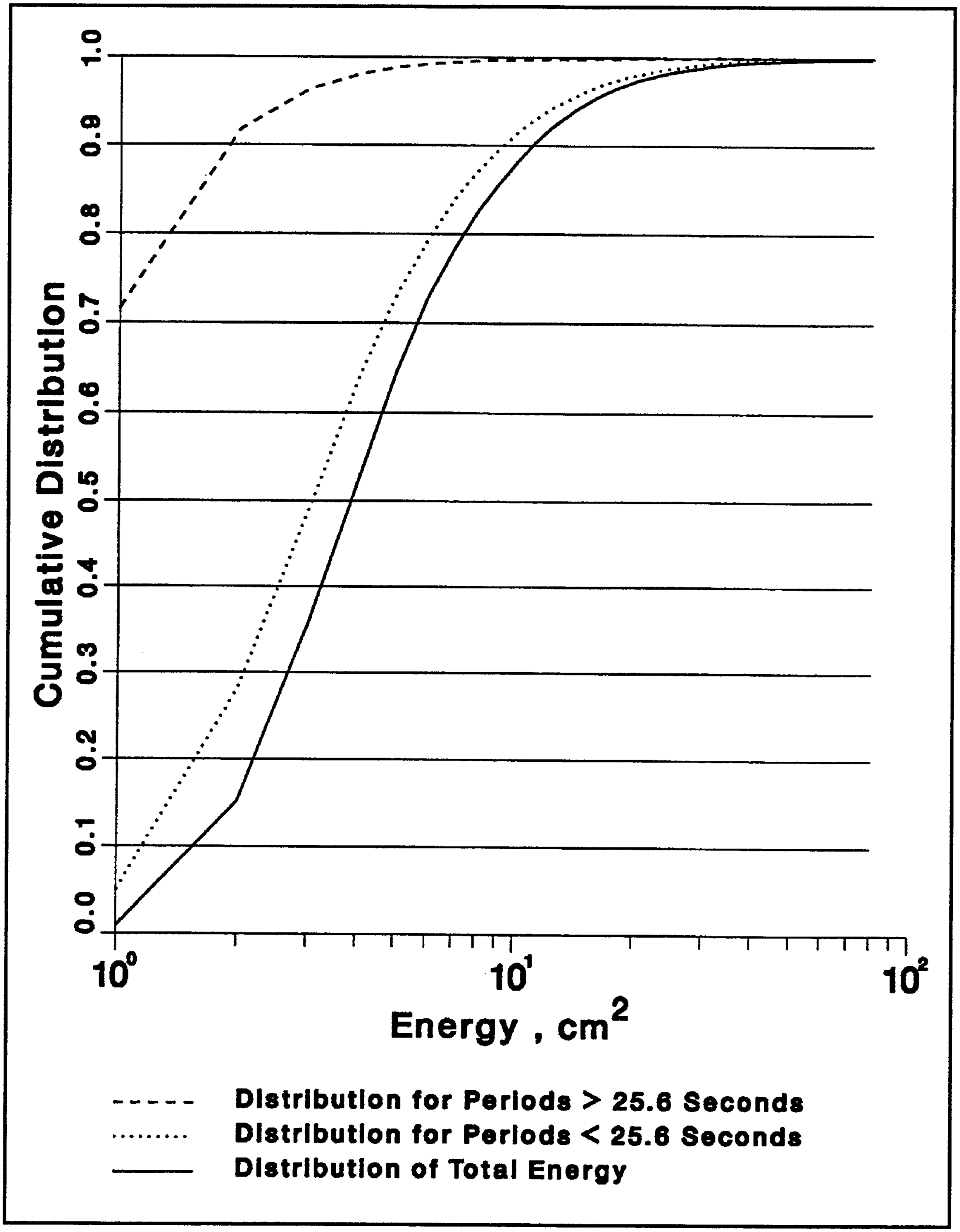


Figure 28. Energy CDF, by frequency ranges, for Long Beach station 2

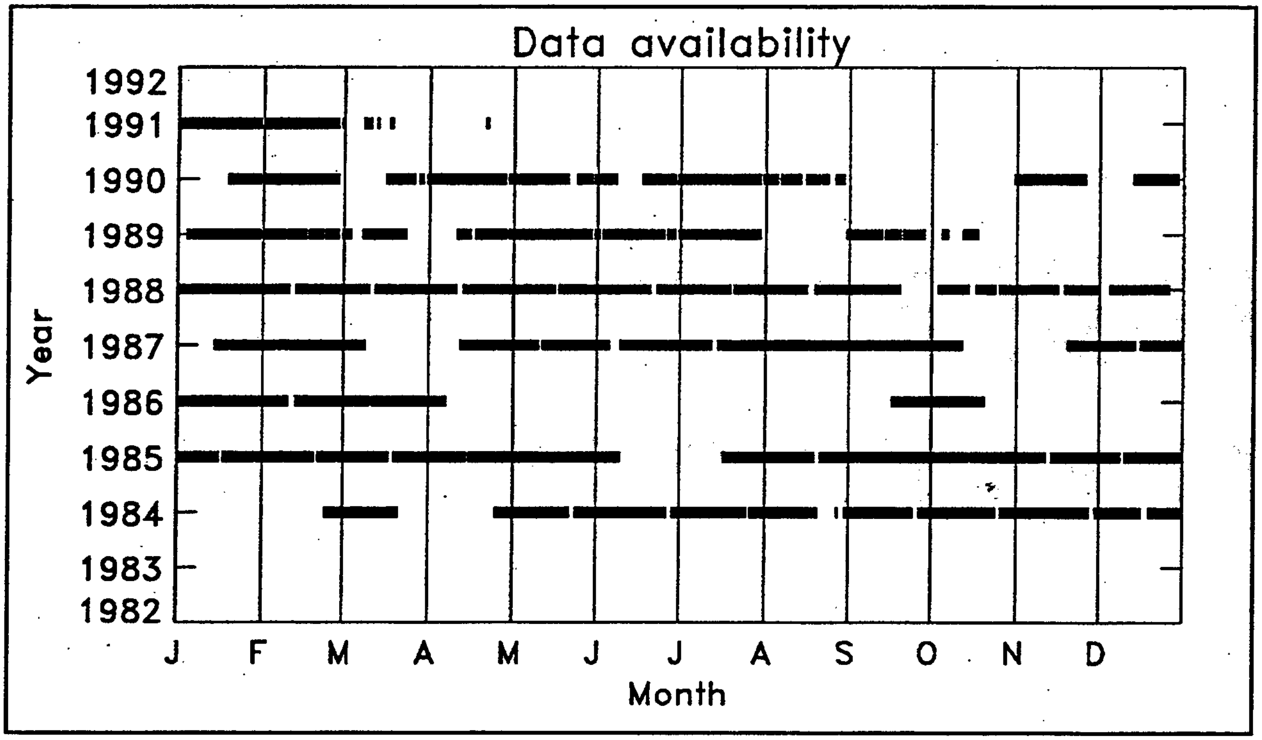


Figure 29. Data availability for Long Beach station 4

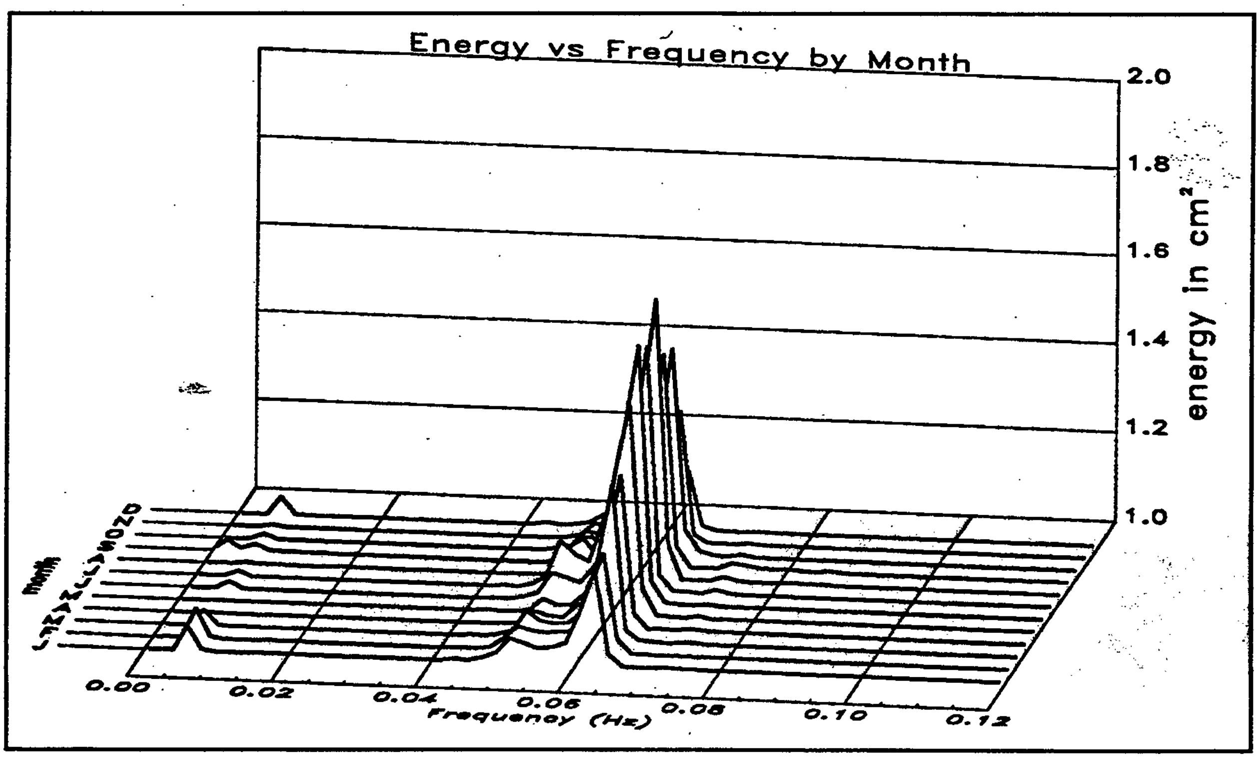


Figure 30. Average energy versus frequency, by month, for Long Beach station 4

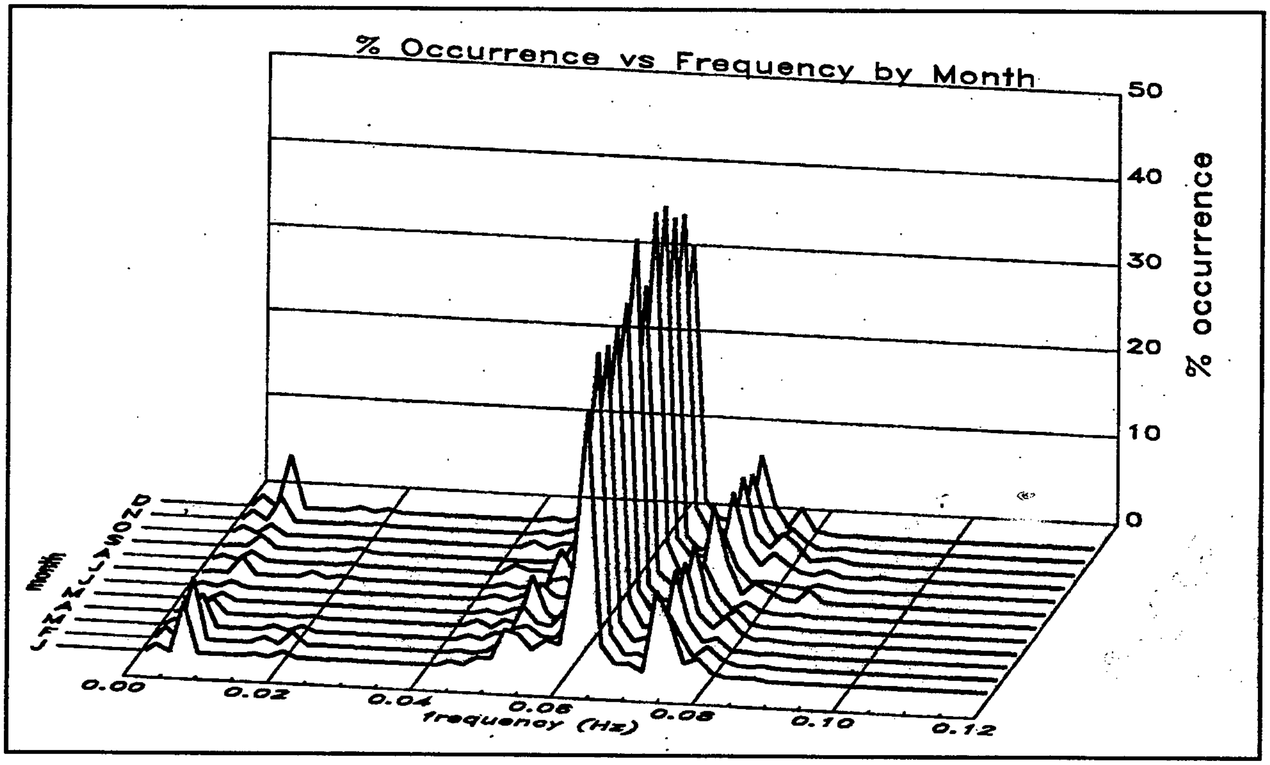


Figure 31. Percent occurrence versus peak frequency, by month, for Long Beach station 4

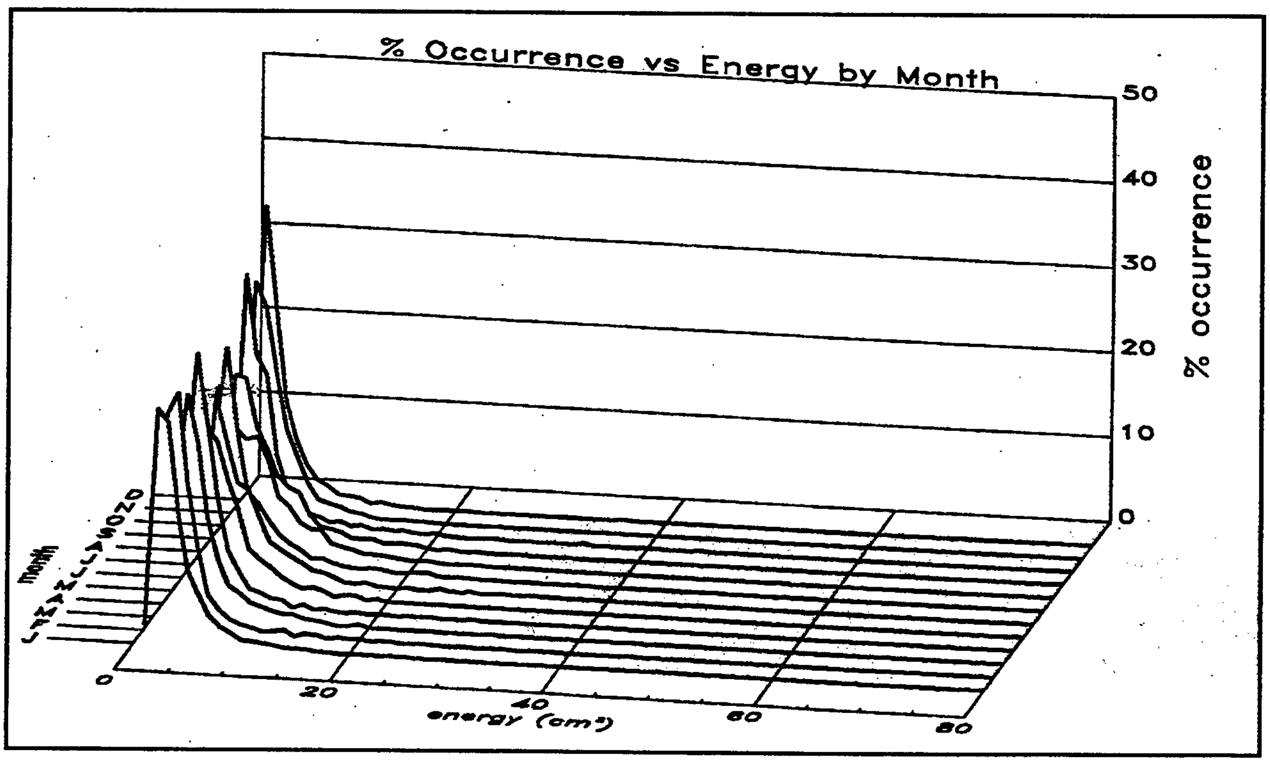


Figure 32. Percent occurrence versus total energy, by month, for Long Beach station 4

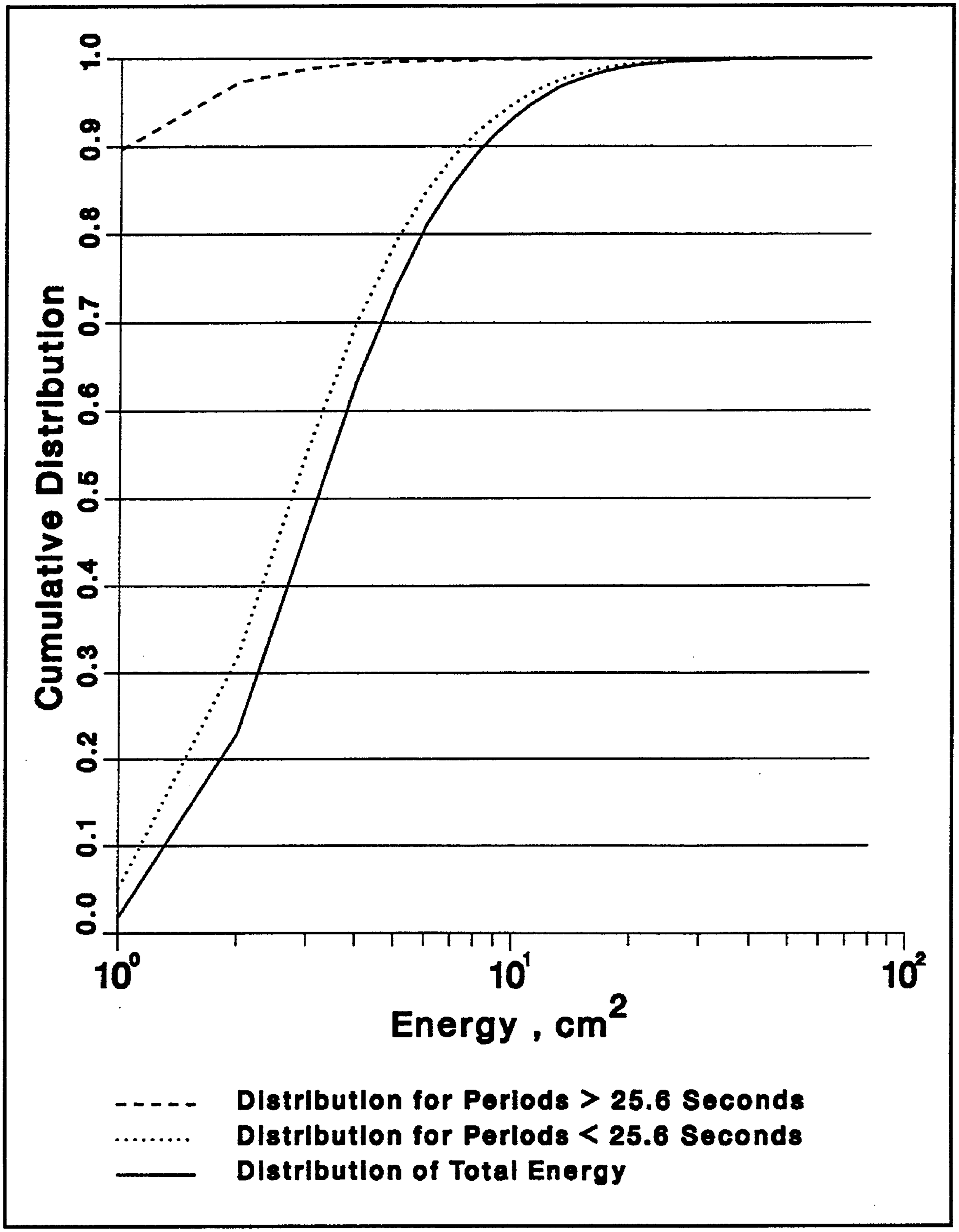


Figure 33. Energy CDF, by frequency ranges, for Long Beach station 4

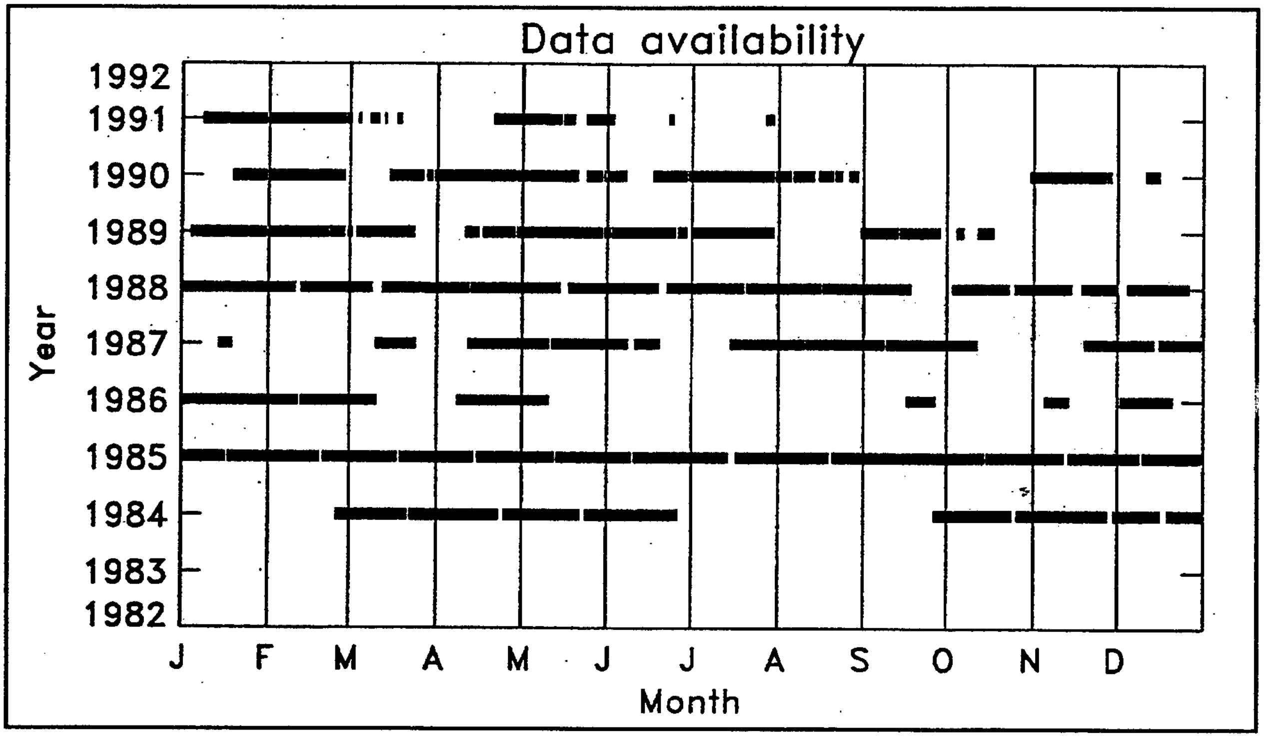


Figure 34. Data availability for Long Beach station 5

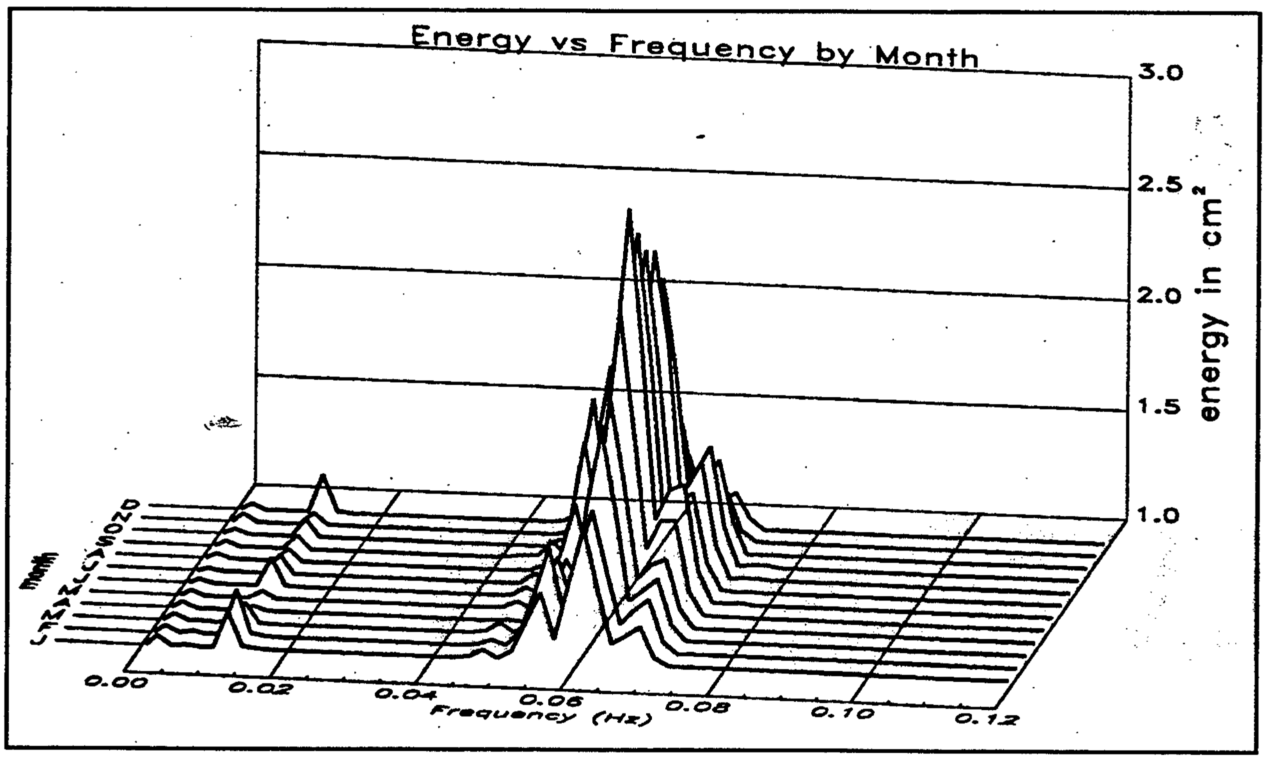


Figure 35. Average energy versus frequency, by month, for Long Beach station 5

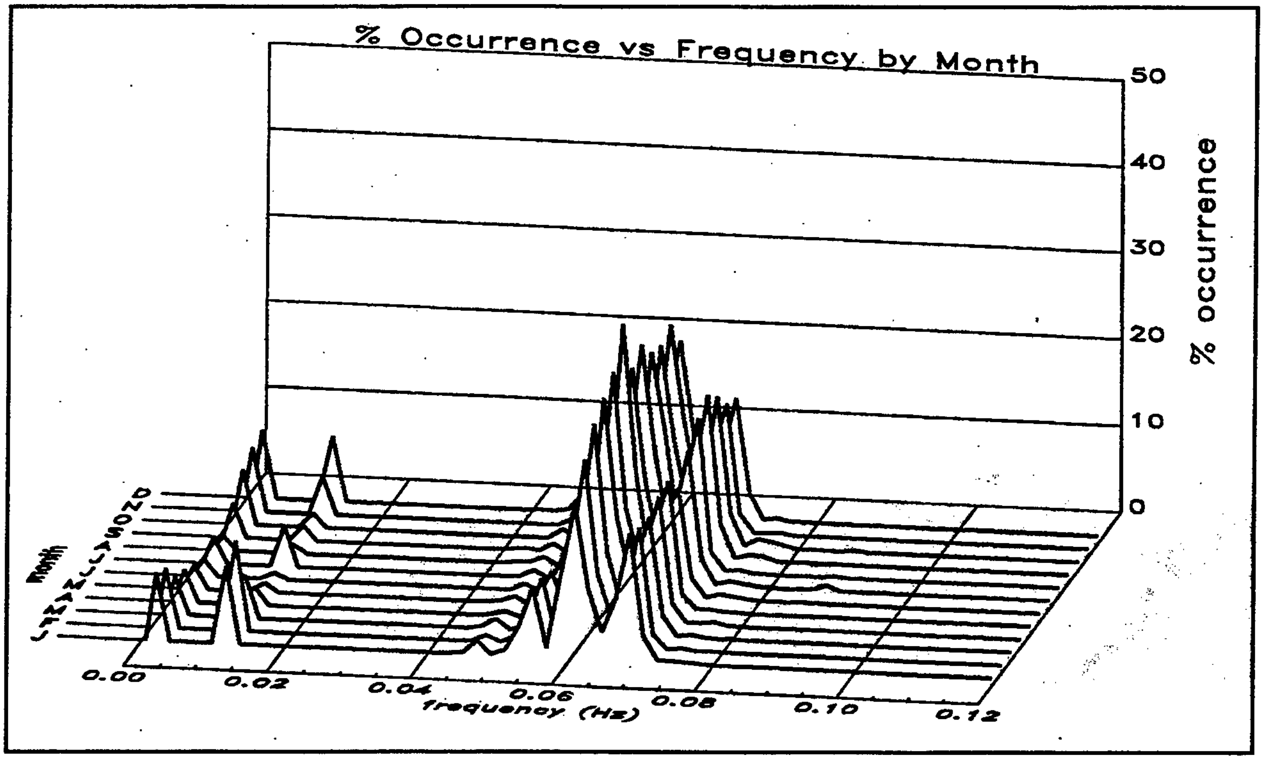


Figure 36. Percent occurrence versus peak frequency, by month, for Long Beach station 5

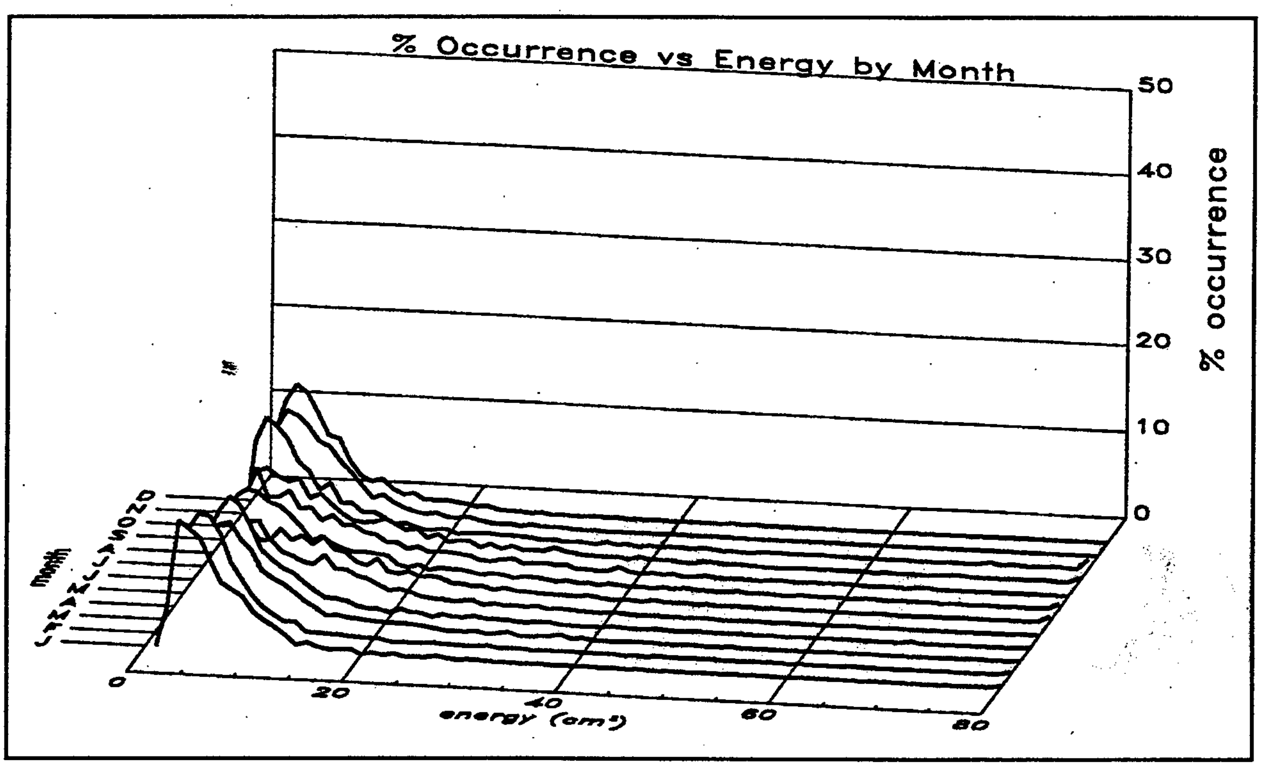


Figure 37. Percent occurrence versus total energy, by month, for Long Beach station 5

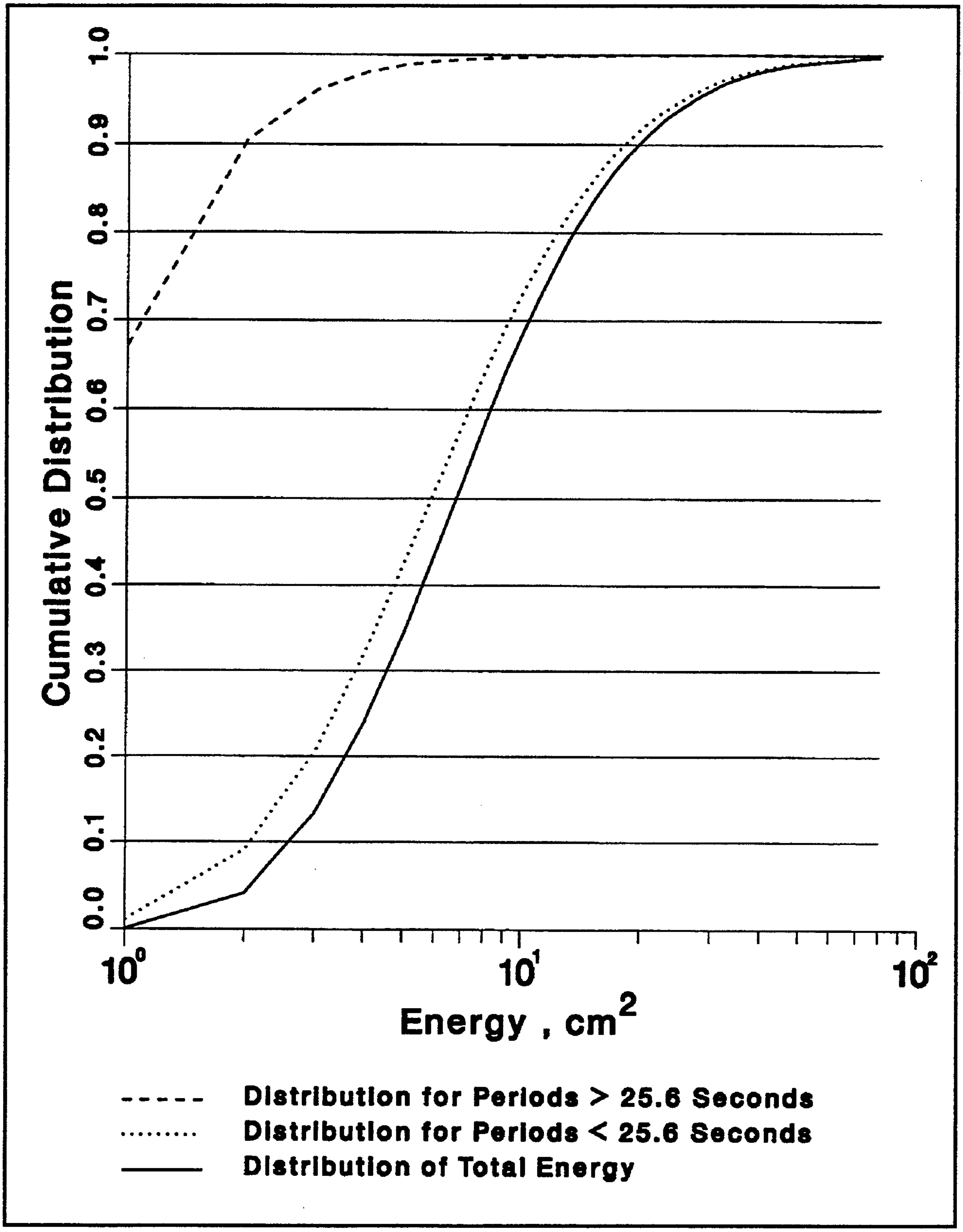


Figure 38. Energy CDF, by frequency ranges, by month, for Long Beach station 5

The third plot (Figure 6) shows percent occurrence versus peak frequency (Ft_p) by month. The fourth plot (Figure 7) shows percent occurrence versus total energy (E_t) for each month. The fifth plot (Figure 8) is a cumulative distribution of wave energy, by frequency, based on all of the data collected for a site.

Following is a brief description of how to interpret the data products presented. Continuing the example with station 1 of Los Angeles Harbor, use Figures 4-8 to study the wave conditions there. Figure 4 gives an idea of the amount of data available for this site and if data are available for a specific time period of interest. Figure 5 shows that two frequency bands contain the majority of the wave energy. The upper band is centered around a frequency of about 0.058 Hz (period of 17.3 sec), which is typical of wind-generated swell. The other band of energy is at a much lower frequency and represents the resonant frequency and its harmonics for this slip in the harbor. Figure 6 shows that, in general, the majority of the waves are at low frequencies and that the percent of low-frequency energy increases during the winter months. Figure 7 indicates that the most frequently occurring total energy is below 5 cm^2.

Figure 8 shows the three cumulative distribution function (CDF) energy curves for E_l (wave periods greater than 25 sec), E_h (wave periods less than 25 sec), and E_t (total energy) for LA1. They are produced by first calculating probability of occurrence of energy levels from tallies of the E_l, E_h, and E_t for all wave records for that site. The CDF is used to determine the probability of any one wave record having energy below a given level. It is computed by summing the probability of occurrence up to and including each energy level.

For example, the CDF for E_t shows a probability of 0.8 for the 10 cm^2 energy value. The total energy can be expected to be less than 10 cm^2 80 percent of the time.

Platform Edith

Figures 39-59 are analysis products for Platform Edith data when the pressure data are analyzed in the same way as harbor gauges. The extra steps needed to analyze Platform Edith pressure data as harbor data are documented in the methods chapter. The remaining figures are based on directional wave data analysis. The analysis results derived from directional wave analysis are wave direction statistics - H_{mo}, T_p (peak period), D_p (wave direction at the peak period), and directional 2-D spectra.

Yearly plots (1985-1991) of total energy (Appendix B), were produced to determine periods of high wave energy and data availability. Directional wave

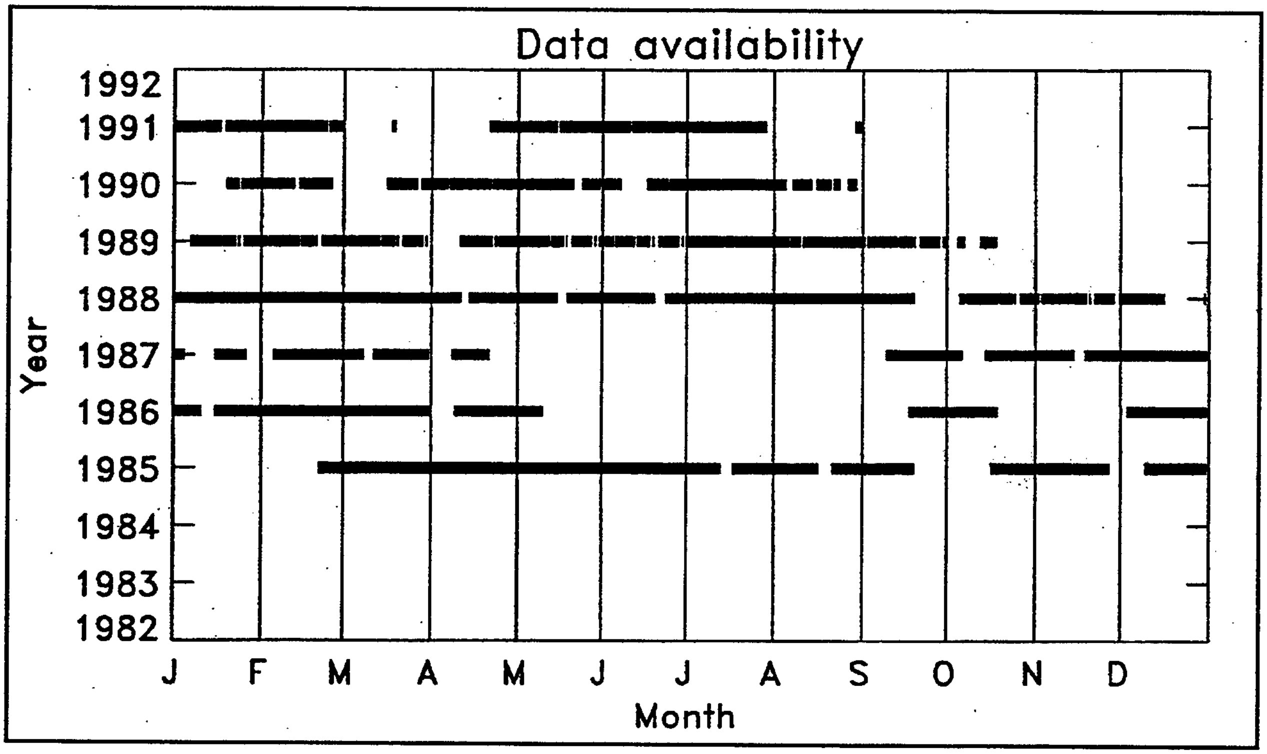


Figure 39. Data availability for nondirectional data for Platform Edith

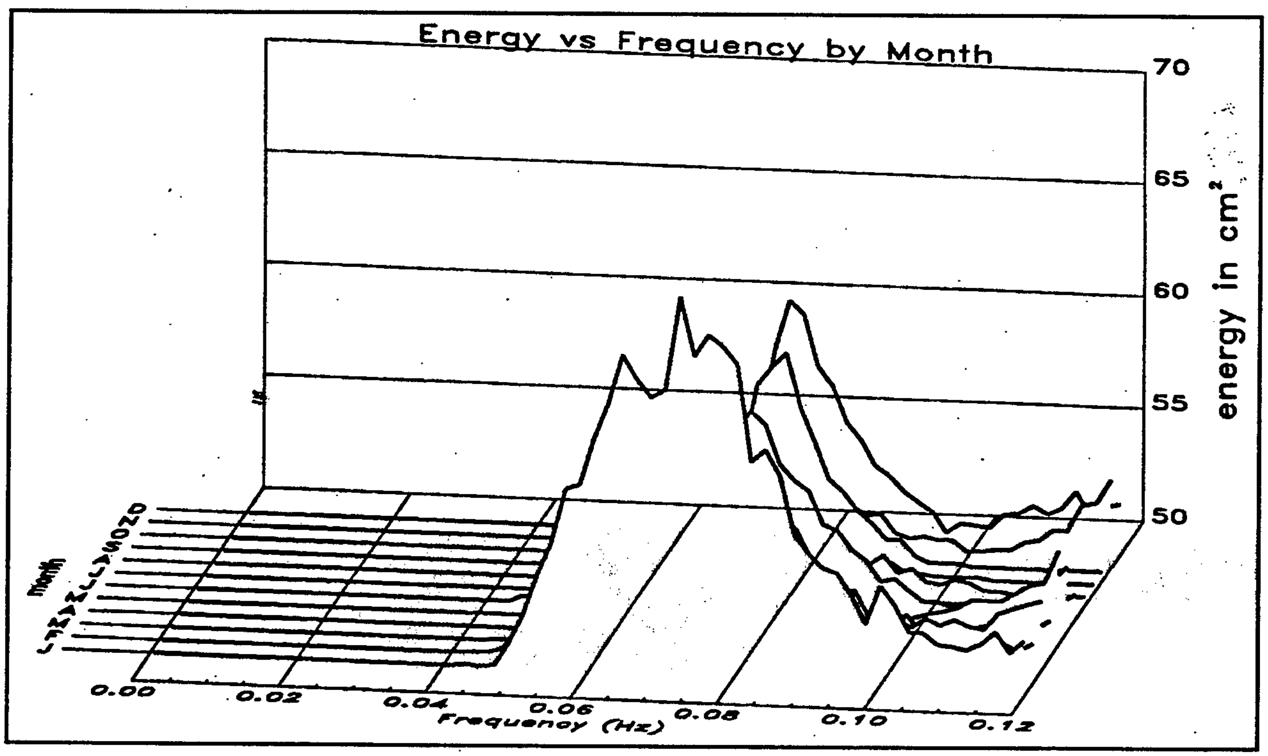


Figure 40. Average energy versus frequency, by month, for Platform Edith

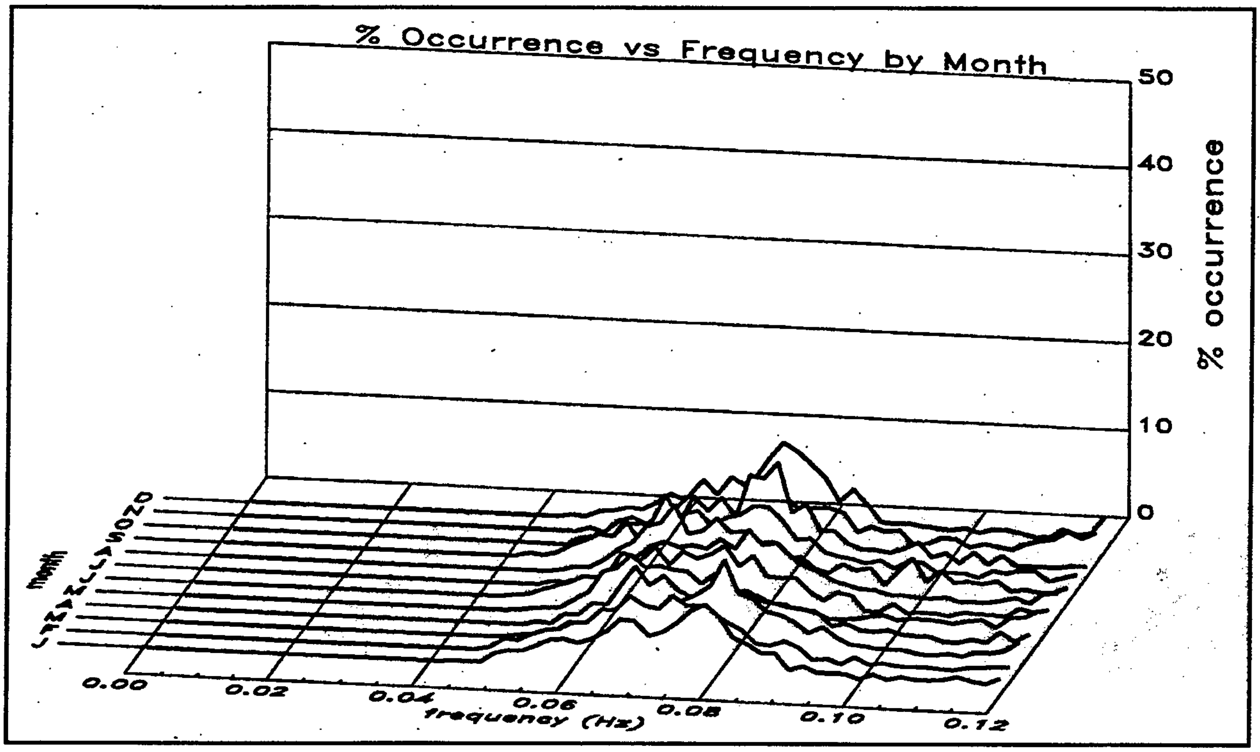


Figure 41. Percent occurrence versus peak frequency, by month, for Platform Edith

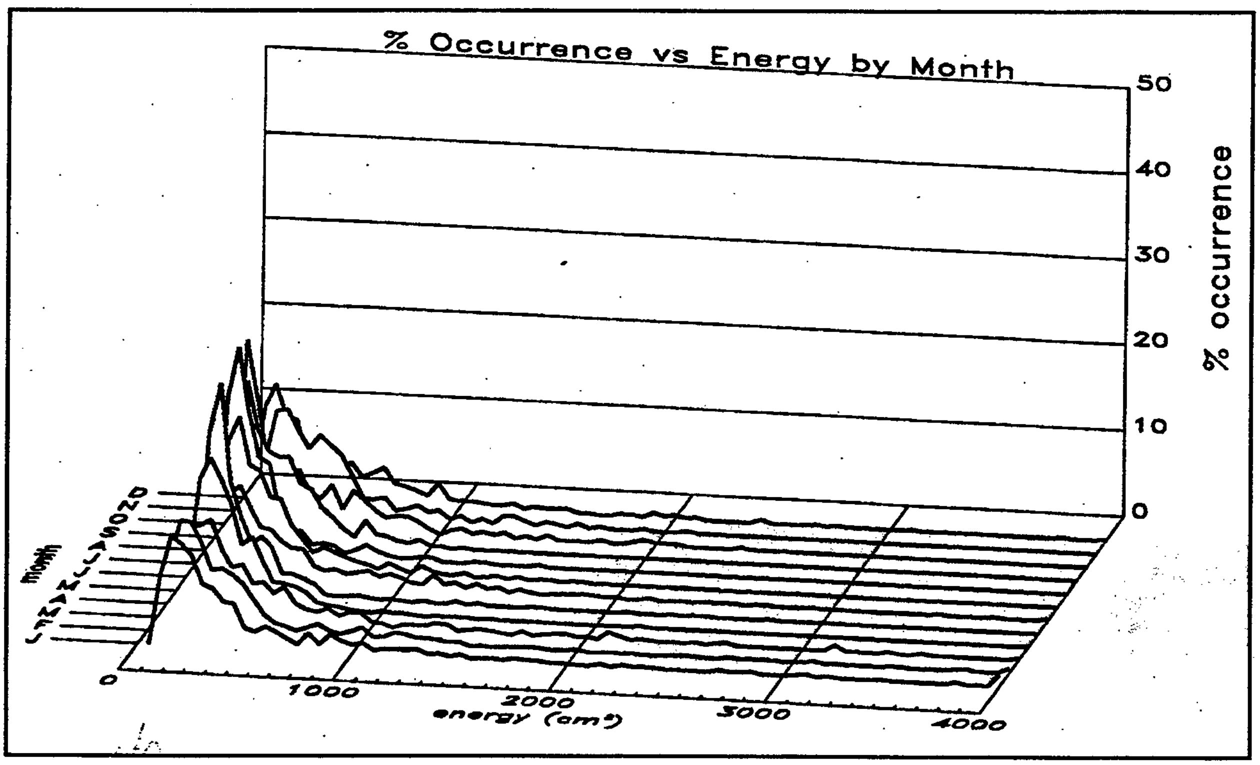


Figure 42. Percent occurrence versus total energy, by month, for Platform Edith

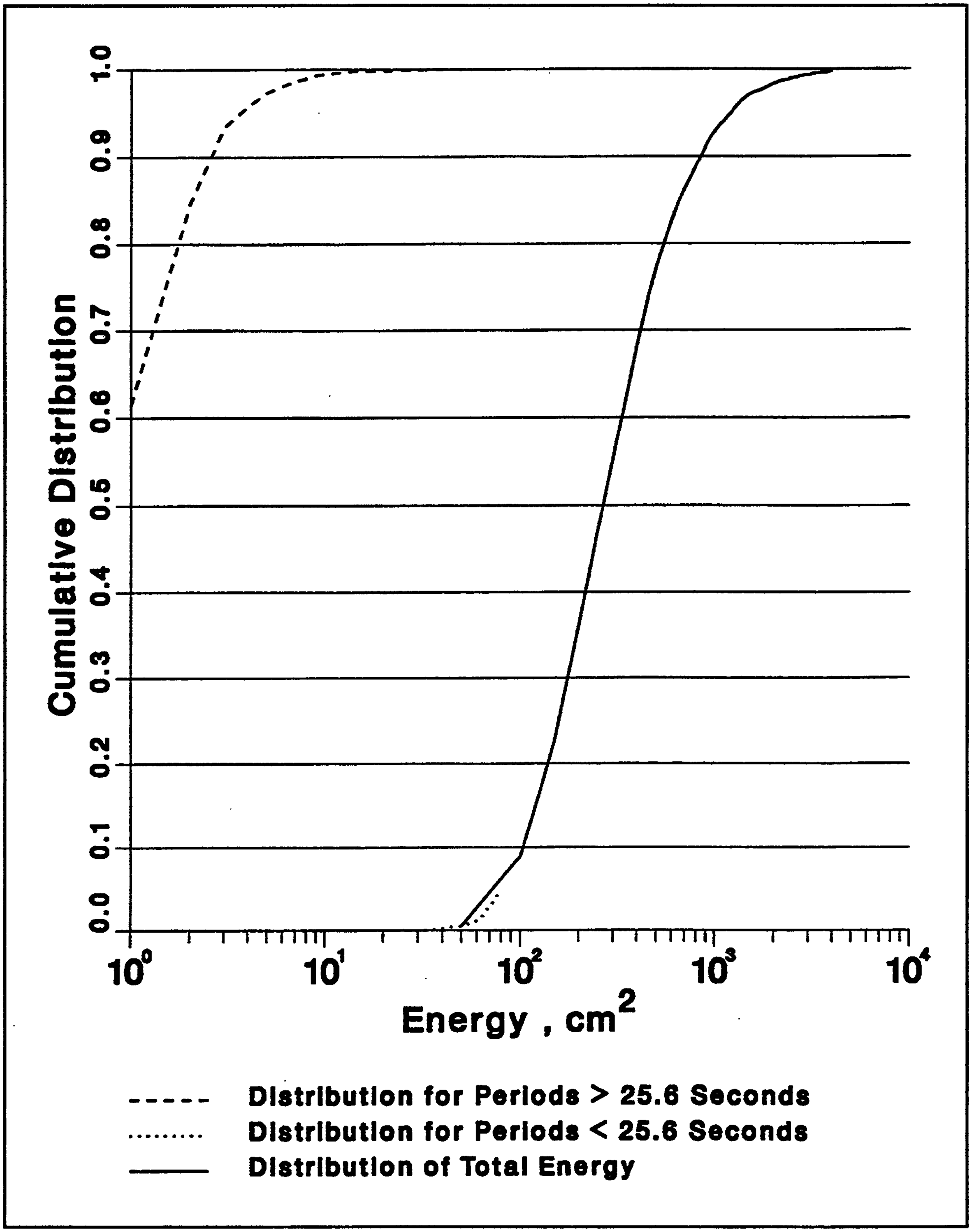


Figure 43. Energy CDF by frequency ranges for Platform Edith

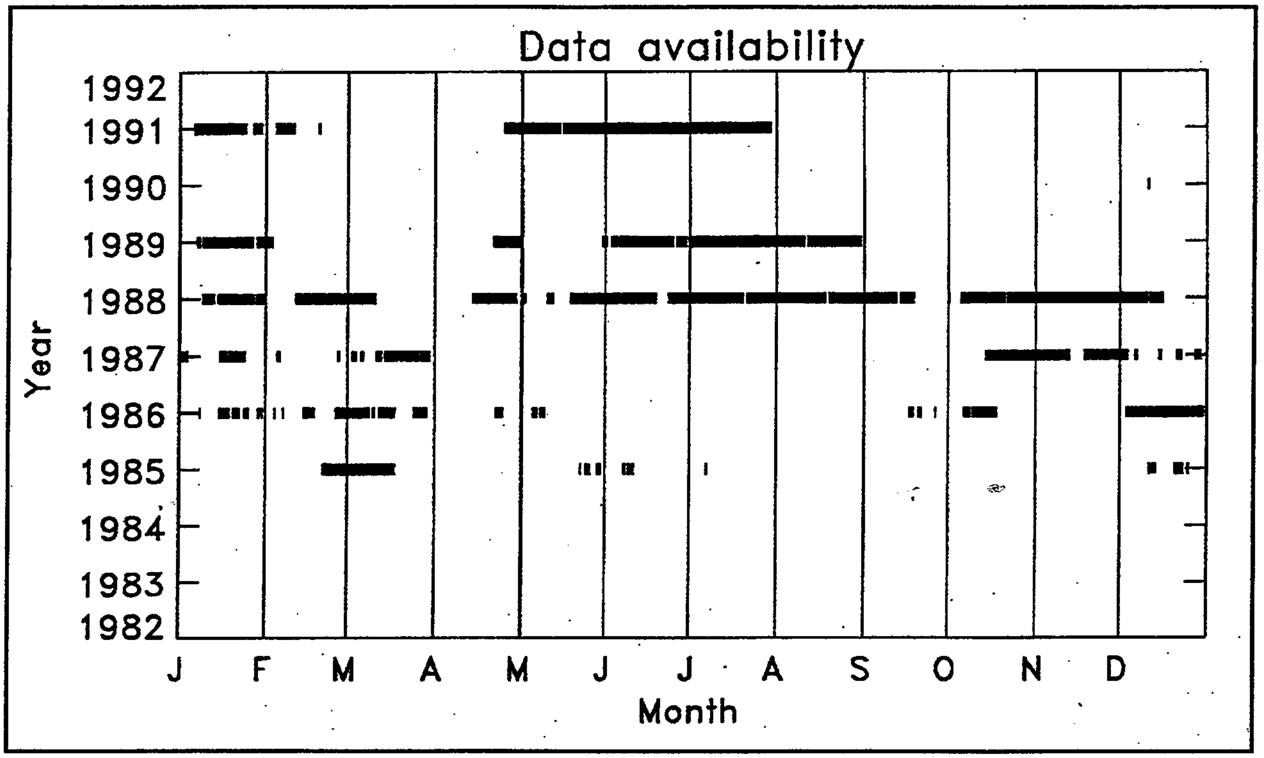


Figure 44. Data availability for directional data for Platform Edith

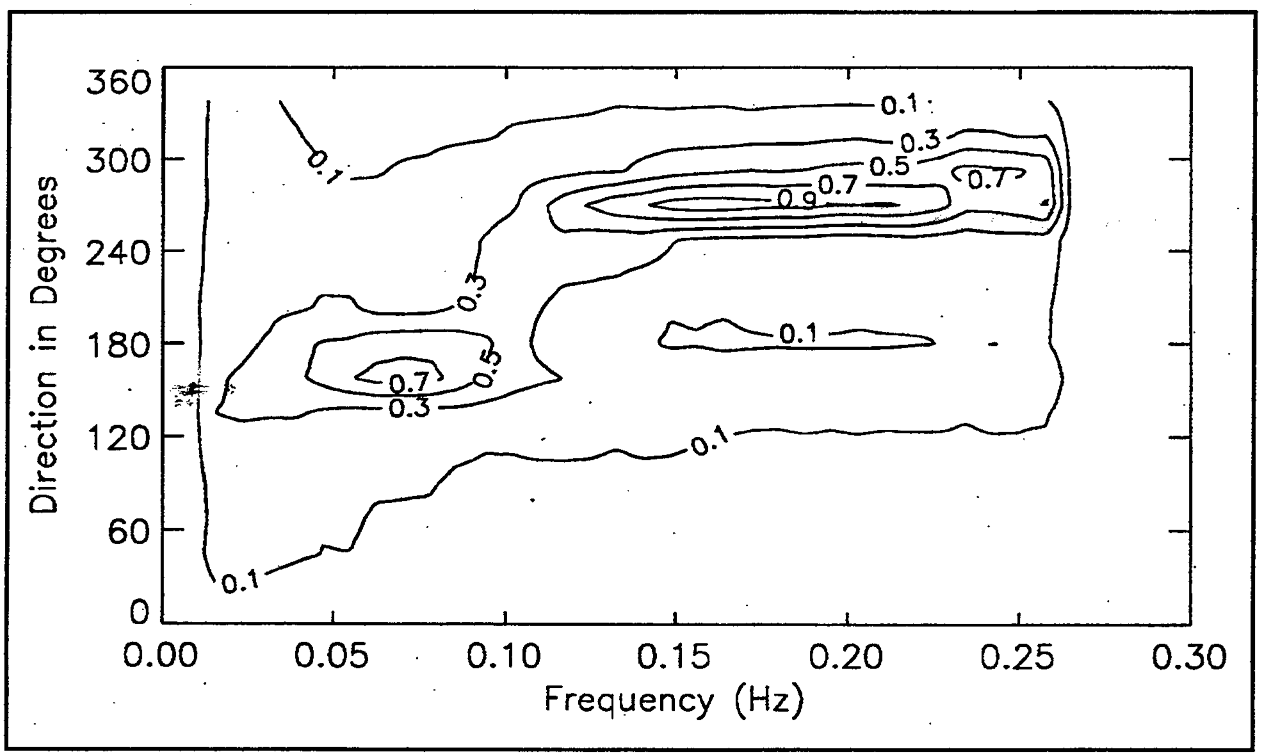


Figure 45. Percentage of spectra having a significant wave height of 0-1 m with given mean direction and frequency for Platform Edith

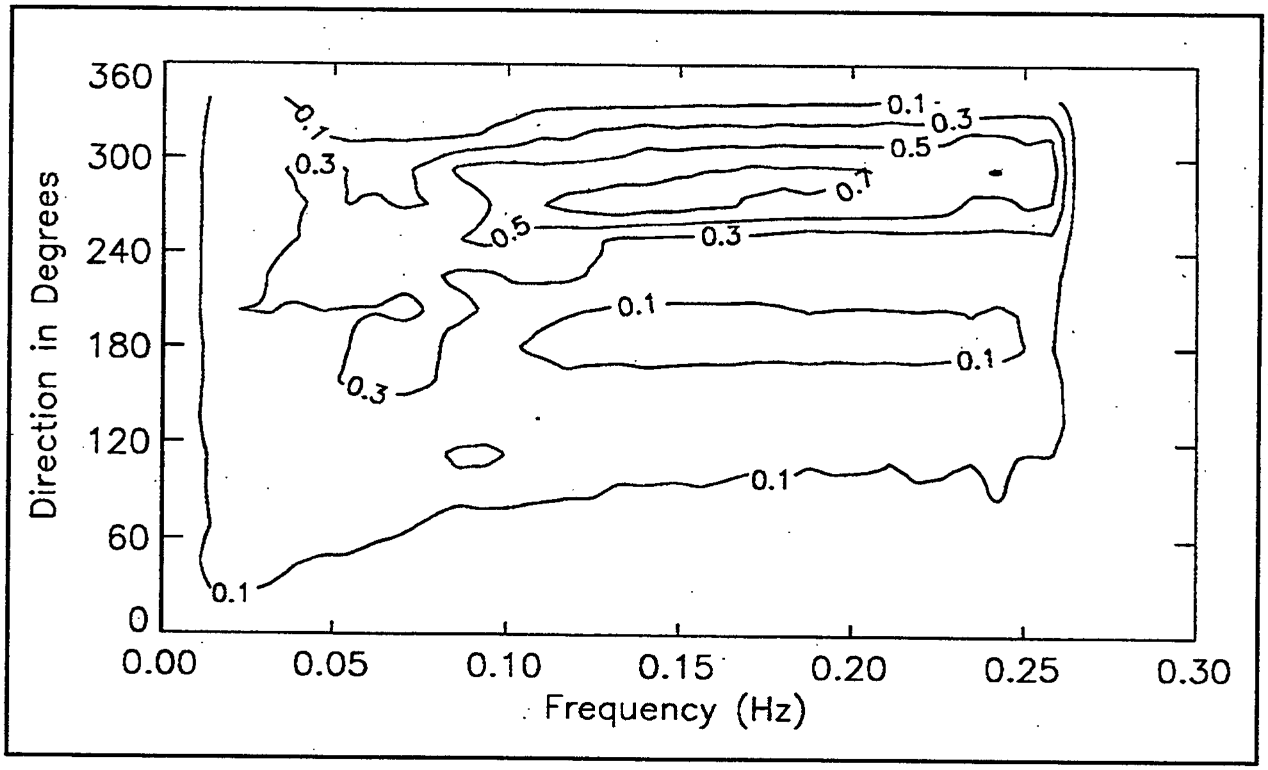


Figure 46. Percentage of spectra having a significant wave height of 1-2 m with given mean direction and frequency for Platform Edith

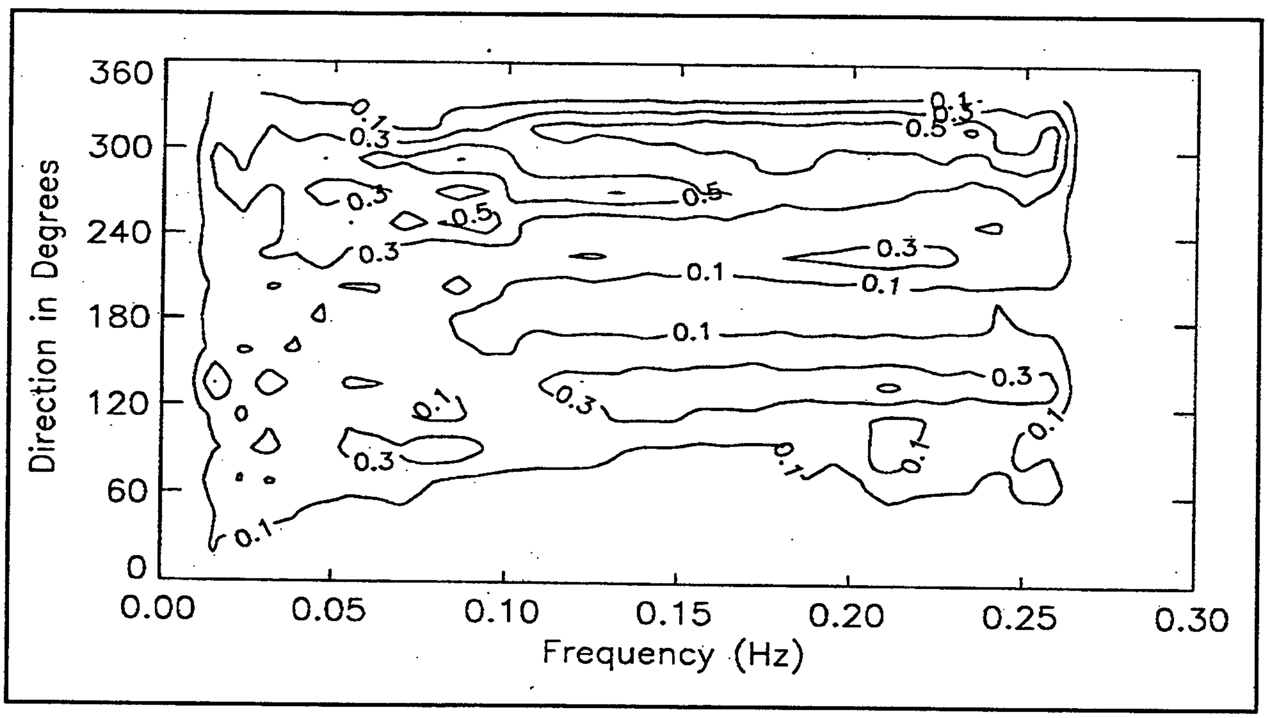


Figure 47. Percentage of spectra having a significant wave height of 2-3 m with given mean direction and frequency for Platform Edith

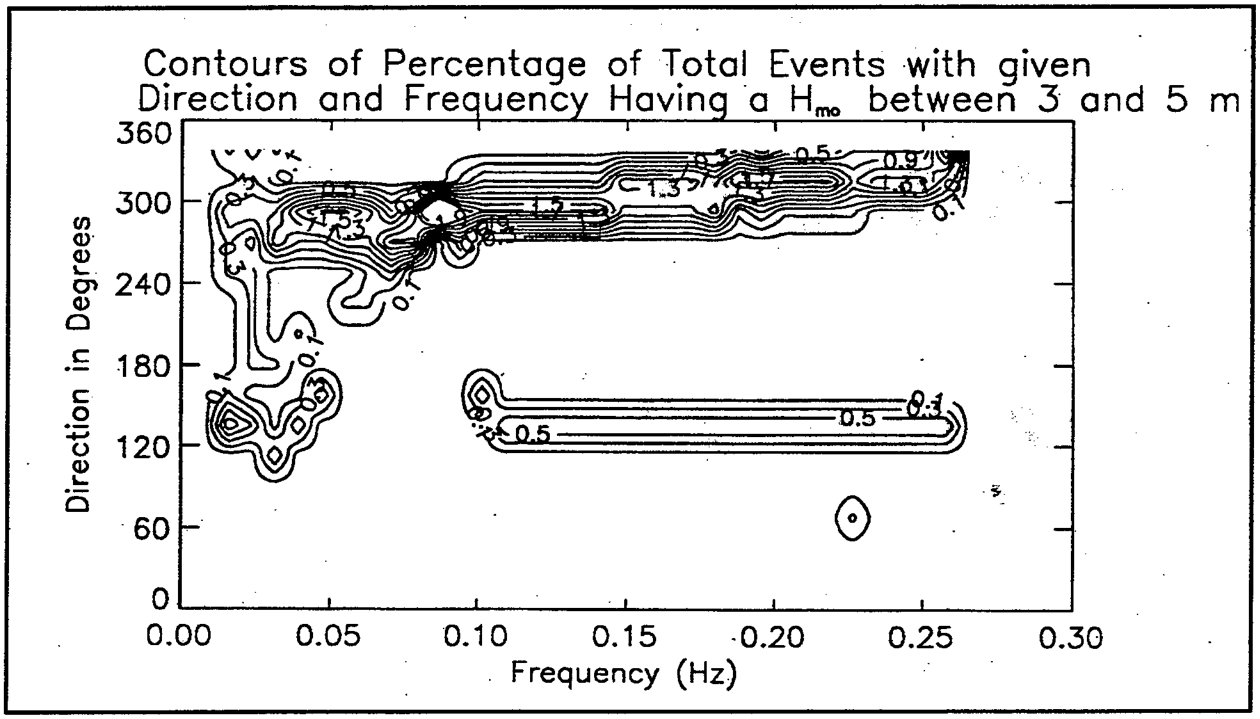


Figure 48. Percentage of spectra having a significant wave height of 3-5 m with given mean direction and frequency for Platform Edith

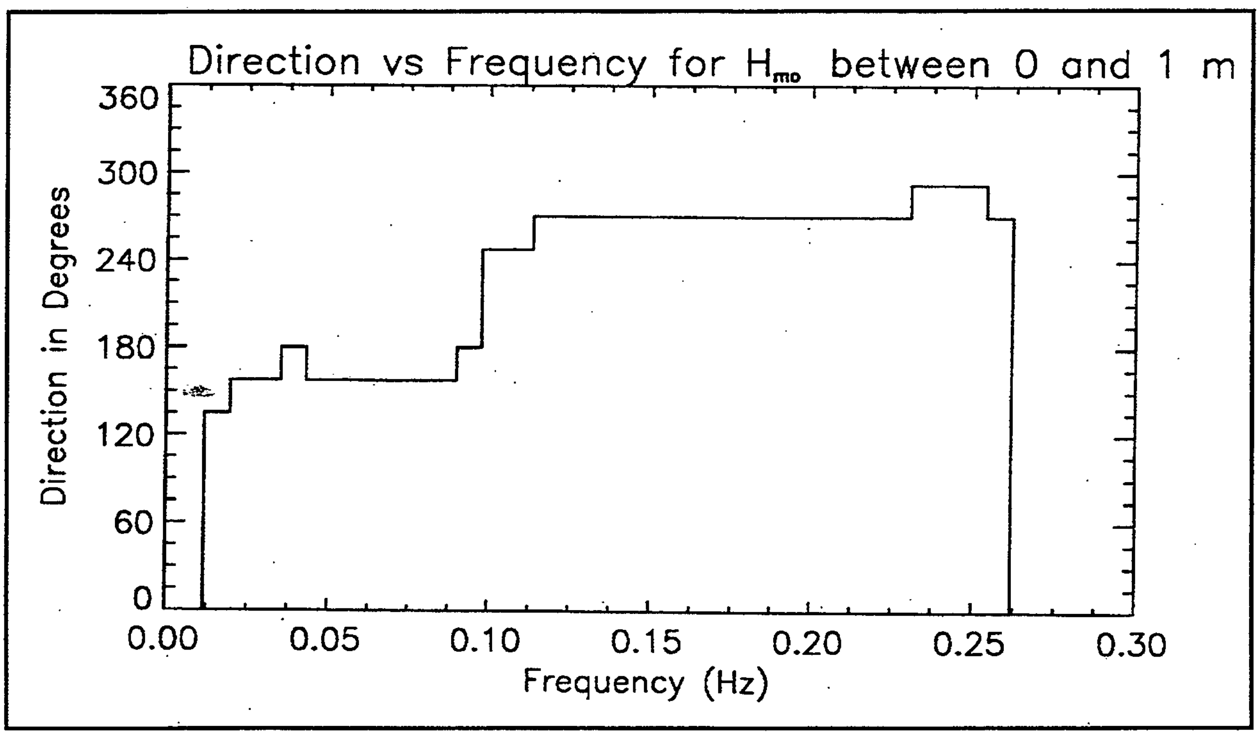


Figure 49. Most frequent direction, by frequency, for significant wave height of 0-1 m for Platform Edith

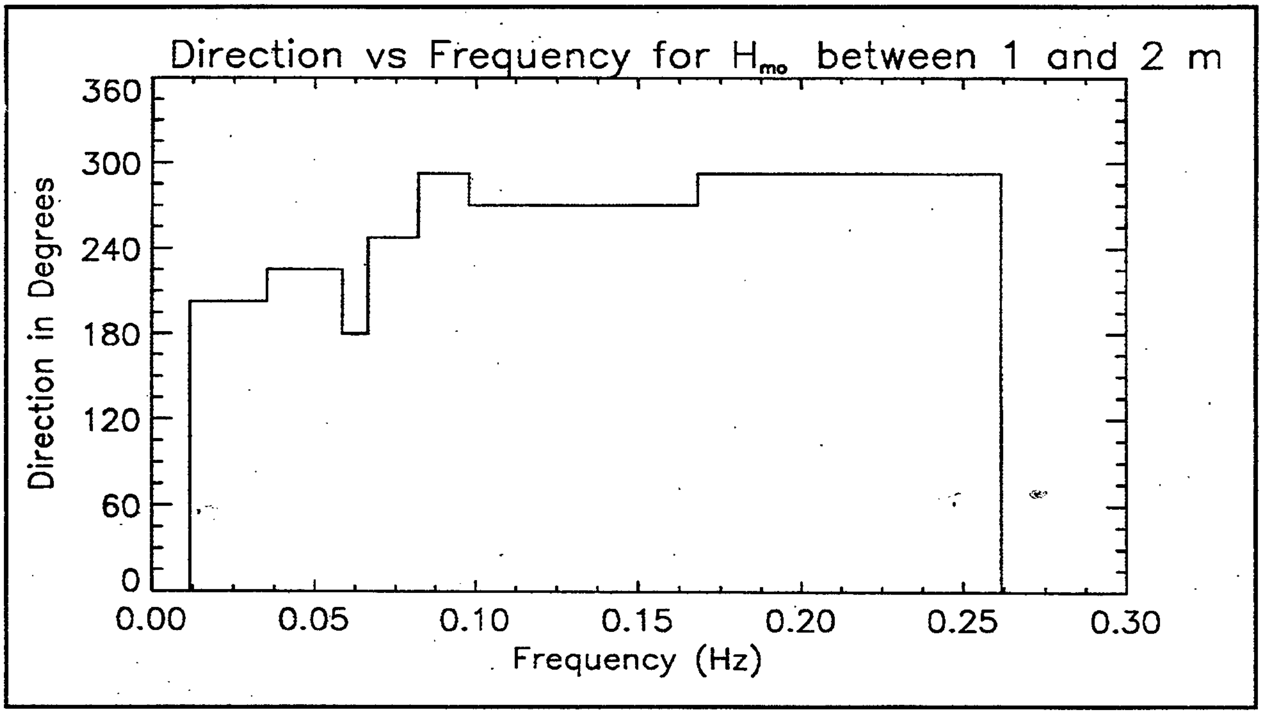


Figure 50. Most frequent direction, by frequency, for significant wave height of 1-2 m for Platform Edith

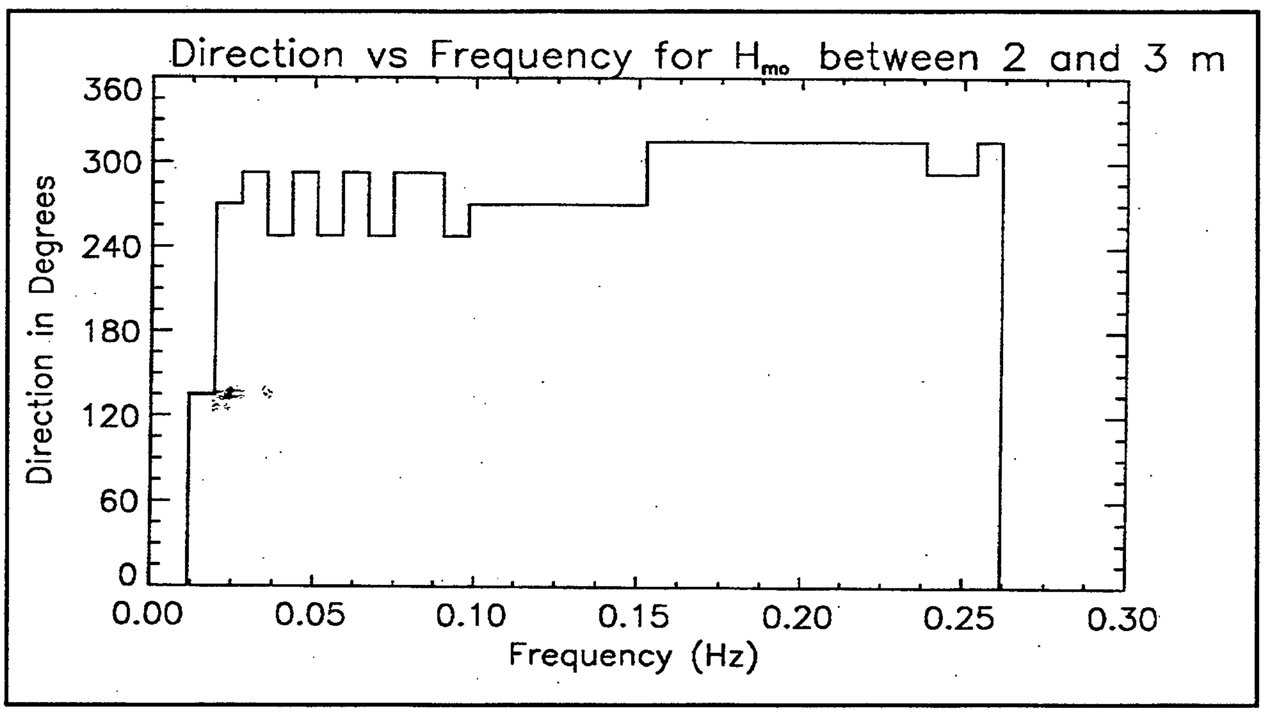


Figure 51. Most frequent direction, by frequency, for significant wave height of 2-3 m for Platform Edith

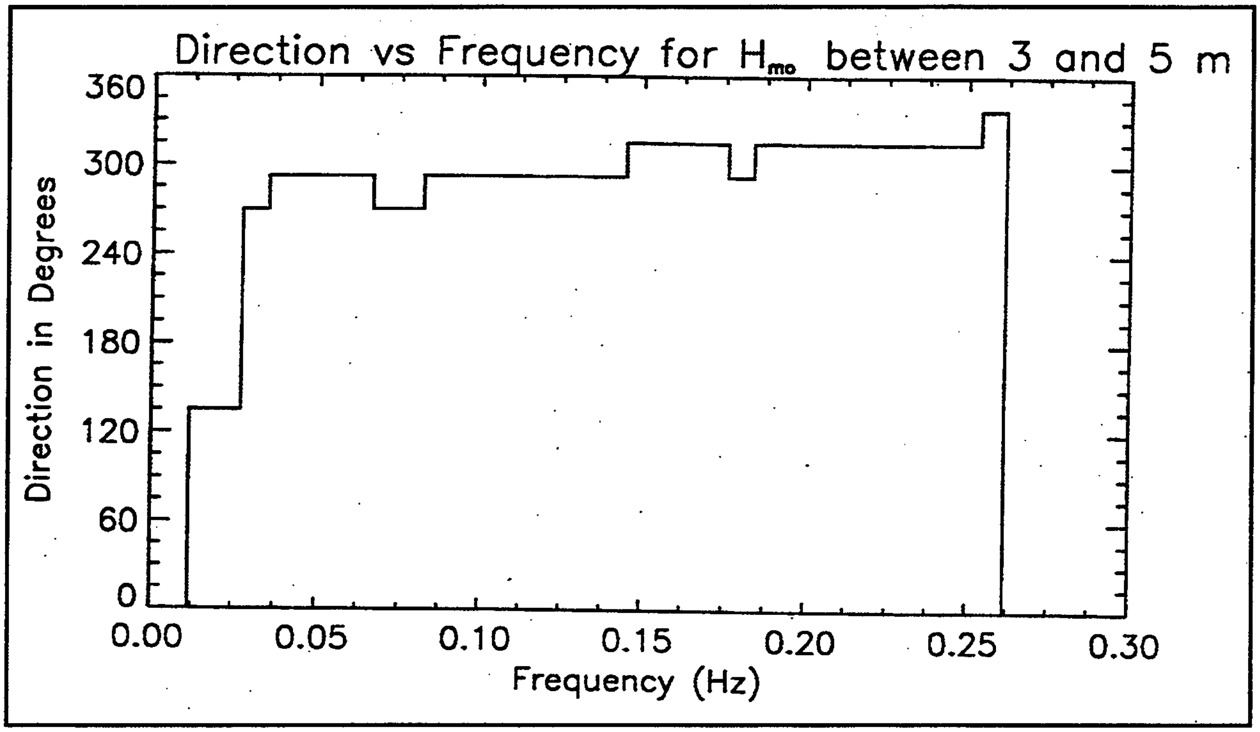


Figure 52. Most frequent direction, by frequency, for significant wave height of 3-5 m for Platform Edith

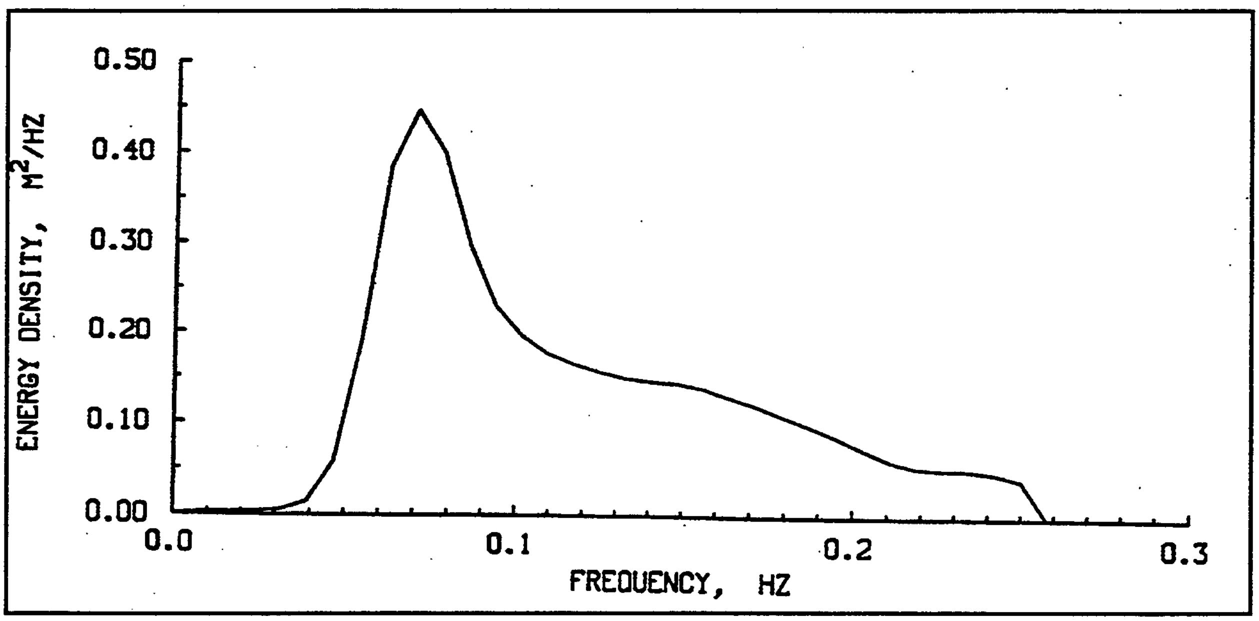


Figure 53. Average spectrum for significant wave height of 0-1 m for Platform Edith

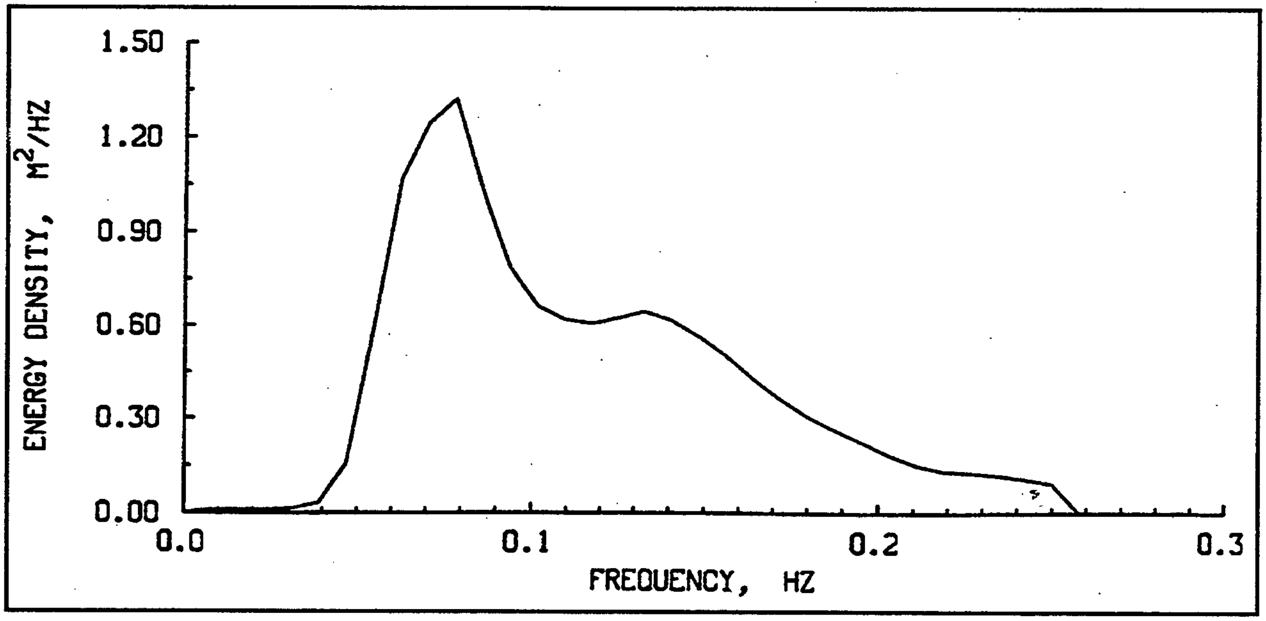


Figure 54. Average spectrum for significant wave height of 1-2 m for Platform Edith

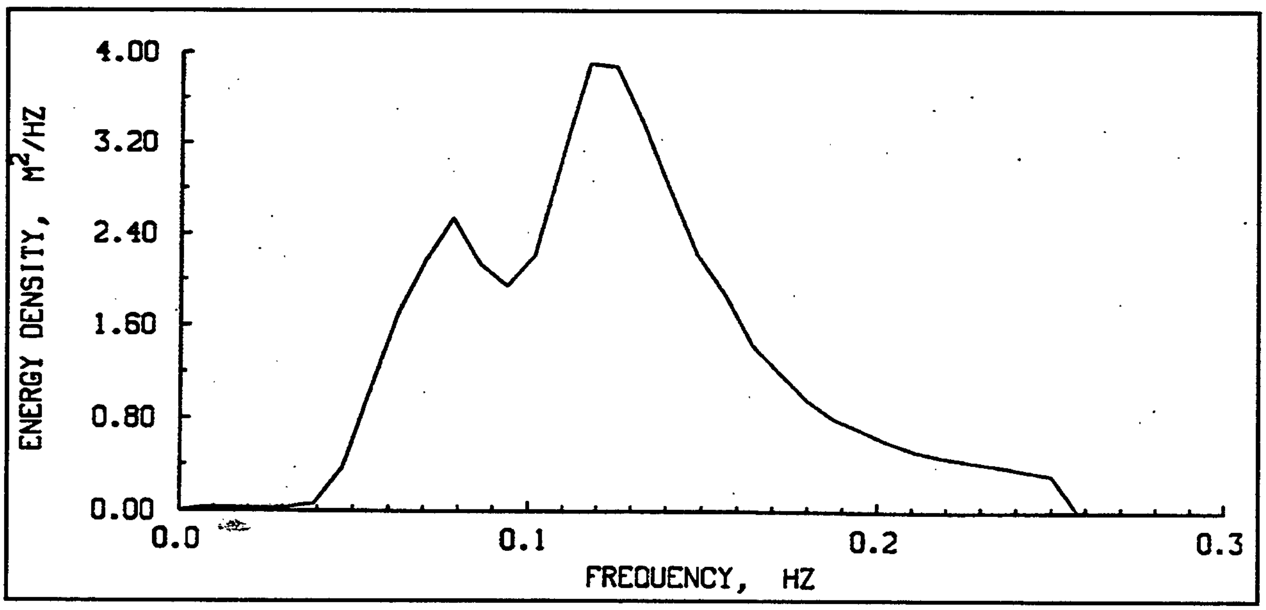


Figure 55. Average spectrum for significant wave height of 2-3 m for Platform Edith

rose plots for summer (April - September), winter (October - March), and for all records are presented in Figures 57-59. These wave roses plot the averaged H_{mo} for D_p within 20-deg increments for all available directional data and their frequency of occurrence.

Figures 53 to 56 present mean energy spectra for times when H_{mo} is within certain ranges.

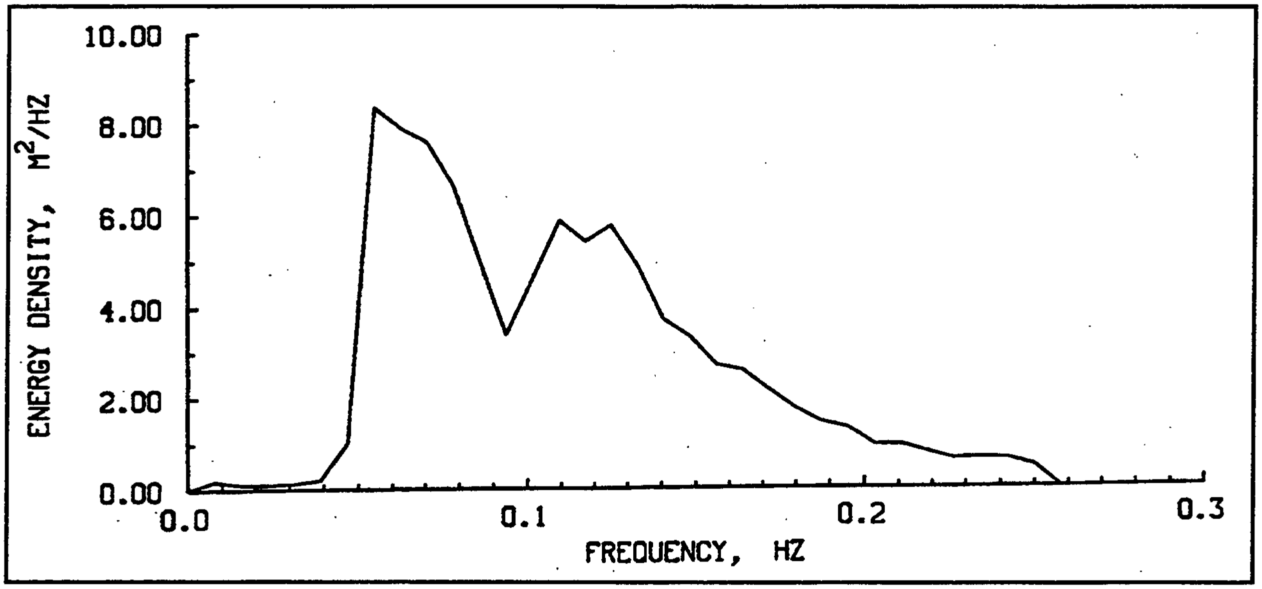


Figure 56. Average spectrum for significant wave height of 3-5 m for Platform Edith

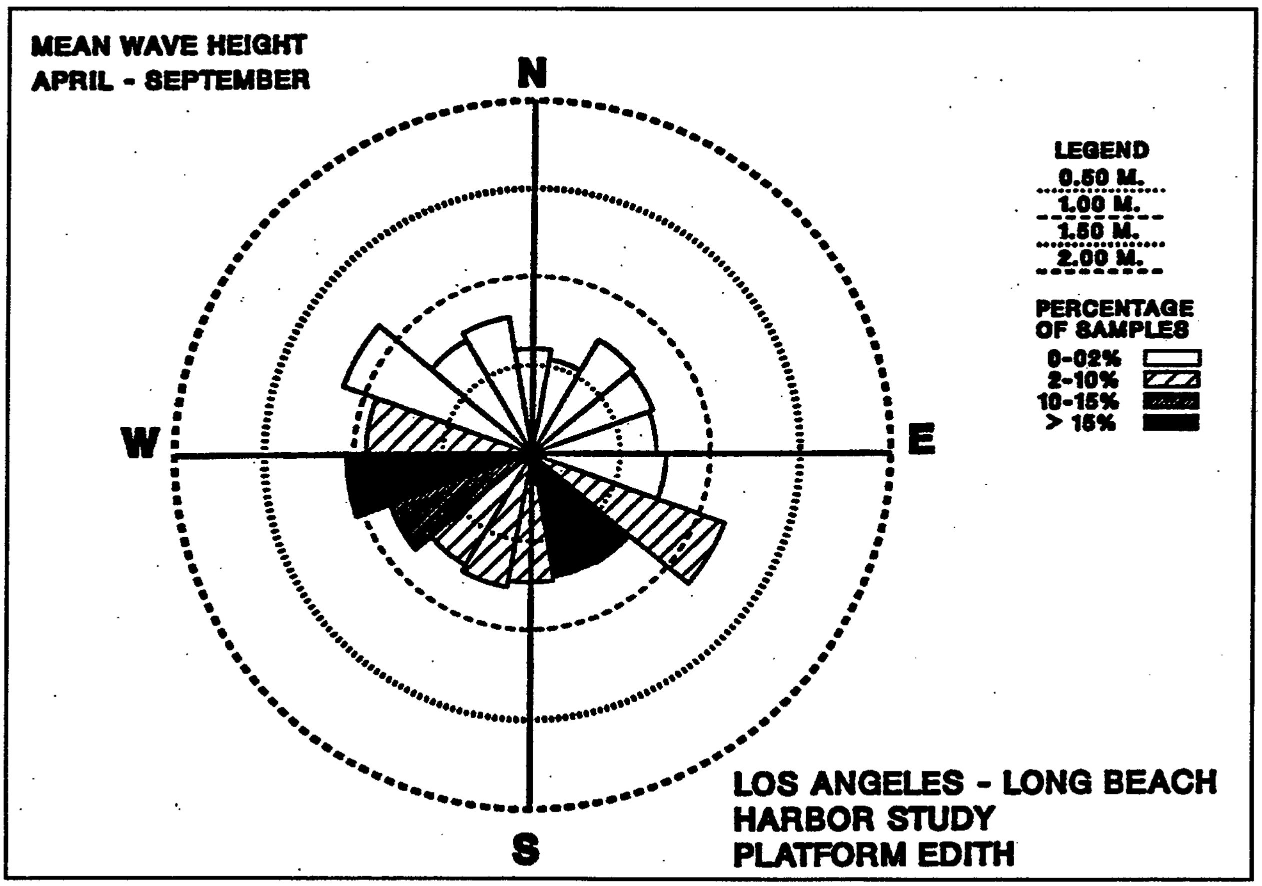


Figure 57. Wave direction for summer months for Platform Edith

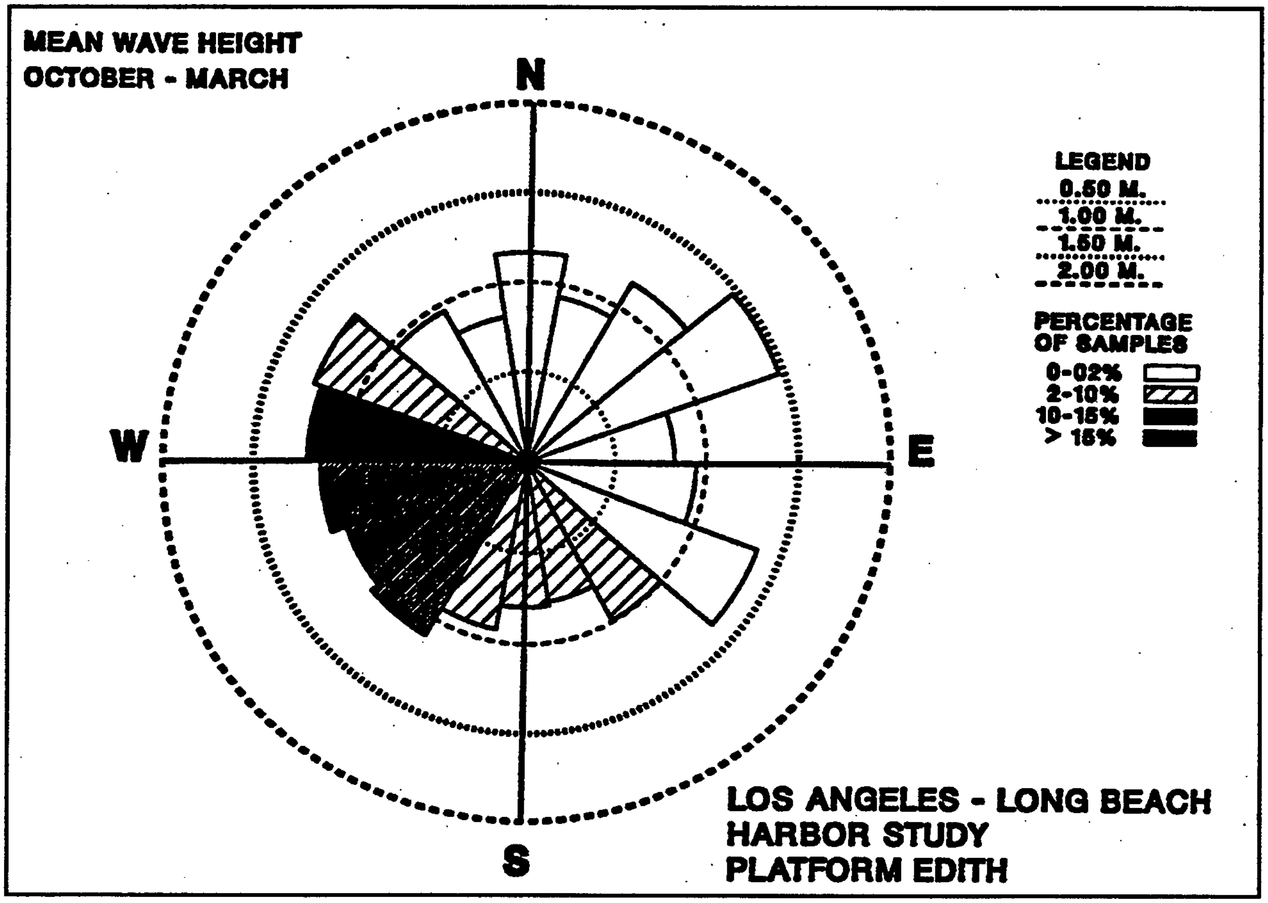


Figure 58. Wave direction for winter months for Platform Edith

Direction frequency of occurrence data are tabulated using directional spectra stored in the database. These data on direction versus frequency are used to plot the following:

a. Figures 45 to 48 show the percentage of the total number of occurrences with a given mean direction and frequency for H_{mo} within certain ranges. These plots were generated by first selecting all spectra within the appropriate energy range. The direction associated with each spectral frequency (64 bands spaced 0.0078 Hz apart) was tallied in sixteen 22.5-deg bins. The tallies in each bin were divided by the total number of spectra in each range times the number of spectral bands (64) to obtain a relative percentage of occurrence for each bin. The sum of all the percentage values in the bins is 100 percent. These percentage values are displayed in contour form. A value of 0.7 on a contour line represents a line of values equivalent to 0.7 percent.

For example, examining Figure 46 shows that waves between 0.1 Hz and 0.2 Hz tend to come from westerly directions as evidenced by the 0.7-percent contour (the highest numbered on the plot). Waves at

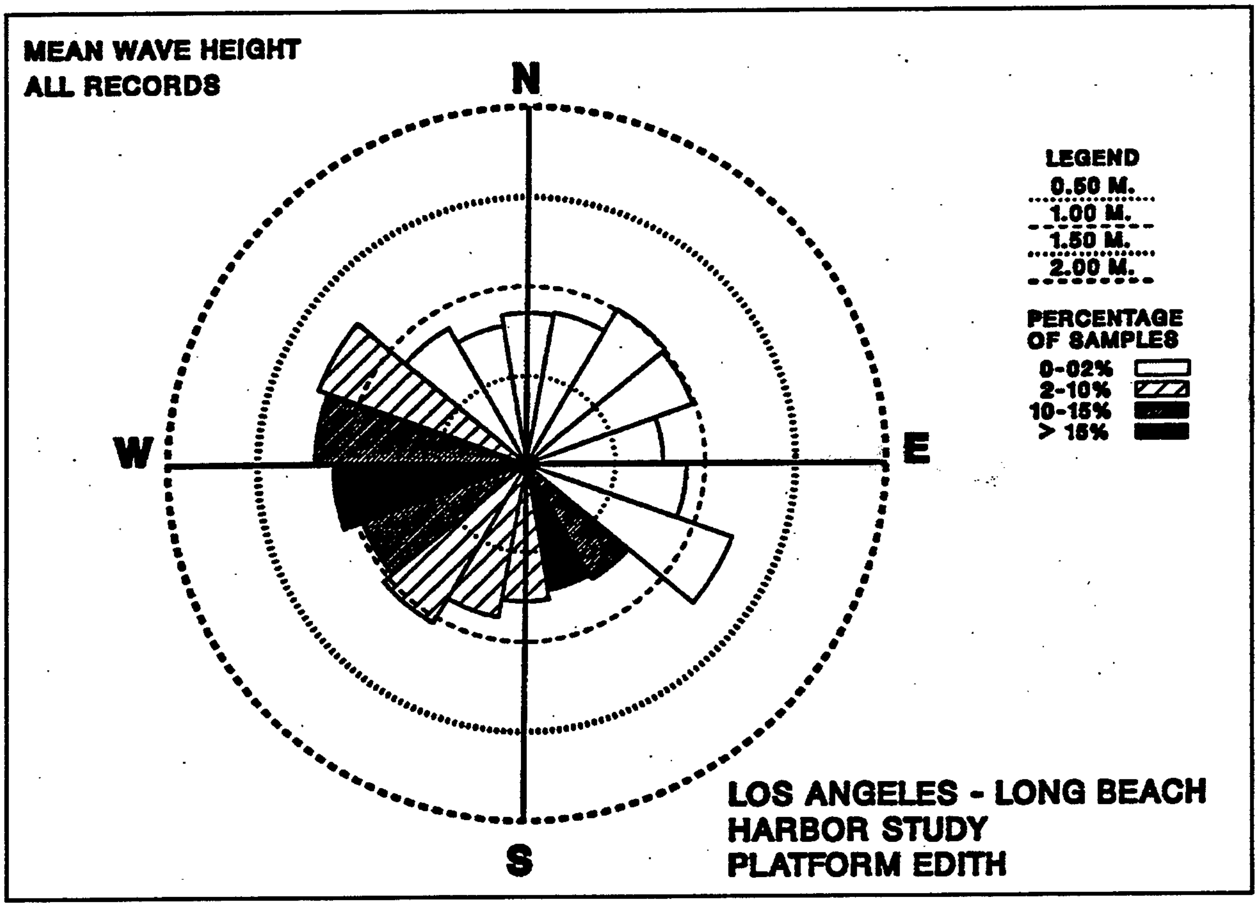


Figure 59. Wave direction for entire year from Platform Edith

frequencies below 0.1 Hz become more directionally spread out with decreasing frequency.

b. Figures 49 to 52 show the most frequent direction from which waves come for each spectral band and when H_{mo} is within certain ranges.

5 Discussion

Wind Wave Analysis

Directional information gathered from Platform Edith helps to describe the incident wave climate for the harbors. Directional rose plots (Figures 57-59) show seasonal variations in size and direction of mean waves. These plots graph the mean direction at the peak frequency and the significant wave height for each wave record. During the summer months, April through September, mean significant wave heights are generally 1 m or less for all directions (Figure 57). The most frequent waves come from two dominant sectors, the south-southeast and the west-southwest. For the winter months, October through March, mean significant wave heights for all directions are larger than the summer months, with the average mean wave height exceeding 1 m. For the winter months, waves most frequently come from the west (Figure 58). The presence of a small number of rather high waves coming from the southeast in the rose plots is explained by the presence of bimodal spectra during storms. For some storm events, significant westerly swell is present, but during a developing sea, relatively short-period (6- to 9-sec) waves coming from the southeast contain the most energy.

Directional frequency of occurrence tables were produced using various wave height ranges. Plots were produced from these tables and are shown in Figures 45-48. For wave heights less than 1 m, swell (> 10 sec) most frequently came from the south-southeast, with the predominant sea coming from the west. Higher swells also tend to come from the west.

Figures 45-48 attempt to show the distribution of wave direction within various energy ranges. When observing these plots, several factors need to be considered. These plots show only frequency and direction. Even when a frequency band had very little energy in it, a direction was still reported. The mean directions derived from these low-energy frequency bands are generally quite variable. Figures 48 and 52 show that when sufficient energy is present throughout the spectrum, the mean directions become less variable.

For significant wave heights less than 2 m, the mean peak period is about 14 sec (Figures 53-54). Wave heights in the 2-3 m range have mean peak periods less than 10 sec (Figure 55). Yet the highest waves in the 3-5 m range are swell waves with a peak period of about 18 sec (Figure 56).

Los Angeles Gauges

Examination of the mean total energy for the inshore sites shows that sites located closest to the harbor entrances that are not sheltered by intervening structures tend to have the greatest total energy (derived but not shown from the information presented in Figures 5, 10, and 15). Site LA3, located at the entrance to the East Channel, is the most energetic site with a mean total energy of 12.19 cm^2 (for comparison, Platform Edith has 431 cm^2). LA1 and LA4 have significantly less mean total energy, with their mean total energies being 71 percent and 65 percent, respectively, of the total energy of LA3. These energy trends are also shown in the CDF plots (Figures 8, 13, and 18). All of the POLA gauges show greater total energies during the winter months.

The amount of low-frequency energy varies between the POLA gauges. LA1's CDF plot (Figure 8) shows that low-frequency energy gives the greatest contribution to the total energy at this site. However, the CDF plots in Figures 13 and 18 show the opposite for the other gauges; higher frequency wind wave energy is the greatest contributor to the total energy. This result is expected since gauge LA1 is the most sheltered from wind wave energy.

Seasonal variations in wave energy occur in the POLA gauges. Gauge LA4 (Figure 15) shows more low-frequency energy during the winter months when more energetic incident waves enter the East Channel. Gauge LA3 (Figure 10) shows a low-frequency peak during the relatively low-energy summer months. LA1's (Figure 5) low-frequency energy remains relatively constant throughout the year. As noted earlier, the prevailing incident direction of wave energy varies from the summer season to the winter season and this could possibly influence the observed harbor response. Also possibly contributing to the observed response is the location of the gauges with respect to nodal points in the East Channel. Gauges in the vicinity of a nodal point for a particular harbor would show less response than a gauge placed at an antinode. Gauge LA1 is located at an antinode due to its position at the end of the berthing slip.

Figures 6, 11, and 16 show the percent occurrence of the peak frequency for gauges LA1, LA3, and LA4, respectively. Spectra for gauges LA3 and LA4 predominately have peak periods between 12 to 18 sec. Gauge LA1 spectra usually have peak periods between 500 and 200 sec. These results are consistent with the data presented in the CDF plots (Figures 8, 13, and 18).

Long Beach Gauges

POLB gauges LB5, LB2, LB4, and LB1 are located in the southeast basin. LB5 has the highest mean total energy, 10.17 cm^2, of the POLB gauges. LB1, which is the most protected, has only 20 percent of the mean total energy of LB5. LB2 and LB4 have 60 percent and 47 percent of the mean total energy of gauge LB5 (derived but not shown from the information presented in Figures 20, 25, 30, and 35). These energy trends are also shown in the CDF plots (Figures 23, 28, 32 and 37). Similar to the Los Angeles gauges, there are variations in the amount of low-frequency energy between gauges.

LB1 spectral results (Figure 20) and the CDF plot (Figure 23) show that almost all of the energy for that site is in the low-frequency portion of the spectrum. Although gauge LB4 (Figure 30) is located closer to the entrance, gauge LB2 located further inside the southeast basin shows slightly more total energy (Figure 25). This is also shown by the CDF plots in Figures 33 and 28. Spectral results show that the spectra of this gauge are significantly broader in wind-wave frequencies than the LB4 spectra. More low-frequency energy is observed in the LB2 spectra than in the LB4 spectra. All of the POLB gauges show greater energies during the winter months and occurrences of higher observed energy levels inside the POLB correspond with occurrences of higher energy waves incident to the harbor.

Similar to the Los Angeles data, the spectra from Long Beach gauges LB2, LB4, and LB5 (Figures 26, 31, and 36) tend to have peak periods between 12 and 18 sec. The spectra from Long Beach's most protected gauge, LB1, most often have peak periods between 500 and 150 sec (Figure 21). These results are consistent with the CDF plots presented in Figures 23, 28, 32, and 37. The spectra from LB2 tend to vary the most between wind wave and long-wave peak frequencies (Figure 26).

Summary

Wave data were successfully acquired and analyzed during the Harbors Model Enhancement Program. The collected wave data contributed to the tidal circulation study of the HME (McGehee, McKinney, and Dickey 1989) primarily by providing water levels. The Ship Motion Study (McGehee 1991) of the HME utilized tidal data and wave spectral analysis results as well as raw pressure time series.

Methods and equipment used for acquiring the data are documented, as well as the analysis methods. The emphasis of this report is on summarizing and documenting the available prototype wave data in fulfillment of the wave data collection and analysis task of the HME.

A database of wave conditions has been established which will aid future analysis by reducing the effort required to access the considerable quantities of collected data. Directional data from Platform Edith show the incident wave climate. The POLB gauges show wave conditions in the southeast basin. The POLA gauges show wave conditions in the East Channel. The acquired data are physically sound and provide a basis for further investigation of the physical characteristics of the harbors. In summary:

a. Between February 1984 and February 1988 wave data were sampled every 2 hr at 1 Hz for 2,048 sec in the harbors. From February 1988 to

August 1991, data were collected continuously in the harbors at an average sample rate of 0.25 Hz.

b. Directional wave data were measured offshore at Platform Edith via a PUV gauge between February 1985 and August 1991. Data for this period were collected at 1 Hz for 2,048 sec every hour but reported every 4 hr.

c. Waves were measured in seven locations in the harbors with highly accurate single-point pressure sensors.

d. The wave measurement system was optimized to gather and report low-frequency wave data suitable for use by other components of the HME and to establish characteristics of the waves incident to and inside Los Angeles/Long Beach Harbors.

e. The largest significant wave height recorded offshore at Platform Edith was 5.6 m during January 1988. The highest average wave heights were measured during the months of January and December (1.2 m and 1.1 m, respectively), where the mean directions were from the west.

f. Plots showing the statistical distribution of wave energy over various time intervals describe the wave climate at each of the harbor gauging sites. Averaged spectra show some seasonal variations, with an apparent peak in the wind wave energy during the months of September and October, when the average incident wave direction was from the south and the average incident wave height was 0.67 m.

g. The harbor spectral results show that low-frequency waves, which affect ship motion, are present throughout the year.

References

Bendat, J. S., and Piersol, A. G. (1971). *Random data: analysis and measurement procedures.* Wiley, New York, 325.

daCruz, F. (1987). *Kermit, a file transfer protocol.* Digital Press, Bedford, MA.

Digital Signal Processing Committee. (1979). *Programs for digital signal processing.* Digital Signal Processing Committee, ed., IEEE press, New York.

Durham, D. L., Thompson, J. K., Outlaw, D. G., and Crosby, L. G. (1976). "Los Angeles and Long Beach Harbors Model Study; Report 3, Analyses of wave and ship motion data," Technical Report H-75-4, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Jenkins, G. M., and Watts, D. G. (1968). *Spectral analysis and its applications.* Holden-Day, San Francisco, CA.

Longuet-Higgins, M. S., Cartwright, D. E., and Smith, N. D. (1963). "Observations of the directional spectrum of sea waves using the motions of a floating buoy." *Ocean wave spectra.* Prentice Hall, Englewood Cliffs, NJ.

McGehee, D. D. (1991). "Los Angeles and Long Beach Harbors Model Enhancement Program; measured response of moored ships to long-period waves," Technical Report CERC-91-12, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

McGehee, D. D., Mckinney, J. P., and Dickey, M. S. (1989). "Los Angeles and Long Beach Harbors Model Enhancement Program; tidal circulation prototype data collection effort, Volumes I, II, and III," Technical Report CERC-89-17, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Seabergh, W. C., and Rosati, J. III. (1992). "Los Angeles-Long Beach Harbors Model Enhancement Program." *Proceedings, Ports* '92. American Society of Civil Engineers, 884-97.

Welch, P. D. (1967). "The use of Fast Fourier Transform for the estimation of power spectra: A method based on time averaging over short, modified periodograms." *IEEE Transactions on Audio and Electroacoustics,* Vol AU-15, 70-3.

Appendix A
Database Data Dictionary

The Los Angeles/Long Beach relational database contains the following information:

Relational database - Interrelated data are stored in tables or two-dimensional arrays of data elements. A data management system recombines the data elements to form new and different tables in defined ways.

Current direction - Units are degrees from true north. This statistic is calculated by determination of mean *u* and *v* orbital velocities and is determined by atan(v/u).

Current velocities - All current velocity statistics, mean, median and maximum currents are determined by calculating instantaneous current velocities using *u* and *v* orbital velocities. These values are the magnitude of the resulting velocity vector calculated by taking the square root of the sum of the orbital velocities squared.

Date/time - Date field, for historic Los Angeles and Long Beach data time is Pacific Standard Time. For data acquired after January 1, 1991, all times are referenced to Greenwich Mean Time (GMT).

D_p - Peak direction, the mean direction in degrees from true north at the peak period.

E_f - Energy per frequency band

E_h - High-frequency energy in square centimeters for all frequencies (< 25.6 sec) from the long-period wave analysis.

E_l - Low-frequency energy in square centimeters for all frequencies (> 25.6 sec) from the long-period wave analysis.

E_t - Total energy in square centimeters for all frequencies (> 8 sec) from the long-period wave analysis.

F_p - Peak frequency refers to the frequency that contains the most energy for each sampling period.

Ft_p - Peak frequency from the long-period wave analysis.

F_{lp} - Peak frequency of all frequencies > 25.6 sec from the long-period wave analysis.

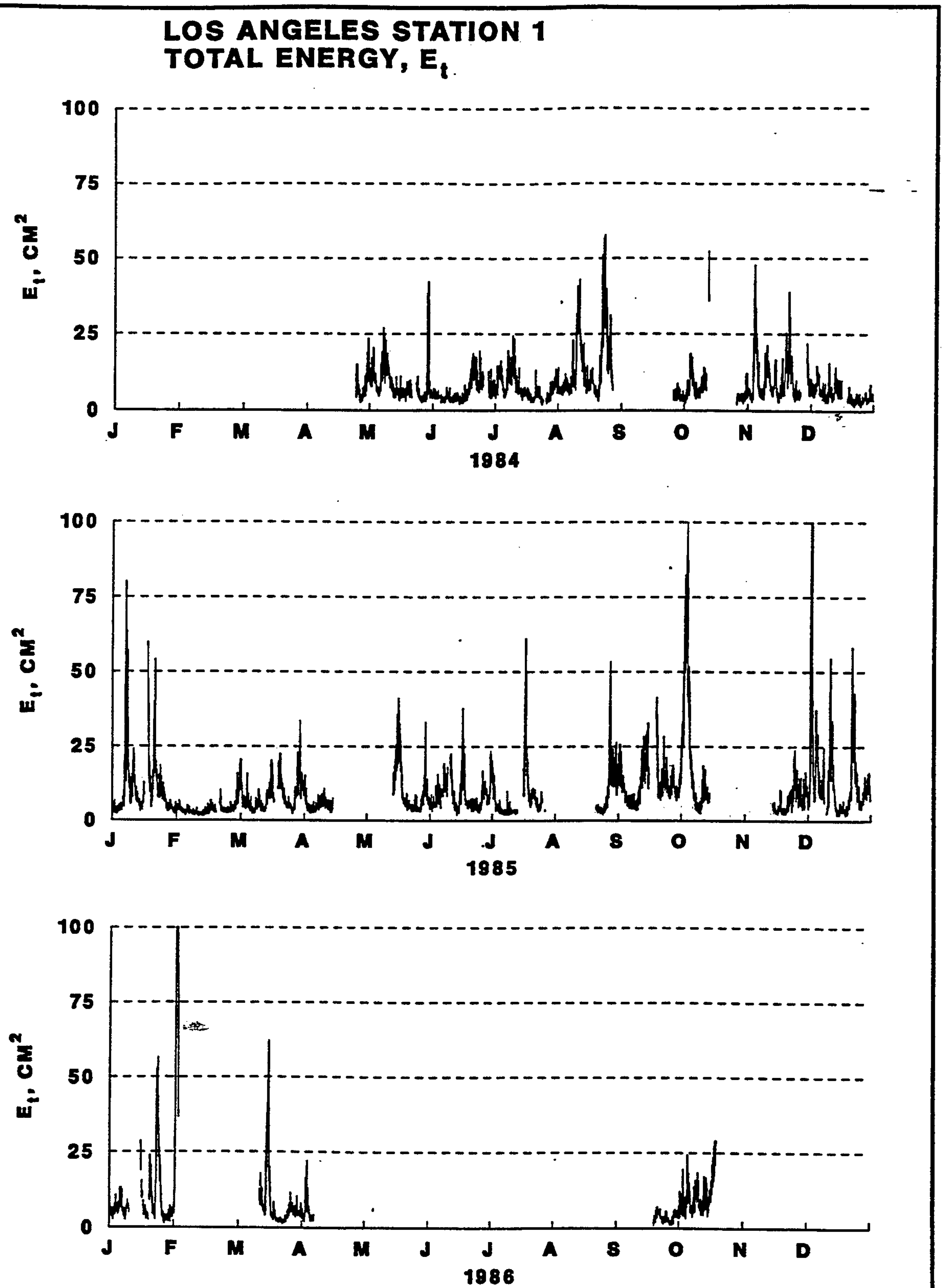
H_{mo} - Energy-based significant wave height expressed in meters.

T_p - Peak period, determined as the inverse of the frequency containing the most energy for any individual wave record. Expressed in seconds.

1-D spectra - Autospectrum calculated from a pressure time series which associates energy in square centimeters with each analysis frequency.

2-D spectra - Cross-spectral analysis results using a pressure, u-velocity, and v-velocity time series. Energy in square centimeters as well as mean direction in degrees from true north associated with each analysis frequency.

Appendix B
Time Series of Total Energy



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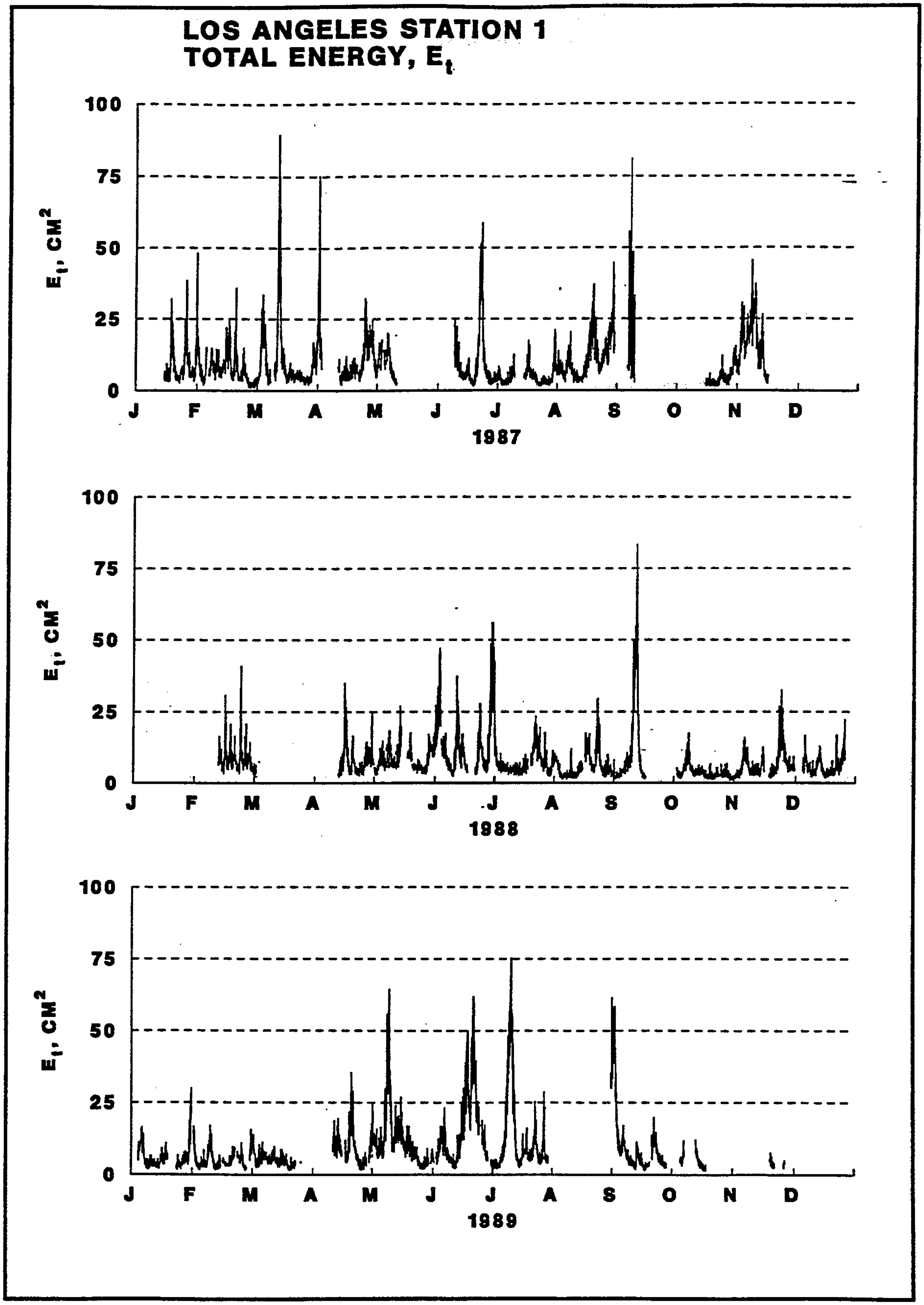

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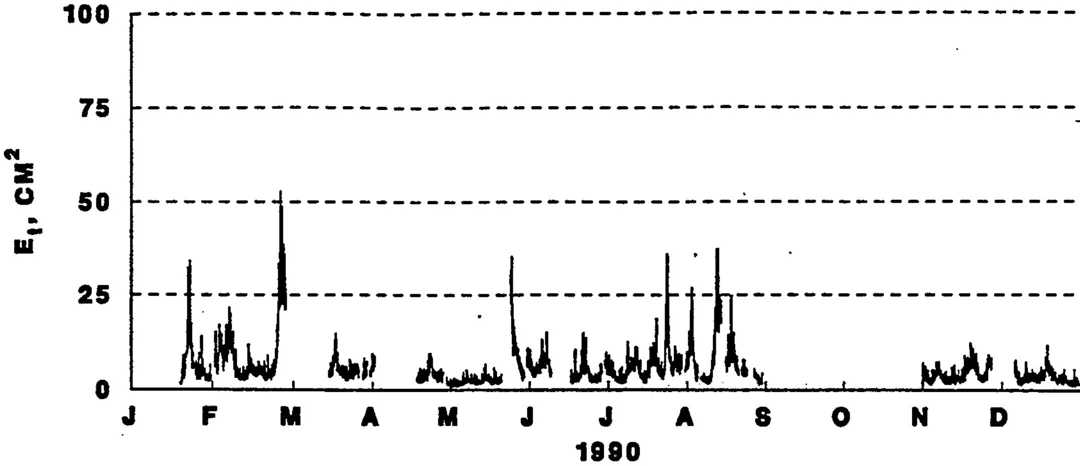
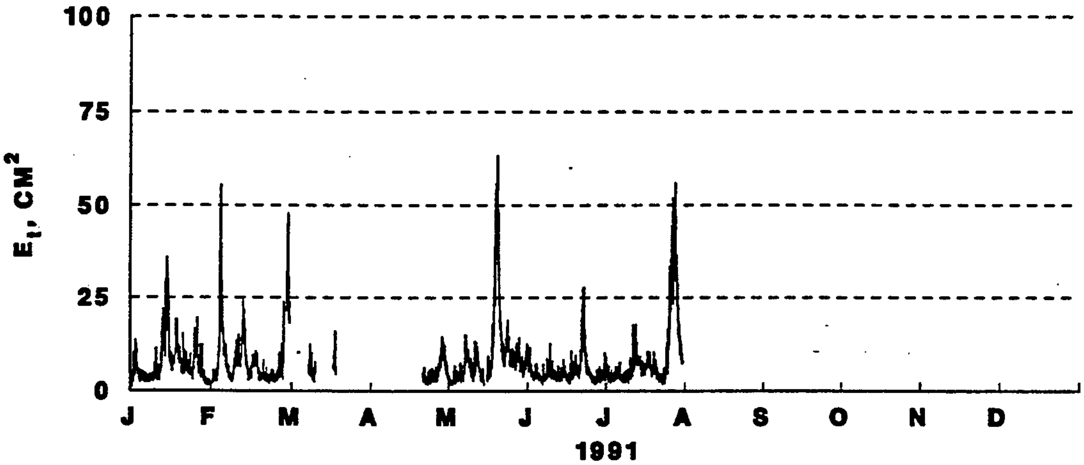
TOTAL ENERGY, E_t





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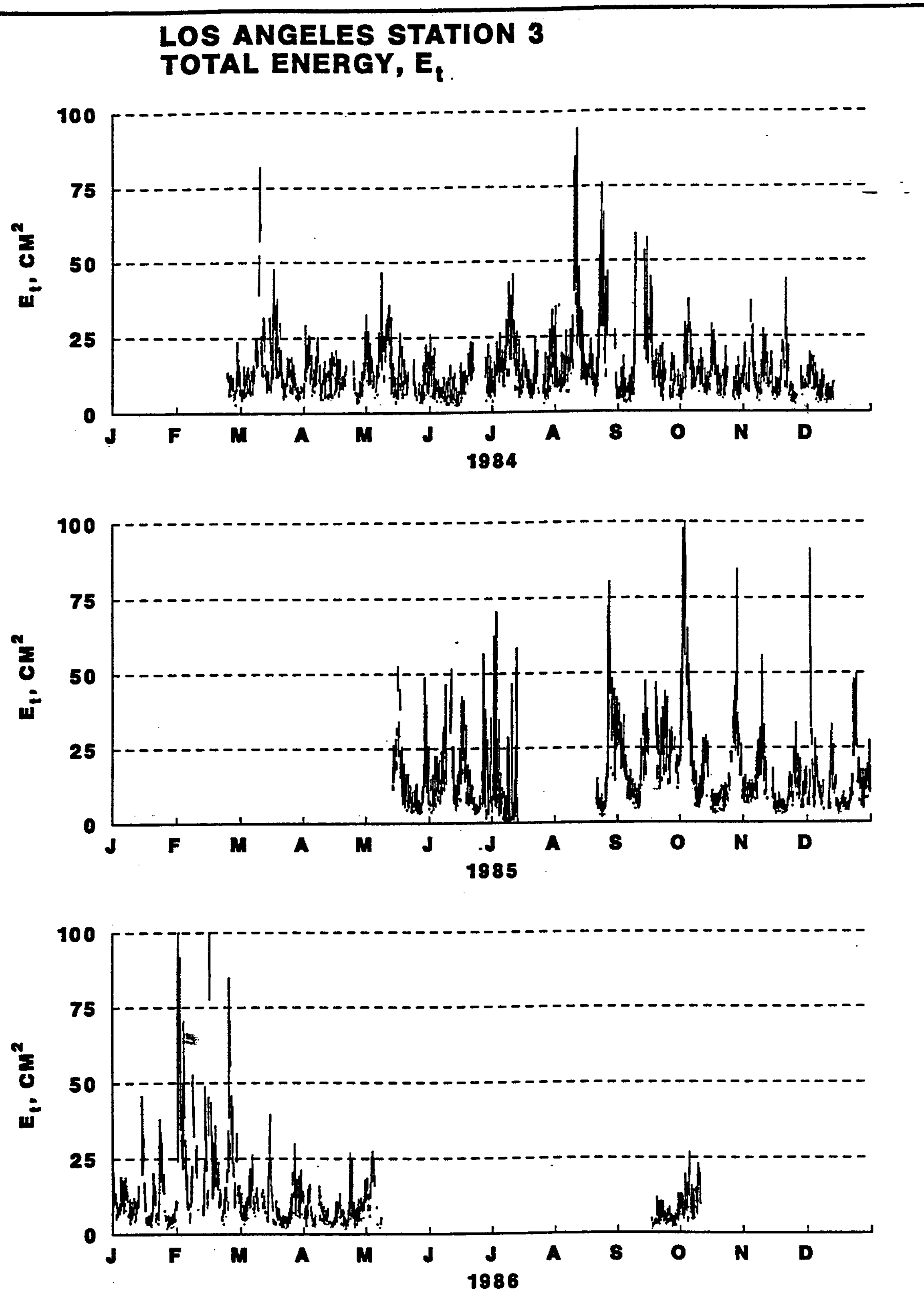

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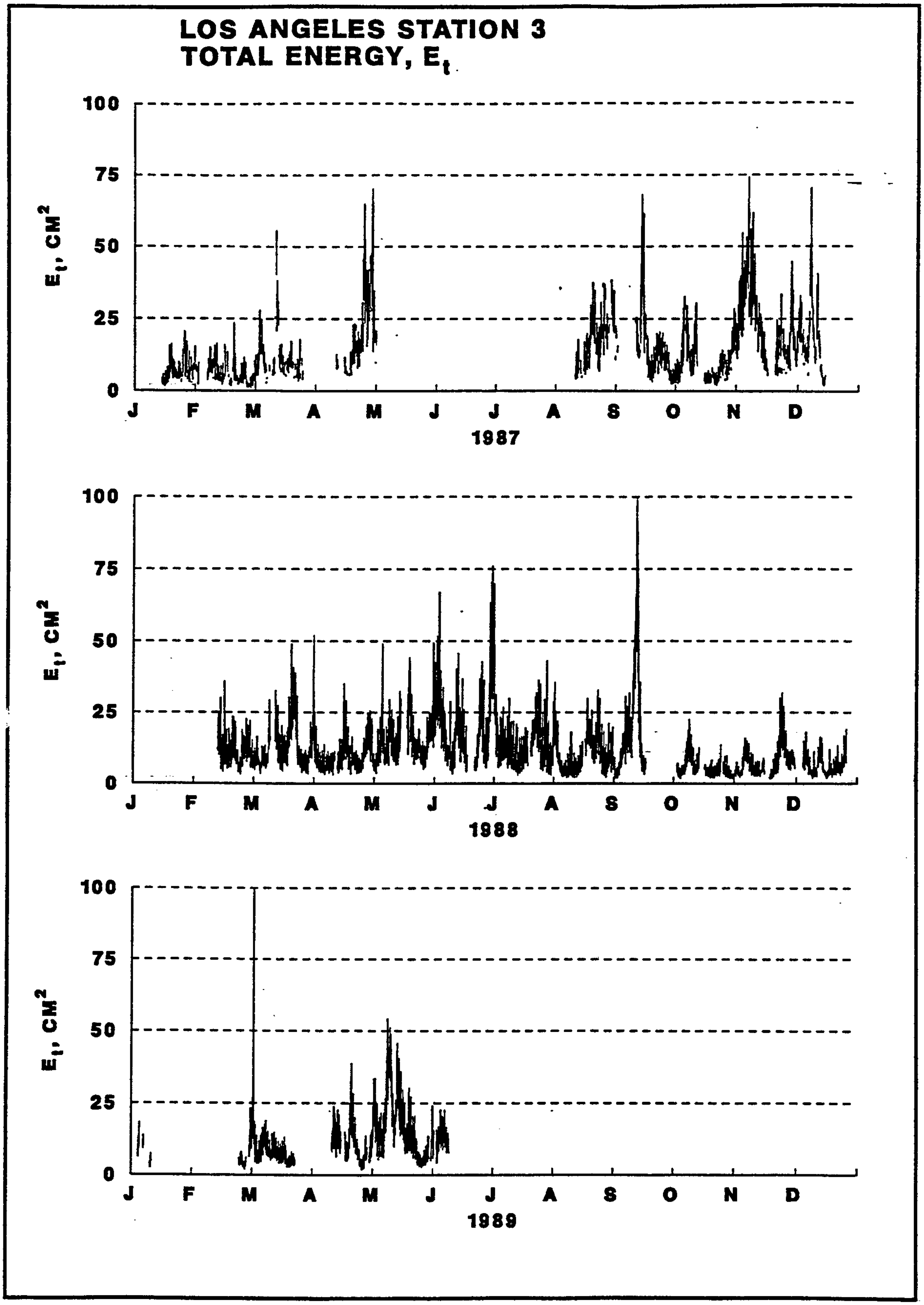

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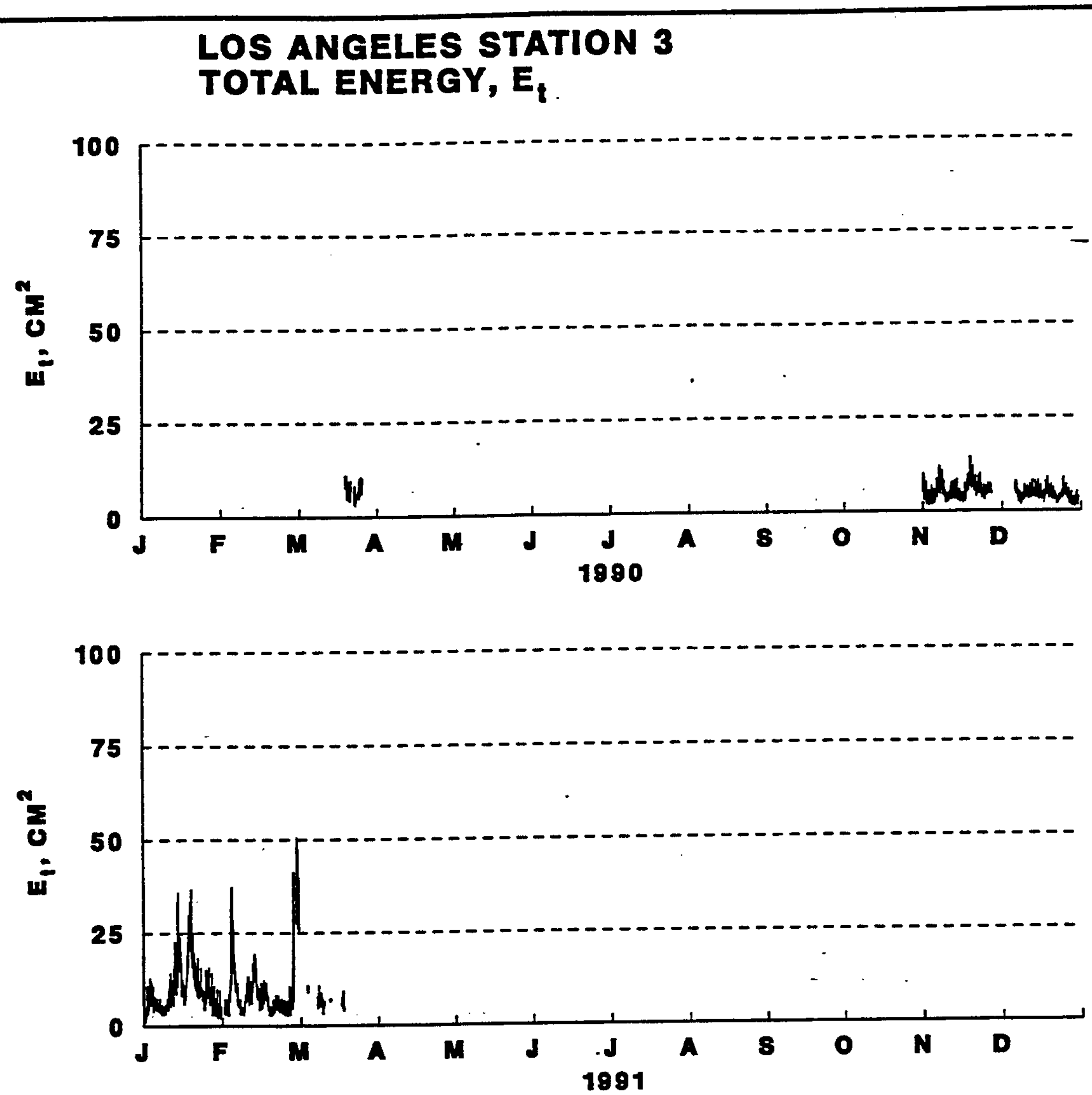

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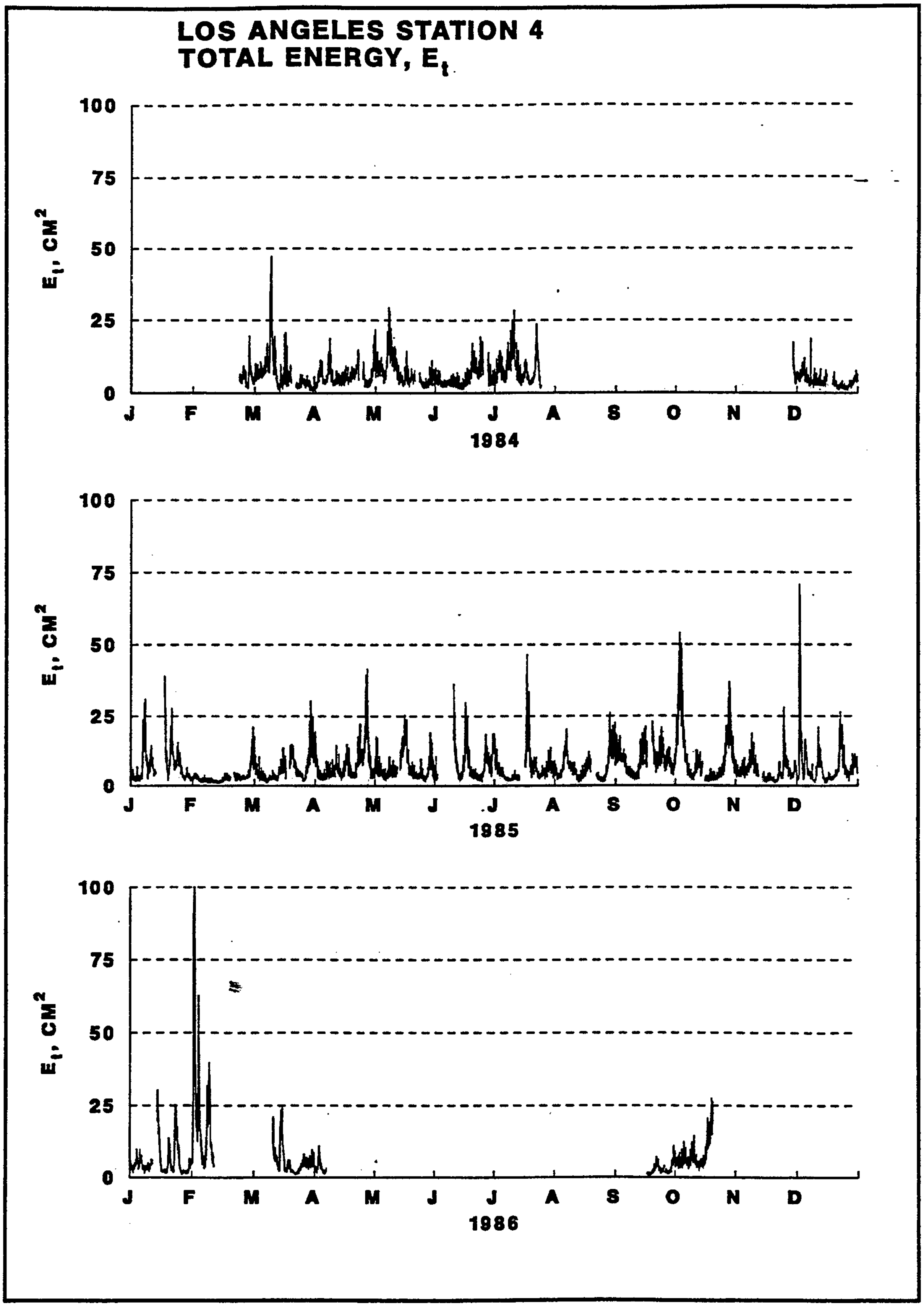

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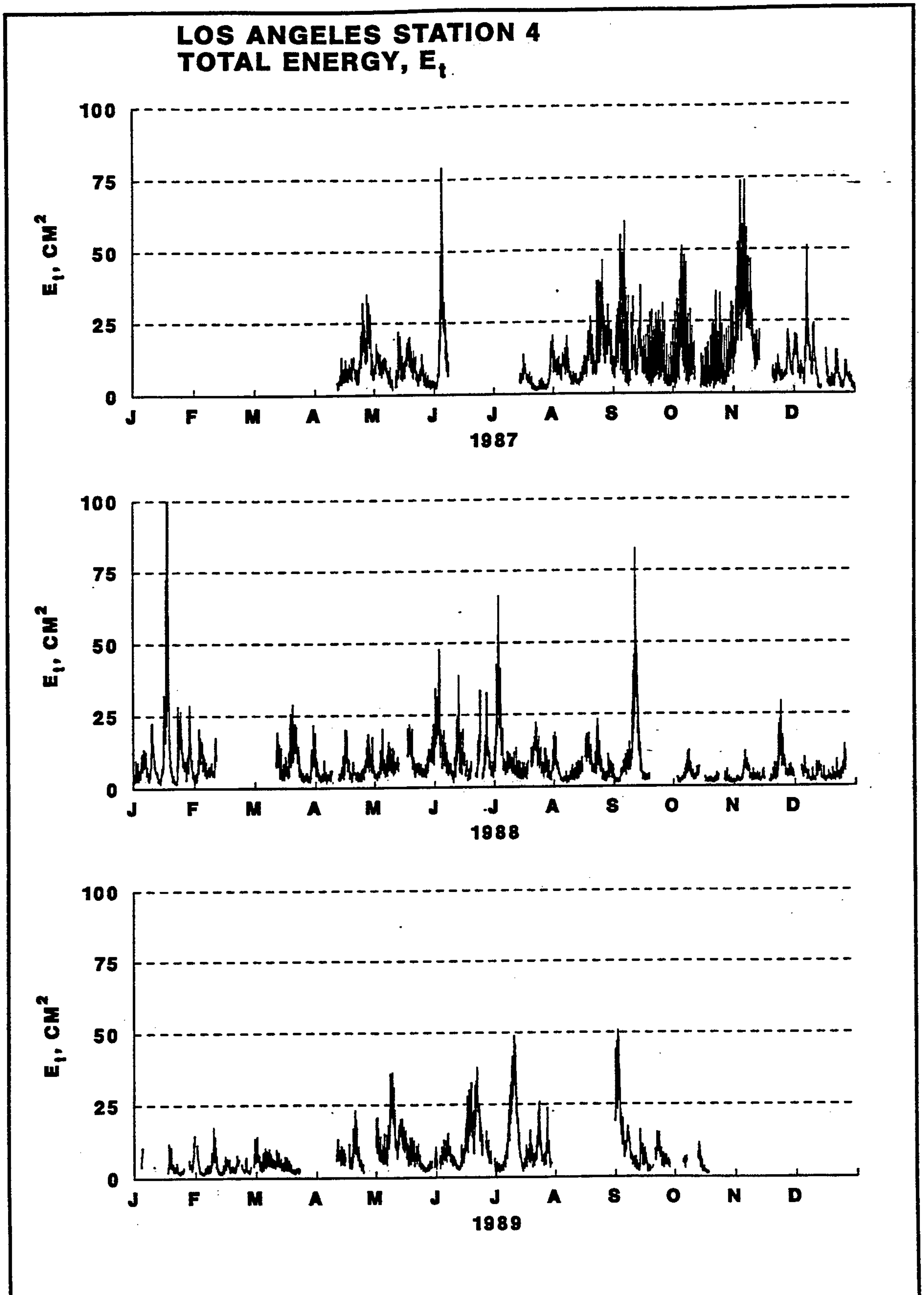

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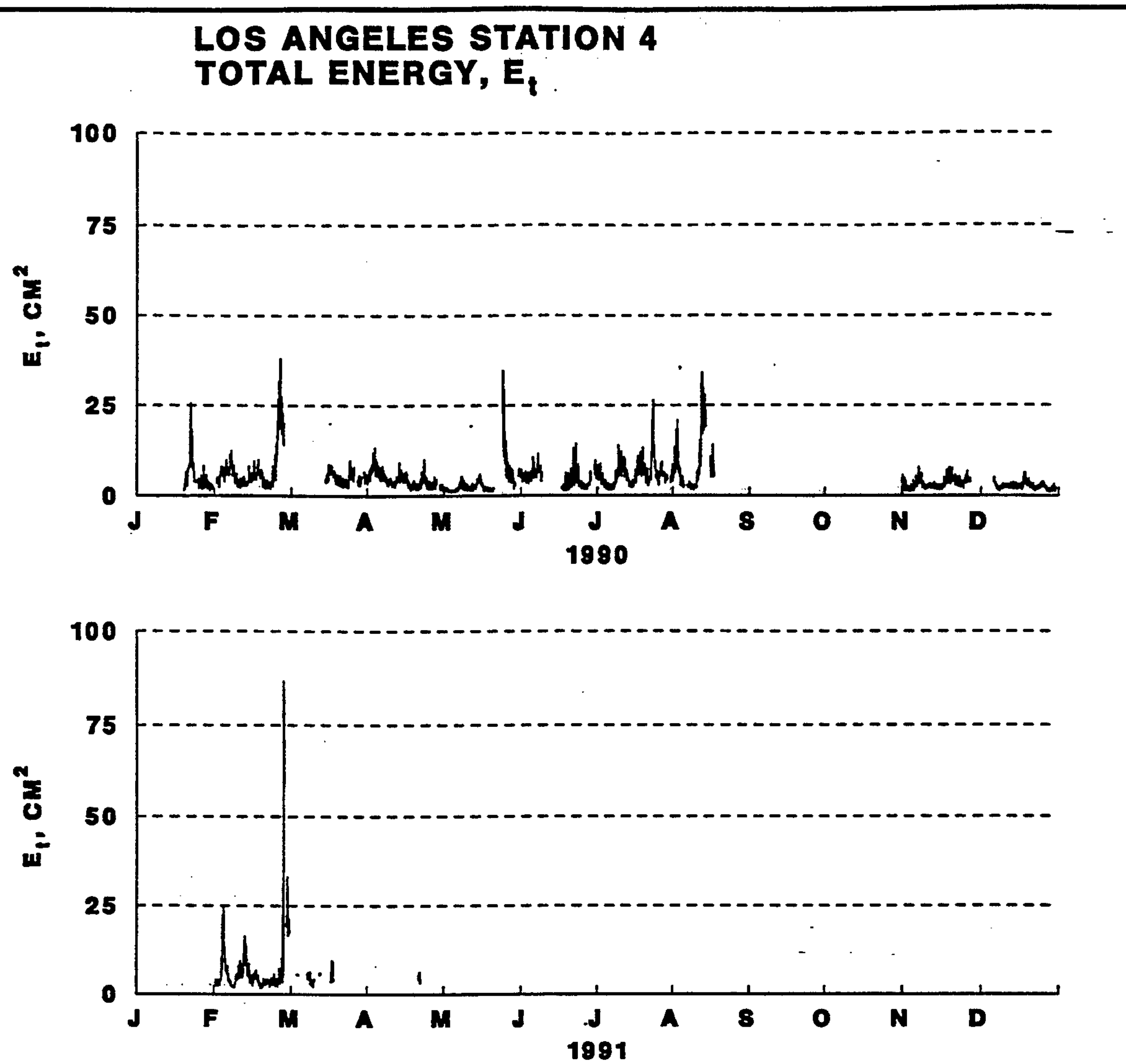
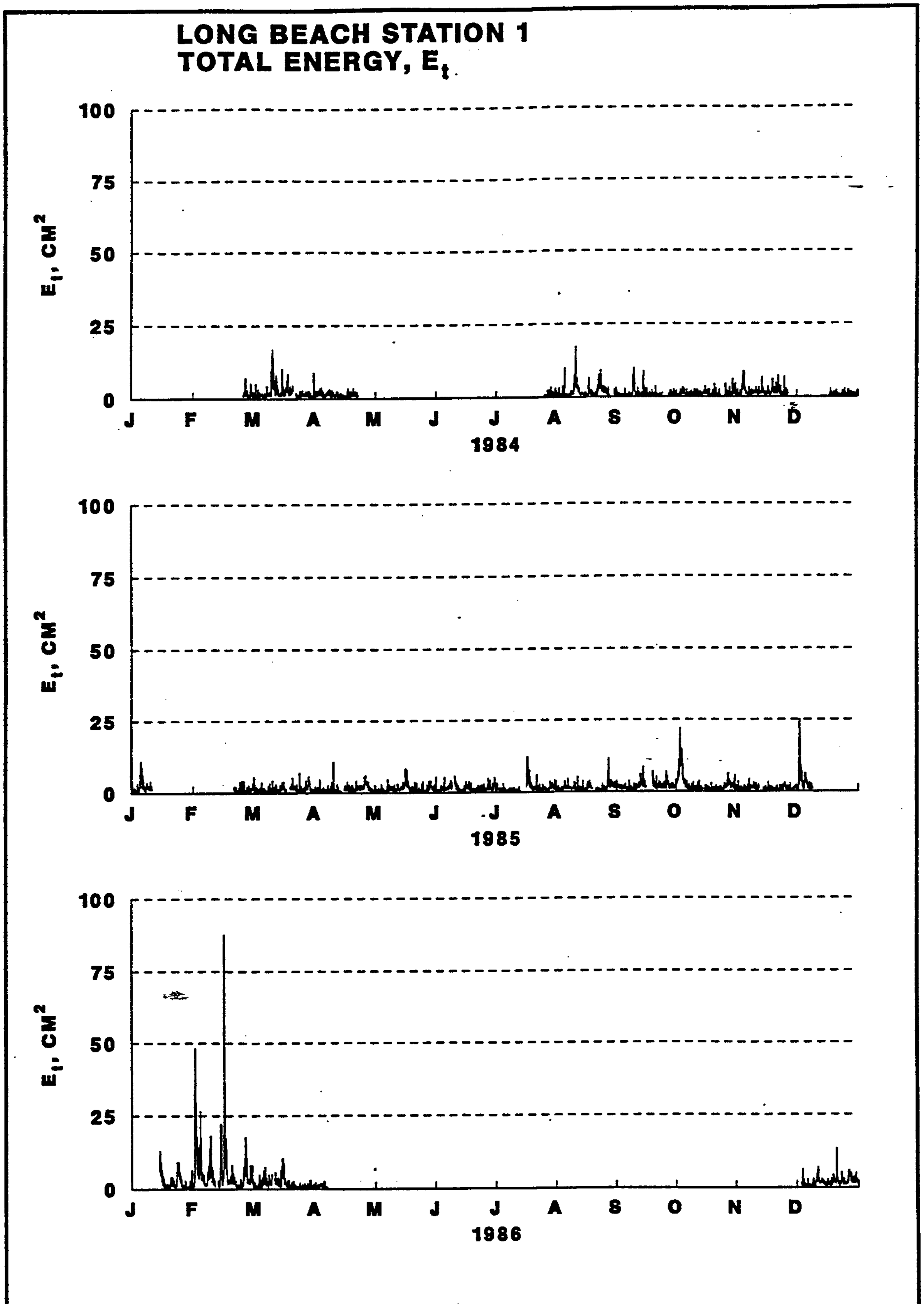


LOS ANGELES STATION 4
TOTAL ENERGY, E_t
100
75
50
25
0
E_t, CM^2
J
F
M
A
M
J
J
A
S
O
N
D
1990
100
75
50
25
0
E_t, CM^2
J
F
M
A
M
J
J
A
S
O
N
D
1991



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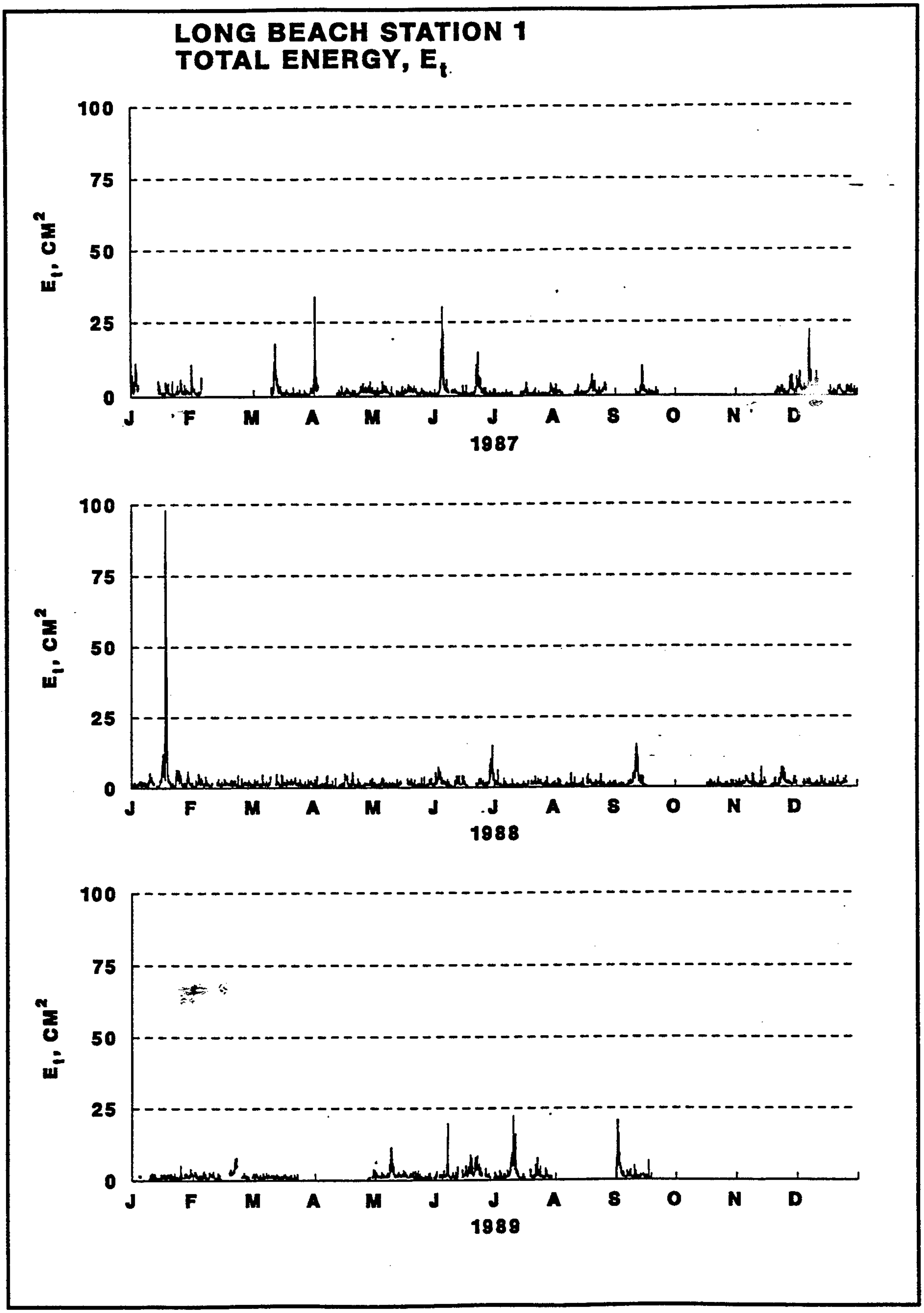
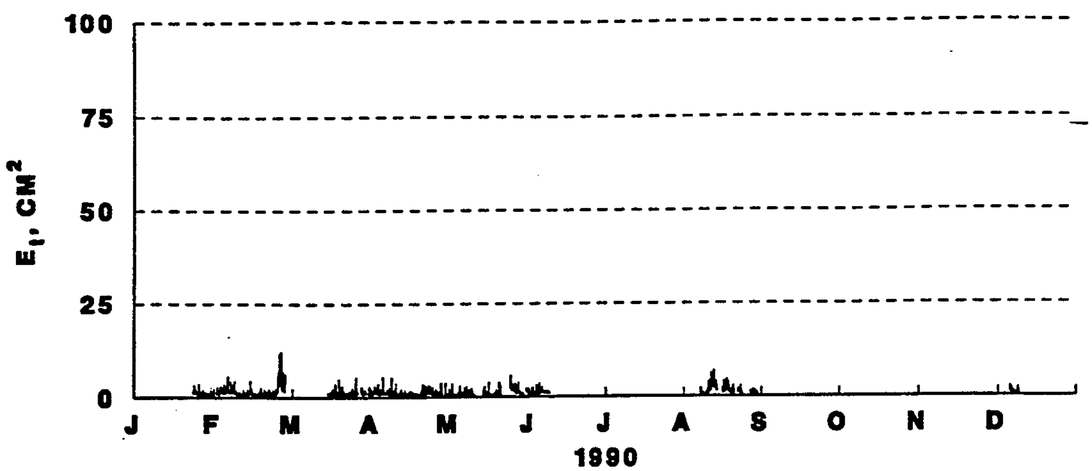
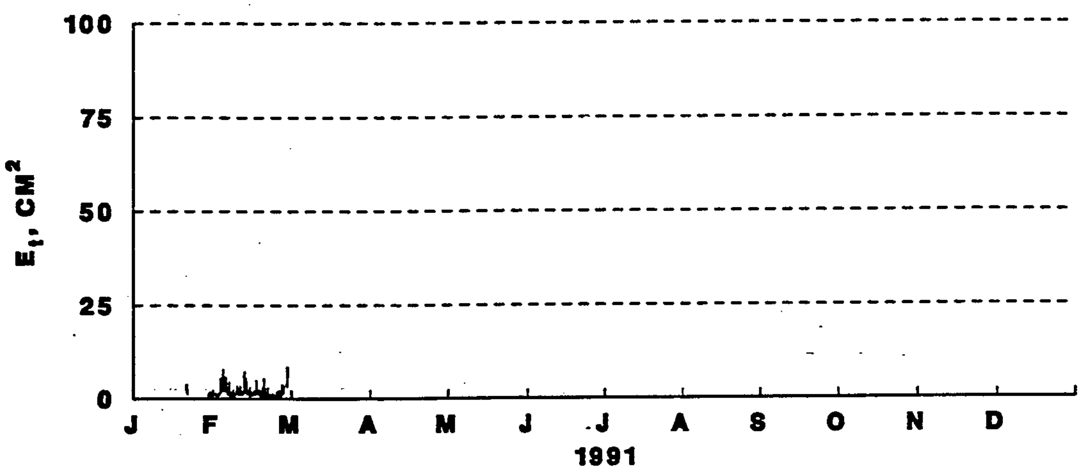


USAE COASTAL ENGINEERING RESEARCH CENTER CEWES-CD-P

LONG BEACH STATION 1
TOTAL ENERGY, E_t





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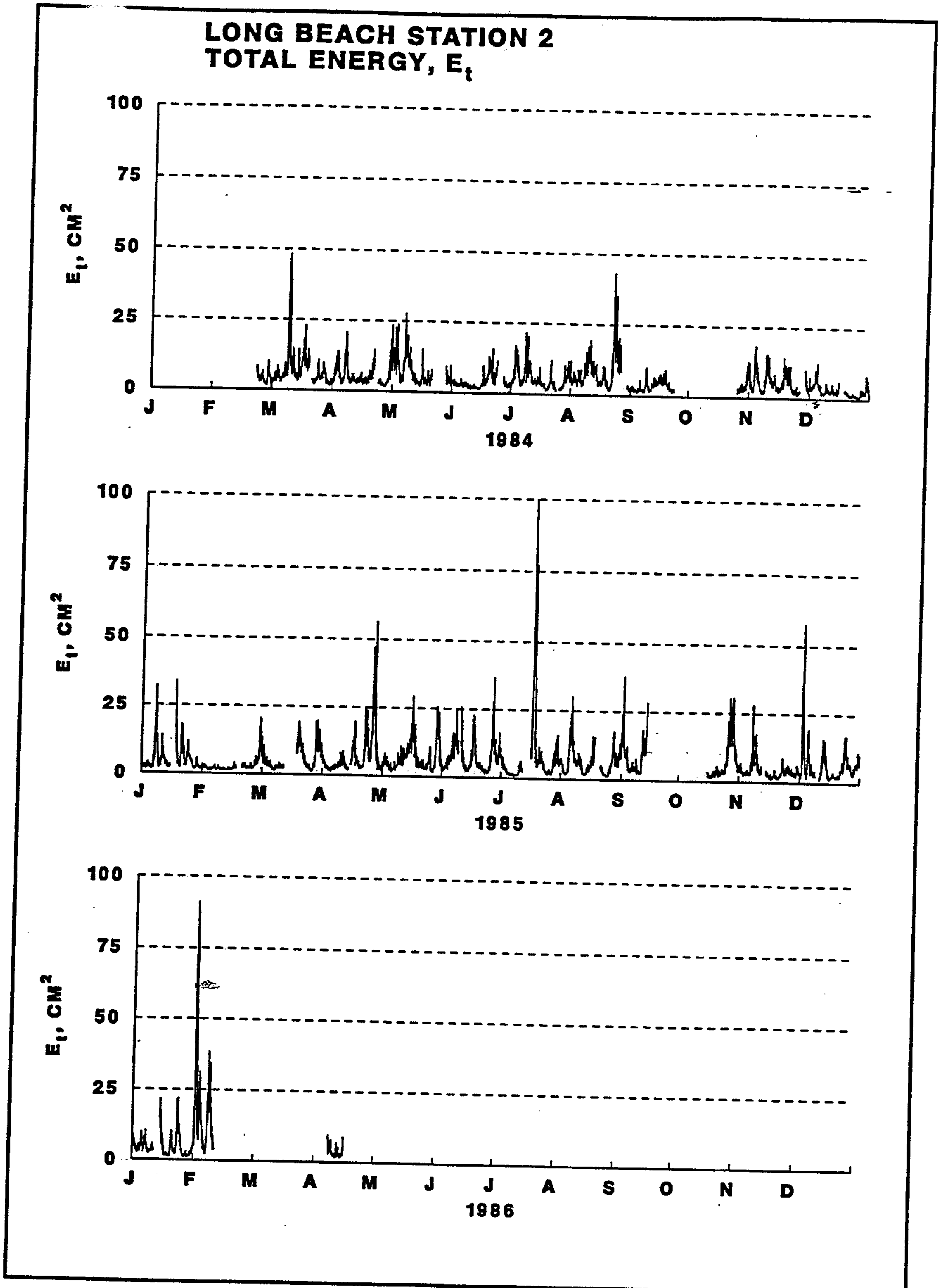

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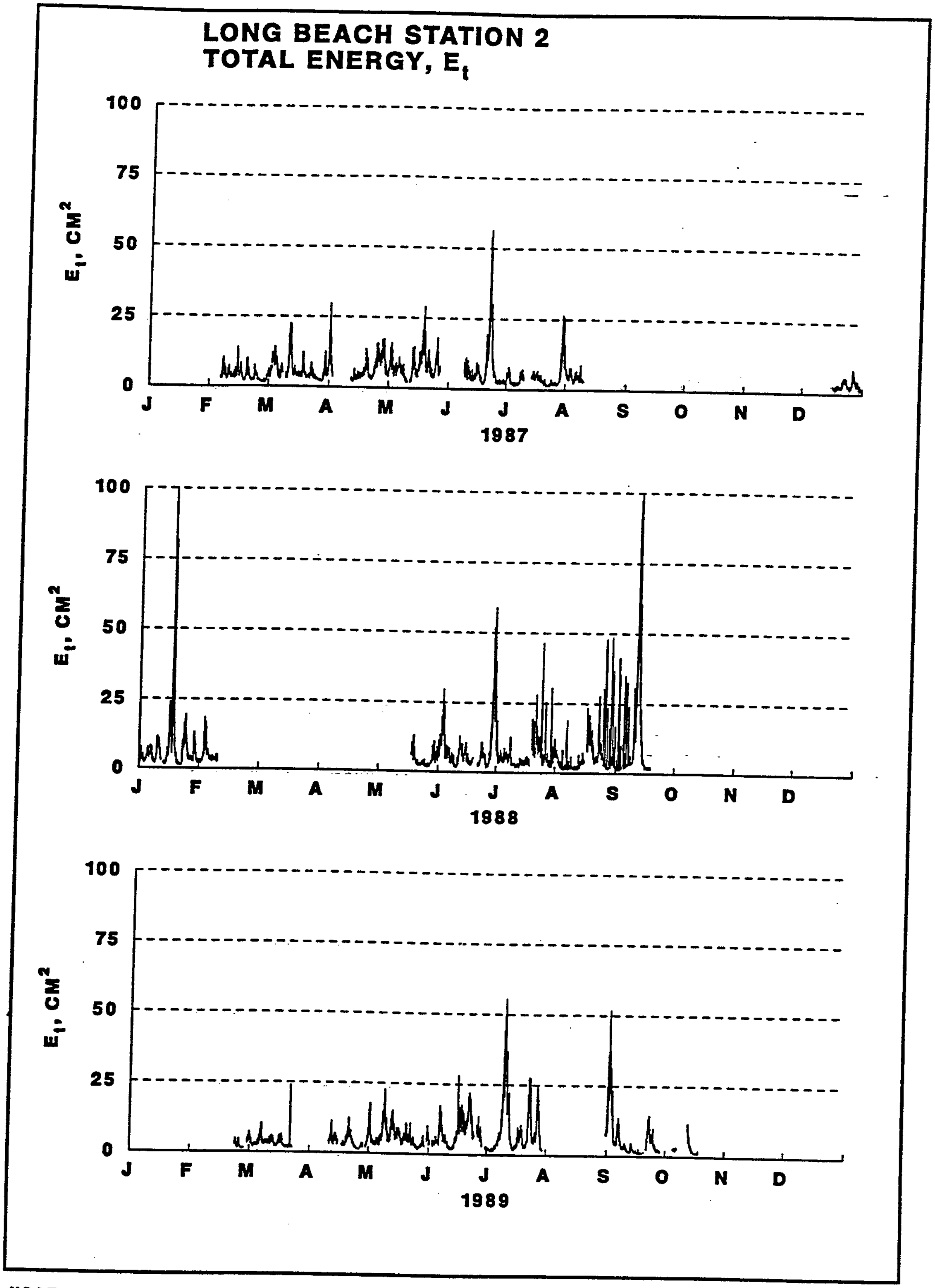

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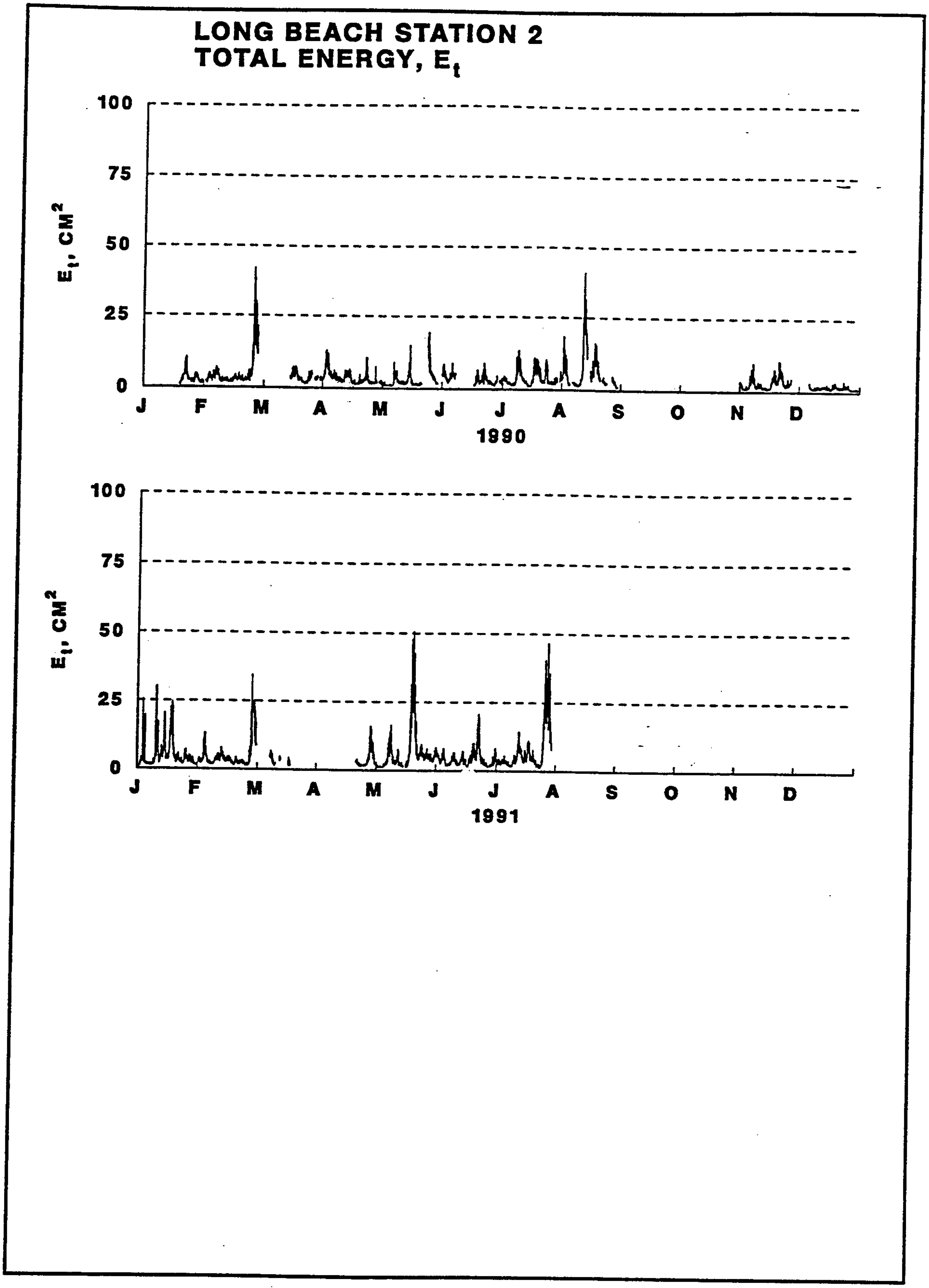
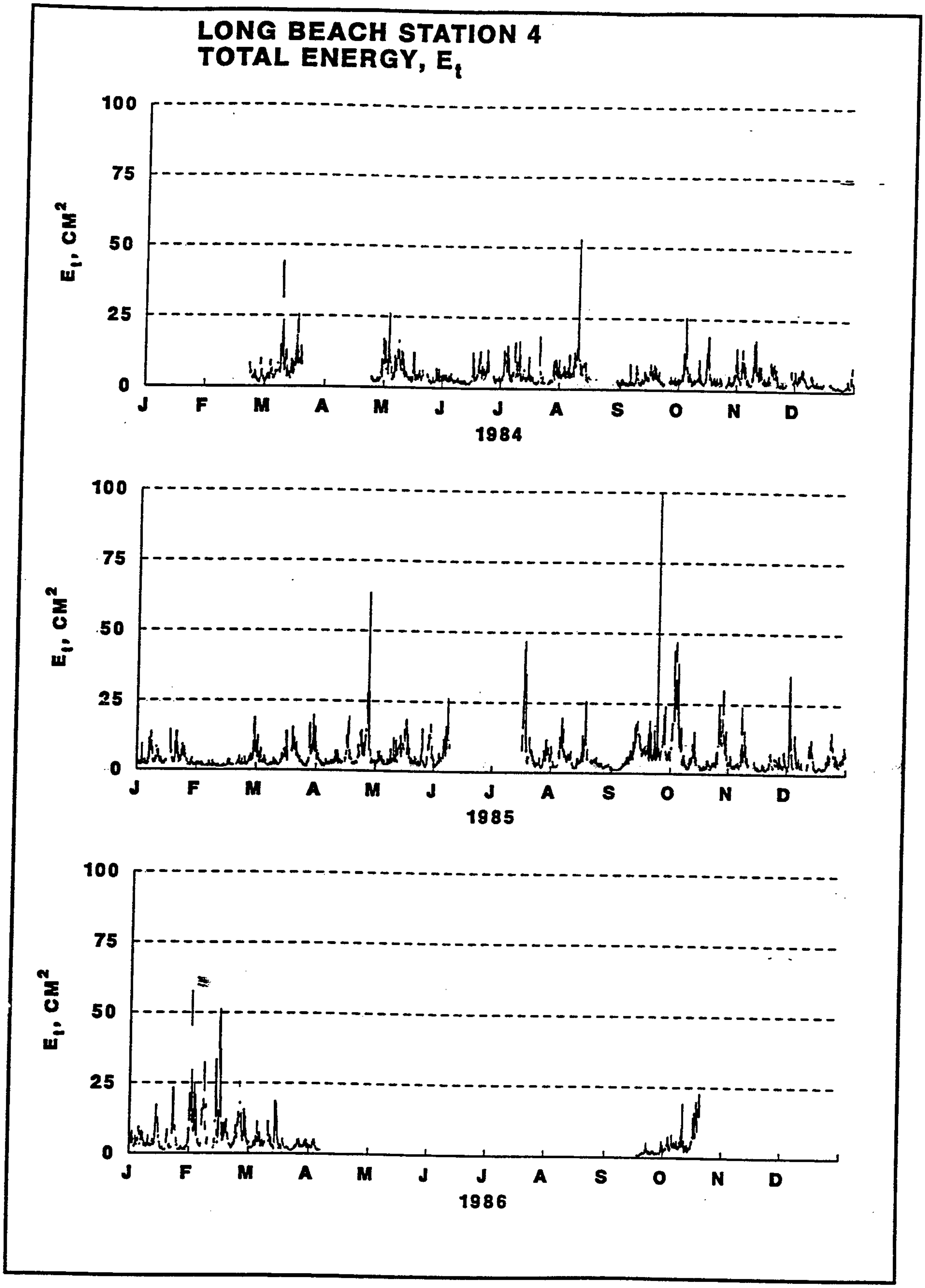

LONG BEACH STATION 2
TOTAL ENERGY, E_t
100
75
50
25
0
E_t, CM^2
J F M A M J J A S O N D
1990
100
75
50
25
0
E_t, CM^2
J F M A M J J A S O N D
1991



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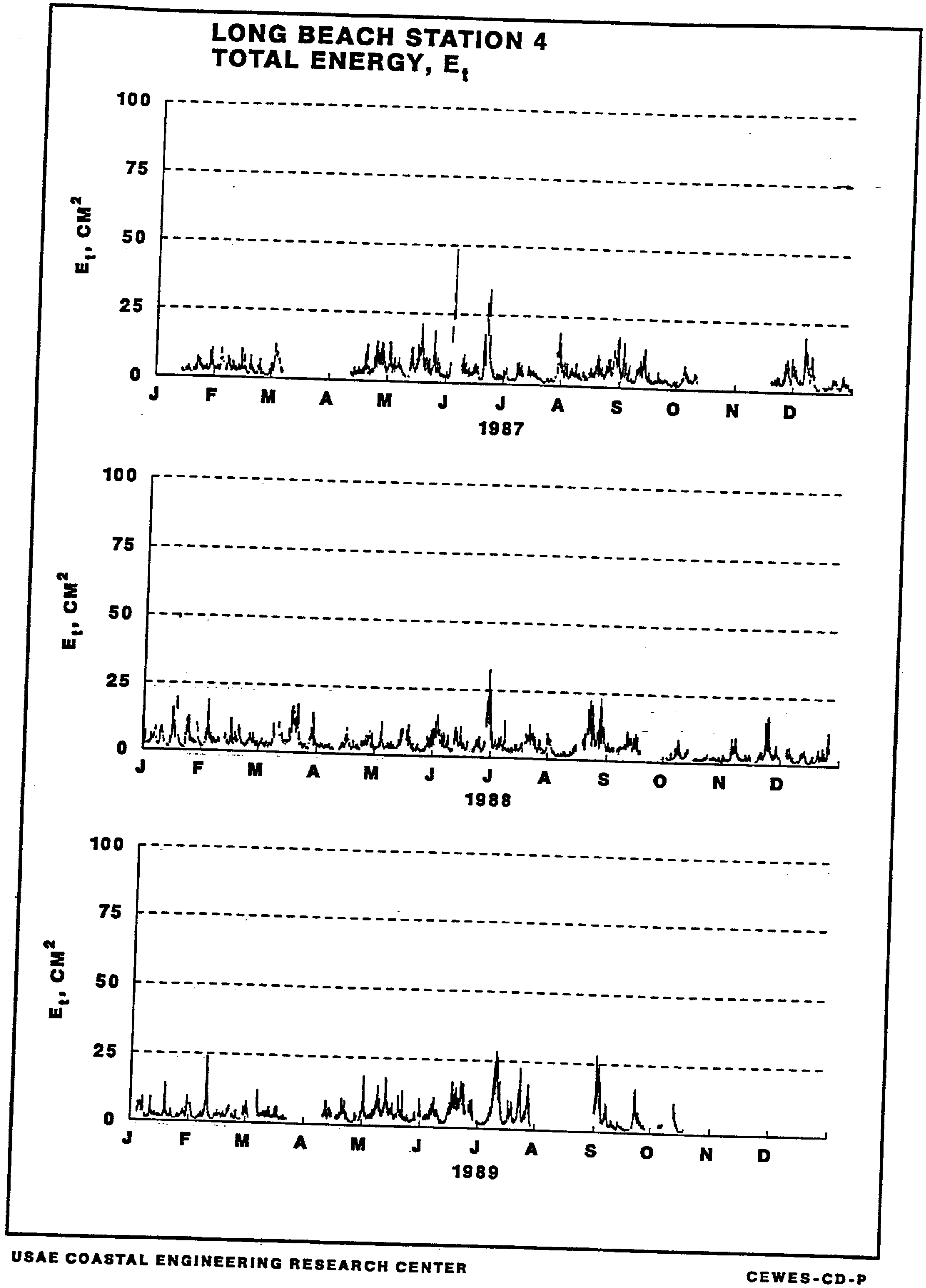
LONG BEACH STATION 4
TOTAL ENERGY, E_t
100
75
50
25
0
E_t, CM^2
J F M A M J J A S O N D
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100
75
50
25
0
E_t, CM^2
J F M A M J J A S O N D
1988
100
75
50
25
0
E_t, CM^2
J F M A M J J A S O N D
1989
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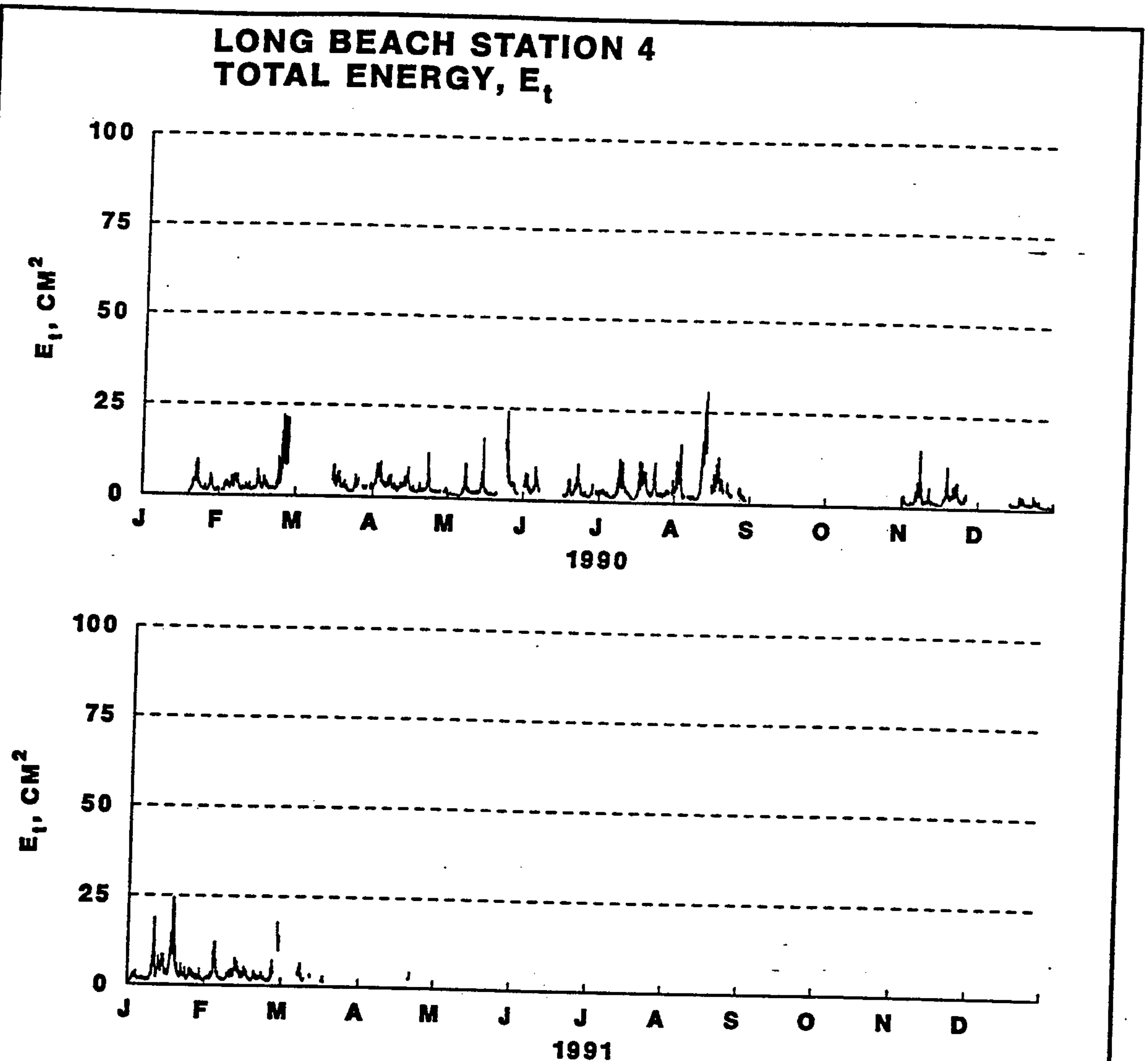

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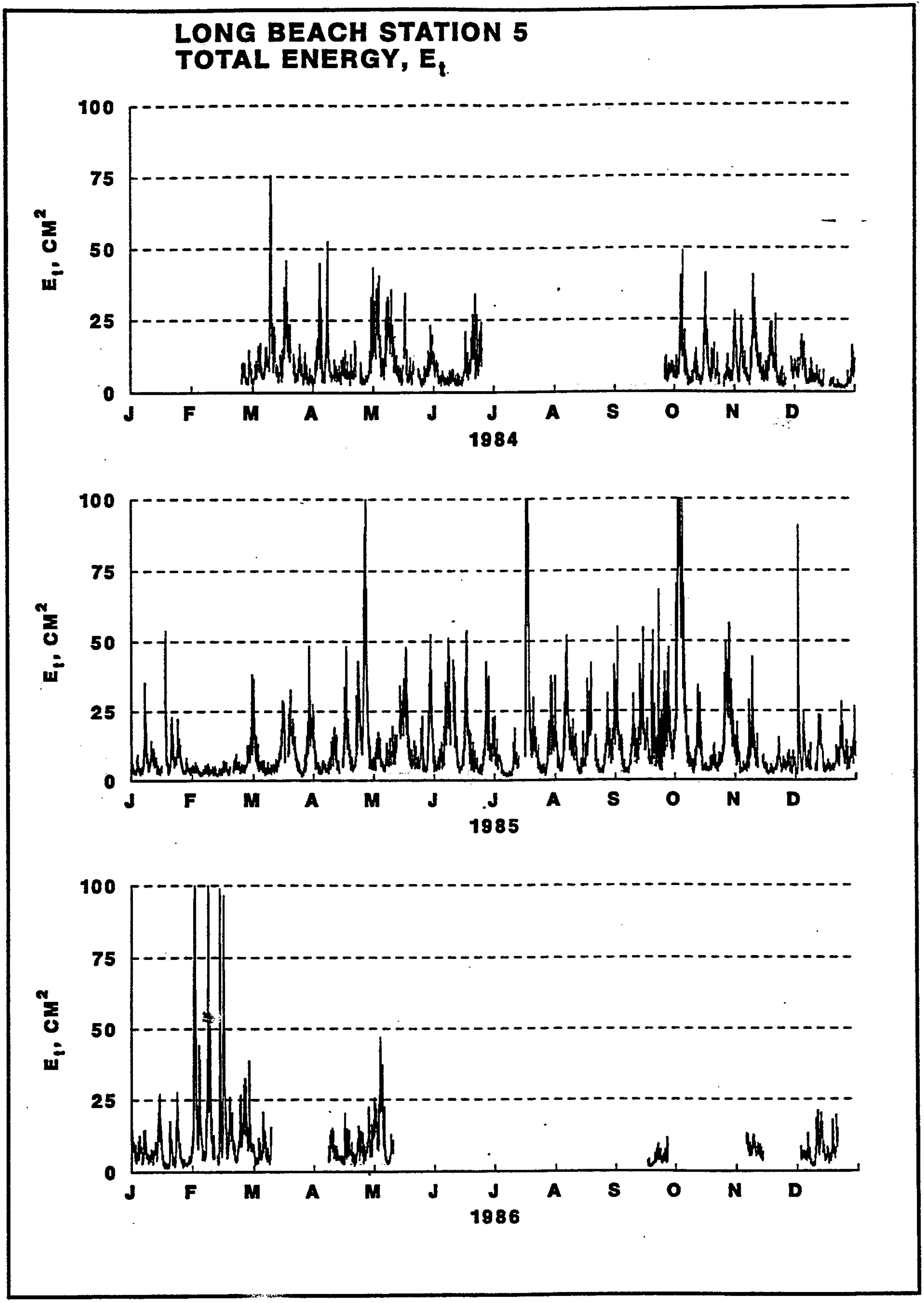
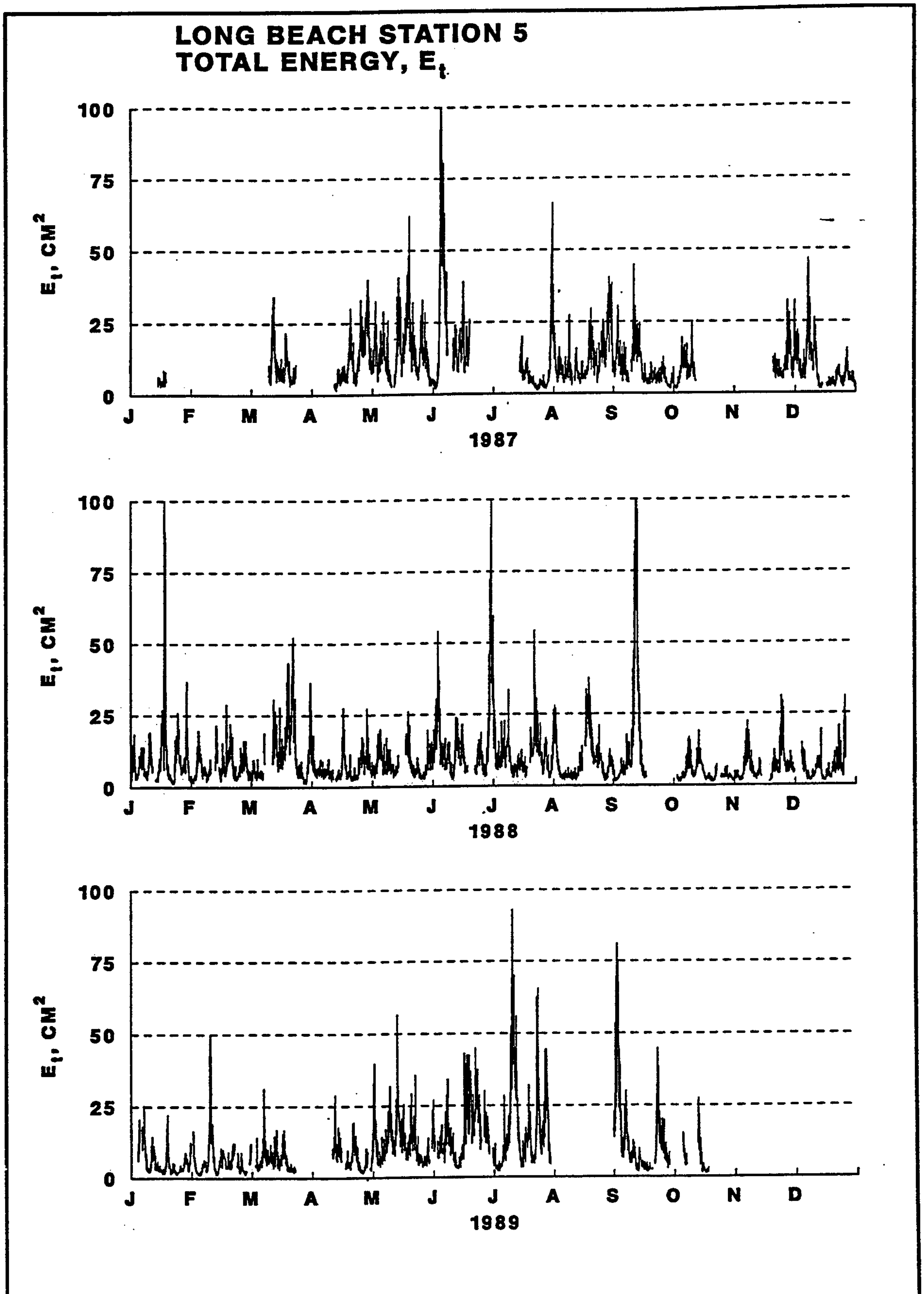


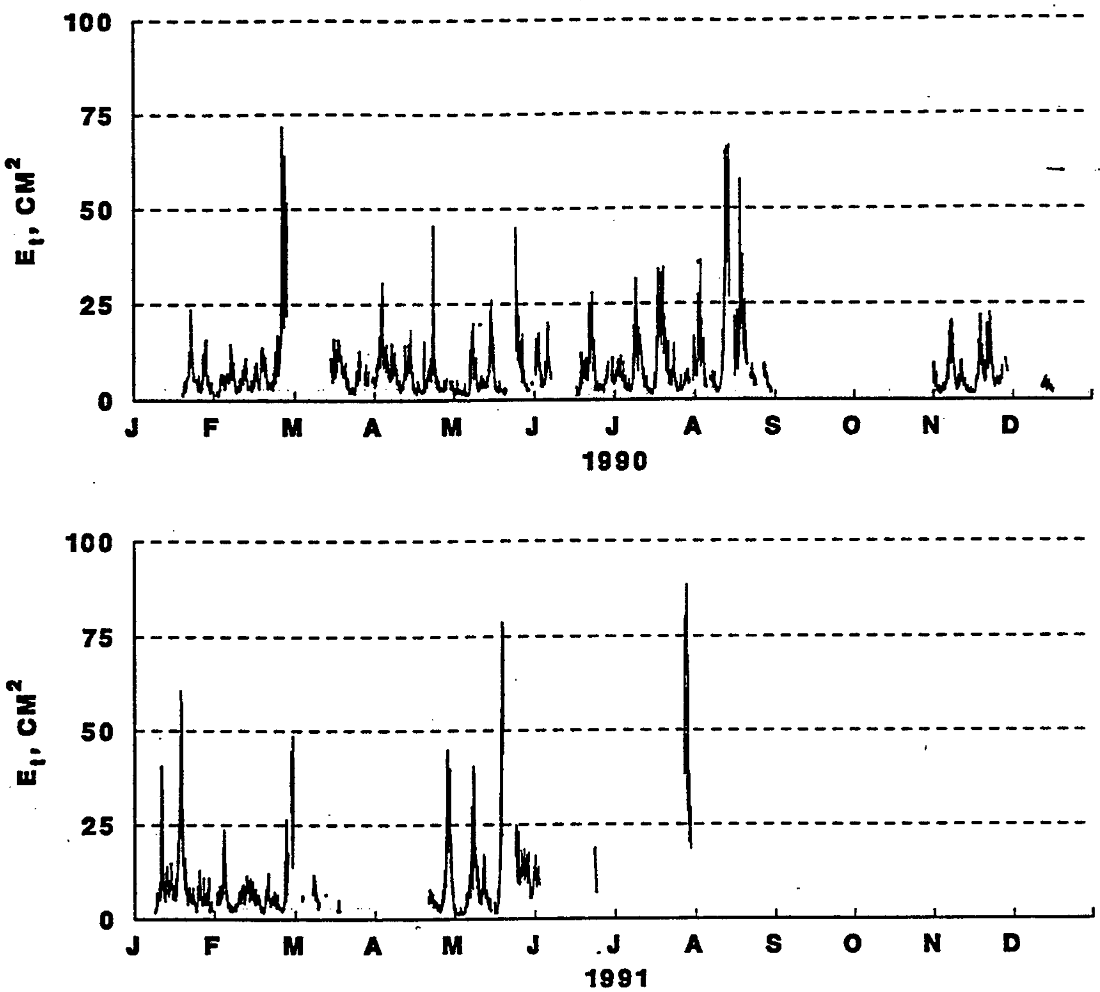
USAE COASTAL ENGINEERING RESEARCH CENTER CEWES-CD-P



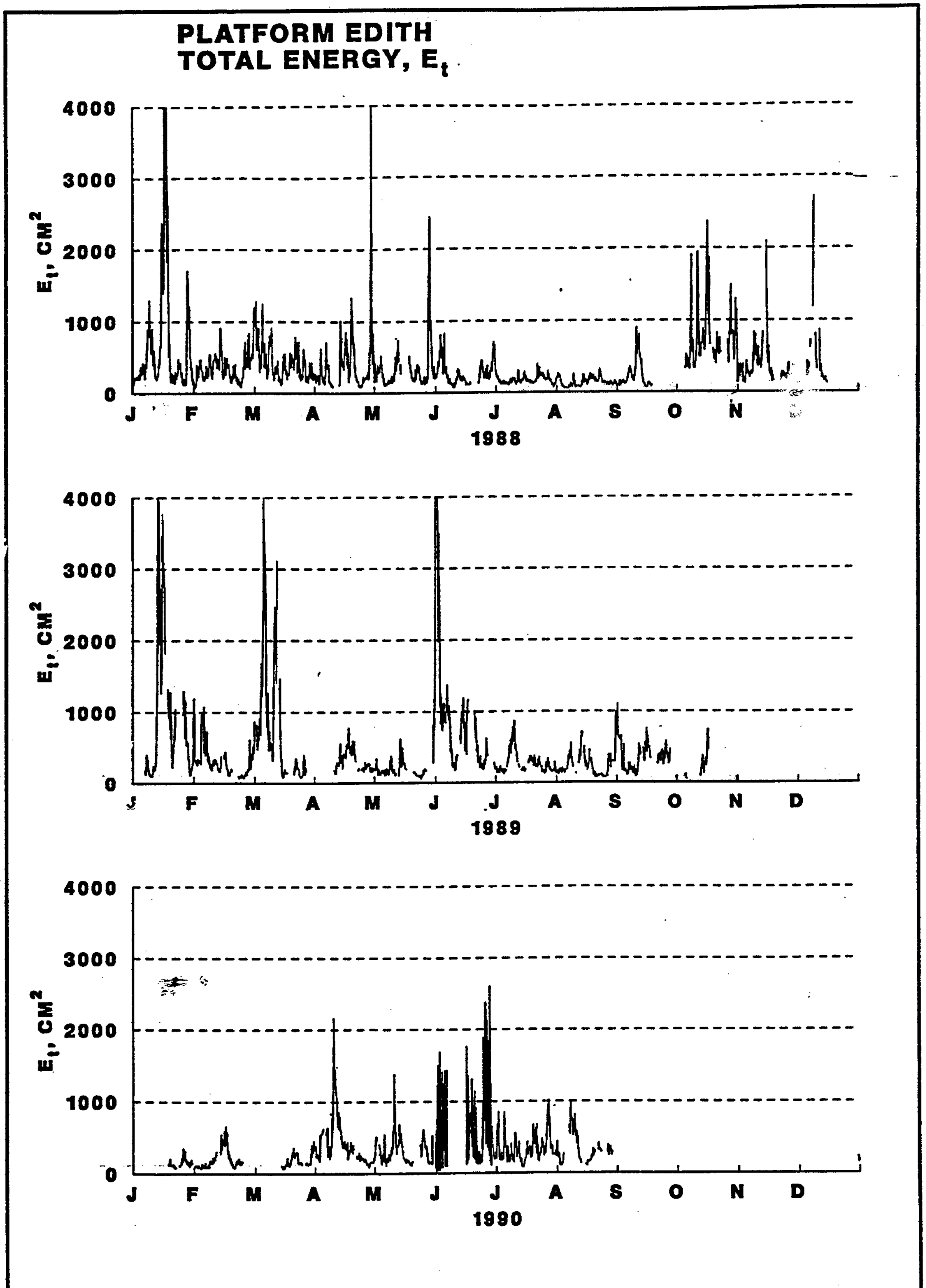
USAE COASTAL ENGINEERING RESEARCH CENTER

CEWES-CD-P

LONG BEACH STATION 5
TOTAL ENERGY, E_t

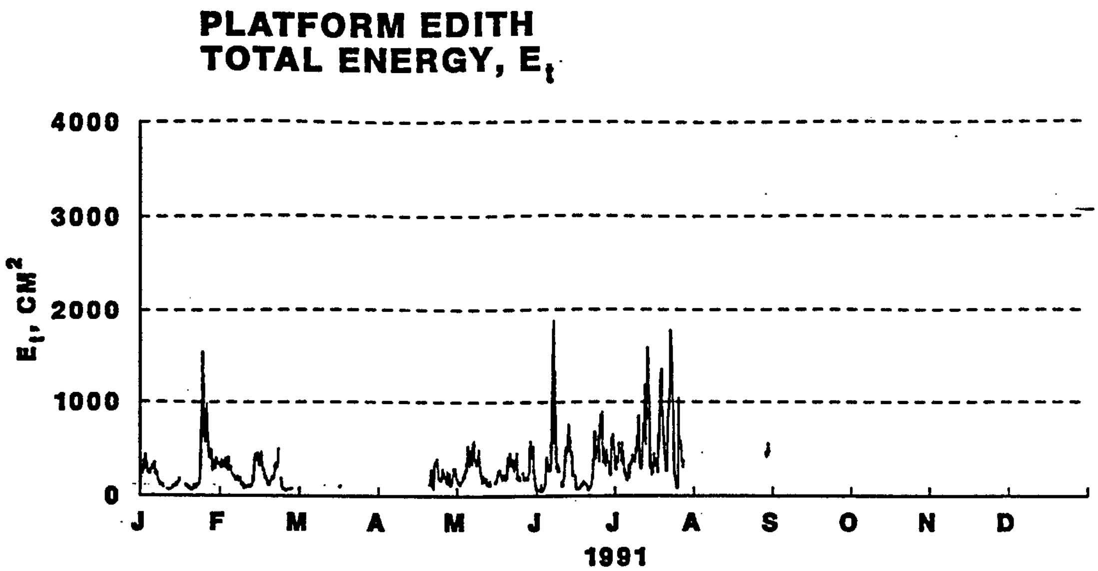


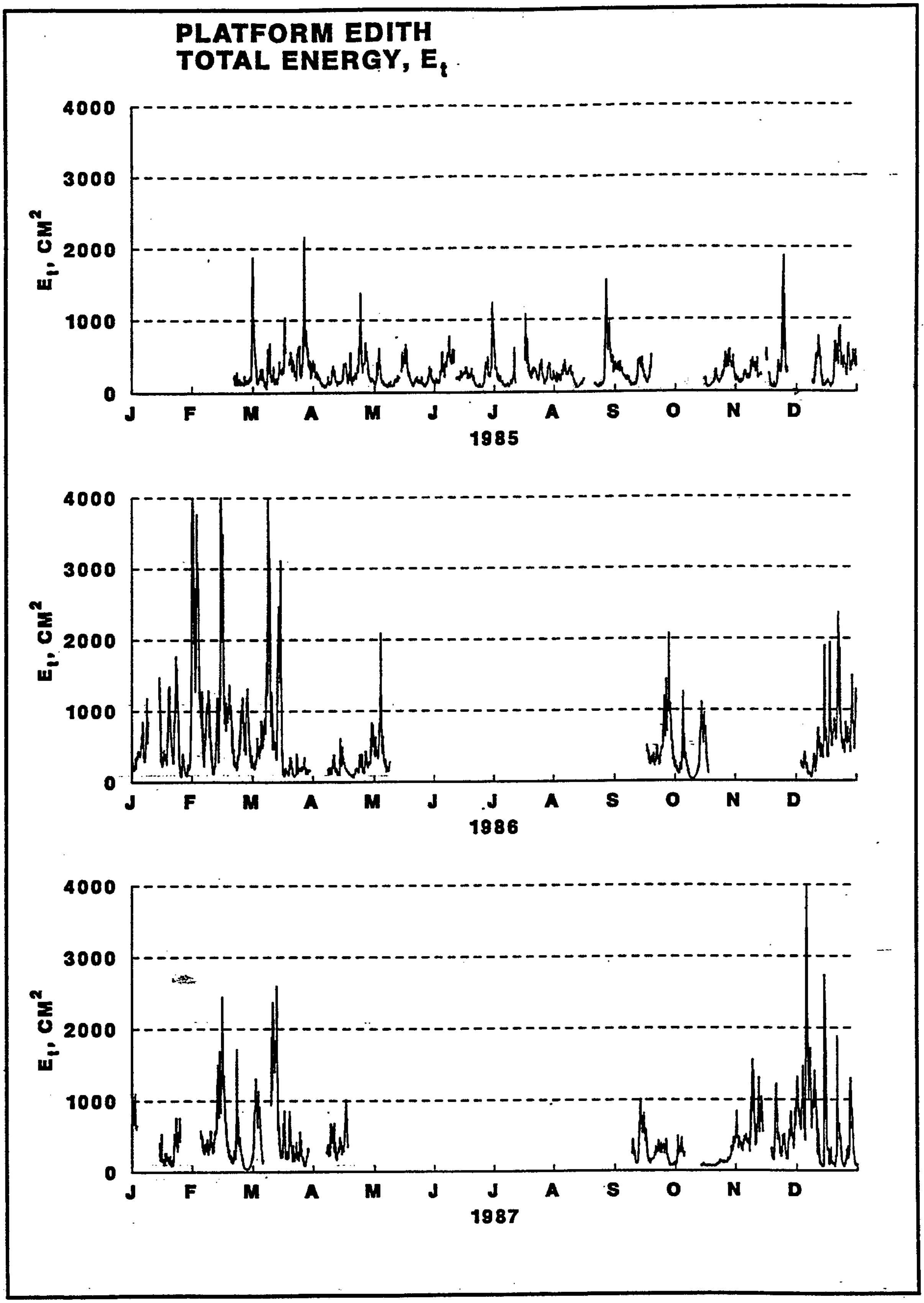
USAE COASTAL ENGINEERING RESEARCH CENTER CEWES-CD-P



USAE COASTAL ENGINEERING RESEARCH CENTER

CEWES-CD-P


PLATFORM EDITH
TOTAL ENERGY, E_t
4000
3000
2000
1000
0
E_t, CM^2
J F M A M J J A S O N D
1991



USAE COASTAL ENGINEERING RESEARCH CENTER CEWES-CD-P

Appendix C
Percent Occurrence Tables

LOS ANGELES, CA
PLATFORM EDITH
Et vs ftp (1985 - 1991)
TOTAL NUMBER OF RECORDS : 8442

FREQUENCY OF OCCURRENCE TABLE

TOTAL ENERGY (CM2)	PERIOD (SEC) 512	256	170	128	102	85	73	64 - 34.1	32 - 20.4	19.7 - 13.8	13.4 - 8.1	TOTALS
50.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0013	0.0034	0.0047
100.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0011	0.0397	0.0437	0.0845
150.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0021	0.0694	0.0674	0.1389
200.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0689	0.0640	0.1331
250.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0007	0.0496	0.0573	0.1077
300.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0004	0.0430	0.0399	0.0833
350.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0012	0.0317	0.0341	0.0670
400.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0005	0.0275	0.0341	0.0621
450.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0007	0.0262	0.0236	0.0505
500.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0158	0.0231	0.0390
550.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0005	0.0115	0.0163	0.0283
600.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0005	0.0082	0.0167	0.0253
650.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0063	0.0145	0.0210
700.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0043	0.0111	0.0156
750.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0041	0.0081	0.0122
> 800.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0012	0.0376	0.0692	0.1079
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0096	0.4450	0.5265	

LOS ANGELES, CA
SITE 1
Et vs fTp (1984 - 1991)
TOTAL NUMBER OF RECORDS : 26202

FREQUENCY OF OCCURRENCE TABLE

TOTAL ENERGY (CM2)	PERIOD (SEC) 512	256	170	128	102	85	73	64 - 34.1	32 - 20.4	19.7 - 13.8	13.4 - 8.1	TOTALS
5.0	0.2229	0.0019	0.0016	0.0348	0.0198	0.0012	0.0128	0.0051	0.0145	0.1080	0.0055	0.4279
10.0	0.1064	0.0014	0.0018	0.0418	0.0272	0.0011	0.0136	0.0048	0.0200	0.1315	0.0026	0.3523
15.0	0.0169	0.0006	0.0008	0.0147	0.0095	0.0007	0.0035	0.0008	0.0097	0.0535	0.0001	0.1109
20.0	0.0053	0.0002	0.0005	0.0056	0.0032	0.0001	0.0012	0.0003	0.0052	0.0218	0.0000	0.0434
25.0	0.0020	0.0001	0.0001	0.0040	0.0028	0.0000	0.0007	0.0002	0.0025	0.0104	0.0000	0.0228
30.0	0.0018	0.0000	0.0001	0.0020	0.0013	0.0002	0.0004	0.0000	0.0016	0.0060	0.0000	0.0133
35.0	0.0010	0.0000	0.0000	0.0013	0.0005	0.0000	0.0002	0.0000	0.0011	0.0036	0.0000	0.0077
40.0	0.0006	0.0000	0.0001	0.0010	0.0005	0.0000	0.0000	0.0000	0.0007	0.0029	0.0000	0.0060
45.0	0.0006	0.0000	0.0000	0.0007	0.0004	0.0000	0.0001	0.0000	0.0005	0.0024	0.0000	0.0048
50.0	0.0005	0.0000	0.0001	0.0003	0.0003	0.0000	0.0000	0.0000	0.0004	0.0024	0.0000	0.0040
55.0	0.0003	0.0000	0.0000	0.0003	0.0002	0.0000	0.0000	0.0000	0.0001	0.0016	0.0000	0.0026
60.0	0.0003	0.0000	0.0000	0.0003	0.0002	0.0000	0.0000	0.0000	0.0001	0.0008	0.0000	0.0018
65.0	0.0002	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0001	0.0004	0.0000	0.0007
70.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0002
75.0	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0002
>80.0	0.0002	0.0001	0.0000	0.0002	0.0002	0.0000	0.0000	0.0000	0.0002	0.0005	0.0000	0.0013
TOTALS	0.3591	0.0044	0.0051	0.1073	0.0661	0.0034	0.0325	0.0113	0.0566	0.3460	0.0082	

LOS ANGELES, CA
SITE 3
Et vs fTp (1984 - 1991)
TOTAL NUMBER OF RECORDS : 16466

FREQUENCY OF OCCURRENCE TABLE

TOTAL ENERGY (CM2)	PERIOD (SEC) 512	256	170	128	102	85	73	64 - 34.1	32 - 20.4	19.7 - 13.8	13.4 - 8.1	TOTALS
5.0	0.0047	0.0002	0.0026	0.0052	0.0000	0.0009	0.0036	0.0000	0.0100	0.1375	0.0441	0.2089
10.0	0.0022	0.0001	0.0024	0.0072	0.0000	0.0005	0.0060	0.0002	0.0165	0.2825	0.0455	0.3631
15.0	0.0010	0.0001	0.0013	0.0031	0.0000	0.0002	0.0019	0.0000	0.0084	0.1654	0.0140	0.1954
20.0	0.0005	0.0000	0.0010	0.0023	0.0000	0.0001	0.0004	0.0000	0.0047	0.0841	0.0063	0.0994
25.0	0.0004	0.0000	0.0004	0.0013	0.0000	0.0000	0.0007	0.0000	0.0035	0.0431	0.0022	0.0516
30.0	0.0004	0.0001	0.0004	0.0010	0.0000	0.0000	0.0002	0.0000	0.0019	0.0236	0.0013	0.0290
35.0	0.0002	0.0000	0.0005	0.0007	0.0000	0.0001	0.0002	0.0000	0.0013	0.0137	0.0009	0.0177
40.0	0.0001	0.0000	0.0000	0.0004	0.0000	0.0000	0.0002	0.0000	0.0013	0.0088	0.0002	0.0111
45.0	0.0001	0.0001	0.0002	0.0005	0.0000	0.0000	0.0000	0.0000	0.0004	0.0052	0.0004	0.0068
50.0	0.0003	0.0001	0.0000	0.0002	0.0000	0.0000	0.0001	0.0000	0.0006	0.0034	0.0004	0.0050
55.0	0.0001	0.0000	0.0001	0.0002	0.0000	0.0000	0.0000	0.0000	0.0004	0.0021	0.0002	0.0031
60.0	0.0001	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0002	0.0010	0.0004	0.0019
65.0	0.0001	0.0000	0.0000	0.0001	0.0000	0.0000	0.0001	0.0000	0.0001	0.0013	0.0003	0.0019
70.0	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0006	0.0001	0.0008
75.0	0.0001	0.0000	0.0000	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0007	0.0002	0.0012
>80.0	0.0001	0.0000	0.0002	0.0004	0.0000	0.0000	0.0001	0.0000	0.0002	0.0012	0.0003	0.0025
TOTALS	0.0104	0.0007	0.0091	0.0230	0.0000	0.0018	0.0134	0.0002	0.0496	0.7743	0.1169	

LOS ANGELES, CA
SITE 4
Et vs fTp (1984 - 1991)
TOTAL NUMBER OF RECORDS : 25197

FREQUENCY OF OCCURENCE TABLE

PERIOD (SEC)

TOTAL ENERGY (CM2)	512	256	170	128	102	85	73	64 - 34.1	32 - 20.4	19.7 - 13.8	13.4 - 8.1	TOTALS
5.0	0.0014	0.0024	0.0029	0.0000	0.0151	0.0001	0.0041	0.0016	0.0218	0.3531	0.0707	0.4732
10.0	0.0003	0.0073	0.0006	0.0000	0.0066	0.0000	0.0017	0.0011	0.0191	0.2707	0.0139	0.3213
15.0	0.0000	0.0053	0.0003	0.0000	0.0018	0.0000	0.0001	0.0001	0.0071	0.0845	0.0026	0.1019
20.0	0.0000	0.0056	0.0001	0.0000	0.0013	0.0000	0.0000	0.0001	0.0035	0.0342	0.0009	0.0457
25.0	0.0000	0.0029	0.0000	0.0000	0.0006	0.0000	0.0000	0.0000	0.0022	0.0171	0.0005	0.0234
30.0	0.0000	0.0024	0.0000	0.0000	0.0003	0.0000	0.0001	0.0000	0.0013	0.0083	0.0002	0.0126
35.0	0.0000	0.0016	0.0000	0.0000	0.0002	0.0000	0.0000	0.0000	0.0004	0.0063	0.0001	0.0087
40.0	0.0000	0.0015	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0001	0.0029	0.0000	0.0048
45.0	0.0000	0.0008	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0017	0.0000	0.0029
50.0	0.0000	0.0008	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0002	0.0013	0.0000	0.0024
55.0	0.0000	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0000	0.0006
60.0	0.0000	0.0004	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0000	0.0007
65.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
70.0	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0002
75.0	0.0000	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003
>80.0	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0006	0.0001	0.0008
TOTALS	0.0017	0.0318	0.0041	0.0001	0.0262	0.0002	0.0060	0.0029	0.0559	0.7813	0.0892	

LONG BEACH, CA
SITE 1
Et vs fTp (1984 - 1991)
TOTAL NUMBER OF RECORDS : 21303

FREQUENCY OF OCCURENCE TABLE

PERIOD (SEC)

TOTAL ENERGY (CM2)	512	256	170	128	102	85	73	64 - 34.1	32 - 20.4	19.7 - 13.8	13.4 - 8.1	TOTALS
5.0	0.3465	0.4724	0.0000	0.0000	0.0450	0.0119	0.0004	0.0229	0.0088	0.0567	0.0000	0.9645
10.0	0.0015	0.0190	0.0000	0.0000	0.0013	0.0001	0.0000	0.0000	0.0005	0.0055	0.0000	0.0281
15.0	0.0001	0.0032	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0008	0.0000	0.0043
20.0	0.0000	0.0013	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0002	0.0000	0.0016
25.0	0.0000	0.0004	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0005
30.0	0.0000	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003
35.0	0.0000	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003
40.0	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
45.0	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
50.0	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
55.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
60.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
65.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
70.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
75.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
>80.0	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
TOTALS	0.3481	0.4974	0.0001	0.0000	0.0466	0.0120	0.0004	0.0230	0.0093	0.0631	0.0000	

LONG BEACH, CA
SITE 2
Et vs fTp (1984 - 1991)
TOTAL NUMBER OF RECORDS : 33952

FREQUENCY OF OCCURENCE TABLE

PERIOD (SEC)

TOTAL ENERGY (CM2)	512	256	170	128	102	85	73	64 - 34.1	32 - 20.4	19.7 - 13.8	13.4 - 8.1	TOTALS
5.0	0.0412	0.0013	0.0014	0.0000	0.0000	0.0005	0.0636	0.0015	0.0118	0.4450	0.0788	0.6451
10.0	0.0014	0.0001	0.0007	0.0000	0.0000	0.0002	0.0168	0.0003	0.0052	0.2046	0.0065	0.2357
15.0	0.0000	0.0000	0.0003	0.0000	0.0000	0.0002	0.0046	0.0000	0.0016	0.0600	0.0007	0.0674
20.0	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0010	0.0000	0.0002	0.0235	0.0001	0.0250
25.0	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0002	0.0000	0.0001	0.0103	0.0001	0.0107
30.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0000	0.0001	0.0052	0.0000	0.0056
35.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0030	0.0001	0.0033
40.0	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0021	0.0001	0.0023
45.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0010	0.0000	0.0010
50.0	0.0000	0.0000	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0008	0.0001	0.0011
55.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0006	0.0000	0.0006
60.0	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003	0.0000	0.0004
65.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0001
70.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0002
75.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0000	0.0002
>80.0	0.0000	0.0001	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0008	0.0002	0.0012
TOTALS	0.0428	0.0016	0.0030	0.0001	0.0000	0.0009	0.0864	0.0019	0.0191	0.7575	0.0867	

LONG BEACH, CA
SITE 4
Et vs fTp (1984 - 1991)
TOTAL NUMBER OF RECORDS : 23561

FREQUENCY OF OCCURRENCE TABLE

TOTAL ENERGY (CM2)	PERIOD (SEC) 512	256	170	128	102	85	73	64 - 34.1	32 - 20.4	19.7 - 13.8	13.4 - 8.1	TOTALS
5.0	0.0061	0.0002	0.0222	0.0003	0.0000	0.0000	0.0000	0.0066	0.0149	0.6088	0.0795	0.7386
10.0	0.0002	0.0000	0.0054	0.0000	0.0000	0.0000	0.0000	0.0007	0.0050	0.1803	0.0028	0.1946
15.0	0.0000	0.0000	0.0017	0.0000	0.0000	0.0000	0.0000	0.0001	0.0008	0.0417	0.0003	0.0445
20.0	0.0000	0.0000	0.0007	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0129	0.0001	0.0138
25.0	0.0000	0.0000	0.0004	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0044	0.0000	0.0048
30.0	0.0000	0.0000	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0014	0.0000	0.0016
35.0	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0007	0.0000	0.0008
40.0	0.0000	0.0000	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003	0.0000	0.0004
45.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0000	0.0003
50.0	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003	0.0000	0.0003
55.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0001
60.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
65.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
70.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
75.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
>80.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
TOTALS	0.0064	0.0003	0.0309	0.0003	0.0000	0.0000	0.0000	0.0074	0.0208	0.8512	0.0828	

LONG BEACH, CA
SITE 5
Et vs fTp (1984 - 1991)
TOTAL NUMBER OF RECORDS : 26815

FREQUENCY OF OCCURRENCE TABLE

TOTAL ENERGY (CM2)	PERIOD (SEC) 512	256	170	128	102	85	73	64 - 34.1	32 - 20.4	19.7 - 13.8	13.4 - 8.1	TOTALS
5.0	0.0376	0.0000	0.0000	0.0000	0.0000	0.0231	0.0000	0.0000	0.0044	0.2713	0.0071	0.3436
10.0	0.0099	0.0000	0.0000	0.0000	0.0000	0.0121	0.0000	0.0000	0.0048	0.3139	0.0016	0.3423
15.0	0.0008	0.0001	0.0000	0.0000	0.0000	0.0042	0.0000	0.0000	0.0017	0.1429	0.0001	0.1498
20.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0021	0.0000	0.0000	0.0011	0.0655	0.0001	0.0689
25.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0006	0.0000	0.0000	0.0003	0.0354	0.0001	0.0363
30.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0004	0.0000	0.0000	0.0003	0.0200	0.0000	0.0207
35.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003	0.0000	0.0000	0.0001	0.0125	0.0000	0.0129
40.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0073	0.0000	0.0074
45.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0049	0.0000	0.0050
50.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0030	0.0000	0.0031
55.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0019	0.0000	0.0019
60.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0015	0.0000	0.0015
65.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0013	0.0000	0.0013
70.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0013	0.0000	0.0013
75.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0007	0.0000	0.0008
>80.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0032	0.0000	0.0033
TOTALS	0.0484	0.0001	0.0001	0.0000	0.0000	0.0430	0.0000	0.0000	0.0128	0.8866	0.0091	

LOS ANGELES, CA
PLATFORM EDITH
El vs flP (1985 - 1991)
TOTAL NUMBER OF RECORDS : 8442

FREQUENCY OF OCCURRANCE TABLE

TOTAL ENERGY (CM2)	PERIOD (SEC) 512	256	170	128	102	85	73	64 - 34.1	32 - 20.4	TOTALS
250.0	0.0194	0.0044	0.0191	0.0539	0.0861	0.0792	0.0810	0.3153	0.3396	0.9999
500.0	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
750.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1000.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1250.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1500.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1750.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2000.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2250.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2500.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2750.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3000.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3250.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3500.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3750.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
>4000.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TOTALS	0.0194	0.0044	0.0192	0.0539	0.0861	0.0792	0.0810	0.3153	0.3396	

LOS ANGELES, CA
SITE 1
El vs flp (1984 - 1991)
TOTAL NUMBER OF RECORDS : 26202

FREQUENCY OF OCCURRANCE TABLE

TOTAL ENERGY (CM2)	PERIOD (SEC) 512	256	170	128	102	85	73	64 - 34.1	32 - 20.4	TOTALS
5.0	0.4591	0.0084	0.0059	0.1170	0.0737	0.0057	0.0551	0.0334	0.0051	0.7633
10.0	0.0592	0.0016	0.0018	0.0463	0.0286	0.0019	0.0168	0.0077	0.0026	0.1665
15.0	0.0105	0.0005	0.0006	0.0111	0.0085	0.0004	0.0032	0.0010	0.0001	0.0358
20.0	0.0045	0.0003	0.0004	0.0063	0.0035	0.0003	0.0009	0.0004	0.0000	0.0166
25.0	0.0026	0.0002	0.0001	0.0029	0.0018	0.0001	0.0004	0.0000	0.0000	0.0081
30.0	0.0013	0.0000	0.0001	0.0016	0.0008	0.0000	0.0002	0.0000	0.0000	0.0040
35.0	0.0006	0.0000	0.0000	0.0010	0.0006	0.0000	0.0000	0.0000	0.0000	0.0024
40.0	0.0004	0.0000	0.0000	0.0004	0.0004	0.0000	0.0000	0.0000	0.0000	0.0012
45.0	0.0002	0.0000	0.0000	0.0004	0.0001	0.0000	0.0000	0.0000	0.0000	0.0007
50.0	0.0002	0.0000	0.0000	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0004
55.0	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0002
60.0	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
65.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
70.0	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
75.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
>80.0	0.0002	0.0001	0.0000	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0006
TOTALS	0.5390	0.0110	0.0089	0.1873	0.1184	0.0085	0.0765	0.0427	0.0077	

LOS ANGELES, CA
SITE 3
El vs flp (1984 - 1991)
TOTAL NUMBER OF RECORDS : 16466

FREQUENCY OF OCCURRANCE TABLE

TOTAL ENERGY (CM2)	PERIOD (SEC) 512	256	170	128	102	85	73	64 - 34.1	32 - 20.4	TOTALS
5.0	0.0745	0.0018	0.1074	0.3298	0.0000	0.0381	0.3071	0.0601	0.0248	0.9438
10.0	0.0022	0.0001	0.0064	0.0199	0.0000	0.0010	0.0086	0.0004	0.0007	0.0393
15.0	0.0009	0.0002	0.0015	0.0046	0.0000	0.0003	0.0016	0.0001	0.0000	0.0090
20.0	0.0005	0.0000	0.0009	0.0011	0.0000	0.0001	0.0002	0.0000	0.0000	0.0028
25.0	0.0004	0.0000	0.0002	0.0008	0.0000	0.0000	0.0002	0.0000	0.0000	0.0016
30.0	0.0004	0.0001	0.0001	0.0005	0.0000	0.0000	0.0001	0.0000	0.0000	0.0011
35.0	0.0002	0.0000	0.0001	0.0003	0.0000	0.0000	0.0001	0.0000	0.0000	0.0006
40.0	0.0001	0.0000	0.0001	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003
45.0	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0001
50.0	0.0004	0.0001	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0005
55.0	0.0001	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002
60.0	0.0001	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003
65.0	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
70.0	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
75.0	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
>80.0	0.0001	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002
TOTALS	0.0800	0.0022	0.1167	0.3575	0.0000	0.0395	0.3179	0.0605	0.0255	

LOS ANGELES, CA
SITE 4
El vs flp (1984 - 1991)
TOTAL NUMBER OF RECORDS : 25197

FREQUENCY OF OCCURRANCE TABLE

TOTAL ENERGY (CM2)	PERIOD (SEC) 512	256	170	128	102	85	73	64 - 34.1	32 - 20.4	TOTALS
5.0	0.0137	0.0209	0.0916	0.0030	0.3113	0.0040	0.2022	0.2163	0.0779	0.9409
10.0	0.0002	0.0120	0.0033	0.0002	0.0135	0.0001	0.0036	0.0035	0.0006	0.0370
15.0	0.0000	0.0069	0.0005	0.0001	0.0021	0.0000	0.0003	0.0001	0.0000	0.0100
20.0	0.0000	0.0052	0.0001	0.0000	0.0004	0.0000	0.0000	0.0000	0.0000	0.0057
25.0	0.0000	0.0029	0.0002	0.0000	0.0002	0.0000	0.0000	0.0000	0.0000	0.0032
30.0	0.0000	0.0010	0.0001	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0012
35.0	0.0000	0.0007	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0008
40.0	0.0000	0.0005	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0005
45.0	0.0000	0.0002	0.0001	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0003
50.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
55.0	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
60.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
65.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
70.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
75.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
>80.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TOTALS	0.0139	0.0504	0.0960	0.0035	0.3277	0.0041	0.2062	0.2199	0.0784	

LONG BEACH, CA
SITE 1
El vs flp (1984 - 1991)
TOTAL NUMBER OF RECORDS : 21303

FREQUENCY OF OCCURRANCE TABLE

TOTAL ENERGY (CM2)	PERIOD (SEC) 512	256	170	128	102	85	73	64 - 34.1	32 - 20.4	TOTALS
5.0	0.3700	0.5115	0.0001	0.0000	0.0506	0.0142	0.0020	0.0291	0.0013	0.9788
10.0	0.0009	0.0149	0.0000	0.0000	0.0008	0.0001	0.0000	0.0000	0.0000	0.0168
15.0	0.0001	0.0020	0.0000	0.0000	0.0002	0.0000	0.0000	0.0000	0.0000	0.0023
20.0	0.0000	0.0006	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0007
25.0	0.0000	0.0005	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0005
30.0	0.0000	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003
35.0	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
40.0	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
45.0	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
50.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
55.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
60.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
65.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
70.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
75.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
>80.0	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
TOTALS	0.3711	0.5303	0.0002	0.0000	0.0517	0.0143	0.0020	0.0291	0.0013	

LONG BEACH, CA
SITE 2
El vs flp (1984 - 1991)
TOTAL NUMBER OF RECORDS : 33952

FREQUENCY OF OCCURRANCE TABLE

TOTAL ENERGY (CM2)	PERIOD (SEC) 512	256	170	128	102	85	73	64 - 34.1	32 - 20.4	TOTALS
5.0	0.2696	0.0208	0.0234	0.0000	0.0001	0.0124	0.6309	0.0257	0.0051	0.9879
10.0	0.0003	0.0002	0.0011	0.0000	0.0000	0.0004	0.0066	0.0001	0.0001	0.0087
15.0	0.0000	0.0000	0.0003	0.0000	0.0000	0.0000	0.0008	0.0001	0.0001	0.0013
20.0	0.0000	0.0001	0.0003	0.0000	0.0000	0.0000	0.0003	0.0001	0.0000	0.0008
25.0	0.0000	0.0000	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000	0.0005
30.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
35.0	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0002
40.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0002
45.0	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
50.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
55.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
60.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
65.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
70.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
75.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
>80.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TOTALS	0.2699	0.0212	0.0254	0.0001	0.0001	0.0128	0.6390	0.0261	0.0053	

LONG BEACH, CA
SITE 4
El vs flp (1984 - 1991)
TOTAL NUMBER OF RECORDS : 23561

FREQUENCY OF OCCURRANCE TABLE

TOTAL ENERGY (CM2)	PERIOD (SEC) 512	256	170	128	102	85	73	64 - 34.1	32 - 20.4	TOTALS
5.0	0.1692	0.0111	0.4319	0.0011	0.0000	0.0095	0.0000	0.3657	0.0079	0.9964
10.0	0.0000	0.0000	0.0025	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0025
15.0	0.0000	0.0000	0.0006	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0006
20.0	0.0000	0.0000	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003
25.0	0.0000	0.0000	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002
30.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
35.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
40.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
45.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
50.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
55.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
60.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
65.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
70.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
75.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
>80.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TOTALS	0.1692	0.0111	0.4353	0.0011	0.0000	0.0095	0.0000	0.3658	0.0079	

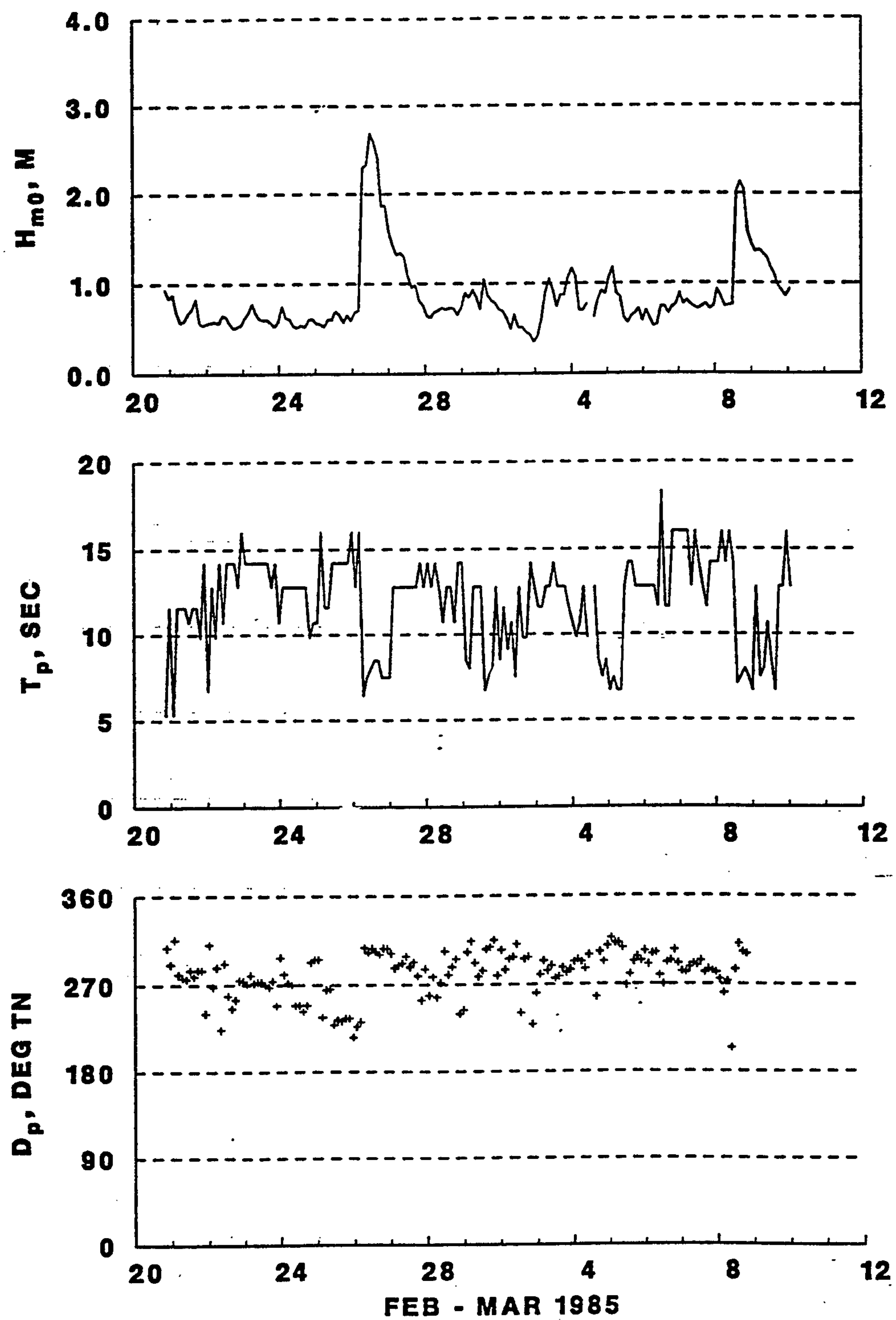
LONG BEACH, CA
SITE 5
El vs flp (1984 - 1991)
TOTAL NUMBER OF RECORDS : 26815

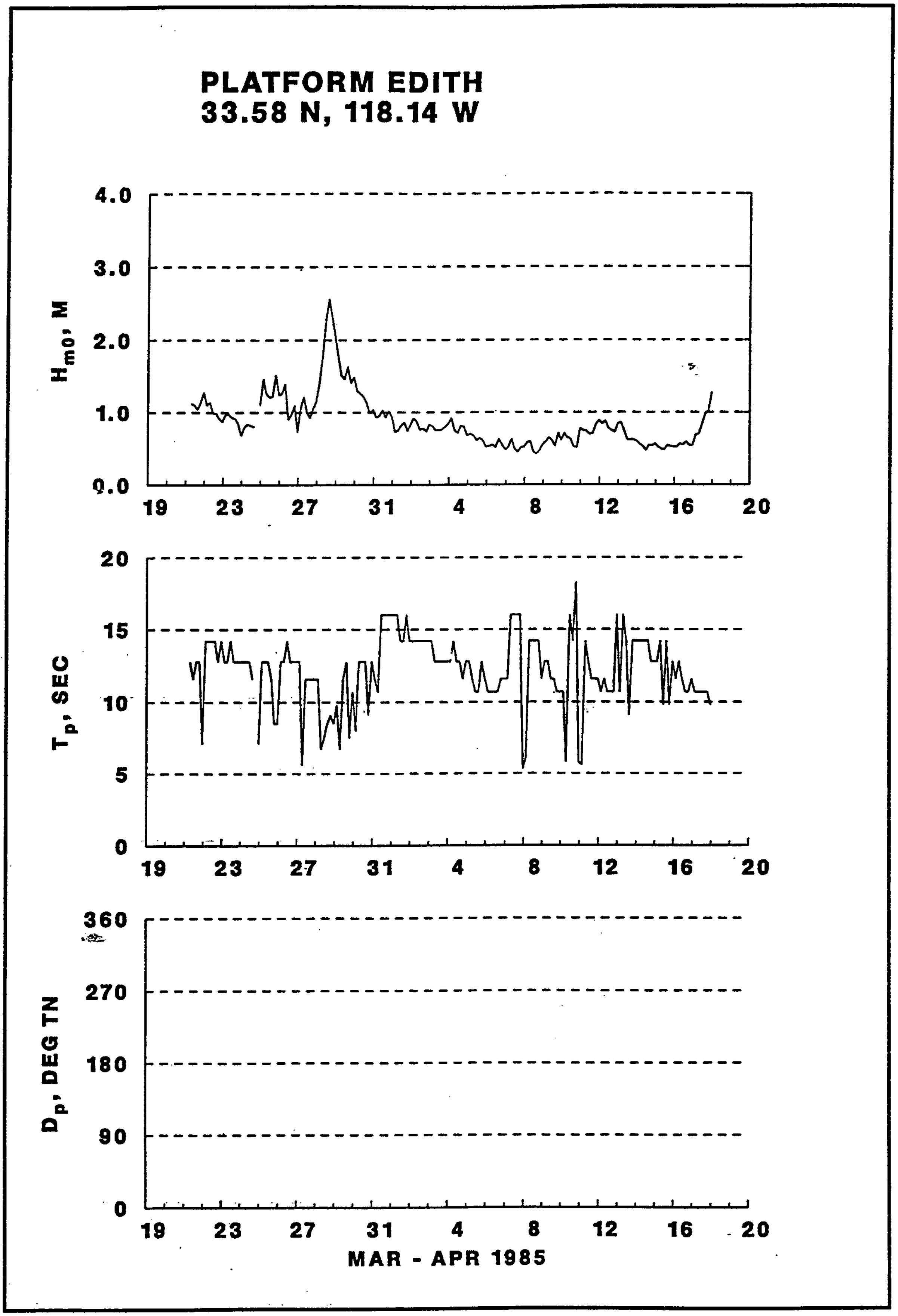
FREQUENCY OF OCCURRANCE TABLE

TOTAL ENERGY (CM2)	PERIOD (SEC) 512	256	170	128	102	85	73	64 - 34.1	32 - 20.4	TOTALS
5.0	0.4101	0.0004	0.0012	0.0000	0.0000	0.5613	0.0011	0.0035	0.0112	0.9887
10.0	0.0008	0.0001	0.0002	0.0000	0.0000	0.0078	0.0000	0.0000	0.0000	0.0089
15.0	0.0000	0.0000	0.0001	0.0000	0.0000	0.0014	0.0000	0.0000	0.0000	0.0015
20.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0004	0.0000	0.0000	0.0000	0.0004
25.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000	0.0000	0.0002
30.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0001
35.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0001
40.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0001
45.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
50.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
55.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
60.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
65.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
70.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
75.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
>80.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TOTALS	0.4109	0.0005	0.0015	0.0000	0.0000	0.5714	0.0011	0.0035	0.0112	

Appendix D
Platform Edith Plots

PLATFORM EDITH
33.58 N, 118.14 W





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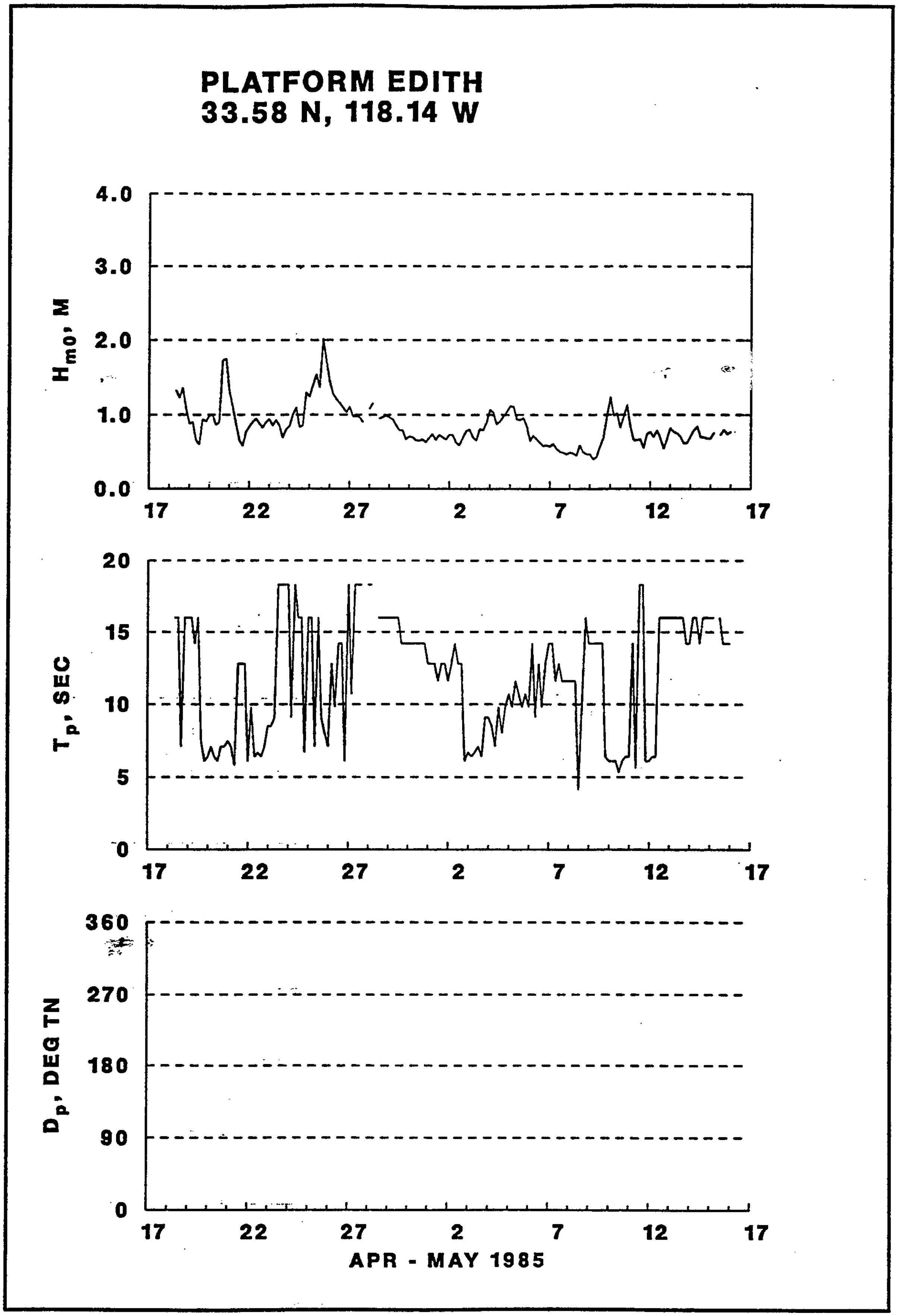
MAR - APR 1985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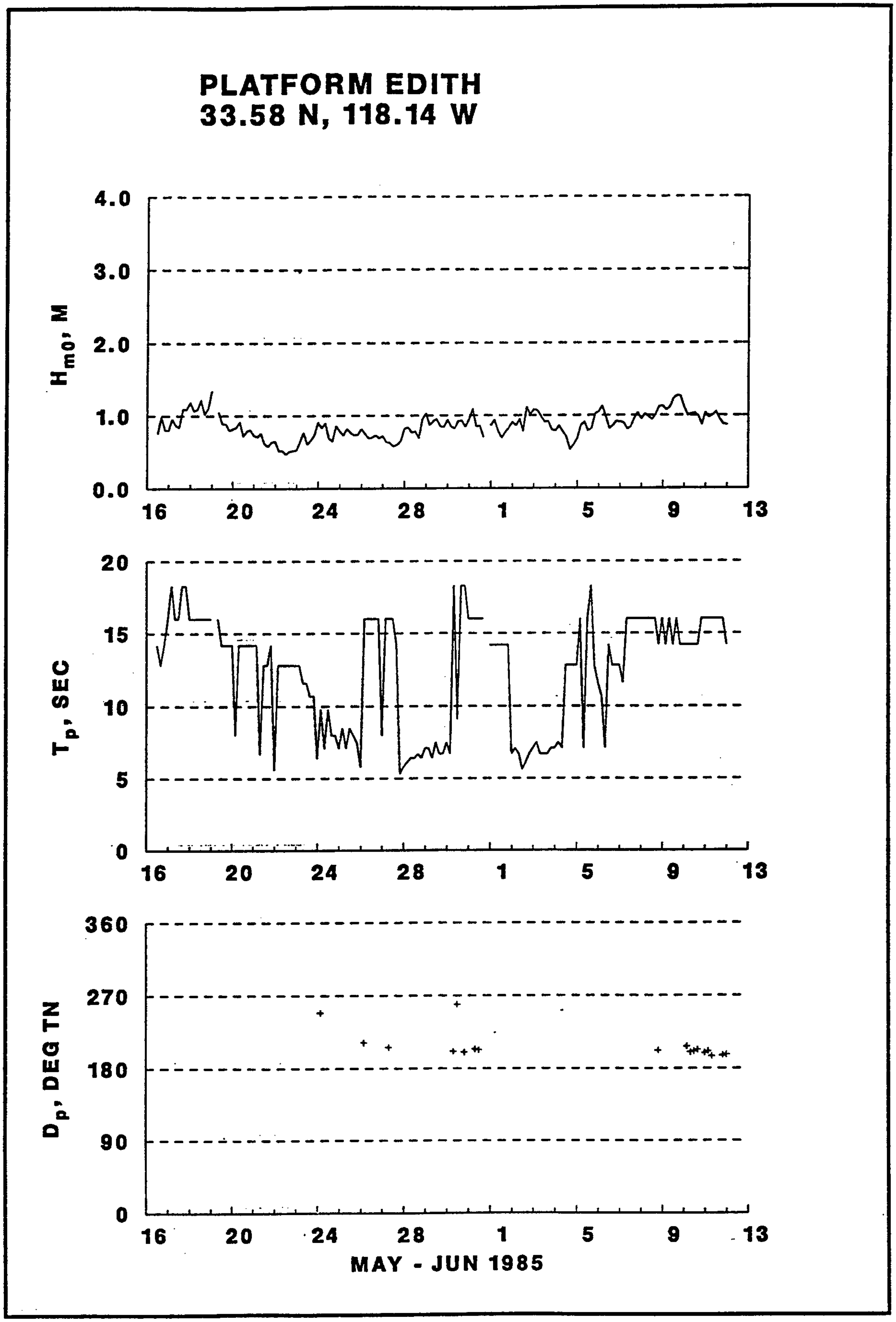
APR - MAY 1985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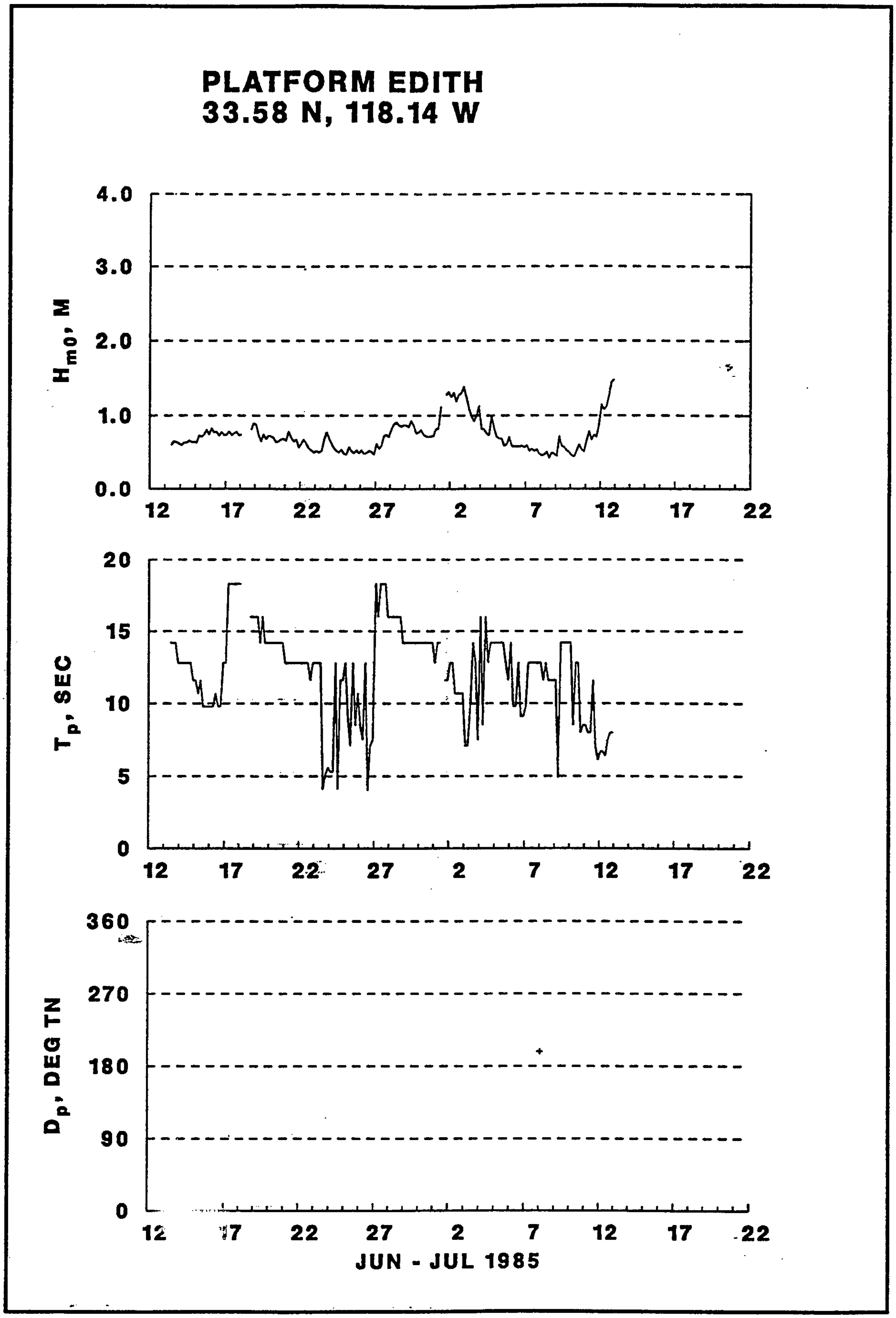

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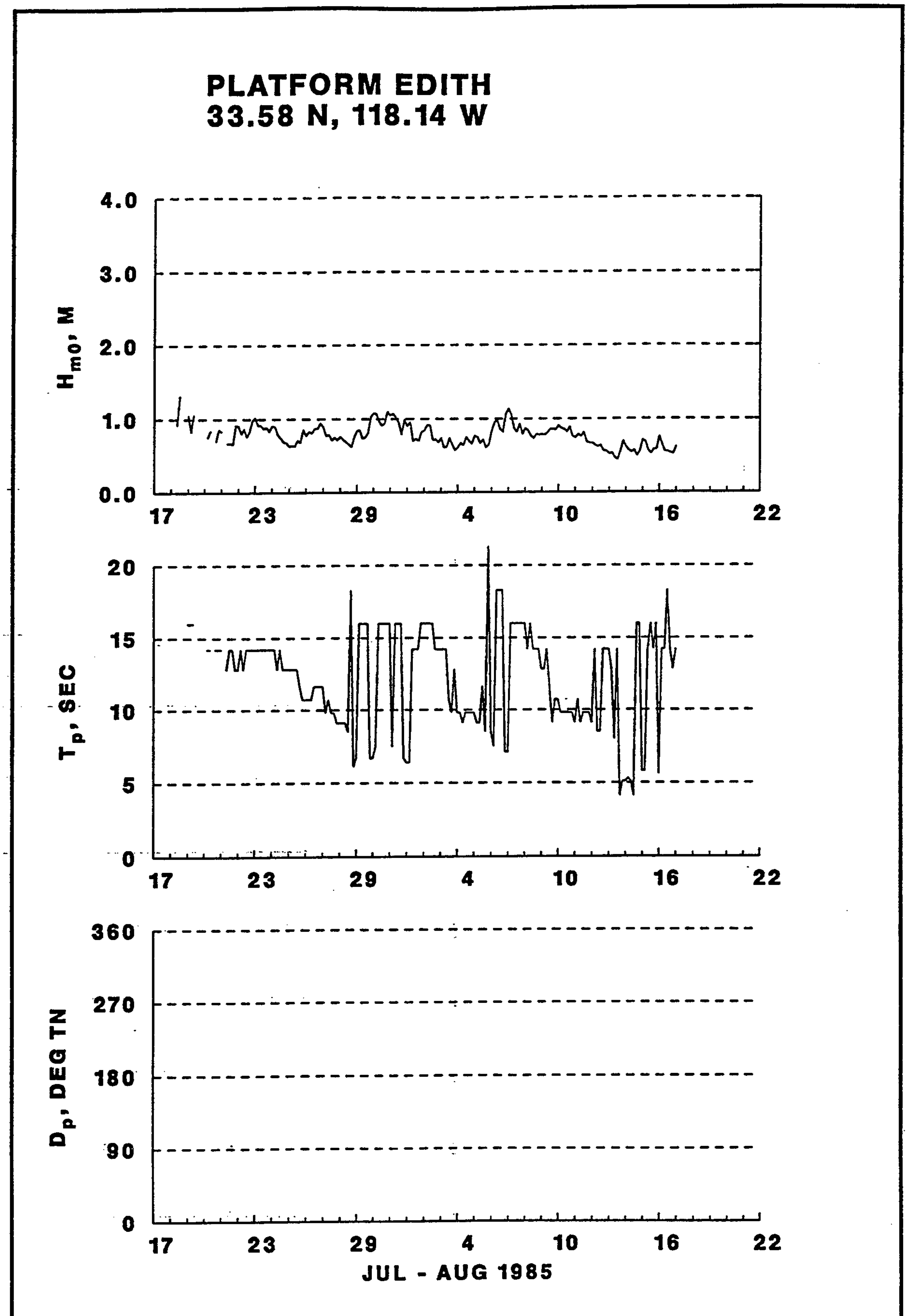

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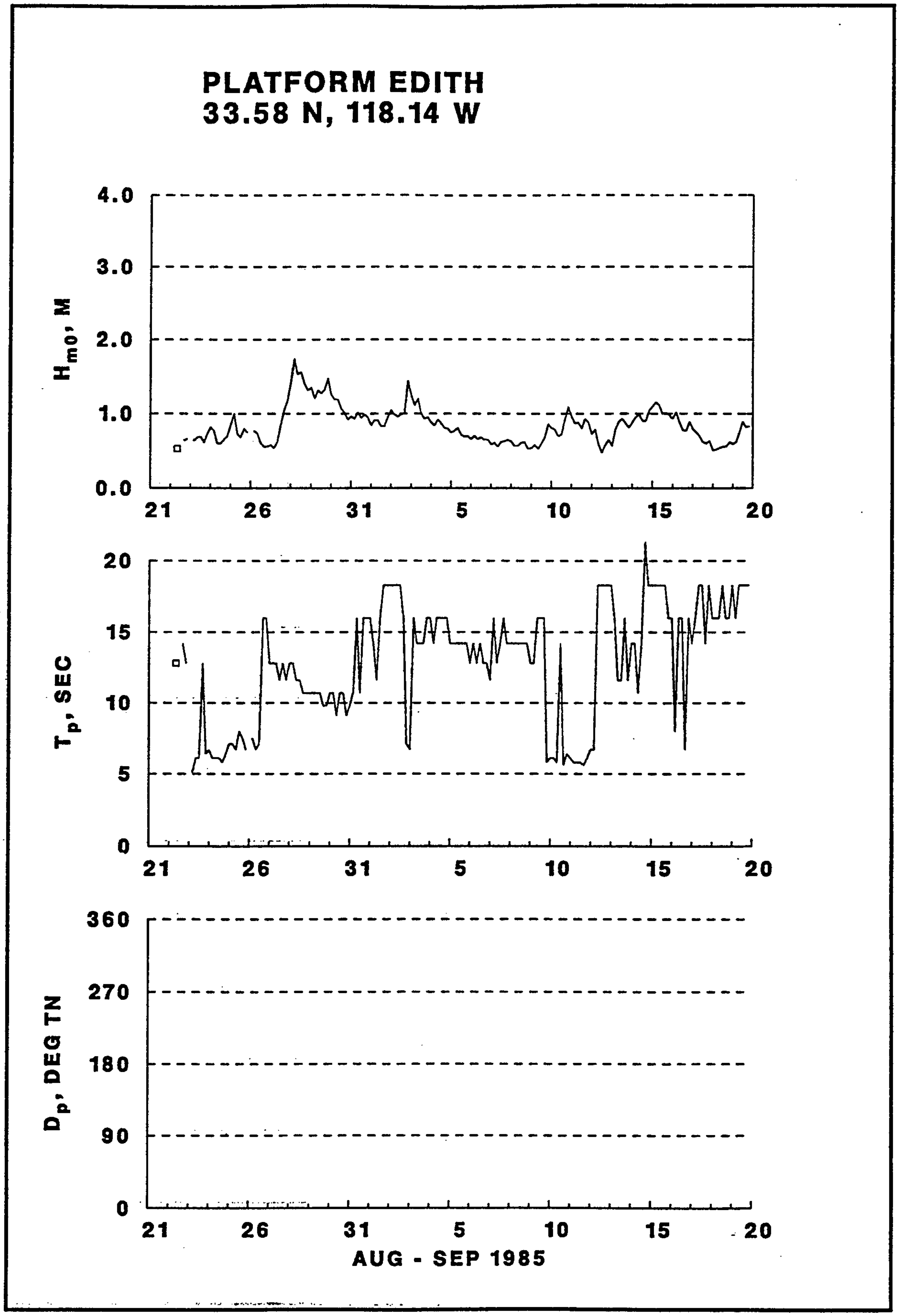
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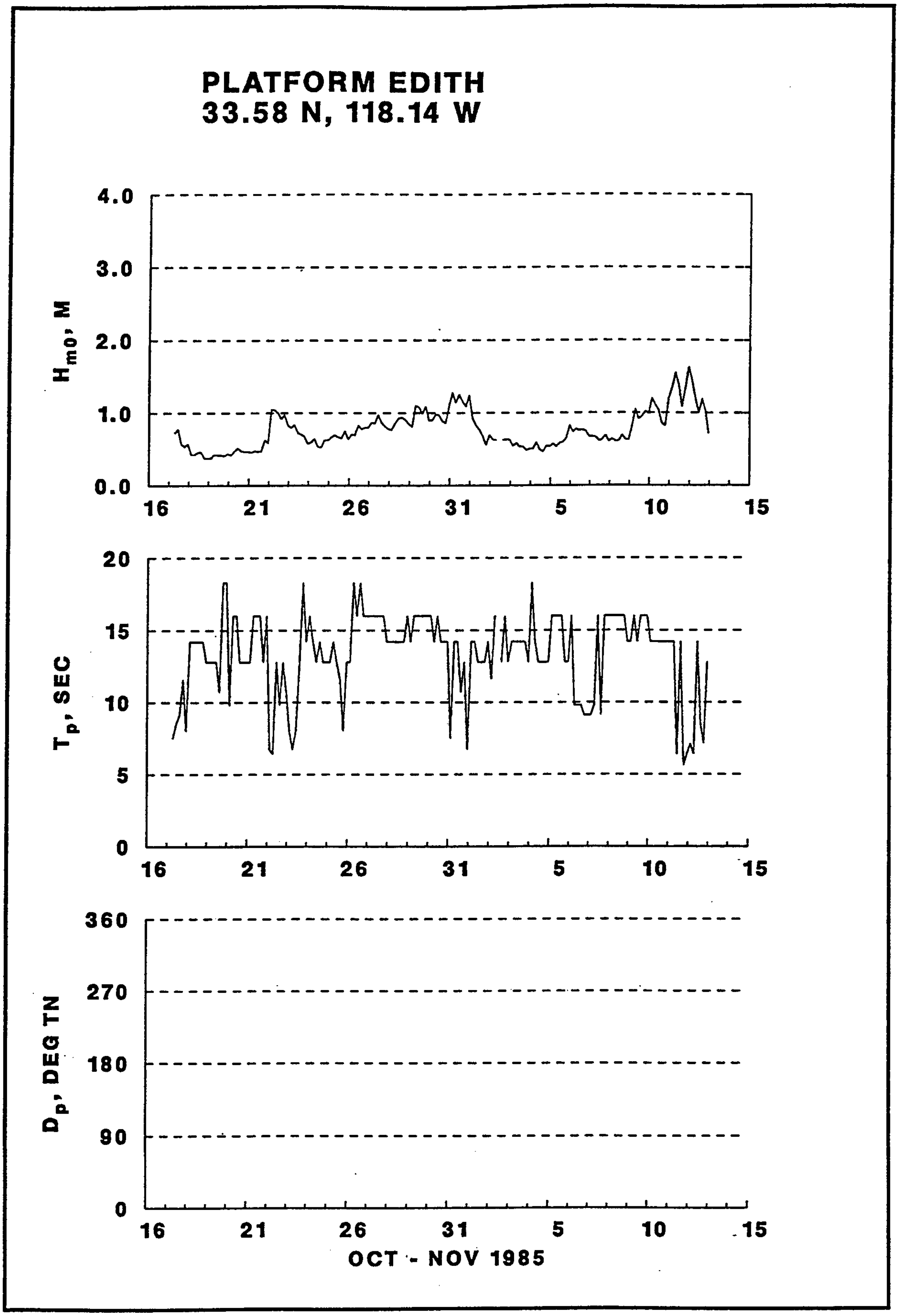
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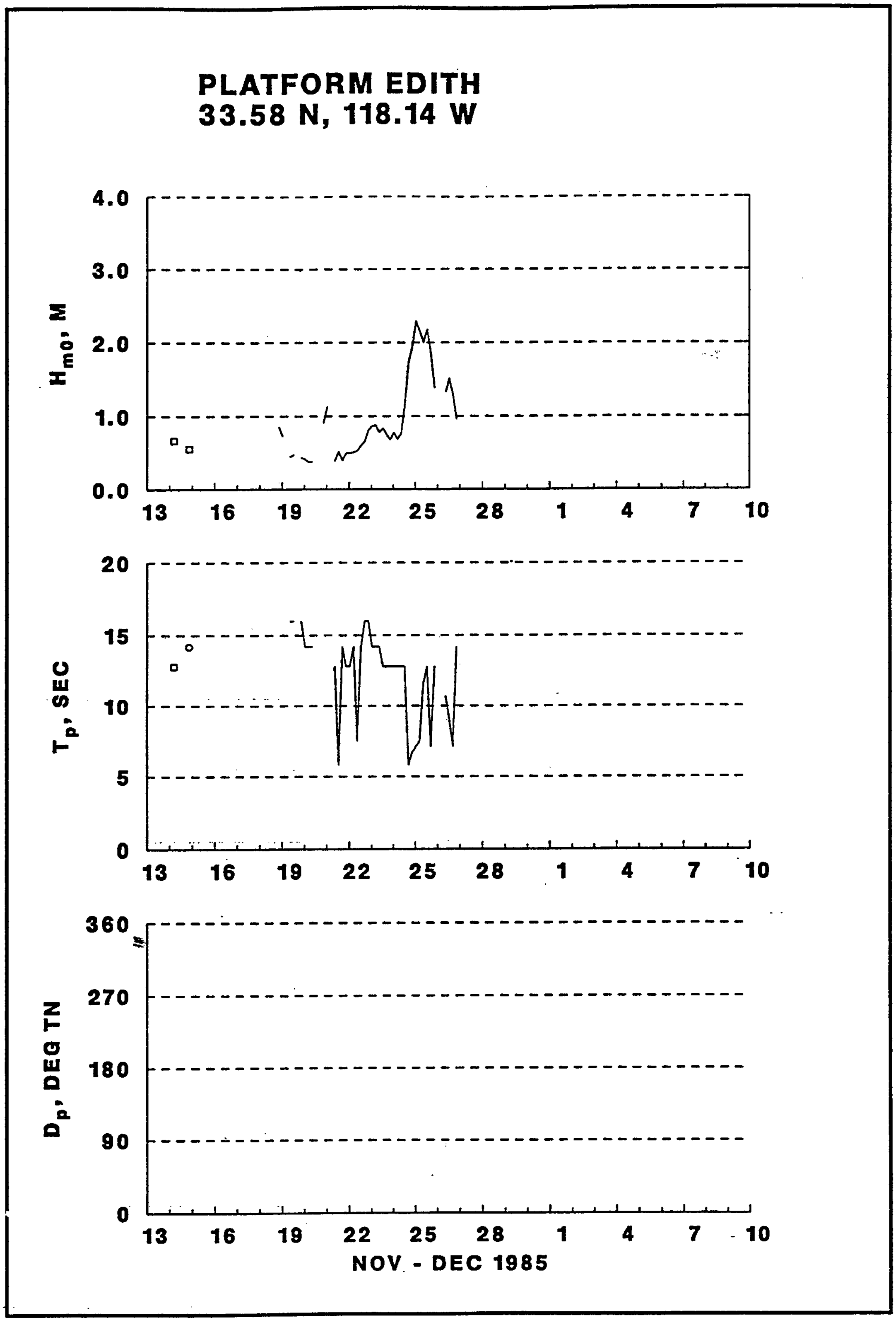
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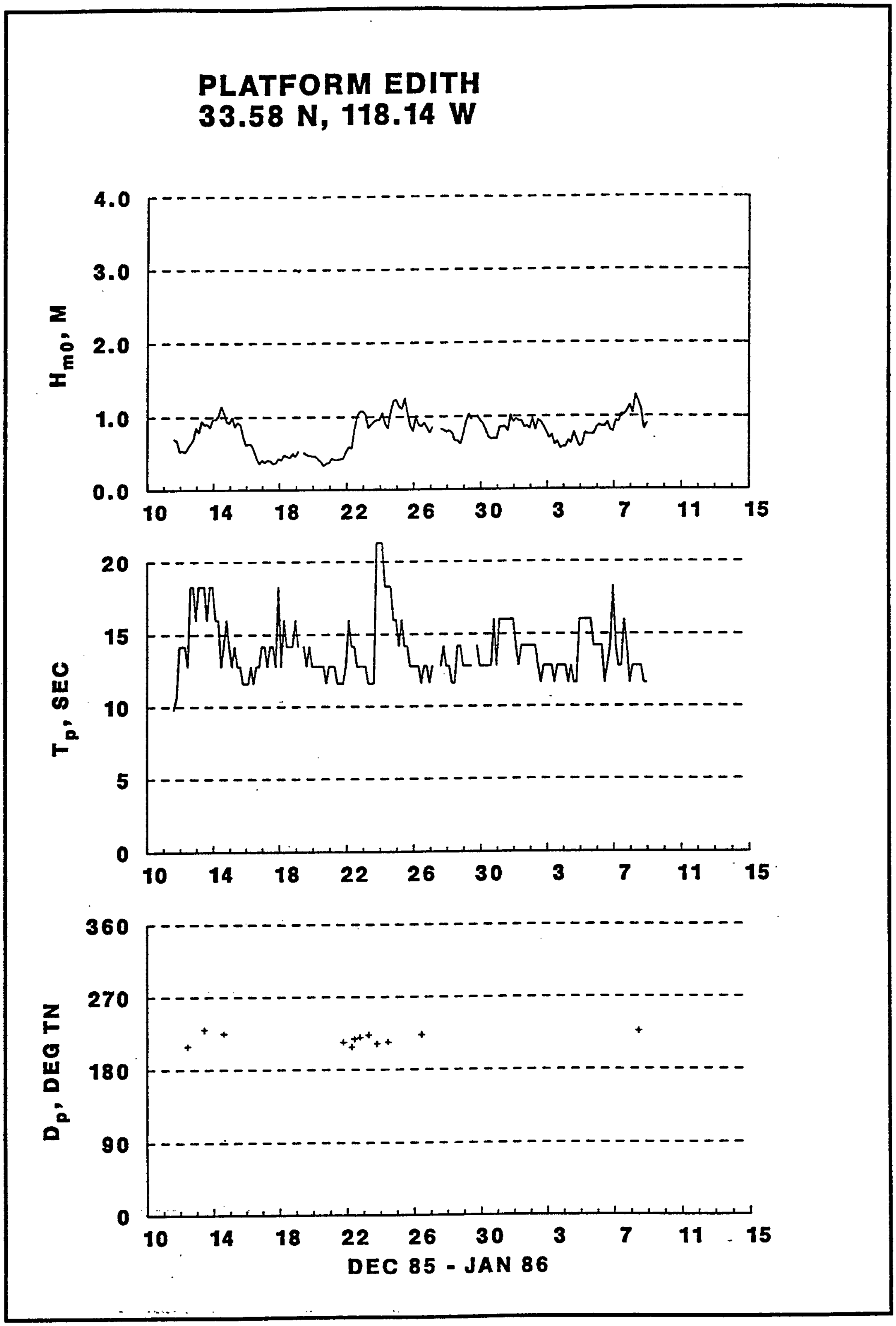
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DEC 85 - JAN 86

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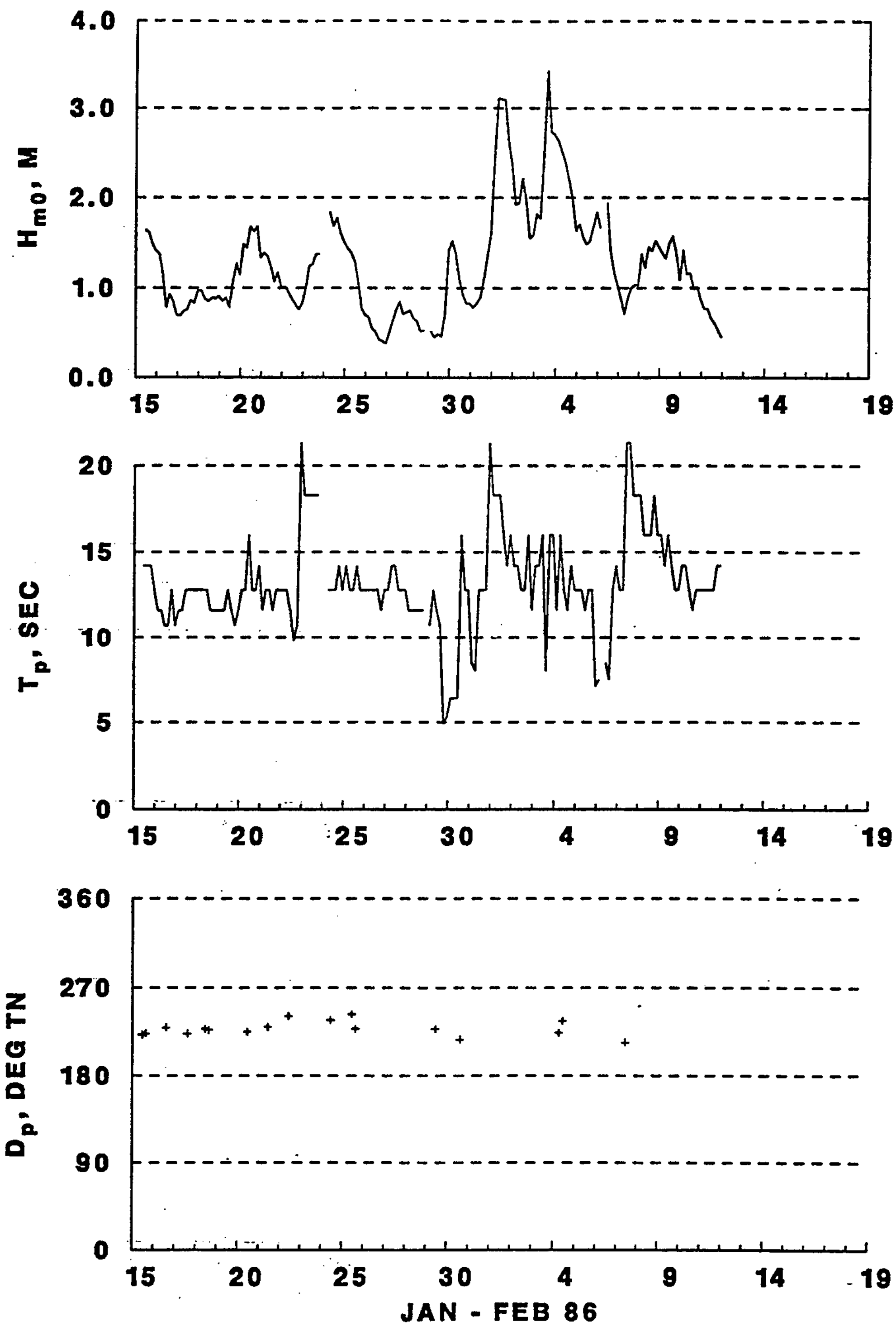

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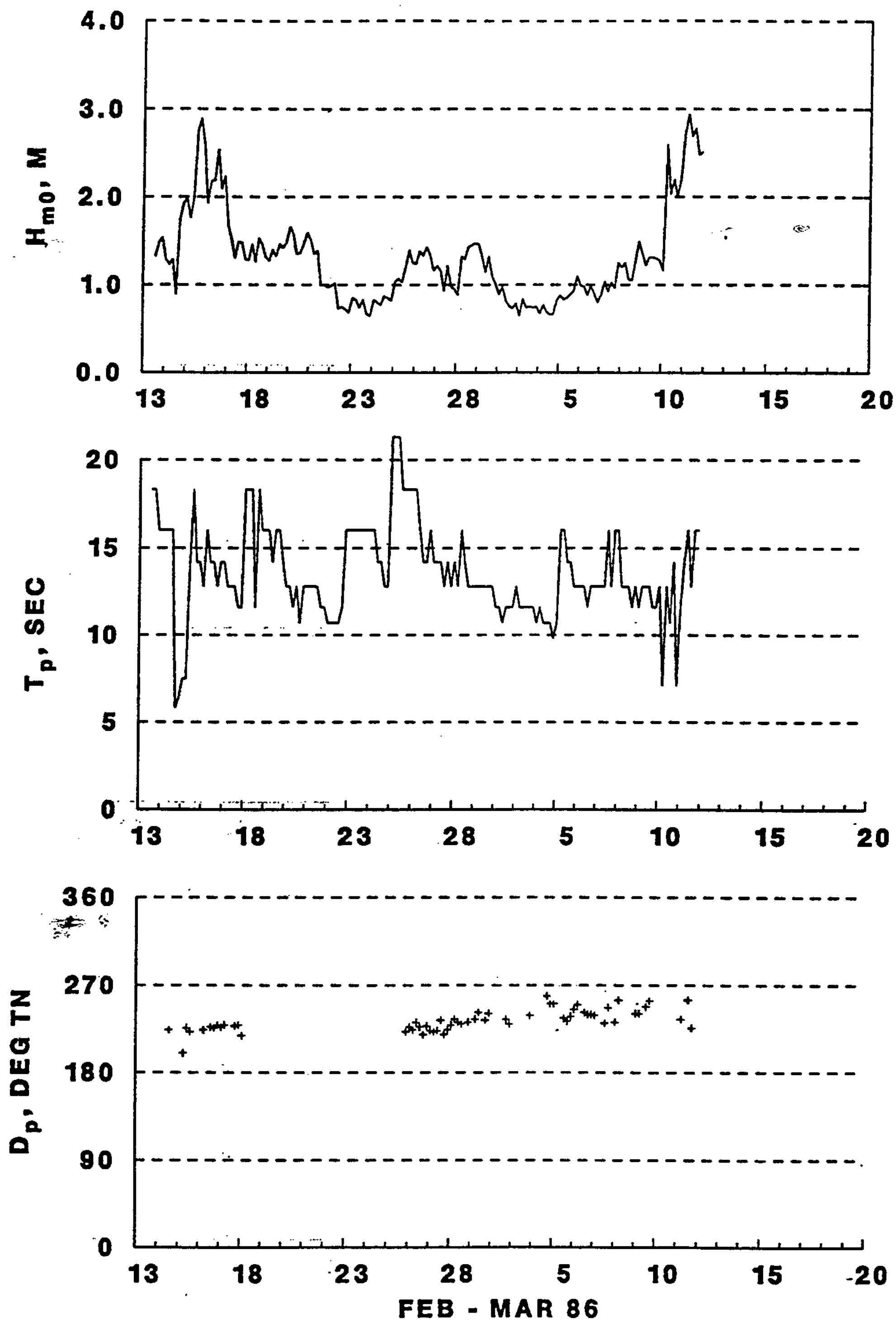

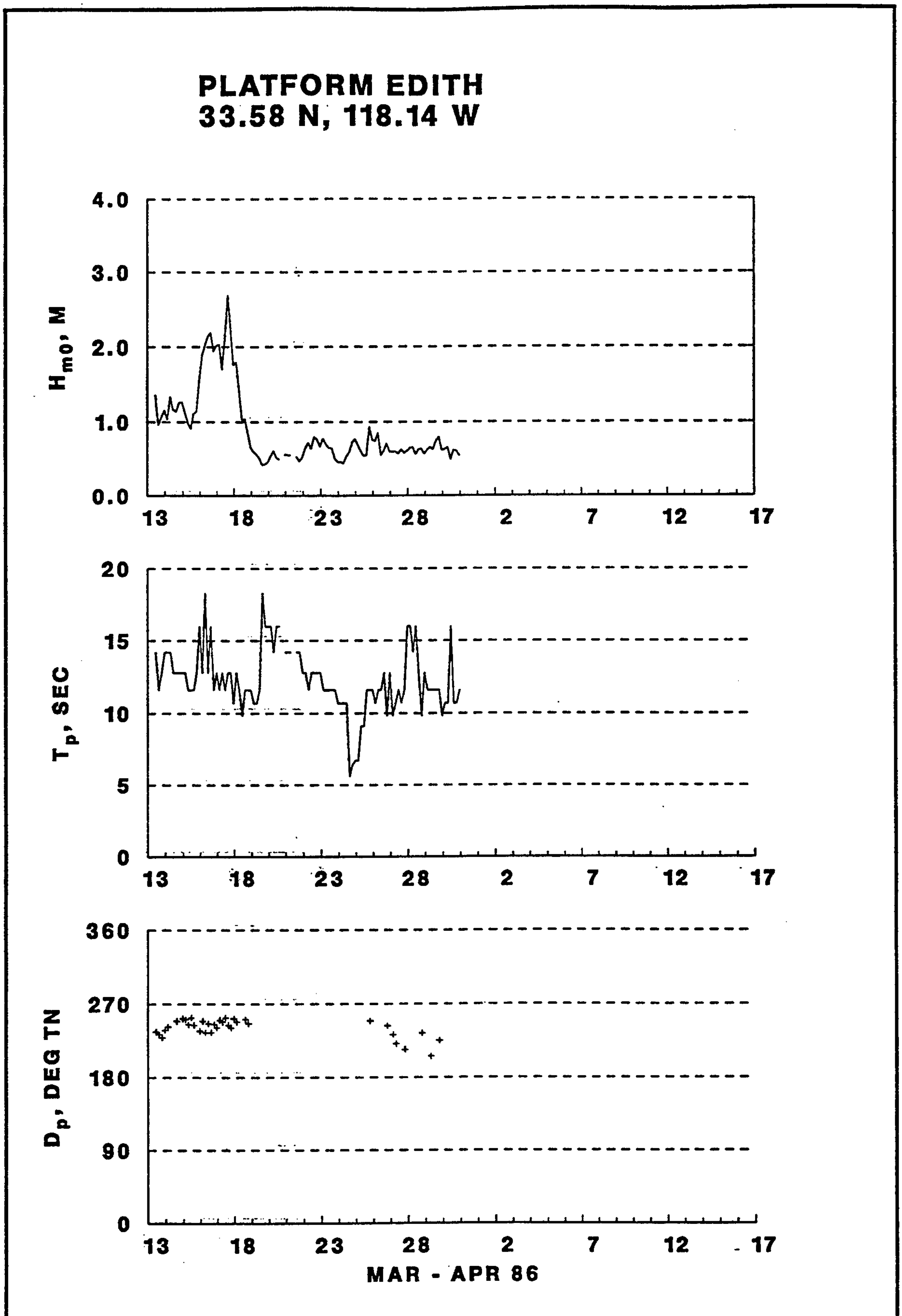
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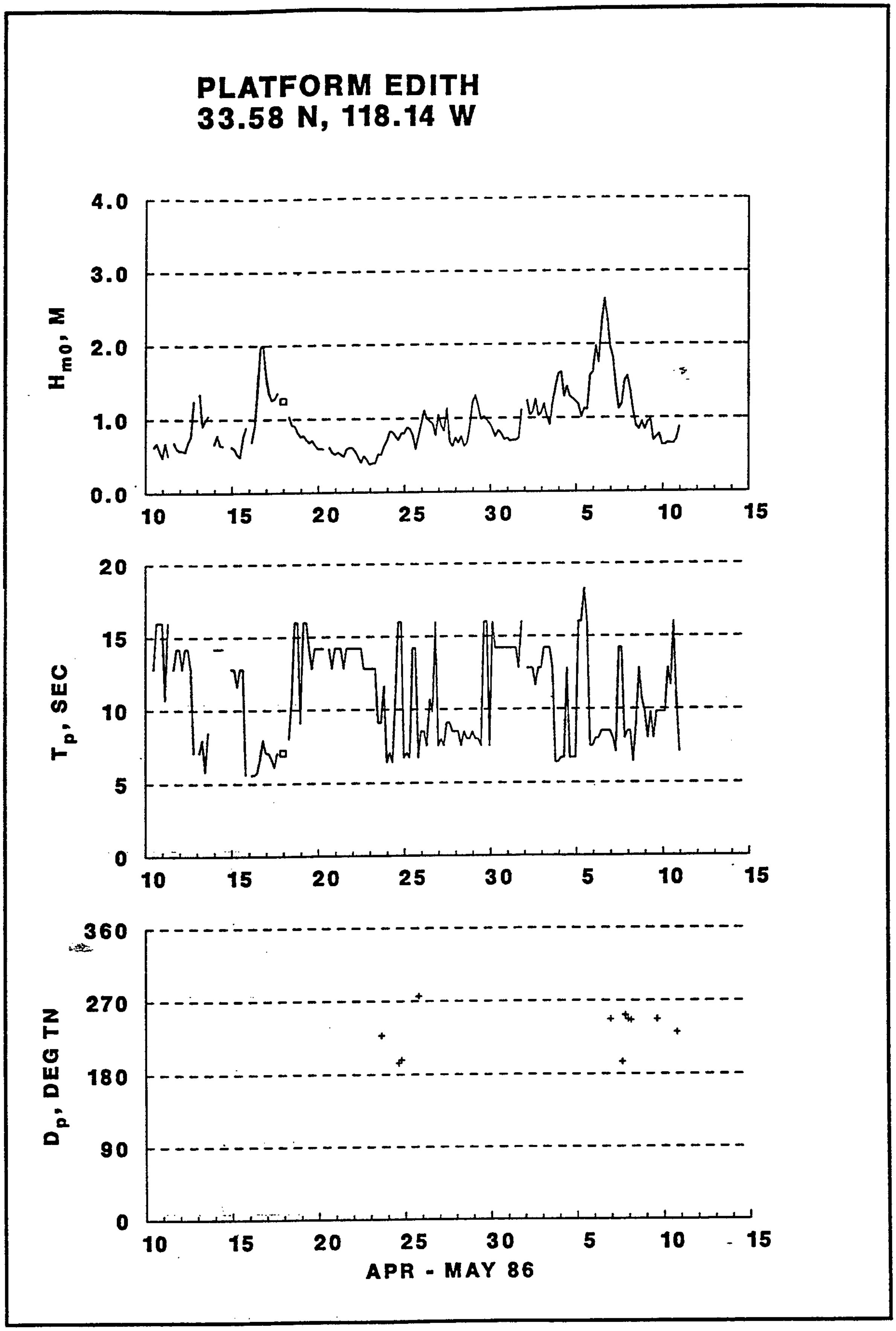
MAR - APR 86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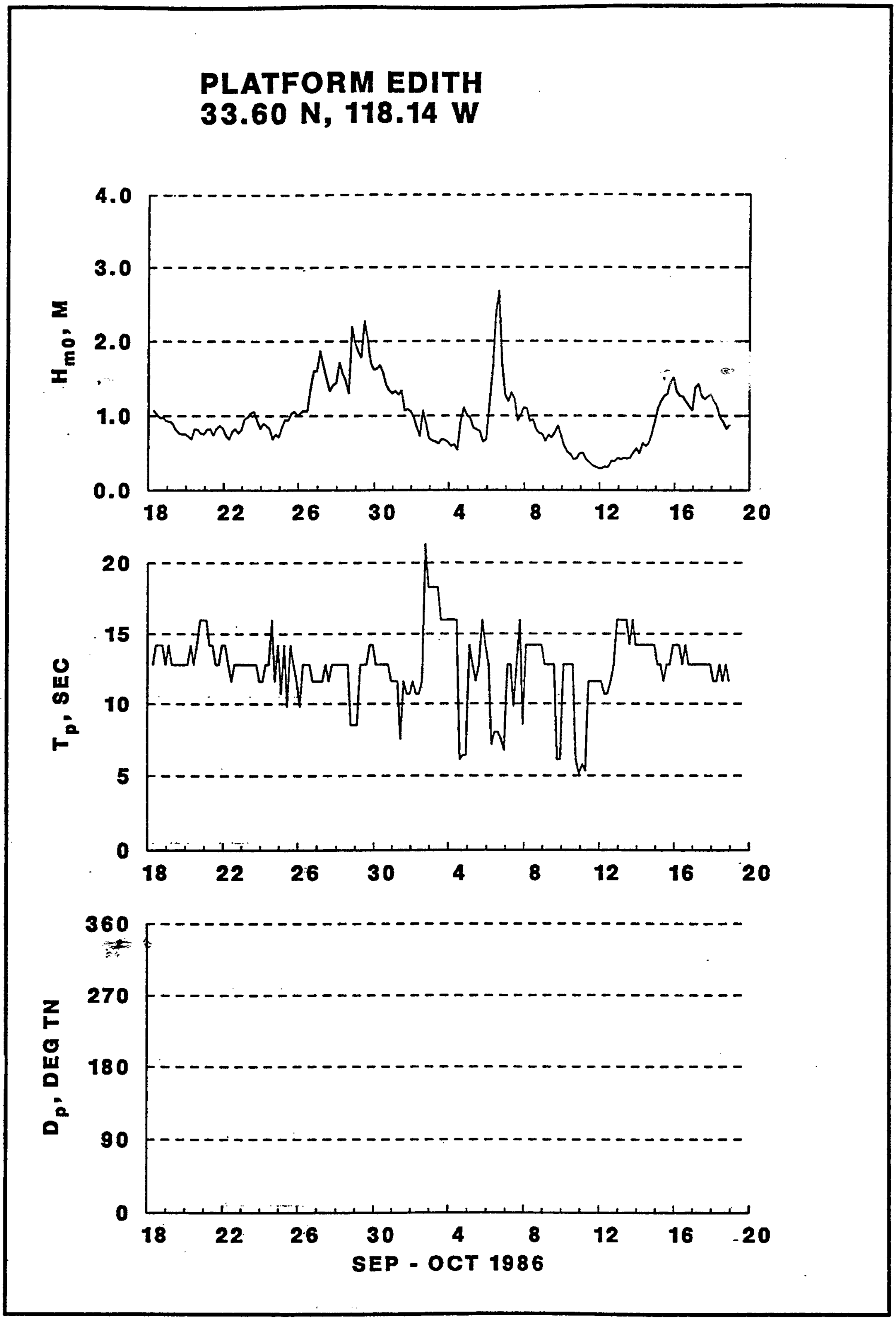
APR - MAY 86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SEP - OCT 1986

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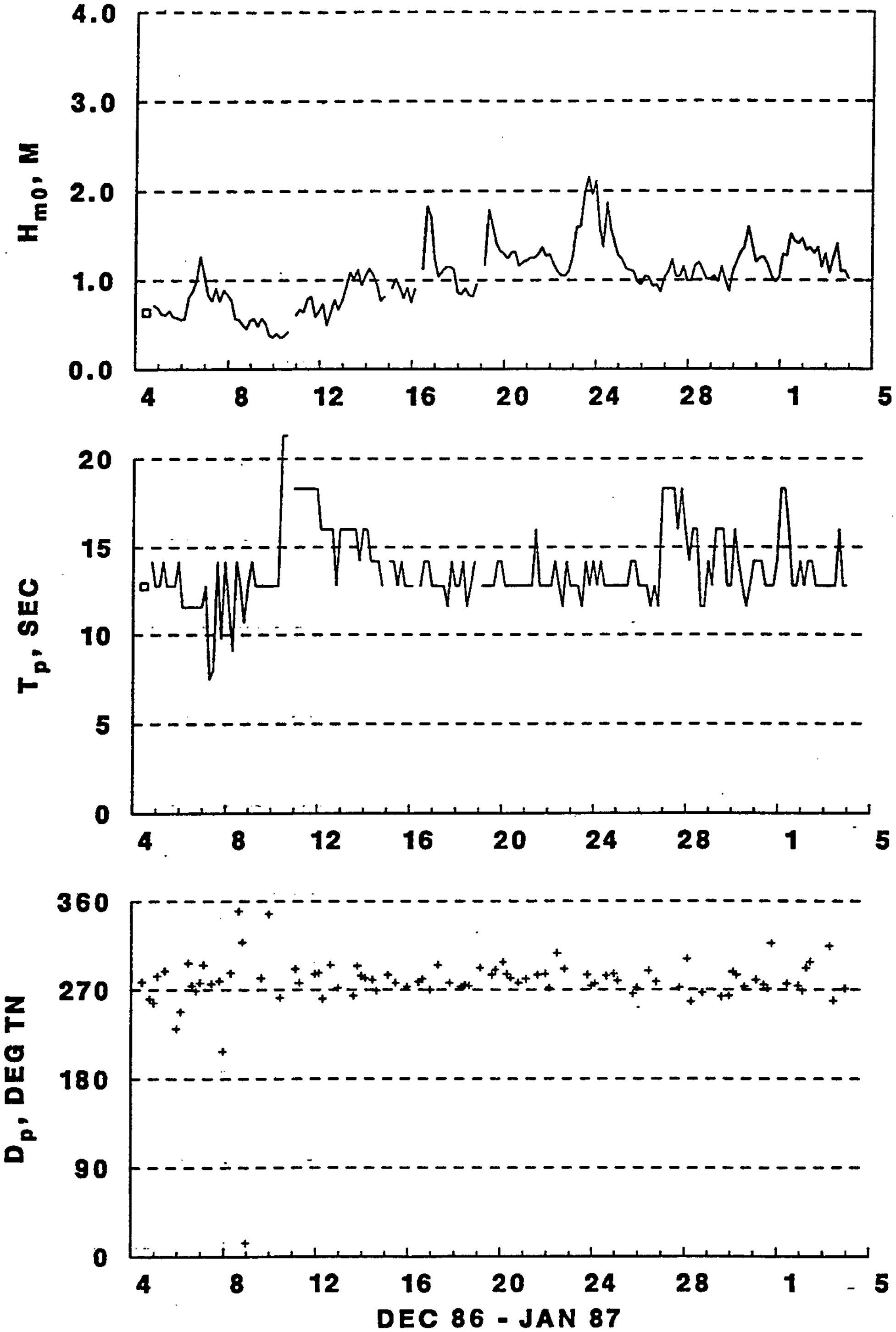

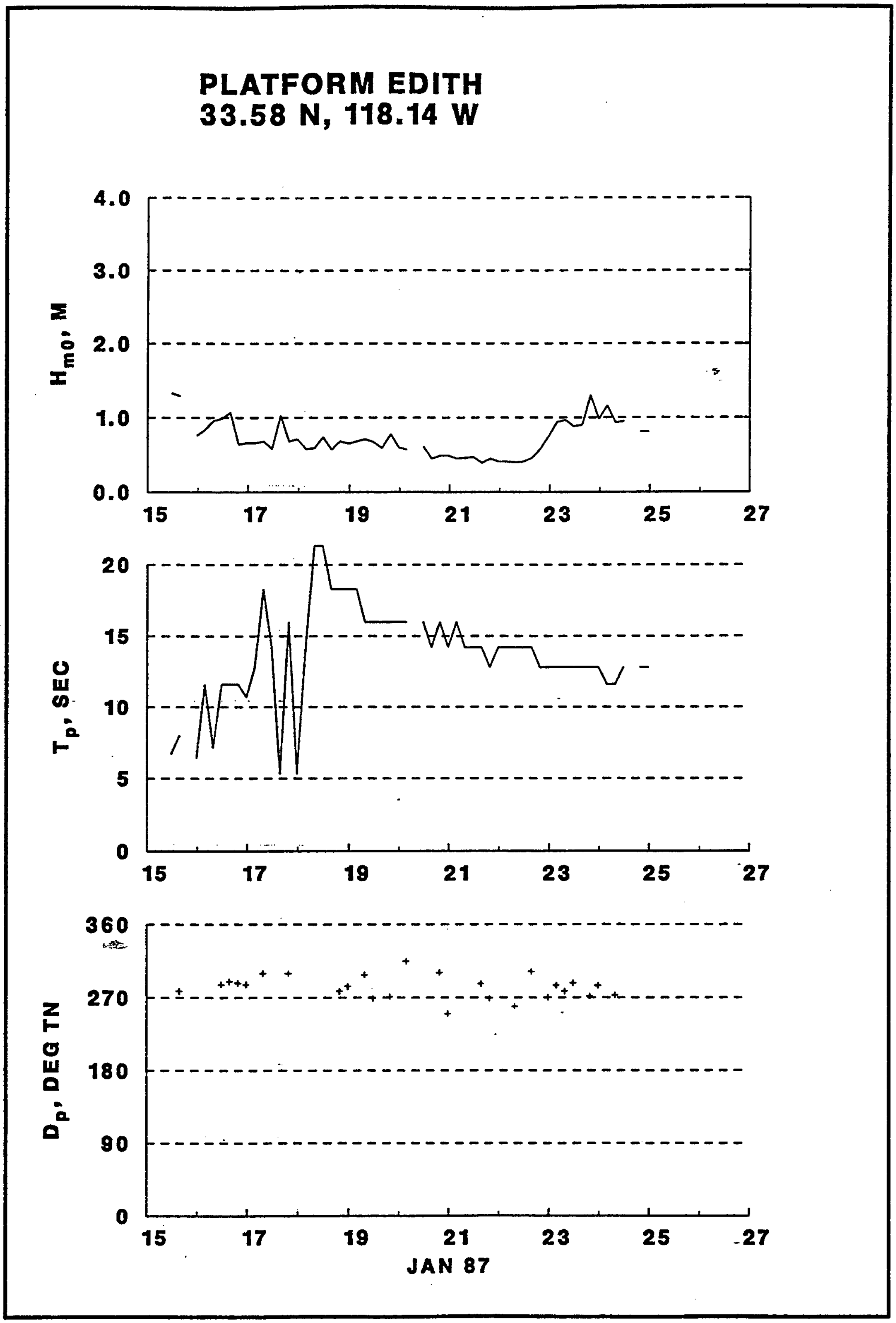
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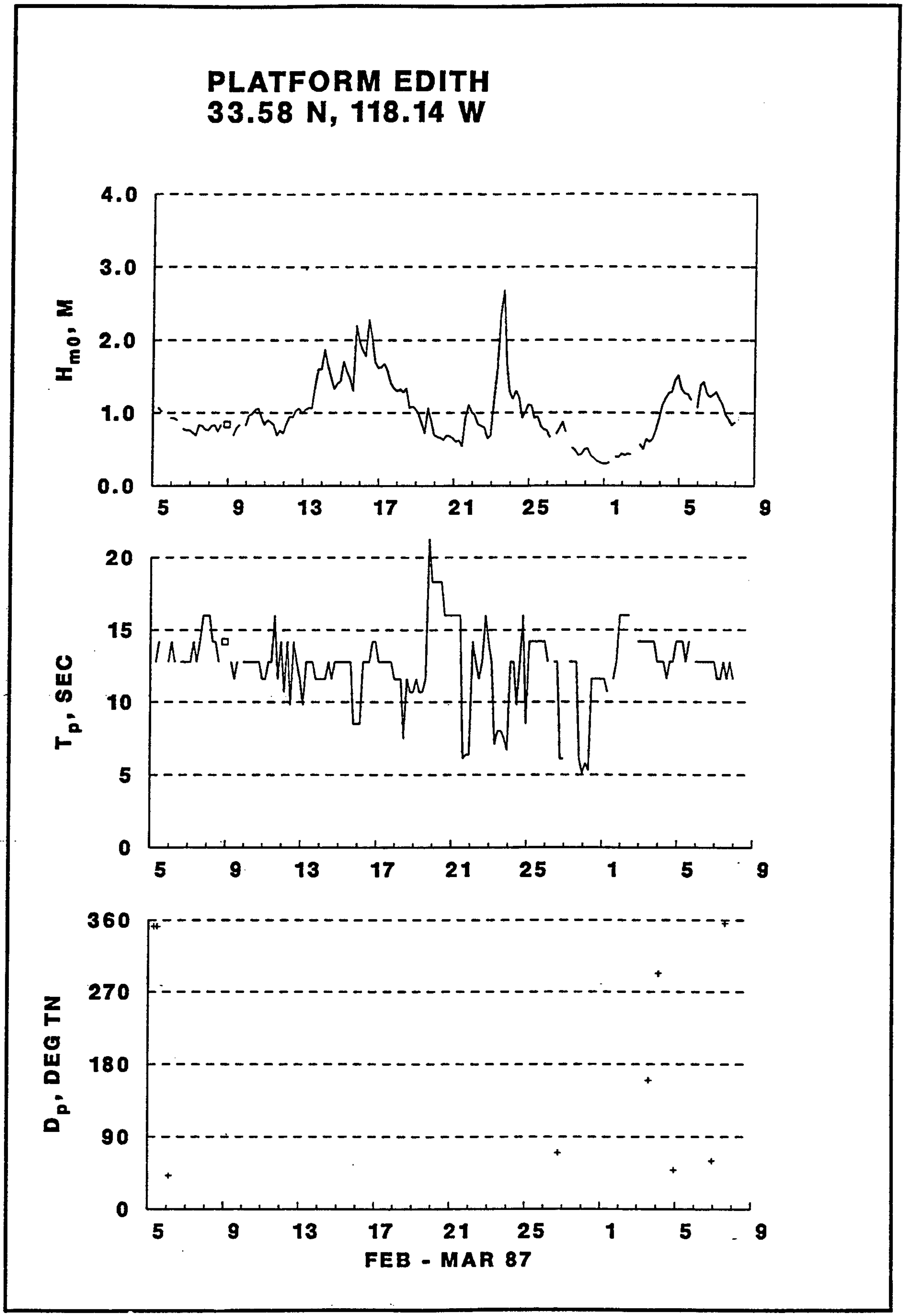
JAN 87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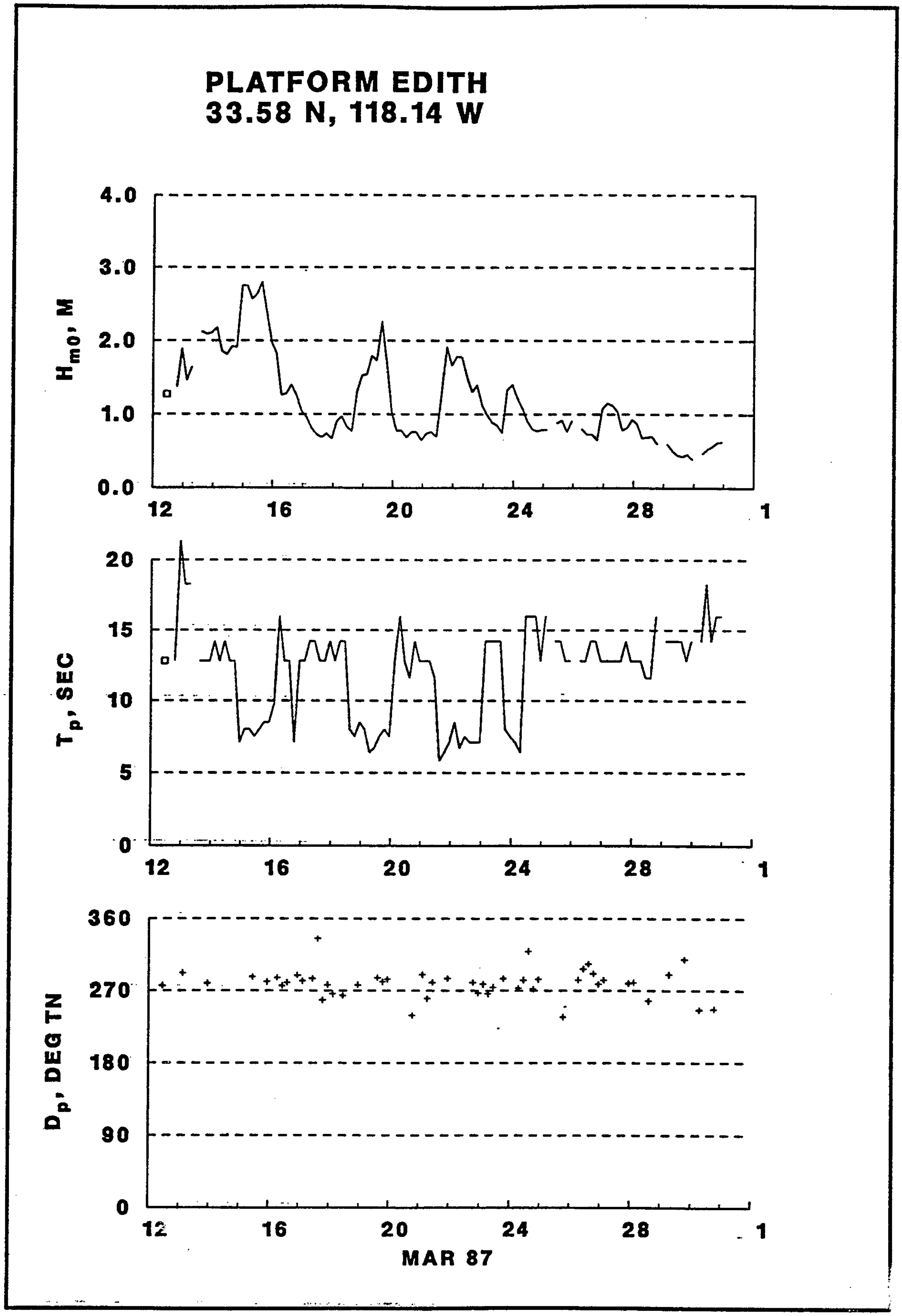
FEB - MAR 87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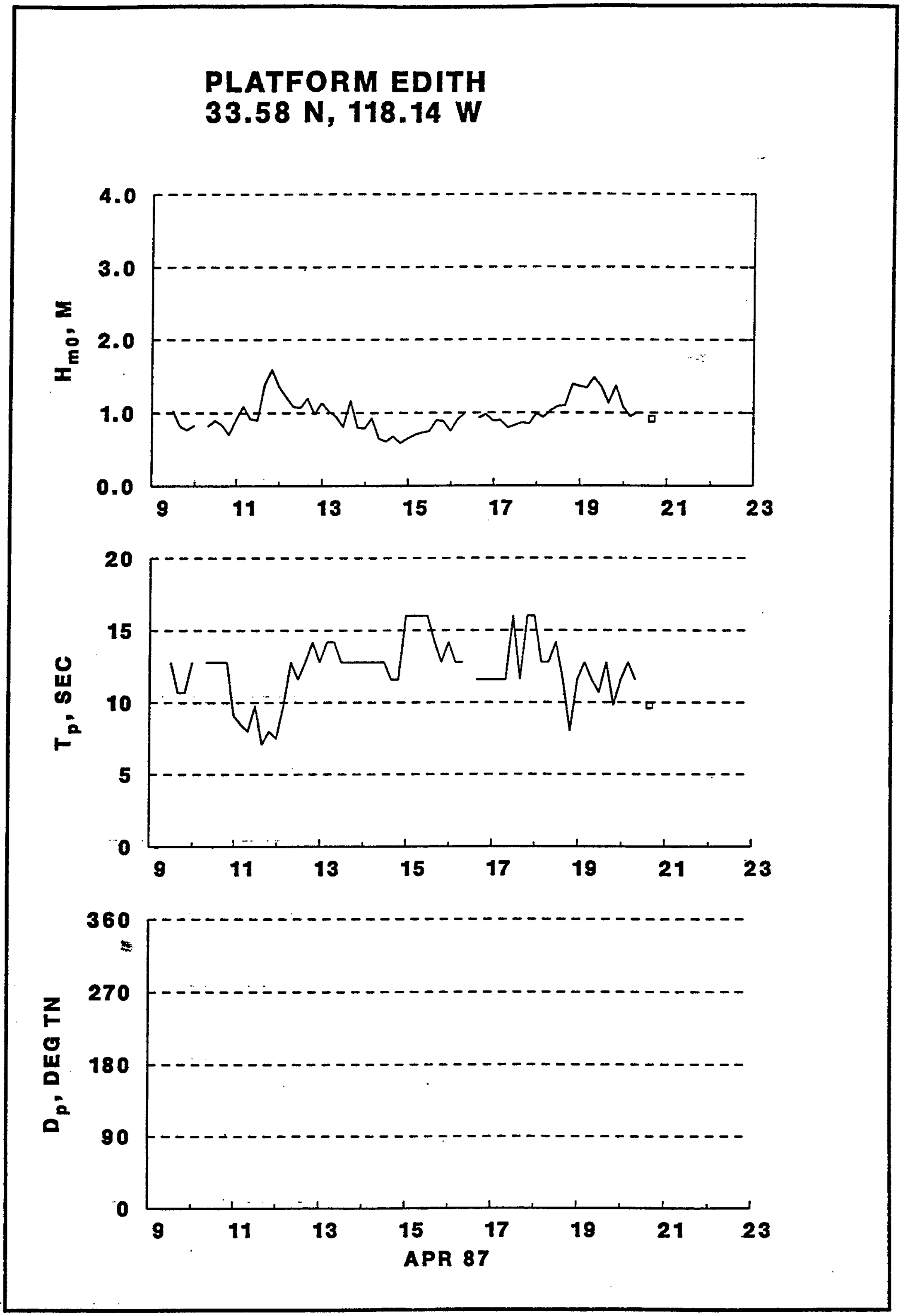

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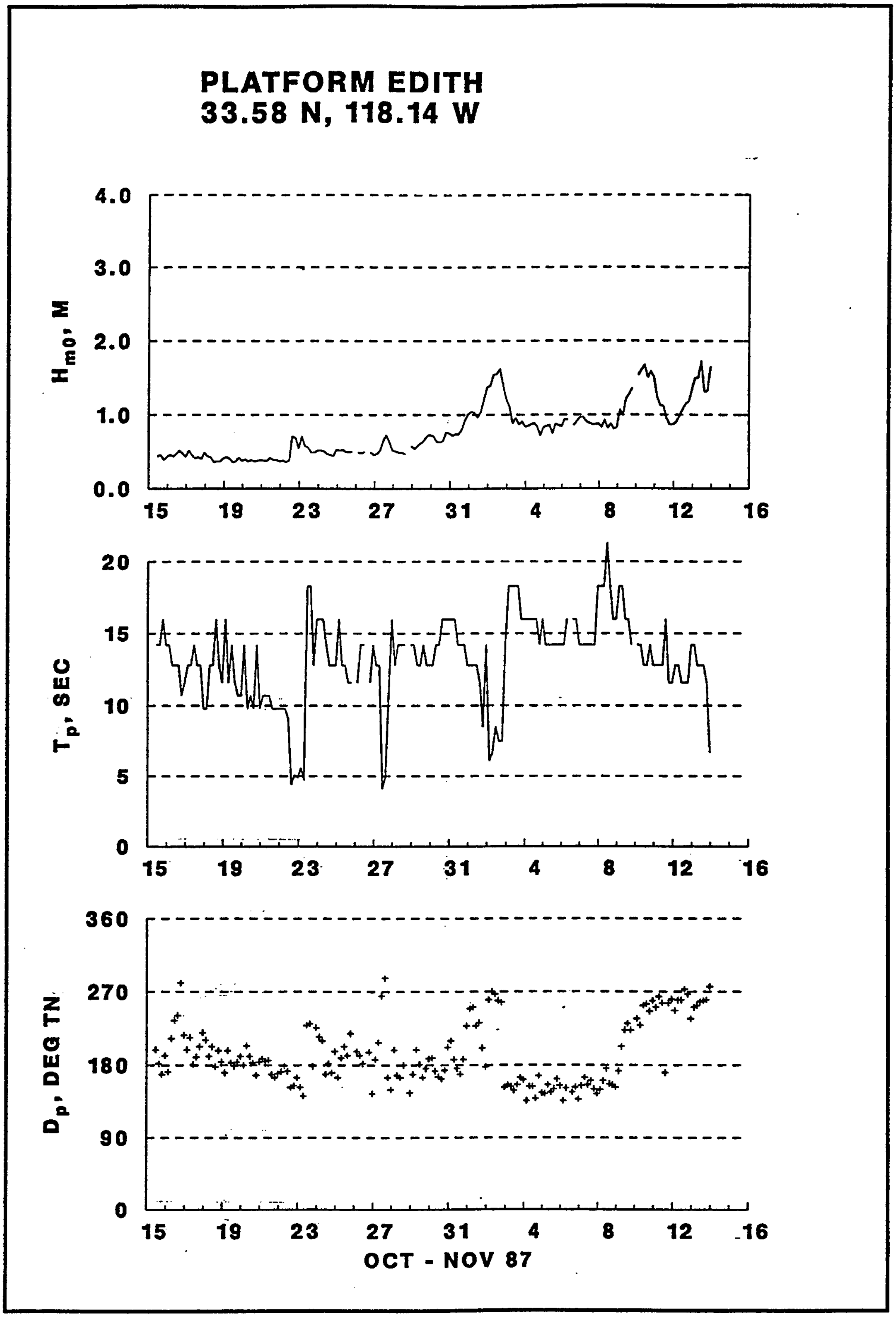
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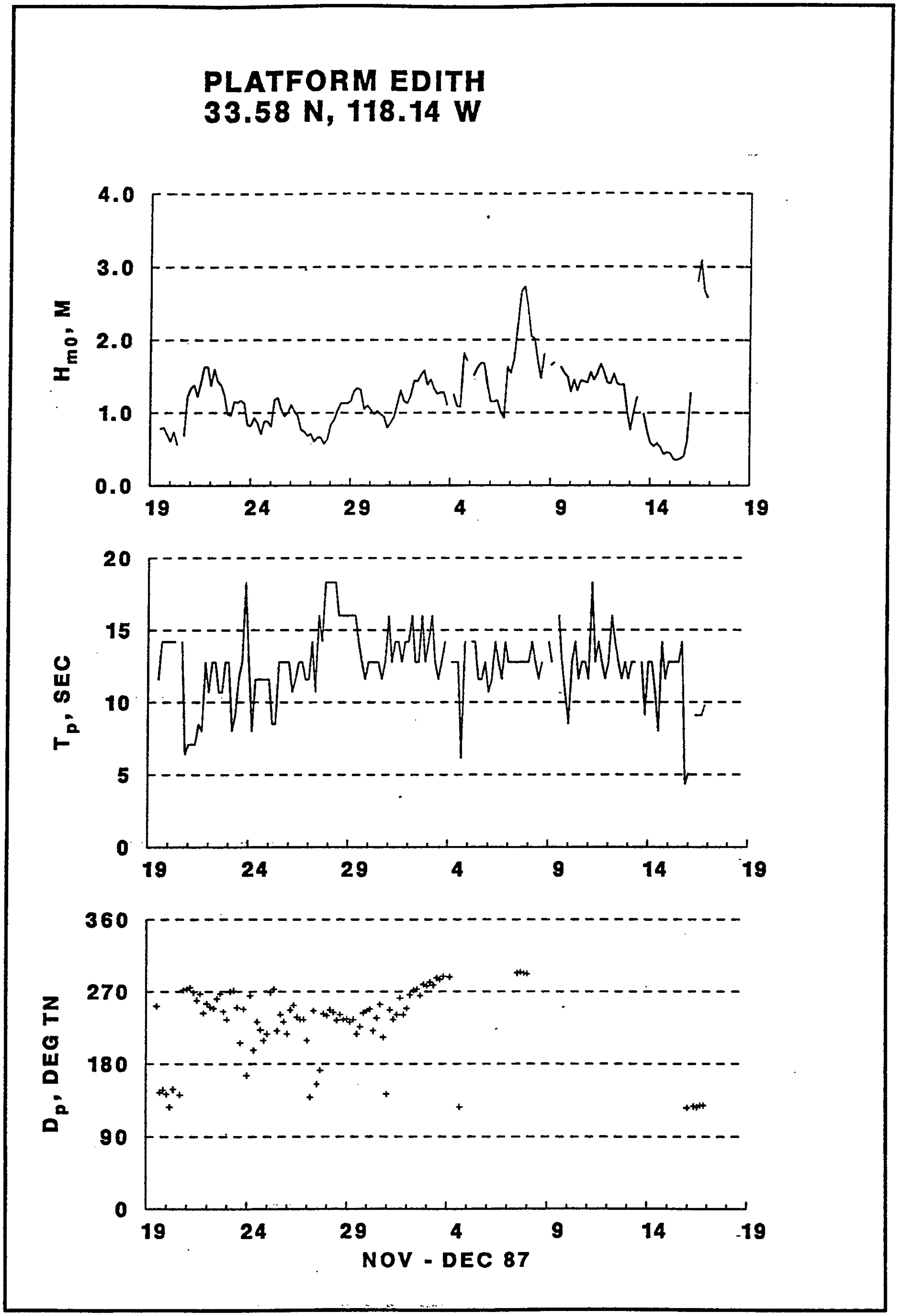
OCT - NOV 87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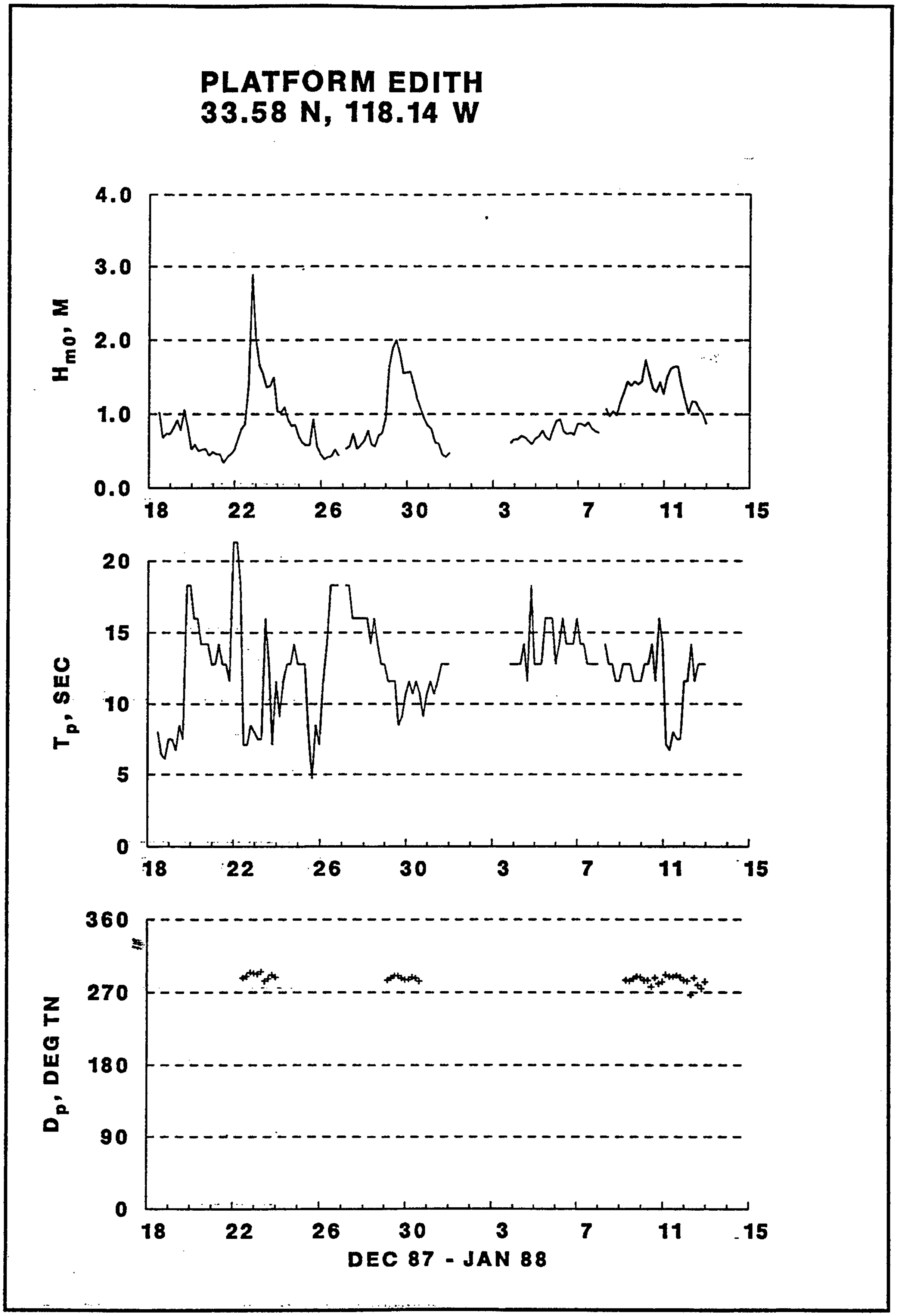

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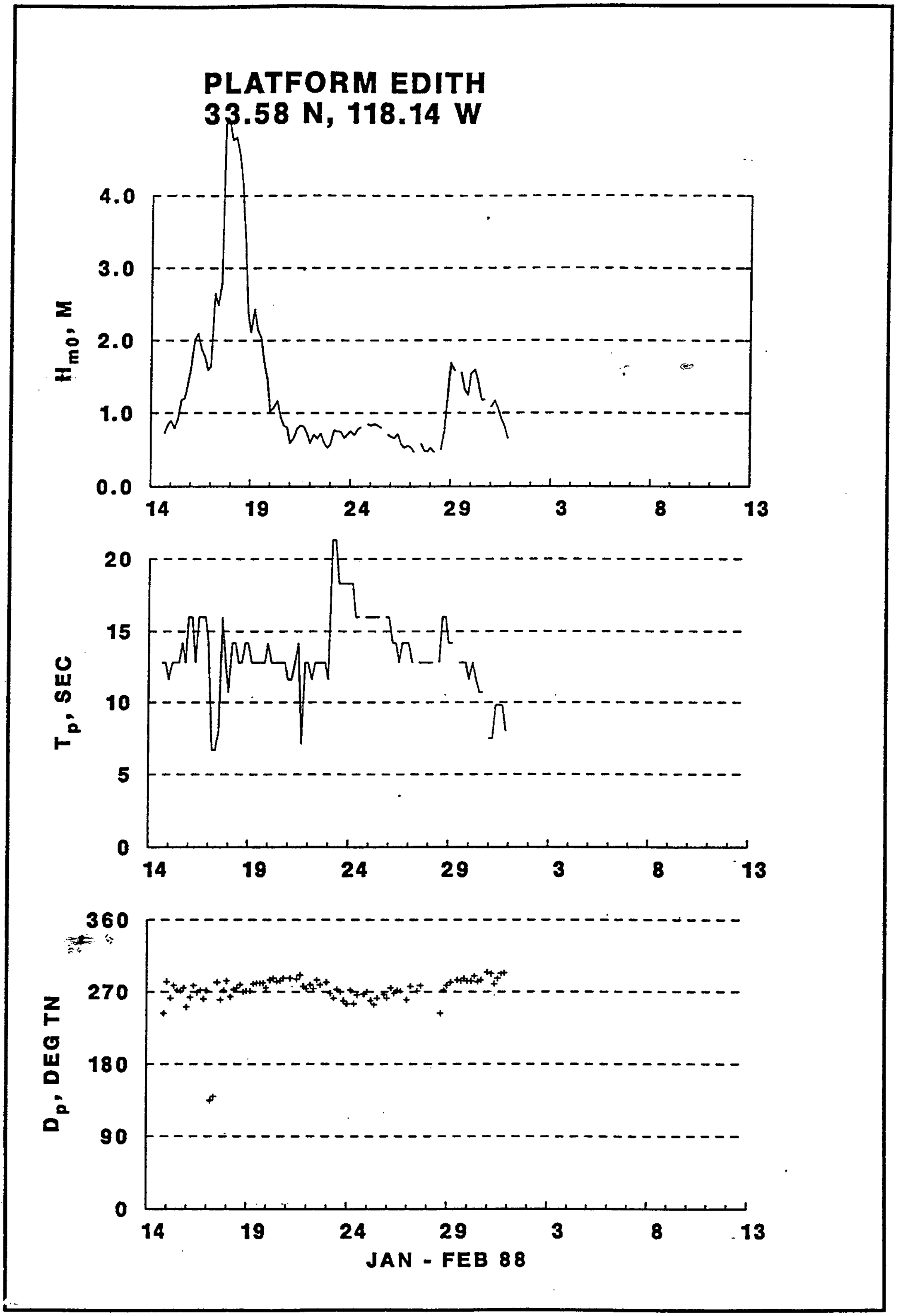

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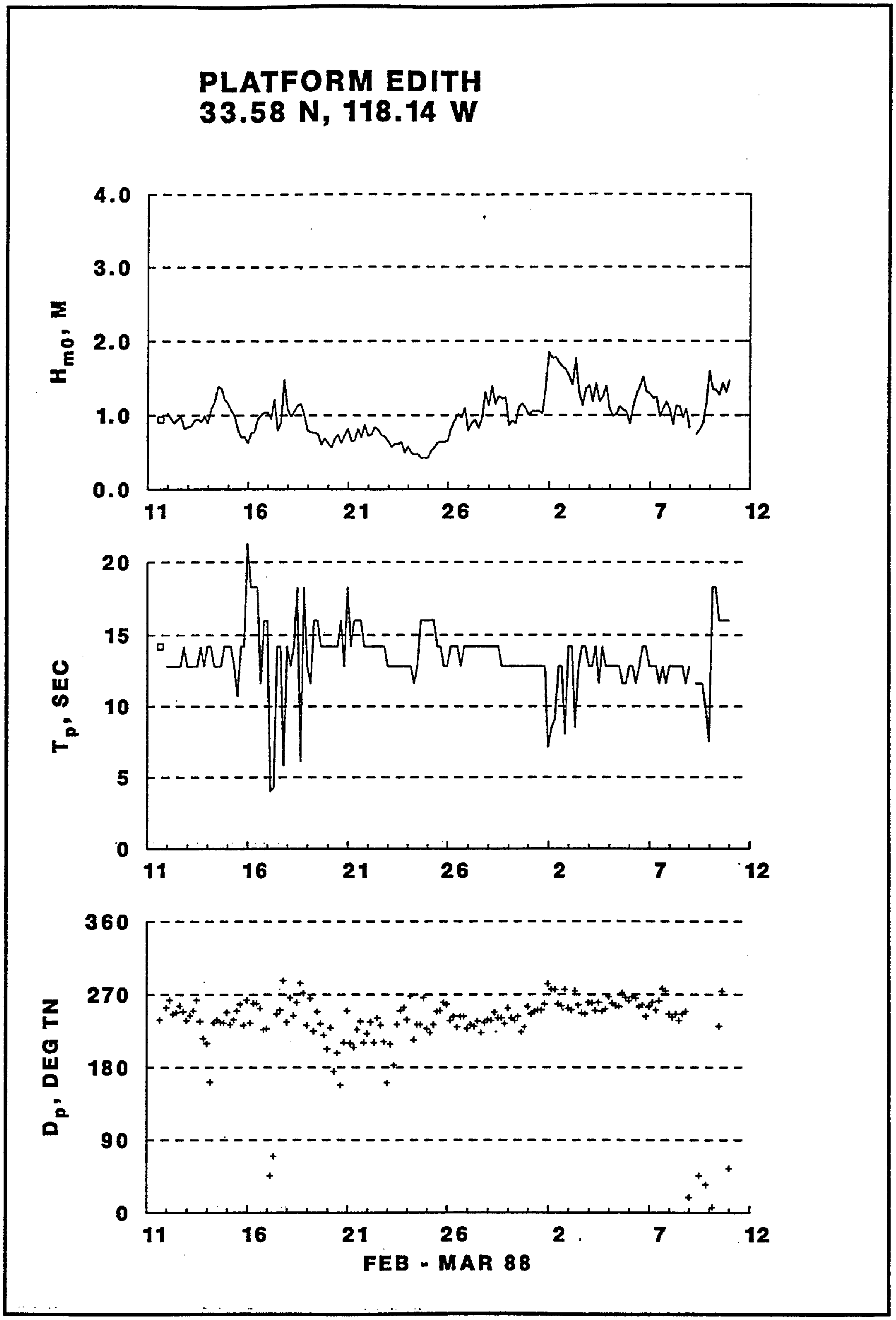
JAN - FEB 88



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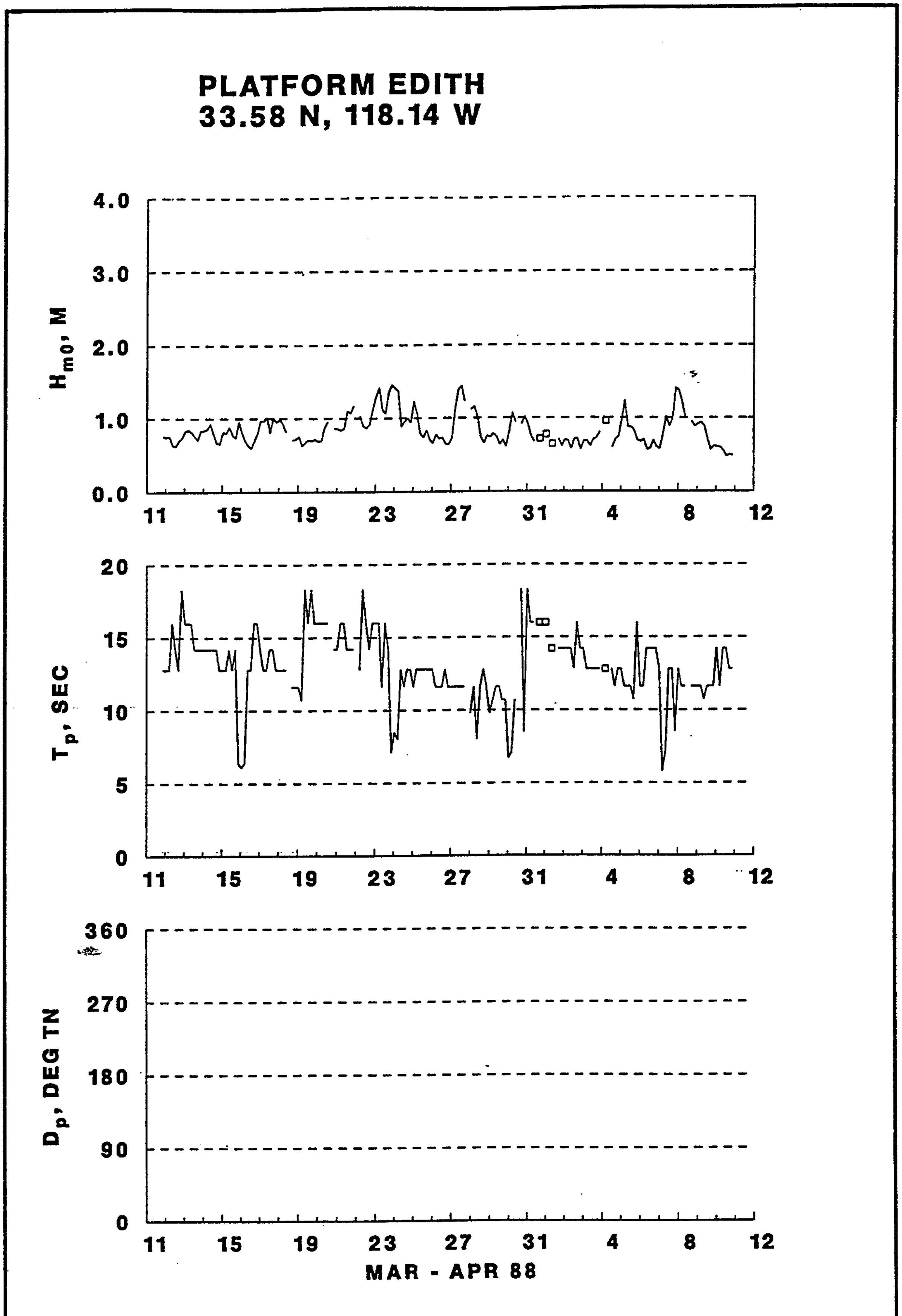
FEB - MAR 88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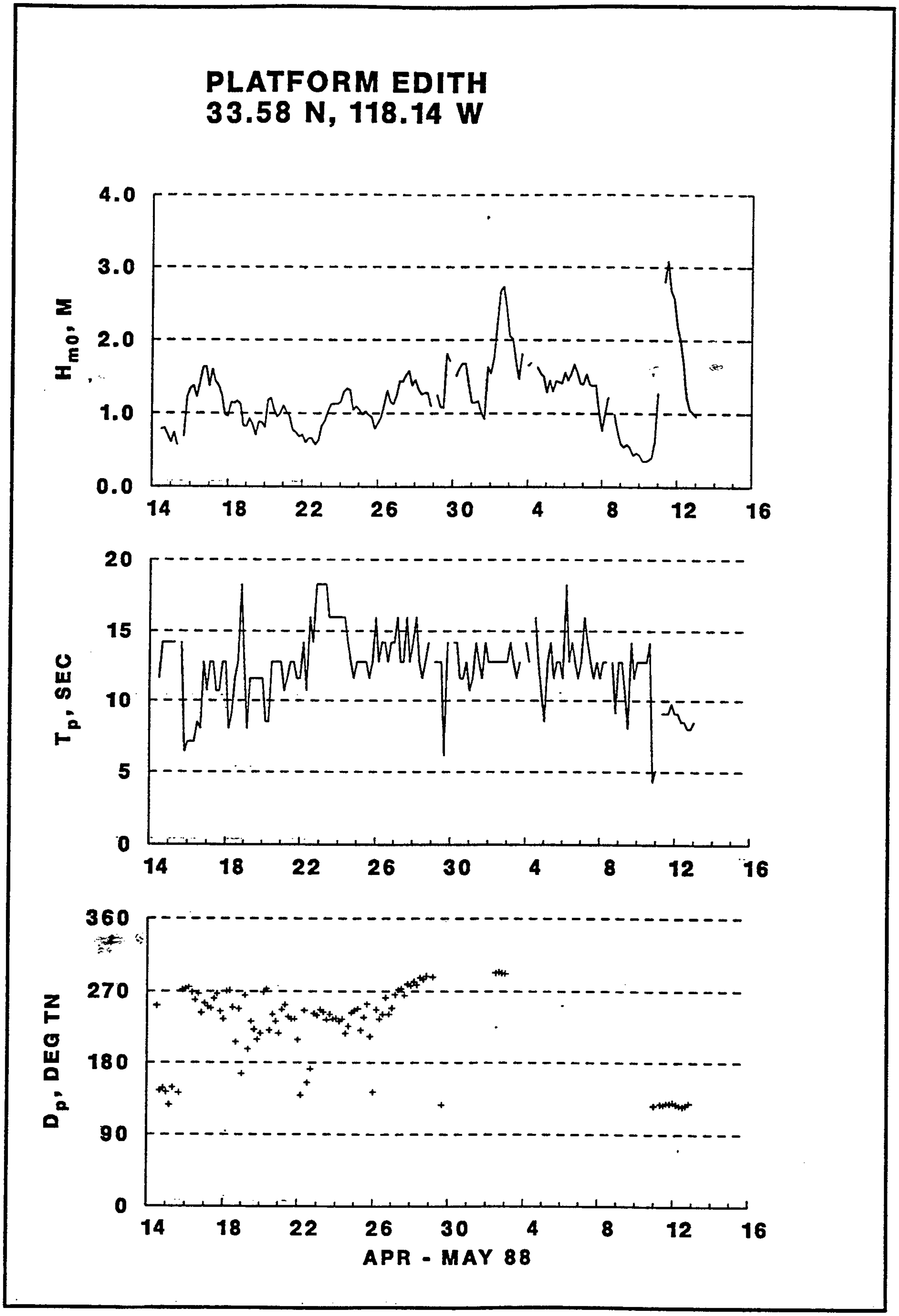
MAR - APR 88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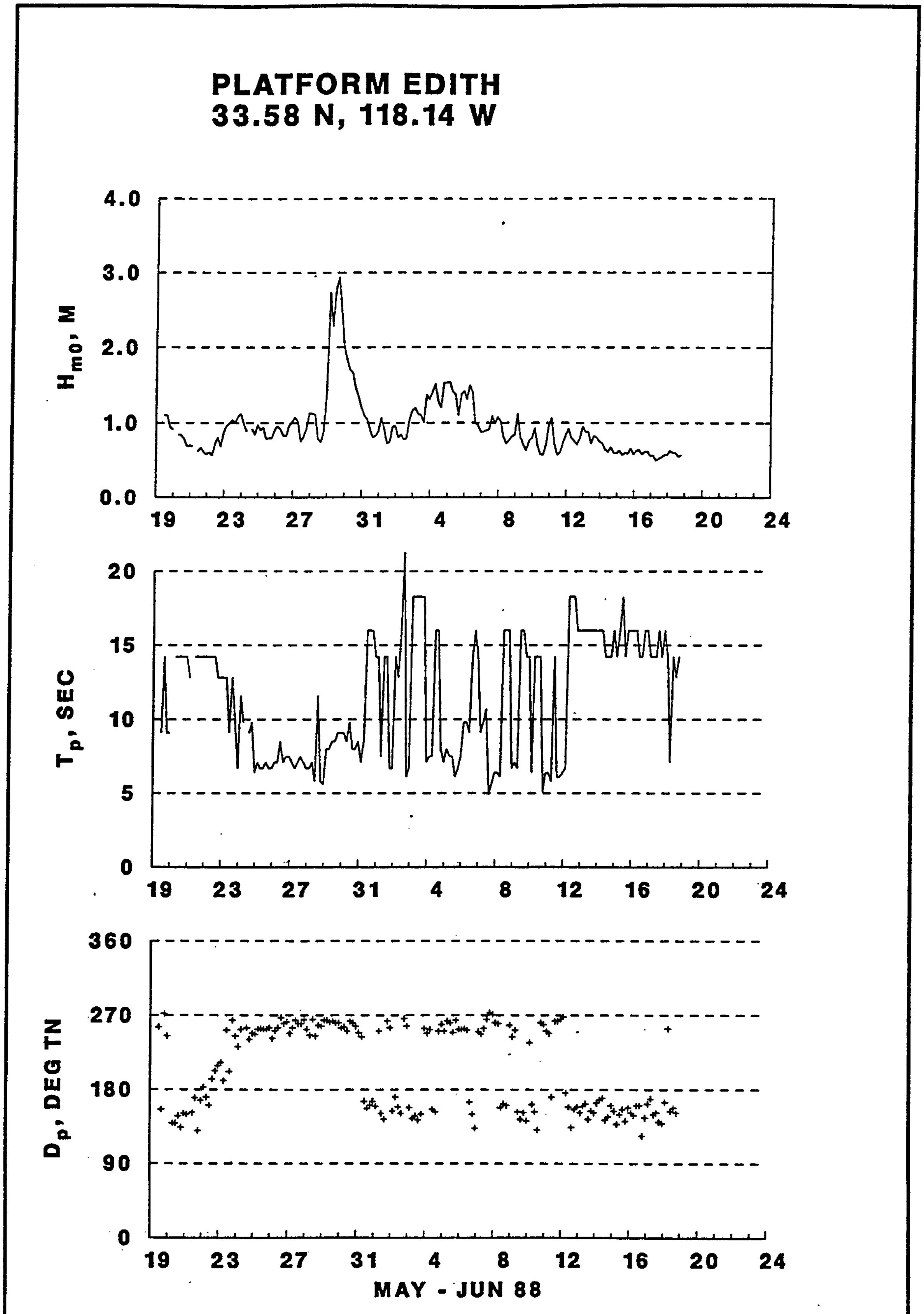
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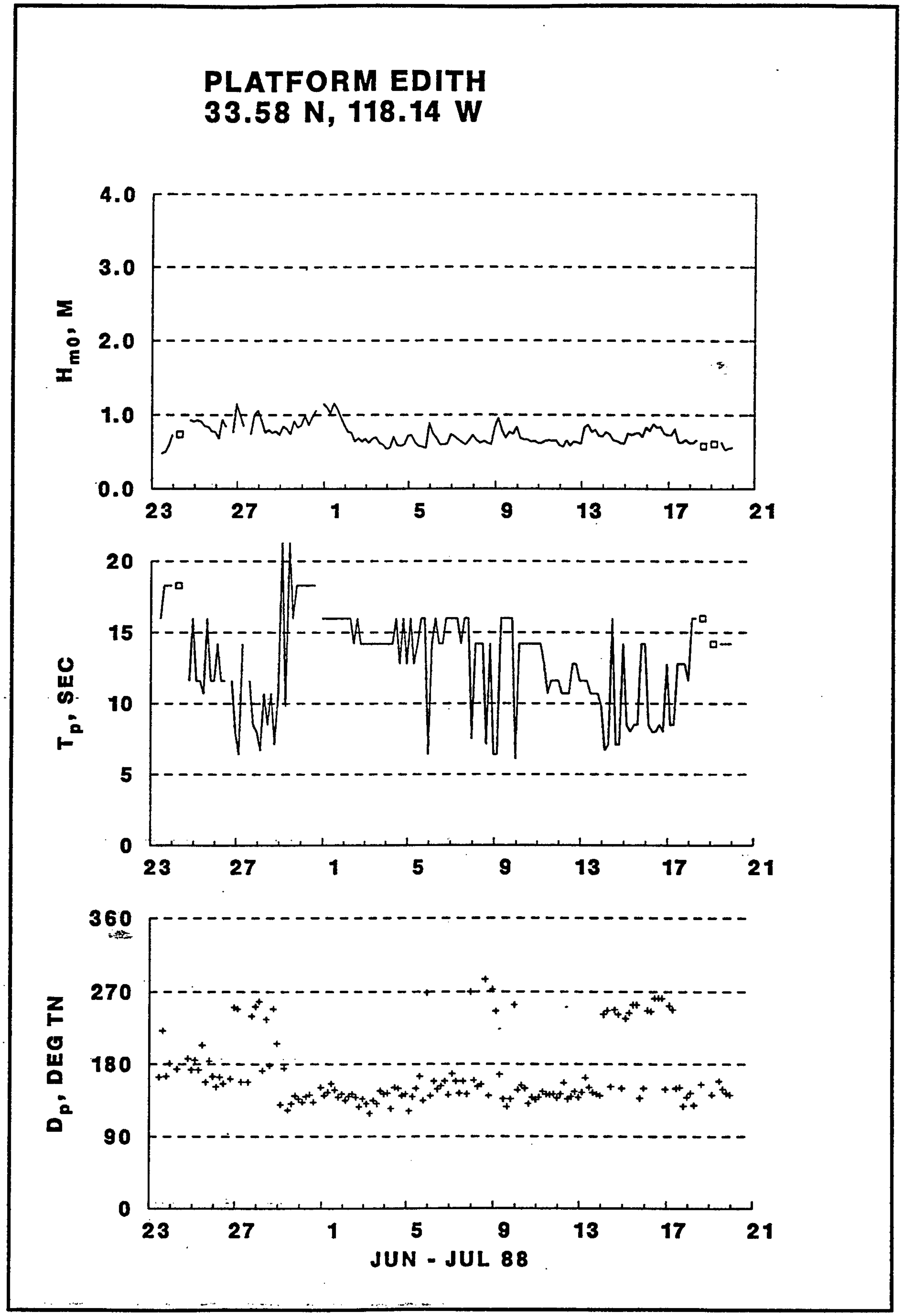
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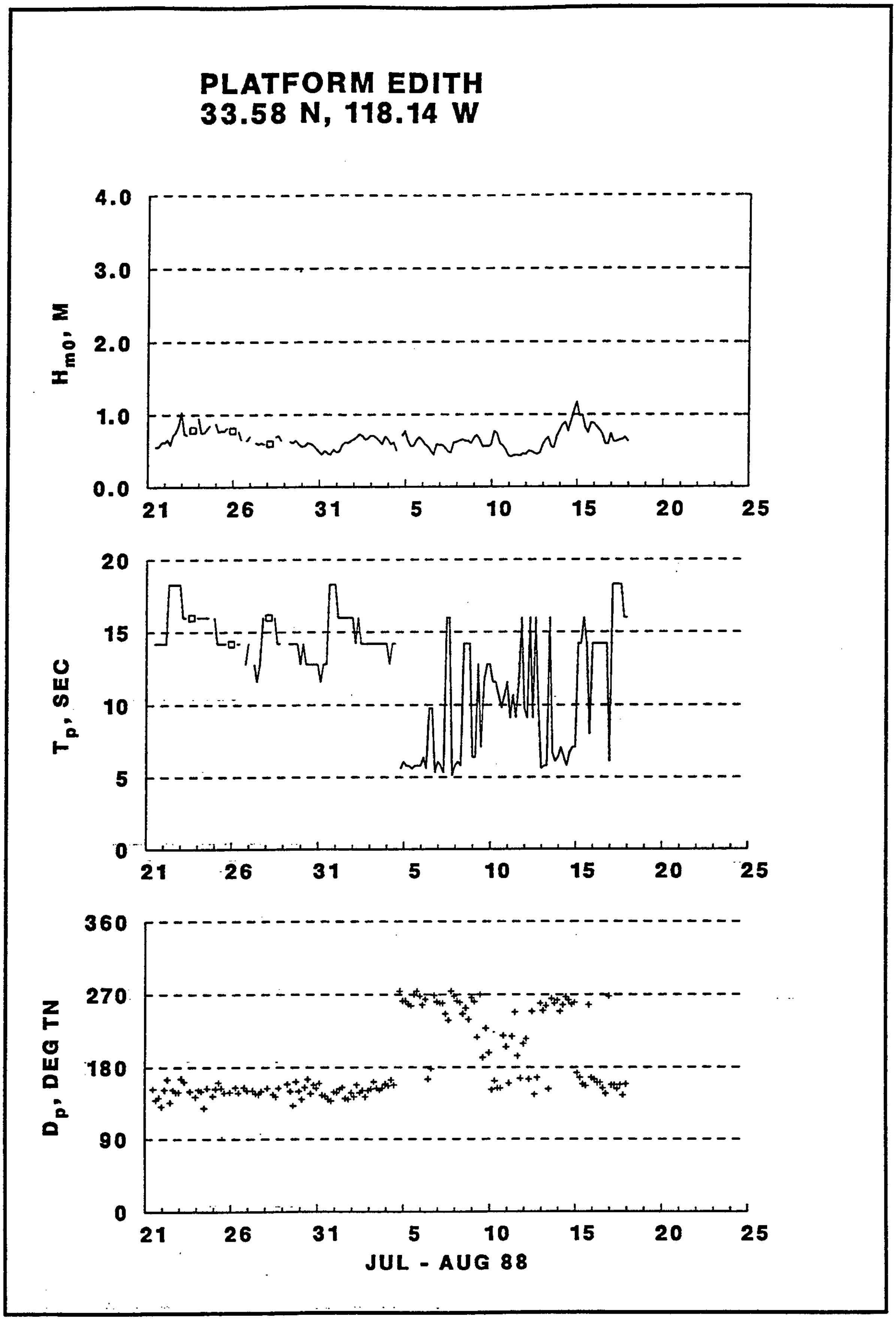
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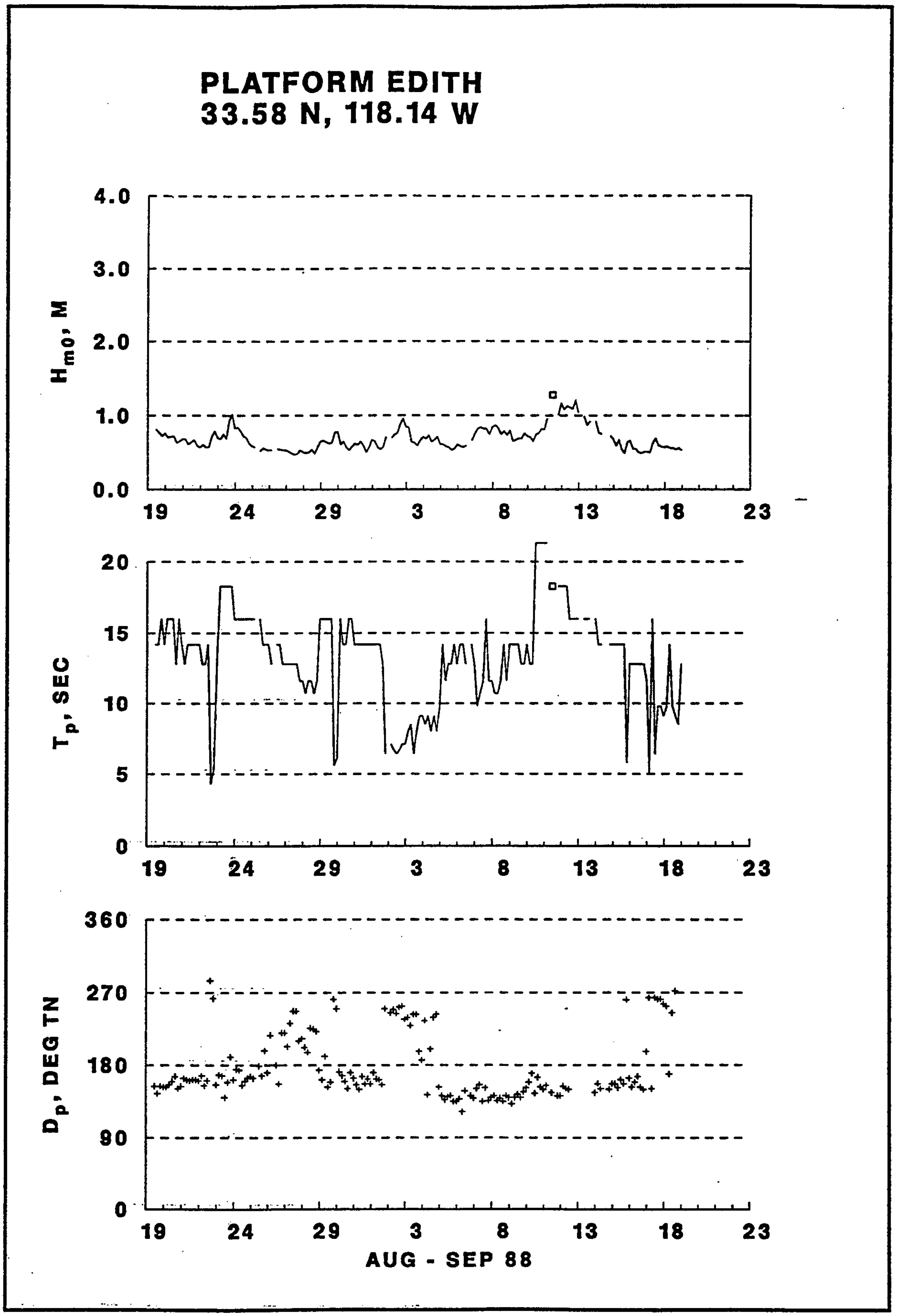
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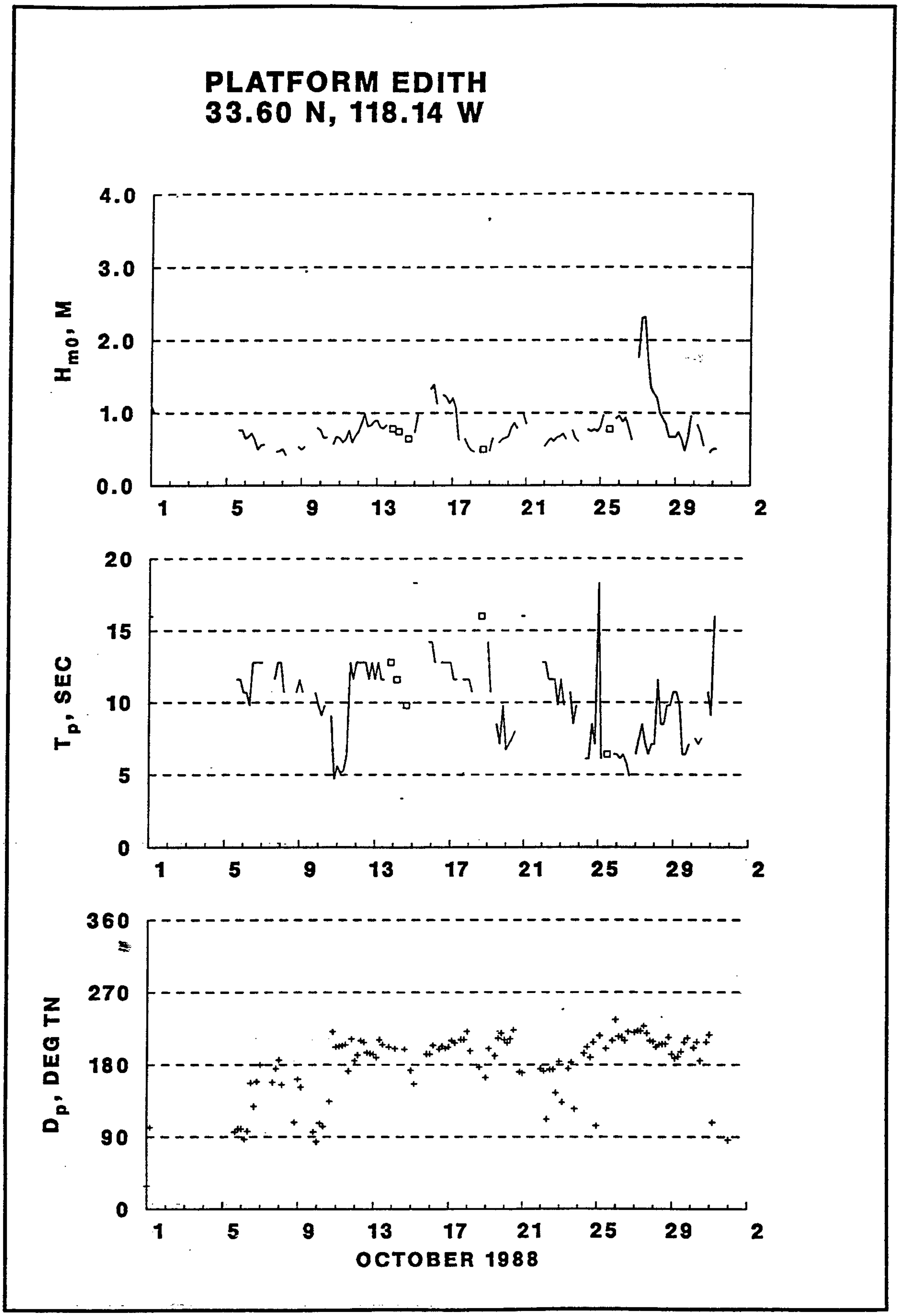
AUG - SEP 88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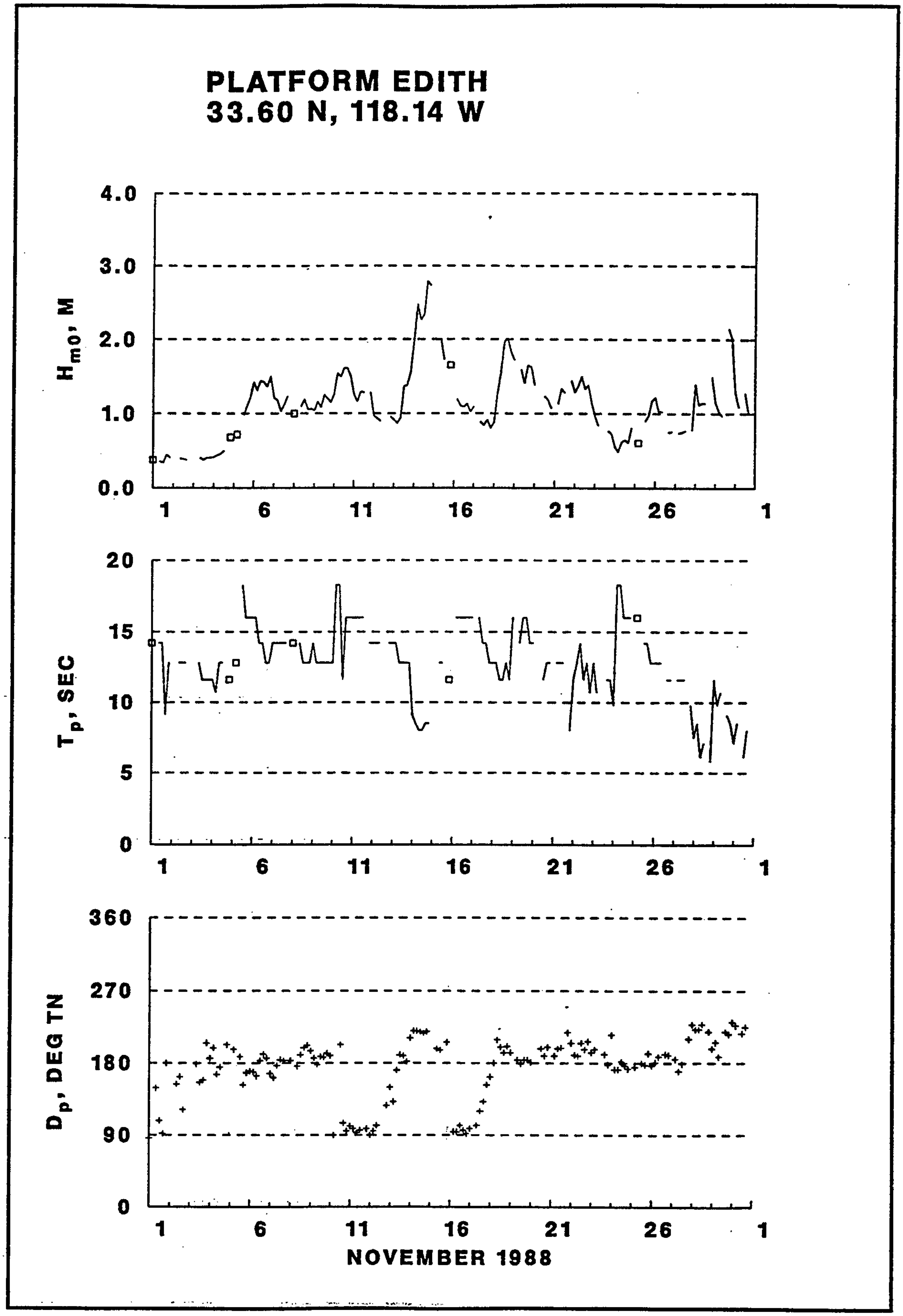
OCTOBER 1988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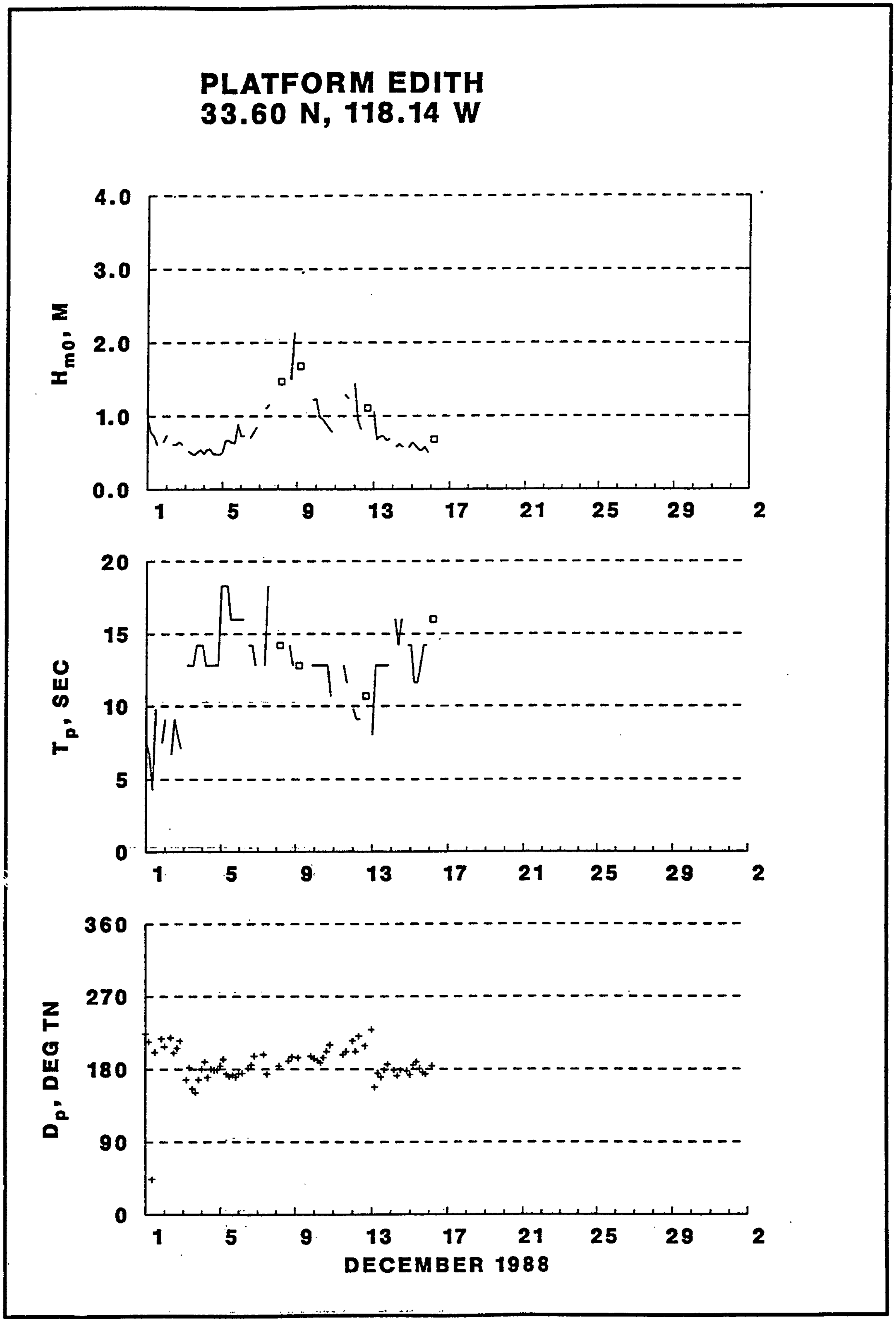
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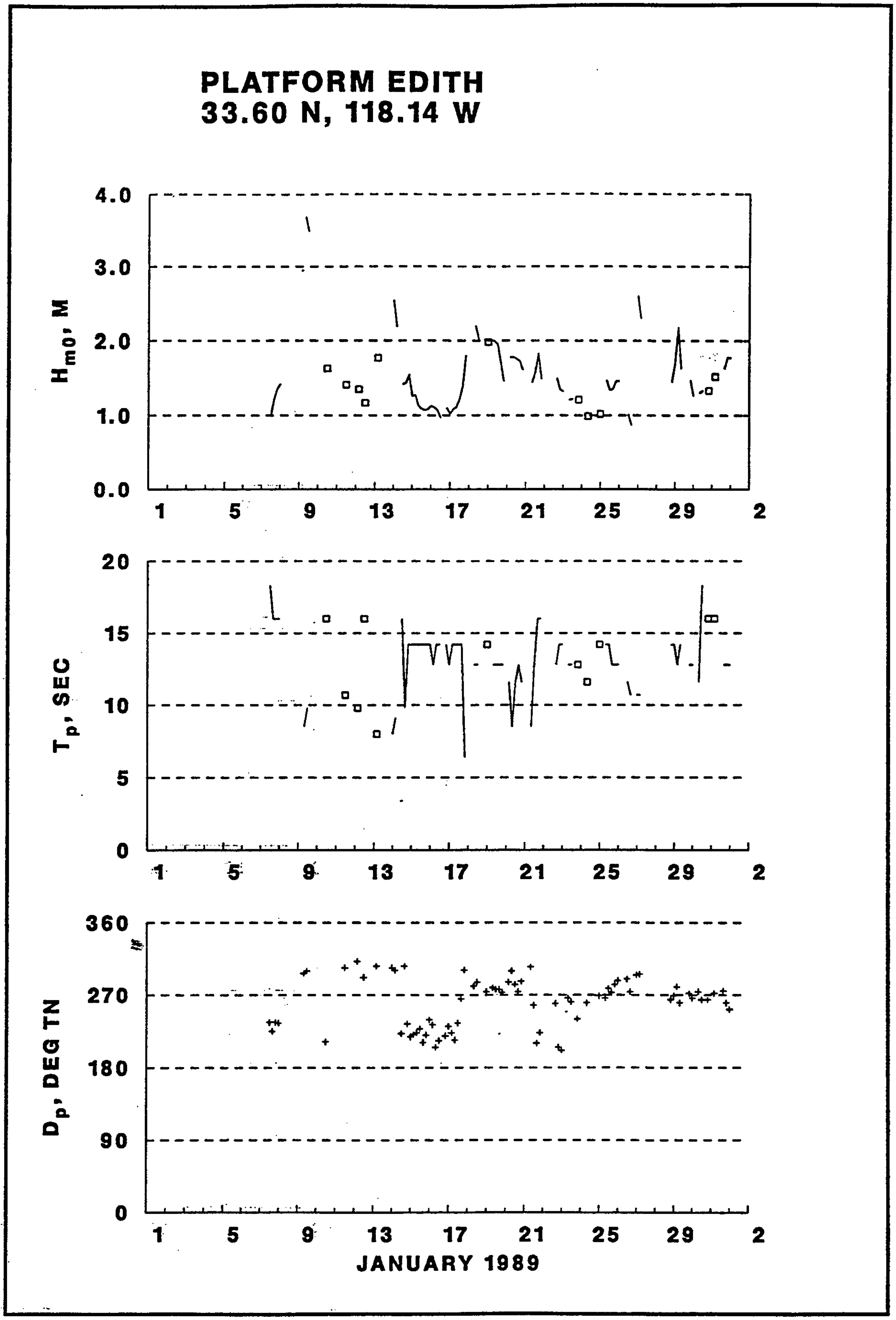
DECEMBER 1988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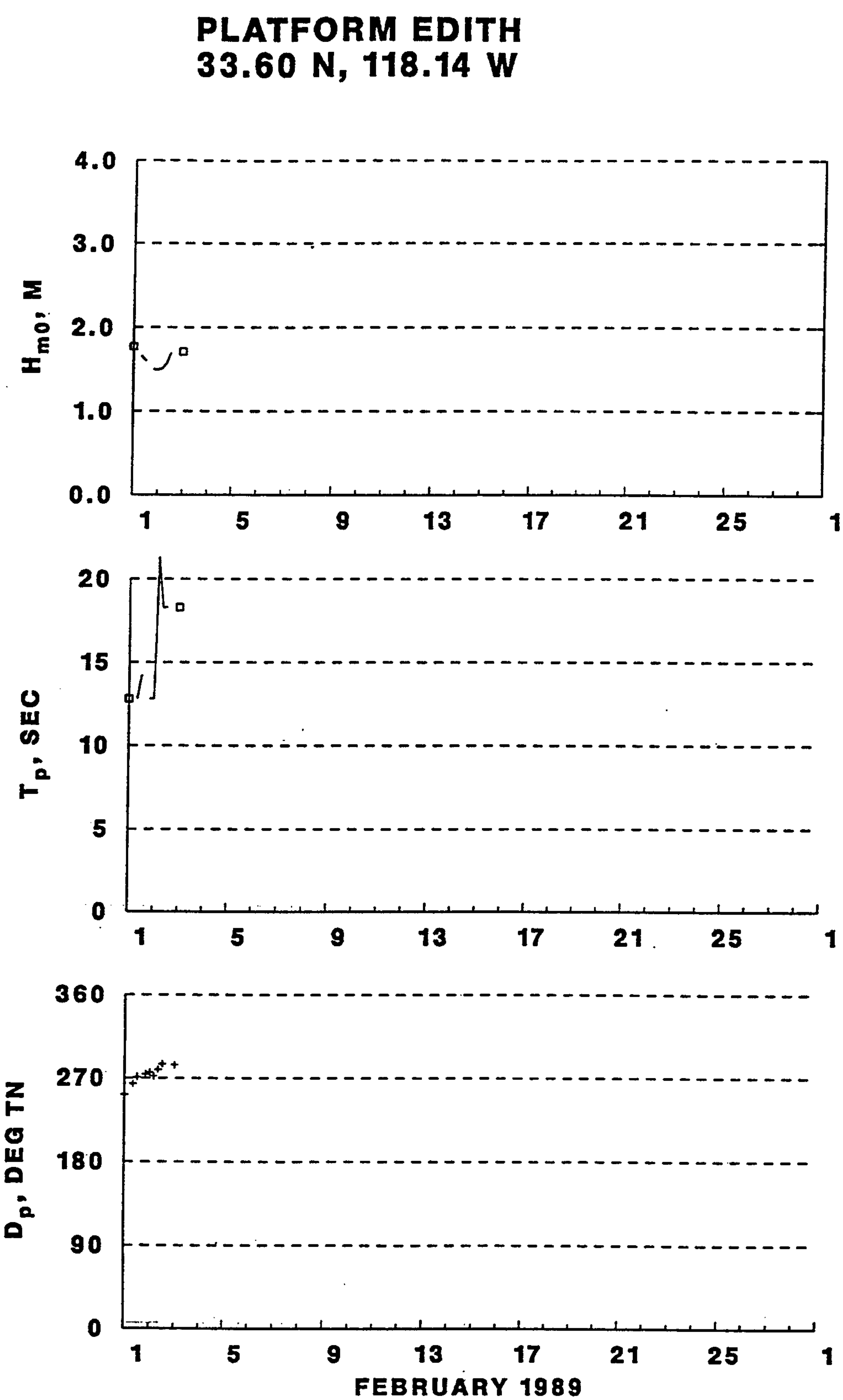
JANUARY 1989



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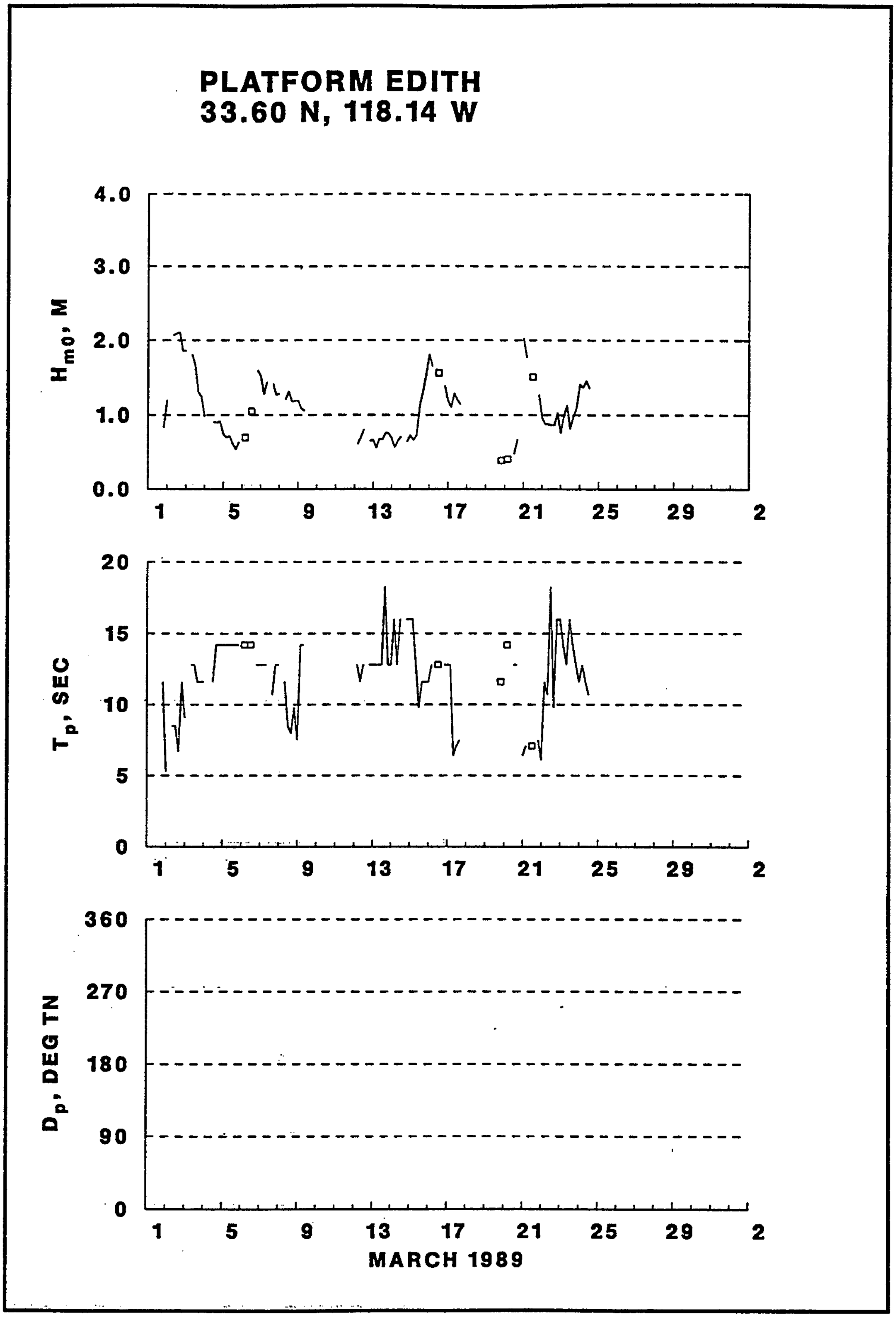
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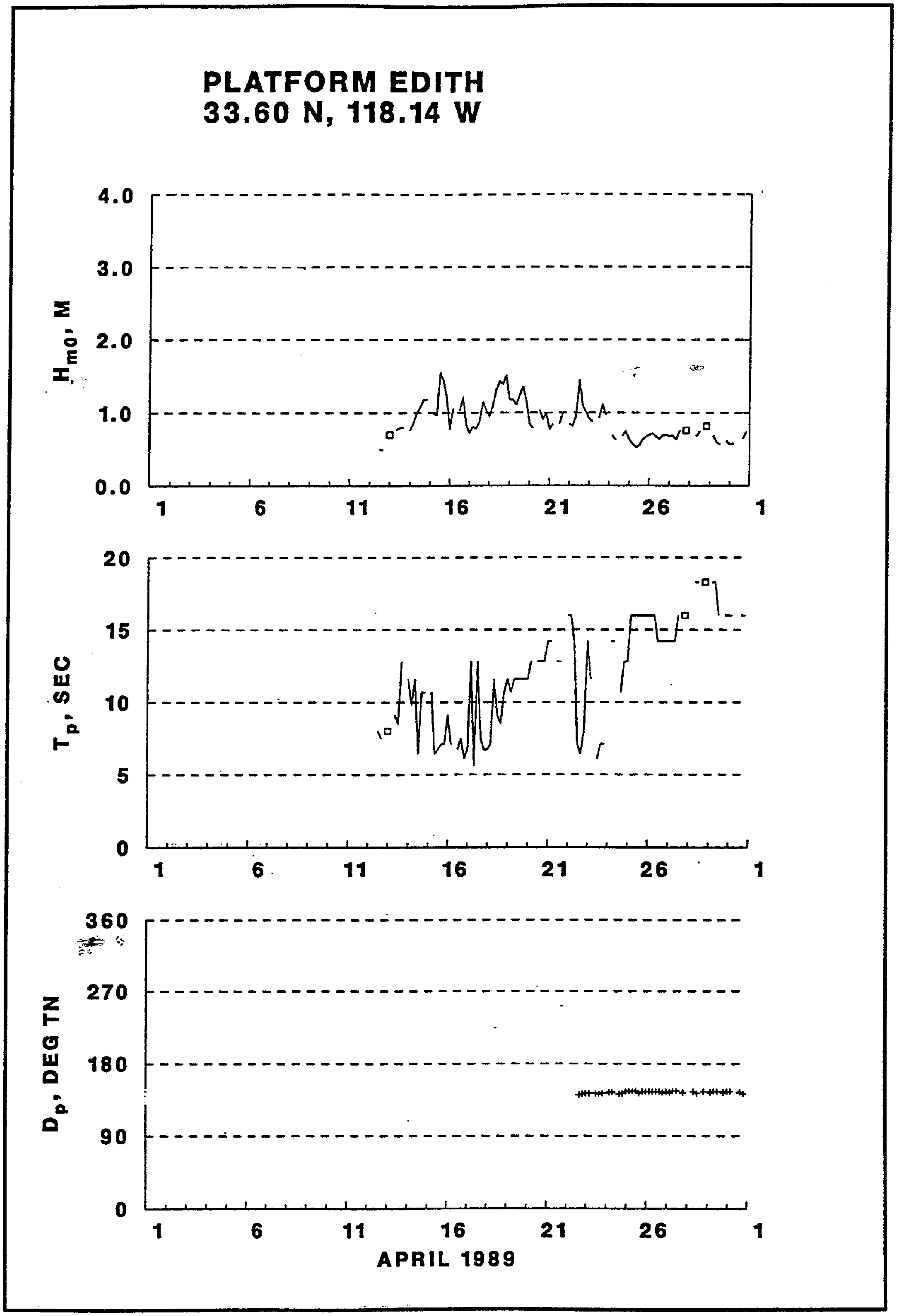

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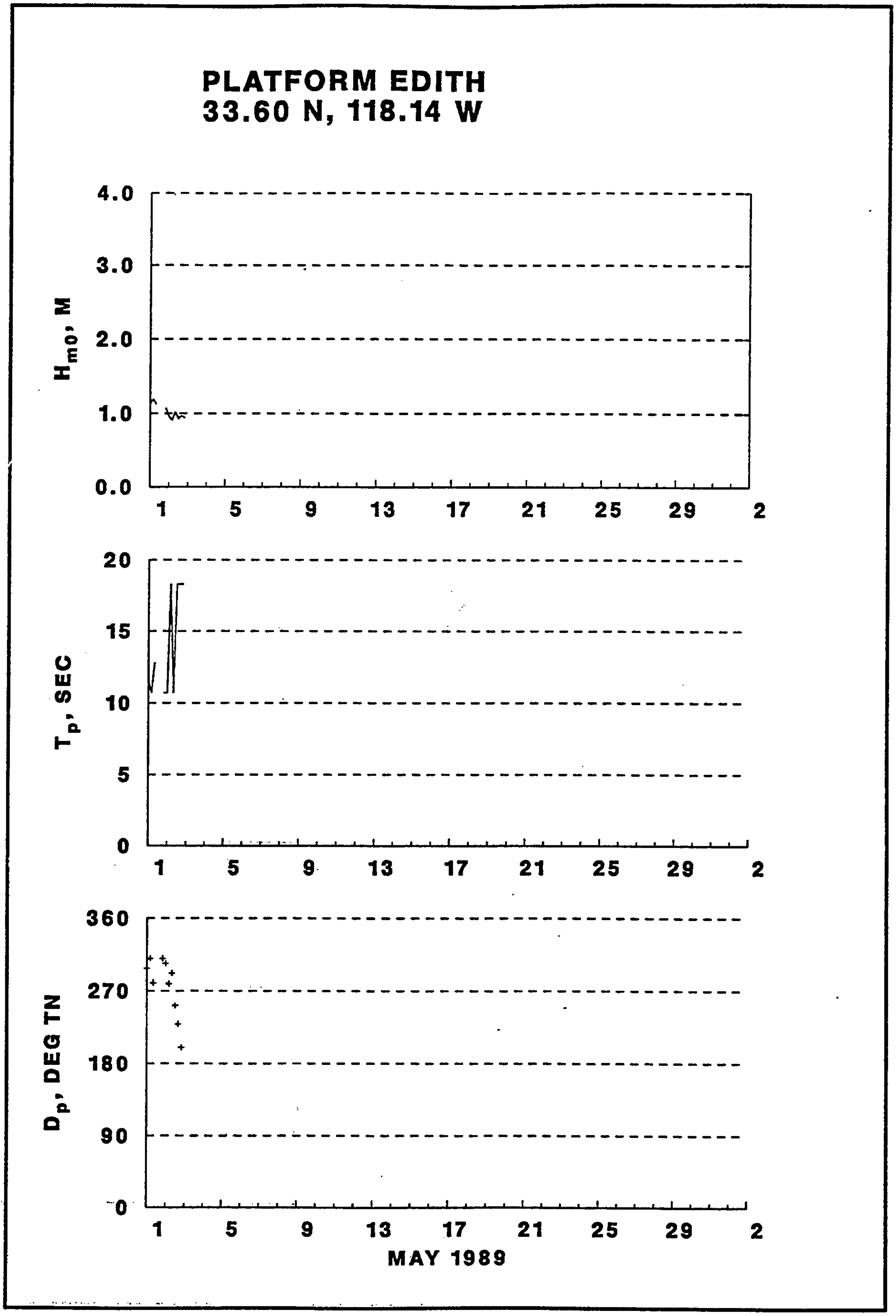
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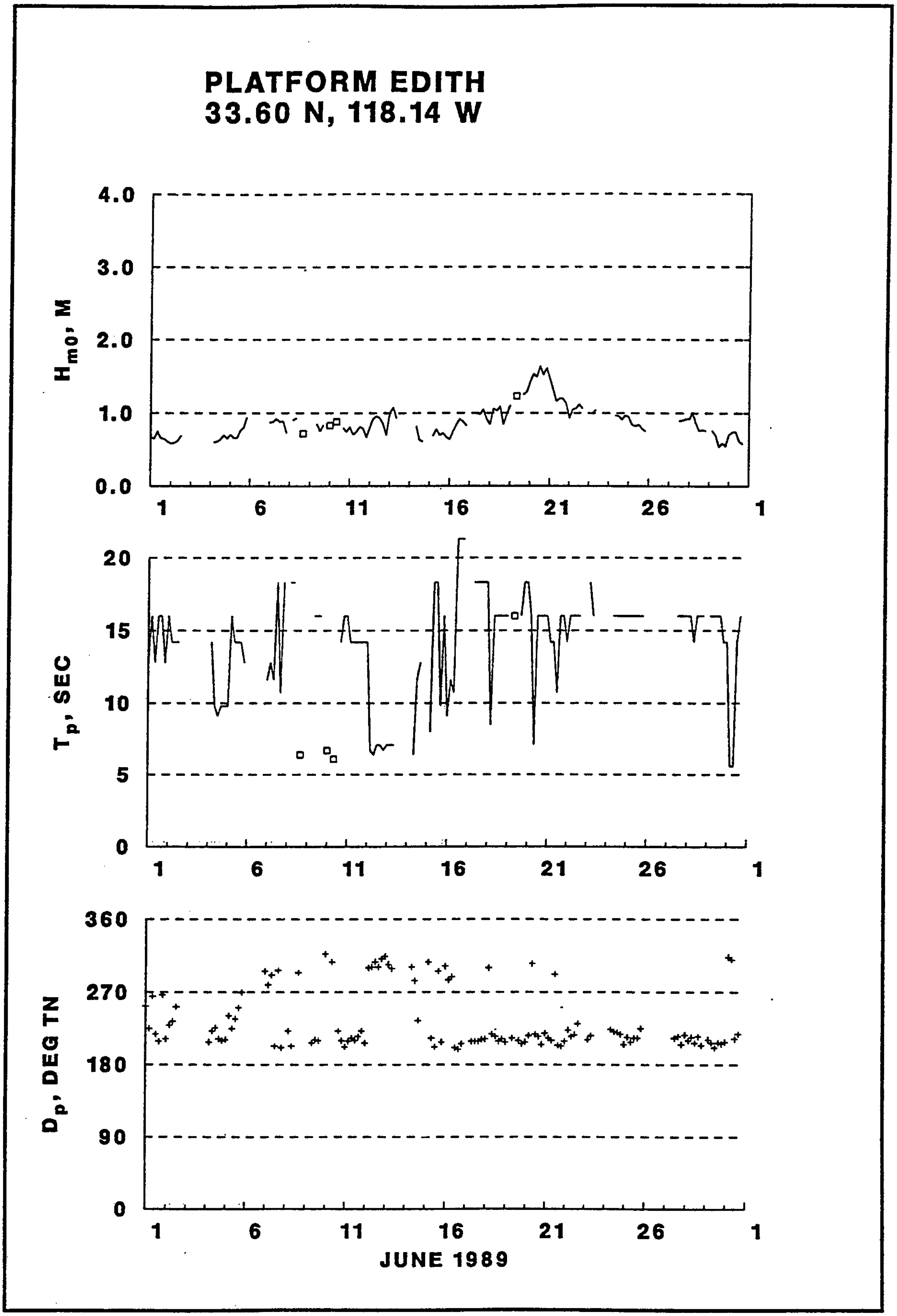
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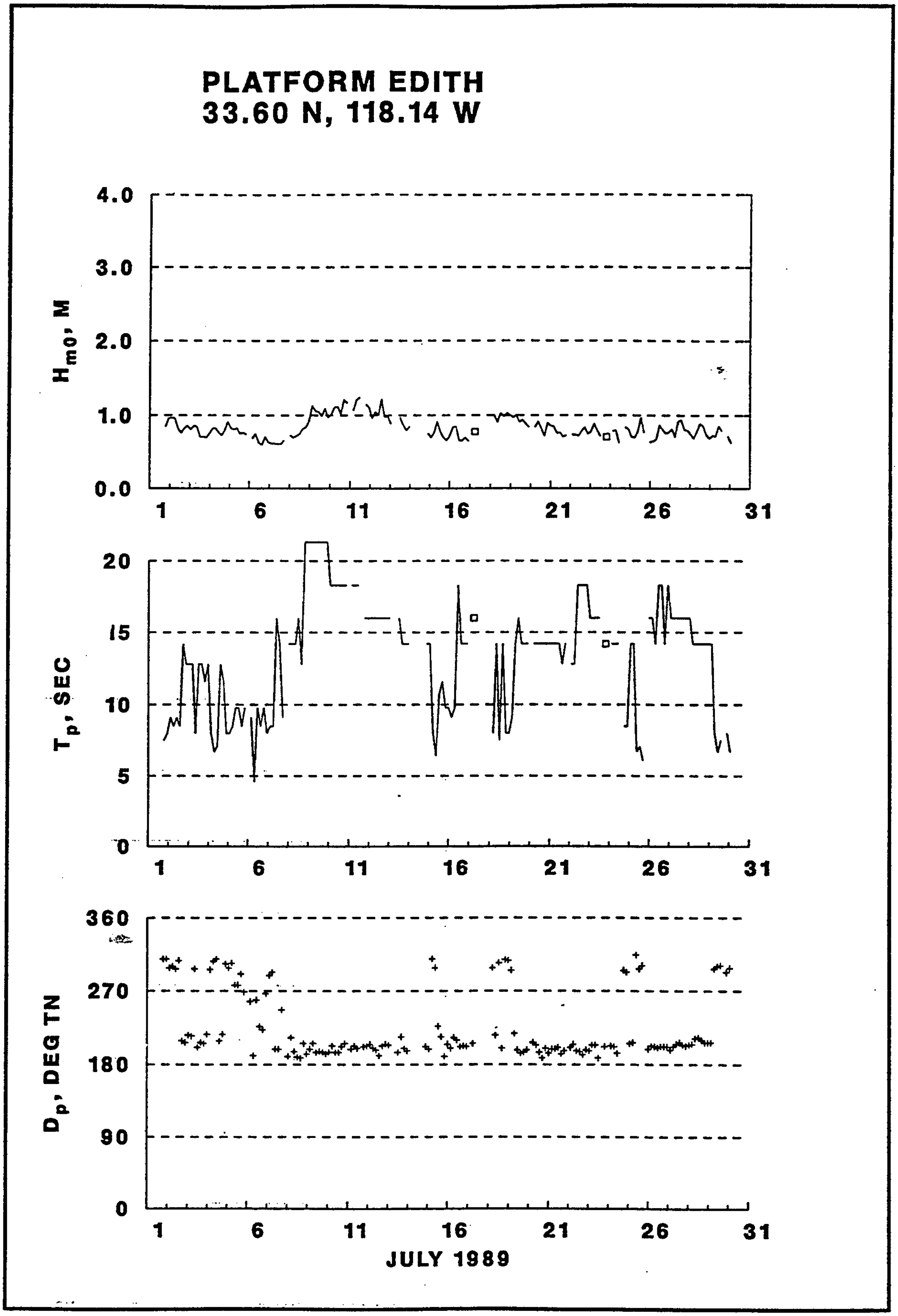
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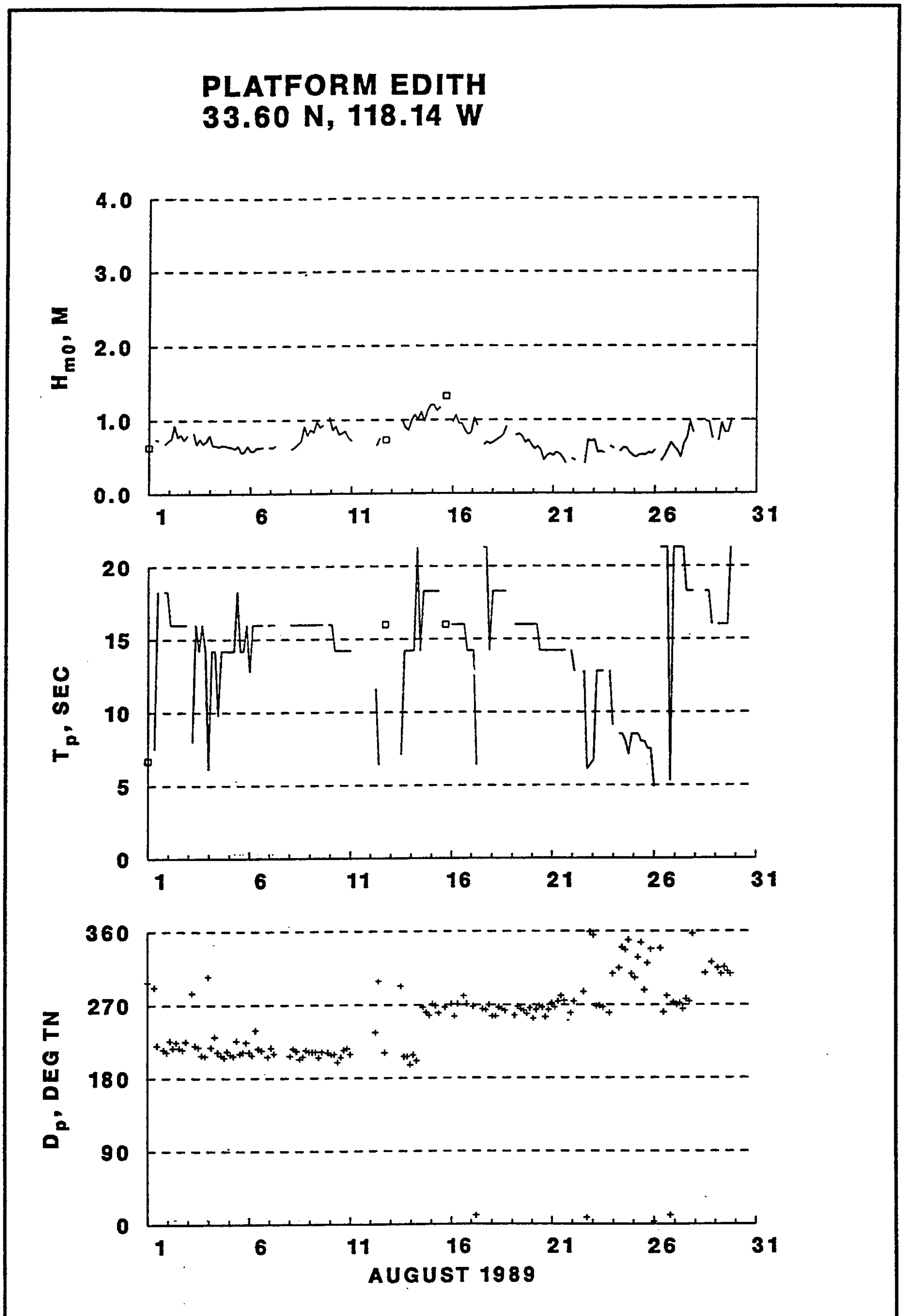
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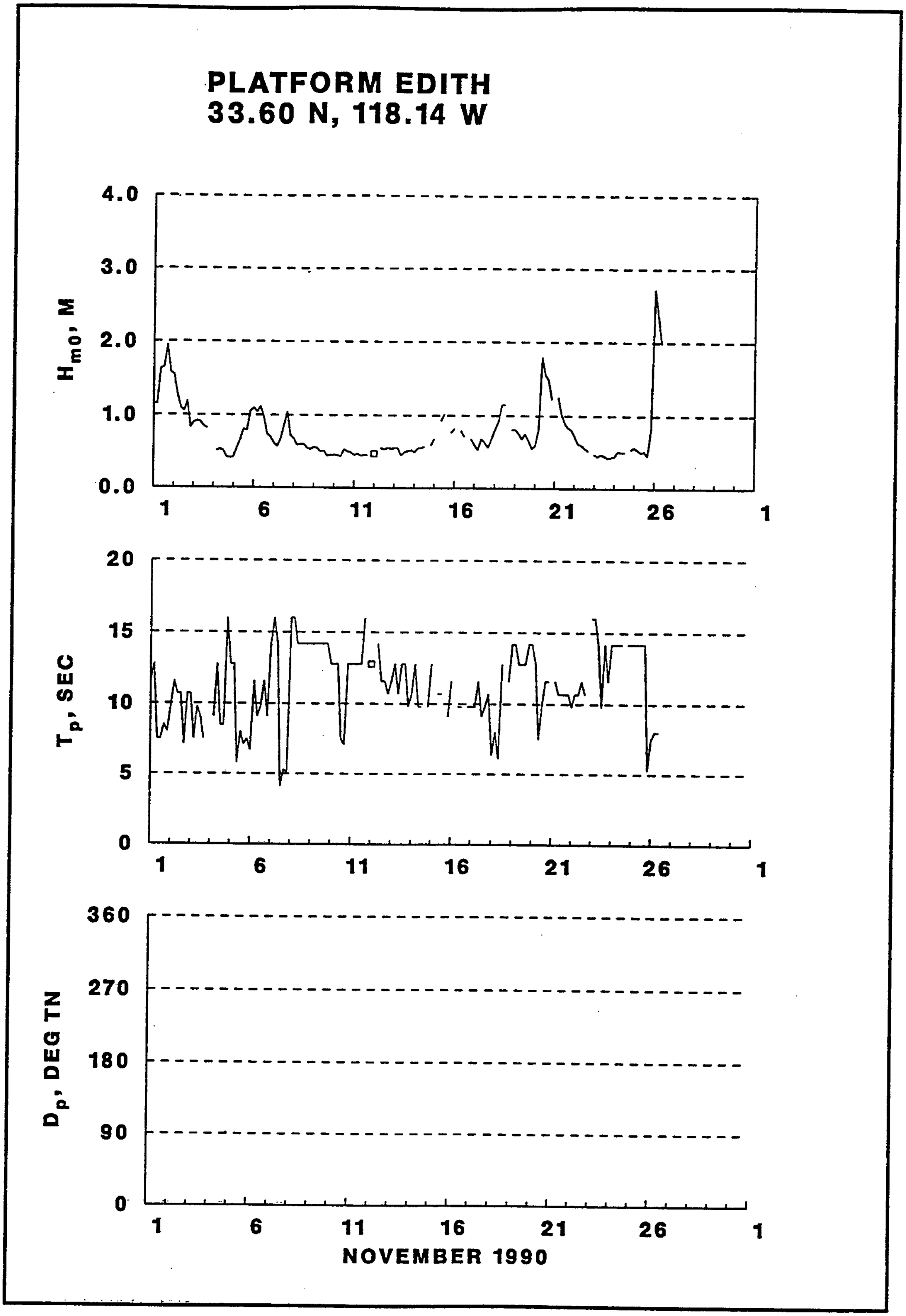
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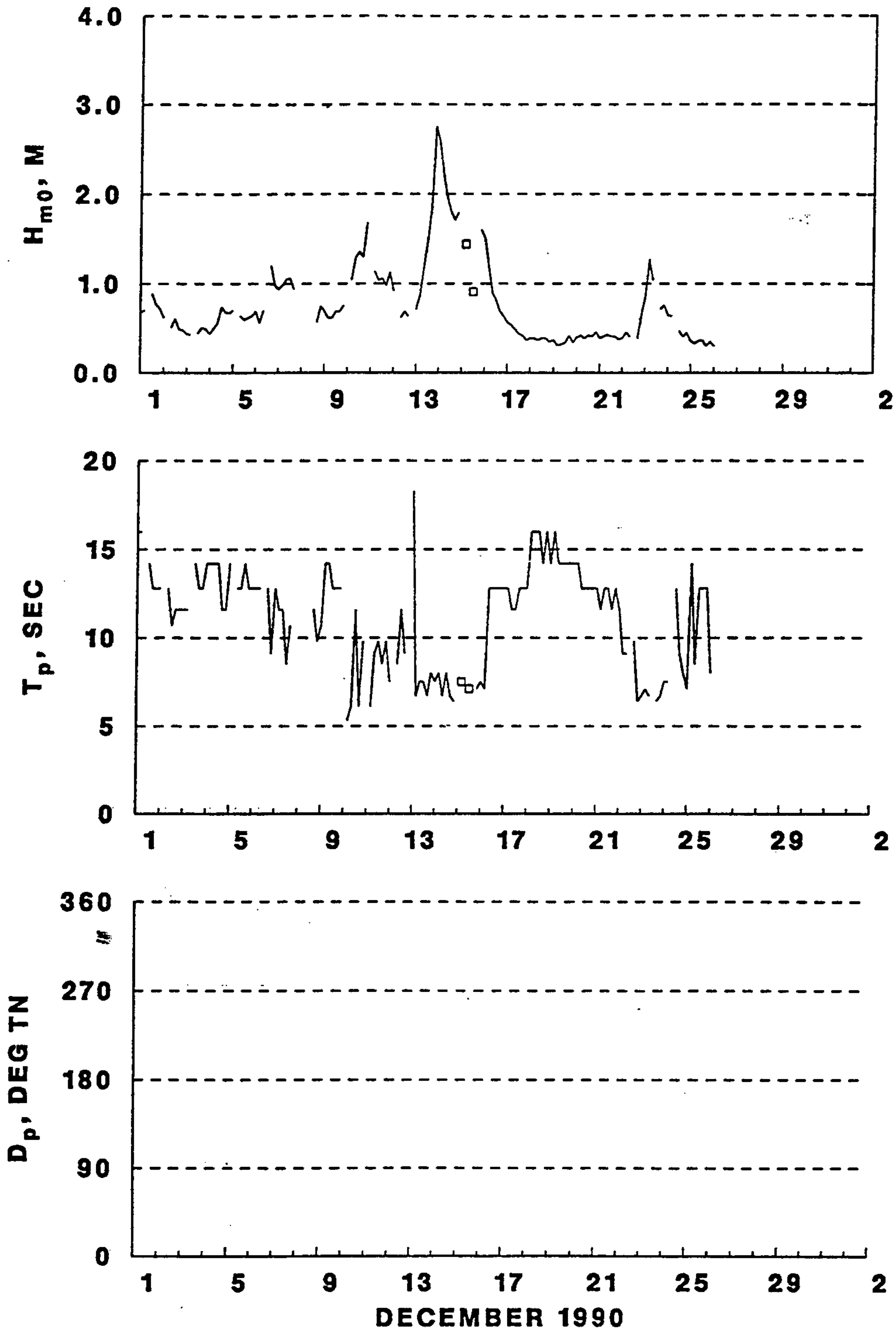

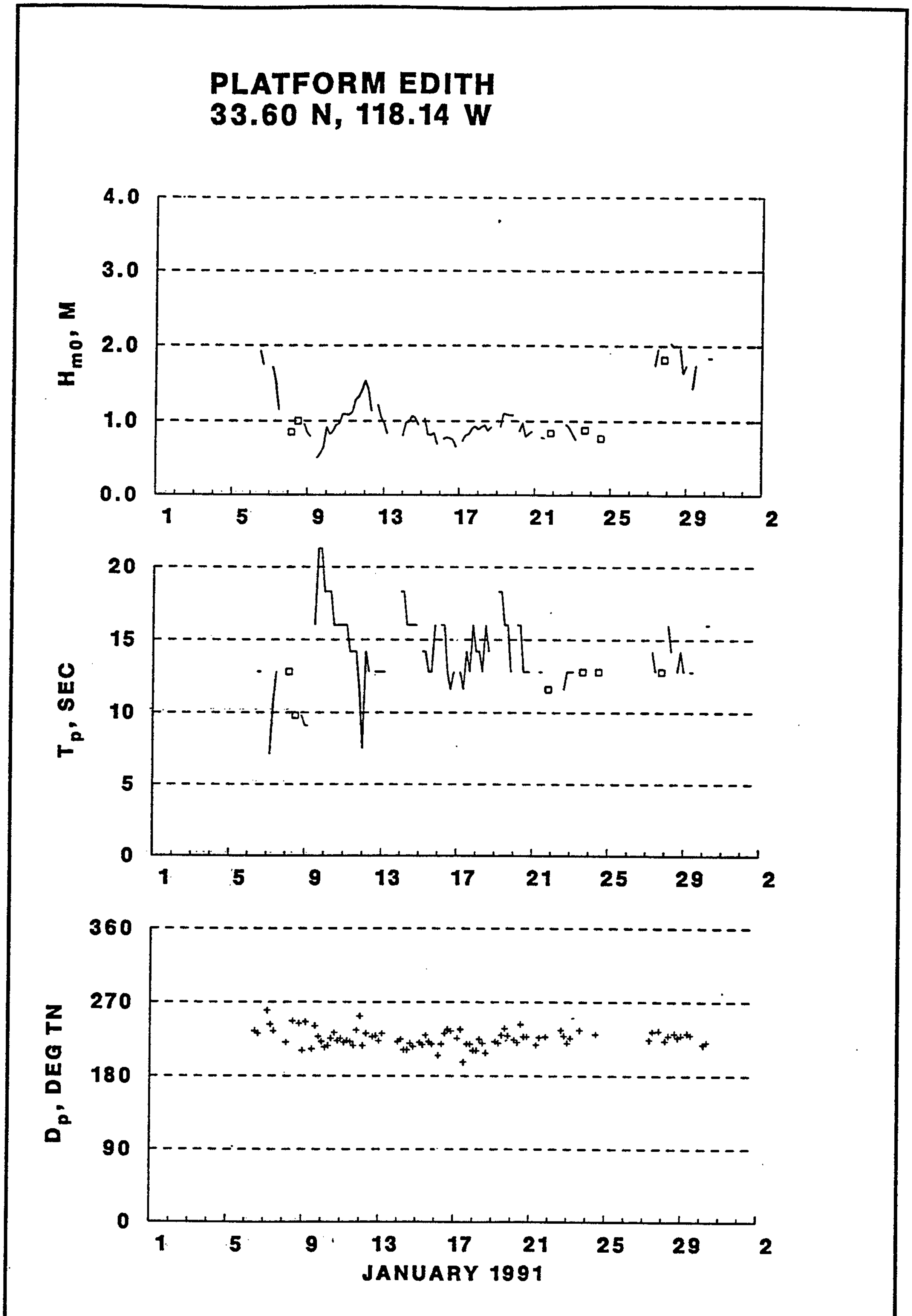
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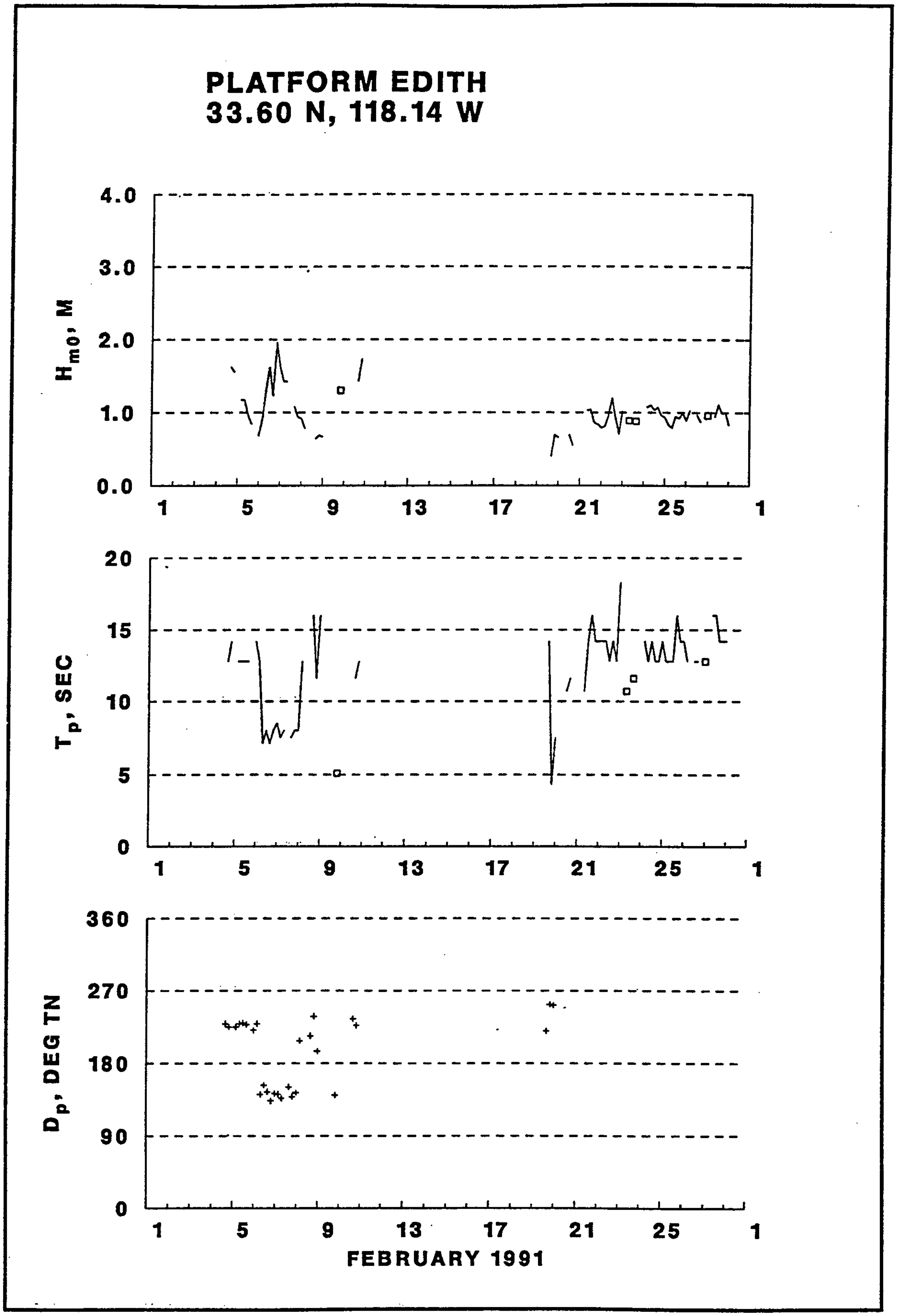
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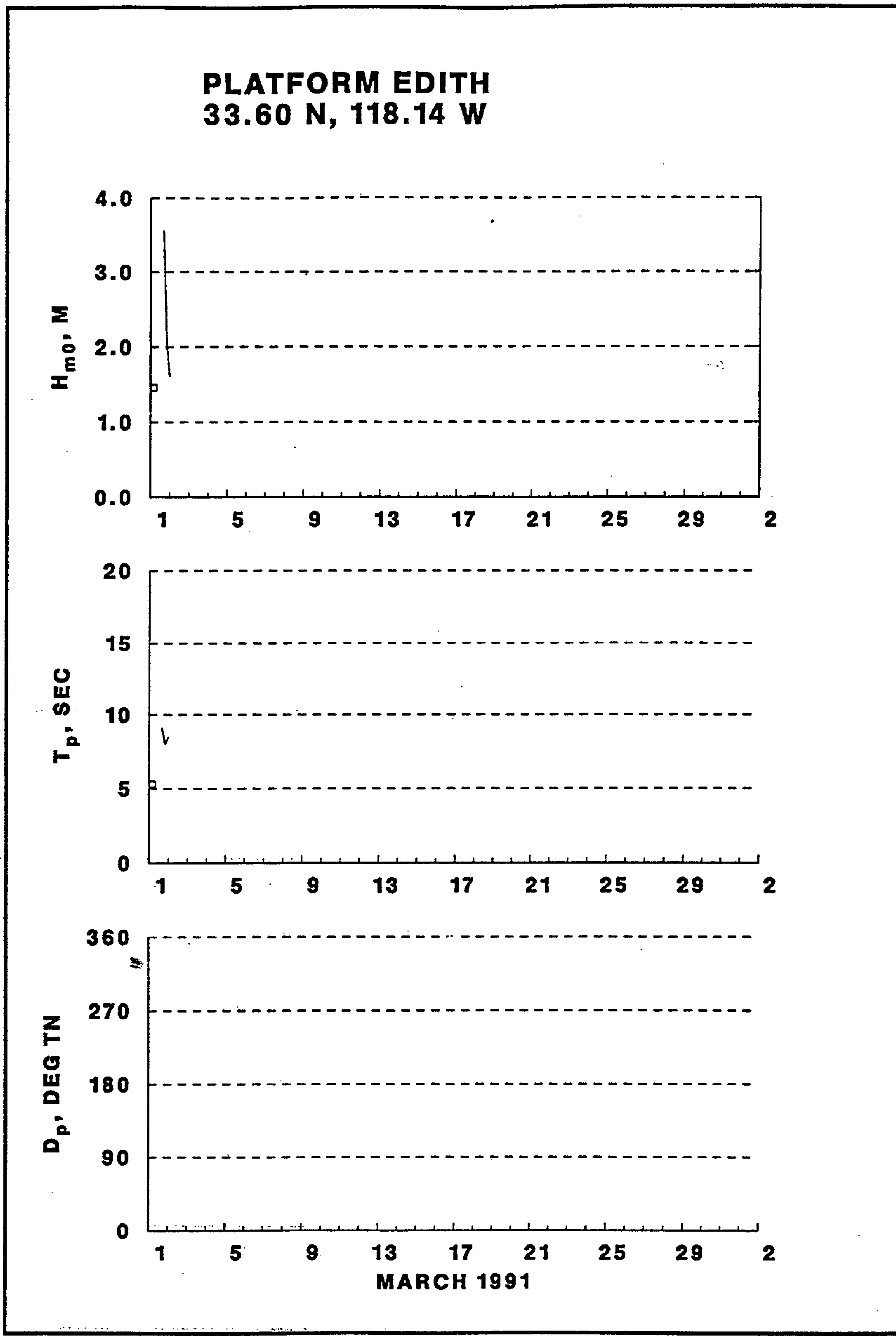
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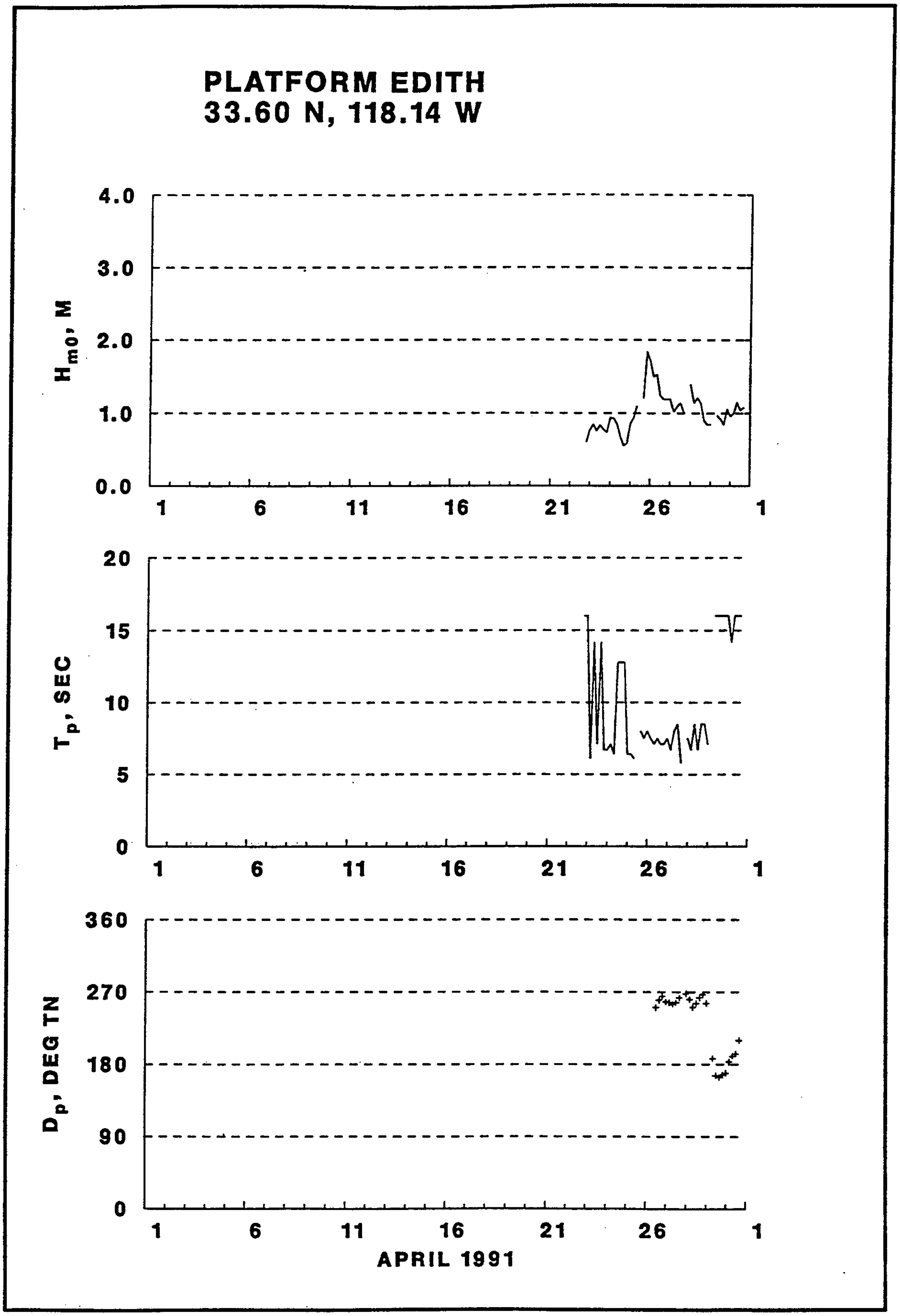
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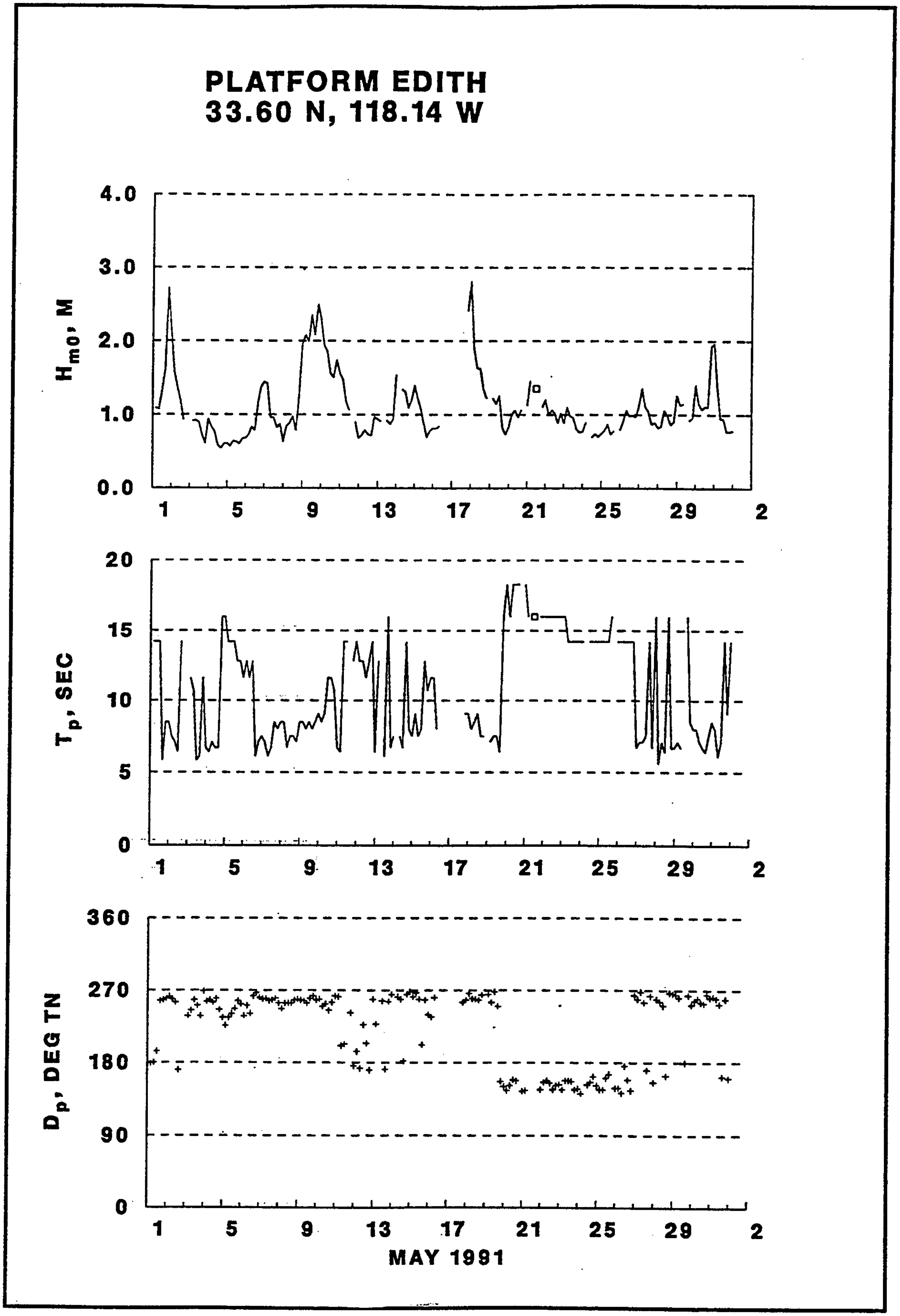
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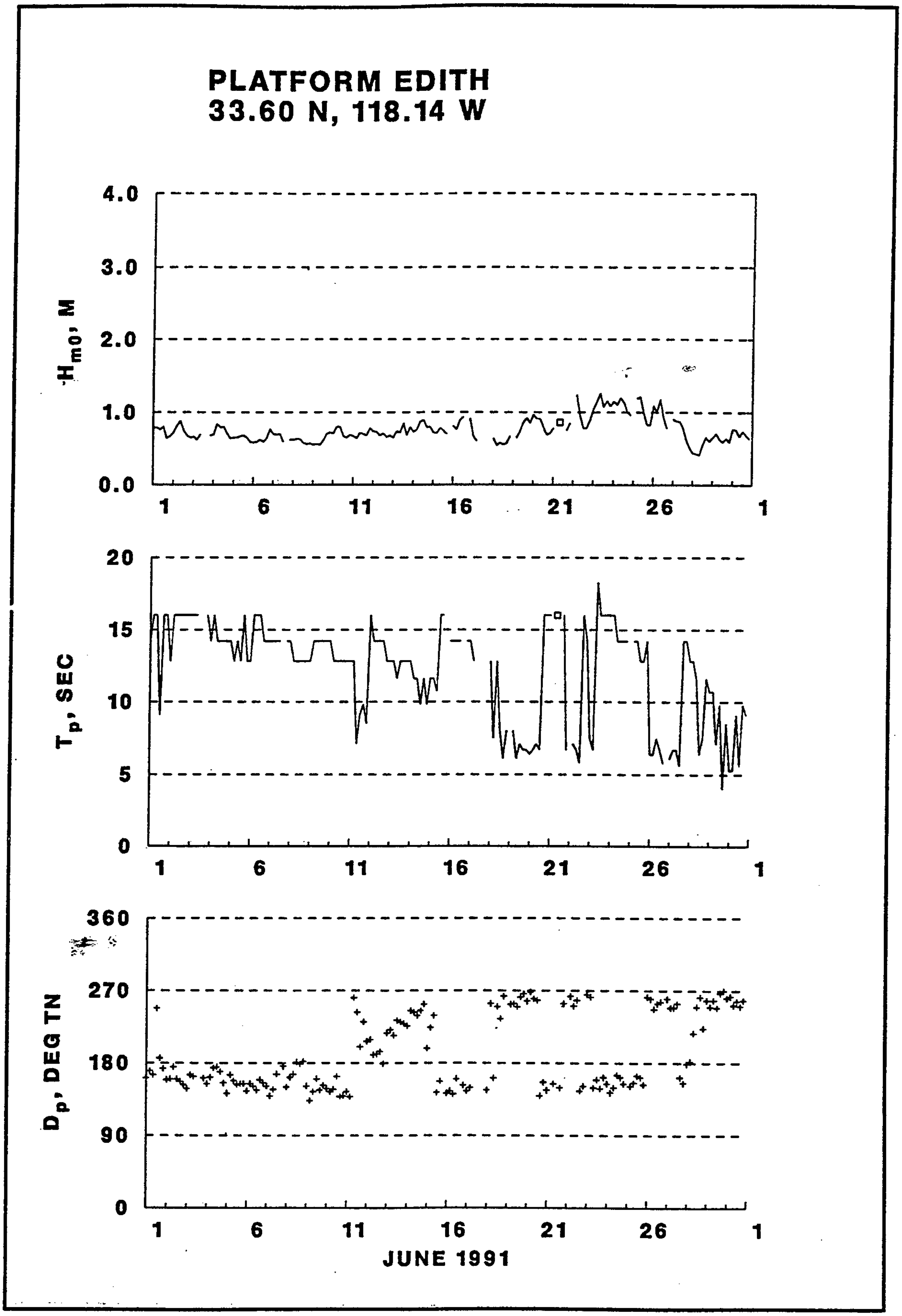

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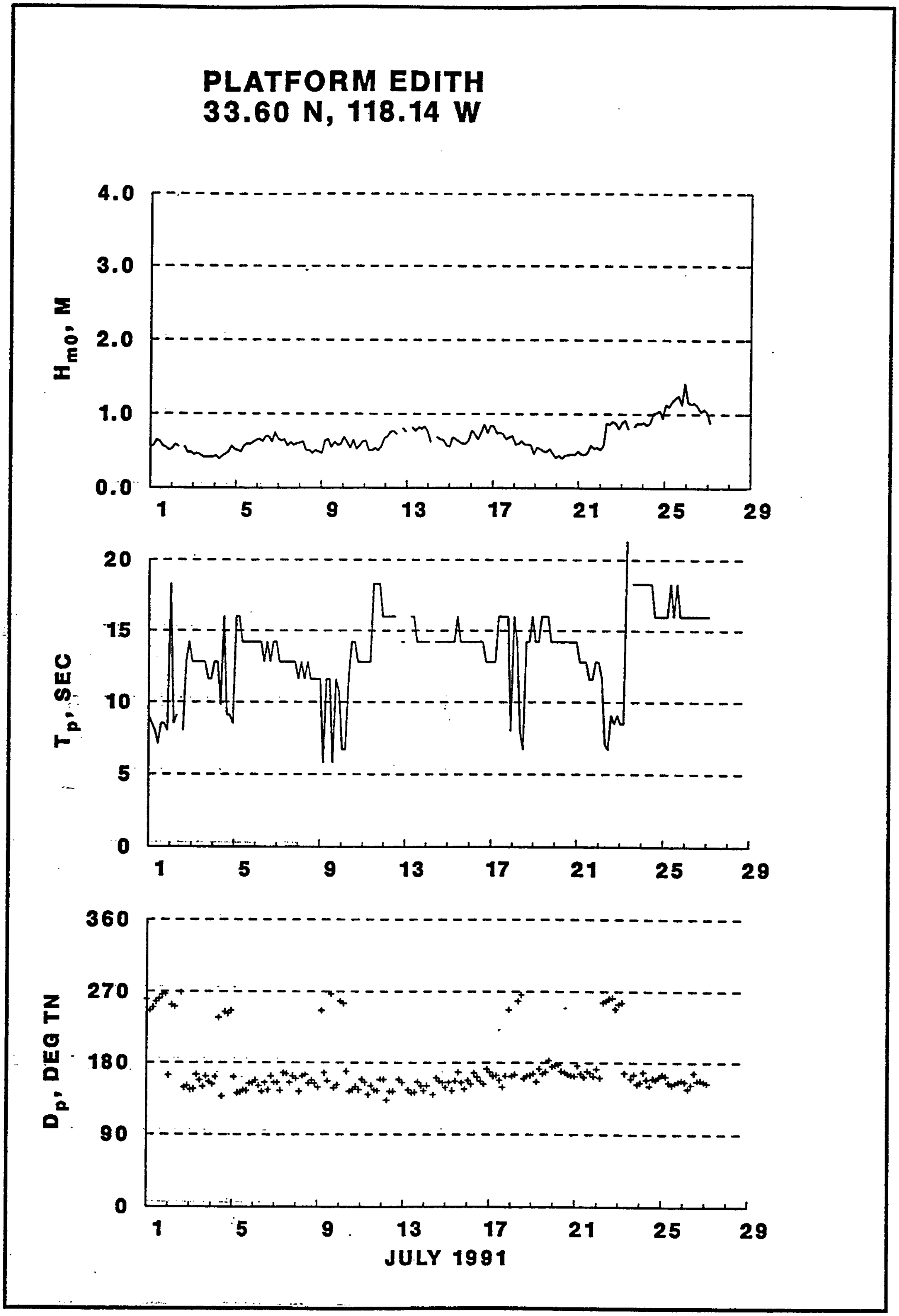
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Appendix E
Pressure Sensor Specifications

Sea Data, Inc. Mdl. 635-11 Wave and Tide Recorder Pressure Sensor: Paroscientific, Inc., "Digi-Quartz"

	100 psia[1]	
	feet	meters
Standard Ranges	190	58
Maximum Depth:	235	70
Resolution - Waves:	0.0035	0.10 cm
Tides:	0.0040	0.12 cm

Accuracy	
(more than 80 ft)	0.03
(less than 80 ft)	0.05
vs. temp @ 30 ft	0.004 ft/°C (max)

Frequency Response: DC to 1.0 Hz (Nyquist limit for 0.5-sec sampling)

Stability:	
vs time:	0.0002 percent FS/month at (almost constant) ocean depths
vs temp:	zero 0.007 percent FS/°C span 0.005 percent FS/°C (at 2/3 FS, 0.004 percent/°C)
Timebase:	4.194304 MHz special quartz crystal
Stability:	0.1 ppm/°C, 1 ppm/year; unmeasurable (0.001 percent) pressure data error at ocean depths

[1] psia = pounds per square inch, absolute.

Physical Specifications:

Size:

Case:	7-in. diam by 24 in. long
Mounts:	two 0.5-in. bolt holes on 13-in. centers, 1.0-in. clearance

Weight: 41 lb in air, with battery: 12.5 lb in water

Pressure Case:

Material:	6061-T6 aluminum
Hardware:	316 stainless and Delrin insulators
Finish:	Hard-coat anodize with electrostatic epoxy overcoat
Depth:	1,100-m operating depth

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Prototype Wave Data Summary

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13.ABSTRACT *(Maximum 200 words)*

This report presents data products from the analysis of seven different wave gauges in Los Angeles and Long Beach Harbors and a directional wave gauge at a nearby offshore site (Platform Edith). These data products were chosen in an effort to summarize all wave data collected during the Harbors Model Enhancements (HME) Program. Data acquisition methods and equipment are documented in this report, along with analysis methods. The emphasis of this report is on summarizing and documenting the available prototype wave data in fulfillment of the wave data collection and analysis tasks of the HME.

Between February 1984 and February 1988 wave data were sampled every 2 hr at 1 Hz for 2,048 sec in the harbors. From February 1988 to August 1991, data were collected continuously in the harbors at an average sample rate of 0.25 Hz. Directional wave data were measured offshore at Platform Edith via a PUV gauge between February 1985 and August 1991. Data for this period were collected at 1 Hz for 2,048 sec every hour but reported every 4 hr. Waves were measured in seven locations in the harbors with highly accurate single-point pressure sensors.

Directional wave measurements show that during the winter months most of the waves come from the west, but during the summer, the majority of the waves come from the south (although a significant number still come from the west) and average

(Continued)

14.SUBJECT TERMS

Harbors Model Enhancement (HME) Program	Platform Edith
Long Beach Harbor	Wave data
Los Angeles Harbor	Wind wave energy

15.NUMBER OF PAGES
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13. (Concluded).

peak in wind wave energy during the months of September and October. However, low-frequency waves that affect ship motion are present throughout the year.